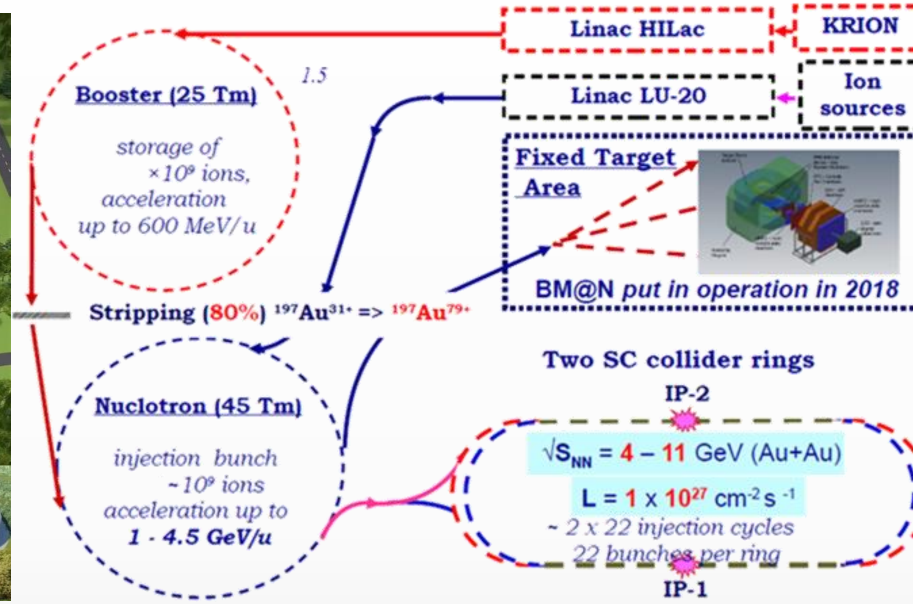
Nuclotron based Ion Colider fAcility

Status of the MPD Experiment at NICA

Arkadiy Taranenko (NRNU MEPhI) for the MPD Collaboration

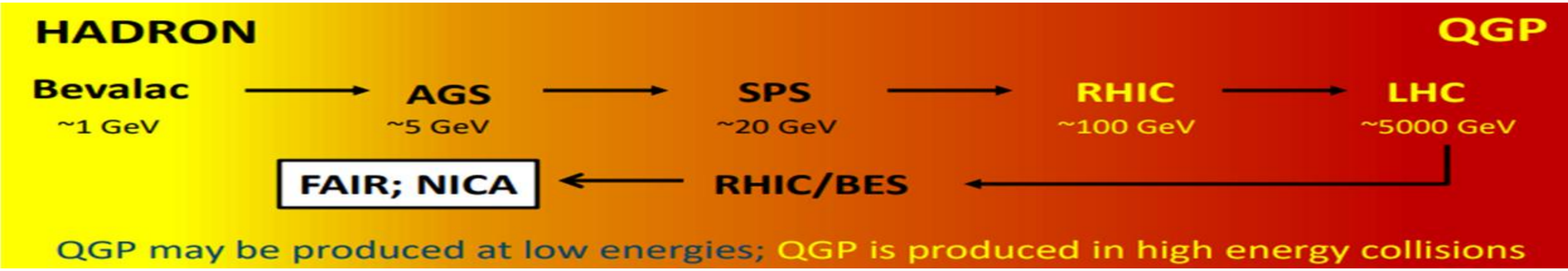
The 6-th International Conference on Particle Physics and Astrophysics (ICPPA-2022), NRNU MEPhI, Moscow, 29 November – 2 December, 2022

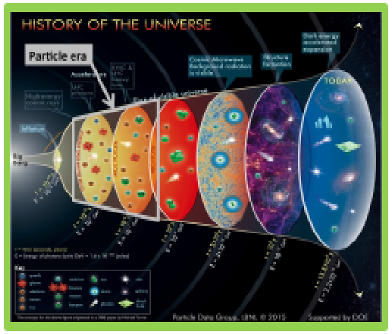
NICA Project



- ❖ The first megascience project in Russia, which is approaching its full commissioning:
  - ✓ already running in the fixed-target mode – BM@N
  - ✓ start of operation in collider mode in 2023-2024 – MPD
- ❖ Expected beam configuration in Stage-I:
  - ✓ not-optimal beam optics with wide z-vertex distribution, σ_z ~ 50 cm
  - ✓ reduced luminosity (~10^{25}) → collision rate ~ 50 Hz
  - ✓ collision system available with the current sources: C (A=12), N (A=14), Ar (A=40), Fe (A=56), Kr (A=78-86), Xe (A=124-134), Bi (A=209) → start with Bi+Bi @ 9.2 GeV in 2023-2024

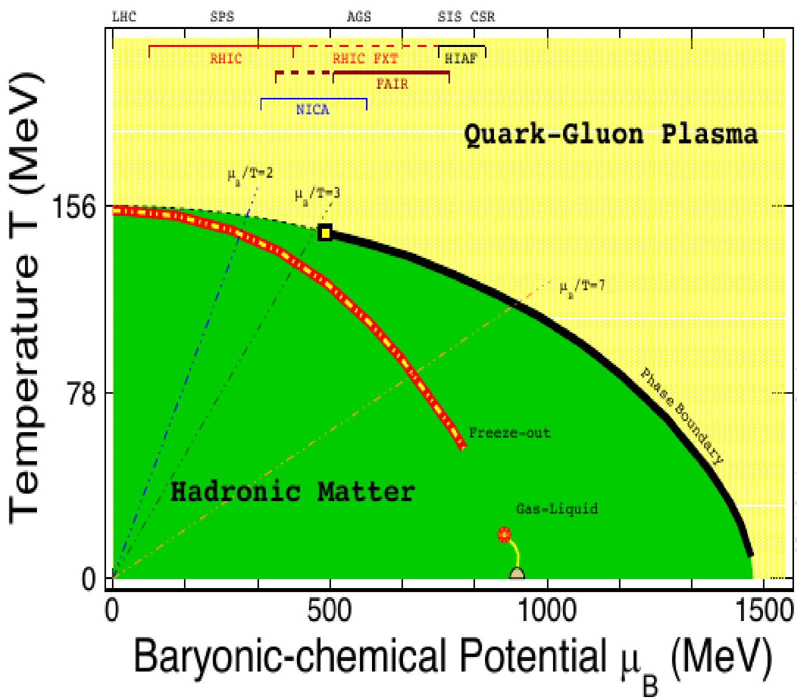
Relativistic Heavy-Ion Collisions and QCD Phase Diagram



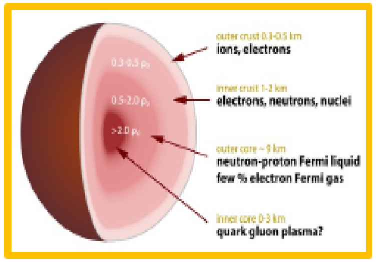


High temperature:
Early Universe evolution

LHC | RHIC BES | FAIR, NICA, …



High baryon density:
Inner structure of
compact stars



1) At $\mu_B = 0$, smooth crossover (LGT + data) ;

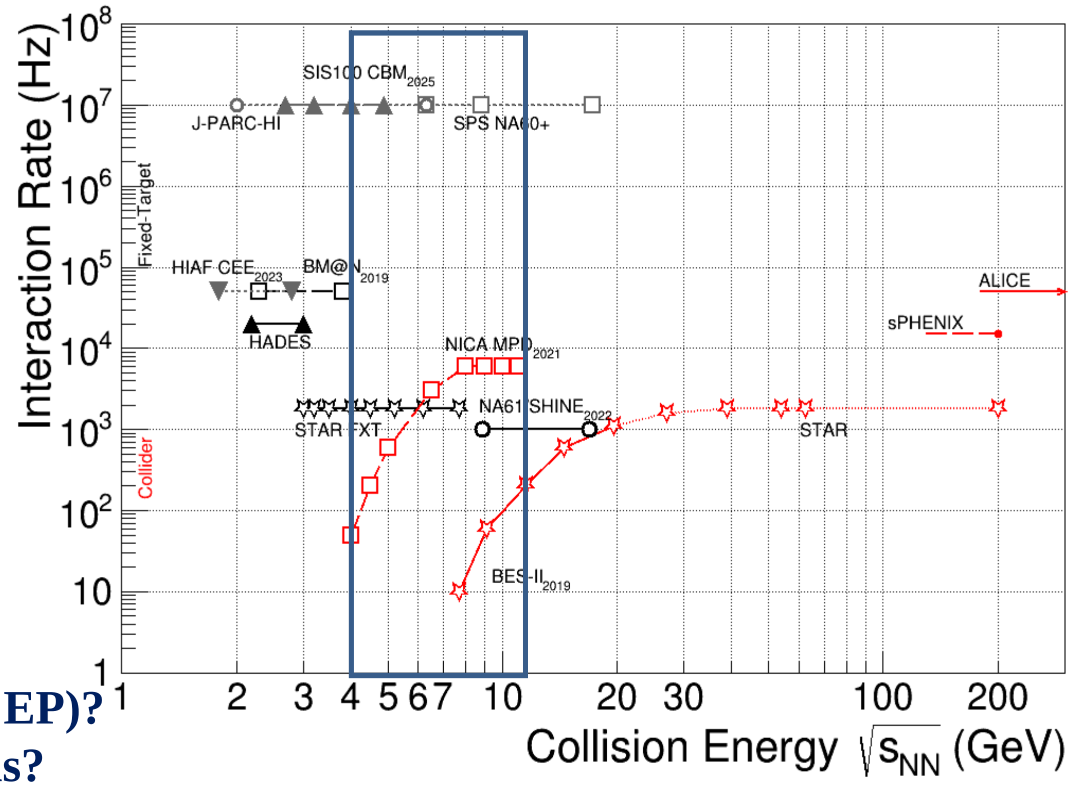
2) Large μ_B, 1st order phase transition → **QCD critical point**

Collision Energy and System Scan Programs

HADES BES (SIS): Au+Au at $\sqrt{s_{NN}}$ = 2.42 GeV, Ag+Ag at $\sqrt{s_{NN}}$ = 2.42 GeV, 2.55 GeV.

STAR BES (RHIC): Au+Au at $\sqrt{s_{NN}}$ = 3-200 GeV

NA61/SHINE (SPS): Be+Be, Ar+Sc, Xe+La, Pb+Pb at $\sqrt{s_{NN}}$ = 5.1-17.3 GeV



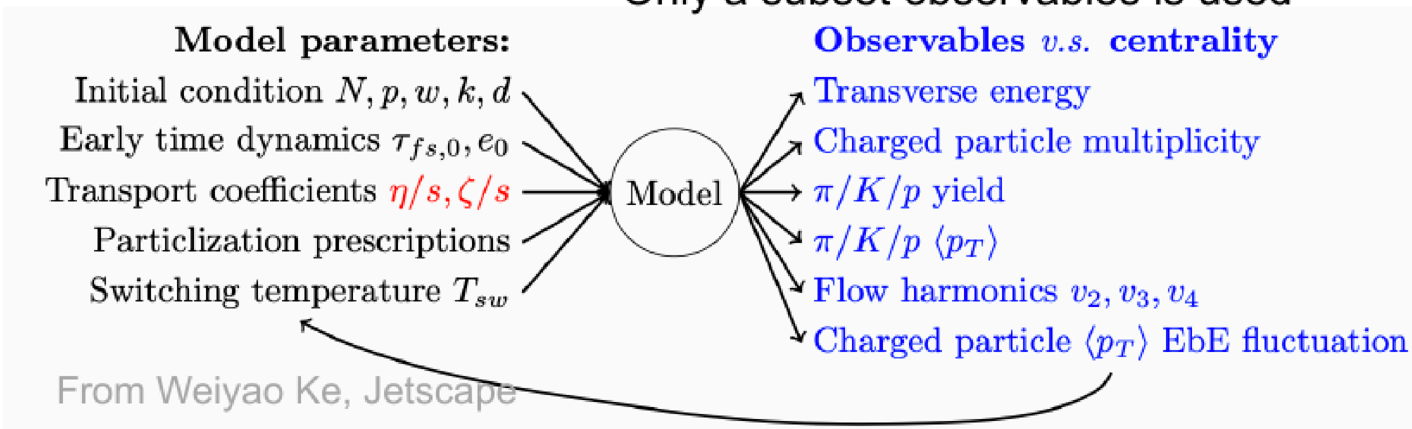
- **Map turn-off of QGP signatures**
- **Location of the Critical End Point (CEP)?**
- **Location of phase coexistence regions?**
- **1st order phase transition signs**
- **Detailed properties of each phase?**

$$\frac{\eta}{s}(T,\mu),\ \frac{\zeta}{s}(T,\mu),\ c_s(T),\ \hat{q}(T),\ \alpha_s(T),\ \text{etc}$$

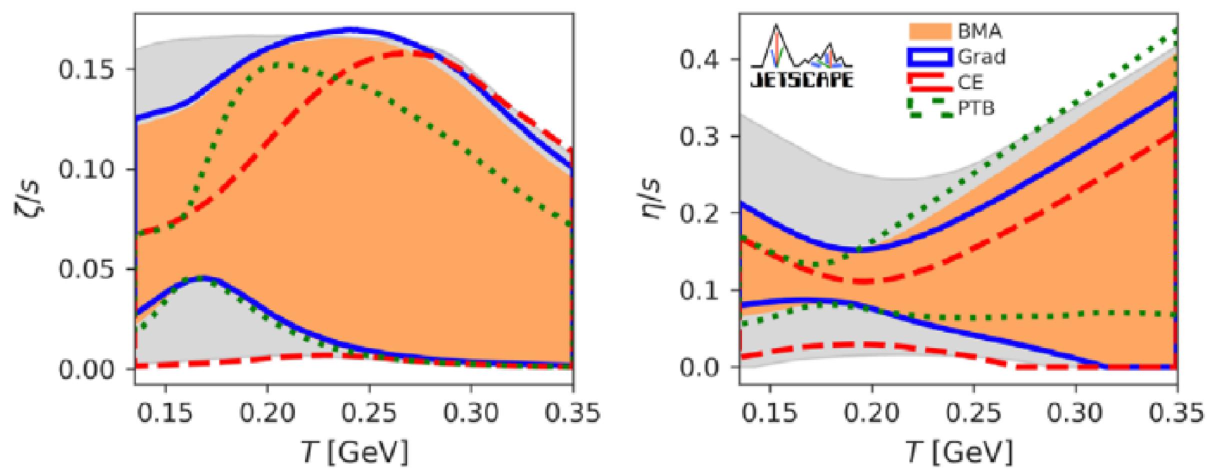
State-of-the-art modeling of HI collisions

- Data-model comparison via Bayesian inference to optimize constraining power.

