中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

Review of solar neutrino in 2028

Xue-Feng DING

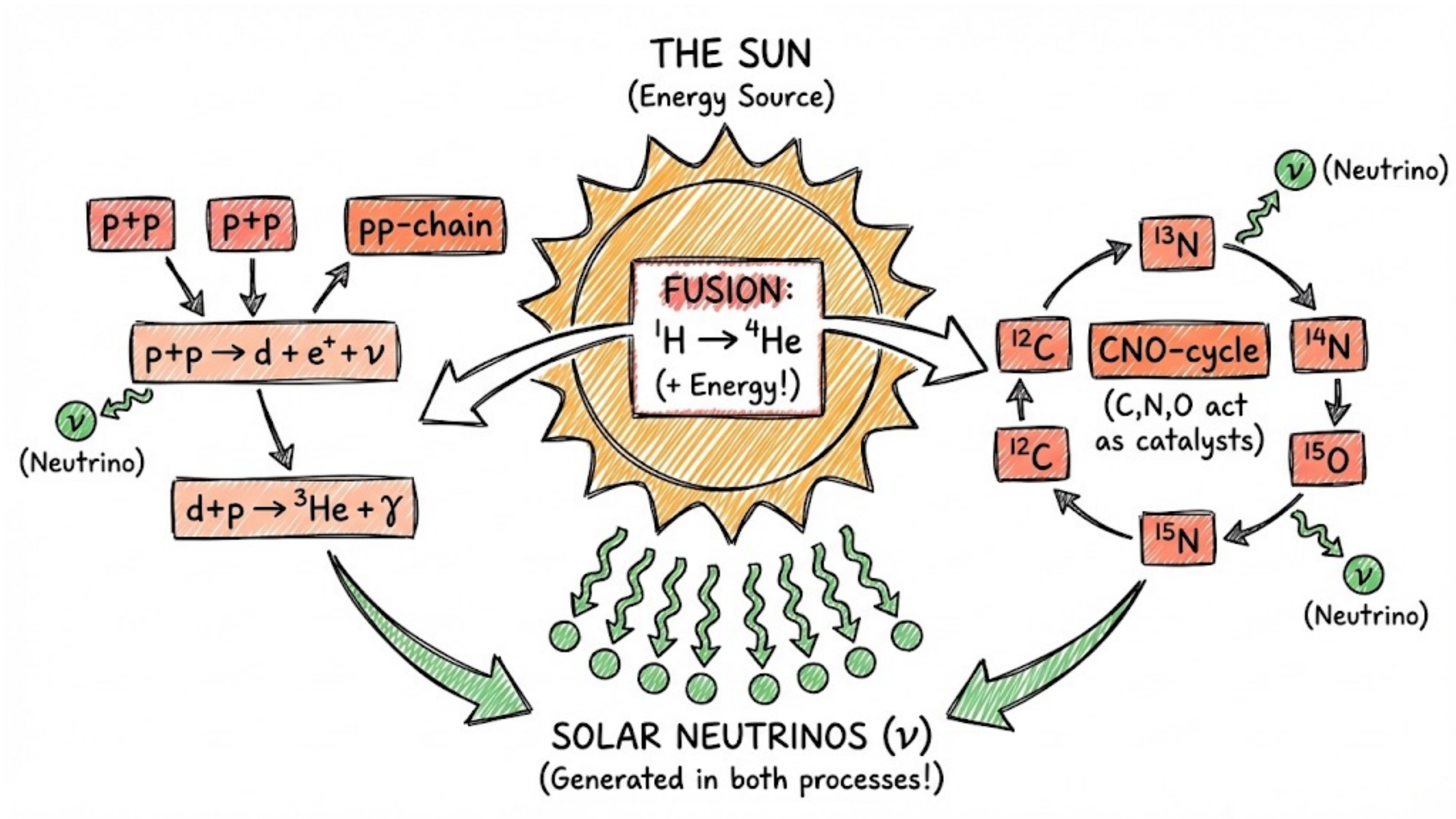
IHEP, CAS

2026 January 28th

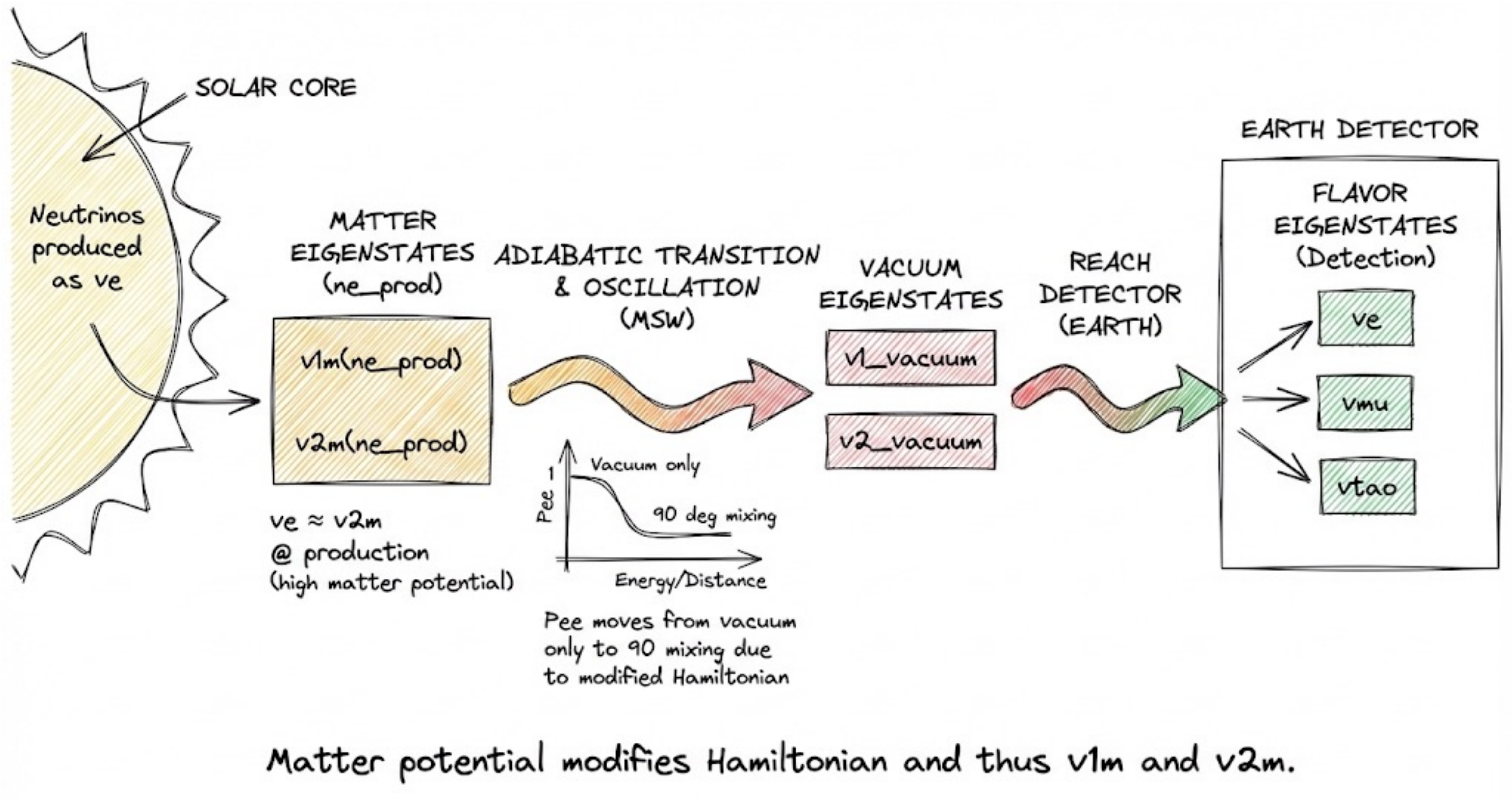
Outline

- Introduction
- Standard solar model
- Neutrino oscillation
- Conclusions

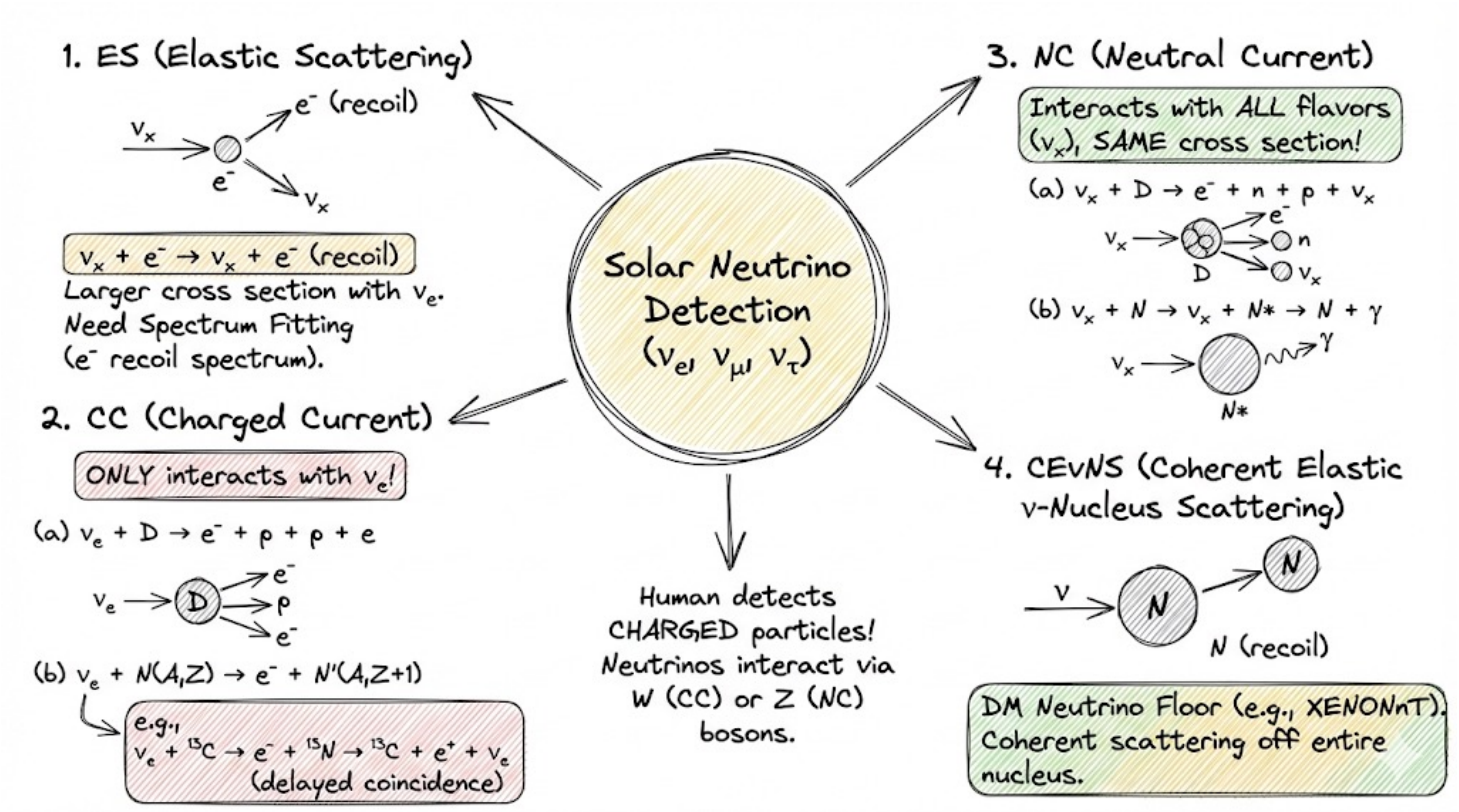
Energy production in the SUN



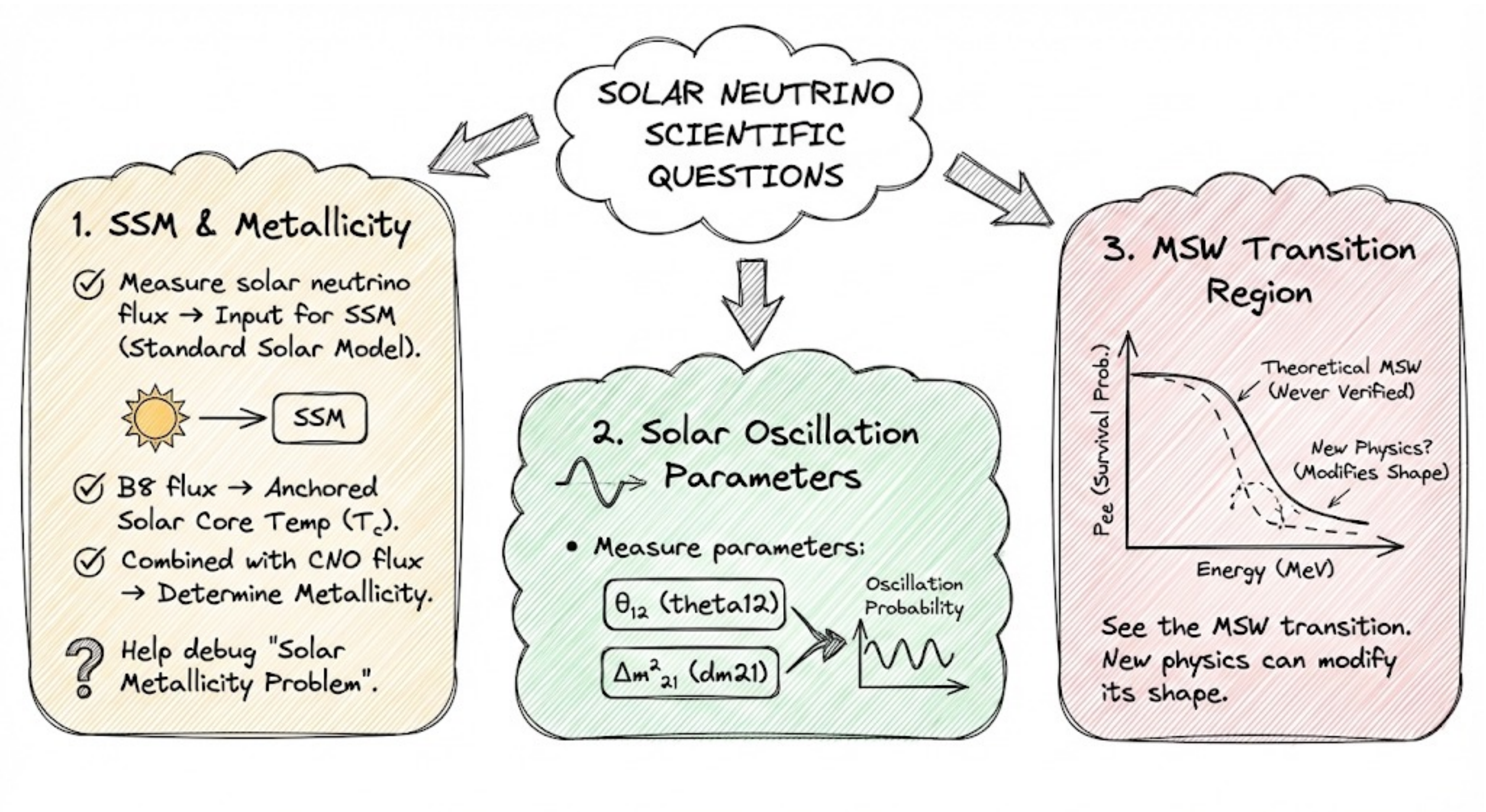
Adiabatic transition: no oscillation



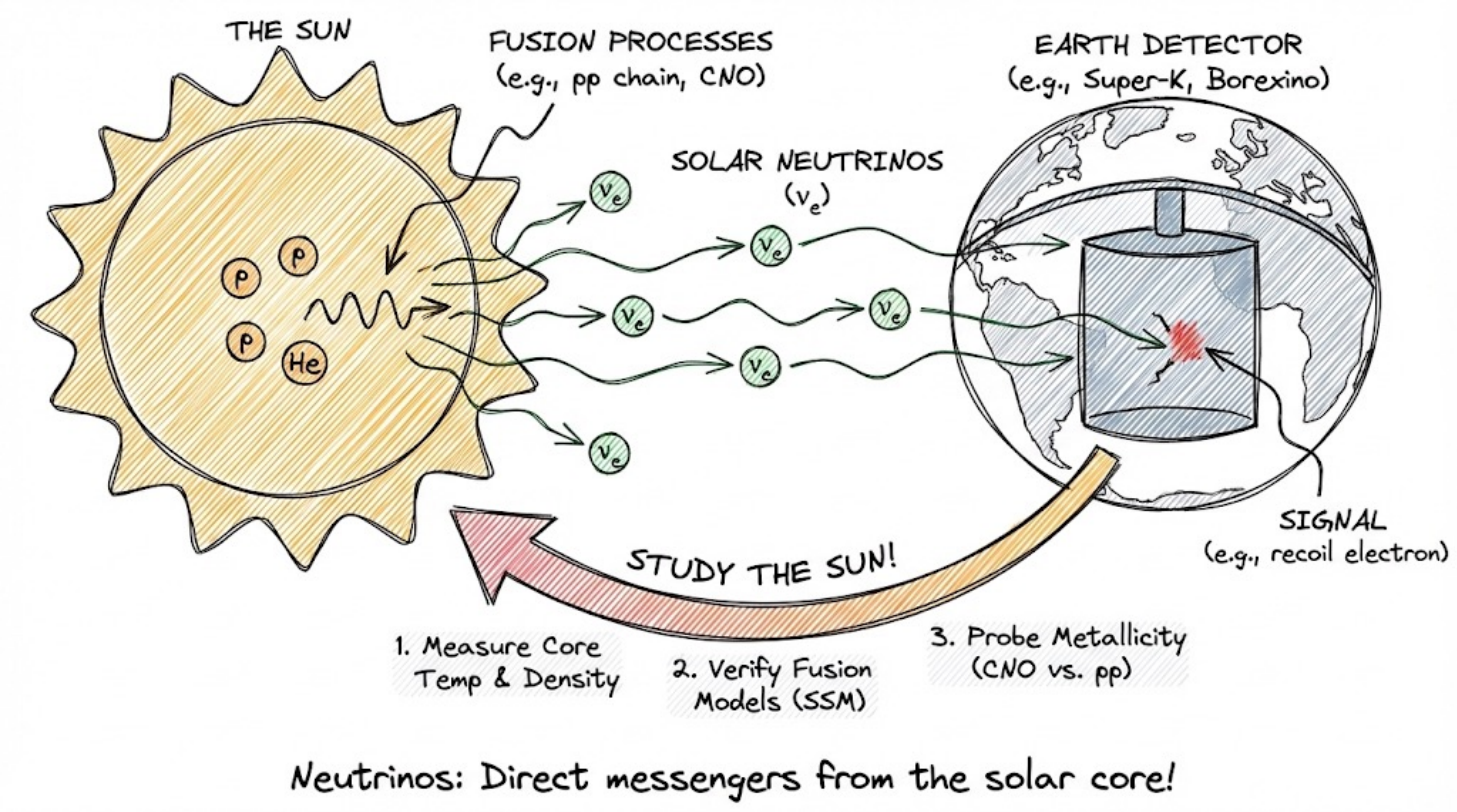
