Non Standard Neutrino Interaction

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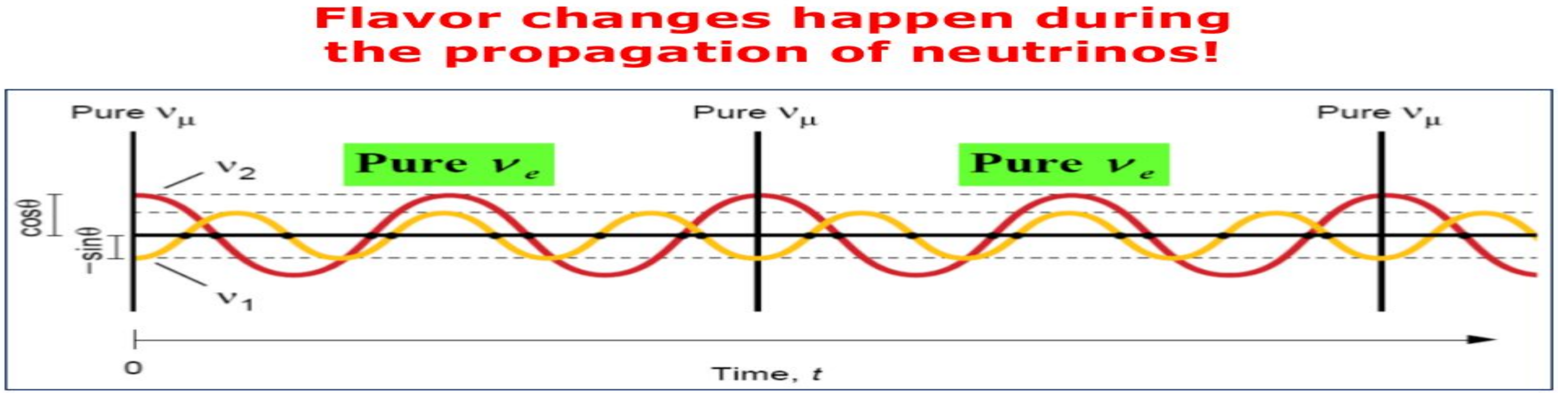
Outline

- ➔ Standard neutrino oscillations
- ➔ Introduction to NSI
- ➔ Neutrino Oscillations with NSI
- ➔ Current status
- ➔ Future prospects
- ➔ NSI at DUNE
- ➔ Conclusion

Standard Neutrino oscillations

➔ Neutrino oscillations have become well-known phenomenon



➔ Neutrino flavour changing mechanism is mainly described by mass eigen states.

➔ However, other mechanisms could be responsible for flavour change on a sub-leading level.

Introduction to NSI

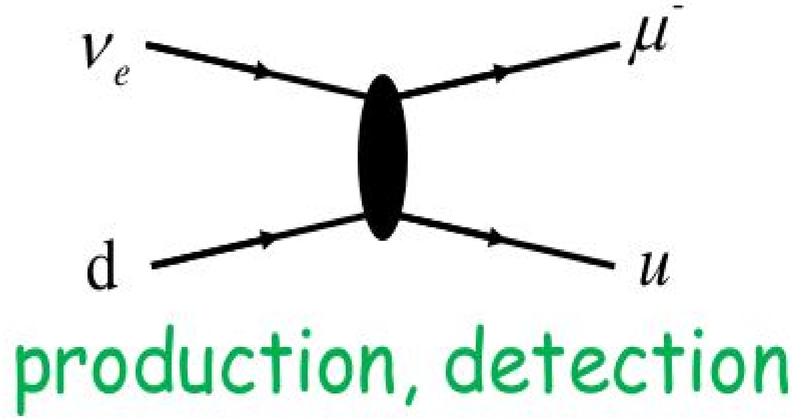
➔ Non Standard Neutrino Interaction is the interaction between neutrino and matter fermions.

