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The BM@N experiment at JINR: status and physics program

Joint Institute for Nuclear Research

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Baryonic Matter BM@N at Nuclotron

Outline

1. Motivation
2. Detector geometry
3. Technical run (Run 5, Dec. 2016):
   - ✓ Spatial resolution: MC vs Exp.
   - ✓ Momentum resolution: MC vs Exp.
   - ✓ Λ reconstruction: MC vs Exp.
4. Summary & Plans

Motivation

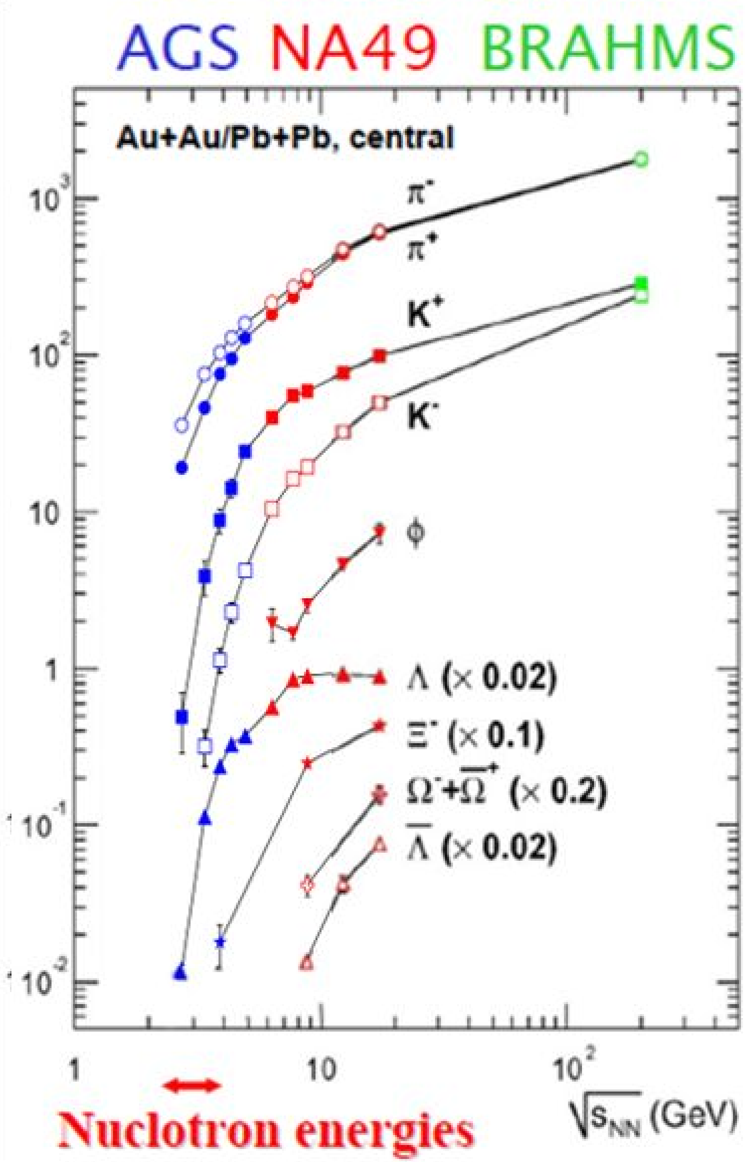
✓ **In A+A collisions** at Nuclotron energies:

Opening thresholds for strange and multi-strange hyperon production

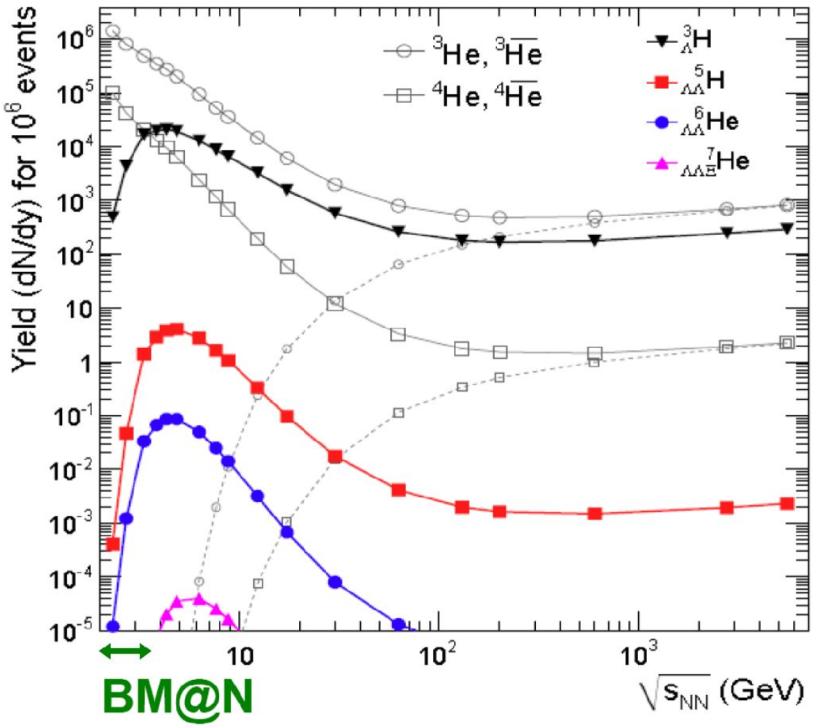
→ strangeness at threshold

✓ **In *p+p, p+n, p+A* collisions:**

hadron production in elementary reactions and ‚cold‘ nuclear matter as ‚reference‘ to pin down nuclear effects



Motivation



✓ In heavy-ion reactions: production of hypernuclei through coalescence of Λ with light fragments enhanced at high baryon densities.

