$\overline{\nu}_\mu$ disappearance measurement at T2K

First results

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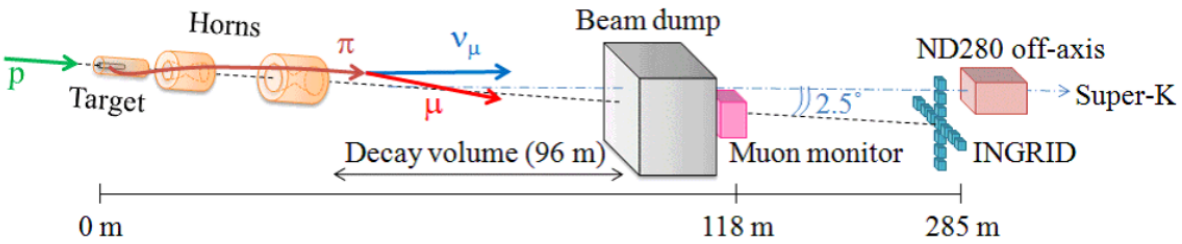
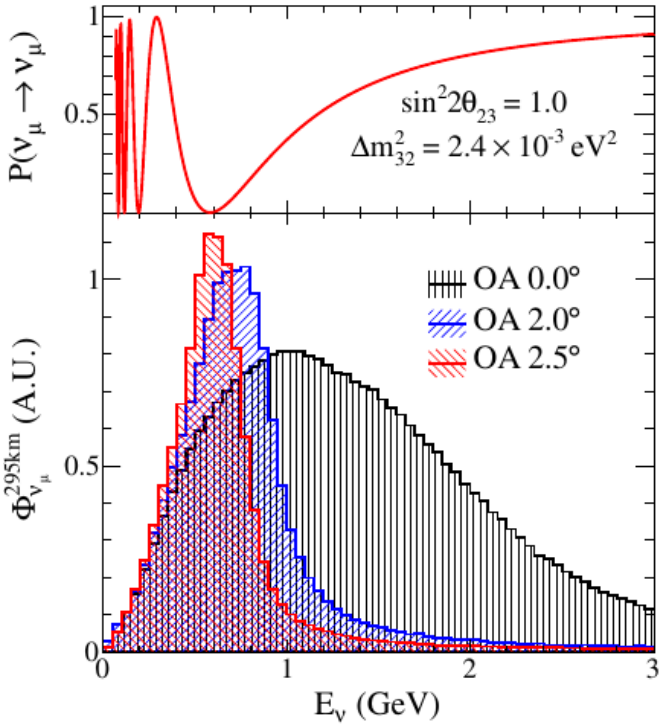
LPNHE

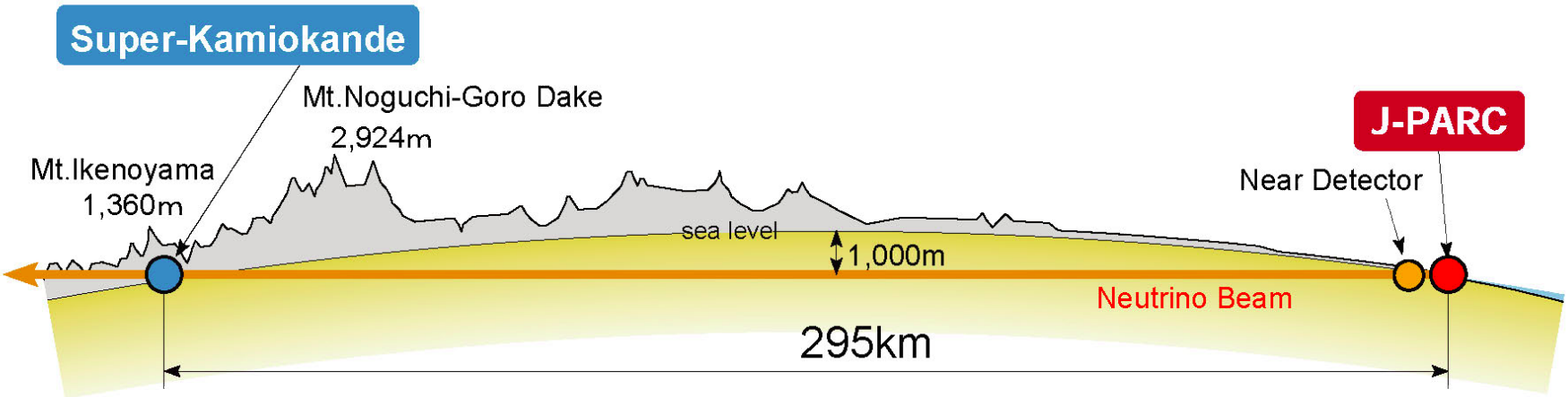
10^{th} June 2015

T2K : Tokai to Kamioka

- 30 GeV protons sent on ^{12}C target $\rightarrow \pi^{\pm}, K^{\pm}$
- Near detector to constrain ν flux and cross-section
- Far detector at maximum ν_μ oscillation probability

