J.E Campagne

# SPL-Fréjus

- Some performances
- Fréjus site
- French Photodetector R&D

Thanks: A. Cazes, M. Mezzetto, L. Mosca, Th. Schwetz
and IPNO & LAL engeeners.

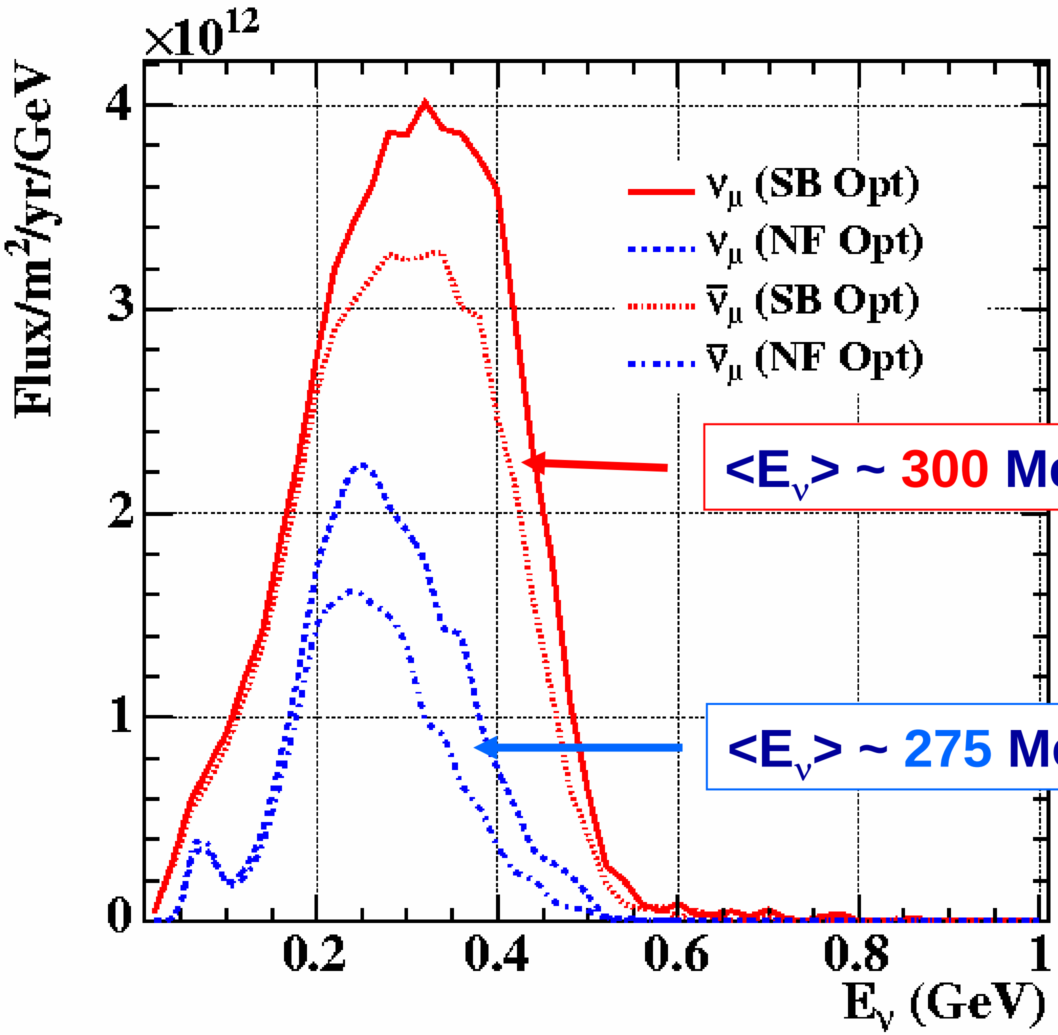
See also talk at Acc. WG

# Some ingredients for physics analysis

- 440kT Water Č located 130km from CERN (see site later)
- Essentially SK analysis with tighter cuts for e/$\mu$ id (cf. hep-ph/0105297)
- Use energy resolution dominated by Fermi motion* (200MeV bins)
- 2% systematics on signal & bkgd
- Optimized machine versions: $\beta$B (M. Mezzetto) and SB (A.C + J.E.C)
- Use Atmospheric Neutrinos
- GLoBES & NUANCE

*: migration matrix for $\beta$B

# Fluxes comparison @ 130km




$\sim 95\ \nu_\mu^{CC}/kT/yr^*$

$<E_\nu> \sim$ 300 MeV, 1.2 $10^{12}/m^2/yr$

3.5GeV SPL optimum

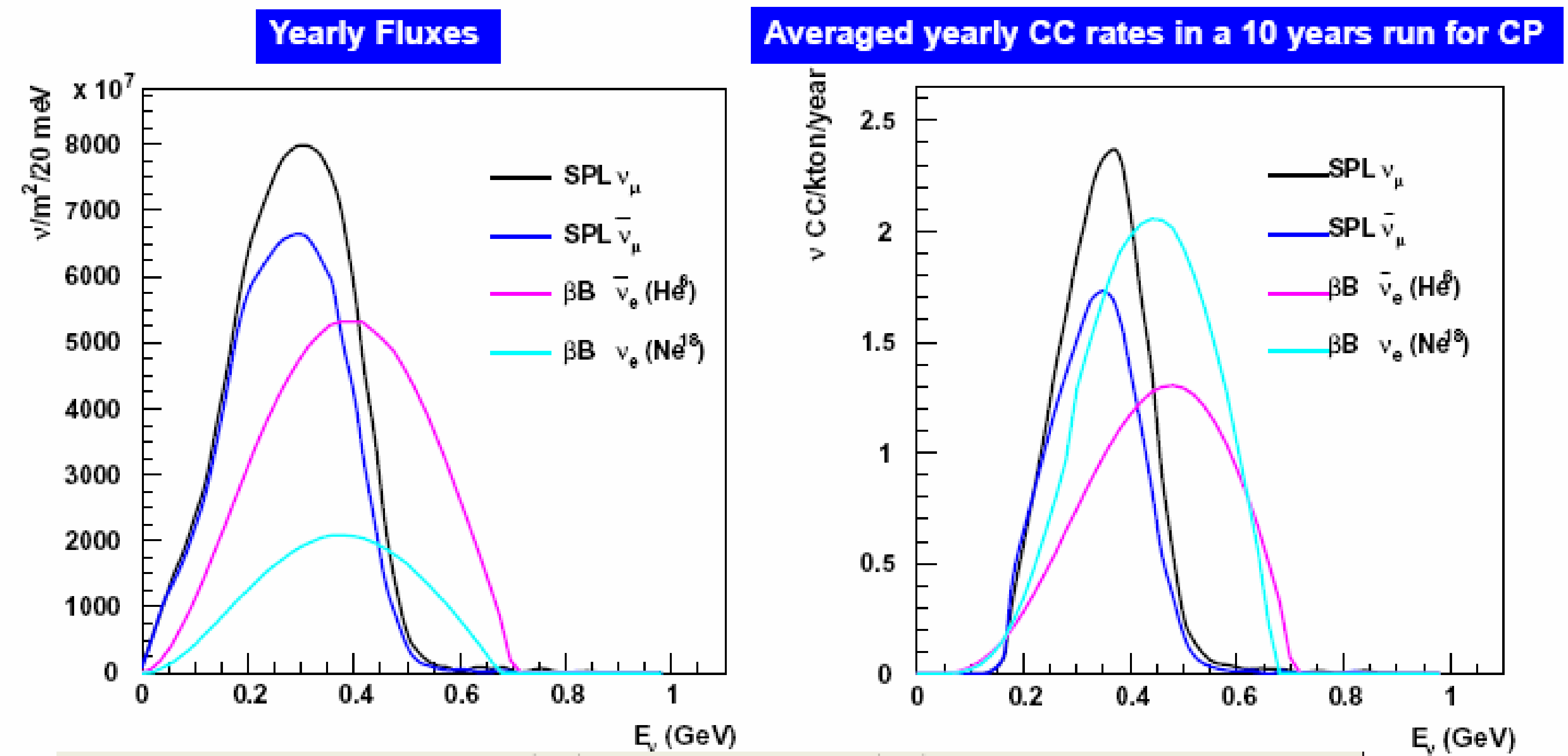
$<E_\nu> \sim$ 275 MeV, 4.5 $10^{11}/m^2/yr$

