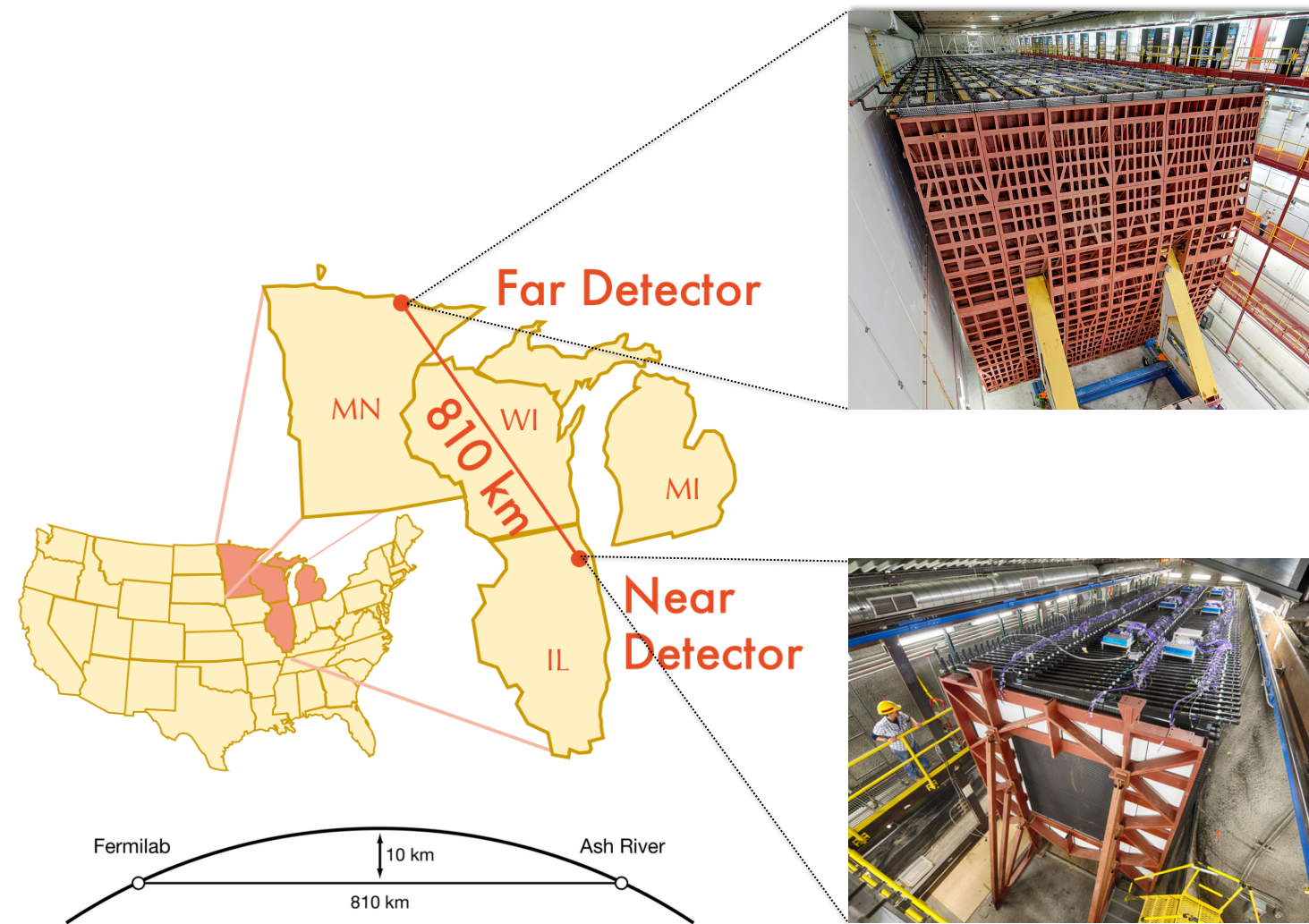


The NOvA Experiment

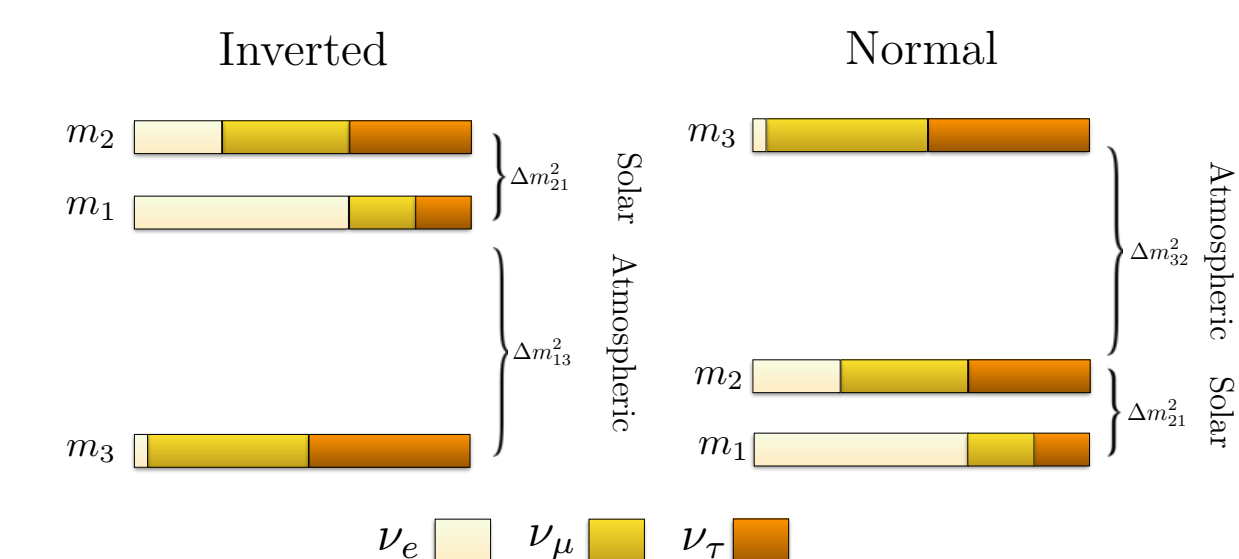
The NOvA experiment is a long baseline neutrino oscillation experiment utilizing the world's most powerful ν_μ ($\bar{\nu}_\mu$) beam—the NuMI beam at Fermilab.

- Two functionally identical detectors (Far and Near).
- Fine-grained, low-Z liquid scintillator calorimeters.
- 14 mrad off the NuMI beam axis.



