Photomultiplicateurs

et

Electronique

Joël Pouthas IPN Orsay

R&D

Photomultiplicateurs
(Grande dimension)

et

Micro-Electronique

IPN Orsay Joël Pouthas LAL Orsay IPN Orsay PHOTONIS

Programme Astroparticules 2004 et 2005

Origine

Observatoire Pierre AUGER

Début : 2000

Fin : avril 2005

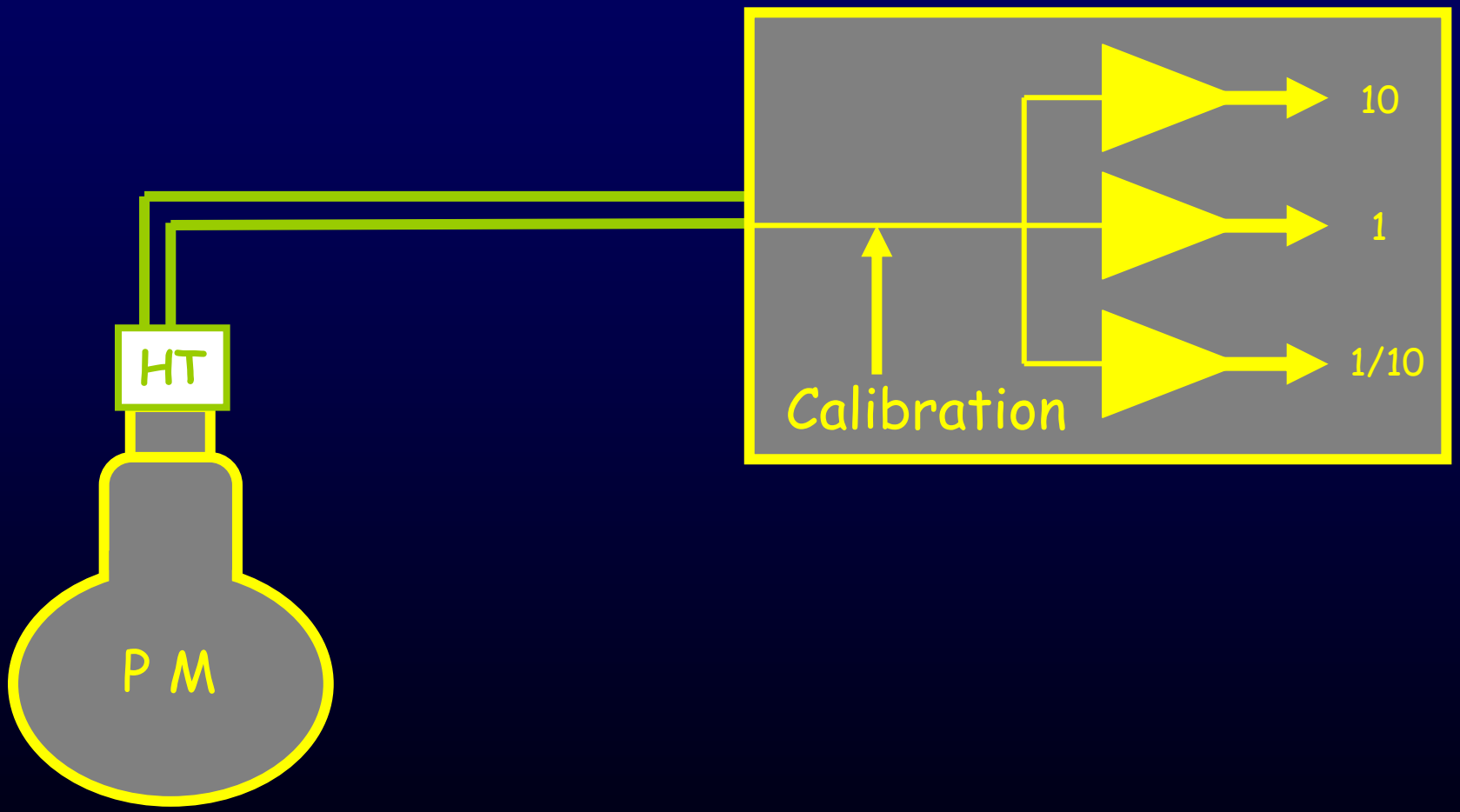
Etudes Photomultiplicateurs

Embases R&D et Construction

Origine

R&D Electronique — Observatoire Pierre AUGER — Site Nord

Collaboration LAL et IPN @ Orsay



Origine

R&D Electronique — Observatoire Pierre AUGER — Site Nord

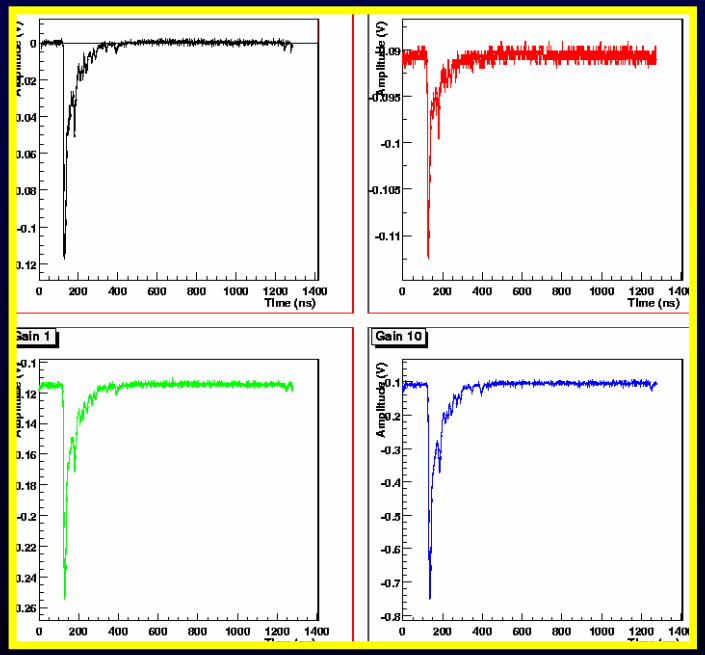
Collaboration LAL et IPN @ Orsay