Old νFact optimum

Reflector: 50% of the Flux

*: Lipari x-sect. (see later)

# βB and SB fluxes




| | Fluxes @ 130 km $\nu/m^2/yr$ | $\langle E_\nu \rangle$ (GeV) | CC rate (no osc) events/kton/yr | $\langle E_\nu \rangle$ (GeV) | Years | Integrated events (440 kton × 10 years) |
|---|---|---|---|---|---|---|
| | | | **SPL Super Beam** | | | |
| $\nu_\mu$ | $11.80 \cdot 10^{11}$ | 0.29 | 121.7 | 0.36 | 2 | 107127 |
| $\overline{\nu}_\mu$ | $9.66 \cdot 10^{11}$ | 0.28 | 23.1 | 0.35 | 8 | 81164 |
| | | | **Beta Beam** | | | |
| $\overline{\nu}_e(\gamma = 100)$ | $10.92 \cdot 10^{11}$ | 0.40 | 46.0 | 0.46 | 5 | 101262 |
| $\nu_e(\gamma = 100)$ | $4.06 \cdot 10^{11}$ | 0.38 | 65.4 | 0.44 | 5 | 143887 |

M. Mezzetto, Nufact 05, LNF, 21-26 June 2005, 3

# Analysis: GLoBES + M. Mezzetto's parameterization file

440kT x 5yrs: 2,2 Mt.yrs (+)

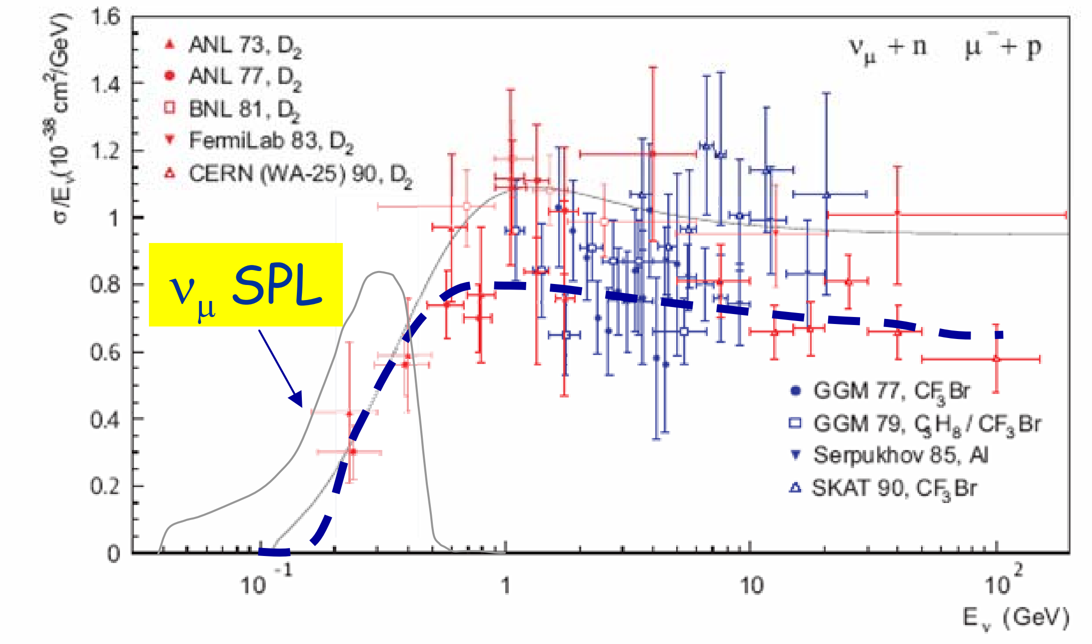
| | $\theta_{13}$ = 1° | $\theta_{13}$ = 3° | $\sin^2 2\theta_{13}$= 0.05 | |
|---|---|---|---|---|
| $\nu_\mu \to \nu_e$ **(Sig)** | **33** ($\delta = \pi/2$) | **330** ($\delta = \pi/2$) | **2200** ($\delta = \pi/2$) | **3670** ($\delta = 0°$) |
| $\nu_\mu \to \nu_e$ **(Bkg)** | **1500** | | | |
| | $\nu_e \to \nu_e$ CC | $\pi^0$ from NC | $\nu_\mu \to \nu_\mu$ CC ($\mu$ missId) | $\bar{\nu}_e \to \bar{\nu}_e$ CC |
| Frac. of Bkg | 90% | 6% | 3% | 1% |
| Reduction Factor | 0.707(1060) | 6.5 $10^{-4}$(90) | 5.4 $10^{-4}$(45) | 0.677(15) |
| $\nu_\mu \to \nu_\mu$ **(Sig)** | **64950** ($\delta = \pi/2$) | | **64414** ($\delta = 0°$) | |
| $\nu_\mu \to \nu_\mu$ **(Bkg)** | **3** (4.310$^{-5}$ $\bar{\nu}_\mu \to \bar{\nu}_\mu$ CC) | | | |

$\sin^2 2\theta_{12}=0.82$, $\theta_{23}=\pi/4$, $\Delta m^2_{21}=8.1\ 10^{-5} eV^2$, $\Delta m^2_{31}=2.2\ 10^{-3} eV^2$

Reduction factor and efficiencies taken from SK simulation (D. Casper) and a tight cut for e/$\mu$ misId. (cf. hep-ph/0105297)

# The X-sections

V.V. Lyubushkin et al., internal NOMAD memo




---: Lipari et al.

