

Developments in joint neutrino oscillations analysis of **NOvA** and **T2K**

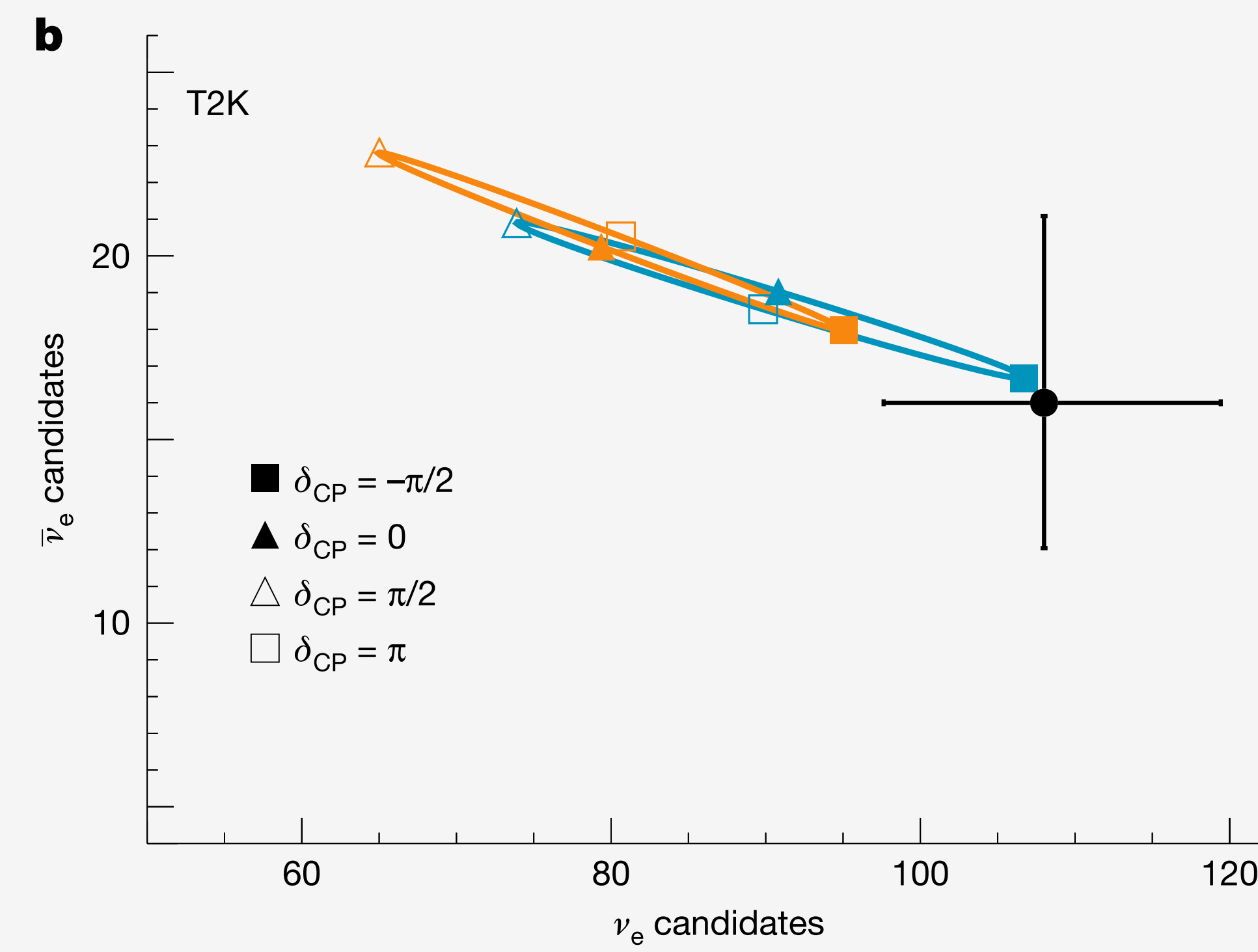
