LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

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

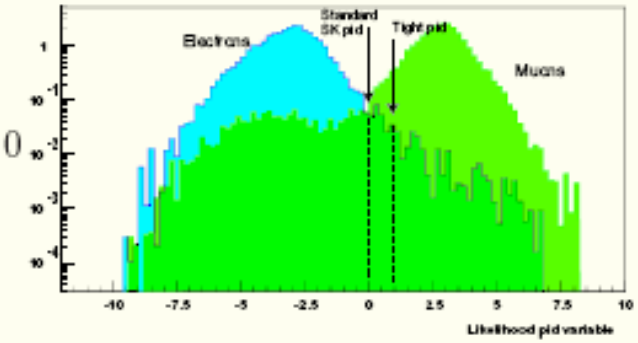
- 440kT Water Č located 130km from CERN (see site later)
- Essentially SK analysis with tighter cuts for e/μ id (cf. hep-ph/0105297)
- Use energy resolution dominated by Fermi motion* (200MeV bins)
- 2% systematics on signal & bkgd (see effect later)
- Optimized machine versions: βB (M. Mezzetto) and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

*: migration matrix for βB

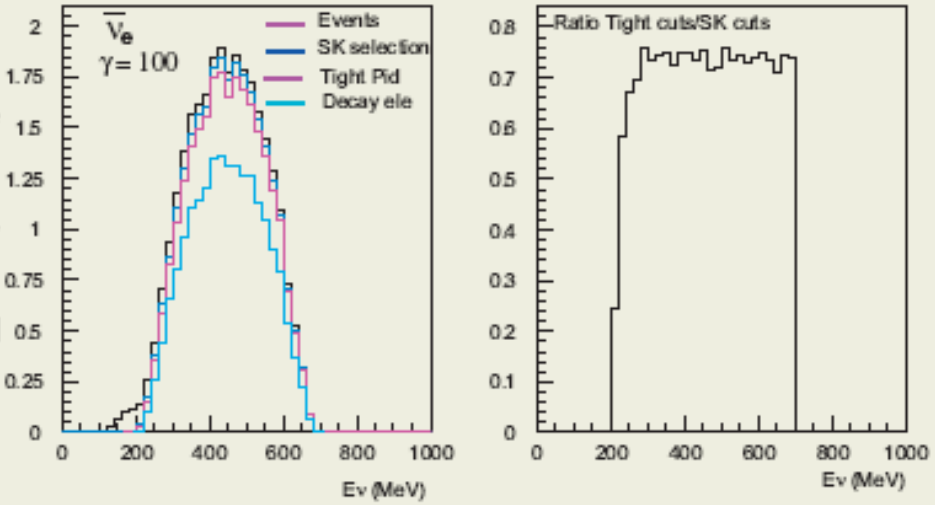
Particle Id (from M. Mezzetto)

Electron/muon misidentification must be suppressed much more than in standard SK analysis to guarantee a negligible background level.

Pid in SK is performed through a Likelihood, $Pid > 0$ identifies muons. Use $Pid > 1$



To further suppress electron background ask for the signal of the Michel electron from μ decay.
Final efficiency for positive muons. Negative muons have an efficiency smaller by $\sim 22\%$ because can be absorbed before decaying. Electron background suppressed to $\sim 10^{-5}$.



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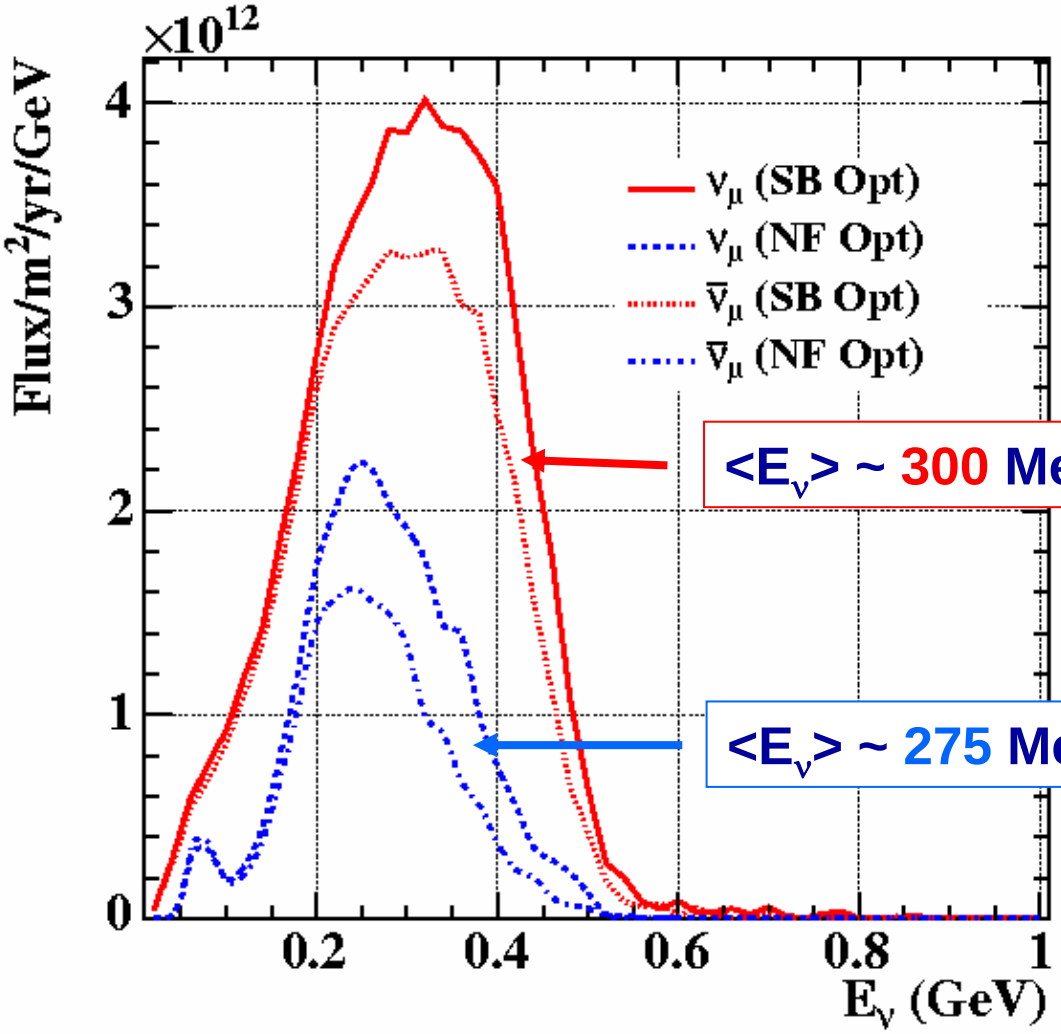
Fluxes comparison @ 130km