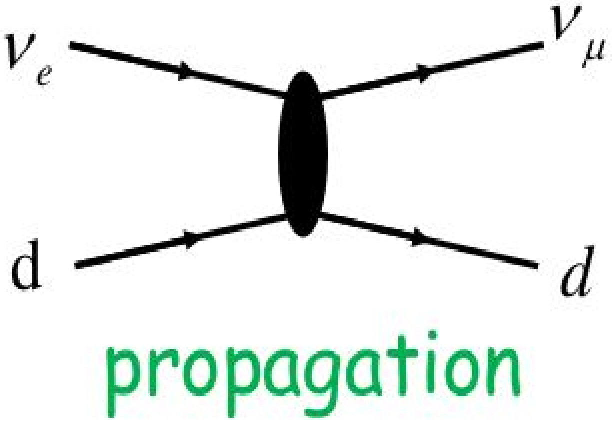
➔ Neutrino evolution equation in presence of NSI will be

$$i\frac{d}{dt}\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix} = \frac{1}{2E}\left[U\begin{pmatrix}0 & 0 & 0\\ 0 & \Delta m^2_{21} & 0\\ 0 & 0 & \Delta m^2_{31}\end{pmatrix}U^\dagger + a\begin{pmatrix}1+\varepsilon_{ee} & \varepsilon_{e\mu} & \varepsilon_{e\tau}\\ \varepsilon^*_{e\mu} & \varepsilon_{\mu\mu} & \varepsilon_{\mu\tau}\\ \varepsilon^*_{e\tau} & \varepsilon^*_{\mu\tau} & \varepsilon_{\tau\tau}\end{pmatrix}\right]\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix}$$

Different Kinds of NSI

- NSI can be seen at neutrino source, during propagation neutrinos, detection of neutrinos.





