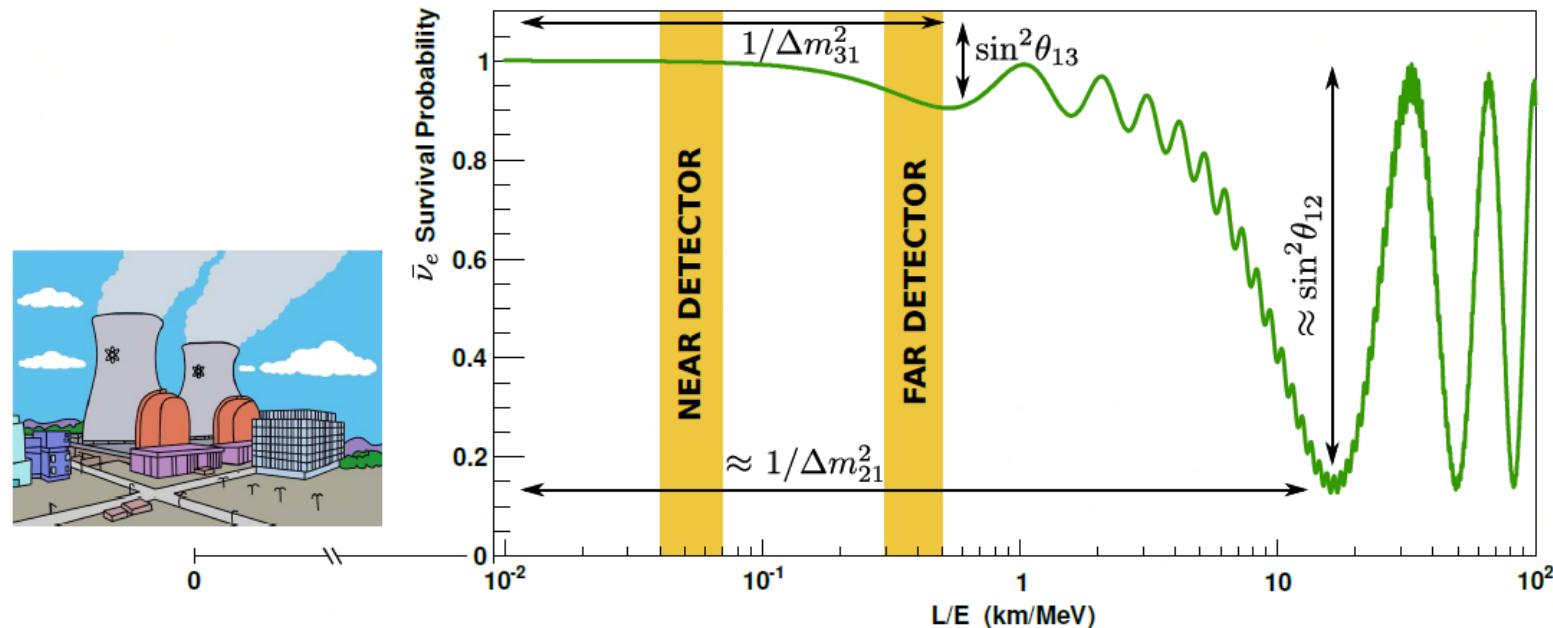




# Status and last near detector data of the Double Chooz Reactor Neutrino Experiment

T. Brugière  
IPHC, Strasbourg  
On behalf of the Double Chooz collaboration

# Measuring $\theta_{13}$ with 2 detectors



$$P_{\bar{\nu}_e \rightarrow \bar{\nu}_e} = 1 - \sin^2(2\theta_{13}) \sin^2 \left( \frac{\Delta m_{31}^2 L}{4E} \right) + O(10^{-3}) \quad \text{for } L/E \lesssim 1$$

- **Anti-neutrinos from reactors :** Pure  $\bar{\nu}_e$ , low energy, high intensity ( $10^{21} \bar{\nu}_e/\text{s}$ )
  - short baseline
  - no matter effect
- **Measurement by 2 identical detectors :** Cancel flux & efficiency uncertainties
  - *Near detector* : unoscillated flux
  - *Far detector* : disappearance around the first minimum

# $\bar{\nu}_e$ detection with DC detectors

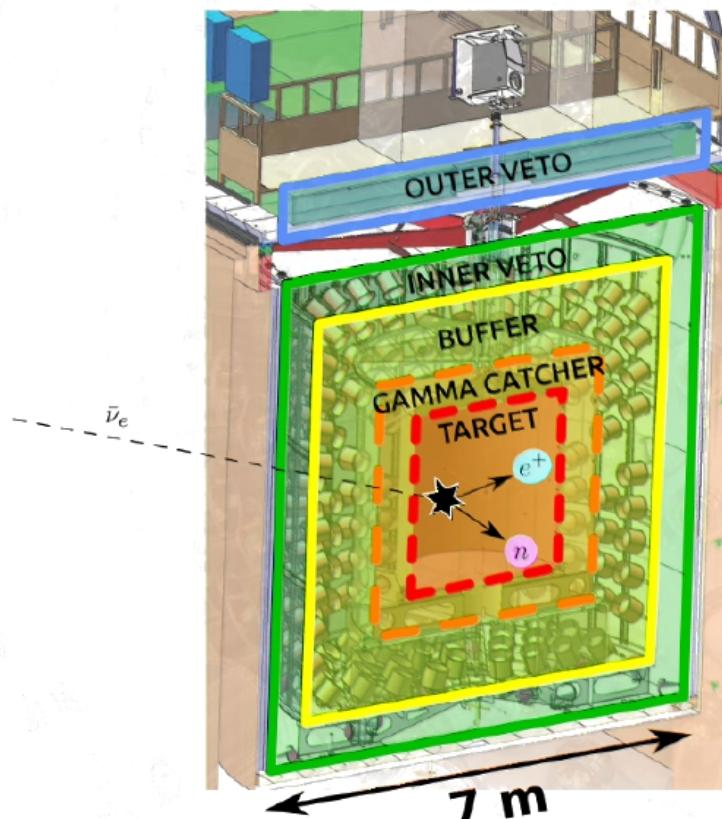


- Inverse  $\beta$  decay on proton (threshold  $\rightarrow$  1.8 MeV)