~95 ν_μ^{CC}/kT/yr*

<E$_\nu$> ~ 300 MeV, 1.2 10^{12}/m²/yr

3.5GeV SPL optimum

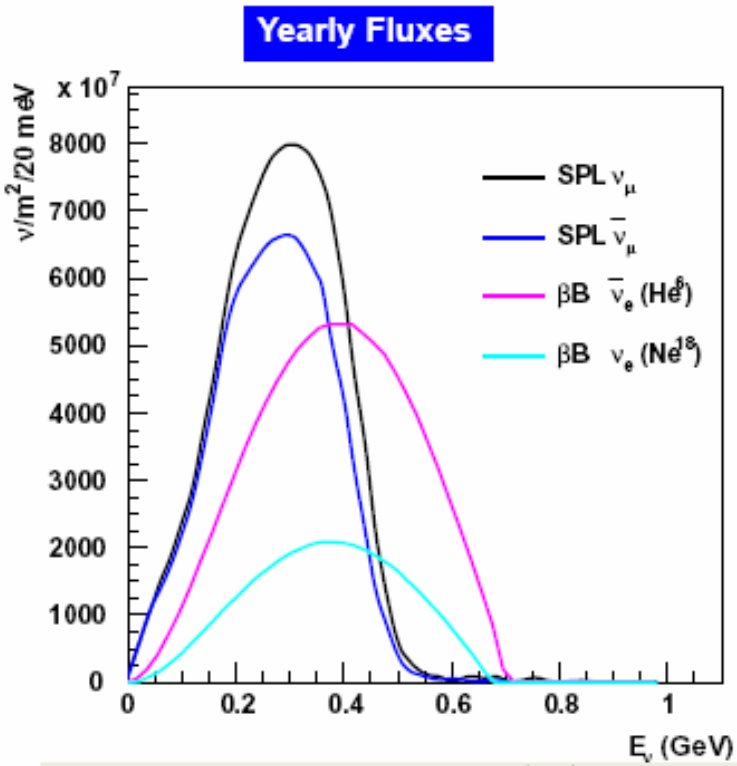
<E$_\nu$> ~ 275 MeV, 4.5 10^{11}/m²/yr

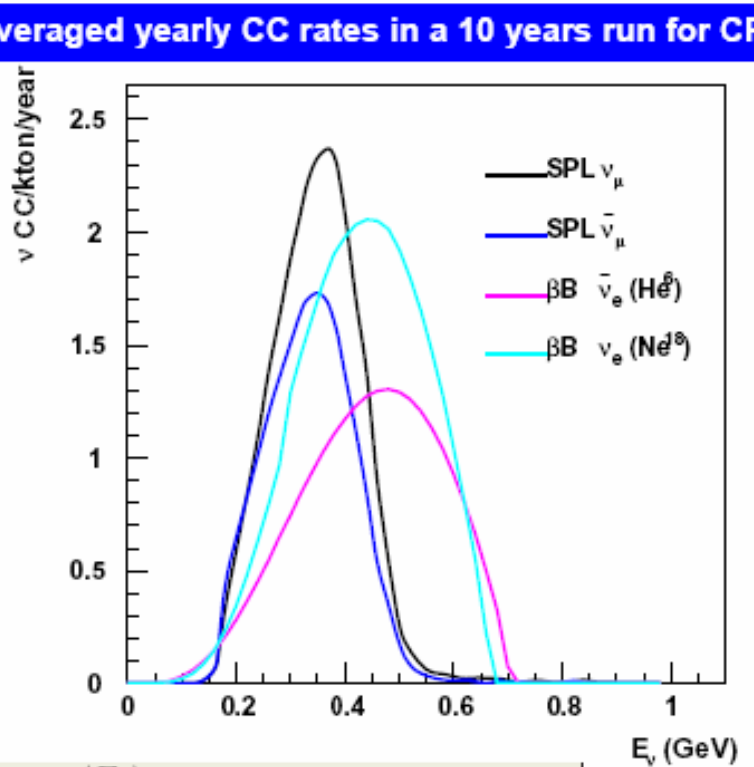
Old νFact optimum

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			
ν_μ	$11.80 \cdot 10^{11}$	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

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Analysis: GLoBES + M. Mezzetto's parameterization file

