



Future of the “V & associates” activities* at LAL

- ✿ PMm2 « photodetection R&D »: information on the approved project funded by ANR which may be a key point for the future
- ✿ T2K: a participation is requested to this SC

*:except SuperNEMO

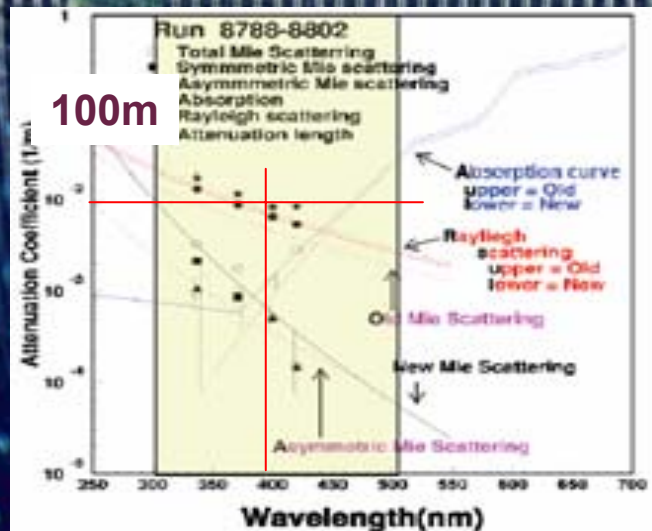
(Inter)national introduction...



Super-K (III) will run ~10yrs more

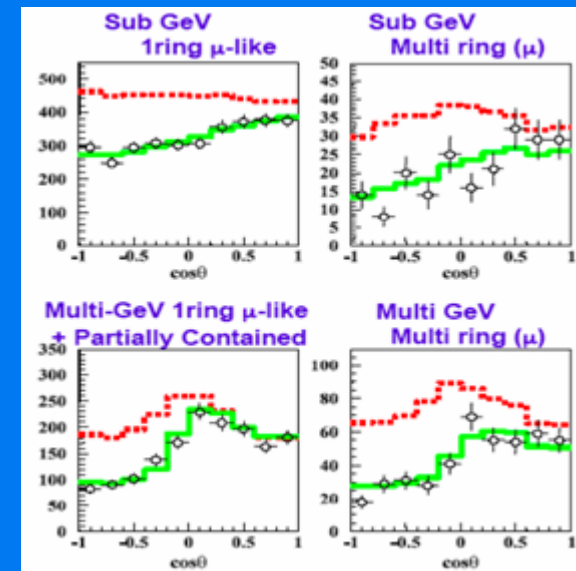
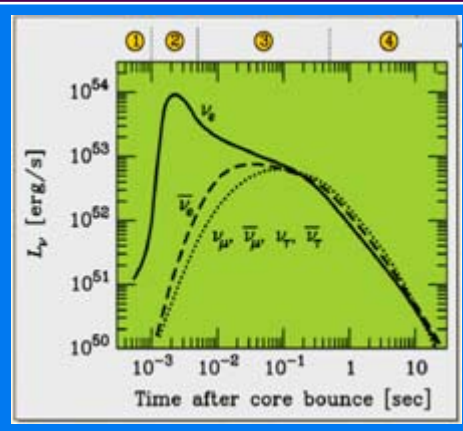
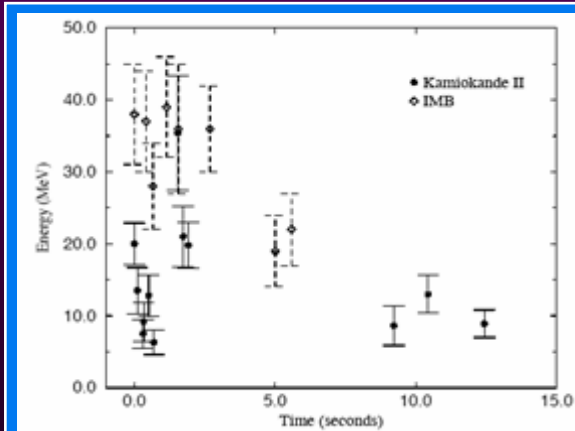
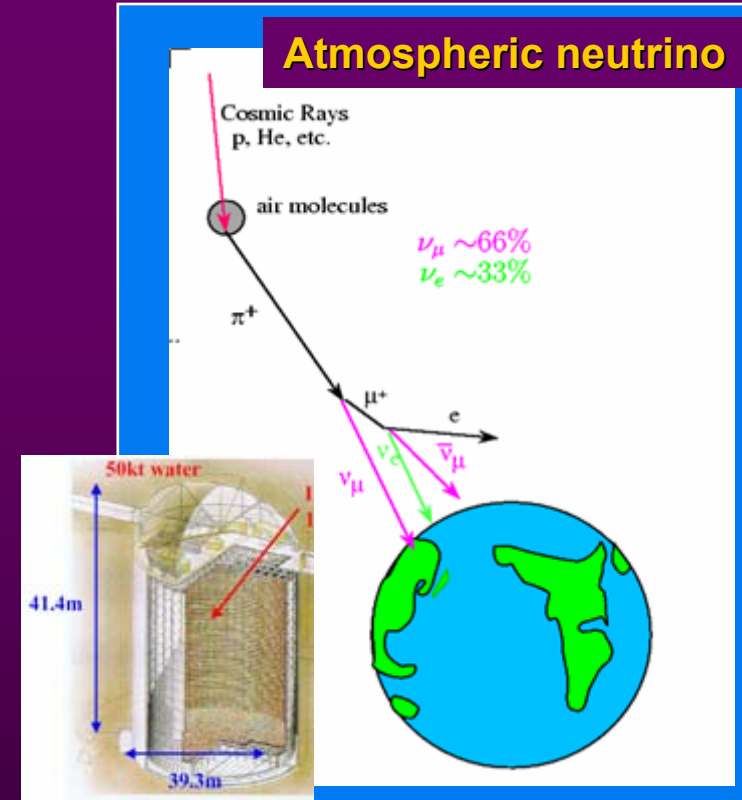
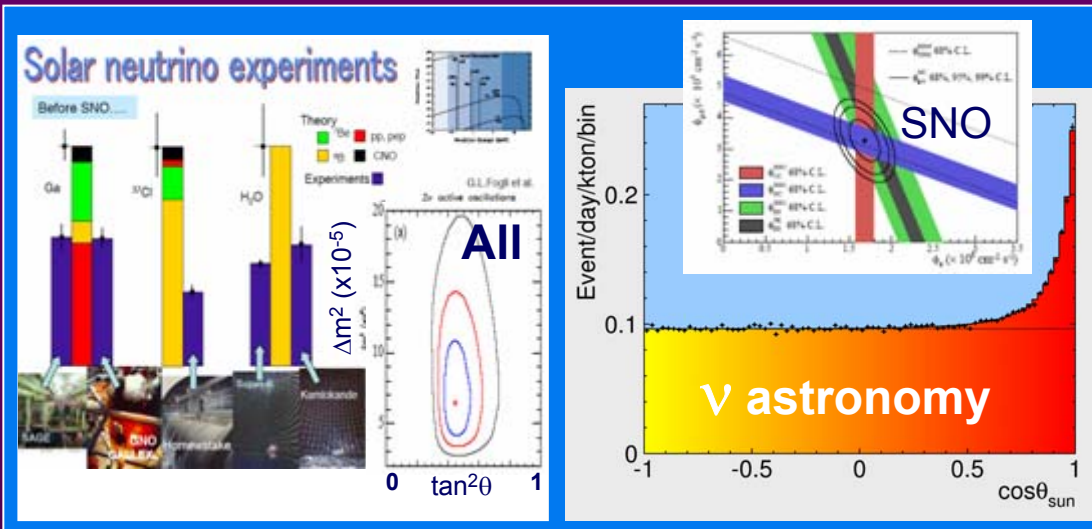
About 170 γ /cm in $350 < \lambda < 500$ nm
 With 11,000 PMT (20") 30% coverage, Q.E. \approx 20%, CE \approx 60%
 Relativistic particle produces
 $\Rightarrow \approx 14$ photoelectrons / cm
 $\Rightarrow \approx 7$ p.e. per MeV

