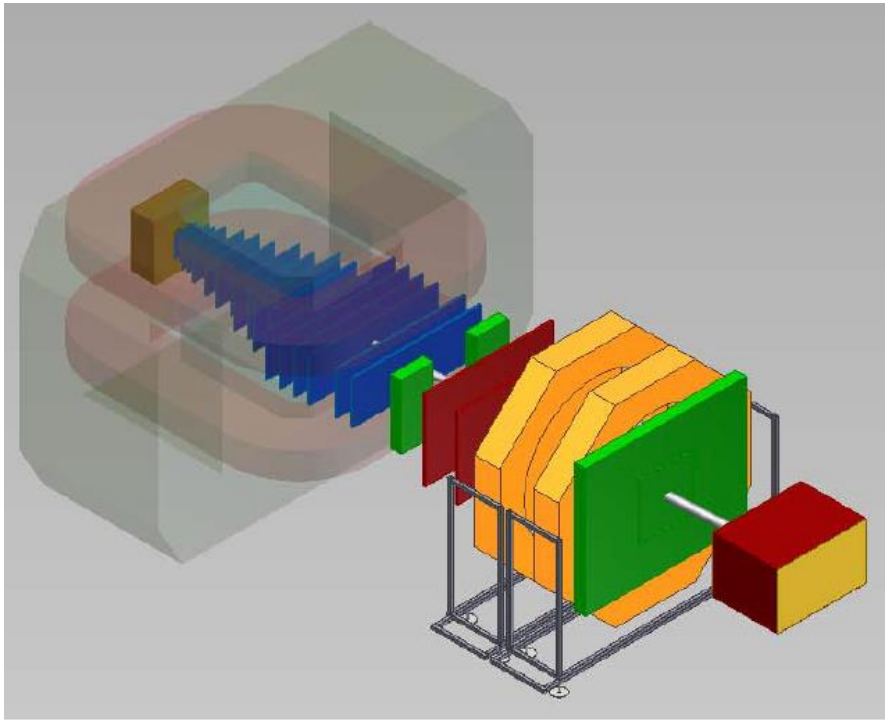
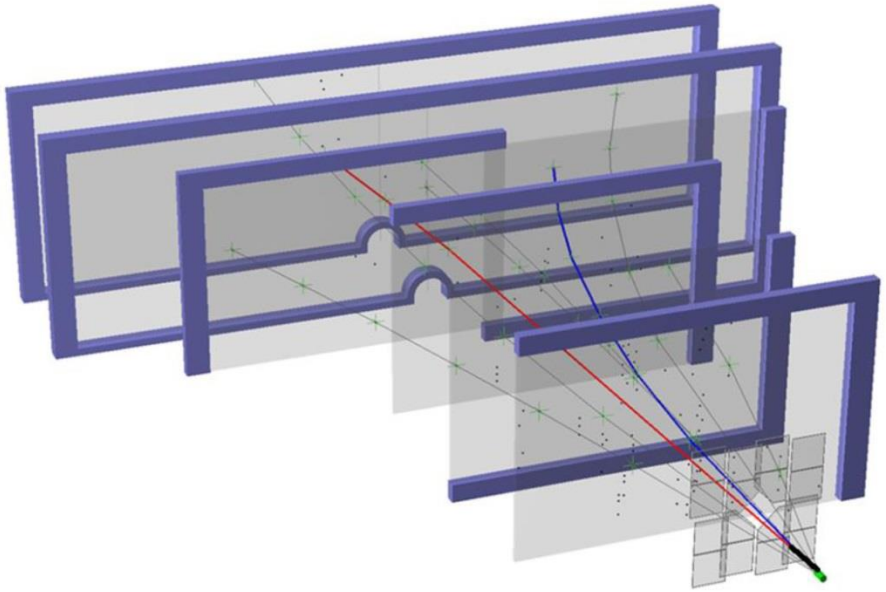
Status of the BM@N experiment

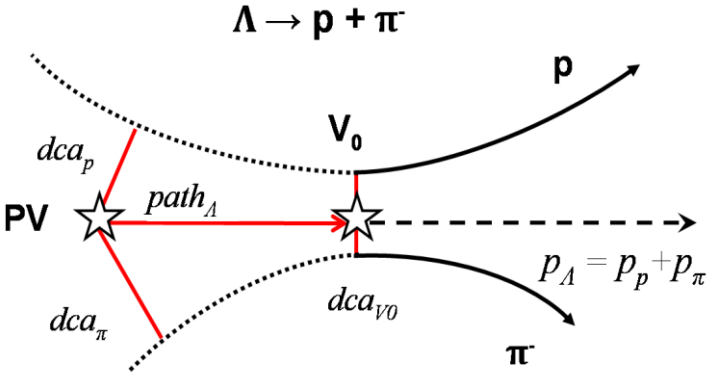
M.Kapishin



First BM@N Preliminary result: Λ hyperon production in 4 AGeV Carbon-nucleus interactions

Λ→pπ⁻ decay reconstruction in Si+GEM tracker in C+C interaction





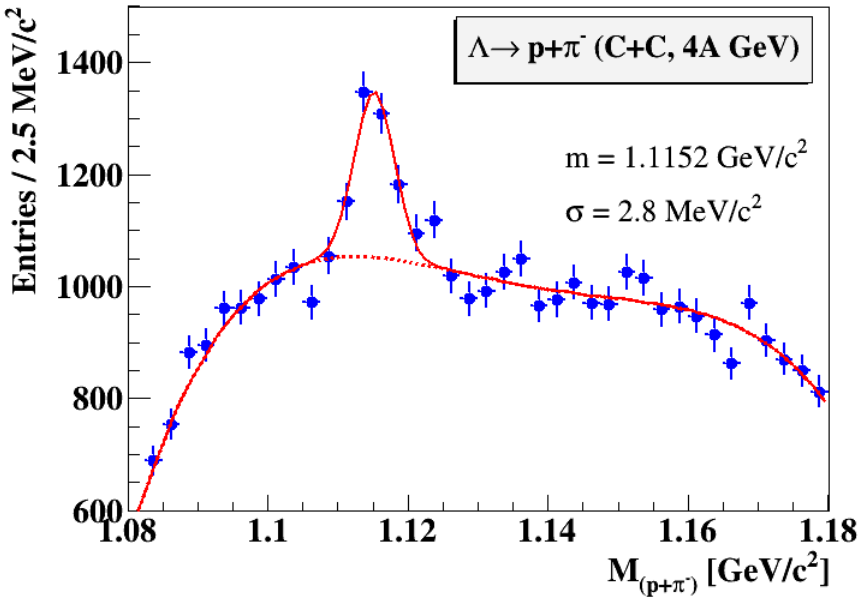
Event topology:

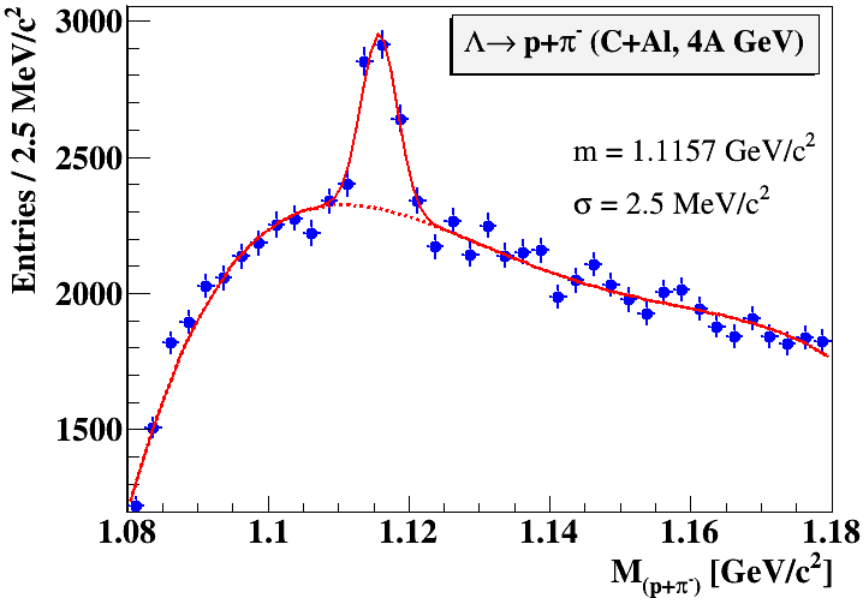
- ✓ PV – primary vertex
- ✓ V_0 – vertex of hyperon decay
- ✓ *dca* – distance of the closest approach
- ✓ *path* – decay length

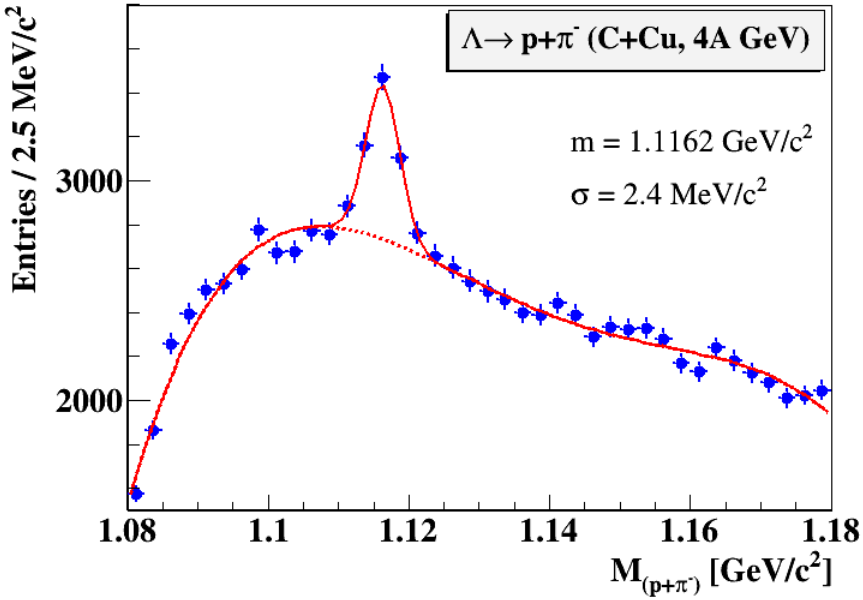
Analysis without PID

Analysis team: Gleb Pokatashkin + Alexander Zinchenko, Yulia Gornaya (MEPhI) Veronika Vasendina, Igor Roufanov, MK

Λ hyperon signals in 4 AGeV Carbon-nucleus interactions





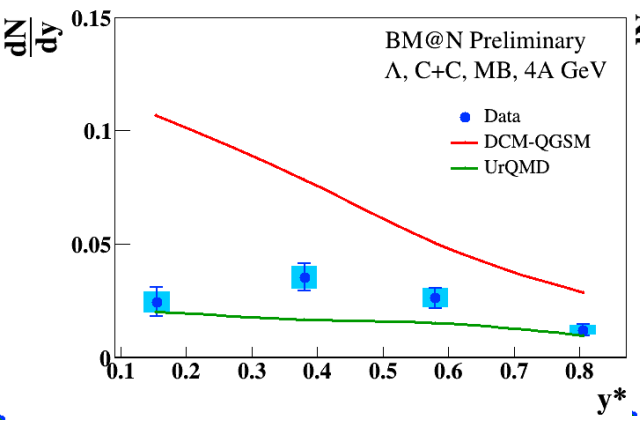


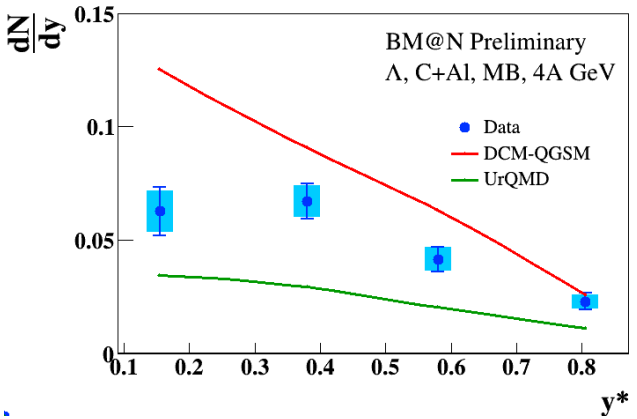
C beam 4 AGeV
C + C,Al,Cu → Λ + X minimum bias
Λ signal width 2.4 – 2.8 MeV

