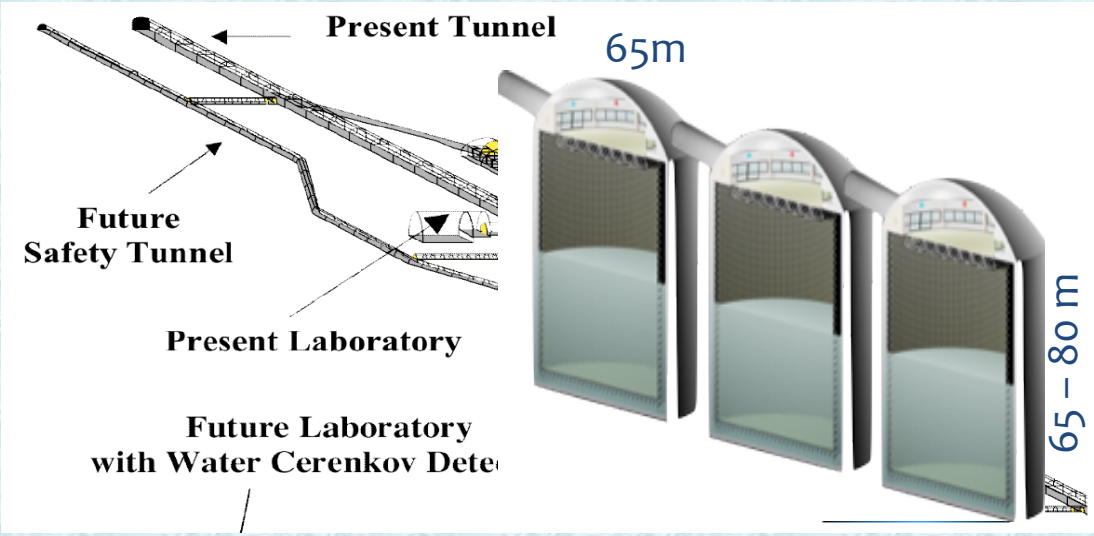
The Memphys Project

Thomas Patzak, APC, University Paris Diderot

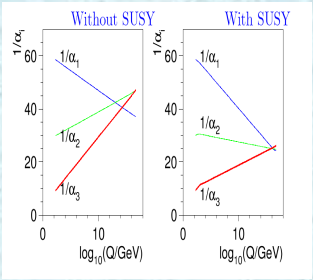


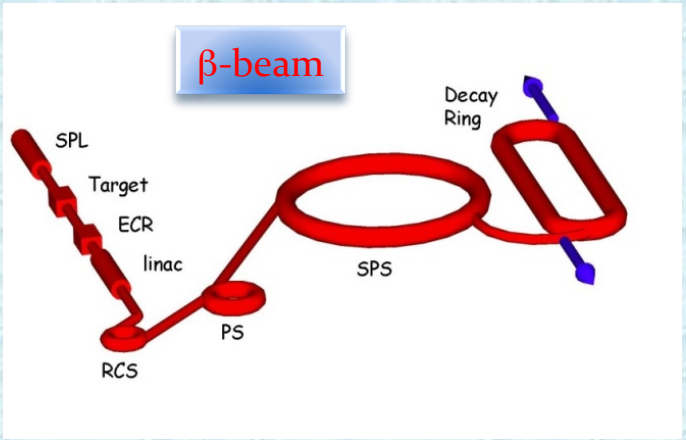
Laguna: Large Apparatus for Grand Unification and Neutrino Astrophysics

New megatonne class, multipurpose detectors will allow to study these fundamental questions

Particle physics

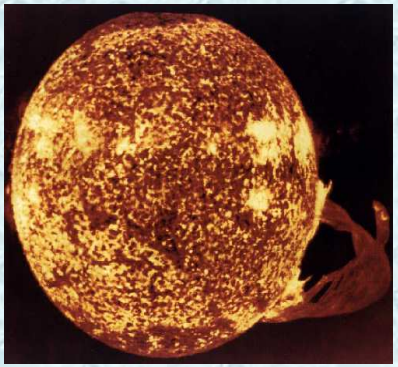
Proton decay
θ13
CP-violation
Atmospheric Neutrinos

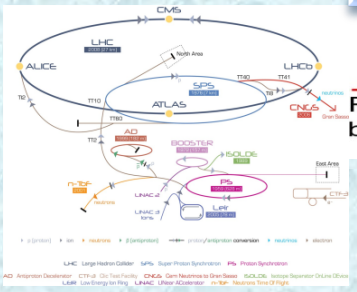


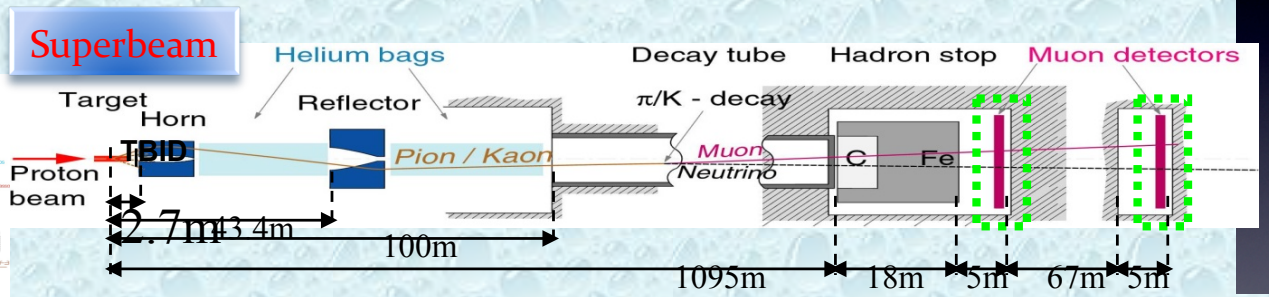


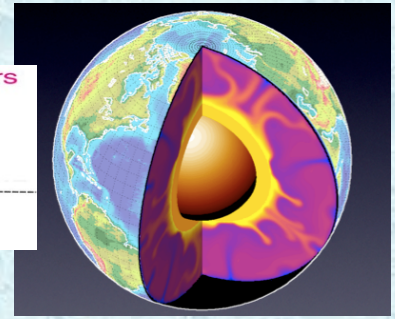
Neutrino astronomy

Supernova neutrinos
Diffuse SN neutrinos
Solar neutrinos
Dark matter annihilation
Geo-neutrinos









