Tracking System Performance of the BM@N Experiment

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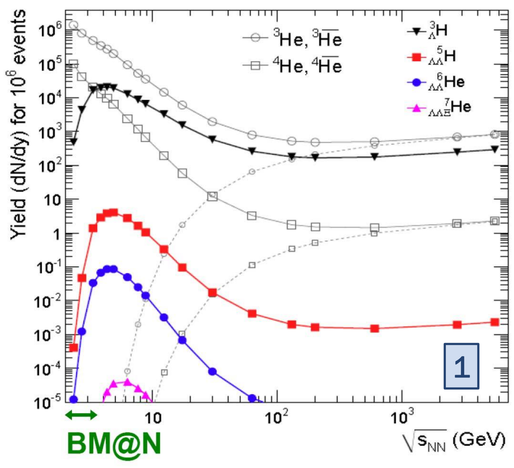
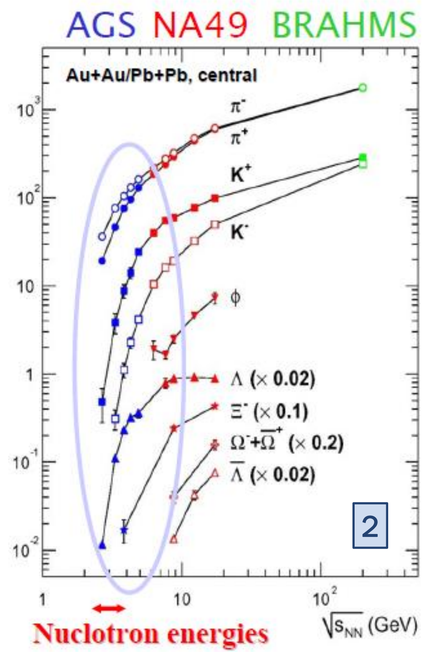
Experiment goals

- Medium and Heavy-ion collisions up to Au+Au, E_{kin}=4.5 AGeV, $\sqrt{s_{NN}}$~3.5 GeV: production mechanisms and modifications of hadron properties in dense nuclear matter – for strangeness (K^0,$K^{+/-}$) and vector mesons decaying in hadron modes ($\varphi \rightarrow K^+K^-$);
- Hyperons & hypernuclei production in AA collisions;
- Measurement of energy / rapidity distributions of beam fragments;
- Collective flows for π/K/p, hadron femtoscopy;
- Study of pA reactions as a reference for AA interactions.





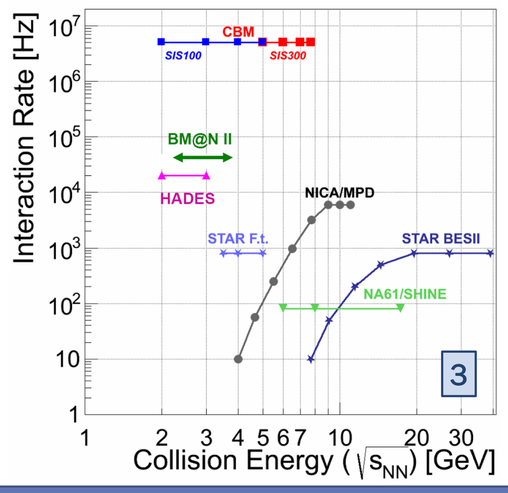


Fig.1. Hypernuclei production enhanced at high baryon densities (*A.Andronic, P.Braun-Munzinger, J.Stachel, H.Stocker*)

Fig.2. Yield of particles at Nuclotron [1] energies.

Fig.3 Heavy Ion Collision experiments. BM@N [2]: $\sqrt{s_{NN}}$ = 2.3 - 3.5 GeV.

BM@N experimental setup

- Detectors to form T0, Level 1 trigger and beam monitors;
- Multi-Wire Proportional Chambers (MWPC) – alignment and incoming beam trajectory positioning;
- Central tracker Gas Electron Multipliers (GEM) + Silicon Detector inside the analyzing magnet to reconstruct AA interactions. Small GEM detectors - 66x41cm^2, big GEM detectors -163x45 cm^2. Strip pitch of GEM 0.8 mm, strip inclination 0, 15°;
- Outer tracker Drift Chambers (DCH) to be replaced by Cathode-Strip Chambers (CSC) behind the magnet to link central tracks to ToF detectors;
- ToF system (ToF-400 & ToF-700) based on mRPC and T0 detectors to identify hadrons and light nuclei;
- ZDC calorimeter to measure the centrality of AA collisions and form trigger
- Electromagnetic calorimeter for γ, e+e-.

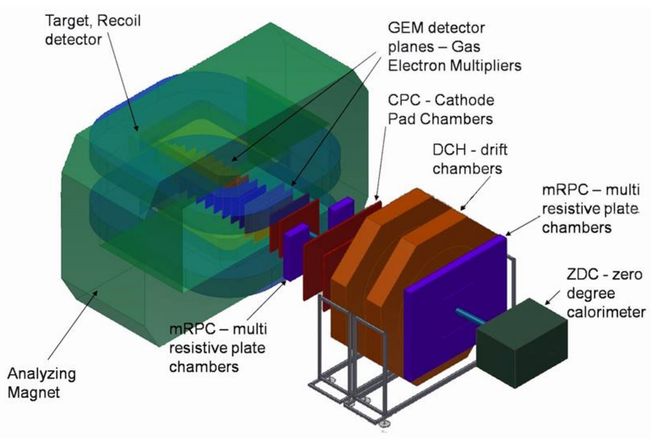


Fig. BM@N experimental setup.