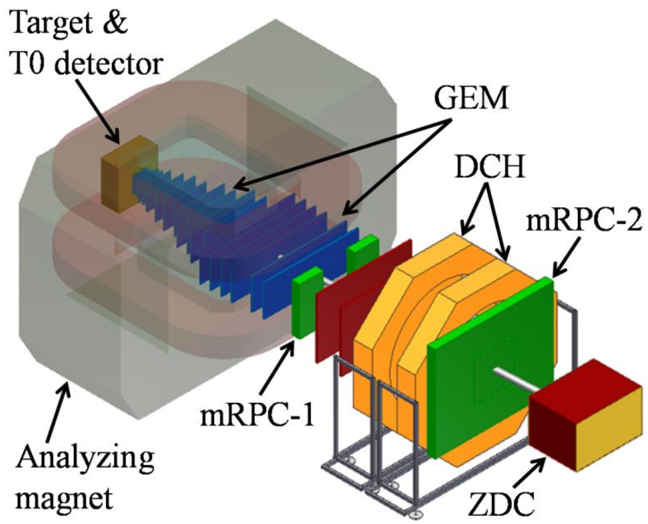
✓ Maximal yield predicted for √s=4-5A GeV (stat. model) (interplay of Λ and light nuclei excitation function).

→ BM@N energy range is suited for the search of hypernuclei.

Detector geometry

BM@N setup:

- ✓ Central tracker (GEM+Si) inside analyzing magnet to reconstruct AA interactions
- ✓ Outer tracker (DCH, CPC) behind magnet to link central tracks to ToF detectors
- ✓ ToF system based on mRPC and T0 detectors to identify hadrons and light nucleus
- ✓ ZDC calorimeter to measure centrality of AA collisions and form trigger
- ✓ Detectors to form T0, L1 centrality trigger and beam monitors
- ✓ Electromagnetic calorimeter for γ,e+e-



BM@N advantage: large aperture magnet (~1 m gap between poles)

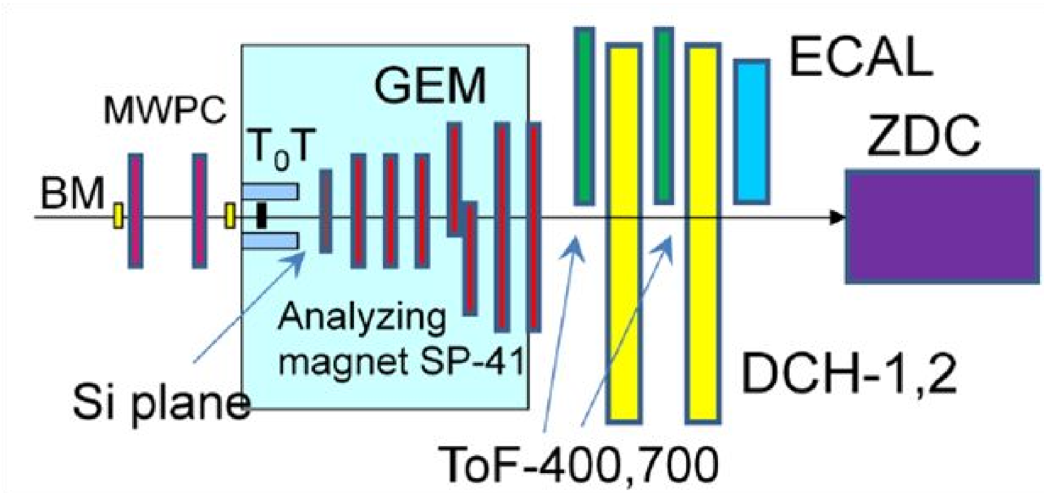
→ fill aperture with coordinate detectors which sustain high multiplicities of particles

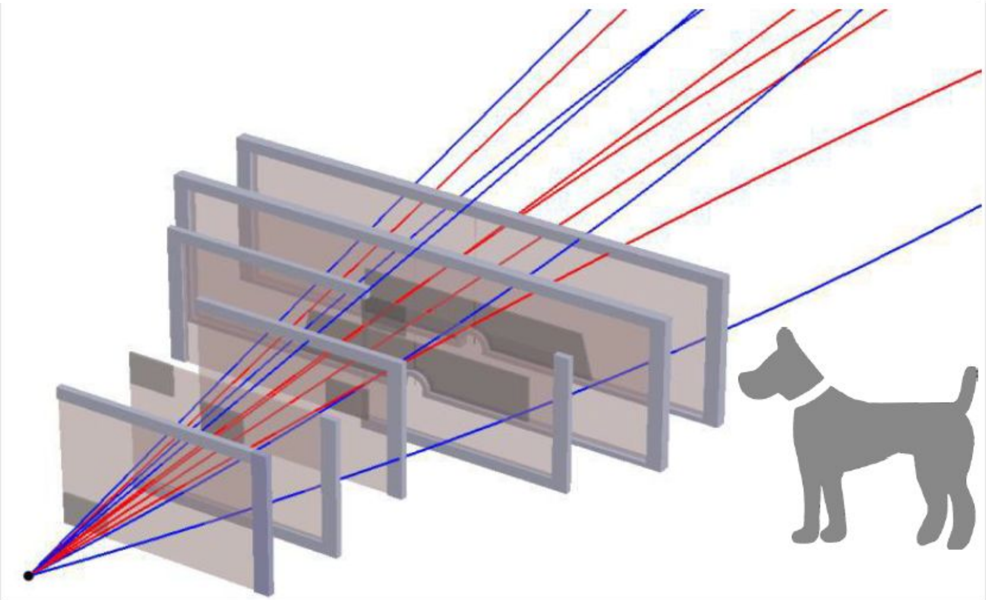
→ divide detectors for particle identification to "near to magnet" and "far from magnet" to measure particles with low as well as high momentum (p > 1-2 GeV/c)

