Joint Institute for Nuclear Research
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Current status of event reconstruction and data analysis at BM@N experiment

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for the BM@N collaboration

VBLHEP, JINR, Dubna, Russia

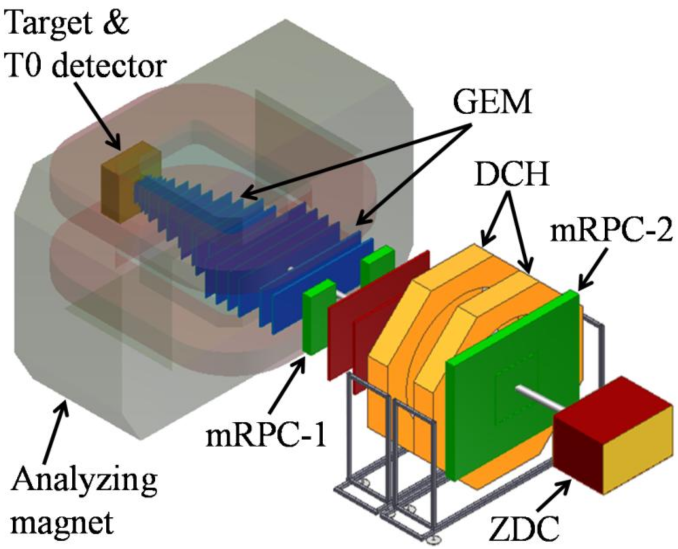
BM@N collaboration meeting

29-30 October 2018

Outline

1. NICA complex & BM@N experiment
2. Technical run with C beam (March 2017)
   - ✓ BM@N detector set-up
   - ✓ Λ & K_s^0 reconstruction
   - ✓ Experiment vs MC
3. Run with Ar & Kr beams (March 2018)
   - ✓ BM@N detector set-up
   - ✓ PV & Λ reconstruction
4. Summary & Plans

Detector geometry



BM@N setup:

✓ Central tracker (GEM+Si) inside analyzing magnet to reconstruct AA interactions

✓ Outer tracker (DCH, CSC) 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

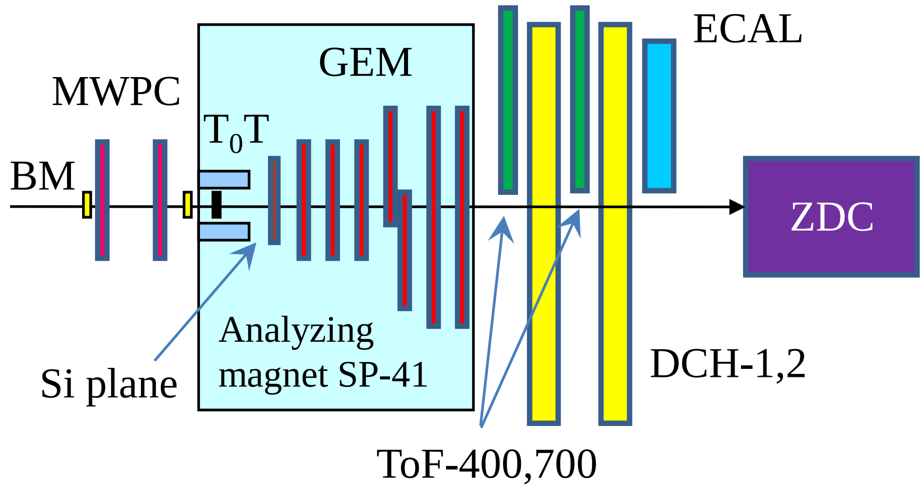
→ divide detectors for particle identification to "near to magnet" and "far from magnet" to measure particles with low as well as high momentum (p > 1-2 GeV/c)

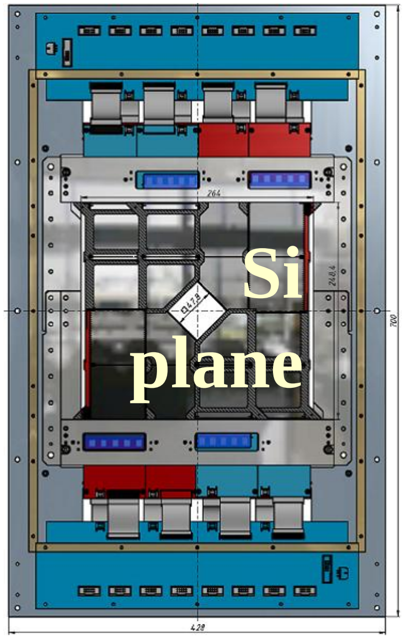
→ fill distance between magnet and "far" detectors with coordinate detectors

BM@N set-up in March 2017

Deuteron beam: T_0= 3.5, 4.0 GeV/n

Carbon beam: T_0= 3.5, 4.0, 4.5, (5.14) GeV/n





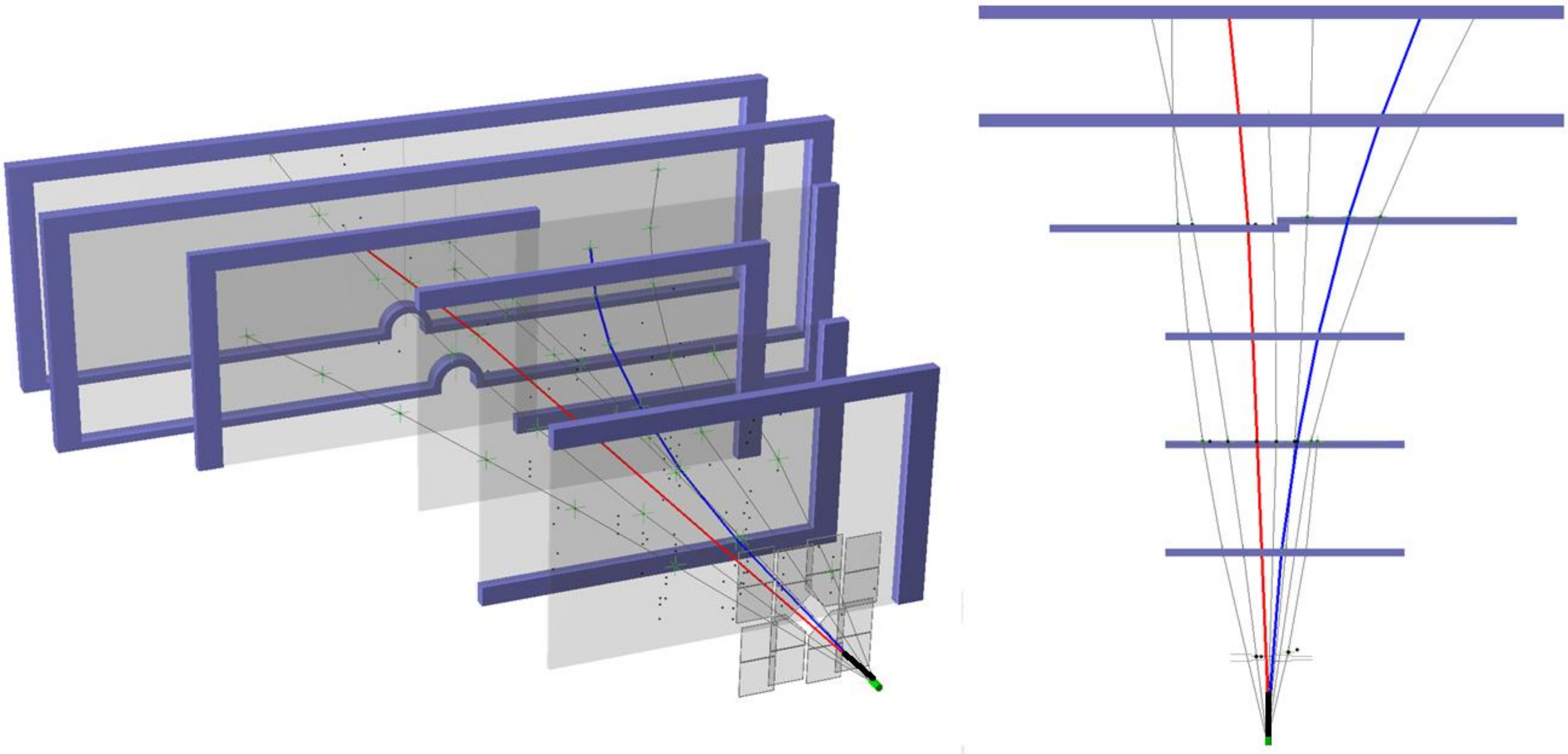
✓ Focus on tests and commissioning of central tracker inside analyzing magnet → 5 GEM detectors 66 x 41cm^2 + 2 GEM detectors 163 x 45 cm^2 and 1 plane of Si detector for tracking (2-coordinate Si detector X-X'(±2.5^o) with strip pitch of 95/103 μm, full size of 25 x 25 cm^2)

Program:

✓ Trace beam through detectors, align detectors, measure beam momentum in mag. field of 0.6 T

✓ Measure inelastic reactions C + target → X with carbon beam energies of 3.5 - 4.6 GeV/n on targets C, Al, Cu, Pb

