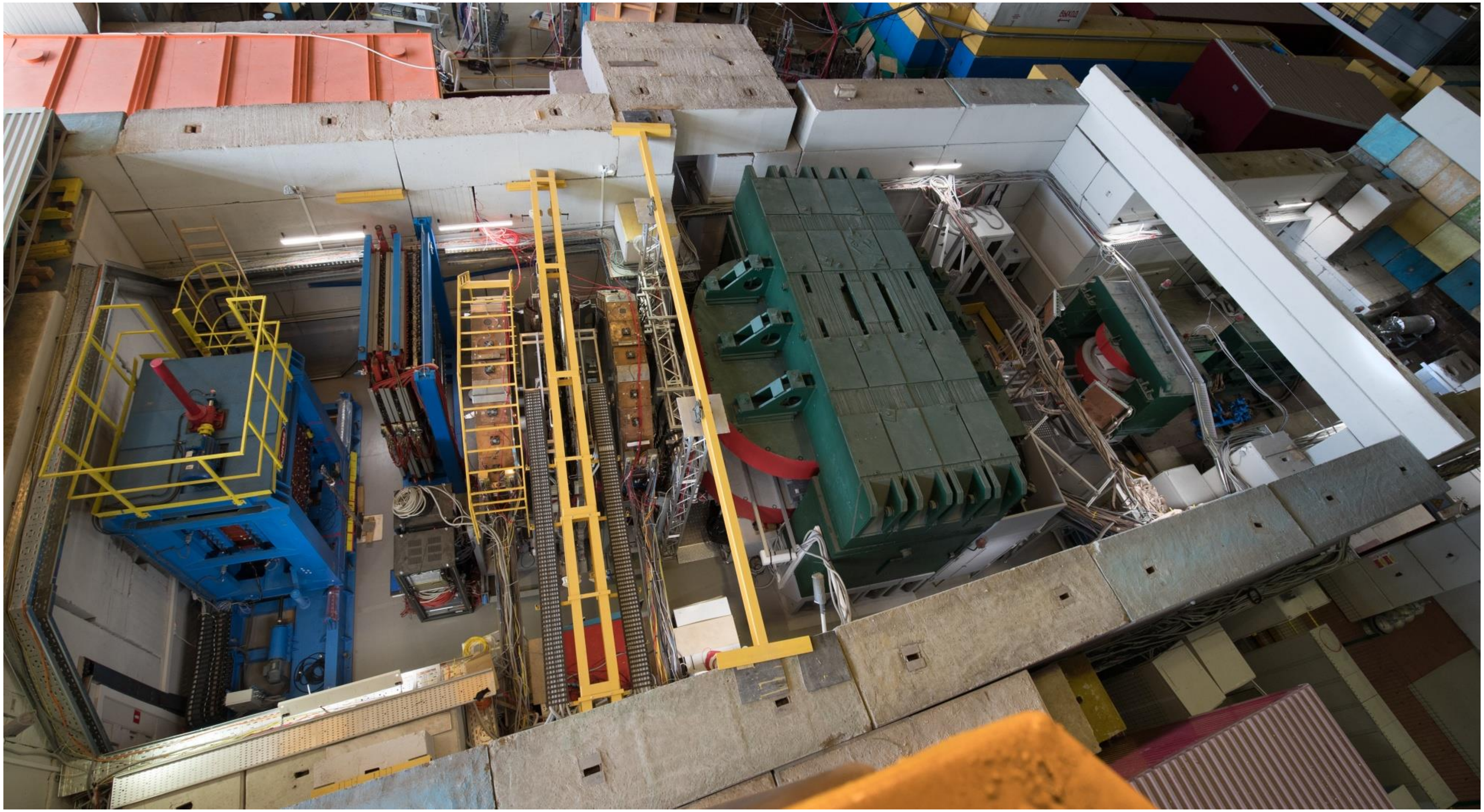
Status of the BM@N experiment

M.Kapishin



Baryonic Matter at Nuclotron (BM@N) Collaboration:

3 Countries, 10 Institutions, 184 participants, 8(7) 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*
- *Skobeltsin Institute of Nuclear Physics, MSU, Russia*
- *Moscow Institute of Physics and Technics*
- *Lebedev Physics Institute of RAS, Moscow*

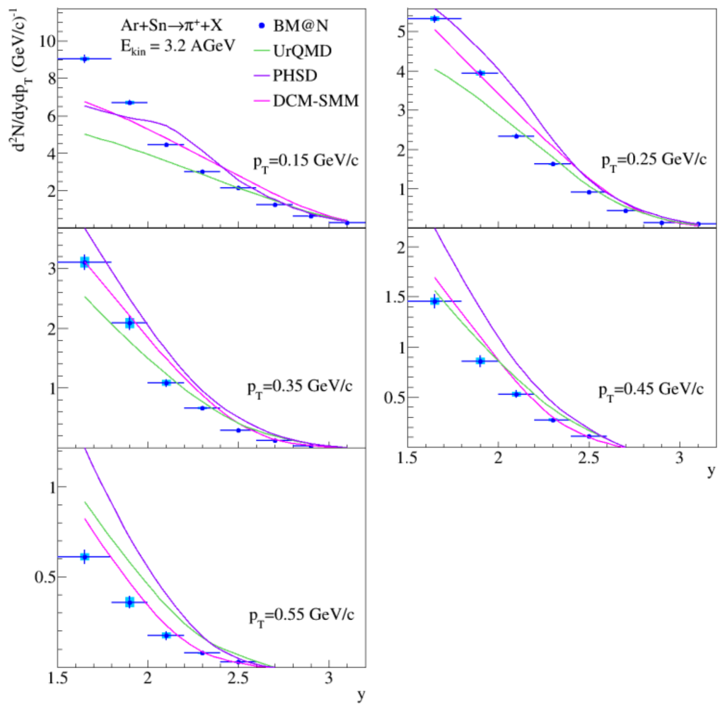
Suspended participation in BM@N:

- *Nuclear Physics Institute CAS, Czech Republic*
- *Tubingen University, Germany*
- *GSI, Germany*
- *Warsaw University of Technology, Poland*
- *University of Wroclaw, Poland*

Finished SRC program at BM@N:

- *CEA, Saclay, France;*
- *TU Darmstadt, Germany;*
- *GSI & FAIR, Germany;*
- *Tel Aviv University, Israel;*
- *Massachusetts Institute of Technology, Cambridge, USA.*

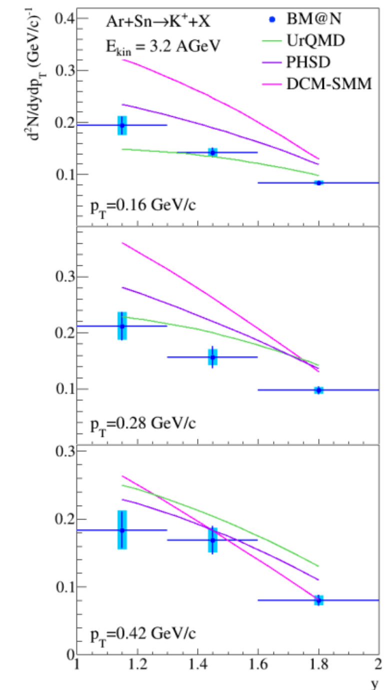
Production of π^+ and K^+ mesons in 3.2 AGeV argon-nucleus interactions at the Nuclotron

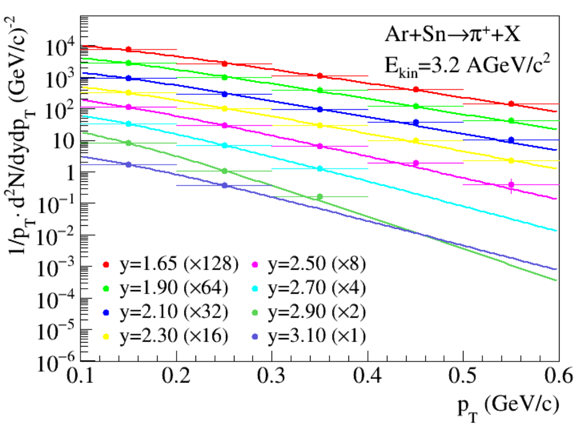


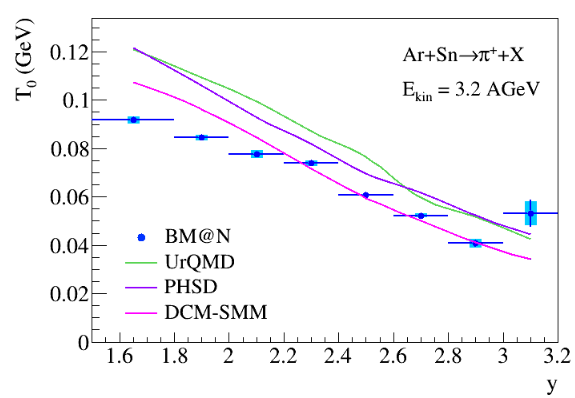
- **Draft of the paper and analysis note circulated**