Physics motivations for studying ν_e ($\bar{\nu}_e$) appearance and ν_μ ($\bar{\nu}_\mu$) disappearance:

- Determine Neutrino Mass Hierarchy.
- Probe δ_{CP} violating phase.
- Resolve the octant of θ_{23} mixing angle.
- Precise measurement of Δm_{32}^2 .



Markov Chain Monte Carlo (MCMC) for Bayesian Analysis

Bayes theorem in practice:

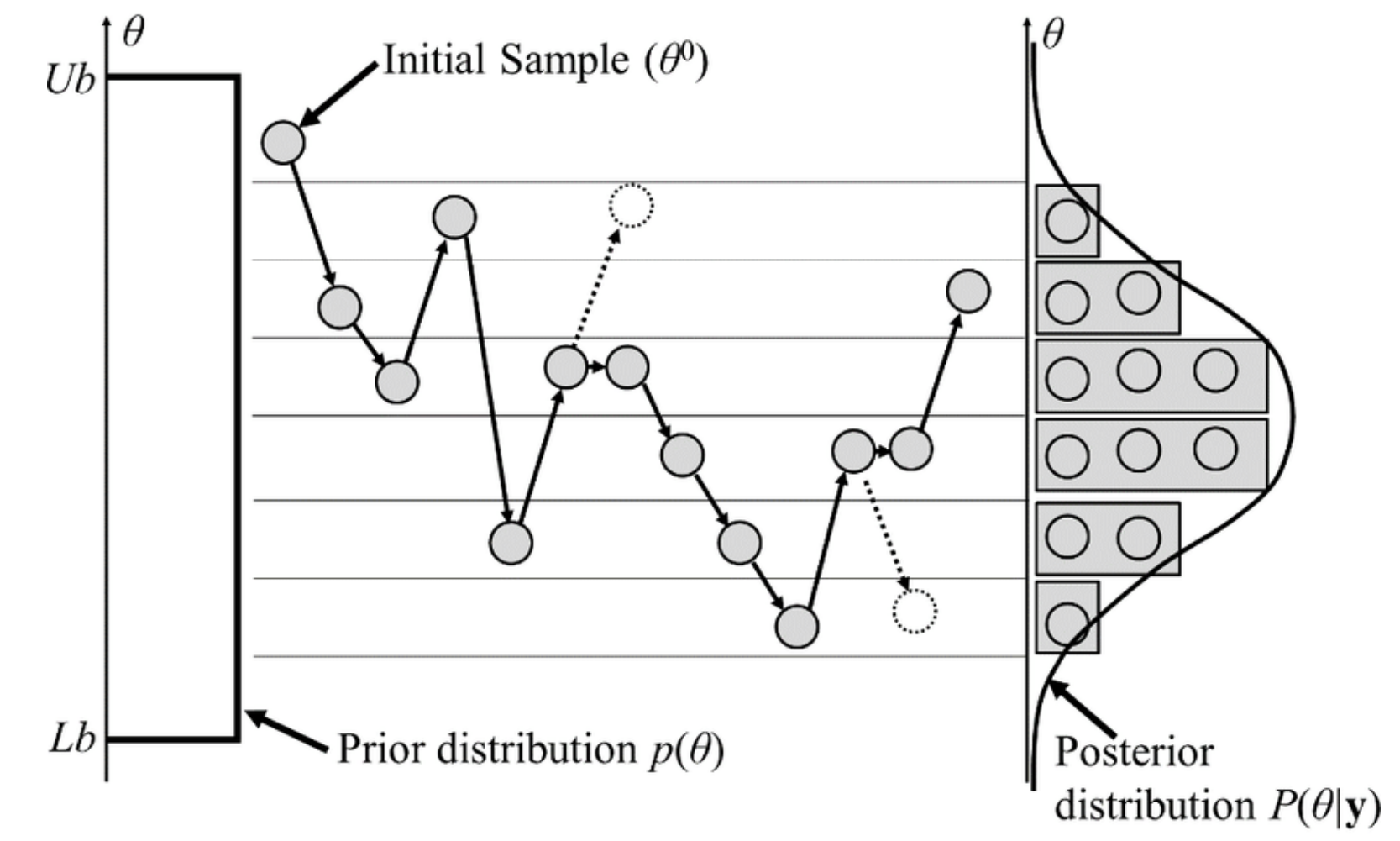
$$P(\theta|Data) = \frac{f(\theta)\mathcal{L}(data|\theta)}{\int f(x)\mathcal{L}(data|x)dx}$$

