NEW GENERATION OF LARGE SCALE SCINTILLATION COUNTERS FOR DETECTION OF EAS AND USE IN GUARD SYSTEMS OF EXPERIMENTAL PHYSICS SETUPS

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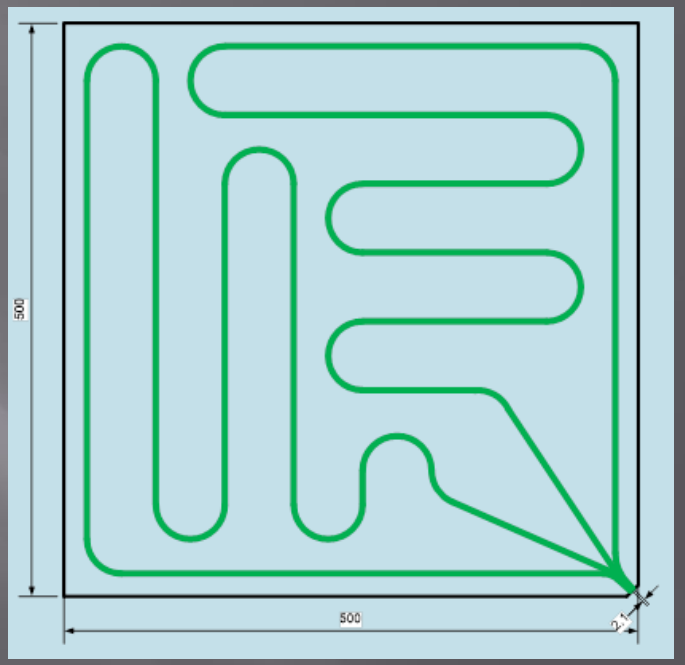
Solid counters based on scintillating PS plates

Photo of the completed counter of 500×500 mm^2 with front-end unit

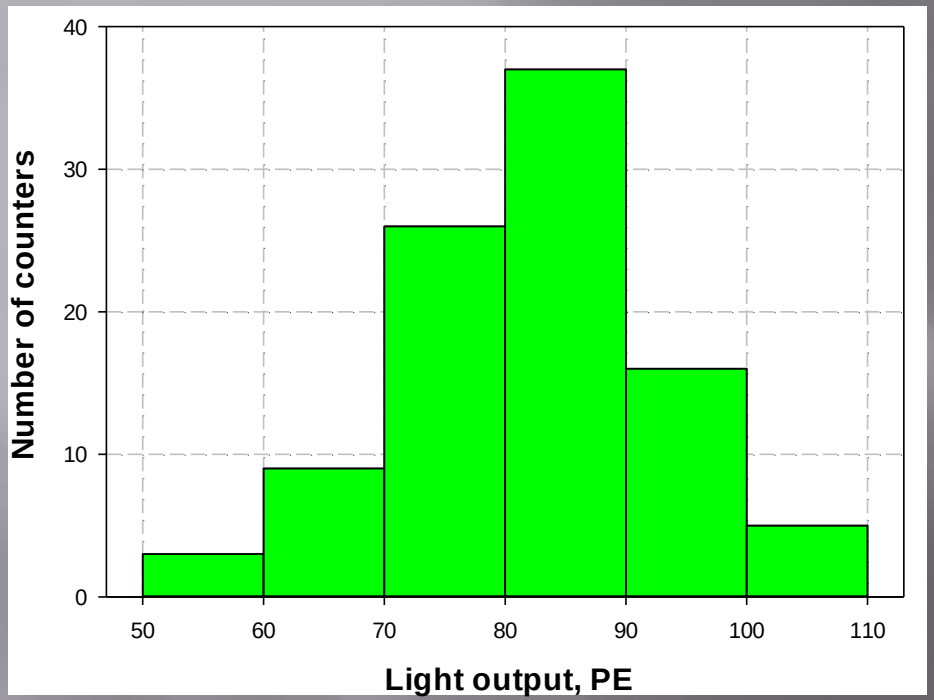
Commercial clear PS granules with PTP and POPOP melted in a mirror mold were used



2 WLS fiber "snake" positioning (green lines) into the surface of the scintillator

1 mm Kuraray Y-11(200 ppm) WLS fibers. Total length is 5,2 m.
Fibers are glued with PK-68 Rexant transparent silicone compound into 1.5 mm wide grooves up to 4 mm deep.

Solid counters based on scintillating PS plates



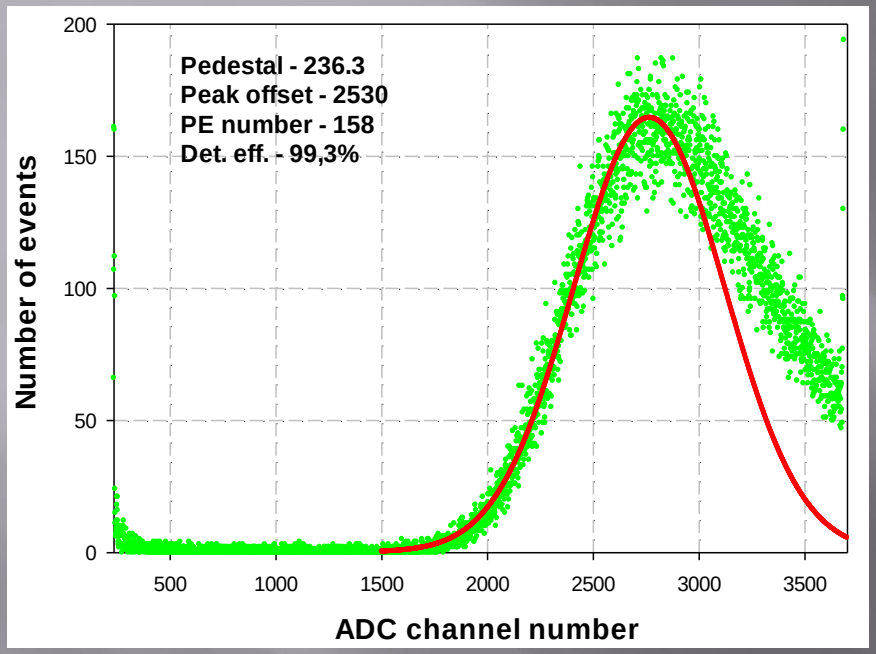
50 mm thick counters
light output histogram