**prompt signal:** scintillation +  $e^+$  annihilation  
 $E_{\text{prompt}} \approx E(\bar{\nu}_e) - 0.8 \text{ MeV}$

**delayed signal:**  $\gamma$  ray(s) from neutron capture  
n-Gd     $E_{\text{delayed}} \approx 8.0 \text{ MeV}$     $\Delta T \approx 30 \mu\text{s}$   
or    n-H     $E_{\text{delayed}} \approx 2.2 \text{ MeV}$     $\Delta T \approx 200 \mu\text{s}$



**Neutrino target:**  
liquid scintillator PXE + Gd

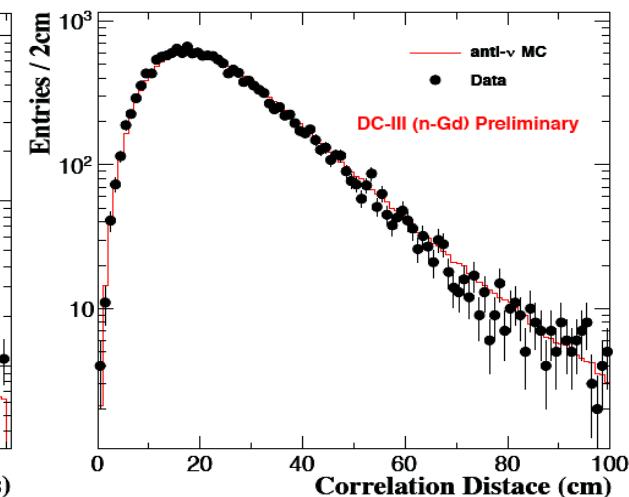
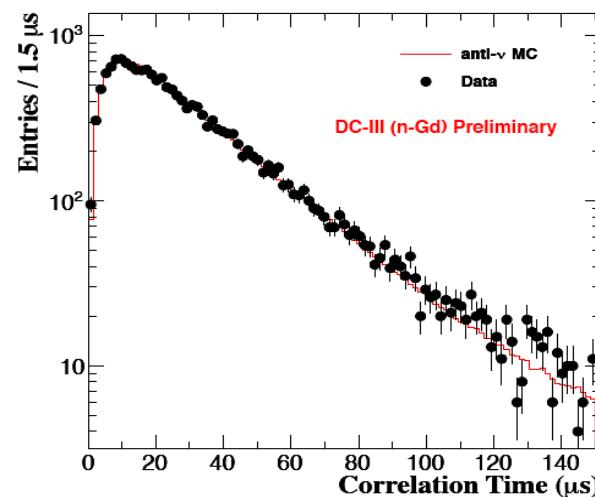
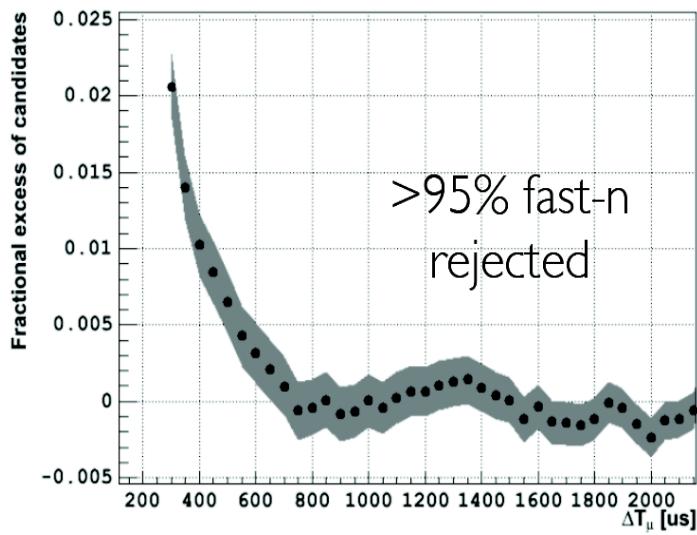
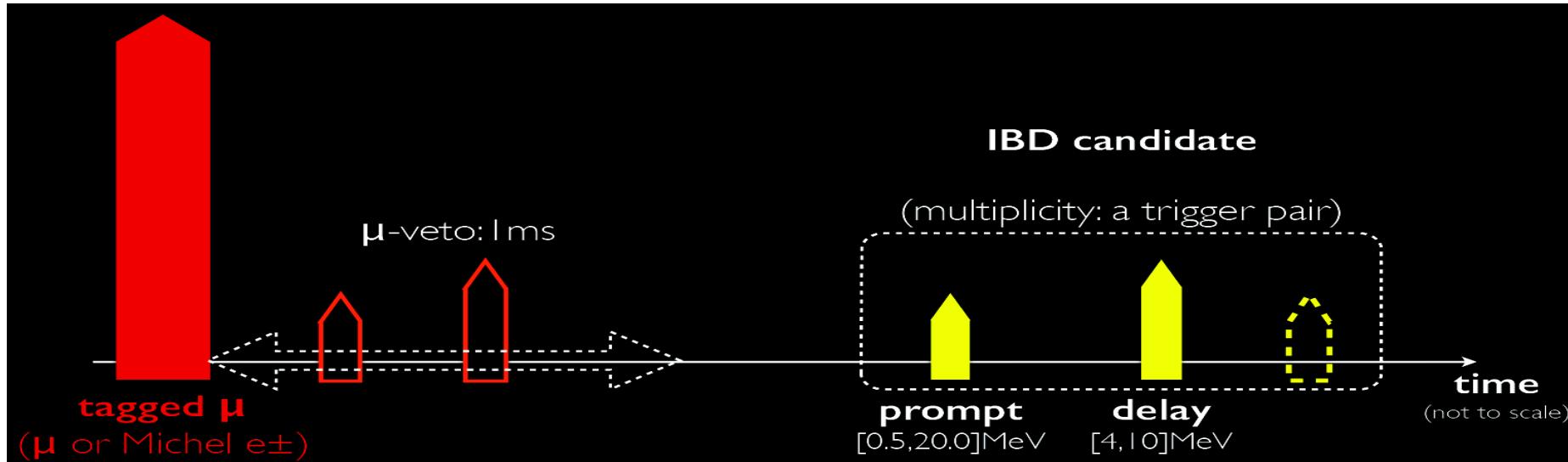
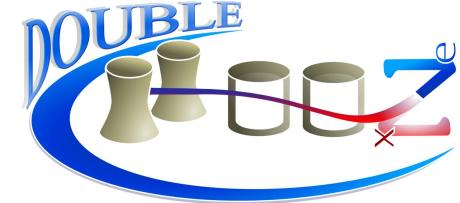
**Gamma catcher:**  
liquid scintillator PXE (no Gd)

