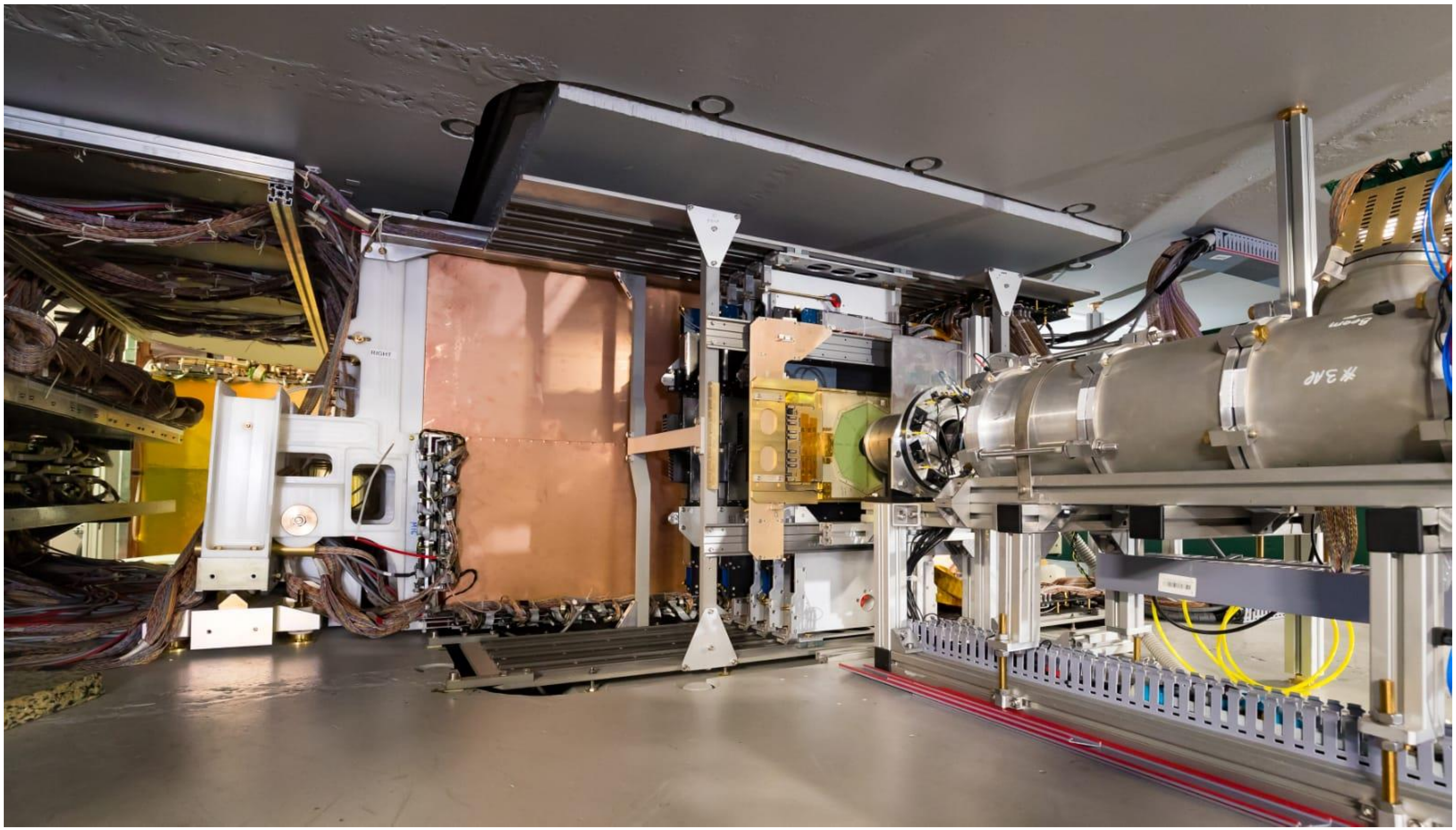
Status of the BM@N experiment

M.Kapishin



Baryonic Matter at Nuclotron (BM@N) Collaboration:

5 Countries, 13 Institutions, 206 participants, 8 Institutions signed MoU + JINR

- *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 (associate member)*

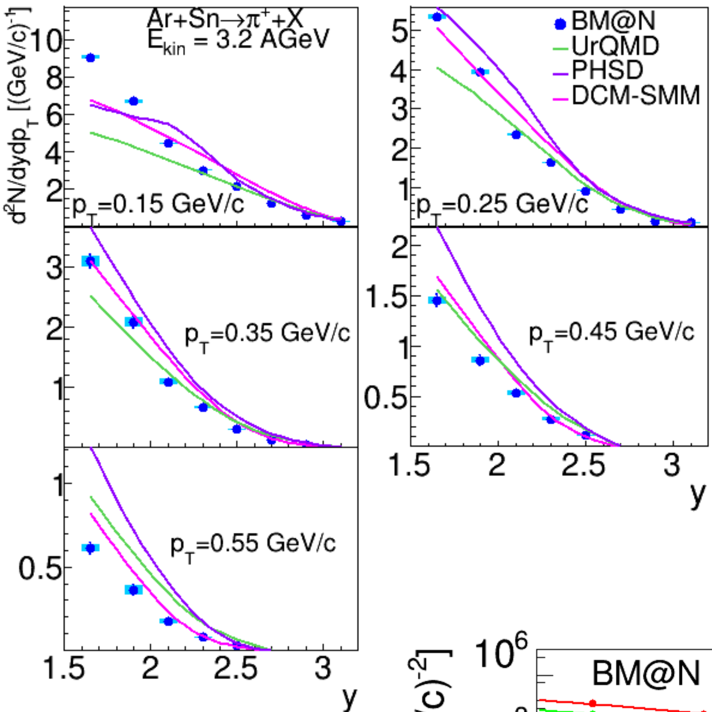
Accepted to Collaboration at the BM@N IB meeting on September 14:

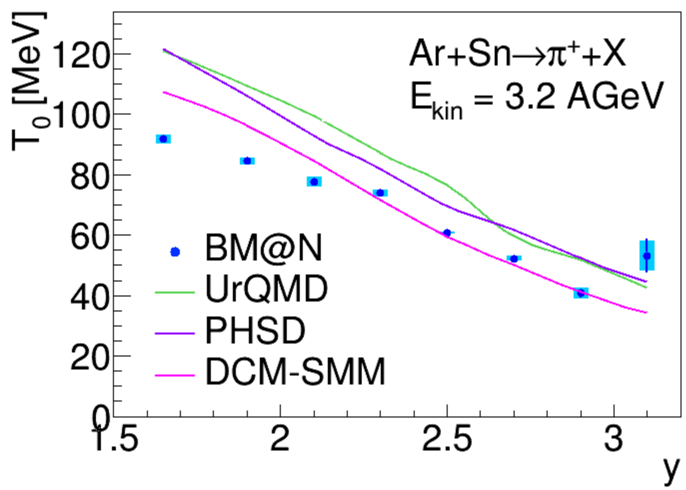
- **Physical-Technical Institute, Uzbekistan Academy of Sciences Tashkent**
- **High School of Economics, National Research University, Moscow**