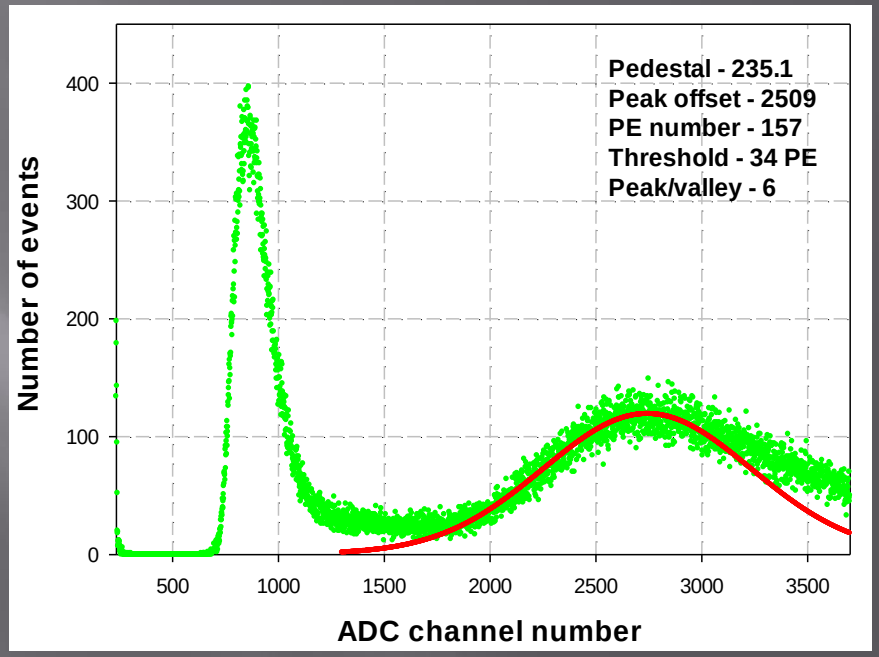
Mean light output – 82 PE
Raw detection efficiency – 99.5%
Event rate (controlled) – 100 ev/s
Time resolution (sigma) – 3-4 ns
Peak/valley ratio:
2.6 (30 mm thick)
~4 (50 mm thick)

SiPM:
SensL (Ireland)
MicroFC-30035-SMT
3×3 mm^2
Bias voltage – 30 V

ADC gate – 80 ns

Solid counters based on scintillating PS plates



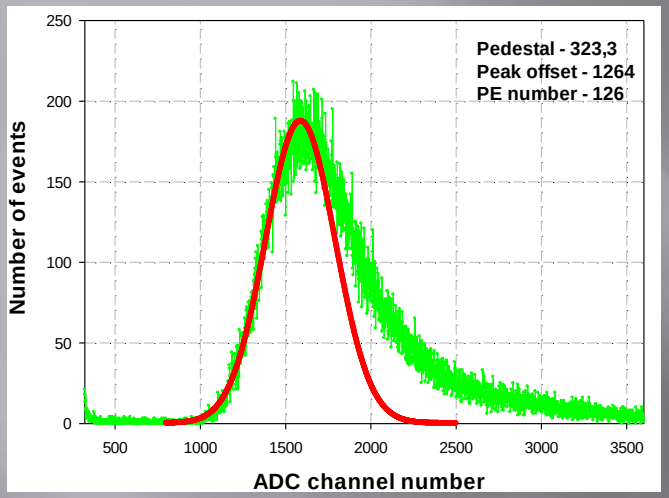


External trigger

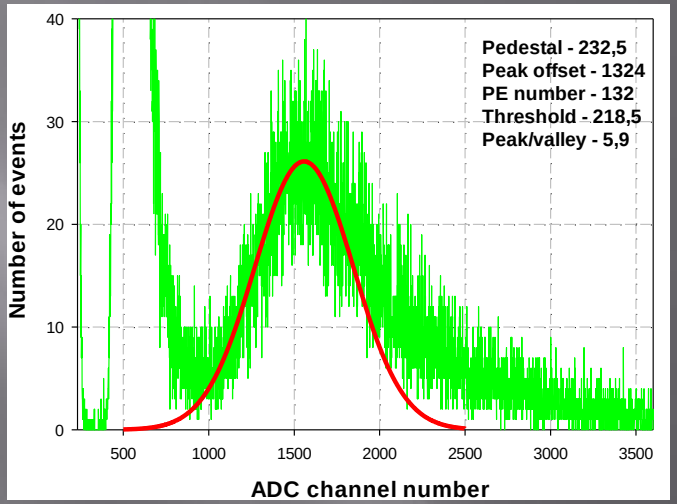
Self-triggering

Amplitude spectra of the counter with 5 cm Sci plate and 2 WLS fibers in a groove (8 edges and 10.4 m in total)
Calibration – 16 ADC ch. per PE

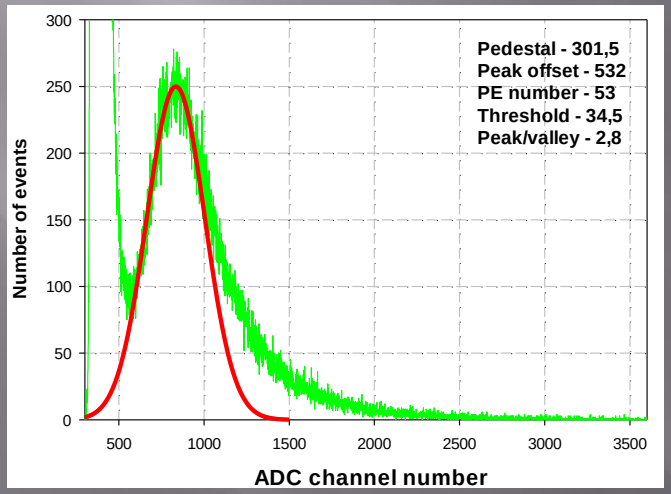
Solid counters based on scintillating PS plates