PRL**74**(95)4384

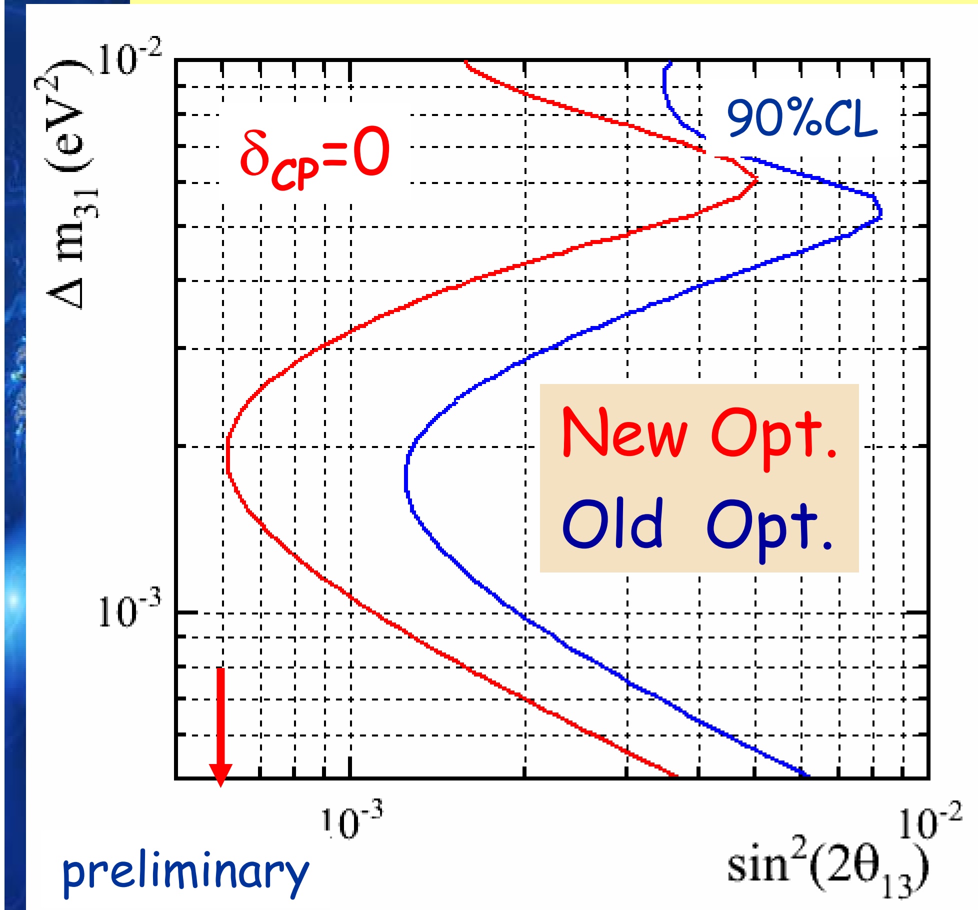
on $H_2O$

$\beta$B is an ideal tool to measure these cross-sections and a 2% systematic error on both signal and background are used.

Require close position

# Some physics performances

440kT water Č, 4MW SPL, GLoBES




## 5yrs (+)

True values: **($\Delta m^2_3$, $\sin^2 2\theta_{13}$)**

**$\sin^2 2\theta_{12}$**=0.82, $\theta_{23}=\pi/4$, $\Delta m^2_{21}$=8.1 $10^{-5}eV^2$

**5%** external precision on $\theta_{12}$ and $\Delta m^2_{21}$ **and use SPL disappearance channel and spectrum analysis***

2% syst. on signal & bkg

**$\text{Sin}^2 2\theta_{13}$(90%CL) = 6 $10^{-3}$ (0.7°)**

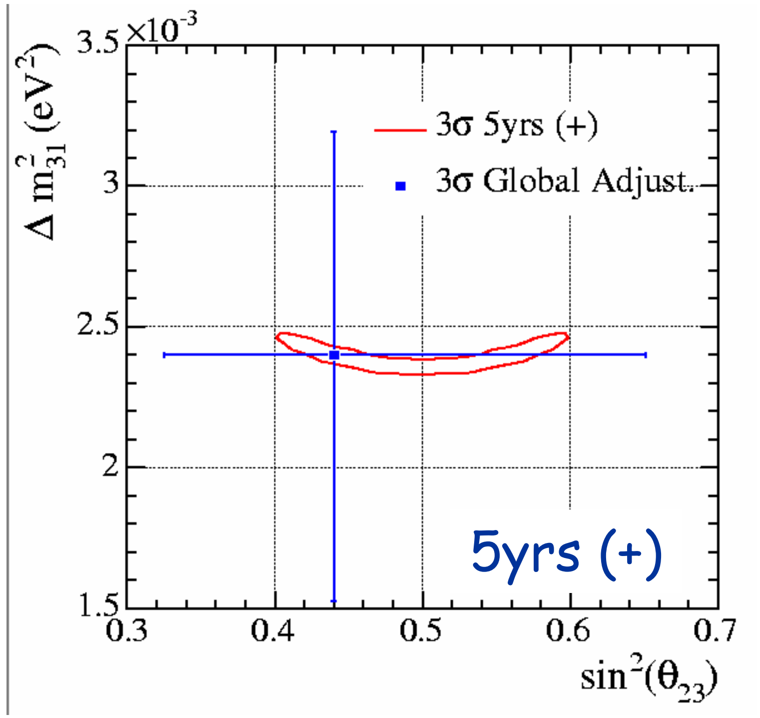
## sizeable improvement

*: 5 bins [0.08,1.08] GeV

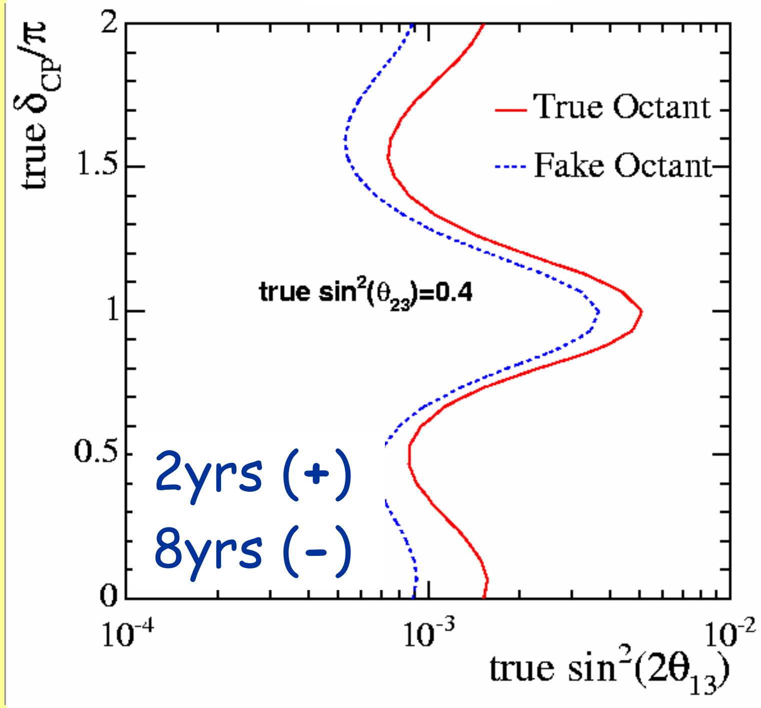
($\chi^2$(2dof)=4.6 or 11.83)