Volume total 52kT
 Fiduciel: 22.5kT



- ☀ $GdCl_3$ highly water soluble but acid
- ☀ Neutron capture on Gd emits a 8.0 MeV γ
- ☀ 100 tons of $GdCl_3$ (0.2% by mass) would yield >90% neutron captures on Gd
- ☀ 3\$/kg
- ☀ Test on the K2K 1kT prototype done
- ☀ Test on SK-like container undertaken now
- ☀ Physics Potential ↗

Past success of the field...



- Solar neutrino anomaly solved
- Detection of SN-1987A (Nobel Koshiba)
- Discovery of atm neutrino oscillations

The need for new generation experiments...

Still many important issues...

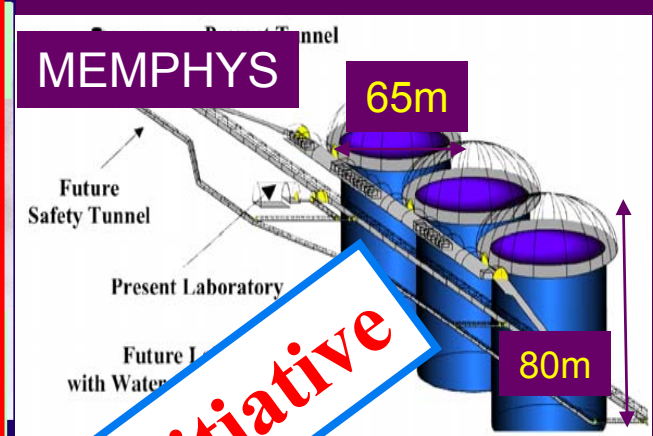
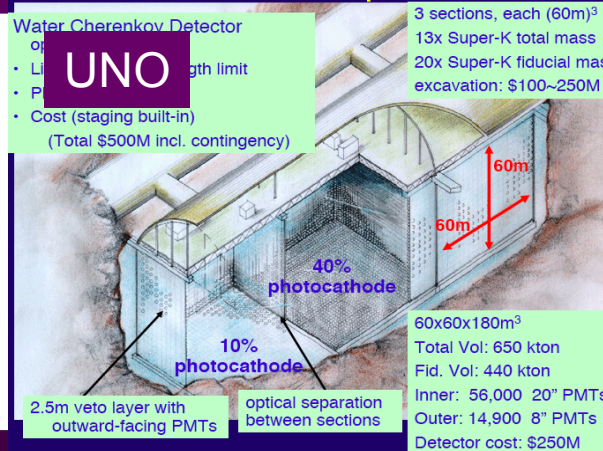
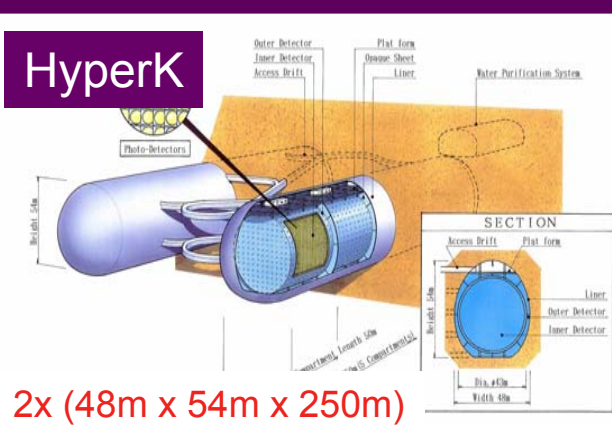


- | | |
|---|---|
| <input type="checkbox"/> Baryon number violation | Proton decay |
| <input type="checkbox"/> Astroparticle physics | |
| ▪ Understand gravitational collapse | Galactic SN ν |
| ▪ Star formation in the early universe | Diffuse SN ν |
| ▪ Explore violent phenomena in the universe | Trigger SN ν |
| ▪ Dark matter and astrophysical sources | Incoming muons |
| <input type="checkbox"/> Neutrino properties | LBL - ν, Atm. - ν, SN - ν |
| <input type="checkbox"/> Solar thermonuclear fusion processes | Solar - ν |
| <input type="checkbox"/> Geophysical models, Earth density profile | Geo - ν, U, Th - ν |

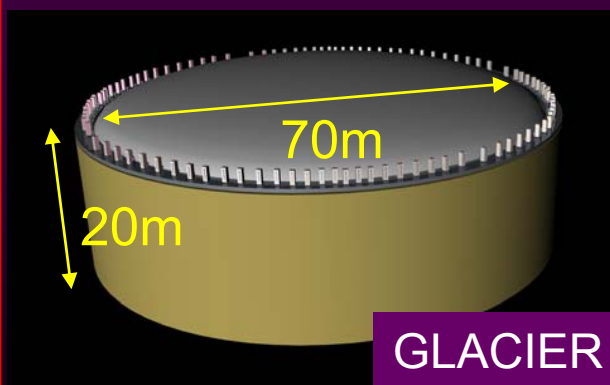
Some detectors presented at **NNN Workshops**

