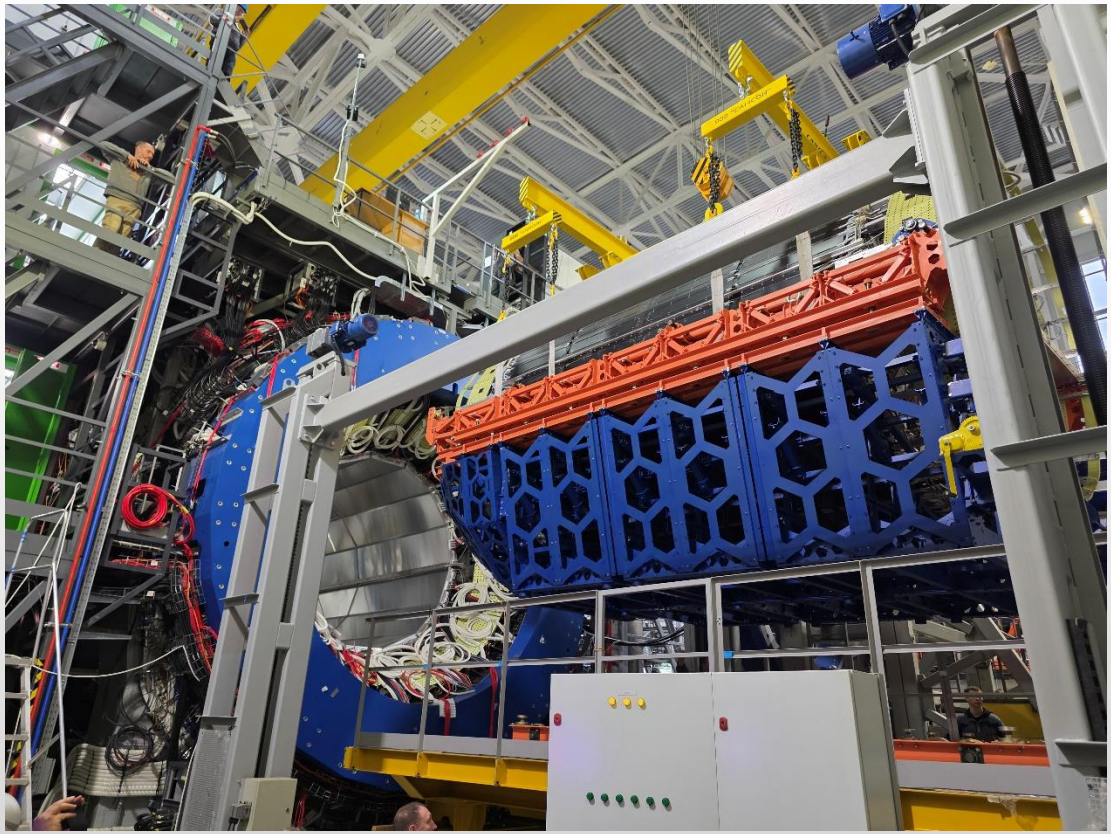
MPD Collaboration Status

V. Riabov for the MPD Collaboration



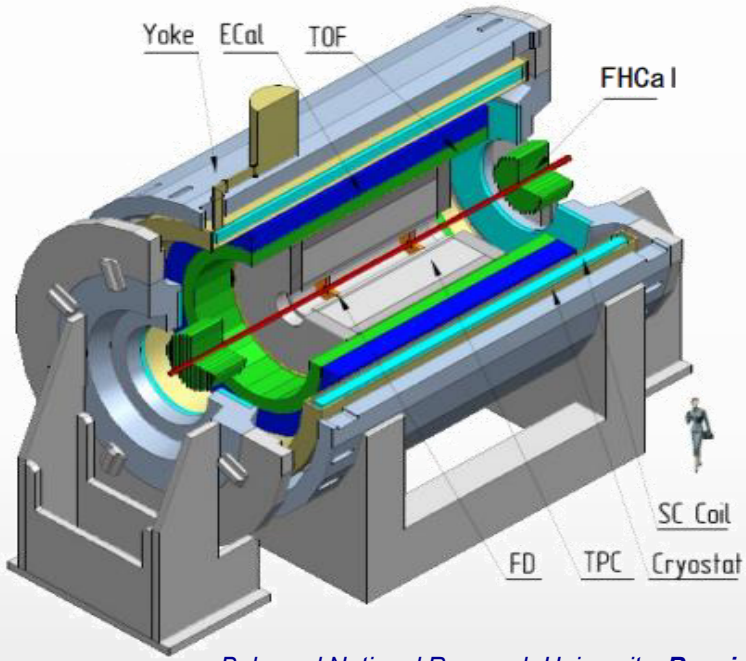
Multi-Purpose Detector (MPD) Collaboration

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

12** Countries, **>500** participants, **39** Institutions and **JINR

Organization

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



***Joint Institute for Nuclear Research**;*
*A.Alikhanyan National Lab of Armenia, Yerevan, **Armenia;***
*Institute for Nuclear Problems of Belarusian State University, **Belarus**;*
*Institute of Power Engineering of the National Academy of Sciences of Belarus, **Belarus**;*
*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, Huizhou, **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**;*
*Egyptian Center for Theoretical Physics, **Egypt**;*
*Tbilisi State University, Tbilisi, **Georgia**;*
*Institute of Nuclear Physics, Almaty, **Kazakhstan**;*
*Instituto de Ciencias Nucleares, UNAM, **Mexico**;*
*Universidad Autónoma de Sinaloa, **Mexico**;*
*Universidad Autónoma Metropolitana, **Mexico**;*
*Universidad de Colima, **Mexico**;*
*Universidad Michoacana de San Nicolás de Hidalgo, **Mexico**;*
*Institute of Physics and Technology, **Mongolia**;*

*Belgorod National Research University, **Russia**;*
*High School of Economics University, Moscow, **Russia;***
*Institute for Nuclear Research of the RAS, Moscow, **Russia**;*
*National Research Nuclear University MEPhI , Moscow, **Russia**;*
*Moscow Institute of Science and Technology, **Russia**;*
*North Ossetian State University, **Russia**;*
*National Research Center "Kurchatov Institute", **Russia**;*
*National Research Tomsk Polytechnic University, **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***

MPD superconducting magnet

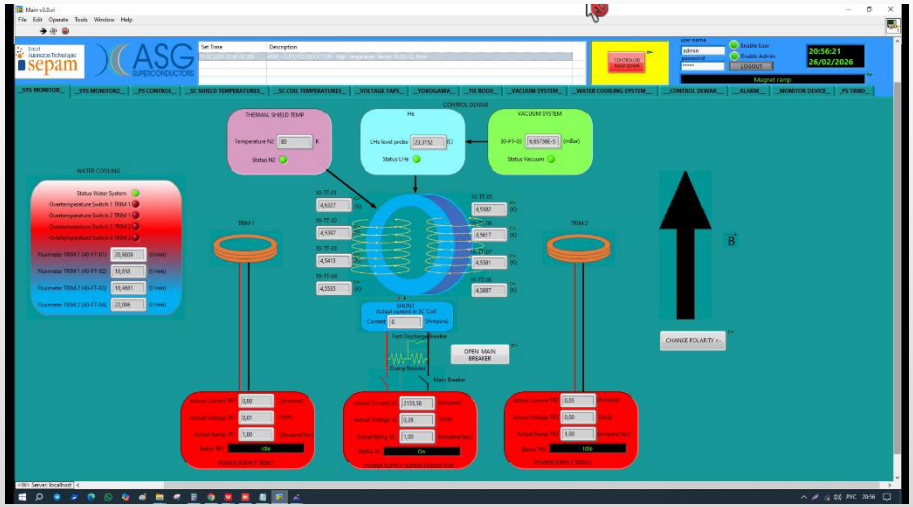
- Cooled the magnet to LN2 and LHe temperatures → nominal magnetic field of 0.57 T reached

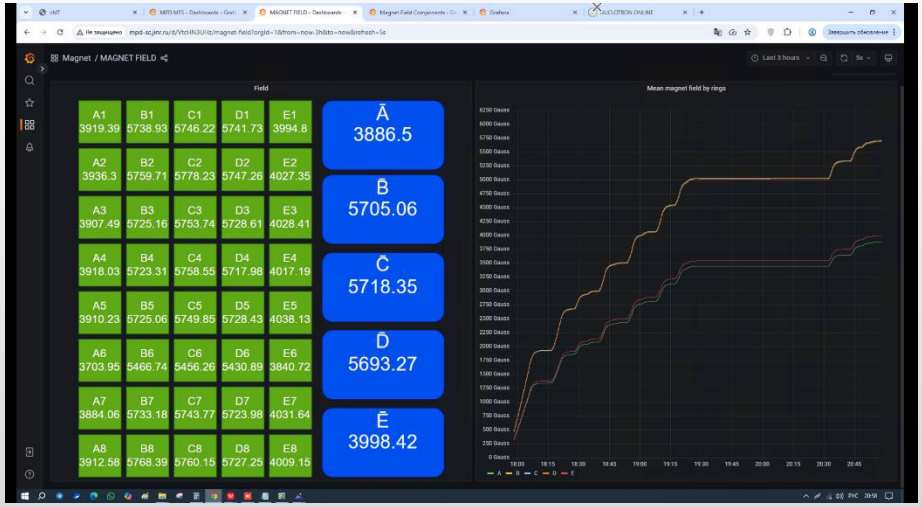
Magnet yoke and cryogenic platform



- ✓ Stable operation with trim coils at maximum field with no current/temperature fluctuations
- ✓ An important milestone reached !!!

