Results from the O.M. components measurements during tests/integration.

S.Aiello, V.Giordano, E.Leonora

INFN-CT

Collaboration meeting KM3NeT – Italia

Roma, 2013, November 12-13

References:

S.Aiello, et al. (NEMO coll.) Nucl. Instr. Meth. A, 614 (2010) 206-212

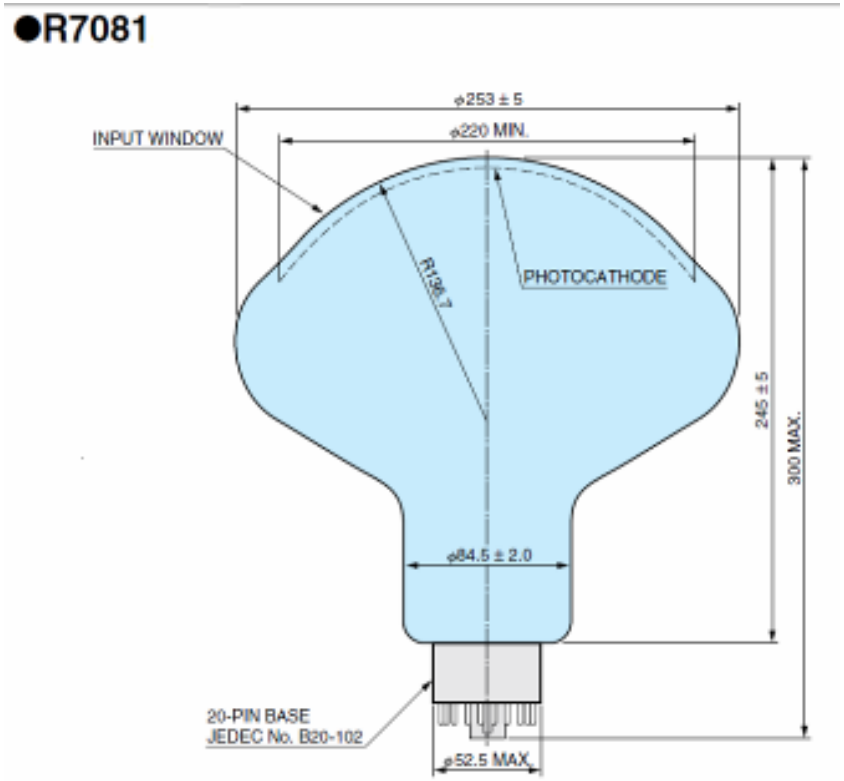
S.Aiello et al. (NEMO coll.) 2013 JINST 8 P07001 doi:10.1088/1748-0221/8/07/P07001

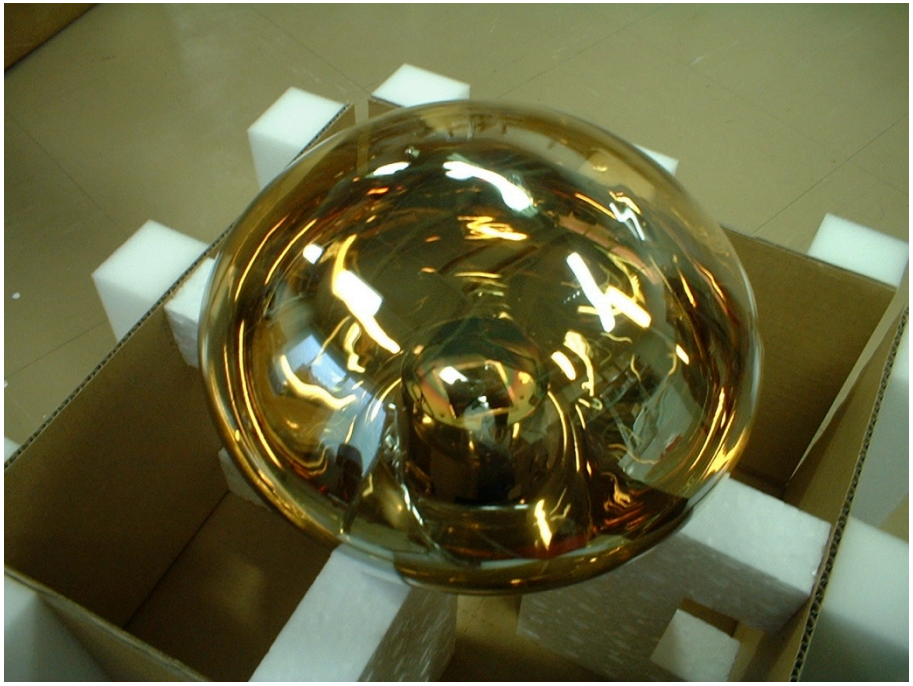
The photomultiplier

R7081 produced by Hamamatsu:

- 10 inch. photocathode
- Standard bialkali photocathode (QE ≈ 25% @ 400nm)
- 10 stages

For NEMO phase-2 a batch of over 70 PMTs has been characterized



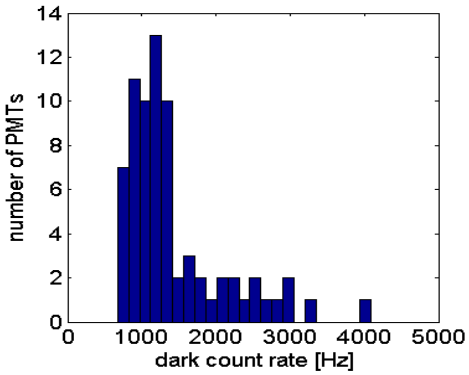


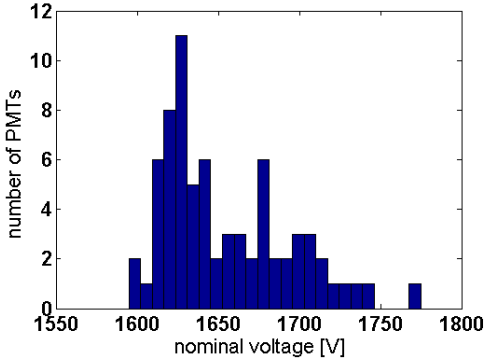
Characteristics of the 72 R7081 Hamamatsu PMTs

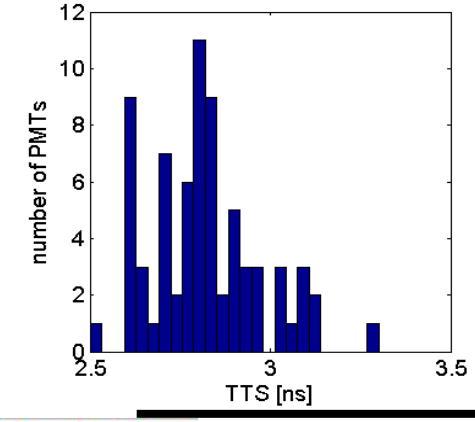
	mean values	values required
Voltage at Gain 5E7 [V]	1655	< 2000
Dark Count rate [Hz]	1388*	< 5000
P/V ratio	3.5	> 2
Charge resolution σ %	31.6	< 50
TTS FWHM [ns]	2.8	< 3
Pre-Pulse %	0.02	< 1
Late Pulse %	5.5	< 5
Type 1 after pulse %	1.1	< 1
Type 2 after pulse %	4.4**	< 5

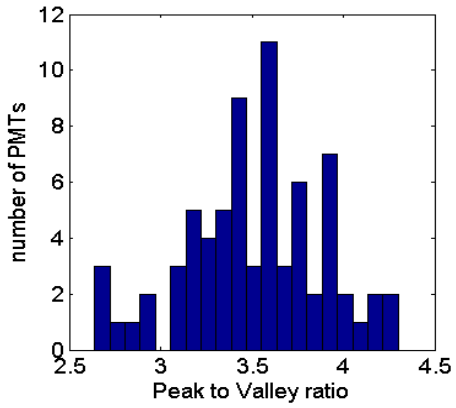
* Excluding one PMT with DC rate of 4093 Hz

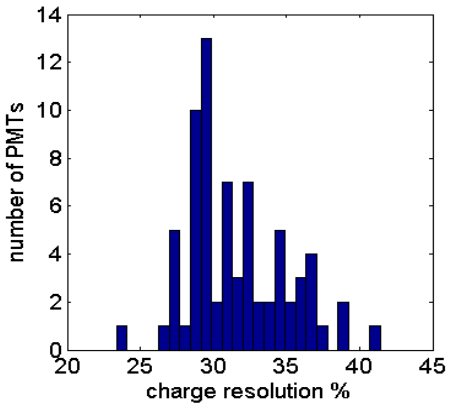
** Excluding one PMT with type 2 after pulse fraction of 10.4%.