Start 99, recent Aussois 05, **Seattle 06**, future Hamamatsu 07, Paris 08

Water Čerenkov 500kT → 1Mt

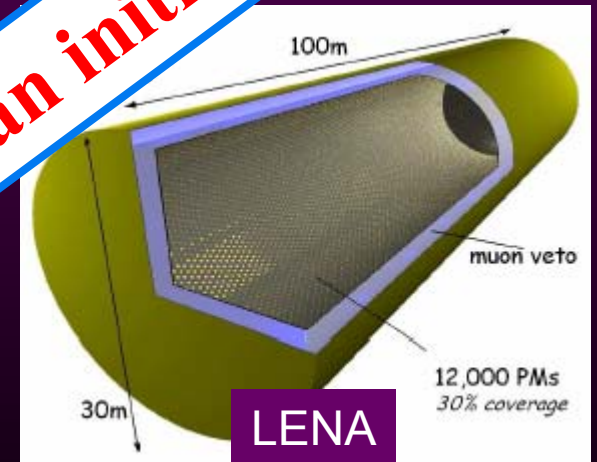


European initiative



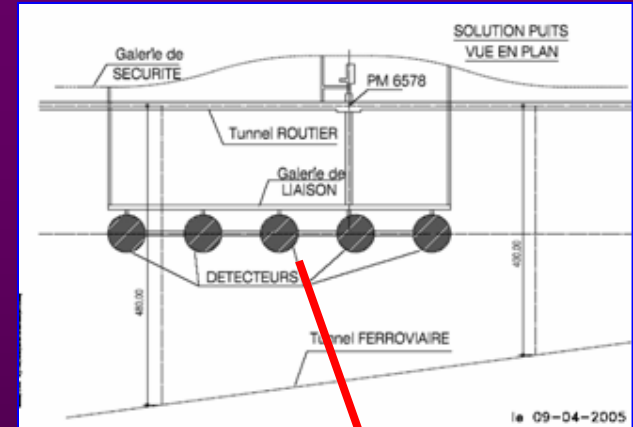
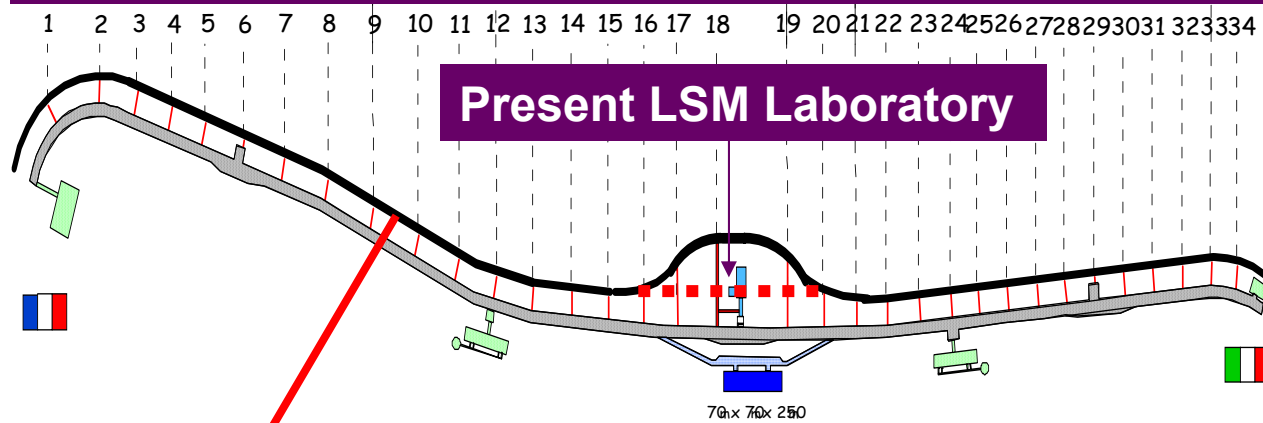
Liq. Argon
→ 100kT

Liq. Scintillator
→ 50kT



Large Apparati for Grand Unification and Neutrino Astrophysics : **LAGUNA**

What about **MEMPHYS** (MEgaton Mass **PHYS**ics) at Fréjus ?



Safety Tunnel status :

April 2006: \varnothing fixed to 8.00m by the "Inter-Governmental Commission French-Italy"

Nov 2006: final decision on Safety plan

Déc. 2006: Inter-Governmental meeting for the founding plan
mid-2008 : start the excavation

Results of a preliminary study done by the SETEC co. (Fréjus road tunnel project leader)

Estimated cost of 1 cavity (stabilised & access) \approx 80 M€
(excavation & stabilisation \sim 160€/m³)



3 shafts H₂O = 450kT fid.; 1 shaft H₂O + Gd: 150kT; 1 shaft: 100kT LAr?

Let us draw some objectives:

☀ Long term plan (~2020):

Participate to a major experiment in the field of Nucleon decay, supernova neutrinos, neutrino properties,...

☀ Short term plan (now-10):

Make generic R&D for large detectors

LAGUNA EU DS request for FP7

⇒ Photodetection R&D in Labs and Co.: eg. PMm2, French-Japan coll.

☀ Medium term plan (now-15):

Consolidate the how-to and how know of the int. community to operate a very large Water Čerenkov

Participate to SuperK:

the largest W Č will still operate for 10yrs

but this subject is still in too early stage

Participate to T2K:

⇒ ND280m-Off axis

2km W Č : very interesting, not yet accepted, contact with Kajita-san

**R&D Program for any detectors
using “large” number of
photodetectors (few 100,000 units)**

The PMm2 program

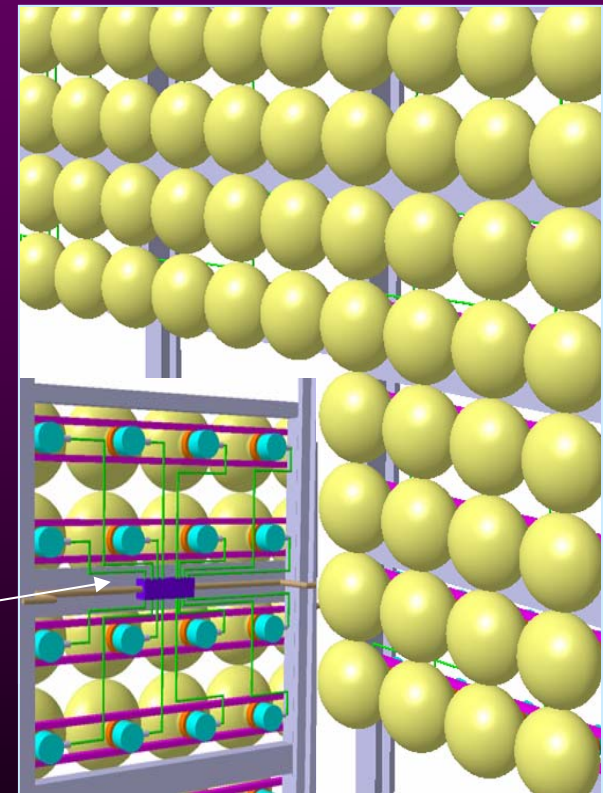
➤ Megaton water tanks

- Hamamatsu and Tokyo U. has developed & produced large number of very large PMTs (20" size) in the context of SuperK; and now development of large HPD in the context of HyperK

➤ Proposal for MEMPHYS

- Replace large PMTs (20") by groups of smaller ones (12"); originally proposed by Photonis Co.

Integrated electronics
(Multichannel, close to the PMTs)



Photodetectors: complementarities among world initiatives

•Diameter	20" <=>	12"	
•projected area	1660	615	cm ²
•QE(typ)	20	24	%
•CE	60	70	%
•Cost	2500	800	€
•Cost/p.e/cm	13	8	€

PMT Photonis@NNN05

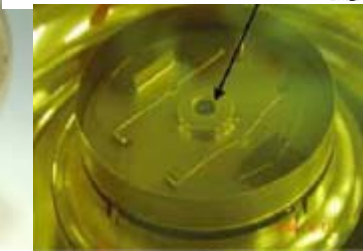
H. Aihara @ NNN05
M. Tanaka@ NNN06

Hamamatsu

HPD



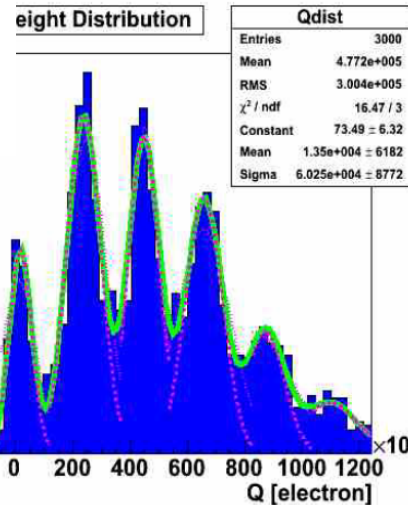
13inch HPD → 20"



