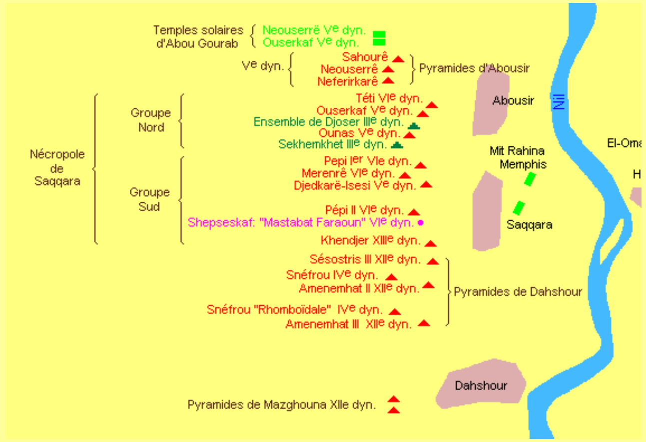
LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE
J.E Campagne

Sur la route de MEMPHYS…

- Some physics highlights
- Fréjus site & consequences
- French Photodetector R&D

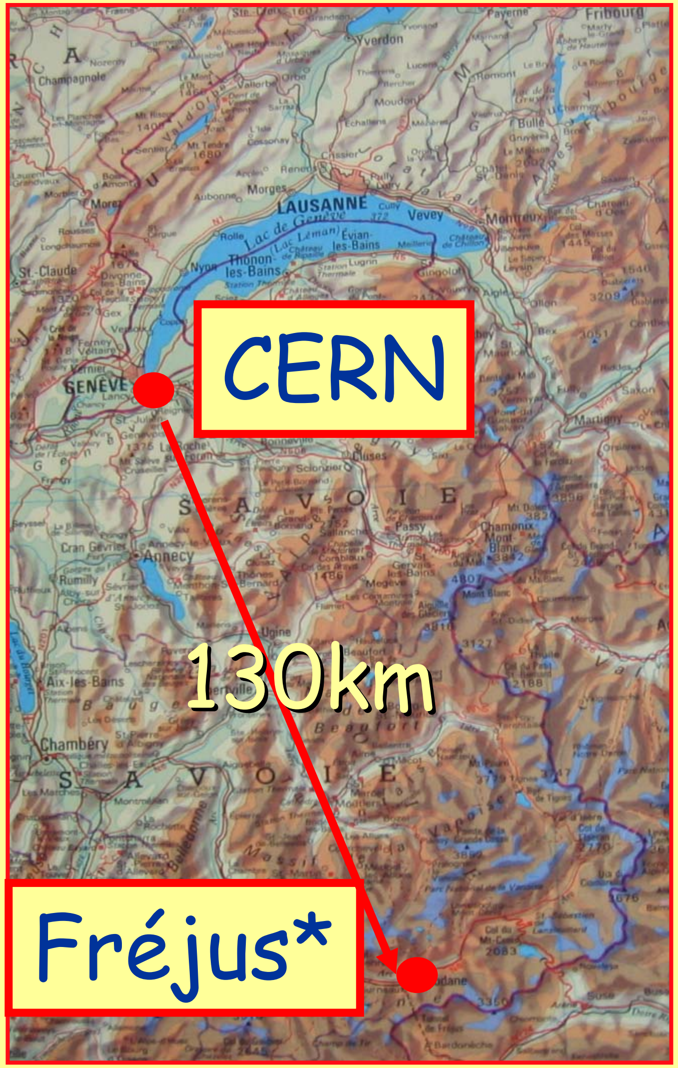
MEgaton Mass PHYSics

« La Bonne Place »

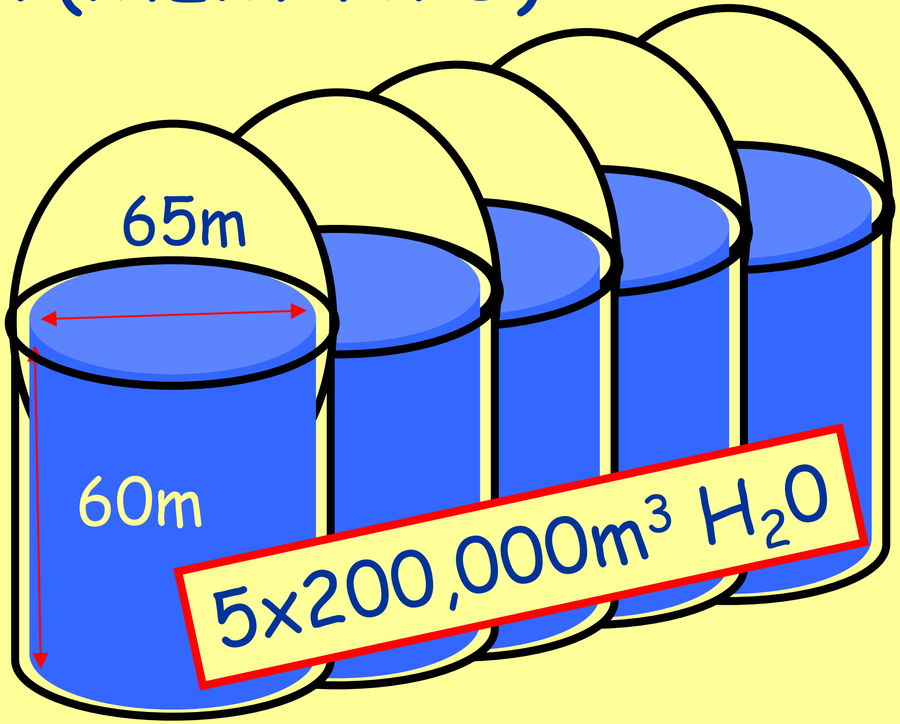


GDRν 20-21/10/05

New Fréjus Cavern (MEMPHYS)

