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CEPC NOTE

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Institute of High Energy Physics
Chinese Academy of Sciences

Higgs Mass and Cross-section Measurement at CEPC

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Abstract

This is a template CEPC paper. It contains the structure, style files and hints on how to produce a paper for which a minimum amount of time is necessary to spend on typographic details. This template can be found on the web pages of the CEPC Collaboration. You can find some LaTeX technical detail about the template in the Appendix of this paper. A couple of remarks about the paper front page:

- **Title:** it should be concise, clear and descriptive, and should include the word "CEPC".
- **Author list:** it will be provided by the CEPC Collaboration, and will be made available on their website. On the front page, you should name "The CEPC Collaboration" as author.
- **Abstract:** it should also be clear, descriptive, and concise. It should ideally be one paragraph long, and certainly no more than half a page. It should stand on its own and, similarly, the main text of the paper should not depend on it. The abstract should state: what was the measurement; where was it done and with what dataset/luminosity; what method was used; what are the primary results and main conclusions. Citations in an abstract should be avoided. If only Monte Carlo data are used in the publication, this fact should be stated explicitly in the abstract.

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Contents

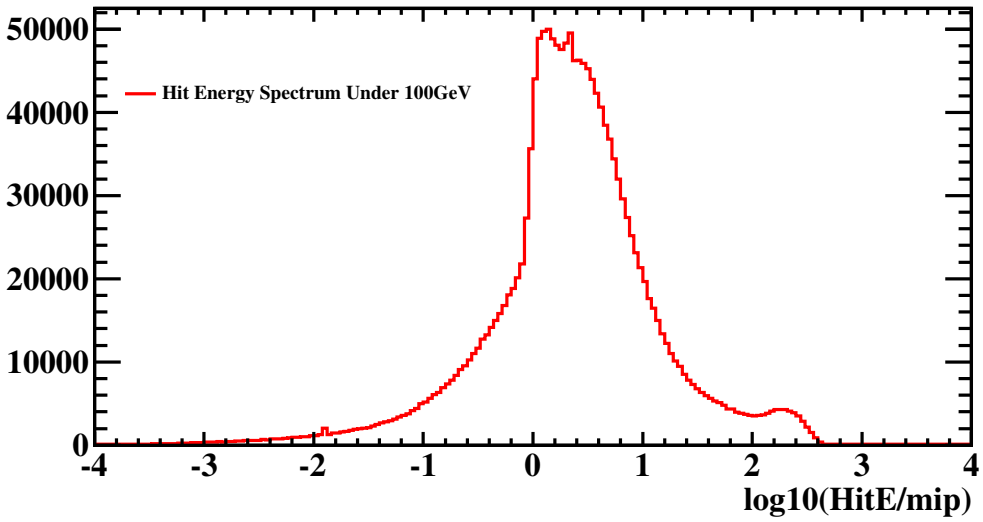


Figure 1: Hit Energy Spectrum.

1 Introduction

Introduce CEPC collision enviorment, the max energy object

According to our physical aim, we don't need our read out system recording arbitrarily high bits. So, we can set a upper limit, that calls saturation. And that makes a dynamic range ensuring a linear response.

A simplified detector simulation tools is provided by Chengdong Fu, and I use Silicon-Tungsten-based ECAL to study the energy response. In this note I set Silicon thickness 0.5 mm, Tungsten thickness 1.4 mm.

2 Analysis Method : L value

L value: L value is defined as a position which represents a given ratio of hits in the Hit Energy Spectrum.

Lx: x% = Nhits(Hit Energy >0.1mip & Hit Energy <Lx) / NHits(Hit Energy >0.1mip)

Hit Energy Spectrum is showed in Figure 5.

L value in different conditions 3.

Parameterization : Lx = f(Energy & Cell Size & Incident Angle)

L99.9 = 0.79x + 0.62y - 0.39z + 1.09 L99 = 0.71x + 0.97y - 0.06z +0.07 L90 = 0.64y + 0.62

x = log10(energy) y = log10(cell size) z = log10(angle)

3 Linearity & resolution at different L values

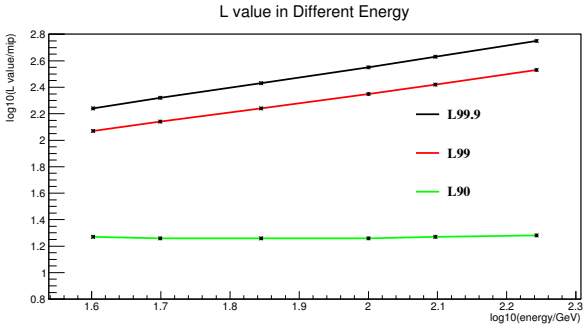
EM object : Photon 3.