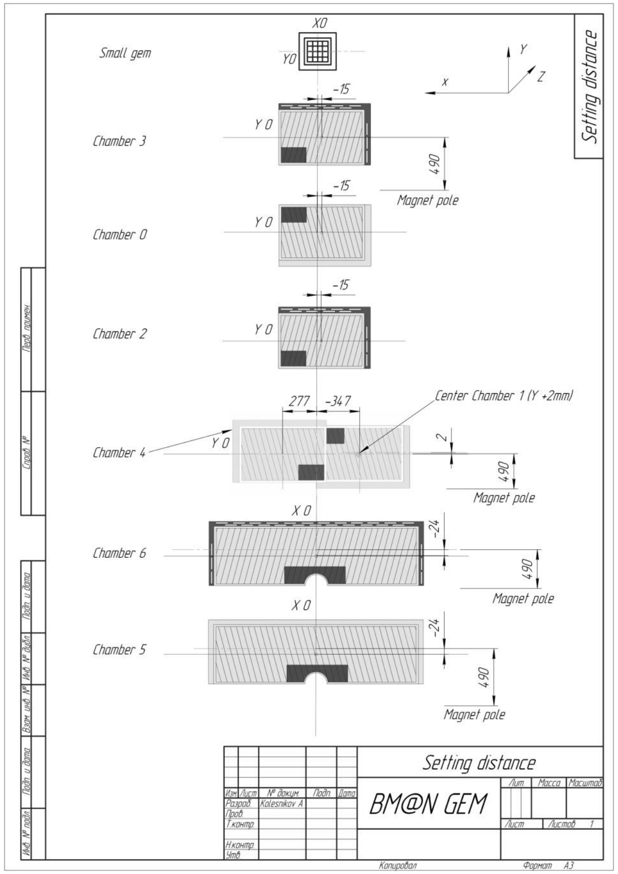
→ fill distance between magnet and "far" detectors with coordinate detectors

Technical run in December 2016

BM@N set-up used in the deuteron run.

