An Electron Neutrino Event Selection Procedure in the SBND Detector

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IOP Joint APP and HEPP 2019

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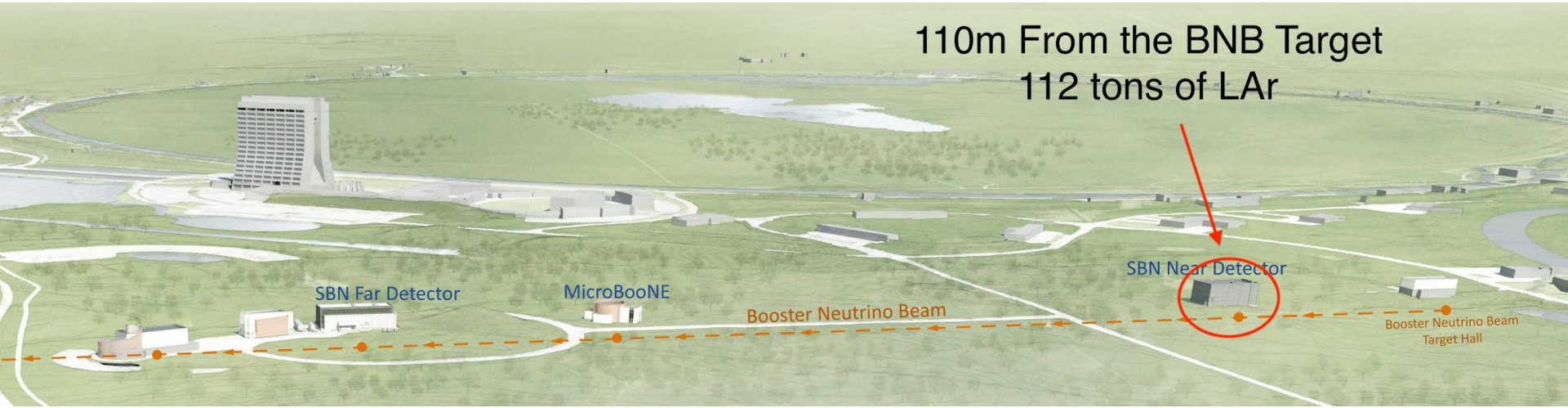
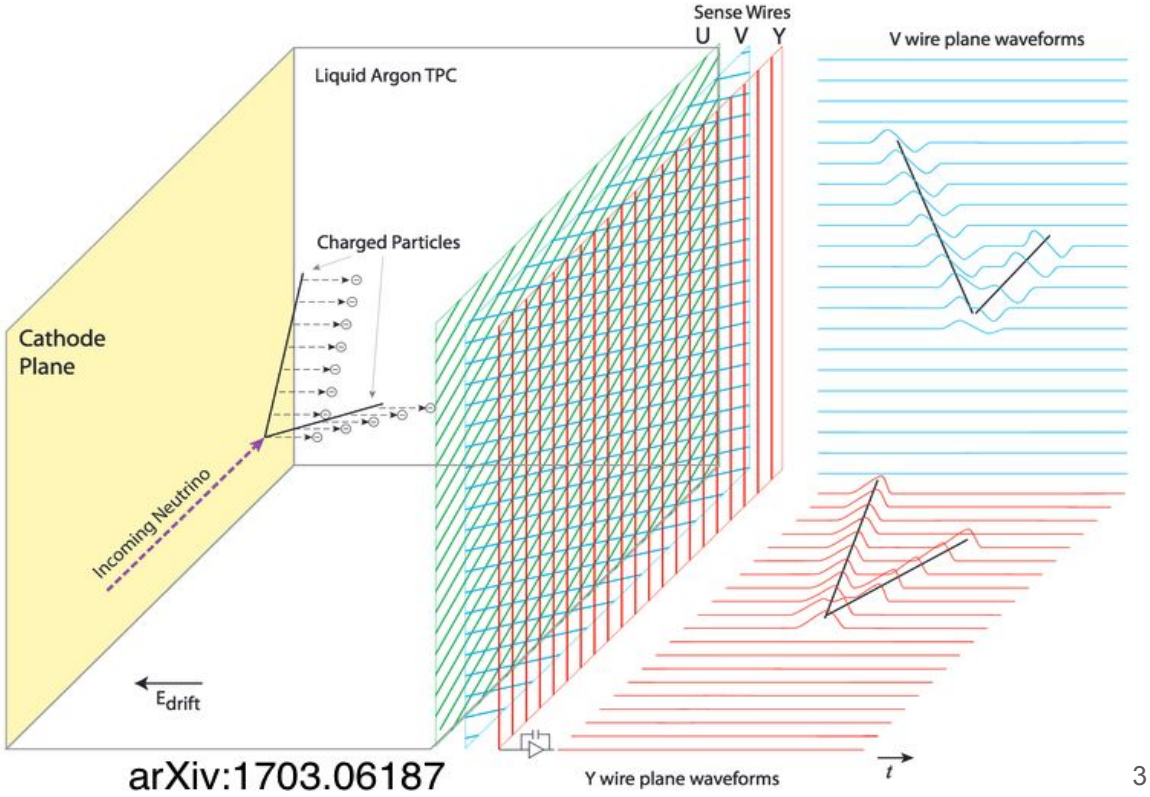
The Short Baseline Near Detector (SBND)