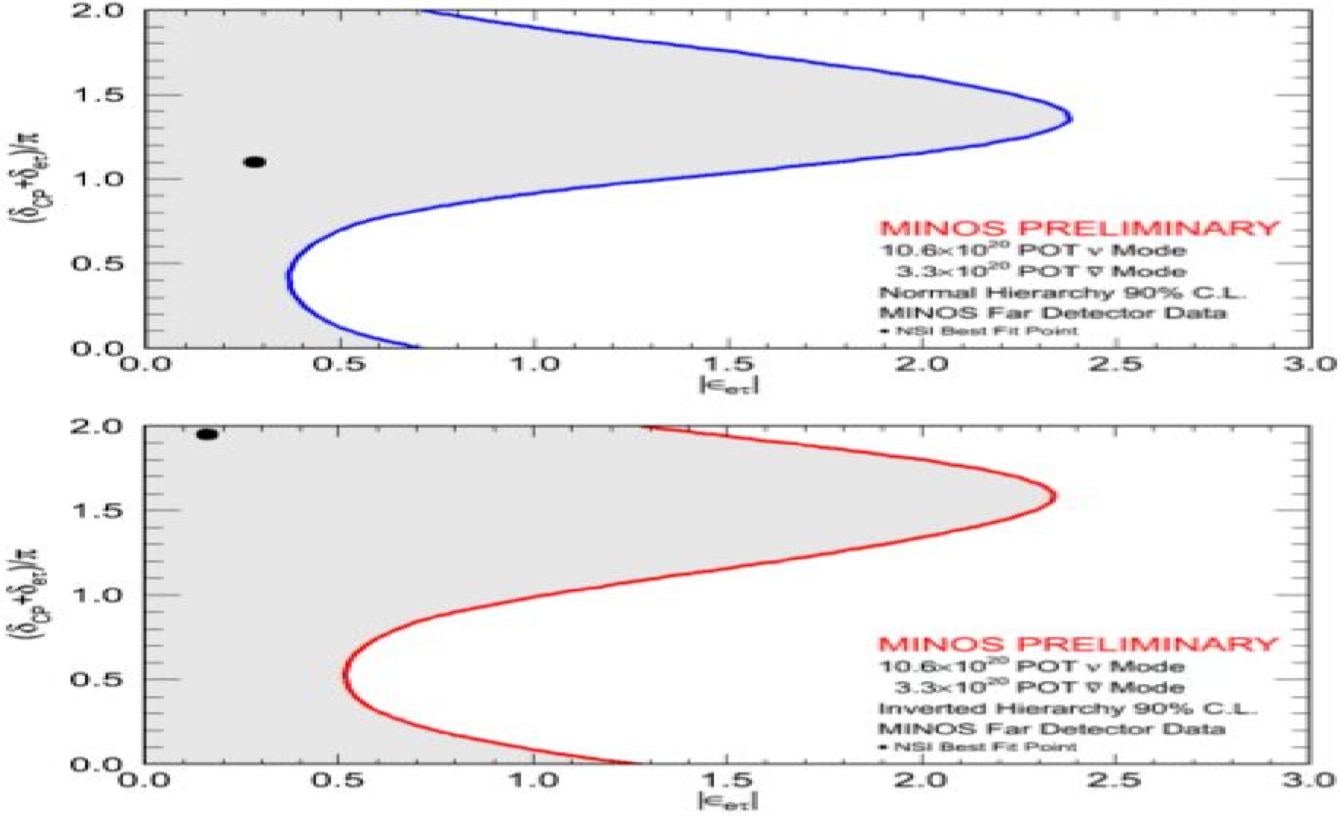
Neutrino Oscillations with NSI

- ➔ Matter potential in the presence of NSI in propagation

$$A^{NSI} = \begin{pmatrix} A & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} + A \begin{pmatrix} \varepsilon_{ee}^{m} & \varepsilon_{e\mu}^{m} & \varepsilon_{e\tau}^{m} \\ \varepsilon_{\mu e}^{m} & \varepsilon_{\mu\mu}^{m} & \varepsilon_{\mu\tau}^{m} \\ \varepsilon_{\tau e}^{m} & \varepsilon_{\tau\mu}^{m} & \varepsilon_{\tau\tau}^{m} \end{pmatrix}$$

- ➔ Change in effective matter potential will change the neutrino evolution equation, hence will change oscillation probability.
- ➔ Obvious questions will be
- ➔ How are the measurements of the standard oscillation parameters affected by the NSIs?
- ➔ How well can we measure/put bounds on the NSI parameters themselves?

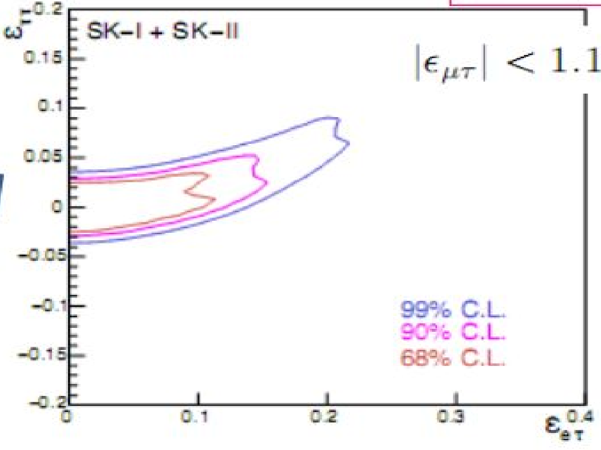
Current status(MINOS)



MINOS
BEAM
DATA

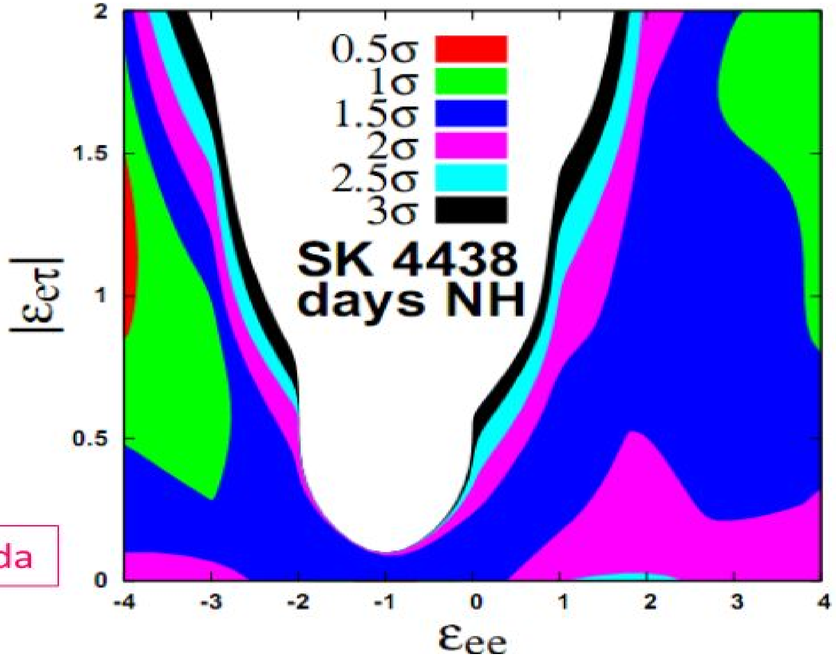
Super Kamiokande

1109.1889: Mitsuka et al.



