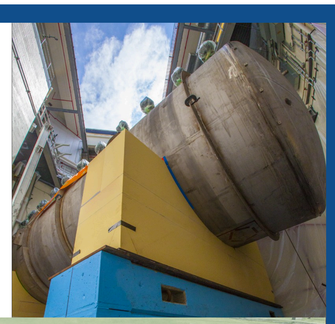
High Performance Reconstruction of π^0 Decays with Wire-Cell Tools in MicroBooNE

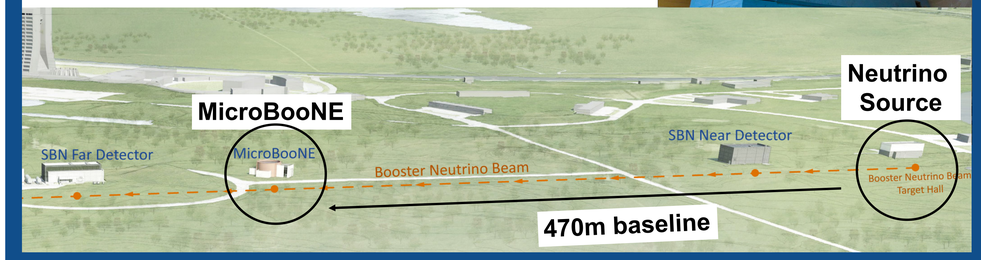
Kaicheng Li (Yale University) on behalf of the MicroBooNE Collaboration

The MicroBooNE Detector

- Investigate MiniBooNE LEE (low energy excess)
- Measure neutrino cross sections on argon
- LArTPC (Liquid Argon Time Projection Chamber) R&D

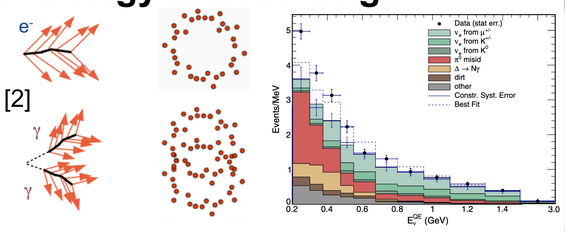
- Short-baseline surface detector
- 2.6m x 2.3m x 10.4m
- 85 tons active mass of liquid argon
- 3 planes of wires and 32 photomultiplier tubes [1]





MiniBooNE Low Energy Excess Origin?

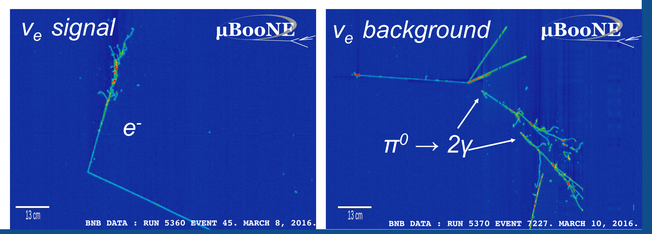
- ν_e / $\bar{\nu}_e$ appearance from BNB
- 4.7σ excess in 200 – 1250 MeV [2]
- *Electron* like *or photon* like?



LArTPC can identify electron-like or photon-like

For *e/γ separation*
- Detached shower vertex
- dQ/dx at shower start

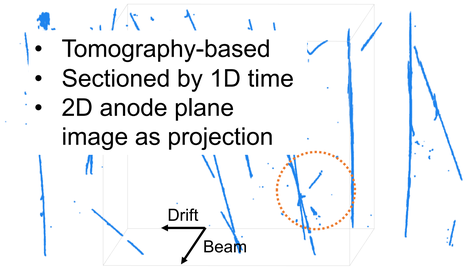
For *e/π⁰ separation*
- **Topology also valuable**
  2 vs 1 EM showers



Event Reconstruction using WireCell Tools in MicroBooNE

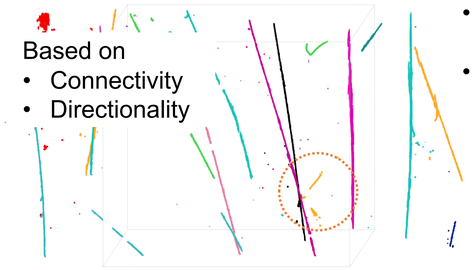
3D Imaging

- Tomography-based
- Sectioned by 1D time
- 2D anode plane image as projection



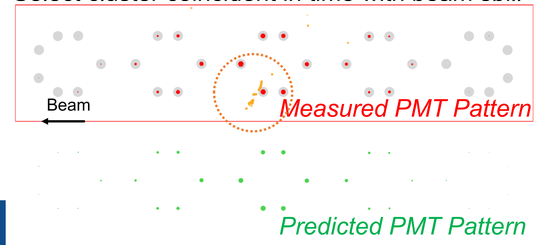
3D Clustering

Based on
- Connectivity
- Directionality



Many-to-many Charge Light Matching

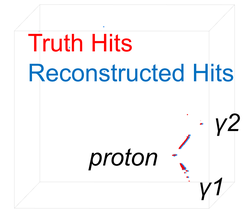
- Simultaneously match many measured PMT patterns to many predicted ones from clusters
- Select cluster coincident in time with beam spill

