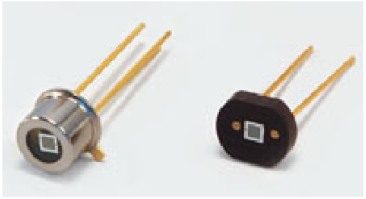
Silicon Photomultiplier tests in LN, LAr

Janicskó József

September 29, 2009

Hamamatsu MPPC

MPPC



The MPPC (Multi-Pixel Photon Counter) is a new type of photon counting device made up of multiple APD (avalanche photodiode) pixels operated in Geiger mode.

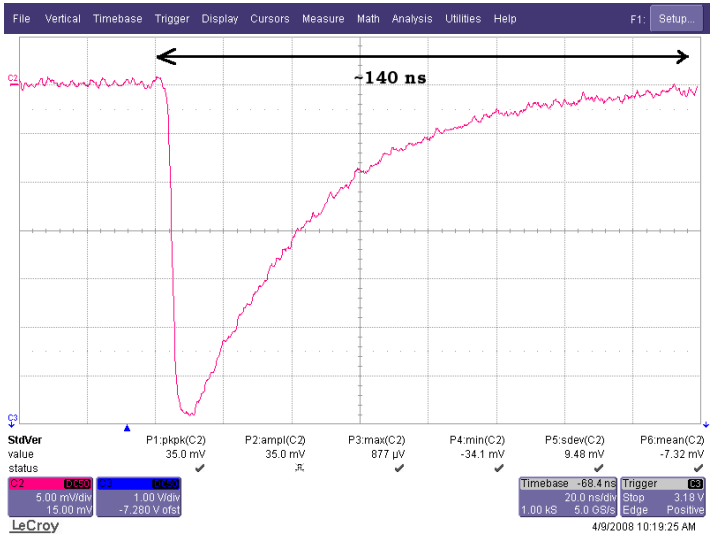
The MPPC is essentially an opto-semiconductor device with excellent photon counting capability and which also possesses great advantages such as low voltage operation and insensitivity to magnetic fields.

How to use filters | Undo last action | Reset table to default | Printable version

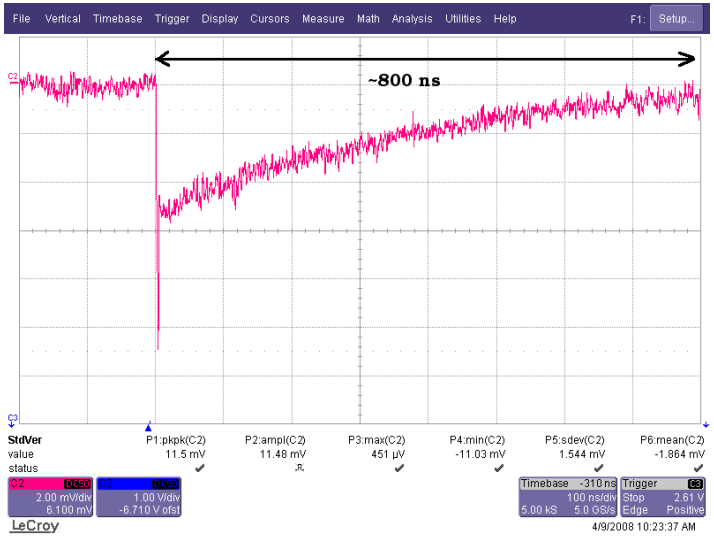
Part Number	Package	Effective active area mm	Number of Pixels	Pixel size m	Min λ nm	Max λ nm	Peak λ nm	Photo Detection Efficiency λ=λp %	Dark count kcps
S10362-11-100U	metal	1 x 1	100	100 x 100	270	900	400	65	400
S10362-11-100C	ceramic	1 x 1	100	100 x 100	270	900	400	65	400
S10362-11-050U	metal	1 x 1	400	50 x 50	270	900	400	50	270
S10362-11-050C	ceramic	1 x 1	400	50 x 50	270	900	400	50	270
S10362-11-025U	metal	1 x 1	1600	25 x 25	270	900	400	25	100
S10362-11-025C	ceramic	1 x 1	1600	25 x 25	270	900	400	25	100
Part Number	Package	Effective active area	Number of Pixels	Pixel size	Min λ	Max λ	Peak λ	Photo Detection Efficiency λ=λp	Dark count

Pulse shape in LN

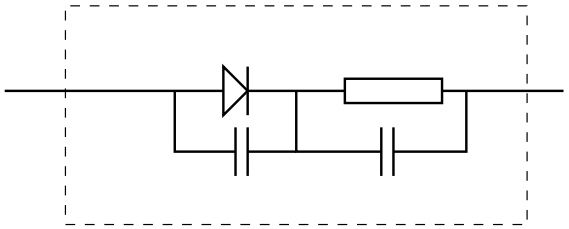
RT



LN

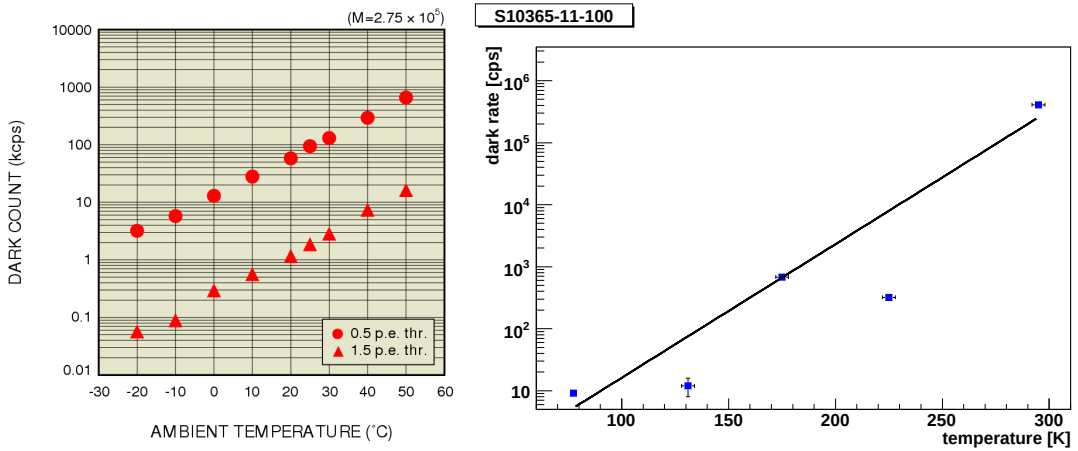


Can be explained by structure of the SiPM. The polysilicon resistor is temperature dependent.



Dark rate in LN

Practically no dark counts at LN temperature



During overnight measurement the rate dropped below 1Hz. $\Longrightarrow$ Up to 6 orders of magnitude reduction in dark rate.

