

# The Technical Design Report (TDR) for SAND in the ND complex

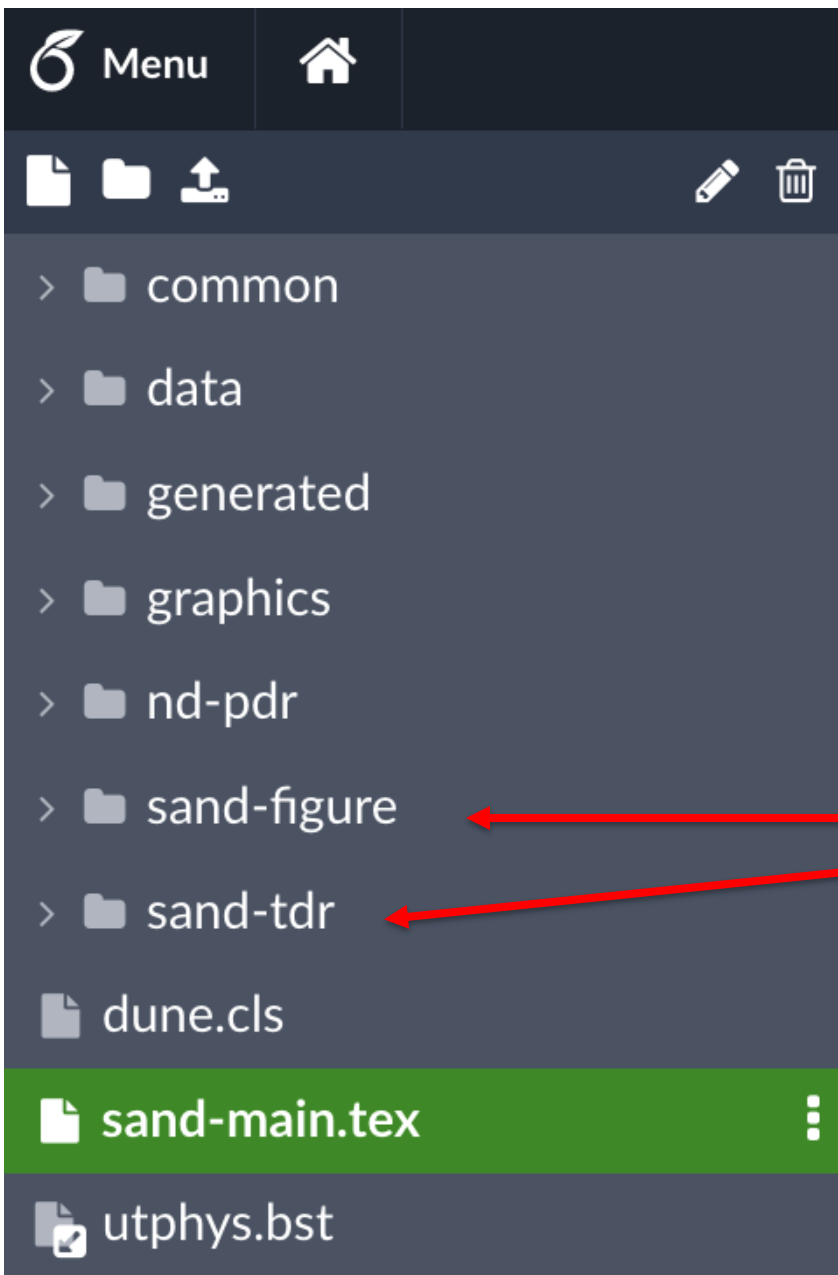
Paolo Bernardini, Lecce  
SAND General Meeting  
December 10<sup>th</sup>, 2024

*yesterday updated*



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DEL SALENTO  
*L'Ateneo tra i due mari*



