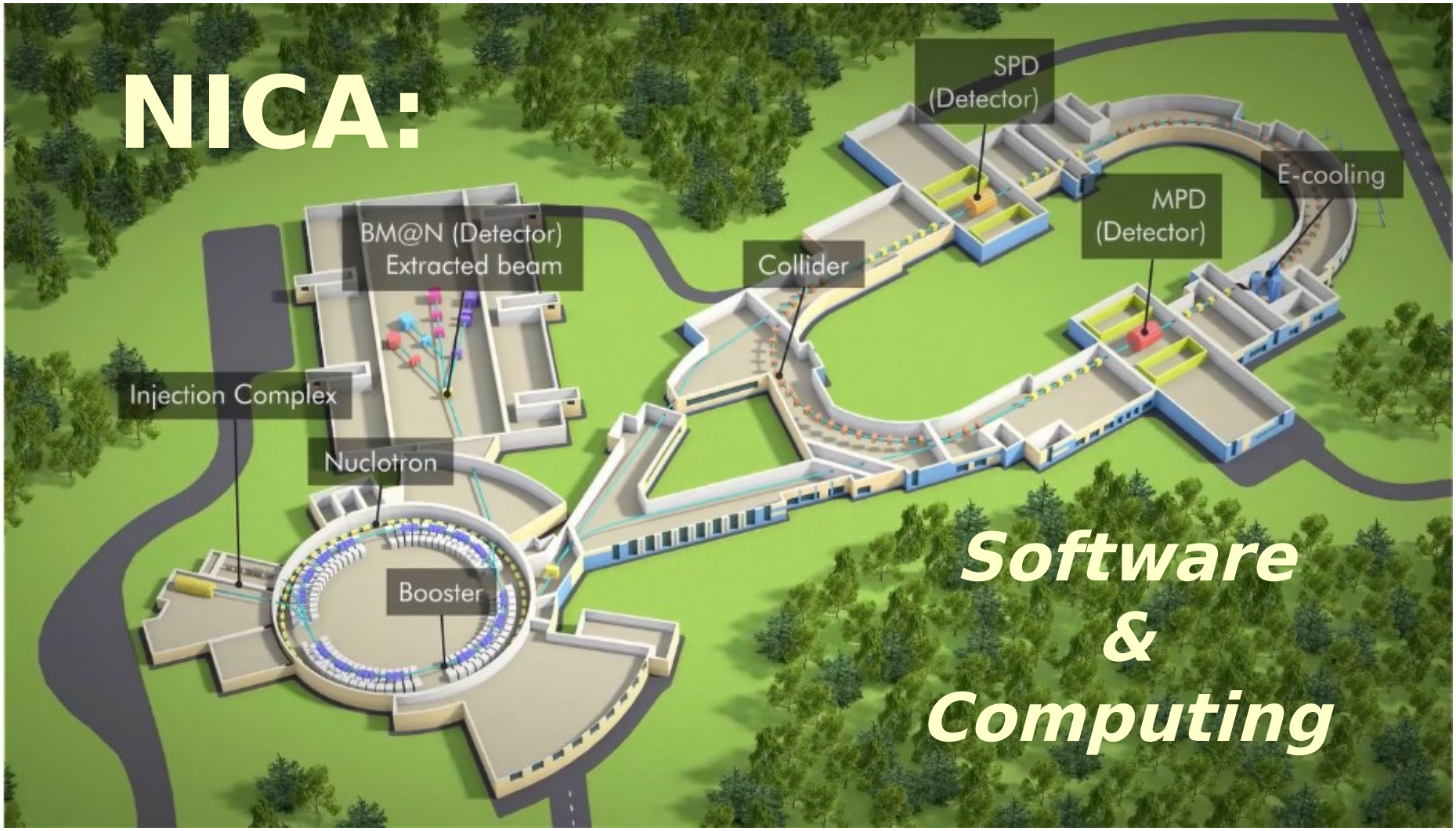
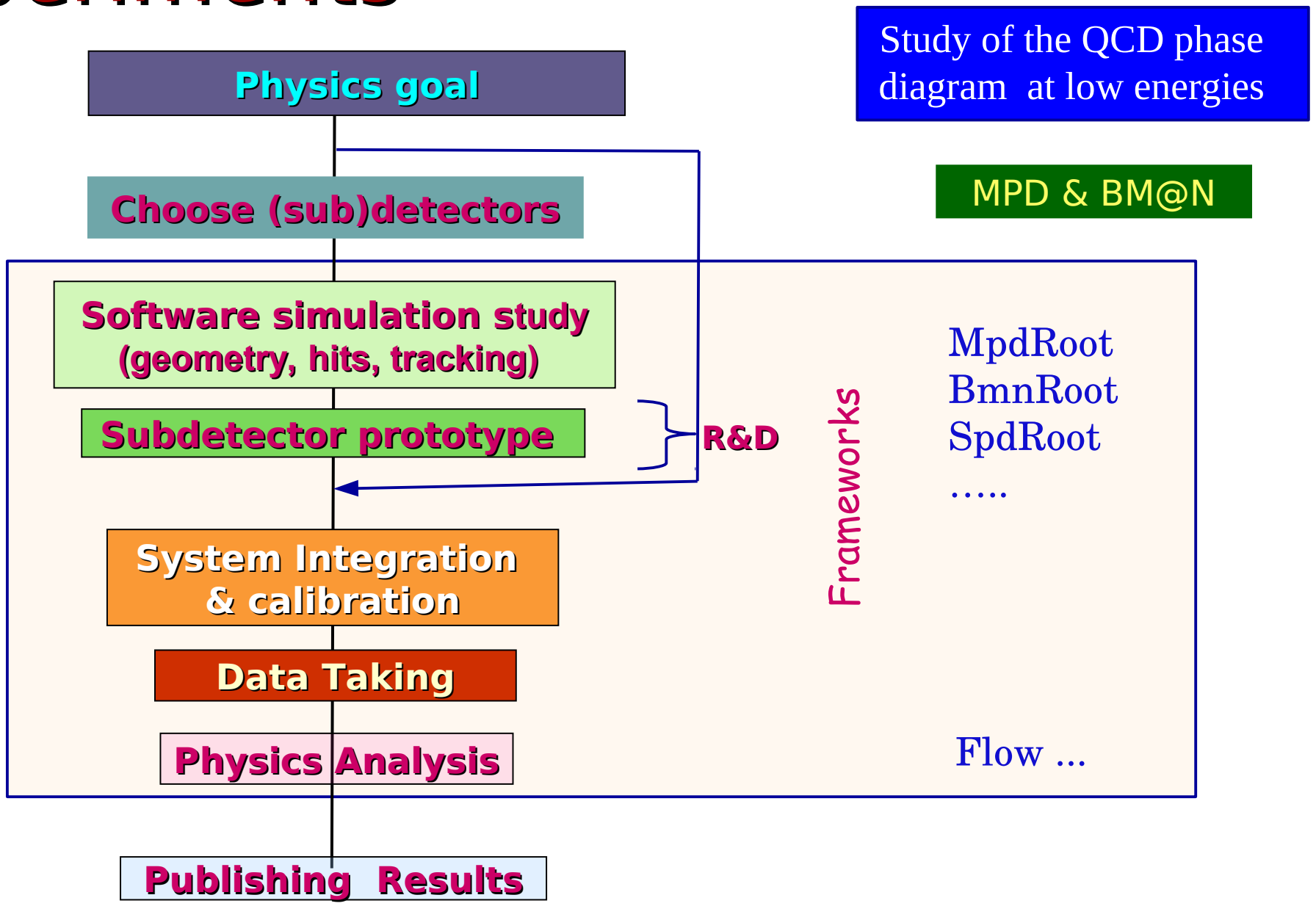


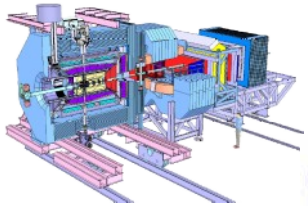
ROGACHEVSKY Oleg
for MPD & BM@N collaboration

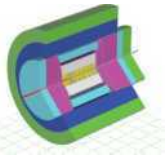
GRID -2018
September 13 2018
Dubna

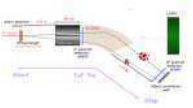
Global sketch of the HEP experiments

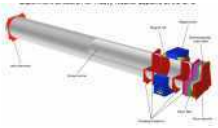


FairRoot based frameworks









Start testing the VMC concept for CBM

Panda decided to join

FairRoot: same Base package for different experiments

R3B joined

EIC (Electron Ion Collider BNL)

EICRoot

SOFIA (Studies On Fission with Aladin)

SHIP - Search for HIdden Particles

SPDRoot

2004 2006 2010 2011 2012 2013 2014 2015 2016 2017 2018

First Release of CbmRoot

MPD (NICA) start also using FairRoot

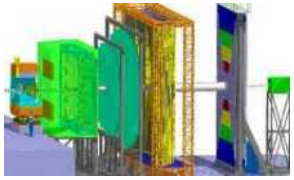
ASYEOS joined (ASYEOSRoot)

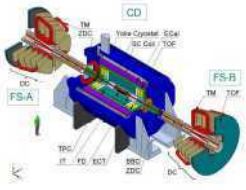
GEM-TPC seperated from PANDA branch (FOPIRoot)

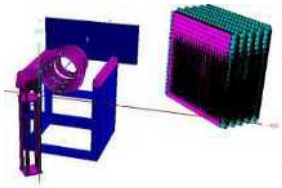
ENSAR-ROOT

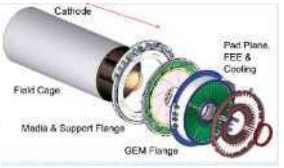
Collection of modules used by structural nuclear phsyics exp.

