Research, development, and test the monitoring system prototype of the electromagnetic calorimeter for MPD experiment.

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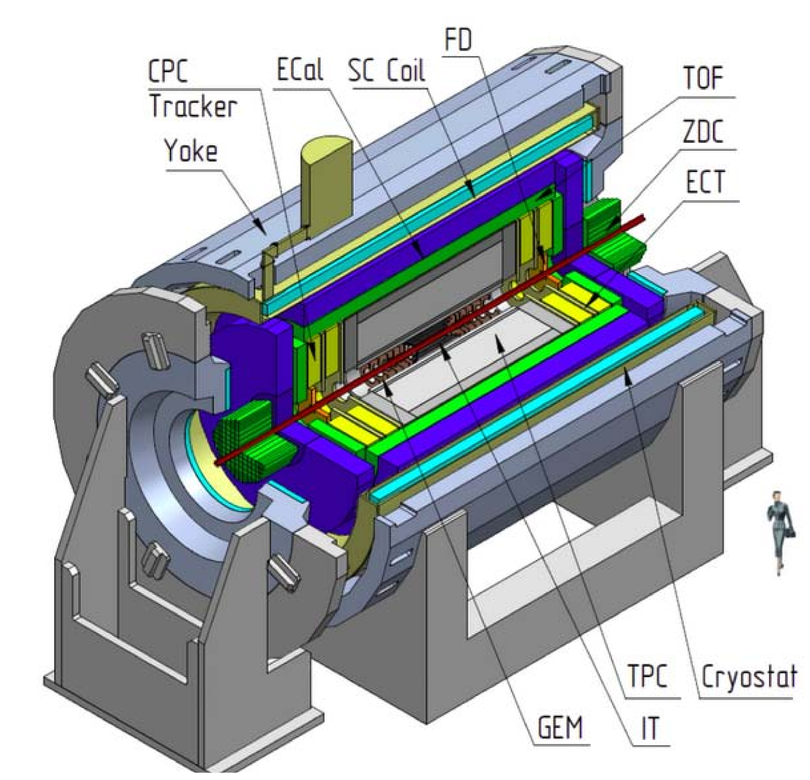
Abstract

The Multi Purpose Detector (MPD) is being created to study the properties of hot and dense nuclear matter at the interaction point of heavy ions beams at the NICA complex. A crucial detector in the new experimental setup is a large-sized barrel electromagnetic calorimeter (ECal), designed for precise spatial and energy measurements for photons and electrons, as well as separating them from hadrons. Taking into account the requirements of high energy resolution, dense active medium with the small Moliere radius, and high segmentation of ECal, the Shashlyk-type electromagnetic calorimeter with projective geometry has been selected.

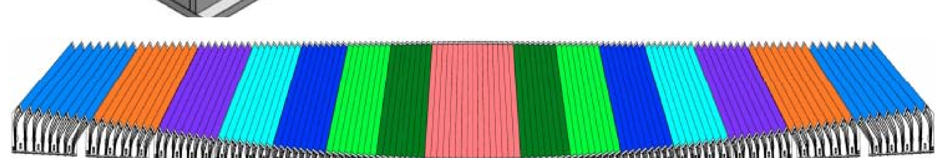
For the stable operation of 38400 calorimeter channels, the pre-production prototype of the local monitoring system with fiber-optic light distribution was created. In this talk, we have presented the results of the study and test of this monitoring system prototype.

ECal MPD Overview



ECal design – type "Shashlyk":

- Sandwich structure, projective geometry
- 38400 towers in 50 half-sectors
- 2400 modules of 8 different geometry types
  Each Ecal tower consist of 210+/-1 layers
- Pb t_{max}= 0.3 /-0.05 mm
- Sc t_{max}= 1.5 mm, 40x40 mm^2, LEGO type
- 16 fibers, Y11-200, 1.2 mm diameter
- Moliere radius 62 mm
- Radiation lengths Z~11.8 X_0
- Photodetector *HAMAMATSU S13360-6025PE MAPD*
- Diffuse glue paint as a reflector between towers
- Powder white paint as a reflector on the Pb plate



