



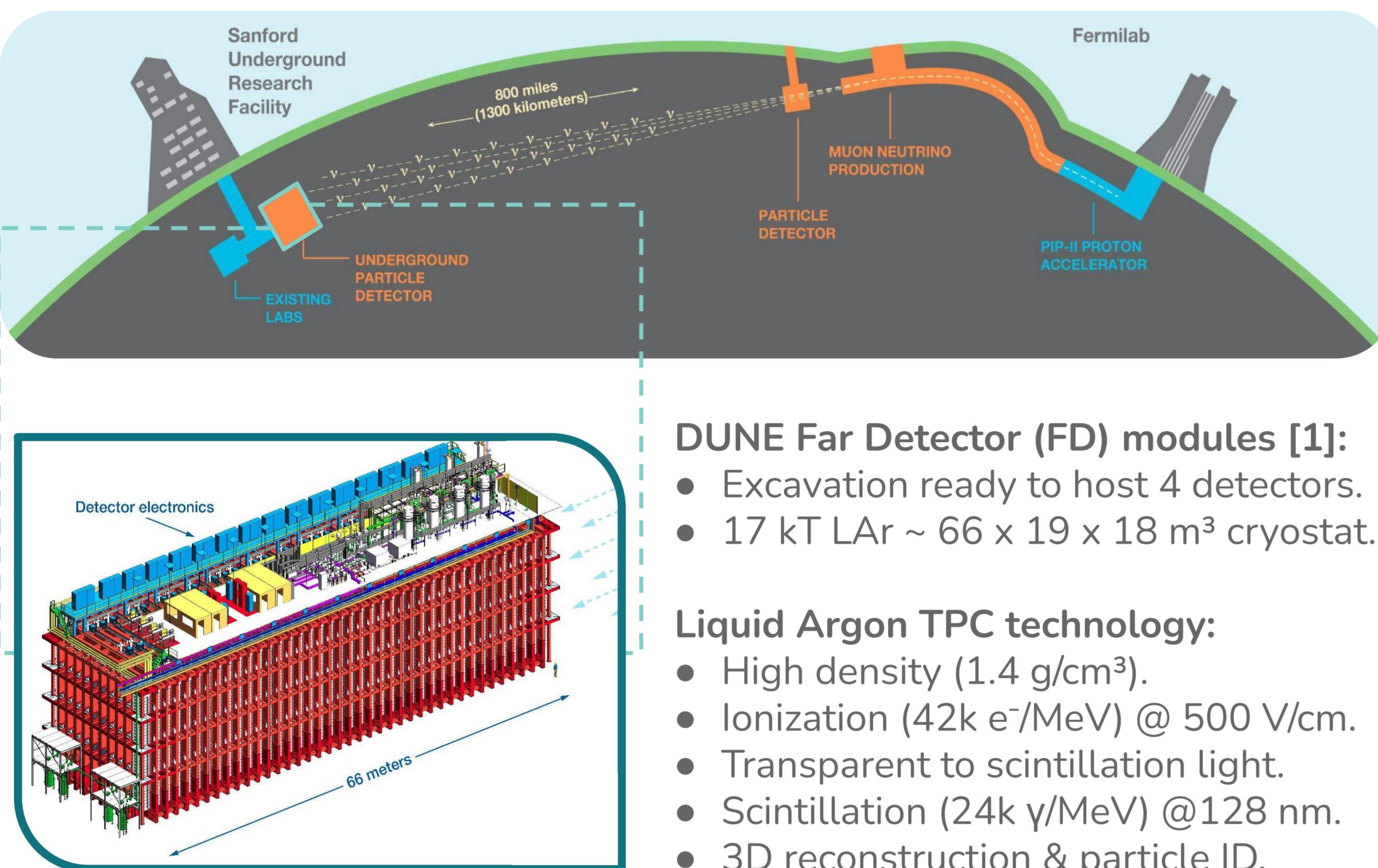
DUNE SENSITIVITY TO SOLAR NEUTRINOS



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Deep Underground Neutrino Experiment

