WORKING STATUS

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NuGroup Meeting, March 02, 2018

Outlines

1. Check event rates and sys. errors of T2K
2. Make plots with updated data and compare with the plots in the paper: **arXiv:1409.7469v2 [hep-ex] 10 Feb 2015**
3. Check event rates and sys. errors of T2K-II
4. Make plots with updated data and compare with the plots in the paper: **arXiv:1607.08004v1 [hep-ex] 27 Jul 2016**

1. Check event rates and sys. errors of T2K

a. The sys. Errors:

Table 2: The systematic errors in percentage on the predicted number of events at Super-K (assuming the oscillation parameters given in Table 3 are the true values of the oscillation parameters) as used in the 2012 oscillation analyses.

	Appearance	Disappearance
Flux and cross section constrained by the near detector	5.0 %	4.2 %
Cross section not constrained by the near detector	7.4 %	6.2 %
Super-K detector and FSI	3.9 %	11.0 %
Total	9.7 %	13.3 %

b. The event rates:

Table 4: Expected numbers of ν_e or $\bar{\nu}_e$ appearance events at 7.8×10^{21} POT. The number of events is broken down into those coming from: appearance signal or intrinsic beam background events that undergo charged current (CC) interactions in Super-K, or beam background events that undergo neutral current (NC) interactions.

	δ_{CP}	Total	Signal $\nu_\mu \to \nu_e$	Signal $\bar{\nu}_\mu \to \bar{\nu}_e$	Beam CC $\nu_e + \bar{\nu}_e$	Beam CC $\nu_\mu + \bar{\nu}_\mu$	NC
100% ν-mode	0°	291.5	211.9	2.4	41.3	1.4	34.5
100% ν-mode	-90°	341.8	262.9	1.7			
100% $\bar{\nu}$-mode	0°	94.9	11.2	48.8	17.2	0.4	17.3
100% $\bar{\nu}$-mode	-90°	82.9	13.1	34.9			

Table 5: Expected numbers of ν_μ or $\bar{\nu}_\mu$ disappearance events for 7.8×10^{21} POT. The first two columns show the number of ν_μ and $\bar{\nu}_\mu$ events, broken down into those that undergo charged-current quasi-elastic (CCQE) scattering at Super-K, and those that undergo other types of CC scattering (CC non-QE). The third column shows CC ν_e and $\bar{\nu}$ events, both from intrinsic beam backgrounds and oscillations, while the fourth column shows NC events.

	Total	CCQE $\nu_\mu(\bar{\nu}_\mu)$	CC non-QE $\nu_\mu(\bar{\nu}_\mu)$	CC $\nu_e + \bar{\nu}_e$ CC $\nu_\mu(\bar{\nu}_\mu) \to \nu_e(\bar{\nu}_e)$	NC
100% running in ν-mode	1,493	782(48)	544 (40)	4	75
100% running in $\bar{\nu}$-mode	715	130(263)	151(138)	0.5	33

#NU_E_Appearance_QE ---------
212 || 212
77.2 || 1.39999 34.5 39.62 1.68

--------- #NU_E_BAR_Appearance_QE ---------
48.8 || 48.8
34.9 || 0.40001 17.3 10.7 6.50001

--------- #NU_MU_Disapperance_QE ---------
782 || 782
74.9999 || 74.9999

--------- #NU_MU_BAR_Disappearance_QE ---------
263.001 || 263.001
33.0001 || 33.0001

--------- #NU_E_Appearance_CC ---------
265 || 265
77.2078 || 1.39999 34.5 39.6557 1.652

--------- #NU_E_BAR_Appearance_CC ---------
61 || 61
35.04 || 0.399999 17.3 10.74 6.60001