Had object : Pion

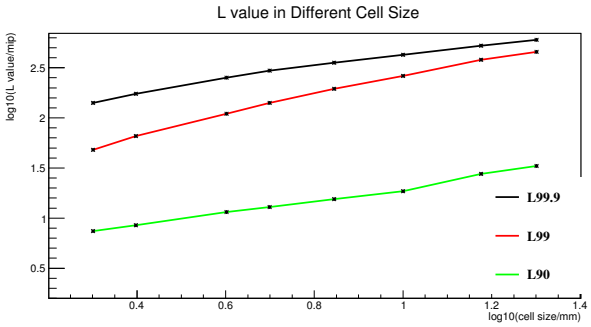
L 1sigma is defined as the saturation position under which the reconstructed energy's peak deviated one sigma from the ideal situation. 5.

L 1sigma value = 0.87x - 0.24yy + 0.97y - 0.43z + 0.82

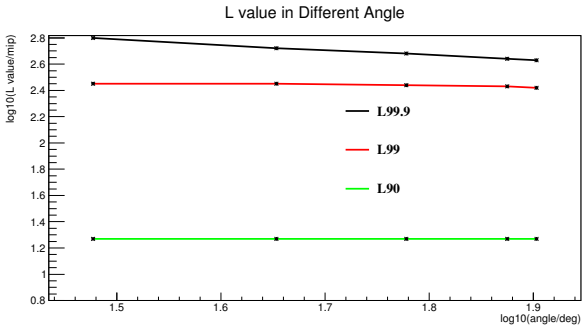
x = log10(energy) y = log10(cell size) z = log10(angle)



(a) One subfigure example

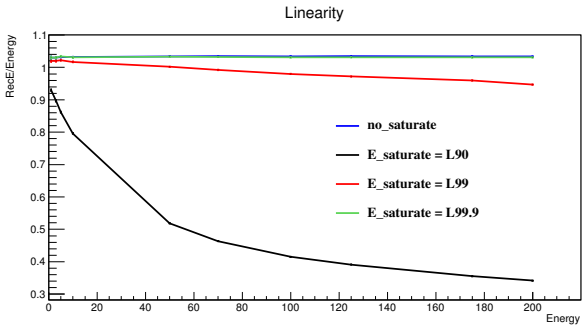


(b) Another subfigure example

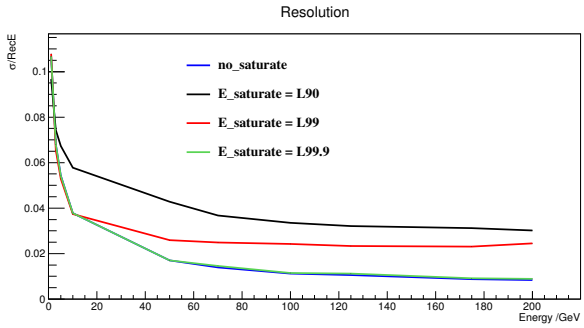


(c) Another subfigure example

Figure 2: Subfigure example (3(a)) and (3(b)) and (2(c)).



(a) One subfigure example



(b) Another subfigure example

Figure 3: Subfigure example (3(a)) and (3(b)).

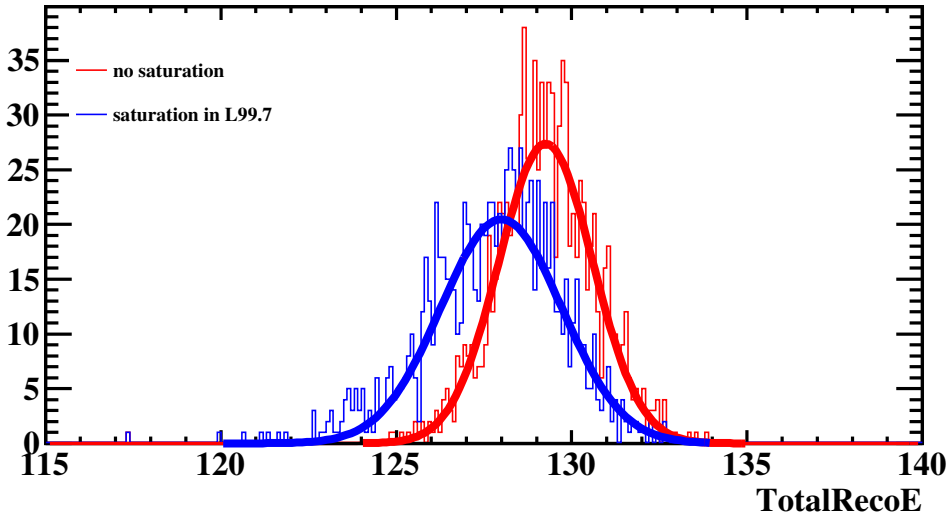


Figure 4: Reconstructed Energy with L 1sigma saturation & no saturation.