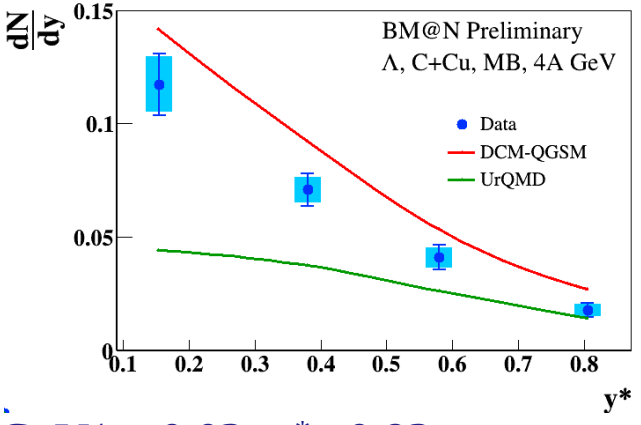
C+C: 4.6M triggers
C+Al: 5.3M triggers
C+Cu: 5.3M triggers

2.5 days of data taking

Λ hyperon yield in 4 AGeV Carbon-nucleus min bias interactions



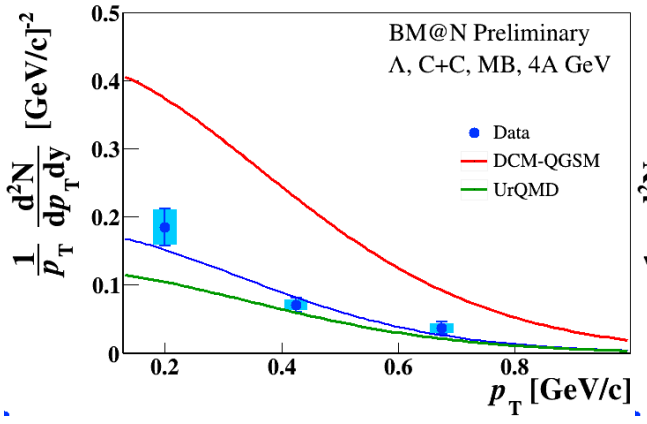


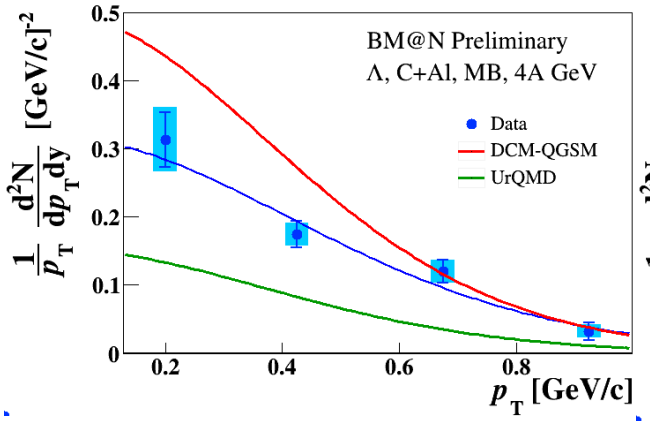


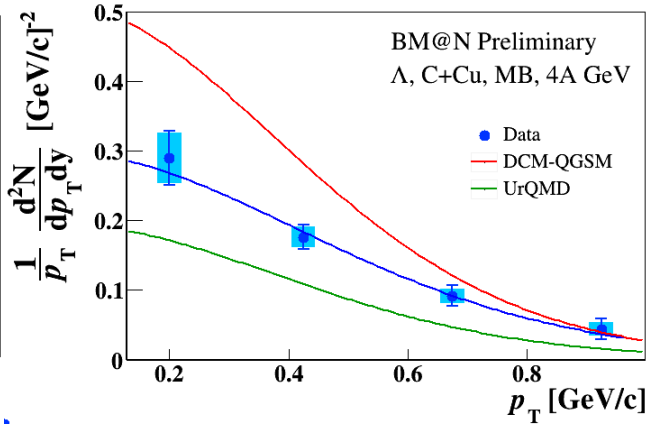
measured kinematic range $0.1<p_T<1.05$ GeV/c, $0.03<y^*<0.93$
data are corrected for acceptance and reconstruction efficiency

- **Yield of Λ in C+C, C+Al, C+ Cu minimum bias interactions in dependence on rapidity y* in c.m.s. $y^* = y_{lab}-1.17$**
- **Data compared with predictions of DCM-QGSM and UrQMD models**

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







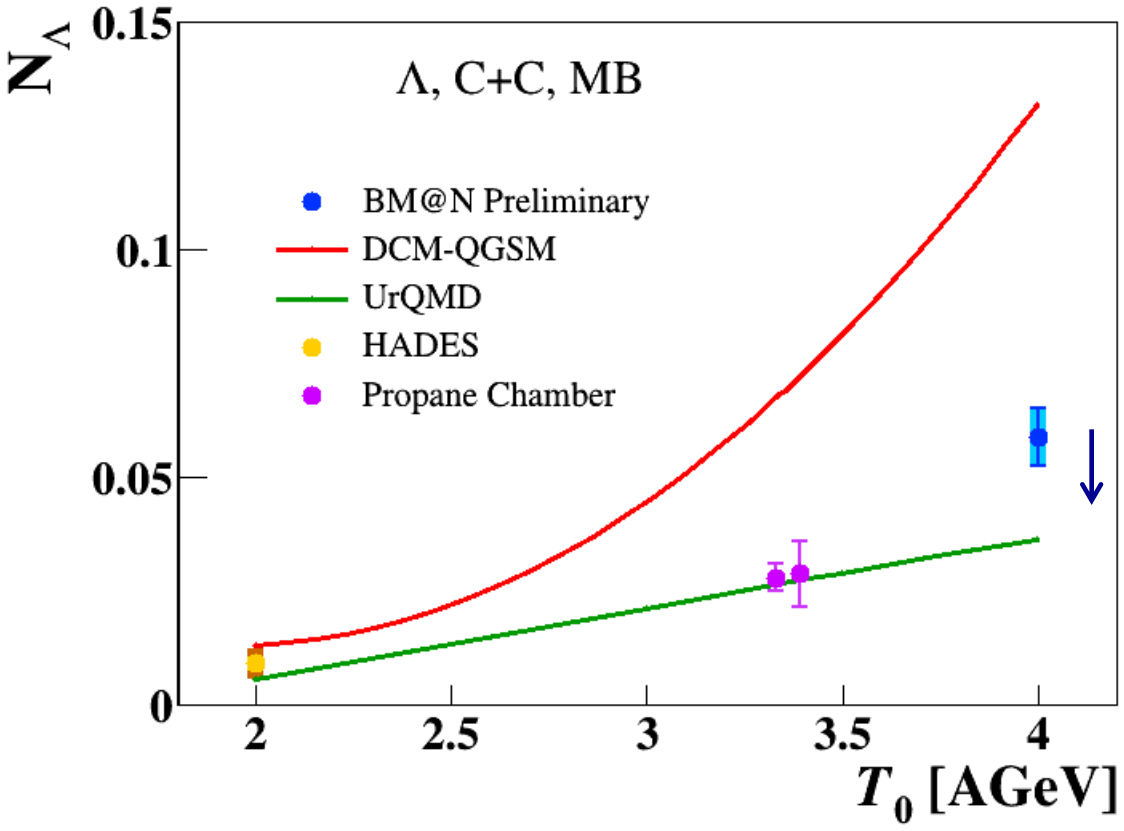
- **Fit of invariant p_T spectra of Λ yields in C+C, C+Al, C+Cu minimum bias interactions by function:**

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

- **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	**98 ± 24 ± 25**	**157 ± 24 ± 12**	**160 ± 27 ± 21**
DCM-QGSM	122	129	131
UrQMD	107	127	132

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



Need revision of normalization down, → see talk of Gleb Pokatashkin

Next plans:

→ add results for 3.5 and 4.5 AGeV Carbon beam data

talk of Gleb Pokatashkin

→ add results for semi-central C+A interactions using ZDC data

status talk of Sergey Morozov (INR RAS)

Status of TOF-400 identification and analysis

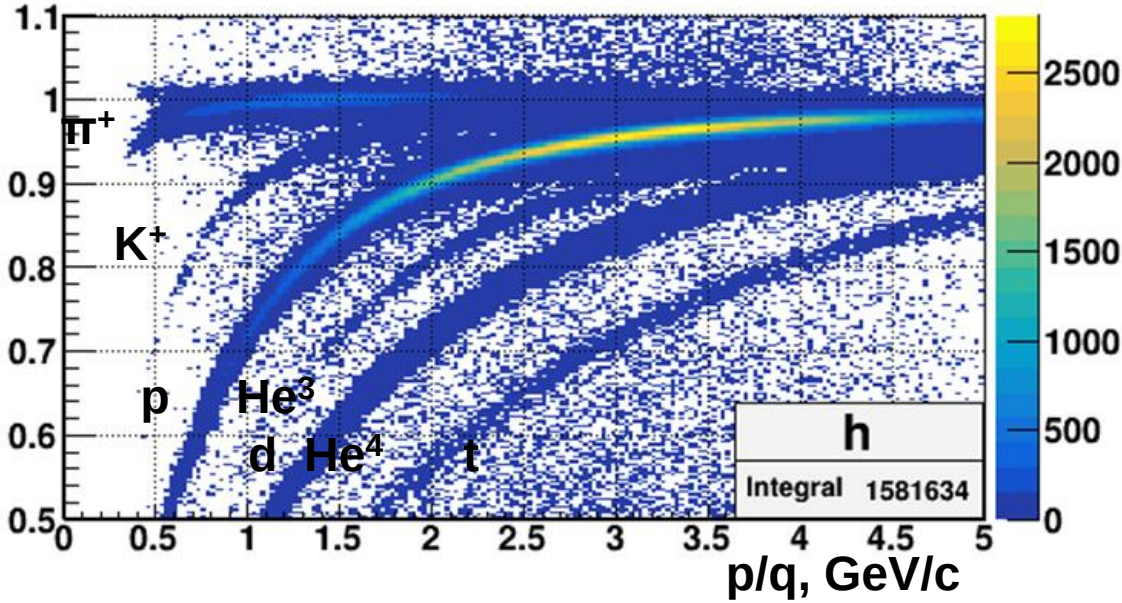
Analysis team:
Vasily Plotnikov
Mikhail Rumyantsev