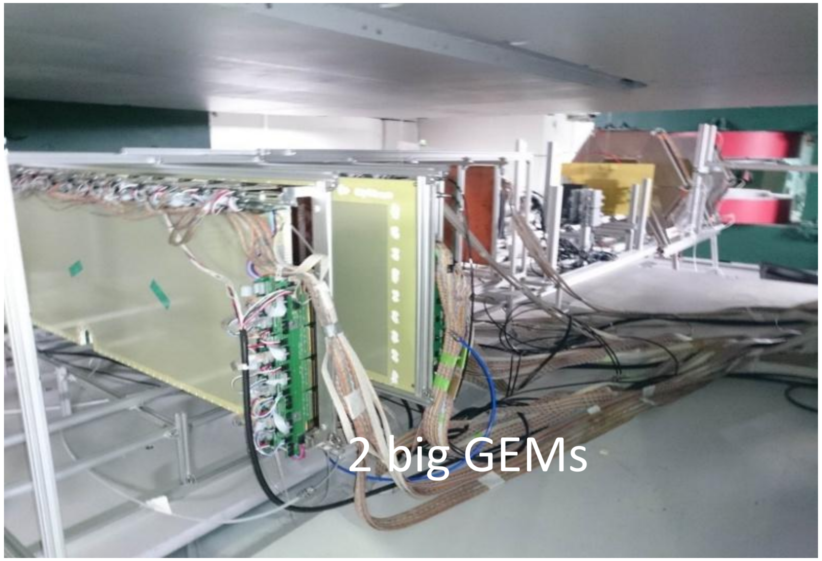


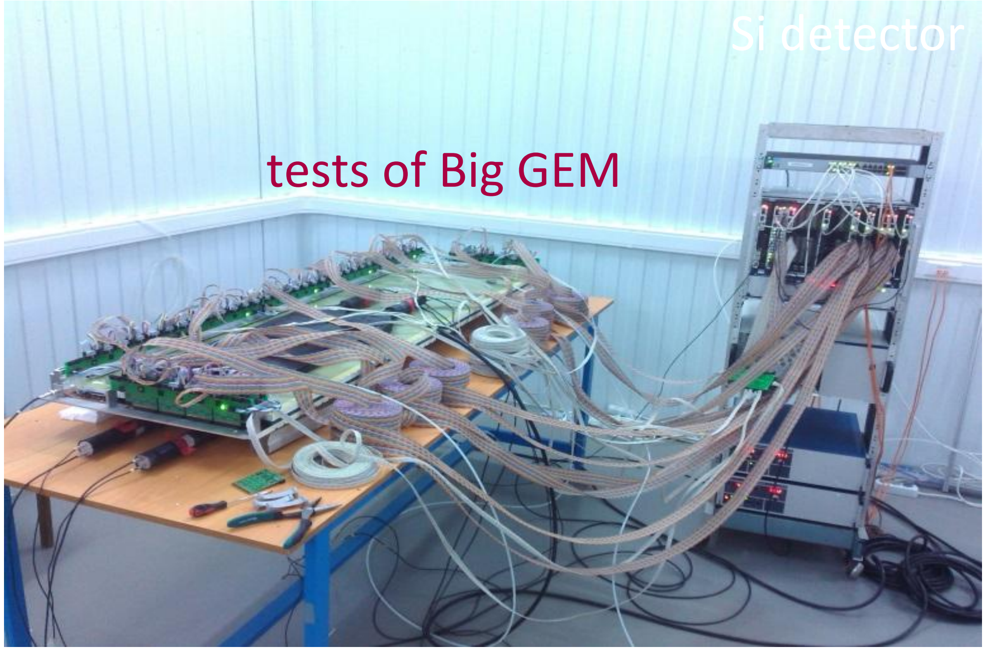


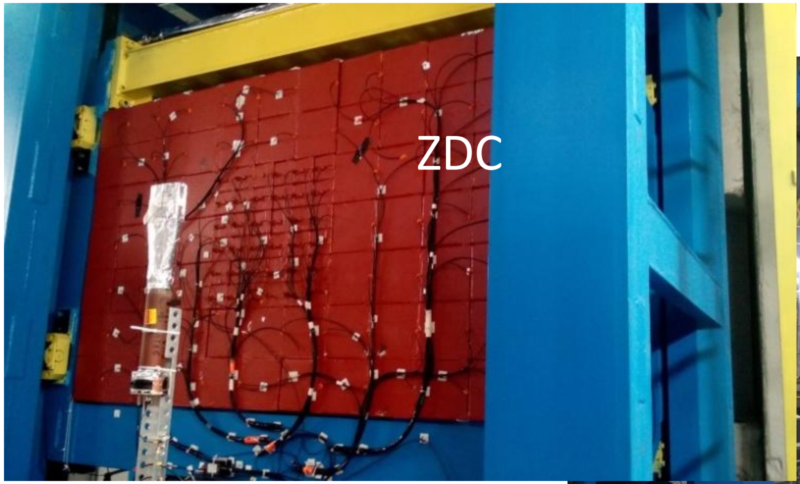


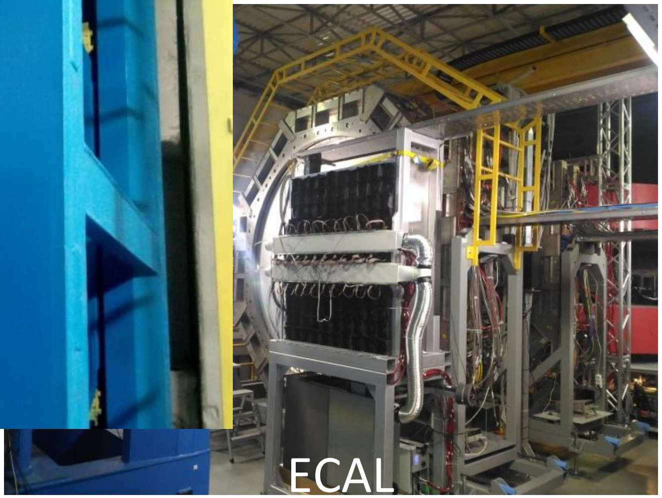
Example of an event reconstruction in the central tracker.

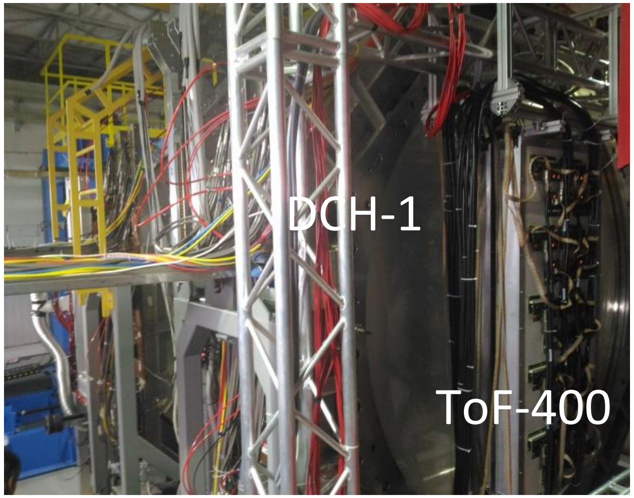
Technical run in December 2016











Data set

Magnetic field: 1600 A (0.79 T)

Events: 7M (0.76M with Λ candidates)