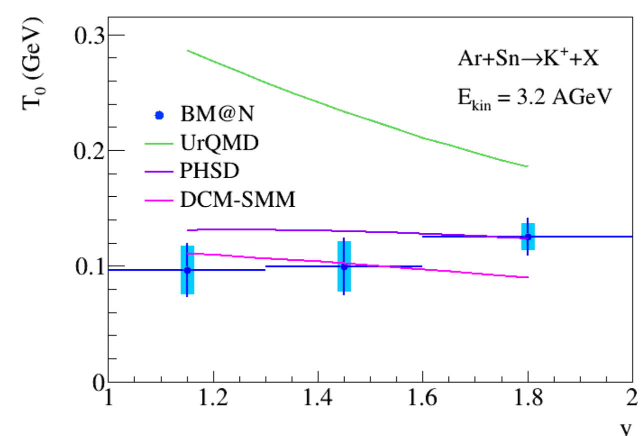
- **T0 talk of V. Plotnikov tomorrow afternoon**

- **Only one set of comments received**





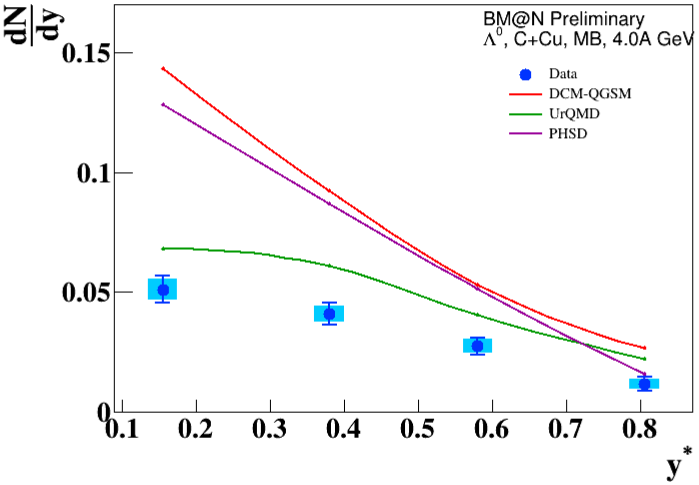




M.Kapishin

BM@N experiment

Production of Λ hyperons in interactions of the 4 and 4.5 AGeV carbon beam with nucleus



Re-analysis of the preliminary results → more precise MC description of Data instead of Data to MC embedding

- Talk of Yu.Stepanenko tomorrow afternoon

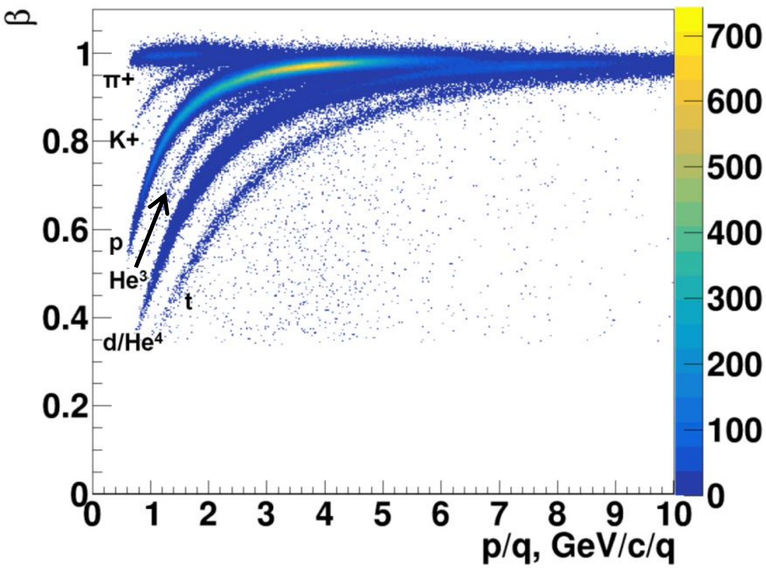
Present status: comparison with the preliminary results

Λ yield 4.0 GeV ($0.1 < p_T < 1.05$ GeV/c , $1.2 < y_{lab} < 2.1$)

Interactions	C+C	C+Al	C+Cu	C+Pb
Note 2020	0.0164±0.0013 ± 0.0010	0.0286±0.0025 ±0.0020	0.0307±0.0020 ±0.0016	0.0366±0.0048 ±0.0036

- Re-analysis of 4.5 AGeV is going on

Advanced analysis: p, t, He3, d/He4 in ToF-700 data



Ar beam , 3.2 AGeV , Ar + Al,Cu,Sn → X

L.Kovachev, Yu.Petukhov, I.Roufanov

L.Kovachev talk tomorrow afternoon

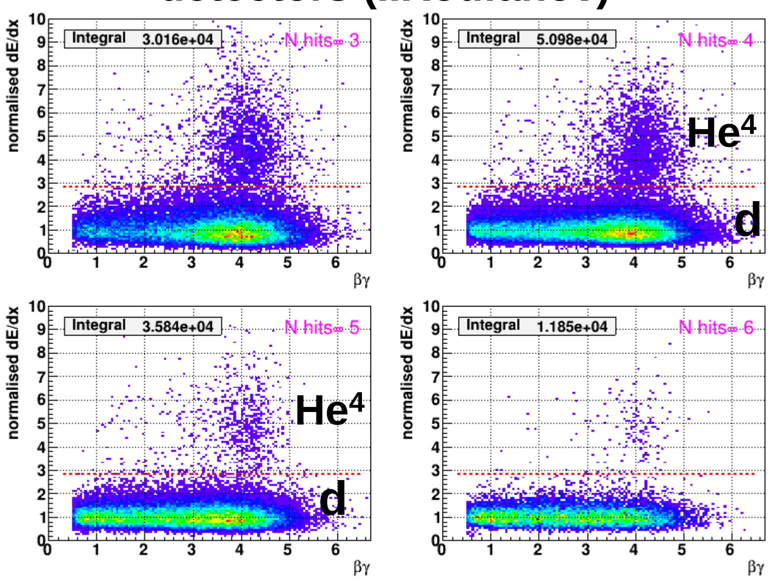
Parallel analyses of argon-nucleus interactions:

K.Alishina (PhD student): p, d in ToF-400

A.Huhaeva (student): π- in ToF-400 data

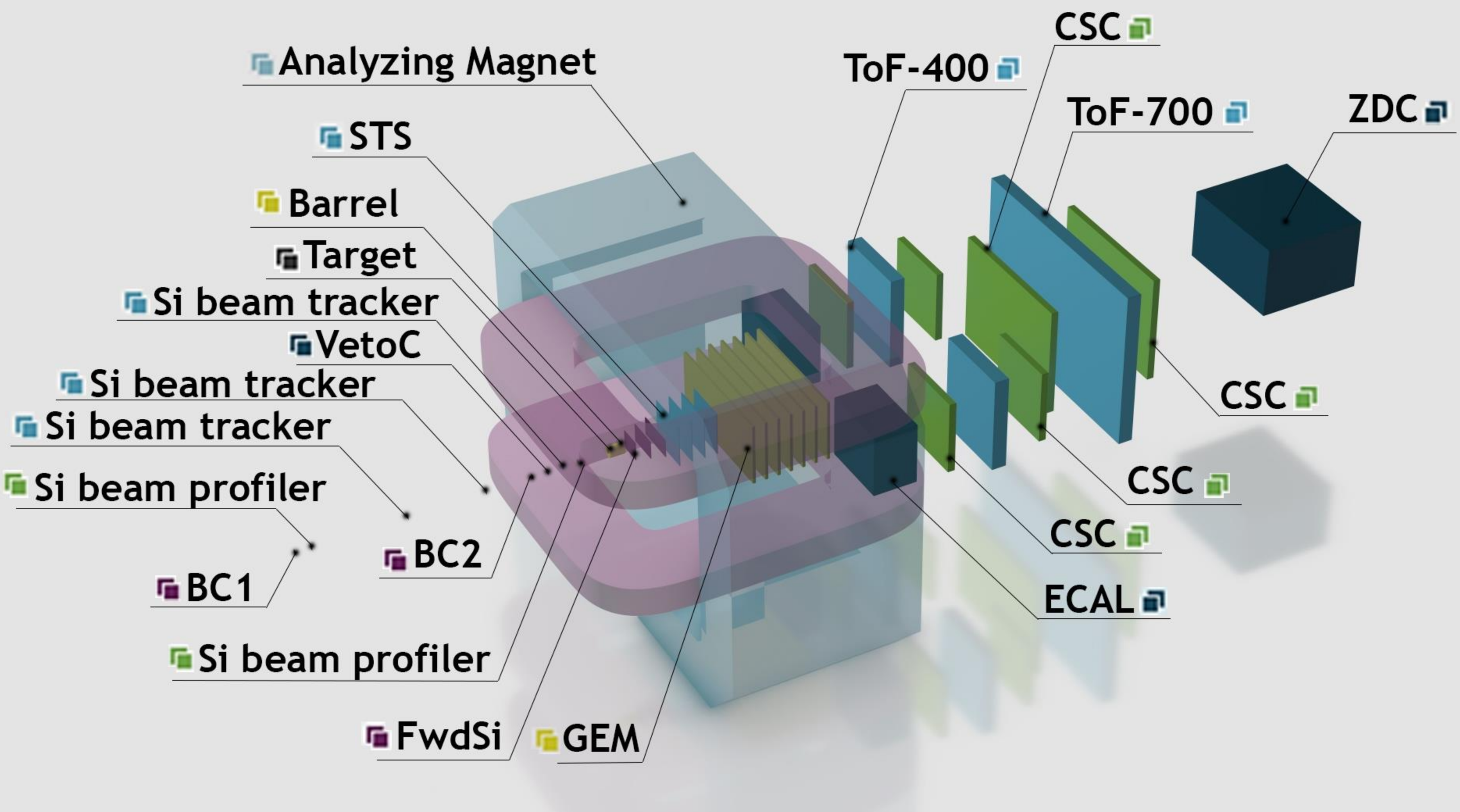
K.Mashitsin (student), S.Merts: π± in ToF-400 and ToF-700 data (independent tracking)

He^4 / d separation by dE/dx in GEM detectors (I.Roufanov)



βγ

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



Plan for BM@N Experimental physics run for 800 hours (33 days) in October-December 2022

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

4 A GeV Xe+Cs collisions, multiplicities from PHSD model,
Beam intensity $2.5 \cdot 10^5$/s, DAQ rate $2.5 \cdot 10^3$/s, accelerator duty factor 0.25

$1.8 \cdot 10^9$ interactions
$1.8 \cdot 10^{11}$ 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	$5 \cdot 10^7$
Ξ^-	3.7	$2.3 \cdot 10^{-2}$	0.2	0.22	$8 \cdot 10^4$
Ω^-	6.9	$2.6 \cdot 10^{-5}$	0.2	$2.6 \cdot 10^{-4}$	90
Anti-Λ	7.1	$1.5 \cdot 10^{-5}$	0.5	$3.7 \cdot 10^{-4}$	130

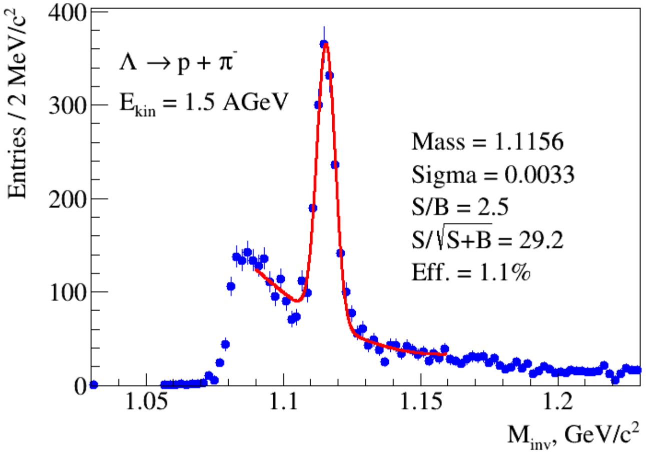
DCM-SMM
x 0.75
x 0.5

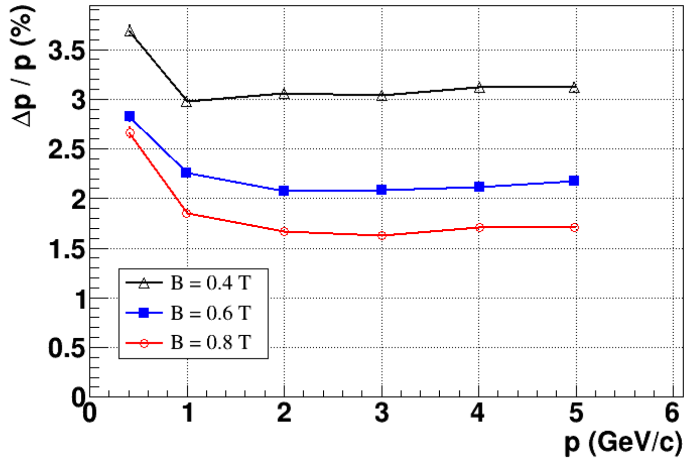
Xe + CsI run configuration of hybrid central tracker: 3 Forward Si + 7 GEM stations

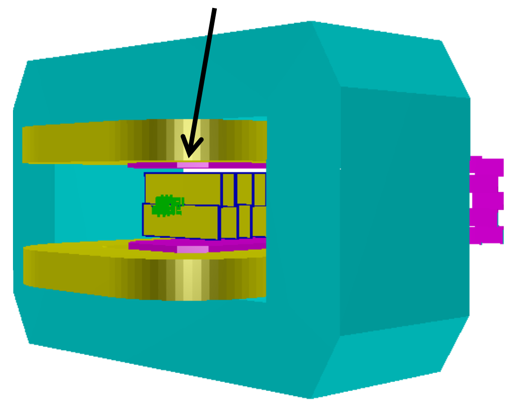
A.Zinchenko, V.Vasendina

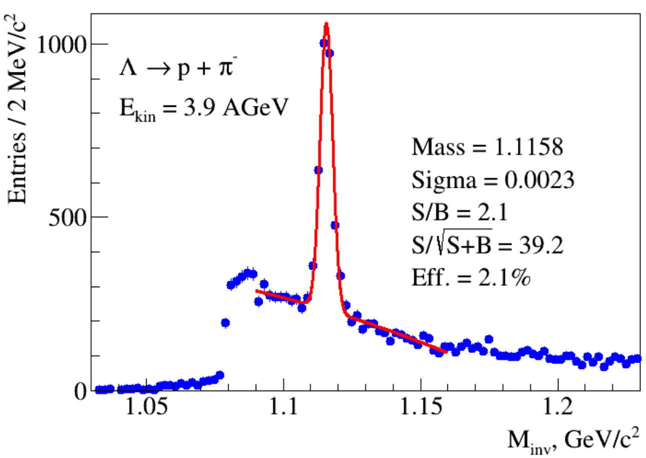
DCM-SMM model: Xe + Sn , T_0= 1.5 - 3.9 AGeV