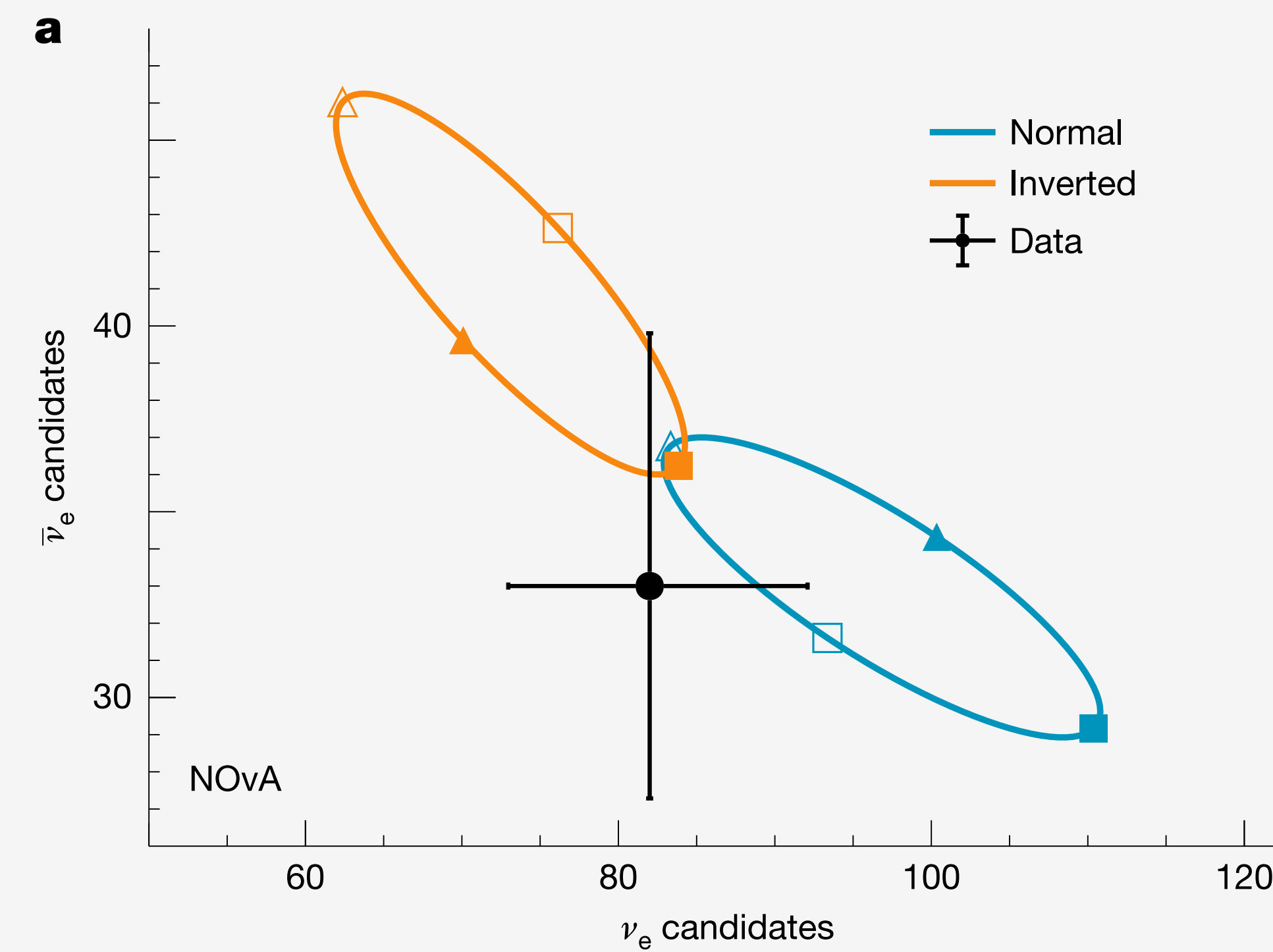
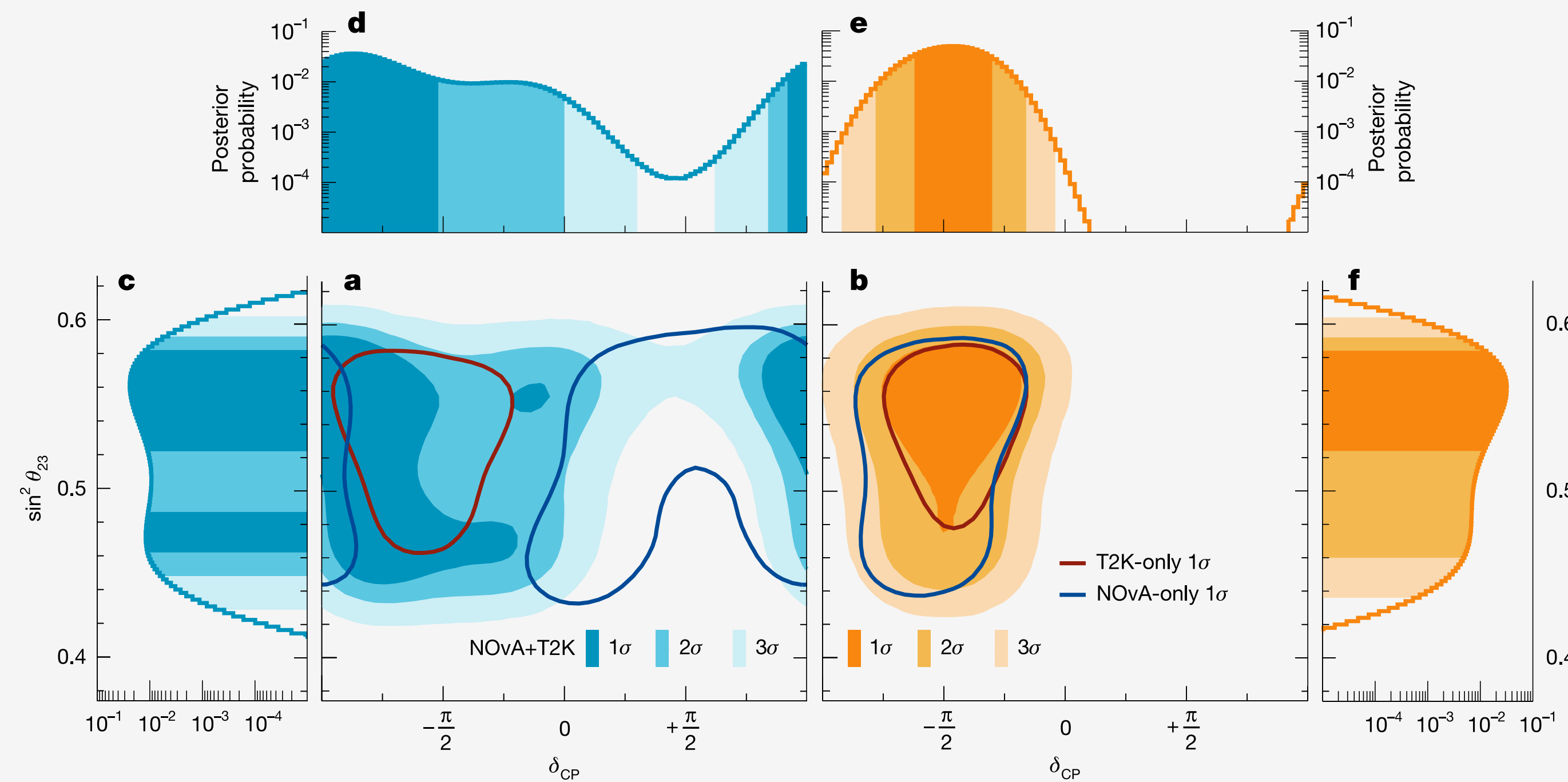
Yuhan (Hank) Hua, on behalf of the T2K and NOvA collaborations | Prepared for **Neutrino 2026**, University of California, Irvine, 21-26 June 2026