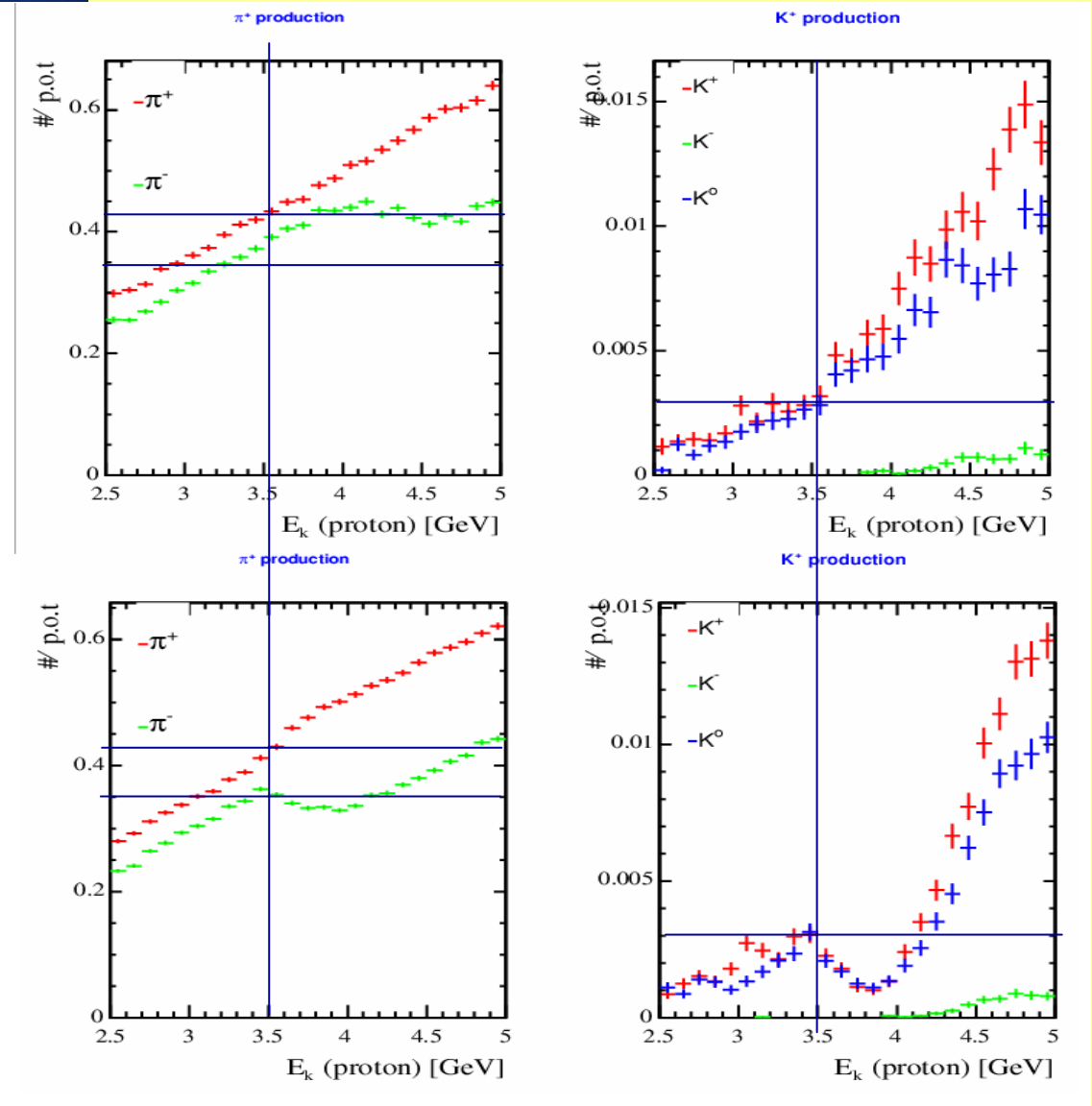
440kT x 5yrs: 2,2 Mt.yrs (+)

$\nu_\mu \to \nu_e$ (Sig)	$\theta_{13} = 1°$	$\theta_{13} = 3°$	$\sin^2 2\theta_{13} = 0.05$	
	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	π^0 from NC	$\nu_\mu \to \nu_\mu$ CC (μ 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/μ misId. (cf. hep-ph/0105297)

Kaon/pion production?



FLUKA 2005.6

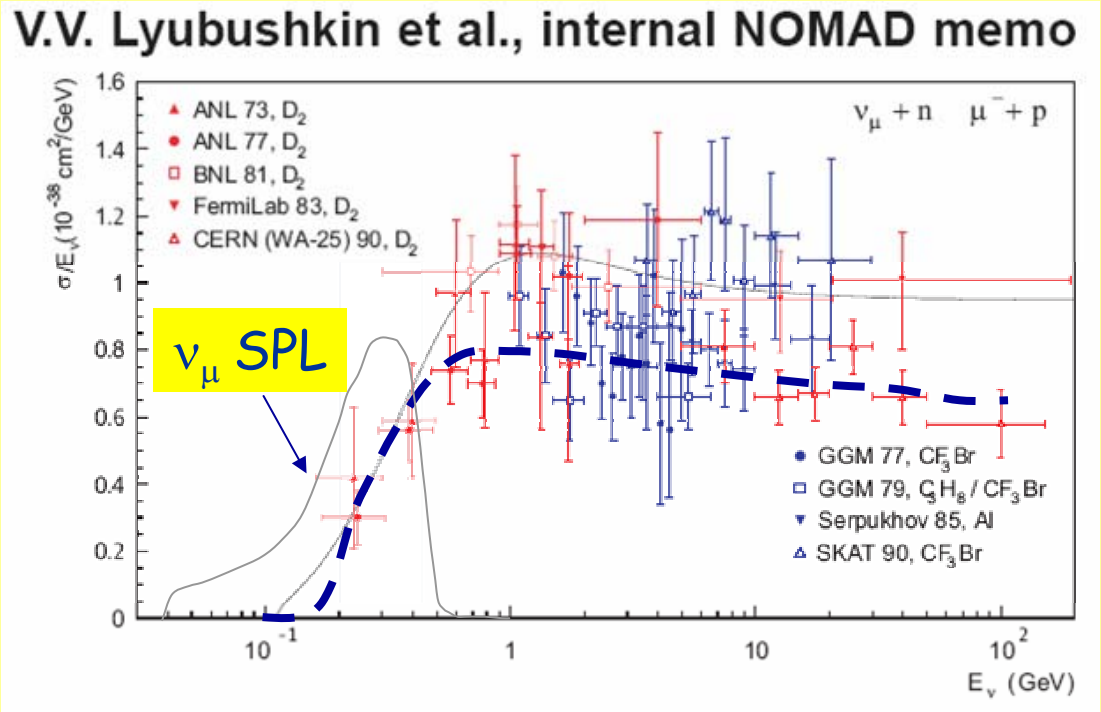
+12.5% π^- @3.5GeV

Big difference [3.5 ÷ 4.5] GeV

FLUKA 2002.4

HARP?