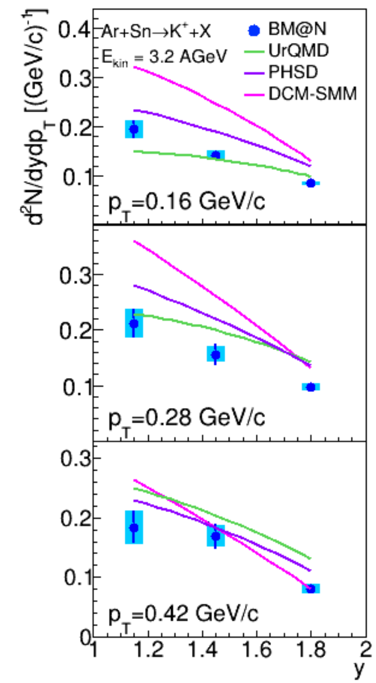
Production of π^+ and K^+ mesons in 3.2 AGeV argon-nucleus interactions at the Nuclotron

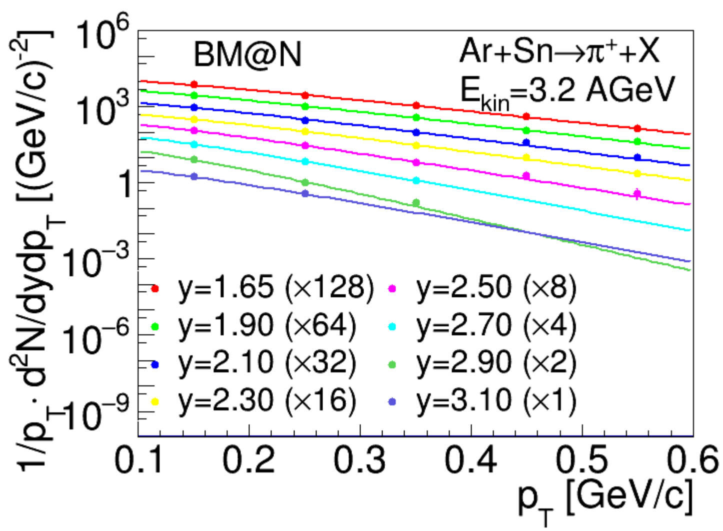
https://arxiv.org/abs/2303.16243v3

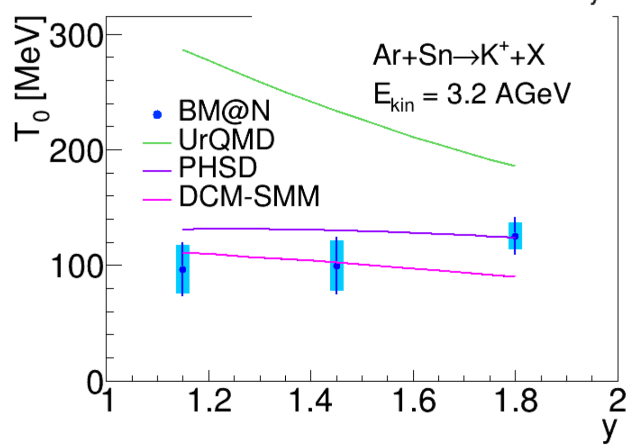
Published in JHEP 07 (2023) 174







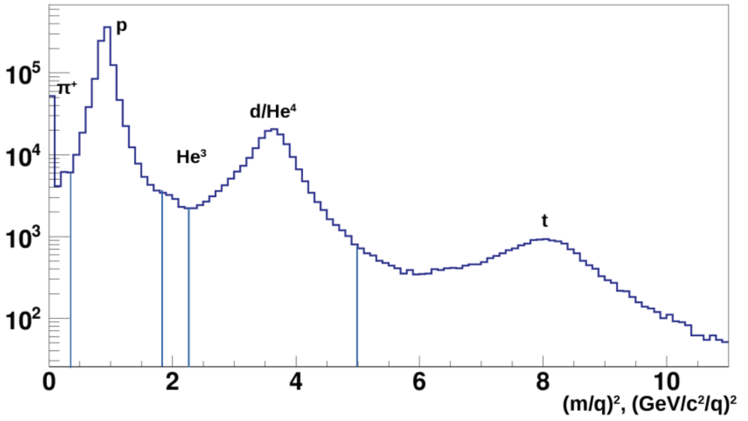




M.Kapishin

BM@N experiment

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

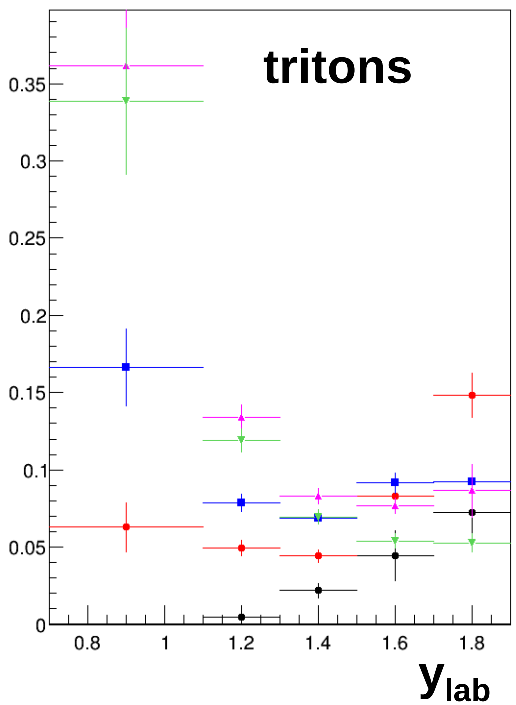


See talk of Lalyo Kovachev

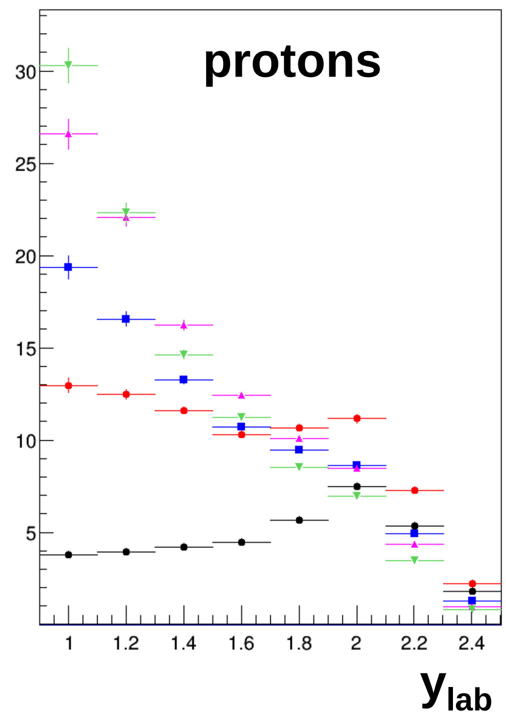
$$d^2N_A/dm_t dy = dN/dy/(T(m+T)\cdot m_t \cdot \exp(-(m_t-m)/T))$$

