Scalar Non Standard Interactions at long baseline experiments

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12 - 23 July, 2021

37^{th} International Cosmic Ray Conference (ICRC), 2021

Scalar Non Standard Interactions

- The non standard coupling of neutrinos with a scalar is an exciting window to probe new physics in Long Baseline experiments (Phys. Rev. Lett. 122, 211801 (2019).
- The Lagrangian for such scalar NSI can be framed as :

$$\mathcal{L}_{\text{eff}}^{\text{S}} = \frac{y_f y_{\alpha\beta}}{m_\phi^2}(\bar{\nu}_\alpha(p_3)\nu_\beta(p_2))(\bar{f}(p_1)f(p_4))$$

- The Hamiltonian in presence of scalar NSI modifies as:

$$\mathcal{H} \approx E_\nu + \frac{(M+\delta M)(M+\delta M)^\dagger}{2E_\nu} \pm V_{\text{SI}}$$

- So, scalar NSI appears as correction/addition/perturbation to the neutrino mass term.

Formalism and Methodology

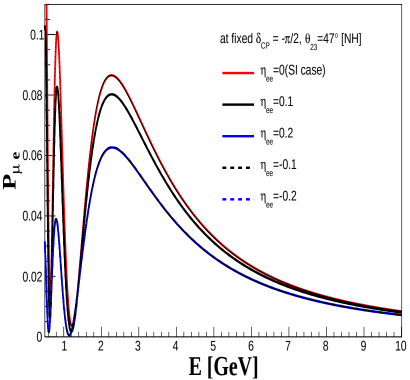
- The mass correction term due to scalar NSI can be parametrize as a 3×3 matrix :

$$\delta M = \sqrt{\Delta m^2_{31}} \begin{pmatrix} \eta_{ee} & \eta_{e\mu} & \eta_{e\tau} \\ \eta_{\mu e} & \eta_{\mu\mu} & \eta_{\mu\tau} \\ \eta_{\tau e} & \eta_{\tau\mu} & \eta_{\tau\tau} \end{pmatrix}$$

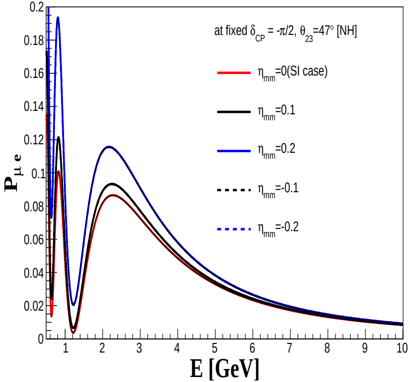
- The $\eta_{\alpha\beta}$ elements are complex and dimensionless and it quantifies the size of scalar NSI.
- A framework is developed with the effective Hamiltonian in GLoBES with a baseline = 1300 km (DUNE).
- The true values of neutrino mixing parameters used in the analysis :

$\sin^2\theta_{12}$	$\sin^2\theta_{13}$	$\sin^2\theta_{23}$	δ_{CP}	Δm^2_{21}	Δm^2_{31}
0.308	0.0234	47°	$-\pi/2$	7.54×10^{-5}	2.43×10^{-3}

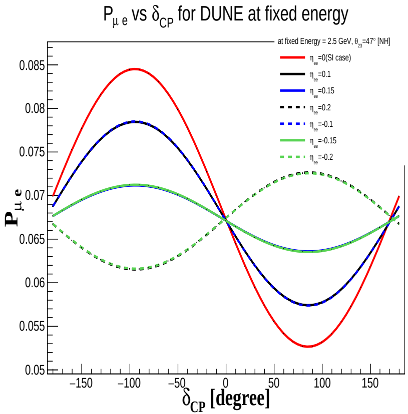
Results : effects on oscillation probabilities



