

Neutrino Mass Ordering Preference Induced by Lorentz Invariance Violation in JUNO

Isotropic SME coefficients with the first 59.1-day JUNO public dataset

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1. MOTIVATION

- Neutrino oscillations reveal physics beyond the Standard Model (SM).
- Lorentz Invariance Violation (LIV) would signal new fundamental physics.
- JUNO's high precision reactor antineutrino data is ideal to probe subleading LIV effects.
- We study isotropic LIV in the minimal SME framework using the first 59.1-day JUNO dataset.

2. THEORETICAL FRAMEWORK

Effective Hamiltonian

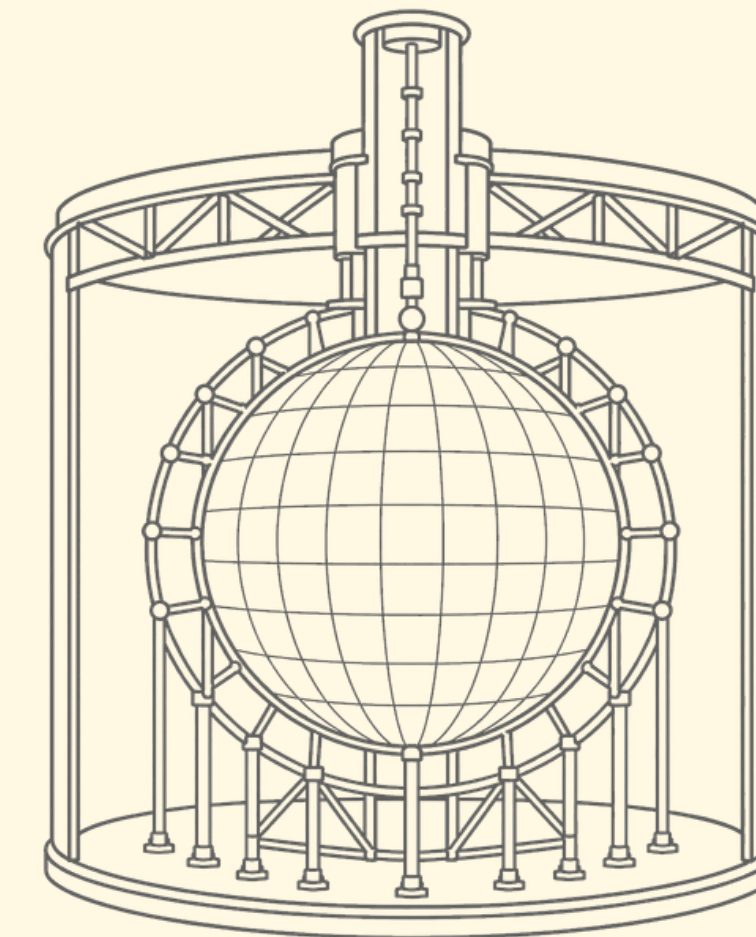
$$H_{\text{eff}} = H_0 + H_{\text{MSW}} + H_{\text{LIV}}$$

$$H_{\text{LIV}} = a_{\alpha\beta} - \frac{4}{3} E_\nu c_{\alpha\beta}$$

Sector	Coefficient	Term in H_{LIV}
CPT-even	$c_{\alpha\beta}$	$\propto E_\nu$
CPT-odd	$a_{\alpha\beta}$	constant

We consider the isotropic parameter combinations:
($c_{ee} - c_{e\mu}$, $c_{ee} - c_{e\tau}$) ($a_{ee} - a_{e\mu}$, $a_{ee} - a_{e\tau}$)