Only a subset observables is used



- Detailed temperature dependence of viscosity!



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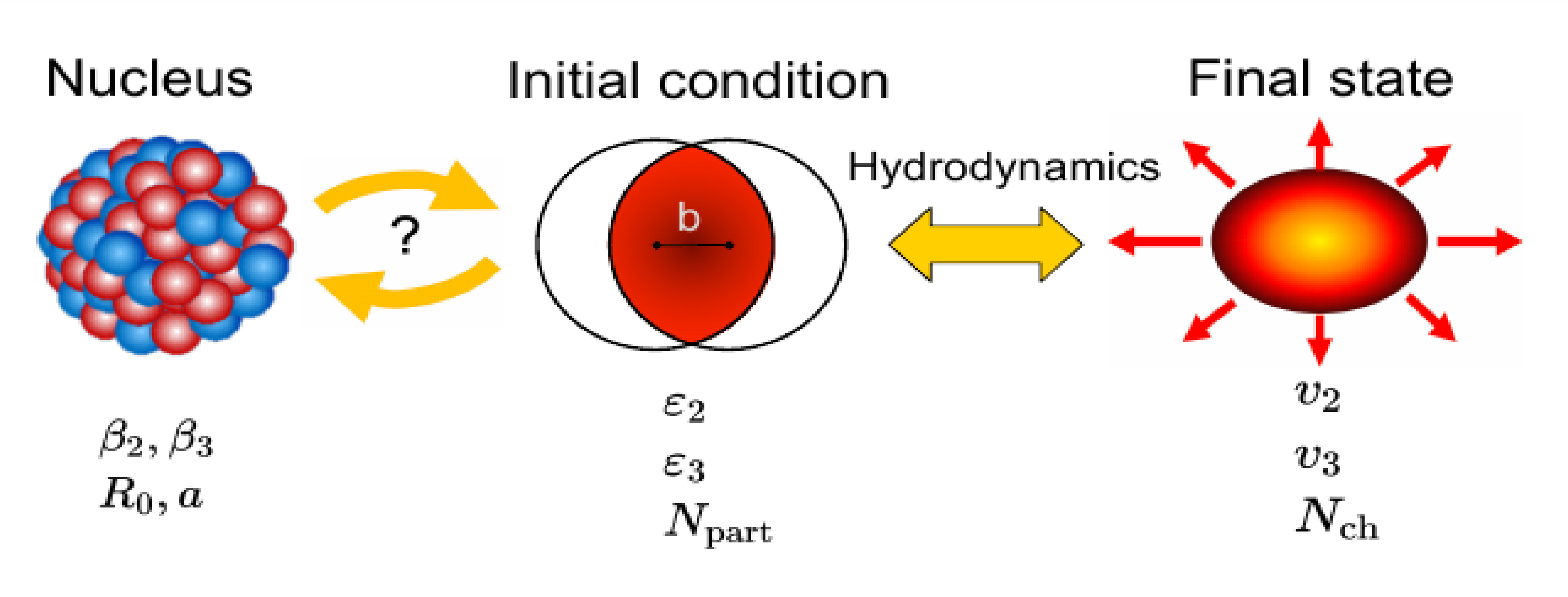
Major uncertainty: initial condition and pre-hydro phase

2022: Imaging the initial condition of heavy-ion collisions and nuclear structure across the nuclide chart



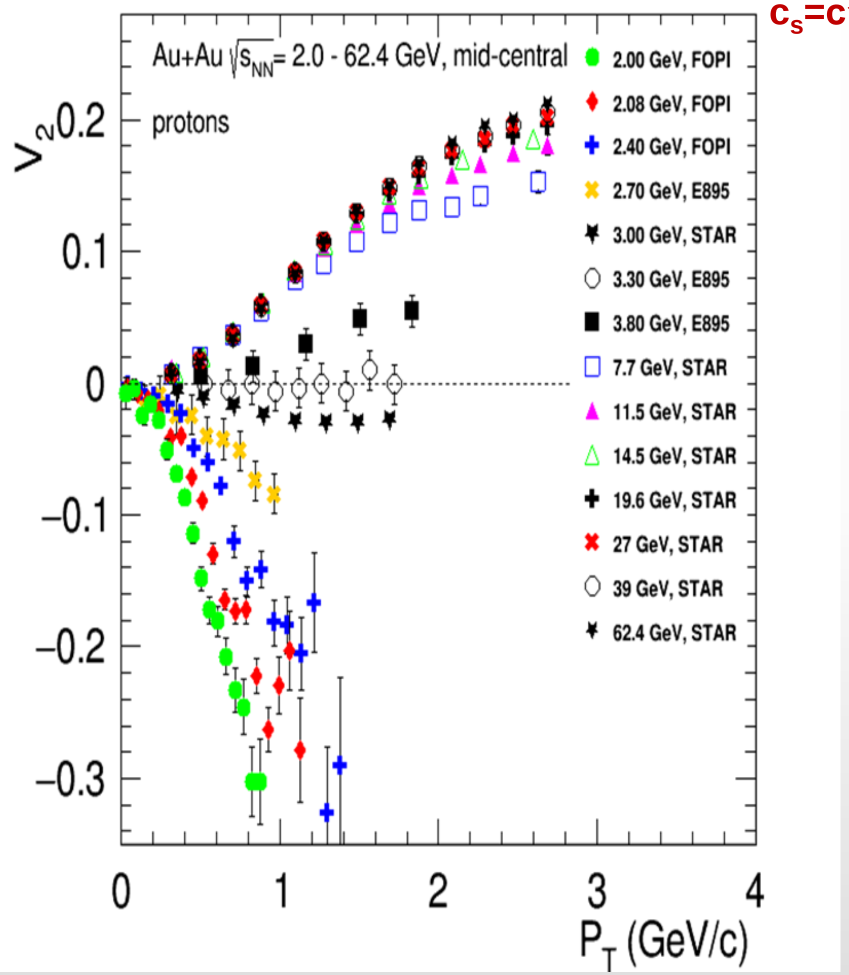
$$\rho(r,\theta,\phi) \propto \frac{1}{1+e^{[r-R_0(1+\beta_2 Y_2^0(\theta,\phi)+\beta_3 Y_3^0(\theta,\phi))]/a}},$$

The extraction of the properties of the QGP, is currently limited by our poor knowledge of the initial condition, in particular how it is shaped from the colliding nuclei ➡

To exploit collisions of selected species to precisely assess how the initial condition changes under variations of the structure of the colliding ions. (https://arxiv.org/abs/2209.11042)

Beam Energy Dependence of Elliptic Flow (v_2)

