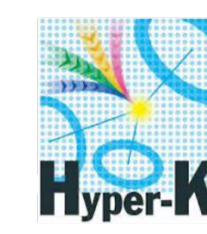


RECENT FREQUENTIST T2K OSCILLATION ANALYSIS RESULTS AND HYPER-KAMIOKANDE SENSITIVITY TO ACCELERATOR NEUTRINO OSCILLATIONS

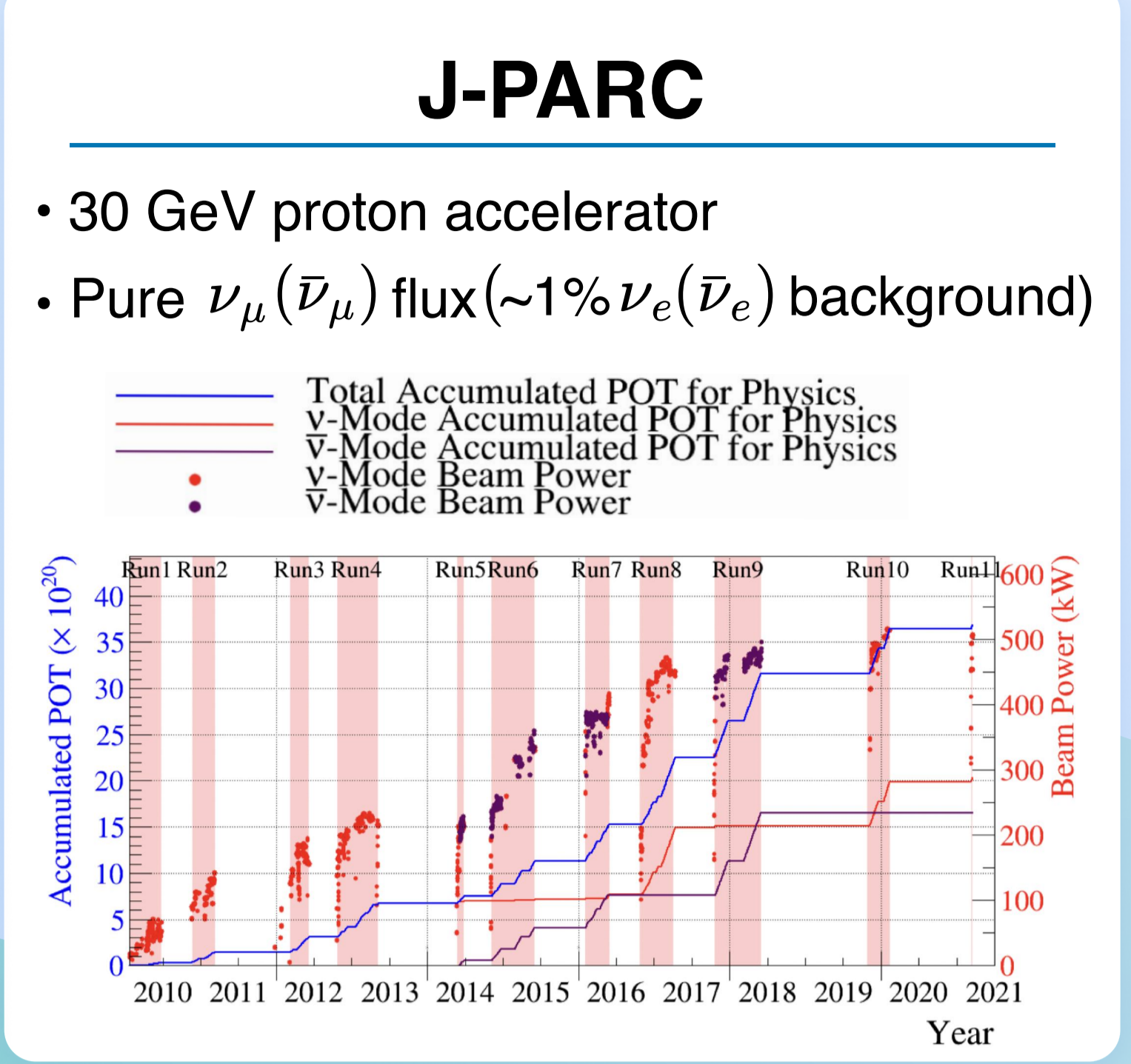
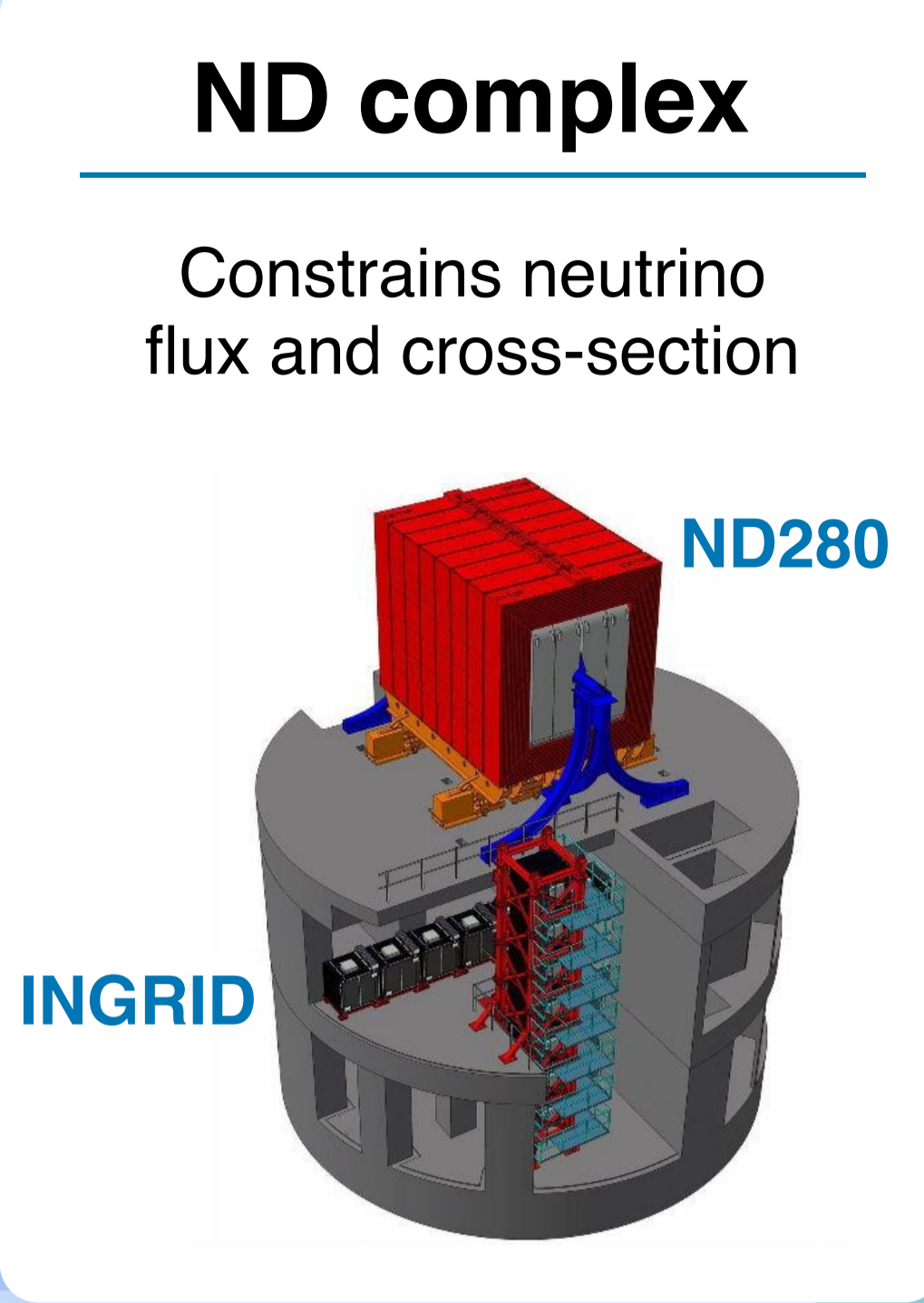


Denis Carabadjac on behalf of the T2K and the Hyper-K collaborations
dcarabadjac@llr.in2p3.fr