Detection of solar neutrino



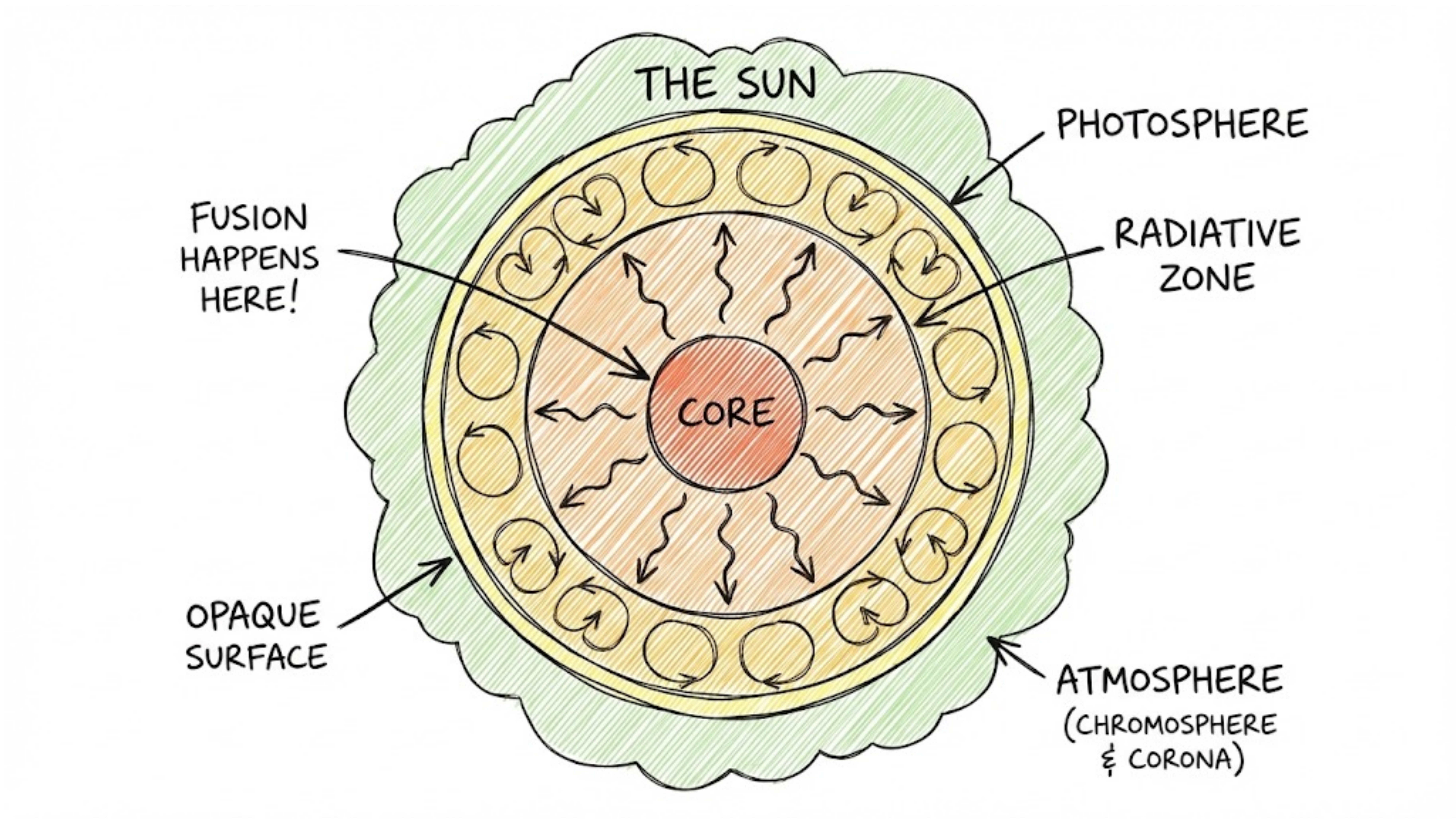
Scientific question of solar ν



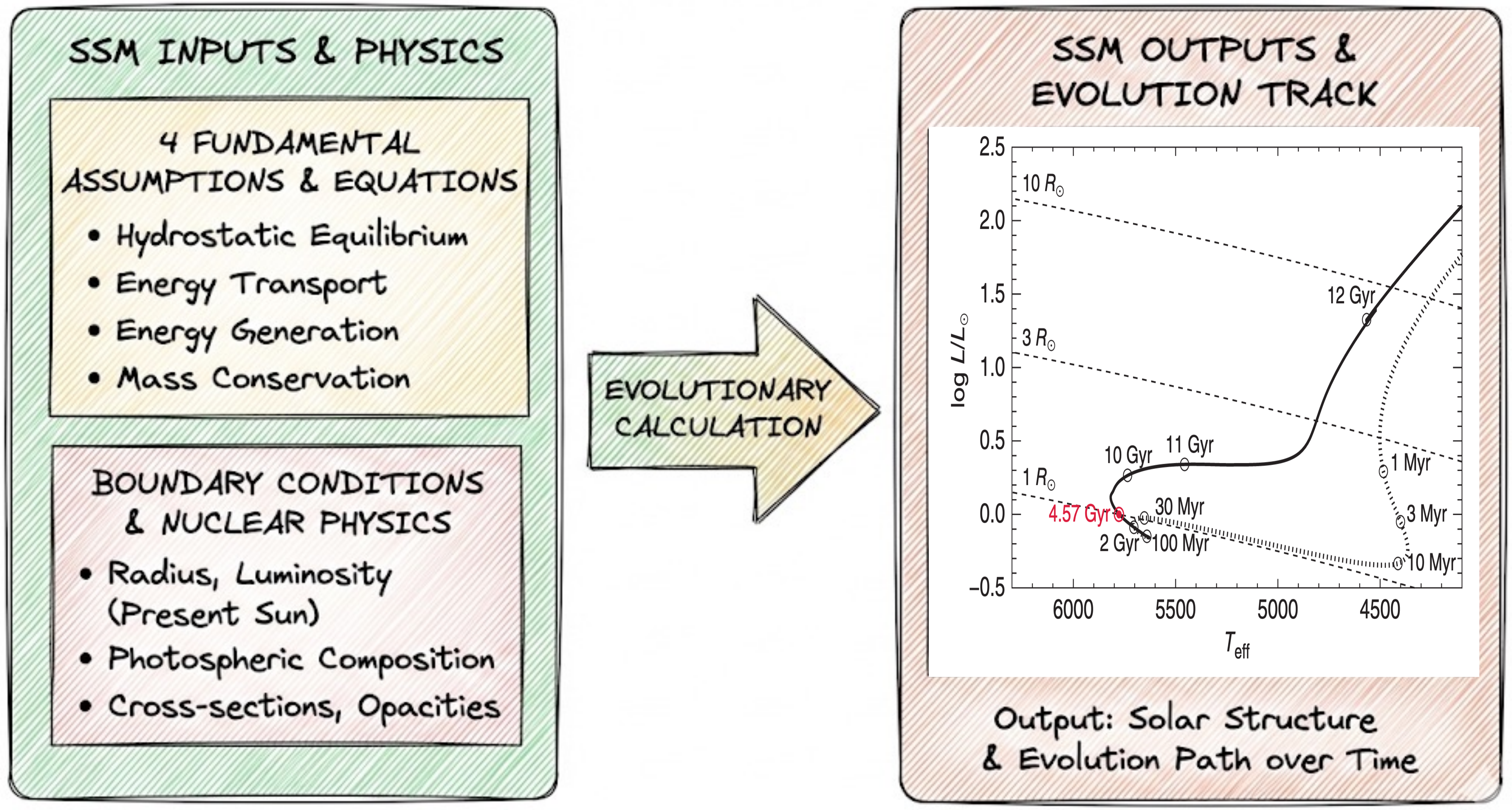
Part 1: study the Sun



The Sun

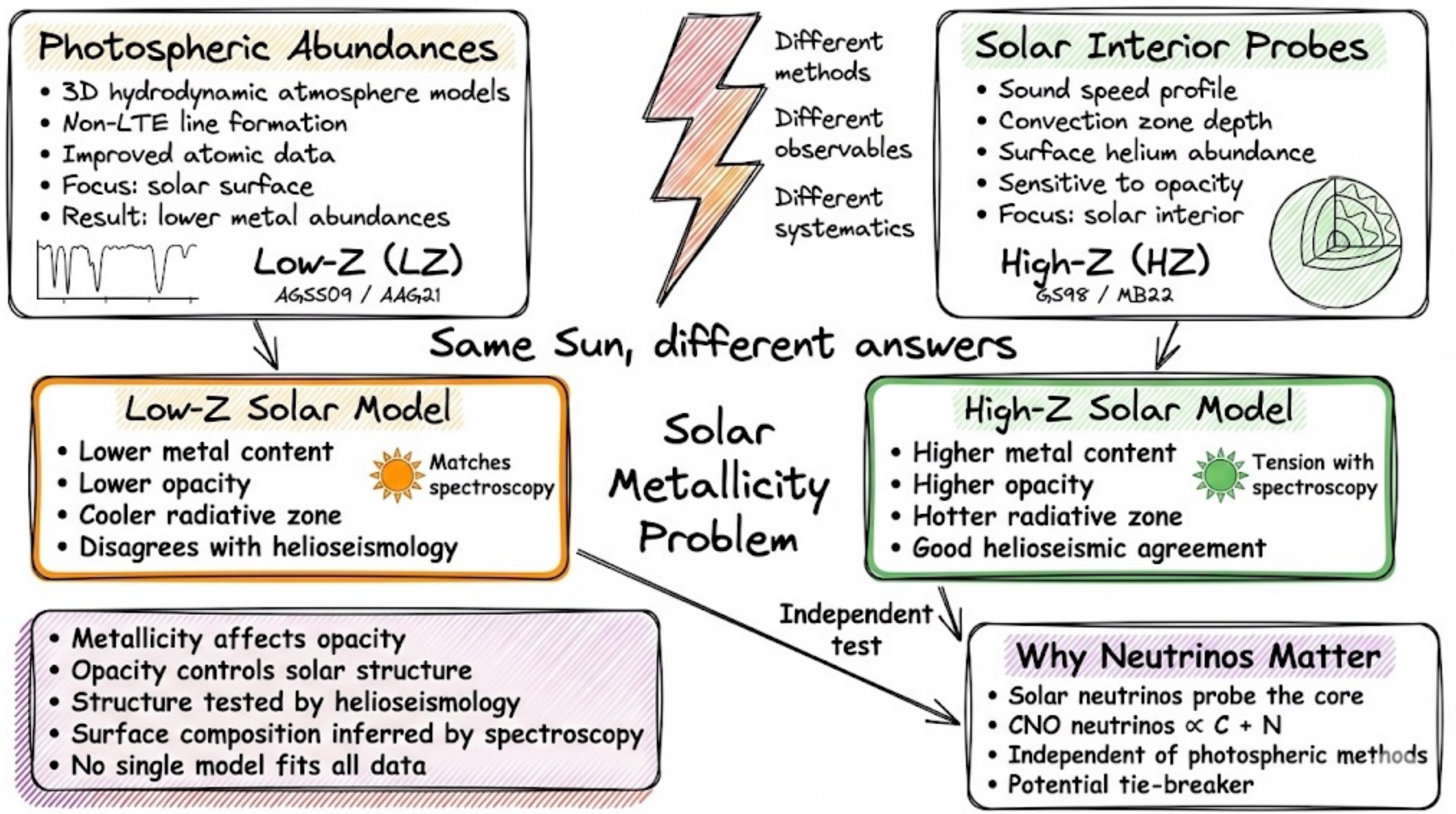

THE SUN
PHOTOSPHERE
FUSION HAPPENS HERE!
RADIATIVE ZONE
CORE
OPAQUE SURFACE
ATMOSPHERE (CHROMOSPHERE & CORONA)

Standard Solar Model

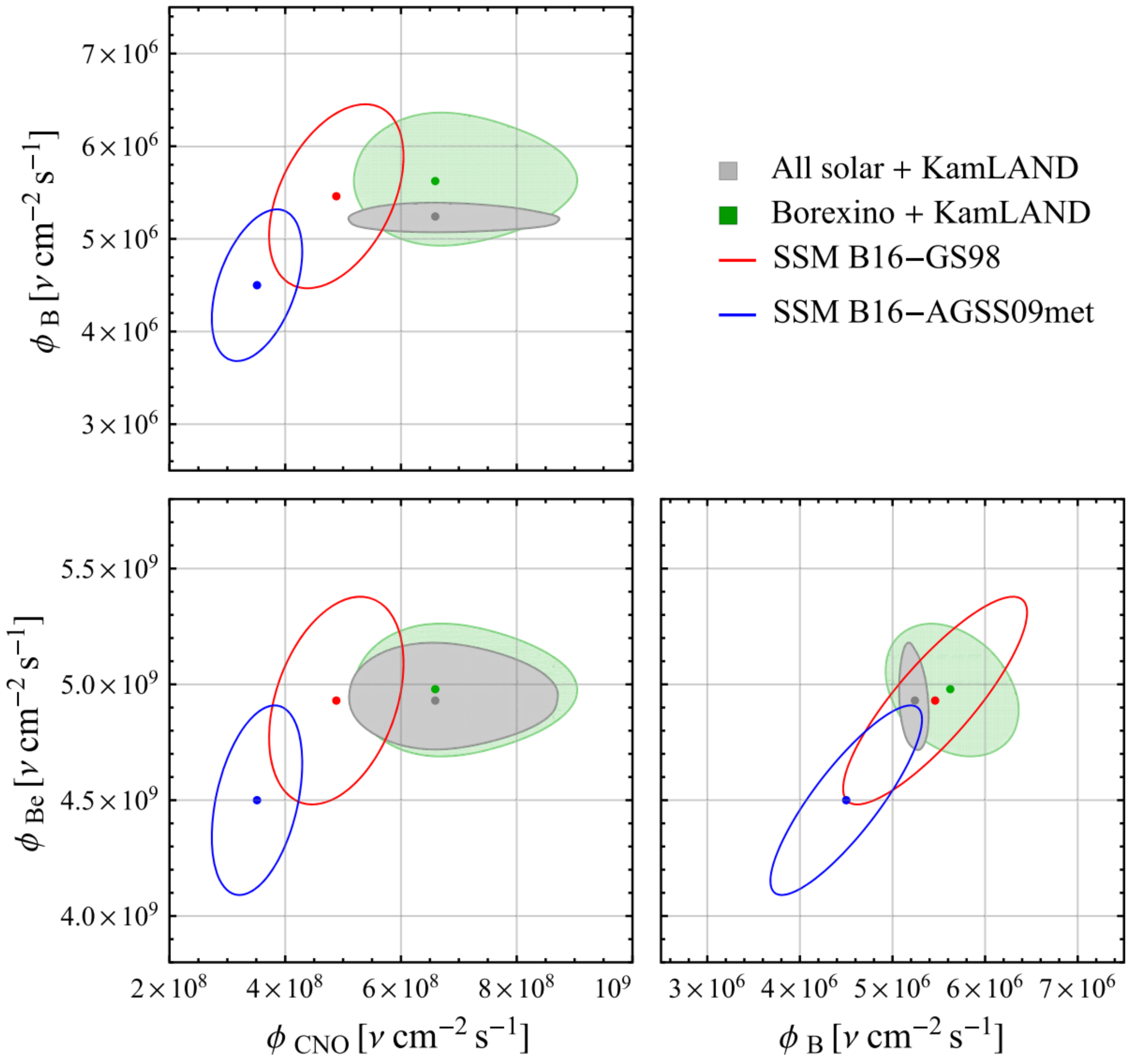


Oberauer, Lothar, Aldo Ianni, and Aldo Serenelli. *Solar Neutrino Physics*. Wiley, 2020. https://doi.org/10.1002/9783527412723.

