

# White Paper

- As Kazu mentioned, one of main goals of this workshop is to produce a white paper
- Title: White Paper on Machine Learning in Neutrino Physics
- Purpose: Community statement about future research directions
  - How can ML enable the physics we want to do over the next 10 years?
- We hope for this to be an input to the Snowmass process, both in the Neutrino and Computing Frontiers
- We need all of your help to make this happen!

# Structure

<b>1 Introduction</b>	<b>3</b>	<b>4 Machine Learning at Current Experiments</b>	<b>5</b>
1.1 Life-cycle of Experimental Neutrino Physics	3	4.1 ANNIE	5
<b>2 Survey of Machine Learning Tools</b>	<b>3</b>	4.2 COHERENT	5
2.1 Classical ML Techniques	3	4.3 NEXT	5
2.2 Modern ML Techniques	3	4.4 nEXO and EXO-200	5
<b>3 Challenges Requiring New Techniques</b>	<b>3</b>	4.5 DUNE	5
3.1 Design Optimization	4	4.6 Hyper-Kamiokande	6
3.2 Analysis Pipeline	4	4.7 IceCube	6
3.3 Operations and Control	4	4.8 KamLAND-Zen	6
3.4 Trigger	4	4.9 MicroBooNE	6
3.5 Uncertainty Quantification	4	4.10 SBN	6
3.6 Data Reconstruction	5	4.11 NOvA	6
3.6.1 Waveform	5	4.12 Project 8	6
3.6.2 Multi-modal detector signals	5	4.13 Theia	6
3.6.3 Geometrical and topological pattern recognition	5	4.14 Inter-Experimental Collaborations	6
3.6.4 Particle kinematics and type reconstruction	5	4.14.1 Distributed Computing	6
3.6.5 Particle flow reconstruction	5	4.14.2 DeepLearnPhysics	6
3.7 Physics Inference	5	4.14.3 Exa.TrkX	6
3.7.1 Neutrino signal identification	5	4.14.4 HXML	6
3.7.2 Oscillation parameters	5	4.14.5 DIDACTS	7
3.7.3 Neutrino-nuclear cross-section	5	<b>5 Conclusions</b>	<b>7</b>
3.8 Physics Modeling	5	<b>6 Acknowledgements</b>	<b>7</b>
3.8.1 Neutrino event generator	5	<b>References</b>	<b>7</b>
3.8.2 Detector simulation	5		

# What Do We Need?

- White paper is on overleaf
  - <https://www.overleaf.com/7722928115sggdrxvbfwbz>
- Your contributions are needed in the middle sections:
  - 2) Survey of Machine Learning Tools
    - Conveners: Nick Prouse and Taritree Wongjirad
  - 3) Challenges Requiring New Techniques
    - Conveners: Corey Adams and Patrick de Perio
  - 4) Machine Learning at Current Experiments
    - Conveners: Jianming Bian and Marco Del Tutto

# How To Get Involved

- If you are presenting a long talk, a slot has already been reserved for you in the section “Machine Learning at Current Experiments.”
  - Please add a short summary of the machine learning activities you showed in your presentation.
- If you are presenting a short talk, a convener may request you contribute to a specific section. Regardless, please look through the document and see if there is a natural place for you to contribute.
- If you are a participate, but not a presenter, we want you to contribute too! Contact a convener to let us know what your expertise is. Consider looking for any topics we left out that you could provide.

# Format Of Your Contribution

Discuss with the appropriate conveners the contribution you want to make – you can contact with DMs on Slack or through the channel #workshop-whitepaper

The image shows a LaTeX editor interface. On the left is a file explorer with a tree structure. The 'challenges.tex' file is highlighted in green. The main editor shows LaTeX code for a contribution, with a yellow circle around the `\paragraph{My Important Contribution - Adam Aurisano}` line. The rendered PDF on the right shows a list of items, with the contribution's title and text circled in yellow. Arrows point from the code editor to the rendered PDF.

```
29 \item Edge/Fast ML for sophisticated trigger logics
30 \end{itemize}
31
32 \subsection{Uncertainty Quantification}
33 \begin{itemize}
34 \item Machine learning model uncertainty
35 \item Physics model (distributional) uncertainty (e.g. data
36 v.s. simulation discrepancy)
37 \item Uncertainty propagation to physics output
38 \end{itemize}
39 \paragraph{My Important Contribution - Adam Aurisano}
40
41 Here is one or two paragraphs with my contribution.
42
43 \subsection{Data Reconstruction}
44
45 \subsubsection{Waveform}
46
47 \subsubsection{Multi-modal detector signals}
48
49 \subsubsection{Geometrical and topological pattern recognition}
50
51 \subsubsection{Particle kinematics and type reconstruction}
52
53 \subsubsection{Particle flow reconstruction}
54
55
```

