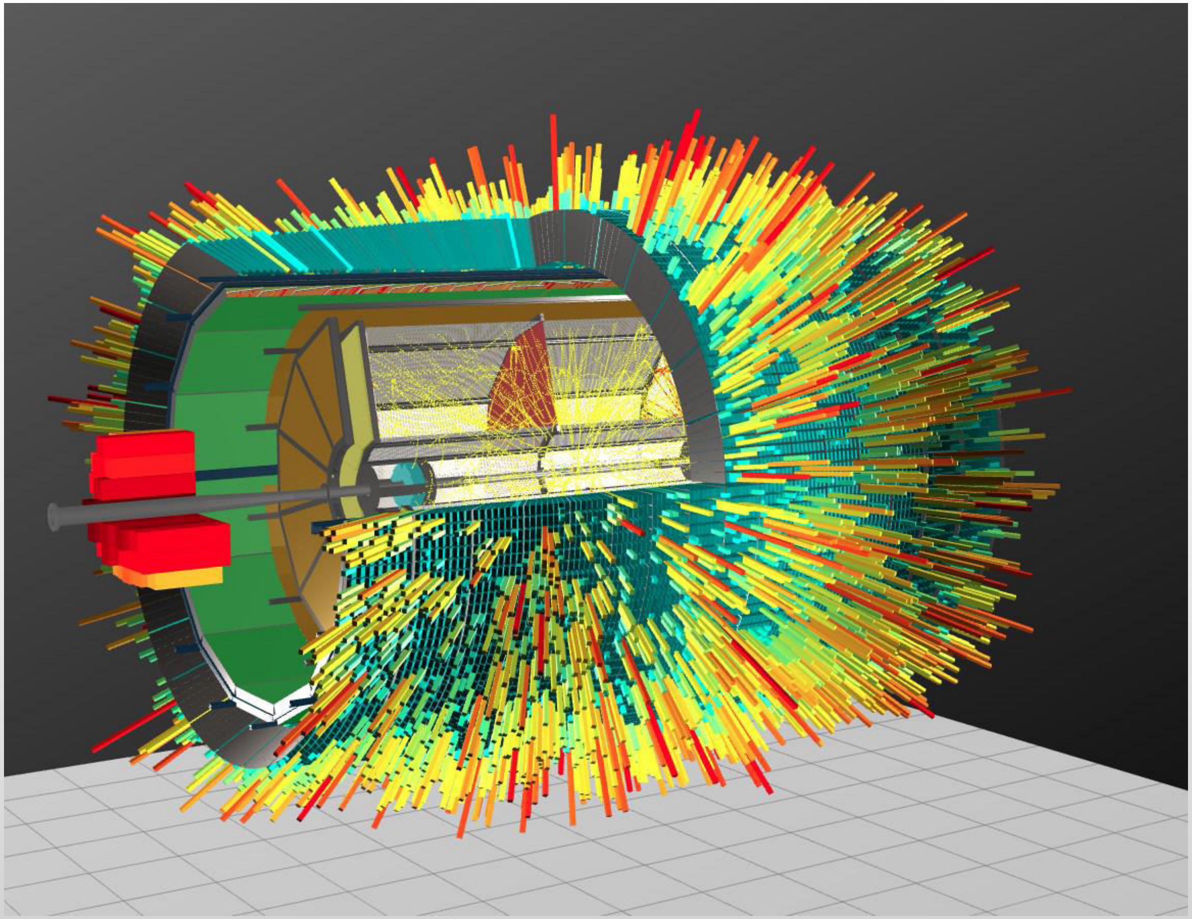
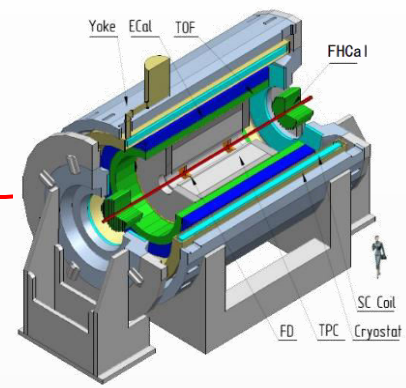
Implementation of the MPD project

V. Riabov for the MPD Collaboration



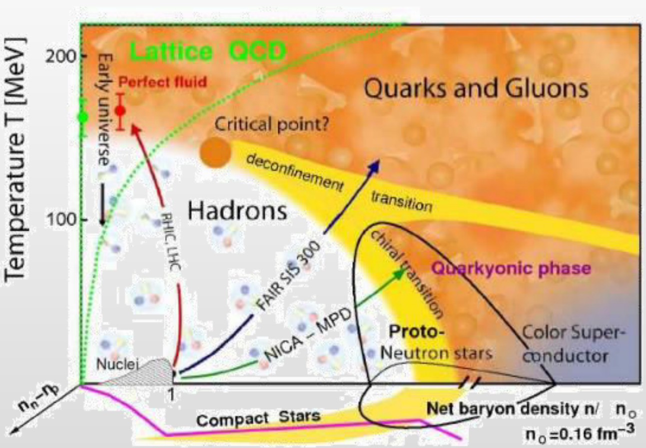
MPD at NICA

- One of two experiments at NICA collider to study heavy-ion collisions at $\sqrt{s_{NN}}$= 4−11 GeV

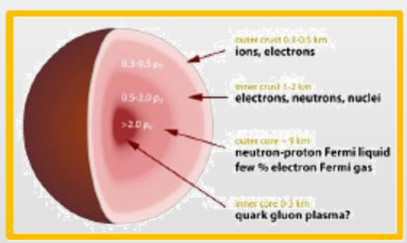


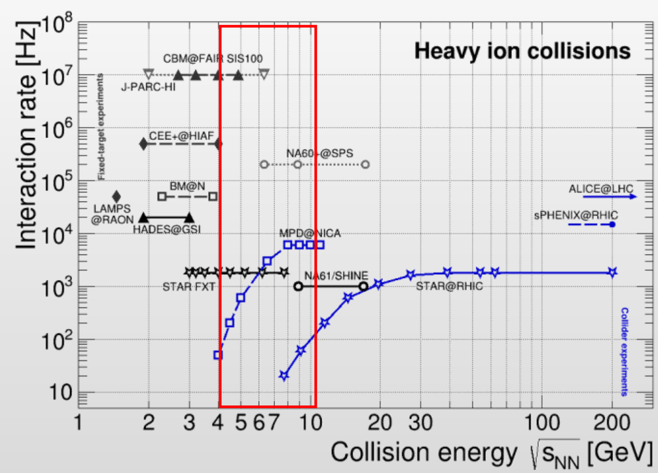
Stage- I

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



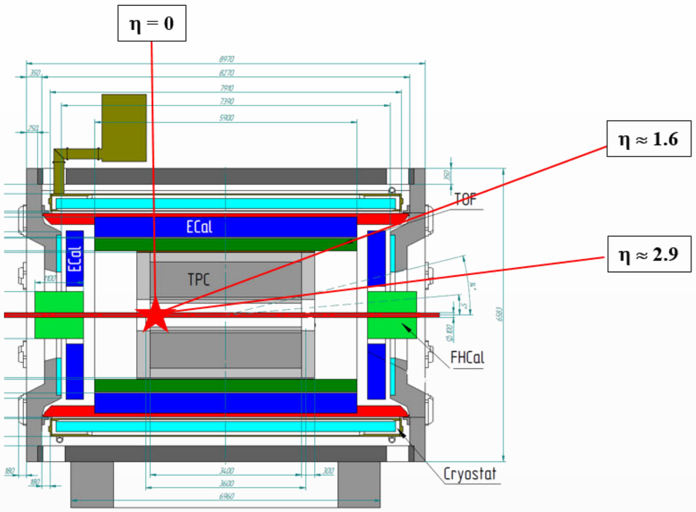
high baryon densities
→ inner structure of
compact stars

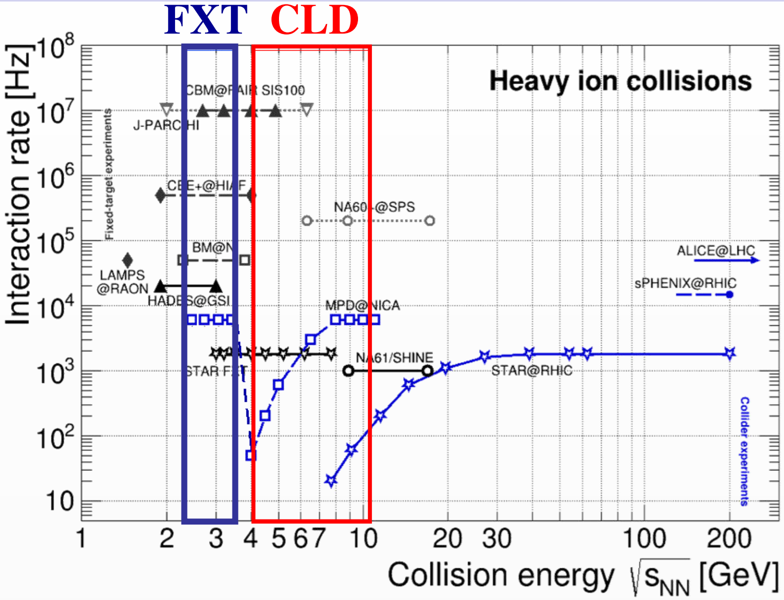




- NICA will study QCD medium at extreme net baryon densities → 1st order phase transition + QCD CEP
- Many ongoing (NA61/Shine, STAR-BES) and future experiments (CBM) in ~ same energy range