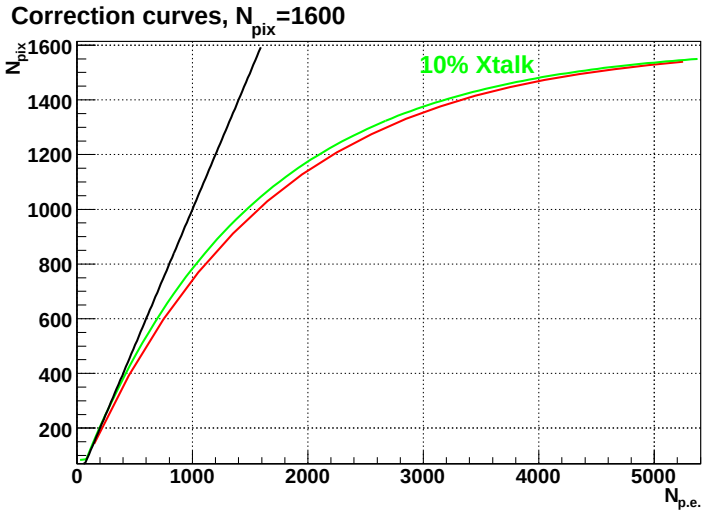
Correction curves

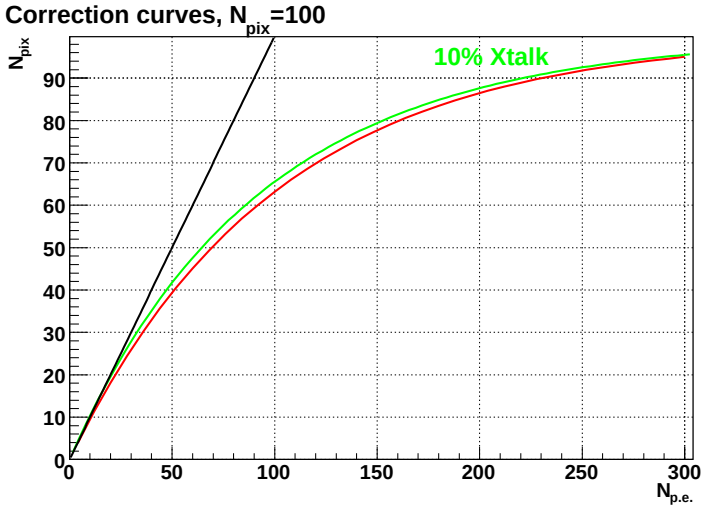
Nonlinear response - because more than one photon can hit the same pixel

...

$$N_{fired} = N_{pix}(1 - e^{-N_{pe}/N_{pix}})(1 + p\, e^{-N_{pe}/N_{pix}})$$

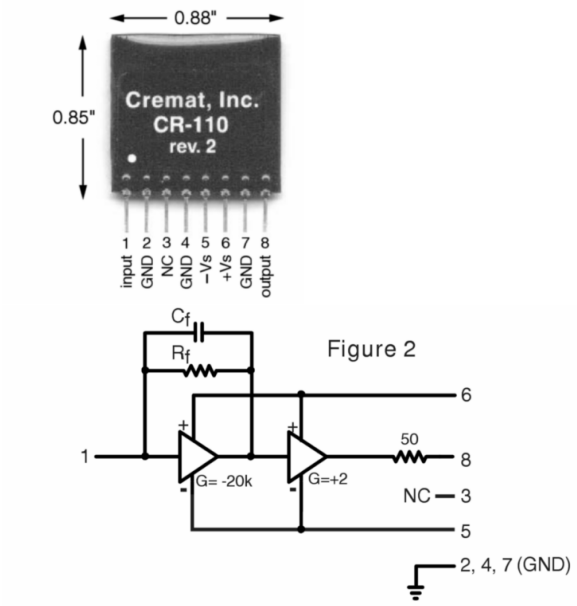
N_{pix} number of pixels
p cross talk probability
$N_{pe} = N_{photons} \times Q.E.$

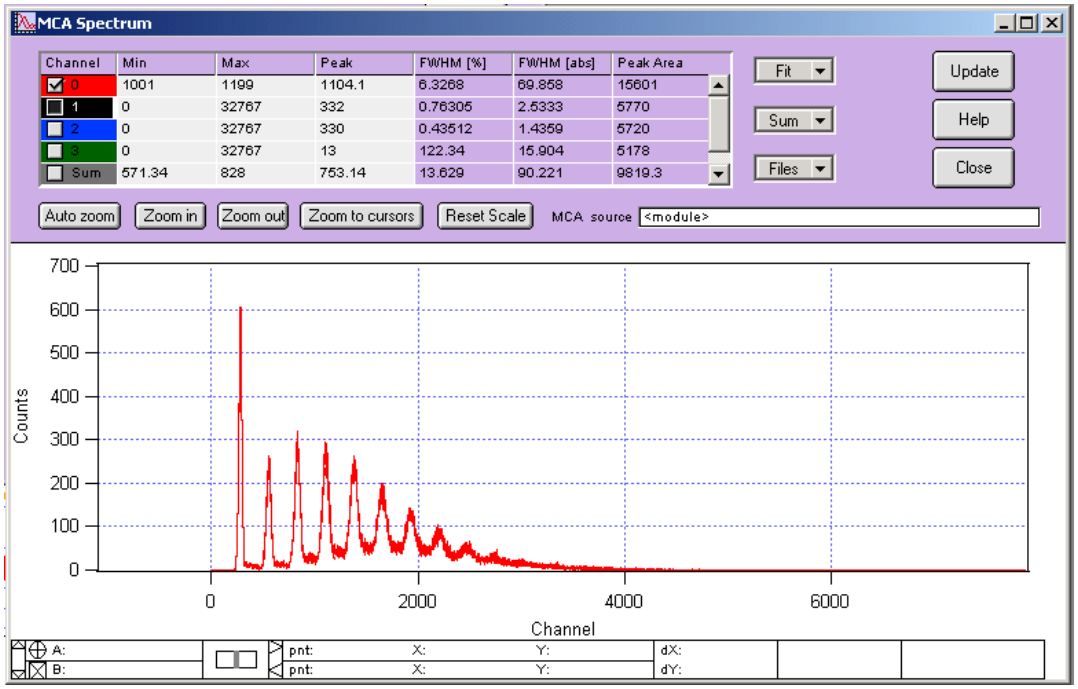




DAQ and SiPM

Charge-sensitive preamplifier CR-111, CR-112





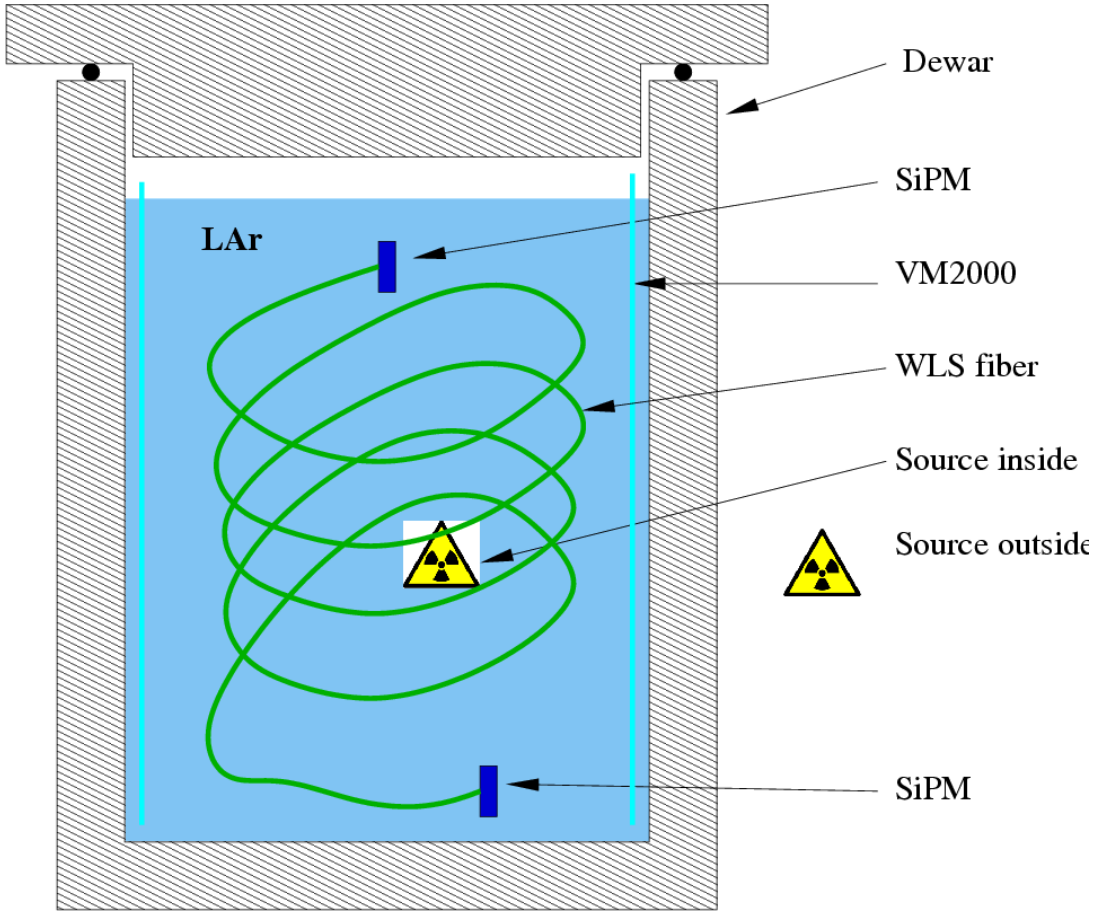
Photon spectrum with charge preamplifier and DAQ