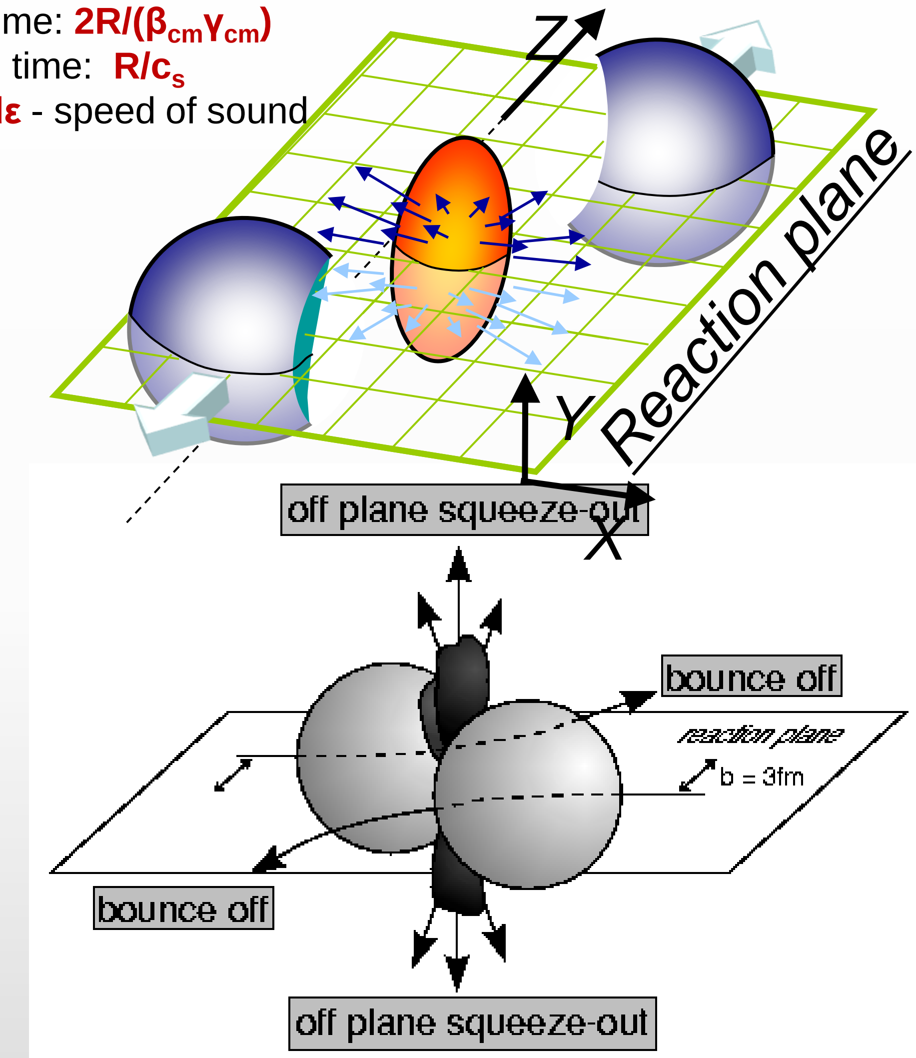
EPJ Web Conf. 204 (2019) 03009



Passage time: $2R/(\beta_{cm}\gamma_{cm})$

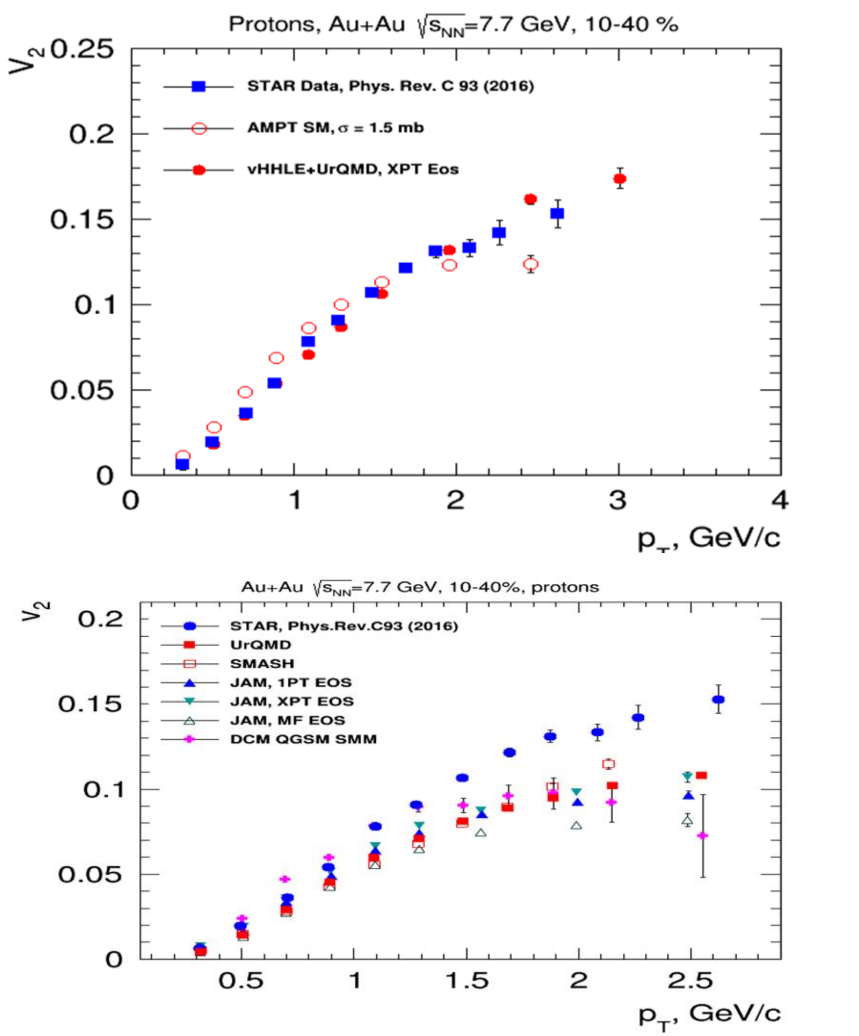
Expansion time: R/c_s

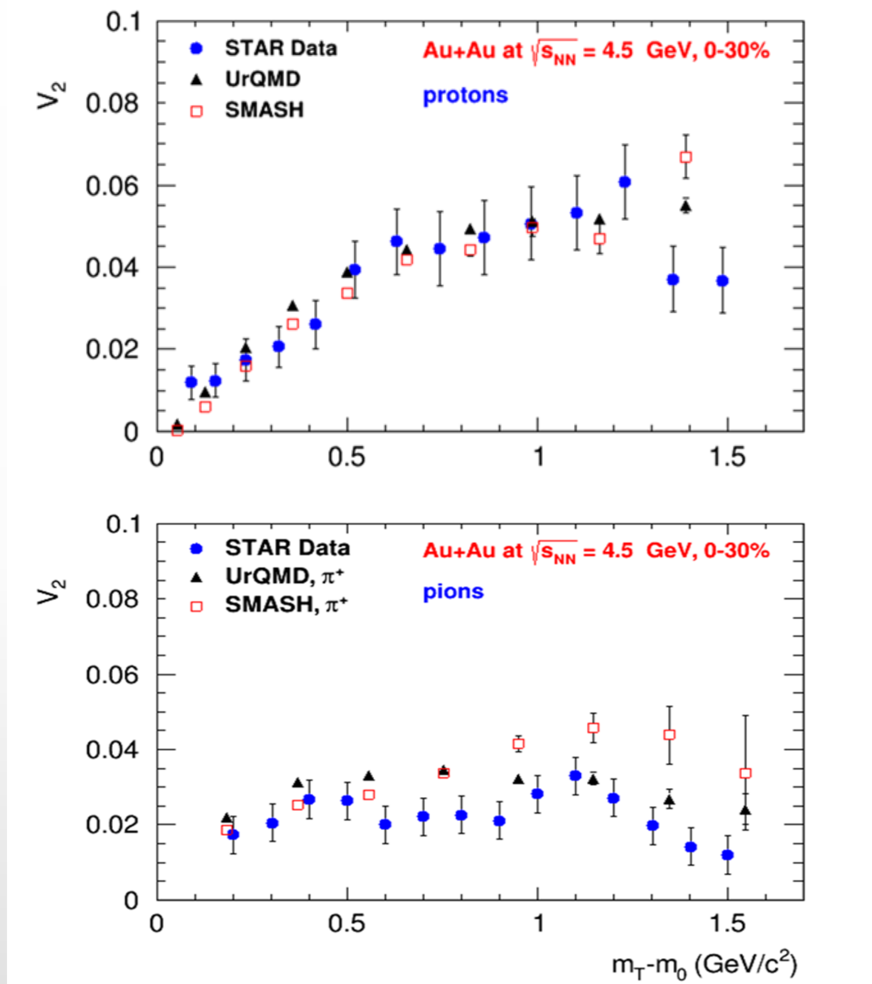
$c_s = c\sqrt{dp/d\varepsilon}$ - speed of sound



- **Strong energy dependence of v_2 at $\sqrt{s_{NN}}$ = 3-11 GeV**
  - $v_2 \approx 0$ at $\sqrt{s_{NN}}$ = 3.3 GeV and negative below

Elliptic Flow (v_2) at NICA energies: Models vs Data





at $\sqrt{s_{NN}} \geq 7.7$ GeV pure string/hadronic cascade models underestimate v_2 – need hybrid models with QGP phase (vHLLE+UrQMD, AMPT with string melting,...) at $\sqrt{s_{NN}} \geq 3\text{-}4.5$ GeV pure hadronic models give similar v_2 signal compared to STAR data

MPD strategy

- MPD strategy – high-luminosity scans in **energy** and **system size** to measure a wide variety of signals:
  - ✓ order of the phase transition and search for the QCD critical point → structure of the QCD phase diagram
  - ✓ hypernuclei and equation of state at high baryon densities → inner structure of compact start, star mergers

- Scans to be carried out using the **same apparatus** in the same configuration/geometry with all the advantages of collider experiments:
  - ✓ maximum phase space, minimally biased acceptance, free of target parasitic effects
  - ✓ correlated systematic effects for different systems and energies → search for non-monotonic behavior of signals

- Continuously develop physical program based on the recent advancements in the field:
  - ✓ identified particle spectra and ratios, collective flow and femtoscopy, production of strangeness and hypernuclei net-proton fluctuations, global polarization of hyperond and spin alignment of vector mesons, dilepton continuum and LVMs, etc.

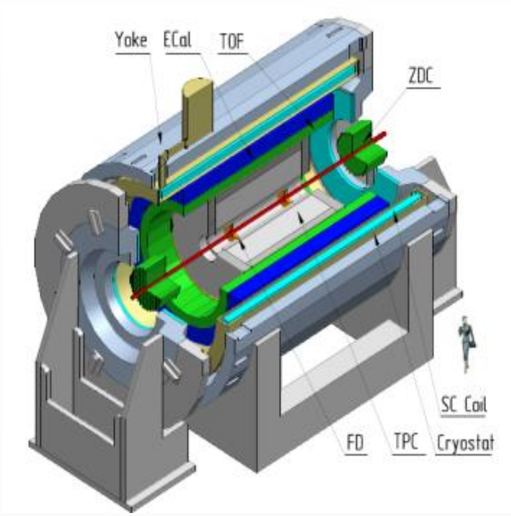
- Work in close cooperation with theoreticians to look for new signals/observables including those unique for the MPD

Physical programs of the MPD ($\sqrt{s_{NN}}$ = 4-11 GeV) and BM@N ($\sqrt{s_{NN}}$ = 2.3-3.5 GeV) are bound and should be realized in close cooperation

International Workshop on "Physics performance studies at NICA“ (NICA-2022), December 13-15, 2022 , ZOOM, http://indico.oris.mephi.ru/event/298/

Multi-Purpose Detector (NICA)

Stage- I

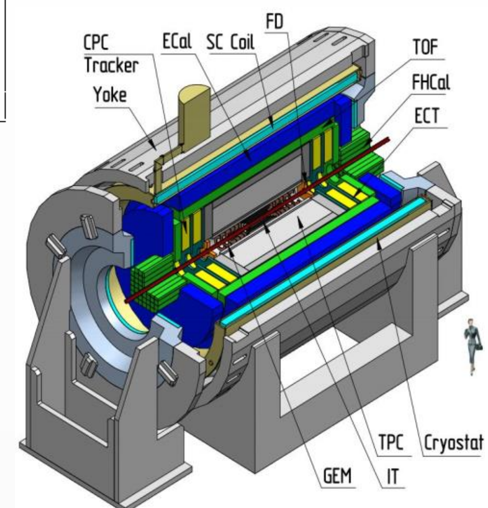


Length	340 cm
Vessel outer radius	140 cm
Vessel inner radius	27 cm
Default magnetic field	0.5 T
Drift gas mixture	90% Ar+10% CH_4
Maximum event rate	7 kHz ($L = 10^{27}$ cm^{-2}s^{-1})

upgrade

($\sqrt{s_{NN}}$ = 4-11 GeV)

Stage- II



+ **ITS** and **forward spectrometers**

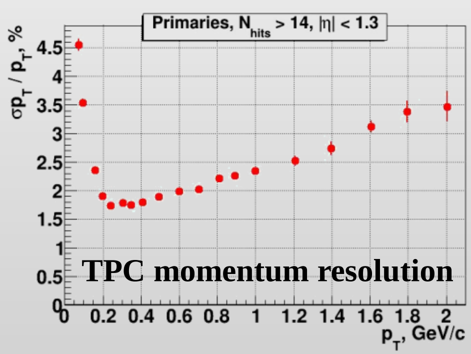
TPC: $|\Delta\varphi| < 2\pi$, $|\eta| \leq 1.6$

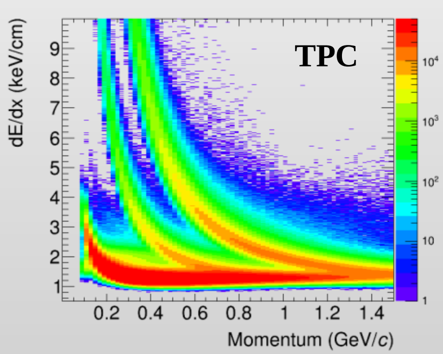
TOF, EMC: $|\Delta\varphi| < 2\pi$, $|\eta| \leq 1.4$

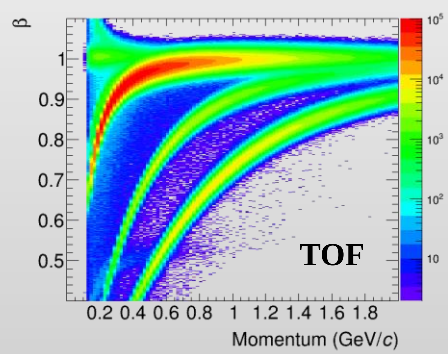
FFD: $|\Delta\varphi| < 2\pi$, $2.9 < |\eta| < 3.3$

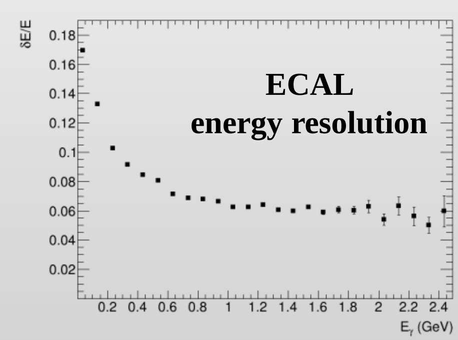
FHCAL: $|\Delta\varphi| < 2\pi$, $2 < |\eta| < 5$

2024?: first run with Bi+Bi @ 9.2 GeV
with luminosity ~ 10^{25} cm^{-2}s^{-1}



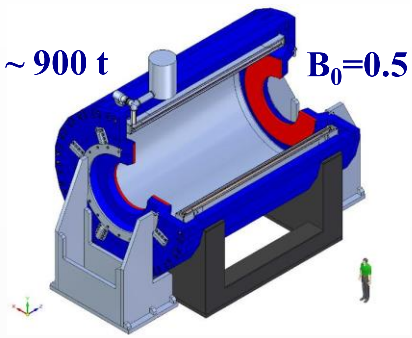






MPD subsystems in production

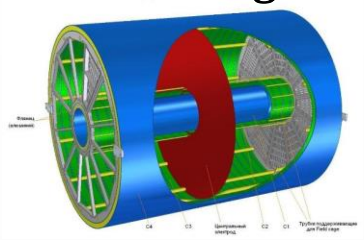
SC Solenoid + Iron Yoke



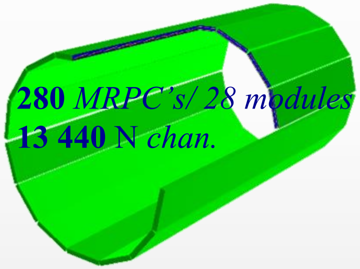
Goal is to cool down and power the magnet + magnetic field measurements in 2023