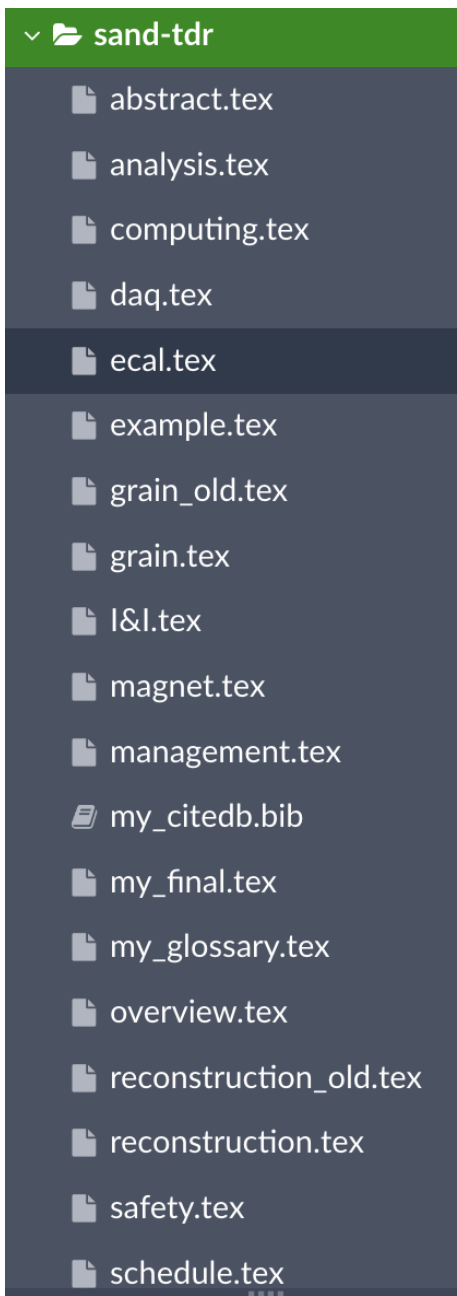


An overleaf is adopted according to  
**LATEX conventions for LBNF/DUNE documents**

shared with **SAND people + J. Lewis**  
**H.A. Tanaka (ND tech. coordinator)**  
**A.E. Heavey (scientific editor)**

The figures in **sand-figure** and the files in **sand-tdr**  
are input for **sand-main.tex**

Dedicated overleaf for **GRAIN**  
and **SOFTWARE Working Groups**,  
periodically copied in main overleaf



# Sections in the SAND chapter

- 1. Overview (requirements & opportunities)
- 2. **Lead/Scintillating-Fiber Calorimeter (ECAL)**
- 3. **Superconducting Magnet**
- 4. **Liquid Argon Active Target (GRAIN)**
- 5. **Tracker**
- 6. Data Acquisition (DAQ) Architecture
- 7. Detector Control (DCS)
- 8. Detector Safety System (DSS)
- 9. Software & Computing
- 10. Event Reconstruction
- 11. Analysis
- 12. Installation & Integration
- 13. Safety
- 14. Organization & Management
- 15. Time Schedule
- 16. Possible Upgrades

} hardware

my\_glossary.tex ←  
my\_citedb.bib ←

New DUNE words and new references in evidence (at the file end)

# INDEX REARRANGEMENT

4. Liquid Argon Active Target (GRAIN)

9. Software & Computer

10. SAND Performance & Event Reconstruction

10.1 Algorithms for event reconstruction

Kalman filter  
Trajectory ...

Algorithms for  
lenses & masks

1.1	Overview . . . . .		<u>1</u>
1.1.1	Requirements and SAND Role . . . . .		<u>2</u>
1.1.2	The Overall Design of SAND . . . . .	7 pages	<u>3</u>
1.1.3	Derived SAND Capabilities . . . . .		<u>4</u>
1.1.4	Opportunities for SAND . . . . .		<u>6</u>

Updated according to the task-force document  
(approved in DUNE general meeting, May 2024)

Possible improvements (mainly in Sec. 1.1.4)

Check in progress

1.2	Lead/Scintillating-Fiber Calorimeter (ECAL)	8
1.2.1	Design and Structure	8
1.2.2	Performance in KLOE Experiment	12
1.2.3	Requirements for ECAL	18
1.2.4	Calibration and Monitor System	18
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1.2.7	Revamping and Test before SAND Installation	66
1.2.8	Installation & Integration	69
1.2.9	Risk Management	70
1.2.10	Schedule and Milestones	72

