



Spectroscopy Software



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3660 Quakerbridge Rd
Trenton, NJ 08619
TEL: 800-874-9789/609-587-9797
FAX: 609-587-1970

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Table of Contents

Part 1 Getting Started	17
Introduction	19
Summary of Chapter Information	19
Part 1, Getting Started	19
Part 2, Advanced Topics	20
Part 3, Reference	21
Online Help.....	21
Tool Tips and Status Bar Messages	22
Additional Documentation.....	22
Chapter 1 Installing and Starting WinSpec/32	23
System Requirements.....	23
Hardware Requirements	23
Operating System Requirements	25
Your System Components	25
Installing the PCI Card Driver	27
Installing the USB 2.0 Card Driver.....	27
WinSpec Version 2.5.25 and later.....	28
Installing the FireWire Card Driver.....	28
Installing the GigE Ethernet Card Driver	28
Installing WinSpec/32.....	29
Installing from the CD.....	30
Installing from the FTP Site	30
Custom Installation Choices.....	31
Changing Installed Components, Repairing, or Uninstalling/Reinstalling	
WinSpec/32	31
Starting WinSpec/32	32
Chapter 2 Basic Hardware Setup.....	35
Introduction.....	35
Basic Hardware Overview	35
Entering the Default System Parameters into WinSpec.....	37
Camera Detection Wizard	37
Editing Controller and Detector Characteristics	41
Entering the Data Orientation	45
Entering the Interface Communication Parameters	46
Entering the Cleans/Skips Characteristics	47
Setting up a Spectrograph	50
Specifying the Active Spectrograph	52
Entering Grating Information	52
Grating Parameters	52
Selecting and Moving the Grating	53
Entering Information for Software-Controlled Slits and/or Mirrors.....	54

Entering Laser Excitation Information	55
Chapter 3 Initial Spectroscopic Data Collection	57
Introduction.....	57
Temperature Control.....	58
Cleans and Skips.....	59
Spectrograph.....	59
Experiment Setup Procedure (All Controllers and Unintensified Cameras).....	59
Experiment Setup Procedures (Intensified Cameras)	63
Data Collection Procedures (Intensified Cameras).....	63
Data Collection (Unintensified Cameras)	63
Chapter 4 Initial Imaging Data Collection	65
Introduction.....	65
Temperature Control.....	66
Cleans and Skips.....	67
Experiment Setup Procedure (All Controllers and Unintensified Cameras).....	67
Experiment Setup Procedures (Intensified Cameras)	70
Data Collection Procedures (Intensified Cameras).....	71
Data Collection Procedures (Controller-Specific)	71
ST-133-Controller	71
Focusing.....	71
Data Collection	72
PentaMAX Controller	73
Focusing.....	73
Data Collection	74
Data Collection (Unintensified Cameras)	75
Chapter 5 Opening, Closing, and Saving Data Files	77
Introduction.....	77
Opening Data Files	77
Saving Data Files	80
Saving Temporary Data Files.....	80
Data File tab	81
Closing a Data File	81
Deleting Data Files	82
Chapter 6 Wavelength Calibration.....	83
Introduction.....	83
Changing the WinSpec/32 Calibration Method.....	83
Changing the Calibration Method.....	83
Calibration Menu	84
Wavelength Calibration Procedure	84
Save as Default	87
No Data	87
Not Live Data.....	87
Live Data.....	87
Calibration, Display, and User Units	87
Calibration Method.....	88
Chapter 7 Spectrograph Calibration	89
Introduction.....	89
Preparation.....	89

Calibration Parameters.....	90
Offset	92
Adjust.....	94
Dispersion	96
Chapter 8 Displaying the Data	99
Introduction.....	99
Screen Refresh Rate.....	100
Data Displayed as a 3D Graph.....	101
Displaying Hid-lamp.spe.....	101
5%-95% Display Range	104
Selecting a Region of Interest	104
Information box.....	105
Displaying a Single Strip.....	106
Cursor.....	107
Strip Selection	107
Cursor Curve and Marker Curves	108
Hidden Surfaces	109
Data Window Context menu.....	110
Labeling Graphs and Images	111
Data Displayed as an Image.....	114
Displaying circuit.spe.....	114
Changing the Brightness Range	115
Brightness/Contrast Control.....	116
Selecting a Region of Interest	116
Opening the Display Layout dialog	117
Viewing Axes and Cross Sections.....	117
Information box.....	118
Autoranging the Intensity in a ROI.....	119
Relabeling the Axes.....	119
Changing the Color of the Axes and Labels.....	120
Specifying a New ROI and Intensity Range	120
Displaying a Z-Slice.....	121
Part 2 Advanced Topics	123
Chapter 9 On-Line Data Acquisition Processes	125
Introduction.....	125
On-Line Thresholding.....	125
Description	125
Parameters	126
On-Line Absorbance.....	126
Description	126
On-Line YT.....	127
Description	127
YT Area and Equation Setup Procedure	128
Baseline Correction	129
Changing/Deleting Areas and Equations	129
YT Analysis Acquisition Modes	130
Focus.....	130

Snapshot.....	131
Average.....	132
YT Analysis Setup Procedure	132
ASCII Output File.....	134
Description	134
Procedure.....	134
Chapter 10 Cleaning	135
Introduction.....	135
Clean Cycles	135
Continuous Cleans	136
Continuous Cleans Instruction.....	138
ROIs and Cleaning.....	138
Kinetics and Cleaning.....	138
Chapter 11 ROI Definition & Binning.....	139
Overview.....	139
General	139
Spectroscopy Mode	140
Imaging Mode	140
Binning (Group and Height parameters).....	140
Overview	140
Hardware Binning.....	140
Software Binning	141
Spectroscopy Mode	141
Imaging Mode	141
Defining ROIs.....	142
Examples of Spectroscopy and Imaging ROIs.....	142
Constraints on Defining Multiple Regions of Interest (ROIs)	143
Methods of Defining and Storing ROIs	143
Chapter 12 Correction Techniques	147
Introduction.....	147
Background Subtraction	147
Background Subtraction with Intensified Detectors.....	148
Flatfield Correction.....	149
CCD Blemishes.....	150
Cosmic Ray Removal	151
Chapter 13 Spectra Math	153
Introduction.....	153
Source Data and Destination Selection.....	153
Operations.....	154
Operation Descriptions	155
Linear Operations	155
Non-Linear Operations.....	155
Bitwise Operations	156
Binary Operations	156
Chapter 14 Gluing Spectra	159
Introduction.....	159
Gluing Existing Spectra	159
Step and Glue.....	160

Theory	162
Calibration and ROI Offsets	164
Chapter 15 Post-Acquisition Mask Processes	165
Introduction.....	165
Input tab.....	165
Output tab.....	165
Edge Enhancement	166
Parameters tab	166
Laplacian Masks.....	167
Sobel Edge Detection	167
Edge Enhancement Procedure.....	167
Sharpening Functions	168
Parameters tab	168
Sharpening Procedure	168
Smoothing Functions	169
Parameters tab	169
Smoothing Procedure	169
Morphological Functions	170
Parameters tab	170
Morphological Procedure.....	171
Custom Filter	172
Filter Matrix tab	172
Custom Filter Procedure.....	172
Look Up Table	173
Look Up Table tab.....	173
Look Up Table Procedure	173
Look Up Table Formats	174
Format 1	174
Format 2.....	175
References.....	175
Chapter 16 Additional Post-Acquisition Processes	177
Introduction.....	177
Input tab.....	177
Output tab.....	177
Threshold and Clipping	178
Procedure.....	178
Cross Section	179
Introduction	179
Procedure.....	179
Binning and Skipping	180
Introduction	180
Procedure.....	180
Binning and Skipping Restrictions and Limitations.....	181
Histogram Calculation	182
Introduction	182
Procedure.....	182
Chapter 17 Printing	183
Introduction.....	183
Setting up the Printer	183
Printing Directly from WinSpec/32	184

Print Preview.....	184
Printing a Screen Capture	185
Saving as TIF and Printing	186
Chapter 18 Pulsar Operation.....	187
Introduction.....	187
PG200 Programmable Pulse Generator	187
DG535 Digital Delay/Pulse Generator	191
Programmable Timing Generator (PTG)	194
SuperSYNCHRO Timing Generator	198
Repetitive Mode Parameters	202
Sequential Mode Parameters.....	203
Timing Generator Interactive Trigger Setup.....	206
Timing Generator Interactive Gate Width and Delay	207
Chapter 19 Custom Toolbar Settings.....	209
Introduction.....	209
Displaying the Custom Toolbar	209
Customizing the Toolbar	209
Individual Dialog Item Descriptions.....	210
Chapter 20 Software Options.....	213
Introduction.....	213
Custom Chip (WXCstChp.opt).....	213
Introduction	213
Custom Timing (WXCstTim.opt).....	214
Introduction	214
FITS (FITS.exe).....	214
Macro Record (WXmacrec.opt).....	215
Spex Spectrograph Control (WSSpex.opt)	216
Virtual Chip (WXvchip.opt).....	216
Introduction	216
Virtual Chip Setup.....	217
Experimental Timing.....	220
Tips.....	220
Part 3 Reference.....	221
Appendix A System and Camera Nomenclature.....	223
System, Controller Type, and Camera Type Cross-Reference	223
System and System Component Descriptions	226
Systems:	226
Controllers:.....	228
Cameras/Detectors:	228
Pulsers:	229
High-Voltage Power Supplies:.....	229
Miscellaneous Components:.....	229
Array Designators	230
Appendix B WinSpec/32 First Light Instructions.....	233
Imaging	233

Assumptions	233
Getting Started.....	233
Setting the Parameters	233
Confirming the Setup	235
Spectroscopy	236
Assumptions	236
Getting Started.....	236
Setting the Camera Parameters.....	237
Setting the Spectrograph Parameters.....	238
Confirming the Setup	238
Rotational Alignment and Focusing	240
Acton Series Spectrograph.....	240
IsoPlane SCT-320 Spectrograph.....	242
Acquiring Data	243
Shutdown.....	243
Appendix C Calibration Lines	245
Appendix D Data Structure	247
Version 1.43 Header	247
Version 1.6 Header	248
Version 2.5 Header (3/23/04)	251
Start of Data (4100 -)	255
Definition of Array Sizes	255
Custom Data Types Used In the Structure.....	255
Reading Data.....	256
Appendix E Auto-Spectro Wavelength Calibration	257
Equations used in WinSpec Wavelength Calibration	257
WinSpec X Axis Auto Calibration	259
Appendix F CD ROM Failure Work-Arounds	261
Appendix G WinSpec/32 Repair and Maintenance	263
Install/Uninstall WinSpec/32 Components at a Later Time	263
Installing More than One Version of WinSpec/32	265
PIHWDEF.INI & SESSION.DAT.....	266
Uninstalling and Reinstalling.....	266
Appendix H USB 2.0 Limitations	267
Appendix I Troubleshooting	269
Introduction.....	269
Camera1 (or similar name) on Hardware Setup dialog.....	269
Controller Is Not Responding	270
Data Loss or Serial Violation.....	270
Data Overrun Due to Hardware Conflict message.....	270
Data Overrun Has Occurred message	271
Error Creating Controller message	272
Ethernet Network is not accessible	272
OrangeUSB USB 2.0 Driver Update	273
Program Error message.....	274
Serial violations have occurred. Check interface cable.	275

Appendix J Glossary	277
Warranty & Service	279
Limited Warranty:.....	279
Basic Limited One (1) Year Warranty	279
Limited One (1) Year Warranty on Refurbished or Discontinued Products	279
XP Vacuum Chamber Limited Lifetime Warranty	279
Sealed Chamber Integrity Limited 12 Month Warranty.....	280
Vacuum Integrity Limited 12 Month Warranty	280
Image Intensifier Detector Limited One Year Warranty.....	280
X-Ray Detector Limited One Year Warranty	280
Software Limited Warranty	280
Owner's Manual and Troubleshooting	281
Your Responsibility.....	281
Contact Information.....	282
Index.....	283

Figures

Figure 1. Opening WinSpec/32 via the Windows Start button.....	32
Figure 2. Splash screen	33
Figure 3. Main WinSpec/32 window	33
Figure 4. Setup menu	35
Figure 5. Possible System Configurations	36
Figure 6. Air-Cooled System (with Internal Controller) Diagram.....	36
Figure 7. Liquid- or Air-Cooled System (with External Controller) Diagram	37
Figure 8. Cryo-Cooled System (with External Controller) Diagram.....	37
Figure 9. Camera Detection Wizard - Welcome dialog.....	38
Figure 10. Camera Detection Wizard - Detected Hardware dialog	38
Figure 11. Camera Detection Wizard - Welcome (Manual selected) dialog	39
Figure 12. Camera Detection Wizard - Optional Configuration Disk dialog	39
Figure 13. Camera Detection Wizard - Test Image dialog	40
Figure 14. Camera Detection Wizard - Finished dialog	40
Figure 15. Hardware Setup Controller/Camera tab.....	41
Figure 16. Display tab; left graphic applies to all controllers except ST-121; right graphic applies to ST-121 only.....	45
Figure 17. Interface tab	46
Figure 18. Cleans/Skips tab	47
Figure 19. Vertical Skips	49
Figure 20. Spectrograph menu	50
Figure 21. Define Spectrograph dialog	50
Figure 22. Install/Remove Spectrographs.....	51
Figure 23. Gratings tab Setting the grating parameters	52
Figure 24. Move Spectrograph Gratings tab.....	53
Figure 25. Define Spectrograph Slits/Mirrors tab.....	54
Figure 26. Slit width and Mirror selection tabs - Move Spectrograph dialog	54
Figure 27. Entering the Laser Line Define Spectrograph Main tab.....	55
Figure 28. Temperature dialog.....	58
Figure 29. Experiment Setup: Main tab.....	59
Figure 30. Experiment Setup dialog Timing tab.....	60
Figure 31. Data Corrections tab	60

Figure 32. Generic ADC tab	61
Figure 33. ROI dialog	61
Figure 34. Data File tab	62
Figure 35. File Browse dialog.....	62
Figure 36. Acquisition menu	63
Figure 37. Typical Mercury-Argon Spectrum	64
Figure 38. Temperature dialog.....	66
Figure 39. Experiment Setup Main tab	67
Figure 40. Timing tab	68
Figure 41. Data Corrections tab	68
Figure 42. Generic ADC tab	69
Figure 43. ROI tab - imaging selected.....	69
Figure 44. Data File tab	70
Figure 45. File Browse dialog.....	70
Figure 46. ST-133 Interactive Camera dialog.....	72
Figure 47. PentaMAX Interactive Operation dialog	73
Figure 48. Typical Data Acquisition Image.....	75
Figure 49. Open dialog	77
Figure 50. High Intensity Lamp Spectrum	78
Figure 51. Data File Save As dialog	80
Figure 52. Save As Data Types.....	80
Figure 53. Data File tab	81
Figure 54. Right-click File Operations menu	82
Figure 55. Calibration Usage dialog	83
Figure 56. Calibration menu	84
Figure 57. Hg-Argon spectrum	85
Figure 58. Calibration Setup dialog after running Find Peaks routine on Hg-Argon spectrum.....	85
Figure 59. Spectrum after running Find Peaks routine	86
Figure 60. Setup Calibration screen after selecting peaks and entering calibration wavelengths	86
Figure 61. Spectrum after Calibration	87
Figure 62. Spectrograph Calibration dialog.....	91
Figure 63. Offset dialog	92
Figure 64. Peak Finder Examples	93
Figure 65. Offset Spectrum for Zero-order Measurement	94
Figure 66. Adjust dialog	95
Figure 67. Calibration Adjust Spectrum	95
Figure 68. Dispersion dialog.....	96
Figure 69. Image display of 256 data strips	99
Figure 70. 3D Image display of eight data strips	99
Figure 71. 3D graph with two data strips.....	100
Figure 72. 3D graph with five data strips	101
Figure 73. Open dialog	101
Figure 74. Display Layout dialog	102
Figure 75. Hid-lamp.spe 3-D Graph	103
Figure 76. Hid-lamp.spe 3D graph with region selected for viewing.....	104
Figure 77. Hide-lamp.spe 3D graph expanded to show defined region.....	105
Figure 78. Graphical Display with Information box.....	105
Figure 79. Single Strip displayed graphically.....	106
Figure 80. 3D Display with Cursor curve and Marker Curves	108
Figure 81. 3D Plot with Hidden Surfaces	110

Figure 82. Data Window Context menu	110
Figure 83. Normal Context menu	111
Figure 84. ROI Context menu.....	111
Figure 85. Label Display action.....	112
Figure 86. Label Options subdialog.....	112
Figure 87. Label text entry box.....	112
Figure 88. Data with Finished Label.....	113
Figure 89. Edit box with line-wrapped label and finished label with same line wraps .	113
Figure 90. ROI resized to correct Line-wrapping	114
Figure 91. Display after changing Font Selection	114
Figure 92. Open dialog	115
Figure 93. Circuit.spe Image.....	115
Figure 94. Brightness/Contrast dialog	116
Figure 95. Circuit.spe with Region Selected for Viewing	116
Figure 96. Circuit.spe Expanded to show Defined Region.....	117
Figure 97. Display Layout dialog	117
Figure 98. Display Layout Range tab	117
Figure 99. Selecting the Large Cursor	118
Figure 100. Circuit.spe with Axes and Cross-sections	118
Figure 101. Information box	118
Figure 102. Display Layout Axes tab	119
Figure 103. Fonts dialog	119
Figure 104. Display Layout Color tab	120
Figure 105. Display Layout Color dialog	120
Figure 106. Multi-frame Data and a Z-Slice of that Data	121
Figure 107. Experiment Setup Processes tab	125
Figure 108. Online Thresholding Setup dialog.....	125
Figure 109. Absorbance Setup dialog.....	126
Figure 110. YT Area & Equation Setup dialog	128
Figure 111. Equation Calculator dialog.....	129
Figure 112. Experiment Setup Process tab	132
Figure 113. YT Setup dialog.....	133
Figure 114. ASCII Output Setup dialog	134
Figure 115. Clean Cycles in Freerun Operation	135
Figure 116. Cleans/Skips tab	136
Figure 117. Timing Tab: External Sync with Continuous Cleans Selected.....	136
Figure 118. External Sync Timing Diagram.....	137
Figure 119. External Sync with Continuous Cleans Timing Diagram	137
Figure 120. Cleans/Skips tab: Continuous Cleans Instruction.....	138
Figure 121. Assumed Array Orientation.....	139
Figure 122. Single Full-width ROI.....	142
Figure 123. Single Partial-width ROI	142
Figure 124. Multiple Full-width ROIs	142
Figure 125. Spectroscopy Mode Multiple Partial-width ROIs	142
Figure 126. Imaging Mode Multiple ROIs with Different Widths	142
Figure 127. Multiple Imaging ROIs and Resulting Data	143
Figure 128. Easy Bin dialog	144
Figure 129. ROI Setup tab (Spectroscopy Mode).....	145
Figure 130. ROI Setup tab (Imaging Mode).....	146
Figure 131. Data Corrections tab.....	148
Figure 132. Blemish Files: CSV format and Tab Delimited format	150
Figure 133. Math dialog.....	153

Figure 134. Operation tab	155
Figure 135. Post-Process Glue dialog	159
Figure 136. Step and Glue Setup dialog	161
Figure 137. Input tab	165
Figure 138. Output tab	165
Figure 139. Edge Enhancement Parameters tab	166
Figure 140. Original Image (left) and Edge-detected Image (right)	167
Figure 141. Sharpening Parameters tab	168
Figure 142. Original Image (left) and Smoothed Image (right)	169
Figure 143. Smoothing Parameters tab	169
Figure 144. Morphological Parameters tab	170
Figure 145. Original Image (left) and Dilated Image (right)	170
Figure 146. Original Image (left) and Eroded Image (right)	170
Figure 147. Original Image (left) and Opened Image with Three Iterations (right)	171
Figure 148. Filter Matrix tab	172
Figure 149. Look-Up Table	173
Figure 150. Input tab	177
Figure 151. Output tab	177
Figure 152. Threshold and Clipping Parameters tab	178
Figure 153. Example Cross Sections of an ROI	179
Figure 154. Cross Section Parameters tab	179
Figure 155. Post-processing Binning and Skipping Parameters tab	180
Figure 156. Post-processing Histogram Parameters tab	182
Figure 157. Print Setup dialog	183
Figure 158. Print dialog	184
Figure 159. Print Preview window	184
Figure 160. Pulsers dialog	187
Figure 161. PG200 Comm Port tab	188
Figure 162. PG200 Triggers tab	188
Figure 163. PG200 Gating tab	189
Figure 164. PG200 Repetitive Gating Setup dialog	189
Figure 165. PG200 Sequential Gating Setup dialog	190
Figure 166. Camera State dialog	191
Figure 167. DG535 dialog	191
Figure 168. DG535 Comm Port tab	192
Figure 169. DG535 Triggers tab	192
Figure 170. DG535 Gating tab	193
Figure 171. DG535 Repetitive Gating Setup	193
Figure 172. DG535 Sequential Gating Setup dialog	193
Figure 173. Camera State dialog	194
Figure 174. Pulsers dialog	194
Figure 175. PTG Triggers tab	195
Figure 176. PTG Gating tab	195
Figure 177. PTG Repetitive Gating Setup	195
Figure 178. PTG Sequential Gating Setup dialog	196
Figure 179. PTG Aux. Trig. Out tab	198
Figure 180. Camera State dialog	198
Figure 181. Pulsers dialog	199
Figure 182. SuperSYNCHRO dialog	199
Figure 183. SuperSYNCHRO Gating tab	200
Figure 184. SuperSYNCHRO Repetitive Gating dialog (Internal Trigger on left; External Trigger on right)	200

Figure 185. SuperSYNCHRO Sequential Gating dialog (Internal Trigger)	201
Figure 186. SuperSYNCHRO Sequential Gating dialog (External Trigger)	201
Figure 187. SuperSYNCHRO Trigger Out tab	202
Figure 188. Range Limits Exceeded Warning	204
Figure 189. Gate Width/Delay Sequence dialog.....	205
Figure 190. Sequence Values File dialog	206
Figure 191. Timing Generator Interactive Trigger Setup dialog	206
Figure 192. Timing Generator Interactive Gate Width and Delay dialog.....	207
Figure 193. Default Custom Toolbar	209
Figure 194. Customize Toolbar dialog	209
Figure 195. Custom Chip tab.....	213
Figure 196. Custom Timing tab	214
Figure 197. FITS dialog.....	215
Figure 198. Macro Record dialog	216
Figure 199. Install/Remove Spectrographs dialog.....	216
Figure 200. Virtual Chip Functional diagram.....	217
Figure 201. Virtual Chip dialog	217
Figure 202. Wavelength Calibration Spectrum	246
Figure 203. Relationships of α and β in terms of ψ and γ	258
Figure 204. Relationship between ξ and the focal length, detector angle, and the distance of λ' from image plane.....	259
Figure 205. WinSpec, WinView, or WinXTest Selection dialogs.....	263
Figure 206. Media Password dialog.....	264
Figure 207. Application Maintenance dialog.....	264
Figure 208. Select Features dialog.....	264
Figure 209. WinSpec/32 has been successfully installed dialog	265
Figure 210. Exit or Install Another Program dialog	265
Figure 211. Camera1 in Camera Name Field.....	269
Figure 212. Data Overrun Due to Hardware Conflict dialog.....	270
Figure 213. Error Creating Controller dialog	272
Figure 214. Ebus Driver Installation Tool dialog	273
Figure 215. Program Error dialog	274
Figure 216. Serial Violations Have Occurred dialog.....	275

Tables

Table 1. PCI Driver Files and Locations	27
Table 2. USB Driver Files and Locations	28
Table 3. Cursor Appearance and Behavior for Images and Graphs.....	107
Table 4. Wavelength Calibration Lines (in nanometers)	245
Table 5. Features Supported under USB 2.0.....	267

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Part 1

Getting Started

Introduction	19
Chapter 1, Installing and Starting WinSpec/32	23
Chapter 2, Basic Hardware Setup	35
Chapter 3, Initial Spectroscopic Data Collection	57
Chapter 4, Initial Imaging Data Collection	65
Chapter 5, Opening, Closing, and Saving Data Files	77
Chapter 6, Wavelength Calibration	83
Chapter 7, Spectrograph Calibration	89
Chapter 8, Displaying the Data	99

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Introduction

The WinSpec manual has been written to give new users of Princeton Instruments detector/camera systems step-by-step guides to basic data collection, storage, and processing operations. The most up-to-date version of this software manual and other Princeton Instruments manuals can be found and downloaded from [ftp://ftp.princetoninstruments.com/public/Manuals/Princeton Instruments/](ftp://ftp.princetoninstruments.com/public/Manuals/Princeton%20Instruments/).

The WinSpec manual is divided into the following three parts:

- **Part 1, *Getting Started***, is primarily intended for the first time user who is familiar with Windows-based applications or for the experienced user who wants to review. These chapters lead you through hardware setup, experiment setup, data collection, file handling, wavelength calibration, spectrograph setup and calibration and data display procedures.
- **Part 2, *Advanced Topics***, goes on to discuss ancillary topics such as cleaning, ROIs, binning, data correction techniques, printing, gluing spectra, Y:T analysis, processing options, pulser operation and customizing the toolbar. These chapters are more informational and less procedural than those in Part 1.
- **Part 3, *Reference***, contains appendices that provide additional useful information, such as
 - commonly used system, controller type and camera type terminology provided in Appendix A,
 - Hg, Ar, Ne calibration spectrum data and graph provided in Appendix C, and
 - data structure information provided in Appendix D.

Also included are appendices that address repair and maintenance of the WinSpec/32 software and installation work-arounds for situations where the CD ROM does not support long file names.

A software hardware setup wizard guides you through the critical hardware selections the first time you select Setup – Hardware. To properly respond to the wizard’s queries, you may have to refer to your ordering information, such as exact detector model, A/D converters, etc. Keep this information handy.

Even though the wizard will assist you in getting started, it will still be necessary to read through this manual to familiarize yourself with the many data-collection and analysis options available.

Note: Throughout the manual references are made to the PI-MAX camera/detector. This camera/detector was previously called the I-MAX and the ICCD-MAX.

Summary of Chapter Information

Part 1, *Getting Started*

Introduction describes the contents of this manual as well as other information sources including online Help and other documentation files.

Chapter 1 **Installing and Starting WinSpec/32** lists system requirements and describes how to install the WinSpec/32 software.

- Chapter 2** **Basic Hardware Setup** provides detailed instructions on how to configure WinSpec/32 for operation with the hardware (detector, controller, and spectrograph) in your particular system. Pulser configuration is discussed in Chapter 18.
- Chapter 3** **Initial Spectroscopic Data Collection** provides a procedure for initial spectroscopic data collection, allowing users to gain some operating familiarity before going on to more complex measurements.
- Chapter 4** **Initial Imaging Data Collection** provides a procedure for initial imaging data collection, allowing users to gain some operating familiarity before going on to more complex measurements.
- Chapter 5** **Opening, Closing, and Saving Data Files** describes how to open, close and save data files in WinSpec/32.
- Chapter 6** **Wavelength Calibration** describes how to calibrate the WinSpec/32 software for one position of the spectrograph grating.
- Chapter 7** **Spectrograph Calibration** discusses how to calibrate the WinSpec/32 software for any position of the spectrograph gratings.
- Chapter 8** **Displaying the Data** describes the data file display options.

Part 2, Advanced Topics

- Chapter 9** **On-Line Data Acquisition Processes** describes data acquisition processes that can be activated to occur during data acquisition. These processes include on-line thresholding, on-line absorbance, on-line Y:T, and ASCII output.
- Chapter 10** **Cleaning** describes the cleaning features that are used while data acquisition is idle to prevent the buildup of unwanted charge on the array.
- Chapter 11** **ROI Definition & Binning** describes how to set a region of interest (ROI), so that data is only collected from the specified portion of the CCD array. It also describes binning, the summing together of charge from several pixels, on the array or in software during data acquisition. Simple or more advanced binning options can be configured easily with WinSpec/32.
- Chapter 12** **Correction Techniques** explains correction options such as background subtraction and flatfield correction.
- Chapter 13** **Spectra Math** covers WinSpec/32's mathematical processing features.
- Chapter 14** **Gluing Spectra** discusses gluing existing files or combining the data acquisition and gluing operations under spectrograph control.
- Chapter 15** **Post-Acquisition Mask Processes** describes digital mask-operations that can be performed on the acquired data. Discussed are Edge Enhancement, Sharpening, Smoothing, Custom Filter and Morphological functions.
- Chapter 16** **Additional Post-Acquisition Processes** describes additional operations that can be performed on an acquired data set. Functions covered include Threshold and Clipping, Cross Section, Binning and Skipping, and Histogram.

- Chapter 17 Printing** describes printing features of WinSpec/32. WinSpec/32 can print directly to almost any Windows printer driver.
- Chapter 18 Pulsar Operation** describes the operation of the Pulsers that can be used with WinSpec/32.
- Chapter 19 Custom Toolbar Settings** describes the Custom Toolbar and explains how to add/remove the available buttons.
- Chapter 20 Software Options** describes WinSpec/32 options that can also be purchased from Princeton Instruments.

Part 3, Reference

- Appendix A System and Camera Nomenclature** provides a cross-reference table for systems, controllers, and cameras/CCD arrays. It also provides brief descriptions of systems and system components. CCD array related abbreviations are also included.
- Appendix B WinSpec/32 First Light Instructions** provides procedures for setting up and focusing a system while in **Imaging** mode and for setting up, aligning, and focusing a system while in **Spectroscopy** mode.
- Appendix C Calibration Lines** contains wavelength tables and a detailed spectrum for Mercury-Argon.
- Appendix D Data Structure** contains descriptions of the data structure for both WinView/WinSpec 1.43 and for 1.6. *The data structure for WinView/32 and WinSpec/32 is the same as that for WinView/WinSpec 1.6.*
- Appendix E Auto-Spectro Wavelength Calibration** discusses the WinSpec/32 wavelength calibration algorithm.
- Appendix F CD Failure Work-Arounds** provides advice on how to successfully complete the installation in situations where the CD ROM doesn't support long file names.
- Appendix G WinSpec/32 Repair and Maintenance** provides information on how to repair, reinstall and uninstall WinSpec/32 components.
- Appendix H USB 2.0 Limitations** covers the currently known limitations associated with operating under the USB 2.0 interface.
- Appendix I Troubleshooting USB 2.0** provides solutions to communication problems that may occur when operating under the USB 2.0 interface.
- Appendix J Glossary** includes brief definitions of terms used in relation to WinSpec/32 and the system hardware.

Online Help

The WINSPEC.CHM online documentation contains:

- information that is in this manual,
- step-by-step instructions on how to use WinSpec functions,
- reference information about WinSpec and its functions, and
- context-sensitive help, which describes a screen or menu item that is being pointed to or that is active when a Help button is clicked on.

Tool Tips and Status Bar Messages

Placing the mouse cursor on a button and resting it there for a few seconds causes a brief tool-tip message to appear that describes the button's function. Tool tips are also provided for the individual panes of the Status Bar (at the bottom of the WinSpec/32 window). Note that tool tips only appear at the desktop level. Tool tips are not provided for the buttons on the individual dialogs and tabs.

More detailed descriptions for each button at the desktop level are provided at the left side of the Status Bar. Status Bar help messages are also provided for the menu selections.

Additional Documentation

Additional documentation can be found in the \WinSpec32\Documentation directory on the hard drive where WinSpec/32 was installed. Among the files that may be in this directory are:

WINHEAD.TXT This file contains documentation on the header structure for WinSpec/32 or WinView/32 Data Files. TXT files can be opened with any ASCII text editor.

WinX_readme.doc This is a read-me file that contains the latest information on new features, fixed problems, and work-arounds for issues not yet solved.

WinX32 Automation 3.X for Visual Basic.pdf This file is stored in the directory when the Visual Basic User Interface component is selected during installation. It describes how to create your own Snap-Ins by using Visual Basic Professional Edition and the WinX32 Automation files. Requires Adobe® Acrobat® Reader®.

WinX32 Programming for Macro Record.pdf This file is stored in the directory when the Macro option is installed. It provides detailed information on how to create and edit macro programs for WinSpec/32. Requires Adobe Acrobat Reader. The Macro option is not supplied with the standard WinSpec/32 program.

Chapter 1

Installing and Starting WinSpec/32

To ensure that the computer you have can operate the Princeton Instruments equipment, please first read the system requirements below carefully. WinSpec/32's requirements differ from those of previous versions of WinSpec.

After confirming that your computer meets all hardware and software requirements, install WinSpec/32 according to the instructions in this chapter. Do not attempt to run the software until you have read Chapters 2, 3 and 4, which discuss important hardware-setup and data acquisition issues. Also, it is recommended that you install the Princeton Instruments interface board in your computer before running the software. Instructions for installing the interface board are provided in your Princeton Instruments hardware manuals.

Note: If your computer and system were purchased together from Princeton Instruments, the Interface card will have been installed at the factory.

System Requirements

The following information lists the system hardware and software requirements.

Hardware Requirements

- Princeton Instruments camera and, if required by the camera, a Princeton Instruments ST series controller with either a TAXI or USB 2.0 Interface Control module for communication between controller and host computer.
- Host Computer (TAXI Protocol):
 - Minimum is AT-compatible computer with 80486 (or higher) processor (50 MHz or faster): Pentium® or better recommended.
 - Princeton Instruments (RSPI) high speed PCI or Photometrics high speed PCI serial card. *Computers purchased from Princeton Instruments are shipped with the card installed.*
 - Minimum of 32 Mbyte total RAM for CCDs up to 1.4 million pixels. Collecting larger images at full frame or at high speed may require 128 Mbytes or more of RAM.
 - Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 17 Mbytes, and the remainder is required for data storage. Collection of large images may require additional hard disk storage, depending on the number of spectra collected and their size. Disk level compression programs are not recommended.

ATTENTION Not all computers are able to satisfy the software and data-transfer performance requirements of Princeton Instruments systems. If you purchased a computer through Princeton Instruments, it will have already been tested for proper operation with a Princeton Instruments system and will have the Interface card installed.

- Super VGA monitor and graphics card supporting at least 256 colors with at least 1 Mbyte of memory. Memory required will depend on desired display resolution.

- Two-button Microsoft-compatible serial mouse or Logitech three-button serial/bus mouse.
- Host Computer (USB 2.0 Protocol):
 - AT-compatible computer with Pentium 3 or better processor that runs at 1 GHz or better.
 - Native USB 2.0 support on the motherboard or USB Interface Card (Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop computers and the SIIG, Inc. USB 2.0 PC Card, Model US2246 is recommended for laptop computers).
 - Minimum of 256 Mb of RAM.
 - CD-ROM drive.
 - Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 17 Mbytes and the remainder is required for data storage, depending on the number and size of spectra collected. Disk level compression programs are not recommended.
 - Super VGA monitor and graphics card supporting at least 256 colors with at least 1 Mbyte of memory. Memory requirement is dependent on desired display resolution.
 - Two-button Microsoft compatible serial mouse or Logitech three-button serial/bus mouse.
- Host Computer (FireWire Protocol):
 - Pentium 3 or better processor running at 1 GHz or better.
 - Native FireWire (IEEE 1394a) support on the mother board or plug-in interface card.
 - Minimum of 512 Mbytes of RAM.
 - CD-ROM drive.
 - Hard disk with a minimum of 1-2 Gbytes available. A complete installation of the program files takes about 25 Mbytes and the remainder is required for data

- Host Computer (GigE Protocol):
 - 2 GHz Pentium 4 (or greater)
 - 1 GB RAM (or greater)
 - CD-ROM drive
 - At least one unused PCI card slot (32-bit) (PCI 2.3 compliant 32-bit 33/66 MHz bus)
 - Super VGA monitor and graphics card supporting at least 65535 colors with at least 128 Mbyte of memory. Memory requirement is dependent on desired display resolution.
 - Hard disk with a minimum of 1 Gbyte available. A complete installation of the program files takes about 50 Mbytes and the remainder is required for data storage, depending on the number and size of images/spectra collected. Disk level compression programs are not recommended. Drive speed of 10,000 RPM recommended.
 - Mouse or other pointing device.

Operating System Requirements

TAXI Protocol: Windows® XP or Windows Vista® (32-bit) operating system.

USB 2 Protocol: Windows XP (with Service Pack 1) or Vista (32-bit).

FireWire Protocol: Windows XP (with Service Pack 2) or Vista (32-bit).

GigE Protocol: Windows XP (32-bit with SP3 or later) or Vista (32-bit).

Your System Components

Take a few minutes and enter the information in the table below. Various pieces of this information will be required when you install WinSpec/32, when the Setup Wizard (see Camera Detection wizard, page 37) runs, and when you begin entering component information on the dialogs and tabs associated with Hardware Setup, Spectrograph Setup, and Pulser Setup. Other information such as software version and hardware serial numbers may be useful if you ever need to contact Customer Support.

System Component	Your System	Notes
Application Software and Version	WinSpec Version 2.6.____	Found on the installation CD or via the WinSpec Help menu.
Software Options		Options (purchased separately from WinSpec) such as Macro Record or Virtual Chip.
PVCAM® Driver	Yes / No	PVCAM driver is used to run Photometrics cameras, PhotonMAX, Princeton Instruments cameras with USB 2, and the Acton InSpectrum™.

System Component	Your System	Notes
Interface Card	Princeton Instruments PCI, Tucson PCI, USB 2.0, FireWire, GigE	Older systems use the Princeton Instruments PCI. Tucson PCI is required for Photometrics cameras and PhotonMAX. Newer Princeton Instruments systems use USB 2, FireWire or GigE.
System Name		Refer to your order and Appendix A
Controller	PentaMAX, ST-121, ST-133, ST-133-2MHz, ST-133-5MHz, ST-138, _____	Refer to your order and Appendix A
Controller Serial Number		Refer to the serial label. Typically, this is located on the bottom of the unit.
Detector/Camera and CCD Array		Refer to your order and Appendix A
Detector/Camera Serial Number		Refer to the serial label. Typically, this is located on the back of the unit.
Shutter Type	Small (≤ 25 mm), Large (≥ 35 mm), None	
Spectrograph Type	Acton, Spex, or _____	
Pulser Type	DG535, PG200, PTG, or SuperSYNCHRO	PTG is associated with the PI-MAX and PI-MAX2 cameras. SuperSYNCHRO is associated with PI-MAX3 and PI-MAX4 cameras.
Pulser Serial Number		Refer to serial label, typically located on the back of the unit and in the lower left corner.

Installing the PCI Card Driver

Administrator privileges are required under Windows X, Vista (32-bit), and Windows 7 (32-bit) to install software and hardware.

Before installing the PCI card in your computer, install WinSpec. Then, turn the computer off. Follow the instructions supplied with your computer for installing an internal card and install the PCI card. After you have secured the card in the computer and replaced the cover, turn the computer on. When Windows boots, it will try to install the new hardware. If it cannot locate the driver, you will be prompted to enter the directory path, either by keyboard entry or by using the browse function.

When WinSpec was installed, the required INF file was put into the Windows/INF directory and PCI card driver file is put in the Windows/System32/ Drivers directory.

Windows Version	PCI INF Filename Located in "Windows"/INF directory*	PCI Device Driver Name Located in "Windows"/System32/Drivers directory
Windows XP, Vista (32-bit)	rspi.inf (in WINDOWS/INF, for example)	rspipci.sys (in WINDOWS/System32/Drivers, for example)

* The INF directory may be hidden.

Table 1. PCI Driver Files and Locations

Installing the USB 2.0 Card Driver

Administrator privileges are required under Windows XP, Vista (32-bit), and Windows 7 (32-bit) to install software and hardware.

Before installing the Princeton Instruments USB2 Interface, install WinSpec. Then, we recommend that you defragment the host computer's hard disk. This operation reduces the time the computer spends locating files. Typically, the "defrag" utility "Disk Defragmenter" can be accessed from the Windows® Start menu and can usually accessed from the Programs/Accessories/System Tools subdirectory.

After defragmenting the hard disk, turn off the computer and make the USB cable connections between the host computer and the ST-133. Then, turn the ST-133 on before turning on the host computer.

At bootup, Windows will detect the Princeton Instruments USB2 Interface hardware (i.e., the USB 2.0 Interface Control module). You may be prompted to enter the directory path(s) for the apausbprop.dll and/or the apausb.sys file(s), either by keyboard entry or by using the browse function. When WinSpec was installed, the required INF, DLL, and USB driver files were automatically put in the "Windows" directories shown in Table 2.

Windows Version	USB INF Filename Located in "Windows"/INF directory*	USB Properties DLL Located in "Windows"/System32 directory	USB Device Driver Name Located in "Windows"/System32/Drivers directory
Windows XP, Vista (32-bit)	rsusb2k.inf (in WINNT/INF, for example)	apausbprop.dll (in WINDOWS/System32, for example)	apausb.sys (in WINDOWS/System32/Drivers, for example)

* The INF directory may be hidden.

Table 2. USB Driver Files and Locations

WinSpec Version 2.5.25 and later

The PVCAM.INI file required by a PVCAM-supported camera (i.e., Princeton Instruments camera with USB 2.0 interface, a PhotonMAX, a Photometrics camera, or an Acton InSpectrum) will automatically be created when the Camera Detection Wizard runs. One of the things this file contains is the default name for the camera (typically "Camera1") that is displayed on the **Hardware Setup|Controller/Camera** tab. Because this name is not particularly descriptive, you may want to change it by editing the PVCAM.INI file: editing instructions are provided in "*Camera1 (or similar name) on Hardware Setup dialog*", on page 269.

Installing the FireWire Card Driver

Administrator privileges are required under Windows XP, Vista (32-bit), and Windows 7 (32-bit) to install software and hardware.

Quad-RO camera systems use FireWire (IEEE1394a) to communicate between the camera and the host computer.

1. Check the connectors at the front or back of your computer for an existing FireWire (IEEE1394a) port that matches the 1394a port on your camera.
2. If your PC does not have a functioning FireWire (1394a) port, you must install a FireWire (IEEE 1394a) interface card. Refer to the interface card and computer manufacturer's documentation for instructions.

Installing the GigE Ethernet Card Driver

Administrator privileges are required under Windows XP, Vista (32-bit), and Windows 7 (32-bit) to install software and hardware.

NIRvana[™], PI-MAX[®]3, ProEM[®], and PyLoN[®] camera systems use the GigE Ethernet to communicate between the camera and the host computer. For best performance, Princeton Instruments recommends the Intel Pro/1000 GigE card.

1. ***Before installing WinSpec***, install the interface card into the host computer. When WinSpec is installed, it will replace the driver supplied with the card with a high performance driver.
2. After you have finished installing WinSpec, make the cable connections between the camera and computer, power on the camera, and then start up WinSpec.

Installing WinSpec/32

Caution Because WinSpec/32 and WinView/32 contain files with the same name but different content, do not install WinSpec/32 and WinView/32 software in the same directory.

Before installing WinSpec/32:

- Verify that your computer meets the requirements listed on pages 23-24.
- Check to see if the interface card has been installed. Note that the interface card is not necessary if the computer will only be used for post-processing data. If you plan to collect data and the card is not installed in your computer, you will need to install it and add the hardware *after WinSpec/32 is installed*.
- If installing under Windows XP, Vista (32-bit), Windows 7 (32-bit), make sure that you are logged on as administrator of the computer. Otherwise, the installation will fail because changes cannot be made to the Windows Registry.
- Check to see if WinView/32 has been installed on your system.
- Determine how you will be installing the software. WinSpec/32 is provided on a CD shipped with the system or it can be installed from the Princeton Instruments FTP site.

During the installation process, you will be given the choice of **Typical**, **Complete**, or **Custom** installation.

Click on **Complete** or **Custom** if you are using a **SPEX** spectrograph.

Typical: The most common application features will be installed. This choice is recommended for most users. If you find out later that you need features that were not installed, you can load the CD, enter the password, and install them via the **Application Maintenance** dialog. See Appendix G, page 263, for more information.

Complete: All application features will be installed. This choice is recommended for best performance.

Custom: Allows you to choose which features to install and where they will be installed. This choice is recommended for advanced users.

Installing from the CD

1. Exit any software currently running. This will speed the installation of WinSpec/32.
2. Insert the WinSpec/32 CD into your CD drive. Windows will detect the CD and the installation will begin automatically.

Note: If the auto-start feature has been disabled on your computer, click the desktop **Start** button, select **Run**, key **x:\Setup** (where "x" is the letter designating your CD drive) and press the **Enter** key on your keyboard. The install sequence will begin.

Caution

If your CD drive doesn't support the Windows long filenames, attempting the installation causes the filenames to be truncated and the installation fails, generating an error message like:

**An error occurred during the move data process: -113
Component: Application\WinXSystem
File Group: WinXSystem**

If this should happen, see Appendix F for workarounds.

3. Click on the program that you want to install. If you have clicked on "Install WinSpec/32 or WinView/32" you will be given additional choices on the next dialog.
4. After selecting the program, follow the instructions provided on the dialogs and continue with the installation process. You can abort the installation at any time by clicking on **Cancel** and following the instructions.

Installing from the FTP Site

If you are not sure how to access the FTP site, contact Princeton Instruments' Customer Support Department for assistance. Contact information follows.

Princeton Instruments
3660 Quakerbridge Road
Trenton, NJ 08619 (USA)
Tel: 800-874-9789/609-587-9797
Fax: 609-587-1970
Customer Support E-mail: techsupport@princetoninstruments.com

For customer support and service outside the United States, see our web page at www.princetoninstruments.com. An up-to-date list of addresses, telephone numbers, and e-mail addresses of Roper Scientific's overseas offices and representatives is maintained on the web page.

1. Log onto the FTP site and go to the **Software/Official/Current** directory.
2. Execute the program WinSpec.exe and follow the instructions on your screen. You can abort the installation at any time by clicking on **Cancel** and following the instructions.

Custom Installation Choices

Help File: Loads the WinSpec Help System files (*.chm), both general and context-sensitive Help.

Documentation: WinSpec manual

Sample Data: Creates a directory **Data** containing sample *.SPE files. This directory is located beneath the one containing the WinSpec/32 files.

Diagnostic Programs: Loads diagnostics programs for specific cameras.

Spectrograph Support: Loads drivers for Acton spectrographs.

Pulser Support: Loads the pulser drivers, if required. Currently supported pulsers include the SuperSYNCHRO, PTG, PG200, and the DG535 Timing Generator (drives the PI-MAX pulsing circuits).

SnapIns: Loads the selected Snap-In files. When a Snap-In is installed, its button will be added to the Snap-In toolbar.

PI Screen Saver: Loads the PI Screen Saver.

Visual Basic Interface: Allows DLLs programmed using Visual Basic 5 or higher to be executed from WinSpec/32. Documentation is provided in the *WinX32 Automation 3.X for Visual Basic* manual.

Options: Allows you to install or uninstall WinSpec/32 options such as Imaging, Macro Record, Spex, Custom Timing, and Custom Chip. Some options may require a password.

Changing Installed Components, Repairing, or Uninstalling/Reinstalling WinSpec/32

Refer to Appendix G.

Starting WinSpec/32

Before starting WinSpec/32, follow the hardware interconnection and power up instructions in the hardware manuals supplied with your system. Then, click on the **Start** button, select **All Programs**, and start WinSpec/32 by clicking on **WinSpec32** in the **Princeton Instruments** folder (see Figure 1).

Note: You can start WinSpec/32 even if you have not installed the interface card or if you have not turned on the controller. If there is no interface card, WinSpec/32 will run in "Demo" mode. This mode allows you to look at and post-process previously stored data (such as the sample data installed with the software) and to become familiar with experiment setup and data acquisition. Some features will not be available because the program looks for information from the controller and camera while WinSpec/32 is loading and initializing.

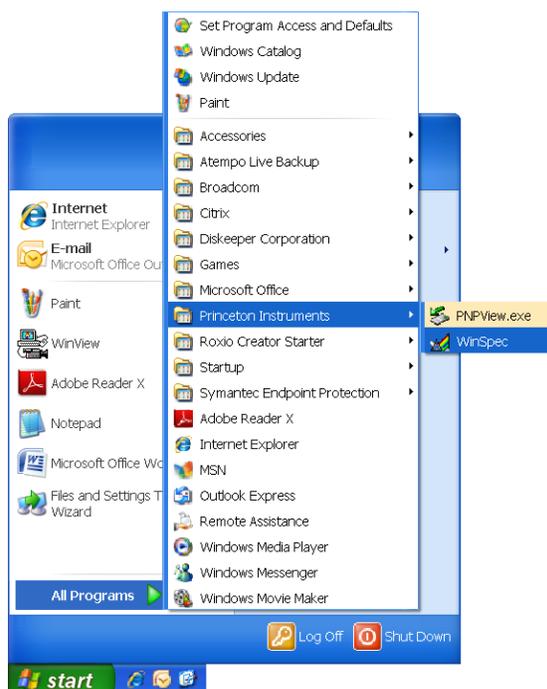


Figure 1. Opening WinSpec/32 via the Windows Start button

While the software is booting, a splash screen such as the one shown in Figure 2 is displayed until the software has finished loading and initializing. Then, the Main Menu appears as shown in Figure 3. From there, you can access the program's functions through menu selection.

Note: If this is the first time you have installed and launched WinSpec/32, the Camera Detection Wizard will pop up. This wizard allows you to specify the camera system and load the default hardware settings before you can access the menu. See Chapter 2, page 37 for more information about the Camera Detection Wizard.

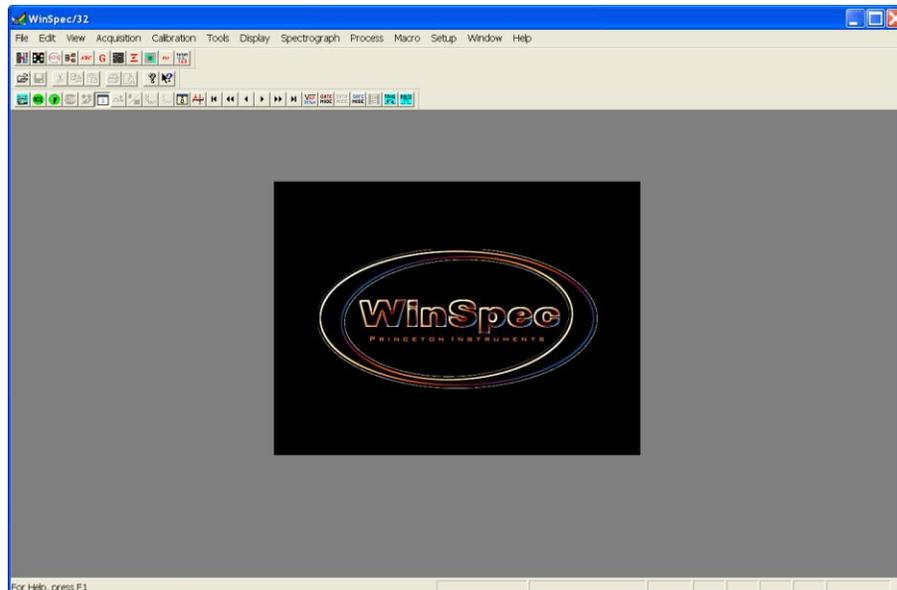


Figure 2. Splash screen

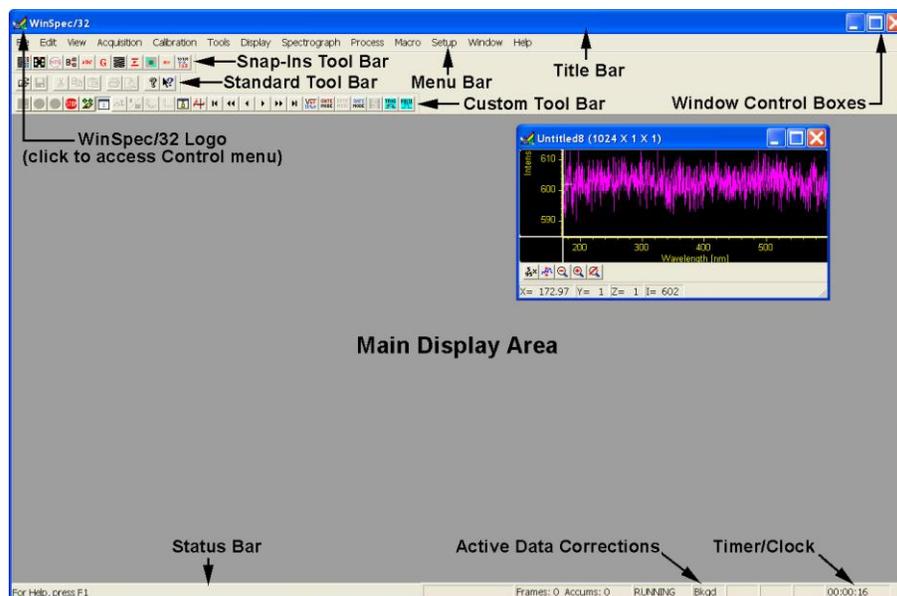


Figure 3. Main WinSpec/32 window

Values, labels, and alphanumeric data are usually entered from the keyboard. Selections and screen control operations are usually done using a mouse or other graphical I/O device, although keyboard selection shortcuts are provided. Mouse selection is typically done by positioning the mouse cursor on the selection item and clicking the left mouse button. In some cases, clicking the *right* mouse button will bring up a dialog with additional information or a special menu that allows additional operations to be performed.

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Basic Hardware Setup

Introduction

This chapter provides an overview of the relationships between the camera, the controller, and the host computer. This overview is followed by a discussion of the Setup Wizard that runs the first time you select Hardware from the Setup menu (Figure 4). The remainder of the chapter presents the Hardware Setup tabs so you will be able to make the appropriate selections and entries for your system.

The chapters that follow describe how to configure a spectrograph, set up a pulser, set up experiment parameters, and control array temperature. Initial data acquisition is discussed in Chapters 3 and 4.

Advanced functions such as Post-Processing, Custom Chip, and Custom Timing are discussed in Part 2 of this manual.



Figure 4. Setup menu

Basic Hardware Overview

The basic components of a Princeton Instruments system are: a camera (or detector), a controller (external or internal), interconnecting cables, a computer interface card, and the application software (in this case WinSpec/32). Note that other components such as a computer, coolant circulator, and pulser can also be ordered.

The interface card, installed in the host computer, permits communication between the host computer and the controller (in some cases an external controller such as an ST-133).

The controller accepts input from the host computer and WinSpec/32 and converts it to the appropriate control signals for the camera. These signals allow you to specify the readout rate, binning parameters, regions of interest, gain, and array temperature. After data is acquired in the camera, it is transmitted to the controller where it is processed, transmitted to the host computer, displayed in the WinSpec/32 window, and can be stored to disk.

Figure 5 illustrates possible system configurations (spectrometers and pulsers are not shown). Figure 6 shows the interconnections for an air-cooled Princeton Instruments



camera with an internal controller, as well as interconnections to an optional external shutter and spectrometer. Figure 7 and Figure 8 show the interconnections for a Princeton Instruments system with an external controller, as well as interconnections to an optional coolant circulator, an optional external shutter, and spectrometers.

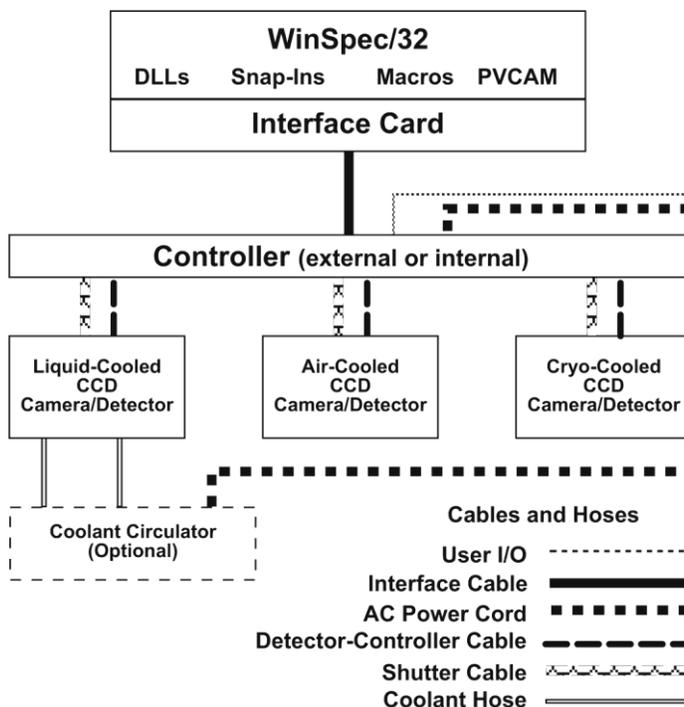


Figure 5. Possible System Configurations

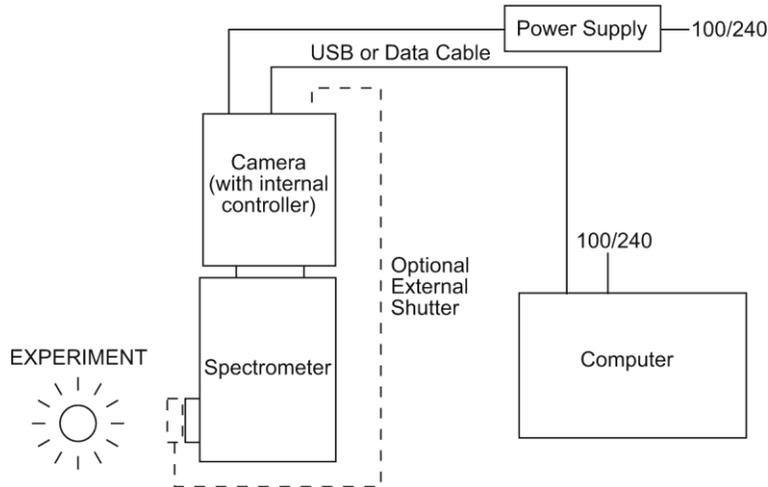


Figure 6. Air-Cooled System (with Internal Controller) Diagram

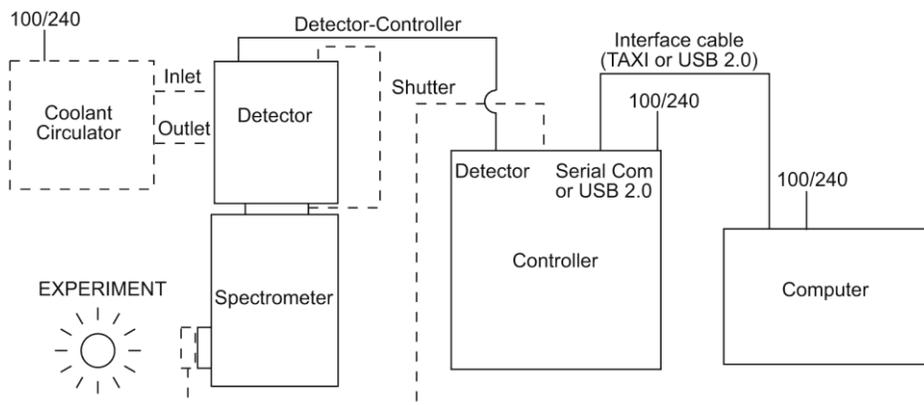


Figure 7. Liquid- or Air-Cooled System (with External Controller) Diagram

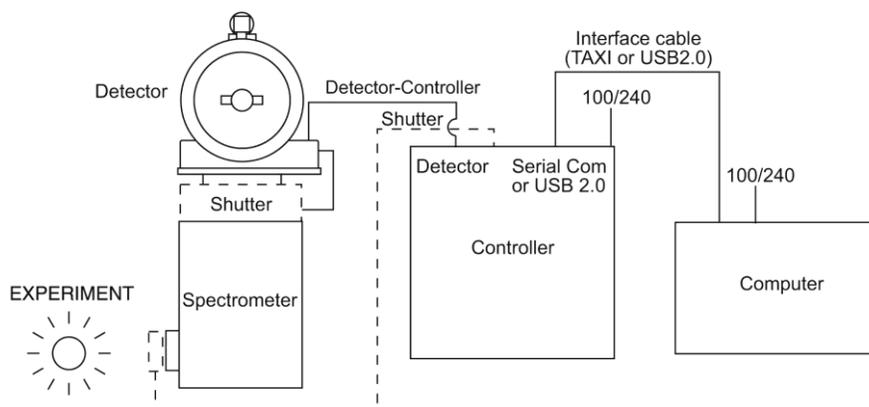


Figure 8. Cryo-Cooled System (with External Controller) Diagram

Entering the Default System Parameters into WinSpec

Camera Detection Wizard

The Camera Detection Wizard is used to load the WinSpec hardware setup parameter fields with default values for a WinSpec-compatible camera system. The Camera Detection Wizard runs automatically the first time you install WinSpec and can be launched at a later date if you decide to control a different WinSpec-compatible camera. The autodetection function can be used for Gigabit Ethernet-base camera systems (PI-MAX3, PI-MAX4, NIRvana, ProEM, and PyLoN), FireWire-based camera systems (Quad-RO), PVCAM-based camera systems (USB 1 interface, USB 2 interface, Photometrics PCI, Acton InSpectrum, and PhotonMAX) and Princeton Instruments PCI (TAXI) interface-based systems.

To Use the Autodetection Function:

1. Make sure the camera system is connected to the host computer and that it is turned on.
2. Start WinSpec. The **Camera Detection Wizard** will automatically run if this is the first time you have installed a Princeton Instruments WinX application (WinView/32, WinSpec/32, or WinXTest/32) and a supported camera. Otherwise, if you installing a new camera type, click on the **Launch Camera Detection Wizard...** button on the **Controller/CCD** tab to start the wizard.

3. On the **Welcome** dialog (Figure 9), leave the checkbox unselected and click on **Next**.



Figure 9. Camera Detection Wizard - Welcome dialog

4. Select the system that you want to install.
 - If there are two camera systems connected to the host computer and turned on, the wizard table should contain two listings.
 - If there are no systems listed, click on **Back**, check the cable connections and/or turn on the camera system, and then click on **Next**.



Figure 10. Camera Detection Wizard - Detected Hardware dialog

- If there are still no systems listed and the camera uses the GigE interface, click on **Cancel** and contact your Information Technology specialist. UDP ports 20200-20202 (often closed by computer security functions such as an anti-virus program or a firewall) must be open for WinX to detect a Princeton Instruments camera using GigE.
5. Follow the instructions on the dialogs to perform the initial hardware setup: this wizard enters default parameters on the Hardware Setup dialog tabs and gives you an opportunity to acquire a test image to confirm the system is working.

To Use the Manual Function:

Note: This function can only be used to install Princeton Instruments PCI (TAXI) interface-based systems (both Princeton Instruments PCI (TAXI) and PVCAM-supported systems can be installed by using the autodetection function previously described.). The manual function is very similar to the Hardware Detection Wizard, but you are not given the opportunity to install a PVCAM-based camera. In addition, unless you want to acquire the optional test image, this function does not require that the system be turned on.

1. Start WinSpec. The **Camera Detection Wizard** will automatically run if this is the first time you have installed a Princeton Instruments WinX application (WinView/32, WinSpec/32, or WinXTest/32) and a supported camera. Otherwise, if you installing a new camera type, click on the **Launch Camera Detection Wizard...** button on the **Controller/CCD** tab to start the wizard.
2. On the **Welcome** dialog (Figure 11), select the checkbox and click on **Next**.



Figure 11. Camera Detection Wizard - Welcome (Manual selected) dialog

3. In most cases you will not be getting a New System Configuration Disk with your system. Therefore, the default selection is "**NO**". If you do have such a disk, you would select "**YES**" and follow the directions for loading the information from that disk. Click on **NEXT** and follow the directions on the subsequent dialogs for selecting the interface, controller, and detector/camera.



Figure 12. Camera Detection Wizard - Optional Configuration Disk dialog

4. When you have finished with these selections, you will see the **Test Image** dialog (Figure 13). The default selection is "**No**". If you select "**Yes**", you must make sure that the system is connected to the host computer and that the camera system is turned **ON** before you click on the **Next** button.



Figure 13. Camera Detection Wizard - Test Image dialog

5. Depending on your radio button selection, the following will happen
 - "**No**": Clicking on the **Next** button will load the camera/controller default parameters into WinSpec and pop up the **Finished** dialog.
 - "**Yes**": Assuming that the camera system is connected to the host computer and turned on, clicking on the **Next** button will acquire a single frame of data (using a 100 msec exposure time), load the camera/controller default parameters into WinSpec, and pop up the **Finished** dialog.
6. Click on **Finish** to complete the camera installation.



Figure 14. Camera Detection Wizard - Finished dialog

Editing Controller and Detector Characteristics

The **Hardware Setup|Controller/Detector** tab (may also be named *Controller/Camera* or *Controller/CCD* depending on the hardware selections) is used to enter and update Controller Type, Detector (Camera or CCD, depending on the system) Type and some of the Controller/ Detector type parameters, such as Shutter Type and Readout Mode. The Controller and Detector Type selections are perhaps the most fundamental and important of all hardware selection decisions and directly influence the appearance of many other WinSpec/32 screens and the selections provided on them. As a result, setting up the software for use in any system should always begin with the Controller selection.

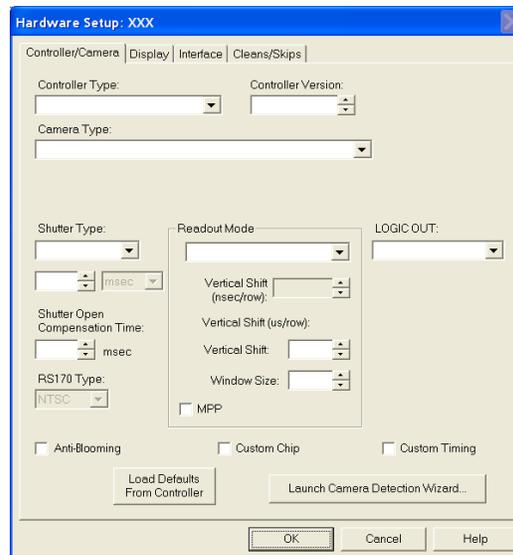


Figure 15. Hardware Setup/Controller/Camera tab

Figure 15 shows the fields and checkboxes that may be present on the **Controller/Detector** tab. WinSpec/32 displays or hides features based on the selected controller, detector, and readout mode. All of the features are described in the text that follows.

Controller Type (Camera Name): The currently selected Controller Type (Camera Name) is displayed in this field. If you change the controller that is being used in the system, choose the correct name from the selection list (displayed by clicking on the button at the end of the field). Appendix A provides a cross-reference table for systems, controllers, and CCD arrays.

Note: After you have selected the **Controller Type**, you can load the default settings for your controller, camera, and array by clicking on **Load Defaults From Controller**, if this button is present.

Controller Version: In the case of the ST-133 and PentaMAX controllers, different versions have been released having different capabilities. The available software selections will correctly reflect these differences when the proper version number is specified in this box.

Camera Type: The selected Camera (Detector/CCD) Type is displayed in this field. Clicking on the button at the end of the box drops the selection list so that the selected type can be changed if necessary. Note that the listed camera types depend on the controller selection, requiring that the controller type be specified first.

Shutter Type: There are six selections.

None: If the camera has no shutter (frame-transfer or interline CCD array) and is not an Intensified camera, select **None**.

Small: A small shutter is one that is typically 25 mm or smaller in diameter. This setting represents a shutter compensation time of approximately 8 msec.

Large: A large shutter is one that is typically 35 mm and larger. In the case of a camera having a very large CCD, such as the Kodak 2k × 2k, a large shutter may have been installed. This setting represents a shutter compensation time of approximately 28 msec.

Remote: **Remote** is primarily intended for spectroscopy applications where an external shutter would be placed ahead of the entrance slit.

Electronic: **Electronic** only applies to operation with an intensified camera, which would normally not be equipped with a mechanical shutter. This selection would apply to both the Gate and Shutter/CW modes of the IIC-100, IIC-200, IIC-300, MCP-100, and PI-MAX.

Custom: This shutter type is automatically selected if you are using a PVCAM-supported camera. When **Custom** is the shutter type, you will be able to enter the shutter close compensation time in the field below the shutter type. Shutter close compensation time delays readout to allow time for the shutter to fully close. The close value will vary depending on the camera and the shutter used.

Phosphor Decay Time: Used by the PI-MAX3 and PI-MAX4 when running in single trigger DIF mode to delay the shift behind mask for the first image.

Shutter Open Compensation Time: Delays the exposure until the shutter is fully open. The open delay value will vary depending on the camera and the shutter used.

Readout Mode: The readout mode is determined by the characteristics of the CCD array and the controller. The possible choices are:

Full Frame: The entire chip can be read out.

Frame Transfer: Only the unmasked area of the chip can be read out. Frame transfer is only available if the camera has a frame-transfer chip such as the EEV 512 × 1024.

Interline: Provides 100% duty cycle operation. Interline is only available with a camera having an interline chip such as the PI 1300 × 1030.

Kinetics: Kinetics is a special type of operation in which most of the CCD is mechanically or optically masked, leaving a small section open to light. This section is then read out very quickly. See the System or Controller manual for more details on the CCD aspects of this readout mode.

DIF or Dual Image Feature: (**MicroMAX, PI-MAX2, PI-MAX3, and PI-MAX4 Interline only**) Dual Image Feature (DIF) is a special feature that allows images to be taken in pairs with very short exposure times (as small as 1 μs). For MicroMAX this feature is only available for factory modified MicroMAX controller/Interline camera systems. The three MicroMAX DIF timing modes are IEC (Internal Exposure Control), EEC (External Exposure Control) and ESABI (Electronic Shutter Active Between Images). These modes are in addition to Free Run mode. The two DIF timing modes for PI-MAX2, PI-MAX3 and PI-MAX4 are Single Trigger and Dual Trigger.

Vertical Shift Time: This information appears for the **Frame Transfer** and **Kinetics** modes. Reports the speed (in microseconds) at which a single row will be shifted vertically. This information is based on the value in the Vertical Shift box. The higher the value in that box, the longer the vertical shift time.

Note: If you are using a PVCAM-supported camera, the **Vertical Shift** rate is expressed in **nsec/row**. Use the up/down arrows to change the Vertical Shift rate.

Vertical Shift: Determines the speed of the image transfer from the exposed area of a frame-transfer chip to the masked area. Also sets the speed of image transfer when operating in the Kinetics mode. Setting a lower value increases the shift speed. A higher value gives a slower shift. If the shift is too fast, not all of the charge will be transferred. If too slow, image smearing will be increased due to the exposure that takes place while the transfer is in progress. The default value gives good results in most measurements.

Note: If you are using a PVCAM-supported camera, this parameter is hidden because the shift time is being adjusted via the **Vertical Shift (nsec/row)** up/down arrows.

Window Size: Determines the height of the window for **Kinetics** mode. The window size must be at least 1 row and less than or equal to the maximum number of rows for the array.

MPP: This checkbox may appear if the CCD array is designed for MPP (multi-pinned-phase) operation. When this box is checked, the array will be run in MPP mode. Some MPP-capable arrays can also be run in Non-MPP mode (MPP box is unchecked). Running in Non-MPP mode may result in higher dark current in addition to larger full well capacity.

Note: MPP capability reduces the rate of dark-current generation by a factor of 20 or more, and thus relaxes CCD cooling requirements to the level where a thermoelectric cooler is sufficient for most applications.

LOGIC OUT Output: The choices for the signal provided at the controller's **SCAN** Output connector vary based on the selected Controller. If the **LOGIC OUT** field doesn't appear on the tab, the choice of output may be done via an internal jumper (for information on how to set the jumper, contact factory Tech Support). Depending on your system, the following choices may appear in the drop down list:

Cleaning: This signal is high when an array Clean cycle is in progress and otherwise low.

Logic 0: Establishes a TTL logic 0 at the **Logic Out** connector.

Logic 1: Establishes a TTL logic 1 at the **Logic Out** connector.

Note: LOGIC 0 and LOGIC 1 can be used to control an external device using the application software.

Not FT Image Shift: This signal is low when a frame-transfer shift is in progress and otherwise high.

Not Ready: After a Start Acquisition command, this output changes state on completion of the array cleaning cycles that precede the *first* exposure. Initially high, it goes low to mark the beginning of the *first* exposure. In free run operation it remains low until the system is halted. If a specific number of frames have been programmed, it remains low until all have been taken, then returns high.

Not Scan: Reports when the controller is finished reading out the CCD array. **NOT SCAN** is high when the CCD array is not being scanned, then drops low when readout begins, returning to high when the process is finished.

Shutter: This signal is low when the shutter is closed and goes high when the shutter is activated, dropping low again after the shutter closes. In Gated operation, **SHUTTER** is the correct choice and the signal should be applied to the inhibit input of the pulser to prevent pulsing during readout.

Shutter Comp Time Pre: Delays the acquisition until the shutter (if present) is fully open. The setting range is 0 to 30 ms. For single-strip spectroscopic measurements, a setting of "0" is recommended.

RS170 Type: Selections are NTSC (US video standard) and PAL (European).

Show Custom Chip: Advanced feature. See Custom Chip discussion on page 213.

Show Custom Timing: Advanced feature. See Custom Timing discussion on page 214.

Anti-Blooming: (THM 1024x1024FT CCD array) Checking this box activates this CCD array's anti-blooming feature.

Load Defaults From Controller: Pops up the **Load Factory Defaults From NVRAM** dialog so you can repopulate the fields and selections with the values stored in the controller's non-volatile RAM.

Launch Camera Detection Wizard: Pops up the Camera Detection Wizard - Welcome dialog so you can set up a new camera system or switch the active camera system to another camera system already connected to the host computer.

Entering the Data Orientation



Figure 16. Display tab; left graphic applies to all controllers except ST-121; right graphic applies to ST-121 only

With the exception of the ST-121, the **Display** tab is the same for all controllers. Three display options, **Rotate**, **Reverse** and **Flip**, are provided. This feature allows you to compensate for CCD array or camera orientation. Before and after thumbnail illustrations show the effect of each selection. If no option is selected, the thumbnails will be the same. Any orientation can be achieved with the proper combination of **Rotate**, **Reverse**, and **Flip**. In the case of the ST-121, only **Reverse** is provided.

Rotate: Rotates the image 90° counterclockwise.

Reverse: Reverses the image horizontally.

Flip: Flips the image vertically.

Entering the Interface Communication Parameters

The **Interface** tab allows you to specify the interface card installed in your computer and to enter the I/O addresses (if required). This functionality is particularly useful if you have multiple PCI cards installed in the host computer. Figure 17 shows all of the fields and checkboxes that exist on the **Interface** tab. WinSpec/32 will display and hide features based on the interface card installed in the host computer. All of the features are described in the text that follows.

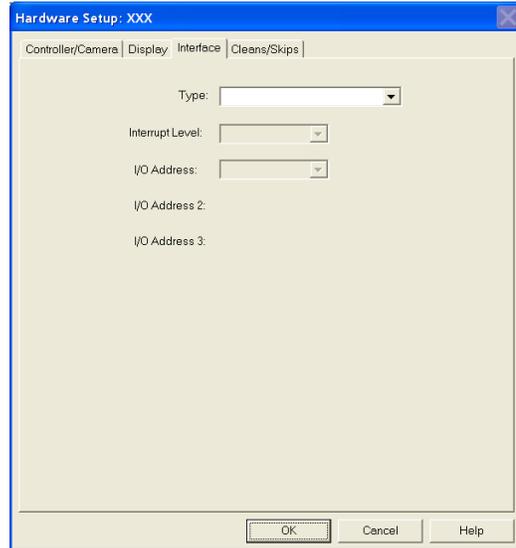


Figure 17. Interface tab

Type: Select the communications type that will be used to transmit data from the controller to the computer. All communications types are not available for all controllers and computers. The "Demo" selection, which allows the software to be

exercised but which does not support data transfer to the computer, would not ordinarily be used in the field.

High Speed PCI: Select if a Princeton Instruments (RSPI) PCI high-speed serial Interface card is installed in your computer and you want data transfer to be interrupt driven. This choice would give the highest performance in most situations.

PCI Timer: Allows data transfer to be controlled by a polling timer if using PCI high-speed serial Interface card. Useful for troubleshooting possible interrupt problems (computer crashes or system fails to return data). Note that data transfer is slower in PCI Timer mode and data overrun more likely. Also PCI Timer cannot be used to continuously acquire small Regions of Interest in Safe Mode timing operation. PCI Timer is not compatible with **Use Interrupts** operation, a timing mode available when using the ST-138 Controller.

Demo: Allows the software to be exercised without being connected to a controller. This mode is used primarily for demonstration purposes or post-processing of acquired data and cannot be used in an actual measurement.

Interrupt Level: The interrupt level for a PCI card is reported but cannot be changed.

Card Number: This field only appears if more than one PCI card has been detected in your computer. This field allows you to set up the communications parameters so each card is uniquely addressed.

I/O Address: The I/O Address for a PCI card is reported but cannot be changed.

I/O Address 2 and 3: (High Speed PCI only) These addresses are reported but cannot be changed; address selection is automatic and under computer control. With other interfaces, these addresses are not displayed.

Entering the Cleans/Skips Characteristics

Caution

For most applications, the default settings will give the best results. We advise contacting the factory for guidance before changing these parameters from their default values. **Exception:** With a PI-MAX camera, we suggest settings of Cleans 1 and Strips per Clean 4, Minimum Block Size 16 and Number of Blocks 32.

The **Cleans/Skips** tab allows you to change the clean and skip parameters from their default values or to reload the default values. Figure 18 shows all of the fields and checkboxes that exist on the **Cleans/Skips** tab. WinSpec/32 will display and hide features based on the controller version. All of the features shown are described in the text that follows. Refer to Chapter 10, starting on page 135, for additional information.