DAQ used with the same settings as for the HPGe detector

I need it to reduce the **countrate**

The Experiment

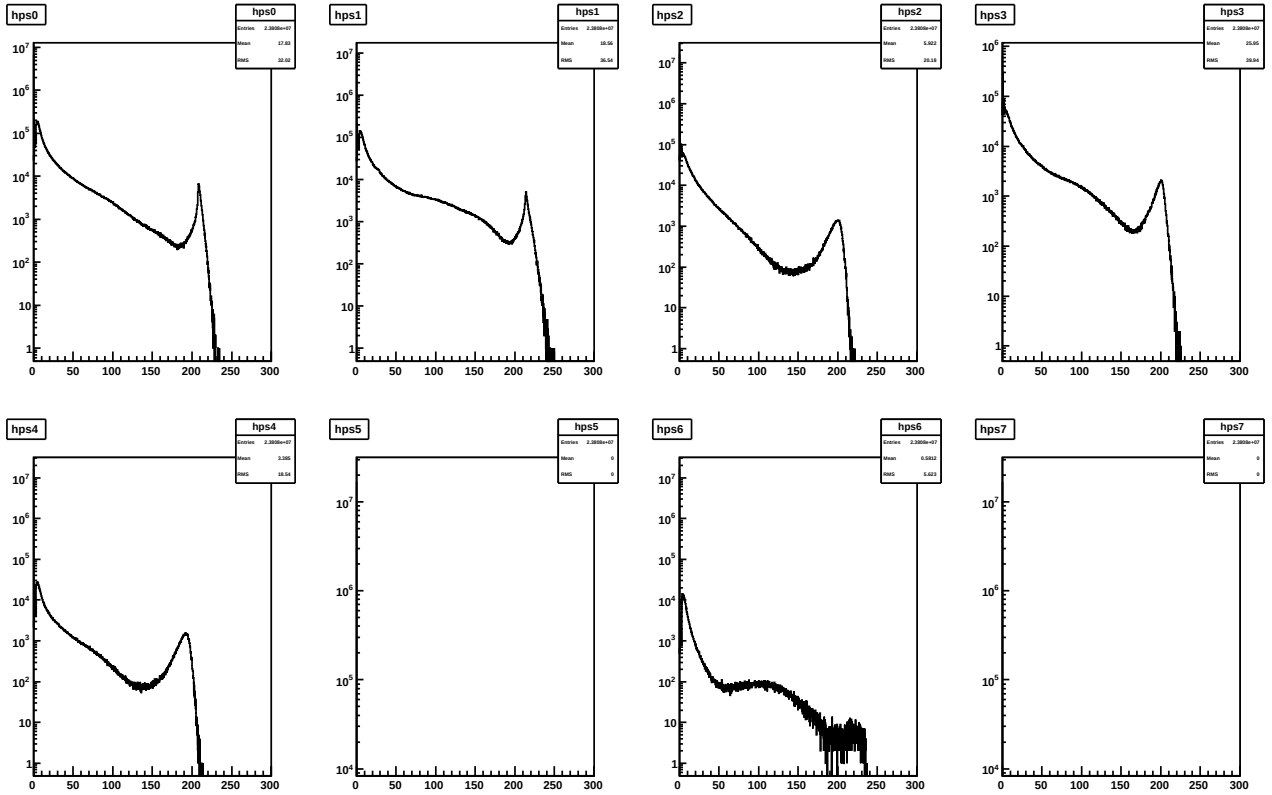
Setup


Dewar
SiPM
LAr
VM2000
WLS fiber
Source inside
Source outside
SiPM

Setup

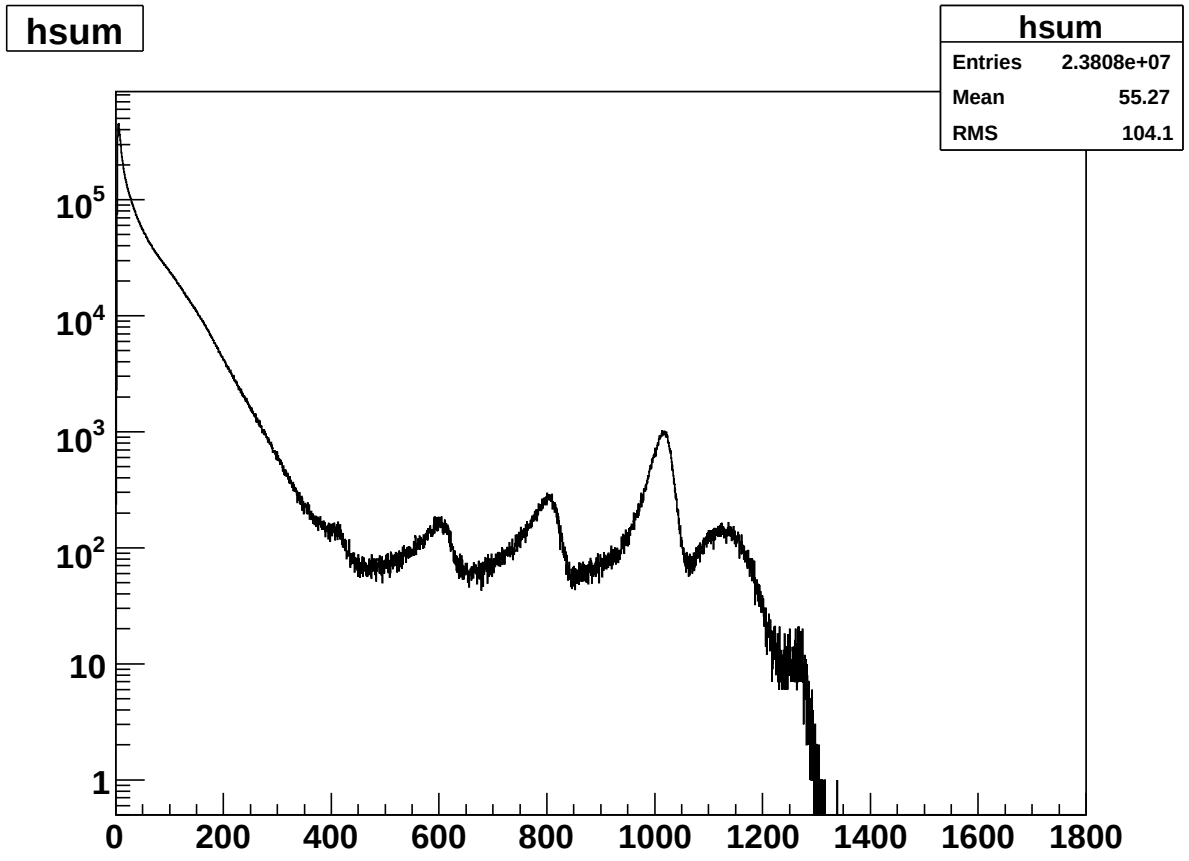
- pressurized dewar
- 4 x 5m WLS fiber total surface: 628cm^2
- 8 x SiPM with 100 pixels
- charge sensitive preamps
- VM2000 foil, no TPB
- VM2000 surface about 3000 cm^2
- 18 l active volume (or less), 25kg Ar