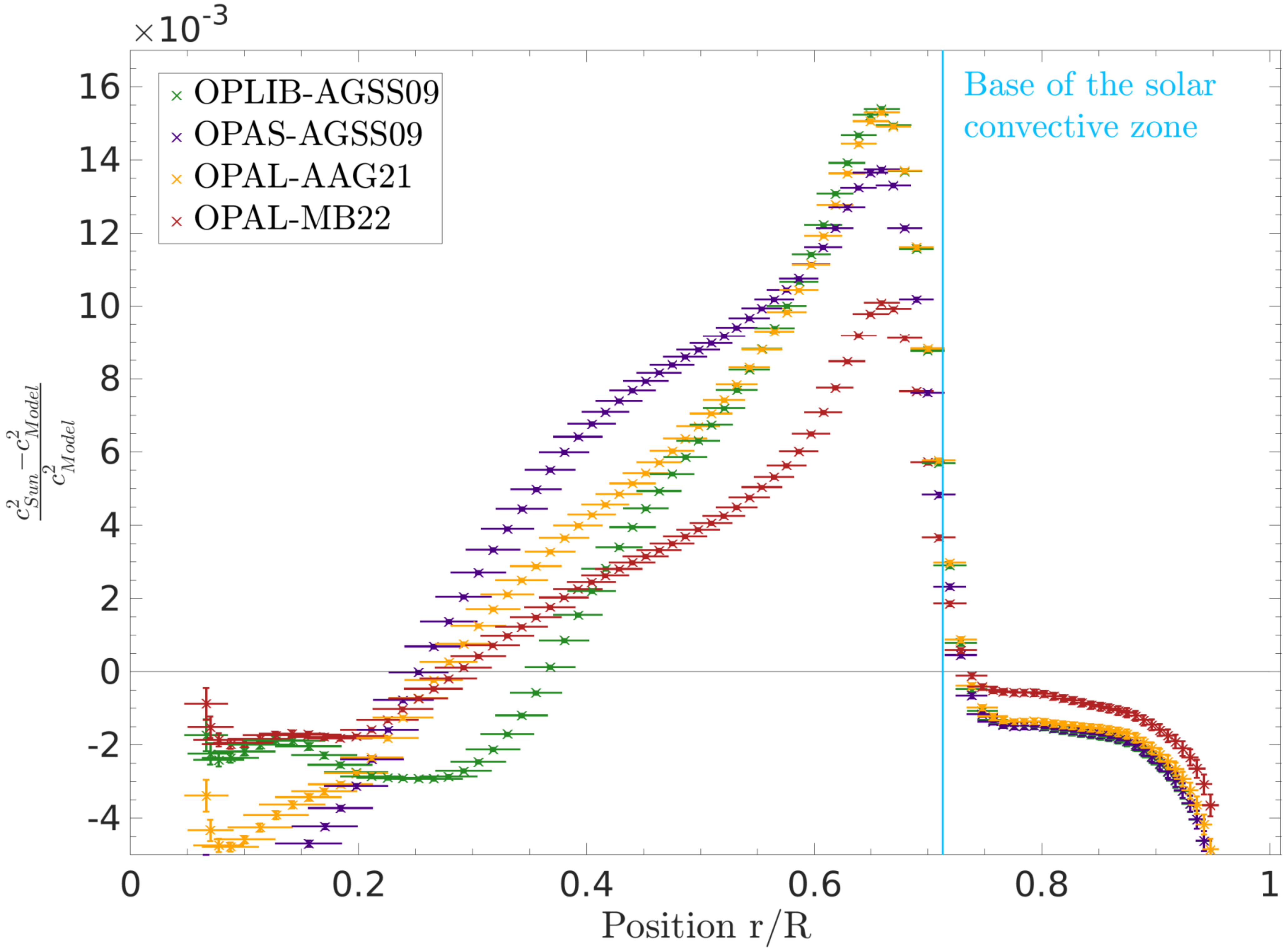
Photosphere vs Helioseismology



Solar metallicity problem

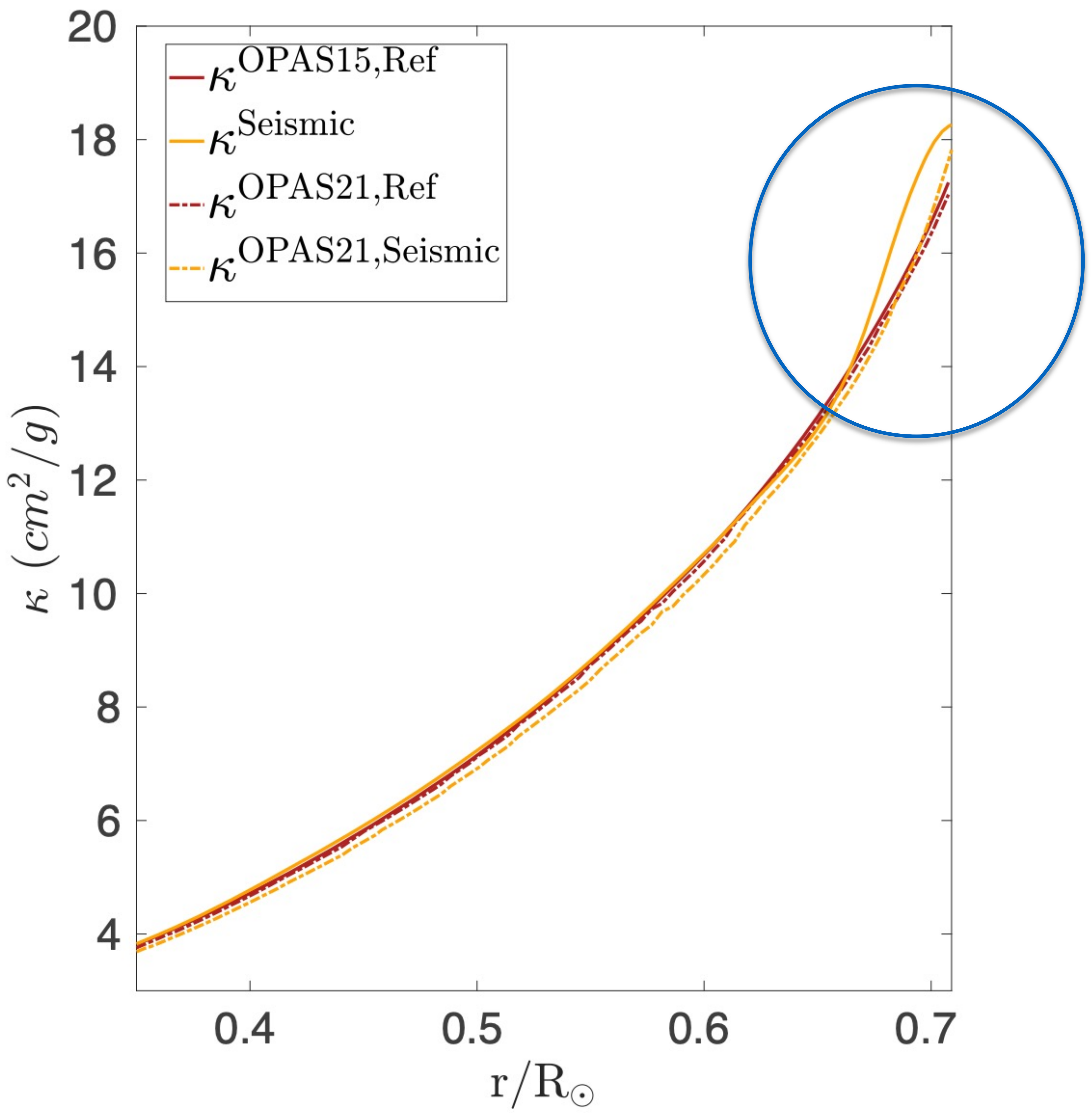


Appel, S., Z. Bagdasarian, D. Basilico, et al. "Improved Measurement of Solar Neutrinos from the Carbon-Nitrogen-Oxygen Cycle by Borexino and Its Implications for the Standard Solar Model." *Physical Review Letters* 129, no. 25 (2022): 252701. https://doi.org/10.1103/PhysRevLett.129.252701.