dN/dy in Ar + C, Al, Cu, Sn, Pb for cent 0-40%

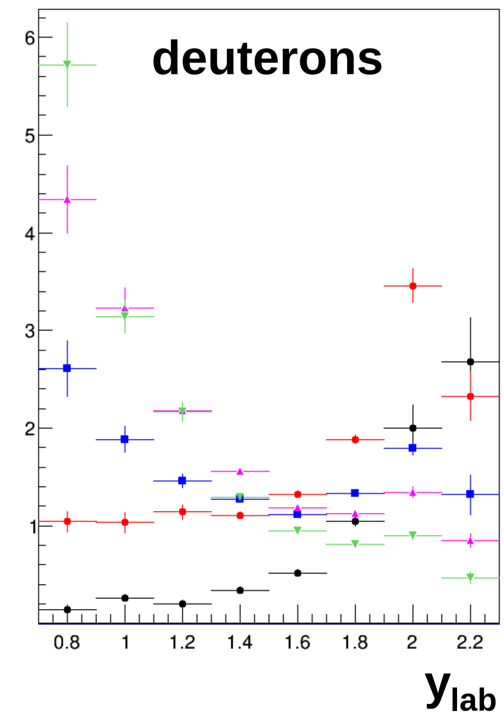
dN/dy tritons



dN/dy protons



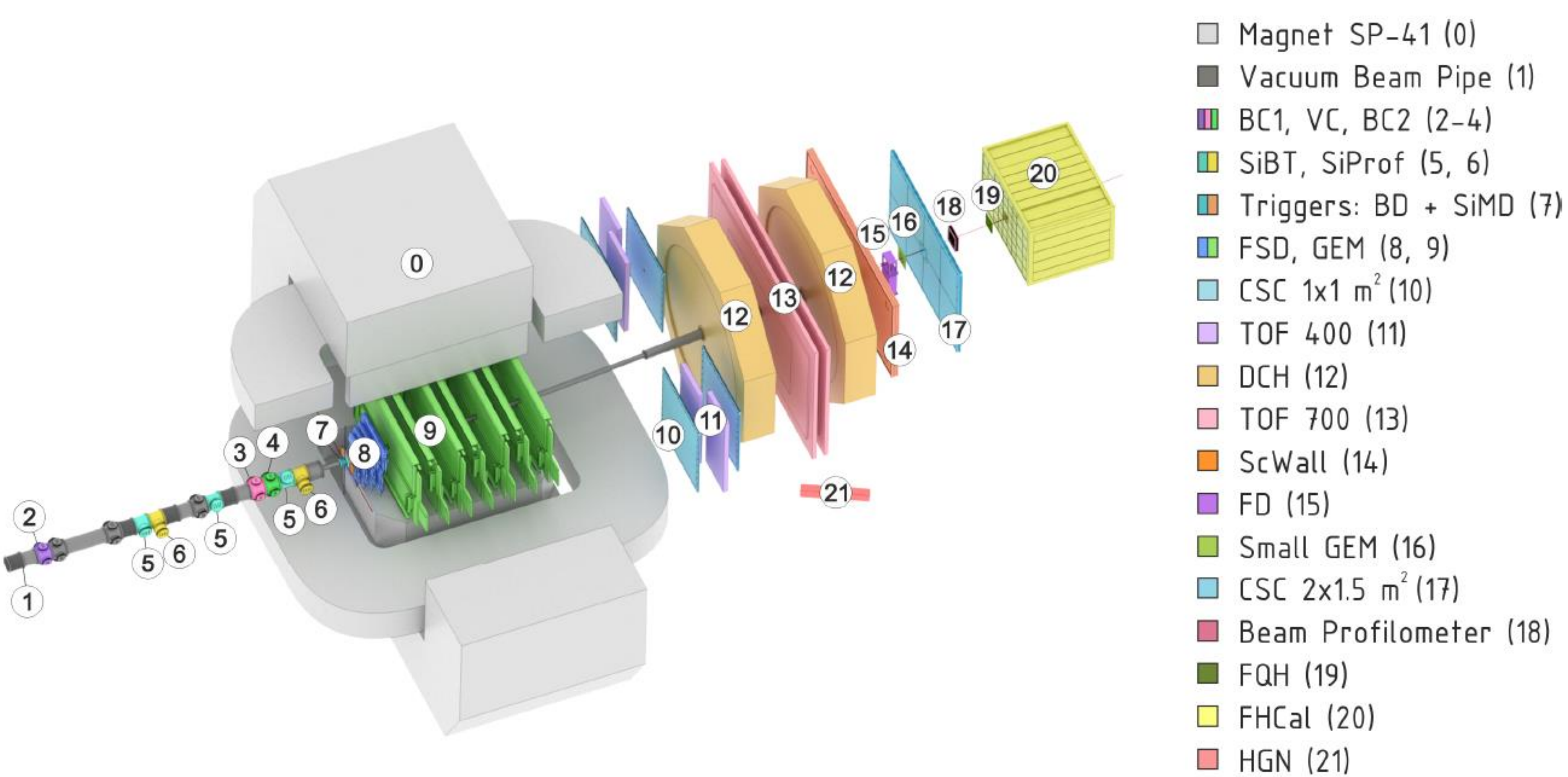
dN/dy deutrons



M.Kapishin

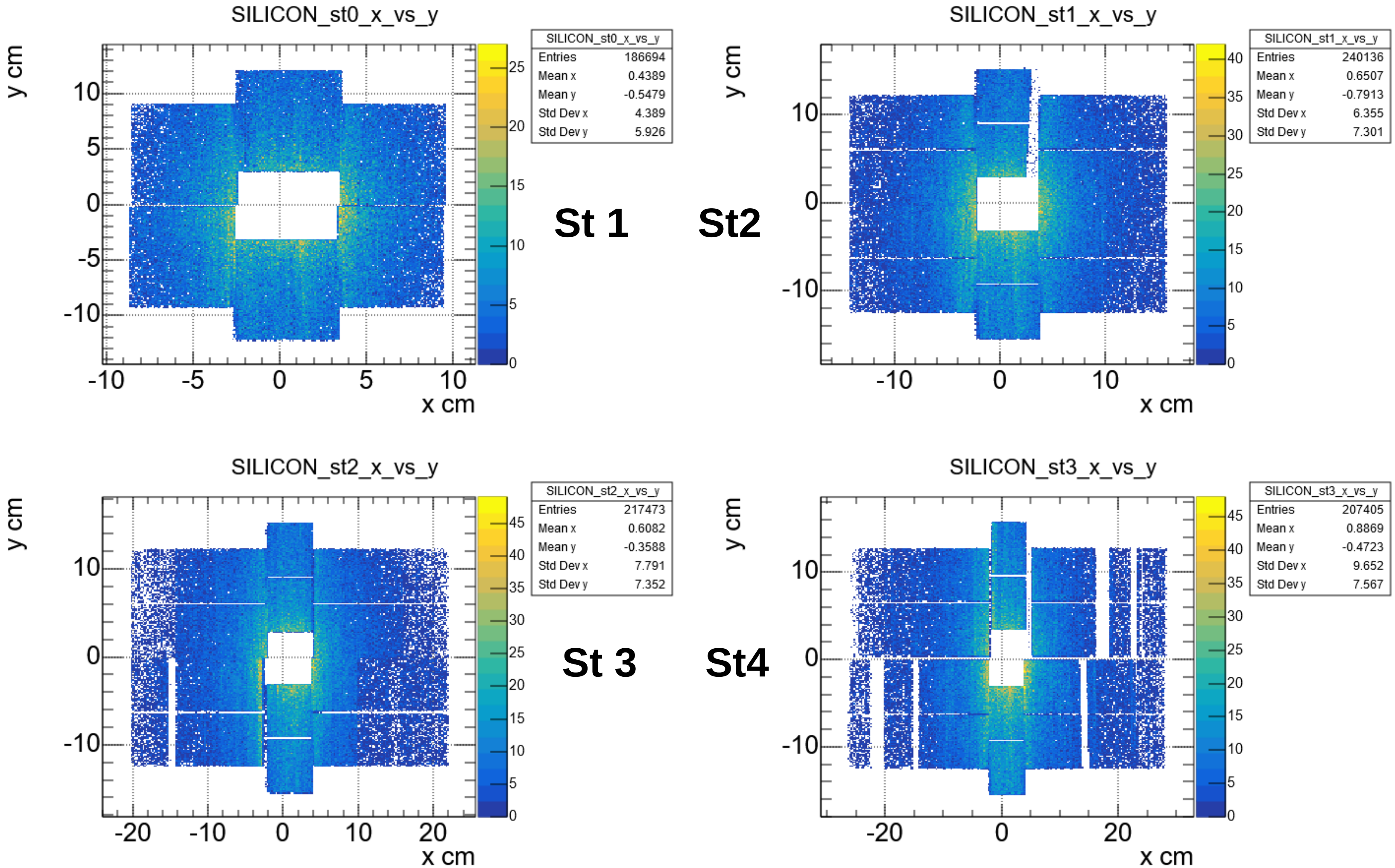
BM@N experiment

Configuration of BM@N detector in Xe run



For the next experimental run 2 Drift chambers DCH (12) are replaced with 2 big Cathode Strip Chambers CSC (13)

FST hit reconstruction in Xe run: 4 Si stations



Readout cards with defected chips in stations 2 and 3 are replaced
