JOINT INSTITUTE
FOR NUCLEAR RESEARCH

BM@N
Baryonic Matter at Nuclotron

Study of the interaction trigger and beam ion fragmentation for Au+Au collisions in BM@N experiment

Lashmanov N., Sedykh S. A., Yurevich V. I.

6th Collaboration Meeting on the BM@N Experiment
October 26, 2020

Content:

- Target Area Detector Performance
  - *Target area detectors*
  - *Background conditions*
  - *Efficiency of triggering Au+Au collisions*
  - *BD - Shielding Optimization*
- Forward Detector Performance
  - *Fragment Detector*
  - *Hadron Calorimeter*
- Interaction Trigger Concept

Introduction

THE TRIGGER DETECTOR SYSTEM CONSISTS OF:

BEAM COUNTERS

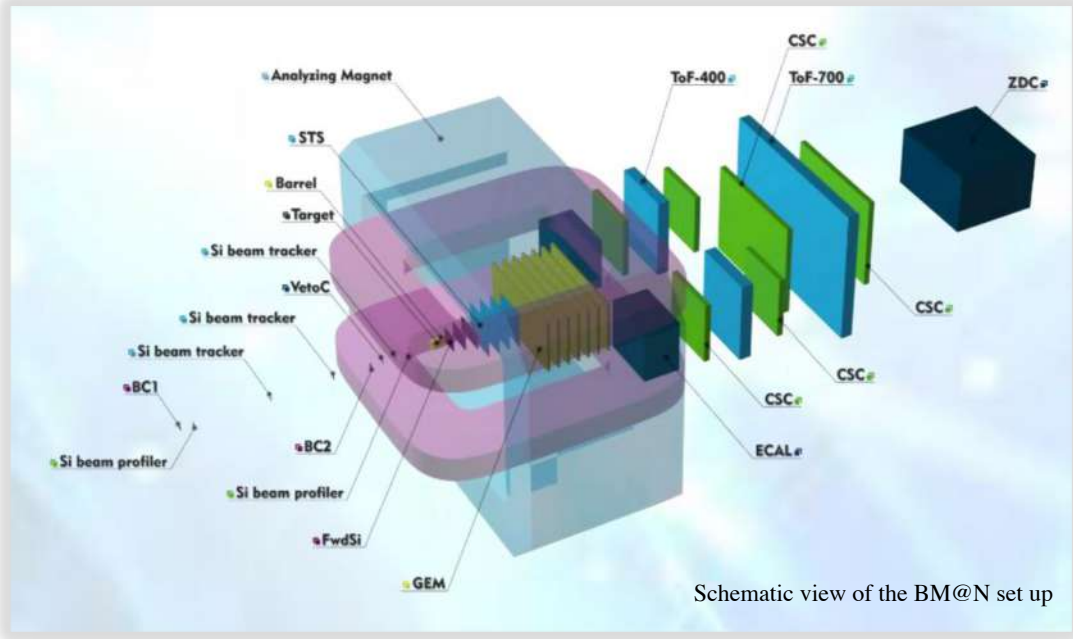
Detecting each beam particle incident on the target

TARGET AREA DETECTORS

Scintillation barrel and silicon multichannel detectors measuring multiplicity of secondary charged particles

FORWARD DETECTORS

Cherenkov detector of beam ion fragments and hadron calorimeter

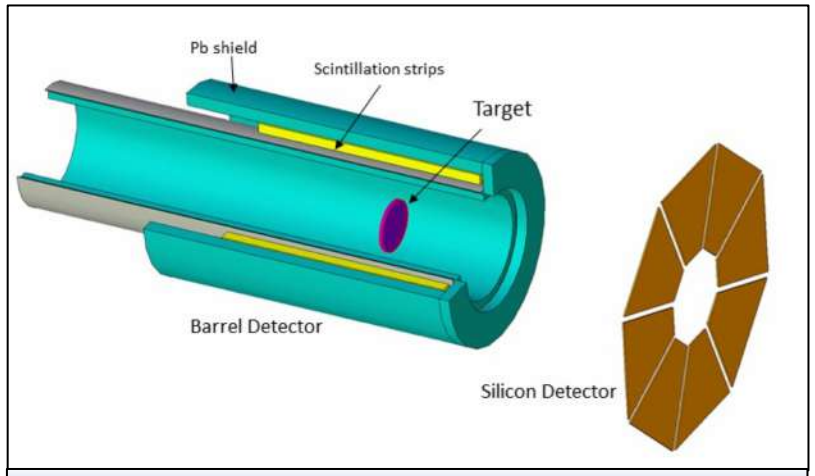


Schematic view of the BM@N set up

- The fast interaction trigger is based on information coming from the target area and forward detectors and it is used for effective selection of collision events in the BM@N target. Selection of the collisions on centrality is important option of the fast interaction trigger.
- The detector and interaction trigger performance for Au + Au collisions at energy of 4 A GeV were studied by Monte-Carlo simulation with a code DCM-QGSM + GEANT4.

Target Area Detector Performance

Target area detectors

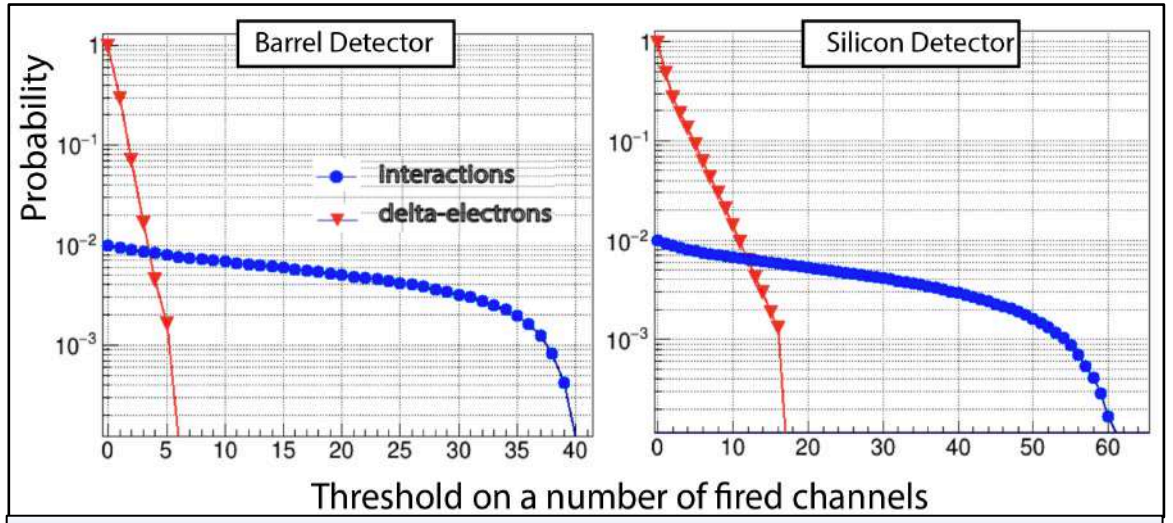


The geometry of the target area of the BM@N experiment.

- The BD consists of 40 scintillation strips 150 × 7 × 7 mm^3 with SiPM readout from one end of the strips. The inner radius of the strip cylinder is 46 mm.
- The BD covers a region of large polar angles and it detects the charged particles, mainly protons and pions, produced in nucleus – nucleus collisions.

- The forward angle region is covered by the SiD with inner and outer radii of 25 and 93 mm respectively. The distance from the target to SiD is 120 mm.
- The SiD has a thickness of 525 mkm and it consists of 64 trapezoidal strips.

Background conditions



The probability of true (blue) and false (red) triggers in the registration of Au + Au collisions as a function of the threshold on the number of counts in BD (left) and SiD (right) detectors.

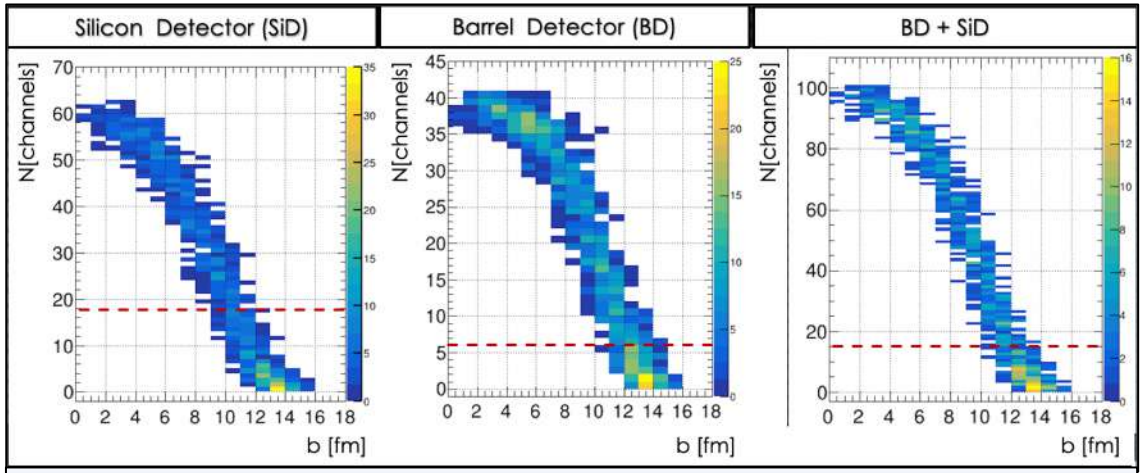
- The δ -electrons produced by Au ions in the target can make an essential contribution to the number of fired channels in BD and SiD detectors. This background reduces the capability of the detectors to select the interactions in the target because trigger signals can be generated even when the incoming beam ion passes the target without interaction.
- A special Pb-shield was applied around the scintillation strips of BD with the purpose to absorb δ -electrons produced by Au ions in the target. The shield is made as inner and outer cylinders plus a layer closing the forward ends of the strips.

• Efficiency of triggering Au+Au collisions

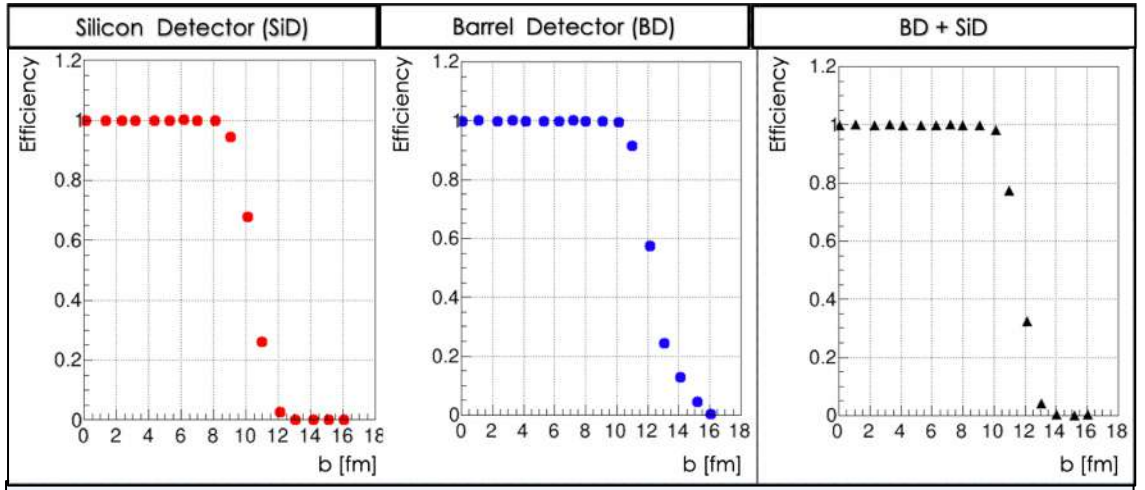
- The study of the BD and SiD responses as a function of impact parameter of Au + Au collisions at 4 A GeV shows that in the central collisions the numbers of fired channels reach the total granularity in both detectors.

- The total granularity of the target area detectors is 40 + 64 = 104 channels.
- The threshold conditions: 17 channels in the SiD, 6 channels in the BD.

- The dashed red lines in the figures correspond to applied thresholds for suppression of the δ -electron background. For this condition the efficiency is 100% for central and semi-central Au+Au collisions as for the individual detectors as for sum of the detector responses.

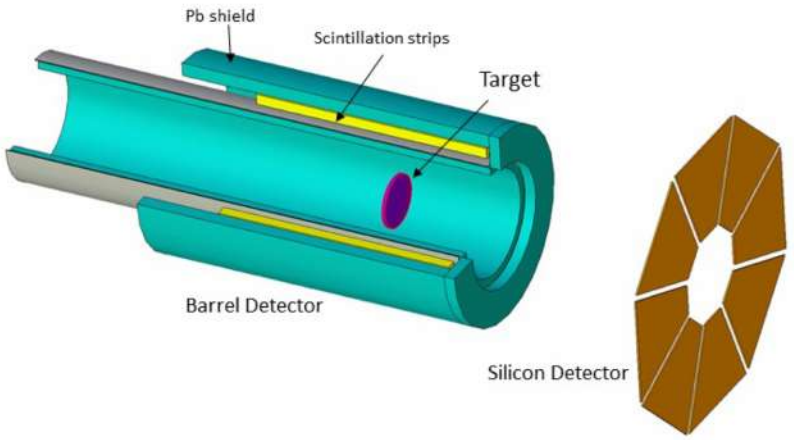


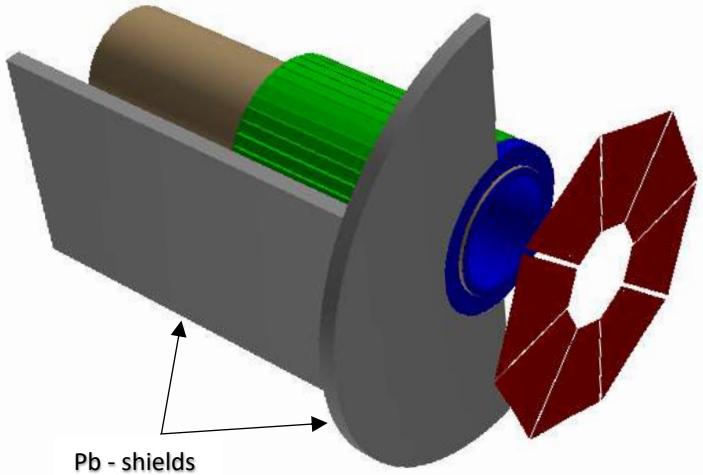
The number of counts in the trigger detectors (SiD, BD, BD+SiD) in the registration of Au+Au collisions depending on the impact parameter.

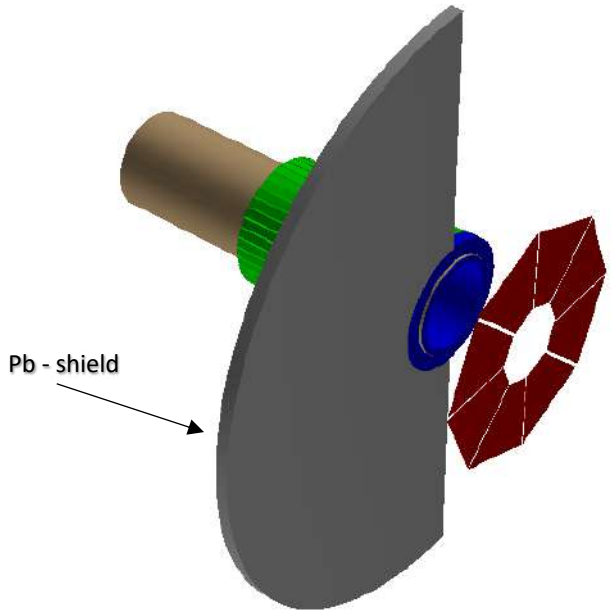


Efficiency of the trigger detectors (SiD, BD, BD+SiD) in the registration of Au+Au collisions as a function of the impact parameter

• BD - Shielding Optimization







- 5 mm inner and 10 mm outer cylindrical shields.

- 5 mm inner cylindrical shield;
- Disk segment, Ø = 300 mm, thickness = 10 mm;
- Lead Plate, thickness = 10 mm.

- 5 mm inner cylindrical shield;
- Disk segment, Ø = 500 mm, thickness = 10 mm.

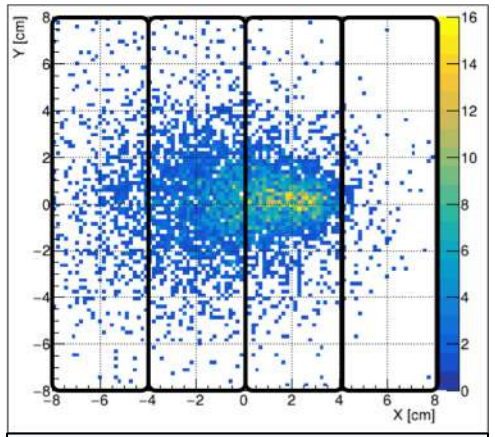
Forward Detector Performance

Fragment Detector

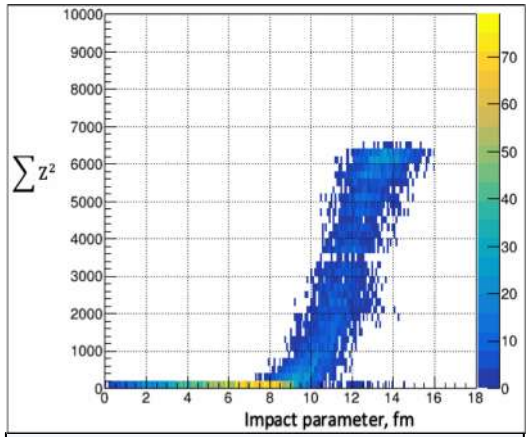
- *Fragment Detector (FD)* with transverse dimensions 160x160 mm^2 will be placed after the vacuum pipe in front of the calorimeter. The FD will consist of 4 quartz plates 160x40x6 mm^3.

- Simulation results demonstrate that nearly all heavy (Z > 6) fragments will be detected by the FD (upper picture).

- The amplitude of the summed signal from the FD can be used for vetoing non-interaction events, for generating a trigger on central and semi-central collisions, and for additional offline characterization of peripheral collisions (bottom picture).



Distribution of charged fragments in the forward detector. (Z > 6).

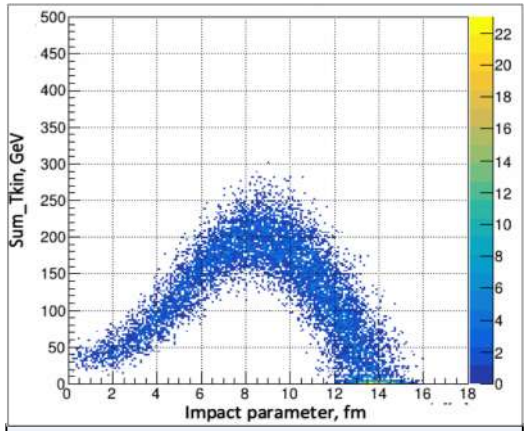


The square sum of the charges as a function of the impact parameter.

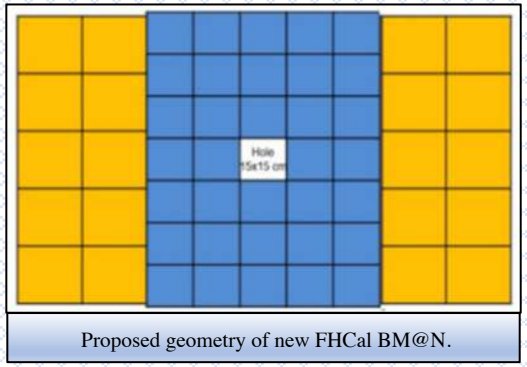
Hadron Calorimeter

- In future BM@N runs the new HCal will replace the ZDC at the end of the beam line at a distance of 9 m from the target. The HCal has a hole in the beam area, and consists of two types of modules for inner and outer regions (upper picture) with transverse size 150x150 mm^2 and 200x200 mm^2, respectively.

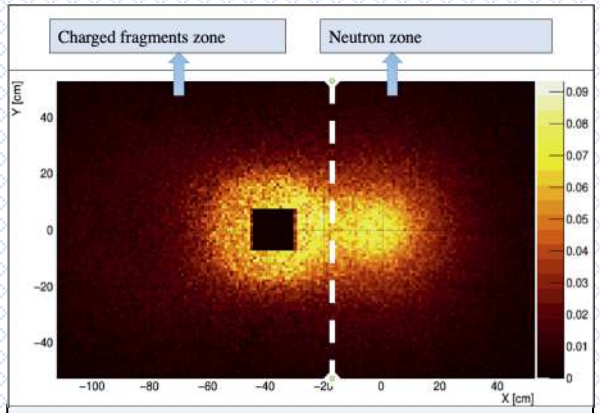
- In the current study, the MC simulations were used to explore the possibility to include the signals from the HCal in the trigger



The total kinetic energy of neutrons as a function of the impact parameter.



Proposed geometry of new FHCal BM@N.



Estimation of the average energy of the interaction products per event in the FHCal area. [GeV].

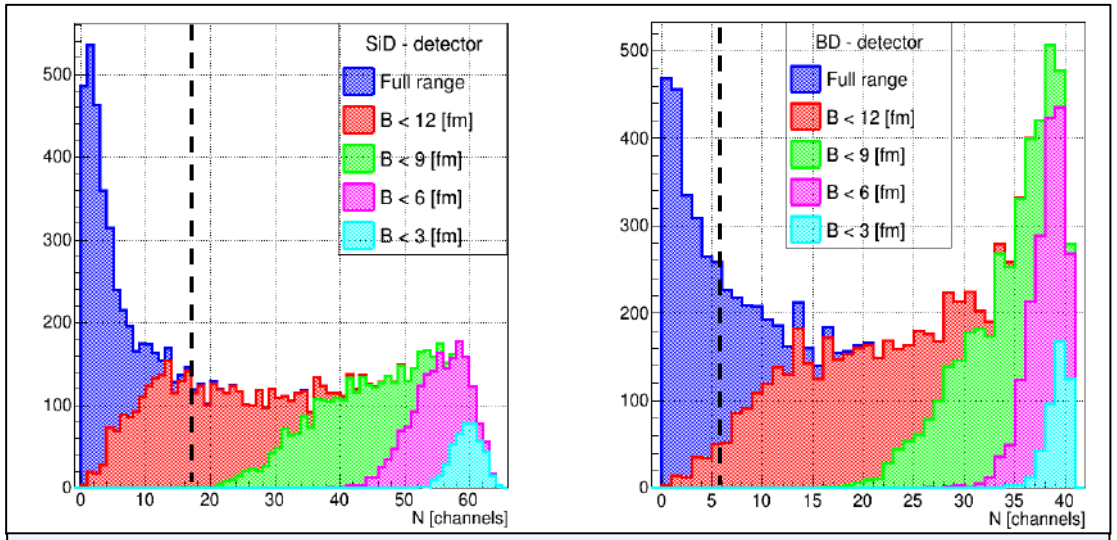
Interaction Trigger Concept

Taking into account the considered results of MC simulation the following concept of the interaction trigger for Au+Au collisions can be realized:

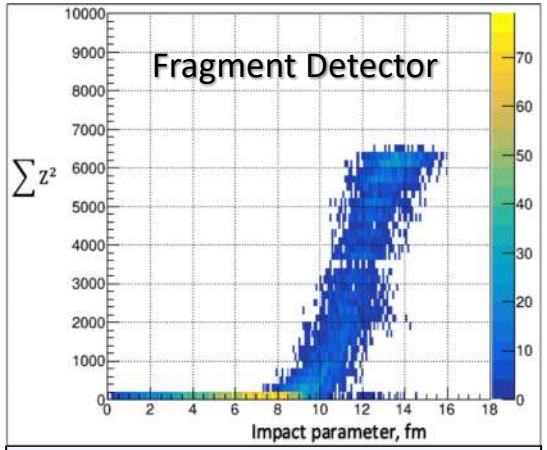
- Min. Bias – FD + HCal:
- Central and semi-central collisions – BD + SiD + HCal;

The first option (Min. Bias) is realized by setting a high threshold on FD pulse height close to Au-ion peak with a low threshold on HCal response.

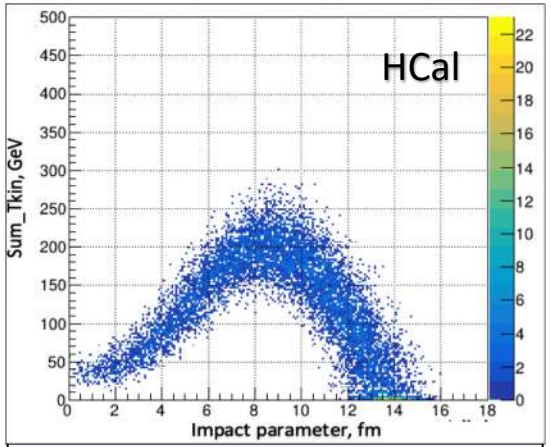
The second option is selection events on the centrality of Au + Au collisions and it is realized by setting the corresponding thresholds on number of fired channels in the BD and SiD, and threshold on HCal pulse height. More central collision means larger responses of BD and SiD and lower response of HCal.



Fired channels of detectors (SiD, BD) for the centrality determination.



The square sum of the charges as a function of the impact parameter.



The total kinetic energy of neutrons as a function of the impact parameter.

JOINT INSTITUTE
FOR NUCLEAR RESEARCH

BM@N

Thank you for your attention