SENSITIVITY TO LONG-BASELINE OSCILLATION PHYSICS

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for the DUNE Collaboration

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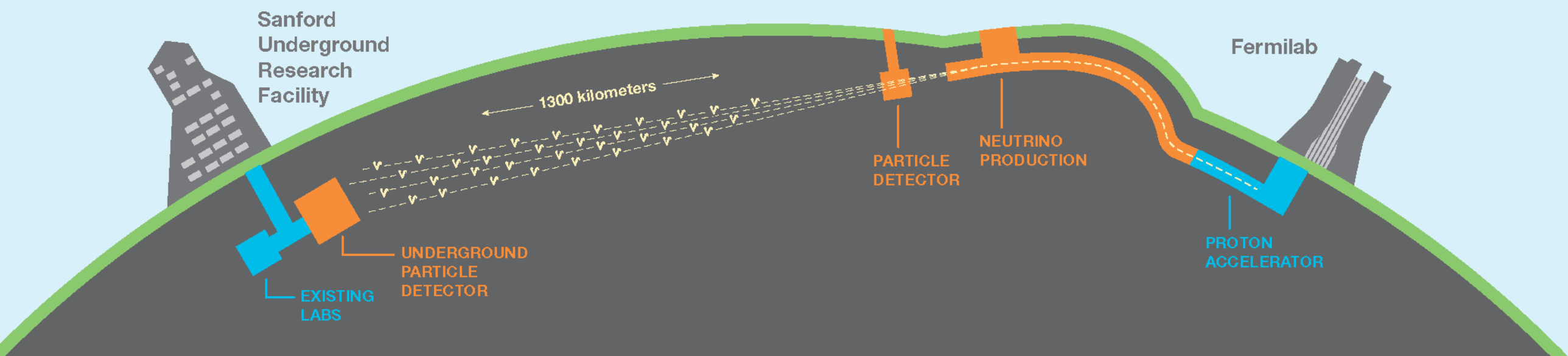
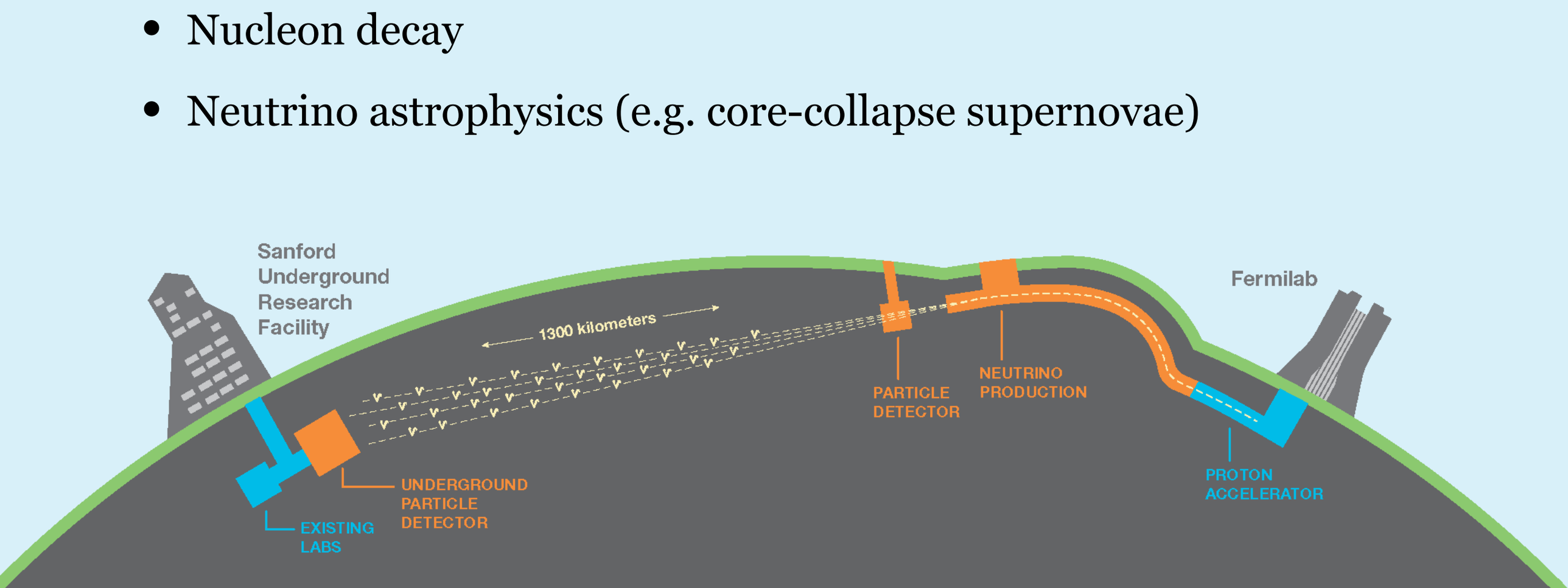
The *Deep Underground Neutrino Experiment* is a next-generation long-baseline oscillation experiment between Fermilab (Illinois) and the Sanford Underground Research Facility (South Dakota) consisting of

- a new MW-scale neutrino beamline (LBNF);
- a 4×10-kilotonne (fiducial) liquid argon far detector;
- a high-resolution, high-rate near detector.

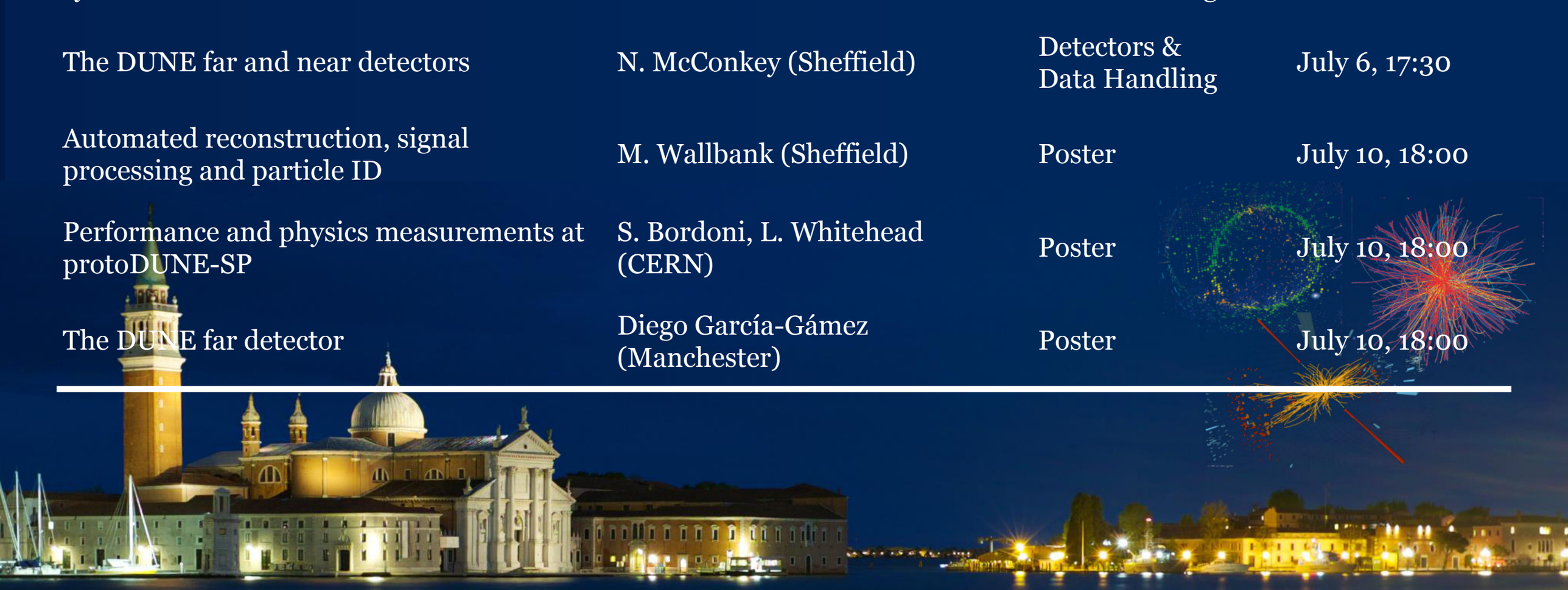


The primary science program of DUNE includes:

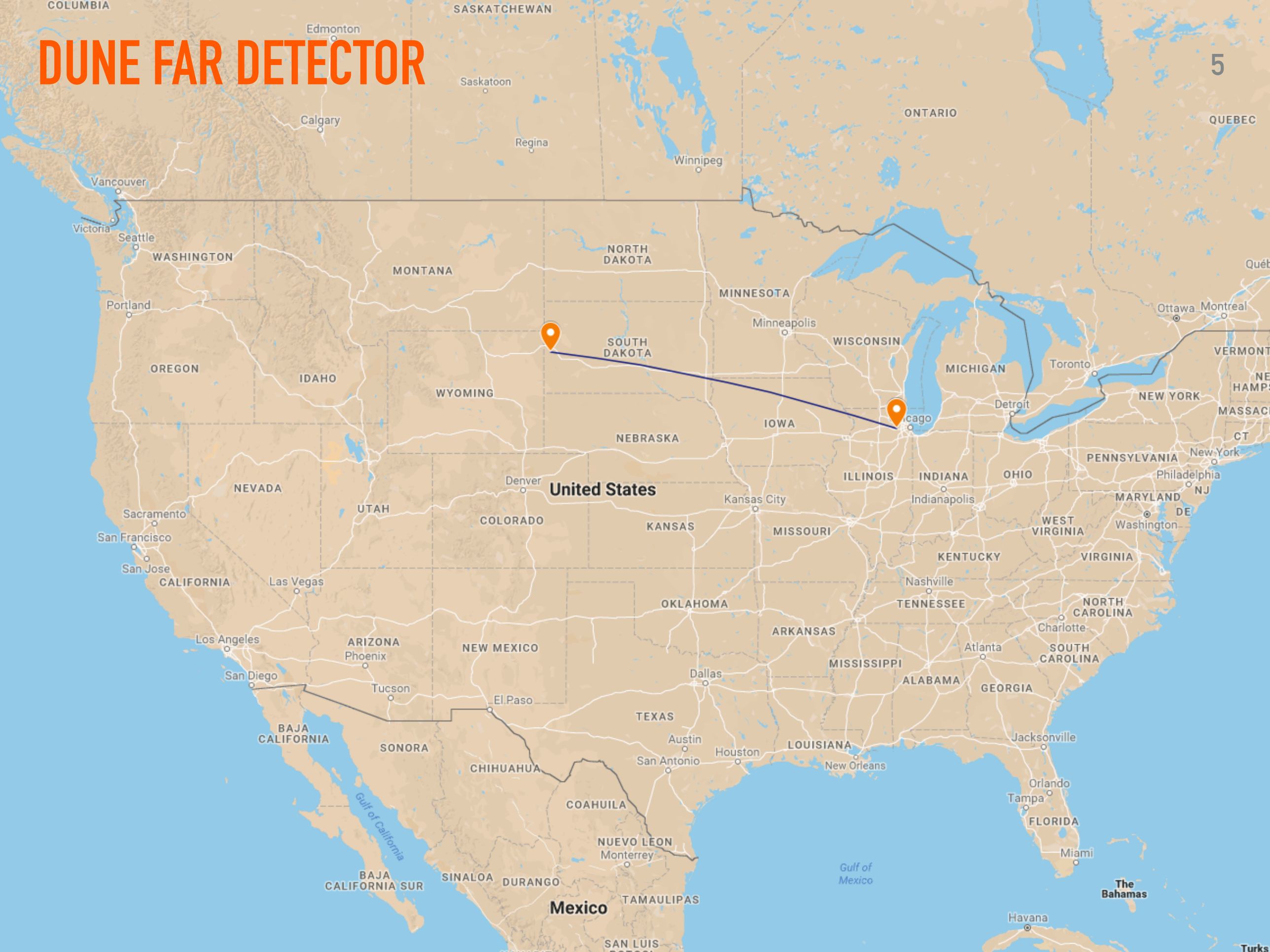
- Long-baseline neutrino oscillations
  - Leptonic CP violation
  - Neutrino mass ordering
  - Precision test of the 3-neutrino mixing framework
- Nucleon decay
- Neutrino astrophysics (e.g. core-collapse supernovae)