MCMC is a method to efficiently sample from a distribution by randomly choosing a new sample point based on the last point.

NOvA has implemented two different MCMC methods to its analysis:

- "ARIA": MR²T² Algorithm – The Metropolis–Rosenbluth–Rosenbluth–Teller–Teller algorithm
- "Stan": Hamiltonian Monte Carlo

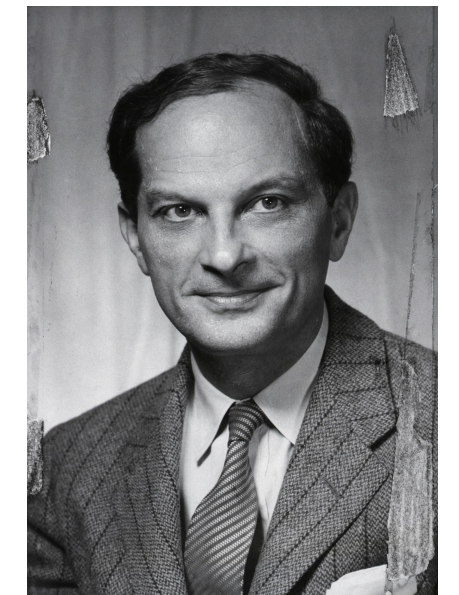
We choose uniform priors for the oscillation parameters, except $\sin^2 2\theta_{13}$, which is constrained with measurements from reactor experiments. NOvA's Bayesian MCMC Fitter was also used for the first NOvA+T2K analysis (see poster 463).



(image taken from L. Jaewook et. al. (2015). Energies. 10.3390/en8065538.)