Why joint analysis?

- Complementarity between experiments: different baseline, energy, and analysis strategy → lifts degeneracy in δ_{CP} and mass ordering

	T2K	NOvA
Location	Tokai→Kamioka	Illinois→Minnesota
Baseline	295 km	810 km
Flux peak	0.6 GeV	1.8 GeV
FD	Water Cherenkov	Tracking calorimeter
ND	Magnetised tracker	Tracking calorimeter

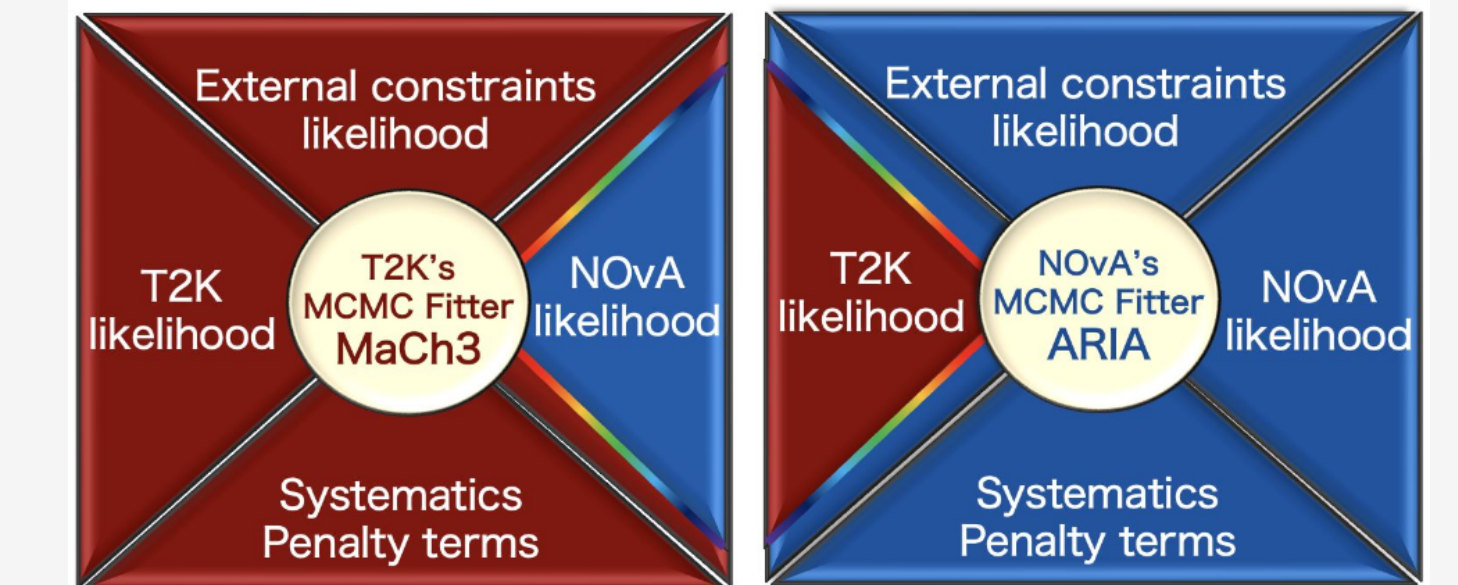
- Full joint-likelihoods: detector response, near detector information, systematics models
- First iteration of joint T2K-NOvA analysis published: Nature 646, 818 (2025)



Anatomy of a joint analysis

- Construct joint likelihood
- Investigate systematics
- Sample from posterior
- Profit!

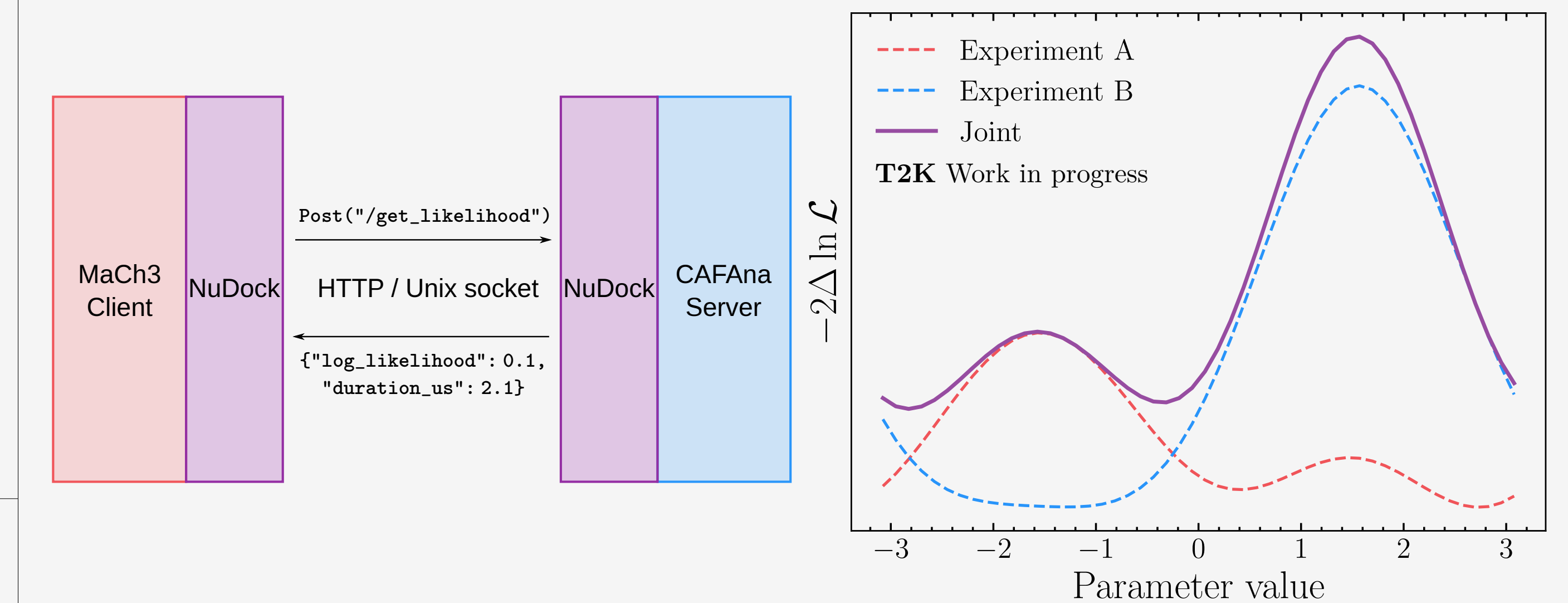
Steps 1-3 highly nontrivial:



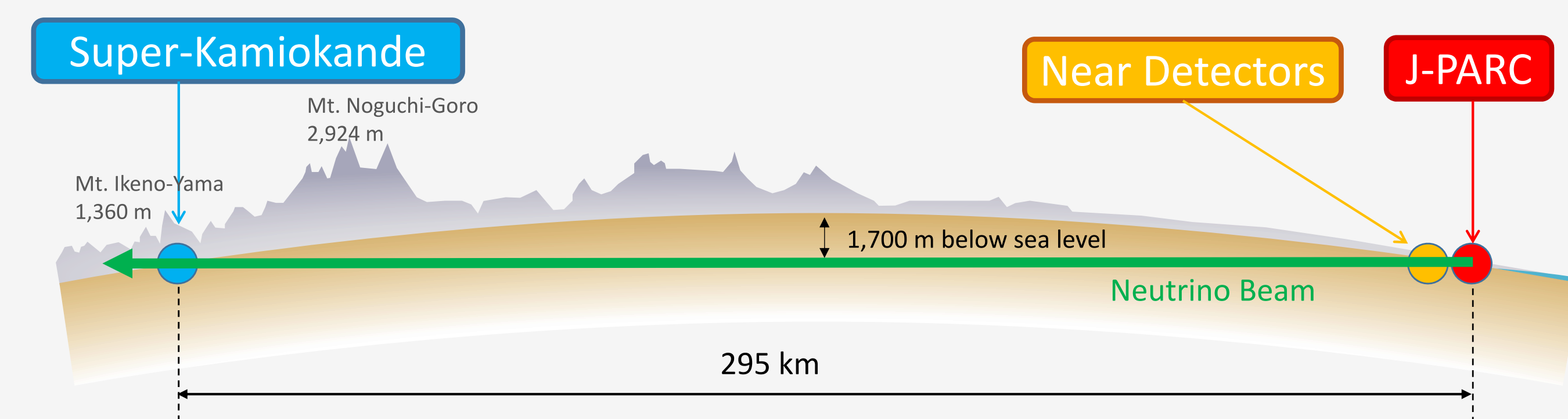
1. Joint likelihood

- Fitters work under very different environment (OS, dependencies, etc.)
- Containerised each fitter: need cross-container communication

	Previous analysis	This analysis (NuDock)
Framework	Standard pipe-based	RESTful API-like
Interface	Hard-coded	Flexible API endpoints
Data type	Array of doubles	Rich types via JSON
Maintainability	Hard to extend	Decoupled server client
Validation	Tightly coupled	Defined via schema



