Oscillation Calculation Assumptions

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The following are the assumptions that have been used in the GLoBES-based calculation of long-baseline neutrino oscillation sensitivities for both NuMI and LBNE-based options. More information can also be found here [1]. GLoBES input files can be found here [2].

I. OSCILLATION PARAMETERS

- $\theta_{12} = 0.593 \pm 0.018$ [3]
- $\theta_{13} = 0.154 \pm 0.005$ ($\sin^2 2\theta_{13} = 0.092 \pm 0.005$) [4]
- $\theta_{23} = 0.705 \pm 0.078$ [3]
- $\Delta m^2_{21} = (7.58 \pm 0.23) \times 10^{-5}$ eV^2 [3]
- $\Delta m^2_{31} = (2.35 \pm 0.12) \times 10^{-3}$ eV^2 [3] (> 0 for NH, < 0 for IH)
- matter density: constant 2.8 g/cm^3 with a 2% uncertainty [5]

II. BEAM PARAMETERS

- NOvA and LBNE: 700 kW at 6×10^{20} POT/year
- T2K: 150kW (2012-2013), 300 kW (2013-2020)
  (will update to numbers sent by Nagamiya-san on 04/19/12)

III. DETECTOR PARAMETERS: LAR

We assume standard LBNE assumptions for LAr detector performance [6].

- appearance:
  - ↪ signal: 80% CC ν_e efficiency for both ν_e and $\overline{\nu}_e$ ($\sigma/E = 15\%/\sqrt{E}$ energy resolution)
  - ↪ backgrounds:
    - ⋆ 1% NC ν_μ (NC energy smearing from WC simulation)
    - ⋆ 1% CC ν_μ ($\sigma/E = 15\%/\sqrt{E}$ energy resolution)
    - ⋆ 80% intrinsic CC ν_e ($\sigma/E = 15\%/\sqrt{E}$ energy resolution)
    - ⋆ wrong-sign backgrounds are taken into account for antineutrino mode running
  - ↪ 1% uncertainty on signal normalization
  - ↪ 5% uncertainty on background normalization
- disappearance:
  - ↪ signal: 85% CC ν_μ efficiency for both ν_μ and $\overline{\nu}_\mu$ ($\sigma/E = 15\%/\sqrt{E}$ energy resolution)
  - ↪ backgrounds: 1% NC ν_μ
  - ↪ 5% uncertainty on signal normalization
  - ↪ 10% uncertainty on background normalization
  - ↪ 2% energy scale uncertainties on both signal and background

IV. DETECTOR PARAMETERS: NOVA

- 15 kton fiducial mass, L= 810 km
- input GLoBES files from P. Huber [7]
- appearance:
  - ↪ signal: 26% CC ν_e efficiency and 41% $\overline{\nu}_e$ CC efficiency ($\sigma/E = 10\%/\sqrt{E}$)
  - ↪ neutrino mode backgrounds:
    - ⋆ 0.28% NC ν_μ ($\sigma/E = 10\%/\sqrt{E}$)
    - ⋆ 0.13% CC ν_μ ($\sigma/E = 5\%/\sqrt{E}$)
    - ⋆ 16.3% intrinsic CC ν_e ($\sigma/E = 10\%/\sqrt{E}$)
  - ↪ antineutrino mode backgrounds:
    - ⋆ 0.88% NC $\overline{\nu}_\mu$ ($\sigma/E = 10\%/\sqrt{E}$)
    - ⋆ 0.13% CC $\overline{\nu}_\mu$ ($\sigma/E = 5\%/\sqrt{E}$)
    - ⋆ 33.6% intrinsic CC $\overline{\nu}_e$ ($\sigma/E = 10\%/\sqrt{E}$)
  - ↪ 5% uncertainty on signal normalization
  - ↪ 10% uncertainty on background normalization
  - ↪ 2.5% energy scale uncertainties on both signal and background
- disappearance:
  - ↪ signal: 100% QE ν_μ efficiency for both ν_μ and $\overline{\nu}_\mu$ ($\sigma/E = 2\%/\sqrt{E} + 8.5\%/E$ energy resolution)
  - ↪ backgrounds: 0.1% NC ν_μ ($\sigma/E = 10\%/\sqrt{E}$ energy resolution)
  - ↪ 2% uncertainty on signal normalization
  - ↪ 10% uncertainty on background normalization
  - ↪ 1% energy scale uncertainties on both signal and background

V. DETECTOR PARAMETERS: T2K

- 22.5 kton fiducial mass, L= 295 km
- input GLoBES files from P. Huber [8]
- appearance:
  - ↪ signal: CC ν_e with an energy-dependent efficiency that is 21% at 0.3 GeV, 72% at 0.6 GeV, 58% at 1.2 GeV, 15% at 6 GeV, etc. ($\sigma/E = 7.5\%/\sqrt{E} + 5\%/E$ energy resolution)
  - ↪ background: intrinsic CC ν_e with an energy-dependent efficiency that is peaked at 0.4 GeV ($\sigma/E = 7.5\%/\sqrt{E} + 5\%/E$ energy resolution)
  - ↪ 2% uncertainty on signal normalization
  - ↪ 5% uncertainty on background normalization
  - ↪ 1% energy scale uncertainty on signal and 5% energy scale uncertainty on background
- disappearance:
  - ↪ signal: QE ν_μ with an energy-dependent efficiency ($\sigma/E = 7.5\%/\sqrt{E} + 5\%/E$ energy resolution)
  - ↪ background: NC ν_μ with an energy-dependent efficiency ($\sigma/E = 7.5\%/\sqrt{E} + 5\%/E$ energy resolution)

$\hookrightarrow$ 0.1% normalization and energy scale uncertainties

[1] https://cdcvs.fnal.gov/redmine/projects/lbne-lblpwgtools
[2] http://lbne2-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=5823
[3] G.L. Fogli *et al.*, Phys. Rev. D84, 053007 (2011), arXiv:1106.6028 [hep-ph].
[4] we use the Daya Bay central value and systematic uncertainty assuming that statistics will improve over time; F.P. An *et al.* [Daya Bay collaboration], arXiv:1203.1669 [hep-ex].
[5] A.M. Dziewonski and D.L. Anderson, Phys. Earth Planet Interiors 25, 297356 (1981); F.D. Stacey, Phys. of the Earth, 2nd edition, Wiley (1977).
[6] T. Akiri *et al.* [LBNE collaboration], arXiv:1110.6249 [hep-ex], appendix A.
[7] http://www.mpi-hd.mpg.de/personalhomes/globes/glb/0709-nova.html
[8] http://www.mpi-hd.mpg.de/personalhomes/globes/glb/0709-t2k.html