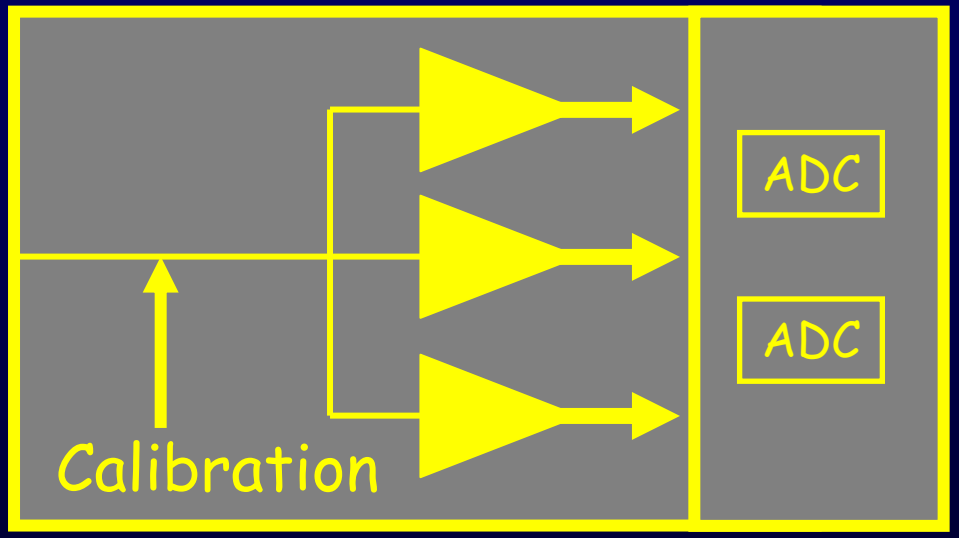
Micro-Electronique (ASIC)

Grande dynamique (équivalent 16 bits)

En 2004

Circuit 3 Amplis





En 2005 et 2006

Etudes ADC (100 MHz)

En 2006 et 2007

Etalonage

Discriminateurs et filtres

IPN Orsay / Photonis Collaboration

Start with AUGER Surface Detectors

PMT : PHOTONIS XP 1805 (9")

Base design : IPN Orsay (End of 2000)
Production : 5000 pieces (2001-2005)
Photonis, IPN Orsay, INFN Torino

Continue with R&D Program on large Photomultipliers

Year 1 (Sept 03-Sept 04)

Definition and construction of the test benches
Validation on reference PMTs

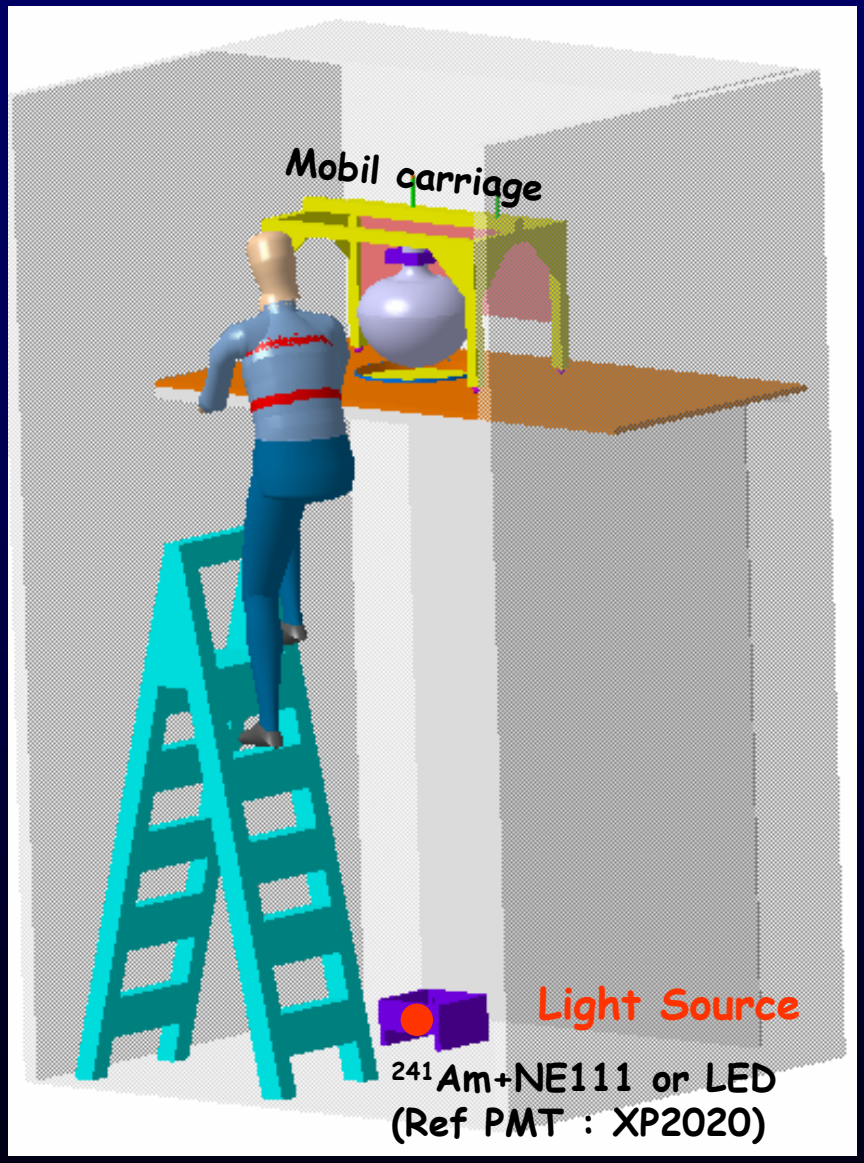
Year 2 (Sept 04-Sept 05)

