Amplitude and Time Parameters of Modules for Hadron Calorimeter at MPD/NICA

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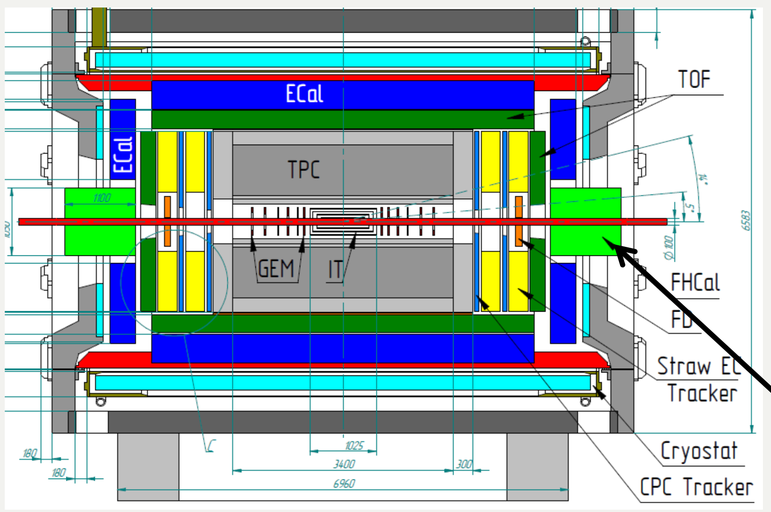
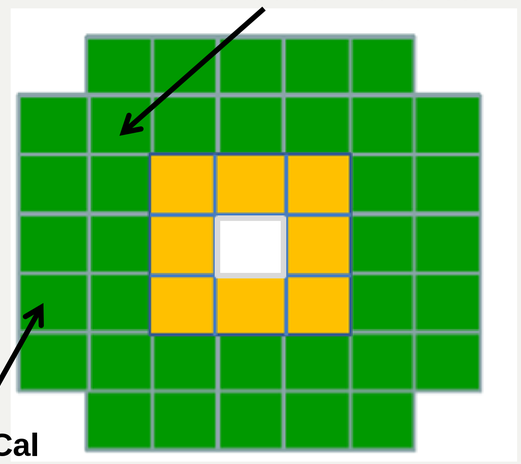
The Forward Hadron Calorimeter (FHCal) is a modular lead-scintillator compensating calorimeter designed to measure the energy distribution of the projectile nuclei fragments (spectators). It consists of two identical arms placed at the left/right sides from the beam collision point. It will detect the protons and neutrons in energy range of 1-5 GeV to measure a heavy-ion collision centrality and orientation of the reaction plane. In addition, it will be used for the trigger to select the most peripheral collision and also for the measurements of the collision point at the beam axis. The signal/noise ratio and time resolution are important parameters for these tasks.





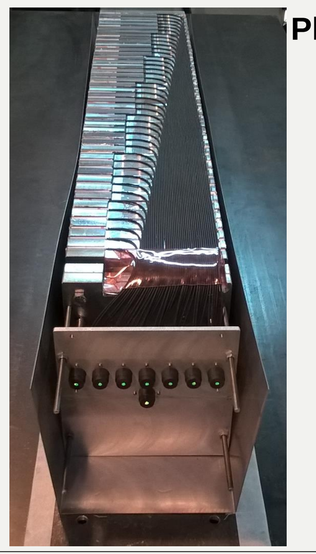


Photo of FHCal module during assembling.

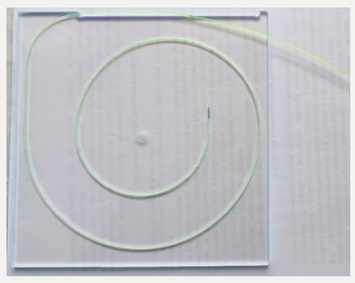


Photo of scintillator tile with spiral groove.