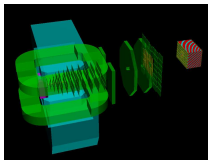
BMNRoot





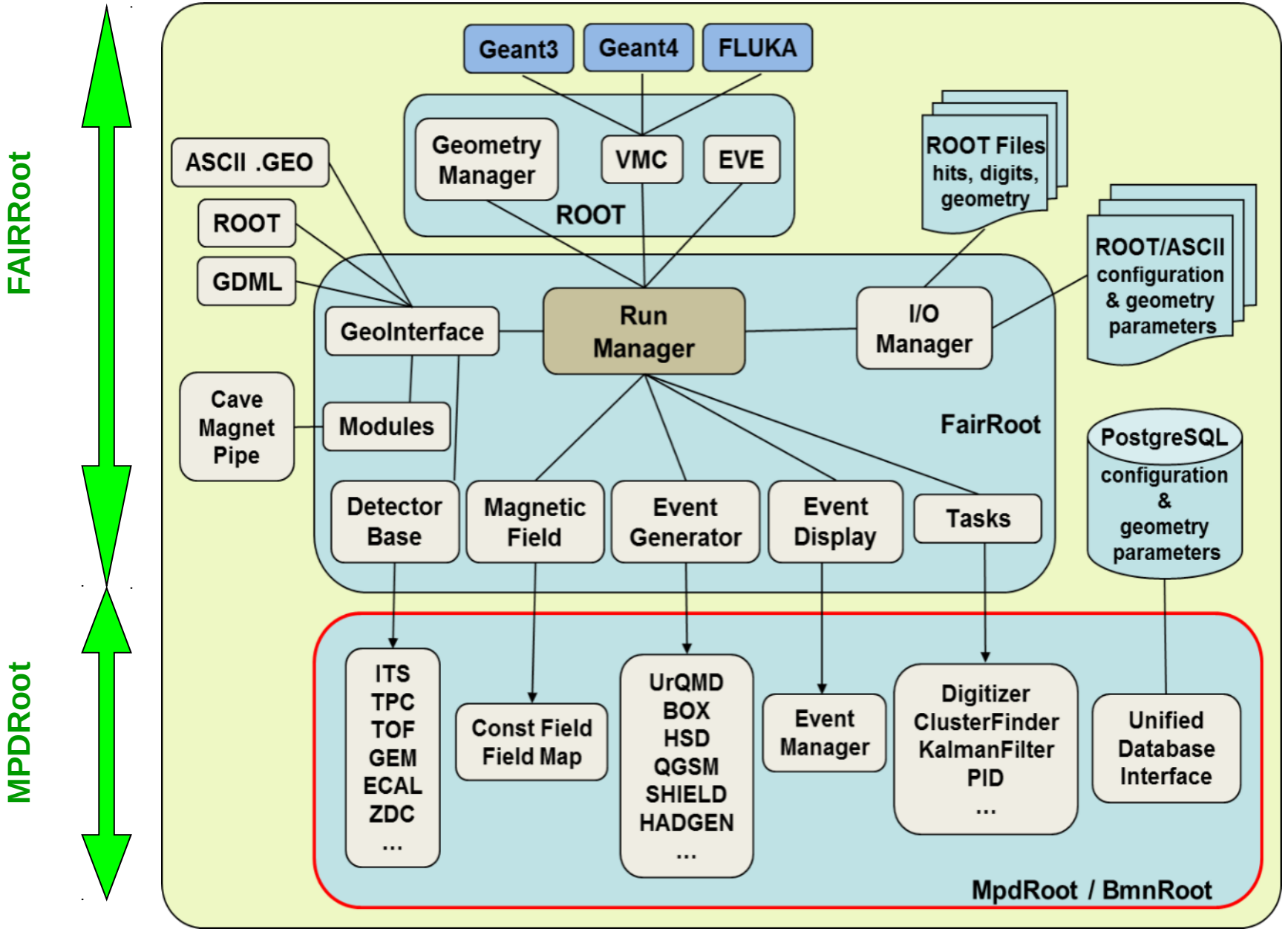




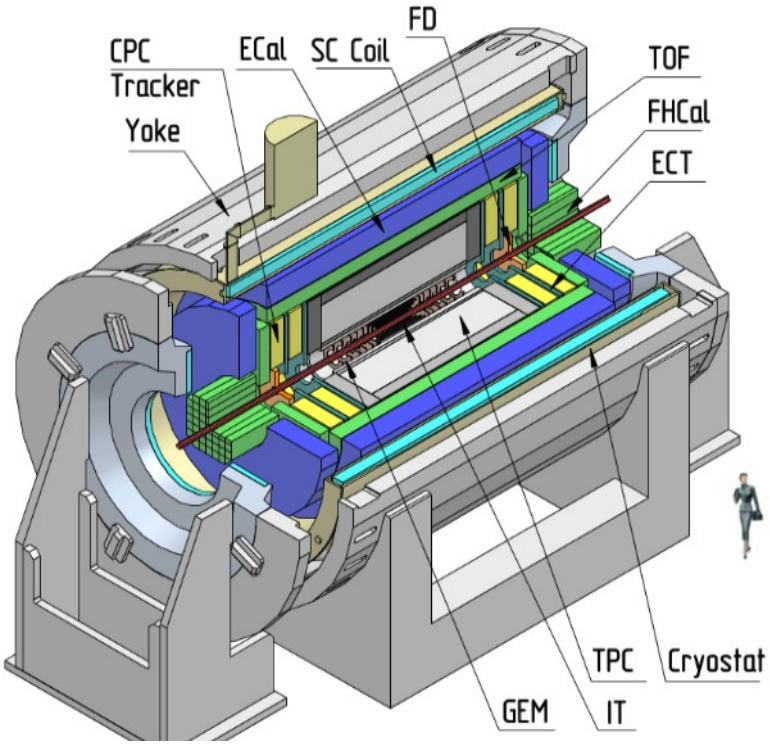


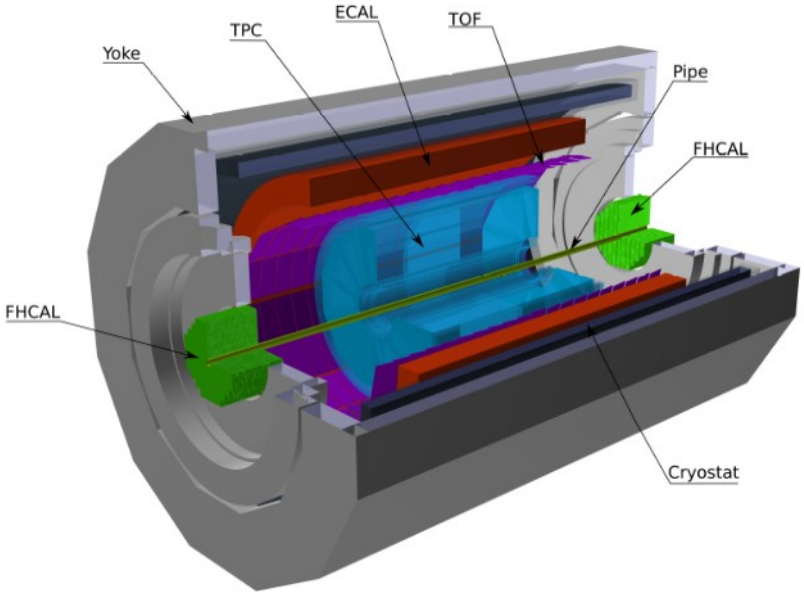
ALICE
FAIR

MPD/BMN/SPDRoot design

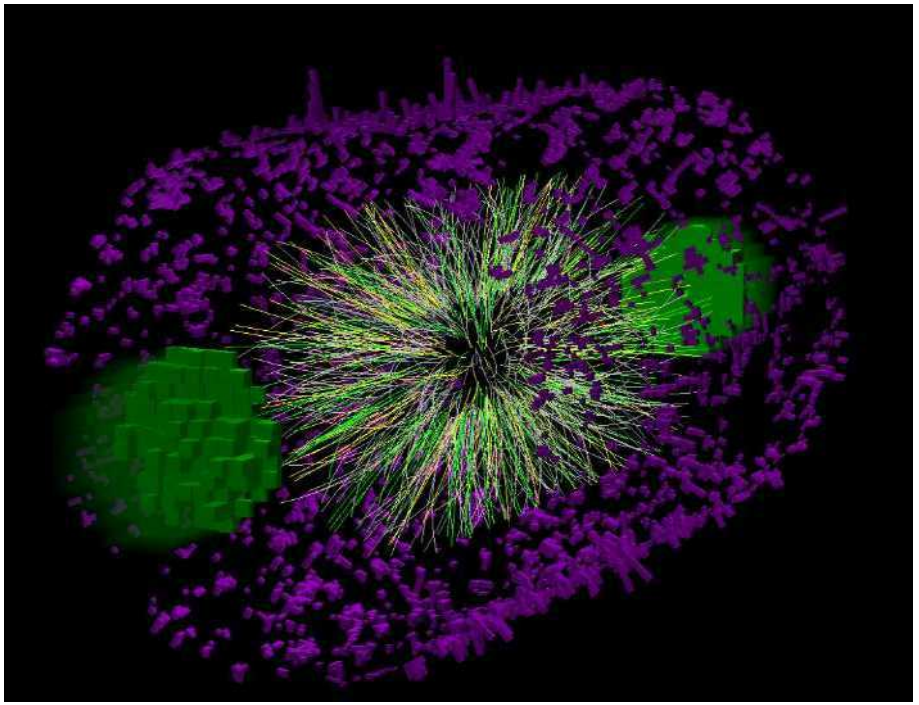


MPD experiment at NICA





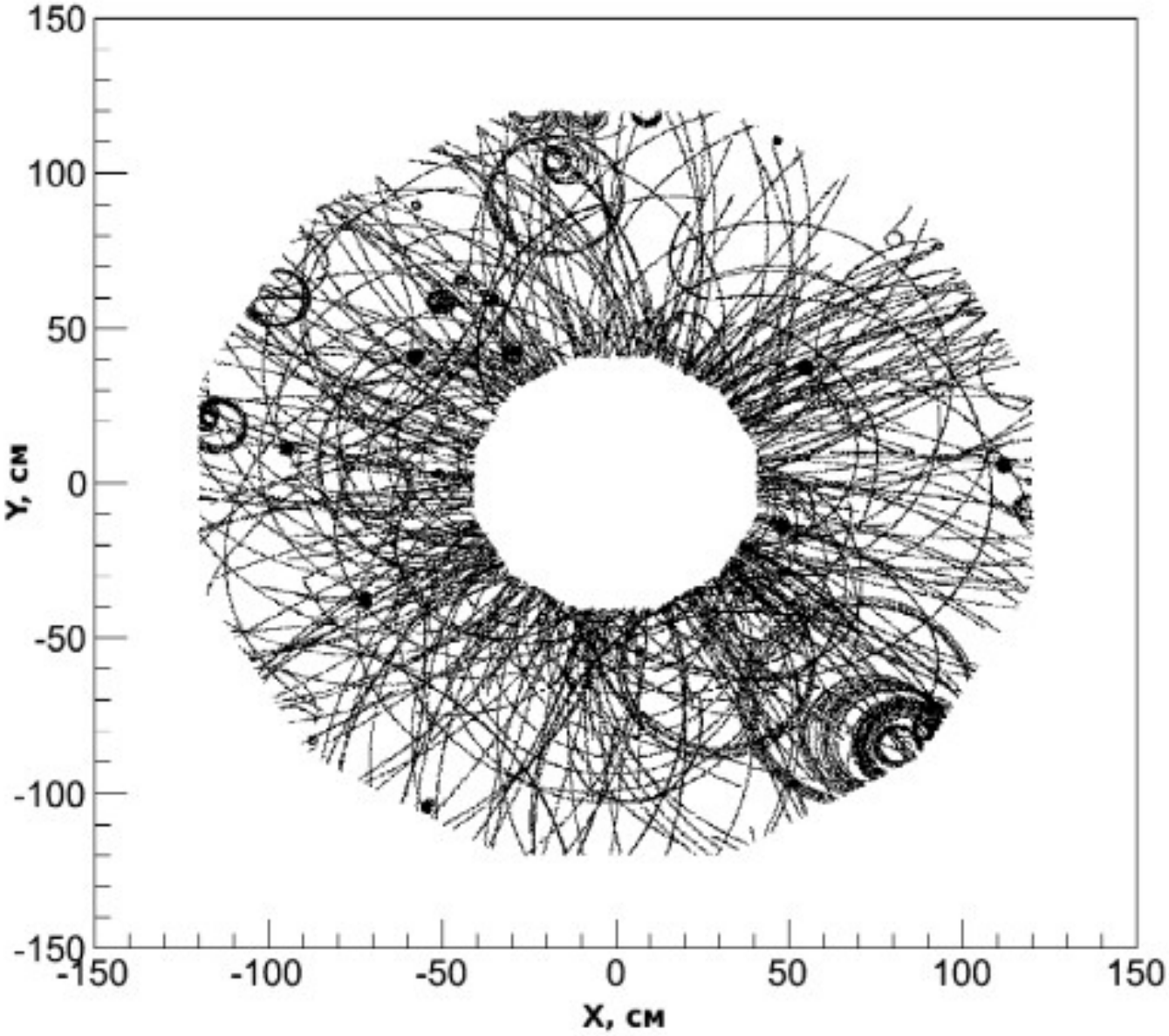
MPD event display
AuAu √s = 11 GeV



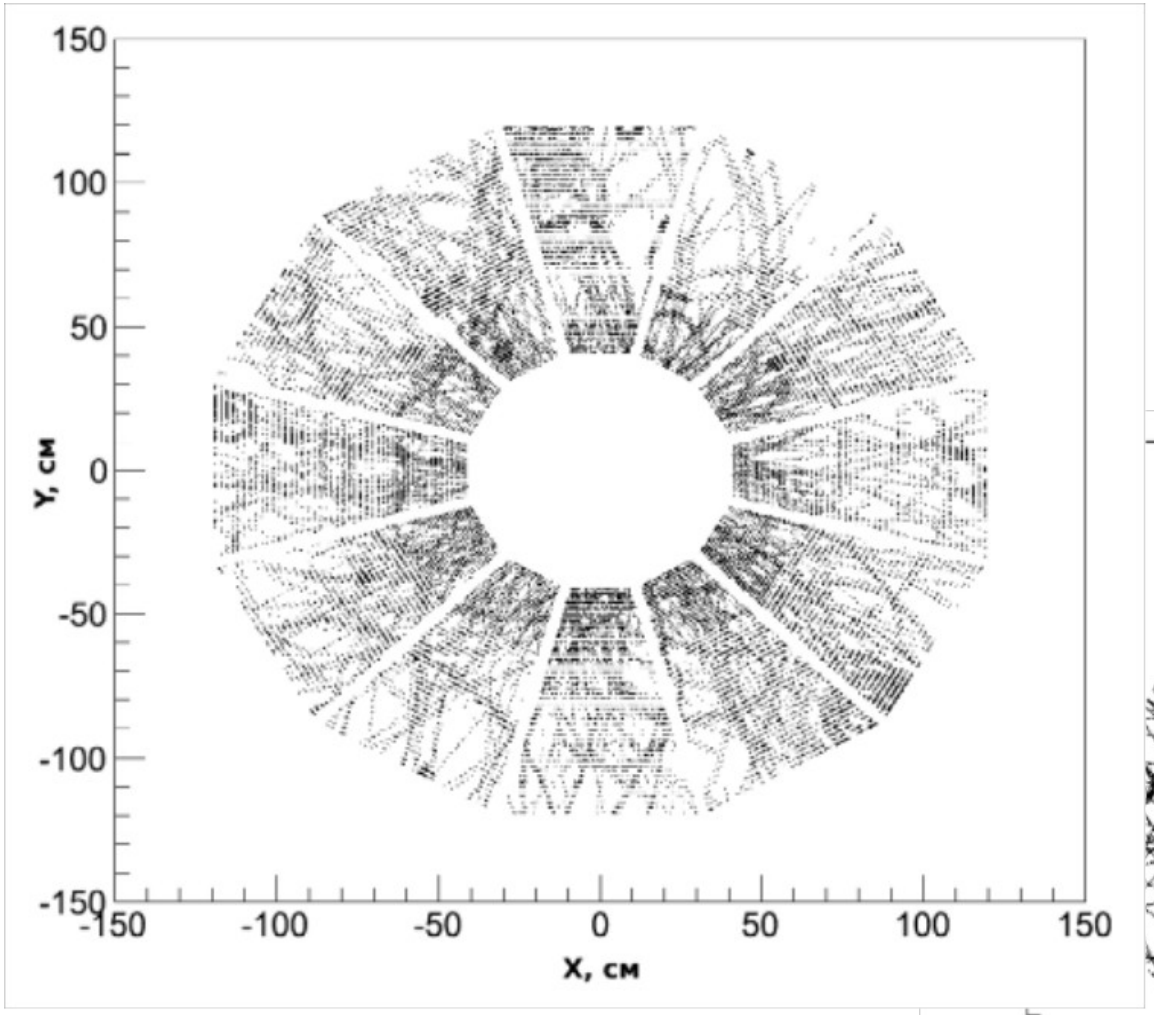
Realistic clustering in MPD TPC

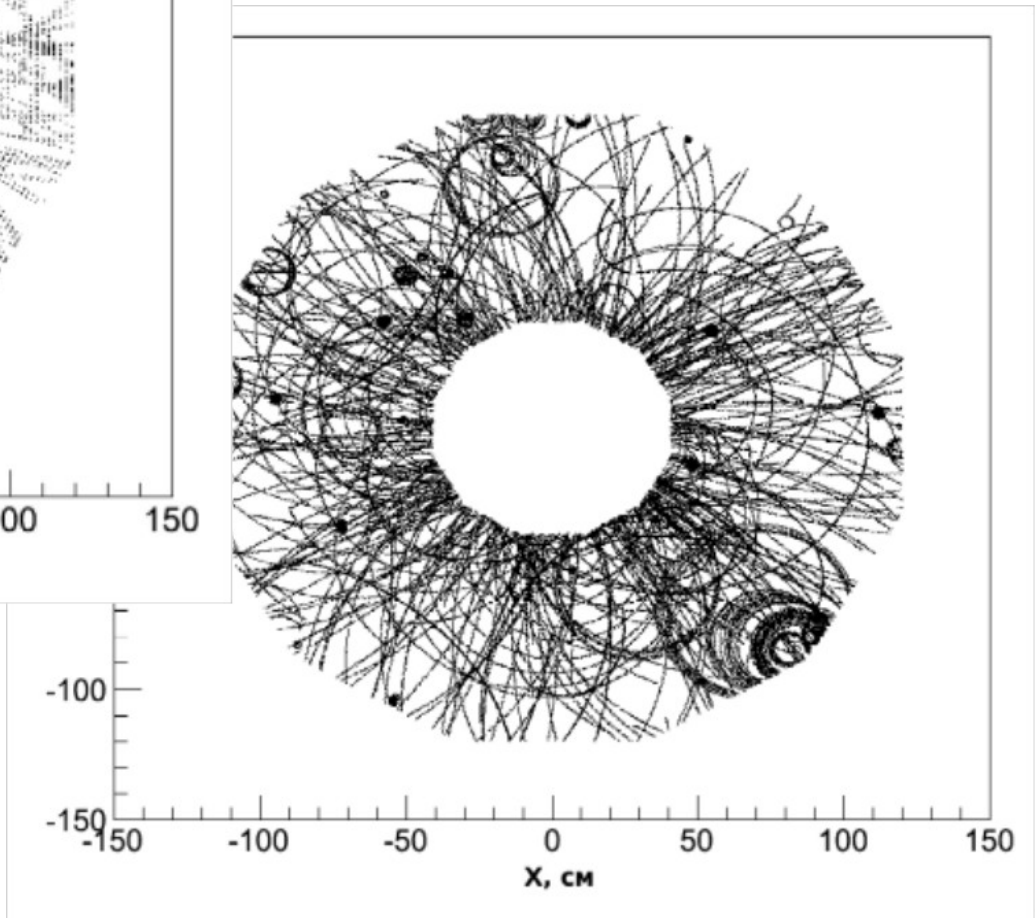
The hit reconstruction algorithm contains the following main steps:

1) Searching for extended clusters in (Pad-Time) for each pad raw.
2) Searching for peaks in time-profile for each pad in the found extended cluster.
3) Combining the neighboring peaks into resulting hits.

