Development of new forward quartz and scintillator hodoscopes for the BM@N

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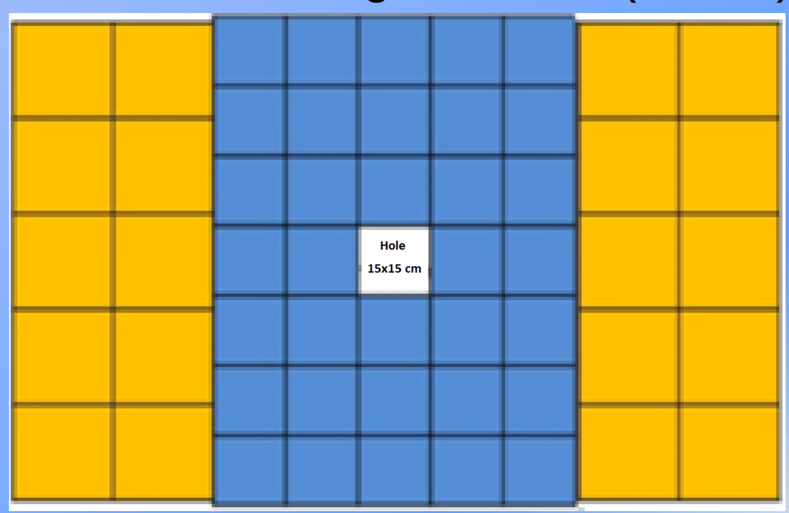
BM@N experiment

The research program of the BM@N (Baryonic Matter at Nuclotron) experiment is aimed at studying the formation of (multi) strange hyperons and searching for hypernucleus in nuclear-nucleus collisions at beam ion energies up to 4.5 AGeV.

These experiments will use a new forward hadron calorimeter with longitudinal and transverse segmentation (FHCal) to determine centrality in ion collisions.



Front view of calorimeter FHCal

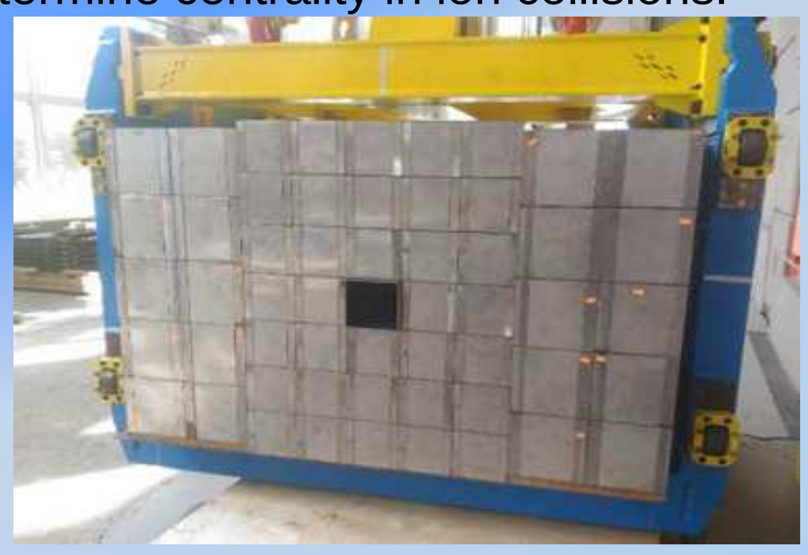
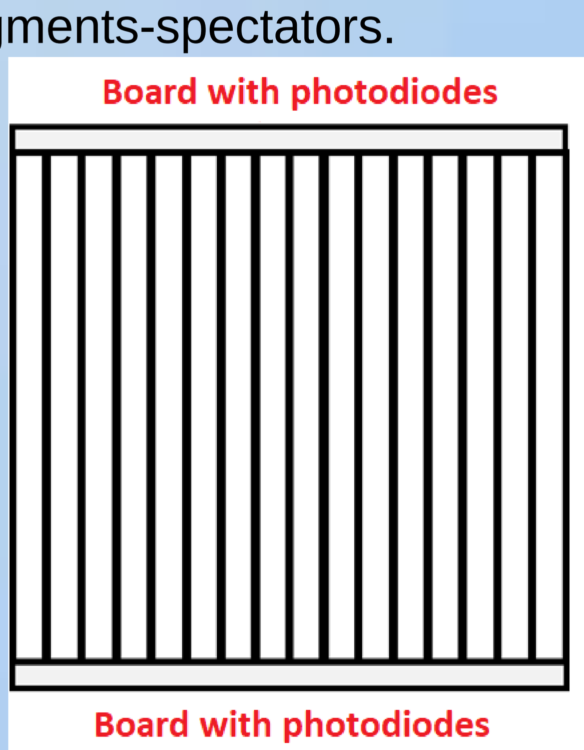