3. EXPERIMENT AND ANALYSIS SETUP



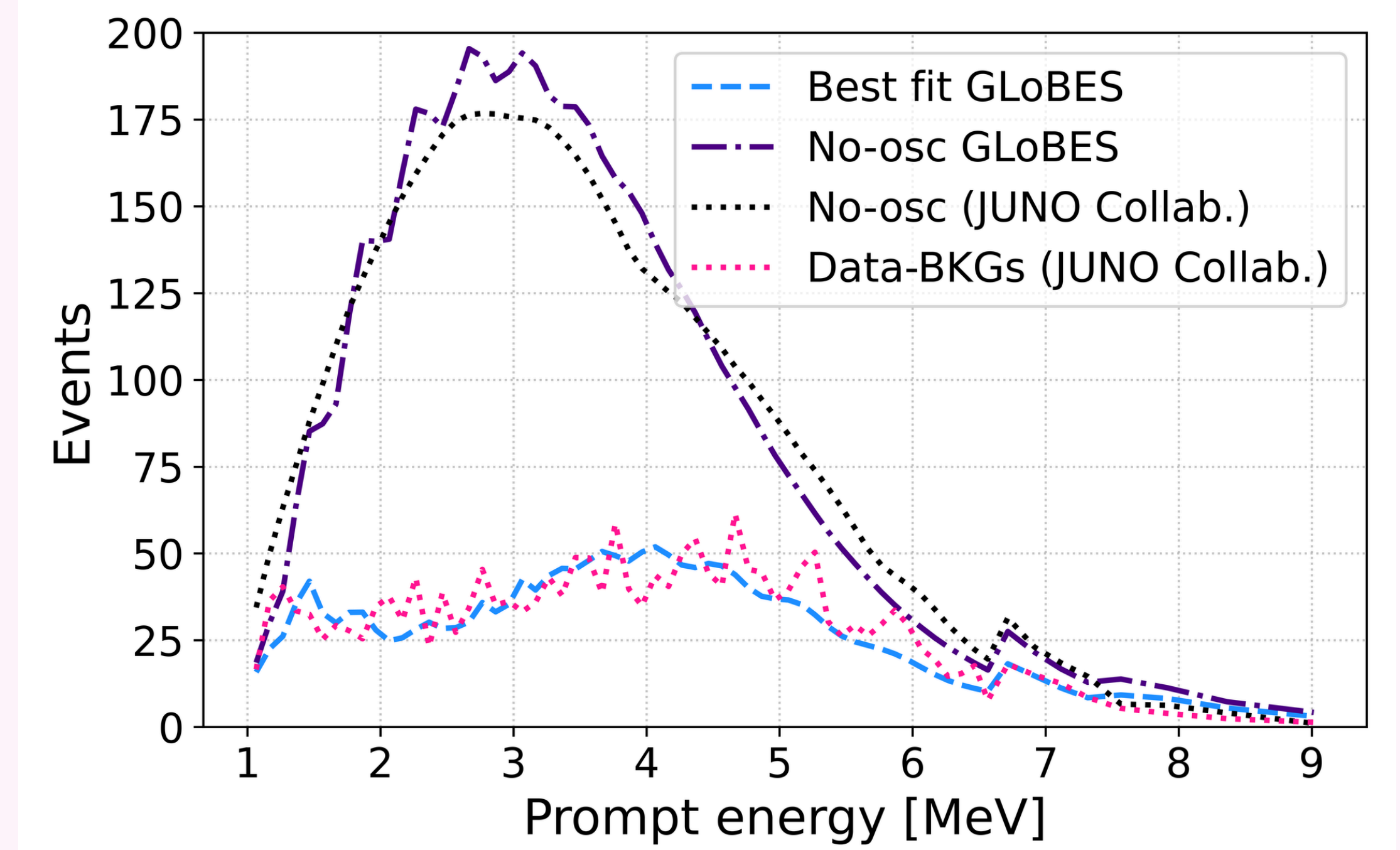
JUNO detector

- JUNO baseline: 52.5 km
- 59.1-day public dataset
- 64 prompt-energy bins (1-9.4 MeV)
- Energy resolution: 3%
- Poisson χ^2 + pull terms
- GLOBES framework modified to include LIV
- Marginalized over:
 θ_{12} , θ_{13} , Δm_{21}^2 , Δm_{31}^2

Goal: evaluate JUNO's sensitivity to LIV and its impact on the neutrino mass ordering.