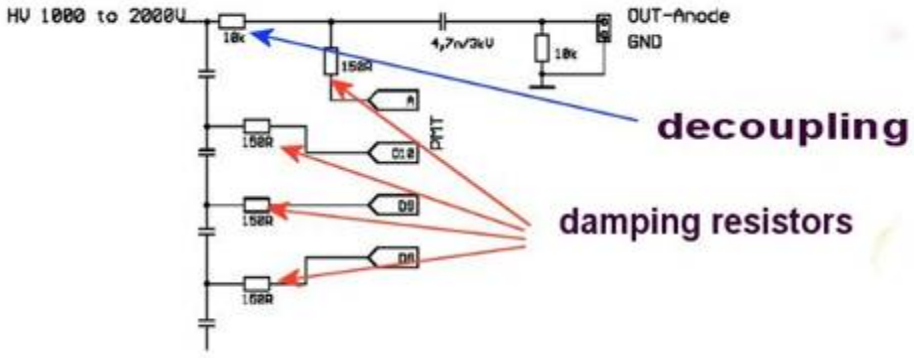


emanuele.leonora@ct.infn.it

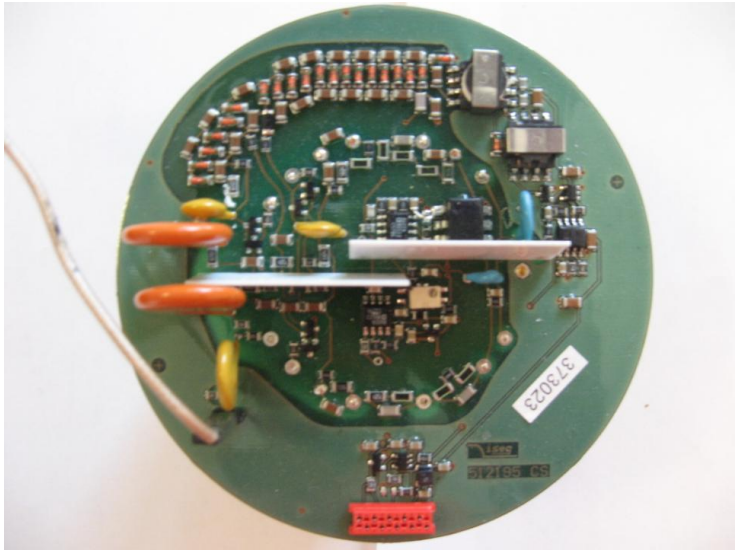
ISEG PMT base PHQ7081-i-2m (modified)

Main features:

- Active base
- +5 Volts supply (bipolar voltage supply before modification)
- Cathode-1^dynode and 1^dynode-anode voltages individually controllable
- Anode current max : 100 microAmpere
- Power consumption : 150mW @ 2000 Volts
- Modified on the ouput on NEMO requiremts



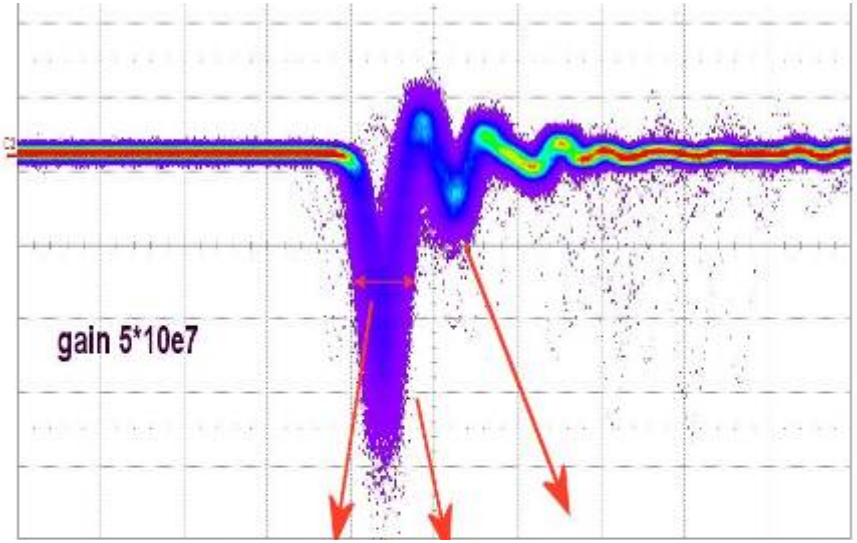
Modifications on ISEG base



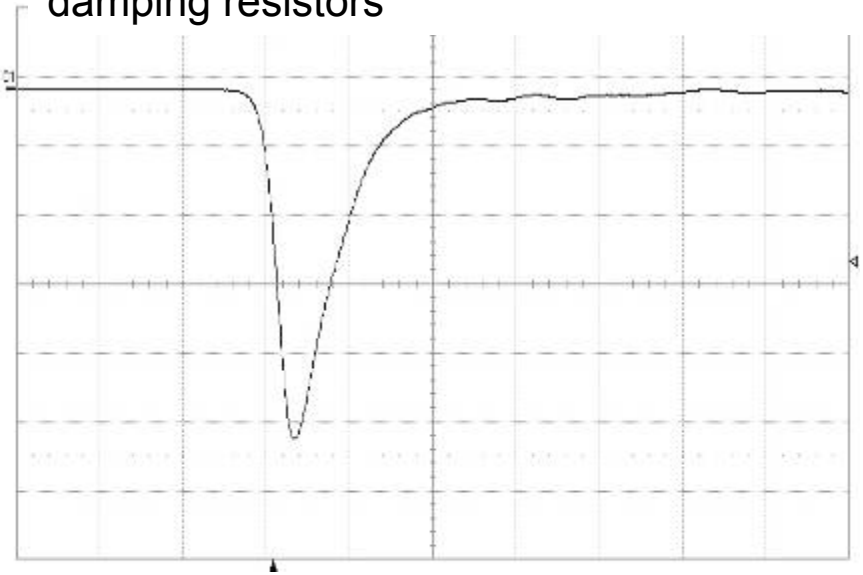
Picture of the ISEG base soldered

Effect on the anode signal of the ISEG modification

1 p.e typycal signal from Hamamatsu R7081with the ISEG base



The same signal obtained with the damping resistors



- no ringing in the signal
- rise time and width increased

emanuele.leonora@ct.infn.it

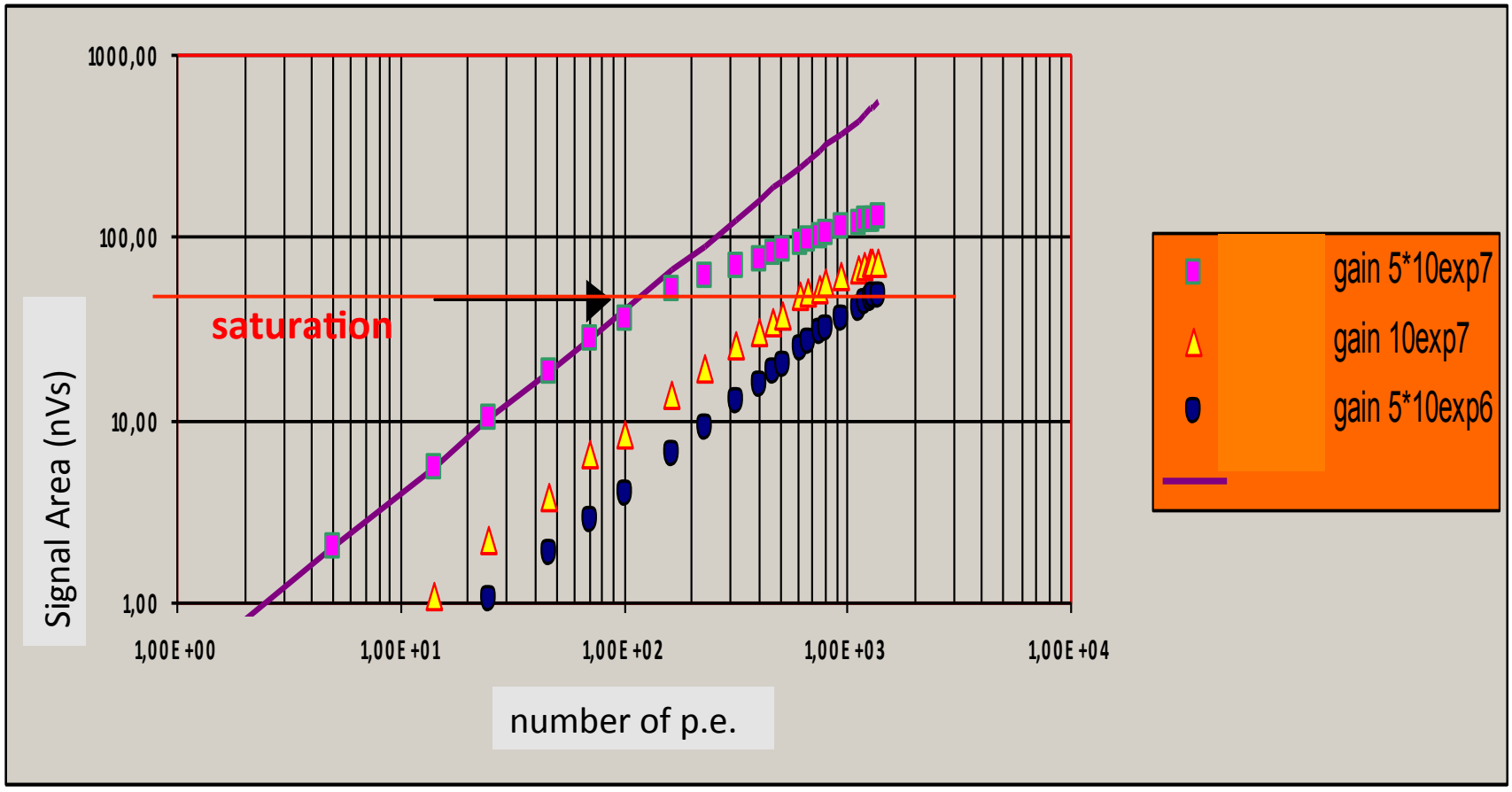
Dynamic Range of the R7081 PMT with ISEG