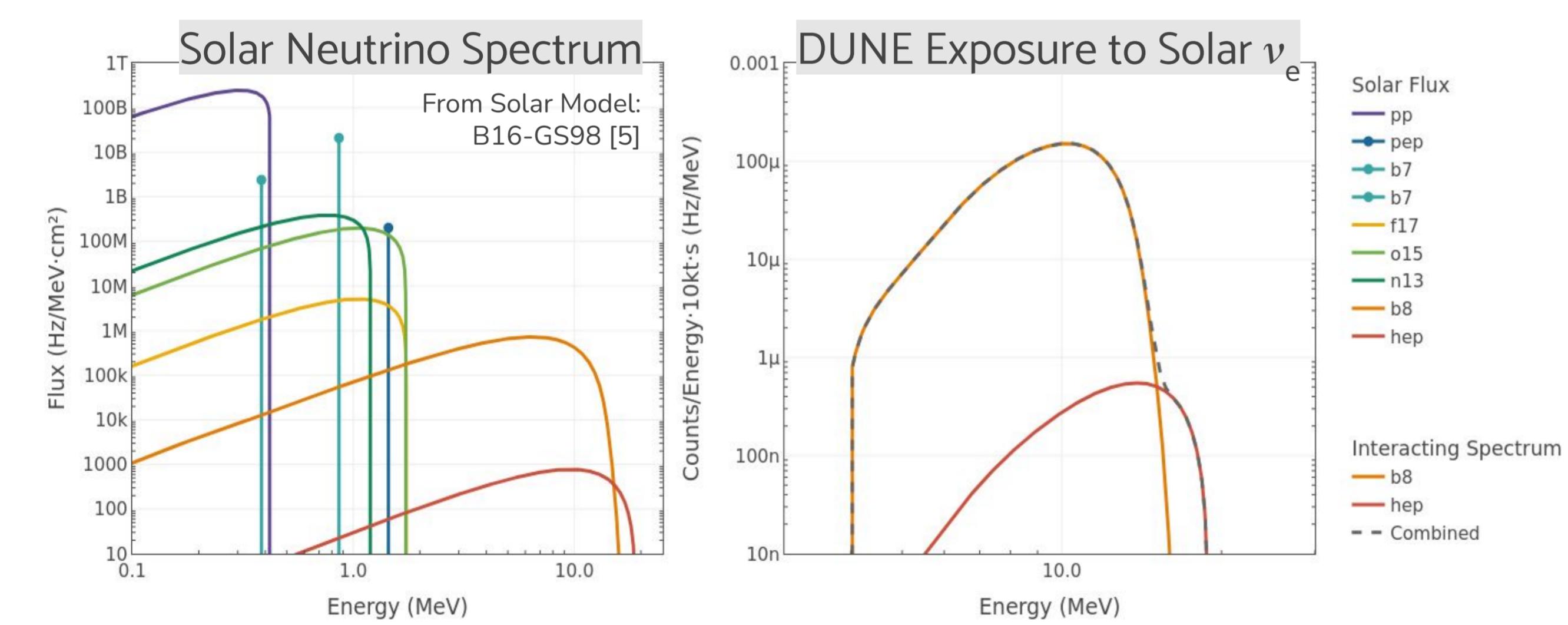
DUNE: Long-baseline neutrino oscillation experiment with a 1.2 MW beam produced at Fermilab (Illinois, USA), characterised with a **ND complex** and measured with **liquid argon detectors** at SURF (South Dakota, USA) 1.5 km underground.