Title	Speaker	Session	Date and time
Astroparticle physics at the DUNE experiment	I. Gil Botella (CIEMAT)	Astroparticles	July 6, 14:30
Studying neutrino oscillations and searches for BSM physics with atmospheric neutrinos in DUNE	A. Higuera (Houston)	Neutrinos	July 6, 17:15
The ProtoDUNE-SP prompt processing system	M. Potekhin (BNL)	Detectors & Data Handling	July 6, 17:15
The DUNE far and near detectors	N. McConkey (Sheffield)	Detectors & Data Handling	July 6, 17:30
Automated reconstruction, signal processing and particle ID	M. Wallbank (Sheffield)	Poster	July 10, 18:00
Performance and physics measurements at protoDUNE-SP	S. Bordoni, L. Whitehead (CERN)	Poster	July 10, 18:00
The DUNE far detector	Diego García-Gámez (Manchester)	Poster	July 10, 18:00



DUNE FAR DETECTOR



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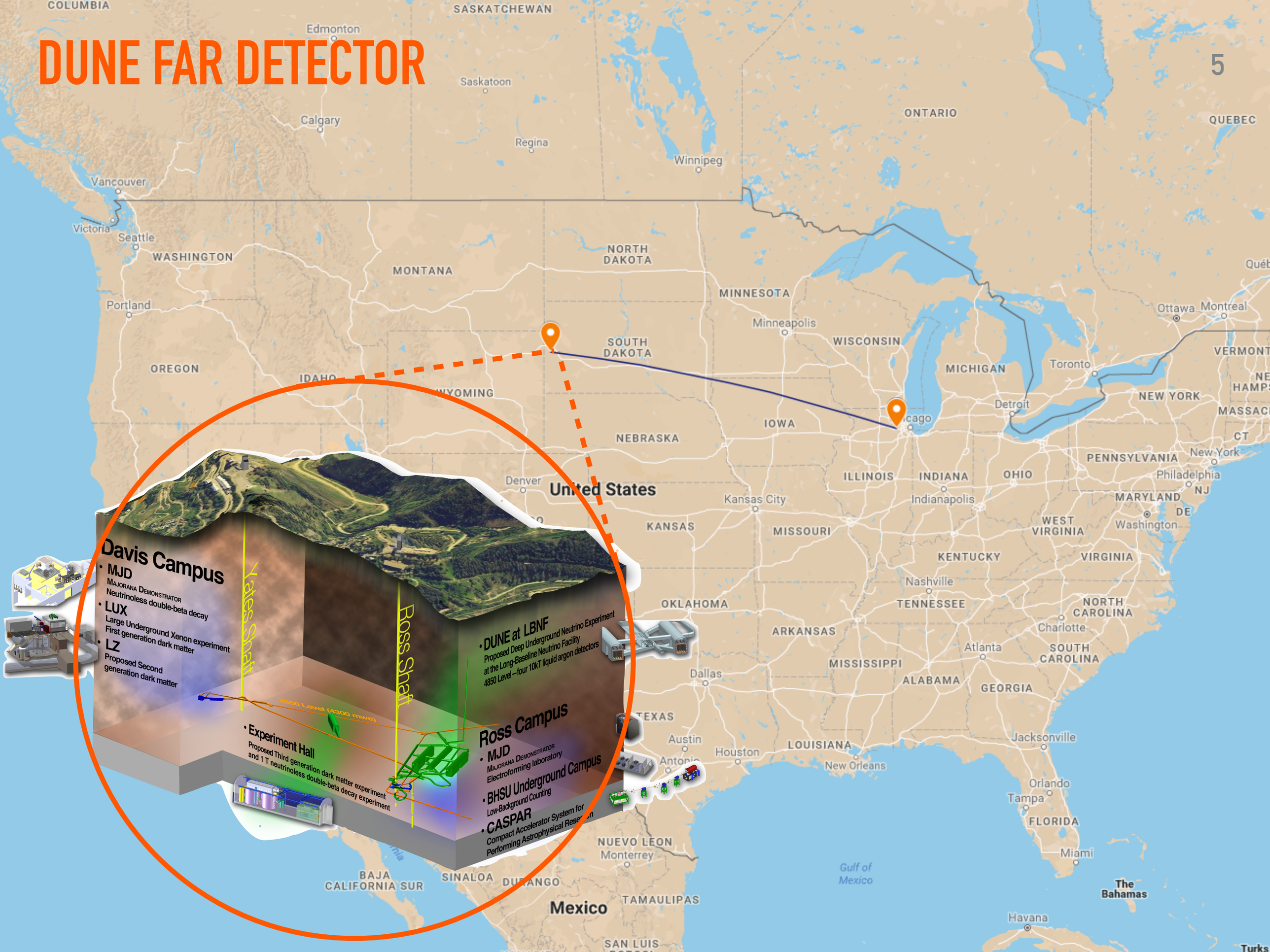

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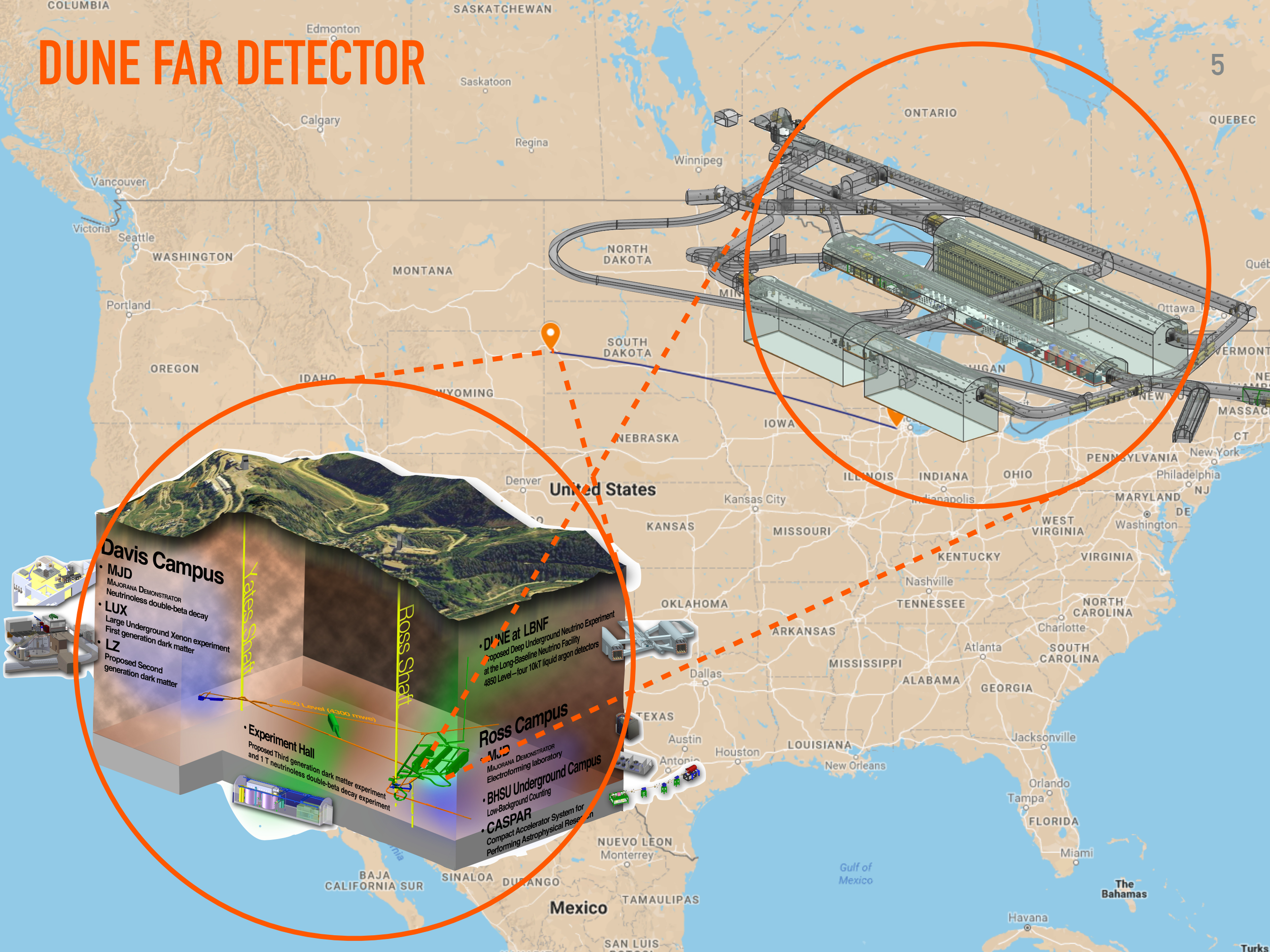