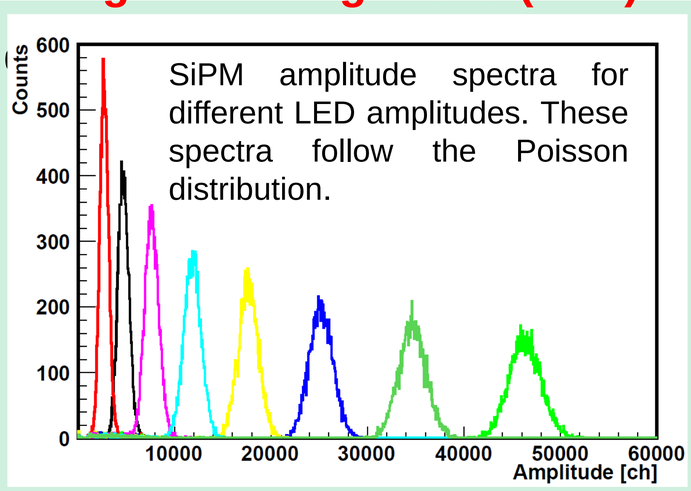
Forward hadron calorimeter (FHCal) together with Time Project Chamber (TPC), Time-of-Flight (TOF), Electromagnetic Calorimeter (ECal) and fast Forward Detector (FD) are basic parts of the MPD experimental setup at NICA, Dubna, Russia.

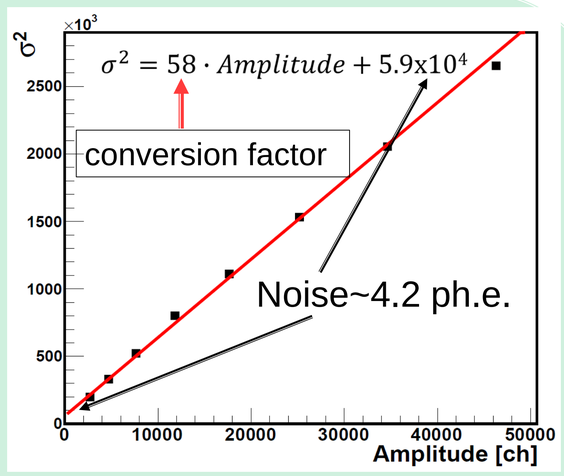
Each of two FHCal parts consists of 44 individual modules. with the transverse sizes 15x15 cm^2. The module includes 42 lead-scintillator sandwiches with the sampling ratio 4:1 (thicknesses of lead plates and scintillator tiles are 16 mm and 4 mm, respectively. Light readout is provided by WLS-fibers embedded in the grooves in scintillator tiles. WLS-fibers from 6 scintillators are viewed by single photodetector at the end of the module.

Calibration of SiPM's with Light Emitting Diode (LED)

Longitudinal segmentation of the calorimeter modules requires 7 compact photo-detectors coupled to the end of WLS-fibers at the rear side of the module. The use of silicon photomultipliers (SiPM) is an optimum choice due to their remarkable properties as high internal gain, compactness, low cost and immunity to the nuclear counter effect and magnetic field.

Hamamatsu MPPC S12572-010C/P with the pixel size 10x10 μm^2.





To measure the absolute light yield (number of photoelectrons) of each longitudinal section in FHCal module, the calibration of SiPM's was performed with the LED emitting the light pulses with different intensities. Based on the Poisson distribution of the obtained amplitude spectra, the correlation between the mean value and the width (sigma squared) of the spectrum is plotted. The linear dependence confirms the Poisson distribution of the amplitude spectra. The **conversion factor** between the amplitudes expressed in the number of channels of ADC and in the number of photoelectrons is the tangent of this line. Constant term is contribution of electronic noise.

Test of FHCal modules with cosmic muons

After the module assembling, the light yield of all longitudinal sections was measured by using the cosmic muons crossing the sections in module. High light yield (of about 50 ph.e/MIP) makes possible the energy calibration of the FHCal modules with the cosmic muons during the calorimeter operation in MPD.

The time resolution of FHCal was measured for the muons, passing trough the vertical column of 4 modules. Here up/down modules selected the geometry of muon track, while two middle modules generated start and stop signals. For whole deposited energy spectrum the time resolution of single FHCal module is equal to 1.3 ns. It is improved to 1 ns at muon deposited energy of about 10 MeV.

