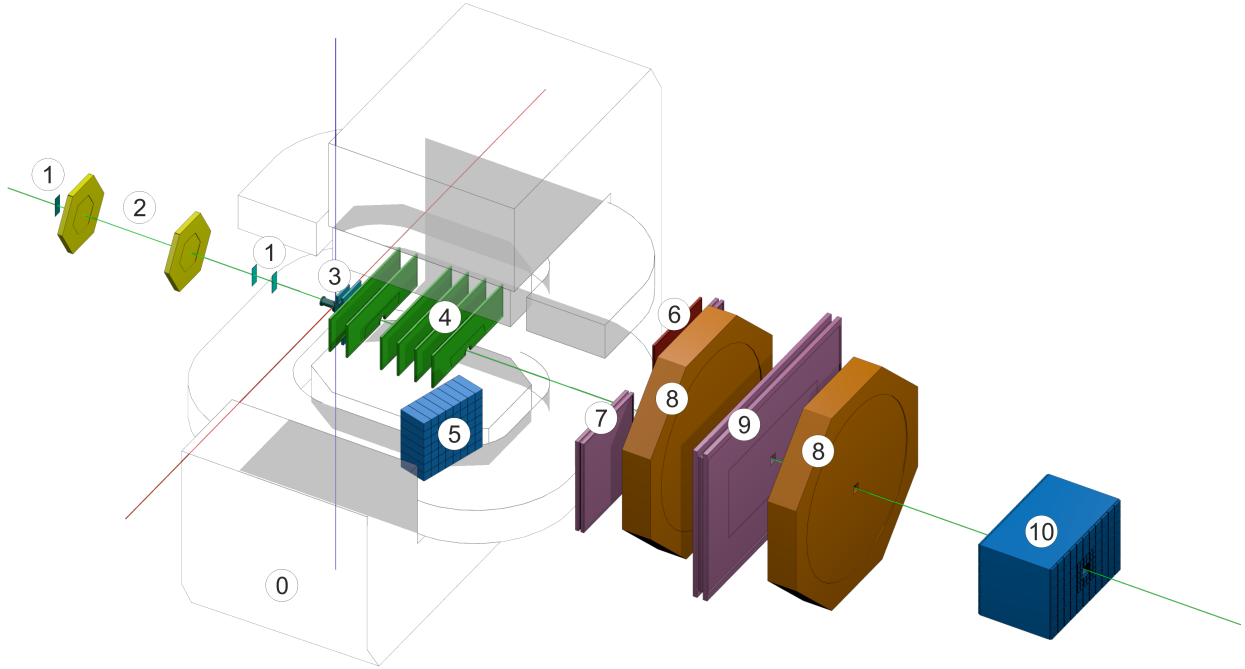


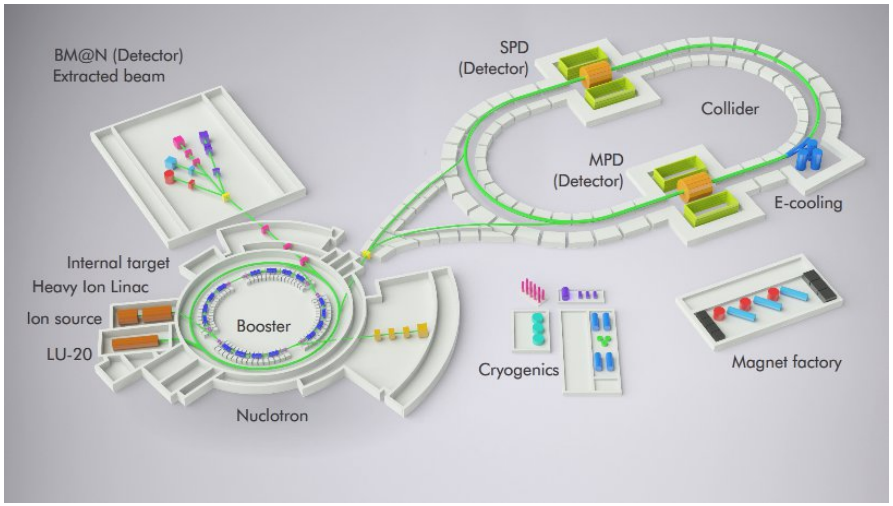
BM@N experiment

P. Batyuk

Dubna, Joint Institute for Nuclear Research

First Open Day of the NICA Complex, October 31

NICA Complex



- Set of accelerators providing particle beams for fixed target and collider experiments
- Experimental facilities
- Line for assembling and cryogenic testing of SC-magnets
- Workshops for construction of the detector elements
- NICA innovation center

Beams - p, d **...** $^{197}Au^{79+}$
Collision energy:
$\sqrt{s_{NN}} =$ **4 - 11 GeV,** $T =$ **1 - 6 AGeV**
Luminosity: $10^{27}\ cm^{-2}s^{-1}$ **(Au),** 10^{32} **(p)**

- **2 interaction points - MPD (First Open Day of the NICA Complex, report of N. Geraksiev) and SPD**
- **Fixed target experiment - BM@N**

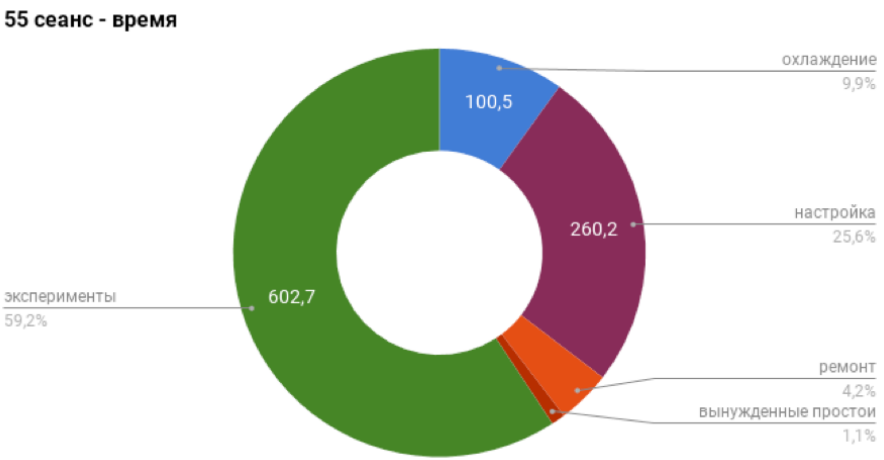
- **2018: extracted beams of heavy ions (Ar, Kr) are available within the BM@N experiment**
- **2020: a first configuration of the MPD setup available.**
- **2023: commissioning of the fully designed NICA-complex is foreseen.**

Nuclotron (in operation since 1993)