Dark current

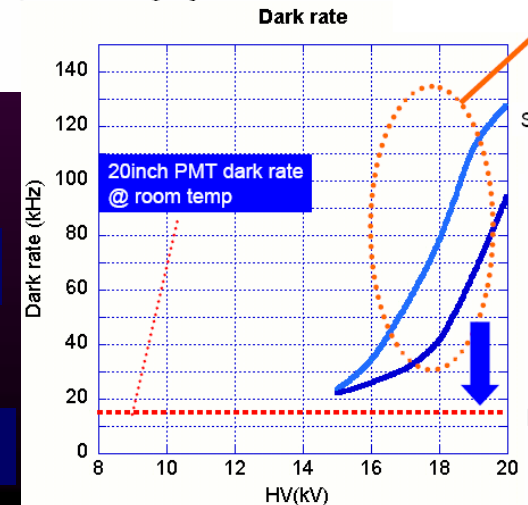
~19kV

Needs low noise electronics



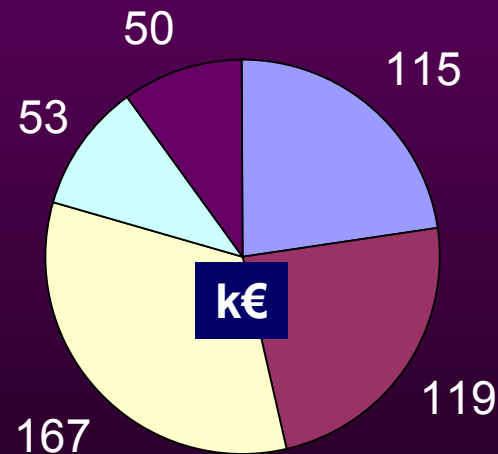
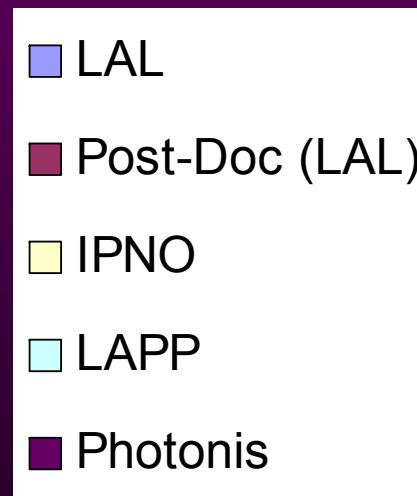
Summary

- 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



National Research Agency (2006)

- ☀ **LAL**: front end electronics
- ☀ **IPNO**: photodetector tests + mechanics
- ☀ **LAPP**: Data network
- ☀ **Photonis**: PMTs provider



Funded* 500k€/3yrs (1 post-doc included) 5FTE Engineers

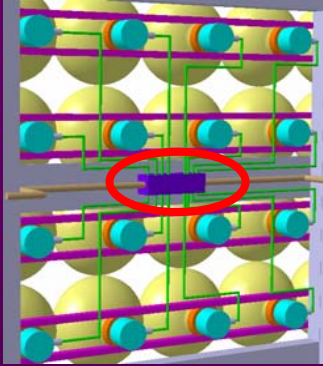
*:95% of the requested money

Man power at LAL (officially declared)

Nom	Emploi actuel	% de temps
Campagne*	CR1	75%
de La Taille	IR HC	25 %
Seguin-Moreau	IR2	50 %
Martin-Chassard	IR1	25 %
Cacérés	IE2	50 %

***: JEC is the coordinator of this ANR program**

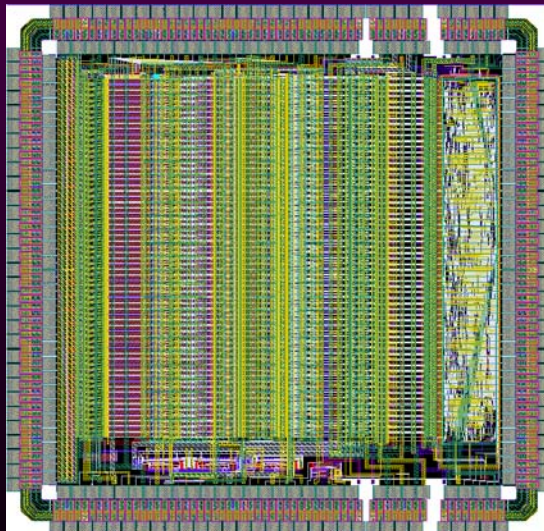
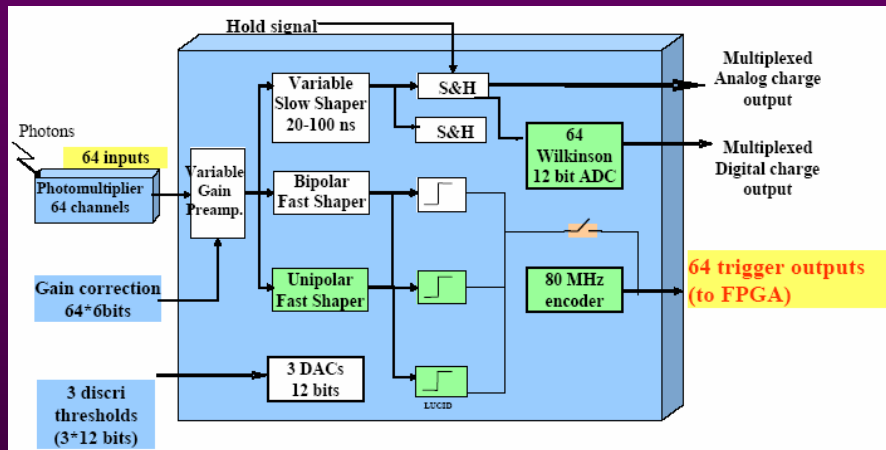
Electronics Requirements



- Need of a multichannel ASIC **close to the detector**
- To reduce the cost, we need to operate **with a common high voltage** and thus need of variable gain to equalize PM response.
- High speed discriminator to **autotrigger on single photoelectron**
- **Digitization of charge** (over 12 bits)
- **Digitization of time** of arrival to provide nano-second accuracy
- **Digital Data out**: power wires

MAROC2 architecture

MAROC2 = MAROC1 + additional features (**ADC**
Wilkinson, 3 discriminators, Encoder)



Technology : AMS SiGe 0.35 μ m

- Submitted March 06
- Area 16 mm²
- Received in june 06
- 240 pins

- Similar to OPERA ROC
- Low input impedance (50-100 Ω)
- **6 bits gain adjustment** ($G=0-4$) per channel
- 64 discriminator outputs
- **100% sensitivity to 1/3 photoelectron (50fC).** Counting rate up to 2 MHz
- Common threshold loaded by internal 10bit DAC (step 3mV)
- 1 multiplexed charge output with variable shaping 20-200ns and Track & Hold.
- **Dynamic range : 11 bits (2fC - 5 pC)**
- Crosstalk < 1%