TPC – central tracking detector

ROCs done
Cyllinders done
Electronics in mass production



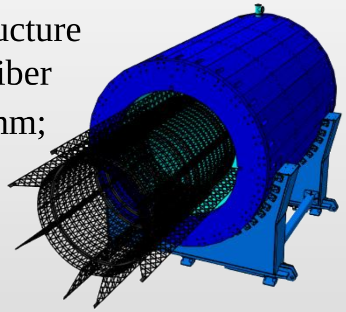
TOF



~ 100% of MRPCs (modules) are ready, cosmic tests ongoing

Support structure

support structure of carbon fiber
sagite ~ **5** mm;
0,13 X_0

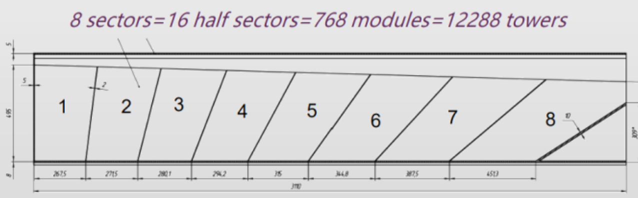


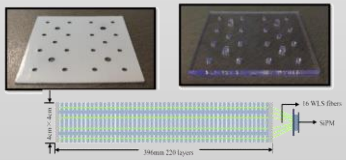
ECAL ~ 100 t

Constructed and delivered

ECAL (projective geometry)

38 400 towers
66-83% of the whole detector will be produced for Stage-I





Pb+Sc "shashlyk"-type towers

See http://mpd.jinr.ru/doc/mpd-tdr/ for details

MPD status and plans

- 2022:
  - ✓ preparation of the SC magnet for cooling
- 2023:
  - ✓ cooling the magnet and MF measurement
  - ✓ installation of the support frame and detectors
- 2024:
  - ✓ MPD commissioning
  - ✓ first run with BiBi@9.2 GeV, ~ 50-100 M events for alignment, calibration and physics
- 2025 and beyond:
  - ✓ Au+Au @ 11 GeV, design luminosity
  - ✓ system size and collision energy scans

- Preparation of the MPD detector and experimental program is ongoing, all activities are continued
- All components of the MPD 1-st stage detector are in advanced state of production (subsystems, support frame, electronics platforms, LV/HV, control systems, cryogenics, cabling, etc.)

Schedule of the MPD-NICA is significantly affected by the current geopolitical situation (suspension of collaboration with CERN and Polish & Czech Republic member institutions, economical sanctions and problems with supplies of many components from western companies). The primary goal to have the MPD commissioned by the first beams at NICA collider is preserved.

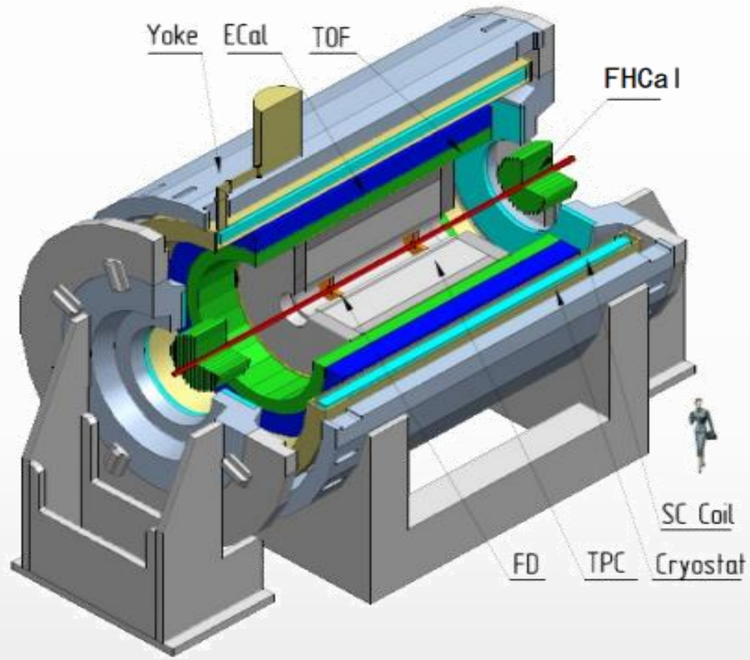
Multi-Purpose Detector (MPD) Collaboration

MPD *International Collaboration was established in **2018***
to construct, commission and operate the detector

10 *Countries, **>450** participants, **33** Institutes and **JINR***

Organization

Acting Spokesperson:	***Victor Riabov***
Deputy Spokesperson:	***Zebo Tang***
Institutional Board Chair:	***Alejandro Ayala***
Project Manager:	***Slava Golovatyuk***



Joint Institute for Nuclear Research*;*
*AANL, Yerevan, **Armenia;***
*University of Plovdiv, **Bulgaria;***
*Tsinghua University, Beijing, **China**;*
*USTC, Hefei, **China**;*
*Huzhou University, Huizhou, **China**;*
*Institute of Nuclear and Applied Physics, CAS, Shanghai, **China**;*
*Central China Normal University, **China**;*
*Shandong University, Shandong, **China**;*
*IHEP, Beijing, **China**;*
*University of South China, **China**;*
*Three Gorges University, **China**;*
*Institute of Modern Physics of CAS, Lanzhou, **China**;*
*Tbilisi State University, Tbilisi, **Georgia**;*
*Benemérita Universidad Autónoma de Puebla, **Mexico**;*
*Centro de Investigación y de Estudios Avanzados, **Mexico**;*
*Instituto de Ciencias Nucleares, UNAM, **Mexico**;*
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*Institute of Physics and Technology, **Mongolia**;*

*Belgorod National Research University, **Russia**;*
*INR RAS, Moscow, **Russia**;*
*MEPhI, Moscow, **Russia**;*
*Moscow Institute of Science and Technology, **Russia**;*
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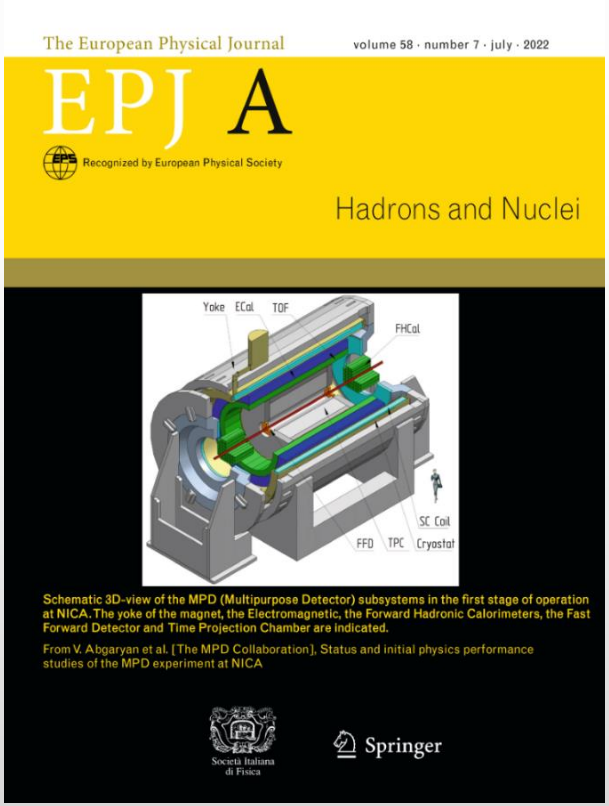
*Plekhanov Russian University of Economics, Moscow, **Russia**;*
*St. Petersburg State University, **Russia;***
*SINP, Moscow, **Russia**;*
*PNPI, Gatchina**, Russia**;*
*Vinča Institute of Nuclear Sciences**, Serbia**;*
*Pavol Jozef Šafárik University, Košice, **Slovakia***

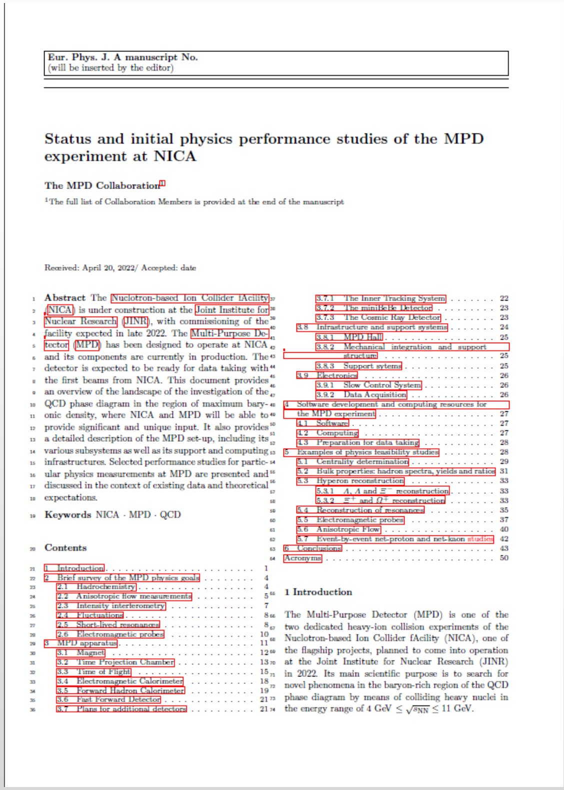
NICA

Collaboration activity

- Many ongoing construction works, theoretical and physics feasibility studies
- MPD publications: over 200 in total for hardware, software and physics studies (SPIRES)
- MPD @ conferences: presented at all major conferences in the field
- First collaboration paper recently published EPJA (~ 50 pages): Eur.Phys.J.A 58 (2022) 7, 140

<u>Status and initial physics performance studies of the MPD experiment at NICA</u>





Eur. Phys. J. A manuscript No.
(will be inserted by the editor)

Status and initial physics performance studies of the MPD experiment at NICA

The MPD Collaboration[1]

[1]The full list of Collaboration Members is provided at the end of the manuscript

Received: April 20, 2022/ Accepted: date

Abstract The Nuclotron-based Ion Collider fAcility (NICA) is under construction at the Joint Institute for Nuclear Research (JINR), with commissioning of the facility expected in late 2022. The Multi-Purpose Detector (MPD) has been designed to operate at NICA and its components are currently in production. The detector is expected to be ready for data taking with the first beams from NICA. This document provides an overview of the landscape of the investigation of the QCD phase diagram in the region of maximum baryonic density, where NICA and MPD will be able to provide significant and unique input. It also provides a detailed description of the MPD set-up, including its various subsystems as well as its support and computing infrastructures. Selected performance studies for particular physics measurements at MPD are presented and discussed in the context of existing data and theoretical expectations.

Keywords NICA · MPD · QCD

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1 Introduction

The Multi-Purpose Detector (MPD) is one of the two dedicated heavy-ion collision experiments of the Nuclotron-based Ion Collider fAcility (NICA), one of the flagship projects, planned to come into operation at the Joint Institute for Nuclear Research (JINR) in 2022. Its main scientific purpose is to search for novel phenomena in the baryon-rich region of the QCD phase diagram by means of colliding heavy nuclei in the energy range of 4 GeV $\leq \sqrt{s_{NN}} \leq$ 11 GeV.

Collaboration activity at ICPPA 2022

Many ongoing construction works, theoretical and physics feasibility studies have been presented:

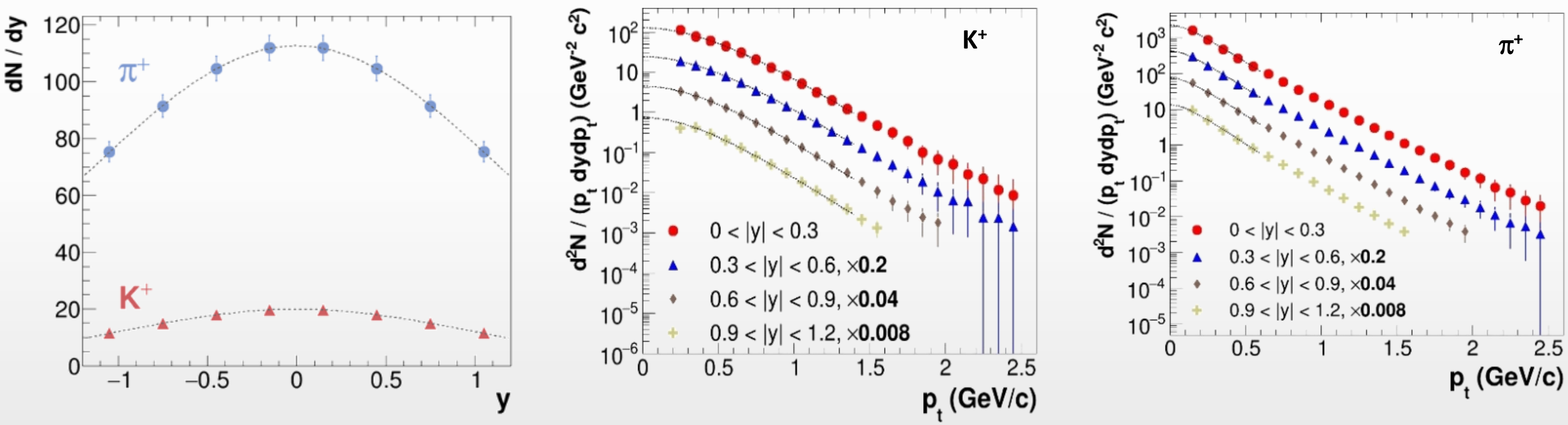
- 01.12, December 1, About an accuracy of ECal/MPD calibration with cosmic muons, V. Kulikov, (NRC "Kurchatov institute“)
- 01.12, Development of ASICs for experiments at NICA, E. Atkin , (NRNU MEPhI)
- 02.12, MPD TPC status, S. Movchan (JINR, Dubna)
- 02.12, Feasibility study of hypernuclei production at NICA/MPD, V. Kolesnikov (JINR, Dubna)
- 02.12, Status of the Time of Flight System of the MPD experiment at the NICA, V. Baryshnikov (JINR,Dubna)
- 02.12. Study of two particles correlations in heavy ion collisions at NICA energies, O. Rogachevsky (JINR, Dubna)
- 02.12 Midrapidity cluster formation within PHQMD approach, V. Kireyeu (JINR, Dubna)
- 02.12 Data acquisition system of the TPC/MPD detector of the NICA project, S. Vereschagin (JINR, Dubna)
- 02.12 Prospects for the measurement of electromagnetic probes in heavy-ion collisions at NICA energies, V. Riabov (PNPI NRC KI, JINR, MEPhI)
- 02.12 Using Machine Learning for Particle Identification in MPD, G. Tolkachev (NRNU MEPhI, JINR)
- 02.12 Investigation of the correlation between mean transverse momentum and anisotropic flow at NICA energy range, D. Idrisov, (NRNU MEPhI)