**Buffer volume:**  
transparent mineral oil  
with 390 x 10" PMTs assembly

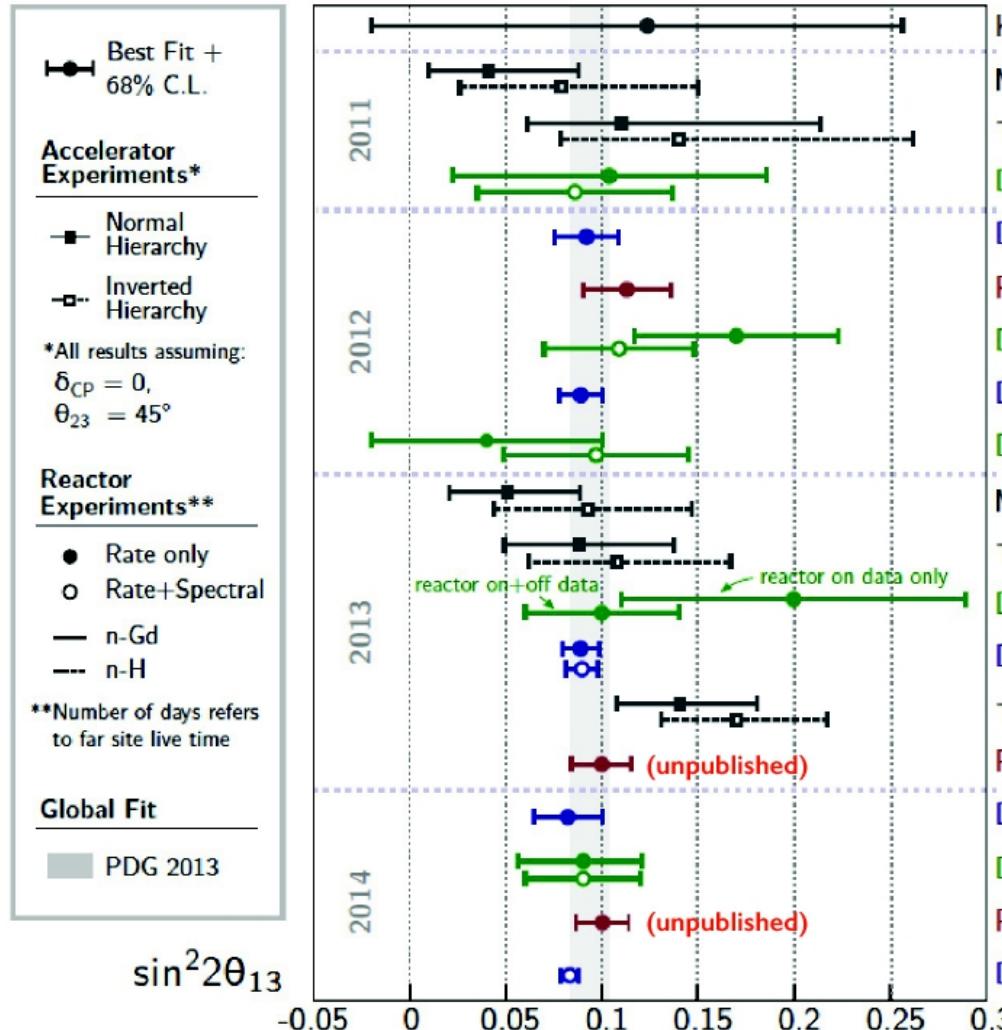
**Inner Veto:**  
liquid scintillator (LAB)  
with 78 x PMTs 8"

**Outer Veto:**  
plastic scintillator strips

# IBD selection



# $\theta_{13}$ -reactor measurements (end of 2014)



KamLAND	[1009.4771]
MINOS $8.2 \times 10^{20}$ PoT	[1108.0015]
T2K $1.43 \times 10^{20}$ PoT	[1106.2822]
DC 97 Days	[1112.6353]
Daya Bay 49 Days	[1203.1669]
RENO 222 Days	[1204.0626]
DC (1 det) 228 Days	[1207.6632]
Daya Bay 139 Days	[1210.6327]
DC (1 det) n-H Analysis	[1301.2948]
MINOS $13.9 \times 10^{20}$ PoT	[1301.4581]
T2K $3.01 \times 10^{20}$ PoT	[1304.0841]
DC (1 det) RRM Analysis	[1305.2734]
Daya Bay 190 Days	[1310.6732]
T2K $6.57 \times 10^{20}$ PoT	[1311.4750]
RENO 403 Days	[TAUP2013]
Daya Bay 190 Days n-H	[1406.6468]
DC (1 det) 468 Days	[1406.7763]
RENO 795 Days	[Neutrino2014]
Daya Bay 563 Days	[Neutrino2014]

Also measurement by T2K, Minos, ...

