CEPC NOTE

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.

Contents

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 LaTeX2e. You should get this version automatically. If you have problems check which LaTeX version you are running.

2 Theory

Give here a brief explanation of the theory relevant for this paper, with proper referencing. Use, for example, `\cite{Glashow:1961tr,Weinberg:1967tq,sm_salam}` to cite the Standard Model [2, 3, 4].

Define important quantities that will be used later. State how the measurement of interest is actually performed, and how parameters are extracted from the data. If quantities are extracted with a fit to the data, describe the fit procedure. If the explanation needs to be a bit longer, a separate section may be appropriate.

The `cepcphysics.sty` style file contains a set of particles, reactions, etc. that may be useful. For example, the missing-E_T symbol ($E_{\mathrm{T}}^{\mathrm{miss}}$) is defined there. Appendix E contains a list of some of the commands in `cepcphysics.sty`.

3 Experimental setup

The Publication Committee will provide a standard text giving a brief description of the CEPC detector, and the appropriate references. If necessary for your analysis, describe a subdetector in more detail.

Describe the data set: when were the data taken, under what special circumstances (if any), and what was the integrated luminosity.

4 Monte Carlo

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.

Category	μ	e
$b \to \ell$	65.2±0.4%	79.3%
$b \to c \to \ell$	7.8±0.3%	5.4%
Total	73.0±0.2%	9.1%

Table 1: Carlo estimates of the fraction of each process in the single lepton data sample. This table uses ± as the intercolumn separator.

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Total	73.0 ± 0.2%	9.1%

Table 2: Monte Carlo estimates of the fraction of each process in the single lepton data sample. This table uses \phantom.

5 Event selection

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

5.1 Tables

All tables appearing in the paper must be mentioned in the text. The tables should appear in the same order as mentioned in the text. Do not abbreviate the word "Table". Capitalize the first word of any row or column heading. Label all rows/columns, including units if appropriate. Units are given in brackets, e.g. "Energy [GeV]". Horizontal and vertical lines should be used as necessary to make the table entries clear. The table caption appears below the table. Any symbols/variables used in the table must be defined in the caption. Always use labels to refer to tables and figures. Note that the label must be included in the body of the caption.

If table entries include uncertainties, the entries should be aligned on the "±" sign. Numbers look best when aligned on the decimal point. Otherwise, column entries should be left-aligned. Table 1 shows the use of ± as the intercolumn character for alignment. An alternative, as shown in Table 2, is to use \phantom to put in extra space equal to the width of a number if you have different numbers of decimal places in the table.

6 Data characteristics

Discuss here the characteristics of the data, in terms of primary quantities and backgrounds.

6.1 Figures

The Publication Committee has a root macro to create figures in CEPC style, it can be found on the PubComm web pages. Use this style consistently throughout the paper. An example figure can be seen in Figure 1.

