Sensivity studies :status report

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- Position of the minimum χ^2
- Feldman-Cousins maps with systematics
- Comparison of T2K plots with NOνA plots

Choice of estimator

See Naho's talk

Use a Poisson likelihood ratio estimator ; changed the number of bins to have always more than ~5 events per bin

- SK 1 ring e-like sample (after all appearance cuts), recontructed Eν, 9 bins
- SK 2 ring e-like sample, invariant mass, 17 bins
- 2KM 1 ring e-like sample (after all appearance cuts), reconstructed Eν, 22 bins
- 2KM 2 ring e-like sample, invariant mass, 28 bins

$$\chi^2 = \chi^2_{1R,SK} + \chi^2_{1R,2km} + \chi^2_{2R,SK} + \chi^2_{2R,2km} + \sum_{k=1}^{N_s} \varepsilon_k^2/\sigma_k^2$$

$$= \sum_{i=1}^{N} 2 \left(E_i^{MC}(1 + \sum_{k=1}^{N_s} F_i^k \varepsilon_k) - O_i + O_i \log \left(\frac{O_i}{E_i^{MC}(1 + \sum_{k=1}^{N_s} F_i^k \varepsilon_k)} \right) \right) + \sum_{k=1}^{N_s} \left(\frac{\varepsilon_k}{\sigma_k} \right)^2$$

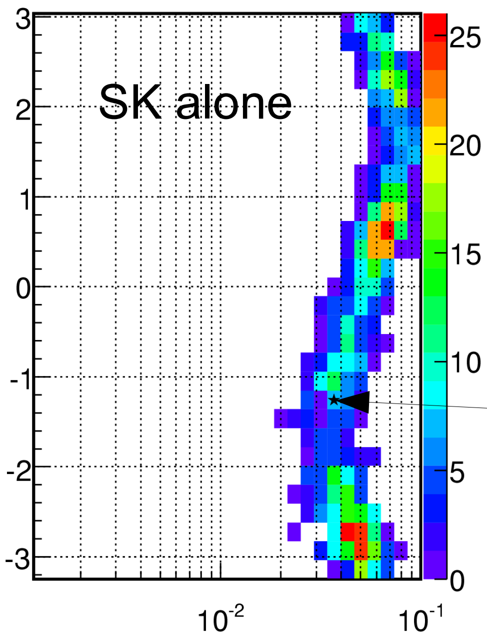
E : expected by MC
O : observed
F_{ik} : effect of kth nuisance parameter on bin i
σ_k : width of kth nuisance parameter

Equation must be solved iteratively
(Poisson stats -> non linear)

19 systematic parameters so far

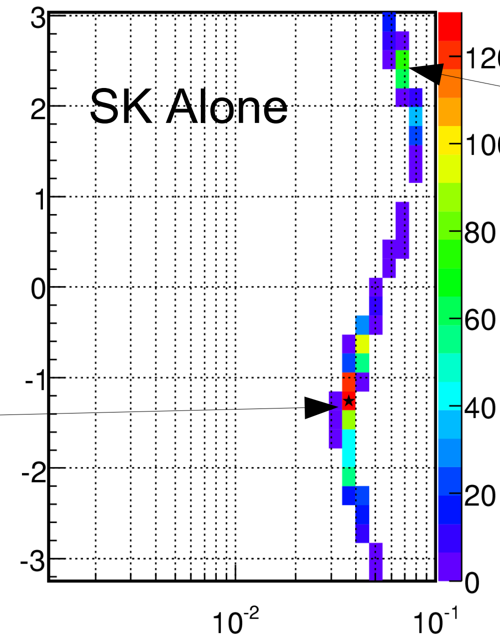
Position of the minimum chi ²

Use sin²2θ = 0.05, and δ = some value.
Make fake data and look at the positions of the minimum
The colour code counts the number of experiments with minimum at this point.



5 T2K years

input



100 T2K years

Ghost solutions at δ+π are expected...

- Without stat fluctuations the input point is the minimum
- The solutions seems to be the same no matter what the input δ is.
- This effect goes away at high stats : very reassuring, probably not a bug.

I checked that the spectra at the input position and best fit are very close together.

Consequence of “quantization” of the number of events in each bin due to Poisson stats ?