... In a

LAGUNA

Large Apparatus for Grand Unification and Neutrino Astrophysics

1,7 M€ from EU

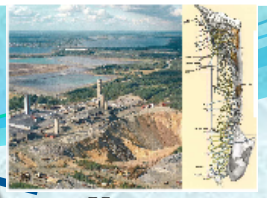
Proton Decay:

- limit up to 10^{35} y

Neutrino Physics:

- supernovae neutrinos (explosion and relic)
- atmospheric neutrinos
- solar neutrinos
- accelerator neutrinos (Superbeam, BetaBeam, NeutrinoFactory)
- geo-neutrinos

Boulby mine
1050 Km



2300 Km
Pyhäsalmi

SUNLAB
950 Km

CASO
659 Km

130 Km

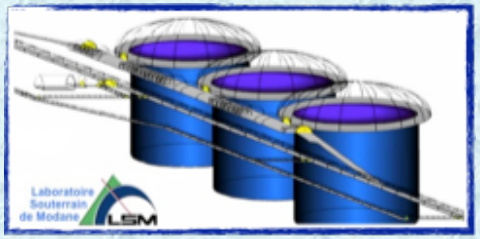
630 Km

http://laguna.ethz.ch

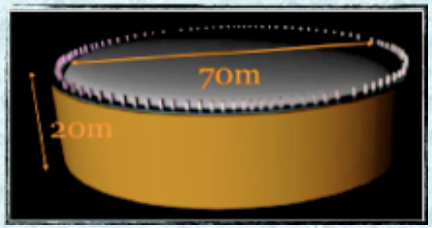
= > 7 canditate sites:

- Boulby
- Fréjus
- Caso
- LSC
- Pyhäsalmi
- Sunlab
- IFIN-HH

MEMPHYS: Water Čerenkov



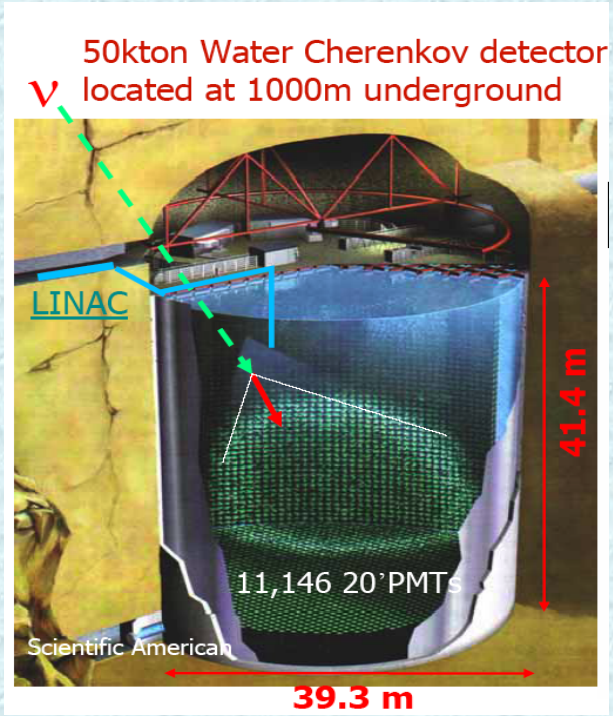
GLACIER: Liquid Argon

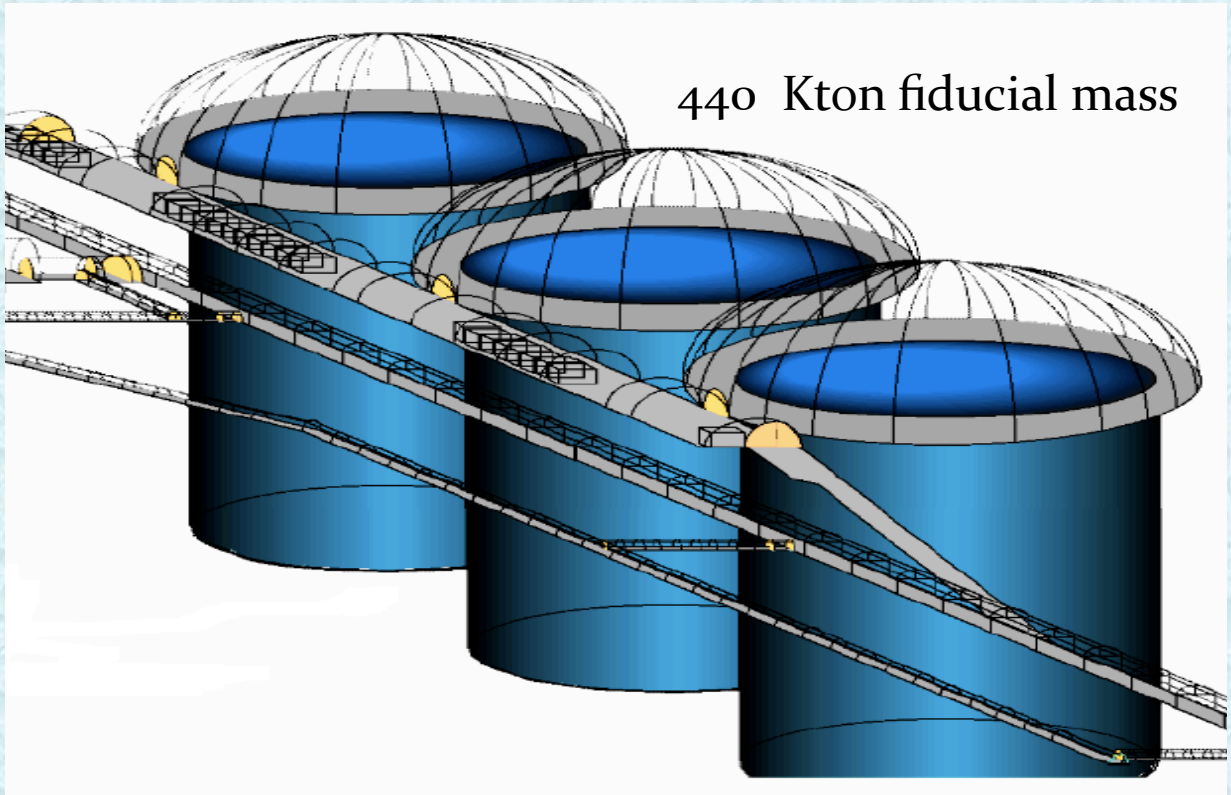


LENA: Liquid Scint.

