Examining the Influence of Quantum Decoherence on Precision Measurements at DUNE and T2HK

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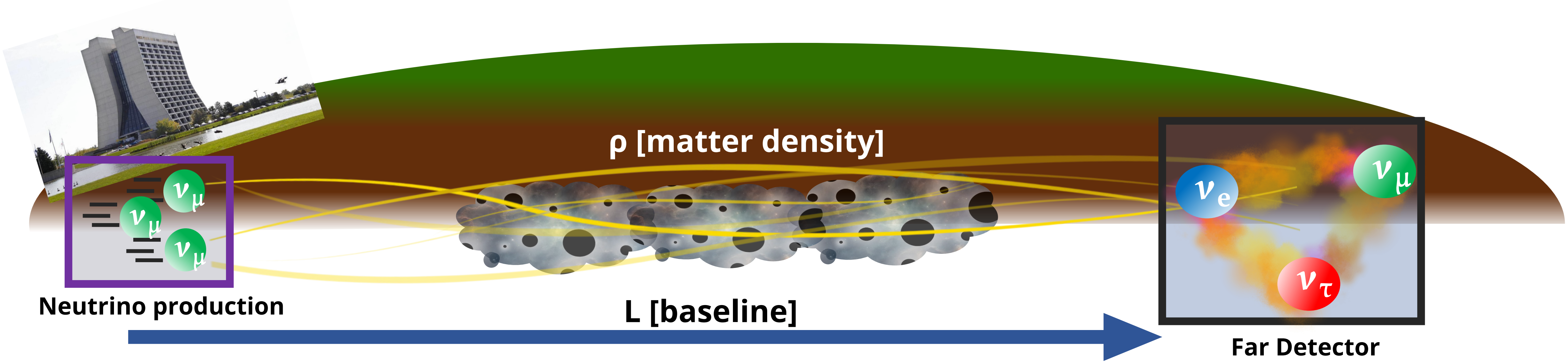
SCAN ME

Why Quantum Decoherence?



Experimental Setup:

	ρ [g/cm³]	L [Km]	Time [yrs]	Fiducial Mass [kt]	Beam Power [MW]
Hyper-Kamiokande	2.60	1284.9	2.5 ν mode 7.5 $\bar{\nu}$ mode	186 (H_2O)	1.3
DUNE	2.848	295.0	6.5 ν mode 6.5 $\bar{\nu}$ mode	40 (LArTPC)	1.2

SCAN ME

- **SO and Quantum Decoherence:**

$$\frac{d\rho(t)}{dt} = -i\,[H\,,\rho(t)] \;+\; L\,[\rho(t)]$$

- **Where:**

$$L\,[\rho(t)] = \sum_{i}\sum_{j} \rho_i (M_D)_{ij}\, \lambda_j$$

$$M_D = \mathrm{Diag}\,(\Gamma_1, \Gamma_2, \Gamma_1, \Gamma_1, \Gamma_2, \Gamma_1, \Gamma_2, \Gamma_1)$$

$$\{\lambda_i\}\ \text{Gell} - \text{Mann matrices}$$

- **And the condition:**

$$\frac{1}{3}\Gamma_1 \leq \Gamma_2 \leq \frac{5}{3}\Gamma_1$$

We take: $\Gamma_2 = \frac{5}{3}\Gamma_1$

$$\Gamma \equiv \Gamma_1 = \begin{cases} 1.5\ \text{GeV} \\ 4.6\ \text{GeV} \\ 7.6\ \text{GeV} \end{cases}$$