With systematics

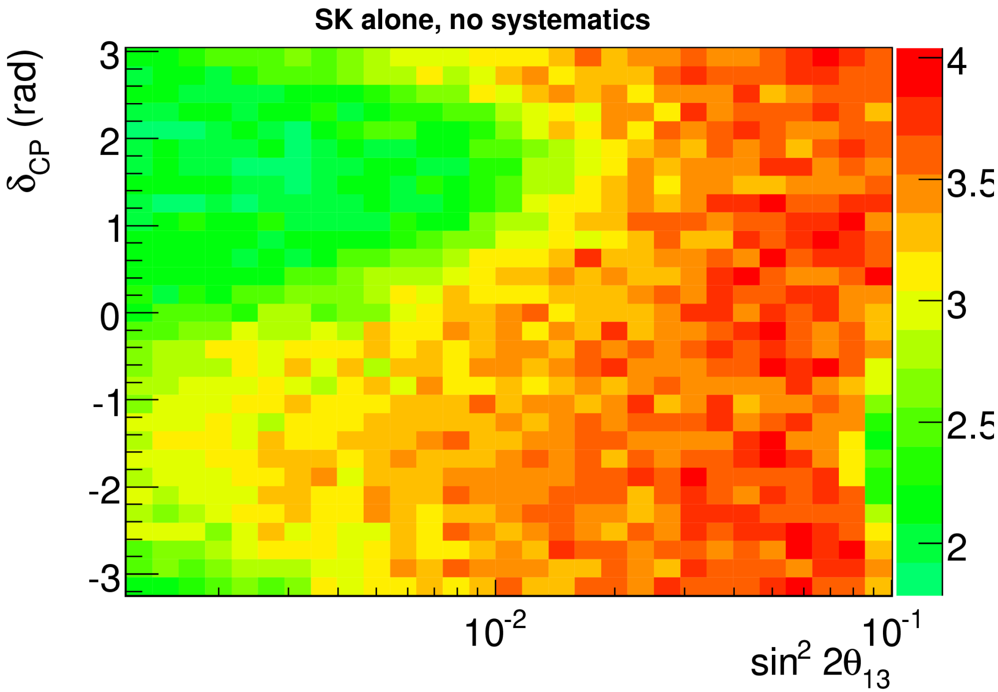
Procedure : χ^2 now is a function of X(oscillation) and ε (nuisance parameters)

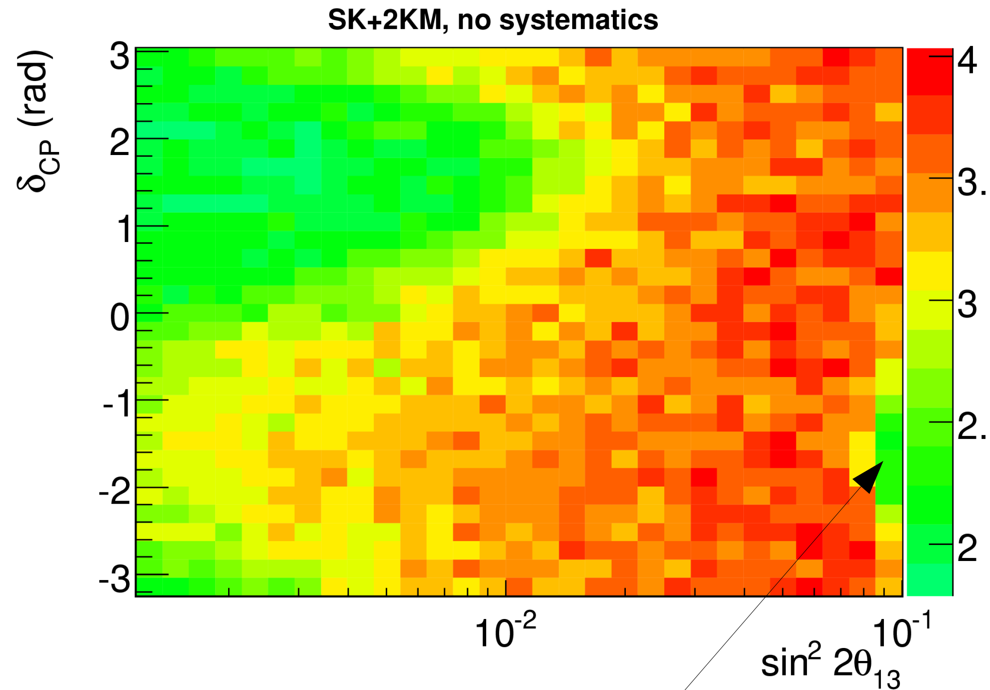
- Pick a point A on the map
- Make fake data from MC(A), setting all the nuisance parameter to 0
- Compute min χ^2(A,best fit ε) and min(χ^2) = χ^2(best fit X, best fit ε')
- Get $\Delta\chi^2$(A) =min χ^2(A,best fit ε) – min χ^2(best fit X, best fit ε') distribution
--> will depend on A (non linearities etc.)
- Determine α CL cut position on $\Delta\chi^2$(A) distribution --> critical value C_α(A)
- Use this cut on χ^2(data,A,best fit ε)- min(X,ε) χ^2(data),
 to decide if data accepts point A or not
- Repeat for all points on the map