MWPC

One MWPC [3] has 6 planes in each chamber: two X, two U and two V-planes with wire angles 0° and ±60°

Wire pitch is d = 2.5 mm.

Resolution is $d/\sqrt{12}$ = 0.72 mm.

Reconstruction steps: Form segment candidates from groups of 6/6, 5/6, 4/6 fired wires -> reconstruct & fit track-segments in each chamber (slope & position) -> extrapolate tracks to the target center.

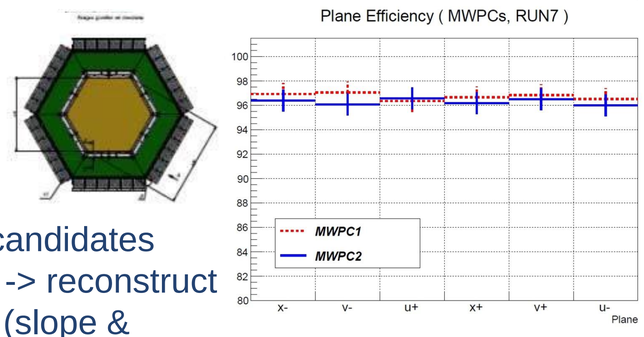


Fig. MWPC efficiency per plane.

References

1. NICA Collaboration (A.Sisakian et al.), The nuclotron-based ion collider facility (NICA) at JINR: New prospects for heavy ion collisions and spin physics J.Phys. G36, 064069 (2009).
2. M.Kapishin, The fixed target experiment for studies of baryonic matter at the Nuclotron (BM@N) Eur. Phys. J. A52 (2016) 213.
3. G.Charpak et al., Nucl. Instrum. Meth. 62 (1968) 262.
4. F.Sauli, Nucl. Instrum. Meth. A386 (1997) 531.
5. D.Bederede et al., Nucl. Instrum. Meth. A367 (1995) 88.

Gas Electron Multipliers[4]

Program:

- Trace charged particles through detectors, align detectors, measure particles' momentum in the magnetic field of 0.79T;
- Measure inelastic reactions C + target → X with the beam energy of 4 AGeV on CH2, C, Cu targets;
- BmnRoot software framework is used for data analysis.

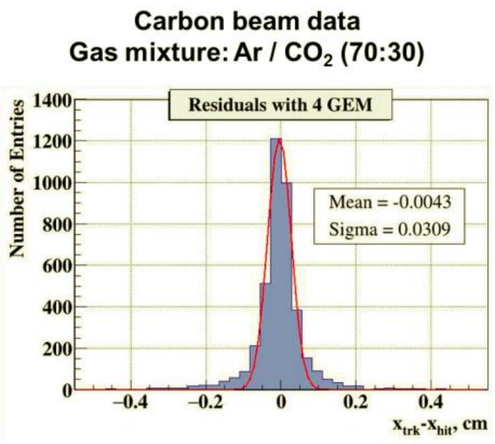


Fig. Hit residuals in GEM plane.

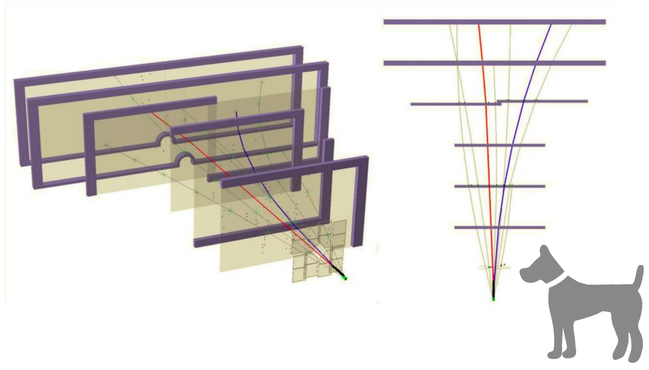


Fig. Λ → pπ⁻ event display in GEM + Si tracker in C+C interaction (2017 data)

