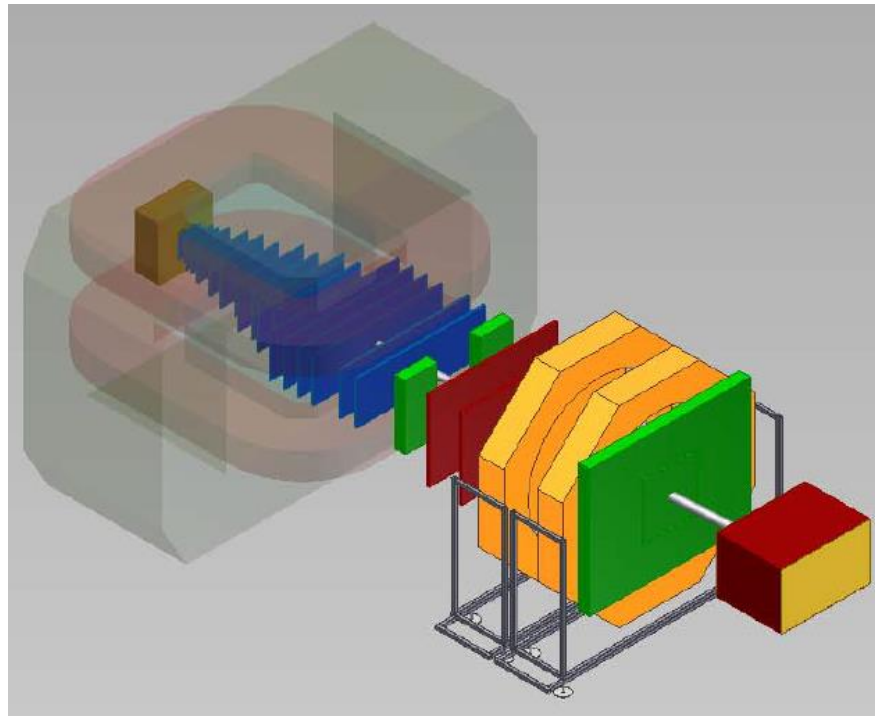




Study of production of hyperons, strange mesons and search for hyper-nuclei in interactions of the carbon, argon and krypton beams in the BM@N experiment

