Status of the BM@N experiment

M.Kapishin

Baryonic Matter at Nuclotron (BM@N) Collaboration:

5 Countries, 13 Institutions, 214 participants

- *University of Plovdiv, Bulgaria*
- *St.Petersburg University*
- *Shanghai Institute of Nuclear and Applied Physics, CFS, China;*
- *Joint Institute for Nuclear Research;*
- *Institute of Nuclear Research RAS, Moscow*
- *NRC Kurchatov Institute, Moscow combined with Institute of Theoretical & Experimental Physics, NRC KI, Moscow*
- *Moscow Engineer and Physics Institute*
- *Skobeltsyn Institute of Nuclear Physics, MSU, Russia*
- *Moscow Institute of Physics and Technics*
- *Lebedev Physics Institute of RAS, Moscow*
- *Institute of Physics and Technology, Almaty*
- **Physical-Technical Institute Uzbekistan Academy of Sciences, Tashkent**
- **High School of Economics, National Research University, Moscow**

BM@N papers, preliminary results, conferences

The BM@N spectrometer at the NICA-Nuclotron facility
The BM@N detector paper for the Xe+CsI run configuration, published in NIM A, NIMA 1065 (2024) 169532, arxiv:2312.17573

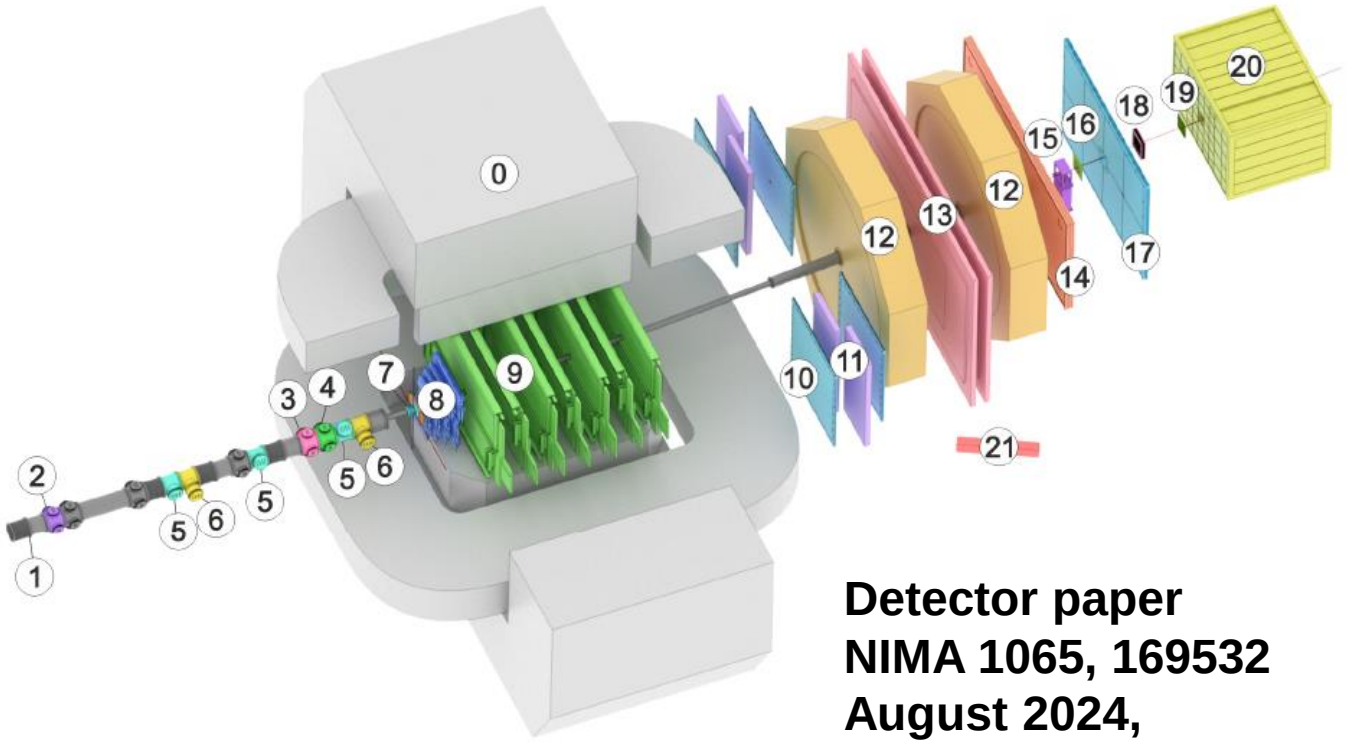
Production of *p, d, t* in 3.2 AGeV argon-nucleus interactions at the Nuclotron, BM@N preliminary, extension of the paper draft

Directed flow $v1$ of protons in the Xe+CsI collisions at 3.8 AGeV, BM@N preliminary

BM@N presented / submitted physics and detector talks at conferences:

Conference Nucleus-2024, Dubna, July 2024
Conference "Hadron Structure and Fundamental Interactions" - HSFI'2024, Gatchina, July 2024
Conference ICPPA-2024, Moscow, October 22-25

Configuration of BM@N detector in Xe+CsI run



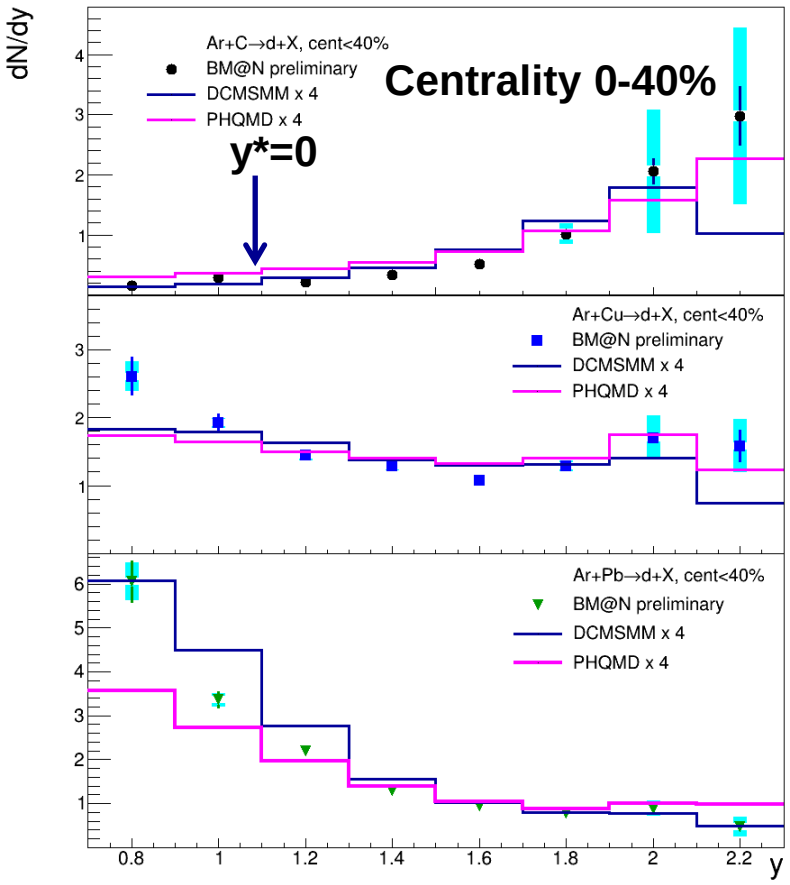
- Magnet SP-41 (0)
- Vacuum Beam Pipe (1)
- BC1, VC, BC2 (2-4)
- SiBT, SiProf (5, 6)
- Triggers: BD + SiMD (7)
- FSD, GEM (8, 9)
- CSC 1x1 m^2 (10)
- TOF 400 (11)
- DCH (12)
- TOF 700 (13)
- ScWall (14)
- FD (15)
- Small GEM (16)
- CSC 2x1.5 m^2 (17)
- Beam Profilometer (18)
- FQH (19)
- FHCal (20)
- HGN (21)

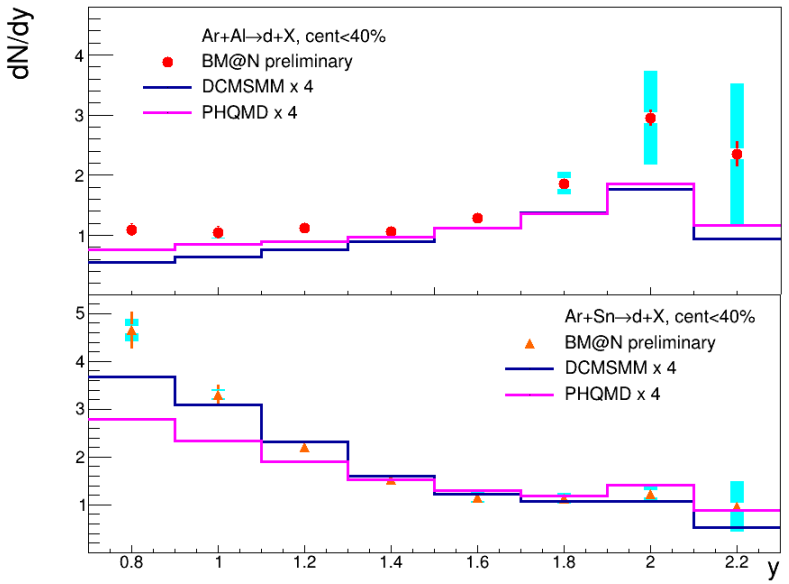
Detector paper
NIMA 1065, 169532
August 2024,
arxiv:2312.17573