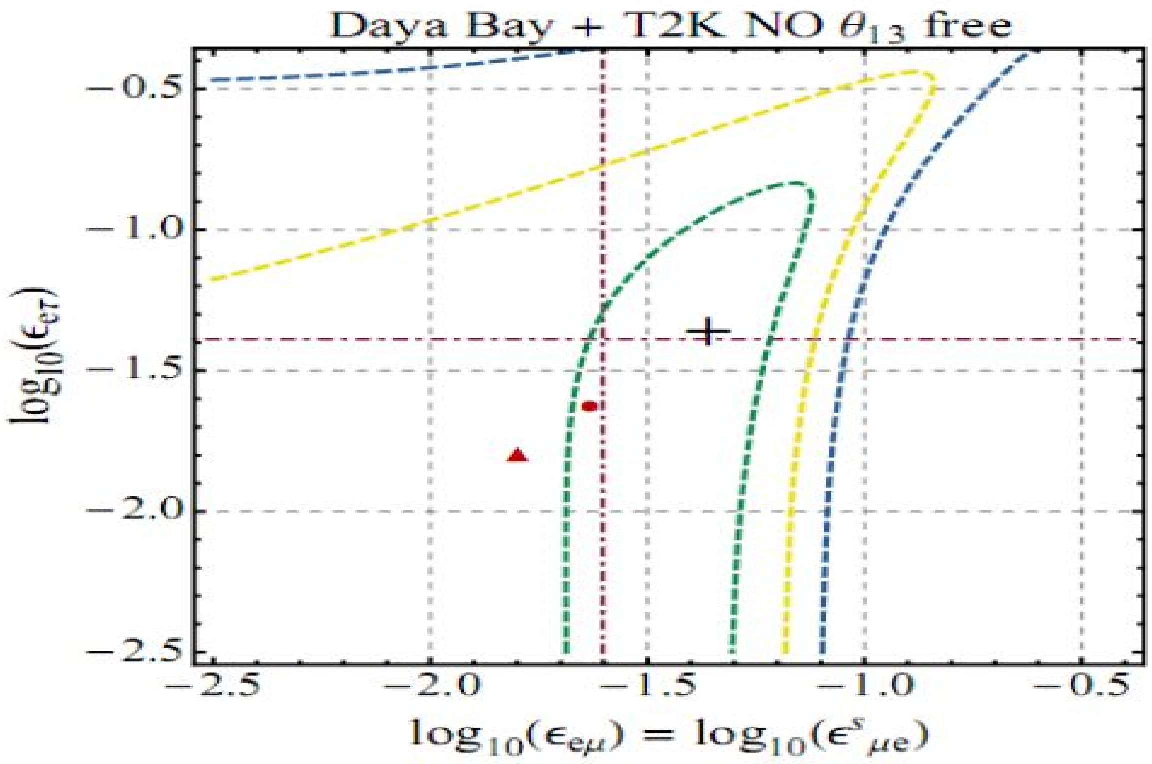
$$|\epsilon_{\mu\tau}| < 1.1 \times 10^{-2}, \quad |\epsilon'| = |\epsilon_{\mu\mu} - \epsilon_{\tau\tau}| < 4.9 \times 10^{-2}$$

(d)$\varepsilon_{ee} = 0.25$



1503.08056: Fukasawa, Yasuda

Daya Bay


Daya Bay + T2K NO θ_{13} free
−0.5
−1.0
−1.5
−2.0
−2.5
$\log_{10}(\epsilon_{e\tau})$
−2.5
−2.0
−1.5
−1.0
−0.5
$\log_{10}(\epsilon_{e\mu}) = \log_{10}(\epsilon^{s}_{\mu e})$