M.Kapishin

RFBR grant 18-02-40036 mega

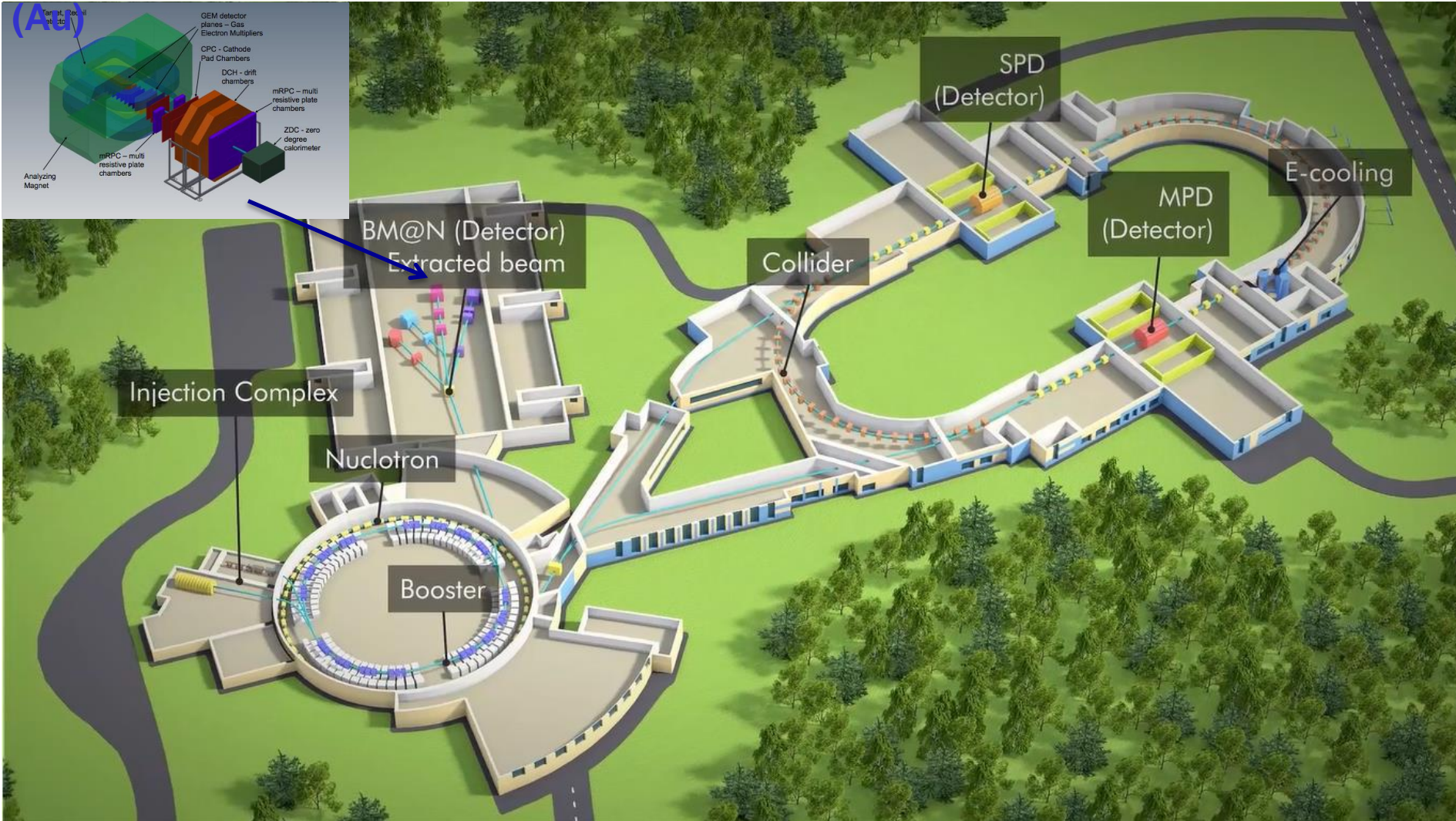




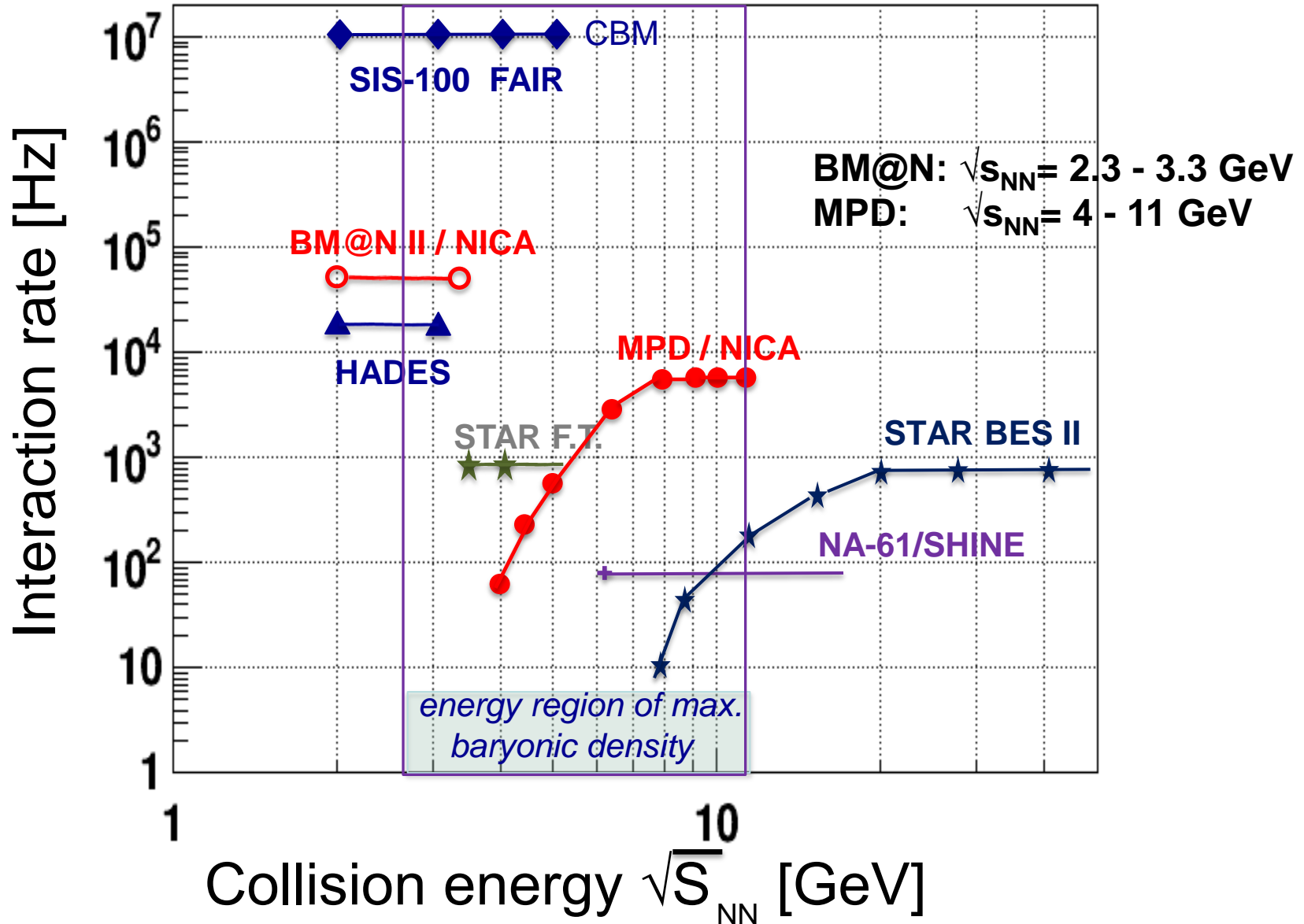
NICA Heavy Ion Complex



BM@N: heavy ion energy 1 – 3.8 GeV/n, beams: p to Au, Intensity ~few 10^6 /s



Heavy Ion Collision Experiments





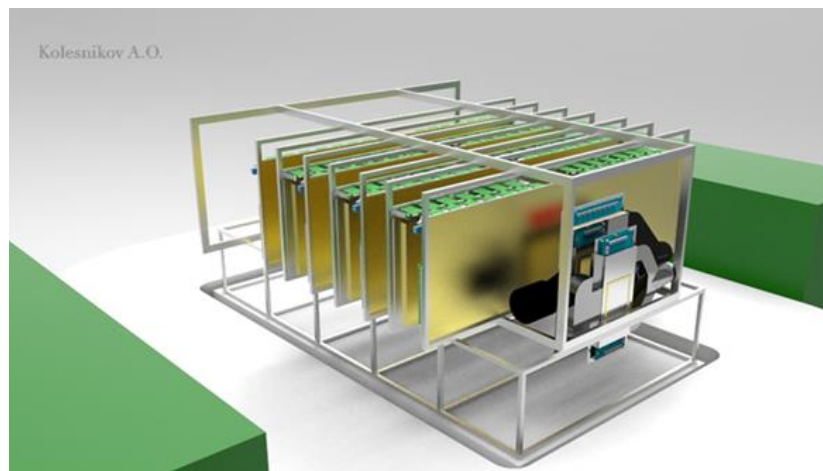
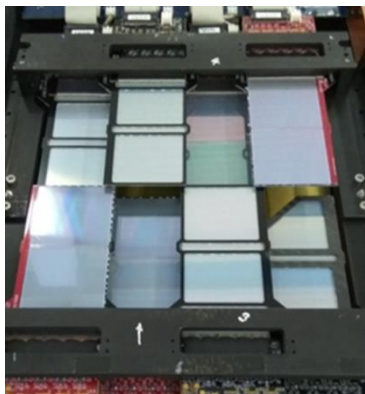
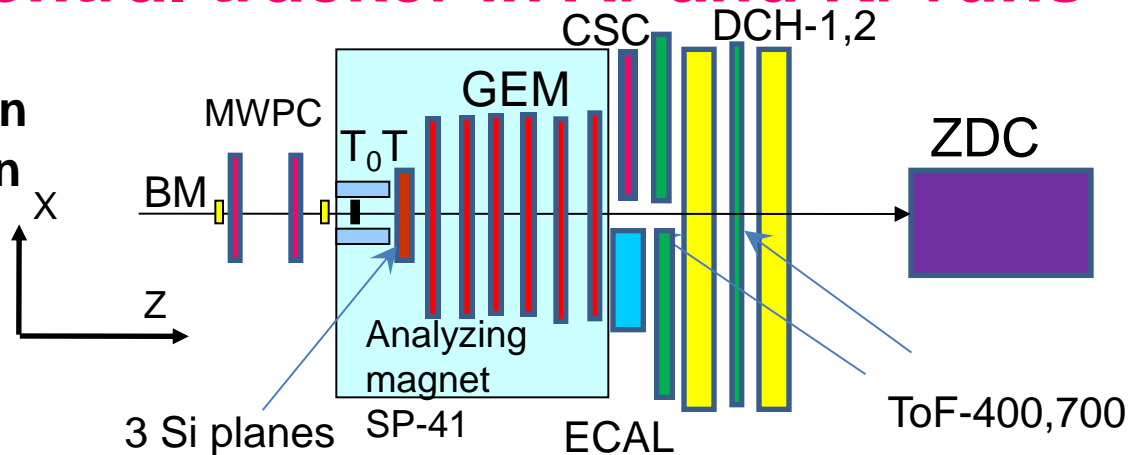
BM@N central tracker in Ar and Kr runs



Ar beam, $T_0 = 3.2$ GeV/n

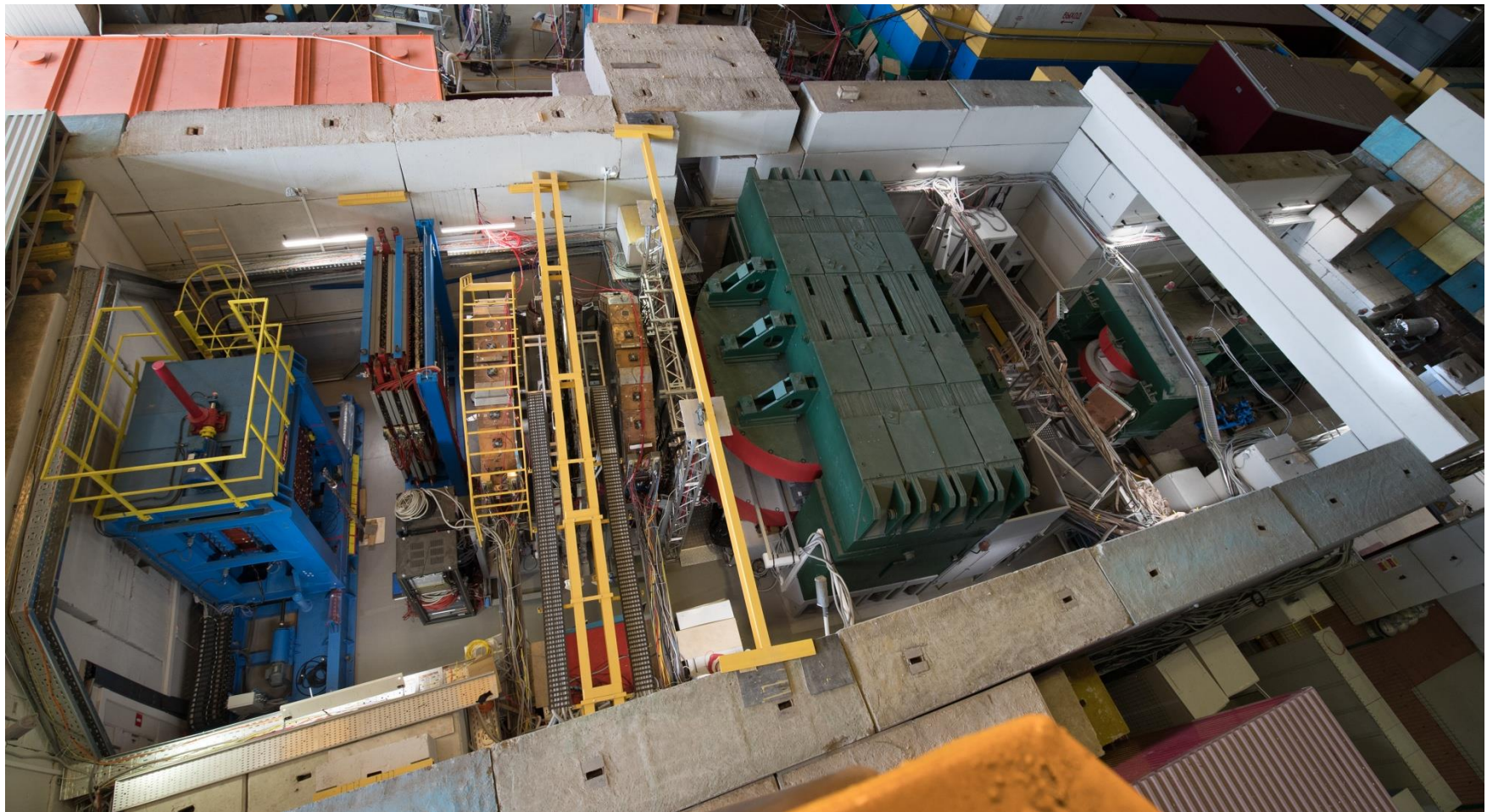
Kr beam, $T_0 = 2.4$ GeV/n

+ data with C beam,
of 4.0, 4.5 GeV/n



**Central tracker: 3 Forward Si detectors
and 6 GEM detectors**



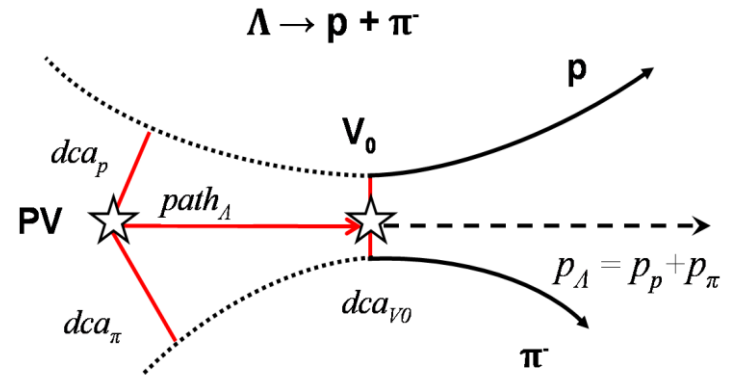
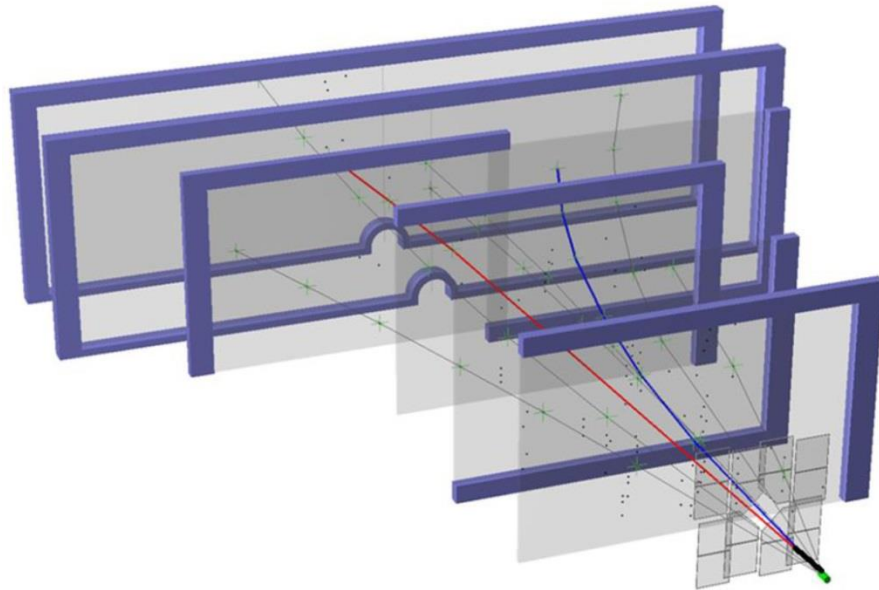