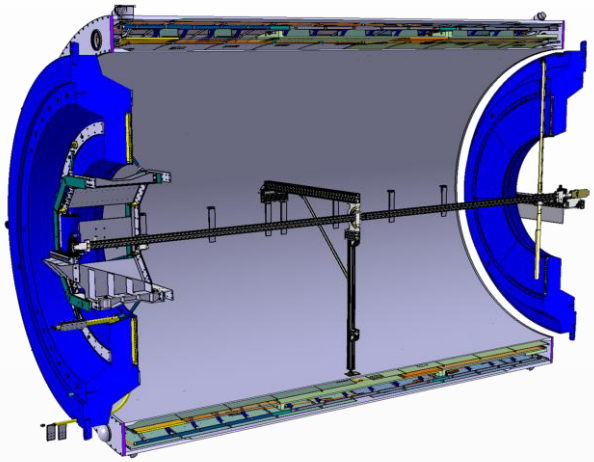
Magnet fully operational since mid-February

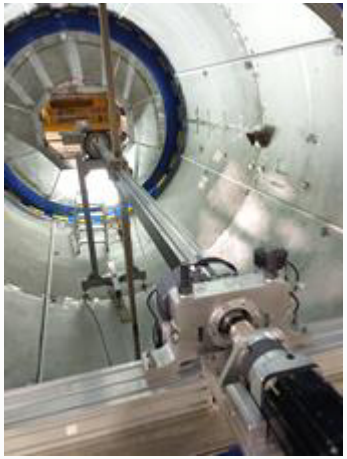




Magnetic field measurements

- Magnetic field measurements (by Novosibirsk INP):



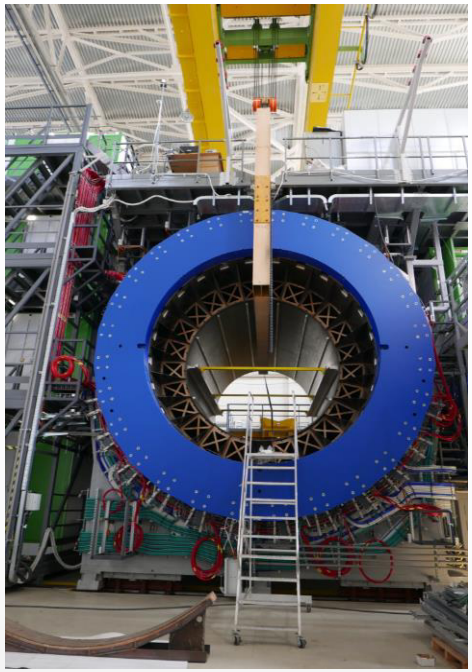


	Along radius (R)	Along azimuth angle (ϕ)	Along beam (z)
Step size, см	5	21	10
Total length, см	220	360° (1380 см at max. R)	700
Number of measurements	44	64	70

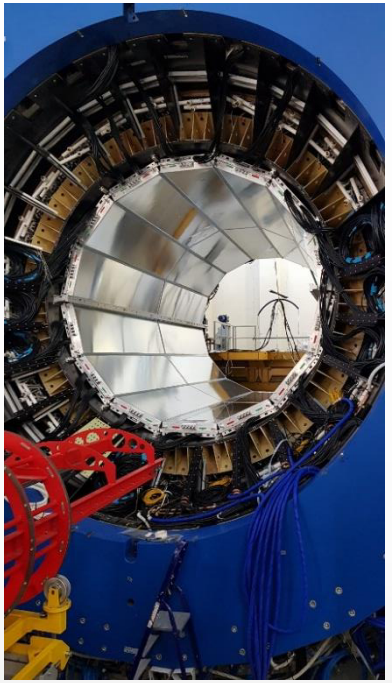
Single 3D Hall probe moves in 3 directions: z , R, ϕ
Accuracy: 0.1 – 0.3 Gs
Fields to measure: 0.2 – 0.5 T
Tunes of the Trim Coil currents (calculations and measurements)

- Magnetic field measurements completed in summer of 2026:
  - ✓ selected optimal currents for warm TRIM coils
  - ✓ measured field maps at 0.2T and nominal field of 0.5T
- Processing of the measured maps is ongoing
- Two groups (Novosibirsk State University and Moscow State University) are working to reproduce the measured map using magnetic field calculations from first principles (geometry, materials and currents)
- Magnet follows specifications and provides a high degree of magnetic field uniformity
- Analysis of the residual non-uniformities and their impact on the TPC coordinate measurements indicates that they will negligibly affect momentum reconstruction during the initial years of operation

Assembly of the central barrel



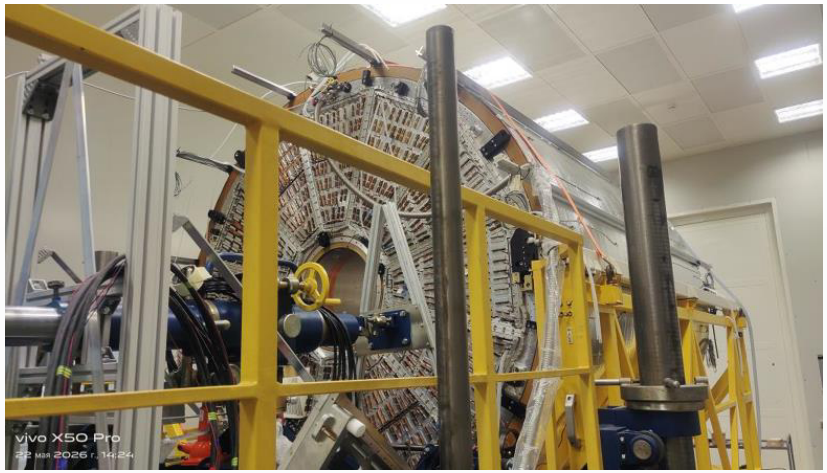




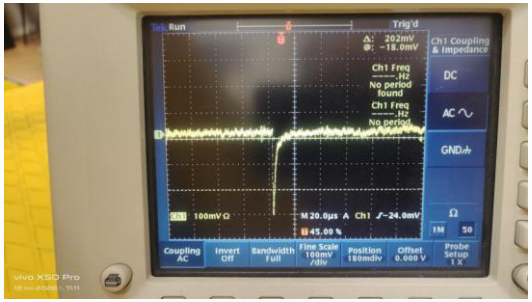
- Carbon fiber power frame installed in the magnet
  - ✓ sagita ~ 5 mm at full load (ECAL ~ 100 t), rails for TPC and TOF installed
- All 50 ECAL half-sectors installed (100%):
  - ✓ 38,400 towers (2400 modules) manufactured in Russia and China
- All 28 TOF modules installed (100%):
  - ✓ 280 MRPC chambers fabricated in JINR

TPC – central tracking detector

- Gas volume assembled, 24 ROCs installed, Leak & HV tests passed, FEE mounted



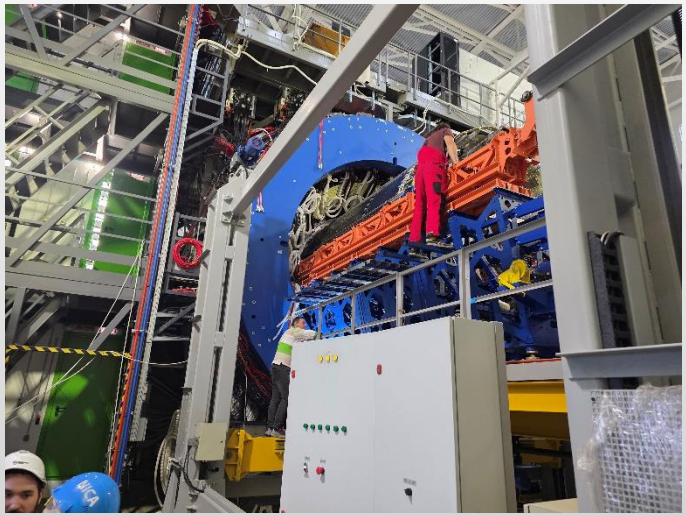
Cosmic and laser track tests



Ar/CH_4 (90:10)
ROC chamber HV +1.6 kV
TPC HV -25 kV

- TPC was successfully transported to the MPD Hall and then installed in the magnet
- Cable & pipe mounting is being finalized