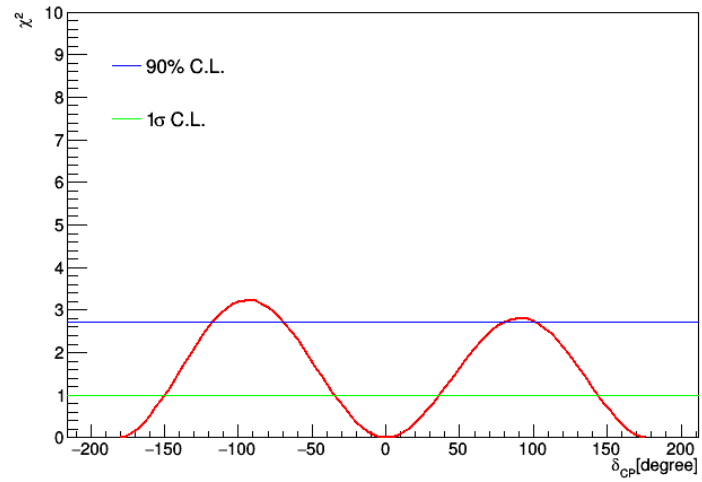
2. Make plots with updated data and compare with plots in the paper: **arXiv:1409.7469v2 [hep-ex] 10 Feb 2015**

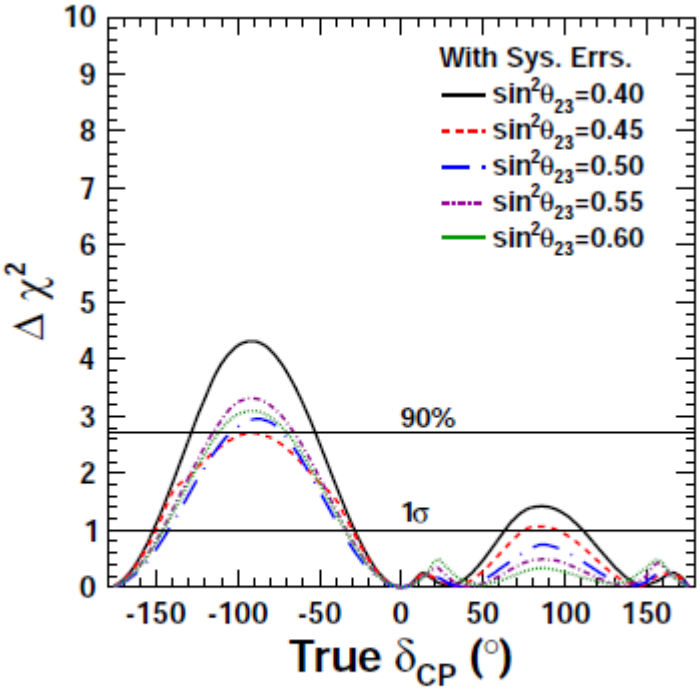
theta12 = asin(sqrt(0.8704))/2;
theta13 = asin(sqrt(0.1))/2;
theta23 = asin(sqrt(0.5));
sdm = 7.6e-5;
ldm = 2.4e-3;
NH

I. delta_cp projection: deltacp = 0

a. 100% nu-mode (24 years nu and 0 year anti-nu) and 100% anti-nu-mode: export nothing

b. 50% nu-mode and 50% anti-nu-mode:

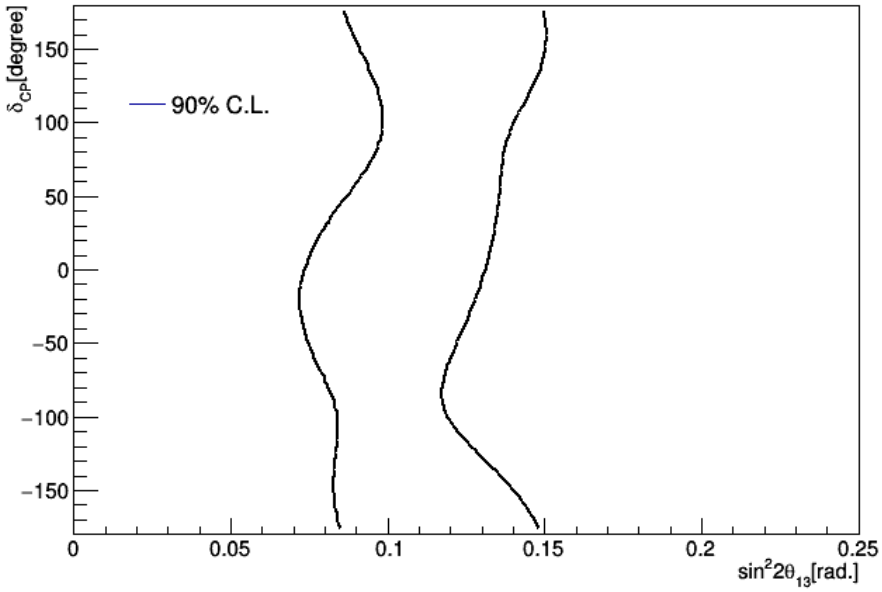


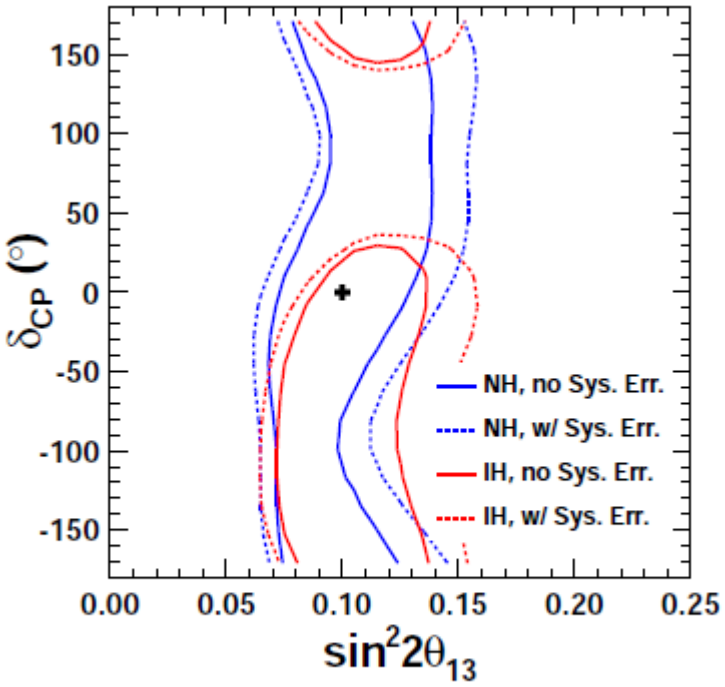


(d) 50% ν-, 50% $\bar{\nu}$-mode,
with the 2012 systematic errors.

II. th13delta: delta_cp = 0

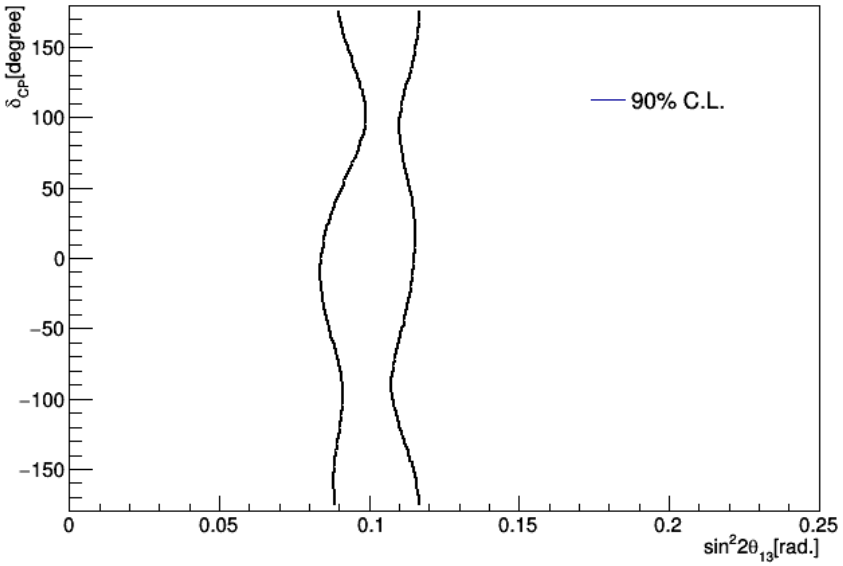
a. 100% nu-mode (24 years nu and 0 year anti-nu) and 100% anti-nu-mode: export nothing
b. 50% nu-mode and 50% anti-nu-mode:

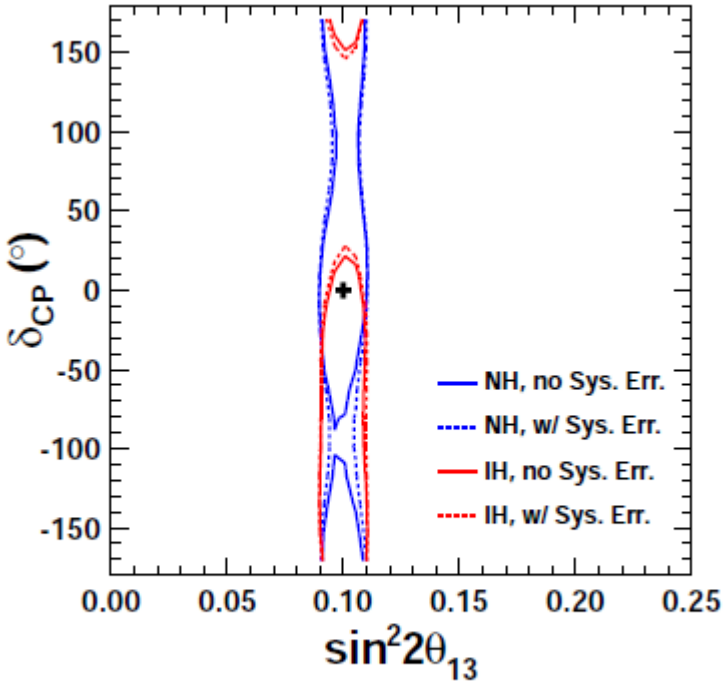




(b) 50% ν-, 50% $\bar{\nu}$-mode.

c. 50% nu-mode and 50% anti-nu-mode with reactor



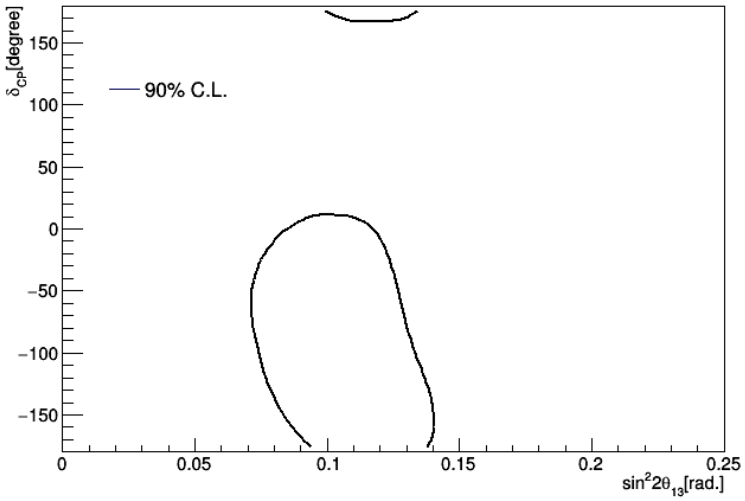


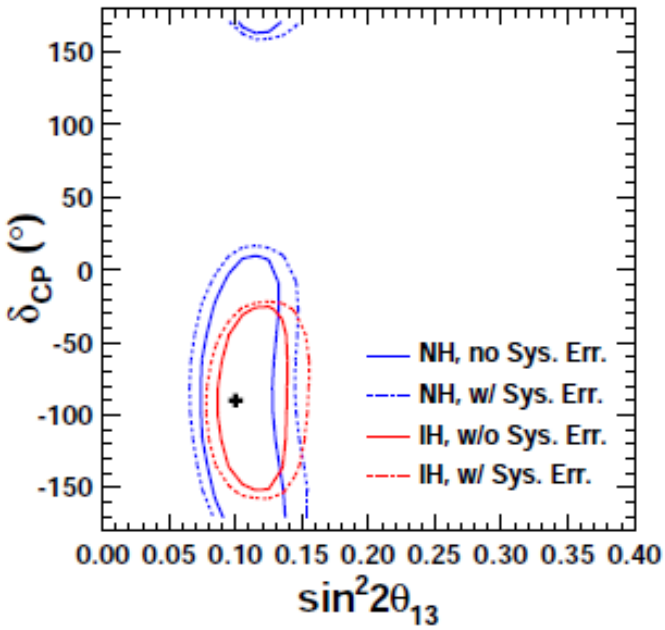
(d) 50% ν-, 50% $\bar{\nu}$-mode, with ultimate reactor constraint.