Λ hyperon production in 4A GeV Carbon-nucleus interactions



$\Lambda \rightarrow p\pi^-$ decay reconstruction in Si+GEM tracker in C+C interaction



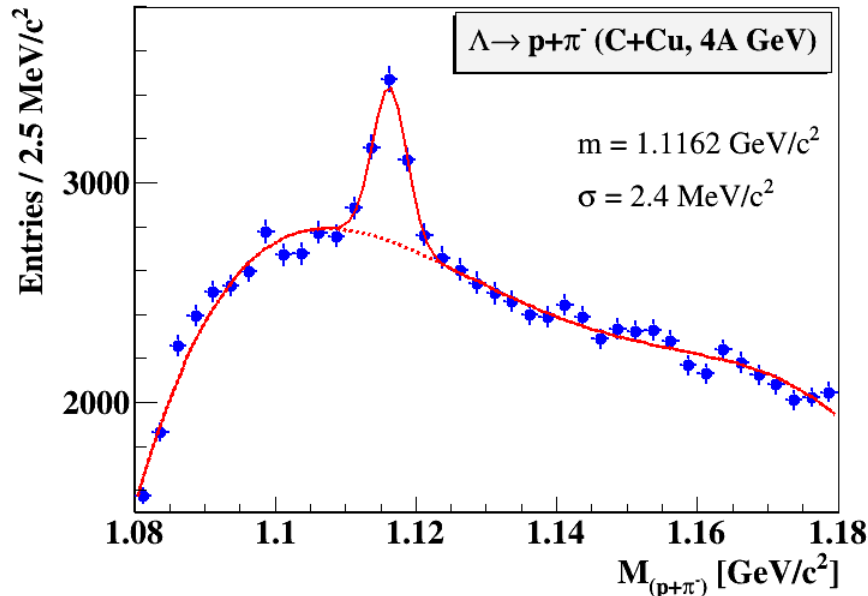
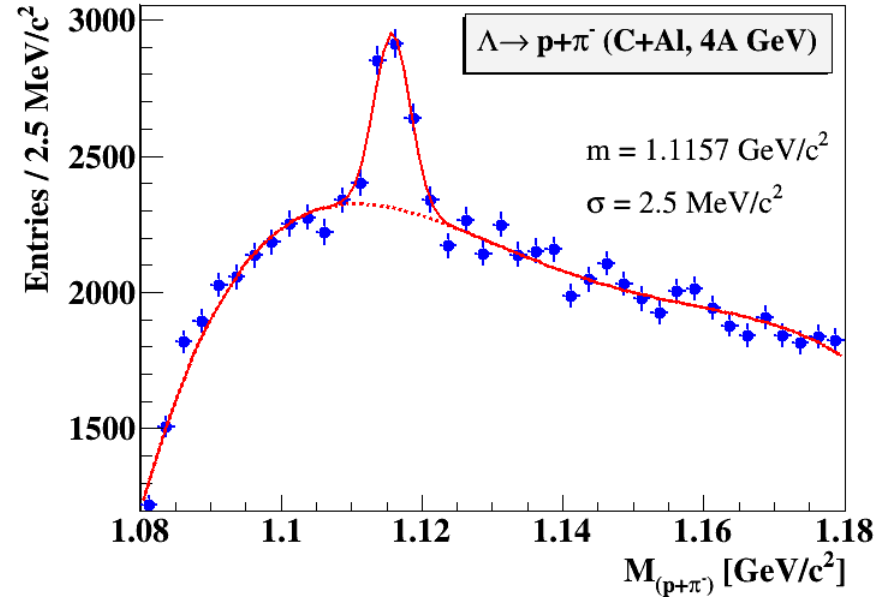
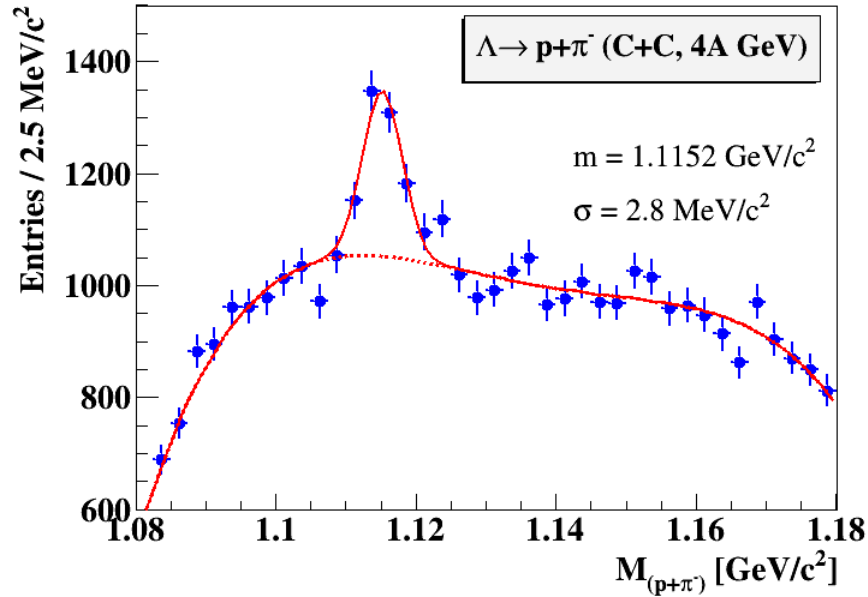
Event topology:

- ✓ **PV** – primary vertex
- ✓ **V₀** – vertex of hyperon decay
- ✓ **dca** – distance of the closest approach
- ✓ **path** – decay length

Analysis without PID



Λ hyperon signals in 4A GeV Carbon-nucleus interactions



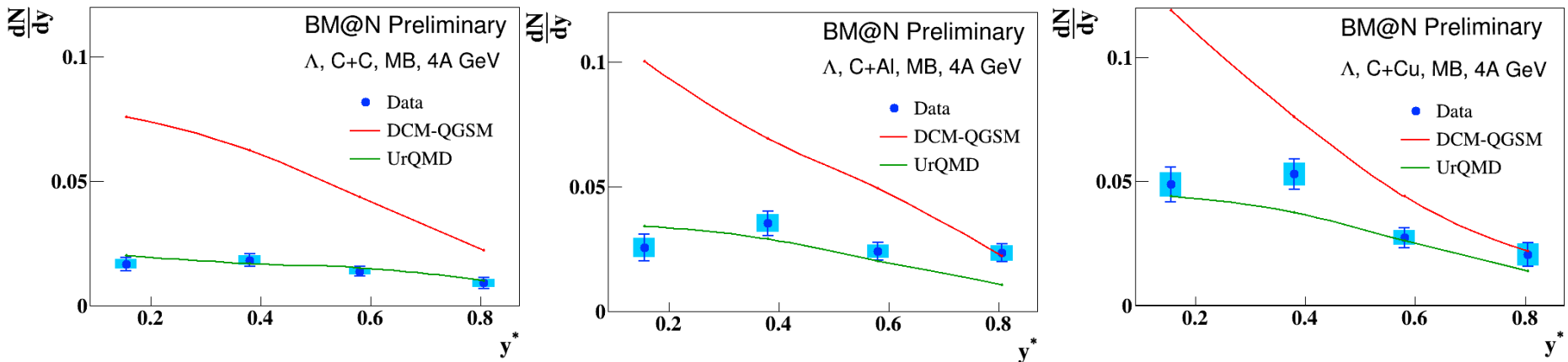
C beam 4 AGeV
C + C,Al,Cu \rightarrow Λ + X minimum bias
 Λ signal width 2.4 – 2.8 MeV

C+C: 4.6M triggers
C+Al: 5.3M triggers
C+Cu: 5.3M triggers

2.5 days of data taking



Λ hyperon yield in 4A GeV Carbon-nucleus min bias interactions

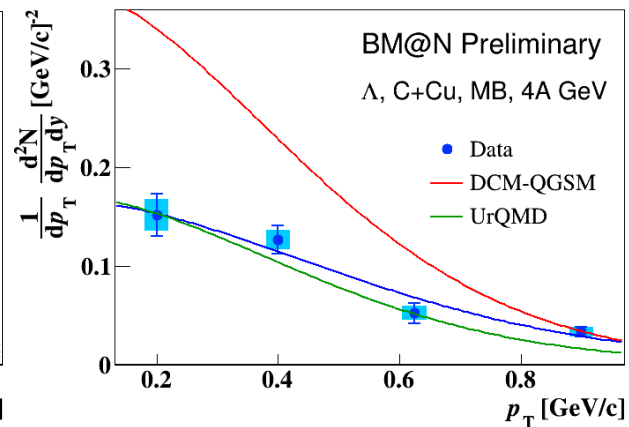
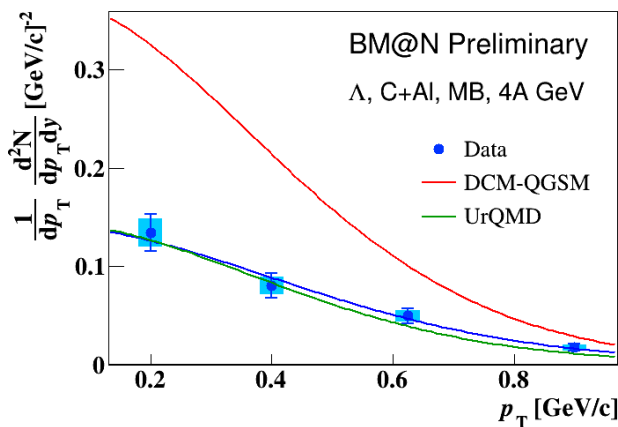
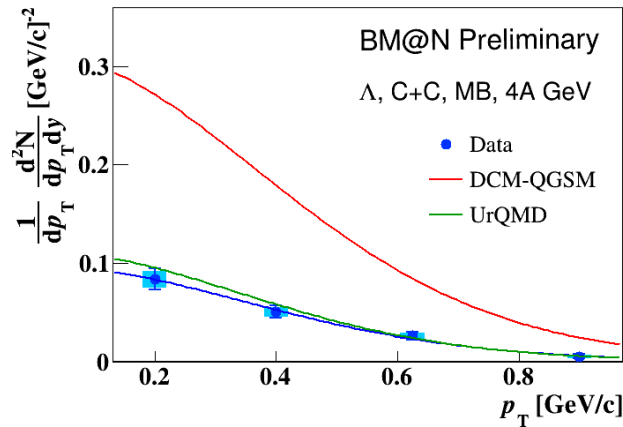


measured kinematic range $0.1 < p_T < 1.05$ GeV/c, $0.03 < y^* < 0.93$
data are corrected for acceptance and reconstruction efficiency