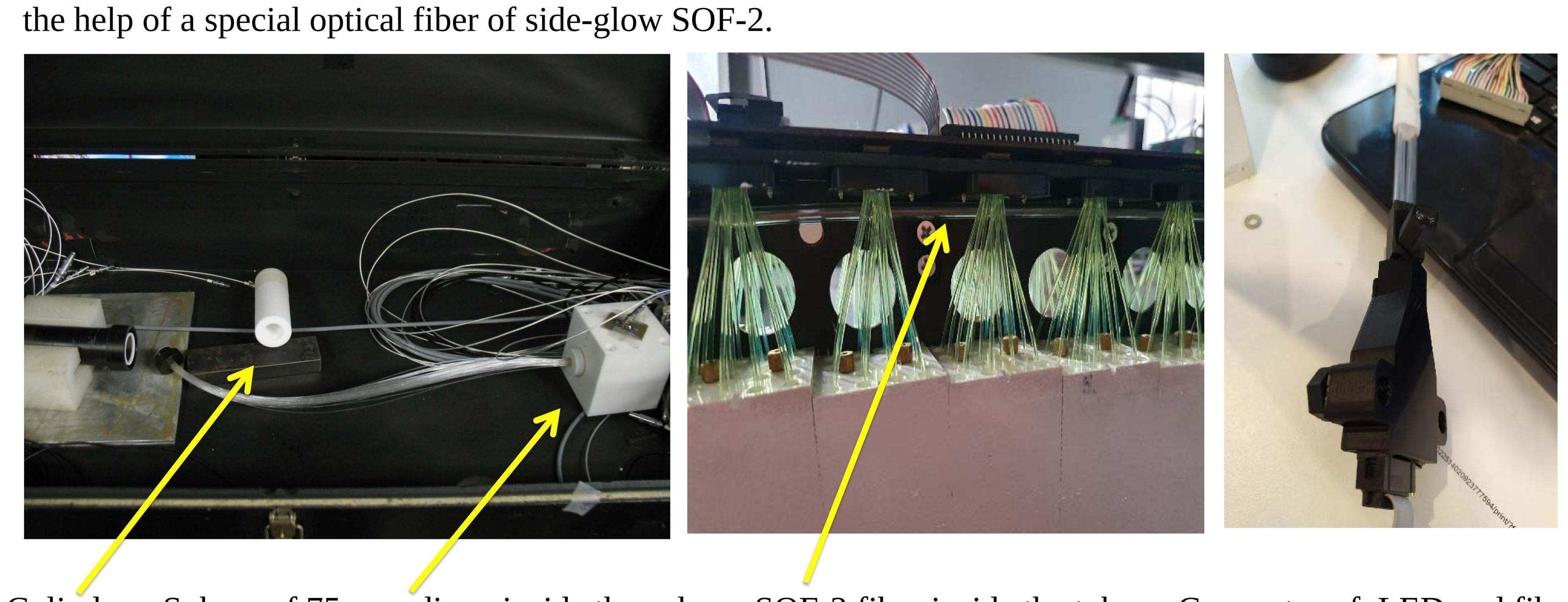
Schematic view of 1/6 sector (16 modules)

One of the first mass-production ECal modules (16 towers)

Study of various options of light distribution systems.

The monitoring system of the electromagnetic calorimeter is an important component of the detector, which allows you to track the state of the calorimeter at any time. For stable operation of the detector, various control methods are used: a radioactive source, a laser, or light-emitting diodes with different light distribution systems over the towers.

For EMC MPD, a monitoring system based on an LED as a light source was chosen. Three schemes of light distribution from the source to the calorimeter towers were studied: an integrating sphere or an integrating cylinder as a mixer-distributor with a subsequent fiber-optic distribution of light, as well as with the help of a special optical fiber of side-glow SOF-2.