T2K since last joint fit

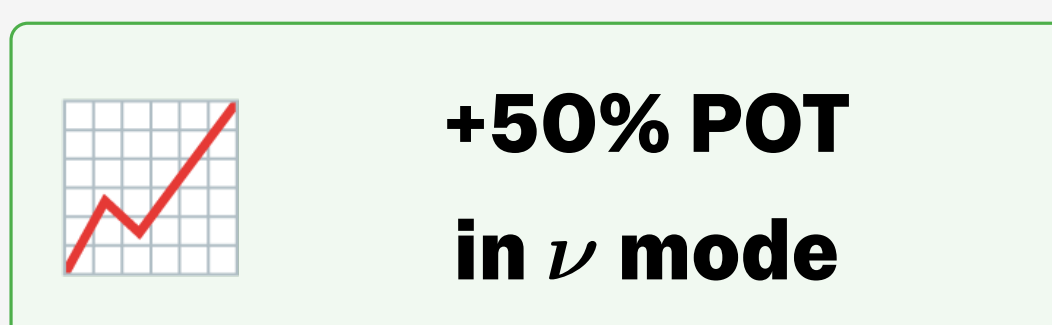


Systematics

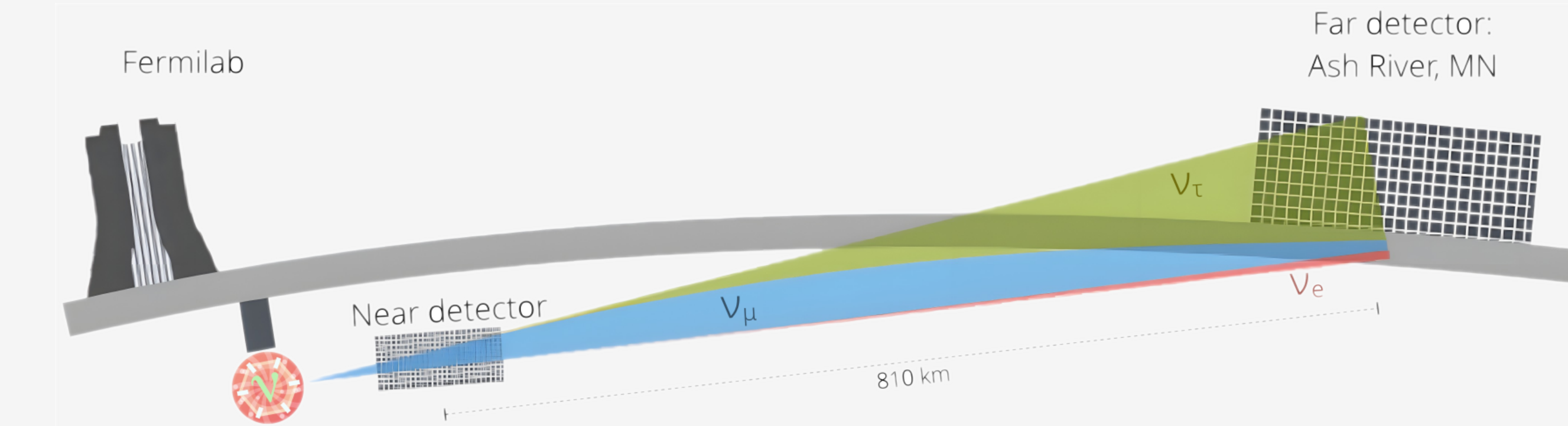
- Improved interaction modelling: spectral function, pion production, final state interactions
- Improved SK atmospheric fit → reduction of detector systematics

Samples

- 250→320 kA horn current
- New ND samples, SK multi-ring samples



NOvA since last joint fit

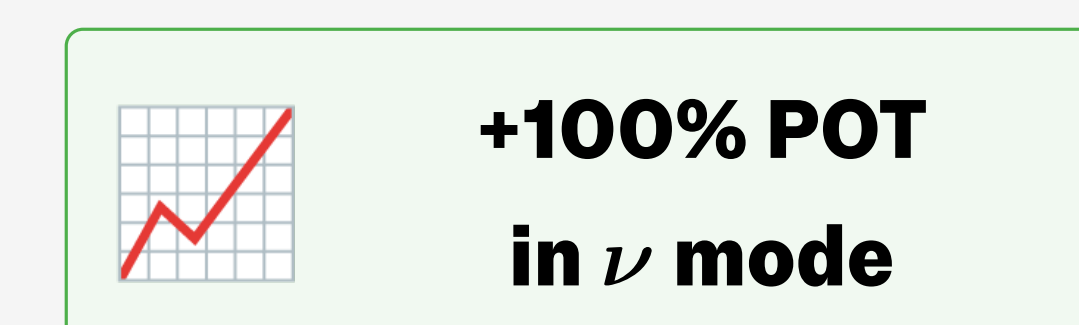


Systematics

- Improved inelastic scattering model
- New pion production uncertainties
- Improved light production model for Cherenkov & scintillation

Samples

- New low-energy ν_e sample



2. Systematics

- Same underlying cross section physics between experiments, but implemented differently
- Previous analysis: effects of correlating individual parameters and “nightmare” parameters; and out-of-model variations
- Studies of not correlating systematics will be repeated in these more sensitive analyses

3. Sampling

- High-dimension: simultaneously varying all systematics from both experiments
- Can achieve higher significance results with more statistics, but need more MCMC samples
- Reduce computation by increasing efficiency via algorithms e.g. adaptive MCMC

See also Poster No. 420: New directions for joint neutrino oscillation measurements with T2K and NOvA