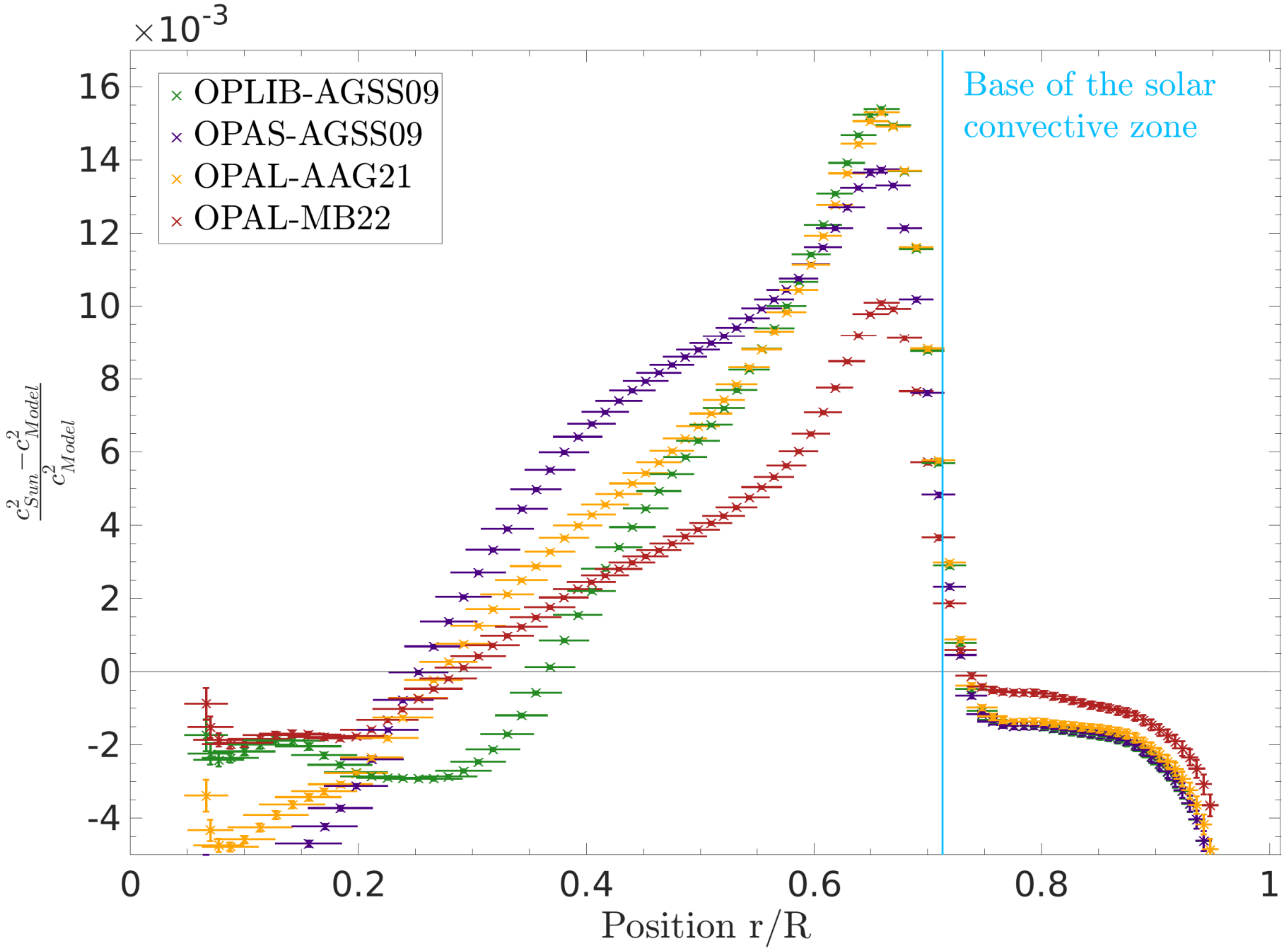


Buldgen, Gael, Gloria Canocchi, Arthur Le Saux, et al. "The Future of Solar Modelling: Requirements for a New Generation of Solar Models." arXiv:2506.14514. Preprint, arXiv, June 17, 2025. https://doi.org/10.48550/arXiv.2506.14514.

What next? Opacity

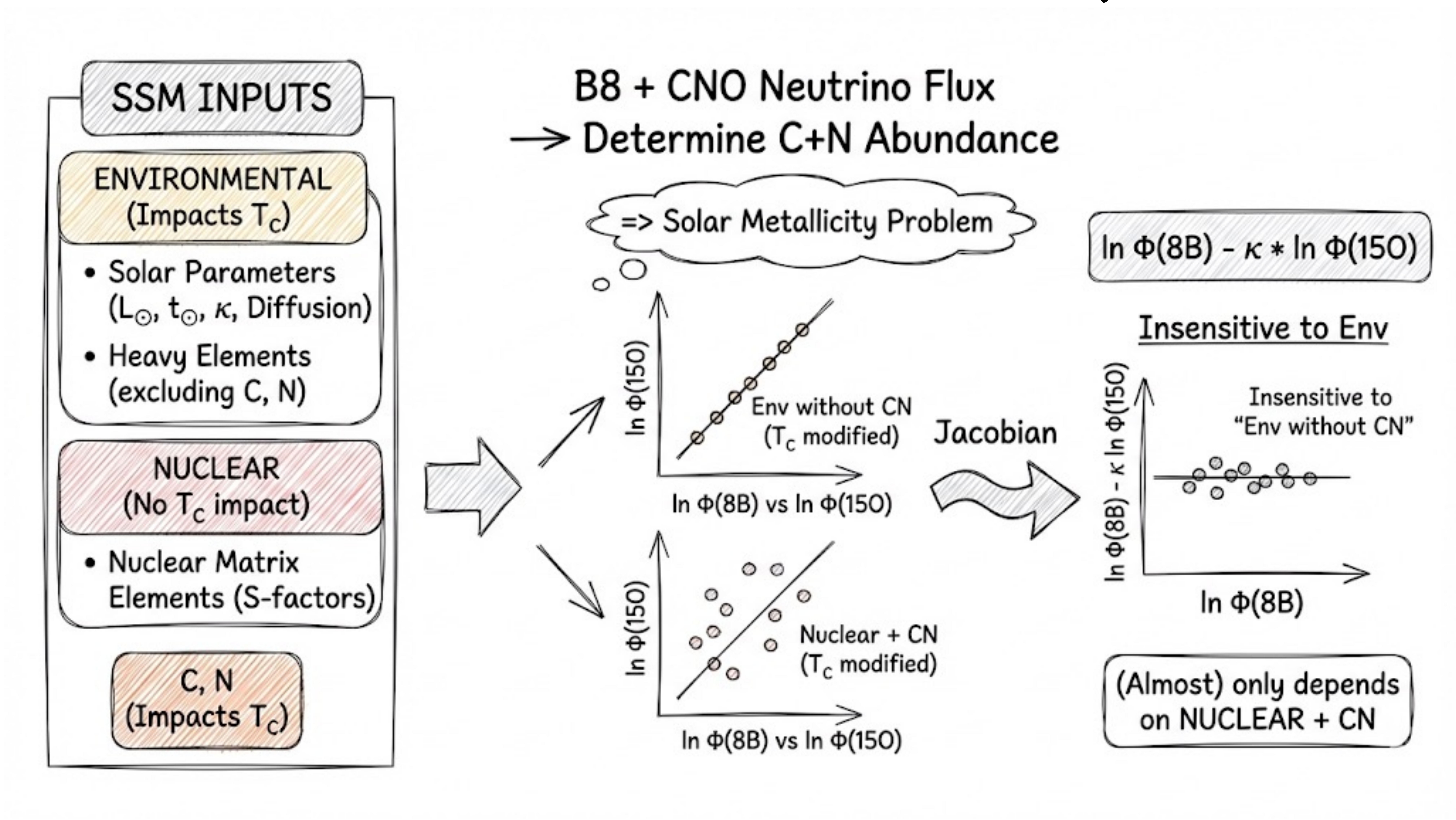


Buldgen, Gaël, Jean-Christophe Pain, Philippe Cossé, et al. “Helioseismic Inference of the Solar Radiative Opacity.” *Nature Communications* 16, no. 1 (2025): 693. https://doi.org/10.1038/s41467-024-54793-y.

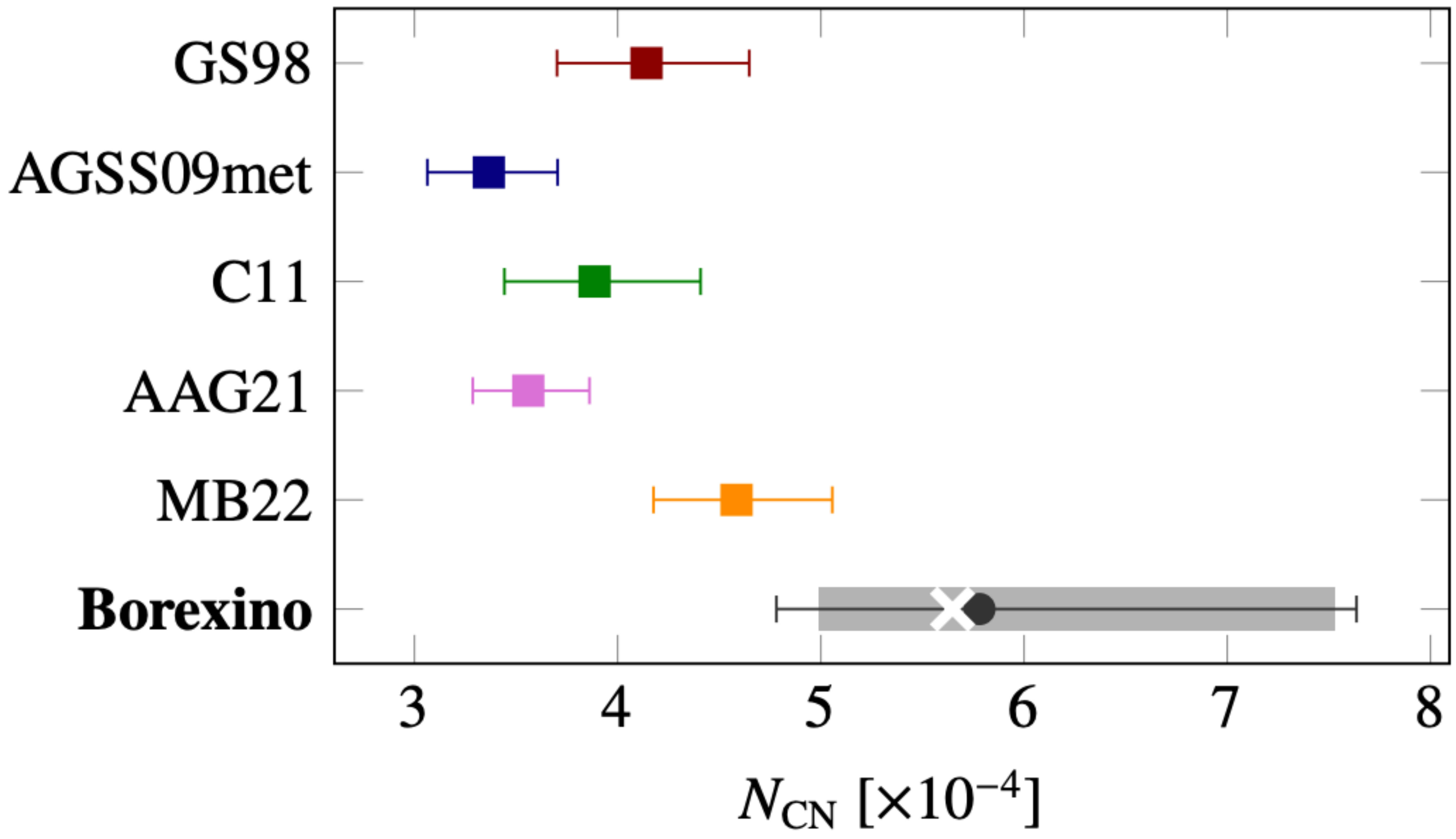


Buldgen, Gael, Gloria Canocchi, Arthur Le Saux, et al. “The Future of Solar Modelling: Requirements for a New Generation of Solar Models.” arXiv:2506.14514. Preprint, arXiv, June 17, 2025. https://doi.org/10.48550/arXiv.2506.14514.