ARIA named after Arianna Rosenbluth



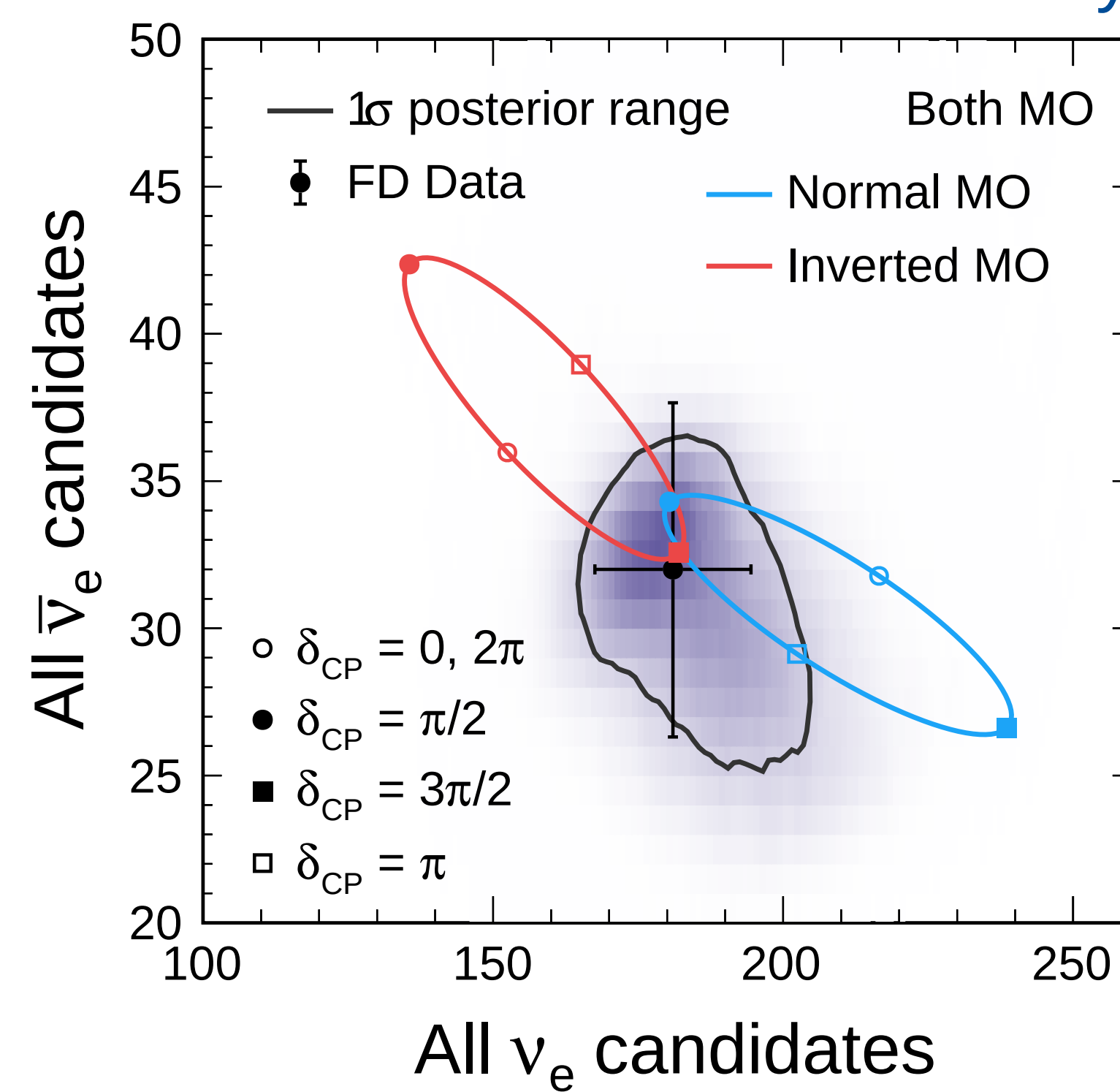
Stan named after Stanislaw Ulam

New NOvA 3Flavor Results in 2024

This year NOvA presents new three-flavor results obtained with 26.6×10^{20} POT with ν beam and 12.5×10^{20} POT with $\bar{\nu}$ beam (+95.6% more statistics with ν beam than in 2020). For more details see J. Wolcott's plenary talk. Accompanying this result, there is a Frequentist result presented at this conference, see poster 456.

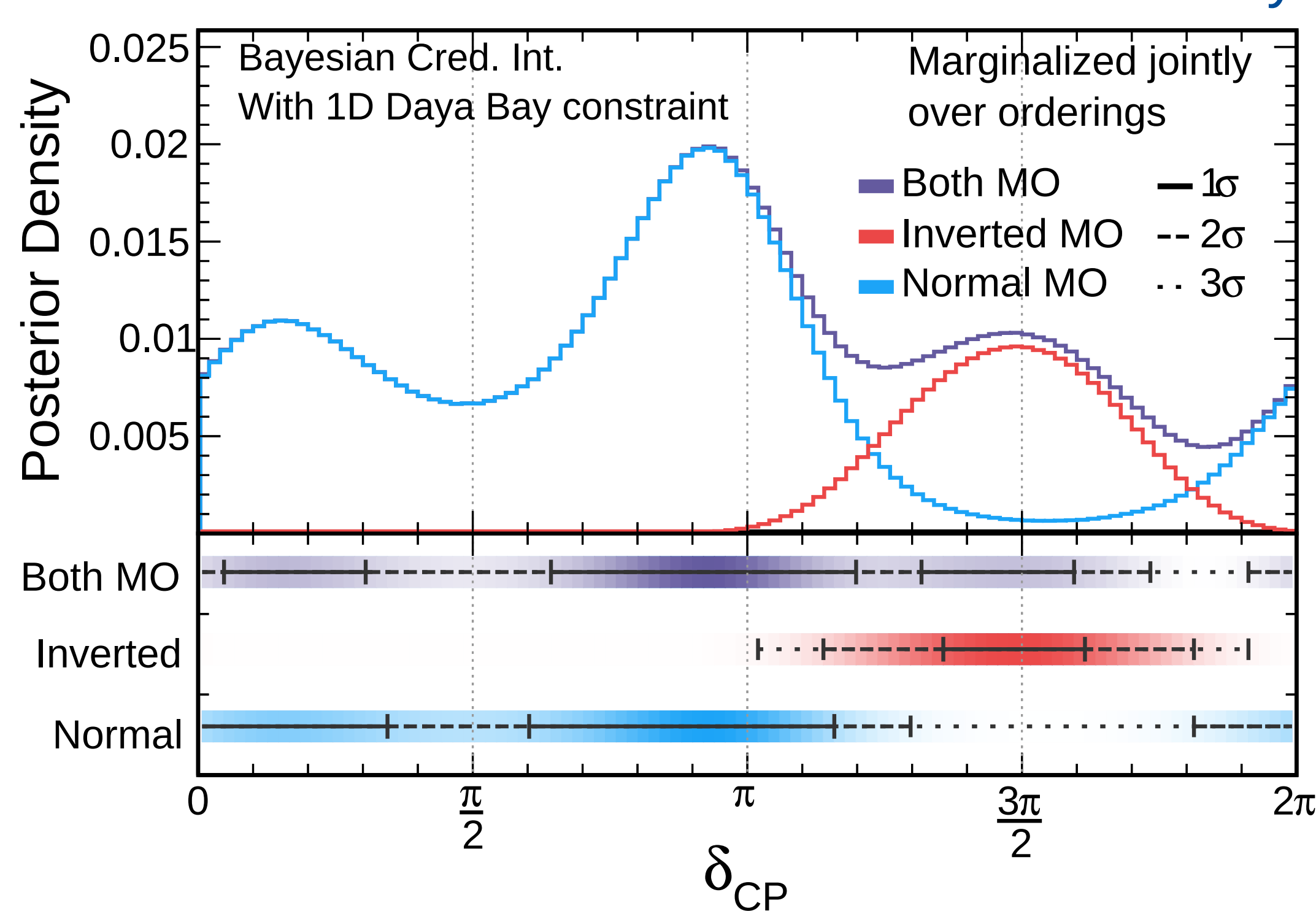
	Neutrino beam			Antineutrino beam		
	ν_μ	ν_e	ν_e LE	$\bar{\nu}_\mu$	$\bar{\nu}_e$	
Signal	398.2	121.6	2.9	96.7	18.2	
Background	11.3	54.9	6.8	1.7	12.2	
Total pred	409.5	176.5	9.7	98.4	30.4	
Observed	384	169	12	106	32	
P-values:	0.68	0.65	0.82	0.45	0.20	