Modernized in 2010 - 2015

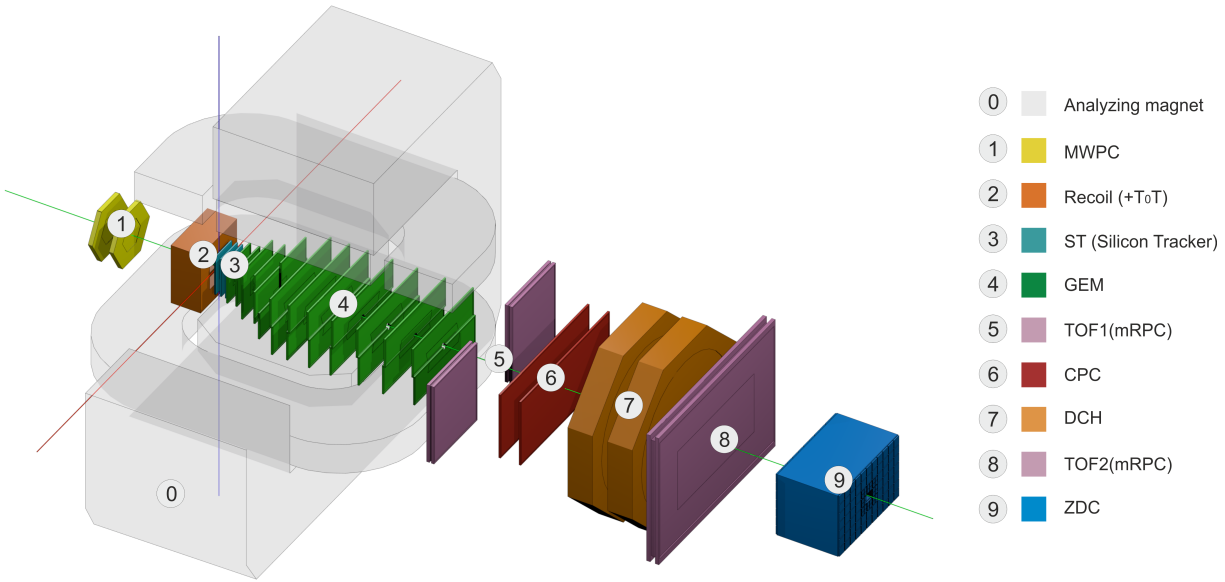
Parameters	Nuclotron
type	SC synchrotron
particles	↑p, ↑d, nuclei
injection energy [MeV/u]	5 (↑p, ↑d), 570-685 (Au)
max. kin. energy [GeV/u]	12.07 (↑p), 5.62 (↑d), 4.38 (Au)
magnetic rigidity [T · m]	25 - 43.25
circumference [m]	251.52
cycle for collider mode [s]	1.5-4.2 (active), 5.0 (total)
vacuum [Torr]	10^{-9}
intensity, Au [ions/pulse]	$1 \cdot 10^{9}$
spill of slow extraction [s]	up to 10

Run55: Feb - Apr, 2018



BM@N experiment

Full setup, layout



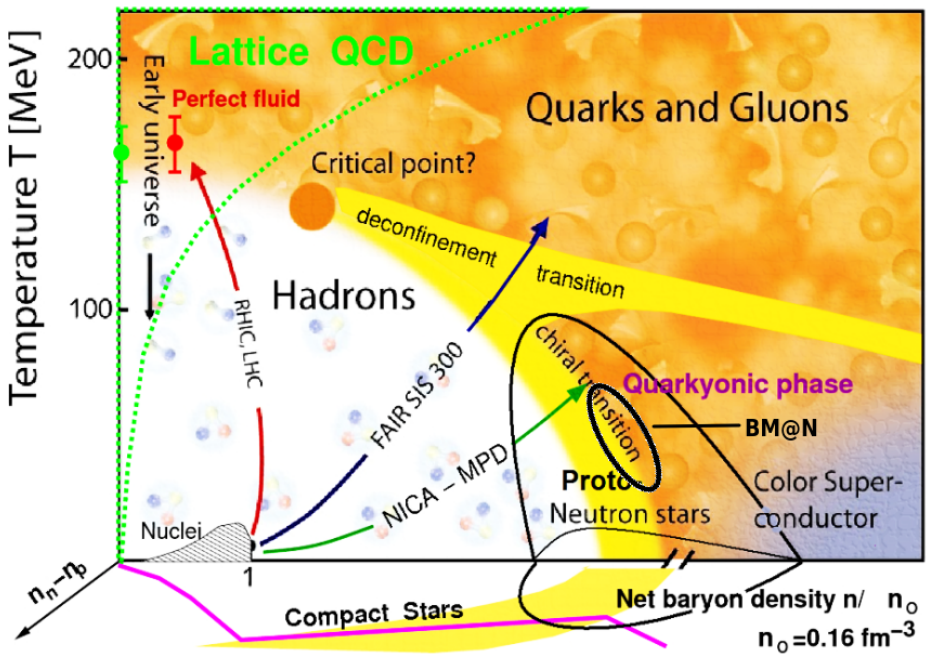
- Central tracker (Silicon tracker + GEM) inside analyzing magnet to reconstruct AA-interactions
- Outer tracker (CPC, DCH) behind magnet to link tracks from central tracker to ToF detectors
- TOF1 & TOF2 system based on mRPC and T0 detectors to identify hadrons and light nuclei
- Detectors to form T0 and beam monitors
- ZDC calorimeter to measure centrality of AA-collisions
- Electromagnetic calorimeter for γ, e^+, e^-

BM@N advantages:

- large aperture analyzing magnet
- sub-detector systems are resistant to high multiplicities of charged particles
- PID: "near to magnet" (TOF1), "far from magnet" (TOF2)

Physics to be investigated

QCD phase diagram



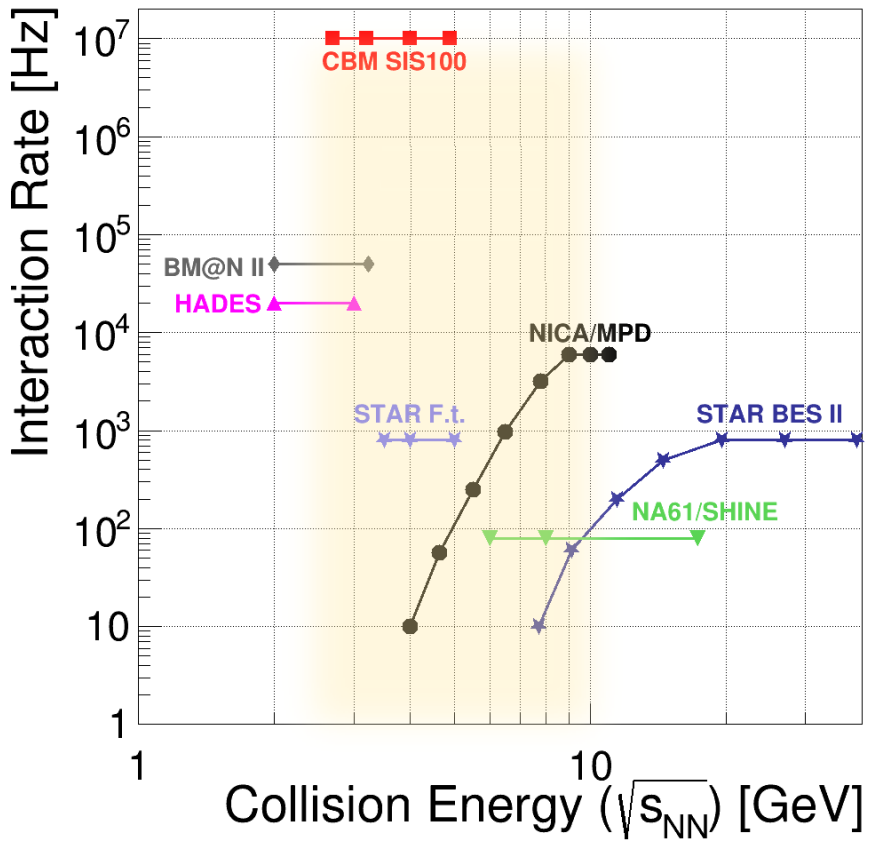
High energy:

- $N_{baryons} \approx N_{antibaryons}$
- Lattice QCD predicts crossover transition between hadronic and partonic matter
- ALICE, ATLAS, CMS, STAR, PHENIX

High net-baryon density:

- $N_{baryons} >> N_{antibaryons}$
- Lattice QCD not applicable, models predict structures and exotic phases
- BES @ RHIC, NA61, CBM, NICA/MPD, BM@N

