



# CEPC NOTE

CEPC\_PERF\_2017\_XXX

August 30, 2017



## Jet energy scale and jet energy resolution study at CEPC

Peizhu Lai

### Abstract

Abstract for JES and JER studies on CEPC

E-mail address: [ligang@mail.ihep.ac.cn](mailto:ligang@mail.ihep.ac.cn)

© Copyright 2017 IHEP for the benefit of the CEPC Collaboration.

Reproduction of this article or parts of it is allowed as specified in the CC-BY-3.0 license.

# Contents

<b>1</b>	<b>Introduction</b>	<b>2</b>
<b>2</b>	<b>Experimental setup</b>	<b>2</b>
<b>3</b>	<b>Samples</b>	<b>2</b>
<b>4</b>	<b>Event selection</b>	<b>2</b>
<b>5</b>	<b>Deriving the jet energy scale and jet energy resolution</b>	<b>2</b>
5.1	Reconstruction of jets in CEPC . . . . .	2
5.2	Methodology . . . . .	2
5.3	results . . . . .	2
<b>6</b>	<b>Discussion</b>	<b>2</b>
<b>7</b>	<b>Summary and conclusion</b>	<b>3</b>
<b>8</b>	<b>Acknowledgements</b>	<b>3</b>
<b>9</b>	<b>Rules for referencing</b>	<b>3</b>
<b>Appendices</b>		<b>4</b>
<b>A</b>	<b>The cepcnote class</b>	<b>4</b>
A.1	Dependencies . . . . .	4
A.2	Custom commands . . . . .	5
<b>B</b>	<b>Bibliography</b>	<b>5</b>
<b>C</b>	<b>Miscellaneous L<sup>A</sup>T<sub>E</sub>X tips</b>	<b>6</b>
C.1	Graphics . . . . .	6
C.2	Definitions . . . . .	6
C.3	Emphasis . . . . .	7
<b>D</b>	<b>General Style</b>	<b>7</b>
<b>E</b>	<b>The cepcphysics.sty style file</b>	<b>7</b>
E.1	Remarks on units and symbols . . . . .	7
E.2	Other shortcuts . . . . .	8

# 1 Introduction

The introduction should be fairly brief, not more than a few pages. State the measurement being made, motivate its importance experimentally and theoretically. Include a summary of what is known to date about this measurement. Give a brief outline for the rest of the paper.

Your first action before embarking on writing a paper should be to read the CEPC Publication Policy [1], available from the web pages of the Publication Committee. Chapter 3 of this document details the refereeing and approval procedures that you will need to follow; chapter 4 gives information on the style.

At some point during writing of an CEPC paper, you should decide what journal it will be submitted to. Please keep in mind that each journal makes specific demands on length and style. Most journals use regular capitalization for titles (i.e. capitalize the first word and all proper nouns, e.g. “The search for large extra dimensions”). The notable exception is Physical Review Letters, which capitalizes the first word and all other important words, e.g. “The Search for Large Extra Dimensions”.

The  $\LaTeX$  file and Postscript versions of this template can be found on the web pages of the CEPC Publication Committee. Example macros for figures can be found there as well. Comments and/or suggestions on improvements to this template are very welcome and should be given to the publication committee.

This paper template has been tested using  $\LaTeX$ 2e. You should get this version automatically. If you have problems check which  $\LaTeX$  version you are running.

## 2 Experimental setup

Description about CECP detector

## 3 Samples

Any Monte Carlo programs used must be clearly stated with full version number. A brief description of the program is useful but not necessary unless a less well known program is used. Any corrections or special parameter settings must be clearly explained. The statistics should be given if the amount used results in a non-negligible uncertainty.

## 4 Event selection

List the trigger and offline selection criteria, give the obtained statistics.

## 5 Deriving the jet energy scale and jet energy resolution

### 5.1 Reconstruction of jets in CEPC

### 5.2 Methodology

### 5.3 results

## 6 Discussion

Put the results into the context of the theory or a model. If the results lead to exclusion plots, make sure that it is clear which region on the plot is excluded.