The X-sections



---: Lipari et al.

PRL**74**(95)4384

on H_2O

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

Require close position

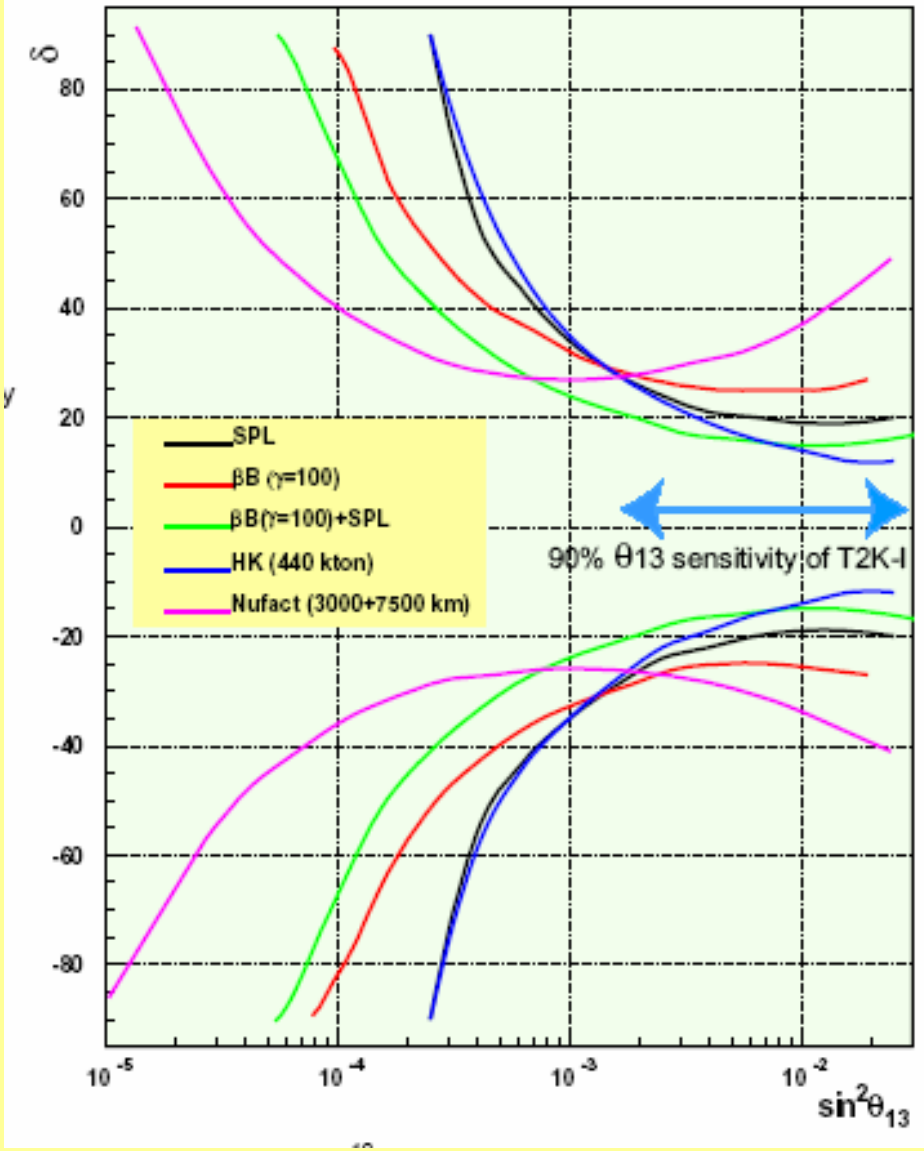
Comparison with other facilities

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.

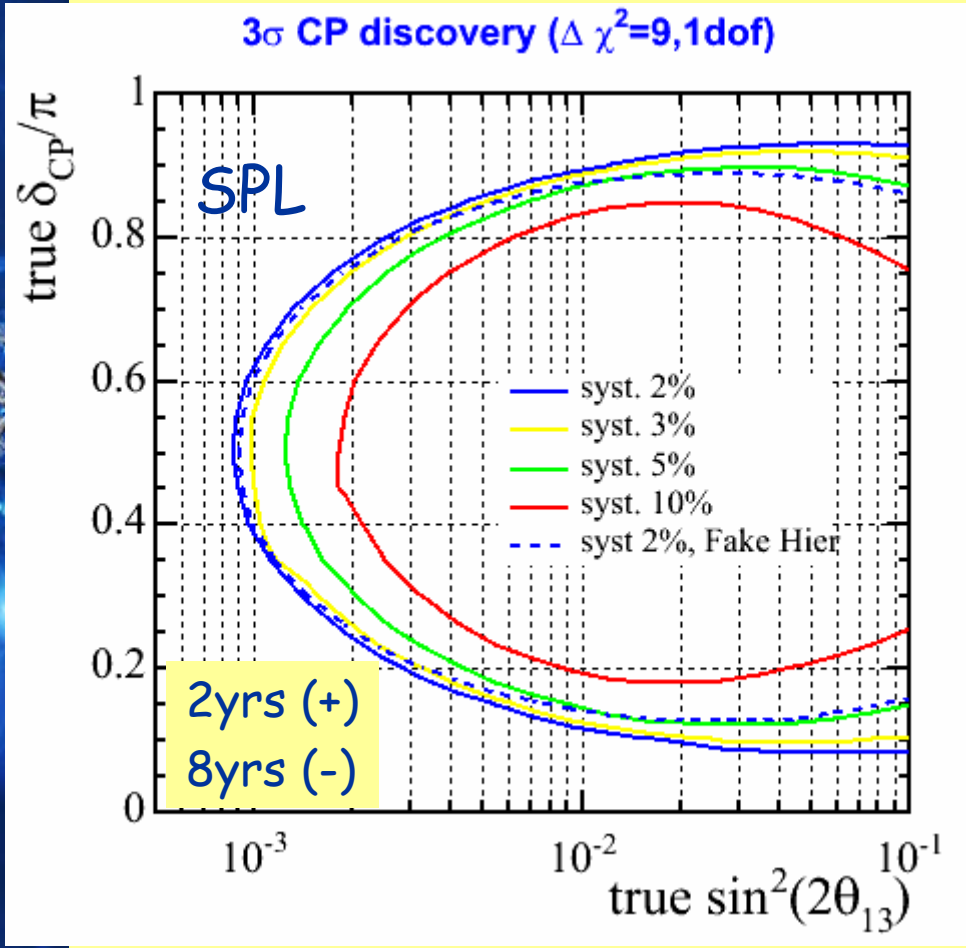
SPL 3.5 GeV (see J.E. Campagne talk) with 2 ν + 8 $\overline{\nu}$ years, 2% systematic error, 200 MeV binning, 440 kton fiducial.



