A Search for Neutrino Oscillations with MiniBooNE

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Oscillation Search

The MiniBooNE experiment [1] is designed to search for $\nu_\mu \rightarrow \nu_e$ oscillations with oscillation parameters the same as those for which the LSND experiment previously reported a positive signal [2], but with greater statistics. Data collection with a ν_μ beam began in September 2002. The proton intensity delivered by the Fermilab 8-GeV booster accelerator was somewhat lower than anticipated for the first year after startup. However, this has been improved and a significant fraction of the proposed intergrated flux has been delivered. As of October, 2005, 6.5×10^{20} POT (protons on target) have been delivered to the 8-GeV neutrino production target.

The current estimate of the MiniBooNE oscillation sensitivity shown in Fig. 1 indicates that the allowed oscillation region as measured by LSND will be covered at a 3-5σ level with the 6.5×10^{20} POT delivered as of this writing.

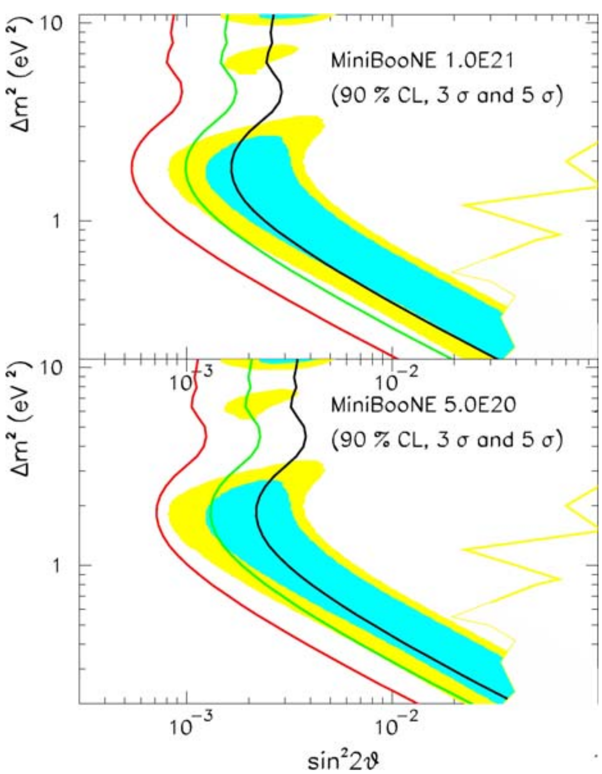

Figure 1: Estimated MiniBooNE oscillation sensitivity for $\nu_\mu \rightarrow \nu_e$ oscillations with 1×10^{21} POT (top) and 5×10^{20} POT (bottom) using an energy-fit method. The blue (yellow) region is the 90% (99%) confidence level region from LSND.

The oscillation analysis consists of searching for ν_e interactions ($\nu_e\,C \rightarrow e^- X$) in the MiniBooNE detector located 550 m downstream from the neutrino production target. The analysis is proceeding with the candidate $\nu_e\,C \rightarrow e^- X$ kept "blinded" until the data selection criteria are determined. For this reason, preliminary oscillation results are not yet available. These results will be available in the near future. In the meantime, the analysis is proceeding using "open" samples of data and Monte Carlo simulations to determine the optimal data selection. The "open" data samples are being analyzed to determine the backgrounds to the oscillation search and to extract interesting physics. Several preliminary results have been presented by the collaboration.

Charged-Current Quasielastic Neutrino Scattering

Charged-Current Quasielastic (CCQE) interactions of muon neutrinos ($\nu_\mu C \rightarrow \mu^- X$, where X is a nuclear fragment) are the most common event type observed in the detector. MiniBooNE has collected a sample of approximately 500k as of this writing. A preliminary result showing the Q^2 (squared 4-momentum transfer) distribution is shown in Fig. 2. An interesting, and not yet completely understood, feature is the low-Q^2 deficit of events compared to the Monte Carlo simulation which includes both detector response and a nuclear-response model of the interaction.