BM@N paper draft: Production of *p, d, t* in 3.2 AGeV argon-nucleus interactions at the Nuclotron

→ Status BM@N Preliminary

L.Kovachev → talk at NUCLEUS-2024,Dubna





$y^* = y_{lab} - y_{CM}$, $y_{CM} \approx \langle y(\pi) \rangle$

Ar+C: $\langle y(\pi) \rangle = 1.27$

Ar+Pb: $\langle y(\pi) \rangle = 0.82$

- dN/dy spectrum softer in interactions with heavier target
- DCM-SMM and PHQMD models describe data shape, but are lower in normalization by factor 4

Extended draft in preparation

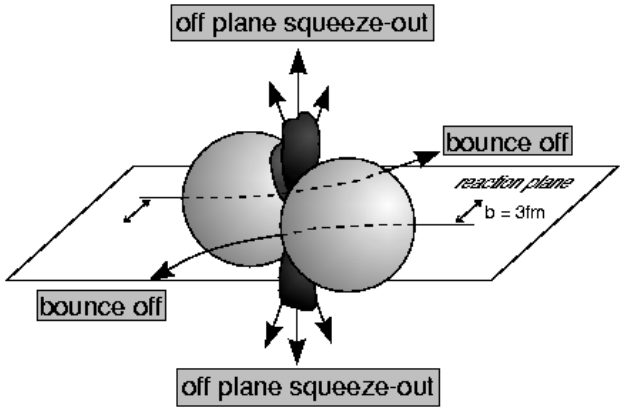
Collective flow of protons in Xe+CsI interactions

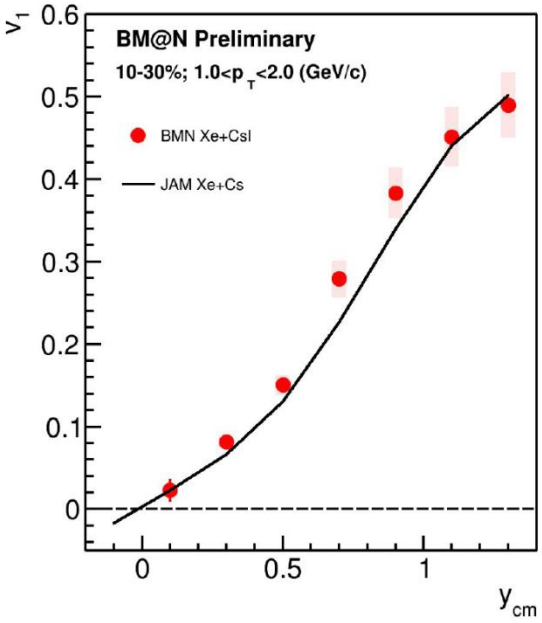
→ **Status BM@N Preliminary**

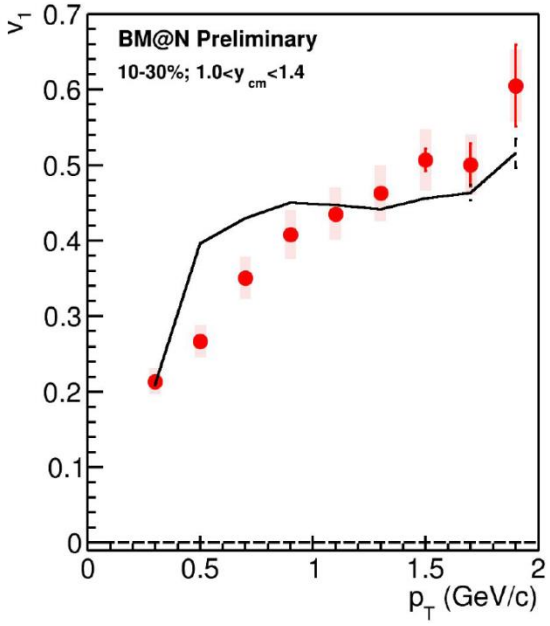
MEPhI group
M.Mamaev→ talk at NUCLEUS-2024, Dubna

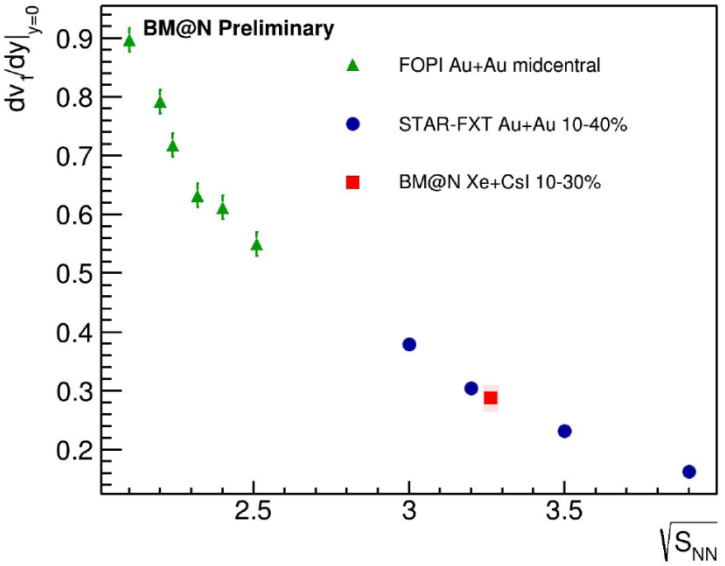
Azimuthal angle distribution:
$dN/d\varphi \propto (1 + 2v_1 \cos\varphi + 2v_2 \cos 2\varphi)$

→ **Direct flow of protons as a function of rapidity, transverse momentum; compared with the JAM model**
→ **BM@@N result is in line with the energy dependence of the world data**





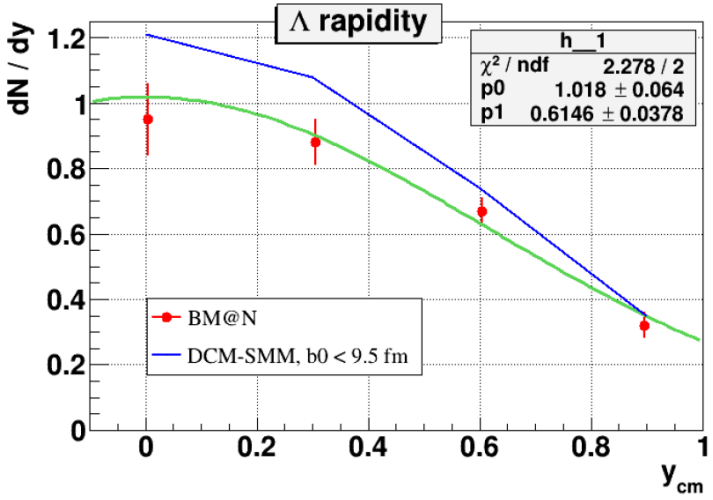


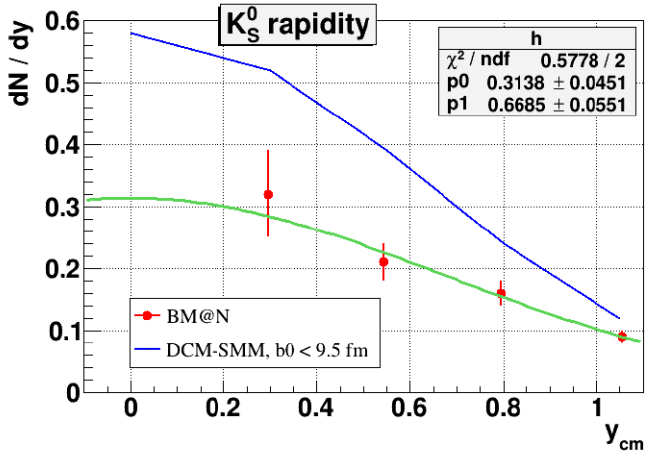


Λ and K^0_s production in Xe+CsI interactions

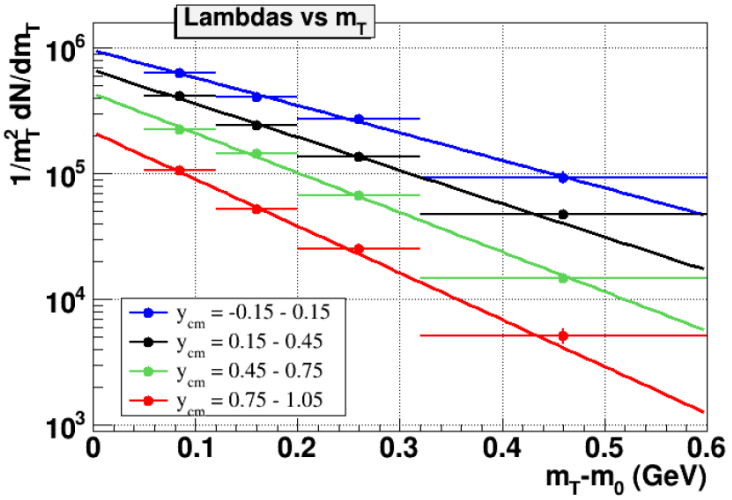
A.Zinchenko→ talk at NUCLEUS-2024, Dubna
Still it is not official BM@N result