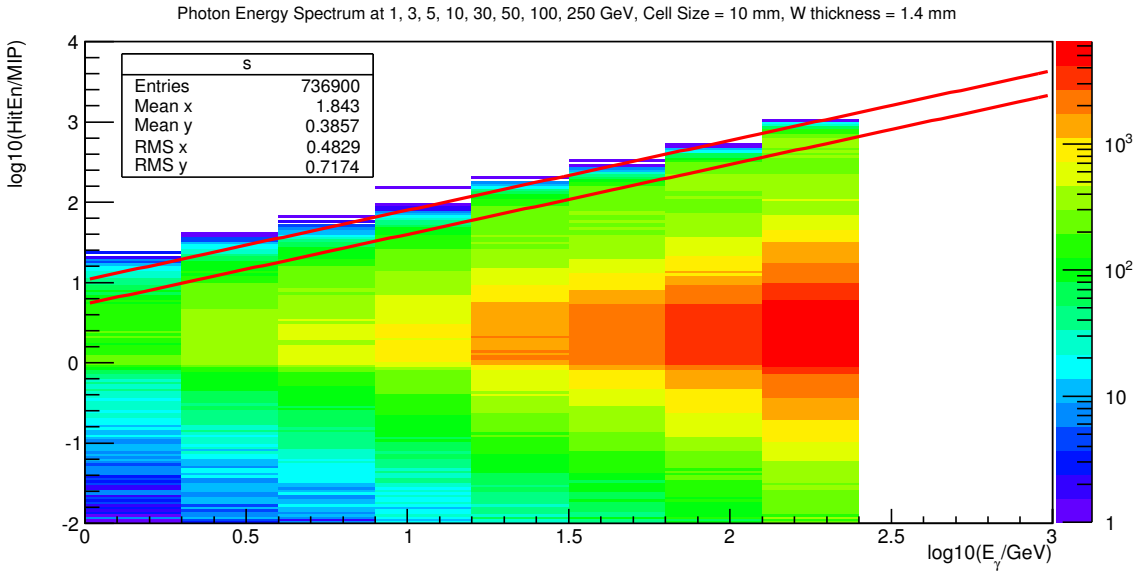


Figure 5: L 1sigma & Hit Energy Spectrum.

Upper Limit of Saturation at CEPC environment : 20 mm cell size, 175 GeV.
L 1sigma(175 GeV, 20 mm) = 3.11

4 CONCLUSION

we put the L 1sigma value and Hit Energy Spectrum together, and gives a two times limit as safety margin 5.

CONCLUSION : Under the the high limit of Saturation at CEPC environment, if we set the saturation at 1289mip, we can safely get reconstructed energy with good Linearity.

5 Systematic uncertainties

Give a detailed list of systematic uncertainties, the method by which they were obtained, and a justification of the resulting values. Use “systematic uncertainty” instead of “systematic errors”. The latter sounds as if you have made a mistake systematically.

6 Results

State the results without interpretations.

7 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.

8 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!

9 Acknowledgements

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

10 Rules for referencing

Use BibTeX 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.

Appendices

Use the Appendices to include all the technical details of your work that are relevant for the CEPC Collaboration only (e.g. datases 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 direclty provided with this package; `cepcnote` was tested on a IHEP `lxslc` login node and worked out of the box. The `cepcnote` class works both with LaTeX and pdfLaTeX.

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 abd 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 lenghtly 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 `espfig` 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 included it in the document preamble.

Always include your graphics file without metioning the file extension. Fior inctance, if you want to include the `figure.eps` file, you should use a sysntax 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 directorym and the proper one will be picked up according to the processing method you chose.

It is a good habit to keep you 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 *perse* (`$per se$`). 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 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 $\mathscr{L}$ or aplanarity $\mathscr{A}$, 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 η-ϕ space, and define η.

Add the word *events* as the unit when quoting the number of events: "The resulting background is 4.0 ± 1.3 events.". The number of expected events should be written as N_{pred} rather than N_{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 ν should not have any subscripts, unless necessary for understanding. For the J/ψ use the command `\Jpsi` from `cepcphysics.sty`: it will produce a lower case ψ.

When in doubt, use the PDG style.

E.2 Other shortcuts

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

`\lapprox`	$\lesssim$	`\rapprox`	$\gtrsim$	`\rts`	$\sqrt{s}$
`\Ecm`	E_{cm}	`\stat`	(stat.)	`\syst`	(syst.)