4. VALIDATION OF THE SETUP

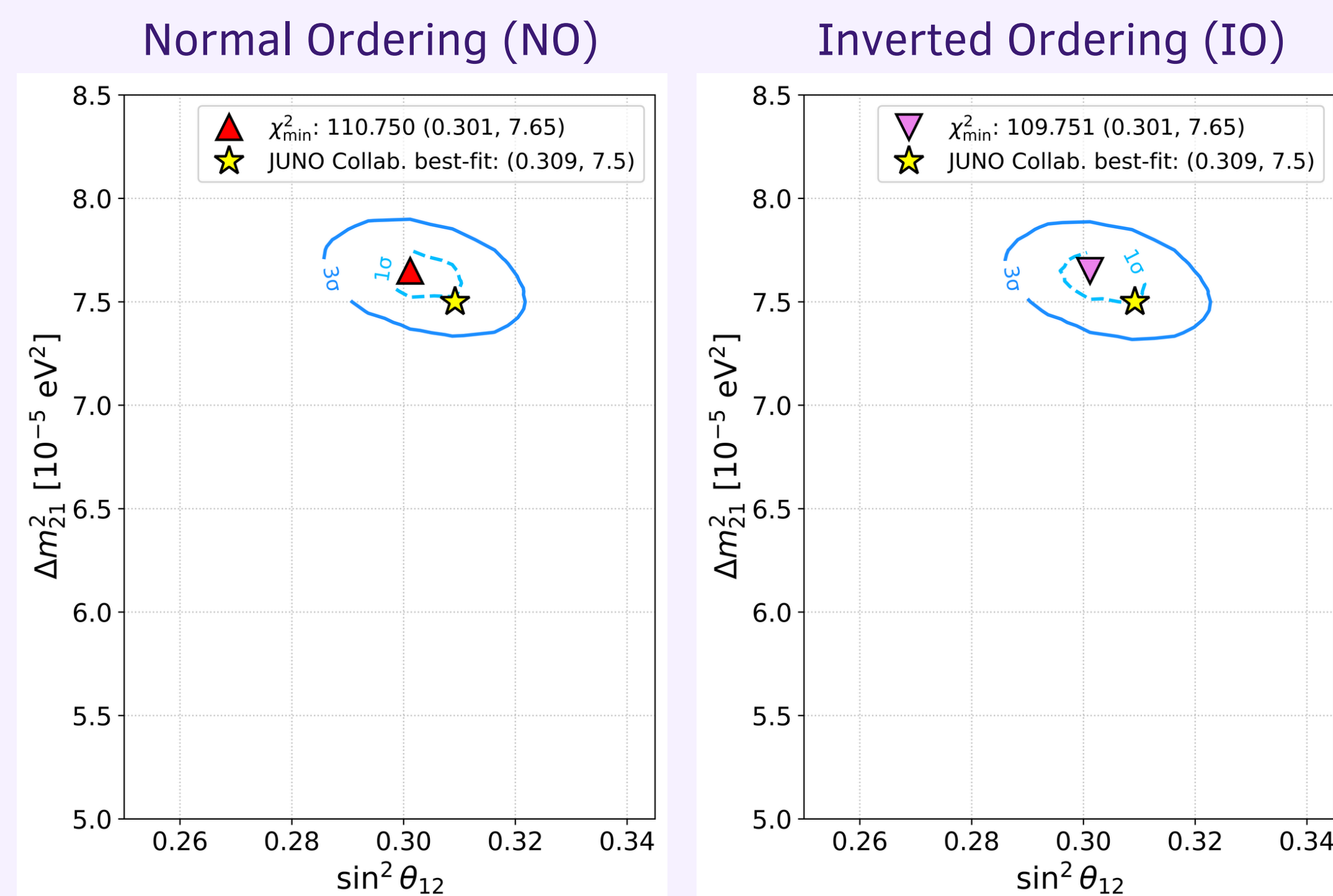
Event rates for JUNO



GLOBES implementation reproduces JUNO data within uncertainties.