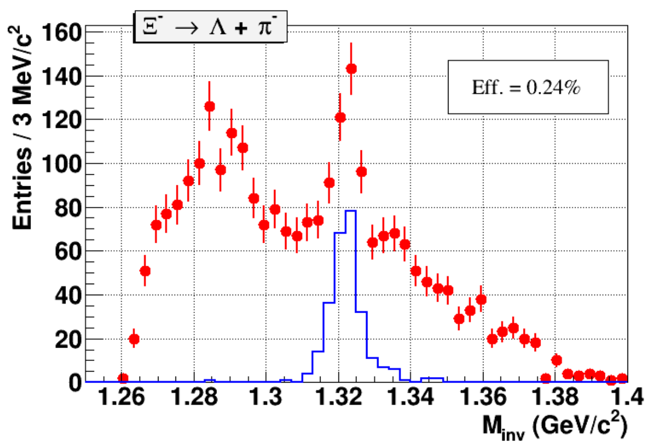
3 Forward Si + 7 GEM



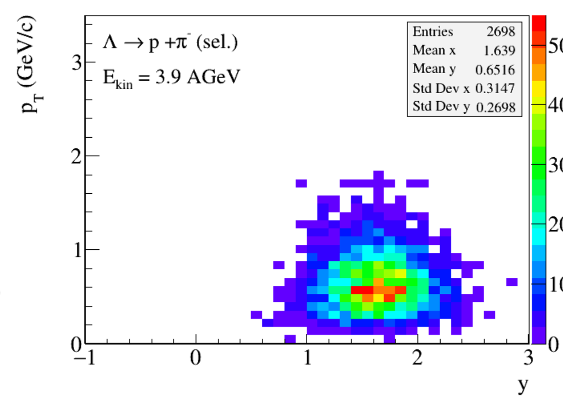






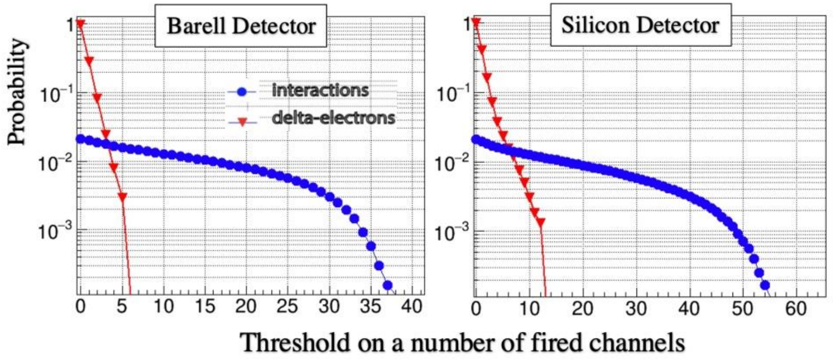


Phase space of reconstructed Λ

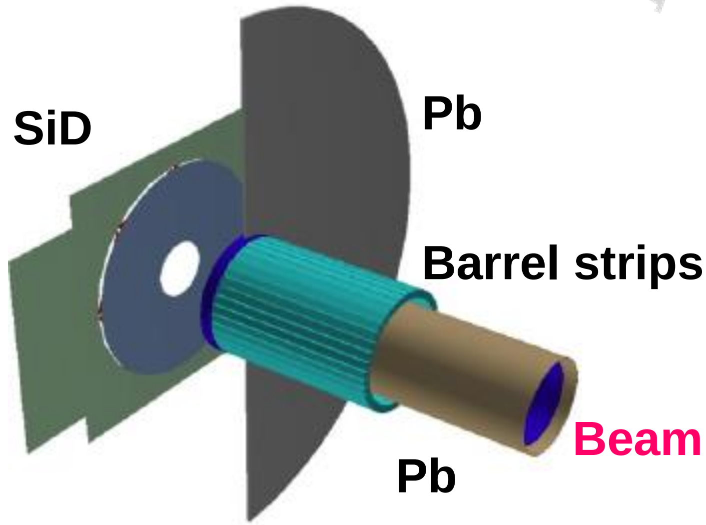


Laboratory system

BM@N Trigger detectors



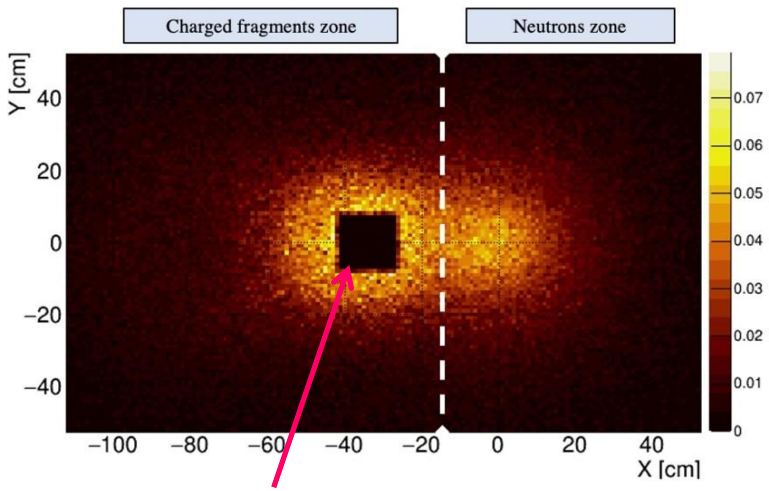
Trigger detectors in target area: multiplicity SiD and Barrel BD



Variants of trigger logics

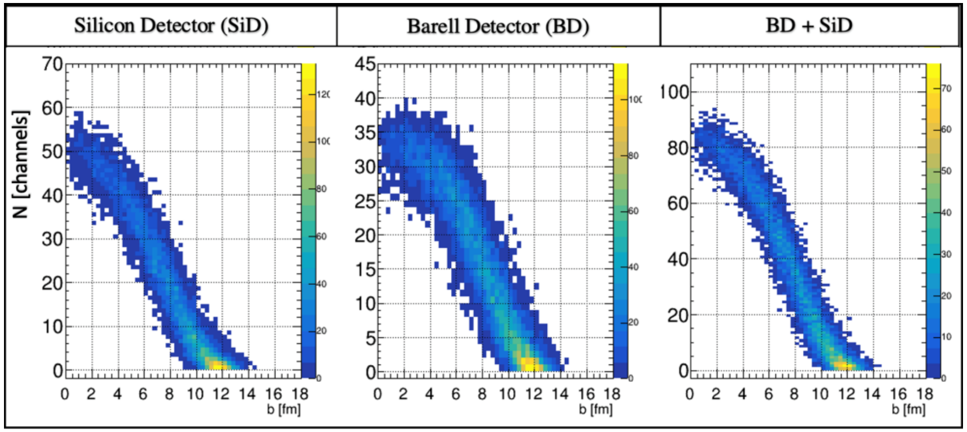
Trigger type	Trigger logic
Beam Trigger (BT)	$BT = BC1 * VC_{veto} * BC2$
Min. Bias Trigger (MBT)	$MBT = BT * FD_{veto} * FHCal$
Centrality Trigger 1 (CCT1)	CCT1 = MBT * BD(low) * SiD(low)
Centrality Trigger 2 (CCT2)	CCT2 = MBT * BD(high) * SiD(high)
No Interaction Trigger (NIT)	$NIT = BT * FD_{Au\text{-}ion} * FHCal_{veto}$