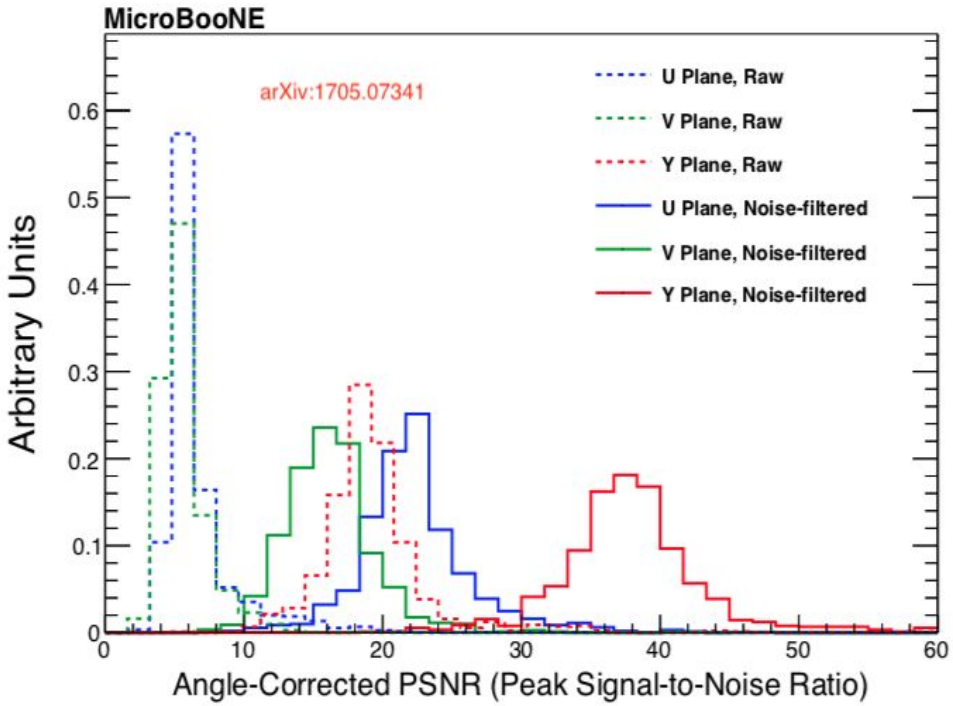


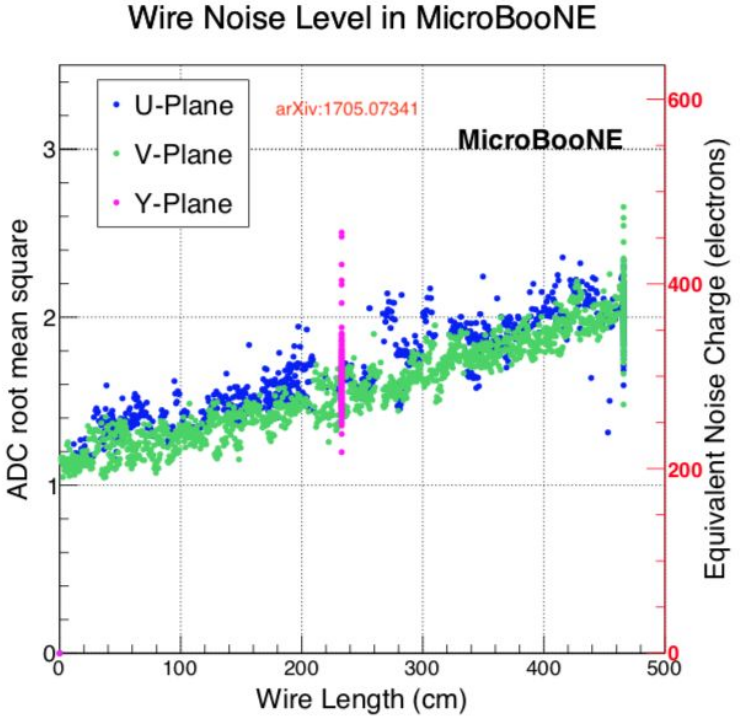
Liquid Argon Time Projection Chambers

- Charged Particles Ionise argon atoms as they travel through the detector.
- Electrons recombine and provide scintillation light that the PDS detects.
- Ionised electrons drift to a wire-plane readout.
- High resolution images in time vs wire space are created in multiple planes.
- 3D reconstruction is then available.



LArTPCs Resolution Quality

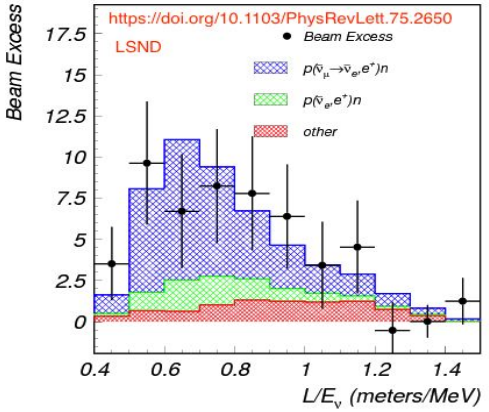


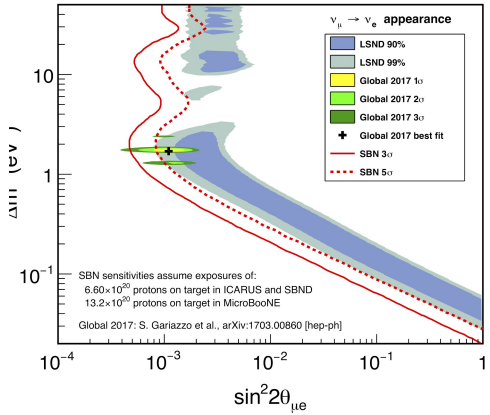


SBN Programme

Electron neutrino identification is important for:

- Searches for the MiniBooNe & LSND electron neutrino excess. The SBN programme will be capable of performing a world leading sensitivity for low mass sterile neutrinos.
- The high statistics allow SBND to perform world leading neutrino cross-section measurements, useful for future LAr experiments.