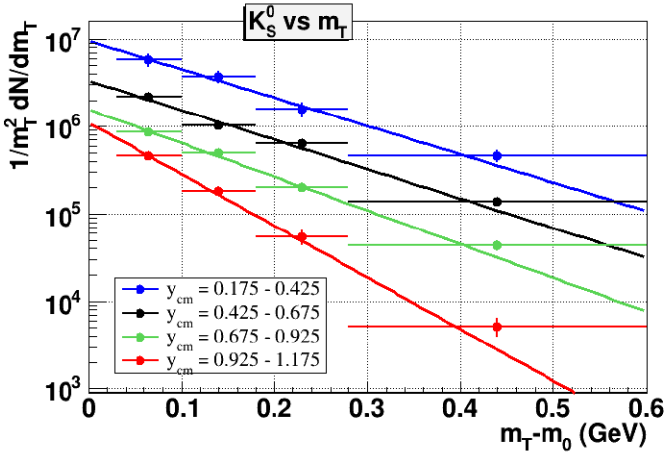
Rapidity distribution of Λ and K^0_s compared with DCM-SMM model





Transverse mass distribution of Λ and K^0_s

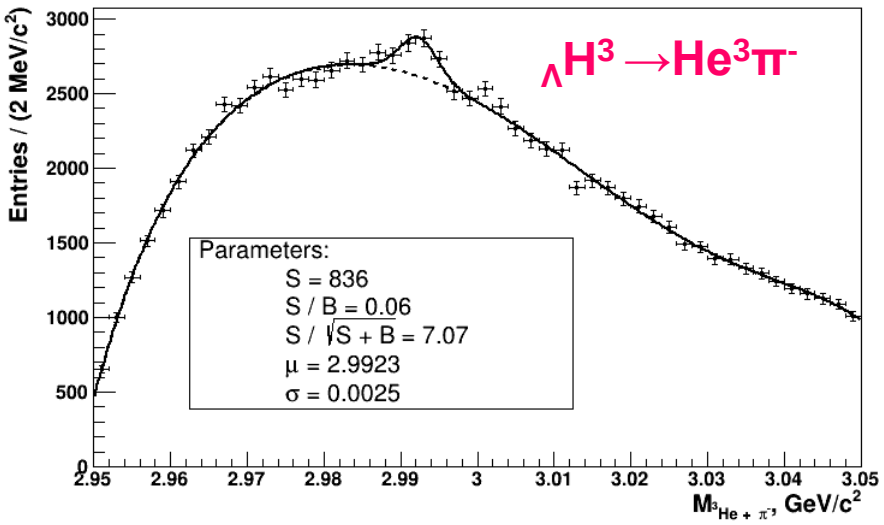


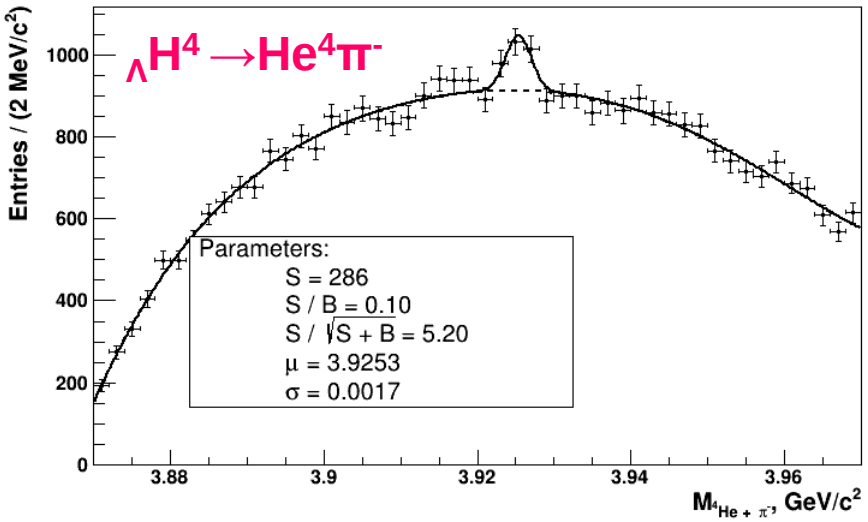


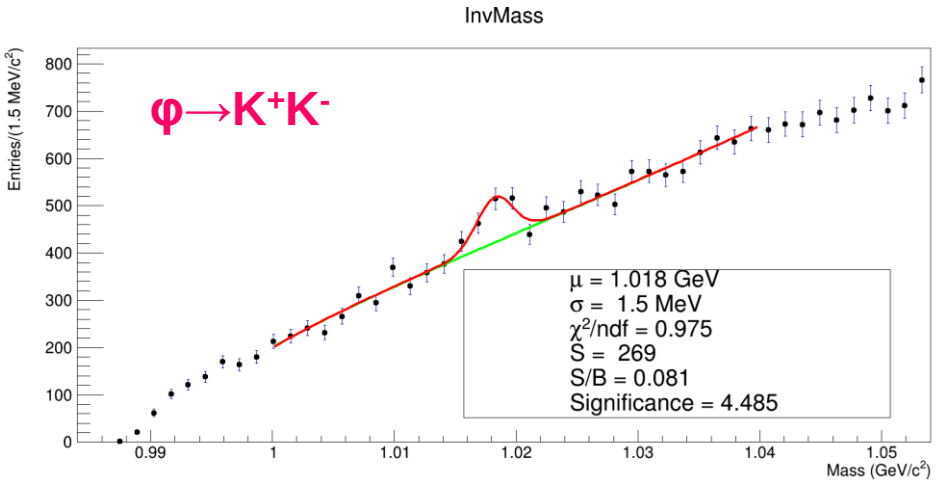
Search for $_{\Lambda}H^3$, $_{\Lambda}H^4$, $\varphi \rightarrow K^+K^-$ in Xe+CsI interactions

Analysis of 300M events

S.Merts, R.Barak



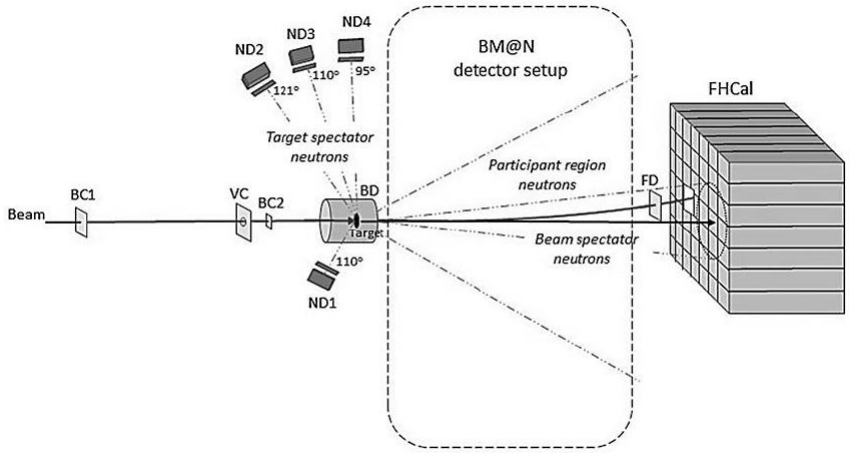




Room for improvements:

- **Increase ToF-700 efficiency**
- **Improve dE/dx in GEMs for He^3, He^4 selection**

Study of neutron emission from target spectators in ^{124}Xe + CsI collisions at 3.8 A GeV