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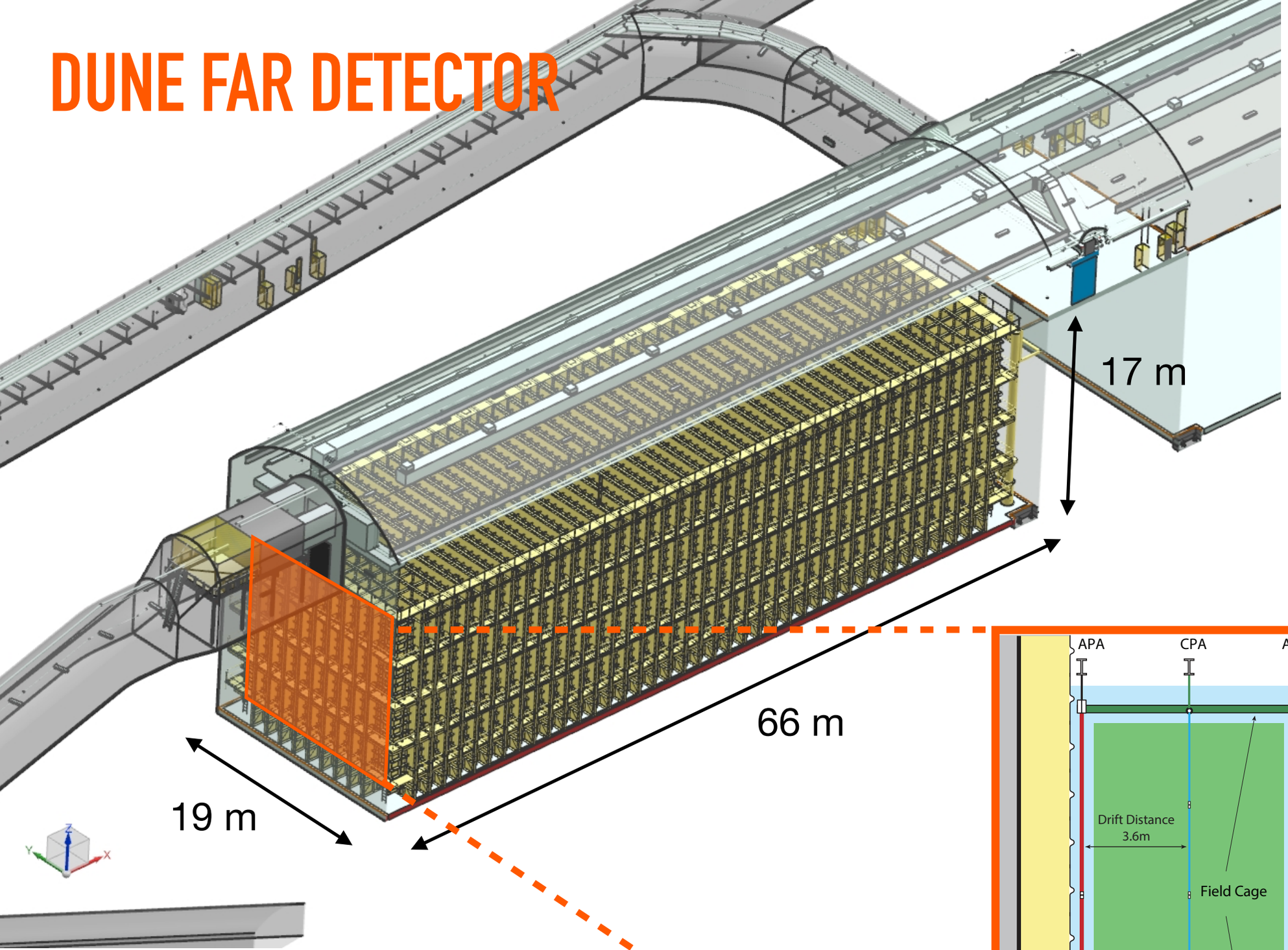
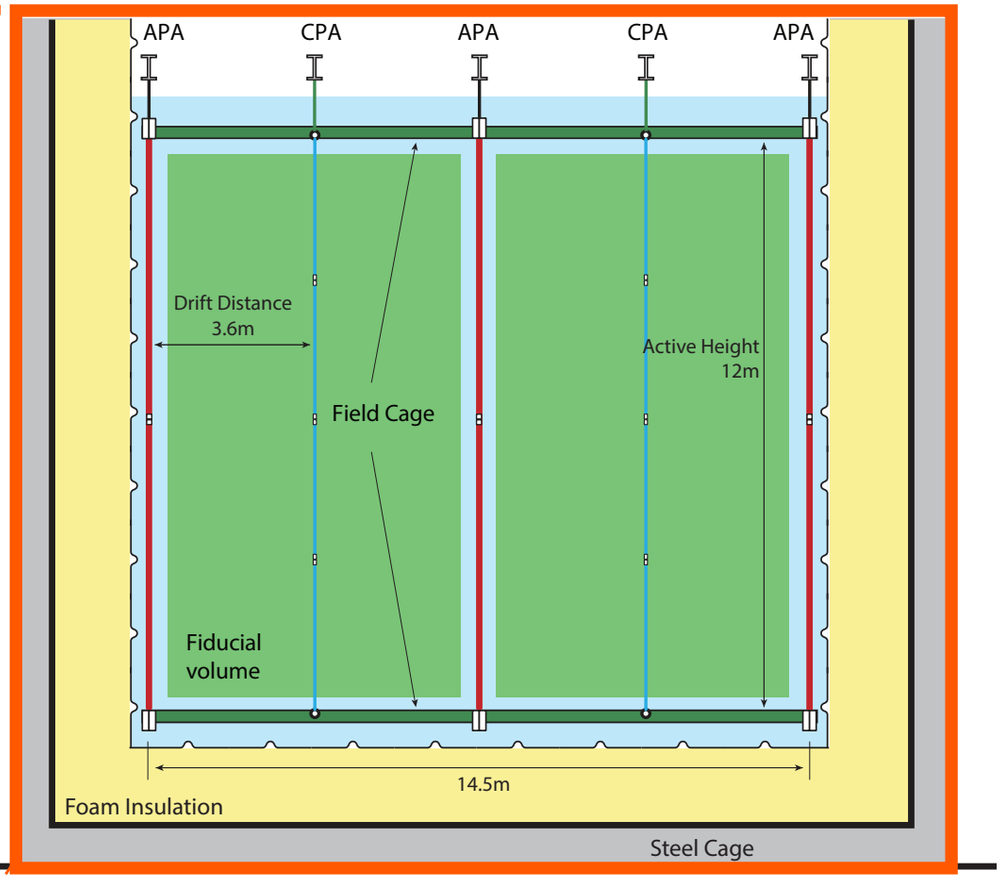
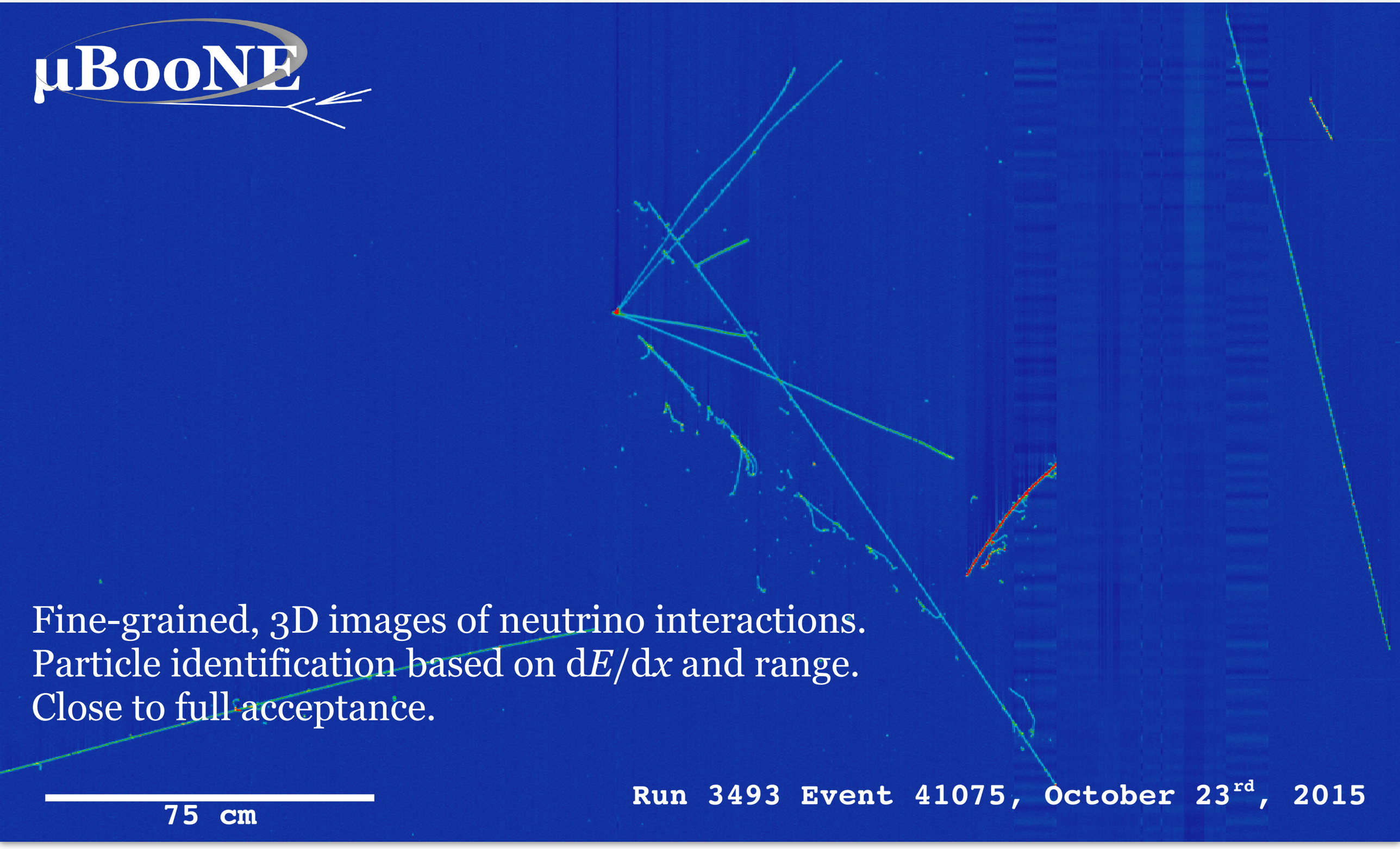




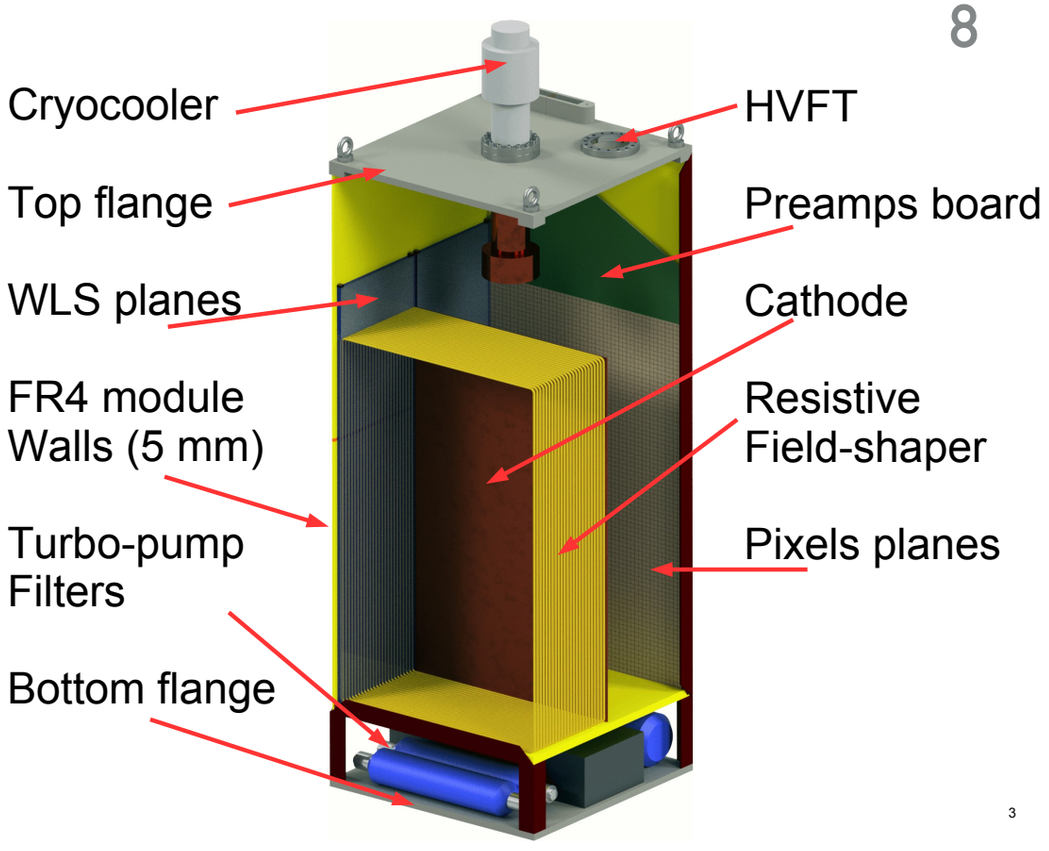
DUNE FAR DETECTOR: LIQUID ARGON TPC



DUNE NEAR DETECTOR

- ND has fundamental role for LBL physics, constraining systematic uncertainties through the measurement of neutrino flux and interaction cross sections.

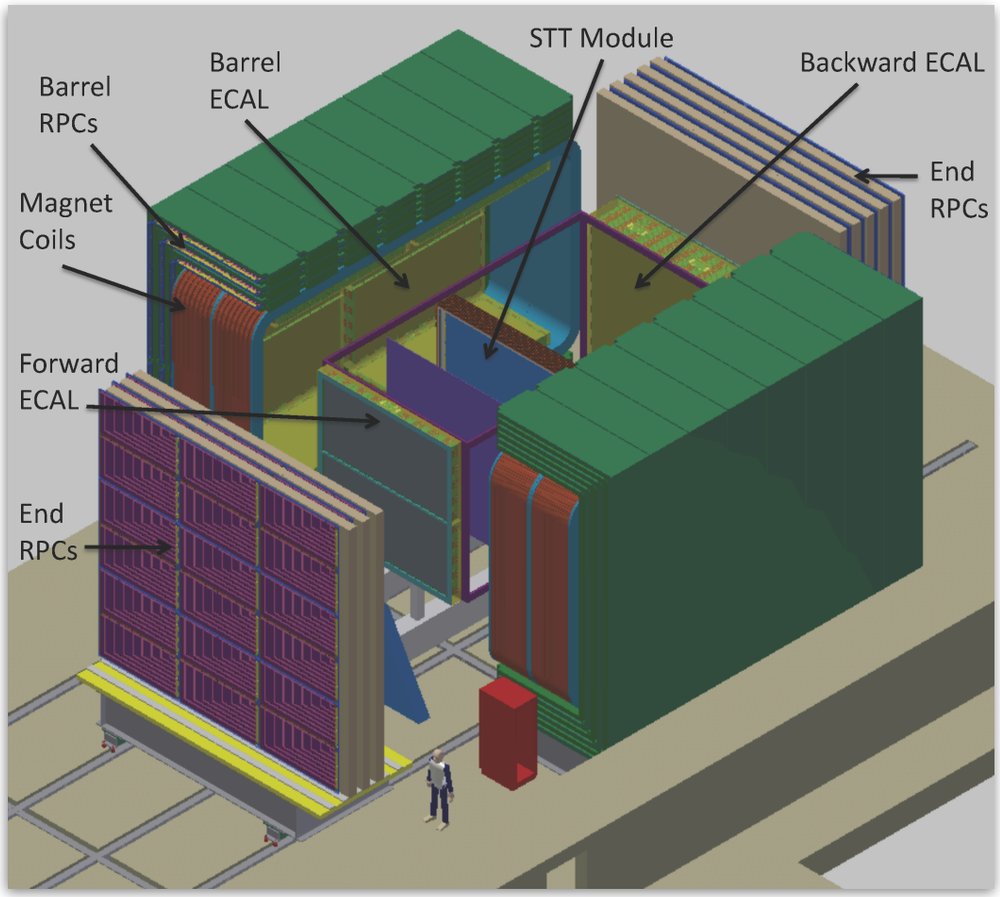
- It will record largest sample of neutrino interactions ever collected.