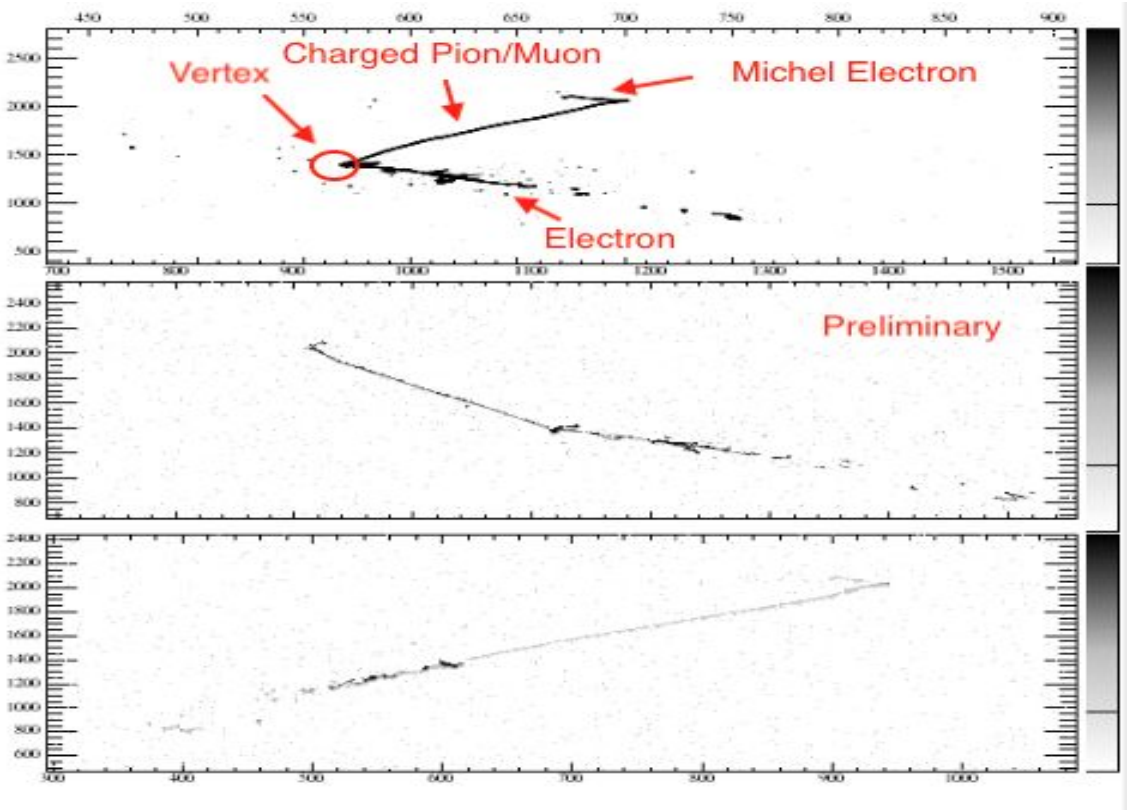


Electron Neutrino in SBND

- BNB electron neutrinos create electromagnetic (EM) showers in the TPC.
- Single EM shower have a range of backgrounds in SBND e.g. Neutral Pion events, Dirt events, cosmic events. Electron scattering…
- Some of these are produced in large numbers in SBND.
- O(100) oscialled electron neutrino events in SBND!

ν_e **Inclusive**	$\approx$ **36,000**
Neutral Current	
ν_μ Inclusive	2,170,990
$\rightarrow 0\pi$	1,595,488
$\rightarrow 1\pi^{\pm} + X$	231,741
$\rightarrow \geqslant 2\pi^{\pm} + X$	343,760
$\rightarrow e(^{-})$	374

