DUNE activities in Edinburgh

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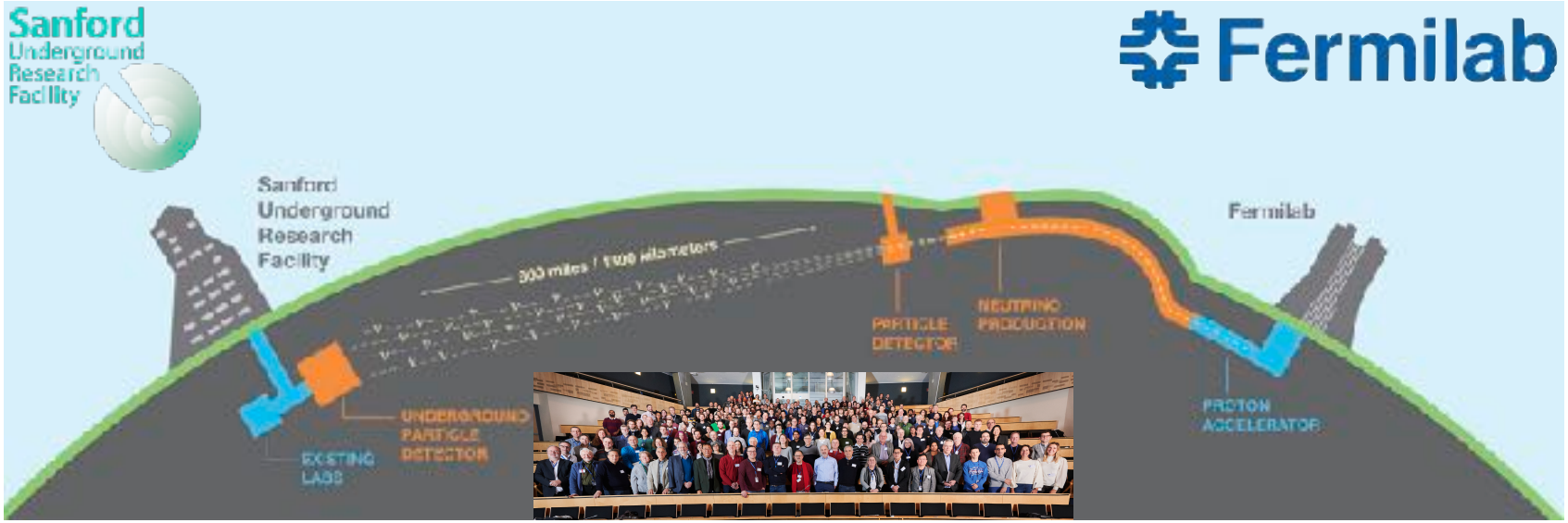
DUNE

Deep Underground Neutrino Experiment

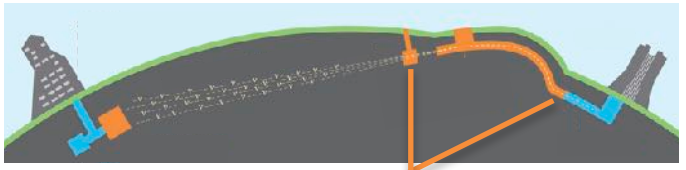
- 1300 km baseline.
- Neutrino source (PIP-II / LBNF)
- Near detector complex, LAr component.
- Large (70 kt) LArTPC far detector 1.5 km underground.

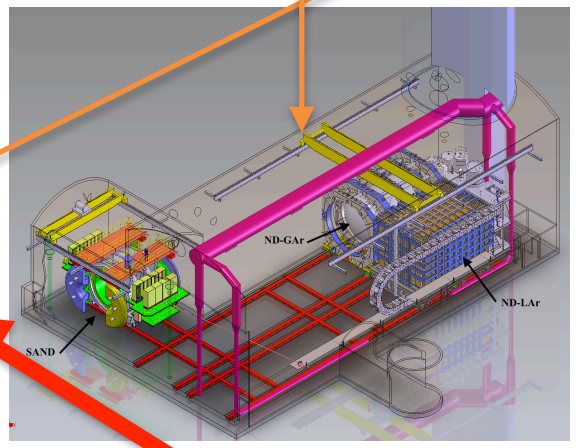
- Observe $\nu_\mu/\bar{\nu}_\mu$ disappearance and $\nu_e/\bar{\nu}_e$ appearance to measure:
  - Neutrino mixing parameters (θ_{23} , θ_{13})
  - CP-violation (δ_{CP})
  - Ordering of ν masses.
- Supernova burst neutrinos.
- BSM processes (baryon number violation, NSI, etc.)