M.M@NuFact05

Systematics...

Effect of the systematic (sig. & bkg)

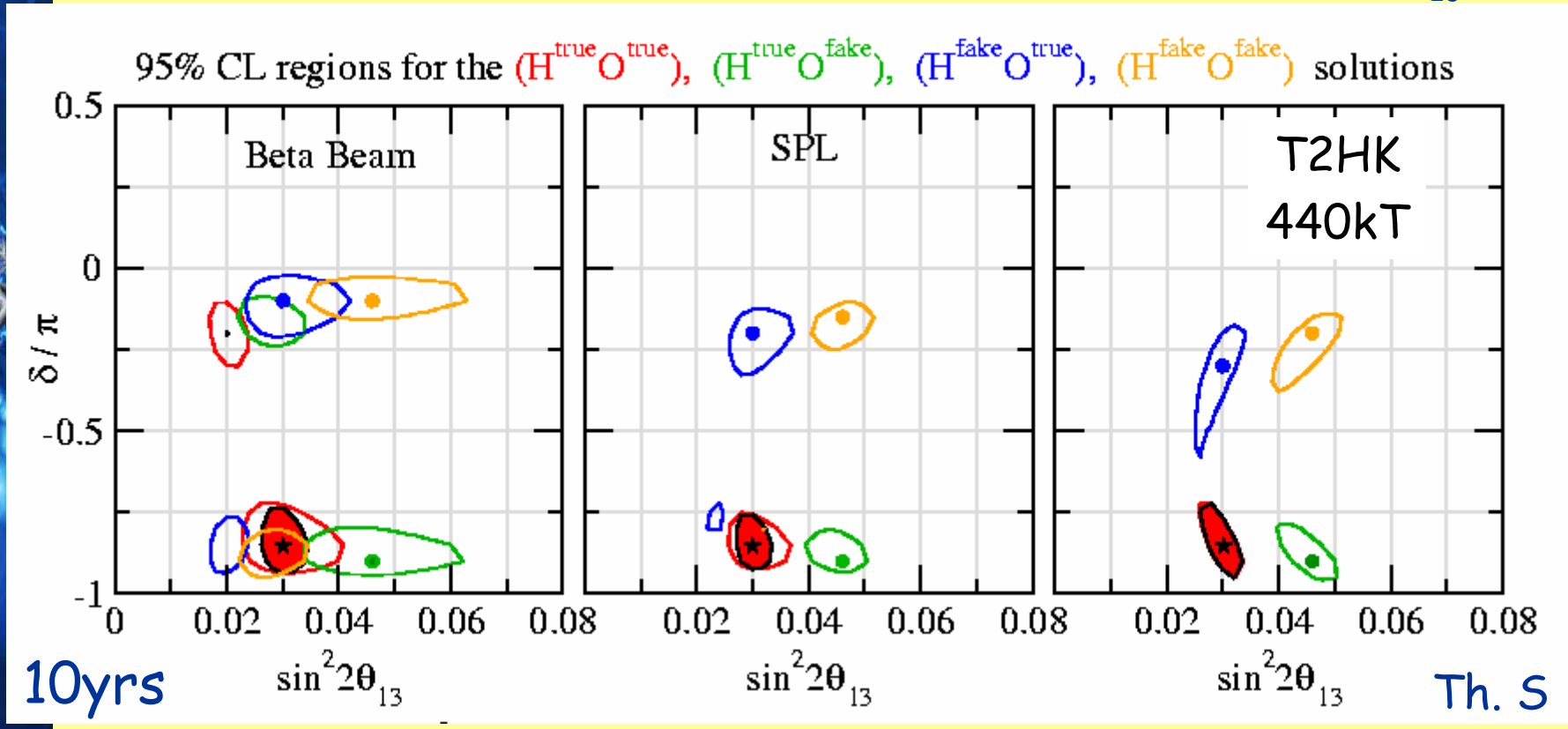


Much more dramatic than ambiguities at small θ_{13}

True values: **(δ/π, $\sin^2 2\theta_{13}$)**
$\sin^2 2\theta_{12}$=0.82, $\sin^2\theta_{23}$=0,4
Δm^2_{21}=7.9 10^{-5}eV², **Δm^2_{31}**=2.4 10^{-3}eV²
5% external precision on θ_{12} **&** **Δm^2_{21}**
use SPL disappearance channel and spectrum analysis

