Conceptual Design Report
The Neutrino Experiment

Volume: README

February 9, 2015

Editor's Note: This document has been prepared in an ad hoc manner to provide a summary of the scope of the LBNE project as of January 2015. It pulls content from version 8 of LBNE's CDR vol 4 and includes some changes made since 2012, with notes added; the changes may not be reflected consistently throughout the document, as a thorough editing pass has not been made. It is planned to update this document in 2015 consistent with the plan resulting from the iIEB's efforts. Changes to note in particular about the current plan relative to the 2012 design include:

- House two detectors, of fiducial mass 10 kton and 30 kton, respectively, in separate, parallel caverns. Outfit the smaller cavern as soon as possible and outfit the larger in a later phase of work. (The 30-kton detector was not part of the 2012 design; its configuration, to be determined by the international collaboration, is not discussed in this interim report.)
- Place the compressors for the nitrogen refrigeration system on the surface, and place the remainder of the refrigeration system in the 10-kton cavern. Deliver argon and nitrogen in gas form to the smaller cavern, where liquification will take place. Liquid will be transferred to and from the detector in the 30-kton cavern.
- Make detector shallower and longer. Build APAs of width 2.3 m and height 6 m (2012 dimensions were 2.5 m $\times$ 7 m). Increase the length of the 10-ton detector from 25 m to 30 m.
- Replace the far detector prototyping plan known as LAr1 by a plan to build and test a prototype with full-size TPC components at CERN.

1

Contents

1

List of Figures

1

List of Tables

1

Todo list

17

Chapter 1

Generalities

ch:generalities

This volume gives guidance to authors and editors of the CDR volumes. It collects "wisdom" learned producing earlier documents, in particular the LBNE CDR and science document, and we will appreciate very much if everyone follows it! It tries to follows its own guidance, so looking at its LaTeX source can provide an example.

1.1 Files

sec:files

The entire CDR consists of a number of volumes, some of which are written in LaTeX. These instructions apply only to the LaTeX volumes. You will find the LaTeX and figure content for a given volume arranged like:

volume-VNAME.tex the main file and is found in the top-level directory. It generally has no content itself but includes content through other files, some shared among the volumes and the bulk that makes each volume unique.

figures/ top-level subdirectory for any static figures shared by more than one volume

volume-VNAME/ subdirectory holding all content for the volume

volume-VNAME/chapter-CNAME.tex holds the content for a chapter

volume-VNAME/figures/ subdirectory holding any static volume-specific figures

volume-VNAME/generated/ subdirectory holding any generated figures (see Section 2.2 for info on generated files)

sec:figures

Where `VNAME` is some label for the volume (this volume is called "`readme`") and `CNAME` is some label for the chapter (this current one is "`general`"). Some general guidance:

- Do not include a volume number in the "`NAME`" nor a chapter number in "`NAME`". The numbers will be determined by editors.
- Except for adding chapters to `volume-NAME.tex` please avoid any other changes to this file. (the editors will probably take care of this anyway)
- Use the `figures/` subdirectory for static figures (see Section 2.2). For how to include generated figures see Section 1.2.2.
- If you find something inadequate or have questions, consult with either:
  Anne Heavey, aheavey@fnal.gov, 630-840-8039 (technical editor)
  Brett Viren, bv@bnl.gov (LaTeX, graphics and git guru – so dubbed by Anne)

Files can get very big. If they become unwieldy, we may want to separate out sections into separate tex documents and "include" them in the chapter document. Do this via an input statement, e.g.,

```
\input{chap-blah-section-blah}
```

Even if your file isn't too long, please make it easier to navigate by using these long comment lines to delineate the beginning of a new section, half the length for a subsection and a quarter the length for a subsubsection.