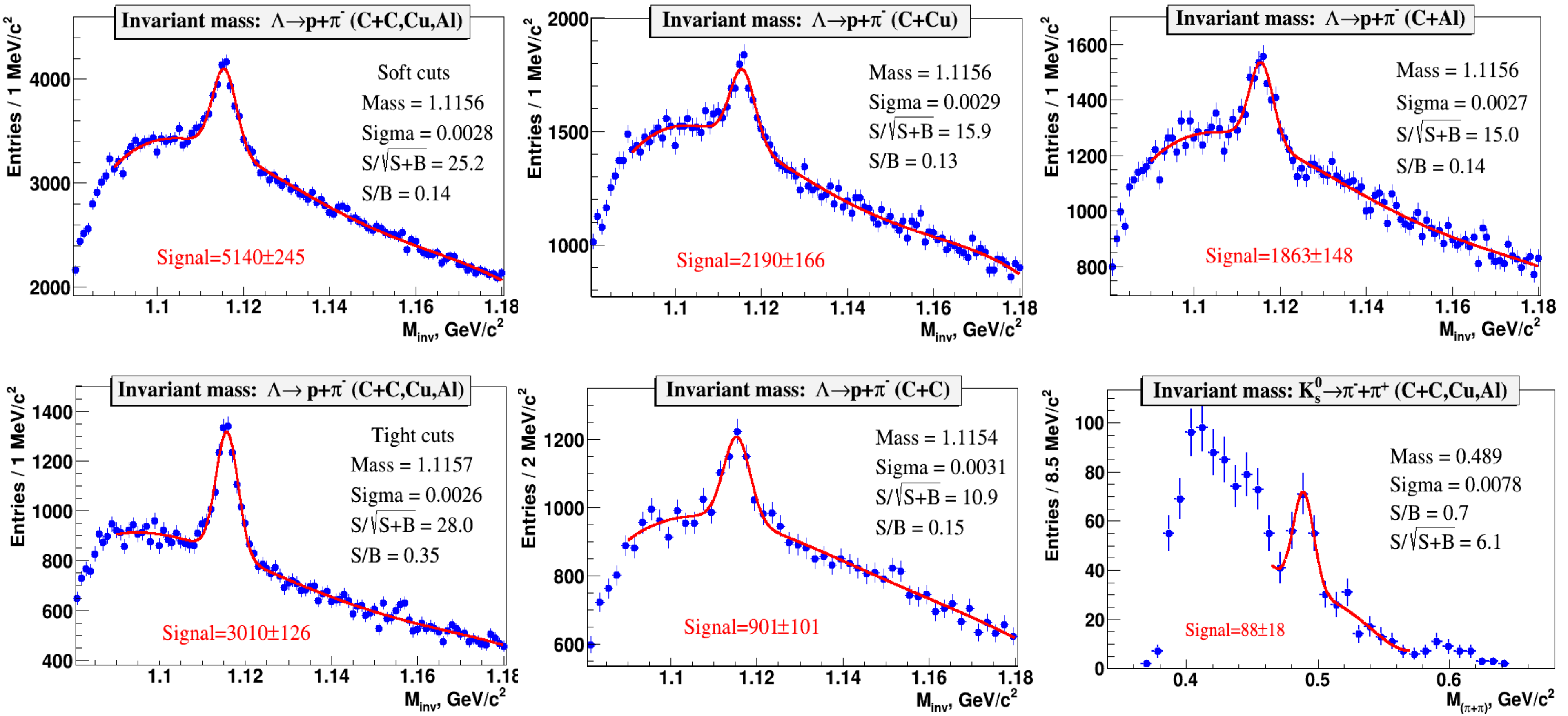
Visualization of Λ decay



Event Display: Example of the Λ decay reconstruction in the tracker (GEM + Si) in C+C interaction.

Λ & K^0_s reconstruction in carbon run

Beam /Target: C/C,Al,Cu; E_{kin} = 4.0A GeV, No PID, only GEM+Si

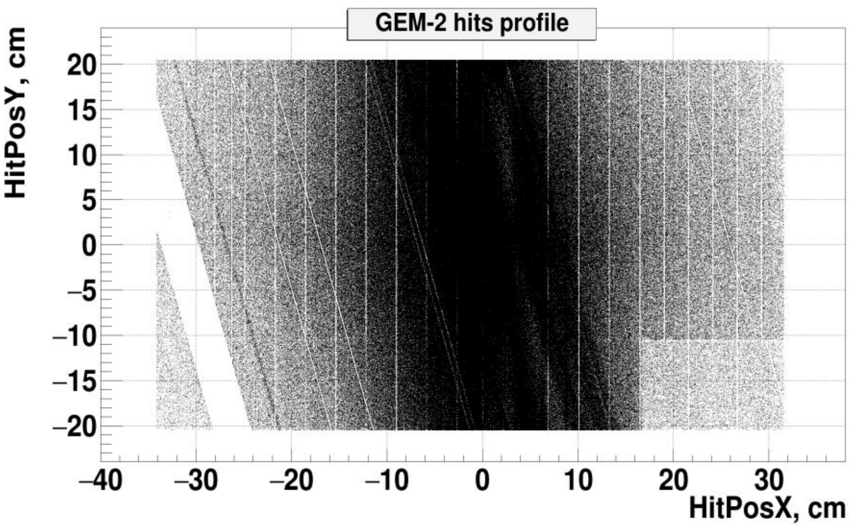


Since the GEM tracker configuration was tuned to measure relatively high-momentum beam particles, the geometric acceptance for relatively soft decay products of strange V0 particles was rather low. The Monte Carlo simulation showed that only **~4%** of Λ and **~0.8%** of K_s^0 could be reconstructed.

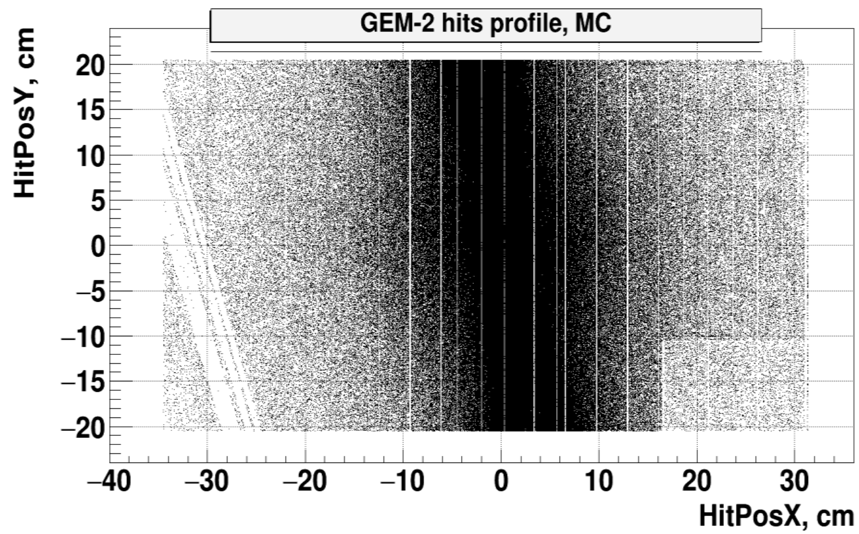
Comparison of data and MC

Number hits in GEM

Realistic geometry of GEM detectors



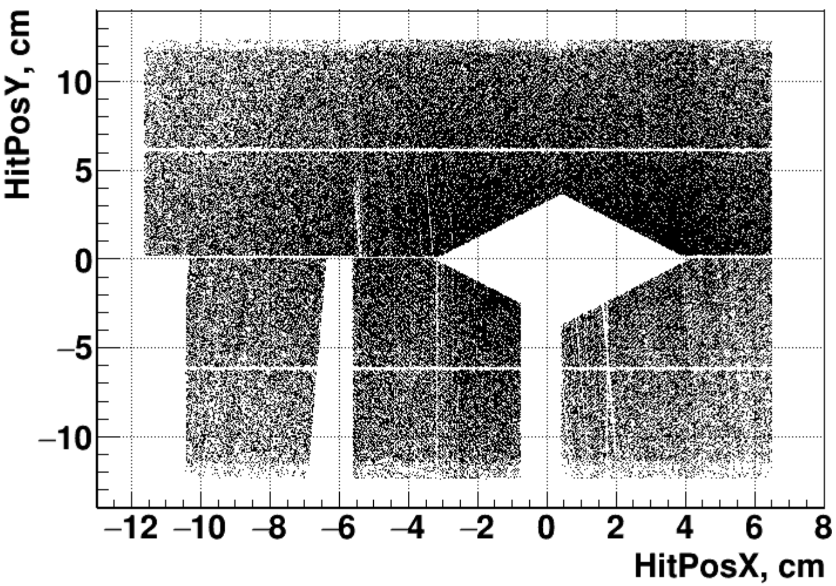
GEM 2, Exp.



