



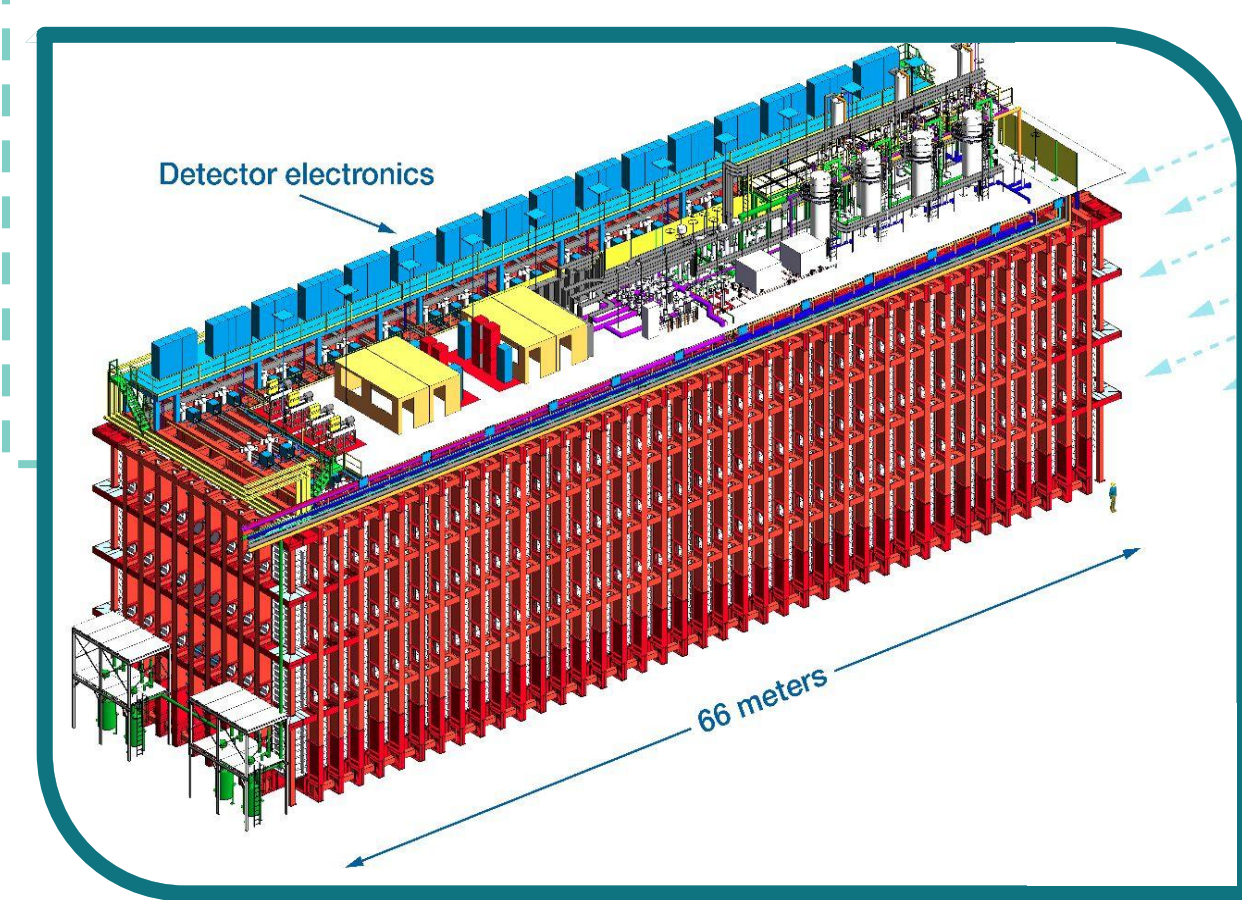