Landscape of experiments exploring QCD phase diagram



Physics possibilities at the Nuclotron

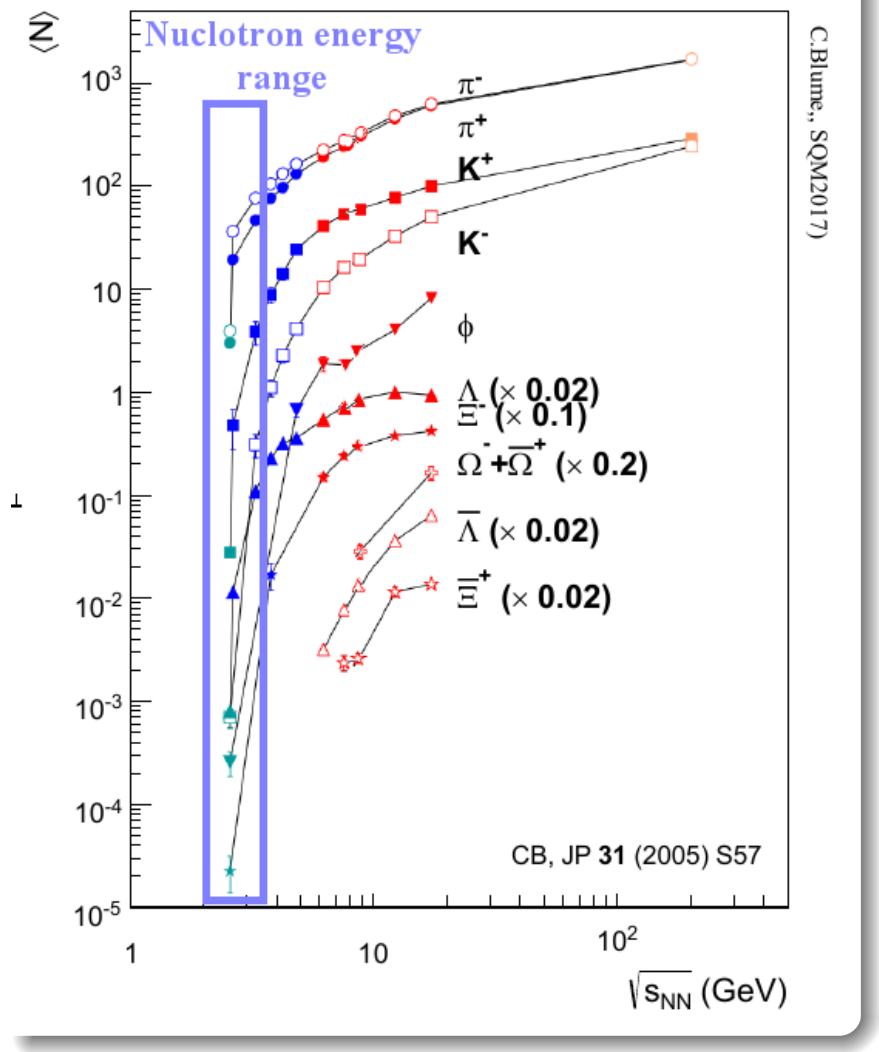
$A + A$ collisions:

- strangeness at threshold
- Need more precise data for strange mesons, hyperons and hypernuclei, multi-variable distributions, unexplored energy range

$p + p$, $p + n$, $p + A$ collisions:

- Hadron production in elementary reactions and "cold" nuclear matter as a "reference" to determine exactly nuclear effects