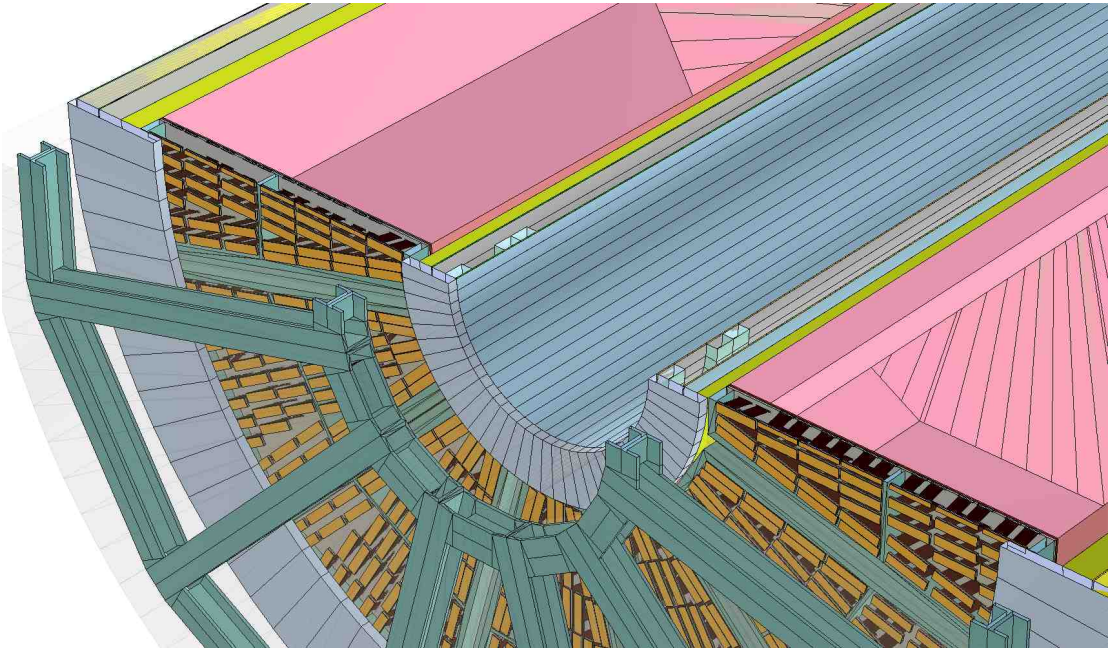


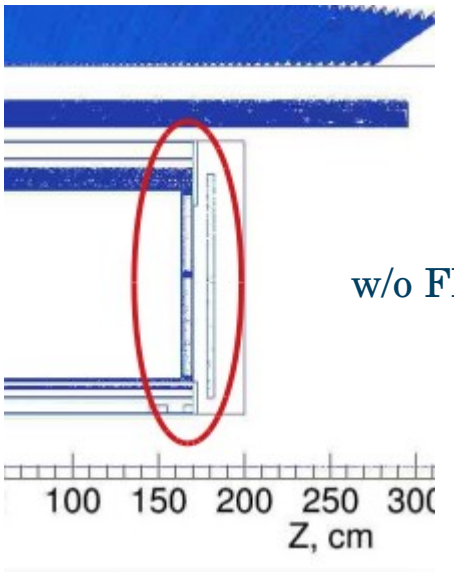
MPD TPC pad plane



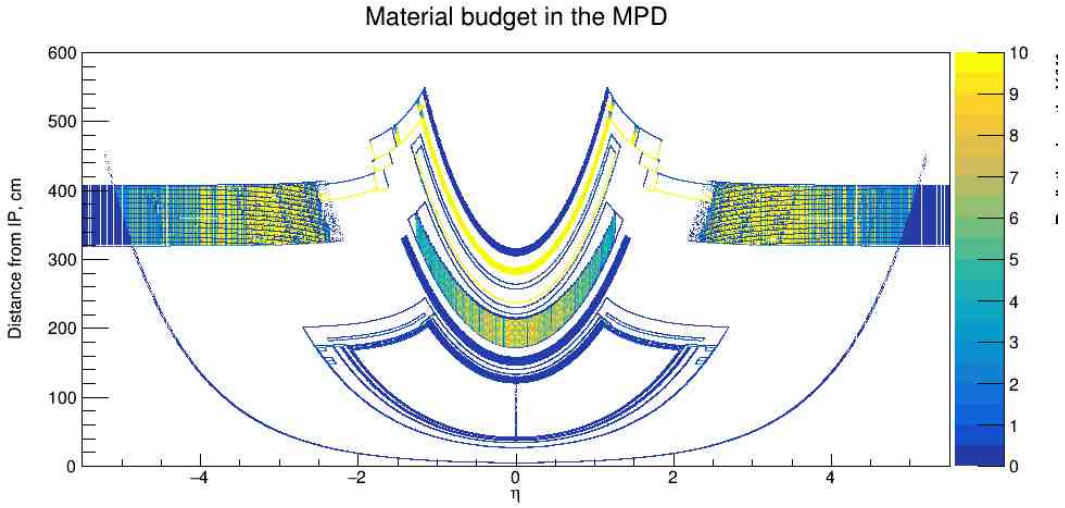


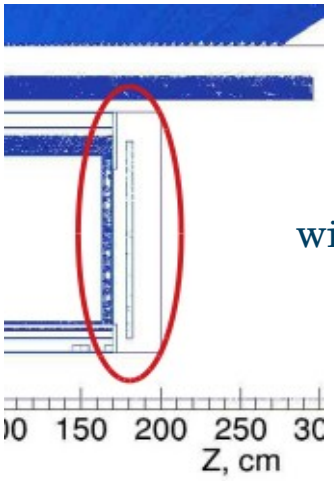
TPC endcap transparency





w/o FEE

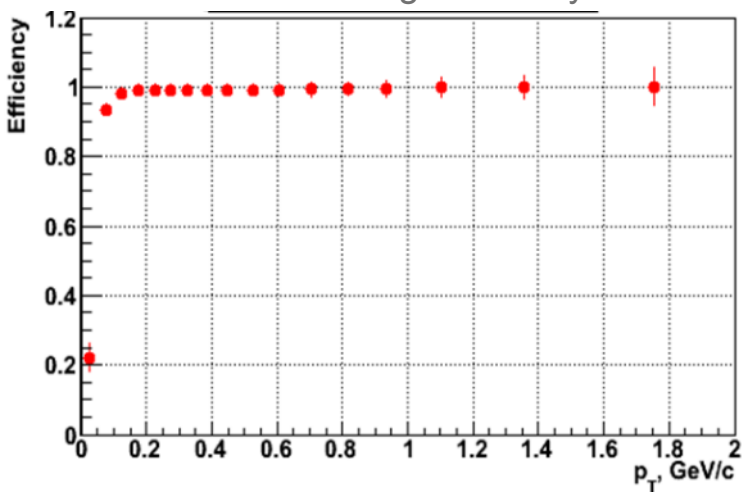




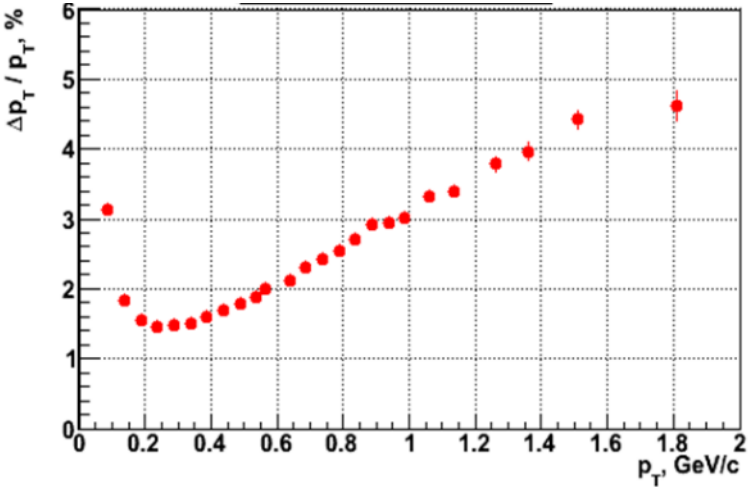
with FEE

Tracking in the MPD TPC

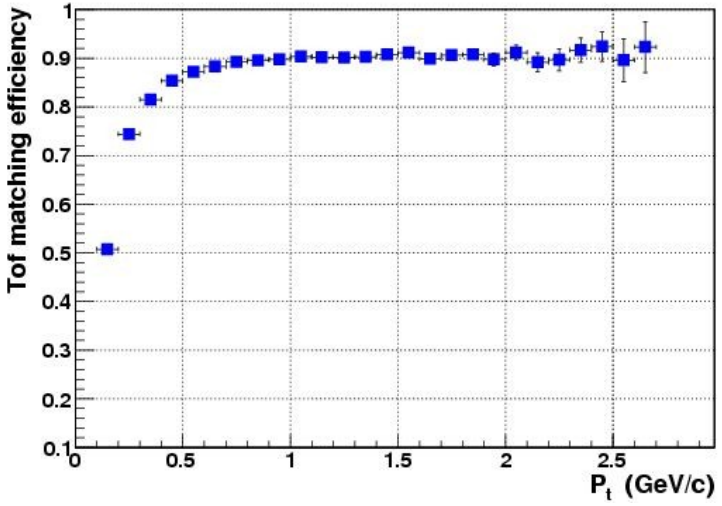
TPC tracking efficiency



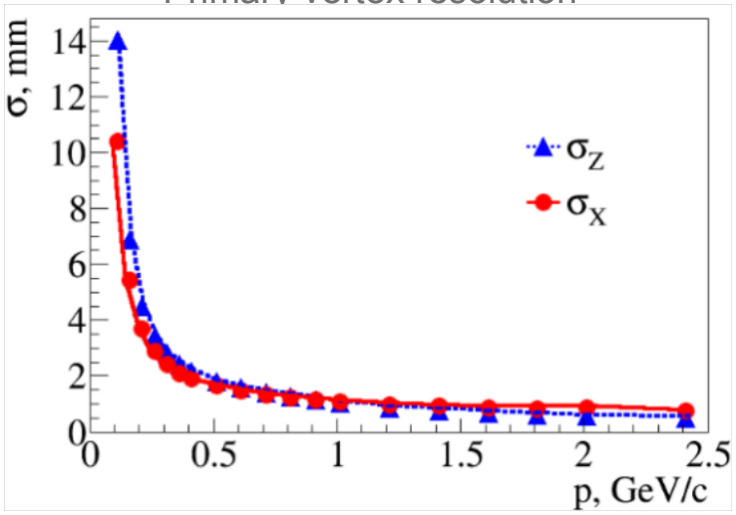
Momentum resolution



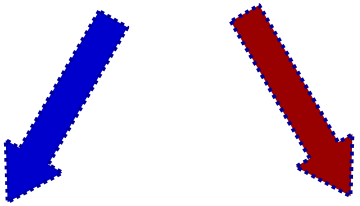
Efficiency of TOF matching



Primary vertex resolution



Software for physics analysis



MC - generators

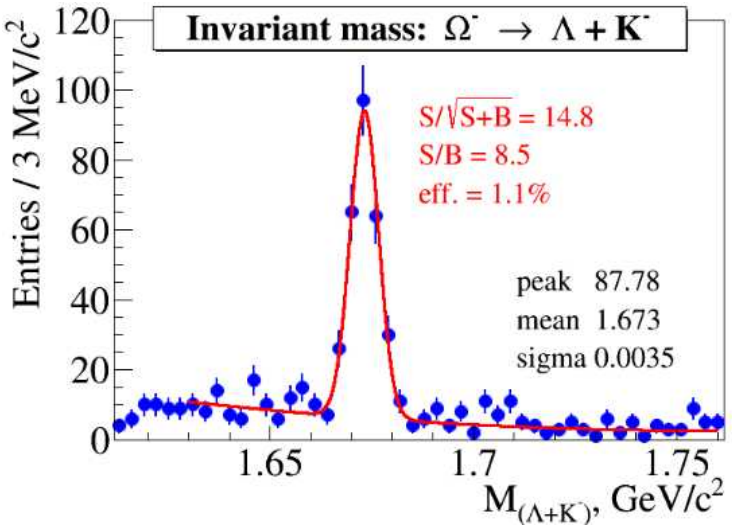
- UrQMD
- QGSM
- Hybrid UrQMD
- VHLLE
- PHSD
- THESEUS (3FD)
- …

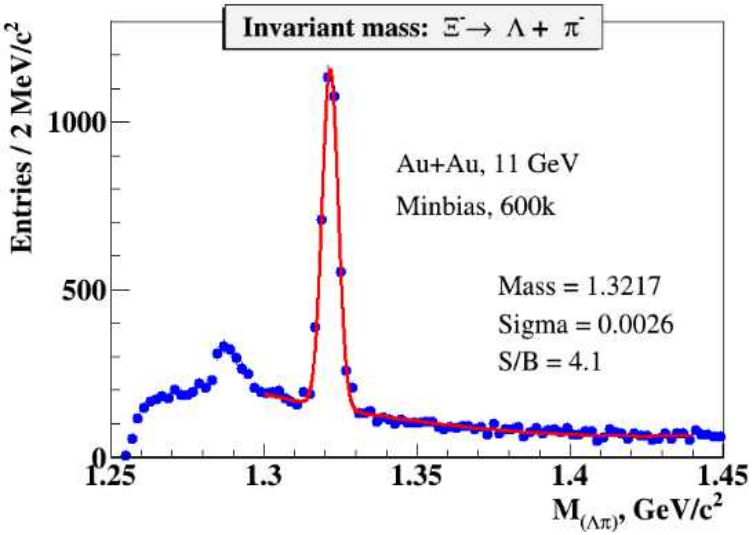
Physics analysis methods

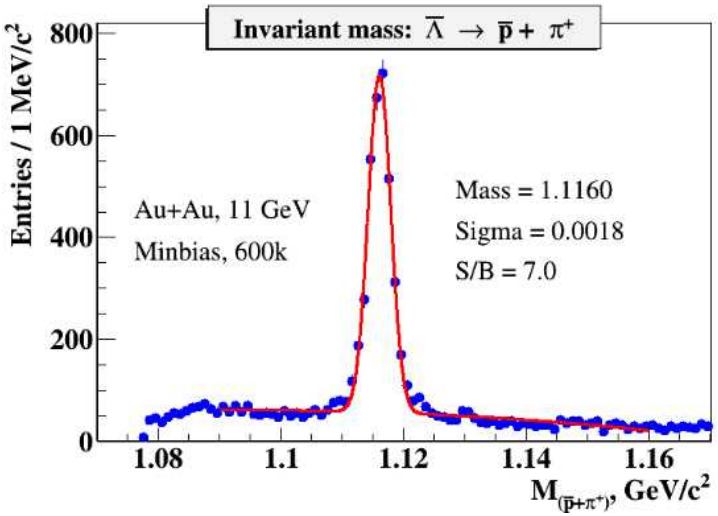
- Flow
- Femtoscopy
- Dileptons
- Stopping power
- Particles decay
- …

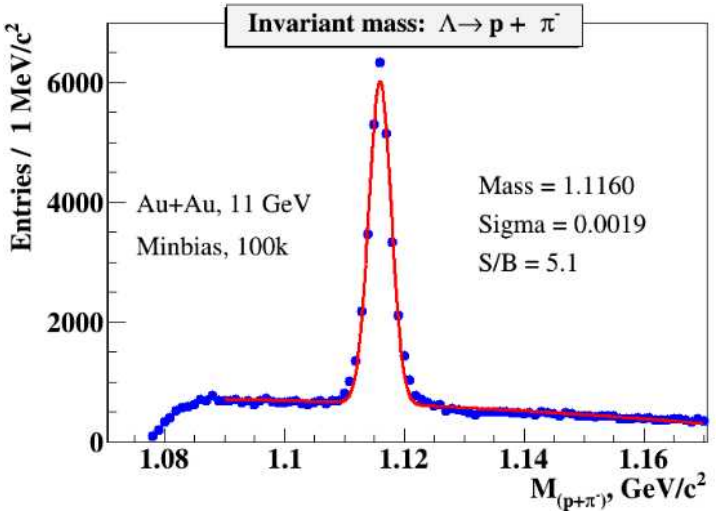
Strange and multi-strange baryons

Stage'1 (TPC+TOF): Au+Au @ 11 GeV, UrQMD



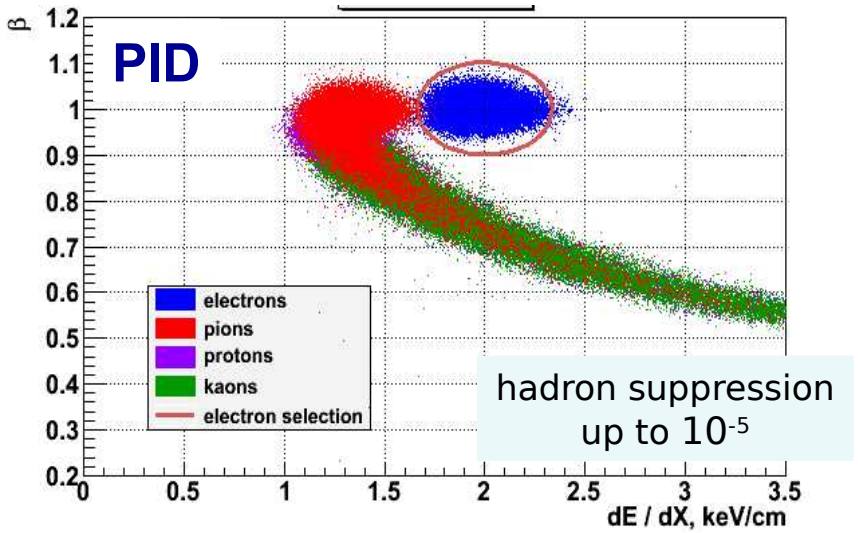




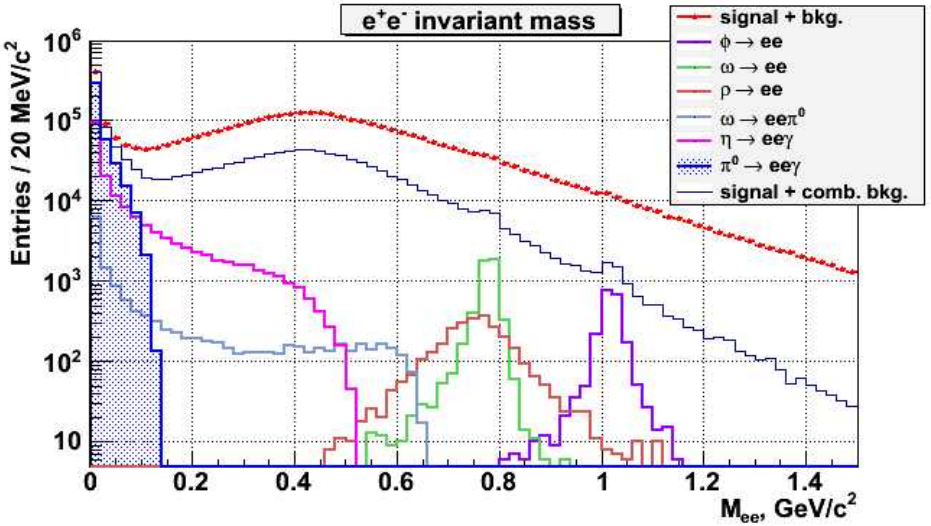


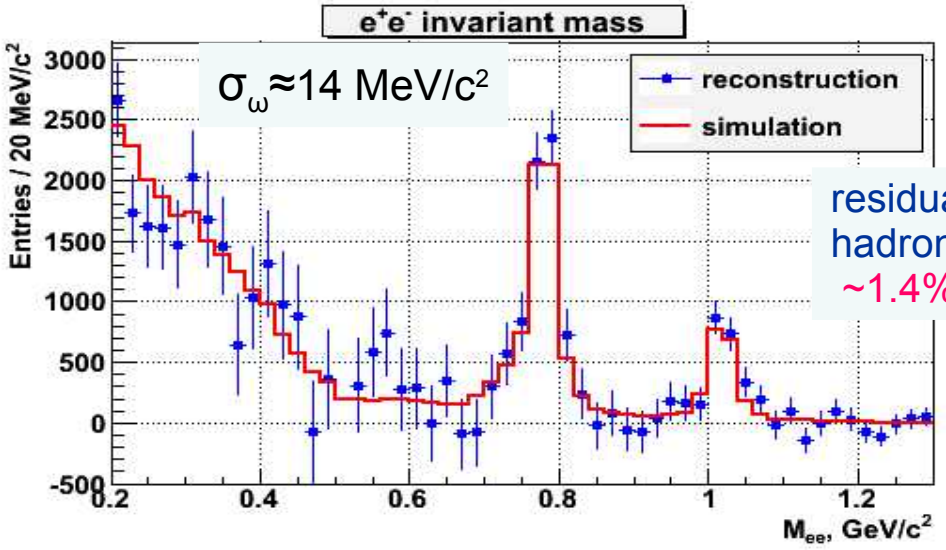
Dilepton study

- **Event generator:** *UrQMD+Pluto (for the cocktail) central Au+Au @ 8 GeV*
- **PID**: *dE/dx (from TPC) + TOF (s ~100 ps) + ECAL*

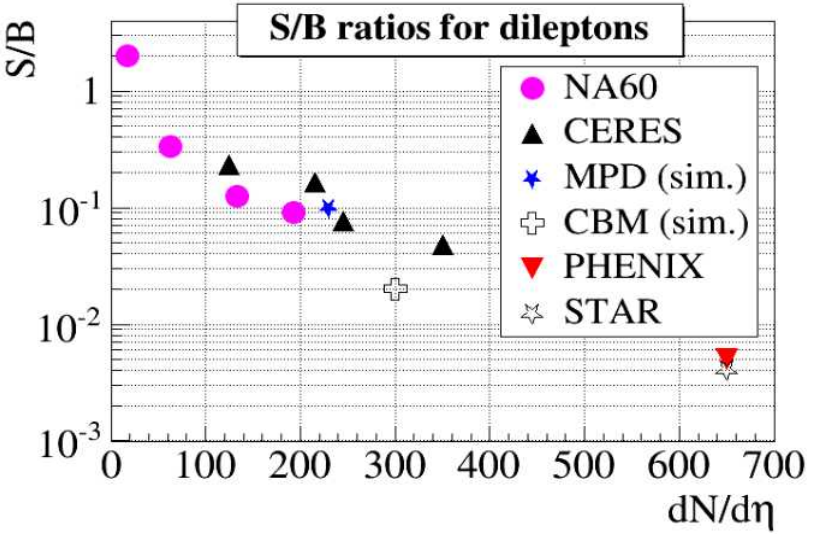


hadron suppression up to 10^{-5}





residual hadrons ~1.4%

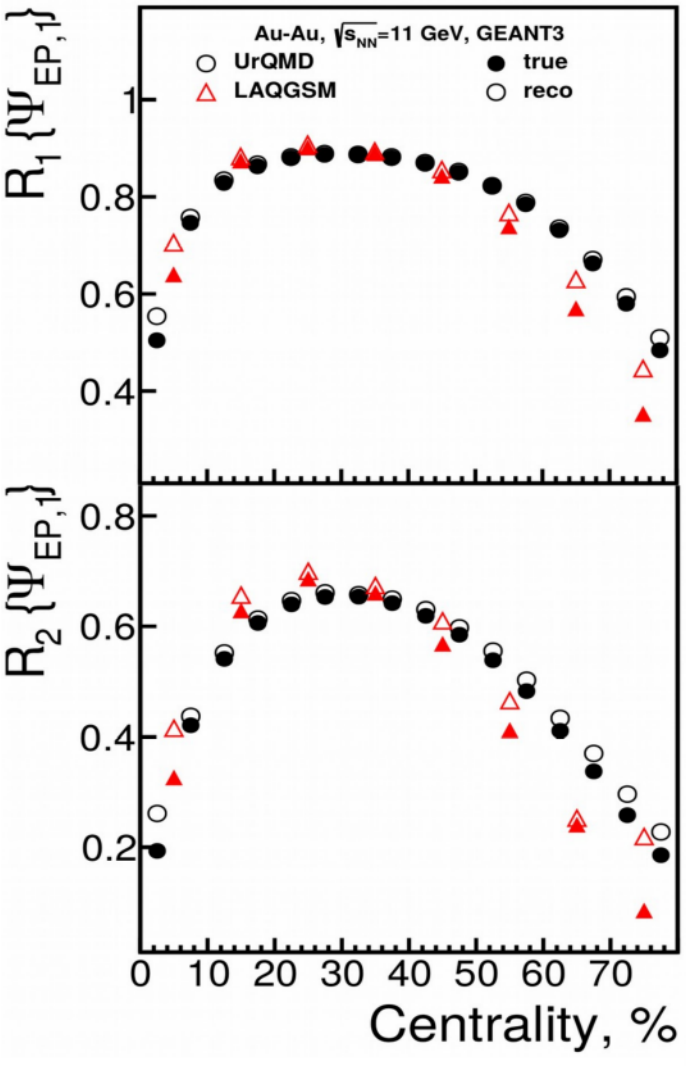


Flow performance

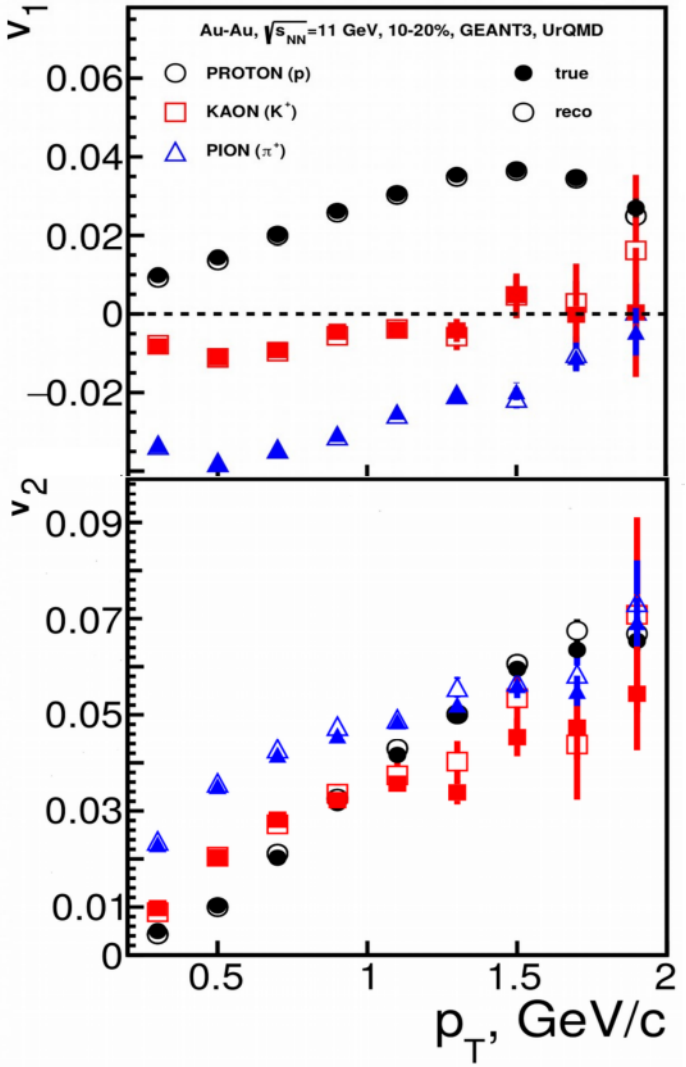
Au+Au@11 A GeV; GEANT3; UrQMD (LAQGSM), 4M events