6 channels were working



100 pixel SiPM saturates the preamp at around 200

6 channel sum

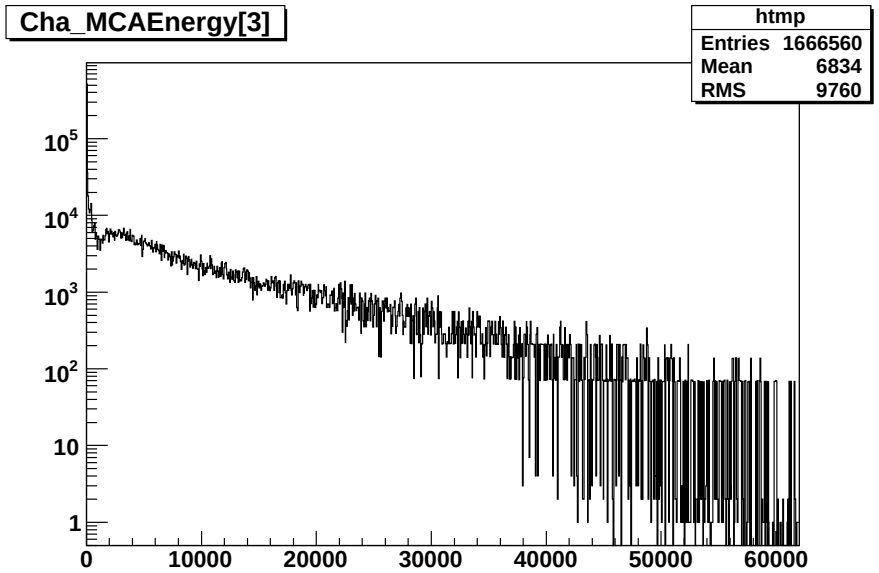


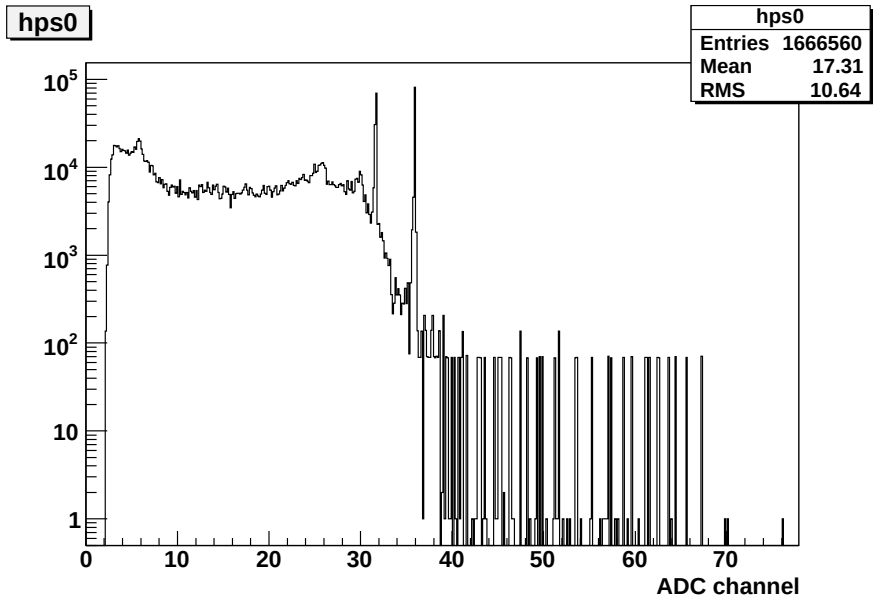
Background

- Internal radioactivity of the WLS fibers
  density 1.2 g/cm3, 10 m = 6.54 g
  Assuming mBq/g (OPERA Kuraray K11 fiber meas.) = 6.5E-3 decay/s negligible
- Internal radioactivity of the LAr, from ^{39}Ar
  1.4 Bq/l, β decay, end-point 565 keV
  20 l = $\sim$ 28 Hz
- Cosmic μ : 1/cm2/min (PDG)
  $(12cm)^2\pi = 452cm^2$ = $\sim$ 7.5 muons/sec expected
  7.9 Hz the rate of events when at least 1 SiPM saturates the preamp.
- I see a $\sim$ 2kHz background. Radioactive background?

Co60 coincidence with ReGe

Data taken in coincidence with a HPGe detector.
Co60 source was between the dewar and the germanium det.

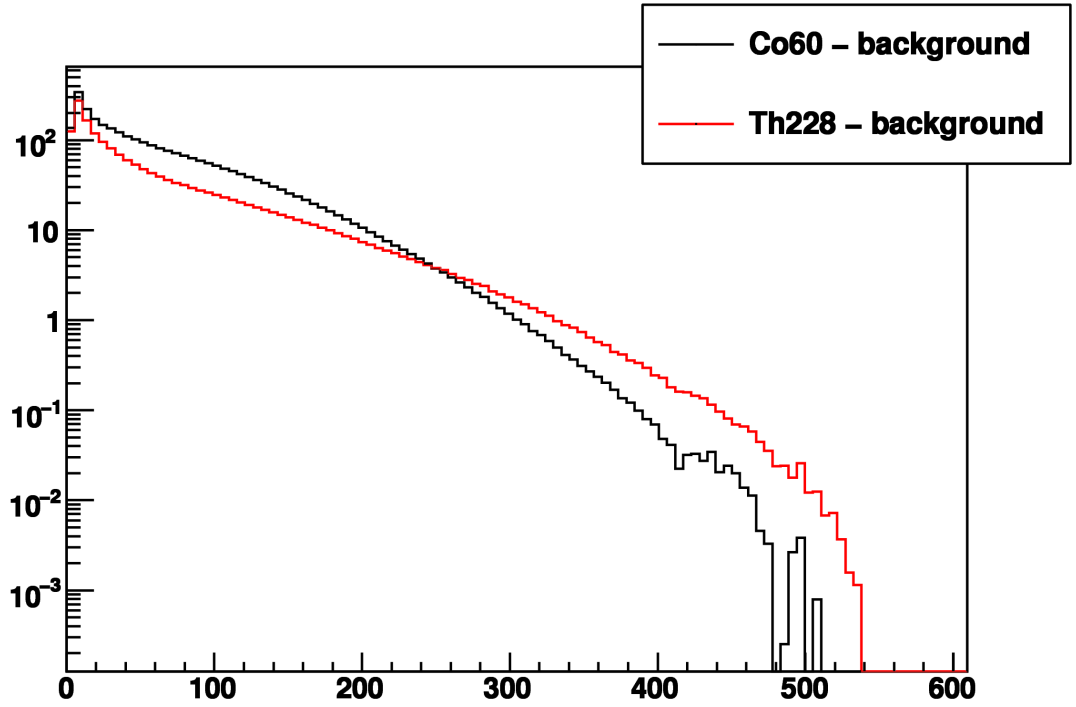




No features in the spectrum. In the HPGe spectrum sum peak suppressed.