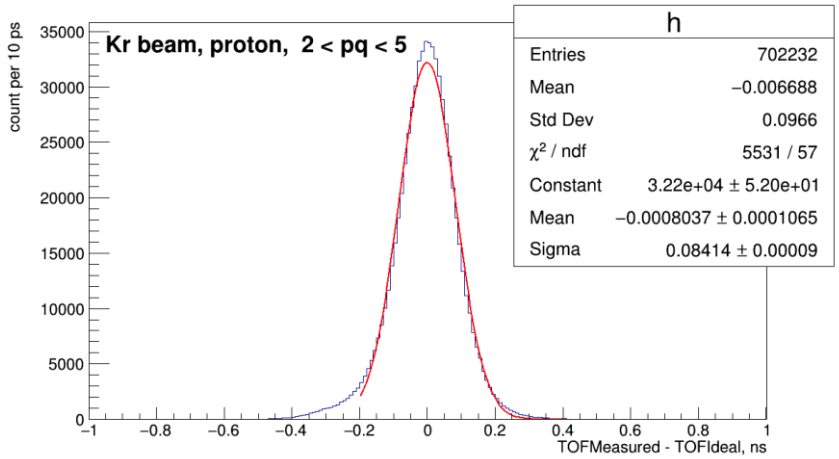
First expected physics results

- **Yields of K^+, π^+ in Ar - nucleus interactions at beam kinetic energy of 3.2 AGeV**

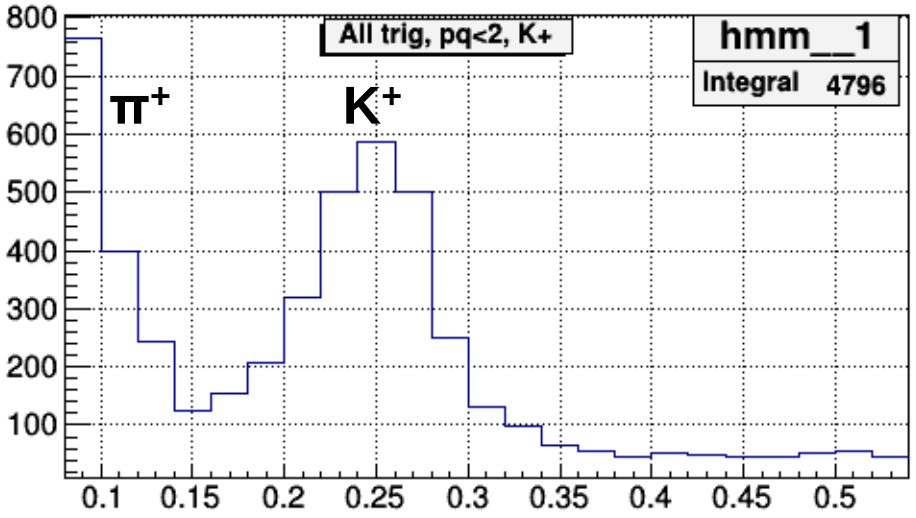
→ **Status report of Vasily Plotnikov**

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

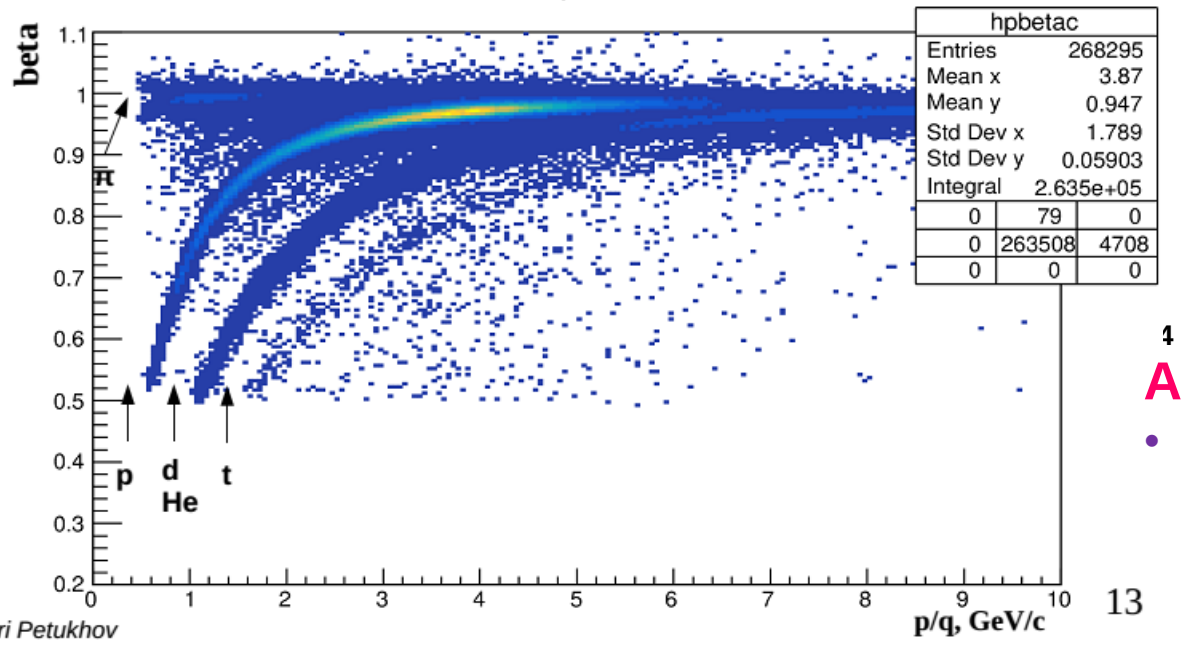




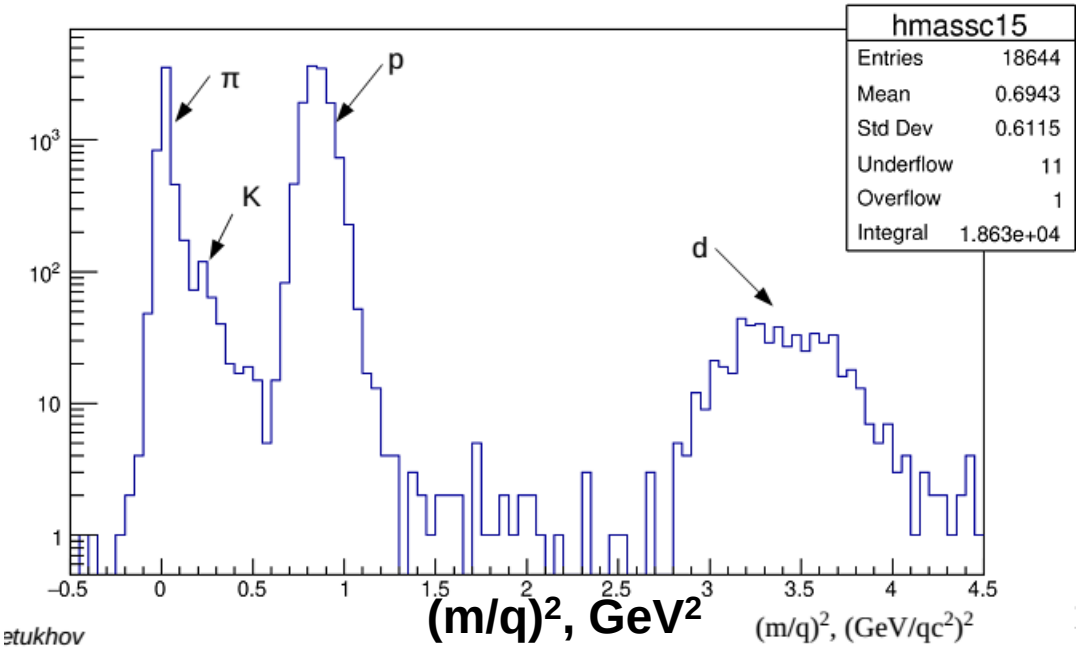
Time resolution within proton band ~85 ps



Status of TOF-700 identification



Yuri Petukhov



etukhov

Ar beam , 3.2 AGeV ,
Ar + Al,Cu → X

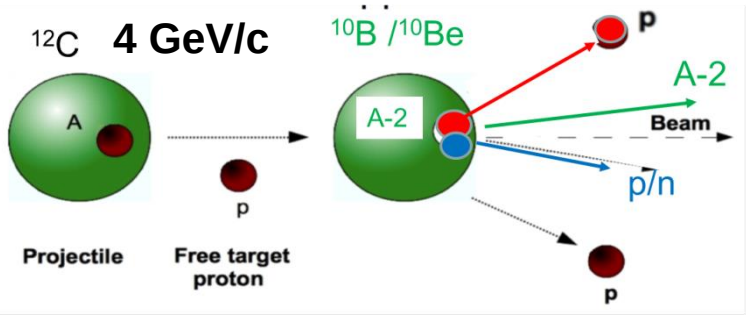
Analysis team:
Yuri Petukhov, Layo Kovachev

Aim:

- **Yields of p, t, d/He^4 in Ar - *nucleus* interactions (in combination with ToF-400 data)**

BMN & SRC program

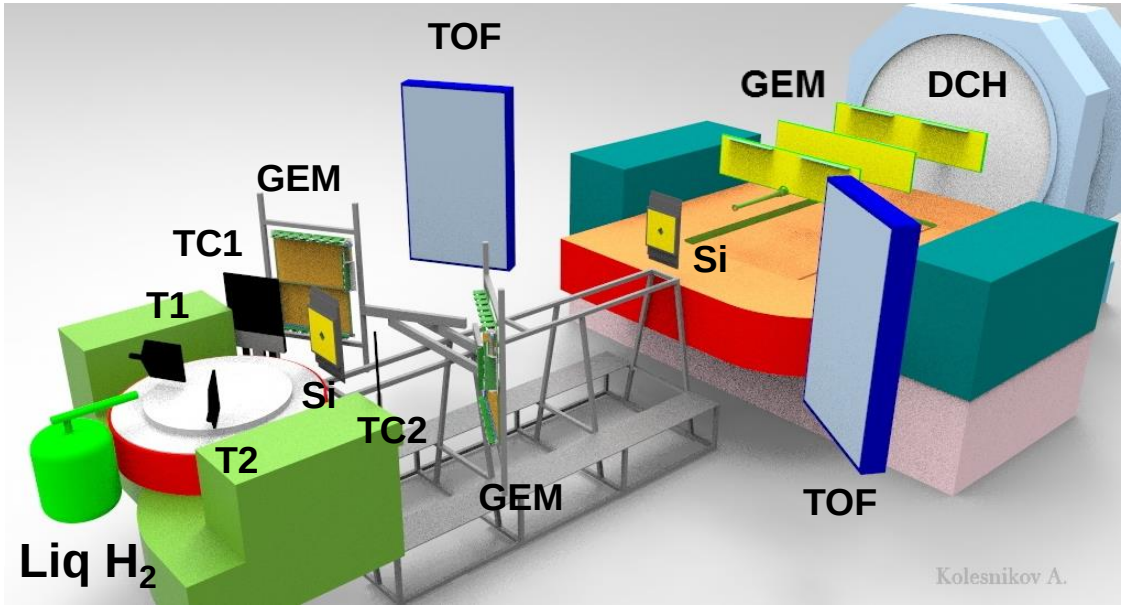
to study SRC with exclusive inverse kinematic reactions



$$^{12}C + p \rightarrow 2p + {}^{10}_{5}B + n \quad \text{np SRC}$$

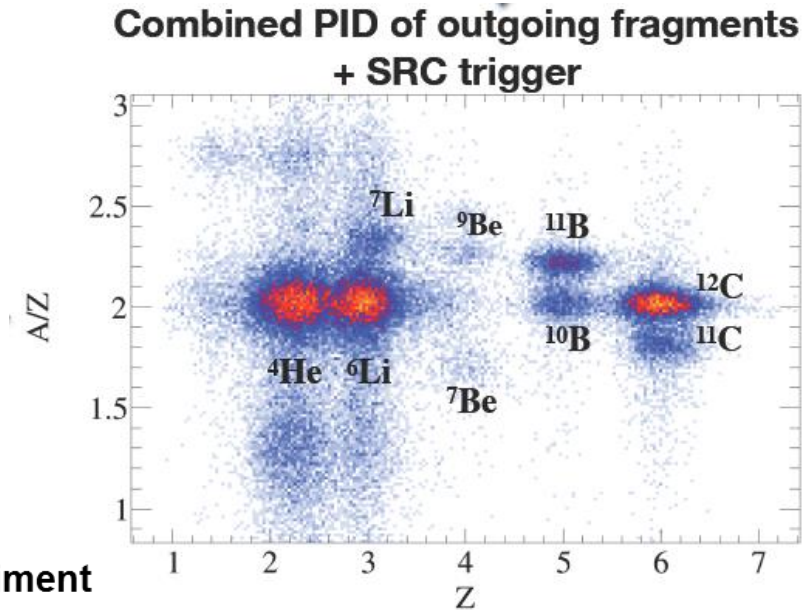
$$^{12}C + p \rightarrow 2p + {}^{10}_{4}Be + p \quad \text{pp SRC}$$

