The First Step in Probing the Unitarity of the Lepton Mixing Matrix with NOvA

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BACKGROUND

- We present posterior distributions for the PMNS matrix elements $|U_{\alpha i}|$ and PMNS unitarity triangles, **assuming unitarity**, as a **first step**.

METHOD

- The posterior samples of oscillation parameters obtained from the **NOvA 2024** Bayesian fit [1] were to produce all plots with NuMCMCTools [2].

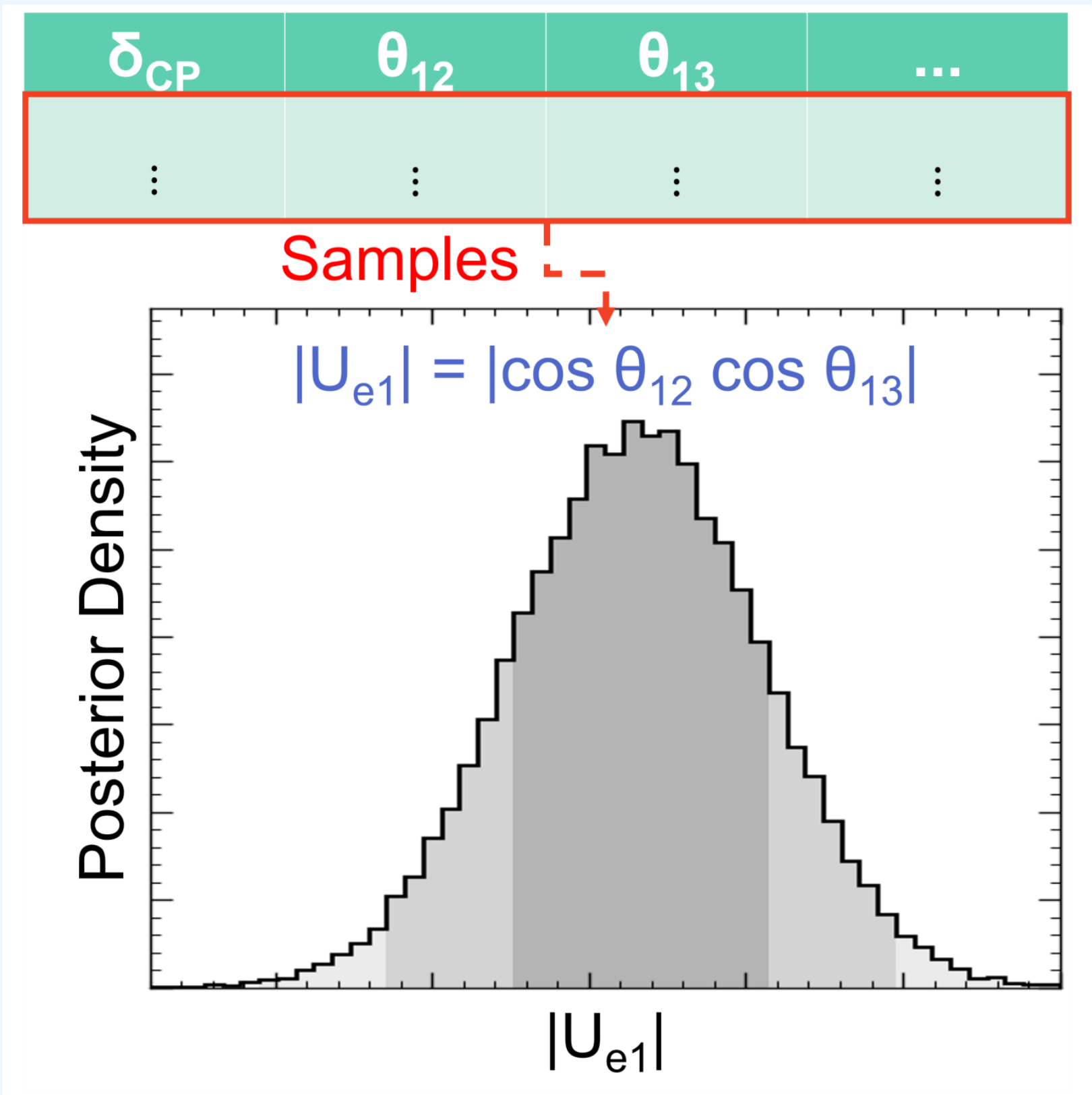

Fig 1: Calculating posterior distributions from samples of oscillation parameters.

PMNS POSTERIORS

- A PDG constraint was applied to θ_{12} since NOvA does not have sensitivity to it.

Priors matter more than you think!