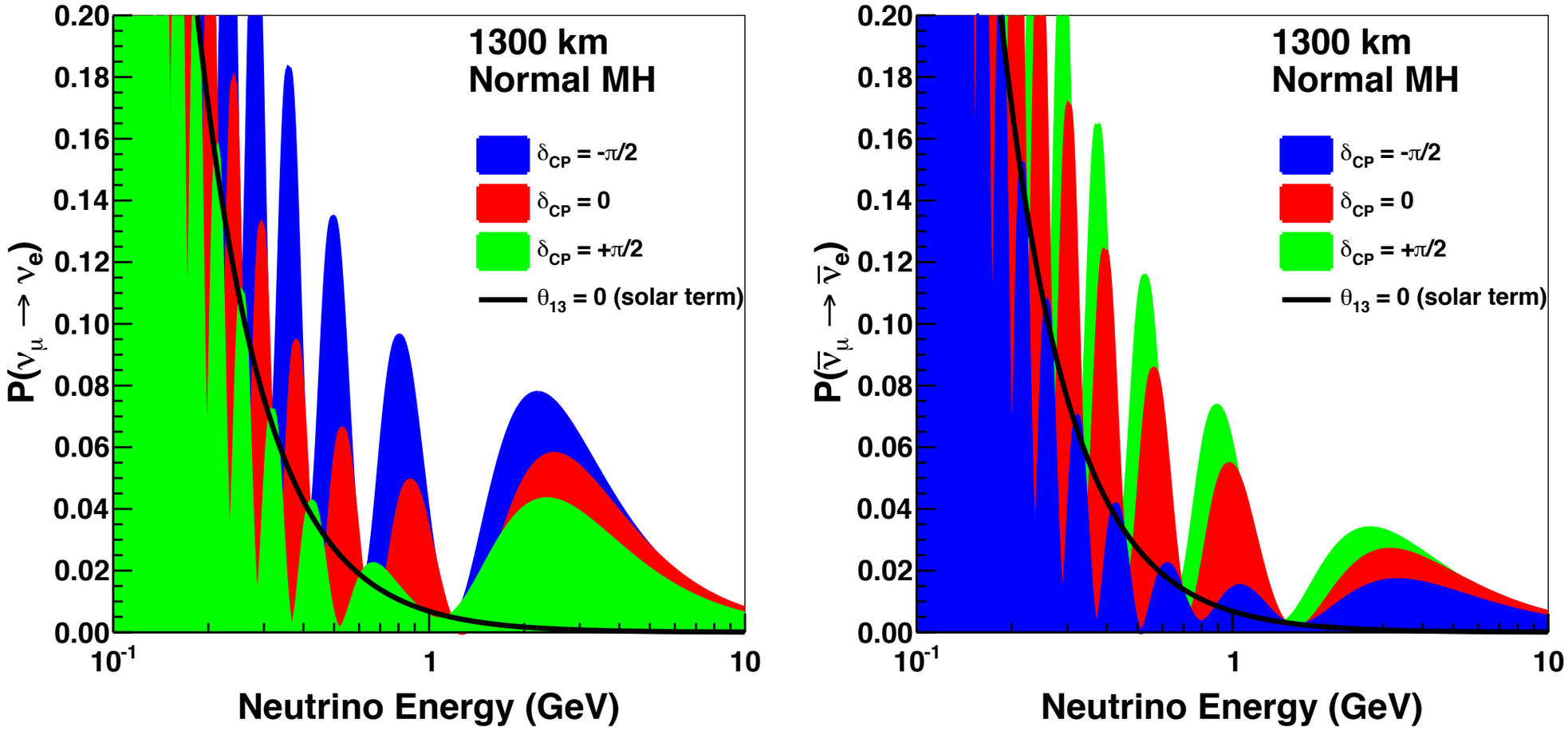
- Also sensitive to new physics (e.g. heavy sterile neutrinos).

- DUNE ND currently under design. Conceptual design ready by 2018.

- It will likely feature a modular liquid argon TPC and a magnetised, high-resolution tracker.



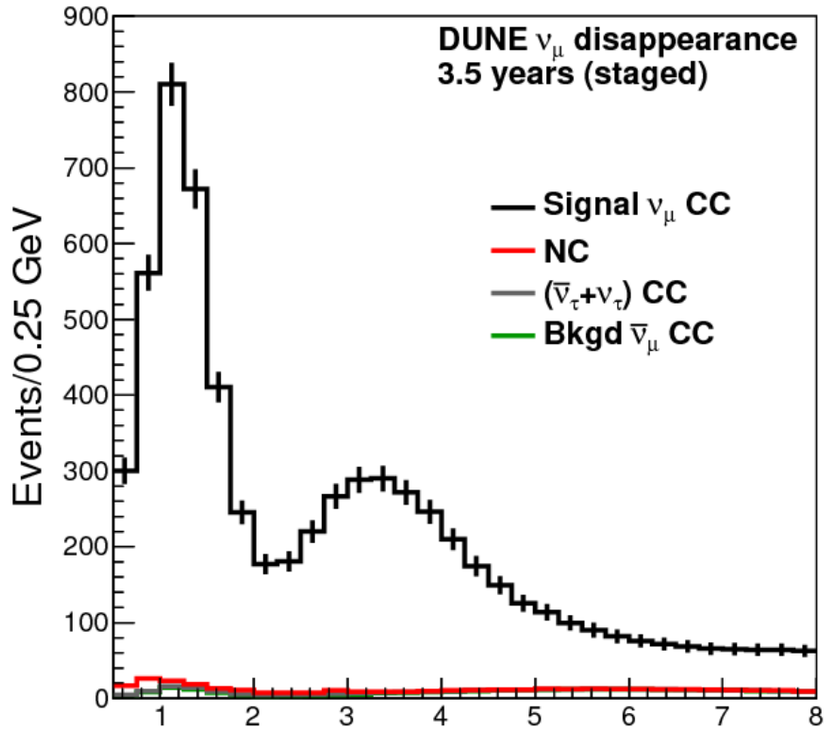
LBL EXPERIMENTAL STRATEGY

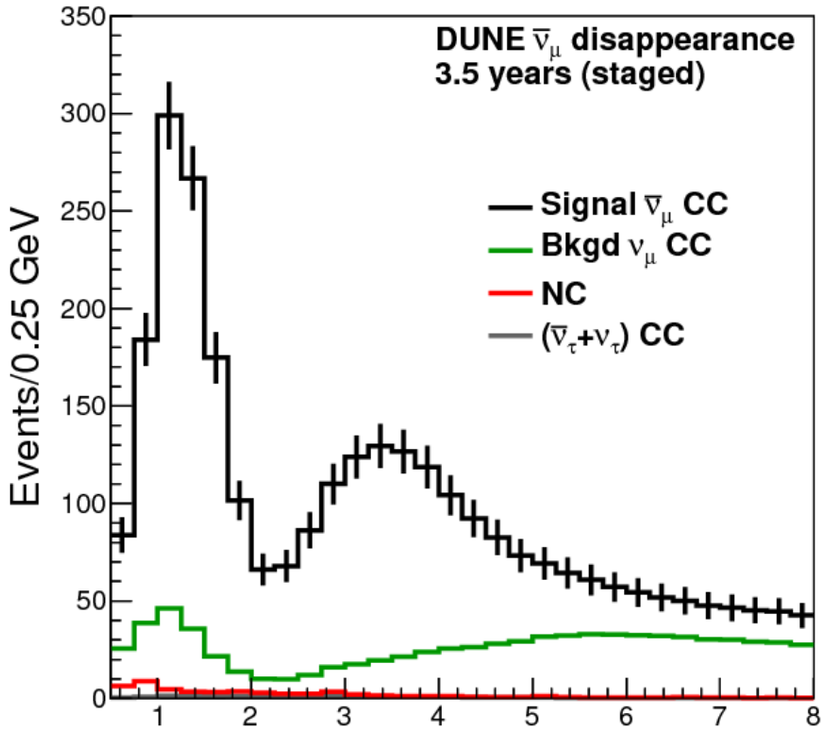


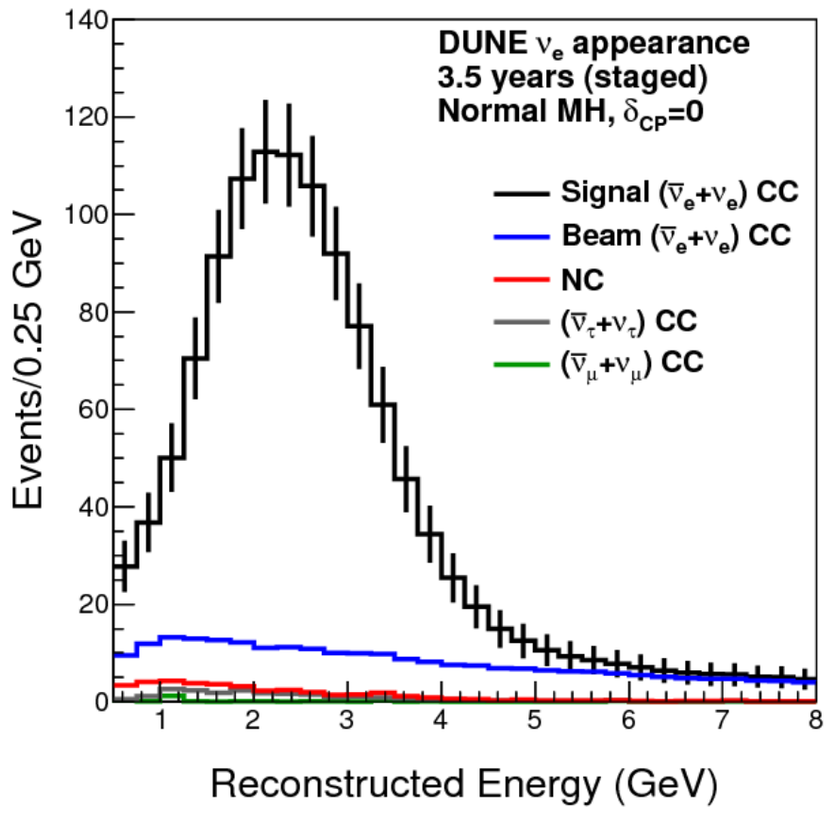
- Electron-neutrino appearance amplitude depends on θ_{13}, θ_{23}, δ_{CP} and matter effects. All four can be measured in a single experiment.

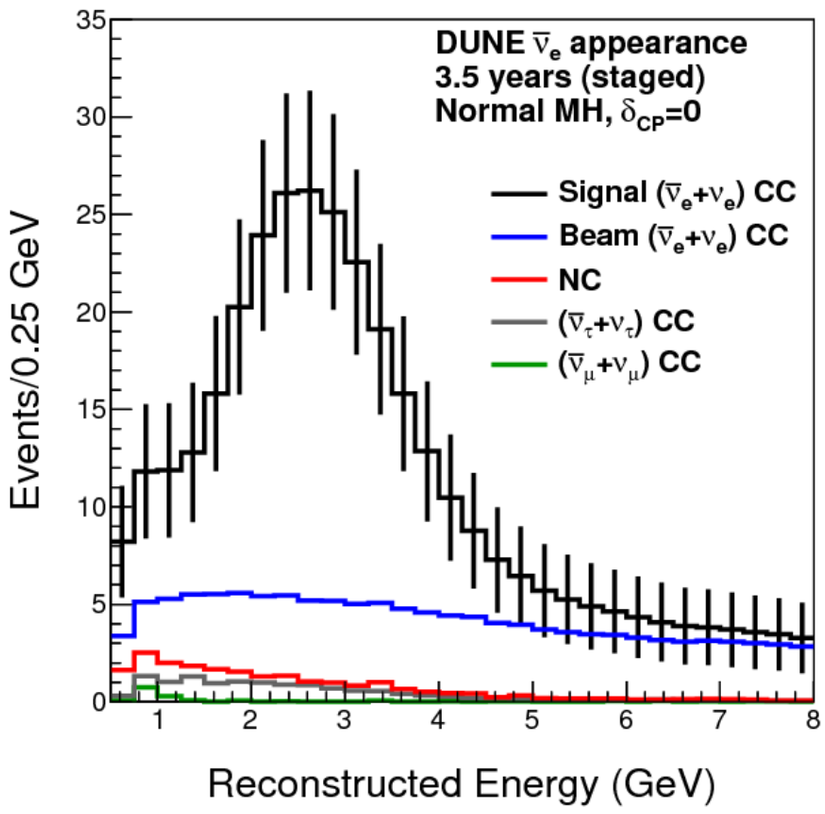
- Broadband beam and long baseline break degeneracy between CPV and matter effects.

