DUNE: Physics program and timeline

Tingjun Yang

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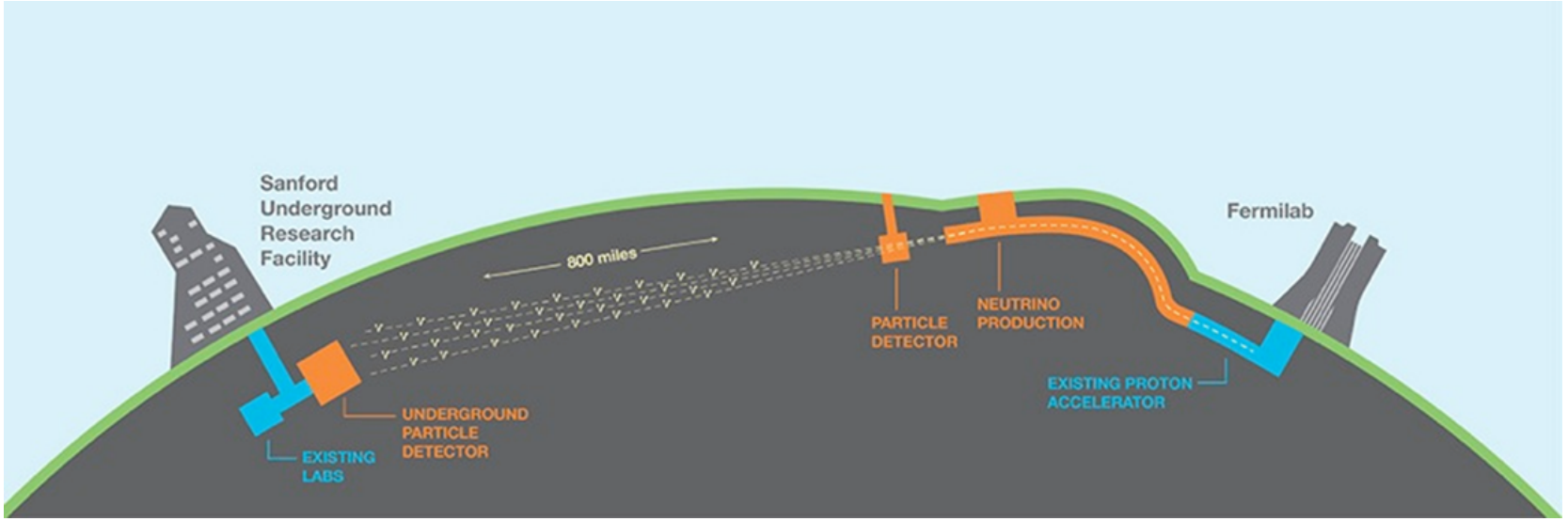
Neutrino Frontier Working Group