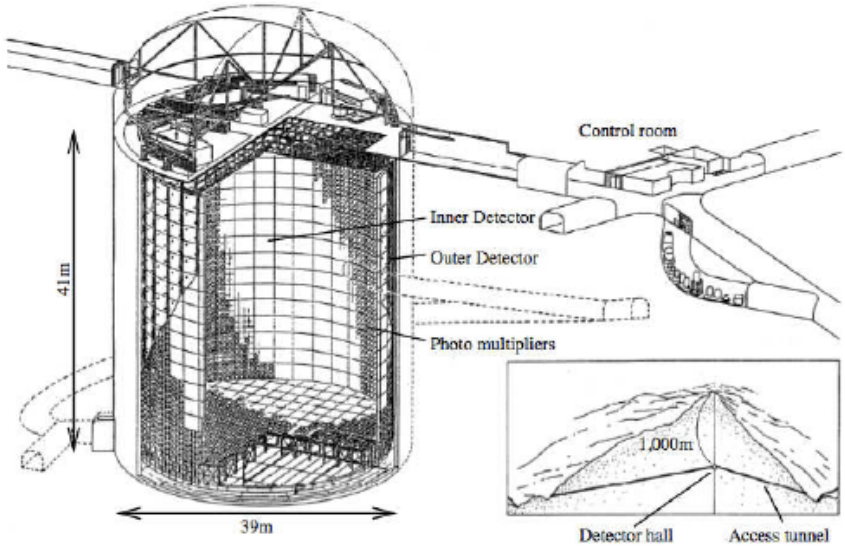


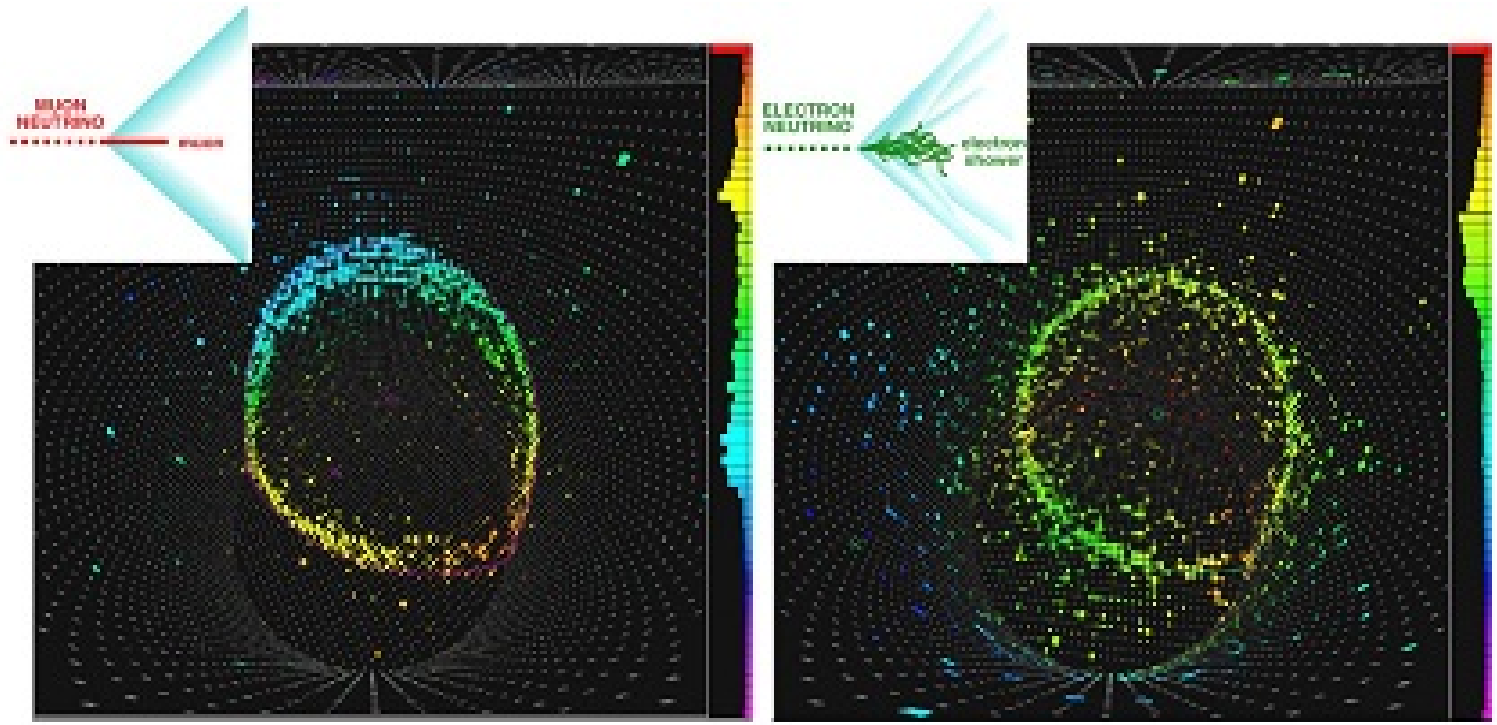




The far detector: Super-Kamiokande

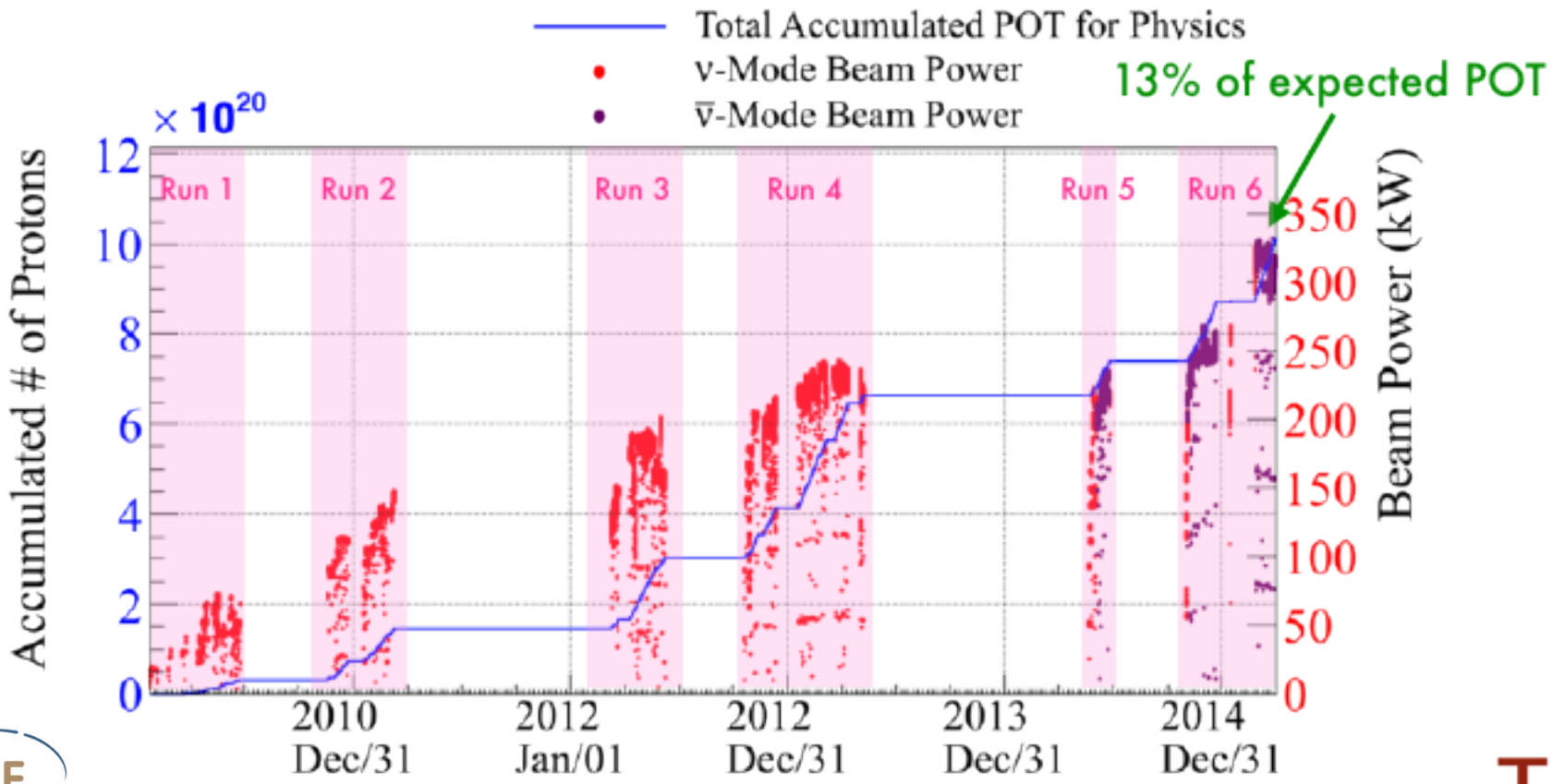
- Water Čerenkov
- 22.5 KTon FV
- Can distinguish μ from e