5. STANDARD OSCILLATION (SM)

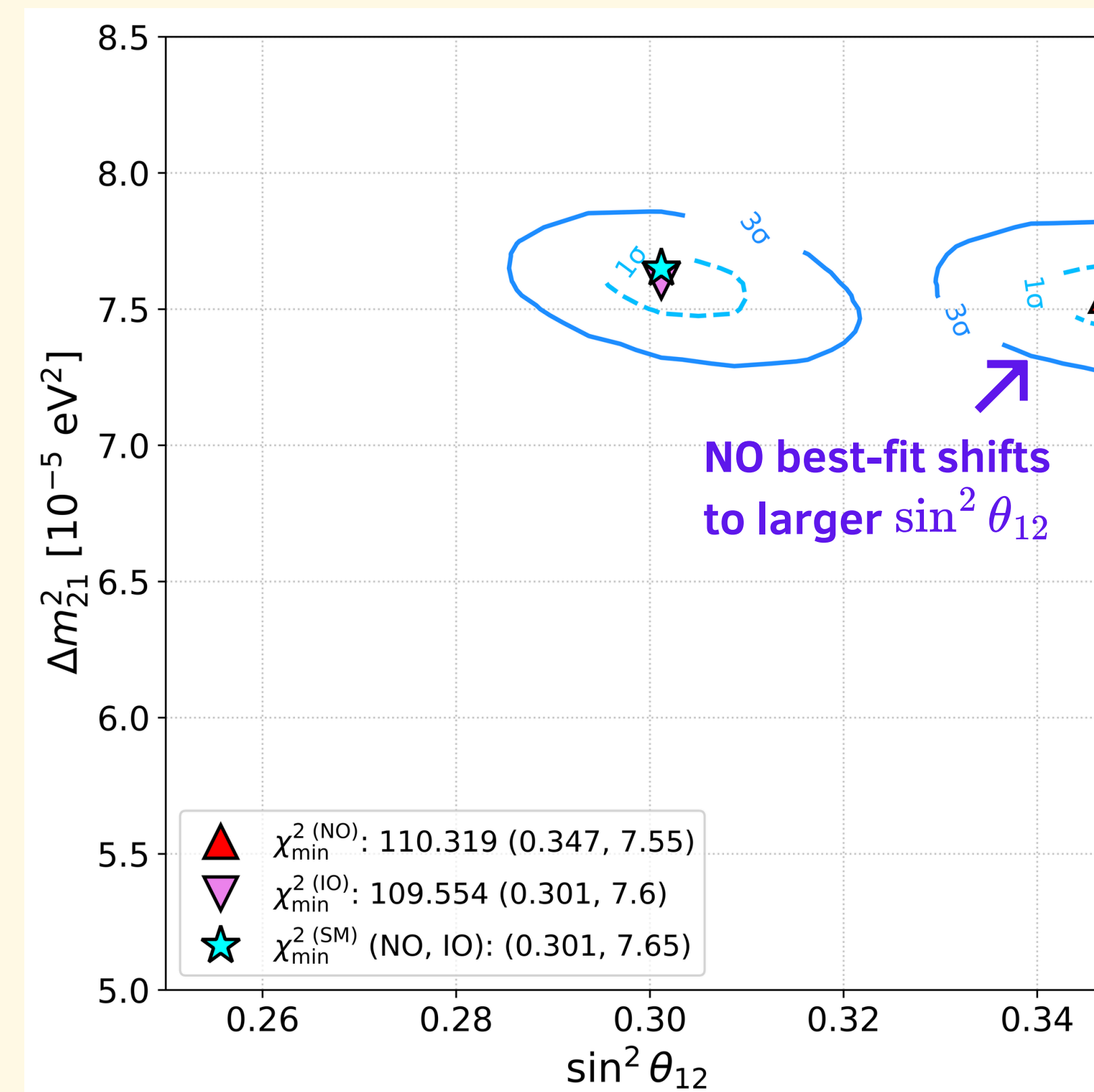
Chi-square in the $\sin^2 \theta_{12} - \Delta m_{21}^2$ plane



In the SM, NO and IO regions strongly overlap and have similar χ_{min}^2 .