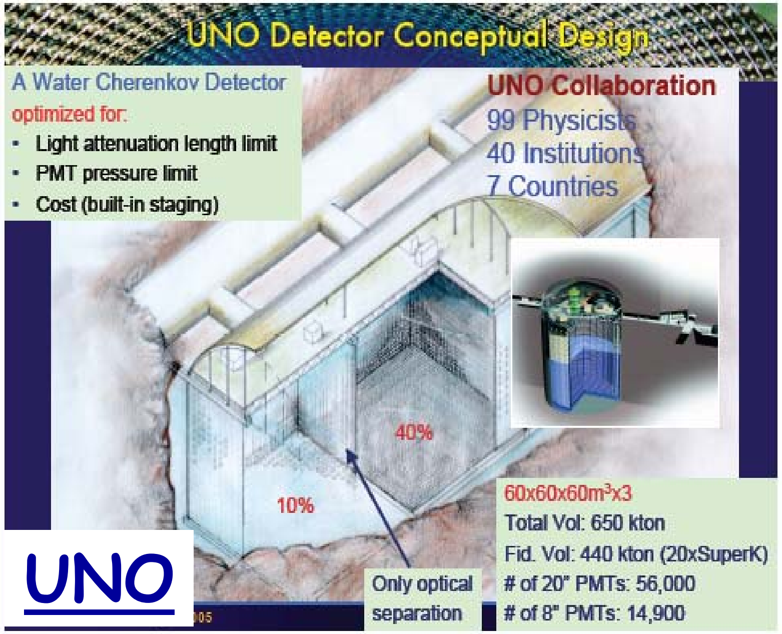


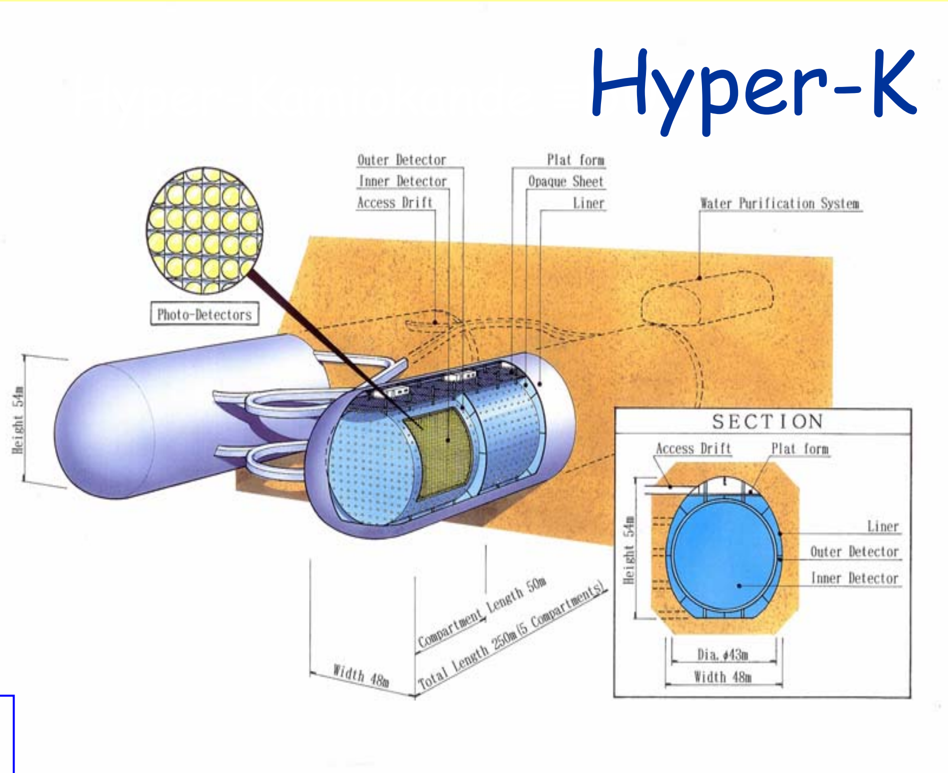
*: Modane 4800mwe

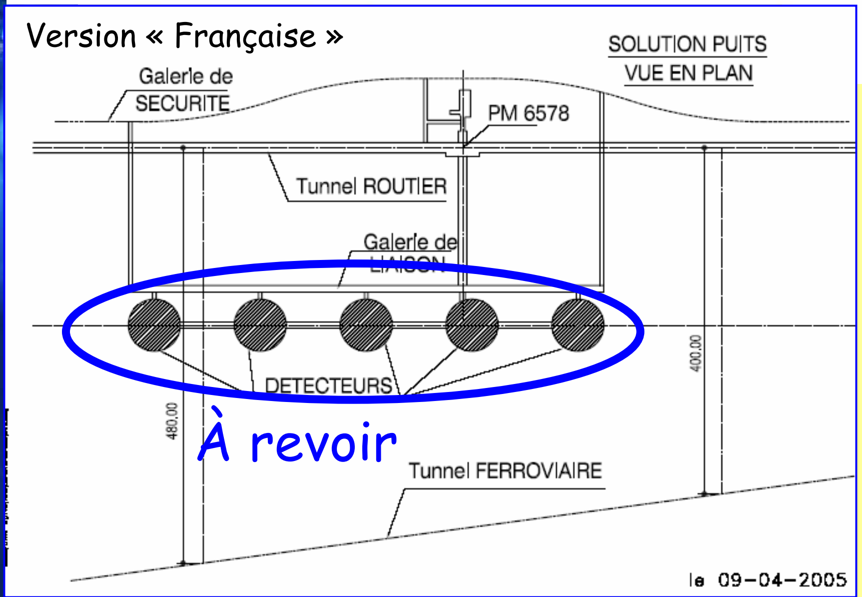


- Based on well experienced civil engineer studies and on extensive measurements of the rock quality parameters.
- First cost and time estimate will come soon for a dedicated operation.
- Beyond that a Design Study is needed

Projets Mt Č dans le monde







La pré-étude a montré le type de configuration possible.

L'étape suivante (Design Study) devra inclure une mesure de la roche précisément sur le site envisagé.

Nucleon decay

Reach of partial lifetime

1. $p \rightarrow e^+\pi^0$ up to ~10^{35} yrs with ~Mton water Cherenkov (present SK limit: 5.4 x 10^{33} yrs)
2. $p \rightarrow \nu K^+$ up to ~a few x 10^{34} yrs with ~100 kton liq. Ar and ~50 kton liq. scintillator (present SK limit: 2.0 x 10^{33} yrs). But progress π^0 id can increase significantly the Mt water C capability (Kobayashi)

There is a lot of life in proton decay

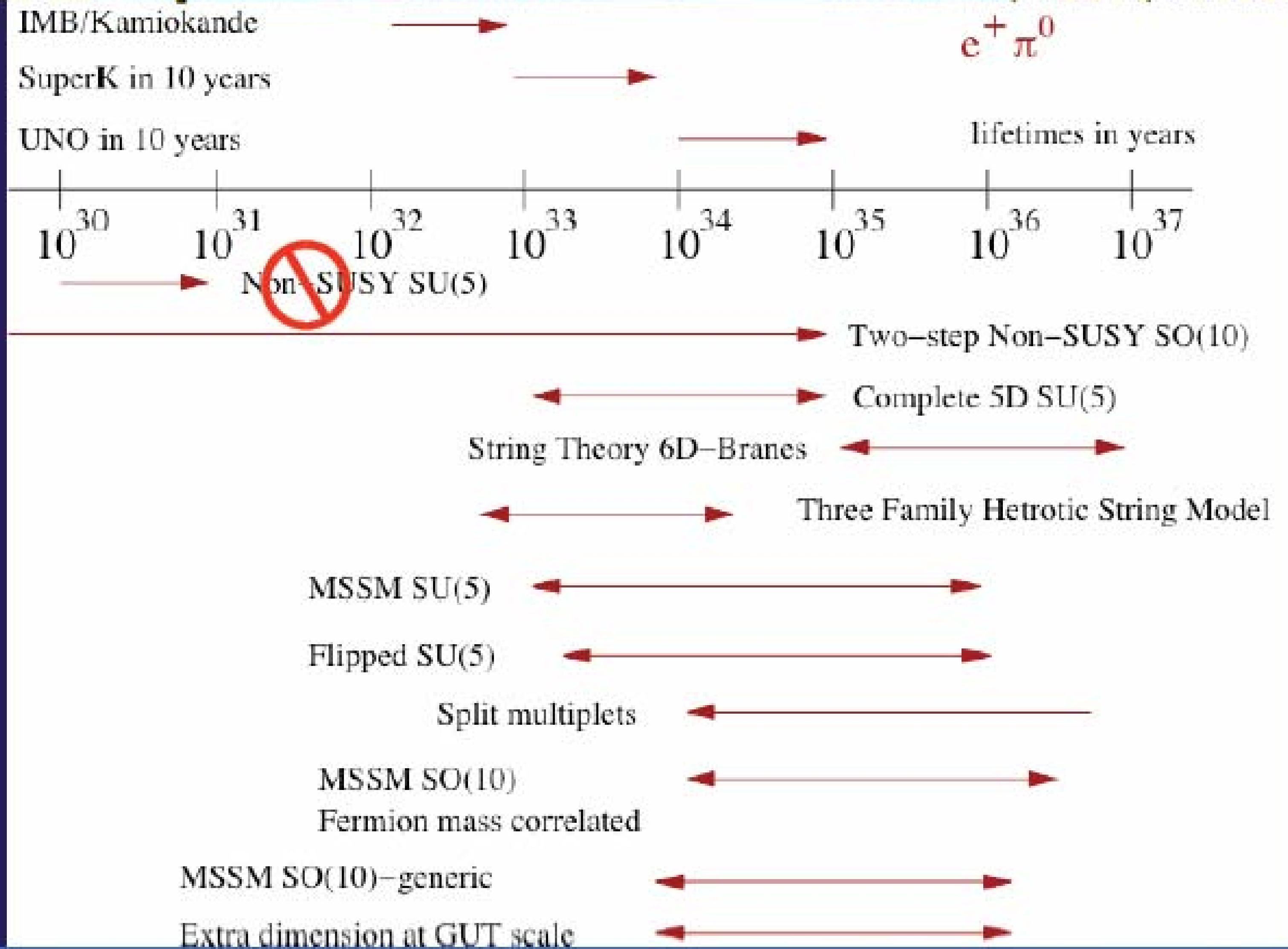
Ellis

It is possible to suppress the decay rate, but in many cases proton decay is just around the corner: keep looking !

Covy

So, next step is significant!

UNO Proton Decay Sensitivity and Updated Theoretical Predictions ($e^+\pi^0$)



Other Non-accelerator neutrino physics with a Mton water Cherenkov

Kajita

- Neutrino oscillation measurements with atmospheric neutrinos: θ_{13}, sgn(Δm_{23}^2), sub-dominant osc., CP phase
- Measurements of low-energy neutrinos

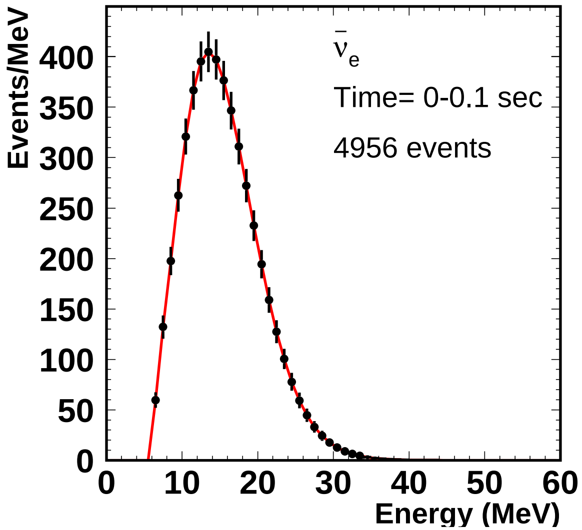
Nakahata

1. ^{8}B Solar neutrino measurements
2. Neutrino burst from Supernova explosion
3. Relic supernova neutrinos