Fixed-target operation





- MPD-CLD and MPD-FXT options approved by accelerator department (now a default option)
- Collider mode: two beams, $\sqrt{s_{NN}}$ = 4-11 GeV
- Fixed-target mode: one beam + thin wire (~ 50-100 μm) close to the edge of the MPD central barrel:
  - ✓ extends energy range of MPD to $\sqrt{s_{NN}}$ = 2.4-3.5 GeV (overlap with HADES, BM@N and CBM)
  - ✓ solves problem of low event rate at lower collision energies (only ~ 50 Hz at $\sqrt{s_{NN}}$ = 4 GeV at design luminosity)
- Expected beam condition for the first year(s):
  - ✓ MPD-CLD: Xe+Xe at $\sqrt{s_{NN}}$ ~ 7 GeV, reduced luminosity → collision rate ~ 50 Hz
  - ✓ MPD-FXT: Xe+W at $\sqrt{s_{NN}}$ ~ 3 GeV

Capability of target and collision energy overlap between MPD and BM@N experiments

MPD assembling milestones and plans

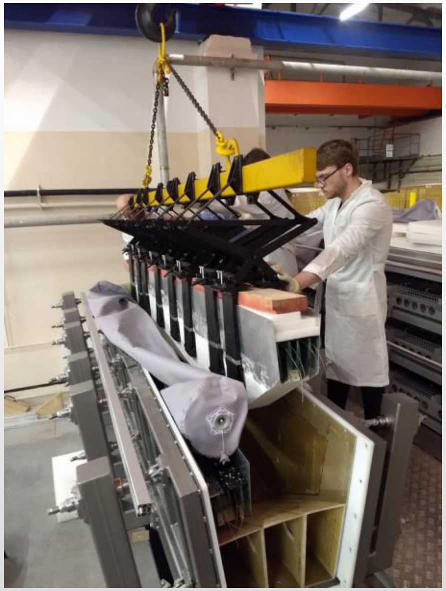
❖ Latest estimates provided by Project manager (V. Golovatyuk)

Year 2024	
January 25th – March 10th	**Cooling Solenoid to the temperature below of liquid Nitrogen 72K**
April – June 25th	Laying water cooling pipes and cable routing for Solenoid powering power supplies
July	Ready to turn on the magnet power supplies **→ water cooling system of bld. 17 (MPD) must be ready to avoid further delays**
July – August	Tests of power supplies and quench protection system
September – October	Cooling of the magnet to LHe temperature
October – December	Magnetic field measurements
November – December	Installation of FHCal in the poles
November	Comissioning of the TPC/Ecal cooling system
November	End of production of 40 ECal half sectors out of 50 (light shifters problem)
December	TPC mechanical body is assembled, leak test and HV test are finished
Year 2025	
January	Installation of the central frame and FHCal
January – March	Installation of ECal sectors
March	Installation TOF modules (access from both sides)
April – June	TPC installation
January – June	Cabling
June	Mounting of the beam pipe
July	**Moving to the beam position**

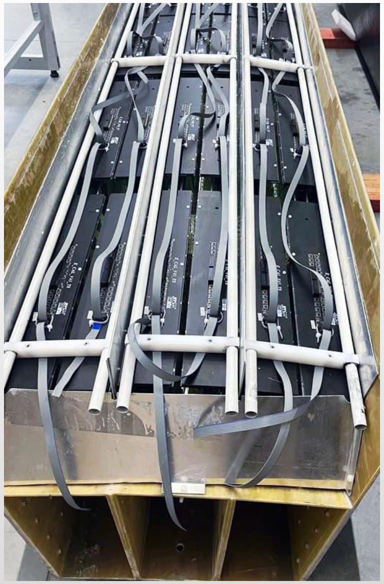
Electromagnetic calorimeter (ECAL)

- Sampling calorimeter with projective geometry (70 tons): 38,400 towers packed in 50 half-sectors
- First 1600 modules out of 2400 have been produced → packed into 32 half-sectors
- Production of additional 400 modules have been finished in Russia
- Production of the remaining 400 modules in JINR → delays with production of WLS fibers in Tver
- Mass assembly of half-sectors and electronics is in progress, all materials and components for electronics and water cooling system are produced and delivered → 41-42 half-sectors (~83%) by December
- The development of first-level ECAL calibration (equalization of signals) with cosmics is in progress

Gluing a half-sector



HV boards



ADCs & cooling system

Mostly finished

ECAL installation in the MPD: January, 2025

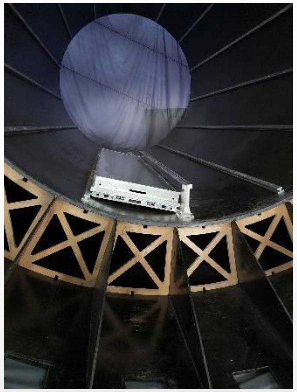
Time-of-Flight (TOF)

- Production of MRPC detectors was completed in September 2022, (107%) chambers
- All 28 TOF modules are assembled → long-term cosmic ray tests → ready for installation
- Electronics & cables, HV distribution modules → in stock
- Assembled the TOF gas system in the MPD hall → commissioning in November

Storage of tested TOF modules

TOF installation bench in LHEP

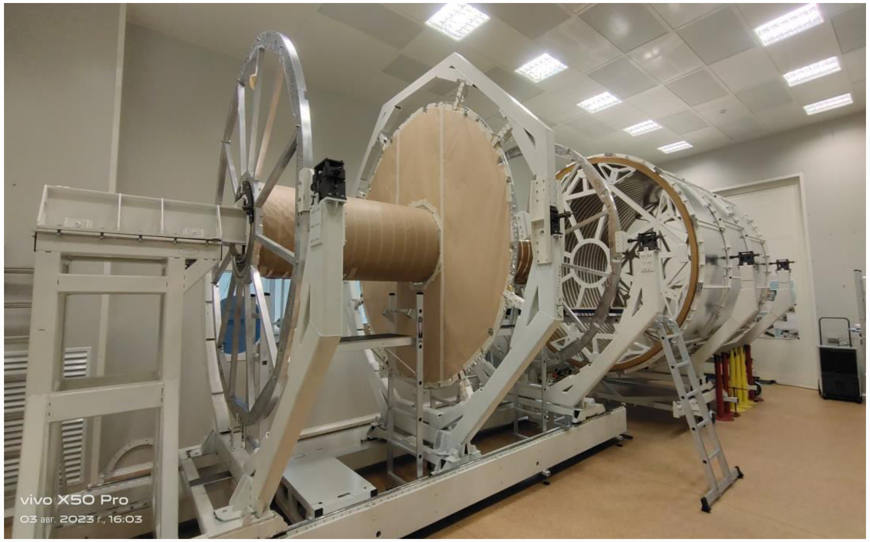
TOF module in the carbon fiber mainframe



- Equipment for installing the modules in the MPD is ready for use and stored in the laboratory
- Rails for TOF modules have been installed in to the carbon fiber mainframe in May 2023

TOF installation in the MPD: March, 2025

Time Projection Chamber (TPC)



- TPC cylinders, central membrane, service wheels, read-out MWPC chambers (24 + 6 spare) → ready
- TPC vessel with field cage→ in progress → assembled and tested for leaks and HV by December
- Electronics: 81% of FEC manufactured (meet target characteristics), RCU-64 controller v1.1 – in production, DCU (6 pcs.), LDC (6 pcs.) based on commercial solutions are available
- Gating grid system → ready
- HV + LV CAEN based power supplies and cables → ready
- Gas system → ready
- Colling system for thermostabilization panels and FEE → in progress → commissioning in December
- Tooling for TPC installation to MPD → in manufacturing → delivery in August
- Laser system (224 laser tracks for calibration), DCS → in developments

TPC installation in the MPD: April, 2025

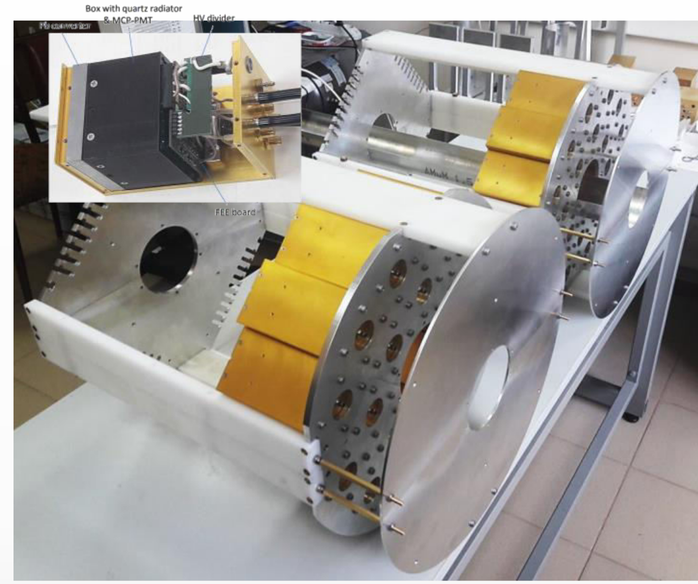
Forward subsystems in production

FHCAL

FHCal assembled on the platform, ready to be installed in the Pole (modules are equipped with FEE)