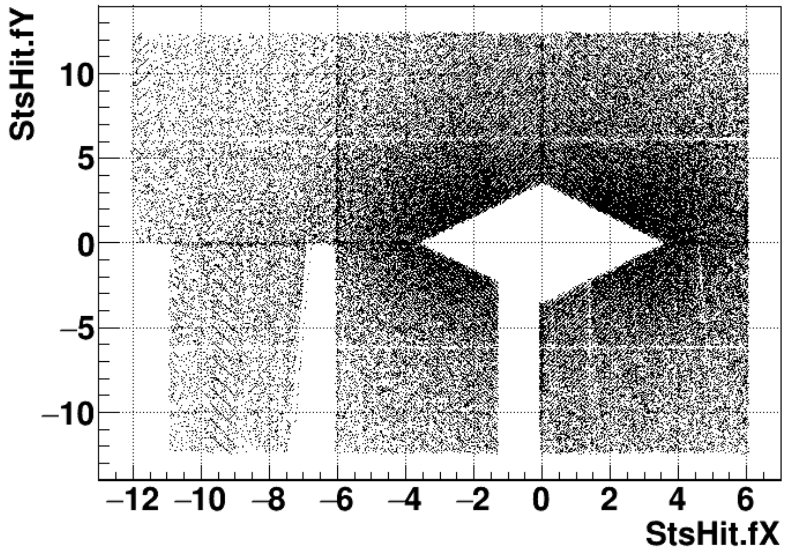
GEM 2, MC

Number of hits in Si

Realistic geometry of Si detectors

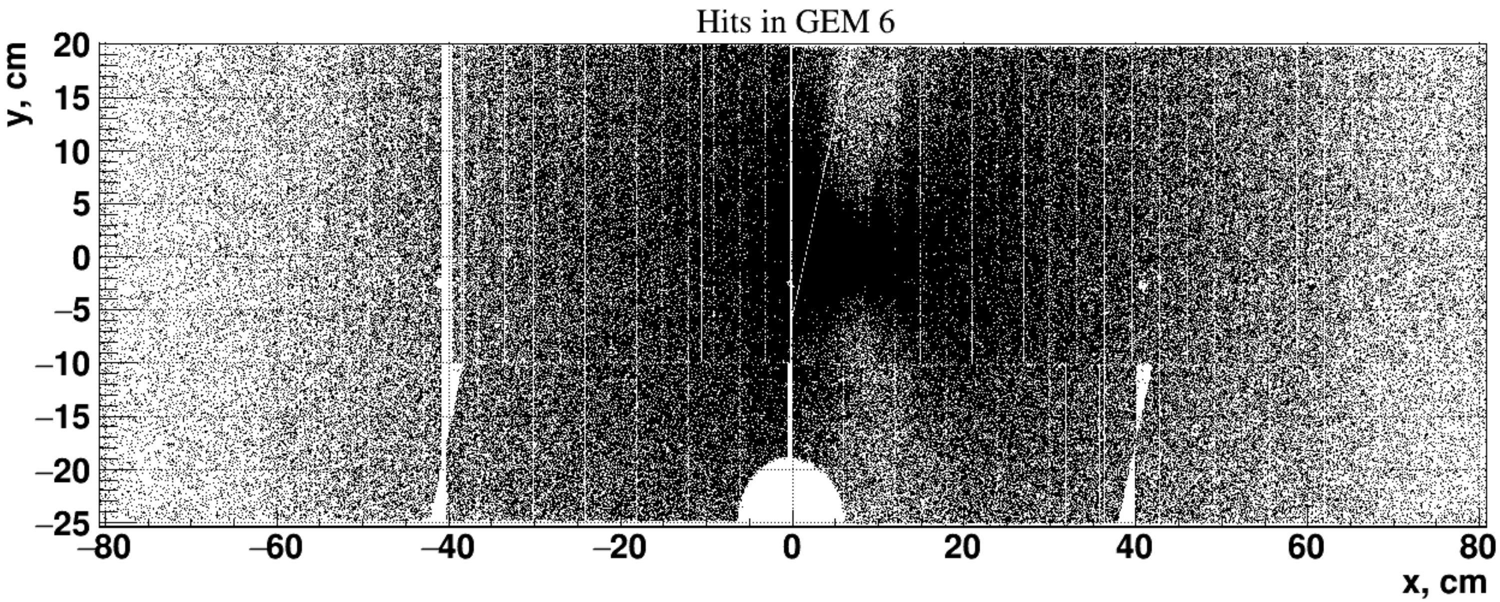


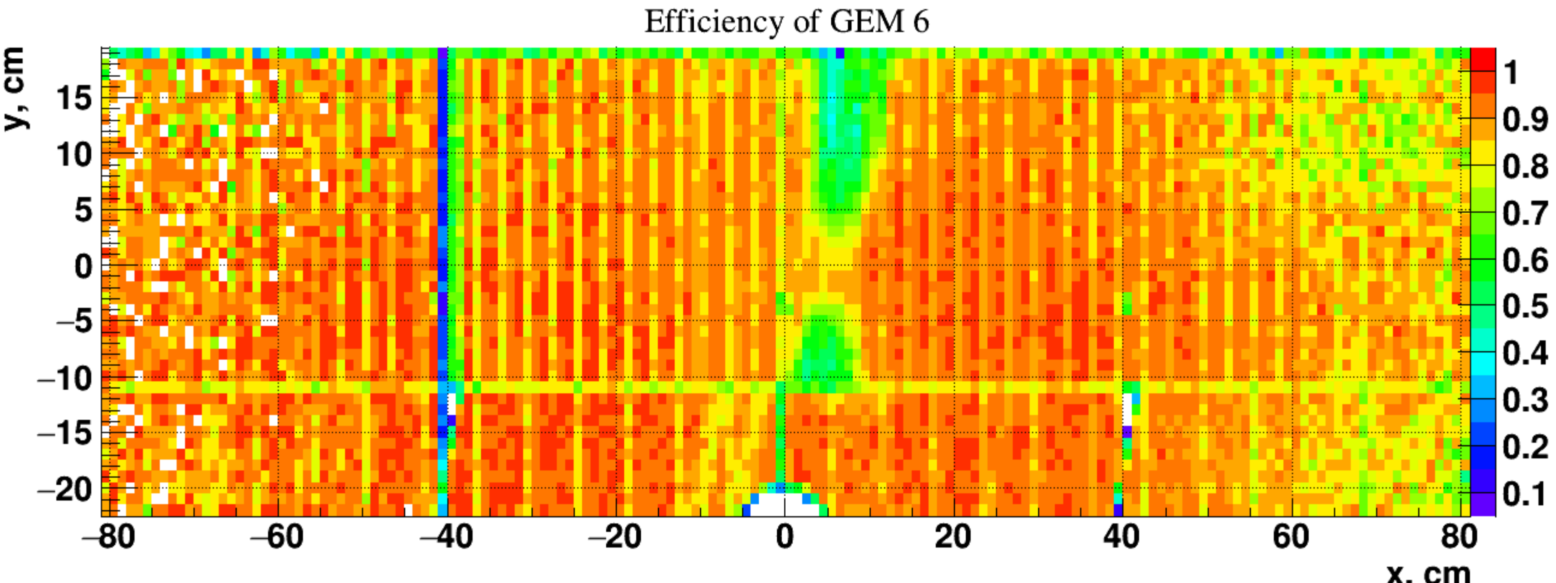
Experiment



MC

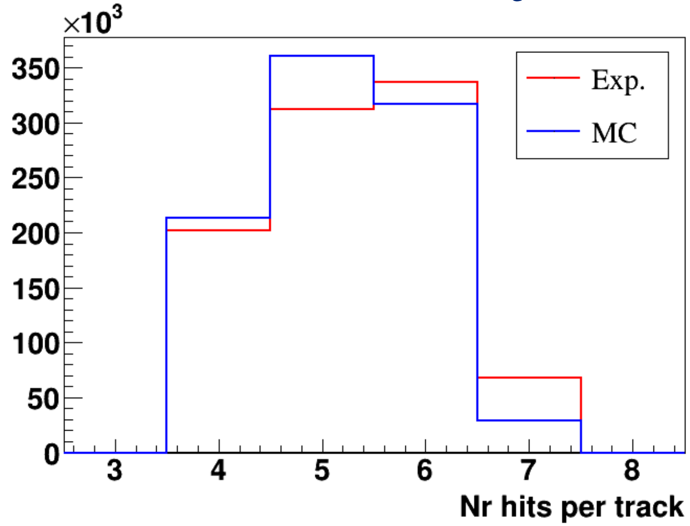
GEM efficiency calculation

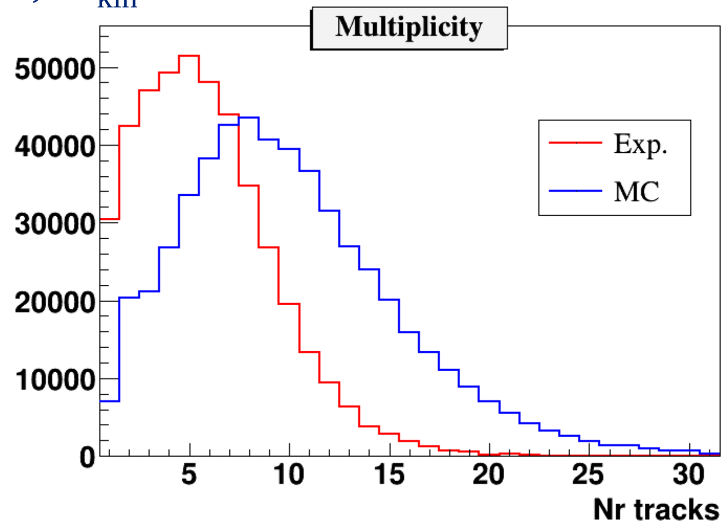




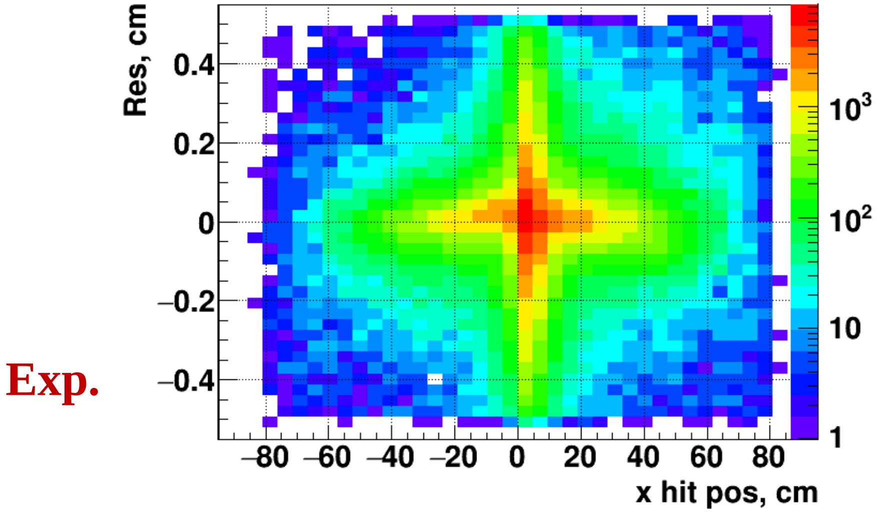
Multiplicity, hits & residuals

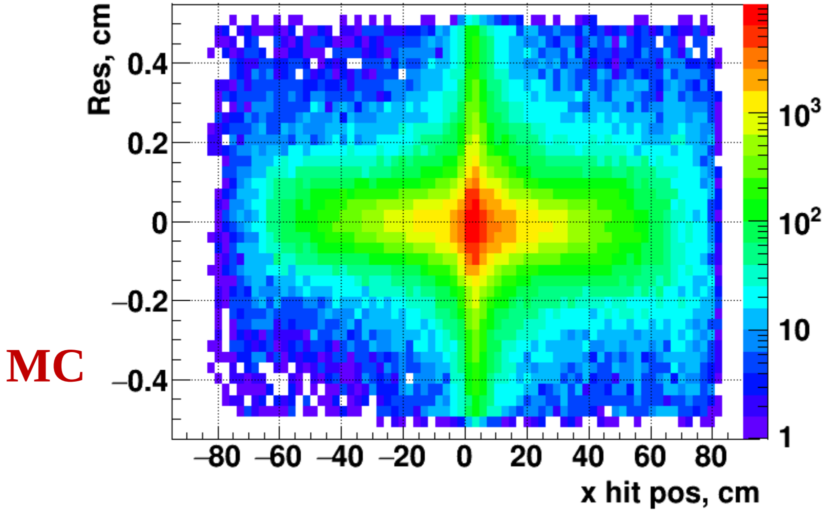
Data & QGSM model: C+Al, E_{kin}=4A GeV





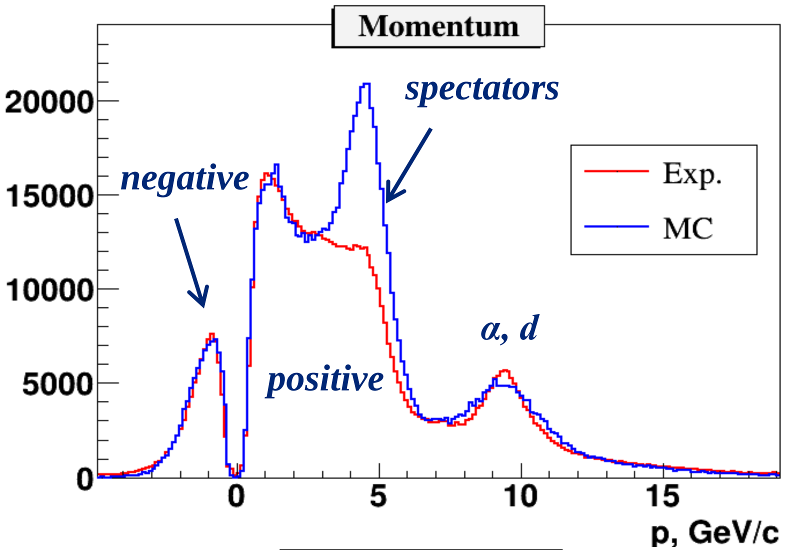
Residuals in GEM detectors:

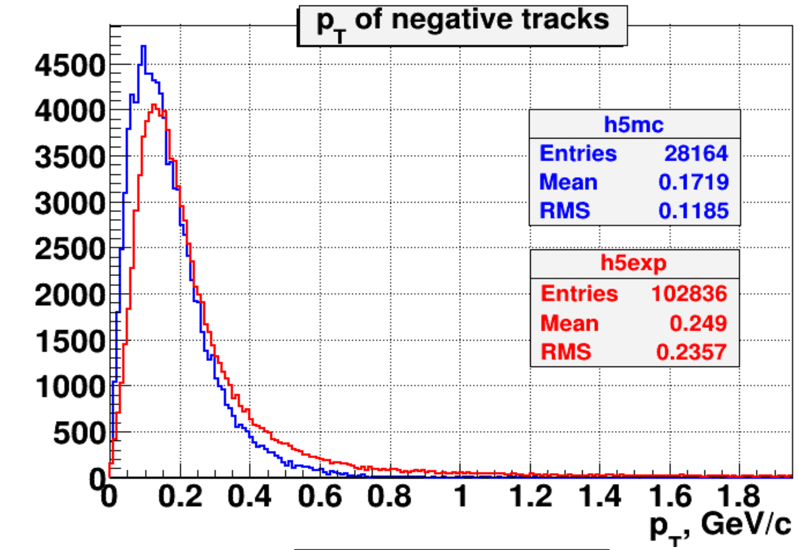


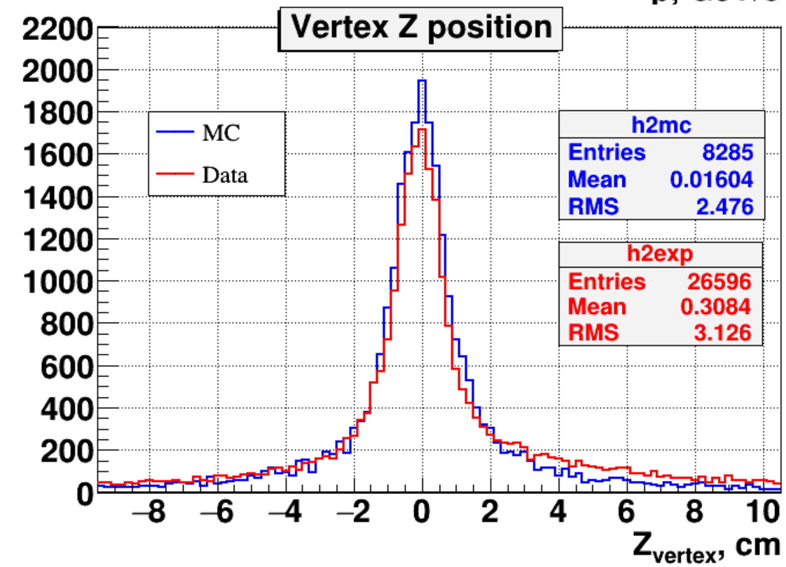


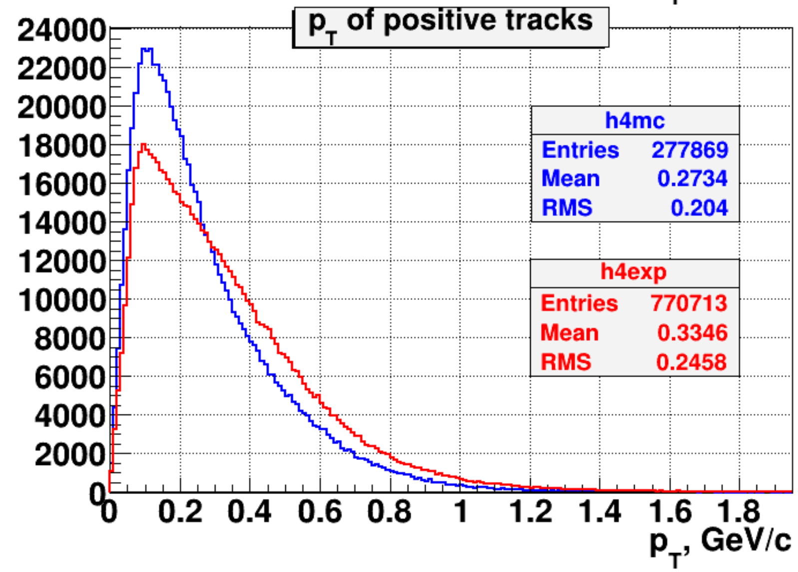
Momentum & PV

Data & QGSM model: C+Al, E_{kin}=4A GeV

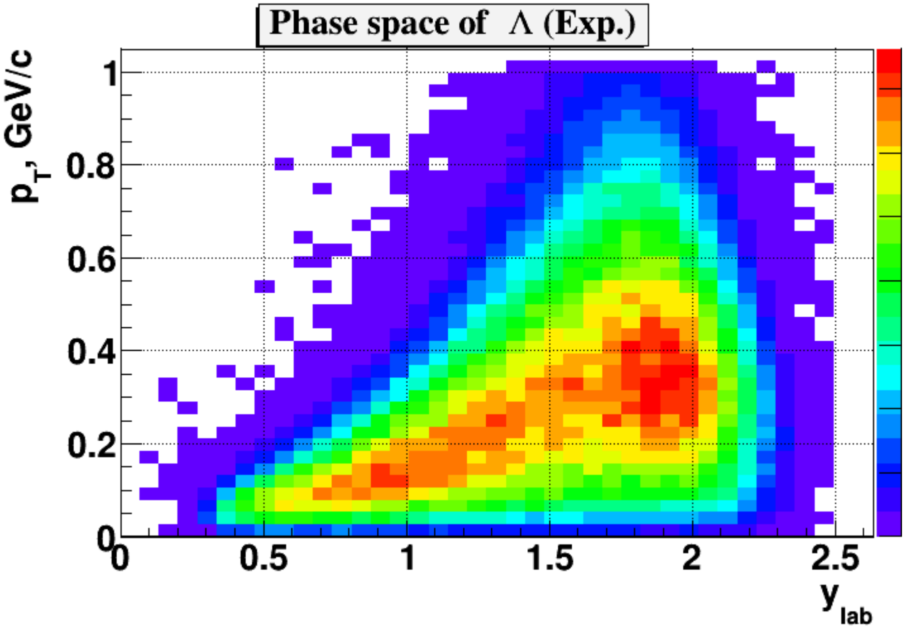




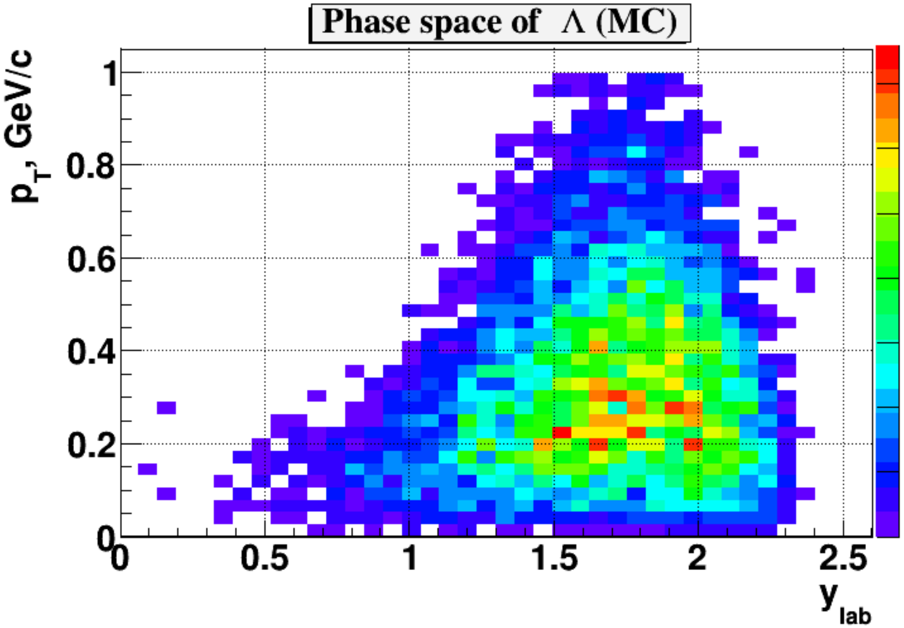




Phase space of Λ

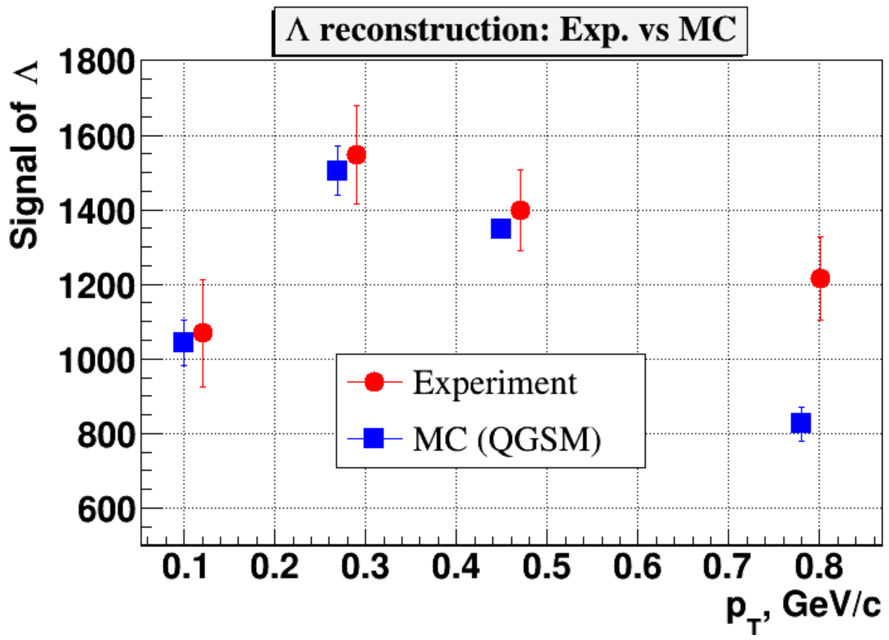