67 pages

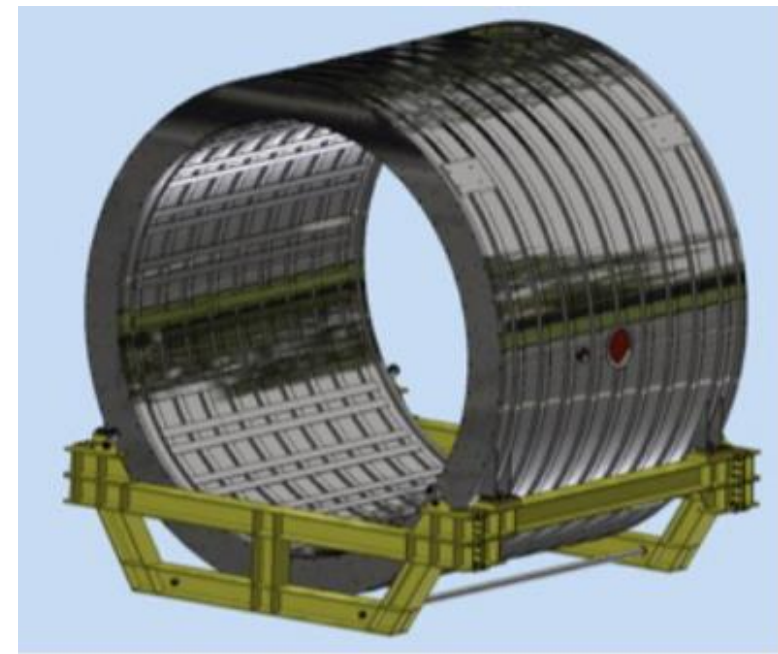


To be completed (i.e. I&I introduction)  
and updated (i.e. schedule)

Refinements expected within November 30 => ?

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1.3.6	Schedule and Milestones . . . . .	97

25 pages

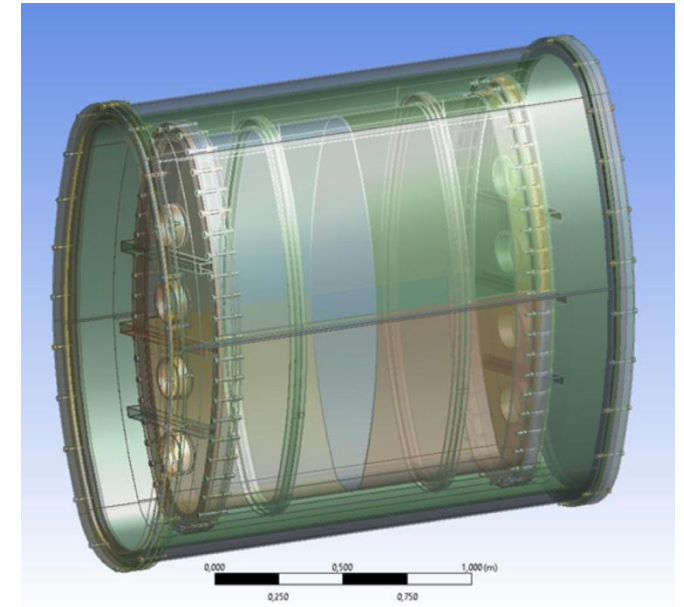


To be checked after minor updates



1.4	LAr Active Target (GRAIN)	100
1.4.1	Introduction and Physics Requirements	100
1.4.2	Mechanical Design	100
1.4.3	Optical Detector	100
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1.4.5	Data Acquisition and Slow Control System	115
1.4.6	Calibration System	115
1.4.7	Cryogenic System	120
1.4.8	Integration and Installation in SAND	120