Remove ambiguities with ATM ν

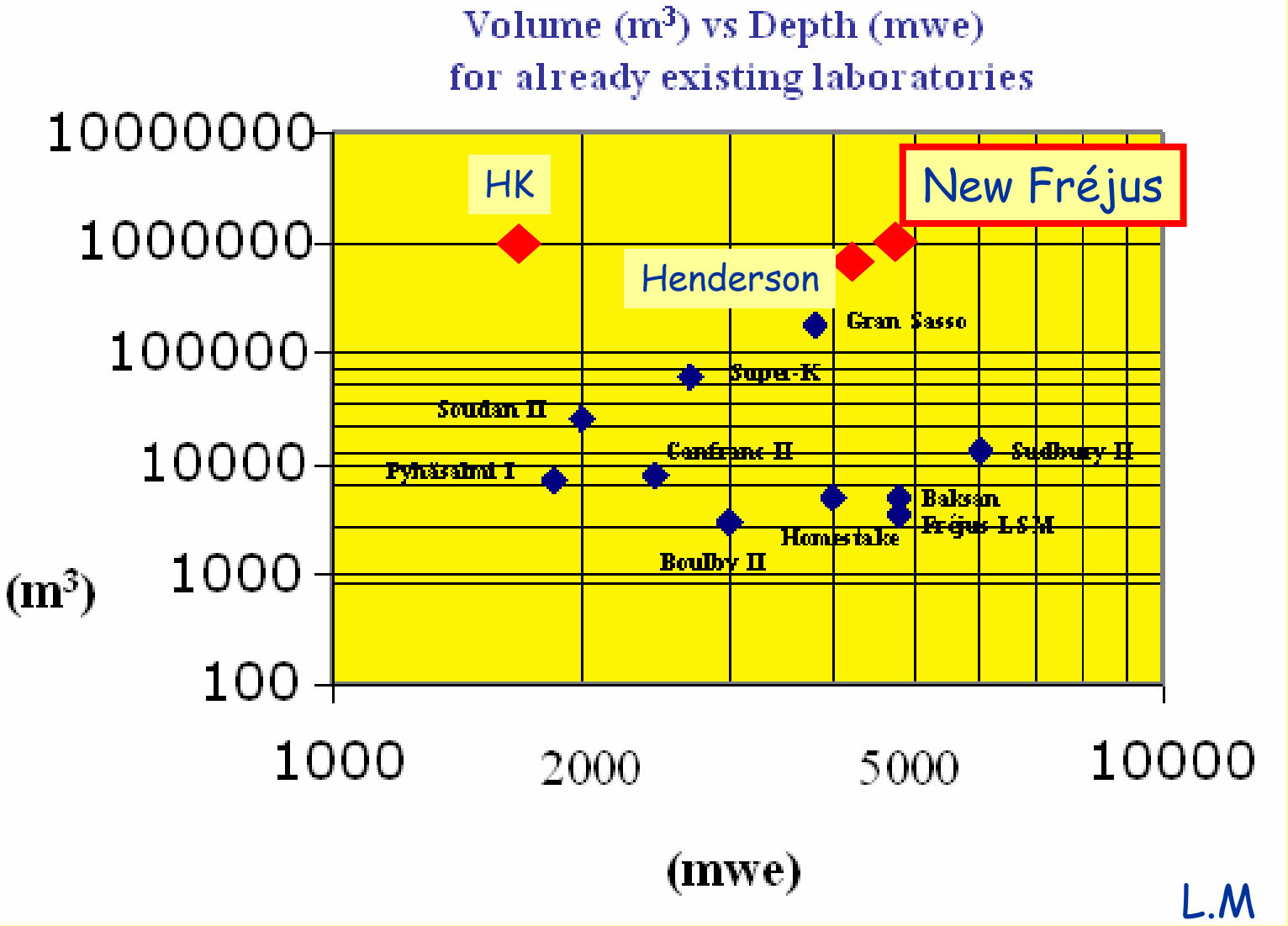
Favorable case $\sin^2\theta_{23}=0.6$



Contour after ATM combination

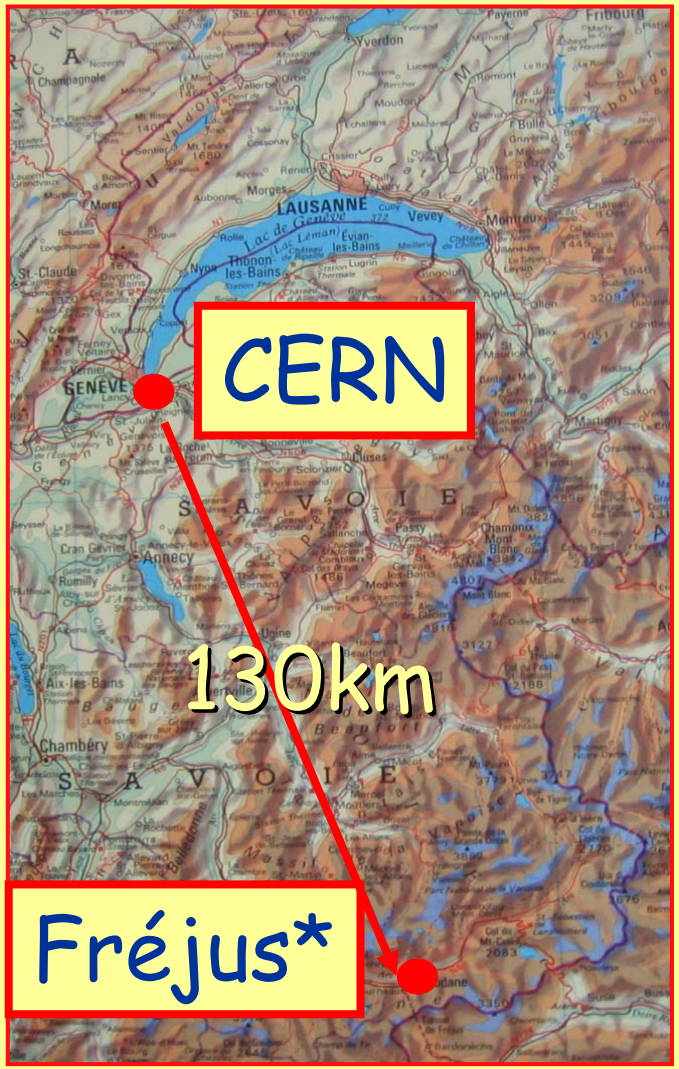
*: true value

Fréjus site possibility

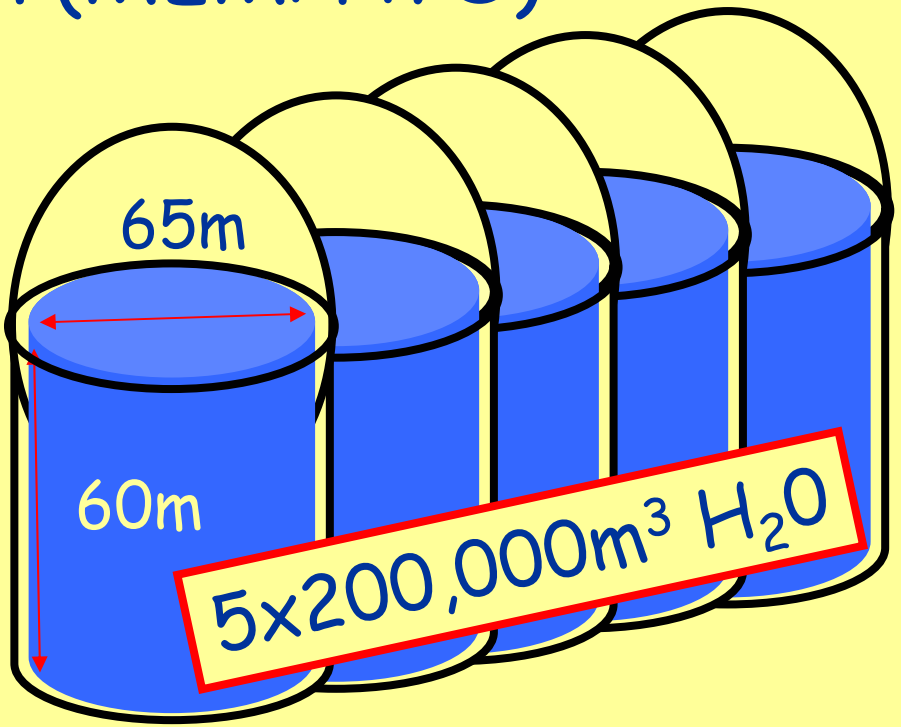


L.M

New Fréjus Cavern (MEMPHYS)



*: Modane 4800mwe



Based on well experienced civil engineer studies.

First cost and time estimate will come soon for a dedicated operation.

Beyond that a Design Study is needed

PMT size <=> cost

Photonis @ NNN05

Diameter	20"	<=>	(20")17"	<=>	12"	
projected area	1660		1450		615	cm^2
QE(typ)	20		20		24	%
CE	60		60		70	%
Cost	**2500**		**2500**		**800**	**€**

- *Cost/cm² per useful* PE_U = cost/(cm^2 x QE x CE)

12.6 **14.4** **7.7**

€/PE_U/cm^2

Quantities and total cost

Photonis @ NNN05

20" ***200,000*** x € 2500 = 500M

12" 540,000 x €800 = ***432M***

Comment:

one should integrate the electronic + HV price

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

New pump capacity needed?

Delivery over 6 years

Photonis @ NNN05

300 working days/year