FHCAL rates

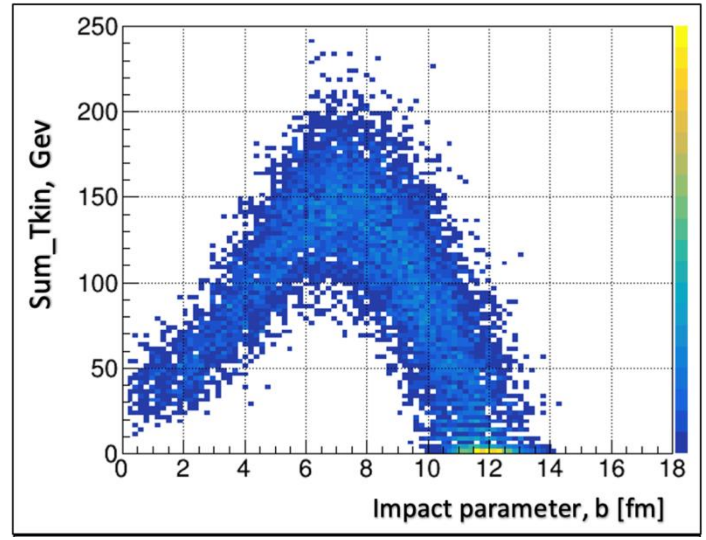


Centrality selection with trigger detectors

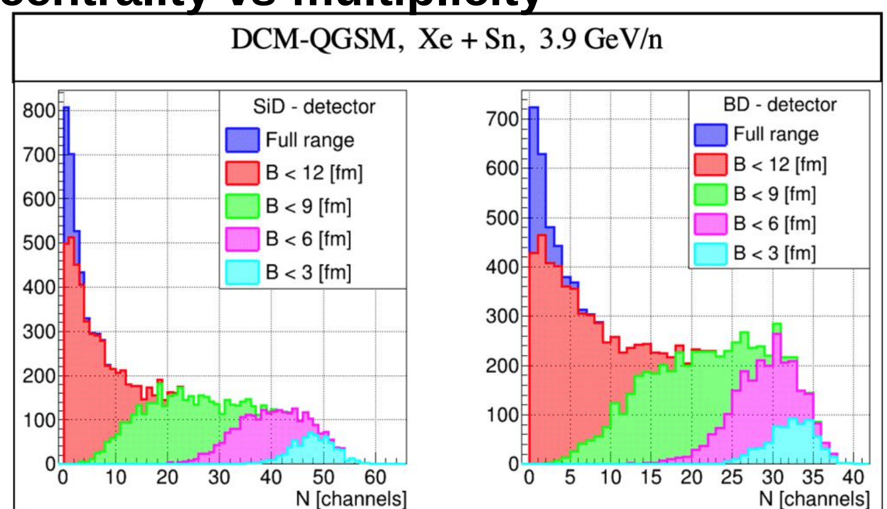
Silicon Detector SiD and Barrel Detector BD: multiplicity vs b



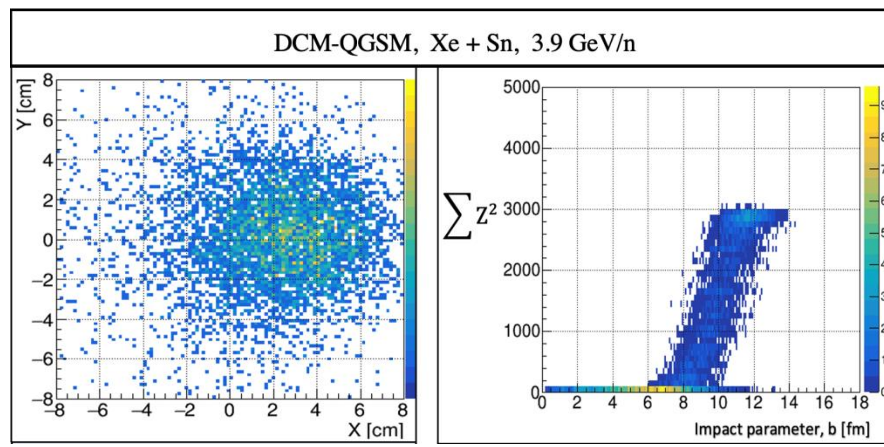
FHCAL: total energy vs collision impact parameter b



SiD and BD detectors : classes of centrality vs multiplicity



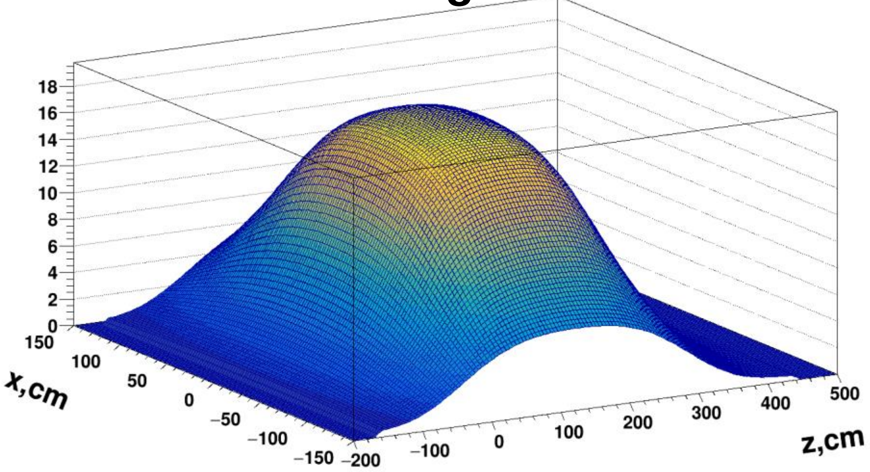
Fragment detector FD: Z^2 vs b

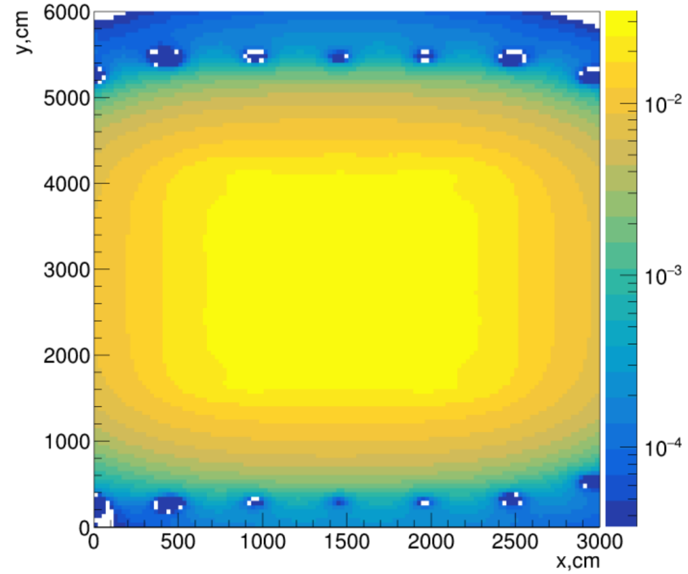


Magnetic field map re-measurement

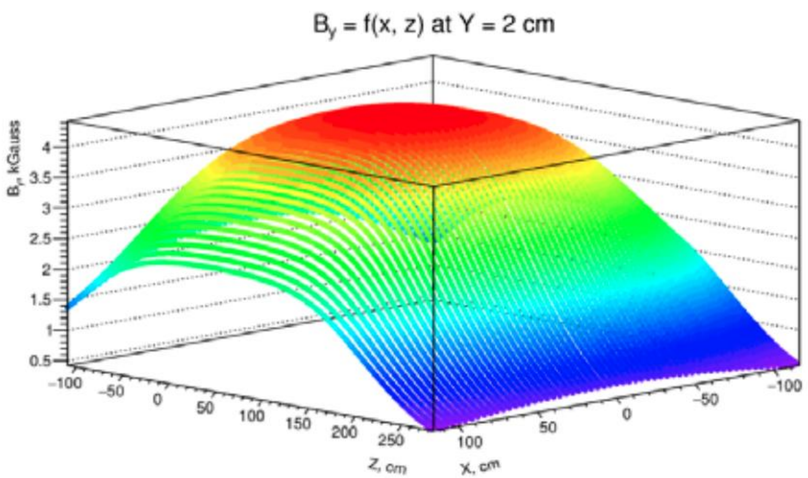
S.Piyadin, R.Shindin, S.Merts, T.Parphilo, B.Kondratiev, M.Mamaev and a team of shifter

New map measured in a wider X,Z range at few values of magnet current

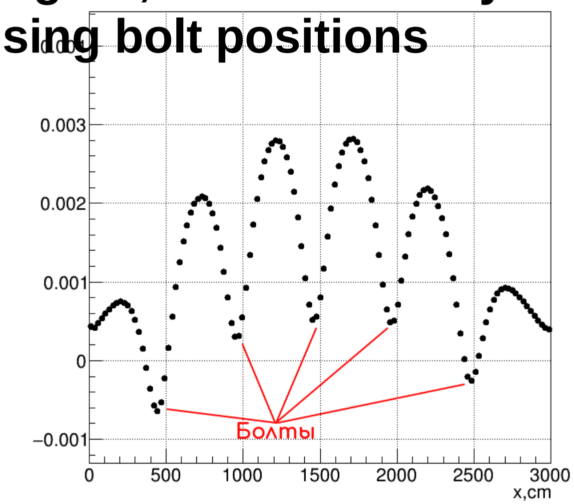




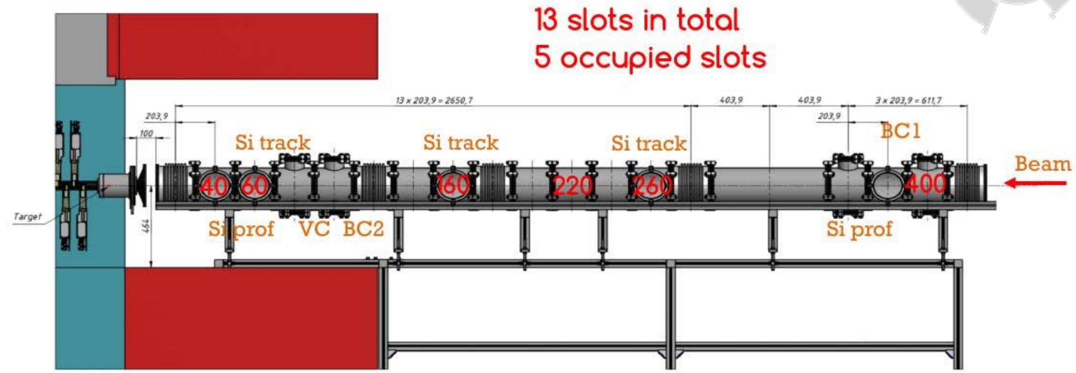
Old map measured in a restricted X,Z range at lower magnet current