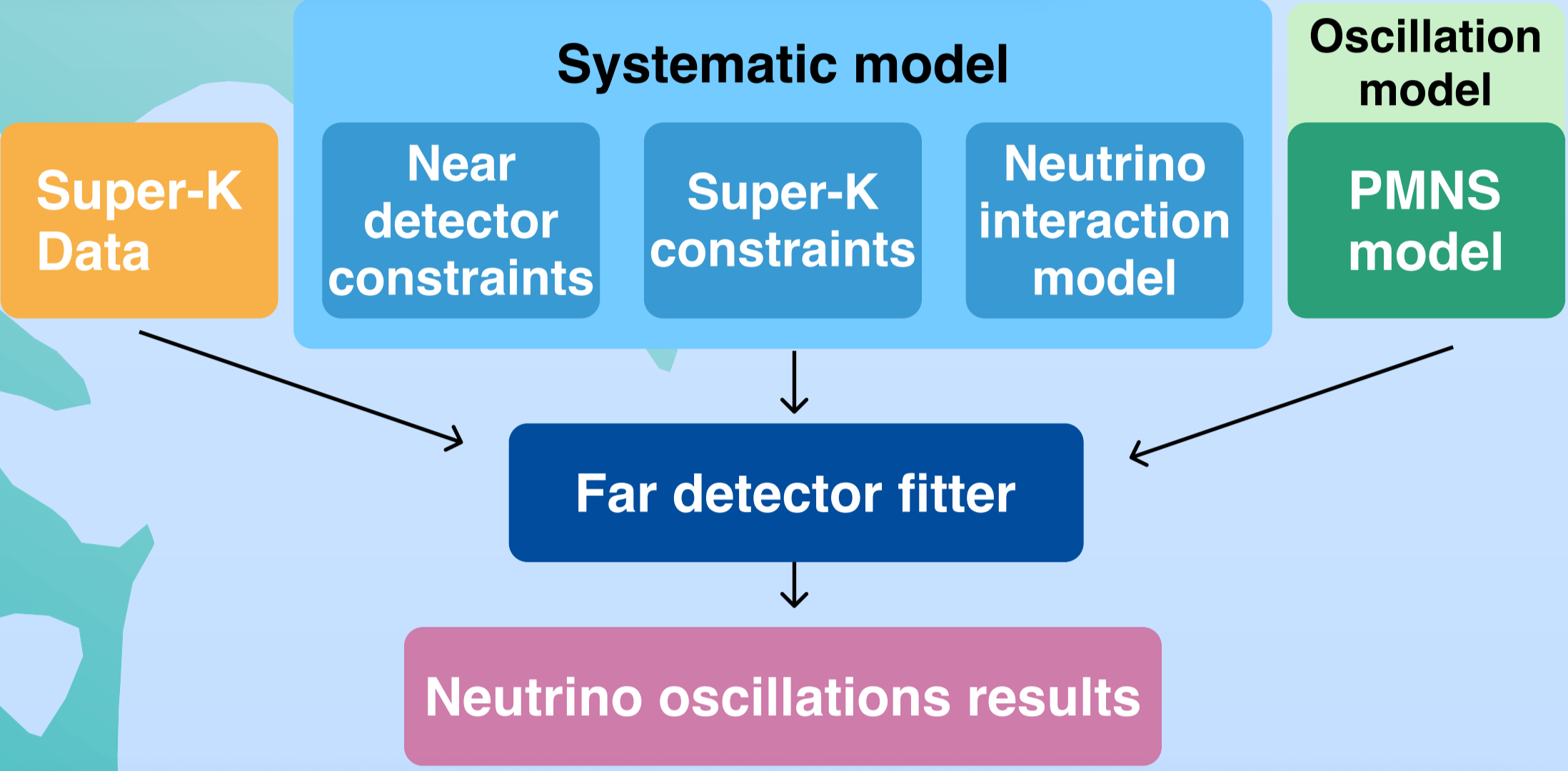