## 7 Summary and conclusion

Reiterate the main points of the paper and the primary results and conclusions.

Note that many readers look mostly at the title, abstract and conclusion. The conclusion should be interesting enough to make them want to read the whole paper. It is not good style to just repeat the abstract.

If your paper is short and only has one result quoted at the end of the paper, then you should consider whether conclusions are necessary.

Try not to end your conclusions with a sentence such as “All the results in this paper are in good agreement with the Standard Model, the current world average and recent measurements by other experiments”. This might lead a referee (internal or external) to wonder why it is worth publishing this paper!

## 8 Acknowledgements

A standard template for the acknowledgements is available on the web pages of the Publication Committee. See reference [1] for the URL.

## 9 Rules for referencing

Use  $\text{BIB}_{\text{TEX}}$  for the references. See Appendix B for an explanation.

Only cite permanent, publicly available, or CEPC approved references. Private references, not available to the general public, should be avoided. Caution should be used when referring to CEPC notes. Only reference approved notes. Do not reference COM or INT notes, as these are not available outside CEPC.

Whenever possible, cite the article’s journal rather than its preprint number. If desired, the hep-ex number can be given in addition. Always double check references when copying them from another source.

Referencing styles are journal-dependent. See the CEPC Publication Policy document for more information.

## References

- [1] “Besiii publication policy.” Available from the besiii management web page:  
[Http://bes3.ihep.ac.cn/orga/besiii\\_publication\\_policy\\_rev\\_12\\_2013.pdf](http://bes3.ihep.ac.cn/orga/besiii_publication_policy_rev_12_2013.pdf).

# Appendices

Use the Appendices to include all the technical details of your work that are relevant for the CEPC Collaboration only (e.g. datasets details, software release used). The Appendices can be removed from an CEPC Internal Note becoming an CEPC Public Note.

Use the following commands to start the Appendices section:

```
\newpage
\appendix
\part*{Appendices}
\addcontentsline{toc}{part}{Appendices}
```

## A The cepcnote class

This paper has been typeset using the `cepcnote.cls` class, that implement the CEPC template can be used for papers, preprints, notes. The `cepcnote` class is available on web pages of the Publication Committee, as well as this instruction paper and the related files.

`cepcnote.cls` derives from the standard  $\LaTeX$  `article.cls` class, thus all the usual commands and options you would have used with `article` will work with it. For instance, this paper has been produced using this very simple preamble:

```
\documentclass[11pt,a4paper]{cepcnote}
\graphicspath{{figures/}}
\usepackage{cepcphysics}
\usepackage{subfigure}
```

### A.1 Dependencies

The `cepcnote` class depends on these packages, which presence in your system is required:

- `graphicx`
- `mathptmx`
- `lineno`

The first two are all usually already installed in any modern  $\LaTeX$  installation, while the latter is part of the `ednotes` package bundle and is directly provided with this package; `cepcnote` was tested on a IHEP `lxs1c` login node and worked out of the box. The `cepcnote` class works both with  $\LaTeX$  and `pdf $\LaTeX$` .

If you wish to use the `cepccover` package with the `cepcnote` class, load the latest version of the package in your system, and invoke it using the `coverpage` option of the class:

```
\documentclass[11pt,a4paper,coverpage]{cepcnote}
```

instead of the the usual `usepackage` command: this will ensure that the cover page is produced before the note title page.

## A.2 Custom commands

The `cepcnote` class implements some custom commands, mainly used to typeset the frontpage content:

- `\title{<Title>}` typesets the paper title. If not given, a dummy *Title goes here* title will be produced.
- `\author{<Author>}` typesets the paper author. If not explicitly given, *The CEPC Collaborations* will be used by default. Note that the `\author{}` command is pretty limited in case you want to display multiple author names and multiple affiliations. For this use case the `authblk.sty` package is provided; this is a typical example of its use:

```
\usepackage{authblk}
\renewcommand\Authands{, } % avoid ‘. and’ for last author
\renewcommand\Affilfont{\itshape\small} % affiliation formatting

\author[a]{First Author}
\author[a]{Second Author}
\author[b]{Third Author}

\affil[a]{One Institution}
\affil[b]{Another Institution}
```