First SRC @ BMN run in March 2018



First expected results:

- Study quasi-elastic (p,2p) with 4 GeV/c/nucleon beam
- Study A-2 residual system after SRC knockout

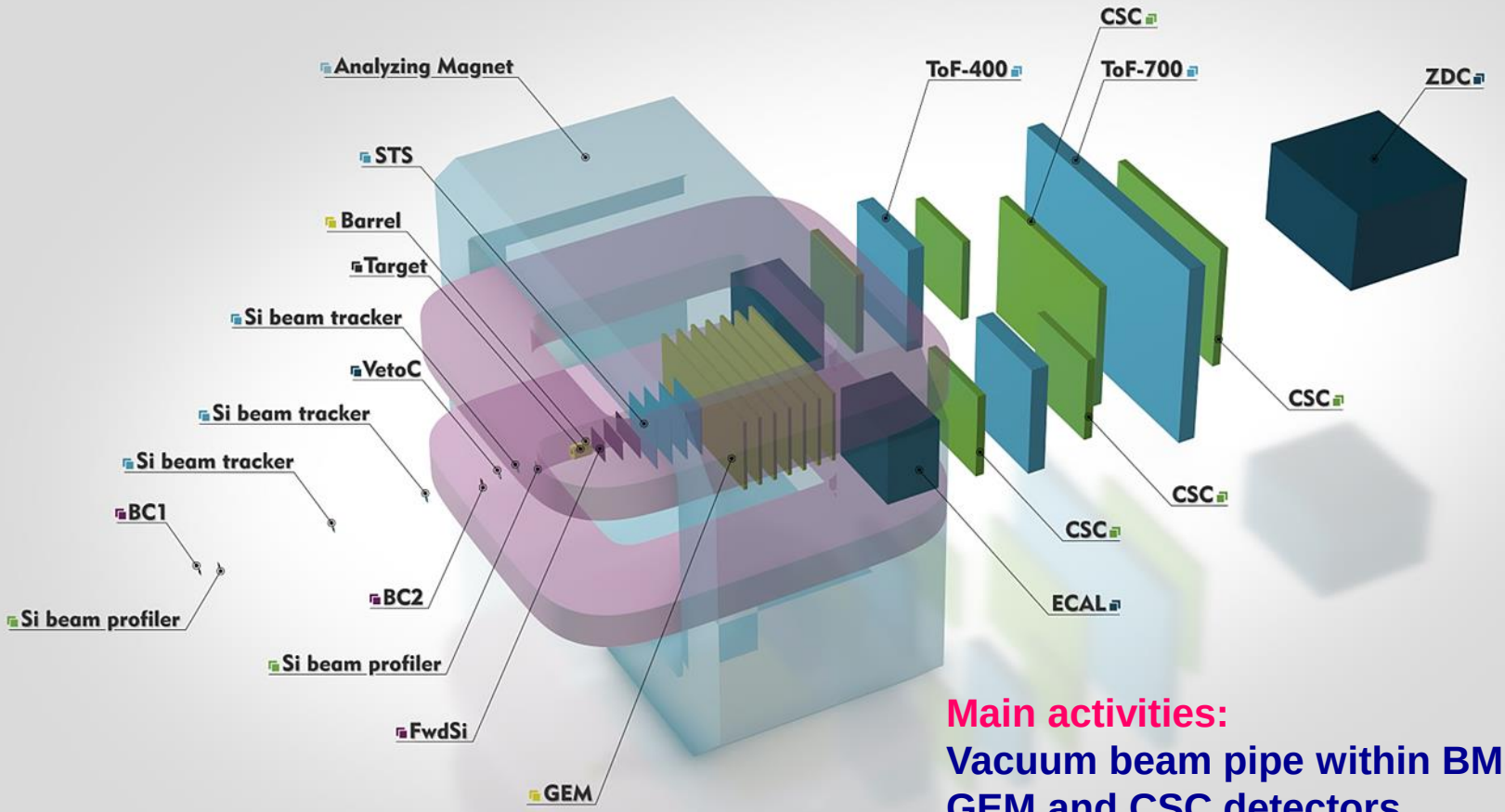


→ SRC status report by Julian Kahlbow

Beam parameters and setup at different stages of BM@N experiment

Year	2016	2017 spring	2018 spring	2021	2022 and later
Beam	d(↑)	C	Ar,Kr, C(SRC)	Kr,Xe	up to Au
Max.intensity, Hz	0.5M	0.5M	0.5M	0.5M	2-5M
Trigger rate, Hz	5k	5k	10k	10k	20k→50k
Central tracker status	6 GEM half planes	6 GEM half planes	6 GEM half planes + 3 forward Si planes	7 GEM full planes + forward Si planes	7 GEM full planes + forward Si + large STS planes
Experimental status	technical run	technical run	technical run+physics	stage1 physics	stage2 physics

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



Main activities:

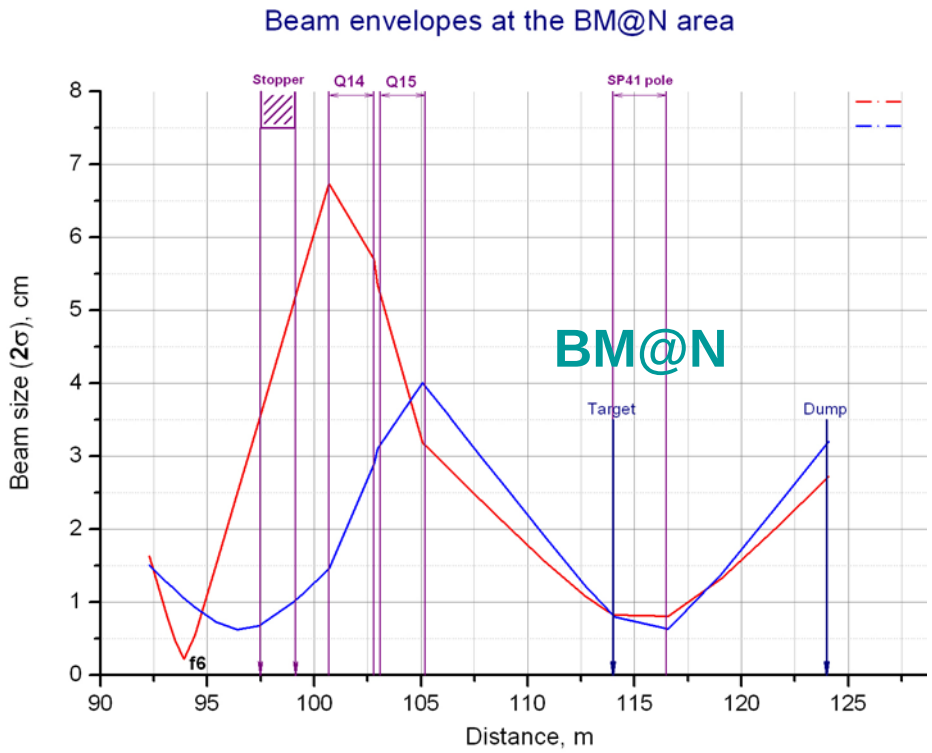
Vacuum beam pipe within BM@N
GEM and CSC detectors
Forward Si and Si beam detectors
New FHCAL (ZDC) calorimeter
CBM STS

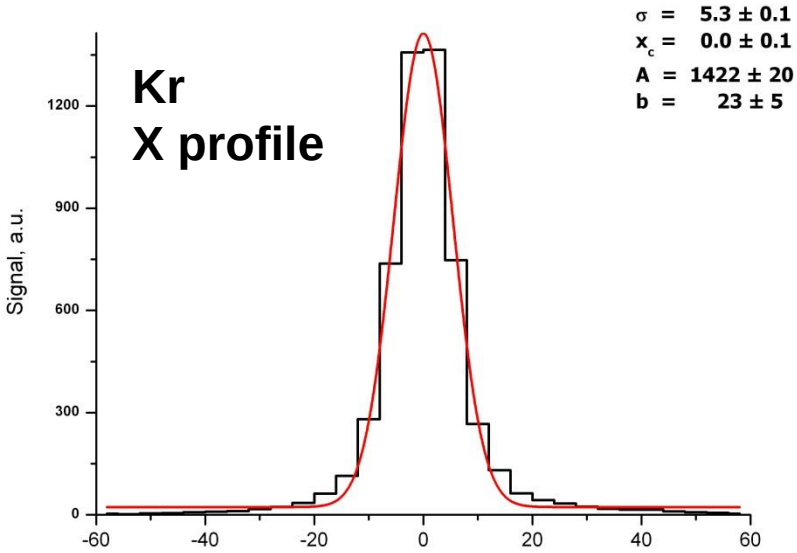
BM@N beam profile

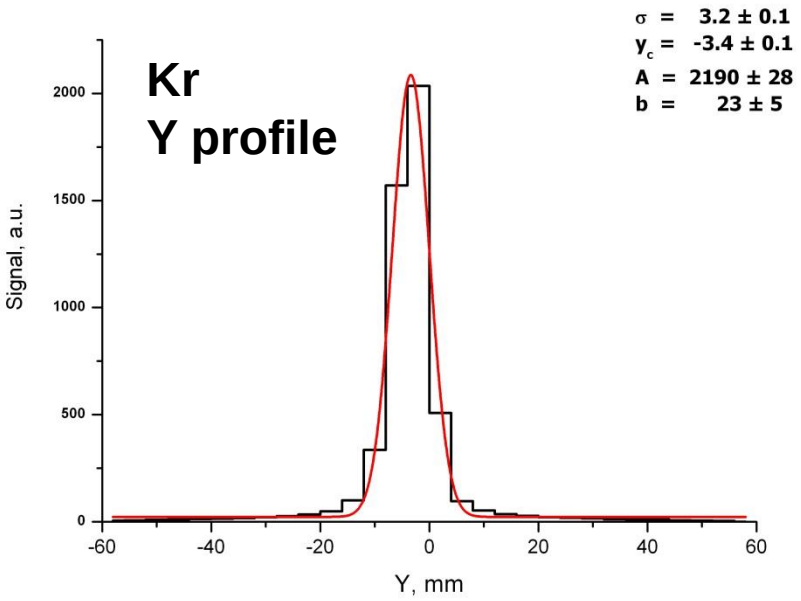
Pavel Rukoyatkin

C^{12} , Ar, Kr beam profiles measured by Nuclotron beam group

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







Nuclotron - BM@N beam line

►Upgrade of Nuclotron - BM@N transport channel for heavy ion program:

→ replace air intervals / foils with vacuum beam pipe along 160 m of BM@N transport line to get minimum dead material

→ implement non-destructive beam position monitoring on movable vacuum inserts

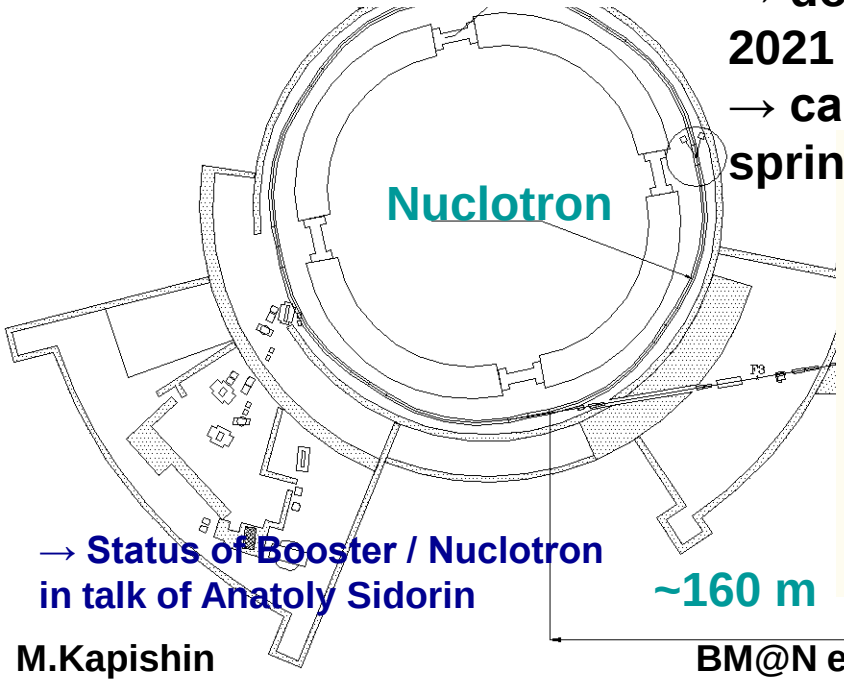
→ implement vacuum beam pipe inside BM@N from target to end

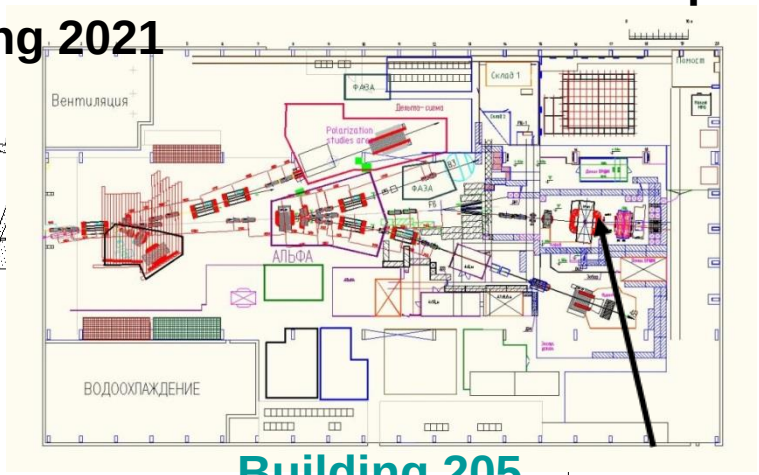
►Replacement of transformers, power supplies and cables to power magnetic elements of the transport channel (need a new building to place transformers)

►To use heavy ion beams from Booster-Nuclotron need construction of a new powerful cryogenic station

→ do not expect heavy ion beams before fall of 2021

→ carbon beam from laser source probably in spring 2021





→ Status of Booster / Nuclotron in talk of Anatoly Sidorin

~160 m

Building 205

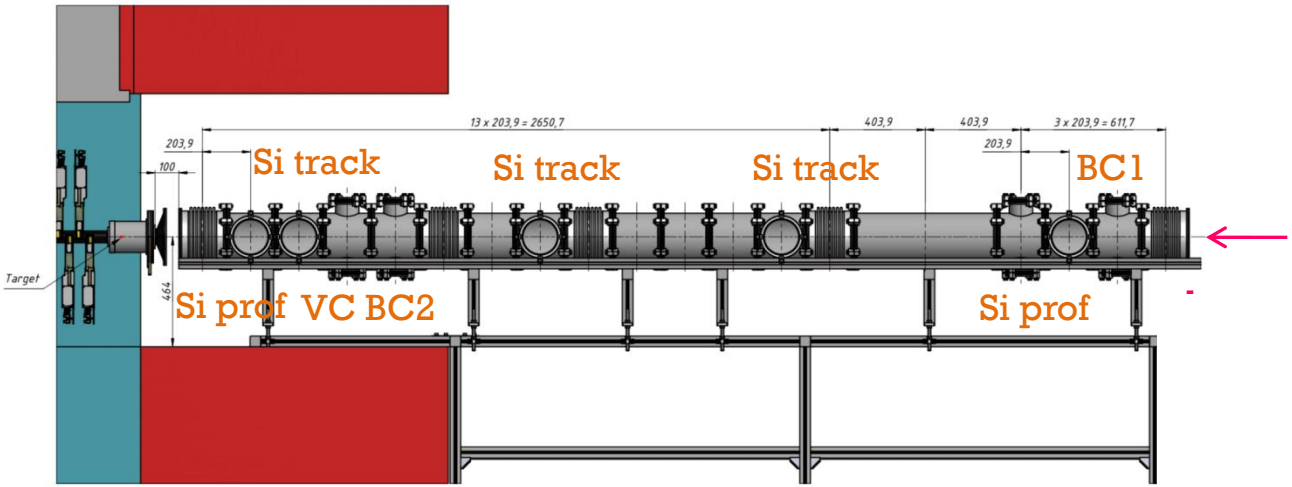
BM@N

M.Kapishin

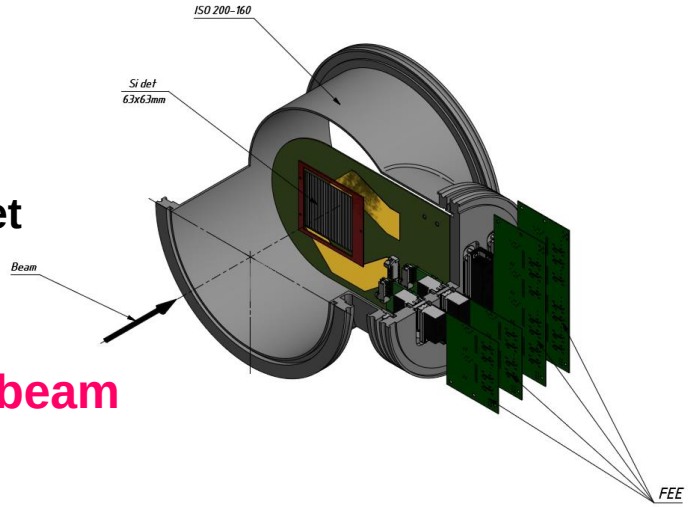
BM@N experiment

Beam Si and trigger detectors

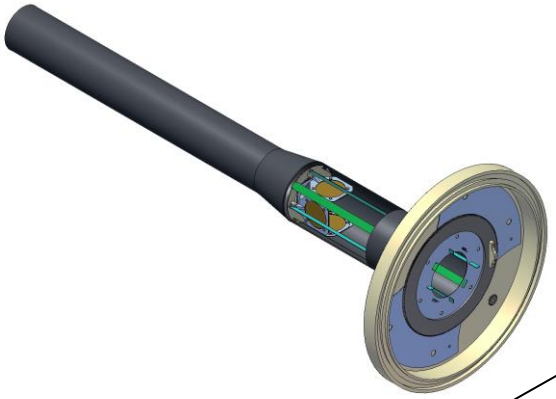
S.Piyadin, Yu.Gusakov
Group of N.Zamiatin
Trigger group