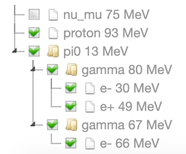


Shower Completeness as Handle to Evaluate Reconstruction of π^0 Decays

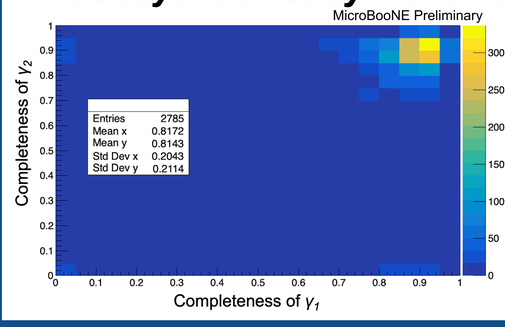
- Use a dedicated neutral current π^0 Monte Carlo sample
- 3596 events with neutrino vertex and π^0 *shower vertices in detector active volume*
- 99.4% find a neutrino candidate coincident in time within the beam spill window
- 77.4% pass various WireCell taggers to reject different cosmic backgrounds
- Examine individual **completeness of each *shower* (γ)** *from* π^0 in passing events
  - Completeness = true hits overlapping the reconstructed 3D images ÷ all true hits
  - True hits are weighted by true deposited energy

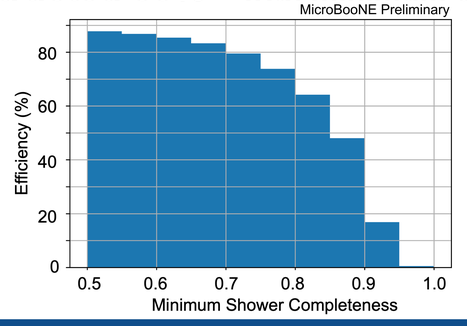
Reconstructed Hits vs Truth Hits

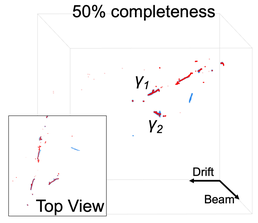


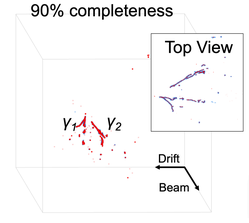


π^0 *Decays Correctly* Reconstructed 88% – with minimum 50% shower completeness





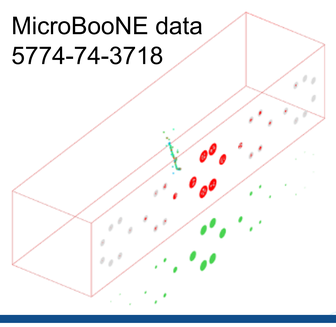




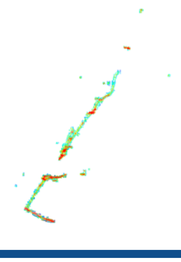
Latest π^0 Pattern Recognition using WireCell Tools

MicroBooNE Preliminary

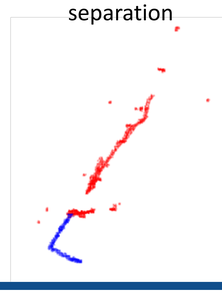
MicroBooNE data
5774-74-3718



Selected neutrino activity

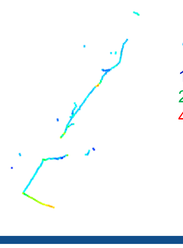


Track/Shower separation

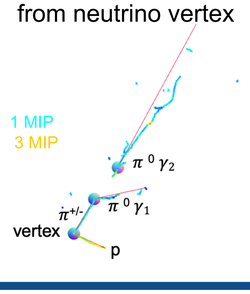


Particle-level sub-clustering

3D dQ/dx displayed with PID capability

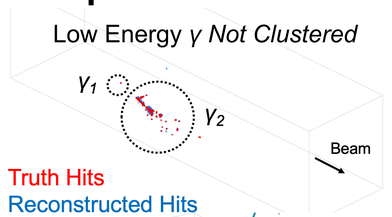


Particle flow starting from neutrino vertex

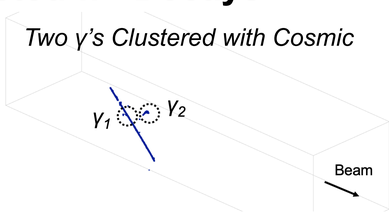


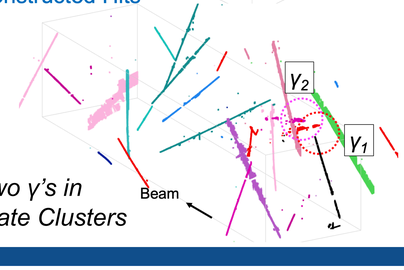
Examples of Mis-Reconstructed π^0 Decays

Low Energy *γ Not Clustered*



Two γ's Clustered with Cosmic





Two γ's in Separate Clusters

References

[1] JINST 12 P02017 (2017)
[2] Phys. Rev. Lett. 121, 221801 (2018)
[3] microboone-note-1040-pub

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