21 pages



To be completed

- prototypes
- cryogenics

- DAQ & slow control

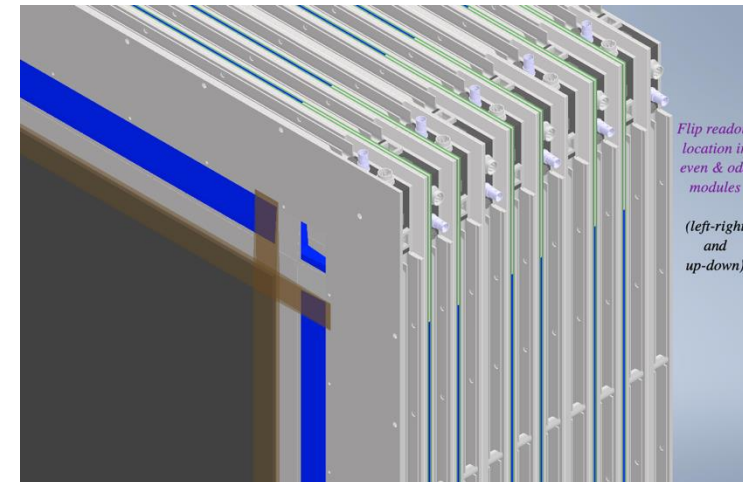
- integration & installation

Complete draft: November 30 => ?



1.5	Tracker	125
1.5.1	STT	125
1.5.2	Drift Chamber	129
1.5.3	Gas System	130

6 pages



Present - figures and tables about STT geometry

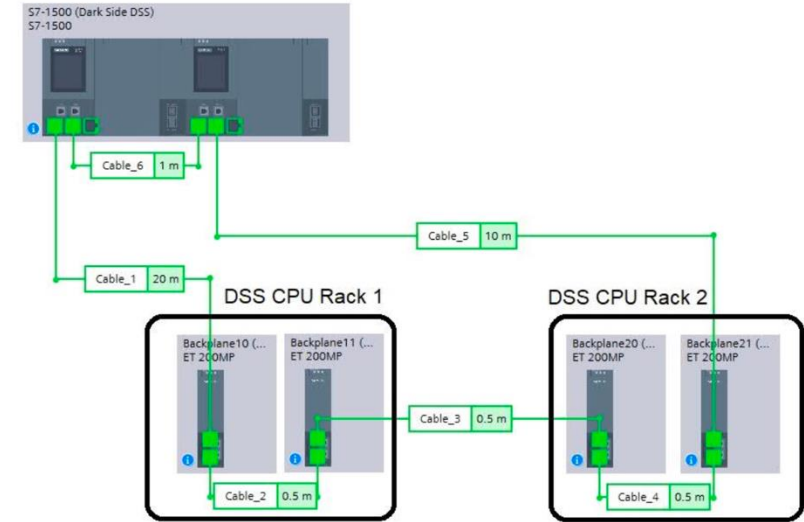
Missing - 14 subsections about STT  
- subsection about Drift Chamber  
- subsection about Gas System

NO progress

Complete draft: December 2024 ?

1.6	DAQ Architecture . . . . .	131
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8 pages



Ready draft - DSS

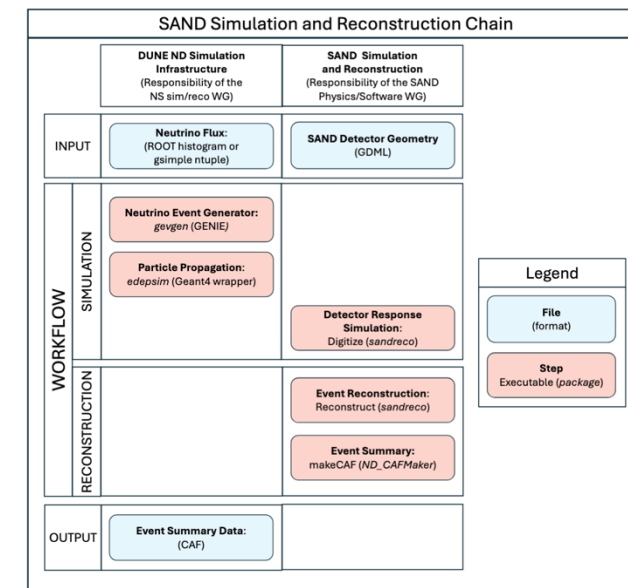
To be completed - DAQ (expected data rates, interfaces)  
 - DCS (preliminary layout, DAQ interfaces)

NO improvement in last months

Complete draft: December 2024 ?