Repair work to replace defected chips in station 4 is going on

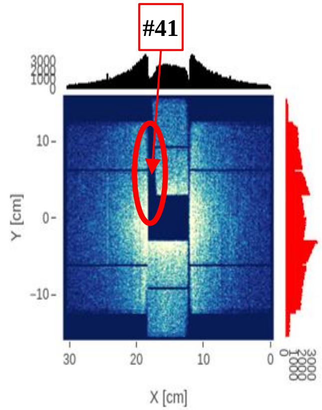
See talk of N.Zamiatin

FSD planes before repair

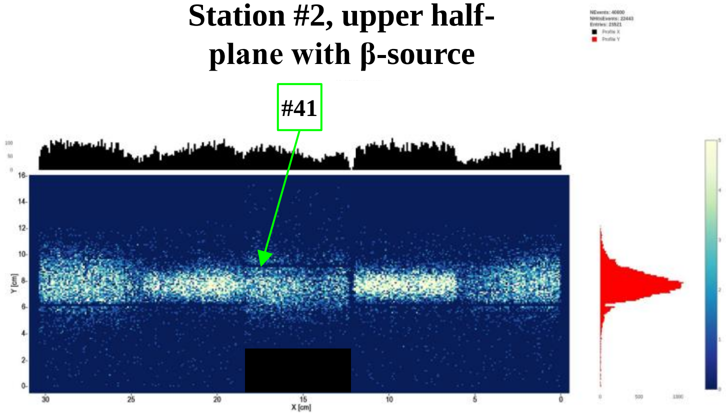
FSD planes after repair

Session BM@N 2022 г. – 2023 г.
RUN 7529

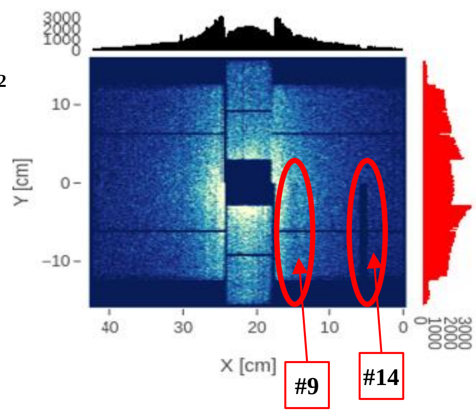
Hits distribution at Station # 2
(10 modules, DSSD 63x63 mm²
1 module = 2 DSSD)



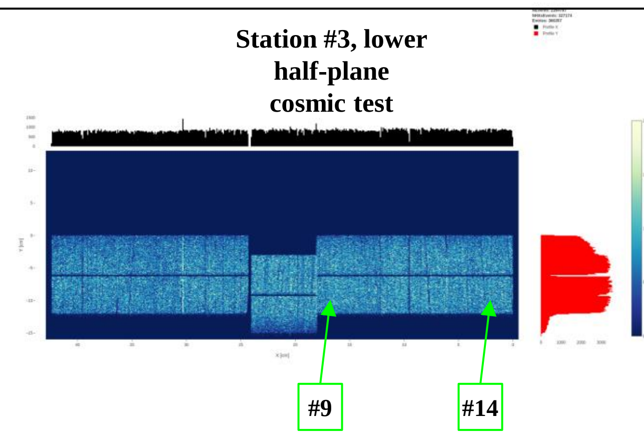
Station #2, upper half-plane with β-source



Hits distribution at Station # 3
(14 modules, DSSD 63x63 mm²
1 module = 2 DSSD)