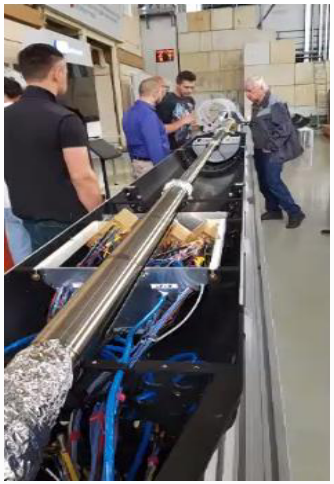




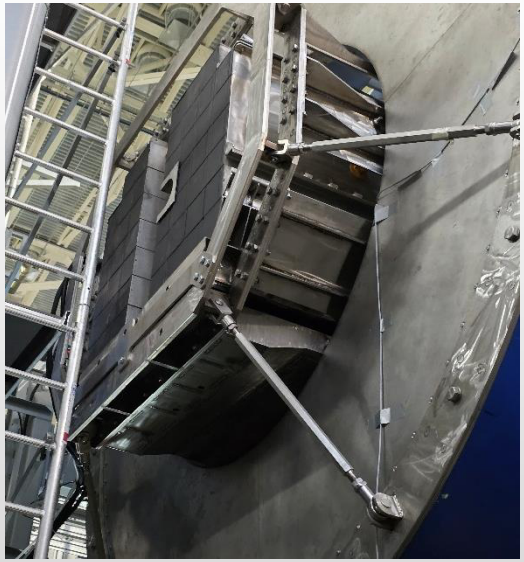
Forward subsystems

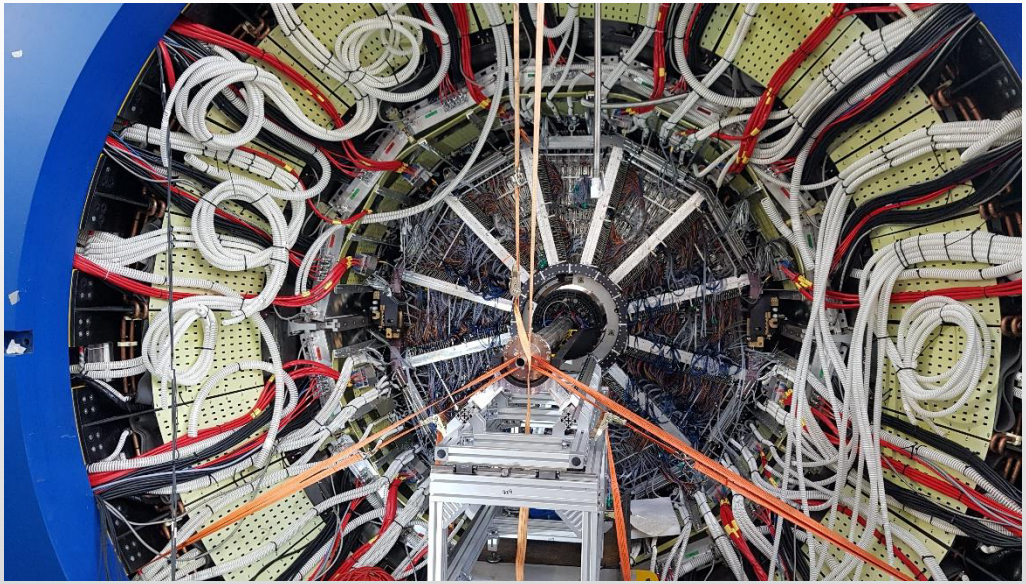
- FHCAL and Central cartridge (FFD, Beam Pipe, ITS/FFD/BP supports) - ready









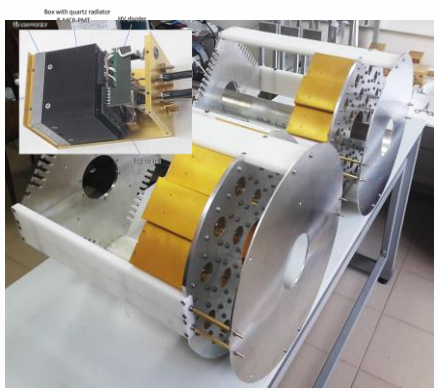


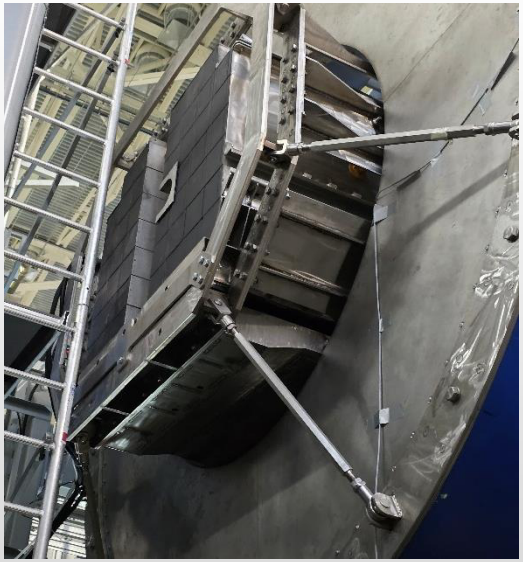
See dedicated talks for each subsystem later today and tomorrow

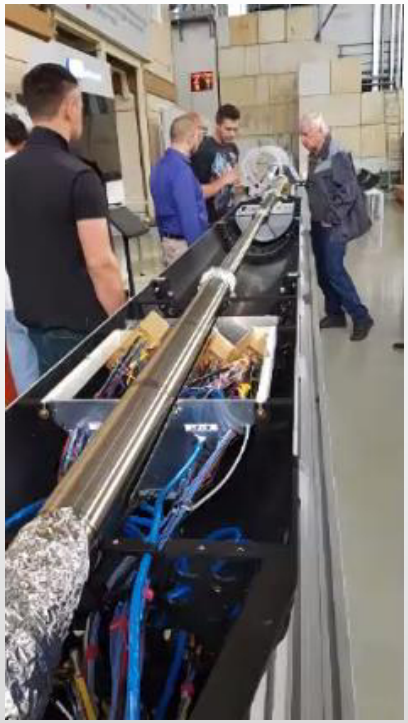
Forward subsystems

FHCAL - ready





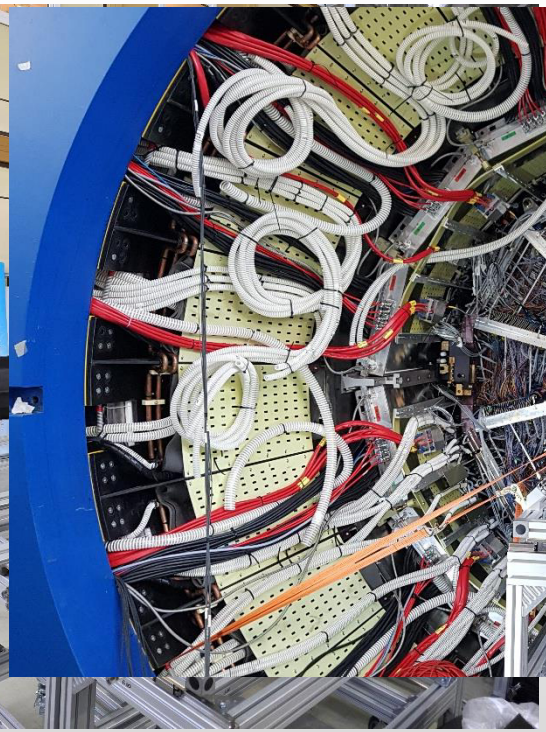




FFD - ready

Assembly of the cartridge with the beam pipe, FFDs and ITS supports





See dedicated talks for each subsystem later today and tomorrow

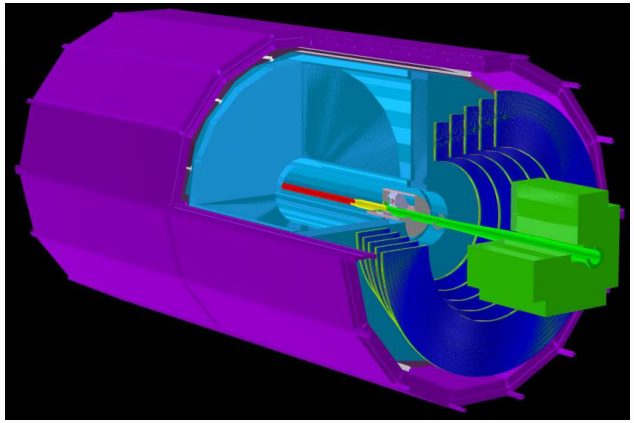
MPD schedule

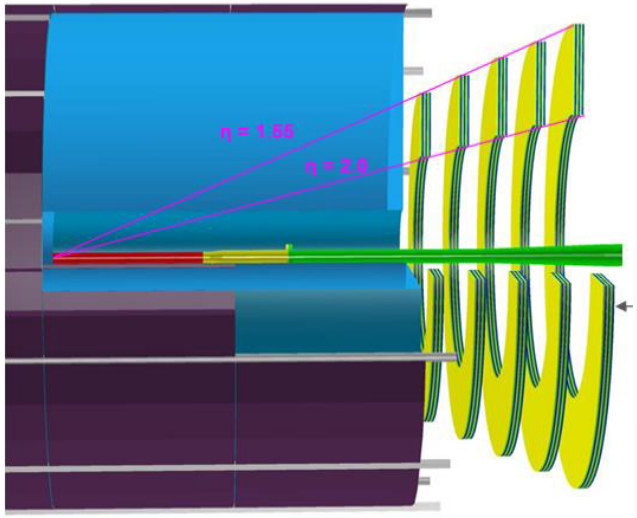
		2026
1	14.10	Installation of the TPC into the MPD
2	15 – 16.10	mounting TPC electronics on both sides (east-west)
3	16.10 – 21.10	Connection of TPC cables and water pipes
3	19.10	Installation of infrastructure for mounting the beam pipe inside the TPC
4	20.10	Installation of the beam pipe inside the MPD
5	23.10	Closing of the western pole (The beam pipe passes through the separated halves of the FHCal)
6	24.10	Closing of the eastern pole. (The beam pipe passes through the separated halves of the FHCal)
7	25.10 -23:00	Beam commissioning / Moving into the beam line