Beam / Target: d / Cu, E_{kin} = 4 AGeV

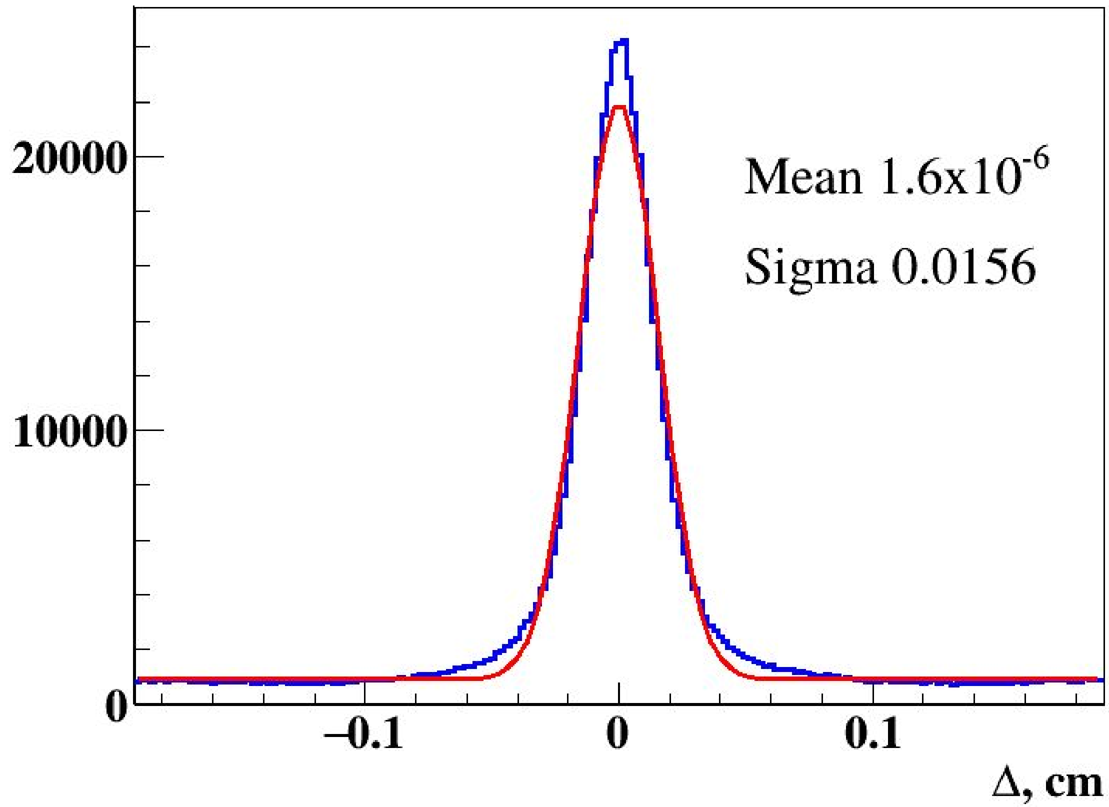
Beam / Target: d / CH_2, E_{kin} = 4 AGeV

Beam / Target: d / C, E_{kin} = 4 AGeV

Gas in GEM: Ar + Isobuthan

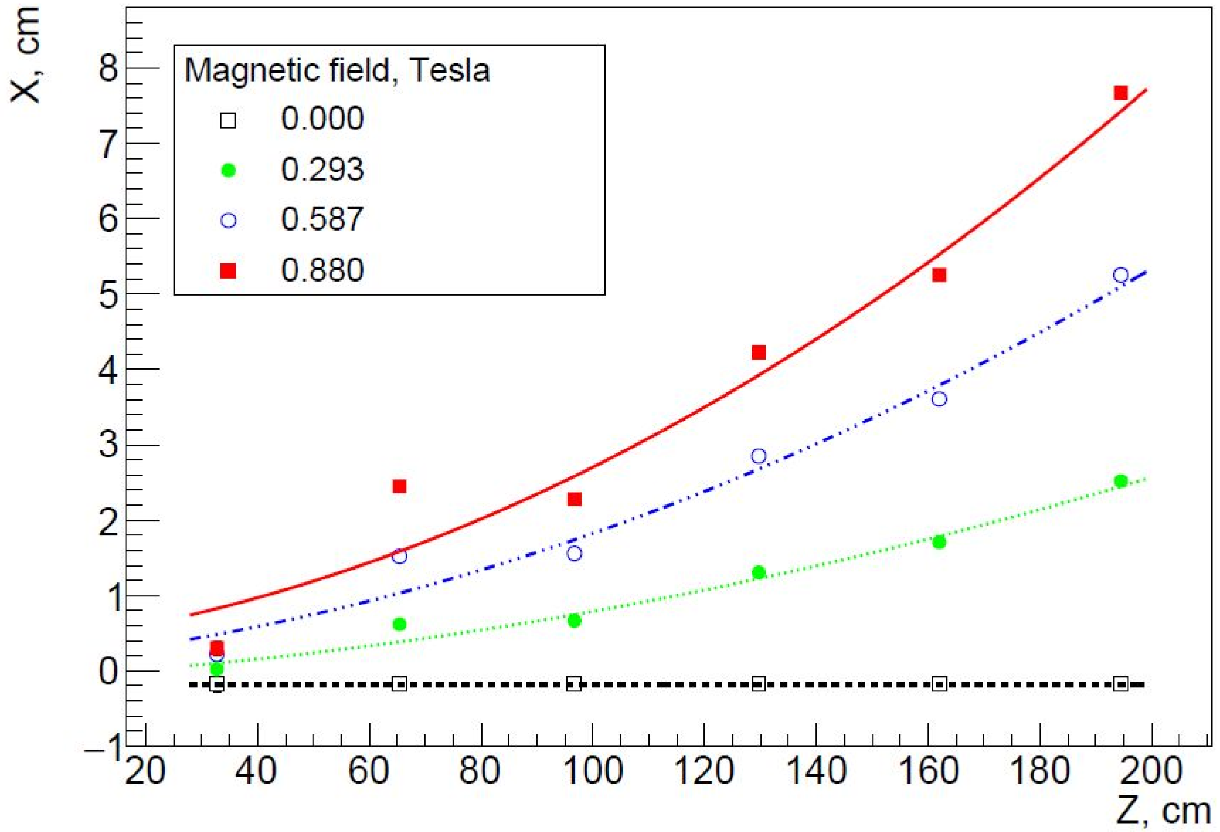
GEM position from target: 51-86-116-151-181-216 cm