1. *20" tube*

   50,000/6/300 => 28 good tubes x yield 0.7 = 40 starts/day

   (1 start/pump/day) => 40 pumps (€ 7M or so)

1. *12" tube*

   135,000/6/300 => 75 good tubes x yield 0.7 = 110 starts/day.

   A multi-array computerised pump at Photonis handles 20 starts/day

   => 6 pumps (€ 2M or so)

Comment: x4 the PMT numbers

+ Sub-conclusions

12" seems much better than 20"/17"

- *cost per useful photoelectron & total PMT cost*
- *Timing*
- *single-electron resolution (17" equal)*
- *granularity*
- *weight and handling*
- *implosion risk*
- *investments and start-up*

Photonis @ NNN05

Photonis has all the technical capability needed!

R&D cooperation: detailed & intensive talks are going on with the MEMPHYS collaboration to define a balanced programme

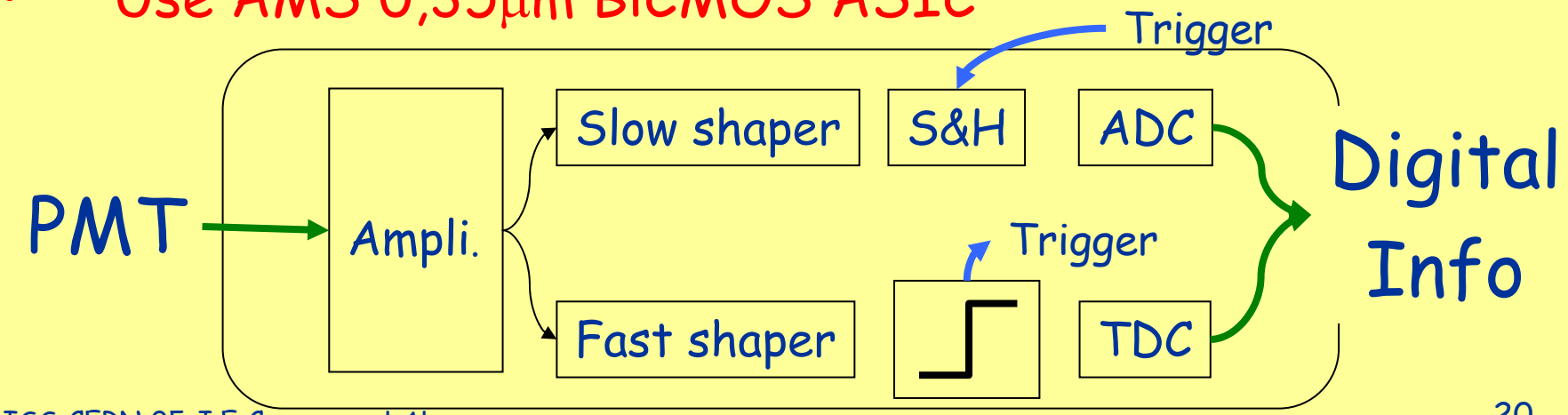
Workshop planned in the spring

Photonis @ NNN05

Electronics

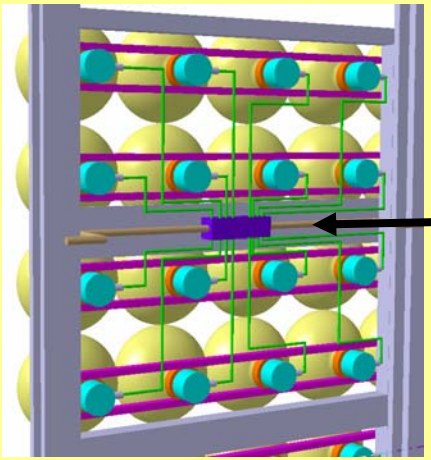
Taken in charge by LAL: from amplifier up to ADC/TDC based on past experience with similar state of the art front-end electronics developed for OPERA, W-Si ILC prototype, LHCb…