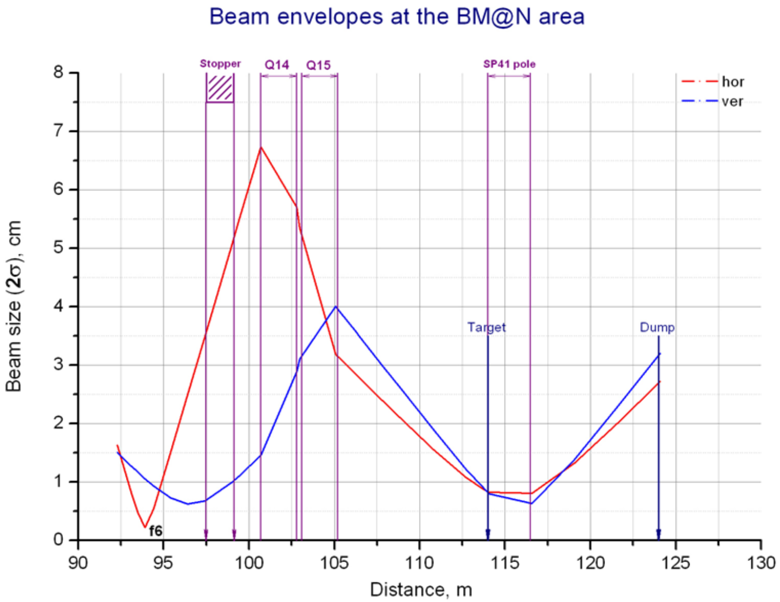
Align X,Z coordinate system using bolt positions



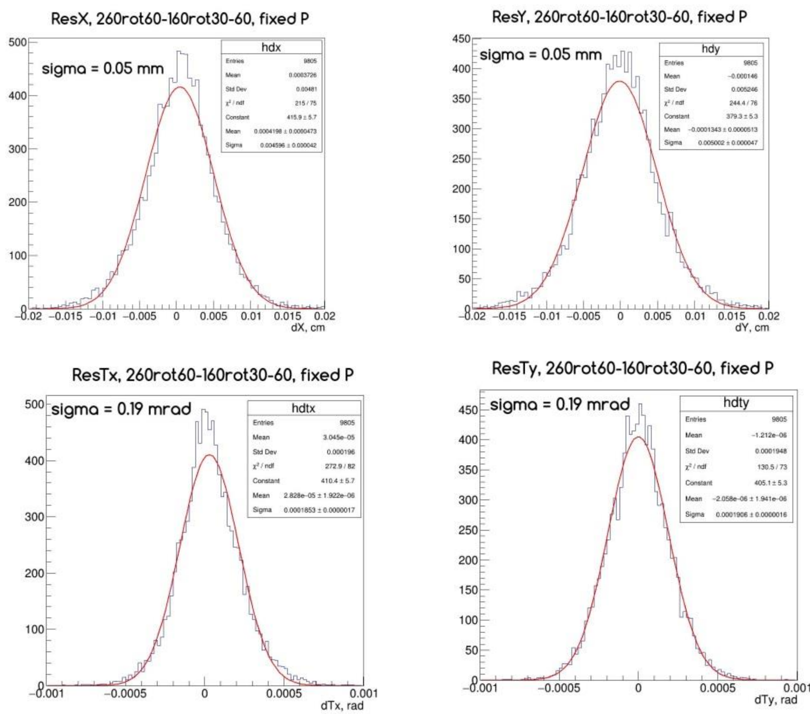
Beam tracking with 3 Si detectors



Magnetic Optics in BM@N area: angular beam spread of ~2 mrad



Vertex and beam angular resolution from simulation of 3 Si detectors (S.Merts)



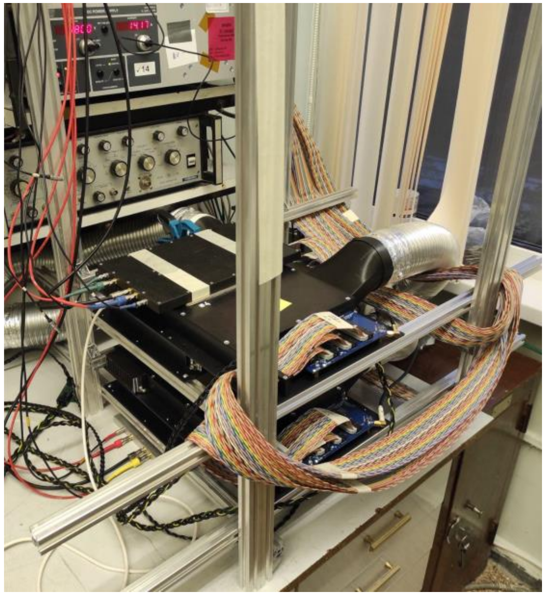
Measured beam spot at target

C^{12} 2017	Ar 2018	Kr 2018
σ_X = 6 mm	5 mm	5.3 mm
σ_Y = 4.9 mm	5 mm	3.2 mm

Forward Silicon Tracker for heavy ion run

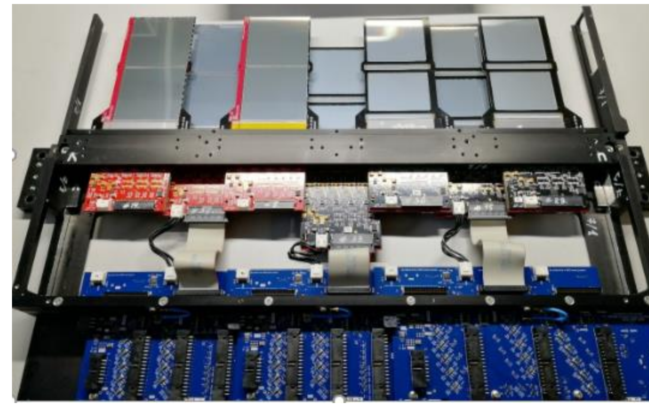
FST group of N.Zamiatin

Setup for FST tests with cosmic rays

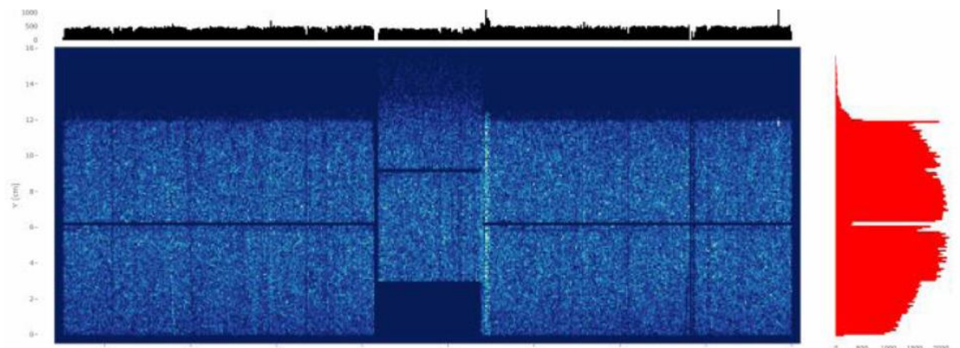


FST support mechanics

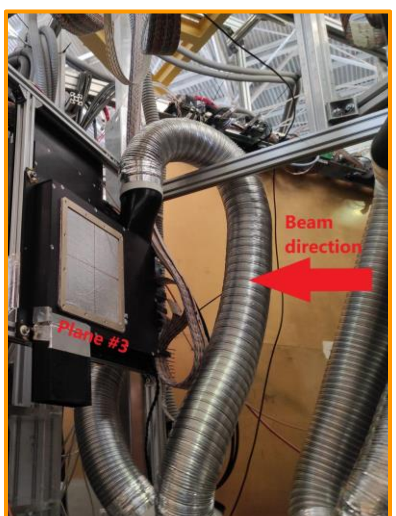
Assembled FST half station of 7 detectors