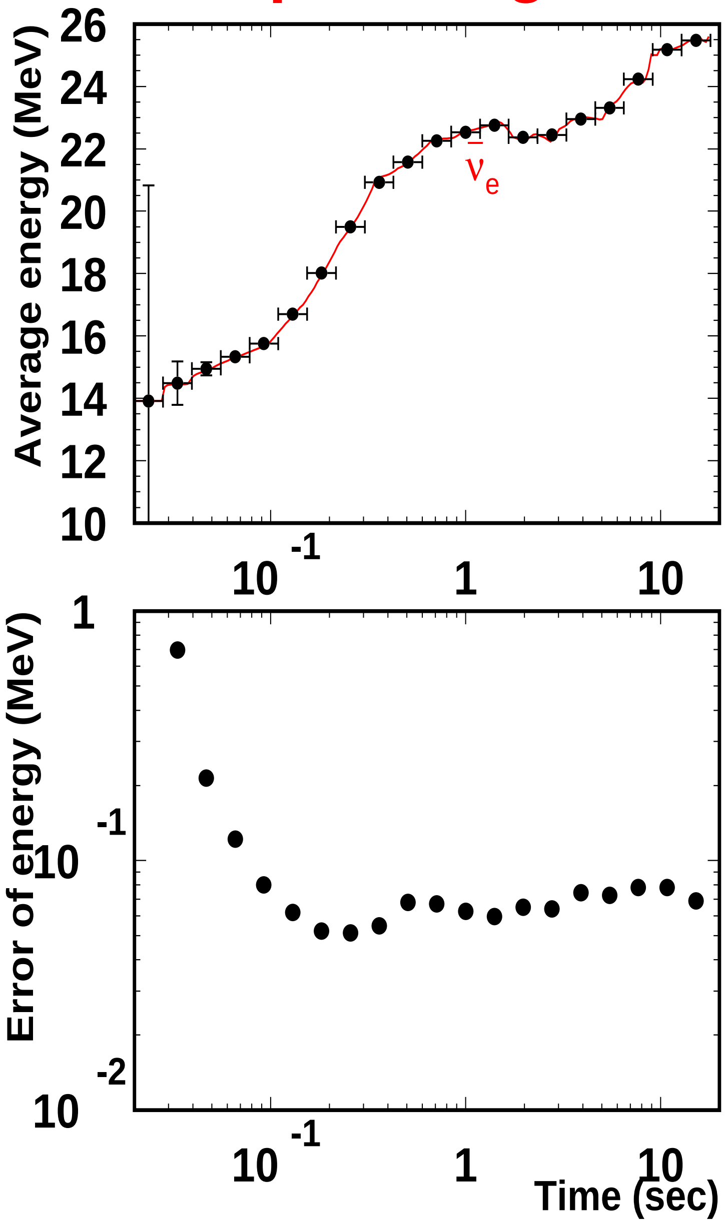
ν_e energy spectrum measurement (SN Burst)

Visible energy spectrum in each time range range

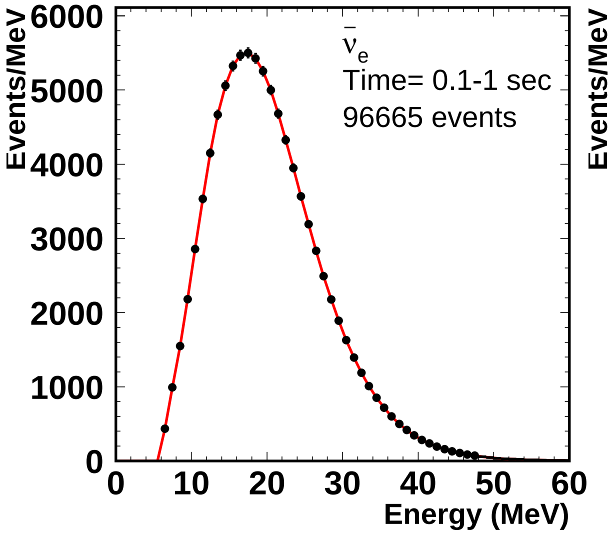
SN at 10kpc, 1mega-ton

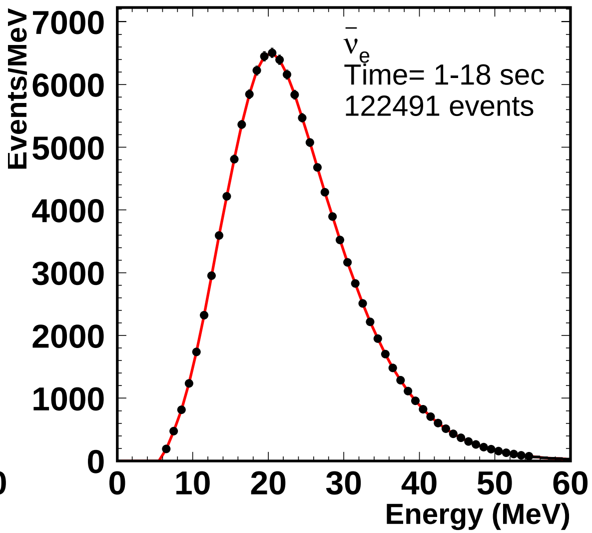


Time variation of average energy

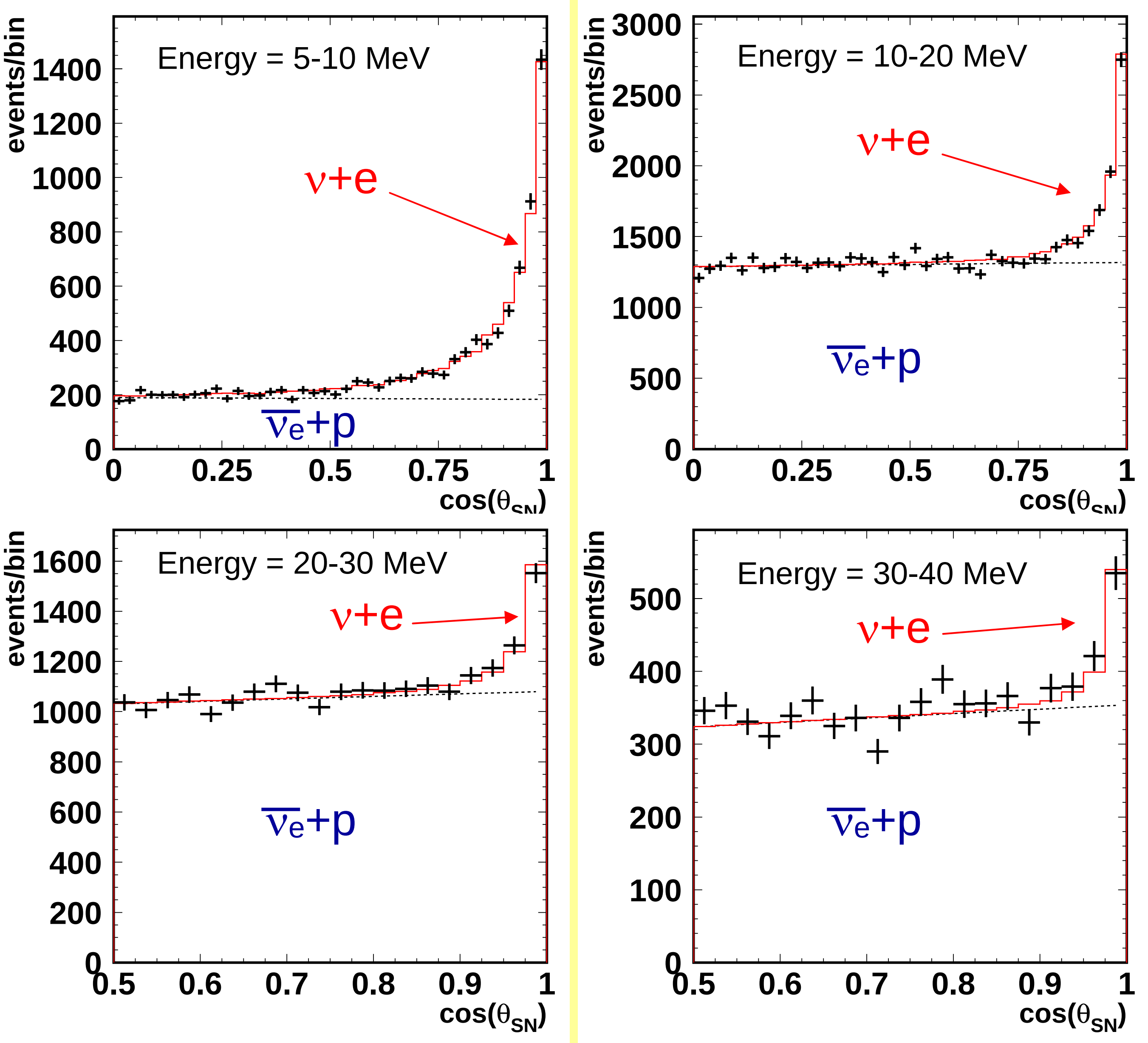


Nakahata





Identification of νe scattering events by direction to supernova



SN at 10kpc,
1 mega-ton

νe scattering events can be statistically extracted using the direction to supernova.