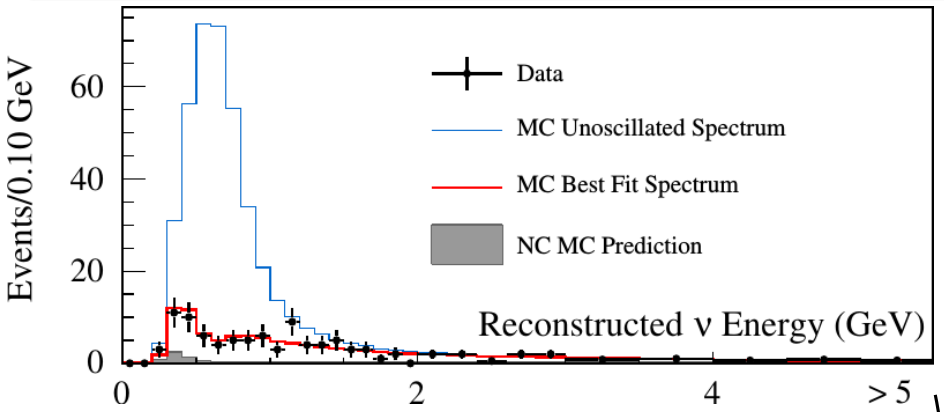
Data taking

- Until this year only ν_μ
  - 6.57 10^{20} POT
- Now running in $\overline{\nu}_\mu$ mode
  - 4.0 10^{20} POT taken
  - 2.32 10^{20} POT in the $\overline{\nu}_\mu$ disappearance analysis

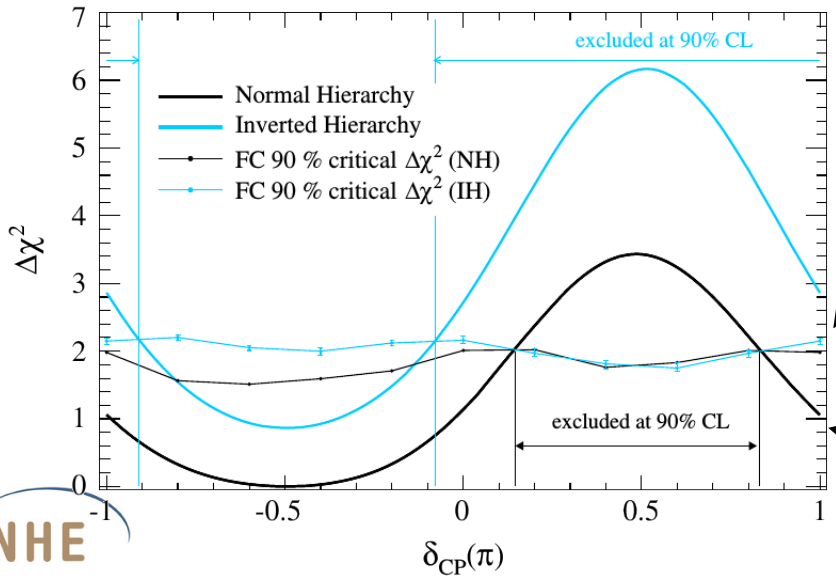


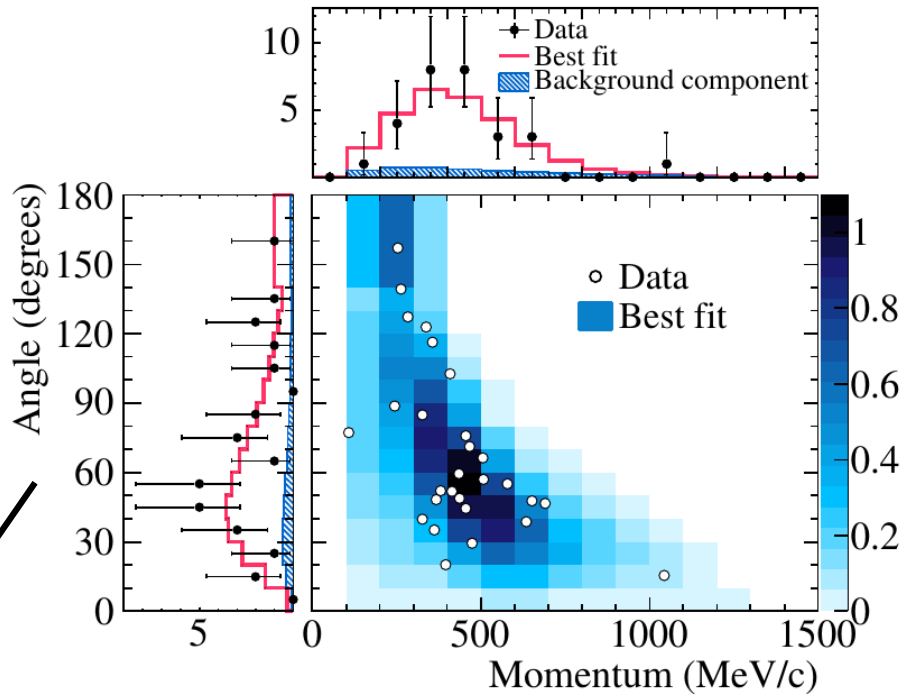
T2K published ν measurements

- Best world measurement of θ_{23} from ν_μ disappearance
- First observation of ν_e appearance
- Combined with $\overline{\nu}_e$ reactor disappearance $\rightarrow$ First constraint on δ_{cp}