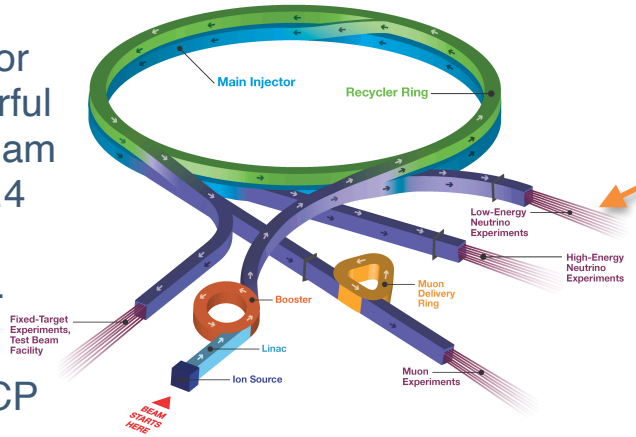
1157 collaborators from 197 institutions in 33 countries (CERN)

Neutrino Source & Near Detector





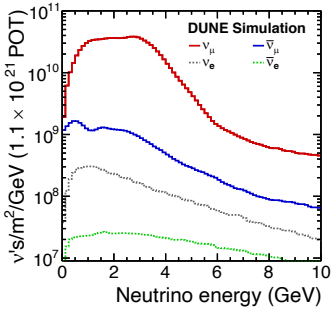
- Fermilab's Main Injector accelerator as a powerful 80-120 GeV proton beam (1.2 MW upgrade to 2.4 MW) to make highest energy neutrino beam.
- Neutrino beam line designed to optimize CP violation sensitivity.
- Neutrino (FHC) and antineutrino (RHC) modes.



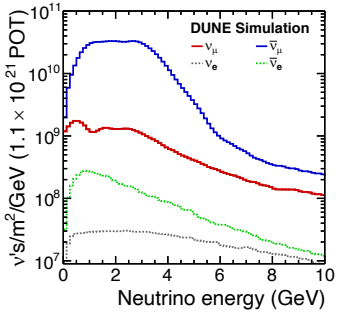
ν

- Located ~574 m from neutrino beam target.
- Primary purpose is to constrain systematic uncertainty for the long-baseline oscillation analysis and predict beam composition at FD.

Neutrino Mode:

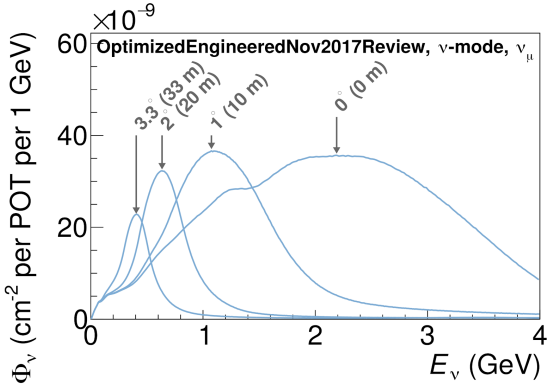


Antineutrino Mode:



LBNF off-axis flux:

- DUNE-PRISM (Precision Reaction-Independent Spectrum Measurement)



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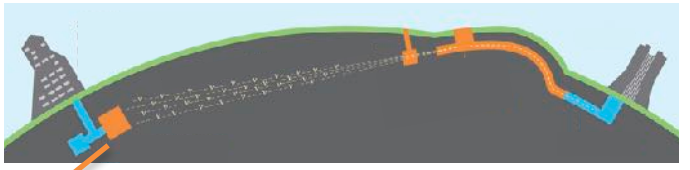
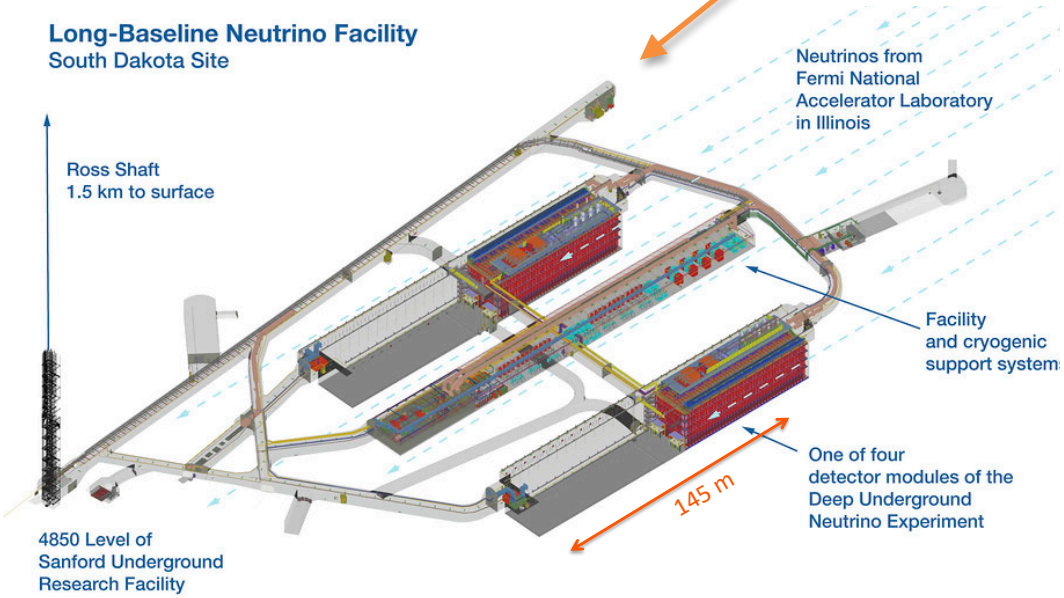
Far Detector