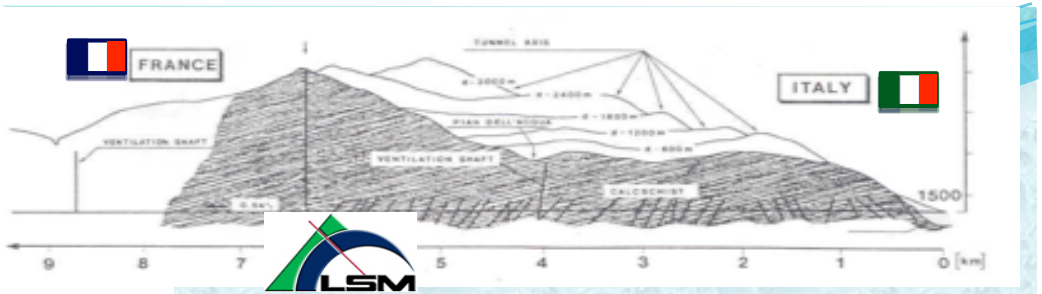
Studies towards a large scale Water Cherenkov detector in Europe

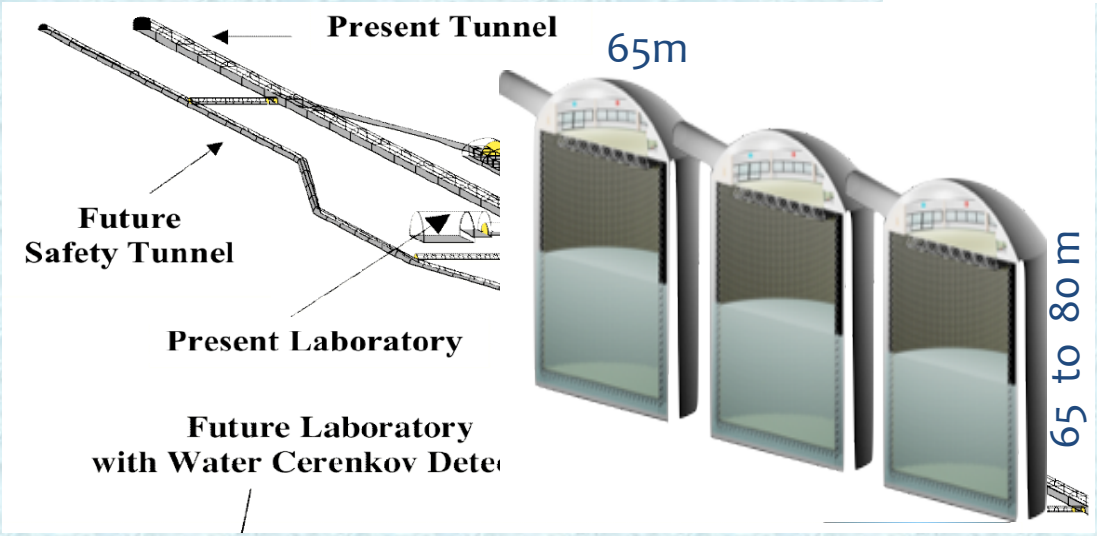
SuperKamiokande → X 20 → ***MEMPHYS***





MEMPHYS





- 130 Km from CERN
- 4800 m.w.e.

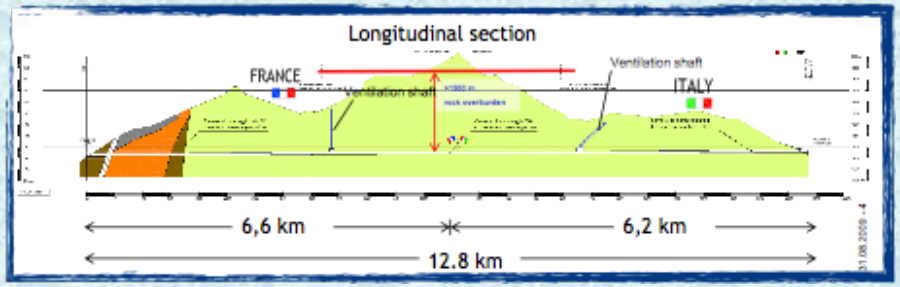
Detector	Overall size (ktons)	Fiducial volume (ktons)	Ratio
SK	47,8	28,7	60%
Memphys H= 60m	211	153	72%
Memphys H= 80m	282	208	74%

- Water Cherenkov (well known technology)
- total fiducial mass: 440 kt
- 3 cylindrical modules 65 x 65 m
  - size limited by light attenuation length (λ~80m) and pressure on PMTs
  - readout : ~3 x 81k 12" PMTs, 30% geom. cover
  - PMT R&D + detailed study on excavation @Fréjus existing & ongoing

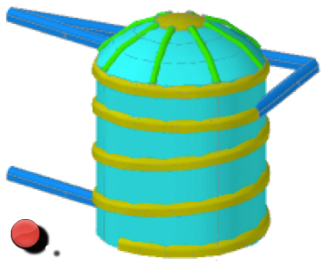
http://www.apc.univ-paris7.fr/APC_CS/Experiences/MEMPHYS/