Construction and measurements on different PMTs (5",8",9",10")
Photocathode characterization. Afterpulse measurements

Year 3 (Sept 05-Sept 06)

End of measurements on standard PMT
Afterpulse studies : detailed simulations and measurements

IPN Orsay / Photonis Collaboration



Test Bench 1

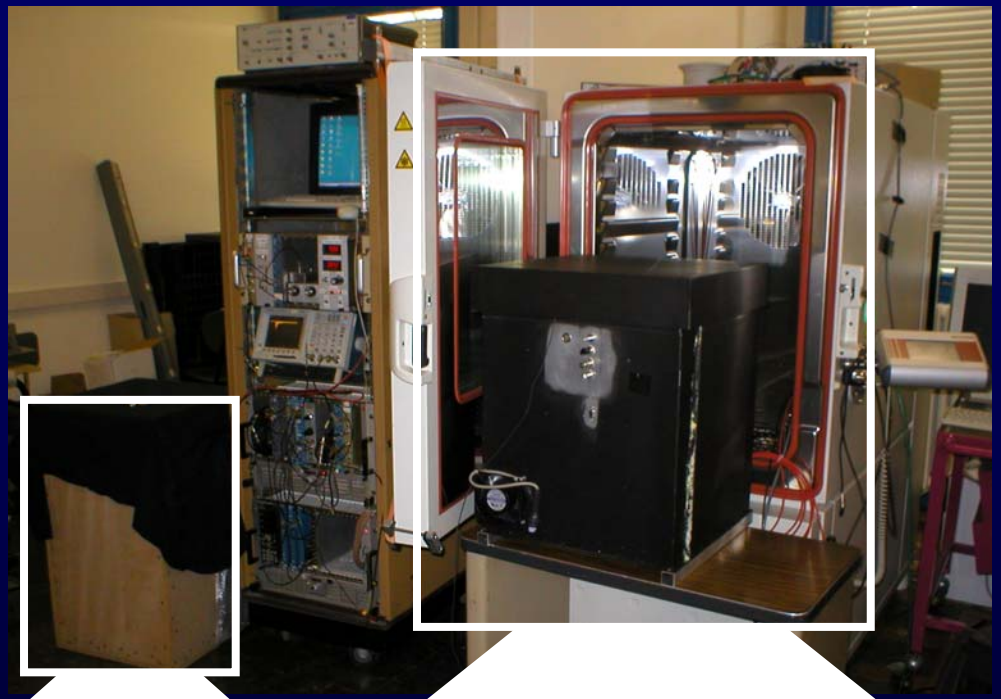
Single electron response
(SER and P/V)

Timing characteristics

Photocathode uniformity

Detection efficiency (relative)

IPN Orsay / Photonis Collaboration



Black box
(Wood)

Climat cabinet

(Voestch VC4034)
+ Black box (Al)

(-40° à +50°)