Solar neutrino as a probe

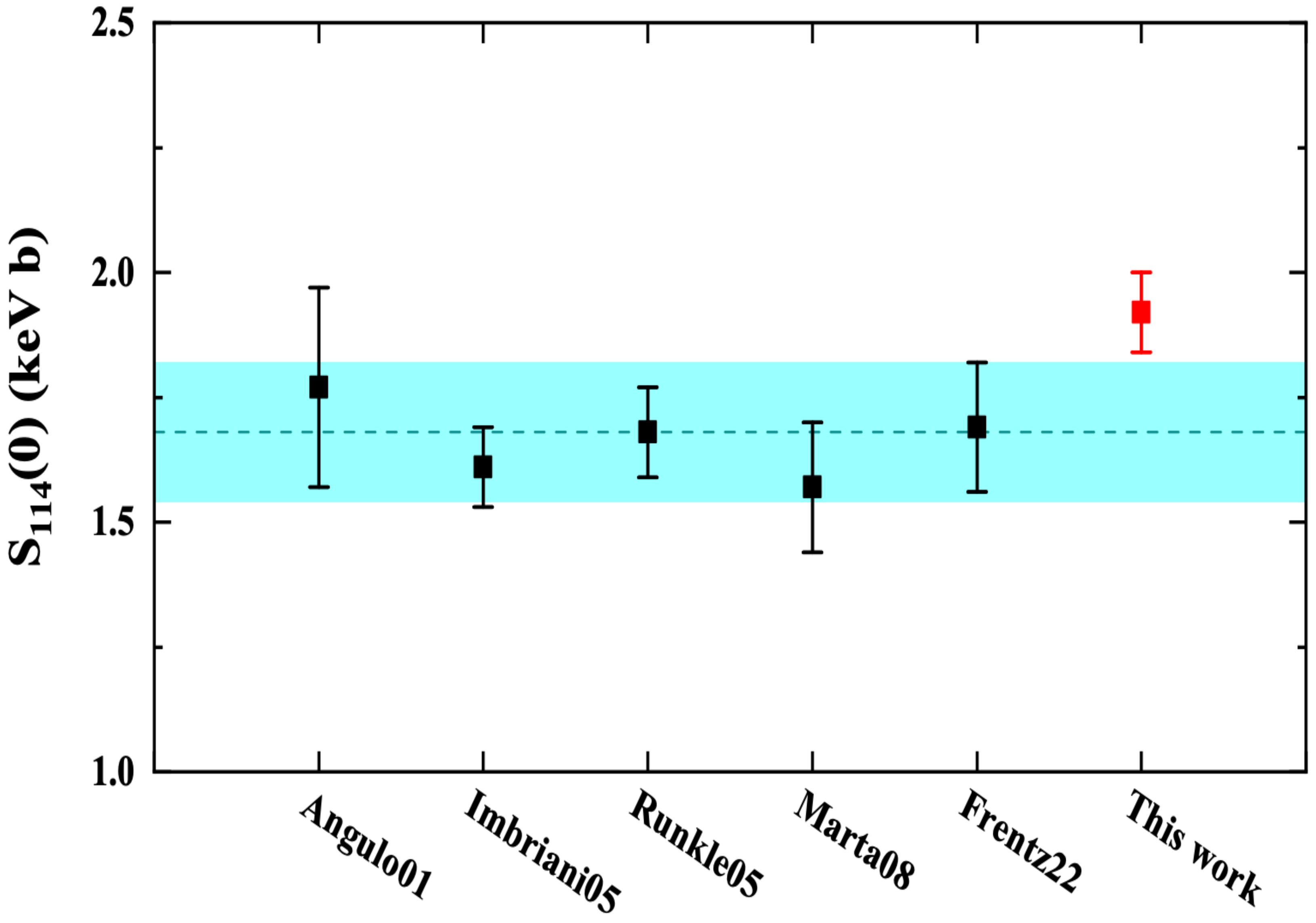


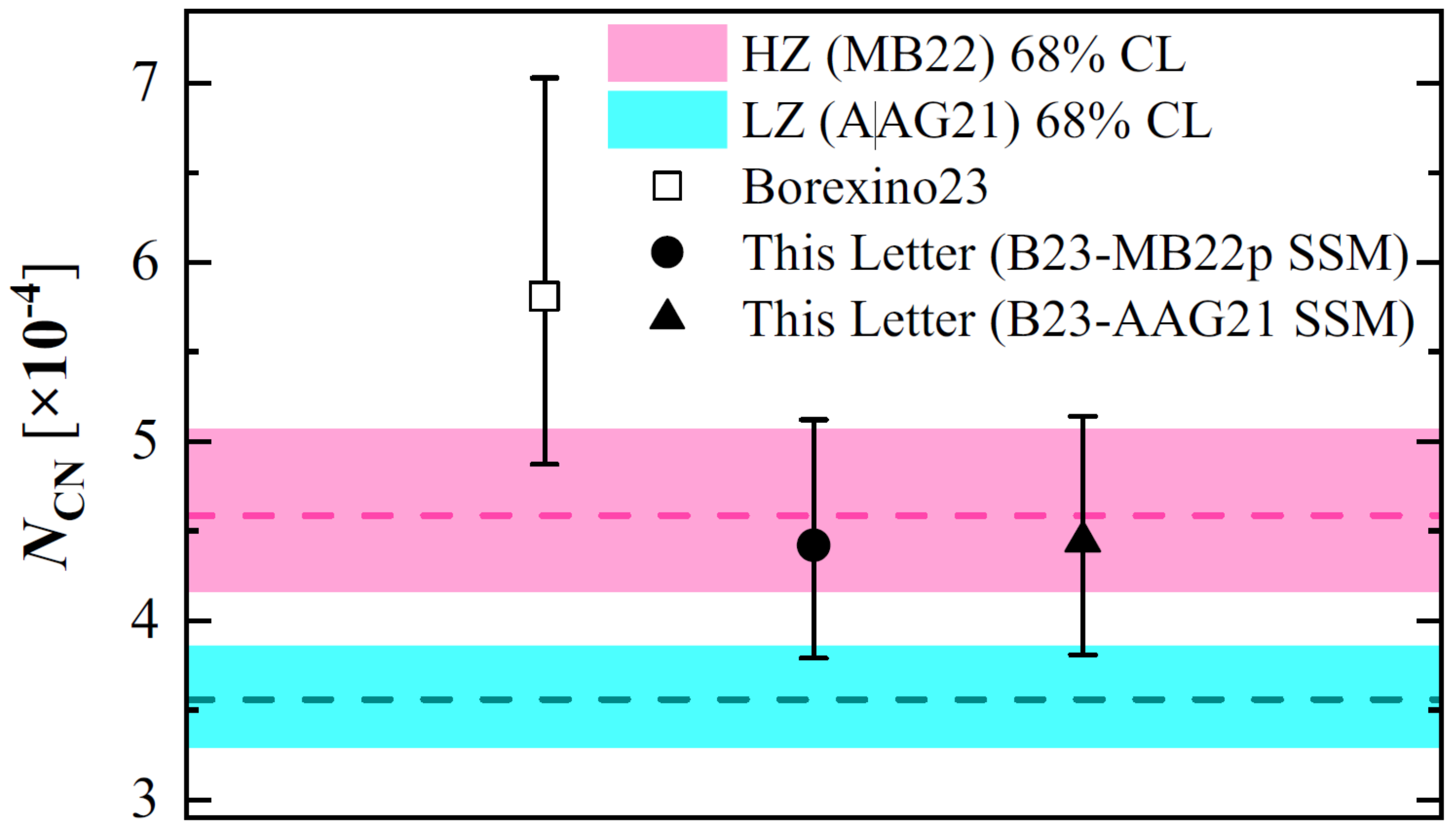
Measured CN abun. by Borexino

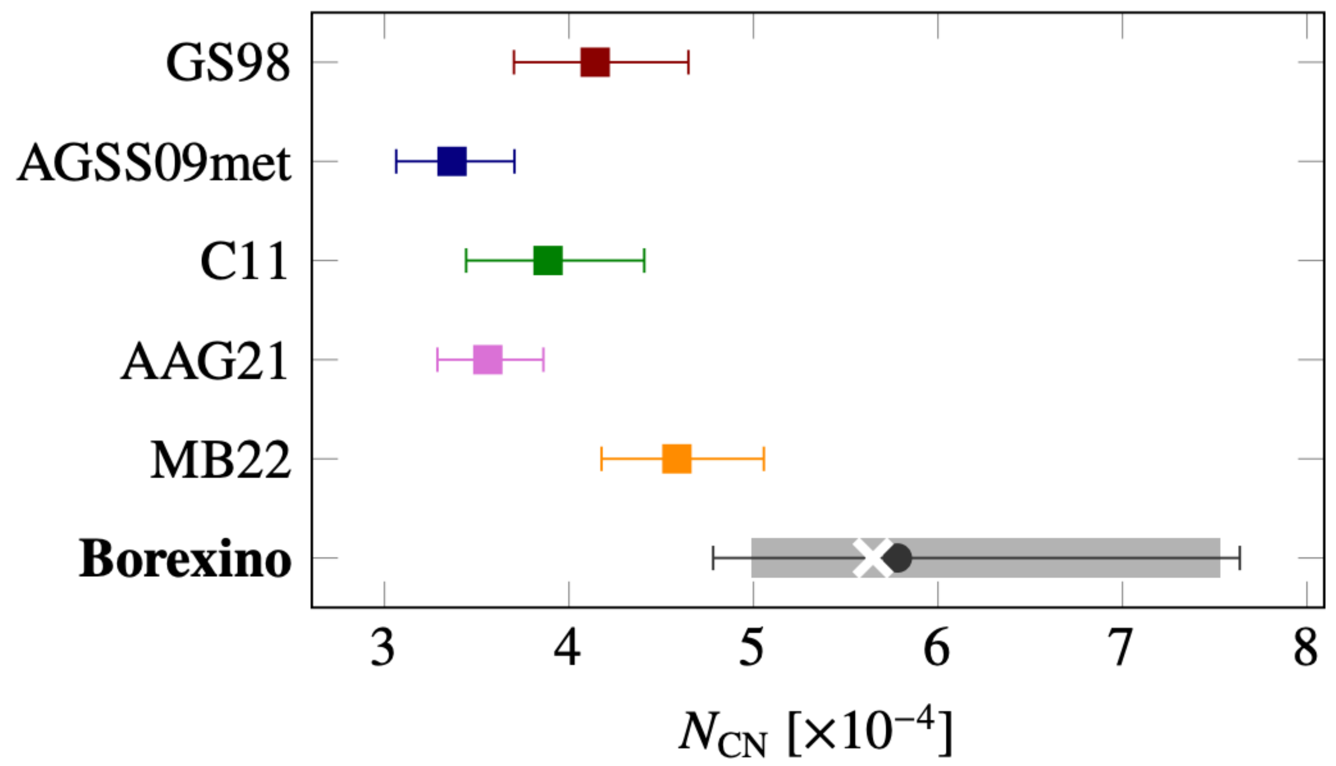


Appel, S., Z. Bagdasarian, D. Basilico, et al. “Improved Measurement of Solar Neutrinos from the Carbon-Nitrogen-Oxygen Cycle by Borexino and Its Implications for the Standard Solar Model.” *Physical Review Letters* 129, no. 25 (2022): 252701. https://doi.org/10.1103/PhysRevLett.129.252701.