- **If $\delta_{CP} = \pi$:**

$$P_{\nu_\mu \to \nu_e}(L) = P^{osc}_{\nu_\mu \to \nu_e}(L) - \left(\frac{1}{3} + 2D_m\right)\left(e^{-\Gamma_1 L} - 1\right) + \left(\frac{\tilde{J}_m}{4}\left(\cos(\bar{\Delta}_{31} - 2aL) - \cos(\bar{\Delta}_{31} - \bar{\Delta}_{21}\cos^2\theta_{12})\right) + 2D_m \cos(2aL)\right)\left(e^{-\frac{1}{2}\Sigma_{12}L} - 1\right) + \Delta\Gamma_{12}\left(\frac{\tilde{J}_m}{8}\left(\frac{\sin(\bar{\Delta}_{31} - 2aL)}{\Delta_{31} - 2aL} - \frac{\sin(\bar{\Delta}_{31} - \bar{\Delta}_{21}\cos^2\theta_{12})}{\Delta_{31} - \Delta_{21}\cos^2\theta_{12}}\right) + D_m \frac{\sin(2aL)}{2a}\right) e^{-\frac{1}{2}\Sigma_{12}L}.$$

- **Where:**

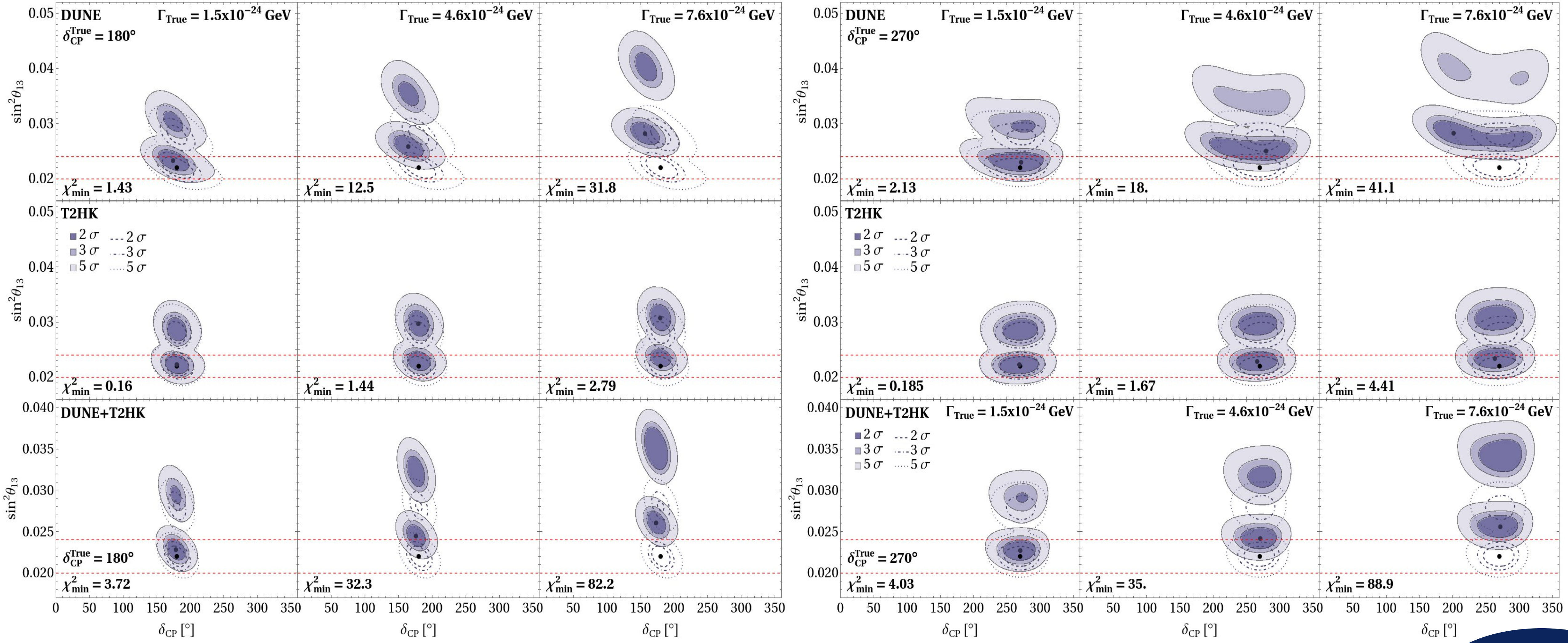
$$\Delta_{ij} = \Delta m^2_{ij}/2E,\ \bar{\Delta}_{ij} = \Delta_{ij}L,\ \Delta\Gamma_{12} = \Gamma_2 - \Gamma_1,\ \Sigma_{12} = \Gamma_2 + \Gamma_1$$