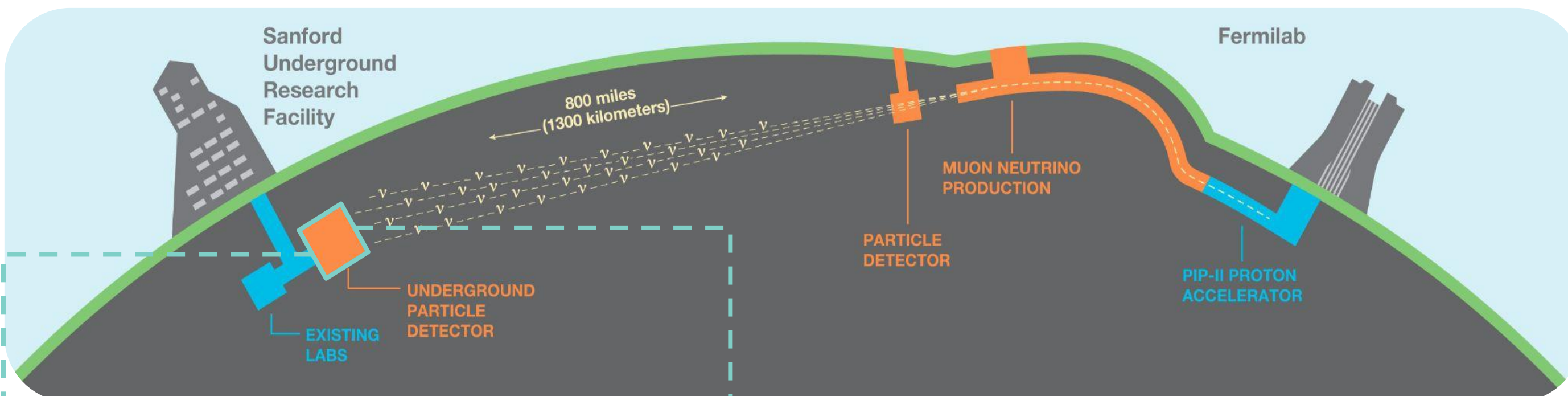
DUNE SENSITIVITY TO SOLAR NEUTRINOS