Partial conclusion

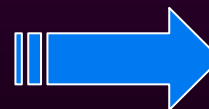
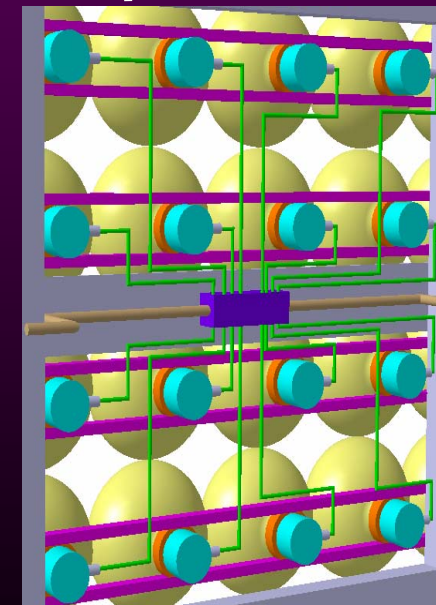
- ✿ MAROC2 fulfils most of the requirements of MEMPHYS
- ✿ With PMm2 LAL will play a central role in the generation of Megaton-like projects

- ✿ To be done:

- Time digitization (TDC)
- Data out: by Anncy (current wires)

- ✿ Test on a prototype (16 PMTs, 8") with MAROC2 foreseen fall 06

ASIC Chip & TEST BOARD designed at LAL



Proposal of collaboration for Mt Č detector FE with KEK

- ✿ J. Bouchez, J.E Campagne, J. Pouthas, S. Katsanevas have met K. Nakamura, M. Tanaka, M. Shiozawa at NNN06 workshop (Seattle 21-23 Sept. 06) and this will continue in the future NNN series
- ✿ Since the visit at KEK* (3rd Oct. 06) of Ch. de La Taille and N. Seguin-Moreau a schema of collaboration has emerged :
 1. to send a test board with MAROC and GPIB/USB based readout to KEK for evaluation
 2. To design and evaluate building blocks necessary in the future readout ASIC and hold joint design reviews for their submission
 3. To measure and characterize at BOTH places a future ASIC that would be designed jointly by LAL and KEK for future Megaton experiments
 4. Last News: M. Tanaka will come next year (Feb 07) to test MAROC2 at LAL

Slide shown at LAL-KEK meeting

*:K. Nakamura, M. Tanaka, M. Shiozawa, C. Saji

Learn how to operate a large Water Čerenkov: SuperK...

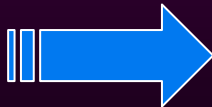
Too early to
be discussed
here.

To work directly on SuperK ?

Contact with Yoichiro Suzuki-san

To work on a smaller WČ: 2km T2K ?

Contact with Takaaki Kajita-san (electronics?)



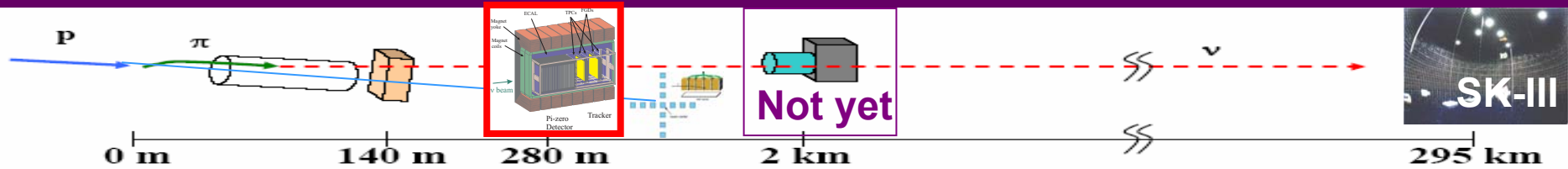
Participate to T2K present version (realistic)

Join French collaboration on 280m near detector

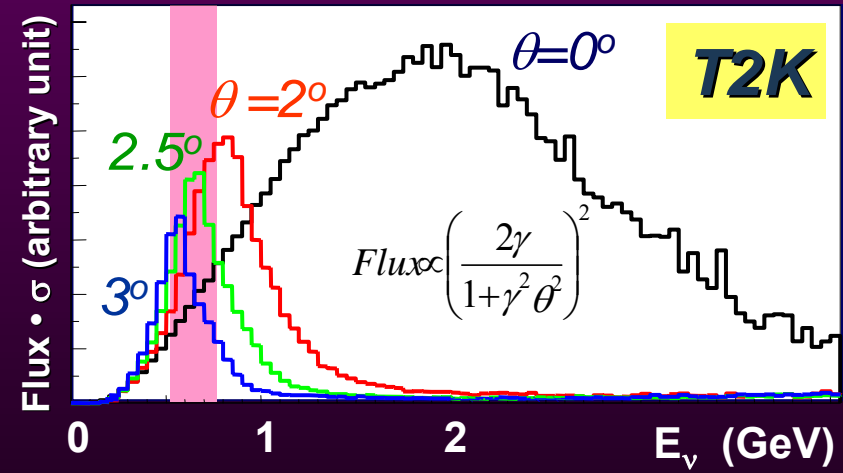
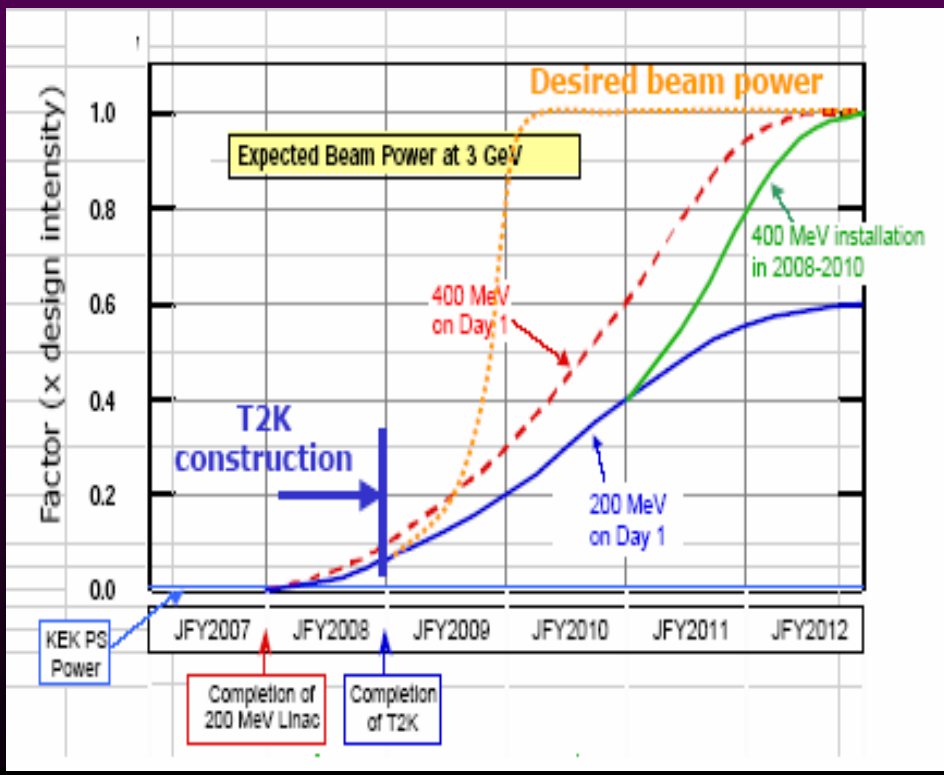
Choose Off-axis detector (Saclay, LPNHE)