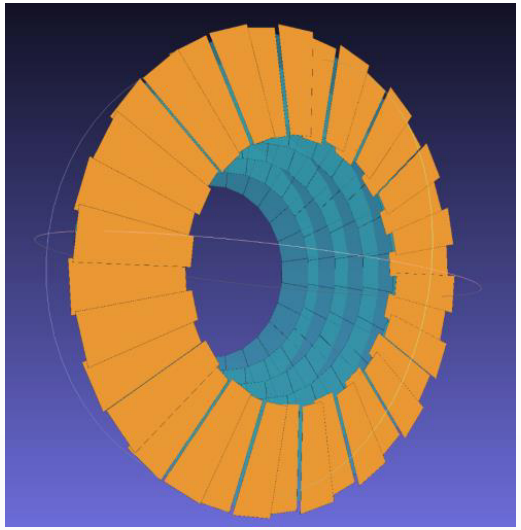
MPD in the beam position and start of commissioning in October-November

Development of the Forward Spectrometers

Conception of the Forward Tracker (FTD)

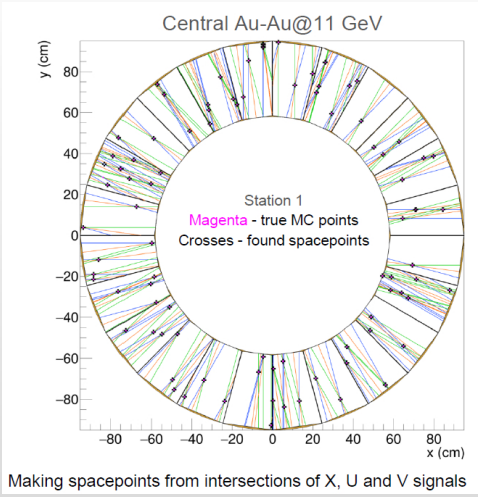


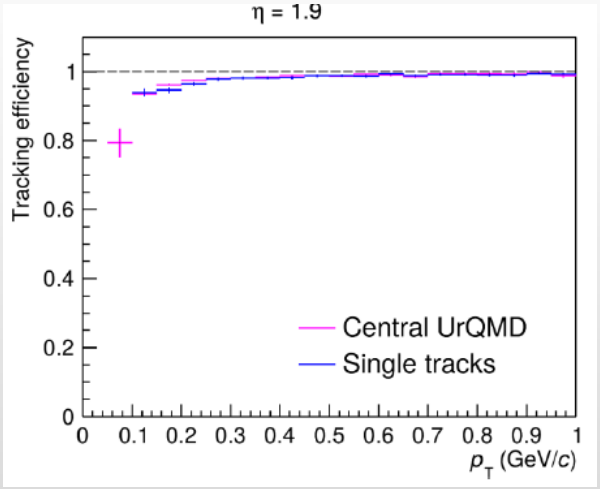


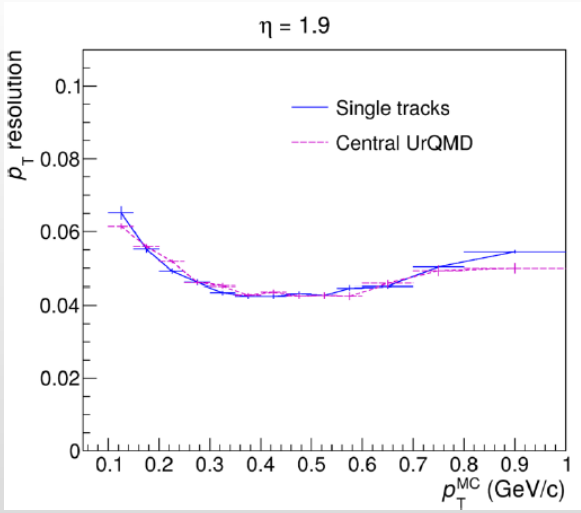


Five tracking layers (straw, asymmetric TGC, etc.)

One time-of-flight outer layer (36 MRPC chambers)



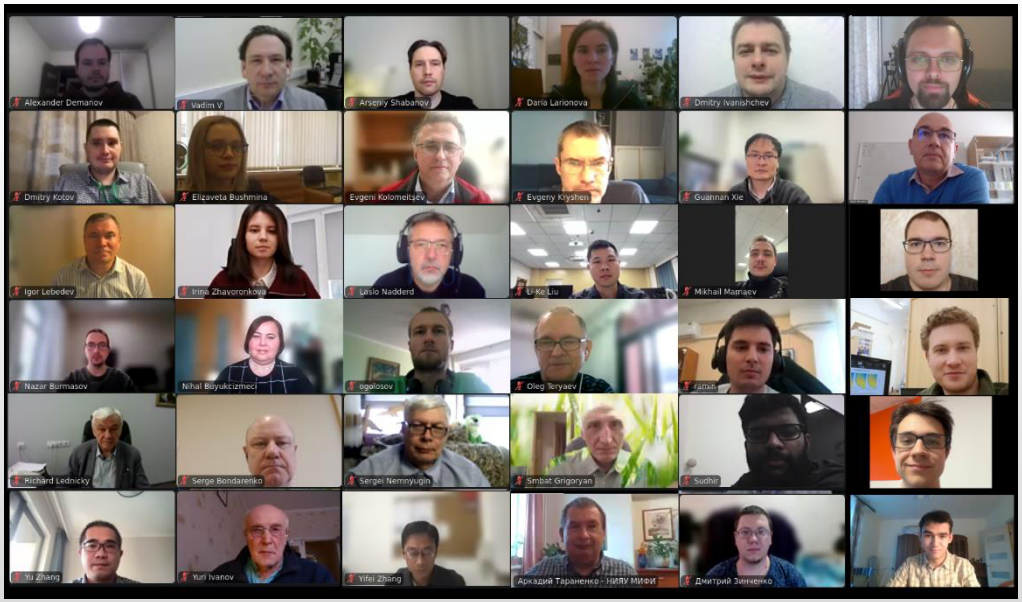




Realistic hit producers → ACTS stand-alone tracking → trying to find optimal technological solutions for the tracking chambers → high efficiency and reasonable momentum/spatial resolution → ongoing

Conference activity

- MPD presentations at conferences since last meeting:
  - ✓ PPIHE-2026, Protvino, Russia, June 2-5
  - ✓ DSPIN-2026, Dubna, Russia, September 7-11
  - ✓ Nucleus-2026, Arkhangelsk, Russia, September 21-27
  - ✓ INTW-2026, Kemer, Turkey, September 20-26
  - ✓ ICPPA-2026, Moscow, Russia, October 27-30
- Submitted two abstracts to QM-2027 → awaiting decision of organizers
- JINR-MEPhI organized International Workshop NICA-2026, Dec. 8-10
  - ✓ discussion of NICA physics at BM@N and MPD
  - ✓ https://indico.jinr.ru/event/6419/

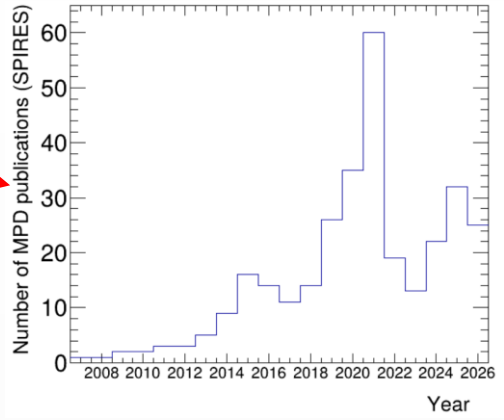


Co-chairs
Arkadiy Taranenko (MEPhI, JINR)
Evgeni Kolomeitsev (JINR, UMB, Banska Bystrica)
Victor Riabov (PNPI, MEPHI)

Organizing commitee
Zebo Tang (USTC, China)
Yi Wang (Tsinghua University, China)
Shusu Shi (CCNU, China)
Natalia Barbashina (MEPhI)
Ivan Astapov (MEPhI)
Dmitry Blau (NRC Kurchatov Institute)
Serge Bondarenko (BLTP JINR)
Fedor Guber (INR RAS)
Vadim Kolesnikov (JINR)

Publication activity

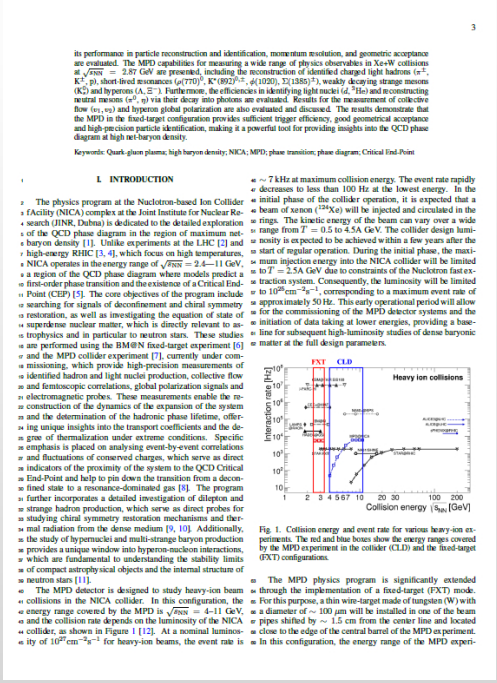
- Overall 250+ publications indexed by SPIRES
- Collaboration papers (published):
  - **I. Status and initial physics performance studies of the MPD experiment at NICA**
    Eur.Phys.J.A 58 (2022) 7, 140 (~ 50 pages)
  - **II. MPD physics performance studies in Bi+Bi collisions at $\sqrt{s_{NN}}$ = 9.2 GeV**
    Rev.Mex.Fis. 71 (2025) 4, 041201, e-Print: 2503.21117 (~ 40 pages)
- Collaboration papers (submitted) :
  - **III. MPD physics performance studies in the fixed-target Xe+W collisions at $\sqrt{s_{NN}}$ = 2.87 GeV**
    Submitted to the Nuclear Science and Techniques journal, September 2026 (~ 40 pages)