Cosmic ray X/Y profile of FST half station



FST modules in SRC setup

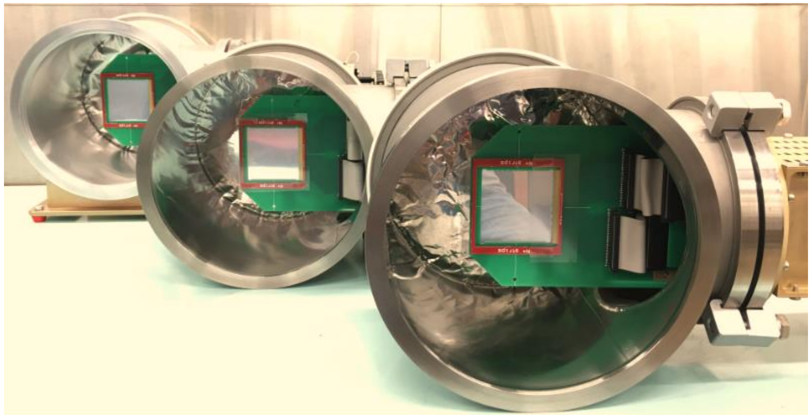


►All 48 modules and 4 FST stations with 6, 10,14,18 modules are assembled, tested and installed

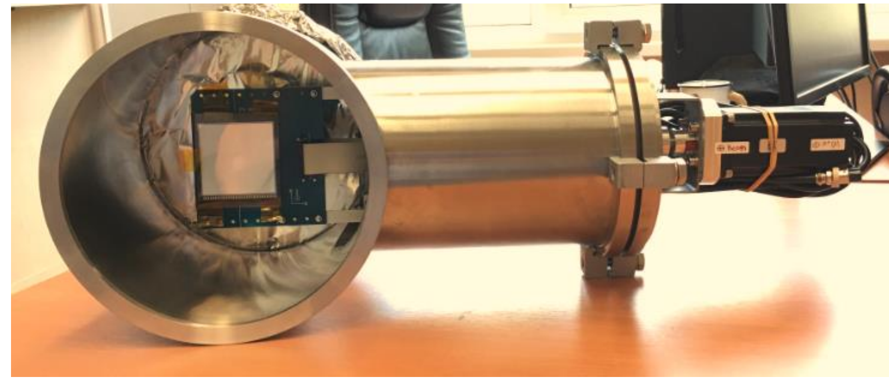
BM@N detector preparation for heavy ion run

FST group of N.Zamiatin

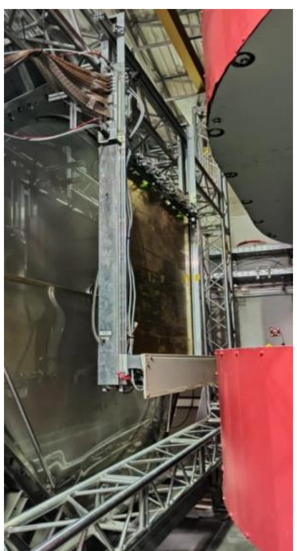
3 Silicon beam tracking detectors



Beam profile meter with Si detector and positioning mechanics



Outer tracker: Cathode Strip Chambers → 4 CSC of 106x106 cm2



Outer tracker group

Big CSC 220x145 cm2

BM@N experiment

Silicon beam tracking detector in SRC setup

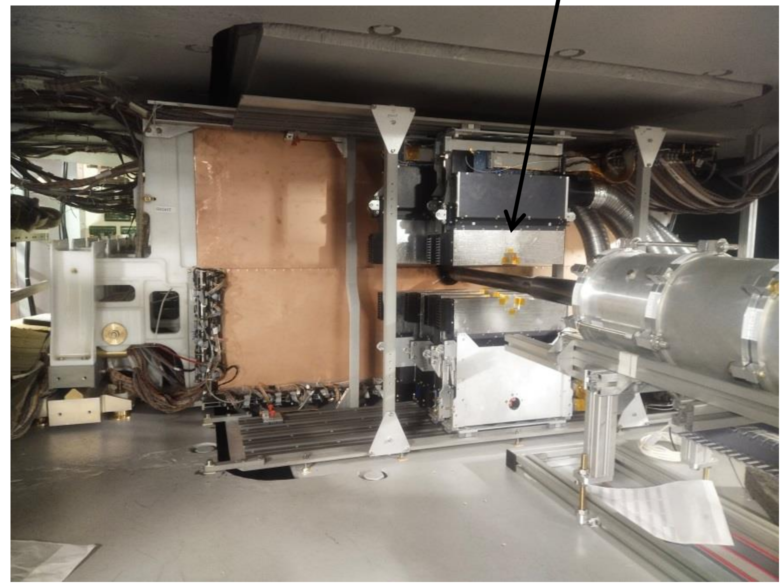
INR RAS group

Forward hodoscope in front of FHCAL

BM@N tracking detector installation for heavy ion run

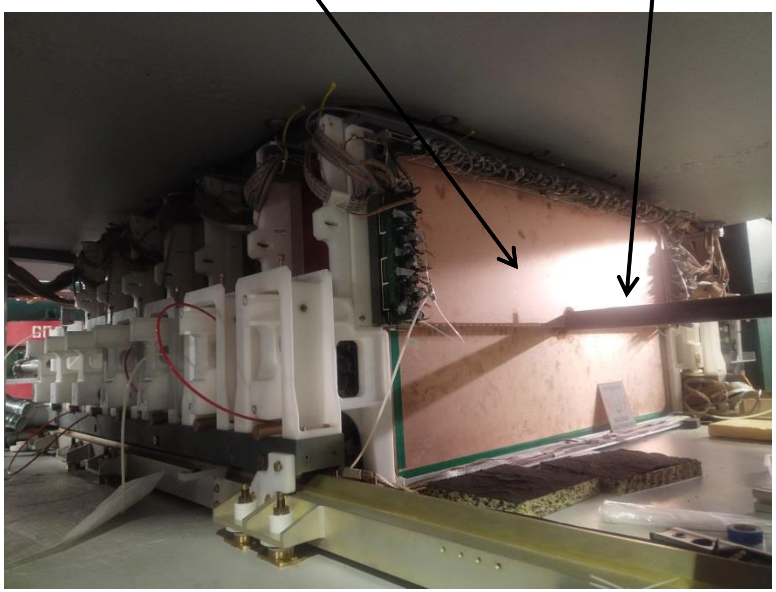
Semen Piyadin, S.Novozhilov,
E.Martovitsky,
FST , GEM tracker groups