Good linearity up to 100 p.e. for Gain 5E7

Saturation is correlated with anodic current

Max value 1 nC → 120-150 p.e at gain $5*10^7$

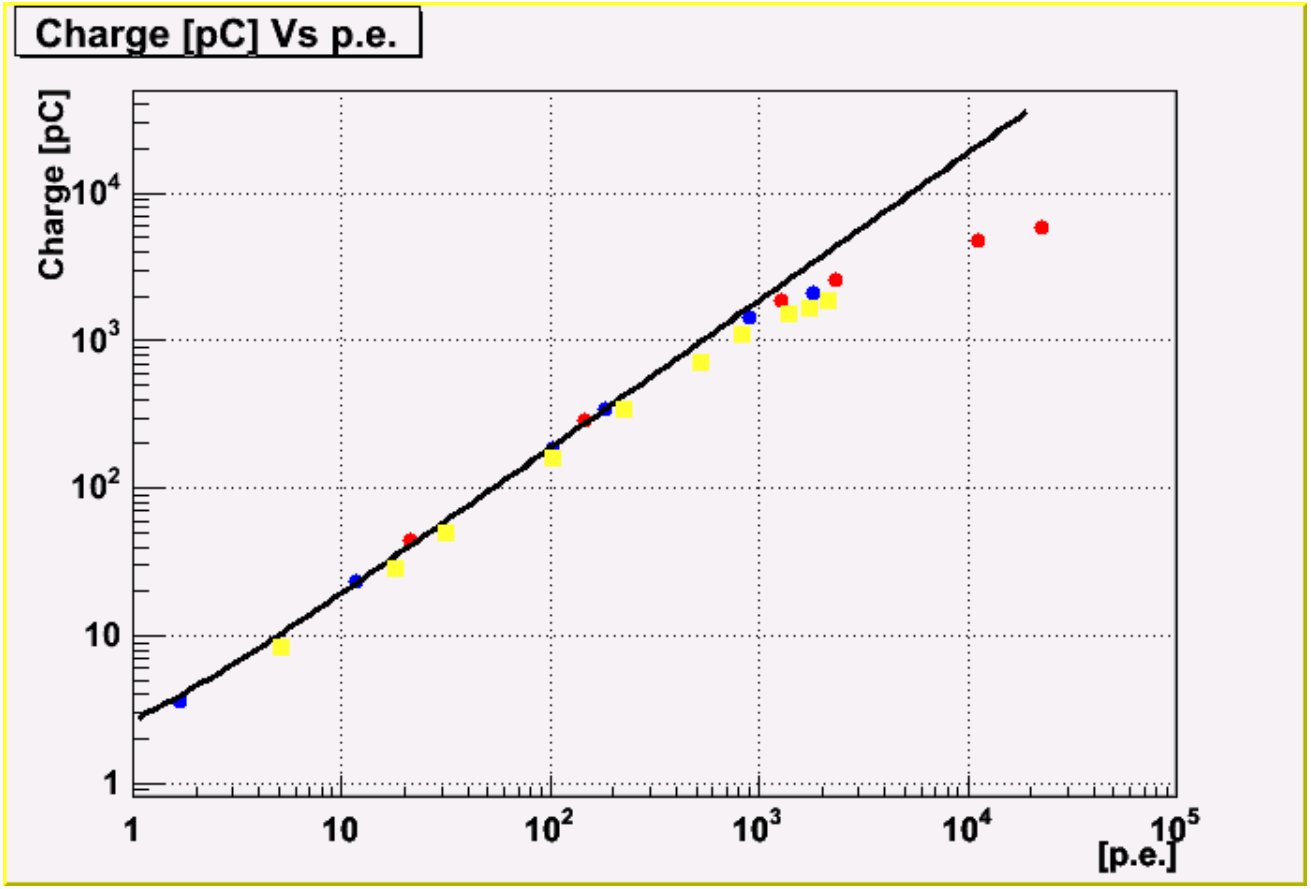
Lower gain , higher dynamic range



Comparison with ICECUBE measurements (same R7081 PMT used)

ICECUBE : gain 1,12*10 ^{7} ; led with different attenuatuation filters

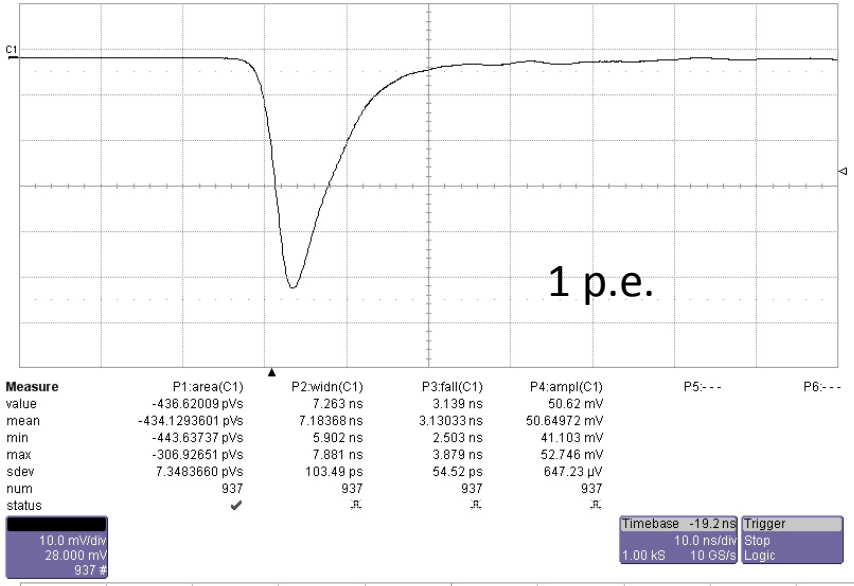
NEMO: gain 1*10 ^{7} ; Laser light source, measured by a bolometer nW