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Deep Underground Neutrino Experiment

DUNE: Long-baseline **neutrino oscillation experiment** with a 1.2 MW beam produced at Fermilab (Illinois, USA), characterised with a **ND complex** and measured with **liquid argon detectors** at SURF (South Dakota, USA) **1.5 km underground**.



DUNE Far Detector (FD) modules [1]:

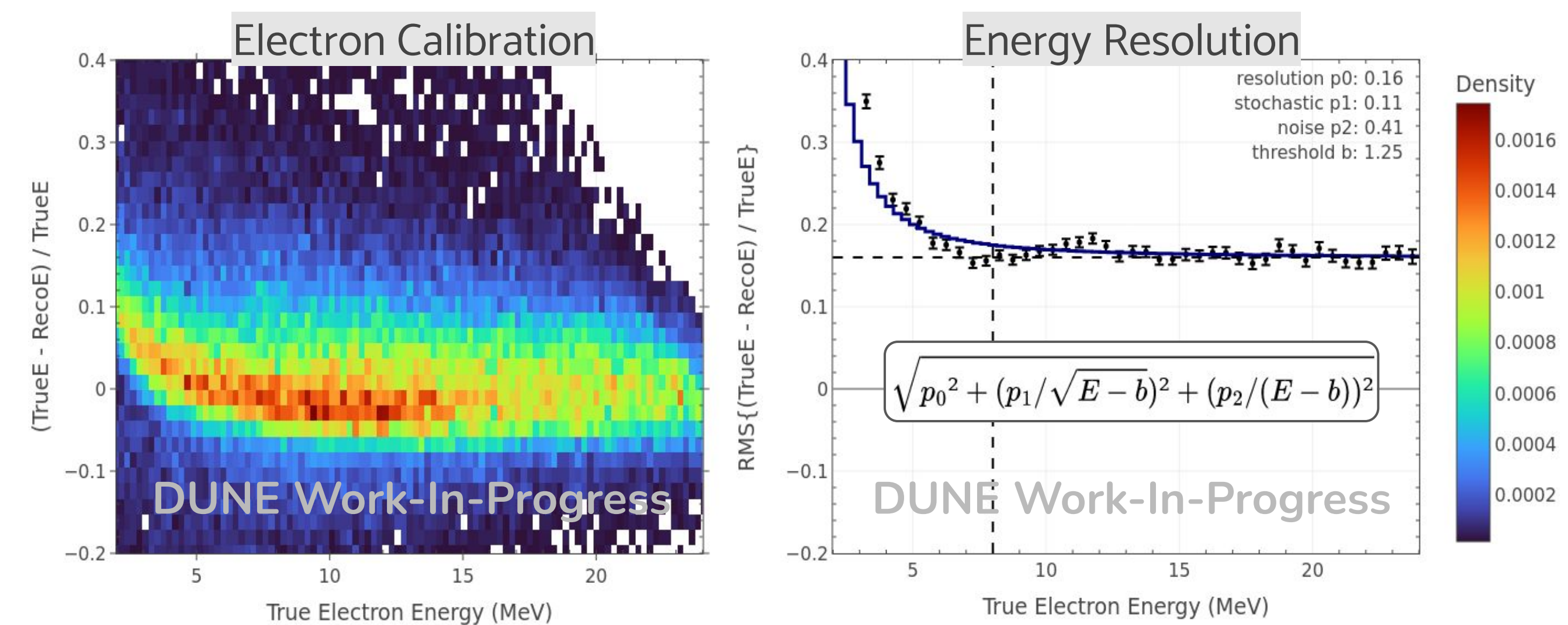
- Excavation ready to host 4 detectors.
- 17 kT LAr ~ 66 x 19 x 18 m³ cryostat.

Liquid Argon TPC technology:

- High density (1.4 g/cm³).
- Ionization (42k e⁻/MeV) @ 500 V/cm.
- Transparent to scintillation light.
- Scintillation (24k γ/MeV) @128 nm.
- 3D reconstruction & particle ID.