6. IMPACT OF CPT-EVEN LIV

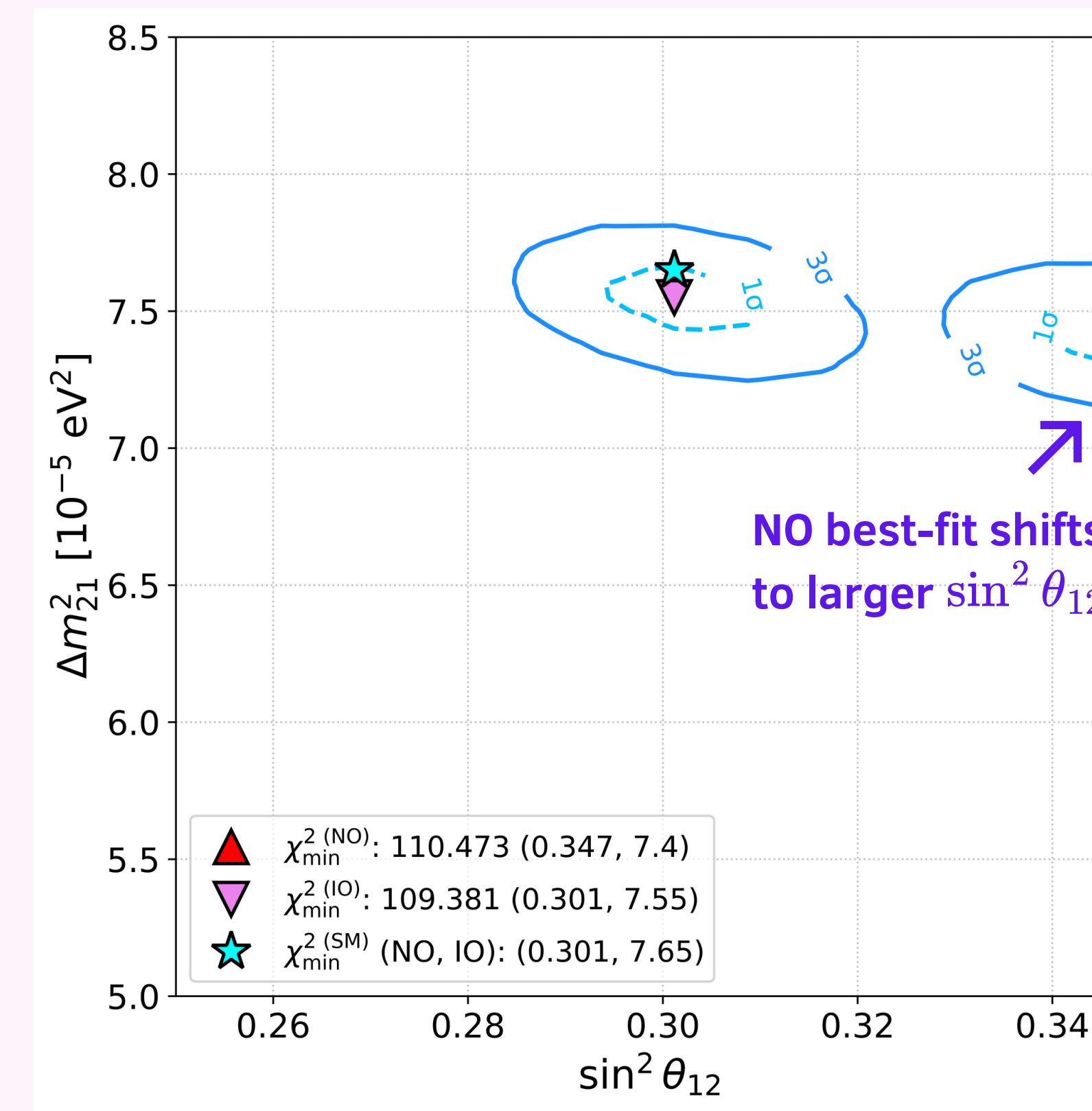
SM + LIV $c_{ee} - c_{e\tau}$ best-fit scenario



- CPT-even LIV reduces the NO-IO overlap, with IO closer to our SM best-fit.

7. IMPACT OF CPT-ODD LIV

SM + LIV $a_{ee} - a_{e\tau}$ best-fit scenario



- CPT-odd LIV also shifts the NO best-fit and further reduces NO-IO overlap.
- IO remains preferred.

8. CONSTRAINTS ON LIV PARAMETERS

Parameter combination	3σ bound (this work)
$c_{ee} - c_{e\mu}$	$< 0.7 \times 10^{-19}$
$c_{ee} - c_{e\tau}$	$< 1.0 \times 10^{-19}$
$a_{ee} - a_{e\mu}$	$< 6.8 \times 10^{-13}$ GeV
$a_{ee} - a_{e\tau}$	$< 7.2 \times 10^{-13}$ GeV

Bounds correspond to correlated 2D scans, not single-coefficient limits.

9. CONCLUSIONS

- JUNO's first data already constrains isotropic LIV coefficient combinations.
- LIV scenarios shift the NO best-fit toward larger $\sin^2 \theta_{12}$ and reduce the overlap with IO.
- Our χ^2 analysis suggests a preference for IO.
- JUNO has strong potential to probe new physics in the neutrino sector.



References

- [1] S. Navas et al, JPhys. Rev. D 110, 030001 (2024).
- [2] JUNO Collaboration, arXiv:2511.14593v1 (2025).

[3-36] See paper for full list of references

Acknowledgments

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