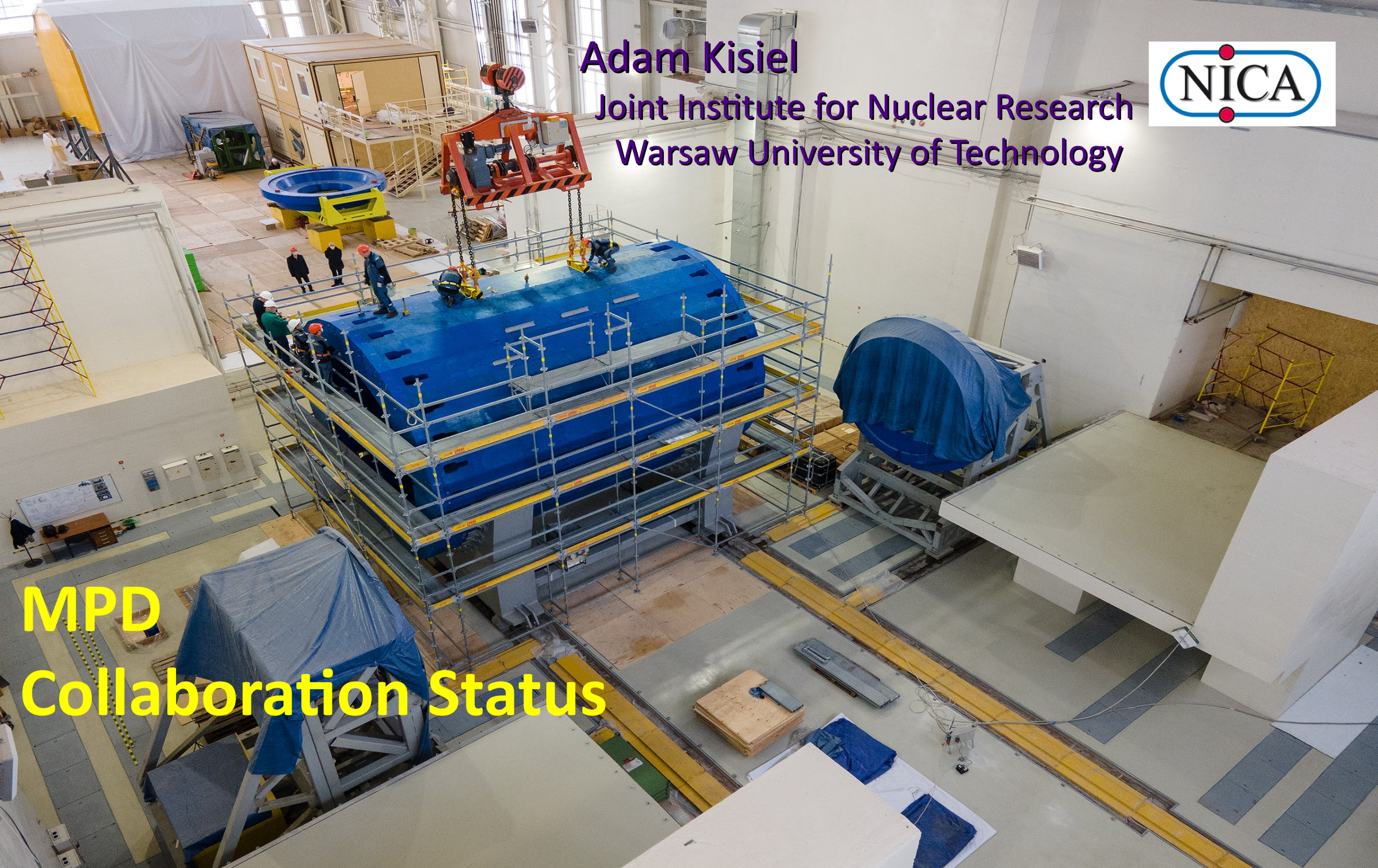
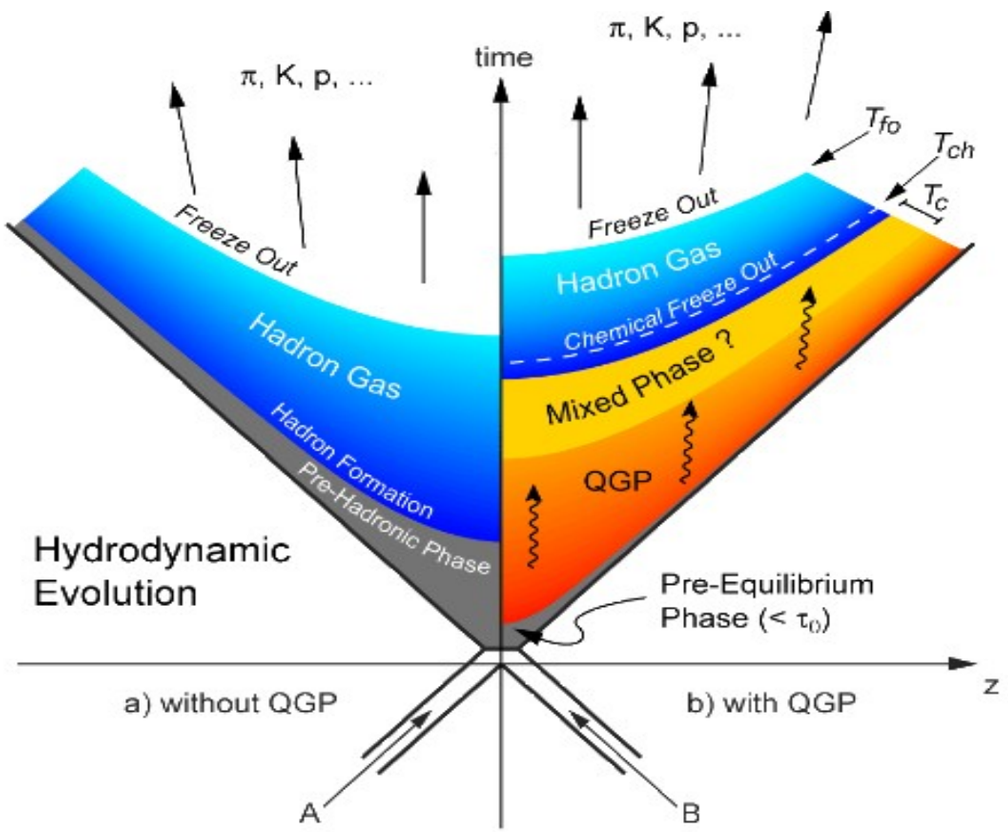


Adam Kisiel
Joint Institute for Nuclear Research
Warsaw University of Technology

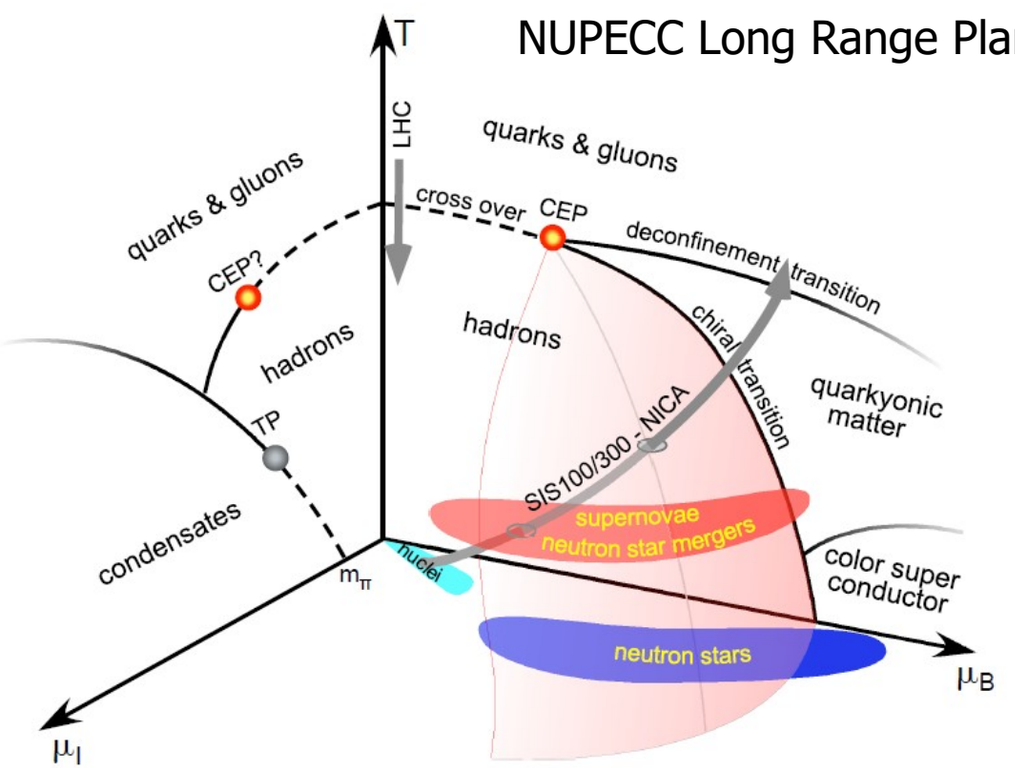
MPD Collaboration Status

A „Phase Transition” in HIC

- Limited exploration of the region of QCD phase-space at large densities
- Main objective: determination of Equation of State of QCD matter
- Investigation of the system size and collision energy dependence for non-monotonic behavior in observables



NUPECC Long Range Plan 2017

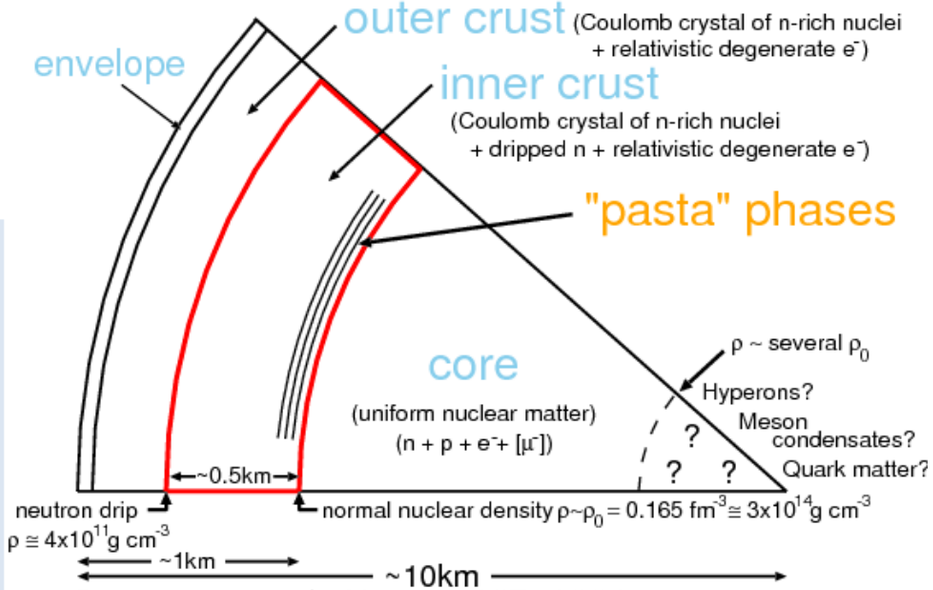


Access neutron star matter in laboratory

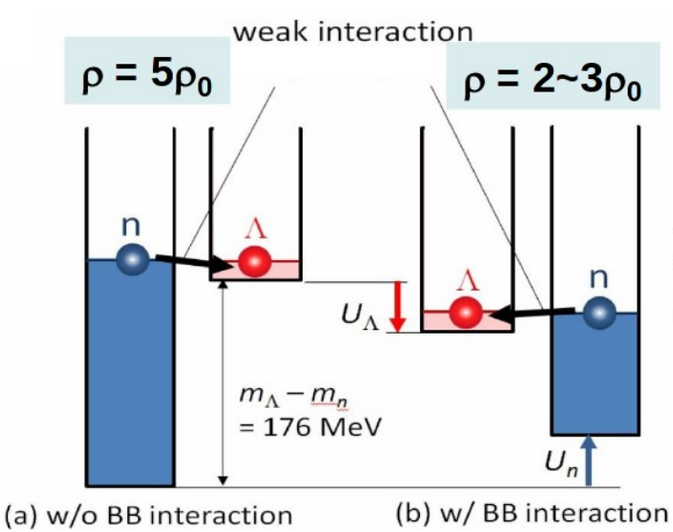
core of neutron stars reaches density several times nuclear density

appearance of strangeness changes Equation-of-State, depends on strangeness-nucleon interaction