E.A. Streletskaya,[3] O.I. Streltsova,[3] M. Strikhanov,[7] T.A. Strizh,[3] A. Strizhak,[11] X. San,[25] D.A. Suvarieva,[40] A. Svetlichnyi,[11] Z. Tang,[36] M.E. Tejeda-Yeomans,[31] A. Taranenko,[7] V.A. Tchekhovski,[23] D.A. Tereshin,[3] A.V. Terletskiy,[3] O.V. Teryaev,[3] V.V. Tikhomirov,[3] A.A. Timoshenko,[3] G. Tinoco-Santillán,[5] V.D. Toneev,[3] N.D. Topilin,[3] T.Yu. Tretyakova,[12] V.V. Trofimov,[3] V.V. Troshin,[27] G.V. Trubnikov,[3] A.Trutse,[3] E.A. Tsapulina,[3] I. Tserruya,[41] I.A. Tyapkin,[3] S.Yu. Udovenko,[3] V.V. Uzhinsky,[3] M. Vala,[13] F.F. Valiev,[4] V.A. Vasendina,[3] A. Vasilyev,[3] C.R. Vázquez Villamar,[5] V.V. Vechernin,[6] V.K. Velichkov,[42] S.V. Vereshagin,[3] A.S. Vodopyanov,[3] K. Vokhmyanina,[34] V. Volkov,[11] A.L. Voronin,[3] A.N. Voronkov,[3] V. Voronyuk,[3] J. Vrláková,[13] J. Wang,[35] X. Wang,[43] Y. Wang,[28] Y. Wang,[33] Y. Wang,[33] Y. Wang,[25] K. Wu,[24] L. Xiao,[25] M. Xiao,[43] G. Xie,[32] C. Yang,[33] H. Yang,[29] Z. Yuan,[32] V.I. Yurevich,[3] S.V. Yurchenko,[6] E.E. Zabrodin,[12] N.I. Zamyatin,[3] S.A. Zaporozhets,[3] E.O. Zemlin,[6] W. Zha,[36] H. Zhang,[29] Y. Zhang,[29] Z. Zhang,[28] C. Zhao,[29] M.A. Zharov,[6] I. Zhavoronkova,[7] V.I. Zhemchevsky,[6] X. Zhu,[24] X. Zhu,[25] A.I. Zinchenko,[3] D.A. Zinchenko,[3] V.N. Zryuev,[3] M.I. Zuev,[3] and I.A. Zur[23]

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[2]A.I. Alikhanyan National Lab of Armenia, Yerevan, ARMENIA
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[4]Institute of Power Engineering of the National Academy of Sciences of Belarus, Minsk, BELARUS
[5]Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de Mexico, Mexico City, MEXICO
[6]Saint Petersburg State University, Saint Petersburg, RUSSIA
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[11]Institute for Nuclear Research of the Russian Academy of Sciences, Moscow, RUSSIA
[12]Skobeltsyn Institute of Nuclear Physics (SINP) of the Moscow State University, Moscow, RUSSIA
[13]Pavol Jozef Šafárik University, Košice, SLOVAKIA
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[18]Institute of Nuclear Physics, Almaty, KAZAKHSTAN
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[33]Shandong University, Qingdao, CHINA
[34]Belgorod National Research University, Belgorod, RUSSIA
[35]Huzhou University, Huzhou, CHINA
[36]University of Science and Technology of China, Hefei, CHINA
[37]Joint Institute for Nuclear Research, Dubna, RUSSIA,
National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Moscow, RUSSIA
[38]Joint Institute for Nuclear Research, Dubna, RUSSIA,
Petersburg Nuclear Physics Institute named by B.P. Konstantinov of NRC "Kurchatov Institute", Gatchina, RUSSIA
[39]"VINCA" Institute of Nuclear Science - National Institute of the Republic of Serbia, University of Belgrade, SERBIA
[40]Faculty of Physics, University of Sofia, BULGARIA
[41]Weizmann Institute of Science, Rehovot, ISRAEL
[42]Institute of Mechanics, Bulgarian Academy of Science, Sofia, BULGARIA
[43]University of South China, Hengyang, CHINA

This paper presents a comprehensive study of the physics performance of the Multi-Purpose Detector (MPD) at the NICA complex, operating in the fixed-target mode. While the MPD is primarily designed for collider experiments at $\sqrt{s_{NN}} = 4 - 11$ GeV, the fixed-target mode extends its research potential, allowing for the investigation of dense baryonic matter in ion collisions at lower center-of-mass energies of $\sqrt{s_{NN}} = 2.4 - 3.5$ GeV, albeit in a different rapidity range. The energy-dependent efficiency of the detector in event triggering,


its performance in particle reconstruction and identification, momentum resolution, and geometric acceptance are evaluated. The MPD capabilities for measuring a wide range of physics observables in Xe+W collisions at $\sqrt{s_{NN}} = 2.87$ GeV are presented, including the reconstruction of identified charged light hadrons ($\pi^{\pm}$, $K^{\pm}$, p), short-lived resonances ($\rho(770)^0$, $K^*(892)^{0,\pm}$, $\phi(1020)$, $\Sigma(1385)^{\pm}$), weakly decaying strange mesons (K^0_S) and hyperons (Λ, Ξ^-). Furthermore, the efficiencies in identifying light nuclei (d, ^{3}He) and reconstructing neutral mesons (π^0, η) via their decay into photons are evaluated. Results for the measurement of collective flow (v_1, v_2) and hyperon global polarization are also evaluated and discussed. The results demonstrate that the MPD in the fixed-target configuration provides sufficient trigger efficiency, good geometrical acceptance and high-precision particle identification, making it a powerful tool for providing insights into the QCD phase diagram at high net-baryon density.

Keywords: Quark-gluon plasma; high baryon density; NICA; MPD; phase transition; phase diagram; Critical End-Point

I. INTRODUCTION

The physics program at the Nuclotron-based Ion Collider fAcility (NICA) complex at the Joint Institute for Nuclear Research (JINR, Dubna) is dedicated to the detailed exploration of the QCD phase diagram in the region of maximum net-baryon density [1]. Unlike experiments at the LHC [2] and high-energy RHIC [3, 4], which focus on high temperatures, NICA operates in the energy range of $\sqrt{s_{NN}} = 2.4$—11 GeV, a region of the QCD phase diagram where models predict a first-order phase transition and the existence of a Critical End-Point (CEP) [5]. The core objectives of the program include searching for signals of deconfinement and chiral symmetry restoration, as well as investigating the equation of state of superdense nuclear matter, which is directly relevant to astrophysics and in particular to neutron stars. These studies are performed using the BM@N fixed-target experiment [6] and the MPD collider experiment [7], currently under commissioning, which provide high-precision measurements of identified hadron and light nuclei production, collective flow and femtoscopic correlations, global polarization signals and electromagnetic probes. These measurements enable the reconstruction of the dynamics of the expansion of the system and the determination of the hadronic phase lifetime, offering unique insights into the transport coefficients and the degree of thermalization under extreme conditions. Specific emphasis is placed on analysing event-by-event correlations and fluctuations of conserved charges, which serve as direct indicators of the proximity of the system to the QCD Critical End-Point and help to pin down the transition from a deconfined state to a resonance-dominated gas [8]. The program further incorporates a detailed investigation of dileptons and strange hadron production, which serve as direct probes for studying chiral symmetry restoration mechanisms and thermal radiation from the dense medium [9, 10]. Additionally, the study of hypernuclei and multi-strange baryon production provides a unique window into hyperon-nucleon interactions, which are fundamental to understanding the stability limits of compact astrophysical objects and the internal structure of neutron stars [11].

The MPD detector is designed to study heavy-ion beam collisions in the NICA collider. In this configuration, the energy range covered by the MPD is $\sqrt{s_{NN}} = 4$–11 GeV, and the collision rate depends on the luminosity of the NICA collider, as shown in Figure 1 [12]. At a nominal luminosity of 10^{27}cm^{-2}s^{-1} for heavy-ion beams, the event rate is ~ 7 kHz at maximum collision energy. The event rate rapidly decreases to less than 100 Hz at the lowest energy. In the initial phase of the collider operation, it is expected that a beam of xenon (^{124}Xe) will be injected and circulated in the rings. The kinetic energy of the beam can vary over a wide range from $T = 0.5$ to 4.5A GeV. The collider design luminosity is expected to be achieved within a few years after the start of regular operation. During the initial phase, the maximum injection energy into the NICA collider will be limited to $T = 2.5$A GeV due to constraints of the Nuclotron fast extraction system. Consequently, the luminosity will be limited to 10^{26}cm^{-2}s^{-1}, corresponding to a maximum event rate of approximately 50 Hz. This early operational period will allow for the commissioning of the MPD detector systems and the initiation of data taking at lower energies, providing a baseline for subsequent high-luminosity studies of dense baryonic matter at the full design parameters.

Fig. 1. Collision energy and event rate for various heavy-ion experiments. The red and blue boxes show the energy ranges covered by the MPD experiment in the collider (CLD) and the fixed-target (FXT) configurations.