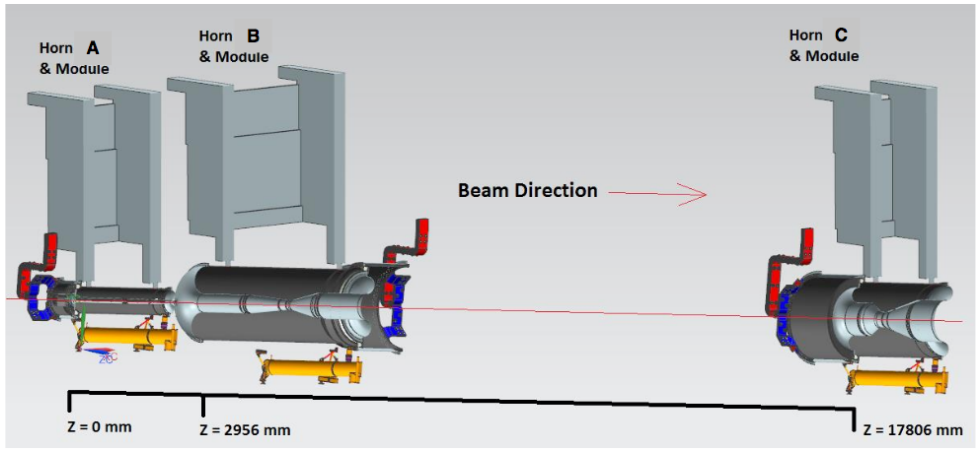
LBNF Facility and DUNE Experiment

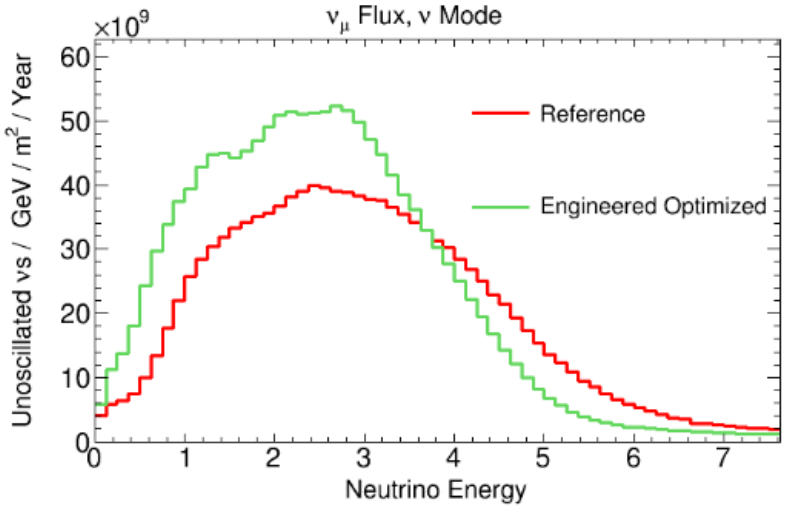
- **LBNF: DOE project with support from non-DOE partners.** Provides facility infrastructure at two locations:
  - **Near site:** Fermilab, Batavia, IL - facilities to create neutrino beam
  - **Far site:** Sanford Underground Research Facility, Lead, SD - facilities to support DUNE detectors
- **DUNE:** Deep Underground Neutrino Experiment - international collaboration
  - A next generation experiment for **neutrino science, nucleon decay, and supernova physics**.
  - Near and far site detectors



Long Baseline Neutrino Facility

- Horn-focused beamline similar to NuMI beamline
  - 60-120 GeV protons from Fermilab's Main Injector
  - 200 m decay pipe at -5.8° pitch, angled at South Dakota (SURF)
  - Initial power 1.1 MW, upgradable to 2.4 MW
- Optimization of target and horns to improve physics sensitivity.





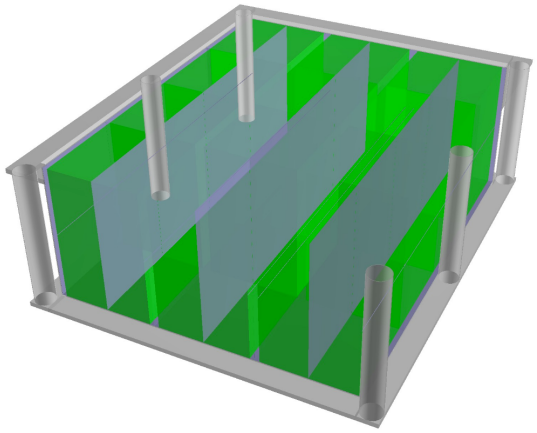
Near Detector

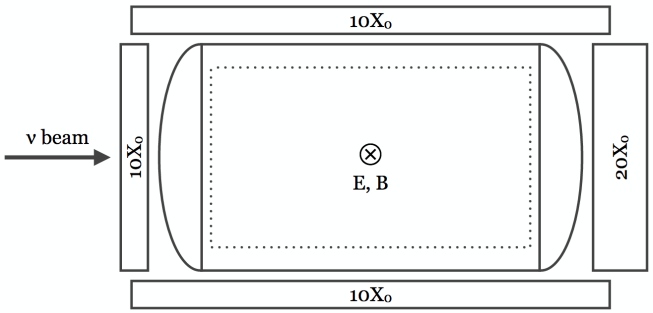
DUNE will have a Near Detector

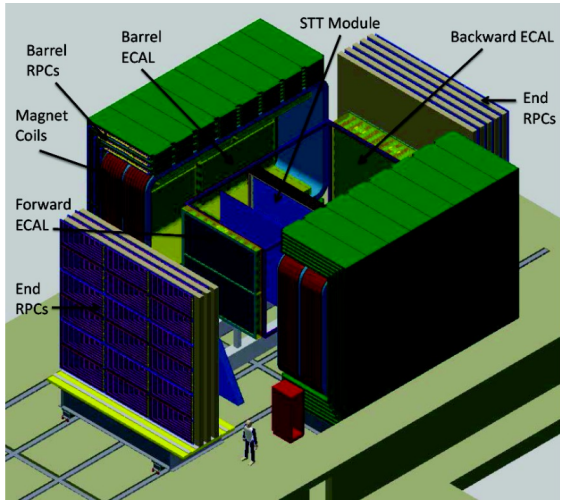
- Constrain **systematic uncertainties** in oscillation measurements
- Precisely measure initial **fluxes** of neutrinos in the beam
- Measure numerous neutrino-nucleus scattering **cross sections**