GEM hit residuals without mag. field



- ✓ X residual of 2-nd station for straight lines (tracks) defined by hit combinations on stations 1 and 3.
- ✓ An assumption of the same resolution of all three stations leads from the 156 um residual to σ = 127 um resolution. ($\sigma_x = \sigma_\Delta / \sqrt{1.5} = 156/\sqrt{1.5} = 127$ um)

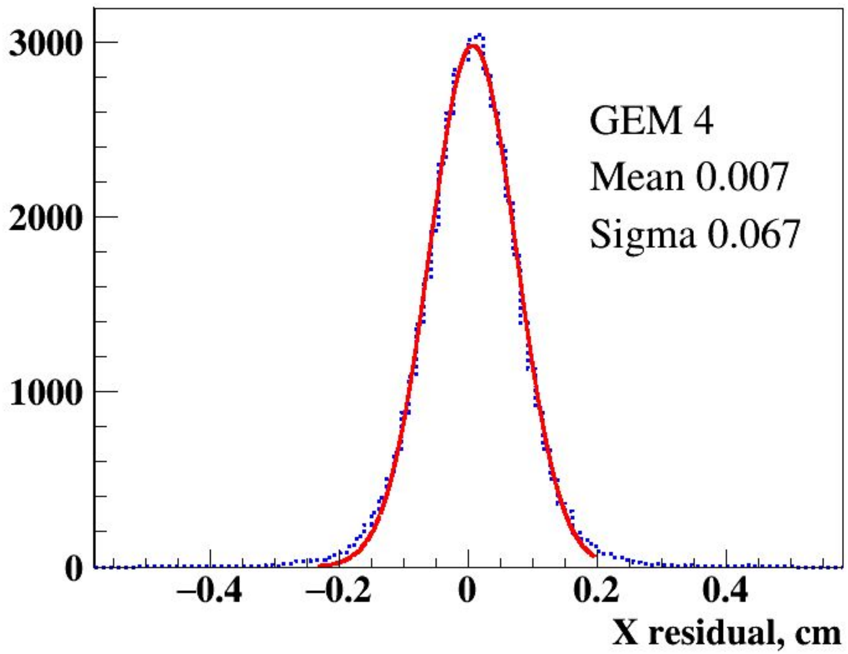
Beam trajectory in GEM detectors



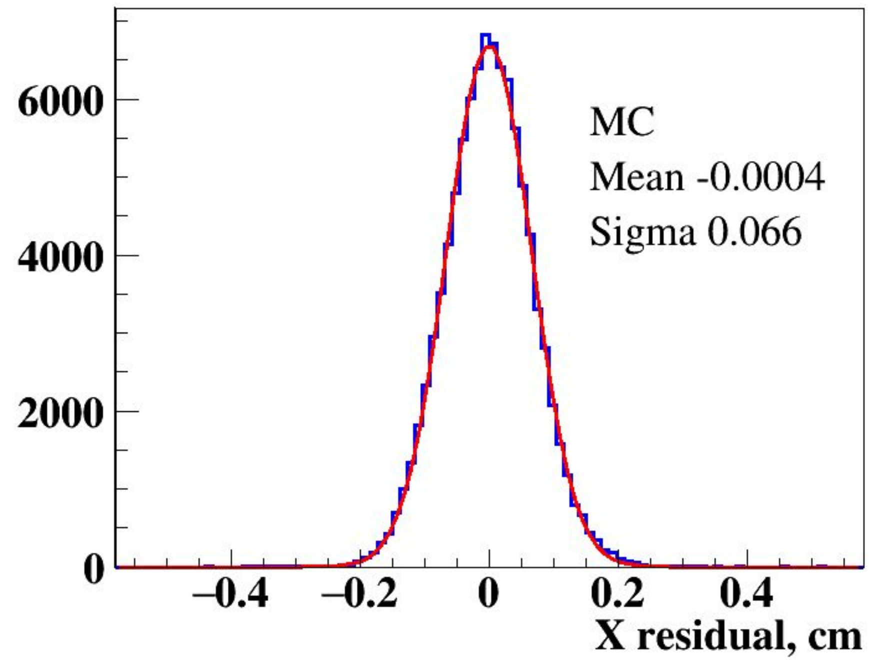
✓ Averaged positions of deuteron beam with $E_{kin} = 4$ AGeV reconstructed in 6 GEM planes at different values of magnetic field.

✓ Opposite electric field direction in consecutive GEM planes.

GEM hit residuals in mag. Field 0.79 T



GEM hit residuals for exp. data.