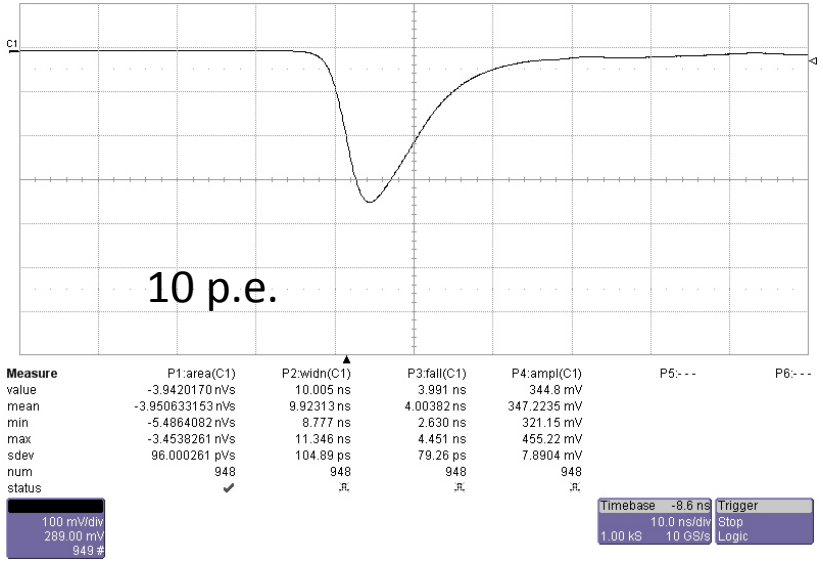


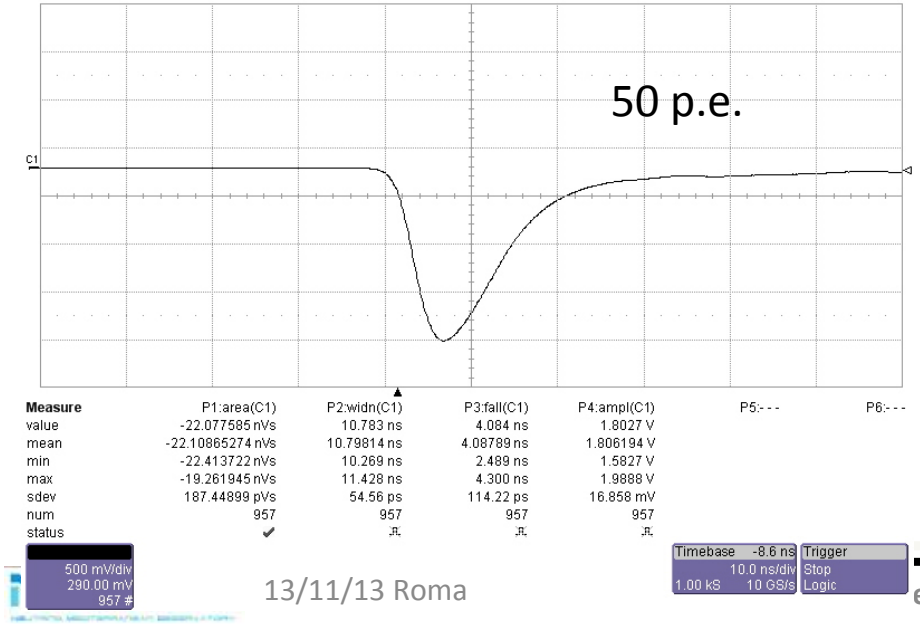
emanuele.leonora@ct.infn.it

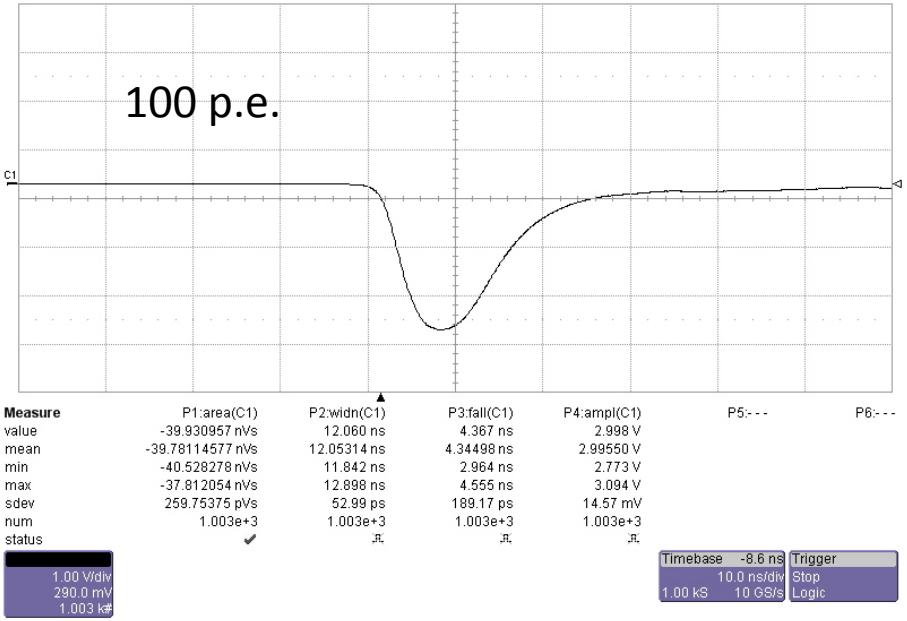
Typical signal parameters vs. light intensity