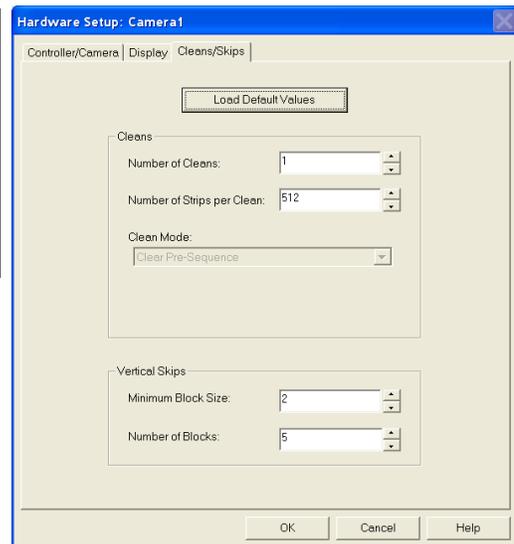


Figure 18. Cleans/Skips tab

Load Default Values: Reloads the factory defaults from the NVRAM.

Cleans

Cleans are applied to the entire CCD array and remove charge that has accumulated on the array while waiting for data acquisition to begin. The charge on the CCD chip is transferred to the shift register and discarded to prevent charge buildup from occurring. On completion of a setup, successive clean cycles occur normally. The **Number of Cleans** and **Number of Strips per Clean** parameters allow you to program additional clean cycles that will be performed after initiating the run but before any data are taken.

Number of Cleans: For most applications the default value should be used.

Clicking on the **Load Default Values** button and then selecting **Yes** will install the default value. Values other than the default can be directly entered in the field or selected via the spin buttons.

Number of Strips per Clean: Sets the number of CCD data strips to be transferred and discarded during each clean. The maximum valid setting is limited by the chip size. The default value will generally give good results.

Clean Mode: (Photometrics brand cameras) Sets when and how charge will be cleared from the array while the camera is waiting to acquire data. Clearing removes charge from the CCD by clocking the charge to the serial register then directly to ground. This process is much faster than readout, because the charge does not go through the readout node or the amplifier. Note that not all clearing modes are available for all cameras. Be sure to check availability of a mode before attempting to set it.

Clear Never: Never clear the CCD. Useful for performing readout after an exposure has been aborted.

Clear Pre-Exposure: Before each exposure, clears the CCD the number of times specified by the Number of Cleans entry. This mode can be used in a sequence. It is most useful when there is a considerable amount of time between exposures.

Clear Pre-Sequence: Before each sequence, clears the CCD the number of times specified by the Number of Cleans entry. If no sequence is set up, this mode behaves as if the sequence has one exposure. The result is the same as using Clear Pre-Exposure.

Clear Post-Sequence: Clears continuously after the sequence ends. The camera continues clearing until a new exposure is set up or started, the abort command is sent, the speed entry number is changed, or the camera is reset.

Clear Pre/Post-Sequence: Clears Number of Cleans times before each sequence and clears continuously after the sequence ends. The camera continues clearing until a new exposure is set up or started, the abort command is sent, the speed entry number is changed, or the camera is reset.

Clear Pre-Exposure Post-Sequence: Clears Number of Cleans times before each exposure and clears continuously after the sequence ends. The camera continues clearing until a new exposure is set up or started, the abort command is sent, the speed entry number is changed, or the camera is reset.

Use Continuous Cleans Instruction: This feature is supported by Version 5 (and higher) ST-133 controllers and will only appear if the detector/camera also supports this feature. Continuous cleans instruction does horizontal shifts while doing vertical shifts for a faster continuous clean. Check this box if you want to apply the continuous cleans instruction to the continuous cleans function available when External Sync timing mode (**Experiment Setup|Timing** tab) is being used to acquire data. *With this instruction, the delay between an External Sync trigger and the start of exposure is minimized.* Refer to Chapter 10, starting on page 135, for more information about continuous cleans and continuous cleans instruction.

Note: Older versions of the ST-133 controllers, as well as other controller types and cameras, do not support this instruction.

Vertical Skips

Vertical skips are associated with regions of interest (ROIs) that are smaller than the full chip. This feature allows you to bin and quickly traverse the rows that precede and follow the ROI. The rows to be processed and discarded are binned into blocks, each containing a number of rows, with the Number of Blocks parameter determining how many blocks there will be before and after the ROI.

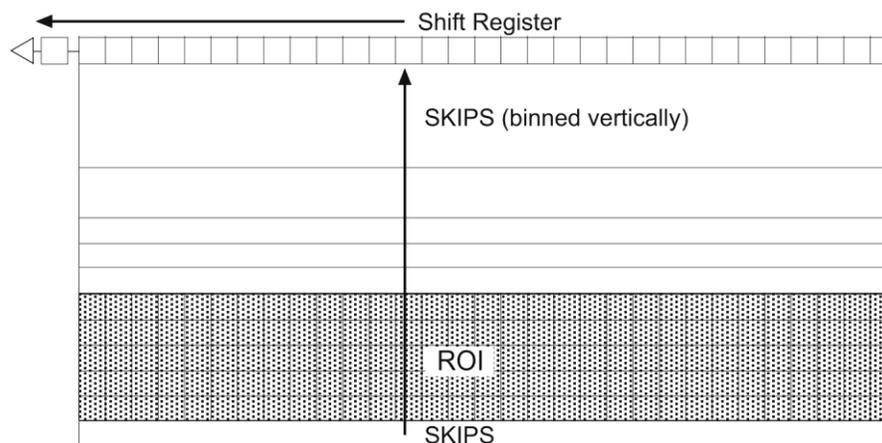


Figure 19. Vertical Skips

The block size determines how quickly the region preceding and following the ROI will be traversed. If the blocks are large, the region will be traversed quickly but there is the possibility of overloading the shift register and causing blooming. With small blocks, the risk of blooming will be minimized but the time to traverse will be large. WinSpec/32 uses an exponential algorithm to simultaneously achieve rapid traversing with minimal risk of blooming. The first block, specified in rows, is as large as possible. Each successive block is a factor of two smaller than the one preceding until the minimum block size is reached. All remaining blocks are the minimum block size. By making the first block as large as possible and subsequent blocks increasingly smaller, the region preceding and following the region of interest is traversed as rapidly as possible while minimizing risk of the shift register saturation.

Minimum Block Size: Sets the size, in rows, of the skip blocks that immediately precede the data. The default value will generally give good results.

Number of Blocks: Sets the number of binned “skip” blocks preceding and following the region of interest. The default value will generally give good results.

Note: The 2-D OMA array does not support vertical skips; and all of the rows on the array are read out and converted before the non-ROI information is discarded. The default Vertical Skips settings of Minimum Block Size: 2 and Number of Blocks: 5, while appearing to work, will result in invalid data. **Instead, you must change these settings to 1 and 256, respectively, for the 2-D OMA array.**

Setting up a Spectrograph

WinSpec/32 allows you to control several types of spectrographs. More than one spectrograph can be installed in the system at one time. The total number of spectrographs is limited only by the number of free communication ports.

The following spectrograph operations can be performed after you define your spectrograph:

- moving a spectrograph grating,
- automatic calibration of acquired data according to the spectrograph position,
- changing to a different grating for some spectrographs, and
- changing the entrance slit size and/or the selected mirror for some spectrographs.

The following steps explain how to set up a spectrograph. You must correctly install a spectrograph before you can control any of its functions through WinSpec/32.

1. Make sure that the spectrograph is correctly connected to a host computer COM port.
2. Turn on the host computer and the spectrograph.

3. Wait for the spectrograph to finish initializing and then boot WinSpec/32. If this is not done, although you will be able to install the spectrograph, it will not be possible to establish communications and an error message will result.



Figure 20. Spectrograph menu

4. Select **Define** on the **Spectrograph** menu (Figure 20). This will open the **Define Spectrograph** dialog (Figure 21).
5. On the **Main** tab, note the Active Spectrograph text entry box. If spectrographs have previously been installed, the active one will be indicated. If no spectrograph has been previously installed, the box will be blank. Note there is a checkbox that allows you to designate a particular spectrograph as the one that will be used for doing an Auto-Spectro Calibration.

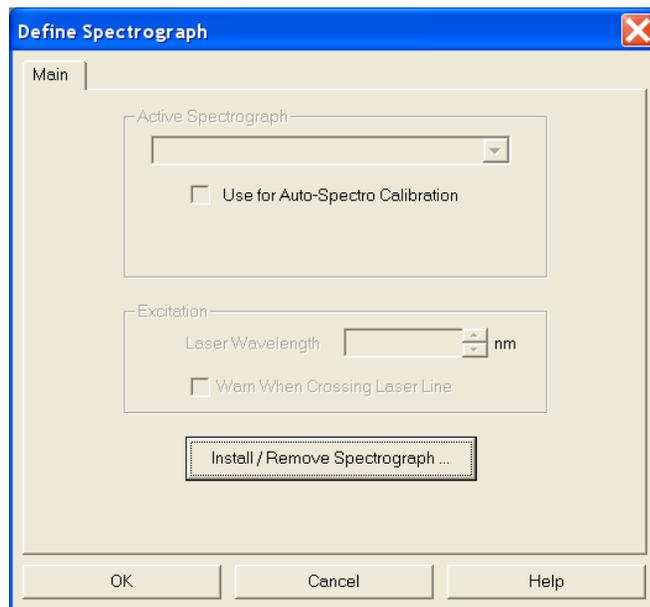


Figure 21. Define Spectrograph dialog

6. Click on **Install/ Remove Spectrograph**. This will open the **Install/Remove Spectrographs** dialog (Figure 22). The lower window lists the supported Spectrographs. The upper window lists those installed. To install a spectrograph, select it from the list in the lower window, select the **Communications Port** (Auto, COM1-COM8, or DEMO) and click on **Install Selected Spectrograph**. The installed spectrograph will then appear in the upper window. In the case of the example shown in Figure 22, the selected spectrograph is an Acton SP300i. When selecting a communications port during the installation, keep in mind the characteristics of the choices.

Auto: When WinSpec is started, it will look for the spectrograph and communicate via the port (USB or COM) at which it is found.

COM1-8: If you select a specific COM port, WinSpec will only look for the spectrograph at that port.

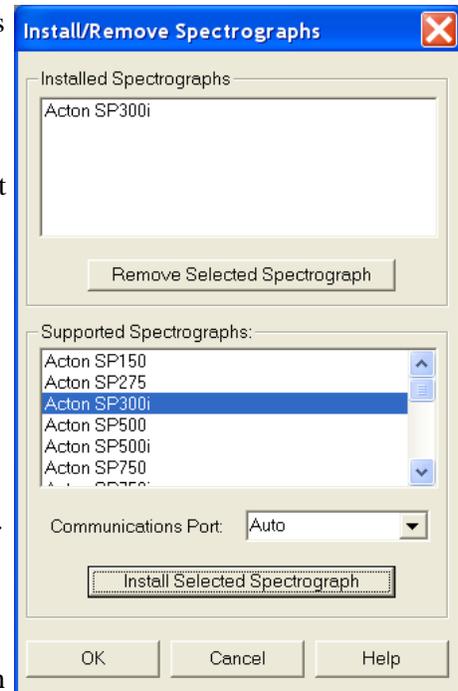


Figure 22. Install/Remove Spectrographs

DEMO: If you select **DEMO**, you can view the spectrograph-related dialogs and functions without having an actual spectrograph.

If the spectrograph is not found when you install it, an error message is displayed. Even if communication is not established, the spectrograph and its assigned port will be added to the list (for example, Acton SP300i on COM2).

Notes:

1. To install another spectrograph, repeat the installation procedure.
2. To remove a spectrograph, select it in the upper box and click on **Remove Selected Spectrograph**. The spectrograph's name will be removed from the upper window.
3. Multiple spectrographs can be assigned to a port. However, only one spectrograph can be active at a time. If you have multiple spectrographs assigned to a port, make sure that the active spectrograph (refer to the **Active Spectrograph** field on the **Main** tab) is the one that is (or will be) physically connected to the port.
4. If you plan to install more than one spectrograph for a COM port, it would be a good idea to make sure that the connection preferences are the same for all of the spectrographs assigned to that port.

7. Click on **OK** to close the **Install/Remove Spectrographs** dialog.
8. If the newly installed spectrograph is the only installed spectrograph, the **Use for Auto-Spectro Calibration** box will be checked by default. If more than one spectrograph is installed, you need to check in the box for the spectrograph that is attached to the active detector. The checked status indicates which spectrograph can be automatically calibrated using the Spectrograph Calibration function, which requires that the controller take data (see Chapter 7 for more information).

Specifying the Active Spectrograph

If you have installed more than one spectrograph, you need to define the Active (controlled) Spectrograph. If there is only one spectrograph, that one is the active one. If there is more than one, then you must designate the active one. This can be done via the **Define Spectrograph|Main** tab, the **Move Gratings** tab (to access, click on **Move** in the **Spectrograph** menu) and via the **Calibrate Spectrograph** dialog (to access click on **Calibrate** in the **Spectrograph** menu). On the **Define Spectrograph|Main** page the selection is called **Active Spectrograph**, on the **Move Gratings** tab it is called **Spectrograph to Move**, and in the **Calibrate** dialog it is called **Spectrograph to Calibrate**. In all three locations the function is simply to specify the active spectrograph, and changing the selection in one location is equivalent to changing it in all three. If only one spectrograph has been installed, the box will not appear in the **Move** or **Calibrate** dialogs, but the spectrograph model will be reported.

Entering Grating Information

Once you have installed a spectrograph, you may need to enter the grating information for the spectrograph if the spectrograph cannot supply them automatically. This is information that WinSpec/32 needs to move and calibrate the spectrograph correctly. *Grating information is supplied automatically for automated Acton spectrographs, as stored in the spectrograph's electronics.*

Grating Parameters

The grating values are required for the dispersion calculation and for the selection of the active grating. Some spectrographs have interchangeable grating turrets, each able to mount up to 3 gratings. Where this is the case, the grating information may have to be separately specified for each turret that may be installed. These parameters are specified on the **Gratings** tab (Figure 23) of the **Define Spectrograph** dialog. *In the case of automated Acton spectrographs, the grating information is automatically supplied.*

Figure 23. Gratings tab
Setting the grating parameters

1. If there are two or more turrets, enter the number of the turrets.
2. Then from the **Current Turret** field, select the turret whose grating parameters will be defined.
3. If entries are missing or incorrect, select the correct grooves/mm value for each grating. Make sure that the gratings are listed in the proper order, Grating 1 listed first, etc.

4. You can also enter a **Name** for each grating. This option is required if you are using two gratings with the same groove density. If, for example, you have two gratings with 300 grooves/mm, one blazed at 300 and one blazed at 500, you could enter BLZ300 and BLZ500 in the Name boxes as identifiers. *These are the Acton default names.* Then, when you subsequently go to the **Move Spectrograph** dialog to select the active grating, they would then be listed as 300/BLZ300 and 300/BLZ500 and there would be no possibility of confusing them.
5. If significant backlash occurs when moving the selected grating, check in the **Required** box and then enter the number of steps required to correct for the backlash.
6. If your spectrograph has more than one turret, replace the turret, change the **Current Turret** value and enter the new grating information. WinSpec/32 will store and recall the different sets of grating information for each turret.
7. Note that there is a checkbox for displaying a warning during a grating change. Since the time to change a grating can vary widely, depending on the spectrograph, this message could be very helpful.
8. If two rates are available for your spectrograph, you can also choose the rate, either faster (slew) or slower (scan). The actual rate will depend on the spectrograph. Depending on the spectrograph manufacturer and model, there may be a difference in wavelength setting accuracy for the two speeds.

Selecting and Moving the Grating

Once the required groove and turret information has been entered on the **Define Spectrograph Gratings** tab, the next step is to select and move the grating. These operations are performed using the **Gratings** tab (Figure 24) of the **Move Spectrograph** dialog. The procedure follows.

1. Open the **Move Spectrograph** dialog by selecting **Move** from the **Spectrograph** menu.
2. On the **Gratings** tab, verify that the indicated active spectrograph is the correct one.
3. Select the grating to be moved. The available gratings were previously entered on the **Define Spectrograph Gratings** tab.
4. Enter the new position (in nm) in the **Move to** field.
5. Enter any speed settings and click on **OK** to execute the selections. The grating will come to rest with the selected wavelength at the center of the CCD array.

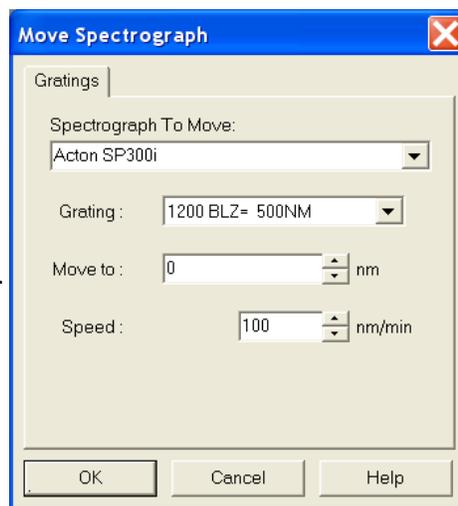


Figure 24. Move Spectrograph Gratings tab

Note: There may well be some finite error in the final position. This error can be measured and compensated for using the Spectrograph Calibrate procedure.

Entering Information for Software-Controlled Slits and/or Mirrors

Some spectrometers allow you to control the slit width and/or do mirror selection under software control. Where this is the case, the **Slits/Mirrors** tab (Figure 25) in the **Define Spectrograph** dialog is used to specify the controllable slits and selectable mirrors. Actually setting the slit width and specifying which mirror to move is accomplished via additional tabs provided in the **Move Spectrograph** dialog as shown in Figure 26. Once the selections are made, simply press **OK** to execute them.

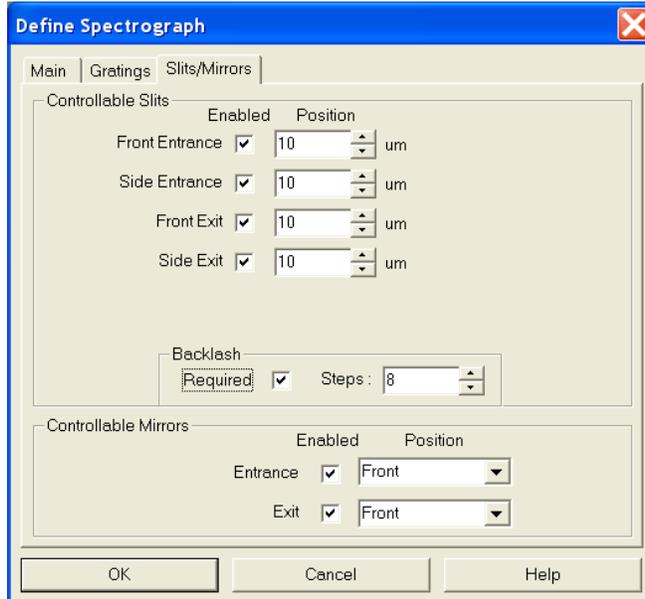


Figure 25. Define Spectrograph Slits/Mirrors tab

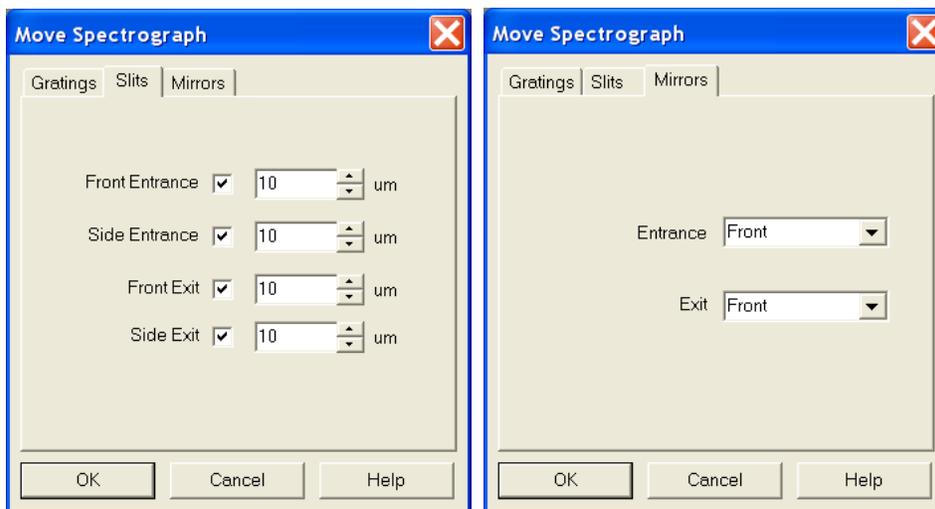


Figure 26. Slit width and Mirror selection tabs - Move Spectrograph dialog

Entering Laser Excitation Information

If you want to be warned if the laser will shine directly on the CCD, you need to enter the Laser Wavelength. This is done via the Main tab in the Define Spectrograph dialog as shown in Figure 27. The **Warn When Crossing Laser Line** selection tells WinSpec/32 to display a message whenever the grating is moved to where the laser light would be visible to the detector. This is critical for detectors that could be damaged if exposed to high light levels. Also, it will be necessary to enter the laser wavelength if you plan to work with units of relative wavenumbers.

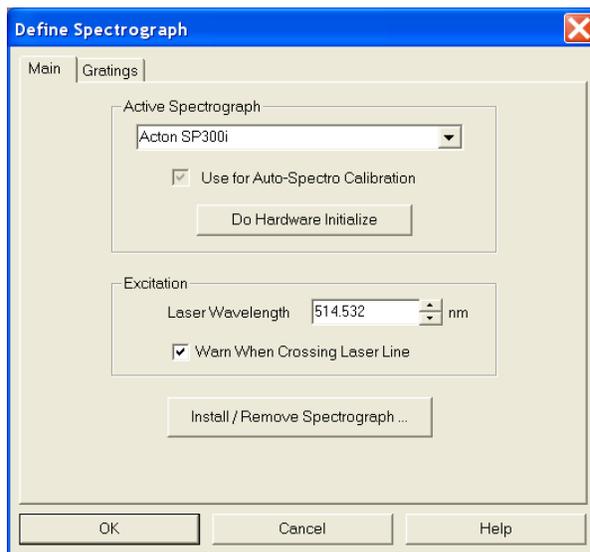


Figure 27. Entering the Laser Line
Define Spectrograph Main tab

- To allow WinSpec/32 to display in units of relative wavenumbers, enter a Laser Wavelength in nanometers, to as many significant digits as desired.
- If you have a bright laser line, check the **Warn when Crossing Laser Line** box and enter the Laser Wavelength in nm. WinSpec/32 will display a warning message whenever the wavelength range viewable by the detector might fall on or pass through the laser line.

WARNING

The **Warn When Crossing Laser Line** is no guarantee that the detector will not be damaged by overexposure. The correct display of the warning depends on all calibration parameters being set correctly. **Changing or moving gratings** may cause the laser to shine on the detector. Always block the source when moving or changing the grating to avoid damage.

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Chapter 3

Initial Spectroscopic Data Collection

Introduction

The procedure in this chapter will enable you to begin collecting real data promptly. Minimum requirements are assumed. If your system is more complex, e.g., requiring consideration of complex timing and synchronization issues, you will have to carefully study the other chapters of this manual as well as the manuals provided for the system hardware components before data acquisition that addresses those needs will be possible. Nevertheless, it is a good idea to begin with the simplest possible operating mode. This approach will give you operating experience and familiarity that will prove very valuable when you go to make more complex measurements. For additional information about the various menus and dialogs, refer to the online Help topics. Note that controllers and cameras ordinarily used for imaging are not discussed in this chapter, but rather in the next chapter, “*Initial Imaging Data Collection*”.

Underlying assumptions for the following procedure are that the hardware installation, including mounting the camera to the spectrograph, has been completed. A further assumption is that the hardware and spectrograph setups as discussed in Chapter 2 have been completed. The last assumption is that a suitable spectrographic source is available. The mercury lines produced by ordinary fluorescent lights can be used. However, it will be better to begin with a low-pressure gas-discharge lamp such as neon, mercury, or mercury-argon, if one is available.

There are two data collection modes, *Focus* and *Acquire*:

- In *Focus* mode operation, no frames of data are stored until **Start Storage** is selected. This mode is particularly convenient for familiarization and setting up. For ease in focusing, the screen refresh rate should be as rapid as possible, achieved by operating with axes and cross-sections off.
- In *Acquire* mode, every frame of data collected is stored. This mode would ordinarily be selected during actual data collection. One limitation of Acquire mode operation is that if data acquisition continues at too fast a rate for it to be stored, data overflow will eventually occur. This could only happen in Fast Mode operation.

Note: The following data collection procedures are done in the *Focus* mode but do not cover rotational alignment and focusing of a camera to a spectrograph’s optics. Refer to your camera system manual, your spectrograph manual, and/or *Appendix B* (page 236 and subsequent pages) of this manual for that information.

WARNINGS!

1. If using a PI-MAX or PI-MAX2 intensified camera, initial data collection will be done in the **Shutter** mode (**Gate** mode for PI-MAX3 and PI-MAX4). In both cases (**Shutter** and **Gate** mode), the camera can be damaged if exposed to light overload. Before powering the controller and camera, reduce the room light to reduce the risk of damage. Note that intensifiers are particularly at risk in pulsed laser operation, where overload spot damage can occur without raising the average current to where the overload detection circuits will be activated. It is far better to be careful than sorry. *Before proceeding, take the time to carefully read the manual for your intensified camera.*
2. Also, take particular care that your intensified camera is connected properly for shutter or gate mode operation. Cabling and peripheral considerations for intensified cameras are more complex than for unintensified cameras. *Again, read your manual.*

Temperature Control

Before continuing, the array temperature should be set to some easily achieved value in the operating range and Temperature lock should be established. The way this is done depends on the controller.

Temperature Control for a System using an ST-133 Controller or for a PVCAM-based System

1. Open the WinSpec/32 Setup menu and click on **Detector Temperature**. This will cause the Temperature dialog to appear as shown in Figure 28.
2. Set the **Target Temperature** to the desired value (the default temperature is suggested for initial data acquisition).
3. Click on the **Set Temp.** button. When the **Current Temperature: Unlocked** message changes to **Current Temperature: Locked**, temperature lock will have been established.



Figure 28. Temperature dialog

Notes:

1. The ST-133 additionally has a **Temp Lock** LED on the Analog/Control module (at the rear of the controller) that visually indicates when temperature lock occurs.
2. If you are using the USB 2.0 interface or have a PVCAM-based system with internal controller, the **Detector Temperature** dialog will not display current temperature information while you are acquiring data.

Temperature Control for Other Systems

ST-121, ST-130 or ST-138 Controller: Change the dial setting on the front panel of the Controller.

PentaMAX: Set the temperature on the front panel of the Temperature/Power Supply unit.

MicroView: Not user-settable. Temperature is solely under software control.

Cleans and Skips

With some controllers, specifically the PentaMAX, ST-130, ST-133, ST-138, and internal controllers, there is a **Cleans/Skips** tab in the **Hardware Setup** dialog. Cleans are used to reduce charge buildup on the CCD array while waiting to begin data acquisition (refer to Chapter 10 for more information). Skips are used when the Region of Interest (ROI) is smaller than the full chip; they allow binning and quick traversing of the rows that precede and follow the ROI. For the procedures that follow, load the default values for these parameters by bringing the **Cleans/Skips** tab to the front, and then clicking on **Load Defaults** followed by **Yes**.

Exception: With a PI-MAX camera, Cleans should be set to 1 and Strips per Clean to 4.

Spectrograph

Before a spectrum can be acquired, it is necessary that the spectrograph be powered and properly installed as described in Chapter 2. It is not necessary to *calibrate* the spectrograph. The default settings will be close enough for initial familiarization purposes. However, it will be necessary to *install* the spectrograph. This is the procedure whereby the WinSpec/32 software is informed of the spectrograph model, communications port, selected gratings, slit-width and mirror selections if applicable. It is also necessary to establish successful communications between the host computer and the spectrograph. These considerations are all discussed in Chapter 2. Additional information for the individual spectrometer setup and dialogs is provided in the online Help.

Experiment Setup Procedure (All Controllers and Unintensified Cameras)

1. Open the **Experiment Setup** dialog (Figure 29) from the **Acquisition** menu or by clicking on the  button on the **Custom Toolbar**.

2. On the **Main** tab, set the following parameters.

Exposure time: 0.1 second.

Number of Spectra: 1

Use Full Chip: selected

Accumulations: 1

Amplifier (if available): High Capacity. *If this is a reported-only parameter, set it by selecting FAST on the ADC tab.*

Avalanche Gain (Cameras with electron-multiplying CCDs): Set to 0 initially and disabled. Enable and increase the gain for low-light level spectra.

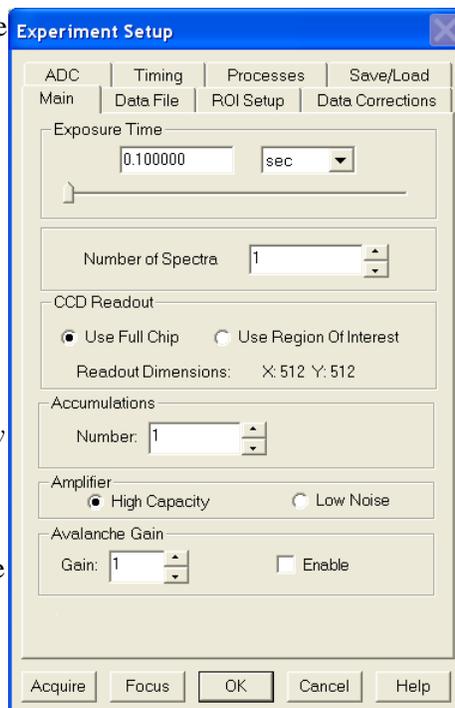


Figure 29. Experiment Setup: Main tab

3. On the **Timing** tab (Figure 30) set the following parameters.

Note: Not all of these parameters are provided for every controller model. Ignore parameters that do not apply to your system.

Timing Mode: Free Run
Triggered Mode: Not checked
Continuous Cleans: Not checked
Shutter Control: Normal
Pre Open: Not checked
Safe Mode: Selected
External Trigger: Not checked
Edge Trigger: + edge
Delay time: 0
Use Interrupts: (ST-138 only) Not checked

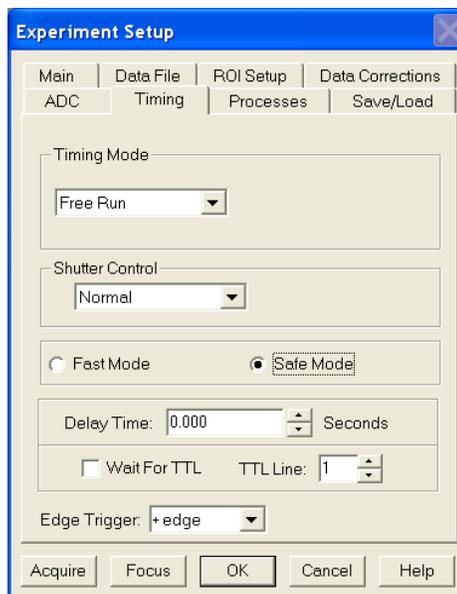


Figure 30. Experiment Setup dialog
Timing tab

4. On the **Data Corrections** tab (Figure 31) all of the correction functions should be OFF.
5. On the **ADC** tab (Figure 32), set the parameters as they apply to your particular system.

Note: Not all of these parameters are provided for every controller model. Ignore parameters that do not apply to your system.

Rate: ADC rate. Only those rates available for your A/D converter will be displayed, making it necessary to designate the A/D type first. Select the maximum speed allowed by the converter. If

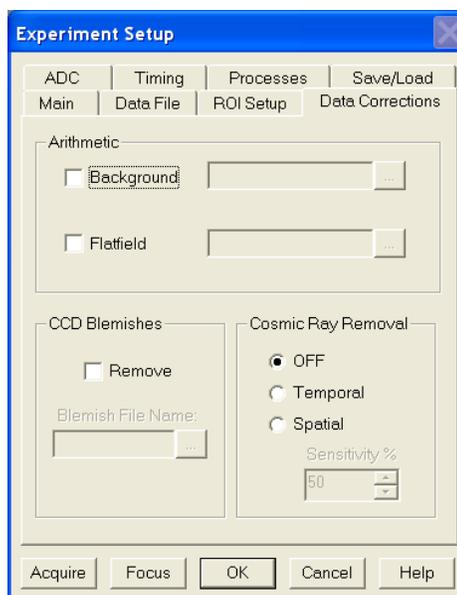


Figure 31. Data Corrections tab

the camera is a PI-MAX with Thomson 512 CCD, select FAST. ST-130 owners must confirm that their controller's internal hardware jumpers are properly set for the desired speed. *See the ST-130 manual for details.*

Type: For systems having more than one A/D converter, both FAST and SLOW will be available. Make this selection before selecting the rate or resolution.

Controller Gain (PentaMAX only): Set to Gain 3

Resolution: Number of bits. Choices limited by A/D type selection.

Bit Adjust (ST-138 only): Set to No Clip

ADC Offset (ST-133-5MHz only): Use the default setting.

Analog Gain (ST-133): Medium

Readout Port: Normal

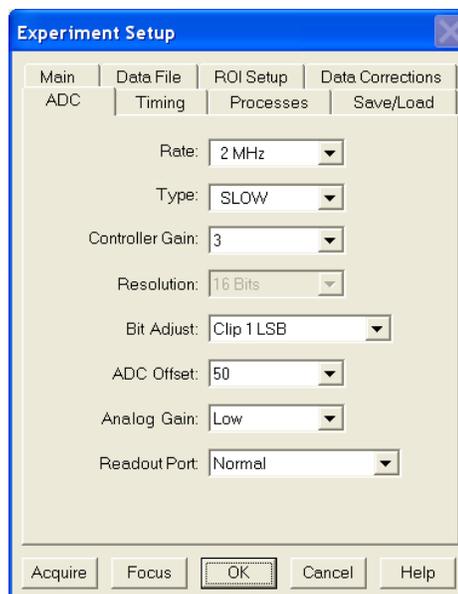


Figure 32. Generic ADC tab

- On the **ROI** tab select **Spectroscopy Mode** as shown in Figure 33. The **Use Full Chip** selection on the **Main** tab overrides any ROI settings that may be present.

Note: The choice of **Spectroscopy** or **Imaging** is only provided if the WinSpec/32 Imaging option has been installed. If this choice is not present, the default state is Spectroscopy.

- No **Processes** tab functions should be selected. For more information about these functions, see Chapter 9, page 125.

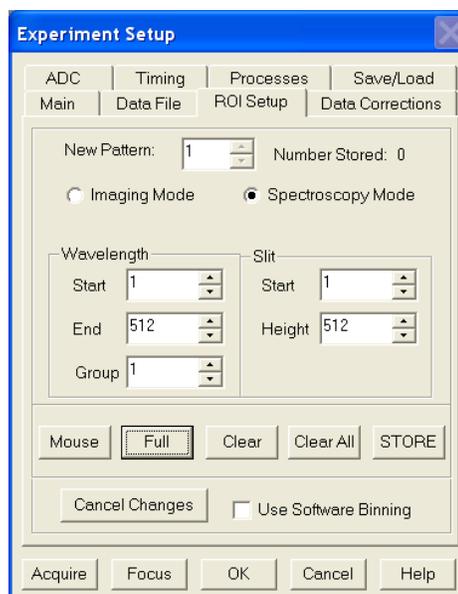


Figure 33. ROI dialog

8. On the **Data File** tab, make the following selections.

Auto Increment File Name

Enable: should be OFF.

Overwrite/Append Existing

Files: Select Overwrite (data file will overwrite an existing file having the same name).

Overwrite Confirmation: Check this box so that you will be warned that the specified file name is already in use. If not checked, the old data file will be overwritten by the new one. No warning is provided.

Data Type AutoSelect: Should be selected.

Auto-save and prompts: Select **Don't auto-save or ask to save**. With this selection, you will not receive a prompt when a file is closed as a result of starting a data collection. A prompt will still be issued if you close the file explicitly and it has not been saved since being collected.

Use a New Window for each run: Leave unchecked.

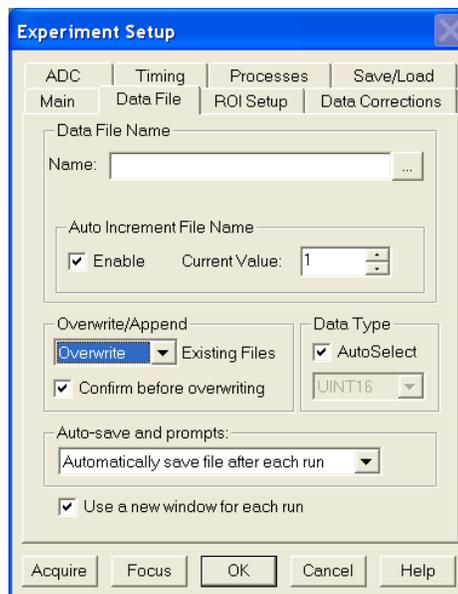


Figure 34. Data File tab

9. Click on the button to the right of the **Name** field. This will open a browse box. Select the directory where you want the stored file to go. In the example illustrated, the file name is *Testfile* and it will be stored in a directory named Data. *If the filename doesn't automatically appear in the browse box, type it in.* The file type should be WinX Data (*.spe).

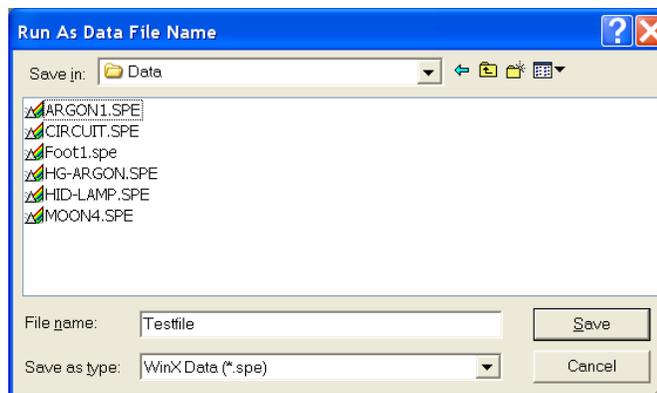


Figure 35. File Browse dialog

10. Click on the **Save** button to save the entered information and return to the Experiment Setup dialog.
11. Click on **OK**. This will close the **Experiment Setup** dialog.

Experiment Setup Procedures (Intensified Cameras)

Refer to your PI-MAX, PI-MAX3, or PI-MAX4 system manual for experiment setup instructions. Cabling and peripheral considerations for intensified cameras are more complex than for unintensified cameras.

Data Collection Procedures (Intensified Cameras)

Refer to your camera system manual for data collection instructions.

WARNING

PI-MAX and PI-MAX2 Intensified Cameras: If working with an intensified camera, the room light should be subdued so as to allow *safe Shutter* mode operation of the camera. *Intensified cameras are quite susceptible to damage from light overload in Shutter mode operation and particularly subject to damage from light overload in Gate mode operation with high-intensity pulsed light sources. See your PI-MAX manual for detailed information.*

PI-MAX3 and PI-MAX4 Intensified Cameras: If working with an intensified camera, the room light should be subdued so as to allow *safe Gate* mode operation of the camera. *Intensified cameras are particularly subject to damage from light overload in Gated mode operation with high-intensity pulsed light sources. See your PI-MAX3 or PI-MAX4 manual for detailed information.*

Data Collection (Unintensified Cameras)

The following data collection procedure works for all controllers. However, it does not exercise some of the special features, such as video monitor support, available on certain controller models.

An underlying assumption is that a suitable light source is available. Although fluorescent room lighting may be adequate, it will probably prove more instructive to use a standard lamp, such as a mercury-argon lamp that provided the spectrum illustrated in Figure 37.

1. Select **Focus** from the **Acquisition** menu (Figure 36) to begin collecting data. An acquisition can also be started by clicking on the **Focus** button in the Experiment Setup dialog or by clicking on the **Focus** button on the **Custom Toolbar**. Data will be continuously acquired and displayed.
2. While observing the displayed data, adjust the system optics for the best possible spectrum (lines as high and narrow as possible). Figure 37 shows a typical mercury-argon spectrum. Your results could appear different depending on the spectrograph grating used.



Figure 36. Acquisition menu

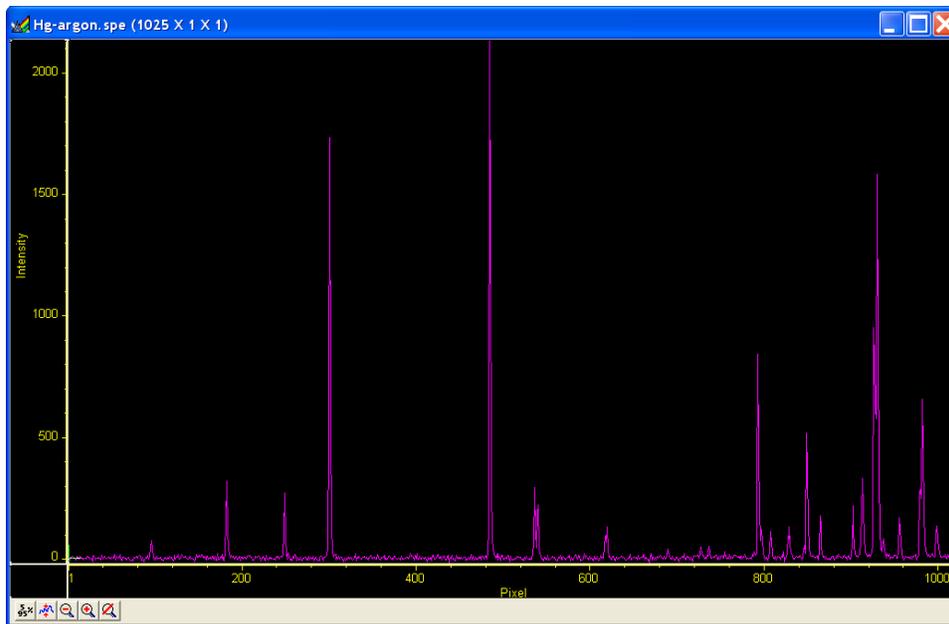


Figure 37. Typical Mercury-Argon Spectrum

3. To store the most recent image, click **Stop Acquisition** on the **Acquisition** menu or click on the **Stop** button on the **Custom Toolbar**.
4. Data acquisition will halt and the most recent image will be displayed. You can now use the Save function on the **File** menu to save the data to a file having the name specified on the **Data File** tab.

This completes the initial spectroscopy data acquisition routine that should work with any Princeton Instruments brand Controller.

Initial Imaging Data Collection

Introduction

ATTENTION Imaging is only possible if the WinSpec/32 software you are using has the Imaging Option installed.

The procedure in this chapter will enable you to begin collecting real image data promptly. Minimum requirements are assumed. If your system is more complex, e.g., requiring consideration of complex timing and synchronization issues, you will have to carefully study the other chapters of this manual as well as the manuals provided for the system hardware components before data acquisition that addresses those needs will be possible. Nevertheless, it is a good idea to begin with the simplest possible operating mode. This approach will give you operating experience and familiarity that will prove very valuable when you go to make more complex measurements. For additional information about the various menus and dialogs, refer to the online Help topics.

Underlying assumptions for the following procedure are that the hardware has been installed per the instructions in the hardware manual(s) and that the hardware setup as discussed in Chapter 2 has been completed. A further assumption is that a good imaging subject is available. Often, a picture or optical target mounted on a wall or lab bench will give good results. If initial data collection is to be done using a microscope, be sure to read the chapter on microscopy in your system manual before attempting data collection.

There are two data collection modes, *Focus* and *Acquire*:

- In *Focus* mode operation, no frames of data are stored until **Start Storage** is selected. This mode is particularly convenient for familiarization and setting up. For ease in focusing, the screen refresh rate should be as rapid as possible, achieved by operating with axes and cross-sections off, and with Zoom 1:1 selected.
- In *Acquire* mode, every frame of data collected is stored. This mode would ordinarily be selected during actual data collection. One limitation of Acquire mode operation is that if data acquisition continues at too fast a rate for it to be stored, data overflow will eventually occur. This could only happen in Fast Mode operation.

Note: The following data collection procedures are done in the *Focus* mode but do not cover the actual focusing of a camera. Refer to your camera system manual, your spectrograph manual, and/or *Appendix B* (page 233 and subsequent pages) of this manual for that information.

WARNINGS!

1. If using a PI-MAX or PI-MAX2 intensified camera, initial data collection will be done in the **Shutter** mode (**Gate** mode for PI-MAX3 and PI-MAX4). In both cases (**Shutter** and **Gate** mode), the camera can be damaged if exposed to light overload. Before powering the controller and camera, reduce the room light to reduce the risk of damage. Note that intensifiers are particularly at risk in pulsed laser operation, where overload spot damage can occur without raising the average current to where the overload detection circuits will be activated. It is far better to be careful than sorry. *Before proceeding, take the time to carefully read the manual for your intensified camera.*
2. Also, take particular care that your intensified camera is connected properly for shutter or gate mode operation. Cabling and peripheral considerations for intensified cameras are more complex than for unintensified cameras. *Again, read your manual.*

Temperature Control

Before continuing, the array temperature should be set to some easily achieved value in the operating range and Temperature lock should be established. The way this is done depends on the controller.

Temperature Control for a System using an ST-133 Controller or for a PVCAM-based System

1. Open the WinSpec/32 Setup menu and click on **Detector Temperature**. This will cause the Temperature dialog to appear as shown in Figure 38.
2. Set the **Target Temperature** to the desired value (the default temperature is suggested for initial data acquisition).
3. Click on the **Set Temp.** button. When the **Current Temperature: Unlocked** message changes to **Current Temperature: Locked**, temperature lock will have been established.



Figure 38. Temperature dialog

Notes:

1. The ST-133 additionally has a **Temp Lock** LED on the Analog/Control module (at the rear of the controller) that visually indicates when temperature lock occurs.
2. If you are using the USB 2.0 interface or have a PVCAM-based system with internal controller, the **Detector Temperature** dialog will not display current temperature information while you are acquiring data.

Temperature Control for Other Systems

ST-121, ST-130 or ST-138 Controller: Change the dial setting on the front panel of the Controller.

PentaMAX: Set the temperature on the front panel of the Temperature/Power Supply unit.

MicroView: Not user-settable. Temperature is solely under software control.

Cleans and Skips

With some controllers, specifically the PentaMAX, ST-130, ST-133, ST-138, and internal controllers, there is a **Cleans/Skips** tab in the **Hardware Setup** dialog. Cleans are used to reduce charge buildup on the CCD array while waiting to begin data acquisition. Skips are used when the Region of Interest (ROI) is smaller than the full chip; they allow binning and quick traversing of the rows that precede and follow the ROI. For the procedures that follow, load the default values for these parameters by bringing the **Cleans/Skips** tab to the front, and then clicking on **Load Defaults** followed by **Yes**.

Exception: With a PI-MAX camera, Cleans should be set to 1 and Strips per Clean to 4.

Experiment Setup Procedure (All Controllers and Unintensified Cameras)

1. Open the **Experiment Setup** dialog (Figure 39) from the **Acquisition** menu or by clicking on the  button on the **Custom Toolbar**.
2. On the **Main** tab, set the following parameters.

Exposure time: 0.1 second

Number of Spectra/Images: 1

Use Full Chip: selected

Accumulations: 1

Amplifier (if available): High Capacity.

If this is a reported-only parameter, set it by selecting FAST on the ADC tab.

Avalanche Gain (Cameras with electron-multiplying CCDs): Set to 0 initially and disabled. Enable and increase the gain for low-light level images.

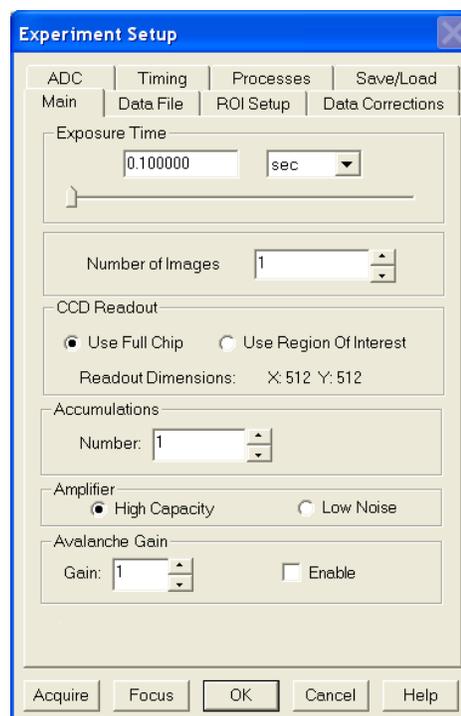


Figure 39. Experiment Setup/Main tab

3. On the **Timing** tab (Figure 40) set the following parameters.

Note: Not all of these parameters are provided for every controller model. Ignore parameters that do not apply to your system.

Timing Mode: Free Run
Triggered Mode: Not checked
Continuous Cleans: Not checked
Shutter Control: Normal
Pre Open: Not checked
Safe Mode: selected
External Trigger: Not checked
Edge Trigger: + edge
Delay time: 0
Use Interrupts: (ST-138 only) Not checked

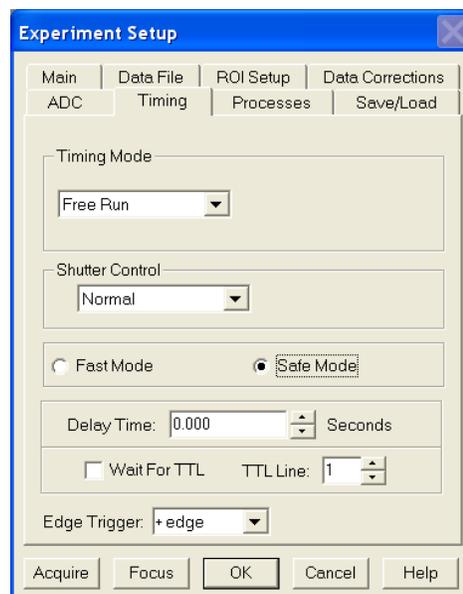


Figure 40. Timing tab

4. On the **Data Corrections** tab (Figure 41) all of the correction functions should be OFF.
5. On the **ADC** tab (Figure 42), set the parameters as they apply to your particular system.

Note: Not all of these parameters are provided for every controller model. Ignore parameters that do not apply to your system.

Rate: ADC rate. Only those rates available for your A/D converter will be displayed, making it necessary to designate the A/D type first. Select the maximum speed allowed by the converter. ST-130 owners must confirm that the internal hardware jumpers of their controller are properly set for the desired speed. *See the ST-130 manual for details.*

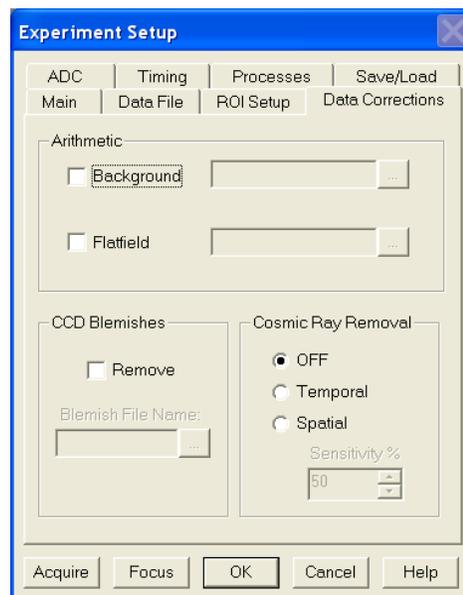


Figure 41. Data Corrections tab

Type: For systems having more than one A/D converter, both FAST and SLOW will be available. Make this selection before selecting the rate or resolution.

Controller Gain (PentaMAX only): Set to Gain 3

Resolution: Number of bits. Choices limited by A/D type selection.

Bit Adjust (ST-138 only): Set to No Clip

ADC Offset (ST-133-5MHz only): Use the default setting.

Analog Gain (ST-133): Medium

Readout Port: Normal

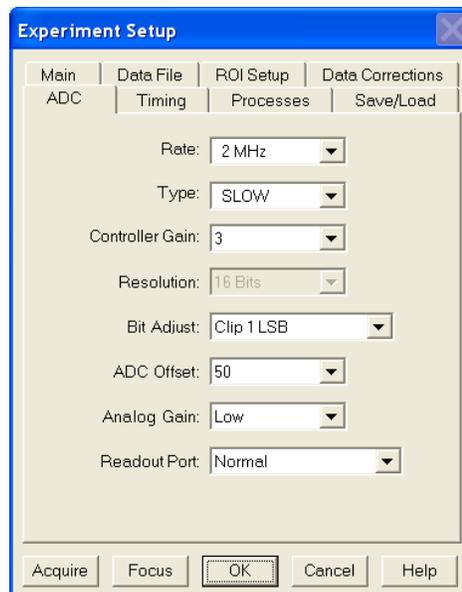


Figure 42. Generic ADC tab

6. On the **ROI** tab (Figure 43), select **Imaging Mode**. WinSpec/32 operated in **Imaging Mode** always uses the full chip area and ROI considerations do not apply.
7. No **Processes** tab functions should be selected. For more information about these functions, see Chapter 9, page 125.
8. On the **Data File** tab (Figure 44), make the following selections.

Auto Increment File Name Enable: should be OFF.

Overwrite/Append Existing Files: Select Overwrite (data file will overwrite an existing file having the same name).

Overwrite Confirmation: Check this box so that you will be warned that the specified file name is already in use. If

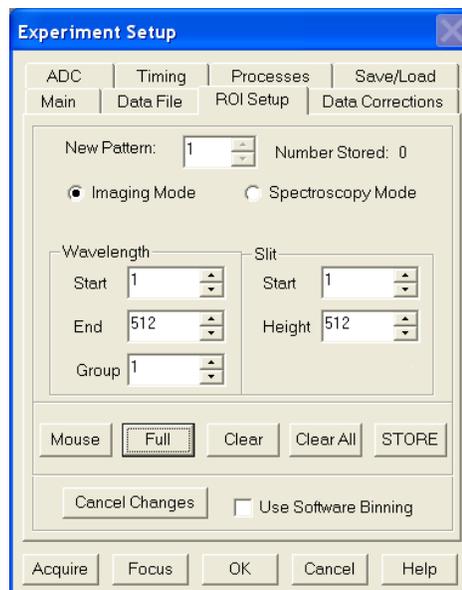


Figure 43. ROI tab - imaging selected

not checked, the old data file will be overwritten by the new one. No warning is provided.

Data Type AutoSelect: Should be selected.

Auto-save and prompts: Select **Don't auto-save or ask to save**. With this selection, you will not receive a prompt when a file is closed as a result of starting a data collection. A prompt will still be issued if you close the file explicitly and it has not been saved since being collected.

Use a New Window for each run: Leave unchecked.

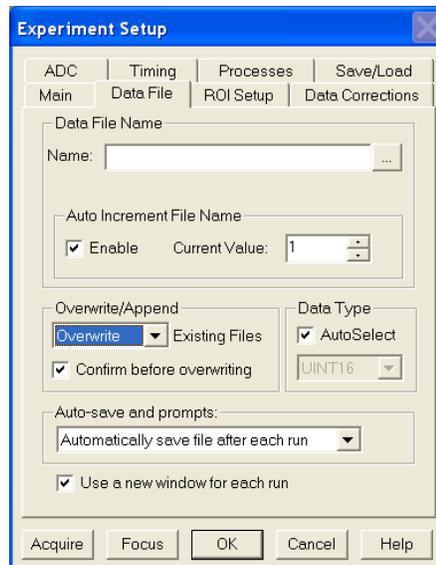


Figure 44. Data File tab

9. Click on the button to the right of the **Name** field. This will open a browse box. Select the directory where you want the stored file to go. In the example illustrated, the file name is TESTFILE1 and it will be stored in a directory named Data. *If the file name doesn't automatically appear in the browse box, type it in.* The file type should be WinX Data (*.spe).

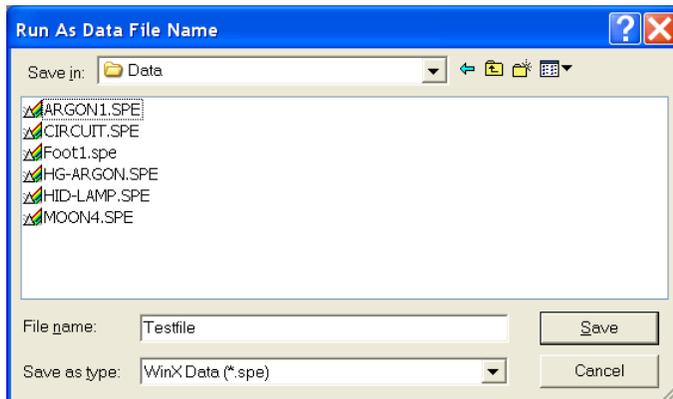


Figure 45. File Browse dialog

10. Click on the **Save** button to save the entered information and return to the **Experiment Setup** dialog.
11. Click on **OK**. This will close the **Experiment Setup** dialog.

Experiment Setup Procedures (Intensified Cameras)

Refer to your PI-MAX, PI-MAX3, or PI-MAX4 system manual for experiment setup instructions. Cabling and peripheral considerations for intensified cameras are more complex than for unintensified cameras.

Data Collection Procedures (Intensified Cameras)

Refer to your camera system manual for data collection instructions.

WARNING

PI-MAX and PI-MAX2 Intensified Cameras: If working with an intensified camera, the room light should be subdued so as to allow *safe Shutter* mode operation of the camera. *Intensified cameras are quite susceptible to damage from light overload in Shutter mode operation and particularly subject to damage from light overload in Gate mode operation with high-intensity pulsed light sources. See your PI-MAX manual for detailed information.*

PI-MAX3 and PI-MAX4 Intensified Cameras: If working with an intensified camera, the room light should be subdued so as to allow *safe Gate* mode operation of the camera. *Intensified cameras are particularly subject to damage from light overload in Gated mode operation with high-intensity pulsed light sources. See your PI-MAX3 or PI-MAX4 manual for detailed information.*

Data Collection Procedures (Controller-Specific)

ST-133-Controller

The procedure that follows for these controllers is in two parts, **Video Focusing** and **Data Collection**. In focusing, images are displayed on the video monitor (not the computer monitor) and no data is collected. This allows rapid and easy adjustment of the system optics. Once the settings have been optimized, data collection begun can begin.

WARNING

If acquiring data with a PI-MAX, PI-MAX2, PI-MAX3, or PI-MAX4 intensified camera, make sure the ambient light levels are low. *Intensified cameras are quite susceptible to damage from light overload in Shutter mode operation and particularly subject to damage from light overload in Gate mode operation with high-intensity pulsed light sources. Refer to your camera system manual for detailed information specific to experiment setup and data acquisition for intensified cameras.*

Focusing

This procedure applies for a system that includes an ST-133 Controller and a video monitor connected to the Video port (BNC connector) on the controller. If your system doesn't include a video monitor, go to the **Data Collection - All Controllers** section, which begins on page 75.

1. Select **Video** from the **Acquisition** menu. This will allow live data to be displayed on your video monitor.

2. Select **Video Focus** from the **Acquisition** menu. The **Interactive Camera** dialog (Figure 46) will open.
3. Click on the **RUN** button in the **Interactive Camera** dialog. The camera will begin acquiring pictures at the fastest possible rate and the image will be displayed on the video monitor. *Note that the image will not be displayed on the computer monitor while the **Interactive Camera** dialog is open.*
4. Focus the system optics and set the **Interactive Camera** dialog **Exposure Time**, **RS170 Scaling** and **Offset** adjustments for the best-viewed image. In addition to the Exposure Time, Intensity Scaling and Offset parameters, the Pattern parameters determine which CCD pixels will be displayed on the video monitor. *Note that, in Focus mode, the images will not appear at the computer but only at the video monitor.* If the number of pixels on the CCD is very much larger than the number of video pixels, you can use the Pan function to select any one of nine different subsets to display. The Zoom function gives additional control. One-to-one mapping from the selected region to the screen occurs with 2× selected. You may additionally have the option of selecting Binning, in which a wider view is achieved by combining adjacent pixels, or Decimation, in which pixels are discarded according to an algorithm.

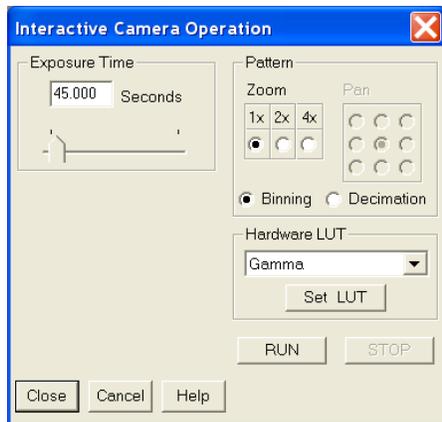


Figure 46. ST-133
Interactive Camera dialog

- The exposure time will be the same as that set via the **Experiment Setup|Main** tab. *The two exposure settings track. Changing it at either location should update the other setting automatically.* The Intensity Scaling, together with the Offset, determines how the image data is mapped to the 256 gray-scale levels. Begin with the Intensity Scaling set to “1 to 4096” (slider all the way to the right). Similarly, the Offset setting should initially be set to 2 (slider all the way to left).
5. When no further improvement in the observed image can be obtained, click on **Stop** in the **Interactive Camera Operation** dialog to halt focus-mode operation.
 6. Click on **Close** to close the **Interactive Camera Operation** dialog and return to the **Experiment Setup** dialog.

Data Collection

1. Click on **Focus** to begin collecting data. An acquisition can also be started by clicking on **Focus** on the **Acquisition** menu or by clicking on the **Focus** button on the **Custom Toolbar**. Images will be continuously acquired and displayed on the computer screen and on the video monitor.
2. To store the most recent image, click **Stop Acquisition** on the **Acquisition** menu or click on the **Stop** button on the **Custom Toolbar**. Data acquisition will halt and the most recent image will be displayed. You can now use the **Save** function on the **File** menu to save the data to a file having the name specified on the **Data File** tab.
3. If you want to initiate data acquisition, select **Focus** again. To store the new data to disk, repeat Step 2.

This completes initial data acquisition with an ST-133 Controller.

PentaMAX Controller

The procedure that follows for the PentaMAX Controller is in two parts, **Focusing** and **Data Collection**. In focusing, images are displayed on the video monitor and no data is collected. This allows rapid and easy adjustment of the system optics. Once the settings have been optimized, focus mode operation should be ended and data collection performed.

Focusing

This procedure applies for a PentaMAX system that includes a video monitor connected to the Video port (BNC) of the PentaMAX. If your system does not include a video monitor, go to the **Data Collection - All Controllers** section, which begins on page 75.

1. Select **Video** from the Acquisition menu. This will allow live data to be displayed on your video monitor.
2. Select **Video Focus** from the **Acquisition** menu. The **Interactive Operation** dialog that will be displayed depends on the PentaMAX version. Version 5 and higher will display the righthand dialog shown in Figure 47. Earlier versions display the lefthand dialog.

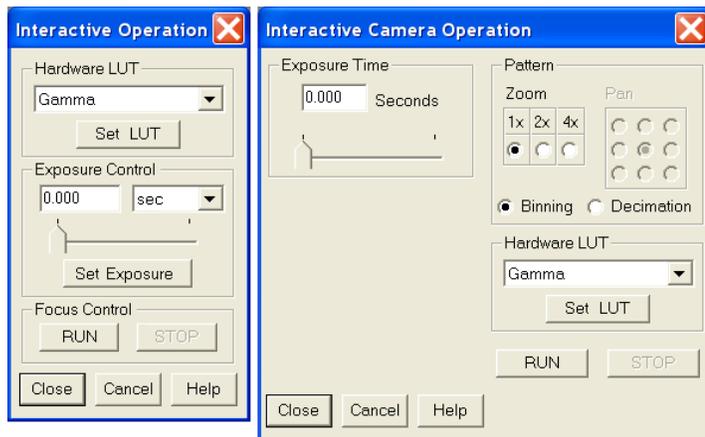


Figure 47. PentaMAX Interactive Operation dialog

3. Note the **Hardware LUT** field. This selection sets the scaling of the video display only. Unless the signal is very weak, the best LUT choice will be Gamma.
4. Click on the **RUN** button in the **Interactive Operation** dialog. Data acquisition at the fastest possible rate will commence immediately and the image will be displayed on the video monitor. *Note that the image will not be displayed on the computer monitor while the Interactive Operation dialog is open.*
5. Focus the system optics and, if necessary, adjust the **Exposure Time** in the Interactive Camera dialog for the best-viewed image. The exposure time will be the same as that set via the **Experiment Setup|Main** tab. *The two exposure settings track. Changing it at either location should update the other setting automatically.*
6. When no further improvement in the observed image can be obtained, click on **Stop** in the **Interactive Operation** dialog to halt focus mode operation.
7. Click on **Close** to close the **Interactive Operation** dialog and return to the **Experiment Setup** dialog.

Data Collection

1. Click on **Focus** to begin collecting data. Data collection can be initiated by means of the **Focus** button in the **Experiment Setup** dialog, by selecting **Focus** from the **Acquisition** menu, or by clicking on the **Focus** button of the **Custom Toolbar**. Images will be continuously acquired and displayed on the computer screen.
2. To store the most recent image, click **Stop Acquisition** on the **Acquisition** menu or click on the **Stop** button on the **Custom Toolbar**. Data acquisition will halt and the most recent image will be displayed. You can now use the **Save** function on the **File** menu to save the data to a file having the name specified on the **Data File** tab.
3. If you want to initiate data acquisition, select **Focus** again. To store the new data to disk, again click **Stop Acquisition** on the **Acquisition** menu or click on the **Stop** button.

This completes initial data acquisition with a PentaMAX Controller.

Data Collection (Unintensified Cameras)

The following data collection procedure works for all controllers. However, it doesn't exercise some of the special features, such as video monitor support, available on certain controller models.

1. Click on **Focus** to begin collecting data. Data collection can be initiated by means of the **Focus** button in the **Experiment Setup** dialog, by clicking on **Focus** on the **Acquisition** menu, or by clicking on the **Focus** button of the **Custom Toolbar**. Images will be continuously acquired and displayed.
2. Observe the displayed data and adjust the system optics for the best possible image. *It may be necessary to readjust the Exposure Time (Experiment Setup|Main tab).*
3. To store the most recent image, click **Stop Acquisition** on the Acquisition menu or click on the **Stop** button on the **Custom Toolbar**.
4. Data acquisition will halt and the most recent image will be displayed. You can now use the **Save** function on the **File** menu to save the data to a file having the name specified on the **Experiment Setup|Data File** tab.

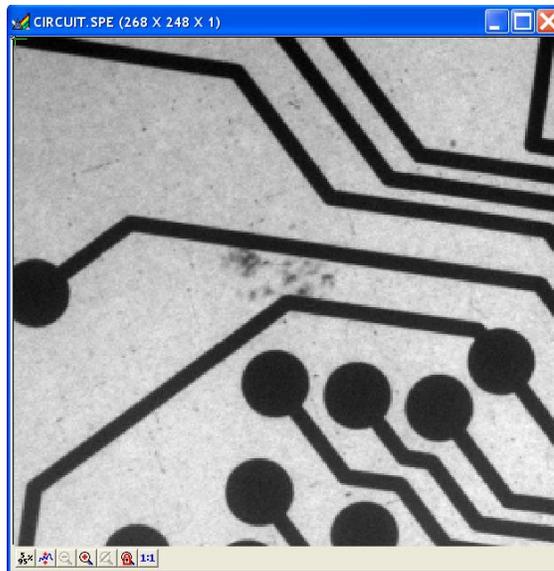


Figure 48. Typical Data Acquisition Image

This completes the initial data acquisition routine, which should work with any Princeton Instruments controller.

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Chapter 5

Opening, Closing, and Saving Data Files

Introduction

This chapter discusses how to open, close, and save existing data files to disk. Options for saving and deleting files will be explained. Data files created with temporary file names should be saved to disk periodically. Files should be closed completely to conserve RAM for data collection.

Data files can be deleted directly from WinSpec/32, without using the File Manager or any other file utility.

Note: WinSpec/32 can read data files acquired with earlier versions of WinSpec. Versions of WinSpec prior to 1.6 cannot read WinSpec/32 data files. Neither can versions prior to 1.6 read data files that were collected with earlier versions and then opened, modified and saved using WinSpec/32. This should be considered carefully before modifying and *saving* old data files with WinSpec/32.

Opening Data Files

In WinSpec/32 files are opened according to Win 95 conventions, as follows.

1. Select **Open** from the **File** menu. The **File Open** dialog will appear (Figure 49).
2. Open the directory containing the data files. Clicking on the button at the right of the **Look In** field opens a browser function, allowing you to quickly and easily access the correct folder. As shown in Figure 49, the data files will be listed below.
3. If you want the software to control how the data will be displayed when the file is opened, check **Auto Select**. Leave **Auto Select** unchecked if you want to retain control over whether the data will be displayed as an **Image**, **Graph** or **3D Graph**.

Auto Select is the factory default selection.* In addition, one of the three radio buttons, **Image**, **Graph** or **3D Graph**, will be selected but grayed out if Auto Select

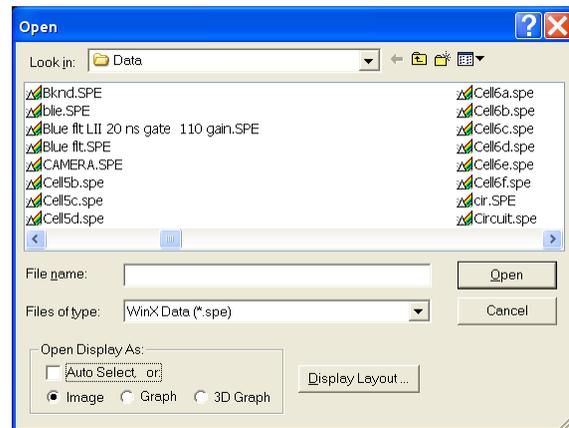


Figure 49. Open dialog

* The open/display default selection can be changed and saved from the Display Layout window.

is checked. If Auto Select is unchecked, the grayed out selection will become active and govern how the file is opened.

- When **Auto Select** is checked, the way the data is displayed depends on the number of data strips it contains.
 - ⇒ If there are eleven or more strips of data, they will be displayed as a normal image, such as that shown in Figure 93 (page 115).
 - ⇒ If there are at least three data strips but less than eleven, the data will be plotted as a 3D Graph as shown in Figure 72 (page 101).
 - ⇒ If there are only two strips of data, they will be displayed as graphs stacked in a two-dimensional plot, the same as for a 3D Graph of two strips as shown in Figure 71 (page 100).
 - ⇒ A single strip *will always* be plotted as a simple X vs. Y plot. Note that from two to ten strips, the intensity (Y axis) scale shifts position as required to read true for the selected strip.
 - If **Image** is selected, all data points will be plotted as a function of the strip and pixel number.
 - If **3D Graph** is selected, multiple data strips will be plotted as a function of intensity versus pixel number, the actual number of data strips plotted depending on the 3D Layout display parameter settings. All of the strips could come from the same frame, or, in the case of a file containing multiple frames, the same numbered strip could come from each frame.
 - If **Graph** is selected, the selected data strip only will be plotted as a function of intensity versus pixel number.
4. Note the **Files of Type** field, which allows you to select files for listing according to their type. If **WinXData** (*.spe) is selected, only files of type *.spe will be listed. This is the native WinSpec/32 format. If **TIFF** or **8-bit TIFF File** (*.tif) is selected, only files of the type *.tif will be listed. If **All Files** (*.*) is selected, all files in the folder will be listed. WinSpec/32 can open either *.spe files or *.tif files (8-bit or 16-bit). Select type **8-bit TIFF File** to open an 8-bit TIFF file. Select type **TIFF File** to open a 16-bit TIFF file.
 5. Either double-click on the name of the file you want to open or single-click on the name and then click on the **Open** button. For example, with **3D Graph** selected, double-clicking on Hid-lamp.spe would open that file, producing the display shown in Figure 50. Note that there are many different ways of controlling how the image will be displayed, as described in

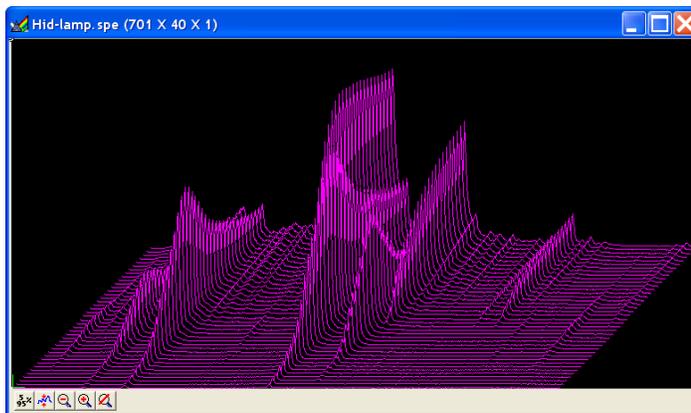


Figure 50. High Intensity Lamp Spectrum

Chapter 8.

Multiple Files: It is also possible to open multiple files at the same time by using the Win95 **Shift + Click** and **Control + Click** selection features.

To select a *range of contiguously listed files* for opening:

- a. Hold the **Shift** key down and click on the first file in the range. The file will be selected.
- b. Then hold the **Shift** key down again and click on the last file in the range. That file *and all the files between the two designated files* will be selected.

To select multiple files which are *not* listed contiguously:

- a. Hold down the **Ctrl** key and then click on the first file. That file will be selected.
- b. Then hold down the **Ctrl** key again and click on the second file. That file will also be selected.
- c. Proceed in similar fashion to select each file to be opened.

Once all files to be opened have been selected, click on **Open** (or double-click on a selected file) and all of the selected files will be opened.

There are a number of additional options and operations that can be performed from the **Open** dialog. For example, clicking the **Display Layout** button will directly open the **Display Layout** dialog, described in Chapter 8. In addition, options for the organization of the **Open** dialog itself can be selected by means of the icons to the right of the **Look In** field, or by right-clicking the mouse anywhere in the file listing area of the box (*but not on a file name*).

Right-clicking *on a file name* opens a Windows shortcut menu that provides a number of additional operations, including open, delete, rename, print, properties, and edit operations such as copy and cut.

Saving Data Files

Data files must be saved to disk before exiting the software. It is also recommended that you save periodically when making measurements to minimize the overall risk of data loss. If you exit and there are unsaved data files, you will be prompted to save them. The **File** menu provides three Save commands, as follows.

- Save:** Saves the active data file using the original file name and type and in the original directory (folder).
- Save As:** The **Save As** dialog is used to save the active data file to a user-specified file name and directory. The file type can be changed.
- Save All:** Saves all open data files using the original file names and directories (folders).

Sometimes during data collection or processing, windows will be opened and display data with an <untitled #> title. These are temporary files, and they must be saved to disk if you want to keep them. The **Save As** dialog performs this function. The **Save As** dialog also allows you to open a file and save it with a different name.

Saving Temporary Data Files

The WinSpec/32 software allows you to work with temporary files, files with names like <untitled 1>. To save these files, or to save any file to a new filename, perform the following steps.

1. Select **Save As** from the **File** menu. The **Data File Save As** dialog (Figure 51) appears.
2. Open the directory where you want the file saved. Clicking on the button at the right of the **Save In** field opens a browser function that will allow you to quickly and easily select the target directory.
3. Type in a name for the file. Windows 95 long file-name convention applies. It is not necessary to add the extension since it will be added automatically according to the specified file type.

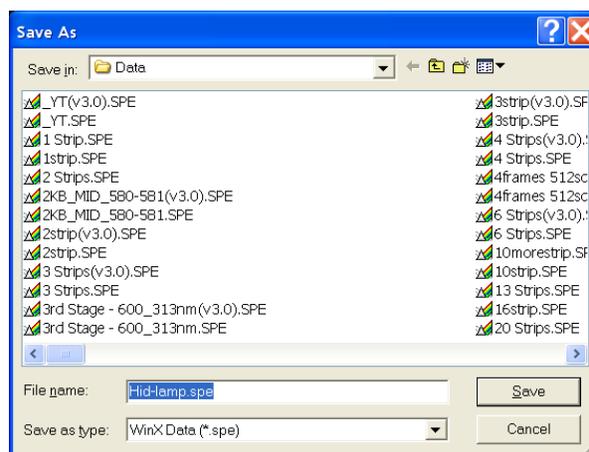


Figure 51. Data File Save As dialog

Save as type: Indicates the file type. The data types currently supported are listed in Figure 52. If **All Files (*.*)** is selected, you will be able to save the file with any extension. The file, however, will be saved in the *.SPE file type format. *Only the data is saved. This could have some unexpected effects. For example, if you save a graph as a *.tif file, and then open the file with an image editor, you will see the data presented as a single strip image, not as a graph.*



Figure 52. Save As Data Types

4. Click on **OK** to save the file or **Cancel** to close the **Data File Save As** dialog without saving the file.

Data File tab

The **Data File** tab provides you with additional control and flexibility in naming and saving newly collected data. Because the settings on this tab are applied to data acquisition, not post-processing, make your entries before acquiring data. The auto-save, auto-name, and auto-increment features allow you to acquire data and save it according to the filename template you define. Also, you can take advantage of the multiple open windows functionality and specify that each new data run opens a new window on the display window.