# The Double Chooz site

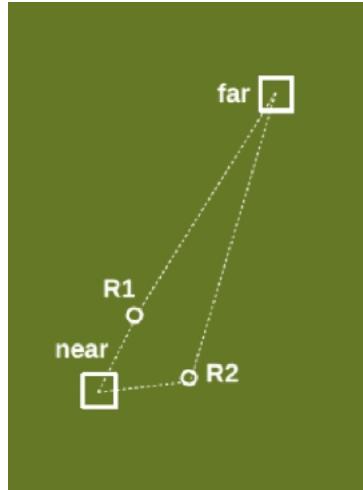


Detector	Baseline to reactor 1 / 2	Overburden	Start of data-taking
Far	1115 m / 998 m	300 mwe	April 2011
Near	465 m / 351 m	120 mwe	December 2014

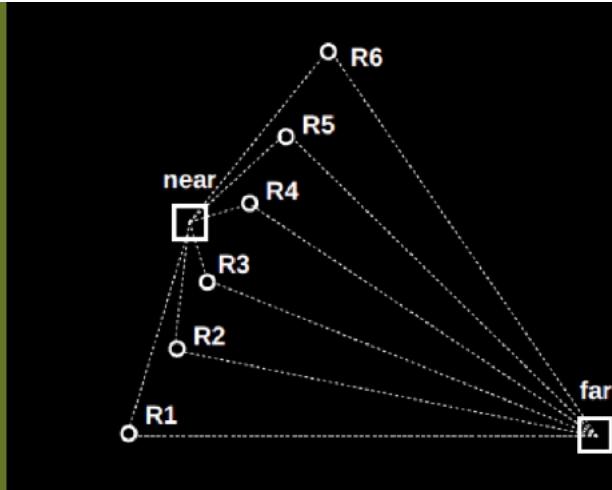
# Double Chooz site « geometry »



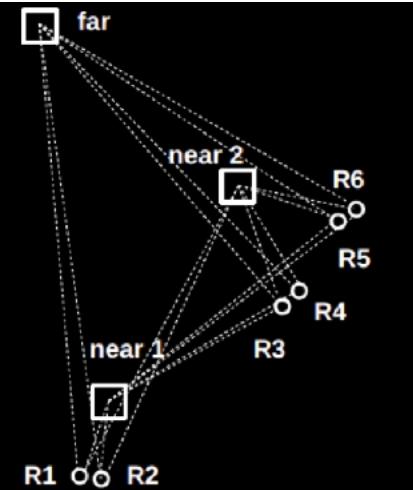
Arxiv:1501.00356 [hep-ex]