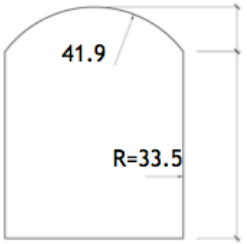
MEMPHYS

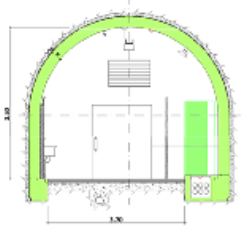
Possibles Layouts and design at Fréjus



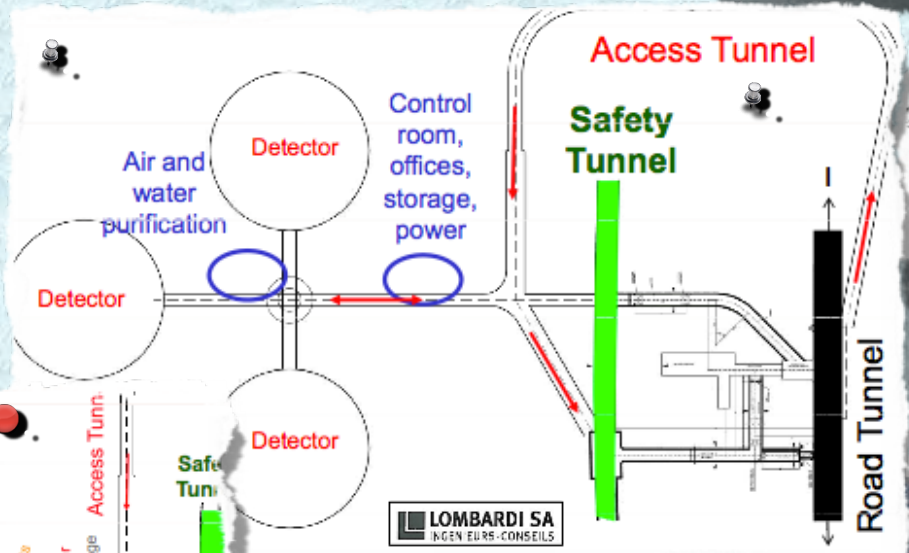
Proposed cavern excavation and layout for the LAGUNA