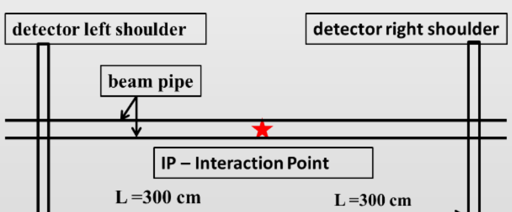
FHCAL modules have been produced and tested → installation in autumn 2024

FFD



Cherenkov modules of FFDE and FFDW, mechanics for installation in container with beam pipe are available, Long term tests with cosmic rays & laser ongoing

Beam and luminosity monitoring



Measurement of transverse sizes of the bunches
Transvers and longitudinal convergence of bunches
Vertices distribution along the beam

- Two sets by 32 scintillator counters readout by SIMPs from both sides
- Observables & methods:
  - ✓ counting rate and z-vertex distribution ($\sigma_{z\text{-vertex}}$ ~ 5 cm with $\delta\tau$ ~ 300 ps)
  - ✓ Van der Meer and ΔZ scans for optimization of beam optics
- Beam tests of prototypes
- Mass production of scintillator detectors

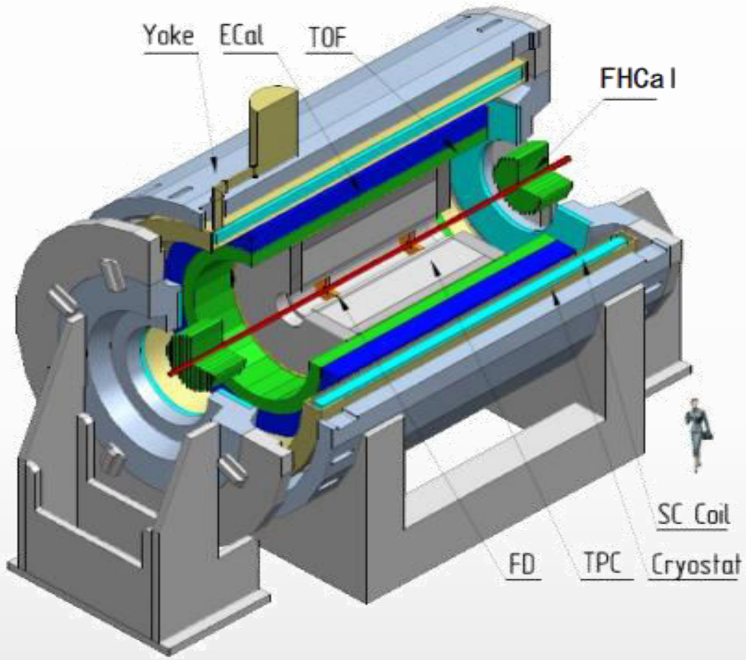
Multi-Purpose Detector (MPD) Collaboration

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

12** Countries, **>500** participants, **38** Institutes and **JINR

Organization

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



Joint Institute for Nuclear Research, Dubna*;*
*A.Alikhanyan National Lab of Armenia, Yerevan, **Armenia;***
*SSI “Joint Institute for Energy and Nuclear Research – Sosny” of the National Academy of Sciences of Belarus, Minsk, **Belarus***
*University of Plovdiv, **Bulgaria;***
*Tsinghua University, Beijing, **China**;*
*University of Science and Technology of China, Hefei, **China**;*
*Huzhou University, Huzhou, **China**;*
*Institute of Nuclear and Applied Physics, CAS, Shanghai, **China**;*
*Central China Normal University, **China**;*
*Shandong University, Shandong, **China**;*
*University of Chinese Academy of Sciences, Beijing, **China**;*
*University of South China, **China**;*
*Three Gorges University, **China**;*
*Institute of Modern Physics of CAS, Lanzhou, **China**;*
*Tbilisi State University, Tbilisi, **Georgia**;*
*Institute of Physics and Technology, Almaty, **Kazakhstan**;*
*Benemérita Universidad Autónoma de Puebla, **Mexico**;*
*Centro de Investigación y de Estudios Avanzados, **Mexico**;*
*Instituto de Ciencias Nucleares, UNAM, **Mexico**;*
*Universidad Autónoma de Sinaloa, **Mexico**;*
*Universidad de Colima, **Mexico**;*
*Universidad de Sonora, **Mexico**;*
*Universidad Michoacana de San Nicolás de Hidalgo, **Mexico***
*Institute of Applied Physics, Chisinev, **Moldova**;*
*Institute of Physics and Technology, **Mongolia**;*

*Belgorod National Research University, **Russia**;*
*Institute for Nuclear Research of the RAS, Moscow, **Russia**;*
*High School of Economics University, Moscow, **Russia***
*National Research Nuclear University MEPhI , Moscow, **Russia**;*
*Moscow Institute of Science and Technology, **Russia**;*
*North Osetian State University, **Russia**;*
*National Research Center "Kurchatov Institute", **Russia**;*
*Peter the Great St. Petersburg Polytechnic University Saint Petersburg, **Russia**;*
*Plekhanov Russian University of Economics, Moscow, **Russia**;*
*St.Petersburg State University, **Russia**;*
*Skobeltsyn Institute of Nuclear Physics, Moscow, **Russia**;*
*Petersburg Nuclear Physics Institute, Gatchina**, Russia**;*
*Vinča Institute of Nuclear Sciences**, Serbia**;*
*Pavol Jozef Šafárik University, Košice, **Slovakia***

Conferences and Workshops

❖ MPD presentations at conferences, last 6 months:

- ✓ NICA-2023, MEPhI, Russia, 25-27 December, 2023
- ✓ Научная сессия Отделения физических наук РАН, г. Дубна, 1-5 апреля, 2024
- ✓ CPOD-2024, Berkley, USA, 20-24 May, 2024
- ✓ Nucleus-2024, Dubna, Russia, 1-5 July 2024
- ✓ Hard Probes - 2024, Nagasaki, Japan, 22-27 September, 2024
- ✓ ICPPA-2024, Moscow, Russia, 22-25 October, 2024

MPD physics program

G. Feofilov, P. Parfenov

Global observables

- Total event multiplicity
- Total event energy
- Centrality determination
- Total cross-section measurement
- Event plane measurement at all rapidities
- Spectator measurement

V. Kolesnikov, Xianglei Zhu

Spectra of light flavor and hypernuclei

- Light flavor spectra
- Hyperons and hypernuclei
- Total particle yields and yield ratios
- Kinematic and chemical properties of the event
- Mapping QCD Phase Diag.

K. Mikhailov, A. Taranenko

Correlations and Fluctuations

- Collective flow for hadrons
- Vorticity, Λ polarization
- E-by-E fluctuation of multiplicity, momentum and conserved quantities
- Femtoscopy
- Forward-Backward corr.
- Jet-like correlations

D. Peresunko, Chi Yang

Electromagnetic probes

- Electromagnetic calorimeter meas.
- Photons in ECAL and central barrel
- Low mass dilepton spectra in-medium modification of resonances and intermediate mass region

Wangmei Zha, A. Zinchenko

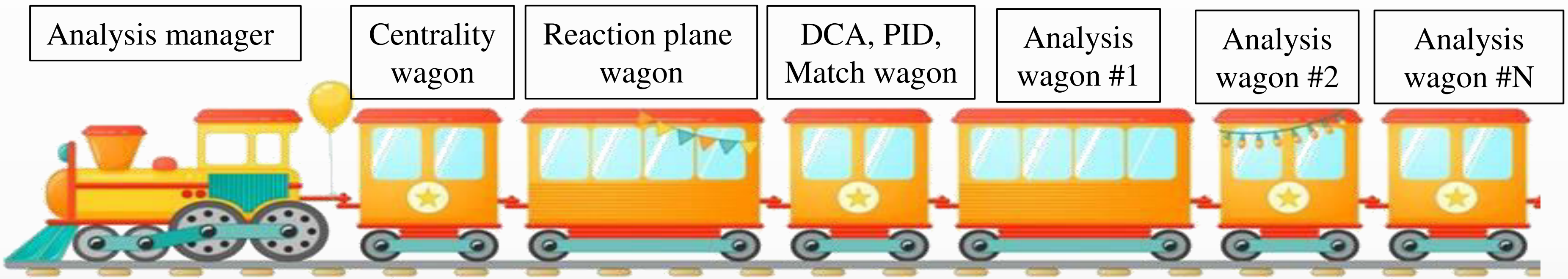
Heavy flavor

- Study of open charm production
- Charmonium with ECAL and central barrel
- Charmed meson through secondary vertices in ITS and HF electrons
- Explore production at charm threshold

❖ Cross-PWG format of meetings for discussion of results and analysis techniques

Physics feasibility studies

- ❖ Physics feasibility studies using centralized large-scale MC productions
- ❖ Centralized Analysis Framework for access and analysis of data → Analysis Train:
  - ✓ consistent approaches and results across collaboration, easy storage and sharing of codes
  - ✓ reduced number of input/output operations for disks and databases, easier data storage on tapes



- ❖ First Analysis Train runs started in September, 2023 → regular runs on request ever since
- ❖ Many new services and improvements (improved PID parameterizations, new wagons):
  - ✓ https://indico.jinr.ru/event/4401/: constrained tracks, track ID refits
  - ✓ https://indico.jinr.ru/event/4314/: track quality selections
- ❖ Train become a new standard for physics (feasibility) studies

Thanks to A. Moshkin (production manager), LIT specialists, computing/software team !!!