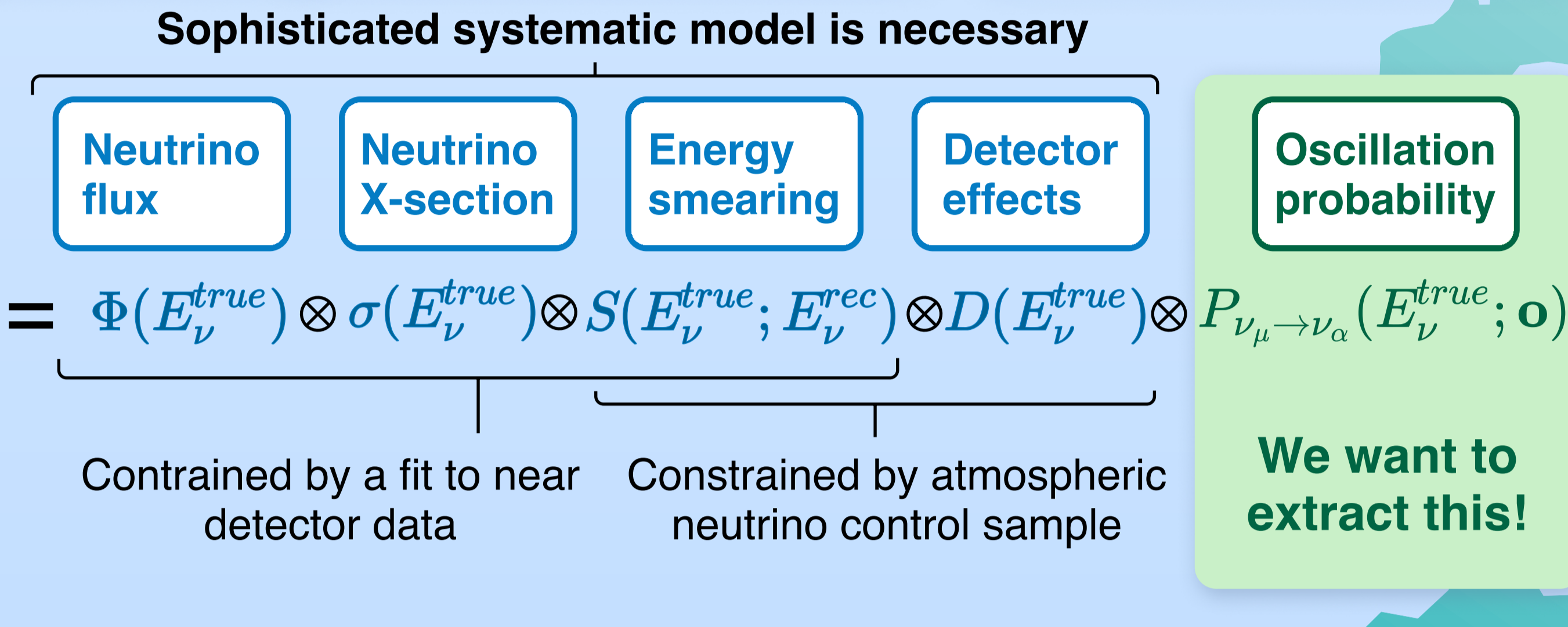