S factor improved

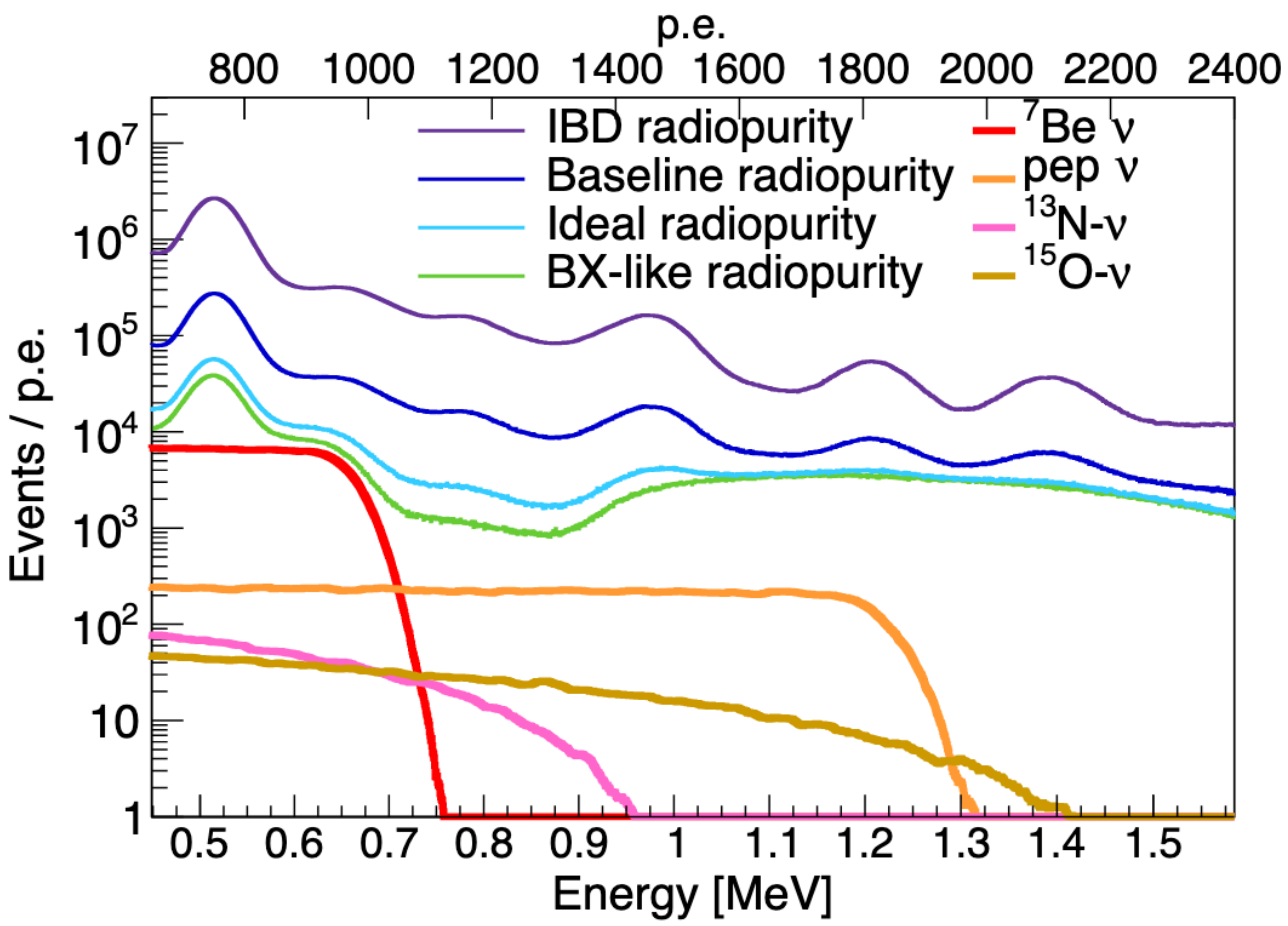




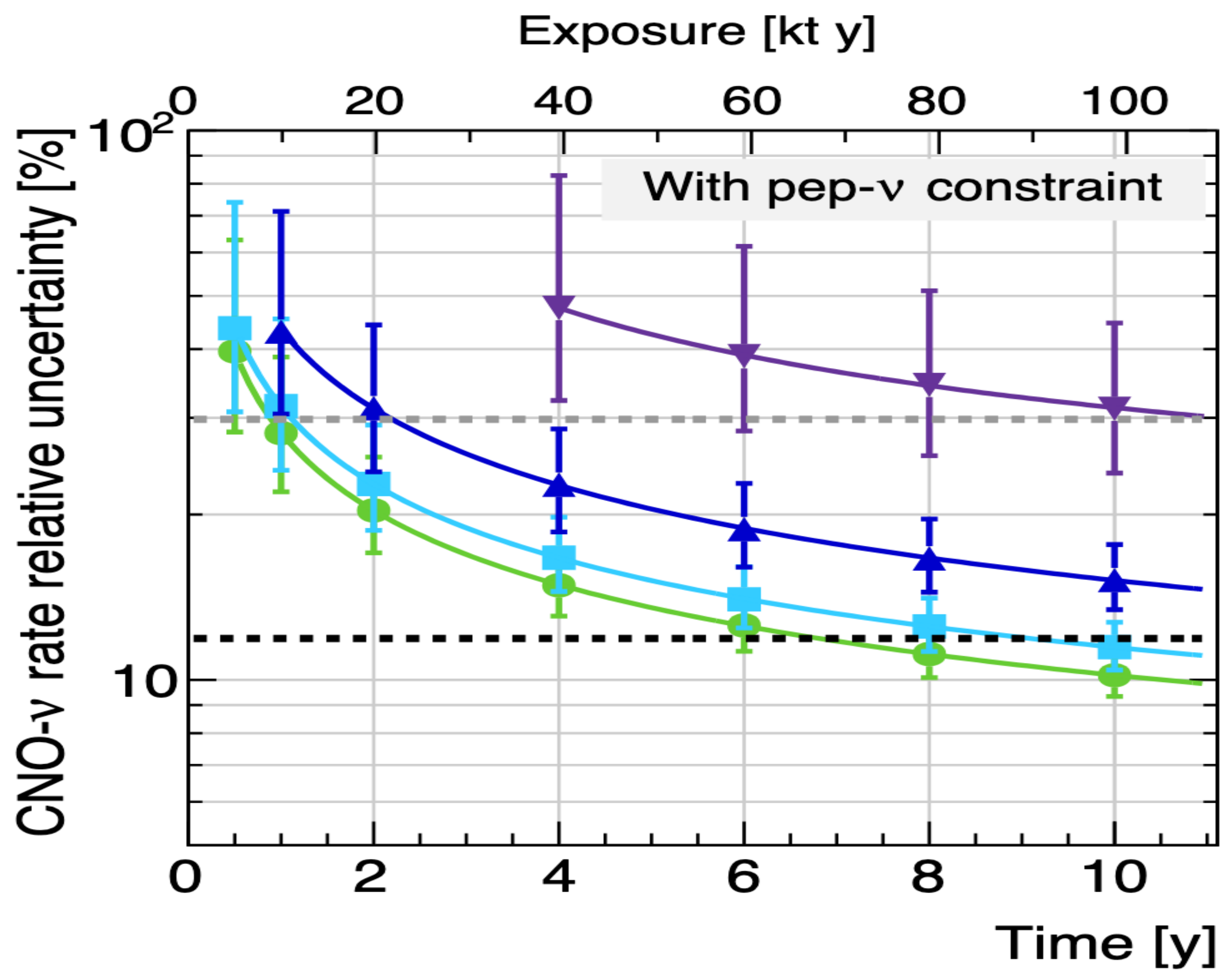


Chen, X., J. Su, Y. P. Shen, et al. "Enhanced S-Factor for the ^{14}N$(p,γ)^{15}$O Reaction and Its Impact on the Solar Composition Problem." arXiv:2410.16086. Preprint, arXiv, October 21, 2024. https://doi.org/10.48550/arXiv.2410.16086.

JUNO's prospects to CNO

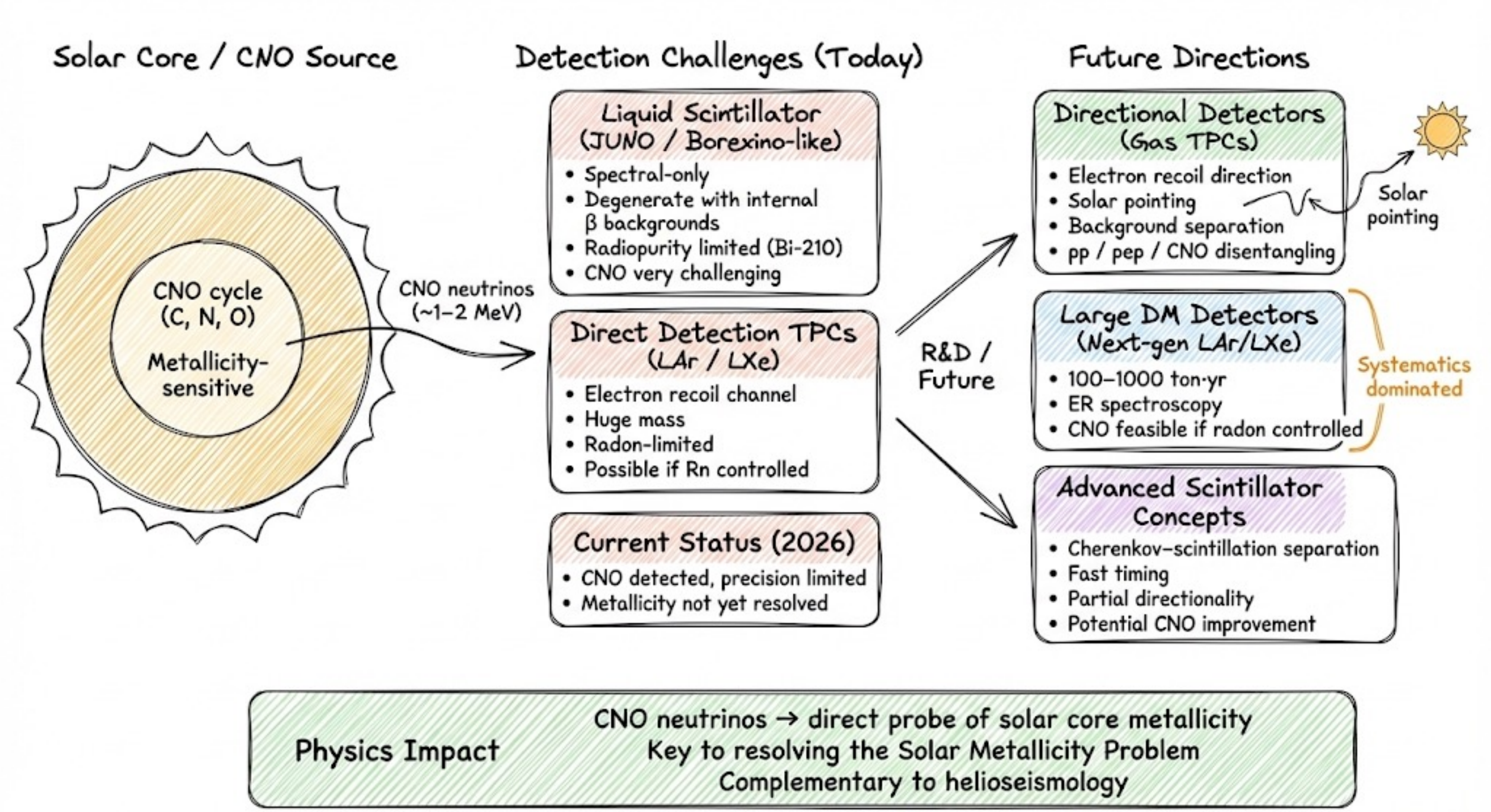


- Limited by internal bkg.
- Direction may help
- Challenging

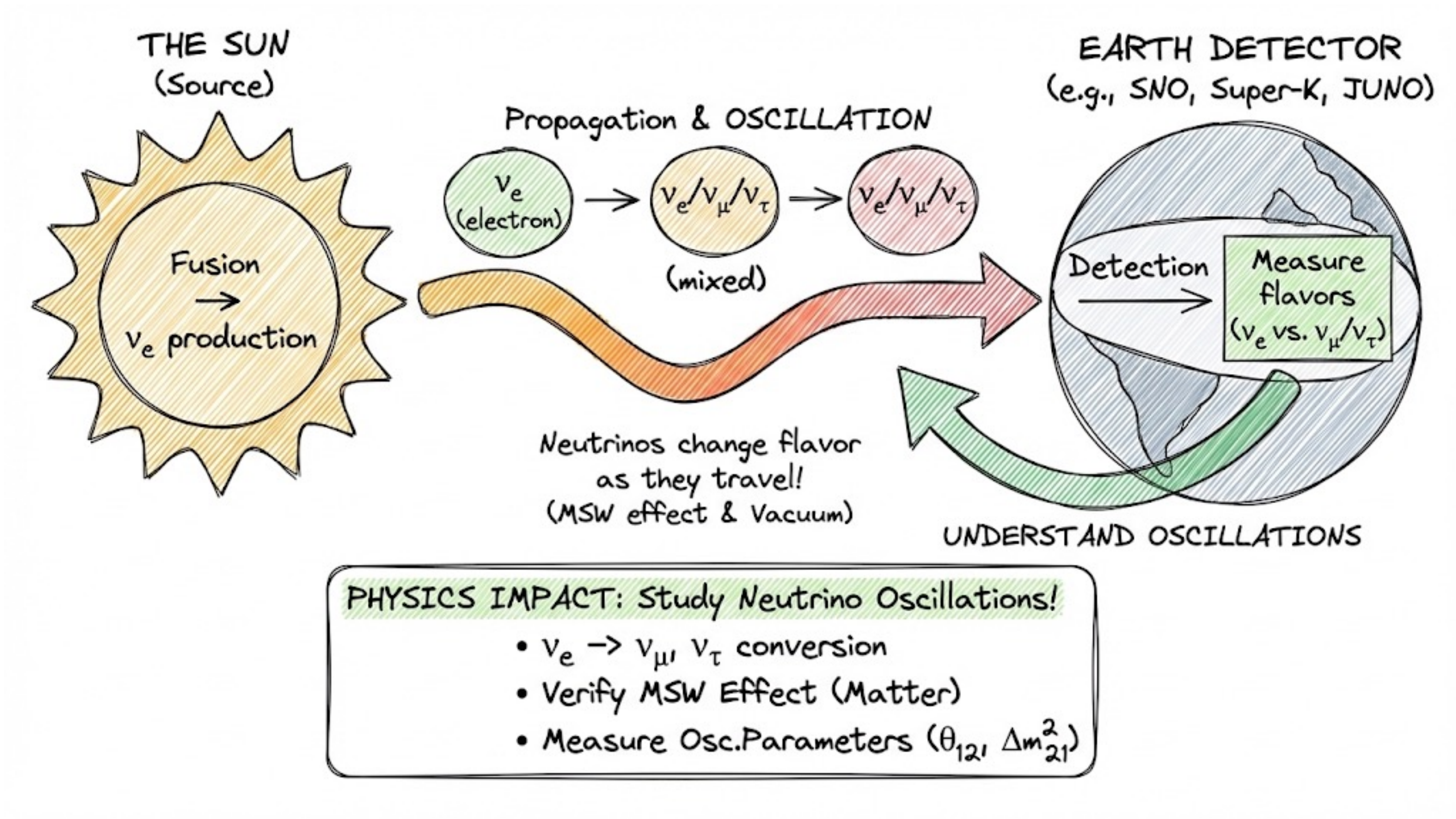


Abusleme, Angel and others. *JUNO Sensitivity to ⁷Be, Pep, and CNO Solar Neutrinos*. March 2023. 2639017. INSPIRE. https://arxiv.org/abs/2303.03910.