Nakahata

Relic SN neutrinos
--- Very encouraging ---

Ando

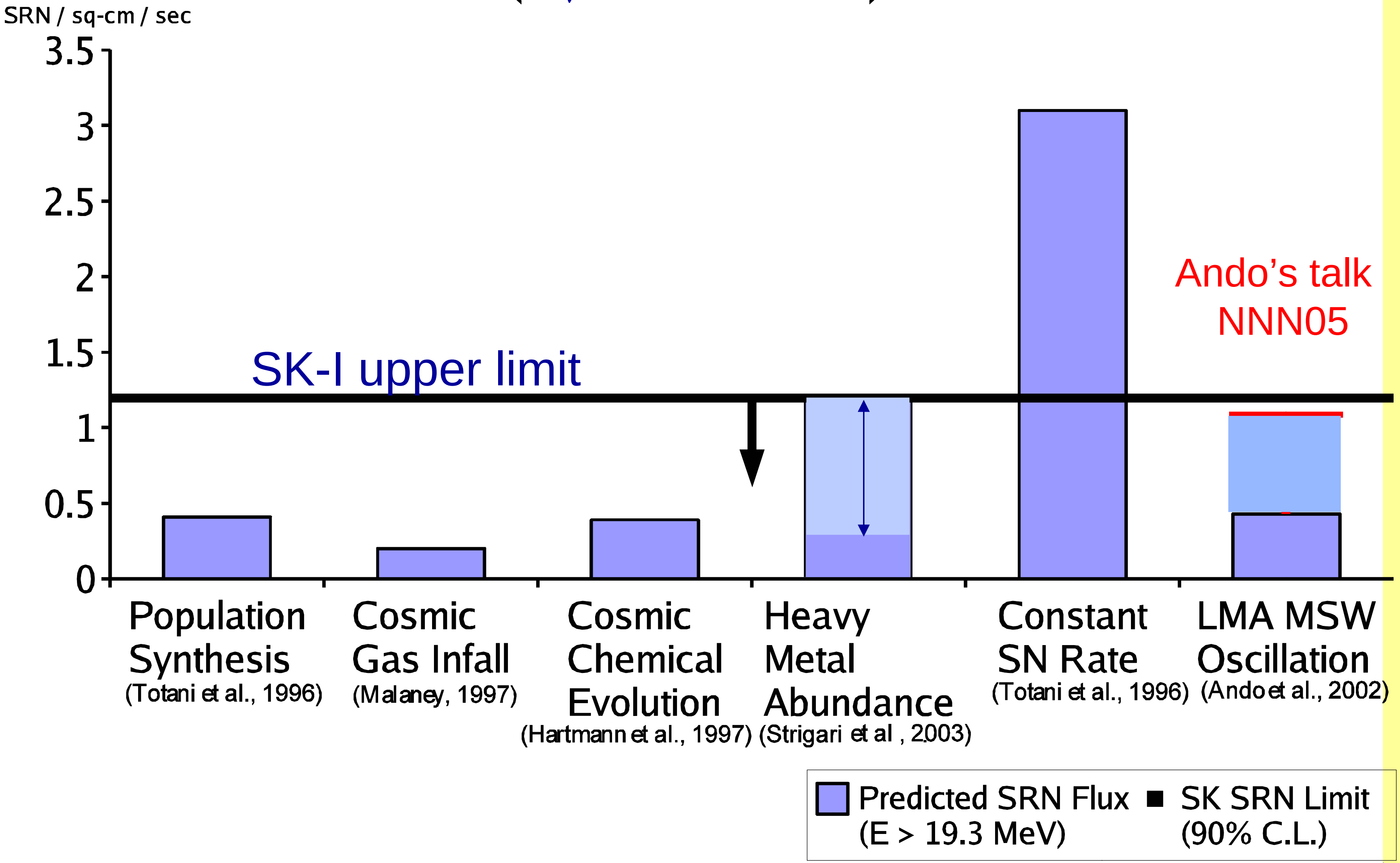
SK data <1.2 $cm^{-2}s^{-1}$ for E_{ν}>19.3 MeV

It is just above the prediction using reasonable models (1.1 $cm^{-2}s^{-1}$) !

5σ detection would be possible with a Mton water Cherenkov.

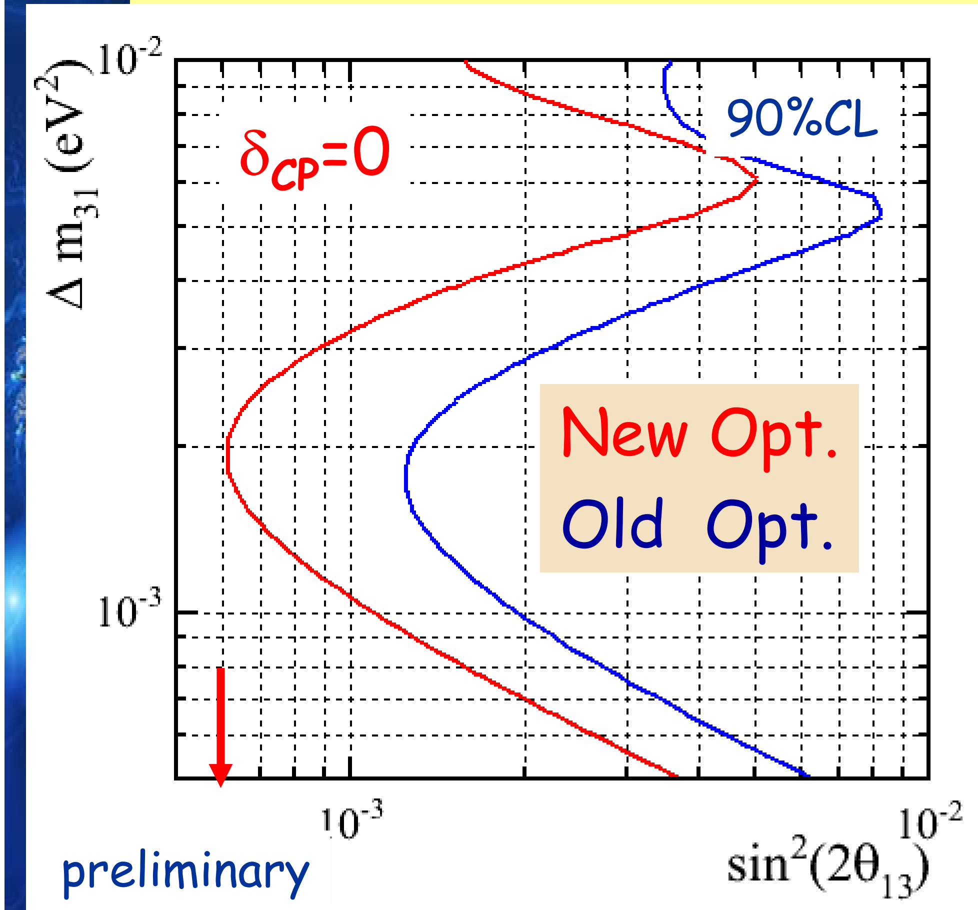
With Gd loaded water, 300 ev/yr expected.

SK SRN Flux Limits vs. Theoretical Predictions (E_ν > 19.3 MeV)



Super Beam (SPL) ν

440kT water Č, 4MW SPL, GLoBES



5yrs (+)

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

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

5% external precision on θ_{12} and Δm^2_{21} **and use SPL disappearance channel and spectrum analysis***

2% syst. on signal & bkg

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

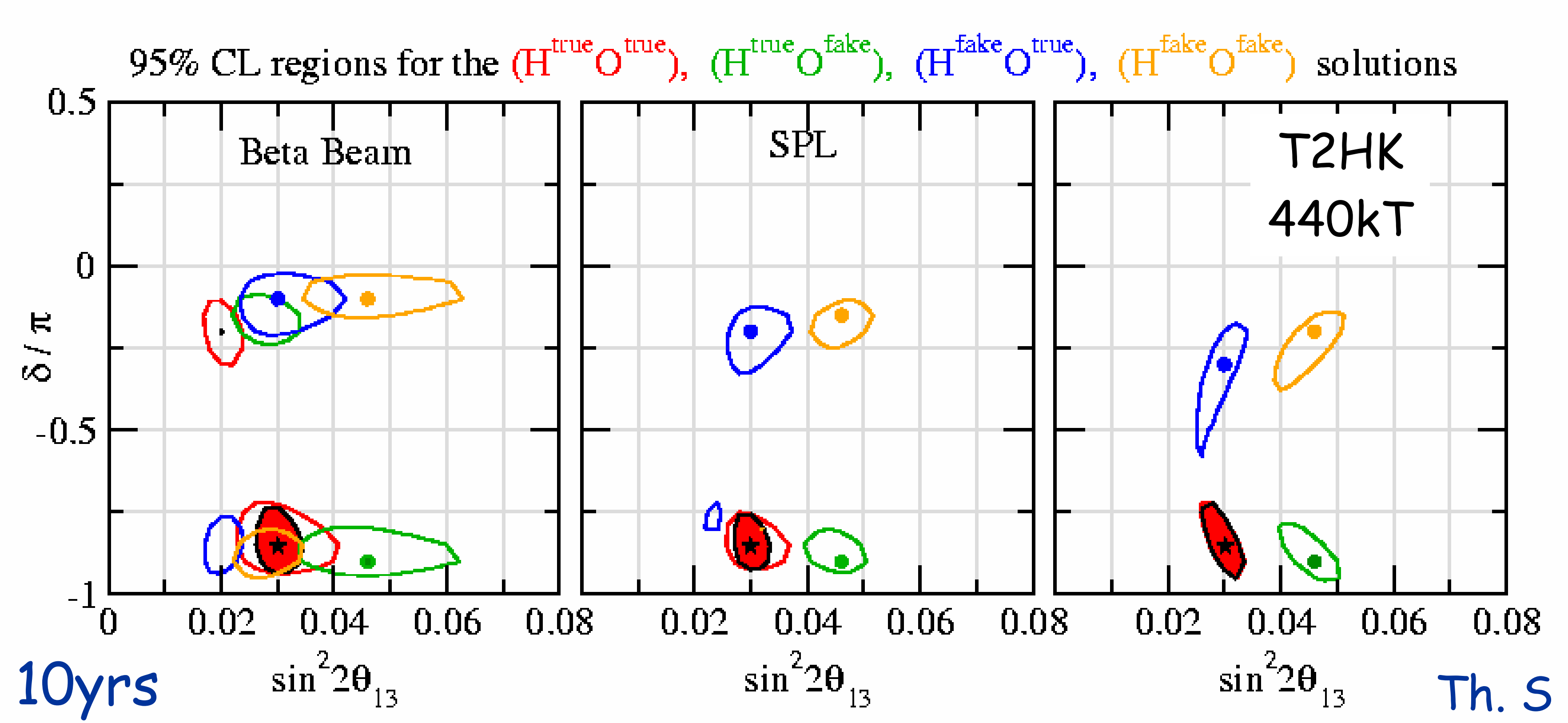
sizeable improvement

*: 5 bins [0.08,1.08] GeV

(χ^2(2dof)=4.6 or 11.83)