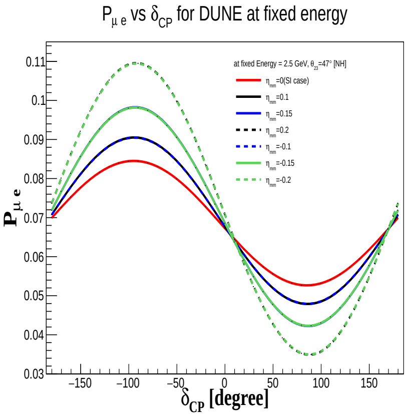
(a) $P_{\mu e}$ vs E for different η_{ee}



(b) $P_{\mu e}$ vs E for different $\eta_{\mu\mu}$



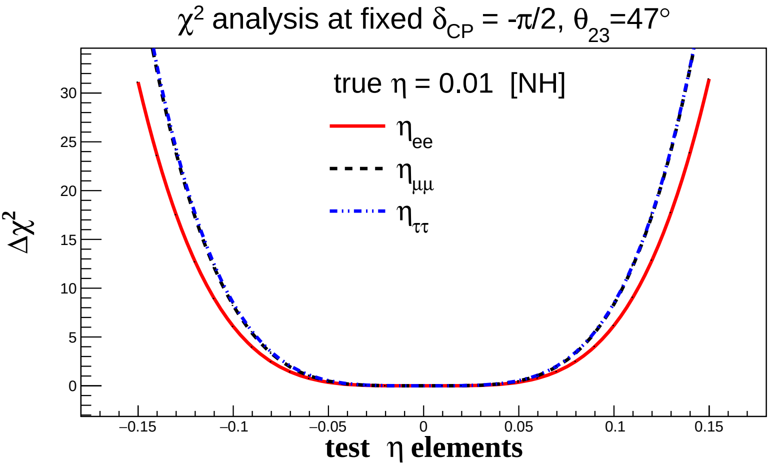
(a) $P_{\mu e}$ vs δ_{CP} for different η_{ee}



(b) $P_{\mu e}$ vs δ_{CP} for different $\eta_{\mu\mu}$

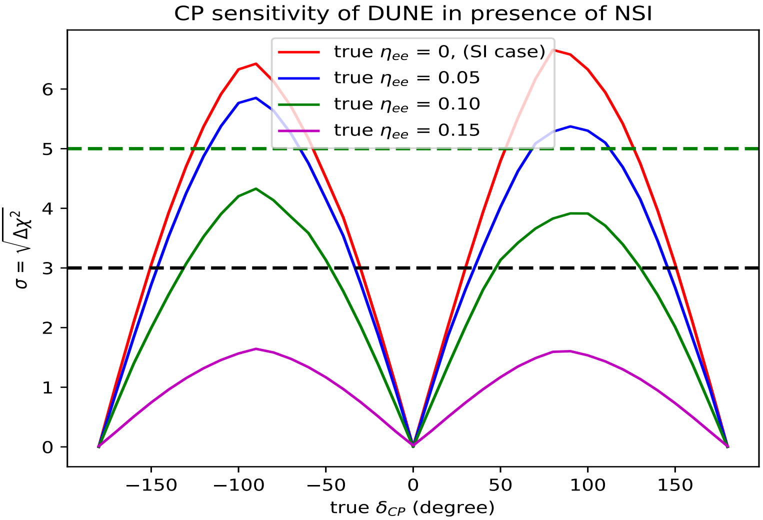
Results : χ^2 analysis

- DUNE: 5 years (ν) + 5 years ($\bar{\nu}$)



Results : CP sensitivity

- DUNE: 5 years (ν) + 5 years ($\bar{\nu}$)



Concluding Remarks

- The effects of scalar NSI on the oscillation probabilities of DUNE is significant.
- Scalar NSI is an excellent window to study new physics beyond Standard Model (BSM).
- The CP sensitivity of DUNE gets spoiled in presence of scalar NSI.
- Understanding these sub dominant effects is critical for precise interpretation of data from neutrino experiments.
- Probing the effects of scalar NSI to study mass models is promising.

Thank You for your kind attention !

Acknowledgement: This work is supported by the Research and Innovation grant 2021 (DoRD/RIG/10-73/1592-A) of Tezpur University and DST SERB grant EMR/2017/001436.