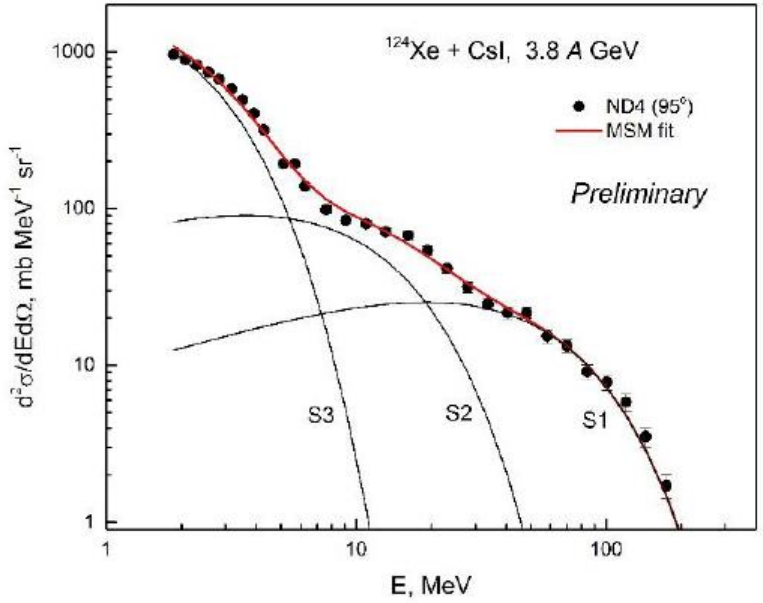
Trigger group

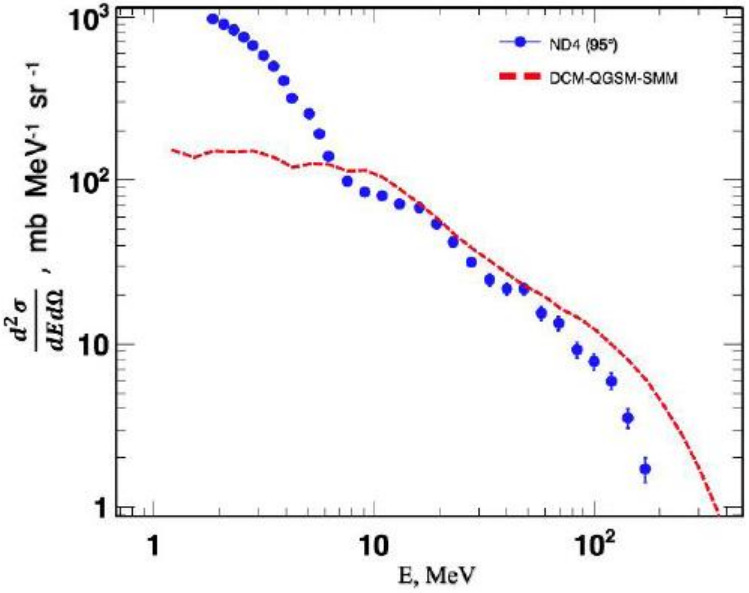
N.Lashmanov→ talk at NUCLEUS-2024, Dubna

Request of BM@N Preliminary

Fit neutron spectra with three moving source model (MSM fit): hard, fragmentation, evaporation

Compare spectra with DCM-SMM model

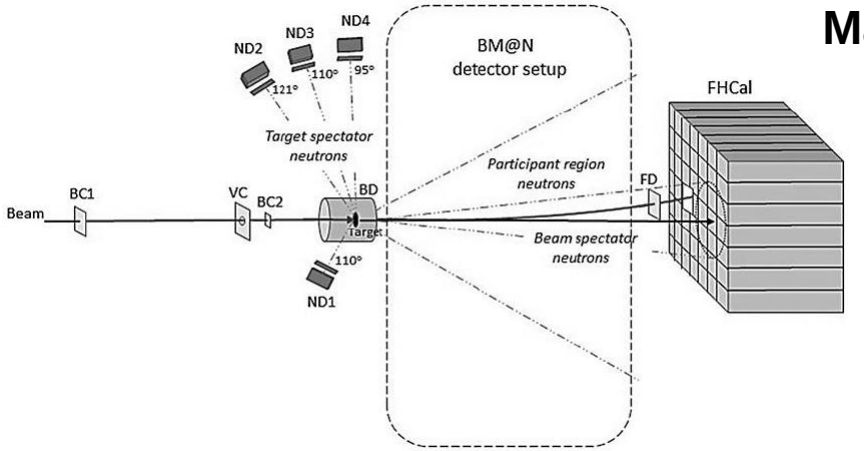


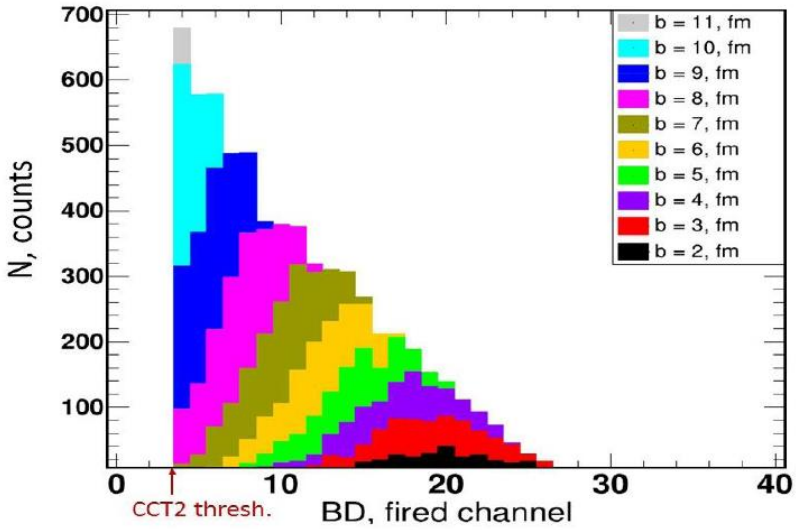


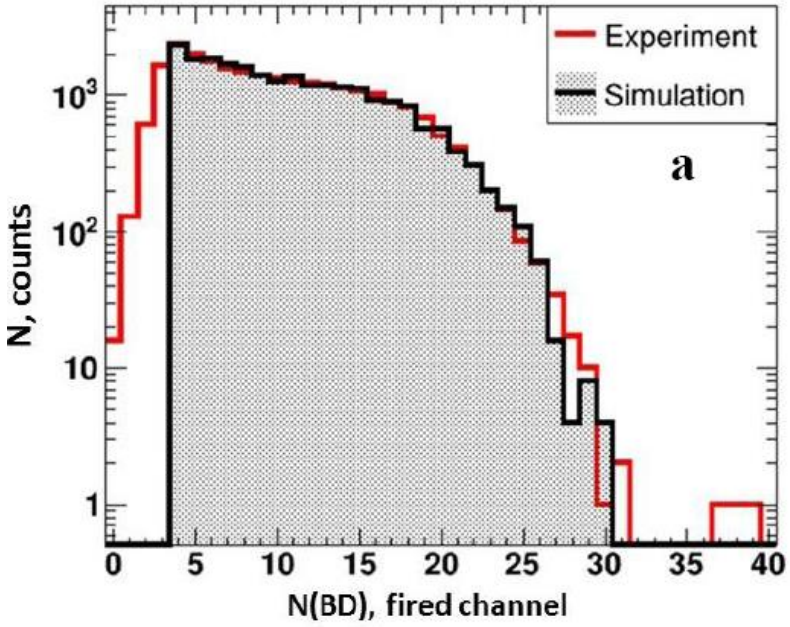
Simulation of trigger efficiency in Xe+CsI run

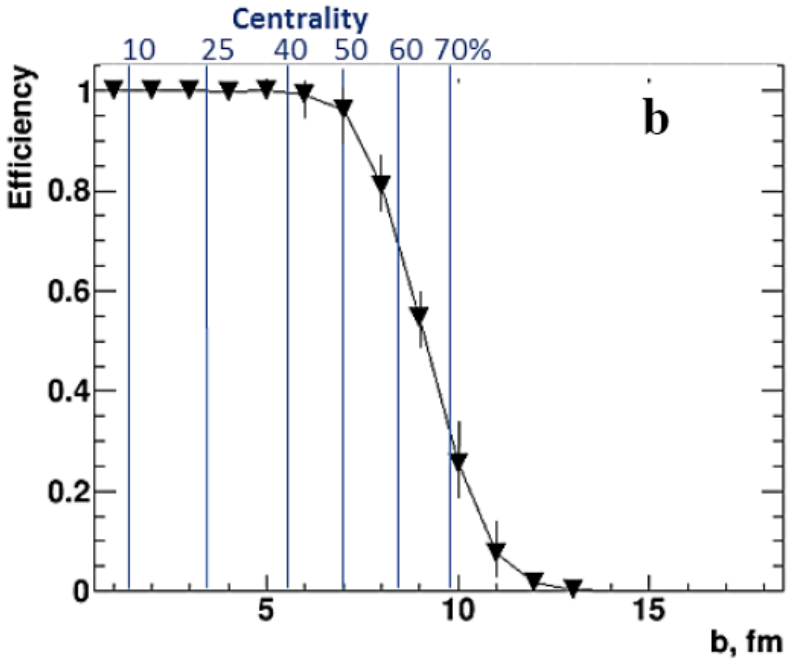
Trigger group

Main CCT2 trigger









→ **Trigger efficiency could be used as 1st approximation in MC to Data adjustment**

Current activities and tasks for the Xe data analysis

- Good agreement between data and reconstructed Λ and K^0_S simulation (A.Zinchenko, V.Vasendina, J.Drnoyan)
- Identification of charged particles in ToF-400 and ToF-700 (M.Rumyantsev, I.Zhavoronkova, S.Merts, N.Huhaeva, V.Plotnikov)

→ ToF-700 hit reconstruction and alignment is not finished yet

- Search for signals of light hyper-nuclei ${}_{\Lambda}H^3$, ${}_{\Lambda}H^4$ and Φ-meson (S.Merts, R.Barak)
- Analysis of v1 and v2 flows for protons and Λ, centrality measurement based on track multiplicity (MEPhI group)

→ Still, centrality measurement in fragment hodoscope and hadron calorimeter is not done yet (INR RAS group)