III. th13delta: delta_cp = -90

a. 100% nu-mode (24 years nu and 0 year anti-nu) and 100% anti-nu-mode: export nothing

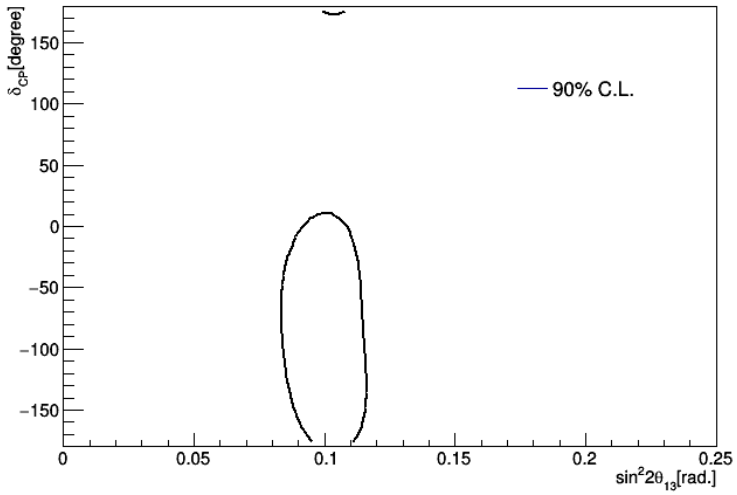
b. 50% nu-mode and 50% anti-nu-mode:

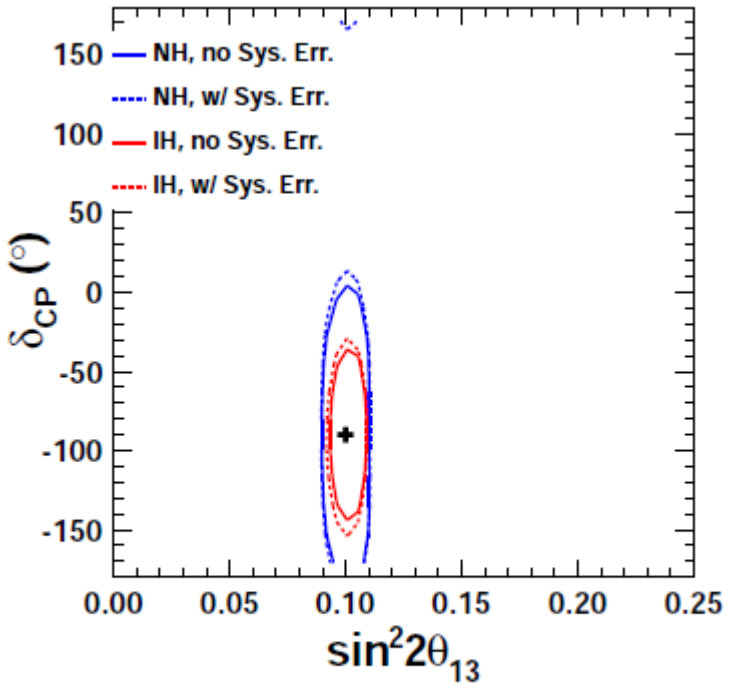




(c) 50% ν-, 50% $\bar{\nu}$-mode.

c. 50% nu-mode and 50% anti-nu-mode with reactor





(d) 50% ν-, 50% $\bar{\nu}$-mode, with ultimate reactor constraint.

3. Check event rates and sys. errors of T2K-II

a. The sys. errors:

TABLE II: Errors on the number of predicted events in the Super-K samples from individual systematic error sources in neutrino (ν mode) and antineutrino beam mode ($\bar{\nu}$ mode). Also shown is the error on the ratio 1Re events in ν mode/$\bar{\nu}$ mode. The uncertainties represent work-in-progress for T2K neutrino oscillation results in 2016.