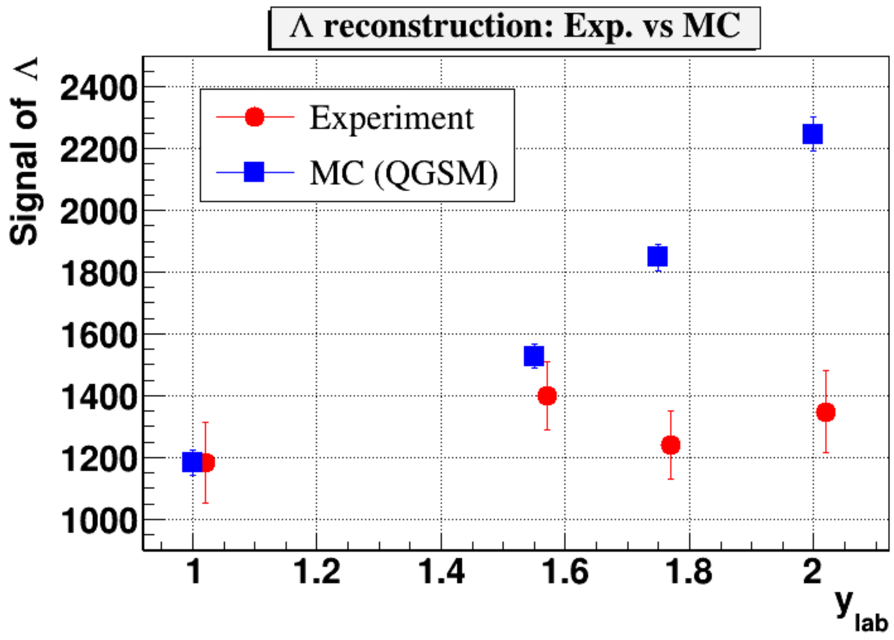
Experiment



MC

Λ: pT & y_{lab} dependence



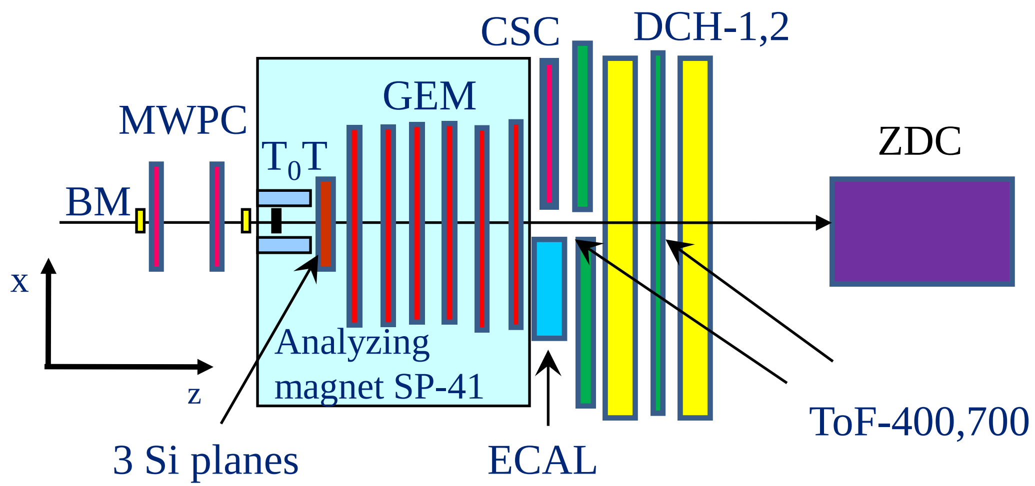


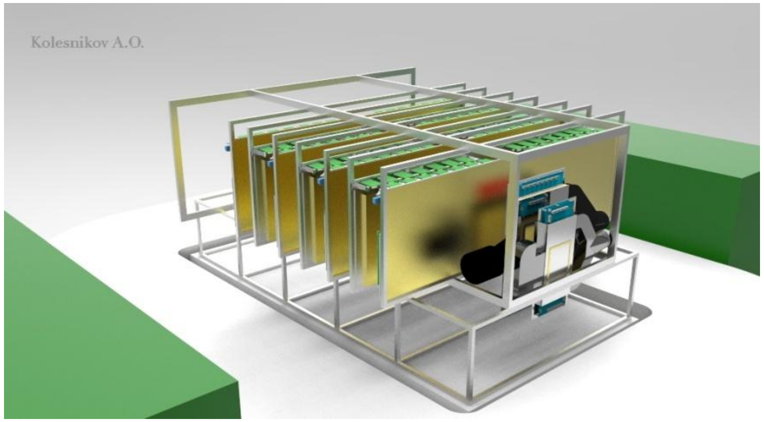
Ar & Kr run in March 2018

BM@N set-up

BM@N run with Ar and Kr beams:

Ar beam, T_0= 3.2 GeV/n
Kr beam, T_0= 2.4 (3.0) GeV/n





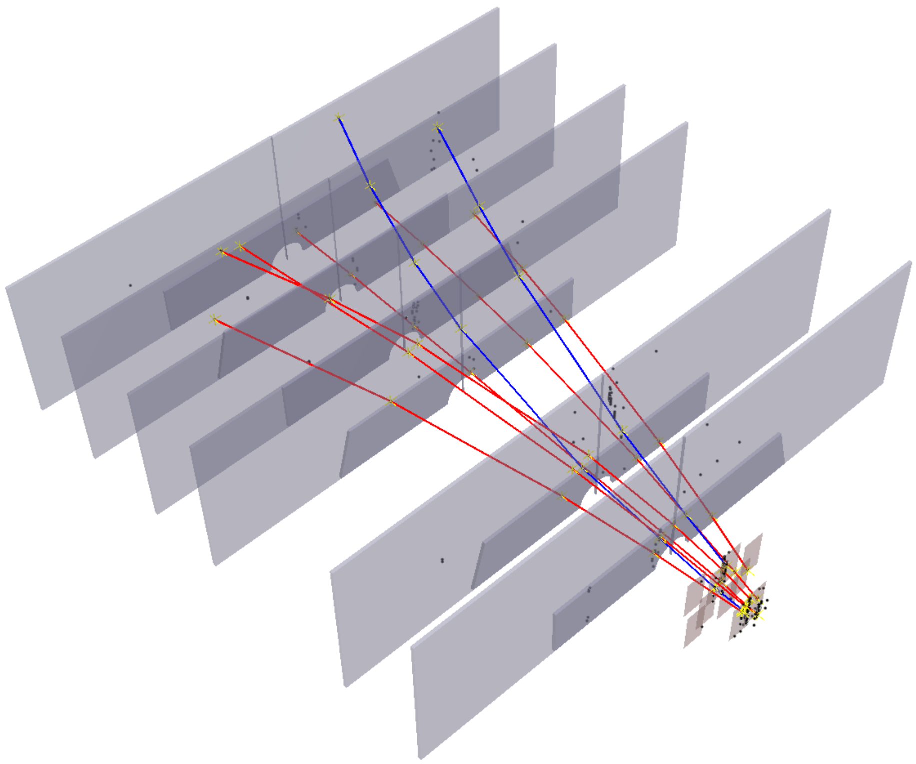
Central Tracker:

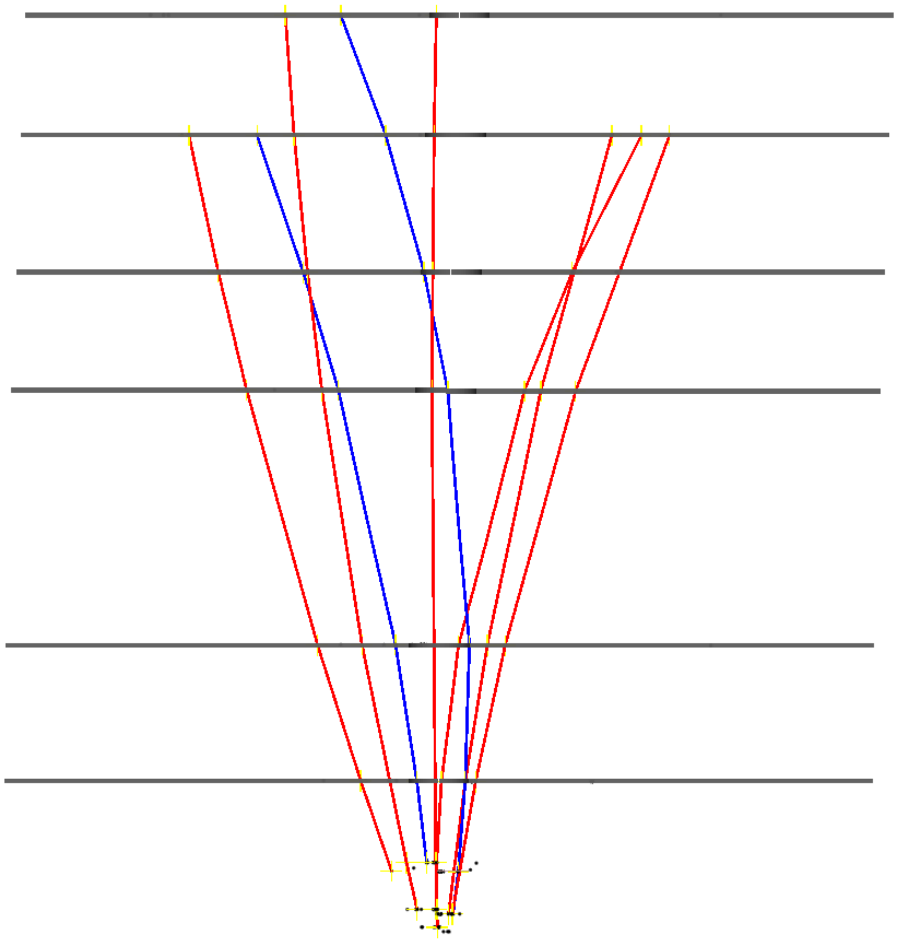
6 planes of big GEM detectors
3 planes of Si detector in front of GEMs
Beam crosses Si detectors in center, big GEMs – in beam hole
→ configuration is based on results of Λ and K^0_S simulation

- 2-coordinate Si detector with strip pitch of 95/103 µm, full size of 25 x 25 cm^2
- Detector combined from 4 sub-detectors arranged around beam

+ 2 smaller vertex detectors

Event reconstruction

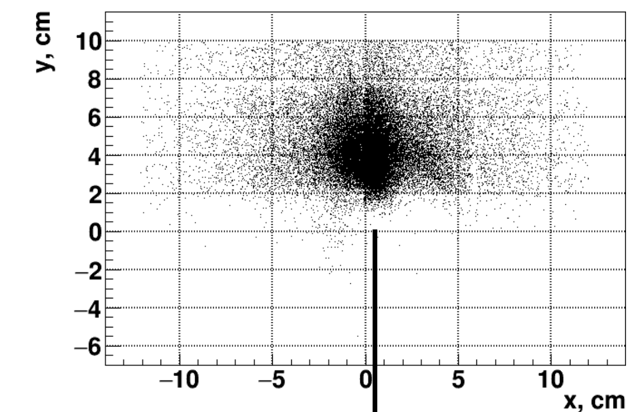




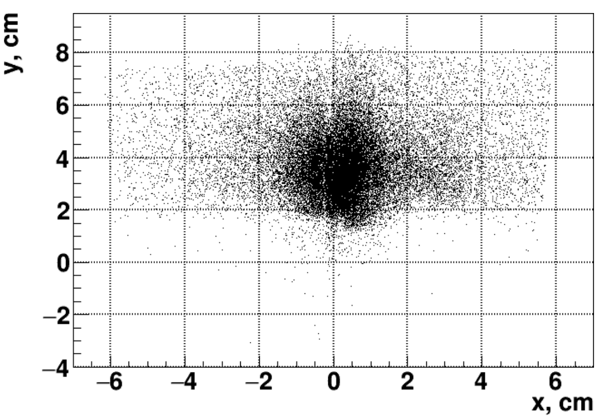
Event Display: Example of event reconstruction in the central tracker (GEM + Si) in Ar+Al interaction.