gain @ 5 E7; acquisition averaged on 1000 pulses

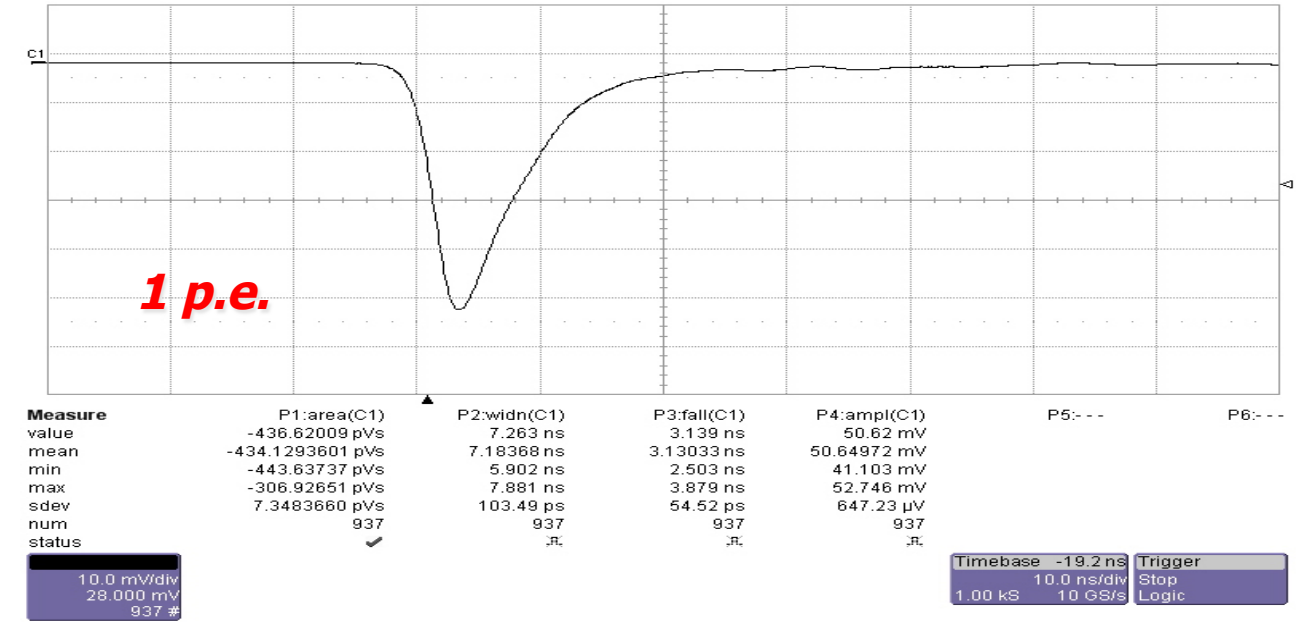




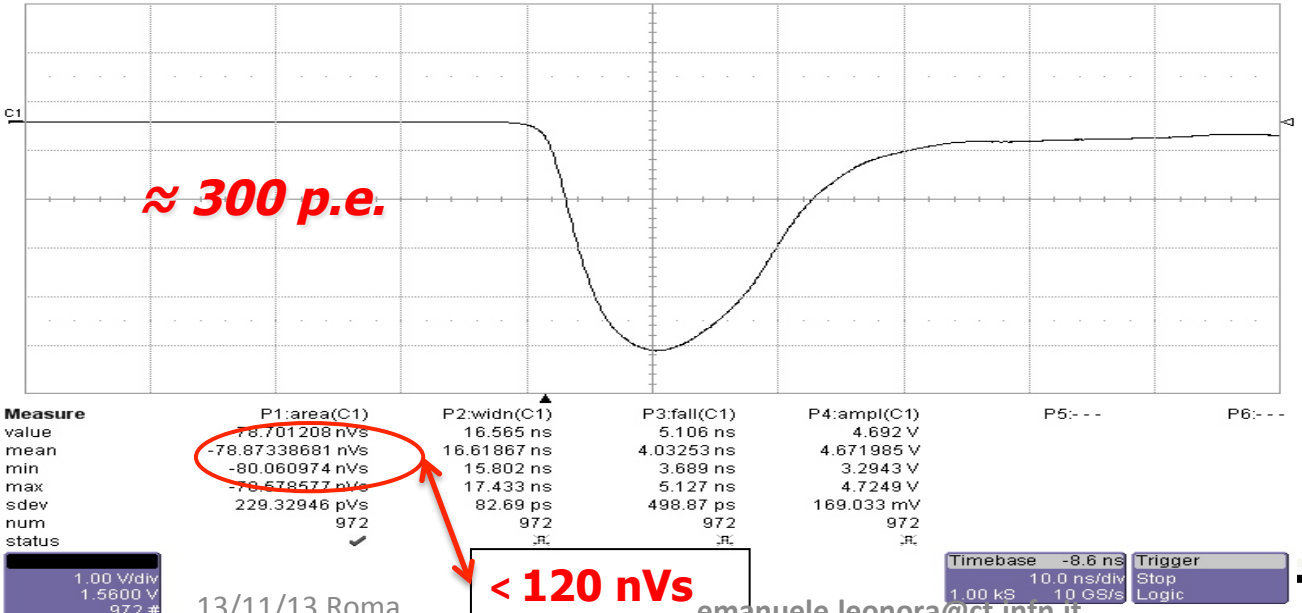




The effect of the PMT saturation



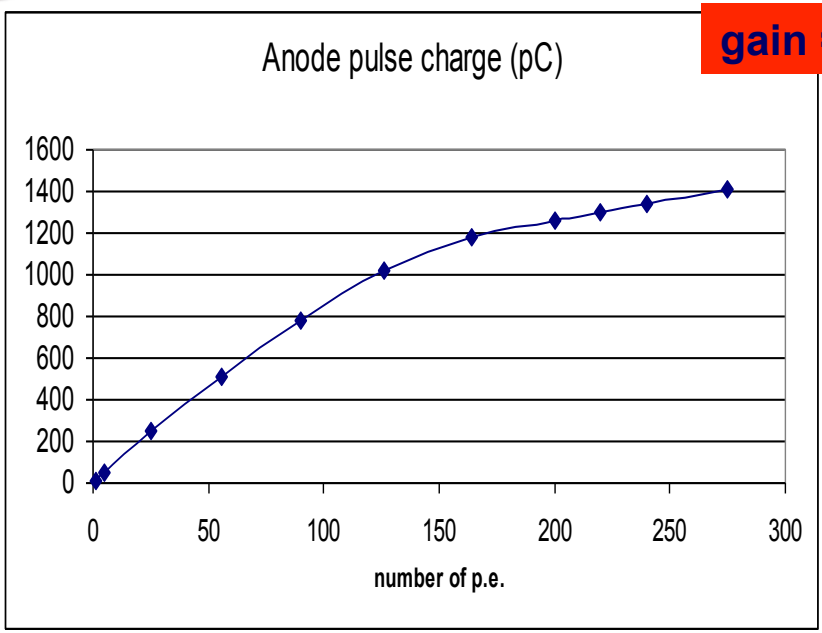
Gain = 5 E7
1 pe → 400 pVs

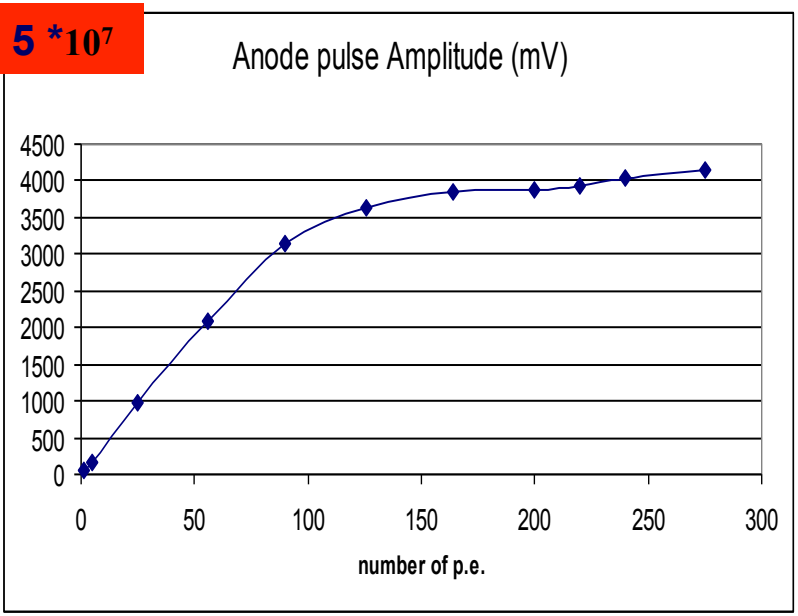


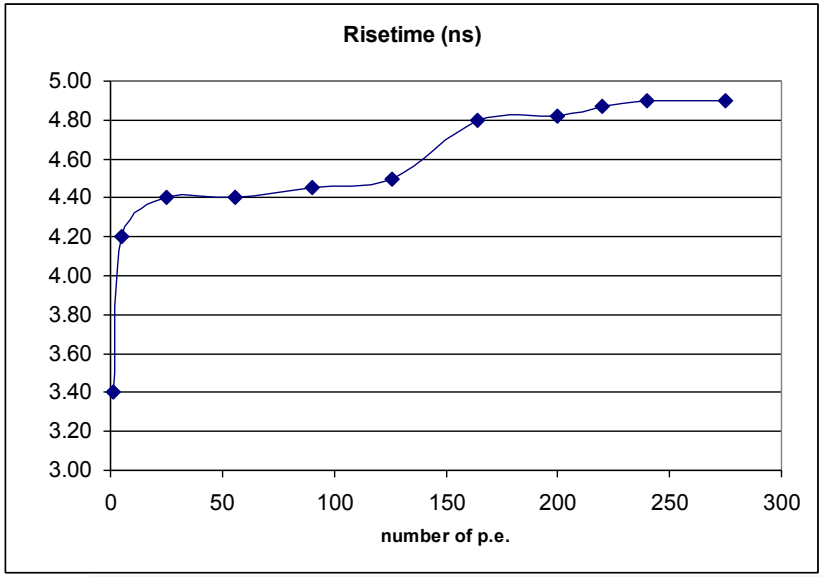
Gain = 5 E7
300 pe → 120 nVs

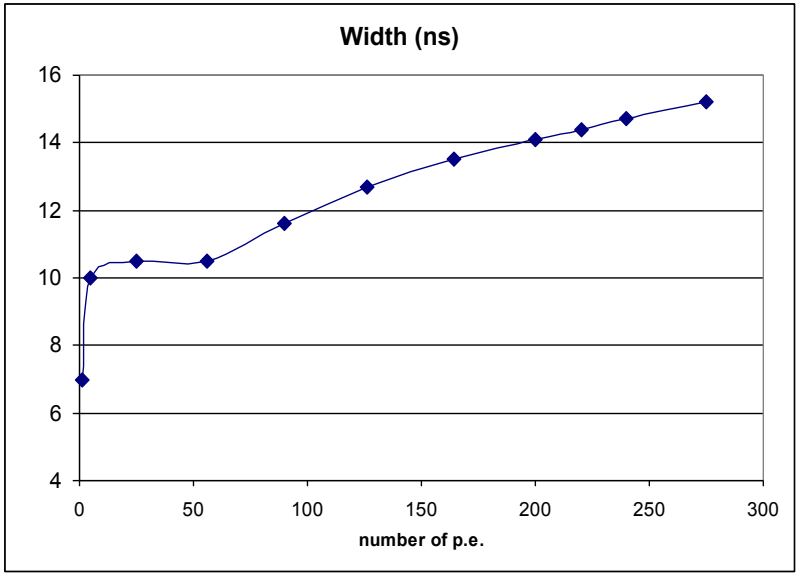
Resume of signal parameters vs. incident light intensity