	$\delta_{N_{SK}}/N_{SK}$ (%)				
	1-Ring μ		1-Ring e		
Error Type	ν mode	$\bar{\nu}$ mode	ν mode	$\bar{\nu}$ mode	$\nu/\bar{\nu}$
SK Detector	4.6	3.9	2.8	4.0	1.9
SK Final State & Secondary Interactions	1.8	2.4	2.6	2.7	3.7
ND280 Constrained Flux & Cross-section	2.6	3.0	3.0	3.5	2.4
$\sigma_{\nu_e}/\sigma_{\nu_\mu}$, $\sigma_{\bar{\nu}_e}/\sigma_{\bar{\nu}_\mu}$	0.0	0.0	2.6	1.5	3.1
NC 1γ Cross-section	0.0	0.0	1.4	2.7	1.2
NC Other Cross-section	0.7	0.7	0.2	0.3	0.1
Total Systematic Error	5.6	5.5	5.7	6.8	5.9
External Constraint on θ_{12}, θ_{13}, Δm^2_{21}	0.0	0.0	4.2	4.0	0.1

b. The event rates:

TABLE I: Number of events expected to be observed at the far detector for 10×10^{21} POT ν- + 10×10^{21} POT $\bar{\nu}$-mode with a 50% statistical improvement. Assumed relevant oscillation parameters are: $\sin^2 2\theta_{13} = 0.085$, $\sin^2 \theta_{23} = 0.5$, $\Delta m^2_{32} = 2.5 \times 10^{-3}$ eV^2, and normal mass hierarchy (MH).

	True δ_{CP}	Total	Signal $\nu_\mu \to \nu_e$	Signal $\bar{\nu}_\mu \to \bar{\nu}_e$	Beam CC $\nu_e + \bar{\nu}_e$	Beam CC $\nu_\mu + \bar{\nu}_\mu$	NC
ν-mode	0	467.6	356.3	4.0	73.3	1.8	32.3
ν_e sample	$-\pi/2$	558.7	448.6	2.8	73.3	1.8	32.3
$\bar{\nu}$-mode	0	133.9	16.7	73.6	29.2	0.4	14.1
$\bar{\nu}_e$ sample	$-\pi/2$	115.8	19.8	52.3	29.2	0.4	14.1

	Total	Beam CC ν_μ	Beam CC $\bar{\nu}_\mu$	Beam CC $\nu_e + \bar{\nu}_e$	$\nu_\mu \to \nu_e +$ $\bar{\nu}_\mu \to \bar{\nu}_e$	NC
ν-mode ν_μ sample	2735.0	2393.0	158.2	1.6	7.2	175.0
$\bar{\nu}$-mode $\bar{\nu}_\mu$ sample	1283.5	507.8	707.9	0.6	1.0	66.2

--------- #NU_E_Appearance_QE ---------
356.3 || 356.3
107.4 || 1.80002 32.2998 70.4001 2.9

--------- #NU_E_BAR_Appearance_QE ---------
73.6 || 73.6
43.6998 || 0.399997 14.0998 23 6.2

--------- #NU_MU_Disapperance_QE ---------
2393 || 2393
175 || 175

--------- #NU_MU_BAR_Disappearance_QE ---------
707.9 || 707.9
66.2001 || 66.2001

--------- #NU_E_Appearance_CC ---------
445.375 || 445.375
107.42 || 1.80002 32.2998 70.4001 2.91988

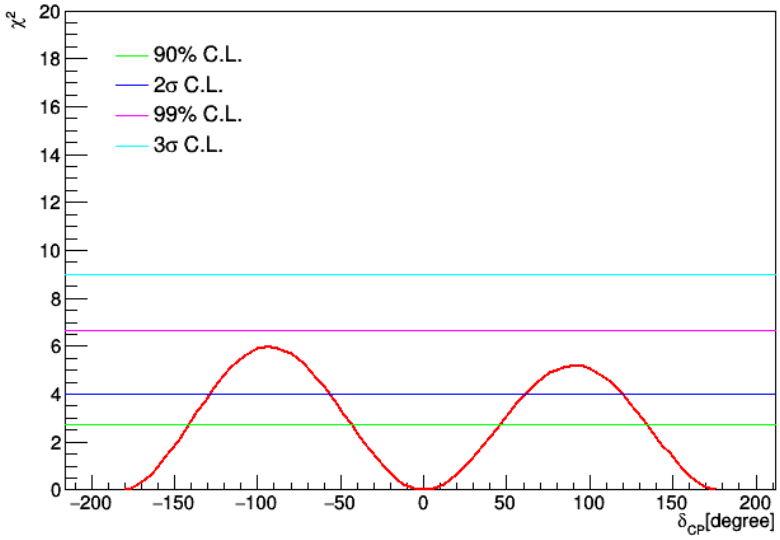
--------- #NU_E_BAR_Appearance_CC ---------
92 || 92
43.6998 || 0.399973 14.0998 25 4.2

