Measurement of Out of Tank (Dirt) Events with MiniBooNE
Hai-Jun Yang (for MiniBooNE Collaboration), University of Michigan, Ann Arbor
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**Goal:** The MiniBooNE experiment is designed to confirm or refute $\nu_\mu \rightarrow \nu_e$ oscillation signal seen by LSND

- The FNAL Booster delivers 8 GeV protons to the MiniBooNE beamline.
- The protons hit a 71 cm beryllium target producing pions and kaons.
- The magnetic horn focuses the secondary particles towards the detector.
- The mesons decay into neutrinos, and the neutrinos fly to the detector, all other secondary particles are absorbed by absorber and 450 m dirt.
- 5.6E20 POT for neutrino mode since 2002.
- Switch horn polarity to run anti-neutrino mode since January 2006.

- L/E, MiniBooNE (0.5 km / 0.8 GeV)
- L/E, LSND (0.03 km / 0.05 GeV)
- About 0.8 GeV $\nu_\mu$ beam (~0.5% intrinsic $\nu_e$)
- 1.5 M neutrino events collected
- Looking for a few hundred $\nu_e$ CCQE
- Major background sources are intrinsic $\nu_e$ (~60%), $\nu_\mu$ mis-ID (~30%) and out of tank events (~10%)

- Neutrino beam interacts with dirt outside of tank, the high energy $\gamma$ (100 ~ 300 MeV) sneak into the tank to produce e-like Cerenkov ring.
- $N_{\text{dirt\_expected}} = 621$, $N_{\text{tank\_expected}} = 726$, $N_{\text{data}} = 1349$
- $N_{\text{dirt\_measured}} / N_{\text{dirt\_expected}} = 0.99 \pm 0.15$
- Dirt events contribute ~10% of background for oscillation $\nu_e$ search.

$U$ – unit vector of reconstructed track direction
$R$ – vector from tank center to track center