- 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

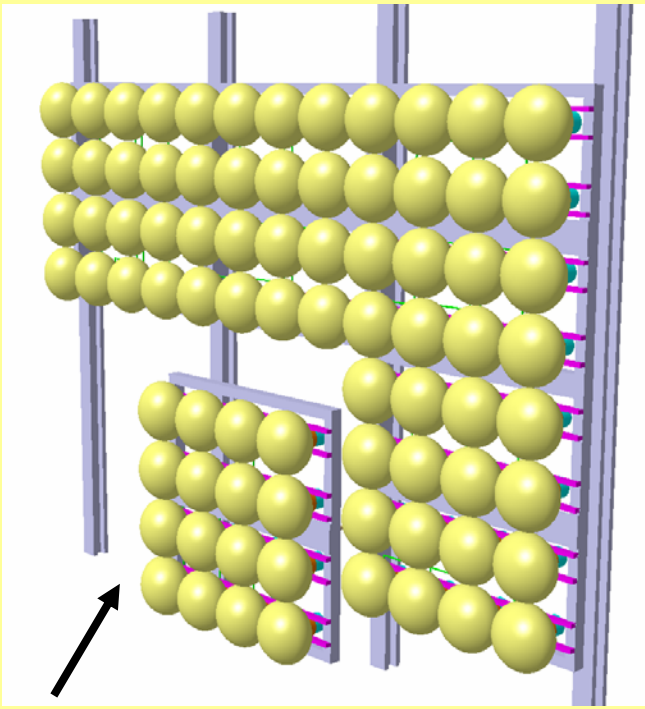


Mechanics & PMT tests

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



IPNO

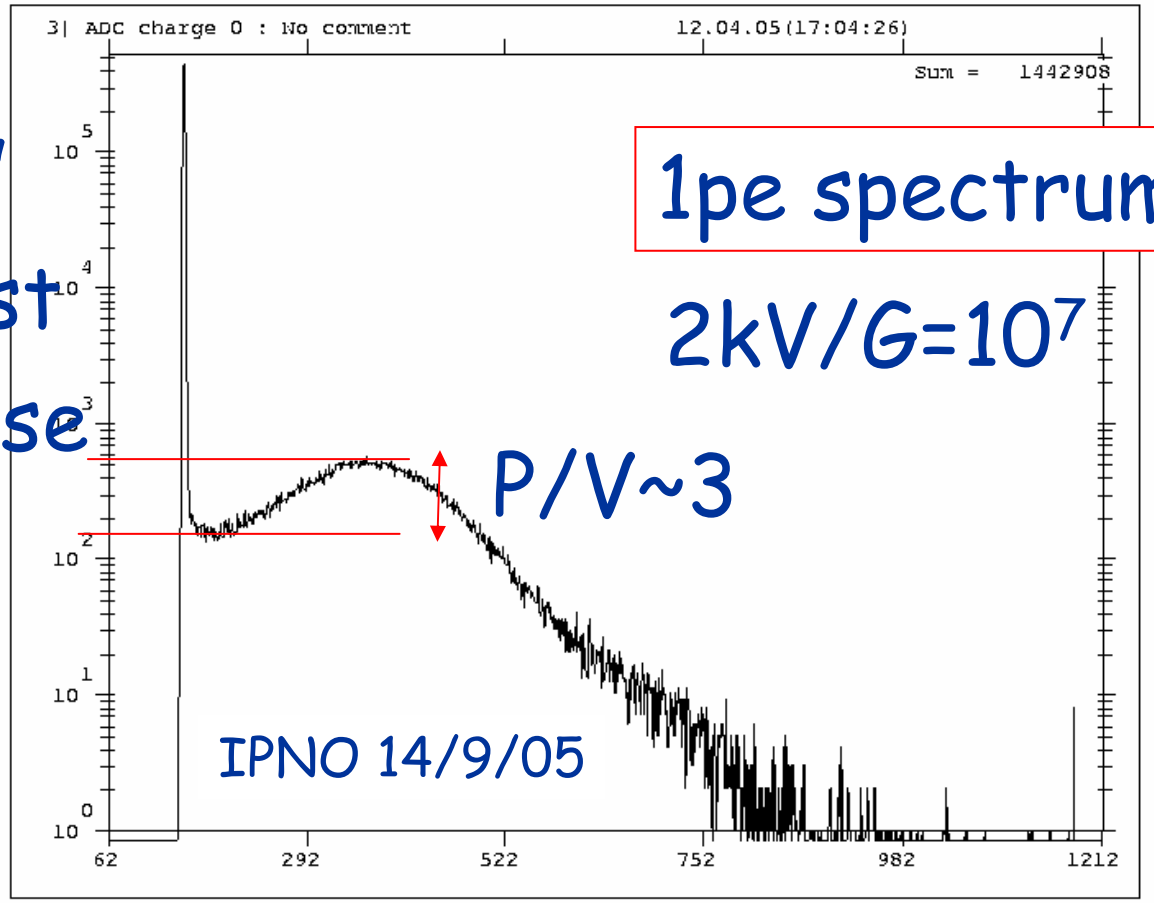
Basic unit that we want to build and test under water

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

Summary

The MEMPHYS Mt-scale Water Cerencov detector has a quite good accelerator neutrino program (not exposed here the Pdk and SN ν)

The R&D on photodetector is started in France and will come in 2006 with first version of "SmartDetector"

The Civil engineer pre-study for new Fréjus Lab. has been performed and seems encouraging (first costing will come soon)

Thank you