Abe, K., et al. Physical Review D 91.7 (2015): 072010



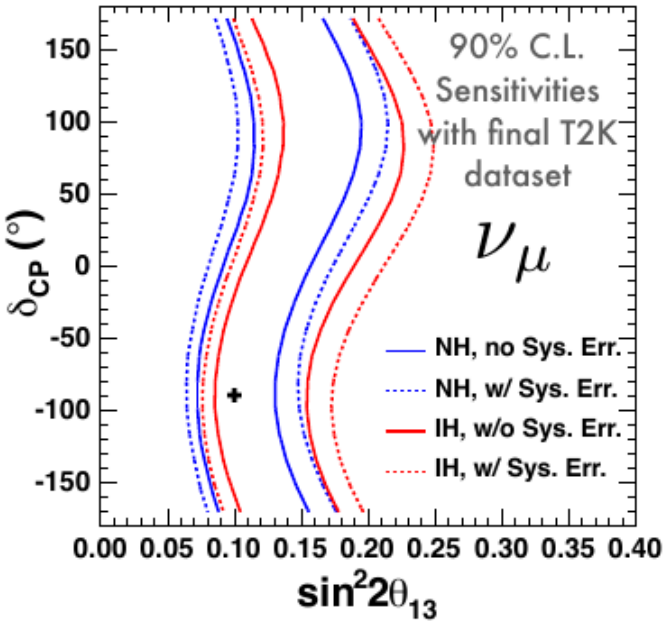


K. Abe et al. Phys. Rev. Lett. 112 (2014), 061802

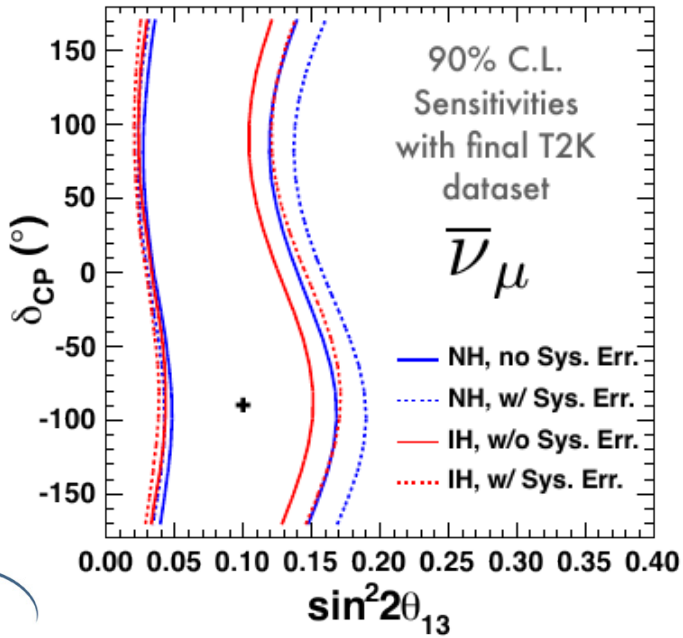
Reactor $\overline{\nu}_e$ disappearance

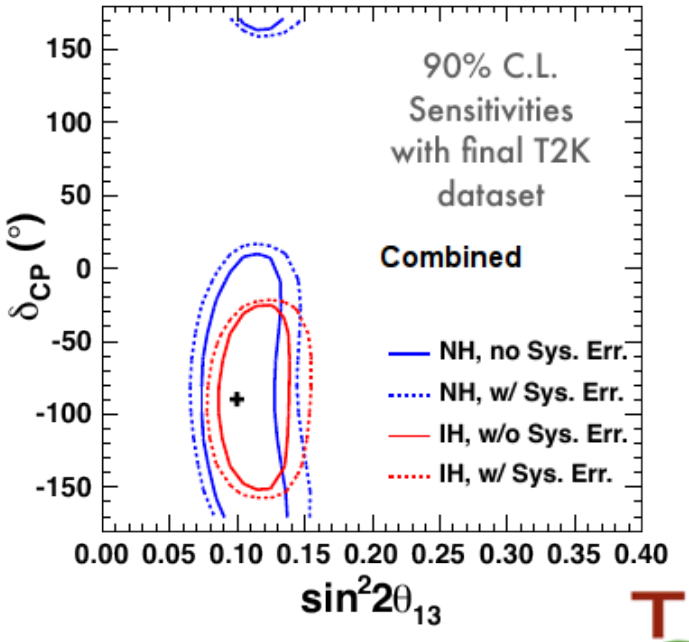
Why looking at $\overline{\nu}_\mu$?

- Measure $\overline{\nu}_\mu$ disappearance to confirm no unexpected difference from ν_μ
- Measure $\overline{\nu}_e$ appearance to give indications on δ_{cp} (combined with reactor measurement)