Event Reconstruction: CC ν_e

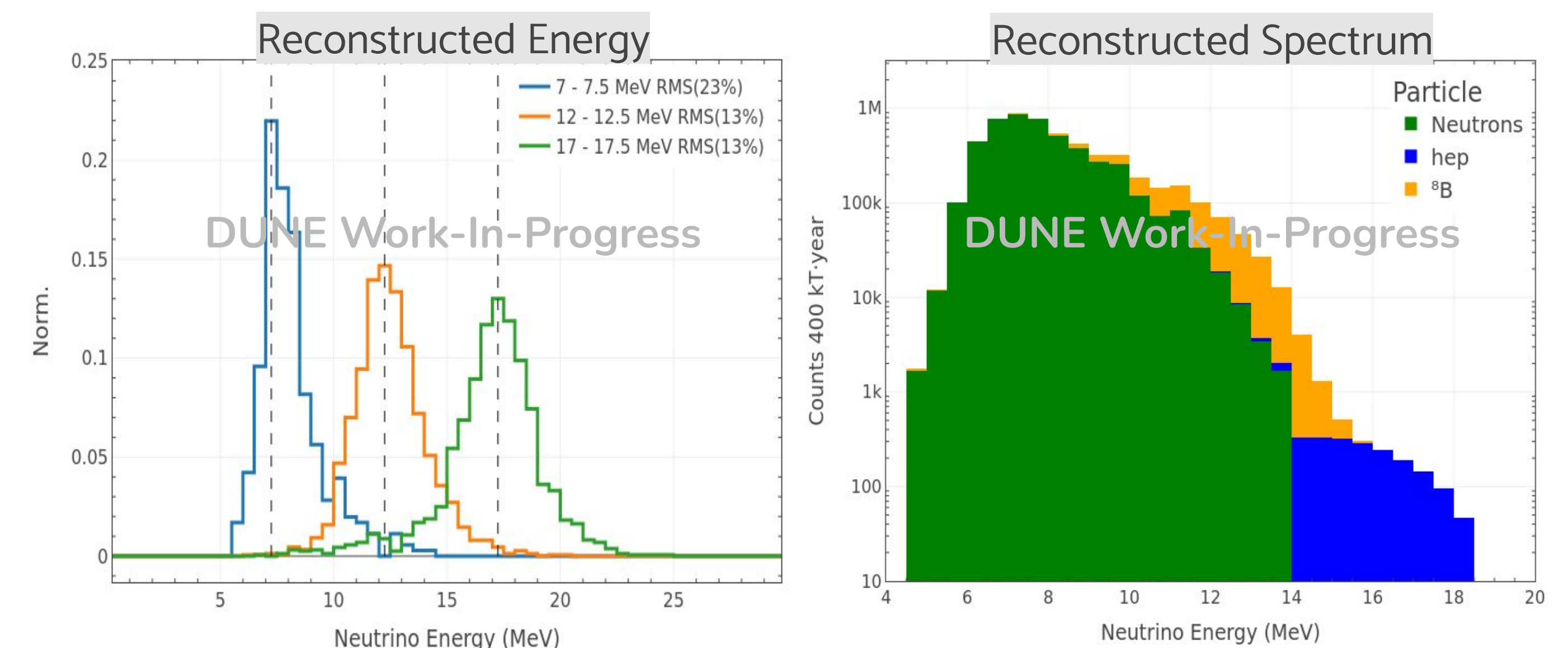
- Data from comprehensive **simulation of the FD geometries** and readout chain (e.g. noise, backgrounds...) using the LArSoft [3] framework.
- Reconstruction for low energy events** follows a hit-clustering scheme based on channel and time proximity (3 channels - 12.5 μs).



- Electron energy resolution ~ 16%** (with ideal drift reconstruction).
- Reconstruction optimised for **main electron**. Additional **deexcitation gammas** from quantised nuclear states add **4 MeV** or **5.9 MeV**.
- Neutrino reconstruction** follows from combining **electron + gamma clusters**.

CC Interaction (nuclear deex.): $^{40}\text{Ar} \rightarrow ^{40}\text{K}^* \rightarrow ^{40}\text{K} + \gamma (+ \text{N} \cdot \gamma)$