Multiple designs under consideration

- **LArTPC**, **high-pressure GAr TPC**, **fine-grained tracker**, hybrid designs
- Decision on conceptual design of ND will be made in late 2017

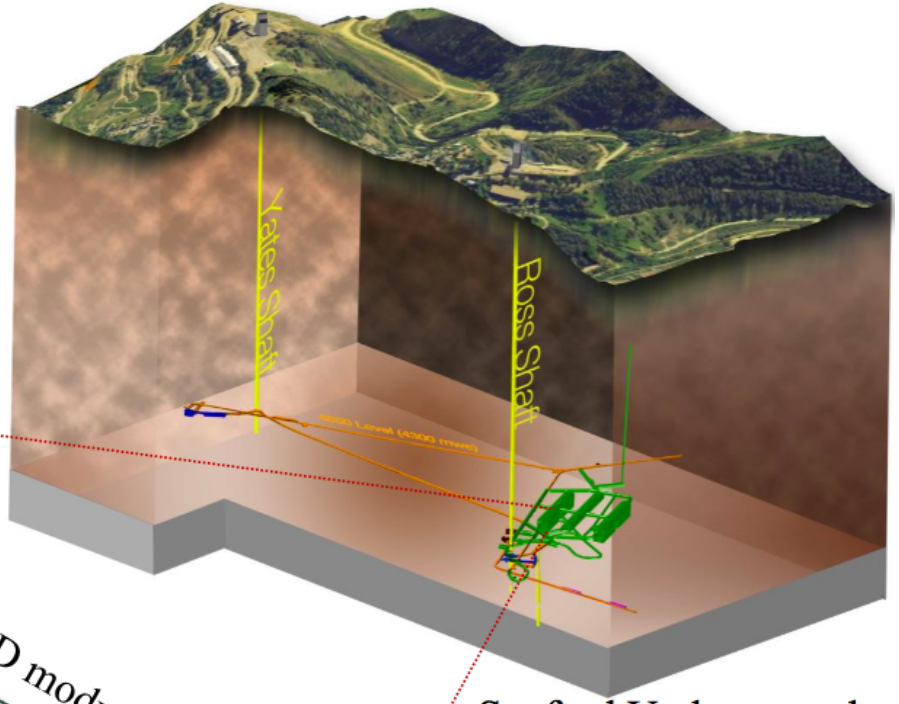