Credit: LIGO Collaboration

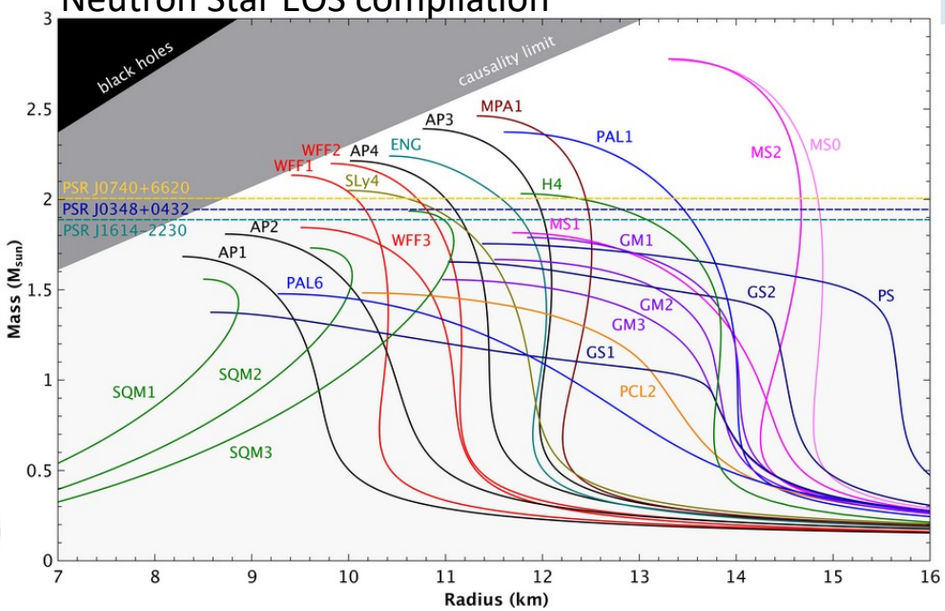


Demorest et al., Nature 467, 1081

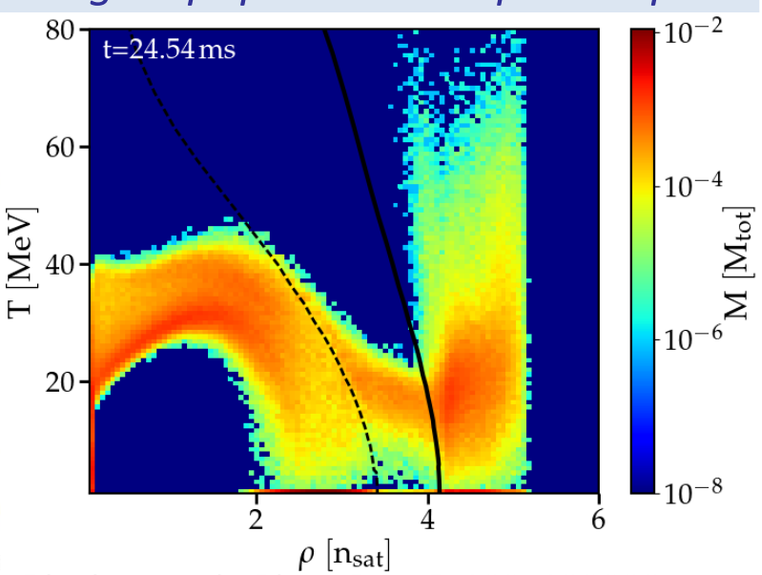


H. Tamura, Hadron 2017

Neutron Star EOS compilation



mergers populate NICA phase space



Blacker et al., Phys. Rev. D 102, 123023

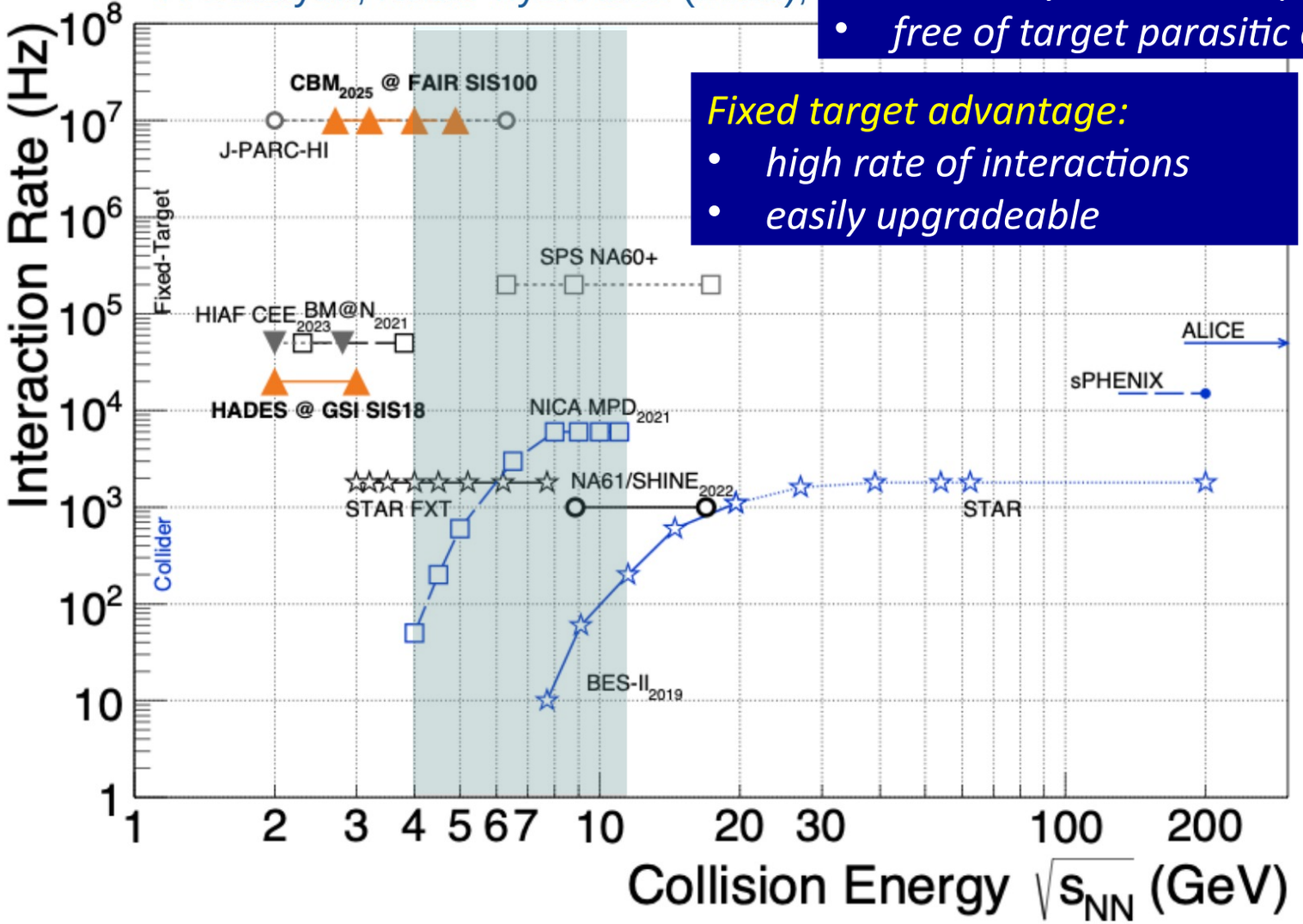
NICA: Unique and complementary

Collider advantage:
- *coverage of max. phase space*
- *minimally biased acceptance*
- *free of target parasitic effects*

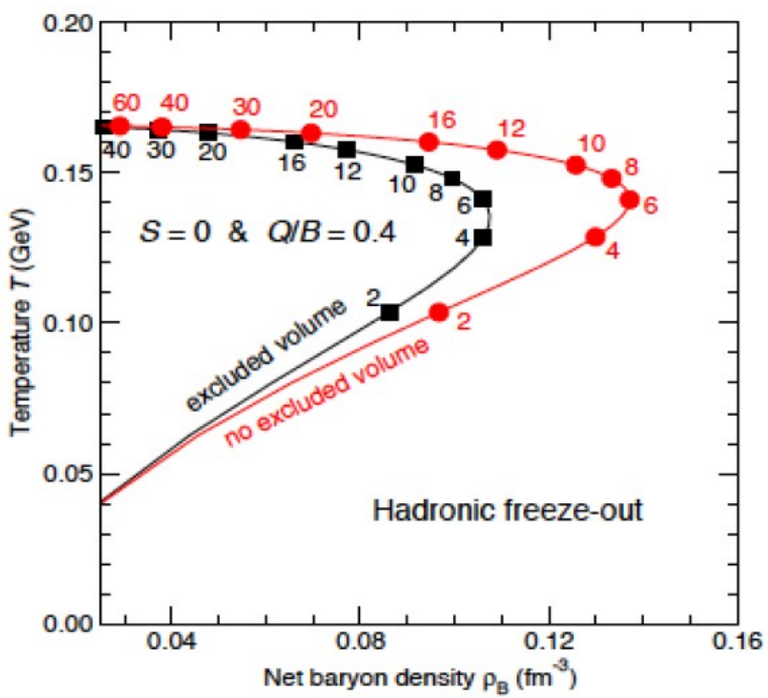
Fixed target advantage:
- *high rate of interactions*
- *easily upgradeable*

In NICA Collider energy range maximum possible net-baryon density is reached, transition from baryon to meson-dominated system

T. Galatyuk, Nucl.Phys. A982 (2019);



Highest baryon density at freeze-out for $s^{1/2}$~6 GeV, slightly lowering with ex.volume

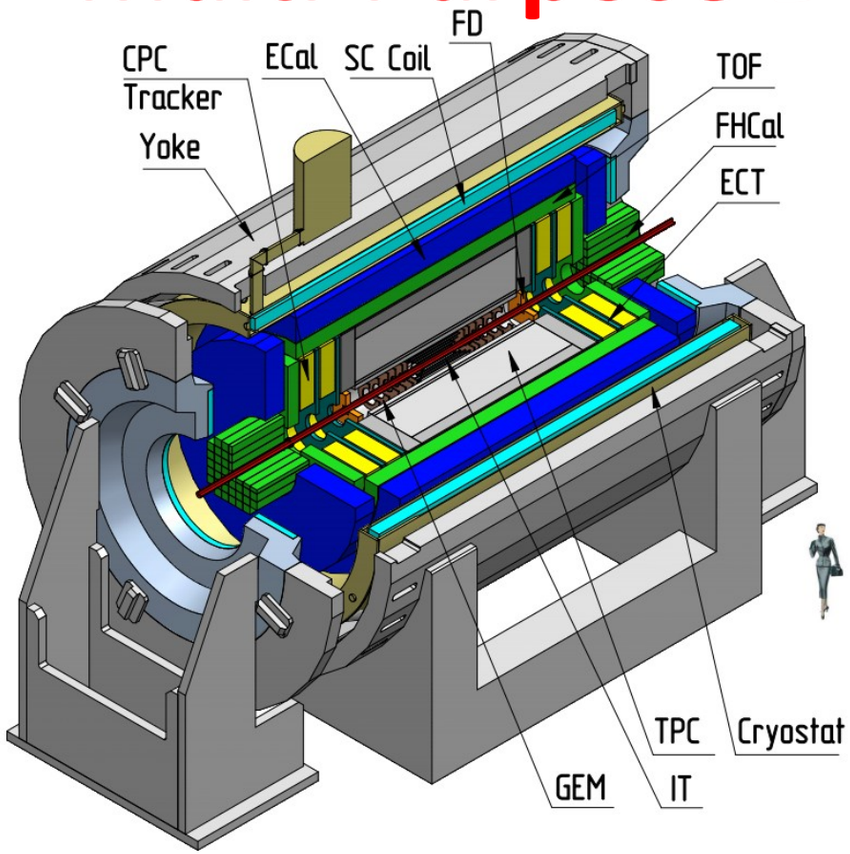


Why MPD at NICA?

- Common question: why is NICA/MPD needed, when there is NA61/SHINE at SPS, STAR BES (with FXT) and FAIR?

	NA61/SHINE at SPS	**CBM at FAIR**	**STAR BES+FXT at RHIC**	**MPD + BM@N at NICA**
Coverage of region of transition from baryon to meson dominance („horn")	only higher $\sqrt{s_{NN}}$	only lower $\sqrt{s_{NN}}$	Yes (mixing collider and fixed target)	Yes (consistent acceptance)
expected luminosity (w.r.t. MPD)	lower	higher	lower	reference
possibility for system size scan	yes	yes	not planned	yes
full centrality range	no	yes (?)	yes	yes
acceptance type	Fixed target	Fixed target	Collider + fixed target	Collider + fixed target
running plan (heavy-ions)	approved for 2021 (per-year decision)	beyond 2025	approved until 2021 later: sPHENIX, EIC	2023 and beyond
status at the facility (possible running time)	in competition with many projects (LHC)	CBM one of four main experiments	end of datataking (heavy-ion) in 2021	flagship experiments

Multi-Purpose Detector (MPD) Collaboration



11 *Countries,* ***>500*** *participants,*
39 *Institutes and* ***JINR***

NICA

Applying to join MPD:

Vinča Institute of Nuclear Sciences,
Serbia

Institute of Nuclear Physics,
Polish Academy of Science,
Krakow, ***Poland***

Universidad Autónoma Metropolitana,
Unidad Iztapalapa,
to be added to the ***Mexican*** *consortium*

AANL, Yerevan, ***Armenia;***
Baku State University, NNRC, ***Azerbaijan****;*
University of Plovdiv, ***Bulgaria;***
University Tecnica Federico Santa Maria, Valparaiso, ***Chile****;*
Tsinghua University, Beijing, ***China****;*
USTC, Hefei, ***China****;*
Huzhou University, Huzhou, ***China****;*
Central China Normal University, ***China****;*
Fudan University, Shanghai, ***China****;*
Shandong University, Qingdao, ***China****;*

IHEP, Beijing, ***China****;*
University of South China, ***China****;*
Three Gorges University, ***China****;*
Institute of Modern Physics, CAS, Lanzhou, ***China****;*
Palacky University, Olomouc, ***Czech Republic****;*
NPI CAS, Rez, ***Czech Republic****;*
Tbilisi State University, Tbilisi, ***Georgia****;*
Joint Institute for Nuclear Research*;*
FCFM-BUAP (Mario Rodriguez) Puebla, ***Mexico****;*
FC-UCOL (Maria Elena Tejeda), Colima, ***Mexico****;*
FCFM-UAS (Isabel Dominguez), Culiacán, ***Mexico****;*
ICN-UNAM (Alejandro Ayala), Mexico City, ***Mexico****;*
CINVESTAV (Luis Manuel Montaño), Mexico City, ***Mexico****;*
Institute of Applied Physics, Chisinev, ***Moldova****;*
WUT, Warsaw, ***Poland****;*
NCNR, Otwock – Świerk, ***Poland****;*
University of Wrocław, ***Poland****;*
University of Silesia, ***Poland;***
University of Warsaw, ***Poland****;*
Jan Kochanowski University, Kielce, ***Poland****;*
Belgorod National Research University, ***Russia****;*
INR RAS, Moscow, ***Russia****;*
MEPhI, Moscow, ***Russia****;*
Moscow Institute of Science and Technology, ***Russia****;*
North Osetian State University, ***Russia****;*
NRC Kurchatov Institute, ITEP, ***Russia****;*
Kurchatov Institute, Moscow, ***Russia****;*
St. Petersburg State University, ***Russia;***
SINP, Moscow, ***Russia****;*
PNPI, Gatchina, ***Russia****;*

Deputy Spokespersons:
Victor Riabov, Zebo Tang

Spokesperson: ***Adam Kisiel***
Inst. Board Chair: ***Fuqiang Wang***
Project Manager: ***Slava Golovatyuk***

Memorandum of Understanding

- Memorandum of Understanding formalizes the participation of the Institution in the Collaboration, defines its rights and obligations
- Currently MPD MoU ready for: **Mexican** Consortium MexNICA, **Poland**: WUT, NCBJ, Warsaw University, UJK in Kielce, University of Wrocław, University of Silesia, **Czech Republic**: Palacky University, NPI CAS, **Azerbaijan**: NNRC Baku, **Bulgaria**: Plovdiv University, **Russian Federation**: SPSU, INR RAS, SINP MSU, Belgorod State University, MIPT Moscow, NRC „Kurchatov Institute" – ITEP, **Armenia:** A. Alikahnyan National Lab of Armenia,
- Recently prepared MoUs: **China:** Tsinghua University, University of Chinese Academy of Sciences, Huzhou University, Shandong University, Central China Normal University, Fudan University, University of Science and Technology of China, University of South China, Three Gorges University

MPD Executive Council

- The Executive Council composition:
  - **Vadim Kolesnikov, Yi Wang, Alejandro Ayala, Alexander Zinchenko, Oleg Rogachevsky, Arkadiy Taranenko**, **Ilya Sleyuzhenkov**, **Andrei Dolbilov**
- We thank **Alejandro Ayala** and **Alexander Zinchenko** for their first term at the Executvie Council. The elections for the two posts will be held by the Institutional Board tomorrow.
- Some of the topics discussed at the EC meetings:
  - Progress on MPD installation
  - IT tools and computing resources for the collaboration
  - Reports from major oversight committee meetings (DAC, Programme Advisory Committee, NuPECC, ECFA, Scientific Council, Cost&Schedule Review Committee, etc.)
  - Common Fund: rules, spending items
  - Execution of Monte-Carlo requests
  - Preparation and execution of MPD Collaboration Meetings
  - New initiatives and detectors in development (MPD ITS TDR)

MPD Physics Programme

G. Feofilov, A. Ivashkin — 1

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 — 2

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 — 3

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

V. Riabov, Chi Yang — 4

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 — 5

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

MPD Status and Performance Publication

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 19, 2021/ Accepted: date

Abstract The Nuclotron-based Ion Collider fAcility (NICA) is under construction at the Joint Institute for Nuclear Research (JINR). The accelerator complex will consist of several components, specifically, the Nuclotron accelerator, the Booster support accelerator, two ion sources, as well as the NICA collider ring with the corresponding transfer lines from the Nuclotron. The commissioning of the NICA collider ring is expected to take place during the second half of 2022. The Multi-Purpose Detector (MPD) has been designed to operate at NICA and its components are currently in production. The on-site detector assembly has started in July of 2020. In 2022 the detector setup will be in the commissioning phase, to be ready for data taking with the first beams from NICA. This document details the preparation and progress of the construction and commissioning of the MPD. It presents plans for the physics measurements at NICA and discusses them in the context of existing and future physics experiments to contribute to the research on the QCD phase diagram.