Photo of the assembled hadron calorimeter

A special feature of FHCal is the presence of a through square hole of 15 x 15 cm^2 in the center of the calorimeter. This hole is necessary for passing a heavy ion beam with an intensity of up to 2 × 10^6 ions/s to the beam dump installed behind the calorimeter and preventing radiation damage to the scintillator plates of the Central calorimeter modules and activating the calorimeter.

Hodoscope of nuclear fragments

The presence of a beam hole in the calorimeter leads to a significant leakage of heavy fragments through this hole and, as a result, leads to a non-monotonic dependence of the released energy in the calorimeter on the centrality in ion collisions. To solve this problem, it is proposed to use a hodoscope of nuclear fragments installed in the hole of the calorimeter, which will measure the charges of heavy fragments-spectators.



Scheme of hodoscope consisting of 16 quartz or scintillator plates and two electronic boards with photodiodes placed on the ends of the plates

Photo of the front hodoscope during the assembly.

Since the experiments will be performed with different ion beams, two types of hodoscope are expected to be used. A scintillator hodoscope will be used for light ion beam, and a quartz hodoscope will be used for heavy ion beam. The General structures of both horoscopes are quite similar, with the exception of schemes for receiving signals.

Experimental setup

To determine the amplitude parameters of the scintillator and quartz detectors of the hodoscope, setup consists of two detectors based on quartz and scintillator plates, respectively, was assembled. Light from the quartz plate was detected by two pairs of photodiodes, and in the scintillator plate by single photodiodes mounted on opposite ends of the plate.

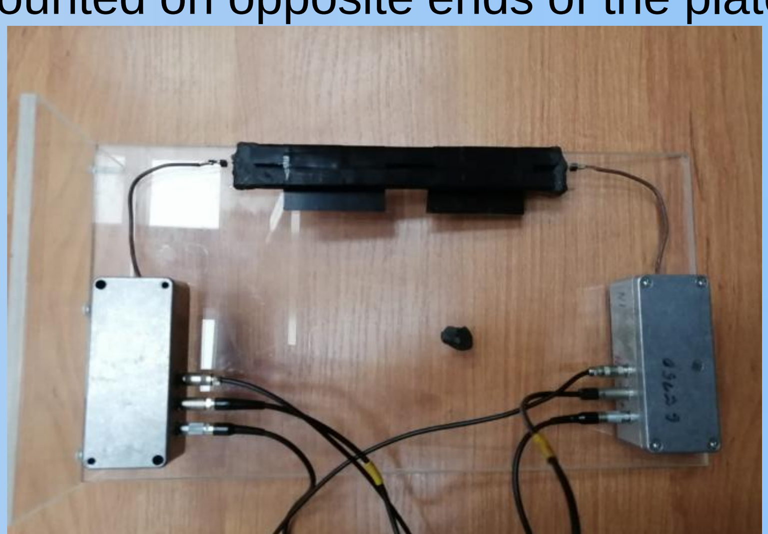


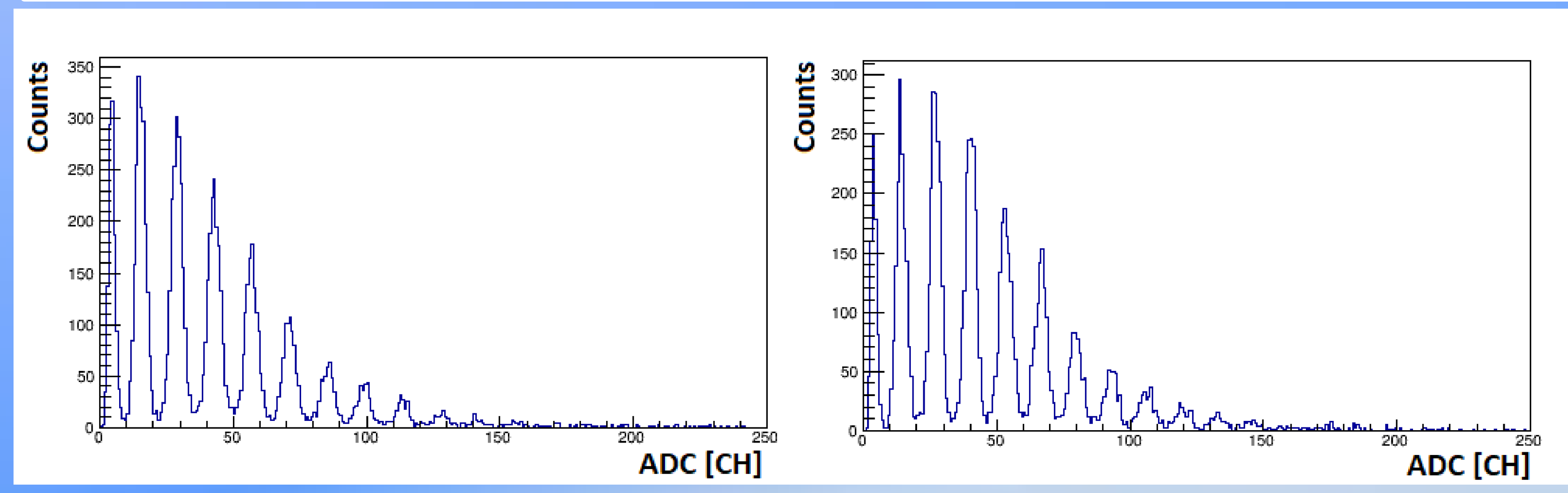
Photo of the setup that consists of two detectors with quartz and scintillator plates, photodiodes and two amplifiers.

In a quartz plate detector, each pair of photodiodes was connected in parallel, so that the supply voltage and signal readout was the same for both photodiodes. Signals from each pair of photodiodes were sent to fast amplifiers placed near the detector on a single support frame made of Plexiglas.

The assembled detector was tested on a test electron beam with an energy of 300 MeV of the Pakhra synchrotron.

The detectors used avalanche photodiodes (silicon photomultipliers) manufactured by Hamamatsu, type MPC S12572-015P with an active region size of 3x3 mm^2 and a quantum efficiency of about 20%.

Amplitude parameters of a quartz Cherenkov detector

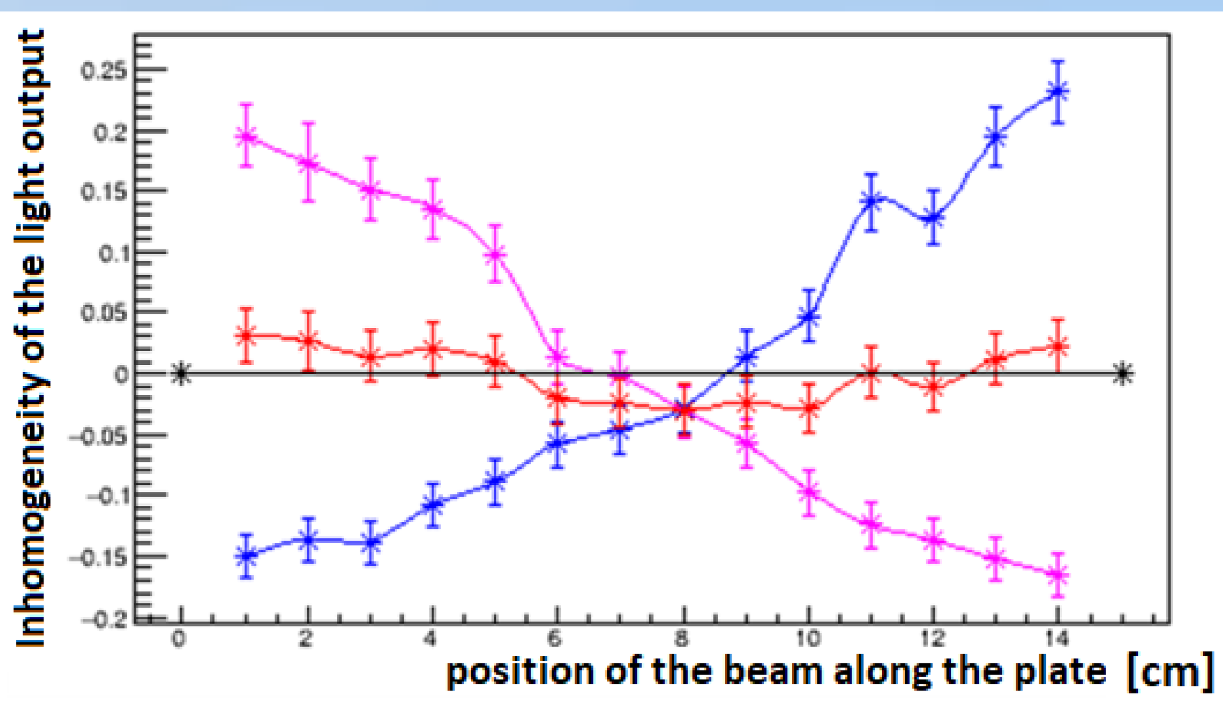


Amplitude spectra from two pairs of photodiodes when an electron beam passes through the center of a quartz plate

From the ratio of the number of zero and non-zero events in this amplitude spectrum, according to the properties of the Poisson distribution, it is possible to determine the average amplitude value of the spectrum.

It was determined that it corresponds to __2.4__ photoelectrons for one pair of photodiodes and about __5__ photoelectrons when reading quartz plates from both ends with two pairs of photodiodes.

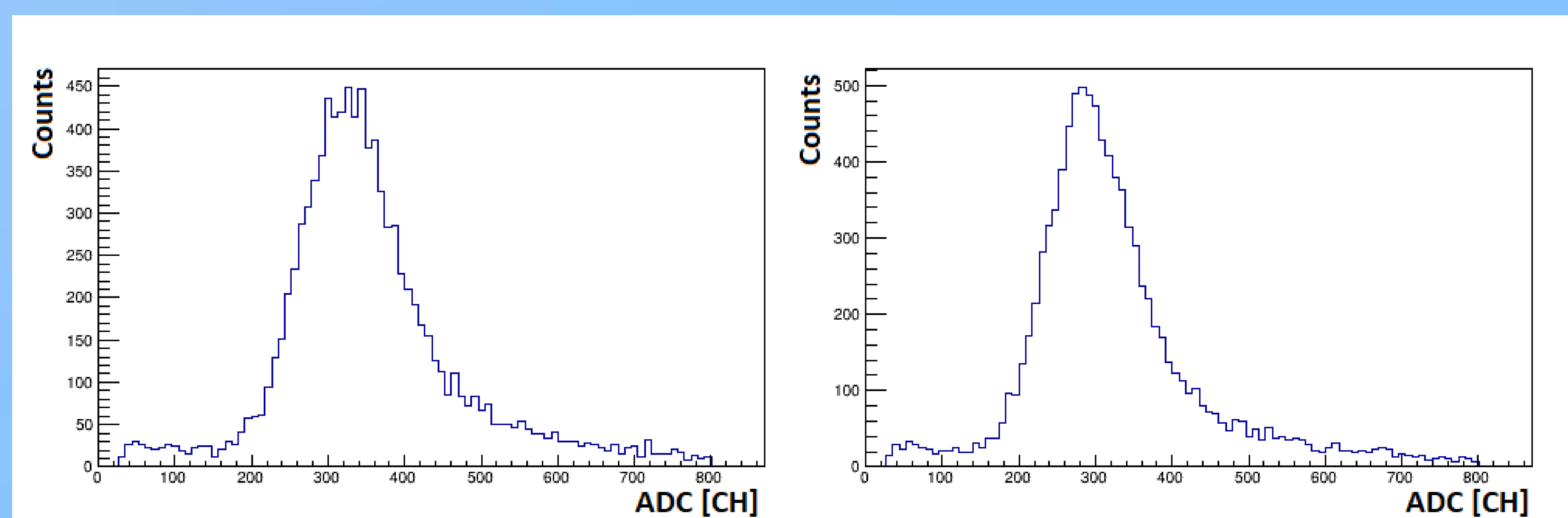
Such measurements were carried out along the all the length of quartz plate, so the dependence of the inhomogeneity of the light collection along the length of the quartz plates on the point of cross of the beam in the quartz plates was obtained.



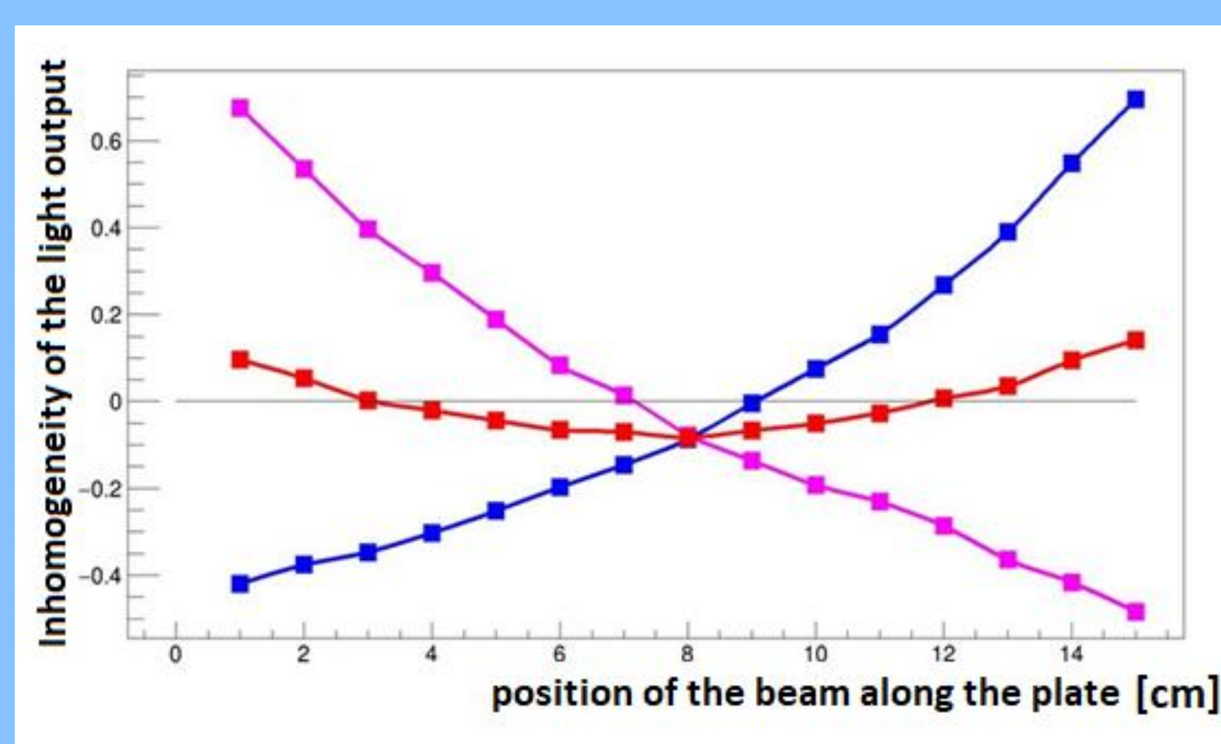
Inhomogeneity of the light output along the length of the quartz plate. The lines with blue and crimson colors correspond to two pairs of photodiodes placed on opposite ends of the plate. The red line corresponds to the inhomogeneity of the light output averaged by signals from opposite ends.

In case of using light readout from only one end of the quartz plate, the inhomogeneity of the light collection is about +-20%, which is obviously an unacceptable value. At the same time, the use of two-side light readout from both ends of the quartz plate reduces the inhomogeneity of the light collection to +-3%, which will provide a satisfactory accuracy in determining the value of the fragment charge.

Amplitude parameters of the scintillator detector



Amplitude spectra from two photodiodes in the case of an electron beam passing through the center of the scintillator plate.



Dependence of the inhomogeneity of the light output signal on the point of beam hit along the axis of the plate. Blue and crimson colors show the amplitudes corresponding to the photodiodes placed on opposite ends of the plate. The red line corresponds to the amplitude averaged by signals from opposite ends.

The value of the inhomogeneity of the light collection averaged along the long side of the plate is +-10% for the scintillator detector.

The larger amount of inhomogeneity of the scintillation plate in comparison with the quartz plate can be explained by the larger light absorption coefficient in the scintillator due to the presence of scintillation and spectrum-shifting additives.

Conclusion

Test of two (quartz and scintillator) prototype detectors were done at electron beam. Light yeld and its inhomogeneity are satisfactory to determine the charges of fragments in ion collisions.

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