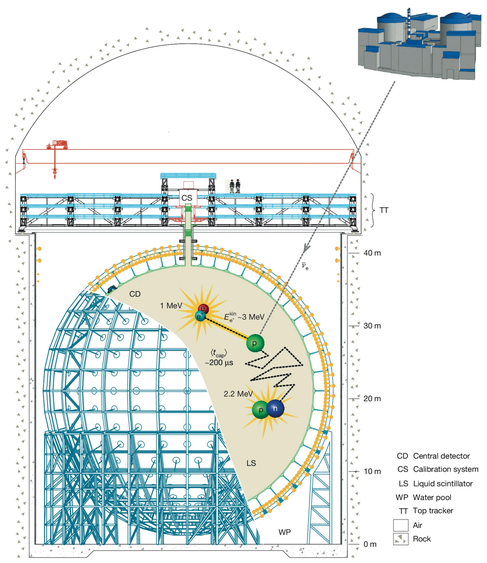
Search for Diffuse Supernova Neutrino Background with JUNO

Geraint Clash, on behalf of the JUNO Collaboration
Institute of High Energy Physics, Chinese Academy of Sciences

NEUTRINO '26 — International Conference on Neutrino Physics and Astrophysics — June 22nd - 26th, 2026 — UCI Department of Physics & Astronomy

DSNB search and event selection

The Diffuse Supernova Neutrino Background (DSNB) is the accumulated neutrino flux from all past core-collapse supernovae.



JUNO at a glance

- 20-kton liquid scintillator (LS) detector.
- 52.5 km from the Yangjiang and Taishan reactor cores.
- About 700 m underground.
- 17,596 20-inch and 25,587 3-inch PMTs; 78% geometrical coverage.

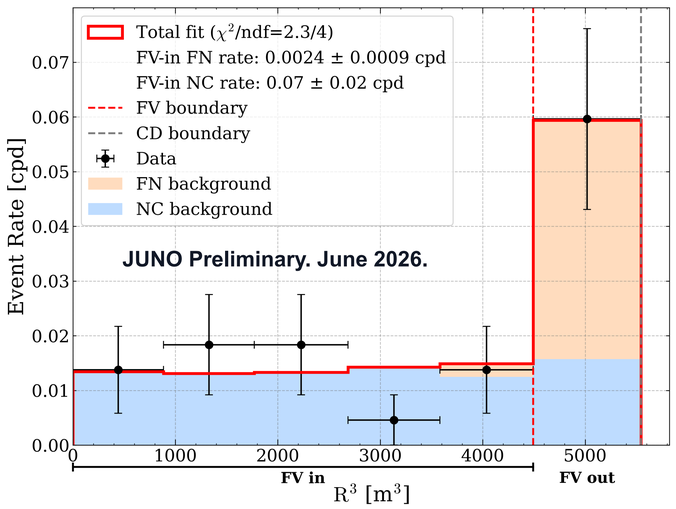
Inverse beta decay (IBD)

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

- Prompt positron followed by delayed neutron capture on hydrogen.
- DSNB candidates are selected with the prompt-delayed coincidence [1].

Fast-neutron (FN) rate estimate

The FN normalization is constrained directly from data using the edge-enhanced R^3 distribution.

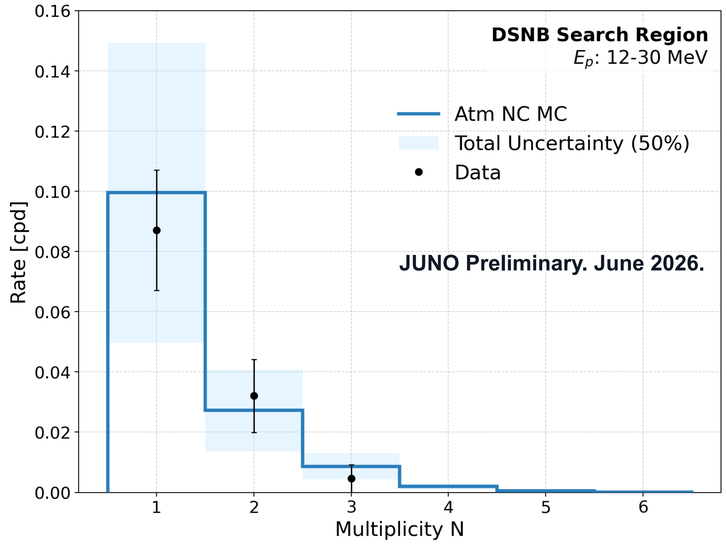


Template fit to the R^3 distribution in the 12–30 MeV region.

- Fast neutrons concentrate near the detector edge.
- Fast-neutron (FN) template: WP-only neutron data control sample.
- Fit performed after removing the fiducial-volume requirement.
- Fitted FN rate: 0.0024 ± 0.0009 cpd.

Background checks

Atmospheric-neutrino neutral-current (NC) interactions dominate the present DSNB background [2].