Remove ambiguities with ATM ν

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



Contour after ATM combination

*: true value

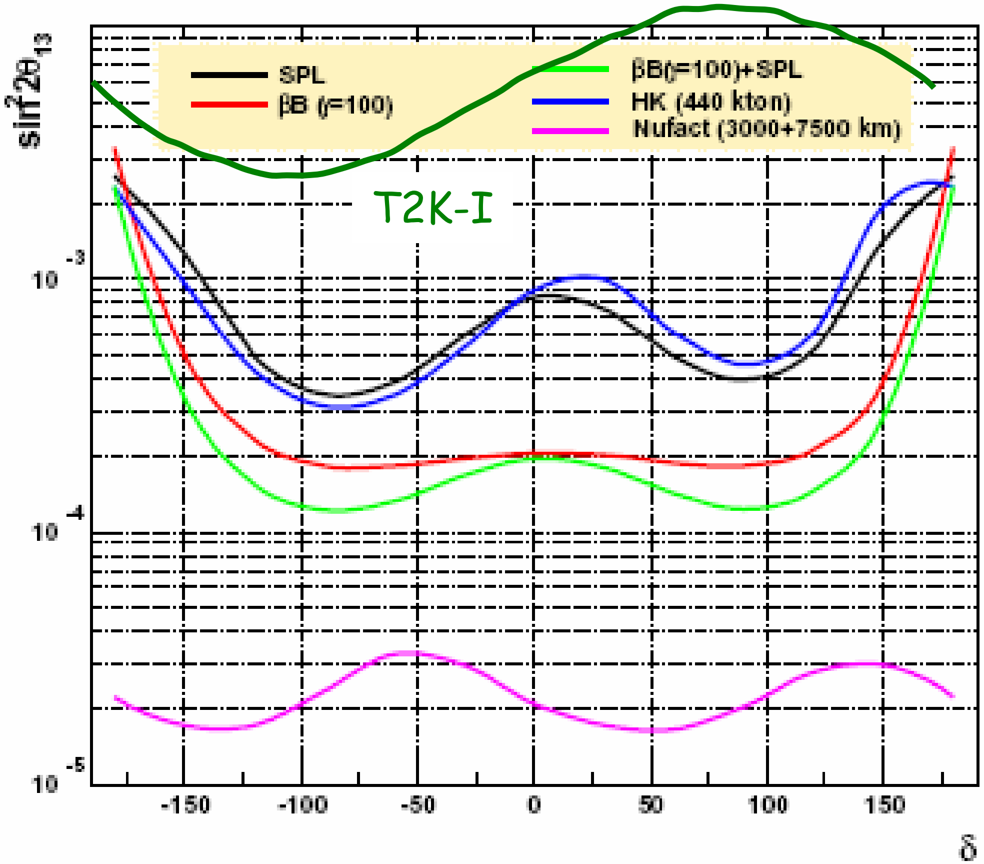
SPL, βB LBL ν

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 $\bar{\nu}$ years, 2% systematic error, 200 MeV binning, 440 kton fiducial.



MM@NuFact05

ISS WG1 meeting 14th - 21st Nov 2005

- *Second-generation super beam:*
  - Beam of the 'SPL type', the 'T2K type', and the 'NOvA type';
  - Megaton water Cherenkov, baselines to be defined.
- *Beta beam:*
  - Helium/neon beta beam in which the relativistic γ of the ions takes the values (100/100) and (350/350). This corresponds to a 'reference' beta beam and a 'green-field site' beta beam;
  - Baselines for the two beta-beam facilities of 130 km and 700 km respectively will be assumed;
  - Megaton water Cherenkov detector for (100/100)&130 km option, the detector for (350/350)&700 km option to be defined.
- *Neutrino factory:*
  - Two Neutrino Factory options with muon energies of 20 GeV and 50 GeV respectively. Assume that each facility will provide 10^{21} muon decays per year;
  - Baselines of 1000 km and 3000 km;
  - 100 kTon magnetised calorimeter.

For the comparison of the various codes, it was agreed that the *sensitivity in the θ_{13} - δ plane* would be used. The following teams agreed to prepare results for comparison:

- *Globes*: P. Huber, P. Harrison
- *'Valencia code'*: P. Hernandez
- *'Madrid code'*: S. Rigolin

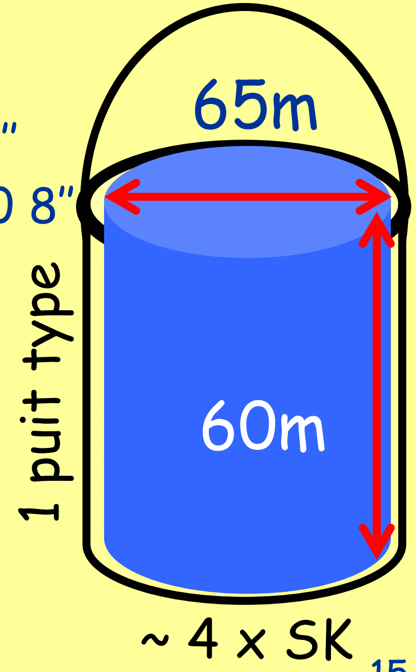
The goal is to establish a baseline for the development of an evaluation of the performance of the facilities and a road-map for the combination of the simulated results.

#puits, #PMTs

- La pré-étude montre que la forme « puit » est envisageable (pas de tunnel)
- Le nombre de PMTs varie selon la surface utile d'un PMT, la couverture et le volume fiduciel considérés (ie. VETO):

SK: 5m/40% (ph.I)÷20%(ph.II): 22kT : 11,146 20" + 1,885 8"
UNO: 3,5m/40%÷10%: 440kT (3x 60³): 56,000 20" + 15,000 8"
HK: 2m/40%: 540kT (2x5x(ØxH:43x50)): ~200,000 20"
ou équivalent.

Simulation LBL avec Vol. Fidu. 440kT



Nb: $Ø_{cath}$(20") = 50cm maxi.

Input de physique: couverture, seuil,...

Préliminaire et doit être complété au fur et à mesure

Canal	Stat. (Mt.y)	Trigger	Couverture	Réf.
ν LBL	$2\ \nu \div 5\ \bar{\nu}$	H.E	(10 ÷ 20)% ? $\mu \rightarrow e$ tagging (delay)	-
νATM	2 (10^5/MT)	H.E	20%?	Kajita [1]
^{8}B ν SOL	1	(S)L.E	40%?	Nakahata [1]
SNova Burst	10kpc $10^4\ \nu_e$/Mt $10^5\ \bar{\nu}_e$/Mt	L.E	40%? $\bar{\nu}_e$ & nTagging*	Idem
SNova Relic	5 (250evts)	L.E	40% 20% QE 300-700nm $\bar{\nu}_e$ & nTagging*	Idem
PDK $e^+ \pi^\circ$ $\nu\ K^+ \rightarrow \pi^\circ \pi^+$	5 10^{35} yrs	H.E	20% Ok? Lumière parasite	Kobayashi [2]

*: $n+p \rightarrow d + \gamma$ (2MeV) ou $n+Gd \rightarrow \gamma$(8MeV), delay

[1]: NNN05
[2]: UNO meeting

Other challenger(s)

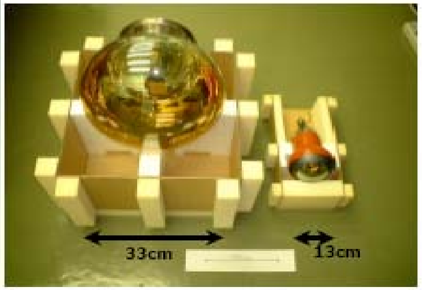
- USA: in 2005 DEP & BURLE (cf. UNO R&D) have been acquired by Photonis
- Japan: Hamamatsu

  Stop PMT R&D with 20"

  R&D of Large HPD: Price???

  Low noise Electronics

13inch HPD



13inch 5inch

20kV !

8

Summary

- R&D for a large format hybrid photo detector has started.
- Initial study shows excellent performance:
  - ✓ Single photon sensitivity
  - ✓ Wide dynamic range (up to the readout limit)
  - ✓ Good time resolution (better than 1ns)
  - ✓ Good uniformity (over a large photocathode)
- Promising

H. Aihara @ NNN05

Photonis @ NNN05

PMT size <=> cost

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/(cm²*x*QE*x*CE)

12.6 **14.4** **7.7** €/PE_U/cm²

Nb: No electronic included at that time

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: x3 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 discussions are going on with the MEMPHYS collaboration to define a balanced programme

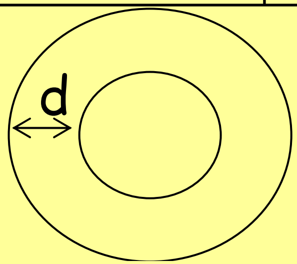
Workshop planned in the spring

Photonis @ NNN05

#puits, #PMTs: MEMPHYS case

*: Photonis @ NNN05

Veto (d en m)	Couverture (en %)	Volume Fid. (en kT/puits)	#puits Vol. Fid	#PMTs/puit 12": 615cm^{2*}
2.0	40	160	3:490	270,000
3.5	40	140	3:420	243,000
5.0	40	120	4:480	140,500
5.0	30	120	4:480	105,375
2.0	30	160	3:490	200,000