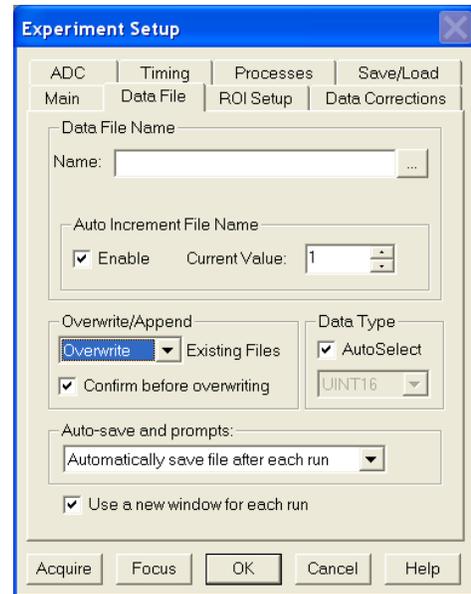


Figure 53. Data File tab

Closing a Data File

An open data window can be closed by clicking on the  box at the upper right of the window or by clicking on **Close** in the **File** menu. An open data window can be removed from view by clicking on the  box at the upper right of the window. The file will be reduced to an icon on the task bar but the data will remain loaded in RAM. There may be situations where you would want to do this to reduce desktop clutter. Unless you intend to expand the file for display again, it is ordinarily better to actually close the file so that the RAM it is using will be freed for other use. If the file has not been saved, you will be prompted.

There are several ways of closing an open data window. Each is described below:

- The  box at the upper right of the data window will close that window only.
- The  box at the upper right of the window will also remove the data window from view by reducing it to an icon on the task bar. There may be situations where you would want to do this to reduce desktop clutter. However, the data will remain loaded in RAM, reducing the memory available for data collection. Unless you intend to expand the file for display again, it is ordinarily better to actually close the file so that the RAM it is using will be freed for other use.
- **Close** in the **File** menu closes all windows using the data set displayed in the active data window. This may be important if **New** in the **Window** menu or in the **Data Window Context** menu has been used to open additional windows with the same data. Simply clicking on **Close** in the **File** menu will close all windows containing the same data, regardless of how it is displayed.
- **Close** in the **Control** menu, accessed by clicking on the WinSpec/32 icon at the left end of the **Title** bar, closes WinSpec/32, as does double-clicking on the WinSpec/32 icon. Similarly, the key combination **Alt+F4** also closes WinSpec/32.
- **Close All** in the Window menu closes *all* open data files.
- The key combination **Ctrl+F4** closes the active window only.

Deleting Data Files

You can delete data files directly from within WinSpec/32, without having to close WinSpec/32, and without having to use the Windows 95 Explorer or another file utility. This is achieved using the File Operations menu, accessed by right-clicking on the file name in the Open dialog, as explained below.

1. Select **Open** from the **File** menu.
*Only files with the selected data type, *.spe or *.tif, will be listed.*
2. Position the mouse cursor on the name of the file you want to delete and click the *right* mouse button. This will open the “right-click” **File Operations** menu, as shown in Figure 54.
3. Click on **Delete**. Then answer yes to the query asking whether you wish to send the file to the recycling bin. The file will be deleted and the **File Operations** menu will close.

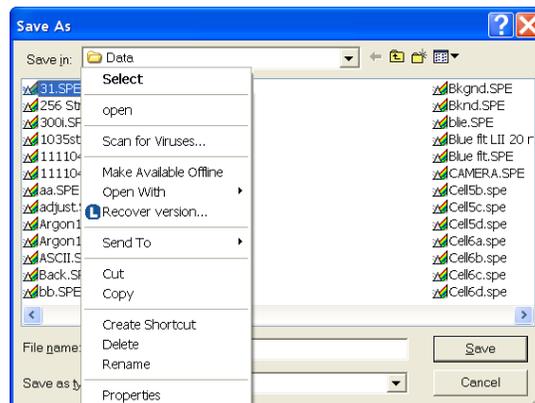


Figure 54. Right-click File Operations menu

Note: Click on the **Open** dialog **Cancel** button to exit the dialog without deleting any files.

Multiple Files: It is also possible to delete multiple files at the same time by using the **Shift + Click** and **Control + Click** selection features.

To select a *range of contiguously listed files* for deleting:

1. Hold the **Shift** key down and click on the first file in the range. The file will be selected.
2. Then hold the **Shift** key down again and click on the last file in the range. That file *and all the files between the two designated files* will be selected.

To select multiple files which are *not* listed contiguously:

1. Hold down the **Ctrl** key and then click on the first file. That file will be selected.
2. Then hold down the **Ctrl** key again and click on the second file. That file will also be selected.
3. Proceed in similar fashion to select each file to be deleted.

Once all files to be deleted have been selected, *right-click* on a selected file to open the **File Operations** menu. Then click on **Delete** to delete all of the selected files.

Wavelength Calibration

Introduction

You can calibrate the WinSpec/32 software either by using the spectrograph stepper motor position (spectrograph calibration) or by performing a wavelength calibration. Spectrograph calibration, described in Chapter 7, precisely calibrates the movement of the spectrograph gratings. Wavelength Calibration is good for one position of the grating only. Once you move the grating (by hand or by controlling the stepper motor) a different wavelength calibration must be performed for that spectrograph position.

Note: Even after the spectrograph setting is fixed, moving the sample, refocusing, or almost any adjustment of the input optics can have an effect on the wavelength calibration. For the most accurate calibration possible, Princeton Instruments recommends recalibrating the system after *any* optical adjustment.

Changing the WinSpec/32 Calibration Method

Switching between Wavelength Calibration and Spectrograph Calibration is controlled using the **Usage** dialog. This dialog determines whether calibration is turned on or off, and which type of calibration is used. The display can be calibrated by controlling the stepper motor of the spectrograph, called Spectrograph Calibration (discussed in Chapter 7), or the display can be calibrated for a fixed spectrograph position by entering the position of known peaks from a known source such as a mercury or neon lamp. The calibration of the spectrograph for a fixed position is called Wavelength Calibration and is described in this chapter.

Changing the Calibration Method

1. Select **Usage** from the **Calibration** menu. The dialog in Figure 55 will be displayed.
2. Select the desired method of calibration.

Auto Spectro selects Spectrograph Calibration as described in Chapter 7. A spectrograph supported by WinSpec/32 must be installed for this selection to be available.

Manual applies the wavelength calibration to the active data. The calibration is performed using the **Default Calibration Setup** dialog, accessed by selecting **Setup** on the **Calibration** menu.

Off selects uncalibrated operation.

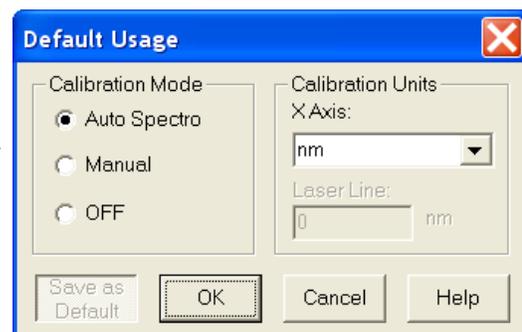


Figure 55. Calibration Usage dialog

3. Select the desired X Axis units. *This option is only available if the data set is calibrated.* If **relative wave numbers** are selected, it will additionally be necessary to enter the wavelength of the laser line.
4. Click on **OK**.

See the discussion of the **Calibration Usage** dialog in the online Help for details concerning the **Calibration Usage** dialog selections.

Calibration Menu

The **Calibration** menu, which can be called by clicking on **Calibration** in the menu bar, is shown in Figure 56. The **Calibration** menu contains two items, **Setup** and **Usage**, which call the **Calibration Setup** and **Calibration Usage** dialogs. Brief descriptions follow.



Figure 56. Calibration menu

Setup: Once a single spectrum has been acquired or loaded, the menu item **Setup** opens the **Calibration Setup** dialog. A calibration session consists of finding the peaks, marking the known peaks to be used for calibration, and saving the calibration data as the default or applying it to the active data set only.

Usage: Selects the Calibration mode and Units. Once the wavelength calibration has been performed, it can be applied by selecting **Manual** or turned off by selecting **Off**. Selections can either be saved as default power-up parameters or be applied to the active data set only. For more information, see the online Help discussion of the **Calibration Usage** dialog.

Wavelength Calibration Procedure

Before a wavelength calibration can be performed, it is necessary to either load a spectrum or acquire one. For good calibration results, the spectrum should have well defined peaks for which you know the wavelength. A calibration requires at least two points defined by pixel and by units. Naturally the more points used, the more accurate the calibration. The ideal calibration spectrum would have one peak at the start of the array (or region of interest), one at the end of the array or region of interest, and one midway between the end peaks. In real life, the ideal spectrum is seldom available, but the closer you can come to this ideal the better the calibration results will be.

Figure 57 shows a mercury-argon spectrum that could serve as the basis for a good calibration in many situations. *Appendix C contains wavelength tables for Argon, Neon and Mercury, together with a detailed spectrum for Hg-Argon.*

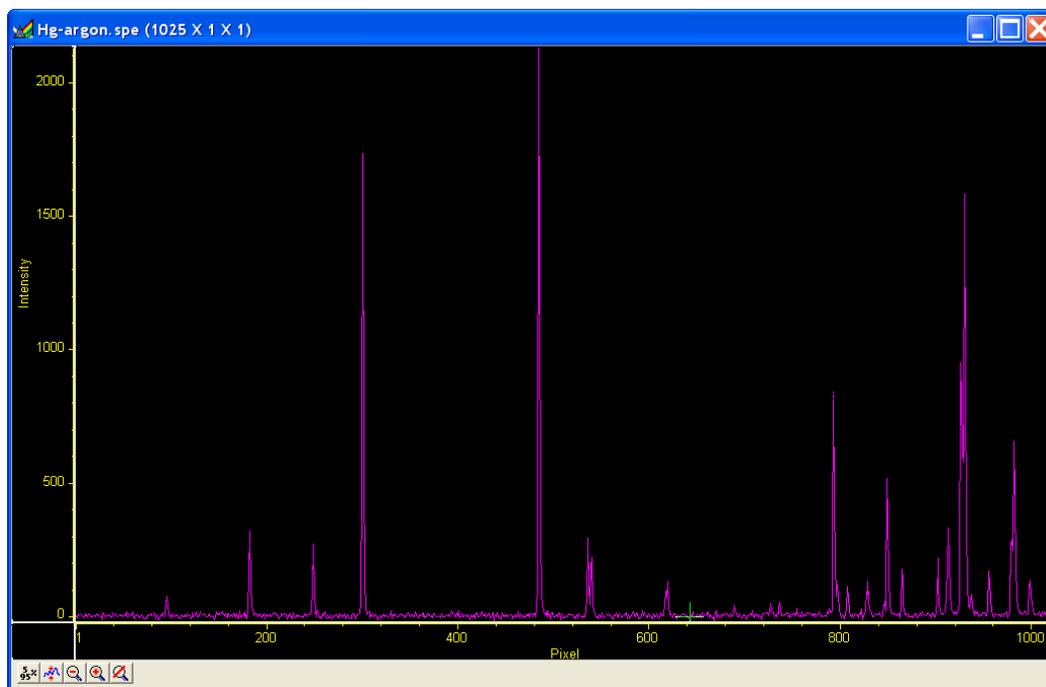


Figure 57. Hg-Argon spectrum

Once you have the calibration spectrum displayed on the screen as the active data set, proceed as follows.

1. Click on **Setup** in the **Calibration** menu to open the **Calibration Setup** dialog box. If a previous calibration had been saved, the calibration values would be listed. If no previous calibration had been saved as the default, no values would be listed. *For more information, see the online Help for this dialog.*
2. Click on **Find Peaks**. An automatic peak finding routine will be performed. The *maximum* number of peaks is equal to one quarter the number of displayed pixels. The pixel values for the 10 highest peaks will be shown in the Pixel boxes in the Calibration Setup dialog as shown in Figure 58. Note that the Find Peaks routine causes a small red arrow to be displayed above each peak found in the spectrum together with a notation indicating the peak location in pixels (Figure 59).

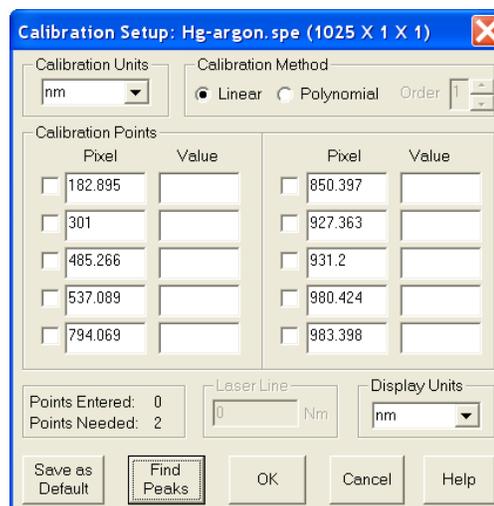


Figure 58. Calibration Setup dialog after running Find Peaks routine on Hg-Argon spectrum

Note: Each time the Find Peaks routine is initiated the *displayed* peak heights will decrease. Clicking on the data window **Autoscale** button will restore their original displayed height.

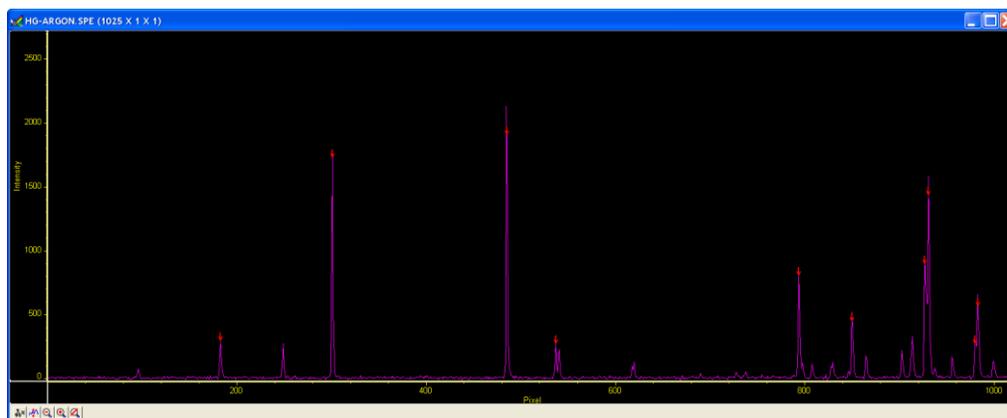


Figure 59. Spectrum after running Find Peaks routine

3. Select the calibration points. For the example being considered, the peaks at 182.90, 301.00, 485.27 and 931.20 would be good choices. *The decimal point locations are based on the calculated center of peak, and not necessarily the largest intensity position.*
4. Select the **Calibration Units** (if not nanometers) and select the **Display Units**. Both the **Calibration Units** and the **Display Units** are nm (the default) in the example.
5. Manually enter the wavelength of the selected peaks. *Appendix C contains wavelength tables and a detailed spectrum for Hg-Argon.* In our example, the wavelengths for the selected peaks would be:

Peak Location (Pixels)	Peak Location (Wavelength in nm)
182.90	365.02
301.00	435.83
485.27	546.07
931.20	811.53

6. Once the wavelengths have been entered for the selected peaks, check the selection box to the left of the **Pixel** box for each peak selected. (Figure 60). A checkmark in the box indicates that the peak is selected. *Note that wavelength values must be entered for these peaks before the selection box can be checked.*
7. Click on **OK**. This completes the wavelength calibration and the dialog will close. At the same time, the **Calibration Mode** selected in the **Usage** dialog will automatically change from **Off** to **Manual**.

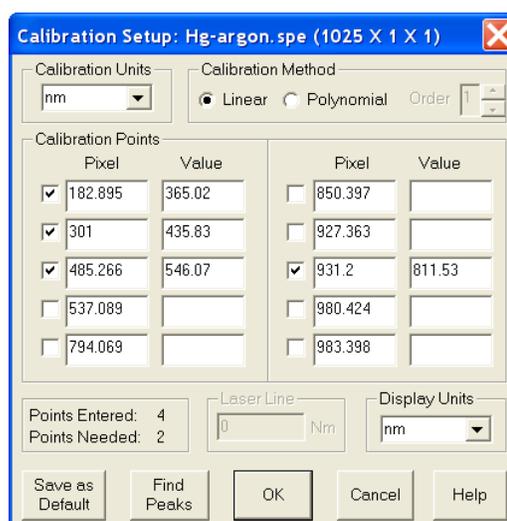


Figure 60. Setup Calibration screen after selecting peaks and entering calibration wavelengths

The peak find routine display data (arrows and pixel number of each peak found) does not change. The x-axis units will however change to reflect the display units.

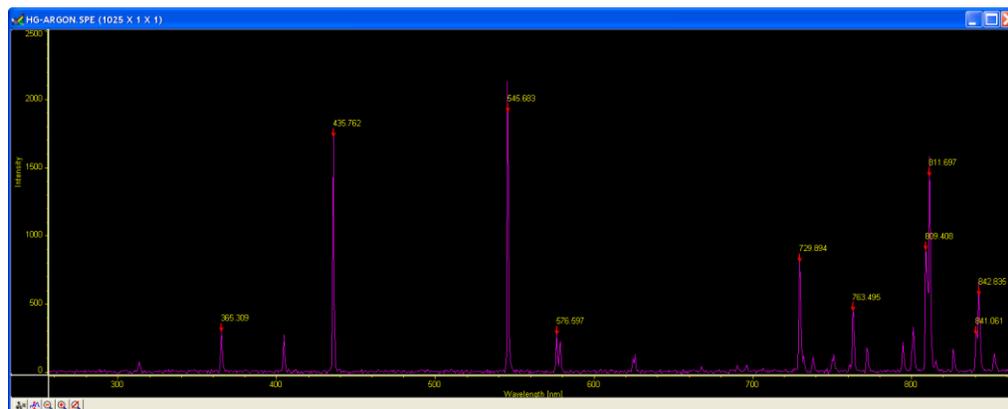


Figure 61. Spectrum after Calibration

Save as Default

The **Save as Default** button in the **Calibration Setup** dialog determines whether a calibration is temporary or permanent (until changed). Once a calibration has been saved as the default, it will be automatically applied to subsequently acquired data. **It will not be applied to data files recalled from disk.**

Note: The default state of the button, not only with respect to the button setting but also with respect to whether it is disabled (grayed out and not user-settable) depends on the situation, as follows.

No Data

If you open the Calibration Setup menu and there is no data, **Save as Default** will be pressed and disabled, that is, it will be locked in the **Save as Default** state. Should you then click on **OK**, no calibration values will be written to the Windows Registry.

Not Live Data

If there is data in the active window when you open the Calibration Setup menu, but the data is not live, such as would be the case if it were recalled from disk, **Save as Default** is under user control, with “not pressed” as the default state. Note that if the opened data file was saved in a calibrated state, that calibration will be in effect when the file is opened, the calibration values will be loaded in the calibration setup, and the data displayed.

Live Data

If the active window is displaying live data, **Save as Default** will be under user control but in the selected or “pressed” state. If **Save as Default** is selected and you click on **OK**, the calibration will be stored in the Windows Registry and will be automatically applied to all subsequent acquired data, unless a new calibration is performed. If **Save as Default** is unselected and you click on **OK**, the calibration in effect (i.e., in the Calibration Setup dialog) will apply to the active data file only.

Calibration, Display, and User Units

The default **Calibration Units** are nanometers (nm). These units can be changed, with the change taking effect immediately. Calibration units to choose from are nm

(nanometers), cm-1 (wavenumbers), rel. cm-1 (relative wavenumbers), and user units (units other than above). For relative wavenumbers only, the wavelength of the excitation laser must be entered in the **Laser Wavelength** box in nm. Display unit choices are the same, with the additional selection of pixels.

The **Display Units** selection can be different from the Calibration units, except in the case of **User Units**. Under Display Units, the choices are pixels, nm (nanometers), cm-1 (wavenumbers), and rel. cm-1 (relative Raman shift wavenumbers). These units are the ones shown on the X-axis whenever calibrated spectra are displayed. To display files without calibration, even files collected with a specific calibration, select the pixel option under Display Units.

User Units allow the operator to scale the spectra to any arbitrary unit.

Calibration Method

A calibration requires at least two points defined by pixel and by units. Naturally the more points used, the more accurate the calibration. The points must always be defined by pixel number, but nanometers can be changed to another unit if desired.

Two mathematical models can be used to fit the calibration to the data. The first, Least Square, calculates a linear approximation of the fit by minimizing the sum of the squares of the errors between the fit and the calibration points. Linear approximation is generally sufficient. The Polynomial method uses a higher order function of the form $a + bx + cx^2 + \dots$ where the "order" of the polynomial is the highest power of x used. The general rule is:

$$\begin{aligned} (\# \text{ Cal Peaks} - 1) &= \text{Order} \\ \text{maximum order} &= 5 \end{aligned}$$

If four peaks are active in the Calibrate dialog, the order of the polynomial can be 2 or 3. Even if ten peaks are used, the maximum order of the Polynomial is 5 (up to x^5). As a general guide, we advise calibrating using the Linear calibration method with widely separated peaks as previous described. If the available peaks are clustered, a Polynomial fit (using the smallest order possible) may give a good fit in the region of the calibration peaks, but have increasing large deviation the further you get from them. In an extreme case, there may even be two values for the same pixel, a clearly impossible condition that will result in an error message.

With the Linear calibration method, at least two peaks are required to calibrate. For a Polynomial calibration, the number of peaks must be at least one higher than the order of the polynomial. This information is displayed at the lower left of the Calibration Setup dialog. The lower Points value is the number of peaks required. The upper points value is the number available for calibration. A peak is available if it has been found, its known value has been entered, and the adjacent checkbox has been checked.

Spectrograph Calibration

Introduction

You can calibrate the WinSpec/32 software by either using the spectrograph stepper motor position (Spectrograph calibration) or by manual wavelength calibration. Spectrograph calibration is achieved using the Calibrate selection on the Spectrograph menu, and is described in detail in this chapter. Wavelength calibration, which is only good for one position of the grating, is explained in Chapter 6.

The spectrograph calibration routine requires you to enter certain default values into a series of dialogs. You are also required to have a known source, such as a mercury lamp, placed near the entrance slit of the spectrograph. Once you have completed the following calibration procedure, any movement of the spectrograph will be accounted for in the display of spectral information.

Notes:

1. The spectrograph **MUST** be focused and aligned properly before a good calibration can be achieved. Spectrograph focusing and alignment is an art unto itself and is beyond the scope of this manual. Basically it consists of filling the aperture from a broad light source and adjusting the focusing mirror for the sharpest image (narrowest possible symmetrical peak) on the CCD. Focusing can also be accomplished by moving the detector in and out. Different detectors and/or spectrographs will have different means for doing this. In addition, it may be necessary to rotate the detector so that the spectral line is perfectly vertical on the CCD.
2. The **Offset**, **Adjust** and **Dispersion** parameter values for WinSpec/32 will not be the same as they were with earlier versions of WinSpec. This is true even if the same spectrograph is used. You cannot simply enter values you may have recorded when using the earlier (16-bit) WinSpec versions. If you do, very large calibration errors will be introduced. The calibration must be performed using the following procedure.

Preparation

1. Install the spectrograph, mounting it to the detector per the instructions in the Detector manual, and turn it on. You may have to restart the WinSpec/32 software after turning on the spectrograph.
2. Mount a suitable light source (mercury lamp preferred) near the entrance slit of the spectrograph so that the light passes through the spectrograph onto the detector.
3. Review the **Define Spectrograph** selections and settings to be sure they are correct for the calibration to be performed.
4. The **Experiment Setup** parameters must be set so that a spectrum can be acquired. Using **Easy Bin**, select a single strip of several rows near the center of the CCD and an exposure time between 0.1 and 0.5 seconds.

5. A filename should have been entered for the test acquisitions using the **Experiment Setup|Data File** tab. Also, **Overwrite Confirmation** should be turned off so you will not see warning messages about overwriting data files. Exit the **Experiment Setup** dialog by clicking on the **OK** button.
6. Acquire some data and display the data as a graph. Next position and size the data window. We suggest locating it at the upper left and sizing it so that it doesn't extend more than half way across the screen. Then select **Keep Window Placement** on the **Display Layout|General** tab, followed clicking on **OK**. This operation assures that all data windows will fall in precisely the same spot and will be precisely the same size, a configuration that conveys a significant convenience advantage when calibrating.

Notes:

1. You must use the supplied cable to control the spectrograph. Do not use a standard 9-pin serial cable, even if it worked with an earlier version of WinSpec.
2. If the spectrograph does not move or you get an error message such as "Communication Error with Spectrograph", the spectrograph setup is probably incorrect. Check the power on the spectrograph, the cable connections, and the settings in the **Spectrograph** dialog. Also try turning off and back on the spectrograph, then closing and reopening the WinSpec/32 software.
3. If wavelength direction is reversed, you will not be able to calibrate successfully. However, a warning message will be displayed. If this happens, open the **Hardware Setup** dialog and select the **Display** tab. If **Rotate** is selected, toggle the **Flip** box. If **Rotate** is not selected, toggle the **Reverse** box. Click on **OK** and then begin Offset calibration again.

Calibration Parameters

1. Select **Auto Spectro** on the **Usage** dialog (to open, select Usage on the Calibration menu). *If the **Use for Auto-Spectro Calibration** checkbox on the **Define Spectrograph|Main** tab was used to designate a particular spectrograph as the one to be used for calibration purposes, that spectrograph will be automatically selected.*
2. If the **Save as Default** button on the **Usage** dialog is not already selected, select it now.
3. Select **Calibrate** on the **Spectrograph** menu. This will open the **Spectrograph Calibration** dialog (Figure 62).

4. Be sure the correct **Spectrograph to Calibrate** is selected. If another spectrograph is indicated, click on the down arrow at the right of the selection box to display all of the installed spectrographs and make the correct selection. *If only one spectrograph has been installed, the selection box will not appear but the spectrograph model will be reported.*
5. Be sure the correct **Grating to Calibrate** is selected. Calibration is grating specific. If the indicated grating is incorrect, click on the arrow at the right of the selection box to display the available gratings and make the correct selection.
6. Be sure the indicated value for the **Detector Pixel Width** in microns is correct. The default value will depend on the type of CCD chip installed. Note that some design factors, such as a tapered fiber optic ahead of the chip, will change *the pixel size seen by the spectrograph* and so will have to be taken into account in determining the value to be entered.
7. Be sure the indicated **Magnification** value is correct for your spectrograph. This parameter is determined by the geometry of the spectrograph. Contact your spectrograph manufacturer if you have any questions about the magnification parameter value.
8. Select the Grating Movement Mode, **Slew** or **Scan**. Operation with Slew selected will be significantly faster than with Scan selected.

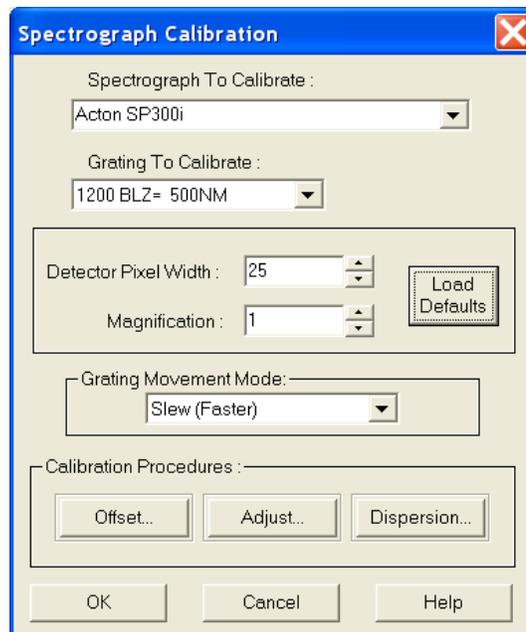


Figure 62. Spectrograph Calibration dialog

Offset

Caution

You must begin calibration with the **Offset** procedure and end with the **Dispersion** procedure. Performing the steps in this order is absolutely necessary for correct calibration.

Theoretically, if you were to move your spectrograph to the zero order peak or any other known peak, the peak would fall exactly on the center of the array. In the real world, the mechanical tolerances of the mounting will probably result in the peak being a few pixels off. The Offset procedure that follows allows you to correct for this small offset error.

1. Select **Info** on the **View** menu. The Info dialog should be visible. This will help indicate the status of spectrograph movement and data collection.
2. In the **Spectrograph Calibration** dialog, click on the **Offset** button. This will open the **Offset** dialog (Figure 63).
3. The dialog that appears has a **Reference Wavelength** entry box. This is the wavelength where the spectrograph is set for the offset measurement. All Acton spectrographs use the zero order, that is, a setting of “0.”
4. Click on the **Start Offset Procedure** button. The spectrograph should now move to the reference wavelength and data acquisition will commence. Then a peak-find will be performed and the resulting data will be displayed.
5. Figure 65 illustrates a typical Offset data acquisition. The reference peak should appear near the center of the display and the cursor should be near or on the highest point of the peak. If the peak is saturated, cancel, lower the exposure time, and repeat the operation. The display X-axis should be calibrated (any units other than pixels). *If the X-axis is calibrated in pixels, select the desired units as the calibration units on the Usage dialog (opened by selecting Usage from the Calibration menu).*

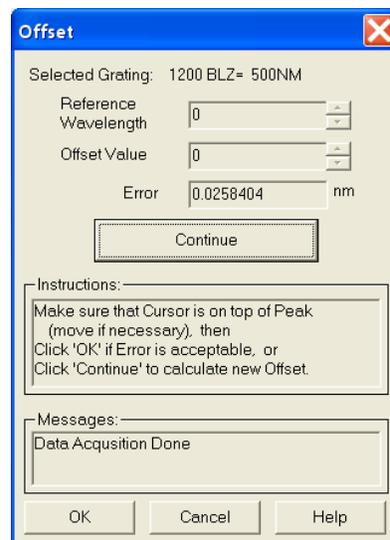


Figure 63. Offset dialog

Peak Finder

Before going on, you have to make a judgment regarding the location of the cursor on the peak. There may be situations where you will need to readjust the cursor position to get it precisely on the correct location. Although this should be a relatively uncommon event, it could happen, and it is important to take a moment to understand how the peak finder works, how it may appear to be in error when in fact it is not, and how it could come to be in error and require manual intervention to correct the cursor position.

The peak finder works by taking the second derivative of the spectrum to find the peaks. Each peak found is then divided in two so that the area to the left of the divider equals the area to the right of the divider. The cursor is located at precisely the point where the divider intersects the peak. Note that, depending on the shape of the peak, the cursor may or may not end up precisely on the highest point. Figure 64 shows three possible peaks, and illustrates the action of the peak finder in each case.

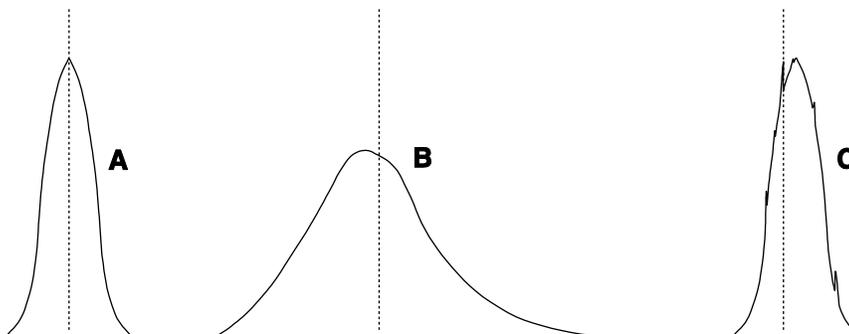


Figure 64. Peak Finder Examples

Peak **A** is perfectly symmetrical. As you would expect, dividing it into two equal areas and locating the cursor at the intersection of the divider with the peak will put the cursor precisely at the highest point. Peak **B**, on the other hand, is not symmetrical but rather extends further to the right than to the left. As a result, the final cursor position is a little to the right of the highest point. *This is the correct peak location. Any attempt to “improve” it by manually moving the cursor to precisely the highest point will degrade the offset computation. Note that moving the cursor immediately changes the reported Error. Do not assume that this means the cursor was not optimally located. Rather it indicates a possible optical problem and the spectrograph may need to be realigned.* Peak **C** is like peak A but is accompanied by a number of noise spikes. The peak finder is quite sensitive and might well select one of these spikes as the real peak and incorrectly place the cursor on the noise spike as shown in **C**. If this happens, the correct action would be to manually adjust the cursor position to the right so that it is on the true peak before going on.

Doublets are also a problem. At any stage of the calibration procedure the peak finder might find the wrong peak of a doublet. For example, if using the 579.066 nm mercury line in doing the Dispersion Calibration, you need to take care to check that the peak finder hasn't selected the 576.96 nm line instead. If it does, it is a simple matter to move the manually move the cursor to the correct peak. *Note that the zoom function can also be controlled using the data window icons.*

If it is difficult to see the precise cursor position, simply press the keyboard **Insert** key to expand the display about the cursor position. The key may have to be pressed several times to achieve the desired resolution. *(Use the Delete key to return to the original display.)* If you do decide to move the cursor, note that each time a cursor-positioning arrow key is pressed, the cursor will move one data point. Assuming no horizontal binning is in effect, one data point will correspond to one pixel on the array.

As a final comment, even if you should move the cursor when it was not necessary, repeating the Calibration Offset cycle a few times will still achieve an optimum offset adjustment.

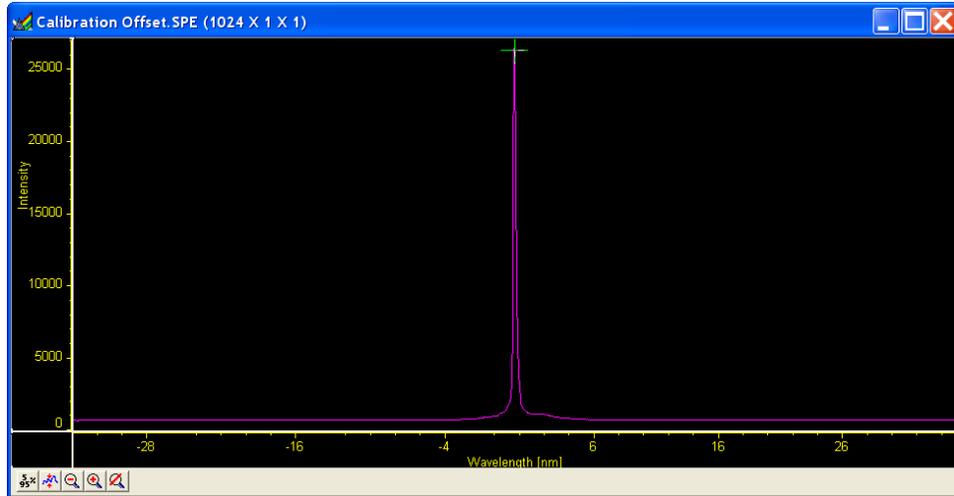


Figure 65. Offset Spectrum for Zero-order Measurement

6. Note the reported **Error** value in the **Offset** dialog. The value is reported in nm. Transposed to pixels it should be less than one pixel. *The number of nm represented by one pixel will depend, of course, on the dispersion of the grating.*
7. Press **Continue** to initiate another offset computation cycle. The reported error should decrease. Repeat the cycle two or three times – until no further reduction in the error can be achieved. The final error value achieved may wander a bit with each cycle repetition, reflecting the noise content of the spectrum.
8. Click on **OK** to close the **Offset** dialog and return to the **Spectrograph Calibrate** dialog.

Adjust

Once you have adjusted the Offset for a reference wavelength (or for the zero order peak) other wavelengths may still be improperly calibrated. To see why this is so, think of the calibration in terms of the linear general equation:

$$y = mx + b$$

Although this is a simplified model, it suffices to show the basic relationships. The “b” term can be thought of as the offset, which is adjusted to place the reference at precisely the center of the array. The location of points away from the offset reference will be determined by the “m” or slope term (as well as “b”) and the Adjust procedure allows “m” to be set so that adjusting the spectrograph to other wavelengths will result in this wavelength falling on the center of the array.

1. Click on the **Adjust** button to open the **Adjust** dialog (Figure 66).
2. Enter as the Reference Wavelength a known line in the observed spectrum, such as 579.066 for Mercury. Next click the **Start Adjust Procedure** button.
3. The spectrograph will move to the reference wavelength and collect a spectrum. It will also perform a peak-find operation and display the acquired data. The reference peak should appear somewhere near the center of the display and the cursor should be on the peak at or near the highest point.
4. Figure 67 illustrates a typical Adjust data acquisition. The reference peak should appear near the center of the display and the cursor should be near or on the highest point of the peak.
5. As was the case for the Offset adjustment, before going on, you have to make a judgment regarding the location of the cursor on the peak. Take particular care that the proper peak has been found. If, for example, the peak finder places the cursor on the 576 peak, manually move the cursor to the 579 peak. For additional information, refer to the earlier discussion of how the peak finder works in the Calibration Offset procedure.

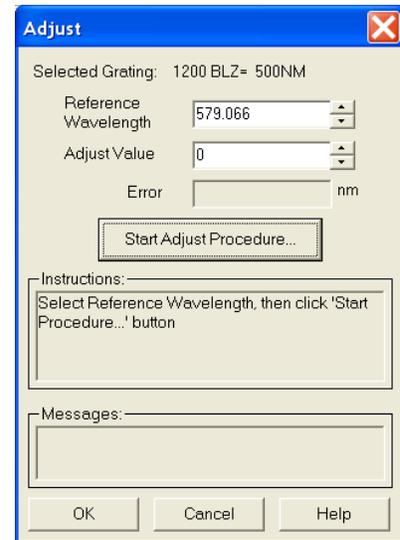


Figure 66. Adjust dialog

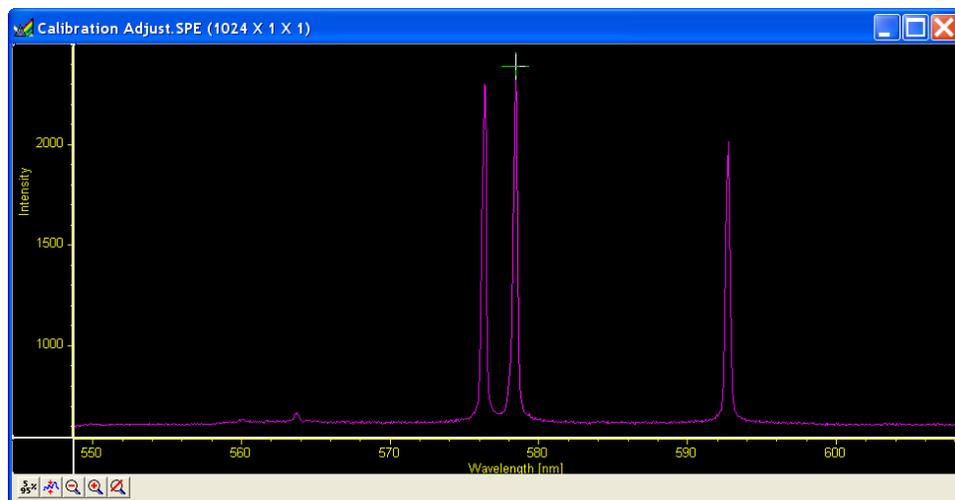


Figure 67. Calibration Adjust Spectrum

6. Note the reported **Error** value in the **Adjust** dialog. The value is reported in nm. Transposed to pixels it should be less than one pixel. *The number of nm represented by one pixel will depend, of course, on the dispersion of the grating. The nm/pixel can be approximated by picking the difference in the location of the two peaks while in pixel mode, and dividing the difference reported in calibration units in the calibration mode.*

Note: The absolute value of the peak is reported in the **Info** box. If it is not already open, open it by selecting **Info** from the **View** menu.

7. Press **Continue** to initiate another Adjust computation cycle. The reported error should decrease. Repeat the cycle two or three times – until no further reduction in the error can be achieved. The final error value achieved may wander a bit with each cycle repetition, reflecting the noise content of the spectrum.
8. Click **OK** to close the **Adjust** dialog and return you to the **Spectrograph Calibrate** dialog.

Dispersion

Now that Offset and Adjust are complete, the spectrograph can move a target peak very close to the center of the display. The final step is to calibrate the wavelength scaling so that peaks on the far left or the far right in the window are also accurately calibrated. This is called the Dispersion calculation, and again it is automated in WinSpec/32.

To adjust the Dispersion calculation you will make two measurements in the lower spectral range (253.652 for Mercury); one measurement with the peak at the left edge of the display and one with the peak at the right edge. Then you will make two measurements in the upper spectral range (579.066 for Mercury). After these steps, WinSpec/32 then tries to find the combination of Focal Length, Inclusion Angle, and Detector Angle that minimizes the error.

Note: Some CCDs have very little response at 253.652. If this is the case for your detector, it will be necessary to use a peak having a longer wavelength as the low value. For mercury, the 435.833 line should prove suitable.

1. Click on the **Dispersion** button to open the **Dispersion** dialog. If you have never calculated the Dispersion before, click on the **Default** button. This provides standard values for Focal Length, Inclusion Angle, and Detector Angle based on the manufacturer's data for the active spectrograph. If you have already run the Dispersion calculation before and it provided satisfactory values, they will be displayed and should be used as your starting values.
2. Enter the **Lower and Higher Reference Wavelengths**. For the mercury spectrum, use 253.652 (low) and 579.066 (high). *Again, if your CCD doesn't have sufficient response to calibrate at 253.652, it will be necessary to use a different peak.* It is not necessary to enter a **Target Wavelength**. It will be calculated during the procedure.

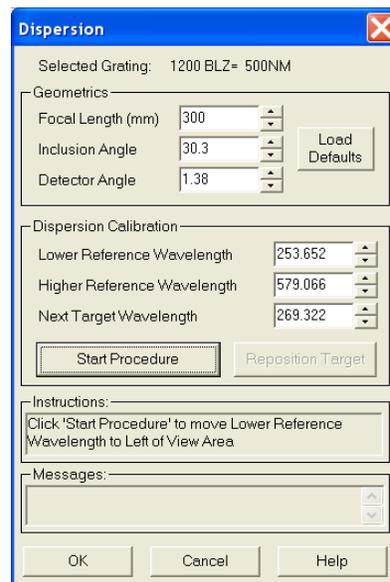


Figure 68. Dispersion dialog

Note: In the following steps, four data sets will be taken, each initiated by you. The **Start Procedure** button initiates the first, and the same button, named **Continue** once the first data set has been taken, is used to initiate each of the other three. After each data set is taken, you have the option of adjusting the cursor position on the peak. However, as previously explained, this will not be required or advisable in most instances. *See the Peak Finder discussion in the Calibration Offset procedure.* The data sets are taken in the following order:

1. Low peak (253.652) at the left of the display.

2. Low peak (253.652) at the right of the display.
 3. High peak (579.066) at the left of the display.
 4. High peak (579.066) at the right of the display.
3. Click on the **Start Procedure** button.
- WinSpec/32 will acquire the first data set and display it. It will also calculate the Target Wavelength so that the Lower Reference Wavelength peak appears near the left edge of the display. *The Target Wavelength is the wavelength the spectrograph must move to in order for the reference wavelength to be properly located near the edge of the display.*
 - If the peak is outside the display, you should enter a Target Wavelength that might be better and click the **Reposition** button. If the peak is too close to the center of the display you should enter a slightly higher Target Wavelength and click on the **Reposition** button. Once the peak appears near the left edge, check, and if necessary adjust, the cursor position on the peak using the same criteria as for the Offset and Adjust operations. Then click on **Continue to Step 2** to initiate the second data acquisition.
 - The spectrograph will acquire the second spectrum. If the peak is close to the right edge of the display as expected, click on **Continue to Step 3** to initiate the third data set acquisition. If the peak is not in the right position, use the **Reposition** button to move the spectrograph as required to position the low peak near the right edge of the display. Then click on **Continue to Step 3** to initiate acquisition of the third data set.
 - The spectrograph will acquire the third spectrum, this time positioning the cursor on the high peak at 579.066. If the peak is close to the left edge of the display as expected, click on **Continue to Step 4** to initiate the fourth data set acquisition. If the peak is not in the correct position, use the **Reposition** button to move the spectrograph as required to position the high peak near the left edge of the display. Then click on **Continue to Step 4** to initiate acquisition of the fourth data set.
 - After completion of the fourth data set, once again check to be sure the cursor is on the correct peak and manually move it if it is not.

After all four reference points are taken, WinSpec/32 begins an iterative process to find the best values. This process is initiated by clicking on the **Calculate Results** button. You will see the parameters change as WinSpec/32 performs the calculations. The program stops when the best parameters are displayed in the Dispersion dialog. If satisfied with the calibration, simply click on **OK** to make the save the final dispersion parameters as part of the calibration data for the grating. Click on **Cancel** to revert back to previously saved parameters. Note that you can also change the parameters manually and click on **OK** to save them.

Having completed the calibration for one grating, select the next grating and repeat the procedure. Continue until all available gratings have been calibrated.

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Displaying the Data

Introduction

WinSpec/32 can display data as an image, as a two dimensional graph, or as a 3D Graph (multiple strips from the same graph or the same strip from multiple frames). You can choose to allow the software control how the data will be displayed or make the selection yourself. To have WinSpec/32 control the data-display mode, simply select the **Auto Select** checkbox provided on the File Open dialog and also on the Display Layout dialog. The Auto Select algorithm makes the selection depending on the number of data strips as follows.

- If there are eleven or more strips of data, they will be displayed as a normal image, such as that shown in Figure 69.

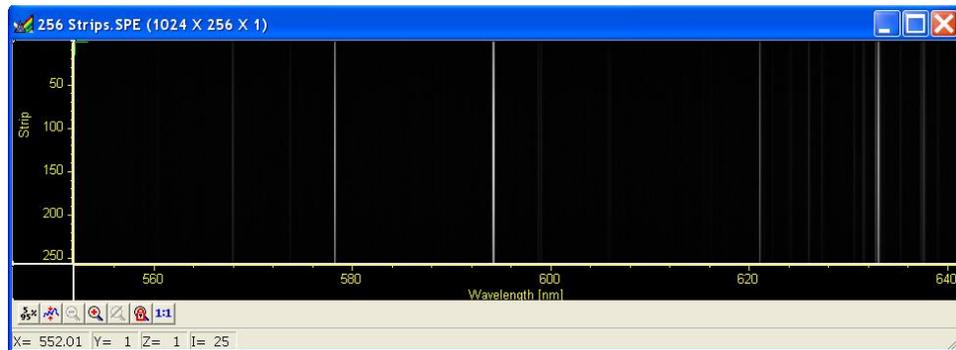


Figure 69. Image display of 256 data strips

- If there are at least three data strips but less than eleven, the data will be plotted as a 3D Graph as shown in Figure 70.

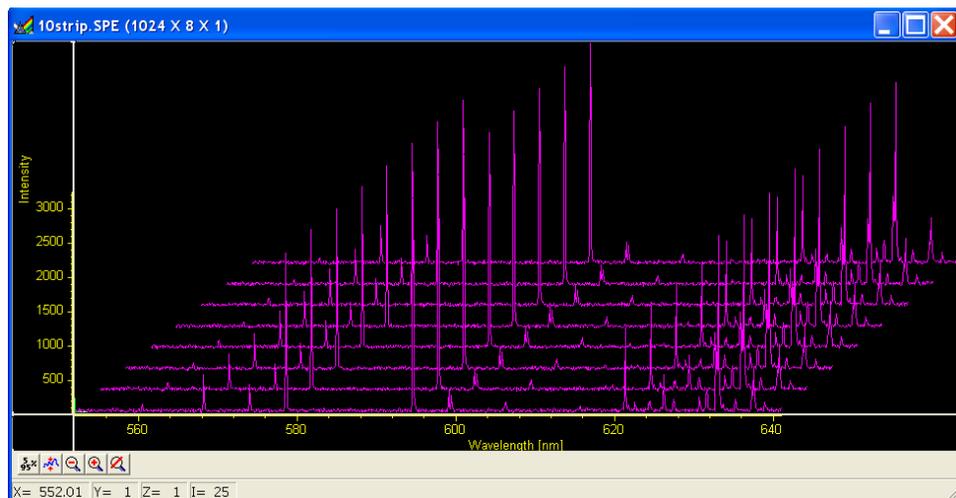


Figure 70. 3D Image display of eight data strips

- If there are only two strips of data, they will be displayed as graphs stacked in a two-dimensional plot, the same as for a 3D Graph of two strips.

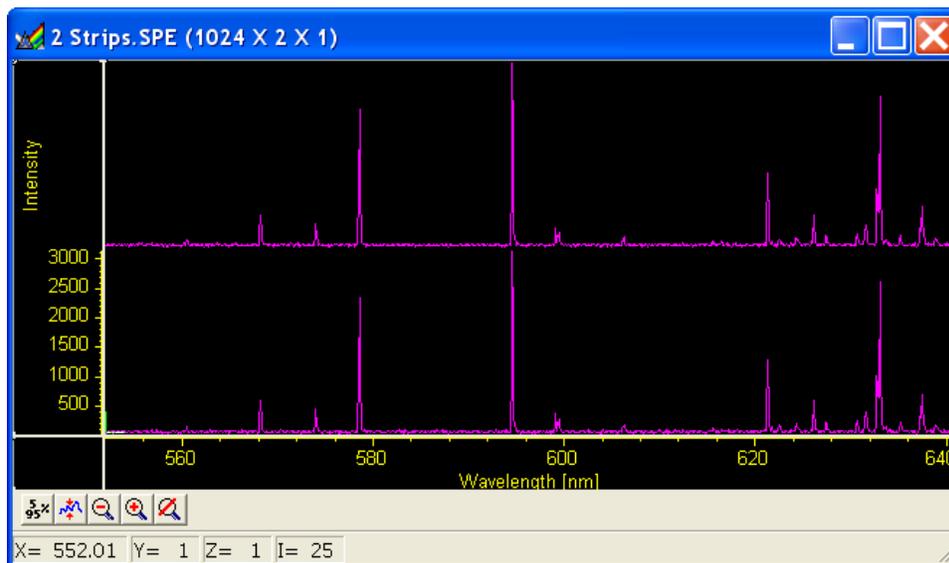


Figure 71. 3D graph with two data strips

A single strip *will always* be plotted as a simple graph. Note that from two to ten strips, the intensity (Y axis) scale shifts position as required to read true for the selected strip.

The file Open dialog and **Display Layout** dialog both contain the three display-mode select radio buttons, **Image**, **Graph** and **3D Graph**. If you want to control the data-display mode yourself, simply leave **Auto Select** unchecked and the display mode will correspond to whichever of the three radio buttons is selected.

Screen Refresh Rate

The Screen Refresh Rate is an important but often overlooked display performance parameter. At times, such as when focusing, by making the screen refresh rate as rapid as possible, the focusing operation may be much easier to perform than it would be with a slow refresh rate. To obtain the fastest possible refresh rate, simply operate with the axes and cross-sections both switched off (View menu) and with the Zoom factor set to 1:1. *Note that the Zoom 1:1 button on the Data Window toolbar is only present when viewing an image.* To check the refresh rate, click on the Status bar (bottom of screen)

Collection Status pane, which is immediately to the left of the Timer pane (right end of **Status** bar). The refresh rate will be displayed in the Collection Status pane. Do not confuse the screen refresh rate with the data collection rate.

Data Displayed as a 3D Graph

Data files can be opened as 3D graphs from the Open dialog. Figure 72 shows a 3D graph with five data strips. Figure 71 (on the previous page) shows a 3D graph with two data strips. Both examples illustrate the behavior of the **Auto Select** algorithm as discussed on page 99. The following paragraphs contain procedures for opening and displaying data in graphical format.

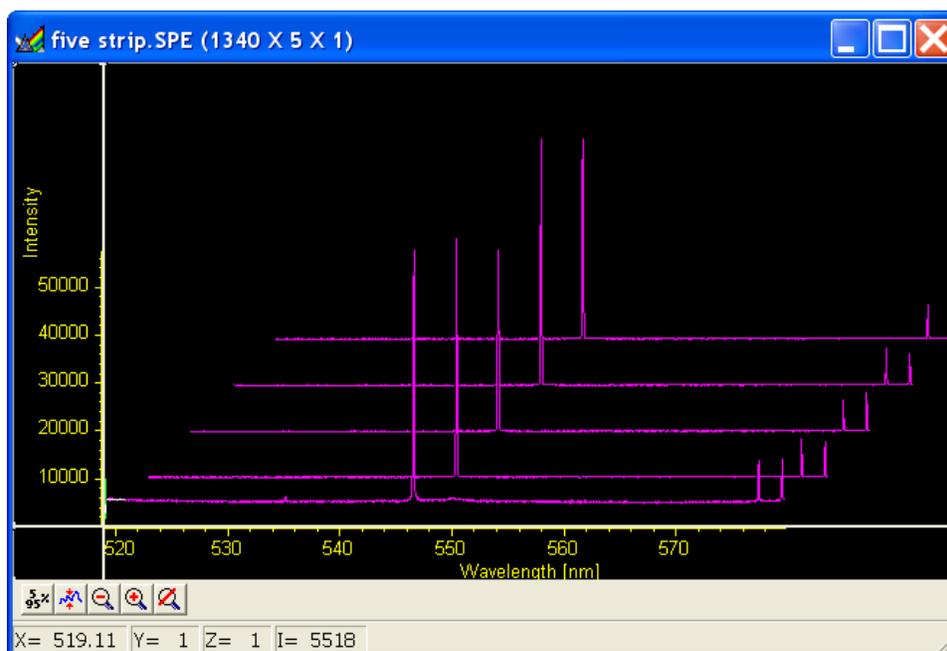


Figure 72. 3D graph with five data strips

Displaying Hid-lamp.spe

The data file used in this exercise is Hid-lamp.spe, one of the data files supplied with your WinSpec/32 software.

1. From the **File** menu select **Open**. The **Open** dialog (Figure 73) will appear, allowing you to select the image to be opened. The Look-In box provides a browser function so that the directory where the images are located can be easily accessed. By default the data directory is a subdirectory of the WinSpec program directory. Files of the specified type (the WinSpec/32 data type is *.spe) in the current directory and any subdirectories are listed in the box below the directory name.

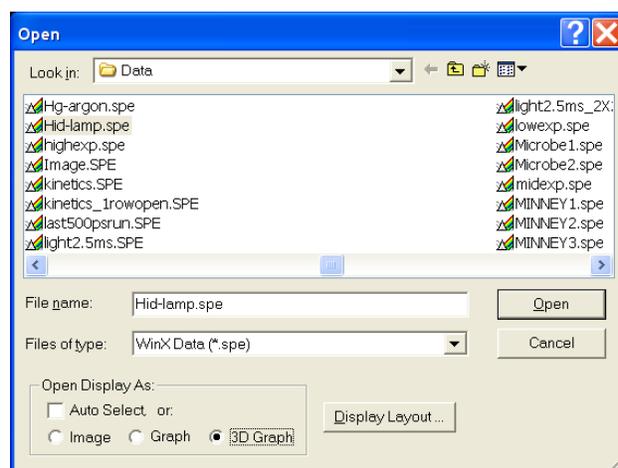


Figure 73. Open dialog

2. The **Image**, **Graph** and **3D Graph** radio buttons at the bottom of the box allow you to select whether the file will be opened and displayed as an image, two-dimensional graph or as a 3D graph. Select **3D Graph**. (Auto Select should not be checked.)
3. From the data directory select the image file called Hid-lamp.spe. Click on the **OK** button. A window of the appropriate dimensions should appear immediately. The graph display may take a few seconds, depending on the speed of the computer. The initial appearance of the display may vary depending on the initial Display Layout parameter settings.
4. Select **Layout** on the **Display** menu. The **Display Layout** dialog will open as shown in Figure 74.
5. Check and, if necessary, set the following parameter selections on each tab.

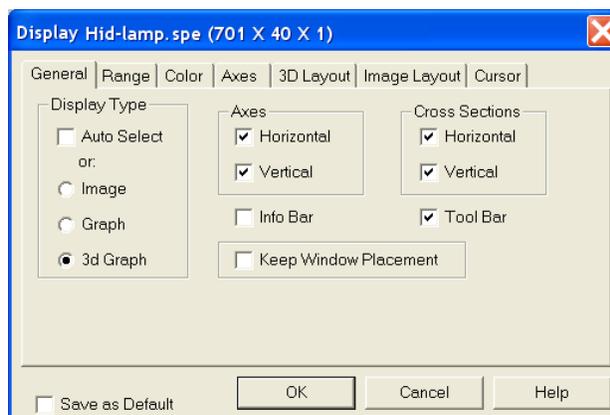


Figure 74. Display Layout dialog

General tab

Display As: 3d Graph

Auto Select:
unchecked

Axes: both boxes
checked

Cross Sections: both
boxes checked

Tool Bar: checked

Keep Window

Placement: unchecked

Range tab

Initial Autoscale: checked

Set to Full Range: checked

Frame: 1

Color tab: no changes

Axes tab

Horizontal axis: checked

Horizontal label: checked

Horizontal label string: Pixel

Vertical axis: checked

Vertical label: checked

Vertical label string: Intensity

3D Layout

3D Mode: Multi-strip; same frame selected

3D Properties: Remove Hidden Line checked; other two boxes unchecked.

Z Axis Endpoint: %X set to 20; %Y set to 40

3D Marker curves: Marker Curves unchecked; Curve set to 5

6. Click on **OK**. The **Display Layout** dialog will close and the data display, exclusive of the intensity profiles, should appear as shown in Figure 75. Each strip is displayed as a plot of intensity vs. pixel number. The first strip is at the front and the last strip is at the back. Initially the cursor will be at the lower left. Use the up arrow key to move to a higher numbered strip and the right arrow key to move to a higher numbered pixel on the strip. Then click the **Intensity Autoscale** key to scale the intensity profiles. *Note that clicking the mouse button at different points on the display will change the pixel selection but not the strip.*

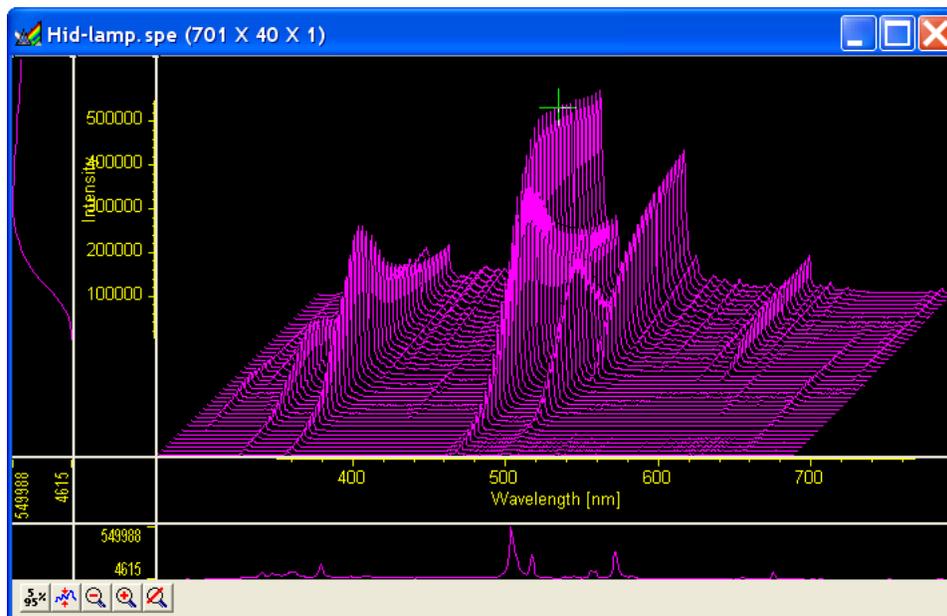


Figure 75. Hid-lamp.spe 3-D Graph

7. Press the **[Insert]** key on the keyboard repeatedly. Each time it is pressed the display expands about the cursor position. Then press the **[Delete]** key repeatedly to contract the display, restoring the appearance of the data display.
8. Note the cross sectional displays in Figure 75. The vertical cross-section profiles the intensity at the same point on each successive strip. The horizontal cross-section profiles the intensity at each point on the same strip. If the large cursor is selected, cursor projections will intersect the cross section to show indicate the cursor position. These projections may not be visually aligned with the cursor position on the main plot. This effect will be particularly noticeable with a long Z axis. Because of perspective effects, the higher numbered strips will be further away and visually smaller. The axes automatically adjust so that they read true for the strip on which the cursor is located. However, because the cross-section profiles expand to use all of the available space, they will not be in alignment visually with the cursor. The profile shapes will be correct, and the point on the profiles intersected by the large cross-hair extensions will accurately indicate the cursor position. Also, the information box will accurately report the pixel number and intensity at the cursor position.

5%-95% Display Range

1. Click on . The data display will shift so that it only fills the 5% to 95% region of the window range. Had the data initially extended all the way to the window boundary, the data display would have been slightly compressed to fit within the 5%-95% range.
2. Click on , restoring the image to its initial appearance.
3. Before advancing to the next topic, open the **View** menu. Then select the **Small** cursor and deselect **Cross-Sections**.

Selecting a Region of Interest

1. Using the mouse, drag a rectangular region on the image as shown in Figure 76.

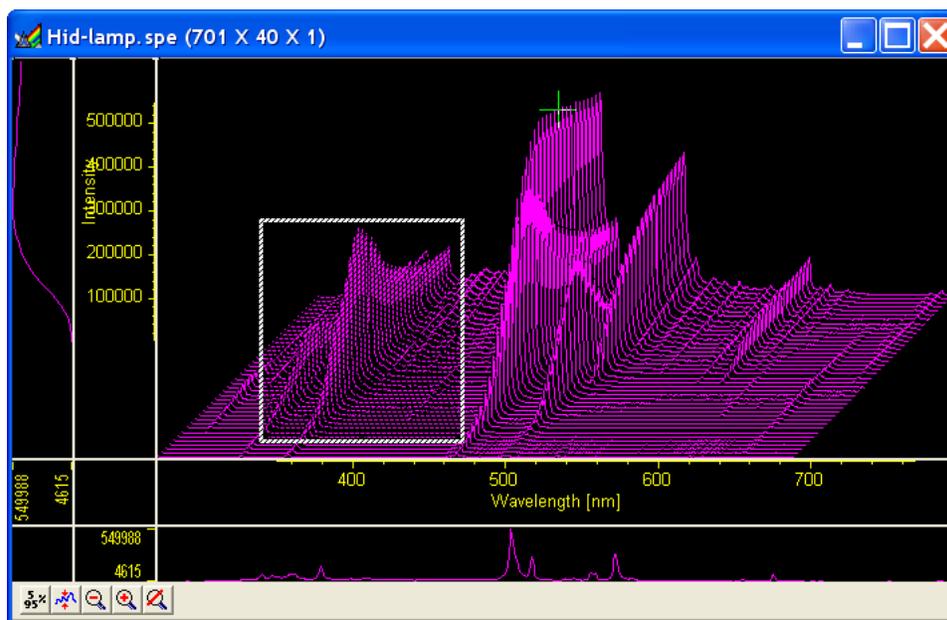


Figure 76. Hid-lamp.spe 3D graph with region selected for viewing

2. Click on  (Zoom In). The view will change so that only the selected region is displayed as shown in Figure 77.

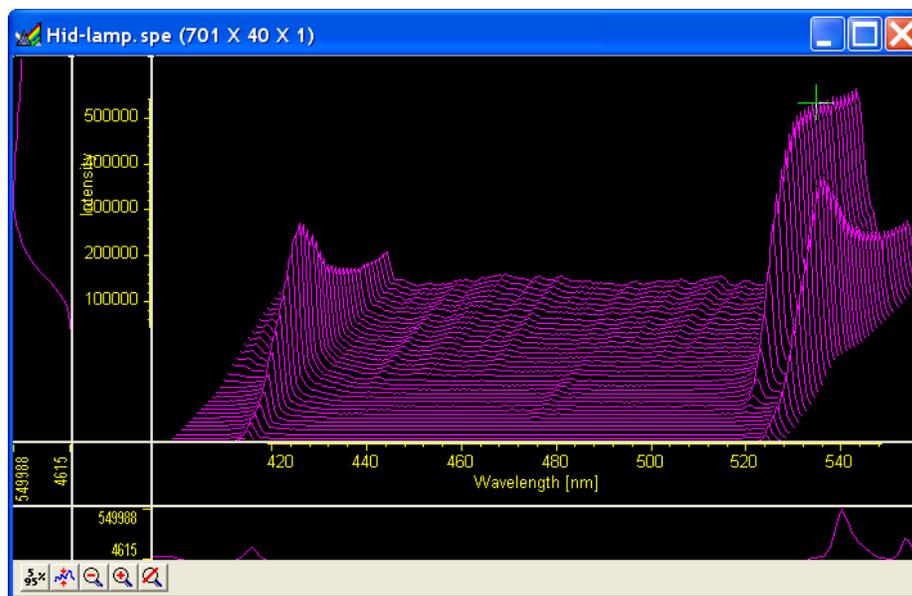


Figure 77. *Hide-lamp.spe* 3D graph expanded to show defined region

3. Click on  (Undo All Zoom-In). The original view will be restored.

Information box

On the **View** menu, select **Info**. The information box should appear as shown in Figure 78. The first line reports the intensity and pixel number at the cursor position. The second line reports the frame number, strip number, and the pixel number. The intensity in A/D counts is reported at the X and Y position corresponding to the cursor position. If a region is defined by dragging the mouse cursor, the region coordinates, length and height will also be reported. *You may have to lengthen the Information box for all this information to appear.*

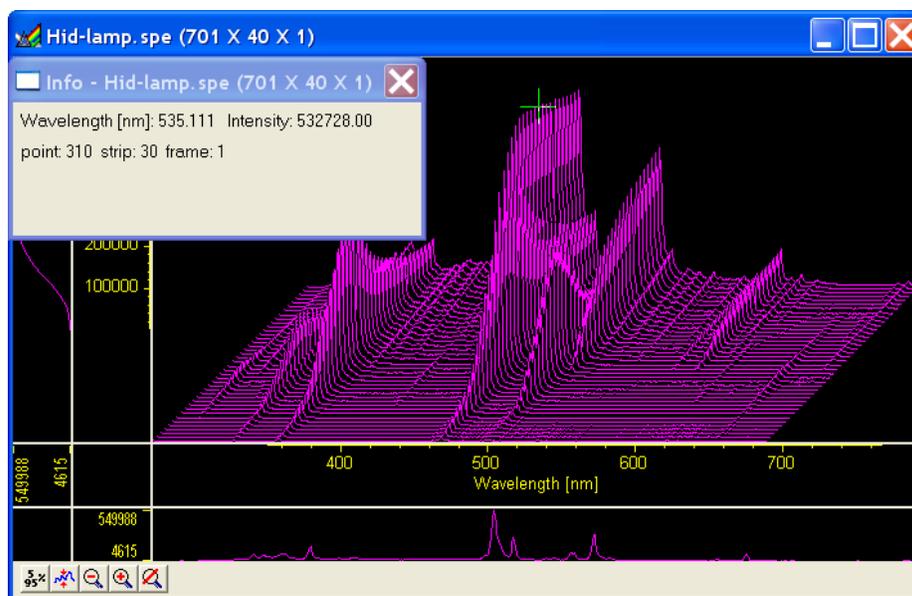


Figure 78. *Graphical Display with Information box*

Note: When you open the information box, it becomes the active window. To perform operations in the data display window, such as changing the selected strip, you must again make the data display window active by clicking the mouse cursor anywhere in the data box. The data-window title bar will become highlighted, indicating that it is the active window, and the cursor positioning functions will become operative again. The data displayed in the information box will continue to be updated automatically.

Displaying a Single Strip

1. Open the **Display Layout** dialog by selecting **Layout** on the **Display** menu.
2. On the **General** tab, with **Auto Select** unselected, click on the **Display Type|Graph** radio button and then on **OK**. The single data curve for the strip on which the cursor is positioned will be displayed.

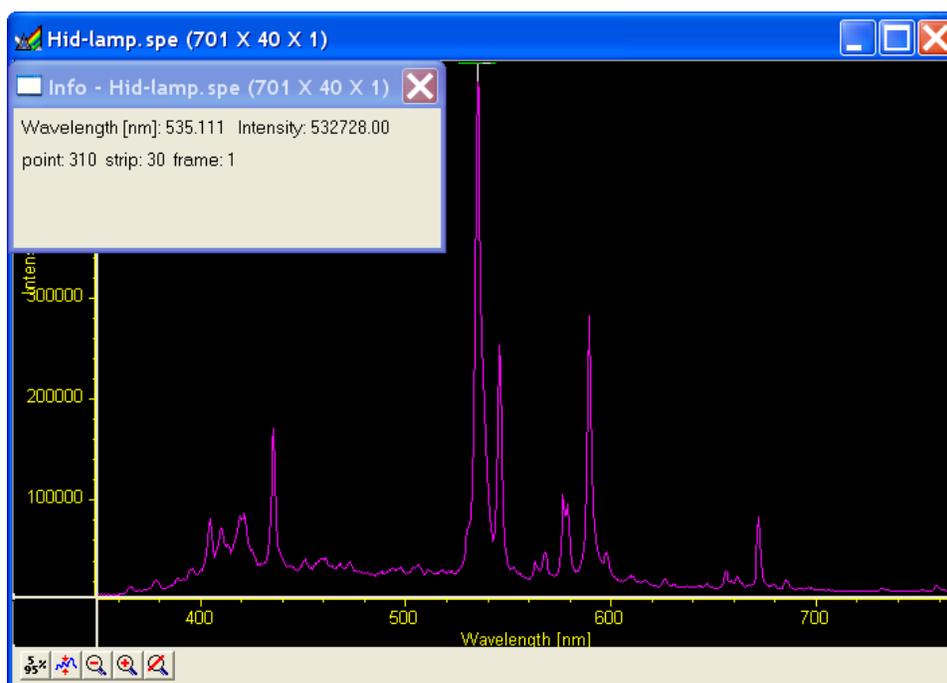


Figure 79. Single Strip displayed graphically

3. Try operating the cursor positioning keys to demonstrate their effect. The left/right arrow keys move the cursor along the strip, and the up/down keys move it from strip to strip. The **[Home]** and **[End]** keys move the cursor to the strip ends, and **Shift + Home** and **Shift + End** move it the first strip and last strip, respectively. The **[Insert]** and **[Delete]** keys expand or contract the data about the cursor position.
4. Restore the 3D display by selecting **3D Graph** on the **Display Layout|General** tab.

Cursor

The cursor's appearance and behavior are a bit different with graphical plots than with image plots, as detailed in the following table.

Selection	Image Plot	Graph	3D Graph
None	No Cursor	No Cursor	No Cursor
Small	Small cross; both mouse and arrow keys can place cursor at any pixel on image. [Home] and [End] keys move cursor to end points on strip. Shift + Home moves cursor to first strip. Shift + End moves it to the last.	Small cross; left/right arrow keys select pixel on strip; up/down arrow keys select strip to be displayed. [Home] key moves to first pixel, [End] key to last pixel.	Small cross; left/right arrow keys change selected pixel on strip; [Home] key moves to first pixel, [End] key to last pixel. Up/down arrow keys move cursor from strip to strip. Shift + Home moves to first strip, Shift + End to last. Strips may all be from same frame or each may be from a different frame.
Large	Large cross; rays extend to edges of data set; with projections through the cross-section profiles if displayed. Both mouse and arrow keys can place cursor at any pixel on image. [Home] and [End] keys move cursor to end points on strip. Shift + Home moves cursor to first strip. Shift + End moves it to the last strip.	Same as Small Cursor and Graph combination.	Same as Small Cursor and 3D Graph except that cursor ray projections through the cross-section profiles are provided. These will not necessarily be visually aligned with the cursor.

Table 3. Cursor Appearance and Behavior for Images and Graphs

Strip Selection

As described above, when displaying data as a graph, the up/down arrow keys can be used to select a higher or lower numbered strip. This is true if displaying multiple strips or a single strip. For additional utility where a large change is required, **Shift + Home** can be used to move the selection to the first strip and **Shift + End** to move it to the last one.

Four of the **Custom Toolbar** buttons similarly allow the selected strip to be changed when data is displayed as a graph.



Selects the first strip.



Selects the last strip.



Selects the next strip.



Selects the previous strip.

These buttons have no effect on the strip selection when viewing data as an image. Instead they select the first, last, next and previous frame respectively if the data set contains multiple frames.

Note: When displaying the data as a graph, to view data from multiple frames, it is necessary to select **Same Strip - Multi Frame** on the **Display Layout|3D Layout** tab.

It might further be noted that these buttons do not appear on the default Custom Toolbar. Instead they must be added using the **Customize Toolbar** dialog, accessed by selecting **Custom Toolbar** on the **Setup** menu.

Cursor Curve and Marker Curves

In analyzing a data display, it is often desirable to highlight the cursor curve and to have every n th curve displayed in a different color as a convenient marker. WinSpec/32 provides these functions as demonstrated in the following procedure.

1. On the **3D Layout** tab, select **Highlight Cursor Curve** and **Marker Curves On**. Then press **OK**. The cursor curve and marker curves should be clearly delineated. Note that on a color monitor they would be in contrasting colors and much easier to see than in a black and white print as shown in Figure 80.

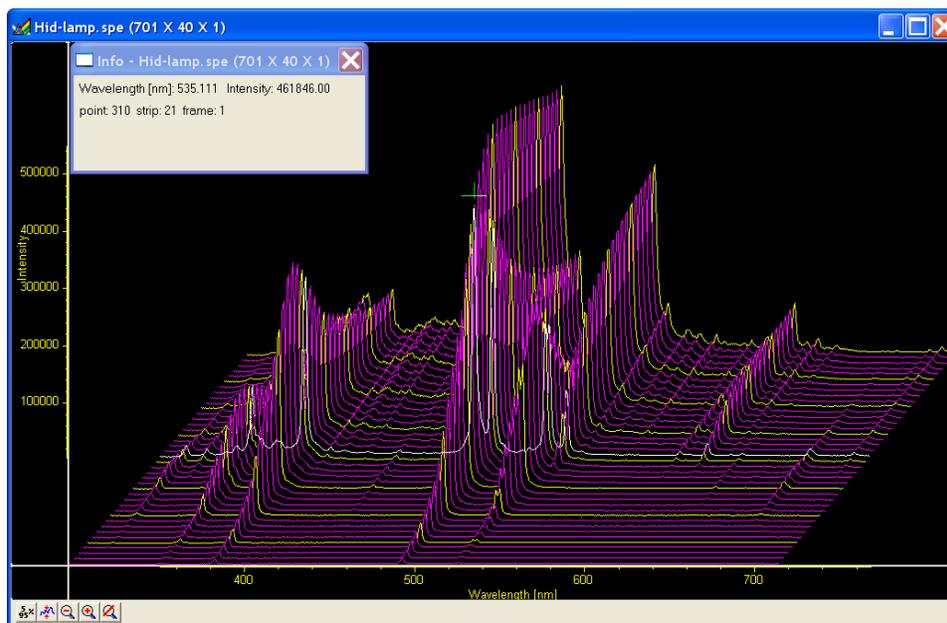


Figure 80. 3D Display with Cursor curve and Marker Curves

Note: Displaying the data with Highlight Cursor Curve displayed affects the time required to step the cursor from curve to curve. If Highlight Cursor Curve is OFF, the cursor can step without updating the entire display. If Highlight Cursor Curve is ON, the entire display updates with each step, a considerably slower operation.

2. If the Cursor Curve and Marker Curves do not appear, the problem may be with the assigned colors, which should be different from the normal graph color and different from the background color. On the **Display Layout|Color** tab, it the **Active 3D Graphs** button that allows the cursor-curve color to be set. The **Marker Graphs** button is used to set the marker-curves color.

Hidden Surfaces

The following procedure shows you how to shift the view to see the hidden or underside of the data.

1. Open the Hid-lamp.spe file as a 3D graph: this sample file is supplied with WinSpec.
2. Open the **Display Layout** dialog and make the following changes.

Range: Change Y so that the range is “from 40 to 1” (not “from 1 to 40”).

3D Layout: Select **Show Hidden Surface** and deselect **Highlight Cursor Curve** and **Marker Curves On. Remove Hidden Lines** should be selected. Change the Z Axis Endpoint to X% 25 and Y% 0.

The Z Axis Endpoint can be set by entering values up to 80% X (either polarity) and 80% Y (positive only) or graphically by using the mouse. If you click on **Adjust Z Graphically** and then on **OK**, the Z Axis Adjust window will appear. With the cursor in that window, depress the left mouse button, and drag the cursor around the WinSpec/32 desktop until you see the desired axis orientation. Then release the mouse button.

Because the data is displayed the moment you depress the mouse button and then updated as you drag the cursor, you can see the effects of dragging the axis while moving it. When working with a high-density data set, every n th line will be suppressed during the adjustment so the process remains fast. When the data is displayed as desired, releasing the mouse button will cause the entire data set to be displayed with the new orientation.

TIP: Since you can move the cursor outside the data window, reducing the data window size before adjusting the Z axis will give you greater range of motion while dragging the axis.