Figures should be always made available in both `eps` and `png` format. Additionally, a `pdf` version of the plots can be useful in case `pdflatex` is used to produce a publication.
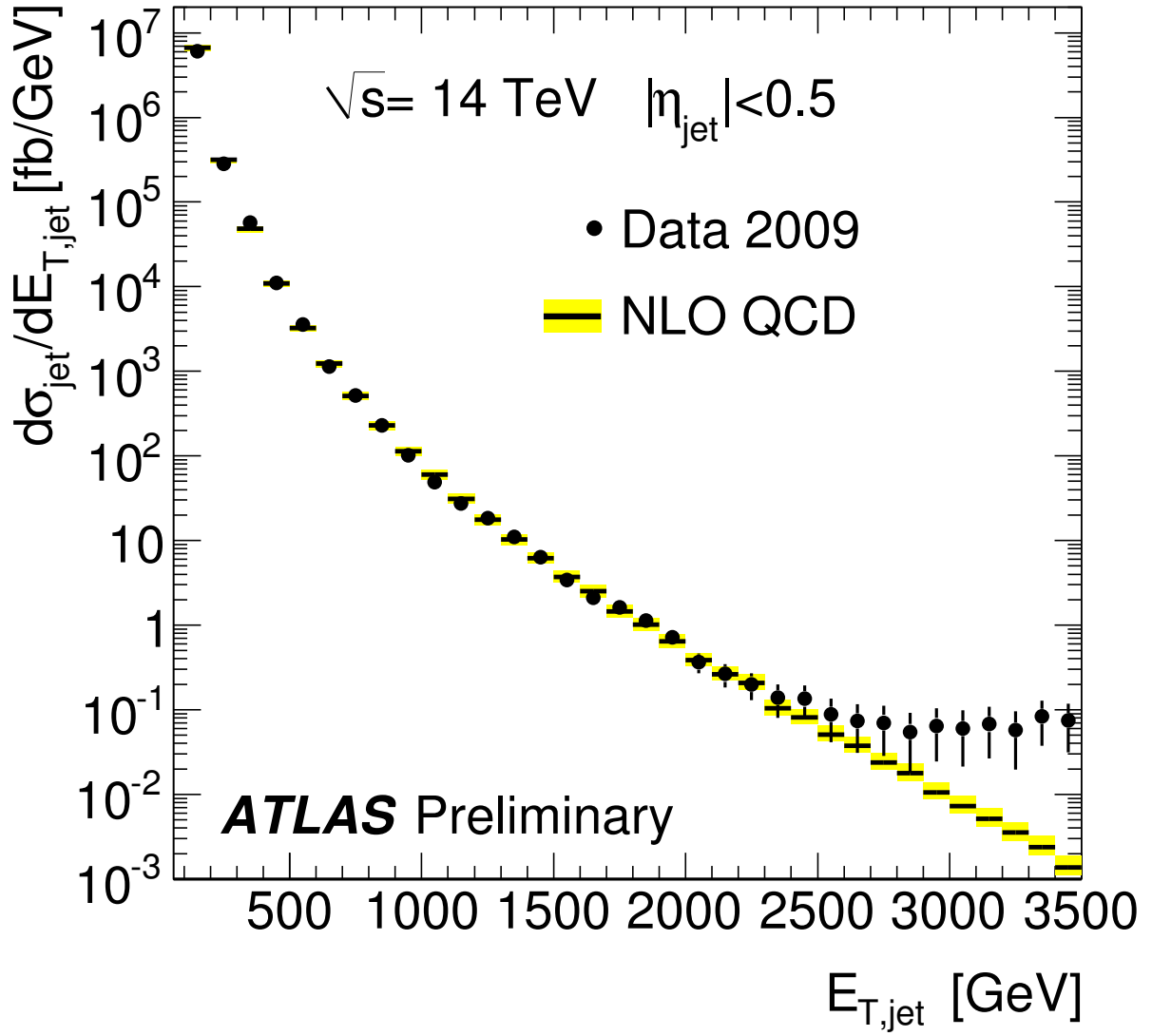
Figure 1: An example CEPC figure.

All figures appearing in the paper must be mentioned in the text. The figures should appear in the same order as mentioned in the text. At the beginning of a sentence, use the full word "Figure". Within a sentence, the abbreviation "Fig." may be used. If a figure appears in two or more parts, refer to it as "Fig. 1(a)" and "Fig. 1(b)". Both "(a)" and "(b)" should appear in the text, in the figure, and in the caption. The word "CEPC" (or "CEPC Preliminary", if appropriate) should appear prominently somewhere in the figure. This becomes important when the figure is copied and shown out of context. If appropriate, it is useful to include information about the luminosity corresponding to a figure.

All axes must be labeled, including units (i.e. "Energy [GeV]"). The vertical axis units should specify the bin width, unless arbitrarily normalized. A legend box explaining all plotting symbols must appear somewhere in the figure.