#PMTs: 420,000 ÷ 810,000
#Puits: 4 ÷ 3

M_{Fid}>440kT

Rq: 20% hauteur (72m)→144kT/puits & 251460 12"→ 3puits ~ 430kT & 754380 12"

Retour sur les coûts…

1 puit (200,000m^3) : 80M€* (inclus galeries + descenderies + locaux techniques à revoir, sinon 44M€)

1 PMT (**800€****) + Électronique/HT (200€***) : 1k€

#Puits	#PMTs	Coût Total	%coût PMTs
3	810,000	1050M€	77%
4	420,000	740M€	57%
3 (H: 72m)	754,400	994M€	76%

* : source J.Bouchez: 300M€/900,000m^3
** : prix Photonis@NNN05
***: prix d'équilibre entre 20" et 12"

Baisser le coût des photocapteurs

Il faut ajouter: purification de l'eau/air, le coût du stockage…

Coût SK: 200M€ (50% cavité)

Photodetector R&D in France (PMm^2)

- R&D launched after NNN05 and 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
- Funded through the GIS with Photonis and dedicated Instrumentation R&D (IN2P3/CESPI): asked 45k€ for 2006.
- New french labs are investigating their possible contributions.
- Two meetings since NNN05 (mai & oct. 05): have a look at http://opera.web.lal.in2p3.fr/WaterCerenkov/index.htm

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

PMm^2 ASIC proposal

Pierre BARRILLON, Christophe de LA TAILLE, Nathalie SEGUIN-MOREAU

(LAL ORSAY)

UNIVERSITÉ PARIS-SUD 11

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

IN2P3

INSTITUT NATIONAL DE PHYSIQUE NUCLÉAIRE ET DE PHYSIQUE DES PARTICULES

GDRν 20-21/10/05

R&D targets

Integrated readout : “digital PM (bits out)”

1. Charge measurement (12bits)
2. Time measurement (1ns)
3. Single photoelectron sensitivity

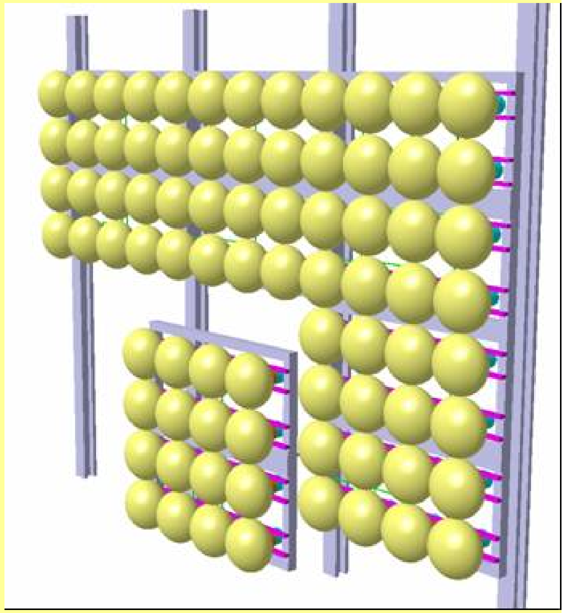
High counting rate capability (target 100 MHz)

Large area pixellised PM : “PMm^2”

1. 16 low cost PMs
2. Centralized ASIC for DAQ
3. Variable gain to have only one HV

Multichannel readout

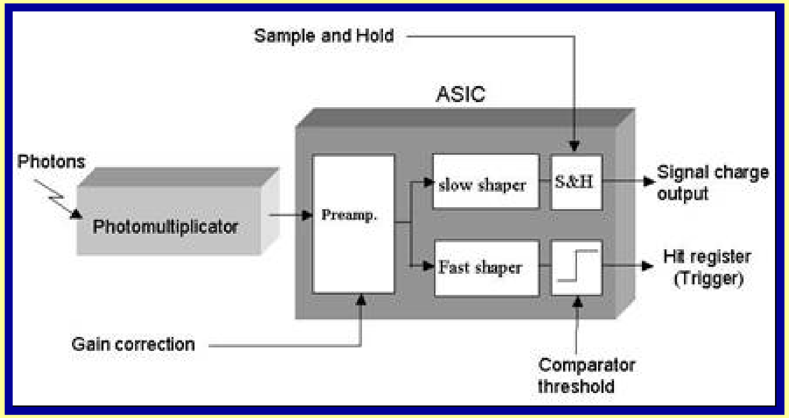
1. Gain adjustment to compensate non uniformity
2. Subsequent versions of OPERA_ROC ASICs



ASIC requirements

Front-end requirements

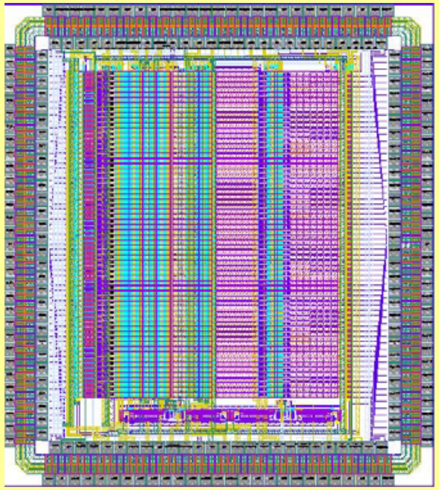
1. High speed discriminator for autotrigger on single photoelectron
2. Coincidence logic to reduce dark current counting rate *(to be defined by MC studies)*
3. Digitisation of charge over 12 bits
4. Digitisation of time of arrival over 12 bits to provide nano-second accuracy
5. Variable gain to equalize photomultipliers response and operate with a common high voltage
6. Data out wireless (*why not?*)



ASICs submissions

MAROC : 64 ch multianode readout

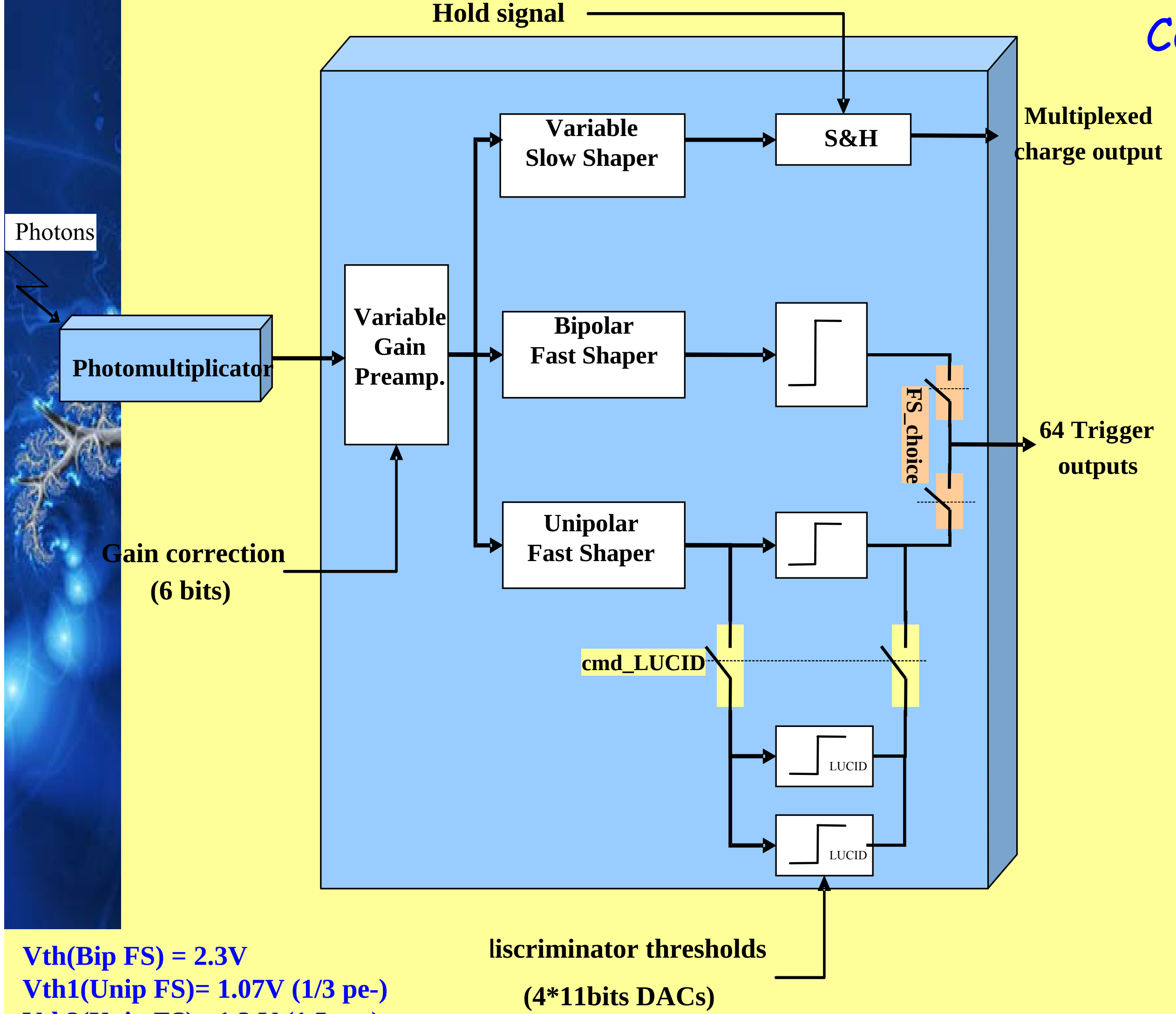
1. 64 fast digital outputs (2ns risetime)
2. Charge measurement with variable shaping
3. Gain adjustment (6bits)
4. 3 Digital thresholds (10bits)
5. Submitted June 05 (SiGe 0.35μm)