Keywords NICA · MPD · QCD

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2 A brief survey of the MPD physics goals . . . 4
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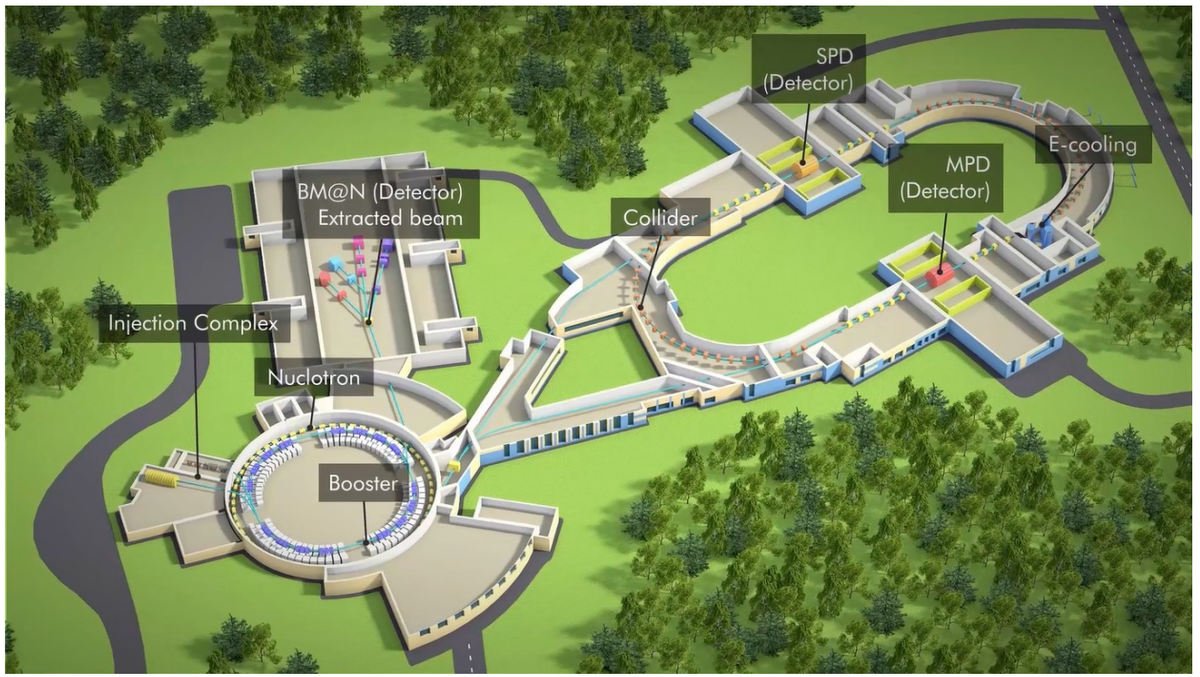
- Large work of Editorial Committee to provide final draft: A. Ayala, D. Blaschke, S. Golovatyuk, A. Kisiel, V. Kolesnikov, V. Riabov, O. Rogachevsky, A. Taranenko
- Main physics goals of MPD in the landscape of current heavy-ion physics and astrophysics
- Status of the readiness of the MPD detector subsystems
- Report on example expected physics results on the first run of MPD, with relation to expected detector performance
- First round of Collaboration Review conducted from Mar 17th until March 31st.
- Answers to comments provided to the Internal Review Committee: I. Tserruya (chair), F. Wang, Z. Tang
- Second round of Collaboration Review expected soon
- Submission as invited review to EPJA

NICA Facility running plan

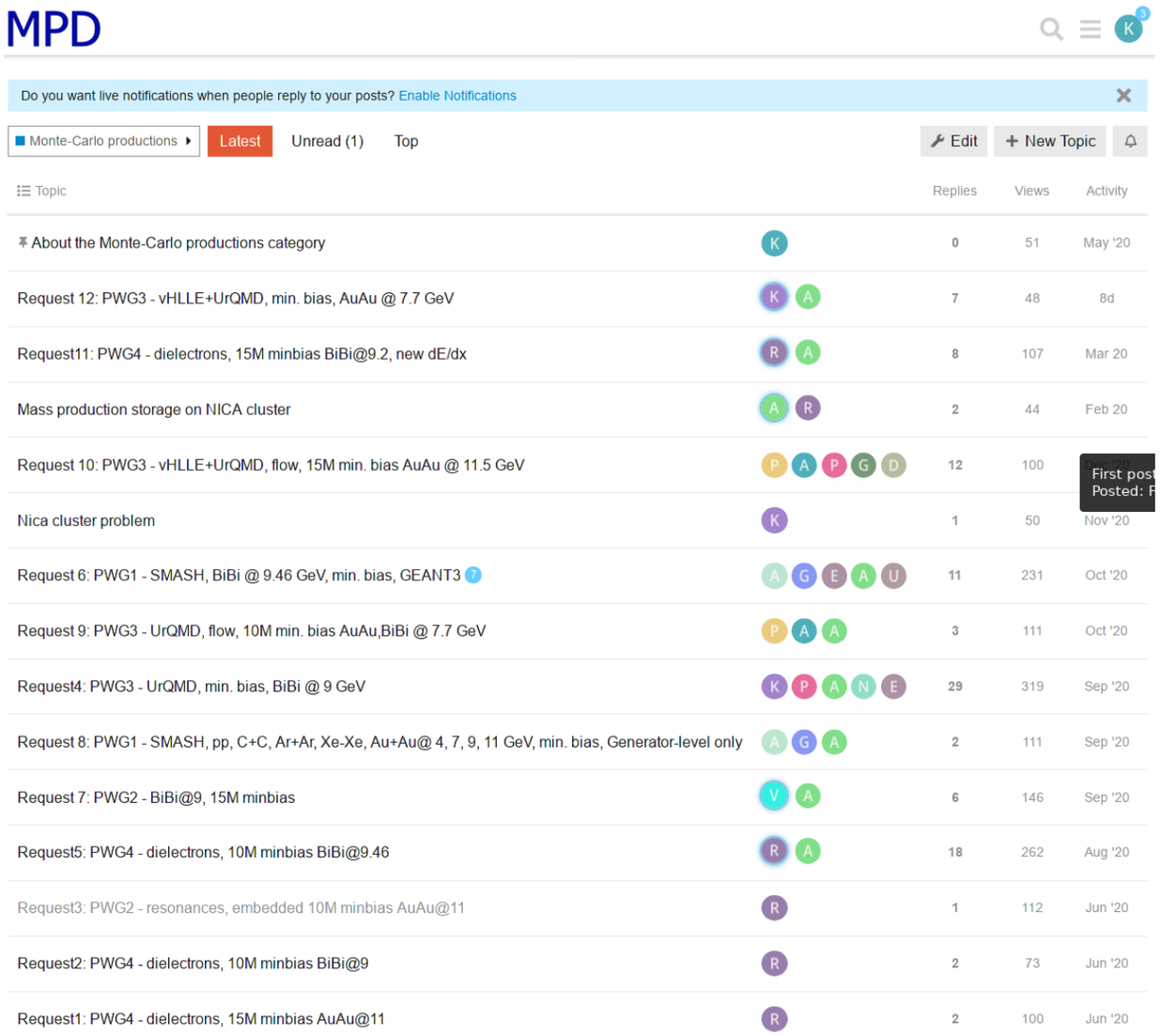
- **Year 2021:**
  - Extensive commissioning of Booster accelerator
  - Heavy-ion (Fe/Kr/Xe) run of full Booster+Nuclotron setup
- **Year 2022:**
  - Completion of NICA Collider and transfer lines
- **Year 2023:**
  - Initial run of NICA with Bi+Bi @ 9.2 AGeV (other energies a second priority)
  - Goal to reach luminosity of 10^{25} $cm^{-2}s^{-1}$, at least 10^{8} collisions at 9.2 AGeV
- **Year 2024:**
  - Goal to have Au+Au collisions and acceleration in NICA (up to 11 AGeV)
- **Beyond 2024:**
  - Maximizing luminosity, possibility of collision energy and system size scan



Next: „First Physics in MPD” Publication

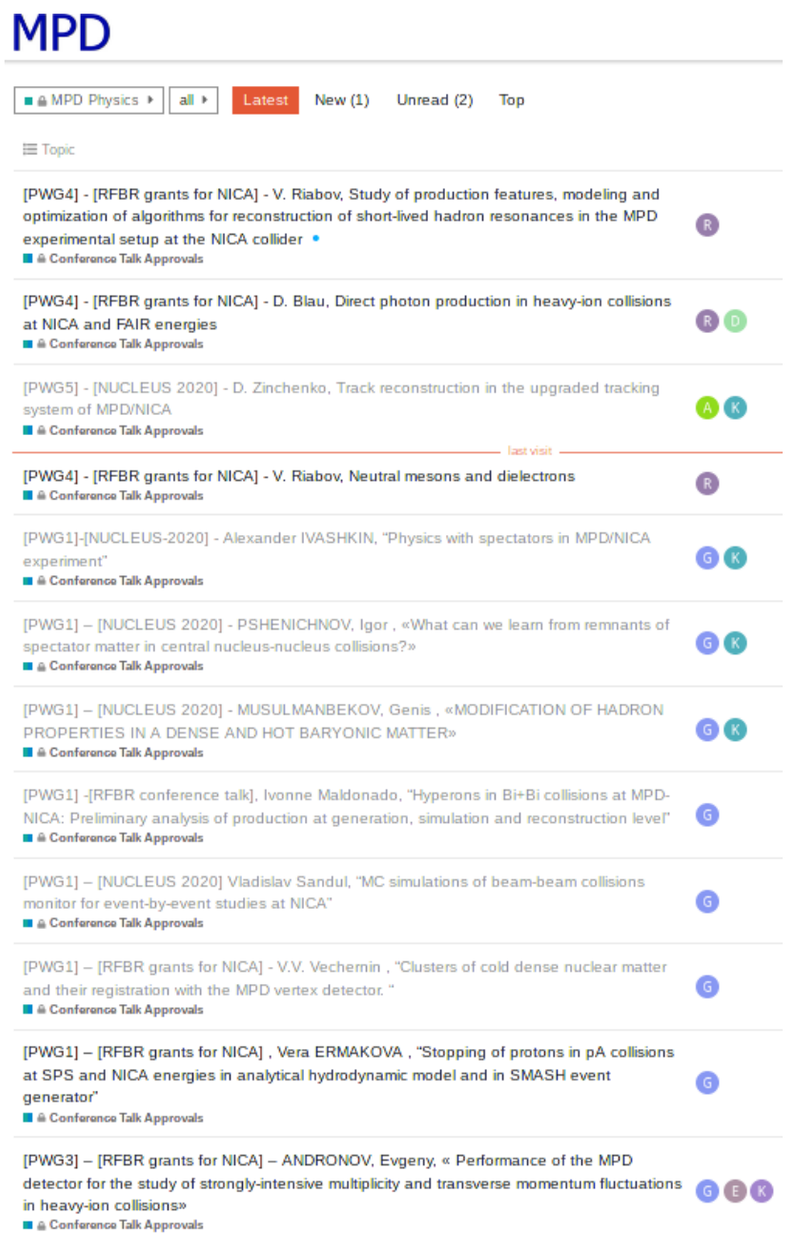
- Initial running plan for the NICA Accelerator, including beam species and collision energy has been recently discussed
- Large experience gained in preparation of the „MPD Status and Performance” manuscript
- Urgent need for an updated document with clear physics focus and consistent plan and message for „First Physics”
- Need to show up-to-date detector performance and relevant Monte-Carlo simulations, addressing recent theoretical developments
- Discussions on the draft started in Physics Council, each PWG is expected to provide input to the manuscript

Monte-Carlo simulations, computing readiness



- Regular productions of Monte-Carlo simulations, using MPD computing resources
- Requests can be made via Physics Working Groups
- Extensive new requests expected in response to clarification of initial NICA beams and in preparation for the next major publication on „First Physics in MPD”

Recent and upcoming MPD talks



- Progress reports for Particle Physics PAC, MPD DAC
- MPD status talk presented at CPOD 2021 (A. Taranenko), next MPD and NICA status report accepted for the SQM 2021 conference
- Abstracts submitted to SQM 2021 and Lomonosov conferences
- Rehearsals for major talks organized during MPD Physics Forum (Thursdays, 10 AM MST) – open to all Collaborators
- Possibility to organize rehearsals also for major seminars. Speakers should contact PWG convenors

Electronic tools for communication

- Resources being actively used by the Collaboration
  - General purpose mailing list: MPD_Coll_List(at)maillist.jinr.ru
  - The MPD Forum (based on the Discourse web forum platform) http://mpdforum.jinr.ru
  - Specific mailing lists for: Executive Council, Physics Council, Institutional Board, new lists can be created on request
  - The INDICO system (coupled to videoconference platforms) for planning, execution and archiving of MPD meetings
  - ZOOM, Volna system, WebEX, Vidyo systems for videoconferencing
- Resources in active development and being kept up to date:
  - General NICA webpage with MPD section: http://mpd.jinr.ru
  - MPD Software webpage: http://mpdroot.jinr.ru
  - „New" MPD-dedicated webpage: http://mpd.jinr.ru/experiment