$v_n = \{\cos[n(\phi - \Psi_{EP,1})]\} / R_n(\Psi_{EP,1})$ - azimuthal flow coefficients

event plane resolution



flow harmonics (v_1 / v_2)



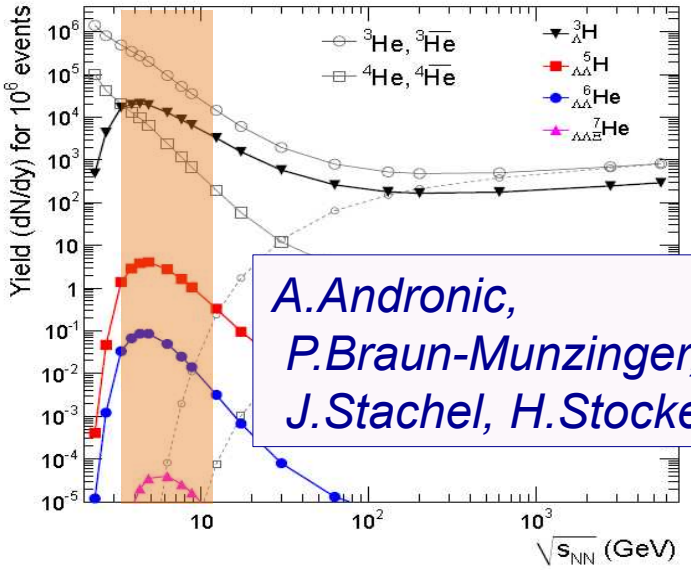
$R_n(\Psi_{EP,1})$ – resolution correction factor

ϕ - azimuthal angle of produced particle

$\Psi_{EP,1}$ – event plane angle

event plane: **FHCal**
centrality: **TPC**
PID: **TOF+TPC**

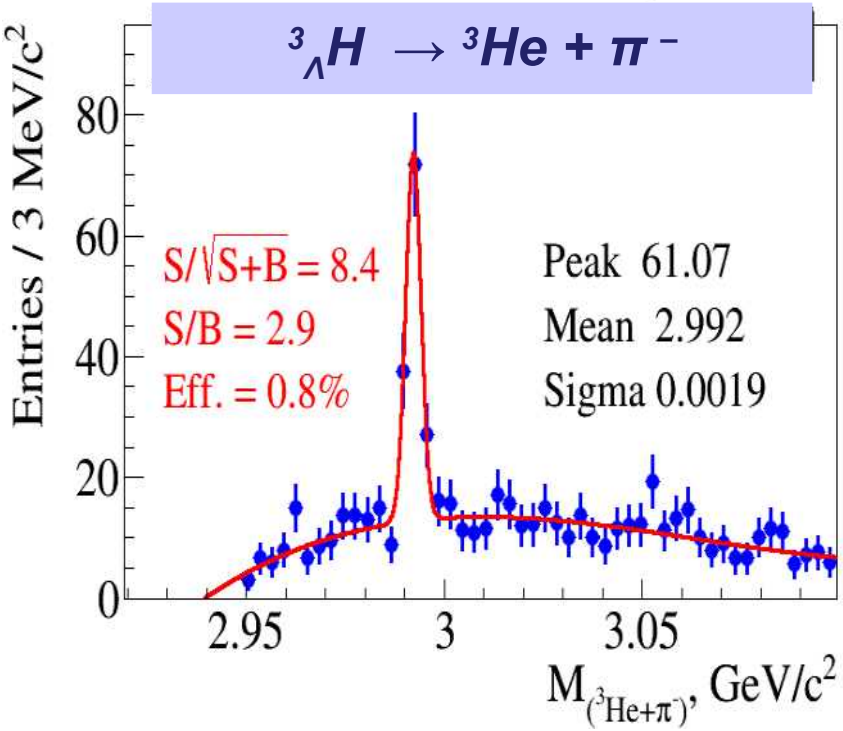
Hyper nuclei

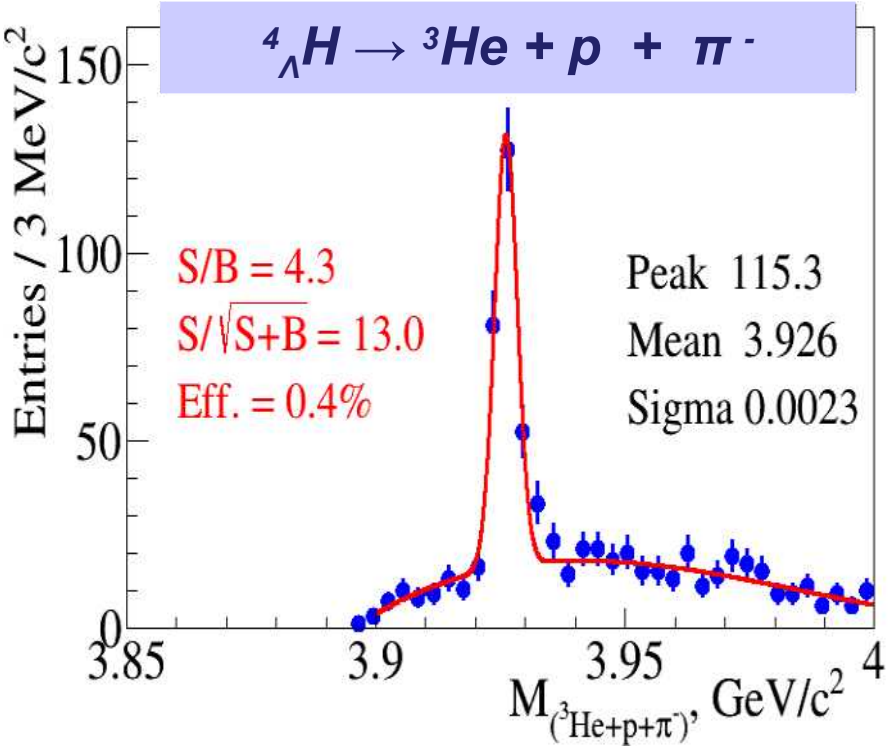


A.Andronic, P.Braun-Munzinger, J.Stachel, H.Stocker

Stage 2: *central **Au+Au** @ **5** AgeV; DCM-QGSM*

hyper nucleus	yield in 10 weeks
$^3_\Lambda$He	$9 \cdot 10^5$
$^4_\Lambda$He	$1 \cdot 10^5$



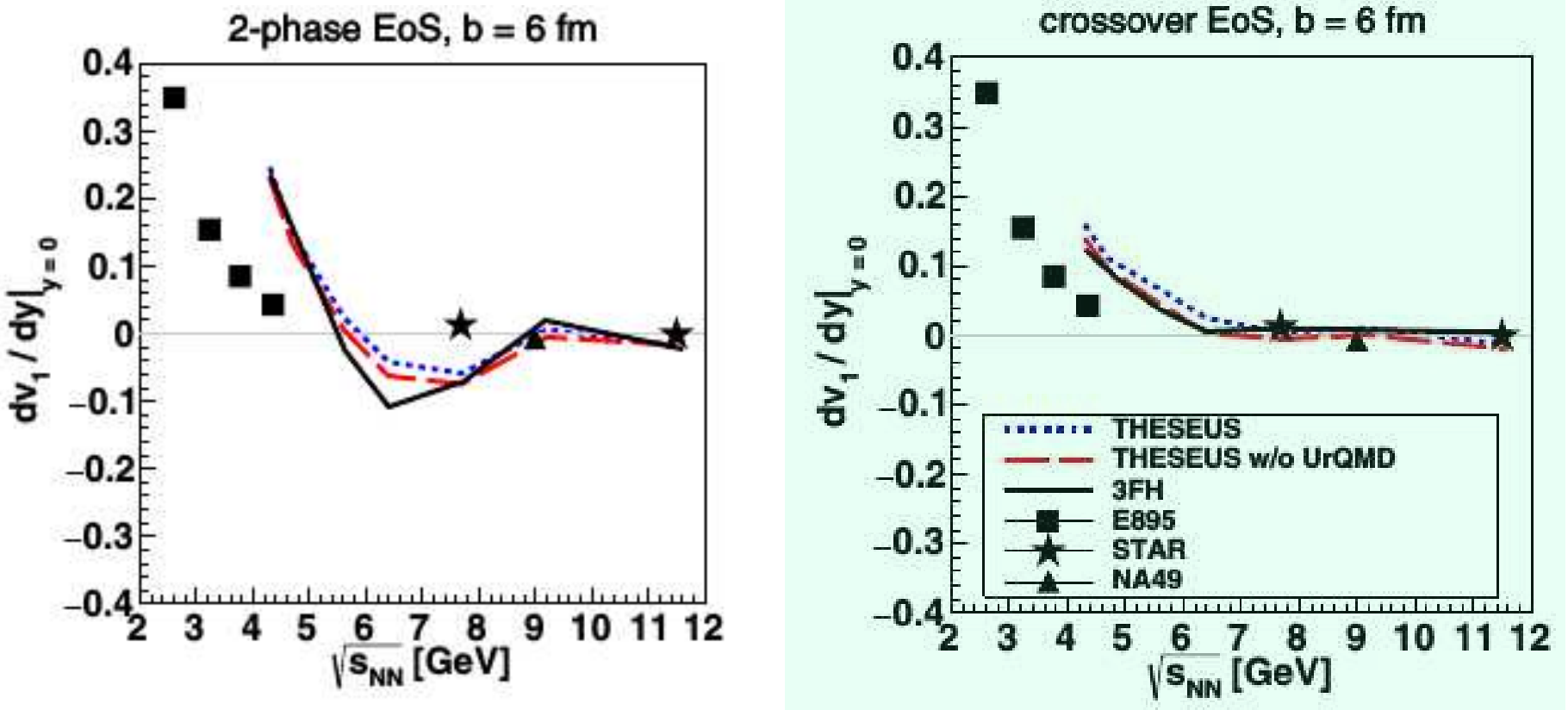


Directed flow slope

THESEUS

P. Batyuk et al. Phys. Rev. C 94, 044917 (2016)

$$v_1(y) = \langle \cos(\phi - \Psi_{RP}) \rangle = \left\langle p_x / \sqrt{p_x^2 + p_y^2} \right\rangle,$$

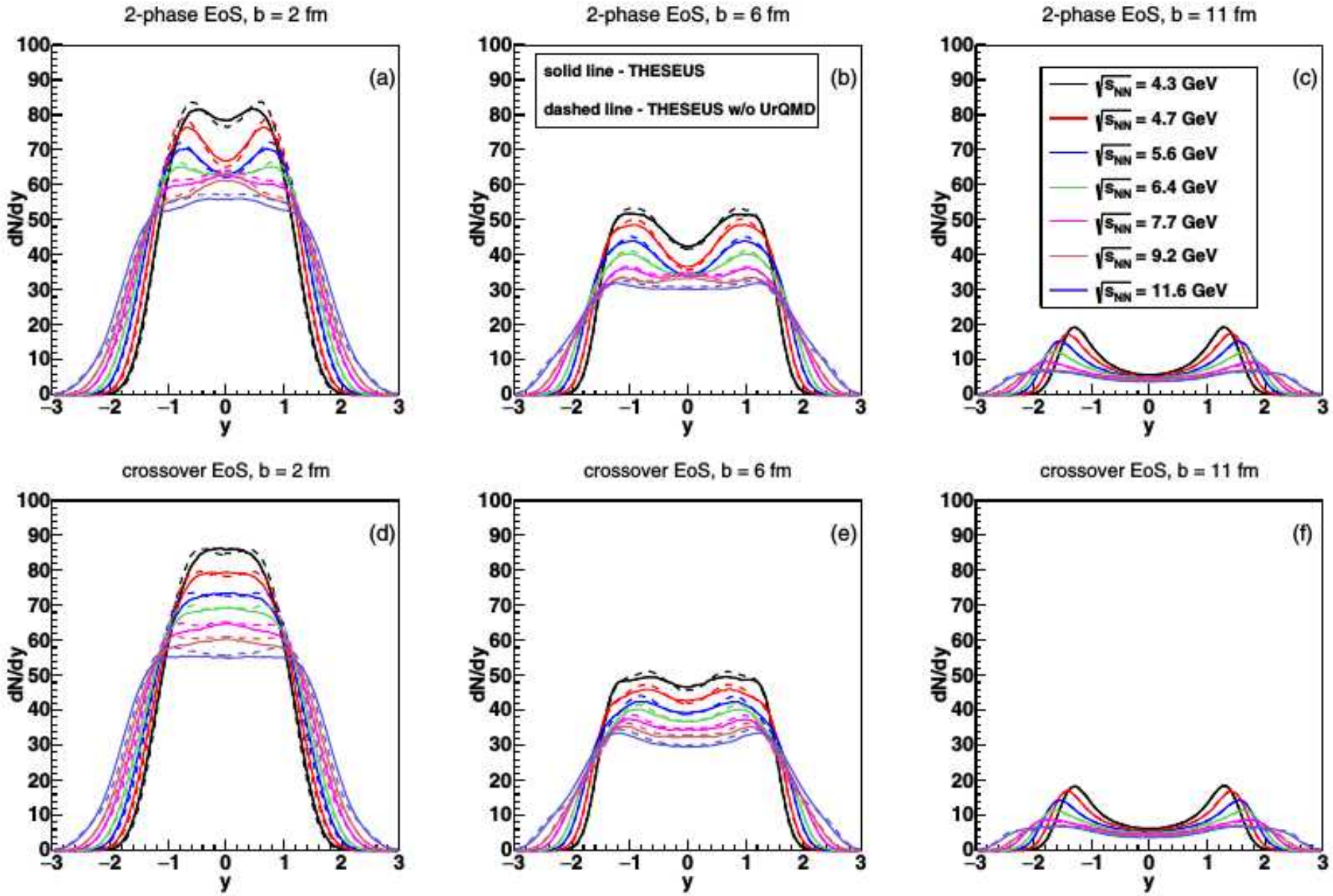


Energy scan of the slope of the directed flow (dv_1/dy) of protons for semicentral (b = 6 fm) Au+Au collisions