Basically same procedure as before, but with a minimization of the nuisance parameters at each step.
This is an approximation, considered to be very good (Kendall& Stuart ?) and certainly much faster than making a full Neyman construction over many (nuisance) parameters.
Question : is it correct to fix the nuisance parameters to their "central value" 0 ? Does it change the coverage when they are set to some other value ? Should they also be randomized ?
→ **in a simple scheme with 2 systematics fixing them to 0 is OK.**

Feldman-Cousins critical values

Code now running at Kashiwa, using 30 CPUs (~10h)





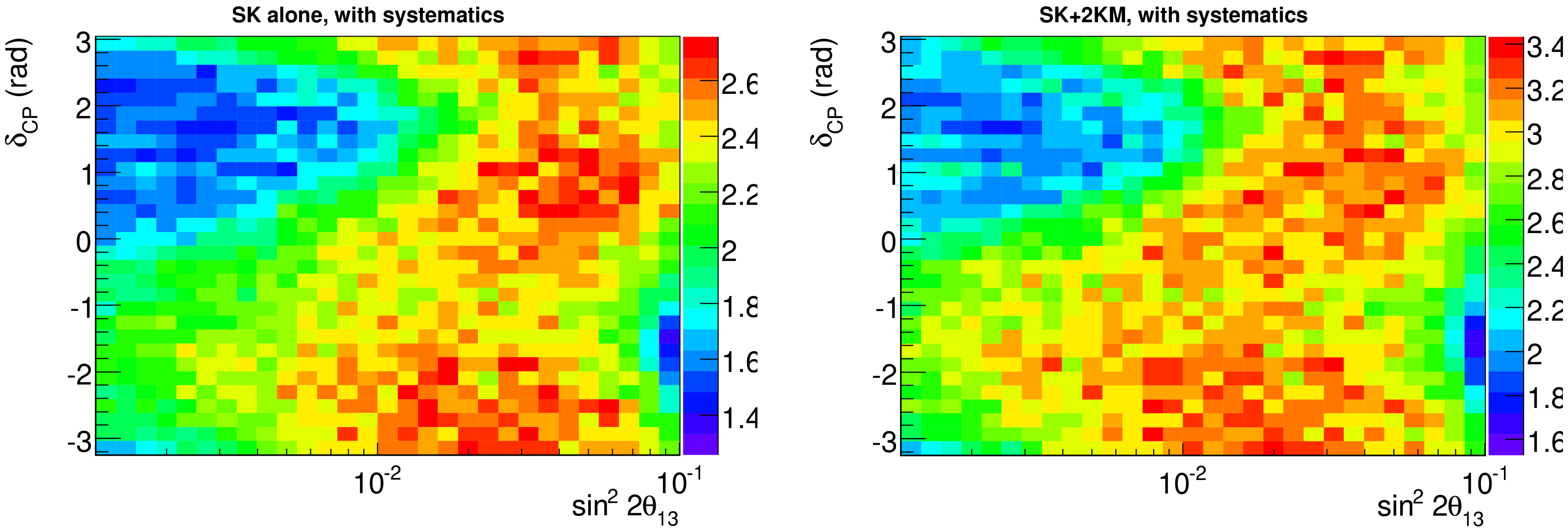
At 90% CL.
Almost no perceptible difference **as expected.**

Critical values definitely lower than those of a 2-dof χ^2 law.

Warning : this is not exactly F-C, because $\sin^2 2\theta_{13}$ does not span the whole physical region.
So there is an edge effect on the right that shouldn't be there.

F-C critical values : with syst

Nuisance parameters fixed at 0 when making fake data, always fitted during the computations as explained on slide 2.