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1.9.5	Computing resources . . . . .	<u>155</u>
1.9.6	Visualization . . . . .	<u>155</u>

22 pages



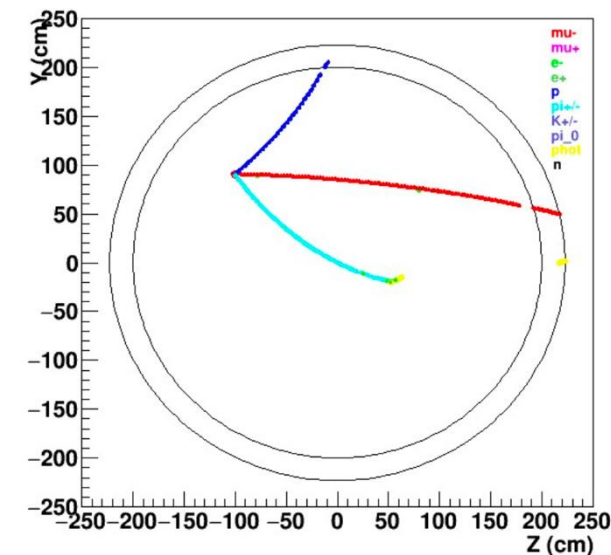
In progress, improvements in the last weeks

- Missing
- simulation of  $\nu$  fluxes, geometries
  - computing architecture
  - event display
  - integration

Complete draft: December 2024

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94 pages



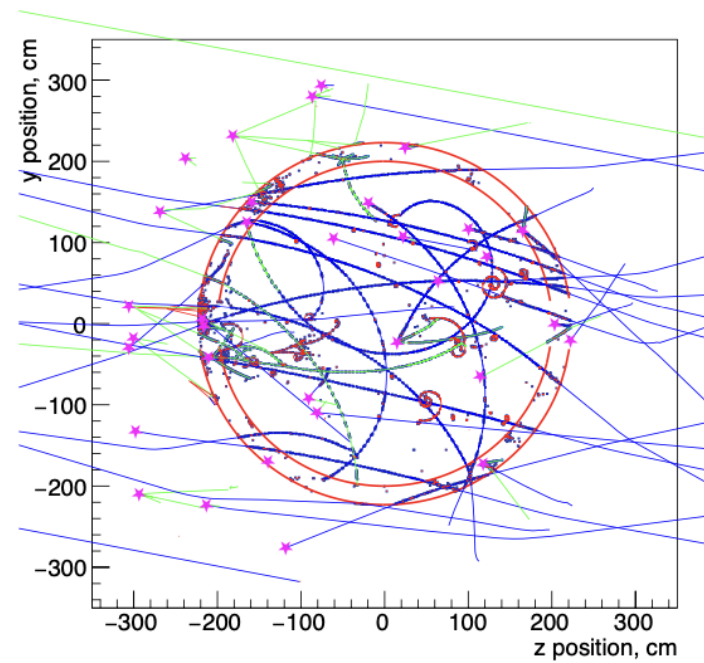
In progress

To write - identification of neutrino event in the spill  
 - use of voxel for lenses

Complete draft: December 2024

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1.11.8 On-Axis Beam Monitoring	254
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80 pages



**Present**

- selection of CC interactions ( $\nu_\mu$ , anti  $\nu_\mu$ ,  $\nu_e$ , anti  $\nu_e$ )
- $\nu$ -H interactions
- nuclear smearing in Ar
- coherent  $\pi$  production
- $\nu_e/\nu_\mu$  ratio
- measurement of fluxes
- $\nu$ -e scattering
- on-axis beam monitoring
- external backgrounds

**To be checked**

From the document  
DUNE-doc-13262-v7

"A Proposal to Enhance  
the DUNE Near-Detector  
Complex"

# To be written (CM & LS in charge)

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Present: tables about sizes, weights and storage @ FNAL of yoke, coil and calorimeter