Tracks in Si and GEM detectors

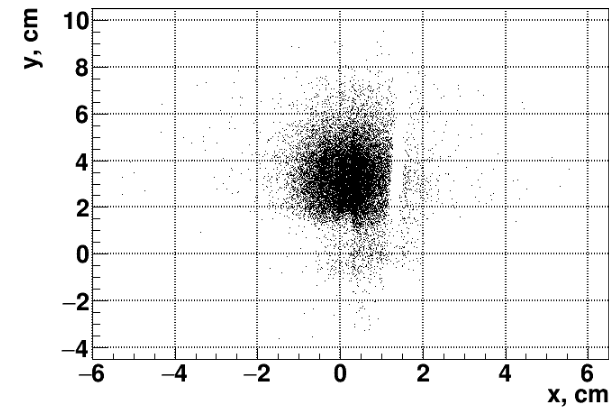
Si-3 track profile

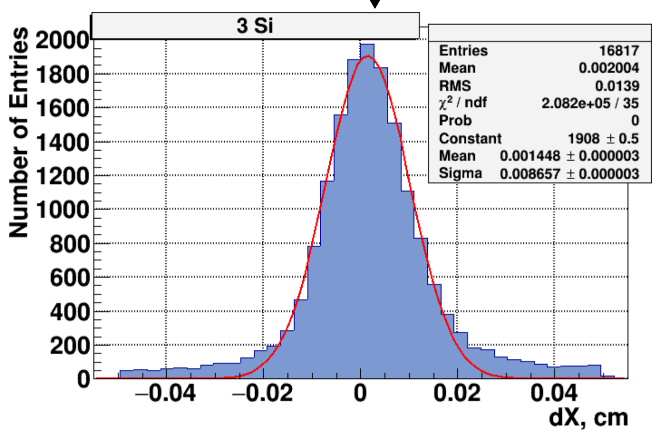


Si-2 track profile

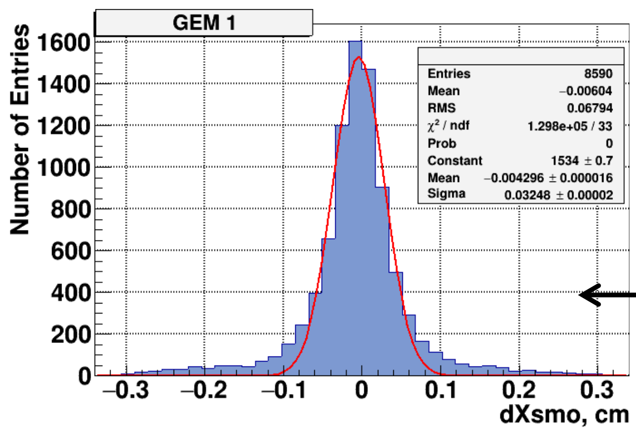


Si-1 track profile

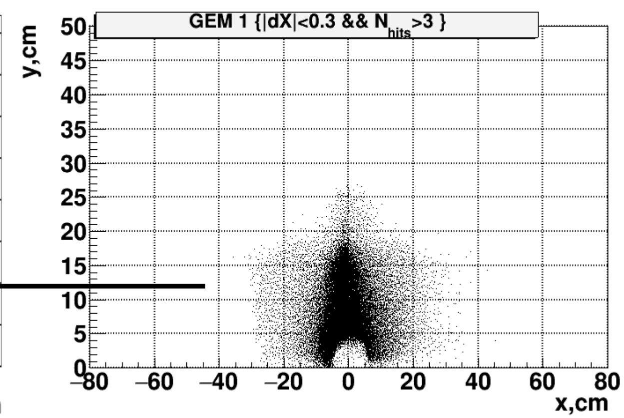




Si-3 detector residual vs GEM+Si track ~ 86 μm

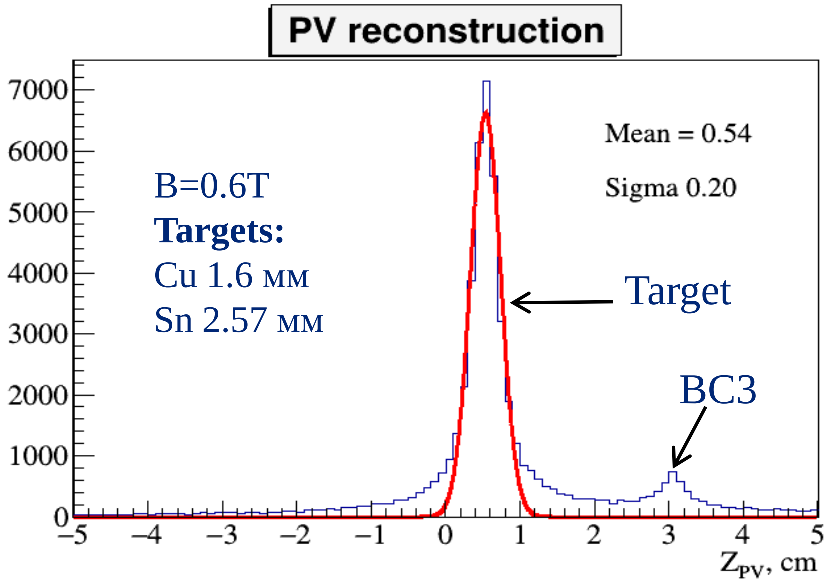


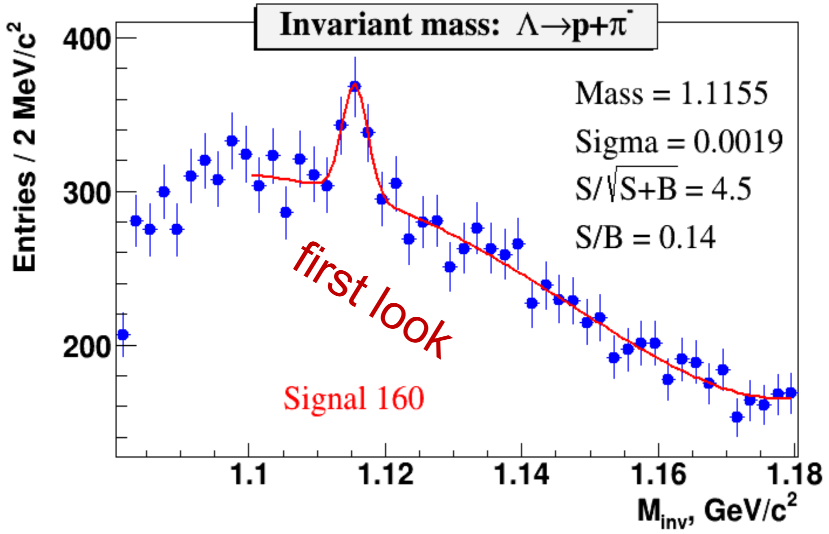
GEM-1 detector residual vs GEM+Si track ~ 320 μm



GEM-1 track profile

Λ & PV reconstruction in argon run

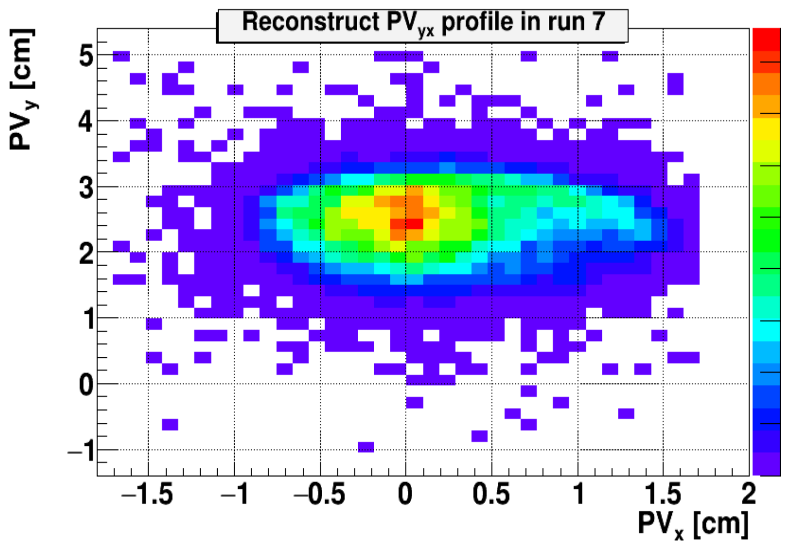




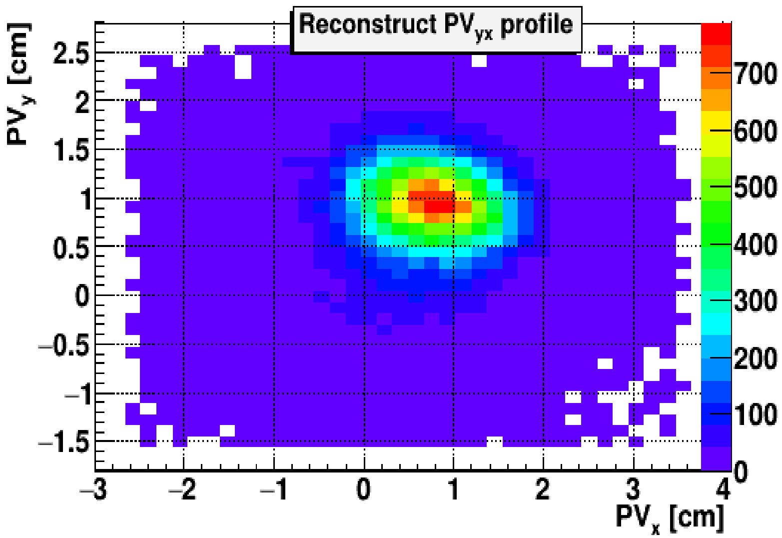
Reconstructed Primary Vertex along the beam (Sigma comparable with target thickness)

Reconstructed $p\pi^-$ –invariant mass spectrum

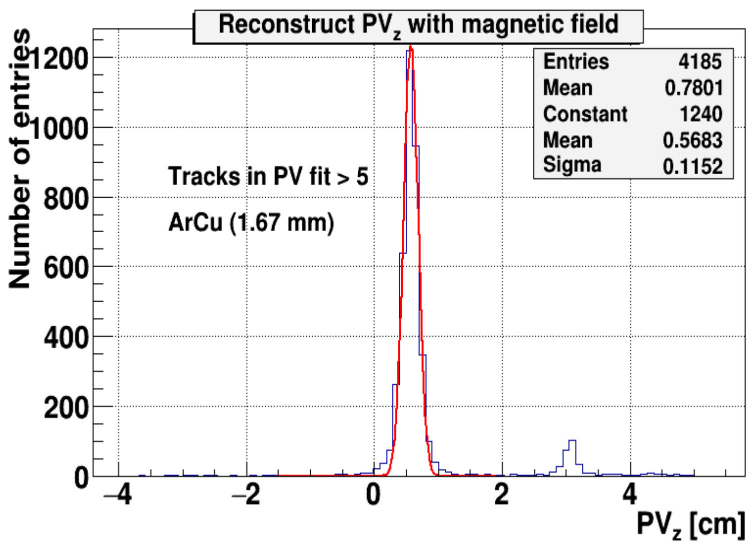
Vertex: Ar run vs Carbon run



Beam in Ar run ~1.8 cm higher in Y and has tail in X



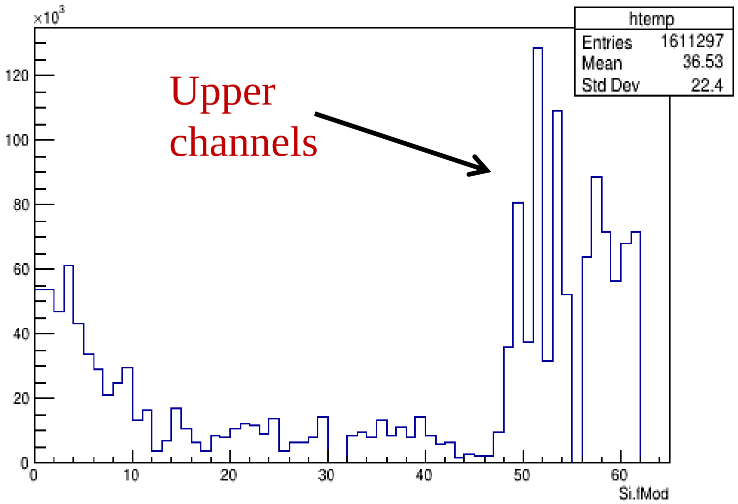
Compare with vertex in Carbon run in March 2017



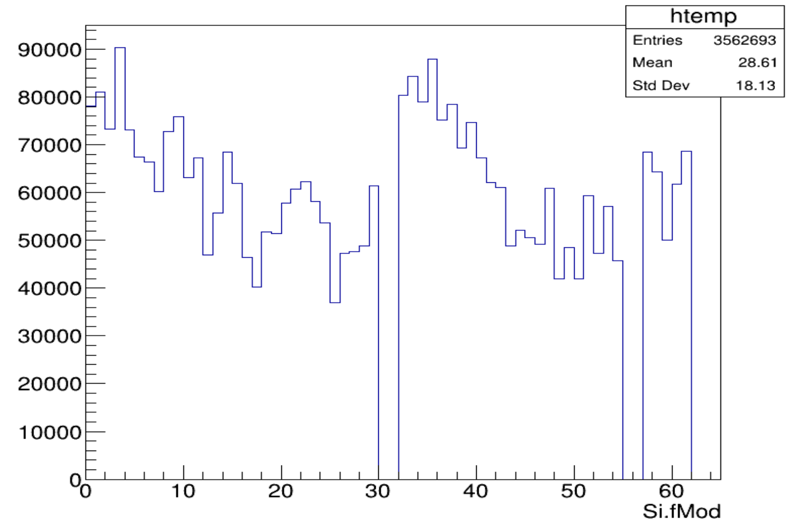
PV reconstruction in high multiplicity events