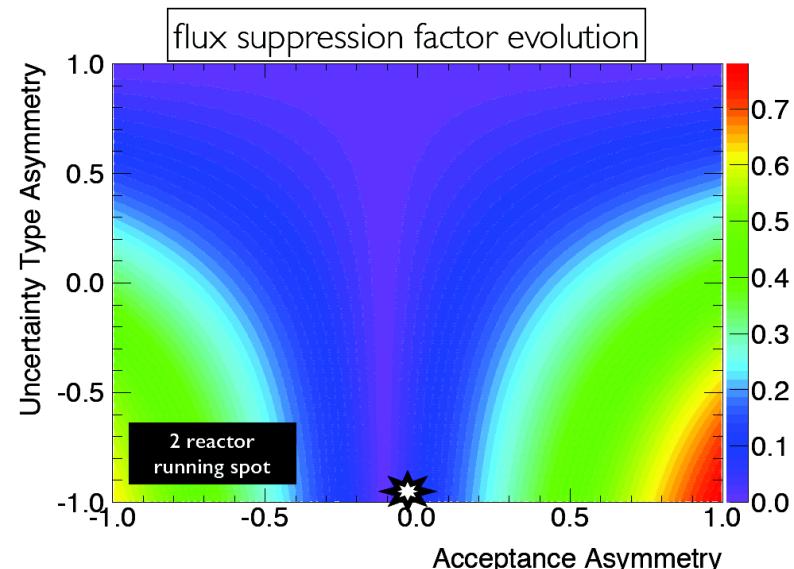
Double Chooz



RENO

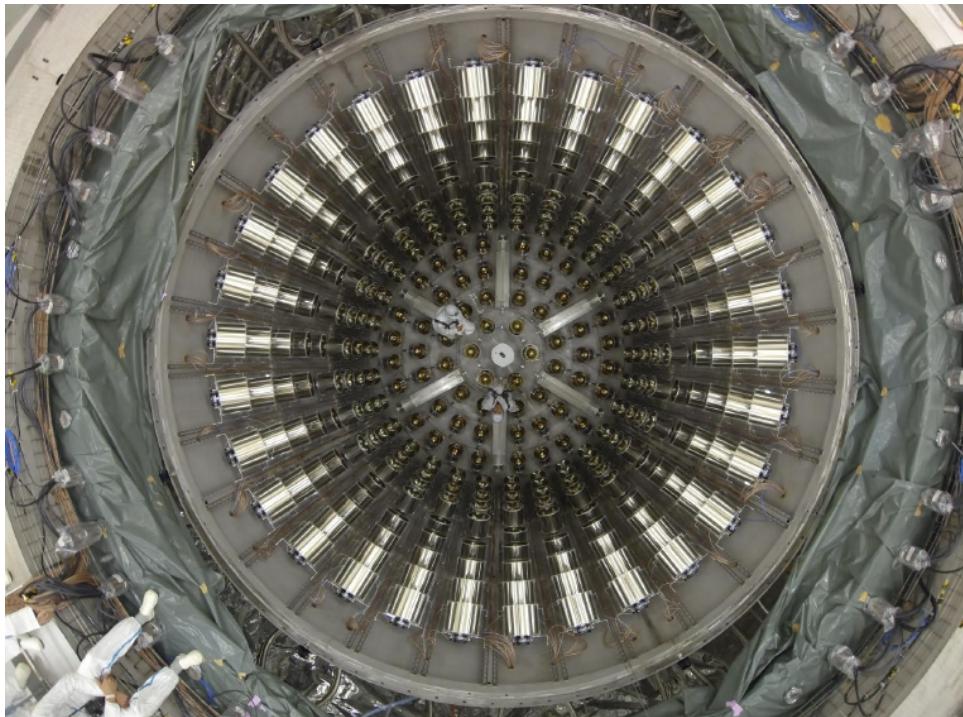


Daya Bay



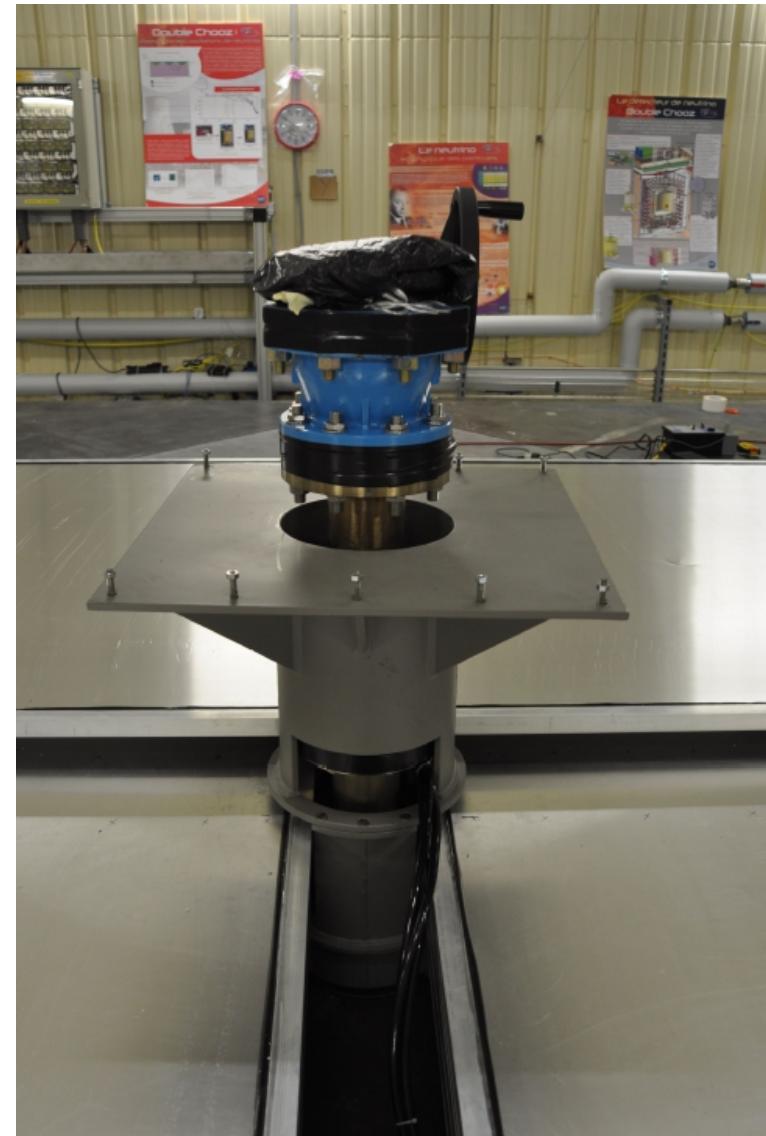
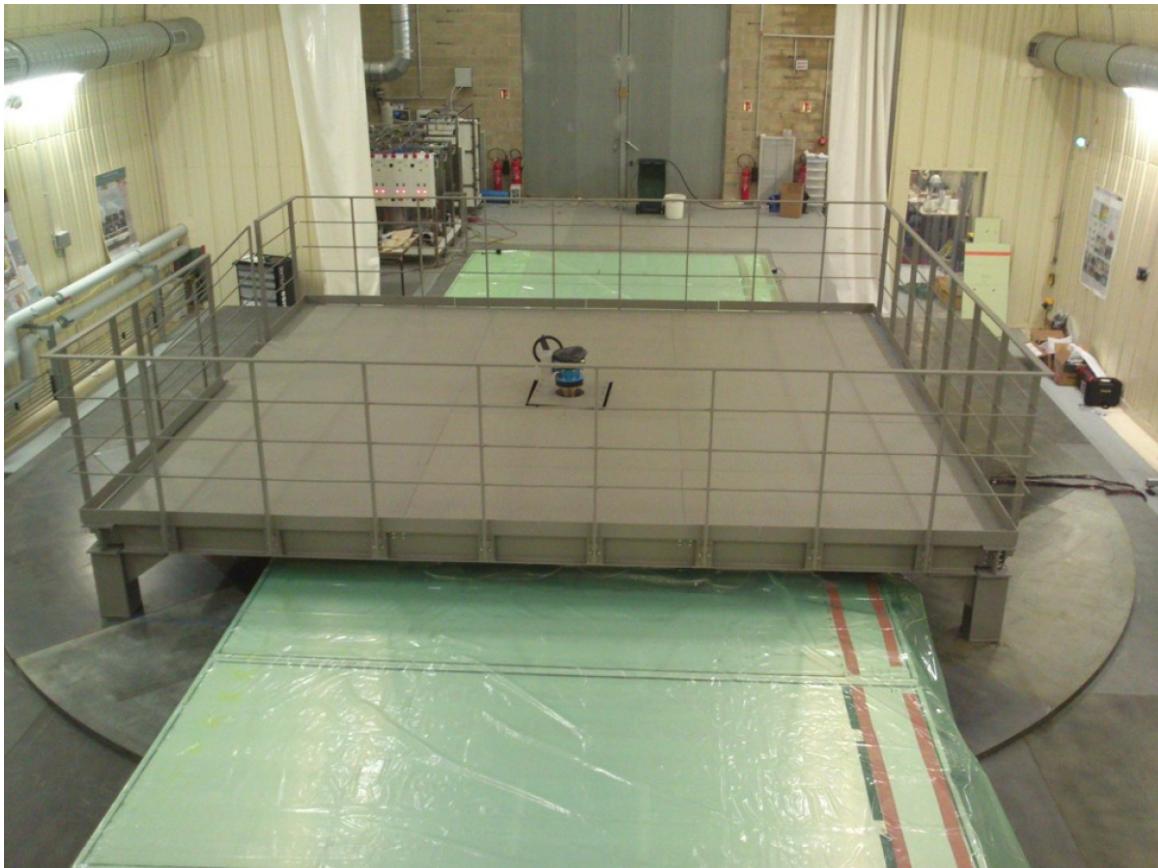
- Double Chooz detectors at nearly isoflux positions :
  - Near detector is almost a perfect flux monitor
  - Error on reactor flux automatically suppressed > 90 %