NOvA Preliminary



δ_{CP} and Mass Ordering

NOvA Preliminary



NO disfavors max CP violating points $\frac{\pi}{2}$ and $\frac{3\pi}{2}$ at >1 and $>2 \sigma$, respectively.

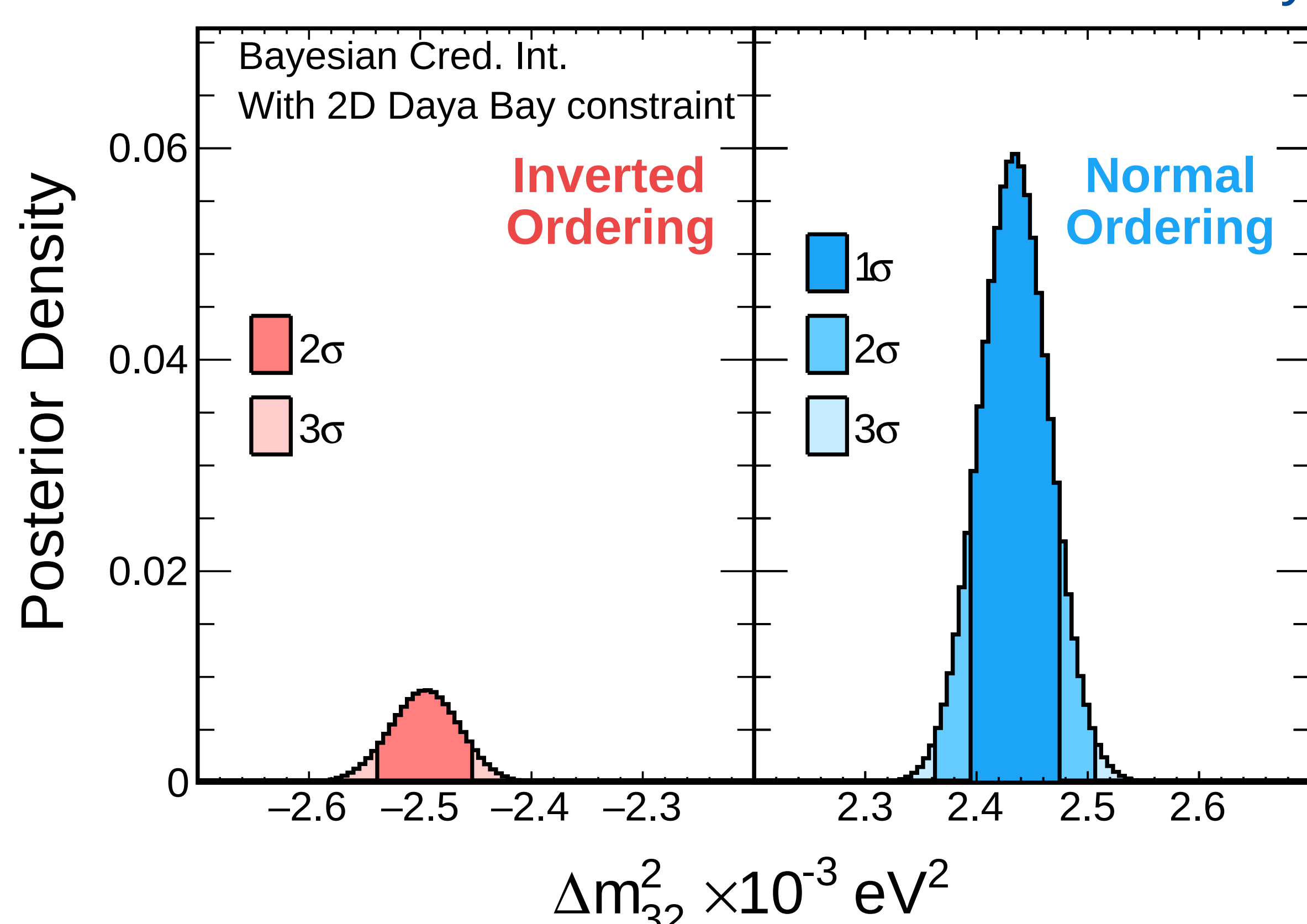
IO rejects CP conserving points, as well as $\frac{\pi}{2}$, at $>3 \sigma$.