gain = 5 *10^7

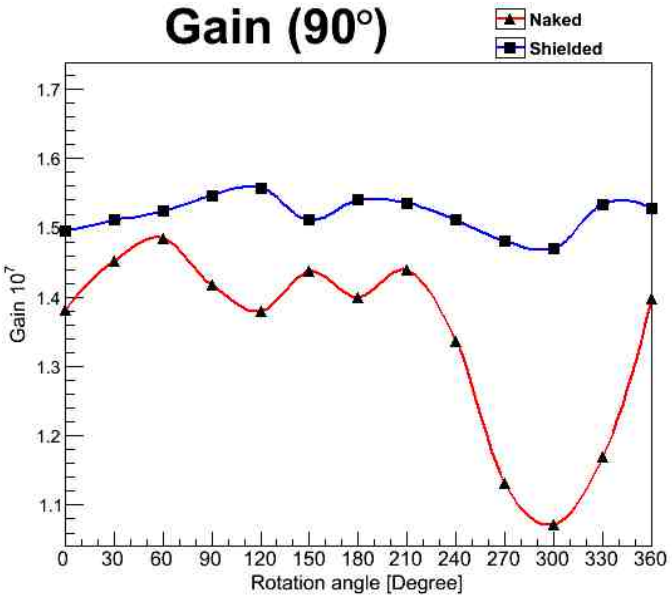


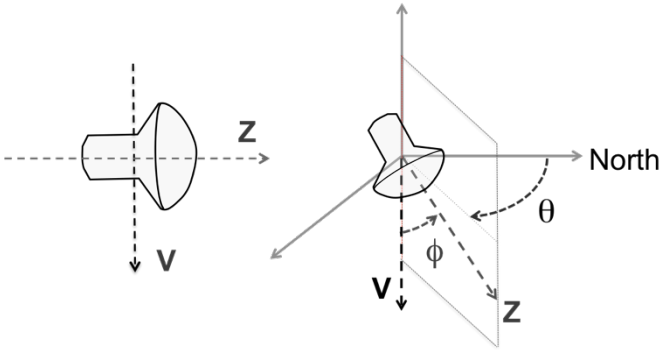


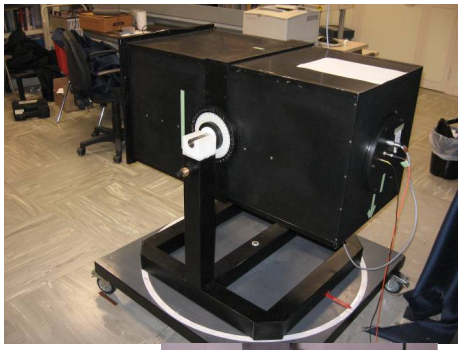


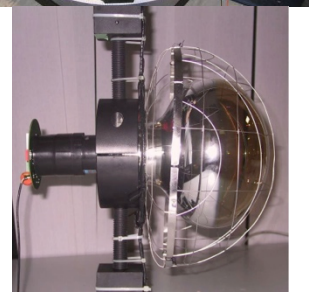


Effects of the Earth's magnetic field and a magnetic shield

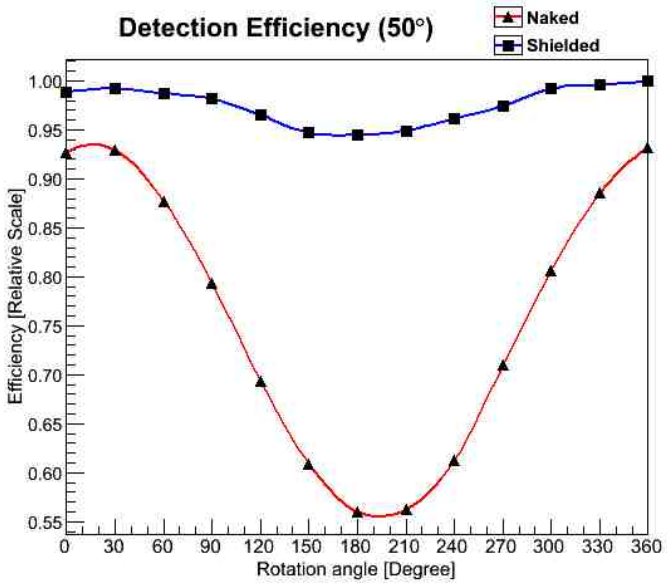






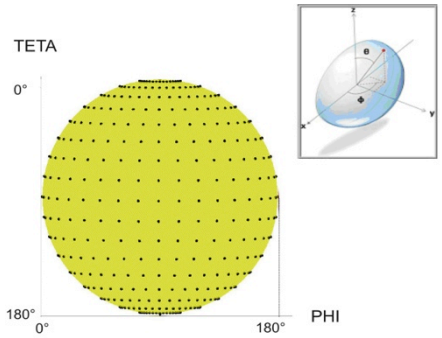


- PMT 360° rotated along its vertical axes
- Three inclinations, with and without a shield:
  Vertical downwards, Horizontal,
  50° vertical downwards

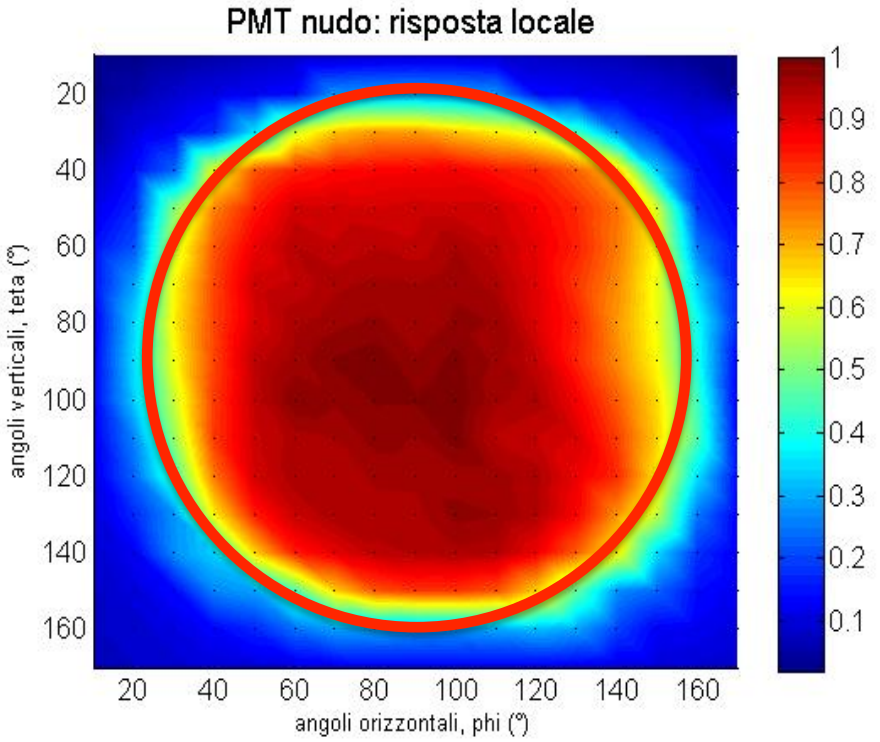


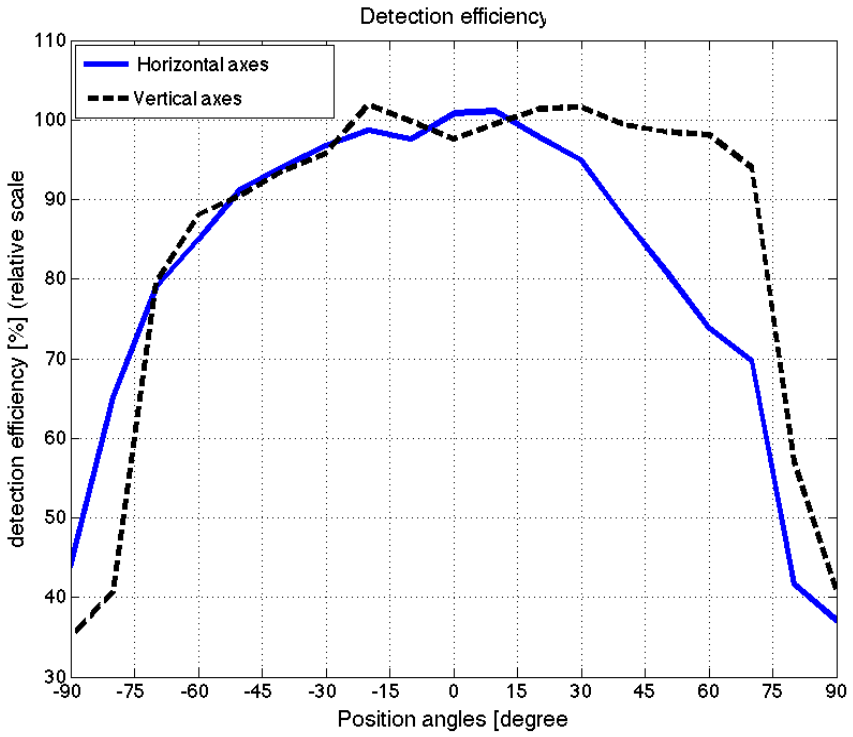
Max Variation % = max – min / max		
	PMT naked	PMT shielded
Detection Eff.	40	6
Gain	29	7
P/V ratio	41	14
Charge Res	50	20
TTS	20	2

Scanning of the R7081 photocathode surface



- 324 points uniformly distributed on the photocathode
- 410 nm Laser Source pulsed in s.p.e. condition
- 5mm light spot diameter, normal to PMT surface





Det. Eff. > 80 % for over the 60% of the photocathode area

Det. Eff > 90 % for over the 40% of the photocathode area

Results complied with them from Dept. of Physics Chiba University on ICECUBE PMT

PMT aging

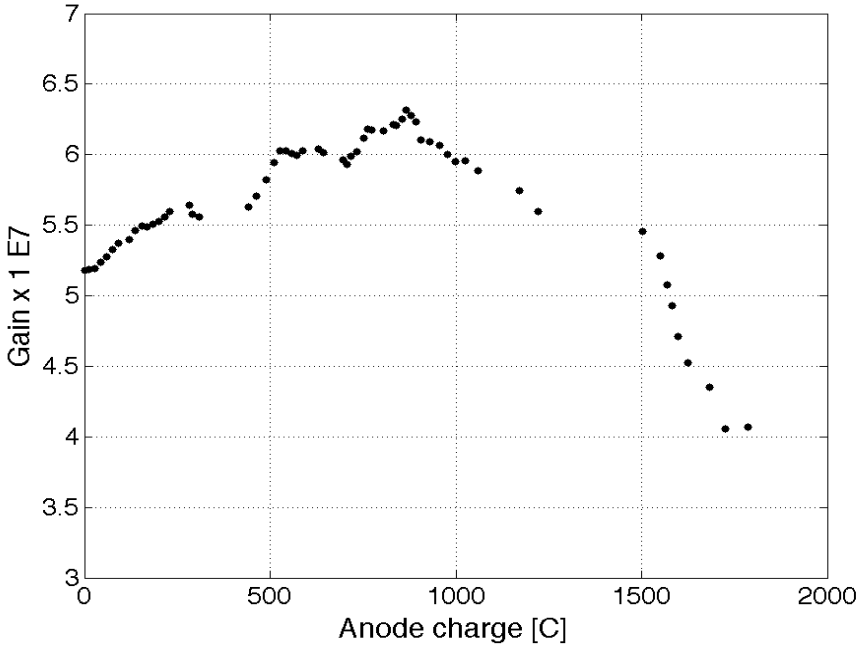
Aging (continuosly)

- LED ON (about 3pe @ 1 MHz)

Measurements of PMT parameters (once a week)

- LED OFF
- Pulsed Laser at s.p.e. condition
- **s.p.e. charge spectrum**
- **s.p.e. Transit Time spectrum**
- **Spurious pulses**

Measurements time : from 28/5/2008 to 8/10/2011 ≈ 3 years of operating time



The measuring time is equivalent to an operating time of about
45 years @ 1 pe @ 200 KHz