- `\mail{<Mail address>}` typesets only one E-mail address in the foot note.
- `\abstracttext{<The abstract text>}` typesets the abstract in the front page.
- `\date{<Date>}` typesets the paper date. If not explicitly given, the current date (`\today`) will be used.
- `\draftversion{<Draft Version>}` displays the draft version on the front page, a DRAFT banner on all the other page headings, and add line numbers to all text to easy commenting and reviewing. Can be omitted.
- `\journal{<Journal Name>}` displays the phrase *to be submitted to Journal Name* at the bottom of the front page. Can be omitted.
- `\skipbeforetitle{<lenght>}` sets the distance between the title page header and the note title. The default value should be fine for most notes, but in case you have a long list of authors or a lengthy abstract you can use this command to buy some extra space. Note that `<lenght>` can also be negative (use it at your own risk!).

`emptynote.tex` contains a basic skeleton that can be used to start typing a new note using the `cepcnote` class. All the custom commands described above are used in this example file, in order to demonstrate their use.

## B Bibliography

We recommend to use `BIBTEX` for the references. Although it often appears harder to use at the beginning, it means that the number of typos should be reduced significantly and the format of the references will

be correct, without you having to worry about formatting it. In addition the order of the references is automatically correct.

A file with the extension `.bib` (in this example: `instruction.bib`) should contain all the references. This file may also contain references that you do not use, so it may act like a library of references. The typical compilation cycle when using `BIBTEX` looks like the following:

```
(pdf)latex instructions
bibtex instructions
(pdf)latex instructions
(pdf)latex instructions
```

`BIBTEX` will create a file with the extension `.bbl`, which will contain the actual references used, and `LATEX` will then take care to include them in your paper. Note that only after the third run of `LATEX` will all references be correct. Unless you change a reference you do not have to do the `bibtex` step again.

A `BIBTEX` style file (`cepcBibStyleWoTitle.bst`) is provided with the CEPC template. You can use it in your text source file like in the following:

```
\bibliographystyle{cepcBibStyleWoTitle}
\bibliography{instructions}
```

**Important:** for further information on `BIBTEX` and on the standard CEPC style for referencing, look at the “QuickGuide.BIBTEX” file shipped with this package.

## C Miscellaneous `LATEX` tips

### C.1 Graphics

Use the `graphicx` package [] to include your plots and figure. The use of older packages like `espgif` is deprecated. Since the `graphicx` package is required by the `cepcnote` class, it is automatically loaded when using it, and there is no need to explicitly include it in the document preamble.

Always include your graphics file without mentioning the file extension. For instance, if you want to include the `figure.eps` file, you should use a `synctex` like this:

```
\includegraphics[width=\textwidth]{figure}
```

This will allow to compile your document using either `LATEX` or `pdfLATEX` without changing your source file: you can in fact have both `figure.eps` and `figure.pdf` in your working directory and the proper one will be picked up according to the processing method you chose.

It is a good habit to keep your graphics file in a separated sub-directory (e.g. in `figure/`). In this case you can include them by mentioning it explicitly every time:

```
\includegraphics[width=\textwidth]{figures/figure}
```

or by telling once for all to the `graphicx` package where to look for them, by using this command:

```
\graphicspath{{figures/}}
```

### C.2 Definitions

You can use `\ensuremath` in definitions, so that they will work in both text mode and math mode, e.g. `\newcommand{\UoneS}{\ensuremath{\Upsilon(\mathrm{1S})}}` to get  $\Upsilon(1S)$  in either mode (`\UoneS` or `UoneS`).

### C.3 Emphasis

Use italics for emphasis sparingly: too many italicized words defeat their purpose. When you do italicize a word, really italicize it: do not use math mode! Note the difference between *per se* (`\emph{per se}`) and *per se* (`$per se$`). Abbreviations like i.e., e.g., etc., and et al. should *not* be italicized! For program names we recommend to use small capitals: `{\sc Pythia}` produces PYTHIA.