The MPD physics program is significantly extended through the implementation of a fixed-target (FXT) mode. For this purpose, a thin wire-target made of tungsten (W) with a diameter of ~ 100 μm will be installed in one of the beam pipes shifted by ~ 1.5 cm from the center line and located close to the edge of the central barrel of the MPD experiment. In this configuration, the energy range of the MPD experi-

Funding

- Support program from Russian Ministry of Education and Science for NICA:
  - ✓ Russian groups from subordinated organizations participating in NICA with signed MOUs
  - ✓ 200 MRUB (~2.2 M$) in 2024 for NICA: MPD, BM@N, SPD, ARIADNA, accelerator
  - ✓ program extended to 2027-2029

- ~ 40 MRUB for MPD per year:
  - ✓ supported organizations: MEPhI, St.Petersburg Polytechnic University, INR RAS, Belgorod National Research University, North Ossetia State University

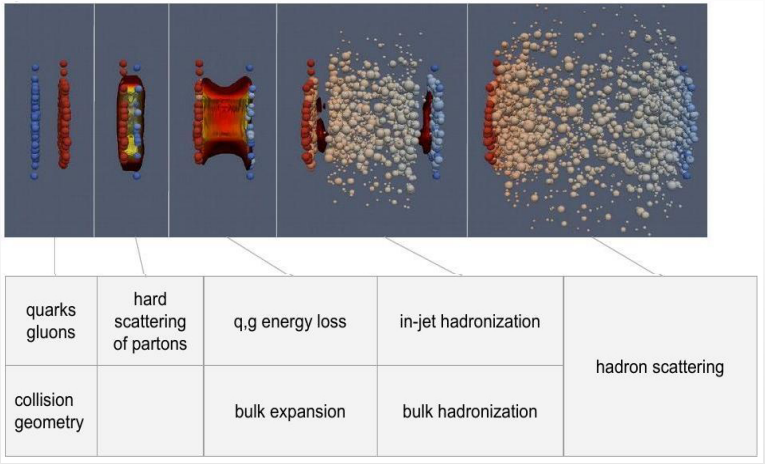
- Problems:
  - ✓ KI, MSU, SPbSU, HSE University are excluded from the program (not subordinated organizations)
  - ✓ no funds for travel (shifts, etc.)

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

- Mescheryakov Laboratory of Information Technologies takes active participation in MPD collaboration works. We are grateful for provided computing resources, development and support of IT services.

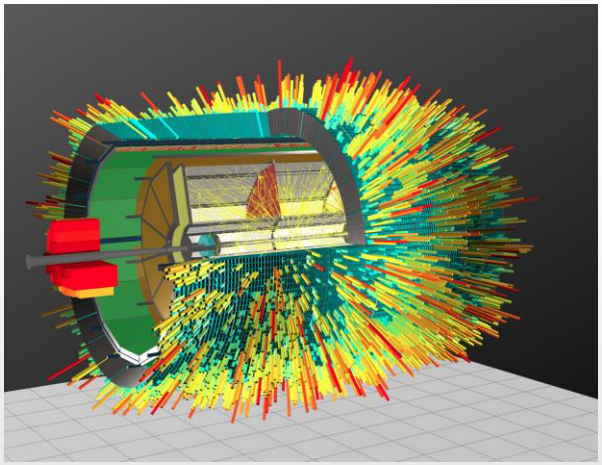
Event generator(s)



MpdRoot

JINR MLIT

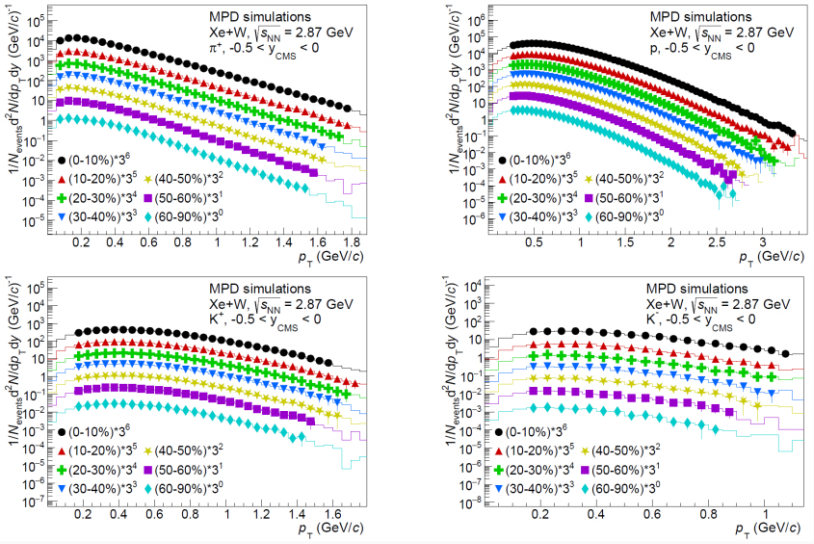
Particle propagation & detector response



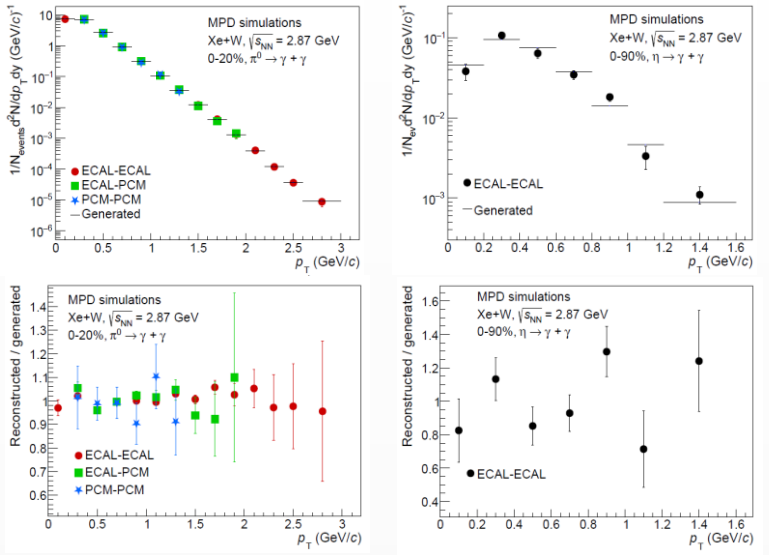
- Develop physics program, software and analysis infrastructure for real data analysis
- MPD-CLD and MPD-FXT studies with simulations:
  - ✓ collider mode: Bi+Bi @ 9.2 GeV
  - ✓ fixed-target mode: Xe + W @ T = 2.5 AGeV

MPD-FXT: light-flavor identified hadron production

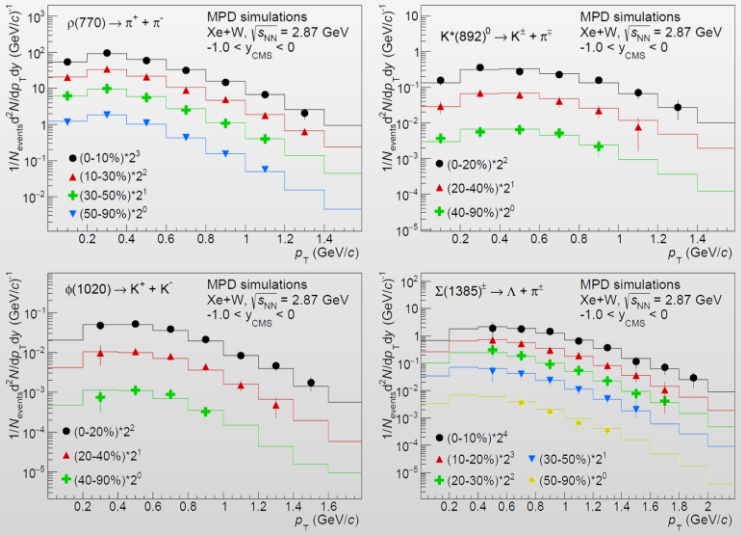
$\pi^{\pm}$, $K^{\pm}$, p (TPC & TOF)



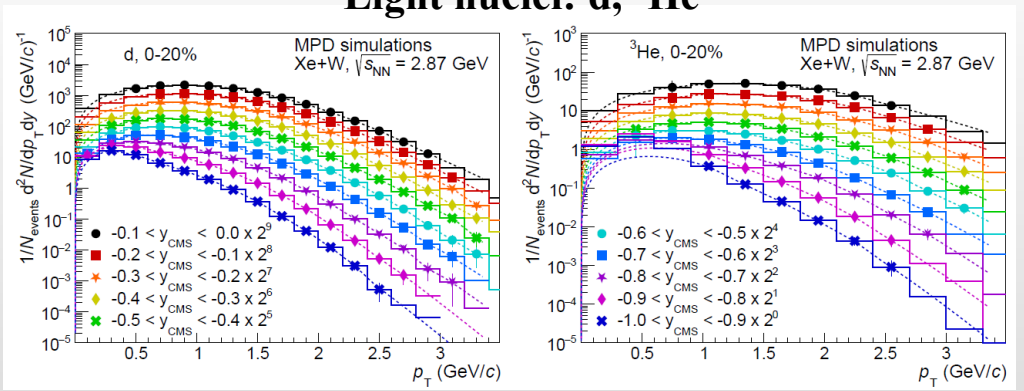
γ, π^0, η (ECAL, TPC & TOF)



ρ, $K^*(892)^{0,\pm}$, $\phi(1020)$, $\Sigma(1385)^{\pm}$ (TPC&TOF)