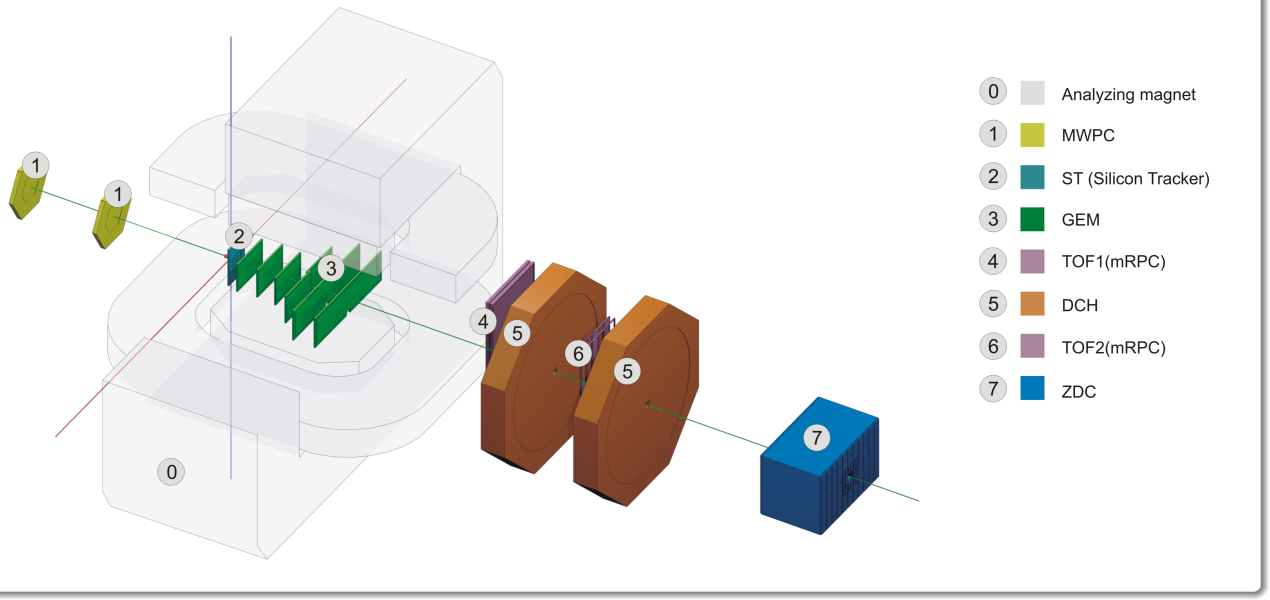
AGS NA49 BRAHMS



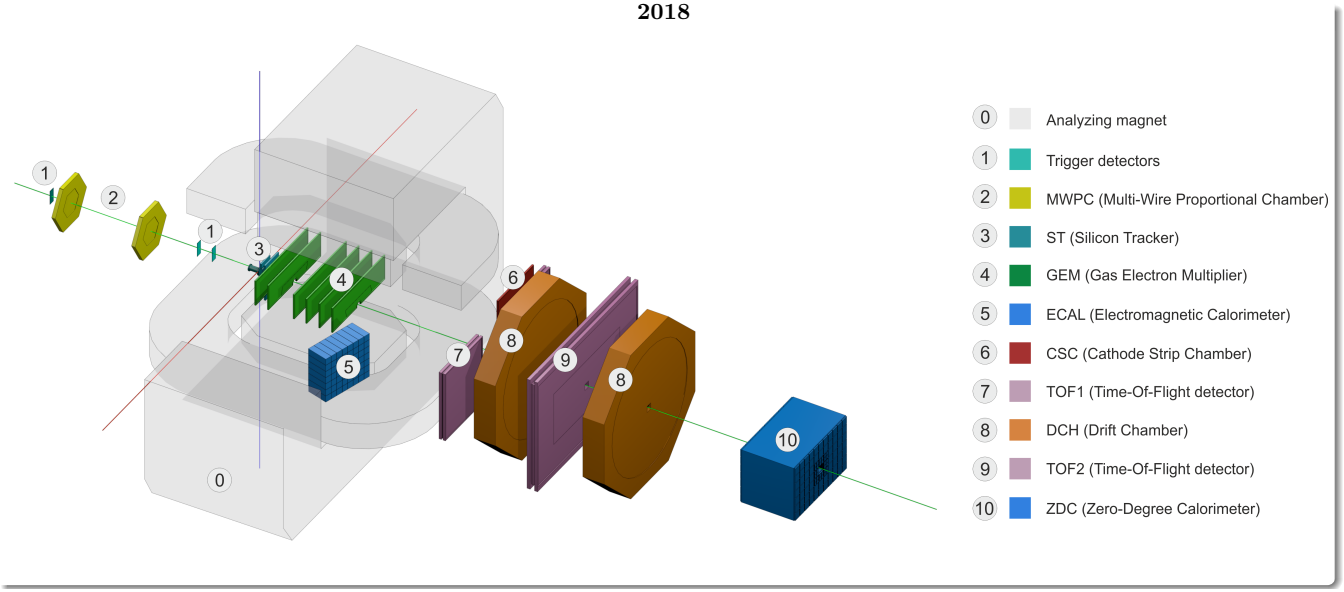
BM@N experimental setup in recent runs

BM@N runs: transition from technical to physical ones

2017

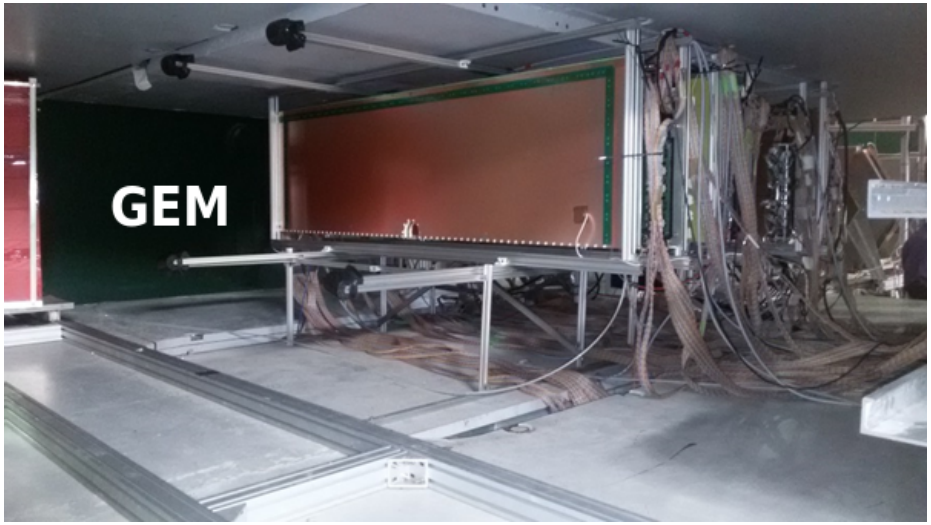


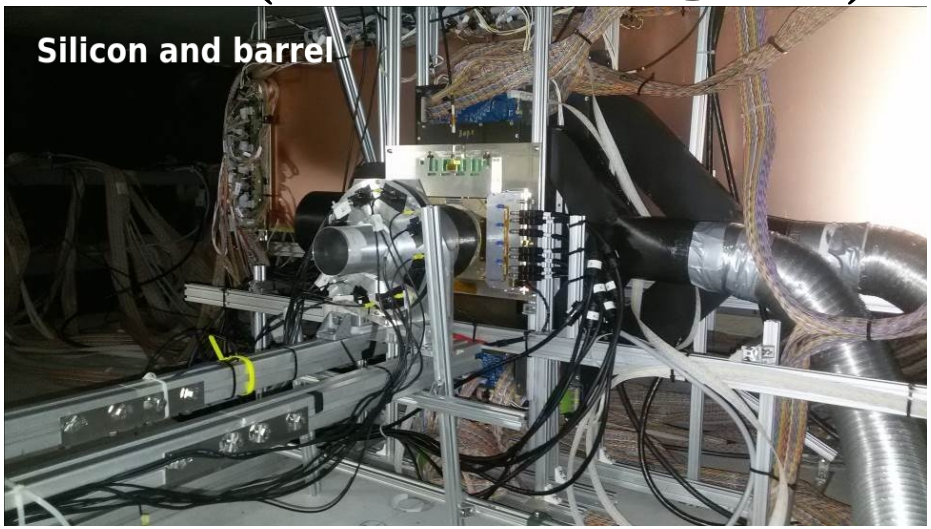
2018

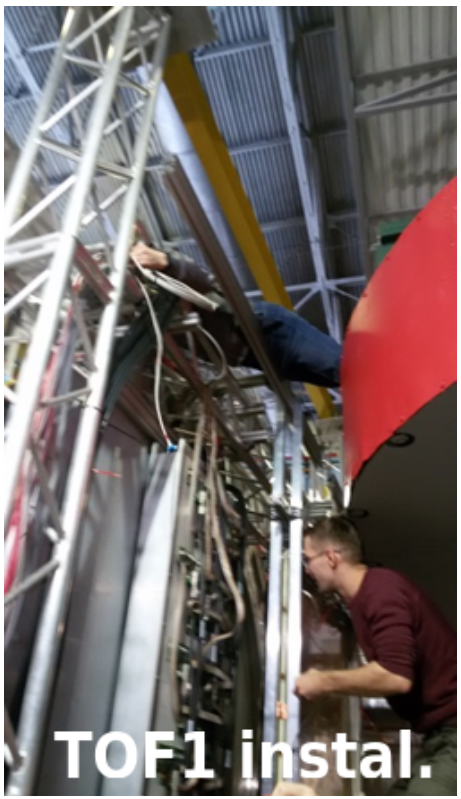


How it was during last experimental run ...

BM@N setup in the last run (before magnet)



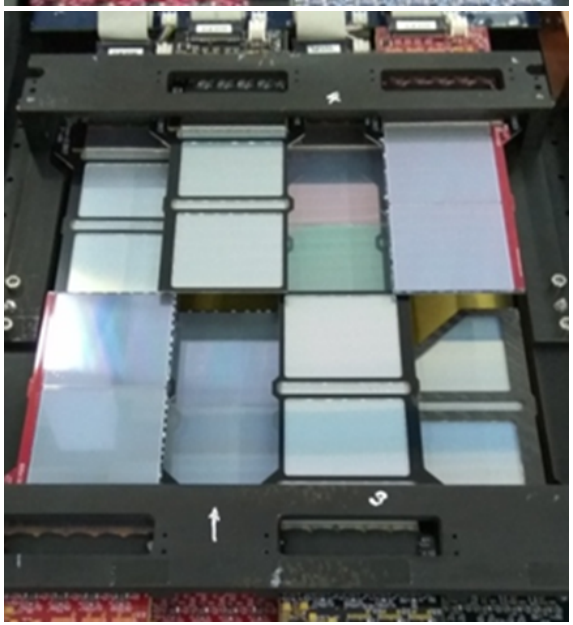




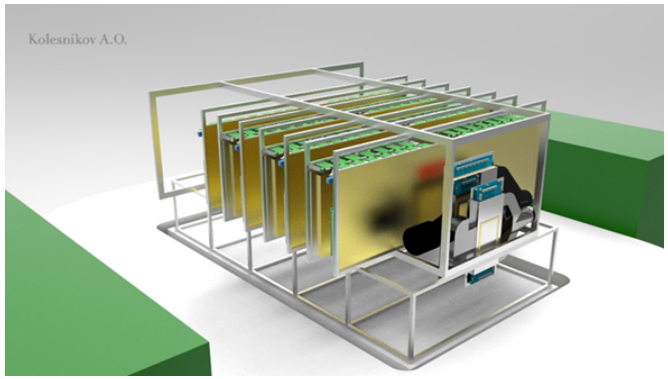
New detector components:

- Six big GEMs
- Trigger detectors
- Three Si detectors
- CSC chamber
- Full set of TOF detectors