→ Need to compare results of two methods

→ Need to evaluate trigger efficiency in data for different centrality classes

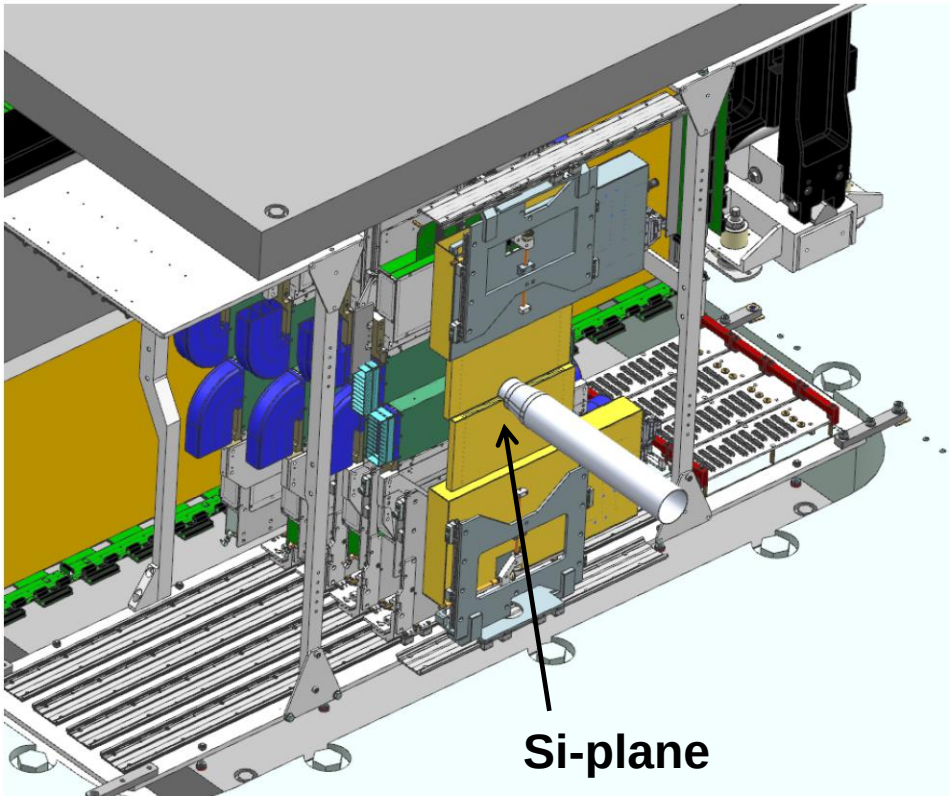
- **Topics of physics analyses:**
- analysis of production of Λ hyperons, K^0_S , K±, π±, Φ mesons, light nuclear fragments and neutrons in Xe+CsI interactions;
- analysis of collective flow of protons, π±, Λ, light nuclear fragments
- femtoscopy of π±, protons, light nuclear fragments
- Analysis of light hyper-nuclei ${}_{\Lambda}H^3$, ${}_{\Lambda}H^4$

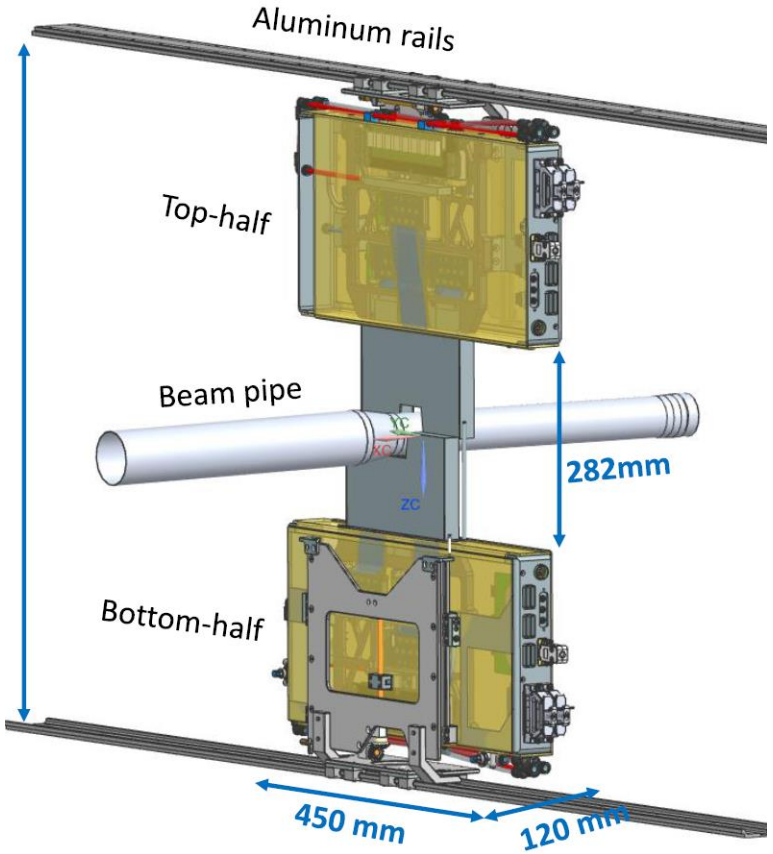
2-coordinate Si-plane based on STS modules

STS group

A new Si-plane based on STS modules to be installed between the **Target** and **Forward Si-Tracker**

Motivation: to improve track and momentum resolution for the low-momentum particles

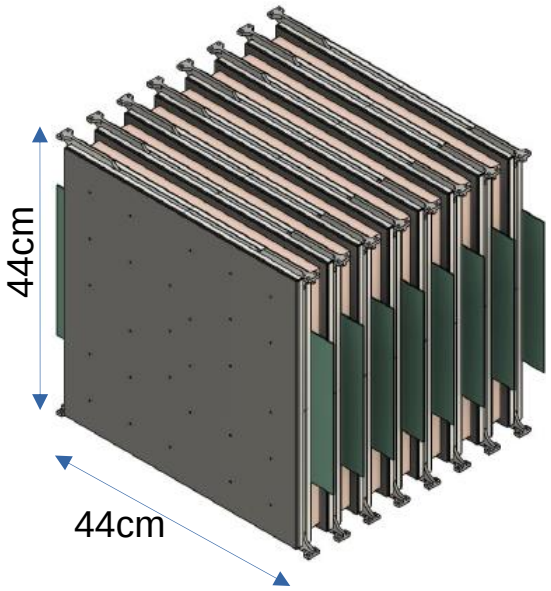


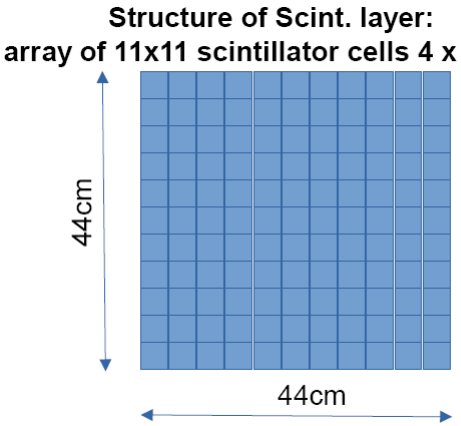


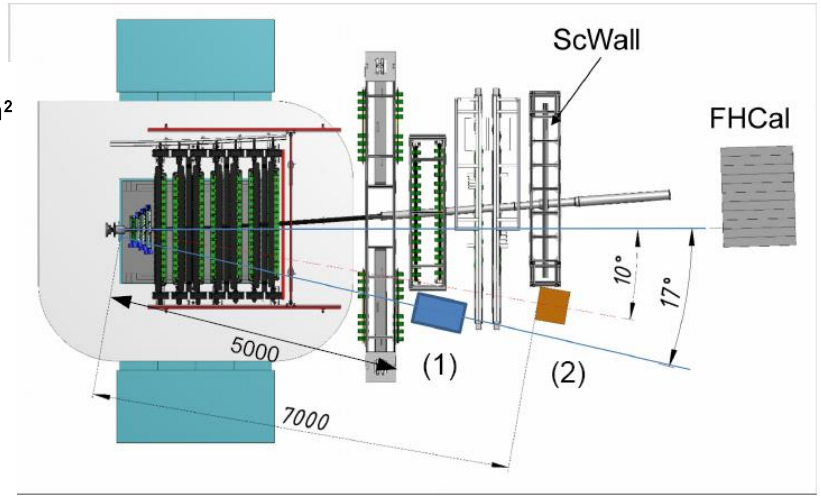
Plan to install and commission the new Si plane for the next experimental run

High Granularity Neutron detector

INR RAS, JINR, NRC Kurchatov → plan to construct in 2025





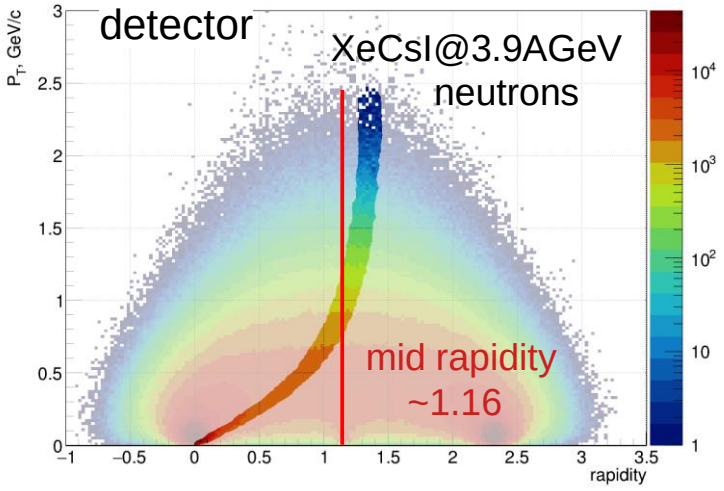


2 positions of HGN detector at BM@N: at 10° and 17°

HGN detector parameters: 2 sub-detectors with 8 layers each (~1.5 λ_{int})