IT resources for the MPD members

- Several IT resources are available to MPD members. To request access, a member **must** be on the MPD Collaboration List (members are added to the list on the request of the Group Leader)
  - Computing account at LIT (HybriLIT) – job submission, access to data, access to the DIRAC Infrastructure
  - Computing account at the NICA Cluster – job submission, access to data, including central Monte-Carlo productions
  - Account at the MPD Forum – place for internal MPD discussions
  - 50GB Private „cloud”: http://disk.jinr.ru (very useful for sharing large files)
- Other useful IT resources, available to all users
  - Account at the JINR INDICO (http://indico.jinr.ru)
  - Account in the Volna webconferencing system

Milestones of MPD assembling in 2020-2022

Year 2020

1. July 15th - MPD Hall and pit are ready to store and unpack Yoke parts
2. August - The first 13 plates of Magnet Yoke are assembled for alignment checks
3. Sept 15th - Oct 1st - Solenoid is ready for transportation from ASG (Italy)
4. November 6th - Solenoid arrived in Dubna
5. Nov-Dec - Assembling of Magnet Yoke at JINR

Year 2021

6. Jan- Sep - Preparation for switching on the Solenoid (Cryogenics, Power Supply et cet.)
7. Oct - Nov - Magnetic Field measurement
8. Dec - Installation of Support Frame

Year 2022

9. Jan- Jun - Installation of TOF, TPC, Electronics Platform, Cabling
10. Jul - Installation of beam pipe, FHCal, Cosmic Ray test system
11. Jul-Dec - Cosmic Ray tests
12. December - Commissioning

Year 2023

13. **March - Run on the beam**

Magnet Yoke assembly

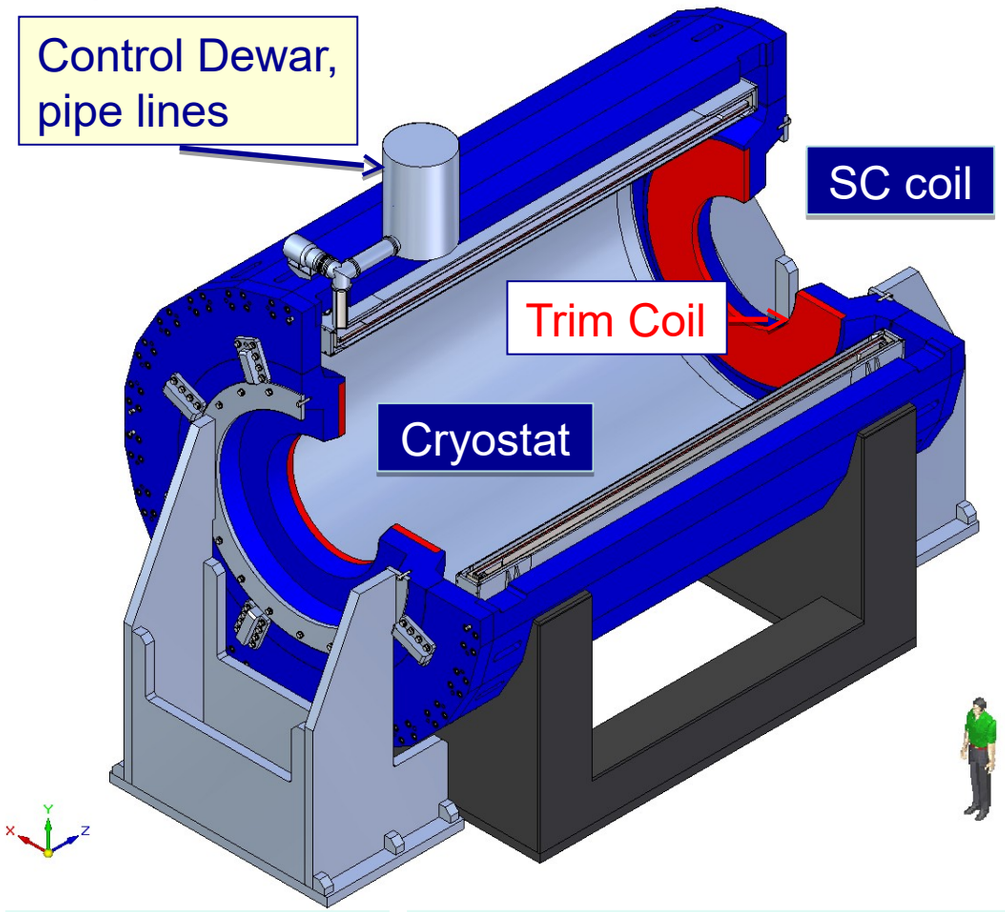
- Assembly of the magnet yoke – start with 13 modules (out of 28) installed with average 200 µm precision, full yoke done in Dec 2020
- Next step: assembly with solenoid in presence of manufacturer team
- Critical assembly path commenced

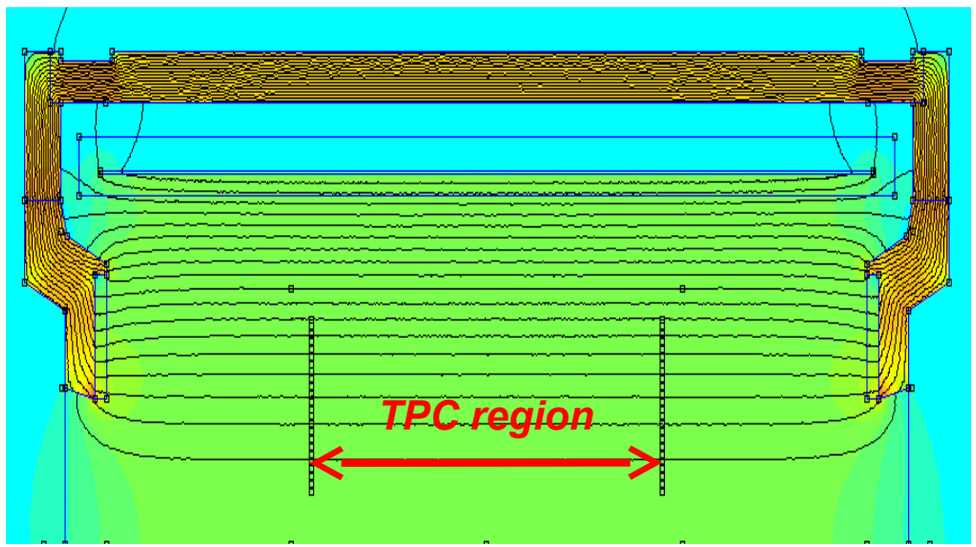
MPD Superconducting Solenoid

B_0=0.5 T

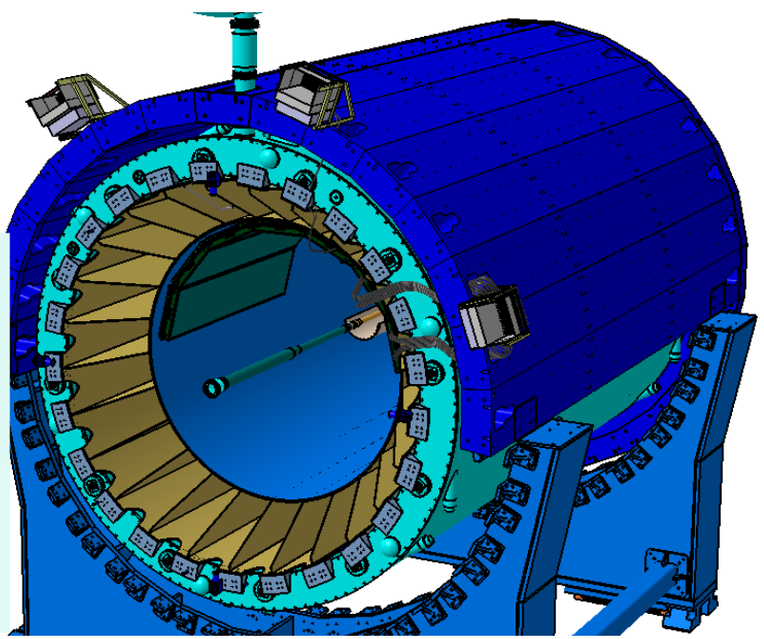
weight ~ **900 t**

rated current: ***1790 A,*** *stored energy:* ***14.6 MJ***





high level (~ ***3x10^{-4}****) of magnetic field homogeneity*



HM Vitkovice, *Czech Republic: fabrication of yoke & supports*

ASG superconductors, *Genova* ***general responsibility:*** *Cold Mass + Cryostat, Trim Coils Vacuum System, Control System*

The Central Research Institute for Special Machinery, *Khotkovo: Carbon Fiber support structure for all MPD subsystems*

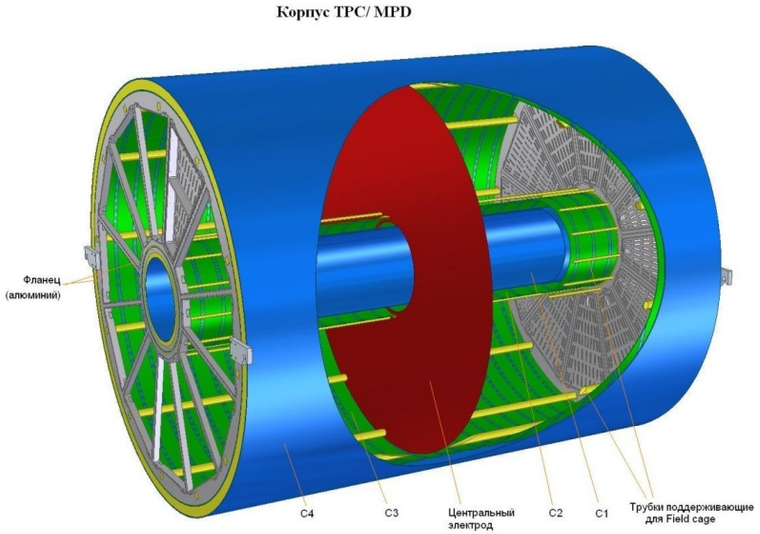
Solenoid in MPD Hall

- On 6-th of November 2020 the MPD Solenoid delivered to MPD Hall

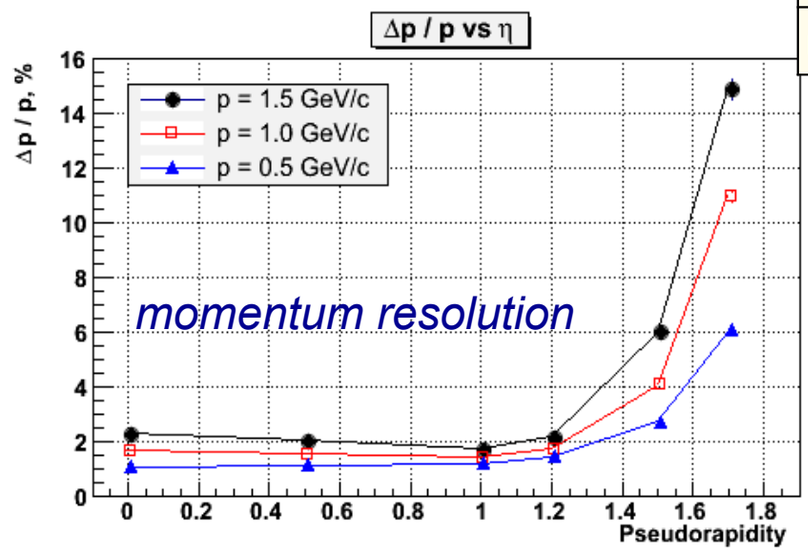
Interior of MPD Hall

Opening of solenoid sarcophagus: Mar. 23rd

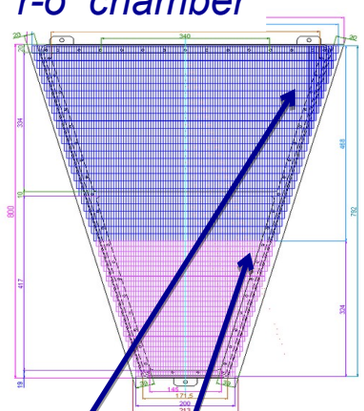
Time Projection Chamber (TPC): main tracker



length	*340 см*
outer Radii	*140 см*
inner Radii	*27 см*
gas	*90%Ar+10%CH_4*
drift velocity	*5.45 см / μs;*
drift time	*< 30 μs;*
# R-O chamb.	*12 + 12*
# pads/ chan.	***95 232***
max rate	*< 7kGz (L= 10^{27})*

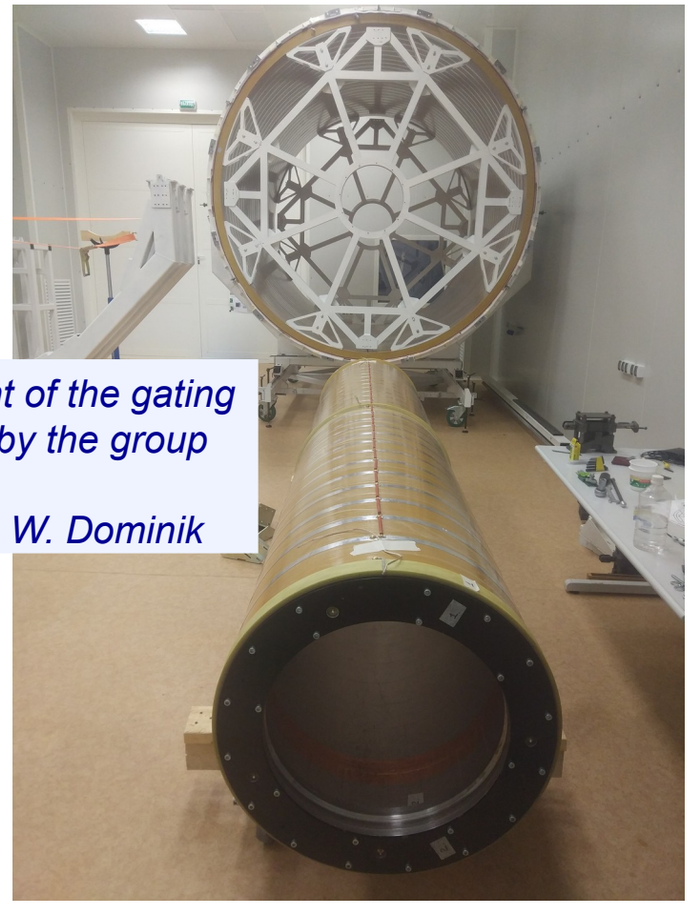


r-o chamber



FE electronics: **FEC64SAM** –
*dual **SAMPA** card (**ALICE** technology)*

pad structure:
- *rows – 53*
- *large pads 5×18 mm²*
- *small pads 5×12 mm²*



Development of the gating grid system by the group from UW, lead by prof. W. Dominik