3. Click on **OK**. The data should be redisplayed as shown in Figure 81, with the hidden surface clearly visible.

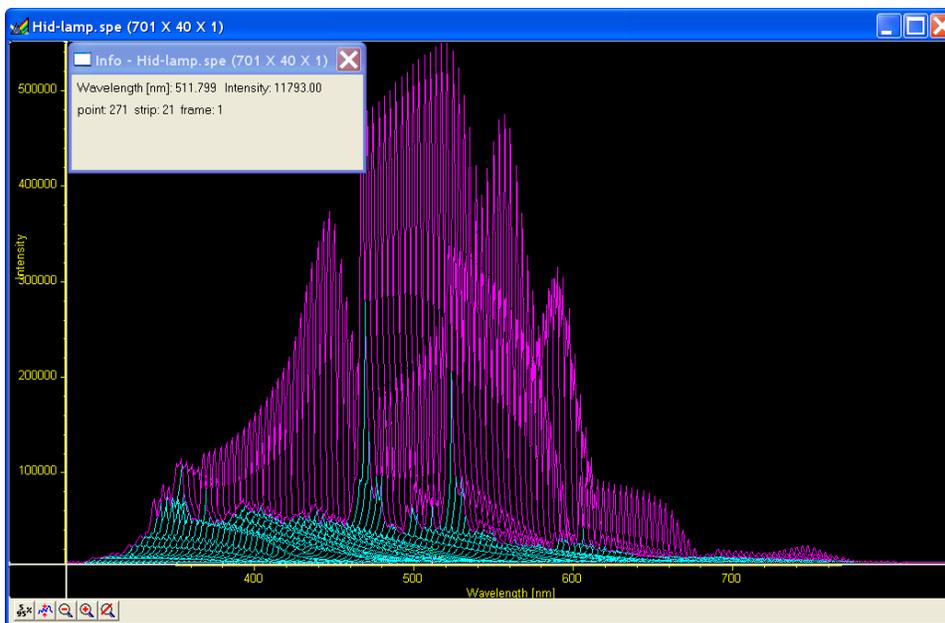


Figure 81. 3D Plot with Hidden Surfaces

4. If the hidden surfaces are not clearly delineated, you may need to change their color. Use the **Normal Hidden Surface** button on the **Display Layout|Color** tab to choose a different hidden-surface color. *Note that the **Marker Hidden Surface** button allows you to set the color of the marker curves in hidden surface regions.*

Data Window Context menu

For your convenience, the essential data window functions have been gathered into a single menu, illustrated in Figure 82. This menu, which is available whether the data is displayed as an image, graph, or 3D graph, can be accessed by right-clicking anywhere in the data display area. Brief descriptions of the provided functions follow.

Note: Right-clicking inside an ROI will open the ROI context menu.



Figure 82. Data Window Context menu

Labeling Graphs and Images

For graphs and images, the normal context menu (right-click) is as shown in Figure 83.

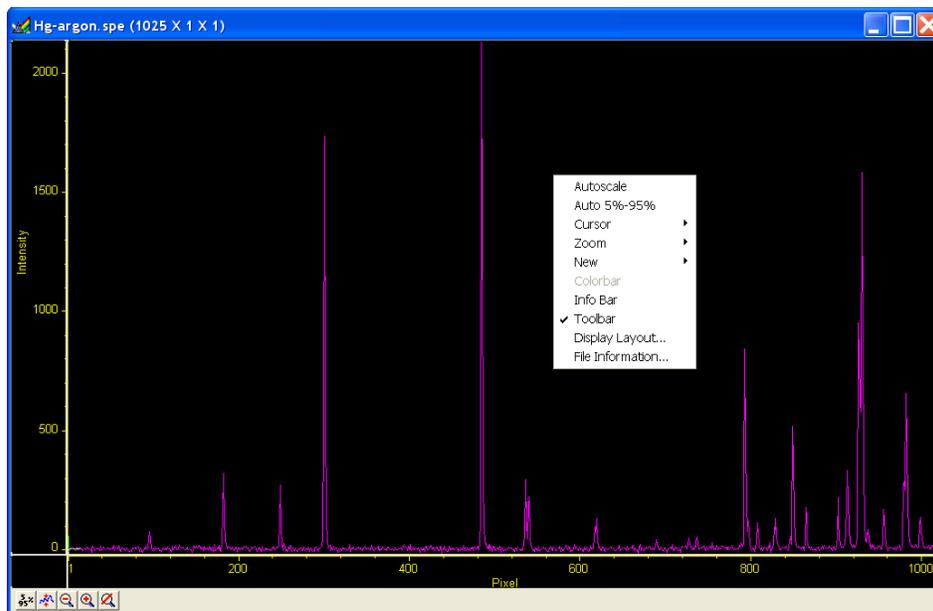


Figure 83. Normal Context menu

This menu was changed for ROIs. If there is an ROI, and if the mouse is right-clicked in the ROI, the context menu changes to that shown in Figure 84.

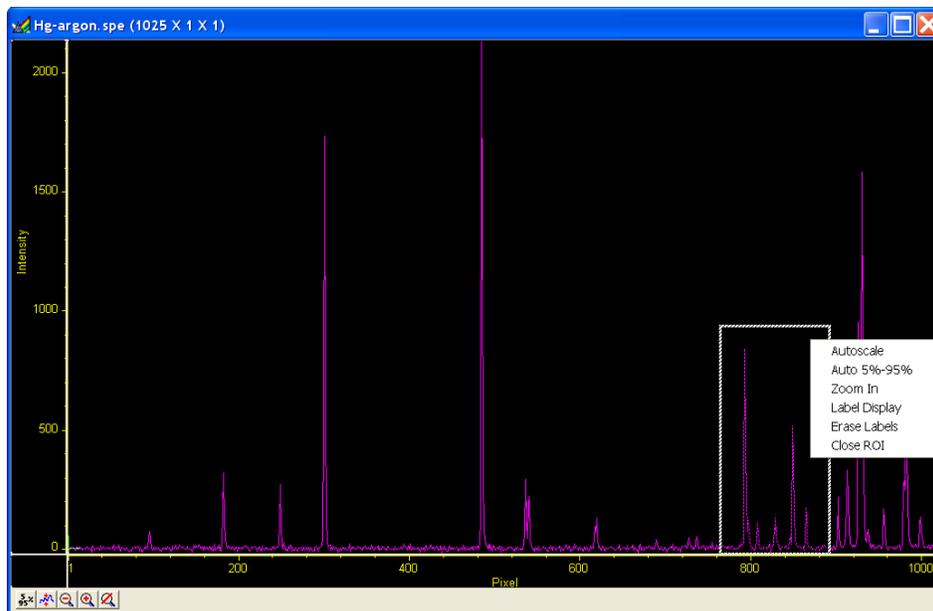


Figure 84. ROI Context menu

If the mouse is right-clicked outside the ROI, the normal menu (Figure 83) appears. The ROI context menu (Figure 84) contains the usual actions pertaining to the ROI (autoscaling on the region inside the ROI, and zooming in to the ROI region) plus three new actions:

Label Display: allows user labels to be placed on the display,

Erase Labels: removes ALL user labels from the display, and

Close ROI: erases the ROI with no other action (it doesn't move the cursor!).

The **Label Display** action brings up a dialog and opens an Edit box - *Inside the ROI!* as shown in Figure 85.

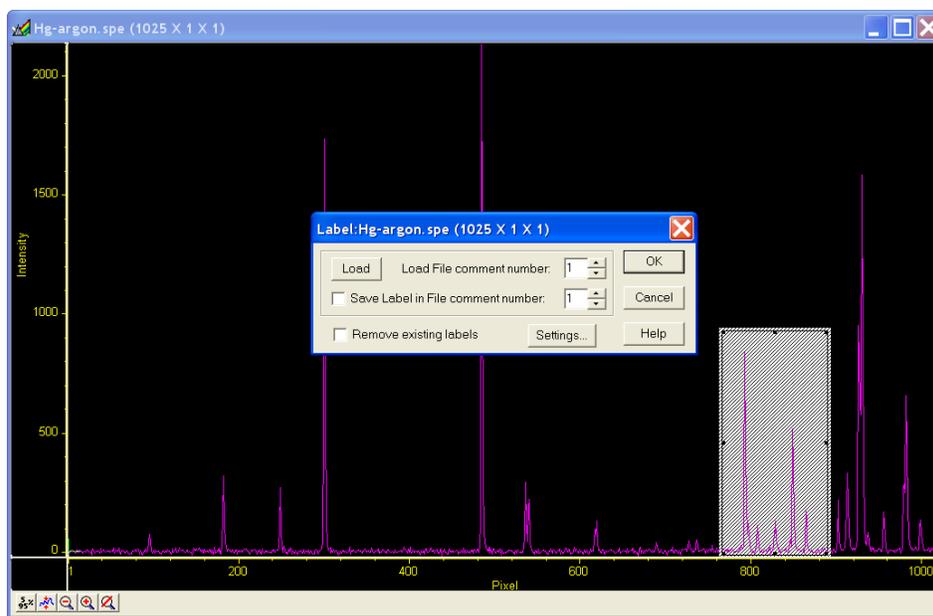


Figure 85. Label Display action

The dialog allows loading a previously saved label (from one on the SPE file's 5 comment fields); alternatively you can type the label into the edit box. The label can be saved into a file's comment field (when **OK** is clicked). The source comment field and the destination comment field can be different.

Clicking **Remove existing labels** will erase all previous labels from the display before adding the current label.

The **Settings** button brings up a dialog with options for the label itself (Figure 86). The **Display Label Settings** dialog allows you to change the color of the label text, to choose between an opaque (white) background and a transparent background, and choose whether the labels are to run vertically or horizontally. The opaque background works well with images, where the label can get lost inside the image.

The simplest way to label a display would be to place the ROI where the label should appear (the origin starts at the top left corner of the ROI box), right-click inside the ROI box, type the label text, and click **OK**.

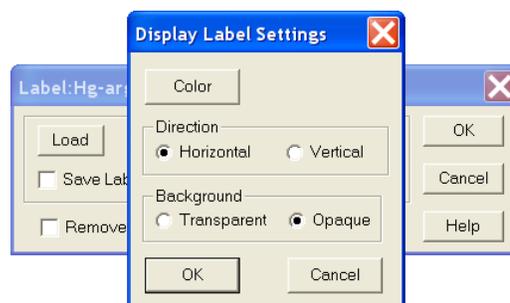


Figure 86. Label Options subdialog



Figure 87. Label text entry box

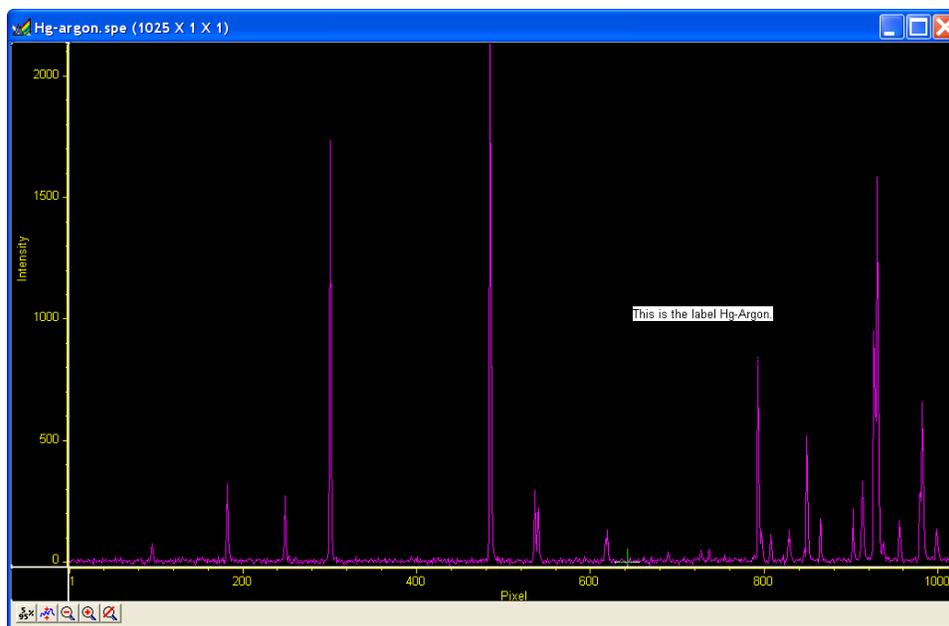


Figure 88. Data with Finished Label

Figure 87 shows a label as entered in the label text entry box. Figure 88 shows the same label as it will appear with the data after clicking on **OK**. Generally it is advisable to save the label in a comment field; otherwise, once the label is printed and the display is closed, the label will be lost. In fact, once the label is on the display, it cannot be edited. However, if it has been saved, it can be edited, as follows.

1. Erase labels.
2. Call up the display label menu.
3. Load the label.
4. Edit the label in the edit box.
5. Check the **Save Label** box to save the changes.
6. Click **OK** to display the corrected label.

Note: Labels are displayed with the same font as is used for the axes labels.

To reposition the label, move or resize the ROI (and Edit) box before you click on OK:

Moving the box, however, requires that you position the mouse very near the edge of the box, because further in, the Edit box will capture the mouse. Resizing is done in the usual way with the ROI box handles. If the ROI box is accidentally erased, just redraw a new one in the desired location, and the Edit box will reappear. The Edit box wraps lines at the end of the box, and the Label function will display the label as it appears in the box (Figure 89).

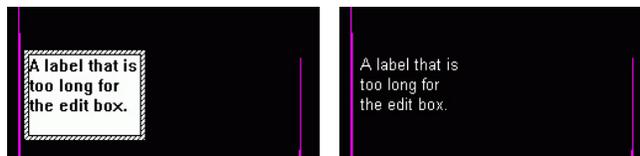


Figure 89. Edit box with line-wrapped label and finished label with same line wraps

To correct the line-wrapping:

Simply resize the ROI as shown in Figure 90.



Figure 90. ROI resized to correct Line-wrapping

To change the background or color:

The label must be erased and reprinted; it can only be altered inside the edit box.

To change the label font or font style:

Open the **Display Layout|Axes** tab, select **Fonts...** (this works even if axes are not displayed), and make your changes. Figure 91 shows that the font style has been changed to italic. Note that the axes labels are also italic.

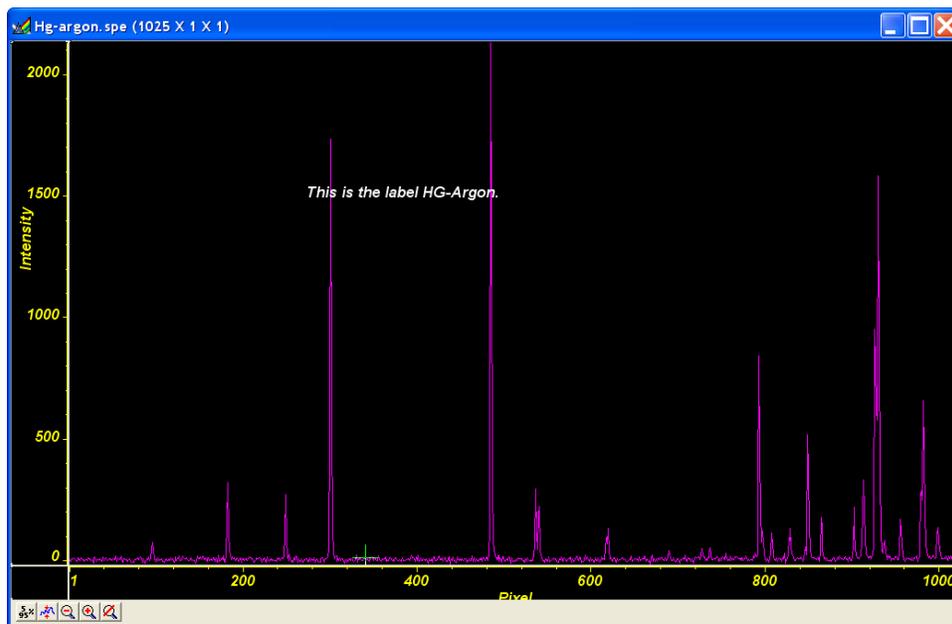


Figure 91. Display after changing Font Selection

Data Displayed as an Image

WinSpec/32 can display data as an image, as a two dimensional graph, or as a 3 D Graph (multiple strips from the same graph or the same strip from multiple frames). You can choose to allow the software control how the data will be displayed or make the selection yourself. To have WinSpec/32 control the data-display mode, simply check the **Auto Select** checkbox provided in the **File Open** dialog and also in the **Display Layout** dialog. The Auto Select algorithm makes the selection depending on the number of data strips as described on page 99.

Displaying circuit.spe

The image used in this exercise is circuit.spe, one of the images supplied with your WinSpec/32 software. Once you become comfortable working with this image, you should have little difficulty in working with images from actual measurement data.

- From the **File** menu, select **Open**. The **Open** dialog (Figure 92) allows you to select the image to be opened. The **Look-In** field provides a browser function so you can easily find the directory where the images. By default, the data directory is a subdirectory of the directory where WinSpec/32 was installed. Subdirectory names and the filenames of all files of the specified type (the WinSpec/32 data type is *.spe) in the current directory are listed in the box below the directory name. The WinSpec/32 data type is WinXData (*.spe).

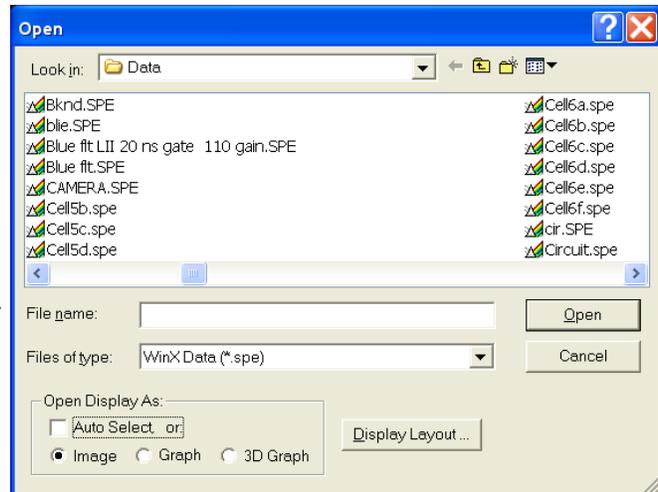


Figure 92. Open dialog

Note: The directory can be changed by changing the selection in the Look-In box. The next time the Open dialog is opened, the new folder name will appear in the box and its contents will be shown.

- If the **Auto Select** checkbox is checked, deselect it. Then select **Image**.
- From the data directory select the image file called CIRCUIT.SPE. Click on the **OK** button. A window of the appropriate dimensions should appear immediately. The image display (Figure 93) may take a few seconds, depending on the speed of the computer.

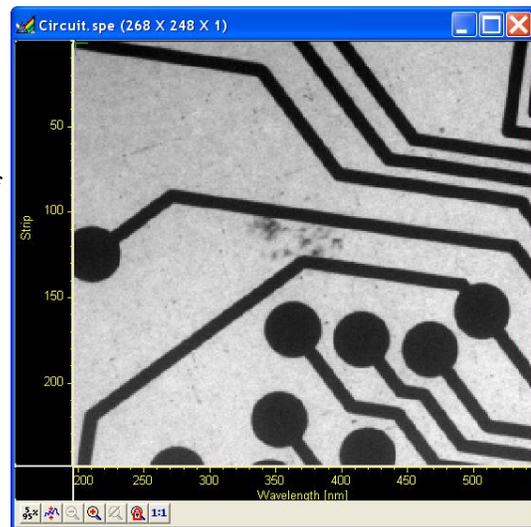


Figure 93. Circuit.spe Image

Changing the Brightness Range

- Click on  (5%-95%) (located beneath the displayed image as shown in Figure 93). You will observe a moderate brightening of the image as it autoscales on the central 90% of the image histogram. The brightest (pixels with high dark charge) and the darkest pixels (pixels with low response) are ignored.
- Click on the  (Autoscale) button, restoring the image to its initial appearance.

Brightness/Contrast Control

Select **Palette** on the **Display** menu. This will open the **Brightness/Contrast** dialog (Figure 94). Note that the window includes a plot of display brightness (Y axis) versus data value (X axis). As settings are changed, the displayed curve changes to reflect the change in the transfer function. (See the online Help for a detailed discussion of the palette and transfer function options.)

1. Change the brightness and contrast settings to obtain the most pleasing image display. Note that clicking on the small square above the Brightness scale and above the Contrast scale will restore the default brightness and contrast values (50).
2. Try different **Function** and **Palette Type** selections to see the effect on the displayed image. Note that the displayed curve will also change, reflecting the change in the brightness transfer function. Until you gain more operating experience, we suggest you leave the **Function Type** set to **Linear**, the **Palette** to **Grayscale**, and the **Brightness** and **Contrast** both to **50**.
3. Click on **OK** to close the dialog. Any setting changes will be applied.

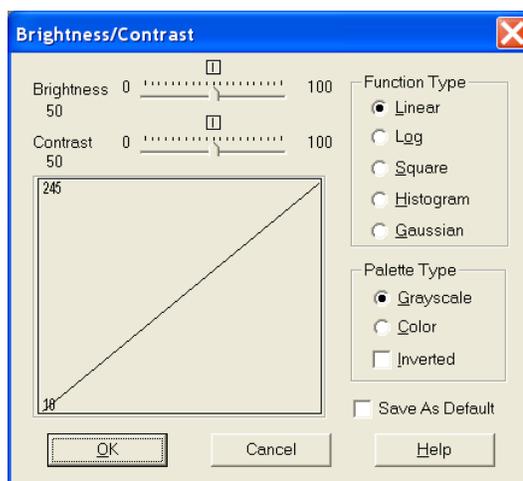


Figure 94. Brightness/Contrast dialog

Selecting a Region of Interest

1. Using the mouse, position the cursor at one corner of the region to be defined, depress the left mouse button, drag the cursor to the diagonally opposite corner, and release the mouse button. Refer to Figure 95.
2. Click on the  (Zoom In) button. The view will change so that only the selected region is displayed as shown in Figure 96.

Note: The **Display Layout Cursor** tab allows you to change how the ROI region is displayed.

3. Click on the  (Undo Zoom-In) Button. The original view will be restored.

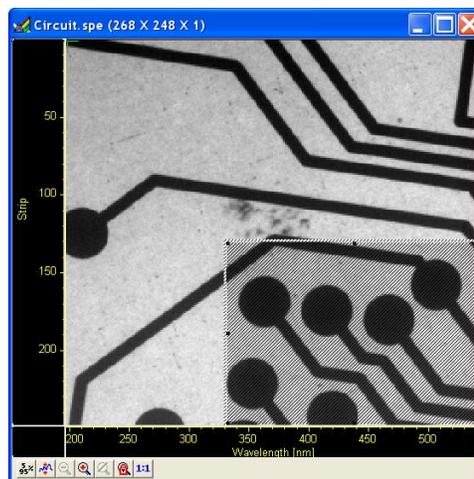


Figure 95. Circuit.spe with Region Selected for Viewing

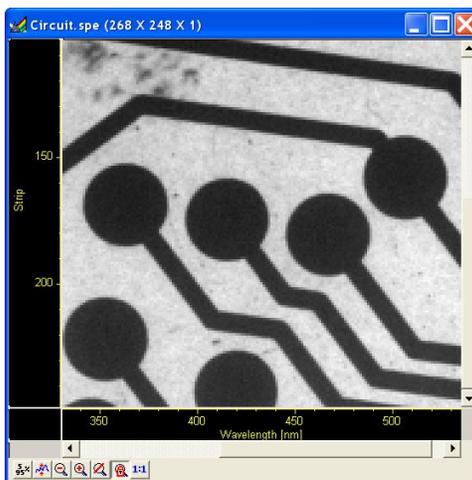


Figure 96. Circuit.spe Expanded to show Defined Region

Opening the Display Layout dialog

With the image still open, select **Layout** from the **Display** menu. The **Display Layout** dialog will open (Figure 97). Note that you can also access the **Display Layout** dialog by clicking on the **Display Layout** button of the **Open** dialog.

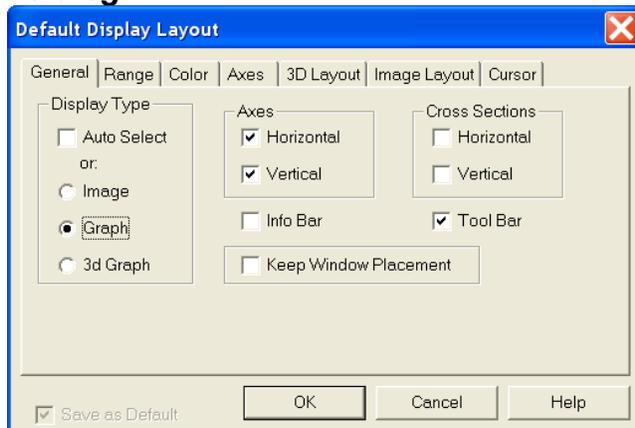


Figure 97. Display Layout dialog

Viewing Axes and Cross Sections

1. Still in the **Display Layout** dialog, select **Axes Horizontal, Axes Vertical, Cross Sections Horizontal and Cross Sections Vertical**. Refer to the online Help for additional information on **Axes and Cross Sections**.
2. Click on the **Range** tab (Figure 98). **Initial Autoscale** and **Set to Full Range** should be selected. The Frame number should be "1."

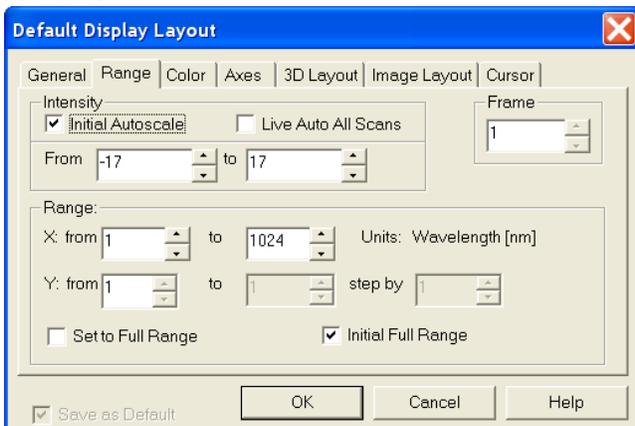


Figure 98. Display Layout/Range tab

- Click on the **OK** button to close the **Display Layout** dialog.
- Click on the  (**Autoscale**) button at the bottom of the image window. Then select the large cursor by clicking on **Cursor** on the **View** menu and then on **Large** as shown in Figure 99.
- The display should now appear as shown in Figure 100. The axes will be labeled in image pixels and strips with respect to the CCD chip used to acquire the image. The vertical image intensity profile at the cursor position will be displayed to the left and the horizontal image intensity profile at the bottom. The minimum and maximum values for each profile are indicated. Note that you can use the mouse and drag the axes and profile boundaries to change the size of the profile display regions. To change the cursor location, simply click the mouse at the new spot. The cross-sectional graphs will change to reflect the profiles at the new location.

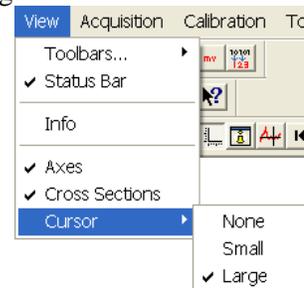


Figure 99. Selecting the Large Cursor



Figure 100. Circuit.spe with Axes and Cross-sections

Information box

On the **View** menu, select Info. The information box should appear as shown in Figure 101. The intensity in A/D counts is reported at the pixel and strip position corresponding to the cursor position. Also reported are the Frame number, Aspect ratio, and X and Y Zoom in effect. If a region is defined by dragging the mouse cursor, the region coordinates and diagonal length will also be reported.

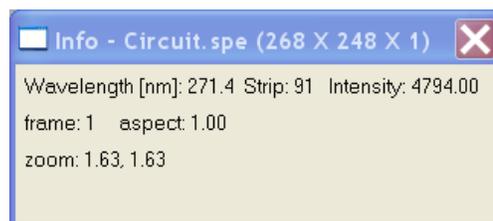


Figure 101. Information box

Autoranging the Intensity in a ROI

1. Drag the mouse cursor to define a rectangular region of interest on the displayed image.
2. Click on  (Autoscale). The display will autorange to the intensity range in the defined region. The effect will be an increase in contrast in the observed image. Throughout the image, pixels darker or lighter than those in the defined region will be displayed as black or white.
3. Click the mouse anywhere in the displayed image and click  again to restore the original image view.

Relabeling the Axes

1. Open the **Display Layout|Axes** tab (Figure 102). Note that the checkboxes for **Horizontal Axis**, **Vertical Axis**, and the **Label** are all checked (If unchecked, the corresponding axis or label would not be displayed.)
2. Change the axis label for both axes. Then click on **OK**. The displayed axes will no longer be named **Pixel** and **Strip**, but rather the new labels.
3. Try selecting different fonts to see the effect. Only True-type or Type 1 (Postscript) fonts will work correctly. Click on the **Fonts** button to open the **Fonts** dialog, change the various font choices, and click on **OK** twice. To return to the original font choices, select 10 pt Arial Regular.
4. Reopen the **Axes** tab and change the axis labels back to their original designations (**Pixel** for horizontal; **Strip** for vertical).



Figure 102. Display Layout/Axes tab

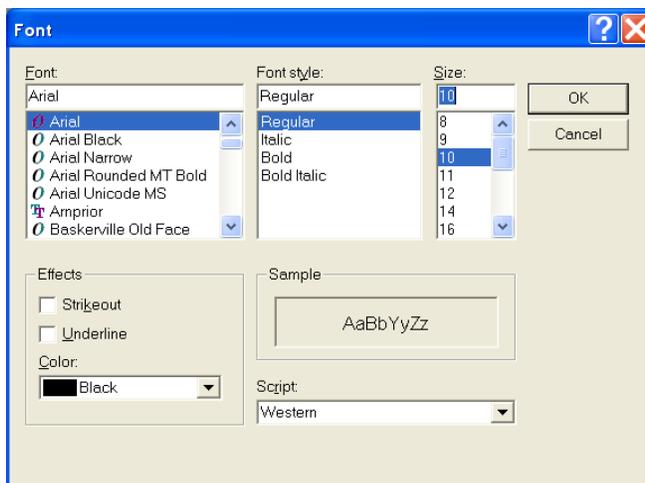


Figure 103. Fonts dialog

Changing the Color of the Axes and Labels

1. Open the **Color** tab. Note that there is a button for each item to which a color can be assigned and that the current color for each item is indicated in a color swatch to the right of the button. The default for the **Axis** is yellow.
2. Click on **Axis**. The color palette will open as shown in Figure 104.

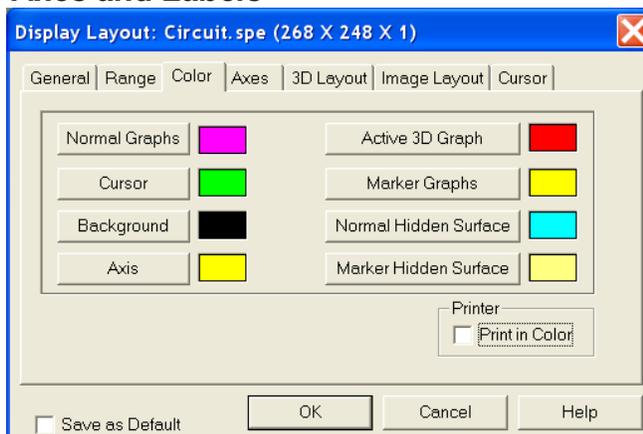


Figure 104. Display Layout/Color tab

3. Select a different color by clicking on the swatch of the desired color. Then click on **OK** to close the **Color** dialog and on **OK** again to close the **Display Layout** dialog. The axes and colors will now appear with the new color.
4. Repeating the process, open the **Color** dialog again and restore the default color. Again, click on **OK** to close the **Color** dialog and on **OK** again to close the **Display Layout** dialog. The axes and labels will now be displayed in the original color.



Figure 105. Display Layout/Color dialog

Specifying a New ROI and Intensity Range

1. Open the **Display Layout|Range** tab. Note that you can change the displayed intensity range as well as the X-Y range.
2. Try entering more restricted ranges and note how the displayed image changes. Changing the X-Y range by entering new values is functionally equivalent to changing the displayed area by dragging the cursor as previously described. Selecting a narrower intensity range results in pixels brighter and darker than the range limits being displayed as white and black respectively. The effect is to increase the contrast of the image. Each time a change is made, click on **OK** to close the **Display Layout** dialog and observe the effect of the change.
3. On completing your display experiments, restore the defaults (**Autoscale Intensity** and **Full Range** checked), close the **Display Layout** dialog, and close the data file.

Displaying a Z-Slice

A z-slice cuts across multiple frames at the cursor location and generates a new data file. The number of points in the z-slice equals the number of frames in the source file. The generated file name is the source file name appended with “_ZVU”. The X-axis is in time units and the Y-axis is in intensity. Figure 106 shows an .SPE file containing five frames and the z-slice .SPE file generated for the cursor location.

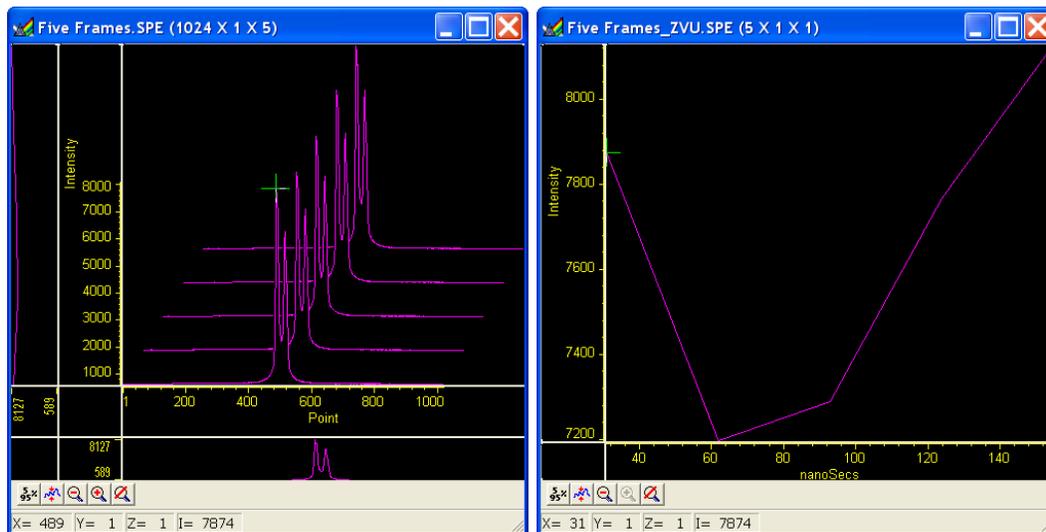


Figure 106. Multi-frame Data and a Z-Slice of that Data

1. Verify that the **Custom Toolbar** is visible and that the **Z-slice**  button is in that toolbar. If the toolbar and/or the button are not present, refer to “**Chapter 19 Custom Toolbar Settings,**” starting on page 209, for information on how to display the toolbar and add an available button.
2. Open a data file with multiple frames.
3. Position the cursor in the data window.
4. Click on the **Z-slice**  button to generate the z-slice data file.

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Part 2

Advanced Topics

Chapter 9, On-Line Data Acquisition Processes.....	125
Chapter 10, Cleaning	135
Chapter 11, ROI Definition & Binning.....	139
Chapter 12, Correction Techniques	147
Chapter 13, Spectra Math	153
Chapter 14, Gluing Spectra	159
Chapter 15, Post-Acquisition Mask Processes	165
Chapter 16, Additional Post-Acquisition Processes	177
Chapter 17, Printing	183
Chapter 18, Pulser Operation	187
Chapter 19, Custom Toolbar Settings	209
Chapter 20, Software Options	213

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Chapter 9

On-Line Data Acquisition Processes

Introduction

The **Processes** tab on the **Experiment Setup** dialog allows you to set up and activate up to four different processes for automatic processing of incoming data. It is most likely that you will only activate one (such as on-line thresholding) or two (such as on-line thresholding and ASCII output file) at a time. Process activation occurs when you select a checkbox. After you click in a checkbox, you can then click on the **Setup...** button and begin entering or reviewing the parameters for the process. After you have clicked on the **OK** button to activate one or more processes, the active processes will be applied to data being acquired.

Note: The on-line thresholding and absorbance processes change the raw data. If you want to retain raw data, you may want to use a post-acquisition process instead.

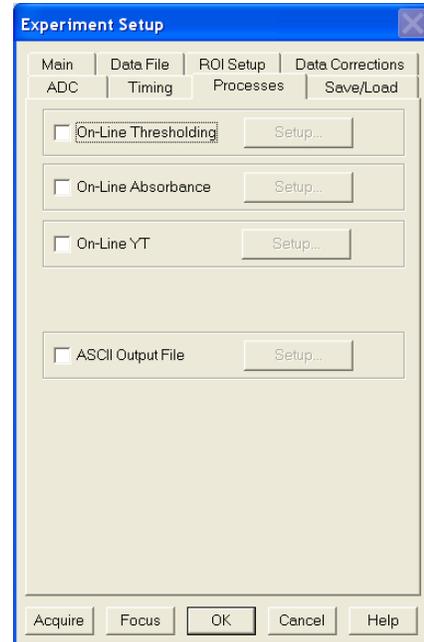


Figure 107. Experiment Setup/Processes tab

On-Line Thresholding

Description

On-line thresholding allows a threshold test to be performed on data as it is acquired. The threshold test is performed after background subtraction and flatfield correction but before software accumulation. Data that falls within the threshold range returns a 1, data that falls below the minimum threshold or above the maximum returns a 0. In an experiment containing n accumulations, only one data set is stored, but with the data added from each accumulation. Thus, if a given bit contained data within the threshold range on 7 of 10 iterations, the value of the bit in the acquired data set would be 7. The minimum and maximum levels can be independently set and checkboxes allow the minimum and maximum threshold functions to be independently toggled on or off.

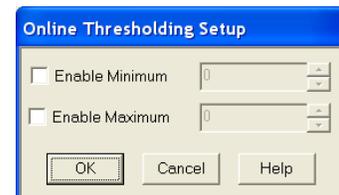


Figure 108. Online Thresholding Setup dialog

Parameters

Enable Minimum: The check box allows the **Minimum** threshold function to be switched ON (checked) or OFF (unchecked). When the function is ON, you can enter the minimum threshold level. This can be any positive or negative value in the range of possible intensities provided the setting is lower than the **Maximum** setting. This setting will be retained when the function is switched OFF.

When the Minimum threshold is ON and data is being acquired, any intensity value below the set value will return a **0**. Intensities higher than the Minimum setting will return a **1**, unless they also exceed the Maximum setting, in which case they will return a **0**. When the Minimum threshold is OFF, all intensities below the **Maximum** will return a **1**; intensities that exceed **Maximum** return **0**.

Enable Maximum: The check box allows the **Maximum** threshold function to be switched ON (checked) or OFF (unchecked). When the function is ON, you can enter the maximum threshold level. This can be any positive or negative value in the range of possible intensities provided the setting is higher than the **Minimum** setting. This setting will be retained when the function is switched OFF.

When the Maximum threshold is ON and data is being acquired, any intensity value above the set value will return a **0**. When it is OFF, all intensities higher than the **Minimum** will return a **1**.

Note: Background subtraction can force negative values.

Procedure:

1. Select **On-Line Thresholding** on the **Experiment Setup|Processes** tab. The **Online Thresholding Setup** dialog will open.
2. Set the **Minimum** and **Maximum** threshold enable status and set the threshold values.
3. Click on **OK** to save your entries and close the dialog. Then click on **Acquire** or **Focus** to start data acquisition.

On-Line Absorbance

Description

Absorbance is defined as the Log (base 10) IR/I , where IR is the reference spectrum and I is the sample spectrum. Absorbance is also defined as the log of the inverse of the transmission. Thus increasing absorbance means the transmission is decreasing and an absorbance of zero means that $IR = I$.

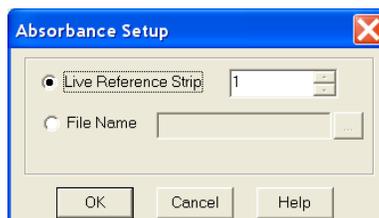


Figure 109. Absorbance Setup dialog

The **Absorbance Setup** dialog allows either of two absorbance modes to be selected, depending on the reference used. The reference signal I_0 can be either live (**Live Reference Strip** selected), or taken from a file (**File Name** selected and entered). If

live, then the experiment generally will have 2 strips, one reference and one sample (there can be more than 2, up to n, with 1 reference and n-1 samples). Any strip in the ROI can be selected. If taken from a file, then the file must have the same dimension as the live data, and in this case, every strip in the file will be the reference for the corresponding strip in the live data. The button at the right of the file name entry box opens a browser to facilitate locating the file.

The largest signal for absorbance (live) is when the reference is full scale and the sample is 1 and you are using an 18-bit A/D. With this configuration the largest signal for absorbance (live) is the $\text{Log}_{10}(262,144/1) = 5.42$. The software therefore limits the signal to 5.5. If the sample goes to zero or negative (background subtract), 5.5 is used as the answer.

In the live mode, because IR equals I for the reference strip, this strip will always have an absorbance of zero.

Procedure:

1. Select **On-Line Absorbance** on the **Experiment Setup|Processes** tab. The **Absorbance Setup** dialog will open.
2. Set the **Minimum** and **Maximum** threshold enable status and set the threshold values.
3. Click on **OK** to save your entries and close the dialog. Then click on **Acquire** or **Focus** to initiate data acquisition.

On-Line YT

Description

Y:T Analysis allows you to easily monitor and study the way *spectral* data changes as a function of time. This is particularly useful in characterizing time-dependent processes. Y:T Analysis provides for defining *areas* on the data, where each area is a region bounded by a starting and ending wavelength and containing a certain number of pixels whose wavelength values lie within the region. The value of an area is the sum of the intensities of the pixels in the area.

If a process study produces spectral lines that change with time, it may be useful to define a separate area for each line of interest, where each line is precisely spanned by its area. The value of each area can be the sum of the total intensities defined with respect to the baseline, or the values can be *baseline-corrected*, in which case the value of each area is the sum of the intensities with respect to an imaginary line joining the first and last pixels of the area. *This latter method is more accurate with a sloping baseline.*

After areas have been defined, they can then be mathematically operated on as specified in user-entered *equations*. These equations allow you to can add, subtract, multiply, divide or otherwise manipulate up to eight areas. You can also include constants or *even other equations*. The Y:T analysis modes provided give you control over when the equation calculations will be performed, how many will be performed, and on which acquired data they will be performed.

Each time equation calculations are performed, one Y:T analysis value is produced for each equation. For example, in a one-hour experiment with one Y:T equation and a Y:T sample time of one minute, at the end of the hour a Y:T analysis curve sixty points in length would have been taken and stored. If two equations had been defined for the same experiment, at the end of the hour there would be two Y:T curves, each sixty points in

length. An additional Y:T curve for the time will always be provided as well. These Y:T curves are stored and can be displayed, printed, or processed the same as any other data.

Note: With on-line YT, the raw data are preserved. Two data sets are acquired and displayed: the raw data and the YT data associated with it.

YT Area and Equation Setup Procedure

Before activating on-line YT analysis, you must define the area(s) to be monitored and enter the equation(s) to be used to perform the Y:T analysis of spectral data as it is acquired. For any given analysis, you can use or delete previously stored equations or define new ones. Y:T analysis will not take place unless the **On-Line YT** check box on the **Experiment Setup|Processes** tab is checked.

The following procedure assumes that there are no stored areas and equations.

1. Select **YT Setup** from the **Acquisition** menu.
2. Click on **New Area** and begin entering the range and baseline correction choice for the area. You can enter up to eight areas.
3. When you enter an area, you can either

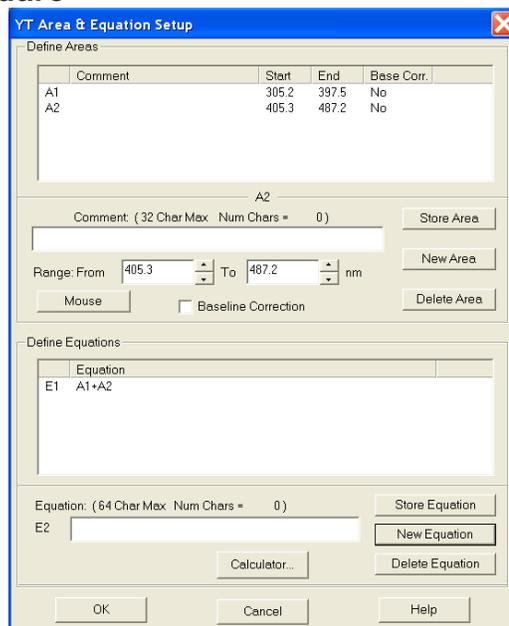


Figure 110. YT Area & Equation Setup dialog

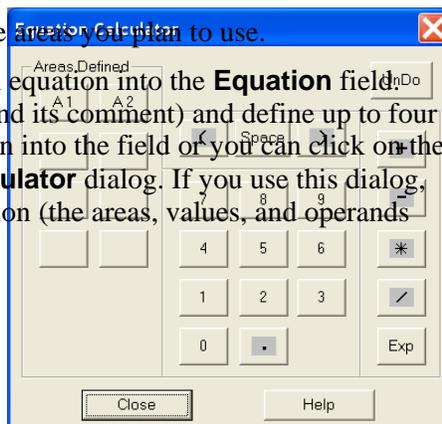
- type in the **Range X-axis** start and end points or use the mouse to select the area on an acquired spectrum and click on the **Mouse** button to make the entries. The units are those specified in the spectrograph **Calibration Usage** dialog. When using the mouse to enter the range, it is generally helpful to have the **Info** box displayed at the same time so you can see the precise values of the start and end points.

Note: The area range is always stored internally in wavelength units. This assures that, if the area is used for Y:T analysis on ROIs spanning different pixel range, the starting and ending wavelengths for the area range will remain correct.

4. You can also enter a comment of up to 32 characters into the **Comment** field and select/unselect baseline correction.
5. When you have finished describing the area, click on the **Store Area** button. The area will be added to the **Area Listing** box at the top. Areas in the box are available for entering into equations.

Note: An asterisk appearing before an area designator (e.g., *A2) indicates that the area range is outside the wavelength calibrated range of the detector.

6. Repeat Steps 2 and 5 until you have entered the areas you plan to use.
7. Click on **New Equation** and begin entering an equation into the **Equation** field. You can enter up to 64 characters per equation (and its comment) and define up to four equations. You can either type the new equation into the field or you can click on the **Calculator** button to open the **Equation Calculator** dialog. If you use this dialog, click on the appropriate buttons for your equation (the areas, values, and operands



will appear in the **Equation** field as you click on the buttons). Close the dialog when you have finished.

Note: To add a comment to an equation, follow the equation with a **:** and the comment text. The colon indicates that what follows is not part of the equation. For example, in the equation **A1+A4:This is a test**, “This is a test” is the comment.

8. Click on **Store Equation** to save the equation. The equation will be added to the **Equation Listing** box. Equations in the box are available for YT Setup.

Note: An asterisk appearing before an equation designator (e.g., *E3) indicates that equation contains areas that lie outside the calibration range of the detector.

Figure 111. Equation Calculator dialog

9. Repeat Steps 7 and 8 until you have finished entering your equations.
10. When you have finished with area and equation entry and storage, click on **OK** to close the **YT Area & Equation Setup** dialog.
11. You are now ready to begin entering acquisition parameters on the **YT Setup** dialog. See “*YT Analysis*” on page 130 for more information.

Baseline Correction

The value of each area is the sum of the intensities over the area’s specified range. The value of an area can be calculated using the intensity heights with respect to the baseline or using the intensity heights with respect to a straight line segment drawn between the start and end points of the specified range. The latter results in a corrected area that is the part of the total area above this line. **Baseline Correction** gives more accurate results on sloping baselines.

Baseline correction is calculated by taking the uncorrected value of the area and subtracting the area below the baseline. This calculation may be expressed as:

$$\text{Correction}_{\text{Base}} = \text{Area}_U - \frac{C_{\text{First}} + C_{\text{Last}}}{2} \times \text{Pixels}$$

Where:

Area_U is the uncorrected value of the area.

C_{First} is the first channel of the specified range.

C_{Last} is the last channel of the specified range.

Pixels is the number of pixels in the area.

Changing/Deleting Areas and Equations

The parameters for an area or an equation can be changed by clicking on that area’s or equation’s designator (at the far left of the item – A1 or E2, for example) in the appropriate listing box and then keying new values for the parameter to be changed. The changes do not take effect until the appropriate **Store** button is pressed.

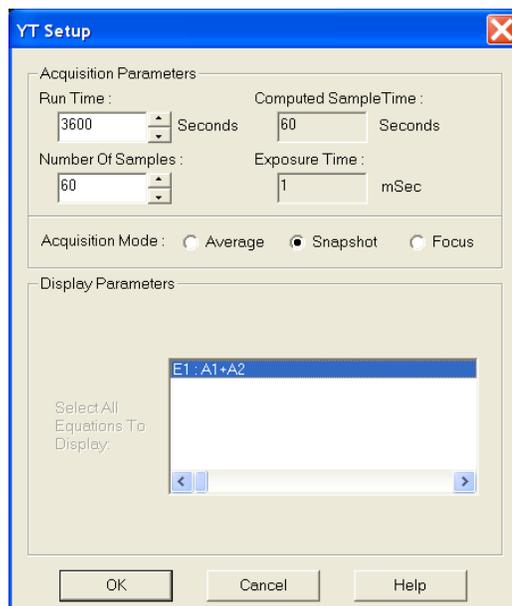
Areas and equations that have been stored can be deleted. To delete an area or an equation, simply click on the area’s or equation’s designator (A1 or E2, for example) in the appropriate listing box and press the appropriate **Delete** button.

YT Analysis Acquisition Modes

The **YT Setup** dialog settings determine how the Y:T analysis will be performed using the areas and equations defined via the **YT Areas and Equations Setup** dialog. YT Setup involves choosing and **Acquisition Mode** and then entering values for one or more **Acquisition Parameters**.

Note: Generally data acquisition does not occur at exactly even times. With a 1 msec exposure time, there is still the readout time for each data set to consider. In reality, the Y:T point will be calculated from the first data set processed on or after the Y:T sample time expires. The actual time the Y:T sample is taken is read using the system clock relative to the start of data acquisition, and the *times are stored with*

the Y:T data as the last Y:T curve. Since data acquisition is done using DMA under the timing of the detector controller, the timing coming into the DMA buffer is very precise. However, Y:T time is taken as the data is transferred from the DMA buffer and processed for background subtraction and flat field. This is under the program control and may be less precise; for longer sample times, this will probably not be noticeable.



Focus

Only the Y:T **Number of Samples** are set in this mode (**Exposure Time** is simply that set on the **Experiment Setup|Main** tab). An advantage of **Focus** mode is that no data is missed. A disadvantage is that the amount of Y:T data stored can quickly become quite large and much of it might be of limited value when studying a process that is changing slowly. **Focus** mode can be quite useful for making an initial evaluation of a process. Inspection of the **Focus** mode results might then suggest more productive Y:T analyses that could then be made using either the **Snapshot** mode or the **Average** mode. How **Focus** mode works is described in the following paragraph.

Assuming you had established two areas (A1 and A2) and one equation ($E1 = A1+A2$), A1 would be the sum of the intensities over one specified range of data points and A2 the sum of the intensities over a second specified range of data points on the spectrum. Adding the two together yields one value for E1. Next, let us assume that you have entered a **Number of Samples** value of 1,000. On starting data acquisition, for each and every acquired data set, the Equation E1 calculation would be performed and the resulting Y:T value stored. This process would continue until the specified Y:T **Number of Samples** have been taken or until data acquisition stops or is stopped. *Once the specified number of Y:T points have been calculated and stored, data sets will continue to be taken according to the **Experiment Setup** parameters but no more YT calculations will be performed.* There would be 1,000 points in the Y:T curve, each point equal to $A1+A2$. The data set(s) and the Y:T curve would be displayed in separate windows. If multiple equations (up to four) had been defined, they would be computed in order and there would be a separate Y:T curve for each. Selecting **3D Graph** on the **Display Layout|Main** tab and deselecting **Remove Hidden Lines** on the **Display Layout|3D Layout** tab would allow all of the Y:T curves and the time line curve to be viewed

simultaneously. If the selection is **Graph**, only one curve would be visible. The keyboard cursor up/down arrow keys can be used to select the curve to be viewed.

Note: If there are four equations, there will be five curves. The fifth curve is a time line. The time at a point is reported as the **I** value in the **Info** box.

Snapshot

In this mode, you set the Y:T **Run Time** and the Y:T **Number of Samples** that will be taken. **Snapshot** mode allows convenient Y:T analyses of long processes to be easily performed. In **Snapshot** mode, data may be taken at short intervals for a long period of time, but a Y:T analysis is only done on the *most recent data set at specified intervals*. *Most of the data sets taken over the course of the experiment are skipped*. For Y:T analysis purposes, you only have access to the first strip of data if acquiring multiple strips.

To better understand this process, assume an experiment designed to characterize a process that will take about an hour. Assume a 1 msec Exposure Time and a repetition rate that is high relative to the Y:T **Sample Time**. Since the experiment is expected to last an hour, a reasonable Y:T **Run Time** setting might be 3600 seconds. Further suppose that you wanted each Y:T curve to be 60 points long, accomplished by setting the Y:T **Number of Samples** to 60. The **Computed Sample Time** would then be 60 seconds. In other words, a Y:T calculation would be performed on the most recent single data set at the end of each minute, regardless of how many data sets were acquired during that minute.

Note: The **Computed Sample Time** (interval between Y:T calculations) indication does not update instantly when the **Run Time** and **Number of Samples** are entered. To force the update, modify **Run Time**, and then either press the [Tab] key on your keyboard or click on another control.

On starting data acquisition, after one minute, the first Y:T analysis would be made, with one Y:T value computed for each equation defined. The timer would reset to zero and begin counting the second minute. At the end of that minute the second Y:T value would be computed for each equation defined. This process would continue for 3600 seconds (one hour). At the end of that time n Y:T curves, n being the number of equations, each 60 points in length, will have been acquired and stored. These could be displayed in the same manner as for the Y:T **Focus** mode. As was the case for the **Focus** mode, data acquisition will continue until it stops or is stopped.

Average

In this mode, as in the **Snapshot** mode, you set both the **Y:T Run Time** and the **Y:T Number of Samples** that will be taken. Also, as in **Snapshot** mode, **Average** mode allows convenient Y:T analyses of long processes to be easily performed. Unlike **Snapshot** mode, however, *no data is skipped* even though only the specified number of Y:T calculations are performed at the computed intervals. *All* of the acquired data is stored in a buffer space over each interval. When the Y:T calculation is performed, it is done on the *average* of all the data acquired over the preceding interval. For example, if doing a one hour run with once a minute Y:T calculations, the data buffer would store all of the data acquired for one minute. Then the Y:T computations would be done on the average of the stored data to develop one Y:T point for each equation. After that the buffer would be cleared and data storage for the next interval would begin anew. As with the **Focus** and **Snapshot** modes, for Y:T analysis purposes, if there is more than one data strip, only the first data strip is available for Y:T analysis purposes.

At the end of our hypothetical one hour run, n Y:T curves, n being the number of equations, each 60 points in length, will have been acquired and stored. These could be displayed in the same manner as for the Y:T **Focus** and **Snapshot** modes, previously described. As is the case for the **Focus** and **Snapshot** modes, data acquisition will continue until it stops or is stopped.

YT Analysis Setup Procedure

This procedure assumes that you have already defined the areas and equations to be used for the analysis. See “**YT Area and Equation Setup**” on page 128 for the area and equation setup procedure.

1. Select **Experiment Setup** from the **Acquisition** menu.
2. Establish the **Experiment Setup** parameters (**Exposure Time** and **Number of Spectra**, for example) for acquiring the data on which the Y:T analysis is to be performed.
3. Click on the **Processes** tab and click in the **On-Line YT** check box to turn on Y:T analysis and activate the **Setup...** button. Y:T analysis will take place during any data acquisition run initiated while this box remains checked.
4. Click on the **Setup...** button to open the **Y:T Setup** dialog.

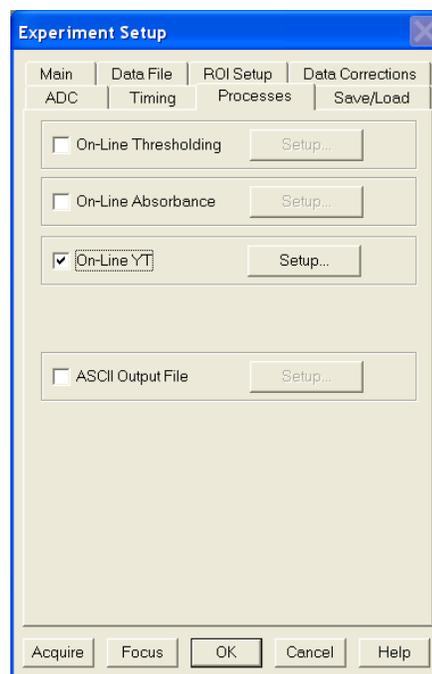


Figure 112. Experiment Setup|Process tab

5. Select the **Y:T Acquisition** mode. (**Average**, **Snapshot** or **Focus**).

Note: **Exposure Time** is set on the **Experiment Setup|Main** tab. **Computed Sample Time** is calculated based on the other parameter values.

Average: In this mode, as in the Snapshot mode, you set the Y:T **Run Time** and the Y:T **Number of Samples** that will be taken. Also, as in the Snapshot mode, the Average mode allows convenient Y:T analyses of long processes to be easily performed. Unlike the Snapshot mode, however, *no data is skipped*, even though only the specified number of Y:T calculations are performed at the computed intervals.

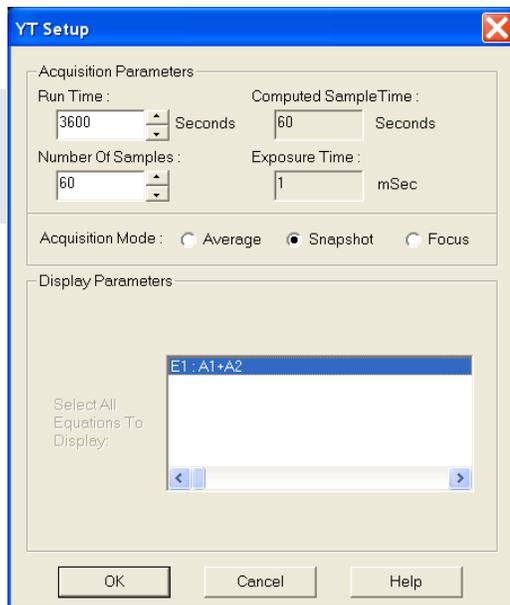


Figure 113. Y:T Setup dialog

Snapshot: In this mode, you set the Y:T **Run Time** and the Y:T **Number of Samples** that will be taken. The Snapshot mode allows convenient Y:T analyses of long processes to be easily performed. Although data might be taken at short intervals for a long period of time, a Y:T analysis is only done on the most recent data set at specified intervals. Most of the data sets taken over the course of the experiment are skipped. For Y:T analysis purposes, you only have access to the first strip of data if acquiring multiple strips

Focus: In this mode you set the Y:T **Number Of Samples** only. **Run Time** and **Computed Sample Time** are not displayed. **Focus** mode can be quite useful for making an initial evaluation of a process and the results may suggest more productive Y:T analyses that could then be made using either the **Snapshot** mode or the **Average** mode. An advantage of **Focus** mode is that no data is missed. A disadvantage is that the amount of Y:T data stored can quickly become quite large, and much of it might be of limited value when studying a process that is changing slowly.

6. Enter the **Y:T Analysis** parameter values appropriate to the acquisition mode.
7. Click on **OK** to save your entries and close the **YT Setup** dialog.
8. Click on **Acquire** or **Focus** to initiate data acquisition. As data are acquired, Y:T points will be computed and stored. If multiple equations were defined (up to four are possible), they would be computed in order and there would be a separate Y:T curve for each. Selecting **3D Graph** on the **Display Layout|Main** tab and deselecting **Remove Hidden Lines** on the **Display Layout|3D Layout** tab would allow all of the Y:T curves and the time line curve to be viewed simultaneously. If the selection is **Graph**, only one curve would be visible. The keyboard cursor up/down arrow keys can be used to select the curve to be viewed and the **Info** box shows which strip is being displayed.

ASCII Output File

Description

The ASCII Output process allows you to select and set parameters for saving the data to an ASCII file. The **ASCII Output Setup** dialog (Figure 114) allows you to specify the delimiter and the line termination character to be used when the data is stored in ASCII format. The choice of delimiter and termination character depends on the requirements of the program into which you will be importing the data. When storing the file, WinSpec uses the filename and location parameters entered on the **Experiment Setup|Data File** tab.

Procedure

1. Select **Experiment Setup** from the **Acquisition** menu.
2. Click on the **Experiment Setup|Data File** tab.
3. Enter the filename to be used when WinSpec saves the .TXT file. Click on the browse button to the right of the **Name** field and select the directory where the file should be saved. You can also select other file saving parameters such as auto-increment, file overwrite, or file append.
4. Click on the **Experiment Setup|Processes** tab and select **ASCII Output File**.
5. Click on the **Setup** button to open the **ASCII Output Setup** dialog.
6. Set the **Delimiter** and **Line Termination Characters** and click on **OK** to save your entries and close the dialog.
7. Click on **Acquire** or **Focus** to initiate data acquisition.
8. At the end of the acquisition, the .TXT file will be saved automatically. Depending on your data file entries (Steps 2 and 3), the acquired data may also be saved automatically as an SPE file or you can save it manually.

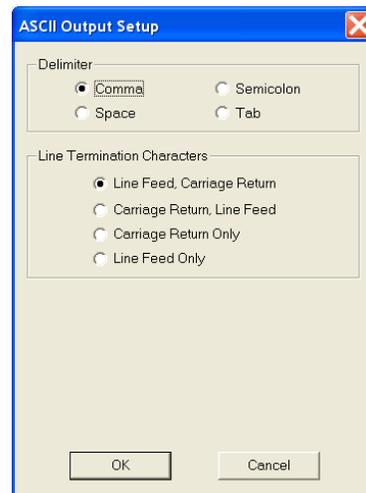


Figure 114. ASCII Output Setup dialog

Cleaning

Introduction

An acquisition is made up of an exposure period and a readout period. For the rest of the time, the camera is waiting to be told to acquire spectra or images. During this waiting period, charge generated from different sources builds up on the array unless some kind of cleaning process is ongoing. Cleaning minimizes the impact of the unwanted signal (noise) by row shifting the accumulated charge to the output register and then discarding it.

Depending on your system, WinSpec/32 will provide you with up to five cleaning features. The most common cleaning feature is Clean Cycles, which occur until **Acquire** is selected and may continue up to the entered number of cleans before exposure begins. If External Synchronization is being used to control exposure, a feature called continuous cleans may be used in addition to the standard clean cycles. Where the detector and controller support it, a specialized version of continuous cleans Continuous Cleans Instruction can be used with the External Sync timing mode. The readout of ROI information is enhanced by the Vertical Skips feature. With Version 5 of the ST-133 Controller, continuous cleans for Kinetics is also supported. All of these cleaning features and their interrelationships are described in the sections that follow.

Clean Cycles

The basic cleaning function is implemented by clean cycles. These cycles start when you turn the controller on and a clean pattern is programmed into the controller. Their purpose is to remove charge that accumulates on the array while the camera not acquiring data (i.e., exposing and reading out the array). The timing diagram below is for an experiment set up to acquire three (3) spectra in Freerun timing mode with normal shutter operation selected. In this diagram clean cycles occur before the first exposure and after the last readout period.

Note: The start of the exposure is signaled by **NOT SCAN** going high but will not occur until the current clean cycle has finished.

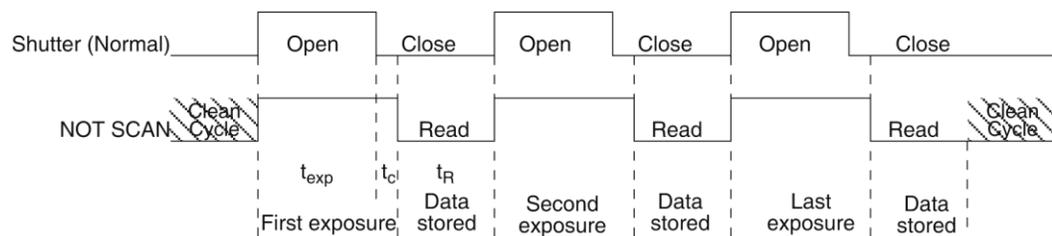


Figure 115. Clean Cycles in Freerun Operation

The configuration of clean cycles is performed on the **Hardware Setup|Cleans/Skips** tab (Figure 116). When you set up the detector for the first time, default values are automatically inserted into these fields. These will give the best results for most applications. Even so it is a good idea to know what these entries mean with regard to cleaning.

Let's begin with **Number of Strips per Clean**. This parameter sets the number of rows that will be shifted and discarded per clean cycle. While a large number such as the number of rows in the array may result in the best cleaning of the array, the tradeoff is that there may be a significant delay between the receipt of a start exposure signal (**NOT SCAN** signal at the **SCAN** BNC goes high) and the beginning of the actual exposure. This delay occurs because the current clean cycle must be completed before a start exposure signal received during the cycle will be implemented. Typically, the default setting is much smaller and in time critical experiments, the setting should be 1 or 2.

The **Number of Cleans** value is usually set to zero (0). These are additional clean cycles that can be required after a start exposure signal is received and the current clean cycle has finished. The maximum value for this entry depends on the controller. For example, the range of values for an ST-133 is 0-7 and is 0-255 for an ST-138.

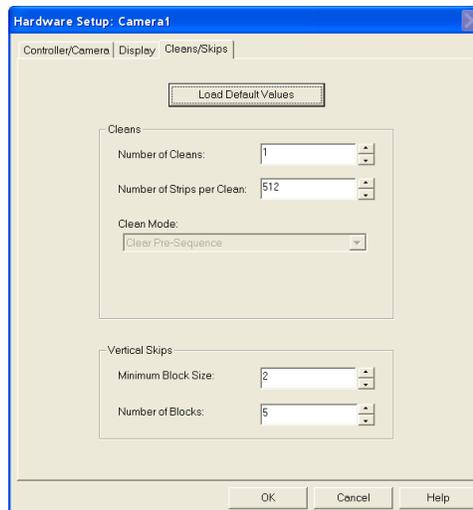


Figure 116. Cleans/Skips tab

Continuous Cleans

Clean cycles will always occur but an additional cleaning function called Continuous Cleans is provided when the start of exposure is tied to an external trigger (i.e., the experiment is being run in **External Sync** timing mode.)

Figure 118 shows the timing diagram for an experiment with External Sync trigger active on the negative edge. Note that the timing diagram shows two possible setups for the shutter. In the first setup (Normal), the shutter is opened when External Sync goes low. Because it takes time to open a shutter, data may be missed while the shutter is opening. In the second setup (Preopen), the shutter is opened when the **NOT SCAN** signal (at the **SCAN** BNC on the back of the ST-133) goes high. The advantage is that the shutter is fully opened when the exposure (triggered by External Sync) begins. The disadvantage is that ambient light is no longer being blocked from the array

during the period between **NOT SCAN** going high and the External Sync going low. Continuous cleans provides a way to get rid of the signal that accumulates on the array during that interval.

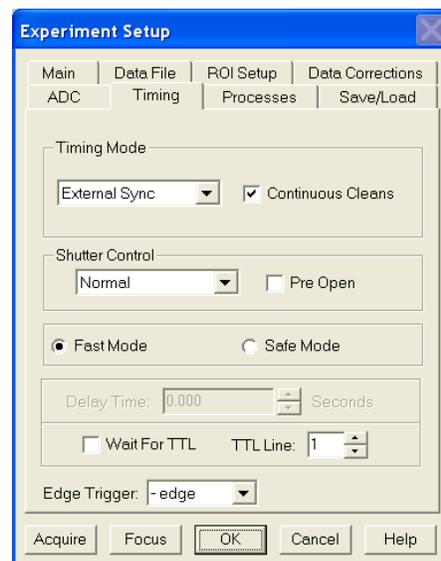


Figure 117. Timing Tab: External Sync with Continuous Cleans Selected

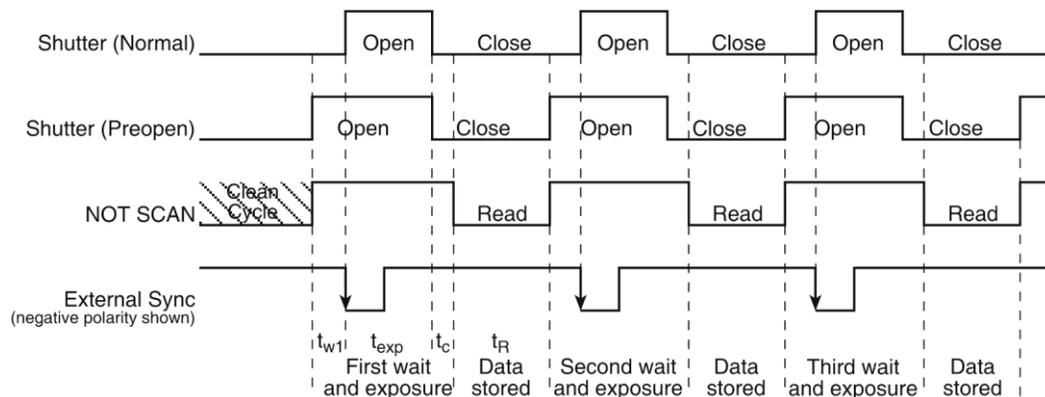


Figure 118. External Sync Timing Diagram

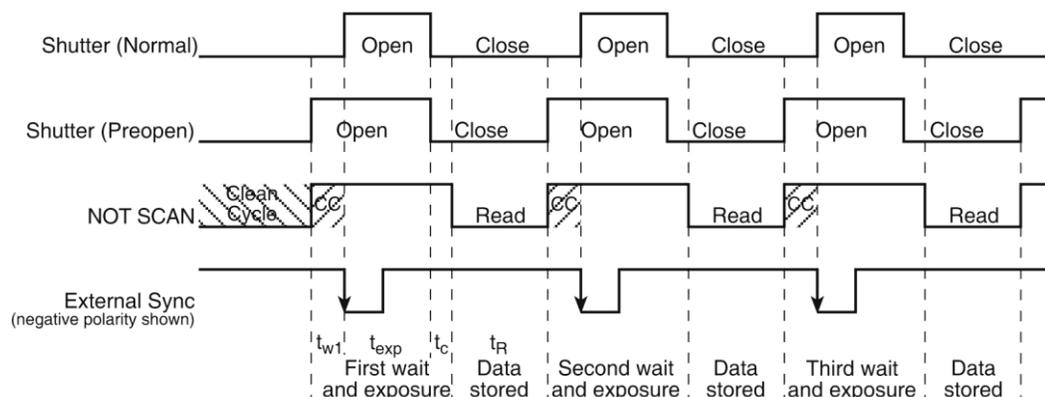


Figure 119. External Sync with Continuous Cleans Timing Diagram

Figure 119 shows the same timing diagram with the addition of continuous cleans (indicated by the shaded areas labeled CC). Continuous cleans are additional clean cycles and defined by the same parameter values as the standard clean cycles. When the External Sync trigger arrives during continuous cleaning, the current clean cycle must be completed before the exposure will begin. In time critical experiments, the number of rows per clean (set on the **Hardware Setup|Controller/Camera** tab) should be 1 or 2 to minimize the delay.

Continuous Cleans Instruction

If the controller and the detector support it, a specialized cleaning function can be used when continuous cleans is active. This function, "Continuous Cleans Instruction", can only be activated if the checkbox for it is visible on the **Hardware Setup|Cleans/Skips** tab (see Figure 120).

Continuous cleans instruction does horizontal shifts while doing vertical shifts for a faster continuous clean. *With this instruction, the delay between an External Sync trigger and the start of exposure is minimized.*

Continuous cleans instruction will be used in place of the standard continuous cleans if both **Use Continuous Cleans Instruction** on the **Cleans/Skips** tab and **Continuous Cleans** on the **Experiment Setup|Timing** tab are checked.

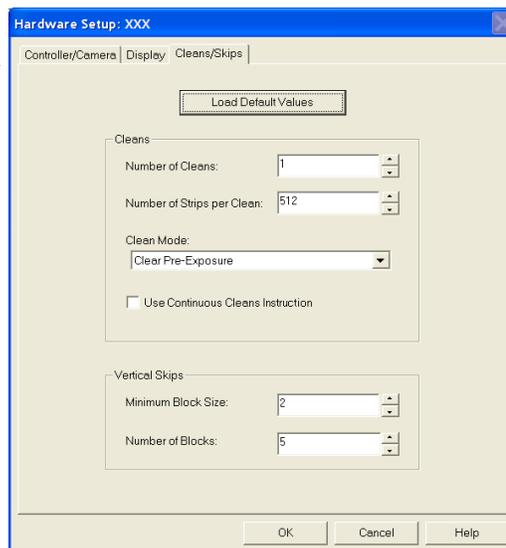


Figure 120. Cleans/Skips tab: Continuous Cleans Instruction

ROIs and Cleaning

An ROI is a user-defined subsection of the array. As with full frames, the defined clean cycles are used to keep charge from accumulating on the array while it is waiting for a start exposure signal and after the data has been readout of the array. The specialized cleaning function for an ROI – Vertical Skips – is applied when the ROI is read out. **Vertical Skips** parameters are used to shorten the readout/discard time for the rows before and after the ROI. **Minimum Block Size** sets the number of invalid rows (horizontal lines of the CCD) to bin before the valid data. **Number of Blocks** sets the number of these blocks to shift and discard before going to a geometric grouping algorithm. Refer to "Vertical Skips" on page 49 for detailed information about vertical skips and the grouping algorithm.

Note: The 2-D OMA array **does not** support vertical skips; and all of the rows on the array are read out and converted before the non-ROI information is discarded. The default Vertical Skips settings of Minimum Block Size: 2 and Number of Blocks: 5, while appearing to work, will result in invalid data. **Instead, you must change these settings to 1 and 256, respectively, for the 2-D OMA array.**

Kinetics and Cleaning

Kinetics is a special type of operation in which most of the CCD is mechanically or optically masked, leaving a small section open to light. This section is then shifted under the mask very quickly. The defined clean cycles are used to keep charge from accumulating on the array while it is waiting for a start exposure signal and after the data has been readout of the array. In addition to clean cycles, continuous cleans for kinetics is supported by Version 5 (or higher) of the ST-133 Controller. For kinetics experiments, continuous cleans are only applied between the first **NOT SCAN** low-to-high transition and the **External Sync** high-to-low transition. Because of the speed at which the array is then shifted, exposed, and shifted no further cleaning occurs until the last frame has been exposed and shifted. At that point, the clean cycles begin again.

Chapter 11

ROI Definition & Binning

Overview

General

A Region of Interest (ROI) may be the entire CCD array or it may be a rectangular subregion of the array. For data acquisition, the definition of such a region is done either from the **Easy Bin** dialog (Figure 128, page 144) accessed from the **Acquisition** menu or from the **Experiment Setup|ROI Setup** tab (Figure 129, page 145), accessible after selecting **Experiment Setup** from the **Acquisition** menu. Easy Bin is a simple way of a defining a single full chip width ROI. ROI Setup allows you to create multiple ROIs with greater flexibility in ROI location and width.

Each ROI is defined in the X and Y direction by a start pixel, an end pixel, and a group/height (binning) factor. After one or more regions have been defined and stored, data acquisition will use these regions to determine which information will be read out and displayed and which information will be discarded.

When ROIs are used to acquire data, the ROI parameter information (for the first 10 ROIs) is stored in the data file when that data is saved to disk. You can review this information for the active data display by using the File Information functionality (accessible from the **File** menu or from the **Display Context** menu).

Notes:

1. For Flatfield Correction, Background Subtraction, etc., the images must be *exactly* the same size.
2. References to X and Y axes assume that the shift register is parallel to the X-axis and that the data is shifted to the shift register in the Y direction. See Figure 121 below.

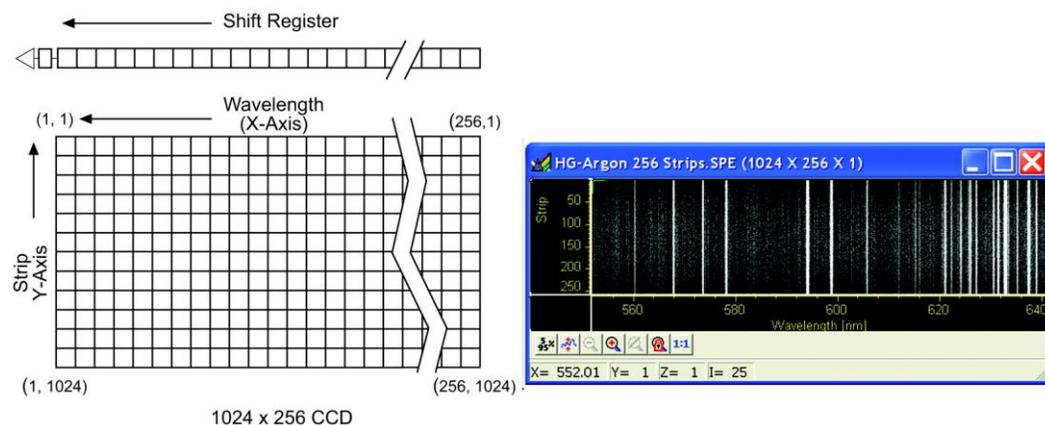


Figure 121. Assumed Array Orientation

Spectroscopy Mode

In Spectroscopy Mode (the default if the Imaging option has not been installed), all pixels in a column are automatically binned. The effect is to produce a single strip of data that is then displayed as a spectrum. If **Use Full Chip** is selected, data acquisition will result in as many data strips as there are pixel strips on the chip, allowing a full frame image to be acquired. If **Use Region of Interest** is selected, data acquisition will result in as many data strips (spectra) as there are defined ROIs.

Imaging Mode

In **Imaging Mode** (available only if the option has been installed) you have the ability to acquire full-frame or ROI-specific images.

If the Imaging option has not been installed, images can only be acquired through the **Use Full Chip** function (on the **Experiment Setup|Main** tab). When this is selected, data acquisition will result in as many data strips as there are pixel strips on the chip, allowing a full frame image to be acquired.