# Near detector completion



- The near detector take data since December 2014

# Outer veto installation

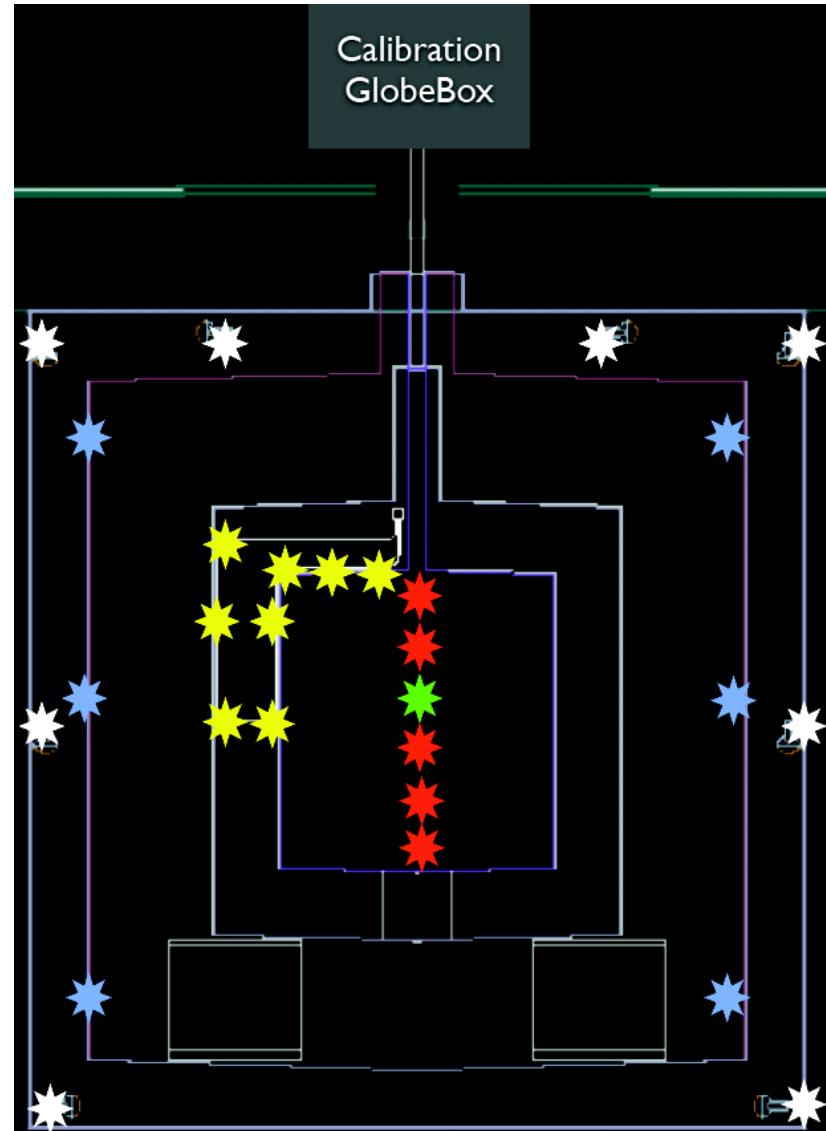


- Outer muon veto installed in April 2015
- Coverage for « chimmey » events

# « Glove box » installation



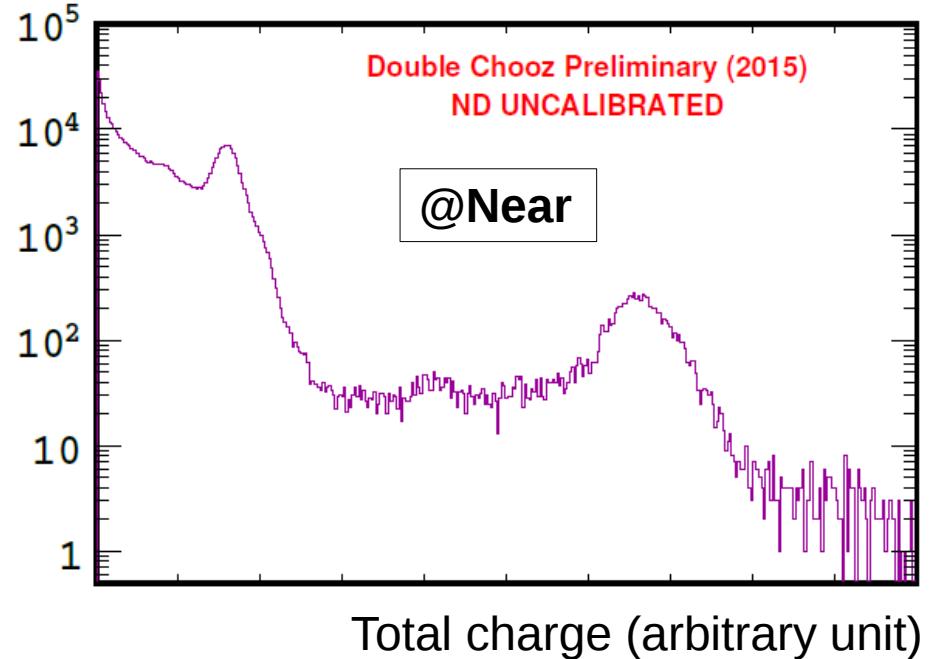
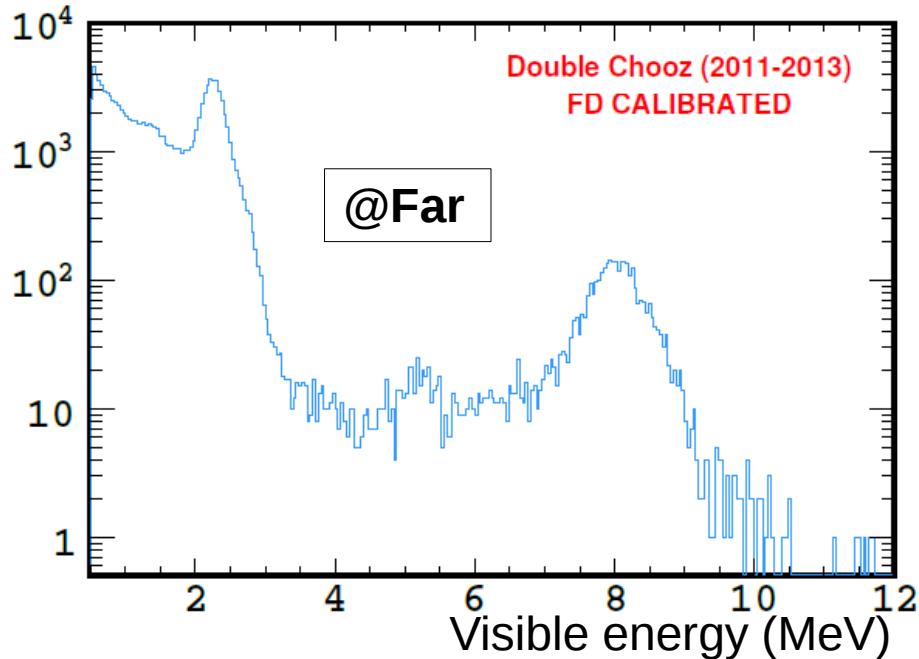
- « Glove box » installed
  - Near detector fully completed !



