

4.2 Measurements of Mass Hierarchy and the CP-Violating Phase

The performance of first phase of LBNE which is a 10 kton far detector and a 708 kW beam are detailed in the LBNE Conceptual Design Report Volume 1 [24]. The sensitivity calculation uses the GLoBeS package with the detector response as summarized in Table 4-2. The sensitivities are obtained by fitting simultaneously both the $\nu_\mu \rightarrow \nu_e$ and $\nu_\mu \rightarrow \nu_\mu$ oscillated spectra (Figures 4-11 and 4-10).

Figure 4-12 summarizes the sensitivities for determining the mass hierarchy and CP violation ($\delta_{cp} \neq 0$ or π) as a function of the true value of δ_{cp} after 10 years of running with a 10kton detector. To interpret the mass hierarchy physics sensitivity, special attentions should be paid, as the mass hierarchy determination only contains two outcomes (normal vs. inverted hierarchy). Ref. [28] carefully examines the statistical nature of this problem. In particular, an experiment with physics sensitivity of $\Delta\chi^2 = 9, 16,$ and 25 (e.g. 3, 4, and 5- σ for an ideal two hypotheses testing problem) would have 93.32%, 97.72%, and 99.38% of chance to give the correct mass hierarchy, respectively. The corresponding average probabilities of determining the correct mass hierarchy are 90.14%, 96.57%, and 99.06%, respectively. These numbers are in general smaller than those based on the simple Gaussian expectation given 3, 4, and 5- σ . On the other hand, since there are only two outcomes in the mass hierarchy determination problem, the standards for 'evidence' and 'discovery' may arguably be lower than those in other commonly encountered problems (e.g. search for Higgs boson, or measure the non-zero θ_{13}).

The sensitivity band in Figure 4-12 presents the variation in sensitivity as a function of the beam designs and normalization uncertainties on the signal and background. The solid red curve at the lower end of the red band is the beam design described the LBNE CDR Volume2 [81]. The dashed line above the solid curve represents the sensitivity with the beam design