Identified light hadrons

- Probe freeze-out conditions, collective expansion, hadronization mechanisms, strangeness production ("horn" for K/π), parton energy loss, etc. with particles of different masses, quark contents/counts
- Charged hadrons: large and uniform acceptance + excellent PID capabilities of TPC and TOF

0-5% central AuAu@9 GeV (PHSD), 5 M events → full event/detector simulation and reconstruction

Phys.Part.Nucl. 53 (2022) 2, 203-206

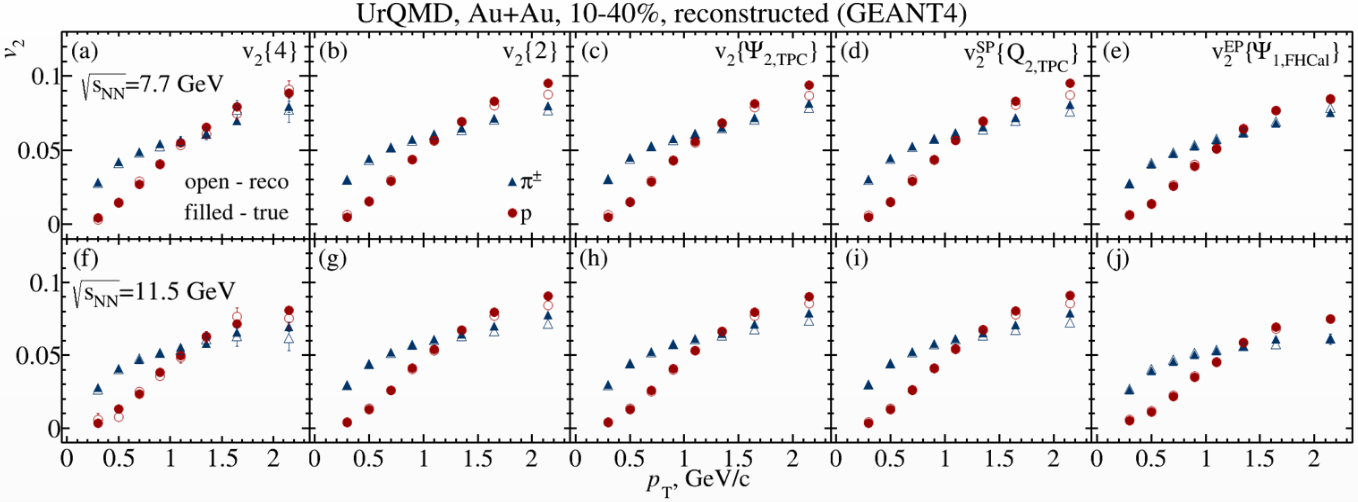


✓ sample ~ 70% of the π/K/p production in the full phase space

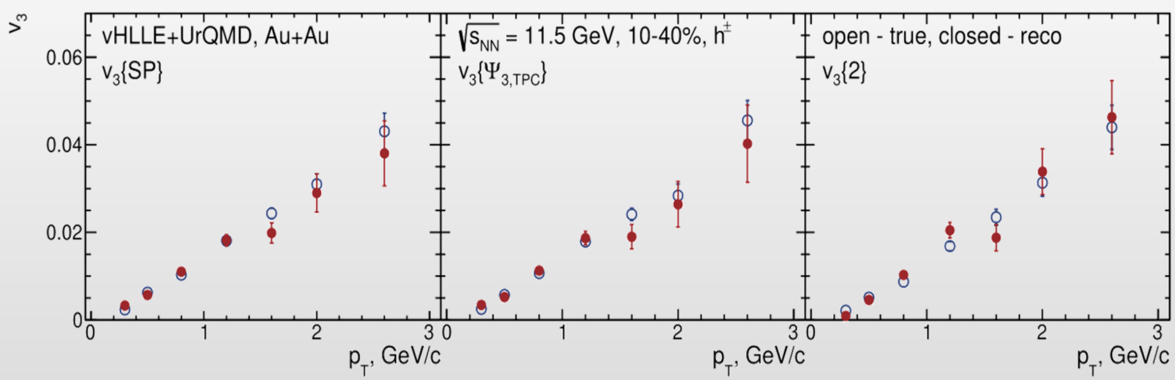
✓ hadron spectra are measured from $p_T \sim 0.1$ GeV/c

MPD performance: v_2 for π/p, v_3 for $h^{\pm}$

AuAu@7.7 GeV (UrQMD), 15 M events → full event/detector simulation and reconstruction



AuAu@11.5 GeV (vHLLE + UrQMD), 15 M events → full event/detector simulation and



- Reconstructed and generated v_2 of pions and protons and v_3 of charged hadrons are in good agreement
- Models show that higher harmonic ripples are more sensitive to the existence of a QGP phase

Reconstruction of strange baryons

AuAu@11 GeV (PHSD), 10 M events → full event/detector simulation and reconstruction

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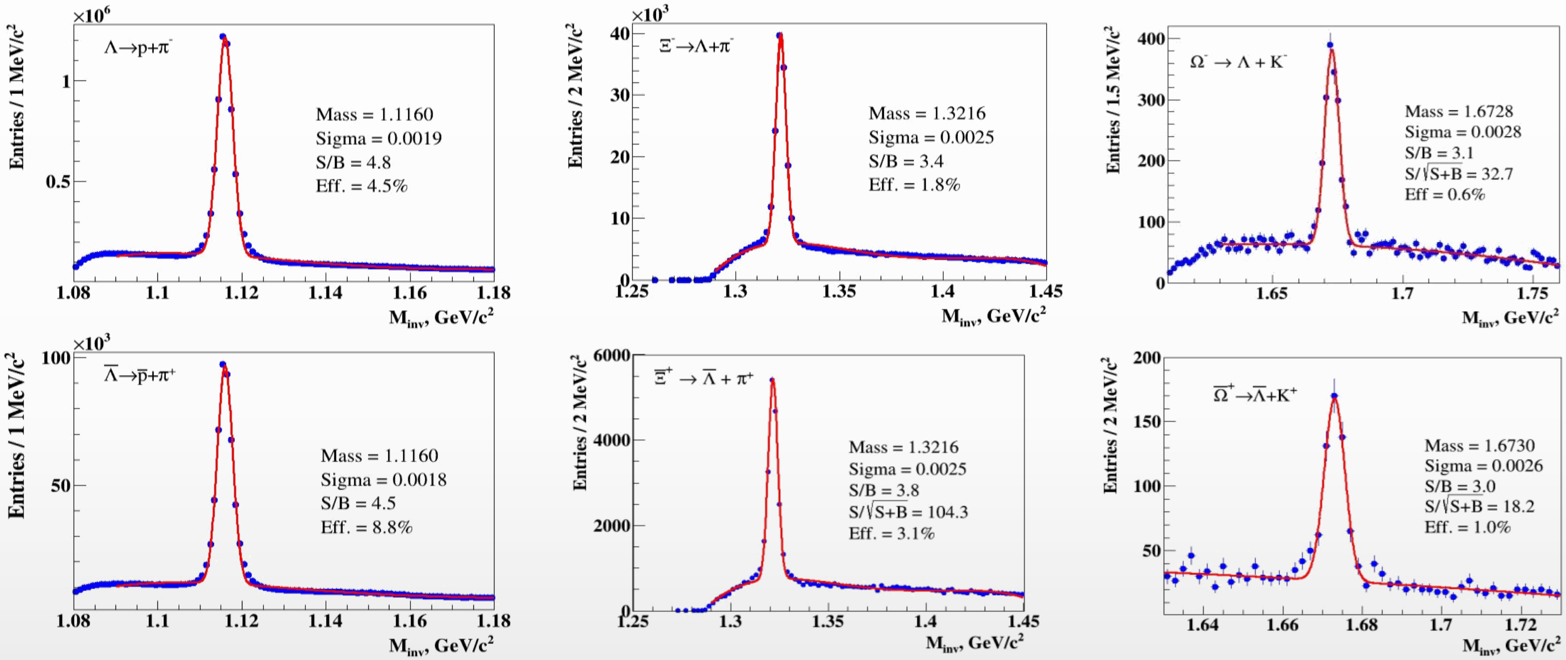
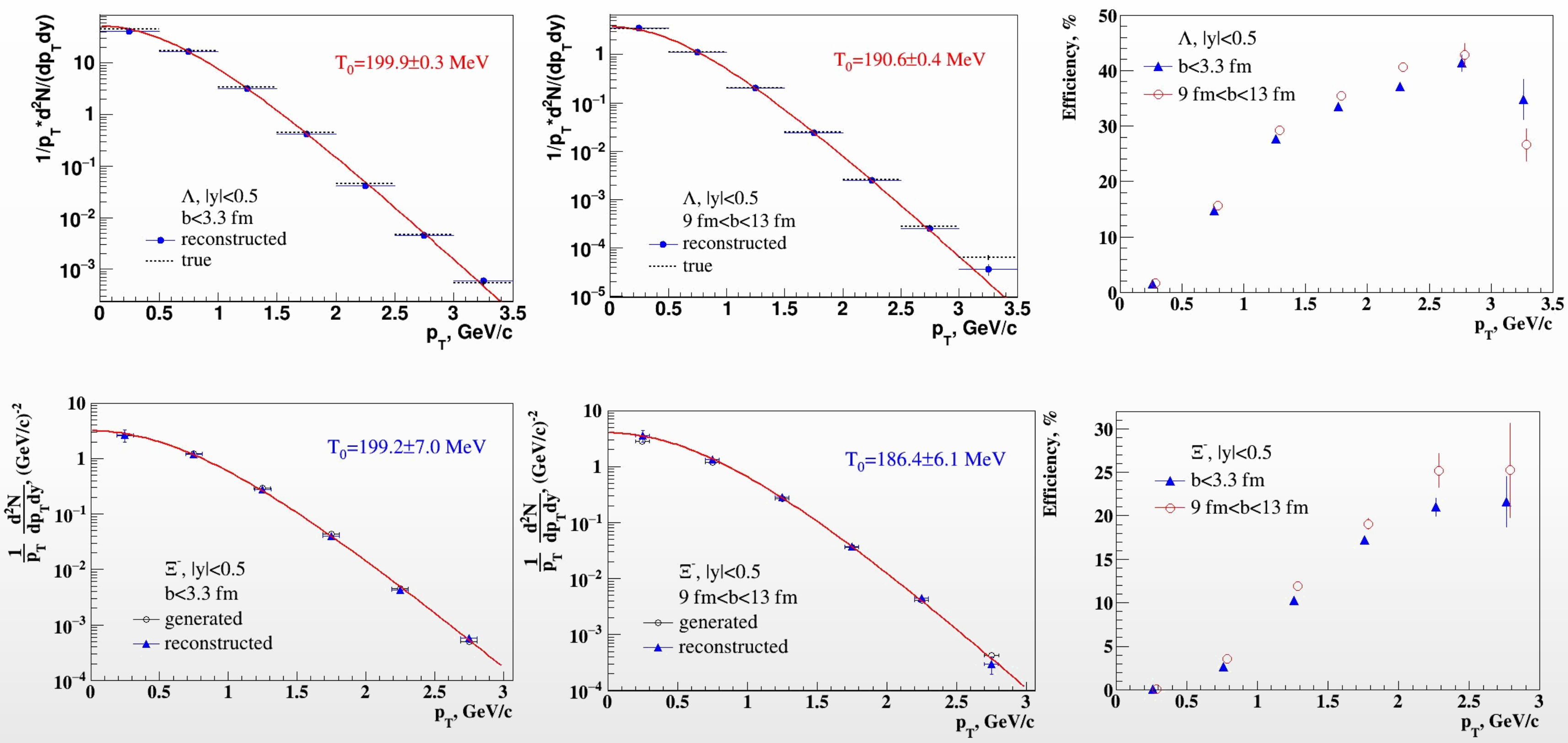