CNO in next years

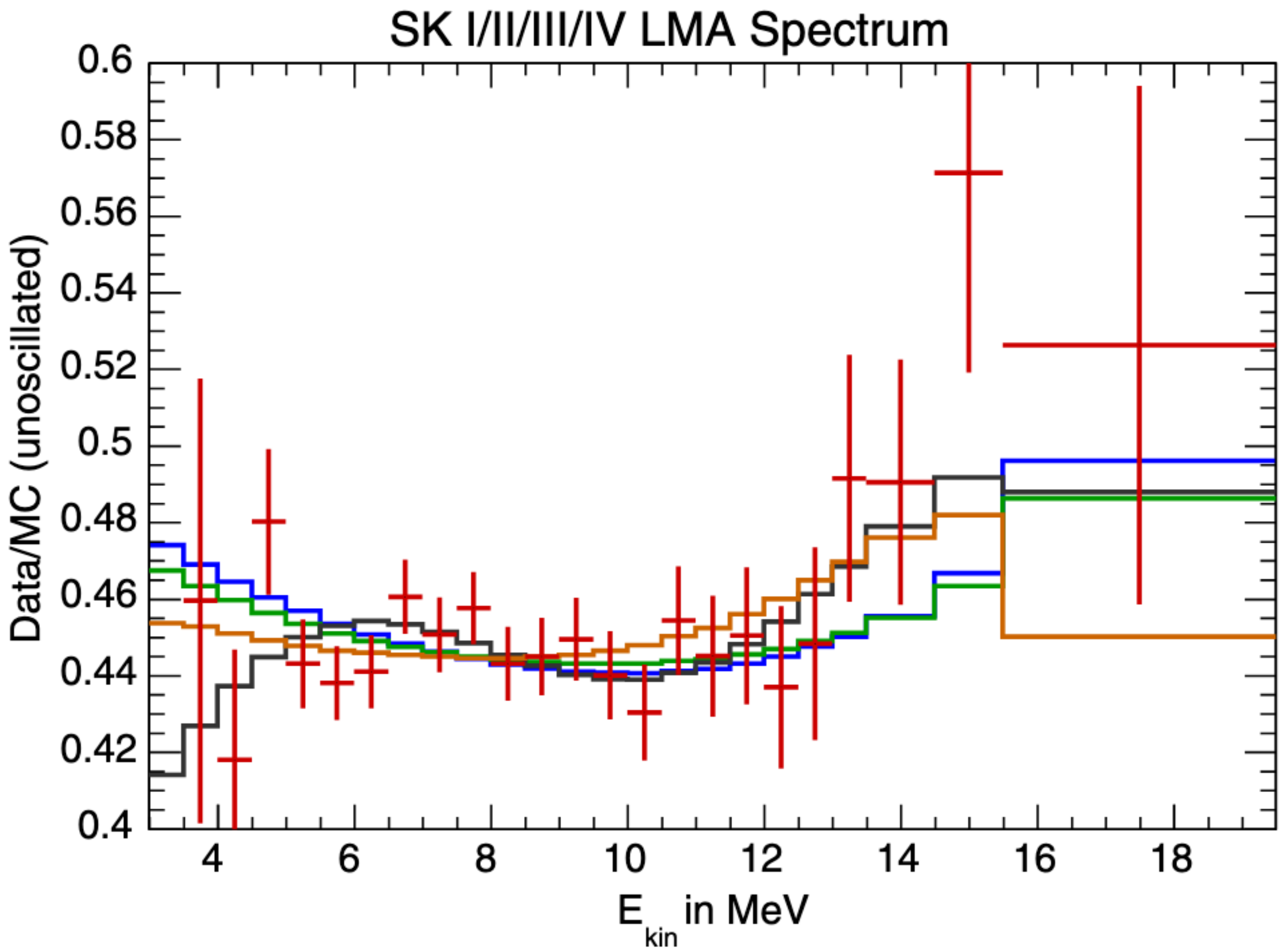


Part 2: study the oscillation



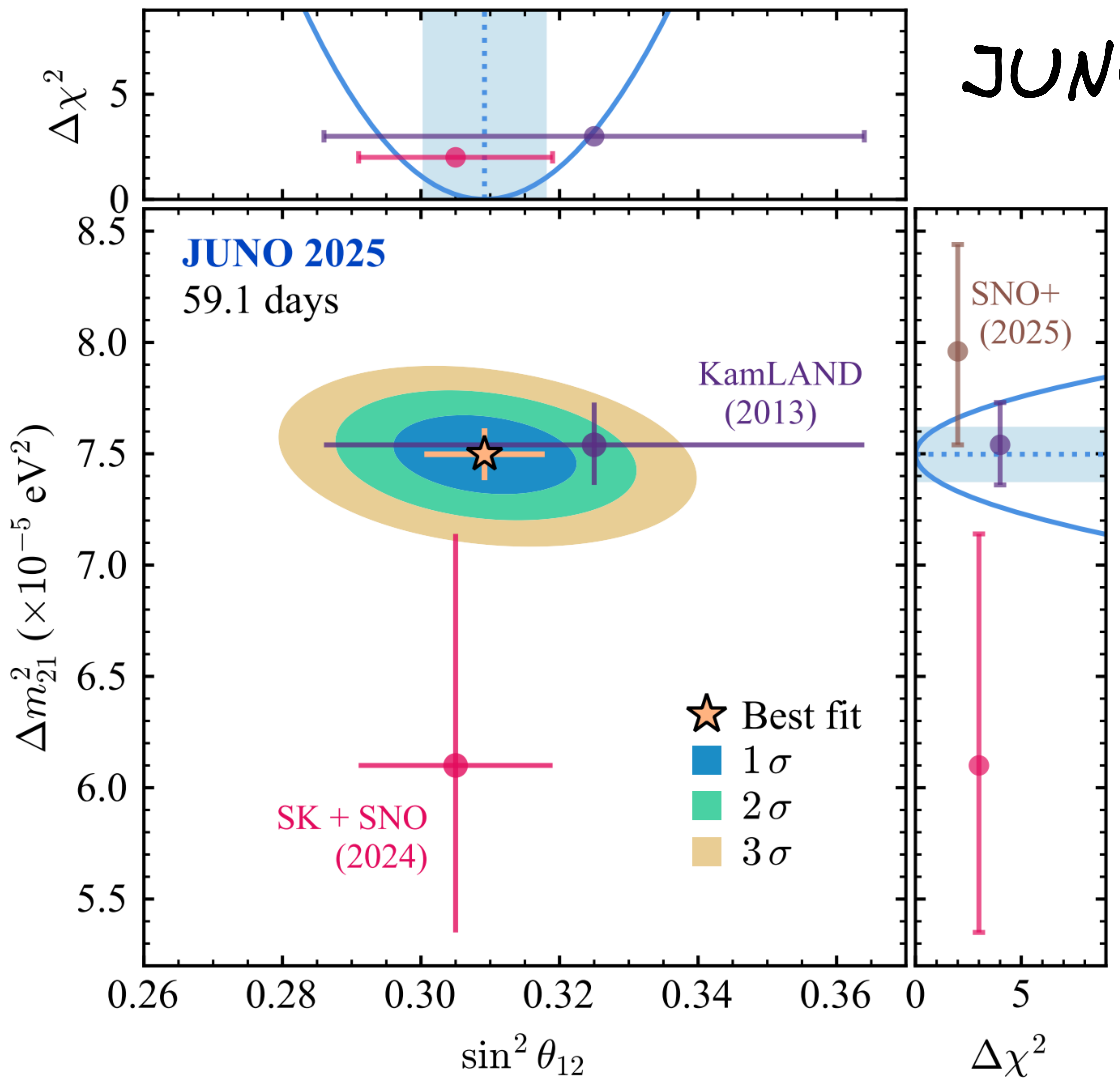
Δm^2_{21} "tension"

SK-I-IV-2016



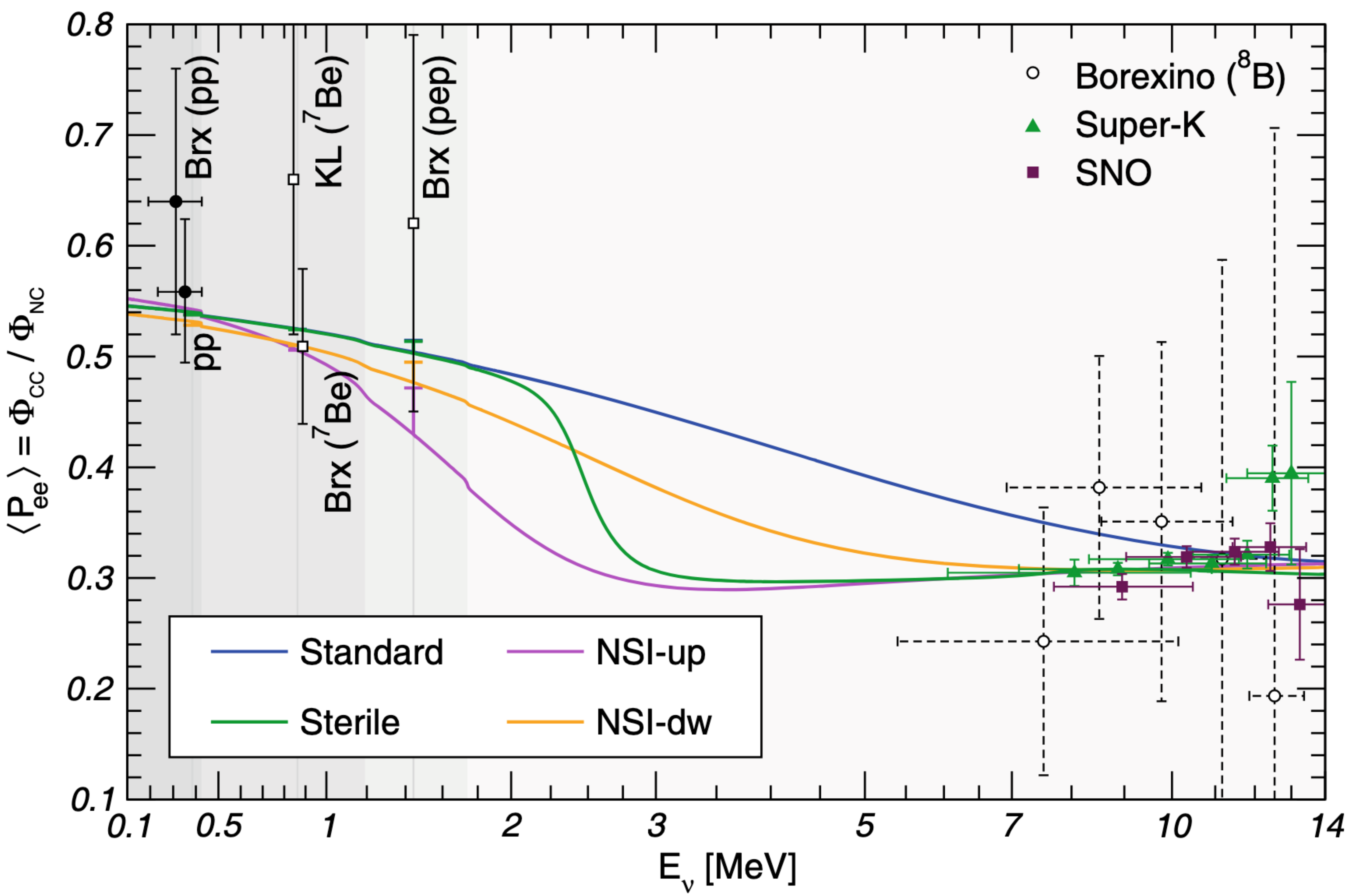
Abe, K., Y. Haga, Y. Hayato, et al. "Solar Neutrino Measurements in Super-Kamiokande-IV." *Physical Review D* 94, no. 5 (2016): 052010. 1472086, p. 052010. INSPIRE. https://doi.org/10.1103/PhysRevD.94.052010.

JUNO-2025



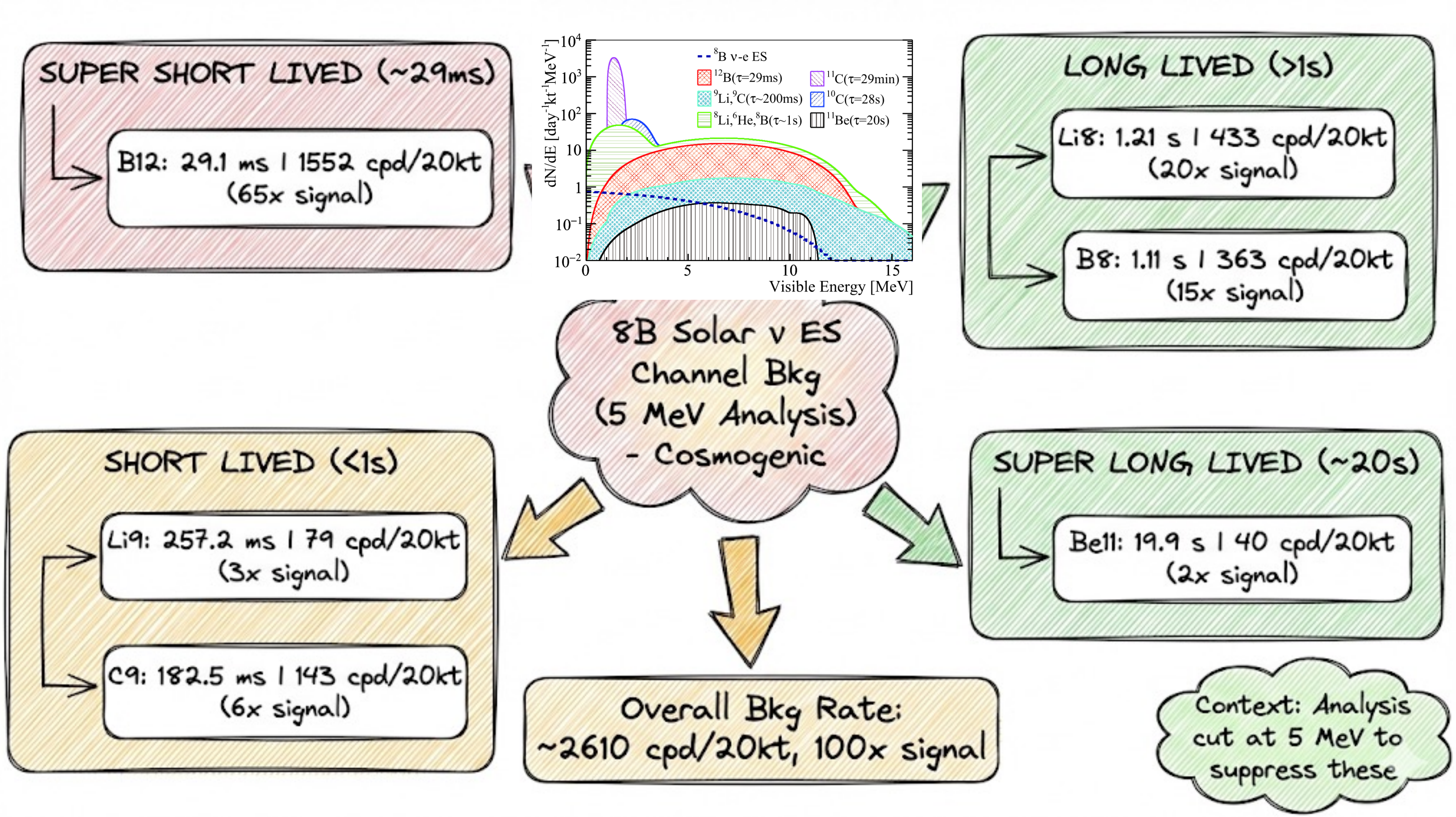
Abusleme, Angel, Thomas Adam, Kai Adamowicz, et al. "First Measurement of Reactor Neutrino Oscillations at JUNO." arXiv:2511.14593. Preprint, arXiv, November 18, 2025. https://doi.org/10.48550/arXiv.2511.14593.