- 11 x 11 cells in one layer with SiPM read-out
- first layer works as VETO
- next 7 layers: 3cm Cu + 2.5cm scintillator
- FPGA based fast TDC read-out with additional ToT amplitude measurement
  - time resolution of one scint. cell ~ 120ps
  - neutron detection efficiency: > 60% @ 1GeV

Acceptance of HGN detector



Plans for BM@N upgrade and physics runs

Physics run with the Xe beam in 2025

→ beam energy scan in the range of 2-3 AGeV
→ same central tracker configuration based on silicon FSD and GEM detectors,
→ additional 1st vertex plane of silicon STS detectors
→ complete replacement of outer drift chambers with cathode strip chambers
→ additional ToF-400 modules to extend acceptance by factor 1.5

Preparations for the physics run with the Bi beam

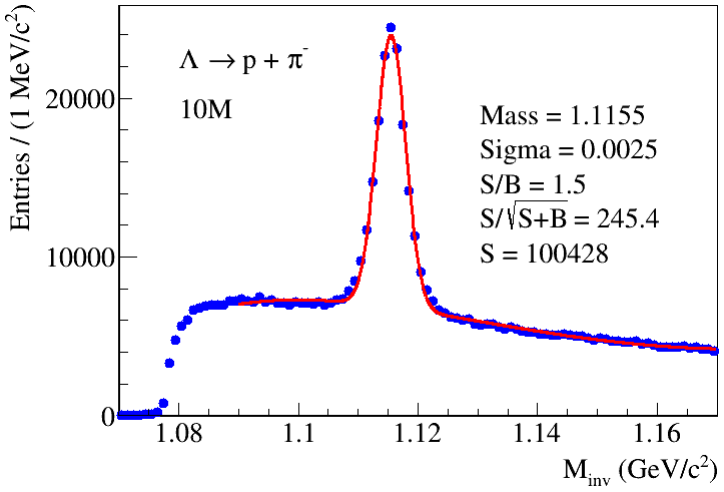
- further development of the central tracker is foreseen: installation of additional station of silicon FSD detectors

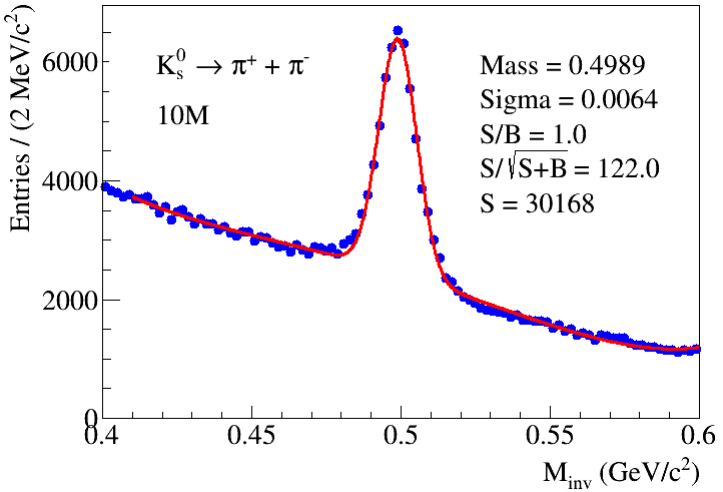
- It is planned to put into operation a 2-coordinate (X/Y) neutron detector of high granularity to measure neutron yields and collective flow

Thank you
for attention!

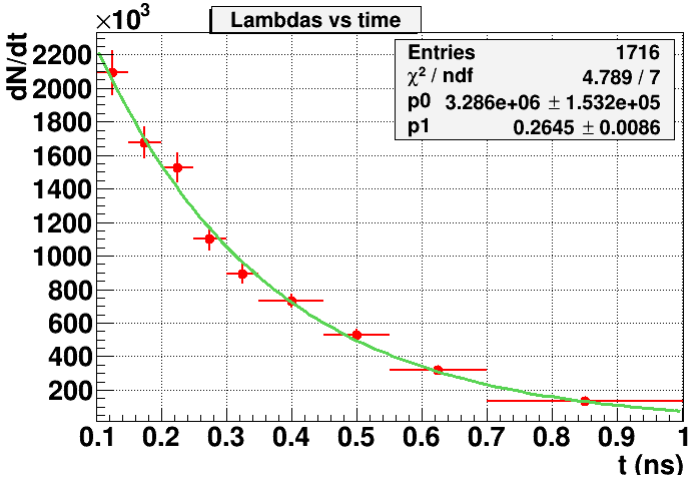
Λ and K^0_s production in Xe+CsI interactions

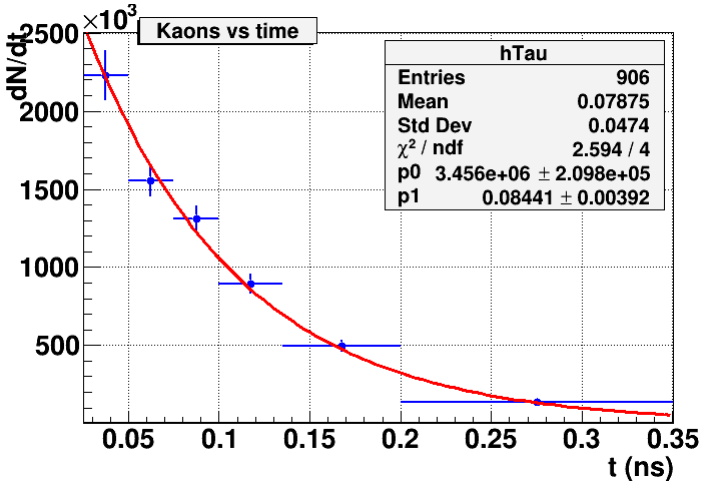
A.Zinchenko → talk at NUCLEUS-2024, Dubna