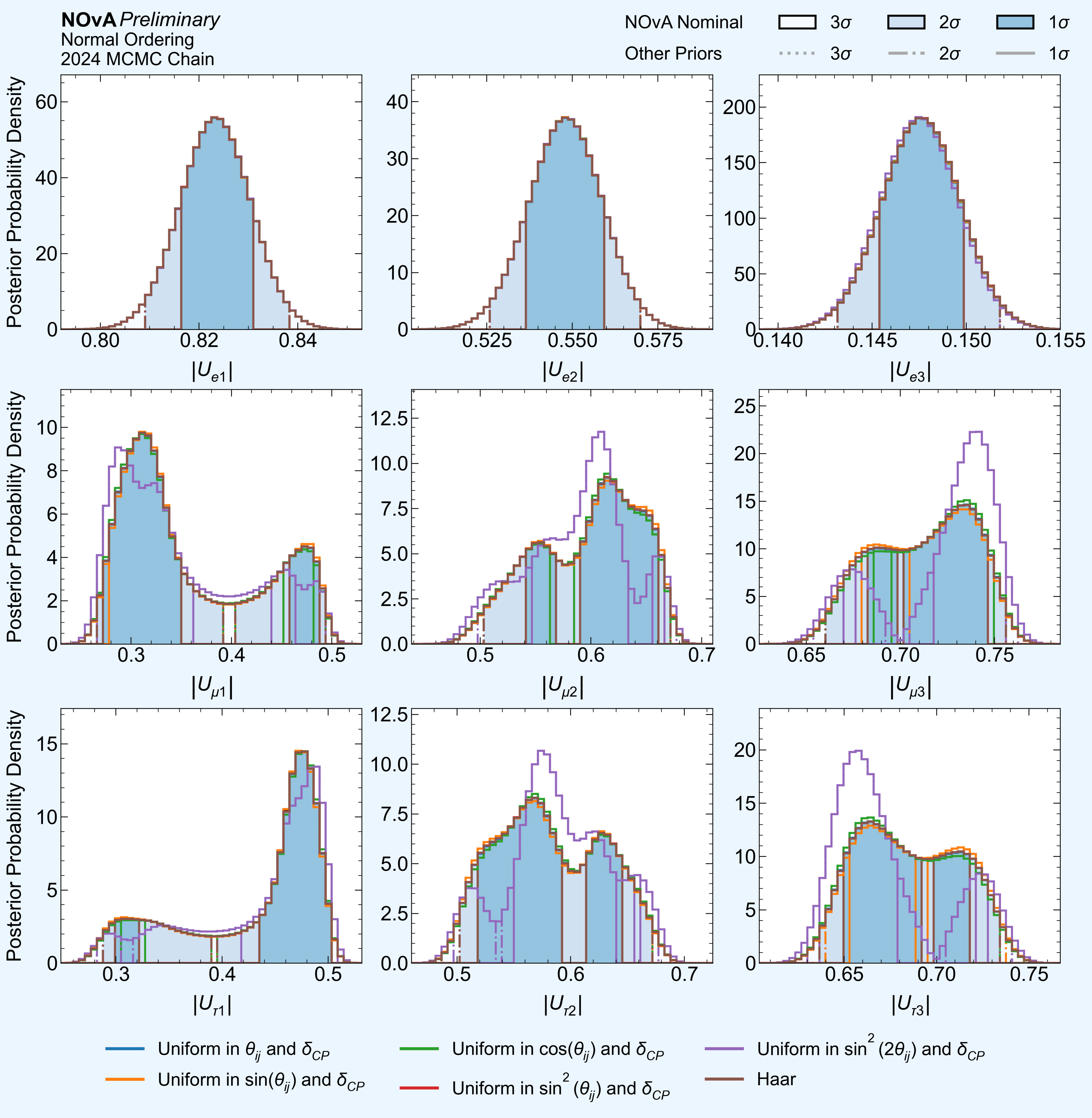

Fig 2: Posterior distributions (area normalised) for the nine PMNS matrix elements under normal ordering.

$$U_{\mathrm{PMNS}} = \begin{pmatrix} c_{12}c_{13} & s_{12}c_{13} & s_{13}e^{-i\delta} \\ -s_{12}c_{23} - c_{12}s_{23}s_{13}e^{i\delta} & c_{12}c_{23} - s_{12}s_{23}s_{13}e^{i\delta} & s_{23}c_{13} \\ s_{12}s_{23} - c_{12}c_{23}s_{13}e^{i\delta} & -c_{12}s_{23} - s_{12}c_{23}s_{13}e^{i\delta} & c_{23}c_{13} \end{pmatrix}$$

UNITARITY TRIANGLES

- Six unitarity triangles were created based upon the three row and three column orthogonality conditions.
- Triangles were normalised such that one side has length 1 using the convention used in [3].