## D General Style

We recommend the use of British English. However, whatever you decide to choose, be consistent throughout the paper. For much more detailed information on writing, spelling and typographic style, etc. please see the CEPC Style Guide []. The CEPC Publication Policy contains a list of CEPC detector acronyms. Standard ways to write these are in the CEPC Glossary.

## E The `cepcphysics.sty` style file

The `cepcphysics.sty` style file implements a series of useful shortcut to typeset a physics paper, such as units or particle symbols. It can included in the preamble of your paper with the usual syntax:

```
\usepackage{cepcphysics}
```

### E.1 Remarks on units and symbols

Use SI units in roman-type font. Leave a *small* space between the value and the units (e.g. 12 mm), and make sure they end up always together on the same line. `12\,mm` will fulfill both the requirements. Natural units, where  $c = \hbar = 1$ , should be used for all CEPC publications. Masses are therefore in GeV, not  $\text{GeV}/c^2$ .

Use the shortcut `\GeV{}` (GeV) defined by `cepcphysics.sty` instead of just typing GeV (GeV), in order not to leave a large space between the *e* and the *V*. Symbols `\TeV`, `\MeV`, `\keV` and `\eV` also exist. In math mode the symbol leaves a space between the number and the unit, i.e. the beam energy is `$7\TeV$` (7 TeV). The symbol works in text mode and in math mode i.e. `99.0 \MeV` (99.0 MeV), `$88.4\keV$` (88.4 keV).

Use math mode for all symbols (e.g. use  $c$  (`$c$`) rather than simply `c`). Momentum is a lower case  $p$ . Transverse momentum is a lower case  $p$  with an upper case  $T$  subscript: `\pT` produces  $p_T$ . Energy is an upper case  $E$ , `\ET` produces  $E_T$ . Use `\mathscr` mode for luminosity  $\mathcal{L}$  or aplanarity  $\mathcal{A}$ , including the package `mathrsfs.sty`.

Trigonometric functions should be in roman type. Natural logarithm should be  $\ln$  and log base 10 is  $\log$ . When in math mode, use `$\ln$`, `$\sin$`, etc. We recommend to specify the base of the logarithm: `$\log_{10}$`.

If your note makes use of cones, for example cone-jets, explain that these cones are constructed in  $\eta$ - $\phi$  space, and define  $\eta$ .

Add the word *events* as the unit when quoting the number of events: “The resulting background is  $4.0 \pm 1.3$  events.”. The number of expected events should be written as  $N_{\text{pred}}$  rather than  $N_{\text{exp}}$ , since the latter could also mean experimental.

For particle names and symbols, CEPC uses the standards of the Particle Data Book. Intermediate vector bosons should be called *W boson(s)* and *Z boson(s)*, not just *W's* or *Ws*. The Z boson should not have a superscript of 0. *W* without the word boson attached may be used in *W pair production*, and similar phrases. Other particle names should be spelled out when used in a sentence: *muon(s)*,



electron(s), tau lepton(s). *Top quark* should be used instead of *top* in most places: say “top quark mass” instead of “top mass”. Top quark and bottom quark may be shortened to *t quark* and *b quark*. The neutrino symbol  $\nu$  should not have any subscripts, unless necessary for understanding. For the  $J/\psi$  use the command `\Jpsi` from `cepcphysics.sty`: it will produce a lower case  $\psi$ .

When in doubt, use the PDG style.