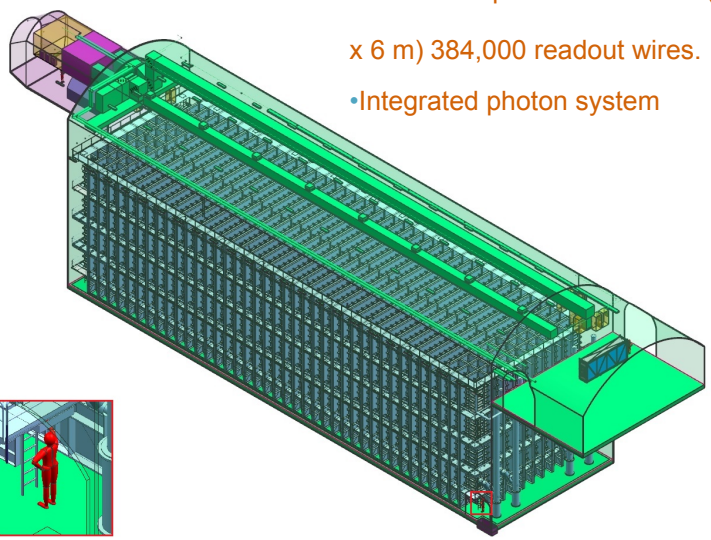


- 40-kt (fiducial) liquid argon TPC at 4850L of SURF with integrated photon detection.
- Four 17kt (~10-kt fiducial) modules LArTPCs installed (on-axis)
- 1475 meters underground at the Sanford Underground Research Facility in Lead, South Dakota.
- Modules will not be identical.



Single-phase:

- 16 m high x 19m wide x 66 m long.
- 150 anode plane assemblies (2.3 m x 6 m) 384,000 readout wires.
- Integrated photon system

