Measuring Neutrino-Argon CC Interactions at 10-50 MeV with the COHERENT 750 kg Detector

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Background and Motivation

- We have yet to see a measurement of inelastic charged-current electron neutrino interactions (ν_e CC) that **covers full 10-50 MeV range**
- Tens of MeV Neutrino-Argon CC cross section measurements are relevant for ongoing theoretical work on weak axial current **gA quenching in Gamow-Teller nuclear transitions**
- This also corresponds to the energy **region of interest expected of supernova neutrino detection** at the DUNE experiment
- Cosmic background reduction is an important challenge in making this measurement and the focus of our study

$$\nu_e + {}^{40}\mathrm{Ar} \rightarrow e^- + {}^{40}\mathrm{K}^*$$

Neutrino Argon Charge Current Inelastic Interaction

Neutrino Production with the SNS Beam

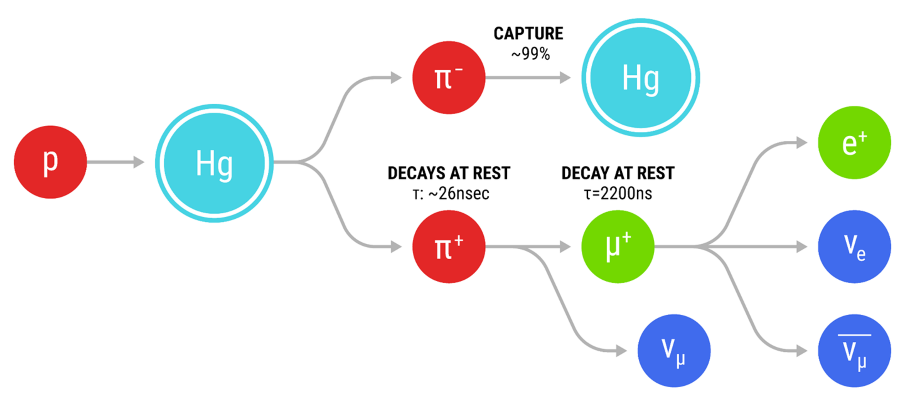
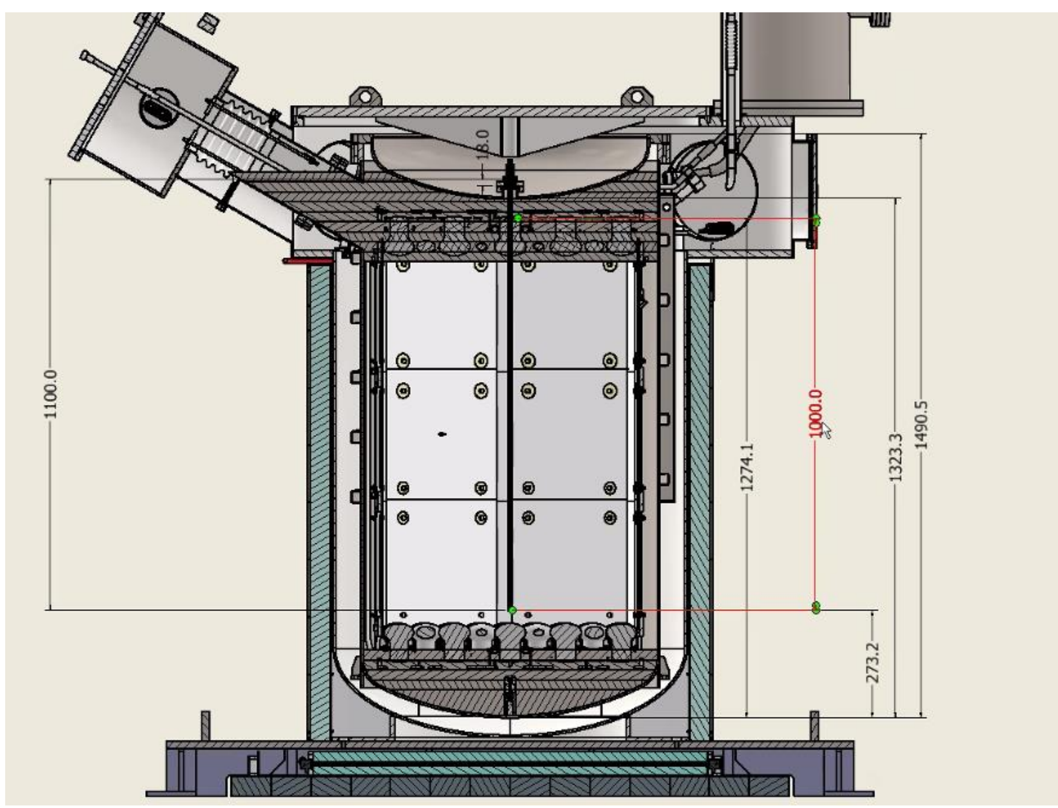


Figure 1:SNS Neutrino Production

- Spallation Neutron Source (SNS) is located at Oak Ridge National Laboratory's neutrino alley
- **High flux of pulsed neutrinos: 4.3 × 10^7 neutrinos/cm²/s at 20 meter**
- **A stopped pion** provides tens of MeV neutrino source