$$\tilde{J}_m = -\cos\theta_{13}\sin 2\theta_{12}\sin 2\theta_{13}\sin 2\theta_{23}\left(\frac{\bar{\Delta}_{21}}{2aL}\right)\left(\frac{\bar{\Delta}_{31}}{\bar{\Delta}_{31} - 2aL}\right)$$

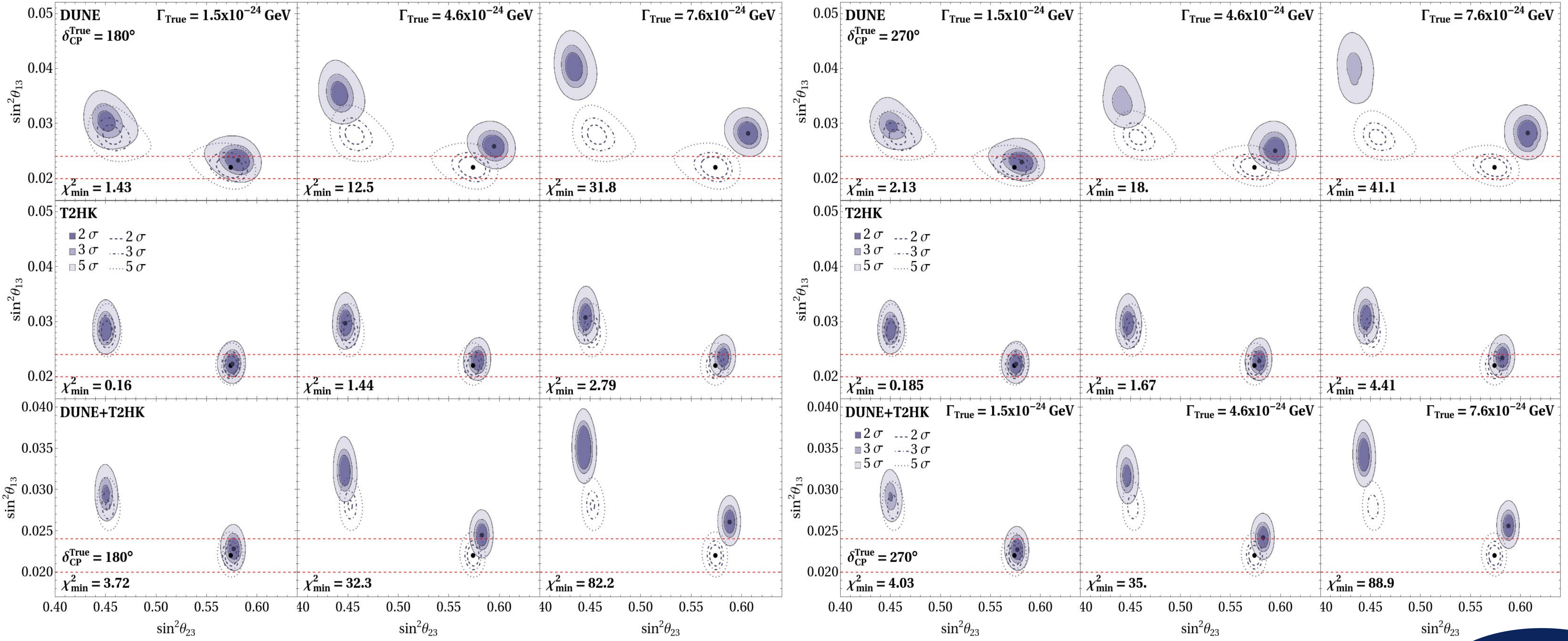
$$D_m = -\frac{\sin 2\theta_{12}}{4}\left(\left(\frac{\bar{\Delta}_{21}}{2aL}\right)^2 \sin 2\theta_{12}\cos^2\theta_{23} + \left(\frac{\bar{\Delta}_{21}}{2aL}\right)\left(\frac{\bar{\Delta}_{31}}{\bar{\Delta}_{31} - 2aL}\right)\sin\theta_{13}\sin 2\theta_{23}\right)$$