# Other expected performances

$\Delta m^2_{31}$ & $\sin^2\theta_{23}$ measurements




$3\sigma\ \theta_{13}\neq 0$



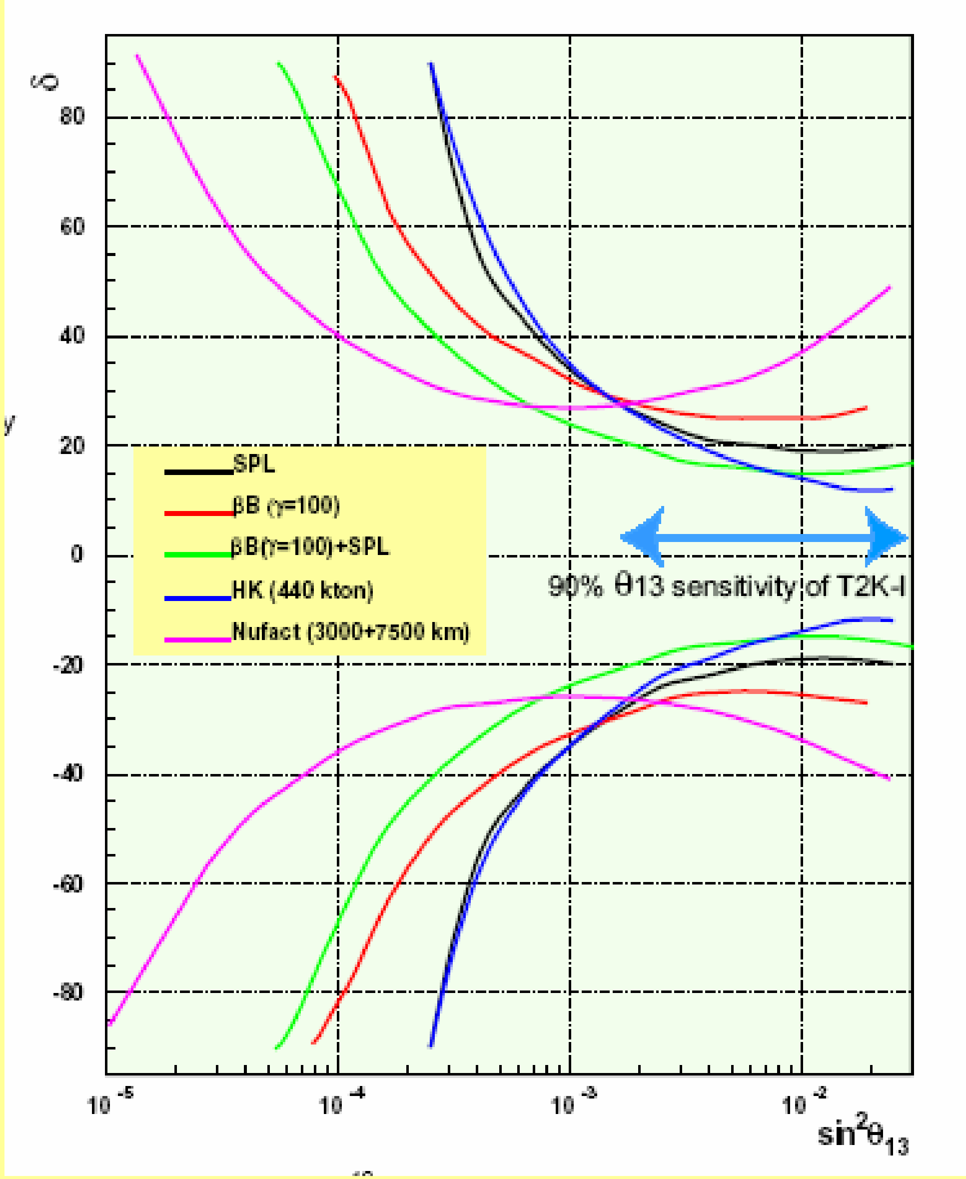
# Comparison with other facilities

Everything computed with the identical program. Thanks to the GLoBES experiment library.

**HK** taken from Huber, Lindner and Winter, hep-ph/0204352, with a fiducial of 440 kton (it was 1 Mton), 2% systematics on QE signal and backgrounds (it was 5%) and 2+8 years running (it was 2+6).

**NUFACT** taken from Huber, Lindner and Winter, hep-ph/0204352, changing the systematics from 0.1% to 2% and the running time to 5+5 years (it was 4+4). Other parameters: two iron magnetized detectors, 50 kton, at 3000 and 7500 km, 50 GeV muons, 1E21 useful decays/year, 5% systematics on matter profile, threshold at 4 GeV, 20 bins from 4 to 50 GeV.