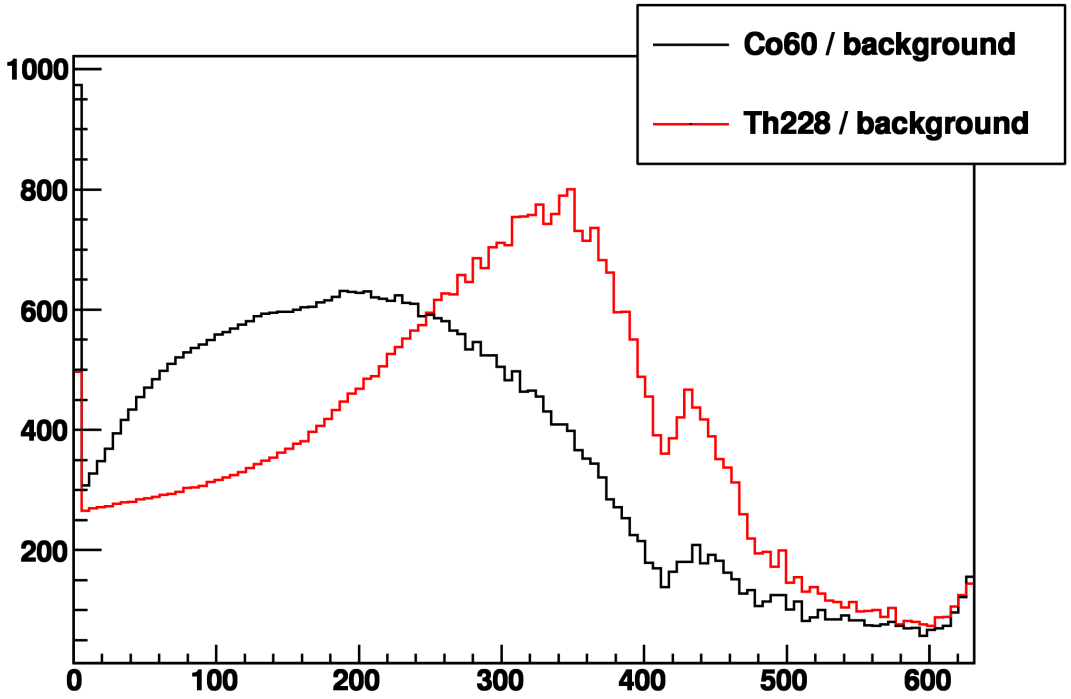
Co60, Th228 - background

Data recorded for Co60, Th228 and background. Histograms were normalized to the run time and the background binwise subtracted from the Co60 and Th228 spectra.



Co60, Th228 / background

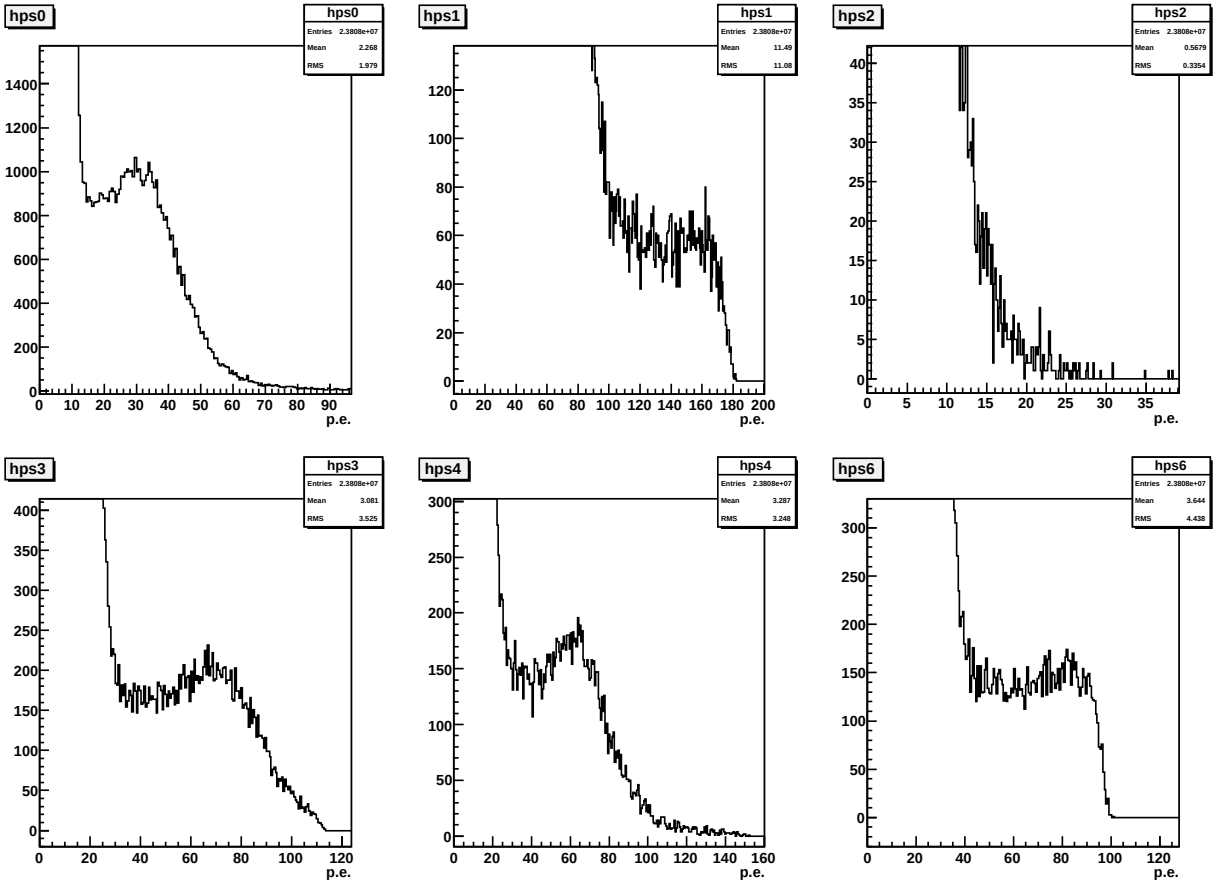
Same procedure but the Co60 and Th228 spectra are divided by the background



The 2.6 MeV peak seems to be out of range. From the Co60 data about 200 p.e./MeV

Th228 source inside

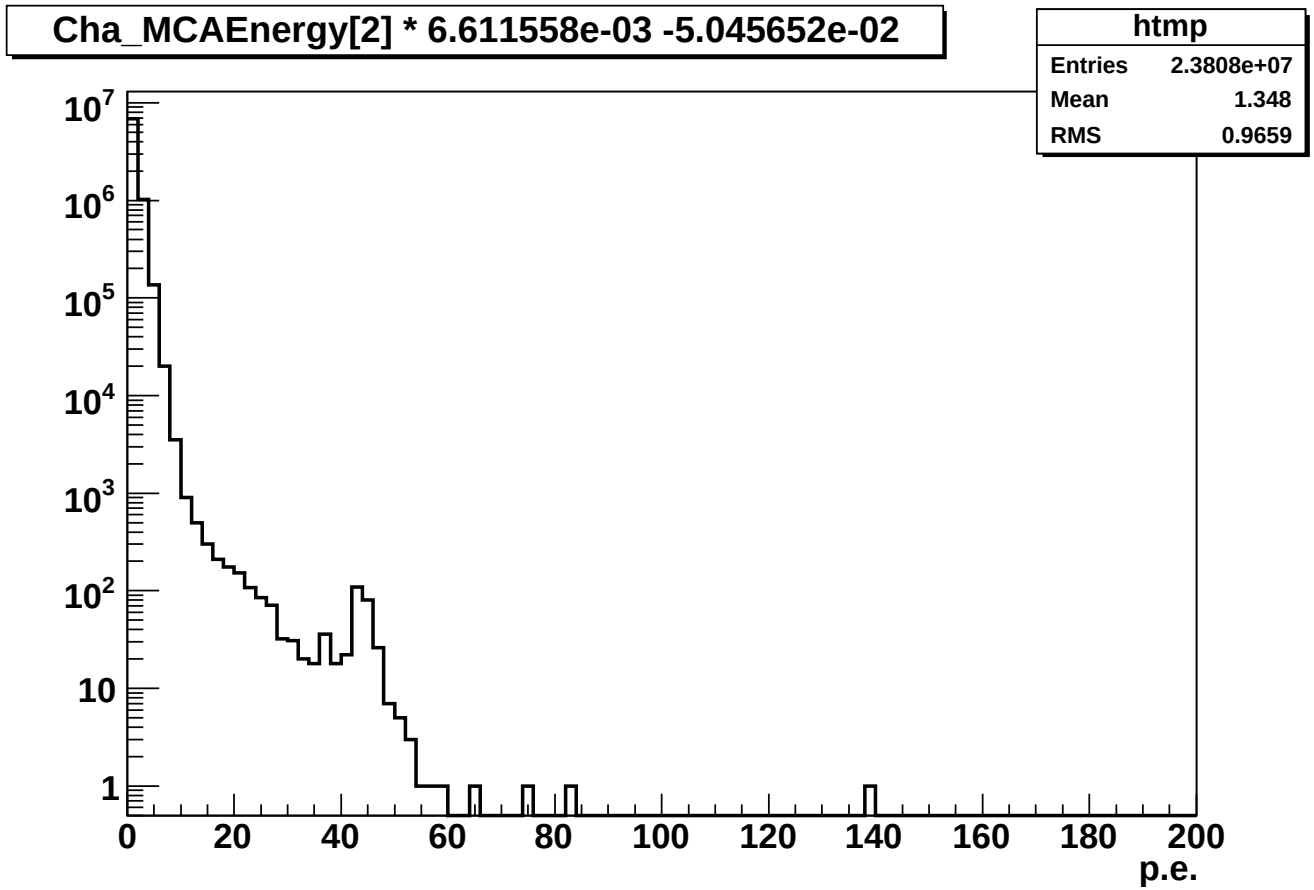
Th228 source inside the dewar. The dewar was not full.