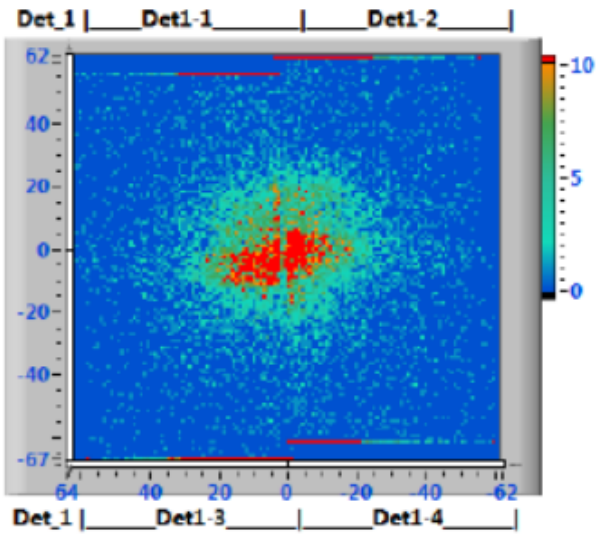
Forward silicon strip detectors



Central tracker (GEM + SI) in Argon/Krypton run

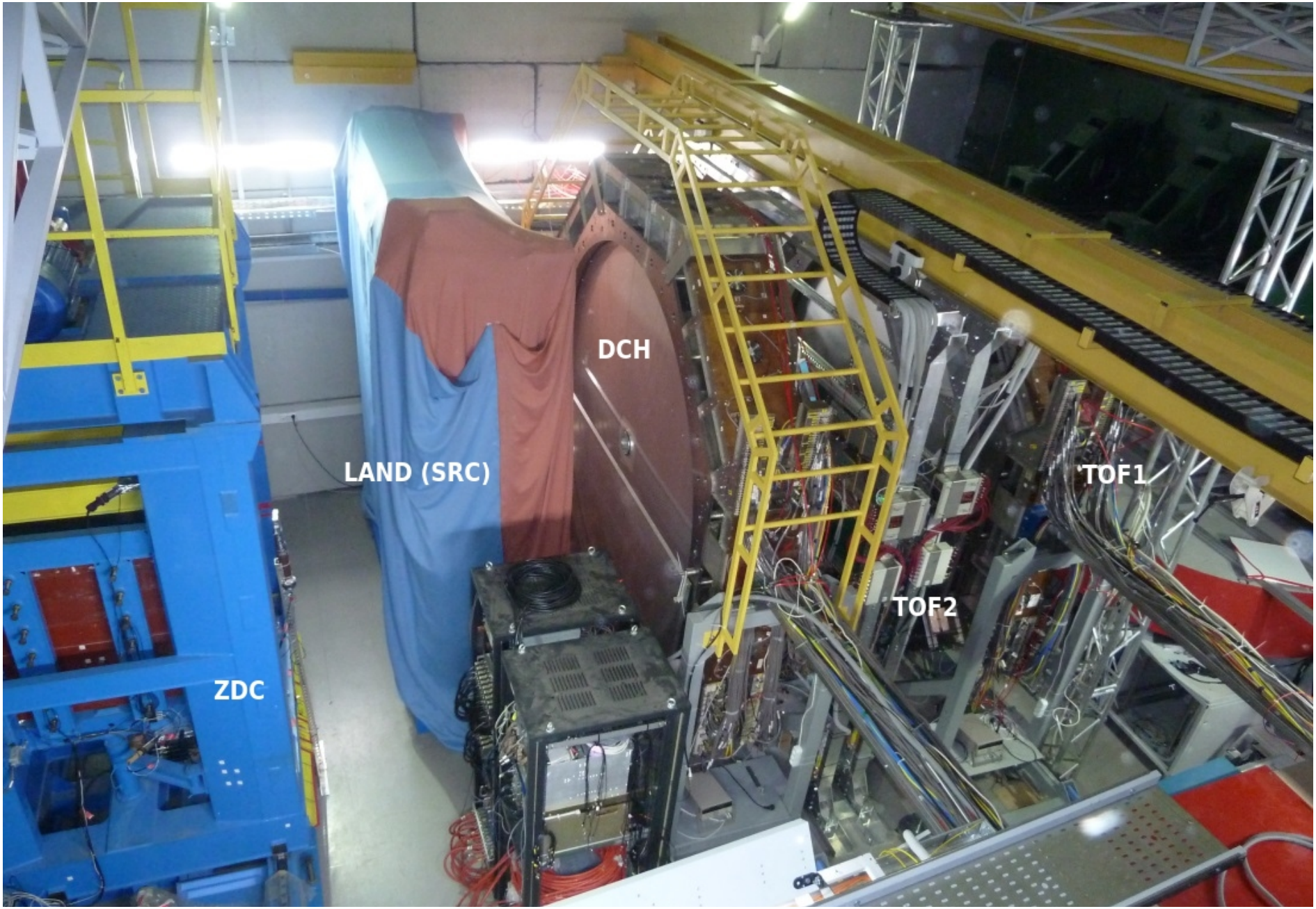


Kr beam fragments in silicon vertex detector



- **Two-coordinate Si detector with strip pitch of $95/103\mu m$, full size of $25 \cdot 25 cm^2$**
- **Detector consists of 4 sub-detectors located around beam**
- **2 smaller vertex detectors (March 2018)**

BM@N setup in the last run (behind magnet)



BM@N and SRC, data collected (March - April, 2018)

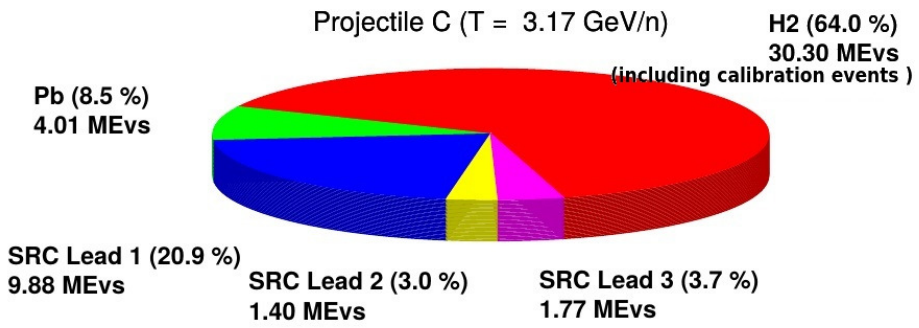
SRC:

- One beam energy available for C-beam
- More than half of the collected statistics can be used for analysis

BM@N:

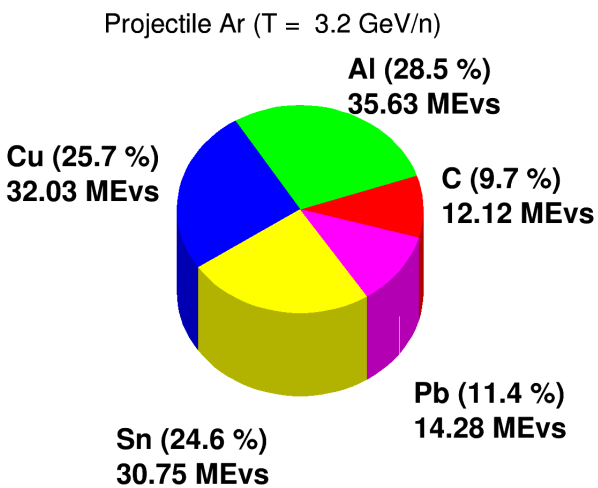
- One beam energy available for Ar-beam and three - for Kr-beam
- Wide set of targets used (C, Al, Cu, Sn, Pb)

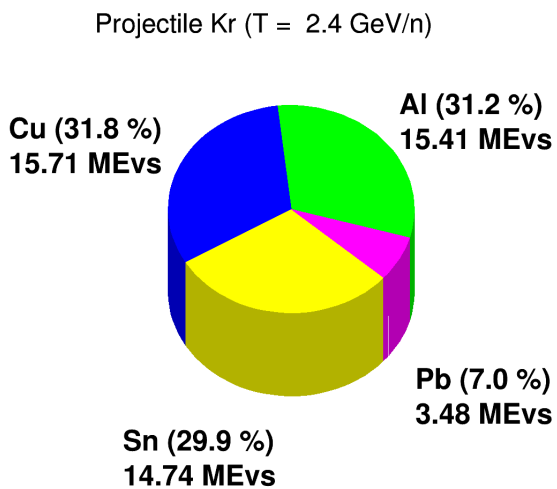
SRC

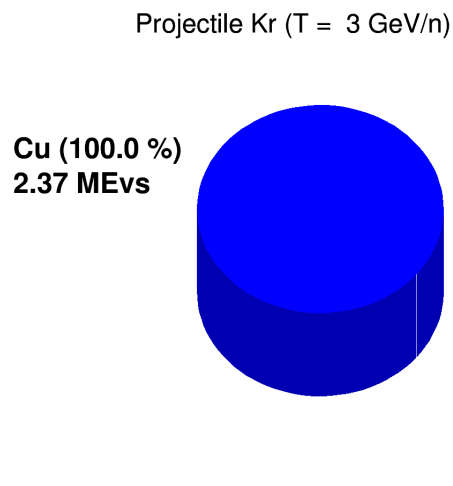


Data analysis is in progress ...