Second collaboration paper

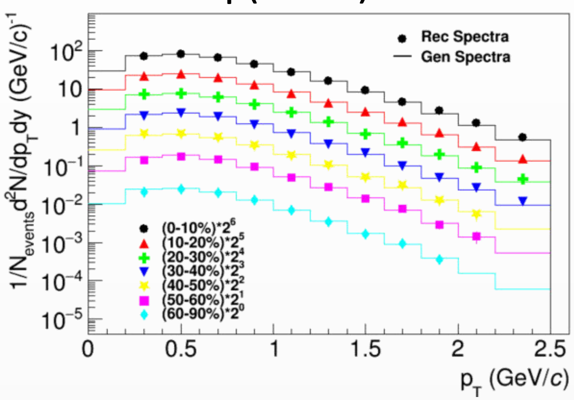
- Consolidation and publication of physics feasibility studies for BiBi@9.2 GeV
  - PWG1:
    - ✓ Trigger efficiency and biases
    - ✓ T_0 resolution and multiplicity-dependent corrections
    - ✓ Centrality, EP event categorization
  - PWG2:
    - ✓ Resonances (rho(770), phi(1020), K0(892), Sigma(1385)+/-, Lambda (1520)), pT-differential yields
    - ✓ Charged hadrons (\pi, K, p, pbar)
    - ✓ Hyperons (\Lambda, \Ksi, \Omega)
    - ✓ (anti)Lambda polarization
    - ✓ Light (hyper) nuclei
  - PWG3:
    - ✓ 1D pion femtoscopy (2 kT bins and 2-3 centrality bins); factorial moments; charged balance function
    - ✓ Factorial moments for different type of EoS (crossover phase transition XPT, first order phase transition XPT)
    - ✓ Chaoticity parameter in two-pion correlation functions
    - ✓ Anisotropic flow (v1, v2, v3) vs. pT, rapidity, centrality for charged pions, kaons, protons + using two-particle (EP,SP) and 4-particle cumulants
  - PWG4:
    - ✓ Neutral meson (pi0, eta) pT/centrality-differential yields and flow
    - ✓ Dileptons

Plan is to prepare a paper draft by the next collaboration meeting

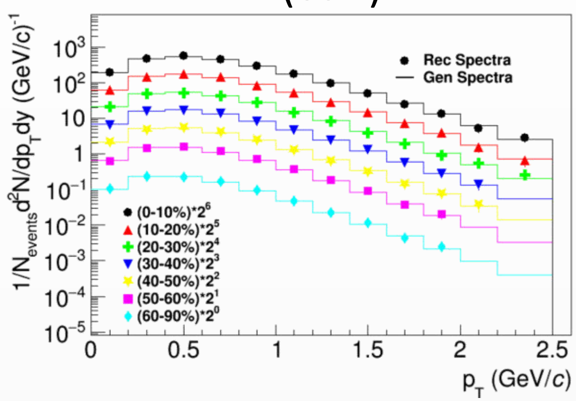
Short-lived hadronic resonances

- Request 25 mass production (UrQMD, 50 M events), BiBi @ 9.2 GeV
- New: most realistic approach to data analysis, centrality dependence

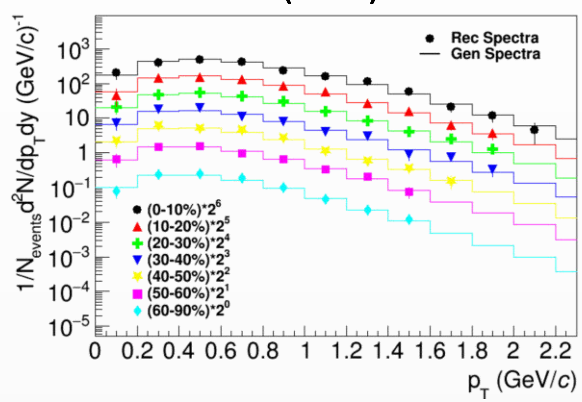
ϕ(1020)



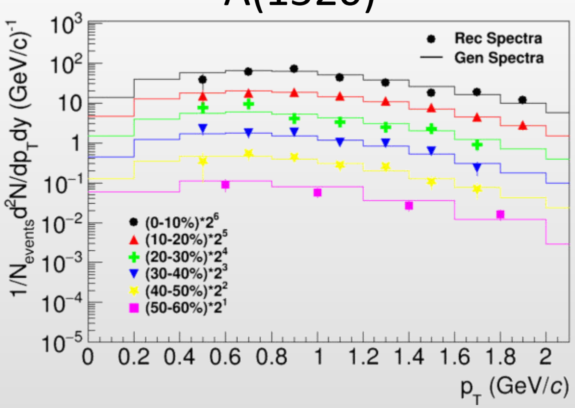
K*(892)⁰



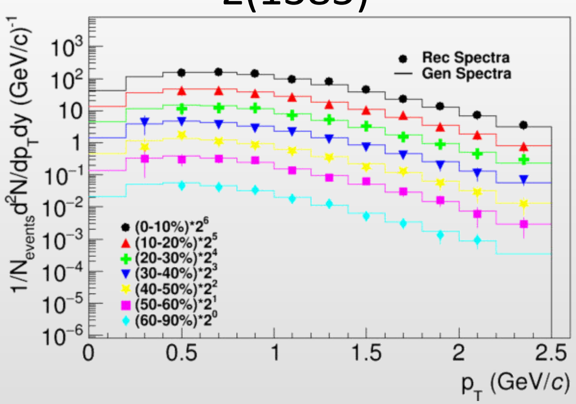
K*(892)±

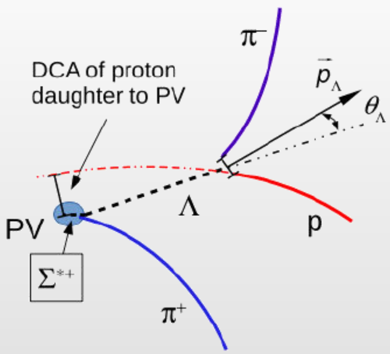


Λ(1520)



Σ(1385)±





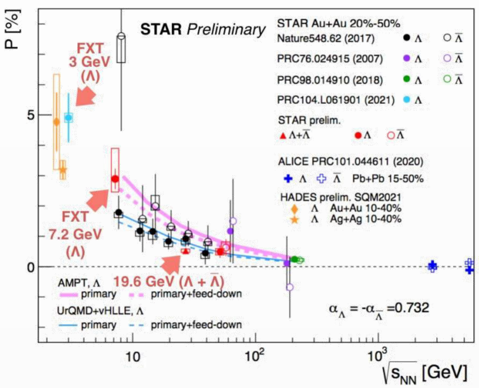
Reconstructed spectra match truly generated ones within uncertainties

Centrality dependent analysis would require ≥ 50 M A+A events

Measurements are possible starting from ~ zero momentum → sample most of the yields

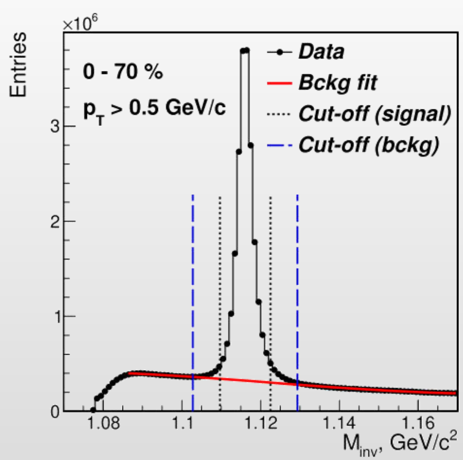
Hyperon global polarization

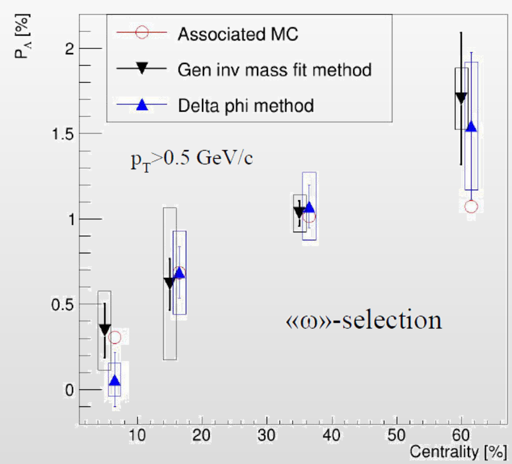
- Request 30 mass production (PHSD, 15 M events), BiBi@9.2 GeV
- Global hyperon polarization (thermodynamical Becattini approach) by PHSD event generator

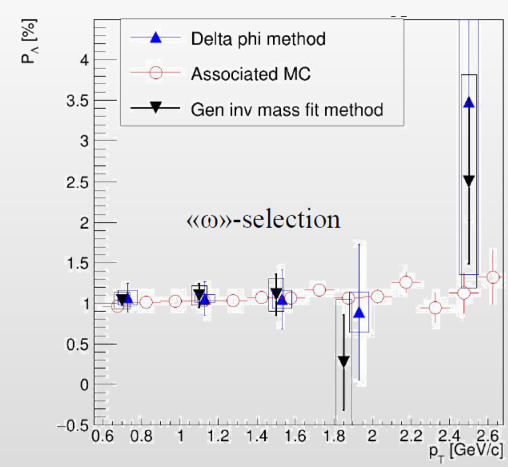


- Two analysis methods:
  - ✓ Δφ-method
  - ✓ generalized invariant mass fit method - default
- Full data reanalysis
- "Performance study of the hyperon global polarization measurements with MPD at NICA" → recently <u>accepted to EPJA</u>