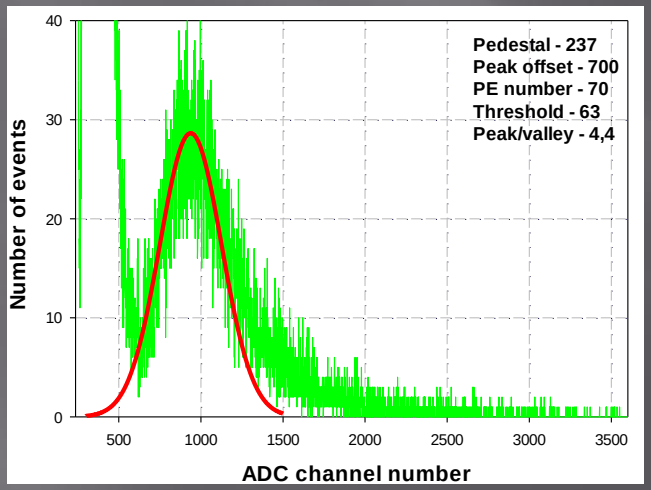
Ex. trigger (14 ev/s), pulse sum



Self-triggering (66 ev/s), sum



Top layer, 1000 ev/s



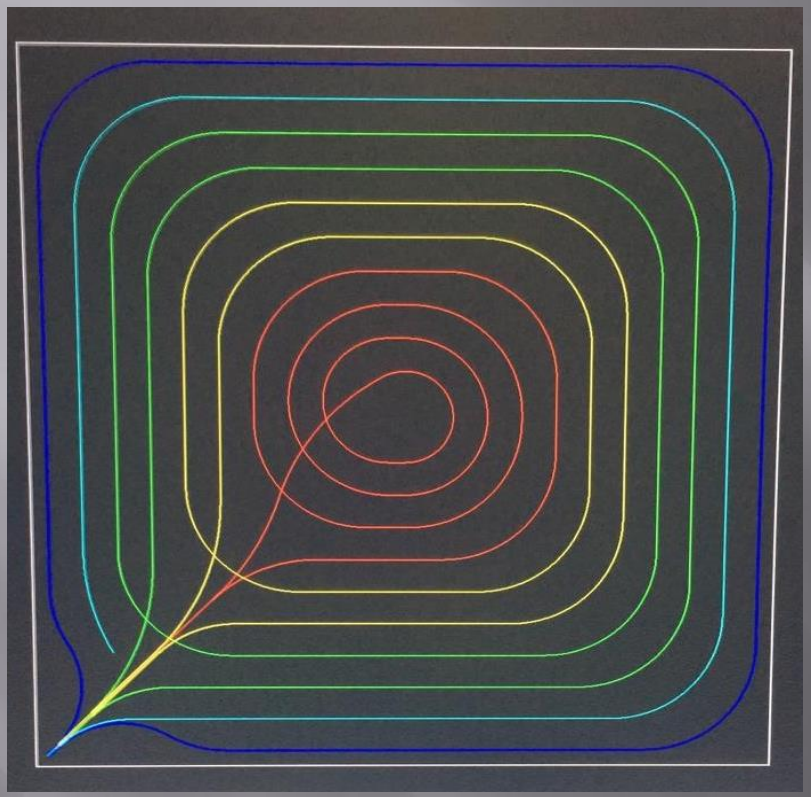
Bottom layer, 1500 ev/s

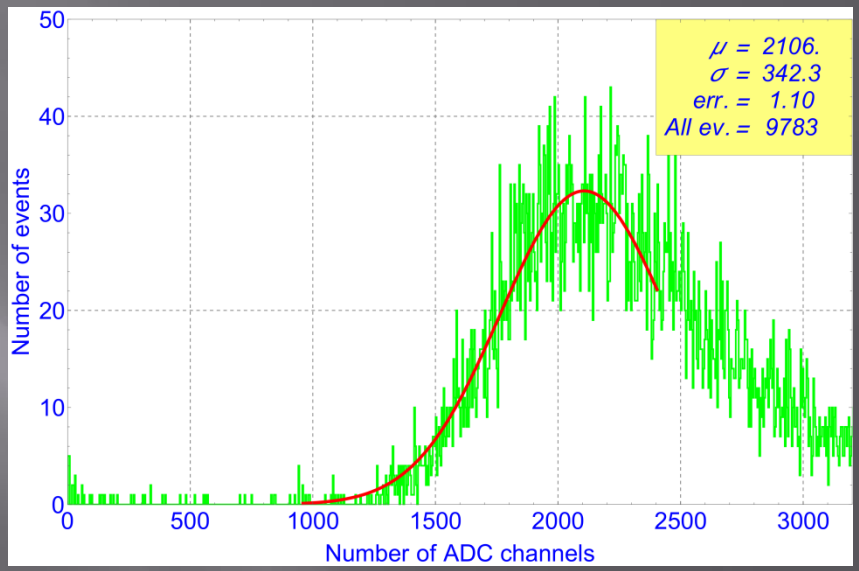
Counter with 2 layers of WLS:
Top and bottom of the Sci plate and 2 SiPM (SensL)

Self - triggering: Top/bottom coincidence (fixed threshold) and analogue sum of top and bottom layers

1 PE ⇒ 10 ADC ch.

Solid counters based on scintillating PS plates

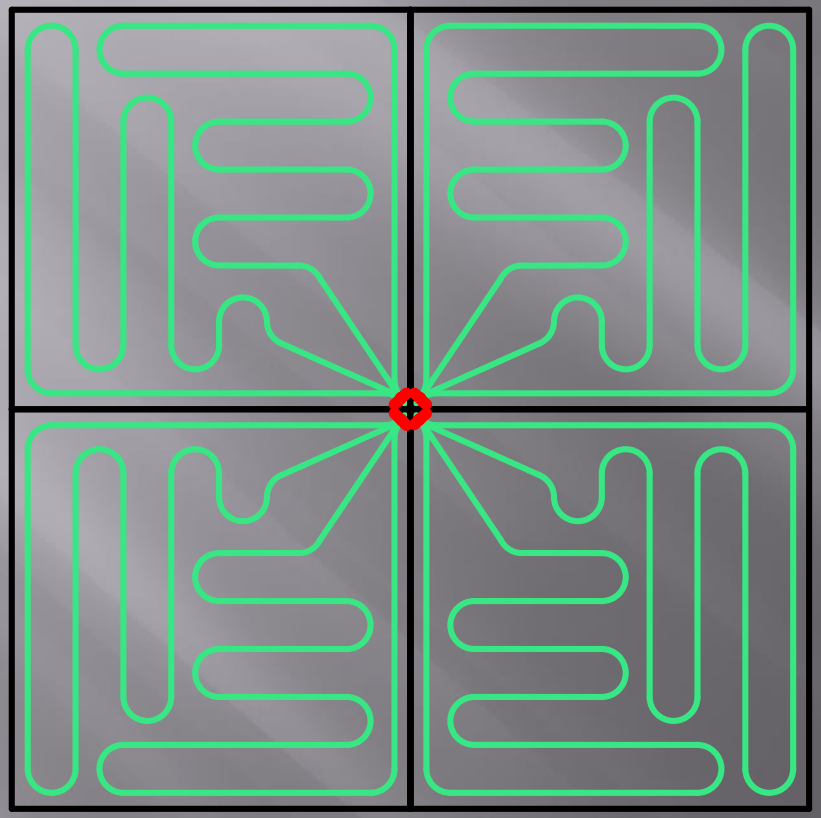




Counter amplitude spectrum
Number of PE is 180

New configuration of WLS fibers (shown in different color) for 0.5×0.5 m^2 counter. Total length of 5 fibers is 10.8 m. Minimal radius of fiber curvature is not less than 50 mm.

Solid counters based on scintillating PS plates

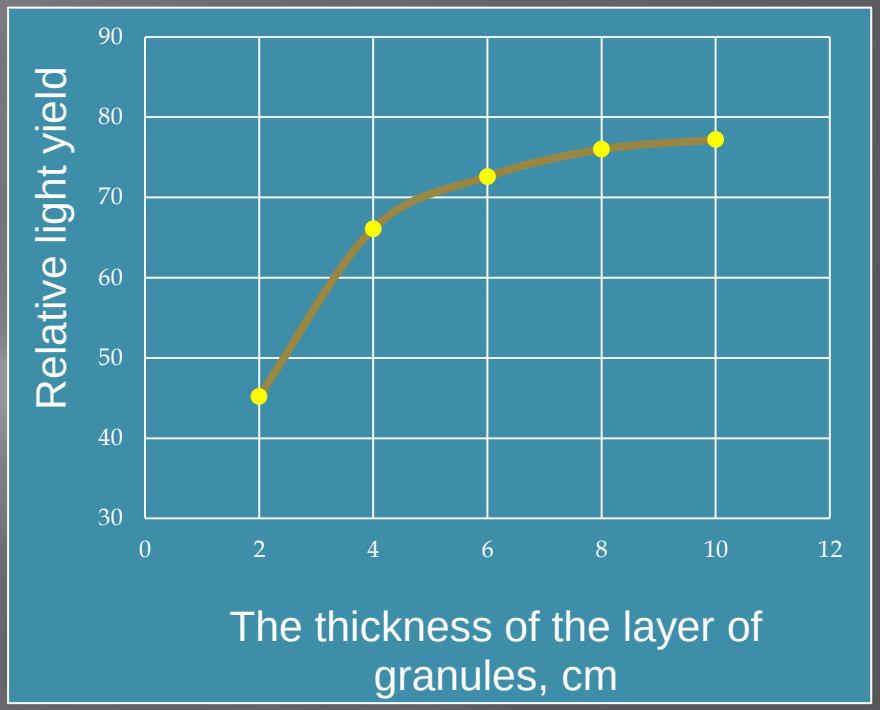


1 m^2 counter composed of four sections.