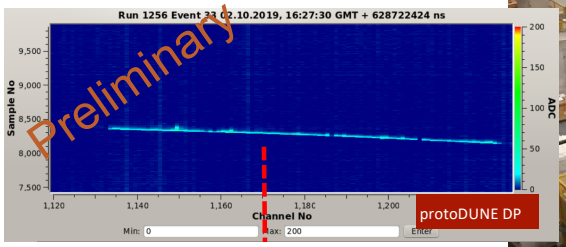


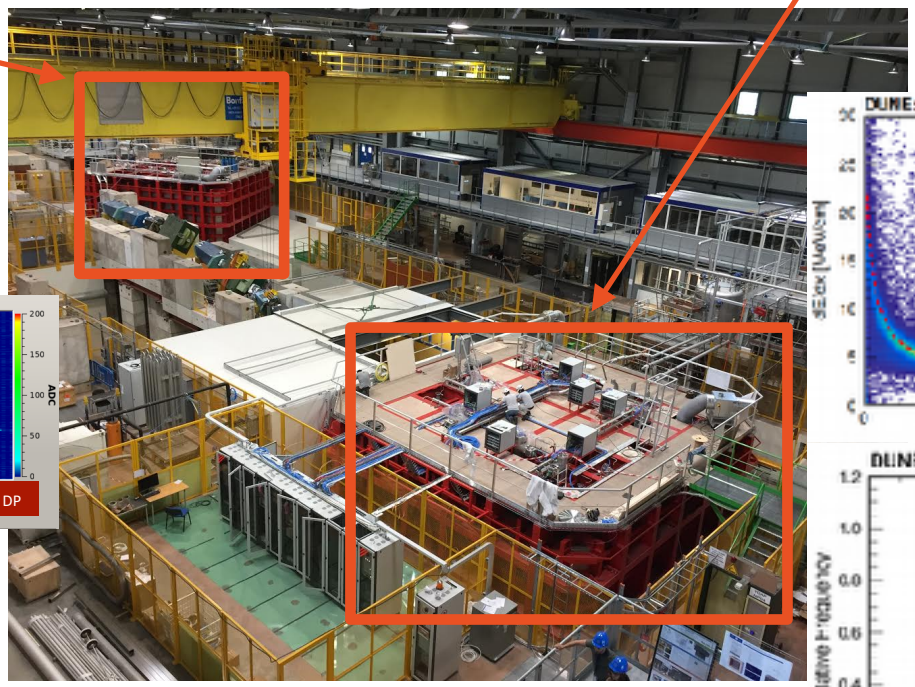
protoDUNEs @

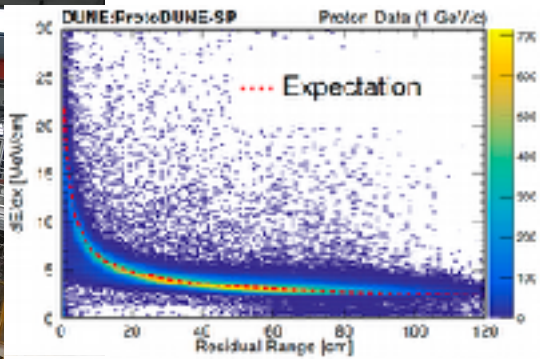
- Prototype technology for charged test beam at CERN's neutrino platform.

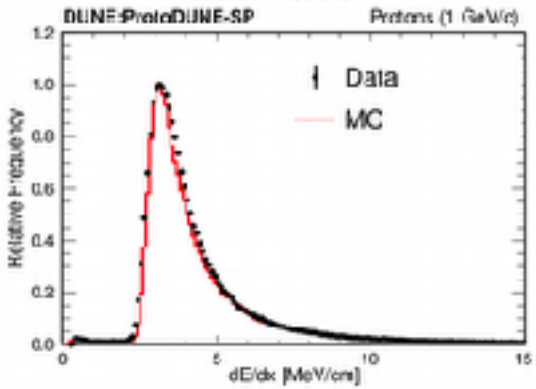
ProtoDUNE-DP

ProtoDUNE-SP









- protoDUNEs - II after LS2.
- Other technology prototyping

First results on ProtoDUNE-SP LArTPC performance from a beam test at the CERN Neutrino Platform
https://arxiv.org/abs/2007.06722

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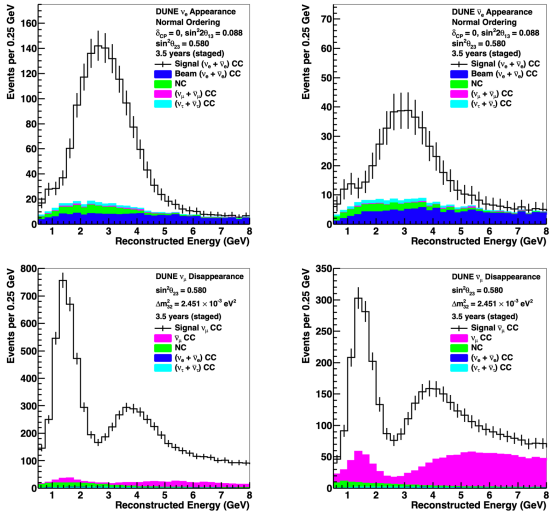
Physics program

- LBL oscillation analysis (including CP-violation and mass ordering):
  - •Three-flavor long-baseline neutrino oscillation
  - •Precise measurement of all parameters governing long-baseline oscillation in a single experiment: θ_{23} , θ_{13} , Δm^2_{32} , δ_{CP}
  - •Definitive measurement of neutrino mass ordering
  - •Discovery potential for CP violation for wide range of δ_{CP} values
  - •Significant potential for determination of θ_{23} octant

- Supernova Neutrino Burst and solar neutrinos:
  - •Large sample of neutrinos for SNB in our galaxy (especially ν_e)
  - •Measure flavor content, spectra, time evolution of SNB neutrinos
  - •Quantitative measurements of SNB evolution, particle physics parameters
  - •Early detection and pointing for multi-messenger astrophysics

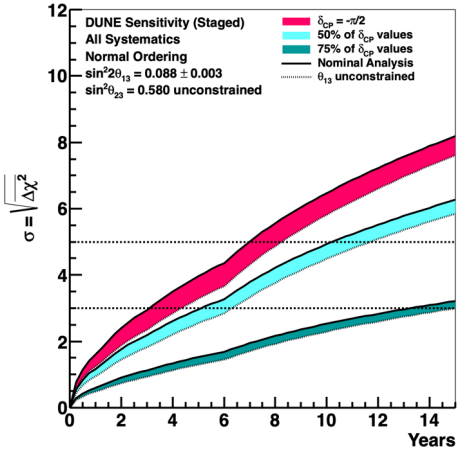
- BSM program:
  - •Baryon number violating processes, sterile neutrinos, non-unitarity of PMNS matrix, non-standard interactions, CPT violation, neutrino trident production, dark matter detection, ….