Proton rapidity in Theseus

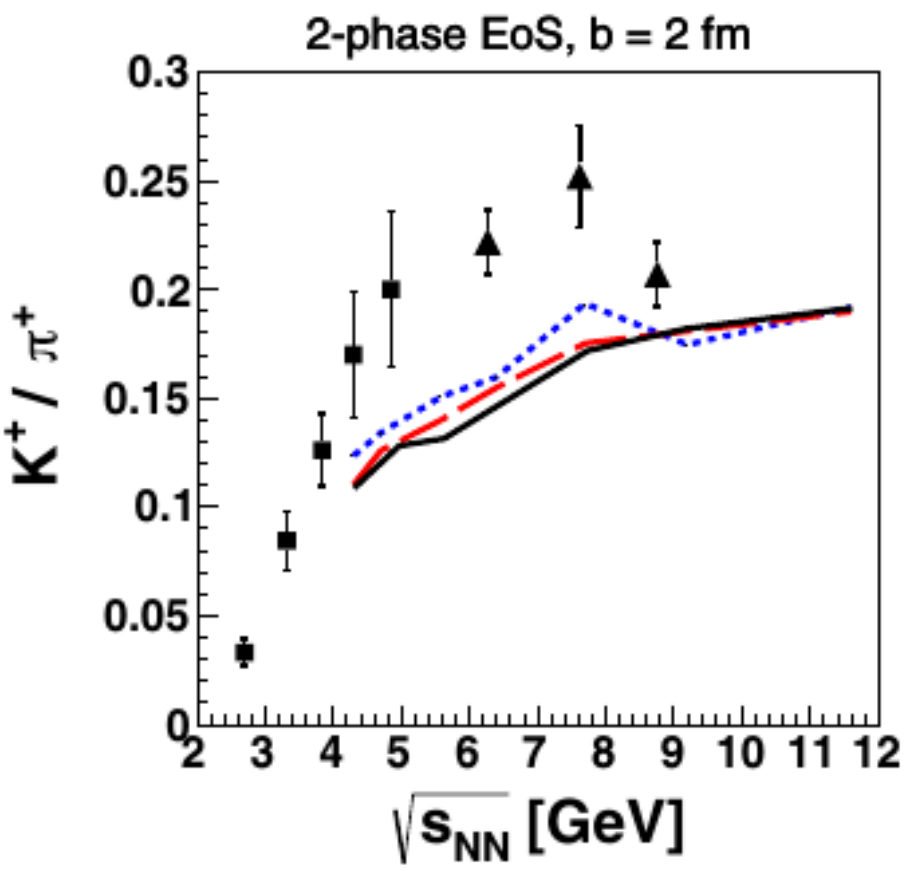
THESEUS

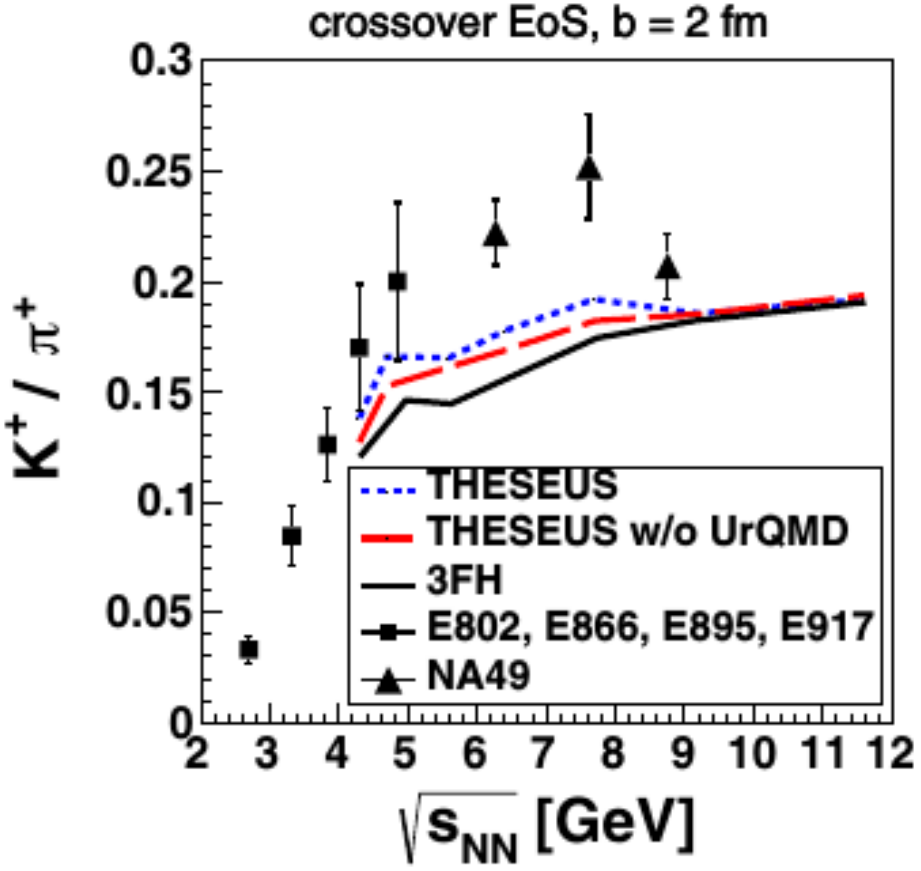
central | semicentral | peripheral



K^+/π^+ ratio

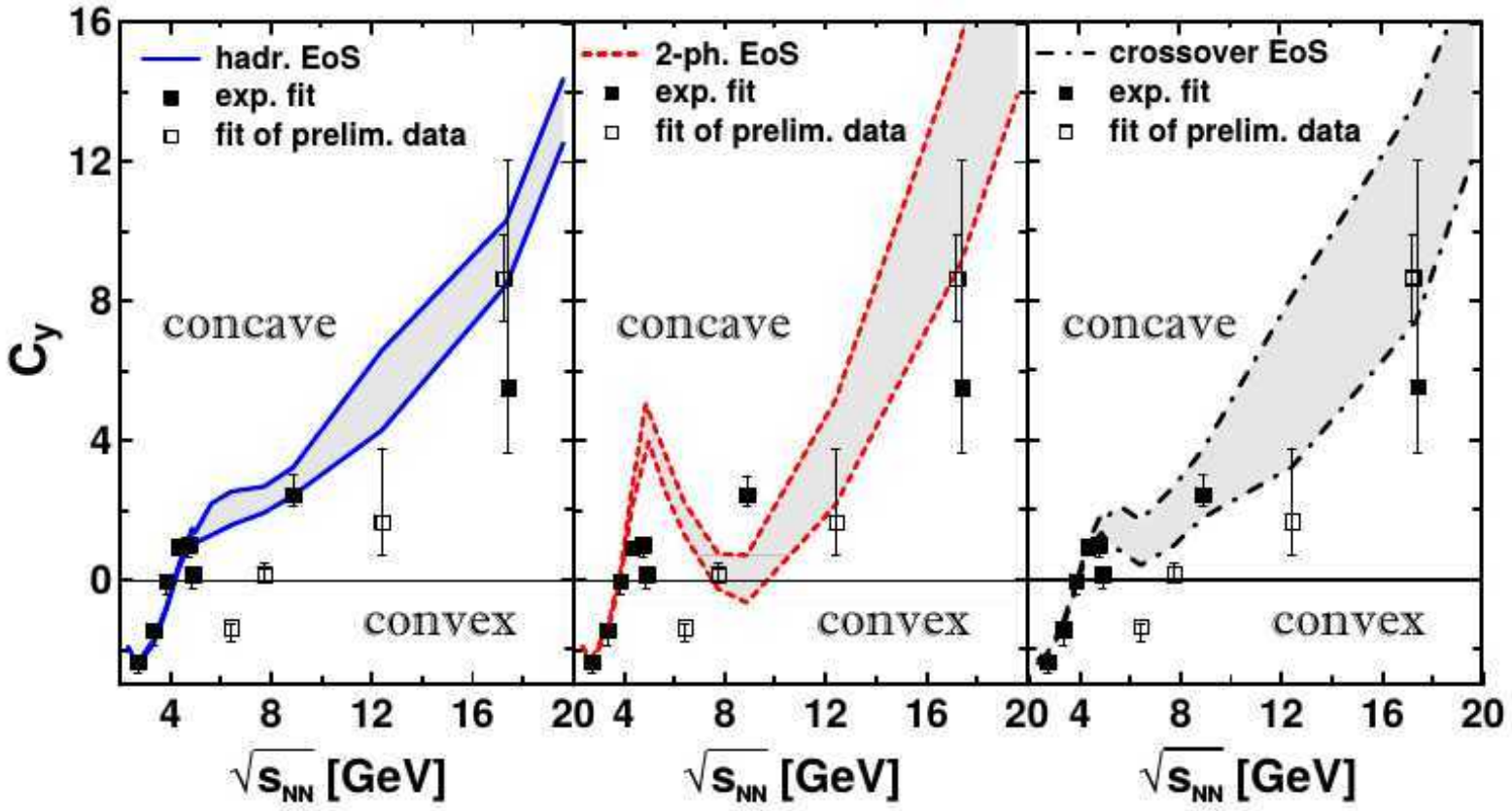
THESEUS





Net-proton mid rapidity Curvature

Yu.B. Ivanov, Phys. Lett. B721 123 (2013)



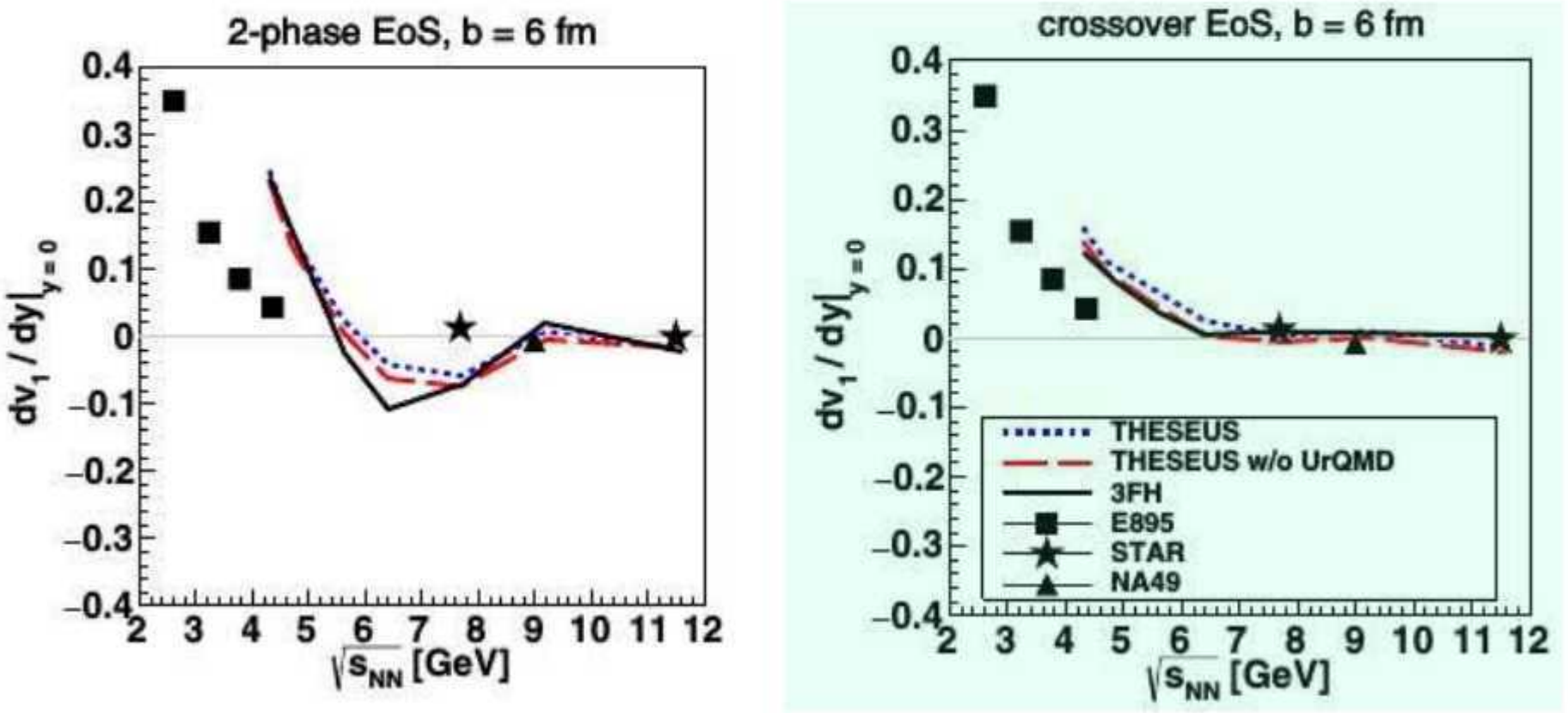
$$C_y = \left(y_{\rm beam}^3 \frac{d^3N}{dy^3}\right)_{y=0} \Big/ \left(y_{\rm beam}\frac{dN}{dy}\right)_{y=0} = (y_{\rm beam}/w_s)^2\left(\sinh^2 y_s - w_s \cosh y_s\right)$$

Directed flow slope

P. Batyuk et al. Phys. Rev. C 94, 044917 (2016)

THESEUS

$$v_1(y) = \langle \cos(\phi - \Psi_{RP}) \rangle = \left\langle p_x / \sqrt{p_x^2 + p_y^2} \right\rangle,$$

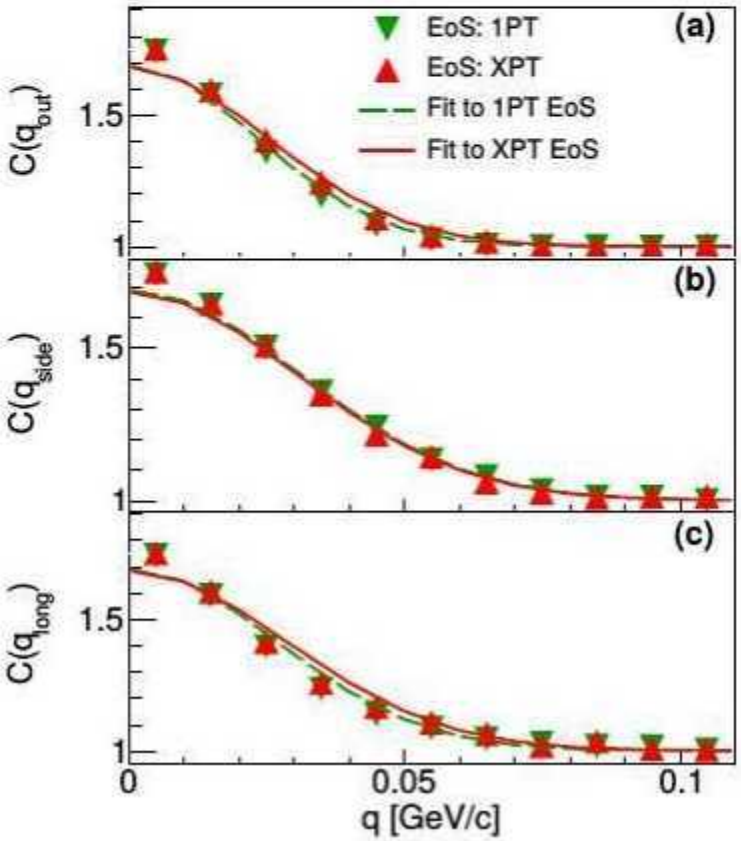


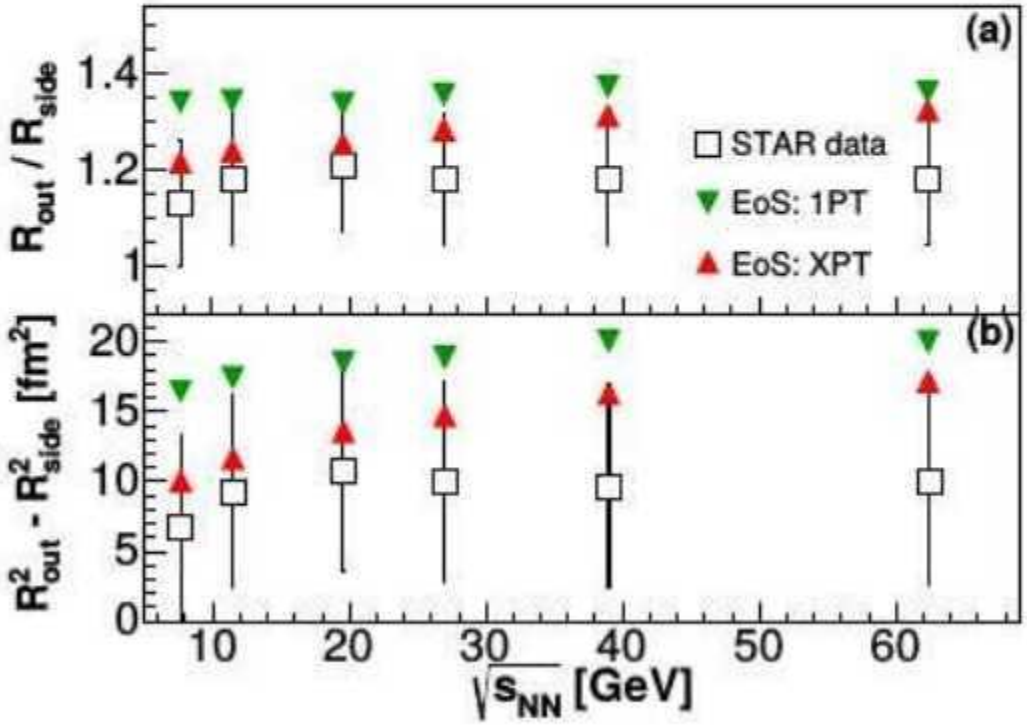
Energy scan of the slope of the directed flow (dv_1/dy) of protons for semicentral (b = 6 fm) Au+Au collisions

Femtoscopy @ NICA

VHLLE+URQMD MODEL
Phys. Rev. C 91, 064901 (2015)

$$C(\mathbf{q}) = N\left(1 + \lambda \exp(-R^2_{\text{out}} q^2_{\text{out}} - R^2_{\text{side}} q^2_{\text{side}} - R^2_{\text{long}} q^2_{\text{long}})\right)$$



