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MiniBooNE

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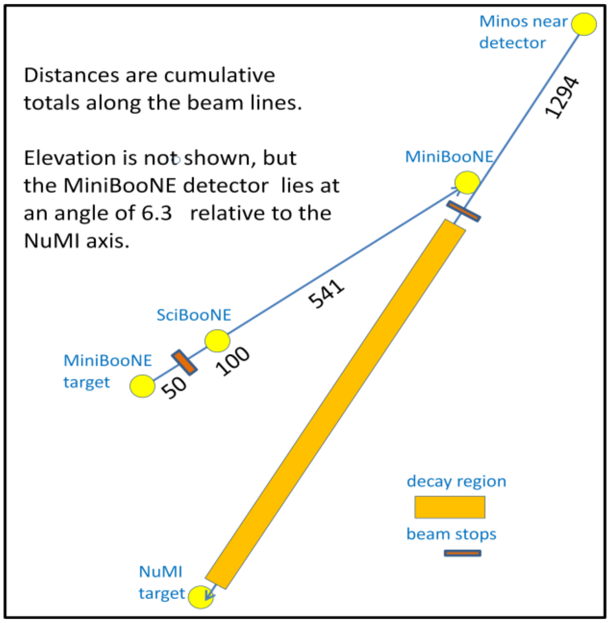


Figure 1: Neutrino beam geometry at Fermilab.

To begin, we examine the relationship between MiniBooNE and the neutrino beam geometry at Fermilab. In Figure 1, a schematic representation is shown of the plan view of the location of MiniBooNE relative to SciBooNE and the NuMI target, where it can be seen that SciBooNE and MiniBooNE share the same beamline and neutrino flux, and therefore share some of the same systematic effects -- A combined analysis between the two experimental groups could yield a superior result compared to segregated individual analysis. MiniBooNE makes an angle of 6.3 degrees with the NuMI beamline, an off-axis measurement if you will, that provides a relatively high yield of electron neutrinos from kaon decay. Furthermore, the proton beam incident on the MiniBooNE target possesses a 53 MHz structure that will be important in timing studies related to the low energy excess.

Let's review of the results of the MiniBooNE: As is well known, MiniBooNE, a test of the LSND effect [1], adds experimental inspiration to the possible existence of new phenomena; although two neutrino-family oscillations were shown to be an unlikely candidate to explain the LSND effect, a low energy excess of 3.0 sigma in the neutrino sector at energies between 200 to 475 MeV [2] - an effect that appears to have no counterpart in the antineutrino sector [3], combined with the 3.8 sigma LSND result - at roughly 50 MeV - strains phenomenology for insight. Miniboones continues to run and collect antineutrino data; will combine disappearance analysis with SciBooNE; take data from the NuMI target, an unusual source with a potentially new look at the low energy anomaly; and use beam timing techniques to further constrain phenomenological models. In this paper we will review current topics related to MiniBooNE and other associated experiments and

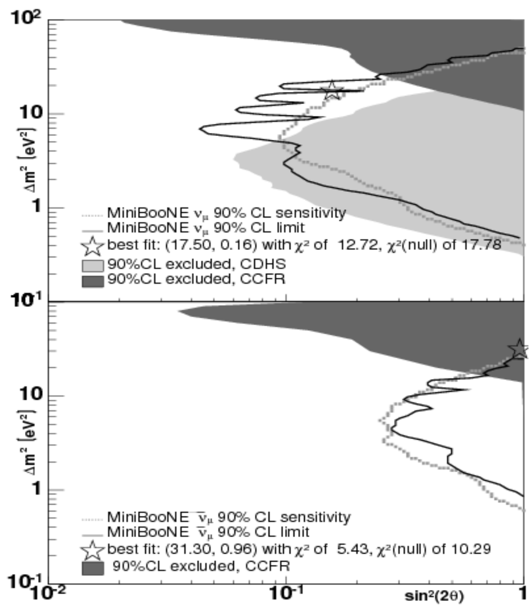


Figure 2: MiniBooNE disappearance results.

phenomenology.