Binning (Group and Height parameters)

Overview

Binning is the process of adding the data from adjacent pixels together to form a single pixel (sometimes called a super-pixel). The combination of pixels can be along the X-axis, the Y-axis, or along both axes. The combination can occur while data is being shifted into the shift register (hardware binning) or after the data has been sent to the host computer (software binning). Both of these types of binning occur during data acquisition. Post-acquisition binning can be performed on previously acquired data.

Hardware Binning

Hardware binning is performed *before* the signal is read out by the preamplifier and may be used to improve the signal to noise (S/N) ratio. For signal levels that are readout-noise limited this method improves S/N ratio linearly with the number of pixels grouped together. For signals large enough so that the detector is photon shot noise limited, and for all fiber-coupled ICCD detectors, the S/N ratio improvement is roughly proportional to the square-root of the number of pixels binned.

Because hardware binning is performed while the signal is shifted into the readout register, the readout time and the burden on computer memory are reduced. However, this time and memory savings are at the expense of resolution. Since shift register pixels typically hold only twice as much charge as image pixels, hardware binning of large sections may result in saturation and “blooming,” spilling charge into adjacent pixels.

If you want to use hardware binning, you define the binning parameters on the **Experiment Setup|ROI** tab. These settings will be used for acquiring data until you change the ROI size or the amount of binning.

Notes:

1. If you have a PCI card, you may need to ensure that the number of pixels to be read out is always an even number: a warning will appear if number of pixels needs to be changed. If you are doing binning, the number of pixels digitized (after hardware binning is complete) must be an even number.

2. The focal plane array (FPA) used in the 2-D OMA does not support hardware binning but does support ROI selection. For this array, any binning must be performed via the software binning function or as a post-acquisition process.

Software Binning

If blooming is an issue, you can use software binning instead of hardware binning. Software binning is activated by checking **Use Software Binning** on the **Experiment Setup|ROI Setup** tab. While software binning will prevent saturation of the CCD chip shift register pixels, it is not as fast as hardware binning.

Note: The binning that is set up on the **Experiment Setup|ROI Setup** tab occurs while data is being acquired. You can also perform post-acquisition binning on previously acquired data. For more information, see "*Binning and Skipping*", page 180.

Spectroscopy Mode

X-axis binning can be used in spectroscopy mode to improve the signal-to-noise ratio. However, in many instances a longer exposure time, higher light level, or use of an intensified system may prove to be better ways of improving the signal-to-noise ratio in that they do not degrade the resolution.

As stated earlier, Y-axis binning is the key factor that distinguishes spectroscopy readout from imaging readout. In spectroscopy, *all* pixels in each column of an ROI (the entire chip or a specified subregion) are *automatically binned*. The effect is to generate a single strip of data that is then displayed as one spectrum.

In WinSpec, the ROI definition and binning parameters for spectroscopy are grouped under the headings of **Wavelength** and **Slit**. The Wavelength (X-axis) parameters determine the start point and length of a data strip and the amount of X-axis binning. By default, the Group value is 1 (no binning) but can be increased to indicate the number of pixels being binned to increase the sensitivity (at the expense of resolution). The Slit (Y-axis) parameters determine the vertical location and height of the Y-axis columns. When multiple ROIs are defined, all of the ROIs will have the same Wavelength values, multiple data strips will be generated, and multiple spectra will be displayed. The Slit values, however, may vary from ROI to ROI as long as the Slits do not overlap.

Imaging Mode

Imaging mode allows you to define rectangular groups of pixels (of any size) that will be binned together to create an image rather than a spectrum. Separate Group parameter values can be entered in the X and Y directions for every defined parameter to give you the greatest possible flexibility in controlling the readout. Although modest binning may be employed to increase the sensitivity, there is a tradeoff in that it adversely affects the image resolution. As a result, binning when imaging is normally limited to a few pixels vertically and horizontally.

Defining ROIs

TIP: You can acquire a full-chip data set without losing your ROI definitions. To do so, simply click on the **Use Full Chip** radio button on the **Experiment Setup|Main** tab. As long as **Use Full Chip** is selected, the ROI setup parameters are ignored and data collection will result in full frame data sets. To switch back to a defined ROI pattern, click on the **Use Region of Interest** radio button on the **Experiment Setup|Main** tab.

Examples of Spectroscopy and Imaging ROIs

Figure 122-Figure 126 show possible ROI patterns. Note that the patterns in Figure 126 demonstrate varying size ROIs, a feature of Imaging Mode.

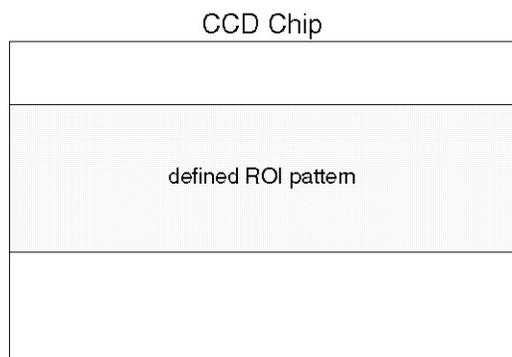


Figure 122. Single Full-width ROI

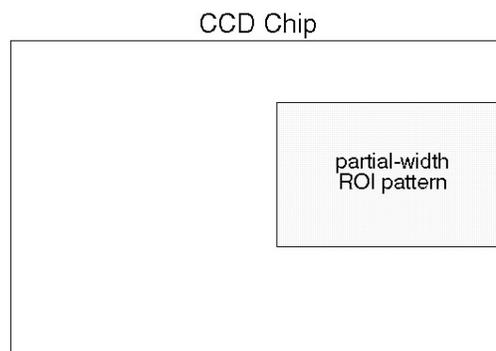


Figure 123. Single Partial-width ROI

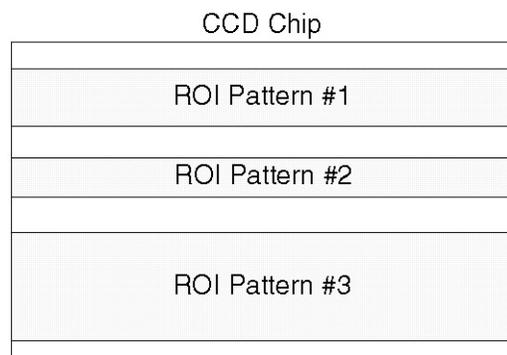


Figure 124. Multiple Full-width ROIs

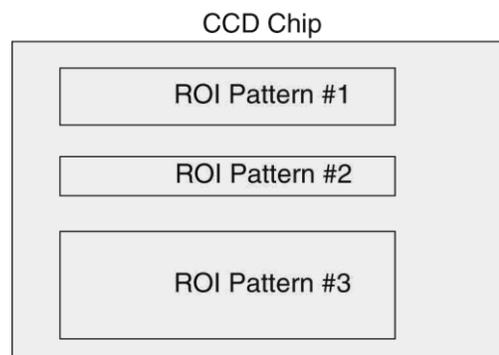


Figure 125. Spectroscopy Mode
Multiple Partial-width ROIs

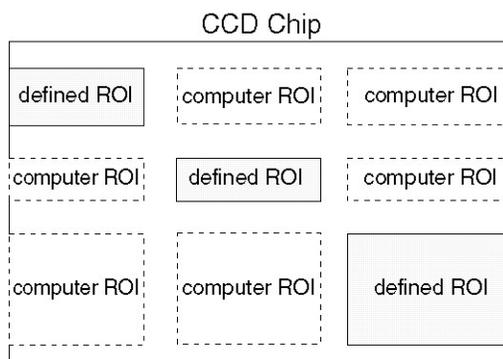


Figure 126. Imaging Mode
Multiple ROIs with Different Widths

Constraints on Defining Multiple Regions of Interest (ROIs)

General: You may create more than 10 ROIs but when data is acquired using these ROIs, the parameter information for only the first 10 ROIs will be stored when you save the data.

Spectroscopy Mode:

1. ROIs cannot overlap. This places restrictions on the Slit (Y) values that can be specified. For example, if Pattern 1 has a Slit Start value of 1 and a Slit Height 100, the Start value for the next ROI must be greater than 100. *If a Full pattern is selected and stored, it overlaps all others, causing all data collections to be full-chip.* Figure 124 illustrates multiple full-width ROIs.
2. Once the first pattern is defined, all subsequent patterns are automatically assigned the same X-axis starting, ending, and grouping values. The first pattern need not be full width — any values in the chip range can be entered, but once stored, those values will apply as well to subsequently defined patterns. The figures below illustrate possible ROI patterns. Note the additional functionality available in Imaging Mode (Figure 126).

Imaging Mode:

In this mode, ROIs can have varying sizes and degrees of overlap. However, when you define multiple ROIs like those in Figure 126, the computer automatically generates six “side-effect” ROIs in the regions where *extensions* of the strips and columns of the defined ROIs intersect. Both the defined and computer generated ROIs will be stored and the data for both will be displayed (see Figure 127). The side-effect ROIs are necessary to accommodate hardware limitations.

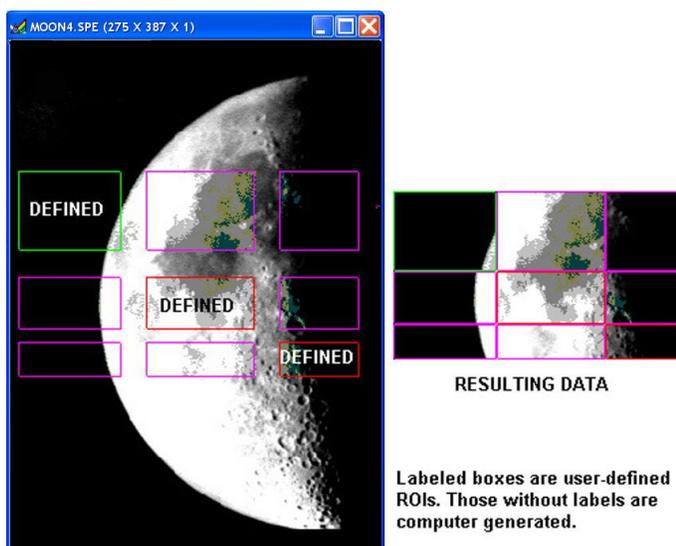


Figure 127. Multiple Imaging ROIs and Resulting Data

Methods of Defining and Storing ROIs

A region of interest (full-width or partial width) can be defined by:

1. Opening the **Easy Bin** dialog and entering the values for a single, full chip wide spectroscopy mode ROI.
2. Entering values for the Wavelength (X) and Slit (Y) parameters from the keyboard.
3. Dragging the mouse cursor on a displayed image to define a rectangular region and then clicking the **Mouse** button. Before using this method, you must acquire a Full-Chip image. Otherwise, you will get a "Size of Image in Active Window is Incompatible with Current Chip Size" message when you try to define an ROI.

Note: In Spectroscopy mode, ROIs created via the mouse are limited to full chip width like the ones depicted in Figure 124. This is not the case in Imaging mode.

4. Defining the region with the mouse and then changing parameter values via the keyboard before storing the pattern. This allows you to change a full-width ROI created by mouse selection to a partial-width ROI like the one in Figure 125.
5. After an ROI is defined, its pattern can be stored, edited, or deleted. All defined areas will be indicated on the displayed image after they have been stored. If a pattern is being edited, its outline will be green and all other patterns will have red outlines. In Imaging mode, purple outlines will be drawn if two or more patterns are defined that do not have identical Wavelength Start and End points (these outlines represent additional data that will be included in the image acquired using the ROI Setup). The display of defined regions of interest is automatically updated when patterns are added or cleared. Stored patterns are save to disk when you exit the WinSpec/32 and are automatically loaded the next time you start the program.

Notes:

1. Right-clicking inside an ROI opens the **ROI Context** menu, which, in addition to providing auto-scale and zoom functions, enables the labeling of image and graphical data.
2. The **Experiment Setup|Save/Load** tab allows all experiment set parameters, including ROI, to be saved in a user-designated file for later recall. See the discussion of the **Save/Load** tab in the online Help.

Defining an ROI via Easy Bin:

Easy Bin allows you to define of a single, full chip wide ROI.

1. Select **Easy Bin** from the **Acquisition** menu.
2. On the **Easy Bin** dialog (Figure 128), click on the appropriate radio button:

Center 1: Establishes an ROI one pixel high.

Center 10: Establishes an ROI 10 pixel high.

Center 100: Establishes an ROI 100 pixel high.

All: Selects the full chip height.

User Defined: Allows you to set the Slit (Y-axis) Start and End pixels. If you have a full chip image displayed, you can use the mouse cursor to create the bounding box for the ROI. Since all Easy Bin ROIs are full chip width, only the box's height parameters will be used.

3. If you have selected **User Defined**, enter the start and end pixels. This allows you to create an ROI that is not centered vertically on the chip.
4. Click on **OK** when you have finished.

To define multiple ROIs, ROIs that are not full chip width, and/or ROIs that are not centered vertically on the chip, use the ROI Setup functions accessible from the **Experiment Setup** dialog.

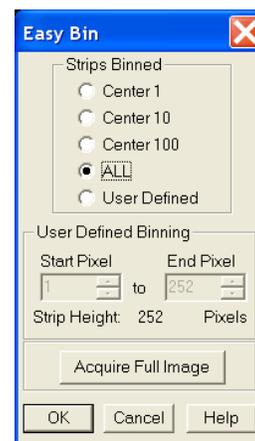


Figure 128. Easy Bin dialog

Defining ROIs by Keyboard entry:

1. Open the **Experiment Setup** dialog and click on the ROI Setup tab to open the **ROI Setup** tab (Figure 129).

2. Select the appropriate mode (**Imaging** or **Spectroscopy**). *If you do not have the Imaging option, the Imaging Mode and Spectroscopy Mode radio buttons will not be present.*

TIP: Acquire a full-chip image before adding or editing ROI patterns. The existing patterns will be superimposed on the image.

3. Note the **Number Stored** value. This will tell you if how many ROIs have already been stored. Depending on what you want to do, you may want click on **Clear** or **Clear All** to remove stored ROI patterns.

4. To add a new pattern, click on the spin buttons (next to the **Number Stored** text) until the text to the far left is **New Pattern**.

This will not be necessary if there are no patterns stored.

a. Enter the Wavelength (X-axis) **Start**, **End**, and **Group** values. The **Group** value controls the X-axis binning: 1 indicates no binning; higher values indicate the number of pixels being binned to increase the sensitivity at the expense of resolution.

- **Spectroscopy Mode:** When multiple ROIs are defined, the Wavelength values for the first pattern are applied to the subsequent patterns created.
- **Imaging Mode:** Multiple ROIs can have different **Wavelength** values.

TIP: If you're not sure of the chip size, open the **Main** tab and note the X and Y values there.

b. Enter the Slit (Y-axis) **Start**, **Height**, and **Group** (if in **Imaging Mode**) values.

- **Spectroscopy Mode: Height** controls the Y-axis binning: 1 indicates no binning; higher values indicate the number of pixels being binned to generate the strip of data. Do not overlap **Slit** values.
- **Imaging Mode: Height** is the height of the image and **Group** determines the Y-axis binning. Image ROIs can overlap.

c. Click on **Store** to store the newly created ROI. The **Number Stored** will be updated. Repeat this process until you have finished adding ROIs.

5. To edit an existing pattern, click on the spin buttons until the pattern number is displayed in the **Edit Pattern** field.

6. Then make your changes.

TIP: If you are changing the Wavelength (X-axis) values in **Spectroscopy Mode**, select the first pattern and enter your changes there.

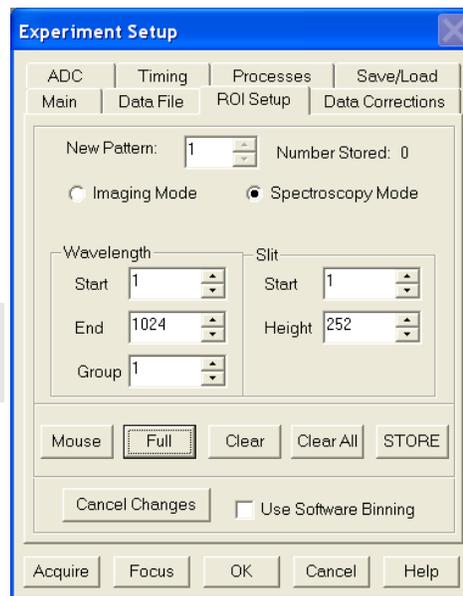


Figure 129. ROI Setup tab
(Spectroscopy Mode)

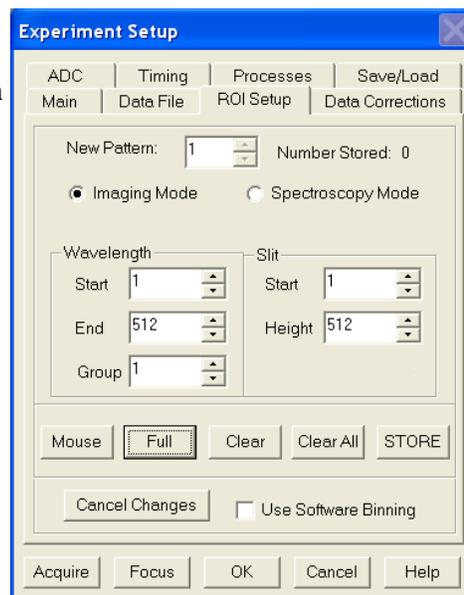
- Click on **Store** to store the changed ROI pattern.

Note: To scan the full CCD chip at any time, simply select the Use Full **Chip** radio button (on the **Main** tab) and begin acquisition.

Defining ROIs by Mouse Input:

Often you can easily identify a region of interest by visually inspecting the full-chip image. When this can be done, it is very easy to define the ROI graphically as follows.

- First, click on the **Use Full Chip** radio button (Experimental Setup Main tab) so that a full-chip image will be acquired. Then click on **Run**. Alternatively, if you already have an image, open this image and display it on screen.
- Next click on the **Use Region of Interest** radio button (**Main** tab). Then click on the ROI Setup tab to display the ROI Setup tab. If there are already regions stored, you will now see them displayed as rectangles on the displayed image.
- Click on the spin button to the right of the **New/Edit Pattern** field until the field label says **New Pattern** (instead of **Edit Pattern**).
- Use the mouse to drag an ROI box over the desired region in the image display.
- Click on **Mouse** (ROI tab) to enter the ROI information. Once this information is displayed on the tab, you edit it.
- Click on **Store** to save the new pattern.



*Figure 130. ROI Setup tab
(Imaging Mode)*

Correction Techniques

Introduction

Advanced data collection includes background subtraction, flatfield correction, CCD blemishes removal and cosmic ray removal. The skillful use of these techniques can significantly enhance measurement capabilities. *Note that not all of these techniques will be available in early releases of the software.*

Background Subtraction

Princeton Instruments systems are adjusted so that data have a small offset. This offset assures that small signals will not be missed. This offset can be subtracted after the signal is acquired to prevent it from having any influence on the data.

Background subtraction allows you to automatically subtract any constant background in your signal. This includes both constant offsets caused by the amplifier system in the controller as well as time-dependent (but constant for a fixed integration time) buildup of dark charge. Some users collect background spectra with the shutter open, including ambient light in their background data. The background subtract equation is:

$$(\text{Raw image data} - \text{Background}) = \text{Corrected image data.}$$

When background and flatfield operations are both performed, background subtraction is always performed first. The equation is the following:

$$(\text{Raw image data} - \text{Background})/\text{Flatfield} = \text{Corrected image data.}$$

Below are instructions for collecting and using background data files.

Acquiring Background Files:

This operation is similar to normal data acquisition.

1. Use exactly the same temperature setting as will be used in data collection. Wait at least 30 minutes after the detector has reached operating temperature to ensure stability.
2. Set the same binning parameters, ROI and Exposure.
3. Select **Acquire Background** from the **Acquisition** menu. This will immediately acquire a background file using the Experiment Setup parameters, only the shutter will remain closed for most applications.

To acquire a background with the shutter open, or if the Acquire Background feature is too restrictive in some other way, a background file can be collected as a normal data file. Once the file is collected and stored, enter the filename in the **Background Subtract** filename box on the **Experiment Setup|Data Corrections** tab (see Figure 131).

Setting Automatic Background Subtraction:

These steps instruct the software to automatically subtract a previously stored background file from each new data acquisition.

1. Select **Experiment Setup** from the **Acquisition** menu or click on the  button on the **Custom Toolbar**. This will open the **Experiment Setup** dialog.
2. Click on the **Data Corrections** tab. The Data Corrections tab will be selected (Figure 131).
3. Click on the **Background** checkbox to turn on background subtraction. Type in the name of a background file if it is in the current directory. Alternatively, click on the button at the end of the entry window to open the file browser to select the background file if it is in a different directory.
4. Once the **Background** filename has been entered, click on the **OK** button. This saves the background filename for all future data acquisitions, or until the Background is turned off.

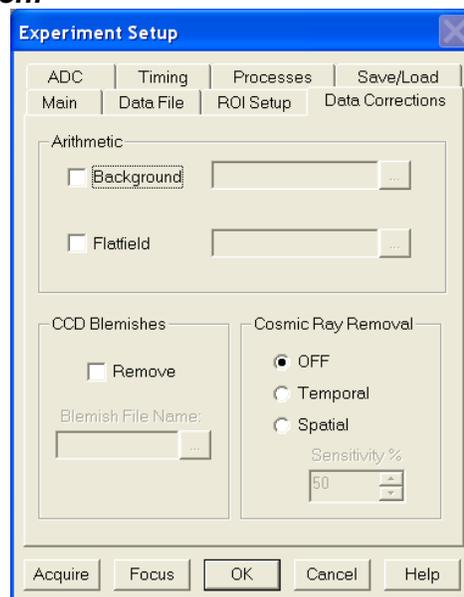


Figure 131. Data Corrections tab

The filename entered in the **Background** box will be subtracted from each new file before it is displayed or stored. If both **Flatfield** and **Background** are selected, the background will be subtracted first, before the flatfield correction.

Background Subtraction with Intensified Detectors

To properly perform background subtraction with an intensified detector, a new background must be acquired whenever the intensifier gain setting is changed. This is necessary because changing the intensifier gain also affects the dark charge of the intensifier (EBI).

Flatfield Correction

Flatfield correction allows you to divide out small nonuniformities in gain from pixel to pixel. The instructions below set the flatfield correction to be performed before data are saved to RAM or disk.

Acquiring a Flatfield File:

This operation is similar to normal data acquisition.

1. Use exactly the same temperature setting as will be used in data collection. Wait at least 30 minutes after the detector has reached operating temperature to ensure stability.
2. Set the same binning parameters and ROI. If you plan to use a background file with data collection, select **Background** on the **Experiment Setup|Data Corrections** tab and enter the name of the background file. This background file will be subtracted from the flatfield file before it is saved to disk.
3. Illuminate the detector uniformly. The accuracy of this uniformity will be translated into an accurate flatfield correction.
4. Select **Acquire Flatfield** from the **Acquisition** menu (Figure 36, page 63). This will immediately acquire a flatfield file using the Experiment Setup parameters. Unlike background subtraction, the shutter will open and close normally.
5. If background subtraction was selected, the background file will be subtracted from the flatfield file before it is saved to disk.

If the Acquire Flatfield feature is found to be too limiting in some way, a flatfield file can be collected as a normal data file. Once the file is collected, enter the filename in the **Flatfield Correction** filename box on the **Experiment Setup|Data Corrections** tab (Figure 131).

Activating Automatic Flatfield Correction:

These steps instruct the software to automatically divide each new data file, pixel-by-pixel, by the specified flatfield file.

1. Select **Experiment Setup** from the **Acquisition** menu or click on the  button on the **Custom Toolbar**. This will open the **Experiment Setup** dialog.
2. Click on the **Data Corrections** tab (Figure 131).
3. Click on the **Flatfield** checkbox to turn on Flatfield correction. Then type in the name of a flatfield correction file in the current directory. Alternatively, click on the button at the end of the field to open the file browser to select the flatfield correction file if it is in a different directory.
4. Once the **Flatfield** filename has been specified, click on the **OK** button. This saves the flatfield filename for all future data acquisitions, or until the Flatfield correction is turned off.

Each pixel in a new file will be divided by the corresponding pixel in the Flatfield file. If both **Flatfield** and **Background** are selected, the background will be subtracted first, before the flatfield correction.

CCD Blemishes

Pixels or columns specified as bad in the blemish file will be replaced by interpolated data (based on the pixel before and the pixel after the bad pixel) as data is collected. After you click on the **Remove** check box, you can select the appropriate blemish file. Clicking on the button at the right of the **Blemish File Name** field opens a browse dialog so you can locate and select a file. If you do not have a blemish file but have determined that there are one or more bad pixels or columns, you can create a file to be used.

Note: CCD Blemishes removal may not be implemented in early releases of the software.

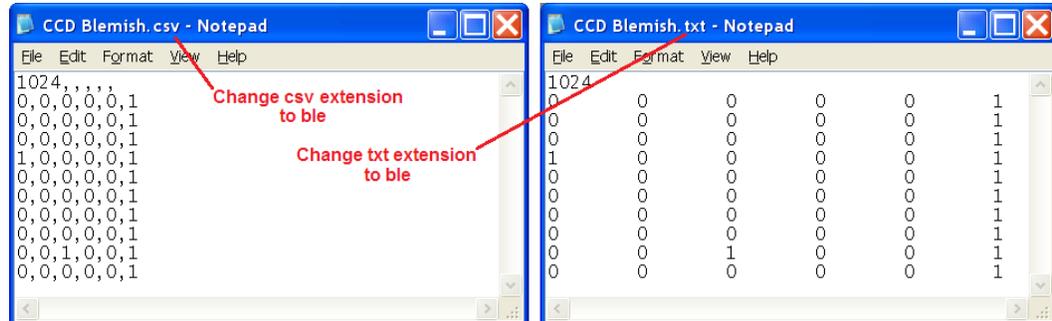


Figure 132. Blemish Files: CSV format and Tab Delimited format

Creating a Blemish File:

1. Open an ASCII text editor or spreadsheet editor.
2. On the first line, key in the number of rows on the sensor. For example, you would key in 1024 if the sensor format was 1024 x 1024.
3. Press [Enter].
4. For each pixel in a row, enter either a 0 (no blemish) or a 1 (blemish), a comma or tab separator, and press [Enter] after you have completed the entries for that row. Figure 132 shows both comma and tab separated entries.

Note: In the files shown in Figure 132, the blemishes did not go beyond the sixth column on the sensor. It was not necessary to enter values for the remaining blemish free columns.

5. If there was only one column blemish and it started in row 1, column 6 of the sensor, you would have five 0s and a 1 in the sixth position as shown in Figure 132. You would repeat this entry in succeeding rows until you reached the limit of the blemish. If there were also individual pixel defects you want corrected, you would replace the appropriate 0s with 1s. Before you can use the blemish file, it must contain the initial row indicating the sensor height and a row of values for each row on the sensor. The blemish file for a 1024 high sensor would contain 1025 rows; for a 200 high sensor, the file would contain 201 rows.
6. When you have finished entering the 0s and 1s, save the file with a .BLE extension. Files with this extension are recognized by WinSpec as blemish files.

TIP: If you have a long array, use a spreadsheet that can save data to .CSV or .TXT files. The numbered rows will help you keep track of where you are. When you have finished with the data entry, save the data to a text file (.TXT extension) and then change the file extension to .BLE.

Cosmic Ray Removal

Removes highly localized spikes, such as would be caused by cosmic rays interacting with the silicon of the CCD, from the data after it is acquired but before it is stored. Two different techniques (in addition to OFF) can be selected. The Temporal technique compares a series of spectra and requires no user parameters. The Spatial technique compares the data with the set threshold level. If Spatial is selected, the Sensitivity setting determines how large a data spike must be to be identified as a cosmic ray effect (essentially the Sensitivity is a gain setting on the thresholding algorithm. A value of 0 will find 0 cosmics, while a setting of 100 will be most sensitive.). A setting of 50 will give good results in most situations. Cosmic ray data is replaced by interpolated before-and-after data.

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Spectra Math

Introduction

A variety of mathematical operations can be performed on WinSpec data files. This functionality, called Spectra Math, is selectable from the **Process** menu. The four tabs on the **Math** dialog (Figure 133) allow you to select the source file(s), operation, and the destination file for the results of the selected mathematical operation (displayed at the top of the dialog). Additionally, you can use the mouse to specify an ROI to be processed (available on tabs A and B).

Source Data and Destination Selection

As many as three data files can be involved in math operations and there is a corresponding tab for each of them, **A**, **B**, and **C**. **A** and **B** are Input Files. **C** is always the Output File. Every operation requires at least one Input File and an Output File. Thus, every operation will require using tabs **A** and **C**. In those cases where a second Input File (or a constant) is required,

tab page **B** will also be used (see the online Help for detailed descriptions of the individual **Math** tabs).

With but a few exceptions, the parameters on the three tabs are the same. Brief descriptions follow.

Frame: If an input file contains multiple frames, you can specify the ones to be processed. The default is to process all frames. You additionally have the option of choosing not to write all of the frames processed to the Output File.

X and Y Range: You can specify the input file pixels to be processed. The default is to process all pixels. You additionally have the option of restricting the X and Y pixel range data written to the Output File. An alternative way to specify a region is to use the mouse to define the region on the active data display of the input file and then click on **Mouse**.

Input (Output) Filename: All three tabs have a field for entering the filename. In each case there is a button at the end of the box which, when pressed, opens a browser to make selecting and specifying filenames and locations as simple as possible. In the case of the **B** tab, there is additionally a field for entering a constant. Radio buttons are provided that activate one or the other of the two fields. Either a constant value or a filename can be entered, but not both.

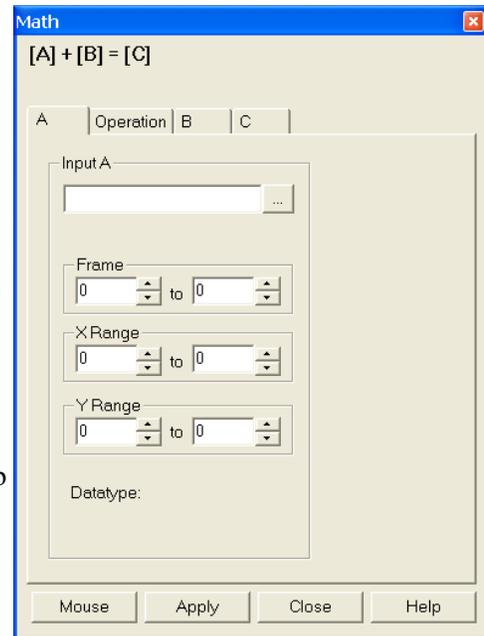


Figure 133. Math dialog

Data Type: For the **A** and **B** tabs, the data type is reported only and cannot be changed. In the case of the **C** (output) tab, you can specify the data type. Data types include:

Byte: 8 bits; only the eight least significant data bits (levels 0 to 255) will be saved.

UnInt: Unsigned integer; 16 bits (0 to 65535)

Int: Signed integer; 16 bits (-32768 to 32767)

Long: Signed integer; 32 bits (-2,147,483,648 to 2,147,483,647)

Float: Floating point; 32 bits ($-1.75494351e^{-38}$ to $3.402823466e^{38}$)

Display Result: This checkbox appears on the **C** tab only. If checked, the output image will be displayed as soon as the processing is complete.

Operations

On the **Operation** tab, the math operations are listed as either Linear or Non-Linear. The operand(s) for math operations can be a single file, a file and a constant, or two files. In addition to allowing you to perform these operations on entire files, WinSpec also allows you to specify the frames (if multi-frame) and a region of interest (ROI).

- When working with a single file, the specified operation is performed on each pixel value of **A** and the result is written to the corresponding pixel of the Output File, **C**. The operations available are grouped under the Non-Linear heading:

Log10	Absolute Value
Natural Log	Bitwise Complement
Square Root	Binary NOT
Squared	

- When working with a single file and a constant, the operation will be performed on each pixel value of **A**, using the constant specified on the **B** tab, and the result is written to the corresponding pixel of the Output File, **C**. The operations available are grouped under the Linear heading:

Addition	Min
Subtraction	Max
Multiplication	Bitwise AND
Division	Bitwise OR
Bitwise Exclusive OR	

- When working with two files, corresponding pixels from the two files, **A** and **B**, are operated on and the result is written to the corresponding pixel of the Output File, **C**. The operations that can be performed are the same as for a Single file and Constant described above.

Operation Descriptions

Linear Operations

Addition: The **A** file is added, pixel by pixel, to the **B** file and the results written to the **C** file. It is also possible to add a constant entered on the **B** tab to each point on the **A** file, with the results written to the **C** file.

Subtraction: The **B** file is subtracted, pixel by pixel, from the **A** file and the results are written to the new file. It is also possible to subtract a constant entered on the **B** tab from each point on the **A** file, with the results written to the **C** file.

Multiplication: The **A** file is multiplied, pixel by pixel, by the **B** file and the results written to the **C** file. It is also possible to multiply each pixel of the **A** file by a constant entered on the **B** tab, with the results written to the **C** file.

Division: The **A** file is divided, pixel by pixel, by the **B** file and the results written to the **C** file. It is also possible to divide each pixel of the **A** file by a constant entered on the **B** tab, with the results written to the **C** file.

MIN: The **A** file is compared, pixel by pixel, with the **B** file and the smaller of the two values written to the **C** file. It is also possible to compare each pixel of the **A** file with a constant entered on the **B** tab, with the smaller of the two values written to the **C** file.

MAX: The **A** file is compared, pixel by pixel, with the **B** file and the larger of the two values written to the **C** file. It is also possible to compare each pixel of the **A** file with a constant entered on the **B** tab, with the larger of the two values written to the **C** file.

Non-Linear Operations

Log10: The Log10 of the **A** file is computed pixel by pixel and the results written to the **C** file.

Natural Log: The natural log of the **A** file is computed pixel by pixel and the results written to the **C** file.

Square Root: The square root of each point in the **A** file is computed and the result written to the corresponding point of the **C** file.

Squared: Each point in the **A** file is squared and the result written to the corresponding point of the **C** file.

Absolute: The absolute value of each point in the **A** file is computed and the result written to the corresponding point of the **C** file.

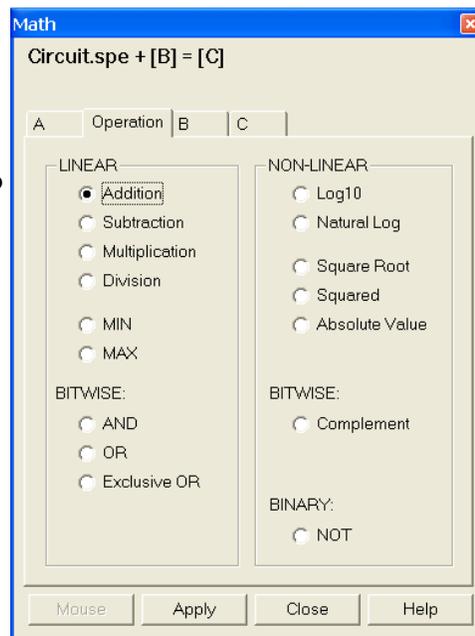


Figure 134. Operation tab

Bitwise Operations

AND: A bitwise AND operation is performed on the binary representation of each pixel of the **A** file and each pixel of the **B** file, with the result written to the **C** file. A twelve-bit example follows.

	Bits	Decimal Value
Pixel value in A	0 1 0 1 0 1 0 1 0 1 0 1	1365
Corresponding pixel value in B	0 0 0 0 0 0 1 1 1 1 1 1	63
Result written to C	0 0 0 0 0 0 0 1 0 1 0 1	21

OR: A bitwise OR operation is performed on the binary representation of each pixel of the **A** file and each pixel of the **B** file, with the result written to the **C** file. An eight-bit example follows.

	Bits	Decimal Value
Pixel value in A	0 1 0 1 0 1 0 1 0 1	1365
Corresponding pixel value in B	0 0 0 0 0 0 1 1 1 1 1 1	63
Result written to C	0 1 0 1 0 1 1 1 1 1 1 1	1407

Exclusive OR: A bitwise Exclusive OR operation is performed on the binary representation of each pixel of the **A** file and each pixel of the **B** file, with the result written to the **C** file. An eight-bit example follows.

	Bits	Decimal Value
Pixel value in A	0 1 0 1 0 1 0 1 0 1	1365
Corresponding pixel value in B	0 0 0 0 0 0 1 1 1 1 1 1	63
Result written to C	0 1 0 1 0 1 1 0 1 0 1 0	1386

Complement: For each pixel value *n* in the **A** file, the corresponding value in the output file **C** is set to $-1-n$. Otherwise stated, each 0 becomes a 1 and each 1 a 0.

Binary Operations

NOT: For each pixel in the **A** file, all non-zero values yield a zero, and all zero values (only) yield a one. The resulting values are written to the corresponding point of the **C** file.

Procedure:

1. Select the operation to be performed on the **Operation** tab.
2. Enter the first input filename on the **A** tab.
3. If the operation involves two files or one file and a constant, enter the second file name on the **B** tab or enter the value of the constant on the **B** tab.
4. If you want to process only part of the input images, change the Frame, X Range, and Y Range values on the **A** tab, and also on the **B** tab if two files are involved. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.
5. Enter the name of the output file on the **C** tab. If you want to restrict the output data range, change the Frame, X Range, and Y Range values as appropriate.
6. Select the output file data type.
7. If you want the output file to be displayed as soon as the processing is complete, check the **Display Result** box.
8. Click on **OK** to begin processing or click on **Cancel** to cancel the operation.

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Gluing Spectra

Introduction

There are two ways to glue together multiple exposures into a single contiguous spectrum. The first is to take existing spectra that have already been calibrated and have the WinSpec/32 software connect the spectra at the appropriate points. The second method requires spectrometer control. With correctly calibrated spectrometer control, the WinSpec/32 software can collect spectra and move the spectrometer, automating the process of collecting a spectrum whose wavelength range can extend the full spectral range of the detector.

Gluing Existing Spectra

You can glue any series of existing data files, providing that they all have been properly calibrated in nm. The files should overlap some in order to provide complete spectral data, but this is not required by the software. Any collection of calibrated single spectrum files can be used to create a glued file. The only requirements are that:

- The files have been wavelength calibrated (either manually or using “Auto-Spectro”).
- The files have the same number of *frames* and *strips* (it is *not* necessary that they have the same number of pixels).

Procedure:

1. Take the series of data files you would like to glue and use the file manager to rename them as a series such as EXP001.SPE, EXP002.SPE, etc. You do not have to arrange these files in any particular order. These data files will not be altered in any way by the following procedure.
2. From the **Process** menu select **Glue**. This will open the **Post-Process Glue** dialog (Figure 135). *For more information, see the online Help for this dialog.*
3. Use the browser to select the files. The **Add Files** button opens a browser to facilitate file selection.

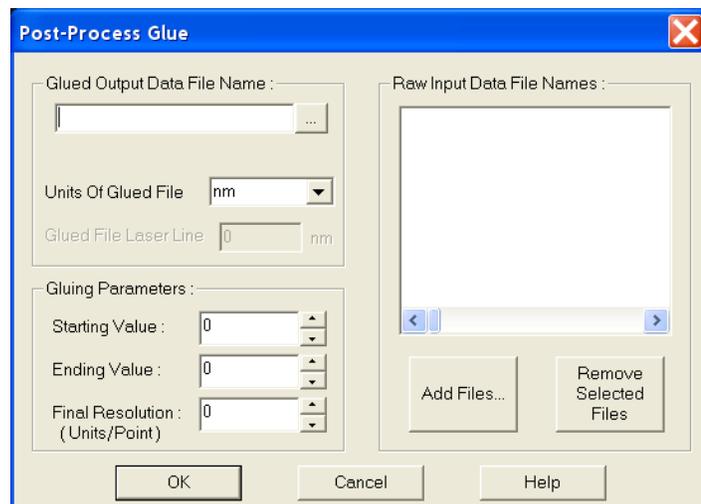


Figure 135. Post-Process Glue dialog

4. Enter the starting and ending wavelength values for the resulting file. If your wavelength range includes values that are not covered by any of the files in your series, the resulting spectrum will have some zero values. Any area where valid data was available will be used to create the glued data.
5. Enter the final resolution you would like the final data file to have. This value is in units per data point in the output file, so the lower the number the higher the resolution and the more data points the glued file will contain. For a 2400 groove per mm grating and a 0.3 m spectrometer a good final resolution would be about 0.1 nm per pixel. For a 1200 groove per mm grating this value would be 0.15 to 0.2 nm per pixel. The total number of data points in the resulting file cannot exceed 65,535.
6. Enter the **Glued Output Data File Name** in the field provided. The glued data will be contained in a single file.
7. If you change your mind about including one or more files in the resulting file, highlight those files in the Raw Input Data File Names listing and click on **Remove Selected Files**.
8. When you have finished selecting files, click on **SET** to execute the glue operation.

Step and Glue

If you have spectrometer control through the WinSpec software, the easiest way to create a glued spectrum is to let the software control both the data collection and the movement of the spectrometer. The software will take an exposure and, while the shutter is closed, will move the spectrometer to the next position. Unlike a monochromator with a single point detector, the wavelength calibration will not depend on the speed and timing of the stepper motor, only on its final position.

In this case you must set the amount of overlap you would like the spectra to have. The overlapping data will be averaged for a smooth transition from one exposure to the next. In addition to the glued data file, the numbered series of individual exposures remain in the computer for later processing.

Procedure:

1. Make sure that you have a spectrometer already installed and properly calibrated. This stepping and gluing procedure depends on having correct spectrometer calibration.
2. Click on **Calibration** on the menu bar and then on **Usage** to open the **Usage** dialog.
3. Select **Auto-Spectro** in the **Usage** dialog. Then select the **Calibration units** (nm, cm^{-1} or rel. cm^{-1}). Be sure the **Save as Default** button is clicked **ON**. Then click on **OK** to close the **Usage** dialog.
4. From the Acquisition menu, select **Step and Glue**. The **Step and Glue** dialog (Figure 136) will appear. *For more information, see the online Help for this dialog.*

Note: Again, you must have **Auto Spectro** and either **nm**, **cm^{-1}** or **rel. cm^{-1}** selected as the **Calibration Units** on the **Usage** dialog (**Calibration** menu) in order for the **Step and Glue** dialog to open. Failure to satisfy this prerequisite will generate an error message.

5. The glued data will be collected as a series of incremental files. These files will then be used to create a single glued data file. Enter the name of the File Name Template, such as EXP, in the File Names Template box. There is

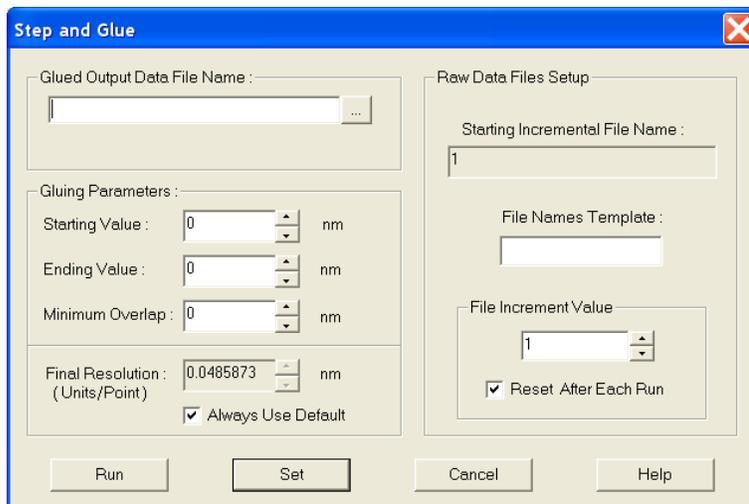


Figure 136. Step and Glue Setup dialog

provision for setting the starting File Increment Value. As each incremental file is taken, the **File Increment Value** will increment by one. If the **Reset After Each Run** box is checked, the File Increment Value will reset to one and the subsequent set of incremental files will overwrite the first. If the **Reset After Each Run** box is unchecked, the File Increment Values assigned to the next and subsequent runs will start with the next digit after the last one used. No files will be overwritten.

6. Enter the **Starting Value**, the **Ending Value**, and the **Minimum Overlap** in the units selected. A good overlap would be about ten times the coverage of a single pixel. To determine the coverage of a single pixel; click on **Always Use Default**; the minimum resolution will be displayed in the Final Resolution edit box (the resolution changes as the wavelength changes, decreasing at higher wavelengths).
7. Enter a **Final Resolution** for the resulting file. Unless you require a certain resolution, it is easiest to let the computer calculate the final resolution, based on the spectrometer calibration and other known quantities. In the resulting file, each point does not represent a physical pixel. The total number of data points in the resulting file cannot exceed 65,536.
8. Click on **SET** to store the Step and Glue parameters. If the experiment is ready to run, click on the **RUN** to begin collecting data. The software will collect one exposure at each spectrometer position. It will automatically move the spectrometer to the next position (with the correct amount of overlap) and collect the next exposure. The software will collect as many exposures as needed.

During data collection, individual spectra may or may not be displayed, depending on the time between spectra.

Theory

The Glue operation is done in two stages. First the data in an input file is converted into an intermediate file with the calibration of the output file, and then the converted file is glued onto the output file.

The algorithm for the file conversion is based on the fact that the pixels have small but finite dimensions; this means that each pixel has some wavelength coverage and is not just a wavelength point. When WinSpec reports the wavelength of a pixel, it is actually the wavelength at the center of the pixel. Since WinSpec uses a polynomial wavelength calibration, the wavelength at the center of a pixel “x” is:

$$\text{Wavelength (center)} = A_0 + A_1x + \dots + A_nx^n;$$

and the wavelengths at the edges are given by:

$$\text{Wavelength (edges)} = A_0 + A_1(x \pm 1/2) + \dots + A_n(x \pm 1/2)^n,$$

where the “+” is for one edge and the “-“ for the other.

The intermediate and output file data points also have a finite wavelength coverage, given by the Final Resolution item on the Step and Glue or Post Process Glue dialog. For example, with a Starting Value of 400 nm, Ending Value of 700 nm, and Final Resolution of 1 nm, the Output File will have 301 data points, each with a coverage of 1 nm (The file itself will actually cover the range from 399.5 nm to 700.5 nm). The data point at 500 nm will have a wavelength coverage from 499.5 nm to 500.5 nm. The wavelength calibration of the Output File will be linear, and the wavelength at point “x” given by:

$$\text{Wavelength (center of point x)} = \text{Starting Value} + \text{Final Resolution} * (x - 1).$$

For each point in the Intermediate File, the conversion routine sums in values from all pixels whose wavelength range overlaps the wavelength range of the data point. If the pixel lies entirely within the range of the data point, then 100 % of its value is added; if a pixel partially lies in the data point’s range, then the percentage of its value that is added is equal to the percentage of the pixel’s wavelength range lying in the data point range. In the above example, if an input file pixel had a value of 1234 and a wavelength range of 498.9 nm to 499.6 nm, then the amount summed into the 500 nm point (499.5-500.5) would be

$$\{(499.6 - 499.5) / (499.6 - 498.8)\} * 1234 = 154.25,$$

where (499.6 - 499.5) is the amount of pixel in data point range, (499.6 - 498.8) is the coverage of the pixel, and 1234 the pixel’s value.

This algorithm, unlike a simple interpolation or curve fitting followed by interpolation, maintains both the general spectral shape and the intensity content of the original files (Interpolation could totally remove a peak if it were between two adjacent output data point wavelengths). The algorithm is general, and doesn’t depend on the input files having the same wavelength resolution or the same number of pixels.

In the second stage of the operation, the intermediate file is glued into the output file. The gluing is done in increasing wavelength point by point, based on the wavelength value of the point. Initially the output file contains all zeroes. Files are glued into the output using several rules, as follows.

- For cases with no overlap between data in the intermediate file and the output file, the intermediate file is just copied to the output file, point by point (pixels in the input file that are outside the wavelength range of the output file are discarded).
- For cases where the intermediate data overlaps the output data, the data from the two files are gradually blended over the overlap region. The most common overlap case for step and glue will be where the intermediate file starts after the output file has data, but before the output data has ended:

```
Output file..... x x x x x x x x 0 0 0 0 0 0 0 0 0 0 0 0 ...
Intermediate file      y y y y y y y y y y y y y y y y y y y ...
```

There are five points in the above overlap region, and the result of the blending would be (left to right):

overlap point number	blending result
1	$(5/6)x + (1/6) y$
2	$(4/6)x + (2/6) y$
3	$(3/6)x + (3/6) y$
4	$(2/6)x + (4/6) y$
5	$(1/6)x + (5/6) y$

(If there is only 1 point in the overlap region then it would have $(1/2)x + (1/2) y$.)

- Another case occurs when the intermediate file starts before the output and ends after the output file has data. In this case also the data is blended across the overlap region.
- Since the glue is a general algorithm, there will be cases such as the following:

```
Output file      .... x x x x x x x x ... x x x x x x x x x x x ...
Intermediate file y y y y y y ... y y y y y y
```

or

```
Output file      ...000000x x x ... x x x x0000000...
Intermediate file y y y y y ... y y y y y y y y
```

In these cases, the composition of the result will be 50% Intermediate and 50% Output.

One of the effects of the above rules is that multiple copies of the same file can be glued and the result will be the same as if only one copy had been used. The blending allows a smooth transition for files with broad spectra.

Calibration and ROI Offsets

In an ideal world, when a CCD camera was attached to a spectrograph, the center of the CCD array would coincide with the center of the spectrograph exit plane. In the real world, they can be separated by several pixels, so that when the spectrograph goes to 0 nm, the peak can show up 5 pixels to the right of the array center, for example. It is the function of the Calibration Offset is to compensate for this. It is a wavelength which, when sent to the Acton, will cause the zero order to land in the center of the array. This offset is then added to every wavelength sent to the Acton. This offset does not depend on the scan pattern of the ROI used.

A second kind of Offset is used when "x" ROIs are programmed into the CCD. The program is designed to keep the requested wavelength in the center of the ROI pattern (in the center of a full x-axis display). If a full x-axis is scanned or if the ROI is symmetrical (just ignore the first and last 10 pixels, e.g.), then this ROI Offset is zero. In the case of a very asymmetrical ROI where the first 512 pixels of a 1024 pixel array are skipped, the center of the array is "pixel" $(1+1024)/2 = 512.5$ and the center of the ROI is $(513+1024)/2 = 768.5$. If the requested wavelength went to the center of the array rather than the center of the ROI, it would be just outside the scanned pixels. The ROI Offset is used to compensate for this. In this example, the ROI Offset is $768.5-512.5 = 256$ pixels. This offset is converted to the equivalent wavelength (at the requested wavelength) and subtracted (in this case) from the requested wavelength before being sent to the Acton.

Suppose you have calibrated your 1200 g/mm grating on the 275 and the calibration offset is 2.2057 nm (as reported on the **Spectrograph | Calibrate | Offset** menu). Using the above ROI, when you ask for 0.00 nm, the 256 pixel ROI is converted to -20.199 nm, and the value sent to the 275 is: $0+2.2057-20.199 = -17.98$ nm.

The ROI Offset pixel to wavelength calculation uses the results of the dispersion calibration. So, if a spectrograph is being calibrated using an asymmetrical ROI, the calibration should be iterated at least once. Because the ROI Offset is calculated separately from the Calibration Offset, once a spectrograph has been calibrated using one ROI, the ROI pattern can be changed without affecting the calibration.

Chapter 15

Post-Acquisition Mask Processes

Introduction

Several post-acquisition mask processes, including Edge Enhancement, Sharpening, Smoothing, a Custom Filter and Morphological Erode and Dilation operations, are provided in the WinSpec/32 software. These processes all use the same **Input** and **Output** tabs but have unique **Parameters** tabs. Since the Input and Output functionality is identical for all of these processes, the Input and Output tabs are described below. The Parameters tabs are described in the appropriate sections.

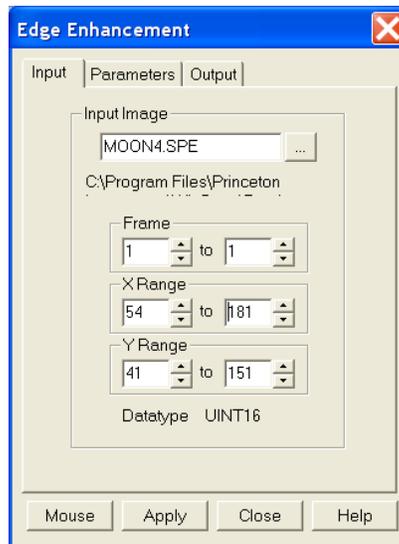


Figure 137. Input tab

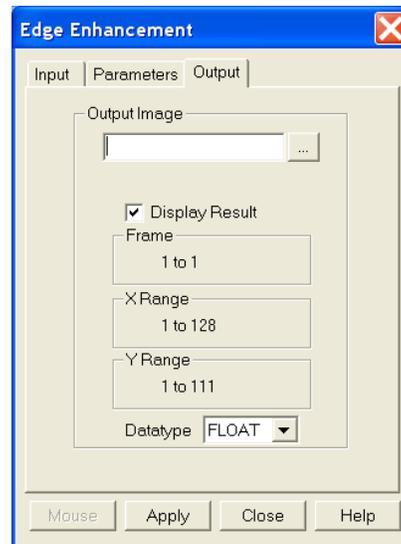


Figure 138. Output tab

Input tab

The **Input** tab (Figure 137) selects the data to be operated on. You can specify the data file, the frames within the file, and the X and Y range on the CCD. The input data-type is reported. Note that the **Mouse** button at the bottom of the window allows you to use the mouse to specify the region to be processed. Simply drag a box in the data region of the active window and then click on **Mouse**. The **Frame** and **Range** parameters will assume the values of the defined region. *The **Mouse** button is only active when the **Input** tab is selected.*

Output tab

The **Output** tab (Figure 138) allows you to name the output file. It additionally allows you to select whether the modified data is to be displayed and to select the data type. The frame and X-Y range are reported information only.

Edge Enhancement

Parameters tab

Edge enhancement is accomplished by mask operations defined by parameters entered on the **Parameters** tab. These functions can enhance edges, sharpen or smooth features, or erode or dilate an image. How these images are processed is briefly described below.

A mask is an $n \times n$ matrix (n is 3 for all WinSpec/32 operations) that is placed over every $n \times n$ subsection of the image. Each parameter in the mask is multiplied by the corresponding value of the image. The results are summed and placed in the central position in the output file. An example will help illustrate the process.

The following is the Laplacian 1 mask, used to enhance edges.

-1	-1	-1
-1	8	-1
-1	-1	-1

Here is an example of a 3×3 subsection of an image. The middle pixel has the coordinates 100, 100.

20	20	19
20	21	20
20	19	20

Multiply each pair of corresponding numbers, and sum the products.

$$(-1 \times 20) + (-1 \times 20) + (-1 \times 19) + (-1 \times 20) + (8 \times 21) + (-1 \times 20) + (-1 \times 20) + (-1 \times 19) + (-1 \times 20) = 10$$

The result is placed at position 100, 100 in the output image file. The mask is now placed over the 9 pixels centered at 101, 100, and the procedure is repeated.

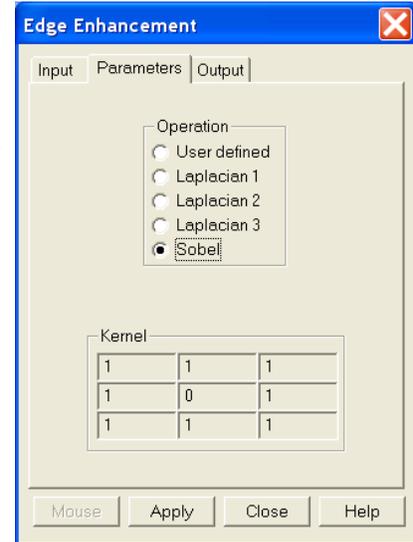


Figure 139. Edge Enhancement/
Parameters tab

Laplacian Masks

The three Laplacian masks on the **Edge Enhancement** dialog operate just as described above. Since the sum of the mask coefficients of the Laplacians sum to zero, the result of a Laplacian operation on a region of uniform density is zero. Boundary features are enhanced by varying degrees.

Sobel Edge Detection

The Sobel edge detection method is more involved, but produces greatly enhanced features. Number the squares of the subregion of the image as follows:

A ₀	A ₁	A ₂
A ₇		A ₃
A ₆	A ₅	A ₄

The replacement for the center cell, called R, is¹

$$R = [X^2 + Y^2]^{1/2}$$

Where:

$$X = (A_2 + 2A_3 + A_4) - (A_0 + 2A_7 + A_6)$$

$$Y = (A_0 + 2A_1 + A_2) - (A_6 + 2A_5 + A_4)$$

Figure 140 illustrates the effect of edge detection on an image.



Figure 140. Original Image (left) and Edge-detected Image (right)

Edge Enhancement Procedure

Use the following procedure to perform Edge Enhancement on an image.

1. Select **Edge Enhancement** from the **Process** menu.
2. Enter the **Input Image** and **Output Image** names.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the **Input Image**, enter the appropriate X-Y range values. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.

¹ Pratt, William K., Digital Image Processing, John Wiley & Sons, New York, 1978, pp. 487-488.

5. Select one of the **Operations**. Since image features vary widely, it is best to simply try the different operations to determine the best one.
6. To set a specialized 3×3 mask, select **User Defined** and change the **Kernel** parameters to their new values.
7. Click on **Apply** to begin processing.

Sharpening Functions

Parameters tab

Sharpening is also accomplished by mask operations, in this case parameters entered on the **Sharpening Parameters** tab. These masks, sometimes called high pass filters, enhance regions of high contrast while not affecting regions of low contrast.

Sharpening Procedure

Use the following procedure to sharpen an image.

1. Select **Sharpening** from the **Process** menu.
2. Enter the **Input Image** and **Output Image** names.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the Input Image, enter the appropriate X-Y range values. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.
5. Select one of the **Operations**. Since image features vary widely, it is best to simply try the different operations to determine the best one.
6. To set a specialized 3×3 mask, select **User Defined** and change the **Kernel** parameters to their new values.
7. Click on **Apply** to begin processing.

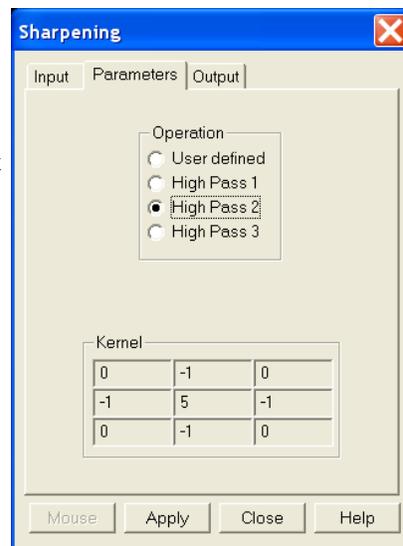


Figure 141. Sharpening/Parameters tab

Smoothing Functions

Parameters tab

Smoothing is also accomplished by mask operations, in this case parameters entered on the the **Smoothing|Parameters** tab (Figure 143). These masks, sometimes called low pass filters, attenuate regions with high contrast, while leaving pixels in regions of low contrast almost unchanged. Figure 142 illustrates the smoothing filter effect.



Figure 142. Original Image (left) and Smoothed Image (right)

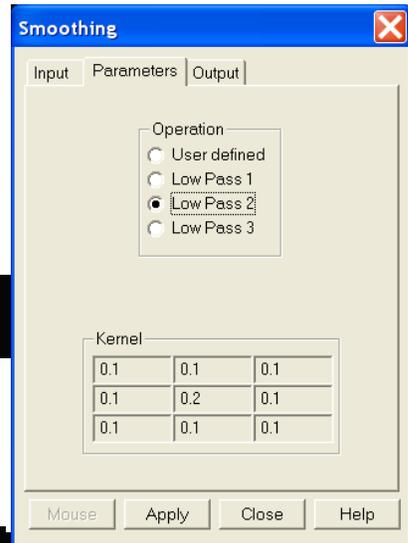


Figure 143. Smoothing|Parameters tab

Smoothing Procedure

Use the following procedure to smooth an image.

1. Select **Smoothing** from the **Process** menu.
2. Enter the **Input Image** and **Output Image** names.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the Input Image, enter the appropriate X-Y range values. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.
5. Select one of the **Operations**. Since image features vary widely, it is best to simply try the different operations to determine the best one.
6. To set a specialized 3×3 mask, select **User Defined** and change the **Kernal** parameters to their new values.
7. Click on **Apply** to begin processing.

Morphological Functions

Parameters tab

Morphological operations are also accomplished by mask operations, in this case parameters entered on the **Morphological|Parameters** tab. There are two basic morphological mask operations, Erode and Dilate. The effect of the Erode process is to reduce the size of a white region, while Dilation increases it. All the options except for Block and User Defined perform the operation in a specific direction only. Block performs the operation in all directions.

Note: Depending on the software version, **Iterations** and the **Open** and **Close** functions may be grayed out as in Figure 144. If these features are not grayed out, **Open** is a number of erodes (specified by Iterations) followed by the same number of dilates. **Close** performs the dilates first and then the erodes.

Examples of some morphological operations follow. References are found at the end of this chapter. In each case the same binary image is shown to the left and the morphologically processed image is shown to the right.

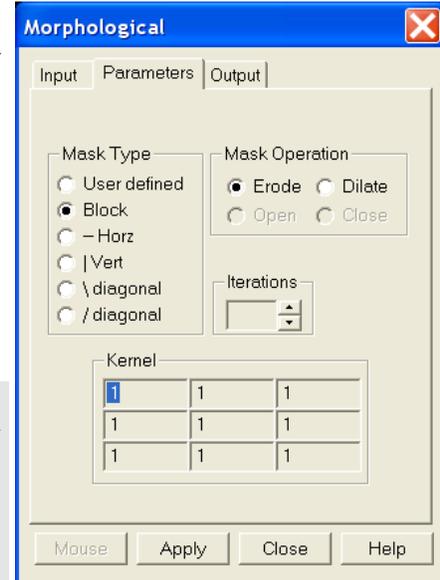


Figure 144. Morphological|Parameters tab



Figure 145. Original Image (left) and Dilated Image (right)



Figure 146. Original Image (left) and Eroded Image (right)



Figure 147. Original Image (left) and Opened Image with Three Iterations (right)

Morphological Procedure

Use the following procedure to morphologically process an image.

1. Select **Morphological** from the **Process** menu.
2. Enter the **Input Image** and **Output Image** names.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the Input Image, enter the appropriate X-Y range values. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.
5. Select the desired **Mask Type** and **Mask Operation**.
6. To set a specialized 3×3 mask, select **User Defined** and change the **Kernel** parameters to their new values.
7. Click on **Apply** to begin processing.

Custom Filter

Filter Matrix tab

The **Custom-Filter|Filter-Matrix** tab allows you to set the filter matrix parameter values. The filter is applied to the dataset specified via the **Input** tab (page 165). The processed data is saved in the file specified by the **Output** tab (page 165).

Filtering is accomplished by mask operations defined by parameters entered in the matrix. These functions can enhance edges, sharpen or smooth features, or erode or dilate an image. How these images are processed is briefly described below.

A mask is an $n \times n$ matrix (n is 5, 7, 9 or 11) that is placed over every $n \times n$ subsection of the image. Each parameter in the mask is multiplied by the corresponding value of the image. The results are summed and placed in the central position in the output file. Users can specify the Filter Size (5×5, 7×7, 9×9 or 11×11). The Filter Sum is displayed in the adjacent box.

The **Load Defaults** button sets the matrix parameters to their factory-default values. When you click on this button, you will see a warning message **"Will erase Data for ALL Filter Sizes; Continue?"** with Yes/No. **"Yes" will erase ALL filter data before loading the factory default values.**

Custom Filter Procedure

Use the following procedure to apply a custom filter to an image.

1. Select **Custom Filter** from the **Process** menu.
2. Enter the **Input Image** and **Output Image** names.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the Input Image, enter the appropriate X-Y range values. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.
5. Define the filter by entering the appropriate values into the matrix.
6. Click on **Apply** to begin processing.

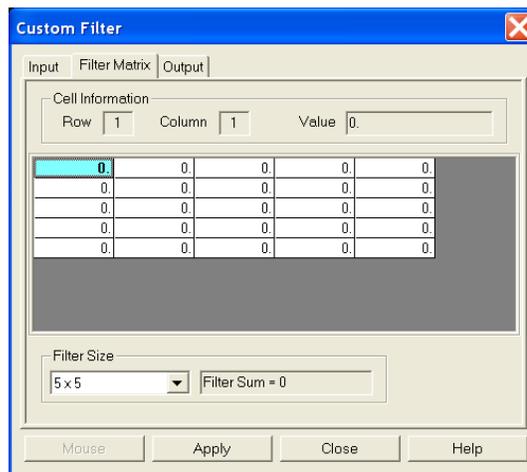


Figure 148. Filter Matrix tab

Look Up Table

Look Up Table tab

The Look Up Table function uses an ASCII text file, provided by the user, to translate pixel intensities from an input file into different intensities in an output file. The input file must be a raw data file (unsigned 16-bit image) since the Look Up Table mapping assumes a 0-65536 range of intensity values in the input file. The map file is a previously created text file (refer to pages 174 and 175 for descriptions of the LUT formats) that must be converted to a binary map file for the actual operation. After the text file is selected, clicking on the **Create Binary LUT** button converts the text information to binary format. Clicking on **Apply** then remaps the image intensities and redraws the data display window appropriately.

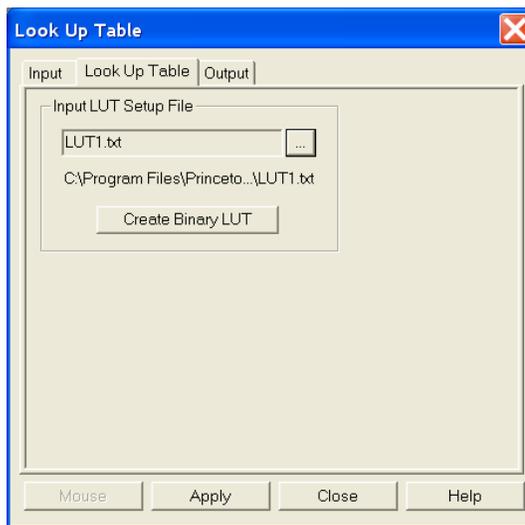


Figure 149. Look-Up Table

Look Up Table Procedure

Use the following procedure to process data using the LUT.

1. Select **Look Up Table** from the **Process** menu.
2. Using the **Input** and **Output** tabs, enter the Input and Output file names.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the Input Image, enter the appropriate X-Y range values. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.
5. Load the LUT. *LUT files must be of the type *.TXT*. The file name can be entered directly or selected by using the browser (clicking on the button at the end of the field opens the browser).
6. Click on the **Create Binary LUT** button to convert the text-LUT to binary.
7. Click on **Apply** to begin convert the input data values to the output values specified per the LUT.

Look Up Table Formats

The contents of a look-up table text file are entered using an ASCII text editor and the file is saved with a .TXT extension. The format used within the file depends on the type of remapping: one-to-one remapping of intensity levels or a user-defined selection of input to output values.

Format 1

This format is for a one-to-one mapping of intensity levels. Imin and Imax (the minimum and maximum input levels, inclusive) are supplied in the first line with a comma delimiter. The subsequent values are supplied one output value per line. The mapping assumes that all of the input intensities in the specified range are represented by an output value. Therefore, the number of output values in the text file must cover the range $[(I_{max}-I_{min}) + 1]$. Input levels below Imin are mapped to the value of Ofirst and input levels above Imax are mapped to the value of Olast.

Imin,Imax	Imin,Imax represents inclusive input range to be remapped
Ofirst	Ofirst is the output value for Imin (or I1)
O2	O2 is the output value for I2
O3	O3 is the output value for I3
O4	O4 is the output value for I4
.	.
.	.
.	.
Olast	Olast is the output value for Imax

Example: The following example is for a one-to-one mapping. As stated previously, the entries after Imin and Imax are output levels. Based on the Imin and Imax values, there are 5 output values $[(7-3) + 1]$. In this example, every input intensity less than 3 (Imin) gets mapped to 20, 3 (Imin) is mapped to 20, 7 (Imax) is mapped to 10, and every input intensity greater than 7 (Imax) is mapped to 10 (Olast). Input intensities 4, 5, and 6 are mapped to 22, 23, and 26 respectively.

```

3,7
20
22
23
26
10

```

Format 2

This format is not a one-to-one mapping in that input intensities between I_{min} and I_{max} , inclusive, can be omitted from the list of In,Out pairs. I_{min} and I_{max} (the minimum and maximum input levels, inclusive) are supplied in the first line with a comma delimiter. This format expects an arbitrary number of entries in the form of In,Out and the In,Out pairs may be listed in any order. The In value must be between I_{min} and I_{max} , inclusive. Anything less than I_{min} is mapped to the first Input mapping. Anything greater than I_{max} gets mapped the output value of the last In,Out pair. Any input value not specified in an In,Out pair is mapped to zero.

I_{min}, I_{max}	I_{min}, I_{max} represents inclusive input range to be remapped
I_{first}, O_{first}	O_{first} is the output value for I_{first} and for any intensity $< I_{min}$
I,O	I is the input value and O is the output value
I,O	O_3 is the output value for I_3
I,O	O_4 is the output value for I_4
.	.
.	.
.	.
I_{last}, O_{last}	O_{last} is the output value for I_{last} and for any intensity $> I_{max}$

Example: The following is a custom mapping. As stated previously, the entries after I_{min} and I_{max} represent are input,output levels. I_{min} and I_{max} are 3 and 7 respectively. Everything less than 3 gets mapped to 13 (the first In,Out mapping). Everything greater than 7 gets mapped to 12 (the last In,Out mapping). Since input values 3 and 4 are not represented in an In,Out pair, these intensities will be mapped to 0.

3,7
6,13
5,11
7,12

References

To explore in further detail the theory and techniques of digital image processing, we suggest the following texts:

1. *Digital Image Processing*, Gregory A. Baxes, Cascade Press, Denver, CO, 1984. ISBN: 0-945591-00-4.
2. *Digital Image Processing*, R. C. Gonzalez, P. Wintz, Addison-Wesley, Reading, MA, 1977. ISBN: 0-201-11026-1.
3. *Digital Picture Processing*, A. Rosenfeld, A. C. Kak, Vol. 1 & 2, Academic Press, New York, 1982. ISBN (Vol. 1): 0-12-1597-301-2, ISBN (Vol. 2): 0-12-597-302-0.
4. *Digital Image Processing*, W. K. Pratt, John Wiley, New York, 1978. ISBN: 0-471-01888-0.

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Chapter 16

Additional Post-Acquisition Processes

Introduction

The processes included in this chapter are accessible from **Processes** menu. These processes all use the same **Input** and **Output** tabs but have unique **Parameters** tabs. Since the Input and Output functionality is identical for all of these processes, the Input and Output tabs are described below. The Parameters tabs are described in the appropriate sections.

Input tab

The **Input** tab (Figure 150) selects the data to be operated on. You can specify the data file, the frames within the file, and the X and Y range on the CCD. The input data-type is reported. Note that the Mouse button at the bottom of the window allows you to use the mouse to specify the region to be processed. Simply drag a box in the data region of the active window and then click on **Mouse**. The **Frame** and **Range** parameters will assume the values of the defined region. *The **Mouse** button is only active when the **Input** tab is selected.*

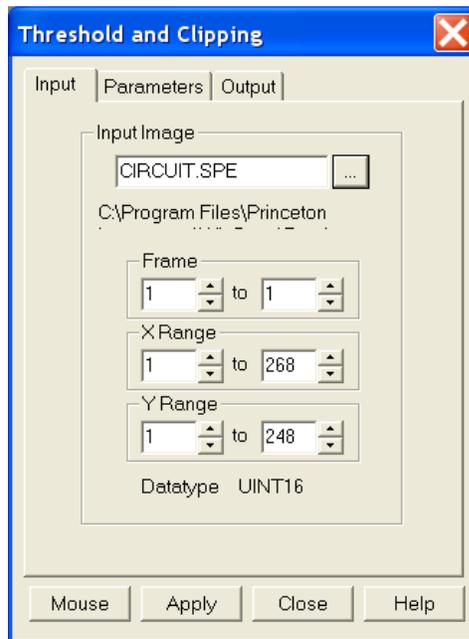


Figure 150. Input tab

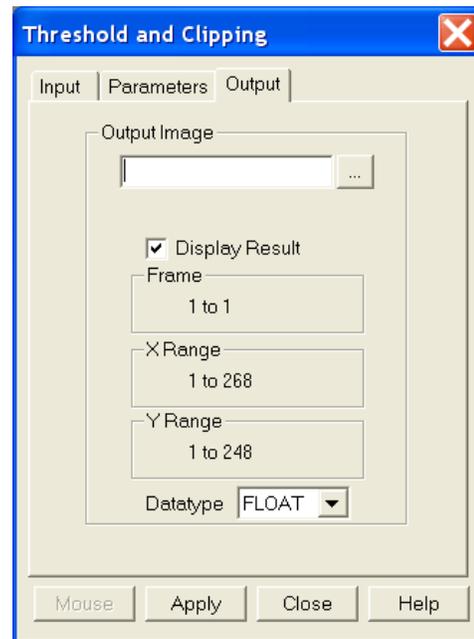


Figure 151. Output tab

Output tab

The **Output** tab (Figure 151) allows you to name the output file. It additionally allows you to select whether the modified data is to be displayed and to select the data type. The frame and X-Y range are reported information only.

Threshold and Clipping

Clipping an image causes pixels outside the specified range to be changed. When **Clip High** is selected, all pixels with values greater than the Clip High value will be changed to the Clip High value. When **Clip Low** is selected, all pixels with values less than the Clip Low value will be changed to the Clip Low value. Selecting **Clip Both** will use both Clip High and Clip low values during the same processing step.

The **Threshold** function converts an image to binary (black and white). All intensity values below the threshold setting are zero (black). All those above become ones (white).

Procedure

1. Select **Clipping/Threshold** from the **Process** menu.
2. On the **Input** tab, if the correct input image does not appear in the **Input Image** box, enter the complete file name or search for a file using the browser, accessed by the button to the right of the field.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the Input Image, enter the appropriate X-Y range values. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.
5. On the **Parameters** tab, if a clipping operation is to be performed, select the clipping option as described above. For a threshold operation, set the threshold level to the desired value.
6. Enter the name of the Output Image on the **Output** tab. *In later editions of the software, it will additionally be possible to specify an output frame and data range.*
7. Click on **Apply** to begin processing.

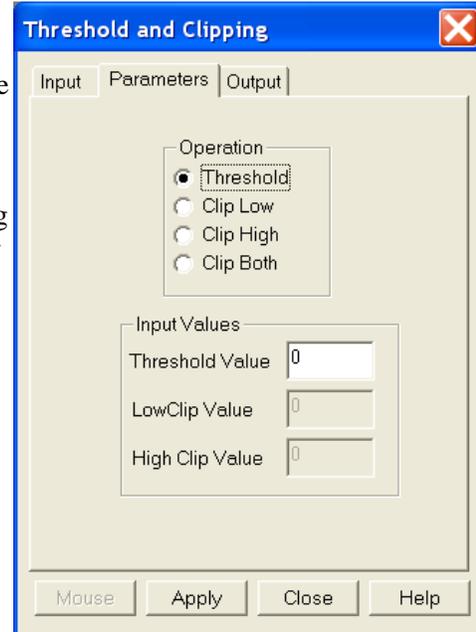


Figure 152. Threshold and Clipping/Parameters tab

Cross Section

Introduction

Selecting **Cross Section** on the **Process** menu opens the **Cross Section** dialog, which allows you to separately display and store horizontal and vertical cross sections of an image. Figure 153 shows two X-axis cross sections based on the same ROI. The upper data is averaged; the lower data is summed.

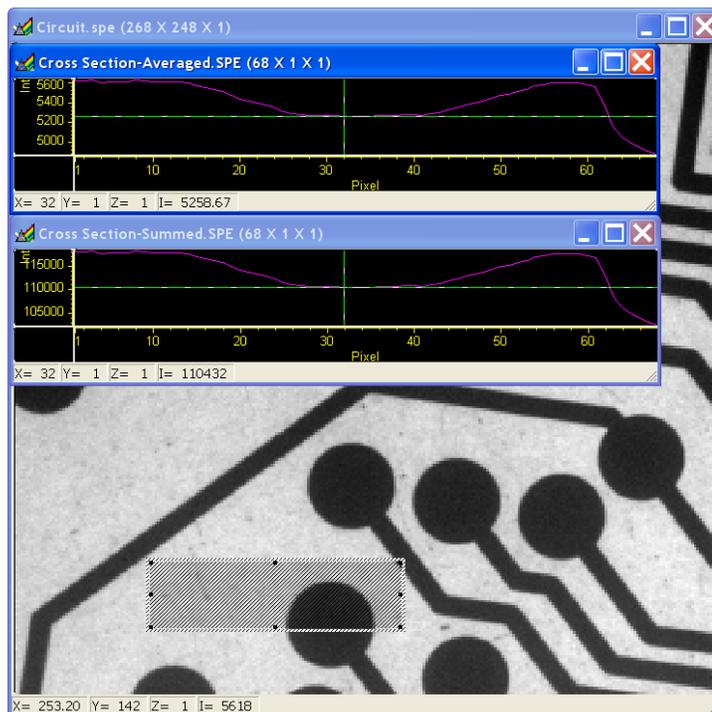


Figure 153. Example Cross Sections of an ROI

Procedure

1. Select **Cross Section** from the **Process** menu.
2. On the **Input** tab, if the correct input image does not appear in the Input Image box, enter the complete file name or search for a file using the browser, accessed by the button to the right of the field.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the Input Image, enter the appropriate X-Y range values. Alternatively, draw an ROI in the active window using the mouse and click the **Mouse** button at the bottom of the dialog to enter those values.
5. On the **Parameters** tab, select either **Sum** or **Average**. If **Sum** is selected, all pixel values in the X, Y, or Z direction, according to whether X-Cross Section, Y-Cross Section or Z-Cross Section is selected, will be summed to generate the output. If **Average** is selected, the average of all of the pixel values in the X, Y, or Z direction will be summed to produce the output.