Keep modest attitude

T2K: Tokai to Kamioka



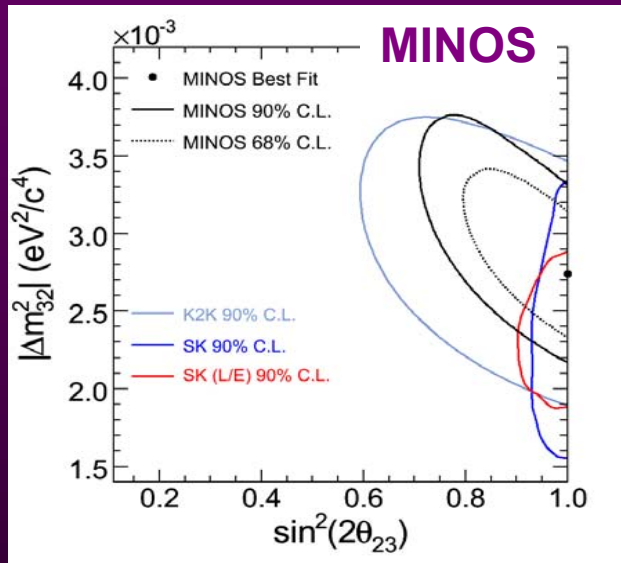
Conventional ν_μ beams from pion decay
 Increased proton beam power: 0.4 \rightarrow 0.8 MW
Off-axis technique: narrow band beam with purer composition
 Tune L/E to the oscillation maximum



- low E_ν (<1 GeV) Super-Beam: $>10^{21}$ pot/year @ 40 GeV (≈ 1.35 MW by 2012)
- SK detector: 22.5 kton x year
- @ $2^\circ \rightarrow 3000 \nu_\mu$ CC/year (x10 w.r.t. K2K)
- 0.2% ν_e contamination and π^0 BG

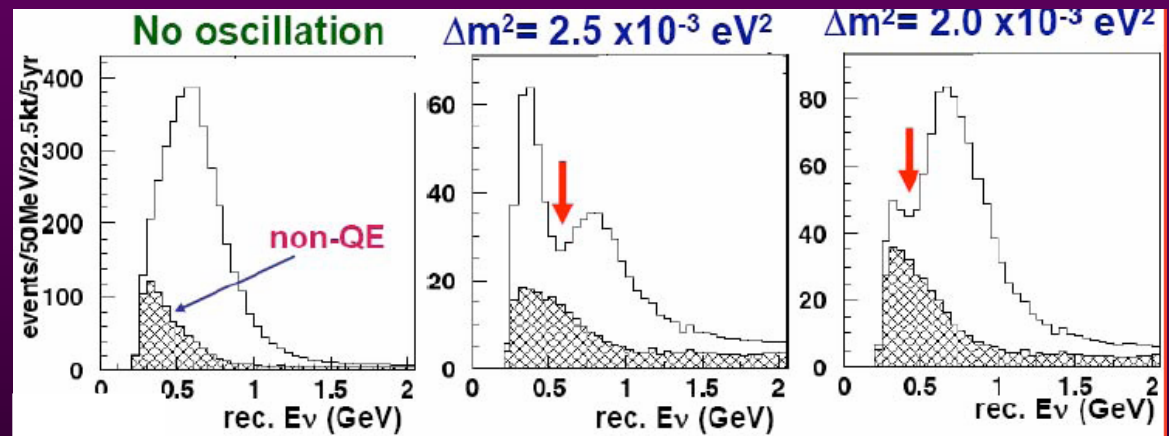
$|\Delta m_{32}^2|$ et $\sin^2 \theta_{23}$ « atmospheric parameters »

$|\Delta m_{32}^2| = 2.74^{+0.44}_{-0.26} \times 10^{-3} \text{ eV}^2$ and $\sin^2(2\theta_{23}) > 0.87$ (68% C.L.) for $1.27 \cdot 10^{20}$ pot

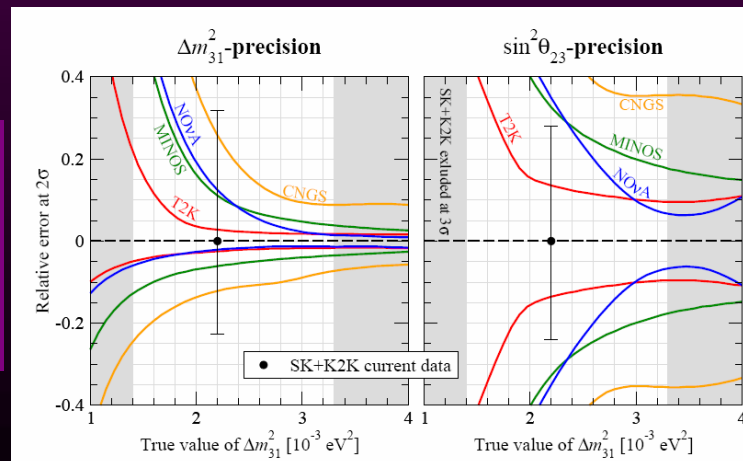


$$P_{\mu\mu} \simeq 1 - \cos^4 \theta_{13} \sin^2 2\theta_{23} \sin^2 \Delta + 2\alpha \cos^2 \theta_{13} \cos^2 \theta_{12} \sin^2 2\theta_{23} \Delta \cos \Delta.$$

$\alpha \sim 0.03$



A good QE/nonQE measurement is fundamental to reduce systematic errors. in K2K its contribution $\sim 10\%$



T2K ~ NOVA

T2K: θ_{13} search

Different systematics

$$|\Delta m_{32}^2| = 2.5 \cdot 10^{-3} \text{ eV}^2 \sin^2(2\theta_{13}) = 0.1$$

$$\pi^0 \quad \nu_\mu/\nu_e \sim 0.2\%$$

5 10^{21} pot

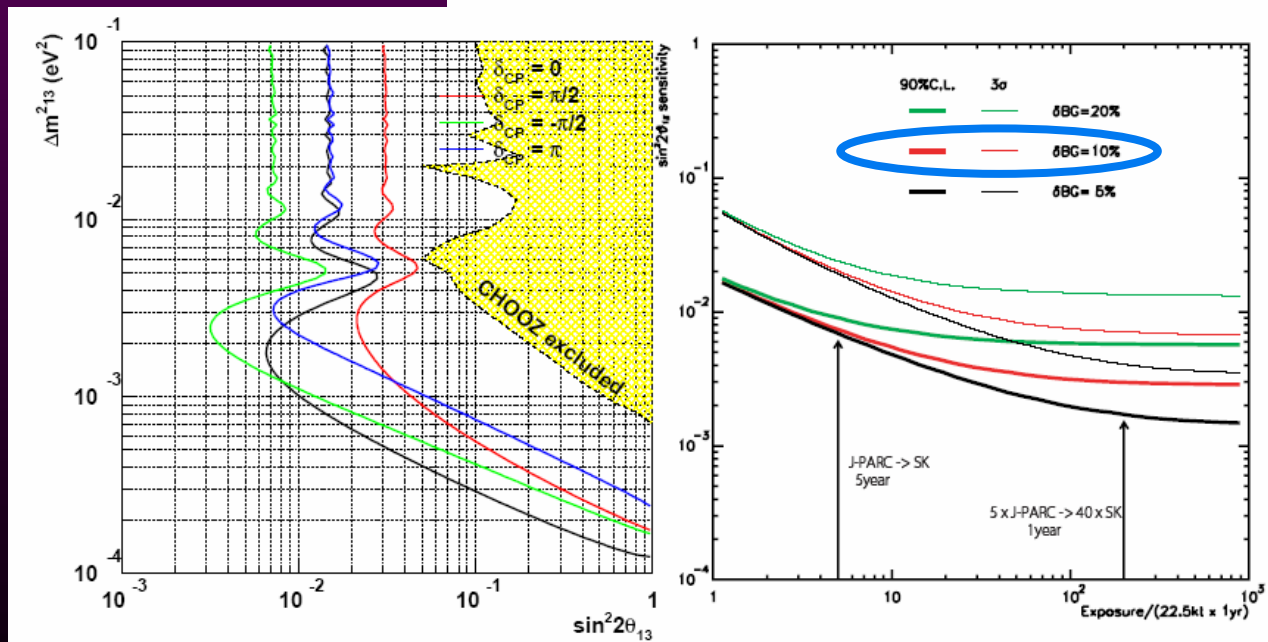
	ν_μ CC BG	ν_μ NC BG	beam ν_e BG	ν_e CC signal
Fully-contained, $E_{vis} \geq 100\text{MeV}$	2215	847	184	243
1 ring e-like, no decay-e	12	156	71	187
$0.35 \leq E_\nu^{rec.} \leq 0.85\text{GeV}$	1.8	47	21	146
e/ π^0 separations	0.7	9	13	103