- Reconstruction of Λ global polarization, BiBi@9.2 GeV:





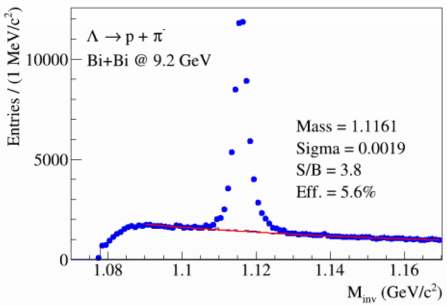


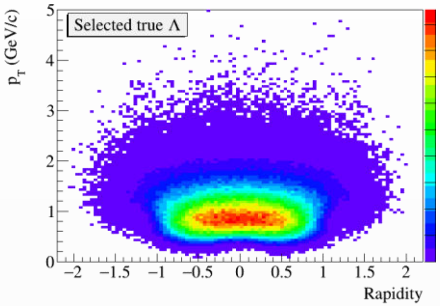
Both methods have an agreement with associated MC

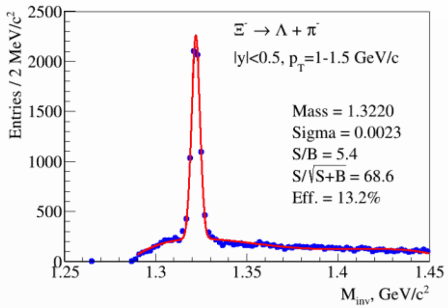
The statistics size of 15M events is not enough for p_T-η measurements

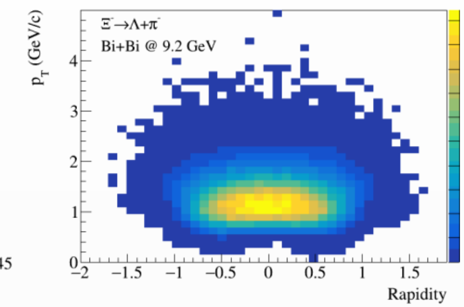
Hyperon reconstruction

❖ Request 25 mass production (UrQMD, 50M events), BiBi@9.2 GeV

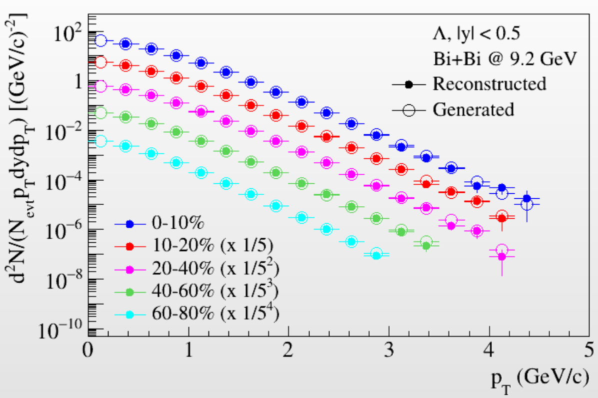


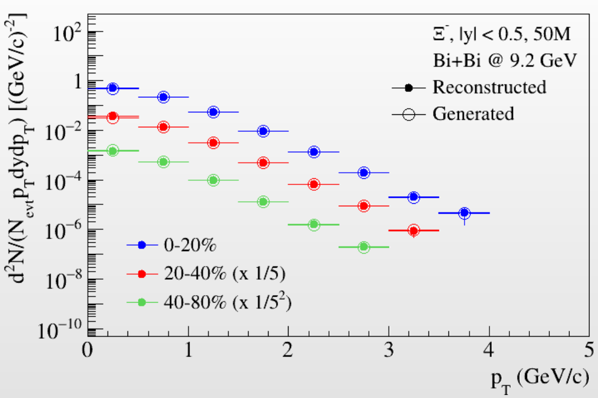


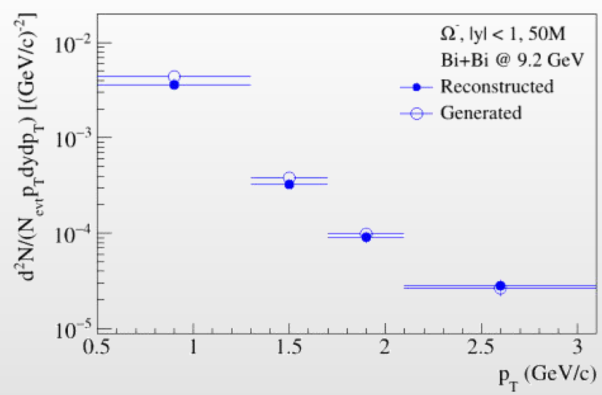




- different background estimates (fit function vs mixed-event)
- different PID selections for high-p_T daughter particles
- testing alternative Machine Learning techniques







MPD has capabilities to measure production of strange kaons, (multi)strange baryons and resonances in pp, p-A and A-A collisions using h-ID in the TPC&TOF and different decay topology selections

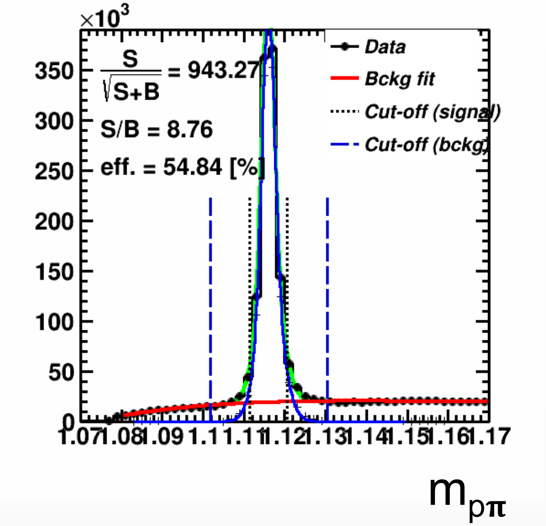
Anisotropic flow for V0 particles

❖ Request 30 mass production (PHSD, 15M events), BiBi@9.2 GeV

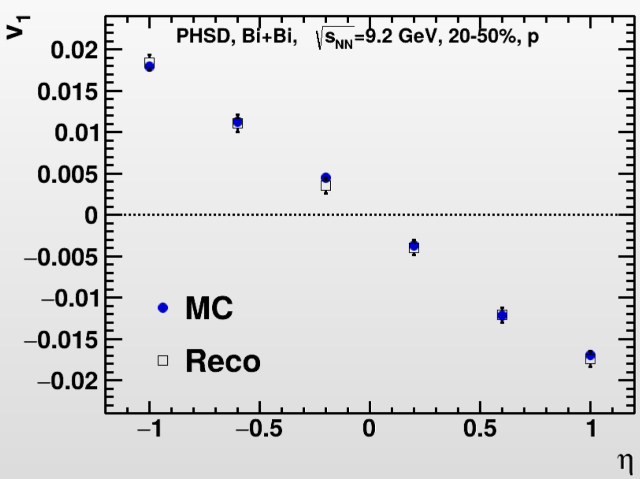
Differential flow can be defined using the following fit:

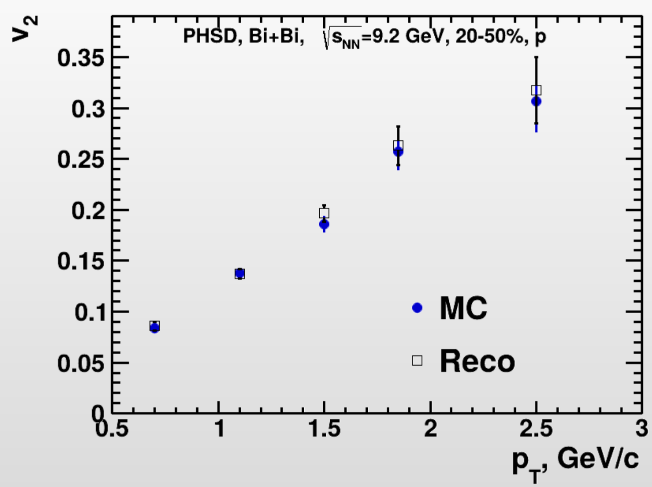
$$v_n^{SB}(m_{inv}) = v_n^S \frac{N^S(m_{inv})}{N^{SB}(m_{inv})} + v_n^B(m_{inv}) \frac{N^B(m_{inv})}{N^{SB}(m_{inv})}$$

- v_n^S - signal anisotropic flow (set as a parameter in the fit)
- $v_n^B(m_{inv})$ - background flow (set as polynomial function)



❖ Performance of v_1 and v_2 of Λ hyperons:

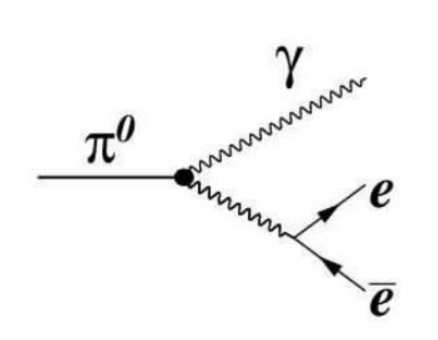




Good performance for v_1, v_2 using invariant mass fit and event plane methods

Neutral mesons (π^0)

