DUNE – Beyond Standard Model Physics Group Meeting

Nonstandard Interactions Subgroup

June 23rd, 2016

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Important previous presentations

- Presentations by, A.deGouvea, P.Coloma, and A.Chatterjee
- The slides of this meeting are in:
  - https://drive.google.com/open?id=0Bz_dKWYW5t-lM3pRZC1HWlpjMUk

Important previous presentations (cont)

- Presentation by Mary Bishai
  - With cases in which this group can improve previous works
  - The slides are found here: https://drive.google.com/open?id=0Bwciidii SXJqSy1SY09lRHA5eFk

LBNE Science Book

- “The LBNE Science Book is still the most comprehensive science study done for DUNE. It also has easy to understand descriptions of the beam and project for graduate students.”
- https://web.fnal.gov/project/lbnearchive/LBNE%20at%20Work/LBNE%20Science%20Program/SitePages/Home.aspx

- Our mission is to improve it.

Some work done and important links

- Animesh reproduced first sensitivity plots using GLoBES and uploaded code to the repository so that other groups can have access to it.
  - https://cdcvs.fnal.gov/redmine/projects/dunebsm/repository
- Wiki of the BSM group:
  - https://cdcvs.fnal.gov/redmine/projects/dunebsm/wiki
- Indico:
  - https://indico.fnal.gov/categoryDisplay.py?categId=501
- Our previous meetings material:
  - https://drive.google.com/folderview?id=0Bz_dKWYW5t-ldFFYY0VCR0NzR2M&usp=sharing

3.8.1 Search for Nonstandard Interactions

For $\nu_{\mu,e} \rightarrow \nu_{e,\mu}$ oscillations that occur as the neutrinos propagate through matter, the coherent forward scattering of ν_e's on electrons in matter modifies the energy and path-length dependence of the vacuum oscillation probability in a way that depends on the magnitude *and* sign of Δm^2_{31}. This is the Mikheyev-Smirnov-Wolfenstein (MSW) effect [59, 60]. NC nonstandard interactions (NSI) may be interpreted as nonstandard matter effects that are visible only in a far detector at a sufficiently long baseline. They can be parameterized as new contributions to the MSW matrix in the neutrino-propagation Hamiltonian [61, 62]:

$$H = U \begin{pmatrix} 0 & & \\ & \Delta m^2_{21}/2E & \\ & & \Delta m^2_{31}/2E \end{pmatrix} U^\dagger + \tilde{V}_{\rm MSW}\,, \tag{3.16}$$

with

$$\tilde{V}_{\rm MSW} = \sqrt{2} G_F N_e \begin{pmatrix} 1+\epsilon^m_{ee} & \epsilon^m_{e\mu} & \epsilon^m_{e\tau} \\ \epsilon^{m*}_{e\mu} & \epsilon^m_{\mu\mu} & \epsilon^m_{\mu\tau} \\ \epsilon^{m*}_{e\tau} & \epsilon^{m*}_{\mu\tau} & \epsilon^m_{\tau\tau} \end{pmatrix} \tag{3.17}$$

Here, U is the leptonic mixing matrix, and the ϵ parameters give the magnitude of the NSI relative to standard weak interactions. For new physics scales of a few hundred GeV, a value of $|\epsilon| \leq 0.01$ is expected [63, 64, 65, 66, 67]. DUNE's 1300-km baseline provides an advantage in the detection of NSI relative to existing beam-based experiments with shorter baselines. Only atmospheric-neutrino experiments have longer baselines, but the sensitivity of these experiments to NSI is limited by systematic effects. See [17] for potential sensitivities to these parameters at a 1300-km baseline.