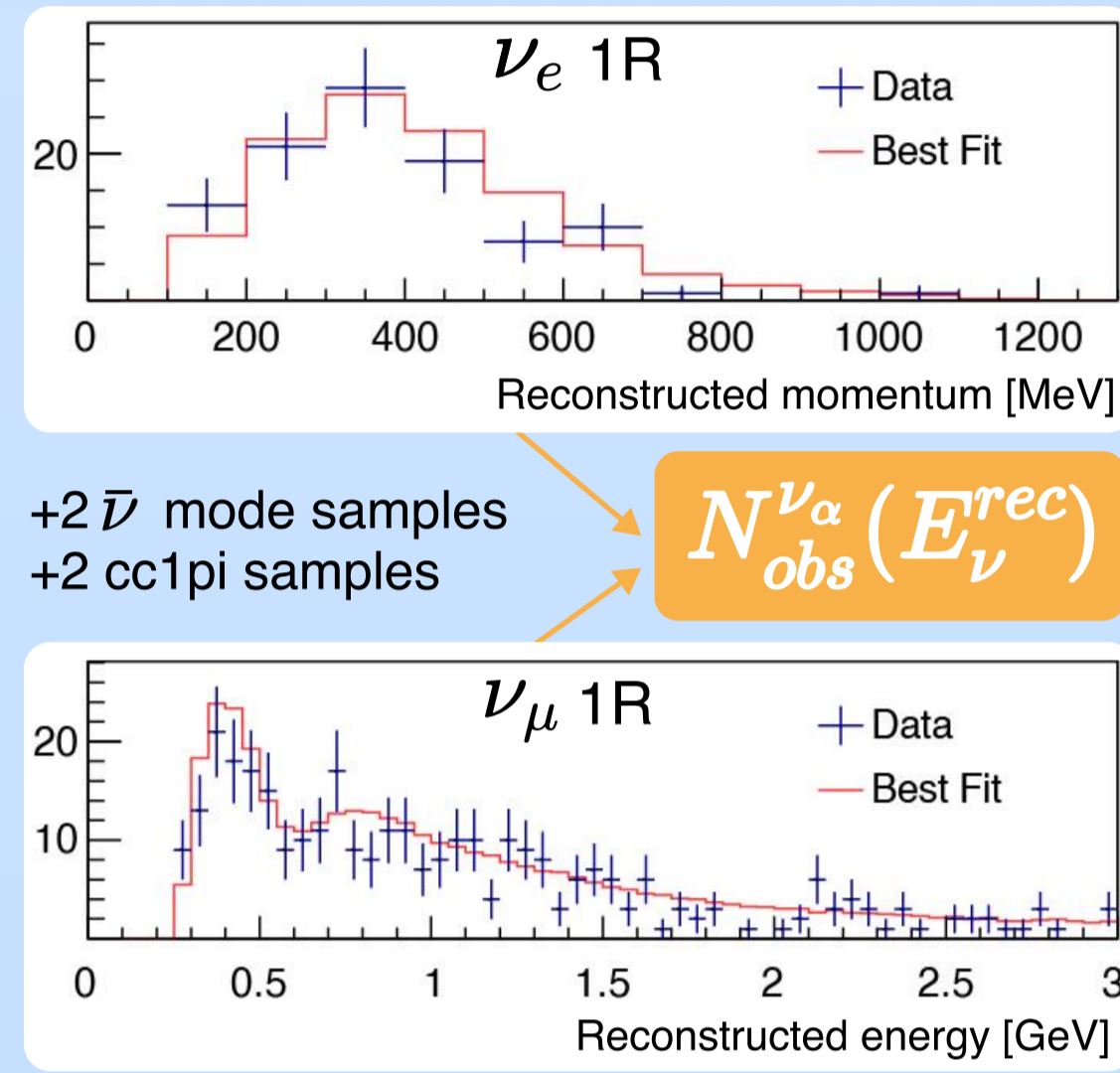