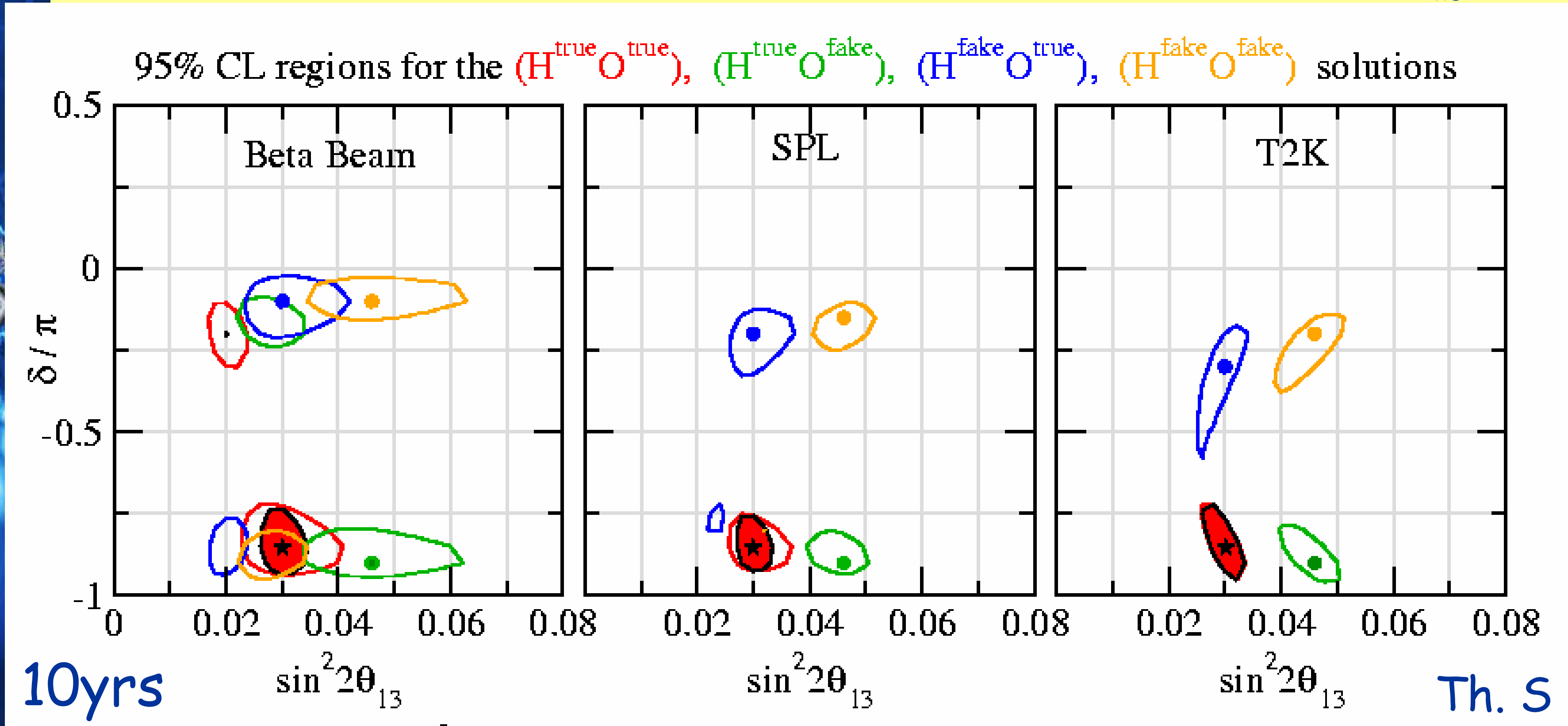
**SPL 3.5 GeV** (see J.E. Campagne talk) with 2 $\nu$ + 8 $\overline{\nu}$ years, 2% systematic error, 200 MeV binning, 440 kton fiducial.