Coherent LAr-750 Neutrino Detector and Veto System

- Single phase liquid argon scintillation detector
- 122 photomultiplier tubes (PMTs)
- **750 kg liquid argon cryostat & 610 kg of fiducial volume**
- 27.5m from Hg target
- Veto system consists of plastic scintillators equipped with silicon photomultipliers (SiPMs)



Bottom Veto Panels

Figure 2: LAr-750 Detector Diagram with Bottom Veto Panels

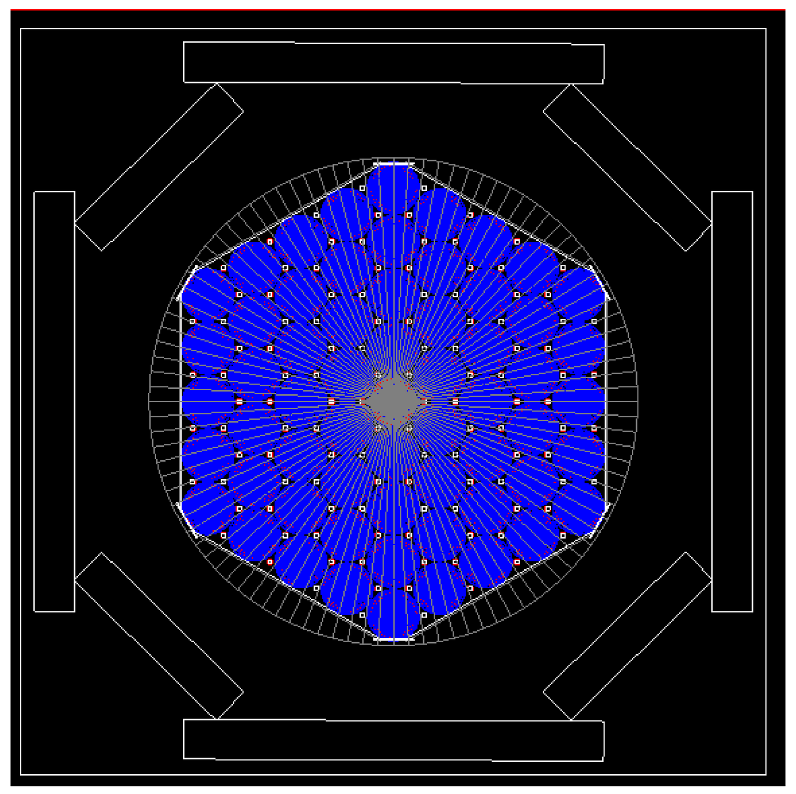


Figure 3: Top View of cryostat in simulation with octagonal side panel arrangement

- Veto Panels will be placed in aluminum enclosures
- **Stage 0: Bottom veto panels only (Figure 2)**
- Stage 1: Add bottom, side, and top veto panels (Figure 3)
- Side panels are arranged octagonally to prevent gaps

Simulation Study of Inelastic Events

Machine Learning Based Veto

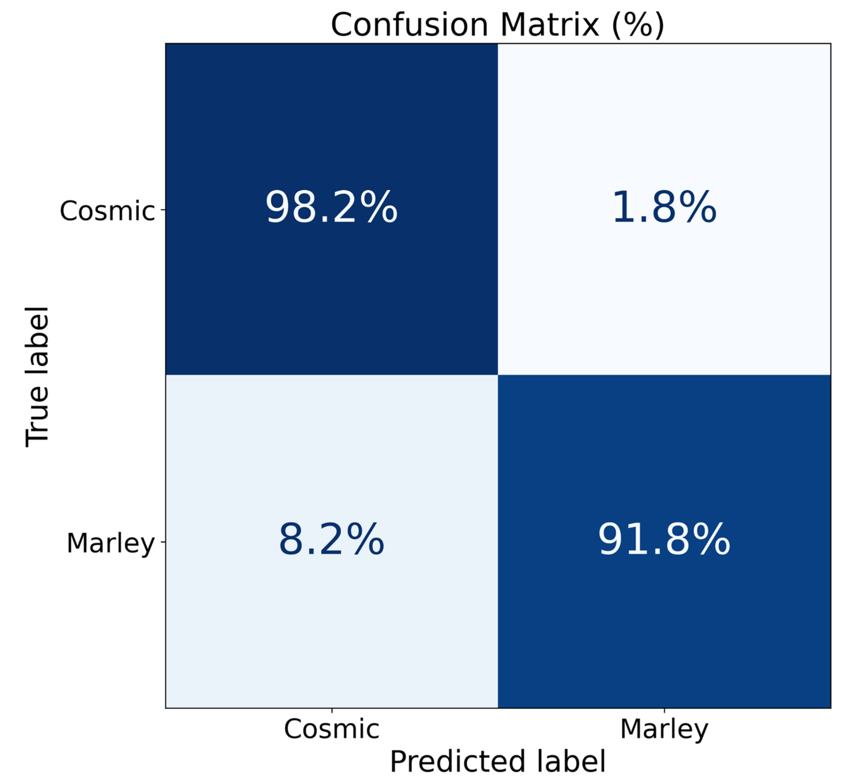


Figure 4: Confusion Matrix Result for Binary Classifier with threshold that maximizes cosmic removal