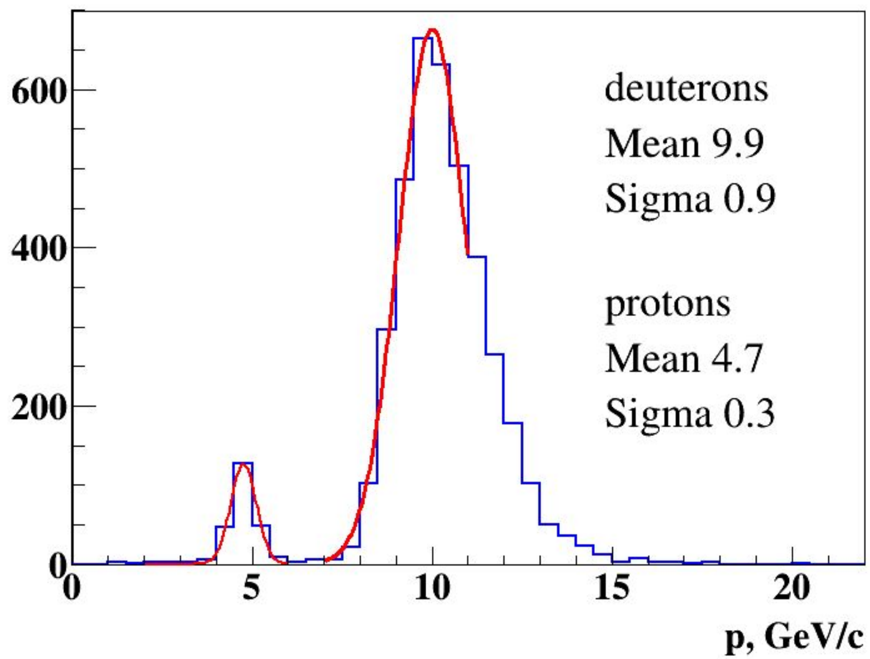


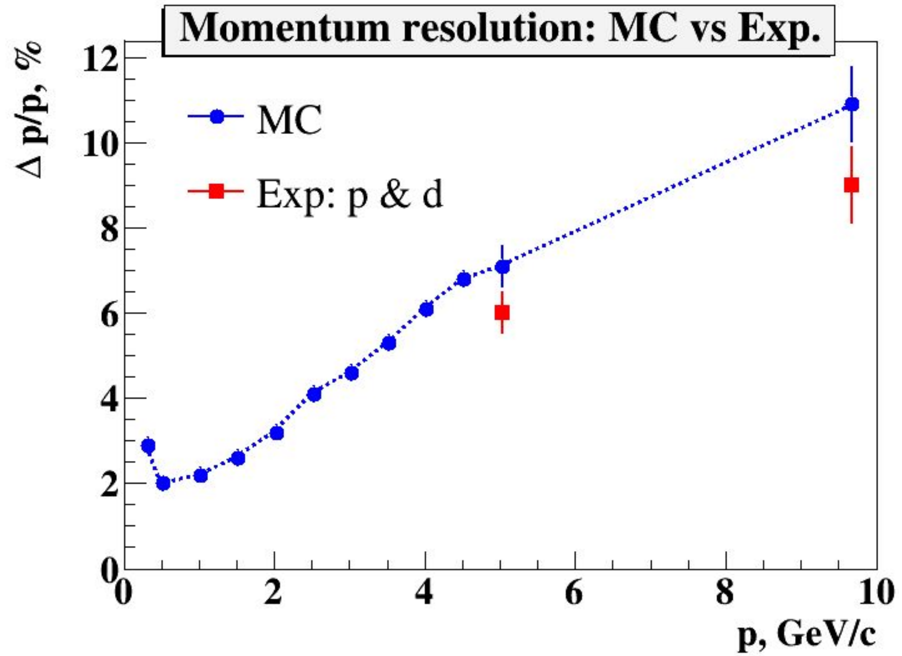
GEM hit residuals for MC simulation with Garfield parametrization.