- Yield of Λ in C+C, C+Al, C+ Cu minimum bias interactions in dependence on rapidity y^* in c.m.s. $y^* = y_{\text{lab}} - 1.17$
- ▶ y^* spectrum becomes softer with increase of target atomic weight
- Data compared with predictions of DCM-QGSM and UrQMD models
- ▶ DCM-QGSM overestimates data in C+C interactions, but more compatible with data measured with heavier targets (C+Cu)
- ▶ UrQMD predictions are more consistent with data in normalization



Λ hyperon invariant p_T spectra in 4A GeV Carbon-nucleus interactions



- Fit of invariant p_T spectra of Λ yields in C+C, C+Al, C+Cu minimum bias interactions by function:

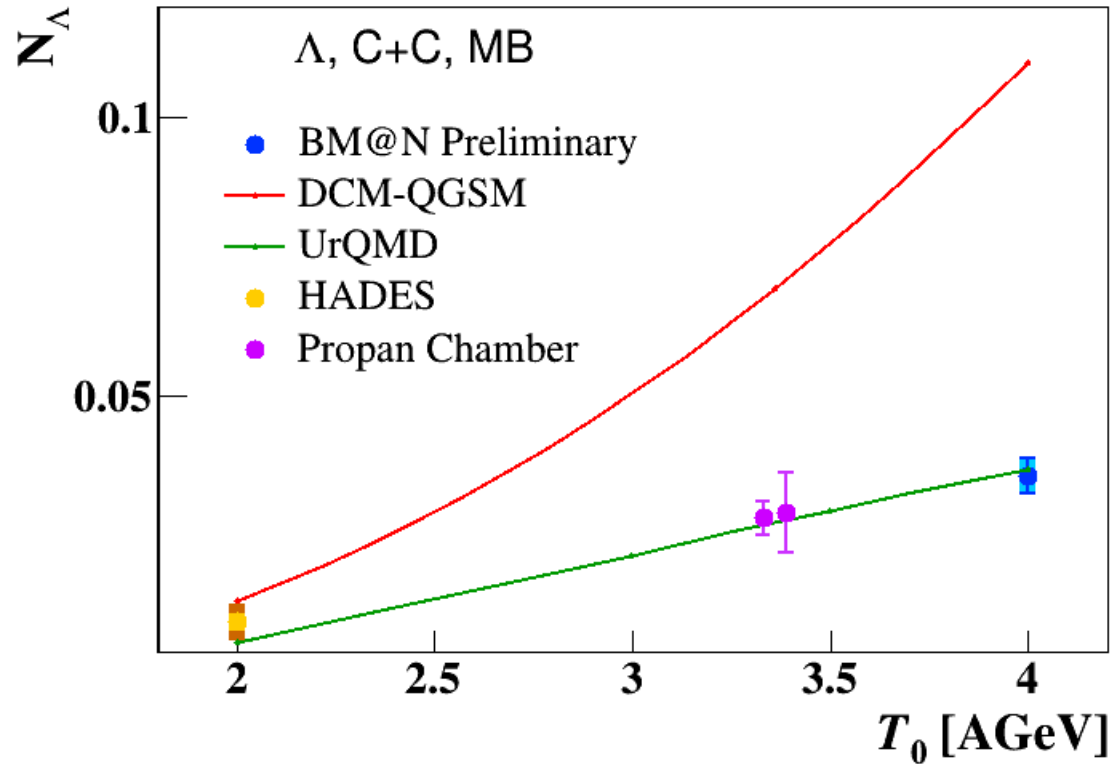
$$1/p_T \cdot d^2N/dp_T dy = A \cdot \exp(-(m_T - m_\Lambda)/T), \quad m_T = \sqrt{(m_\Lambda^2 + p_T^2)}$$

- Inv slope T in comparison with predictions of DCM-QGSM and UrQMD models

	T [MeV] C+C	T [MeV] C+Al	T [MeV] C+Cu
BM@N Preliminary	$113 \pm 14 \pm 11$	$146 \pm 19 \pm 15$	$170 \pm 24 \pm 20$
DCM-QGSM	124 ± 4	123 ± 4	130 ± 4
UrQMD	105 ± 4	123 ± 4	133 ± 4



Energy dependence of Λ hyperon yields in minimum bias C+C interactions



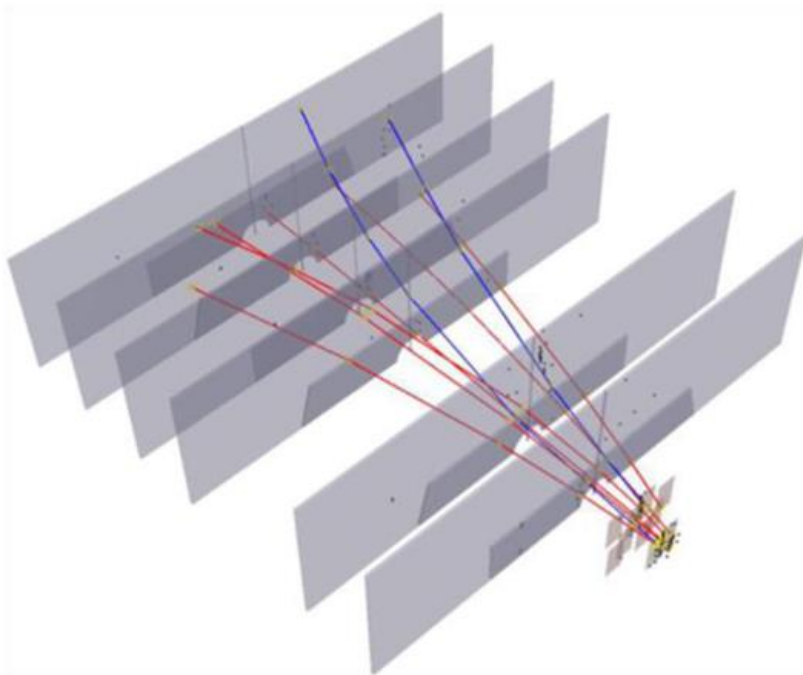
Next plans:

→ **finalize results for 4 and 4.5 AGeV Carbon beam data**

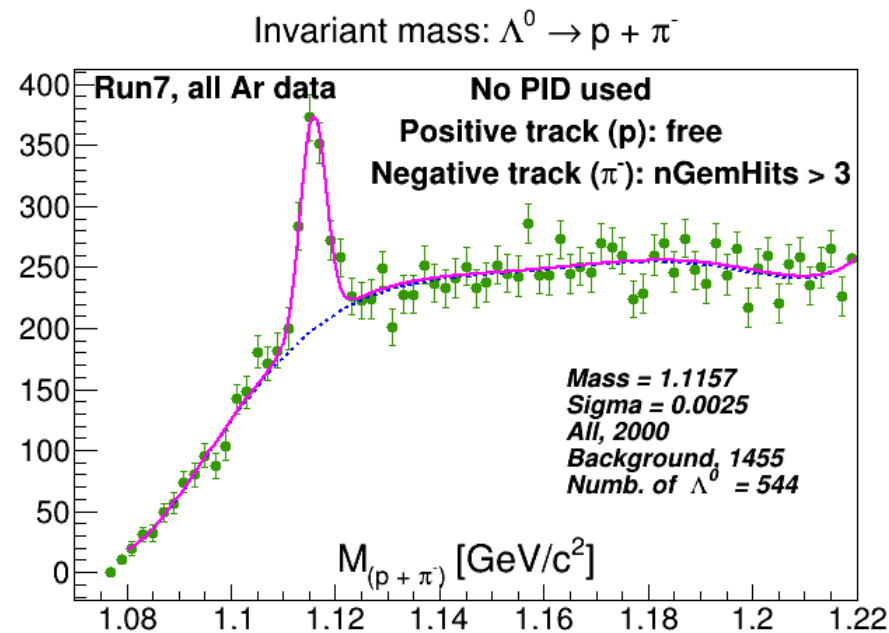


Λ hyperon signals in 3.2A GeV Argon-nucleus interactions

P.Batyuk, S.Merts



Ar+Cu interaction reconstructed in central tracker



Ar (3.2 AGeV) + Target $\rightarrow \Lambda + X$
 Λ signal width 2.5 MeV

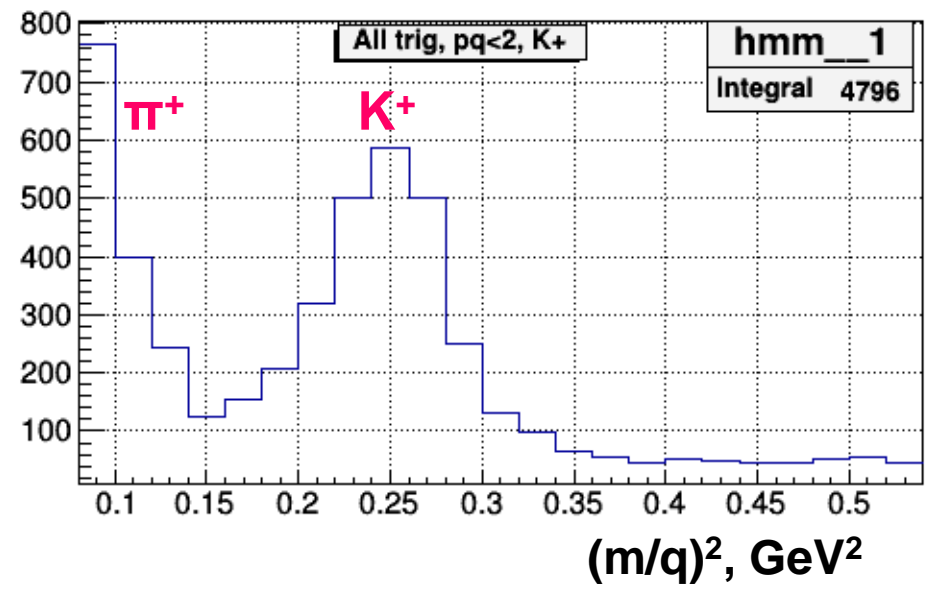
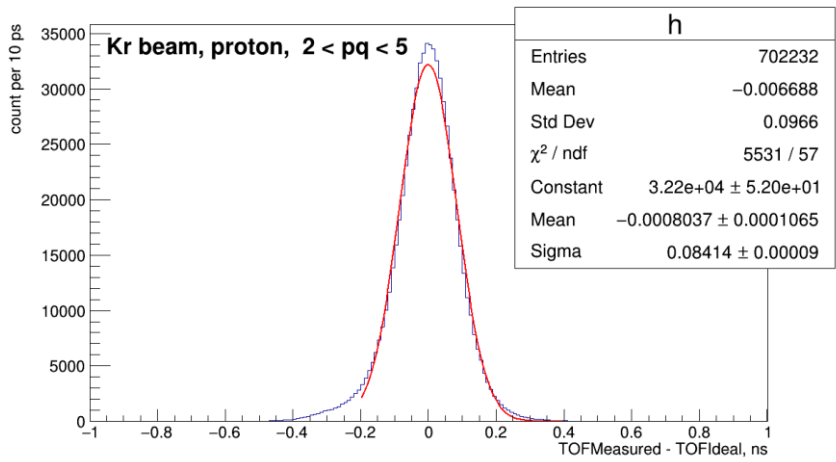
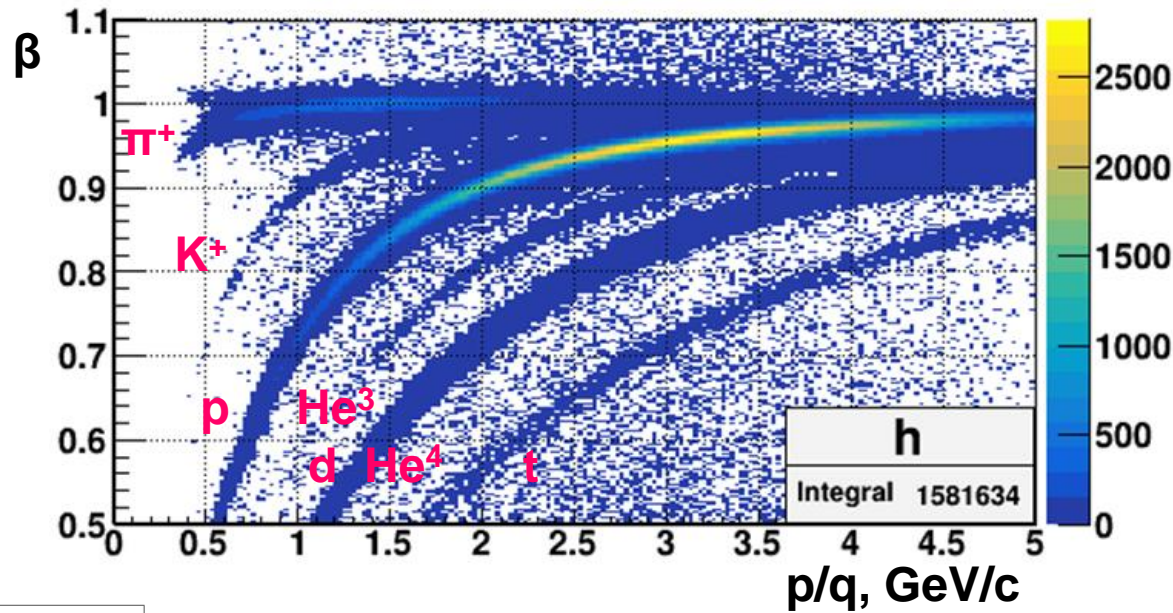
Status of TOF-400 particle identification

V.Plotnikov, M.Rumyantsev

First expected results:

- Ratio of K^+/π^+ in argon - nucleus interactions at beam kinetic energy of 3.2 AGeV

Ar beam , 3.2 AGeV , Ar + C,Al,Sn,Cu \rightarrow X



Time resolution within proton band
~85 ps



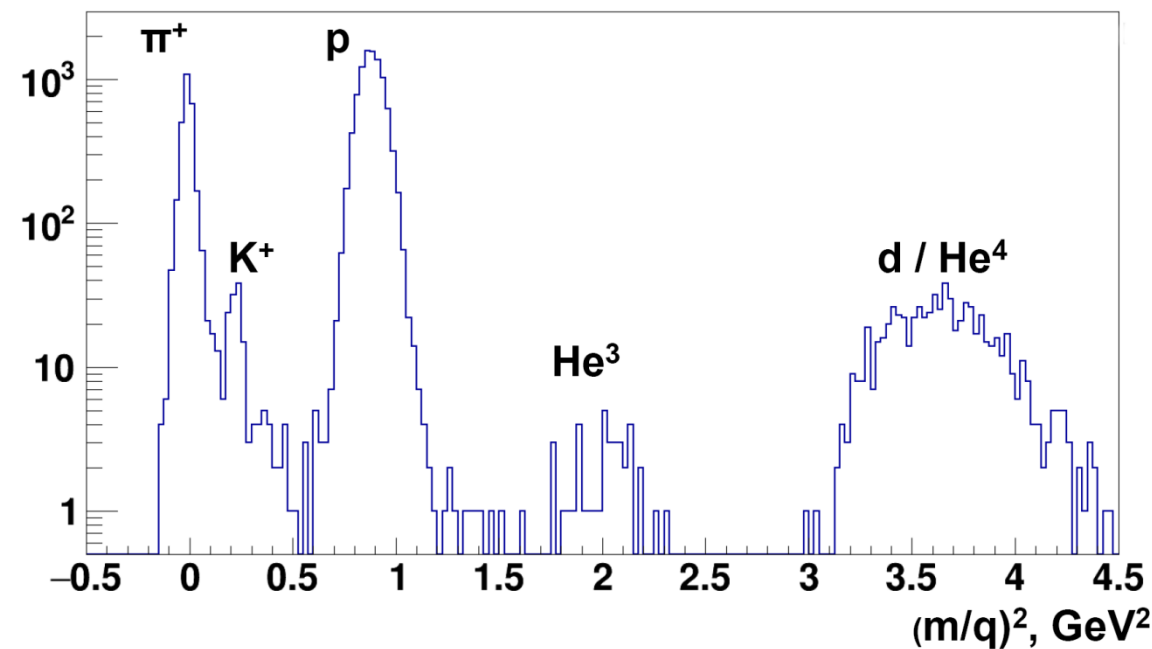
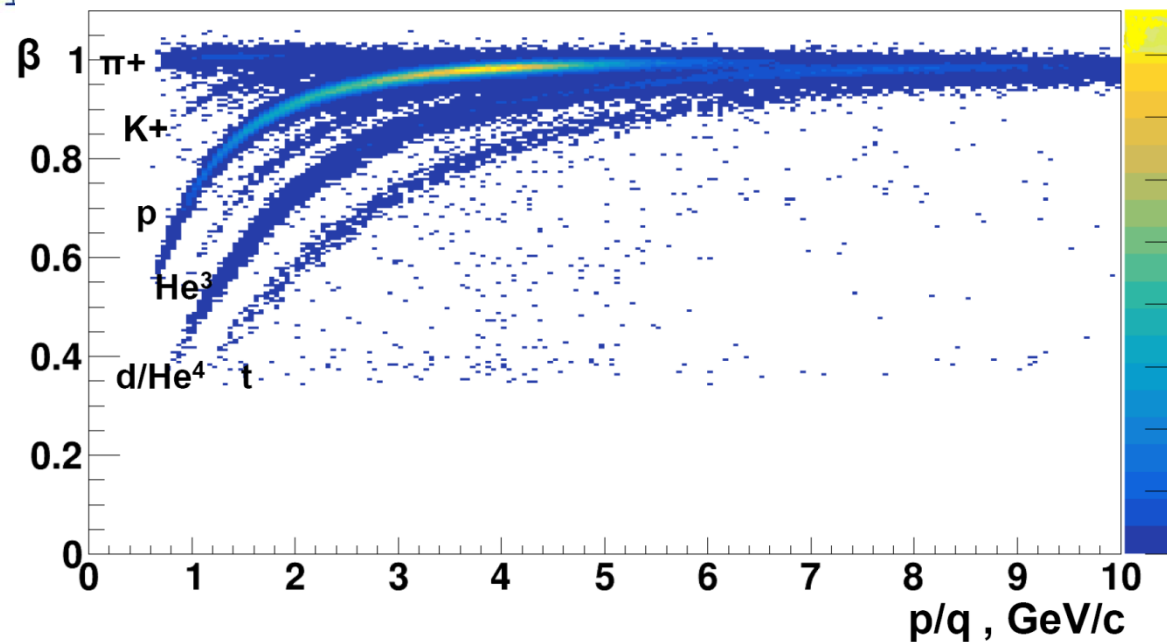
Status of TOF-700 particle identification