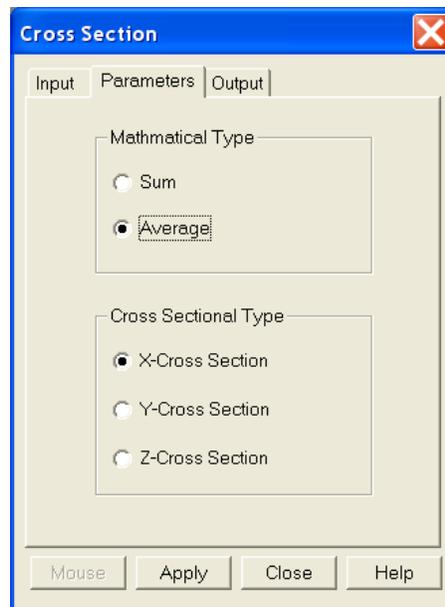


Figure 154. Cross Section/Parameters tab

6. On the **Parameters** tab, select **X-Cross Section**, **Y-Cross Section** or **Z-Cross Section**, whichever is wanted.
7. Enter the name of the Output file on the **Output** tab. *In later editions of the software, it will additionally be possible to specify an output frame and data range.*
8. Click on **Apply** to begin processing.

Binning and Skipping

Introduction

Selecting **Binning** on the **Process** menu opens the **Binning and Skipping** dialog, which allows binning to be accomplished in software after the data has been collected. The **Parameters** tab allows the bin size to be set independently in the X and Y directions. The Skipping parameter allows you to define the interval between binned regions. The Skipping parameter size can be independently set for X and Y. There is also provision for either averaging or summing the binned data points. If Average is selected, each output data value will be the average of the binned data values in each region. If Average is unselected, each output data value will be the sum of the binned data values. The procedure follows.

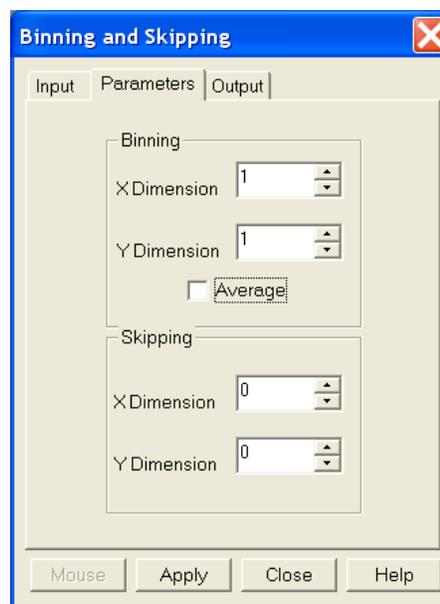


Figure 155. Post-processing Binning and Skipping/Parameters tab

Procedure

1. Select **Binning and Skipping** from the **Process** menu.
2. On the **Input** tab, if the correct input image does not appear in the Input Image box, enter the complete file name or search for a file using the browser, accessed by the button to the right of the field.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the Input Image, enter the appropriate X-Y range values. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.
5. On the **Parameters** tab, set the X and Y bin size.
6. On the **Parameters** tab, select **Average** if the binned data values are to be averaged. If the **Average** box is left unchecked, the binned values will be summed.
7. On the **Parameters** tab, set the **Skip X** and **Y** values. Data points that fall in the skip zones do not contribute to the output. Skip values of zero are allowable, that is, no points will be skipped. Leftover points at the end of a strip or column are discarded.

8. Enter the name of the Output file on the **Output** tab. *In later editions of the software, it will additionally be possible to specify an output frame and data range.*
9. Click on **Apply** to begin processing.

Binning and Skipping Restrictions and Limitations

The following are some restrictions and limitations of the Binning and Skipping function.

- This function can resize an image down to a minimum of 1 pixel but WinSpec/32 cannot display an image less than 2×2 pixels.
- May cause data overflow in the output image if the output data type is selected as “integer.” If data to be binned will exceed 32,000 counts, select Unint or Long.
- The maximum binning and skipping size is the size of the input image. When the maximum is reached, to increase the binning size you must first decrease the skipping size, then increase the binning size.

Histogram Calculation

Introduction

Two types of histograms are available for graphing the distribution of intensities of an image. The **Histogram** operation groups pixels of a similar intensity together. The X-axis indicates the intensity, and the Y-axis displays the number of pixels in that intensity range.

The **Cumulative Histogram** operation groups pixels of a similar intensity together, once again using the X-axis to show intensity. This time, however, the Y-axis indicates the total number of pixels with intensity less than or equal to the range. Thus the Cumulative Histogram is always an increasing function.

Procedure

1. Select **Histogram** from the **Process** menu.
2. On the **Input** tab, if the correct input image does not appear in the Input Image box, enter the complete file name or search for a file using the browser, accessed by the button to the right of the field.
3. On the **Input** tab, select the data frame containing the data on which the operation is to be performed.
4. If you want to process only part of the Input Image, enter the appropriate X-Y range values. Alternatively, use the mouse to draw an ROI in the active window and click the **Mouse** button at the bottom of the dialog to enter those values.
5. On the **Parameters** tab, select either **Histogram** or **Cumulative Histogram**, whichever is wanted.
6. On the **Parameters** tab, under **Values**, enter the **Low Intensity** and **High Intensity** values. These are the Y-Max and Y-min. Then enter the **Group Size**, which is the range of intensity that the software will group together as a single data point. In other words, if the Group Size is 50, pixels having intensities in the range of 1-50 will be counted and graphed as a single point on the histogram.
7. Enter the name of the Output file on the **Output** tab. *In later editions of the software, it will additionally be possible to specify an output frame and data range.*
8. Click on **Apply** to begin processing.

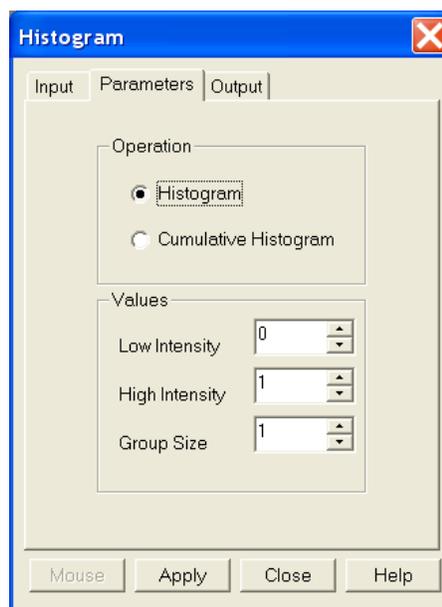


Figure 156. Post-processing Histogram/Parameters tab

Printing

Introduction

WinSpec/32 can be used to print images directly. Methods are listed below both for direct printing and for using the clipboard to transfer the image to another program for printing.

Setting up the Printer

1. Open the file you want to print. Make sure that window is the active one. From the **File** menu, open the **Print Setup** dialog (Figure 157).
2. The **Print Setup** dialog is similar to that found in many Windows programs. You can use the default printer or select a specific printer from the list of installed devices. For information on installing printer drivers, consult the Windows documentation. The **Properties** button shows more features of the selected printer driver – again, a standard Windows feature.
3. Select the **Paper Size** and **Source**. The **Landscape** format (where the paper is wider than it is tall) is probably the best way to print out data.
4. Click on **OK** to execute the printer setup selections or **Cancel** to exit the dialog leaving the original settings unchanged.

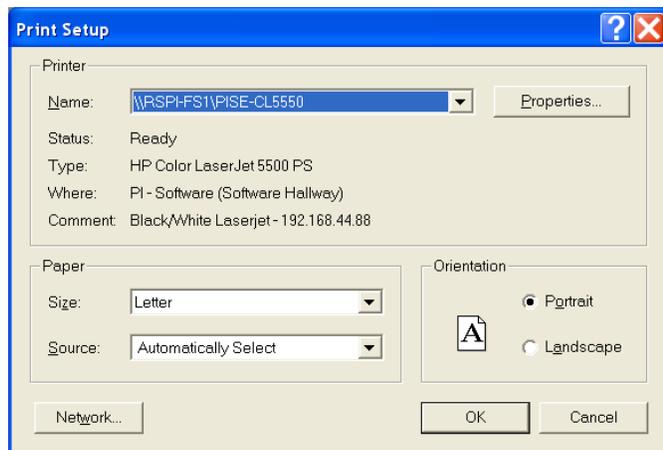


Figure 157. Print Setup dialog

Printing Directly from WinSpec/32

This procedure assumes you have already set up the printer you will be using.

1. From the **File** menu, open the **Print** dialog (Figure 158).
2. Select the number of copies and pages (if a file contains multiple frames, each will be printed as a separate page).
3. Click on **OK** to initiate the print.

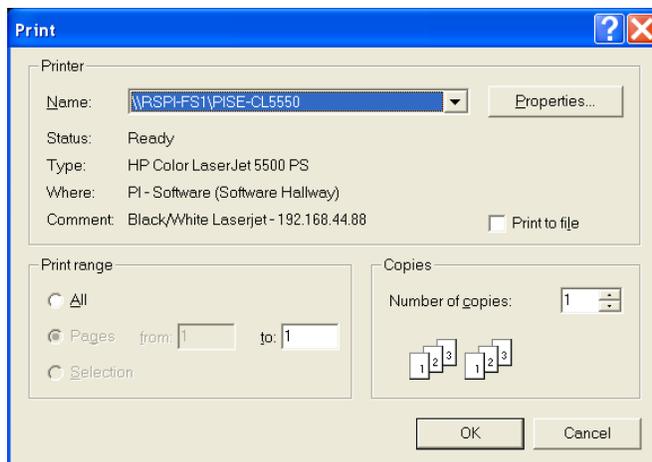


Figure 158. Print dialog

Notes:

1. Once the Print Setup is properly configured, you can print the active window simply by selecting Print from the File menu (shortcut Alt, F, P) or by clicking on the Print button in the standard toolbar.
2. Color mapping to the printer may differ from that shown on the screen. To obtain the desired output color mapping, you may wish to do a screen capture and then paste the image into a graphics program for final adjustment before printing.

Print Preview

The Print Preview function gives you a quick idea of how the printed image will look. It produces an “on-screen print” that looks as closely as possible like a “real” print, allowing changes in the printer setup to be made quickly and conveniently. Figure 159 show the **Print Preview** window.

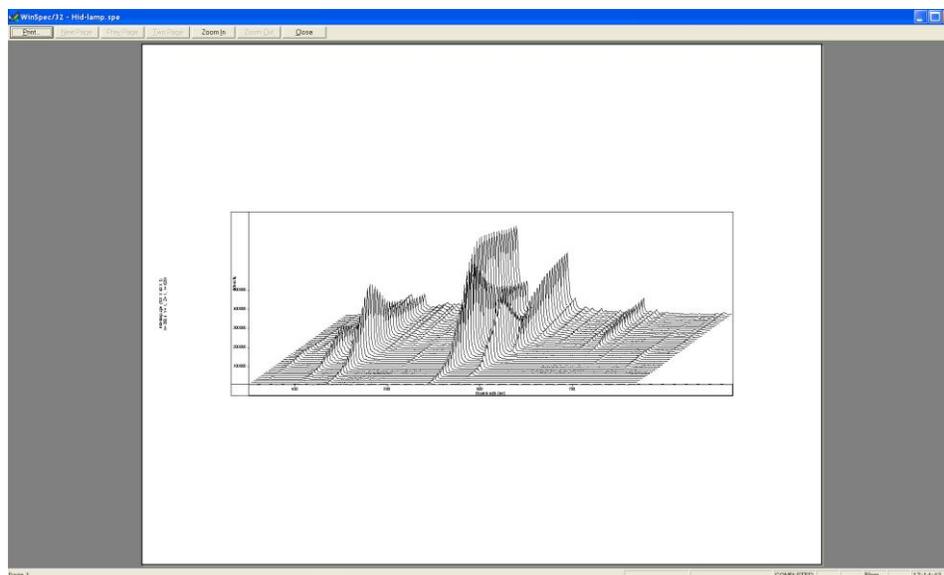


Figure 159. Print Preview window

The button functions are as follows.

Print...: Opens the Print screen so a print can be initiated.

Next Page: If the file contains multiple frames, each one will occupy a different page. The **Next Page** button allows you to step forward sequentially through all available pages. If the file contains only one image, the **Next Page** button will be grayed out.

Prev Page: Allows you to step backwards sequentially through the pages of a multiple image file.

Two Page: Causes two pages to be displayed at a time in a side-by-side layout.

Zoom In: Allows you to zoom in on the previewed page, allowing a selected area to be examined in detail. There are two zoom levels. Note that, if not at full zoom, the cursor becomes a “magnifying glass” if positioned on the image area.

Zoom Out: Allows you to return to the normal (unzoomed) preview display.

Close: Closes the **Print Preview** window and returns you to the normal WinSpec/32 display.

Printing a Screen Capture

It is also possible to do a screen capture of the entire WinSpec/32 window. This is the best way to capture such information as cross sections, scaling, and color lookup tables. A limitation of screen shots is that the resulting image is based on the resolution of the monitor, not the resolution of the image. For a 1 million pixel CCD, even a 600 × 800 video mode is not enough to show all the pixel information.

1. Display the desired image or images in WinSpec/32. Click once on the WinSpec/32 title bar to make this the active window.
2. Press **Alt + Print Screen**. This copies the entire contents of the WinSpec/32 window, including image or graph displays and dialog windows, to the clipboard.

Note: Alternatively, press **Ctrl+C** or select **Copy** on the **Edit** menu to copy an image to the clipboard. *This function only works on image displays and only on the image itself (i.e., scales and cross section information is not transferred). However, it has an advantage in that the full resolution of the image is retained.*

Many text editors and graphics programs allow images to be pasted directly from the clipboard. Paint Shop Pro, a shareware program, is one example of an inexpensive program that can edit and save clipboard screen shots.

1. Open the application. Open a new file within that application.
2. Select **Paste** from the **Edit** menu. This will place the contents of the clipboard into the application. If the image seems cut off, try opening a bigger blank image before pasting the clipboard. The image is now an 8-bit color or grayscale image.
3. Crop the image, if desired. This feature is available in almost any image editing program.
4. Select **Print** from the **File** menu. Print the file.
5. Save the file, if desired. TIFF is an excellent image format for either grayscale or color shots.

Note: Screen-capture images lose the high dynamic range of the original. The Copy function (**Ctrl+C**) retains the full resolution of the data file.

Saving as TIF and Printing

It is also possible to save an image file directly to 8-bit Tif or 16-bit TIFF format by using the **Save As** function on the **File** menu. The resulting file could then be copied to a graphics editing program for further processing and then printed.

Images saved as 8-bit Tif can be opened with a variety of programs (for example, Imaging for Windows (Kodak), Microsoft® Paint, Jasc® Paint Shop Pro®, or Adobe® Photoshop®). The 16-bit TIFF format is not as widely supported. Images saved in this format can be opened and processed with Adobe Photoshop.

Pulser Operation

Introduction

Four different pulser/timing generators are available for use with WinSpec/32. To be available, pulser support must have been installed as described in the Installation chapter. Pulser support is then accessed by selecting **Pulsers** on the **Setup**

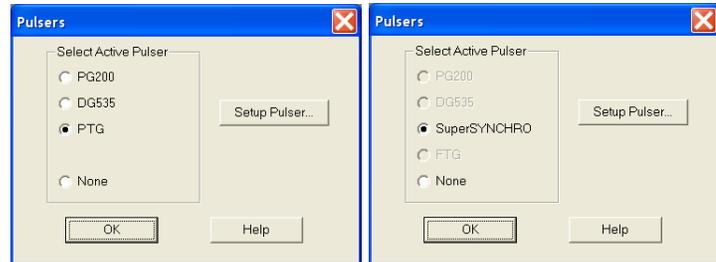


Figure 160. Pulsers dialog

menu and then selecting the pulser to be used with the system.

Available selections include the Princeton Instruments brand PG200 Pulser, the Princeton Instruments brand Programmable Timing Generator (PTG) plug-in module for the ST-133 (high power ver. 3+), the Stanford Research Systems DG535 Digital Delay/Pulse Generator with Inhibit Option, and the SuperSYNCHRO. The Model PG200 is available for all Princeton Instruments intensified detectors except the PI-MAX family of intensified cameras. The PI-MAX and PI-MAX2 require the PTG or DG535. In the case of the PI-MAX3 or PI-MAX4 camera (which has an internal controller), its internal pulser is the SuperSYNCHRO. All four pulser/timing generators are programmable from WinSpec/32. Consult the applicable hardware manuals for detailed instructions on setup and connection to other devices.

PG200 Programmable Pulse Generator

The PG200 is programmed via one of the serial ports of the computer, such as COM1 or COM2. The choices provided by the tabs are the same ones that are available using the PG200 front panel. Basic PG200 operation is reviewed in the following procedure.

1. Make sure the PG200 is connected to one of the serial ports of the computer. Later you will tell WinSpec/32 the name of this port (COM1, COM2, etc.). The software cannot automatically detect the location of the PG200.
2. Following the intensifier precautions listed in the hardware manuals, turn on the PG200 Pulser and wait for it to initialize. If the PG200 is not turned on, the WinSpec/32 software cannot program it.
3. Select **Setup**, then **Pulsers**, then **PG200**. Then click on the **Setup PG200** button to open the PG200 dialog. *If PG200 is grayed out on the **Pulsers** dialog, PG200 pulser support has not been installed.*
4. Click on the **Comm Port** tab.
5. Select the Comm Port type, **Serial** or **Demo. Serial** must be selected to control the PG200.

6. Select the PG200 Comm Port.
Generally, the mouse is connected to COM1 and the Pulser is connected to COM2. COM ports 1 through 8 can be selected.
7. Once you have selected the correct port, click on **Initialize Port**, which will cause the software to search for the pulser. If it cannot find the pulser on the specified port, such as would occur if the pulser were not turned on or if it were connected to a different port, you will get an error message. If this happens, check the cable connections, check that the pulser is powered, or try a different Comm port.

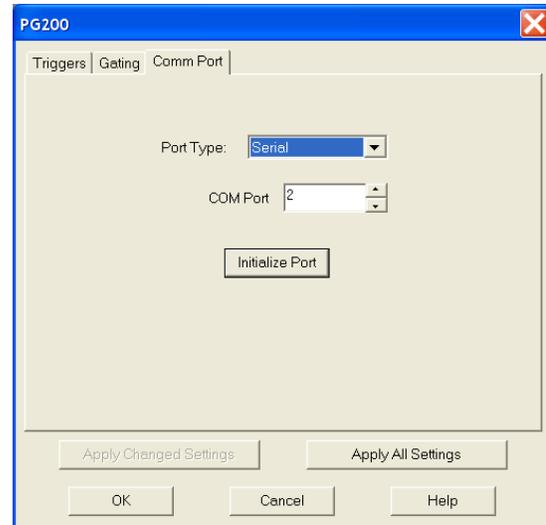


Figure 161. PG200/Comm Port tab

8. Click on the **Triggers** tab (Figure 162).
9. Select the Trigger mode, either **Internal**, in which the PG200 free runs, or **External**, in which it is triggered from an external source.
10. If operating in the Internal trigger mode, set the **Trigger Frequency** in Hz. Consult the PG200 Manual to determine the maximum Trigger Frequency for a given set of conditions.

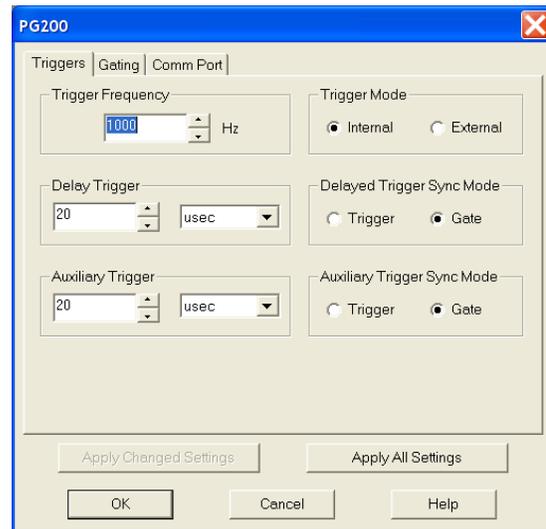


Figure 162. PG200/Triggers tab

The PG200 **Delay Trigger** and **Auxiliary Trigger** outputs, are programmed from the **Triggers** tab. They produce trigger outputs that are synchronized to and delayed from the trigger (**Trigger Sync mode**) or from the trailing edge of the gate pulse (**Gate Sync mode**). In the Gate Sync mode, as the gate pulse changes its position and width, the trigger outputs remain synchronized with the gate, moving with it. In the Trigger Sync mode, the trigger outputs do not sweep with the gate but maintain their initial position. The Delayed Trigger and Auxiliary Trigger outputs are independently programmable.

Programming the Delayed Trigger and Auxiliary Trigger Outputs:

1. Set the **Delay Trigger** and **Aux Trigger** initial delay.
2. Set the **Delay Trigger** output to be synchronized to either the **Trigger** or the **Gate** pulse.

3. Set the **Aux Trigger** output to be synchronized to either the **Trigger** or the **Gate** pulse.
4. Click on the **Gating** tab (Figure 163).
5. Select **Repetitive** or **Sequential** and then click on the adjacent **Setup** button. *For safety, the **Gating Mode (HV Pulsing)** selection should be **Disabled**.*

Note: In setting the PG200 gating parameters, whether for Repetitive or Sequential operation, see your PG200 Manual for pulse width and delay limitations. Note that gate pulses are capacitively coupled in many Princeton Instruments intensified camera heads, so high duty cycles and gate widths longer than 1 ms may lead to reduced gating efficiency.

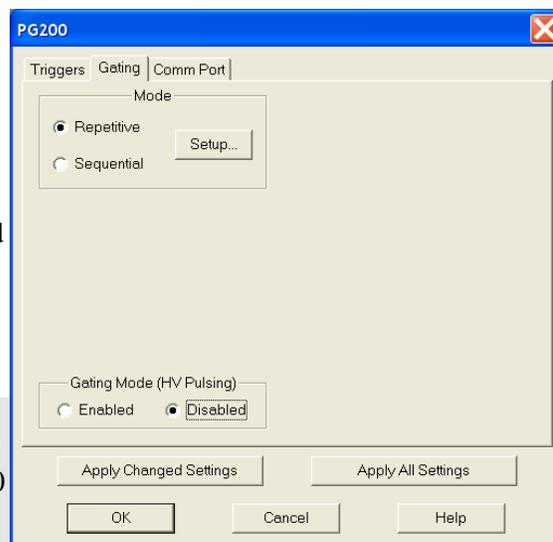


Figure 163. PG200/Gating tab

Repetitive Mode

If Repetitive is selected, the **Repetitive Gating Setup** dialog will appear as shown in Figure 164. In the Repetitive gating mode, the Gate Width and Gate Delay remain constant over the course of the measurement. Set the Gate Width and Gate Delay to the desired values and click on **OK**. The **Repetitive Gating Setup** dialog will close and you will return to the **PG200** dialog.

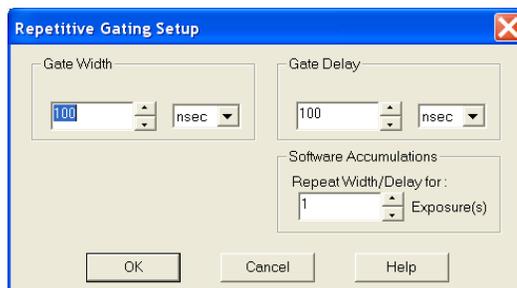


Figure 164. PG200/Repetitive Gating Setup dialog

Sequential Mode

If Sequential is selected, the **Sequential Gating Setup** dialog will appear as shown in Figure 165. In the Sequential Gating mode, the Gate Width and Gate Delay do not remain constant but change either linearly (Fixed) or exponentially as the measurement progresses. Fixed is suited to sweeping over a time interval to locate and recover an event that takes place at the same time with each iteration. Exponential is well suited to fluorescence decay experiments where the effect under study changes rapidly at the start of an experiment and then slower and slower, following a logarithmic curve, as the experiment progresses.

If the measurement is to be done in the sequential gating mode, set the gating parameters (see "**Sequential Mode Parameters**" on page 203 for more information) as appropriate for your intended measurement and click on **OK**. The **Sequential Gating Setup** dialog will close and you will return to the **PG200** dialog.

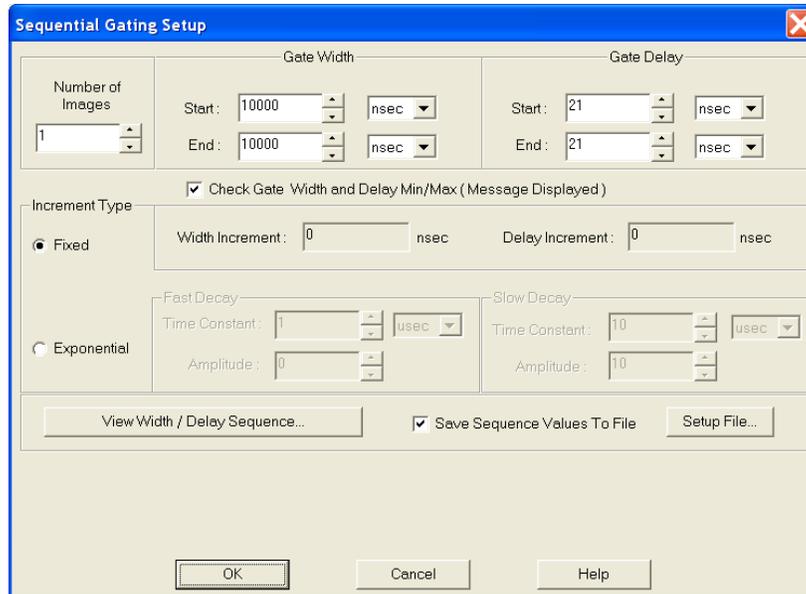


Figure 165. PG200/Sequential Gating Setup dialog

6. Click on the **Gating** tab.
7. Select **Gating Mode (HV Pulsing) Enabled** to start gating the intensifier. Be sure you have followed all intensifier precautions stated in the hardware manuals before making this selection.
8. Click the **Apply Changed Settings** button. This writes all changed parameters to the PG200. It may take several seconds, depending on the number of parameters that have been changed. To set *all* of the parameters, click on the **Apply All Settings** button.
9. Click on **OK** to close the dialog.

DG535 Digital Delay/Pulse Generator

The DG535 is programmed via the IEEE-488 GPIB port of the computer (default GPIB address is 15). The choices provided by the tabs are the same ones that are available using the DG535 front panel. Basic DG535 operation is reviewed in the following procedure. The individual tab selections are discussed in detail in the online Help topics.

Note: The DG535 is used to control the PI-MAX gate functions. If the system is equipped with a PI-MAX camera, the Camera State dialog (Figure 166) will appear when the software is started. Although the software always initially places the PI-MAX in Safe mode, you have the option of restarting with the last setting (Shutter Mode or Gate Mode).

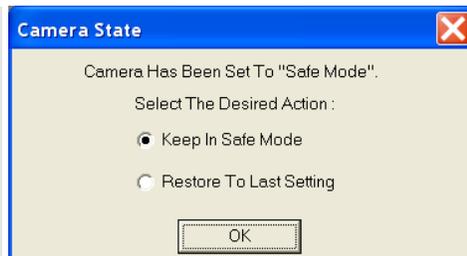


Figure 166. Camera State dialog

1. Make sure the DG535 is connected to the computer's IEEE-488 GPIB port. Later you will tell WinSpec/32 the DG535's GPIB address. *The default setting is 15.*
2. Following all intensifier precautions listed in the hardware manuals, turn on the DG535 and wait for it to initialize. If the DG535 is not turned on, the WinSpec/32 software will not be able to program it.
3. Select **Setup** and then **Pulsers** to open the **Pulsers** dialog.
4. Select **DG535**. Then click on the **Setup DG535** button. The **DG535** dialog will open.

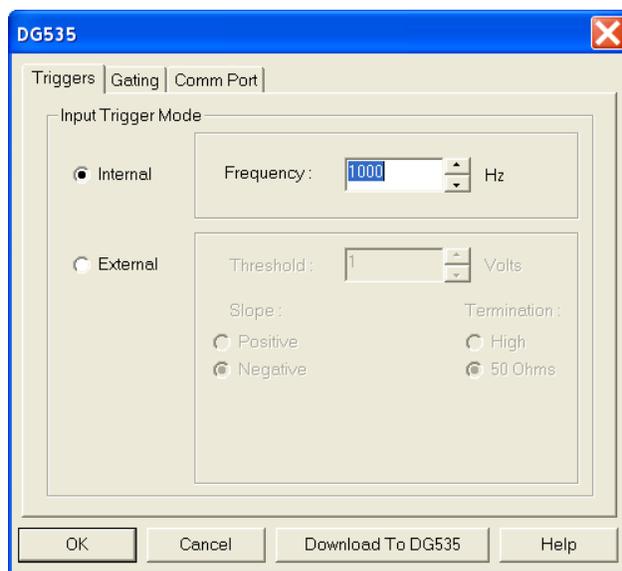


Figure 167. DG535 dialog

5. Click on the **Comm Port** tab (Figure 168).
6. For the Port Type select GPIB. Then set the **Port Address** to the GPIB address of the DG535. *Default setting is 15.*
7. Once you have selected the correct port address, click on **Initialize Port**. If the software cannot find the pulser on this port, such as if the pulser is not turned on or if the address setting incorrect, you will get an error message. If this happens, check the address, check the cable connections and check that the pulser is powered.

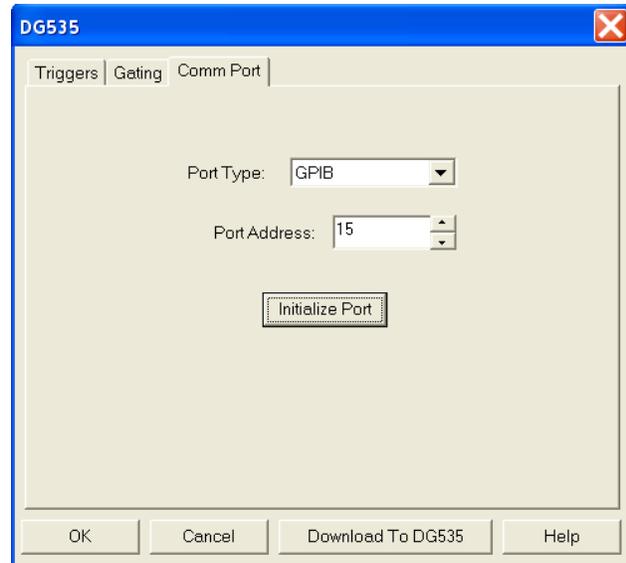


Figure 168. DG535/Comm Port tab

8. Click on the **Triggers** tab (Figure 169).
9. Select the Trigger mode, either **Internal**, in which the DG535 free runs, or **External**, in which it is triggered from an external source.
10. If operating in the **Internal** trigger mode, set the **Trigger Frequency** in Hz. Consult the DG535 Manual to determine the maximum Trigger Frequency that can be used in your application.
11. If operating in the **External** trigger mode, specify the **Slope**, **Threshold**, and **Termination** appropriate for the trigger source.

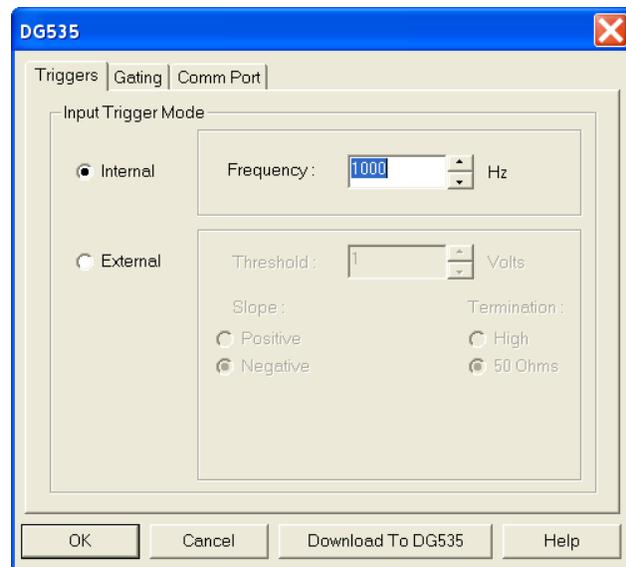


Figure 169. DG535/Triggers tab

12. Click on the **Gating** tab.
13. Select **Repetitive** or **Sequential** and then click on the adjacent **Setup** button.

Repetitive Mode: If

Repetitive is selected, the **Repetitive Gating** setup dialog will appear (Figure 171). In this mode, the Gate Width and Gate Delay remain constant over the course of the measurement.

If operating in the Repetitive Gating mode, simply set the Gate Width and Gate Delay to the desired values and click on **OK**. The **Repetitive Gating Setup** dialog will close and you will return to the **DG535** dialog.

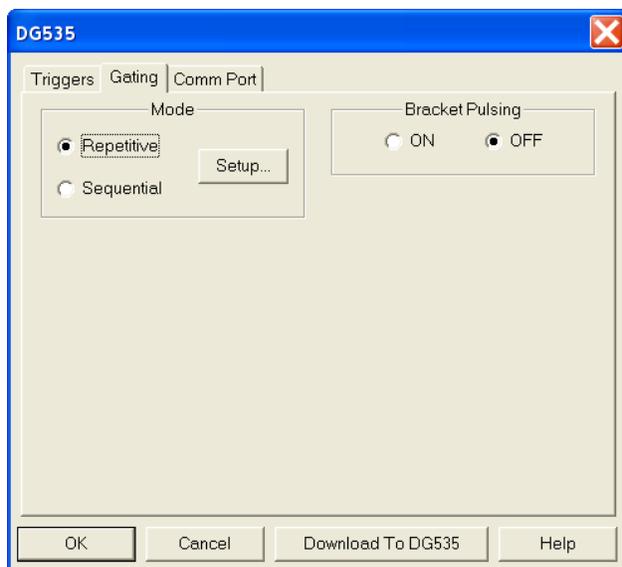


Figure 170. DG535/Gating tab

Sequential Mode: If

Sequential is selected, the **Sequential Gating Setup** dialog will appear as shown in Figure 172. In the Sequential Gating mode, the Gate Width and Gate Delay do not remain constant but change either linearly or exponentially as the measurement progresses.

Linear is suited to sweeping over a time interval to locate and recover and event that takes place at the same time with each iteration.

Exponential is well suited to fluorescence decay experiments where the effect under study changes rapidly at the start of an experiment and then slower and slower, following a logarithmic curve, as the experiment progresses. The

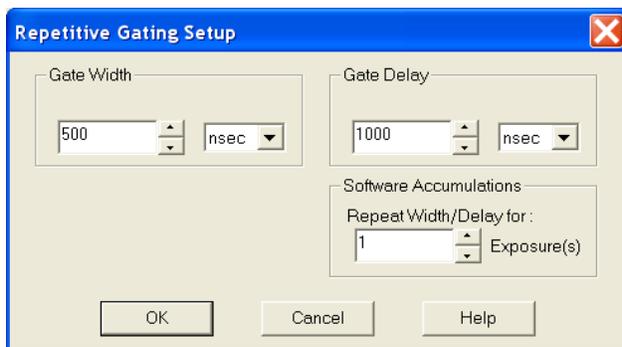


Figure 171. DG535/Repetitive Gating Setup

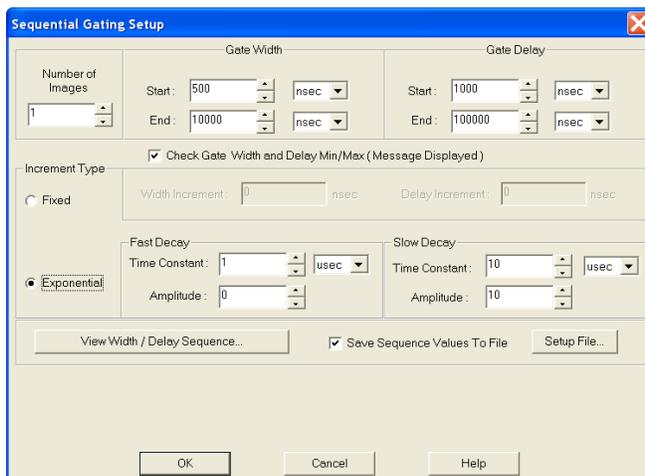


Figure 172. DG535/Sequential Gating Setup dialog

resulting data points can be spline-fitted to generate the complete curve so that the decay constant can be calculated, even where the data derives from two decay processes occurring simultaneously.

If the measurement is to be done in the sequential gating mode, set the gating parameters (see “*Sequential Mode Parameters*” on page 203 for more information) as appropriate for your intended measurement and click on **OK**. The **Sequential Gating Setup** dialog will close and you return to the **DG535** dialog.

14. Select **Bracket Pulsing On** or **Off**.

Note: Bracket pulsing is only useful in low duty factor gated measurements in the UV with the PI-MAX camera. See your PI-MAX manual for detailed information.

15. After you have finished setting up the parameters, click on **Download to DG535**. This writes all of the parameter values to the DG535.
16. Click on **OK** to close the window.

Note: The DG535 can also be controlled interactively as data is being collected.

Programmable Timing Generator (PTG)

Unlike the PG200 and the DG535, the PTG is not a free-standing instrument but rather a plug-in module designed for installation in a special version of the ST-133 Controller. This novel and highly integrated approach to timing generator design, with its advanced high-speed electronics, low insertion delay and programmable functions, achieves superior performance as the ultimate gate controller for the PI-MAX Intensified Camera.

Basic PTG operation is reviewed in the following procedure. The individual tab selections are discussed in detail in the online Help topics.

Note: The gate functions of the PI-MAX camera are controlled by the PTG. If the system is equipped with a PI-MAX camera, the **Camera State** dialog (Figure 173) will appear when the software is started. Although the software always initially places the PI-MAX in Safe mode, you have the option of restarting with the last setting (Shutter Mode or Gate Mode).

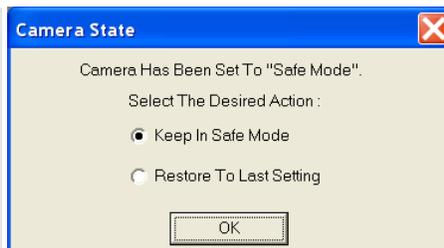


Figure 173. Camera State dialog

1. Following the intensifier precautions stated in the hardware manuals, turn on the Controller (PTG installed). *If the Controller is not turned on, the WinSpec/32 software will not be able to control the PTG.*
2. On the **Setup** menu select **Pulsers** to open the Pulsers dialog.
3. Select **PTG**. Then click on the **Setup Pulser** button. The PTG dialog (Figure 175) will open. *If PTG is grayed out on the Pulsers dialog, PTG support has not been installed.*

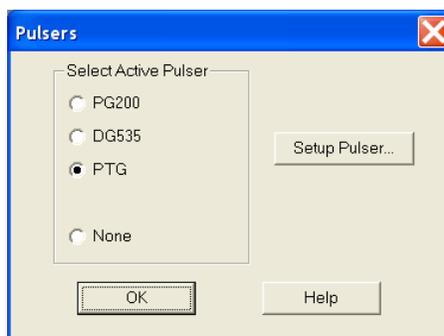


Figure 174. Pulsers dialog

4. Select the Trigger mode, either **Internal**, in which the PTG free runs, or **External**, in which it is triggered from an external source.
5. If operating in the **Internal** trigger mode, set the trigger **Frequency** in Hz.
6. If operating in the **External** trigger mode, specify the **Threshold, Slope, Coupling, Termination** and **Gate Delay From** appropriate for the trigger source. Note that the gate delay from the T0 connector is approximately 24 ns.
7. Click on the **Gating** tab (Figure 176).

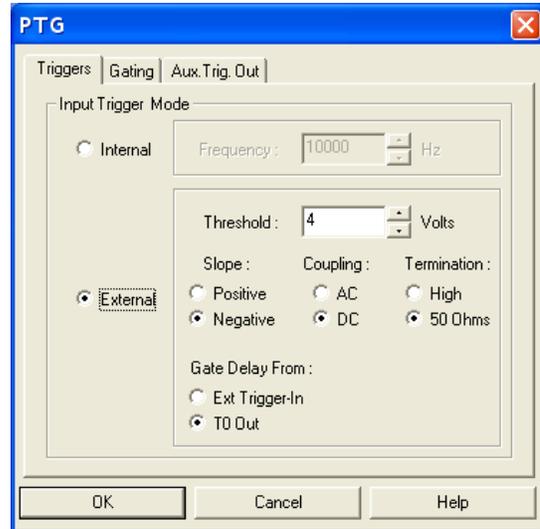


Figure 175. PTG/Triggers tab

8. Select **Repetitive** or **Sequential** and then click on the adjacent **Setup** button.

Repetitive Mode

If Repetitive is selected, the **Repetitive Gating Setup** dialog will appear as shown in Figure 177. In the Repetitive gating mode, the Gate Width and Gate Delay remain constant over the course of the measurement. If operating in the Repetitive Gating mode, simply set the **Gate Width** and **Gate Delay** to the desired values and click on **OK**. The **Repetitive Gating Setup** dialog will close and you will return to the **PTG** dialog.

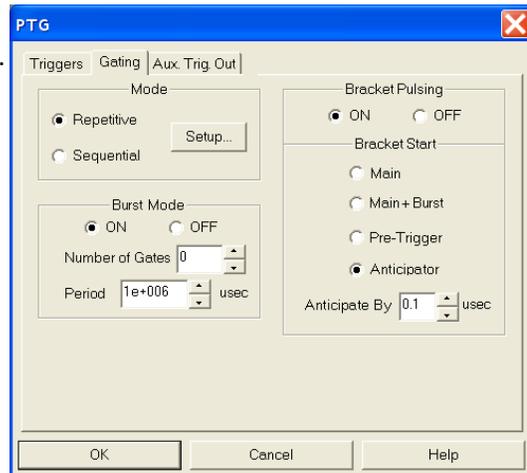


Figure 176. PTG/Gating tab

Sequential Mode

If Sequential is selected, the **Sequential Gating Setup** dialog will appear as shown in Figure 178. In the Sequential Gating mode, the Gate Width and Gate Delay do not remain constant but change either linearly (**Fixed**) or exponentially as the measurement progresses.

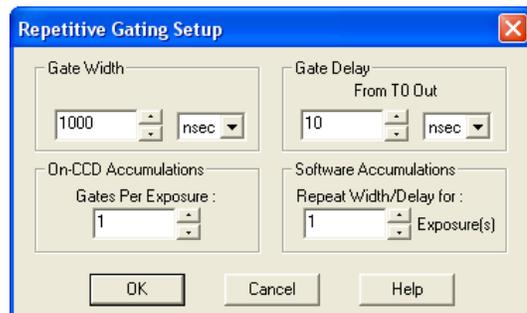


Figure 177. PTG/Repetitive Gating Setup

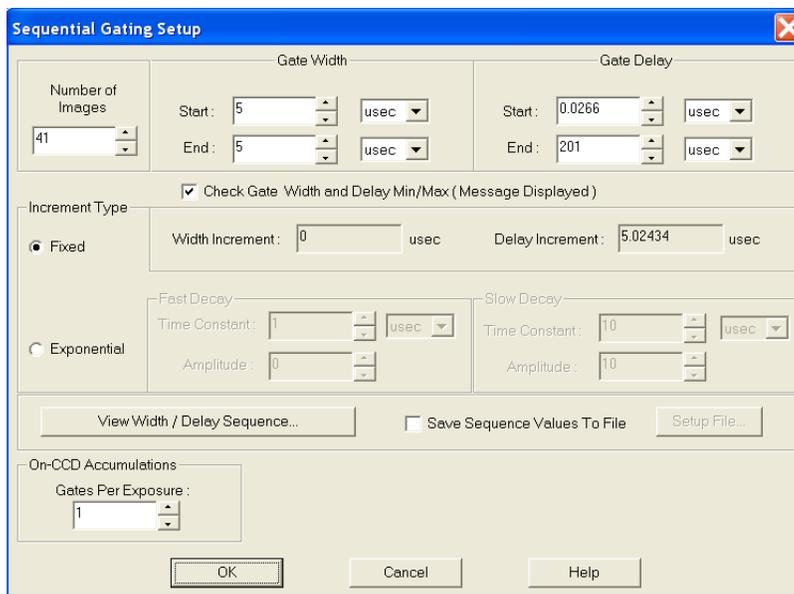


Figure 178. PTG/Sequential Gating Setup dialog

Fixed is suited to sweeping over a time interval to locate and recover an event that takes place at the same time with each iteration. **Exponential** is well suited to fluorescence decay experiments where the effect under study changes rapidly at the start of an experiment and then slower and slower, following a logarithmic curve, as the experiment progresses. In any case, if the measurement is to be done in the sequential gating mode, set the gating parameters (see “*Sequential Mode Parameters*” on page 203 for more information) as appropriate for your intended measurement and click on **OK**. The **Sequential Gating Setup** dialog will close and you return to the **PTG** dialog.

9. Select Burst **ON** or **OFF**. If you select **ON**, each trigger will initiate a burst of gate pulses. Set the number of pulses in the burst and their period.

Note: If Burst and Bracket Pulsing are both selected, the entire burst will be bracketed but not the individual pulses within a burst. When both of these modes are active, you must select Main+Burst for the Bracket Start.

10. Select Bracket Pulsing **ON** or **OFF**.

Note: Bracket pulsing is only useful in low duty factor gated measurements in the UV with the PI-MAX camera. See your PI-MAX system manual for detailed information.

11. If you select Bracket Pulsing **ON**, next select the **Bracket Start** appropriate to your setup. Keep in mind that the on/off switching of the MCP bracket pulsing is slow, taking about 500 ns to turn on and 200 ns to turn off.

The **Bracket Start** choices are:

- **Main:** Main times the bracket start from the main trigger (either an external or an internal trigger). Select this if the event of interest will occur at least 1 μ s after the main trigger (the 1 μ s includes the 500 ns required to turn the MCP fully on).
- **Main+Burst:** Select this if Burst mode is active. Brackets an entire burst but not the individual pulses within a burst.

- **Pre-Trigger:** Allows you to capture an event that would otherwise occur while the MCP was turning on. This selection requires that, in addition to the main trigger at **Ext Trig In**, you trigger the PTG by a pulse applied to the **Pre-Trig In** BNC. The pre-trigger must be at least 525 ns before the main trigger. After an insertion delay of approximately 25 ns, the MCP will be gated on before the main trigger occurs. The main trigger plus the gate delay and width parameters determine the photocathode gating and the MCP turn off. Because the MCP is gated on earlier, it is on for a longer period of time and therefore there is a slight loss of on/off ratio. However, you would be able to capture a non-repetitive event.
- **Anticipator:** Select this if the experiment is repetitive, driven by an external trigger at a constant frequency, and the event of interest would occur before the MCP has fully turned on. It is critical that the trigger pulse be as jitter free as possible, since the anticipator circuit will look at the pulse repetition rate (for the first pulse to pulse period), and then anticipate each of the subsequent external triggers in the series. In this way, the bracketing pulse is timed to lead the photocathode gate pulse by the anticipate time entered in the **Anticipate By** field. The on/off ratio in the UV is retained.

For proper operation, the bracketing pulse must begin at least 500 ns before the gate pulse. The minimum Anticipator Time is 500 ns (or the minimum PI-MAX bracket lead-time from EEPROM) minus the minimum Gate Delay time. For example, with a minimum Gate Delay time of 200 ns, the minimum Anticipator time would be 300 ns.

12. The **Aux. Trig. Out** tab sets the delay time of the Auxiliary Trigger Output with respect to the PTG trigger time. The minimum delay is 24 ns and the longest is 10 ms. The resolution is 0.04 ns. The auxiliary timer's output is available through the Aux. Trig. Out rear panel BNC for triggering other system components.

The **Automate for Single Trigger Kinetics Delay** check box will only appear if you have set up the PTG for single trigger kinetics. When this box is checked, the Delay from T0 box will be grayed out and the Delay from T0 will be automatically calculated from the gate width + gate delay times whenever either or both of these times is changed.

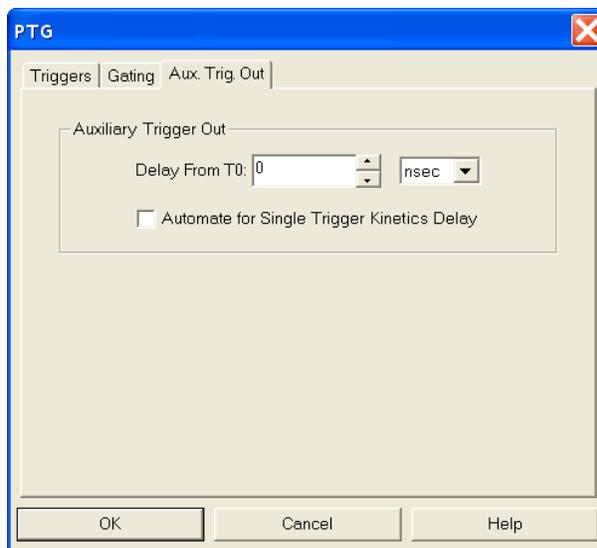


Figure 179. PTG/Aux. Trig. Out tab

13. Click the **OK** button. This writes all of the parameter values to the PTG.

Note: The PTG can also be controlled interactively as data is being collected. For more information, see “*Timing Generator Interactive Trigger Setup*,” starting on page 206.

SuperSYNCHRO Timing Generator

SuperSYNCHRO is a timing generator that has been designed into the PI-MAX3 and PI-MAX4. Basic SuperSYNCHRO operation is reviewed in the following procedure.

Note: The gate functions of the PI MAX3 or PI-MAX4 camera are controlled by the SuperSYNCHRO. Because the system is equipped with a PI-MAX3 or PI-MAX4 camera, the **Camera State** dialog will appear when the software is started. Although the software always initially places the camera in Safe mode, you have the option of restarting with the last mode setting.



Figure 180. Camera State dialog

Procedure:

1. Following the intensifier precautions stated in the PI-MAX3 or PI-MAX4 system manual, turn on the camera. Then start the WinSpec/32 software.
2. On the **Setup** menu select **Pulsers** to open the **Pulsers** dialog.

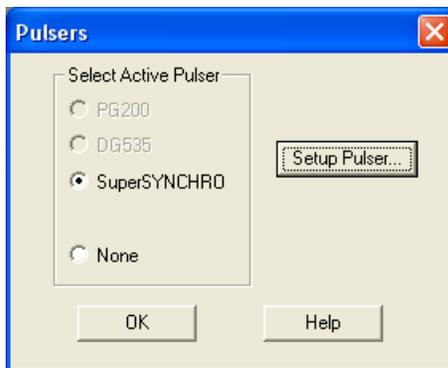


Figure 181. Pulsers dialog

3. Select **SuperSYNCHRO**. Then click on the **Setup Pulser** button. The **SuperSYNCHRO** dialog will open.

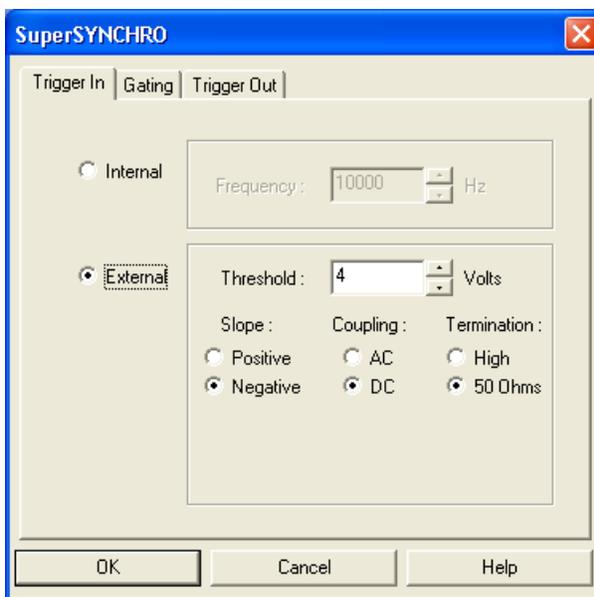


Figure 182. SuperSYNCHRO dialog

4. Select the Trigger In mode, either **Internal**, in which SuperSYNCHRO free runs, or **External**, in which it is triggered from an external source.
5. If operating in the **Internal** trigger mode, set the trigger **Frequency** in Hz.
6. If operating in the **External** trigger mode, specify the **Threshold**, **Slope**, **Coupling** and **Impedance** appropriate for the trigger source.



Figure 183. SuperSYNCHRO\Gating tab

7. If the PI-MAX3 or PI-MAX4 has a Gen II intensifier, you can turn **Bracket Pulsing ON** or **OFF**. When it is turned **ON**, the MCP will be biased OFF except for an interval that brackets the timing of the photocathode gate. This minimizes optical leakage through the photocathode to the UV-sensitive MCP when the photocathode is gated Off. Bracket pulsing does not help in the visible region.

Note: Bracket pulsing is only useful in low duty factor gated measurements in the UV with the PI-MAX3 or PI-MAX4 camera. See your PI-MAX3 or PI-MAX4 system manual for detailed information.

8. Click on the **Gating** tab.
9. Select **Repetitive** or **Sequential** and then click on the adjacent **Setup** button.

Repetitive Mode

If Repetitive is selected, the **Repetitive Gating Setup** dialog will appear. In the Repetitive Gating mode, the Gate Width and Gate Delay remain constant over the course of the measurement. If operating in the Repetitive Gating mode, simply set the Gate Width and Gate Delay to the desired values and click on **OK**. The **Repetitive Gating Setup** dialog will close and you will return to the **SuperSYNCHRO** dialog.

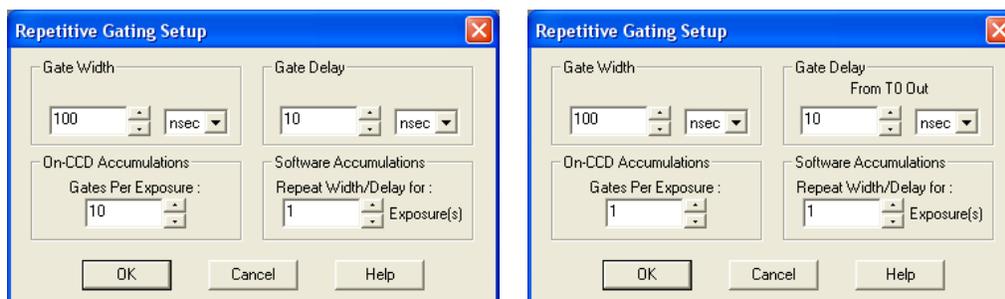


Figure 184. SuperSYNCHRO/Repetitive Gating dialog (Internal Trigger on left; External Trigger on right)

Sequential Mode

If Sequential is selected, the **Sequential Gating Setup** dialog will appear. In the Sequential Gating mode, the Gate Width and Gate Delay do not remain constant but change either linearly (**Fixed**) or exponentially as the measurement progresses. **Fixed** is suited to sweeping over a time interval to locate and recover an event that takes place at the same time with each iteration. **Exponential** is well suited to fluorescence decay experiments where the effect under study changes rapidly at the start of an experiment and then slower and slower, following a logarithmic curve, as the experiment progresses. In any case, if the measurement is to be done in the Sequential Gating mode, set the gating parameters as appropriate for your intended measurement and click on **OK**. The **Sequential Gating Setup** dialog will close and return you to the **SuperSYNCHRO** dialog.

The screenshot shows the 'Sequential Gating Setup' dialog box with the following settings:

- Number of Images:** 41
- Gate Width:** Start: 5 usec, End: 5 usec
- Gate Delay:** Start: 1 usec, End: 201 usec
- Check Gate Width and Delay Min/Max (Message Displayed)**
- Increment Type:**
 - Fixed**: Width Increment: 0 usec, Delay Increment: 5 usec
 - Exponential**:
 - Fast Decay:** Time Constant: 1 usec, Amplitude: 0
 - Slow Decay:** Time Constant: 10 usec, Amplitude: 10
- Buttons:** View Width / Delay Sequence..., Save Sequence Values To File (unchecked), Setup File...
- On-CCD Accumulations:** Gates Per Exposure: 1
- Bottom Buttons:** OK, Cancel, Help

Figure 185. SuperSYNCHRO/Sequential Gating dialog (Internal Trigger)

The screenshot shows the 'Sequential Gating Setup' dialog box with the following settings:

- Number of Images:** 41
- Gate Width:** Start: 5 usec, End: 5 usec
- Gate Delay:** Start: 0.0266 usec, End: 201 usec
- Check Gate Width and Delay Min/Max (Message Displayed)**
- Increment Type:**
 - Fixed**: Width Increment: 0 msec, Delay Increment: 0 nsec
 - Exponential**:
 - Fast Decay:** Time Constant: 1 usec, Amplitude: 0
 - Slow Decay:** Time Constant: 10 usec, Amplitude: 10
- Buttons:** View Width / Delay Sequence..., Save Sequence Values To File (unchecked), Setup File...
- On-CCD Accumulations:** Gates Per Exposure: 1
- Bottom Buttons:** OK, Cancel, Help

Figure 186. SuperSYNCHRO/Sequential Gating dialog (External Trigger)

10. The functions on the **Trigger Out** tab (Figure 187) allow you to enable the SyncMASTER trigger output from the SyncMASTER1 and SyncMASTER2 connectors on the **AUX I/O** cable and set up the Aux. Out signal at the **AUX OUT** connector on the rear of the PI-MAX3 or PI-MAX4.

- When you enable SyncMASTER1, the output of that connector will be at the frequency entered on the **Trigger In** tab.
- The output of the SyncMASTER2 connector will be at the same frequency as that of SyncMASTER1. However, you can enter a delay so the edges of that signal will occur after the edges of SyncMASTER1.
- If you will be using the Aux. Out signal from the SuperSYNCHRO to trigger a piece of equipment, enter the **Auxiliary** pulse width needed to trigger the equipment. Then enter the pulse delay time. The delay is based on T₀ (in effect it is a delay from SyncMASTER1 which also starts at T₀).

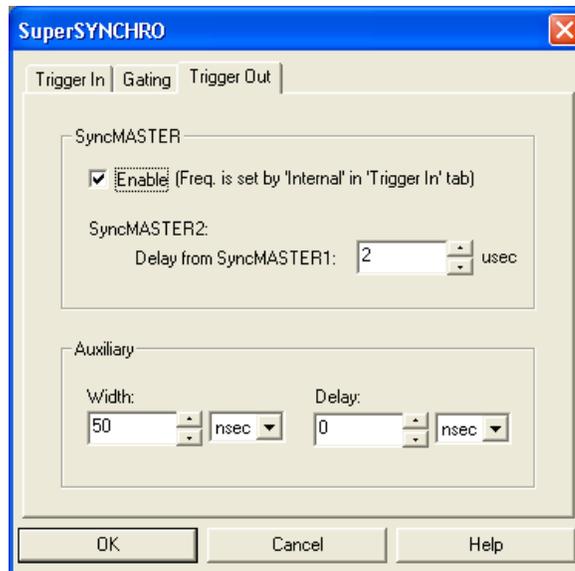
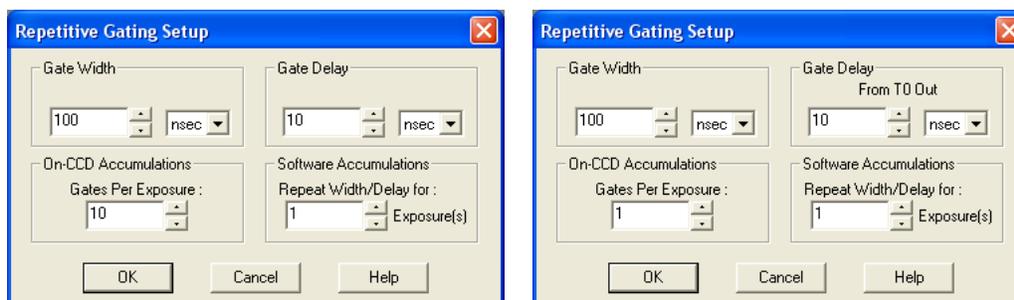


Figure 187. SuperSYNCHRO/Trigger Out tab

11. Click the **OK** button. This writes all of the parameter values to SuperSYNCHRO.

Note: If you are acquiring data and decide that some of the trigger or gating parameters need to be changed, you must stop data acquisition first. Then you can make the changes and restart data acquisition.

Repetitive Mode Parameters



Gate Width: The starting and ending gate widths are independently set. The first Shot will have the **Starting** gate width and the last Shot will have the **Ending** gate width. This is true for both the Fixed and Exponential increment type.

Gate Delay: The starting and ending gate delay values are independently set. When External Trigger is active, the first Shot will be taken at the **Starting** delay with respect to T₀ and the last Shot will occur at the **Ending** delay with respect to T₀. This is true for both the Fixed and Exponential increment type.

On-CCD Accumulations: Sets the number of gates to occur during an exposure.

Software Accumulations: Sets the number of exposures to be taken for each Shot.

Note that the number of Accumulations set here must be the same as the value set on the **Experiment Setup|Main** tab for proper operation.

Sequential Mode Parameters

Number of Images: With an Accumulations setting of one, **Number of Images** equals the number of exposures, each of which is followed by a readout. After each exposure, the **Gate Width** and **Gate Delay** change as programmed before the next exposure occurs. If multiple Accumulations are programmed, each exposure is repeated n times, where n is the number of accumulations specified. Every accumulation is processed before the gate delay and width change for the next shot. The total number of exposures equals the specified **Number of Images** times the number of **Accumulations**.

ATTENTION

Accumulations can be set on the Sequential Gating Setup dialog and on the **Experiment Setup|Main** tab. The two settings must be the same for proper operation.

Gate Width: The starting and ending gate widths are independently set. The first Shot will have the **Starting** gate width and the last Shot will have the **Ending** gate width. This is true for both the Fixed and Exponential increment type.

Gate Delay: The starting and ending gate delay values are independently set. The first Shot will be taken at the **Starting** delay with respect to T_0 and the last Shot will occur at the **Ending** delay with respect to T_0 . This is true for both the Fixed and Exponential increment type.

ATTENTION

The precise timing of both the gate and signal at the camera will additionally depend on a number of different delay mechanisms that can significantly affect the experiment. These are discussed for the PI-MAX camera in some detail in *Tips and Tricks* section of the PI-MAX/PI-MAX2, PI-MAX3 or PI-MAX4 system manual.

Check Gate Width and Delay Min/Max (Message Displayed): If this box is checked and you specify a gate width or delay outside the allowable range, a warning message (Figure 188) will be displayed. Clicking **Yes** will cause the parameter in question to be set to the limit value. Clicking **No** will cause the parameter *setting* to be retained, but the *actual* value will still be the applicable minimum or maximum. If the box is not checked, the applicable minimum or maximum will be established automatically.

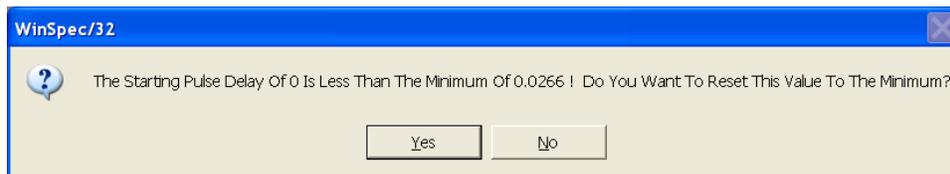


Figure 188. Range Limits Exceeded Warning

Fixed Increment Type: With this selection, the increment or change in **Gate Width** and **Gate Delay** is the same from shot to shot. The actual increments depend on the specified starting and ending values and on the **Number of Images**. The increment values are calculated and reported in the associated fields.

Exponential Increment Type: With this selection, the increment or change in **Gate Width** and **Gate Delay** changes from shot to shot. The precise delay and width of each shot with respect to T_0 is determined by the values entered for the **Fast Decay** and **Slow Decay Time Constant** and **Amplitude** parameters. In fluorescent decay experiments, for example, there will typically be two species contributing to the output data, one of which decays much faster than the other. For example, there might be a fast fluorophor with a decay time of at most a few nanoseconds, and a slower one with a decay time of perhaps a hundred nanoseconds. By sweeping both the delay *and* the width, and making provision for entering time constant and amplitude information for two species, the sequential exponential algorithm is ideally suited to making this type of measurement. At the start of the decay where the amplitude is high but the decay is rapid, the gate pulses are narrow and close together. Towards the end of the decay where the decay is slow, the gate pulses are further apart but much wider to accommodate the lower signal amplitude. The result is output data that is relatively constant in intensity over the decay time. This data can be easily normalized by dividing each point by the exposure time and then using a spline fit to recover the curve. The logarithm (base e) can then be taken to obtain a straight line (or two lines successive line segments, each with a different slope for two species). Tangents can be fitted to each segment to determine the rate constant for each species.

Fast Decay

Time Constant: In a two species system, enter the *decay time* of the faster of the two species. Note that it is not *essential* that you enter a value. If you have the decay time information, you will get better data if the information is entered, but acceptable results can be obtained in many situations by using the default. If there is only one species, or if you want to discard the fast decay process, simply enter zero for the *Amplitude*.

Note that the Gate Width and Gate Delay values need to be selected with some care in fluorescence decay experiments. Typically the starting gate width will be very narrow, perhaps 2 ns, and the final gate width should be wider by about the ratio of the anticipated signal amplitude decrease over the course of the

measurement timebase. Similarly, the starting gate delay has to take the various insertion delays into account, and the final delay value might typically be set to a value on the order of five times the anticipated decay time of the process.

Amplitude: This is the *relative* amplitude of the fast decay with respect to the slow one. For example, if you know that the amplitude of the fast decay signal is typically five times the amplitude of the slow decay signal, you could enter "5" for the fast decay amplitude and "1" for the slow decay amplitude. Keep in mind that it is the *ratio* that is being expressed. For example, there is no difference between entering fast and slow amplitude values of "5" and "1" and entering fast and slow amplitude values of "50" and "10." Note that the default values will give satisfactory results in many measurements.

Slow Decay

Time Constant: In a two species system, enter the *decay time* of the slower of the two species. Note that it is not *essential* that you enter a value. If you have the decay time information, you will get better data if the information is entered, but acceptable results can be obtained in many situations by using the default. If there is only one species, or if you want to discard the fast decay process, simply enter zero for the *fast decay Amplitude*.

Amplitude: This is the *relative* amplitude of the slow decay with respect to the fast one. For example, if you know that the amplitude of the slow decay signal is typically one-fifth the amplitude of the fast decay signal, you could enter "1" for the slow decay amplitude and "5" for the fast decay amplitude. Keep in mind that it is the *ratio* that is being expressed. For example, there is no difference between entering slow and fast amplitude values of "1" and "5" and entering fast and slow amplitude values of "10" and "50."

View Width/Delay Sequence: Opens the **Width/Delay Sequence** dialog (Figure 189) which lists the currently programmed sequence of gate width and gate delay values.

Save Sequence Values to File: When this box is checked, the sequence values will be saved *on completion of the run*. The values saved are those actually used to take the data. The file could be recalled later and used for data normalization or other purposes.

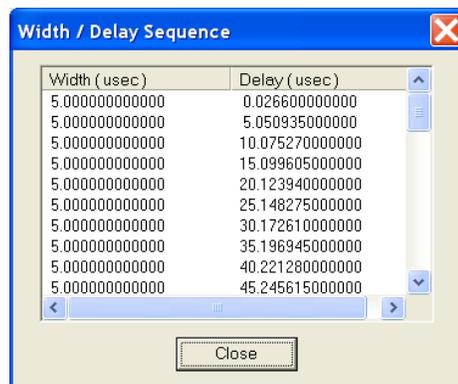


Figure 189. Gate Width/Delay Sequence dialog

Setup File: Opens the **Sequence Values File** dialog (Figure 190), which enables the following:

Ask Before Overwriting: If checked, you will be queried before a new sequence value file overwrites an existing one. If unchecked, overwriting can occur without warning.

Notify When File Has Been Saved: The file is saved at the end of the data-acquisition run. You will be notified that this has occurred if this box is checked.

Use Default File Name: If checked, the sequence value file name will be experiment file name, but with the extension **PDW**. If unchecked, you must enter the name in the **Name** field.

Name: If not using the default name for the sequence value file, enter the file name in the provided field. The button at the end of the box opens a browser to facilitate assigning the file location.

On-CCD Accumulations: Sets the number of gates to occur during an exposure.

Software Accumulations: Sets the number of exposures to be taken for each Shot. Note that the number of Accumulations set here must be the same as the value set on the **Experiment Setup|Main** tab for proper operation.

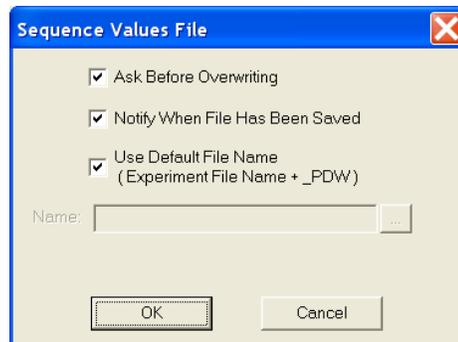


Figure 190. Sequence Values File dialog

Timing Generator Interactive Trigger Setup

The  button on the **Custom Toolbar**, allows you to select the PTG or DG535 trigger mode (**Internal** or **External**) while acquiring data. In the case of the SuperSYNCHRO must stop data acquisition before you can make changes and apply them.

Internal: The Timing Generator will create its own trigger signals at the selected frequency.

External: The Timing Generator will be triggered by trigger signals that originate in an external piece of equipment.

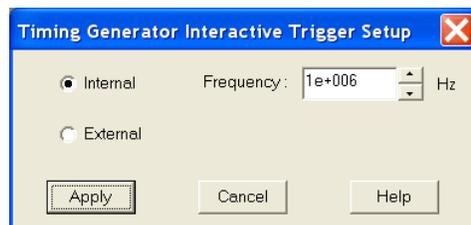
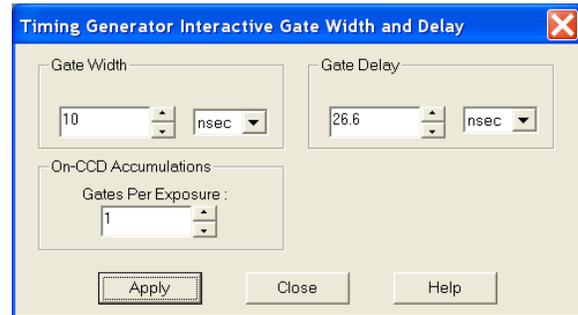


Figure 191. Timing Generator Interactive Trigger Setup dialog

Timing Generator Interactive Gate Width and Delay

The  button of the **Custom Toolbar**, allows you to control the Gate Width and Gate Delay parameters of the PTG or DG535 Timing Generator while acquiring data. In the case of the SuperSYNCHRO, you must stop data acquisition before you can make changes and apply them.



Gate Width: Sets the duration of the pulse applied to the PI-MAX intensifier to gate the photocathode. The units available are nanoseconds (ns), microseconds (μ s), or milliseconds (ms). Only some values are allowed, so the Timing Generator will adjust the input value to the nearest allowable value.

Figure 192. Timing Generator Interactive Gate Width and Delay dialog

Gate Delay: Sets the time between the beginning of the trigger pulse (either internal or external) and the beginning of the photocathode gate pulse. The units available are nanoseconds (ns), microseconds (μ s), or milliseconds (ms). Only some values are allowed, so the Timing Generator will adjust the input value to the nearest allowable value.

Gates Per Exposure: Allows you to specify the number of times the photocathode will be gated on during the exposure. Charge will accumulate on the CCD array as those gates occur during the exposure and the accumulated charge will be readout at the end of the exposure. The acquired data will contain signal from multiple exposures and read noise from a single readout. Signal is limited by pixel well capacity and the A/D converter (for a 16-bit A/D, this is 65536 counts).

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Custom Toolbar Settings

Introduction

The **Custom Toolbar** feature of WinSpec/32 allows you one-button access to many features or combinations of features available through the software. The **Custom Toolbar** layout and the number of buttons displayed on the **Custom Toolbar** can easily be changed.

Displaying the Custom Toolbar

1. To make the **Custom Toolbar** visible, select **Toolbars** and then **Custom** on the View menu. The **Custom Toolbar** will appear on the desktop and its default configuration will be as shown in Figure 193.
2. You can change position of the **Custom Toolbar**, its layout, and the number of buttons it contains.



Figure 193. Default Custom Toolbar

Customizing the Toolbar

Although the **Custom Toolbar** defaults with the buttons shown in Figure 193, many additional buttons are in fact available and can be added to the button using the **Customize Toolbar** dialog (Figure 194). Buttons can be added or removed at any time and the new configuration will be saved when the dialog is closed.

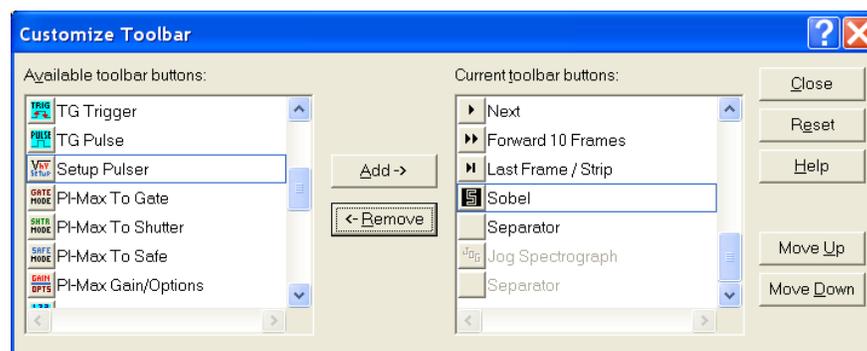


Figure 194. Customize Toolbar dialog

Adding an Available Button:

1. Open the **Customize Toolbar** dialog by clicking on **Custom Toolbar** in the **Setup** menu.
2. Referring to Figure 194, note that the buttons available for placement on the **Custom Toolbar** are listed on the left. Buttons already on the toolbar are on the right.
3. To add an available button to the **Custom Toolbar**, first select it from the left-hand list. You may have to scroll through the list of available buttons to find the one you want. You can choose where to place the button by selecting a button on the *right* side (which will then be highlighted). The new button will be placed *before* the highlighted one.
4. Click on the **Add** button. The button will disappear from the list of **Available** buttons and will be added to the list of **Toolbar** buttons.
5. Click on **Close** to close the dialog.

Removing a Button:

1. Open the Customize Toolbar dialog by clicking on **Customize Toolbar** in the **Setup** menu.
2. Referring to Figure 194, note that buttons already on the toolbar are listed on the right. Available but unused buttons are listed on the left.
3. To remove an available button from the **Custom Toolbar**, first select it from the right-hand list. You may have to scroll through the listed buttons to find the one you want.
4. Click on the **Remove** button. The button will disappear from the list of **Toolbar** buttons and will be added to the list of **Available** buttons.
5. Click on **Close** to close the dialog.

Individual Dialog Item Descriptions

Available Buttons: You can select the button you wish to add to the **Custom Toolbar** from this section. Many buttons, each with its own preassigned function as described below, are available.

Toolbar Buttons: These are the buttons that will actually appear on the **Custom Toolbar**.

Add: Causes the selected button on the **Available Buttons** list to be transferred to the **Toolbar** buttons list before the selected button.

Remove: Causes the selected button on the **Toolbar** list to be transferred to the **Available Buttons** list.

Close: This button closes the **Custom Toolbar Assignment** dialog and implements changes made to the **Custom Toolbar**.

Reset: Restores the default Custom Toolbar configuration.

Help: Opens the context-sensitive help for the **Custom Toolbar**.

Move Up: Together with **Move Down**, **Move Up** determines the position of a given button on the **Custom Toolbar**. Each time this button is clicked, the selected button on the **Toolbar** buttons list moves up one position.

Move Down: Together with **Move Up**, **Move Down** determines the position of a given button on the **Custom Toolbar**. Each time this button is clicked, the selected button on the **Toolbar** buttons list moves down one position.

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Software Options

Introduction

The WinSpec/32 options described in this chapter can also be purchased from Princeton Instruments. Contact Princeton Instruments Customer Support for order information.

Custom Chip (WXCstChp.opt)

Introduction

If this option has been installed, selecting **Show Custom Chip** check box on the **Controller/Camera** tab adds the **Custom Chip** tab to the dialog. The Custom Chip parameters are shown in Figure 195. The default values conform to the physical layout of the CCD array and are optimum for most measurements.

Caution

Princeton Instruments does not encourage users to change these parameter settings. For most applications, the default settings will give the best results. We *strongly advise* contacting the factory for guidance before customizing the chip definition.