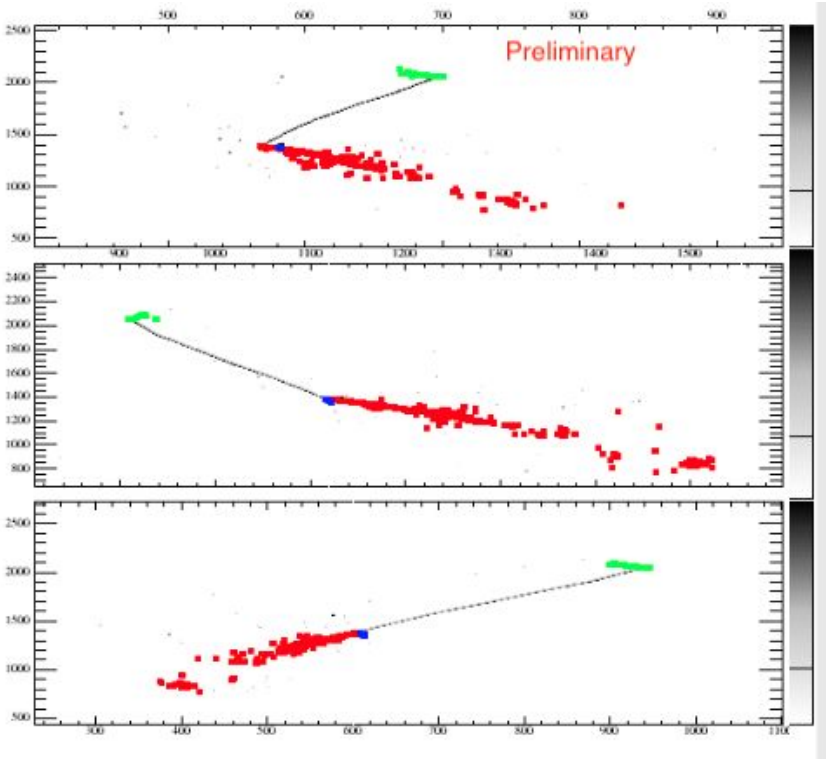
Simulated Electron Neutrino in SBND



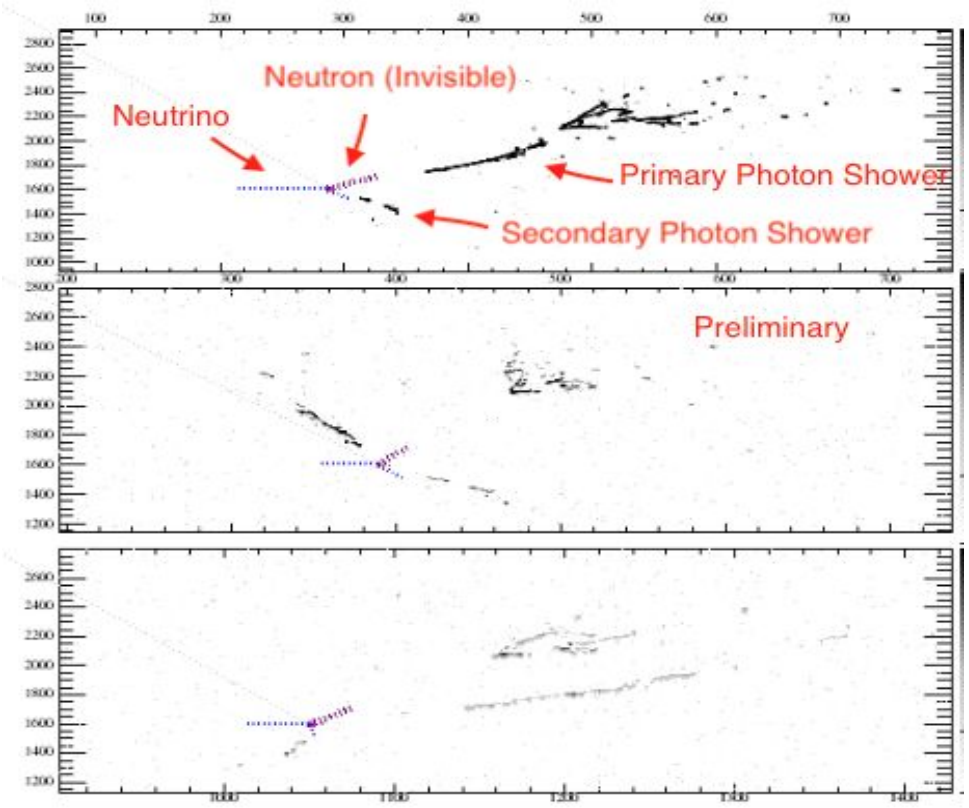
Reconstructed Simulated Electron Neutrino in SBND

Shower Reconstruction Chain

- SBNDs reconstruction chain is implemented in LArSoft (https://larsoft.org), which is a global software shared amongst most of the LAr experiments.
- Firstly we perform 1D deconvolution on the waveforms to remove electric field and electronic effects.
- 1D Hits are then found on the wires
- Clustering of hits and 3D projection matching is done by the PANDORA PFA (arXiv:1708.03135)
- For Shower-like particles the particles direction, initial position, energy and the dEdx of the initial track are calculated.

