A DAQ-Level Pure Neutrino Stream For SBND

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Introduction

This poster presents a preliminary look at a DAQ-level 100% pure selection of neutrino events, to be used in the development and validation of calibration, monitoring, and analysis tools for SBND.

Motivation

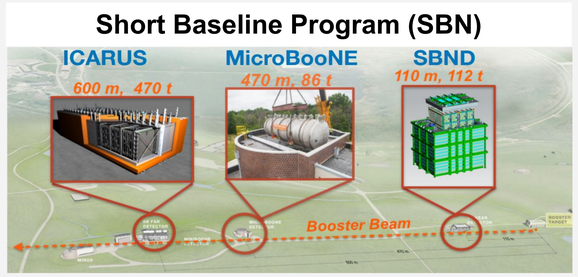
Develop a DAQ-level, high purity neutrino selection with low cosmic background that can be used to:

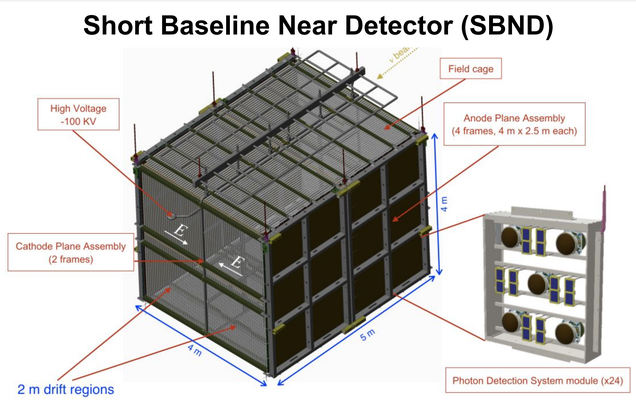
- Aid in commissioning projects, such as setting trigger thresholds
- Monitor beam intensity and position
- Provide data to help develop and validate particle ID and other analysis tools

SBND

The Short-Baseline Near Detector (SBND) is a Liquid Argon Time Projection Chamber (LArTPC) currently being built as part of Fermilab's Short Baseline Neutrino Program (SBN). Located along the Booster Neutrino Beam (BNB) just 110m from the target, SBND expects to see over a million neutrino interactions per year[1].

- Highest neutrino event rate in SBN, with an expected neutrino flux ~30x higher than MicroBooNE.
- One year exposure of SBND will provide an event sample 6-7 times larger than will be available in the full MicroBooNE phase I run.
- Neutrino-to-cosmic ray signal-to-background ratio anticipated to be at least 3:1, and as high as 8:1 with a 100% efficient trigger[2].

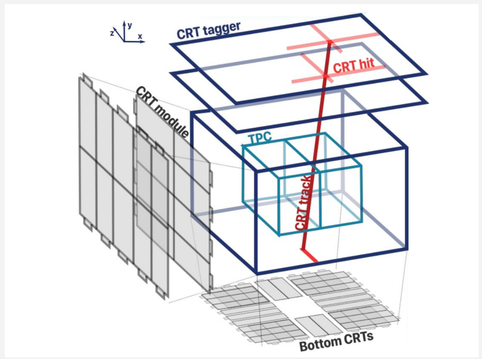




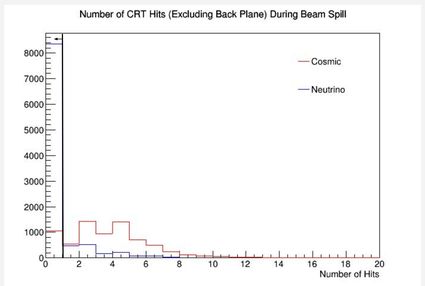
Monte-Carlo Simulation Samples

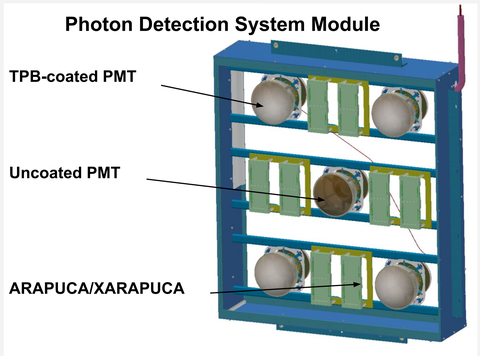
- This selection was developed using simulated events from two samples.
- Neutrino Overlay Sample
  - Signal events for this selection
  - Simulated neutrino BNB events overlaid on simulated cosmic rays
  - 10000 total events
- In-time Cosmic Sample
  - Background events for this selection
  - Simulated cosmic rays, with at least one cosmic ray that occurs during the beam spill, with high enough energy to trigger the readout
  - No neutrino interactions from BNB
  - 7203 total events
- Overlay plots use raw event numbers, normalization is done only to calculate purity