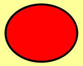



M.M@NuFact05

# Remove ambiguities with ATM ν

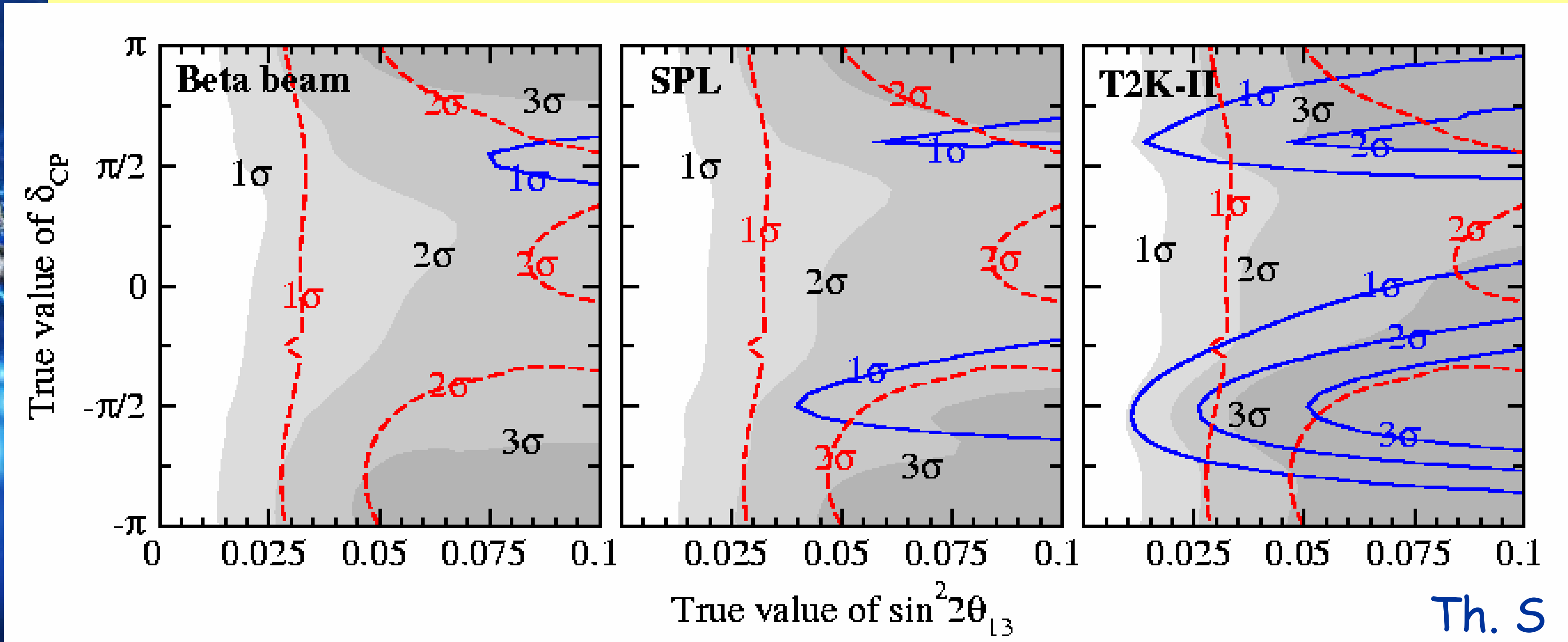
Favorable case $\sin^2\theta_{23}$=0.6




 Contour after ATM combination

*: true value

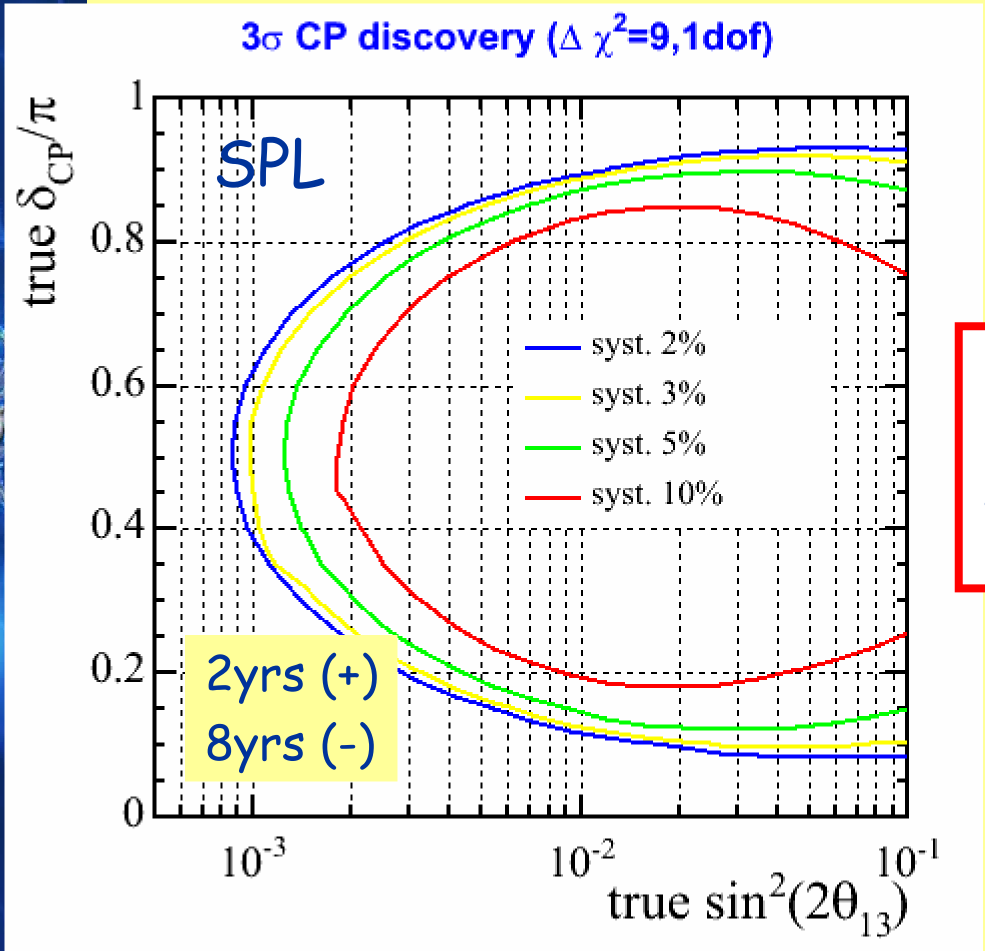
# Mass hierarchy sensitivity




- - - Atm.
— LBL
▇ Atm+LBL

T2K-II takes benefit of more matter effect

# Effect of the systematic (sig. & bkg)

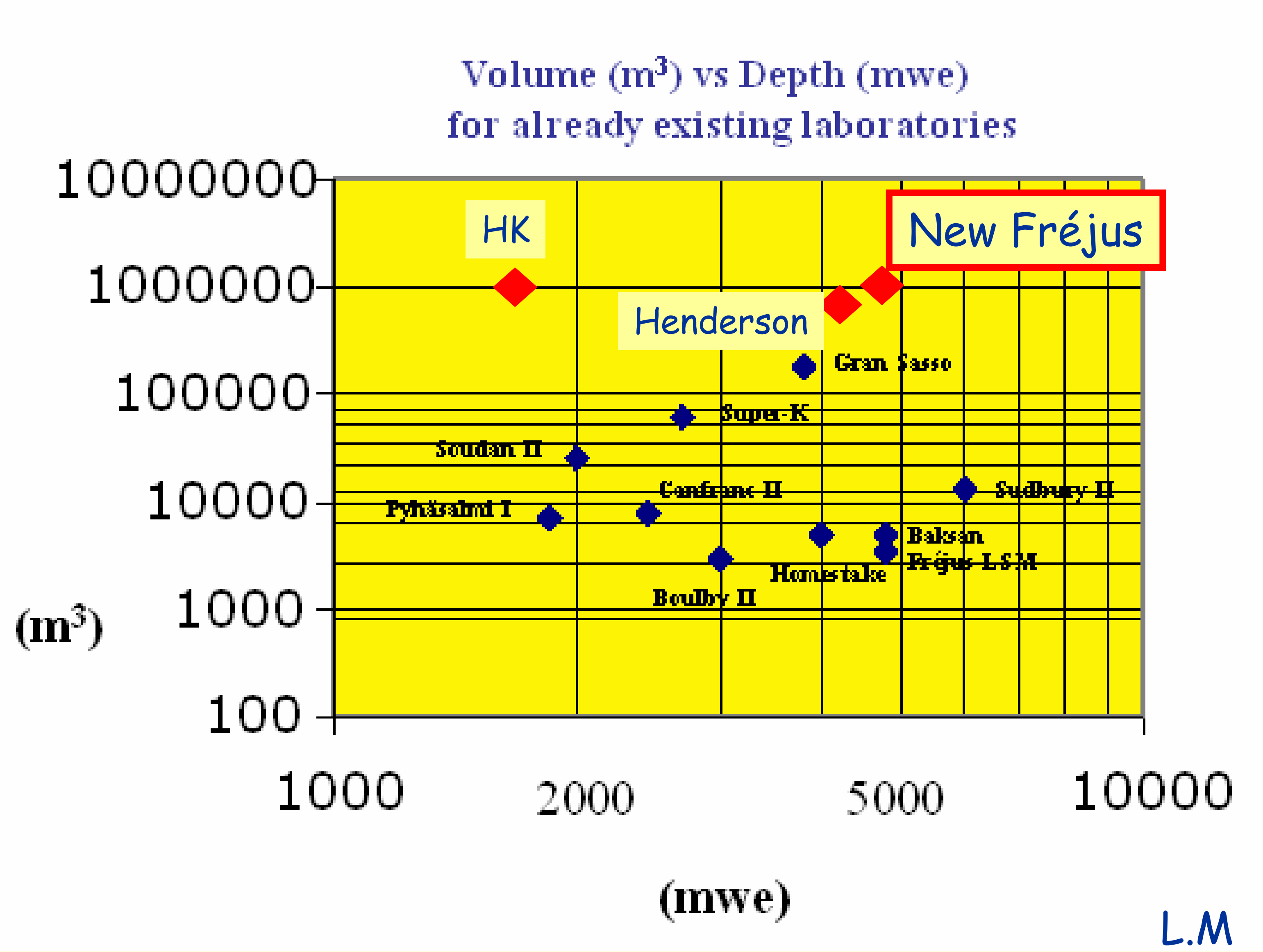



**Much more dramatic than ambiguities**

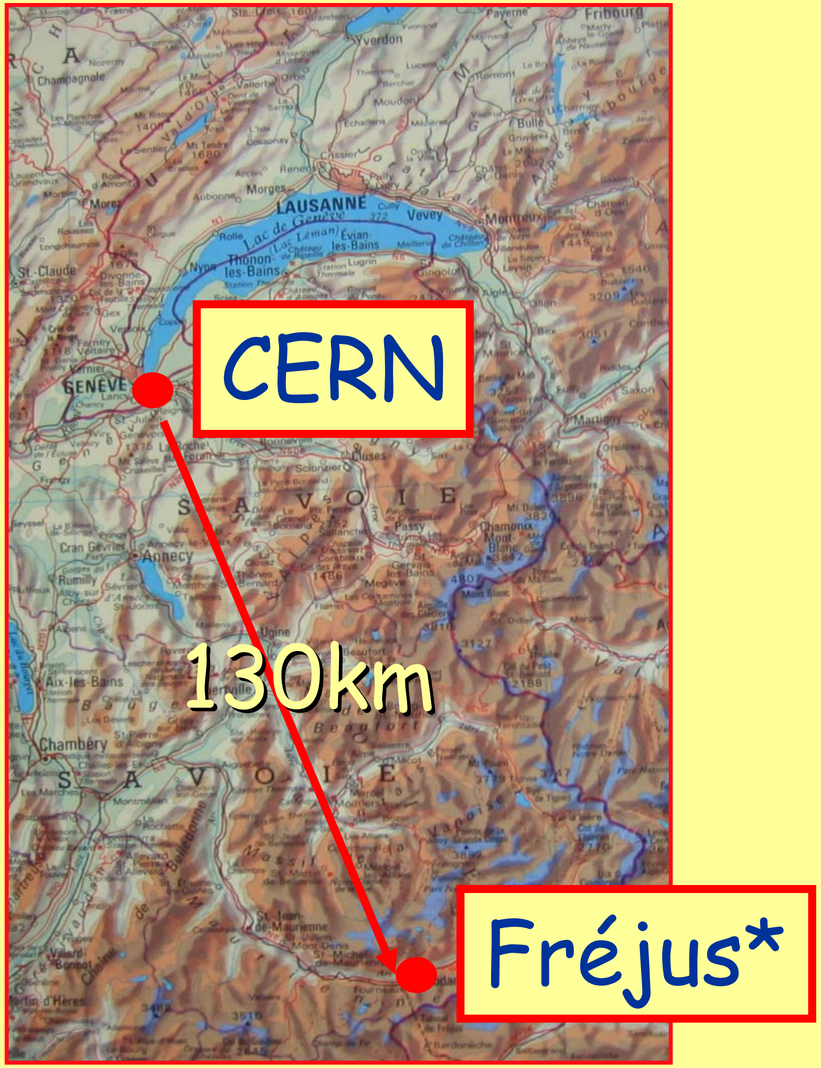
Old opti. is 3x worse

True values: ($\delta/\pi$, $\sin^2 2\theta_{13}$)
$\sin^2 2\theta_{12}$=0.82, $\sin^2\theta_{23}$=0,4
$\Delta m^2_{21}$=7.9 $10^{-5}$eV$^2$, $\Delta m^2_{31}$=2.4 $10^{-3}$eV$^2$