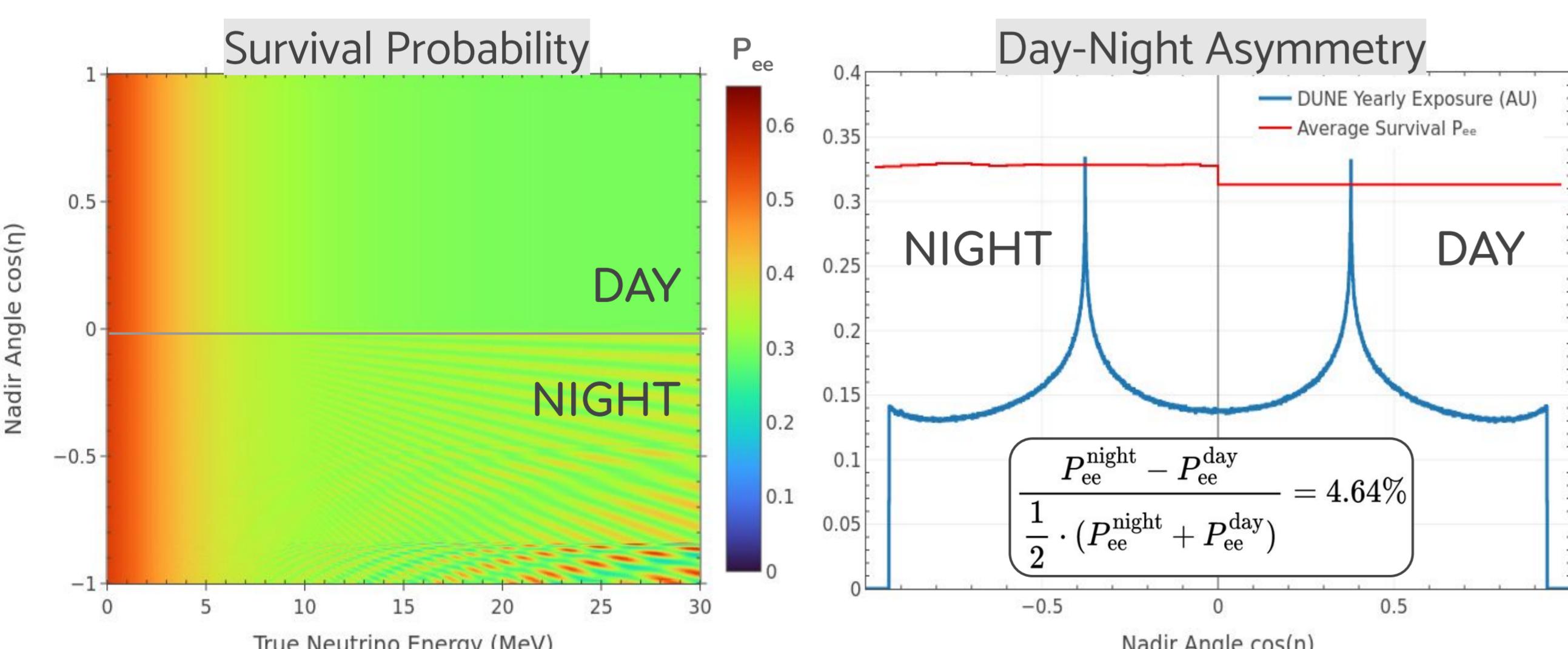
Solar Neutrinos in DUNE

- DUNE will be sensitive to solar neutrinos 1.5 - 19 MeV (⁸B + hep).
- Mostly detected from CC Ar - ν_e with x-section $\sim 10^{-42} \text{ cm}^2$ [2].
- For 4 FD modules $\rightarrow 171 \text{ k CC } \nu_e$ events per 70 kT · year exposure.