Long baseline neutrino oscillation experiment – a precise way to probe the mixing of the muon neutrino with other neutrino flavours.

| Super-K | | Hyper-K | |
|---------|-------------------|--------------------|----------------------|
| | Mozumi | Site | Tochibora |
| 41m | 11,129 | Number of ID PMTs | 20,000 |
| 39m | 40% | Photo-coverage | 20% (x2 sensitivity) |
| | 50 kton/22.5 kton | Mass/Fiducial Mass | 260 kton/187 kton |
| | | | |



- θ_{12}
 - Δm_{21}^2
 - θ_{13}
 - $|\Delta m_{32}^2|$
 - θ_{23}
 - Mass Ordering
 - δ_{CP}
- Parameters of interest in T2K and Hyper-K

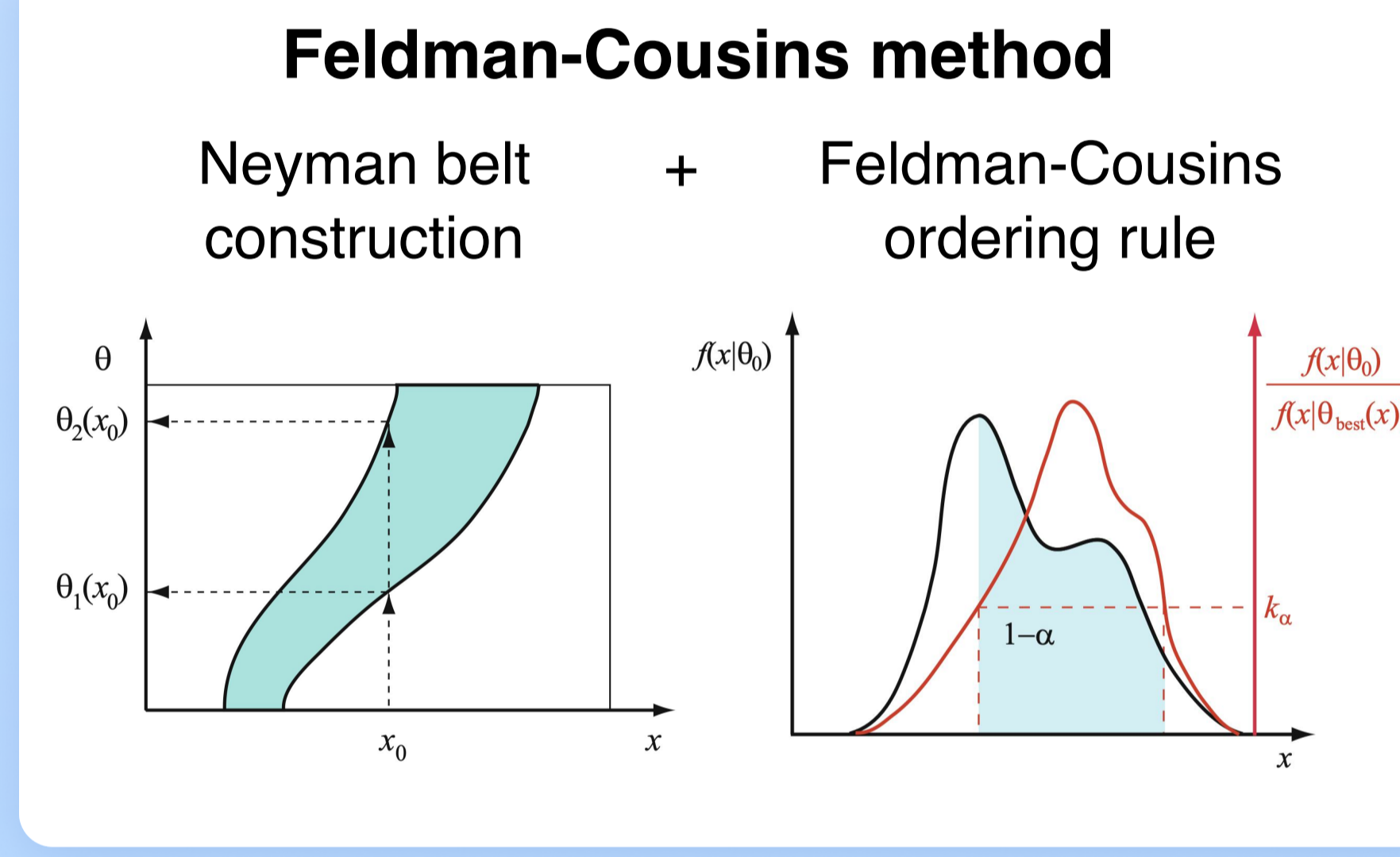


$$-\ln L(\mathbf{o}, \mathbf{f} | \text{Data}) = \sum_{s,i} \left[N_{s,i}^{exp}(\mathbf{o}, \mathbf{f}) - N_{s,i}^{obs} + N_{obs} \ln \frac{N_{s,i}^{obs}}{N_{s,i}^{exp}(\mathbf{o}, \mathbf{f})} \right] + \frac{1}{2} (\mathbf{f} - \mathbf{f}_0)^T V^{-1} (\mathbf{f} - \mathbf{f}_0)$$



Why Wilks' theorem is not valid?

- Degeneracies in PMNS model: (δ_{CP}, MH) , θ_{23} octant, sign of $\cos \delta_{CP}$
- Physical boundaries: $|\sin \delta_{CP}| \leq 1$, $\sin^2 2\theta_{23} \leq 1$

