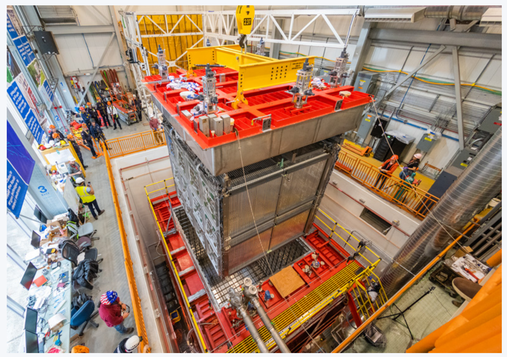
Optimizing the Reconstruction of Neutral Pions at Short-Baseline Near Detector with Pandora

Saandeep Unnikrishnan, on behalf of the SBND collaboration
Department of Physics and Astronomy, University of Kansas

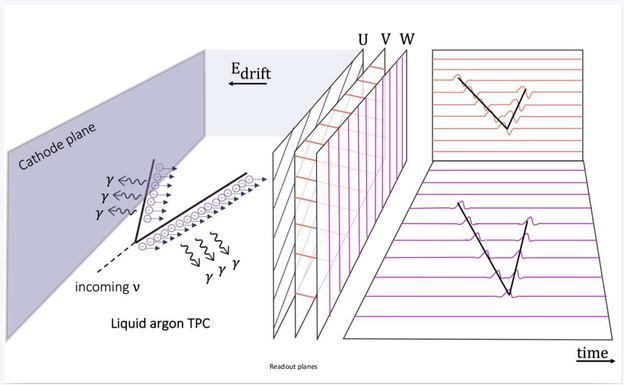
1. Introduction to SBND

The Short-Baseline Near Detector (SBND) is a 112-ton LArTPC located 110m from Fermilab's Booster Neutrino Beam (BNB) target.



- The program aims to measure neutrino argon interactions with high precision, search for BSM physics, and resolve short-baseline anomalies

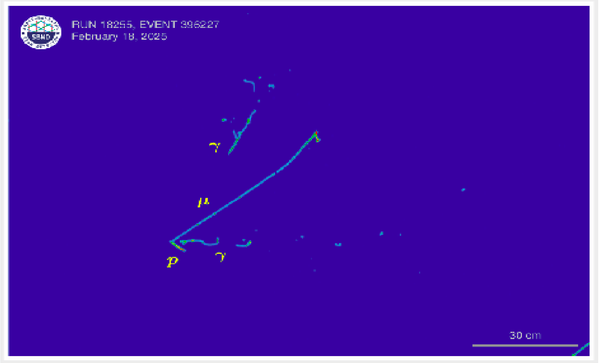
2. Liquid Argon Time Projection Chamber



- Charged particles from neutrino interactions leave electron trails in liquid argon.
- An external electric field drifts these electrons toward readout planes.
- Wire planes record the drifting electrons.
- The LArTPC technology is successfully used in ICARUS, MicroBooNE, SBND, ArgoNEUT, LArIAT, and DUNE, and its prototypes.

3. Physics Motivation

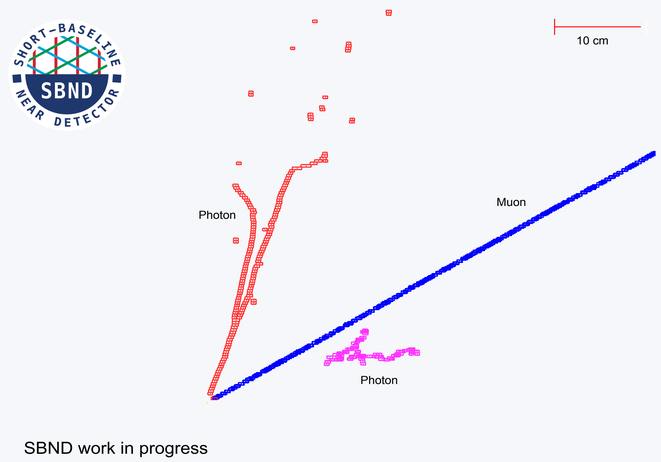
- My current work studies the SBND ν_μ charged-current neutral pion ($\nu_\mu CC\pi^0$) interaction channel, where $\pi^0 \rightarrow \gamma + \gamma$



- Showers from π^0 decay closely mimic single-electron showers in LArTPCs $\rightarrow$ major background in ν_e appearance analyses.

4. Sample Generation & Event Reconstruction

- **Sample Generation:** Created a $\nu_\mu CCN\pi^0$-enhanced sample from a simulation containing SBND BNB beam neutrinos and cosmic rays.
- **Pandora Framework:** A pattern-recognition software kit used to reconstruct neutrino interactions. It employs a multi-algorithm approach tailored to cluster and identify particle tracks and showers in LArTPCs. [1]

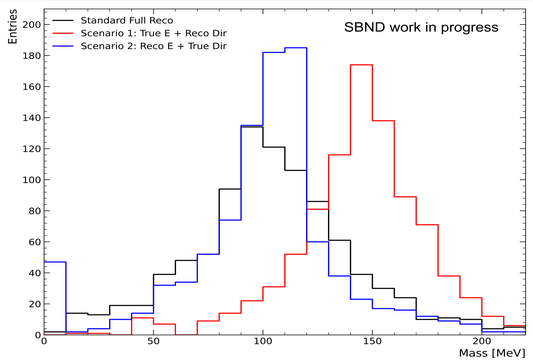


5. π^0 Invariant Mass Reconstruction

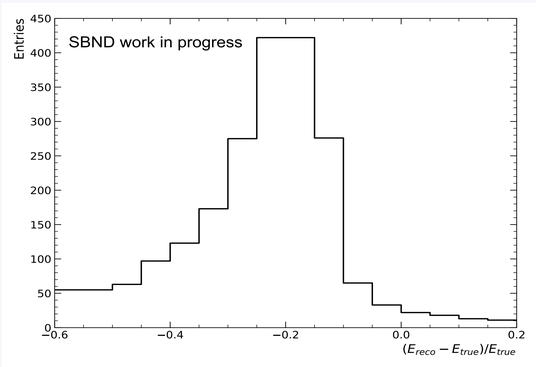
Events with exactly two reconstructed showers are selected

$$M_{\gamma\gamma} = \sqrt{2E_1E_2(1-\cos\theta)}$$

$\cos\theta$ is the opening angle of the showers.



- "Cheating" studies: Invariant mass is calculated with MC energy and reconstructed direction (red), reconstructed energy and MC direction (blue).
- Shower energy resolution:



6. Summary & Future Plans

- Study of the Pandora $\nu_\mu CC\pi^0$ reconstruction performance.
- Generated a π^0 sample $\rightarrow$ Study the π^0 invariant mass.
- Observed a systematic underestimation of reconstructed energy.
- Optimize π^0 mass reconstruction by identifying steps that would improve shower energy reconstruction
- Later, perform differential cross-section measurement for this channel.

References

R. Acciarri *et al.* (MicroBooNE Collaboration), *Eur. Phys. J. C* **78**, 82 (2018).