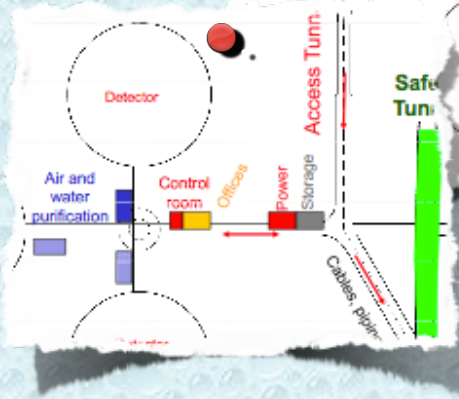






LOMBARDI SA
INGENIEURS-CONSEILS

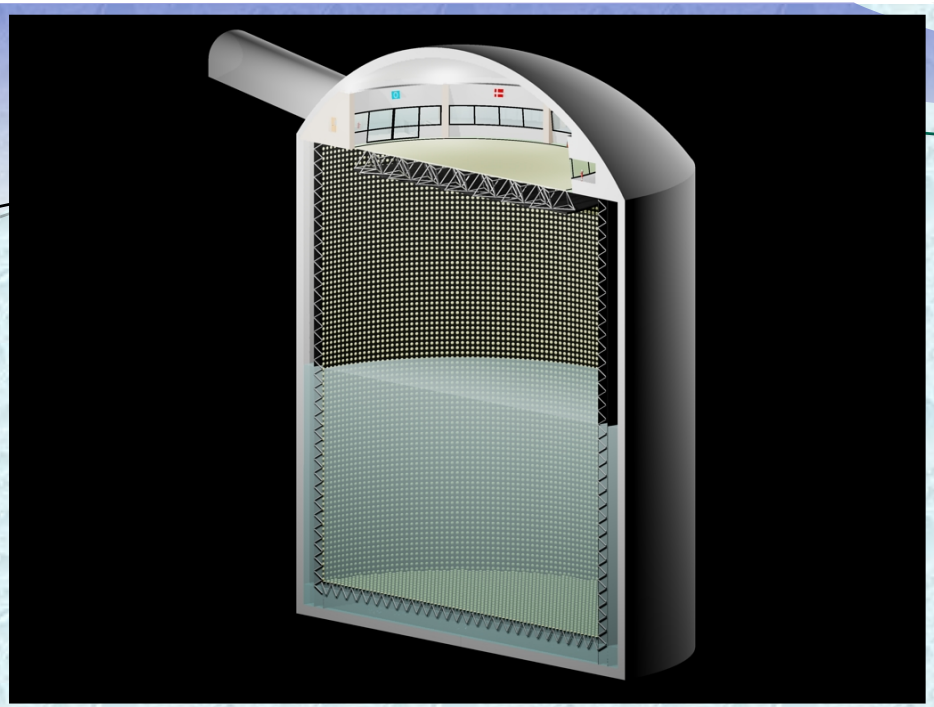


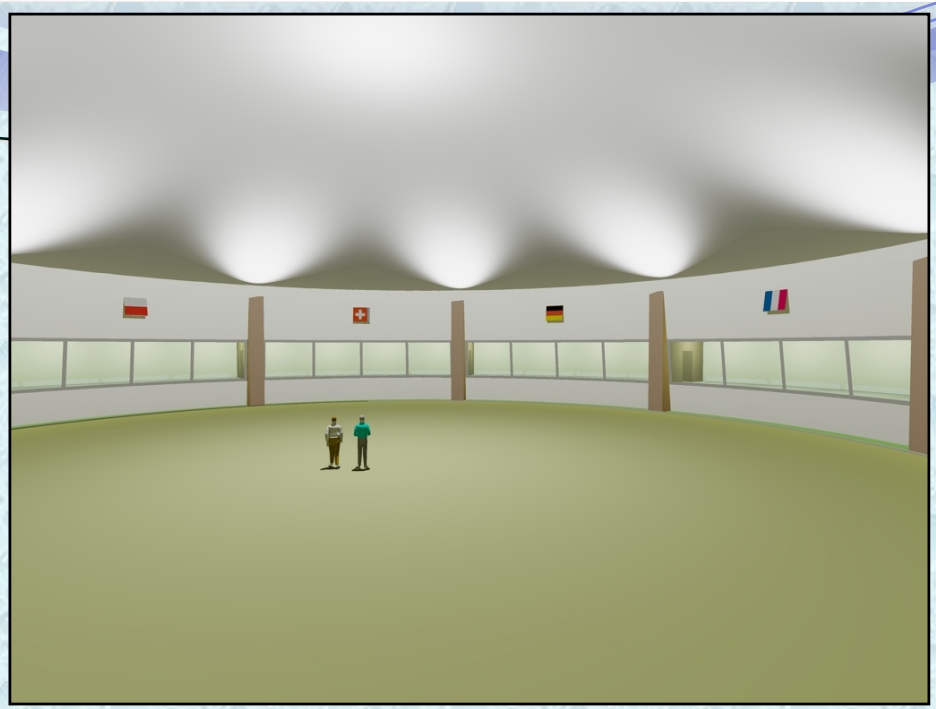


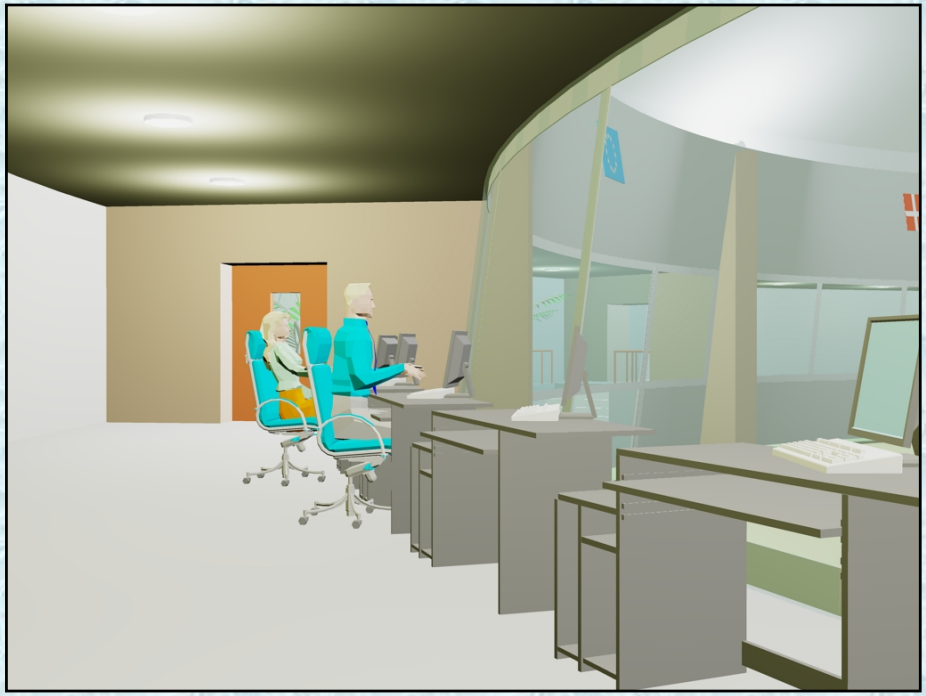
Draft version.. study in progress

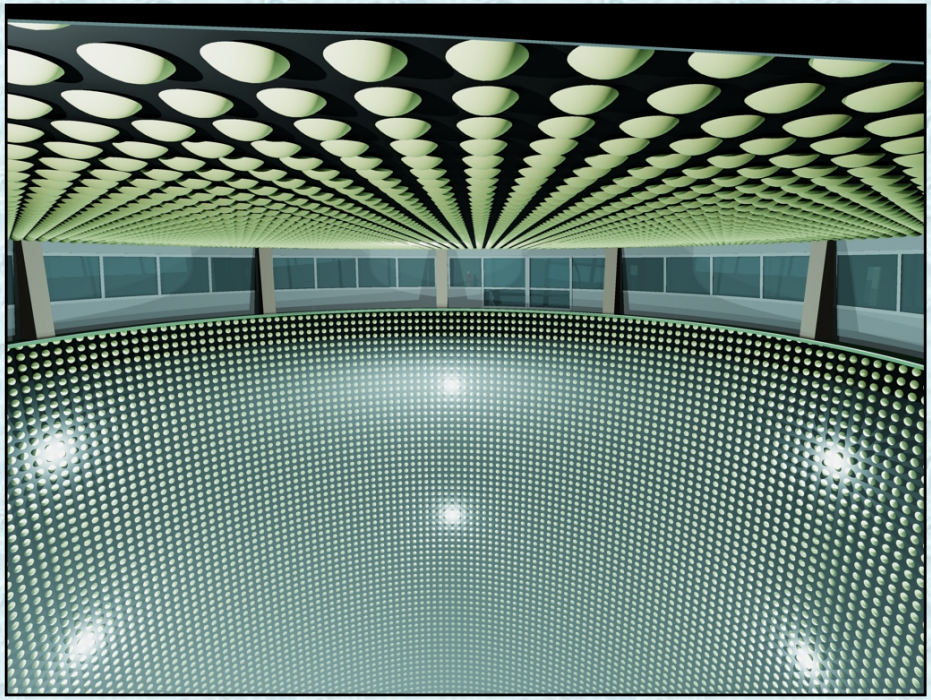
Fresh water

Shaft access



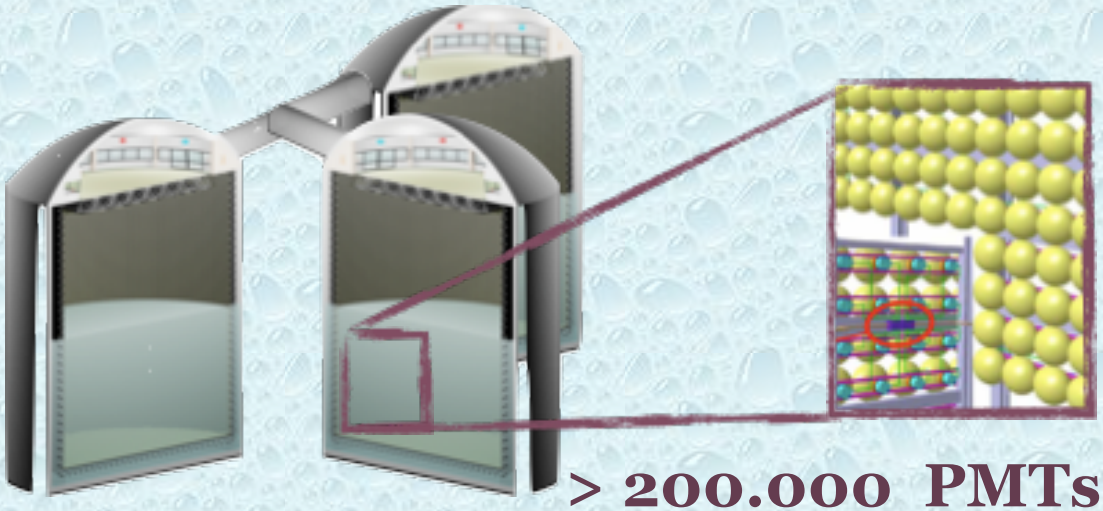






MEMPHYNO THE R&D FOR MEMPHYS

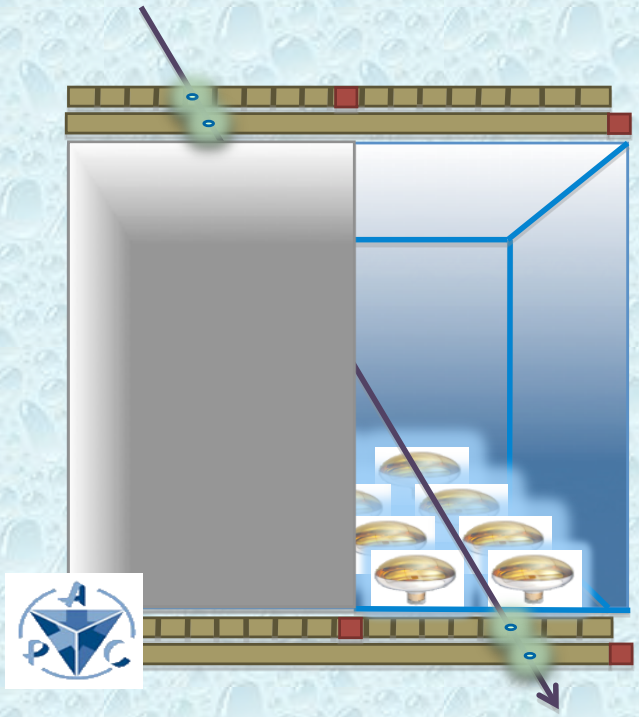
6,5 x 10^8 litres of water



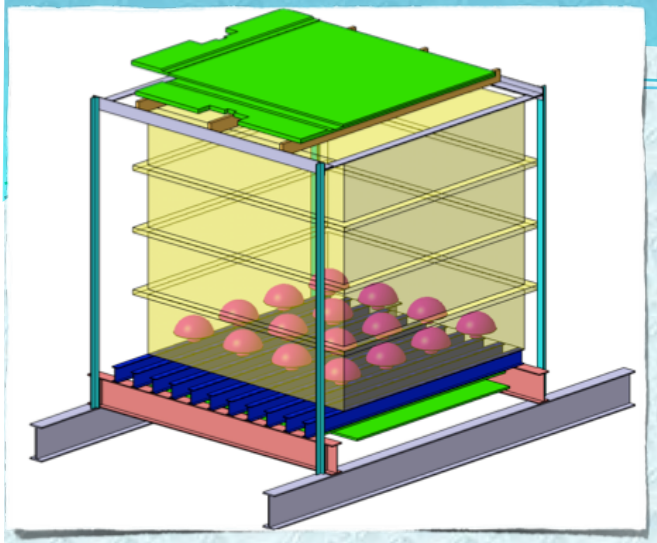
> 200.000 PMTs

R&D

8 x 10^3 litres of water



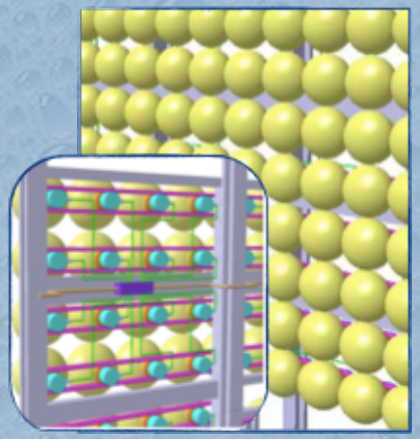
TEST BENCH for photodetection and electronic solutions for LARGE detectors



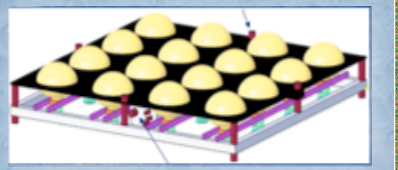