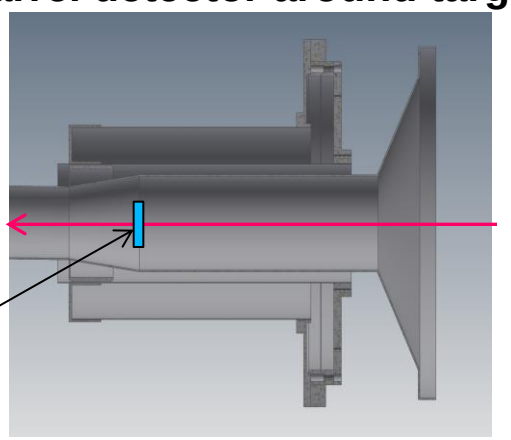


Si beam tracker



Barrel detector around target

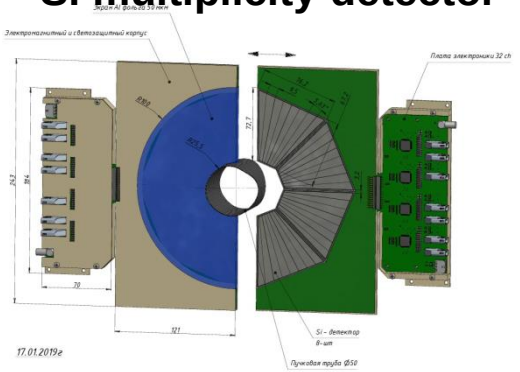




beam

Target station
with 3 targets
in vacuum box

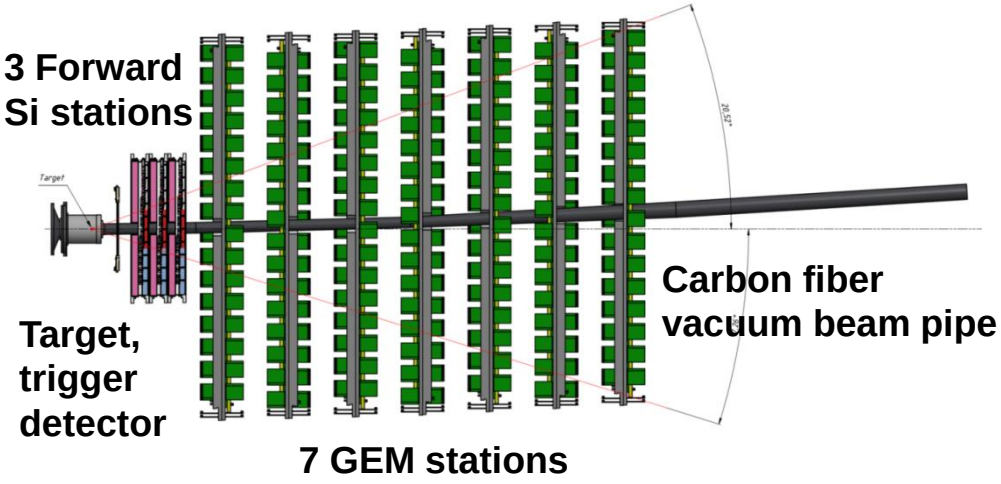
Si multiplicity detector



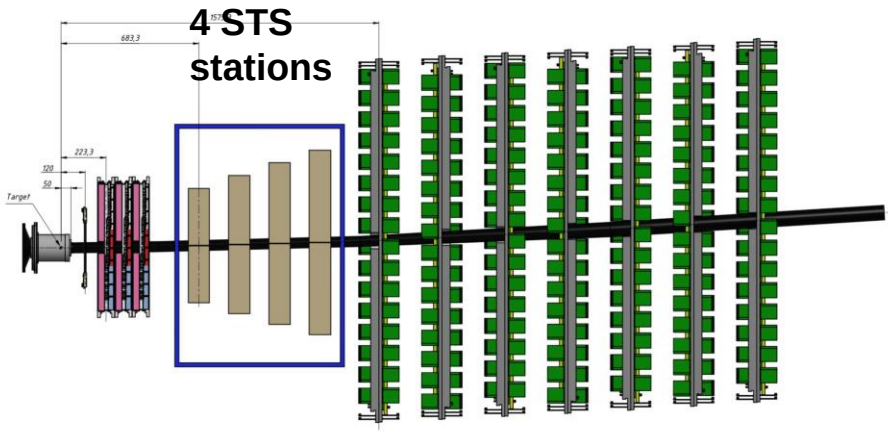
→ talk of Sergey Sedykh

Hybrid central tracker: Forward Si + CBM STS + GEM

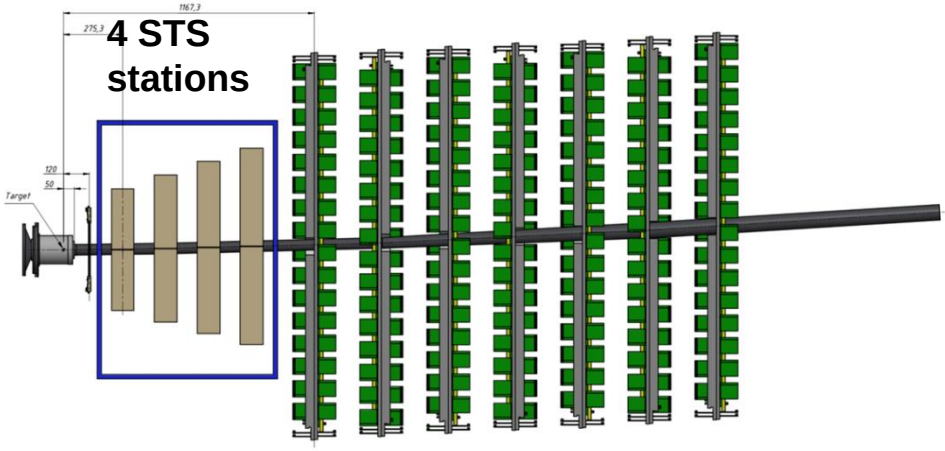
Startup 2021 -



2022 -



After 2022 (high intensity beam)



For heavy ion beam intensities of few 10^6 Hz
→ keep 4 STS + 7 GEM
→ fast FEE and readout electronics

→ talk of Anna Maksymchuk

BM@N working group activities

Detector board meetings
Technical coordinator Anna Maksymchuk

Data analysis meetings
(Mikhail Kapishin, one per month)

Regular meetings of Physics and Analysis working groups (PAWG) and Technical working groups (TWG)

Hyperon reconstruction, simulation and analysis (PAWG)
Convener: Alexander Zinchenko

Particle identification and analysis (TWG+PAWG)
Convener: Mikhail Rumyantsev

Event reconstruction and simulation (TWG)
Convener: Sergey Merts

Software development and data quality analysis (TWG) Conveners: Konstantin Gertsenberger, Pavel Batyuk

SRC data analysis and simulation (PAWG)
Conveners: Or Hen, Maria Patsyuk

ZDC centrality and ECAL data analysis and simulation (TWG)
Conveners: Sergey Morozov, Sergey Afanasiev, Alexey Stavinskiy

Present contributions of participating Institutions

Institution	Detector development	Analysis	Software development
MEPhI, Moscow	GEM, GEM+STS TDR		
NPI CAS, Rez	Carbon beam pipe		
INR RAS, Troitsk	New FHCAL	Centrality with ZDC in C+A data	
MIPT, Moscow			Visualization and web-services
ITEP, Moscow		Centrality with ZDC in Ar+A data, ECAL	
SINP, Moscow Tubingen University	STS development	STS simulation	
Tev Aviv University MIT Cambridge, MA SEA, Saclay		SRC analysis	
Plovdiv University		Particle identification	
LIT JINR		DCM QGSM model, DCH reconstruction	Software for data processing, computing

+ JINR LHEP major contributions

BM@N present status and next plans

► First preliminary result obtained on Λ yields in interactions of 4 AGeV Carbon beam with C, Al, Cu targets

→ plan to add results for 3.5 and 4.5 AGeV Carbon beam data

- Analyses of interactions of Ar, Kr beams with targets and SRC data are in progress:

► K^+ / π^+ yields in Ar - nucleus interactions at beam energy of 3.2 AGeV

► Study A-2 residual system after SRC knockout

BM@N is on the way for heavy ion high intensity runs in 2021 and later:

- Extend central tracker with large aperture STS silicon detectors in front of GEM setup (in collaboration with CBM)
- Extend forward Si tracking detectors
- Extend GEM central tracker and CSC outer tracker to full configuration
- Install MPD / CBM type of hadron FHCAL calorimeter, implement vacuum beam pipe through BM@N setup

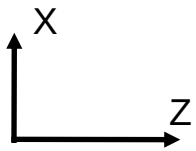
► One year delay of heavy ion program with an uncertainty due to upgrade of infrastructure for Nuclotron and extracted beams: new cryogenic station, new power station for beam transport channels, new vacuum beam line

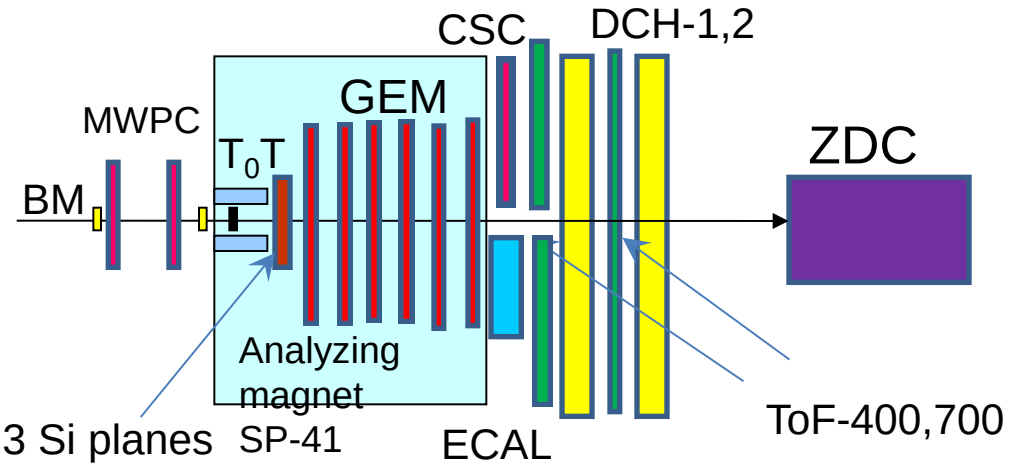
Thank you
for attention!

BM@N run with Ar and Kr beams in March 2018

Ar beam, T_0= 3.2 GeV/n

Kr beam, T_0= 2.4 (2.9) GeV/n





- **Central tracker inside analyzing magnet → 6 GEM detectors 163 x 45 cm^2 and forward Si strip detectors for tracking**
- **ToF system, trigger detectors, hadron and EM calorimeters, outer tracker**

Program:

- **Measure inelastic reactions Ar (Kr) + target→ X on targets C,Al,Cu,Sn,Pb**

→ Hyperon production measured in central tracker (Si + GEM)

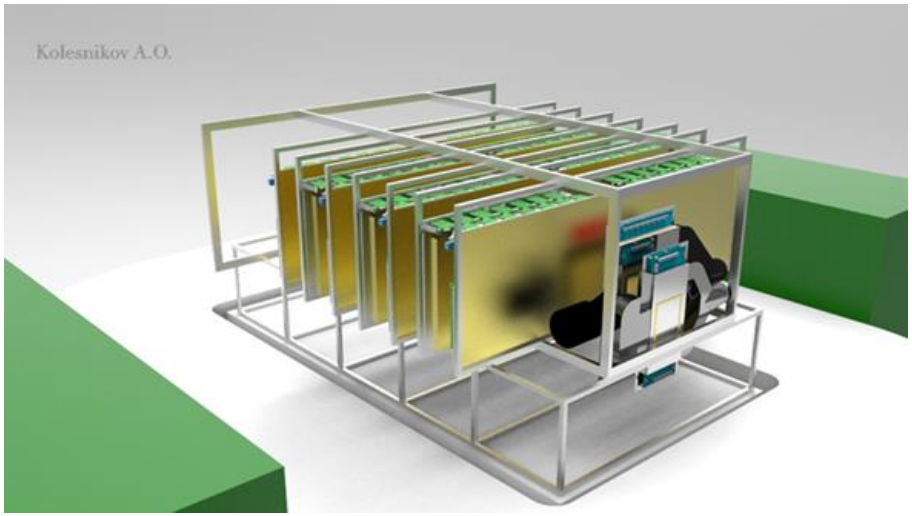
→ Charged particles and nuclear fragments identified with ToF

→ Gamma and multi-gamma states identified in ECAL

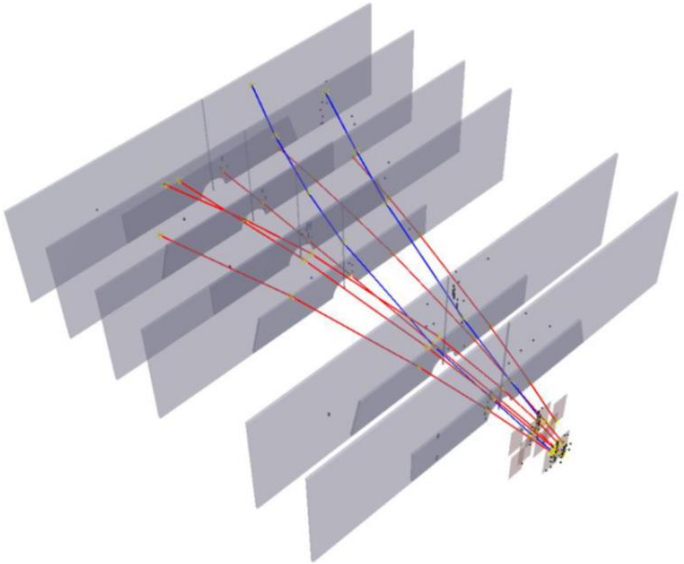
+ analyze data from previous technical run with Carbon beam of 3.5 - 4.5 GeV/n

Central tracker in Ar / Kr runs

3 forward silicon strip planes and 6 GEM detectors



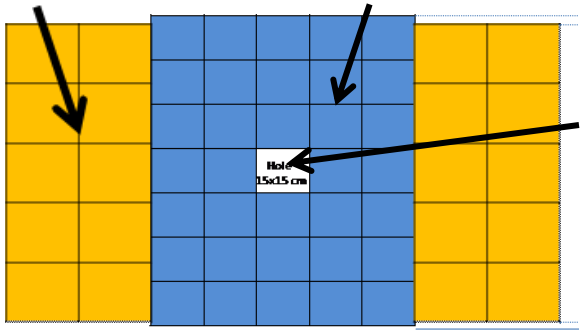
Ar-target interaction reconstructed in central tracker