# First near detector data



- Spallation neutron capture spectrum :

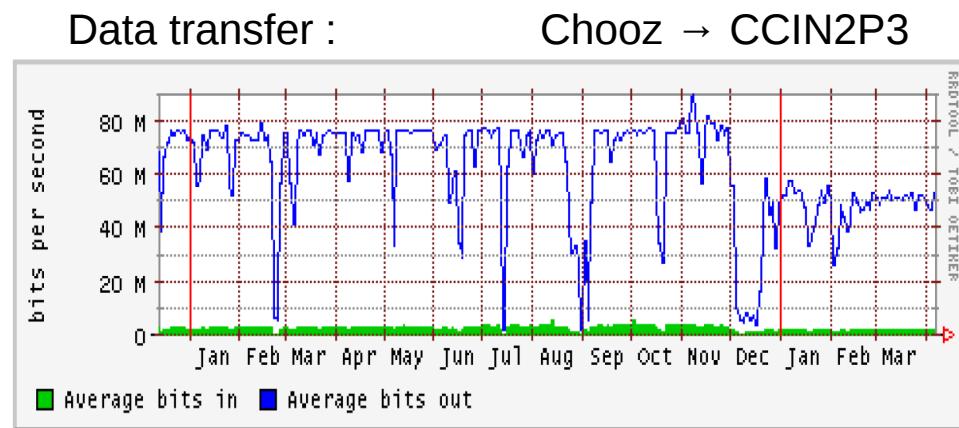
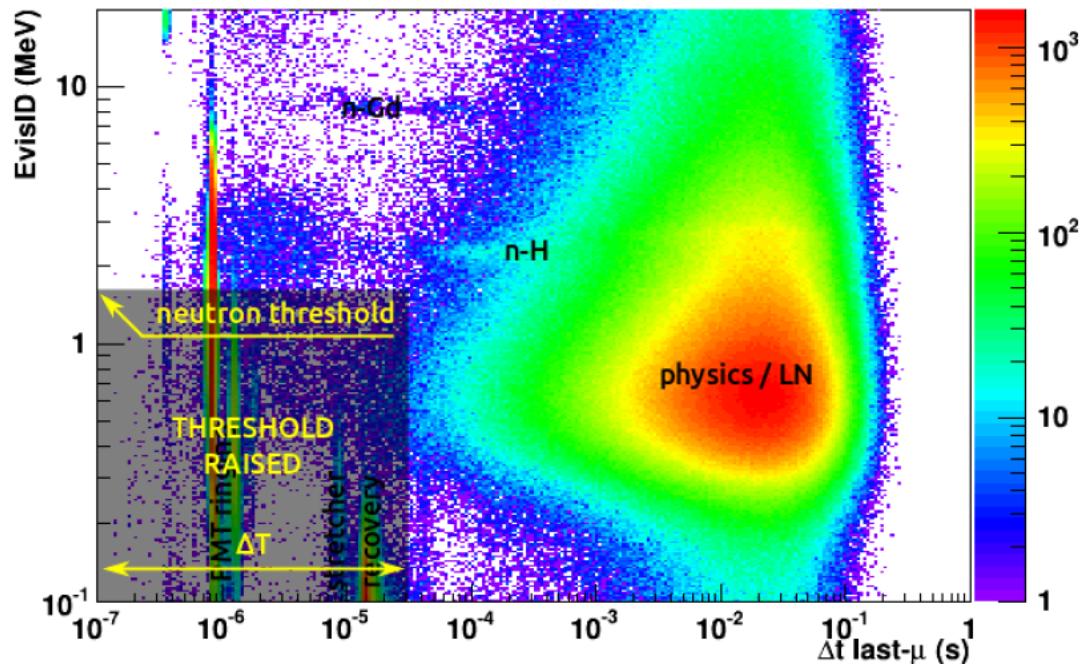


- Similarities of Near and Far detector responses
- Validation of the IBD detection capability @ Near

- Similar singles rate in near and far detectors
  - **Confirms achievement of radiopurity and shielding goals**

