EOS: Results with water

Tanner Kaptanoglu for the EOS Collaboration
University of California, Berkeley

National Nuclear Security Administration

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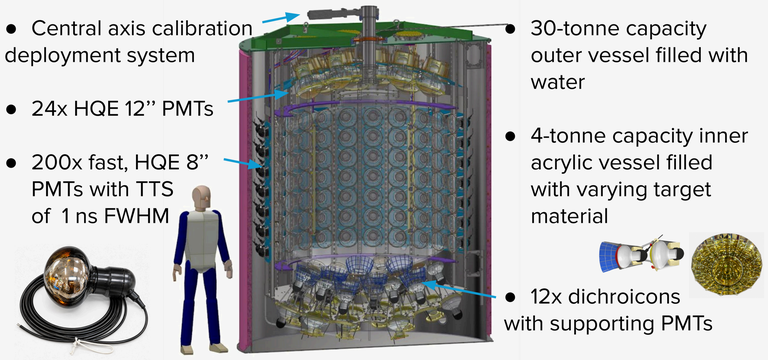
EOS

EOS is a tonne-scale demonstrator of hybrid detector technology, enabling Cherenkov/scintillation separation in optical neutrino detectors.

- Central axis calibration deployment system
- 24x HQE 12'' PMTs
- 200x fast, HQE 8'' PMTs with TTS of 1 ns FWHM
- 30-tonne capacity outer vessel filled with water
- 4-tonne capacity inner acrylic vessel filled with varying target material
- 12x dichroicons with supporting PMTs



The EOS inner vessel was first filled with water to calibrate the detector and validate the modeling. This poster presents the results from this water phase.

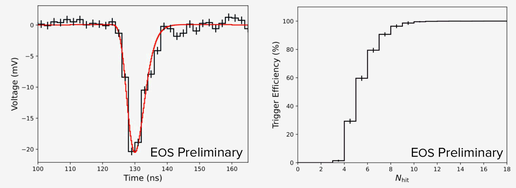
As of June, 2026, this work has been submitted to PRD and is pending review. It can be found on the here: arXiv:2606.10234 [hep-ex].

Datasets

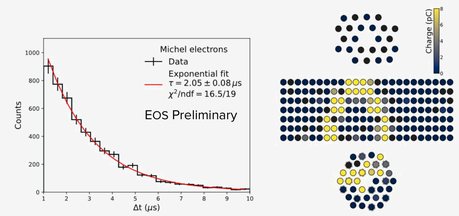
Collected data with deployed calibration sources at various positions along the central axis. Additionally took cosmic data to tag Michel e⁻.

Source	z range (cm)	z step (cm)	Events per run (10^5)	Trigger scheme
Laserball	[-60, 60]	10	2	Pulsed
Thorium	[-50, 50]	10	5	Single threshold
AmBe	[-30, 30]	30	10	Coincidence
Directional	[-50, 50]	various	0.5	Self-triggered

Store fully digitized waveforms for all PMTs. Processed offline to extract PMT hit-times & charges. Trigger 100% for # PMT hits (N_{hit}) > 10.

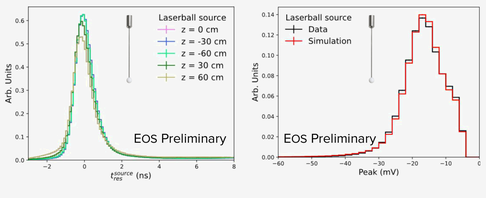


Events selected using energy, position, direction, and coincidence tagging.

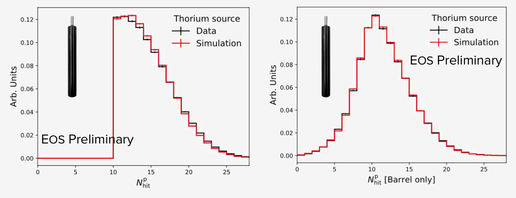


Calibrations

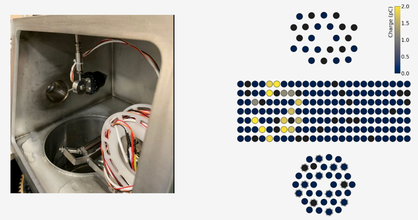
PMT time offsets and pulse-heights calibrated with isotropic, picosecond light from "laserball".