❖ Strange baryons can be reconstructed with good S/B ratios using charged hadron identification in the TPC&TOF and different decay topology selections

Measurement of strange baryons

❖ Reconstructed spectra are consistent with the generated ones

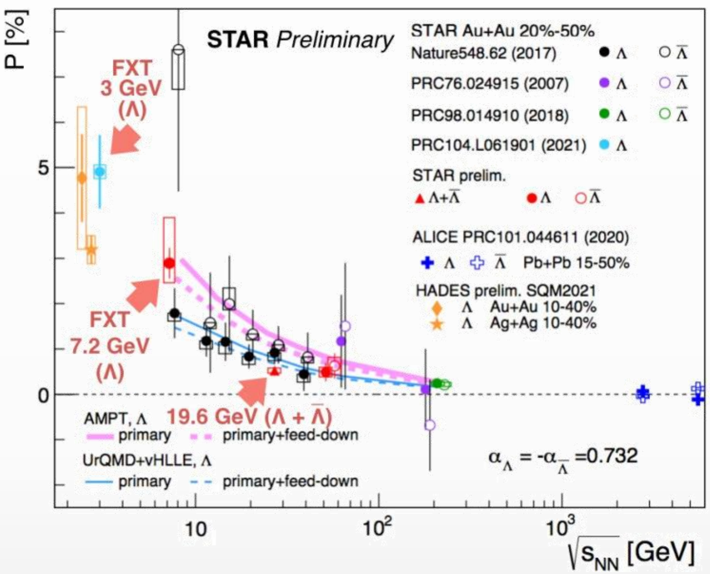


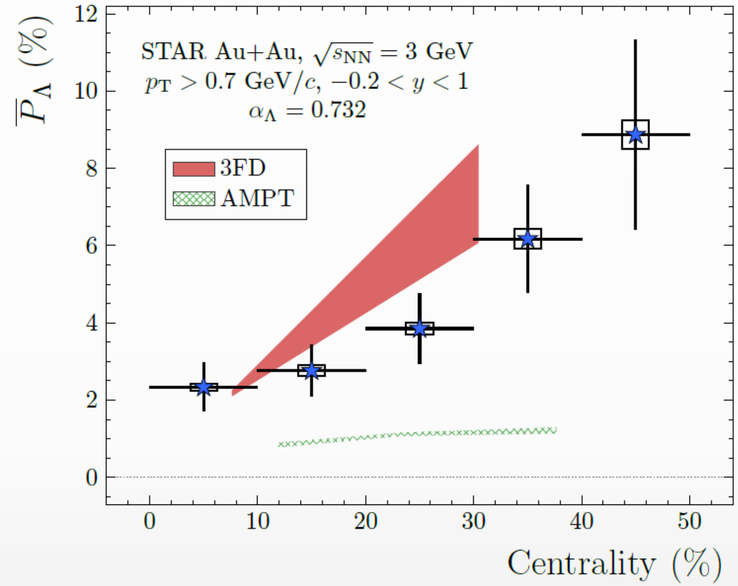
MPD has capabilities to measure production of charged π/K/p and (multi)strange baryons in pp, p-A and A-A collisions using charged hadron identification in TPC&TOF and different decay topology selections

Global hyperon polarization

❖ Global hyperon polarization measurements in mid-central A+A collisions at $\sqrt{s_{NN}}$= 3-5000 GeV

STAR, Phys.Rev.C, 104(6):L061901, 2021





❖ Global polarization of hyperons experimentally observed, decreases with $\sqrt{s_{NN}}$

❖ Hint for a Λ-$\bar{\Lambda}$ difference, magnetic field, $P_\Lambda \simeq \frac{1}{2}\frac{\omega}{T} + \frac{\mu_\Lambda B}{T}$, $P_{\bar{\Lambda}} \simeq \frac{1}{2}\frac{\omega}{T} - \frac{\mu_\Lambda B}{T}$?

❖ Feed down from Σ(1385) → Λπ, Σ^0 →Λγ; Ξ→Λπ reduces polarization by ~ 10-20%

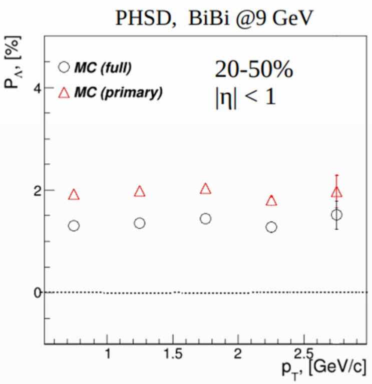
❖ Energy dependence of global polarization is reproduced by AMPT, 3FD, UrQMD+vHLLE

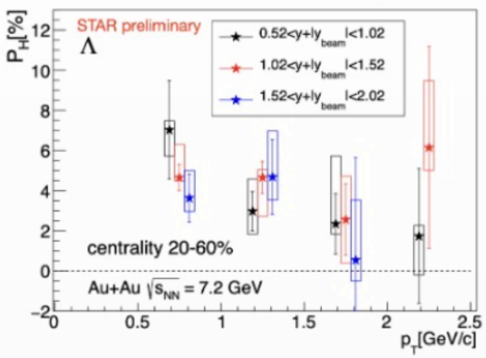
❖ AMPT with partonic transport strongly underestimates measurements at $\sqrt{s_{NN}}$ = 3 GeV → hadron gas?

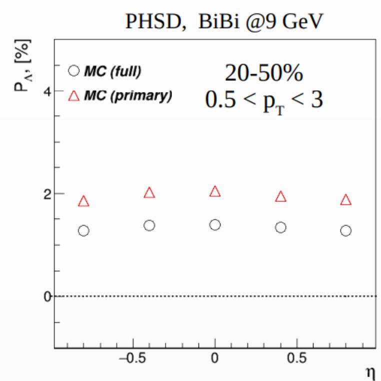
MPD: extra points in the energy range 3-10 10 GeV with small uncertainties; centrality, p_T and rapidity dependence of polarization not only for Λ, but other (anti)hyperons (Λ, Σ, Ξ)

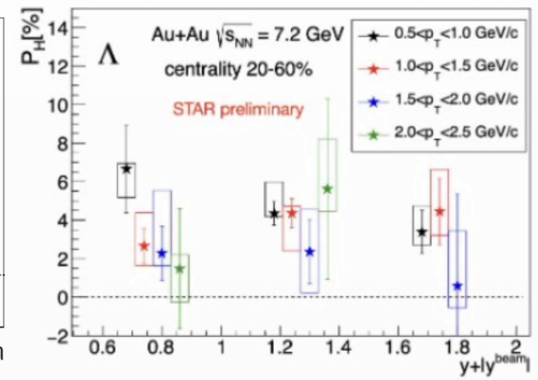
Measurement of global polarization

- BiBi@9.2 GeV (PHSD), ~1 M events → full event/detector simulation and reconstruction
- Global hyperon polarization (thermodynamical Becattini approach [1]) by the event generator
  → reproduce at generator level basic features measured by STAR

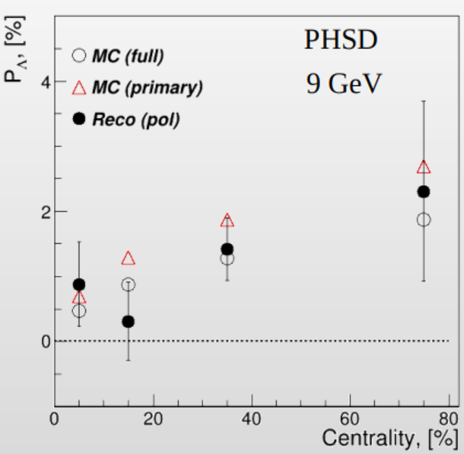








- Reconstruction of Λ global polarization with 1M sampled AuAu@9 events (work in progress):



- Measured polarization is consistent with the generated one
- First global polarization measurements for $\Lambda/\bar{\Lambda}$ will be possible with ~ 10M data sampled events

[1] F. Becattini, V. Chandra, L. Del Zanna, E. Grossi, Ann. Phys. 338 (2013) 32

Short-lived resonances

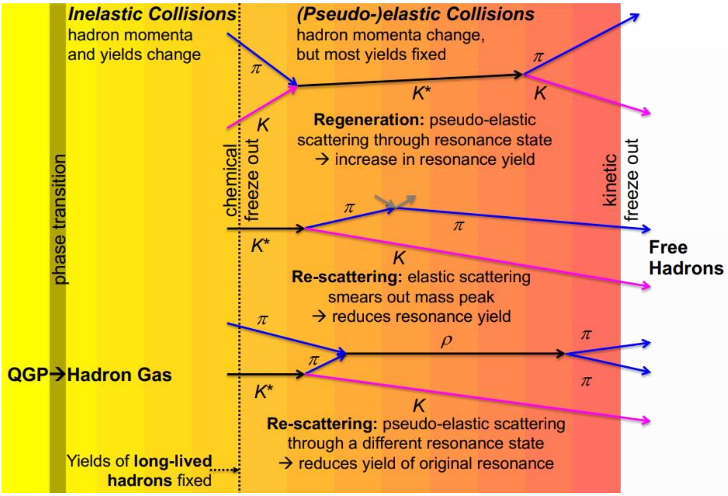
❖ Resonances are best suited to probe density and lifetime of the late hadronic phase of HI collisions

increasing lifetime →

	$\rho(770)$	$K^*(892)$	$\Sigma(1385)$	$\Lambda(1520)$	$\Xi(1530)$	$\phi(1020)$
$c\tau$ (fm/c)	1.3	4.2	5.5	12.7	21.7	46.2
$\sigma_{rescatt}$	$\sigma_\pi\sigma_\pi$	$\sigma_\pi\sigma_K$	$\sigma_\pi\sigma_\Lambda$	$\sigma_K\sigma_p$	$\sigma_\pi\sigma_\Xi$	$\sigma_K\sigma_K$

Final state yields of resonances depend on:

resonance yields at chemical freeze-out
lifetime of the resonance and the hadronic phase
type and scattering cross sections of daughter particles



❖ Suppression of short-lived ρ^0, $K^*(892)^0$, $\Sigma(1385)^\pm$ and $\Lambda(1520)$ resonances was observed in central A+A collisions at SPS, RHIC and LHC → dominance of rescattering over regeneration → consistent with existence of a long enough hadronic phase → hadronic phase lifetime ~ 10 fm/c

❖ Hadronic phase affects most of observables measured in the final state (flow, correlations, yields, etc.)