21 (out of 24+2) Read-Out Chambers (ROCs) are ready and tested (production at JINR)
113 Electronics sets (8%) produced
Two sites (Moscow, Minsk) tested for electronics production
C1-C2 and C3-C4 cylinders assembled
TPC flange under finalization

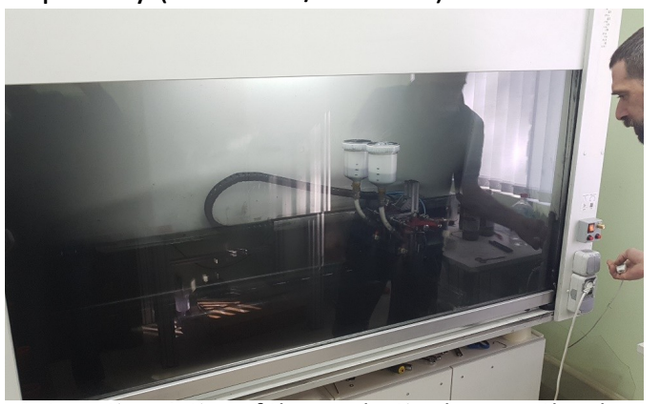
MPD Time-of-Flight

Mass production staff: 4 physicists, 4 technicians, 2 electronics engineers

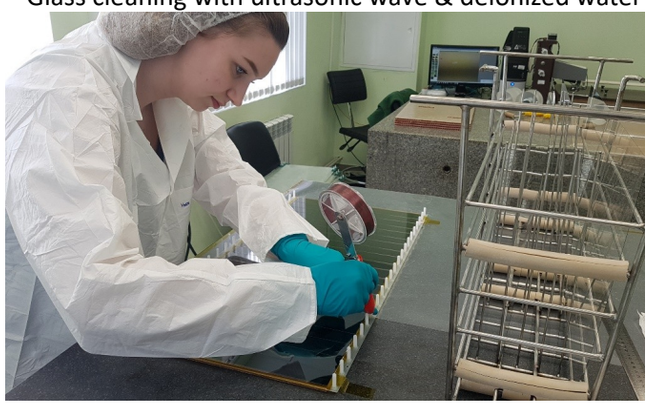
Productivity: ~ 1 detector per day (1 module/2 weeks)

All procedure of detector assembling and optical control is performed in a clean rooms ISO class 6-7.

Glass cleaning with ultrasonic wave & deionized water

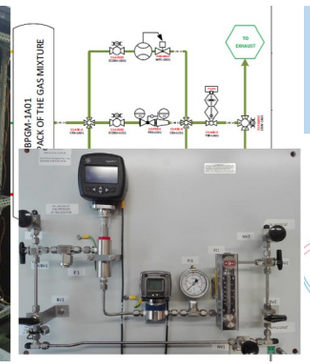


Automatic painting of the conductive layer on the glass

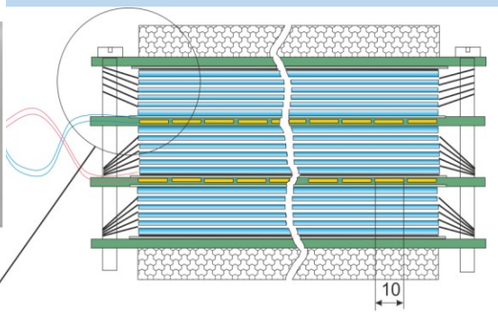


MRPC assembling

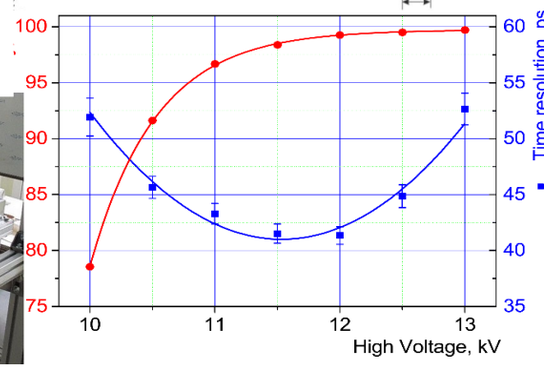
Soldering HV connector and readout pins



Dimensions of sensitive area
600 x300 mm²



TOF gas system:
Responsibility of the Polish group (WUT)



Single detector time resolution: 50ps

	Number of detectors	Number of readout strips	Sensitive area, m²	Number of FEE cards	Number of FEE channels
MRPC	1	24	0.192	2	48
Module	10	240	1.848	20	480
Barrel	280	6720	51.8	560	**13440** (1680 chips)

Purchasing of all detector materials completed

So far 40% of all MRPCs are assembled

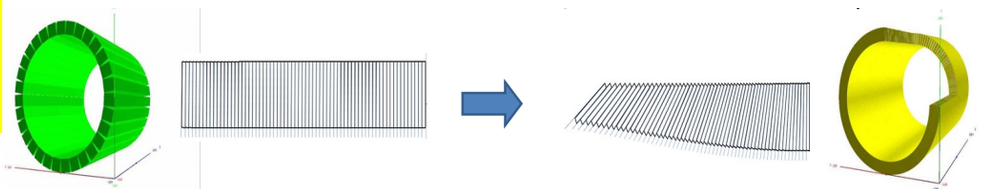
Assembled half sectors of TOF are under Cosmics tests

Investigation of solutions for detector integration and technical installations

Electromagnetic Calorimeter (ECAL)

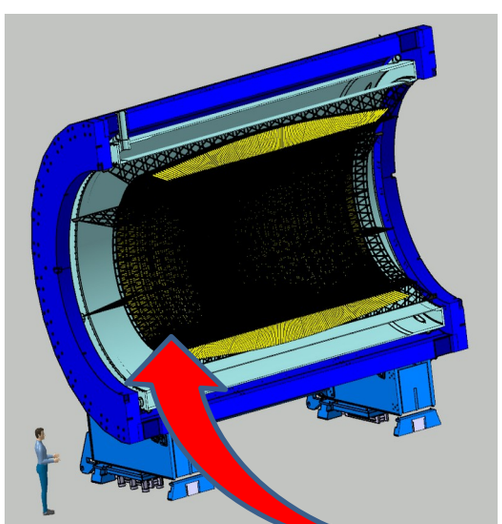
- *Pb+Sc "Shashlyk"* — *read-out: WLS fibers + MAPD* — *L ~35 cm (~ 14 X_0)*
- *Segmentation (4x4 cm²)* — *σ(E) better than 5% @ 1 GeV* — *time resolution ~500 ps*

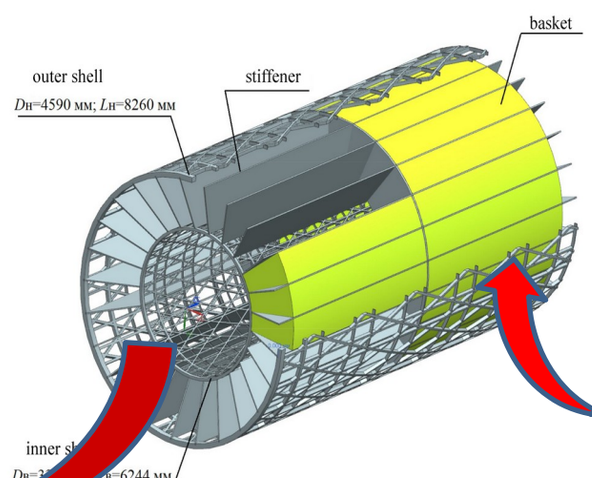
Barrel ECAL = <u>38400</u> ECAL towers (2x25 half-sectors x 6x8 modules/half-sector x 16 towers/module)

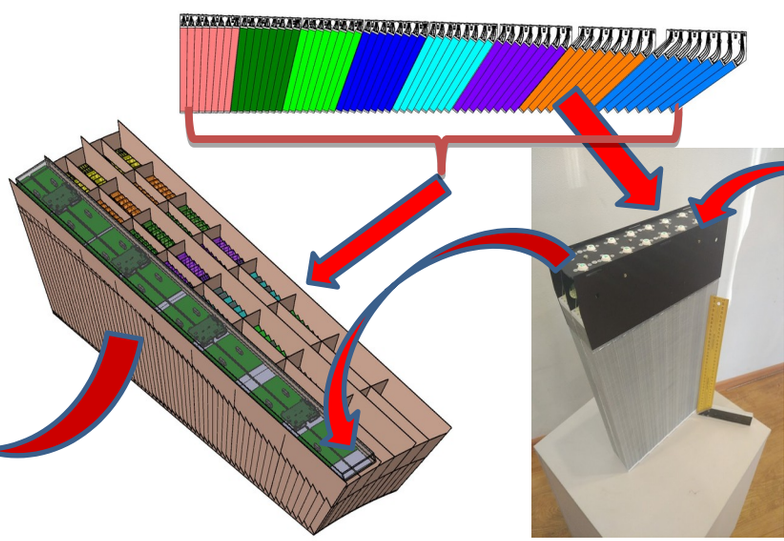


Projective geometry

So far ~300 modules (16 towers each) = 3 sectors are produced
Another 3 sectors are planned to be completed by May 2021
Chinese collaborators will produce 8 sectors by the end of 2021
25% of all modules are produced by JINR (production area in Protvino)
75% produced in China, currently funding is secured for approx. 25%







Sectors in dedicated Containers

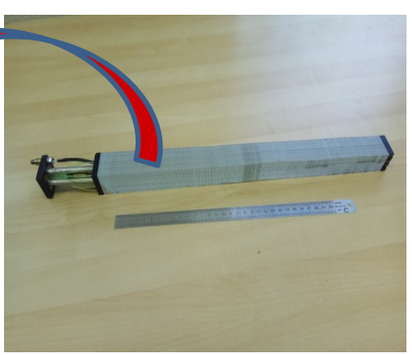
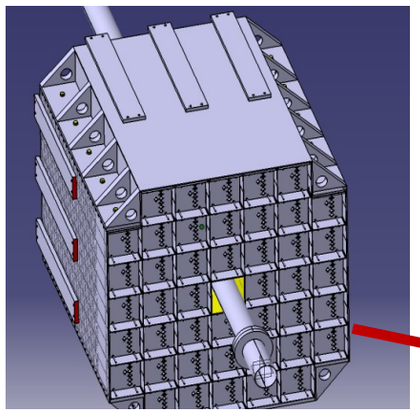
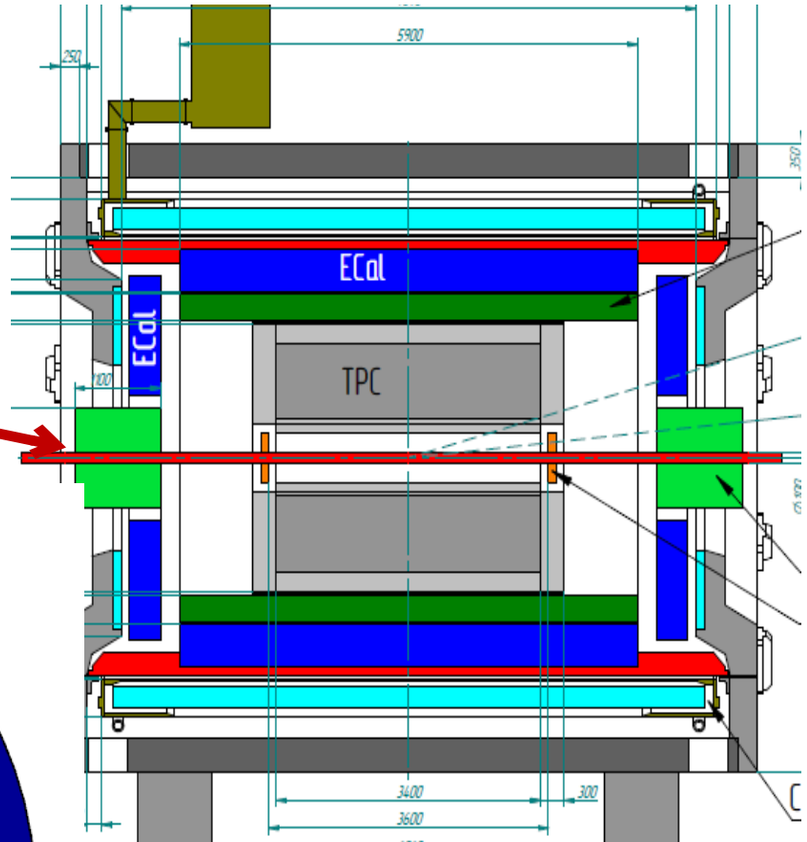
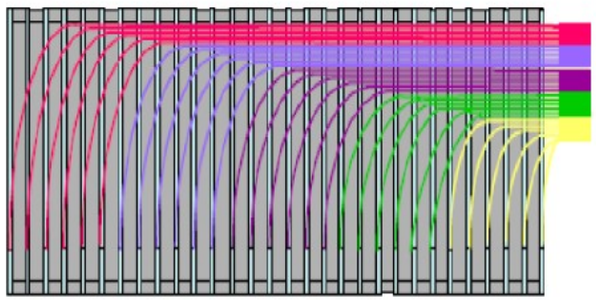


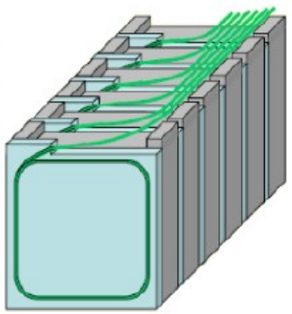
Photo of one element

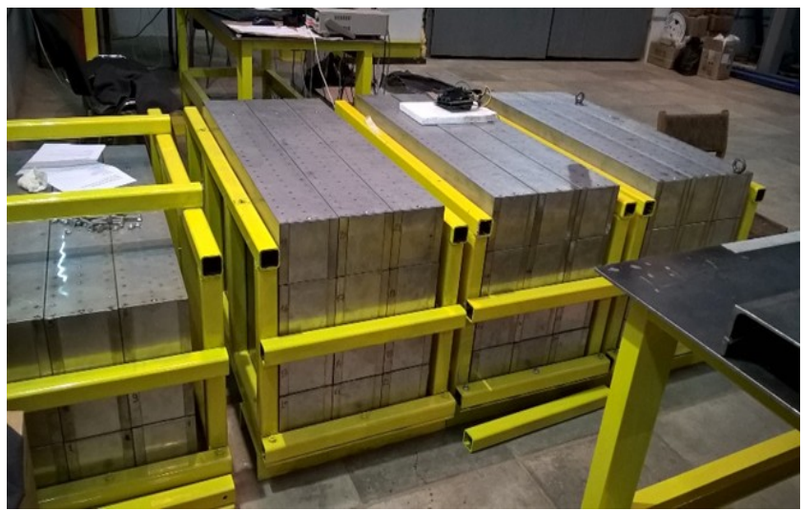
Forward Hadron Calorimeter (FHCal)

