Low Energy Single-Photon Search in MicroBooNE

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MiniBooNE Low Energy Excess (LEE)

- MiniBooNE was a cherenkov detector on the Booster Neutrino Beamline (BNB).
- Observed an excess of electromagnetic (EM) events in the low energy range.
- However, it was unable to discriminate between electrons and photons.
- Electron-like LEE could be evidence for the existence of sterile neutrinos.
- 2.5 Neutrino 2.0 Data (stat err.) from u Events/MeV from K" 1.5 from K⁰ misid ∆ → Ny 1.0 dirt other Constr. Syst. Error 0.5 0.0 0.4 0.6 0.8 1.4 1.5 1.0 1.2 3.0 E_v^{QE} (GeV) arXiv: 0812.2243
- Photon-like LEE could be evidence for photon background process not predicted by MiniBooNE.





NC Δ Radiative Decay

- Produces a single EM shower giving it the same signature as the LEE events.
- Irreducible background for the electron neutrino search in MiniBooNE.



 Used to benchmark MicroBooNE's sensitivity to a photon LEE.

Diagram of NC Δ radiative decay.

 Rare in MicroBooNE, ~100 expected events per 6.6e20 POT (in fiducial volume).





Event Topologies









Event Reconstruction







MC Samples

Signal:

 NC △ radiative - only events with true neutrino vertices inside the fiducial volume.

Background:

• BNB + cosmic – any neutrino interaction from the BNB with simulated cosmic tracks and showers.

+

 In-time cosmic - Simulated cosmic tracks and showers that produce light in time with the beam.



MicroBooNE simulation: BNB π^{0} .









































Selection Efficiency



Successive Cut	Total Efficiency %		
	NC Δ radiative	BNB + cosmic	In-time cosmic
Cosmic background mitigation	53	10	0.4
Longest associated track length <= 30 cm	50	3	0.2
Shower dE/dx and conversion distance	TBD	TBD	TBD

Further Background Mitigation Strategies

Cosmogenics are the largest background contribution despite a factor 500 reduction.



Consider shower proximity to cosmic tagged tracks.

More aggressive fiducial volume cut for external π^0 events.

Summary

- This is the first attempt at a search for low energy single photon events in MicroBooNE.
- Challenging analysis due to low signal event rate.
- Signal selection efficiency of 50 % with cosmic background reduced by a factor of 500.
- Next steps:
 - introduce dE/dx vs conversion distance cut.
 - implement further background mitigation strategies.



