Novel deep micro-well MAPD with super high pixel density and their applications

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Matrix Geiger-Mode Avalanche Micro-Pixel Photo Diodes
for Frontier Detector Systems, Prague 2010

Different producers and names of MAPD

- CPTA/Photnique (Moscow/Geneva)
- Zecotek (Canada/Singapore) in collaboration with JINR
- MEPhI/Pulsar (Moscow)
- Hamamatsu Photonics (Hamamatsu, Japan)
- SensL(Cork, Ireland)
- RMD (Boston)
- MPI Semiconductor Laboratory (Munich, Germany)
- FBK-irst(Trento, Italy)

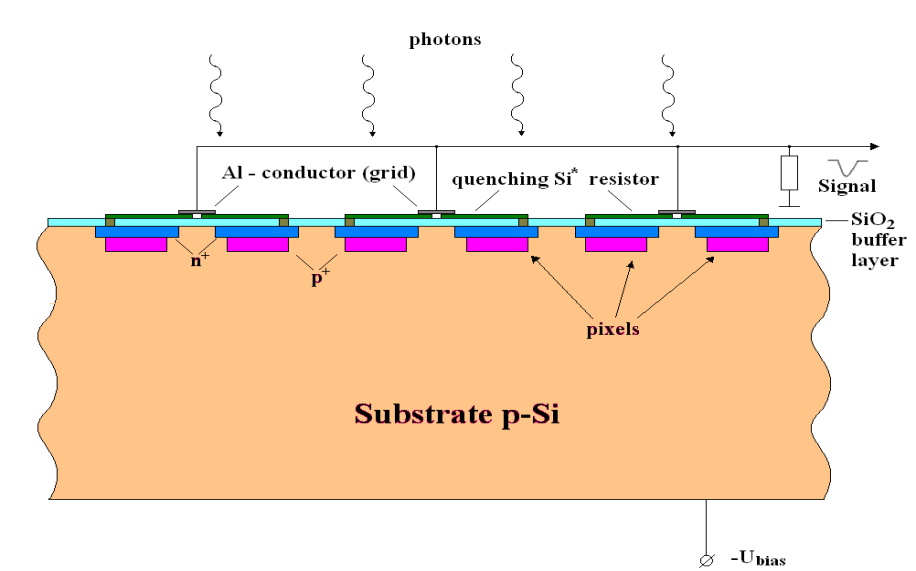
Different names of MAPD:

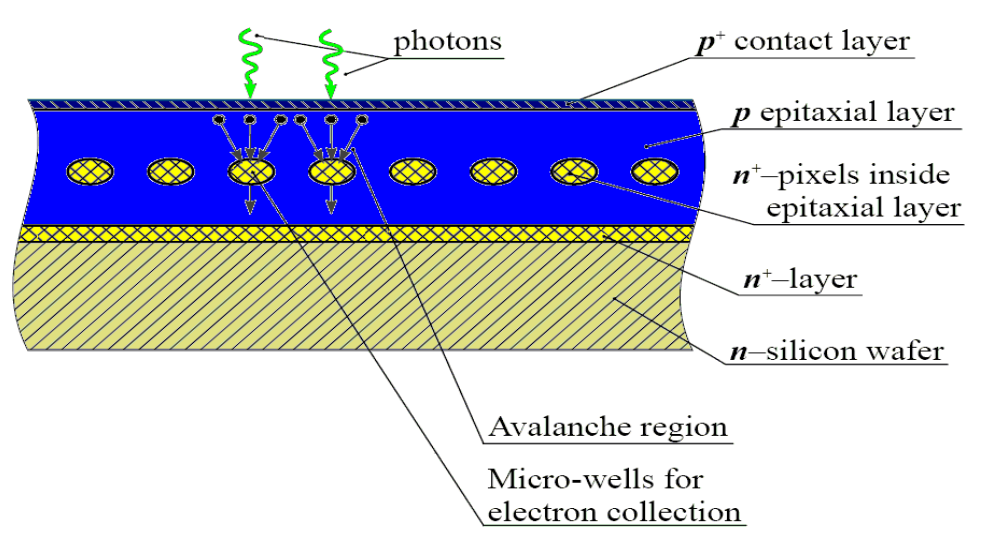
MRS APD, MAPD, SiPM, MPPC, SSPM, SPM, APDg, et al.

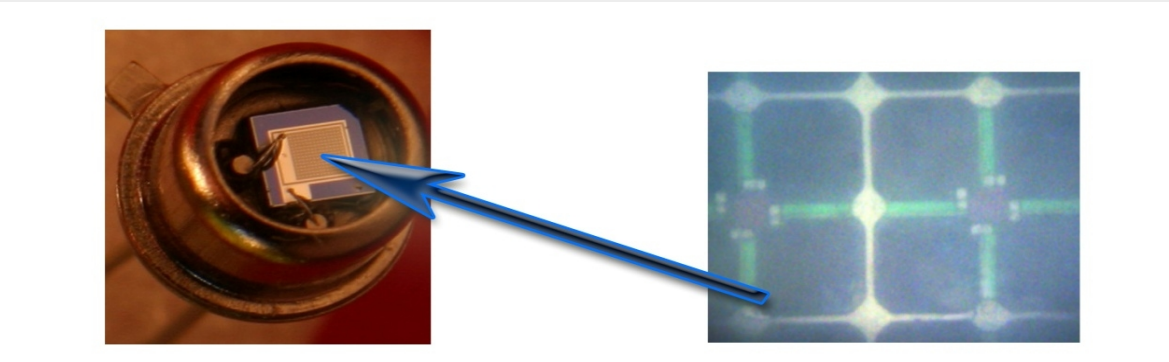
All these companies produce structures with surface pixels.

Deep micro-well technology is property of Zecotek only.

Two basic constructions of MAPDs







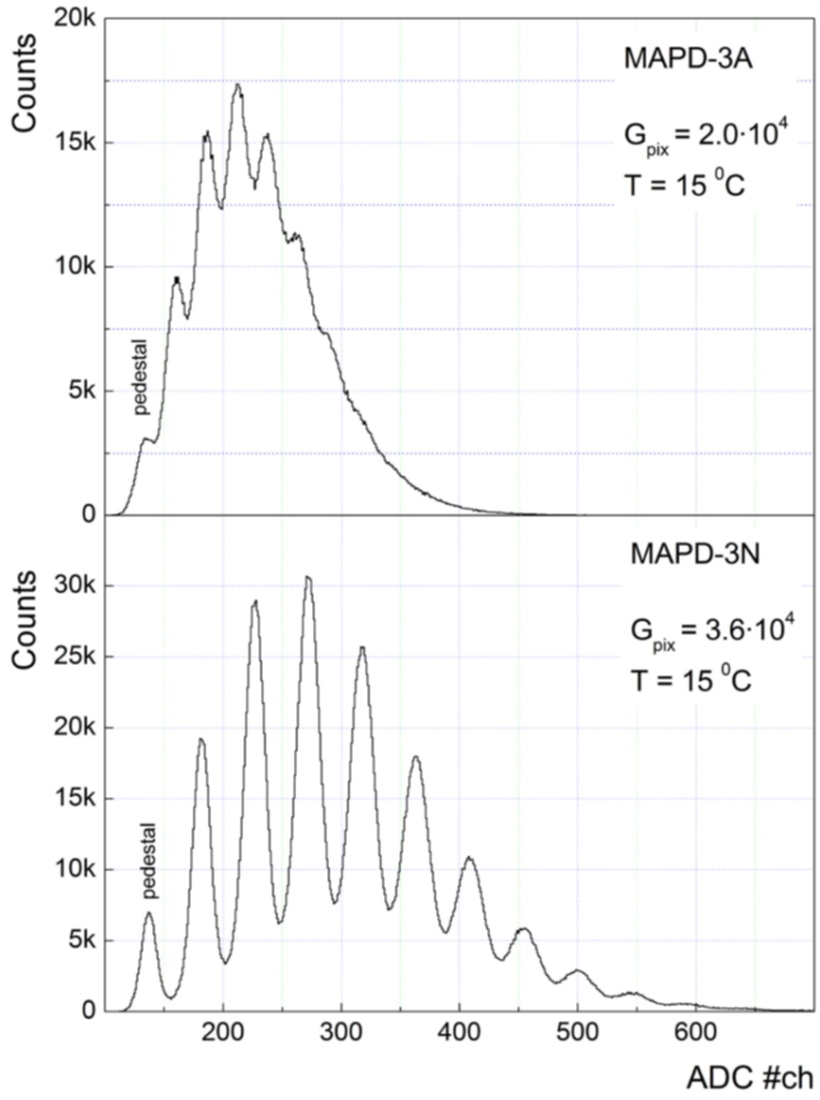
Main Features of DMW-MAPD:

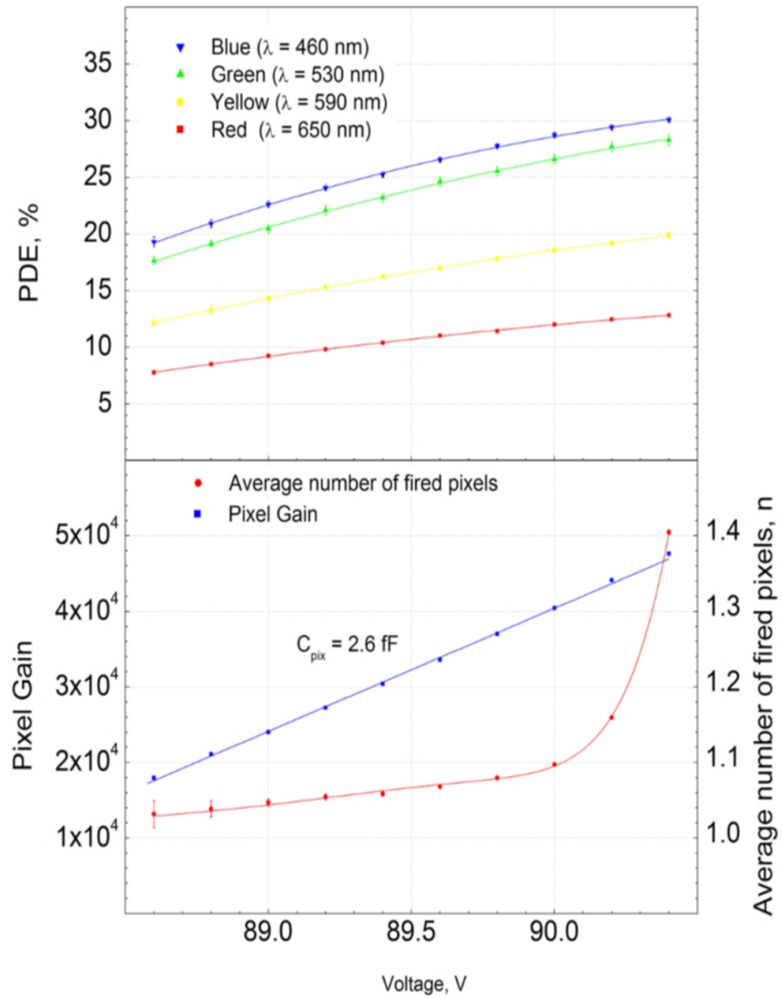
- High Dynamic Range (pixel densities of up to 40000 mm^{-2})
- Photon Detection Efficiency up to 30 %
- Gain up to 10^5
- Better radiation hardness
- Insensitivity to magnetic field.
- Compact and rigid
- Low voltage supply (<100 V)

Drawbacks:

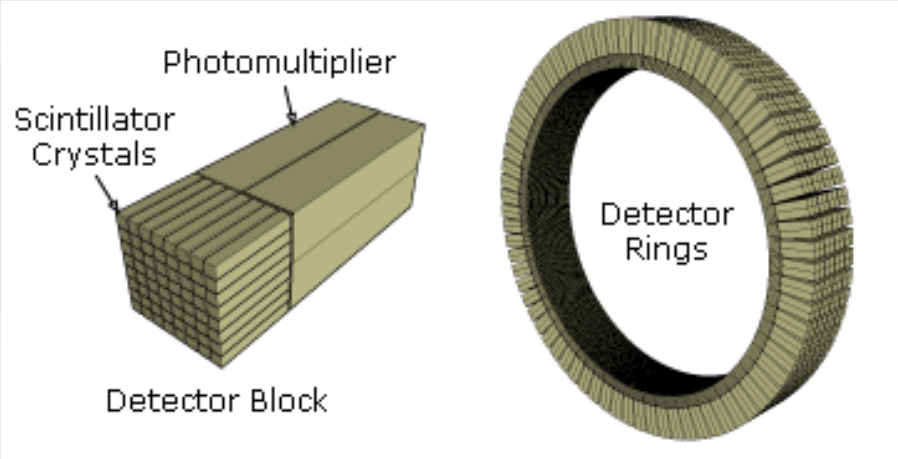
- Temperature dependence (a few %%/^oC)
- High dark rate (> 0.5 MHz/mm^2)
- Large Recovery time.

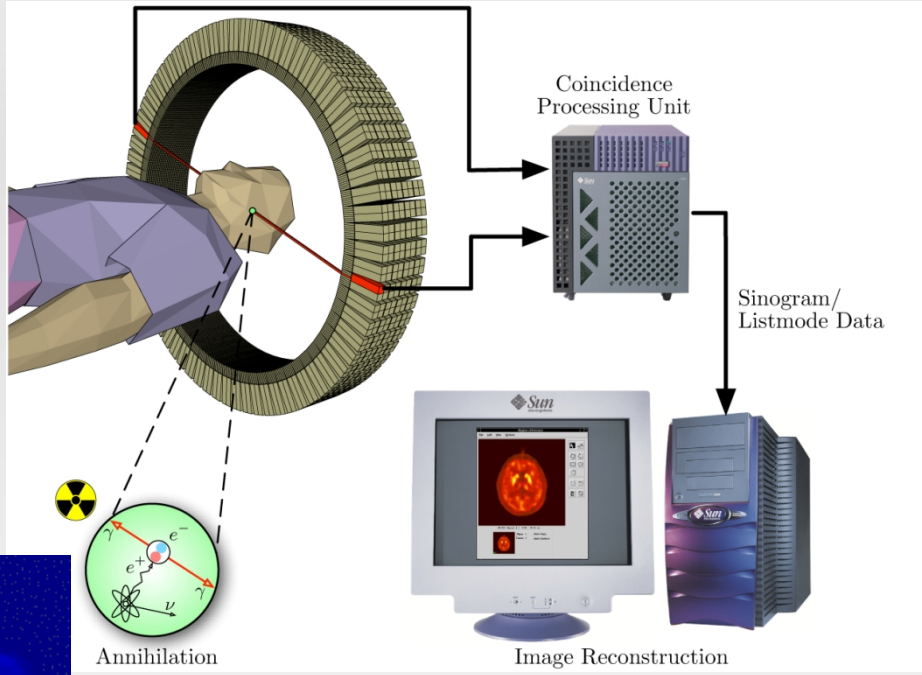
Main Characteristics of DMW-MAPD:

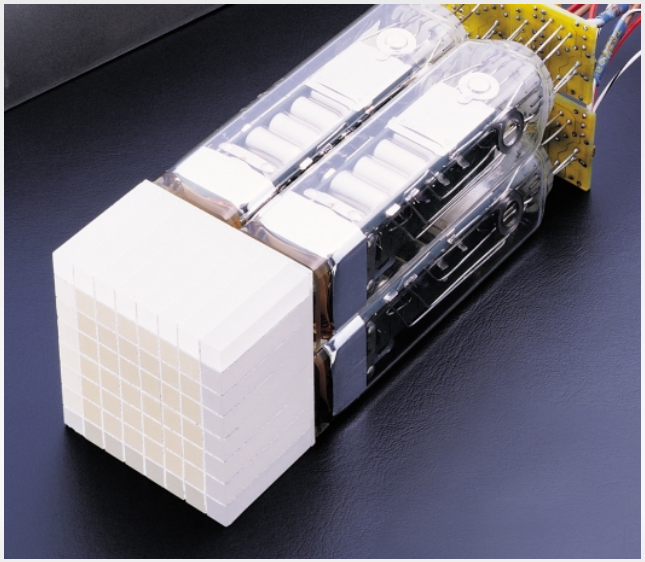


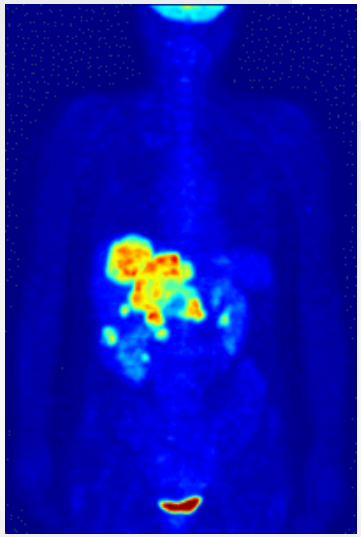


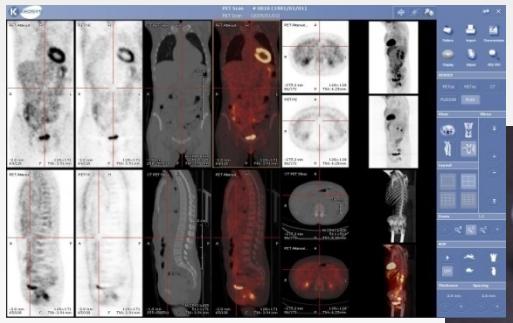
Positron Emission Tomography applications

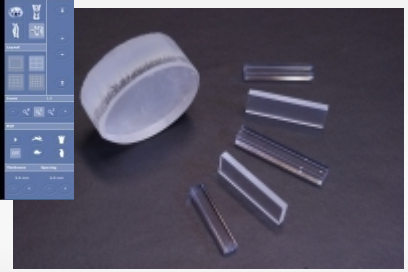




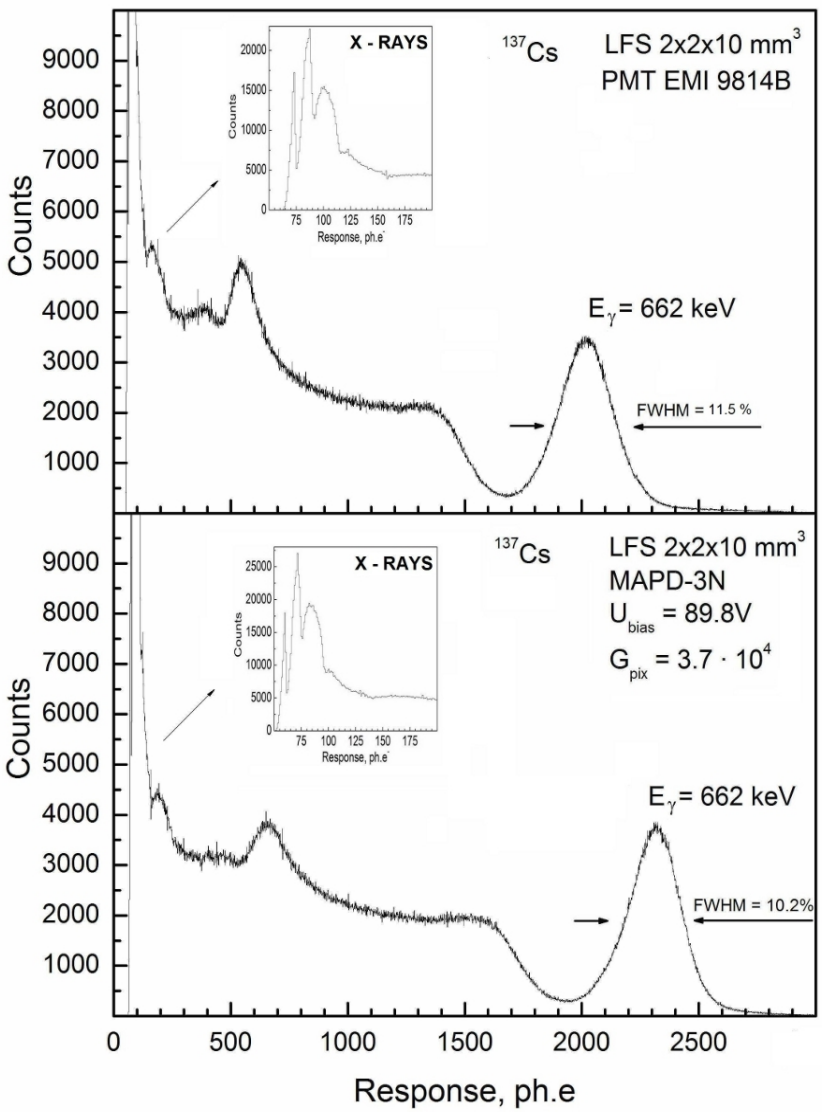


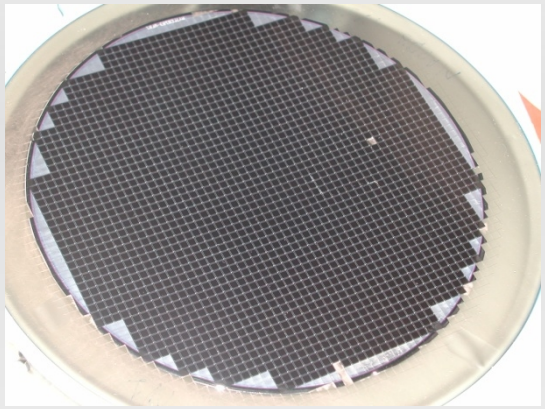


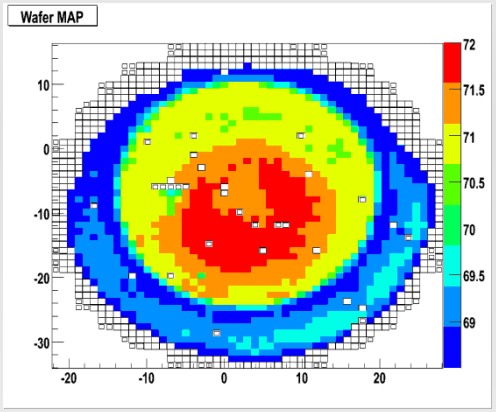


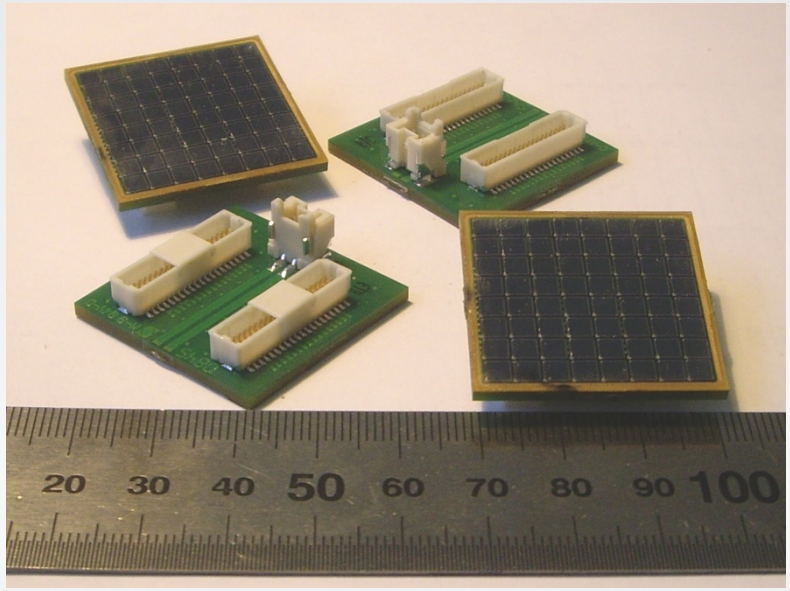


Positron Emission Tomography applications



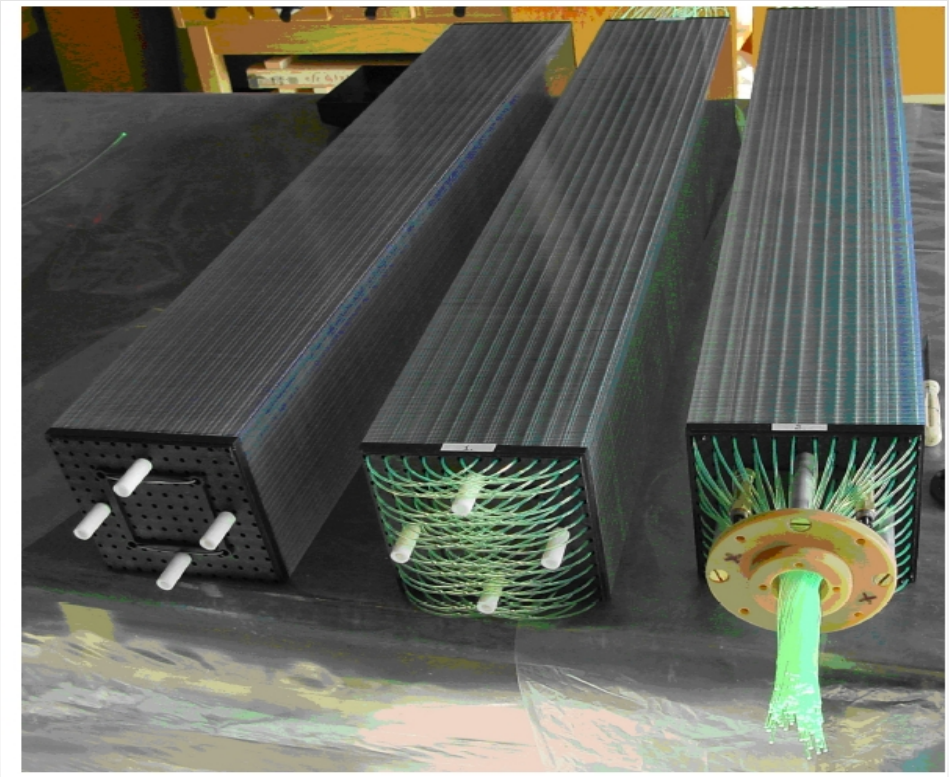


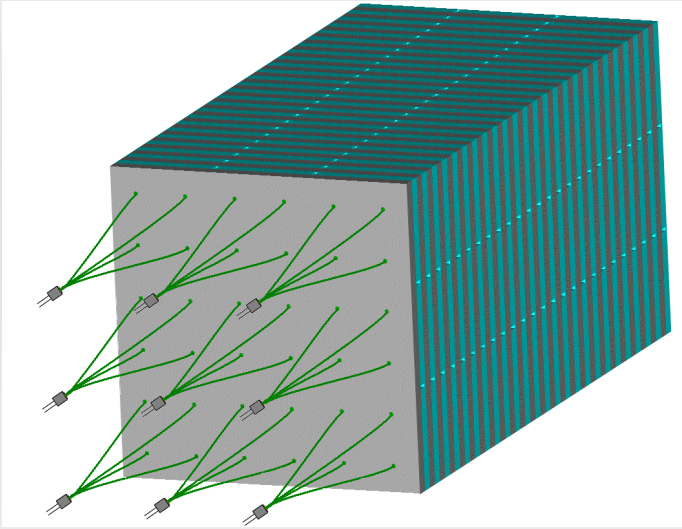


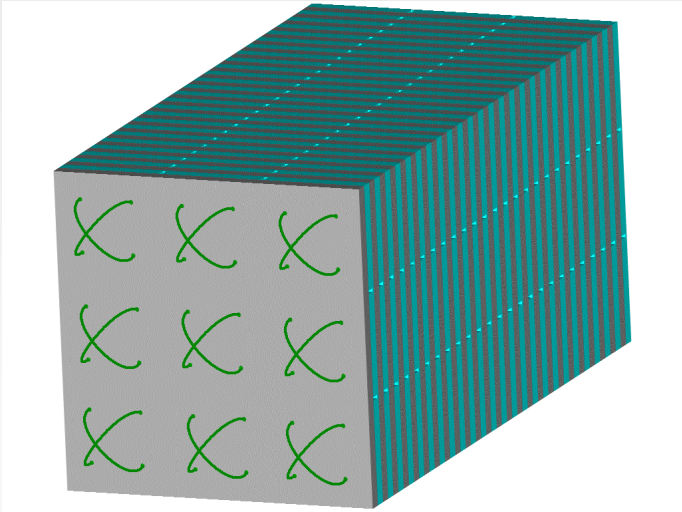


High energy physics applications: EM-calorimetry

- Insensitivity to magnetic field;
- High dynamic range $\sim 10^5$ ph.e.

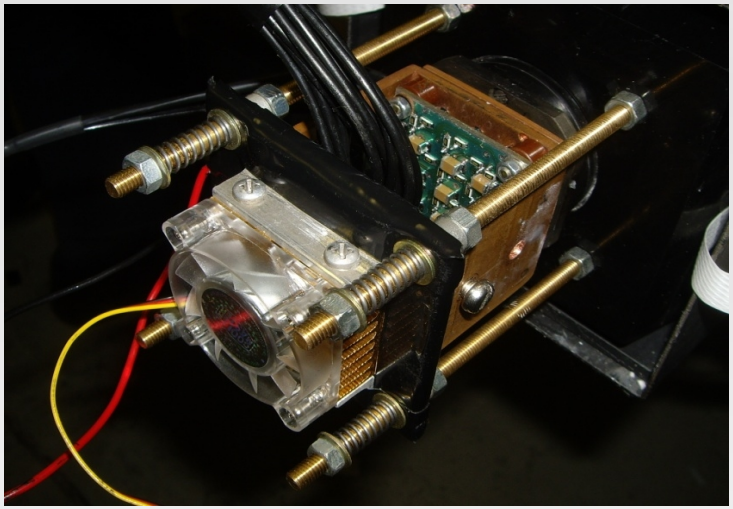


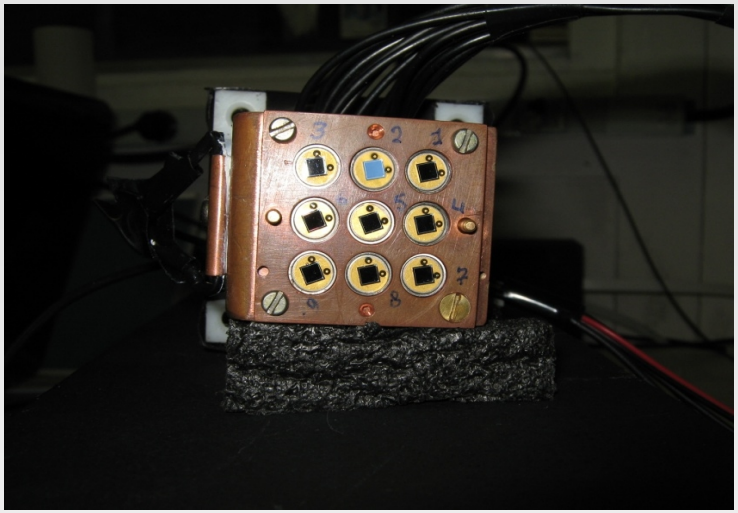


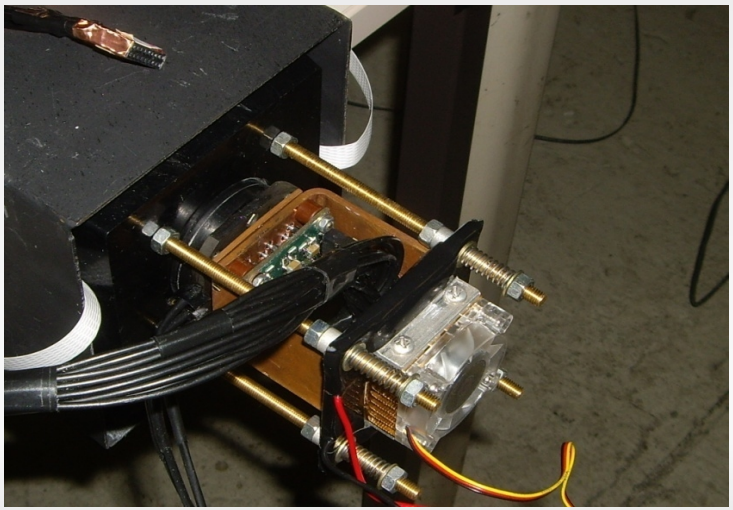


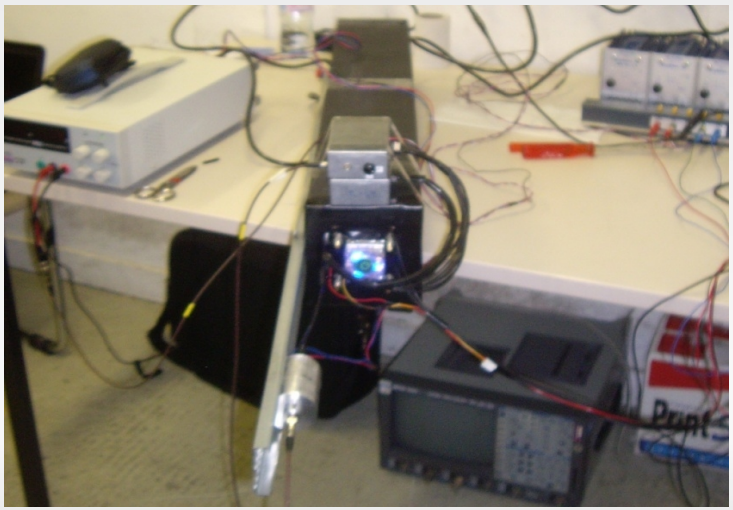
High energy physics applications: EM-calorimetry

General view of detection block consisted of 9-MAPD and it's composition with EM-module









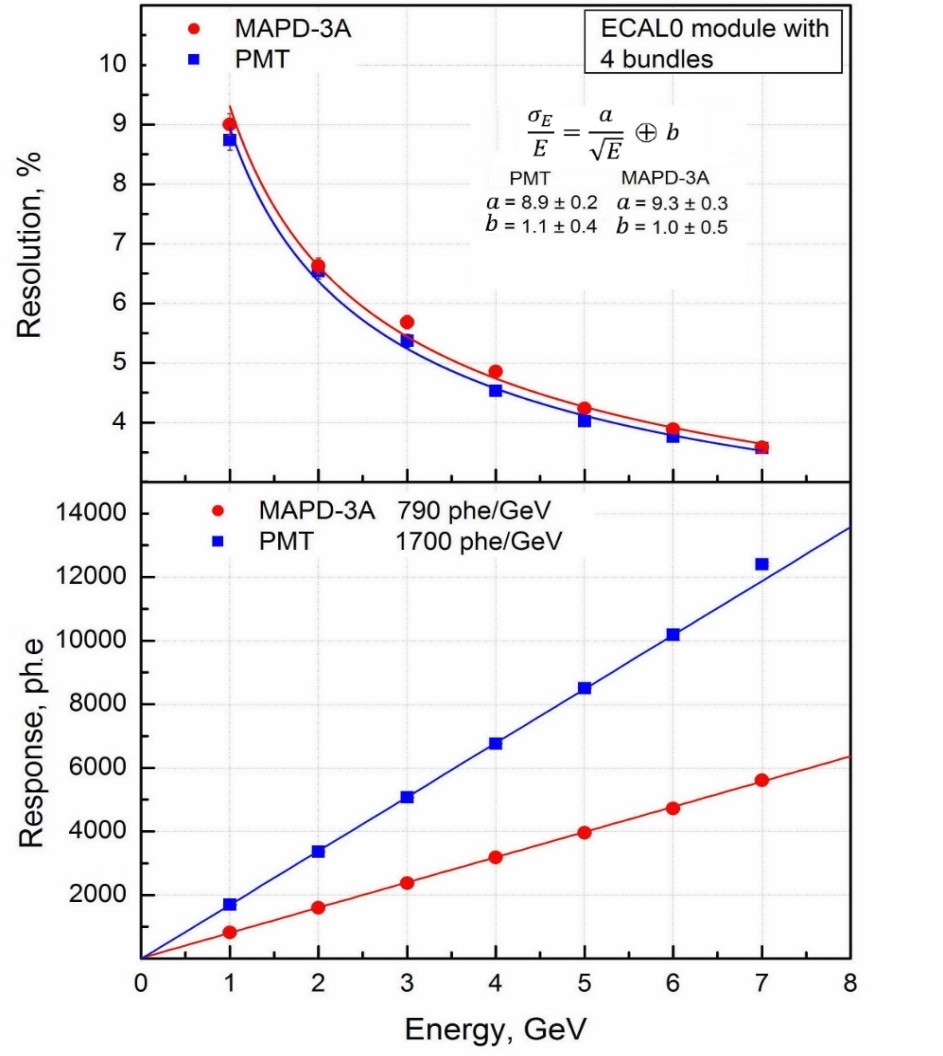
High energy physics applications: EM-calorimetry

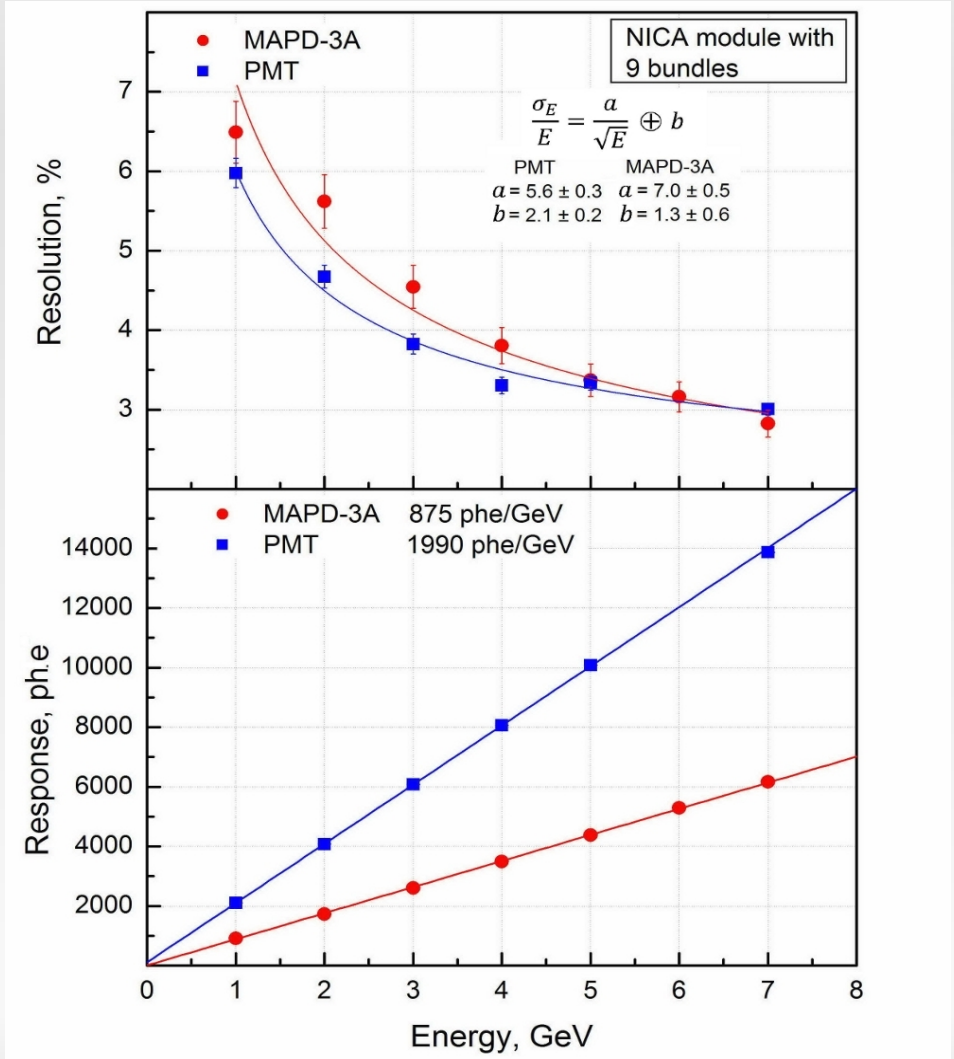
Parameters of the tested modules:

ECAL0 – 4 bundles	NICA – 9 bundles
Scintillator – 4 mm	Scintillator - 1.5 mm
Lead - 2 mm	Lead - 0.275 mm
Distance between scintillators – 2.36 mm	Distance between scintillators – 0.35 mm
Number of pair – 66 pcs.	Number of pair – 300 pcs.
Size of plates - 121.0×121.0 mm^2	Size of plates - 109.7×109.7 mm^2
Radiation length – 16.4 mm	Radiation length, X_0 – 34.9 mm
Total length – 420 mm (25 X_0)	Total length – 555 mm (15.9 X_0)
Moliere radius – 35 mm	Moliere radius – 59. 8 mm
Number of fibers – 64 pcs	Number of fibers – 144 pcs
Number of bundles – 4 pcs	Number of bundles – 9 pcs
Diameter of fibers – 1.2 mm	Diameter of fibers – 1 mm
Bundle diameter – 6.5 mm	Bundle diameter – 6 mm

High energy physics applications: EM-calorimetry

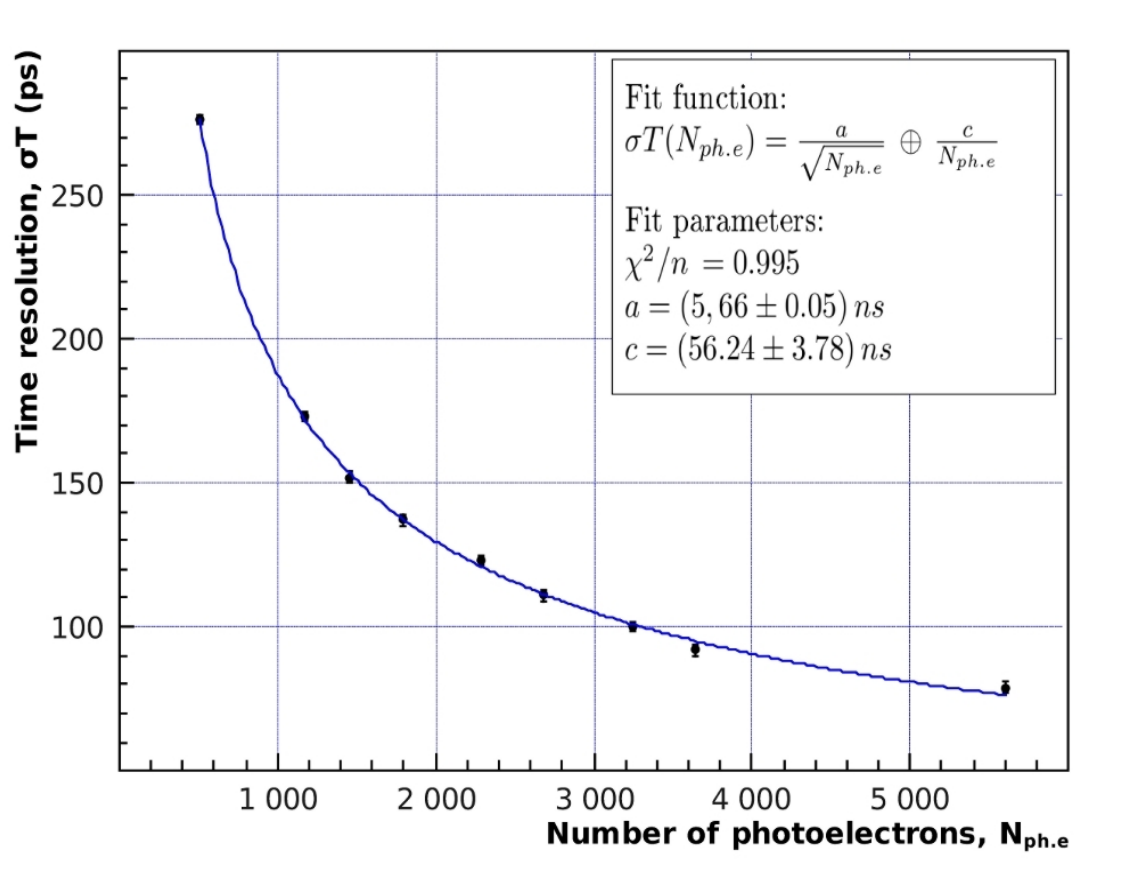
Energy resolutions for two different modules
MAPD readout in comparision with PMT readout

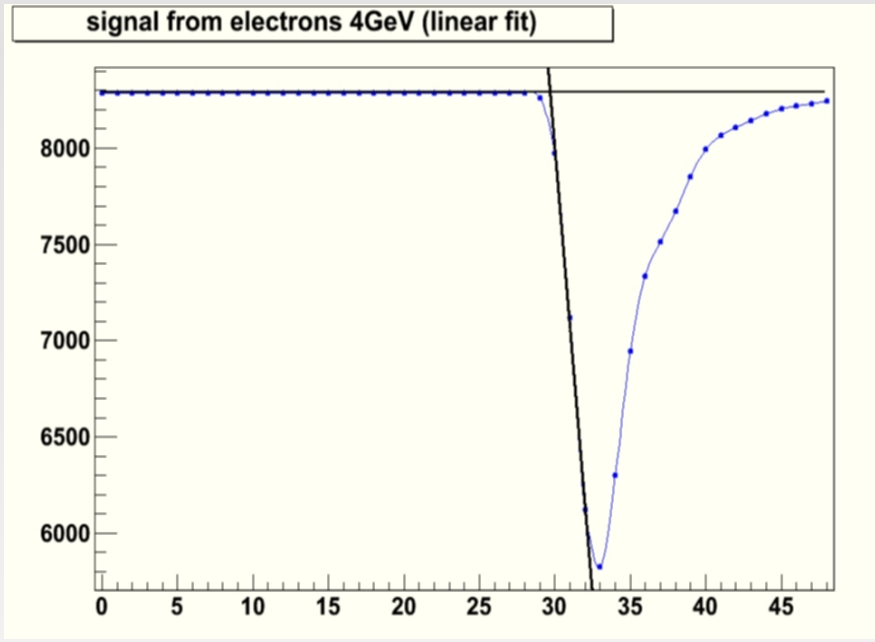




High energy physics applications: EM-calorimetry

Time resolution of one channel (bundle) MAPD-3N

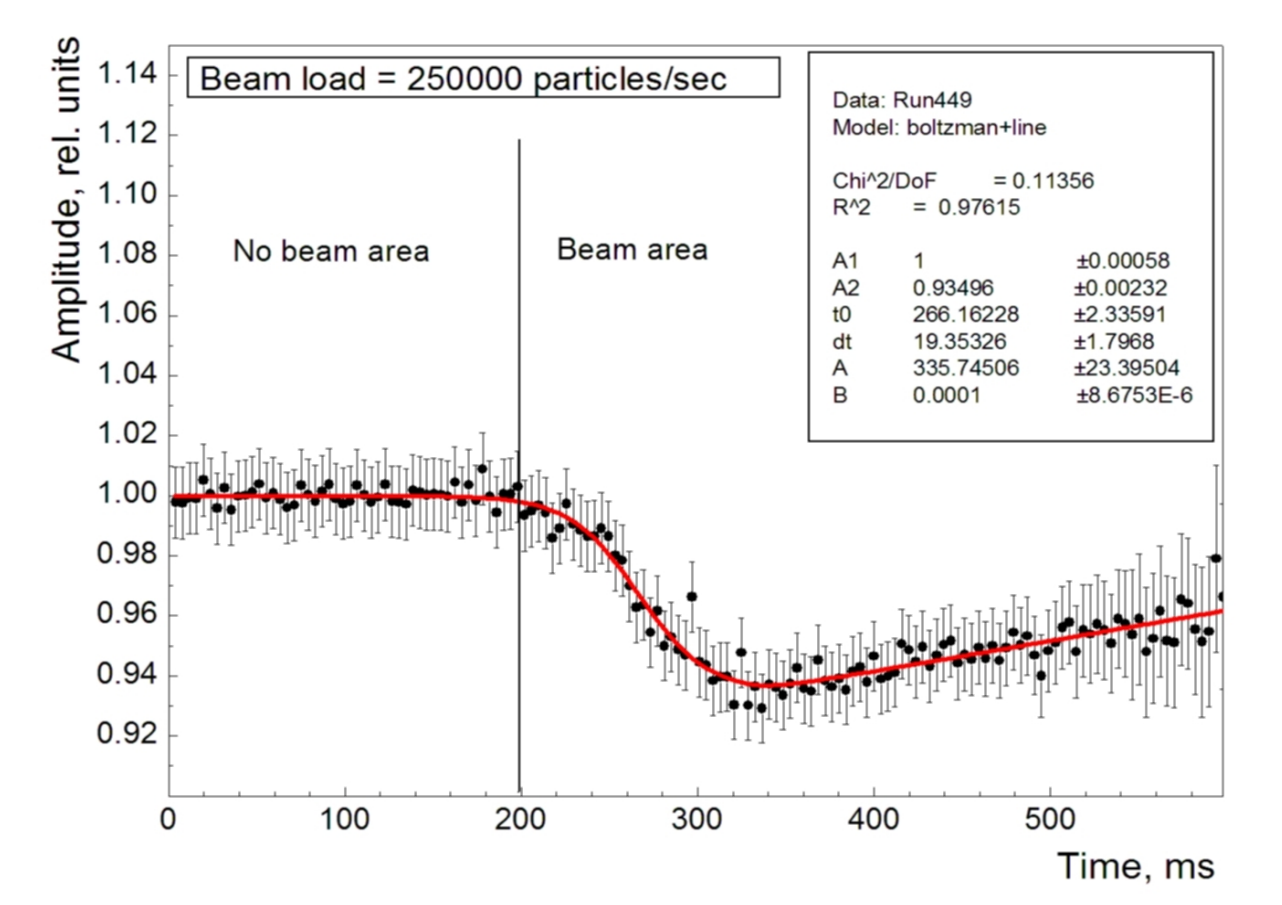




Sampling ADC 100 Mhz
1.6V/14-bit

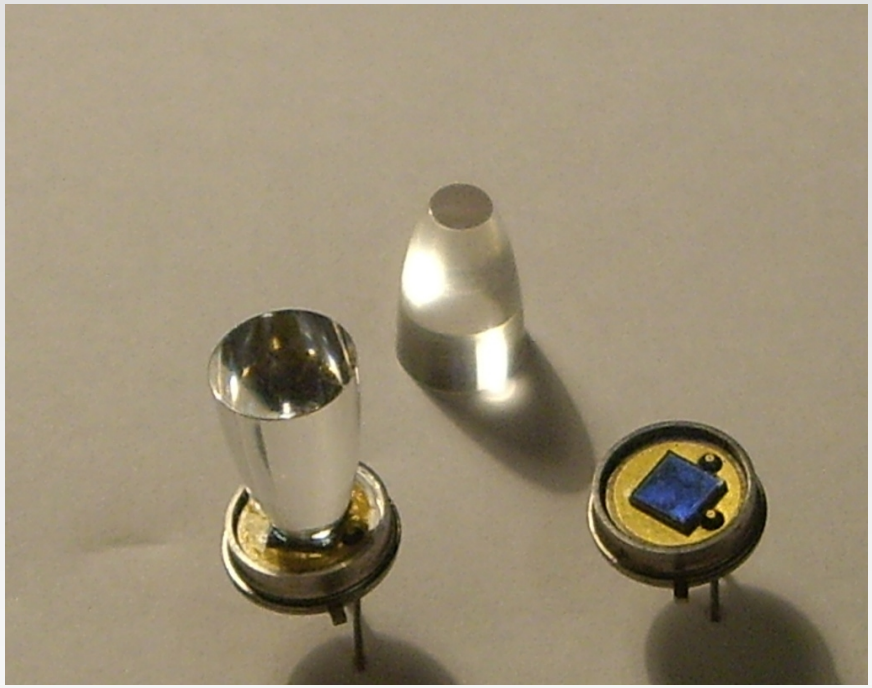
High energy physics applications: EM-calorimetry

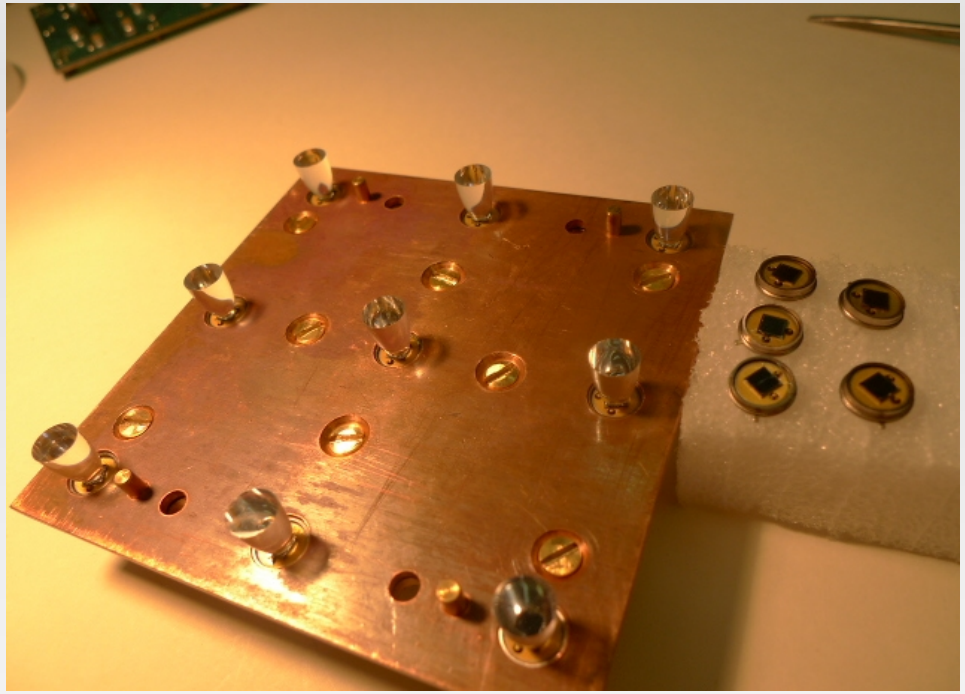
Effect of beam load (MAPD-3A)



High energy physics applications: EM-calorimetry

Winston's cones allow gather more light



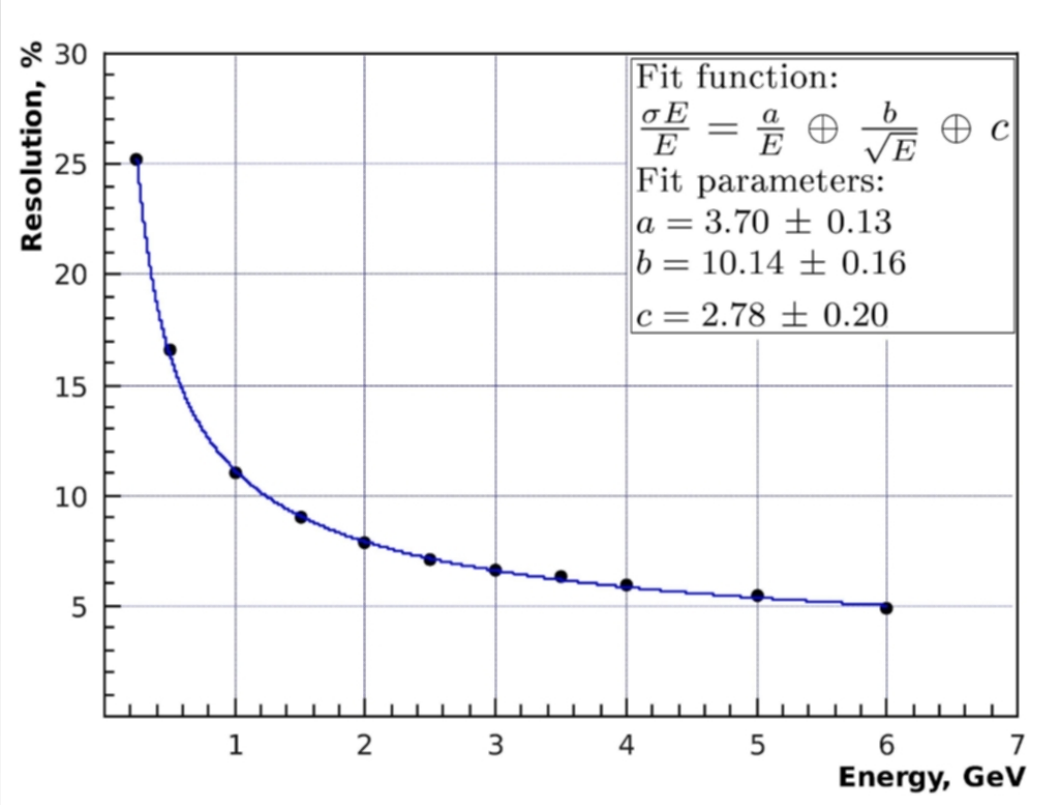


Increasing of
MAPD sensetive area

High energy physics applications: EM-calorimetry

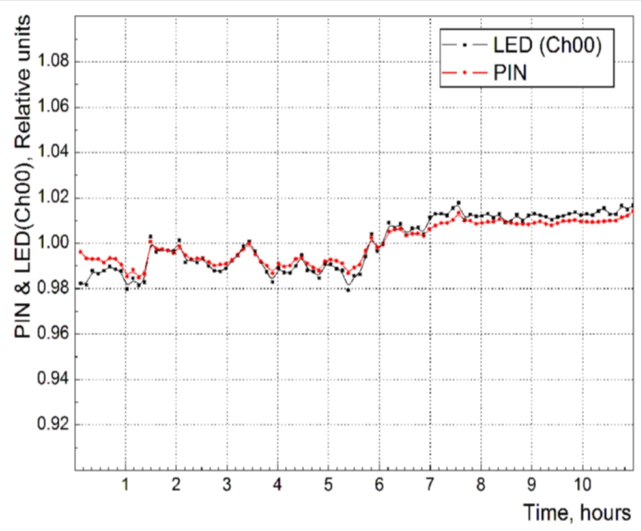
ECAL0 (MAPD-3B) - 9 towers

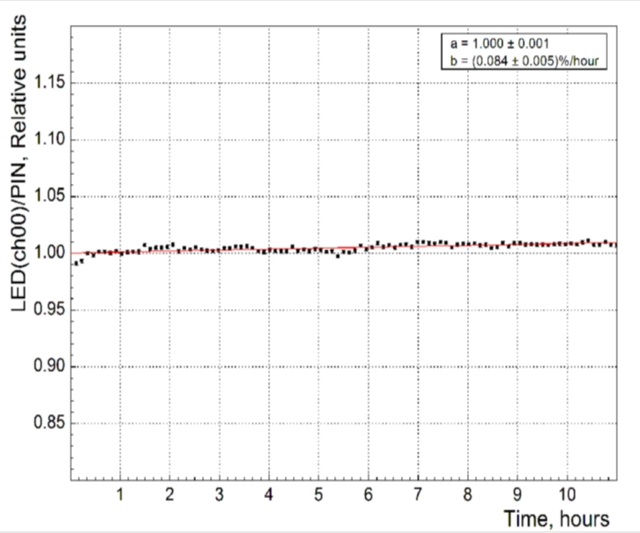
Scintillator – 4 mm
Lead - 2 mm
Distance between scintillators – 2.36 mm
Number of pair – 40 pcs.
Size of lead plates - 121.0×121.0 mm^2
Size of scint. plates – 40x40 mm2
Radiation length – 16.4 mm
Total length – 254.5 mm (15.5 X_0)
Moliere radius – 35 mm
Number of fibers – 144 pcs
Number of bundles – 9 pcs
Diameter of fibers – 1.2 mm
Bundle diameter – 6.5 mm

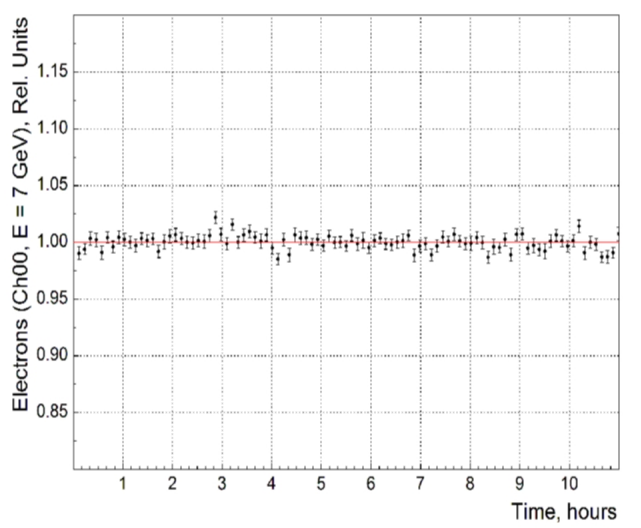


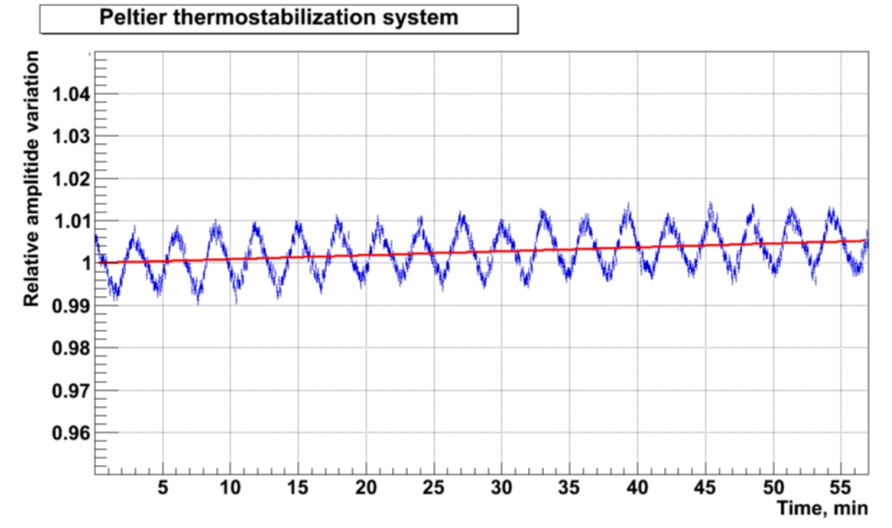
High energy physics applications: EM-calorimetry

Thermostabilization system









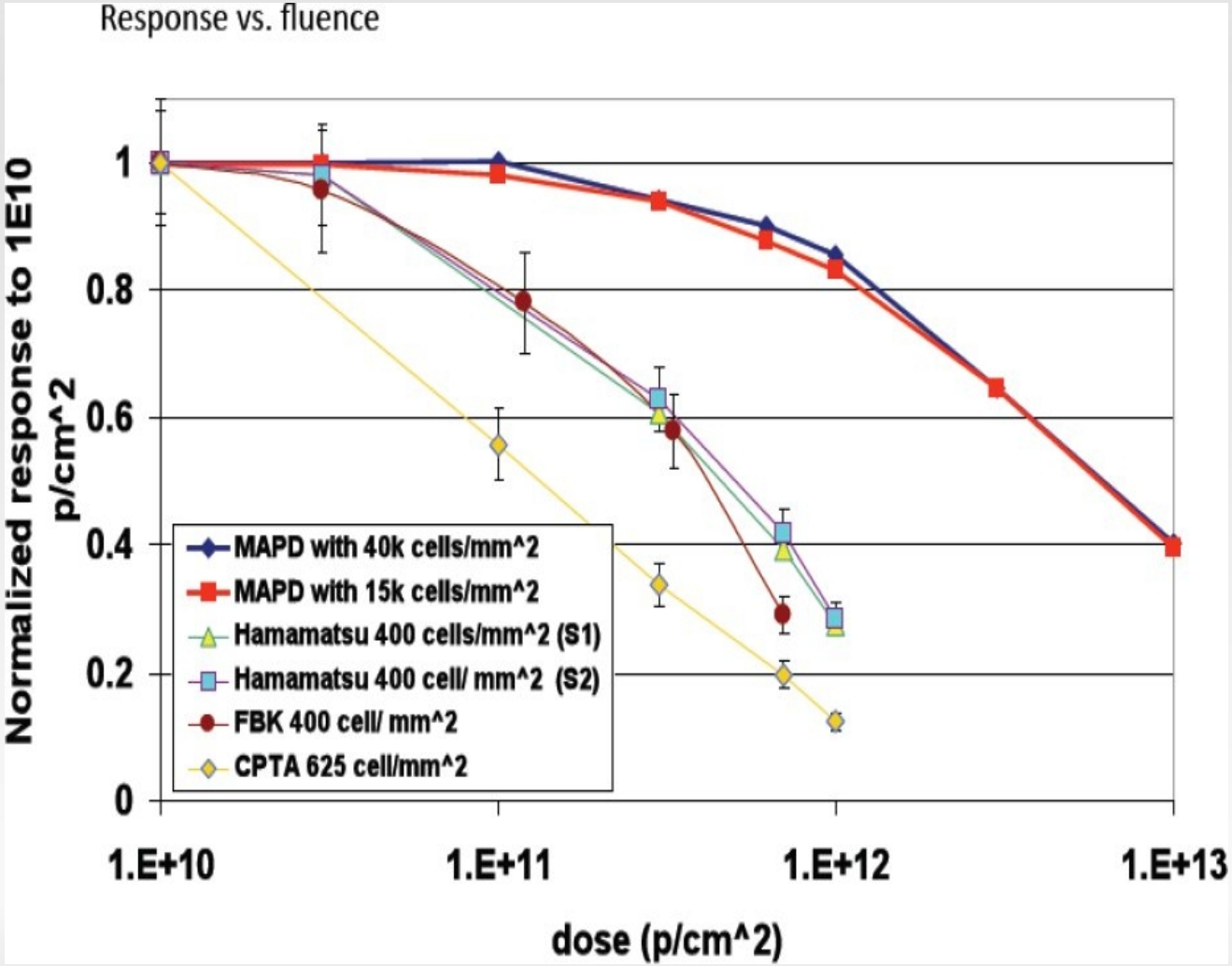
Thank you for your attention!!!

Questions???

Additional materials

Radiation Hardness (Mesuared by Yu. Musienko)

Irradiation by neutrons



Additional materials

Energy spectra (compasion 9-MAPD & PMT)