Si trigger performance in Ar & Kr runs

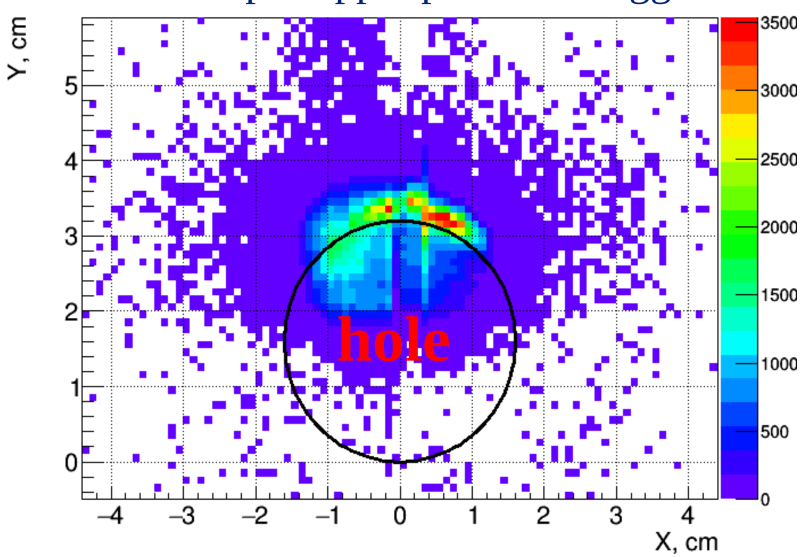
Si trigger detector profile, Ar run



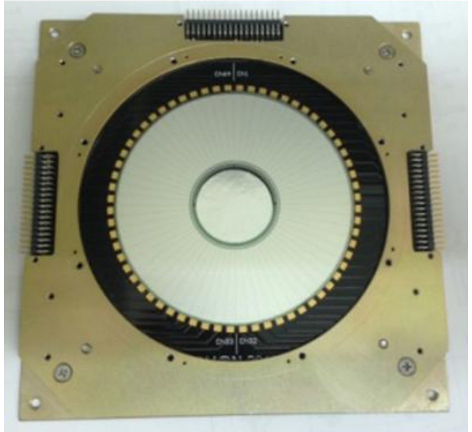
Si trigger detector profile, Kr run



Beam scrapes upper part of Si trigger detector



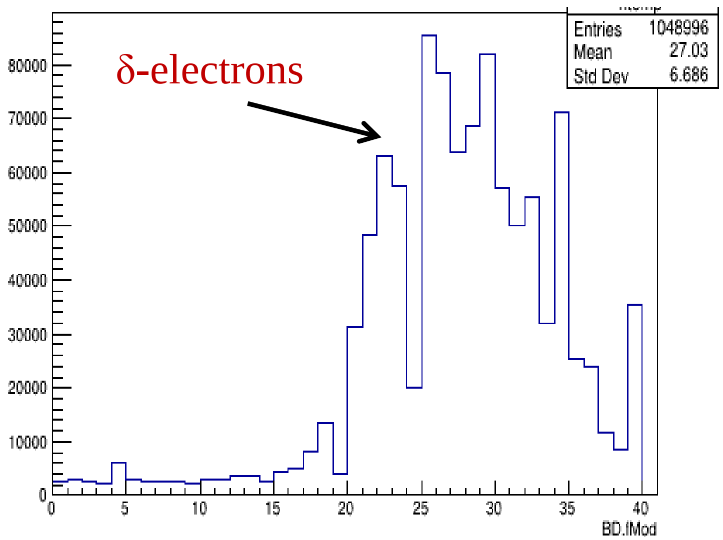
Si trigger detector



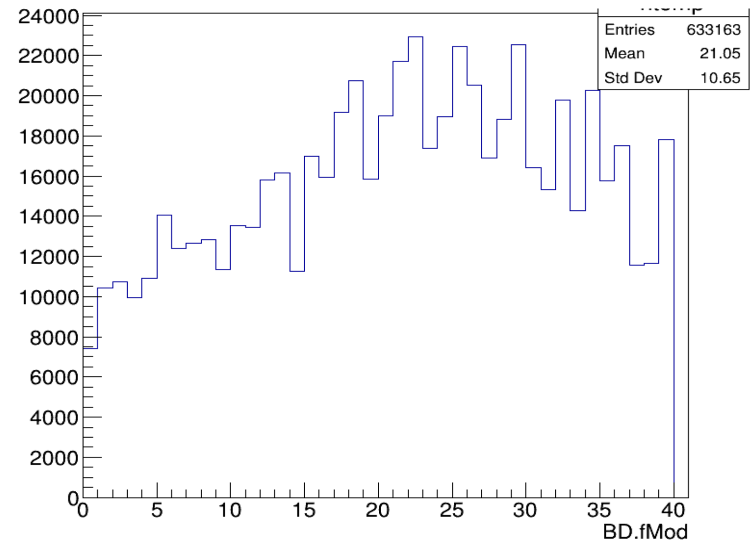
- Adjusted beam position in Kr run

Barrel detector trigger performance

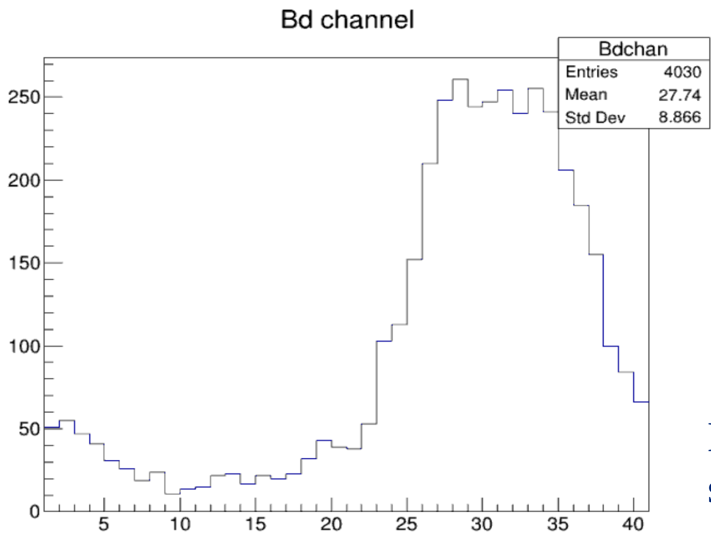
BD trigger detector profile, Ar run



BD trigger detector profile, Kr run



- ➢ Implementation of 4 mm Pb shielding inside BD cylinder diminished δ-electron rate



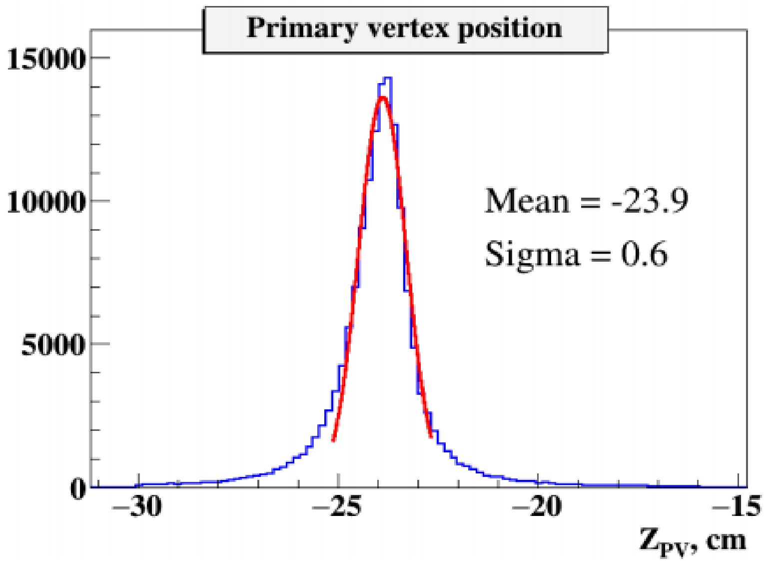
BD detector profile in Ar+Cu, GEANT4 simulation of δ-electrons

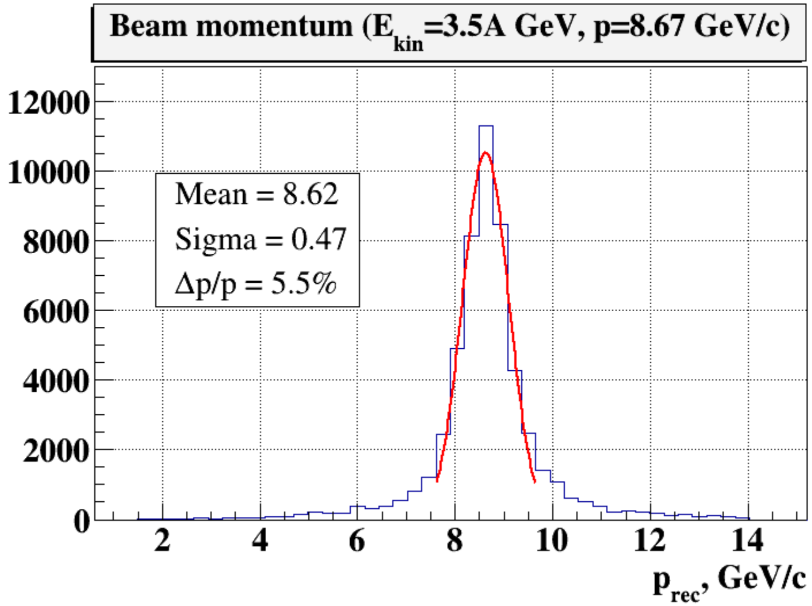
Summary & Plans

- ✓ BM@N experiment has recorded experimental data with carbon, argon and krypton beams at several energies and on several targets.
- ✓ Minimum bias interactions were analyzed with the aim to reconstruct tracks, primary and secondary vertices using central GEM and Si tracking detectors.
- ✓ Reconstructed signals of Λ-hyperon and K_s^0 are visible in proton-pion and pion-pion invariant mass spectra.
- ✓ Work is ongoing to tune MC simulation for carbon beam to describe the data and extract detector efficiencies in order to obtain Λ-hyperon yields.
- ✓ For better results in Ar (Kr) run we have to improve track finding algorithm.
- ✓ Alignment of central tracker in Ar(Kr) run was performed, data analysis has started.

Thank you for attention!

Primary Vertex & Beam momentum





Primary Vertex (along the beam) with Si detector & Pile-up suppression

Beam momentum reconstruction

To improve vertex and momentum resolution and reduce background under Λ:

- ✓ Need few planes of forward Silicon detectors
- ✓ Need more GEM planes to improve track momentum reconstruction