$$a = \frac{G_F N_e}{\sqrt{2}}$$

Results and Conclusion:

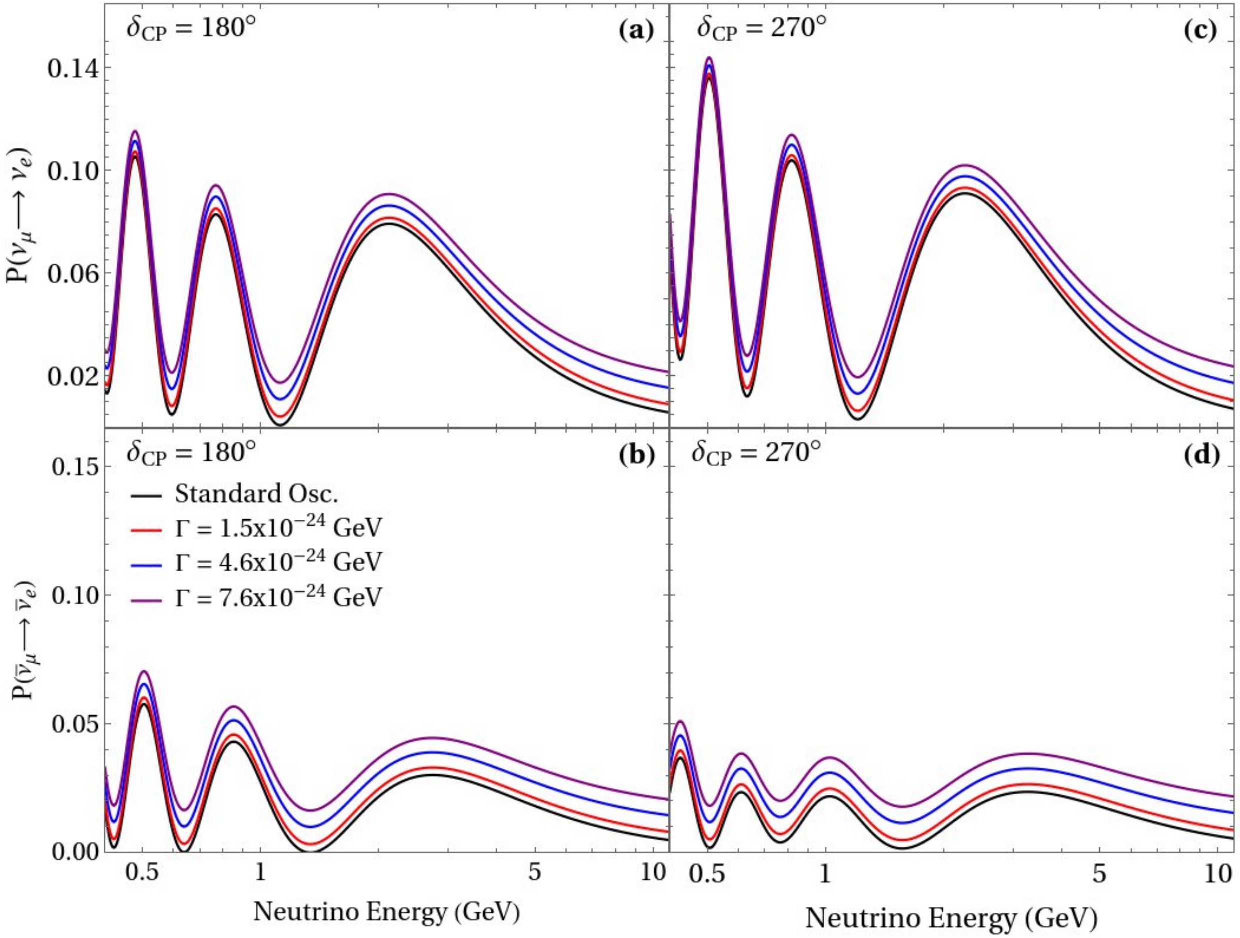