PMm2

http://pmm2.in2p3.fr

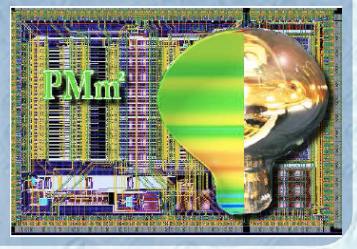
- Hight number of **light sensor**: need grouped acquisition;
  - 12 bit ADC
  - 12 bit TDC
  - gain adjustment
  - common HV
  - digitization



Demonstrator:



PARISROC



~8t of water (+Gd?):

2x2x2m^3 HDPE tank

- Matrix of 16 PMTs and/or other photodetectors (e.g.: X-HPX)

- **Muon hodoscope:**
- 2+2 planes of OPERA scintillator bars
- 4 Pmt multi anodes (64 channels)

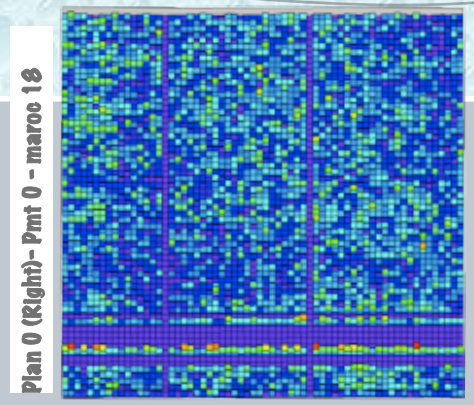
R&D program:

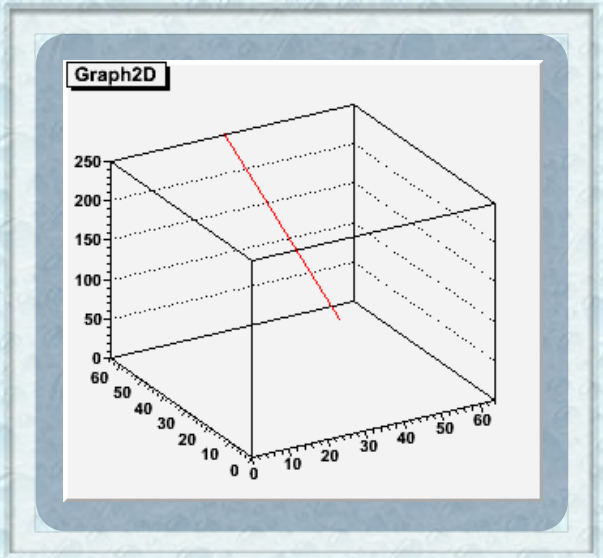
- ☐ Timing
- ☐ Internal clock noise
- ☐ Synchronization between boards
- ☐ Time resolution
- ☐ Dead time
- ☐ Trigger less acq.
- ☐ Single vs Multi ph.e
- ☐ ..