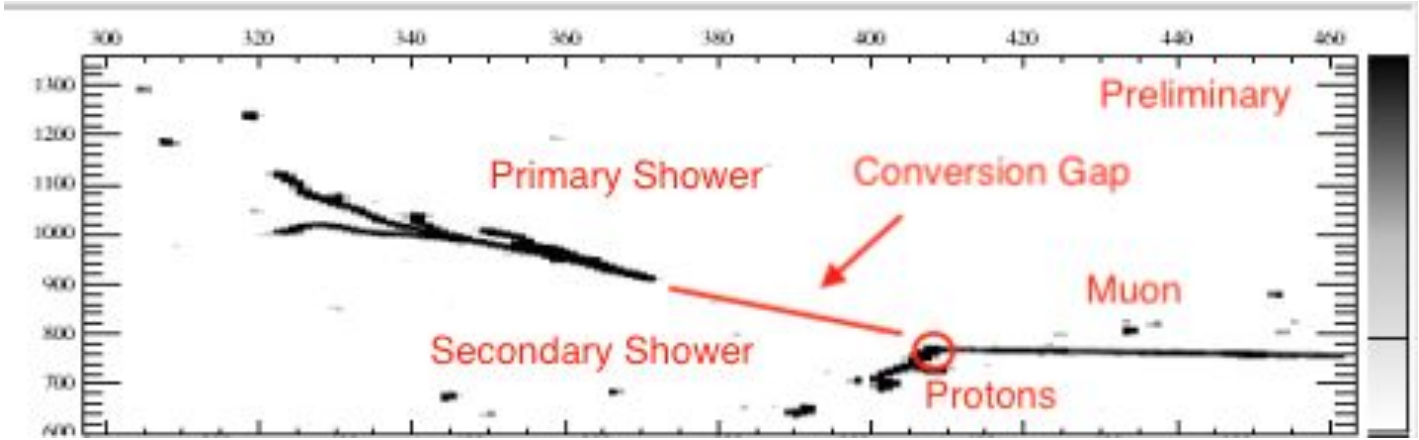


Simulated Neutral Current Pion Event



- A Background to electron neutrino events are neutral current events.
- In the events neutral pions can be produced which decay into two photons.
- The two photons decay into e+ & e- which shower.
- If the secondary photon is reconstructed within the active volume one could identify this as a neutral pion event and remove it.

Using the Conversion Length to Remove Neutral Currents