BM@N



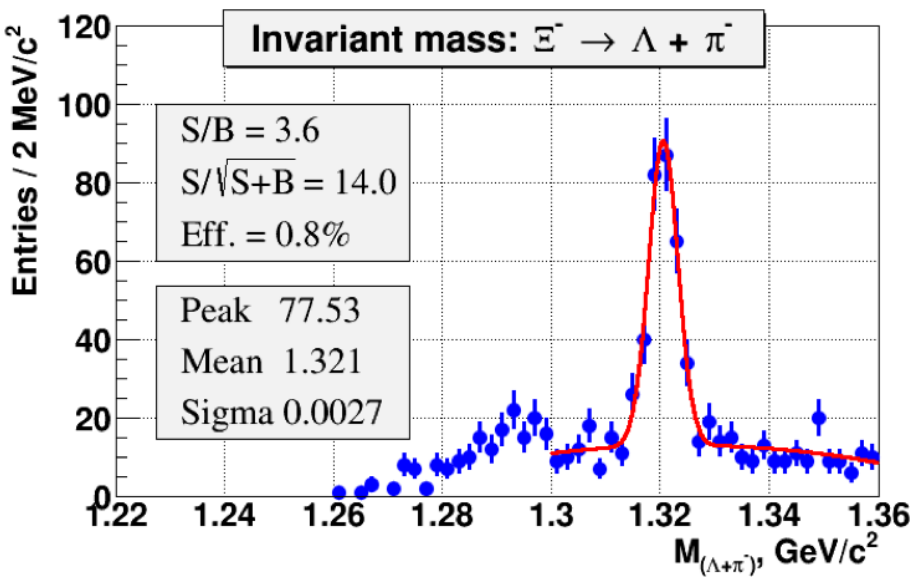




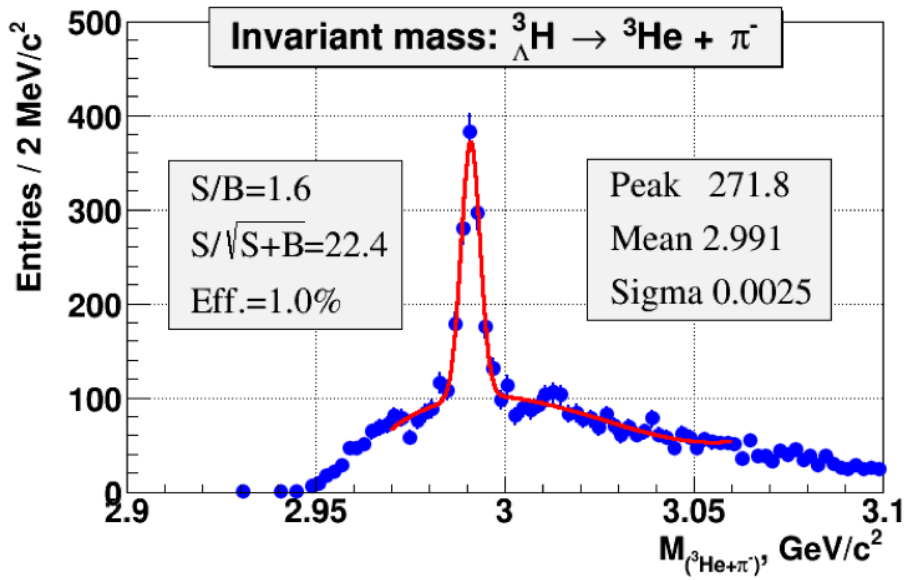
Why do we need Monte Carlo?

Simulation: UrQMD & DCM-QGSM, Au+Au, T = 4.5 AGeV

900k central events,
7.5M Ξ^- in 1 month
20 kHz trigger

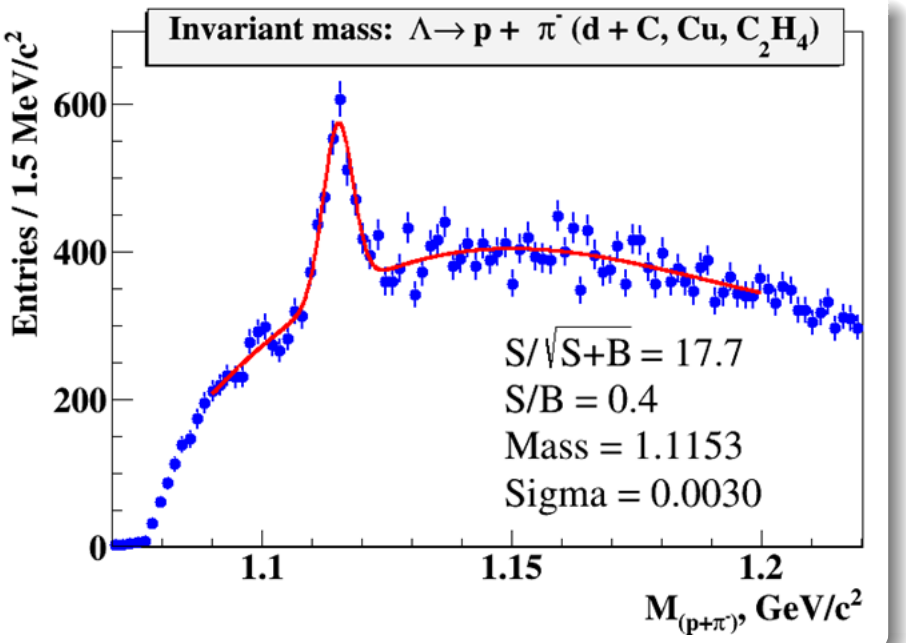


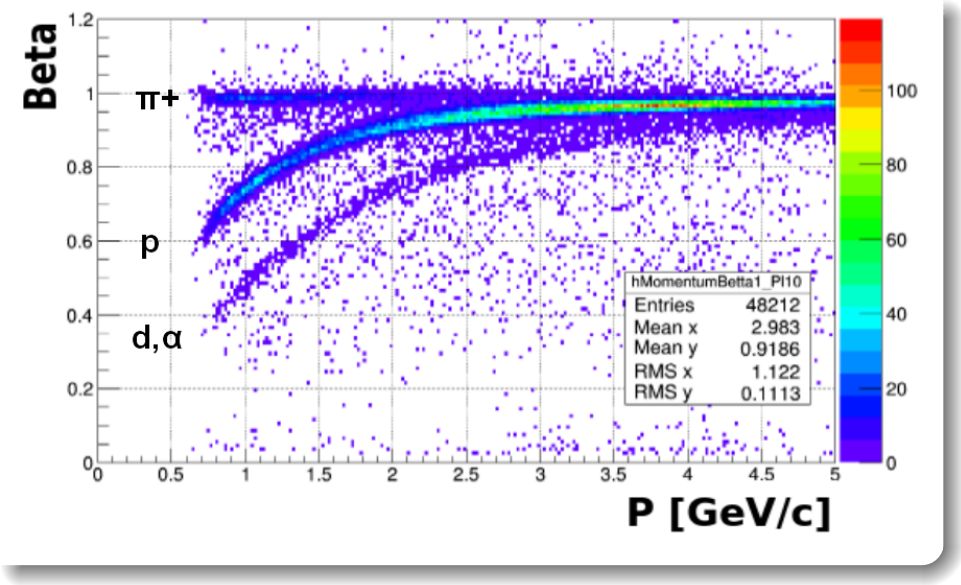
2.6M central events,
8.5M $^{3}_{\Lambda}$H in 1 month
20 kHz trigger