L.Kovachev, Yu.Petukhov

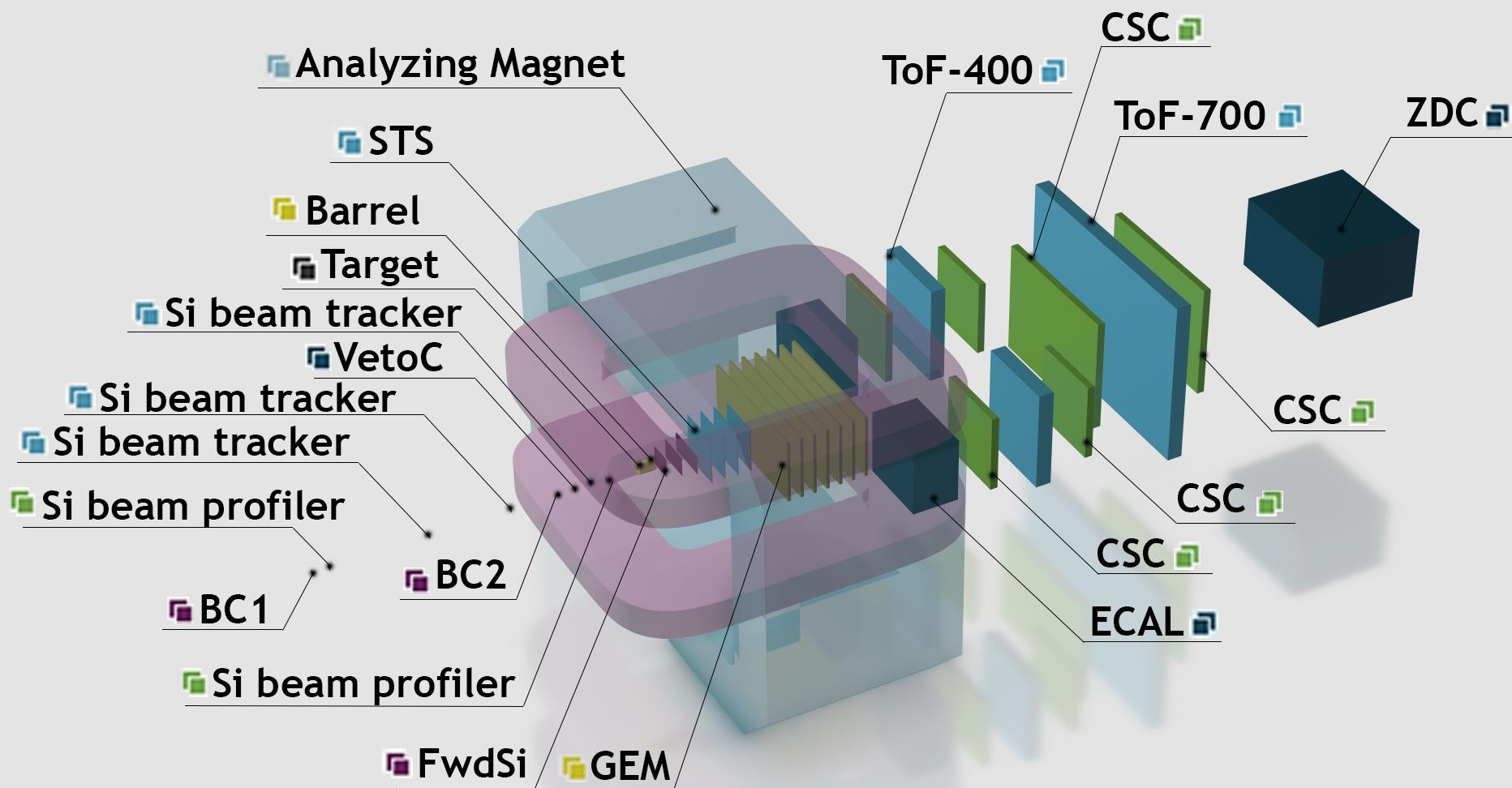
Ar beam , 3.2 AGeV ,
Ar + Al,Cu,Sn \rightarrow X

Aim:
Yields of π , p, t, He³, d/He⁴
in *argon - nucleus*
interactions (combination
of ToF-400 and ToF-700)

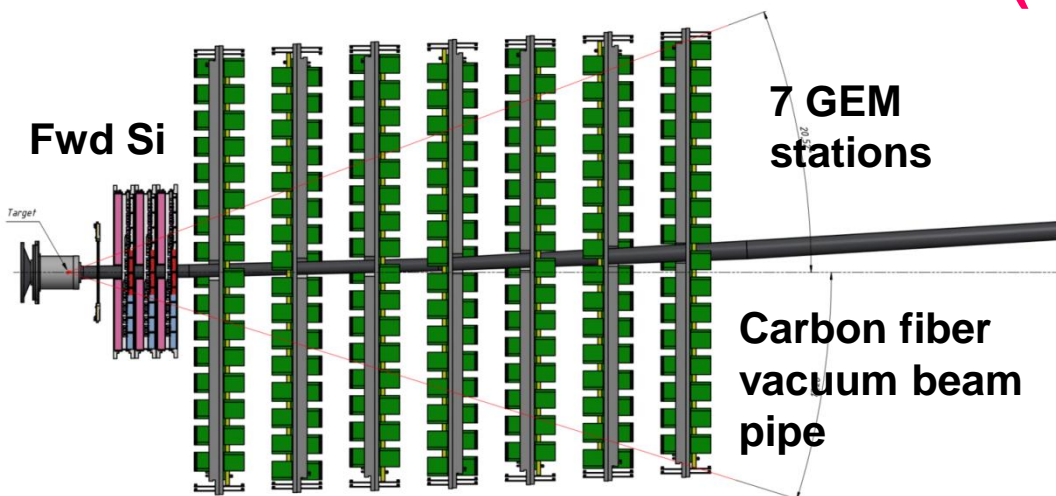




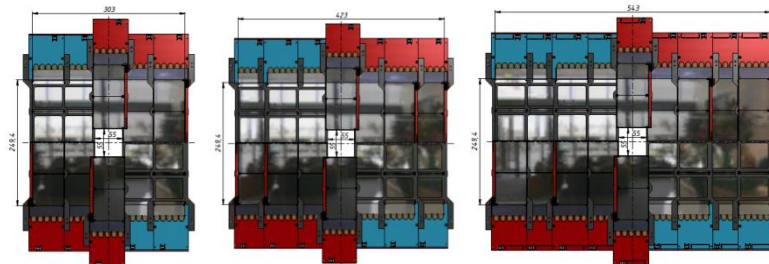
Configuration of BM@N detector for heavy ion program (without beampipe)



First stage of hybrid central tracker: Forward Si + GEM (from 2021)



3 Forward Si stations

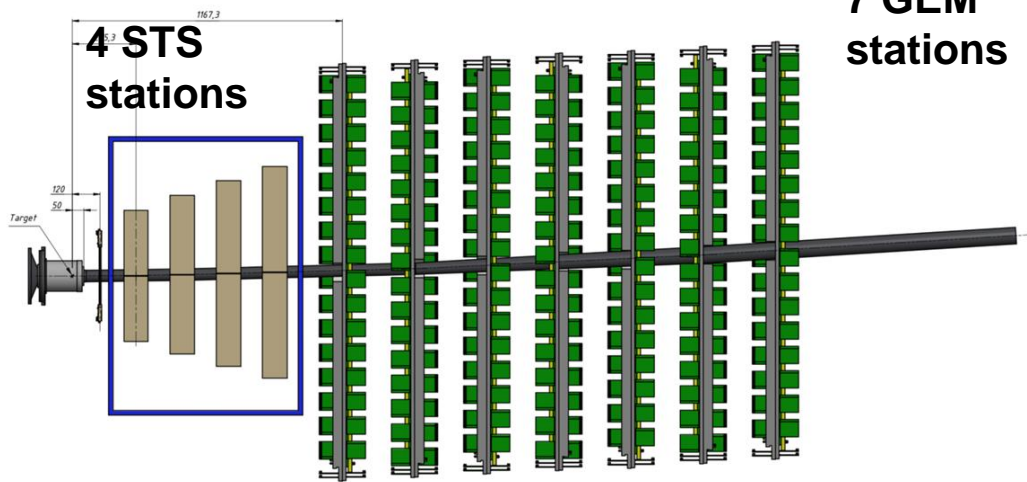


Groups of A.Maksymchuk, N.Zamiatin

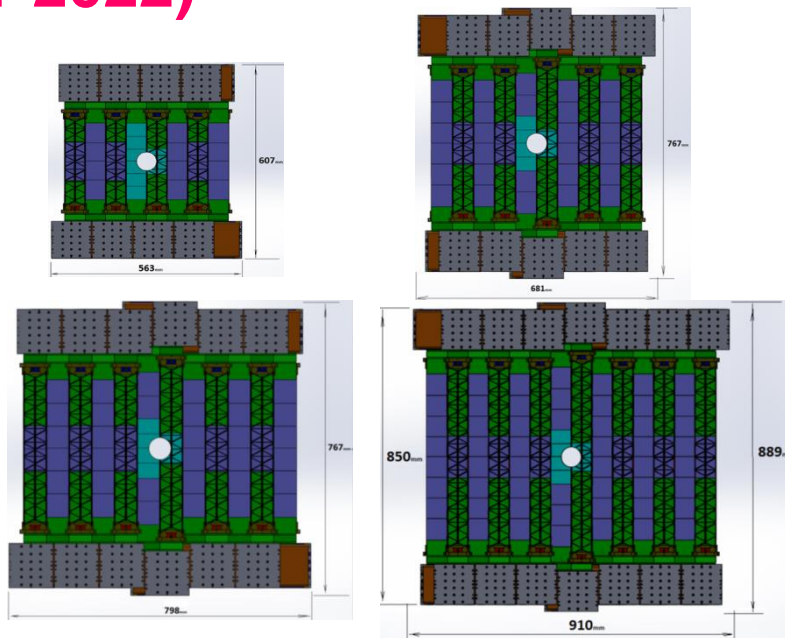
Hybrid central tracker for high intensity heavy ion runs: STS +GEM (after 2022)