PMT efficiency scaling calibrated using central thorium data (monoenergetic 2.6 MeV γ-ray).



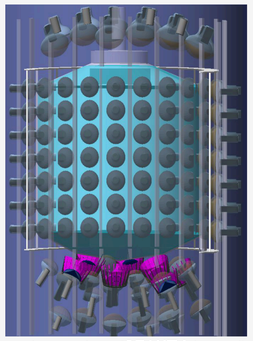
The directional source provides a sample of events with known event direction.



Simulations

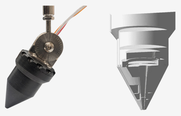
A primary goal of EOS is to develop simulation, reconstruction, and analysis methods for hybrid detectors.

- Detailed detector geometry from database table
- Full 3D PMT model, includes measured properties (QE, TTS, etc.)
- Intricate models for each calibration source



`ratpac-two` (GEANT4-based)

- Custom photon production and tracking
- Fully integrated DAQ, trigger, and waveform digitizer modeling
- Detailed dichroicon model, including bench-top dichroic filter characterization



^{90}Sr Directional source

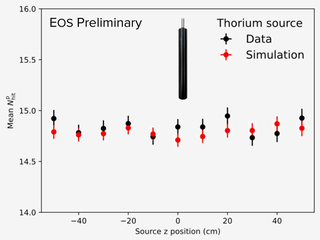
Thorium source

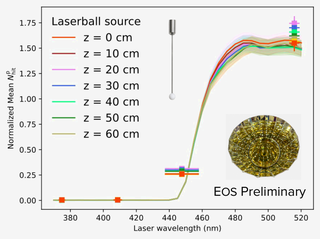
AmBe source

The EOS collaboration has developed likelihood and ML-based reconstruction algorithms (vertex & direction). Performances are compared across different source types, positions, and directions.

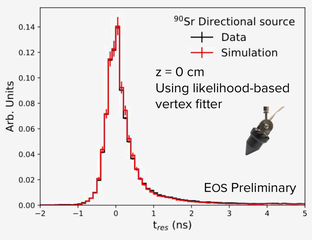
Model Validation

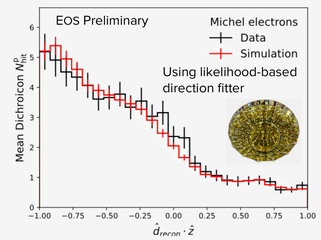
The simulation model (MC) is validated by comparing to data across a variety of calibration sources, source positions, and source directions.





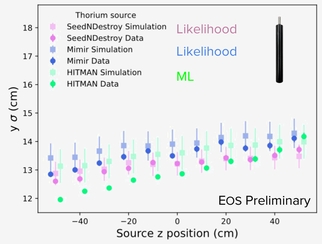
Varying particle type (β, n, γ), position, energy, and PMT type, the agreement between data and MC in N_{hit} and timing is excellent.

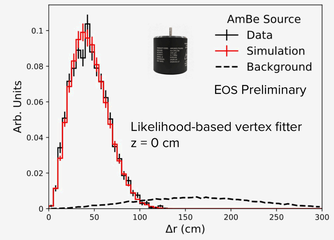




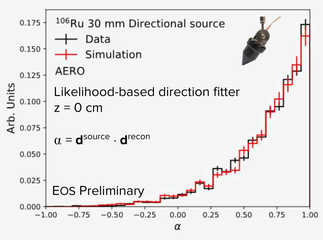
Reconstruction Results

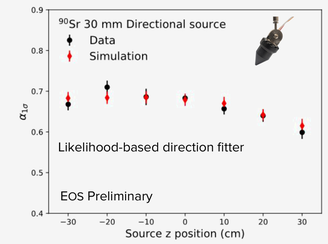
Vertex reconstruction performance is evaluated using the thorium (2.6 MeV) and AmBe (2.2 and 4.4 MeV) sources at various positions.





Direction reconstruction performance is evaluated using the directional source with two different isotopes (^{90}Sr and ^{106}Ru).





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