**5%** external precision on $\theta_{12}$ & $\Delta m^2_{21}$
use SPL disappearance channel and spectrum analysis

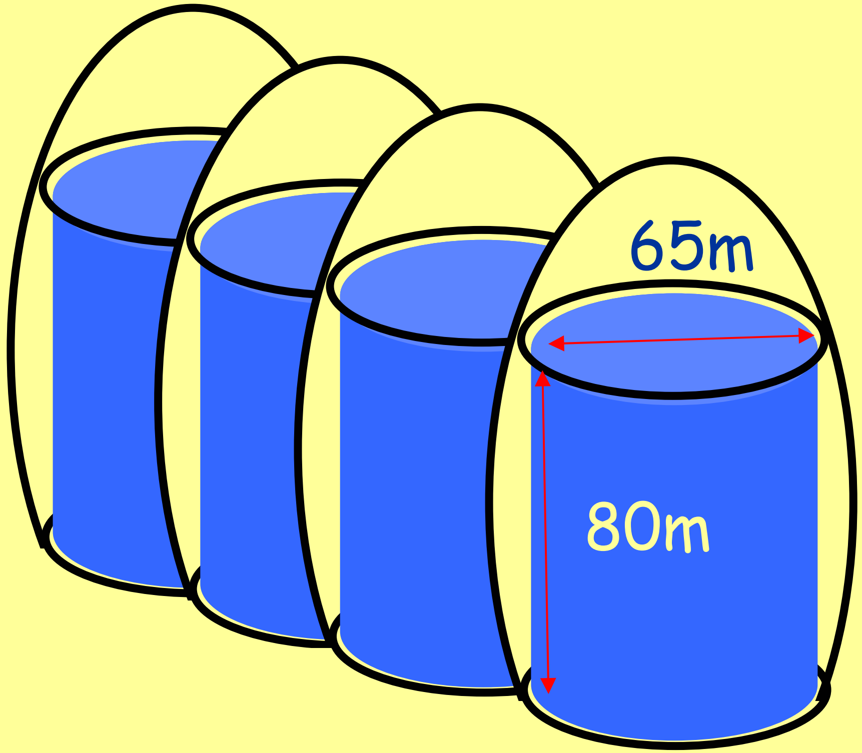
# Fréjus site possibility



# New Fréjus Cavern (MEMPHYS)




*: Modane




$4 \times 250{,}000 m^3$ $H_2O$

Based on well experienced engineer studies. First cost estimate soon

# Photodetector R&D in France

- R&D launched after NNN05 but based on on-going R&D with Photonis
- IPN-Orsay, LAL & Photonis together in an official GIS to develop Smart-Photodetectors (*ie electronic up to ADC/TDC included*): 6 engineers + 2 post-docs + Photonis engineers
- 200k€/3yrs has been asked at the new National Research Agency (ANR)

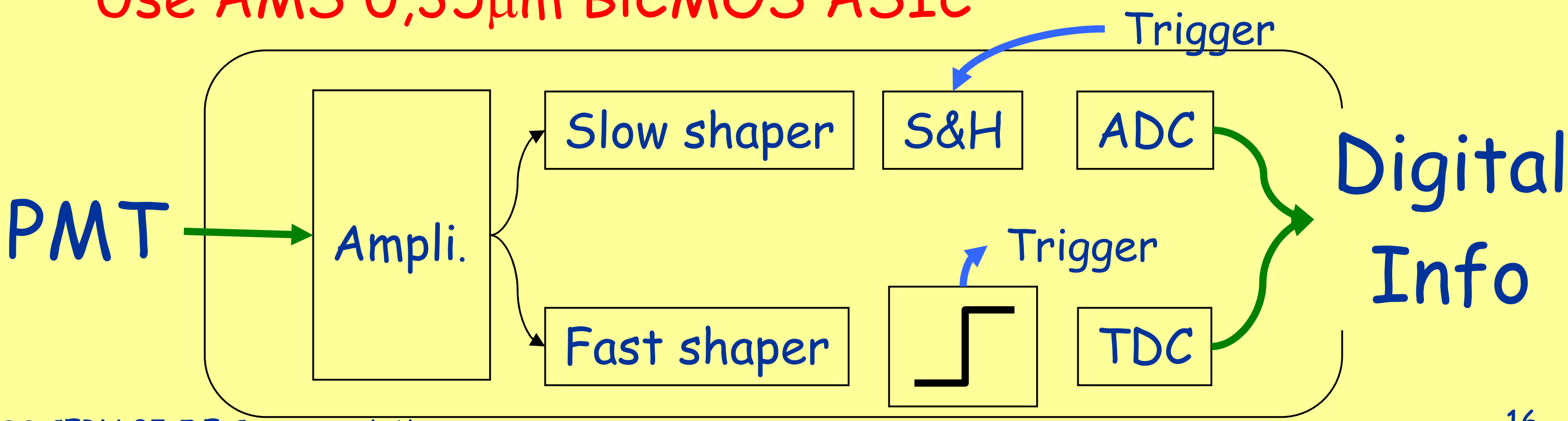
Photonis @ NNN05: 500,000 PMT -12"- 800€/u