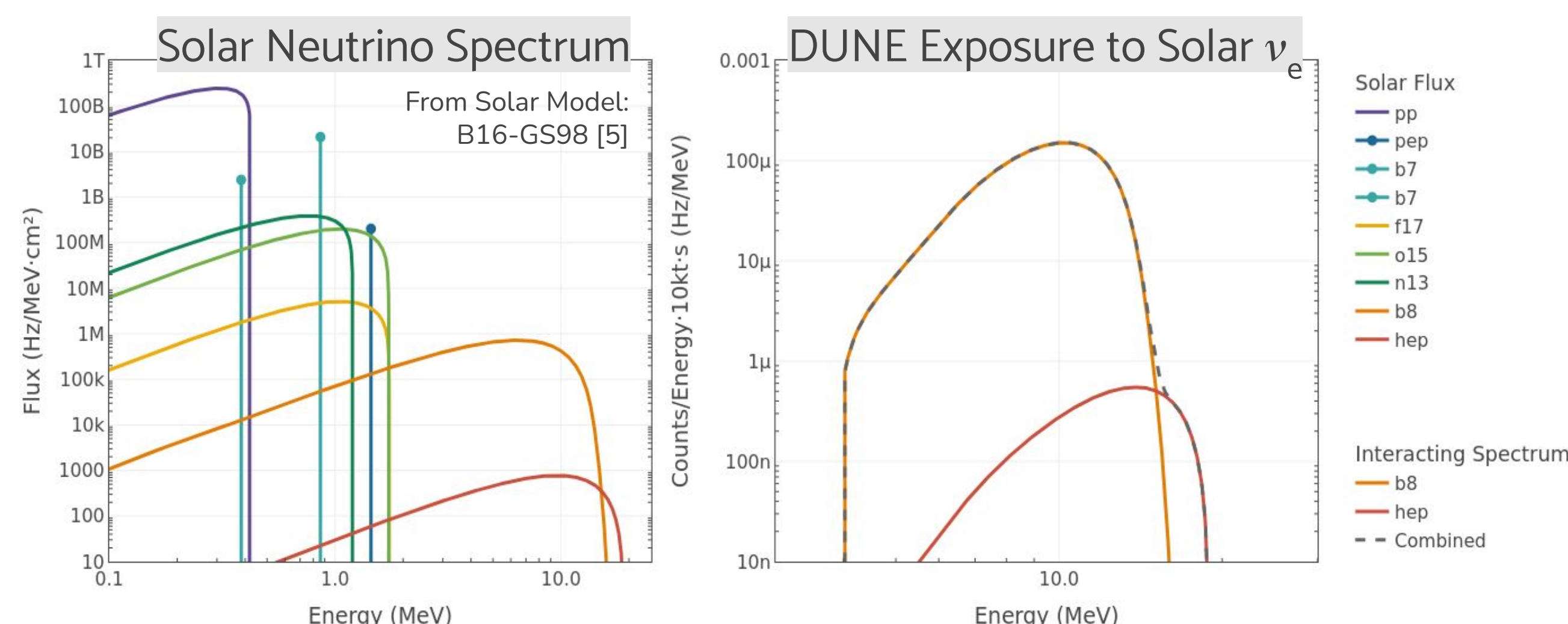
- Currently **studying full range of radiological & external backgrounds**.
- Neutrons** → Most challenging due to penetration and signal topology.
- Appropriate cut selection result in **S/B 119%** (> 10 MeV).