MECANO2

1. Large dynamic range variable gain preamps
2. Fast unipolar shaper for 100 MHz counting rate
3. Submitted June 05 (SiGe 0.35μm)

MAROC1: BLOCK FUNCTIONALITY DIAGRAM



Vth(Bip FS) = 2.3V
Vth1(Unip FS)= 1.07V (1/3 pe-)
Vth2(Unip FS)= 1.3 V (1.5 pe-)
Vth3(Unip FS)= 1.7 V (3.5pe-)

Complete front-end chip with 64 channels

Submitted in **June 2005**

Expected in **October 2005**

Gain and Bandwidth flexibility:

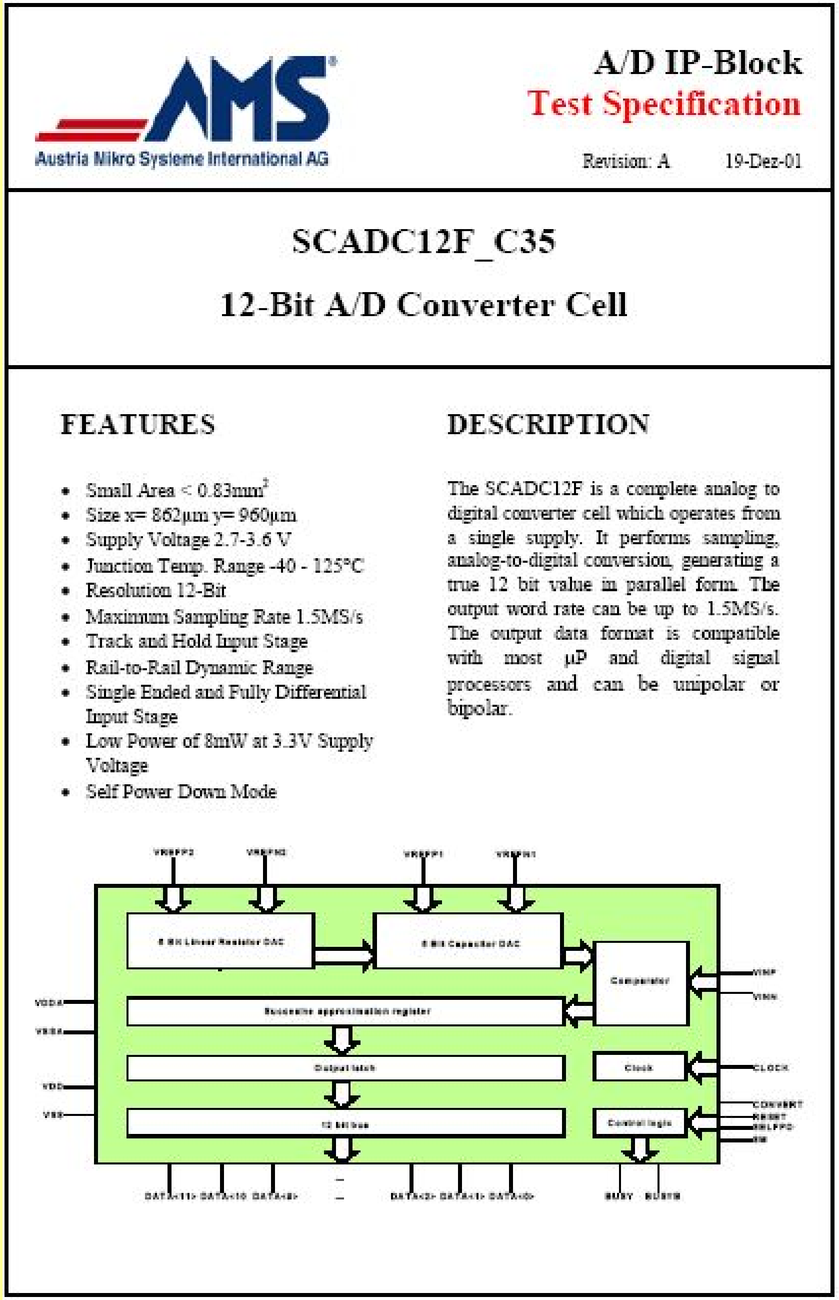
1. Gain adjustment per channel (6 bits: 0 to 4)
2. Bipolar Fast Shaper:
   - Gain=5mV/fC
   - BW=10MHz
3. Unipolar Fast Shaper:
   - Gain:5mV/fC
   - BW:100MHz
   - 3 thresholds: LSB=3mV, range=1V to 3.5V
4. Multiplexed charge measurement Peaking time with variable feedback network
   - Tp=25ns to 200ns

Integrating the ADCs :

Possible use of IPs (expensive)

Huge effort started in in2p3/CEA

1. Several designs in institutes
2. 10 bit pipeline ADC (LPCC) 10MHz
3. 10 Bit C/2C SAR (LAL) 1 mW 1 MHz
4. 10 bit FADC (LAL) 100 MHz
5. 12 bit Wilkinson (CEA,LAL,LPCC)



Austria Mikro Systeme International AG

A/D IP-Block
Test Specification

Revision: A 19-Dez-01

SCADC12F_C35

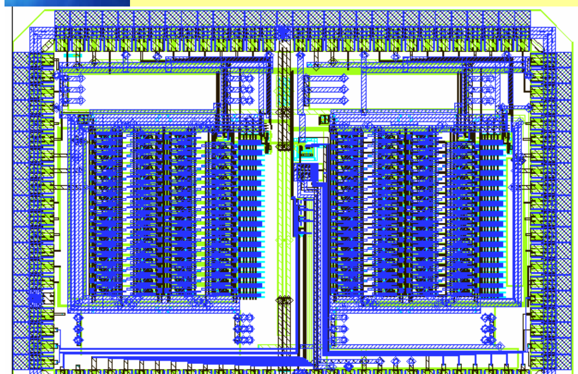
12-Bit A/D Converter Cell

FEATURES

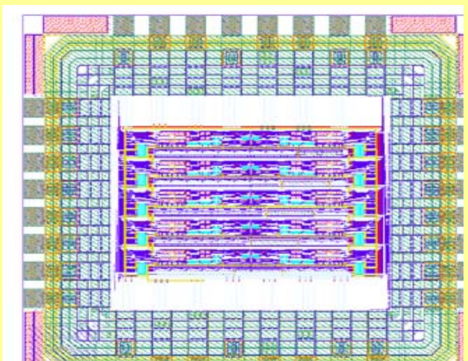
- Small Area < 0.83mm²
- Size x= 862µm y= 960µm
- Supply Voltage 2.7-3.6 V
- Junction Temp. Range -40 - 125°C
- Resolution 12-Bit
- Maximum Sampling Rate 1.5MS/s
- Track and Hold Input Stage
- Rail-to-Rail Dynamic Range
- Single Ended and Fully Differential Input Stage
- Low Power of 8mW at 3.3V Supply Voltage
- Self Power Down Mode

DESCRIPTION

The SCADC12F is a complete analog to digital converter cell which operates from a single supply. It performs sampling, analog-to-digital conversion, generating a true 12 bit value in parallel form. The output word rate can be up to 1.5MS/s. The output data format is compatible with most µP and digital signal processors and can be unipolar or bipolar.