Neutrino Mode

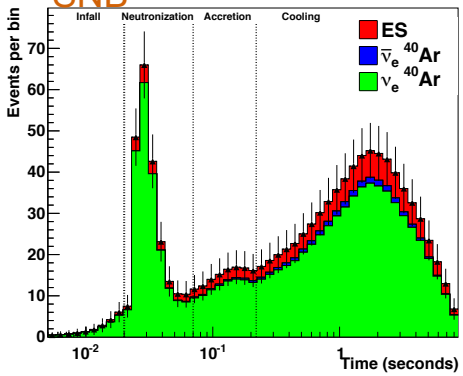


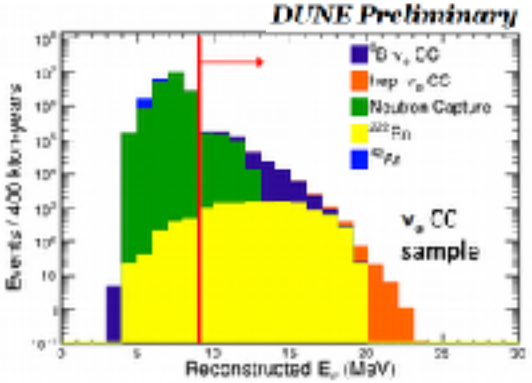
Antineutrino Mode

CPV Sensitivity Over Time



SNB





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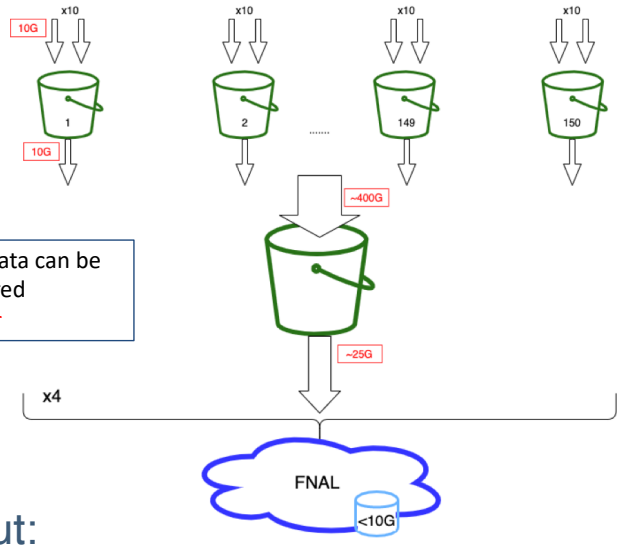
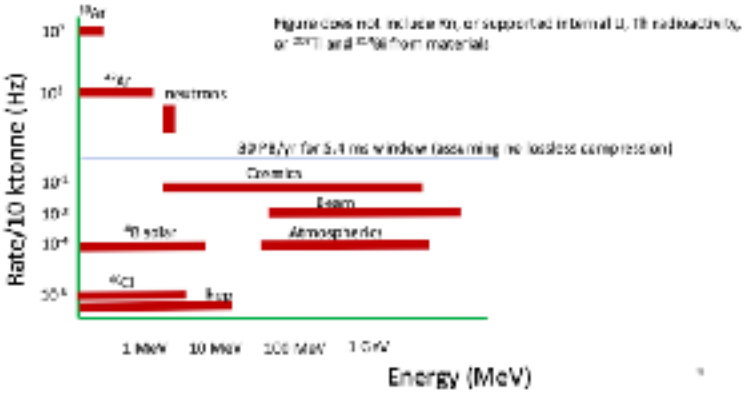
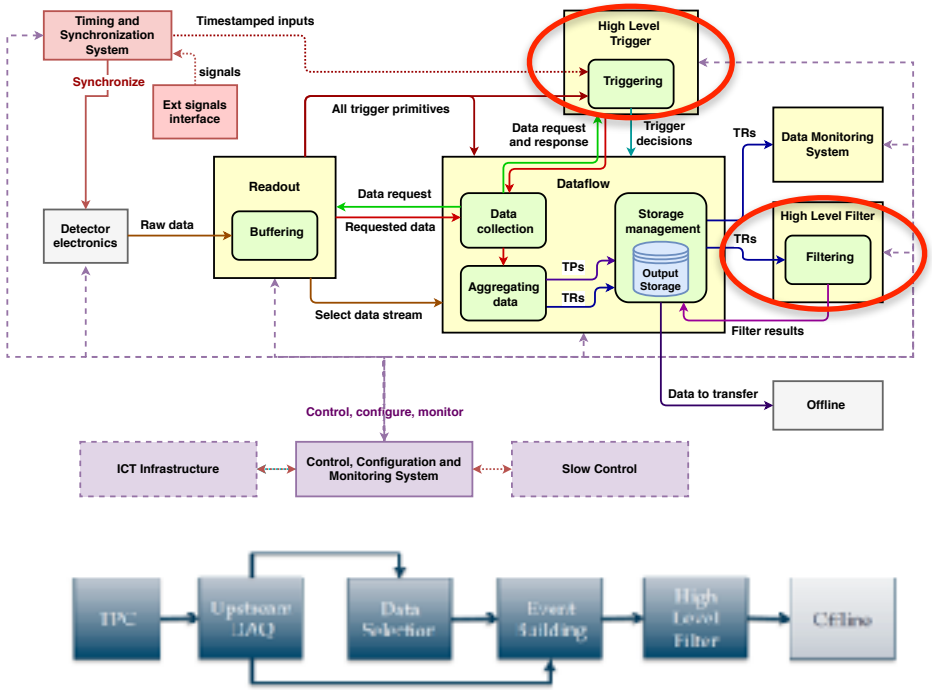
DUNE-EDI: DAQ