WLS fibers with a total length of 20.8 m are shown in green, the location of the 4 SiPM in red color.

SiPMs may be utilized separately or connected in series with a common front-end.

Counters based on PS scintillation granules

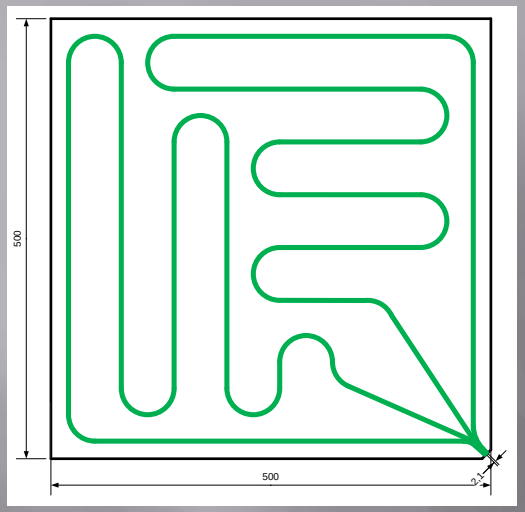


Light output of the granules layer as a function of its thickness

Extruder for scintillation granules manufacturing

Granules volume density 0.6 g/cm^3

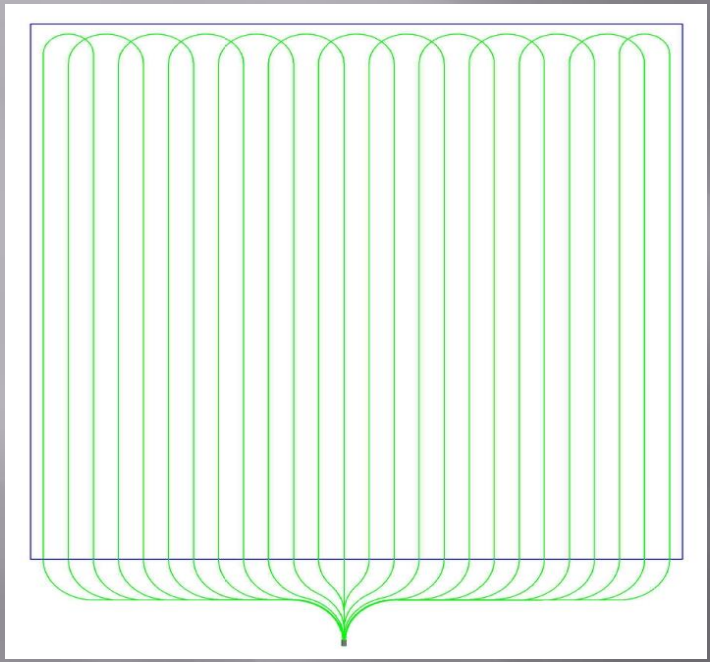
Counters based on PS scintillation granules



Configuration of the 1 mm WLS fibers placed in the middle height of Sci granule layer

Type of scintillation granules	10×10 cm² trigger counter position	Number of photoelectrons	Granule layer thickness, mm
Lentil shaped, Made in Protvino	Detector center	49	50
	Far corner	53	
	Close corner	69.5	

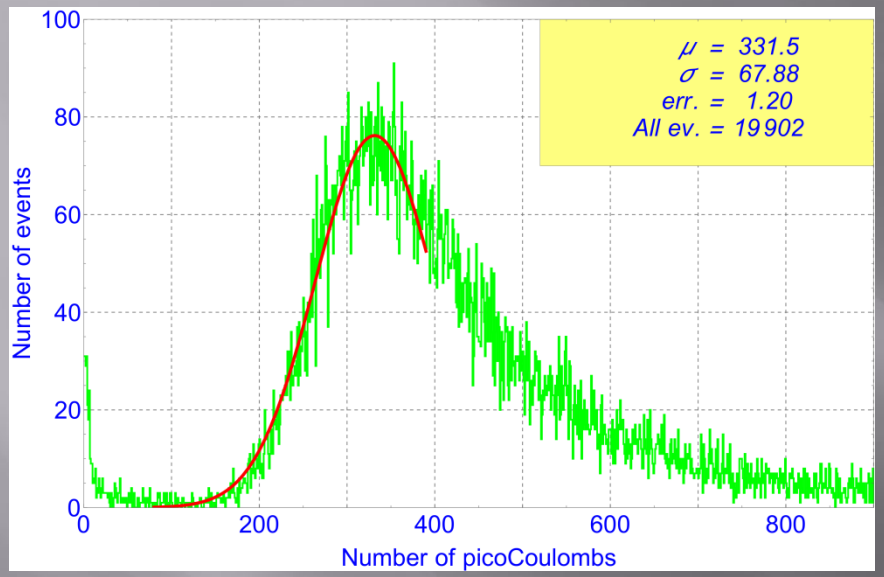
Counters based on PS scintillation granules



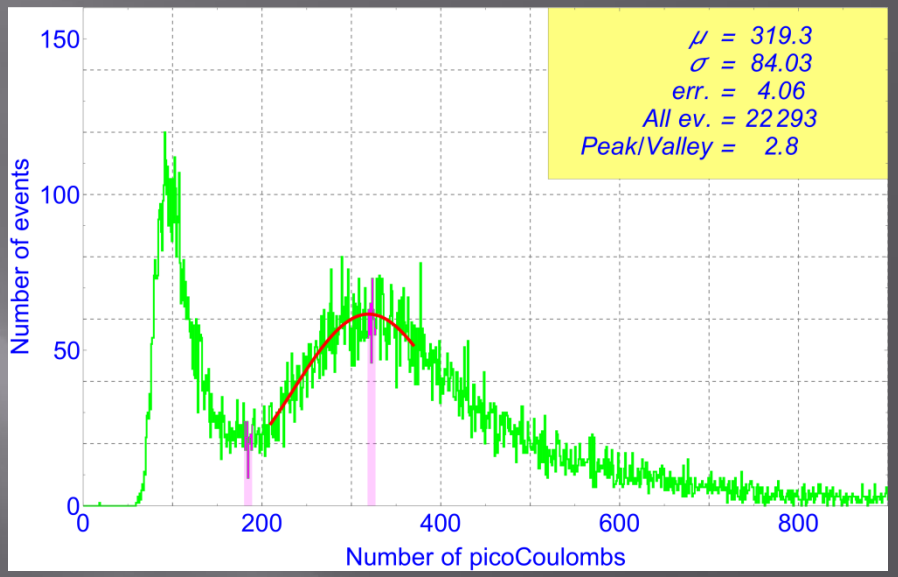
- WLS fibers with 26 m working length are shown in green.
  - 6×6 mm^2 SiPM
- Radius of fiber curvature is not less than 100 mm
- Granule layer thickness – 8 cm
- Light output – 130±6 PE
- Peak/valley ratio – 2.8

Single section 1 m^2 counter.

Counters based on PS scintillation granules

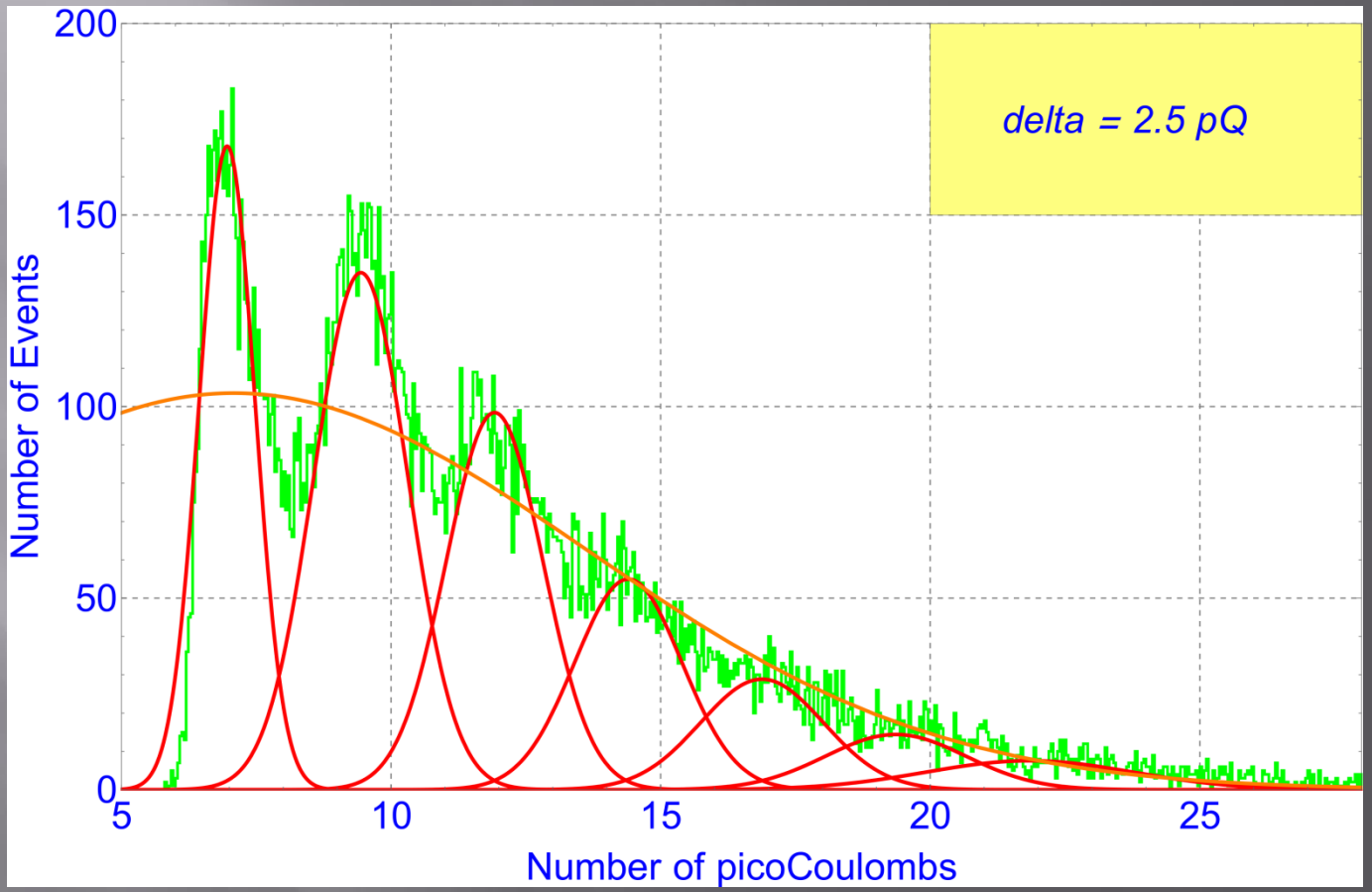


External trigger, 133 PE.



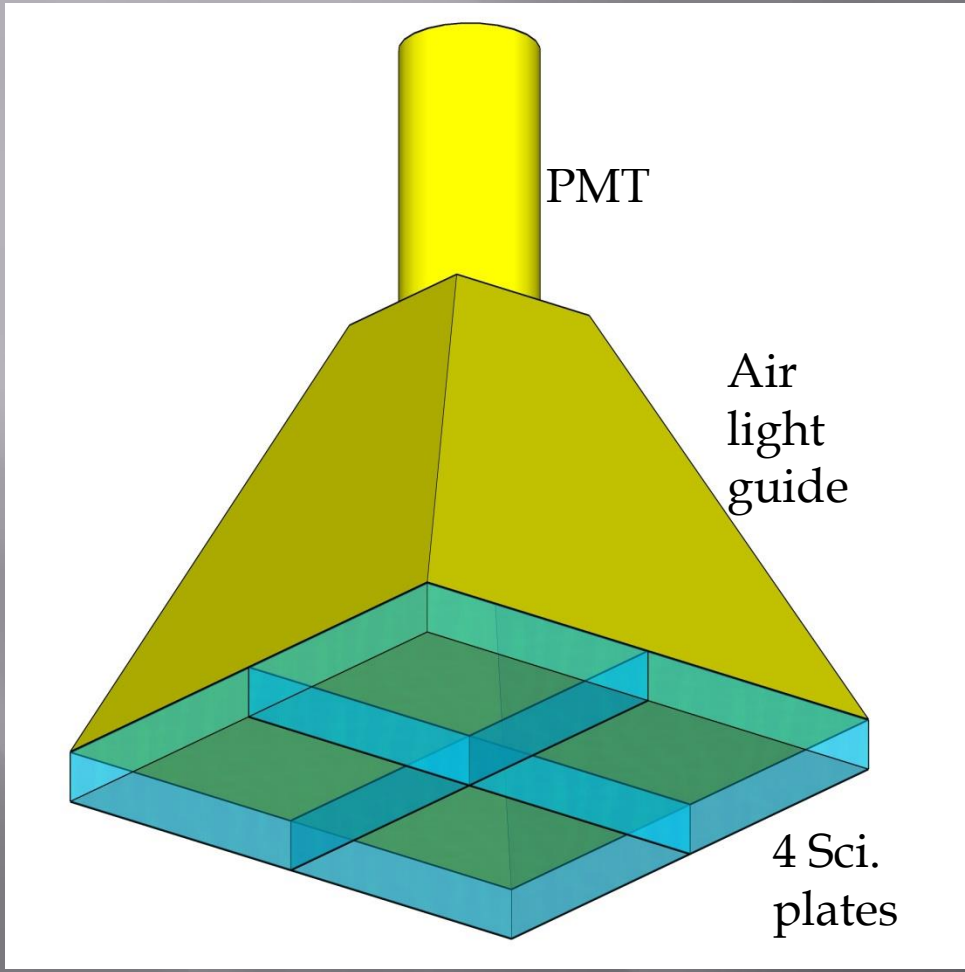
Self triggering, 128 PE.

Counters based on PS scintillation granules



LED calibration. Left peak is pedestal,
SER is 2.5 pQ.

Hip roof counters with PS scintillation granules

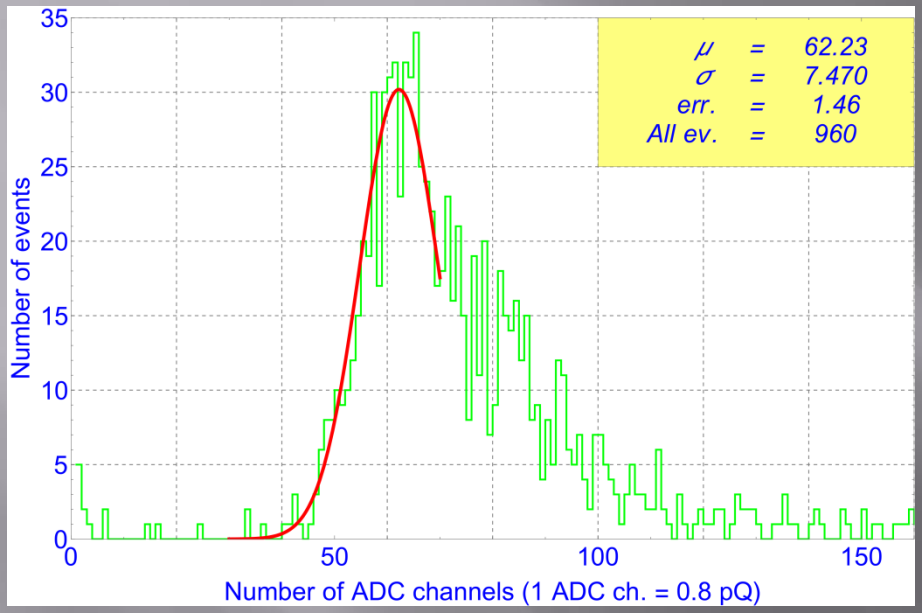


Counter sketch
(view from the bottom)

with 4 blue scintillator
(or Sci granules layer)
50×50 cm^2 plates

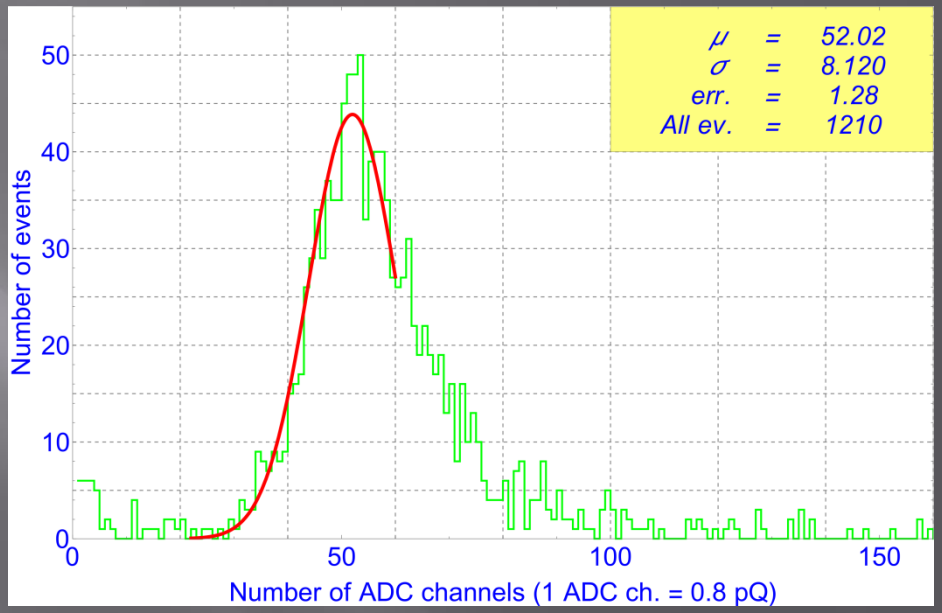
PMT – FEU-125
with 170 mm in diameter
photocathode

Hip roof counters with PS scintillation granules



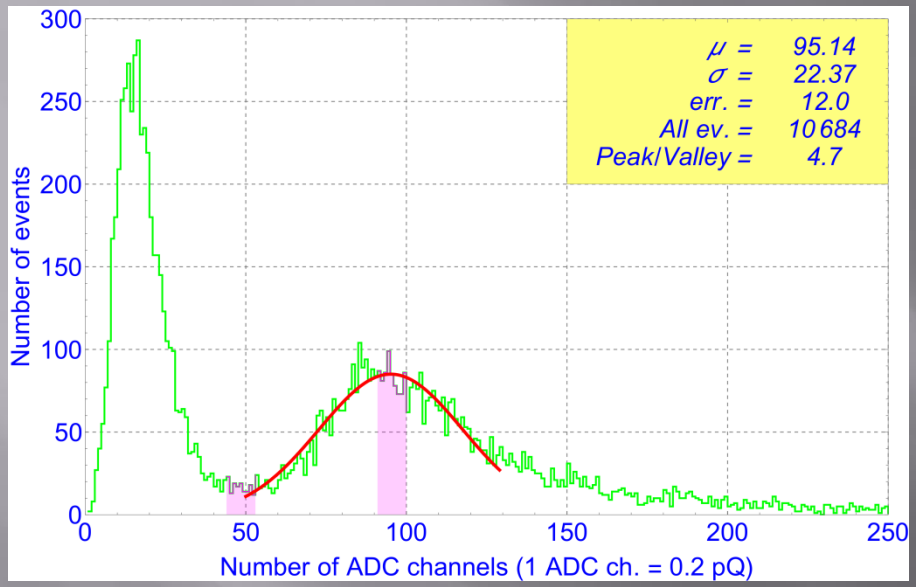
Amplitude spectrum of the pulses of FEU-125 PMT mounted on top of the tent reflector of the Kharkov scintillator 50 mm thick.

External trigger, 140 PE

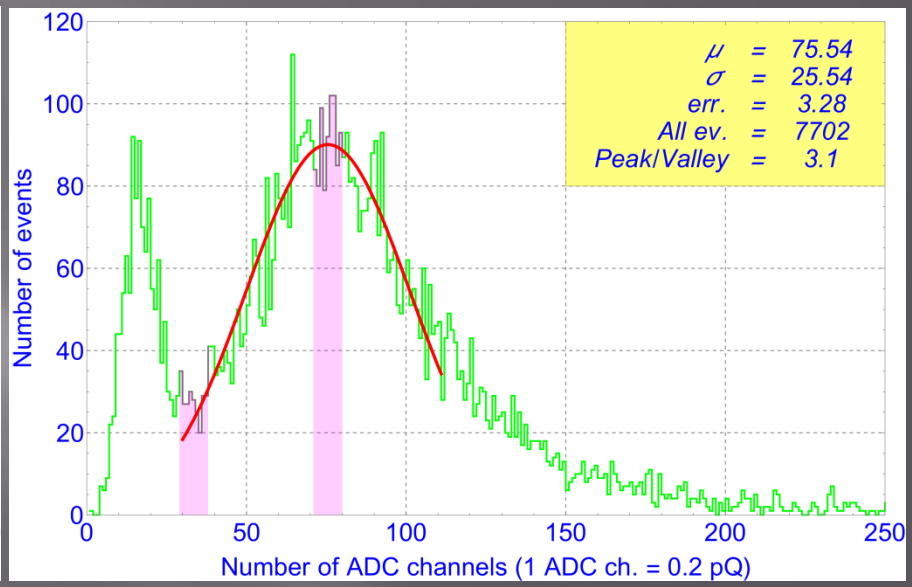


Amplitude spectrum of PMT signals of 8 cm thick layer of granules.
External trigger, 110 PE

Hip roof counters with PS scintillation granules



The amplitude spectrum of the Kharkov scintillator (50 mm) for self-triggering PMT.