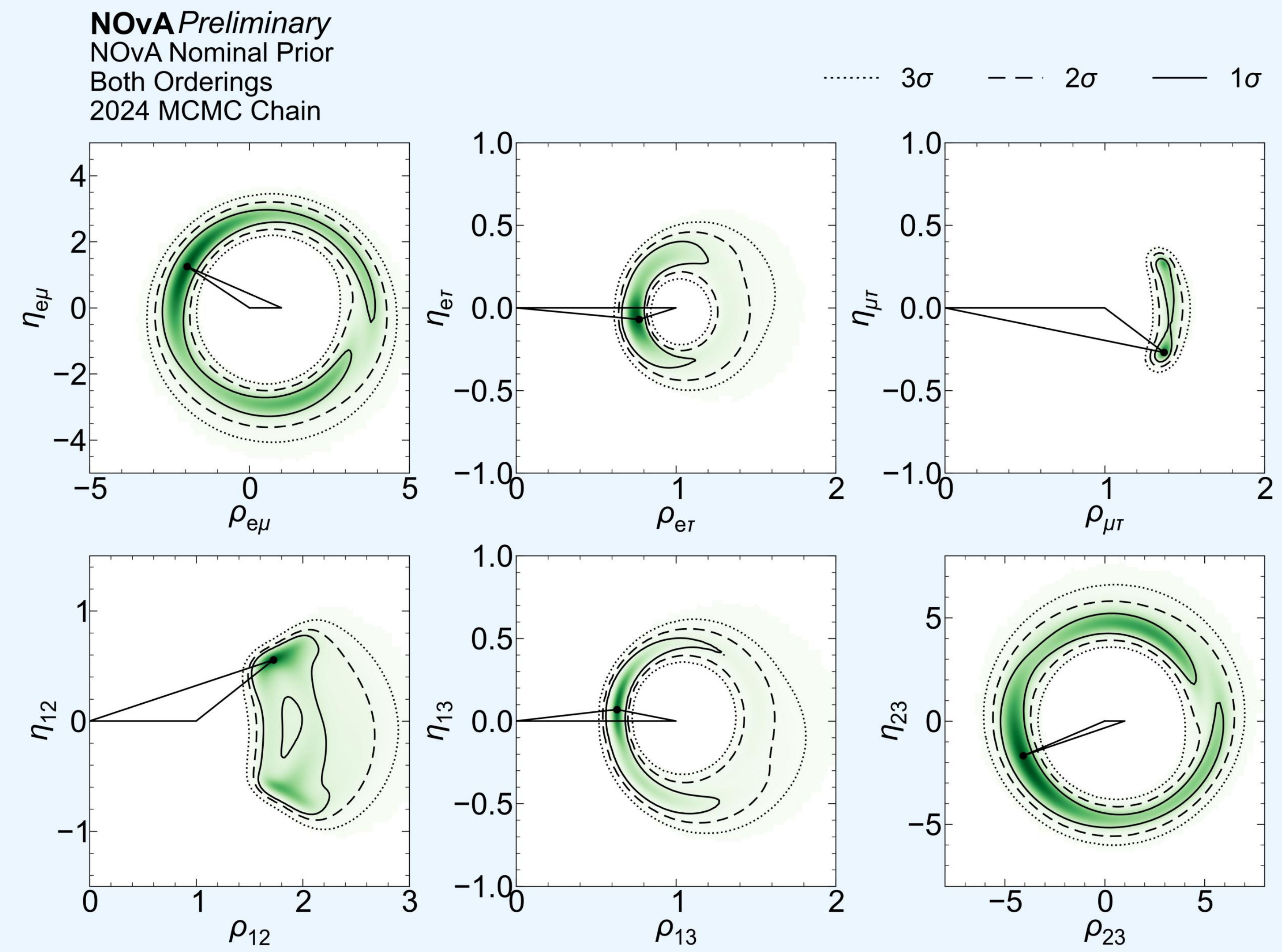

Fig 3: Leptonic unitarity triangles. Refer to Fig 1 in [3].

CONCLUSION

- $|U_{\alpha i}|$ distributions are prior-dependent due to weaker NOvA constraints on the θ_{23} and δ_{CP} parameters.
- Comparing unitarity triangles across experiments can probe potential new physics (e.g., NSI); agreement alone does not imply PMNS unitarity.

REFERENCES

[1] : S. Abubakar *et al.*, 2025. DOI: https://doi.org/10.48550/arXiv.2509.04361.
[2] : A. Sztuc *et al.*, 2024, GitHub: https://github.com/NuMCMCTools/NuMCMCTools.
[3] : S. A. R. Ellis *et al.*, 2020. DOI: https://doi.org/10.1103/PhysRevD.102.115027.

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