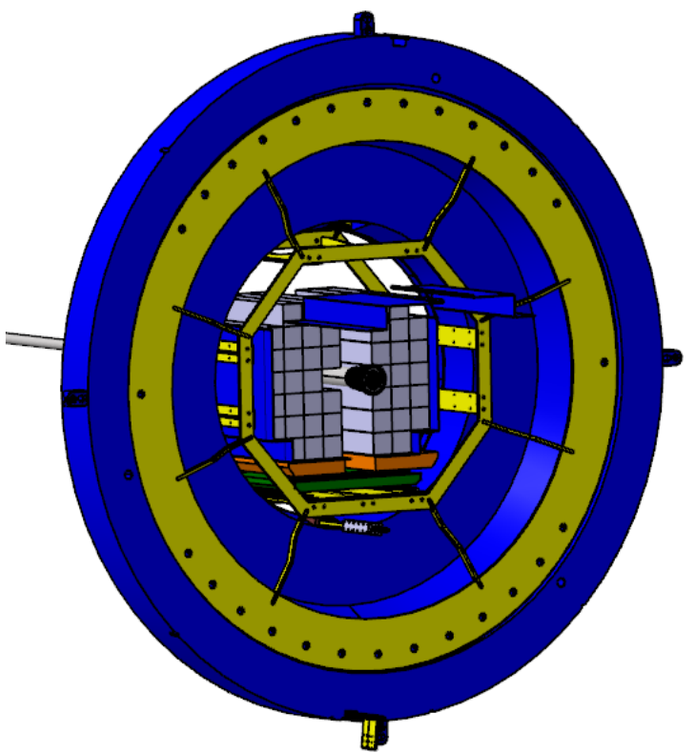






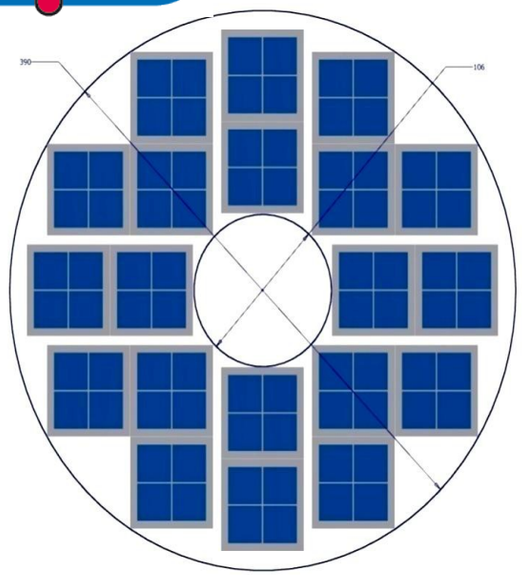


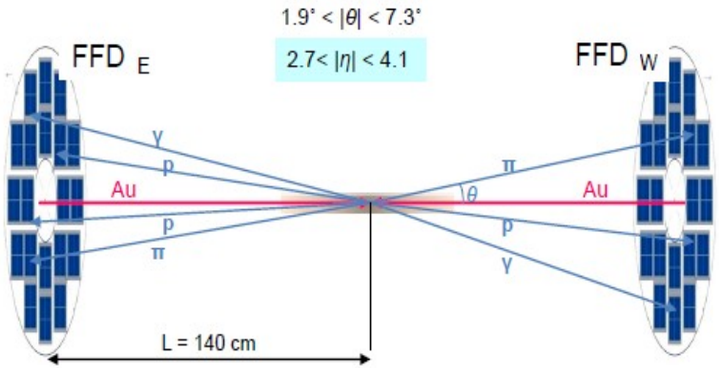




- **Two-arms at ~3.2 m from the interaction point.**
- **Each arm consists of 44 individual modules.**
- **Module size 150x150x1100cm³ (42 layers)**
- **Pb(16mm)+Scint.(4mm) sandwich**
- **7 longitudinal sections**
- **6 WLS-fiber/MAPD per section**
- **7 MAPDs/module**

FFD - Fast Trigger L_0 for MPD





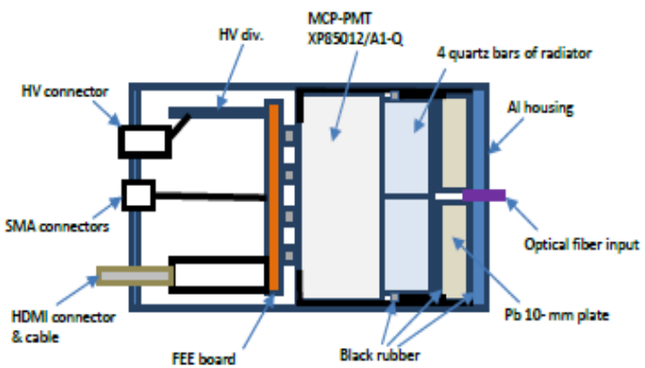


Fig. 4-1. A scheme of the FFD module.

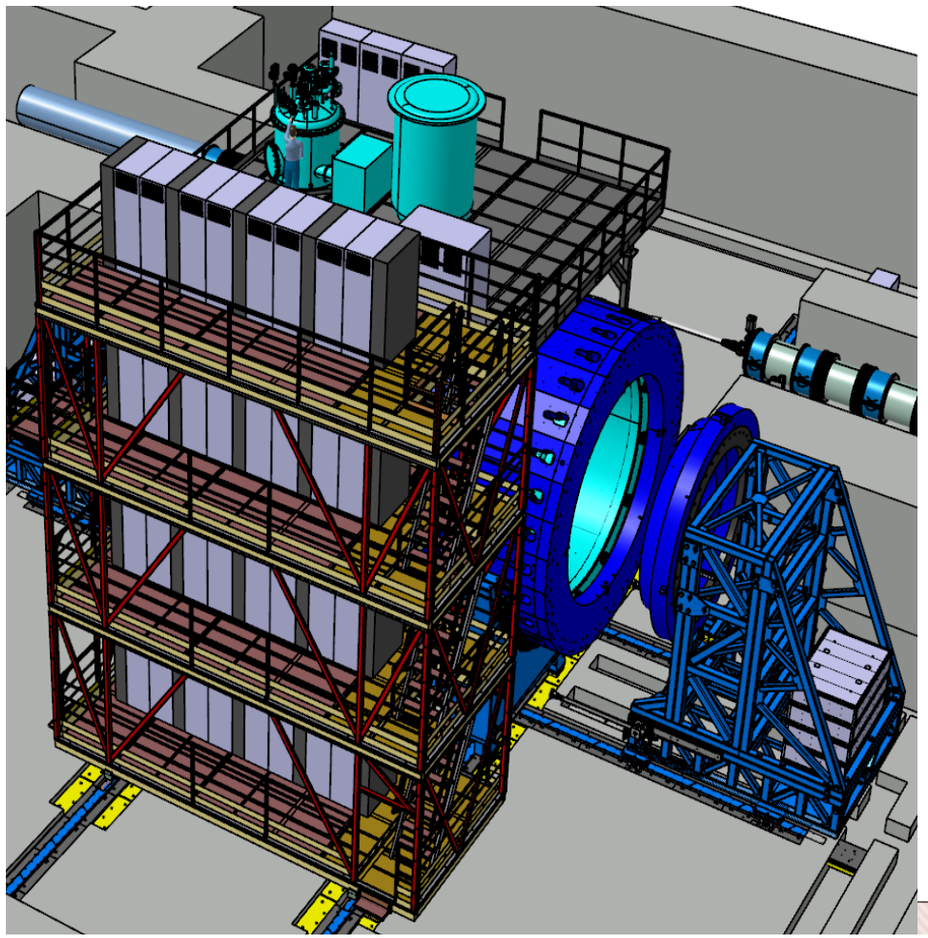
FFD provides information on
- interaction rate (luminosity adjustment)
- bunch crossing region position

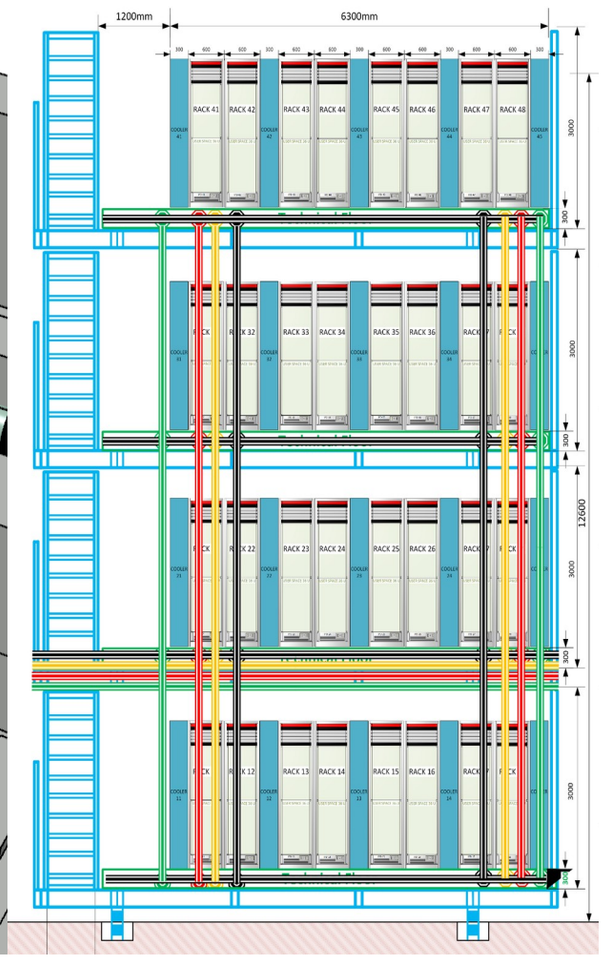
15 mm quartz radiator
10 mm Lead converter

The FFD sub-detector consists of
20 modules based on
Planacon multianode MCP-PMTs
80 independent channels

MPD trigger group is created on the basis of FFD team
Beside FFD we consider the signals from FHCal to be implemented into trigger L0
The FHCal team have produced trigger electronics.
Monte Carlo studies will be used to optimize the properties of the L0 trigger

NICA-MPD-Platform for Electronics



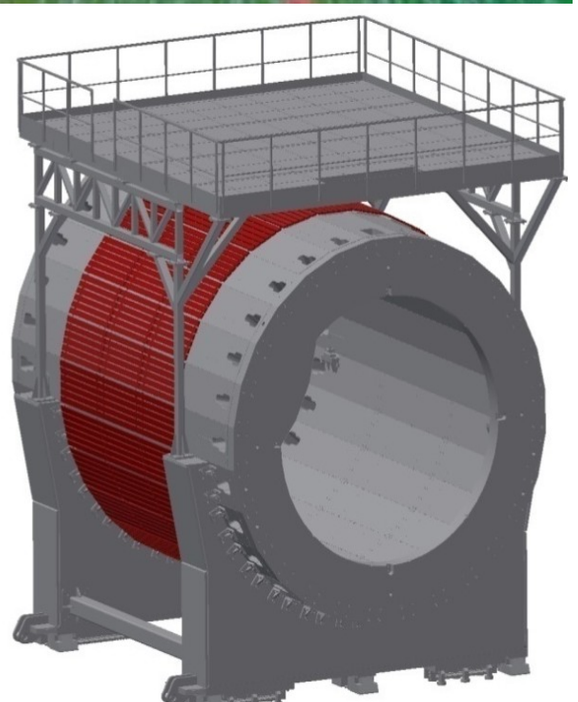


NICA-MPD-Platform is a contribution of the Polish groups to MPD

M. Peryt (WUT) K. Rosłon (WUT)

- Electronics platform has 4 levels with 8 racks on each level
- Each Rack provides cooling, fire safety and radiation control system
- Cable ducts connect detectors inside of MPD and Electronics Platform
- The mechanical part of the Platform is ready

MPD Cosmic Ray Detector (MCORD)



NCBJ, Świerk - WUT, Warsaw – UJK, Kielce (Poland) 18 scientists+12 engineers

Project leaders: Ł. Świderski, M. Bielewicz (NCBJ)

As soon as possible - start tests of MPD subsystems before Collider operation

Cosmic Ray Detector required for Commissioning and tests of the MPD.

The signals from MCORD will be used for TPC and TOF tests after their installation.

We'll need the elements of MCORD (scintillation panels with readout electronics) in 1st half 2021

CDR for MCORD approved by the MPD DAC

Cosmic Ray Detector consists of plastic scintillators with SiPM (Phototubes) light converters

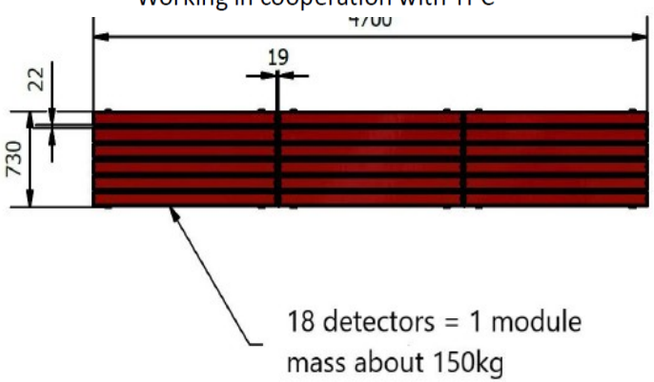
a) Trigger (for testing or calibration)
- testing before completion of MPD (testing of TOF, ECAL modules and TPC)
- calibration before experimental session

b) Veto (normal mode - track and time window recognition) Mainly for TPC and eCAL

Additionally

c) Astrophysics (muon shower and bundles)
- unique for horizontal events

Working in cooperation with TPC



5. MCORD Detector

SCINTILLATORS

Number of scintillators:	660 pcs
Dimensions of scintillators:	95x25x1500 [mm]
Dimensions of detector:	100x30x1554 [mm]
Scintillators are placed in the rectangle profile	10x30x2.5 [mm]
Weight of detector:	6.5 kg
Material of scintillators casing:	Aluminum alloy

MODULES

Number of detector in one module:	18
Number of Modules:	28
Dimensions of module:	730x90x4700 [mm]
Weight of one module:	150 kg