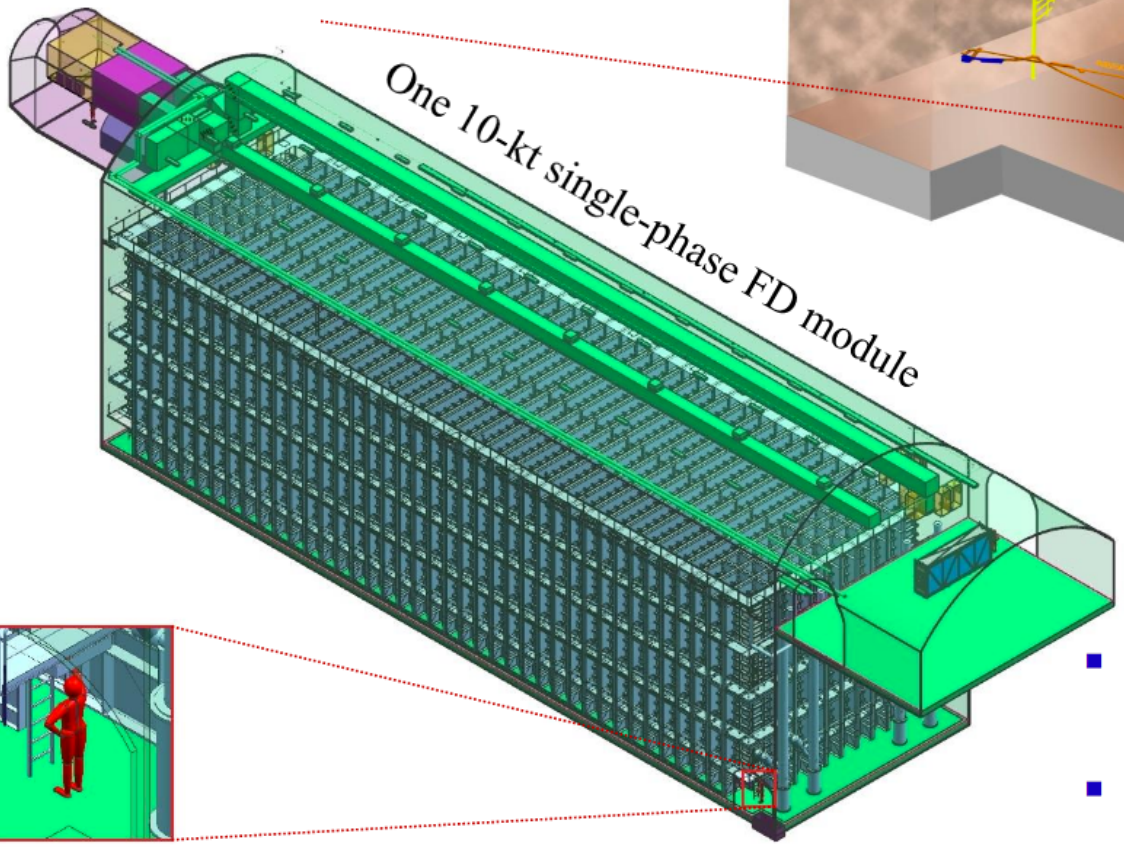


Far Detector

- **40-kt (fiducial)** LAr TPC
- Installed as four 10-kt modules at 4850' level of SURF



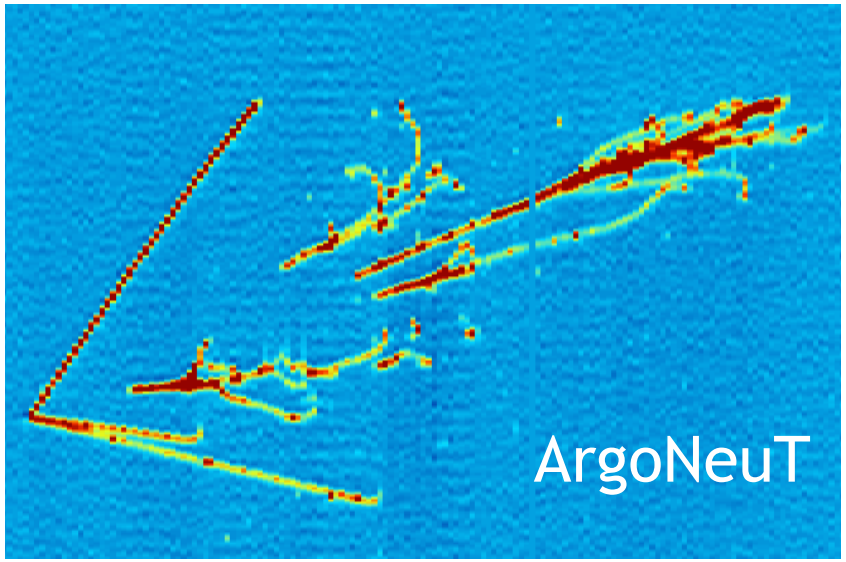
Sanford Underground Research Facility (SURF)