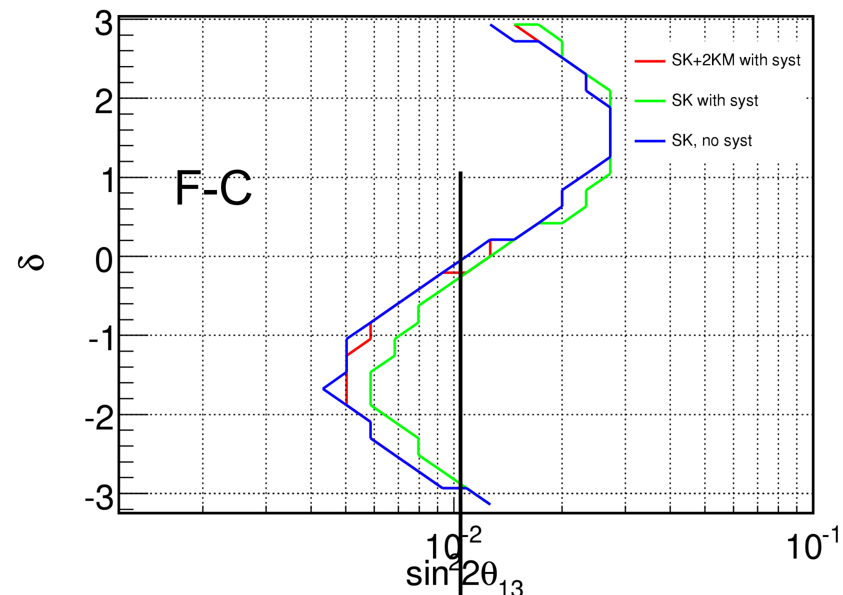


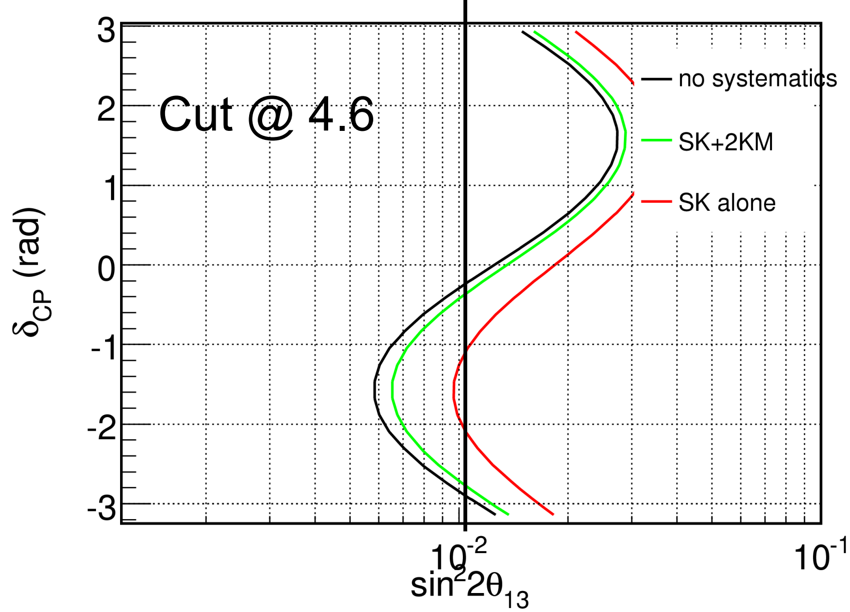
At 90% CL.

Two main comments :

- Values lower than in the absence of systematics (nuisance parameters give extra freedom to lower the $\Delta\chi^2$).
- Values lower at SK than at SK+2KM : same reason [fewer constraints when SK is alone]