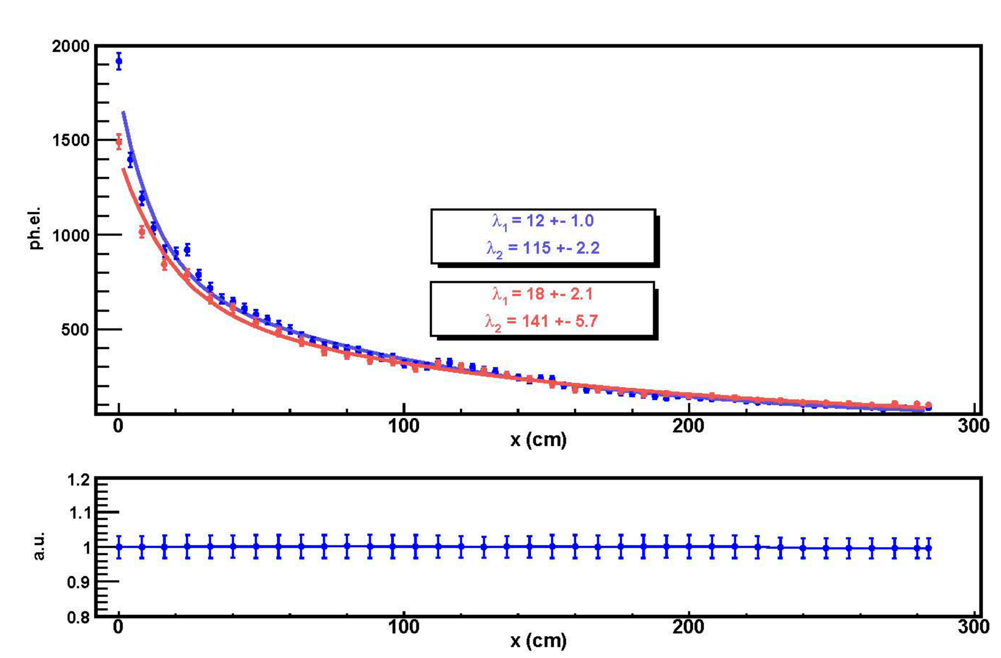


Cylinder Sphere of 75-mm diam. inside the cube SOF-2 fiber inside the tube Connector of LED and fibers

For the first and the second prototype monitoring systems:

- Pros - measurements have shown that the non-uniformity of the detector towers illumination for the first and the second options is <10% without additional polish.
- Cons - Long transportation fiber length, and therefore the system is expensive.

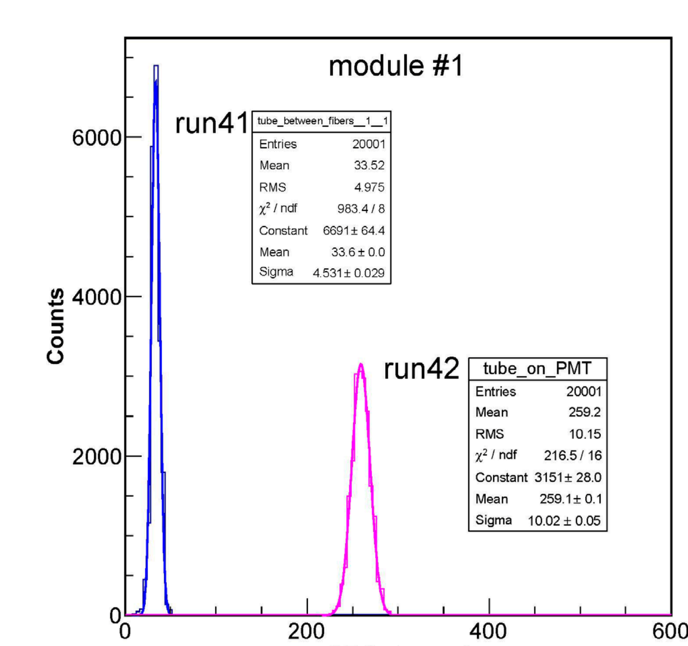
The variant of side-glow optical fiber SOF-2 in a special polycarbonate tube was chosen for the Ecal monitoring system.



Top: Attenuation lengths measurements. Blue points are for the signals from PMT (in photoelectrons) without a reflector on the end of the fiber, pink – with the TiO_2 reflector. Bottom: pin-diode stability graph.

$$I(x) = exp\,(p_0 + p_1 \cdot x) + exp\,(p_2 + p_3 \cdot x),$$

where λ_1 = -1/p_1, λ_2 = -1/p_3 a are attenuation lengths for "short" and long" exponential functions, x is the distance from the measurement point to the light source, p_0 and p_2 are the normalization coefficients.