We apply the constraint to $\sin^2 2\theta_{13}$ from Daya Bay two ways:

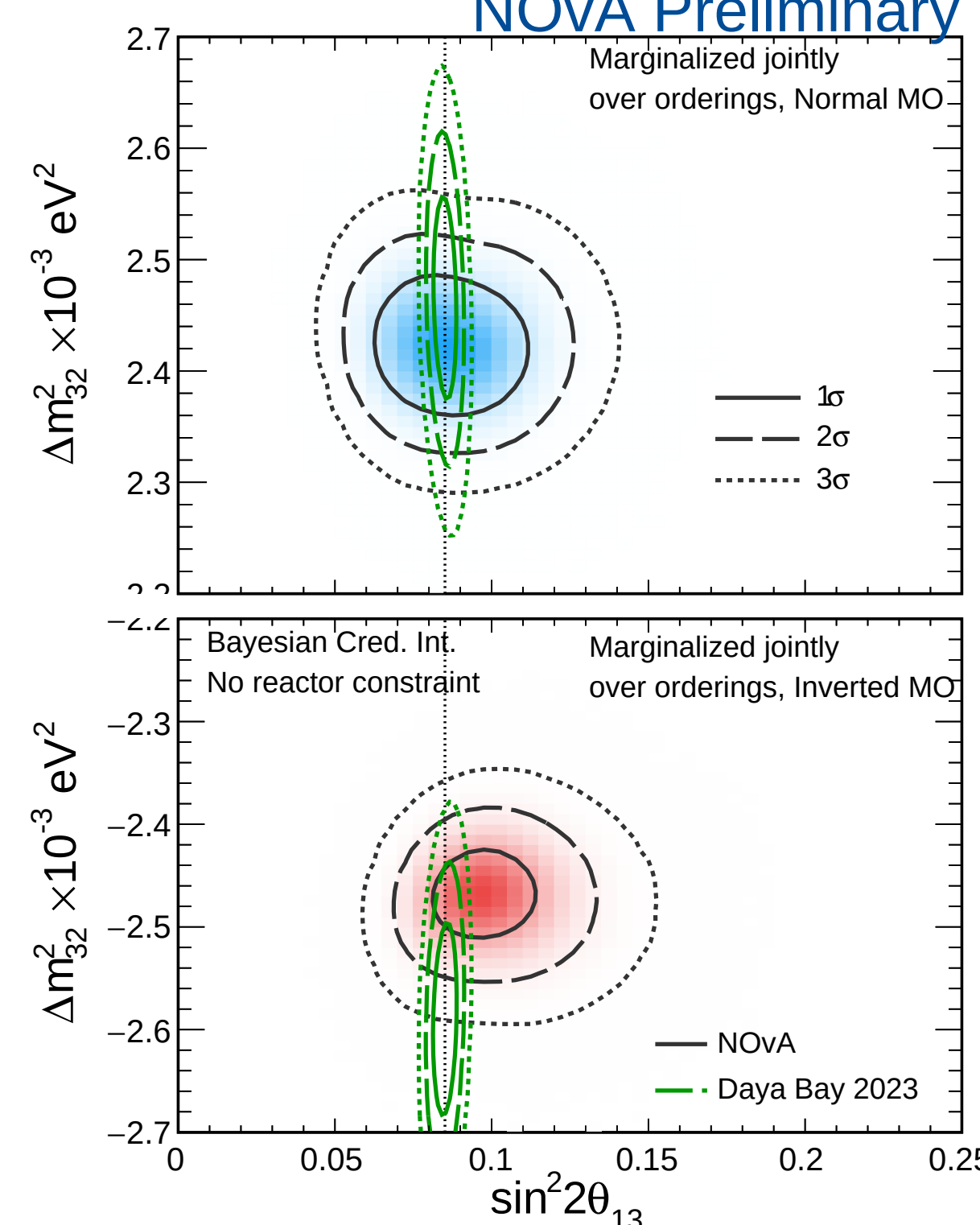
- As a prior for $\sin^2 2\theta_{13}$ only (the "1D" reactor constraint)
- As a prior for $\sin^2 2\theta_{13}$ vs Δm_{32}^2 from Daya Bay's 2D surface (the "2D" reactor constraint)