LBL EXPERIMENTAL STRATEGY





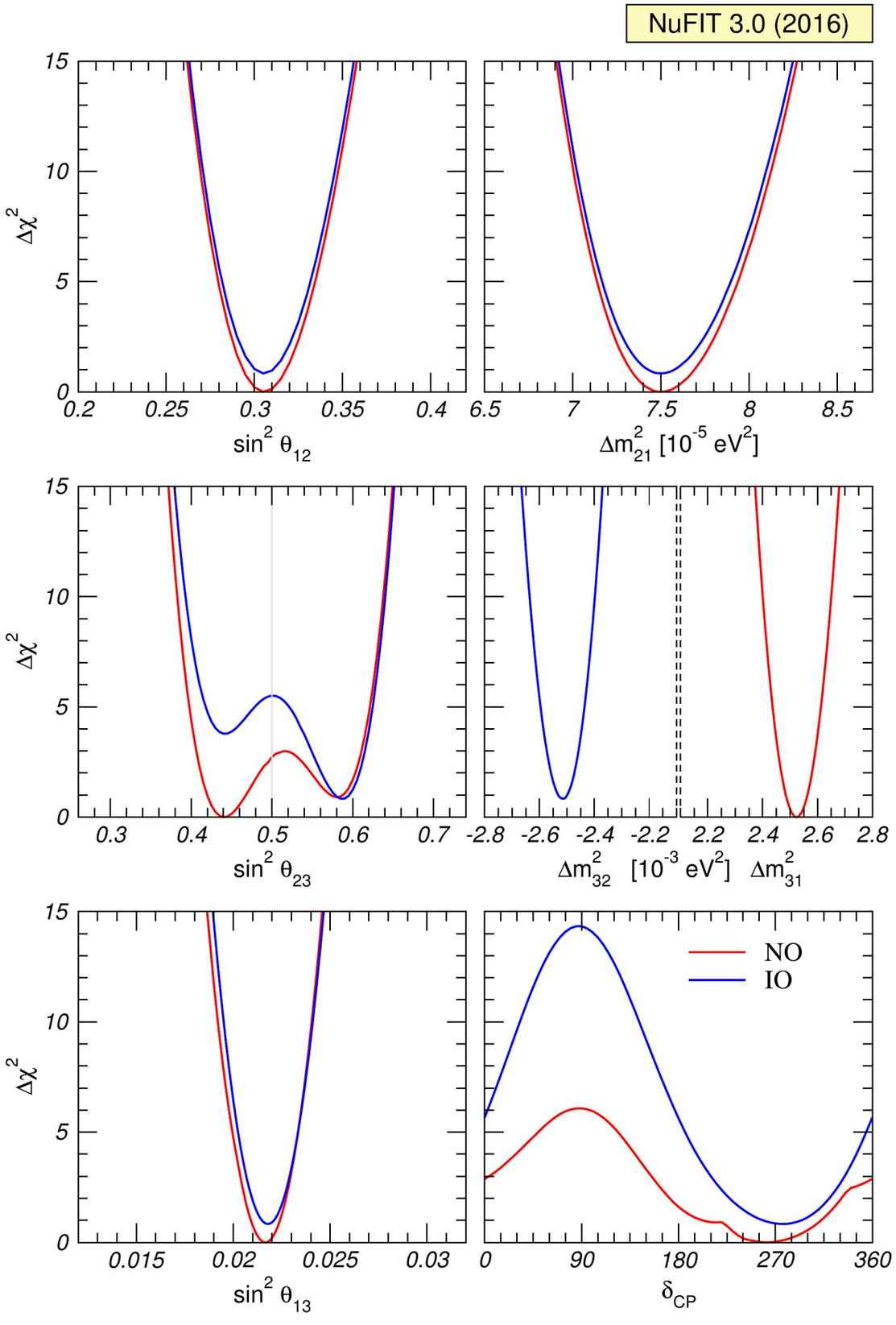




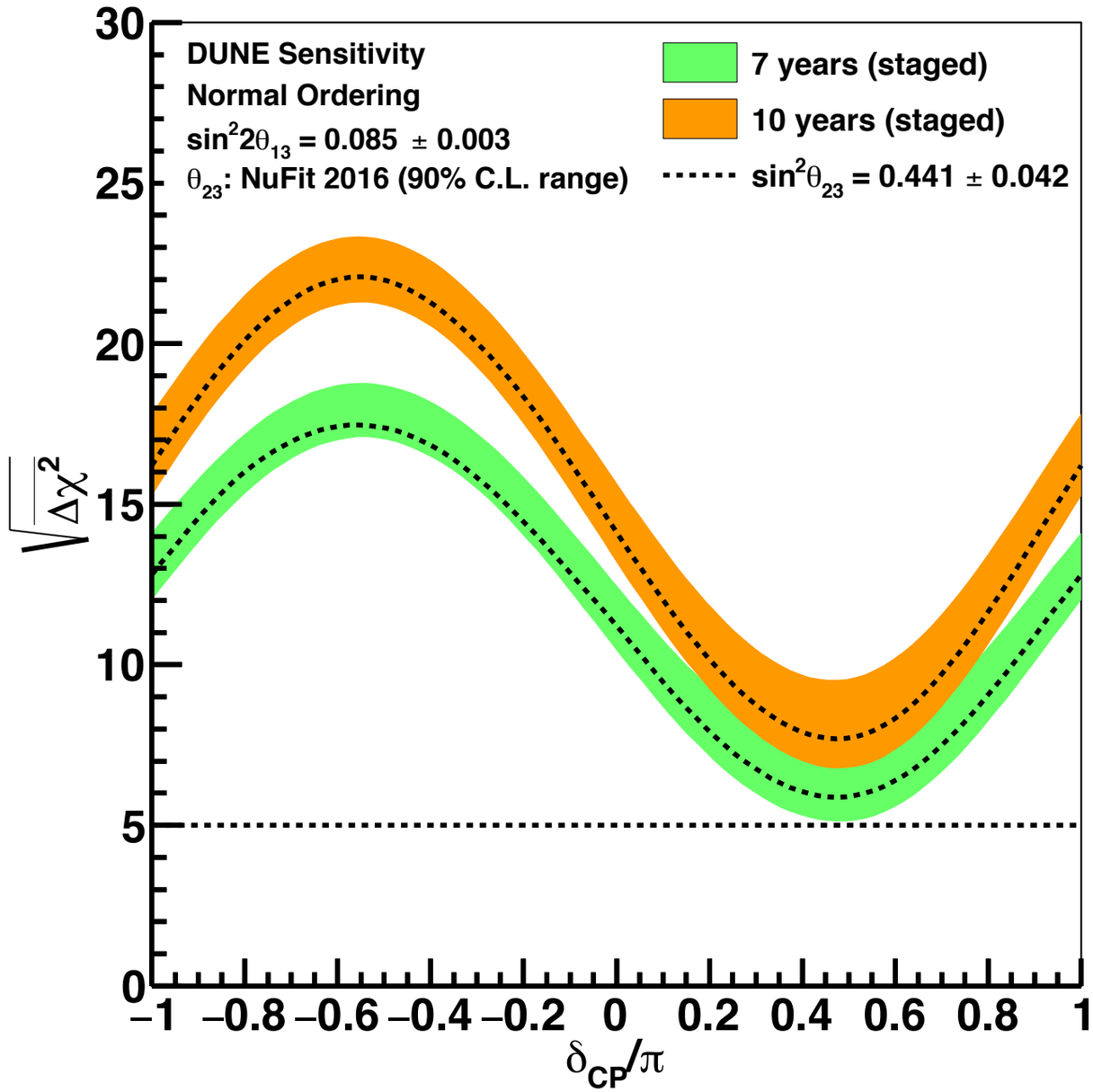
LBL EXPERIMENTAL SENSITIVITIES

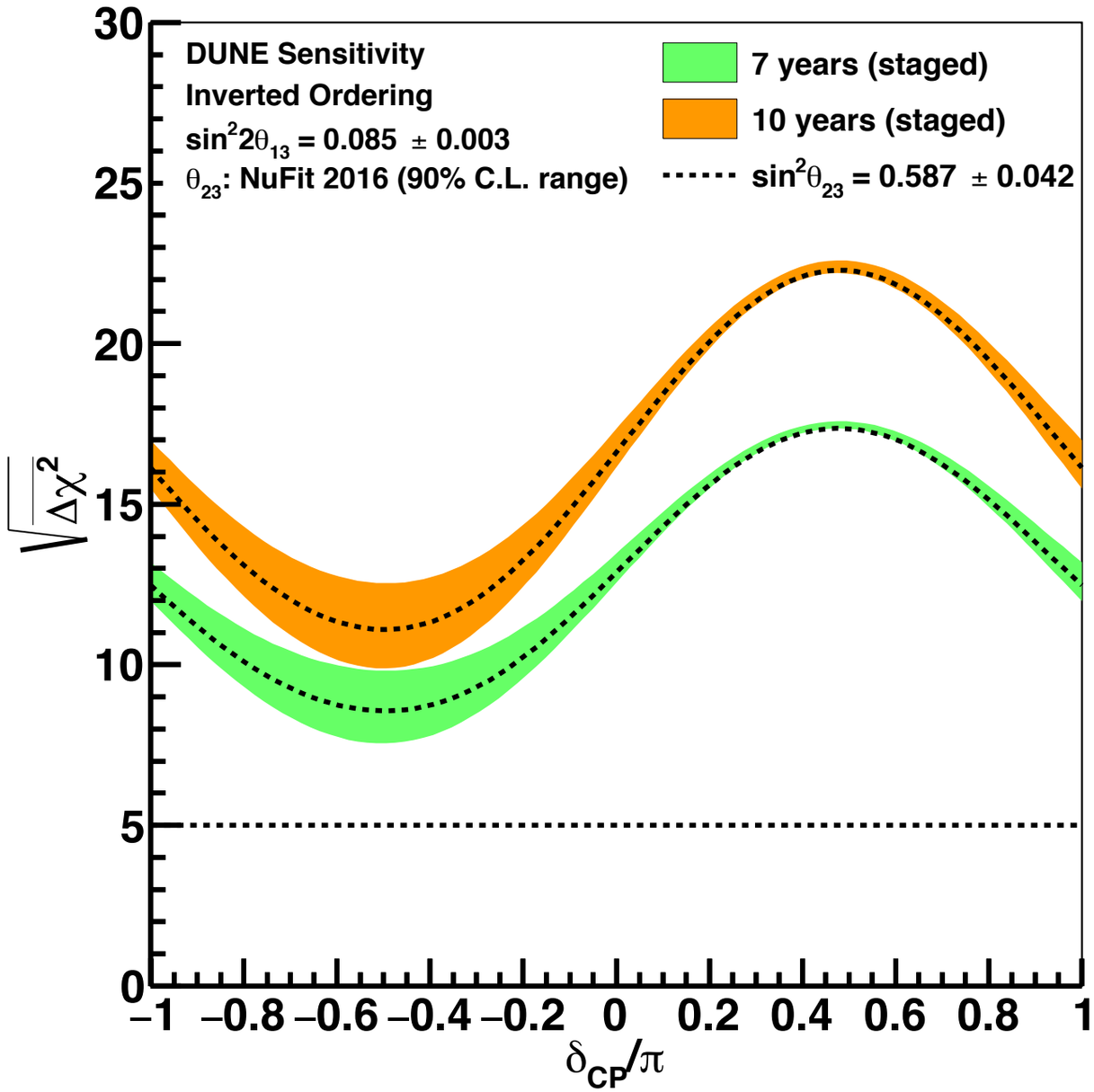
All the following sensitivity plots consider these assumptions:

- Oscillation parameters from NuFit2016.
- Staging scenario with equal running in neutrino and antineutrino modes:
  - Year 1 (2026): 20-kt FD with 1.07 MW beam.
  - Year 2 (2027): 30 kt FD.
  - Year 4 (2029): 40 kt FD.
  - Year 7 (2032): upgrade to 2.14 MW beam.
- GLoBES-based fit to the FD samples, with parameterised detector response.