<2.5% of the data can leave the readout units
-> trigger

<0.015% of the data can be permanently stored
-> high level filter



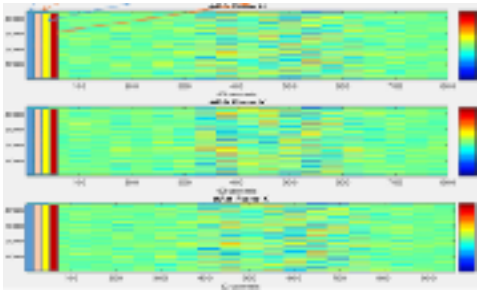


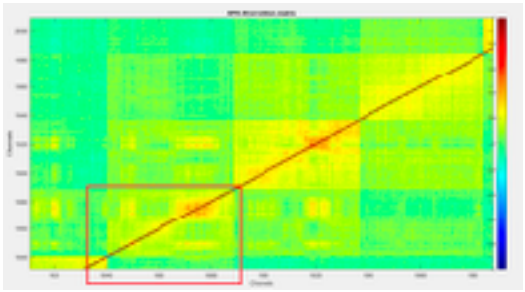


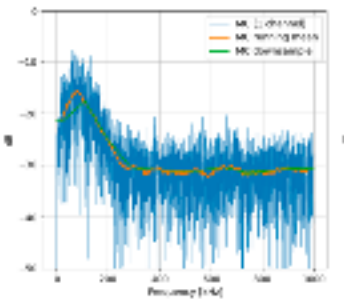
- Readout:
  - TPC channels sampled/digitized at ~2MHz: complete data volume sent to DAQ (~1.5 TB/s)
  - Photon detectors sampled at 62.5 MHz: when signal above threshold is detected a waveform of few μs is sent to DAQ (expected ~50-100 GB/s)
- Max storage:
  - All of DUNE FD has a budget of 30 PB/y: the DAQ thus needs to reduce data by >10^4

DUNE-EDI: DAQ

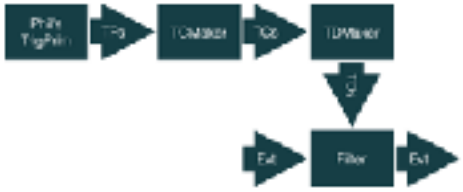
- Detector readout simulation including realistic waveforms and noise
- Automated reconstruction: signal processing and hit finding, clustering algorithms, energy reconstruction



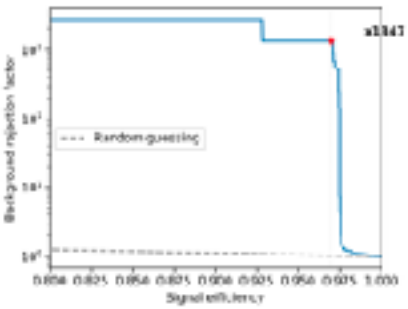




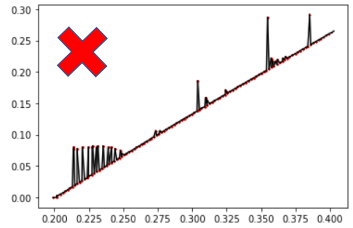
- DAQ appfmwk: Trigger
- Data selection:HLT