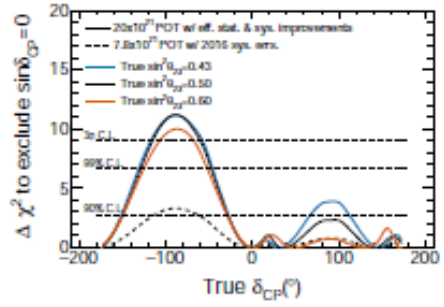
4. Make plots with updated data and compare with the plots in the paper:

arXiv:1607.08004v1 [hep-ex] 27 Jul 2016

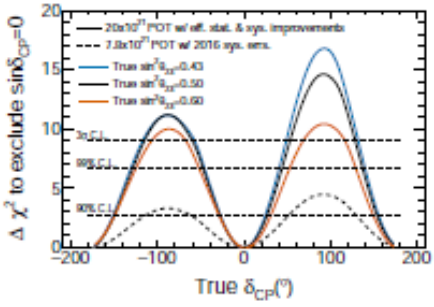
theta12 = asin(sqrt(0.8704))/2;
theta13 = asin(sqrt(0.085))/2;
theta23 = asin(sqrt(0.5));
sdm = 7.6e-5;
ldm = 2.5e-3;
NH

I. delta_cp projection: deltacp = 0
a. 100% nu-mode (24 years nu and 0 year anti-nu) and 100% anti-nu-mode: export nothing
b. 50% nu-mode and 50% anti-nu-mode:





(a) Assuming the MH is unknown.



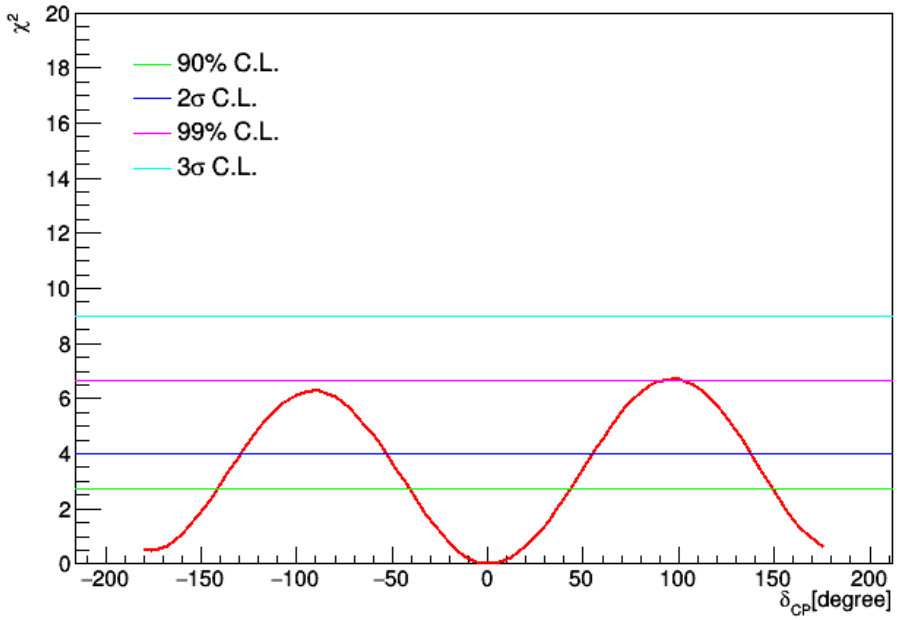
(b) Assuming the MH is known – measured by an outside experiment.

FIG. 2: Sensitivity to CP violation as a function of true δ_{CP} for the full T2K-II exposure of 20×10^{21} POT with a 50% improvement in the effective statistics, a reduction of the systematic uncertainties to 2/3 of their current size, and assuming that the true MH is the normal MH.

II. delta_cp projection with reactor: deltacp = 0

a. 100% nu-mode (24 years nu and 0 year anti-nu) and 100% anti-nu-mode: export nothing

b. 50% nu-mode and 50% anti-nu-mode:



III. delta_cp projection with reactor: deltacp = -90

a. 100% nu-mode (24 years nu and 0 year anti-nu) and 100% anti-nu-mode: export nothing

b. 50% nu-mode and 50% anti-nu-mode: