A study of the correlation between the kinetic energy of a track and its energy response in the ZDC for run7 at the BM@N experiment

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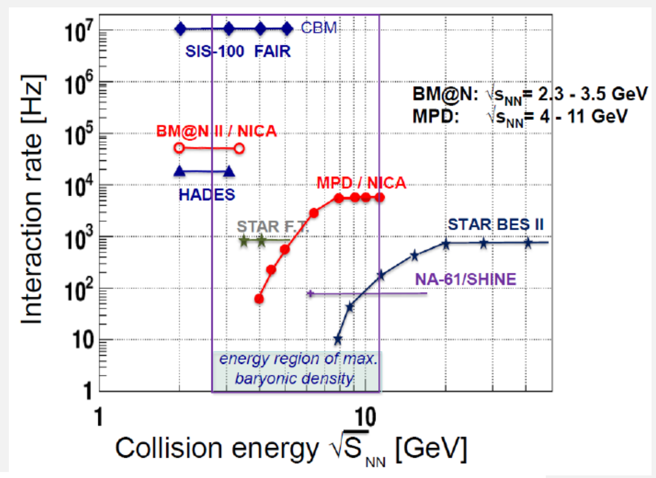
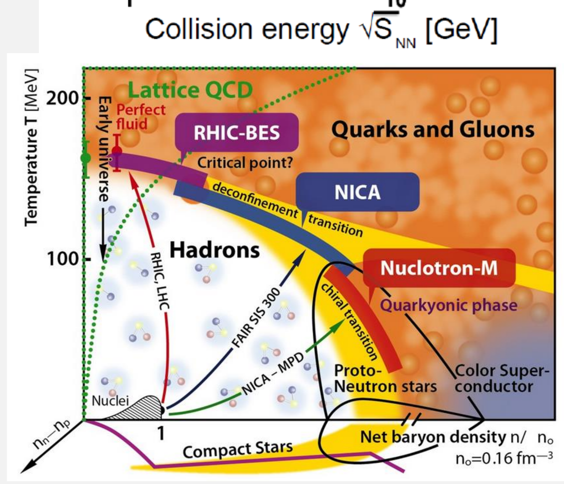
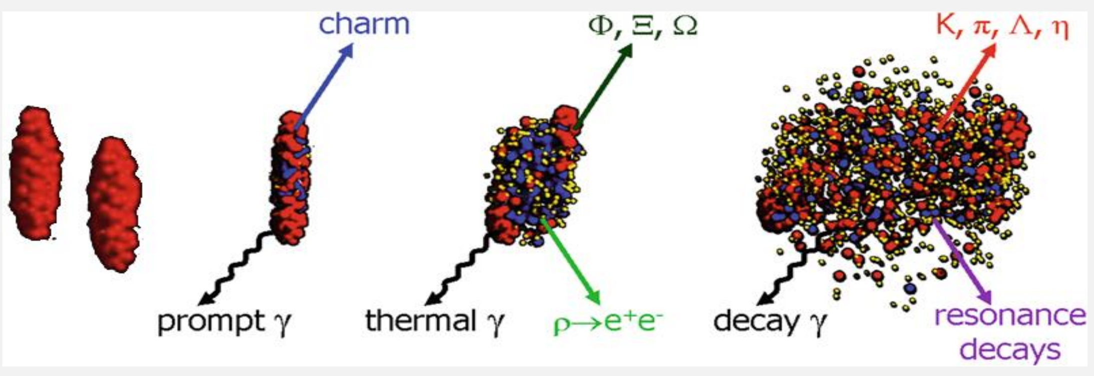
Heavy-Ion Collisions

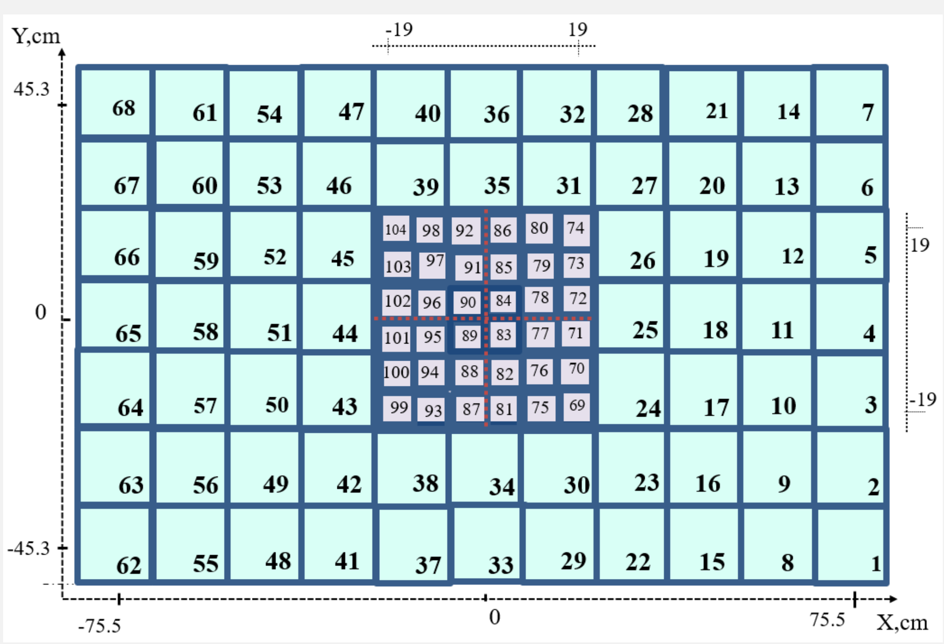
- At √s energies of 2 - 4.5 GeV, nucleon densities in a collision zone exceed the saturation density by the factor of 3-4.
- Hadrons with strangeness are early produced in the collision and not presented in the initial state of two colliding nuclei.
- Heavy-ion collisions are a rich source of strangeness, and the coalescence of kaons with lambdas or lambdas with nucleons will produce a vast variety of multi-strange hyperons or of light hypernuclei.



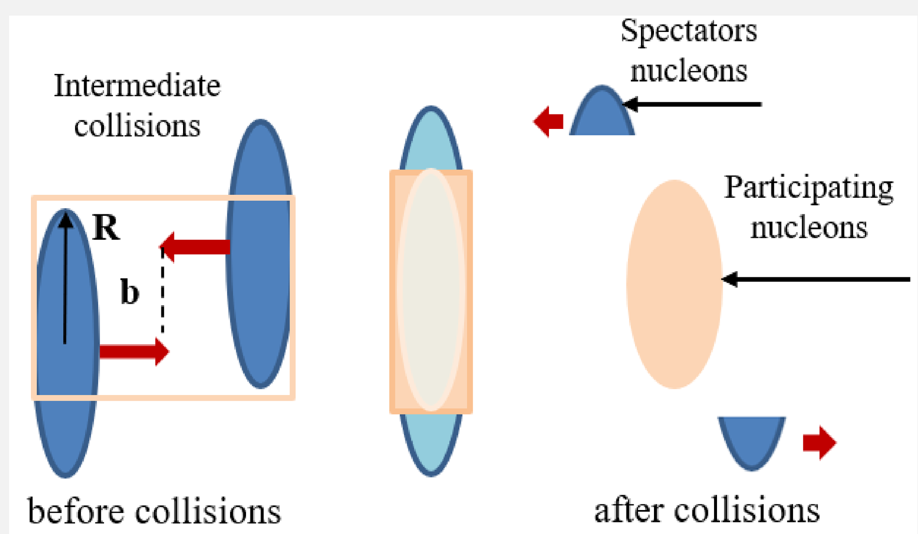




ZDC at BM@N



Schematic of the ZDC module map.

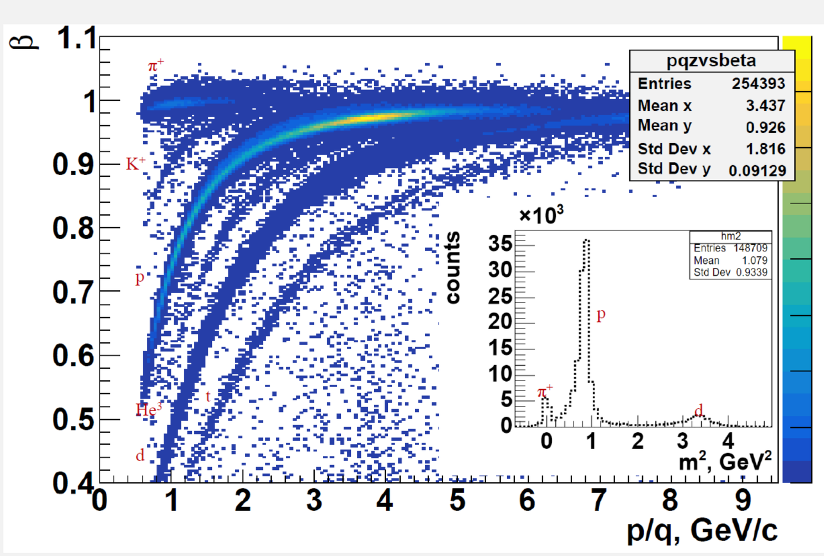


Schematic view of centrality of the collision. Where b is impact parameter.

One of the important directions of the relativistic heavy-ion collisions studies is the measurements of different observables as a function of the centrality parameter. **Zero Degree Calorimeter (ZDC)** is used to measure the centrality of events.

Expected kinetic energy

The ZDC is foresee for the analysis of the collision centrality by measuring the energy deposited by forward going particles. The particle type identification in BM@N based on time-of-flight system (TOF700).



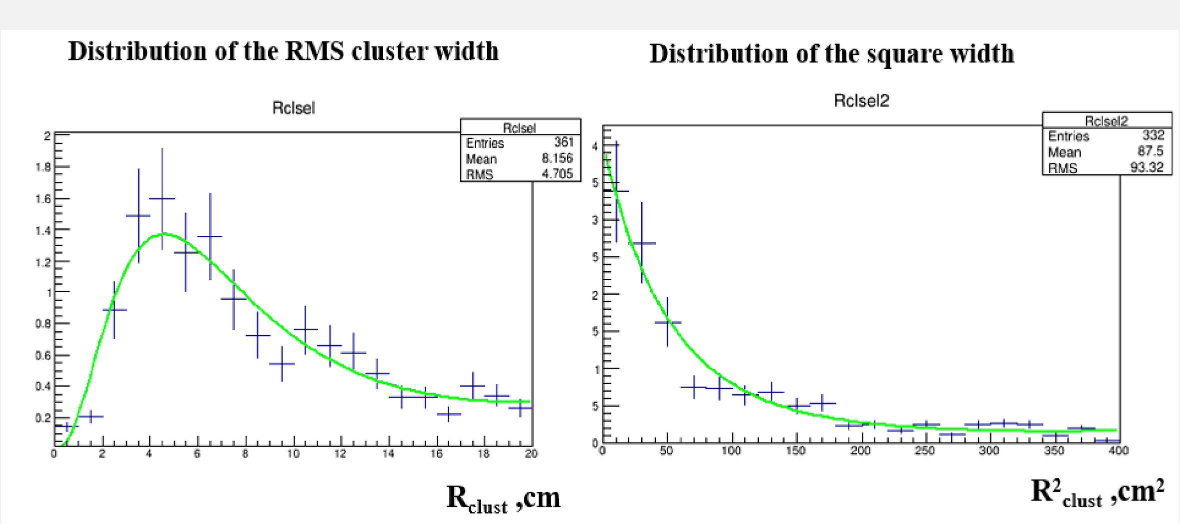
The kinetic energy of the identified particle evaluated be the formular : $T_{kin} = \sqrt{(p/z \cdot Z_{id})^2 + m^2 \cdot Z_{id}^2} - \sqrt{m^2 Z_{id}^2}$;

In calculation the tabular mass of deuteron $m_d c^2 = 1.875613$ GeV/c and proton $m_p c^2 = 0.938272$ GeV/c is used.

The momentum of the particle the threshold of ZDC: $p/z > 2.5$ GeV/c

Figure taken from [1] K. Alishina et al., Phys.Part. Nucl.,53(2022), no 2,470 – 475

Correlation estimation procedure



Procedure:

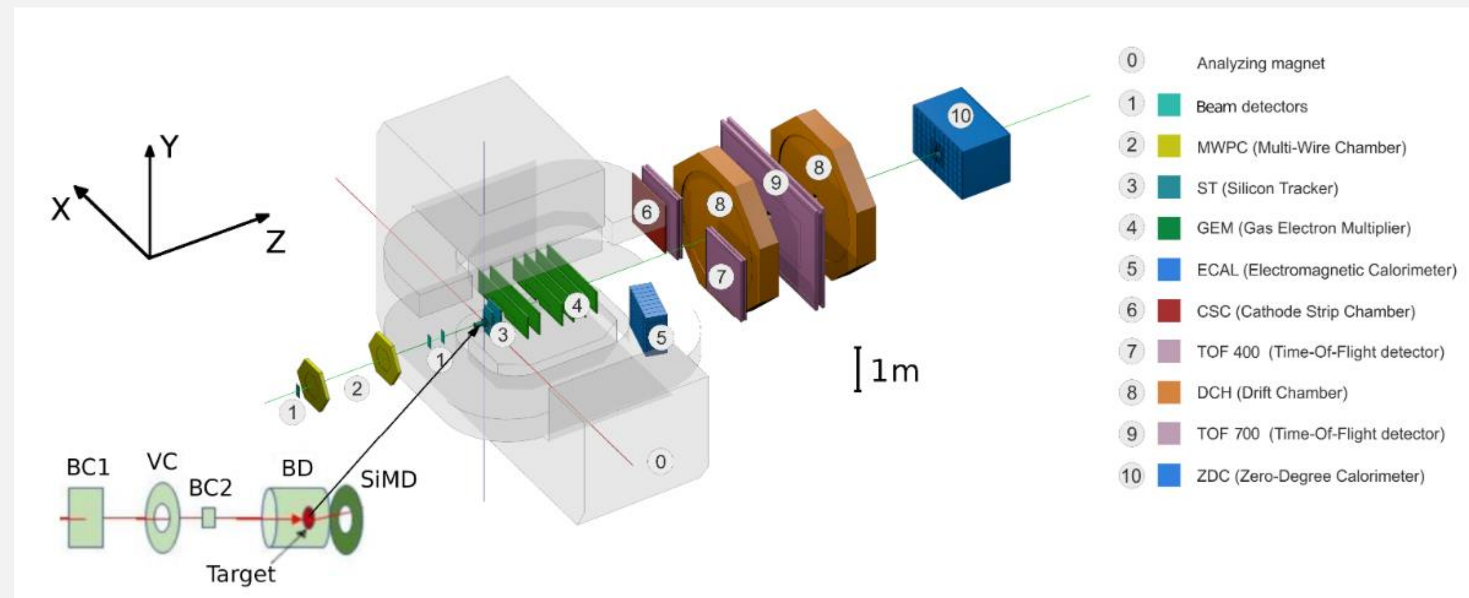
- Extrapolate the tracks from TOF700 to the ZDC plane.
- Calculate the energy that was released in the triggered module and its environment.
- Discard the event if the energy release in the module in which the track was hit is less than the energy release in any other environment module.
- Compare with the kinetic energy of the track in the triggered module

The track with the smallest distance is selected, which is calculated by the formula: $R_i = \sqrt{(X_{extr} - X_i)^2 + (Y_{extr} - Y_i)^2}$

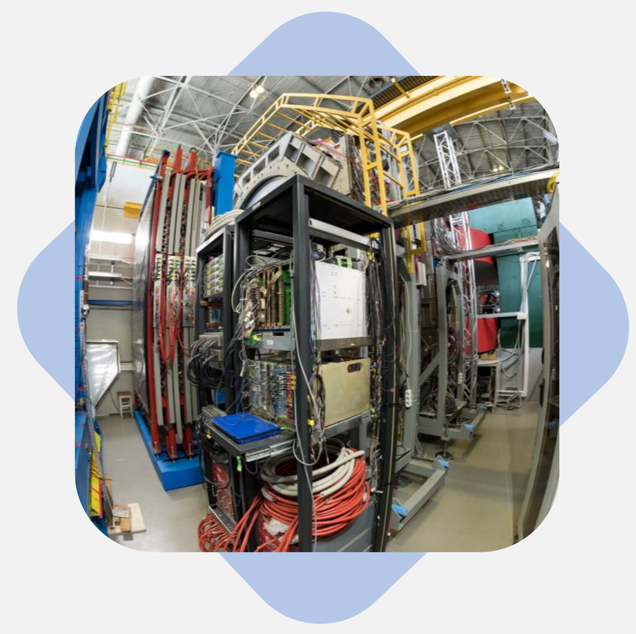
Where X_i is the coordinate of the center of the i-th triggered module along the x-axis, Y_i is the coordinate of the center of the i-th triggered module along the y-axis.

The ZDC was calibrated in 2015. The beam was irradiated with different modules.
From the Figure (Rclust , R²clust) - selection criterion: $R_i < 8 - 9$ cm

Experimental Setup



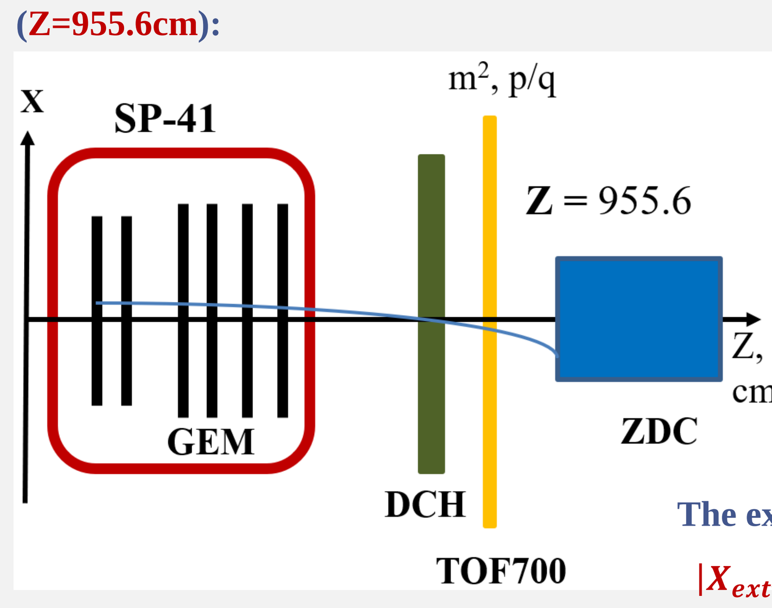
Schematic view of the BM@N setup in the argon-beam run(RUN7)



- BM@N is the experiment with a **fixed target** at the NICA.
- It is designed to study nuclear-nuclear collisions at high densities.
- The Nuclotron provides heavy ion beams with energies ranging from 2.3 to 4.5 GeV

Extrapolation of tracks from TOF700 to ZDC

Since TOF700 and ZDC detector subsystems are placed outside the magnetic field region the linear extrapolation is used to evaluate the particle coordinate at Z position of ZDC (Z=955.6cm):