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\section{My Section}

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\subsection{My Subsection}

%%%%%%%%%%%%%%%%
\subsubsection{My Subsubsection}
```

1.2 Figure Format

:figure-format

It is essential to use high-quality, efficiently sized figures (aka "graphics"). You will be asked to redo them if they do not meet some basic standards. The standards

are in place to avoid sub-optimal figures, bloated files sizes, and delayed publishing schedules.

This section provides guidance on how to create figures according to the standards.

1.2.1 Graphic Types

:graphic-types

There two basic graphic content types; these are important to understand:

raster a two dimensional array of pixels

vector a two dimensional drawing description language

The CDR volumes compile with `pdflatex` and so can use graphics in PDF, JPEG or PNG file formats. In general:

JPEG use for photographs

PDF use of any line drawings, plots, illustrations

PNG use due to some inability to produce proper JPEG or PDF (contact editors)

It is possible (though unwise) to store inherently raster information in PDF or to rasterize inherently vector information into JPEG or PNG. **This is the main cause for bloated, low-quality graphics.** Here are some guidelines to avoid this:

- Only save photographic images to JPEG.
- Save line drawings, plots or illustrations directly to vector PDF.
- Follow special guidance on annotation (see Section sec:annotate 1.2.3).
- Never convert any raster data (JPEG/PNG) to PDF.
- Never raster what is really vector data in to a JPEG/PNG.
- Never use MicroSoft PowerPoint for any figure as it tends to lead to poor quality and bloated files.
- Do save using native application formats for later modification or conversion by experts.
- Consider providing plots as ROOT, Python or other scripts. (see Section sec:plots 1.2.2)

If authors find these guidelines can not be followed, please contact the technical editors.

1.2.2 Plots

sec:plots

Where possible, it is recommended that any plots be submitted in a form that can be built along with the LaTeX. This allows editors to apply consistent in-plot fonts, colors, wording. More info to be added.

1.2.3 Annotated Figures

sec:annotate

One common figure type is to take a figure and annotate it with arrows or labels. Ideally you will do this in LaTeX, for example using TikZ. If you can't do that, then take care not to produce a bloated, low-quality graphic, and please choose fonts and colors that "work" with the document. If the underlying graphic is JPEG then produce the final version in JPEG and never save as PNG. If the annotation is on top of an original vector drawing and your annotation software will not raster it, save it as PDF.

Chapter 2

Writing LaTeX

This is the start of a chapter and gives some introduction before its first section. This chapter describes basic LaTeX you need to know.

2.1 Sectioning

sec:sectioning

The following sectioning macros are available, ordered in descending importance:

```
\chapter{A Chapter}
\section{A Section}
\subsection{A Sub Section}
\subsubsection{A Sub Sub Section}
\subsubsubsection{A Sub Sub Sub Section}
```

Three-sub's is all you get. Consult with the technical editors if you feel finer grained sectioning is required. Starting from `\subsection`, this produces the following:

2.1.1 A Sub Section

This is a subsection.

A Sub Sub Section

This is a subsubsection.

A Sub Sub Sub Section

This is a subsubsubsection and is getting to be a bit too fine-grained. It will not appear in the table of contents, which will show entries as low as subsubsection only.

2.1.2 Section Labels

Just after defining a chapter and any significant section a `\label` should be added so it can be referenced. A label can be added later for a ''less significant" section that turns out to need one. You can label them all.

For example:

```
\chapter{A Chapter}
\label{ch:a-chapter}

\section{A Section}
\label{sec:a-section}

\subsection{A Sub Section}
\label{subsec:a-subsection}
```

sec:refs

See Section 2.4 for how to reference labeled sections.

2.2 Figures

sec:figures

sec:figure-format

See Section 1.2 for guidelines on the graphics files themselves. Instead of using the usual `figure` environment a custom `cdrfigure` environment is used in order to provide for a consistent presentation. The environment is called with one optional and two required arguments:

1. An initial, optional short caption for the List Of Figures, in square brackets.
2. A label for referencing (it will have `fig:` prepended). Curly brackets.
3. The full caption. Curly brackets, again.

This is followed by including the graphic file.

When the figure contains a graphic, usually `includegraphics` is used. The filename is assumed relative to a volume-specific `graphicspath` as described in Section 1.1 and as such one typically should **not** specify any directory parts in its name.

sec:files

Figure 2.1: An aerial photograph of Fermilab showing Wilson Hall and surrounding accelerator rings (Fermilab Visual Media Services) fig:aerial