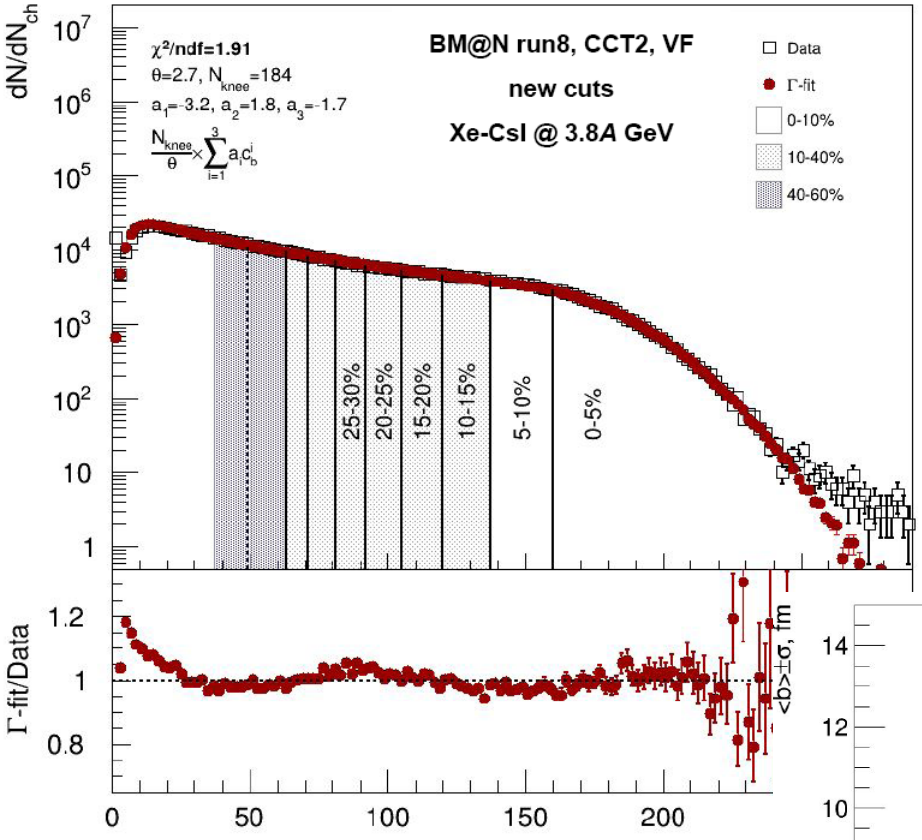
In 500M events expect: 4M Λ, 1.2M K^0_s





Life time is in agreement with PDG values: 0.2632 ns for Λ, 0.0895 ns for K^0_s

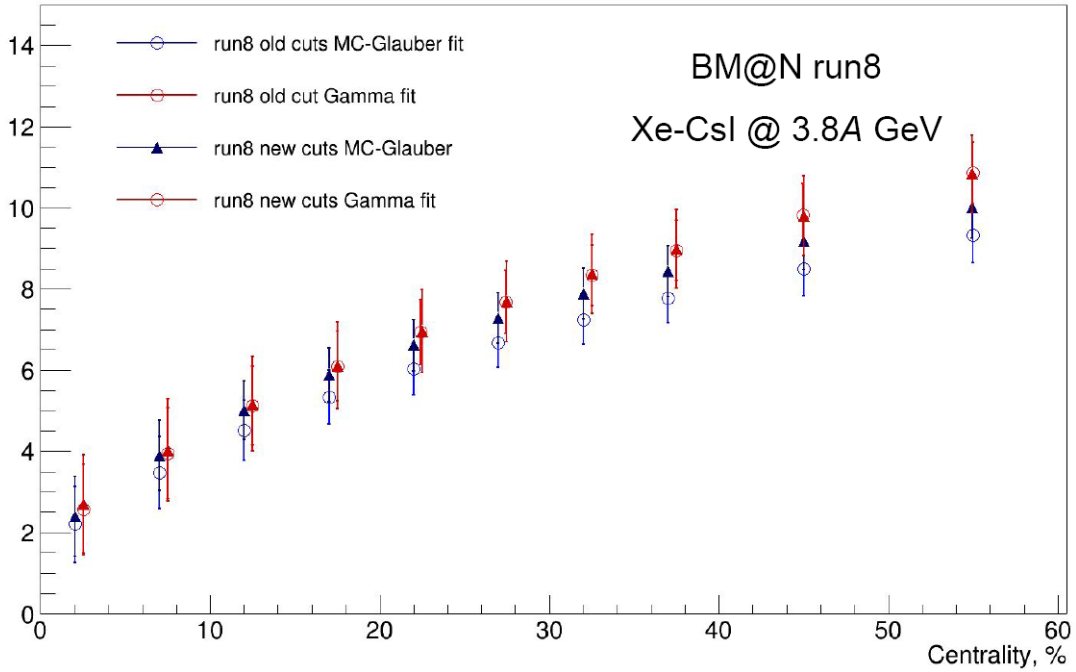
Centrality selection from fits of the track multiplicity



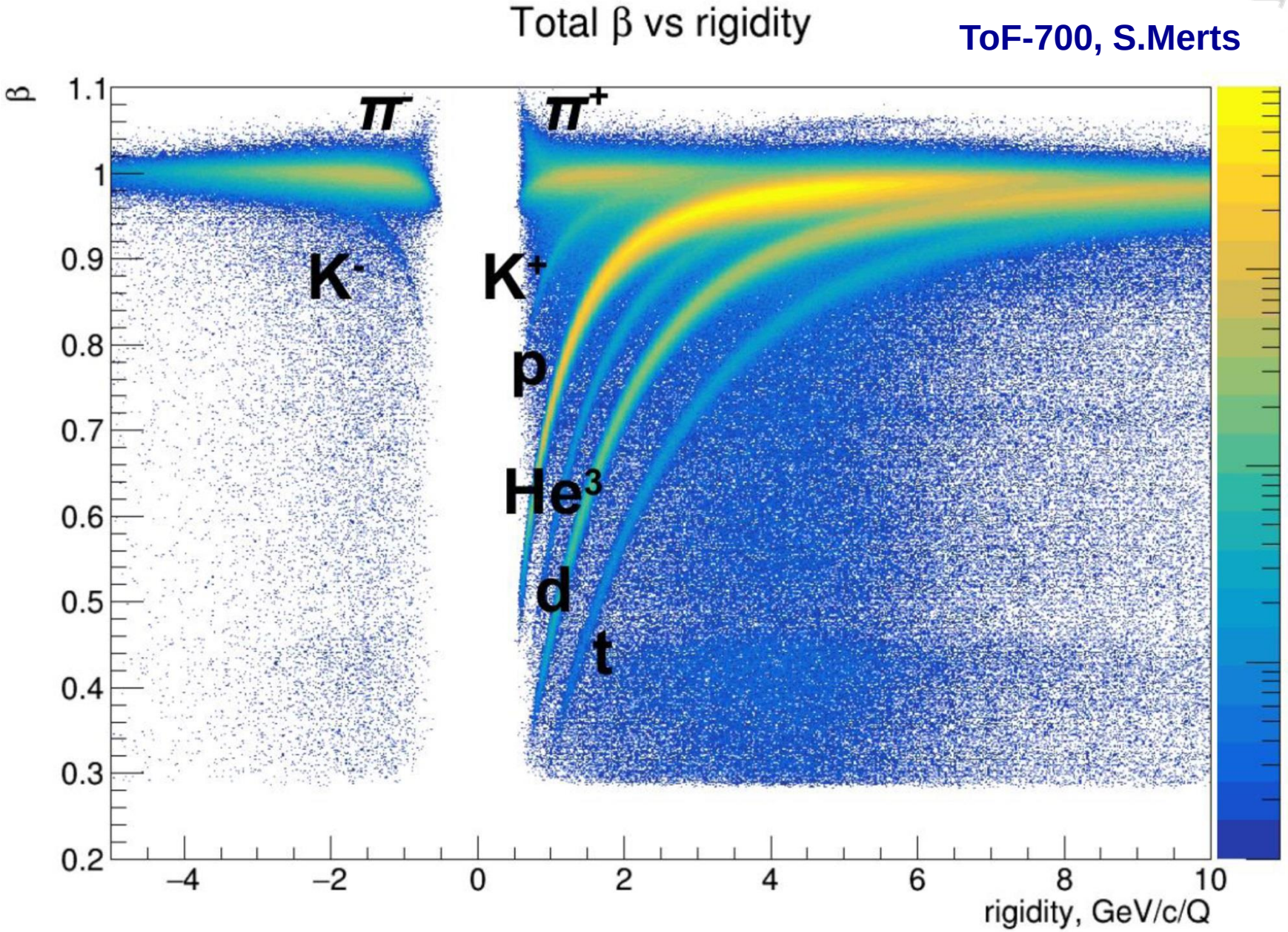
Γ-fit and MC-Glauber fit are in agreement

MEPhI group

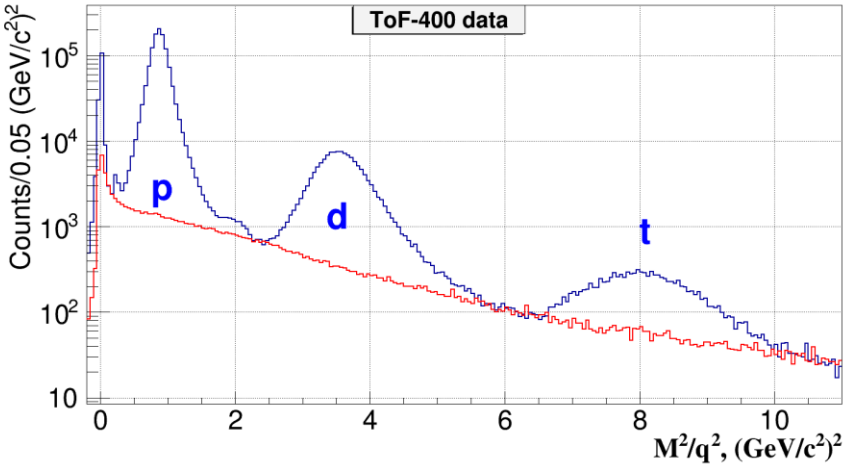
- Parametrization of data track multiplicity N_{ch} by MC Glauber model or Negative Binominal Distribution (Γ-fit) with free parameters
- Extract $P(b \mid N_{ch})$
- Still need to correct for trigger efficiency, changes in central tracker (FST, GEM) efficiency

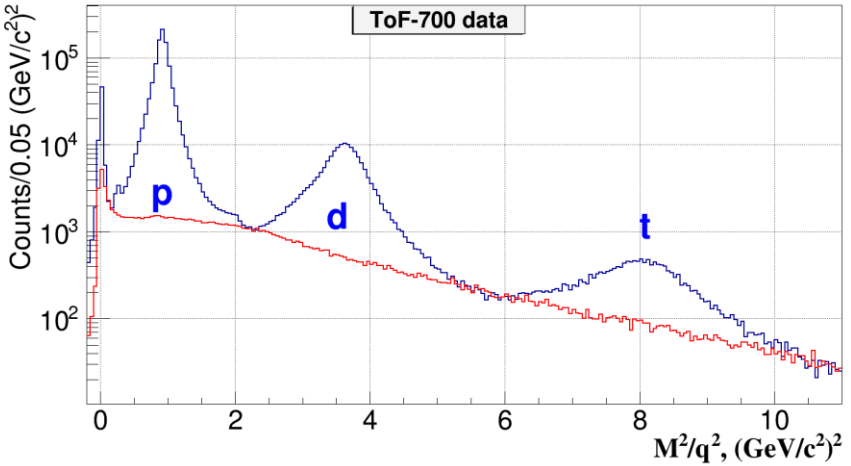


Xe+CsI data: π±, K±, p, He3, d, t identification



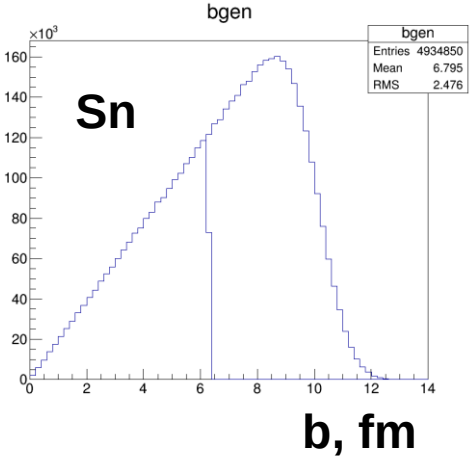
Production of *p, d, t* in 3.2 AGeV argon-nucleus interactions