Test Bench 2

Noise

After pulses

Variation with temperature

Magnetic field effects

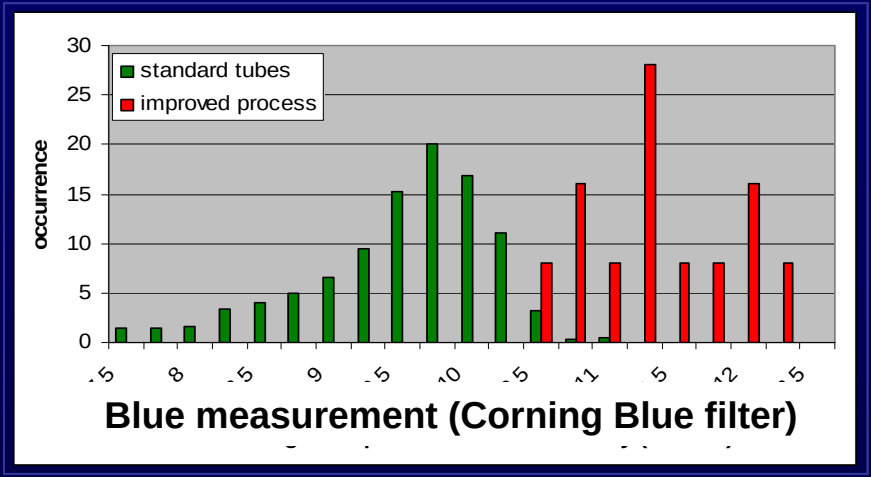
Data Acquisition

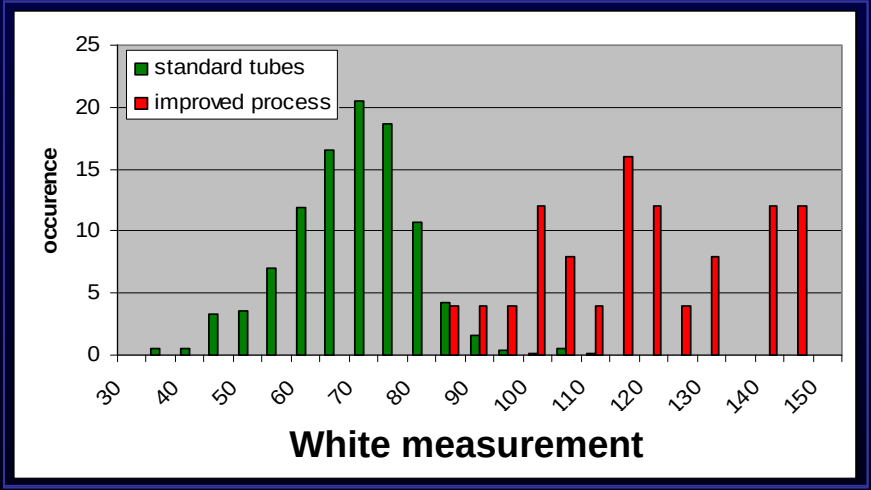
CAMAC
Oscilloscope
MATAC (2GHz, 12bits)

Overview on results

Improved photocathode

D. Dornic et al, Beaune Conference, France, June 2005
Nucl. Instr. and Meth. A 567(2006)27





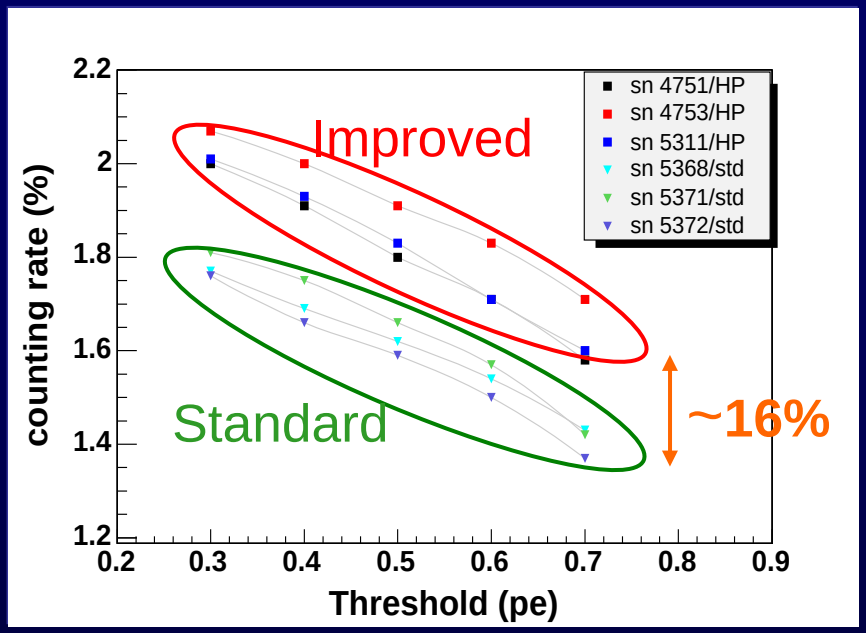
XP1805 (9", AUGER PMT)

Standard (~800 PMTs)
Sk CB: 9.32 µA/lmF
Sk White: 68. 37 µA/lm

Improved (~25 PMTs)
Sk CB: 11.35 µA/lmF
Sk White: 118.00 µA/lm

Increase of Sk CB: ~19%
Increase of Sk White: ~42%

Overview on results

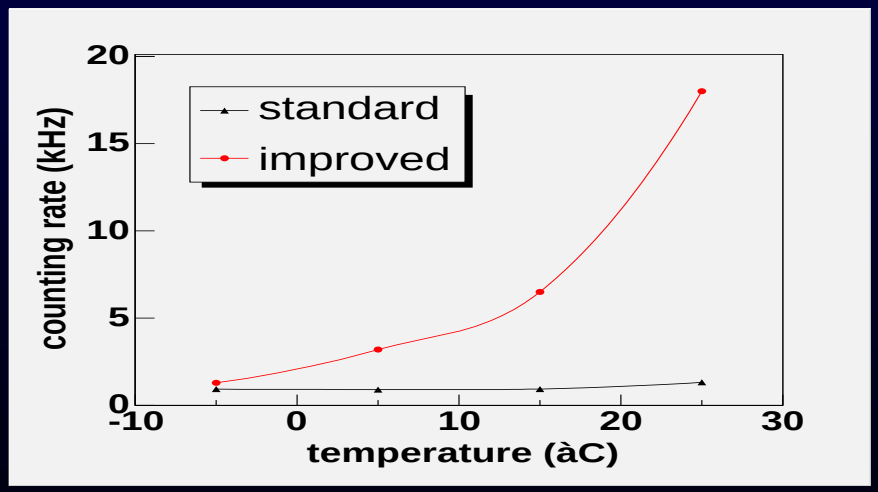


Improved photocathode

D. Dornic et al, Beaune Conference, France, June 2005
In press in Nucl. Instr. and Meth.

Quantum efficiency (400 nm)
Standard ~26%
Improved ~32%

Control by
Pulse measurements in SER
(Relative detection efficiency)

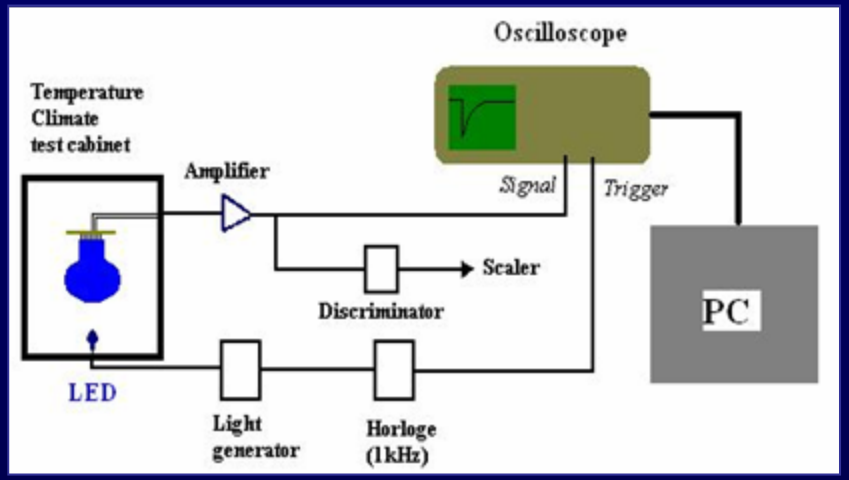


Drawbacks ?