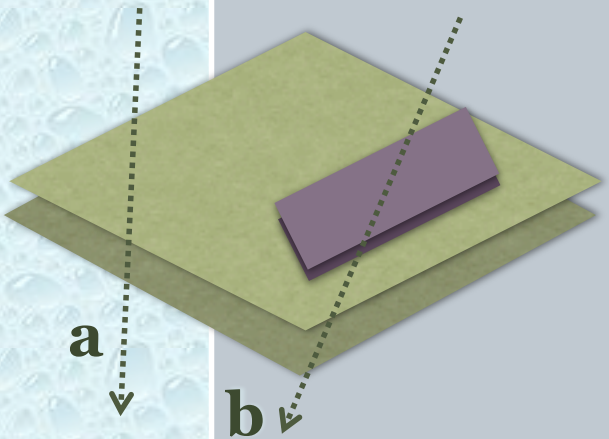
R&D photosensor:

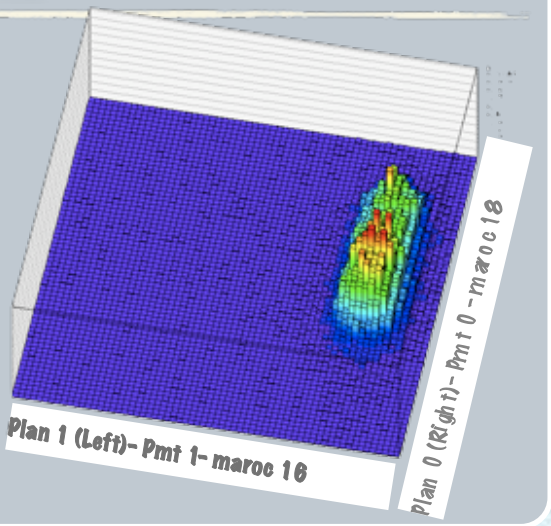
- ☐ flat panels PMTs
- ☐ new ideas (X-HPD,..)
- ☐ solid state
- ☐ ..