SiPM/MMPC

Number of SiPMs (Chanels)	1320
Number of SiPMs (with two fibers)	2640

RESOLUTION

Position resolution: In X axis – up to 5 cm, In Y axis – 5-10 cm

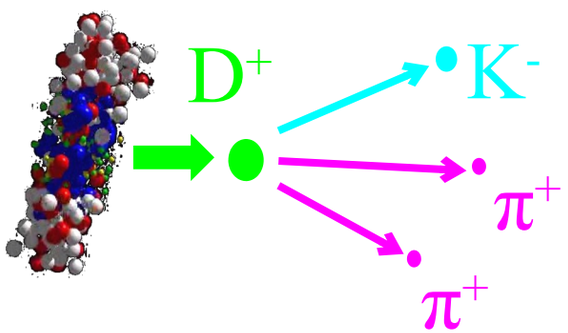
Time Resolution – about 300-500 ps

Number of events (particles): about 100-150 per sec per m2

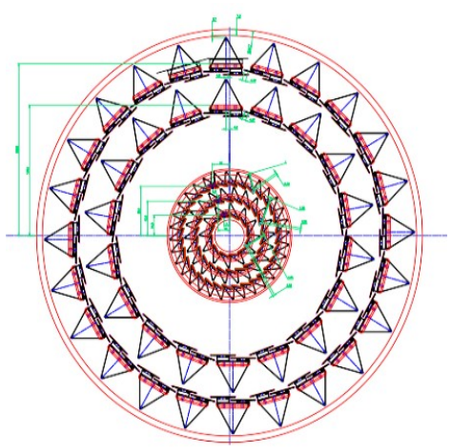
Calculated Coincidence factor: about 98%

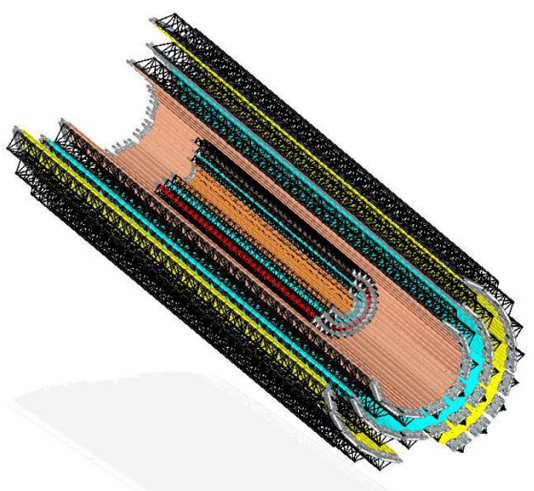
Inner Tracker System (ITS): precise tracking

Consortium includes JINR, NICA (BM@N & MPD) , **FAIR, Russian, Polish and Ukrainian Institutes + CCNU Central China Normal Univ., IMP- Institute of Modern Physics, USTC – Hefei**

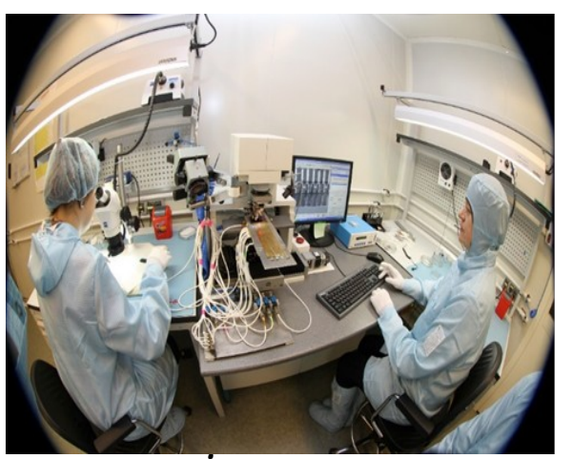


Protocol # 134 between CERN and JINR states the legal terms for transaction of CERN developed novel technology and the know-how for building the MPD-ITS on the basis of Monolithic Active Pixel Sensors *(the **MAPS***) ALPIDE, signed in 2018. This document laid a clear road towards the MPD ITS.



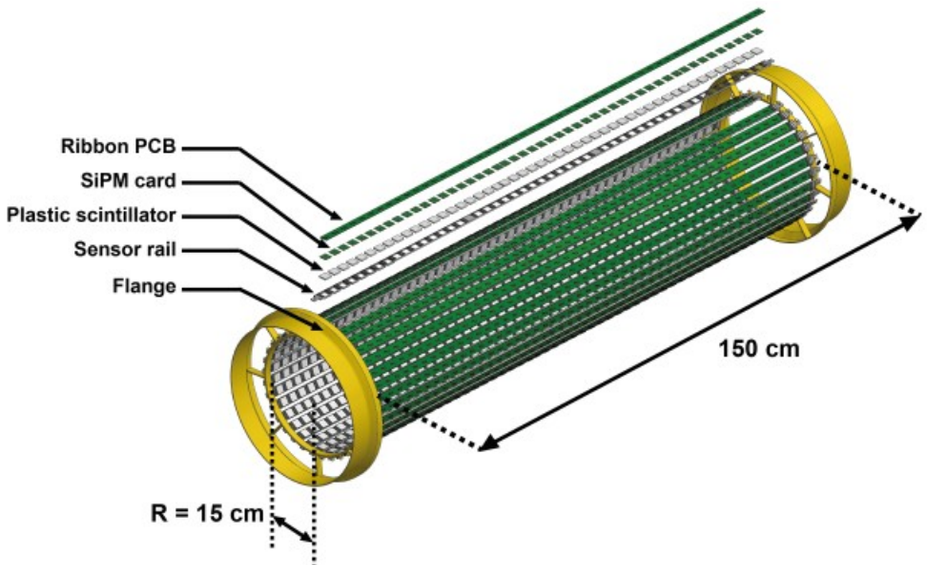


MPD ITS based on ALICE type staves



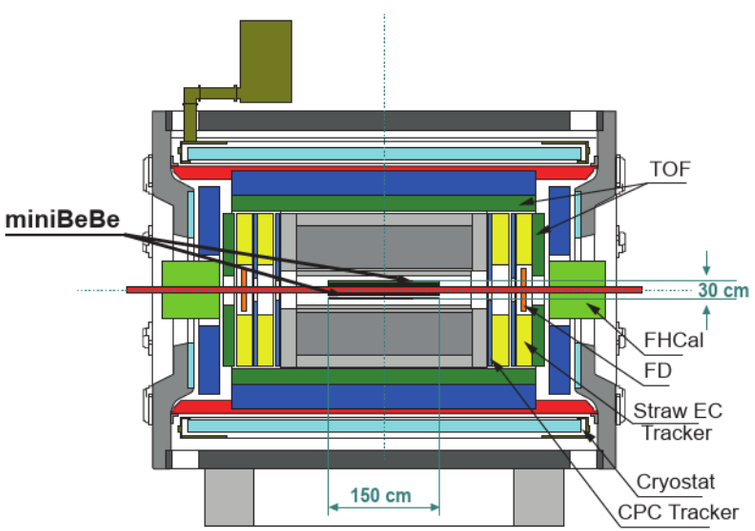
MiniBeBe (Mini Beam-Beam Counter)

MexNICA Collaboration



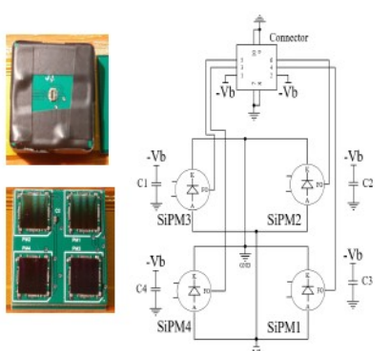
Main requirement:

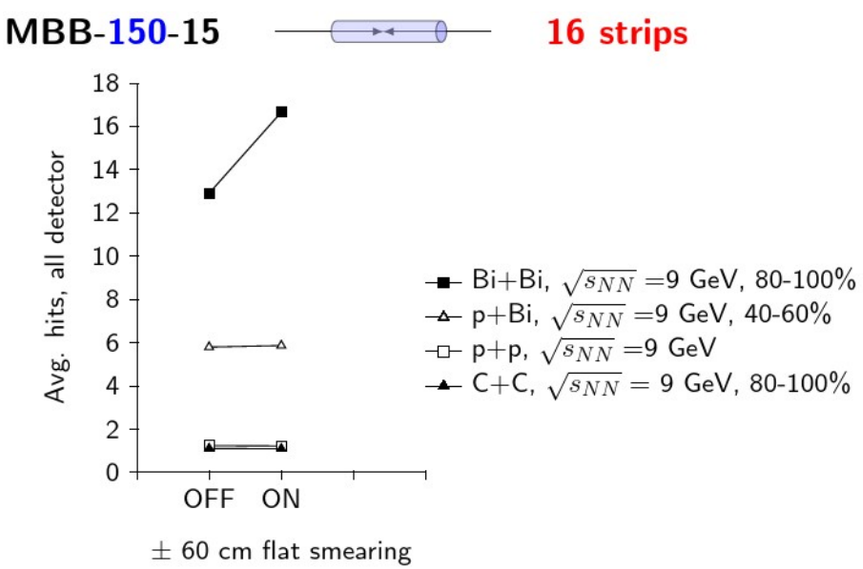
- Provide fast wake-up signal for TOF and reference time for TOF measurement with time resolution of ~30 ps
- Improve trigger efficiency for p+p, p-A and low multiplicity A-A
- Provide possibility to perform luminosity measurements at Phase 0 of NICA operation



Basic cell with four SiPMs & electronics

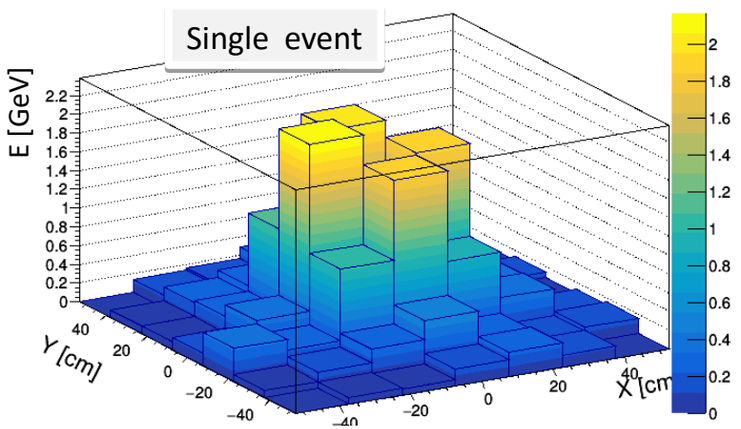
- 20x20 mm²
- 4 SiPMs card attached to BC404 plastic scintillator
- Fast outputs to "connector" (micro mezzannine)
- DC decoupling capacitors

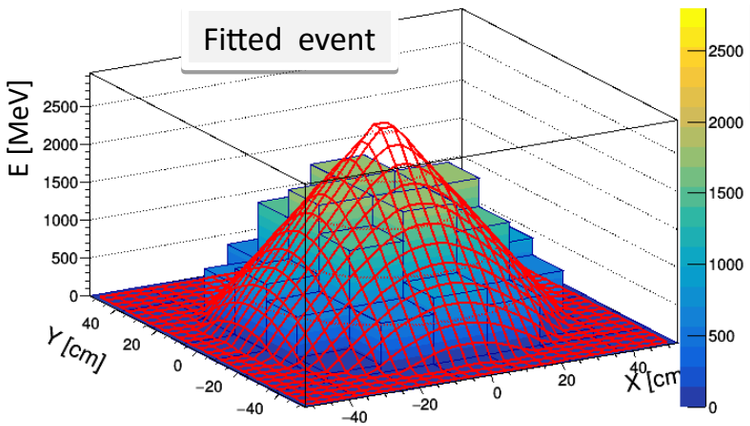




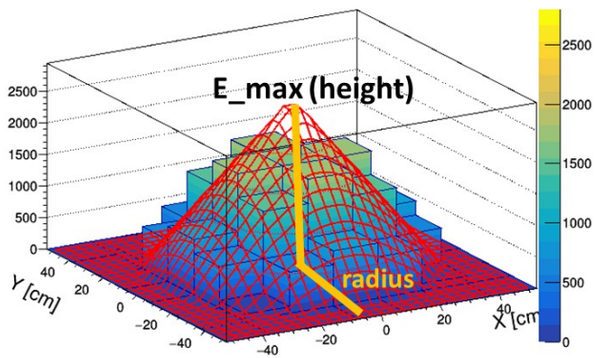
Centrality and reaction plane in FHCal

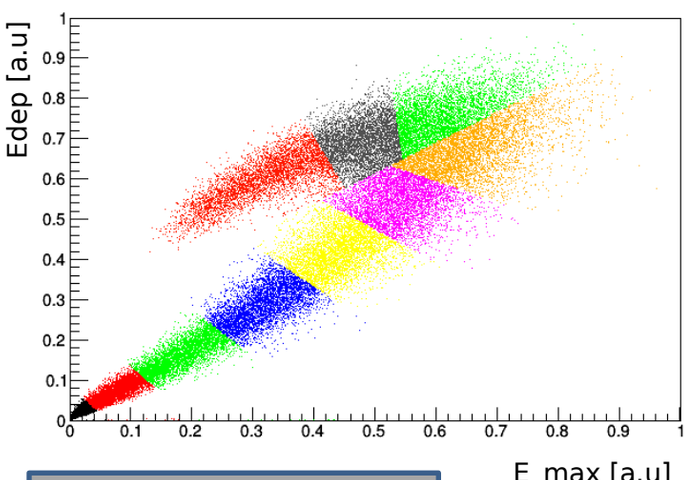
Energy distribution in FHCal modules



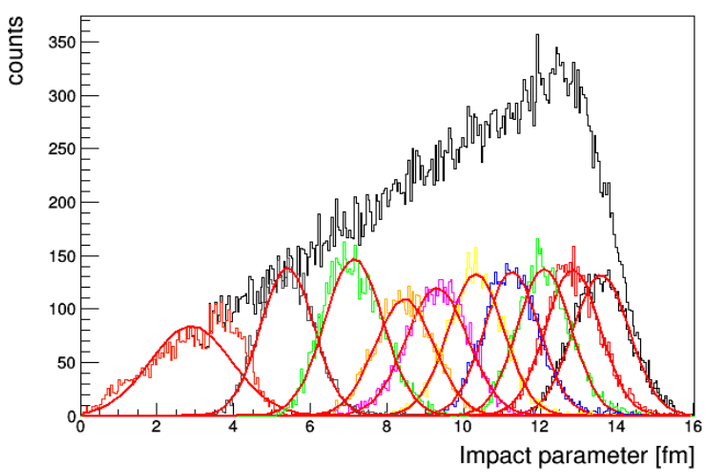


Initially we have experimental energy deposition E_{dep} in FHCal.