Dark count rate

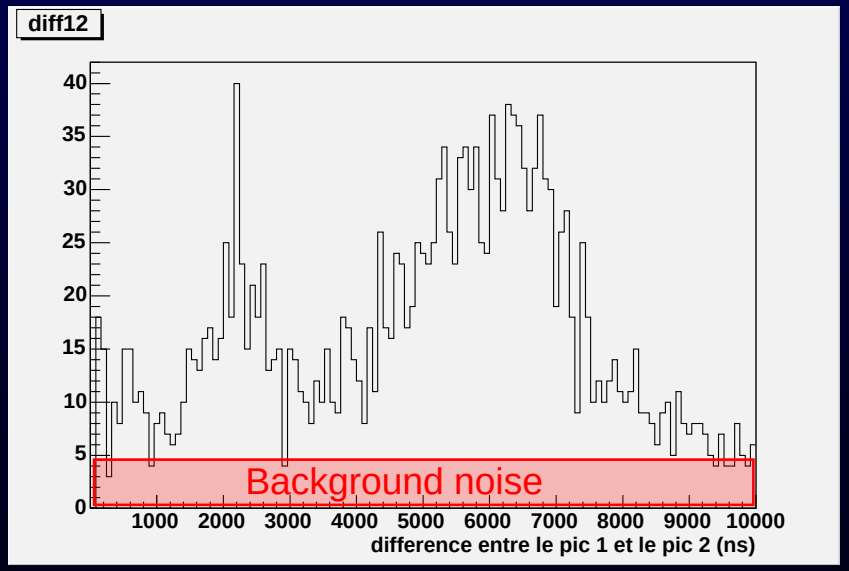
Same at low temperature
Increase with temperature