Light nuclei: d, ^{3}He

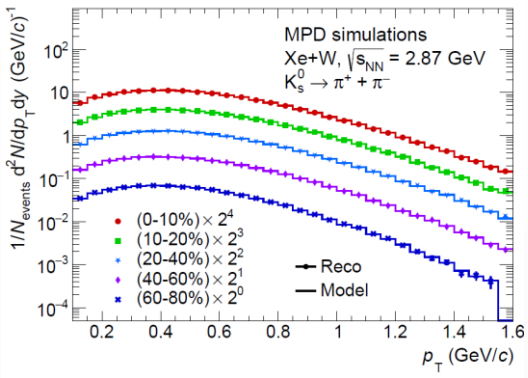


Differential and integrated yield of a wide variety of identified light-flavor hadrons

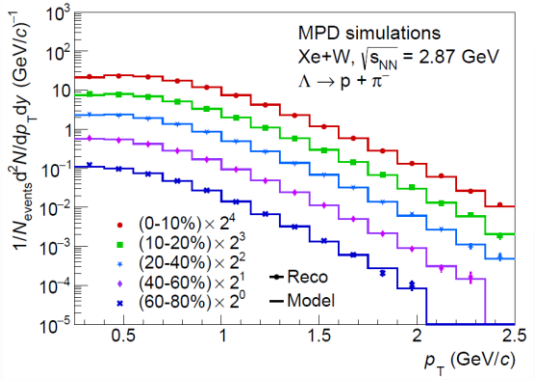
→ asymmetric rapidity coverage

MPD-FXT: (multi)Strange hadrons

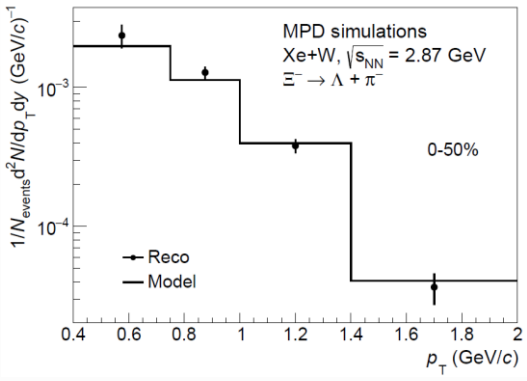
$K_s^0 \rightarrow \pi^+ + \pi^-$



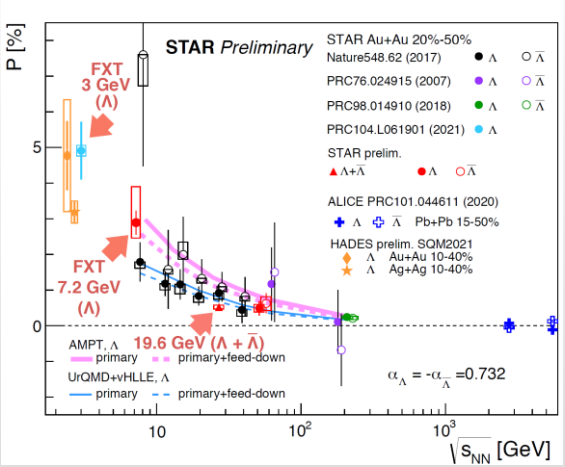
$\Lambda \rightarrow p + \pi^-$

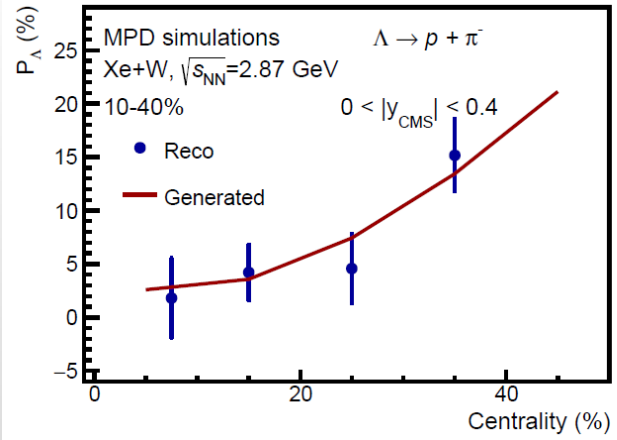


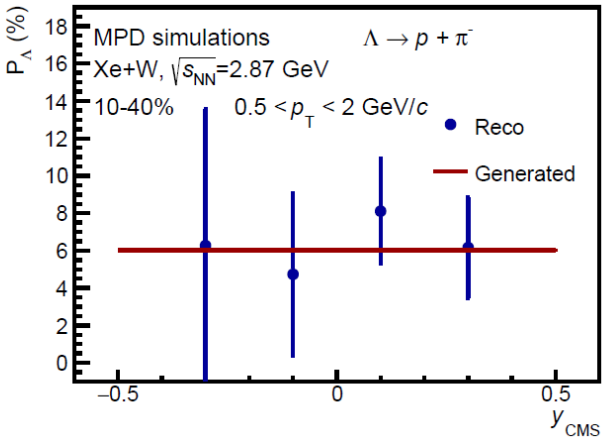
$\Xi^- \rightarrow \Lambda + \pi^-$



Centrality/energy dependent study in a wide p_T range → strangeness enhancement, near or sub-threshold production, p_T-differential hyperon-to-meson ratios for hadronization mechanisms, etc.



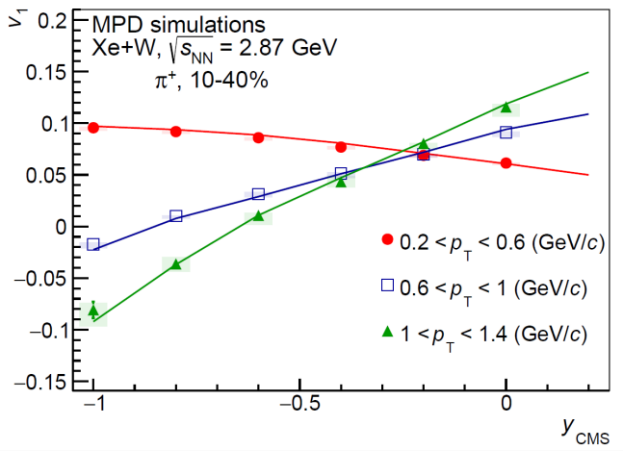


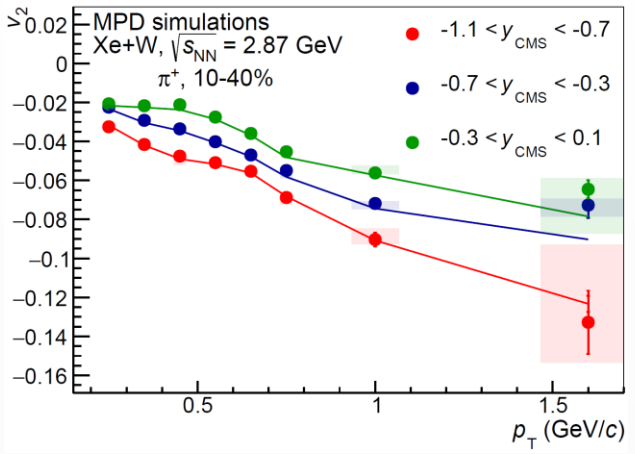


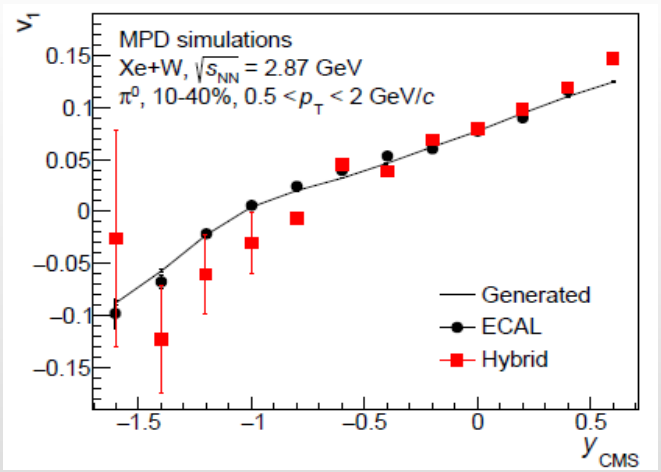
Global polarization signals are constructible → very statistics hungry analysis