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

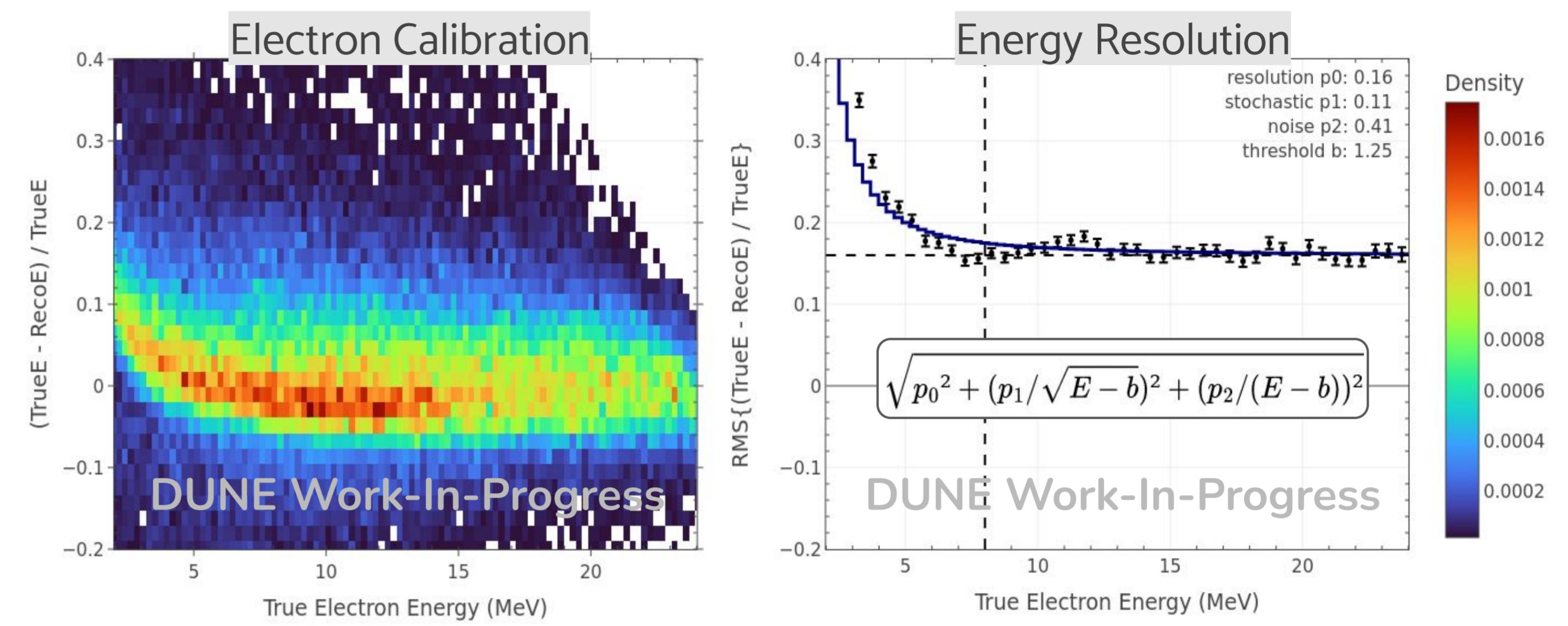


- Solar neutrinos arrive almost entirely as ν_2 mass eigenstate ($\sim \frac{1}{3} \nu_e$).
- Upon detection @SURF, **matter effects** (from Earth) influence the oscillation probability causing the day / night asymmetry.



