MicroBooNE: Addressing the low energy events observed by MiniBooNE

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First results from the MiniBooNE experiment rule out a two neutrino interpretation of the LSND signal observing no events above background in the 475-1250 MeV energy range. However, a 3.7σ excess of events above background is observed below 475 MeV as shown in Figure 1 [1]. MiniBooNE is actively working to understand this discrepancy which could suggest new physics or a not well understood background. There are a number of theory papers both pre-dictions and post-dictions that can explain the low energy discrepancy within the context of new physics [2, 3, 4, 5]. If not new physics, the discrepancy will still need to be understood for the next generation of neutrino experiments looking for neutrino oscillations in this same energy range. Here we describe the MicroBooNE experiment to address this low energy excess using a Liquid Argon TPC (LArTPC) detector which is particularly sensitive at low energies and nearly background-free. Specifically, with ν_e efficiency at 80% or larger and ability to reject the ν_μ misID background at low energy a LArTPC is ideal detector for this experiment. With these qualities the detector can be an order of magnitude smaller in size than MiniBooNE, thus reducing costs. As well, employing a LArTPC to address these low energy events advances the R&D effort towards massive LArTPCs for long baseline ν_e appearance physics.

MiniBooNE has observed 92 events above background. Assuming 80% efficiency, a LArTPC of the same 500 ton fiducial mass would observe 147 events from the Booster Neutrino Beam. Because of the imaging capability of a LArTPC, virtually all of the ν_μ misID background is eliminated. In particular, π^0 showers have a distinct signature compared to electron showers due to dE/dx deposition in the first $\sim$2 cm of the shower. Thus, backgrounds from Neutral Current π^0 interactions, Radiative delta decays, and dirt backgrounds which come primarily from π^0s produced outside the detector, are eliminated. Backgrounds due to ν_μ mis-IDs are rejected via topology of the muon vs electron. Only intrinsic electron neutrino interactions remain, however these are falling off at low energies as shown in Figure 2. Assuming we understand the intrinsics only as well as MiniBooNE has, twenty ν_e intrinsics in MiniBooNE (known to 20%) correspond to 32 in the equivalent fiducial volume of LAr remain. Reducing the size of the LArTPC by an order of magnitude to 50 tons leaves 14.2 events $\pm 3.7_{stat} \pm 0.6_{intrinsic}$, a 3 σ signal. With a similar L/E for the low energy, off axis events from the NuMI beam, an excess as observed by MiniBooNE in this beam can be identified in MicroBooNE as well.

An approximately 100 ton module is imagined to achieve this 50 ton fiducial volume. The detector will be located near the MiniBooNE detector hall, on the surface, exposed to the on axis Booster Neutrino Beam and/or the off axis NuMI neutrino beam. A data set of a size similar to MiniBooNE's from the Booster Neutrino beam (corresponding to 6×10^{20} protons on target) and from the NuMI off axis beam will suffice to address the MiniBooNE result.

MicroBooNE is a small, focused experiment using an LArTPC, ideal at low energies and nearly background-free, to address the low energy excess of events observed by the MiniBooNE experiment.

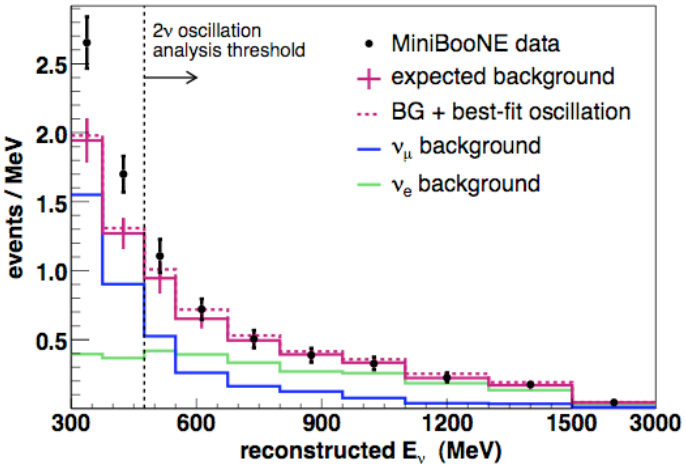

Figure 1: First results from MiniBooNE show an excess of events below 475 MeV.

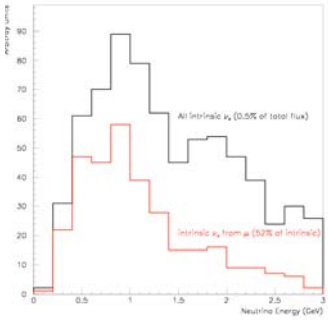

Figure 2: Intrinsic electron neutrino backgrounds shown here are dropping at low energies.

References

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