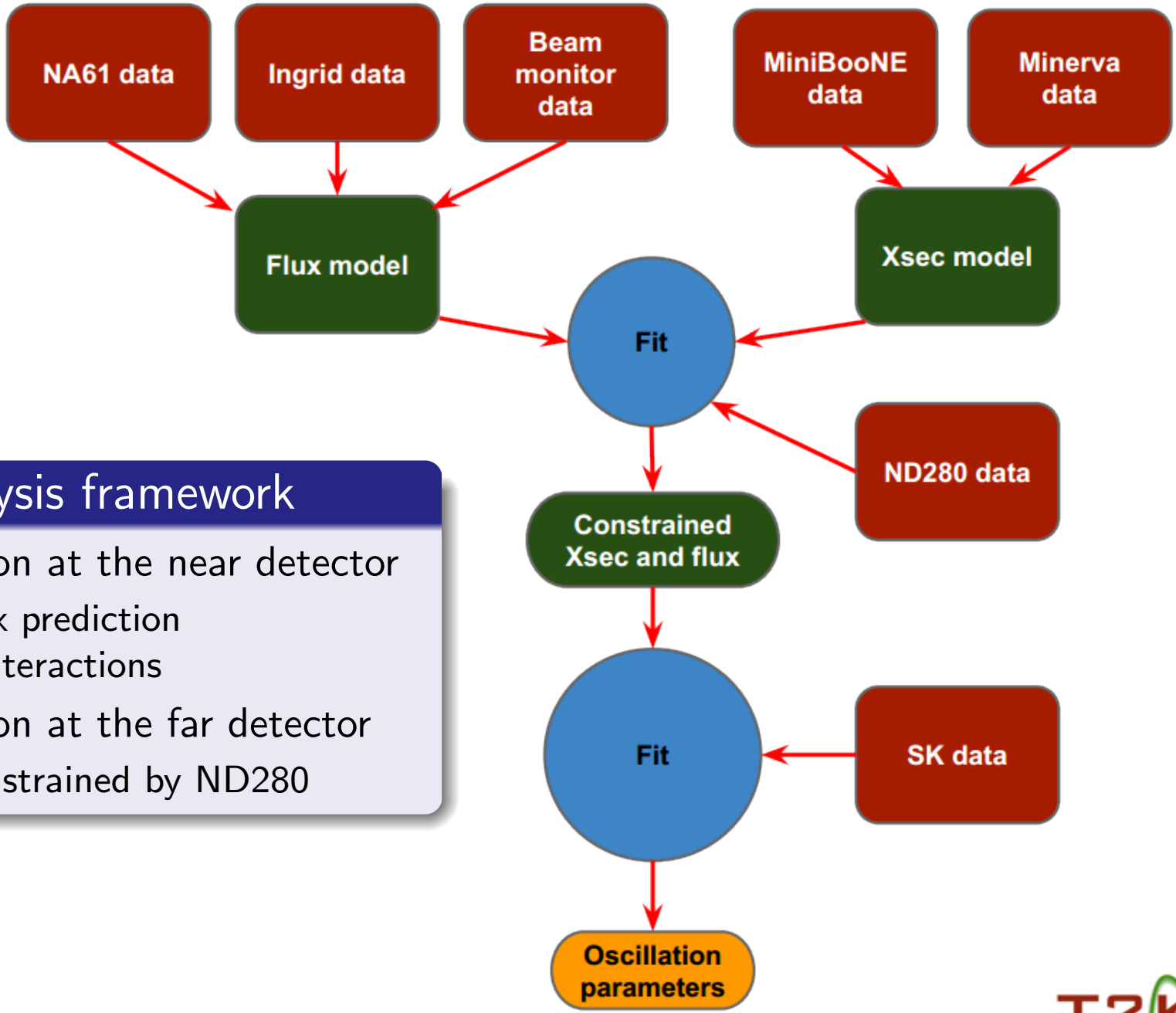
Prog. Theor. Exp. Phys. (2015) 043C01





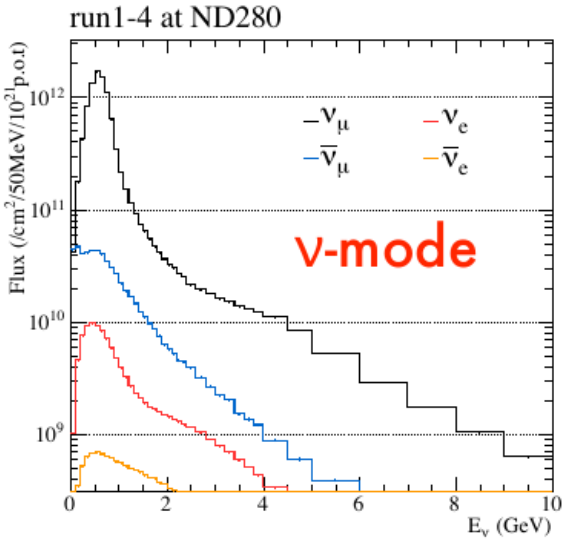
Analysis framework

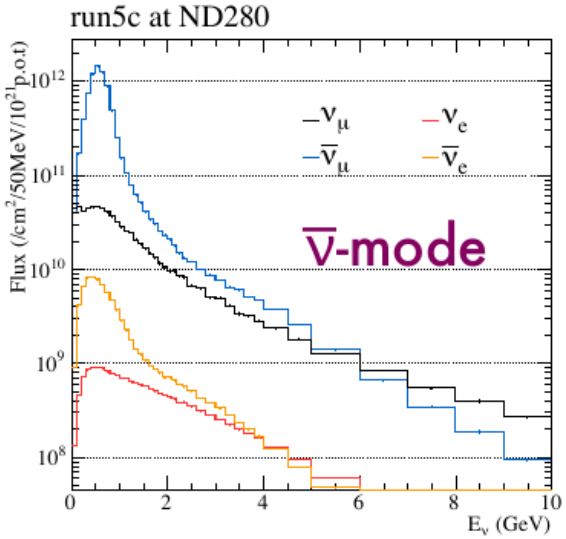
- Prediction at the near detector
  - Flux prediction
  - ν interactions
- Prediction at the far detector
  - Constrained by ND280

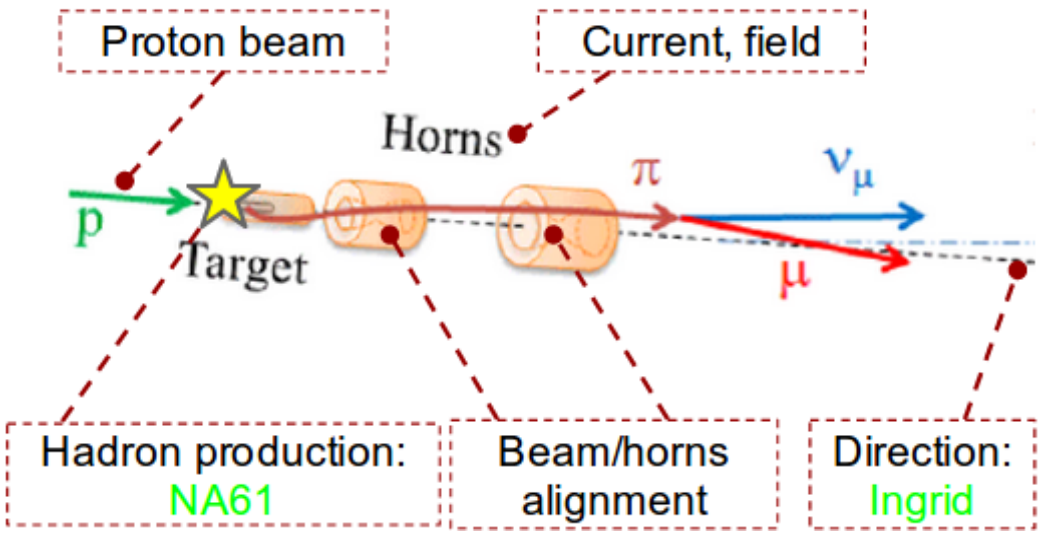


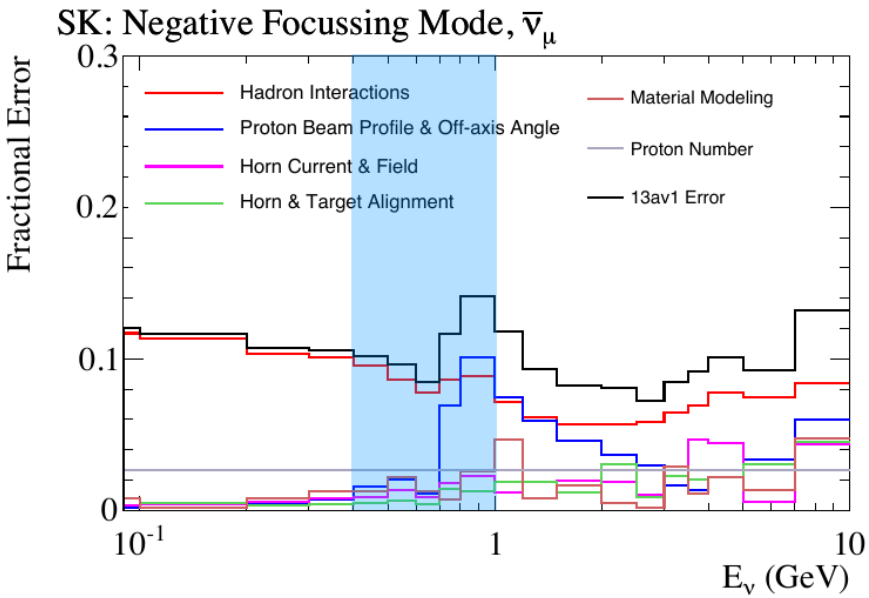
The beam

- $\overline{\nu}_\mu$ mode : more ν_μ contamination
- NA61: reduces flux uncertainties to $\sim 10\%$