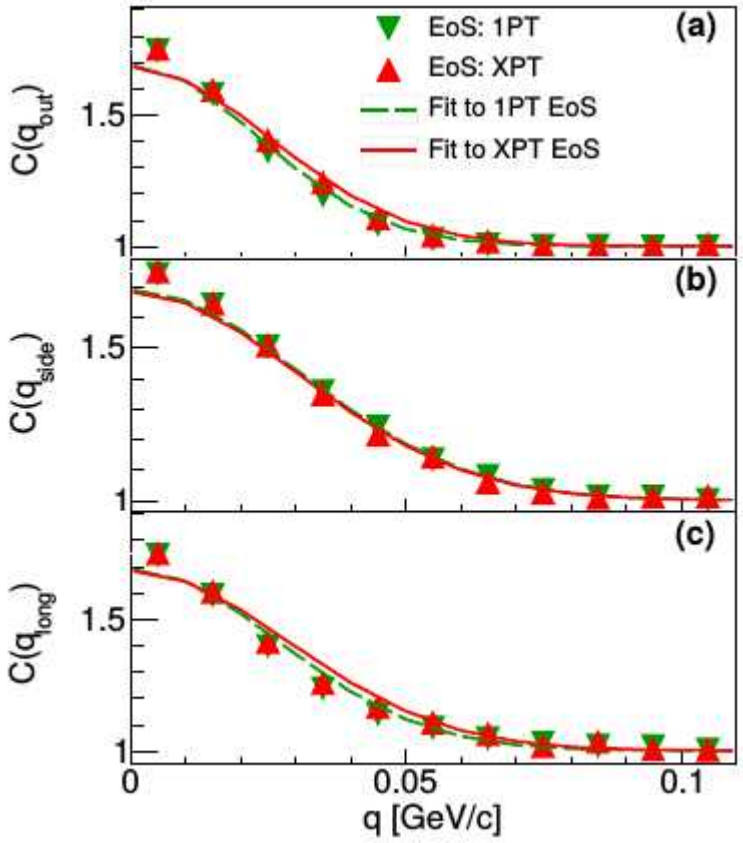


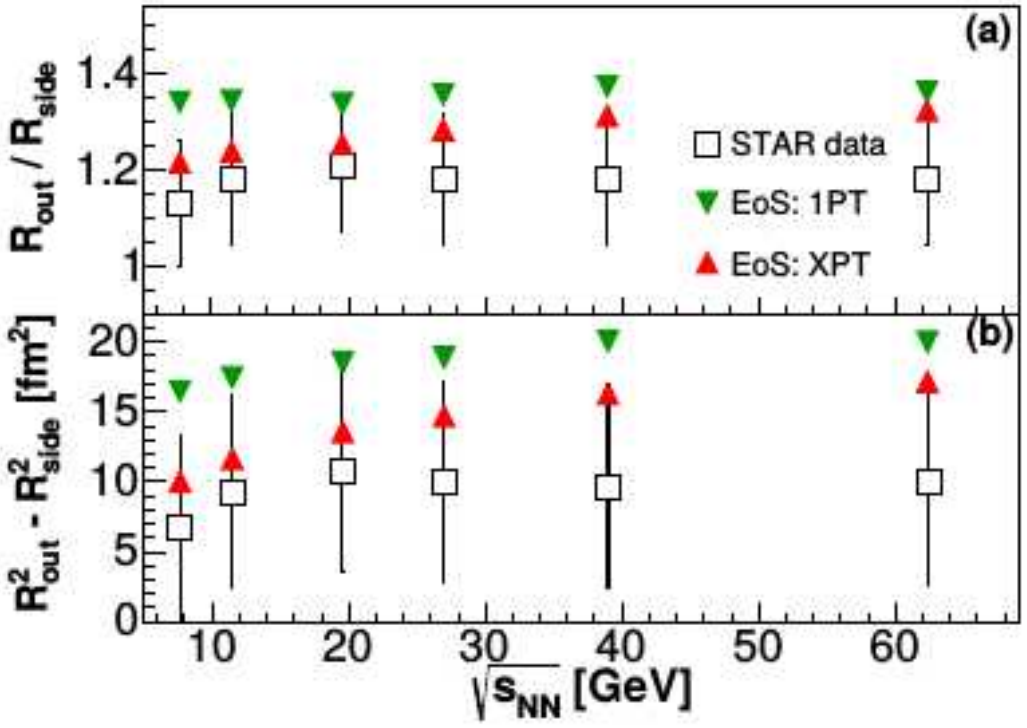
STAR data ($0.15 < k_T < 0.25$ GeV/c, 0-5% centrality)

Femtoscopy @ NICA

VHLLE+URQMD MODEL
Phys. Rev. C 91, 064901 (2015)

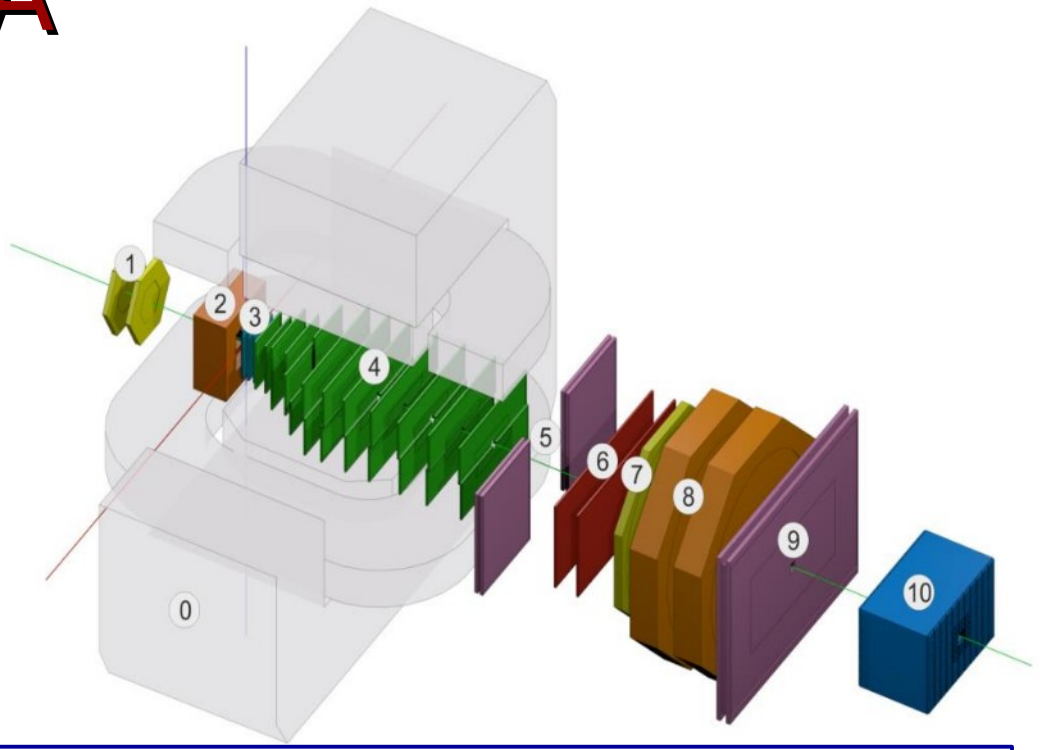
$$C(\mathbf{q}) = N\left(1 + \lambda \exp(-R^2_{\text{out}} q^2_{\text{out}} - R^2_{\text{side}} q^2_{\text{side}} - R^2_{\text{long}} q^2_{\text{long}})\right)$$





STAR data ($0.15 < k_T < 0.25$ GeV/c, 0-5% centrality)

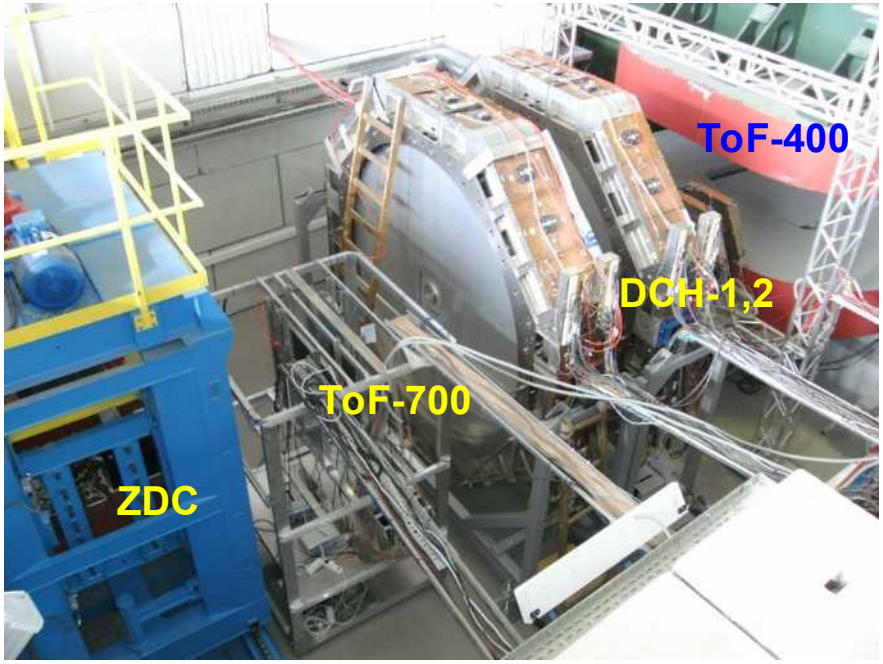
BM@N: fixed target experiment at NICA



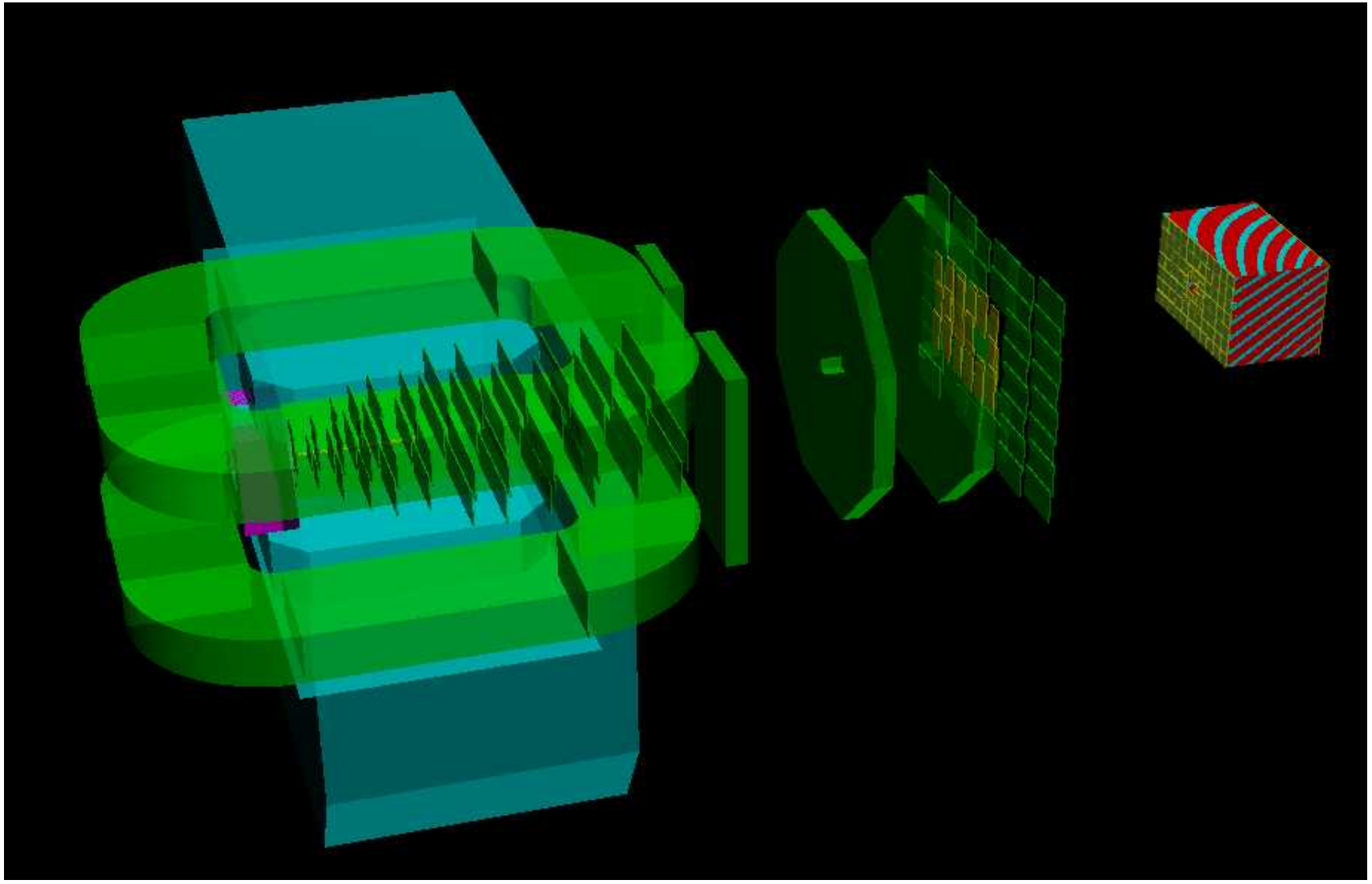
Year	2016	2017 spring	2018 spring	2020	2021 and later
Beam	d(↑)	C	Ar,Kr, C(SRC)	Au	Au,p
Max.intensity per spill	0.5M	0.5M	0.5M	1M	5M
Trigger rate, Hz	5k	5k	10k	10k	20k→50k
Central tracker status	6 GEM half planes	6 GEM half planes	6 GEM half planes + 3 small Si planes	7 GEM full planes + small + large Si planes	7 GEM full planes + small + large Si planes
Experimental status	technical run	technical run	technical run+physics	stage1 physics	stage2 physics

0 Analyzing magnet
1 MWPC
2 Recoil (+T0T)
3 ST (Silicon Tracker)
4 GEM
5 TOF1(mRPC)
6 CPC
7 Straw
8 DCH
9 TOF2(mRPC)
10 ZDC

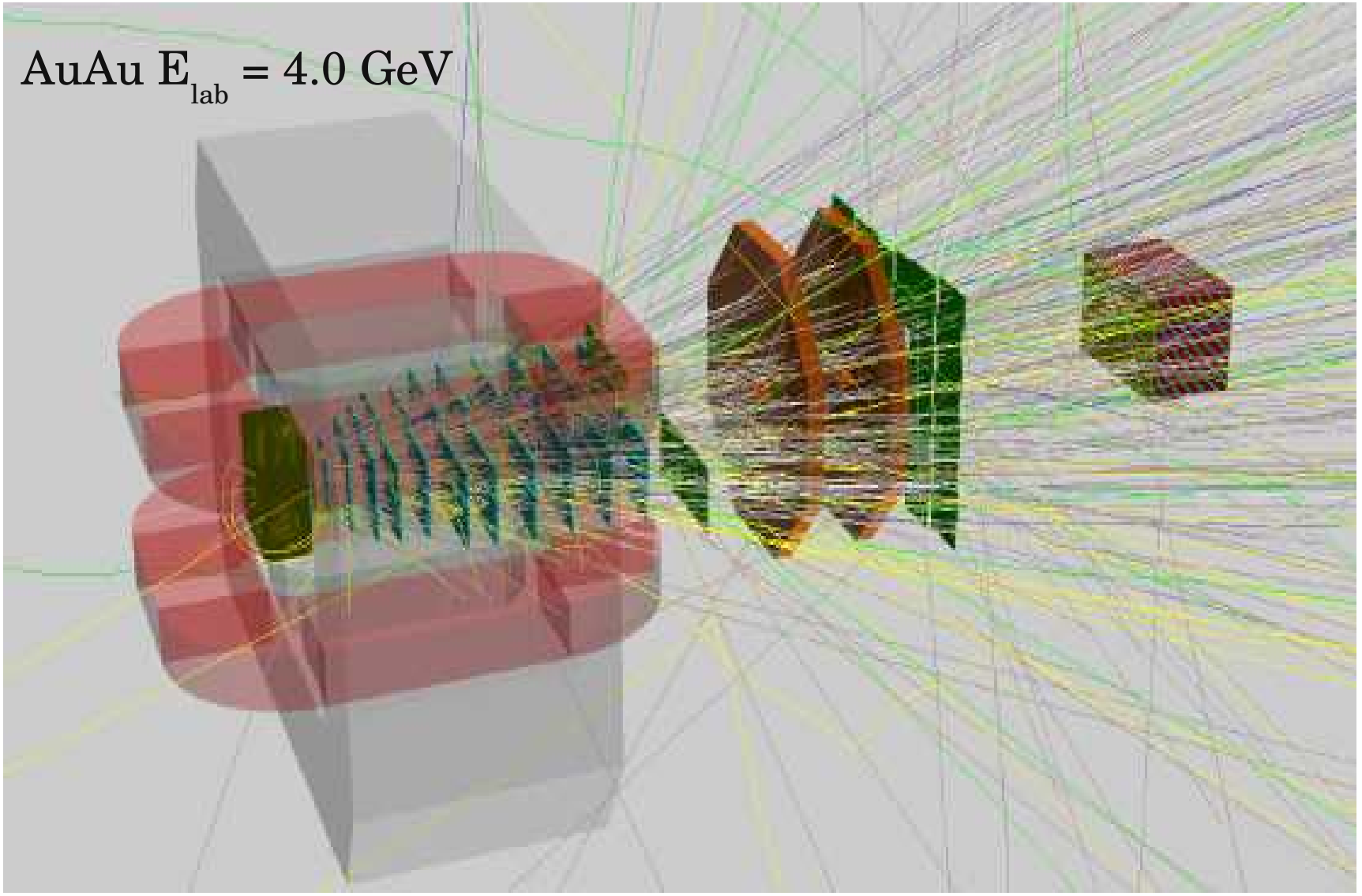
BM@N experiment setup



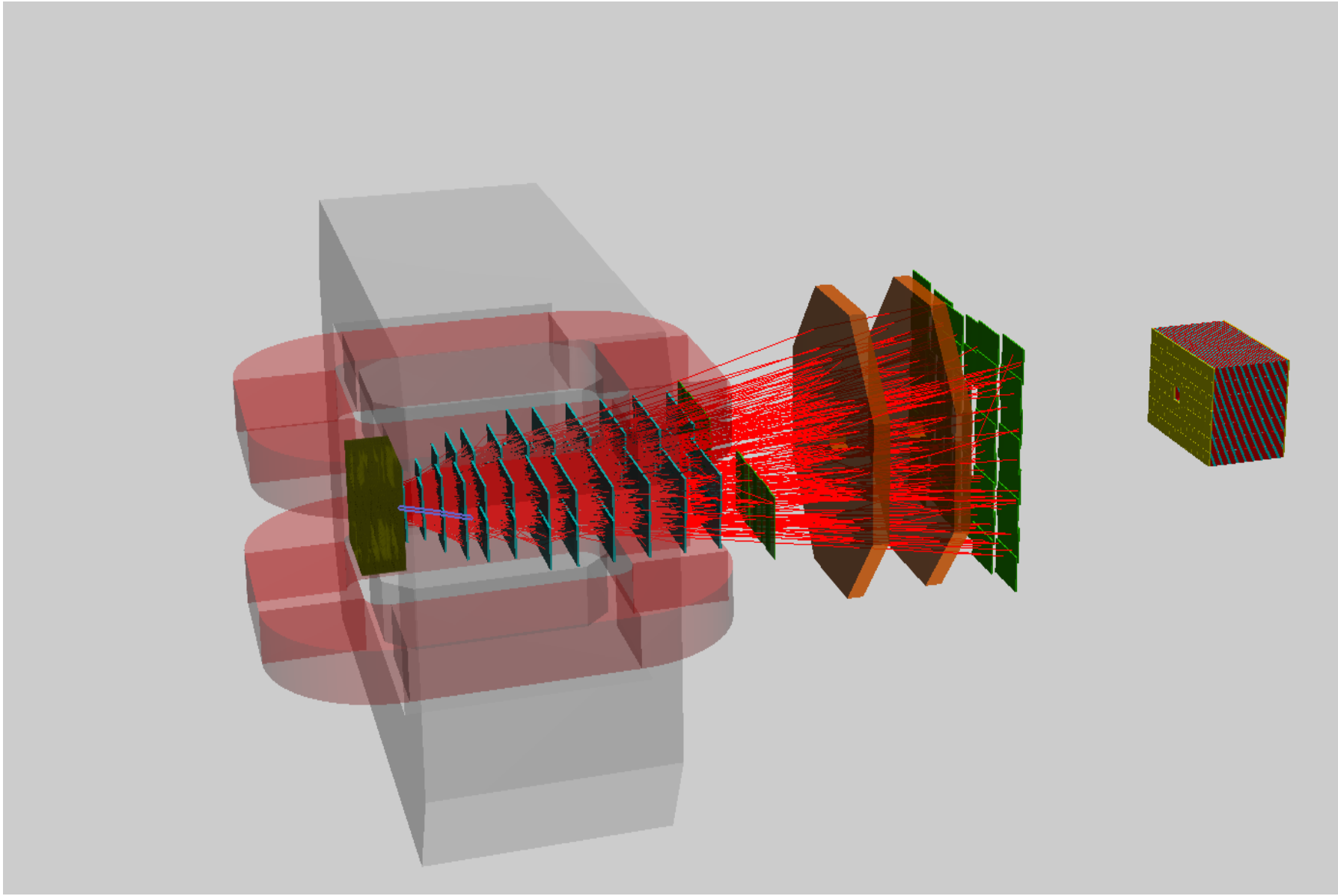
BM@N Geant geometry



Monte-Carlo tracks (all charged)