## E.2 Other shortcuts

The `cepcphysics.sty` style file contains among other things:

<code>\lapprox</code>	$\lesssim$	<code>\rapprox</code>	$\gtrsim$	<code>\rts</code>	$\sqrt{s}$
<code>\Ecm</code>	$E_{\text{cm}}$	<code>\stat</code>	(stat.)	<code>\syst</code>	(syst.)
<code>\Zboson</code>	$Z$	<code>\Wboson</code>	$W$	<code>\Wplus</code>	$W^+$
<code>\Wminus</code>	$W^-$	<code>\Wpm</code>	$W^\pm$	<code>\Wmp</code>	$W^\mp$
<code>\Afb</code>	$A_{fb}$	<code>\GW</code>	$\Gamma_W$	<code>\GZ</code>	$\Gamma_Z$
<code>\Wln</code>	$W \rightarrow \ell\nu$	<code>\Zll</code>	$Z \rightarrow \ell\ell$	<code>\Zee</code>	$Z \rightarrow ee$
<code>\Zmm</code>	$Z \rightarrow \mu\mu$	<code>\mZ</code>	$m_Z$		
<code>\mW</code>	$m_W$	<code>\mH</code>	$m_H$		
<code>\Mtau</code>	$m_\tau$	<code>\swsq</code>	$\sin^2\theta_W$	<code>\swel</code>	$\sin^2\theta_{\text{eff}}^{\text{lept}}$
<code>\swsqb</code>	$\sin^2\bar{\theta}_W$	<code>\swsqon</code>	$\sin^2\theta_W \equiv 1 - m_W^2/m_Z^2$	<code>\gv</code>	$g_V$
<code>\ga</code>	$g_A$	<code>\gvbar</code>	$\bar{g}_V$	<code>\gabar</code>	$\bar{g}_A$
<code>\Zprime</code>	$Z'$	<code>\Hboson</code>	$H$	<code>\GH</code>	$\Gamma_H$

The command `\Zzero` is identical to `\Zboson`.

<code>\tbar</code>	$\bar{t}$	<code>\ttbar</code>	$t\bar{t}$	<code>\bbar</code>	$\bar{b}$
<code>\bbbar</code>	$b\bar{b}$	<code>\cbar</code>	$\bar{c}$	<code>\ccbar</code>	$c\bar{c}$
<code>\sbar</code>	$\bar{s}$	<code>\ssbar</code>	$s\bar{s}$	<code>\ubar</code>	$\bar{u}$
<code>\uubar</code>	$u\bar{u}$	<code>\dbar</code>	$\bar{d}$	<code>\ddbar</code>	$d\bar{d}$
<code>\fbar</code>	$\bar{f}$	<code>\ffbar</code>	$f\bar{f}$	<code>\qbar</code>	$\bar{q}$
<code>\qqbar</code>	$q\bar{q}$	<code>\nbar</code>	$\bar{\nu}$	<code>\nnbar</code>	$\nu\bar{\nu}$
<code>\ee</code>	$e^+e^-$	<code>\mumu</code>	$\mu^+\mu^-$	<code>\tautau</code>	$\tau^+\tau^-$
<code>\epm</code>	$e^\pm$	<code>\leplep</code>	$\ell^+\ell^-$	<code>\lnu</code>	$\ell\nu$
<code>\BoBo</code>	$B^0-\bar{B}^0$	<code>\BodBod</code>	$B_d^0-\bar{B}_d^0$	<code>\BosBos</code>	$B_s^0-\bar{B}_s^0$
<code>\Bd</code>	$B_d^0$	<code>\Bs</code>	$B_s^0$	<code>\Bu</code>	$B_u$
<code>\Bc</code>	$B_c$	<code>\Lb</code>	$\Lambda_b$	<code>\jpsi</code>	$J/\psi$
<code>\Jpsi</code>	$J/\psi$	<code>\Jee</code>	$J/\psi \rightarrow e^+e^-$	<code>\Jmm</code>	$J/\psi \rightarrow \mu^+\mu^-$
<code>\psip</code>	$\psi'$	<code>\kzero</code>	$K^0$	<code>\kzerobar</code>	$\bar{K}^0$
<code>\kaon</code>	$K$	<code>\kplus</code>	$K^+$	<code>\kminus</code>	$K^-$
<code>\klong</code>	$K_L^0$	<code>\kshort</code>	$K_S^0$	<code>\Ups</code>	$\Upsilon$
<code>\alphas</code>	$\alpha_S$	<code>\Lms</code>	$\Lambda_{\overline{\text{MS}}}$	<code>\Lmsfive</code>	$\Lambda_{\overline{\text{MS}}}^{(5)}$
<code>\KT</code>	$k_\perp$				
<code>\Vud</code>	$ V_{ud} $	<code>\Vus</code>	$ V_{us} $	<code>\Vub</code>	$ V_{ub} $
<code>\Vcd</code>	$ V_{cd} $	<code>\Vcs</code>	$ V_{cs} $	<code>\Vcb</code>	$ V_{cb} $
<code>\Vtd</code>	$ V_{td} $	<code>\Vts</code>	$ V_{ts} $	<code>\Vtb</code>	$ V_{tb} $
<code>\Azero</code>	$A^0$	<code>\hzero</code>	$h^0$	<code>\Hzero</code>	$H^0$
<code>\Hplus</code>	$H^+$	<code>\Hminus</code>	$H^-$	<code>\Hpm</code>	$H^\pm$