```
\begin{cdrfigure}[Short ToF caption.]{aerial}{An aerial photograph of Fermilab
    showing Wilson Hall and surrounding accelerator rings (Fermilab
    Visual Media Services)}
  \includegraphics[width=0.8\textwidth]{fermilab-aerial.jpg}
\end{cdrfigure}
```

Figure 2.2: LaTeX showing how to do include a figure. fig:aerial-lat

The file's extension may be omitted. An example can be seen in Figure 2.1, which is created with the following LaTeXshown in Figure 2.2

fig:aerial

fig:aerial-latex

2.3 Tables

sec:tables

Like figures, we use a special environment, `cdrtable` for tables to achieve a degree of consistency. This is instead of the usual double `table` + `tabular` environments. The `cdrtable` environment takes one optional and three required arguments:

1. An initial, optional short caption for the List of Tables. Square brackets.
2. The tabular column specification. Curly brackets for the last three.
3. A label for referencing (it will have `tab:` appended)
4. The full caption.

Inside the actual contents of the table you are required to provide a initial row containing the headings for the table's rows followed by a `toprowrule` macro. Following every regular row (except the last) you should include a `colline` macro. Both of these take the place of the usual `hline`.

Table 2.1: This is an example table. We will use better colors, don't worry.

Rows	Counts
Row 1	First
Row 2	Second
Row 3	Third

tab:example

tab:example

Table 2.1 is thus made like (arguments can span lines):

```
\begin{cdrtable}[The LoT caption]{cc}{example}
{This is an example table. We will use better colors, don't worry.}
  Rows & Counts \\ \toprowrule
  Row 1 & First \\ \colhline
  Row 2 & Second \\ \colhline
  Row 3 & Third \\
\end{cdrtable}
```

tab:pdecay

Table 2.2 shows a more complex example. See the source for how it is written. Note that special column specifications are used.

Table 2.2: Efficiencies and background rates for nucleon decay channels of interest for a large underground LArTPC, and comparison with water Cherenkov detector capabilities

Decay Mode	Water Cherenkov		Liquid Argon TPC	
	Efficiency	Background	Efficiency	Background
$p \to K^+\bar{\nu}$	19%	4	97%	1
$p \to K^0\mu^+$	10%	8	47%	< 2
$p \to K^+\mu^-\pi^+$			97%	1
$n \to K^+e^-$	10%	3	96%	< 2
$n \to e^+\pi^-$	19%	2	44%	0.8

tab:pdecay

2.4 Referencing and Citations

sec:refs

Note: if you see a grey label blox containing `sec:refs` between this paragraph and the section heading (or in general elsewhere in chapters, sections, figures, etc), it means this document was built in draft mode. These artifacts show up to help you know what label was used to reference each particular thing.

2.4.1 Intra-document References

Assume that any chapter, section or important sub-, subsub-, section or within any figure or table environment may need to be referenced elsewhere in the text. As described in Section 2.1, define a label (`\label{...}` for these items. Use the defined label in a `\ref{...}` in order to make reference to the chapter, section, figure, etc. For example:

sec:sectioning

```
\chapter{Some Chapter}
\label{ch:some-chapter}

\subsection{Some Sub Section}
\label{subsec:some-sub-section}

...

As described in Chapter~\ref{ch:some-chapter} ...