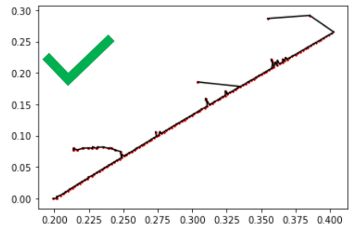


CNN



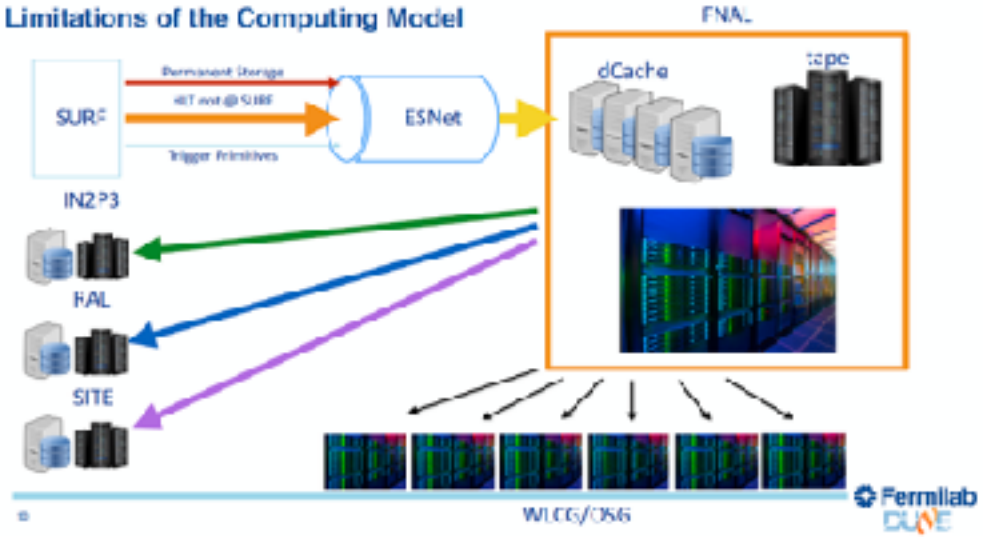
GNN





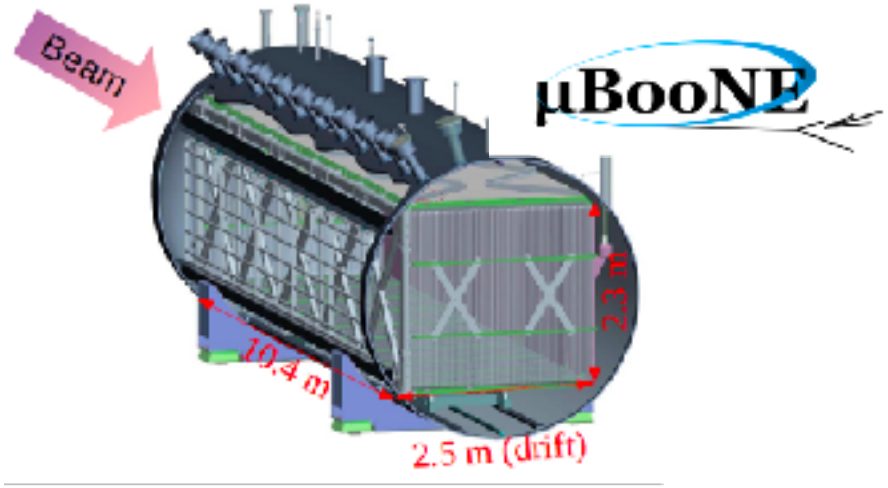
DUNE-EDI: Computing

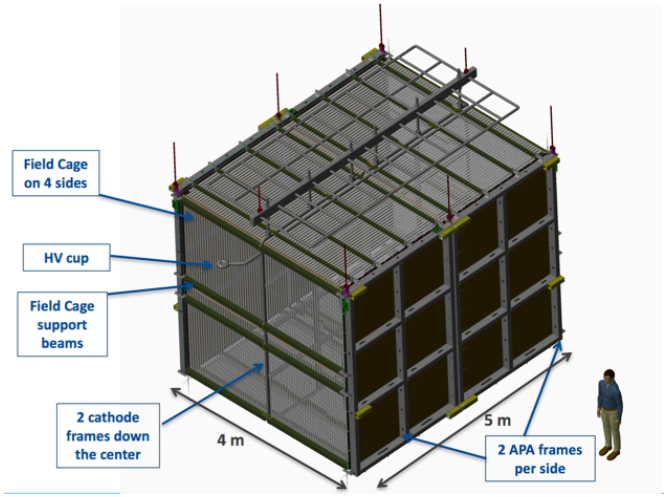
- Computing Resources
- Data management
- Data model-computing model
- Metadata