$$P_{e\mu} \simeq \sin^2 2\theta_{13} \sin^2 \theta_{23} \sin^2 \Delta$$

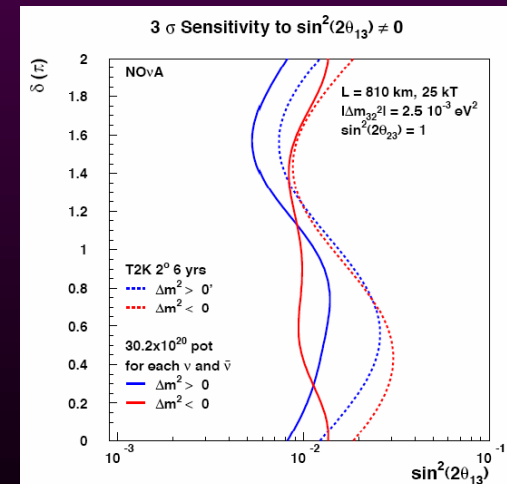
$$\mp \alpha \sin 2\theta_{13} \sin \delta_{CP} \cos \theta_{13} \sin 2\theta_{12} \sin 2\theta_{23} \sin^3 \Delta$$

$$- \alpha \sin 2\theta_{13} \cos \delta_{CP} \cos \theta_{13} \sin 2\theta_{12} \sin 2\theta_{23} \cos \Delta \sin^2 \Delta$$

$\alpha \sim 0.03$



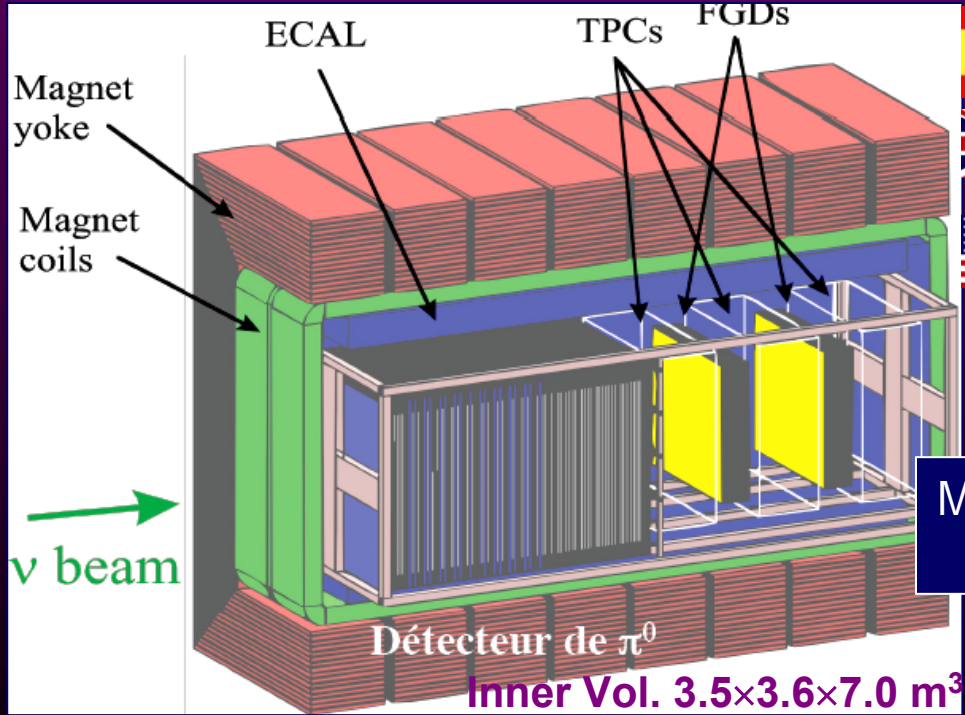
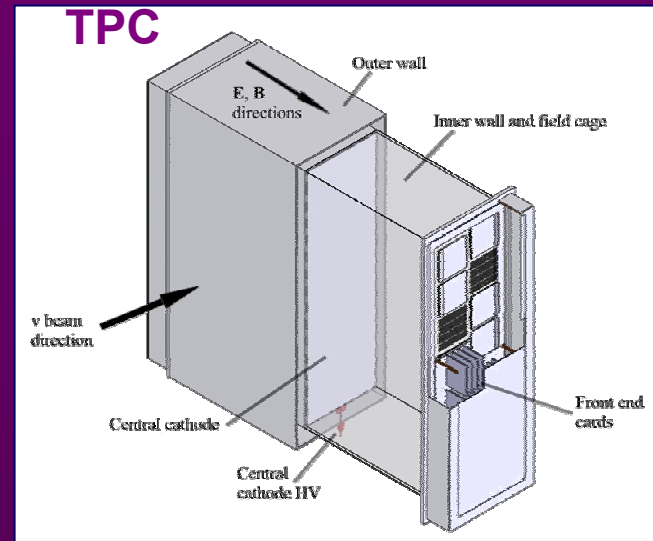
T2K ~ NOvA



T2K may not be latest

T2K : near detector (280 m)

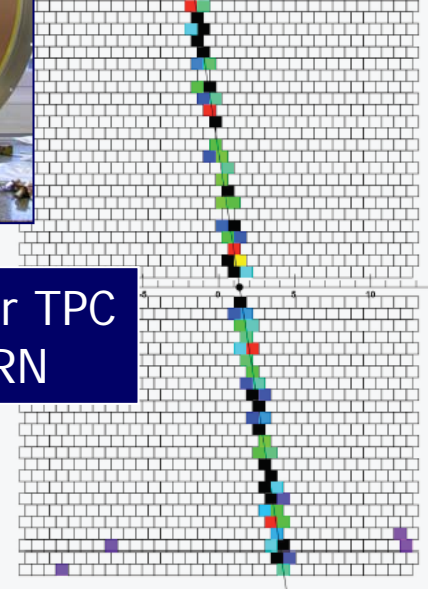
- In UA1 magnet, 3 large TPC (2x2x1m³):
- Conception of Micromegas detector (**Dapnia**)
 - Electronics, o(100K) channels, front-end (**Dapnia**), back-end (**LPNHE**)
 - Cross-section measurement (QE, non-QE, C/H₂O)
- On-axis detector (**LLR**)