Apart the Gain, all the measured parameter were stable

Gain: A first phase of Up-drift with a gain increase of about 20 % followed by a final phase of down-drift with an gain decrease of about the 40% from max value

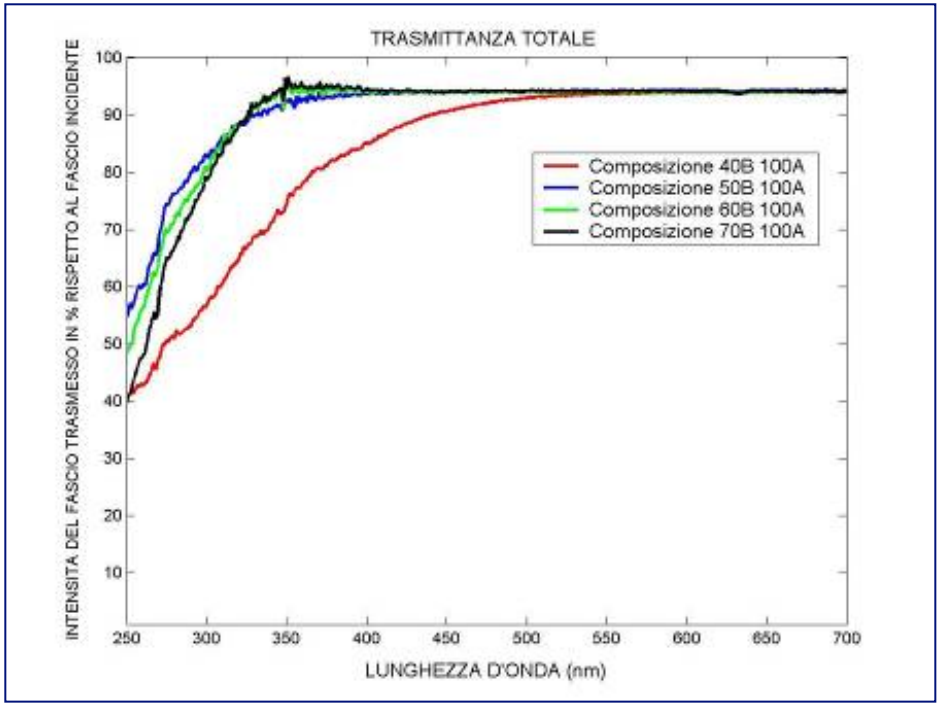
Silgel optical properties measurements

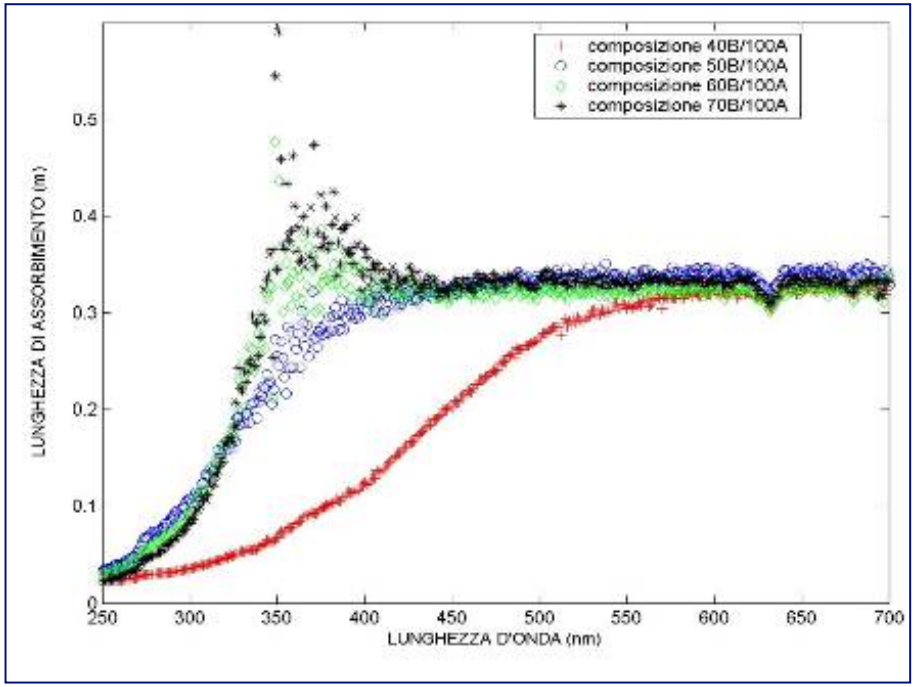
Waker SilGel 612 two components (A e B) (silicone gel)

4 different mixtures have been tested: **40B/100A, 50B/100A, 60B/100A, 70B/100A**

Results are different from ANTARES and finally have been confirmed by NIKHEF

mixture SilGel	40B/ 100A	50B/ 100A	60B/ 100A	70B/ 100A
Transmittance at 400 nm	85%	93.8%	94.3%	94.7%

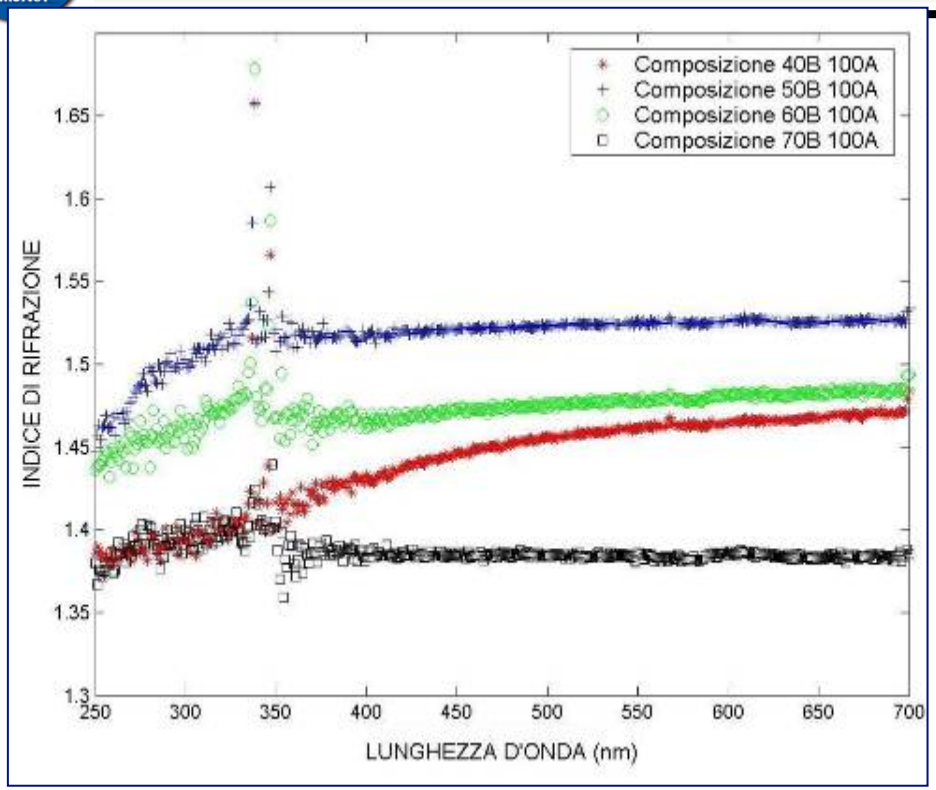


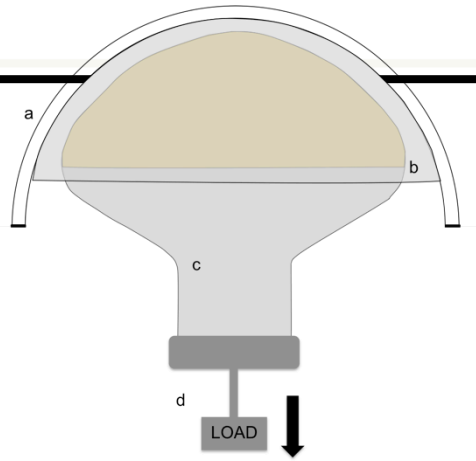


mixture SilGel	40B/ 100A	50B/ 100A	60B/ 100A	70B/ 100A
absorption length at 400 nm	12 cm	30 cm	33 cm	35 cm

emanuele.leonora@ct.infn.it

The selected silgel mixture





mixture SilGel	40B/ 100A	50B/ 100A	60B/ 100A	70B/ 100A
Load/ surface [kg/cm ^{2}]	**0.5**	**1.2**	**0.6**	**0.7**

mixture SilGel	40B/ 100A	50B/ 100A	60B/ 100A	70B/ 100A
Refraction index at 400 nm	**1.43**	**1.50**	**1.47**	**1.38**

Good matching with the glass sphere (n=1,48 at 350÷450 nm) for ratios 50B/100A and 60B/100A

Considering optical tests and mechanical tests →

The chosen mixture was :