With the 1D constraint, we have 76% NO, and with 2D, we have 87% NO.

NOvA Preliminary



NOvA Preliminary

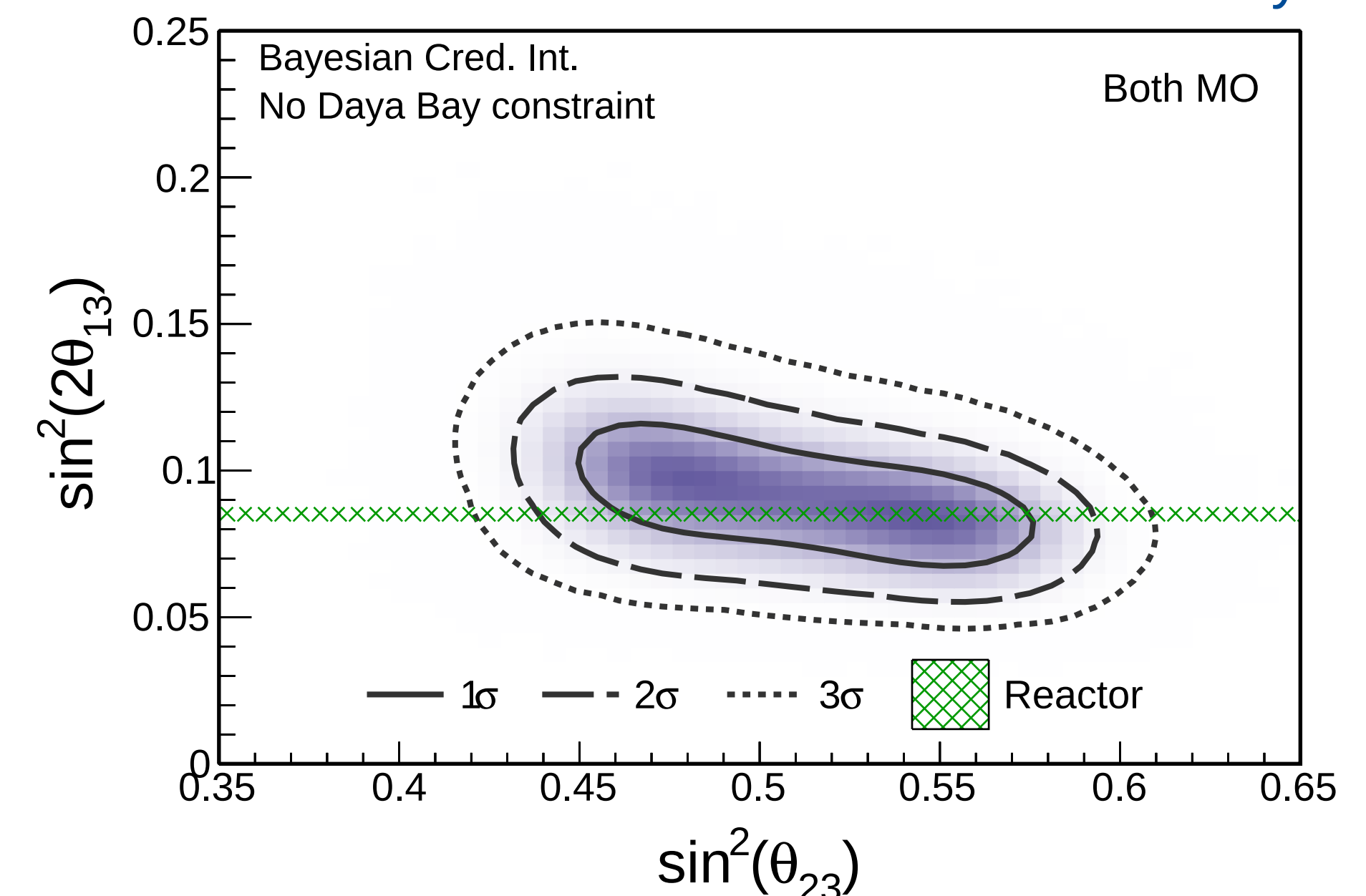


Mixing Angles

Without including an external constraint on θ_{13} , we can make a measurement of θ_{13} with NOvA data alone, showing consistency with reactor experiments' measurements. Here, the prior for $\sin^2 2\theta_{13}$ is uniform.