http://arxiv.org/abs/1307.7335

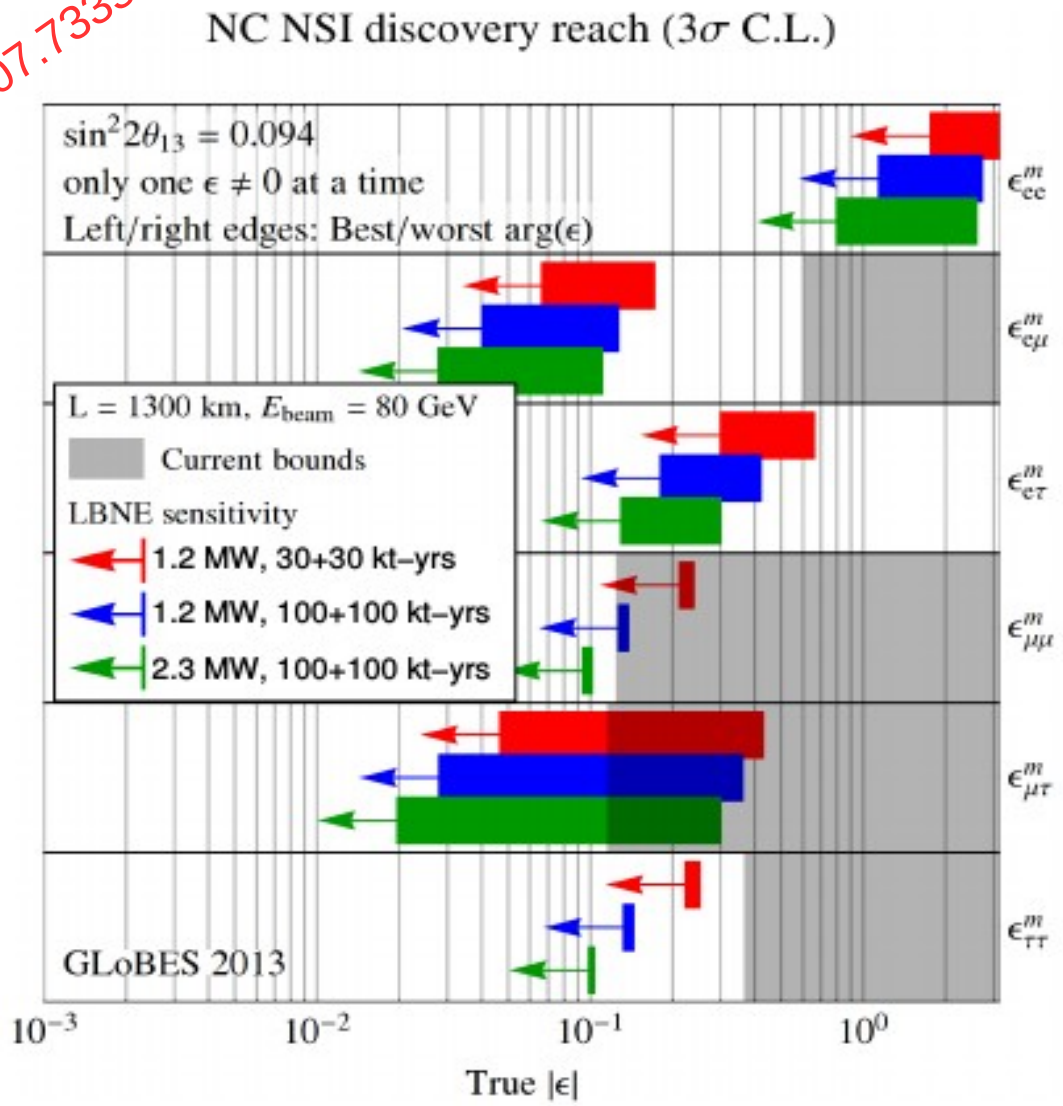

Figure 4.31: Nonstandard interaction discovery reach in LBNE with increasing exposure: 1.2 MW, 60 kt·years (red) + 1.2 MW, 200 kt · year (blue) + 2.3 MW, 200 kt · year (green). The left and right edges of the error bars correspond to the most favorable and the most unfavorable values for the complex phase of the respective NSI parameters. The gray shaded regions indicate the current model-independent limits on the different parameters at 3σ [172,173]. For this study the value of $\sin^2 2\theta_{13}$ was assumed to be 0.09. Figure courtesy of Joachim Kopp.