The amplitude spectrum of 8 cm thick layer of scintillation granules for self-triggering PMT.

Scintillating granules with WLS plate and WLS fibers

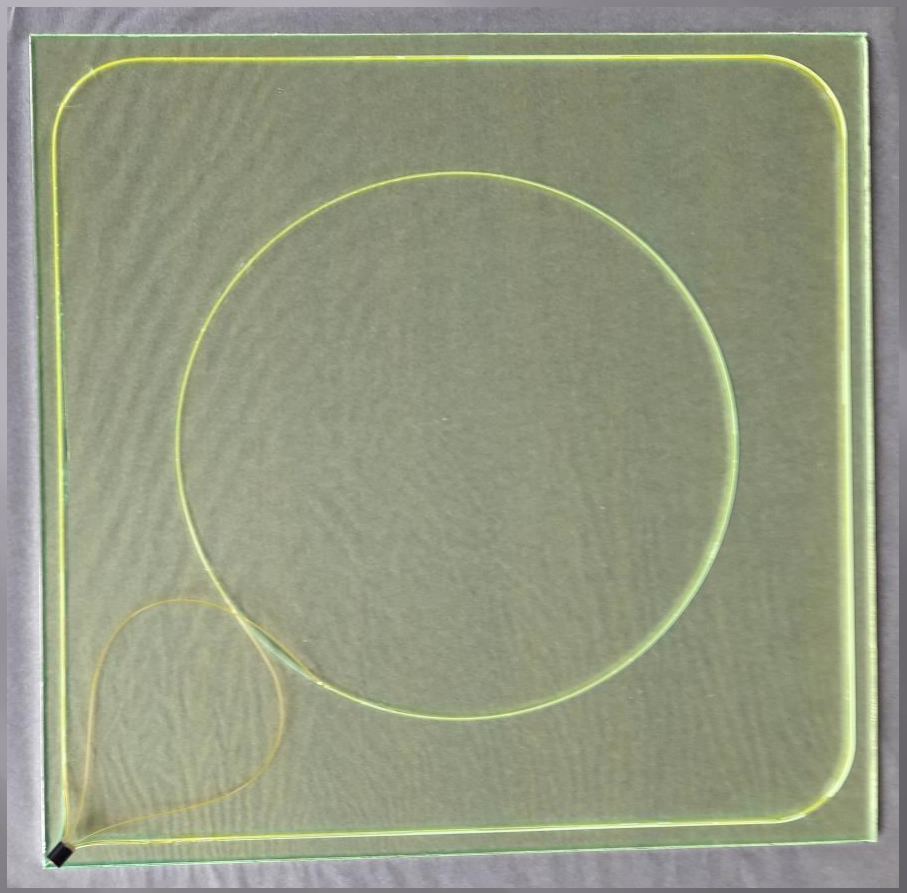
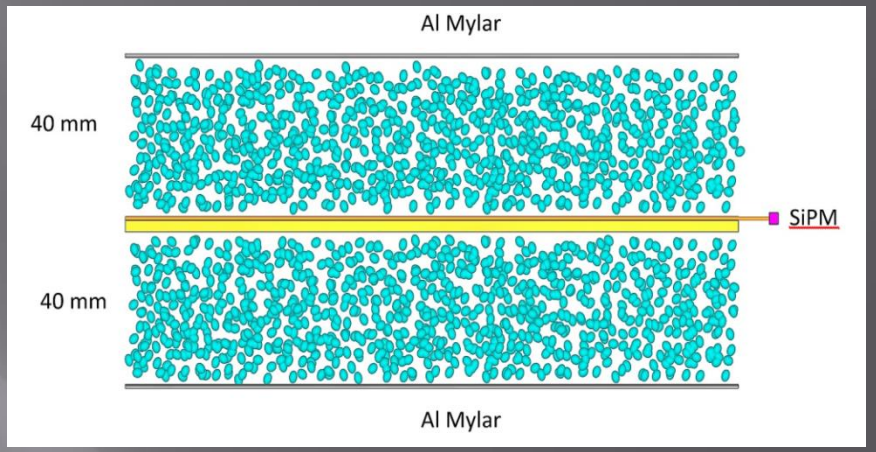
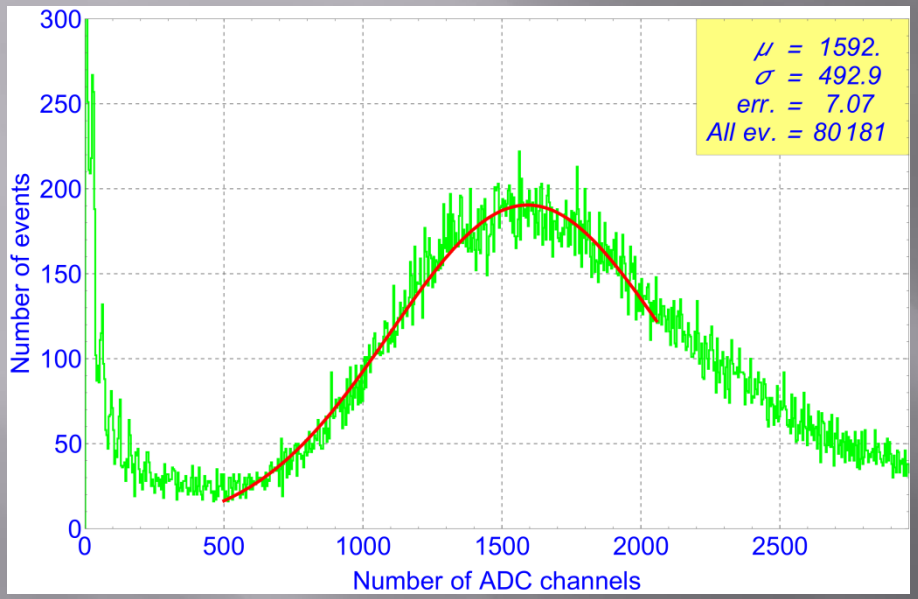