Present: time schedule from the single sections

Complete draft: December 2024

**Present:**  
**352 pages**  
**285 figures**  
**68 tables**

1. Overview **7 pages - to be checked**
2. Lead/Scintillating-Fiber Calorimeter (ECAL) } 91 pages - to be updated
3. Superconducting Magnet }
4. Liquid Argon Active Target (GRAIN) **21 pages - to be completed**
5. Tracker **6 pages - at the beginning**
6. Data Acquisition (DAQ) Architecture } 8 pages - to be completed
7. Detector Control (DCS) }
8. Detector Safety System (DSS) }
9. Software & Computing **22 pages - to be completed**
10. Event Reconstruction **94 pages - to be completed**
11. Analysis **80 pages - to be checked**
12. Installation & Integration } 10 pages - in progress
13. Safety }
14. Organization & Management }
15. Time Schedule }
16. Possible Upgrades }



## Long todo-list

Essentially missing or wrong references

Standardize (as possible) quantity names,  
reference systems and so on

Each author is responsible of his/her section  
He/she introduces update when necessary

## Check priorities

Physics and coherence

English language

Rules of the DUNE documents

## Todo list

complete the sentence . . . . .	65
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# Instructions for the authors

- Insert the reference in the bibliography (bibitex format)
- Check if some word is present in the glossary and use it
- Insert new words in the glossary
- Check the reference to equations, figures, tables
- Write your name in the text %% author ?
- Take into account the DUNE editing rules

<https://dune.bnl.gov/docs/guidance.pdf>

# Final remarks

- ❖ TDR status
  - 352 pages / 68 tables / 285 figures
  - 2 sections to be checked
  - 2 sections to be updated
  - 6 sections to be completed
  - 6 sections in progress
- ❖ Main part of data are available, it's just a matter of writing
- ❖ Criticality
  - Tracker system
  - DAQ / DCS
- ❖ Complete SAND-TDR is expected within February 2025
- ❖ First draft (in DUNE-docdb) is expected within 2024. Two possible choices:
  1. delay the publication of two months
  2. publish only the completed sections

# Backup slides

# SAND: Design Milestones

SYSTEM	DECISION	Date
SAND	GRAIN inner cryostat material	2024
SAND	Tracker technology	2025 Q3
SAND	ECAL readout	2025 Q1
SAND	GRAIN outer vessel material	2025 Q4
SAND	GRAIN readout configuration	2025 Q4

H. A. Tanaka  
Neutrino Scope Group  
23 October 2024

- SAND is on the path to preliminary design.
  - A few major decisions (Tracker, GRAIN readout configuration) remain pending prototyping results
- Some elements (Magnet, ECAL) are built and undergoing refurbishment
  - Close coordination is needed to ensure smooth compliance and testing process at FNAL.

## RECENT AND UPCOMING REVIEWS

SYSTEM	Review	Date
SAND	KLOE-2-SAND Preliminary Design Review	2024 Q2
ND-LAr Cryostat	Preliminary Design Review	2024 Q3
TMS	Preliminary Design review	2025 Q1
PRISM	Preliminary Design review	2025 Q1
ND-LAr	Final Design Reviews start	2025 Q1
ND-LAr/TMS	ND Director's Review and IPR status review	2025 Q2
SAND	GRAIN readout configuration	2025 Q4

**Hiro Tanaka, September 9, 2024  
Collaboration Meeting**

	Chapter Draft	Design Review	Ready for LBNC
Intro/Physics	Jun 24	N/A	<b>Jul 24</b>
ND-LAr (final)	Nov 24	Dec 24	<b>Feb 25</b>
TMS	Nov 24	Jan 25	<b>Feb 25</b>
SAND*	Jun 24-Feb 25	Jul 24-Mar 25	<b>Apr 25</b>
ND-LAr Cryostat	Jun 24	Jul 24	<b>Aug 24</b>
NS LAr Cryogenics	Jun 24	N/A	<b>Aug 24</b>
DUNE-PRISM	Nov 24	Dec 24	<b>Jan 25</b>
ND DAQ	Nov 24	Jan 25	<b>Feb 25</b>
ND Slow Control			<b>Feb 25</b>
ND I&I	Nov 24	Dec 24	<b>Jan 25</b>