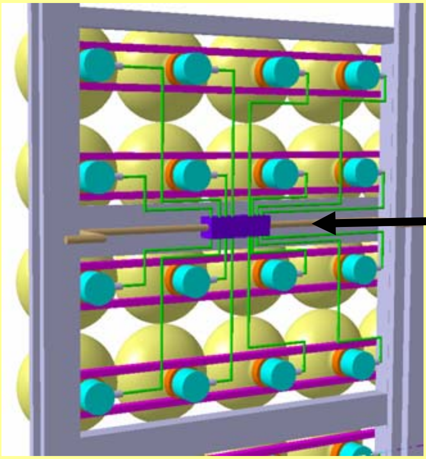
100 MHz FADC ©V. Tocut



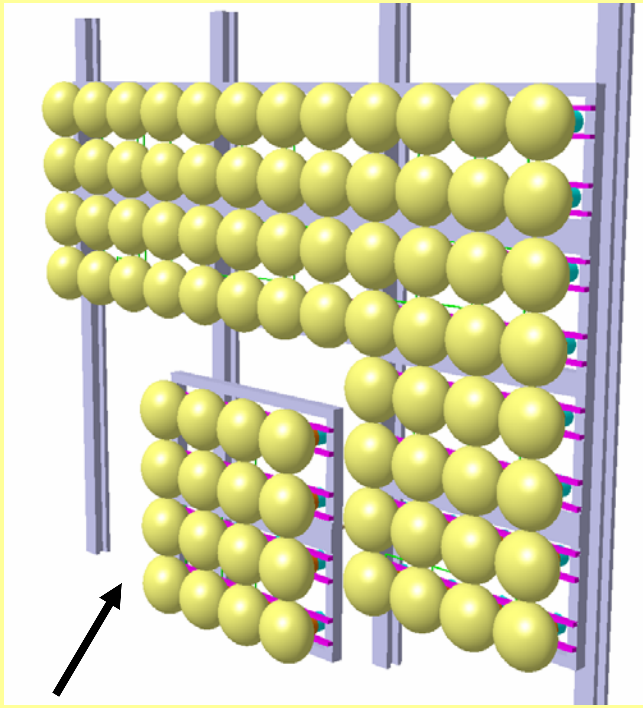
Pipeline ADC ©J. Lecoq

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



Basic unit that we want to build and test under water

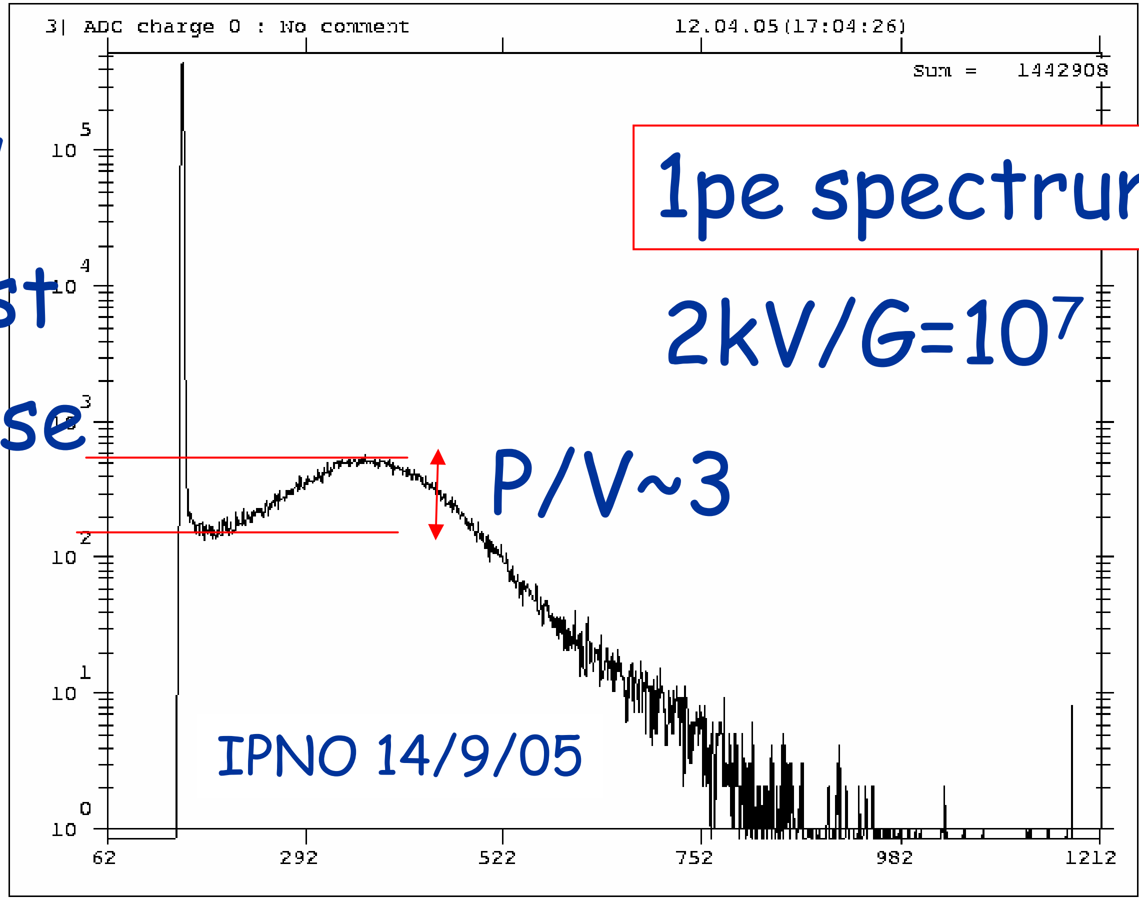
IPNO

Some PMT characteristics measurements

XP1806 8"

Not the best

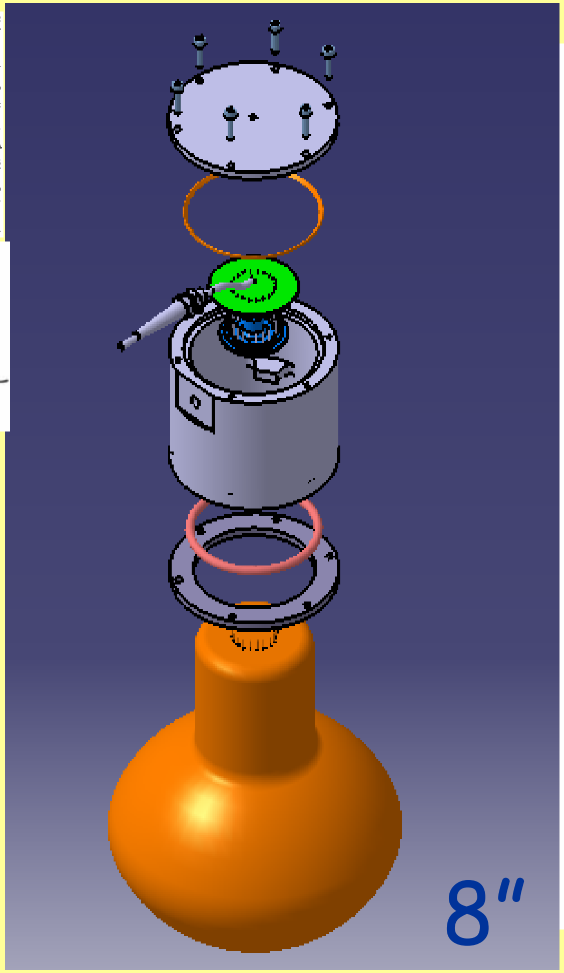
Not the worse

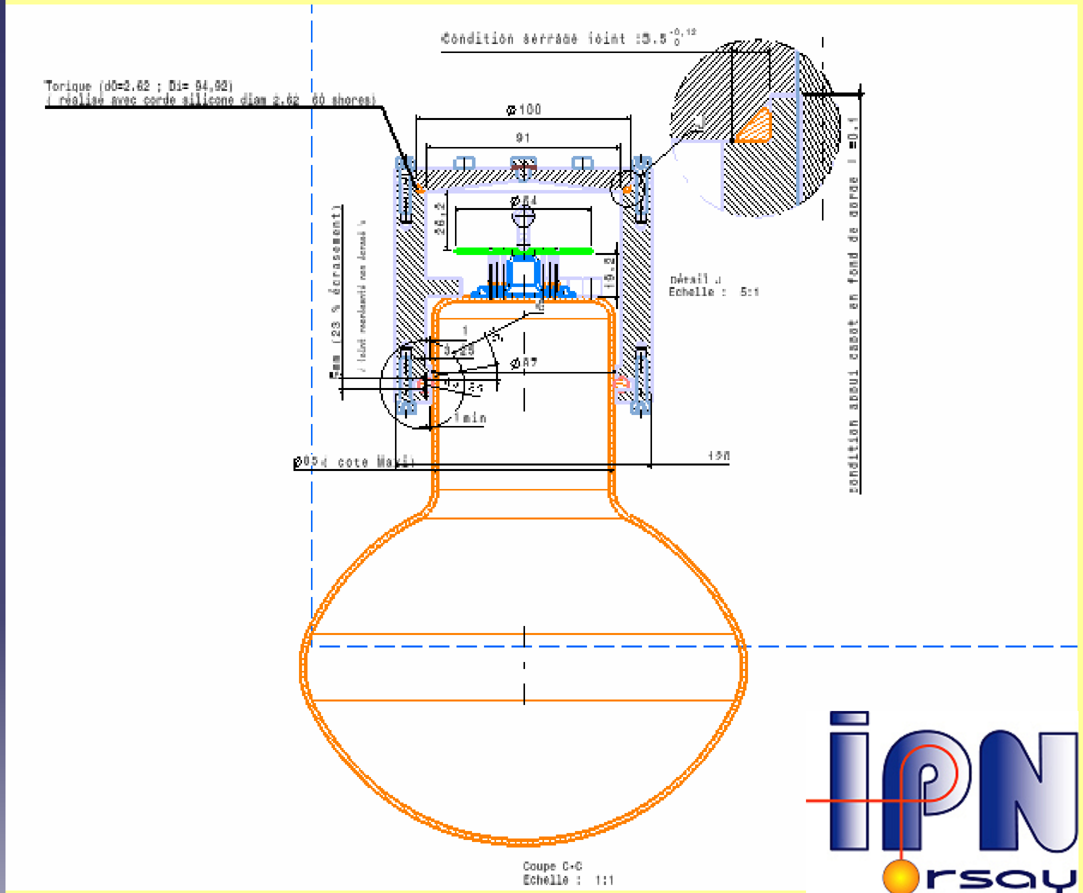


g=25 before ADC

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

Watertightness test funded by Photonis





Test November-December 05

Envisaged roadmap

- Physicists side
  1. Write White Book (EOI) on MEMPHYS physics case with present knowledge (Pdk, SN, LBL)
  2. Undertake a dedicated MEMPHYS MC
     - To study in more details the impact of the coverage percentage on the different physics channels (take benefit of SK-T2K french expertise)
     - to drive the electronic R&D (Trigger aspects)
  3. Make lobby in ISS, CERN Strategy Group,…
- Photocaptor side
  1. Mechanics: test the watertightness of the PMTs (2-3bars) then investigate a test for waterproofness at higher pressure (8-10bars).
  2. Continue to test PMT (8$\rightarrow$12") and in parallel Hybrid PMT, HPD with cost estimate comparison for large industrial production.
  3. Electronics:
     - Use OPERA_ROC & MAROC + external trigger logic (Altera) and external ADC with a unique HV to be used in a test with 16 PMTs illuminated with variable intensity (down to 1pe) to look at variable gain efficiency and influence of dark current.
     - Continue design of
       - 12bits ADC
       - 12bits TDC
       - wireless

END