Rejecting Backgrounds for Eos@SNS with Equivariant Spherical Transformers

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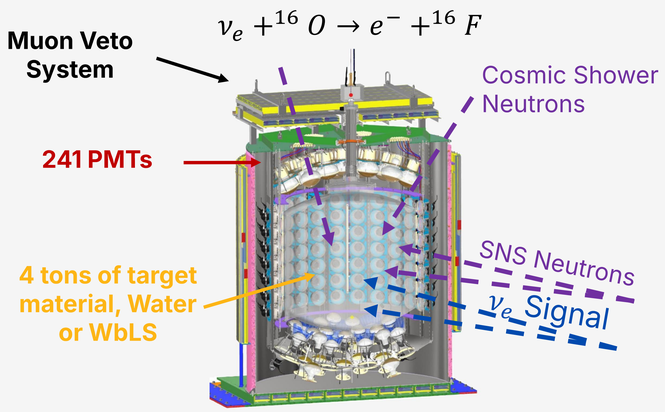
Eos@SNS

A proposed redeployment of the Eos detector at the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory (ORNL), with the primary physics goal of measuring **Charged Current on Oxygen**.

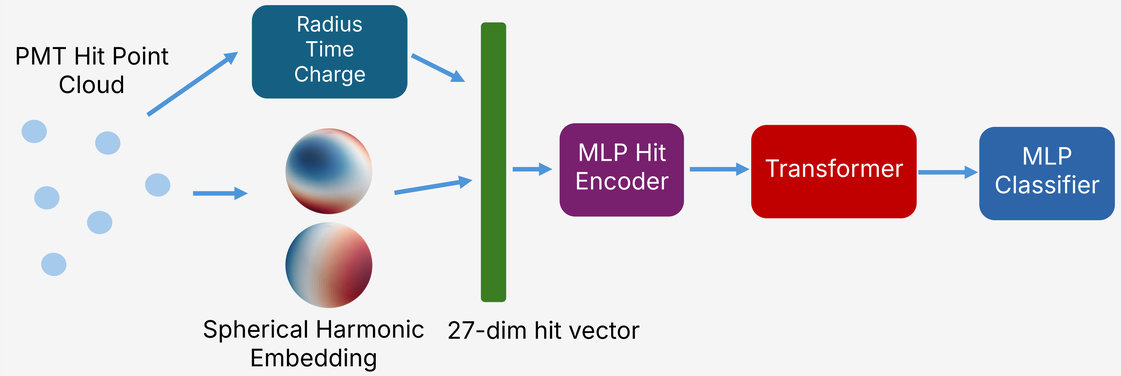


One of the major backgrounds will be **fast neutrons** from the SNS itself and from external cosmic showers.

The SNS is the world's most intense low-energy neutrino source. We are projecting a 10% cross-section measurement in 3 years.

The CC cross section on Oxygen is key to interpreting supernova neutrino data.

Equivariant Spherical Transformers

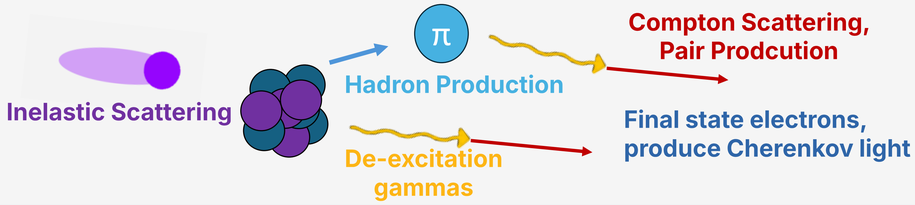


Spherically equivariant position encoding allows for learning of features, independent of orientation. ESTs are a natural choice for analyzing light patterns radiating out from point sources.

Model takes in PMT hit positions, charges, and times, then outputs a binary classification score.

Neutron-Related Backgrounds

Primary neutron-related backgrounds are gammas produced from neutron-nucleus inelastic scattering and nuclear de-excitation gammas. These gamma energies can overlap with the expected CC on Oxygen interactions.



Other Eos Posters at Neutrino 2026

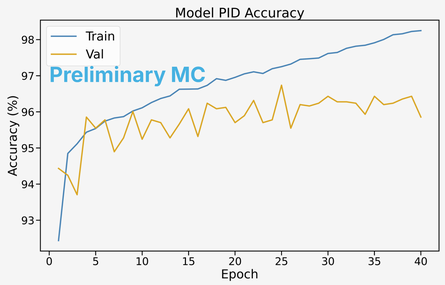
Neutrino applications within nonproliferation – L. Pickard
Performance of the Eos demonstrator with a water target – T. Kaptanoglu
Water-based liquid scintillator deployment at Eos – Y. Bezawada
Developing the Optical Model for WbLS Using the Eos Detector – P. Englezos
PuBe deployment at Eos – S. Gadamsetty
Machine Learning to Constrain Optical Parameters at Liquid Scintillator Detectors – S. Arora
Neutrino-Oxygen Cross Sections with Eos at the Spallation Neutron Source – J. Newby

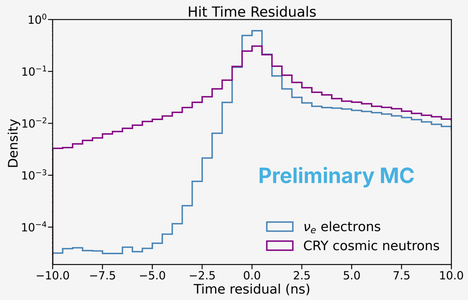
Results

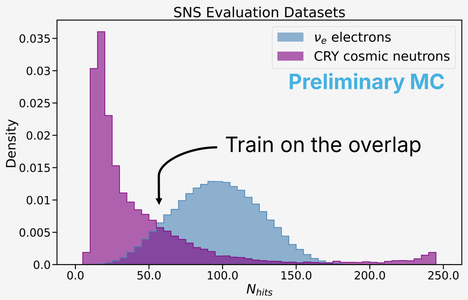
EST model is trained on 200k events each signal and background. Trained on simplified simulations of ν_e-electron events and external cosmic neutrons.

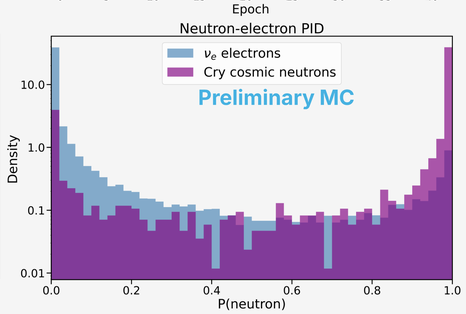
"N_{hit} matching" datasets ensures that we are isolating PID performance.

EST model achieves near perfect identification of expected neutron backgrounds without the N_{hit} signal. The model learns to identify the multi-site nature of high-energy gamma events in the detector.









Acknowledgements

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Future Work

Incorporate EST-based neutron background rejection into the Eos@SNS analyses and estimate sensitivity improvement for CCES on Oxygen.

References

[1] Askins, M., et al. Theia: an advanced optical neutrino detector. Eur. Phys. J. C 80, 416 (2020).
[2] An et al., "Equivariant Spherical Transformer for Efficient Molecular Modeling," arXiv:2505.23086 (2025).