Event Reconstruction: CC ν_e

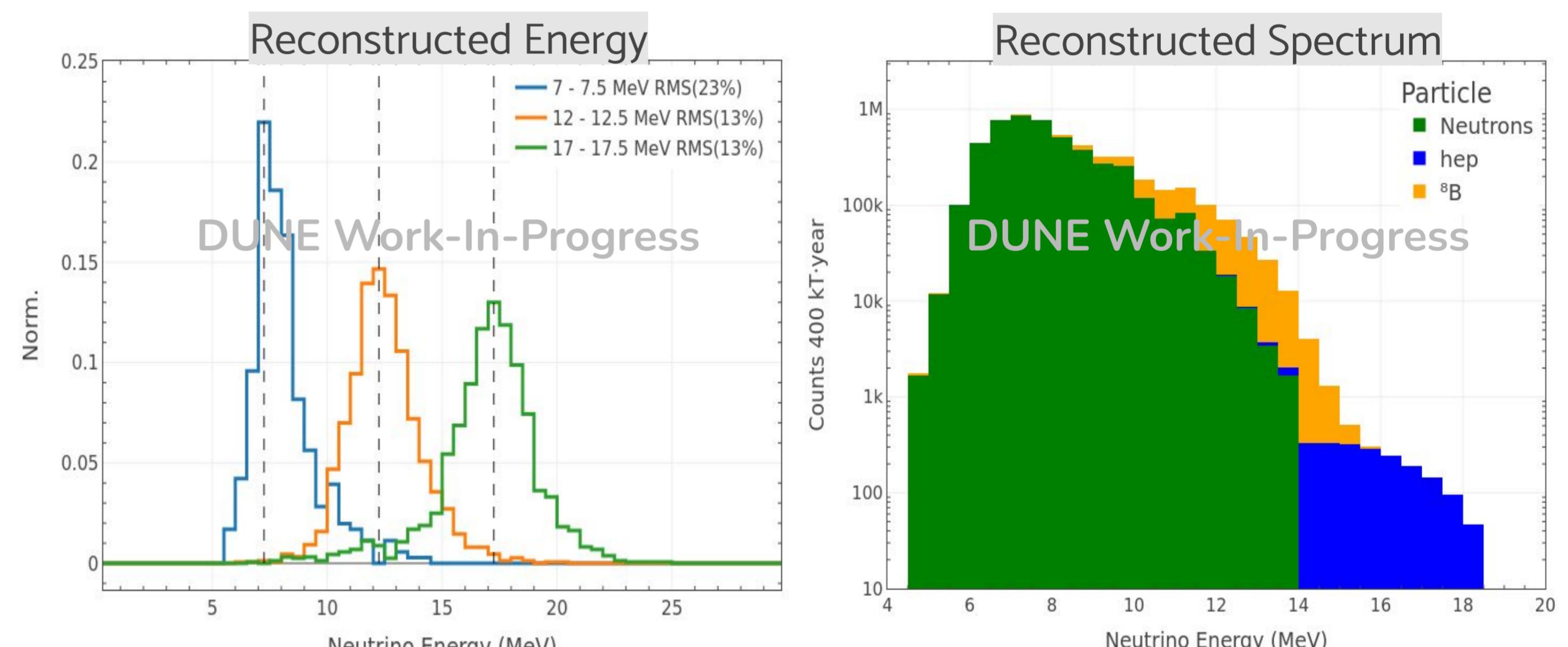
- Data from comprehensive simulation of the FD geometries and readout chain (e.g. noise, backgrounds...) using the LArSoft [3] framework.
- Reconstruction for low energy events follows a hit-clustering scheme based on channel and time proximity (3 channels - 12.5 μ s).



- Electron energy resolution $\sim 16\%$ (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.