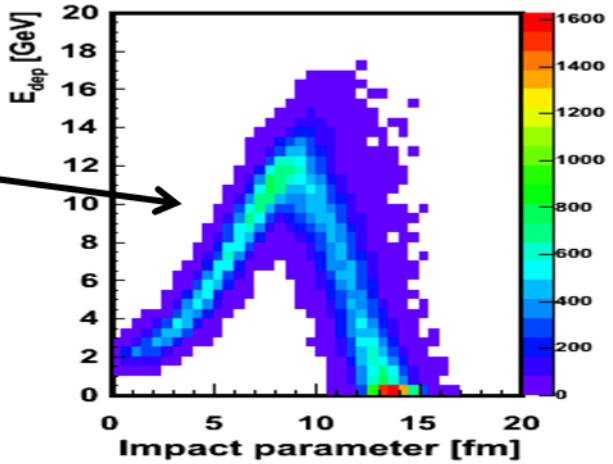
MPD / CBM hadron ZDC calorimeter

INR RAS Moscow

CBM modules MPD modules

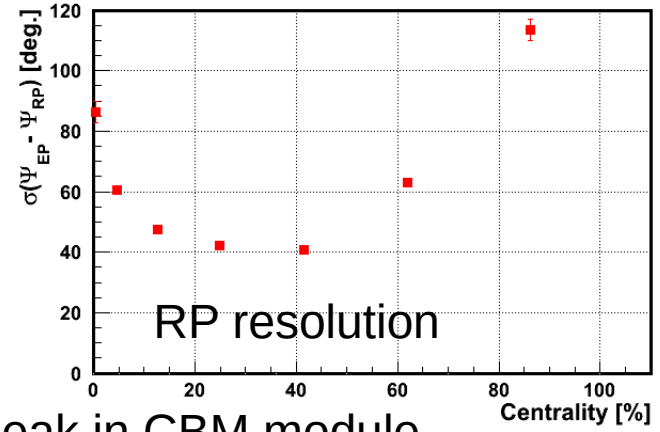


dE/dx scintillator to resolve central / peritheral interactions

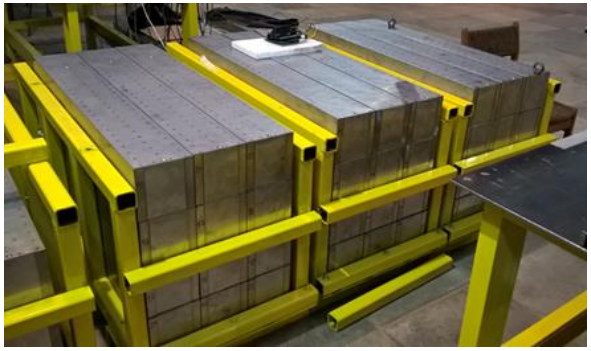


- **Modern technics;**
- **Light yield ~x10 higher;**
- **Detection of low energies;**
- **Stable operation at high count rates;**
- **Experience in operation for later MPD/CBM experiments**
- **Motivated team**

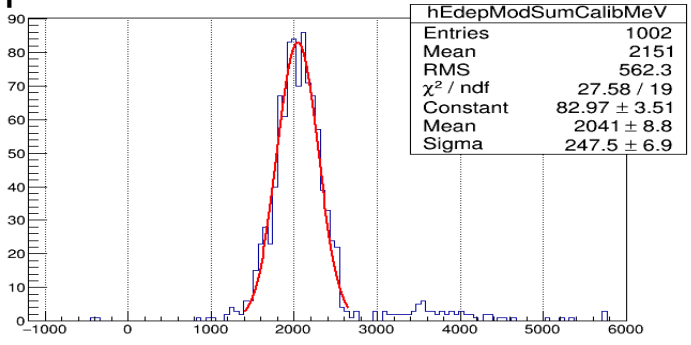
CBM module in BM@N



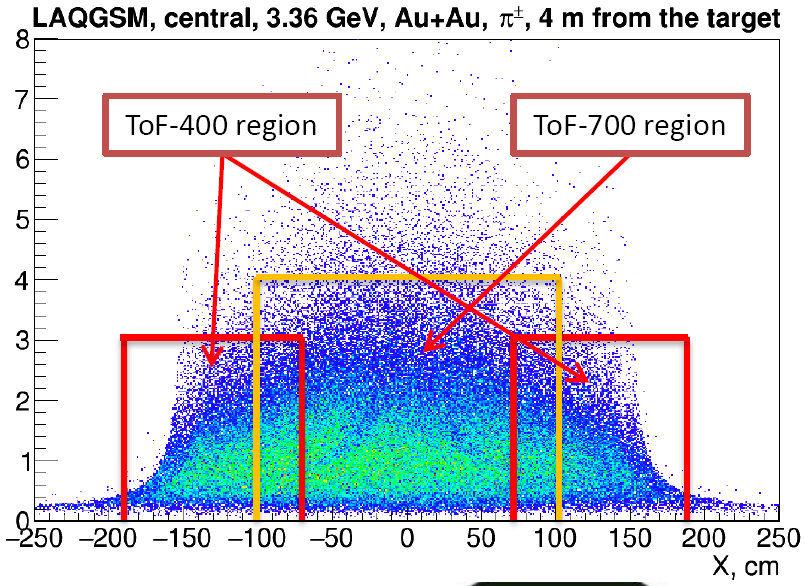
MPD FHCAL modules



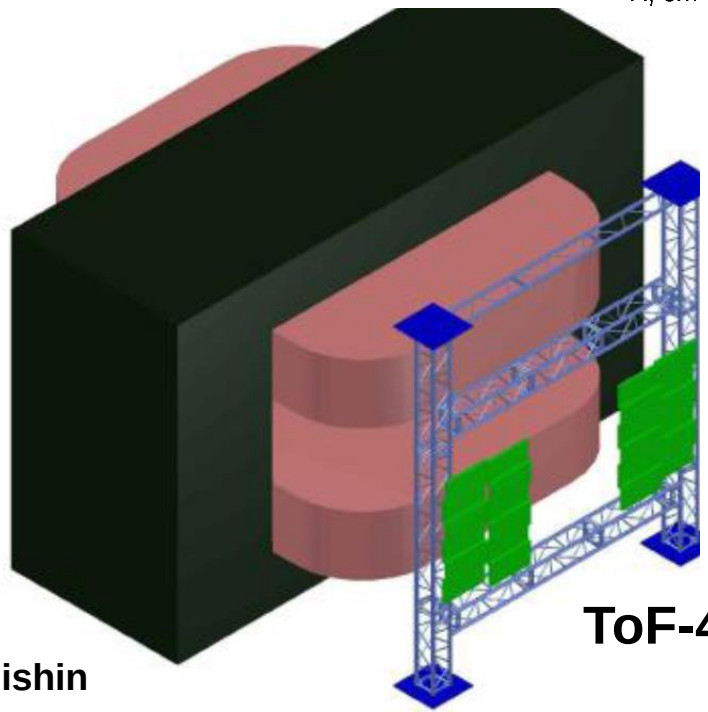
Ar peak in CBM module



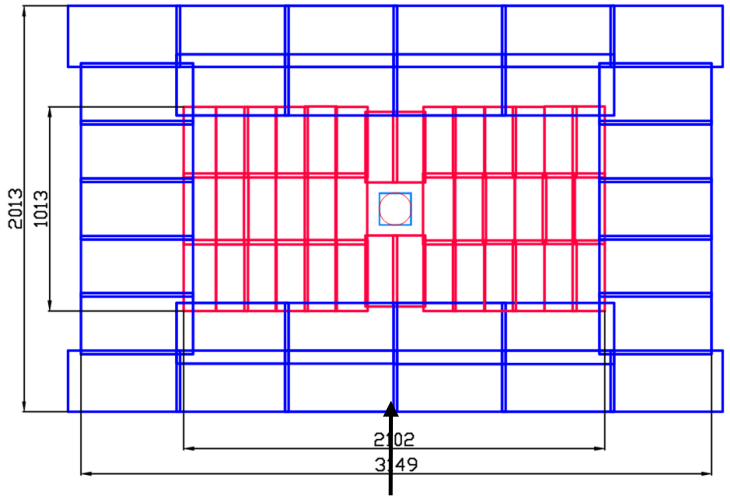
ToF-400 and ToF-700 based on mRPC



ToF-700 wall



ToF-400 wall

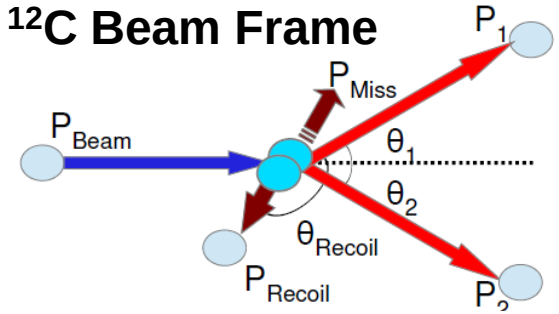


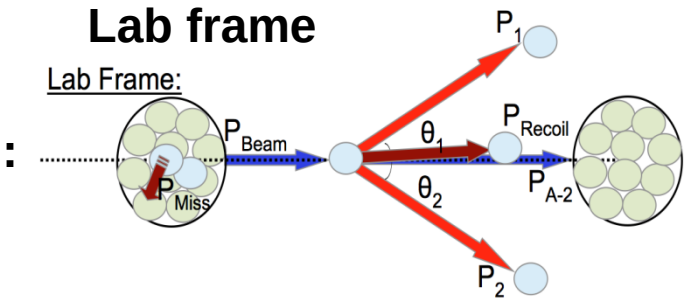
BM@N beam axis

M.Kapishin

A proposal for BM@N experiment

to study SRC with hard inverse kinematic reactions

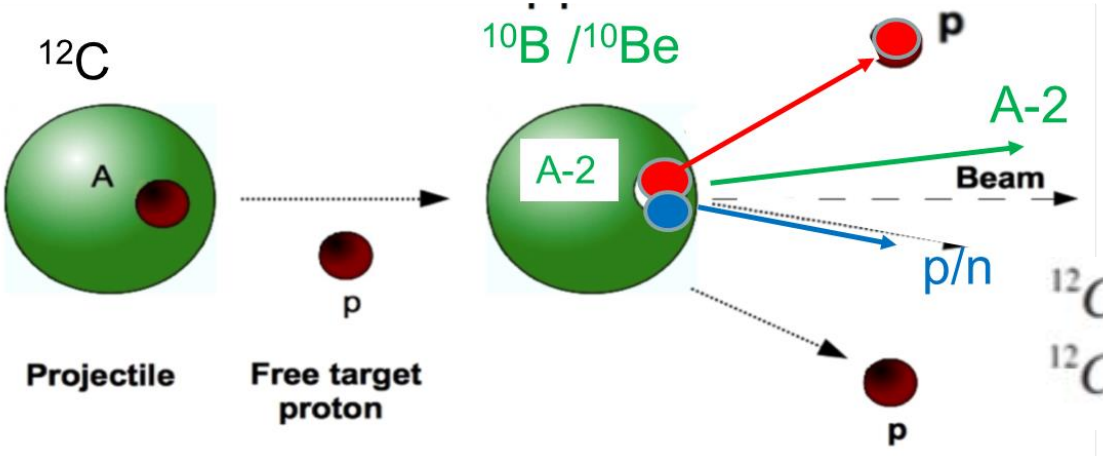




JINR (Dubna): BM@N
Israel: Tel Aviv University
Germany: TUD and GSI
USA: MIT
FRANCE: CEA