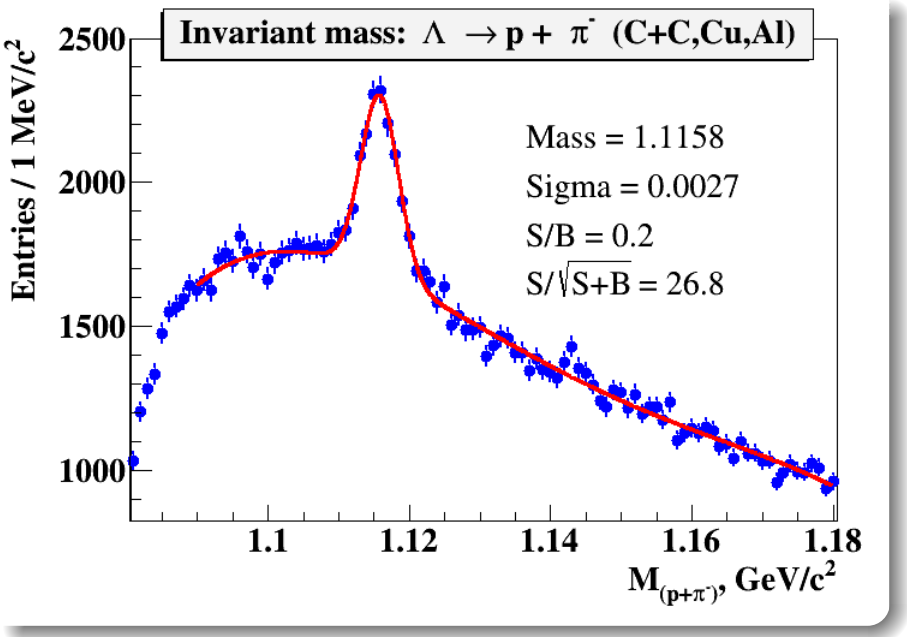


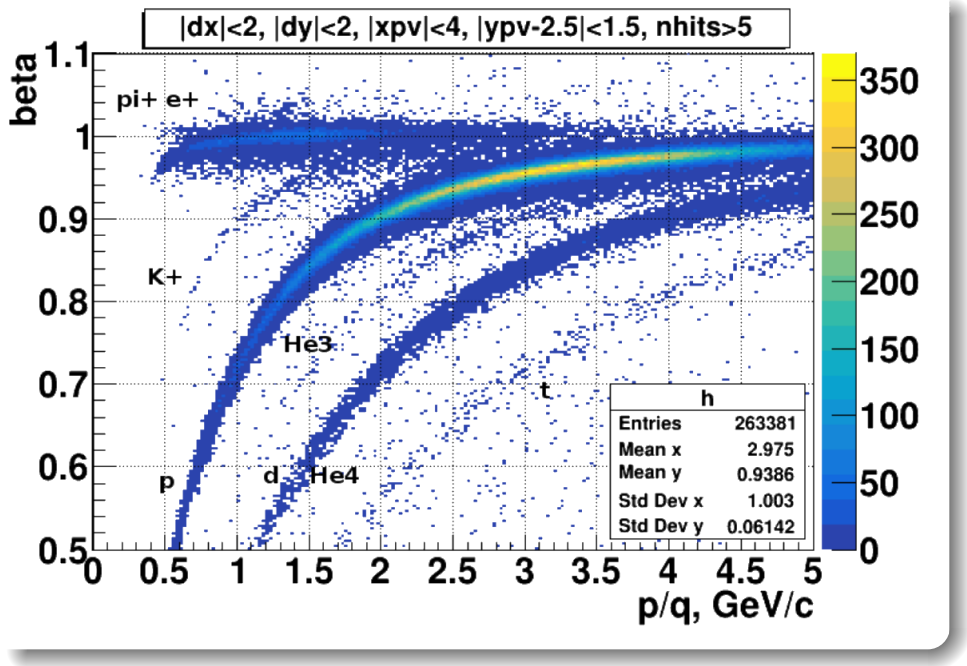
The feasibility study indicates reliable reconstruction of cascades and hypernuclei of order of 10 millions per month

Obtained physics results ...