A generic macro `\susy#1` is defined, so that for example `\susy{q}` produces  $\tilde{q}$  and similar.

<code>\chinop</code>	$\tilde{\chi}^+$	<code>\chinotwom</code>	$\tilde{\chi}_2^-$	<code>\chinopm</code>	$\tilde{\chi}^\pm$
<code>\nino</code>	$\tilde{\chi}^0$	<code>\ninothree</code>	$\tilde{\chi}_3^0$	<code>\gravino</code>	$\tilde{G}$
<code>\squark</code>	$\tilde{q}$	<code>\gluino</code>	$\tilde{g}$	<code>\slepton</code>	$\tilde{\ell}$
<code>\stop</code>	$\tilde{t}$	<code>\stopone</code>	$\tilde{t}_1$	<code>\stopL</code>	$\tilde{t}_L$
<code>\sbottom</code>	$\tilde{b}$	<code>\sbottomtwo</code>	$\tilde{b}_2$	<code>\sbottomR</code>	$\tilde{b}_R$
<code>\sleptonL</code>	$\tilde{\ell}_L$	<code>\sel</code>	$\tilde{e}$	<code>\smuR</code>	$\tilde{\mu}_R$
<code>\stauone</code>	$\tilde{\tau}_1$	<code>\snu</code>	$\tilde{\nu}$	<code>\squarkR</code>	$\tilde{q}_R$

For  $\tilde{q}$ ,  $\tilde{t}$ ,  $\tilde{b}$ ,  $\tilde{\ell}$ ,  $\tilde{e}$ ,  $\tilde{\mu}$  and  $\tilde{\tau}$ , L and R states are defined; for stop, sbottom and stau also the light (1) and heavy (2) states. There are four neutralinos and two charginos defined, the index number unfortunately needs to be written out completely. For the charginos the last letter(s) indicate(s) the charge: p for +, m for -, and pm for  $\pm$ .

<code>\pt</code>	$p_T$	<code>\pT</code>	$p_T$	<code>\et</code>	$E_T$
<code>\eT</code>	$E_T$	<code>\ET</code>	$E_T$	<code>\HT</code>	$H_T$
<code>\ptsq</code>	$p_T^2$	<code>\met{}</code>	$E_T^{\text{miss}}$		

Use `\met{}` rather than just `\met` to get the spacing right. In principle this works for any macro, although in most cases it will not be needed as `xspace.sty` will take care of the spacing. Somehow `xspace.sty` doesn't do a good job for  $E_T^{\text{miss}}$ .

<code>\ifb</code>	$\text{fb}^{-1}$	<code>\ipb</code>	$\text{pb}^{-1}$	<code>\inb</code>	$\text{nb}^{-1}$
<code>\TeV</code>	TeV	<code>\GeV</code>	GeV	<code>\MeV</code>	MeV
<code>\keV</code>	keV	<code>\eV</code>	eV		

And `\tev`, `\gev`, `\mev`, `\kev`, and `\ev` have the same results.

A generic macro `\mass#1` is defined, so that for example `\mass{\mu}` produces  $m_{\mu\mu}$  and similar. `\twomass{\mu e}` will produce  $m_{\mu e}$ .