50B/100A

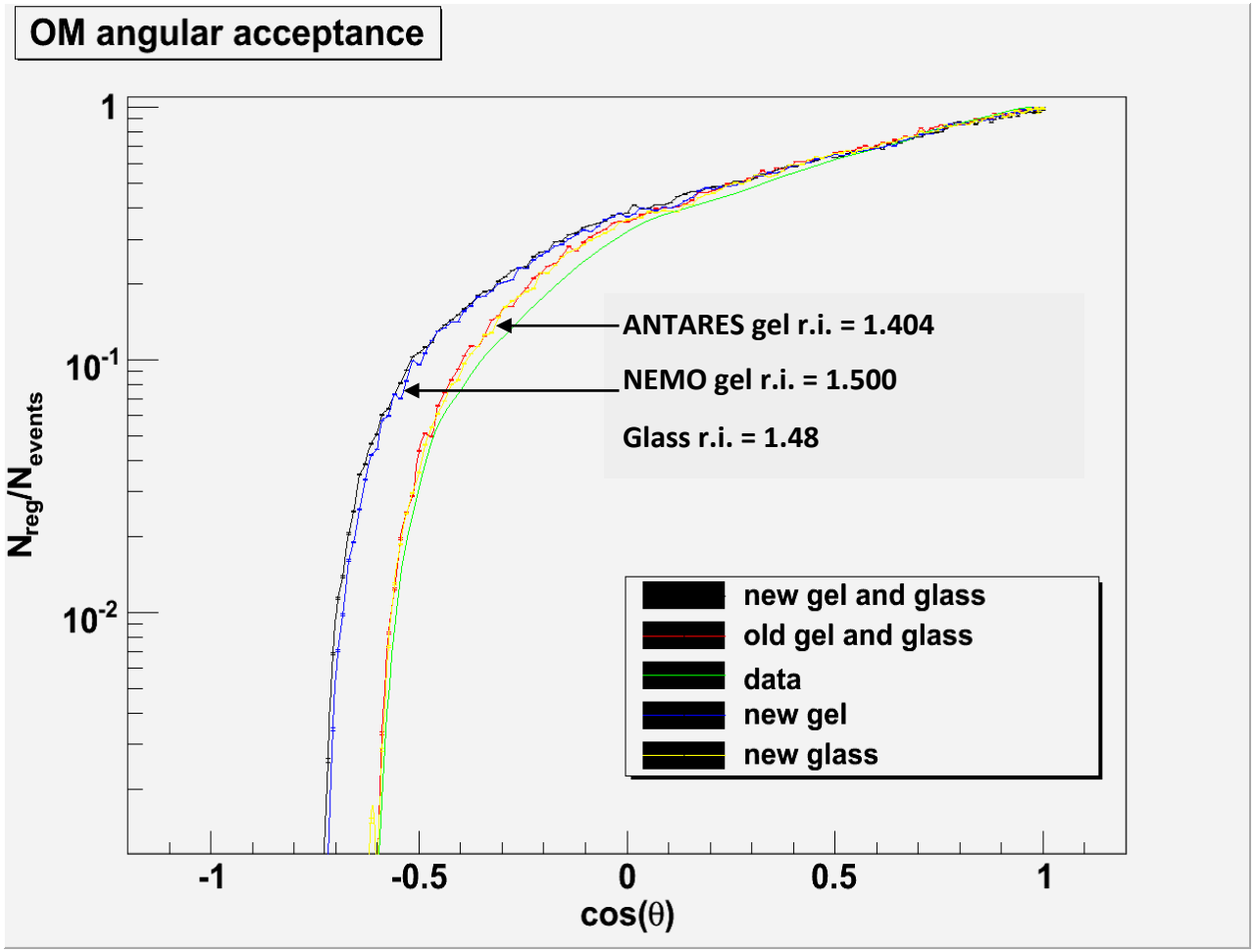
(ANTARES OM e KM3 DOM :

1 B / 1.5 A ≈ 66 B / 100 A

OM angular acceptance

A Simulation of angular acceptance for ANTARES O.M. 17 in. sphere was done as function of two different gel composition

(Geant4 : Taiuti, Heide, Yakovenko : Genoa group)



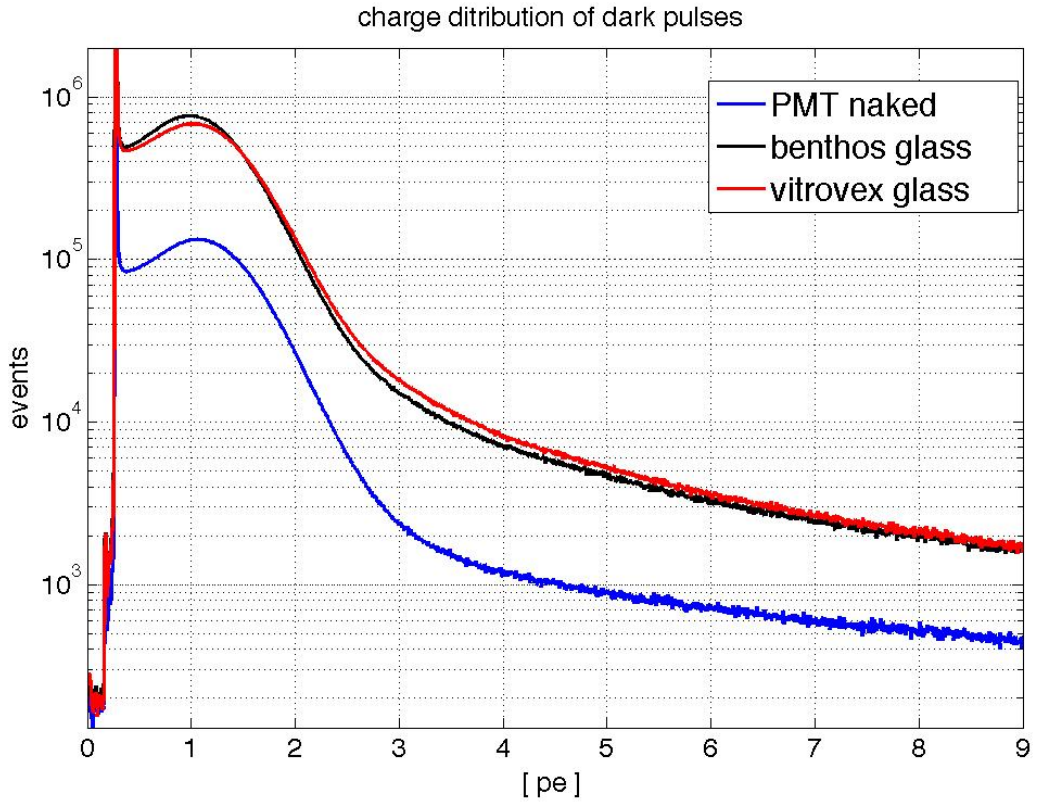
NEMO gel choice presents a greater angular acceptance

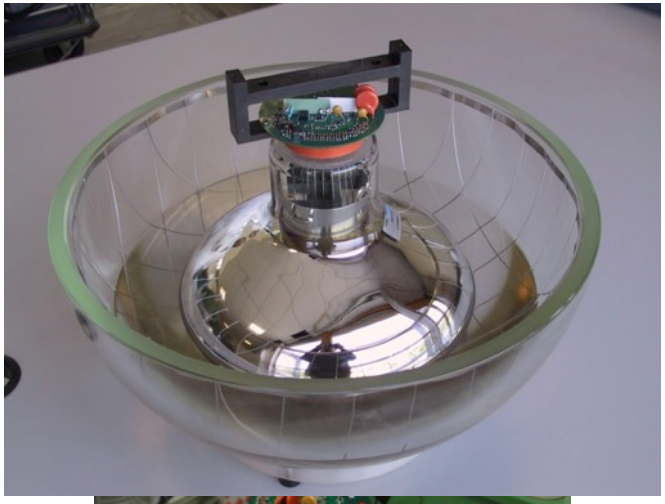
Effects of the glass vessel on the PMT noise signals

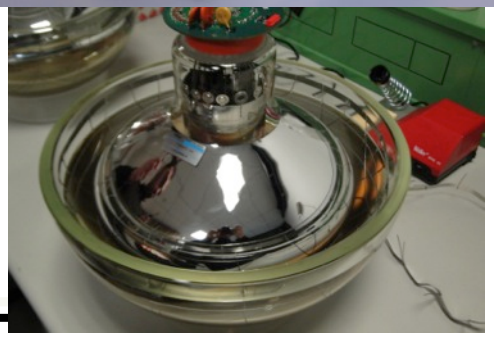
	naked	Vitrovex 17”		Vitrovex 13”	
THR [pe]	DC rate [Hz]	DC rate [Hz]	**Incr. [Hz]**	DC rate [Hz]	**Incr. [Hz]**
1/3	660	3432	**2772**	3200	**2540**
2	52	333	**281**	222	**170**
4	16	111	**95**	96	**80**

$$\text{Incr.} = \text{Rate}_{\text{glass}} - \text{Rate}_{\text{naked}}$$

- the external glass increases the rate of dark pulses at different amplitudes
- The increment of the DC rate depends on the area of the photocathode







emanuele.leonora@ct.infn.it