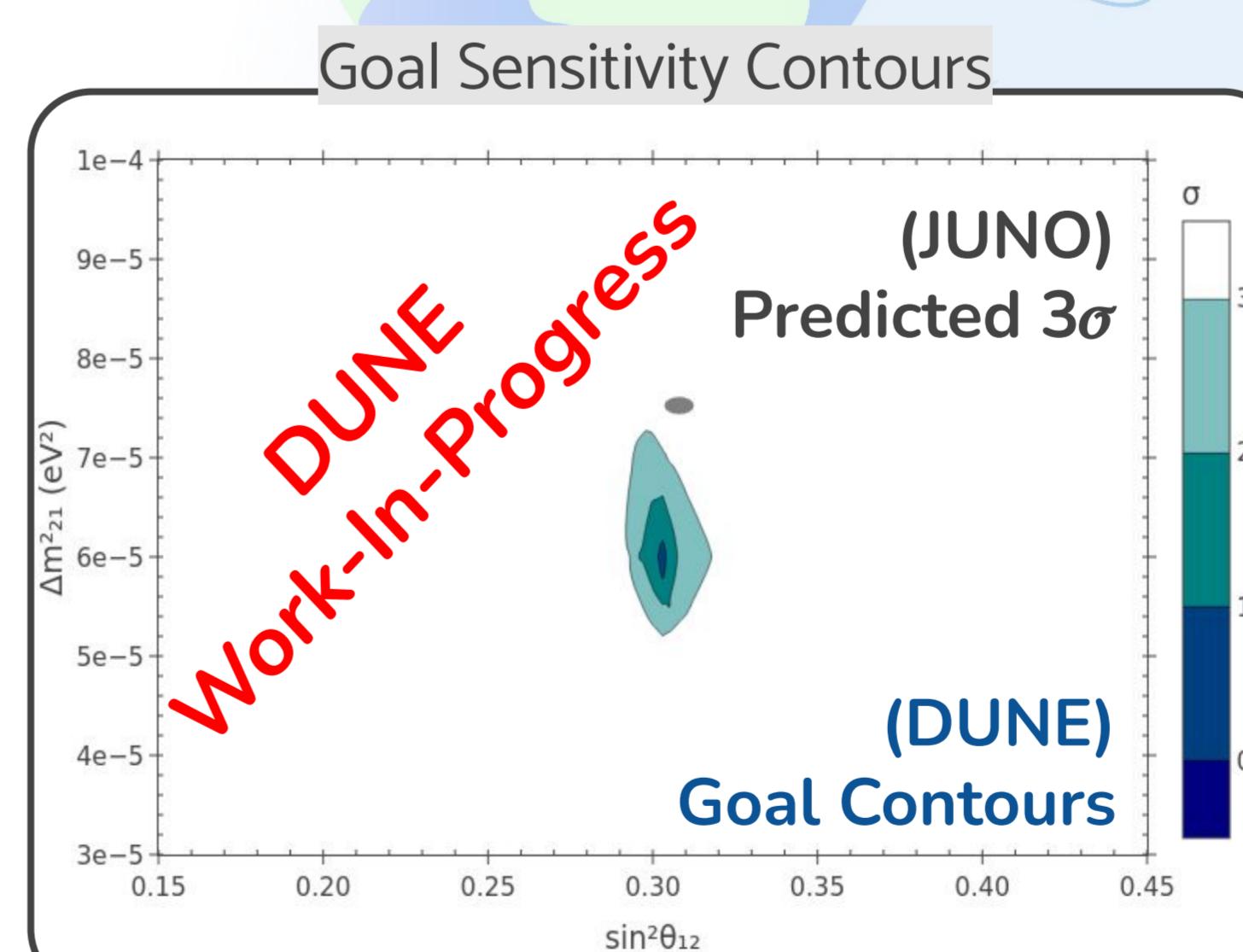
CC Interaction (nuclear deex.): ${}^{40}\text{Ar} \rightarrow {}^{40}\text{K}^* \rightarrow {}^{40}\text{K} + \gamma (+ \text{N} \cdot \gamma)$

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



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 \rightarrow Needs specific trigger.
- FD1 layout allowing for internal fiducialization (2nd module).
- Uncertainty 4% (S) & 2% (B).

Result:

- Separation $\Delta m_{21}^2 > 3\sigma$ wrt. reactor measurement.

References

- [1] DUNE Collaboration, Far Detector Technical Design Report, Volume I: Introduction to DUNE, *JINST* 15 (2020) T08008, [arXiv:2002.02967](https://arxiv.org/abs/2002.02967) (2020).
- [2] S. Gardiner, Simulating low-energy neutrino interactions with MARLEY, *Comput. Phys. Commun.*, [arXiv:2101.11867](https://arxiv.org/abs/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](https://arxiv.org/abs/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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