After-pulses

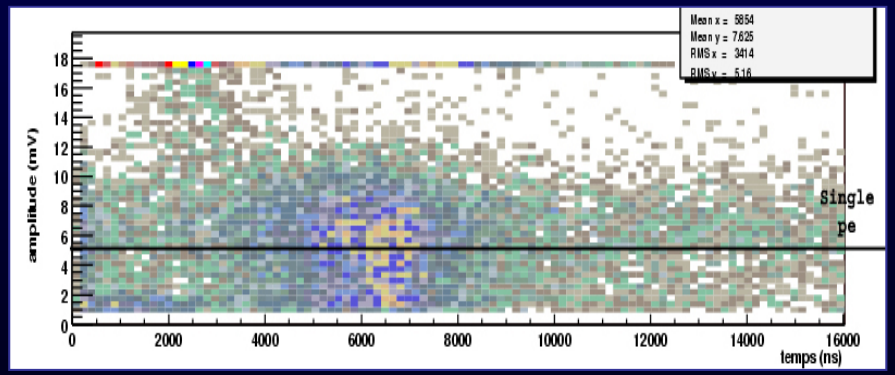


Digital Oscilloscope + PC

- 100 ns to 20 µs
- Sampling : 0.5 GSPS
- 500 Events/s

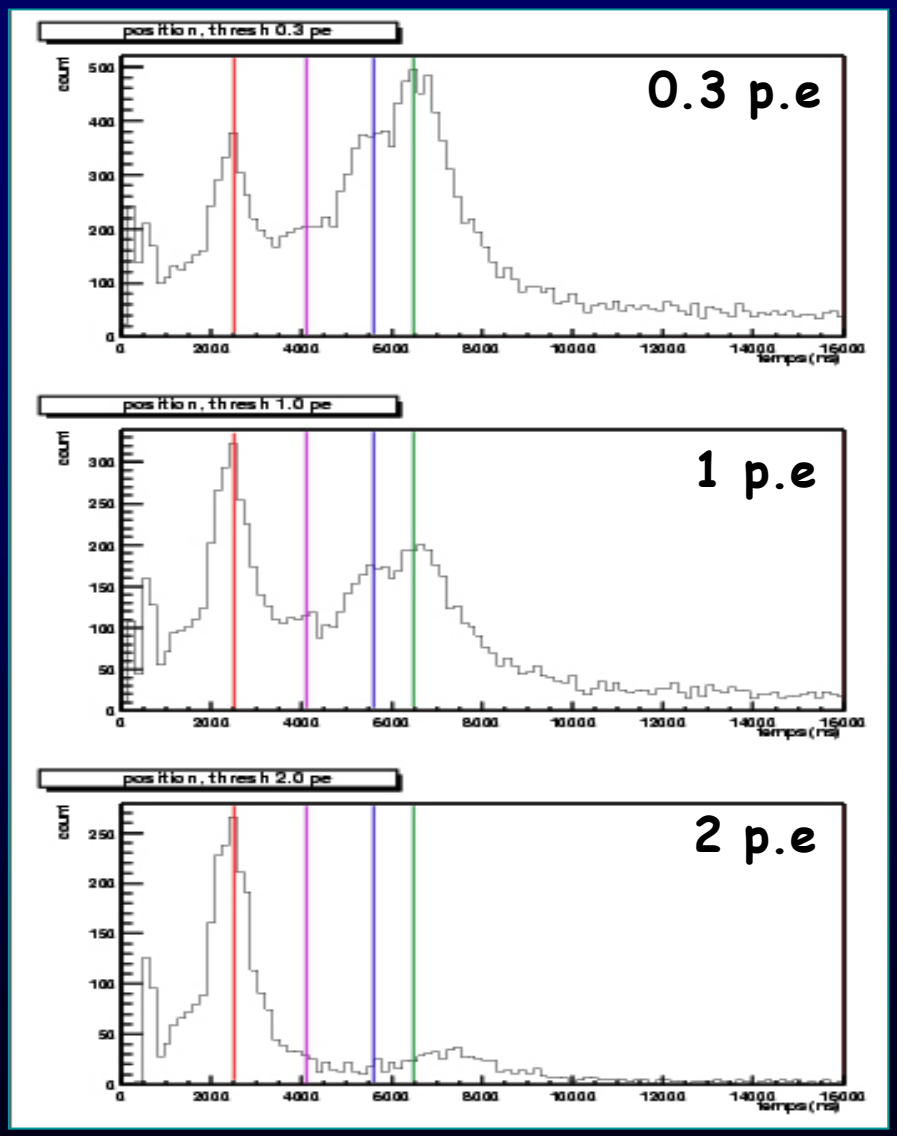


Time distribution

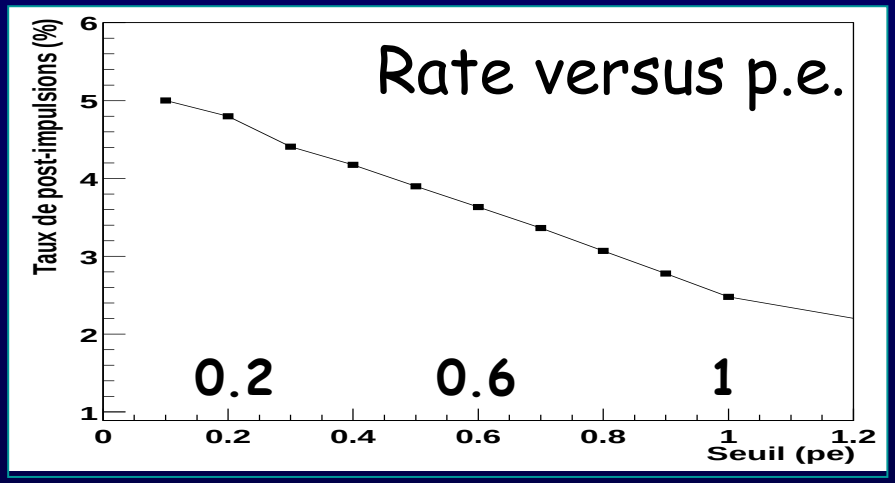


2D : Amplitude versus time

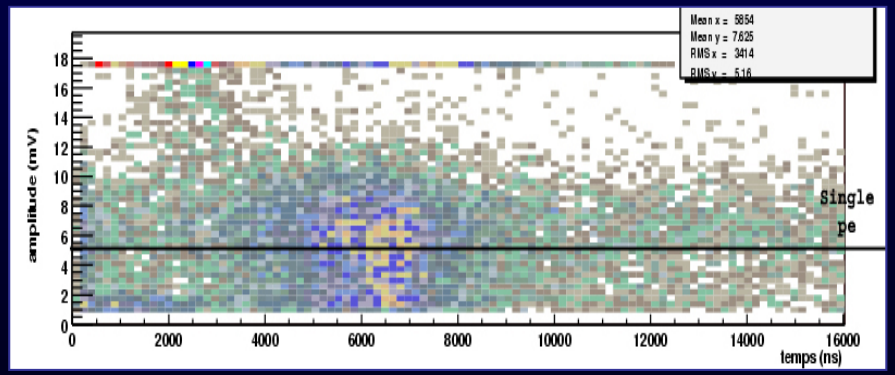
IPN Orsay / Photonis — Overview on results