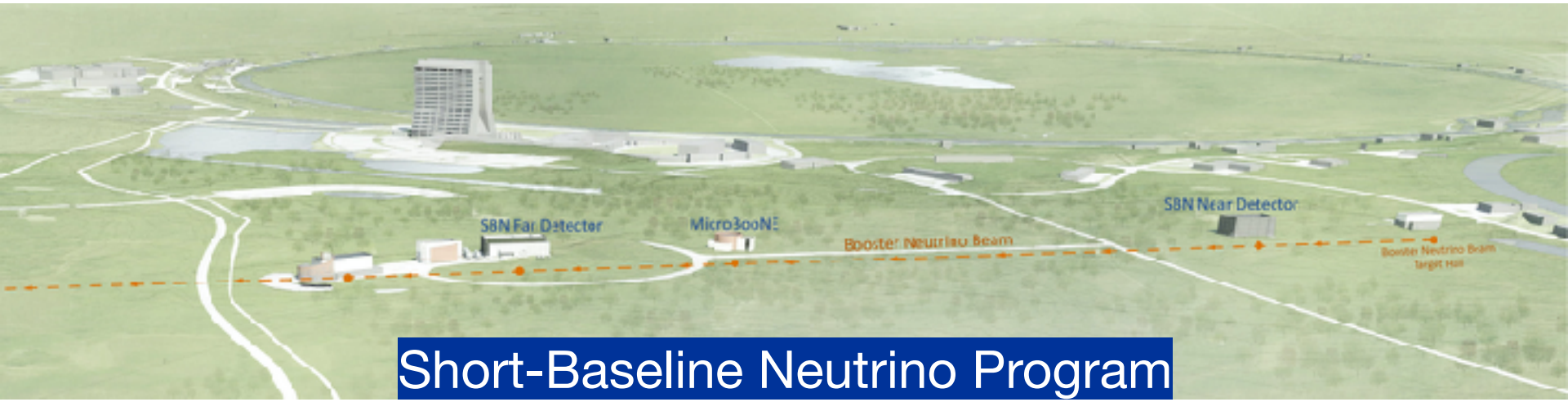


DUNE-EDI: expanding LArTPC activities

New involvement in microBooNE and SBND





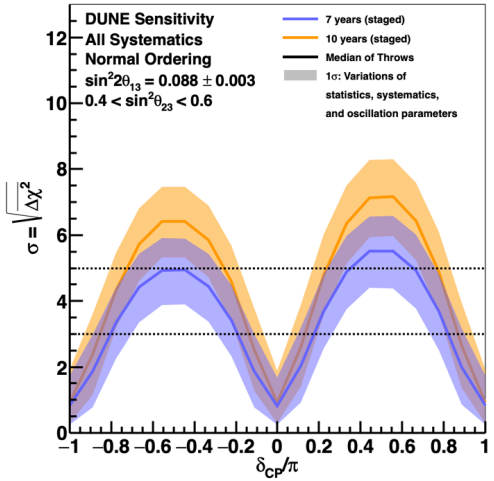


Short-Baseline Neutrino Program

Thanks!

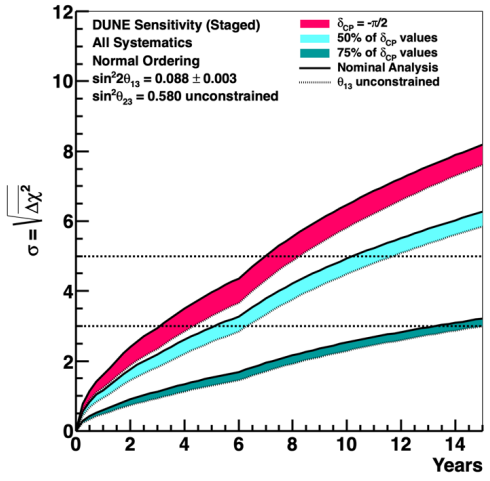
LBL oscillation analysis

CP Violation Sensitivity (True NO)

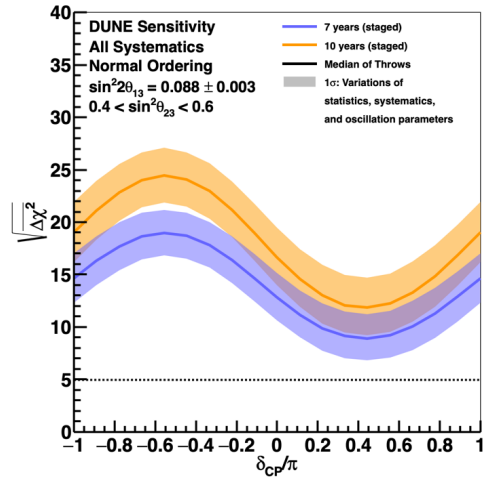


- CP violation discovery potential over wide range of true δ_{CP} values.
- CP violation discovery for 50% of true δ_{CP} values in ~10 years.

CPV Sensitivity Over Time



Mass Ordering Sensitivity (True NO)



- Definitive determination of neutrino mass ordering for all possible parameters.
- δ_{CP} precision of 10°-20° in ~10 years (staged)
  θ_{13} measurement comparable with reactor experiments after ~15 years (staged)

Precision δ_{CP} Measurement