- **Goal : To distinguish Marley neutrino signal events from cosmic background using individual PMT hit patterns.**
- Input Features were selected to provide model with pulse energy, geometry, timing, and shape information
- Model was trained in **2 steps:**
  - **Masked autoencoder** learned embeddings without labels (self supervised)
  - **Binary classifier** was trained to classify events as cosmic ray (background) vs. neutrino (signal)
- Model can maintain **above 90% accuracy in Neutrino classification**

NueCC-Ar Expected 3 Year Signal Estimate with Bottom Veto Panel

- **We expect to observe a signal in the ~14–46 MeV range after 3 years of running**
- The energy veto alone provides limited background reduction, motivating a full detector veto system
- The ML veto demonstrates meaningful additional rejection power beyond the energy cut, improving S/σ across the signal region
- Full detector veto is anticipated to be in place before the full 3-year exposure**, the results shown here are conservative**

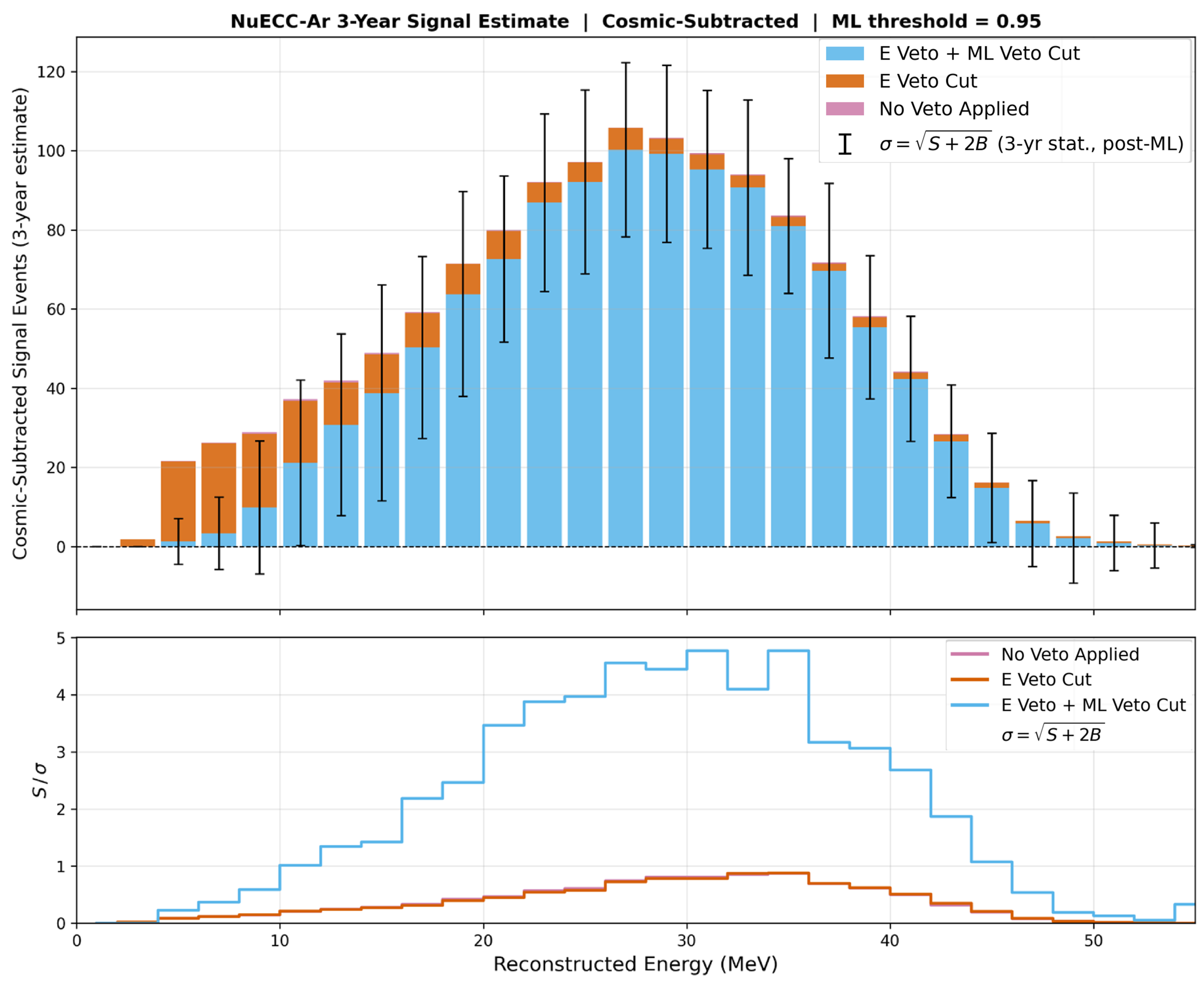


Figure 5: Three year background subtracted signal prediction

References & Acknowledgements

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