Station #3, lower half-plane cosmic test



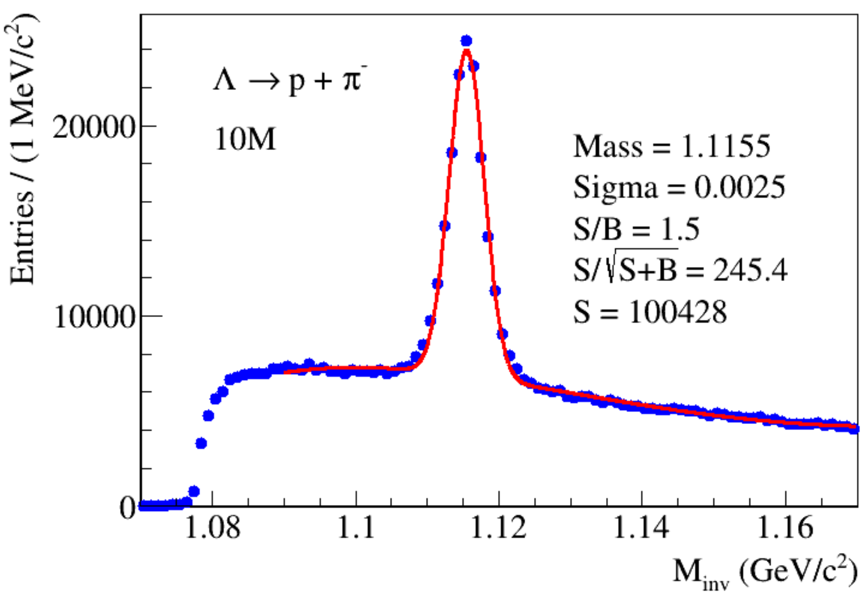
Details in talk of N.Zamiatin

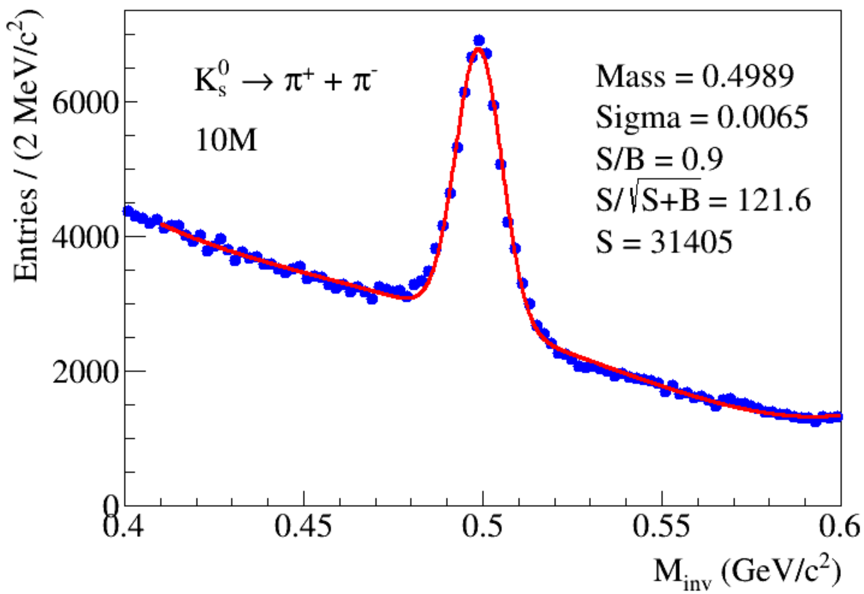
Data reconstruction: $\Lambda \rightarrow p\pi^-$ and $K^0_s \rightarrow \pi^+\pi^-$ signals

A.Zinchenko, V.Vasendivna, J.Drnoyan

Central tracking activities:

- **optimize Vector Finder tracking algorithm**
- **improve alignment of silicon and GEM tracking detectors**
- **estimate FST and GEM detector efficiencies with central tracks**





DCM-SMM predictions assuming 2% (Λ) and 0.5% (Ξ-) reconstruction efficiency → 210k Λ and 550 Ξ- in 10M MB events

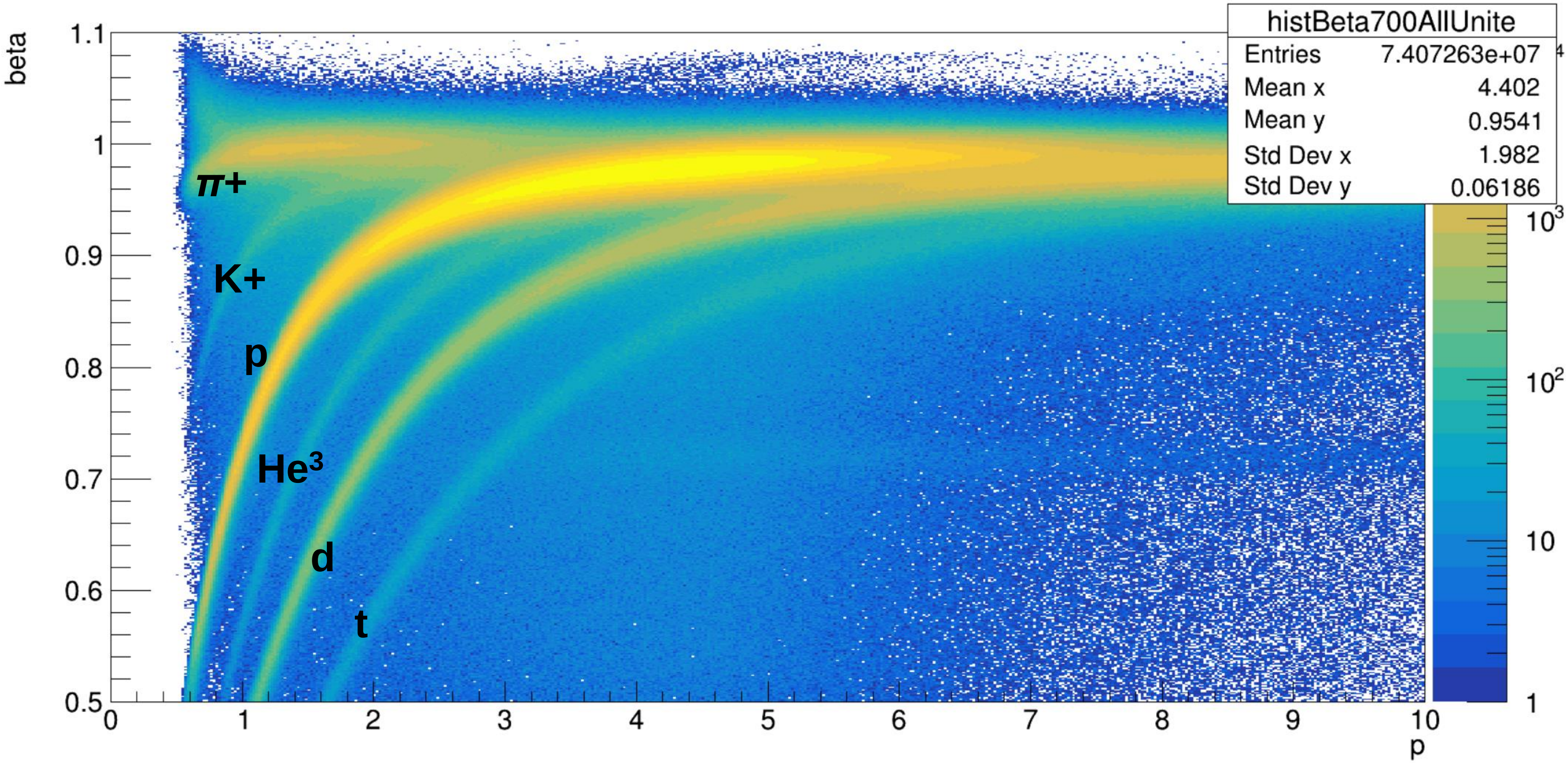
Experimental 10M events: 100k Λ and 220 Ξ-