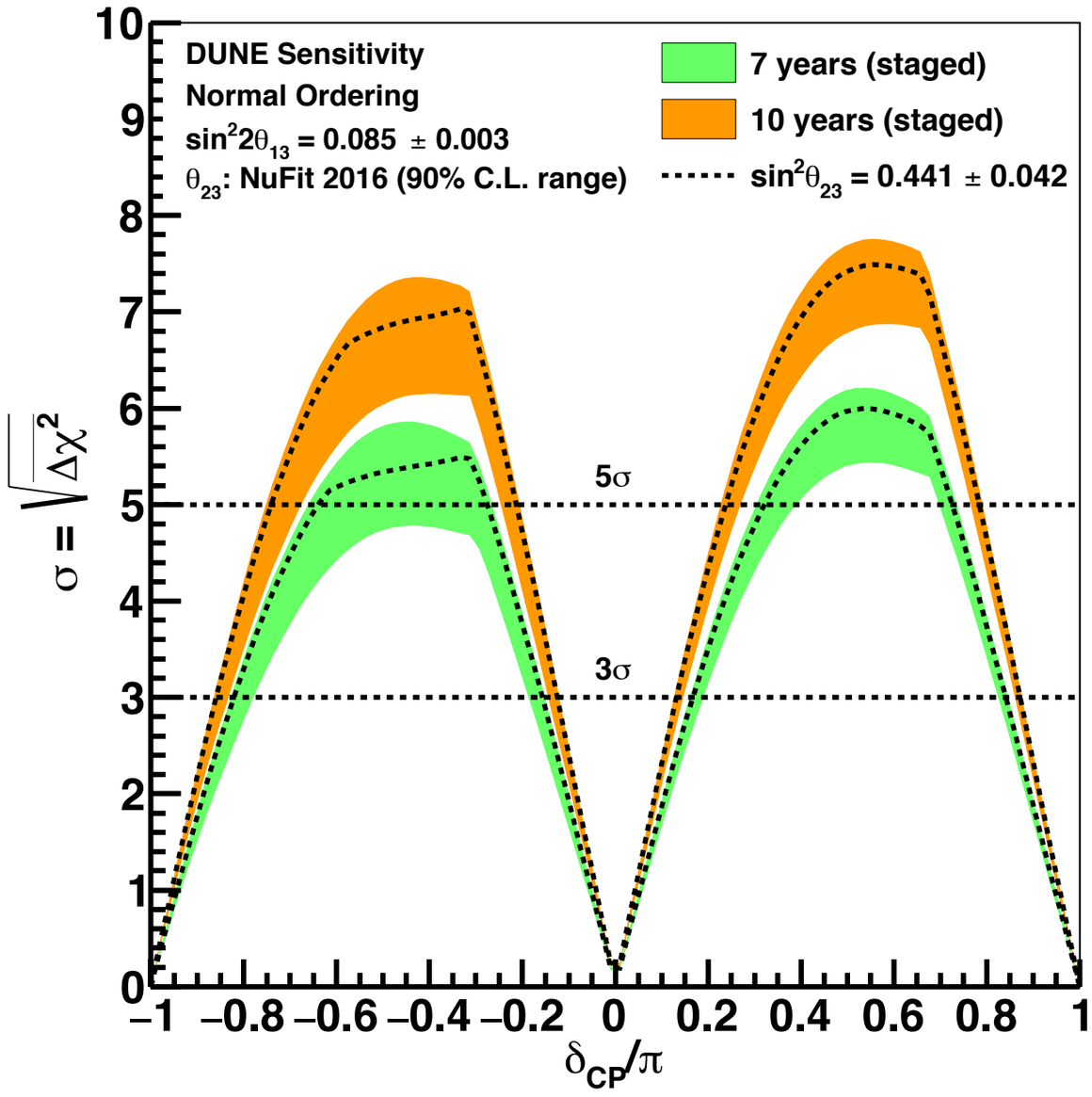
SENSITIVITY TO MASS HIERARCHY

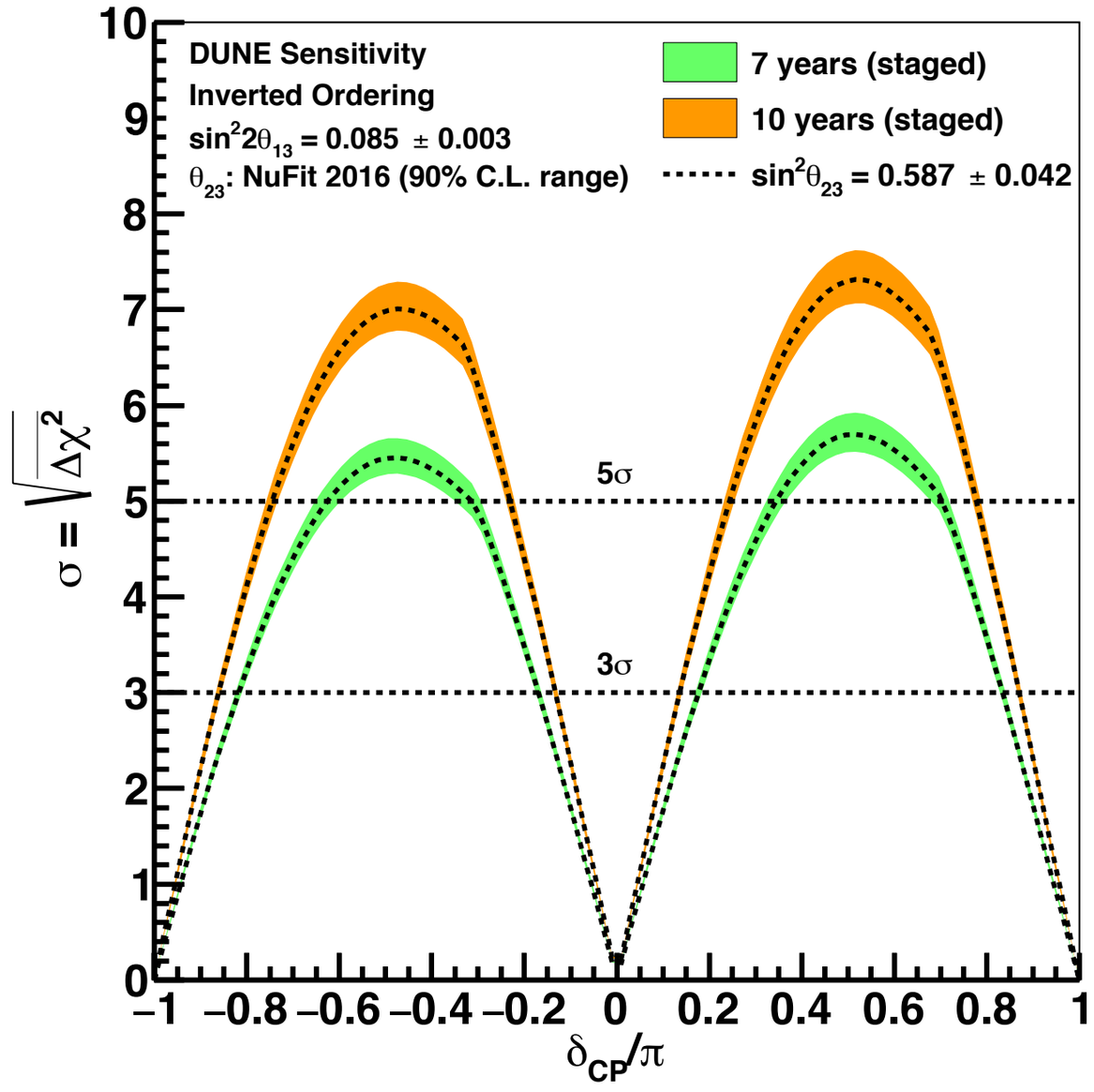




Width of bands represents range of sensitivities for the 90% CL region in θ_{23} values.
Sensitivity increases with increasing θ_{23}.

SENSITIVITY TO CP VIOLATION





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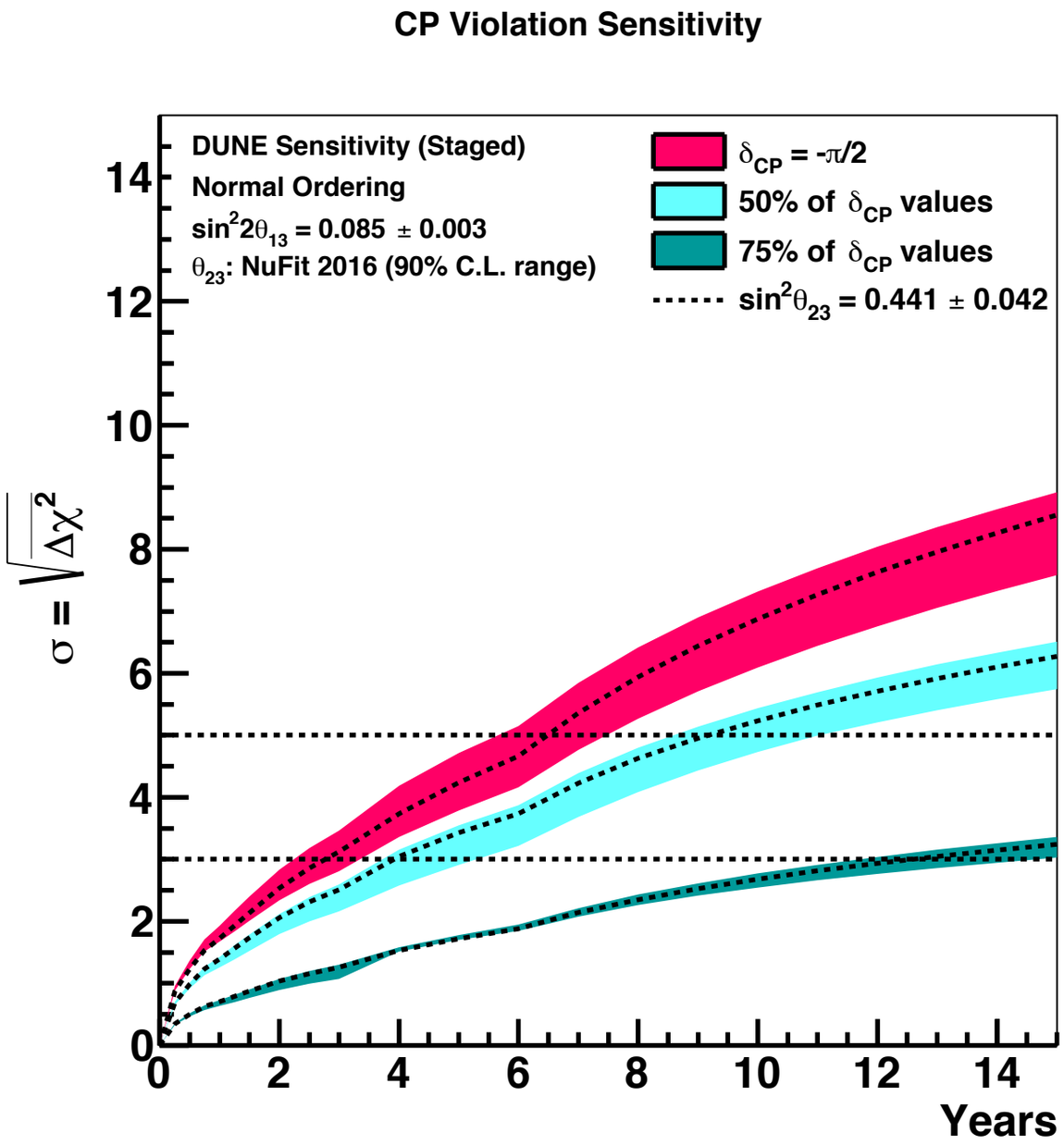
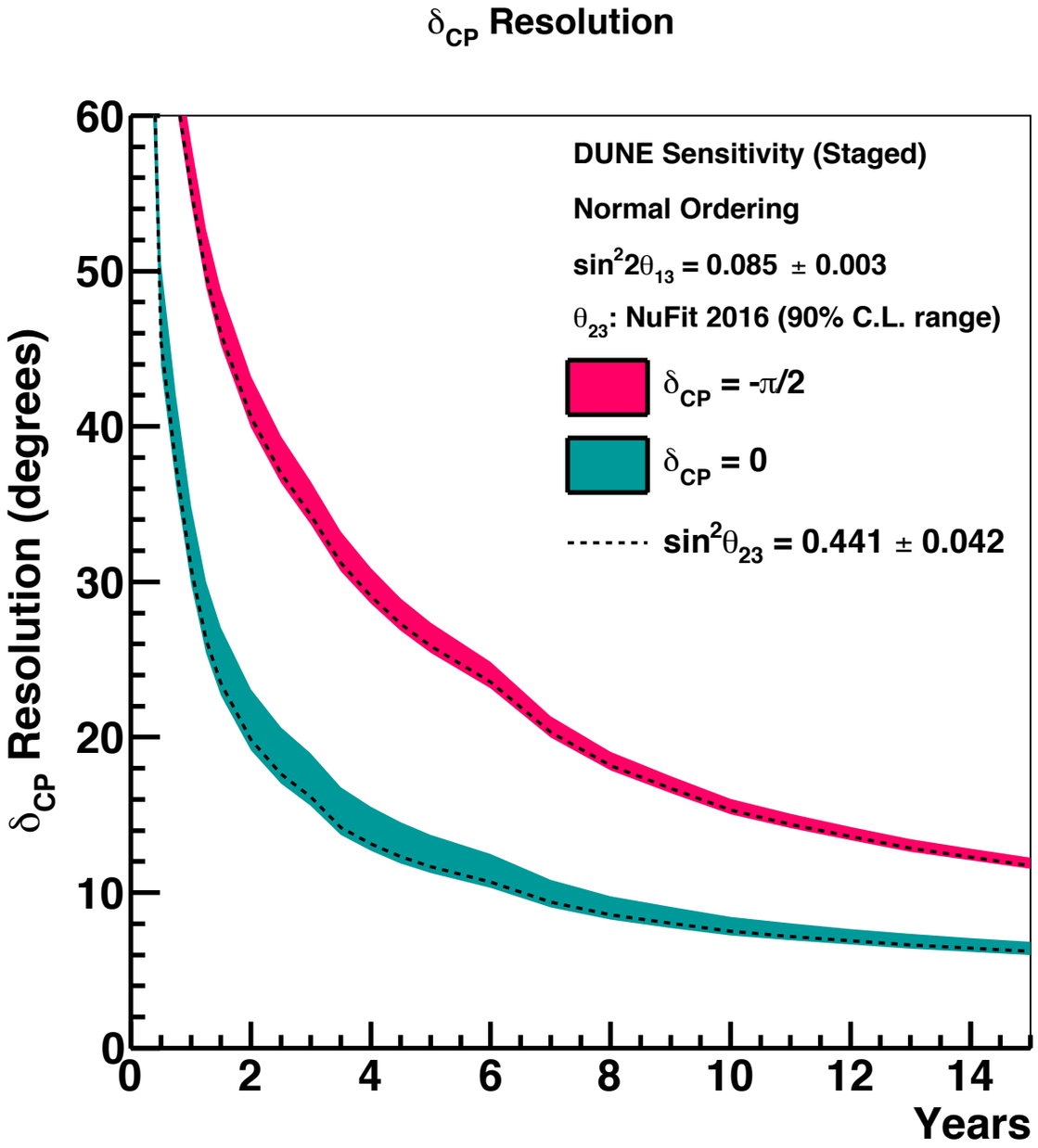
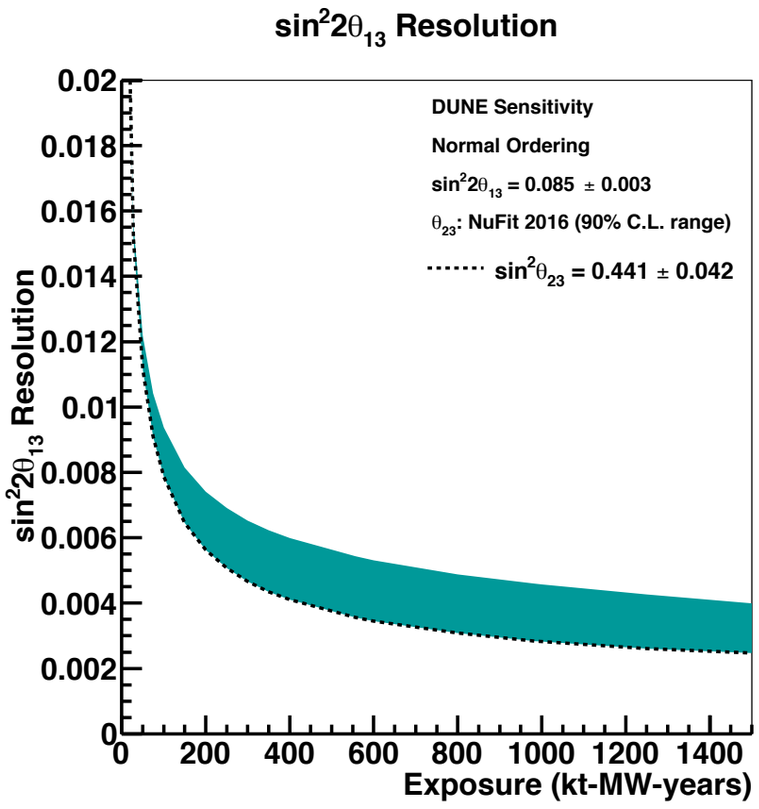
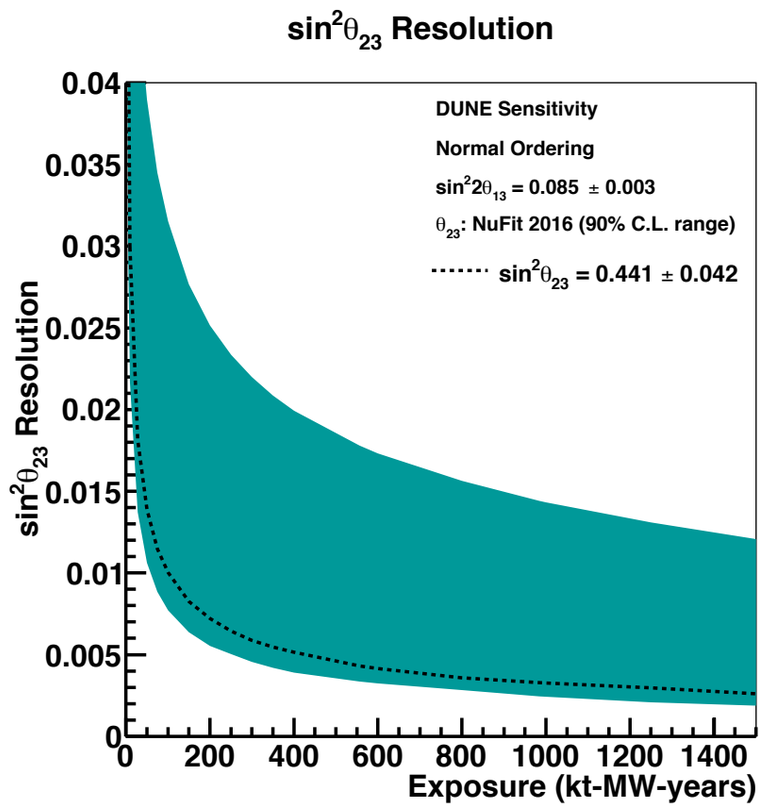
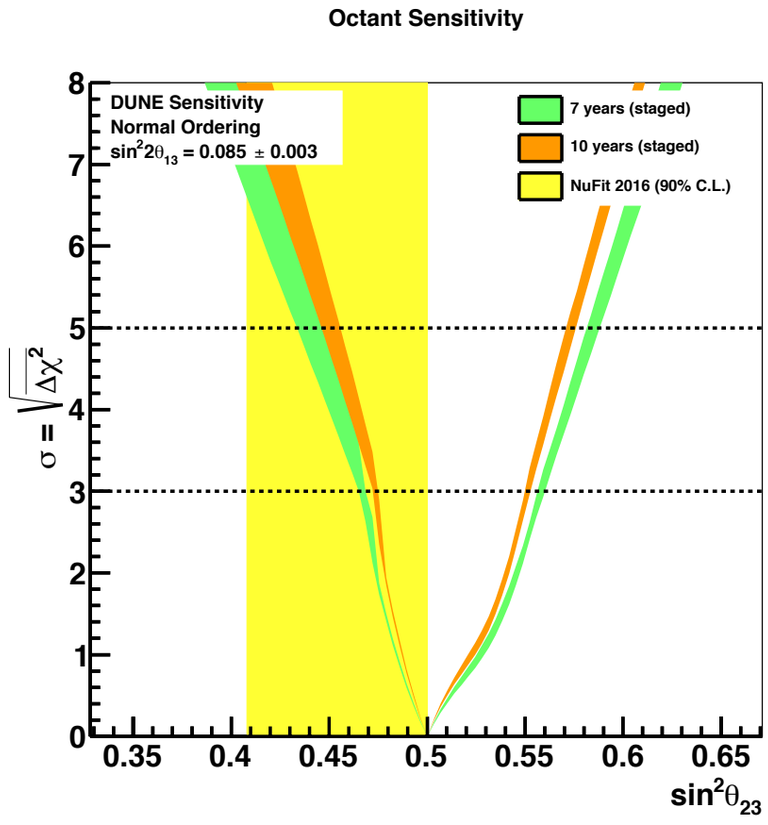




MEASUREMENT OF OSCILLATION PARAMETERS



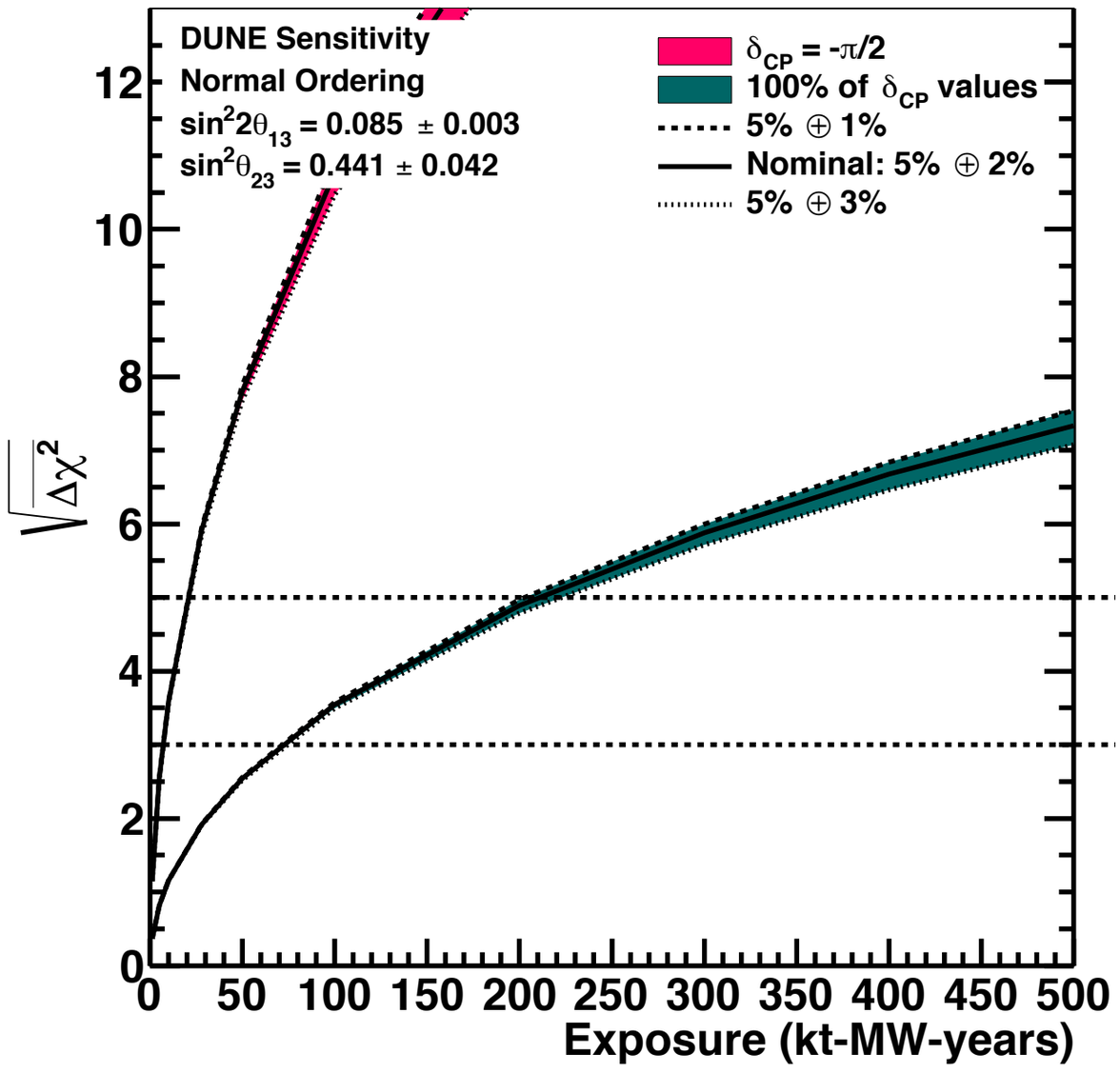




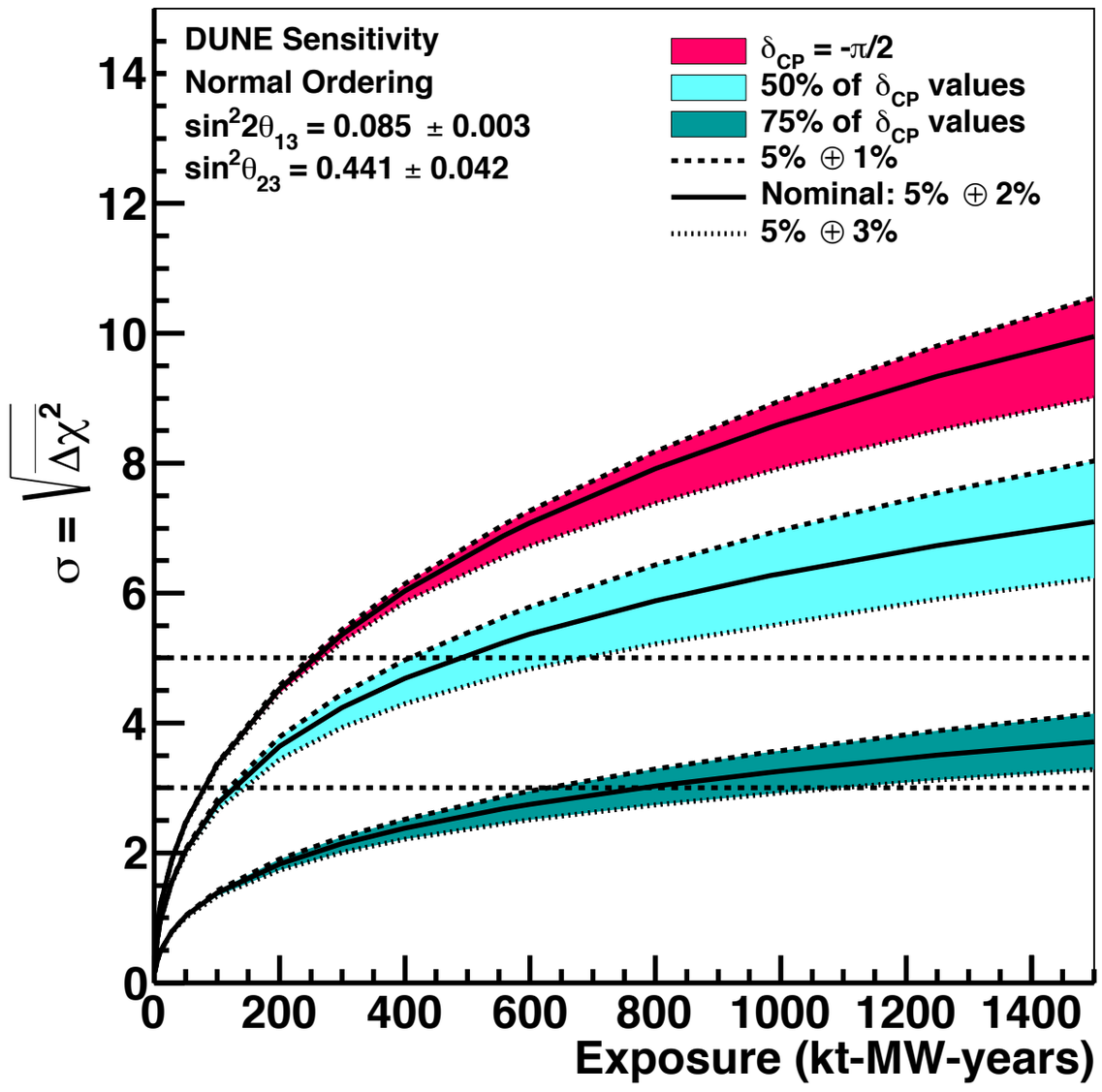
Long-baseline experiments will approach the resolution of reactor experiments in the measurement of the mixing angles.

IMPACT OF SYSTEMATIC UNCERTAINTIES

MH Sensitivity



CP Violation Sensitivity



The difference between 1% and 3% normalisation uncertainty in the electron neutrino sample translates into a factor of 2 in exposure.

SUMMARY

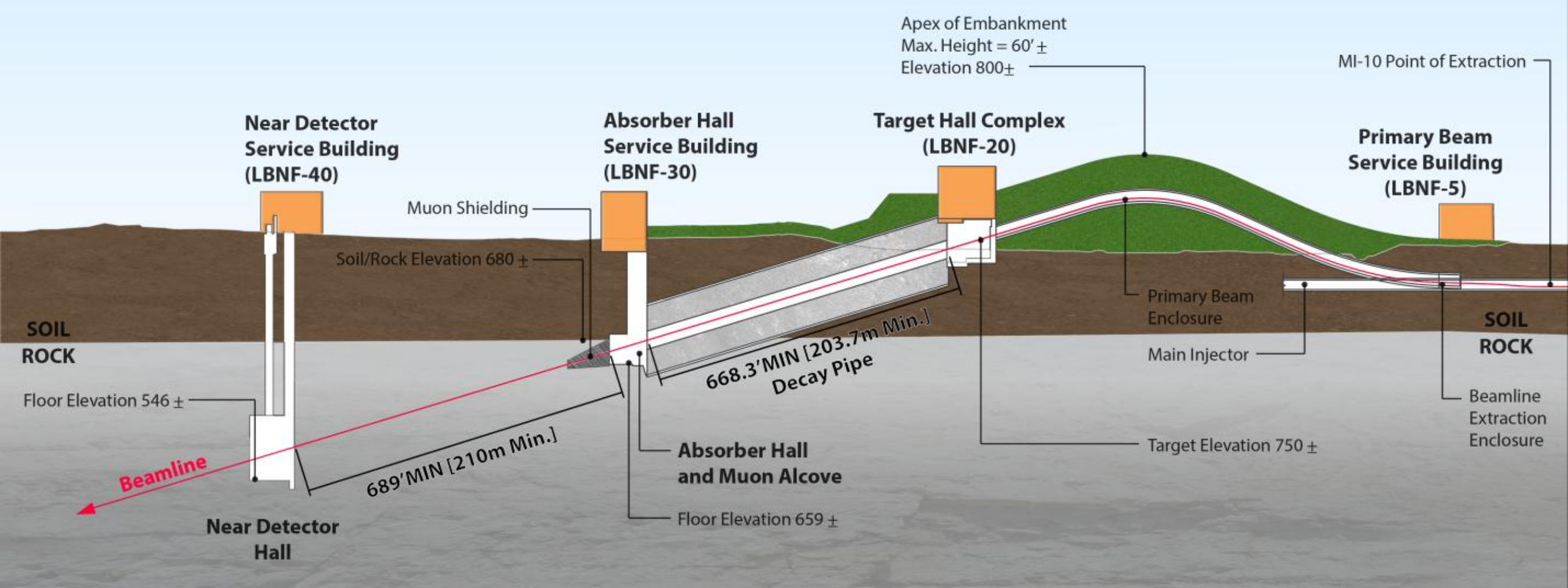
- DUNE will use a broadband beam and a long baseline (1300 km) to make a precise, simultaneous measurement of the mass ordering, the CP-violation phase and the neutrino mixing angles.
  - Comparison to other oscillation channels allows unitarity test.
  - Sensitive as well to new physics affecting oscillation probabilities.
- The mass, high granularity and deep underground location of the DUNE far detector provide good sensitivity to baryon non-conservation and supernova burst neutrinos.
- DUNE physics program will produce interesting results at each stage of 20+ year operation.

BACKUP SLIDES

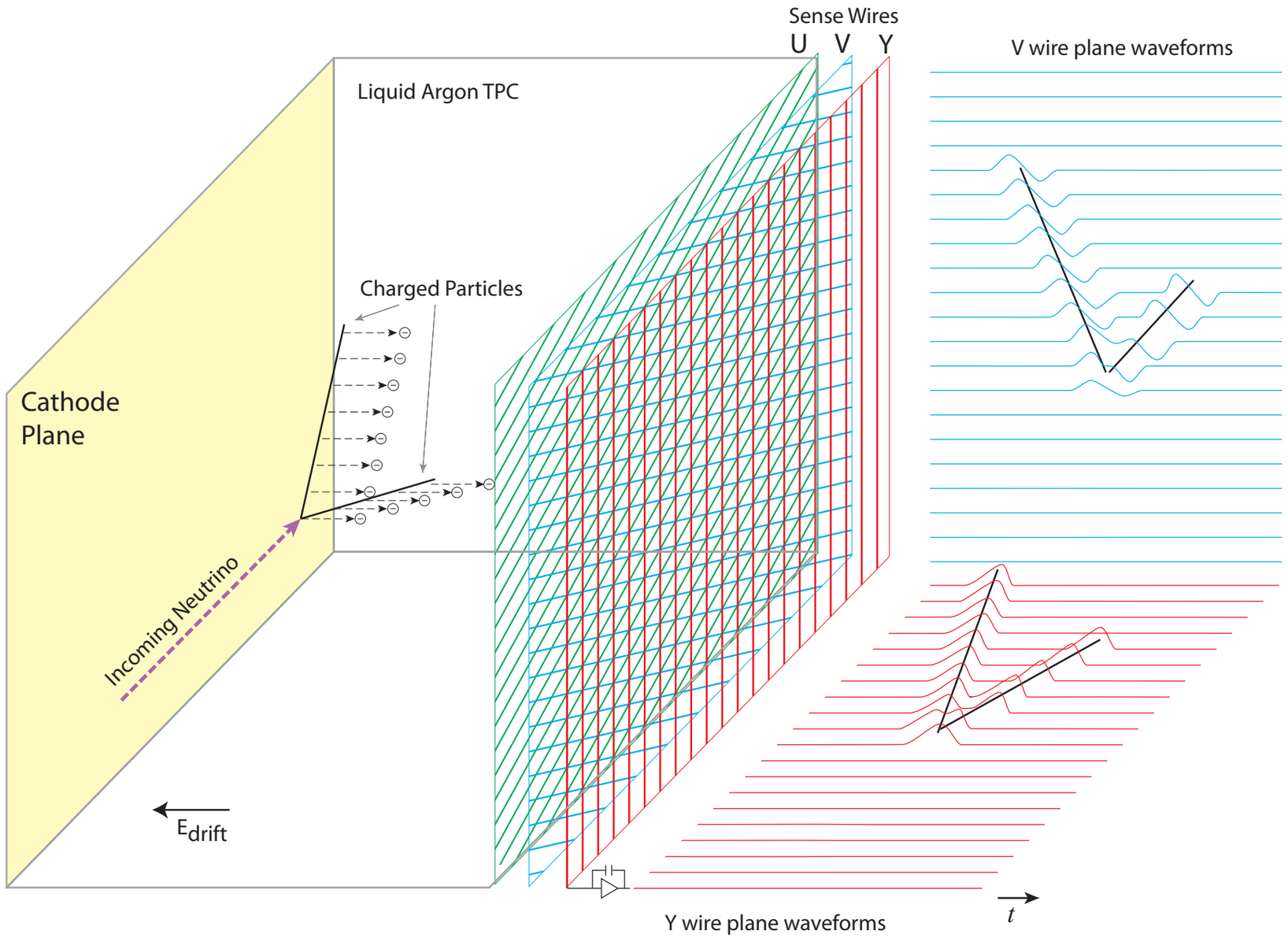
EPS Conference on High Energy Physics – Venice, 5th June 2017

LBNF NEUTRINO BEAMLINE

- 60-120 GeV protons from Fermilab Main Injector.
- Wide energy spectrum covers the 1st and 2nd oscillation maxima.
- Initial upward pitch, 101 mrad pitch to point to South Dakota.
- Initially 1.2 MW, upgradeable to 2.4 MW.



DUNE FAR DETECTOR: LIQUID ARGON TPC



Working principle of a (single phase) liquid argon time projection chamber.