After-pulses



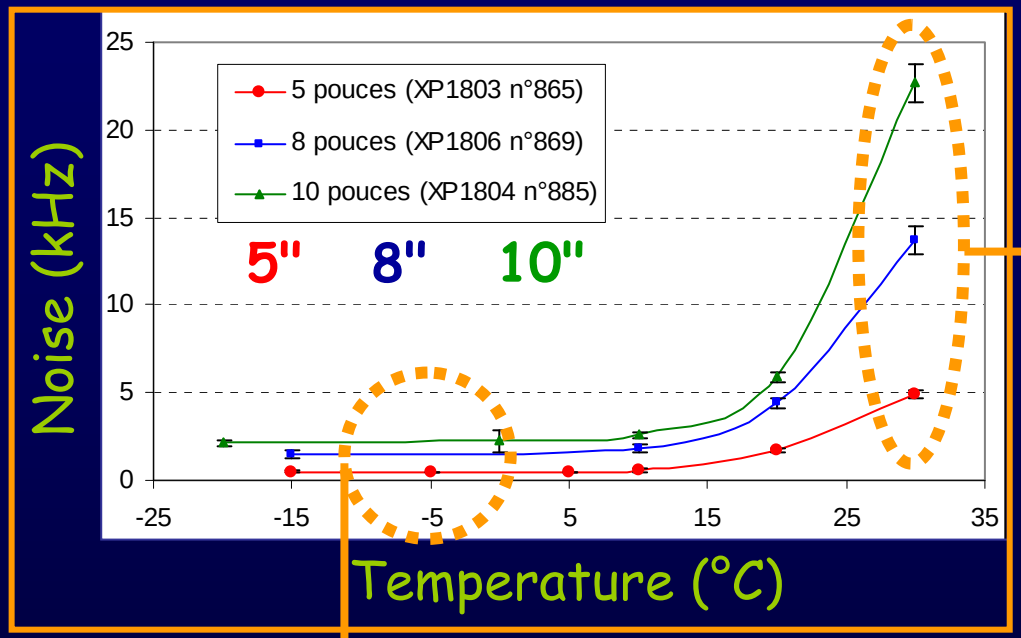
Time distribution

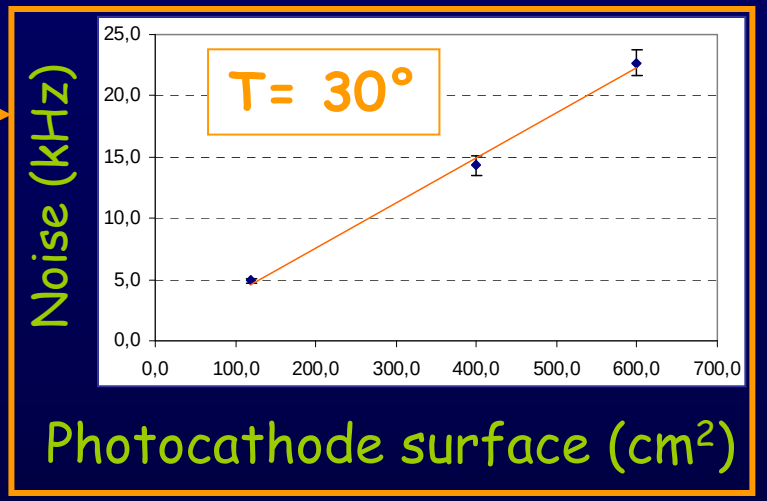


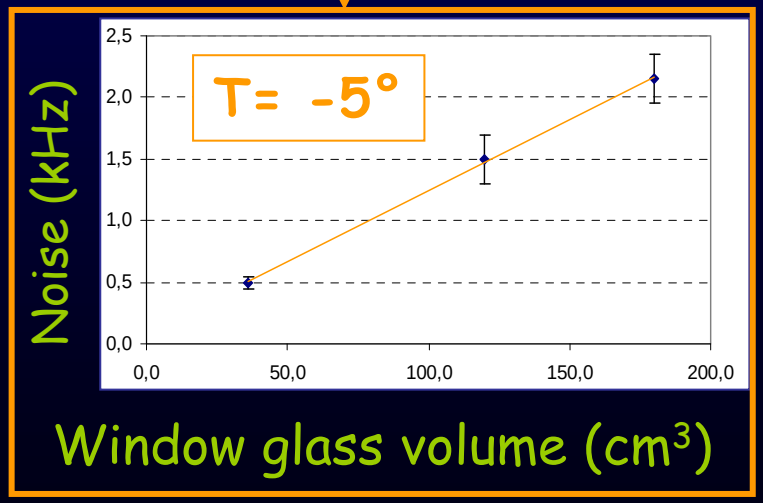
2D : Amplitude versus time

IPN Orsay / Photonis — Overview on results

Noise (dark pulses)





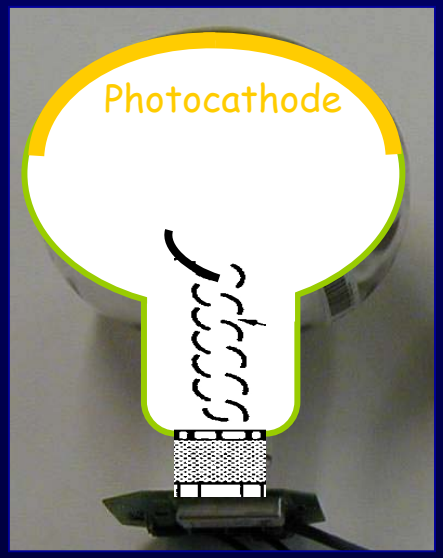


All the main results in

PhD of D. Dornic , 09 - 29 - 06

IPN Orsay / Photonis Collaboration

New 3 years R&D Program (2006 – 2009)



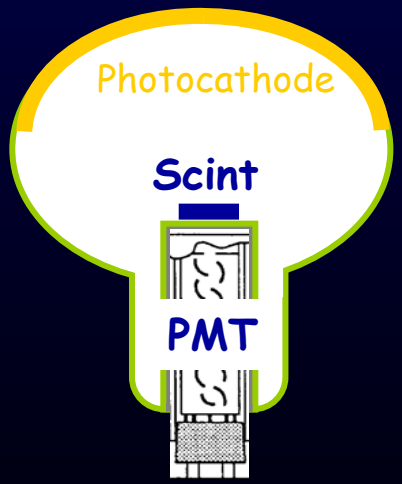
Standard PMTs

More detailed studies on :

"Late pulses" (T < 100 ns) with a laser
Glass noise (time structure)

End of the "scaling" studies

Parameter correlations (5" to 12") , (15" ?)
New types of multipliers



Hybrid PMTs

"Smart Tube" type (Scintillator)

Comparison with standard PMT
(Same size, 8" or 10")