See talk of A.Zinchenko

ToF-700 π+, K+, p, He3, d, t identification

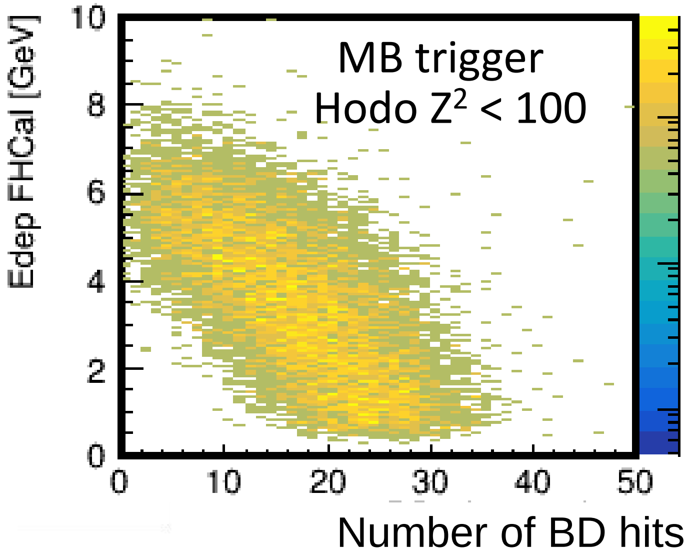
S.Merts, I.Kozlov

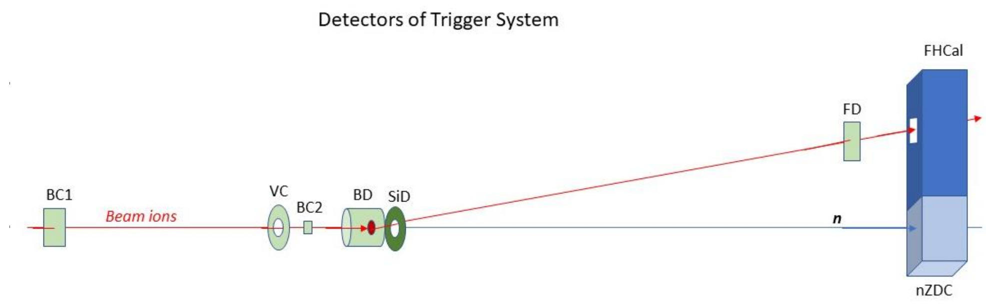
Still need dedicated ToF calibration to constrict proton mass peak



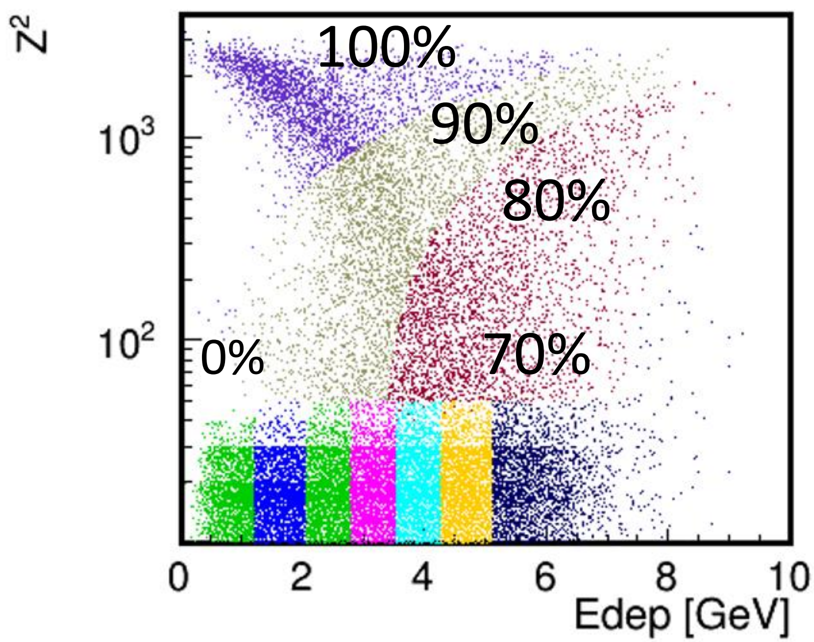
Centrality selection with Hodoscope and FHCal detectors

See talks of INR RAS group





It is time to define centrality classes on the scale of impact parameter of nucleus-nucleus interaction



Color bins – 10% of number of events in each bin

Current tasks for the Xe data analysis

Activities since the last Collaboration meeting in May:

- **Optimization of the central tracking algorithm** based on Vector Finder (Si+GEM): A.Zinchenko, V.Vasendina, J.Drnoyan
- alignment of the central and outer tracker
- implementation of a newly measured magnetic field map (S.Merts)
- few iterations to update / improve performance of the central track finder
- Version for data processing has been completed
- first processing of reconstruction of 300M events is done using DIRAC at Tier MLIT

→ Reasonable signals of Λ and K^0_S

Task to be completed:

- **Particle identification in ToF-400 detectors**: M.Rumyantsev, M.Mamaev, I.Zhavoronkova, A.Huhaeva
- **Particle identification in ToF-700 detectors**: P.Alexeev, S.Merts
- need alignment of ToF-detectors with central tracks in magnetic field
- need calibration of time of flight to squeeze proton mass peak
- **Centrality measurement with forward detectors**: INR RAS team
- need pile-up corrections of fragment hodoscope signals (beam area)
- **Topics of physics analyses:**
- analysis of production of Λ, Ξ- hyperons, K^0_S , K±, π± mesons, light nuclear fragments in Xe+CsI interactions;
- analysis of collective flow of protons, π±, light nuclear fragments
- search for light hyper-nuclei $_\Lambda H^3$, $_\Lambda H^4$

Plans for BM@N upgrade and physics runs

In fall 2024, physical run in the Xe beam is feasible (depends on the status of the NICA collider construction):

→ beam energy scan in the range of 2-3 AGeV
→ same central tracker configuration based on silicon FST and GEM detectors,
→ additional 1st vertex plane of silicon STS detectors
→ complete replacement of outer drift chambers with cathode strip chambers

- Physics run with Bi beam is possible after 2024, depends on the implementation of plans for the NICA collider
- To be ready for the experiment with Bi beam, further development of the central tracker is necessary: installation of additional stations of silicon 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

Outer tracker: 2 big 2.1x1.5 m^2 cathode strip chambers installed

BM@N

Team:
A.Vishnevsky
R.Kattabekov
A.Makankin
A.Morozov
E.Martovitsky
V.Spaskov

1st big CSC was installed and operated in the Xe run
2nd big CSC has been tested with cosmic particles and installed for the next experimental run

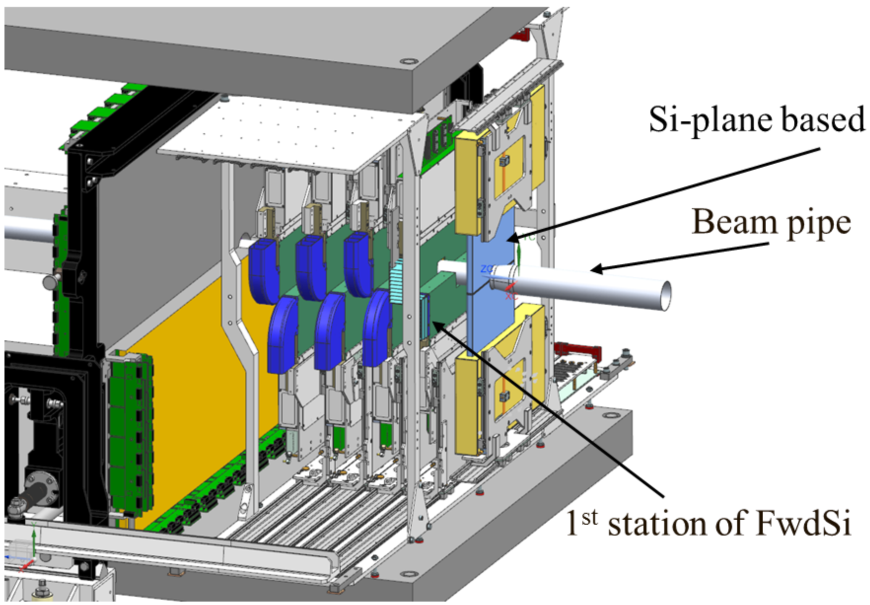
→ 2 big DCH chambers fulfilled their task to measure interactions of middle size nuclei !!!