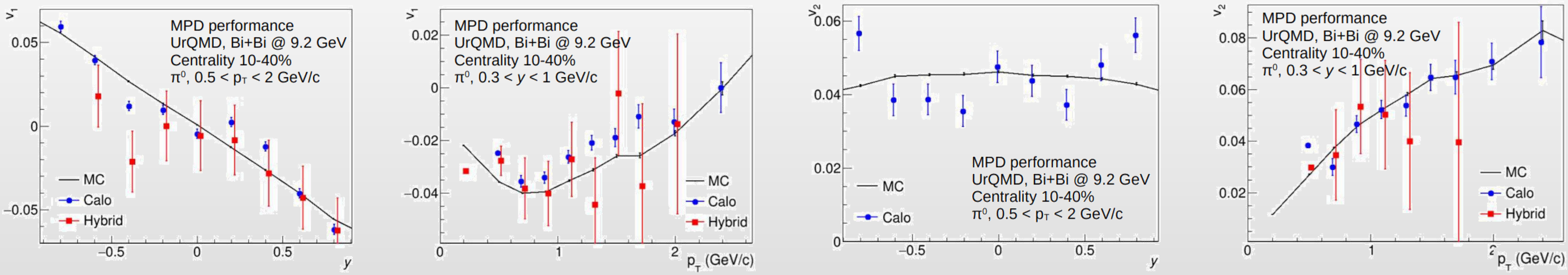
- Request 25 mass production (UrQMD, 50 M events), BiBi @ 9.2 GeV
- New: most realistic approach to data analysis



- Two photon reconstruction techniques:
  - ✓ ECAL
  - ✓ photon conversion
- Three techniques for meson reconstruction:
  - ✓ ECAL-ECAL
  - ✓ ECAL-conversion
  - ✓ Conversion-conversion

- Differential p_T spectra for π^0 and η mesons reconstructed up to ~ 4-5 GeV/c
- Collective flow measurements v_1 and v_2:

v_1 vs. rapidity and p_T **v_2 vs. rapidity and p_T**



Reconstructed v_1 and v_2 qualitatively consistent with generated signals

PCM and Hybrid methods generally require higher statistics but provide better resolution

Further plans

- Xe+Xe @ ~ 7 GeV, collider mode:
  - ✓ not much difference for analysis techniques and expectations wrt. to BiBi @ 9.2 GeV
  - ✓ collected statistics might be small due to low luminosity and short beam lifetime

- Xe+W @ ~ 3 GeV, fixed-target mode:
  - ✓ “terra incognita” for detector performance and physics capabilities
  - ✓ may provide most of statistics for physics analyses in the first years

Give priority to study of the detector capabilities in the fixed target mode

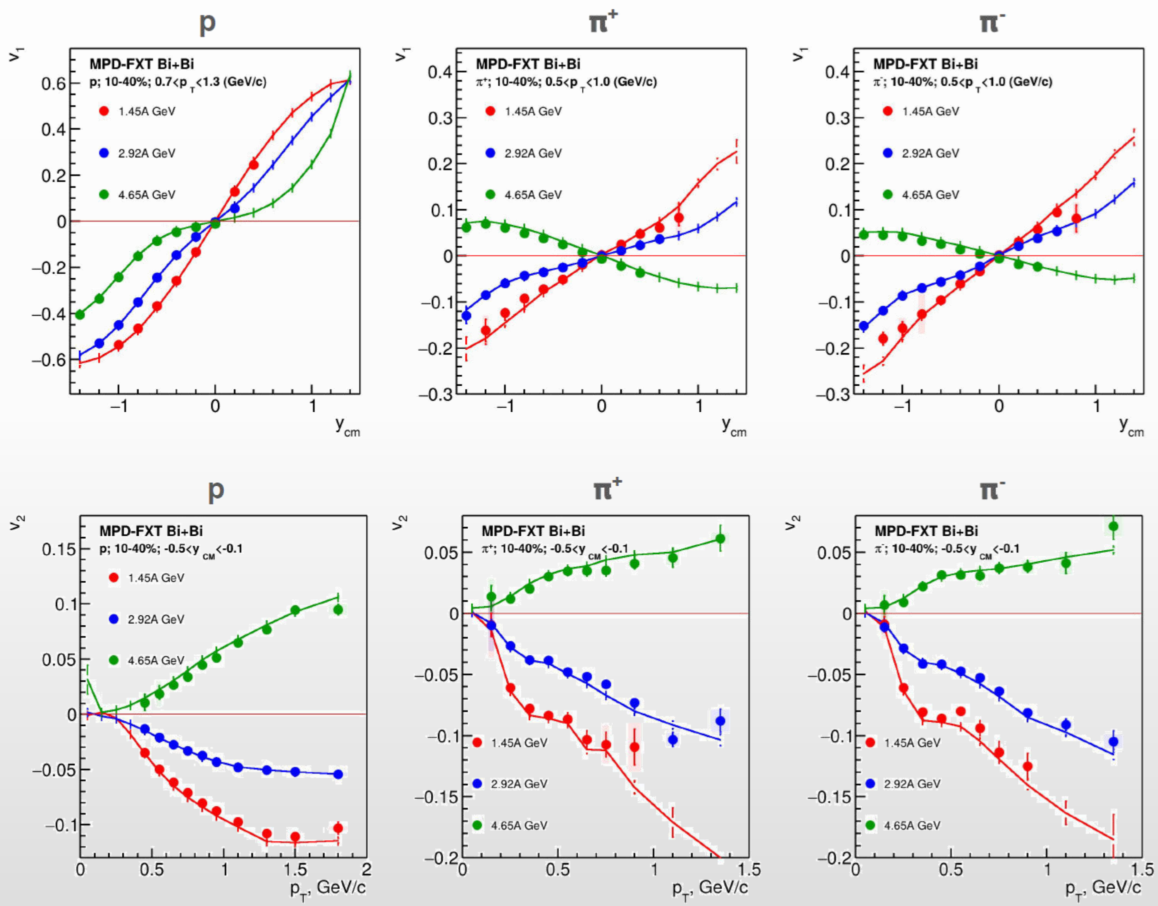
- Program of support of participation of Russian scientific groups in the NICA project by Russian government → starts right now → great expectations

MPD-FXT, v_1 & v_2 for protons/pions

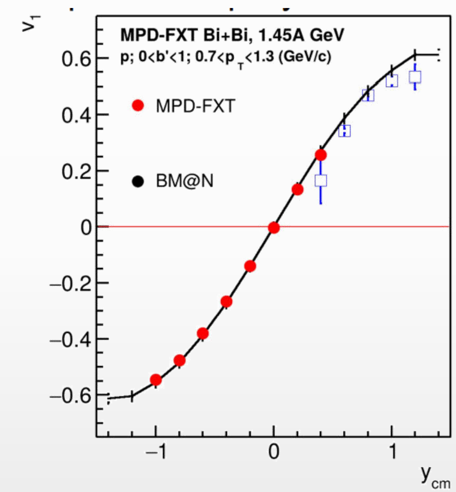
- ❖ Request 33 mass production (UrQMD mean-field, 10 M events), BiBi @ 2.5, 3.0 and 3.5 GeV
- ❖ New: realistic PID (TPC+TOF); efficiency corrections; centrality by TPC multiplicity

v_1 **vs. rapidity**

v_2 **vs. p_T**



MPD vs. BM@N



Reconstructed v_1 & v_2 are quantitatively consistent with truly generated signals

MPD and BM@N complete each other with modest overlap

New MPD Collaboration web site

mpd.jinr.ru

General information | Collaboration | MPD Setup | Presentations | Publications | Meetings

GENERAL INFORMATION
- MPD DOCUMENTS
- NEWS AND ANNOUNCEMENTS
- UPCOMING EVENTS
- MPD FORUM
- CONTACTS
- MAILING LISTS

COLLABORATION
- PARTICIPANTS INSTITUTIONS
- EXECUTIVE COUNCIL
- INSTITUTIONAL BOARD
- TECHNICAL BOARD
- PHYSICS COUNCIL
- SPEAKER'S BUREAU
- COLLABORATION LIST

MPD SETUP
- DETECTOR
- SOFTWARE

MPD PRESENTATIONS
- SEMINARS
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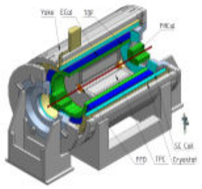
MPD PUBLICATIONS
- COLLABORATION PUBLICATIONS
- PUBLISHED PAPERS
- DISSERTATIONS AND DIPLOMAS

MPD MEETINGS
- CROSS-PWG MEETINGS
- COLLABORATION MEETINGS
- MINUTES

Multi Purpose Detector
The mega-science project "NICA"

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 at the Joint Institute for Nuclear Research (JINR). 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$<\sqrt{s_{NN}}<$11GeV. A wealth of results, obtained by colliding heavy ions at different beam energies, has been gathered by experiments at SIS, AGS, SPS, RHIC and the LHC facilities. The new experimental program at the NICA-MPD will fill a niche in the energy scale, which is not yet fully explored, and the results will bring about a deeper insight into hadron dynamics and multiparticle production in the high baryon density domain.

It is foreseen that the MPD will be installed in two stages. The first stage of the detector configuration is planned to be ready for commissioning in 2025. The overall set-up of the MPD and the spatial arrangement of detector subsystems in the first stage are shown in the figure.