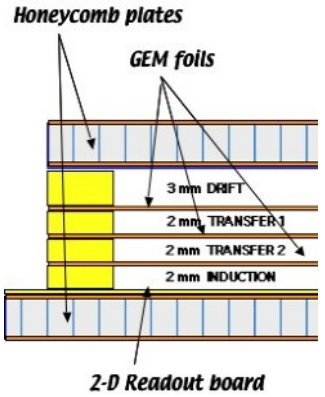


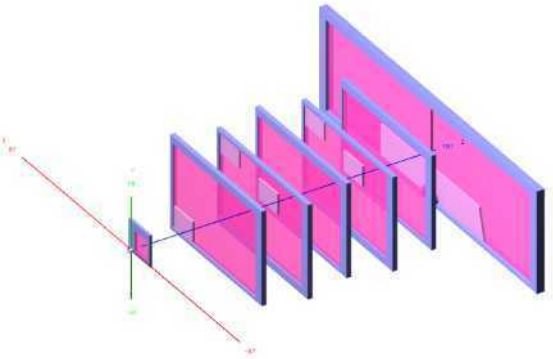
BM@N reconstructed tracks



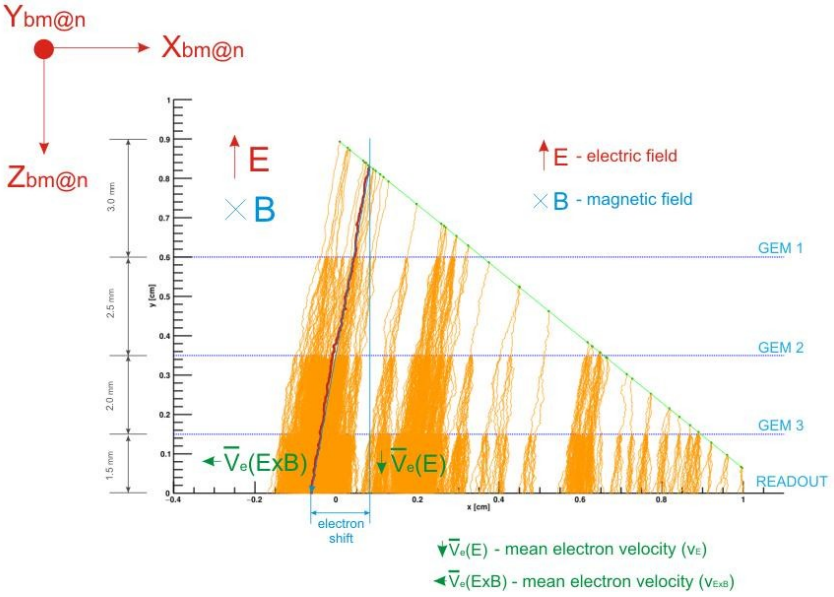
Clustering in GEM

- There are realistic hit finder in GEMs
- For the GEM stations procedure of the fake hits production is implemented

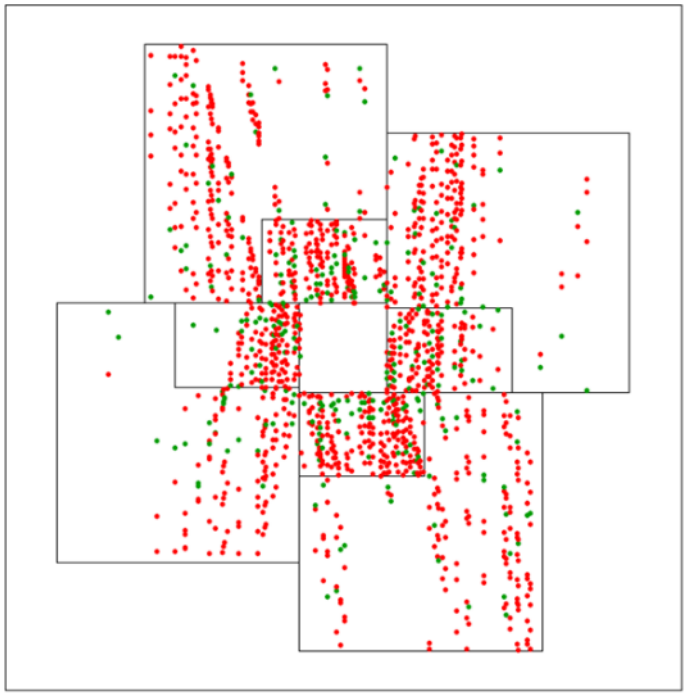




Station 0 (what is it)

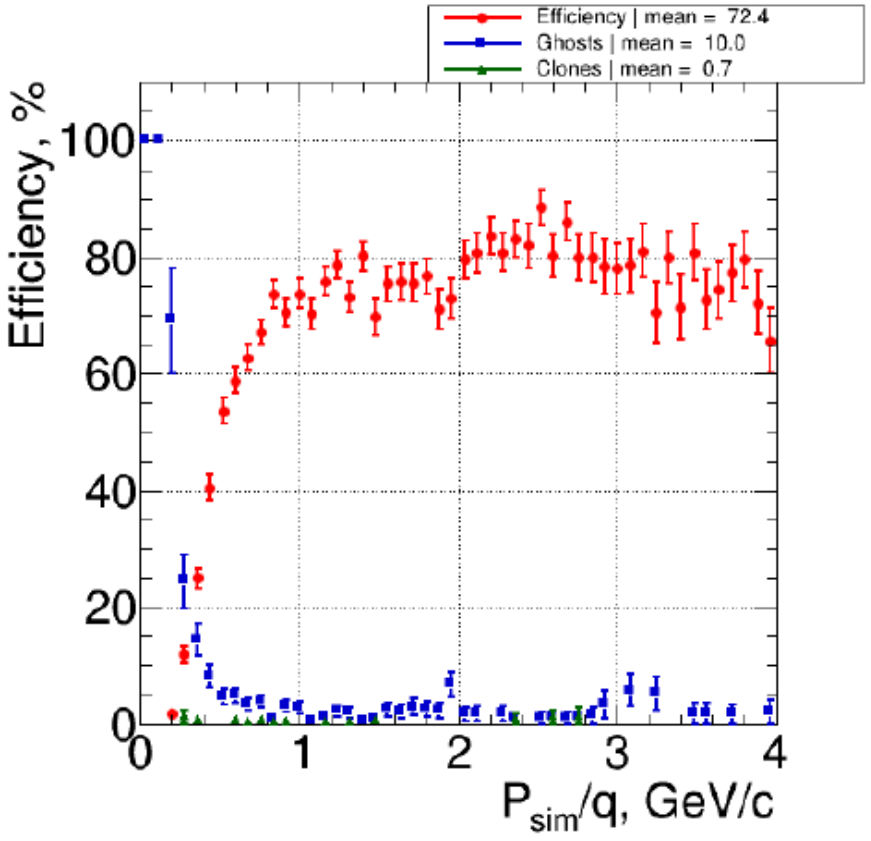


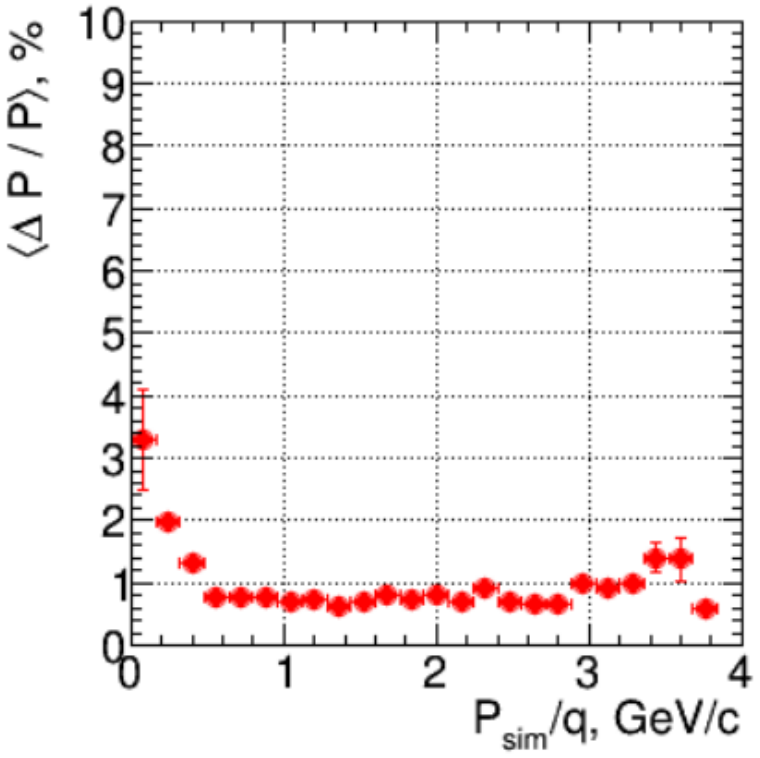
electron avalanches in the BM@N GEM chamber



BM@N tracking

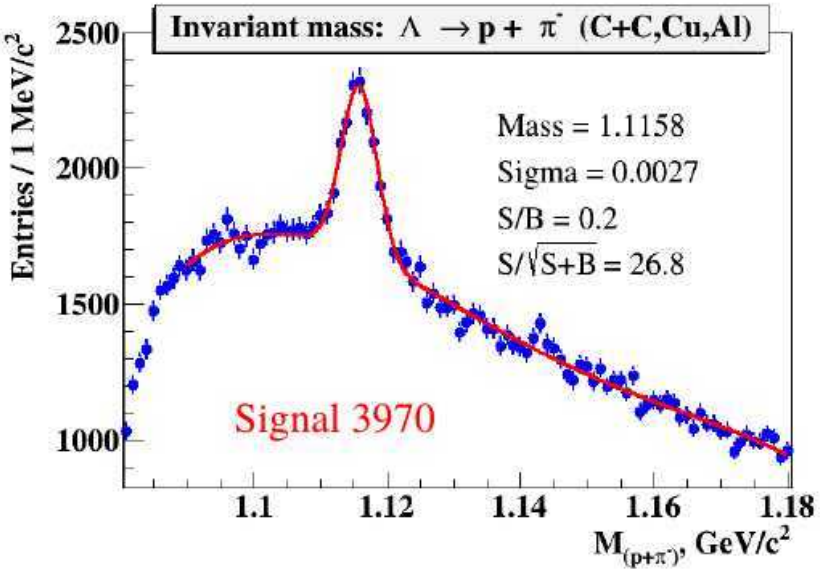
Generator: QGSM, ArPb (T = 3.2 GeV/n), minbias, 2k events
Magnetic field: B = 0.59 T

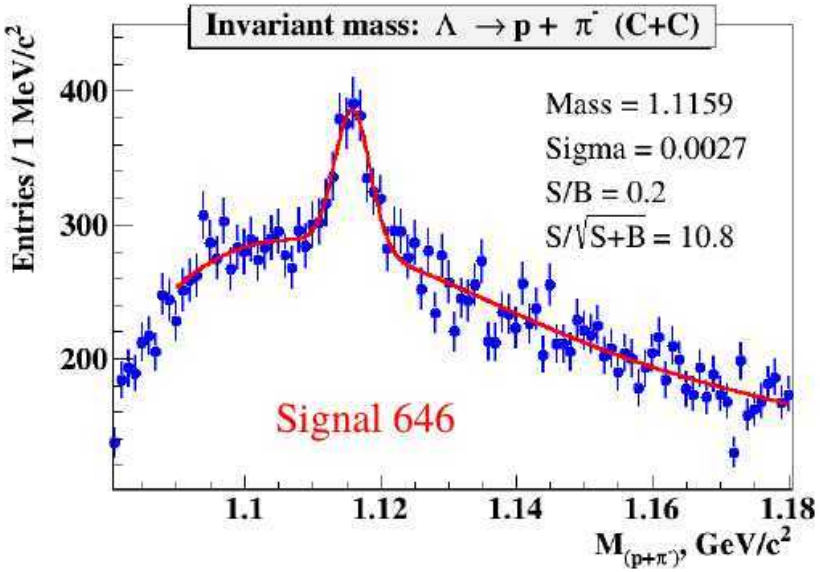


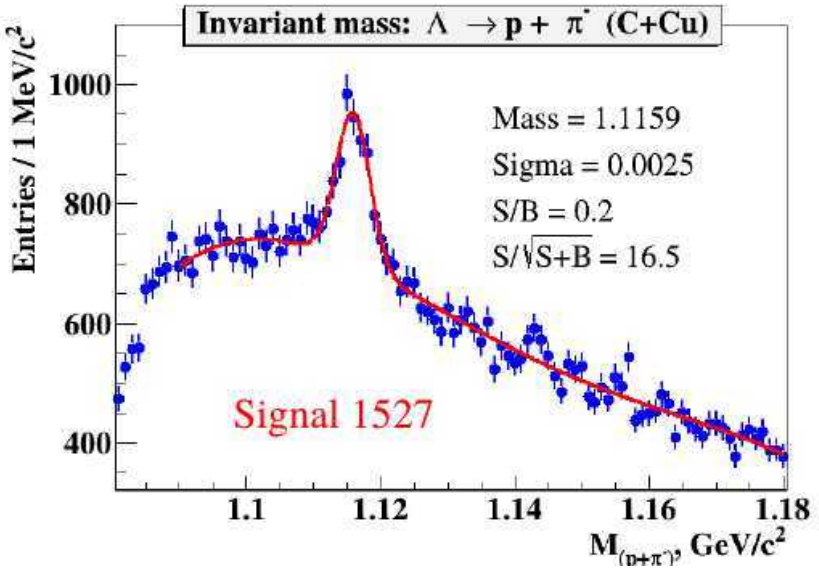


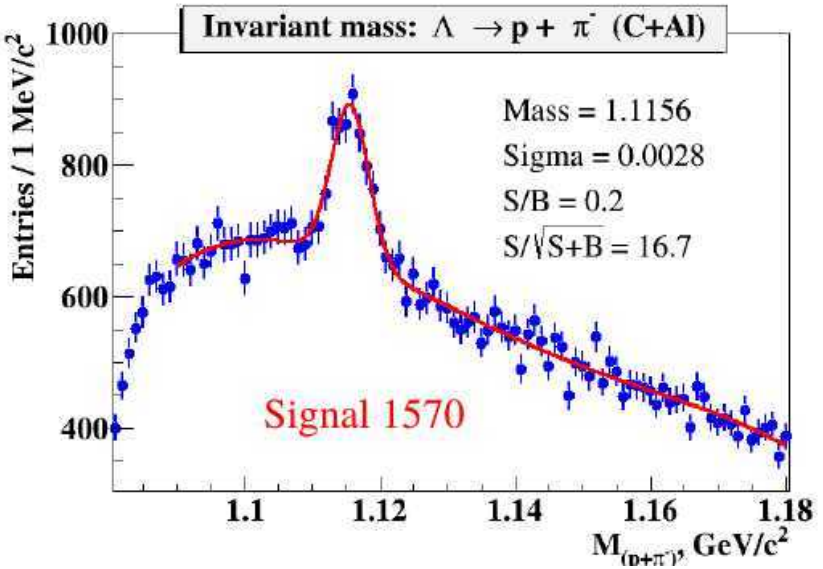
BM@N Λ^0 reconstruction

(E_{kin}^{beam} = 4.0 AGeV)