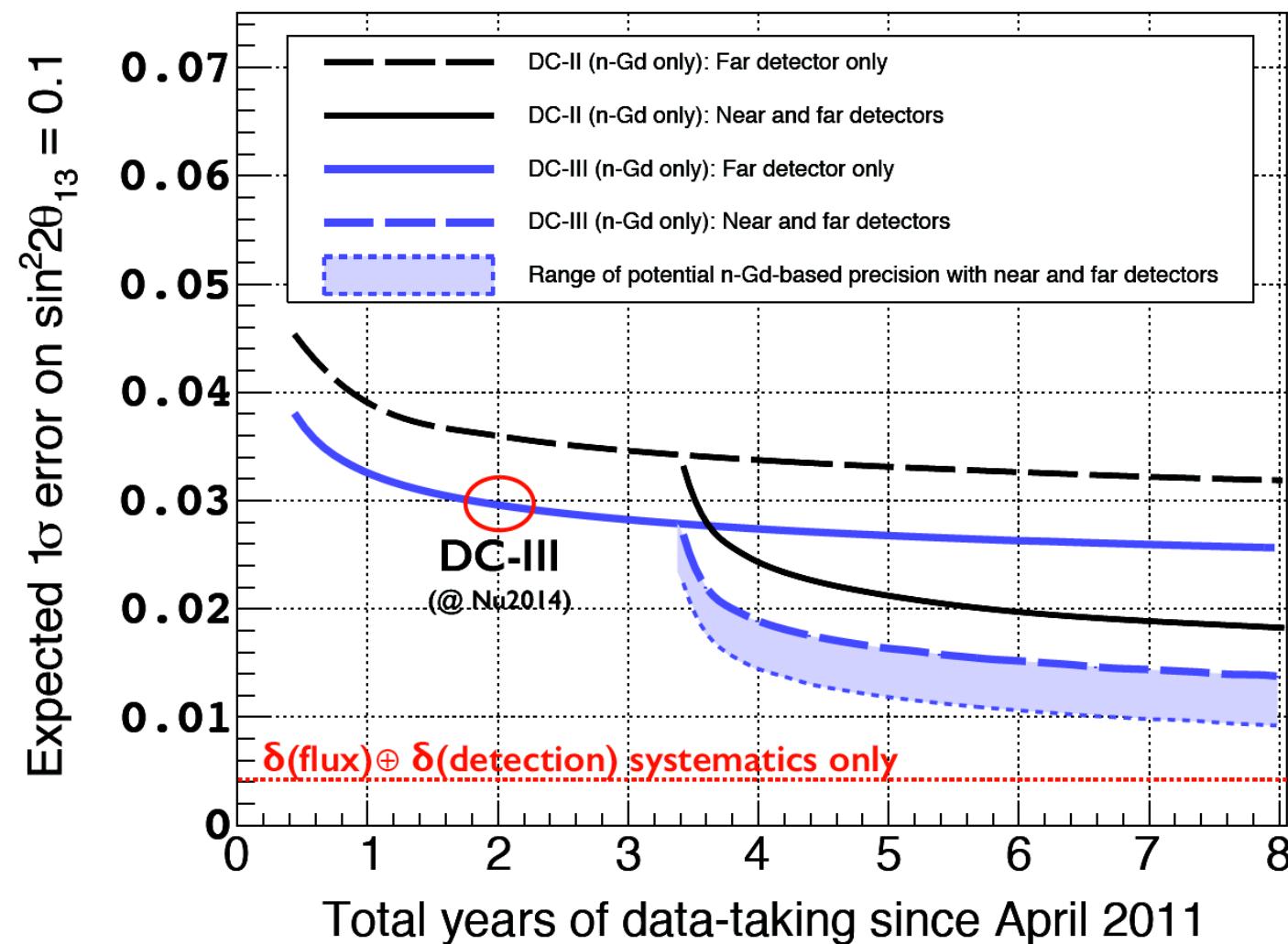
# Dynamic Data Reduction

- **Online event tagging** → cut ~70 % of the light noise, reduced data for muon events
- **Threshold raised temporary after a muon** → avoid ghost trigger, PMT ringing



→ Bandwidth occupancy Near+Far lower than Far only !

# Projection of $\theta_{13}$ precision



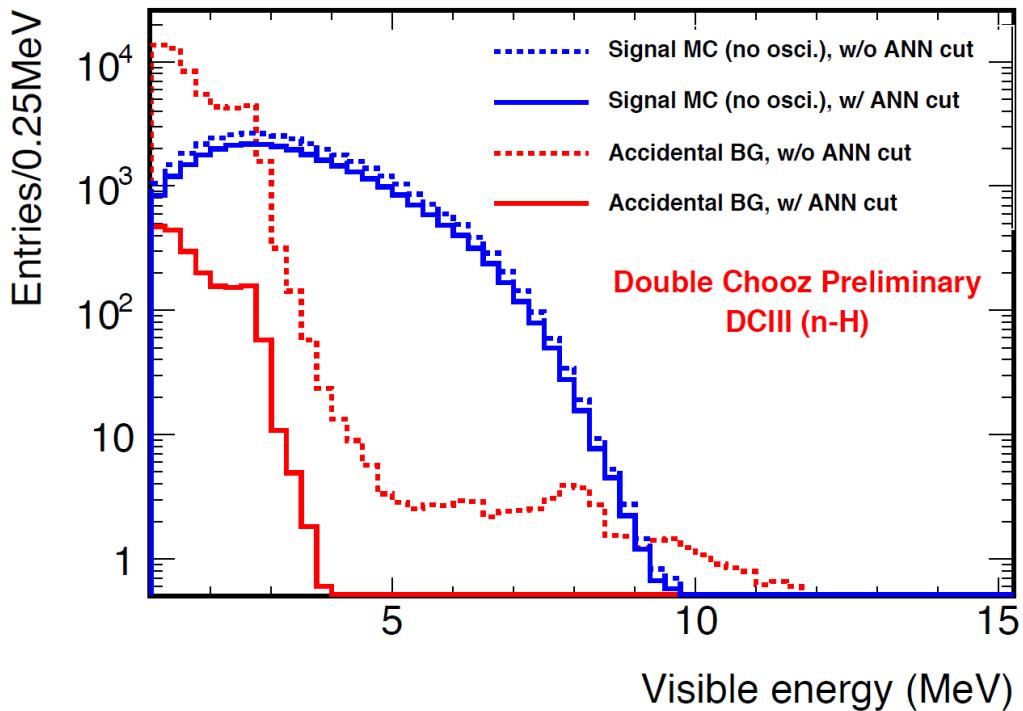
GD-n analysis prospect inputs :

- $\delta(\text{flux}) < 0.1 \%$   
→ iso-flux
- $\delta(\text{detection}) < 0.2 \%$
- $\delta(\text{BG}) \sim 0.3 \%$   
→ DCIII – R+S constraint

# DC results coming in 2015



- Final single-detector  $\theta_{13}$  analysis : using n-H



- Inputs : Delayed energy, correlation time and correlation space
- Strong reduction of accidental BG
- Signal / Background improved by a factor 10 (compared to previous n-H analysis)

- First two-detector  $\theta_{13}$  analysis !