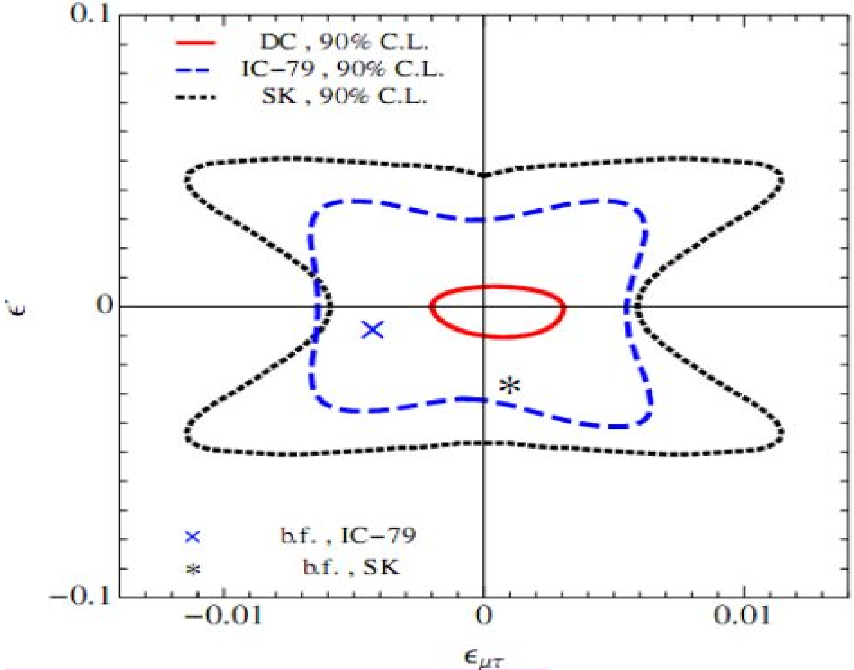
Bounds on NSI parameters

- ➔ Bounds on NSI parameter from different neutrino experiments

$$|\varepsilon_{\alpha\beta}| < \begin{pmatrix} 4.2 & 0.3 & 0.5 \\ 0.3 & 0.068 & 0.04 \\ 0.5 & 0.04 & 0.15 \end{pmatrix} .$$