Conclusion: the procedure of the photodetectors calibration with LED pulses was developed. It is based on the properties of Poisson distribution and allows the measurements of absolute light yield and the contribution of the electronic noises. The light yield and time resolution of FHCal modules were measured with cosmic muons.

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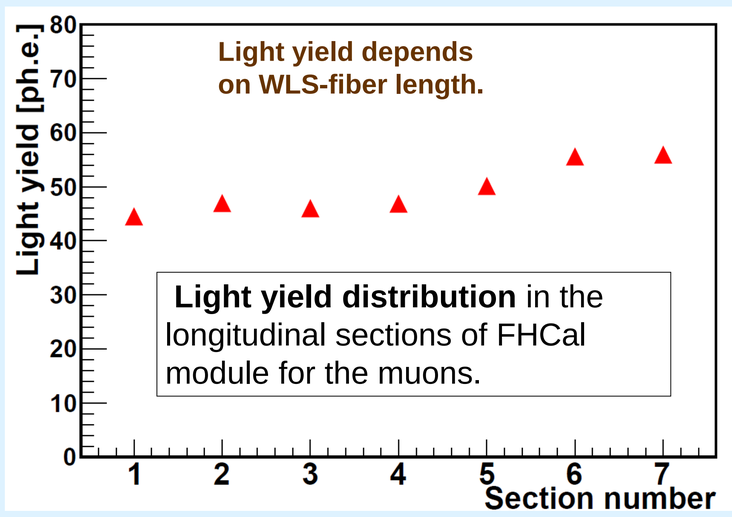
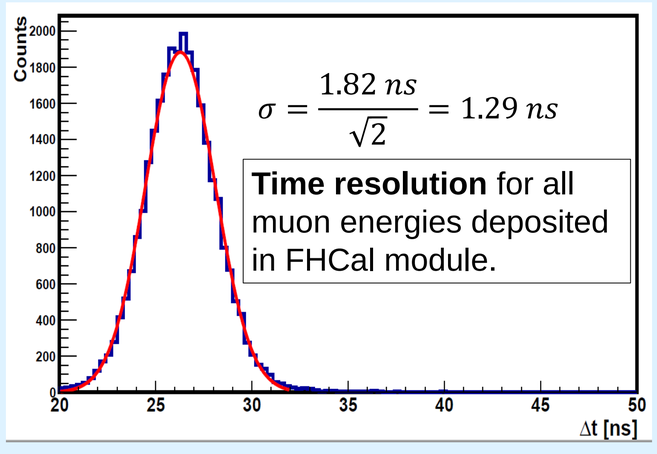
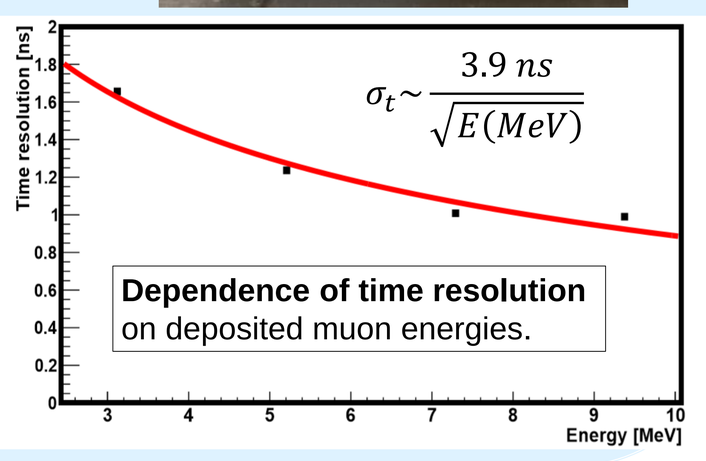


Light yield distribution in the longitudinal sections of FHCal module for the muons.



Time resolution for all muon energies deposited in FHCal module.



Dependence of time resolution on deposited muon energies.