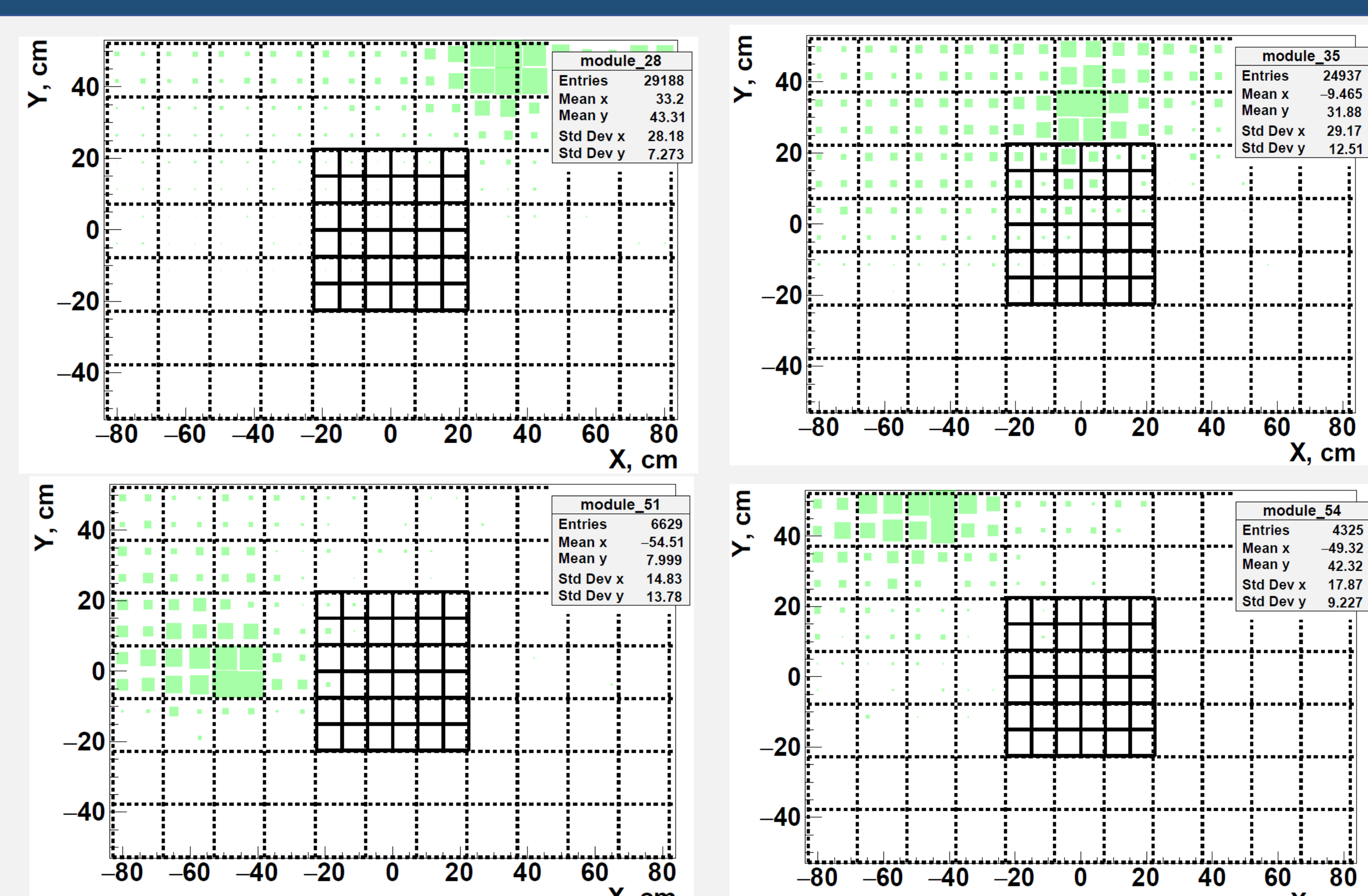


$$X_{extr} = X_{tof} + (Z - Z_{tof}) \cdot tgX_{tof}$$
$$Y_{extr} = Y_{tof} + (Z - Z_{tof}) \cdot tgY_{tof}$$

Where X_{tof}, Y_{tof} are coordinates and tgX_{tof}, tgY_{tof} are the slopes of the of particle momentum to the beam direction at Z position of TOF700 detector.

The extrapolated coordinates are limited within the region of $|X_{extr}| < 83$ cm, $|Y_{extr}| < 52$ cm.

Distributions of signal from tracks extrapolated in the different modules of the ZDC



Summary

- ✓ Green square shows the place where the track hit. The area of the green square is proportional to the kinetic energy of the track.
- ✓ Obtained an algorithm to estimate the energy in the ZDC.
- ✓ The position of the track after extrapolation to the module matches the expected position of the module with an accuracy of ΔX = ± 5 cm, ΔY = ± 5 cm .
- ✓ The expected position of the module is obtained from the detector map.