Hodoscope response tests



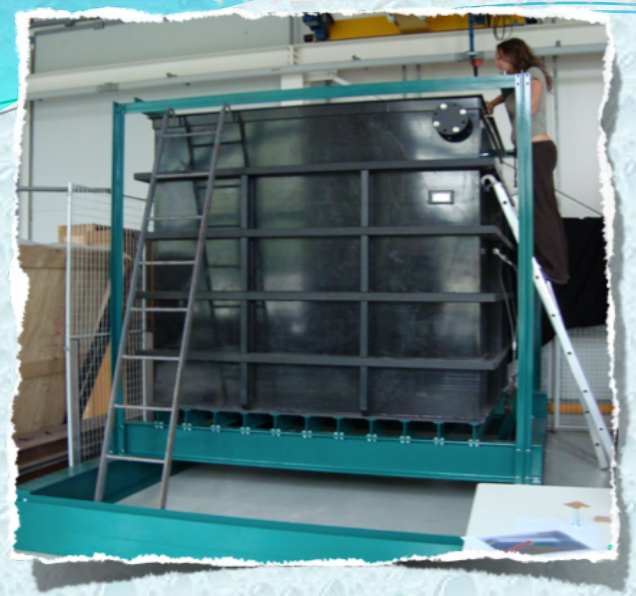


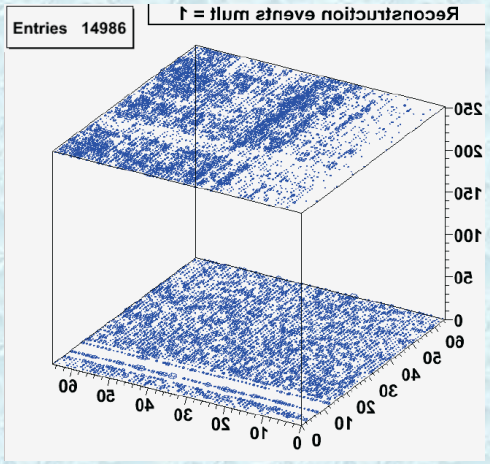


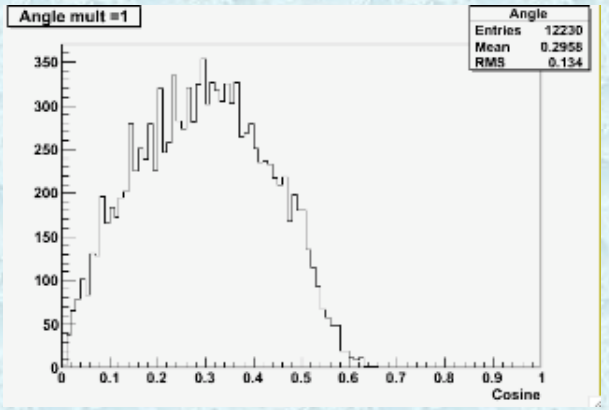


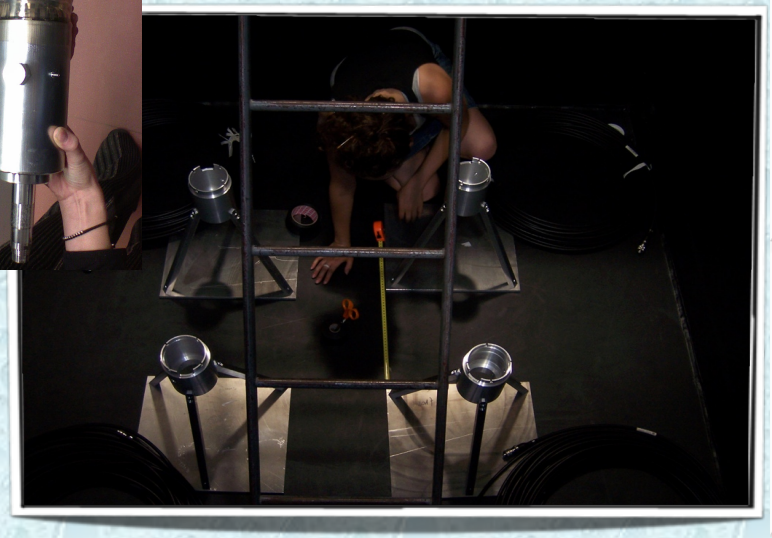
MEMPHYNO

STATUS AT PRESENT TIME

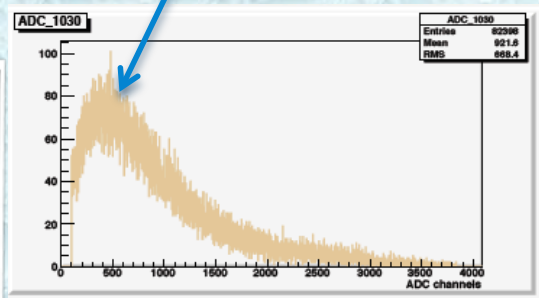


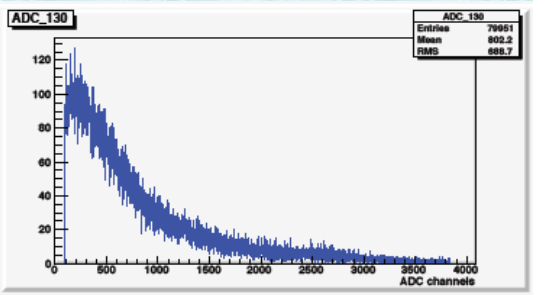


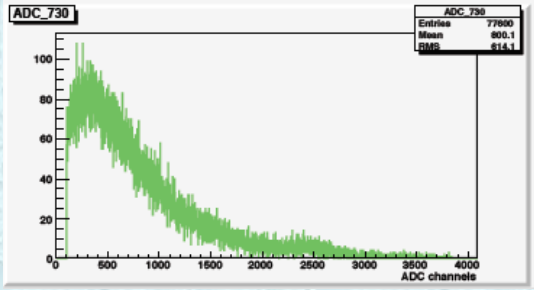


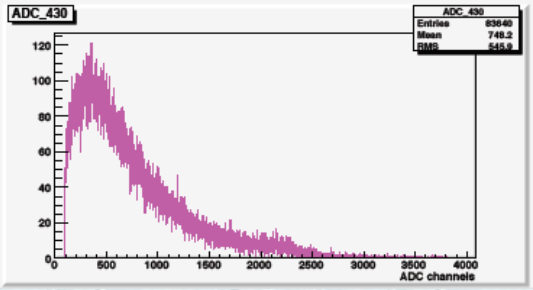


80 – 100 p.e.



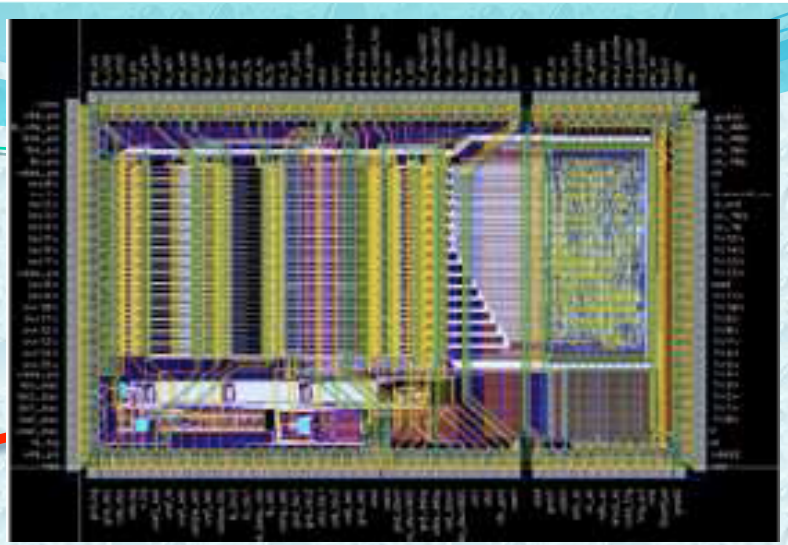






PMm² Matrix

16 8" Hamamatsu PMTs



Chip: PARISROC (4 x 4 PMTs)

Technology: 0,35 mm SiGe

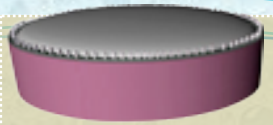
- ✓ Range: 0 to 300 p.e.
- ✓ 12 bit ADC
- ✓ 12 bit TDC
- ✓ gain adjustment
- ✓ common HV (2 kV, 2 mA)
- ✓ digitization
- ✓ Timetag accurancy 200 ps

Summary:

- Memphys is a mild extrapolation of SK (factor 6 for 1 module) -> safe
- + 240,000 PMTs (baseline is 12" for 30% surface coverage)
- Number of channels, background reduction and costs ask for intelligent electronics
- Make sub-marine electronics and regroup PMTs
- Such electronics is developed in the PMm2 program and available, tests ongoing
- Need to industrialize production and maintenance for the electronics (lifetime – 30 y)
- 15000 electronics boards for the final detector

Backup slides

Outstanding physics goals

	 GLACIER	LENA	MEMPHYS
Total mass	100 Kton	50 kton	500 Kton
$p \rightarrow e\pi^0$ in 10 y	0.5×10^{35} y $\varepsilon = 45\%$, ~1 BG event	?	1.2×10^{35} y $\varepsilon = 17\%$, ~1 BG event
$p \rightarrow \nu K$ in 10 y	1.1×10^{35} y $\varepsilon = 97\%$, ~1 BG event	0.4×10^{35} y $\varepsilon = 65\%$, <1 BG event	0.15×10^{35} y $\varepsilon = 8.6\%$, ~30 BG events
SN cool off at 10 Kpc	38·500 (all flavors) (64·000 if NH-L mixing)	20·000 (all flavors)	194·000 (mostly $\nu_e p \rightarrow e^+ n$)
Sn in Andromeda	7 - (12 if NH-L mixing)	4 events	40 events
SN burst at 10 Kpc	380 ν_e CC (flavor sensitive)	~ 30 events	~ 250 ν-e elastic scattering
DSN	50	20-40	250 (2500 with Gd)
Atm. neutirnos	~1·100 events/y	5600/y	56·000 events/y
Solar neutrinos	324·000 events/y	?	91·250·000/y
Geo-neutirnos	0	~ 3·000 events/y	0