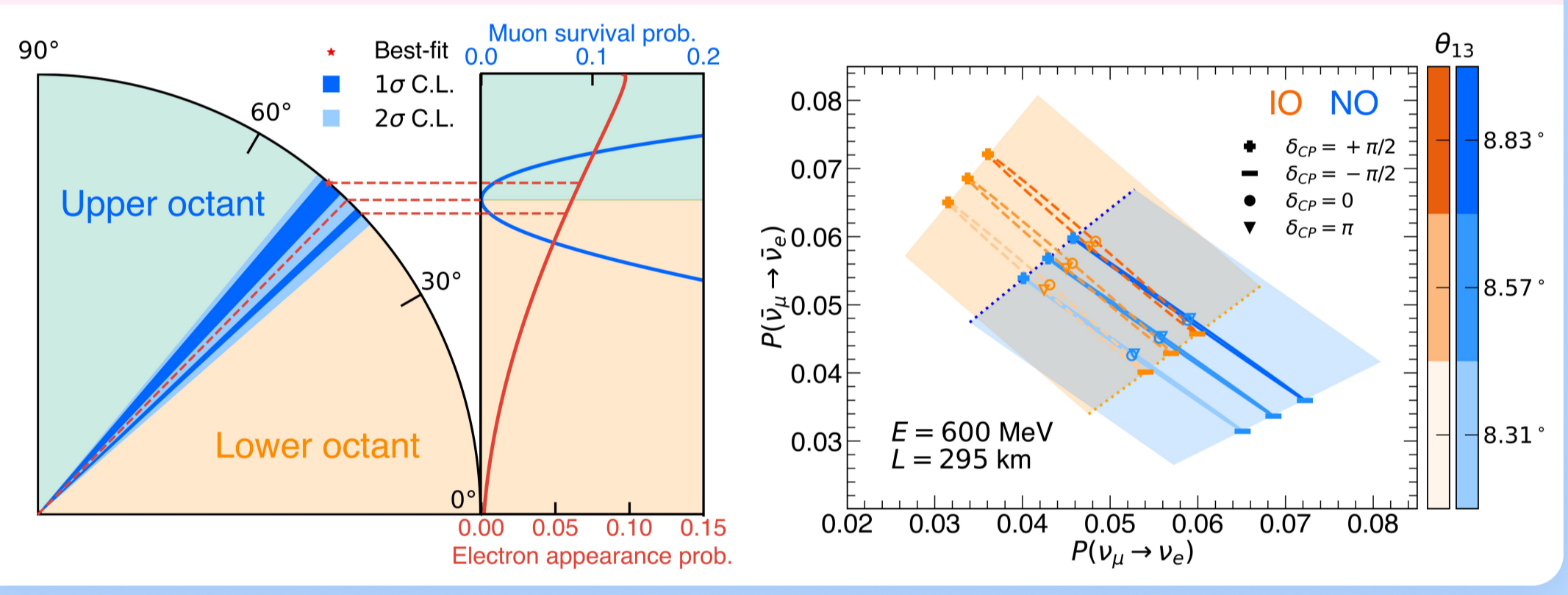


Marginalisation \mathbf{o}_I - parameters of interest

$$\Delta\chi^2(\mathbf{o}_I) = -2[\ln L_{\text{marg}}(\mathbf{o}_I) - \max \ln L_{\text{marg}}(\mathbf{o}_I)]$$

- $\Delta\chi^2(\mathbf{o}_I) \sim \chi^2(k)$, if Wilks' theorem conditions are satisfied where $k = \#$ of params of interest
- Otherwise **Feldman-Cousins method is used**

Caveats: Toys generation way, Nuisance parameters handling, CPU time



The latest T2K oscillation results

- First T2K oscillation analysis including data after Gd loading in Super-K (0.17×10^{21} POT)
- Protons on target (POT) = 3.78×10^{21}



The most recent Hyper-K long baseline sensitivity studies

- New powerful frequentist far detector fitter implemented in Hyper-K
- Scaling of T2K inputs done to reproduce HK MC simulations and systematic constraints
- Comprehensive sensitivity studies performed to all oscillation parameters for 10 years of HK operation

| δ_{CP} | $\sin^2 \theta_{23}$ | Δm_{32}^2 | MO |
|--|---|---------------------------|--|
| $-2.08^{+1.33}_{-0.61}$ | $0.568^{+0.024}_{-0.125}$ (90%) | $2.521^{+0.037}_{-0.050}$ | Normal Ordering preference (IO excl. with 1.25σ) |
| <ul style="list-style-type: none"> CP-C exclusion with 90% C.L. Maximal CP-V region preference | <ul style="list-style-type: none"> Upper octant preference | $\times 10^{-3} eV^2/c^4$ | |