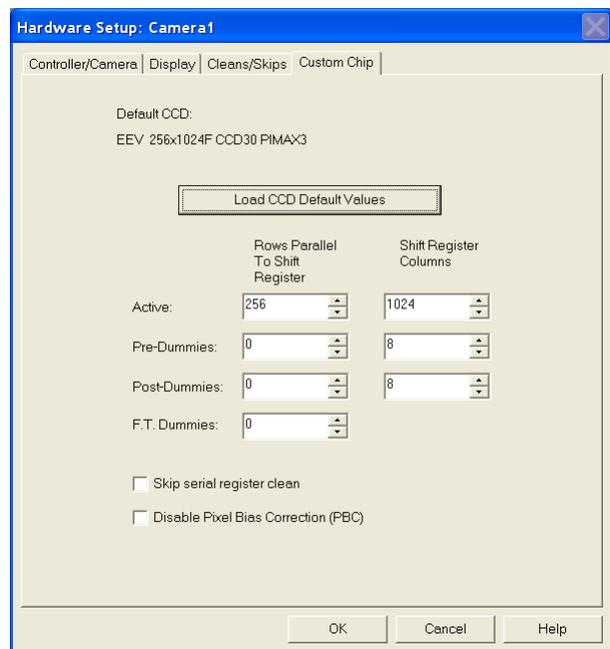


Figure 195. Custom Chip tab

Normally, not all of the pixels in a CCD array are exposed and read out: a frame of “dummy” pixels bounds the active area. These dummy pixels are usually masked and are not normally read out. However, they could be read out by changing the chip definition in software. For example, in the case of the EEV 256×1024 chip illustrated in Figure 195, the 256 active rows are preceded by 0 dummy rows and followed by 0 dummy rows. There are 8 dummy columns on one side of the active region and 8 dummy columns on the other side. By changing the chip definition to increase the active area while decreasing the dummy settings, the dummy cells would be read out. By doing so, one could measure the dark charge with every readout. (Note that F.T. Dummies are chip-specific and are dummy rows at the boundary of the masked and visible areas of a frame transfer device.)

It is also possible to increase image acquisition speed by reducing the size of the active area in the definition. The result will be faster but lower resolution data acquisition. Operating in this mode would ordinarily require that the chip be masked so that only the reduced active area is exposed. This will prevent unwanted charge from spilling into the active area or being transferred to the shift register.

By default, if there are no Pre-Dummy rows, the serial register will be cleared before rows are shifted. If the **Skip Serial Register Clean** check box is selected when there are no Pre-Dummy rows, the register cleanout will be skipped and the chip readout will be faster. This feature is not available for PVCAM-supported cameras.

Pixel Bias Correction (not available for all cameras) is active by default. This function generates a pixel bias correction scan code that is applied to the raw data to correct for output amplifier and electronics drift. The correction is performed either on a line-by-line or frame-by-frame basis depending on the camera. The correction process may add to the readout time. If the **Disable Pixel Bias Correction (PBC)** check box is available on the **Custom Chip** tab, you can disable pixel bias correction if you want to maximize the readout time and are not concerned about drift. Disable the correction if you only want raw (uncorrected) data.

Custom Timing (WXCstTim.opt)

Notes:

1. Fully supported by WinSpec Version 2.5.18.1 (and higher).
2. This option is not supported for 5 MHz systems.

Introduction

If this option has been installed, selecting **Show Custom Timing** check box on the **Controller/Camera** (or **Controller/Detector**) tab adds the **Custom Timing** tab to the dialog. The Custom Timing selections are shown in Figure 196. The default timing parameter values have been determined to give the fastest possible performance without compromising data acquisition performance.

Caution

Princeton Instruments does not encourage users to change these parameter settings. For most applications, the default settings will give the best results. We **strongly advise** contacting the factory for guidance before customizing the chip timing parameters.

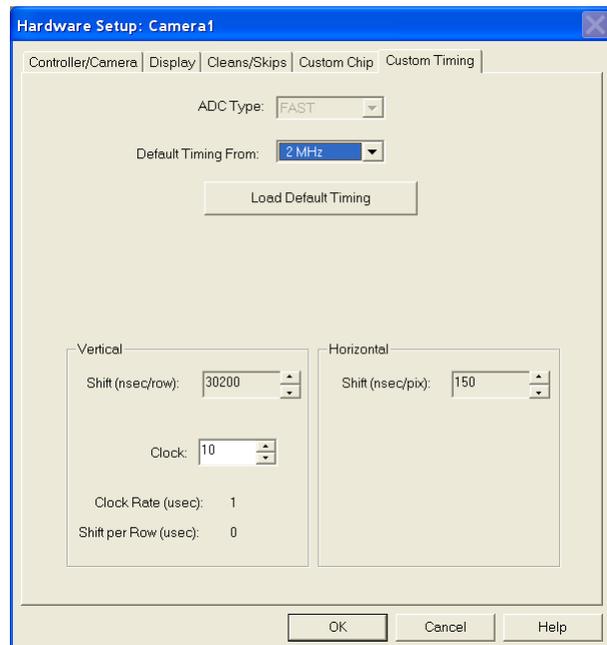


Figure 196. Custom Timing tab

FITS (FITS.exe)

FITS (Flexible Image Transport System) is the data format most widely used within astronomy for transporting, analyzing, and archiving scientific data files. FITS is

primarily designed to store scientific data sets consisting of multidimensional arrays (images) and 2-dimensional tables organized into rows and columns of information. The FITS option allows you to acquire and save WinSpec/32 data in the FITS format. This option also provides a file conversion function that allows you to convert existing WinSpec/32 .SPE data files into the FITS format. F1 help is included with the option.

Acquiring data in the FITS format starts with setting up the experiment parameters in WinSpec/32. With WinSpec still open, you then open the FITS.exe program (by opening it at its directory location or by opening it from the Execute Macro dialog if the Macro option has been installed). When you click on **Run Experiment** on the **FITS** dialog, the experiment will begin. At completion of the experiment, the data will be displayed in WinSpec and a FITS file will automatically be generated and saved.

Note: When this option is installed, the FITS.exe file is placed in the same directory as the Winspec.exe file.

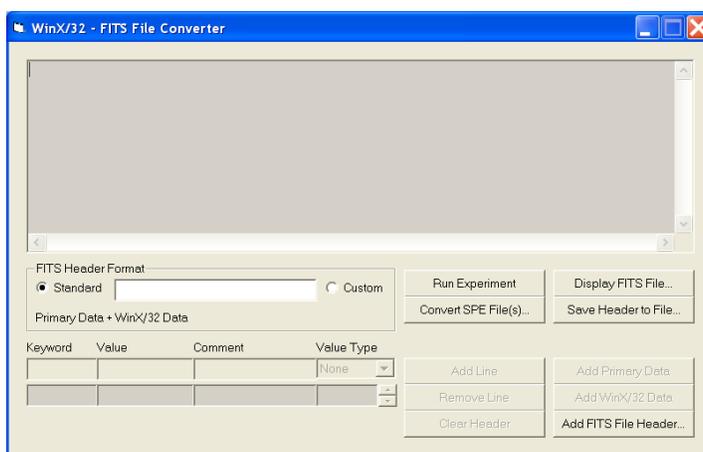


Figure 197. FITS dialog

Macro Record (WXmacrec.opt)

Macro Record is a convenient method to automate routines and repetitive data acquisition and analysis tasks. A macro is created automatically whenever a sequence of operations is performed in WinSpec. The recorded macro generates a VBScript file that can be edited to provide maximum flexibility. For more information, refer to the WinSpec/32 online help and the PDF of the *WinX32 Programming for Macro Record* manual, provided as part of the option package. Typically, the manual is stored in the WinSpec32/Documentation directory when you install the option.

Note: As part of the Macro option installation, the **Macro** menu is added to the WinSpec/32 menu bar.

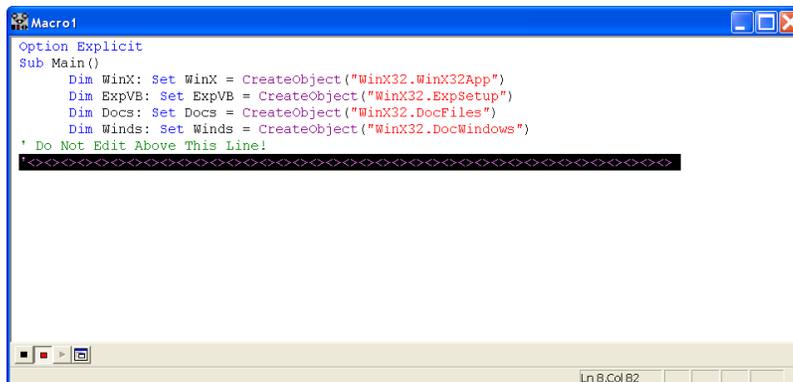


Figure 198. Macro Record dialog

Spex Spectrograph Control (WSSpex.opt)

This option adds spectrograph support for the Spex 270M, ISA TRIAX 180, ISA TRIAX 190, ISA TRIAX 320, and the Spex Spex232 Retrofit (older Spex that have been retrofitted for RS-232 communication).

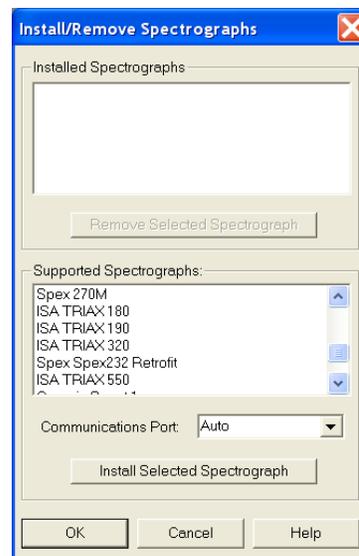


Figure 199. Install/Remove Spectrographs dialog

Virtual Chip (WXvchip.opt)

Introduction

This option is used to set the parameters for Virtual Chip operation, a special fast-acquisition technique that allows frame rates in excess of 100 fps to be obtained. For the Virtual Chip selection to be available on the WinSpec/32 Setup menu, it is necessary that:

- the system is a PentaMAX or has an ST-133 Controller,
- the camera has a frame transfer chip such as the EEV 512 × 512 FT,
- the Frame Transfer readout mode is selected, and
- the file WXvchip.opt is present in the same directory as the executable WinSpec/32 program.

The virtual chip method of data acquisition requires that the chip be masked as shown in Figure 200. Masking can be achieved by applying a mechanical or optical mask or by

positioning a bright image at the ROI against a dark background on the remainder of the array. In operation, images are continually piped down the CCD at extraordinarily high frames per second (FPS).

The mini-frame transfer region is defined by an ROI as illustrated in Figure 200. The charge from this ROI is shifted under the frame-transfer mask, followed by a readout cycle of an ROI-sized region under the mask. Since the ROI is far from the serial register, the stored image is just shifted repeatedly with the readout and the first few images collected will not contain useful data. After the readout period, the next frame is shifted under the mask and another ROI sized frame is read out. The net result is a series of images, separated by spacer regions, streaming up the CCD under the mask.

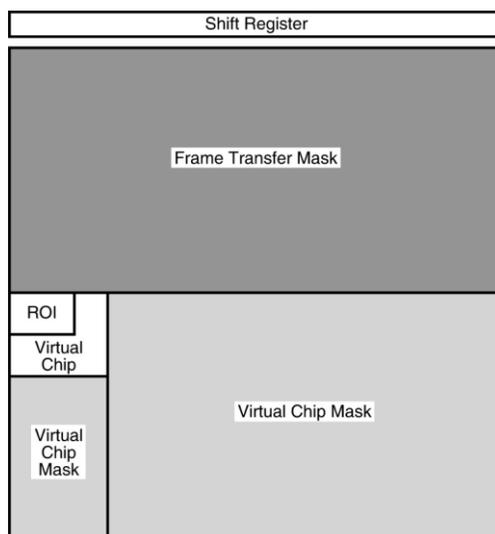


Figure 200. Virtual Chip Functional diagram

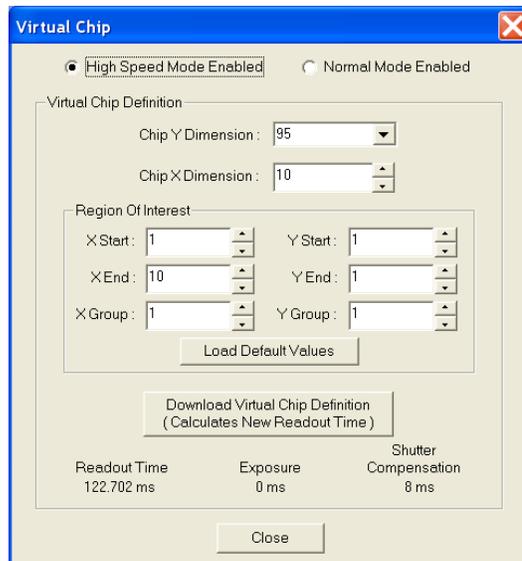


Figure 201. Virtual Chip dialog

Virtual Chip Setup

The following procedure covers the basic hardware and software setup for Virtual Chip operation.

Equipment:

Suitable Princeton Instruments detector with 512x512FT or other frame transfer CCD array
 Suitable ST-133
 PCI Interface Card and High Speed Serial (TAXI) cable
 Suitable Host Computer

Software:

WinSpec/32, version 2.4 or higher

WXvchip.opt installed in the same directory as the executable WinSpec/32 program.

Assumptions:

- You are familiar with the WinSpec/32 software and have read the hardware manuals.
- Masking is for a 47x47 pixel Virtual Chip with its origin at 1,1.

Procedure:

1. Verify that the power is **OFF** for **ALL** system components (including the host computer).

2. Verify that the correct line voltages have been selected and that the correct fuses have been installed in the ST-133.
3. Connect the TAXI cable to the interface card at the host computer and to the **Serial Com** connector at the rear of the Controller. Tighten down the locking screws.
4. Connect the **Camera-Controller** cable to the **Detector** connector on the rear of the Controller and to the **Detector** connector at the rear of the camera. Tighten down the locking screws.
5. If it has not been installed already, connect a line cord from the Power Input module on the back of the Controller to a suitable AC power source.
6. Turn on the Controller.
7. Turn on the host computer and select the WinSpec/32 icon.
8. From the **Setup** menu, select **Hardware**, and enter the following settings:
 - Controller/CCD tab**
 - Controller:** PentaMAX or the appropriate ST-133 controller
 - Controller Version:** 5
 - CCD Type:** appropriate frame transfer array (EEV 512x512FT, for this procedure)
 - Shutter Type:** None
 - LOGIC OUT Output:** Shutter
 - Readout Mode:** Frame Transfer
 - Interface tab**
 - Type:** the appropriate interface card. For this procedure, the selection is High Speed PCI.
 - Cleans/Skips tab**
 - Number of Cleans:** 1
 - Number of Strips per Clean:** 512
 - Minimum Block Size:** 2
 - Number of Blocks:** 5
9. From the **Acquisition** menu, select **Experiment Setup** and enter the following settings:
 - Main tab**
 - Exposure Time:** Enter a value. The exposure time can either be greater than the readout time or it can be equal to the readout time. If you want an exposure time > readout time, enter a value larger than the readout time calculated when the virtual chip definition was downloaded. If you want an exposure time = readout time, enter 000 sec.
 - Number of Images:** Enter the desired number of images.
 - Use Region of Interest**
 - Accumulations:** 1
 - ADC tab**
 - Type:** FAST
 - ROI Setup tab:** Make no changes to the settings on this tab unless you have re-enabled Normal Operating Mode. ROI setup for Virtual Chip (High Speed Mode) is performed through the Virtual Chip dialog.
10. From the **Setup** menu, select **Virtual Chip**, and enter the following settings:
 - High Speed Mode Enabled**

Virtual Chip Definition: The settings below assume a 47x47 pixel virtual chip. The X and Y dimensions are established by the external mask. The virtual chip is fully flexible in the X direction. However, the set of choices for the Y-dimension has been pre-selected for optimal performance. Note that the origin point that Princeton Instruments uses for a CCD array is 1,1.

Chip Y Dimension: 47. Select this dimension from the drop down list.

Chip X Dimension: 47. Enter this dimension manually.

11. Click on the **Load Default Values** button. This enters the default ROI values. These values are: Start pixels of 1,1; End pixels based on the Chip Y and Chip X dimensions; and Groups of 1.
 - **Region of Interest:** The settings below assume a 47x47 pixel ROI (i.e., the entire virtual chip). An ROI that is a subset of the virtual chip can be defined.
X Start: 1 Y Start: 1
X End: 47 Y End: 47
X Group: 1 Y Group: 1
 - Click on the **Download Virtual Chip Definition** button. This will download the definition, set up the ROI, and calculate the readout time.
 - Observe the calculated readout time. If you need a shorter period, change the settings (for example, enter a smaller Y-dimension or use binning in the Y-direction) and click on the **Download Virtual Chip Definition** button again.
 - Click on **Close**.
12. From the **Setup** menu, select **Environment**.

Note: When setting up for focusing, the number of Frames/Interrupt should be left at 1.

 - **DMA Buffer (Mb):** By default, the buffer size is 8 Mb. Using the following formula, calculate the amount of DMA memory required:

$$X \times Y \times \#Frames \times (2 \text{ bytes/pixel}).$$

For example, the buffer size required for a 47x47 virtual array acquiring 1000 frames would be $47 \times 47 \times 1000 \text{ frames} \times (2 \text{ bytes/pixel}) = 4.4 \text{ Mb}$. If the calculated value is greater than 8 Mb, enter the appropriate size.

Note: This value is not enabled until you restart your computer.
 - **Frames/Interrupt:** If the number of frames is greater than 256 (the preprogrammed slot limit for a PCI card), increase the number of **Frames/Interrupt** value. Use the formula $\#Frames/256$ and round the result to the next highest integer to calculate that value. For example, $1000 \text{ frames}/256$ will result in 3.9, so enter 4.

Note: This value should be 1 for **Focus** mode.
13. Click on **OK** after you have finished entering the Environment settings.
14. Place a suitable target in front of the camera and click on **Focus** to verify that the camera is seeing the target.
15. Make any focusing, gain, or other adjustments necessary to fine-tune the image.
16. Stop running in **Focus** mode.

17. Now click on **Acquire**.

Experimental Timing

Triggering can be achieved through the software via the **Software Trigger** timing mode (selectable on the **Experiment Setup** dialog, **Timing Mode** tab) or it can be achieved via the **Ext Sync** input on the rear of the camera. Triggering from the **Ext Sync** input allows you to acquire a single image per TTL pulse. If **Software Trigger** has been selected, back-to-back collection of the requested number of images will be initiated when **Acquire** is selected: no further TTL trigger input is required.

Tips

- If mechanical masking is used, the mask can be a static one (fixed dimensions) in which case, multiple masks should be made to accommodate a variety of imaging conditions. Alternatively, a more flexible mask can be manufactured by taking two thin metal sheets with a square hole the size of the exposed region of the CCD cut in the center. For a 512×512 pixel CCD array with 15 micron pixels, the exposed region would be $7.68 \text{ mm} \times 7.68 \text{ mm}$. These masks should be anodized black to prevent reflections in the optical system and they should be very flat. These two sheets can then be slid relative to one another to achieve any rectangular shape required. The sheets should be placed flat in the optical plane and their openings should be centered on the optical axis. Ideally they should be able to move with an accuracy of 2-3 pixels per step (30-45 microns) in the X and Y directions.

Consult the factory for off-the-shelf optical masking accessories.

- Running the camera in Free Run mode with 0.0 msec exposure time will result in the fastest acquisition time. Under these conditions, the acquisition time is limited by the readout time of the ROI (exposure time \equiv readout time).
- When you return the system to "Normal" chip mode (radio button on **Virtual Chip** dialog), you should also open the Experiment Setup dialog at the **ROI Setup** tab and click on the **ClearAll** button to clear the ROI setup downloaded for Virtual Chip operation.
- If frame acquisition appears to be slow in Focus mode, check the **Frames/Interrupt** value on the **Environment** dialog and reset the value to 1 if it is greater than 1.
- When processing large stacks of data, you may want to use a third-party scientific image processing package.
- Due to CCD design, you may see some edge artifacts when acquiring data from the entire virtual chip. Crop these artifacts by defining an ROI that is slightly smaller than the virtual chip dimensions.

Part 3

Reference

Appendix A, System and Camera Nomenclature	223
Appendix B, WinSpec/32 First Light Instructions	233
Appendix C, Calibration Lines	245
Appendix D, Data Structure	247
Appendix E, Auto-Spectro Wavelength Calibration	257
Appendix F, CD ROM Failure Workarounds	261
Appendix G, WinSpec/32 Repair and Maintenance	263
Appendix H, USB 2.0 Limitations	267
Appendix I, Troubleshooting USB 2.0	269
Appendix J, Glossary	277

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Appendix A

System and Camera Nomenclature

System, Controller Type, and Camera Type Cross-Reference

Use the cross-reference table below if you need to determine the controller type and/or camera/CCD type used by your system. This table is based on the Princeton Instruments brand systems that are currently being sold by Roper Scientific, Inc. Many of these systems incorporate non-volatile RAM (NVRAM) that has been factory programmed with the default hardware setup parameters for the controller, camera, and CCD array included in your system. If you know the controller type used by your system, you should be able to download these default parameters. However, if this functionality is not available for your system, you will need to manually enter the information.

Note: Because Marconi changed its name to e2v, you may see CCD types with the prefix "MAR," "EEV," or "e2v." These CCDs are manufactured by e2v.

System	Controller Type	Camera/CCD Type
2D-OMA V: 320	ST-133-5 MHz	XEN 320
I-PentaMAX (Gen II or Gen III)	PentaMAX*	EEV 512x512FT
MicroMAX: 512EBFT	ST-133	EEV 512x512FT CCD57
MicroMAX: 782Y	ST-133	PID 582x782
MicroMAX: 782YHS	ST-133-5 MHz	PID 582x782
MicroMAX: 1024B	ST-133	EEV 1024x1024 CCD 47_10
MicroMAX: 1300B	ST-133	EEV 1300x1340B
MicroMAX: 1300Y	ST-133	PID1030x1300
MicroMAX: 1300YHS	ST-133-5 MHz	PID1030x1300
MicroMAX: 1300YHS-DIF	ST-133-5 MHz	PID1030x1300
NIRvana:640 (formerly PIoNIR:640)	N/A	PI InGaAs 640
OMA V:InGaAs 256	ST-133	InGaAs 1x256
OMA V:InGaAs 512	ST-133	InGaAs 1x512

* Does not support NVRAM function.

System	Controller Type	Camera/CCD Type
OMA V:InGaAs 1024	ST-133	InGaAs 1x1024
PDA	ST-121*	Diode Array 1024
PhotonMAX: 512B	N/A	e2v CCD97B
PhotonMAX: 1024B	N/A	e2v CCD201B
PI-LCX: 400	ST-133	EEV 400x1340F
PI-LCX: 576	ST-133	EEV 576x384 (3 ph)
PI-LCX: 1242	ST-133	EEV 1152x1242 (3 ph)
PI-LCX: 1300	ST-133	EEV 1300x1340F
PI-MAX: 512HQ	ST-133	THM 512x512
PI-MAX: 512RB	ST-133	THM 512x512
PI-MAX: 512SB	ST-133	THM 512x512
PI-MAX: 512UV	ST-133	THM 512x512
PI-MAX: 1024HQ	ST-133	EEV 256x1024F CCD30
PI-MAX: 1024RB	ST-133	EEV 256x1024F CCD30
PI-MAX: 1024SB	ST-133	EEV 256x1024F CCD30
PI-MAX: 1024UV	ST-133	EEV 256x1024F CCD30
PI-MAX MG: 1024	ST-133	EEV 256x1024F CCD30
PI-MAX2:512 (Gen II or Gen III)	ST-133-5 MHz	THM 512x512
PI-MAX2:1003 (Gen II or Gen III)	ST-133-5 MHz	KAI 1024x1024
PI-MAX3:1024i	N/A	Kodak KAI-1003
PI-MAX3:1024x256	N/A	e2v CCD 30-11
PI-MAX4:1024i	N/A	Kodak KAI-1003
PI-MAX4:1024i-RF	N/A	Kodak KAI-1003
PI-MAX4:1024x256	N/A	e2v 256x1024F CCD 30-11
PI-MAX4:1024x256-RF	N/A	e2v 256x1024F CCD 30-11
PI-MTE: 1300B	ST-133, ST-133-2 MHz	EEV 1300x1340B

System	Controller Type	Camera/CCD Type
PI-SCX: 1242	ST-133	EEV 1152x1242(6 ph)
PI-SCX: 1300	ST-133	EEV 1300x1340F
PI-SCX: 4300	ST-133	KAF 2084x2084 SCX
PI-SX: 400	ST-133	EEV 400x1340B
PI-SX: 512	ST-133	TEK 512x512DB
PI-SX: 1024	ST-133	TEK 1024x1024DB
PI-SX: 1300	ST-133	EEV 1300x1340B
PIoNIR:640 (now NIRvana:640)	N/A	PI InGaAs 640
PIXIS:100F, B, BR, R	N/A	EEV 100x1340F/B
PIXIS:400F, B, BR, R	N/A	EEV 400x1340F/B
PIXIS:512F, B	N/A	MAR 512x512 CCD 77
PIXIS:1024F, B	N/A	EEV 1024x1024 CCD 47-10
PIXIS-XF:1024	N/A	e2v 1024x1024 CCD 47-10
PIXIS-XO:100B	N/A	PI 1340x100B
PIXIS-XO:400B	N/A	PI 1340x400B
PIXIS-XO:512B	N/A	e2v 512x512B CCD 77-00
PIXIS-XO:1024B	N/A	e2v 1024x1024 CCD 47-10
PIXIS-XO:2KB	N/A	PI 2048x512B
ProEM:512B	N/A	e2v CCD97B
ProEM:512BK	N/A	PI exclusive
ProEM:1024B	N/A	e2v CCD201B
PyLoN:100F, B, BR	N/A	PI 1340x100B
PyLoN:100B, BR eXcelon	N/A	PI 1340x100B
PyLoN:400F, B, BR	N/A	PI 1340x400B
PyLoN:400B, BR eXcelon	N/A	PI 1340x400B
PyLoN-IR:1024-1.7	N/A	SUI 1024x1 InGaAs (LE-1.7)
PyLoN-IR:1024-2.2	N/A	SUI 1024x1 InGaAs (LE-2.2)

System	Controller Type	Camera/CCD Type
Quad-RO:4096	N/A	FCD 4096x4096F MT
Quad-RO:4320	N/A	KAF 2084x2084 MT
Spec-10: 100, B, R, BR	ST-133	EEV 100x1340F, 100x1340B
Spec-10: 120	ST-133	HAM 124x1024
Spec-10: 120B	ST-133	HAM 122x1024B
Spec-10: 256, B, E	ST-133	EEV 256x1024F CCD30, B, OE
Spec-10: 400, B, R, BR	ST-133	EEV 400x1340F/B
Spec-10 ^{XP} : 100, B, R, BR	ST-133-2MHz	EEV 100x1340F/B
Spec-10 ^{XP} : 400, B, R, BR	ST-133-2MHz	EEV 400x1340F/B
SpectruMM:120	ST-133	HAM 124x1024
SpectruMM:120B	ST-133	HAM 122x1024B
SpectruMM:250	ST-133	HAM 252x1024
SpectruMM:250B	ST-133	HAM 250x1024B
VersArray: 512B, F	ST-133	TEK 512x512DB/DF
VersArray: 1024B, F	ST-133	TEK 1024x1024DB/DF
VersArray: 1300B, F	ST-133	EEV 1300x1340B/F
VersArray ^{XP} : 512B, F	ST-133-2MHz	MAR 512x512 CCD77
VersArray ^{XP} : 1K, KB	ST-133-2MHz	EEV 1024x1024 CCD47_10

System and System Component Descriptions

The following information briefly describes Princeton Instruments brand systems and the system components. For more information, contact your Princeton Instruments representative or Customer Support.

Systems:

2D-OMA V: Cryogenically-cooled focal plane array (FPA) based system for low light level NIR imaging (0.8 μ m-1.7 μ m).

InSight: Includes an f/3.9 imaging spectrograph integrated with a high performance digital CCD. The system is pre-aligned and focused at the factory, allowing for effortless integration into experiments.

MicroMAX: Name used for some ST-133 based imaging systems, usually with an RTE head. The 5 MHz version is characterized by duplex head cable

NIRvana (formerly PloNIR): Compact, permanent vacuum camera platform with internal controller. Designed for NIR spectroscopy and imaging.

OMA V: Cryogenically-cooled Photodiode array (PDA) based system for spectroscopy applications.

PDA: Low-cost spectroscopy system uses ST-121 controller.

PentaMAX: A/D electronics are in the head so no controller is necessary. Runs with PCI card only. Both unintensified and intensified versions are available.

PhotonMAX: EMCCD (electron-multiplying CCD). Optimized for both traditional CCD and "on-chip multiplication gain" operation. Internal controller. Vacuum guaranteed for the life of the camera.

PI-Echelle: Spectrograph that achieves high spectral resolution over the entire wavelength range of the camera (one of several compatible Princeton Instruments cameras) without any moving parts. The system is ideal for both general spectroscopy applications as well as Laser Induced Breakdown Spectroscopy.

PI-LCX: High-performance photon counting system. Medium X-ray, direct detection

PI-MAX: ICCD design with internal high voltage power and gating. Controller is ST-133, and gating timing is provided by a DG535, PTG or other TTL timing source.

PI-MAX2: High speed PI-MAX. ICCD design with internal high voltage power and gating. Controller is ST-133-5MHz, and gating timing is provided by a DG535, PTG or other TTL timing source.

PI-MAX3: High speed PI-MAX. ICCD design with internal high voltage power and gating with internal controller. Gate timing is controlled by the internal SuperSYNCHRO timing generator or an external source.

PI-MAX4: High speed PI-MAX. ICCD design with internal high voltage power and gating with internal controller. Gate timing is controlled by the internal SuperSYNCHRO timing generator or an external source.

PI-MTE: Compact high-sensitivity digital imaging system designed to deliver scientific performance inside high-vacuum chambers over long operation times.

PI-SCX: X-ray diffraction, fiberoptically-coupled detector.

PI-SX: High-sensitivity, deep-vacuum interface for soft X-ray acquisition.

PIoNIR (renamed NIRvana): Compact, permanent vacuum camera platform with internal controller. Designed for NIR spectroscopy and imaging.

PIXIS: Compact, permanent vacuum camera platform with internal controller. Designed for low-light-level spectroscopy and imaging.

PIXIS-XF: Compact, permanent vacuum camera platform with internal controller. Designed for lens-free, indirect imaging of X-rays using phosphor screens or other Lambertian sources.

PIXIS-XO: Compact, vacuum open-nose camera platform with internal controller and rotatable ConFlat flange. Designed for direct imaging of very low energy X-ray (< 30 eV).

ProEM: EMCCD (electron-multiplying CCD). Optimized for both traditional CCD and "on-chip multiplication gain" operation. Internal controller. Air- and liquid-cooling. Vacuum guaranteed for the life of the camera.

PyLoN: Liquid nitrogen cooled detector with internal controller and 1.7 liter Dewar capacity.

Quad-RO: High performance X-ray system. Systems can effectively provide X-ray photon-counting capability with up to 16-bit dynamic range. 1:1 fiberoptic taper and multi-port output. Thermoelectric cooling.

SPEC-10: High performance, spectroscopy system. Wide variety of CCD arrays. Thermoelectric or cryogenic cooling available.

SPEC-10^{XP}: High performance spectroscopy system with "XP" lifetime vacuum. This system can be thermoelectrically (air) cooled down to -80C° and has software-selectable six-speed digitization (up to 2 MHz).

SpectruMM: Name used for some ST-133 based spectroscopy systems with an RTE head.

TriVista: Consists of three imaging-corrected Acton Research spectrographs that can be used in single, double, and triple configurations. May incorporate PMT detectors and/or one or more Princeton Instruments CCD detectors.

VersArray: High-performance, general purpose imaging system. Wide variety of CCD arrays in imaging formats. Thermoelectric or cryogenic cooling available.

VersArray^{XP}: High-performance low-light imaging system for astronomy, MCP readout, pressure-sensitive paint (PSP) / wind tunnel testing, semiconductor failure analysis, and streak tube readout applications. Deep thermoelectric cooling (air).

Controllers:

ST-121: Diode array controllers shipped with diode array detectors, controlled by a PCI card.

ST-130: Obsolete controller but still supported in the WinX/32 software.

ST-133: Controller that can run the vast majority of Princeton Instruments brand cameras, including MicroMAX, PI-MAX, Spec-10, PI-LCX, PI-MTE, PI-SCX, PI-SX, OMA V, and VersArray. Different hardware types are needed to run different detectors (for example, liquid nitrogen-cooled vs. thermoelectrically-cooled).

ST-133 2 MHz: ST-133 controller, characterized by six software-selectable ADC rates.

ST-133 5 MHz: ST-133 controller, characterized by duplex head cable.

ST-138: Older controller for TE, LN, ICCD, and ITE units. It offers a few special features such as hardware accumulator. In general, this controller is being phased out.

Cameras/Detectors:

HCTE/CCD: See **NTE/CCD** and **NTE 2**.

ICCD: Standard, "classic" intensified camera, requires purging, has internal high voltage power but requires external high voltage pulses for gating. Controlled by ST-133 or ST-138.

LN/CCD: Liquid nitrogen cooled detector, 1.5 liter Dewar is standard, can be run with ST-138 or ST-133.

LN/InGaAs: Indium gallium arsenide detector controlled by a ST-133 controller

MTE 2: Miniature liquid cooled camera, designed for in vacuum chamber operation, can be run with ST-133 controller. Included in a PI-MTE system.

NTE/CCD and **NTE 2:** Stands for new TE head. More cube shaped than the TE, designed for maximum cooling. NTE 2 requires high-power version of ST-133.

RTE/CCD: Round thermoelectrically cooled camera, can be run with ST-133 controllers.

TE/CCD: Water- cooled camera, can be run with ST-138 or some ST-133 controllers.

TEA/CCD: Forced air-cooled camera, can be run with ST-138 or some ST-133 controllers.

V/ICCD: Video intensified detector. Always shipped with its own control box, produces standard video out so no interface card or software required. As of Version 2.5, this detector will not be supported by WinX/32.

XP: TE/air-cooled camera with lifetime vacuum, can be run with ST-133 controllers. Six-speed digitization is an option.

XTE: TE/air-cooled detector with cooling down to -100°C, can be run with ST-133 controllers.

Pulsers:

FG-100: Pulser with 5 nsec - 3 µsec gating, Gen II intensifiers only.

FG-101: Obsolete version of an ICCD unit, with internal high voltage power and gating.

PG-10: Pulser with 200 nsec to 6 msec gating, Gen II intensifiers only.

PG200: Software programmable pulser with 5 nsec to 80 msec gating. Highest performance pulser with the most features, Gen II intensifiers only

PTG: Dedicated "programmable delay generator" board that generates TTL level pulses to control intensifier gating in PI-MAX models. It is an option that sits in the third slot of an ST-133 controller.

High-Voltage Power Supplies:

IIC-100: High voltage power supply for intensified cameras without internal high voltage supplies (intensified PentaMAX, ITE, or lens-coupled intensified systems) for CW operation only. Not necessary for ICCD or PI-MAX cameras. For gated operation of intensified PentaMAX or ITE cameras buy the board version of the IIC-100, called the MCP-100, built into the pulser. During manufacture, a Model IIC-100 is configured for operation with a Gen II intensifier or with a Gen III intensifier, ***but not for operation with both types.***

IIC-200: Compact high voltage power supply for intensified cameras without internal high voltage supplies (intensified PentaMAX, ITE, or lens-coupled intensified systems) for gated and CW/Shutter operation. During manufacture, a Model IIC-200 is configured for operation with a Gen II intensifier or with a Gen III intensifier, ***but not for operation with both types.***

IIC-300: Combined image intensifier power supply and moderate performance gating pulse generator. Gated and CW/Shutter operation. PIV version available. During manufacture, a Model IIC-300 is configured for operation with a Gen II intensifier or with a Gen III intensifier, ***but not for operation with both types.***

Miscellaneous Components:

OFA: An adapter for connecting a fiber optic input to a spectrometer. Two versions are available for the best possible f/# matching, see the price list for details.

CC-100: Closed coolant circulator (not a chiller) designed for TE, TEA, or ICCD cameras

UV Lens: f/1.2 catadioptric lens only for ICCD or PI-MAX cameras

Array Designators

In the past, the designators in the following list were often used on camera serial labels to identify the array in the camera.

B: Back-illuminated CCD

DDA: Dual diode array CCD

F: Front illuminated CCD, in many cases no letter is used

E: CCD made by EEV

T: CCD made by Thomson

K: CCD made by Kodak

H: CCD made by Hamamatsu

HS: "High speed" MicroMAX system runs at 5 MHz

FT: Frame transfer detector

M: MPP (multi-pin phasing) CCD

P: (Usually) CCD offered exclusively by Princeton Instruments

PDA: Photodiode array

R: Deep depletion

S: Usually refers to SITE arrays, also see TK

TK: CCD made by SITE (formerly Tektronix), sometimes labeled S

UV: UV-to-VIS standard lumogen coating for UV-response to 195 nm

UVAR: Permanent UV-to-NIR A/R coating on some SITE CCDs (not lumogen/metachrome)

VISAR: Permanent VIS to NIR A/R coating on some SITE CCDs (not lumogen/metachrome)

Y: Interline CCD made by Sony

/1: grade 1 CCD

/2: grade 2 CCD

/3: grade 3 CCD

64: array format is 1024 x 64 pixels

100: array format is 1340 x 100 pixels

128: array format is 1024 x 128 pixels

256: 256 element linear array

400: array format is 1340 x 400 pixels

512: array format is 512 x 512 pixels; or 512 elements for linear arrays

576: array format is 576 x 384 pixels

768: array format is 768 x 512 pixels

782: array format is 782 x 582 pixels

1000: array format is 1000 x 800 pixels

1024: array format is 1024 x 256 (EEV or Hamamatsu) or 1024 x 1024 (SITE)

- 1100:** array format is 1100 x 330 pixels
- 1242:** array format is 1152 x 1242 pixels
- 1280:** array format is 1280 x 1024 pixels
- 1300:** array format is 1300 x 1030 pixels (Sony) or 1300 x 1340 pixels (EEV)
- 1317:** array format is 1317 x 1035 pixels
- 1340:** array format is 1340 x 100, 400, or 1300; family is exclusive to Princeton Instruments
- 1536:** array format is 1536 x 1032 pixels
- 2032:** array format is 2025 x 2032 pixels
- 2500:** array format is 2500 x 600, rectangular pixels
- 3072:** array format is 3072 x 2048 pixels

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Appendix B

WinSpec/32 First Light Instructions

Imaging

This section provides step-by-step instructions for acquiring an image for the first time. The intent of this procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other configurations, ones with more complex timing modes, can be performed.

Note: The additional setup steps required for the PI-MAX family of cameras have been omitted.

Assumptions

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in the camera's system manual and the "*Part 1 Getting Started*" section of this manual.
2. You are familiar with the application software.
3. The camera has a software-controlled internal shutter.
4. The system is being operated in imaging mode.
5. The target is a sharp image, text, or a drawing that can be used to verify that the camera is "seeing" and can be used to maximize focus.

Getting Started

1. Mount a test target in front of the camera.
2. Power ON the camera (i.e., switch the controller or power supply ON).

Note: The camera must be turned on before WinSpec is opened, and WinSpec must be closed before the camera is turned off.

3. Turn on the computer power.
4. Start the application software.

Setting the Parameters

Note: The following procedure is based on WinSpec/32: you will need to modify it if you are using a different application. Basic familiarity with the WinSpec/32 software is assumed. If this is not the case, you may want to review the software manual or have it available while performing this procedure.

Set the software parameters as follows:

Environment dialog (Setup|Environment): Check the DMA Buffer size. Large arrays (2048x2048, for example) require a buffer size on the order of 32 Mbytes. If you change the buffer size, you will have to *reboot the computer* for this memory allocation to be activated, and then restart WinSpec.

Controller/Camera tab (Setup|Hardware): These parameters should be set automatically to the proper values for your system.

- **Use PVCAM:** Verify that this box is checked.

Note: This check box is not present on software versions 2.5.19.6 and higher.

- **Controller type:** This information is read from the camera.
- **Camera type:** This information is read from the camera.
- **Shutter type:** None or Small (System dependent).
- **Readout mode:** Available modes are read from the camera. Select Full frame.

Detector Temperature (Setup|Detector Temperature...): The default temperature setting is read from the camera. When the array temperature reaches the set temperature, the **Detector Temperature** dialog will report that the temperature is **LOCKED**. Note that some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction. Once lock is established, the temperature will be stable to within $\pm 0.05^\circ\text{C}$.

Note: The **Detector Temperature** dialog will not display temperature information while you are acquiring data.

Cleans and Skips tab (Setup|Hardware): Click on **Load Default Values** and click on **Yes**.

Experiment Setup|Main tab (Acquisition|Experiment Setup...):

- **Exposure Time:** 100 ms
- **Accumulations & Number of Images:** 1

Experiment Setup|ROI tab (Acquisition|Experiment Setup...): Use this function to define the region of interest (ROI).

- **Imaging Mode:** Select this mode.
- Clicking on **Full** loads the full size of the chip into the edit boxes.

Experiment Setup |Timing tab (Acquisition|Experiment Setup...):

- **Timing Mode:** Free Run
- **Shutter Control:** Disabled Opened
- **Safe Mode vs. Fast Mode:** Fast

Confirming the Setup

1. If you are using WinSpec/32 and the computer monitor for focusing, select **Focus** from the **Acquisition** menu. Successive images will be sent to the monitor as quickly as they are acquired.
2. Adjust the lens aperture, intensity scaling, and focus for the best image as viewed on the computer monitor. Some imaging tips follow:
 - Begin with the lens blocked off and then set the lens at the smallest possible aperture (largest f-stop number).
 - Make sure there is a suitable target in front of the lens. An object with text or graphics works best.
 - Adjust the intensity scaling (by clicking the **5%-95%** button at the bottom left corner of the data window) and adjust the lens aperture until a suitable setting is found. Once you've determined that the image is present, select a lower setting for better contrast. Check the brightest regions of the image to determine if the A/D converter is at full-scale. *A 16-bit A/D is at full scale when the brightest parts of the image reach an intensity of 65535.* Adjust the aperture to where it is just slightly smaller (higher f-stop) than the setting where maximum brightness on any part of the image occurs.
 - Set the focus adjustment of the lens for maximum sharpness in the viewed image.
 - In the case of a camera with an F-mount, the camera lens adapter itself also has a focus adjustment. If necessary, this focus can be changed to bring the image into range of the lens focus adjustment.
3. After you have focused the camera, you can stop **Focus** mode, continue **Focus** mode, begin **Acquire** mode, or wait for the CCD to reach the operating temperature before going to **Acquire** mode.

Reminder: Because **Shutter Control** was set to **Disabled Opened** for focusing the image, you may want to reset shutter operation to **Normal** before continuing in **Focus** or **Acquire** mode.

Spectroscopy

Caution

Overexposure Protection: Cameras that are exposed to room light or other continuous light sources may become quickly saturated. If the camera is mounted to a spectrograph, minimize the entrance slit of the spectrograph to reduce the incident light.

The following paragraphs provide step-by-step instructions for operating a camera in a spectroscopy setup for the first time. The intent of this simple procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other configurations, ones with more complex timing modes, can be performed. An underlying assumption for the procedure is that the camera is to be operated with a spectrograph (such as an Acton Series 2300 or IsoPlane[®]) on which it has been properly installed (refer to the camera's system manual or the quick start instructions shipped with the camera. A suitable light source, such as a mercury pen-ray lamp, should be mounted in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.

Note: The additional setup steps required for the PI-MAX family of cameras have been omitted.

Assumptions

The following procedure assumes that:

1. You have already set up your system in accordance with the instructions in the camera system manual and the **"Part 1 Getting Started"** section of this manual.
2. You are familiar with the application software.
3. The system is being operated in spectroscopy mode.
4. The camera does not have an internal shutter.
5. The spectrograph has an entrance slit shutter that is being controlled by the camera via the **Shutter** connector.

Caution

If the camera has an internal shutter, **DO NOT USE** the **Shutter** connector to drive a spectrograph entrance slit shutter. If both the camera and the spectrograph have shutters, the entrance slit shutter will have to be removed or a Princeton Instruments SHC-EXT Shutter Control Box may be used to control the opening and closing of the entrance slit shutter. See the spectrograph manual.

Getting Started

1. Set the spectrograph entrance slit width to minimum (10 μm if possible).
2. Power ON the spectrograph (i.e., switch the power supply ON).
3. Mount a light source such as a Princeton Instruments Hg and Ne/Ar Dual Switchable light source at the spectrograph entrance slit.
4. Mount the camera to the spectrograph exit port.
5. Connect the shutter cable between the entrance slit shutter and the camera's Shutter connector. If the camera is a ProEM or ProEM+, make sure the shutter knob for the manual shutter is pushed in (i.e., manual shutter is open).

- **External Slit Shutter:** A shutter assembly mounted externally to the spectrograph has shutter cable that plugs into the **Shutter** connector.
 - **Internal Slit Shutter:** A shutter mounted internally has an external shutter connector in the sidewall of the spectrograph. Connect a shutter cable from the camera's **Shutter** connector to that connector.
6. Power ON the camera (i.e., switch the power supply ON).
- Note:** With USB 2.0, the camera must be turned on before WinSpec is opened, and WinSpec must be closed before the camera is turned off.
7. Turn on the computer power.
 8. Start the application software.

Setting the Camera Parameters

Note: The following procedure is based on WinSpec/32: you will need to modify it if you are using a different application. Basic familiarity with the WinSpec/32 software is assumed. If this is not the case, you may want to review the software manual or have it available while performing this procedure.

Set the software parameters as follows:

Environment dialog (Setup|Environment): Check the DMA Buffer size. Large arrays (2048x2048, for example) require a buffer size on the order of 32 Mbytes. If you change the buffer size, you will have to *reboot the computer* for this memory allocation to be activated, and then restart WinSpec.

Controller|Camera tab (Setup|Hardware): These parameters should be set automatically to the proper values for your system.

- **Use PVCAM:** Verify that this box is checked.

Note: This check box is not present on software versions 2.5.19.6 and higher.

- **Controller type:** This information is read from the camera.
- **Camera type:** This information is read from the camera.
- **Shutter type:** Remote (entrance slit shutter). You would select **None** if the camera had no shutter and was not controlling an entrance slit shutter.
- **Readout mode:** Available modes are read from the camera. Select Full frame.

Detector Temperature (Setup|Detector Temperature...): The default temperature setting is read from the camera. When the array temperature reaches the set temperature, the **Detector Temperature** dialog will report that the temperature is **LOCKED**. Note that some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction. Once lock is established, the temperature will be stable to within $\pm 0.05^\circ\text{C}$.

Note: The Detector Temperature dialog will not display temperature information while you are acquiring data.

Cleans and Skips tab (Setup|Hardware): Click on **Load Default Values** and click on **Yes**.

Experiment Setup|Main tab (Acquisition|Experiment Setup...):

- **Exposure Time:** 100 ms
- **Accumulations & Number of Images:** 1

Experiment Setup|ROI tab (Acquisition|Experiment Setup...): Use this function to define the region of interest (ROI).

- **Spectroscopy Mode:** Selected
- Clicking on **Full** loads the full size of the chip into the edit boxes.

Experiment Setup|Timing tab (Acquisition|Experiment Setup...):

- **Timing Mode:** Free Run
- **Shutter Control:** Disabled Opened.
- **Safe Mode vs. Fast Mode:** Fast

Setting the Spectrograph Parameters

1. **Define Spectrograph dialog (Spectrograph|Define):** Click on **Install/Remove Spectrograph**, highlight the appropriate spectrograph name in the **Supported Spectrographs** list (for example, **Acton SP-300i** for an Acton SP-2300i or **Acton SCT320** for an IsoPlane), and click on **Install Selected Spectrograph**.
2. **Move Spectrograph dialog:** Choose the grating to be move, and then set it to 500 nm if using a mercury lamp or to 0.0 nm if using a broadband source.

Confirming the Setup

1. Turn on the light source at the spectrograph entrance slit.
2. In WinSpec, select **Focus** (on the **Acquisition** menu or on the **Experiment Setup** dialog) to begin data accumulation. Depending on the display settings, you should see either a spectral band (image) or a graph. Background noise will decrease as the camera cools to its default temperature.
3. Turn off the light source. The data displayed should change to a background noise pattern or low intensity graph. If this occurs, you have confirmed that light entering the spectrograph is being seen by the camera. Skip Steps 4-5 and continue to the **“Rotational Alignment and Focusing”** topic on page 240.
4. If there is no difference between the data displayed when the light source is on or off:
 - a. Verify that the light source has power and is turned on.
 - b. If the camera is a ProEM or ProEM+, verify that the shutter knob for the manual shutter is in the open position (i.e., pushed in).
 - c. Verify that the entrance slit is open at least 10 μm .
 - d. Check the **Exposure Time (Experiment Setup Timing tab)**.
 - e. Confirm that **Shutter Control** is set to Normal (**Experiment Setup Timing tab**).
 - f. Check the shutter cable connections.

- g. Verify shutter operation. You should hear the shutter open and close while running in **Focus** mode.
 - If you hear a shutter operating and you have done Steps a-f, turn the light source on, wait a minute and then turn the light off while you view the data display. If the problem is fixed, stop acquisition or continue to the “*Rotational Alignment and Focusing*” topic on page 240; otherwise, **stop data acquisition** and continue to Step h.
 - If you do not hear a shutter operating and you have done Steps a-f, **stop data acquisition** and continue to Step h.
 - h. Make sure the spectrograph has an entrance slit shutter. An externally mounted shutter is easily confirmed. Verifying an internally mounted shutter requires access to the inside of the spectrograph: refer to the spectrograph manual for instructions.
 - i. Check to see if the camera has an internal shutter. Loosen and remove the camera from the spectrograph. If you see the CCD when you look into the front of the camera, the camera does not have an internal shutter. Re-mount the camera to the spectrograph.
 - j. If the camera and spectrograph both have shutters, permanent damage to the shutter driver may occur. You can either disconnect and remove the entrance slit shutter or control it via a Princeton Instruments SHC-EXT Control Box. To disconnect and remove an entrance slit shutter:
 - **External Slit Shutter:** Disconnect the shutter cable and remove the shutter assembly from the spectrograph entrance port.
 - **Internal Slit Shutter:** Disconnect the shutter cable. Removing an internally mounted shutter requires access to the inside of the spectrograph: refer to the spectrograph manual for removal instructions.
5. If you need more help, contact Customer Support. See page 282 for contact information.

Rotational Alignment and Focusing

The camera mounting hardware provides two degrees of freedom: rotation and focus. Rotation means the physical rotation of the camera while watching a live display on the monitor so that spectral lines will be perpendicular to the rows on the array. In this context, focus means to physically move the camera back and forth through the focal plane of the spectrograph while watching a live display until the optimal focus is achieved. The following procedure, which describes the rotational alignment and focusing operations with an Acton SP-2300i spectrograph, can be easily adapted to other spectrographs. For IsoPlane SCT-320 alignment and focusing information, see “*IsoPlane SCT-320 Spectrograph*” on page 242.

Caution

If the camera has an internal shutter, **DO NOT USE** the **Shutter** connector to drive a spectrograph entrance slit shutter. If both the camera and the spectrograph have shutters, the entrance slit shutter will have to be removed or a Princeton Instruments SHC-EXT Shutter Control Box may be used to control the opening and closing of the entrance slit shutter. See the spectrograph manual.

Acton Series Spectrograph

The initial rotational alignment assumes that you have already connected and turned on the camera and spectrograph, have opened WinSpec, and identified the camera and spectrograph. It also assumes that you have already confirmed the setup (see “*Confirming the Setup*”, page 238).

After you have aligned the optics the first time, you may want to repeat the process to fine tune the alignment.

- If you have not already done so, mount a light source such as a Princeton Instruments Hg and Ne/Ar Dual Switchable light source at the spectrograph’s entrance slit. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no “line” sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.
- Choose the grating to move, and then set it to 500 nm if using a mercury lamp or to 0.0 nm if using a broadband source.

Hint: Overhead fluorescent lights produce a mercury spectrum. Use a white card tilted at 45 degrees in front of the entrance slit to reflect overhead light into the spectrograph. Select 500 nm as the spectral line.

- Verify that the slit is set to 10 μm at a minimum. *If necessary, adjust the Exposure Time to maintain optimum (near full-scale) signal intensity.*
- Wait until the camera temperature locks at its default temperature.
- Make sure that the spectroscopy-mount adapter moves freely at the spectrograph (you may need to loosen the two set screws that lock the sliding tube in place).
- In WinSpec, select **Focus** (on the **Acquisition** menu or on the **Experiment Setup** dialog) to begin data accumulation. Data will be continuously acquired and displayed but will not be stored until you stop acquisition and use the **Save** function on the **File** menu.

- Adjust the rotational alignment. To perform the alignment you can:
 - Rotate the camera while watching a live display of the line. Choose a peak to monitor during the rotational alignment. This peak will go from broad to narrow and back to broad. Leave the camera rotation set for the narrowest achievable peak.
 - Take an image, display the horizontal and vertical cursor bars, compare the vertical bar to the line shape on the screen, and rotate the camera until the line shape on the screen is parallel with the vertical bar.
 - Set up three ROIs (one at the top, middle, and bottom of the array) with 10 rows binned for each via the **Experiment Setup|ROIs** tab, Then change the data display via the **Display Layout** dialog, so that **3d Graph** is selected (**General** tab), the **Z Axis Endpoints (3D Layout** tab) are %X = 0 and % Y = 40, and the **Save as Default** check box is checked. After clicking on **OK**, you should see three stacked graphs. Aligning the large cursor with a prominent peak, rotate the detector until the peak aligns with the cursor in all three ROIs.

Note: When aligning other accessories, such as fibers, lenses, optical fiber adapters, first align the spectrograph to the slit. Then align the accessory without disturbing the camera position. The procedure is identical to that used to focus the spectrograph (i.e., do the alignment and focus operations while watching a live image).

- The next step is to focus the camera. Slowly move the camera in and out of focus. You should see the spectral line go from broad to narrow and back to broad. Maximize the intensity level and minimize the FWHM of a selected peak or peaks. You may want to use the **Focus Helper** function (**Process|Focus Helper...**) to determine the narrowest line width: it can automatically locate peaks and generate a report on peak characteristics during live data acquisition (see the WinSpec/32 on-line help for more information).

Note that the way focusing is accomplished depends on the spectrograph, as follows:

- **Long focal-length spectrographs such as the Acton SP-2300:** The mounting adapter includes a tube that slides inside another tube to move the camera in or out as required to achieve optimum focus.
 - **Short focal-length spectrographs:** There is generally a focusing mechanism on the spectrograph itself which, when adjusted, will move the optics as required to achieve proper focus.
 - **No focusing adjustment:** If there is no focusing adjustment, either provided by the spectrograph or by the mounting hardware, then the only recourse will be to adjust the spectrograph's focusing mirror.
- Tighten the spectrograph set screws to secure the spectrograph adapter. Then stop data acquisition.

IsoPlane SCT-320 Spectrograph

Because the camera is mounted directly to the mounting plate on the IsoPlane, the rotational alignment and focusing operations are different from the way that rotational alignment and focusing are performed for an Acton Series spectrograph. The following information assumes that you are familiar with the locations of the mounting plate, Micrometer Compartment, and the locking set screw. If not, refer to the IsoPlane manual supplied with the spectrograph.

The initial alignment assumes that you have already connected and turned on the camera and spectrograph, have opened WinSpec, and identified the camera and spectrograph. It also assumes that you have already confirmed the setup ((see “*Confirming the Setup*”, page 238).

After you have aligned the optics the first time, you may want to repeat the process to fine tune the alignment.

1. Mount a Princeton Instruments light source such as the dual HG/NeAr source in front of the entrance slit of the spectrograph.
2. Select **Move** from the **Spectrograph** menu, choose the grating to move, and then set it to 500 nm if using a mercury lamp or to 0.0 nm if using a broadband source.
3. Set the slit to 10 μm at a minimum. *If necessary, adjust the Exposure Time to maintain optimum (near full-scale) signal intensity.*
4. Wait until the camera temperature locks at its default temperature.
5. Turn on **Focus** mode.
6. Adjust the rotational alignment. First, use a 9/64” hex wrench to loosen the four screws at the corners of the camera mounting plate. To perform the alignment you can:
 - Rotate the camera while watching a live display of the line. Choose a peak to monitor during the rotational alignment. This peak will go from broad to narrow and back to broad. Leave the camera rotation set for the narrowest achievable peak.
 - Take an image, display the horizontal and vertical cursor bars, compare the vertical bar to the line shape on the screen, and rotate the camera until the line shape on the screen is parallel with the vertical bar.
 - Set up three ROIs (one at the top, middle, and bottom of the array) with 10 rows binned for each via the **Experiment Setup|ROIs** tab, Then change the data display via the **Display Layout** dialog, so that **3d Graph** is selected (**General** tab), the **Z Axis Endpoints (3D Layout** tab) are %X = 0 and % Y = 40, and the **Save as Default** check box is checked. After clicking on **OK**, you should see three stacked graphs. Aligning the large cursor with a prominent peak, rotate the detector until the peak aligns with the cursor in all three ROIs.
7. After completing the rotational alignment, re-tighten the four mounting plate screws. The next steps are required for focusing the camera.
8. Remove the cover from the Micrometer Compartment.
9. Using a 3/32” hex wrench, loosen the locking set screw Refer to the IsoPlane manual for the screw location.
10. While continuously acquiring data, adjust the micrometer until you maximize the intensity level and minimize the FWHM of a selected peak or peaks.

11. Tighten down the locking set screw.
12. Place the Micrometer Cover on the spectrograph. Replace and tighten all of the cover screws. Then stop acquisition.

Acquiring Data

1. After you have completed rotational alignment and focusing, you can stop running in **Focus** mode.
2. Make any required changes to your experiment setup and software parameters. Changes might include adjusting the exposure time, setting up an entrance slit shutter, changing the timing mode to External Sync, lowering the temperature, or resetting Shutter Control to Normal.
3. Begin running **Acquire** mode. Data will be acquired and displayed/stored based on the experiment settings.
4. If you have completed data collection, you can leave the camera power on so the array temperature will remain locked or you can shut down the system.

Shutdown

1. Close WinSpec.
2. Turn off the light source and the spectrograph.
3. Turn off the camera power.

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Appendix C

Calibration Lines

MERCURY	184.91 194.17	226.22 237.83 248.20 253.65** 265.20 280.35 289.36 296.73	302.15 312.57* 313.17 334.15 365.02* 365.44 366.33	404.66* 407.78 434.75 435.84*	507.30* (2x253.65)	625.14 (2x312.57)	730.04 (2x365.02)	
ARGON			394.90	404.44 415.86* 416.42 418.19 419.10 420.07* 425.94 427.22 430.01 433.36		696.54*	706.72 727.29 738.40 750.39 751.46 763.51** 772.38* 794.82	800.62 801.48 810.37 811.53* 826.45 840.82 842.46
NEON			336.99 341.79 344.77 346.66 347.26 352.05* 359.35		533.08 534.11 540.06 585.25** 588.19 594.48 597.55	603.00 607.43 609.62* 614.31* 616.36 621.73 626.65 630.48 633.44 638.30* 640.23* 650.65* 653.29 659.90 667.83* 671.70 692.95	702.41 703.24* 705.91 717.39 724.52 743.89 748.89 753.58 754.41	837.76 849.54 863.46 865.44 878.20 878.38 885.39

100

200

300

400

500

600

700

800

Table 4. Wavelength Calibration Lines (in nanometers)

* indicates strong line within a wavelength group

**indicates strongest line for the element

() indicates 2nd or 3rd order

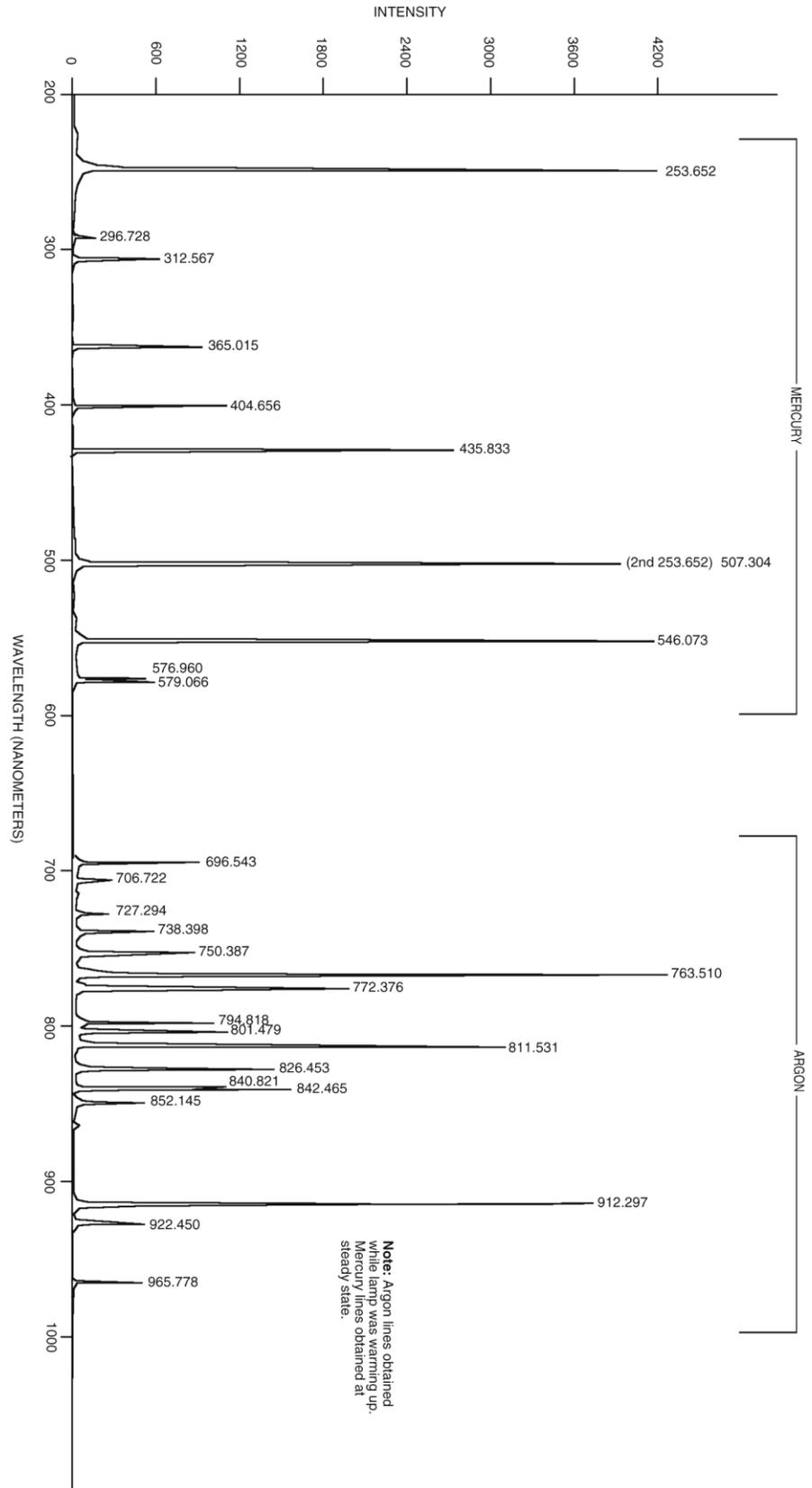


Figure 202. Wavelength Calibration Spectrum

Appendix D

Data Structure

Version 1.43 Header

All WinView or WinSpec files (version 1.43) must begin with the following 4100 byte header:

```
typedef WINXHEAD {
0      int dioden;          /* CCD X dimension */
2      int avgexp;         /* Not used by WinView */
4      int exposure;      /* exposure if -1 see lexpos */
6      int datarange;     /* Not used by WinView */
8      int mode;          /* Not used by WinView */
10     float wexsy;       /* Not used by WinView */
14     int asyavg;        /* Not used by WinView */
16     int asyseq;       /* Not used by WinView */
18     int linefreq;     /* Not used by WinView */
20     int date0;        /* Not used by WinView */
22     int date1;        /* Not used by WinView */
24     int date2;        /* Not used by WinView */
26     int date3;        /* Not used by WinView */
28     int date4;        /* Not used by WinView */
30     int ehour;        /* Not used by WinView */
32     int eminute;      /* Not used by WinView */
34     int noscan;       /* # of stripes collected if -1 see
                          /* lnoscan. */
36     int fastacc;      /* Not used by WinView */
38     int avgtime;      /* Not used by WinView */
40     int dmatotal;     /* Not used by WinView */
42     int faccount;     /* X dimension : Actual dim of image. */
44     int stdiode;      /* Not used by WinView */
46     float nanox;      /* Not used by WinView */
50     float calibdio[10]; /* Not used by WinView */
90     char fastfile[16]; /* fast access file. Not used by WinView */
106    int asylen;       /* Not used by WinView */
108    int datatype;     /* 0 -> float (4 byte)
                          /* 1 -> long integer (4 byte)
                          /* 2 -> integer (2 byte)
                          /* 3 -> unsigned integer (2 byte)
                          /* 4 -> String/char (1 byte)
                          /* 5 -> double (8 bytes) Not implemented
                          /* 6 -> byte (1 byte)
                          /* 7 -> unsigned byte (1 byte)
110    float calibnan[10]; /* Not used by WinView */
150    int rtanum;        /* Not used by WinView */
152    int astdiode;     /* Not used by WinView */
154    int int78;         /* Not used by WinView */
156    int int79;         /* Not used by WinView */
158    double calibpol[4]; /* Not used by WinView */
190    int int96;         /* Not used by WinView */
192    int int97;         /* Not used by WinView */
194    int int98;         /* Not used by WinView */
196    int int99;         /* Not used by WinView */
198    int int100;       /* Not used by WinView */
200    char exprem[5][80]; /* comments */
600    int int301;       /* Not used by WinView */
602    char label[16];   /* Not used by WinView */
618    int gsize;        /* Not used by WinView */
620    int lfloat;       /* Not used by WinView */
622    char califile[16]; /* calibration file. Not used by WinView */
638    char bkgdfile[16]; /* background file. Not used by WinView */
654    int srccmp;       /* Not used by WinView */
}
```

```

656     int stripe;           /* number of stripes per frame */
658     int scramble;        /* 0 - scramble, 1 - unscramble */
660     long lexpos;         /* exposure val 32-bits(when exposure=-1) */
664     long lnoscan;        /* no. of scan 32-bits(when noscan = -1) */
668     long lavgexp;        /* no. of accum 32-bits(when avgexp = -1) */
672     char stripfil[16];   /* strip file. Not used by WinView */
688     char version[16];    /* SW version & date "01.000 02/01/90" */
704     int controller_type; /* 1-new st120, 2-old st120,
                          /* 3-st130 type 1, 4-st130 type 2,
                          /* 5-st138, 6-DC131, and ST133.

                          /* YT_FILE_HEADER */
                          /* The YT variables are not used by WinView.
706     int     yt_file_defined; /* set TRUE for YT data file
708     int     yt_fh_calib_mode; /* calibration type*/
710     int     yt_fh_calib_type; /* time-unit (calibration type)
712     int     yt_fh_element[12]; /* element number
736     double  yt_fh_calib_data[12]; /* data
832     float   yt_fh_time_factor; /* time-factor
836     float   yt_fh_start_time; /* start time
840     int     reverse_flag; /* set to 1 if data should be
                          /* reversed, 0 do not reverse
};

```

Version 1.6 Header

All WinView/WinSpec files (version 1.6) and WinView/32 and WinSpec/32 data files must begin with the following 4100 byte header. Data files created under previous versions of WinView/WinSpec *can still be read correctly*. However, files created under the new versions (1.6 and higher) *cannot* be read by previous versions of WinView/WinSpec.

Header Structure Listing

			Decimal	Byte	
			Offset		

unsigned int	dioden;	/* 0 num of physical pixels (X axis)			*/
int	avgexp;	/* 2 number of accumulations per scan			*/
		/* if > 32767, set to -1 and			*/
		/* see lavgexp below (668)			*/
int	exposure;	/* 4 exposure time (in milliseconds)			*/
		/* if > 32767, set to -1 and			*/
		/* see lexpos below (660)			*/
unsigned int	xDimDet;	/* 6 Detector x dimension of chip			*/
int	mode;	/* 8 timing mode			*/
float	exp_sec;	/* 10 alternative exposure, in secs.			*/
int	asyavg;	/* 14 number of asynchron averages			*/
int	asyseq;	/* 16 number of asynchron sequential			*/
unsigned int	yDimDet;	/* 18 y dimension of CCD or detector.			*/
char	date[10];	/* 20 date as MM/DD/YY			*/
int	ehour;	/* 30 Experiment Time: Hours (as binary)			*/
int	eminute;	/* 32 Experiment Time: Minutes(as binary)			*/
int	noscan;	/* 34 number of multiple scans			*/
		/* if noscan == -1 use lnoscan			*/
int	fastacc;	/* 36			*/
int	seconds;	/* 38 Experiment Time: Seconds(as binary)			*/
int	DetType;	/* 40 CCD/DiodeArray type			*/
unsigned int	xdim;	/* 42 actual # of pixels on x axis			*/
int	stdiode;	/* 44 trigger diode			*/
float	nanox;	/* 46			*/
float	calibdio[10];	/* 50 calibration diodes			*/
char	fastfile[16];	/* 90 name of pixel control file			*/
int	asynen;	/* 106 asynchron enable flag 0 = off			*/
int	datatype;	/* 108 experiment data type			*/
		/* 0 = FLOATING POINT			*/
		/* 1 = LONG INTEGER			*/

```

/*          2 = INTEGER          */
/*          3 = UNSIGNED INTEGER */
float      calibnan[10]; /* 110 calibration nanometer */
int        BackGrndApplied; /* 150 set to 1 if background sub done */
int        astdiode; /* 152 */
unsigned int minblk; /* 154 min. # of strips per skips */
unsigned int numminblk; /* 156 # of min-blocks before geo skps */
double     calibpol[4]; /* 158 calibration coefficients */
unsigned int ADCrate; /* 190 ADC rate */
unsigned int ADCtype; /* 192 ADC type */
unsigned int ADCresolution; /* 194 ADC resolution */
unsigned int ADCbitAdjust; /* 196 ADC bit adjust */
unsigned int gain; /* 198 gain */
char       exprem[5][80]; /* 200 experiment remarks */
unsigned int geometric; /* 600 geometric operations rotate 0x01
/*          reverse 0x02, flip 0x04 */
char       xlabel[16]; /* 602 Intensity display string */
unsigned int cleans; /* 618 cleans */
unsigned int NumSkpPerCln; /* 620 number of skips per clean. */
char       califile[16]; /* 622 calibration file name (CSMA) */
char       bkgdfile[16]; /* 638 background file name */
int        srccmp; /* 654 number of source comp. diodes */
unsigned int ydim; /* 656 y dimension of raw data. */
int        scramble; /* 658 0 = scrambled, 1 = unscrambled */
long       lexpos; /* 660 long exposure in milliseconds
/*          used if exposure set to -1 */
long       lnoscan; /* 664 long num of scans
/*          used if noscan set to -1 */
long       lavgexp; /* 668 long num of accumulations
/*          used if avgexp set to -1 */
char       stripfil[16]; /* 672 stripe file (st130) */
char       version[16]; /* 688 version & date:"01.000 02/01/90" */
int        type; /* 704 1 = new120 (Type II)
/*          2 = old120 (Type I )
/*          3 = ST130
/*          4 = ST121
/*          5 = ST138
/*          6 = DC131 (PentaMAX)
/*          7 = ST133 (MicroMAX/SpectroMax)
/*          8 = ST135 (GPIB)
/*          9 = VICCD
/*          10 = ST116 (GPIB)
/*          11 = OMA3 (GPIB)
/*          12 = OMA4
int        flatFieldApplied; /* 706 Set to 1 if flat field was applied */
int        spare[8]; /* 708 reserved */
int        kin trig mode /* 724 Kinetics Trigger Mode */
char       empty[702]; /* 726 EMPTY BLOCK FOR EXPANSION */
float      clkspd_us; /* 1428 Vert Clock Speed in micro-sec */
int        HWaccumFlag; /* 1432 set to 1 if accum done by Hardware */
int        StoreSync; /* 1434 set to 1 if store sync used. */
int        BlemishApplied; /* 1436 set to 1 if blemish removal applied */
int        CosmicApplied; /* 1438 set to 1 if cosmic ray removal done */
int        CosmicType; /* 1440 if cosmic ray applied, this is type */
float      CosmicThreshold; /* 1442 Threshold of cosmic ray removal. */
long       NumFrames; /* 1446 number of frames in file. */
float      MaxIntensity; /* 1450 max intensity of data (future) */
float      MinIntensity; /* 1454 min intensity of data (future) */
char       ylabel[LABELMAX]; /* 1458 y axis label. */
unsigned int ShutterType; /* 1474 shutter type. */
float      shutterComp; /* 1476 shutter compensation time. */
unsigned int readoutMode; /* 1480 Readout mode, full, kinetics, etc. */
unsigned int WindowSize; /* 1482 window size for kinetics only. */
unsigned int clkspd; /* 1484 clock speed for kinetics &
/*          frame transfer.
unsigned int interface_type; /* 1486 computer interface (isa-taxi,
/*          pci, eisa, etc.)
unsigned long ioAdd1; /* 1488 I/O address of interface card. */
unsigned long ioAdd2; /* 1492 if more than one address for card */
unsigned long ioAdd3; /* 1496 */
unsigned int intLevel; /* 1500 interrupt level interface card */

```

```

unsigned int  GPIBadd;          /* 1502 GPIB address (if used) */
unsigned int  ControlAdd;      /* 1504 GPIB controller address (if used) */
unsigned int  controllerNum;   /* 1506 if multiple controller system will
                               /* have controller # data came from.
                               /* (Future Item)
unsigned int  SWmade;          /* 1508 Software which created this file */
int          NumROI;          /* 1510 number of ROIs used. If 0 assume 1
                               /* 1512 - 1630 ROI information
struct ROIinfo {
    unsigned int startx;       /* left x start value.
    unsigned int endx;         /* right x value.
    unsigned int groupx;       /* amount x is binned/grouped in hw.
    unsigned int starty;       /* top y start value.
    unsigned int endy;         /* bottom y value.
    unsigned int groupy;       /* amount y is binned/grouped in hw.
} ROIinfoblk[10];
                               /* ROI Starting Offsets:
                               /* ROI 1 = 1512
                               /* ROI 2 = 1524
                               /* ROI 3 = 1536
                               /* ROI 4 = 1548
                               /* ROI 5 = 1560
                               /* ROI 6 = 1572
                               /* ROI 7 = 1584
                               /* ROI 8 = 1596
                               /* ROI 9 = 1608
                               /* ROI 10 = 1620
char          FlatField[120];  /* 1632 Flat field file name.
char          background[120]; /* 1752 Background sub. file name.
char          blemish[120];    /* 1872 Blemish file name.
float         software_ver;    /* 1992 Software version.
char         UserInfo[1000];   /* 1996-2995 user data.
long         WinView_id;       /* 2996 Set to 0x01234567L if file was
                               /* created by WinX

```

Calibration Structures

There are three structures for the calibrations.

- The Area Inside the Calibration Structure (below) is repeated two times.

```

xcalibration, /* 3000 - 3488 x axis calibration */
ycalibration, /* 3489 - 3977 y axis calibration */

```

Start of X Calibration Structure

```

double  offset;          /* 3000 offset for absolute data scaling */
double  factor;          /* 3008 factor for absolute data scaling */
char    current_unit;    /* 3016 selected scaling unit
char    reserved1;       /* 3017 reserved
char    string[40];      /* 3018 special string for scaling
char    reserved2[40];   /* 3058 reserved
char    calib_valid;     /* 3098 flag if calibration is valid
char    input_unit;      /* 3099 current input units for
                               /* "calib value"
char    polynom_unit;    /* 3100 linear UNIT and used
                               /* in the "polynom_coeff"
char    polynom_order;   /* 3101 ORDER of calibration POLYNOM
char    calib_count;     /* 3102 valid calibration data pairs
double  pixel_position[10]; /* 3103 pixel pos. of calibration data
double  calib_value[10]; /* 3183 calibration VALUE at above pos
double  polynom_coeff[6]; /* 3263 polynom COEFFICIENTS
double  laser_position;  /* 3311 laser wavenumber for relative WN
char    reserved3;       /* 3319 reserved
unsigned char new_calib flag; /* 3320 If set to 200, valid label below
char    calib_label[81]; /* 3321 Calibration label (NULL term'd)
char    expansion[87];   /* 3402 Calibration Expansion area

```

Start of Y Calibration Structure

```

double  offset;          /* 3489 offset for absolute data scaling */
double  factor;         /* 3497 factor for absolute data scaling */
char    current_unit;   /* 3505 selected scaling unit */
char    reserved1;     /* 3506 reserved */
char    string[40];     /* 3507 special string for scaling */
char    reserved2[40];  /* 3547 reserved */
char    calib_valid;    /* 3587 flag if calibration is valid */
char    input_unit;    /* 3588 current input units for
                        /* "calib_value"
char    polynom_unit;   /* 3589 linear UNIT and used
                        /* in the "polynom coeff"
char    polynom_order;  /* 3590 ORDER of calibration POLYNOM
char    calib_count;    /* 3591 valid calibration data pairs
double  pixel_position[10]; /* 3592 pixel pos. of calibration data
double  calib_value[10]; /* 3672 calibration VALUE at above pos
double  polynom_coeff[6]; /* 3752 polynom COEFFICIENTS
double  laser_position; /* 3800 laser wavenumber for relative WN
char    reserved3;     /* 3808 reserved
unsigned char new_calib_flag; /* 3809 If set to 200, valid label below
char    calib_label[81]; /* 3810 Calibration label (NULL term'd)
char    expansion[87]; /* 3891 Calibration Expansion area

```

End of Calibration Structures

```

char    lstring[40];   /* 3978 special Intensity scaling string */
char    empty3[80];   /* 4018 empty block to reach 4100 bytes */
int     lastvalue;    /* 4098 Always the LAST value in the header */

```

Version 2.5 Header (3/23/04)

The current data file used for WINX files consists of a 4100 (1004 Hex) byte header followed by the data. Beginning with Version 2.5, many more items were added to the header to make it a complete as possible record of the data collection. This includes spectrograph and pulser information. Many of these additions were accomplished by recycling old information that had not been used in previous versions. All data files created under previous 2.x versions of WinView/WinSpec CAN still be read correctly. HOWEVER, files created under the new versions (2.5 and higher) CANNOT be read by previous versions of WinView/WinSpec OR by the CSMA software package.