Creating the Neutrino Stream

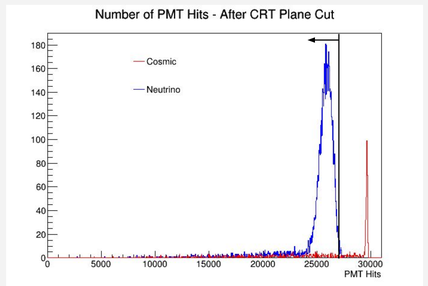


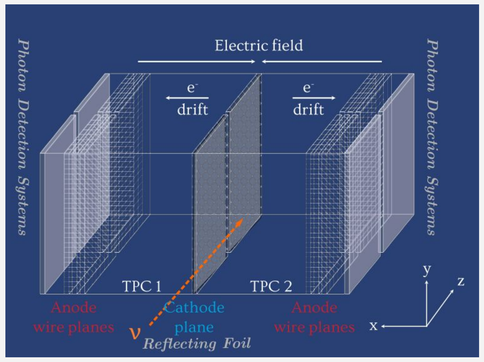
Cosmic Ray Tagger (CRT): Keep events with no CRT hits on all planes except the back plane (beam downstream direction) within the beam spill time



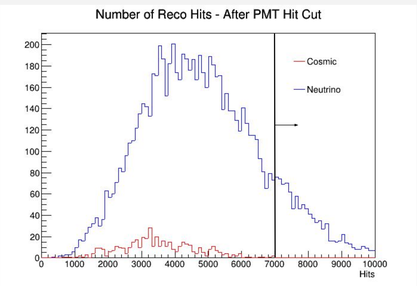


PMT Hits: Keep events with less than 27000 PMT hits on the TPB-coated PMTs over the 1.28ms readout window





TPC Wire Hits: Keep events with more than 7000 TPC collection plane hits over the 1.28ms readout window



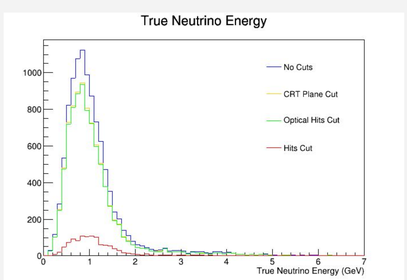
Efficiency and Purity

Cuts	ν Efficiency	ν Purity
No CRT Hits for Planes≠2	83.64%	94.46%
PMT Hits ≥27000	82.79%	97.61%
TPC Wire Hits > 7000	10.60%	100%

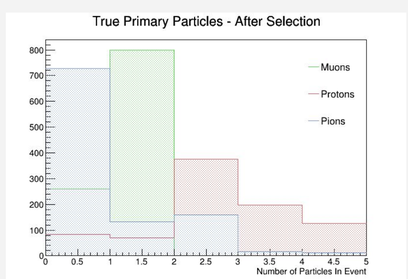
- Selection cuts chosen to obtain 100% neutrino purity.
- Purity calculated assuming neutrino to in-time cosmic ratio of 3:1.
- 10.6% efficiency corresponds to an estimated 700 neutrino events per day.

Neutrino Stream Composition

- 98% muon neutrinos
- 78% Charged Current Events, 22% Neutral Current Events



- Plenty of muons, protons, and charged pions in events - useful for particle identification tool validation
- Muon and Proton tracks can also be used to find the neutrino vertex and monitor the beam position



Conclusion and Next Steps

- Using low-level CRT, PMT, and TPC collection plane information, a preliminary 100% pure neutrino selection has been developed.
- This selection will be implemented as a software trigger inside the DAQ, selected events will be tagged and copied to temporary disk storage to be used for nearline monitoring and fast turn-around studies.
- Further refinement can now be done to separate the neutrino sample into sub-samples optimized for their specific use.
- See the poster "Status of the Short-Baseline Near Detector at Fermilab" in this session for more details on SBND.

References

[1] R. Acciarri, et al. "A Proposal for a Three Detector Short-Baseline Neutrino Oscillation Program in the Fermilab Booster Neutrino Beam" arXiv: 1503.05120

[2] M. Auger, et al. "A Novel Cosmic Ray Tagger System for Liquid Argon TPC Neutrino Detectors" arXiv: 1612.04614