❖ Measurements for resonances are vital to cross check the hadronic phase models

❖ Only models with validated hadronic phase afterburners can be used for comparison with real data to infer properties of the early partonic phase of heavy-ion collisions

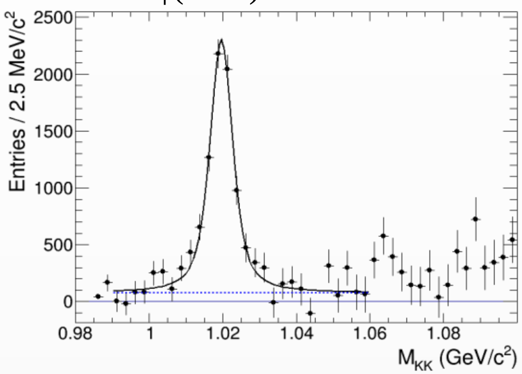
Reconstruction of resonances

BiBi@9.2 GeV (UrQMD), 10 M events→ full event/detector simulation and reconstruction

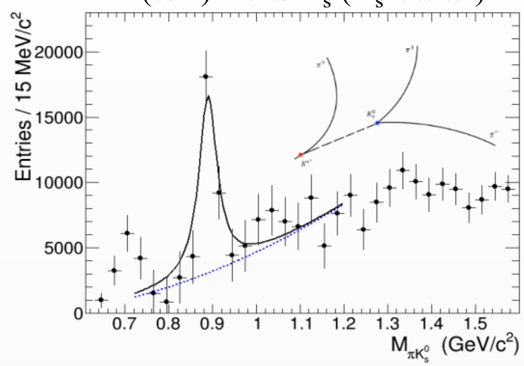
Invariant mass distributions after mixed-event background subtraction

Phys.Scripta 96 (2021) 6, 064002

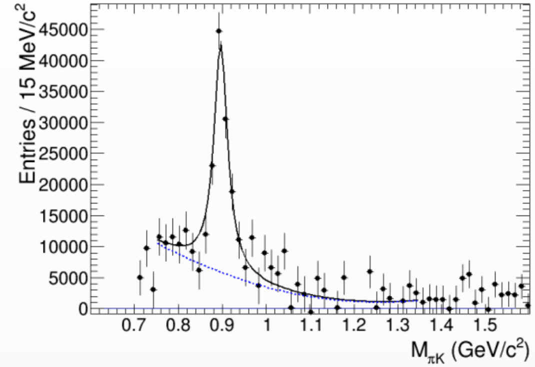
$\phi(1020) \to K^+K^-$



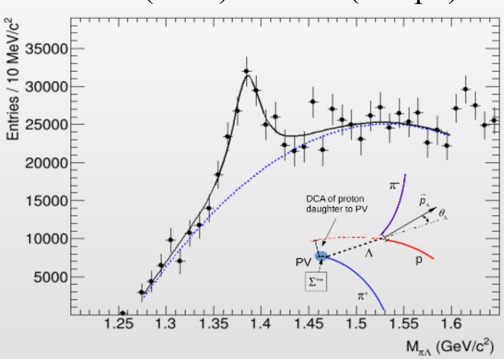
$K^*(892)^\pm \to \pi^\pm K_s$ ($K_s \to \pi^+\pi^+$)



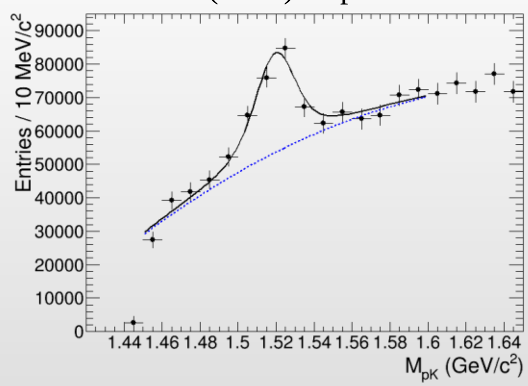
$K^*(892)^0 \to \pi^\pm K^\pm$



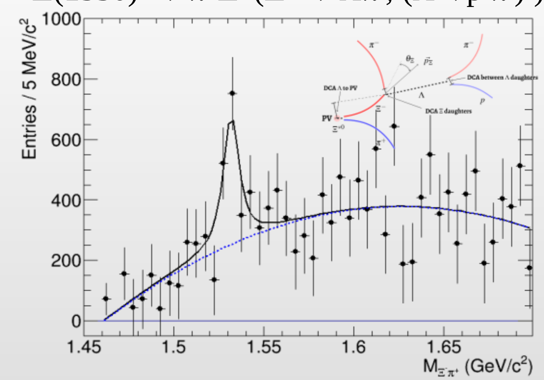
$\Sigma(1385)^\pm \to \pi^\pm\Lambda$ ($\Lambda \to p\pi$)



$\Lambda(1520) \to pK^-$



$\Xi(1530)^0 \to \pi^+\Xi^-$ ($\Xi^- \to \Lambda\pi^-$, ($\Lambda \to p\,\pi^-$))



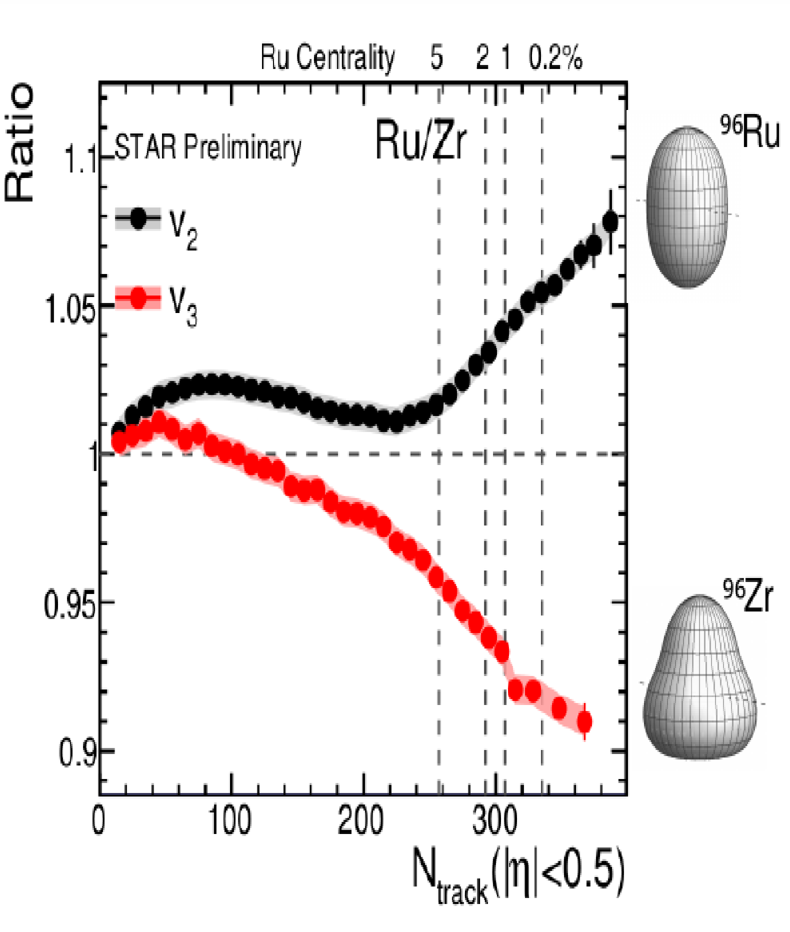
❖ MPD can reconstruct resonance signals using combined charged particle identification in TPC+TOF and secondary vertex topology selections for weakly decaying daughters

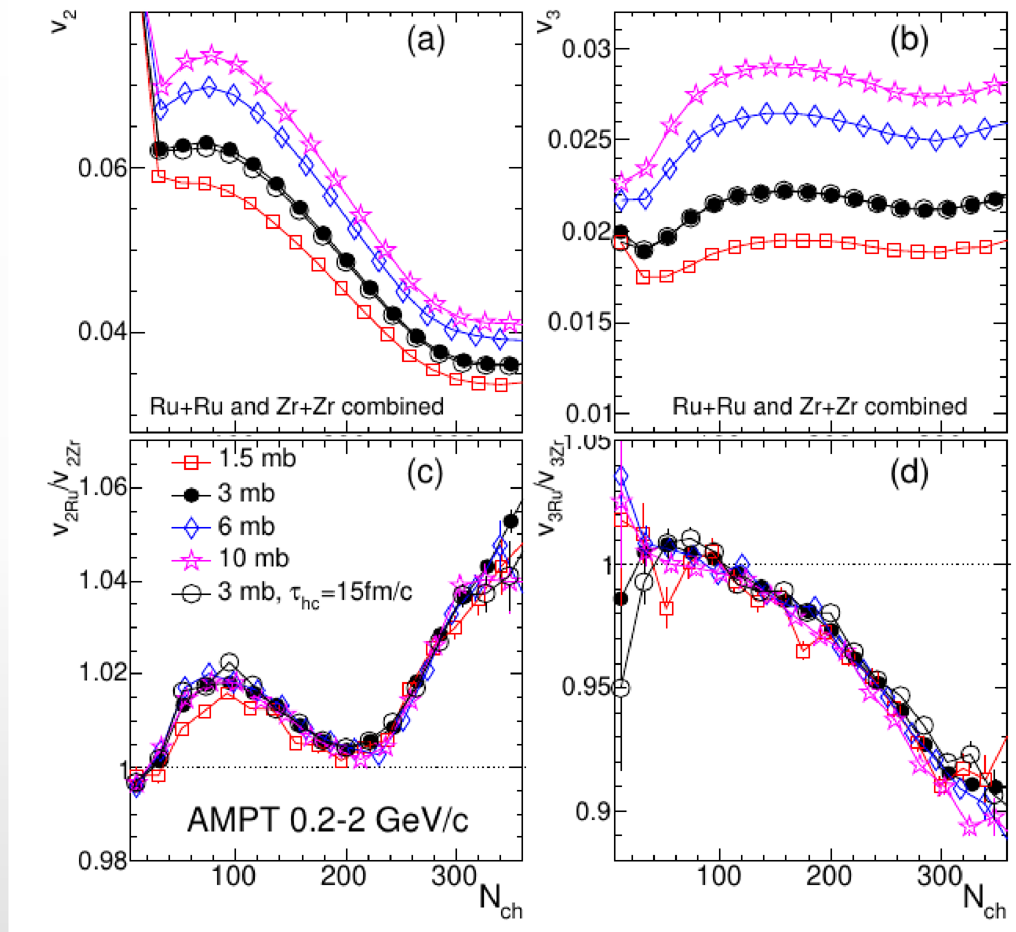
Summary

- ❖ Preparation of the MPD detector and experimental program is ongoing, all activities are continued
- ❖ All components of the MPD 1-st stage detector are in advanced state of production
- ❖ Commissioning of the MPD Stage-I detector and the first data taking with BiBi@9.2 in 2024
- ❖ Further program will be driven by the physics demands and NICA capabilities

NICA

2022: Nuclear structure via V_n ratio





Phys.Rev.C 105 (2022) 1, 014901 • e-Print: 2109.00131

The V_n ratio for isobars – not affected by final state – is a good tool for precision studies of nuclear shapes.

STAR BES-I and BES-II Data Sets

Au+Au Collisions at RHIC

Collider Runs

	$\sqrt{s_{NN}}$ (GeV)	#Events	μ_B	y_{beam}	run
1	200	380 M	25 MeV	5.3	Run-10, 19
2	62.4	46 M	75 MeV		Run-10
3	54.4	1200 M	85 MeV		Run-17
4	39	86 M	112 MeV		Run-10
5	27	585 M	156 MeV	3.36	Run-11, 18
6	19.6	595 M	206 MeV	3.1	Run-11, 19
7	17.3	256 M	230 MeV		Run-21
8	14.6	340 M	262 MeV		Run-14, 19
9	11.5	157 M	316 MeV		Run-10, 20
10	9.2	160 M	372 MeV		Run-10, 20
11	7.7	104 M	420 MeV		Run-21

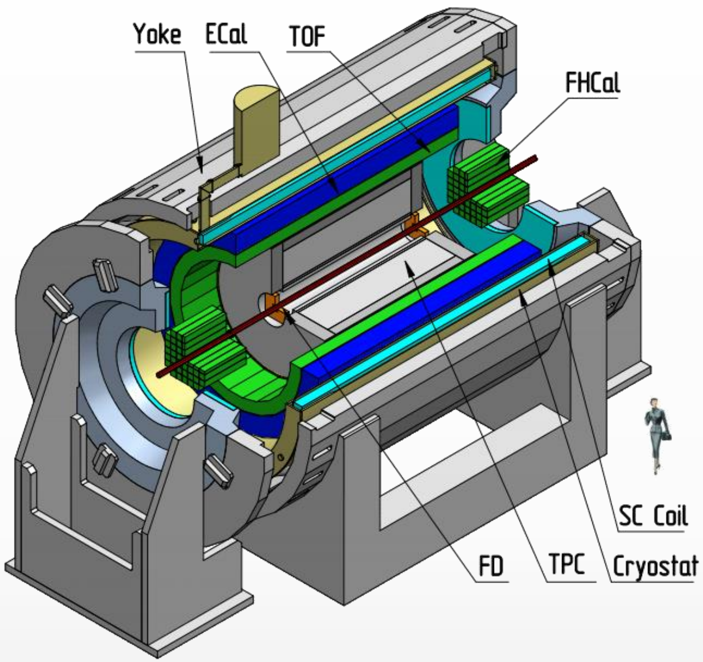
Fixed-Target Runs

	$\sqrt{s_{NN}}$ (GeV)	#Events	μ_B	y_{beam}	run
1	13.7 (100)	50 M	280 MeV	-2.69	Run-21
2	11.5 (70)	50 M	320 MeV	-2.51	Run-21
3	9.2 (44.5)	50 M	370 MeV	-2.28	Run-21
4	7.7 (31.2)	260 M	420 MeV	-2.1	Run-18, 19, 20
5	7.2 (26.5)	470 M	440 MeV	-2.02	Run-18, 20
6	6.2 (19.5)	120 M	490 MeV	1.87	Run-20
7	5.2 (13.5)	100 M	540 MeV	-1.68	Run-20
8	4.5 (9.8)	110 M	590 MeV	-1.52	Run-20
9	3.9 (7.3)	120 M	633 MeV	-1.37	Run-20
10	3.5 (5.75)	120 M	670 MeV	-1.2	Run-20
11	3.2 (4.59)	200 M	699 MeV	-1.13	Run-19
12	3.0 (3.85)	2000 M	750 MeV	-1.05	Run-18, 21