Applying the FC maps to contours



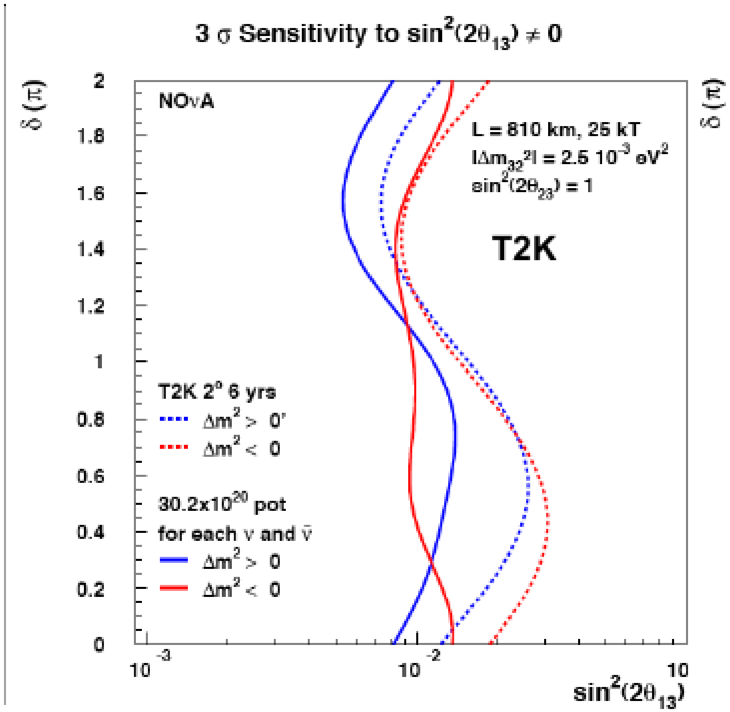


90% CL <u>sensitivity</u> contours using Δm^2=2.5e-3 eV² and θ_{13}=0,δ=0

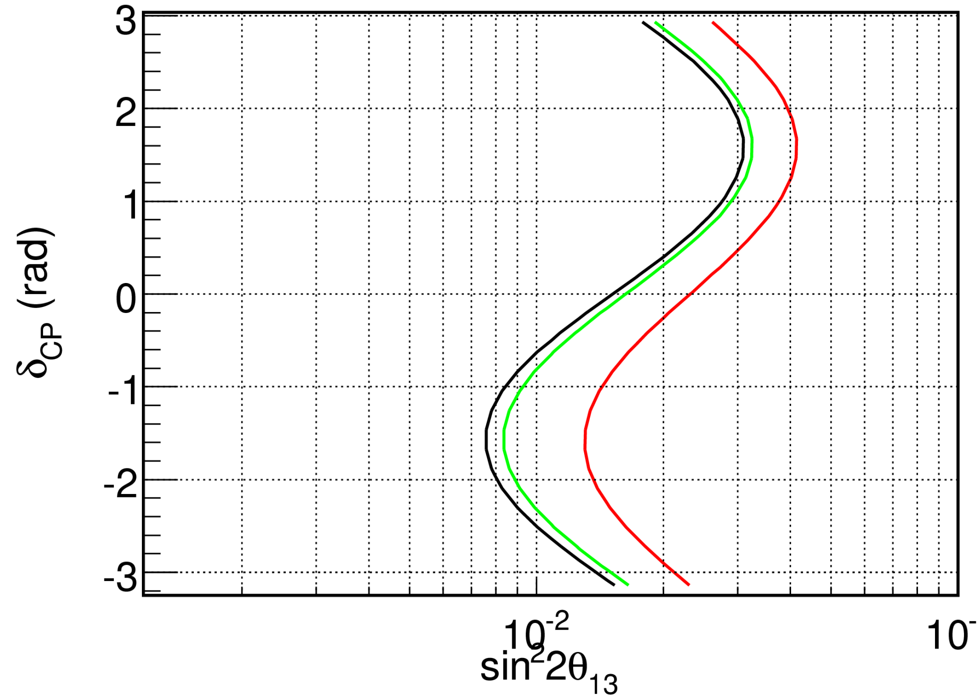
Fake data has no fluctuations

- Using 4.6 is too conservative (more than 90% CL)
- But need to find a way to smoothe the F-C contours !

Plots à la NOνA



From Gary Feldman, P5 at Fermilab, 18/04/06



- These are raster scans : δ is fixed, and the $\Delta\chi^2$ is minimized along horizontal lines
- These are discovery potential : they show which true value of θ_{13} is necessary to claim that θ_{13} is non zero at 3σ, for a fixed value of δ (critical value is 9 i.e. 1 dof x^2).
- NOνA is considered to be a counting experiment only, with 5% systematics on background subtraction – use 6.10^{21} pot for both experiments.
- My own T2K lines are made with all 19 systematic errors, and full fitting, but no matter effects.

Conclusion

- Need to “smoothe” the F-C maps and apply them to obtain both sensitivity and discovery potential, over many fake experiments, using methods outlined in a previous talk without systematics.
- Position of the minimum χ^2 : puzzling, but seems to be a consequence of the low statistics and not a bug.
- Comparison with NOνA plots : need to add matter effects to the fitter.