- If there is track like activity at the vertex we can see the vertex.
- Photon showers, due to the radiation length. of the photon, start showering away from the vertex.
- Events such as these can be removed (currently we do this to 3 cm).
- Currently we propose to be able to see 20 MeV hadron tracks and vertices with energy > 50 MeV to remove these events.

Using dEdx to Remove Photon Showers

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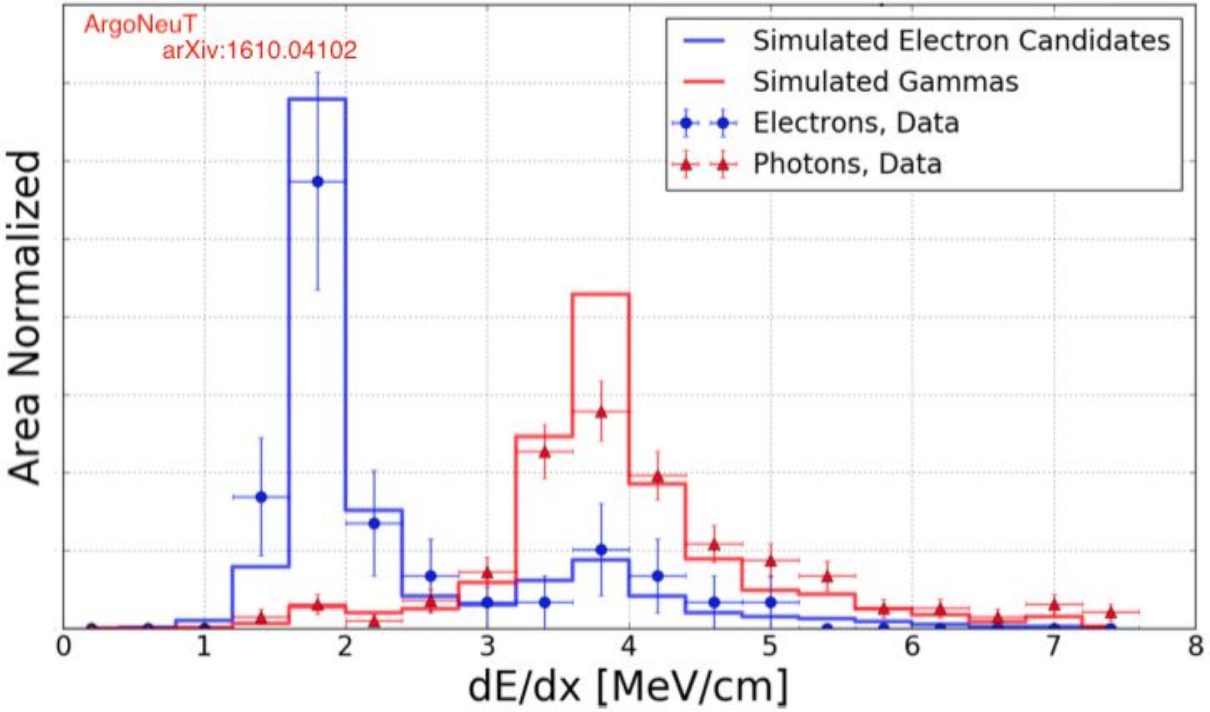
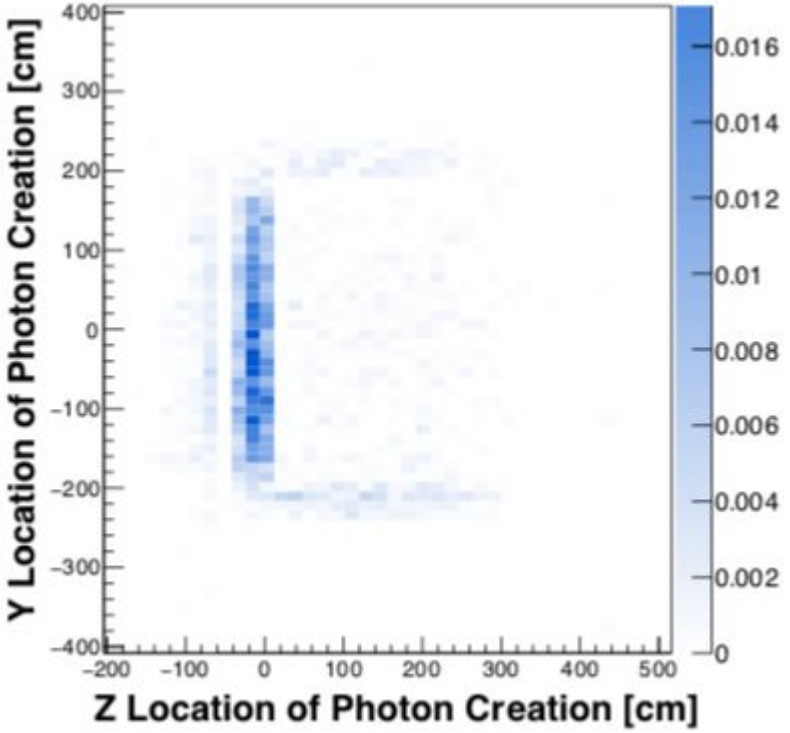


- dEdx of the initial track of the shower is a powerful metric to remove photon backgrounds from the electron neutrino selection.
- This is because for photon showers a e+ e- pair create the track rather than a single electron.
- We propose that 94% of background events can be removed from the sample. This is based on previous LArTPCs efforts.

Dirt Events

- Photons from beam events that interact outside of the active volume can convert inside the TPC, mimicking electron neutrino events.
- A fiducial volume cut helps to remove these events.
- Currently a 25 cm cut is applied to the active volume in the non-beam directions. A further 5 cm upstream of the beam and a further 25 cm downstream is applied.
- Dirt Events undergo the dEdx cut as well.



Cosmogenic Backgrounds

- As SBND is on the surface the cosmic flux is high.
- Using the beam spill timing, the PDS and the cosmic ray tagging system we estimate a 95% efficiency in cosmic rejection.
- A further 94% of cosmics can be removed from a dEdx.
- Simple methods using the TPC data have shown to remove cosmics up to a further 99% with minimal fiducial volume loss in a truth analysis.

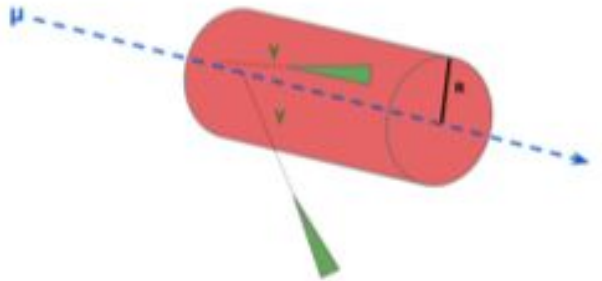
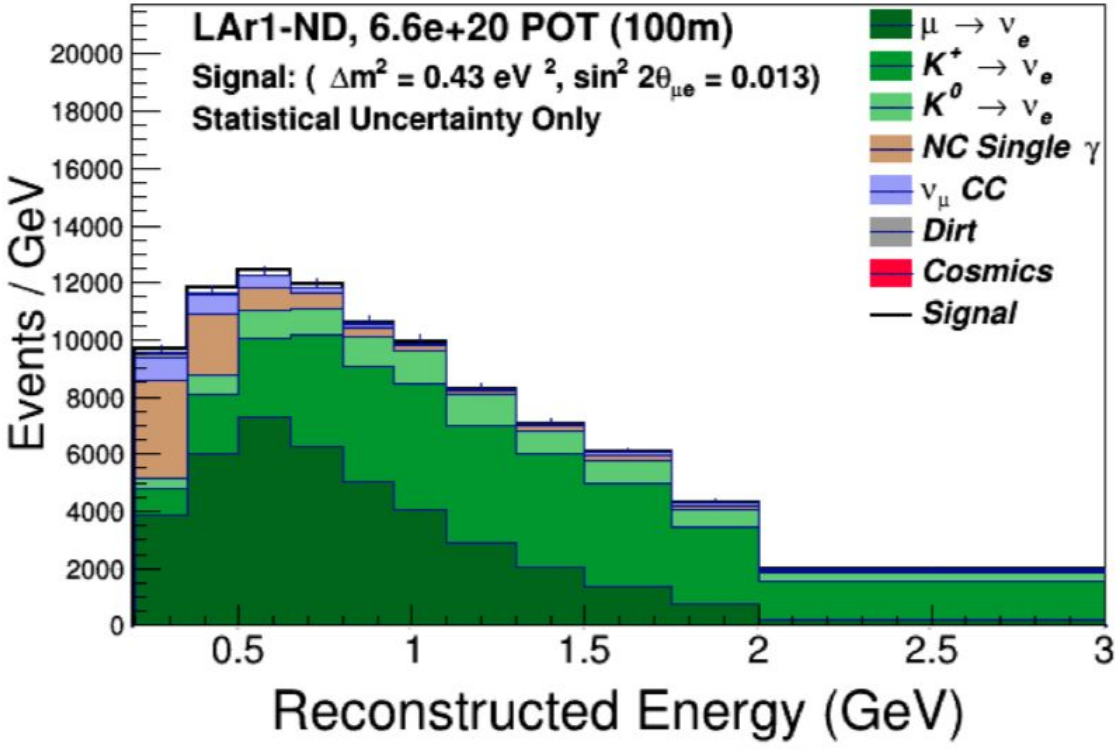
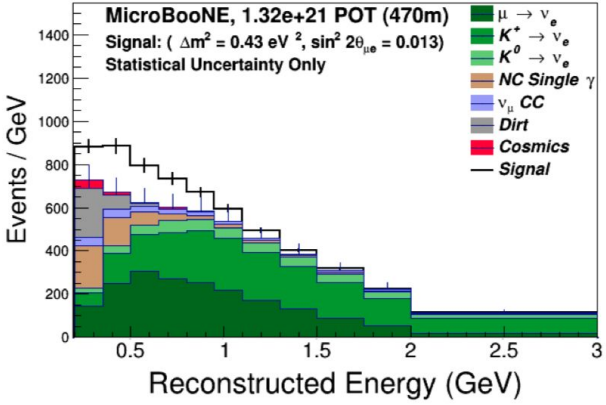
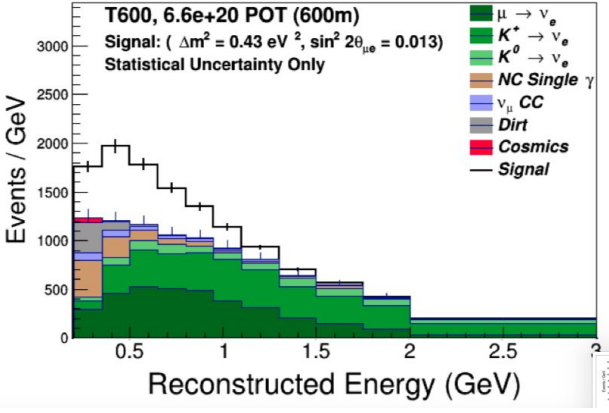


Figure: Placing a 15 cm cylinder around cosmic muon significantly reduces the number of electron neutrinos.

Electron Neutrino Event Selection From MC Truth.







Conclusions and the Future.

- The SBN programme is capable of performing a world leading search for low energy sterile neutrinos.
- Due to the high resolution and the good signal to noise ratio LArTPCs are capable of identifying electron neutrino candidates, whilst removing a large fraction of background events.
- The reconstruction chain is capable of reconstructing electron neutrino events but improvements are being made.
- Improvements are also being made to monte carlo electron neutrino selection procedure.

Thank You. Are there any questions?