Enhancing the low-energy flux in LBNE using a beam created from 8-GeV Protons

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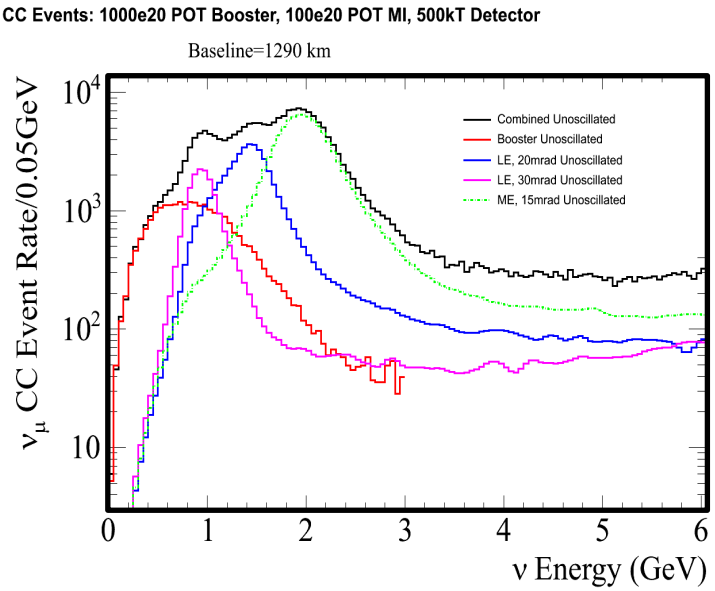
The purpose of this paper is to remind people of a 2005 study on using a future replacement for the booster as a second source of neutrinos for a long baseline experiment. The goal would be to provide additional neutrino flux at low energies to allow for better flux at the second oscillation maximum.

The primary goal for the planned LBNE long-baseline neutrino-oscillation experiment is to explore oscillations in a GeV-range horn-based muon neutrino beam. The LBNE design can use the current Main Injector (MI) and booster complex, but it is primarily envisioned as an experiment that would exploit the full intensity of the Project X accelerator feeding the MI.

The current baseline design for the LBNE neutrino is well optimized for the first oscillation maximum. The real power of the longer LBNE baseline is to exploit the second oscillation maximum too. The differences between the oscillation patterns between the first and second oscillation maximum would allow sensitive studies of the mass hierarchy and the CP violating phase. The LBNE team has worked hard to make a beam design that which maximizes the beam at both oscillation maxima. Their work shows it is hard to achieve a good optimization for both in the same beam line with the same initial proton energy [1].

In 2004, Michael and Smith proposed an experiment based on two primary proton sources targeting the same detector [2]. They proposed that in addition to an MI-based beam targeting the first oscillation maximum that there be a simultaneous second beam produced using 8-GeV protons that would have a peak energy of about 800 MeV, which is well matched to the second oscillation maximum. In simultaneous operation the two beams, with different timing, allow the source of each neutrino to be identified on an event-by-event basis. This significantly reduces backgrounds from neutral current feed down.

The current booster does not produce enough neutrinos to allow a viable experiment. This idea must wait until the Project X era. The lower pion energies in the beam would mean a much shorter, and less expensive decay volume for the lower energy beam. Note that the current Booster Neutrino Beam design is not optimal for a long baseline experiment so a MiniBooNE flux is not an appropriate or optimal assumption. A 2004-era simulation of a flux from 8-GeV protons is plotted in the red in the figure.



Project X has MW power beams of 3-GeV protons and for MI injection. If an upgrade or design change could allow both MI injection and parasitic 8-GeV beams with high power, the low energy beam would have a much better neutrino yield due to better pion production at constant beam power.

[1] M. Bishai, this working group meeting (2011).
[2] D. Michael, C. Smith, "A Fermilab to Homestake Experiment," Proton Driver Workshop, Oct 7, 2004. http://tdserver1.fnal.gov/8gevlinacpapers/WWWtest/PhysicsIncludes/Workshop/Talks/FeHo.pdf