The "central barrel" components have an approximate cylindrical symmetry within $|\eta|<1.5$. The beam line is surrounded by the large volume Time Projection Chamber (TPC) which is enclosed by the TOF barrel. The TPC is the main tracker, and in conjunction with the TOF they will provide precise momentum measurements and particle identification. The Electromagnetic Calorimeter (ECal) is placed in between the TOF and the MPD magnet. It will be used for detection of electromagnetic showers, and will play the central role in photon and electron measurements. The MPD superconducting solenoid magnet is designed to provide a highly homogeneous magnetic field of up to 0.57 T (with a default operational setting of 0.5 T), uniform along the beam direction, to ensure appropriate transverse momentum resolution for reconstructed particles within the range of momenta of 0.1-3 GeV/c. As the average transverse momentum of the particles produced in a collision at NICA energies is below 500 MeV/c, the detector was designed to have a very low material budget. In the forward direction, the Fast Forward Detector (FFD) is located still within the TPC barrel. It will play the role of a wake-up trigger. The Forward Hadronic Calorimeter (FHCal) is located near the magnet end-caps. It will serve for determination of the collision centrality and the orientation of the reaction plane for collective flow studies.

Additional detectors are proposed in the later stages. The silicon-based Inner Tracking System (ITS) will be installed

Summary

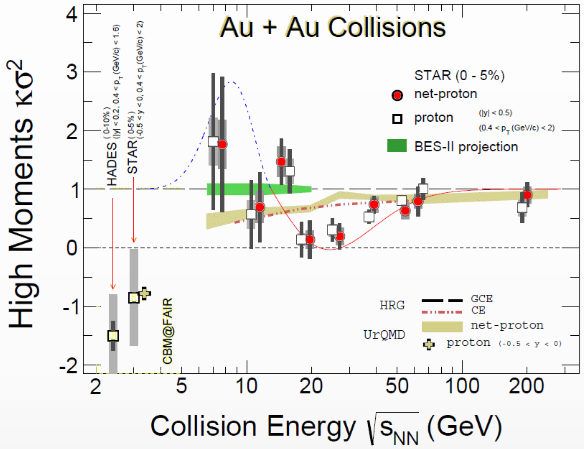
MPD Collaboration meeting in JINR (Dubna): April 23-25

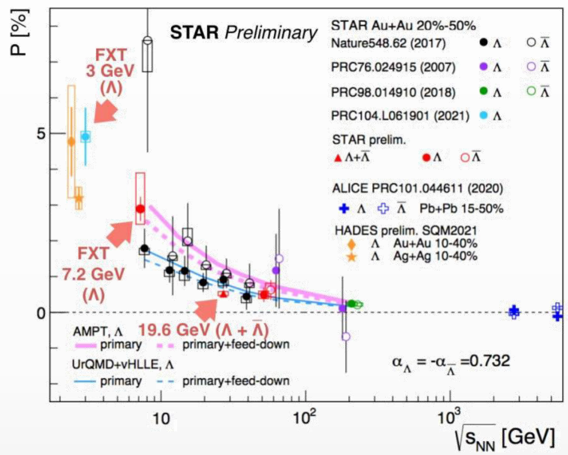
- ❖ All components of the Phase-I detector are advancing → MPD commissioning with beams in 2025
- ❖ Collider and fixed-target operation modes for start-up
- ❖ Develop software and analysis infrastructure for real data analysis

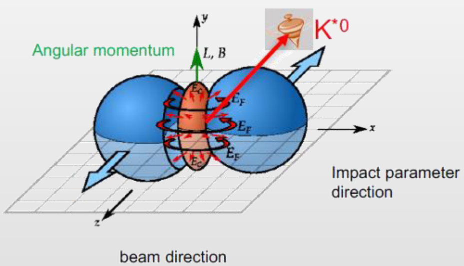
BACKUP

Hot physics topics

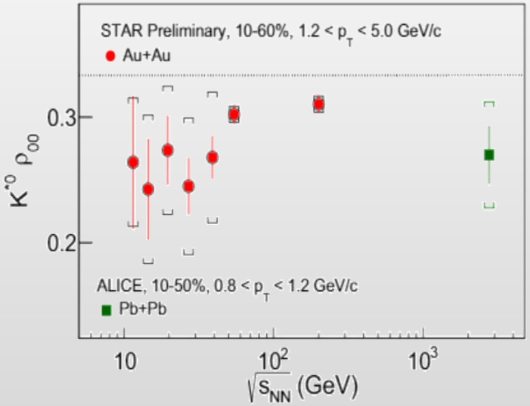
- Critical fluctuations for (net)proton/kaon multiplicity distributions
- Global hyperon polarization in mid-central A+A collisions (Λ, Ξ, Ω and antiparticles)
- Spin alignment of vector mesons ($K^*(892)$, $\phi(1020)$)

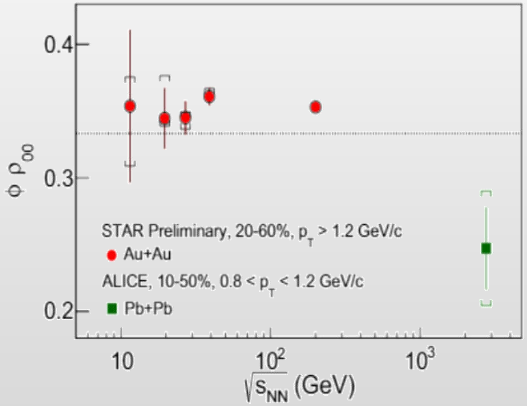






$$\frac{dN}{dcos\theta} = N_0\left[1 - \rho_{0,0} + cos^2\theta\left(3\rho_{0,0} - 1\right)\right]$$



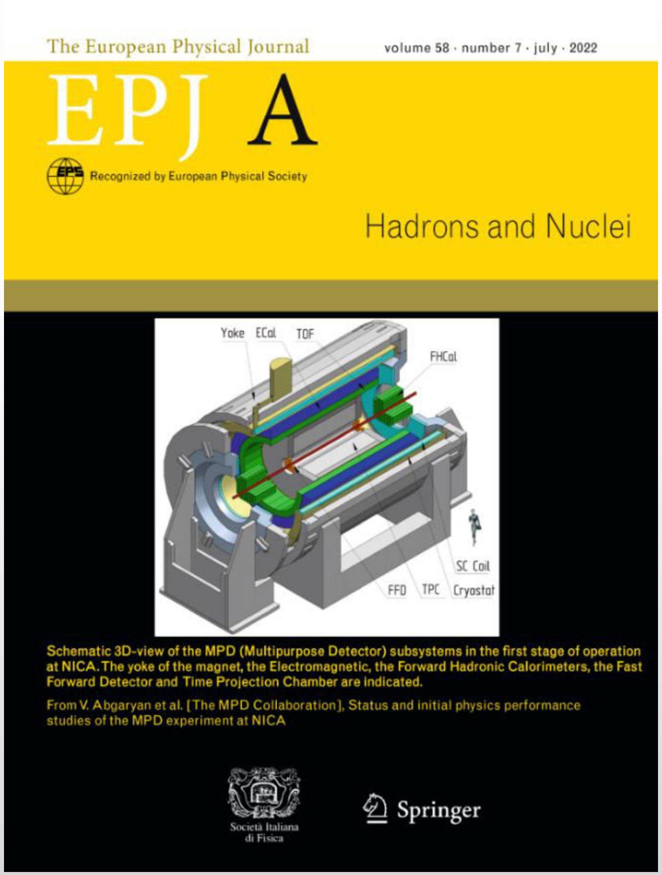


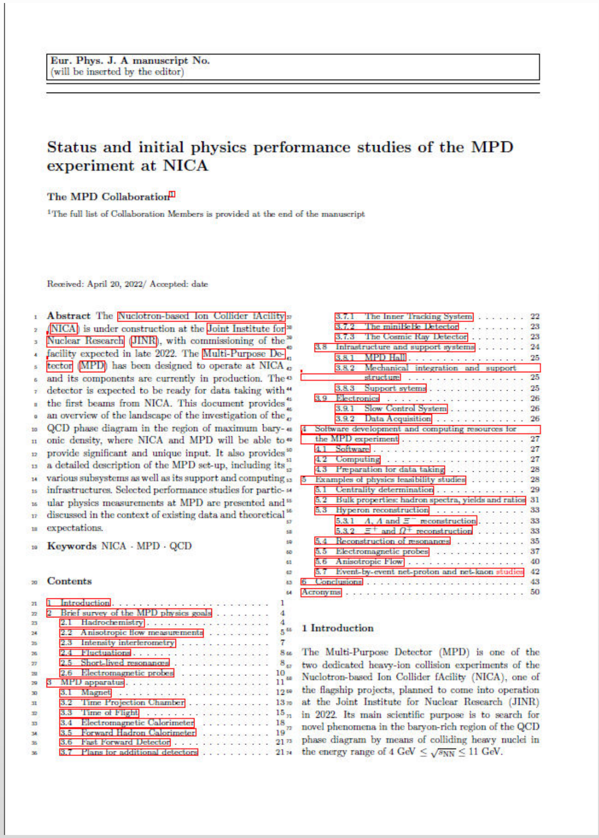
Task for NICA: extra points in the energy range 4-11 GeV with small uncertainties

Status and performance

- MPD publications: over 200 in total for hardware, software and physics studies (SPIRES)
- First collaboration paper recently published EPJA (~ 50 pages): Eur.Phys.J.A 58 (2022) 7, 140

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





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.