`\Zboson`	Z	`\Wboson`	W	`\Wplus`	W^+
`\Wminus`	W^-	`\Wpm`	$W^\pm$	`\Wmp`	$W^\mp$
`\Afb`	A_{fb}	`\GW`	Γ_W	`\GZ`	Γ_Z
`\Wln`	$W \to \ell\nu$	`\Zll`	$Z \to \ell\ell$	`\Zee`	$Z \to ee$
`\Zmm`	$Z \to \mu\mu$	`\mZ`	m_Z		
`\mW`	m_W	`\mH`	m_H		
`\Mtau`	m_τ	`\swsq`	$\sin^2\theta_W$	`\swel`	$\sin^2\theta^{\mathrm{lept}}_{\mathrm{eff}}$
`\swsqb`	$\sin^2\overline{\theta}_W$	`\swsqon`	$\sin^2\theta_W \equiv 1 - m_W^2/m_Z^2$	`\gv`	g_{V}
`\ga`	g_{A}	`\gvbar`	$\bar{g}_{\mathrm{V}}$	`\gabar`	$\bar{g}_{\mathrm{A}}$
`\Zprime`	Z'	`\Hboson`	H	`\GH`	Γ_H

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

`\tbar`	$\bar{t}$	`\ttbar`	$t\bar{t}$	`\bbar`	$\bar{b}$
`\bbbar`	$b\bar{b}$	`\cbar`	$\bar{c}$	`\ccbar`	$c\bar{c}$
`\sbar`	$\bar{s}$	`\ssbar`	$s\bar{s}$	`\ubar`	$\bar{u}$
`\uubar`	$u\bar{u}$	`\dbar`	$\bar{d}$	`\ddbar`	$d\bar{d}$
`\fbar`	$\bar{f}$	`\ffbar`	$f\bar{f}$	`\qbar`	$\bar{q}$
`\qqbar`	$q\bar{q}$	`\nbar`	$\bar{\nu}$	`\nnbar`	$\nu\bar{\nu}$
`\ee`	e^+e^-	`\mumu`	$\mu^+\mu^-$	`\tautau`	$\tau^+\tau^-$
`\epm`	$e^\pm$	`\leplep`	$\ell^+\ell^-$	`\lnu`	$\ell\nu$

`\BoBo`	B^0–$\bar{B}^0$	`\BodBod`	B^0_d–$\bar{B}^0_d$	`\BosBos`	B^0_s–$\bar{B}^0_s$
`\Bd`	B^0_d	`\Bs`	B^0_s	`\Bu`	B_u
`\Bc`	B_c	`\Lb`	Λ_b	`\jpsi`	J/ψ
`\Jpsi`	J/ψ	`\Jee`	$J/\psi \to e^+e^-$	`\Jmm`	$J/\psi \to \mu^+\mu^-$
`\psip`	ψ'	`\kzero`	K^0	`\kzerobar`	$\overline{K}^0$
`\kaon`	K	`\kplus`	K^+	`\kminus`	K^-
`\klong`	K^0_{L}	`\kshort`	K^0_{S}	`\Ups`	Υ

`\alphas`	α_{S}	`\Lms`	$\Lambda_{\overline{\mathrm{MS}}}$	`\Lmsfive`	$\Lambda^{(5)}_{\overline{\mathrm{MS}}}$	`\KT`	$k_\perp$

`\Vud`	$\lvert V_{ud}\rvert$	`\Vus`	$\lvert V_{us}\rvert$	`\Vub`	$\lvert V_{ub}\rvert$
`\Vcd`	$\lvert V_{cd}\rvert$	`\Vcs`	$\lvert V_{cs}\rvert$	`\Vcb`	$\lvert V_{cb}\rvert$
`\Vtd`	$\lvert V_{td}\rvert$	`\Vts`	$\lvert V_{ts}\rvert$	`\Vtb`	$\lvert V_{tb}\rvert$

`\Azero`	A^0	`\hzero`	h^0	`\Hzero`	H^0
`\Hplus`	H^+	`\Hminus`	H^-	`\Hpm`	$H^\pm$

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

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

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 ±.

\pt	p_{T}	\pT	p_{T}	\et	E_{T}
\eT	E_{T}	\ET	E_{T}	\HT	H_{T}
\ptsq	p_{T}^2	\met{}	$E_{\mathrm{T}}^{\mathrm{miss}}$		

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 $E_{\mathrm{T}}^{\mathrm{miss}}$.

\ifb	fb^{-1}	\ipb	pb^{-1}	\inb	nb^{-1}
\TeV	TeV	\GeV	GeV	\MeV	MeV
\keV	keV	\eV	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 $m_{\mu e}$.