JINR, MSU, GSI/FAIR,
Tübingen Uni, WUT

4 STS stations



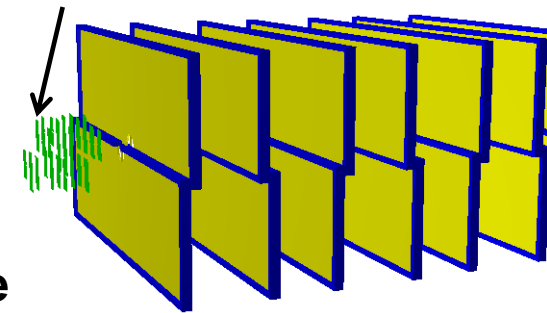
7 GEM stations



Simulation of 1st stage of hybrid central tracker: 3 Forward Si + GEM

A.Zinchenko, V.Vasendina

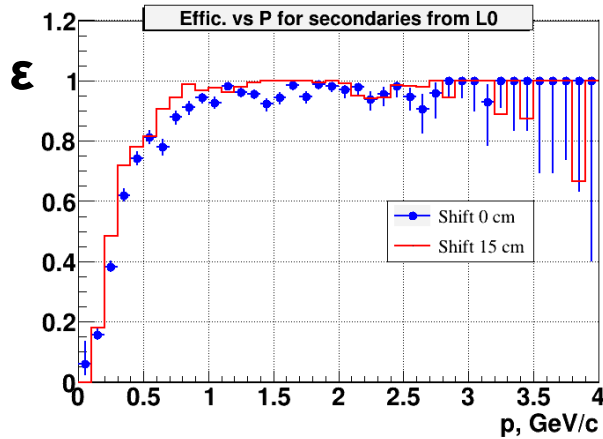
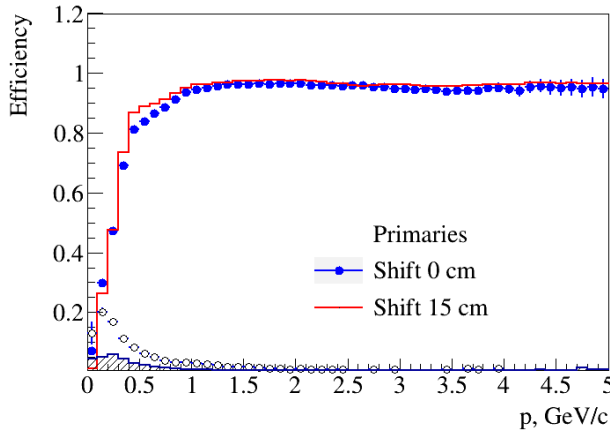
3 Forward Si + 7 GEM



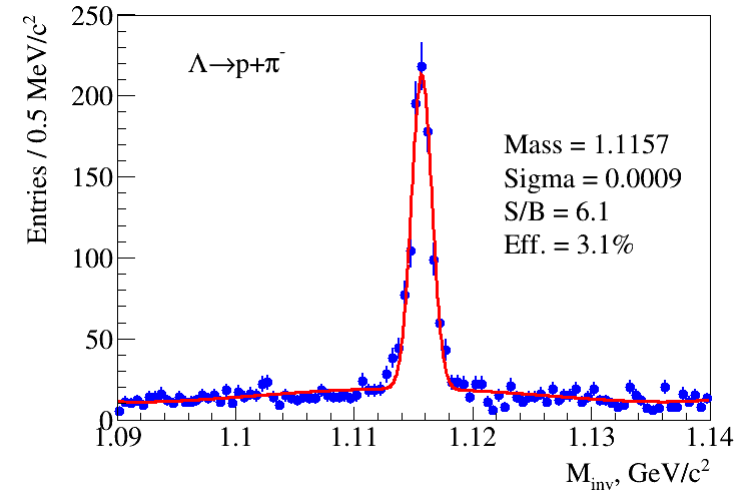
DCM-QGSM model
Kr + Pb, $T_0 = 2.4$ AGeV

Aim:

- Optimization of detector positions and rotation angle of Forward Si stations
- Estimation of track reconstruction efficiency and momentum resolution



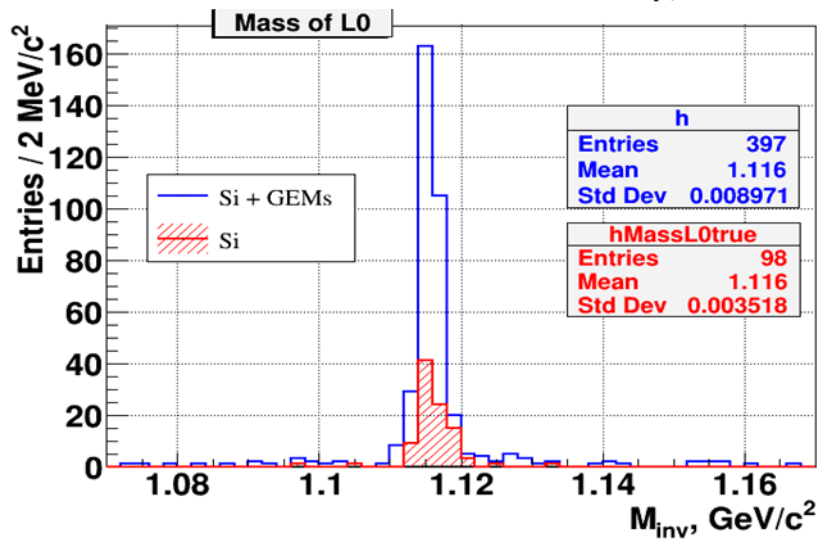
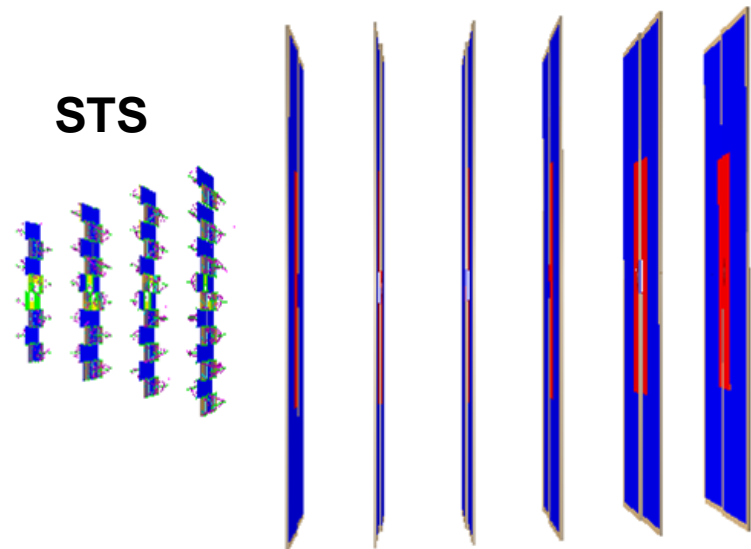
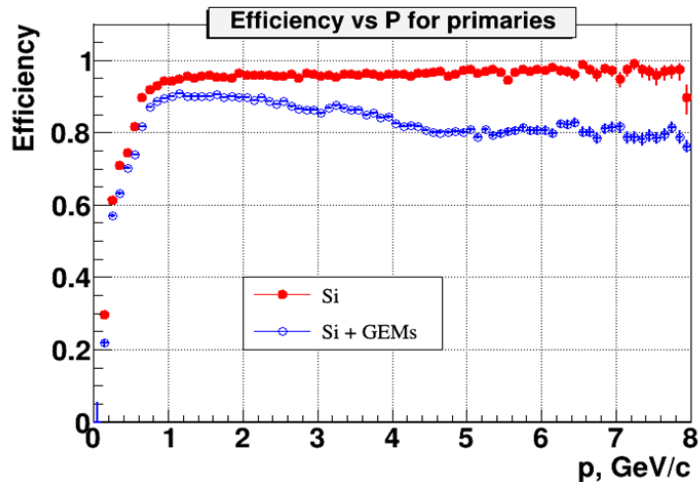
More details in talk of Alexander Zinchenko:
Performance evaluation of the upgraded BM@N
set-up for the strangeness production studies