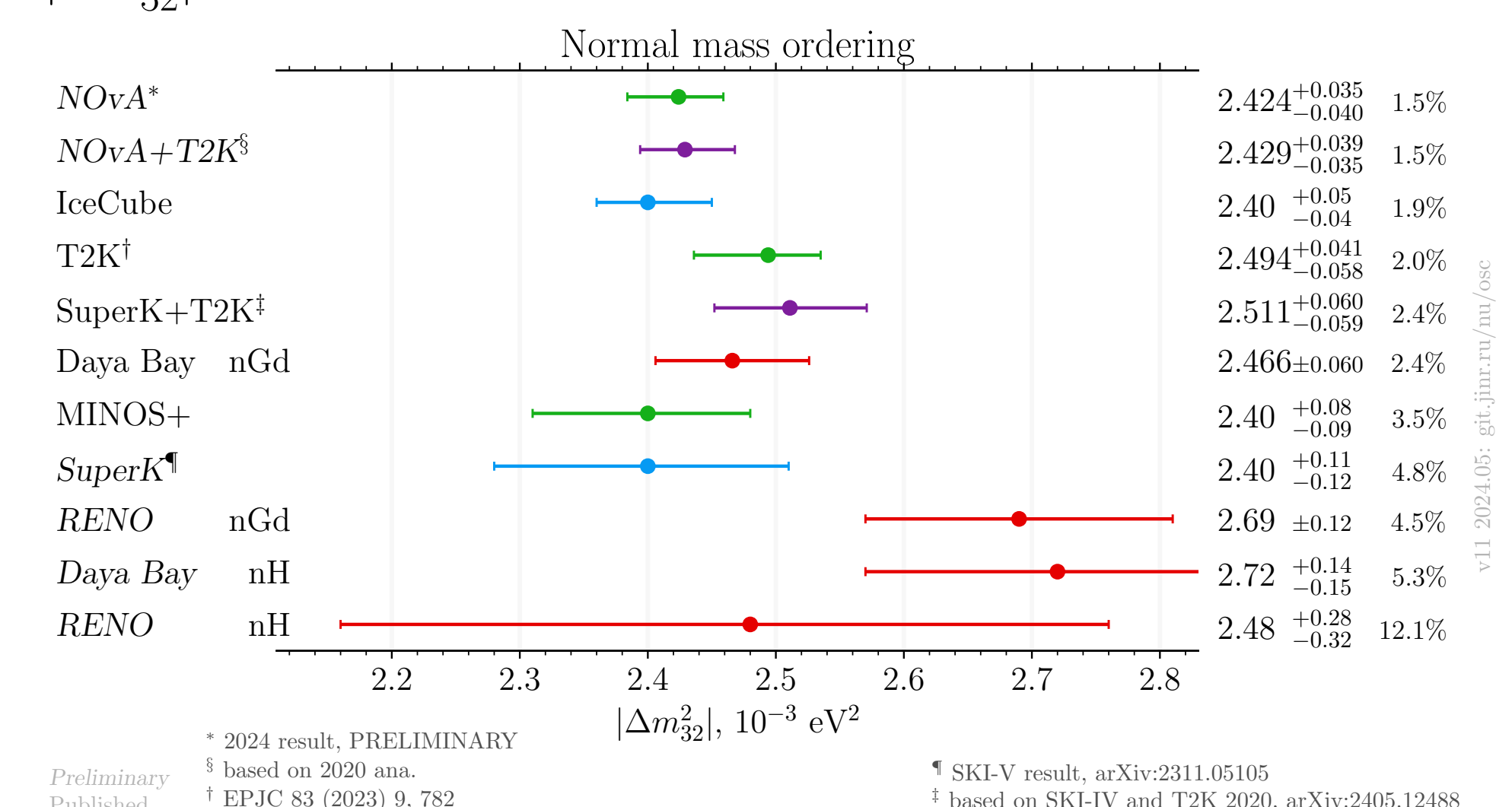
NOvA prefers the upper octant, with 69% for the 1D reactor constraint. Without reactor constraint the octant preference changes.

NOvA Preliminary



Result Comparisons with Other Experiments

This result gives the most precise individual measurement of $|\Delta m_{32}^2|$.



* 2024 result, PRELIMINARY
† based on 2020 ana.
‡ EPJC 83 (2023) 9, 782
§ SKI-V result, arXiv:2311.05105
¶ based on SKI-IV and T2K 2020, arXiv:2405.12488

NOvA and T2K favor different values of δ_{CP} . New NOvA results are consistent with previous ones.

NOvA Preliminary