The caption should be placed below the figure. All lines, all plotting symbols, and all variables used in the figure must be defined in the caption. Do not refer to any characteristic that is not distinguishable in black-and-white. If relevant, the normalization method of the plot should be specified.

A figure with subfigures can be made as shown in the example of Figure 2.

7 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.

8 Results

State the results without interpretations.

9 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.

10 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!
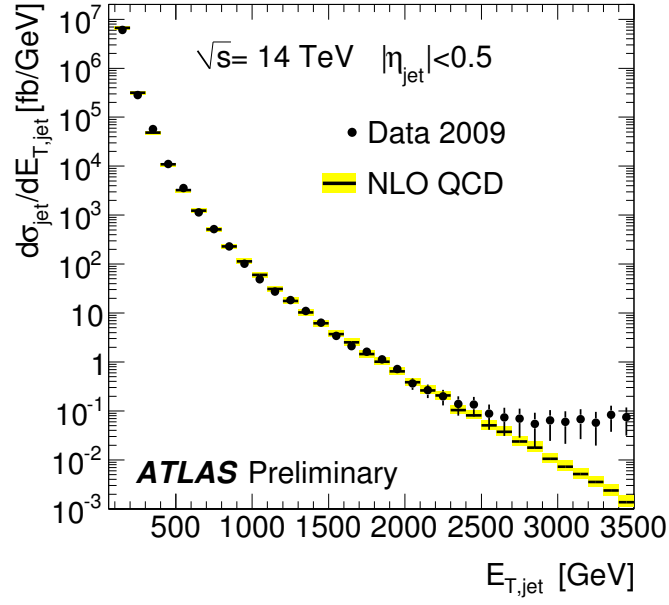
(a) One subfigure example
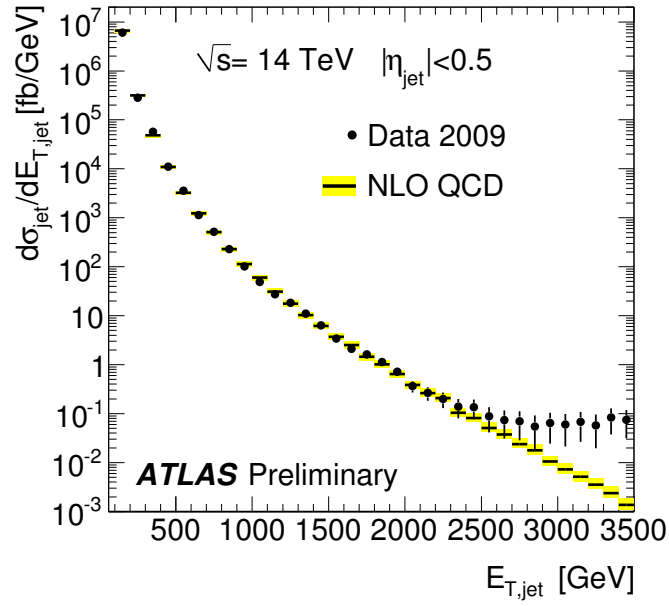
(b) Another subfigure example

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

11   Acknowledgements

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

12   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.

[2] S. L. Glashow, Nucl. Phys. **22** (1961) 579–588.

[3] S. Weinberg, Phys. Rev. Lett. **19** (1967) 1264–1266.

[4] A. Salam,, *in Elementary Particle Theory*. Almqvist and Wiksell, Stockholm, 1968.

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 BⅠʙTᴇX 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 (`$p$`). 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	$\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$
\swsqb	$\sin^2\bar\theta_W$	\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	$B^0\text{–}\bar{B}^0$	\BodBod	$B_d^0\text{–}\bar{B}_d^0$	\BosBos	$B_s^0\text{–}\bar{B}_s^0$
\Bd	B_d^0	\Bs	B_s^0	\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_{L}^0	\kshort	K_{S}^0	\Ups	Υ

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

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

\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 $m_{\mu e}$.