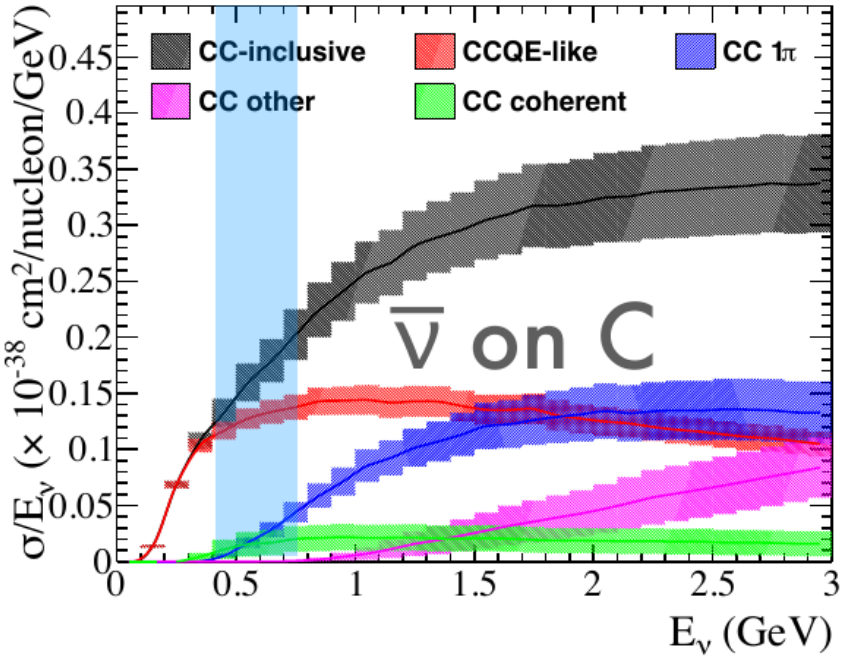


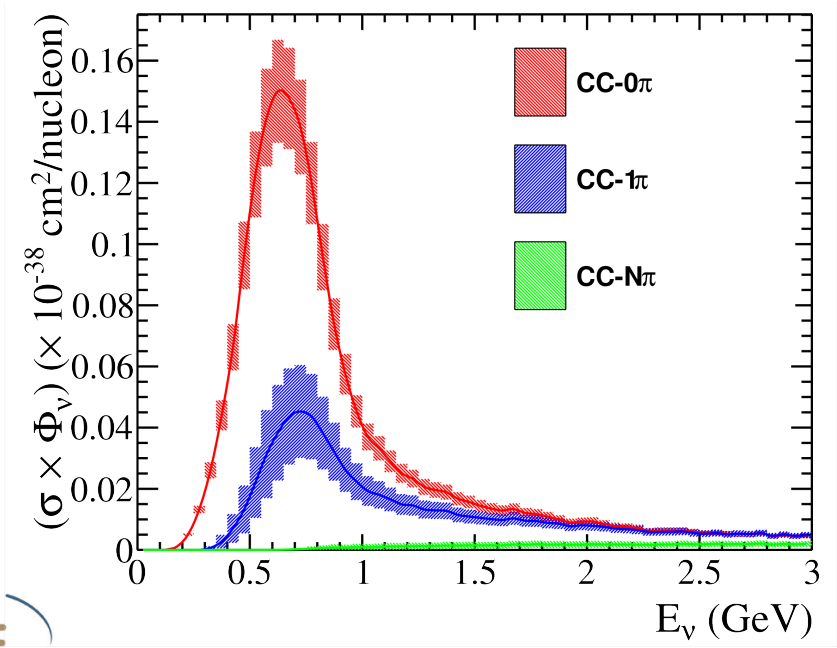


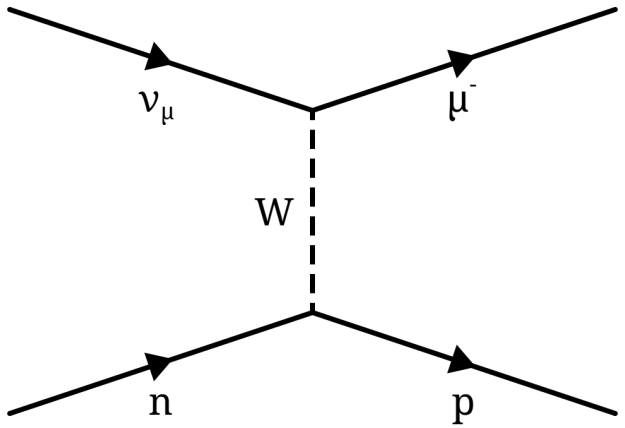
ν xsec

- Build model with data from MiniBooNE and Minerva

$\rightarrow$ ND280 prediction

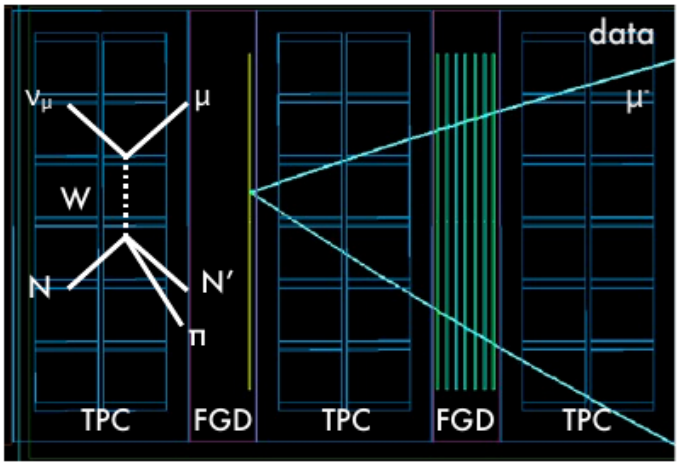


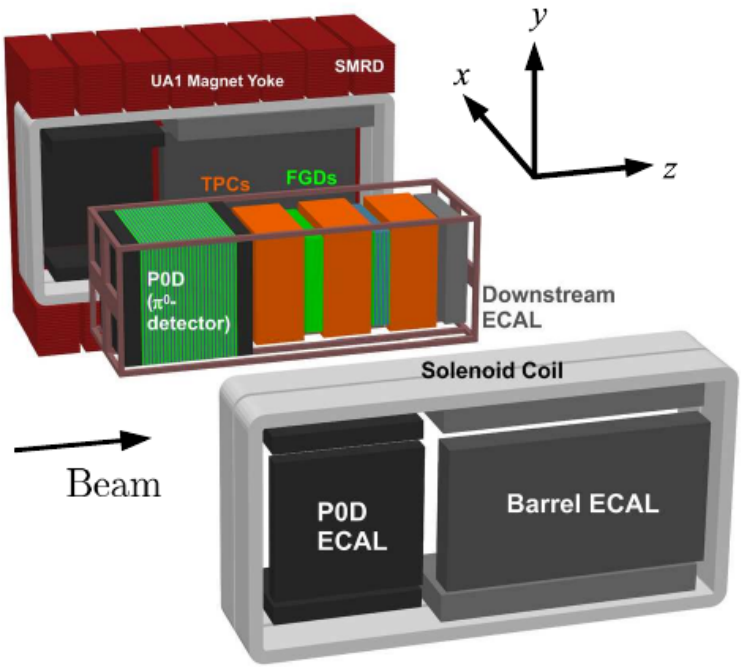


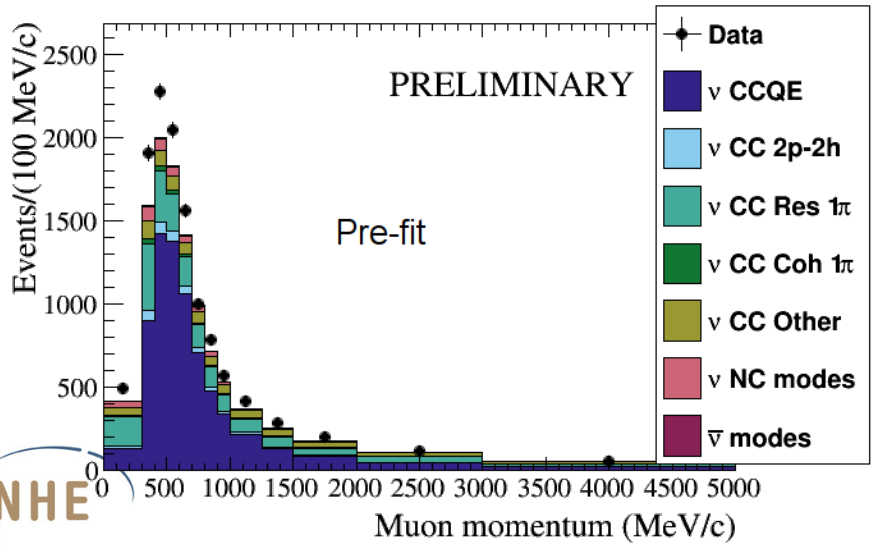


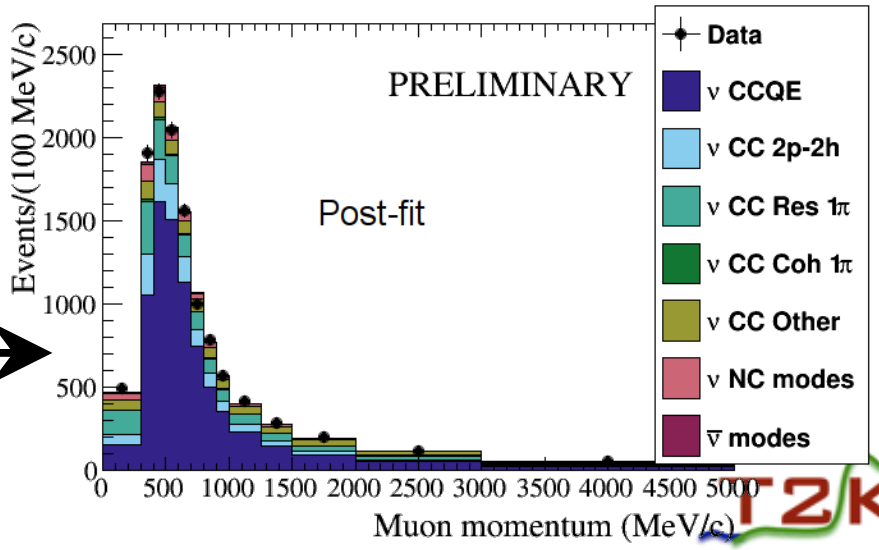
The near detector: ND280

- To constrain flux and xsec
- Particle & charge identification



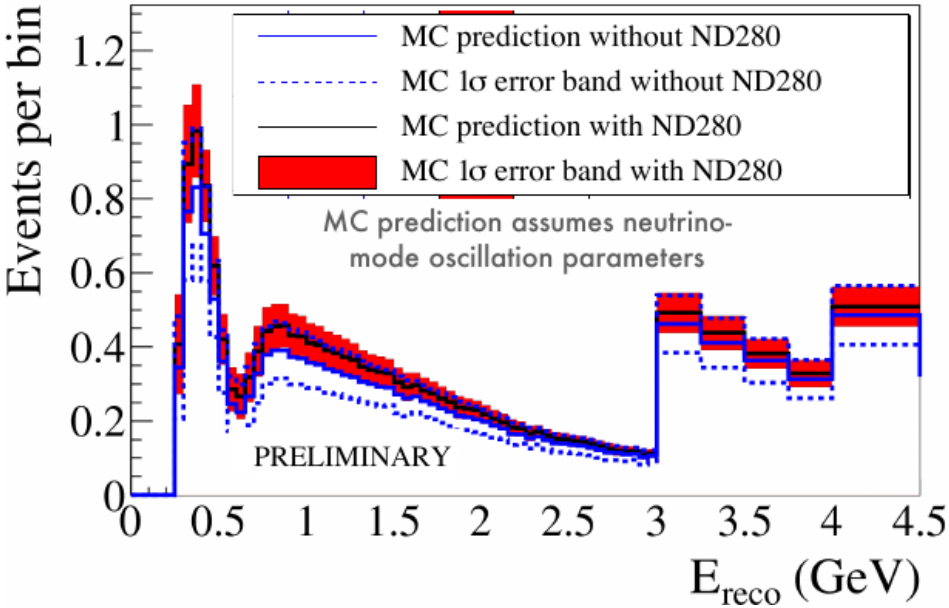