The result of a search for neutrino disappearance in MiniBooNE [4], shown in Figure 2, shows no disappearance effects at the 90% CL. This data will be enhanced by being added to SciBooNE data, but already constrains certain 3+2 models [5]. (3+2 models are a class of 3 active plus 2 sterile neutrinos used for fit existing neutrino and antineutrino data.) Furthermore, the ratio R" defined as

$$\mathrm{X}^{S/M}_{\nu_\mu/\bar{\nu}_\mu} = \text{CCQE events per proton on target for SciBooNE/MiniBooNE and for } \nu_\mu/\bar{\nu}_\mu,$$

$$\text{and } R'' = (\mathrm{X}^{M}_{\bar{\nu}_\mu} / \mathrm{X}^{S}_{\bar{\nu}_\mu})/(\mathrm{X}^{M}_{\nu_\mu} / \mathrm{X}^{S}_{\nu_\mu})$$

is constrained to unity within systematic and statistical differences between MiniBooNE and SciBooNE.

In Figure 3a, we show the neutrino flux at MiniBooNE from the NuMI target, where kaon decays account for 93% of the flux. In Figure 3b, we show the data compared to the predicted flux, with an error band that illustrates the span of systematic errors. No excess is apparent, and further analysis should improve both statistical and systematic errors [6].

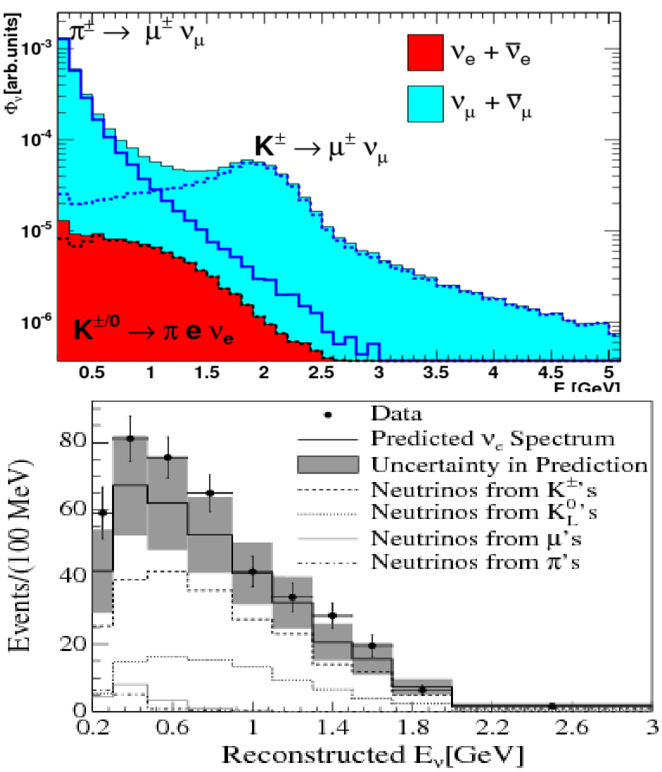
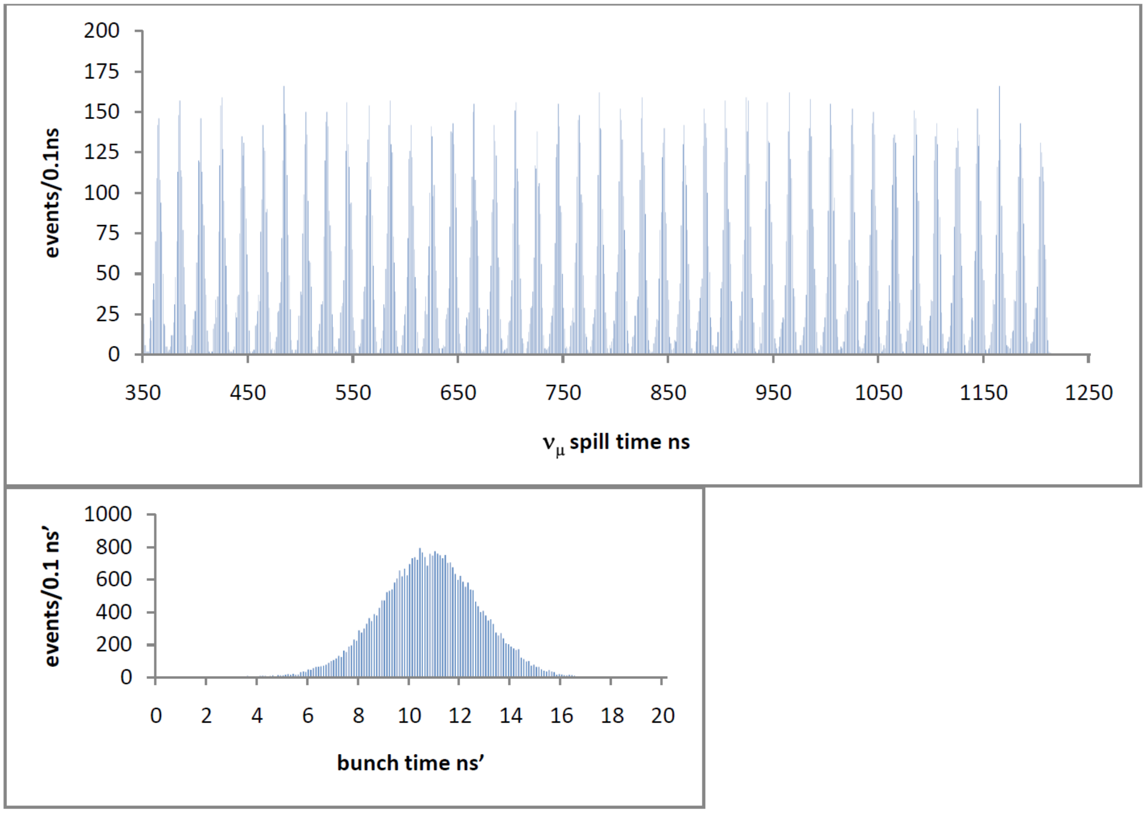