Between 30 and $>$100 p.e. for the 2.6 MeV peak

Th228 inside

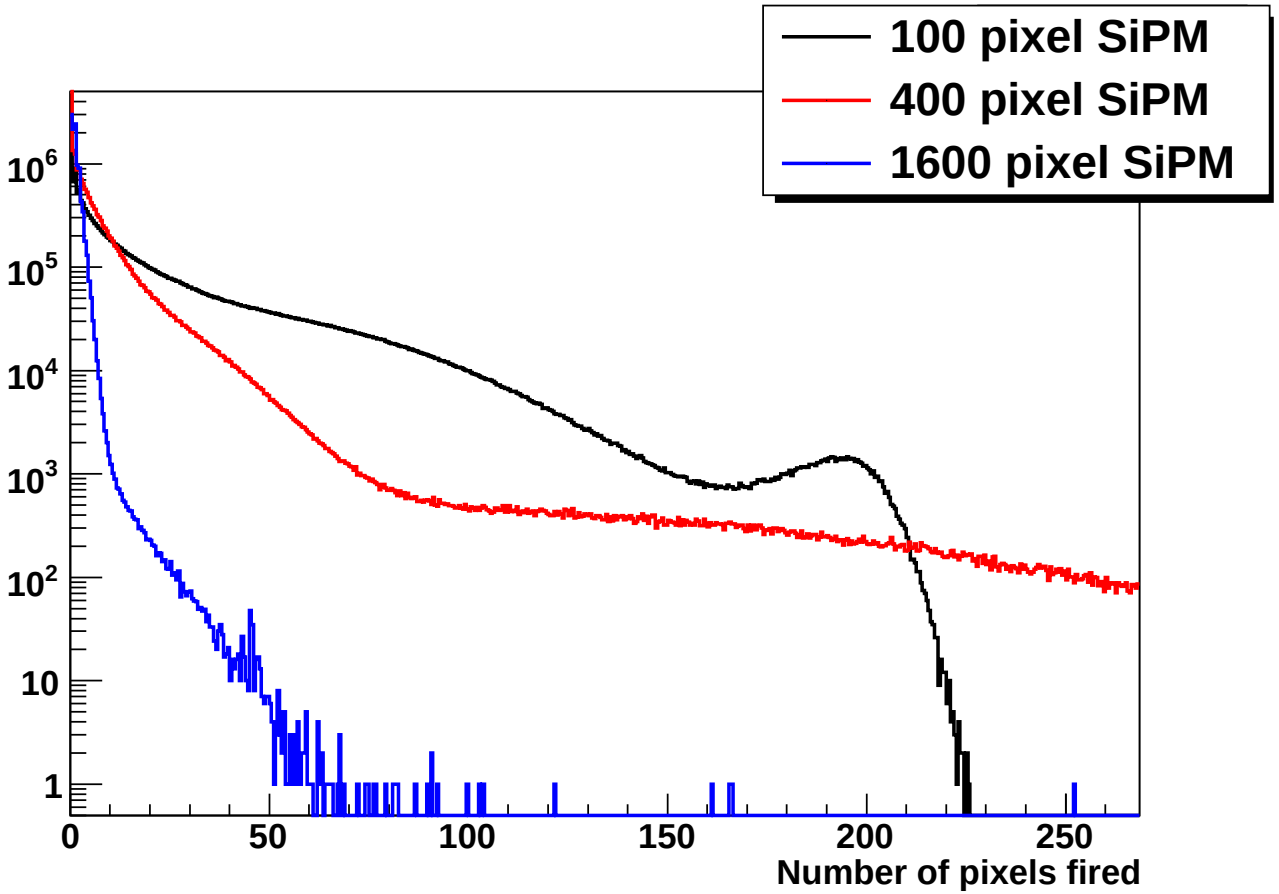
Trying to extend the range: 1600 pixel SIPM (2.6× lower Q.E. than the 100 pixel device)



Under investigation

Comparison of different SiPM's

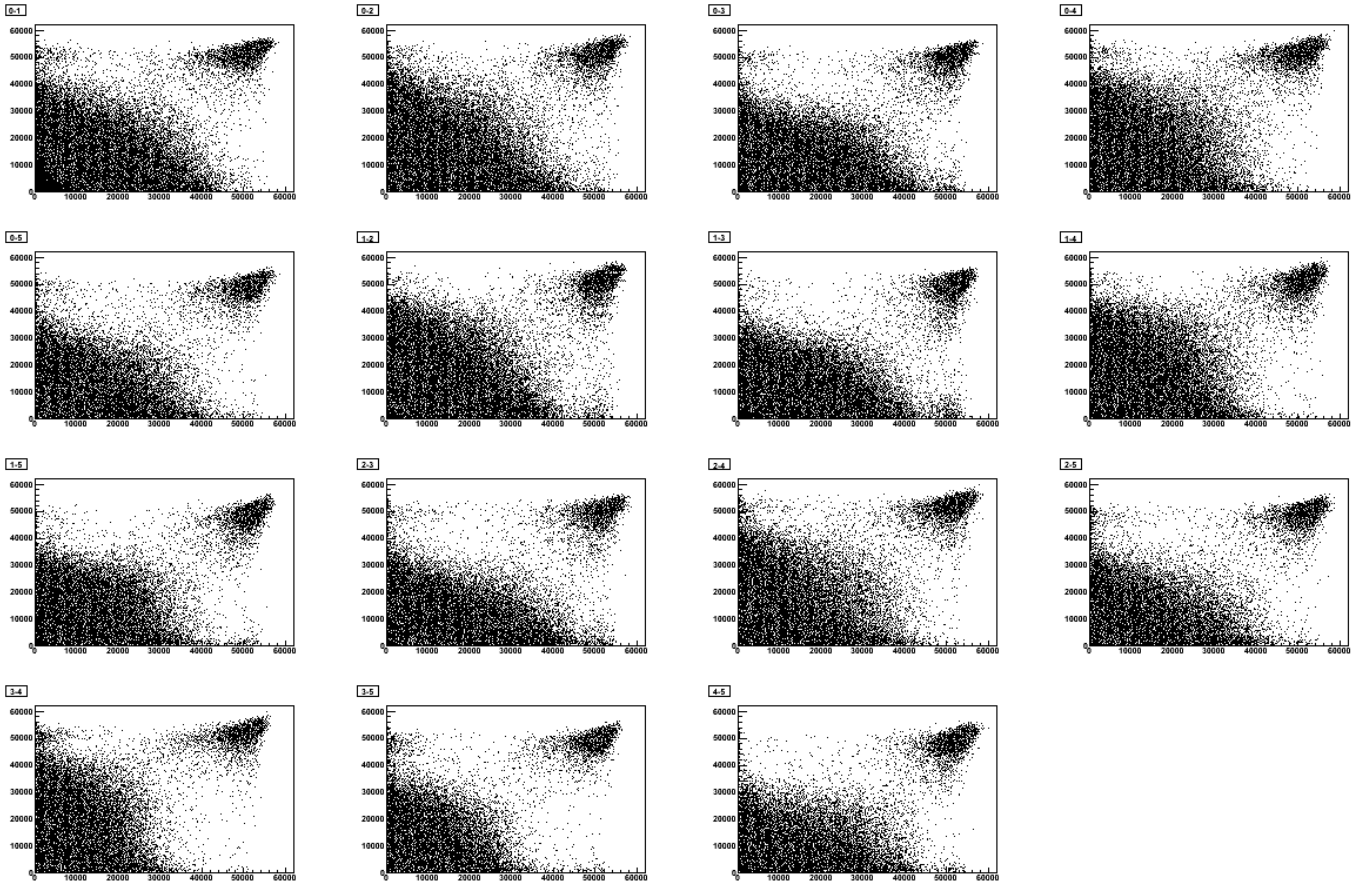
In order to increase the dynamic range we can try different SiPM's



