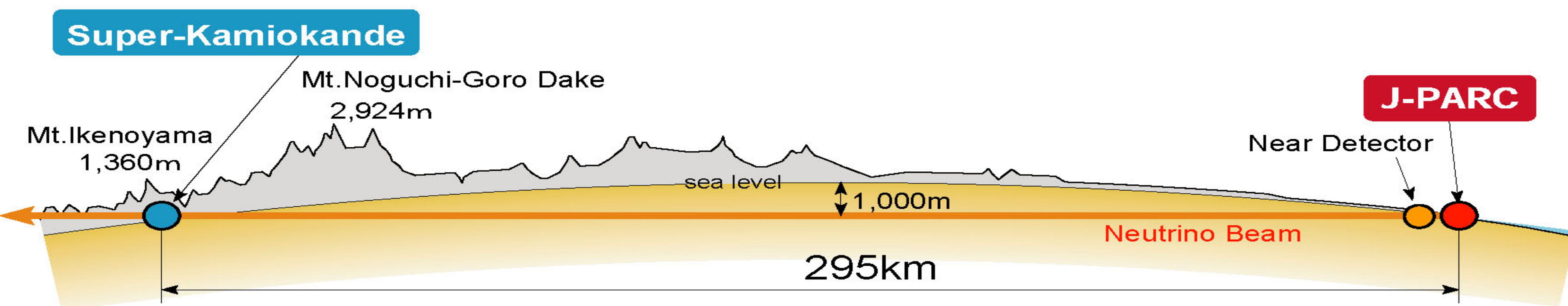


Daive Sgalaberna (University of Geneva) for the T2K and VALOR group

**T2K** is a neutrino long baseline experiment (near and far detector) which aims to search for CP violation in neutrino sector by measuring  $\nu_\mu \rightarrow \nu_e$  and  $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$



**VALOR**: neutrino fitting group involved in the T2K, Hyper-K, DUNE, MicroBooNE and SBND experiments. Specialized in neutrino oscillation fits

Hybrid bayesian-frequentist analysis:

- Neutrino flux, cross section and detector systematics are nuisance parameters
- Minimize the binned negative log-likelihood ratio as a function of the parameters of interest (converge to  $\chi^2$  at high statistic)

$$-2 \ln \lambda(\vec{\theta}, \mathbf{a}) = 2 \cdot \sum_{i=0}^{N-1} \left( n_i^{obs} \cdot \ln(n_i^{obs} / n_i^{exp}) + (n_i^{exp} - n_i^{obs}) \right)$$

$n_{obs}$ : observed data  
 $n_{exp}$ : expected template

- Nuisance parameters are marginalized [1]:

$$\lambda_{marg}(\vec{\theta}) = \int_A \lambda(\vec{\theta}, \mathbf{a}) \pi(\mathbf{a}) d\mathbf{a} = \frac{1}{n} \sum_{i=1}^n \lambda(\vec{\theta}; \mathbf{a}_i) \quad \chi_{marg}^2(\vec{\theta}) = -2 \ln \lambda_{marg}(\vec{\theta})$$

Proper confidence intervals at X% CL are provided by the “Feldman-Cousins” method [2]:

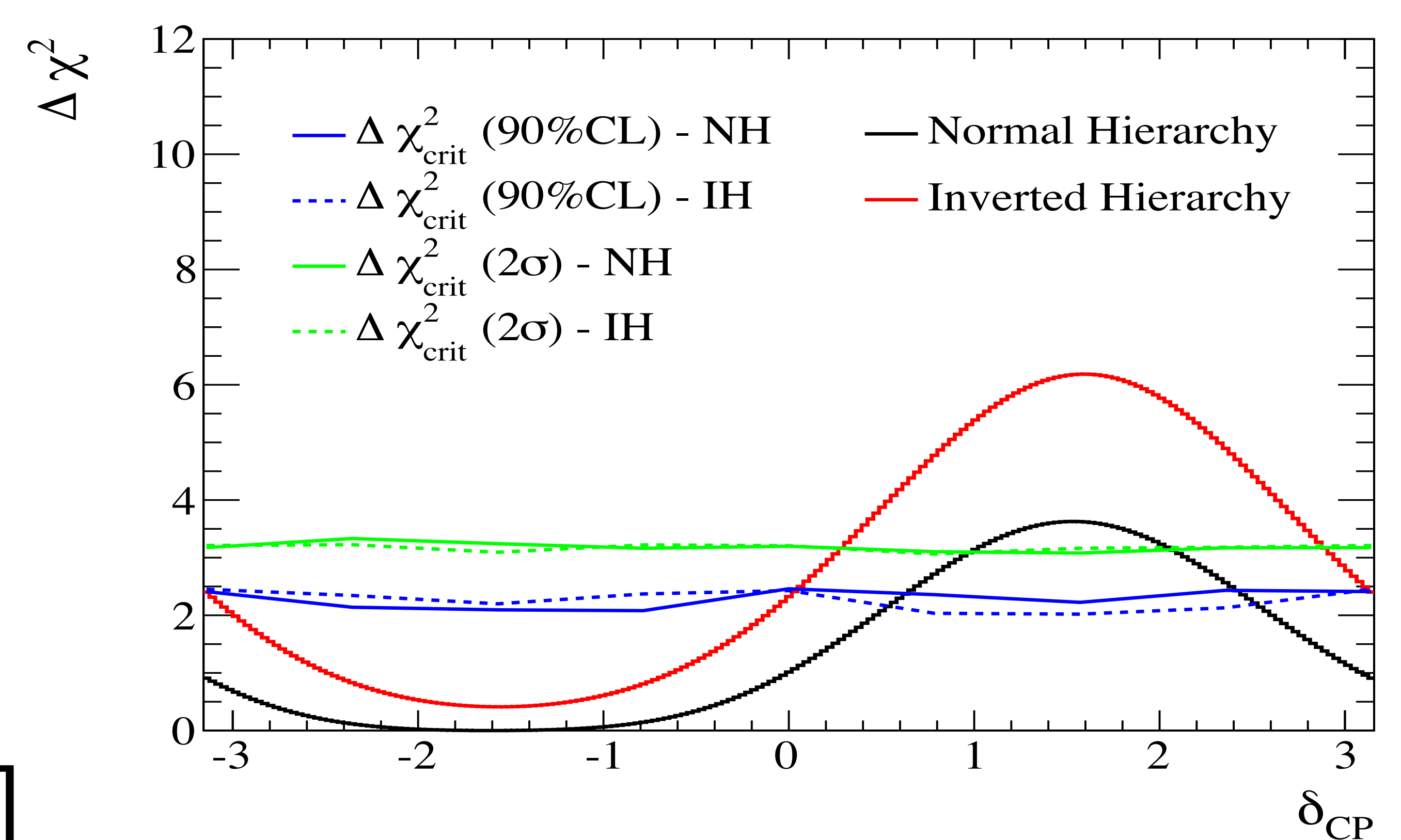
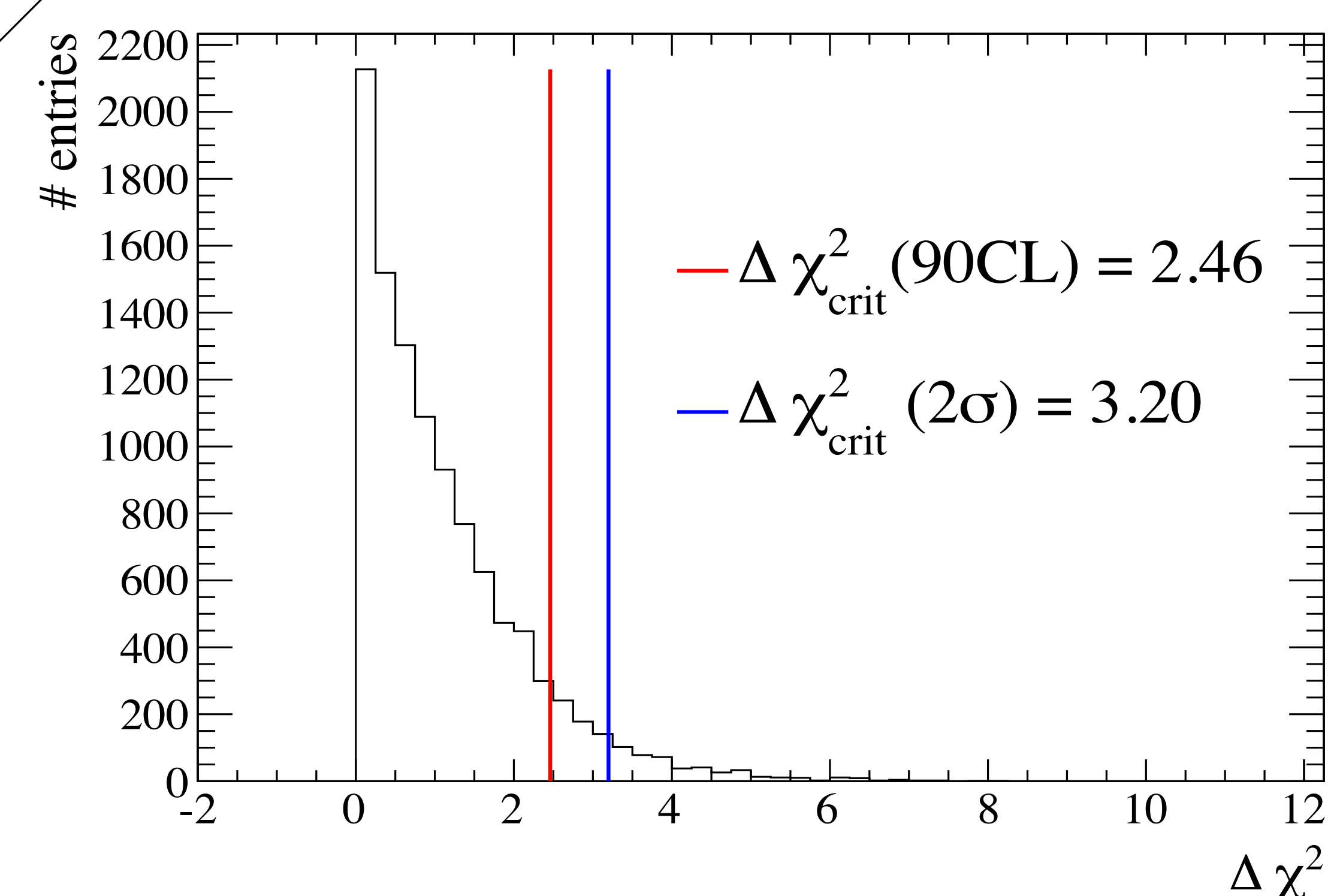
- perform many toy MC experiments by randomizing the nuisance parameters with correlations
- calculate the test statistic and obtain

the expected distribution of  $\Delta\chi^2 = \chi^2(\vec{\theta}_{fix}) - \chi^2(\vec{\theta}_{bf})$

- $\Theta_{fix}$ : marginalize nuisance parameters and fix  $\delta_{CP}$  and MH to “true” values
- $\Theta_{bf}$ : marginalize nuisance parameters and fit  $\delta_{CP}$  and MH
- calculate new critical values for  $\Delta\chi^2$  for each “true” point of  $\delta_{CP}$  and mass hierarchy:

$$\Delta\chi_{crit}^2 : \int_{-\infty}^{\Delta\chi_{crit}^2} f(\Delta\chi^2) d(\Delta\chi^2) = X\%$$

- Sensitivity study using the Asimov data set [3]



(1) R.D. Cousins and V.L.Highland, Nucl.Instr. and Meth. A320:331035, 1992.  
(2) G.J. Feldman and R.D. Cousins, Phys.Rev.D57:3873-3889,1998; physics/9711021  
(3) G.Cowan, K.Cranmer, E.Gross, O.Vitells, arXiv:1007.1727v2