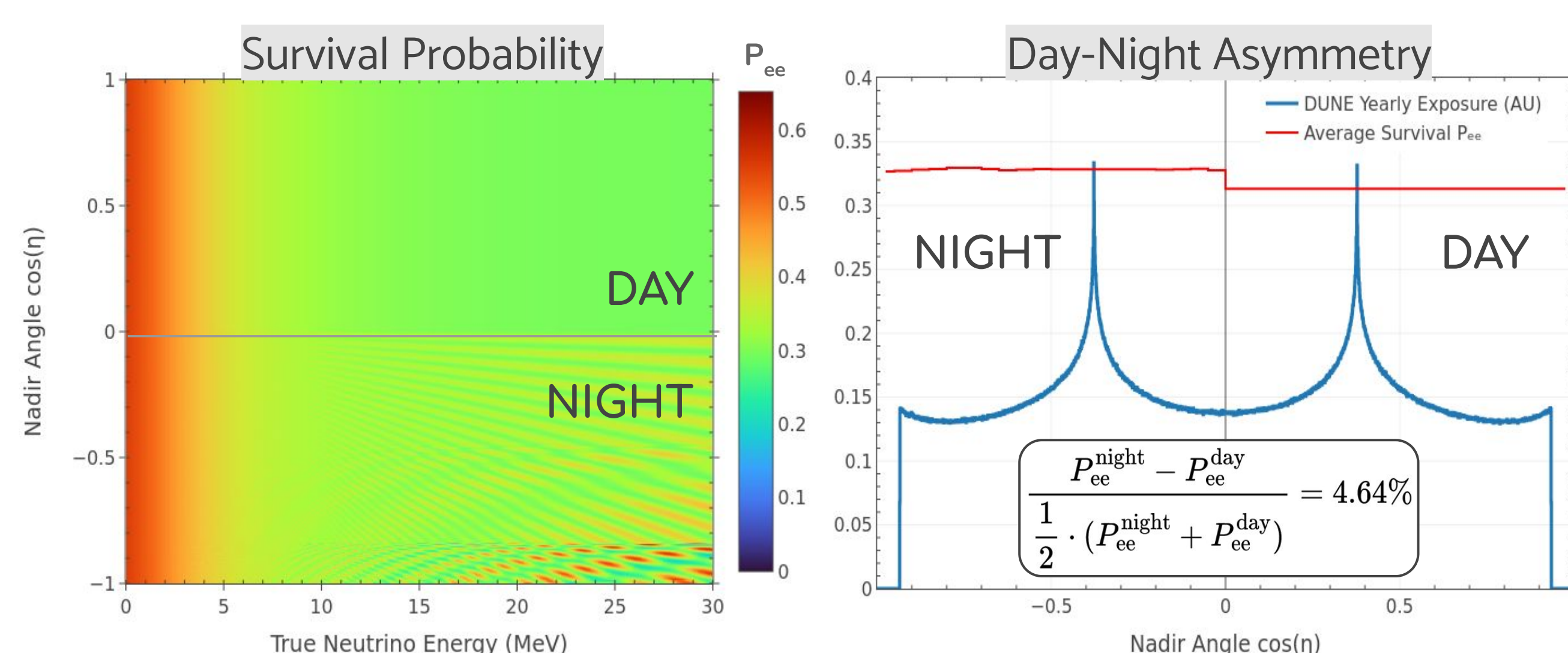
Solar Neutrinos in DUNE

- DUNE will be sensitive to solar neutrinos 1.5 - 19 MeV (⁸B + hep).
- Mostly detected from CC Ar - ν_e with x-section ~ 10⁻⁴² cm² [2].
- For 4 FD modules → **171 k CC ν_e events** per 70 kT · year exposure.

CC Interaction (Q 1.5 MeV): ν_e + $^{40}\text{Ar} \rightarrow \text{e}^- + ^{40}\text{K}^*$