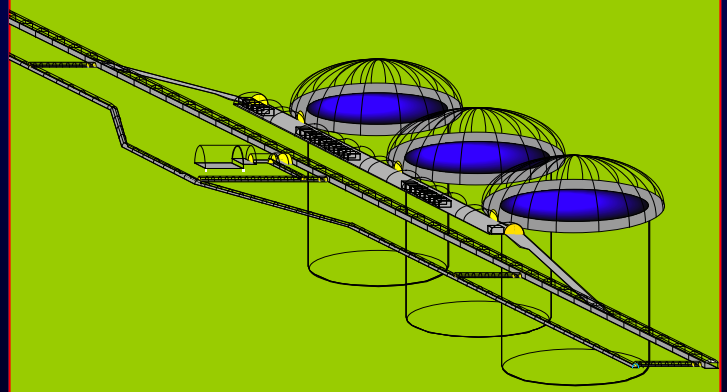
R&D for Memphys

Memphys

Nucleon decay and neutrino detectors

Future

UNO
Hyper Kamiokande
Memphys



10 to 20 times Super K

200 000 to 300 000 Large PMTs !!!

KamiokaNDE
Super KamiokaNDE
KamLAND
(Japon)

SNO (Canada)

MiniBooNE (USA)

Borexino (Italie)

Photomultiplier Requirements

Large area
with maximum efficiency

Good SER
(Single electron response)
in charge and time

Low noise

R&D program for Memphys

"PMm2" (2006 – 2009), granted by the ANR (National Agency for Research)

LAL Orsay, IPN Orsay, LAPP Annecy and Photonis

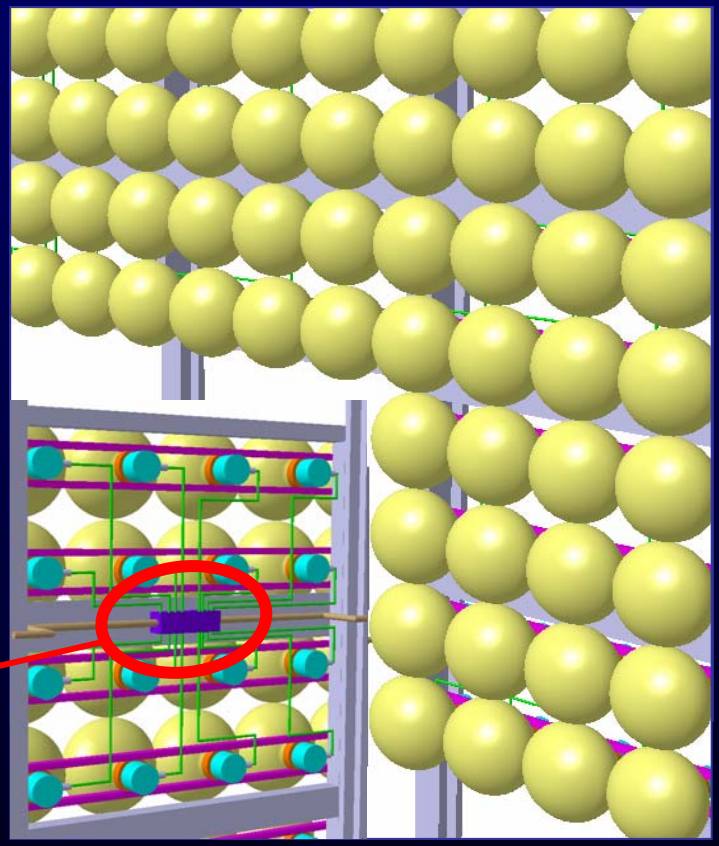
Megaton water tanks

Huge amount of
very large photodetectors

(PMTs of 20" size)

Proposition

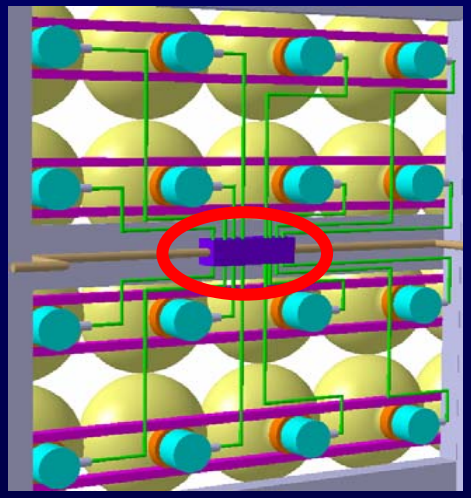
Replace large PMTs (20")
by groups of smaller
ones (12")



Integrated electronics (Multichannel, close to the PMTs)

Electronics for Memphys

Roadmap



What already exists

Front-end (OPERA_ROC & MAROC)

What remains to be done

Charge and time digitization
Data Transmission (LAPP Annecy)

Some characteristics still to be fixed

Possible use of a local coincidence ?
depends of the dark noise of the photodetectors

Digitization of all signals ? Dynamic range ?

Then…

Chip on Board

Tests on a prototype (16 PMTs 10")

Conclusion

R&D sur le photomultiplicateurs et l'électronique associée

IPN Orsay , LAL Orsay, PHOTONIS Brive
(Financement Eté 2004 et Eté 2005)

Résultats

Bancs de tests PM (-> 15 pouces) pérennisés
Mise en oeuvre d'un programme de R&D en micro-électronique
Communications (2 à Beaune 2005, NNN05 et NNN06)
Thèse (50% sur les PMs) en Sept 2006 (D. Dornic)

Développement d'une collaboration étroite avec PHOTONIS

Suite du programme

Nouvelle thèse 100% PMs (en BdI, Oct 06 – Sept 09)
Poursuite de la R&D Micro-électronique pour AUGER Site Nord
« PMm2 », ANR sur 2006 -2009 (LAL, IPN, Photonis et LAPP Annecy)

MERCI au Programme Astroparticules