MSW transition region

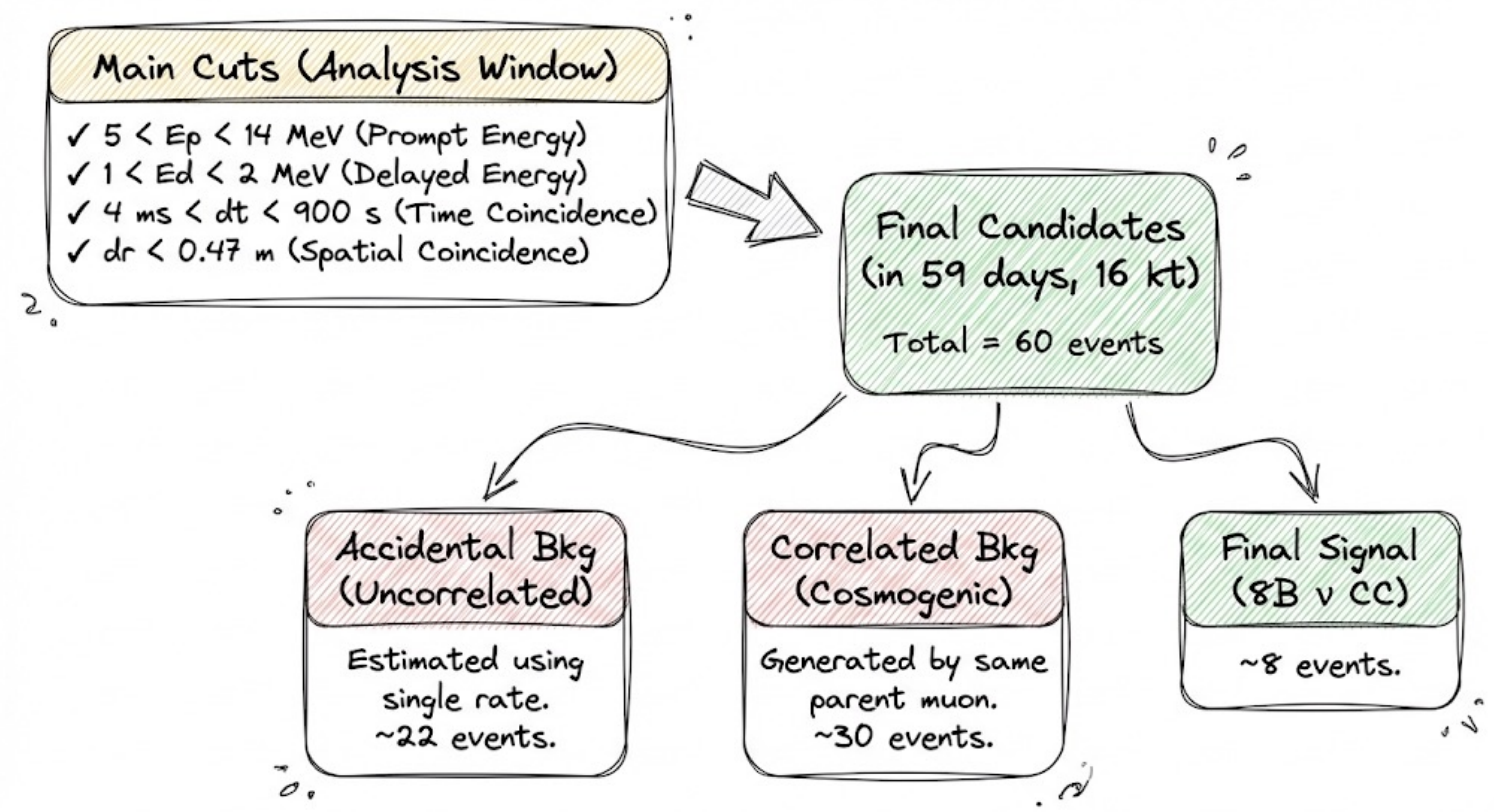


Maltoni, Michele, and Alexei Yu. Smirnov. "Solar Neutrinos and Neutrino Physics." *The European Physical Journal A* 52, no. 4 (2016): 87. 1383834, p. 87. INSPIRE. https://doi.org/10.1140/epja/i2016-16087-0.

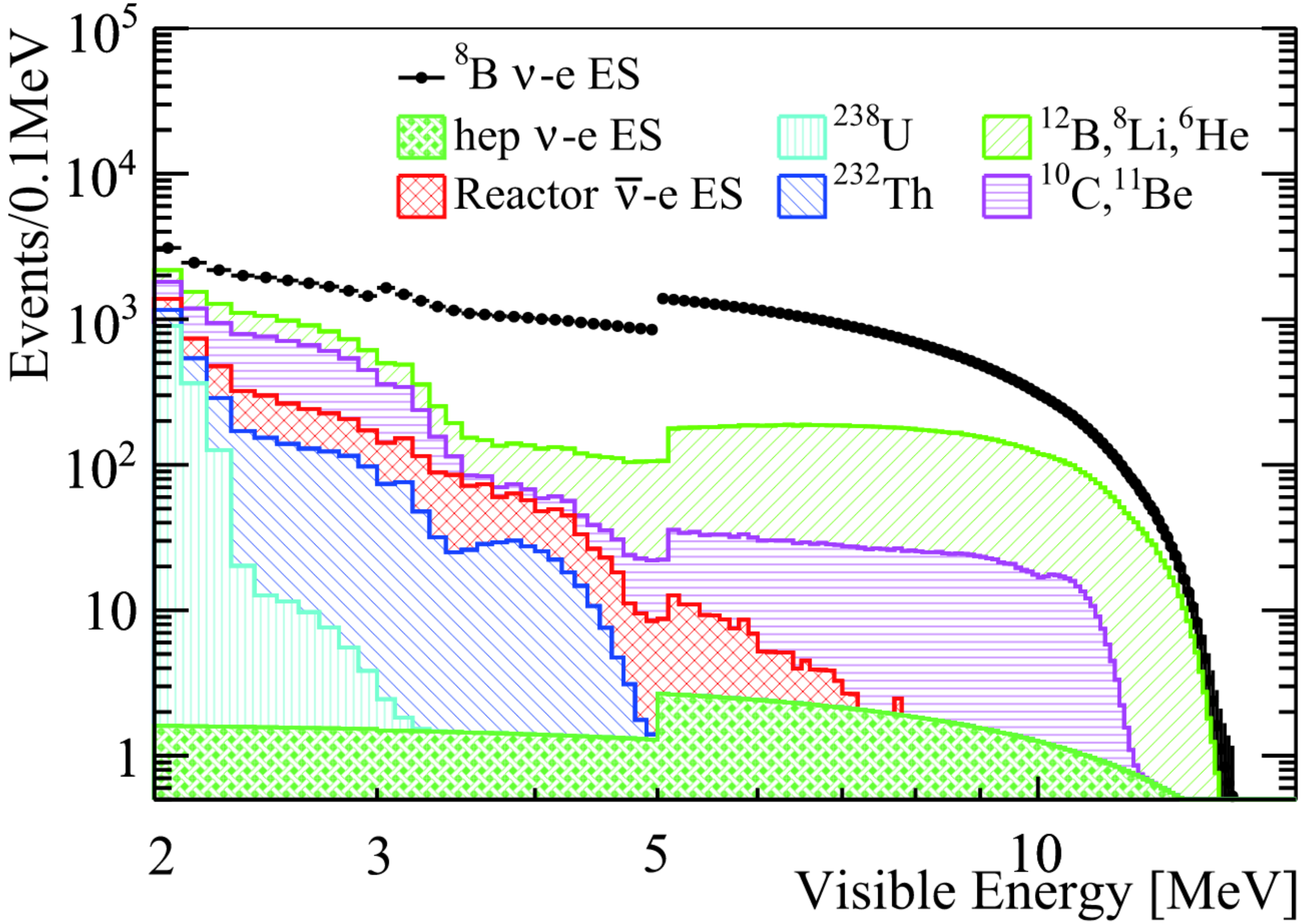
JUNO: 5 MeV ^{8}B ES



JUNO: 5 MeV ^8B CC

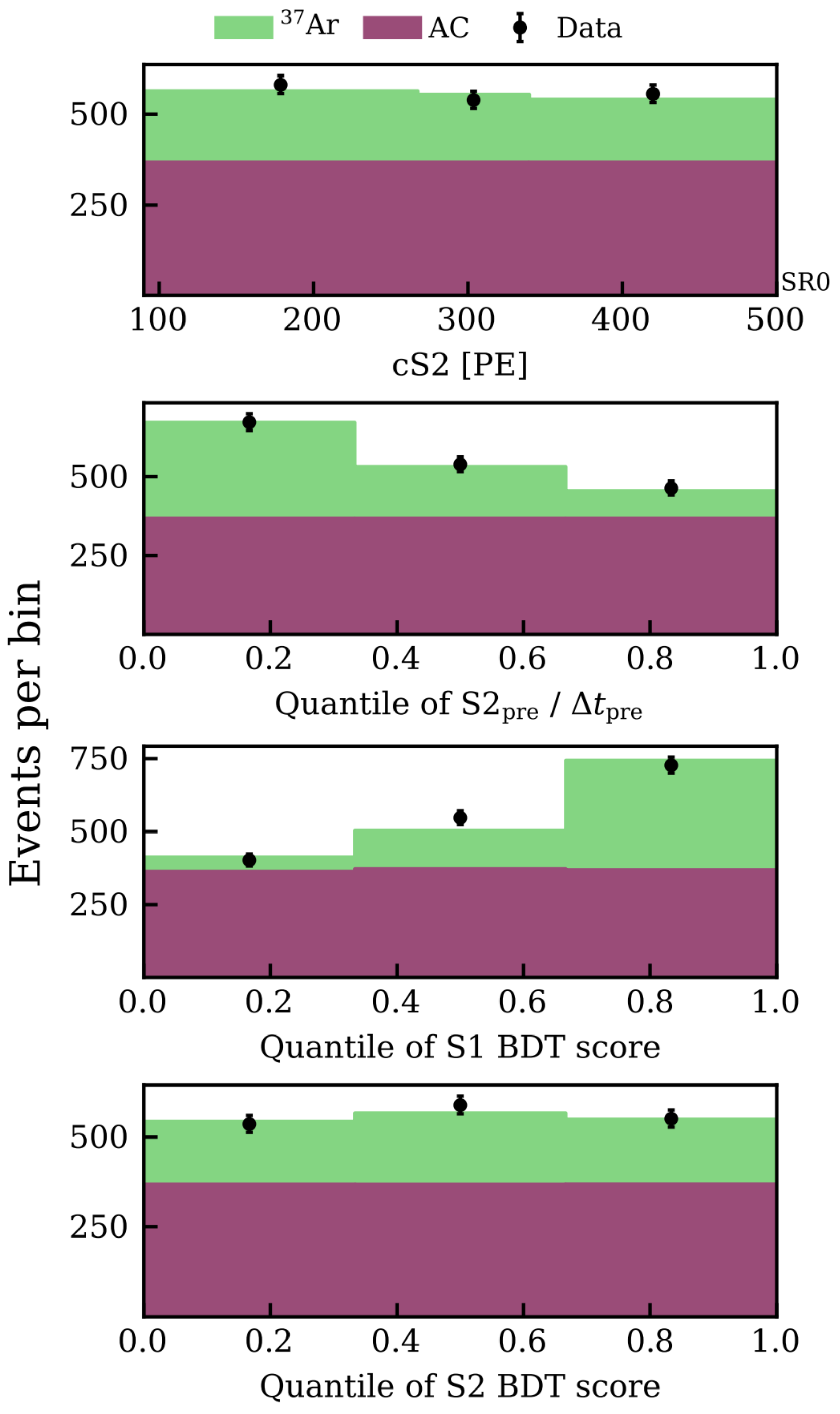


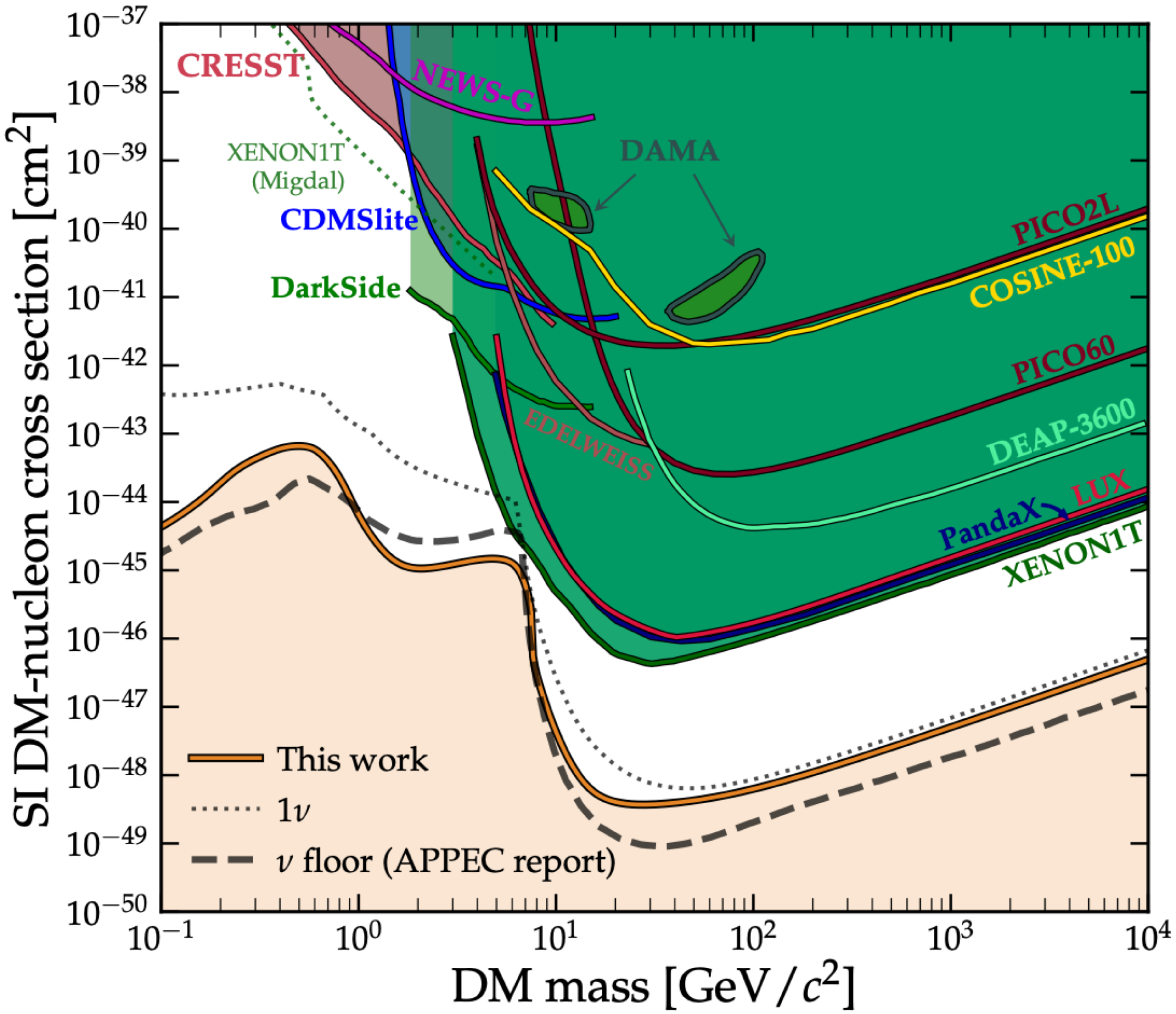
Next: 2 MeV JUNO



Abusleme, Angel, Thomas Adam, Shakeel Ahmad, et al. "Feasibility and Physics Potential of Detecting 8B Solar Neutrinos at JUNO *." *Chinese Physics C* 45, no. 2 (2021): 023004. https://doi.org/10.1088/1674-1137/abd92a.

Dark matter: ER and NR





Conclusions

- Solar neutrinos can study both the Sun and oscillations
- For solar metallicity problem, precise CNO flux is essential
- For solar oscillations, JUNO may push to 2 MeV
- Dark matter is also evolving fast, yet not world leading.