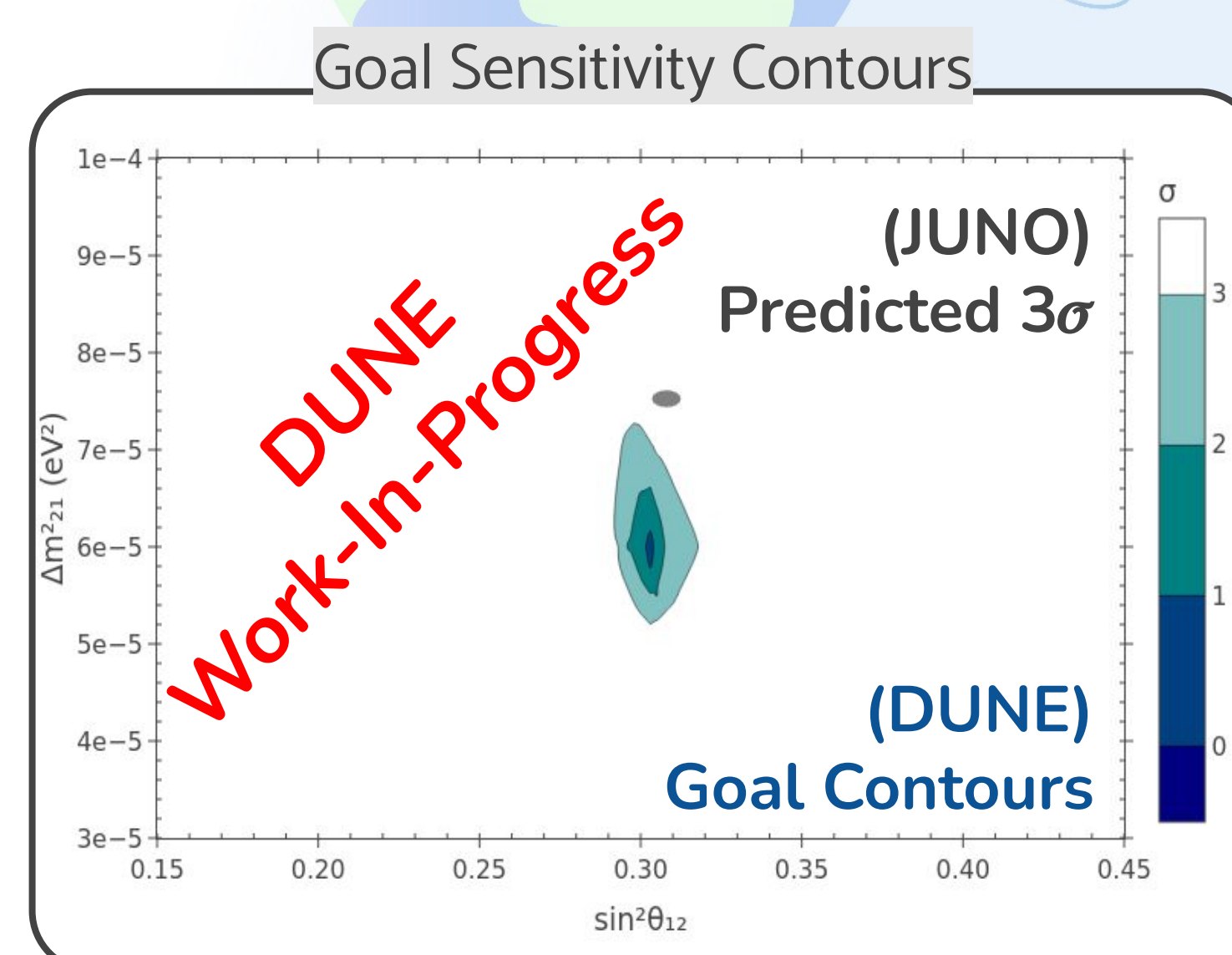


- Solar neutrinos arrive almost entirely as **ν₂ mass eigenstate** (~ 1/3 ν_e).
- Upon detection @SURF, **matter effects** (from Earth) influence the oscillation probability causing the **day / night asymmetry**.



Goal Solar Neutrino Sensitivity

- Fitting the final neutrino spectrum** (solar best fit [4]) against results from an oscillation parameter scan provides **statistical sensitivity contours**.



Assumptions:

- 100% efficient flash-matching**
 - Electron drift time correction.
 - Bkg. fiducialization.
 - Offline study**
 - Needs specific trigger.
 - FD1 layout allowing for internal **fiducialization** (2nd module).
 - Uncertainty 4 % (S) & 2 % (B).**
- Result:**
- Separation **Δm²₂₁ > 3σ** wrt. reactor measurement.

References

- [1] DUNE Collaboration, Far Detector Technical Design Report, Volume I: Introduction to DUNE, [JINST 15 \(2020\) T08008](#), [arXiv:2002.02967](#) (2020).
- [2] S. Gardiner, Simulating low-energy neutrino interactions with MARLEY, [Comput. Phys. Commun.](#), [arXiv:2101.11867](#) (2021).
- [3] E.L. Snider and G. Petrillo, [LArSoft](#): toolkit for simulation, reconstruction and analysis of liquid argon TPC neutrino detectors, [J. Phys.: Conf. Ser.](#) (2017).
- [4] Esteban, Ivan, et al. The fate of hints: updated global analysis of three-flavor neutrino oscillations. [JHEP 09 \(2020\) 178](#), [arXiv:2007.14792](#), [NuFIT 5.3 \(2024\)](#).
- [5] Vinyoles, Núria, et al. A new generation of standard solar models. [The Astrophysical Journal](#) (2017).

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