Results and Conclusion:

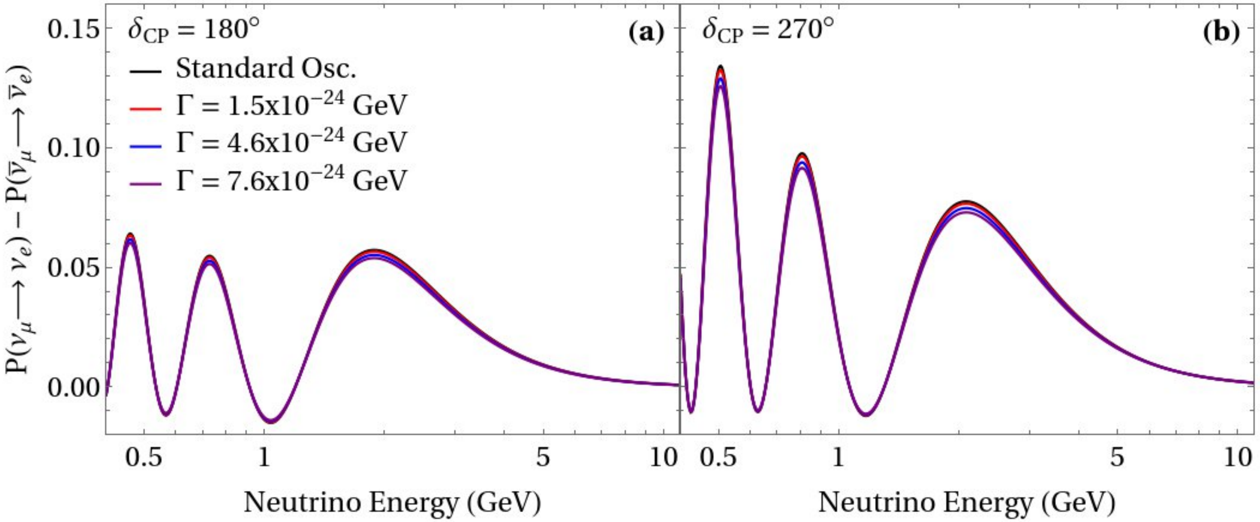


Backup 1:

DUNE Probabilities:

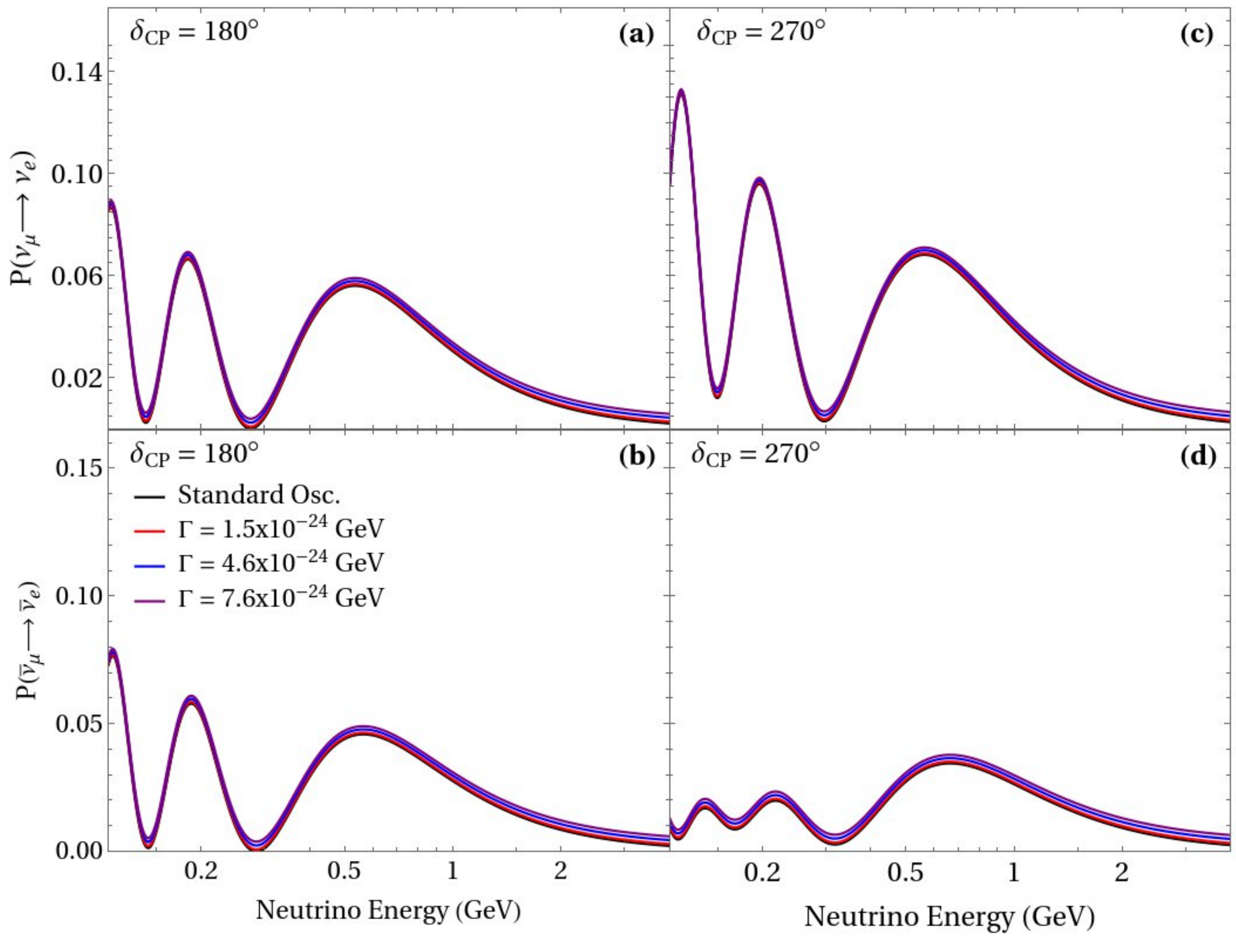


DUNE Asymmetry:



Backup 2:

T2HK Probabilities:



- The χ^2 function for the analysis of T2HK and DUNE pseudo-data is given by

$$\chi^2_{T/D}(\vec{p}) = \min_{\vec{\alpha}} \sum_{\text{channels}} 2\sum_i \left[N_{\text{exp},i}(\vec{p},\vec{\alpha}) - N_{\text{dat},i} + N_{\text{dat},i} \log\left(\frac{N_{\text{dat},i}}{N_{\text{exp},i}(\vec{p},\vec{\alpha})} \right) \right] + \sum_i \left(\frac{\alpha_i}{\sigma_i} \right)^2 + \chi^2_{\text{solar}},$$

where $\vec{p}$ is the set of oscillation parameters and $\vec{\alpha}$ is the systematic uncertainties. The second terms are the penalty factors for all the systematic uncertainties, with expectation value 0 and standard deviation σ_i. The last term contains a penalty for the solar parameters.