Forward Si tracker detectors in front of GEM detectors

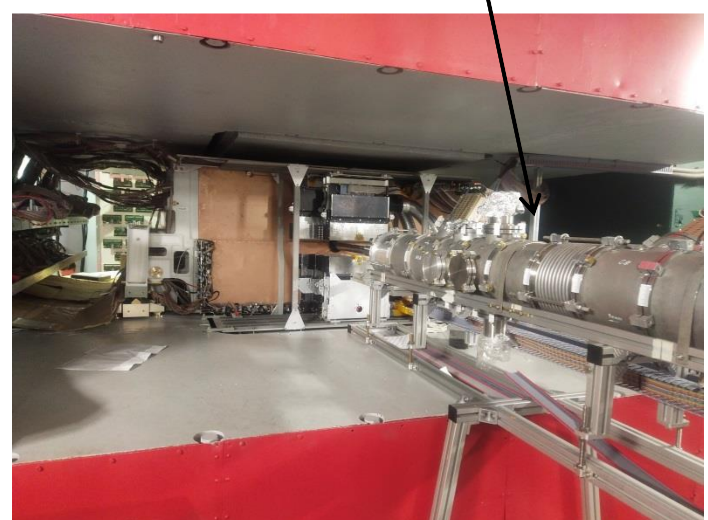


GEM detectors on positioning mechanics in magnet

Carbon vacuum beam pipe

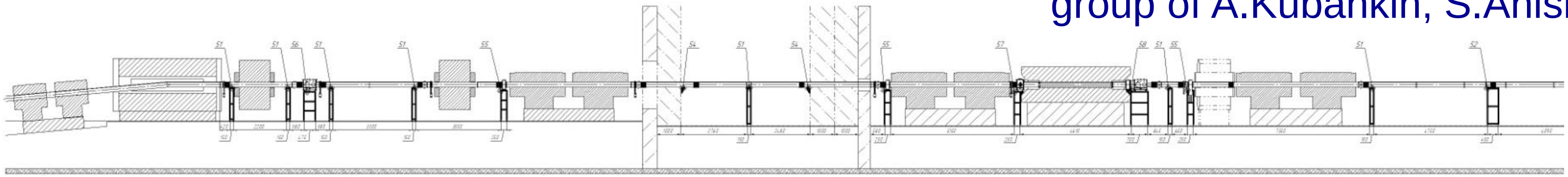


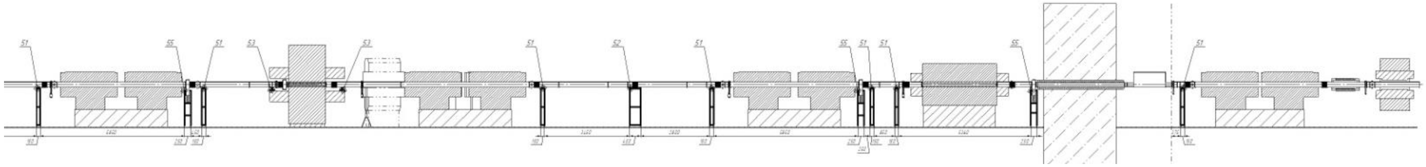
Vacuum boxes for beam detectors



Vacuum ion beam pipe from Nuclotron to BM@N

group of A.Kubankin, S.Anisimov





Status of BM@N detector upgrade

Forward Si tracking FST detectors:

► Proven technology and FEE readout electronics → used in C, Ar, Kr runs

► 4 stations, 48 modules assembled, tested and installed

Beam Si tracking detectors and beam profile meters:

► Tracking detectors ready and tested

► Profile meters and electronics are ready

GEM tracking detectors:

► All 2 x 7 detectors produced at CERN, tested in C, Ar, Kr runs and with cosmic rays, installed

Trigger and T0 detectors:

► BD, SiD, FD trigger detectors, beam and T0 counters are ready, performance to be tested in first heavy ion run

CSC chambers for Outer tracker:

► 4 chambers are tested and installed

► 1st big CSC chamber is still under tests, not ready for 2022 run

Time of Flight identification system:

► ToF-400 and ToF-700 detectors and readout electronics are in operation since 2018

Carbon fibre beam pipe inside BM@N:

► Vacuum beam pipe and target station are installed, beam pipe elements and detector boxes are installed

FHCAL, fragment and neutron detectors:

► FHCAL, Forward quartz hodoscope and Fragment Wall installed into BM@N setup

► Prototype of granular ToF neutron detector to be tested in the run

Large aperture STS tracker:

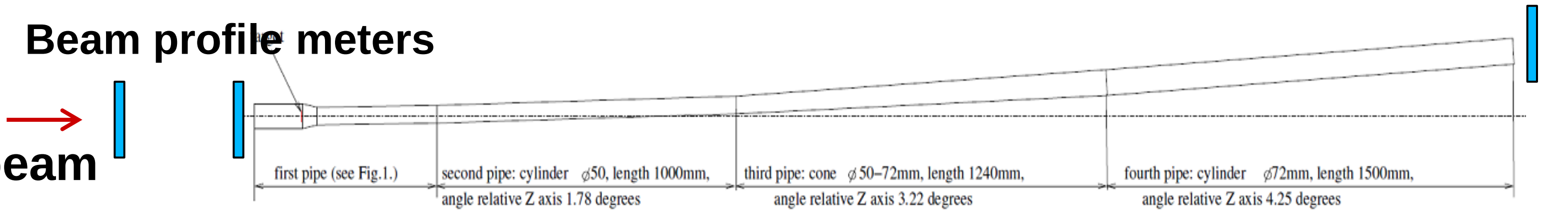
► joint project with GSI and Polish institutions on FEE and readout electronics is frozen

► need our own FEE chip and readout chain

Beam tracing through BMN beam pipe and profile monitoring

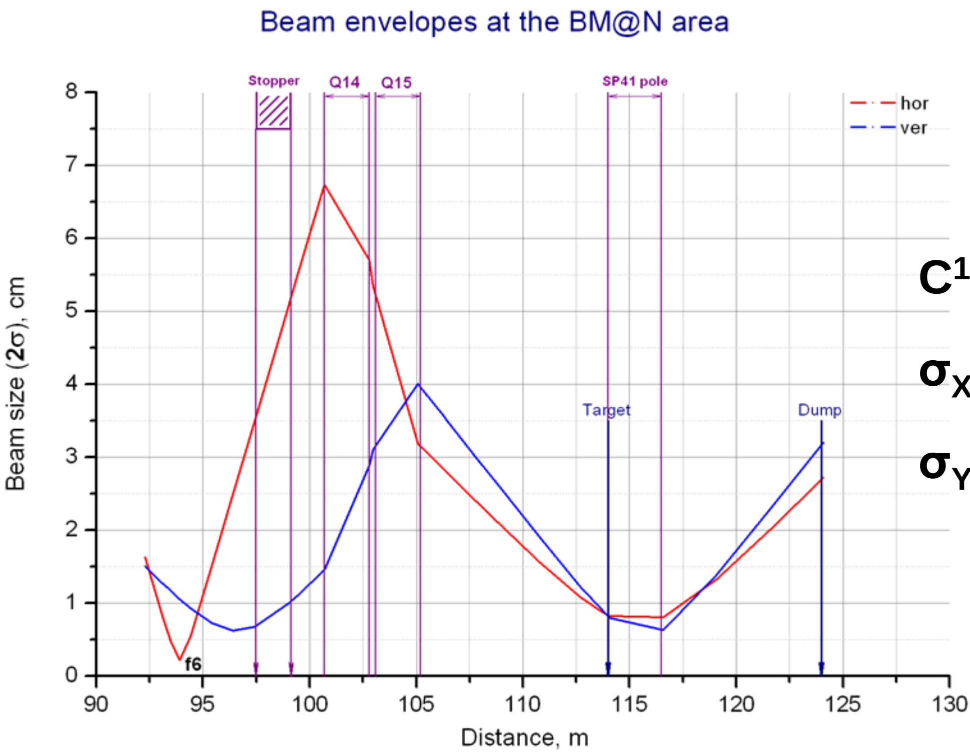
Beam profile meters

beam



Additional beam profile meter

First task of the next run → trace beam and monitor its profile in the end of the setup (try to find optimal trajectory to reduce background)



C^{12} 2017	Ar 2018	Kr 2018
σ_X = 6 mm	5 mm	5.3 mm
σ_Y = 4.9 mm	5 mm	3.2 mm

Plans for Xe+CsI experimental run

- **Need few days for technical run before physics run to prove beam quality and detector response, in case of problems → postpose physics run**

Plans for physics run :
► requested 800 hours of physics data taking to collect up to $1.8 \cdot 10^9$ Xe + CsI interactions
► detect and measure yields of Λ , Ξ^- hyperons and ${}_{\Lambda}^{3}H$ hyper-nuclei in dependence on kinematical variables: transverse momentum, rapidity and event centrality. Expect to detect statistics of Λ (40-50M), Ξ^- (40-80K), ${}_{\Lambda}^{3}H$ (10K)
► measure yields and azimuthal flows of charged π, K-mesons, protons and light nuclear fragments in dependence on transverse momentum, rapidity and event centrality

► Few scenarios:
collect bulk of data at maximal energy (3.5 – 3.9 AGeV) to get higher yields of cascade hyperons and hyper-nuclei;
or collect data at 2.9 AGeV to compare results with STAR fixed target run (but Au+Au interactions);

+ collect a fraction of data at reduced energy (~2 AGeV) to measure larger azimuthal fluxes of mesons, protons, fragments and energy dependence of hyperon yields

Thank you
for attention!