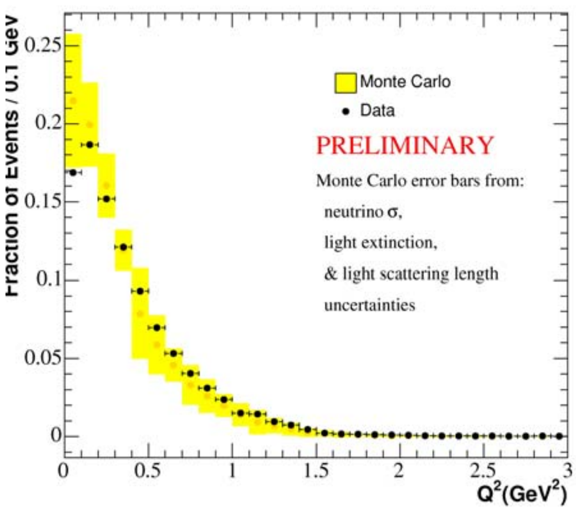

Figure 2: Preliminary result showing the Q^2 distribution of charged-current quasielastic interactions observed with MiniBooNE.

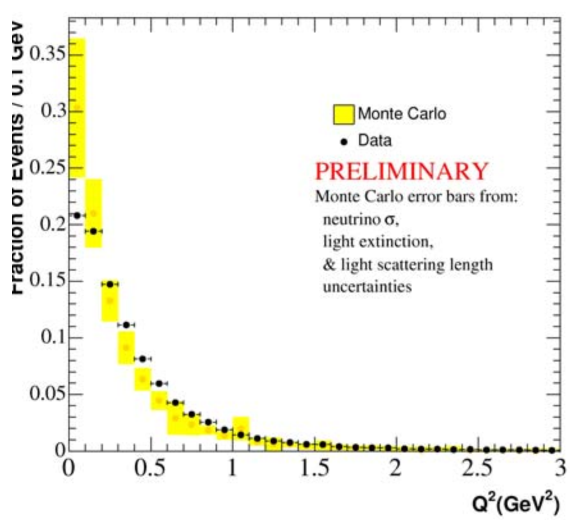

Figure 3: Preliminary result showing the Q^2 distribution of charged-current π^+ interactions observed with MiniBooNE.

Charged-Current Pion Production

MiniBooNE is also able to identify and measure charged-current pion (CCπ) interactions. The $\nu_\mu C \rightarrow \mu^- \pi^+ X$ channel is identified by the characteristic signature of two subsequent muon decays ($\pi^+ \rightarrow \mu^-$) following the primary interaction. The (preliminary) Q^2 distribution for this reaction is shown in Fig. 3. The agreement with the simulation is reasonable, however, this distribution also shows an anomalously large rollover at low Q^2. This feature of both the CCQE and CCπ is currently under investigation.

Neutral-Current Pion Production

Neutral-current π^0 (NCπ^0) interactions are produced in MiniBooNE and require close scrutiny because they are one of the important backgrounds to the $\nu_\mu \rightarrow \nu_e$ oscillation search. In this interaction, $\nu_\mu C \rightarrow \nu_\mu \pi^0 X$, one of the photons from the $\pi^0 \rightarrow \gamma\ \gamma$ may be missed in the reconstruction and will result in a signal that looks like the $\nu_e C \rightarrow e^- X$ interaction. For this reason, it is important to measure $\nu_\mu C \rightarrow \nu_\mu \pi^0 X$ to high accuracy. This is being accomplished and preliminary results for the measured π^0 mass are shown in Figure 4.

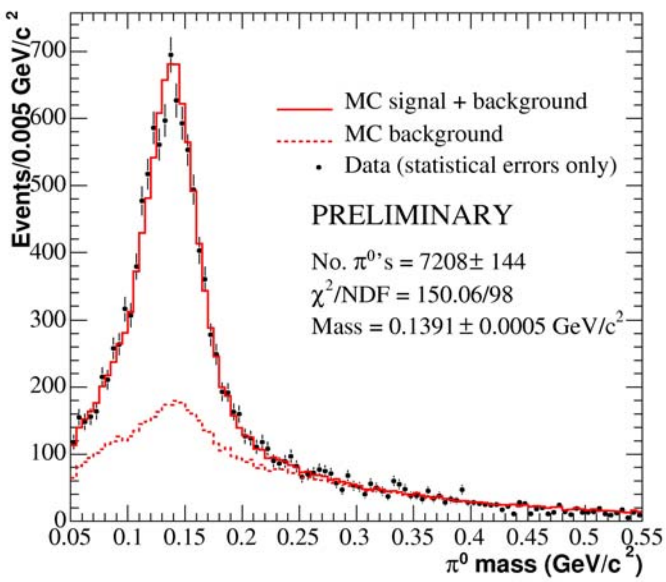

Figure 4: Preliminary results showing the reconstructed π^0 mass as measured by MiniBooNE.

1. E. Church et al., (BooNE Collaboration), FERMILAB-PROPOSAL-0898.
2. A. Aguilar, *et al.*, Phys. Rev. D **64** (2001) 112007.