$\sigma < 10\%$ $p < 1\text{GeV}$
 Charge dE/dx (7%) e/μ

Total 10m²

TPC Micromegas Run 832 Event 4



Micromegas end plate for TPC
 Successful test at CERN

Planning TPC



Apr. 2007

Apr. 2008

version 0.4	juil-06	août-06	sept-06	oct-06	nov-06	déc-06	janv-07	févr-07	mars-07	avr-07	mai-07	juin-07	juil-07	août-07	sept-07	oct-07	nov-07	déc-07	janv-08	févr-08	mars-08	avr-08	mai-08	juin-08	juil-08	août-08	sept-08	oct-08	nov-08	déc-08	janv-09	févr-09	mars-09	avr-09	mai-09			
Prototypes																																						
Continued tests with prototypes																																						
Module 0																																						
Mechanical design																																						
Design review																																						
TPC construction																																						
pre-prod MM fabrication/tests																																						
Prototype FE/BE electronics																																						
Prototype gas/monitor/laser																																						
Tests with module 0																																						
Production modules																																						
Design modifications/setup																																						
TPC construction																																						
MM fabrication/tests																																						
Final FE/BE electronics																																						
Final gas/monitor/laser																																						
Integration and tests at TRIUMF																																						
Ship to Japan																																						
Installation in ND280																																						
Commissioning of detector																																						

From M. Zito (Dapnia) co-project Leader

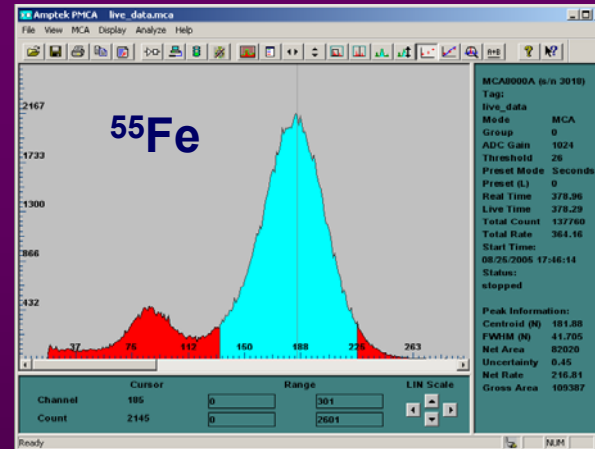
Tests to be done (M. Zito June 06')

- ✿ Gain homogeneity on the detection surface
- ✿ Gain with other gas: Ar-Ethane, Ar-Isobutane, Ar-Ethane-CF₄, Ar-Methane
- ✿ Test with "short-cuts"
- ✿ **Stability Test** 
- ✿ Ageing Test
- ✿ Test the new modules 
 - 25x25 cm² → 35x25 cm²
 - 1024 pads → 1720 pads

We dispose
of a quiet test room @ LAL

Test bench

A. Delbart, A. Giganon, Y. Giomataris, M.Zito at Saclay



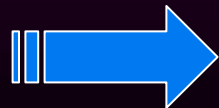
J.E.C + help from V. Chaumat, V. Lepeltier, V. Puil
DAQ adapted from V.C LabView by J.-Cl. Marrucho + Cl. Pailier
Captors by A. Thiebault

Time survey of the gain
(^{55}Fe + mesh signal)
and external parameters (T,P)



UA1/NOMAD Magnet refurbishment

- ✿ Under the responsibility of European groups involved in ND280m-Off axis: France, Germany, Spain, Switzerland, United-Kingdom and *Italy*
- ✿ **Italy** was project leader till the INFN decision to suspend any T2K participation. Italy was also in charge of CERN interface and moving system design. Waiting for a **new decision (nov. 06)**
- ✿ But all the magnet component should be in Japan by end of 2008, the heaviest components by first 3 months of 2008.



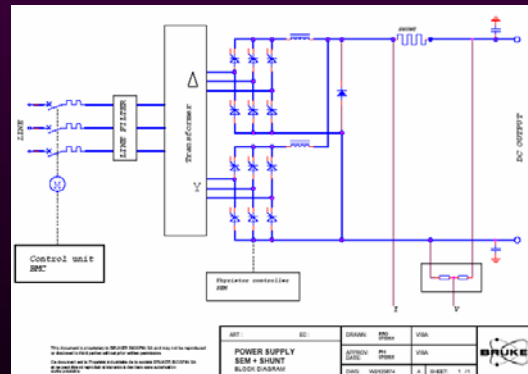
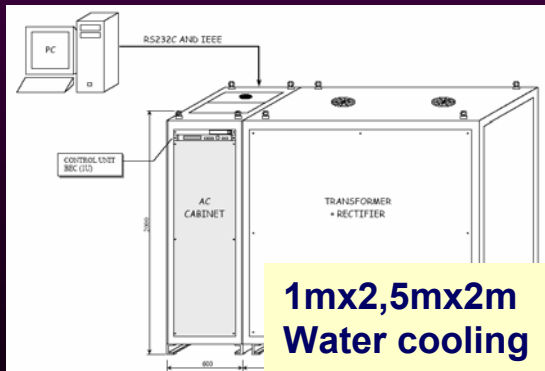
Critical Path

Power supply and cables

	Field	Power	Max Current	Voltage	Water flux	Delta T
UA1	0.7T	5500KW	10.000A	555V	50 l/s	30°C
Nomad	0.4T	2400KW	8.000A	400V	20 l/s	30°C
T2K	0.2T	600KW	3.300A	188V	15 l/s	10° C

Firme	Puissance	Courant	Tension	Prix
OCEM	620 kW	3300 A	188 V	123k€ HT/TTC ?
BRUKER	650 kW	3300 A	195 V	86 k€ HT
MIDEC	660 kW	3300 A	200 V	103 k€ HT
HAZEMEYER	650 kW	3300 A	195 V	~100k€ HT

Contacted by
M. Omeich



Add
(6+6) power cables
60 m
~ 40k€ (Draka)

~150k€ IN2P3+CEA

Power supply

- ✿ T. Nakaya (Tokyo): ND280 project leader
- ✿ T. Tsukamoto is the Technical Board coordinator
- ✿ Missing yet is the Magnet Project Leader
- ✿ Request: France (LAL) Power Supply Project Leader

150k€ requested budget (IN2P3+CEA) for French Magnet contribution fits to present Power Supply + cables budget.



M. Omeich is a key-person in this operation. Call tenders foreseen **mid-2007** to get the power supply **mid 2008** and installation **end 2008** at KEK.

Commissioning in situ (Japan) would be in charge of LAL
No cabling installation foreseen by LAL
No maintenance on site

Summary

- ☀ A perspective for next generation of experiment for **Nucleon Decay & Neutrino properties research** at the horizon of 2020 has been reminded
- ☀ The funded **PMm2 ANR program** coordinated by JE.C is the first R&D for **photodetection optimisation** for very large detectors as **MEMPHYS/HyperK, GLACIER, LENA** and would place **LAL** at the central position in the future landscape of the field
- ☀ The requested participation to **T2K** by mean of
 - Magnet power supply + cables project (equiv. French part)
 - Micromegas chamber studies at LALwould make for 10yrs **Neutrino properties research complementary to SuperNemo**, and if possible **open** the participation to evolution of 2km site, and may be the new **SuperK** physics program