- Edge/Fast ML for sophisticated trigger logics

### 3.5 Uncertainty Quantification

- Machine learning model uncertainty
- Physics model (distributional) uncertainty (e.g. data v.s. simulation discrepancy)
- Uncertainty propagation to physics output

**My Important Contribution - Adam Aurisano** Here is one or two paragraphs with my contribution.

Neutrino Physics and Machine Learning White Paper

Find the file corresponding to the section you are contributing to

Add your contribution as `\paragraph` – include a title of the topic you are covering. This is the only way we can know who the authors of the paper are!

# Adding Images

```
6  
7 \begin{figure*}[t]  
8 \centering  
9 \includegraphics[width=0.98\textwidth]{graphics/ExperimentalWork  
flow.png}  
10 \caption{A workflow in a life cycle of experimental physics}  
11 \label{fig:lifecycle}  
12 \end{figure*  
13  
14  
15  
16  
17  
18  
19
```

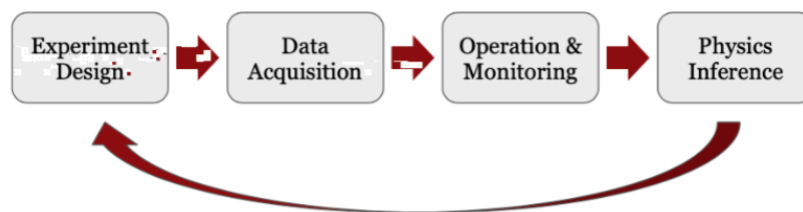
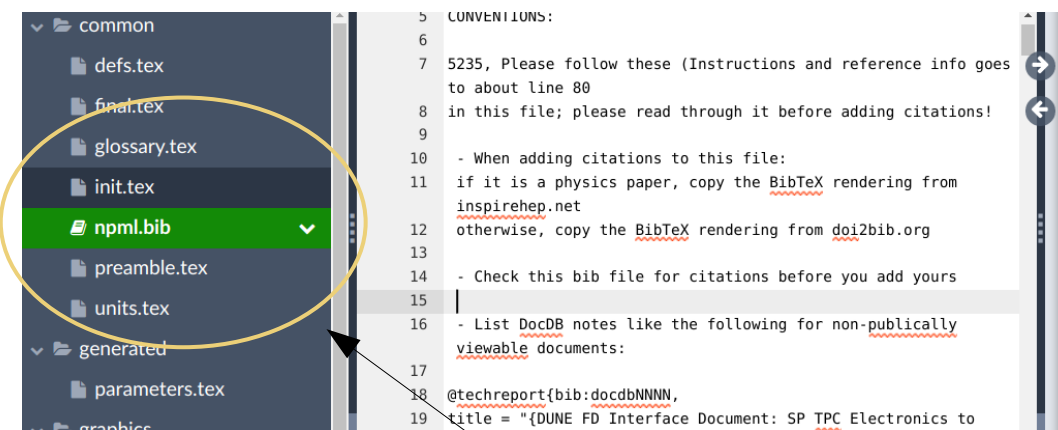


Figure 1: A workflow in a life cycle of experimental physics

## Preamble

# Adding References

All references should be in BibTeX format.  
For physics papers, copy format from [inspirehep.net](http://inspirehep.net)  
For all other papers, copy format from [doi2bib.org](http://doi2bib.org)



The authors also would like to thank the following colleagues who have endorsed this paper while they are not authors: *other endorsers*.

## References

- [1] "Study of Hadron Production in Hadron-Nucleus and Nucleus-Nucleus Collisions at the CERN SPS; CERN-SPSC-2006-034," 2006. <http://cds.cern.ch/record/995681?ln=en>.

Add all references to the common bib file

# Final Word

- This will only work if everyone is invested in this process
- The most important thing is to get the raw material down quickly
  - Don't be concerned with word-smithing now – there will be an editing process going forward
- On the last day, I will go over the status of the white paper, and we will discuss timelines for turning it into a finished product
  - Ideally most of the raw material will be in the overleaf within ~1 week after the end of the workshop
- Please start contributing today – as speakers finish talks, turn your attention to putting material in the document