Total systematics

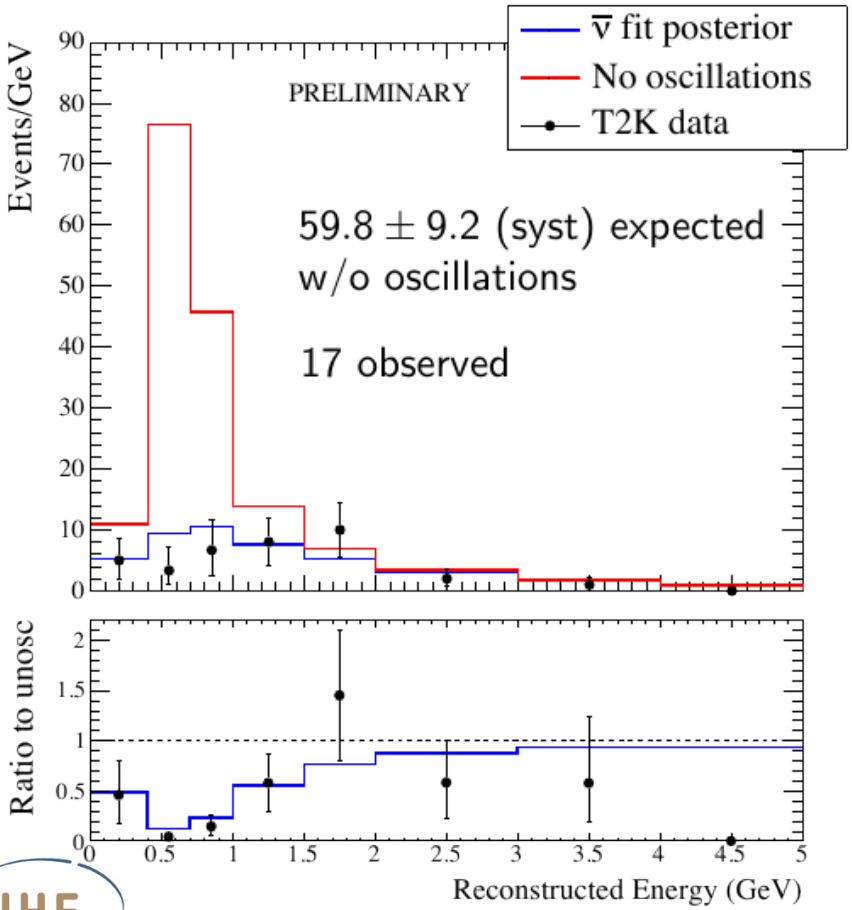
- Flux and xsec dominate
- Largest contribution: $^{12}C/^{16}O$ xsec difference

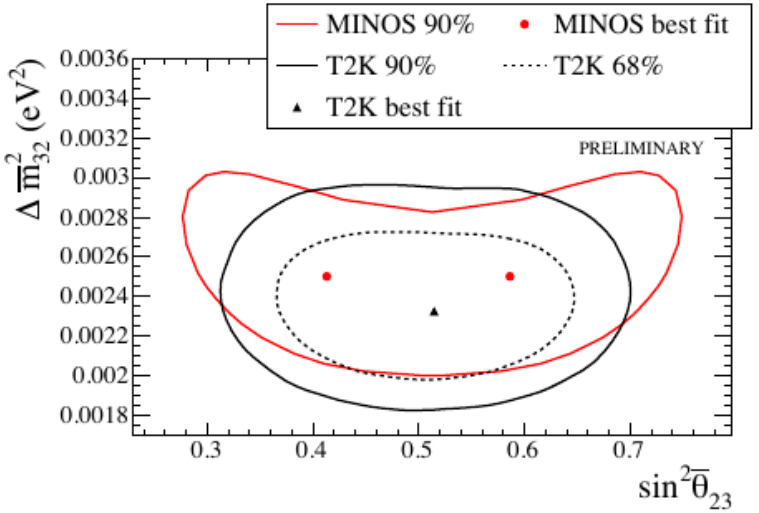


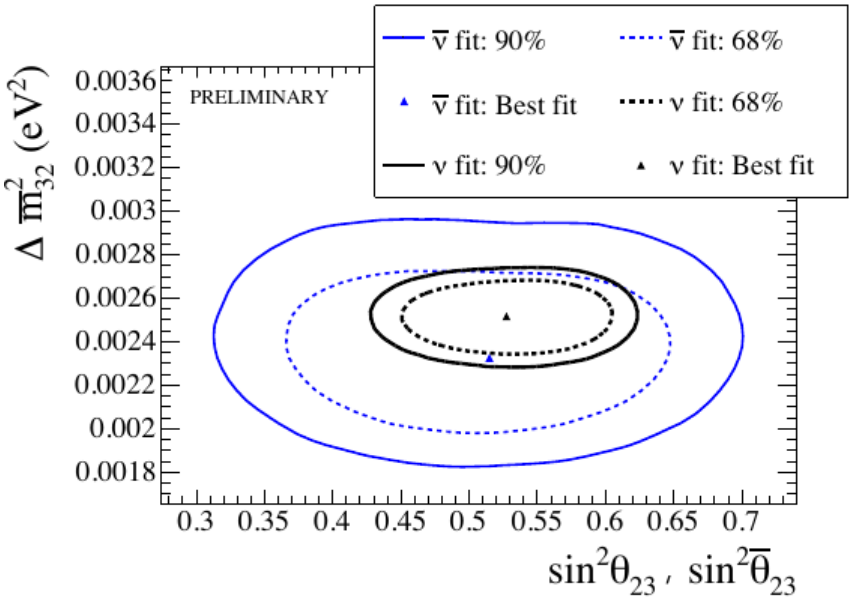
Systematic		Without ND	With ND measurement
Flux and Cross Section	Common to ND280/SK	9.2%	3.4%
	SK only	10%	
	All	13.0%	10.0%
Final State Interaction/Secondary Interaction		2.1%	
SK Detector		3.8%	
Total		14.4%	11.6%

Oscillation fit results

- Maximize likelihood for reconstructed ν energy
- All parameters fixed but $sin^2(\overline{\theta_{23}})$ and $\Delta\overline{m_{32}}^2$







$\lvert\Delta\bar{m}^2_{32}\rvert$	$\sin^2(\bar{\theta}_{23})$
$2.33^{+0.27}_{-0.23} \times 10^{-3}$ eV^2	$0.515^{+0.085}_{-0.095}$

Conclusions

- T2K first $\overline{\nu}_\mu$ disappearance results with 2.32 10^{20} POT
- Best $\overline{\theta_{23}}$ measurement
- Limited by statistics: update to 4.0 10^{20} POT for this summer
- First $\overline{\nu}_e$ appearance measurement will be released this summer