See talk of Al. Sheremetev

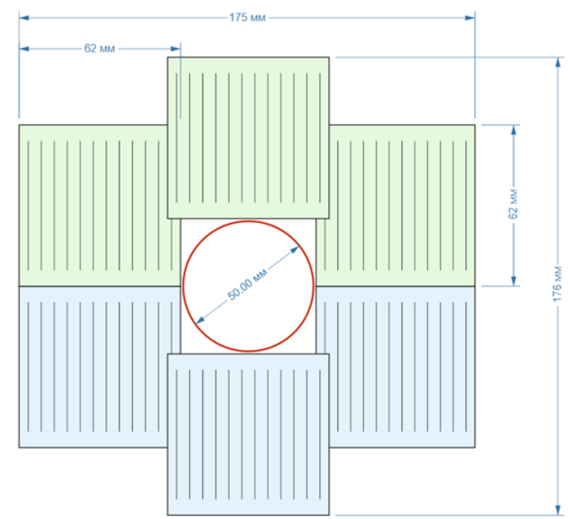
Vertex two-coordinate Si-plane based on STS modules

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

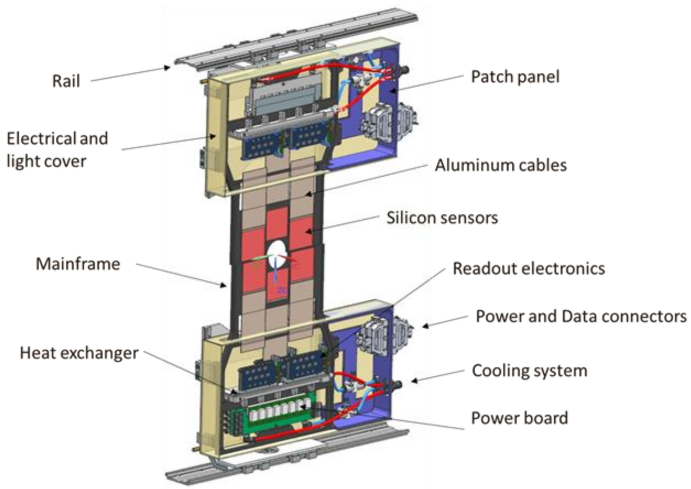


BM@N setup inside the magnet

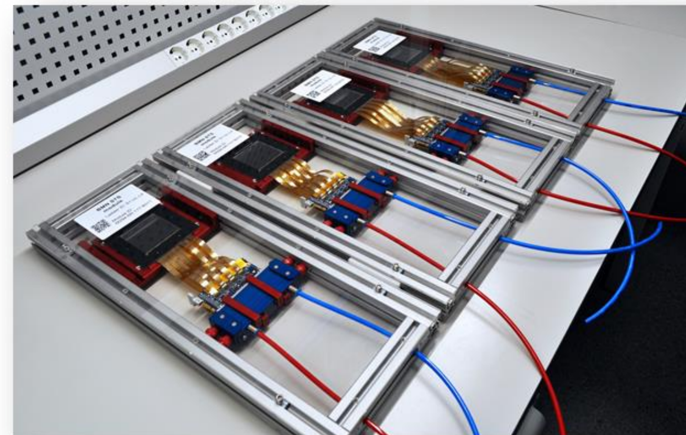


Sensitive area of Si-plane

Vertex two-coordinate Si-plane based on STS modules



Conceptual design of the vertex Si plane



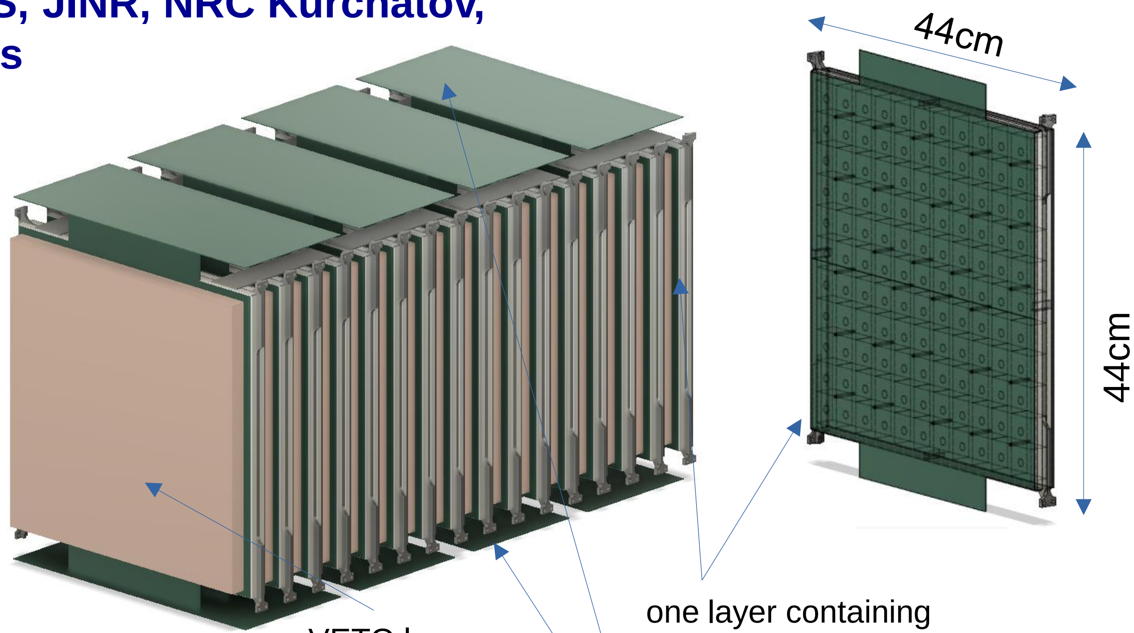
STS modules

- Vertex Si-plane will consist of 6 STS modules which are already assembled and tested;
- Si-plane will be divided in two parts: upper and bottom halves;
- Sensitive area of the plane: ~175×175 mm²;
- Mechanical design is being developed;