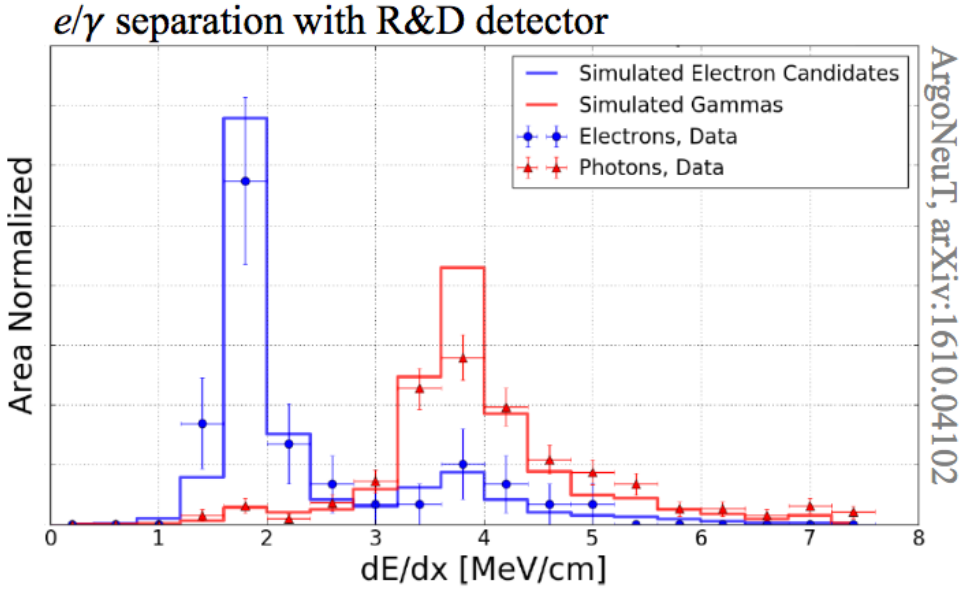


- First module will be a **single phase LAr TPC**
- Modules installed in stages. Not necessarily identical

Liquid Argon Time Projection Chamber - LArTPC

- Excellent spatial and energy resolution.
- High background rejection.
- Low energy threshold.
- Photon detectors provide trigger and t0 information.
- Need to maximize electronics signal/noise.
- Challenges in reconstruction.





Fermilab

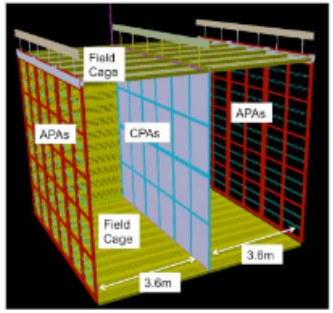
DUNE Far Detector Prototyping

Single-Phase

35-TON

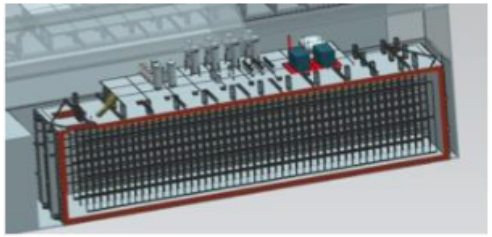
2016

ProtoDUNE-SP



2018

DUNE Reference Design



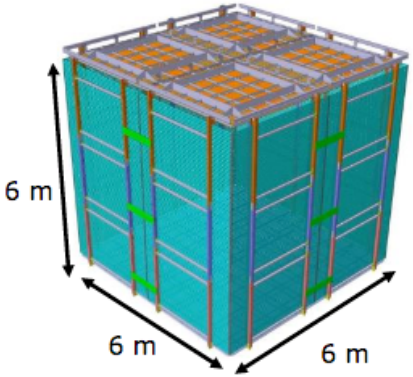
2024

Dual-Phase

WA105 (1x1x3 m^3)