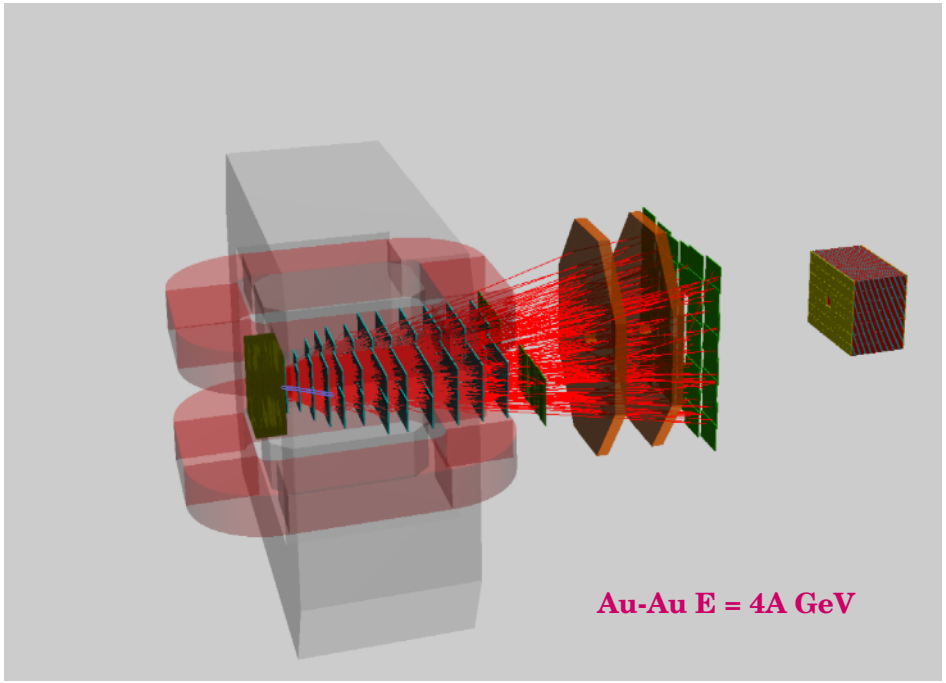






Event Displays for the NICA experiments

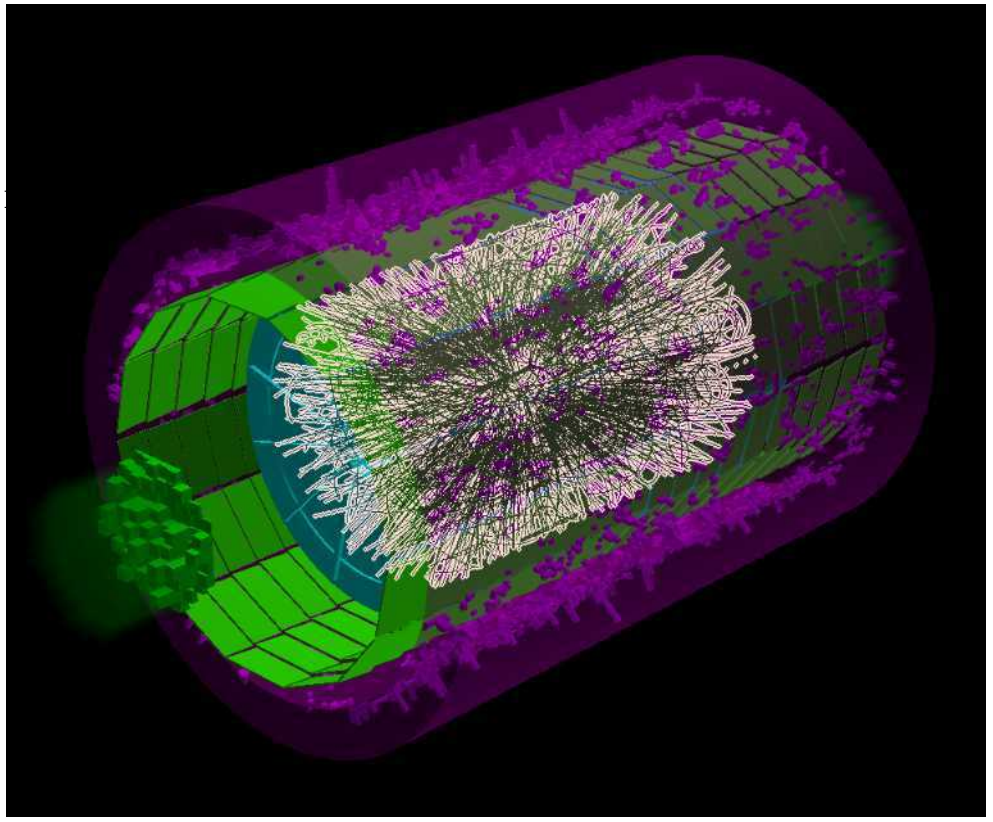
based on EVE package



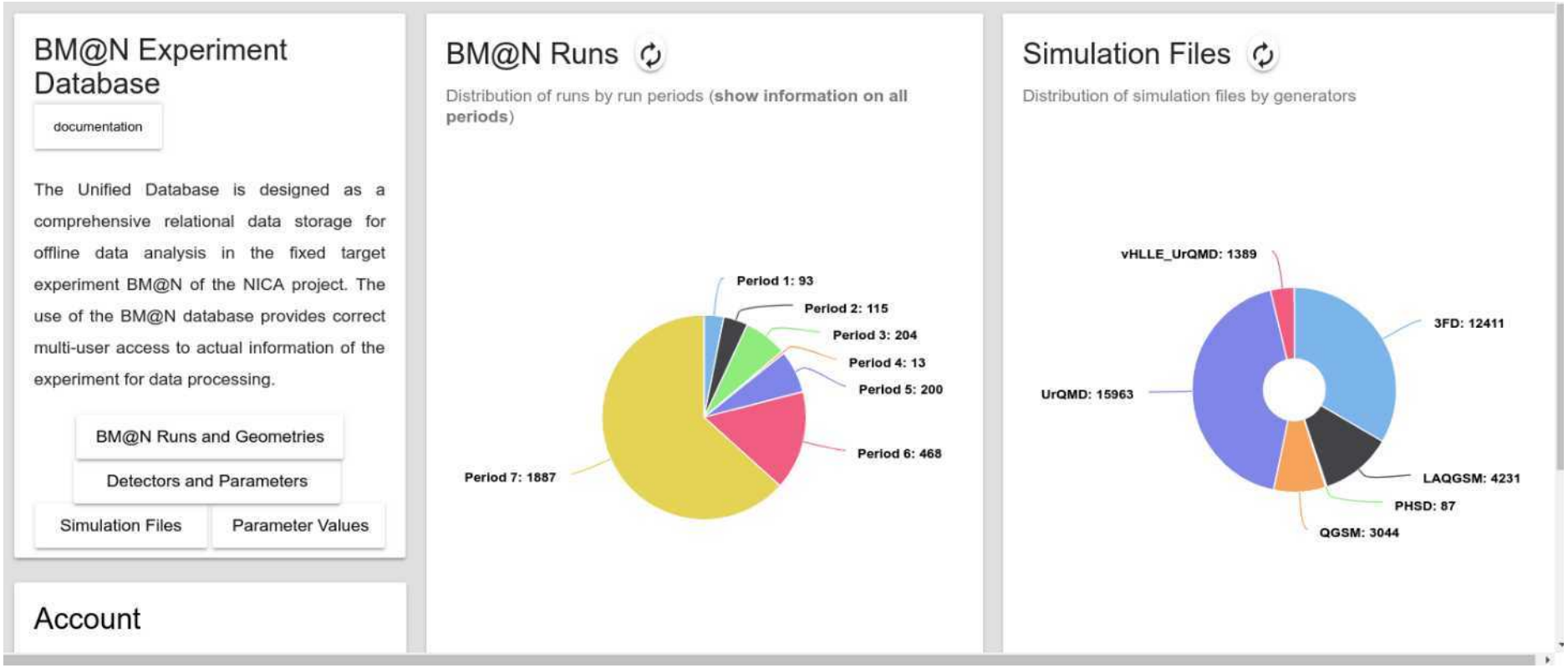
BM@N event data:
GEM points and reconstructed tracks

MPD event data:
TPC hits and EMC towers

Au-Au



Event generators + exp. data databases



- ✔ UrQMD
- ✔ QGSM
- ✔ PHSD

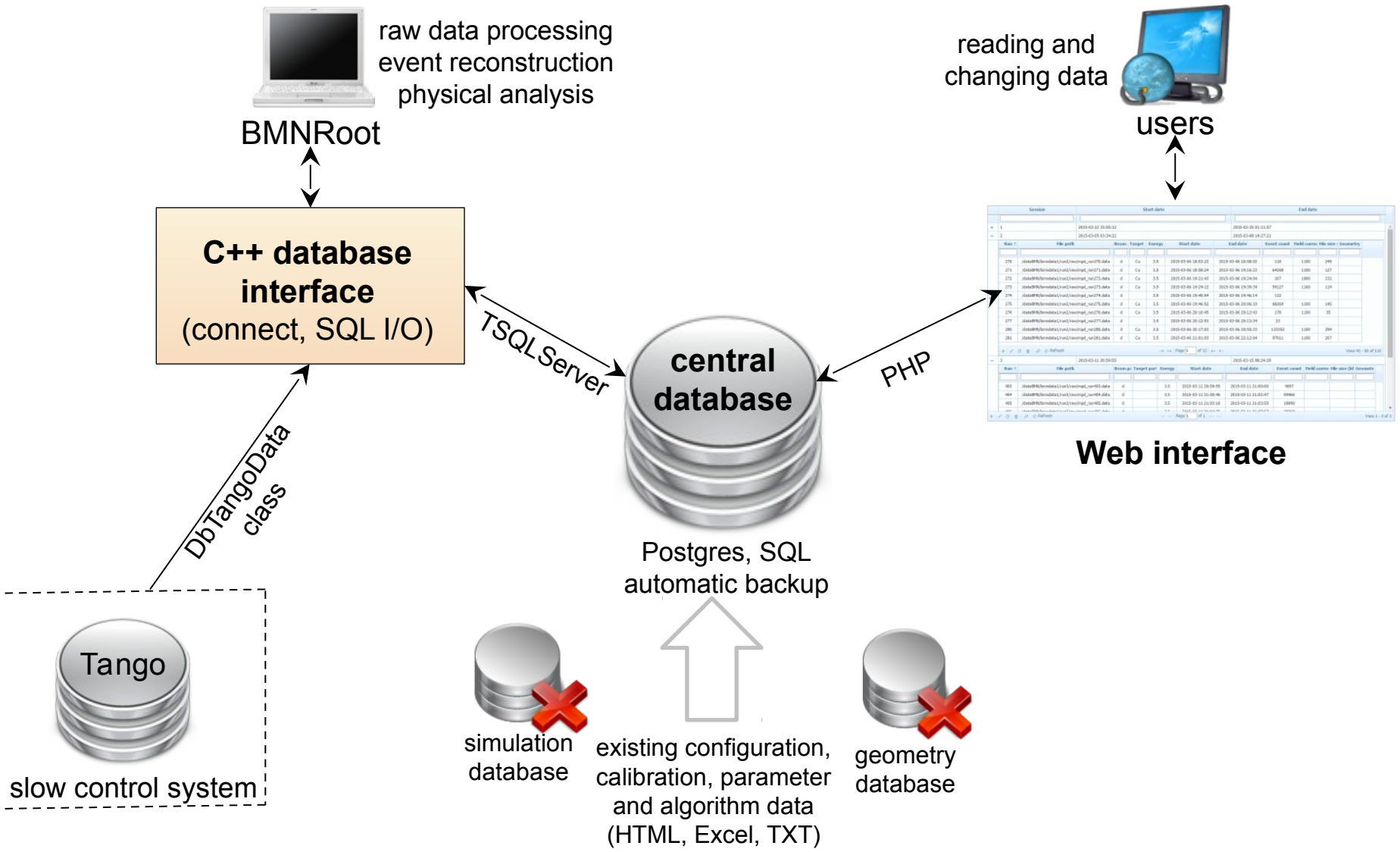
- ✔ Hybrid UrQMD
- ✔ vHLLE_UrQMD
- ✔ 3FD(Theseus)

Interactions
AuAu MC
pC MC+exp
CC

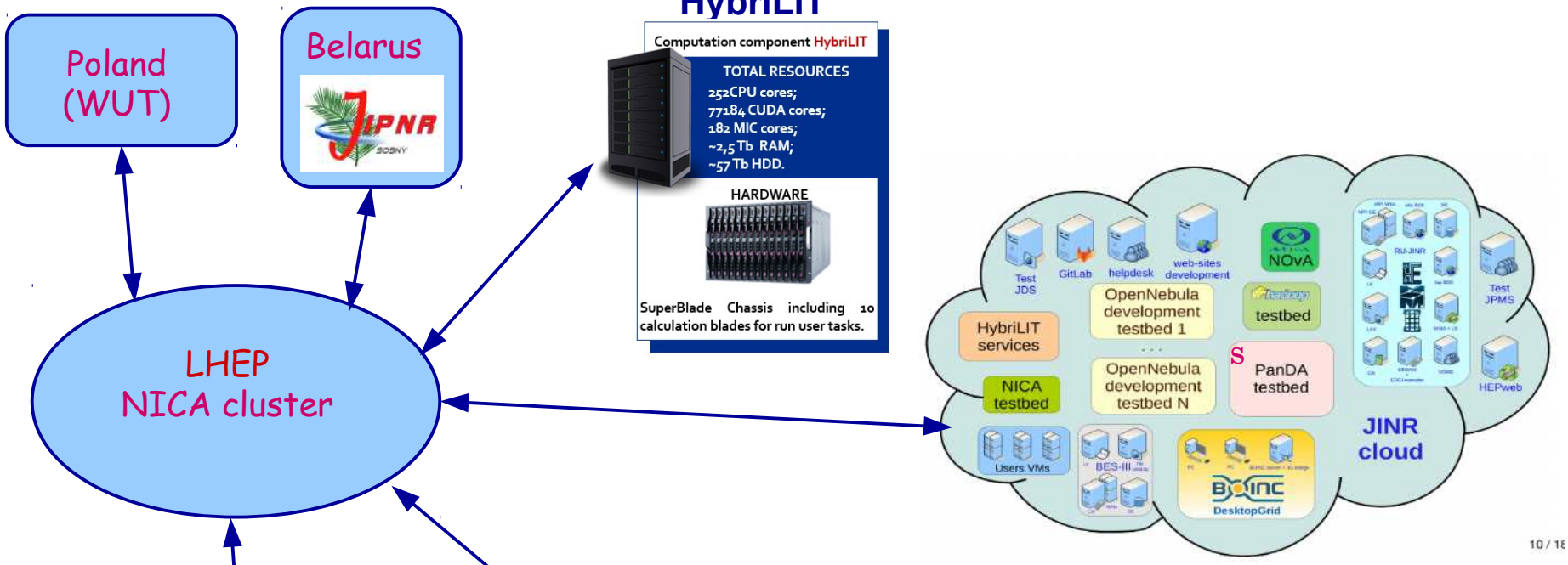
Energy s
2, 4, 7, 9, 11

32902 files
~ 10^6 events
for each
interaction

Data... Data... Database



NICA distributed computing



BATCH farm

2018 year: August

Laboratory	Jobs number	CPU time (kiloSPECint2000*hour)	Wall time (kiloSPECint2000*hour)
mpd	2517	45892.88	46287.04
LIT	35	43415.25	4093.52
Inovai	28636	38951.69	74460.88
compass	8110	16663.03	42517.94
DLNP	3430	11016.49	17784.63
Ibes	5771	1653.52	6732.95
VBLHEP	1	9.17	9.17
BLTP	2	0.53	0.54
Istar	2	0.01	0.14

Total CPU time used: 157602.58 kiloSPECint2000*hour

NICA center

Reports for NICA at this conference

Geometry Database for the CBM experiment and its first application to experiments in the NICA project

Elena Akishina, Evgeny Alexandrov, Igor Alexandrov, Irina Filozova, Volker Friese, Victor Ivanov, O. R., Konstantin Gertsenberger

Current workflow execution using job scheduling for the NICA experiments

Konstantin Gertsenberger, O.R.

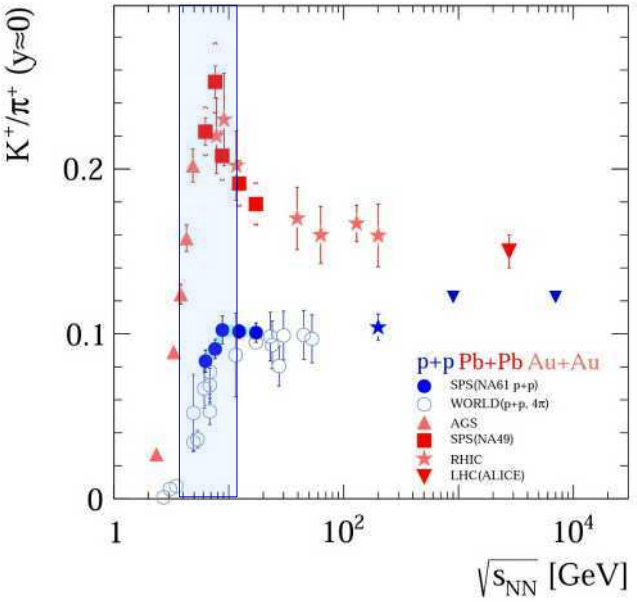
Possible application areas of machine learning techniques at MPD/NICA experiment and their implementation prospects in distributed computing environment

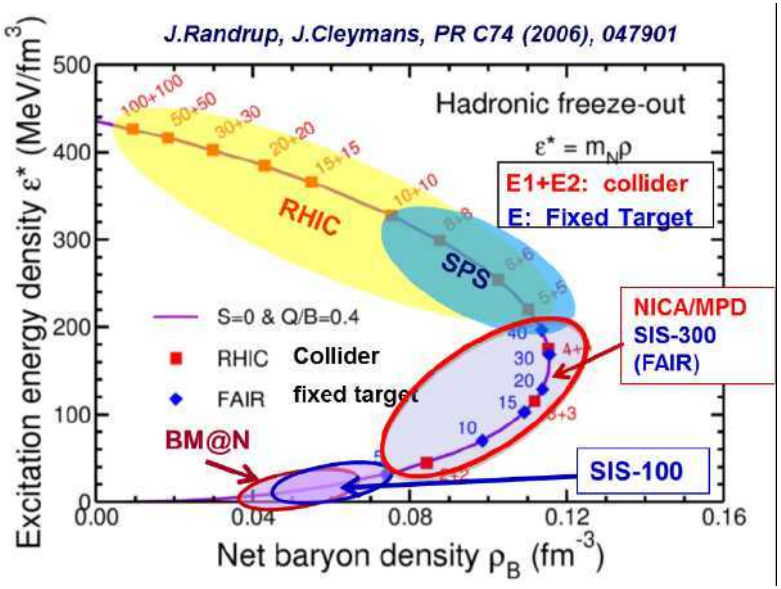
Dmitry Zinchenko, Alexander Zinchenko, Eduard Nikonov

NICA advantagies

J. Cleymans
MPD collaboration Meeting April, 2018

- ✔ Maximum in K^+/π^+ ratio is in the NICA energy region,
- ✔ Maximum in Λ/π ratio is in the NICA energy region,
- ✔ Maximum in the net baryon density is in the NICA energy region,
- ✔ Transition from a baryon dominated system to a meson dominated one happens in the NICA energy region.





Thank you for attention

to NICA physics

Nuclotron based Ion Collider fAcility

Beams – p,d(h)..$^{197}Au^{79+}$

Collision energy $\sqrt{s}$= **4-11** GeV/u (Au), **12-27** (p)

Beam energy (fixed target) - **1-6** GeV/u

Luminosity: 10^{27} $cm^{-2}s^{-1}$(Au), 10^{32} (p)

Experiments:

2 Interaction points – **MPD** and SPD

Fixed target experiment **BM@N**