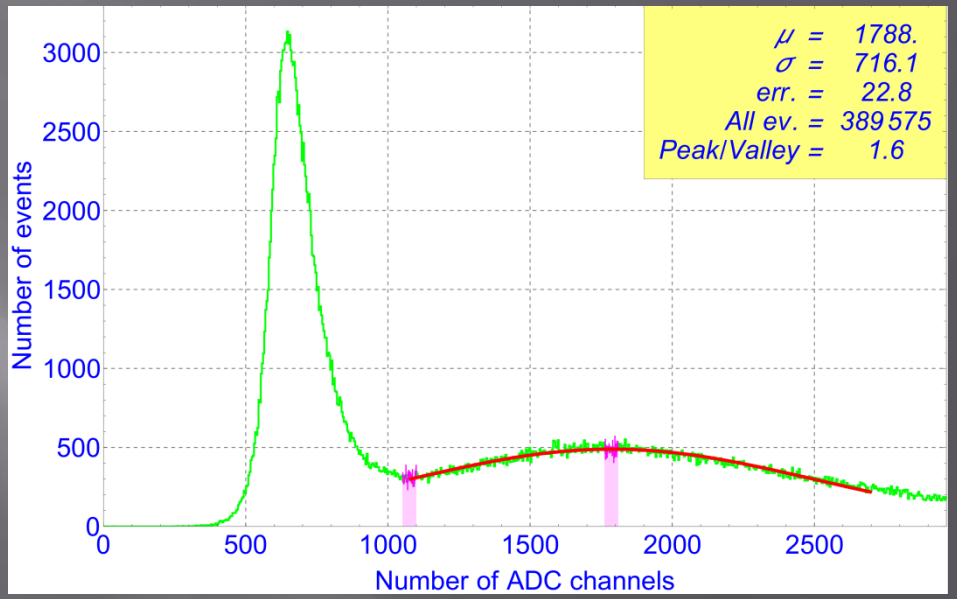
Photo of the green WLS plate with glued 1 mm orange WLS fibers



Detector structure

Scintillating granules with WLS plate and WLS fibers



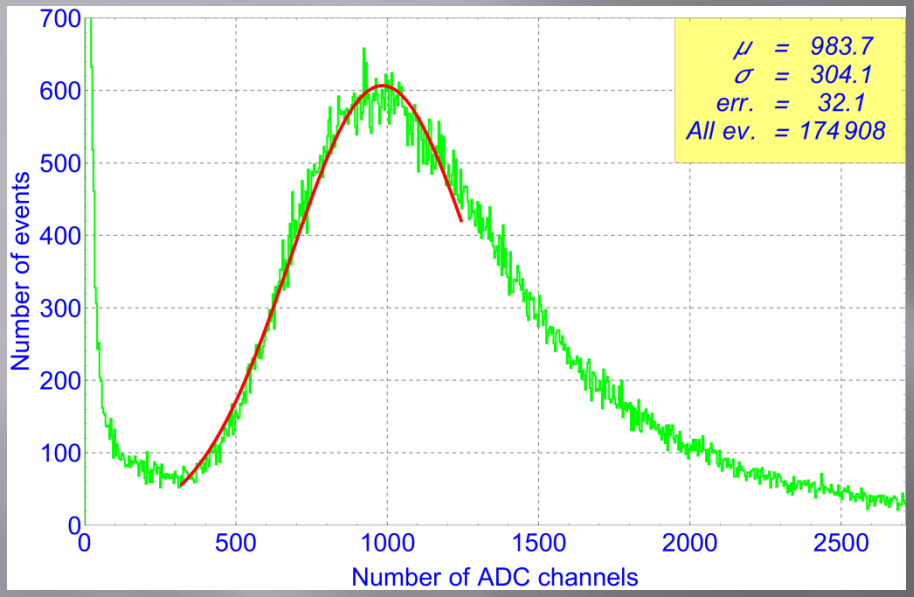


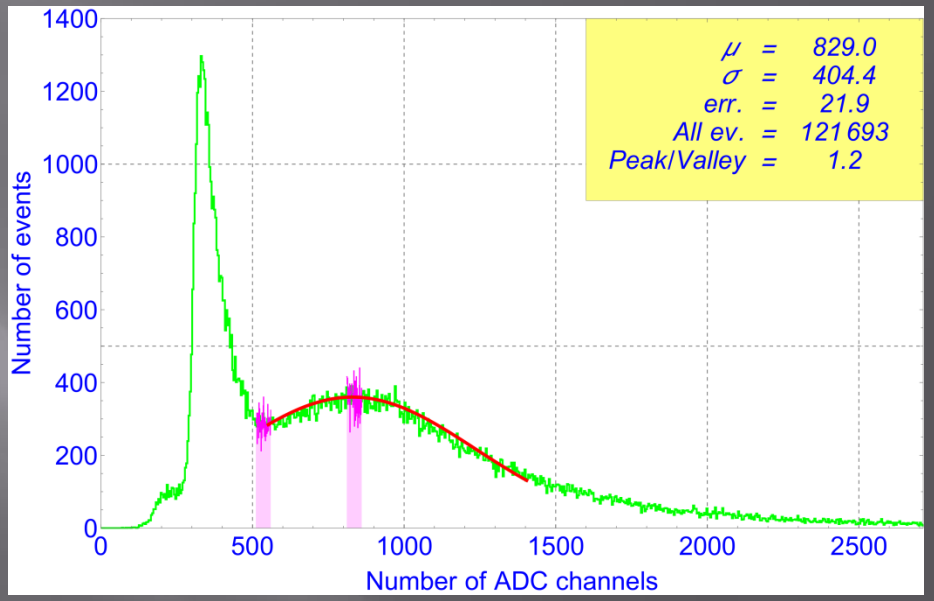
Amplitude spectra with ex. Trigger (left) and self-trig. (right) for the 5 mm thick green WLS plate with glued 3 WLS fibers (O2 Kuraray) loops (6 edges) connected with SiPM

Light output – 50 PE (32ch/pe), Peak/valley – 1.6

40 + 40 mm granule layers, 180 ns ADC gate

Scintillating granules with clear plate and WLS fibers





Amplitude spectra with ex. Trigger (left) and self-trig. (right) for the 3 mm thick transparent PMMA plate with 2 WLS fibers (Y11 Kuraray) "snake" (4 edges) connected with SiPM

Light output – 54 PE (19 ch/pe), Peak/valley – 1.2

40 + 40 mm granule layers, 180 ns ADC gate

Conclusion

- The use of polystyrene granules (both melted in a block and separate) with WLS fibers and SiPM readout allows one to make inexpensive and reliable detectors for wide applications in Cosmo- and experimental physics especially if time resolution and high rate at hard radiation load are not required.
- Minimal gap between solid counters made of melted granules is important for quality improvement of the guard systems of large area.
- The light output of the detector may be controlled (improved) with a larger amount of WLS fibers.
- The uniform parameters of SensL SiPMs allow one to create a multichannel detector with common bias voltage to simplify detecting system.

References

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2. V. Rykalin, V. Brekhovskikh, S. Chernichenko, A. Gorin, V. Semenov. Development of the polystyrene scintillator Technology and particle detectors on their Base. Journal of Physical Science and application 5(1) (2015) 1043-1046.
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6. N.Ampilogov, M. Amelchakov, G. Britvich et al. Scintillation detector with the fiber-optical readout. Bulletin of the Russian Academy of Sciences: Physics, v.73(5):637-639 · May 2009