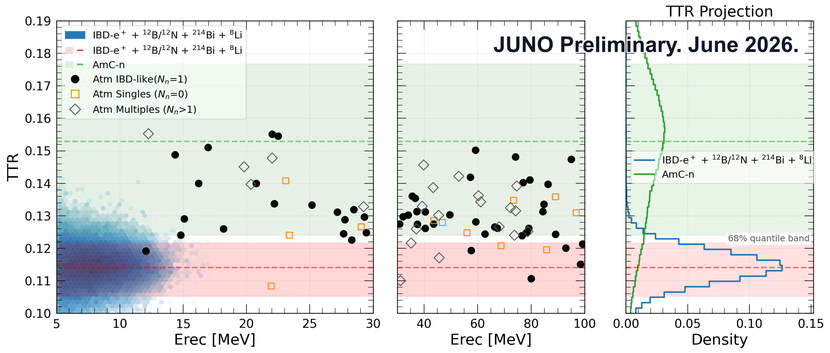
Neutron multiplicity after relaxing the nominal one-neutron requirement.

- Atmospheric-NC interactions can produce multiple neutrons in the final state, providing a validation region for background modeling.
- The nominal NC rate is taken from the bin-by-bin average of five dedicated MC model predictions from GENIE 3.4.2 [3] and NuWro 21.09 [4].
- The observed multiplicity distribution is consistent with the NC MC within uncertainty.

Pulse-shape discrimination (PSD) exploits particle-dependent differences in LS scintillation time profiles [5]. Here, PSD is evaluated using the Tail-to-Total Ratio (TTR):

$$\mathrm{TTR} = \frac{Q_{\mathrm{tail}}}{Q_{\mathrm{total}}}$$

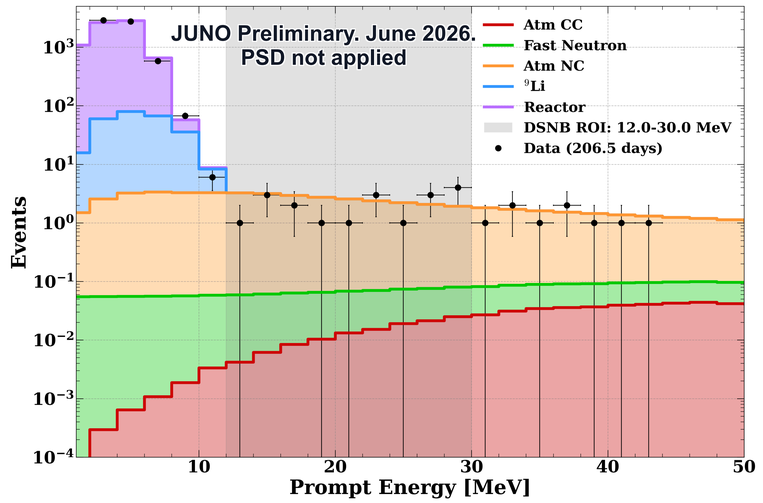
Q denotes the integral of the charge-weighted time profile after dark-noise subtraction.



Comparison of TTR distributions for different data samples.

- Candidates and atmospheric-neutrino samples have larger TTR, consistent with NC-like backgrounds.
- PSD is used as a cross-check in the current analysis and shows potential for further background rejection.

Energy spectrum and flux limits

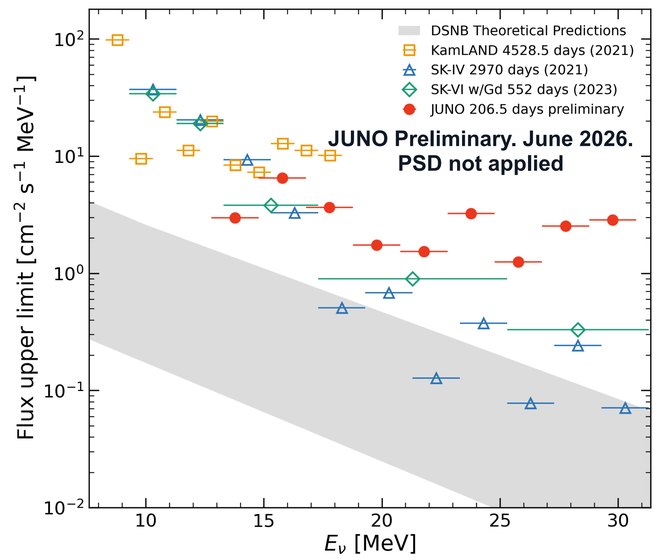


Prompt-energy spectrum; the shaded band marks the DSNB search region.

- 12–30 MeV window: 19 candidates with 206.5-day exposure.
- Total predicted background: 21.3 ± 10.5 events.

$$\phi_{90} = \frac{N_{90}}{N_p \cdot \sigma \cdot \epsilon_{\mathrm{IBD}} \cdot T},$$

N_{90}: Feldman-Cousins 90% C.L. signal-event limit
N_p: target protons
σ: IBD cross section
ϵ_{IBD}: efficiency
T: exposure



Model-independent 90% C.L. upper limits on the DSNB $\bar{\nu}_e$ flux, compared with SK-IV [6], KamLAND [7], SK-IV-Gd [8] and representative DSNB predictions.

References:
[1] JUNO Collaboration, JCAP 2022(10), 033 (2022).
[2] J. Cheng et al., Eur. Phys. J. C 85, 295 (2025).
[3] C. Andreopoulos et al., Nucl. Instrum. Meth. A 614, 87 (2010).
[4] T. Golan et al., Nucl. Phys. B Proc. Suppl. 229-232, 499 (2012).
[5] J. Cheng et al., Eur. Phys. J. C 84, 482 (2024).
[6] K. Abe et al., Phys. Rev. D 104, 122002 (2021).
[7] S. Abe et al., Astrophys. J. 925, 14 (2022).
[8] M. Harada et al., Astrophys. J. Lett. 951, L27 (2023).