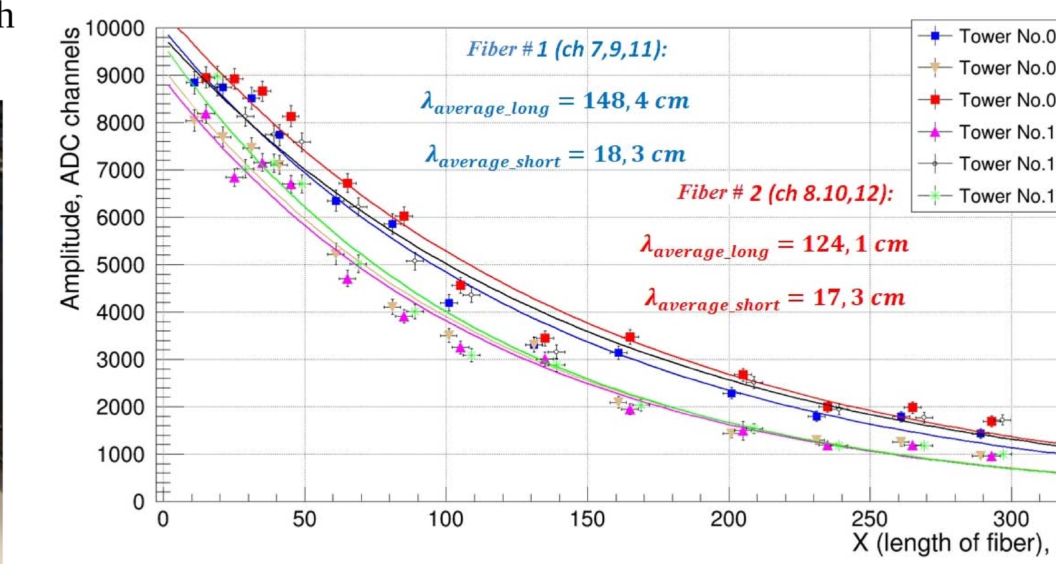


The light loss during the transition from the SOF-2 fiber through the tube to the WLS fibers of the towers is shown.

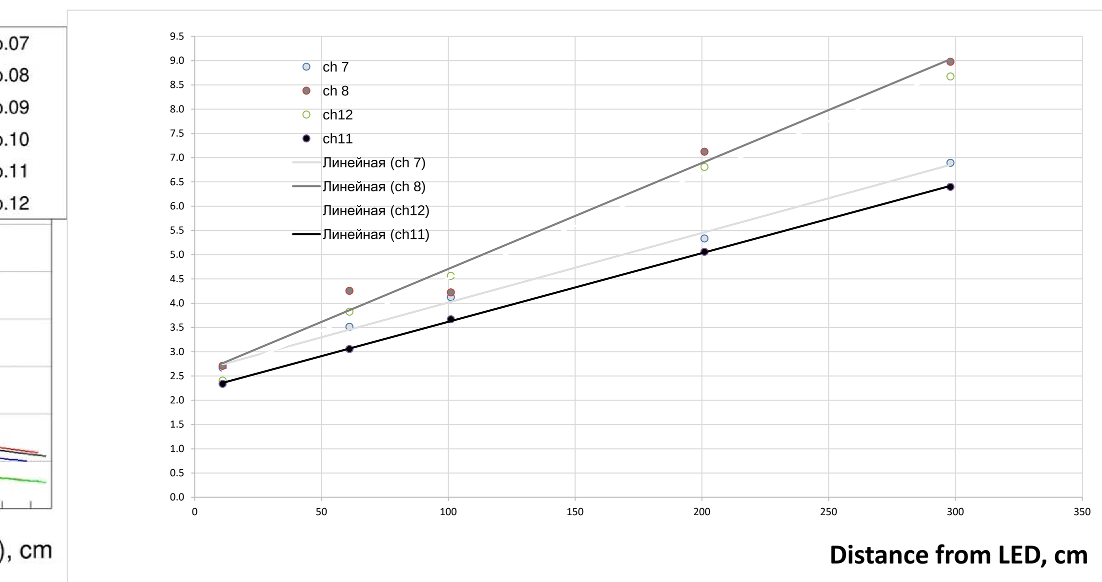
Study of preproduction prototype of the monitoring system.