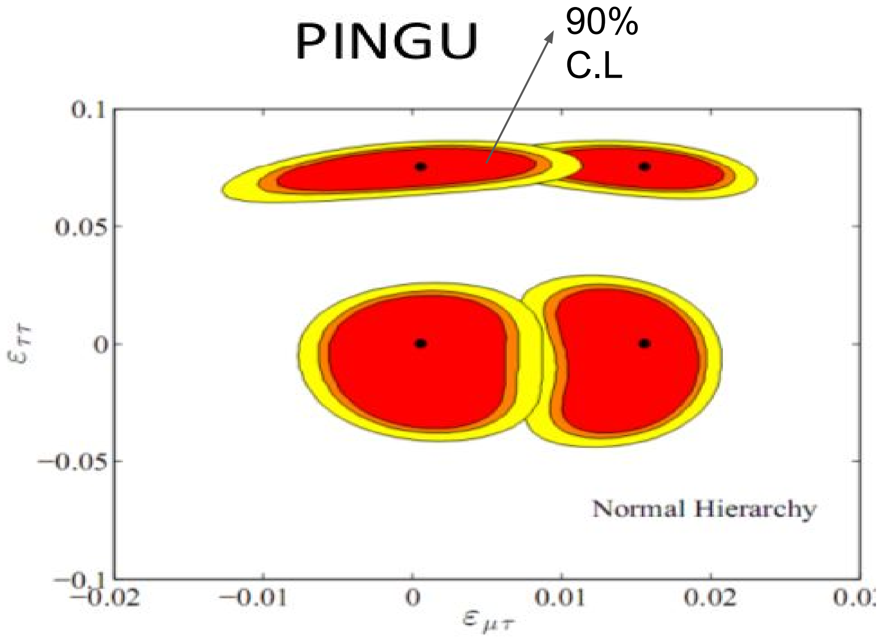
Future prospects

IceCube & Deep Core



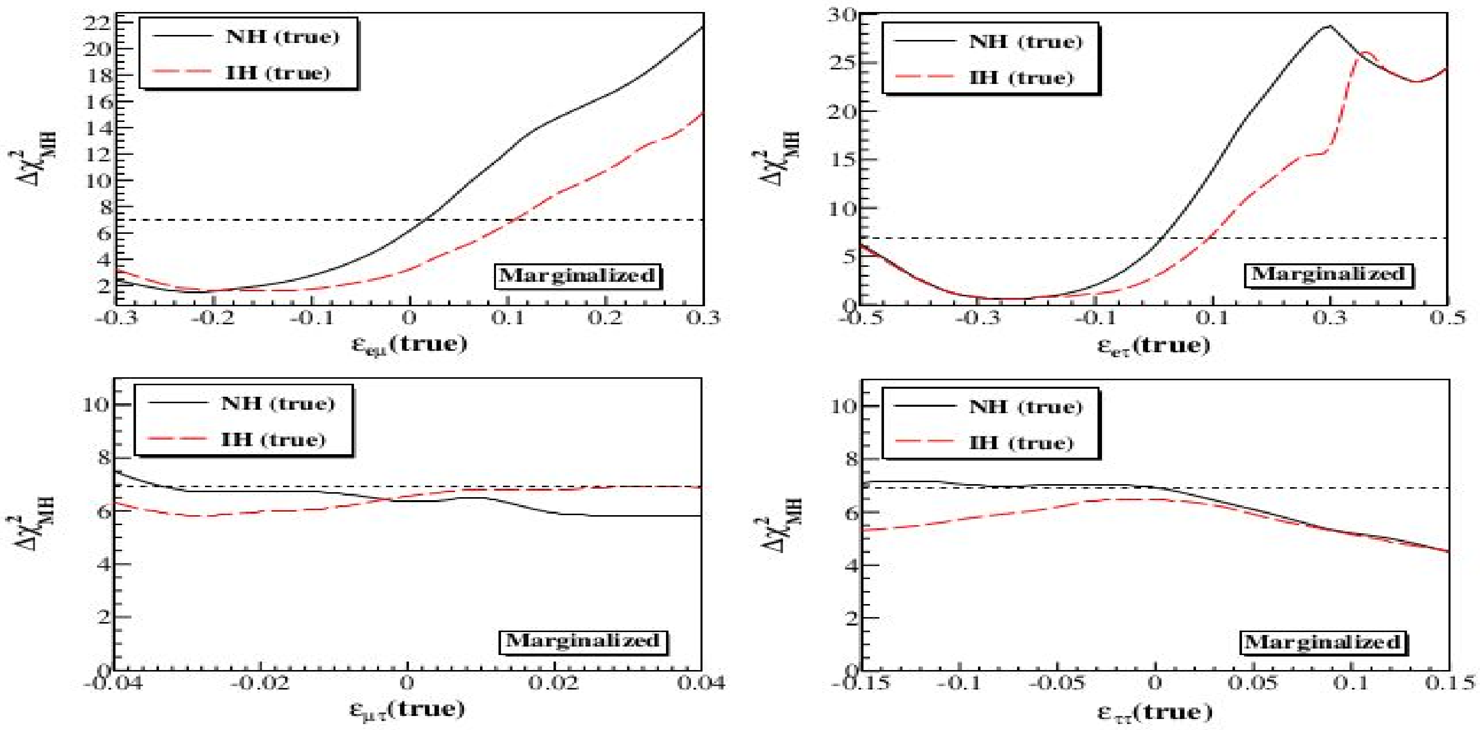
1304.1042: Esmaili, Smirnov

PINGU