RHIC BES program

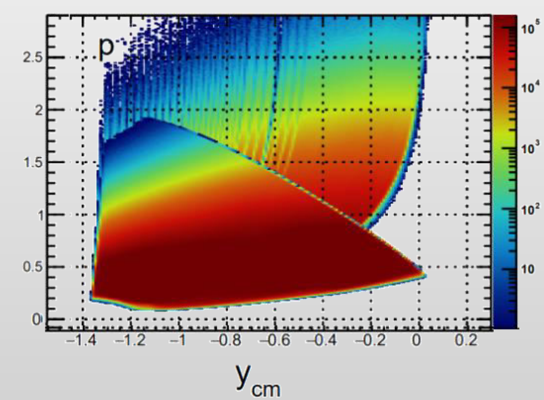
- Data taking by STAR at RHIC: $3 < \sqrt{s_{NN}} < 200$ GeV ($750 < \mu_B < 25$ MeV)

Au+Au Collisions at RHIC

Collider Runs						Fixed-Target Runs					
	$\sqrt{s_{NN}}$ (GeV)	#Events	μ_B	y_{beam}	run		$\sqrt{s_{NN}}$ (GeV)	#Events	μ_B	y_{beam}	run
1	200	380 M	25 MeV	5.3	Run-10, 19	1	13.7 (100)	50 M	280 MeV	-2.69	Run-21
2	62.4	46 M	75 MeV		Run-10	2	11.5 (70)	50 M	320 MeV	-2.51	Run-21
3	54.4	1200 M	85 MeV		Run-17	3	9.2 (44.5)	50 M	370 MeV	-2.28	Run-21
4	39	86 M	112 MeV		Run-10	4	7.7 (31.2)	260 M	420 MeV	-2.1	Run-18, 19, 20
5	27	585 M	156 MeV	3.36	Run-11, 18	5	7.2 (26.5)	470 M	440 MeV	-2.02	Run-18, 20
6	19.6	595 M	206 MeV	3.1	Run-11, 19	6	6.2 (19.5)	120 M	490 MeV	1.87	Run-20
7	17.3	256 M	230 MeV		Run-21	7	5.2 (13.5)	100 M	540 MeV	-1.68	Run-20
8	14.6	340 M	262 MeV		Run-14, 19	8	4.5 (9.8)	110 M	590 MeV	-1.52	Run-20
9	11.5	157 M	316 MeV		Run-10, 20	9	3.9 (7.3)	120 M	633 MeV	-1.37	Run-20
10	9.2	160 M	372 MeV		Run-10, 20	10	3.5 (5.75)	120 M	670 MeV	-1.2	Run-20
11	7.7	104 M	420 MeV		Run-21	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

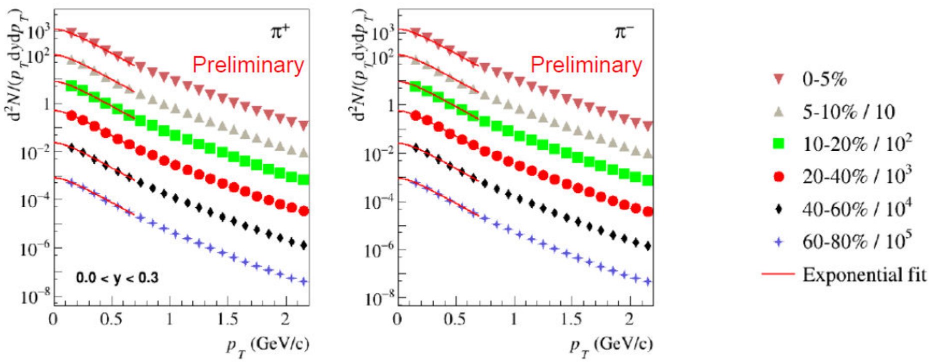
- A very impressive and successful program with many collected datasets, already available and expected results
- Limitations:
  - ✓ Au+Au collisions only
  - ✓ Among the fixed-target runs, only the 3 GeV data have full mid-rapidity coverage for protons (|y| < 0.5), which is crucial for physics observables

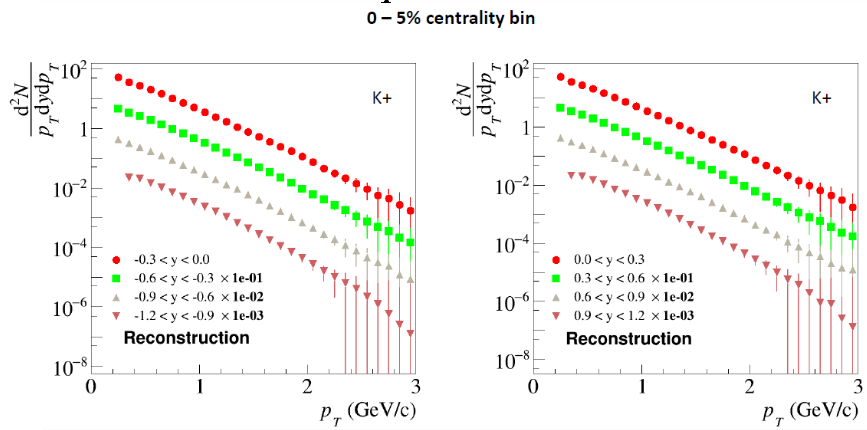
Au+Au @ 3.9 GeV



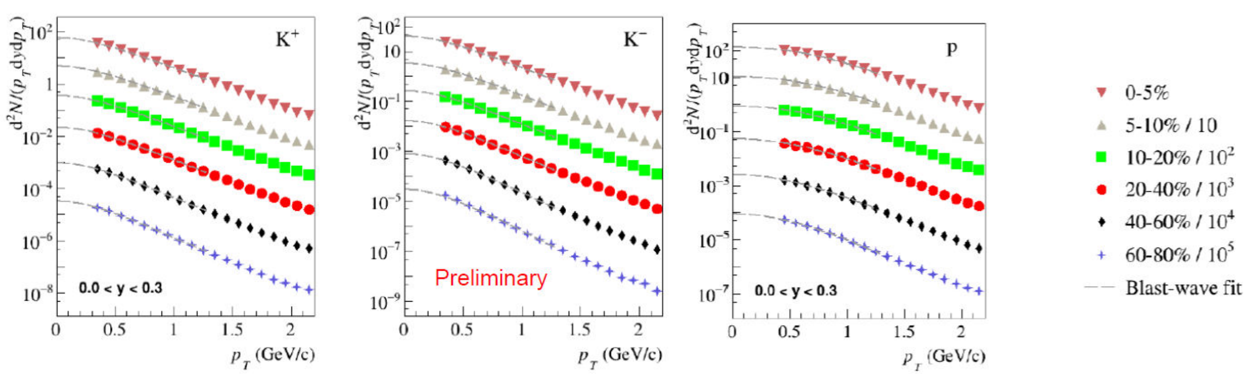
Identified light hadrons

❖ 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





Functions used to fit spectra are m_T-exponential : $\frac{1}{p_T}\times\frac{d^2N}{dy\,dp_T}=\frac{dN/dy}{T(m+T)}\cdot\exp\left(-\frac{m_T-m}{T}\right)$

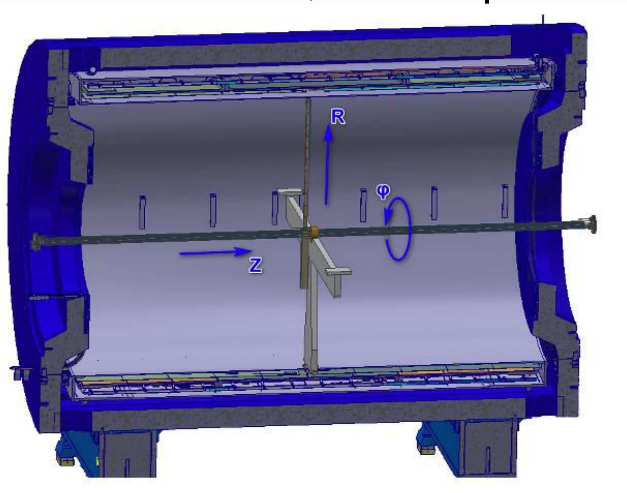


Functions used to fit spectra are blast-wave: $\frac{d^2N}{p_t\,dp_t\,dy}=C\int_0^1 p_t f(\xi) K_1\left(\frac{m_t\cosh(\rho)}{T}\right) I_0\left(\frac{p_t\sinh(\rho)}{T}\right)\xi\,d\xi$

B-field Mapper

Evgeny Antokhin, INP Novosibirsk

Concept of Novosibirsk INP mapper:
1 - 3D Hall probe moves in 3 directions: z , R and ϕ



	Along radius (R)	Along azimuth angle (φ)	Along the axes of Solenoid (Z)
Step size, см	5	21	10
Total length, см	220	360^{O} (1380 см on max. R)	700
Number of measurements	44	64	70

The total number of measurements: 44 x 64 x 70 = 197120 (200000)

Total time of one cycle of measurements: 1,5 сек

One measurement (200000x1,5) : 3600 = 84 h +6 h on preparations = 90 hour Fields to measure : 0.57T; 0.53T; 0.5T; 0.45T; 0.4T; 0.3T –

In total - 6 nominals of field.

For each field one need about 5 adjustments of current in correction coils