The preproduction prototype of the monitoring system was installed on ECal. It includes:

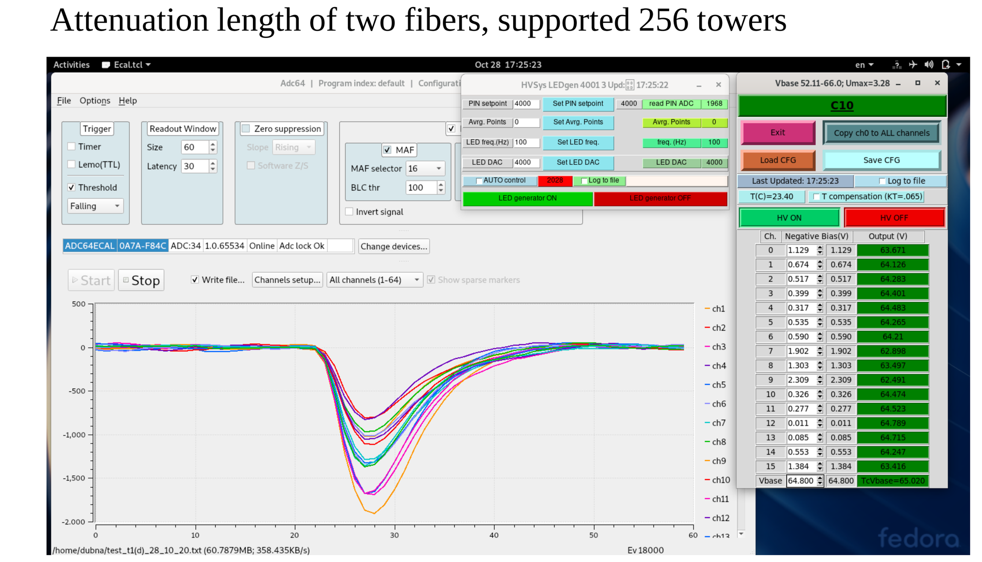
- LED as light source with LED driver from hvsys
- Pin-diode to control the stability of the LED intensity
- Special connectors to split the light from the LED to two fibers (each feed 64 towers)
- SOF-2 optical fibers of side-glow in special polycarbonate tubes
- Generator, power supplies, electronics to read signals from pin-diodes



Attenuation length of two fibers, supported 256 towers



Resolution for some channels



Snapshot of "Run Control" GUI of prototype. LED control information is in the top-center, MAPD control is in the right.

How to build the references histogram to control current state of ECal?

Collect information about signals from MAPDs, pin-diodes, pedestals at time 0 (time, when physics run will start). Then:

$$Amp_i^{norm} = (Amp_i^t - Ped_i^t)/(Amp_i^0 - Ped_i^0) \cdot (Mon_j^0 - Ped_j^0)/(Mon_j^t - Ped_j^t),$$

where Amp_i^{norm}- MAPD signal normalized for the signal from pin-diode, Amp_i^t and Amp_i^0 - MAPD signals in the current moment and in the "time zero",
Ped_i^t and Ped_i^0 - Pedestal signals in the current moment and in the "time zero",
Mon_j^t and Mon_j^0 – pin-diode signals in the current moment and in the "time zero".

Conclusion

- Various options of the control system were studied.
- The design of the Ecal monitoring system was established.
- The prototype of the monitoring system was studied:
  - ✓The light intensity of the LED is enough to feed 128 towers
  - ✓The attenuation length of the fiber is 135 +/- 15 cm. Adding the reflector on the end of the fiber was improve the attenuation length by ~18%
  - ✓No effect of the clear polycarbonate tube on light emission from the fiber SOF-2 was detected. It needs additional work to clean the polycarbonate tube before installation into the detector (using warm water cleaning, for example)
  - ✓The light loss during the transition from the SOF-2 fiber through the tube to the WLS fibers of the towers was estimated

As a result, the local monitoring system for 128 towers was created and tested. The advantage of this light wiring configuration: ease of installation and an optimal price-performance ratio due to the small number of LEDs and the short fiber length.

Acknowledgments

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