\* SAND will divide process into KLOE-2-SAND, Tracker, GRAIN, Integration



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# Glossary

 my\_glossary.tex

**Insert new DUNE words and new DUNE abbreviations  
at the end of this file**

**Check if the word is already present**

To define a DUNE term that has no abbreviation use:

```
\newduneword{label}{term}{description}
```

To define a DUNE term with an abbreviation use:

```
\newduneabbrev{label}{abbrev}{term}{description}
```

## Examples

```
\newduneword{detmodule}{detector module}{The entire DUNE far detector is segmented into four modules, each with a nominal  $\text{SI}_{10}$  fiducial mass}
```

```
\newduneabbrev{adc}{ADC}{Analog Digital Converter}{A sampling of a voltage resulting in a discrete integer count corresponding in some way to the input}
```

# Bibliography

 my\_citedb.bib

**Insert references (bibtex format) at the end of this file**

**Check if the reference is already present**





## DUNE Words from the [glossary](#)

`\dfirst{fnal}`      first time      Fermi National Accelerator Laboratory (Fermilab)

`\dword{fnal}`      following times      Fermilab

### More informations in the glossary

**Fermi National Accelerator Laboratory (Fermilab)** U.S. national laboratory in Batavia, IL. It is the laboratory that hosts Deep Underground Neutrino Experiment (DUNE) and serves as its near site. [1](#)

`\dfirst{nd}`      near detector (ND)      *with link*

`\dword{nd}`      ND      *with link*

`\dlong{nd}`      near detector      *w/o link*

`\dshort{nd}`      ND      *w/o link*

`\dword`      singular      `\dwords`      lower case & plural

`\Dword`      capital      `\Dwords`      capital & plural



`common/units.tex` to define commands for units

Examples

“m” is written `\si{\meter}`

**bare units**

“V” is written `\si{\volt}`.

“123.456” is written as `\num{123.456}`.

**bare numbers**

“ $1 \pm 2i$ ” is written as `\num{1+-2i}`.

“ $3 \times 10^{45}$ ” is written as `\num{3e45}`.

“ $0.3 \times 10^{45}$ ” is written as `\num{.3e45}`

“120 GeV” is written as `\SI{120}{\GeV}`,

**numbers and units**

“4850 ft” is written as `\SI{4850}{\ft}`,

# Figures

**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)

**Please, complete the plots with axis labels and measurement units**

# English

- Use American spelling: e.g., ionization (not ionisation), flavor (not flavour) and so on.
- In general, avoid use of first person (e.g., I, we, our). “We” may appear in introductory sections.
- Avoid use of second person, i.e., “you.”

## Many many rules/instructions in the writing of DUNE documents :

<https://github.com/DUNE/document-guidance/releases/>

Latex structure

<https://ctan.mirror.garr.it/mirrors/ctan/macros/latex/contrib/siunitx/siunitx.pdf>

units

<https://dune.bnl.gov/docs/technical-proposal/dune-words.pdf>

DUNE words

<https://ctan.mirror.garr.it/mirrors/ctan/macros/latex/contrib/glossaries/glossaries-user.pdf>

glossary

**An almost synthetic guidance (49 pages)**

<https://dune.bnl.gov/docs/guidance.pdf>

**Help by Anne Heavey, scientific editor at FNAL**



**Anne Heavey**

Scientific editor  
Fermilab, United States



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**Hiro Tanaka, September 9, 2024  
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ND DAQ	Nov 24	Jan 25	Feb 25
ND Slow Control			Feb 25
ND I&I	Nov 24	Dec 24	Jan 25

\* SAND will divide process into KLOE-2-SAND, Tracker, GRAIN, Integration

## More details for SAND

### Preliminary Design Review

	topics
✓ Jul 2024	ECAL + magnet
Nov 2024	I & I
Dec 2024/Jan 2025	GRAIN
Mar 2025	Tracker

### Review of TDR chapter draft

	reviewer
Jan 2025	SAND consortium
Feb 2025	DUNE collaboration
Mar 2025	LBNC