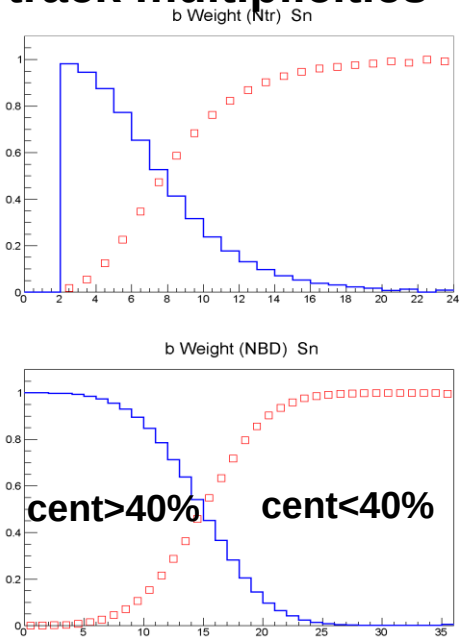




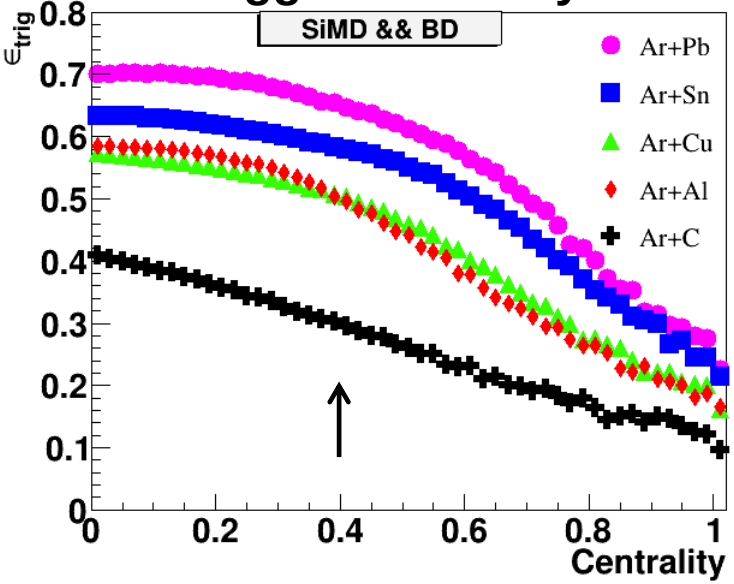
Two classes of centrality <40% and >40% based on barrel detector and track multiplicities

cent<40% cent>40%

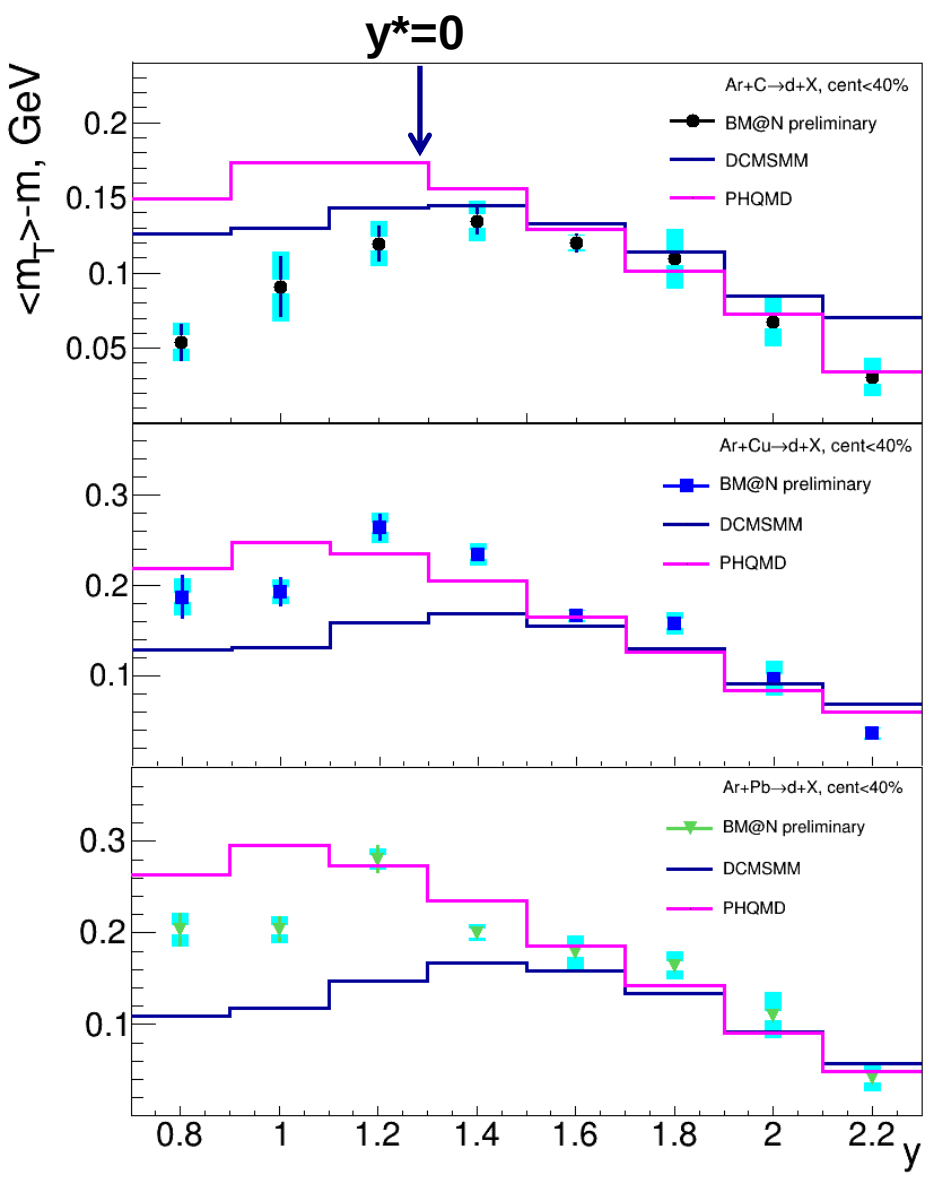


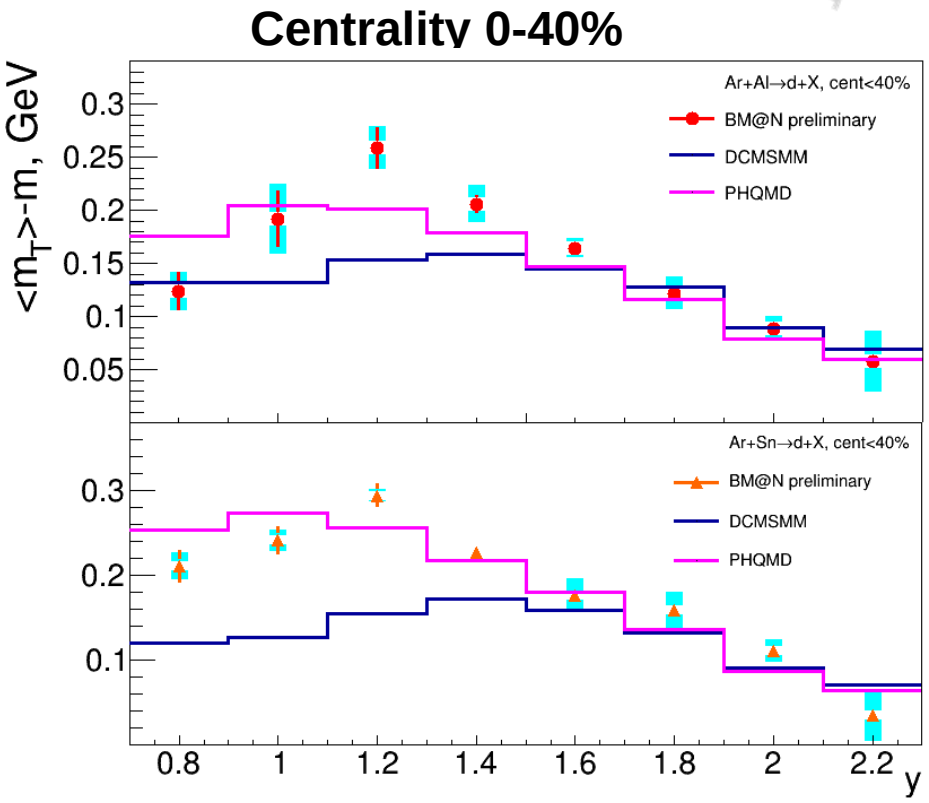


Trigger efficiency



Deuterons: <m_t> dependence on y





- **Maximum <m_t> at mid-rapidity y***
- **PHQMD model is in better agreement with data at mid-rapidity than DCM-SMM**