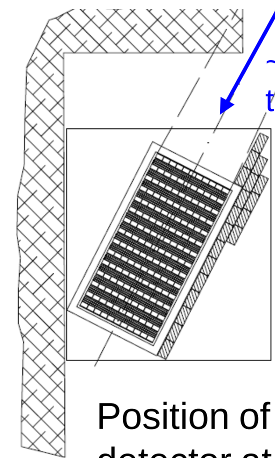
The new Si-plane will be installed and commissioned in the fall of 2024

High Granularity Neutron detector

INR RAS, JINR, NRC Kurchatov, see talks



→ plan to construct in 2023-2024

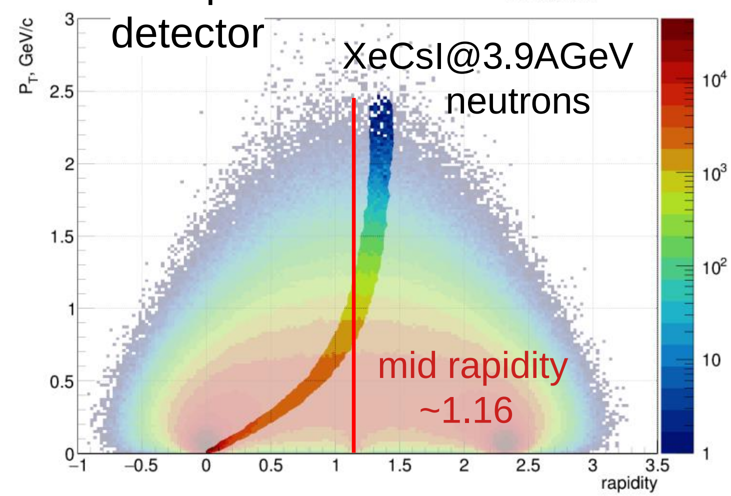


Position of HGN detector at BM@N

HGN detector parameters:

- 11 x 11 cells in one layer
- first layer works as VETO
- next layers: 3cm Cu + 2.5cm scintillator
- number of layers: 16 (~3 λ_{int})
- time resolution of one scint. cell ~ 100ps
- neutron detection efficiency: > 80% @ 1GeV

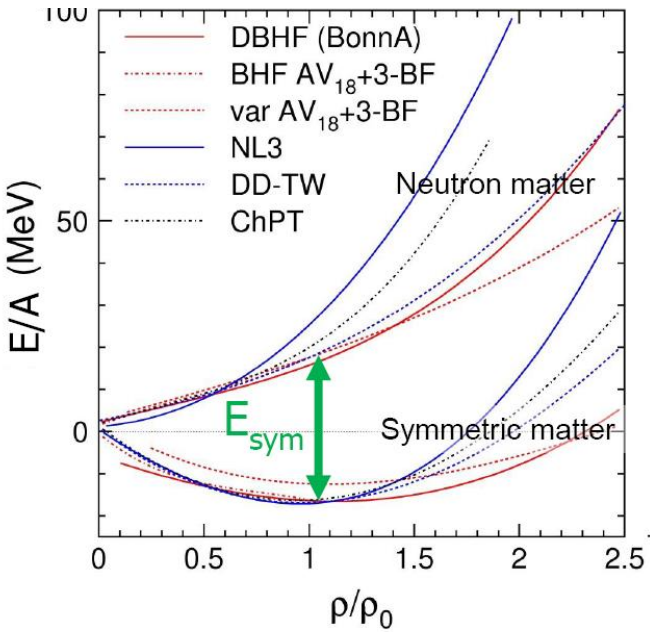
Acceptance of HGN detector



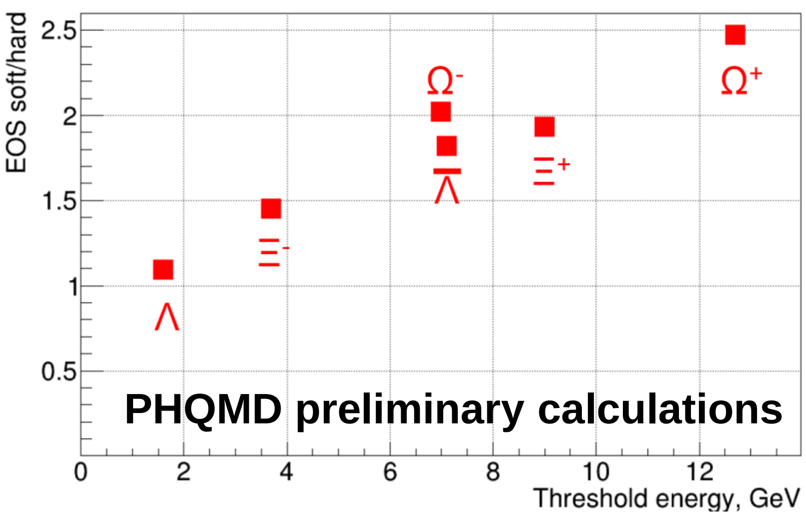
Thank you for attention!

EOS of symmetric and asymmetric nuclear matter

Ch. Fuchs and H.H. Wolter, EPJA 30 (2006) 5



Hyperon yield in 4A GeV Au+Au:
soft EOS (K=240 MeV) / hard EOS (K=350) MeV



EOS: relation between density, pressure, temperature, energy and isospin asymmetry

$$E_A(\rho,\delta) = E_A(\rho,0)+E_{sym}(\rho)\cdot\delta^2$$

with $\delta = (\rho_n - \rho_p)/\rho$ $\quad$ $E/A(\rho_o) = -16$ MeV

Curvature defined by nuclear incompressibility: $K = 9\rho^2\ \delta^2(E/A)/\delta\rho^2$

►Study symmetric matter EOS at ρ=3-5 ρ_0
→ elliptic flow of protons, mesons and hyperons
→ sub-threshold production of strange mesons and hyperons
→ extract K from data to model predictions
►Constrain symmetry energy E_{sym}
→ elliptic flow of neutrons vs protons
→ sub-threshold production of particles with opposite isospin

BM@N Experimental physics run in Xe beam with CsI target

BM@N: Estimated hyperon yields in Xe + Cs collisions

4 A GeV Xe+Cs collisions, multiplicities from PHSD model,
Beam intensity $2.5\cdot10^5$/s, DAQ rate $2.5\cdot10^3$/s, accelerator duty factor 0.25

$1.8\cdot10^9$ interactions
$1.8\cdot10^{11}$ beam ions

Particle	E_{thr}NN GeV	M b<10 fm	ε %	Yield/s b<10fm	Yield / 800 hours b<10 fm
Λ	1.6	1.5	2	150	$5\cdot10^7$
Ξ^-	3.7	$2.3\cdot10^{-2}$	0.5	0.55	$2\cdot10^5$
Ω^-	6.9	$2.6\cdot10^{-5}$	0.25	$3.2\cdot10^{-4}$	110
Anti-Λ	7.1	$1.5\cdot10^{-5}$	0.5	$3.7\cdot10^{-4}$	130

DCM-SMM
x 0.75
x 0.5

DCM-SMM: reconstructed signals in 10M MB events: $2\cdot10^5$ Λ, 550 Ξ^-

GEM hit reconstruction: 7 stations + small GEM profile meter

GEM Hits