Figure 3a: (top) Composition of flux from the NuMI target. 3b (bottom) Data compared to predicted flux.

Figure 4a gives the distribution of CCQE muon-neutrino interactions as a function of beam spill time, showing the 53 MHz RF structure. In Figure 4b, we show a single bunch within a 20 ns' bucket time. The clean signal combined with similar data for electron neutrinos should give limits on slow, heavy semi-stable particle production in the MiniBooNEbeam [7].

Let's now examine phenomenology: A potential explanation of the low energy anomaly within the Standard Model; an application of the axial vector anomaly to radiative neutrino scattering, where the radiated photon mimics an electron in MiniBooNE, is disfavored, because it predicts the same excess in both the neutrino and antineutrino modes [8]. A model that depends on shortcuts in the brane -- and application of the use of Altered Dispersion Relations -- predicts resonant phenomena at MiniBooNE energies, but also requires a normal hierarchy and a larger excess in antineutrinos than in the neutrino sector [9]. Another form of the theory is based on a breakdown in Lorentz invariance gives a better simulation of the combined

LSND, and MiniBooNE results [10]. As more data become available from MiniBooNE and other experiments, the models may be sufficiently constrained to provide a clear and specific explanation of the anomaly.



Figture 4a (top) Muon-neutrino distribution as a function of beam spill time. 4b (bottom) Muon-neutrino bunch time within an RF bucket.

Summary

MiniBooNE results act as constraints for a variety of models, including those built on Altered Dispersion Relations using sterile neutrinos. Additional running in antineutrino mode will clarify the distinction between the low energy excess for neutrinos and antineutrinos. Combined analysis from SciBooNE and MiniBooNE will further clarify the disappearance results and may offer a direct test of CPT invariance. Further analysis with data from the NuMI beam and analysis using timing techniques will also add to our vision through "Windows on the Universe."

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