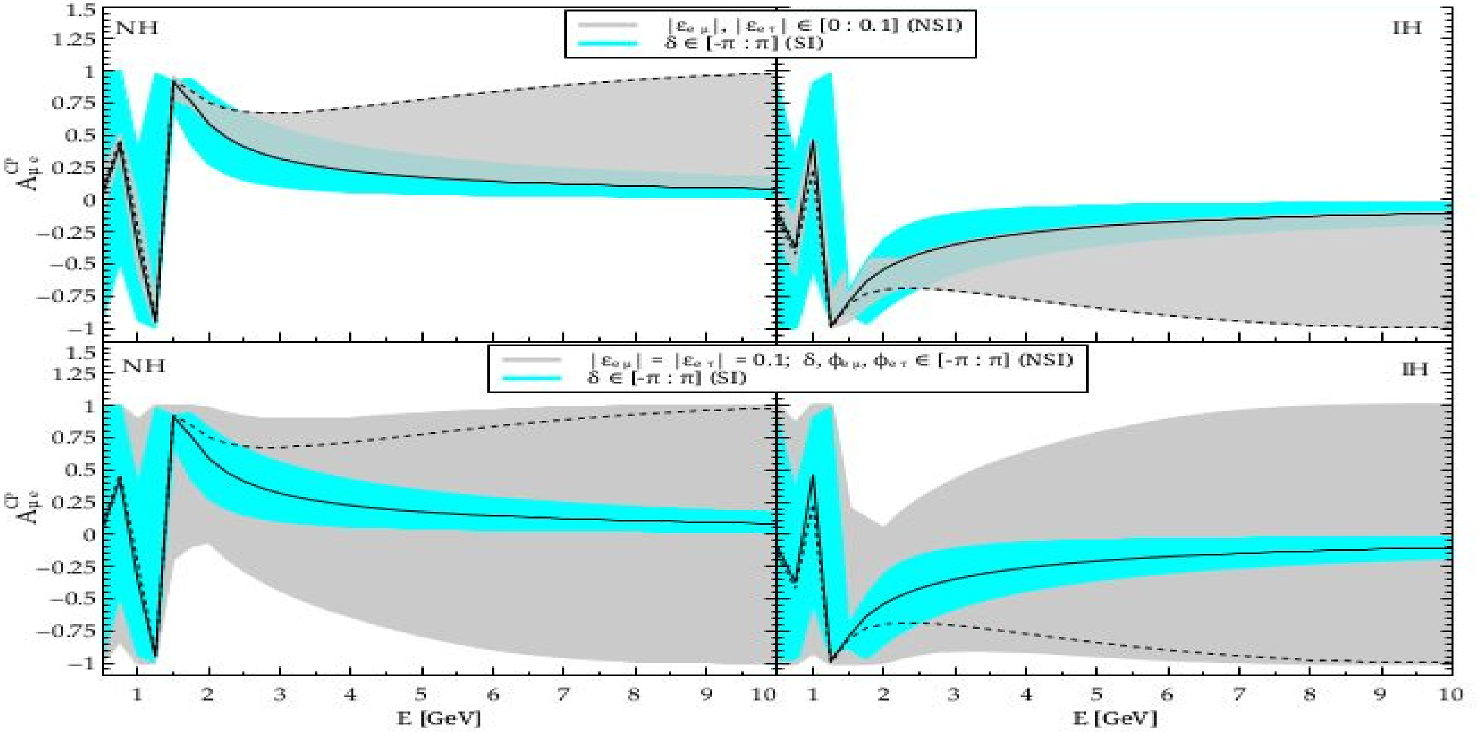
1410.0410: Choubey, Ohlsson

Effect on Mass hierarchy at ICAL@INO



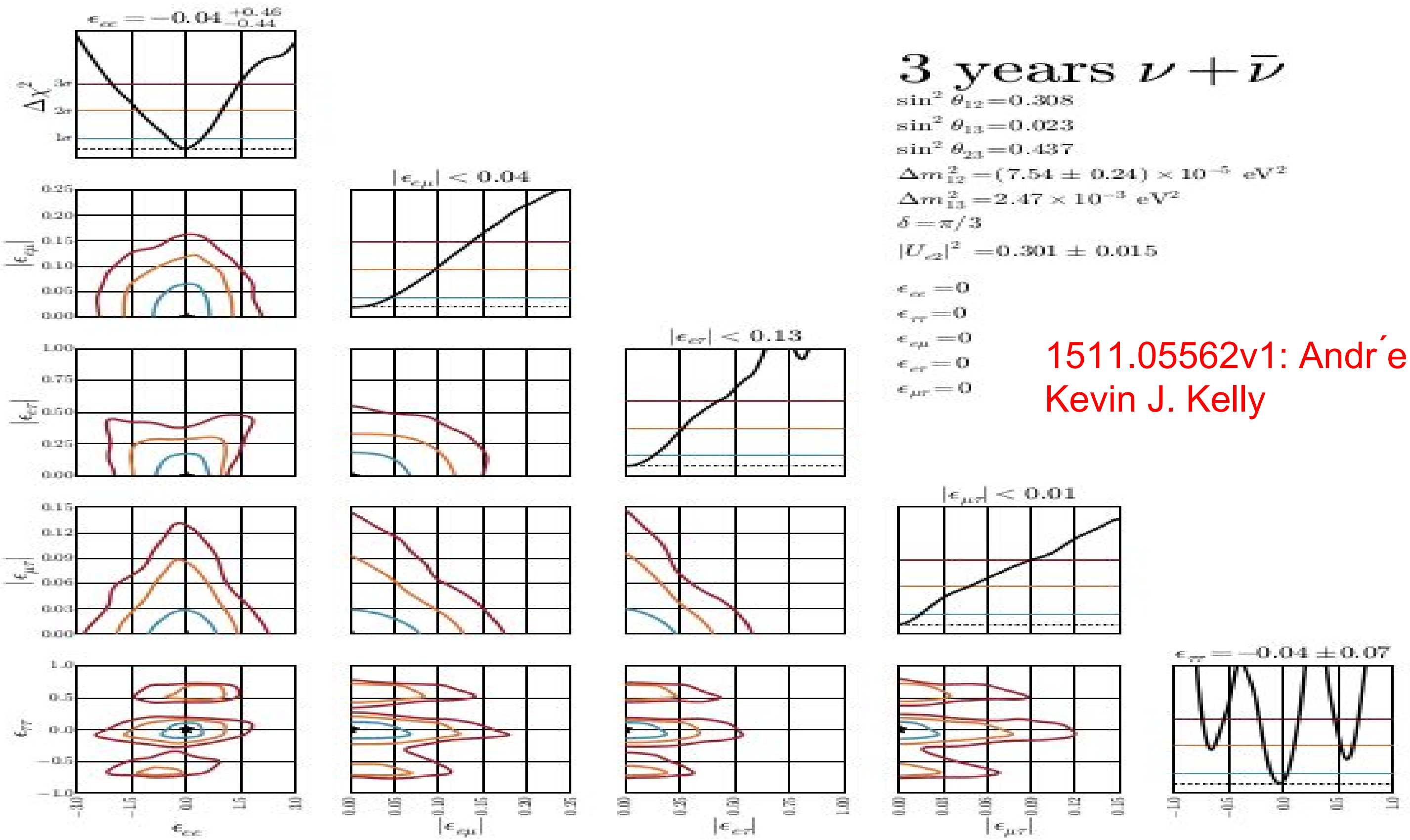
1507.02211: Choubey, Ghosh, Ohlsson, Tiwari