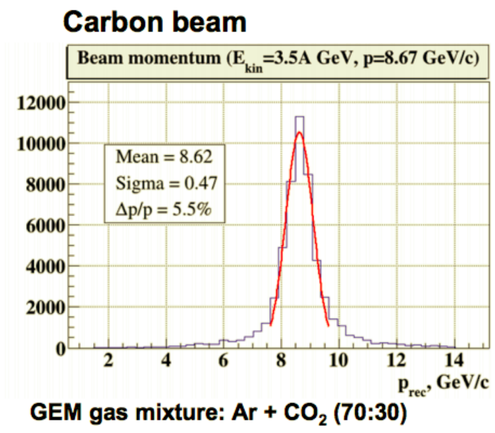


Fig. Beam momentum resolution for Carbon beam

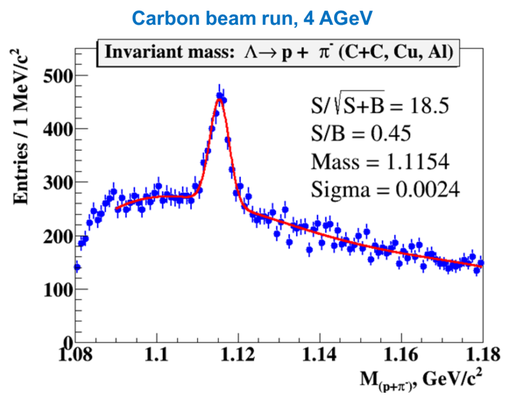


Fig. Mass of Λ reconstruction (2017 data)

Drift Chambers

The detectors were brought from NA48 [5] experiment:

- 4 double coordinate planes
- wire angles 0,90,±45°,
- wire pitch 10 mm,
- Rmin = 10 cm,
- 2048 wires per chamber,
- Yout ± 1.35 m, Xout ± 1.35 m.

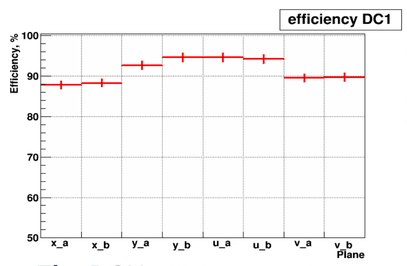


Fig. DCH efficiency per layer.

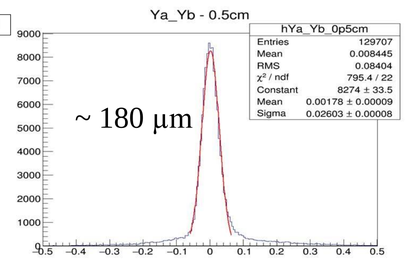
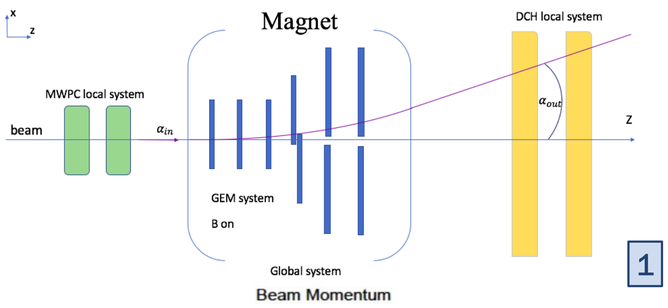
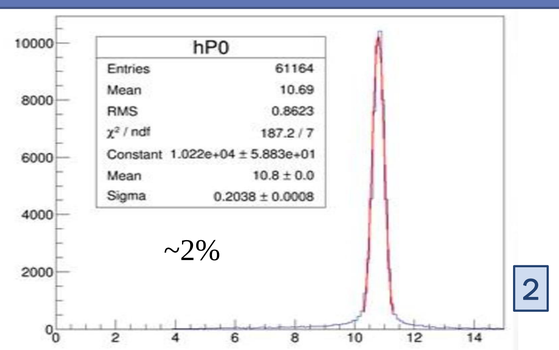


Fig. Average DCH spatial resolution.

Beam Momentum Estimation





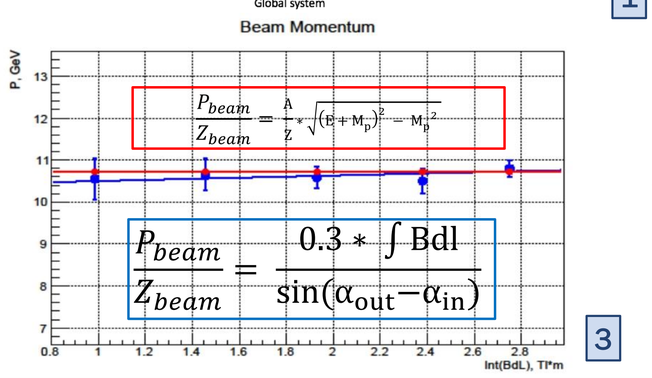


Fig.1. Beam momentum estimation procedure using outer tracker.

Fig.2. Beam momentum resolution for the working value of the magnetic field.

Fig.3. C beam kinetic energy 4.5 GeV/nucleon momentum estimation. The red line is the nominal beam momentum value. The blue points are the beam momentum values estimated from experimental data.

Summary & Plans

First BM@N results on Λ hyperon reconstruction have been obtained with the starting detector configuration. The software for the main tracking detector systems was developed. All systems show good performance for different beams, targets and magnetic field values.

year	2016	2017 spring	2018 spring	2020	2021
beam	d	C	Ar, Kr, C(SRC)	Au	Au, p
max. intensity, Hz	0.5M	0.5M	0.5M	1M	5M
trigger rate, Hz	5k	5k	10k	10k	50k
experiment status	technical run	technical run	technical run + physics	stage 1 physics	stage 2 physics

Table 1. Beam parameters and setup at different stages of the BM@N experiment.