Mag. field 0.79 T

Gas mixture Ar+ Isobuthan

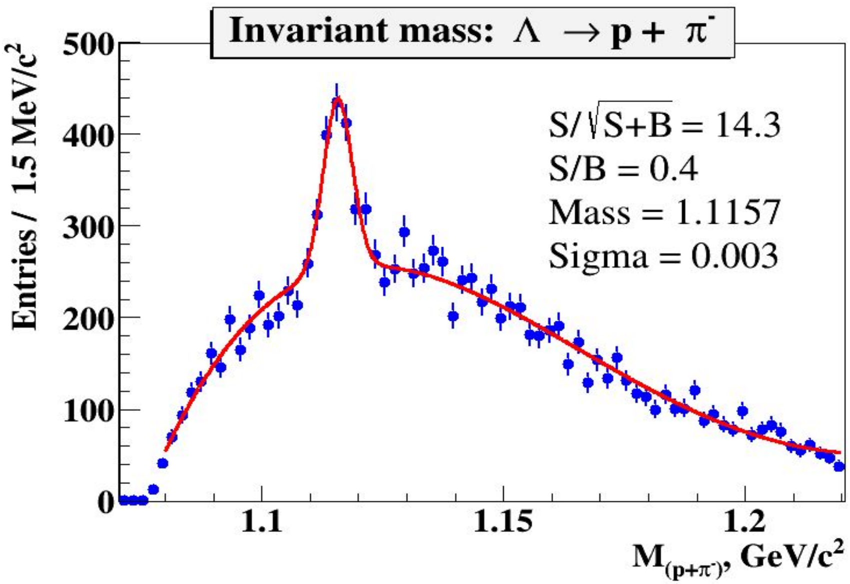
Momentum resolution: Exp. vs MC

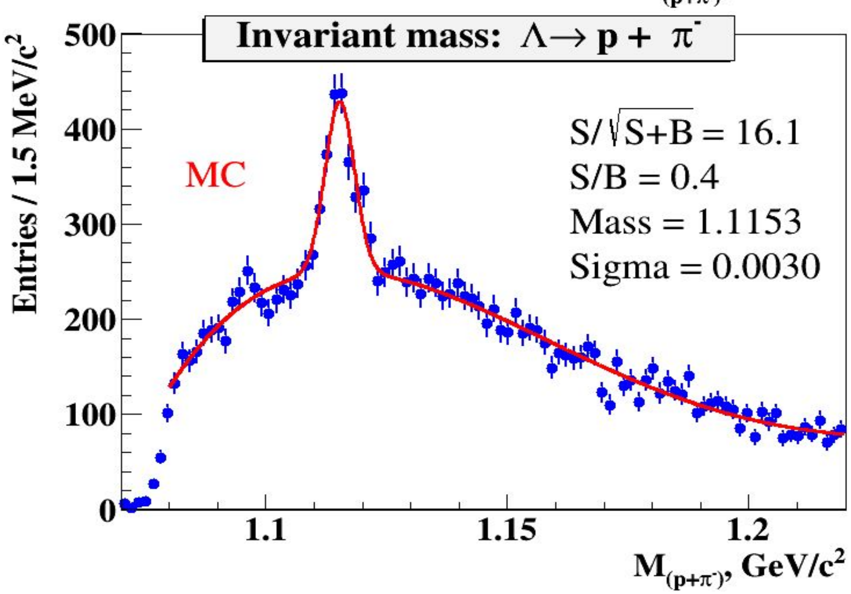




- ✓ Momentum resolution for deuteron beam of 9.7 GeV/c ~9%.
- ✓ Momentum resolution for proton spectators with momentum of 4.85 GeV ~6%.
- ✓ Momentum resolution from MC as function of particle momentum.
- ✓ MC results reproduce exp. data for spectator protons and deuteron beam.

Λ reconstruction (d + Cu, C, CH_2)





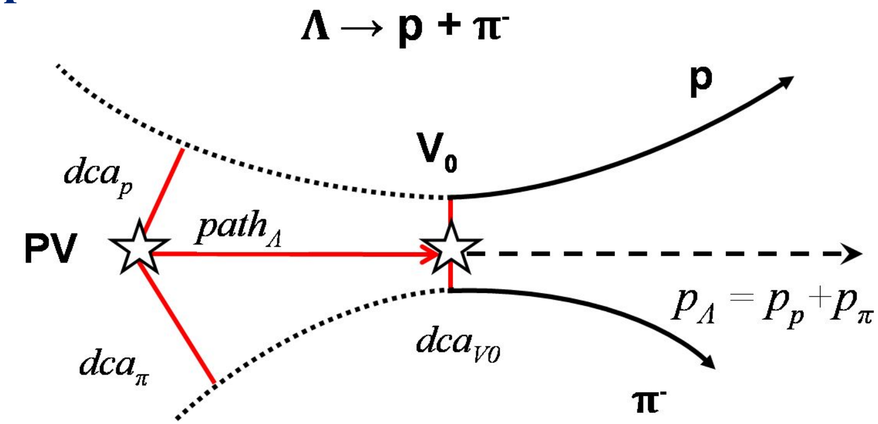
Signal event topology defined selection criteria:

✓ relatively large distance of closest approach (DCA) to primary vertex of decay products

✓ small track-to-track separation in decay vertex

✓ relatively large decay length of mother particle

Λ signal width of 3 MeV and background level is reproduced by MC simulation.



Event topology:

✓ PV – primary vertex

✓ V_0 – vertex of hyperon decay

✓ dca – distance of the closest approach

✓ path – decay length

Summary and next plans

✓ BM@N experiment is in starting phase of its operation and has recorded first experimental data with deuteron beam of 4 AGeV.

✓ Minimum bias interactions of deuteron beam with different targets were analyzed with aim to reconstruct tracks, primary and secondary vertexes using central GEM tracking detectors.

✓ Spatial, momentum and primary vertex resolution of GEM tracker are reproduced by Monte Carlo simulation.

✓ Signal of Λ-hyperon is reconstructed in proton-pion invariant mass spectrum.

✓ To improve vertex and momentum resolution and reduce background under Λ-hyperon signal, additional planes of GEM detectors and a set of silicon detectors in front of GEM tracking detectors will be implemented.

✓ BM@N set-up will extend continuously to adapt its performance for measurements of interactions of heavier ion beams with targets.

Thank you
for attention!

Backup slides

K_s^0 simulation: MC-2015 vs MC-2017

MC-2015	**MC-2017**
DCM model (minbias events)	DCM model (minbias events)
C+C interactions	d+C interactions
E_{kin} = 4 AGeV	E_{kin} = 4 AGeV
0.5 M events	1 M events
GEM position from target: 30-45-60-80-100-130 cm	GEM position from target: 51-86-116-151-181-216 cm
K_s^0: 28229 (gen) / 2500 (rec)	K_s^0: 19020 (gen) / 167 (rec)
Eff. Rec. = **8.9%**	Eff. Rec. = **0.8%**
Magnetic field B = **0.44** T	Magnetic field B = **0.7** T

Λ simulation: MC-2015 vs MC-2017

MC-2015	**MC-2017**
DCM model (minbias events)	DCM model (minbias events)
C+C interactions	d+C interactions
E_{kin} = 4 AGeV	E_{kin} = 4 AGeV
0.1 M events	1 M events
GEM position from target: 30-45-60-80-100-130 cm	GEM position from target: 51-86-116-151-181-216 cm
Λ: 11933 (gen) / 2359 (rec)	Λ: 43432 (gen) / 1832 (rec)
Eff. Rec.= **19.8%**	Eff. Rec.= **4.2%**
Magnetic field B = **0.44** T	Magnetic field B = **0.7** T