Objectives:

- identify 2N-SRC events with inverse kinematics
- study isospin decomposition of 2N-SRC
- study A-2 spectator nuclear system

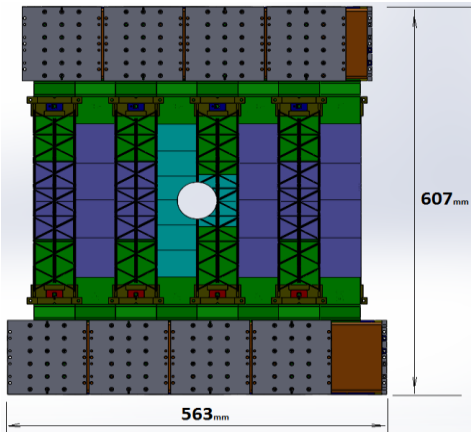


$$^{12}C + p \rightarrow 2p + {}^{10}_{5}B + n \quad \text{np SRC}$$

$$^{12}C + p \rightarrow 2p + {}^{10}_{4}Be + p \quad \text{pp SRC}$$

Upgrade of central tracker with CBM STS

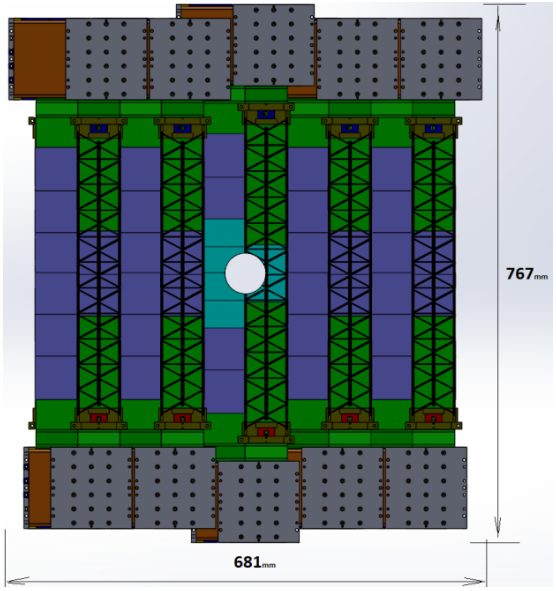
STS-1



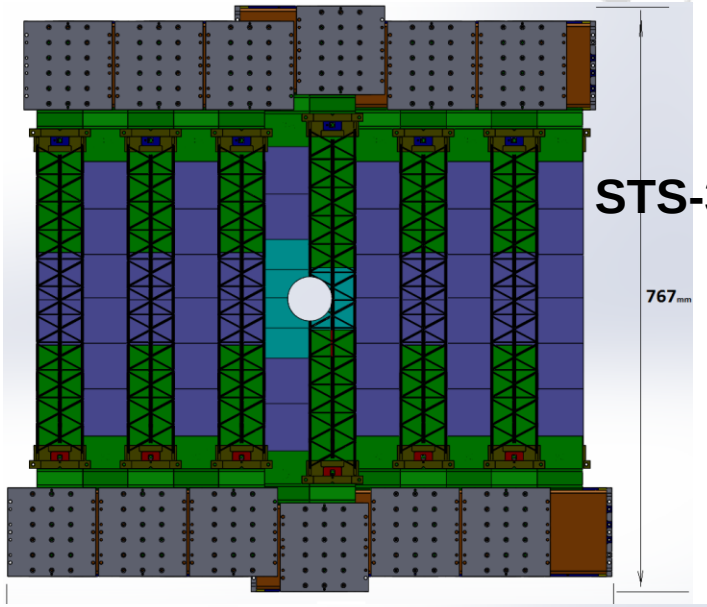
Team: LHEP JINR, MSU, GSI, Tübingen University

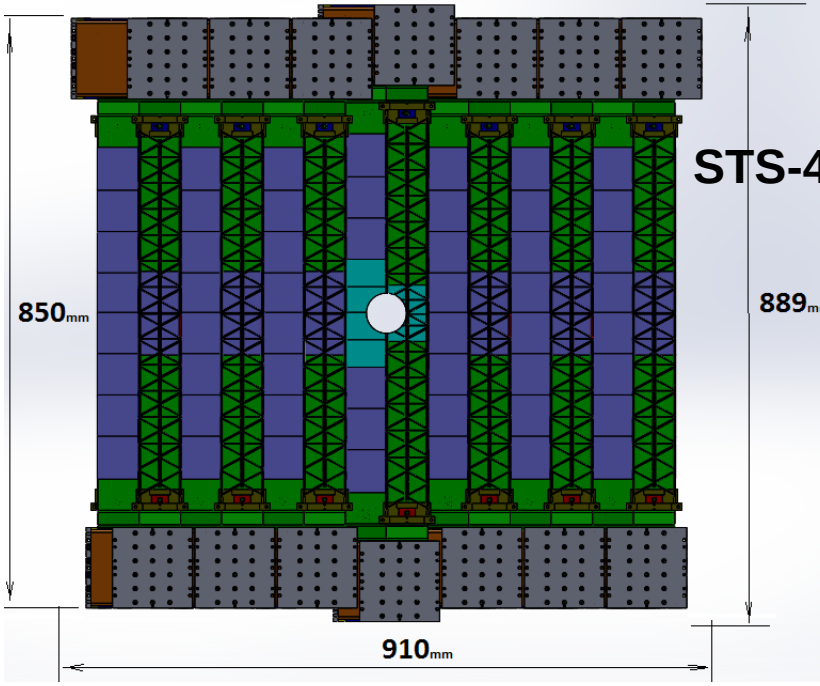
→Talks on detector status and simulation

STS-2



Total: 292 modules, ~600k channels





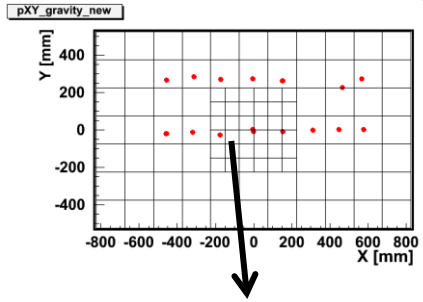
Towards centrality measurement with ZDC in Carbon / Argon runs

Team: F.Guber, A.Ivashkin, S.Morozov, M.Golubeva

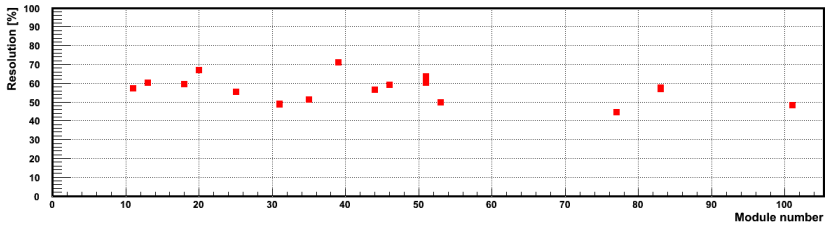
Team: A.Stavinskiy, P.Alexeev, N.Zhigareva

C beam , 4.5 AGeV, March 2017

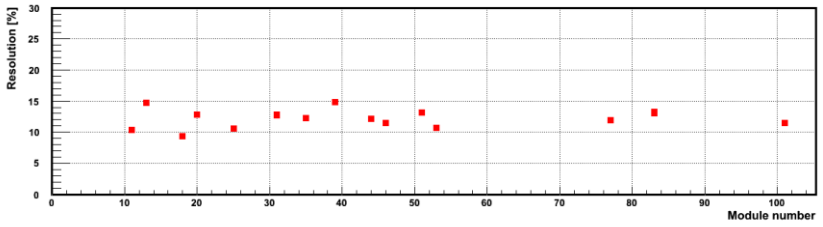
ZDC beam scan along X, Y



Mean energy, systematics ~12%

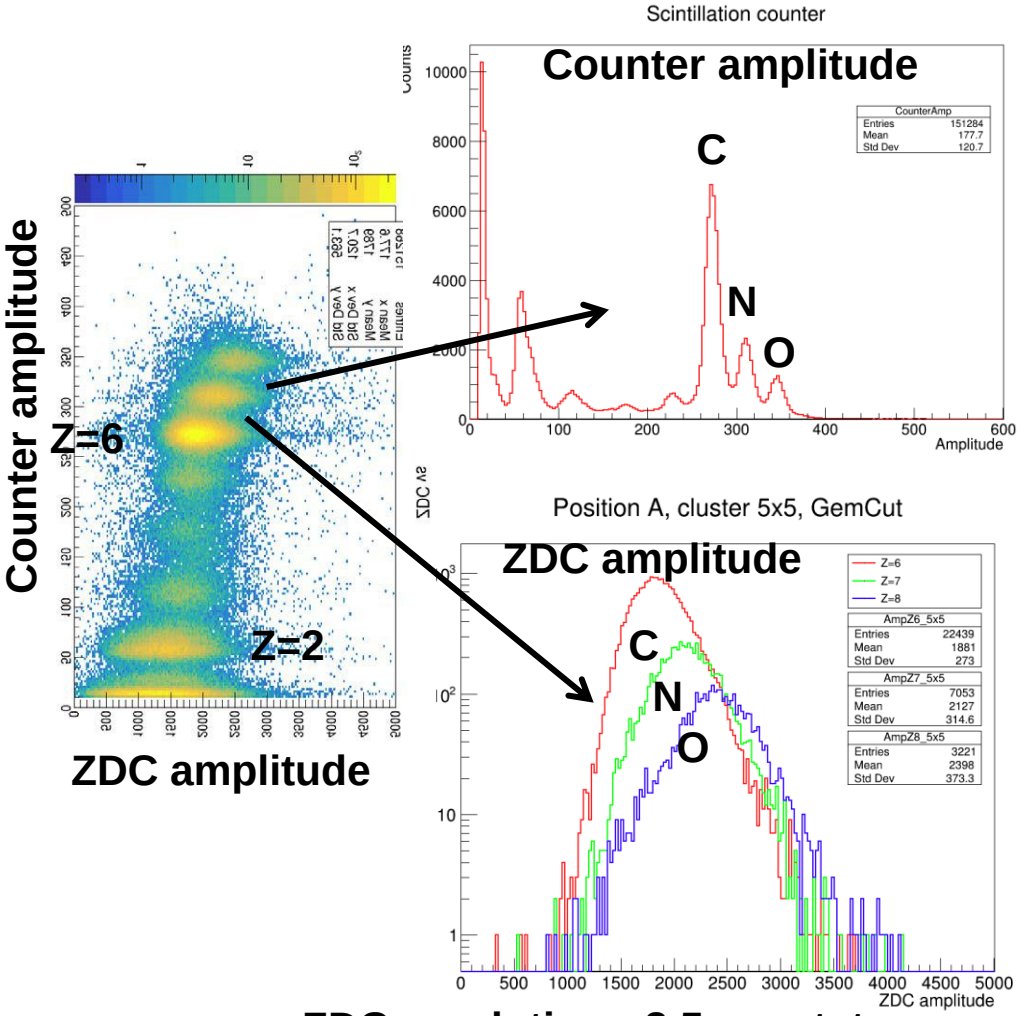


Energy resolution ~12%



→ talks of Sergey Morozov and Petr Alekseev

SRC run, C beam, 3.14 AGeV, March 2018 → ZDC calibration for Ar run



ZDC resolution ~2.5 spectators