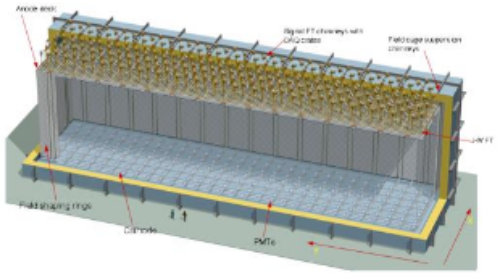
2017

ProtoDUNE-DP



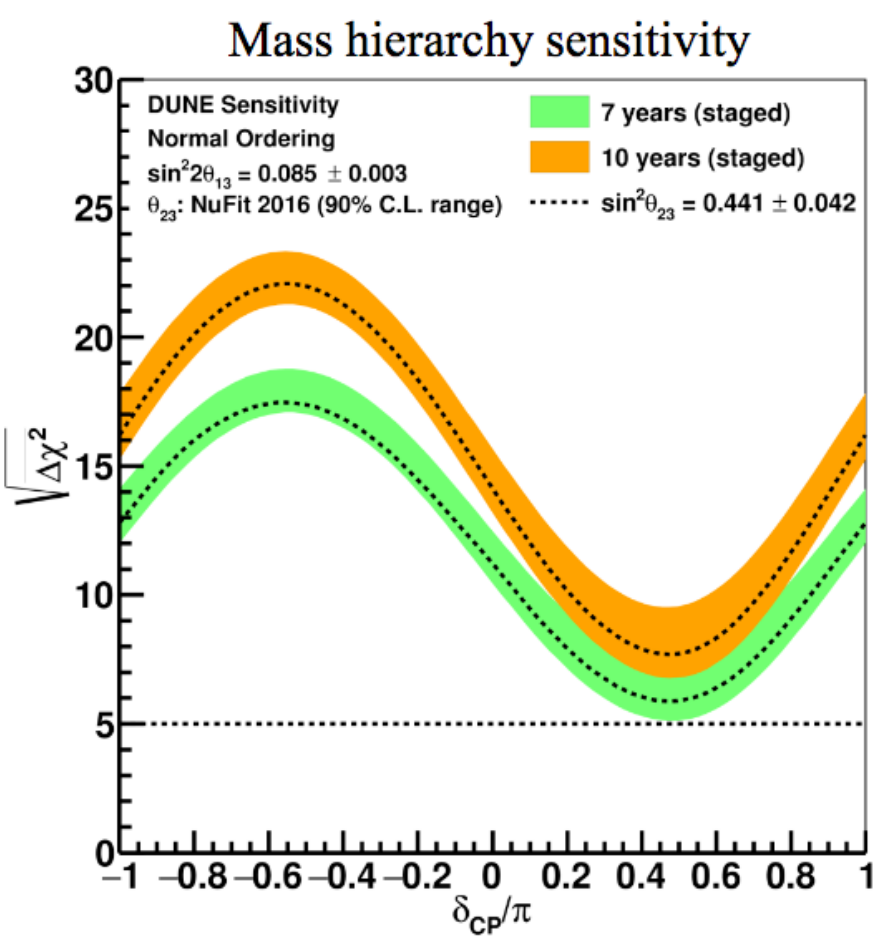
2018

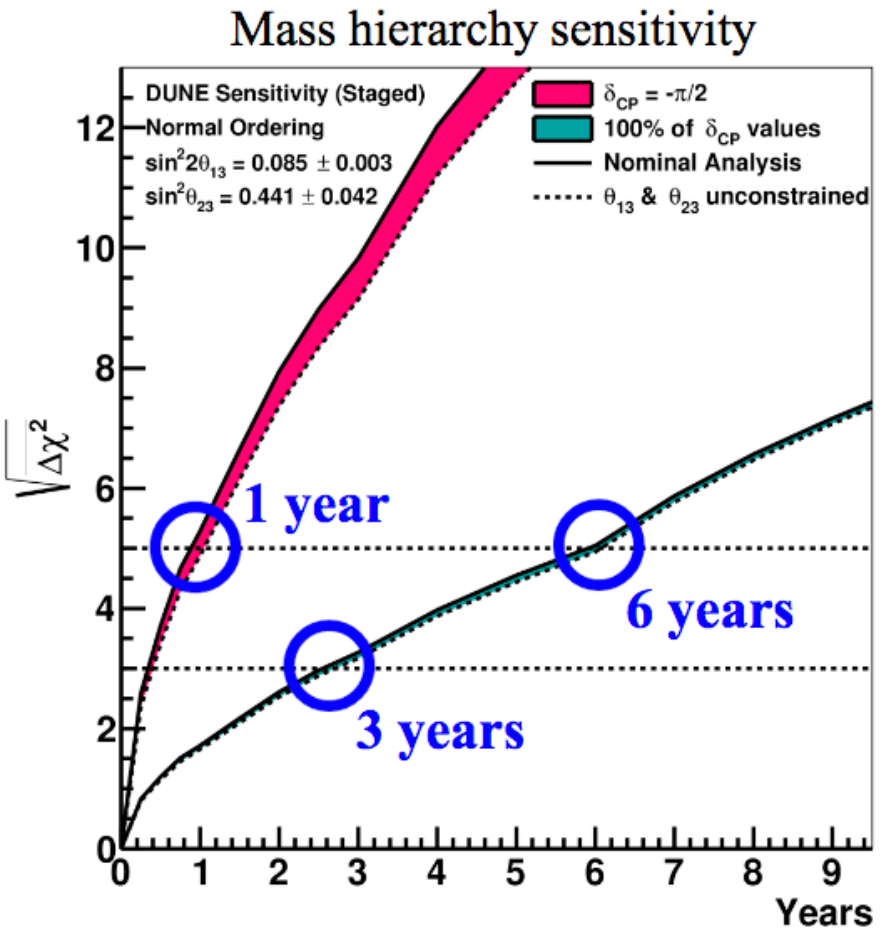
DUNE Alternative Design



Fermilab

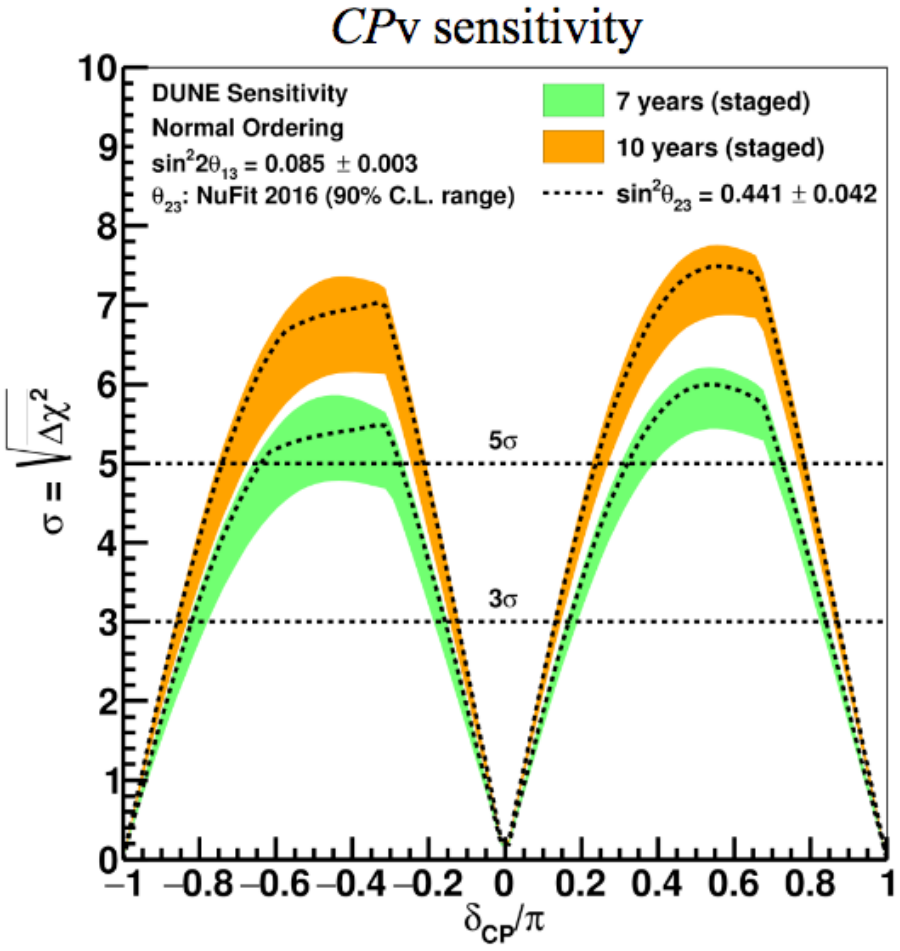
Mass Hierarchy Sensitivity

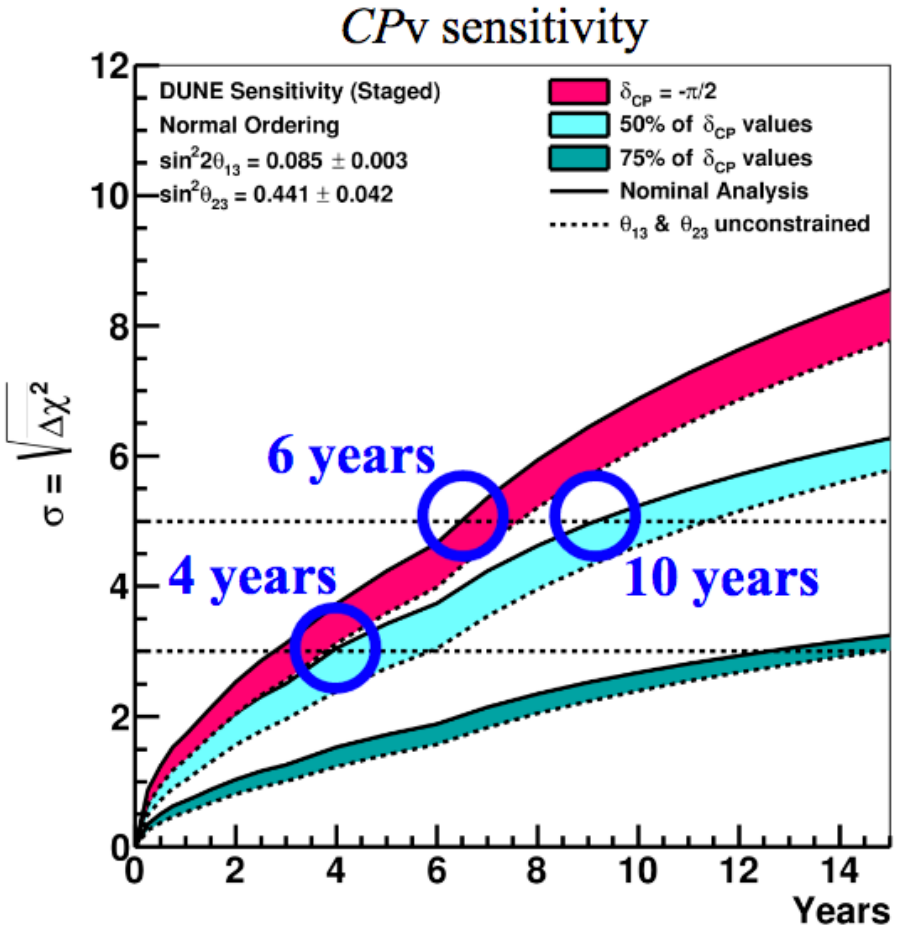




After 7 years: >5σ regardless of other parameter choices.

CP Violation Sensitivity



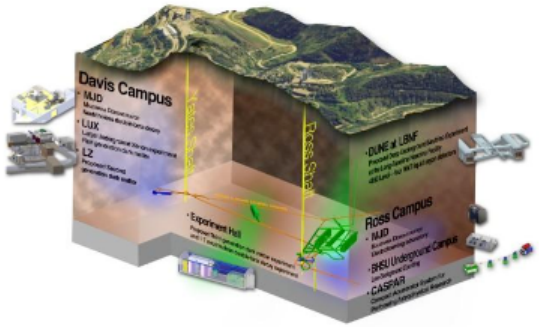


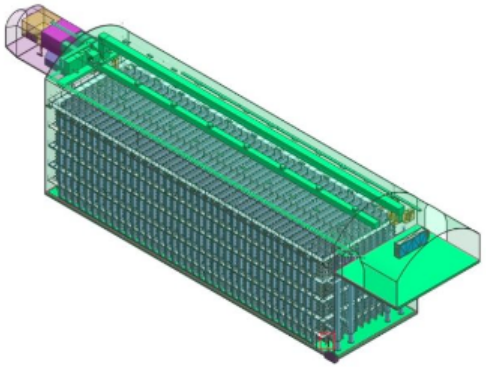
After 7 years: 5σ near δ=π/2, 3σ for 65% of δ range.

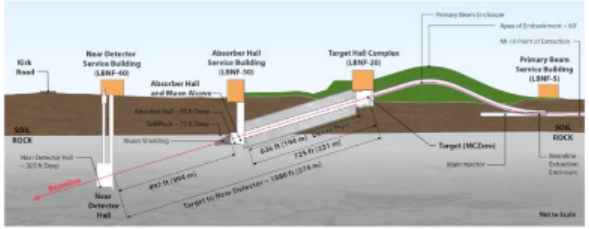