Q.E. decreases with the number of pixels

Correlation plots

No correlation between SiPM's

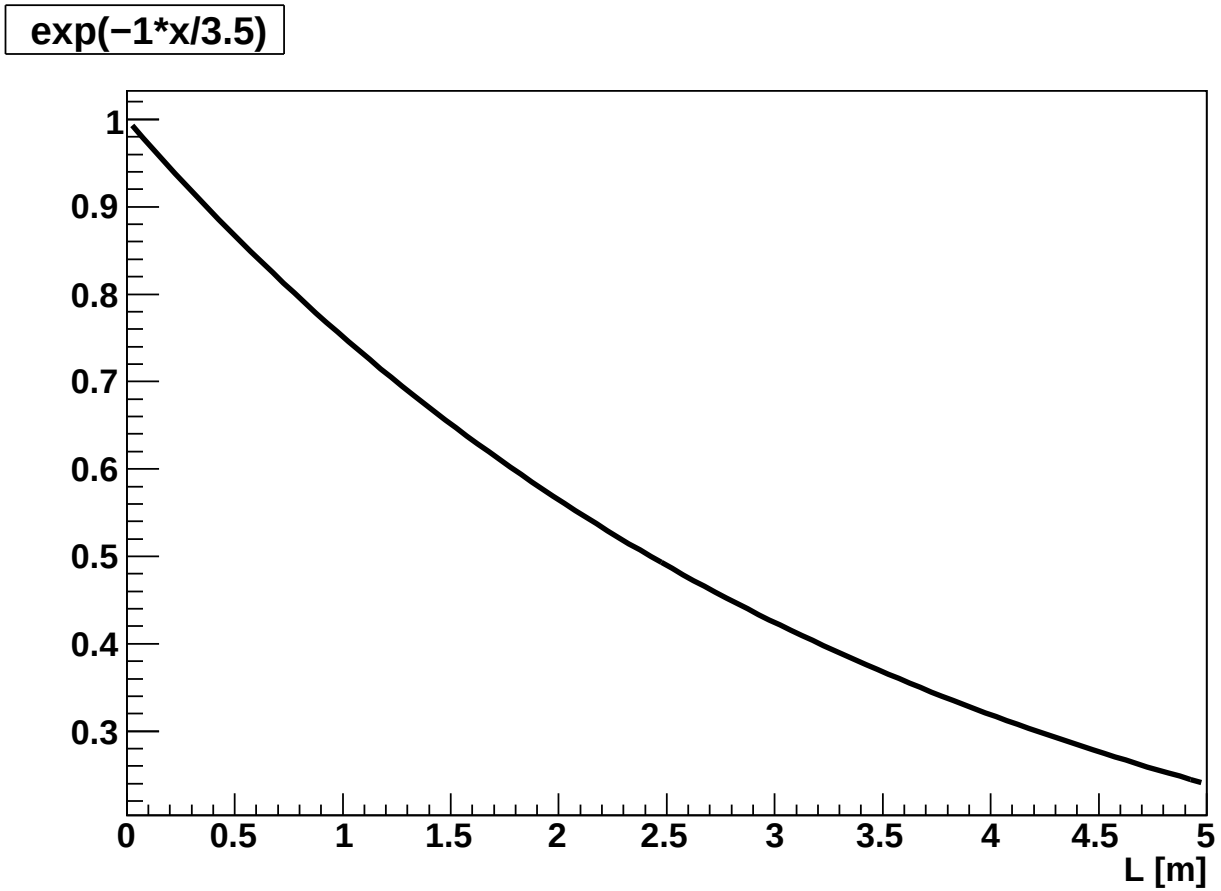


Conclusion

- hundreds of p.e.'s detected
- Preliminary result: $\sim$200 p.e. / MeV summing up all channels
- Response of the detector under investigation
- Room for improvement:
  - VM2000 + TPB, at least 2x the light yield expected
  - optimize WLS fiber length
  - Increase the usefull range
- One of the next experiments will be with a HPGe detector inside

Backup slides

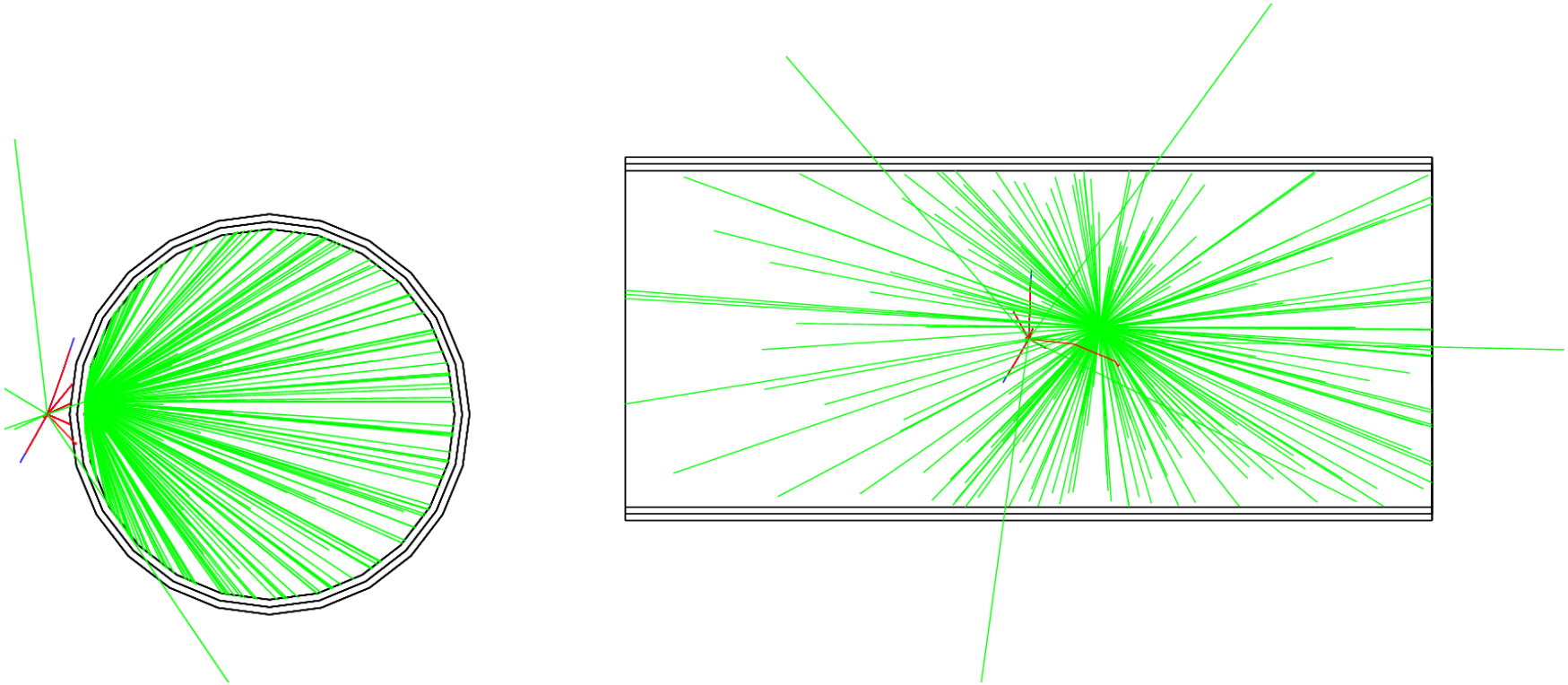
Anticorrelation because of the WLS fiber?