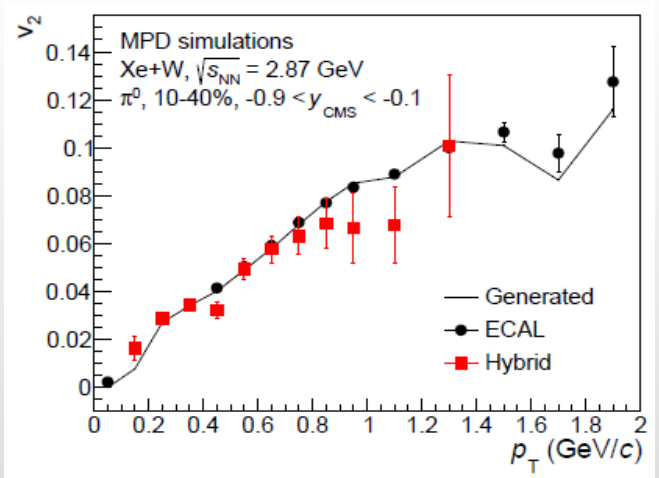
MPD-FXT: Collective flow

Charged and neutral pions





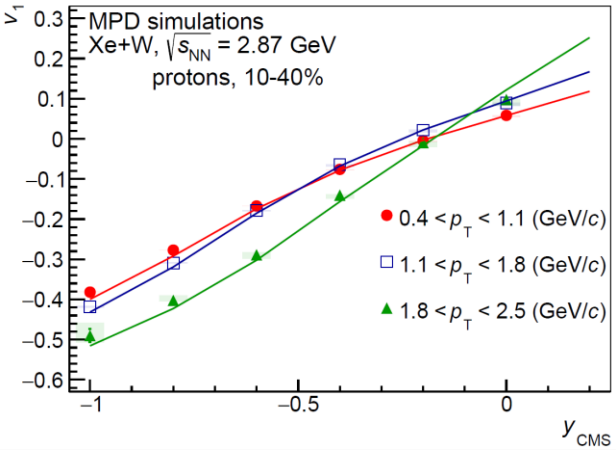


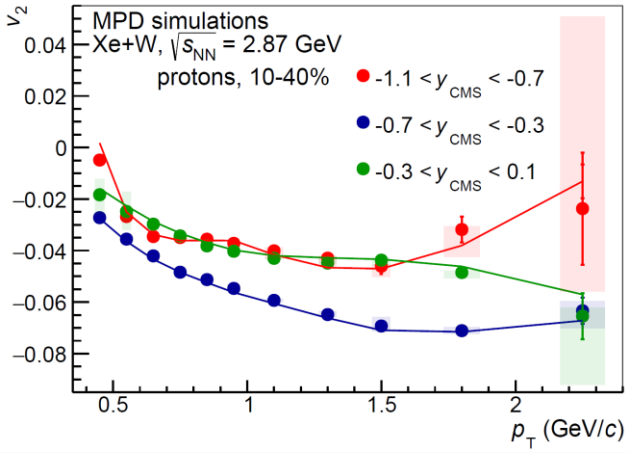


Reliable reconstruction of v1/v2 → cross checks → different momentum/rapidity coverage

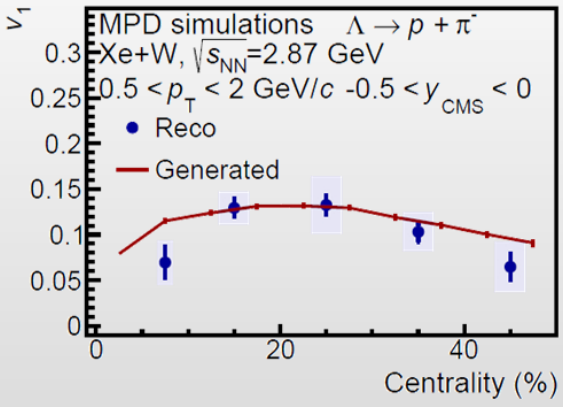
MPD-FXT: Collective flow

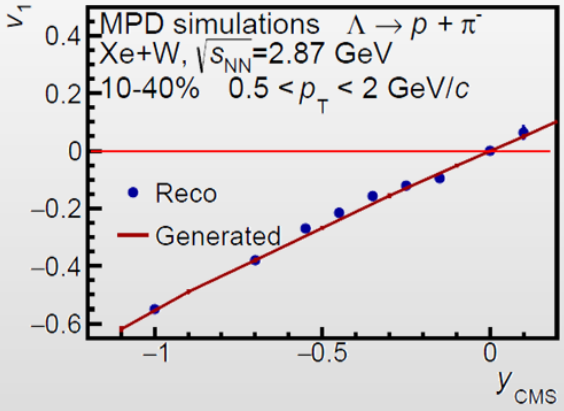
Protons

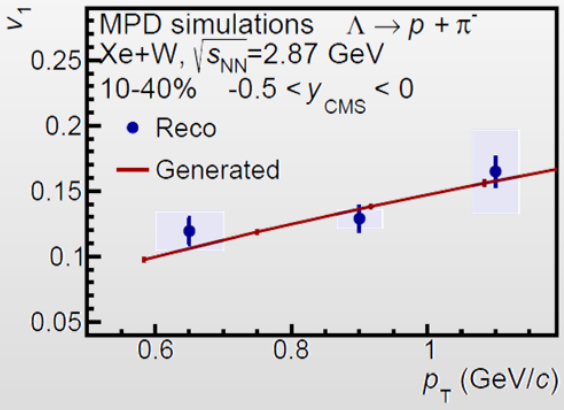




Lambda (weak decays)







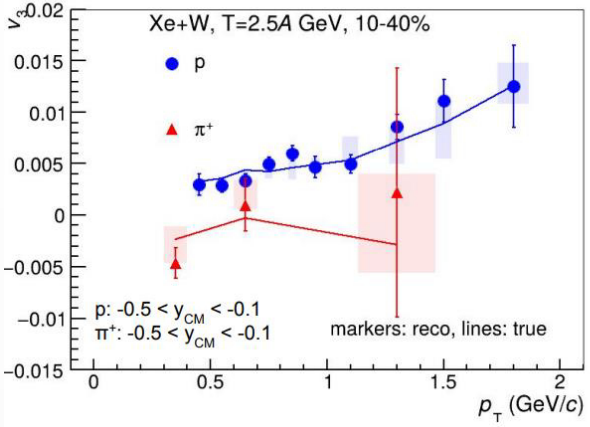
Reliable reconstruction of v1/v2 → weak decays + resonances

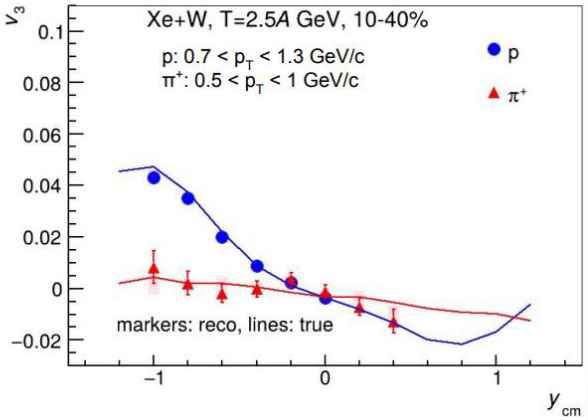
MPD-FXT: Collective flow, higher harmonics

Results: v_3

Statistics: ~100M events

Sub-event selection: (u F1 F2 F3), (u F1 F1 F1), (u F2 F2 F2), (u F3 F3 F3)
Projections: (y3 X1 X1 Y1), (y3 X1 Y1 X1), …

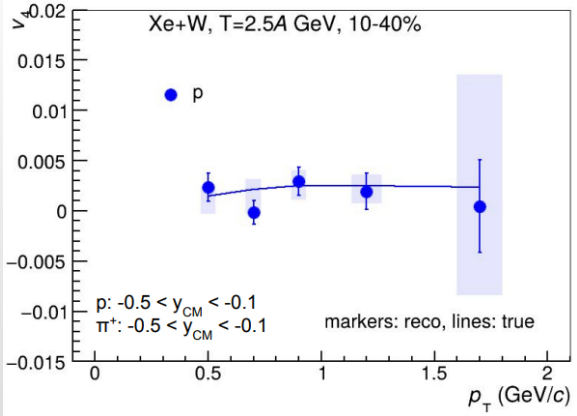


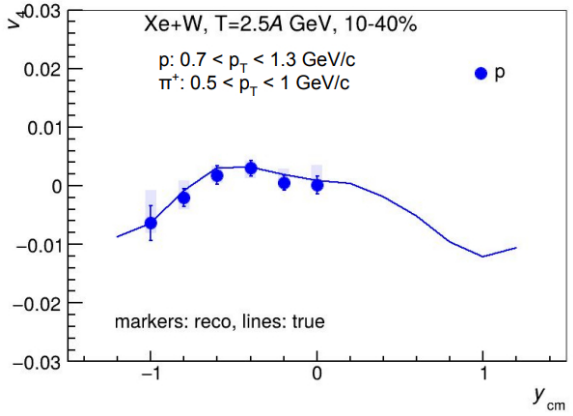


Results: v_4

Statistics: ~100M events

Sub-event selection: (u F1 F1 F1 F1), (u F2 F2 F2 F2), (u F3 F3 F3 F3)
Projections: (xXXYY), (xXYXY), (xXYYX), …





Systematics sources: different projections, different symmetry planes
Not enough statistics for pions - only protons shown

Higher harmonics are possible → statistics hungry

Near future, paradigm/complications/expectations

- We are entering a new era where new results from the MPD are expected to stem not from simulations - no matter how professional or impressive they are - but from the analysis of real data and the demonstration of actual detector performance

- This poses a problem - we have always advertised the MPD as an almost ready detector with superb capabilities, but in reality, we are just approaching its technical commissioning with beams of uncertain/poor quality. We are yet to see what kind of detector we have actually built, and we already know in advance that it will not be fully operational (not all subsystems) from the start

- All these complications will hardly serve as an excuse for us and will not give us a long grace period to bring the detector and simulations to a working state and to start demonstrating at least some detector performance and the physics-related results

- We have started to collect ideas on what we could demonstrate for the MPD using data collected during the upcoming run in a Google Doc:
https://docs.google.com/document/d/1UTnOtmWc19xtaRNjbx6W9qgx8ED6eT_YTIxWEjvwX68/edit?usp=sharing

Please come with good ideas, report at cross-PWG, contact privately → all ideas are welcome

Summary



- Significant progress with detector construction and assembly in the last half an year
- Detector in the beam position and first attempts of data taking in October-November
- Focus shifts from physics feasibility studies to real detector studies
- Continue to prepare software and analysis infrastructure for real data analysis

BACKUP