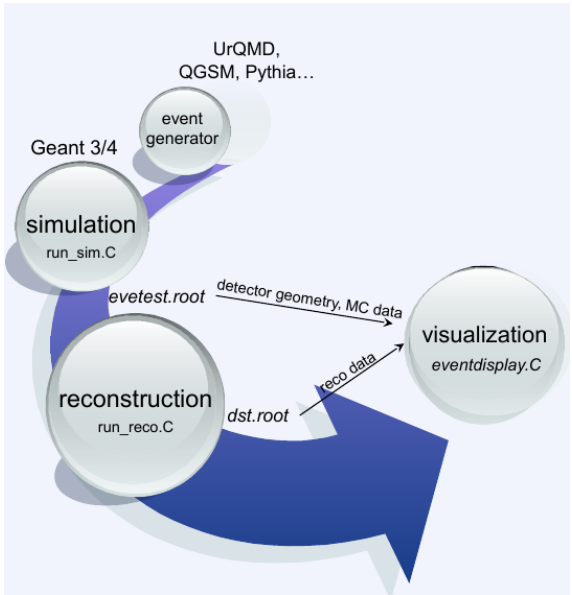


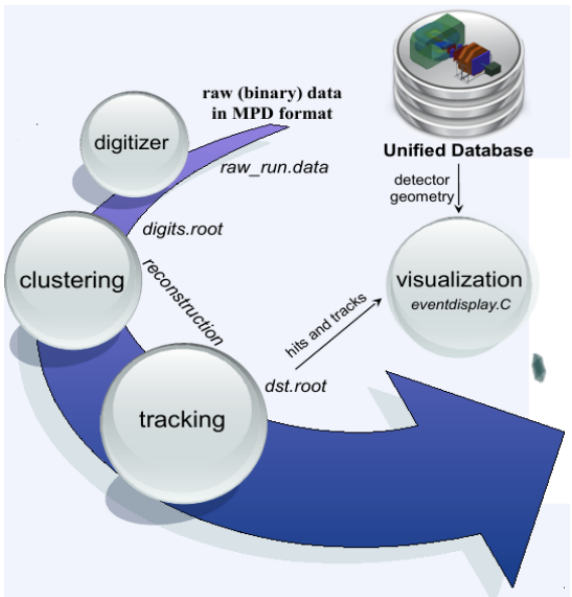


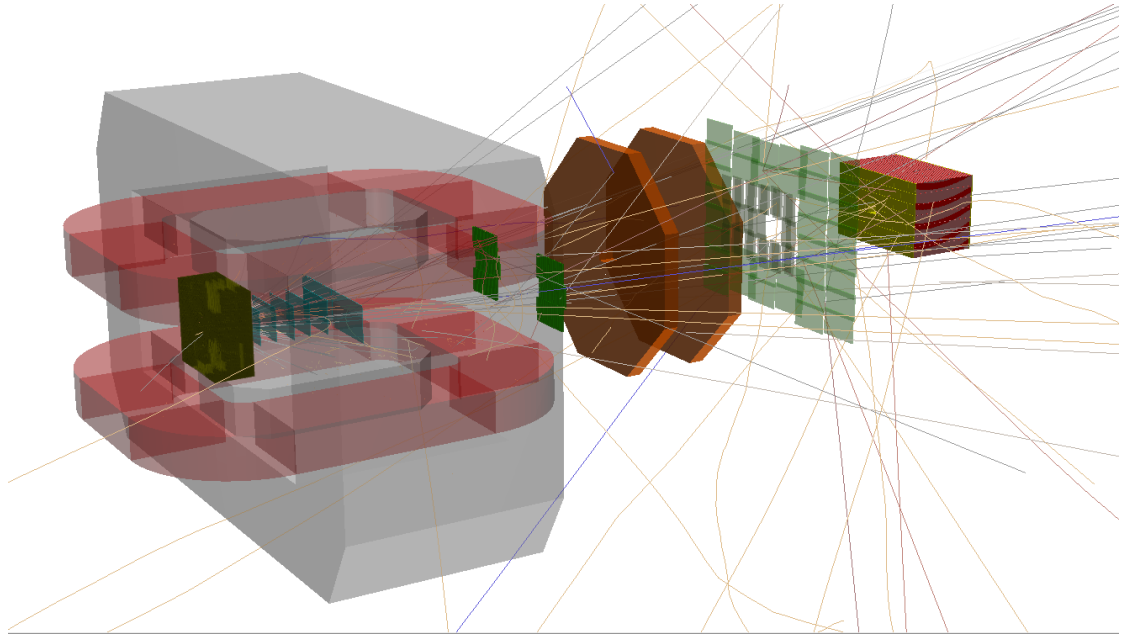


Data processing for offline Event Display

Sim & Reco





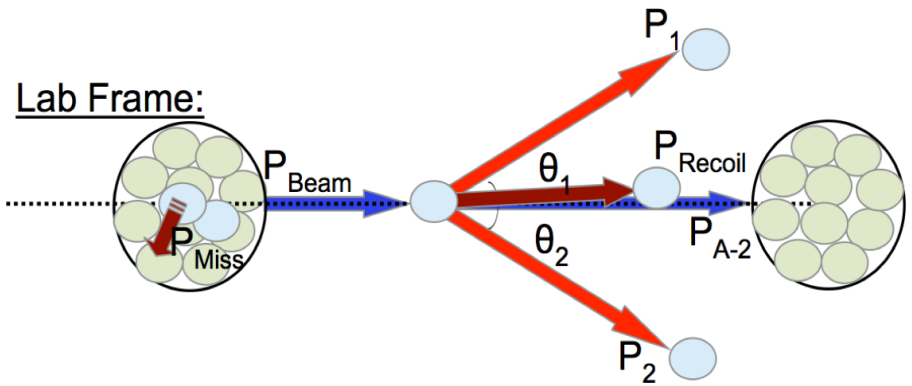


- **The Event Display has been developed for graphical representations of the NICA experiments in offline as well as online mode and integrated into the BmnRoot software.**
- **The visualization system gives an opportunity to visually check the developed algorithms for reconstruction and physical analysis of data.**

Short Range Correlations (SRC) @ BM@N

How to study SRC?

Inverse kinematics



$^{12}_{6}C + p \rightarrow 2p + {}^{10}_{5}B + n$ (np SRC)

$^{12}_{6}C + p \rightarrow 2p + {}^{10}_{4}Be + p$ (pp SRC)

Super exclusive measurement!

Four particles detected:

- scattered probe
- knocked-out nucleon
- recoil
- (A-2)-fragment system

Participants

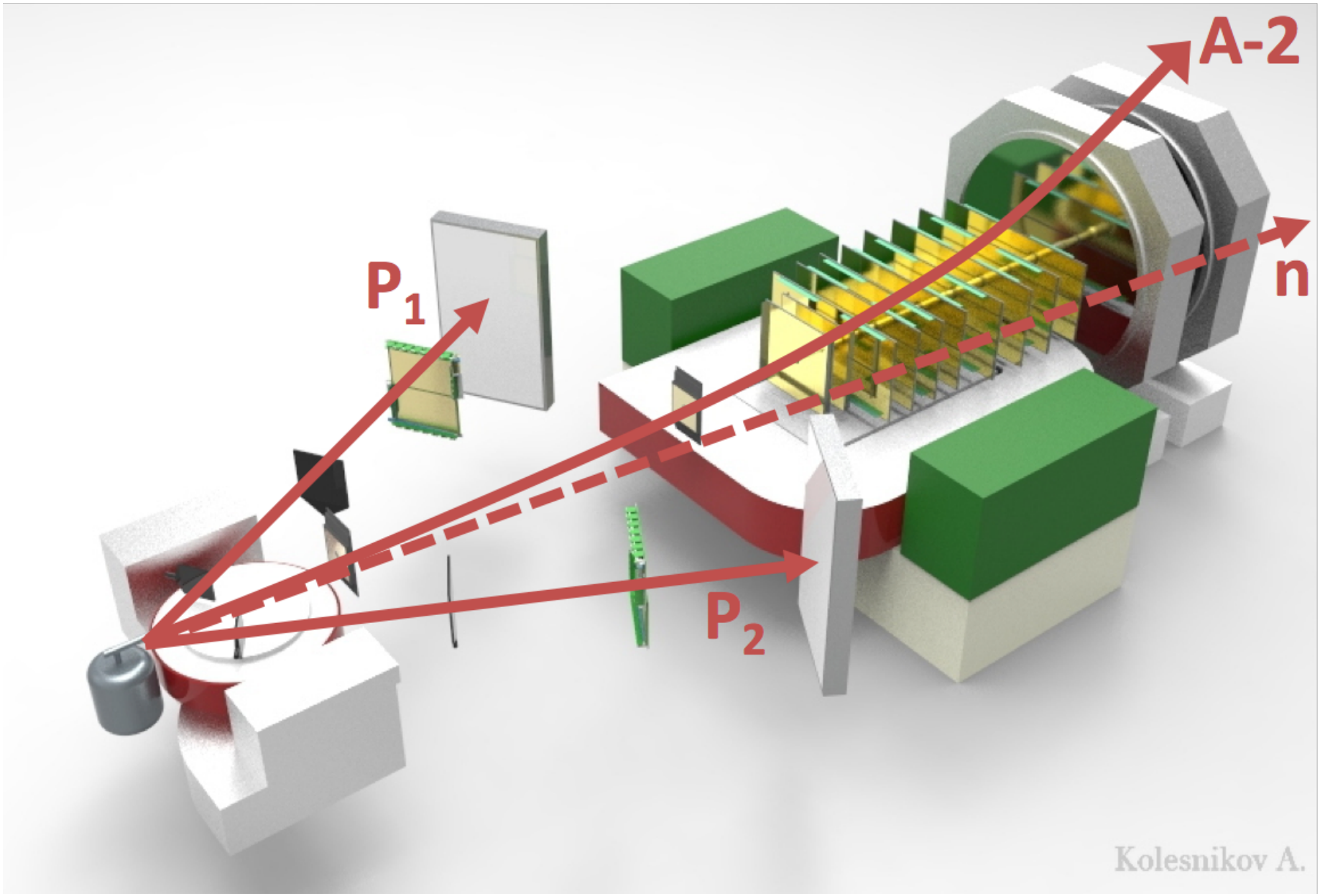
- JINR: BM@N
- Israel: Tel Aviv University
- Germany: TUD and GSI
- USA: MIT
- France: CEA

Objectives

- identifying 2N-SRC events with inverse kinematics
- studying isospin decomposition of 2N-SRC
- studying (A-2) spectator nuclear system

First BM@N SRC program run in March 2018: ~ 30 MEvents collected

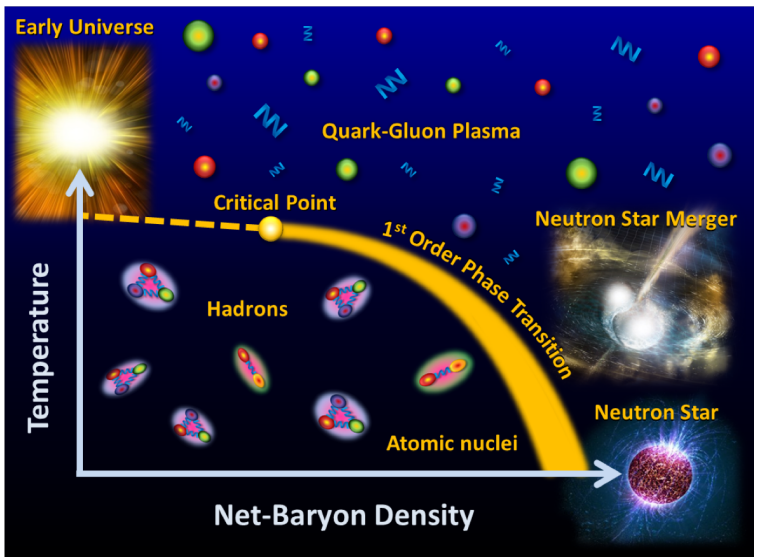
Experimental setup



Thank you for you attention!

NICA energy region:

- Maximum in K^+/π^+-ratio
- Maximum in Λ/π-ratio
- Maximum in the net-baryon density
- Transition from a Baryon dominated system to a Meson dominated one



- The construction of accelerator complex and both detectors BM@N & MPD are going close to the schedule
- NICA got a recognition as a part of European research infrastructure
- You are kindly invited to join the BM@N or/and MPD Collaborations