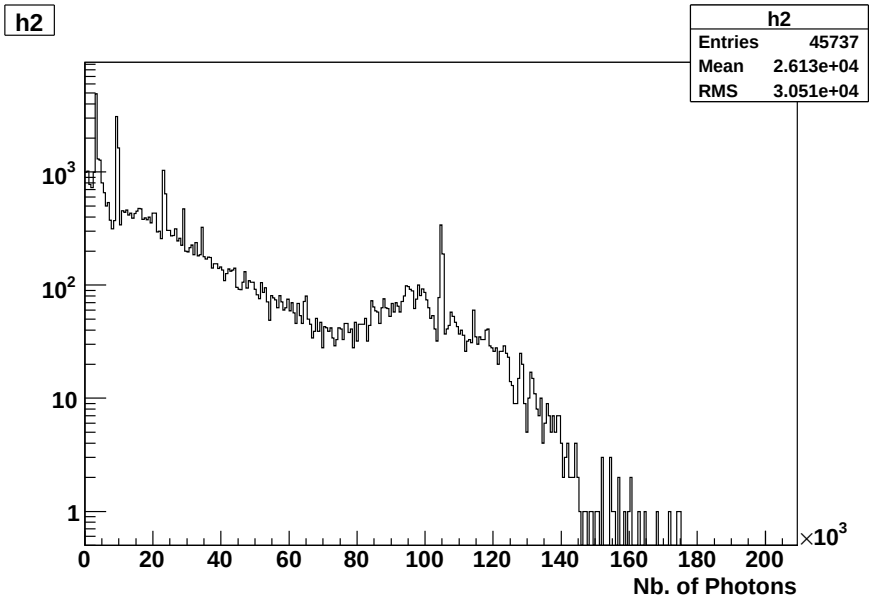
Attenuation length: 3.5m, fiber length 5m

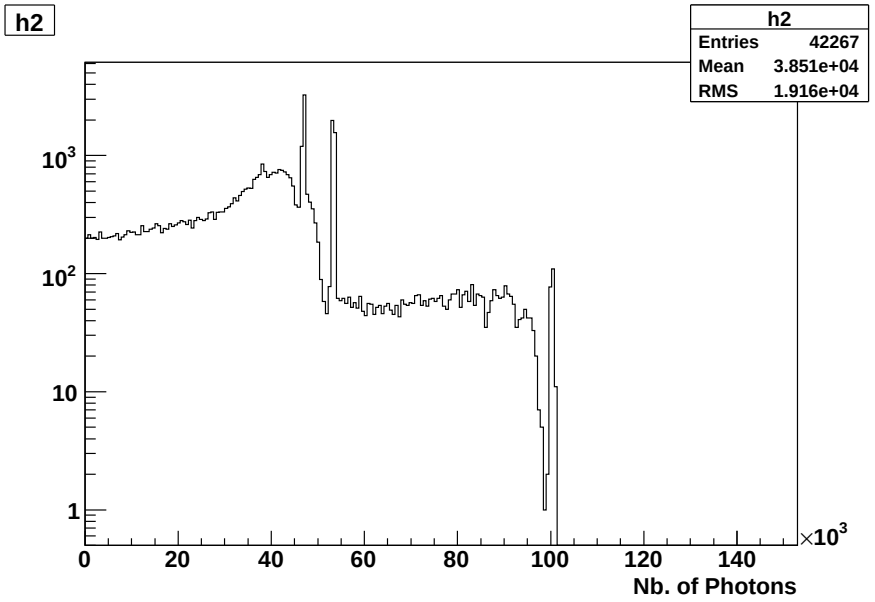
G4 simulation

cylindrical volume filled with LAr. 40000 photons/MeV. Source outside of the volume. Example with Th228 source



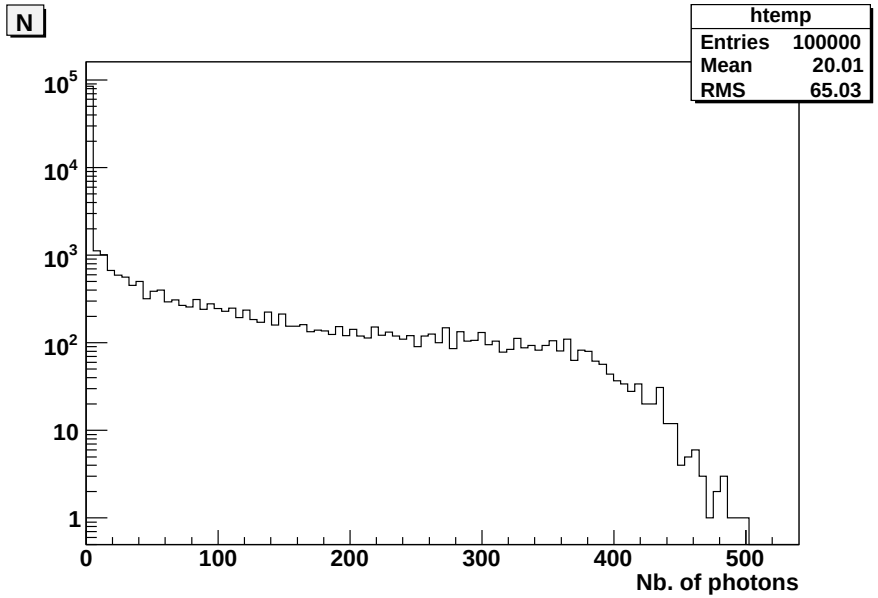
MC Th228 and Co60 scint. spec.

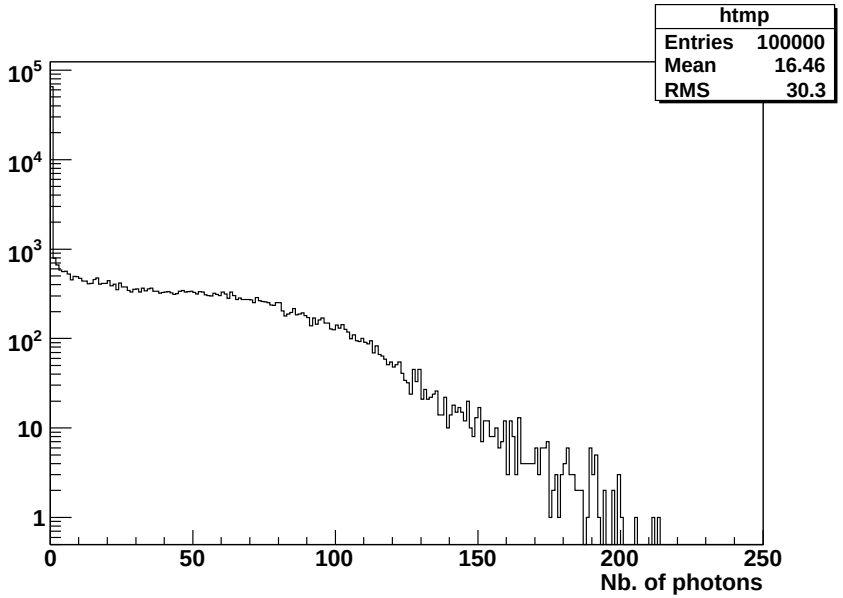




Number of opptical photons produced by G4 assuming 40000 photon/MeV

MC Th228 and Co60 Cerenkov spec.





Cerenkov threshold for e- in H2O = 775keV in LAr 892 keV assuming n = 1.22

G4 default 300ph/cm - depends on the spectral sensitivity of the PMT

Ikarus paper: 690ph/cm for a mip

The simulated spectrum is featureless (no peaks)!