Simulation of hybrid central tracker for heavy ion runs: STS + GEM

QGSM model, Au+Au, $T_0 = 4$ AGeV

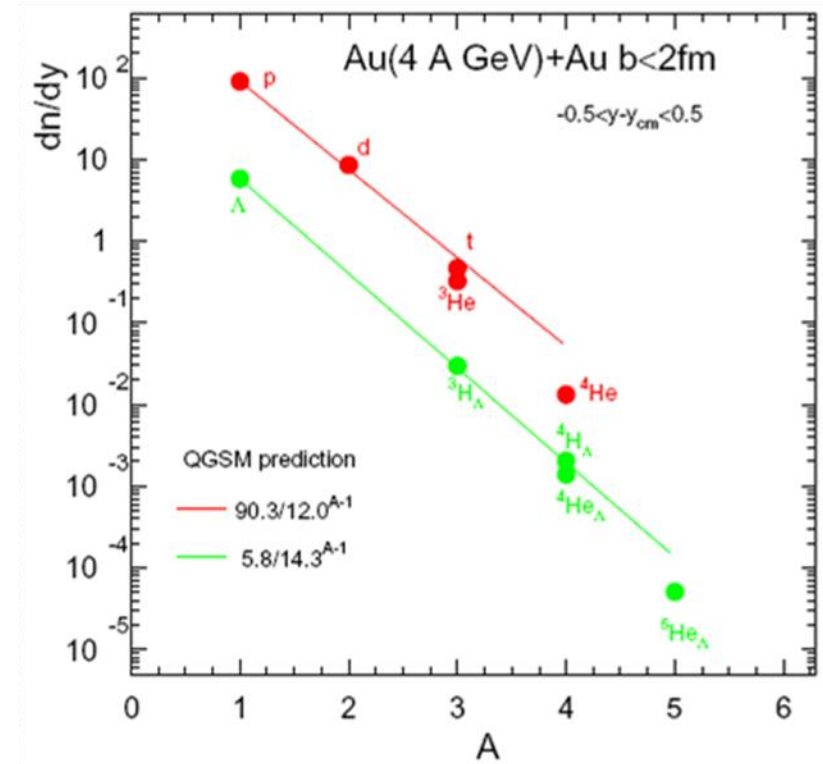
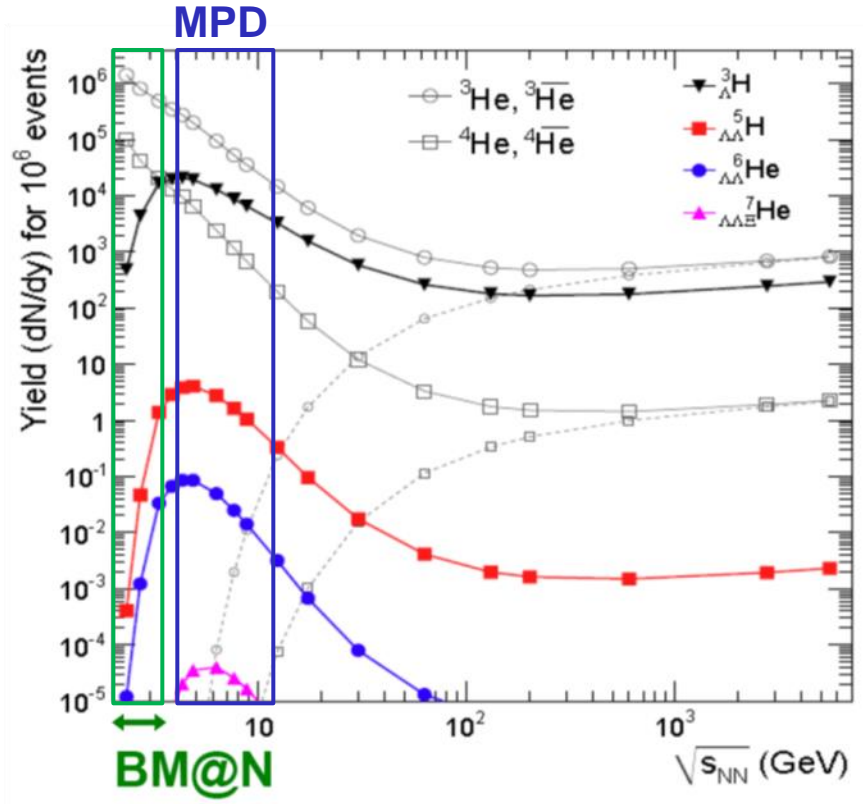
GEM



Hybrid STS + GEM tracker:
 ► 4 times increase in number of reconstructed tracks and Λ hyperons



Heavy-ions A+A: Hypernuclei production



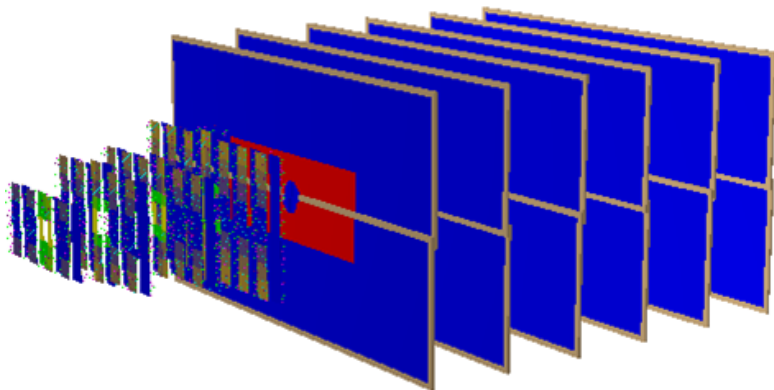
❑ **In heavy-ion reactions:** production of hypernuclei through coalescence of Λ with light fragments enhanced at high baryon densities

❑ **Maximal yield** predicted for $\sqrt{s}=4\text{-}5A$ GeV (stat. model) (interplay of Λ and light nuclei excitation function)

▶ **BM@N** energy range is **suited** for search of hyper-nuclei

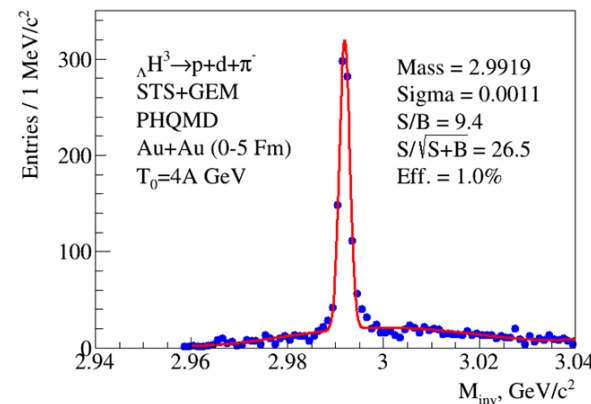
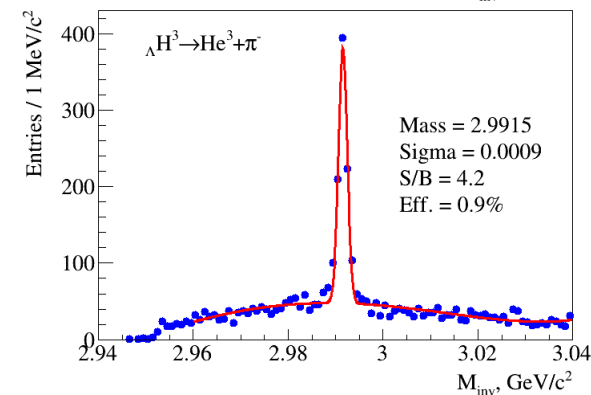
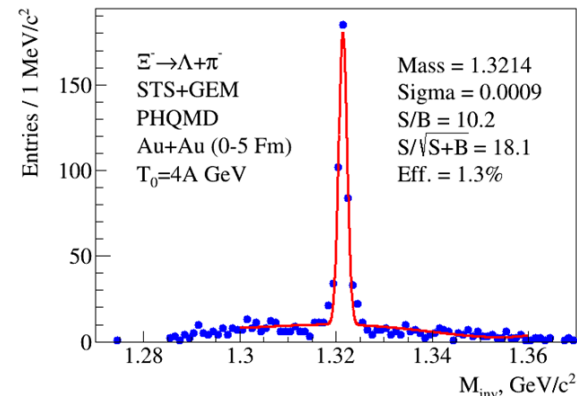
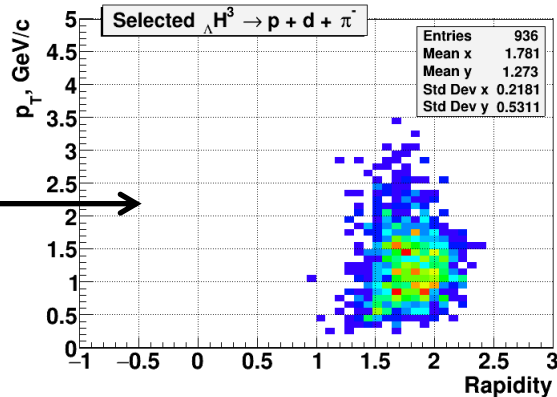
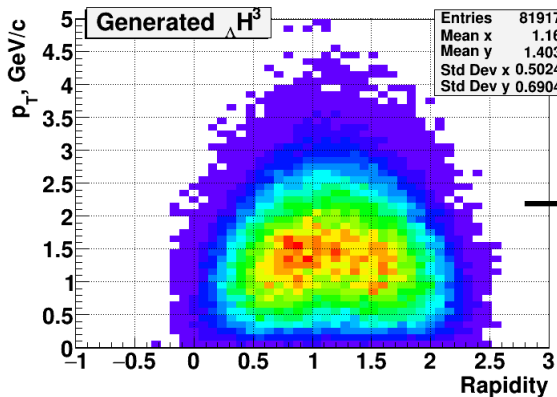
Simulation of hybrid central tracker for heavy ion runs: Ξ^- and ΛH^3 reconstruction

A.Zinchenko, V.Vasendina



PHQMD model, Au+Au, $T_0 = 4A$ GeV,
 $b = 0-5$ fm, 500k events

ΛH^3 phase space





Analyses of BM@N experimental runs performed with carbon beam of 4 and 4.5 AGeV and argon beam of 3.2 AGeV on fixed targets are in progress:

- ▶ Preliminary physics results obtained on Λ yields in C + C, Al, Cu interactions at 4 AGeV
→ aim to finalize results for 4 and 4.5 AGeV carbon beam data
- ▶ Signals of π , K, p, t, He^3 , d/ He^4 and Λ hyperons are identified in argon - nucleus interactions
→ aim to measure yields of mesons, Λ hyperons and nuclear fragments

Feasibility studies of hybrid central tracker based on STS silicon and GEM detectors are performed to evaluate its performance to measure hyperons and light hyper-nuclei in heavy ion interactions

**Thank you
for attention!**