NSI@DUNE(Effect on the measurement of CP phase)



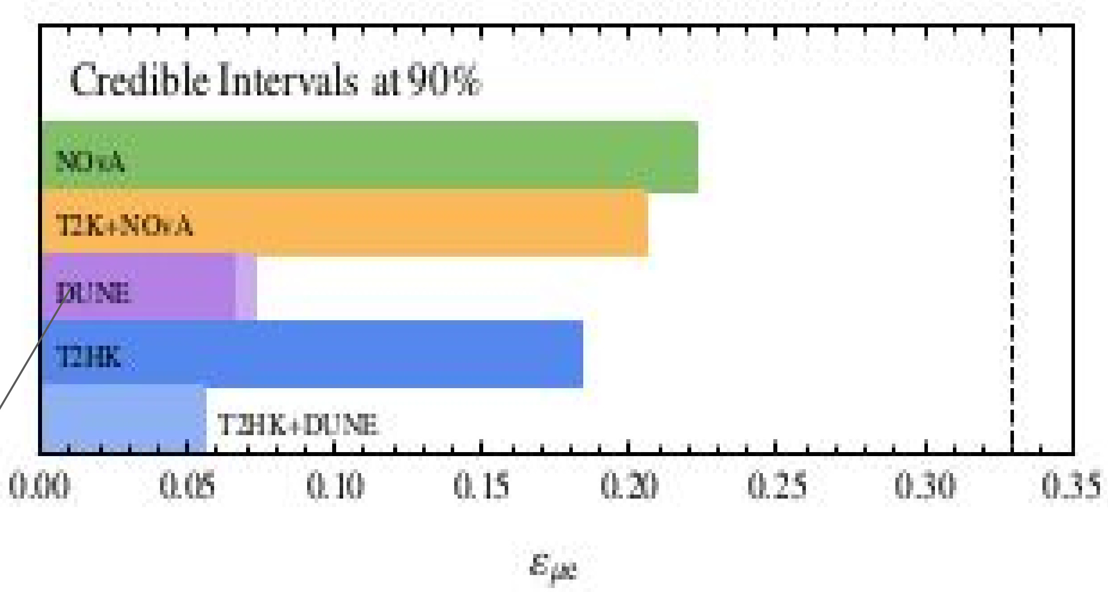
1510.08261v1:M Masud,A Chatterjee, P Mehta

Exclusion limit on NSI parameter



1511.05562v1: Andr´e de Gouv^ea
Kevin J. Kelly

Comparisons of the expected sensitivities to NSI parameters



1511.06357v1:
Pilar Coloma

Much better than other experiments

Conclusions

- ➔ Non-standard effects arise from various possible BSM scenarios, and can affect neutrino oscillations.
- ➔ Current bounds on NSI parameters are at the 10 -2 level. Future experiments will impose more stringent.
- ➔ DUNE will be able to put more lights on NSI parameters due to the long baseline and excellent detector properties.
- ➔ Effect of NSI on the measurement of CP phase will be interesting to understand.