More of the physics program

- **Supernova neutrinos**
  - DUNE at 10 kpc: ~3000 ν_e events over 10 seconds
  - Potential for diffuse supernova discovery and ~20% rate measurement
- **Nucleon decay**
  - A general prediction of **grand unified theories.**
  - LArTPC technology particularly shines for complex *p* decay modes with **final state kaons**, as favored by SUSY GUTs.
  - DUNE is expected to improve existing limits by one order of magnitude with 40 kton detector after 20 years.
- **Light sterile neutrinos**
- **Non-standard interactions**
- **Dark matter and more…**
- Plus **millions of interactions** in the Near Detector for exploring ν-nucleus scattering: final state interactions, nuclear structure, MEC/2p2h channels, ...

DUNE Timeline







2017: Far Site Construction Begins

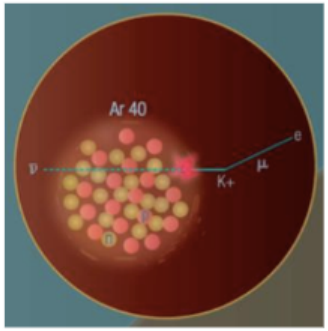
2018: ProtoDUNEs at CERN

2021: Far Detector Installation Begins

2024: Physics Data Begins (20 kt)

2026: Neutrino Beam Available

The CERN Neutrino Platform



40 kton + 2 MW beam to follow in subsequent years

A lot of materials from Ryan Patterson's Aspen talk.