Target electronics + HV: 200€/channel

# Electronics

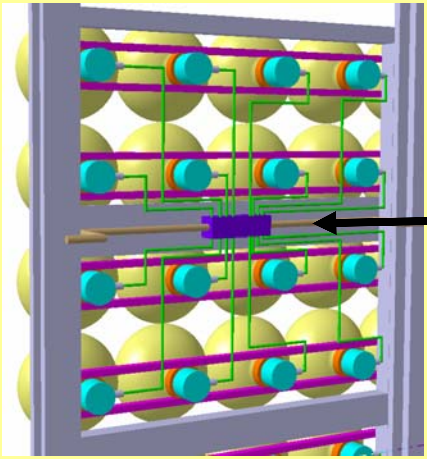
Taken in charge by LAL: from amplifier up to ADC/TDC
based on past experience with similar state of the art front-end electronics developed for OPERA, W-Si ILC prototype, LHCb…

- Trigger @ $\frac{1}{4}$ p.e (3kHz from SK)
- TDC: 12bits 0,4ns/c
- ADC: 12bits 0,15pC/c with 1 p.e @ 20-30 adc channels.
- High speed digital readout
- Cost reduction thanks to high level of integration
- Use AMS 0,35μm BiCMOS ASIC

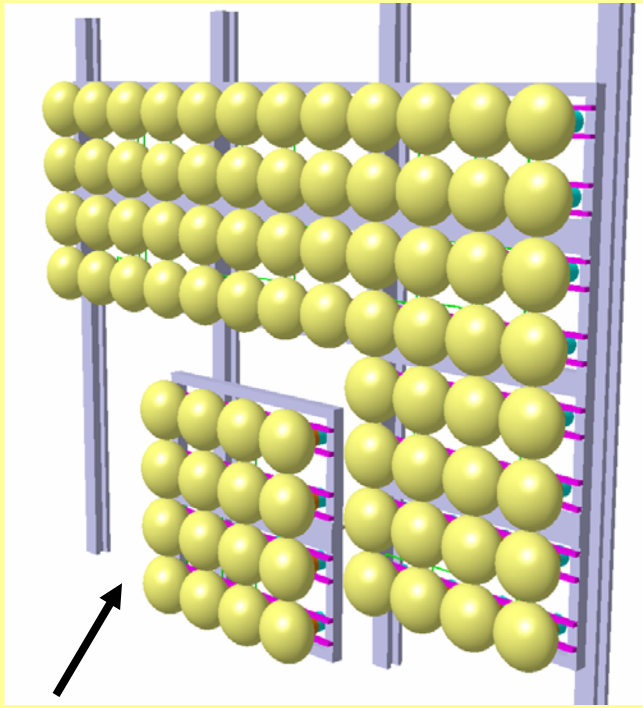


# Mechanics

Taken in charge by IPNO: well experienced in photodetectors (last operation: Auger). With PHOTONIS tests of **PMT** 8", 9" → **12"** and Hybrid-PMT and HPD



Electronic box water tight



Basic unit that we want to build and test under water

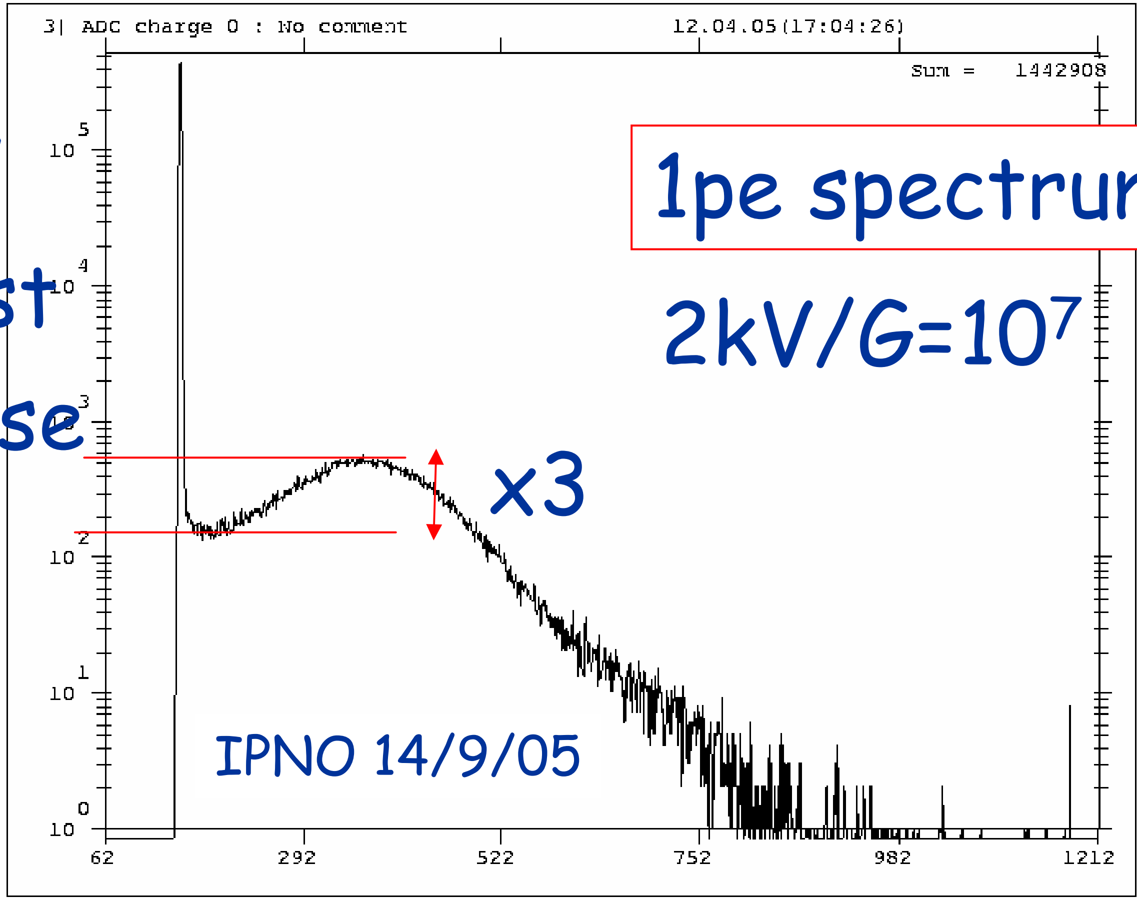
IPNO

# Some PMT characteristics measurements

XP1806 8"

Not the best

Not the worse




g=25 before ADC

No diff. 5",8",10" so 12" should be identical