As shown in Figure~\ref{fig:fermilab-aerial} ...
```

When you reference a chapter, section, subsection, figure, table, etc., capitalize the word "Chapter" or whatever it is, e.g., "as shown in Section 1.2.2." Use the word "Section" even if it's a subsection or subsubsection, and use the tilde sign to keep the number on the same line as the word that precedes it.

Examples for figures and tables have been given above. Here I reference this section: 2.4.

2.4.2 Citations

Referencing citations is done like `\cite{strunk}` which gives [1]. (Compiling the bibliography entries into the document requires an extra step: run "bibtex" on volume-readme.tex, then run pdflatex on it again a couple of times. Otherwise you'll see [?] here and no bibliography entry at the end.) The key `strunk` matches an entry in the `common/citedb.bib` file (as relative to the top-level directory).

The `citedb.bib` file is in BibTex format. This is **not** LaTeX format and in particular does not indicate comments via `%` characters. The content and order of entries in this file is not reflected in the generated Bibliography. However, manual care must be taken to avoid duplication. Before adding any entry to `citedb.bib` read/search through it to ascertain that the entry you wish to add is not already there.

2.5 Common Names

To enforce consistency, use a LaTeX macro in place of any name or term which is frequently used. It is especially important to do this if the name or term is subject to multiple "spellings". The file `common/defs.tex` is where all such macros should be defined.

Some examples:

- δm^2_{21} is written as `\dm{21}`.
- Sanford Underground Research Facility is written as `\SURF`.

2.6 Numbers and Units

All numerical quantities expressed as literal number **must** have units unless they are inherently do not have a unit. In order to enforce consistency the `siunitx` package is used and a collection of common units are defined in `common/units.tex`.

2.6.1 Bare Numbers

To enforce consistent writing of numbers encase them in the `\num{}` command:

- "100" is written as `\num{100}`.
- "1,000" is written as `\num{1000}`.
- "123.456" is written as `\num{123.456}`.

2.6.2 Bare Units

If you need to write a bare unit, one with not associated number, use `\si{}` (lower case "si")

- "m" is written `\si{m}`.
- "pc" is written `\si{pc}`.

2.6.3 Numbers and Units

When a quantity has a unit write both the numerical part and the unit using the `\SI{}{}` command like:

- "120 GeV" is written as `\SI{120}{GeV}`.
- "4,850 foot" is written as `\SI{4850}{foot}`

2.6.4 Adjective Quantities

Some language uses quantities as adjectives. These require proper outfitting with a dash which is easy to forget. To accommodate this a set of "adjective quantities" commands are defined. A generic `\SIadj` is provided as are some commonly used ones. For example:

- "The 4,850-ft level" is written as `The \SIadj{4850}{ft} level`.
- "The 4,850-ft level" is written as `The \ftadj{4850} level`.
- "A typical 2-GeV event" is written as `A typical \GeVadj{2} event`.
-

2.6.5 Common compound units

There are some common units that rather long to type out each time especially when we require nice formatting.

- "per m · sr" is written as `per \msr`
- "exposure in kt · MW · years" is written as `exposure in \ktmwyr{}s`

Chapter 3

Reviewing and Editing

3.1 Markup

While reviewing, it is possible to mark up the document with simple LaTeX macros as provided by the "todonotes" class. This class has many features but a few are more important.

Note: if you do not see the examples in this section your copy may have been built with the "`final`" option turned on.

3.1.1 Inline Fixme

You may prefer to place an inline note to mark up the text. This can be accomplished with a

Think of something critical about this sentence

`\fixme{...}` command.

3.1.2 Margin notes

You can add notes to the margine easily which are associated with some text using:

run spell checker

```
\todo{run spell checker.}
```

3.1.3 Highlighting

If you wish to make add a comment on some section of text you may highlight it with a comment.

This shows how.

```
1 \hlfix{highlight it}{This shows how.}
```

Chapter 4

Technical

This chapter describes some of the more technical aspects of the CDR.

4.1 Getting the Files and Compiling after your Changes

tfiles-compile

Instructions for getting the files and compiling a volume are given on the home page of the repository, at https://github.com/LBNE/lbn-cdr. Scroll down to "Guidance" and "Getting Started."

Note that any acronyms list that a volume has requires an extra step to be included; this step is not documented there. The technical editors will take care of it.

4.2 The LaTeX CDR class

All of the LaTeX configuration for the document that pertains to the general CDR style and not to the actual content is in the `cdr.cls` file. The class takes some options that control high-level style:

`draft` produce markup to assist in editing (line numbers, draft water mark, label tags)

`print` print quality (remove editing markup)

Instructions for producing one or the other are listed on the GitHub site referenced in Section 4.1.

sec:getfiles-compile

4.3 Volume-generic LaTeX files

There are several files specific to the topic of the CDR but used for all the volumes, hence they are in the `common` directory:

`common/preamble.tex` placed before the document begins and should provide all macros to define common terms or units.

`common/init.tex` placed immediately after the document starts and should provide things like title page, author list, toc/lof/lot, etc.

`common/final.tex` placed immediately before the document ends and should provide the bibliography setup or any other common trailing matter.

`common/defs.tex` (input to the preamble) contains macros for some commonly used terms and expressions. Please review this file and use the definitions to help ensure consistency throughout the document.

Also in the `common` directory are two content-related files: `intro.tex` and `supp-doc-list.tex`. All volumes except the introductory volume will share the introduction contained in `intro.tex`. The other is a list of supporting documents that this introduction file pulls in.

4.4 The volume-(name).tex file

Contributors do not need to do this!

To start a new volume, copy the `volume-readme.tex` to a new name and edit as directed by the comments.

1. Set the graphics path
2. Redefine the volumes sub-title
3. Input each chapter file.

Bibliography

[1] W. Strunk, Jr. and E. B. White, *The Elements of Style*. Macmillan, third ed., 1979.