Start of Header Information (0 - 2996)

		Decimal	
		Byte	
		Offset	
short	ControllerVersion	0	Hardware Version
short	LogicOutput	2	Definition of Output BNC
WORD	AmpHiCapLowNoise	4	Amp Switching Mode
WORD	xDimDet	6	Detector x dimension of chip.
short	mode	8	timing mode
float	exp_sec	10	alternative exposure, in sec.
short	VChipXdim	14	Virtual Chip X dim
short	VChipYdim	16	Virtual Chip Y dim
WORD	yDimDet	18	y dimension of CCD or detector.
char	date[DATEMAX]	20	date
short	VirtualChipFlag	30	On/Off
char	Spare_1[2]	32	
short	noscan	34	Old number of scans - should always be -1
float	DetTemperature	36	Detector Temperature Set
short	DetType	40	CCD/DiodeArray type
WORD	xdim	42	actual # of pixels on x axis
short	stdiode	44	trigger diode

float	DelayTime	46	Used with Async Mode
WORD	ShutterControl	50	Normal, Disabled Open, Disabled Closed
short	AbsorbLive	52	On/Off
WORD	AbsorbMode	54	Reference Strip or File
short	CanDoVirtualChipFlag	56	T/F Cont/Chip able to do Virtual Chip
short	ThresholdMinLive	58	On/Off
float	ThresholdMinVal	60	Threshold Minimum Value
short	ThresholdMaxLive	64	On/Off
float	ThresholdMaxVal	66	Threshold Maximum Value
short	SpecAutoSpectroMode	70	T/F Spectrograph Used
float	SpecCenterWlNm	72	Center Wavelength in Nm
short	SpecGlueFlag	76	T/F File is Glued
float	SpecGlueStartWlNm	78	Starting Wavelength in Nm
float	SpecGlueEndWlNm	82	Starting Wavelength in Nm
float	SpecGlueMinOvrLpNm	86	Minimum Overlap in Nm
float	SpecGlueFinalResNm	90	Final Resolution in Nm
short	PulserType	94	0=None, PG200=1, PTG=2, DG535=3
short	CustomChipFlag	96	T/F Custom Chip Used
short	XPrePixels	98	Pre Pixels in X direction
short	XPostPixels	100	Post Pixels in X direction
short	YPrePixels	102	Pre Pixels in Y direction
short	YPostPixels	104	Post Pixels in Y direction
short	asynen	106	asynchron enable flag 0 = off
short	datatype	108	experiment datatype 0 = float (4 bytes) 1 = long (4 bytes) 2 = short (2 bytes) 3 = unsigned short (2 bytes)
short	PulserMode	110	Repetitive/Sequential
WORD	PulserOnChipAccums	112	Num PTG On-Chip Accums
DWORD	PulserRepeatExp	114	Num Exp Repeats (Pulser SW Accum)
float	PulseRepWidth	118	Width Value for Repetitive pulse (usec)
float	PulseRepDelay	122	Width Value for Repetitive pulse (usec)
float	PulseSeqStartWidth	126	Start Width for Sequential pulse (usec)
float	PulseSeqEndWidth	130	End Width for Sequential pulse (usec)
float	PulseSeqStartDelay	134	Start Delay for Sequential pulse (usec)
float	PulseSeqEndDelay	138	End Delay for Sequential pulse (usec)
short	PulseSeqIncMode	142	Increments: 1=Fixed, 2=Exponential
short	PImaxUsed	144	PI-Max type controller flag
short	PImaxMode	146	PI-Max mode
short	PImaxGain	148	PI-Max Gain
short	BackGrndApplied	150	1 if background subtraction done
short	PImax2nsBrdUsed	152	T/F PI-Max 2ns Board Used
WORD	minblk	154	min. # of strips per skips
WORD	numminblk	156	# of min-blocks before geo skps
short	SpecMirrorLocation[2]	158	Spectro Mirror Location, 0=Not Present
short	SpecSlitLocation[4]	162	Spectro Slit Location, 0=Not Present
short	CustomTimingFlag	170	T/F Custom Timing Used
char	ExperimentTimeLocal[TIMEMAX]	172	Experiment Local Time as hhmmss\0
char	ExperimentTimeUTC[TIMEMAX]	179	Experiment UTC Time as hhmmss\0
short	ExposUnits	186	User Units for Exposure
WORD	ADCoffset	188	ADC offset
WORD	ADCrate	190	ADC rate
WORD	ADctype	192	ADC type
WORD	ADCresolution	194	ADC resolution
WORD	ADcbitAdjust	196	ADC bit adjust
WORD	gain	198	gain
char	Comments[5][COMMENTMAX]	200	File Comments
WORD	geometric	600	geometric ops: rotate 0x01,reverse 0x02, flip 0x04
char	xlabel[LABELMAX]	602	intensity display string
WORD	cleans	618	cleans
WORD	NumSkpPerCln	620	number of skips per clean.
short	SpecMirrorPos[2]	622	Spectrograph Mirror Positions
float	SpecSlitPos[4]	626	Spectrograph Slit Positions
short	AutoCleansActive	642	T/F
short	UseContCleansInst	644	T/F
short	AbsorbStripNum	646	Absorbance Strip Number
short	SpecSlitPosUnits	648	Spectrograph Slit Position Units
float	SpecGrooves	650	Spectrograph Grating Grooves
short	srccmp	654	number of source comp.diodes

WORD	ydim	656	y dimension of raw data.
short	scramble	658	0=scrambled,1=unscrambled
short	ContinuousCleansFlag	660	T/F Continuous Cleans Timing Option
short	ExternalTriggerFlag	662	T/F External Trigger Timing Option
long	lnoscan	664	Number of scans (Early WinX)
long	lavgexp	668	Number of Accumulations
float	ReadoutTime	672	Experiment readout time
short	TriggeredModeFlag	676	T/F Triggered Timing Option
char	Spare_2[10]	678	
char	sw_version[FILEVERMAX]	688	Version of SW creating this file
short	type	704	1 = new120 (Type II) 2 = old120 (Type I) 3 = ST130 4 = ST121 5 = ST138 6 = DC131 (PentaMax) 7 = ST133 (MicroMax/SpectroMax) 8 = ST135 (GPIB) 9 = VICCD 10 = ST116 (GPIB) 11 = OMA3 (GPIB) 12 = OMA4
short	flatFieldApplied	706	1 if flat field was applied.
char	Spare_3[16]	708	
short	kin_trig_mode	724	Kinetics Trigger Mode
char	dlabel[LABELMAX]	726	Data label.
char	Spare_4[436]	742	
char	PulseFileName[HDRNAMEMAX]	1178	Name of Pulser File with Pulse Widths/Delays (for Z-Slice)
char	AbsorbFileName[HDRNAMEMAX]	1298	Name of Absorbance File (if File Mode)
DWORD	NumExpRepeats	1418	Number of Times experiment repeated
DWORD	NumExpAccums	1422	Number of Time experiment accumulated
short	YT Flag	1426	Set to 1 if this file contains YT data
float	clkspd_us	1428	Vert Clock Speed in micro-sec
short	HWaccumFlag	1432	set to 1 if accum done by Hardware.
short	StoreSync	1434	set to 1 if store sync used
short	BlemishApplied	1436	set to 1 if blemish removal applied
short	CosmicApplied	1438	set to 1 if cosmic ray removal applied
short	CosmicType	1440	if cosmic ray applied, this is type
float	CosmicThreshold	1442	Threshold of cosmic ray removal.
long	NumFrames	1446	number of frames in file.
float	MaxIntensity	1450	max intensity of data (future)
float	MinIntensity	1454	min intensity of data future)
char	ylabel[LABELMAX]	1458	y axis label.
WORD	ShutterType	1474	shutter type.
float	shutterComp	1476	shutter compensation time.
WORD	readoutMode	1480	readout mode, full,kinetics, etc
WORD	WindowSize	1482	window size for kinetics only.
WORD	clkspd	1484	clock speed for kinetics & frame transfer
WORD	interface_type	1486	computer interface (isa-taxi, pci, eisa, etc.)
short	NumROIsInExperiment	1488	May be more than the 10 allowed in this header (if 0, assume 1)
char	Spare_5[16]	1490	
WORD	controllerNum	1506	if multiple controller system will have controller number data came from. This is a future item.
WORD	SWmade	1508	Which software package created this file
short	NumROI	1510	number of ROIs used. if 0 assume 1.
struct	ROIinfo{		
WORD	startx		left x start value.
WORD	endx		right x value.
WORD	groupx		amount x is binned/grouped in hw.
WORD	starty		top y start value.
WORD	endy		bottom y value.
WORD	groupy		amount y is binned/grouped in hw.

```

} ROIinfoblk[ROIMAX]
                                ROI Starting Offsets:
                                ROI 1 = 1512
                                ROI 2 = 1524
                                ROI 3 = 1536
                                ROI 4 = 1548
                                ROI 5 = 1560
                                ROI 6 = 1572
                                ROI 7 = 1584
                                ROI 8 = 1596
                                ROI 9 = 1608
                                ROI 10 = 1620
char    FlatField[HDRNAMEMAX]    1632 Flat field file name.
char    background[HDRNAMEMAX]    1752 background sub. file name.
char    blemish[HDRNAMEMAX]      1872 blemish file name.
float   file_header_ver          1992 version of this file header
char    YT_Info[1000]            1996-2995 Reserved for YT information
long    WinView_id                2996 == 0x01234567L if file created by WinX

```

Calibration Structures

There are three structures for the calibrations

- The Area Inside the Calibration Structure (below) is repeated two times.

```

xcalibration, /* 3000 - 3488 x axis calibration*/
ycalibration, /* 3489 - 3977 y axis calibration*/

```

Start of X Calibration Structure (3000 - 3488)

```

double  offset                    3000 offset for absolute data scaling
double  factor                    3008 factor for absolute data scaling
char    current_unit              3016 selected scaling unit
char    reserved1                 3017 reserved
char    string[40]                3018 special string for scaling
char    reserved2[40]            3058 reserved
char    calib_valid               3098 flag if calibration is valid
char    input_unit                3099 current input units for "calib_value"
char    polynom_unit              3100 linear UNIT and used in the
                                "polynom_coeff"
char    polynom_order             3101 ORDER of calibration POLYNOM
char    calib_count               3102 valid calibration data pairs
double  pixel_position[10]        3103 pixel pos. of calibration data
double  calib_value[10]           3183 calibration VALUE at above pos
double  polynom_coeff[6]          3263 polynom COEFFICIENTS
double  laser_position            3311 laser wavenumber for relative WN
char    reserved3                 3319 reserved
BYTE    new_calib_flag            3320 If set to 200, valid label below
char    calib_label[81]           3321 Calibration label (NULL term'd)
char    expansion[87]             3402 Calibration Expansion area

```

Start of Y Calibration Structure (3489 - 3977)

```

double  offset                    3489 offset for absolute data scaling
double  factor                    3497 factor for absolute data scaling
char    current_unit              3505 selected scaling unit
char    reserved1                 3506 reserved
char    string[40]                3507 special string for scaling
char    reserved2[40]            3547 reserved
char    calib_valid               3587 flag if calibration is valid
char    input_unit                3588 current input units for "calib_value"
char    polynom_unit              3589 linear UNIT and used in the
                                "polynom_coeff"
char    polynom_order             3590 ORDER of calibration POLYNOM
char    calib_count               3591 valid calibration data pairs
double  pixel_position[10]        3592 pixel pos. of calibration data
double  calib_value[10]           3672 calibration VALUE at above pos

```

double	polynom_coeff[6]	3752	polynom COEFFICIENTS
double	laser_position	3800	laser wavenumber for relative WN
char	reserved3	3808	reserved
BYTE	new_calib_flag	3809	If set to 200, valid label below
char	calib_label[81]	3810	Calibration label (NULL term'd)
char	expansion[87]	3891	Calibration Expansion area

End of Calibration Structures (3978-4098)

char	Istring[40]	3978	special intensity scaling string
char	Spare_6[25]	4018	
BYTE	SpecType	4043	spectrometer type (acton, spex, etc.)
BYTE	SpecModel	4044	spectrometer model (type dependent)
BYTE	PulseBurstUsed	4045	pulser burst mode on/off
DWORD	PulseBurstCount	4046	pulser triggers per burst
double	PulseBurstPeriod	4050	pulser burst period (in usec)
BYTE	PulseBracketUsed	4058	pulser bracket pulsing on/off
BYTE	PulseBracketType	4059	pulser bracket pulsing type
double	PulseTimeConstFast	4060	pulser slow exponential time constant (in usec)
double	PulseAmplitudeFast	4068	pulser fast exponential amplitude constant
double	PulseTimeConstSlow	4076	pulser slow exponential time constant (in usec)
double	PulseAmplitudeSlow	4084	pulser slow exponential amplitude constant
short	AnalogGain;	4092	analog gain
short	AvGainUsed	4094	avalanche gain was used
short	AvGain	4096	avalanche gain value
short	lastvalue	4098	Always the LAST value in the header

Start of Data (4100 -)

4100	Start of Data
.	
.	
.	

***** End of File *****

Definition of Array Sizes

HDRNAMEMAX = 120	Max char str length for file name
USERINFOMAX = 1000	User information space
COMMENTMAX = 80	User comment string max length (5 comments)
LABELMAX = 16	Label string max length
FILEVERMAX = 16	File version string max length
DATEMAX = 10	String length of file creation date string as ddmmyyyy\0
ROIMAX = 10	Max size of roi array of structures
TIMEMAX = 7	Max time store as hhmmss\0

Custom Data Types Used In the Structure

BYTE = unsigned char

WORD = unsigned short

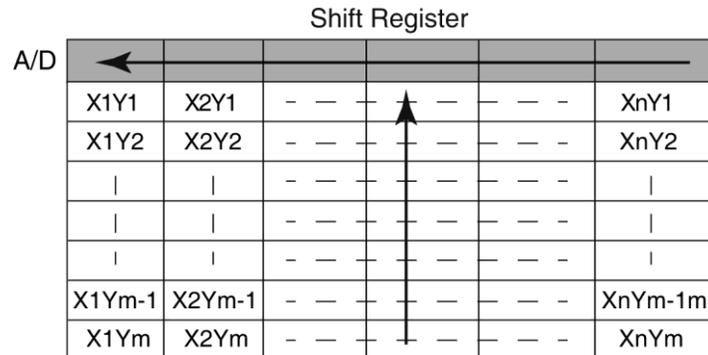
DWORD = unsigned long

Reading Data

Data follow the header beginning at offset 4100. In WinView/WinSpec, the data are always stored exactly as they are collected. The order of the data depends on the placement of the shift register. In the diagram below, the shift register is on the TOP of the sensor. Each ROW of data is first shifted UP into the shift register and then LEFT. The data are read (and stored) in this order:

First row read: X1Y1, X2Y1, ... XnY1

Last row read: X1Ym, X2Ym, ... XnYm



The data are stored as sequential points and the X, Y, and Frame dimensions are determined by the header.

The X dimension of the stored data is in "xdim" (Offset 42).

The Y dimension of the stored data is in "ydim" (Offset 656).

The size of a frame (in bytes) is:

One frame size = "xdim" x "ydim" x "datatype" (Offset 108)

The number of frames of data stored is in "NumFrames" (Offset 1446).

Appendix E

Auto-Spectro Wavelength Calibration

Equations used in WinSpec Wavelength Calibration

WinSpec/32 wavelength calibration is based on the grating equation for Czerny-Turner or Ebert spectrographs (see Figure 203).

$$(\mathbf{m}/\mathbf{d})\lambda = \sin \alpha + \sin \beta, \text{ or } \lambda = (\mathbf{d}/\mathbf{m})(\sin \alpha + \sin \beta), \quad (1)$$

where: λ = wavelength at the center of the image plane,

\mathbf{m} = diffraction order

\mathbf{d} = distance between grooves (the inverse of grooves per mm), and

α, β = angles of the incident and exit beam relative to the grating normal.

The angles α and β are related to the inclusion angle, γ , and the rotational angle of the grating, ψ :

$$\alpha = \psi - \gamma/2, \text{ and } \beta = \psi + \gamma/2.$$

Thus the grating equation can be written as:

$$(\mathbf{m}/\mathbf{d}) \lambda = \sin (\psi - \gamma/2) + \sin (\psi + \gamma/2) = 2 \sin \psi \cos (\gamma/2),$$

and the grating angle is given by:

$$\psi = \text{asin} \{ \mathbf{m}\lambda / (2\mathbf{d} \cos (\gamma/2)) \}. \quad (2)$$

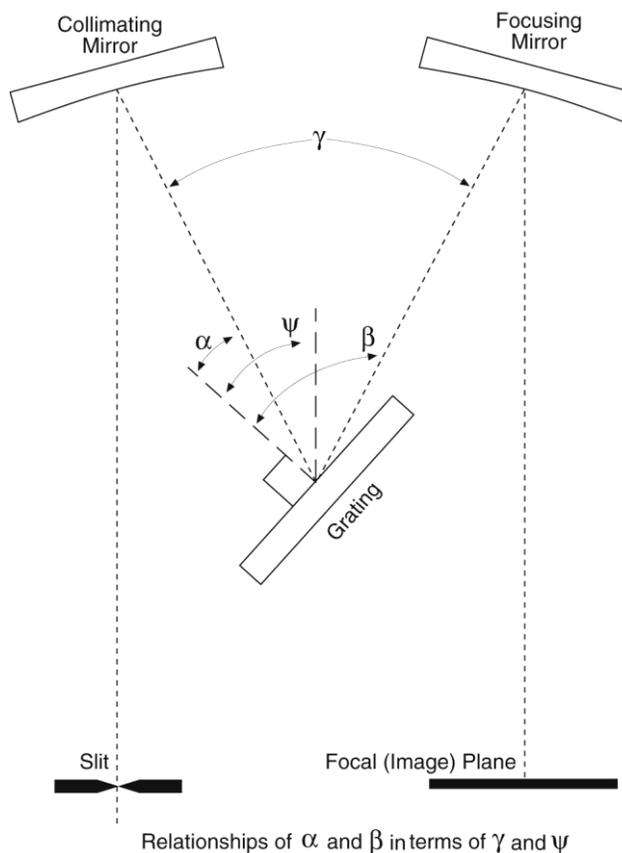


Figure 203. Relationships of α and β in terms of ψ and γ

Note that the wavelength at the **center** of the exit plane does not depend on the focal length, f . However, the wavelength at points off center depends on both the focal length and the detector angle, δ (the angle of the image plane relative to the plane perpendicular to the spectrograph focal axis at the center of the image plane; see Figure 204). For some wavelength λ' relatively close to λ (at the same grating angle),

$$\begin{aligned}\lambda' &= (\mathbf{d}/\mathbf{m})(\sin \alpha + \sin \beta') = (\mathbf{d}/\mathbf{m})(\sin \alpha + \sin (\beta + \xi)) \\ &= (\mathbf{d}/\mathbf{m})\{\sin (\psi - \gamma/2) + \sin (\psi + \gamma/2 + \xi)\}.\end{aligned}\quad (3)$$

The angle ξ depends on the focal length f , the detector angle δ , and the distance of λ' from the center of the image plane, \mathbf{nx} , where \mathbf{n} is the number of pixels from the center and \mathbf{x} is the pixel width; the relationship is given by:

$$\mathbf{tan} \xi = (\mathbf{nx} \cos \delta) / (f + \mathbf{nx} \sin \delta), \text{ as shown in Figure 204.} \quad (4)$$

When the image plane is perpendicular, $\delta = 0$, and this reduces to:

$$\mathbf{tan} \xi = (\mathbf{nx} / f)$$

Using the known parameters of focal length f , detector angle δ , number of pixels from center \mathbf{n} , and pixel width \mathbf{x} , first calculate the angle ξ from equation 4. The grating angle ψ can be calculated using the known parameters center wavelength λ , diffraction order \mathbf{m} , grating grooves per mm $1/\mathbf{d}$, and inclusion angle γ , from equation 2. Finally, the wavelength at pixel \mathbf{n} is calculated using equation 3.

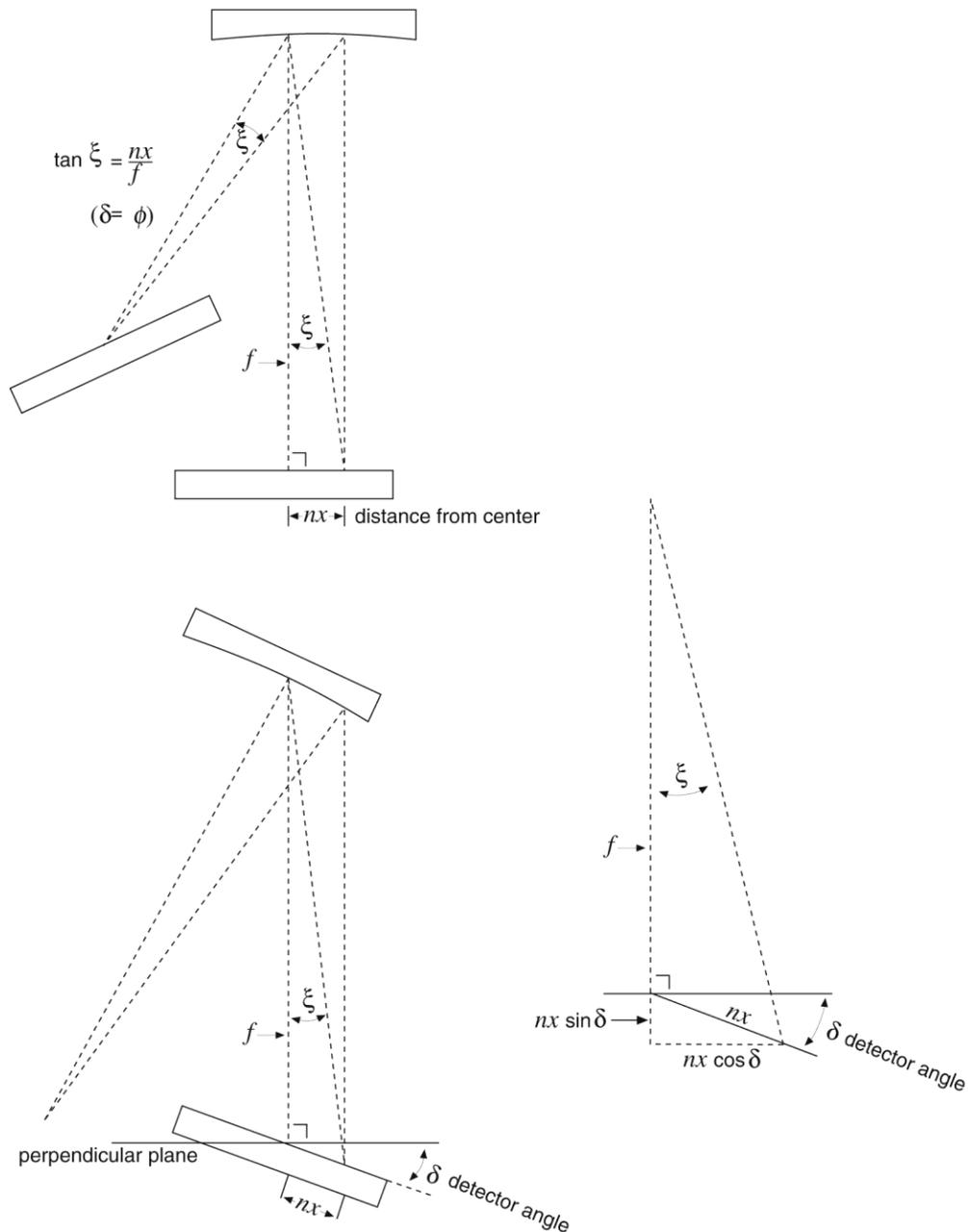


Figure 204. Relationship between ξ and the focal length, detector angle, and the distance of λ' from image plane

WinSpec X Axis Auto Calibration

When “Calibration Usage” is set to “Auto Spectro” in WinSpec/32, the X Axis calibration is done in the following steps after a wavelength change. First the wavelength is calculated at each end of the array using the method above. Then these two points, plus the third center wavelength point, are automatically fit to a 2nd order polynomial using the wavelength calibration functions.

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Appendix F

CD ROM Failure Work-Arounds

Although not common, there are CD drives that are not compatible with the Win '95 long filename convention. Attempting to install on such a system causes the filenames to be truncated and the install fails, causing a message like:

**An error occurred during the move data process: -113
Component: Application\WinXSystem
File Group: WinXSystem**

Fortunately there are a couple of workarounds, both involving copying the install files to the customer's hard drive first, then installing the software from that location.

1. If possible, copy the files to the customer's hard drive via another computer that supports long file names. If the customer's computer is part of a network then the files can be copied first to the hard drive of a computer that supports long file names, then transferred through the network to the customer's hard drive. Check the list of files below to make sure that the long filenames remain intact. Then install the software from this location on the hard drive.
2. Copy the files to the customer's hard drive from the customer's CD-ROM, then fix the names of the files that were truncated. There are only 7 files that are not DOS compatible (8 + 3), so this at most a 10 minute job. Here are their abbreviated and full filenames. (Not all of these files are used in the standard installation but all are present on the CD.)
 - CLSSNA~1.CLS, rename to clsSnapIn.cls
 - PIXCMT~1.DLL, rename to PIXCMTXT32.dll
 - WINX_R~1.DOC, rename to WinX_readme.doc
 - WINX32~1.BAS, rename to Winx32Test.bas
 - WINX32~1.DOC, rename to Winx32 Automation - VB Version.doc
 - WINX32~1.FRM, rename to Winx32Test.frm
 - WINX32~1.FRX, rename to Winx32Test.frx

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Appendix G

WinSpec/32 Repair and Maintenance

Note: When WinSpec/32 is installed, it modifies the Windows Registry file. If for any reason you reinstall Windows, the Registry file may be replaced, and WinSpec/32 may not run correctly. Reinstall WinSpec/32 to correct this problem.

Install/Uninstall WinSpec/32 Components at a Later Time

After you have installed WinSpec/32, you may want to install additional WinSpec/32 files or to uninstall selected files. To do so:

1. Start the installation program, click on **CONTINUE**, click on **Install WinSpec/32 or WinView/32**, and then click on **Install WinSpec/32 for Windows**. Refer to Figure 205 below.

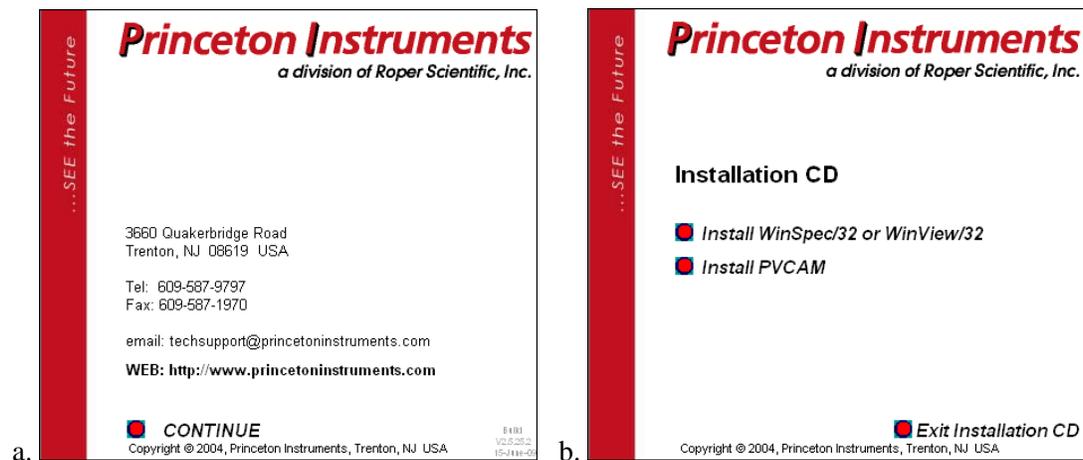


Figure 205. WinSpec, WinView, or WinXTest Selection dialogs

2. On the **Enter Password** dialog, enter the password and click on **Next**.



Figure 206. Media Password dialog

3. Because WinSpec/32 was previously installed, the **Application Maintenance** dialog (Figure 207) will be displayed.

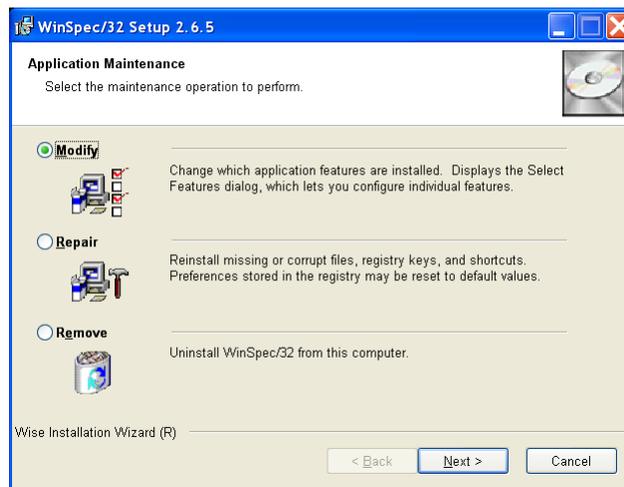


Figure 207. Application Maintenance dialog

4. Select the **Modify** radio button and click on **Next**.

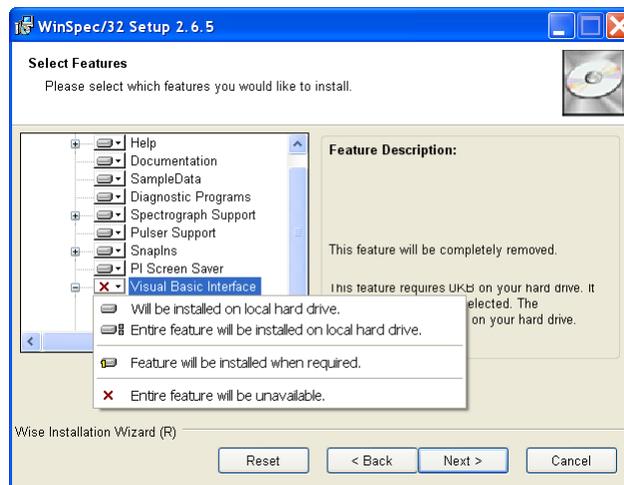


Figure 208. Select Features dialog

5. On the **Select Features** dialog, click on the feature you want to install or uninstall and select the appropriate action from the list.
6. Then click on **Next** and follow the instructions on the dialogs.

- Click on **Finish** when the **WinSpec/32 has been successfully installed** dialog is displayed.

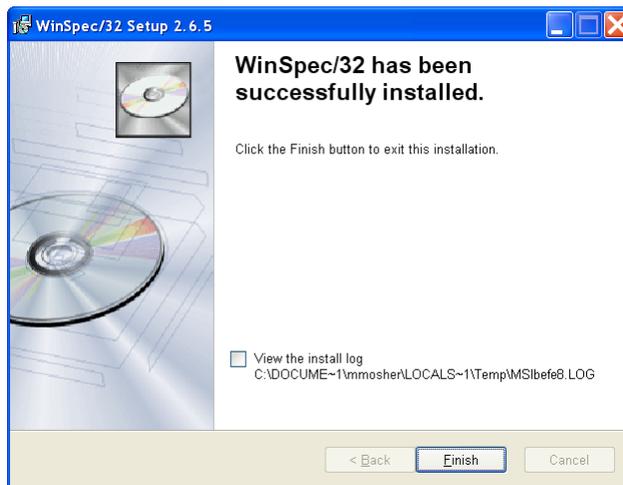


Figure 209. WinSpec/32 has been successfully installed dialog

- Exit from the installation program or choose another program to install, perform maintenance on, or uninstall.



Figure 210. Exit or Install Another Program dialog

Installing More than One Version of WinSpec/32

You can install more than one version of WinSpec/32, WinView/32 or any combination of the two on a single computer. The install program will automatically create the new directory.

Caution

Do not install both the WinSpec/32 and WinView/32 software packages in the same directory.

Caution

Although several different versions of WinSpec/32 and/or WinView/32 can be installed on the same computer without conflicts, you should not run more than one version at any one time. The manner in which Princeton Instruments software allocates memory for data collection precludes collecting data using two software packages at once.

PIHWDEF.INI & SESSION.DAT

WinSpec/16 and PIHWDEF.INI: The hardware initialization file PIHWDEF.INI, is included with *16-bit versions of WinSpec software*. The file contains all of the hardware settings necessary to get started and is read the first time WinSpec is executed. At the end of the first operating session, the settings in effect are written to SESSION.DAT, which is read the next time WinSpec software is operated so that the new session will begin with the same settings that were in effect at the end of the previous one.

WinSpec/32 and the Windows Registry: WinSpec/32 doesn't need PIHWDEF.INI or SESSION.DAT, because it automatically stores the settings in the registry at the end of each operating session. However, WinSpec/32 will read the WinSpec/16 PIHWDEF.INI or SESSION.DAT if they are copied to the directory containing the WinSpec/32 software. This allows users who are upgrading from a 16-bit version of WinSpec to WinSpec/32 to transfer their previous operating settings to the new software. However, there is a constraint: if there are settings in the registry (i.e., WinSpec/32 has been operated at least once), the software will not read PIHWDEF.INI or SESSION.DAT unless the file date is newer than the date of the stored registry settings. This problem can be avoided by simply copying PIHWDEF.INI or SESSION.DAT to the WinSpec/32 directory *before* operating it the first time. If that opportunity is lost, a newer SESSION.DAT can be created by booting the 16-bit WinSpec software and then exiting the program in the usual manner. Similarly, a text editor could be used to open/edit a copy of PIHWDEF.INI and then save it so that it has the current date.

Uninstalling and Reinstalling

If you suspect any of the WinSpec/32 files have become corrupt, you should first delete all WinSpec/32 files, then reinstall the software from the CD or the FTP site. Follow the steps below to remove WinSpec/32. Note that some files may remain. They will have to be removed manually.

To uninstall WinSpec/32 from your computer:

1. Open the **Windows Control Panel**.
2. Double-click on **Add/Remove Programs**.
3. Highlight the WinSpec/32 version to uninstall and click on **Add/Remove**.

Notes:

1. The directory in which WinSpec/32 was originally installed will remain, as will any files it contains that were not placed there during the original installation.
 2. The Data directory created during the original installation may also be deleted. Any data files you want to save should be copied to a safe location before uninstalling.
 3. The Version # and User identification will be removed from the registry. However, the registry also contains much information that was placed there in the course of setting up and operating the software. That information will remain and will be available for use if WinSpec/32 is later reinstalled.
4. Follow the instructions on the dialogs.

To reinstall WinSpec/32 and any options, follow the procedure as described beginning on page 23.

Appendix H

USB 2.0 Limitations

The following information covers the currently known limitations associated with operating under the USB 2.0 interface.

- Maximum cable length is 5 meters (16.4 feet)
- 1 MHz is currently the upper digitization rate limit for the ST-133 Controller.
- Large data sets and/or long acquisition times may be subject to data overrun because of host computer interrupts during data acquisition.
- USB 2.0 is not supported by the Princeton Instruments PC Interface Library (Easy DLLS).
- Some WinView/WinSpec 2.5.X features are not fully supported with USB 2.0. See the table below.

Feature	Supported with USB 2.0 in WinX 2.5.X	Remarks
Demo Port Capability	NO	
DIF	NO	
Kinetics	YES	WinX 2.5.18.1
Reset Camera to NVRAM Defaults	NO	
Temperature Lock Status	YES	WinX 2.5.x doesn't utilize hardware lock status
PTG	YES	
Virtual Chip	NO	
Custom Timing	YES	WinX 2.5.18.1
Custom Chip	YES	WinX 2.5.18.1
Frames per Interrupt	NO	
RS170 (Video Output)	NO	
Online Exposure	NO	
File Information	YES	Not all header info is currently available in WinX 2.5.x through PVCAM
Overlapping ROIs	NO	

Table 5. Features Supported under USB 2.0 (continued on next page)

Feature	Supported with USB 2.0 in WinX 2.5.X	Remarks
Macro Record	YES	Macros recorded for non-PVCAM cameras may have to be re-recorded to function
TTL I/O	NO	

Table 5. Features Supported under USB 2.0

Troubleshooting

Introduction

The following information is provided for troubleshooting communication errors that may occur.

Camera1 (or similar name) on Hardware Setup dialog



Figure 211. Camera1 in Camera Name Field

When a PVCAM-based camera is detected/selected during the Camera Detection Wizard (formerly the Hardware Wizard), a default name such as Camera1 will be shown in the Detected Hardware table and will be entered in the **Camera Name** (or **Controller Type**) field on the **Setup|Hardware|Controller/CCD** tab. Because this name is not particularly descriptive, you may want to change it. Such a change is made by editing the PVCAM.INI file that is generated by Camera Detection Wizard.

To change the default Camera Name:

1. Using **Notepad** or a similar text editor, open **PVCAM.INI**, which is located in the Windows directory (C:\WINNT, for example). You should see entries like the ones below.

```
[Camera_1]
Type=1
Name=Camera1
Driver=apausb.sys
Port=0
ID=523459
```

2. Change the "Name=" entry to something more meaningful for you (for example, ST133USB - to indicate that this is a PVCAM-based system using an ST-133 with a USB 2.0 interface) and save the edited file.

```
[Camera_1]
Type=1
Name=ST133USB
Driver=apausb.sys
Port=0
ID=523459
```

3. The new Camera Name (or Controller Type) name will now appear on the **Hardware Setup|Controller/Camera** tab.

Controller Is Not Responding

If this message pops up when you click on **OK** after selecting the "Interface Type" during **Hardware Setup** (under the WinSpec/32 **Setup** menu), the system has not been able to communicate with the Controller. Check to see if Controller has been turned ON and if the interface card, its driver, and the interface cable have been installed.

- If the Controller is ON, the problem may be with the interface card, its driver, interrupt or address conflicts, or the cable connections.
- If the interface card is not installed, close the application program and turn the Controller OFF. Follow the interface card installation instructions in provided with your interface card and cable the card to the SERIAL COM port on the rear of the Controller. Then do a "Custom" installation of WinSpec/32 with the appropriate interface component selected: "PCI Interface" or "ISA Interface", depending on the interface card type. Be sure to deselect the interface component that does not apply to your system.

Note: WinX (versions 2.5.25 and higher) does not support the ISA interface.

- If the interface card is installed in the computer and is cabled to the SERIAL COM port on the rear of the Controller, close the application program and turn the Controller OFF. Check the cable connections and tighten the locking screws if the connections are loose.
- If the interface card was installed after WinSpec/32 has been installed, close that application and do a "Custom" installation of it with the appropriate interface component selected: "PCI Interface" or "ISA Interface", depending on the interface card type. Be sure to deselect the interface component that does not apply to your system.

Note: WinX (versions 2.5.25 and higher) does not support the ISA interface.

Data Loss or Serial Violation

You may experience either or both of these conditions if the host computer has been set up with Power Saving features enabled. This is particularly true for power saving with regard to the hard drive. Make sure that Power Saving features are disabled while you are running WinSpec/32.

Data Overrun Due to Hardware Conflict message

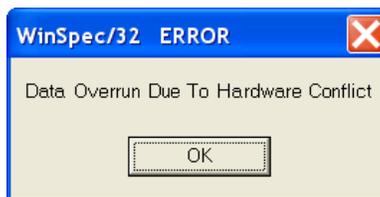


Figure 212. Data Overrun Due to Hardware Conflict dialog

If this dialog appears when you try to acquire a test image, acquire data, or run in focus mode, check the CCD array size and then check the DMA buffer size. A large array (for example, a 2048x2048 array), requires a larger DMA buffer larger setting than that for a smaller array (for example, a 512x512 array).

To change the DMA buffer setting:

1. Note the array size (on the **Setup|Hardware|Controller/CCD** tab or the **Acquisition|Experiment Setup|Main** tab Full Chip dimensions).
2. Open **Setup|Environment|Environment** dialog.
3. Increase the DMA buffer size to a minimum of 32 Mb (64 Mb if it is currently 32 Mb or 128 Mb if it is currently 64 Mb), click on **OK**, and close WinSpec.
4. Reboot your computer.
5. Restart WinSpec and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

Data Overrun Has Occurred message

Because of memory constraints and the way that USB transfers data, a "Data overrun has occurred" message may be displayed during data acquisition. If this message is displayed, take one or more of the following actions:

1. Minimize the number of programs running in the background while you are acquiring data with WinSpec/32.
2. Run data acquisition in Safe Mode.
3. Add memory.
4. Use binning.
5. Increase the exposure time.
6. Defragment the hard disk.
7. Update the Orange Micro USB2 driver. See "*OrangeUSB USB 2.0 Driver Update*", page 273.

If the problem persists, your application may be USB 2.0 bus limited. Since the host computer controls the USB 2.0 bus, there may be situations where the host computer interrupts the USB 2.0 port. In most cases, the interrupt will go unnoticed by the user. However, there are some instances when the data overrun cannot be overcome because USB 2.0 bus limitations combined with long data acquisition times and/or large data sets increase the possibility of an interrupt while data is being acquired. If your experiment requirements include long data acquisition times and/or large data sets, your application may not be suitable for the USB 2.0 interface. Therefore, we recommend replacement of the USB 2.0 interface module with our TAXI interface module and Princeton Instruments PCI card. If this is not the case and data overruns continue to occur, contact Customer Support (see page 282 for contact information).

Error Creating Controller message

This message may be displayed if you are using the USB 2.0 interface and have not run the RSConfig.exe program (see previous topic), if the PVCAM.INI file has been corrupted, or if the ST-133 was not turned on before you started WinSpec/32 and began running the Hardware Setup wizard.

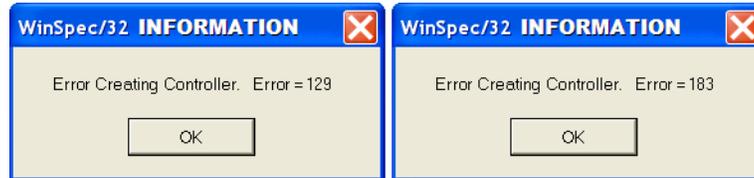


Figure 213. Error Creating Controller dialog

Error 129: Indicates that the problem is with the PVCAM.INI file. Close WinSpec/32, run RSConfig, make sure the ST-133 is on, reopen WinSpec, and begin running the Hardware Setup wizard.

Error 183: Indicates that the ST-133 is off. If you are running the Hardware Setup wizard when this message appears, click on **OK**, turn on the ST-133, and, on the PVCAM dialog, make sure **Yes** is selected and then click on **Next**. The Hardware Setup wizard should continue to the Controller Type dialog.

Ethernet Network is not accessible

When the Princeton Instruments software is installed, all Intel Pro/1000 interface card drivers found on the host computer are updated with the Intel Pro/1000 Grabber Adapter (Vision High-Performance IP Device) driver provided by Pleora Technologies, Inc. If this computer is connected to an Ethernet network via an Intel Pro/1000 card that does not use the Pleora driver, the network connection will be broken.

To restore the driver for the Ethernet card that is used to connect to the network:

1. Locate the EbDriverTool32.exe file.
 - Download the **EbDriverTool32.exe** file to your computer from <ftp://ftp.princetoninstruments.com/public/Software/Official/WinX32/GigE/>
 - Or open the default Pleora directory. Typically it is located at **C:\Program Files\Common Files\Pleora**. The **EbDriverTool32.exe** (or EbDriverTool.exe) file may be in a subdirectory.
2. Run the file.
3. When this program executes, select the appropriate Ethernet card and under the **Action** category, choose “**Install High-Performance IP Device Driver**” from the pulldown menu.

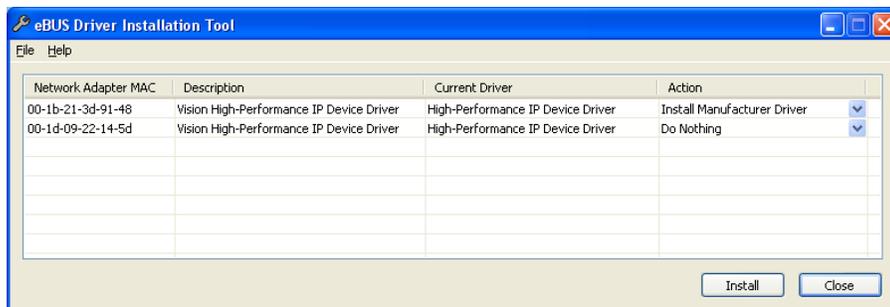


Figure 214. Ebus Driver Installation Tool dialog

4. After making the selection, click on **Install**.
5. After the installation you may be asked to reboot the computer. If you are asked to reboot, you can
 - Click on “**Yes**” to initiate the reboot.
 - Click on “**No**” to wait before rebooting. If you select “**No**,” you may be required to close the **eBUS Driver Installation Tool** dialog. Reboot the computer at your convenience.
6. Verify that the network connection has been re-established. If a reboot was required, wait until the reboot has occurred before verifying the connection.

OrangeUSB USB 2.0 Driver Update

This procedure is highly recommended when a laptop computer will be used to communicate with the ST-133. We recommend the SIIG, Inc. USB 2.0 PC Card, Model US2246 if USB 2.0 is not native to the laptop's motherboard. To reduce the instances of data overruns and serial violations, the OrangeUSB USB 2.0 Host Controller installed for the SIIG card should be replaced by the appropriate Microsoft driver (Windows XP or Vista (32-bit), depending on the laptop's operating system.)

Note: This procedure may also be performed for desktop computers that use the Orange Micro 70USB90011 USB2.0 PCI.

1. Download and install Microsoft Service Pack 1 (for Windows XP) if the service pack has not been installed.
2. From the Windows **Start** menu, select **Settings|Control Panel**.
3. Select **System** and then **System Properties**.
4. Select the **Hardware** tab and click on **Device Manager** button.
5. Expand **Universal Serial Bus Controllers**.
6. Right-mouse click on **OrangeUSB USB 2.0 Host Controller** and select **Properties**.
7. On the **Driver** tab, click on the **Update Driver...** button. You may have to wait a minute or so before you will be allowed to click on the button.
8. When the **Upgrade Device Driver Wizard** appears, click on **Next**. Select the **Search for a suitable driver ...** radio button.
9. On the next screen select the **Specify a location** checkbox.

10. Browse and select the location. Click on **OK**.
11. In the **Driver Files Search Results** window, check the **Install one of the other drivers** check box.
12. Select the **NEC PCI to USB Enhanced Host Controller B1** driver (Microsoft is the provider). Click on **Next** and the installation will take place. When the **Completing the Upgrade Device Driver Wizard** window appears, click on **Finish**. You will then be given the choice of restarting the computer now or later. According to the window text, the hardware associated with the driver will not work until you restart the computer.

Program Error message



Figure 215. Program Error dialog

This dialog may appear if you have tried to acquire a test image, acquire data, or run in focusing mode and the DMA buffer size is too small. A large array (for example, a 2048x2048 array), requires a larger setting than that for a smaller array (for example, a 512x512 array).

To correct the problem:

1. Click on **OK**.
2. Reboot WinSpec.
3. Note the array size (on the **Setup|Hardware|Controller/CCD** tab or the **Acquisition|Experiment Setup|Main** tab Full Chip dimensions). If your camera contains a large array (such as a 2048x2048 array), and the DMA buffer size is too small, there will not be enough space in memory for the data set.
4. Open **Setup|Environment|Environment** dialog.
5. Increase the DMA buffer size to a minimum of 32 Mb (64 Mb if it is currently 32 Mb or 128 Mb if it is currently 64 Mb), click on **OK**, and close WinSpec.
6. Reboot your computer.
7. Restart WinSpec and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

Serial violations have occurred. Check interface cable.



Figure 216. Serial Violations Have Occurred dialog

This error message dialog will appear if you try to acquire an image or focus the camera and either (or both) of the following conditions exists:

- The camera system is not turned ON.
- There is no communication between the camera and the host computer.

To correct the problem:

1. Turn **OFF** the camera system (if it is not already OFF).
2. Make sure the Detector-Controller cable is secured at both ends and that the computer interface cable is secured at both ends.
3. After making sure that the cables are connected, turn the camera system power **ON**.
4. Click **OK** on the error message dialog and retry acquiring an image or running in focus mode.

Note: This error message will also be displayed if you turn the camera system **OFF** or a cable comes loose while the application software is running in **Focus** mode.

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Glossary

A/D converter: Analog-to-digital converter. In a CCD detector system, the electronic circuitry that converts the analog information (continuous amplitudes) acquired by the detector into the digital data (quantified, discrete steps) used for image display.

ADU: Analog-to-digital unit. A number representing a CCD's output. The relationship between the ADUs generated and the number of electrons acquired on the CCD is defined by the system gain. Intensities given in ADUs provide a convenient method for comparing images and data generated by different detectors. Also referred to as *count* and *digital number*.

Anti-blooming: Blooming is caused by saturation of one or more CCD pixels. This can occur if the incoming light is too bright or when extensive serial and parallel binning is being performed. When this saturation happens, the excess charge overflows into the adjacent pixels and results in a streak or a blob appearing on the image. Anti-blooming is traditionally controlled by specific CCD architecture designs that drain the excess charge.

Avalanche Gain: Also called "on-chip multiplication gain". A technology that enables multiplication of charge (i.e., electrons) collected in each pixel of the CCD's active array. Secondary electrons are generated via an impact-ionization process that is initiated and sustained when higher-than-typical voltages are applied to an "extended" portion of the CCD's serial register. Multiplying the signal above the read noise of the output amplifier enables ultra-low-light detection at high operation speeds. (Some CCD cameras with on-chip multiplication gain utilize two output amplifiers, an "on-chip multiplication gain" amplifier that allows the camera to be used for low-light, high-speed applications and a "traditional" amplifier for wide-dynamic-range applications.)

Backlash: Applied to the movement of gratings or slits, this is the amount of play between gears when changing the direction of travel.

Bias: In a CCD detector system, the minimum intensity required for each exposure (equivalent to performing a zero-second exposure with the shutter closed). Without adding any light, the bias allows charge to be read out on the CCD while raising the intensity level high enough to ensure that the detector does not deliver a negative number to the A/D converter. (The A/D converter only works in the set of positive numbers and has no instructions for processing negative numbers.) The bias may be user settable. However, it is set at the factory and should remain stable over the lifetime of the detector system.

Binning: Hardware binning is the process of combining the charge from adjacent pixels in a CCD *before* the signal is read out by the preamplifier. A binning of 1 in both directions reads out each pixel at full X-axis resolution. A binning of 2 in both directions combines four pixels, cutting the X-axis resolution in half, but quadrupling the light-collecting area. If the CCD chip shift register is being saturated due to hardware binning, you can use software binning instead by checking **Use Software Binning** on the ROI Setup tab. Note that software binning is not as fast as hardware binning.

Cancel button: Exits a dialog without performing any processing. Any changes to the dialog are lost.

Close button: Closes the dialog or window with no action taken.

Dark current: (1) The charge accumulated within a well, in the absence of light. (2) The background current that flows in a charge-coupled device or image intensifier of a camera system. Cooling the photodetector's primary imaging surface (i.e., the CCD's photoconductor or the image intensifier's photocathode) can reduce or eliminate dark current. Also called *thermally generated charge*. Dark current can be subtracted from an image.

Gating: In an intensified detector system, the application of a voltage that switches the image intensifier on and off in very short intervals. Gating improves temporal resolution. Gating can be controlled by the programmed exposure time (Shutter Mode) or is determined by the Pulser settings (Gate Mode).

Help button: Opens the context-sensitive help for the active tab or dialog.

Host computer: The primary or controlling computer for a detector.

Mouse button: Allows you to specify a region to be processed using the mouse. Simply drag a box in the data region of the active window and then click on **Mouse**. The **Frame** and **Range** parameters will assume the values of the defined region. Note that the **Mouse** button is only active when the **Input** tab is selected.

MPP: Multi-pinned-phase operation. A mode that reduces the rate of dark current generation by a factor of 20 or more, relaxing CCD cooling requirements to the level where a thermoelectric cooler is sufficient for most applications. Also called *inverted operation*.

NVRAM: Non-Volatile Random Access Memory. NVRAM contains factory-programmed information about the controller and, in many cases, the camera/detector.

Process button: Causes the specified operation or process to be performed. The process is performed on the data specified on the Input tab and saved using the file name and data type specified on the Output tab.

PVCAM: Programmable Virtual Camera Access Method. An exclusive (Roper Scientific) universal programming interface. A set of software library routines that implements a detector or camera's operations in a hardware-independent, platform-independent (or "virtual") suite of function calls. Once an application has been written to control one PVCAM-enabled camera, all PVCAM-enabled cameras are then compatible with that application.

ROI: Region of interest. A user-defined, rectangular area (a square is common) on a CCD that is exposed and processed as an image.

Shutter Compensation Time: The time it takes for a mechanical shutter to open or close. This time needs to be accounted for during hardware setup so the software can allow enough time for the shutter to open before starting data acquisition and allow enough time for it to close before reading out the array.

Warranty & Service

Limited Warranty:

Princeton Instruments, a division of Roper Scientific, Inc. ("Princeton Instruments", "us", "we", "our") makes the following limited warranties. These limited warranties extend to the original purchaser ("You", "you") only and no other purchaser or transferee. We have complete control over all warranties and may alter or terminate any or all warranties at any time we deem necessary.

Basic Limited One (1) Year Warranty

Princeton Instruments warrants this product against substantial defects in materials and / or workmanship for a period of up to one (1) year after shipment. During this period, Princeton Instruments will repair the product or, at its sole option, repair or replace any defective part without charge to you. You must deliver the entire product to the Princeton Instruments factory or, at our option, to a factory-authorized service center. You are responsible for the shipping costs to return the product. International customers should contact their local Princeton Instruments authorized representative/distributor for repair information and assistance, or visit our technical support page at www.princetoninstruments.com.

Limited One (1) Year Warranty on Refurbished or Discontinued Products

Princeton Instruments warrants, with the exception of the CCD imaging device (which carries NO WARRANTIES EXPRESS OR IMPLIED), this product against defects in materials or workmanship for a period of up to one (1) year after shipment. During this period, Princeton Instruments will repair or replace, at its sole option, any defective parts, without charge to you. You must deliver the entire product to the Princeton Instruments factory or, at our option, a factory-authorized service center. You are responsible for the shipping costs to return the product to Princeton Instruments. International customers should contact their local Princeton Instruments representative/distributor for repair information and assistance or visit our technical support page at www.princetoninstruments.com.

XP Vacuum Chamber Limited Lifetime Warranty

Princeton Instruments warrants that the cooling performance of the system will meet our specifications over the lifetime of an XP style detector (has all metal seals) or Princeton Instruments will, at its sole option, repair or replace any vacuum chamber components necessary to restore the cooling performance back to the original specifications at no cost to the original purchaser. *Any failure to "cool to spec" beyond our Basic (1) year limited warranty from date of shipment, due to a non-vacuum-related component failure (e.g., any components that are electrical/electronic) is NOT covered and carries NO WARRANTIES EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Sealed Chamber Integrity Limited 12 Month Warranty

Princeton Instruments warrants the sealed chamber integrity of all our products for a period of twelve (12) months after shipment. If, at anytime within twelve (12) months from the date of delivery, the detector should experience a sealed chamber failure, all parts and labor needed to restore the chamber seal will be covered by us. *Open chamber products carry NO WARRANTY TO THE CCD IMAGING DEVICE, EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Vacuum Integrity Limited 12 Month Warranty

Princeton Instruments warrants the vacuum integrity of “Non-XP” style detectors (do not have all metal seals) for a period of up to twelve (12) months from the date of shipment. We warrant that the detector head will maintain the factory-set operating temperature without the requirement for customer pumping. Should the detector experience a Vacuum Integrity failure at anytime within twelve (12) months from the date of delivery all parts and labor needed to restore the vacuum integrity will be covered by us. Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Image Intensifier Detector Limited One Year Warranty

All image intensifier products are inherently susceptible to Phosphor and/or Photocathode burn (physical damage) when exposed to high intensity light. Princeton Instruments warrants, with the exception of image intensifier products that are found to have Phosphor and/or Photocathode burn damage (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all image intensifier products for a period of one (1) year after shipment. *See additional Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

X-Ray Detector Limited One Year Warranty

Princeton Instruments warrants, with the exception of CCD imaging device and fiber optic assembly damage due to X-rays (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all X-ray products for one (1) year after shipment. *See additional Basic Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Software Limited Warranty

Princeton Instruments warrants all of our manufactured software discs to be free from substantial defects in materials and / or workmanship under normal use for a period of one (1) year from shipment. Princeton Instruments does not warrant that the function of the software will meet your requirements or that operation will be uninterrupted or error free. You assume responsibility for selecting the software to achieve your intended results and for the use and results obtained from the software. In addition, during the one (1) year limited warranty. The original purchaser is entitled to receive free version upgrades. Version upgrades supplied free of charge will be in the form of a download from the Internet. Those customers who do not have access to the Internet may obtain the version upgrades on a CD-ROM from our factory for an incidental shipping and handling charge. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

Owner's Manual and Troubleshooting

You should read the owner's manual thoroughly before operating this product. In the unlikely event that you should encounter difficulty operating this product, the owner's manual should be consulted before contacting the Princeton Instruments technical support staff or authorized service representative for assistance. If you have consulted the owner's manual and the problem still persists, please contact the Princeton Instruments technical support staff or our authorized service representative. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

Your Responsibility

The above Limited Warranties are subject to the following terms and conditions:

1. You must retain your bill of sale (invoice) and present it upon request for service and repairs or provide other proof of purchase satisfactory to Princeton Instruments.
2. You must notify the Princeton Instruments factory service center within (30) days after you have taken delivery of a product or part that you believe to be defective. With the exception of customers who claim a "technical issue" with the operation of the product or part, all invoices must be paid in full in accordance with the terms of sale. Failure to pay invoices when due may result in the interruption and/or cancellation of your one (1) year limited warranty and/or any other warranty, expressed or implied.
3. All warranty service must be made by the Princeton Instruments factory or, at our option, an authorized service center.
4. Before products or parts can be returned for service you must contact the Princeton Instruments factory and receive a return authorization number (RMA). Products or parts returned for service without a return authorization evidenced by an RMA will be sent back freight collect.
5. These warranties are effective only if purchased from the Princeton Instruments factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Princeton Instruments is not responsible for installation, setup, or disassembly at the customer's location.
7. Warranties extend only to defects in materials or workmanship as limited above and do not extend to any product or part which:
 - has been lost or discarded by you;
 - has been damaged as a result of misuse, improper installation, faulty or inadequate maintenance or failure to follow instructions furnished by us;
 - has had serial numbers removed, altered, defaced, or rendered illegible;
 - has been subjected to improper or unauthorized repair;
 - has been damaged due to fire, flood, radiation, or other "acts of God" or other contingencies beyond the control of Princeton Instruments; or
 - is a shutter which is a normal wear item and as such carries a onetime only replacement due to a failure within the original 1 year Manufacturer warranty.
8. After the warranty period has expired, you may contact the Princeton Instruments factory or a Princeton Instruments-authorized representative for repair information and/or extended warranty plans.

9. Physically damaged units or units that have been modified are not acceptable for repair in or out of warranty and will be returned as received.
10. All warranties implied by state law or non-U.S. laws, including the implied warranties of merchantability and fitness for a particular purpose, are expressly limited to the duration of the limited warranties set forth above. With the exception of any warranties implied by state law or non-U.S. laws, as hereby limited, the forgoing warranty is exclusive and in lieu of all other warranties, guarantees, agreements, and similar obligations of manufacturer or seller with respect to the repair or replacement of any parts. In no event shall Princeton Instruments' liability exceed the cost of the repair or replacement of the defective product or part.
11. This limited warranty gives you specific legal rights and you may also have other rights that may vary from state to state and from country to country. Some states and countries do not allow limitations on how long an implied warranty lasts, when an action may be brought, or the exclusion or limitation of incidental or consequential damages, so the above provisions may not apply to you.
12. When contacting us for technical support or service assistance, please refer to the Princeton Instruments factory of purchase, contact your authorized Princeton Instruments representative or reseller, or visit our technical support page at www.princetoninstruments.com.

Contact Information

Roper Scientific's manufacturing facility for this product is located at the following address:

Princeton Instruments
3660 Quakerbridge Road
Trenton, NJ 08619 (USA)

Tel: 1-800-874-9789 / 1-609-587-9797

Fax: 1-609-587-1970

Customer Support E-mail: techsupport@princetoninstruments.com

For immediate support in your area, please call the following locations directly:

North America	800 899 1144 (toll free) or 609 587 9797
France	+33 (1) 60 86 03 65
Germany	+49 (0) 89 660 7793
Japan	+81 (3) 5639 2741
UK & Ireland	+44 (0) 1628 472 346
Singapore	+65 6408 6240
China	+86 10 659 16460

Otherwise, see our Support web page at www.princetoninstruments.com. An up-to-date list of addresses and telephone numbers is posted on the www.princetoninstruments.com/Support page. In addition, links on this page to support topics allow you to send e-mail based requests to the Customer Support group.

Index

#

- 3D Graph display 101
- 3D Layout tab page
 - Z Axis Endpoint 109

A-B

- Absolute math operation 155
- Absorbance (on-line) process 126
- Accessories, alignment of 241
- Active spectrograph, specifying 52
- Acton Series spectrograph
 - focusing 241
 - rotational alignment 240
- Addition math operation 155
- Adjust calibration procedure 94
- Adjust error 95
- Alignment, rotational 240
- Amplitude 205
- AND math operation 156
- Areas (Y:T) 127
- ASCII output (on-line) process 134
- Auto Select
 - at least three strips 78
 - eleven or more strips 78
 - two strips 78
- Auto Select algorithm 78
 - at least three strips 99
 - eleven or more strips 99
 - single strip 100
 - two strips 100
- Auto Select Image, Graph or 3D Graph 77
- Auto-Spectro *See* Spectrograph Calibration
- AUX DLY'D TRIG OUT 188
- Avalanche gain 59, 67, 277
- Axis labeling 119
- Background subtraction 147, 148
 - acquiring background files 147
 - automatic 148
- Binary math operations 156
- Binning
 - constraints with PCI card 140, 277, 278
 - hardware 140
 - in spectroscopy 140
 - post-process 180
 - software 140, 141
- Binning and Skipping
 - post processing 180
 - procedure 180
- Binning and Skipping (cont.)

- restrictions and limitations 181
- Bitwise math operations
 - AND 156
 - complement 156
 - exclusive OR 156
 - OR 156
- Block size 49
- C**
- Calibration
 - menu 84
 - method 88
 - Off 83
 - reference lines 245
 - Setup dialog 85
 - structures 250, 254
 - suitable light sources 240, 242
- Camera Detection wizard 37
- Camera, rotation of 241
- Cautions
 - calibration sequence 92
 - changing Cleans and Skips settings 47
 - running different versions 265
 - WinSpec/32 and WinView/32 in same directory 29, 30
- CCD Blemish removal 150
- Circuit.spe displayed 114
- Clean cycles 135
- CLEANING signal 43
- Cleans/Skips tab page 47
 - Cleans 47
 - Minimum Block Size 49
 - Number of Blocks 49
 - Number of Cleans 47
 - Number of Strips per Clean 47
 - Use Continuous Cleans Instruction 48
- Cleans/Skips tab page parameters
 - Clean Mode 47
 - Vertical Skips 49
- Clipping and Threshold procedure 178
- Closing a data file 81
- Color
 - axes, labels, graphs, background and surfaces .. 120
- Communication Error with Spectrograph 90
- Complement math operation 156
- Computer requirement 23
- Contact information 282
- Continuous cleans 136
- Continuous Cleans Instruction 48, 138
- Correction techniques 147

Cosmic Ray removal	151	Data displayed as image (cont.)	
Cross Sections (post processing)	179	brightness	115
Cross sections procedure	179	color of axes and labels	120
Cursor Curve	108	context window	110
Cursor functions		cursor functions	107
data displayed as graph or image	107	Display Layout dialog box	117
Custom Chip	44	Display Layout Range tab page	120
Custom filter procedure	172	information box	118
Custom Timing	44, 214	ROI	116
Custom Toolbar		Data file compatibility	77
adding a button	210	Data File tab	81
customization of	209	Data files	
display	209	closing	81
removing a button	210	deleting	82
settings	209	via File menu	82
Custom Toolbar dialog box		deleting multiple files	82
Add	210	iconizing	81
Available Buttons	210	opening	77
Close	210	reducing to icon	81
Help	210	saving	80
Move Down	211	Data files (temporary), saving	80
Move Up	211	Data start	256
Remove	210	Data structure	
Reset	210	Ver 1.43	247
Toolbar Buttons	210	Ver 1.6 and 32-bit versions	248
Customer support	282	Ver 2.5	251
D		Data Type, Save As	80
Dark charge	148	Data Window Context menu	110
Data collection (Initial)		DELAYED TRIGGER OUT	188
PentaMAX	73	Deleting data files	82
ST-133	71	Demo interface	46
Data correction techniques	147	Detector pixel width	91
Data display types	99	DG535	
Data displayed as 3D graph	101	active mode	193
Data displayed as graph		bracket pulsing	194
5%-95% display range	104	continuous exponential mode	193
brightness/contrast control	116	continuous linear mode	193
context window	110	Interactive Gate Width and Delay	207
cursor	107	Interactive Trigger Setup	206
Cursor Curve	108	operation of	191
cursor functions	107	port address	192
displaying one strip	106	repetitive gating setup	193
hidden surfaces	109	sequential gating setup	193
Information box	105	slope, threshold & termination	192
Marker Curve	108	trigger mode	192
multiple strips	108	DG535 Digital Delay/Pulse Generator	187
ROI	104	Dispersion	96
strip selection	107	Dispersion data sets	97
Undo All Zoom In	105	Display color control	120
Zoom In	104	Display tab page	45
Data displayed as image		Flip	45
autoranging ROI	119	Reverse	45
axes and cross sections	117	Rotate	45
axes labeling	119	Displaying data as 3D graph	101
		Division math operation	155
		Documentation, additional	22

E-F

EbDriverTool32 file	272
EBI.....	148
Edge Enhancement	165, 177
Laplacian masks	167
parameters	166
procedure.....	167
Sobel edge detection	167
Equations (Y:T).....	127
Ethernet network is not accessible.....	272
Exclusive OR math operation.....	156
Exponential Data type	204
Files of Type text box.....	78
Filter Matrix tab page custom filter	172
Find Peaks	
effect on displayed peak height	85
in wavelength calibration procedure	85
FireWire installation.....	28
First light	233, 236
FITS converter.....	215
Fixed Increment type.....	204
Flatfield corrections.....	149
acquiring a flatfield file	149
automatic	149
Focusing and alignment.....	240
Focusing, spectroscopy.....	241
FT IMAGE SHIFT signal.....	44
Full lateral resolution.....	277

G-H

Gate Delay	202, 203
Gate Width	202, 203
Gigabit Ethernet	
installation	28
Gluing spectra.....	159
existing data files.....	159
final resolution.....	160
Glued Data File Name	160
starting/ending wavelength values.....	160
theory	162
GPIB default address setting	191
Graphics card.....	24
Graphs, labeling.....	111
Grating	
name	53
parameters	52
selecting and moving.....	53
turrets	52
Grouping in spectroscopy	140
Hard disk	23
Hardware setup	
Camera Detection wizard	37
Custom Chip	213
Custom Timing.....	214
Display tab page	45

Hardware setup (cont.)

Interface tab page	46
overview	35
requirements.....	23
Hid-lamp.spe	101
High speed PCI interface.....	46
Histograms	
cumulative	182
post-processing.....	182
procedure.....	182
standard	182

I-K

I/O address.....	46
I/O Address 2 & 3	46
IEEE-488 GPIB port.....	191
Image, Graph and 3D Graph selection	100
Images, labeling.....	111
Imaging data collection (Initial)	65
Experiment Setup procedure	
steps common to all controller types	67
PentaMAX.....	73
procedure for all controllers	75
Skips and Cleans	67
ST-133.....	71
temperature control	66
Imaging mode.....	139
Information box as active window	106
Install/Remove Spectrographs dialog box	51
Installation	
aborting	30
FireWire driver.....	28
from FTP site.....	30
GigE driver.....	28
multiple versions of WinSpec/32	263
PCI card driver	27
USB 2.0 driver	27
Installing WinSpec/32	23
Intensifier gain, effect on dark charge	148
Interface tab page.....	46
interrupt level	46
Type	46
Demo	46
high-speed PCI	46
PCI Timer	46
Interrupt level	46
Interrupt tab page	
I/O address	46
I/O address 2 and 3.....	46
Introduction to manual	19
ISA interface card driver installation.....	270
IsoPlane spectrograph	
focusing	242
rotational alignment.....	242
Kinetics.....	42, 138

L-M

Labeling graphs and images	111
Laser excitation	55
laser line	84
Least Squares Fit calibration method	88
Linear math operations	155
Log10 math operation.....	155
Logic 0 PentaMAX output	43
Logic 1 PentaMAX output	43
Look Up Table	
formats.....	174
procedure.....	173
Macro Record	215
Magnification	91
Main menu.....	33
Manual wavelength calibration	83
Math	
A, B and C tab pages.....	153
data types	
byte.....	154
float.....	154
int154	
long	154
uint	154
file tabs	153
operations	
single file	154
single file and constant	154
Parameters	
data type.....	154
display result.....	154
Frame	153
Input (Output) file name	153
X and Y Range	153
procedure.....	157
Mathematical Models	
wavelength calibration	88
MAX math operation.....	155
Memory requirements.....	23
Mercury spectrum, fluorescent lights	240
MIN math operation	155
Morphological	
parameters	170
procedure.....	171
Mouse cursor	33
Mouse requirement	24
Multiplication math operation	155

N-O

Natural Log math operation.....	155
Non-Linear math operations	155
NOT math operation.....	156
NOT SCAN signal.....	44
NOTREADY signal.....	44
Number of Images	203
Offset, Adjust and Dispersion parameters	89

On-CCD Accumulations.....	202, 206
On-line data acquisition processes	
absorbance.....	126
ASCII output	134
thresholding.....	125
Y:T analysis	127
Online Help, overview.....	21
Opening data files.....	77
multiple files.....	79
Operations	
Absolute	155
Addition	155
AND	156
Complement	156
Division.....	155
Exclusive OR	156
Log10	155
MAX	155
MIN	155
Multiplication	155
Natural Log	155
NOT	156
OR	156
Square Root.....	155
Squared.....	155
Subtraction	155
Options	
Custom Chip	213
Custom Timing.....	214
FITS	215
Macro Record.....	215
SPEX/TRIAX support.....	216
Virtual Chip.....	216
OR math operation	156
Overexposure protection	236

P-Q

Paper Size and Source	183
PBC	<i>See</i> Pixel bias correction
PCI card driver installation.....	27
PCI interface, binning constraints	140, 277, 278
PCI Timer interface	46
Peak finder function	92
Peaks, Hg-Argon spectrum.....	86
PentaMAX	
data collection	74
focusing	73
PG200 pulser	187
continuous exponential mode.....	189
continuous linear mode	189
operation of	187
repetitive gating setup	189
sequential gating setup	189
PIHWDEF.INI	266
Pixel bias correction	214
Pixels, binning or grouping	140
Polynomial method of calibration	88

Post-processing	
binning and skipping	180
cross sections	179
edge enhancement	166
histograms	182
morphology	170
sharpening	168
smoothing	169
threshold and clipping	178
Print Preview	184
Print Preview buttons	
Close	185
Next Page	185
Prev Page	185
Print	185
Two Page	185
Zoom In	185
Zoom Out	185
Print Setup dialog box	183
Printing from WinSpec/32	183
color mapping	184
saving as *.TIF file before printing	186
screen capture	185
Process Mask operations	165
references	175
PTG	
active mode	195
Auxiliary Trigger output	197
continuous exponential mode	196
continuous linear mode	196
Interactive Gate Width and Delay	207
Interactive Trigger Setup	206
operation of	194
repetitive gating setup	195
sequential gating setup	195
slope, threshold, termination & gate delay from	195
trigger mode	195
Pulsar operation	187
PVCAM.INI	28, 269, 272
R-S	
Reference Wavelength	95
Registry	266
Registry file	263
Reinstallation of WinSpec/32	266
ROI	
defining a single region	145
graphical input (mouse)	146
image binning	141
imaging mode	139
setup mode	139
spectroscopy	141
spectroscopy mode	139
Roper Scientific FireWire driver installation	28
Roper Scientific GigE driver installation	28
Roper Scientific USB2 driver installation	27
Rotational alignment	240
RS170	44
RSConfig.exe	272
Save As dialog box	80
Save as Type	80
Save Sequence Values to File	205
Saving data files	80
Saving temporary data files	80
SCAN signal	44
Screen capture, printing	185
Sequential Mode Setup	
Exponential Increment	204
Fast Amplitude parameter	205
Fast decay and Slow decay	204
Fixed Increment	204
Gate Delay	202, 203
Gate Width	202, 203
On-CCD Accumulations	202, 206
Save Sequence	205, 206
sequential exponential algorithm	204
Slow	
Amplitude parameter	205
Time Constant parameter	205
Software Accumulations	203, 206
Time Constant	204
View Width/Delay	205
SESSION.DAT	266
Setup	
Common	29
Custom	29
Typical	29
Setup program	30
Sharpening	
parameters	168
procedure	168
SHUTTER signal	44
Shutter type	42
Smoothing	
parameters	169
procedure	169
Snapshot mode (Y:T)	131, 133
Sobel edge detection	167
Software Accumulations	203, 206
Spectra Math	153
Spectrograph	
active	52
cable	90
focusing	240, 242
grating change warning	53
Grating selection and moving	53
grating setup and selection	52
installation procedure	50
magnification parameter	91
overview	59
rotational alignment	240, 242
slit and port selections	54

Spectrograph calibration	
(Linear) Adjust	95
Adjust procedure	94
Auto-Spectro method	51, 83, 90, 160
detector pixel width parameter	91
dispersion	96
dispersion data sets	97
increasing error	90
introduction to	89
linear calibration equation	94
manual	83
offset, reason for	92
parameters	90
peak finder function	92
preparation for	89
sequence	92
Use for Auto-Spectro Calibration checkbox	51
Spectroscopy data collection (Initial)	57
Experiment Setup procedure	
steps common to all controller types	59
procedure for all controllers	63
Skips and Cleans	59
temperature control	58
Spectroscopy mode	139
SPEX spectrometer installation	29
SPEX/TRIAX control	216
Splash screen	32
Square Root math operation	155
Squared math operation	155
Status Bar messages	22
Step and Glue	
file overlap	160
file starting and ending values	161
incremental files	161
overwriting incremental files	161
SET and RUN	161
Strip selection	
Shift End key combination	107
Shift Home key combination	107
via Custom Toolbar	107
Subtraction math operation	155
SuperSYNCHRO	187
active mode	200
Auxiliary output	202
continuous exponential mode	201
continuous linear mode	201
Interactive Gate Width and Delay	207
operation of	198
repetitive gating setup	200
sequential gating setup	201
SyncMASTER outputs	202
trigger mode	199
SyncMASTER	202
T-V	
Target Wavelength	97
Technical support	282
Temperature	
how done with each controller type	58, 66
Temperature control	58, 66
Threshold and Clipping procedure	178
Thresholding (on-line) process	125
TIFF files	186
Time Constant	204
Timing Generator Interactive Gate Width and Delay ..	207
Timing Generator Interactive Trigger Setup	206
Tool tips	22
Troubleshooting	269
Turrets	52
Uninstalling WinSpec/32	266
Upgrade Device Driver wizard	273
USB 2.0	
data overrun	271
installation	27
Use for Auto-Spectro Calibration checkbox	51
User Units	88
Vertical skips	49, 138
View Width/Delay Sequence	205
Virtual Chip	216
W-Z	
Warn When Crossing Laser Line selection	55
Warnings	
Crossing Laser Line warning to guarantee of	
protection	55
intensified cameras	58, 66
susceptibility of intensified cameras to light overload	
damage	58, 66
Warranties	
image intensifier detector	280
one year	279
one year on refurbished/discontinued products ..	279
owner's manual and troubleshooting	281
sealed chamber	280
software	280
vacuum integrity	280
XP vacuum chamber	279
x-ray detector	280
your responsibility	281
Wavelength calibration	83
display units	88
effect of any optical adjustment	83
manual	83
Mercury-Argon spectrum	245
method selection	83
modes and units	84
procedure	84
Save as Default button	87

Website.....	282	Y:T analysis (on-line) process (cont.)	
Wizard		equations	127
Camera Detection.....	37	overview.....	127
Upgrade Device Driver	273	procedure.....	132
X axis wavelength calibration spectrum.....	245	YT analysis.....	<i>See</i> Y:T analysis...
Y:T analysis (on-line) process		Z Axis Endpoint	109
acquisition modes.....	130	Z-slice.....	121
areas	127		

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