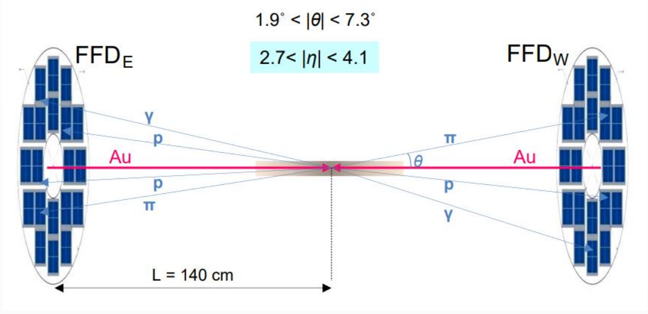
Precision data to map the QCD phase diagram

$3 < \sqrt{s_{NN}} < 200$ GeV; $750 < \mu_B < 25$ MeV

Trigger system

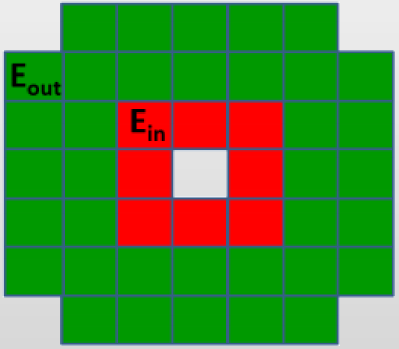


- FFD (Fast Forward Detector):
  - ✓ fast event triggering
  - ✓ T_0 for time measurements in the TOF and ECAL



- FHCAL (Forward Hadron Calorimeter) – detector for event centrality and reaction plane measurements with potential for event triggering

- MPD challenges at NICA energies:
  - ✓ low multiplicity of particles produced in heavy-ion collisions
  - ✓ particles are not ultra-relativistic (even the spectator protons)
- Forward detectors are in advanced state of production (electronics and integration)

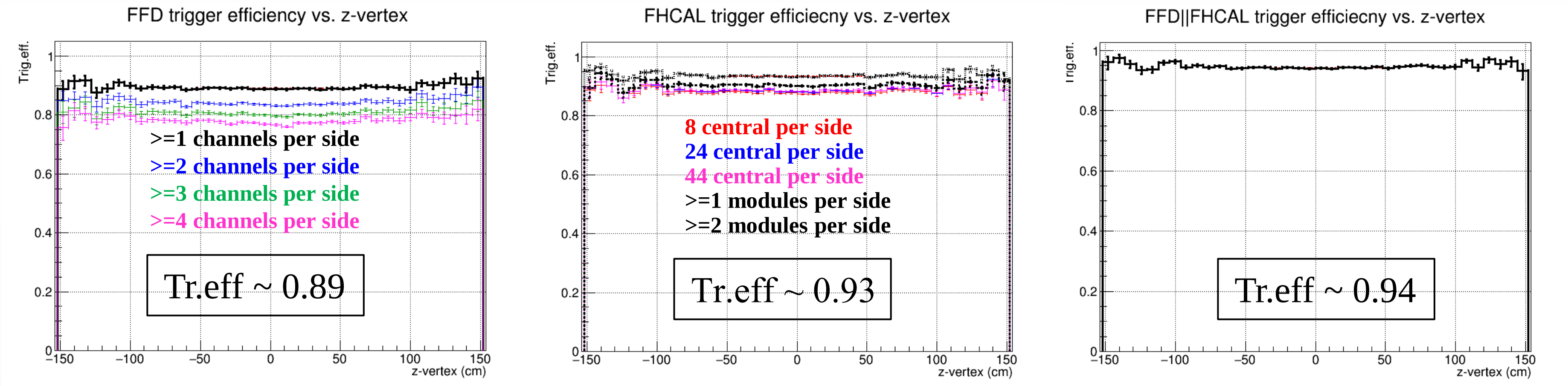


$2 < |\eta| < 5$

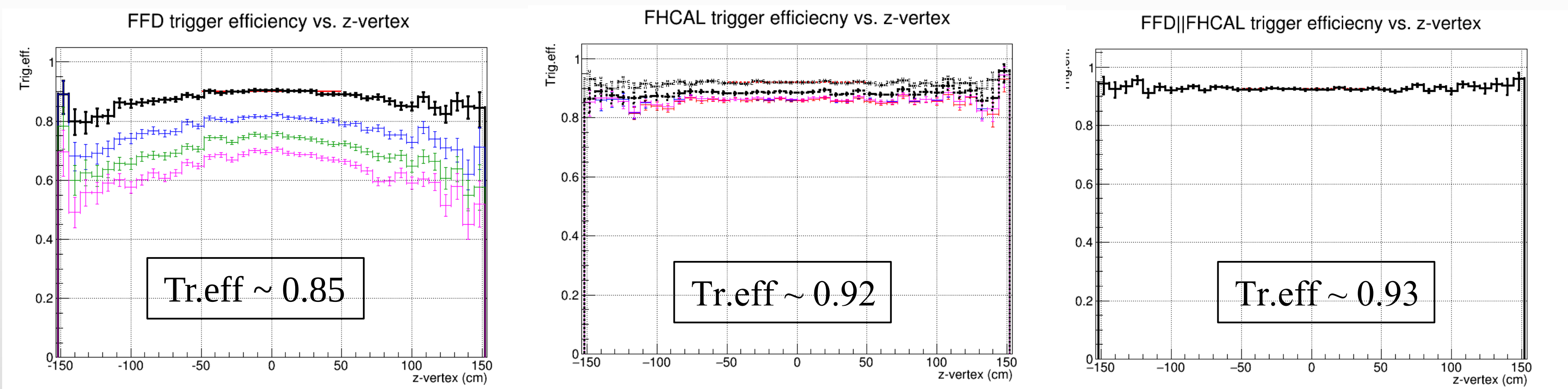
$\sim 1x1\ m^2$

Trigger efficiency vs. z-vertex

DCM-QGSM-SMM, BiBi@9.2



PHQMD, BiBi@9.2



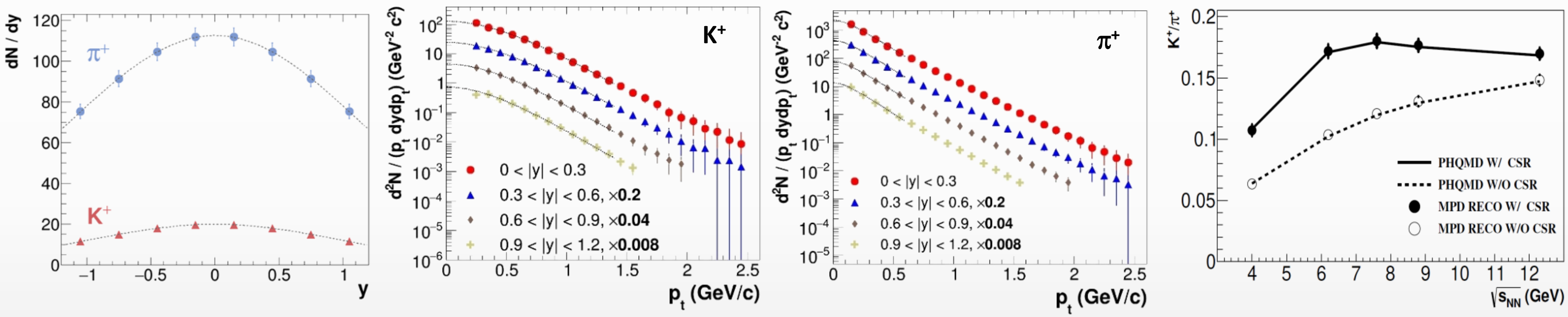
- Efficiency is 80-95% in different trigger configuration; approximately the same numbers for two generators
- FFD efficiency shows z-vertex dependence for PHQMD; FHCAL and FFD||FHCAL does not

Identified hadron spectra

- Particle spectra, yields and ratios probe bulk properties of the fireball and flow
- Advantage of the MPD is in large and uniform acceptance, excellent PID capabilities using combined analysis of TPC (dE/dx) and TOF signals

- 0-5% central AuAu@9 GeV (PHSD, with partonic phase and chiral symmetry restoration effects):

Phys.Part.Nucl. 53 (2022) 2, 203-206



- ✓ MPD samples ~ 70% of the π/K/p production in the full phase space
- ✓ hadron spectra are measured from 0.2 MeV/c to 2.5 GeV/c in transverse momentum with the TPC&TOF
- ✓ unmeasured hadron yields at low p_T and large values of rapidity can be extracted from extrapolation of the measured spectra (B-W for p_T spectra and Gaussian for rapidity spectra in exampled above)

- Ability to cover full energy range of the “horn” with consistent acceptance across different collision systems and collision energies

Weak decays of strange baryons - I

- Strangeness production probes the EoS, phase boundaries and onset of deconfinement
- Antibaryon-to-baryon ratios at intermediate momenta are sensitive to CEP (a falling trend in contrast to a constant behavior in the scenario without CEP)
- AuAu@11 GeV (PHSD):

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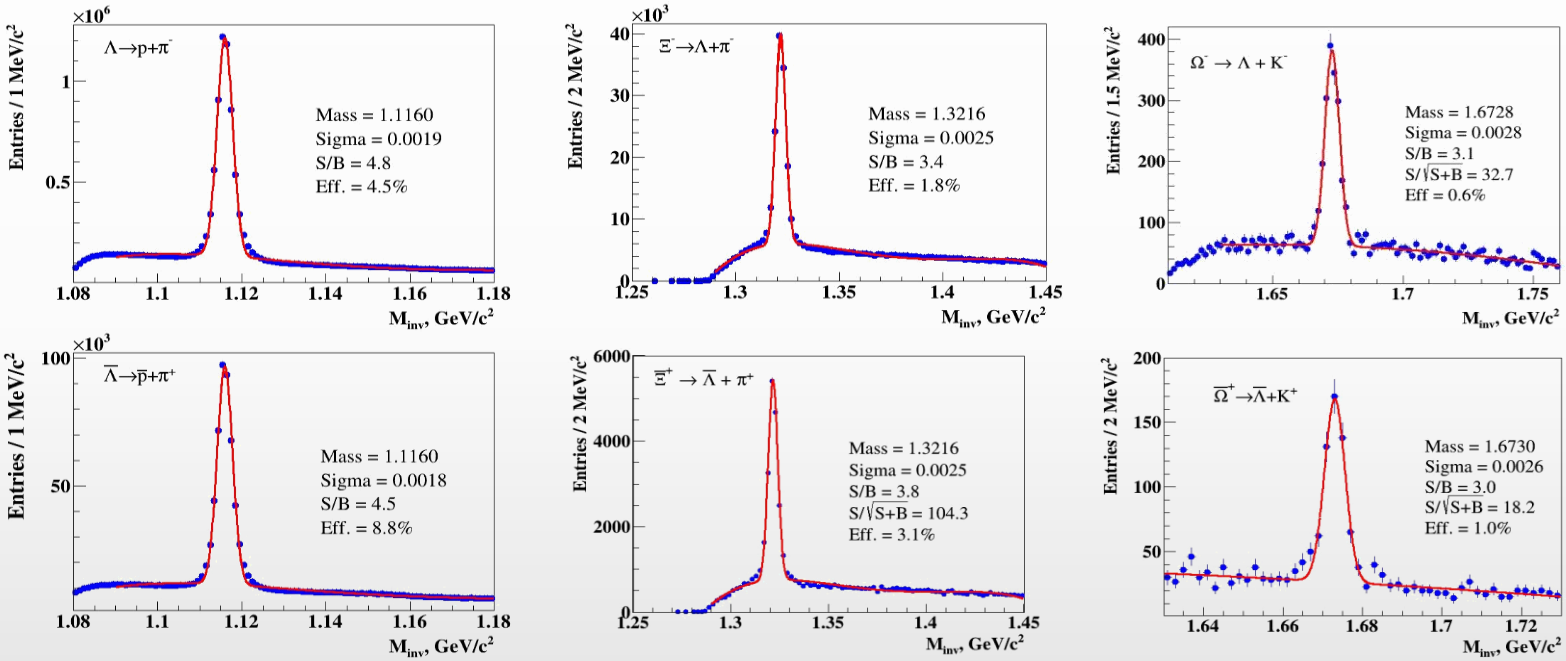

- ✓ Strange baryons can be reconstructed with good S/B ratios using charged hadron identification in the TPC&TOF and different decay topology selections
- ✓ Relative yields of the baryons for ~ 500 M sampled events:

Λ	anti-Λ	Ξ⁻	anti-Ξ⁺	Ω⁻	anti–Ω⁺
$3 \cdot 10^8$	$3.5 \cdot 10^6$	$1.5 \cdot 10^6$	$8.0 \cdot 10^4$	$7 \cdot 10^4$	$1.5 \cdot 10^4$

BACKUP