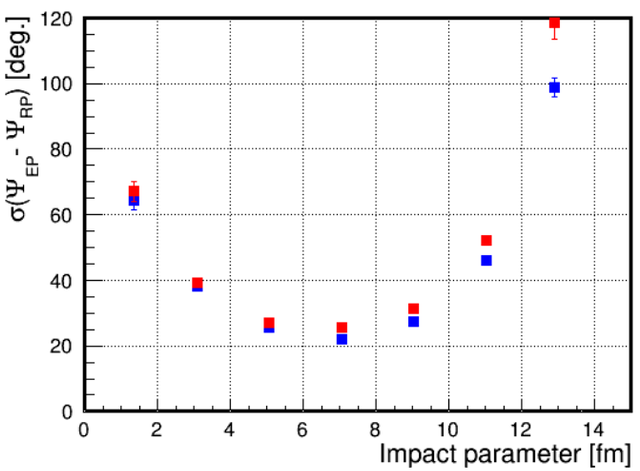




Each color bin is 10% fractions of the total number of events.



Centrality resolution



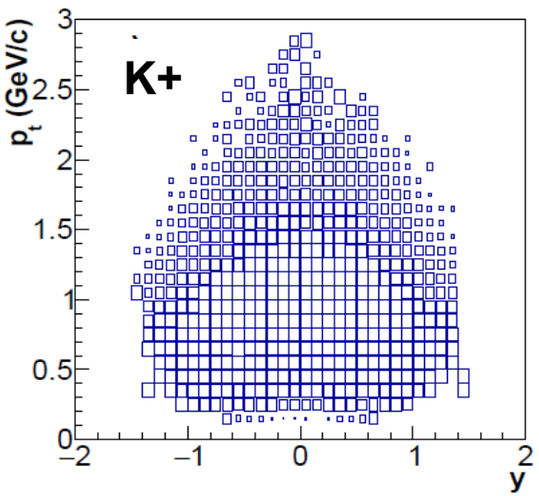
Reaction plane resolution

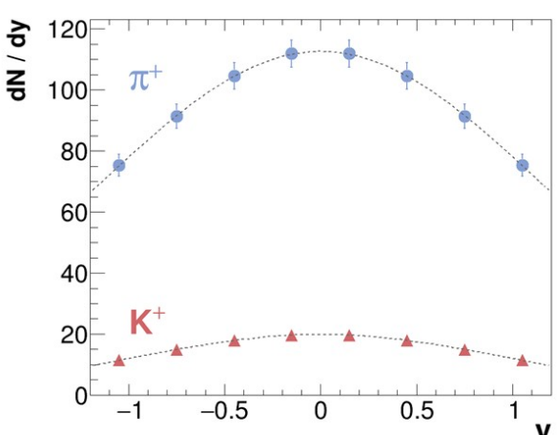
Hadroproduction with MPD

- **Particle spectra, yields & ratios are sensitive to bulk fireball properties and phase transformations in the medium**
- **Uniform acceptance and large phase coverage are crucial for precise mapping of the QCD phase diagram**

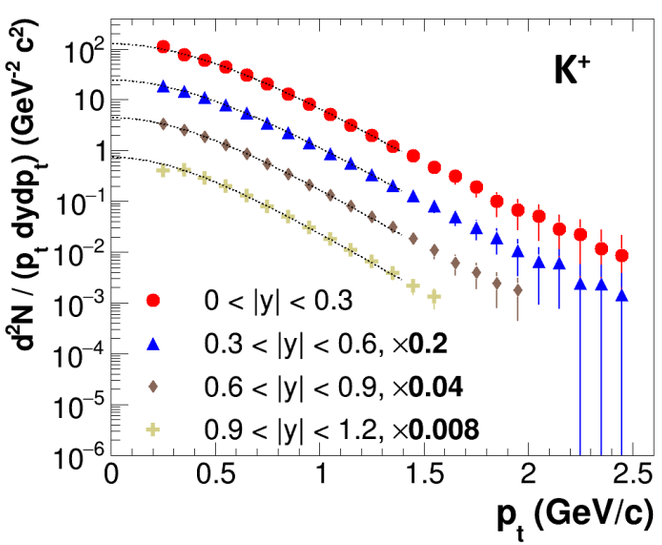
✓ *0-5% central Au+Au at 9 GeV from the PHSD event generator, which implements partonic phase and CSR effects*

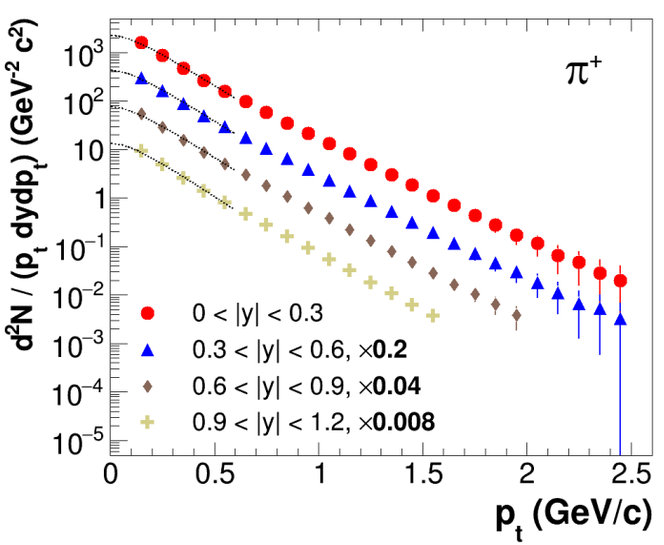
✓ *Recent reconstruction chain, combined dE/dx+TOF particle ID, spectra analysis*





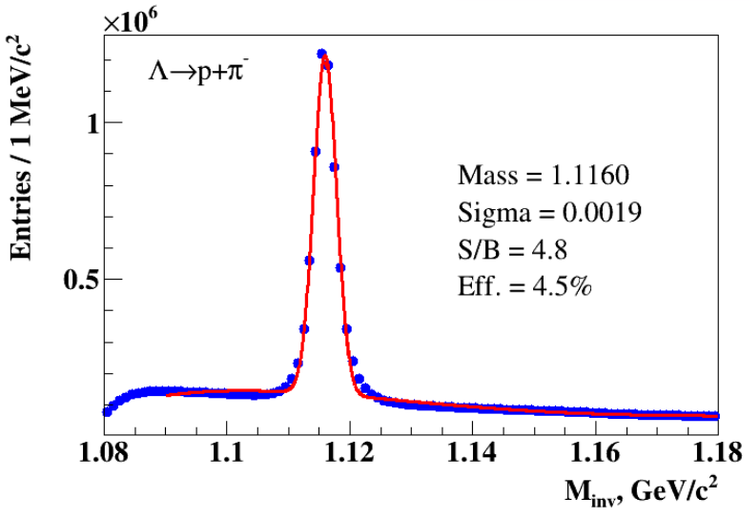
- MPD provides large phase-space coverage for identified pions and kaons (> 70% of the full phasespace at 9 GeV)
- Hadron spectra can be measured from p_T=0.2 to 2.5 GeV/c
- Extrapolation to full p_T-range and to the full phase space can be performed exploiting the spectra shapes (see BW fits for p_T-spectra and Gaussian for rapidity distributions)

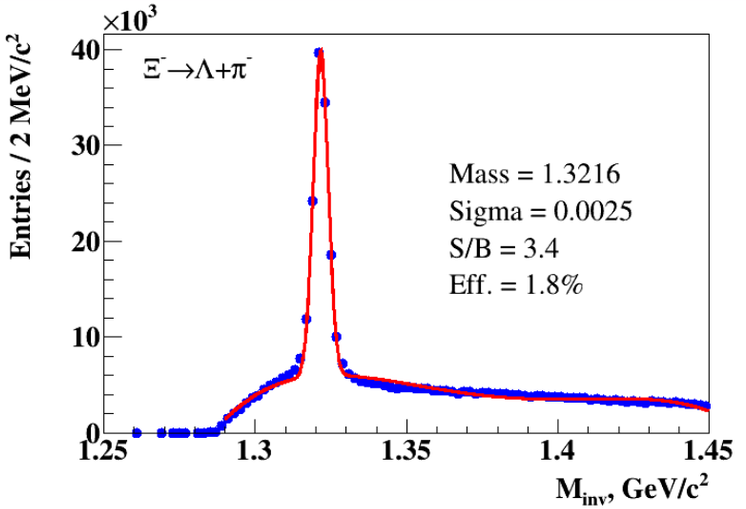


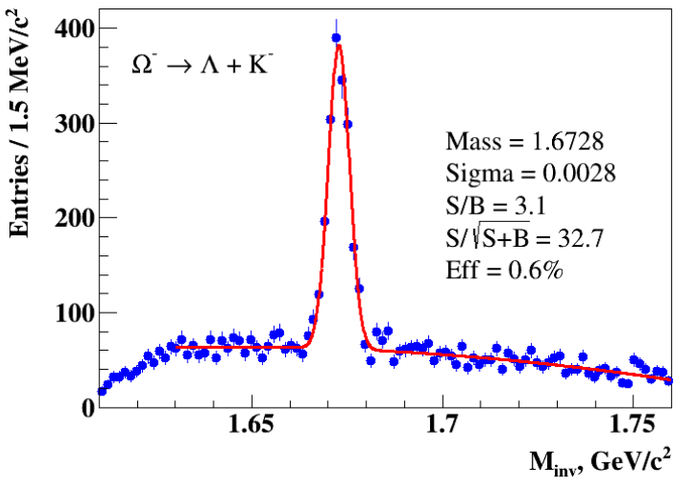


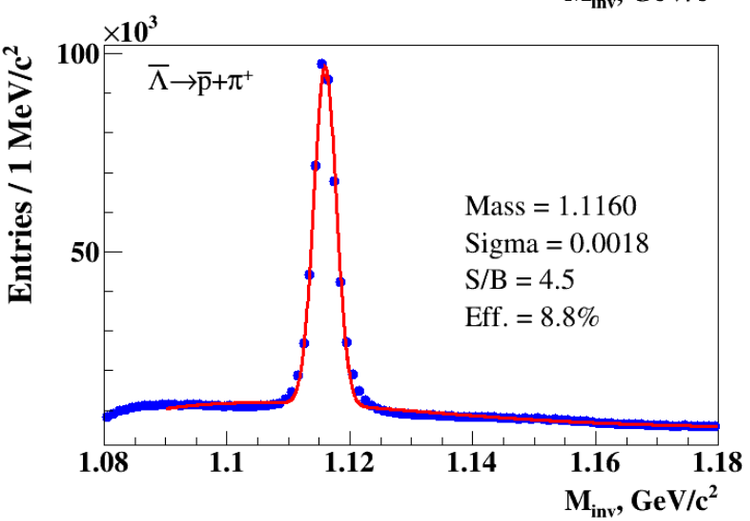
Strange and multi-strange baryons

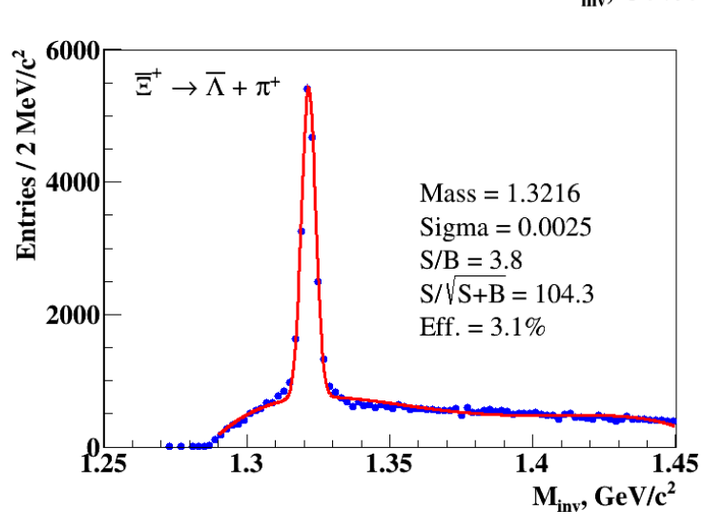
Stage'1 (TPC+TOF): Au+Au @ 11 GeV, PHSD + MPDRoot reco.

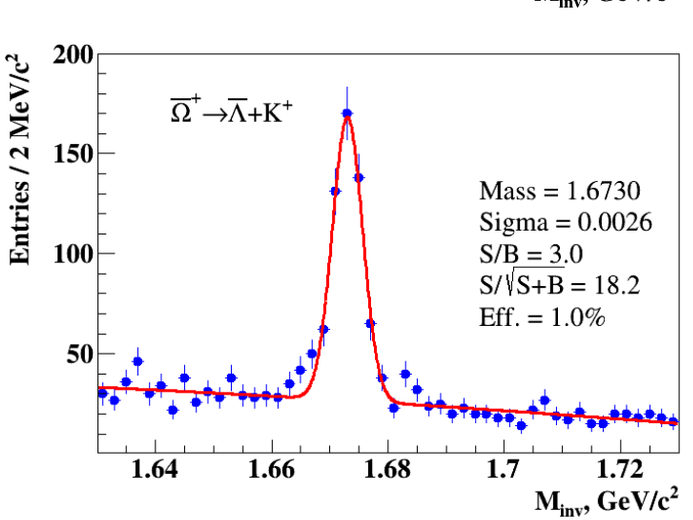










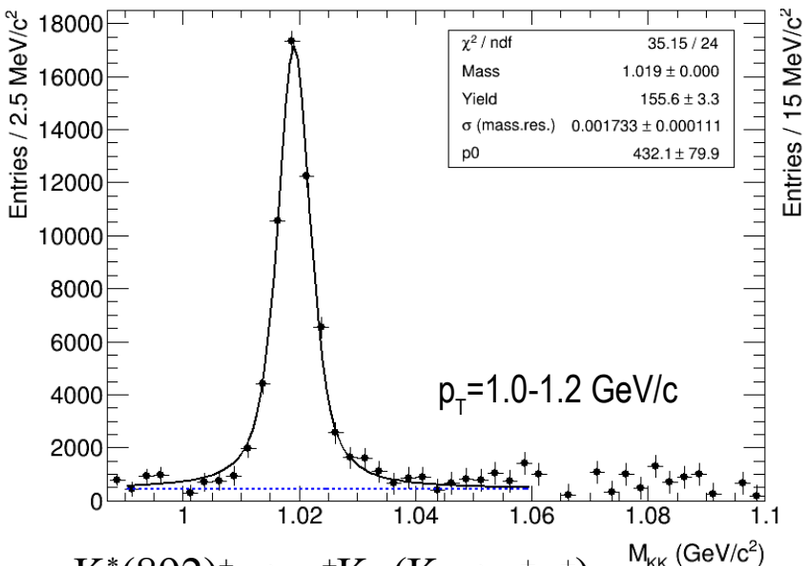


particle	Λ	anti-Λ	Ξ⁻	anti-Ξ⁺	Ω⁻	anti–Ω⁺
yield in 10 weeks	$3 \cdot 10^8$	$3.5 \cdot 10^6$	$1.5 \cdot 10^6$	$8.0 \cdot 10^4$	$7 \cdot 10^4$	$1.5 \cdot 10^4$

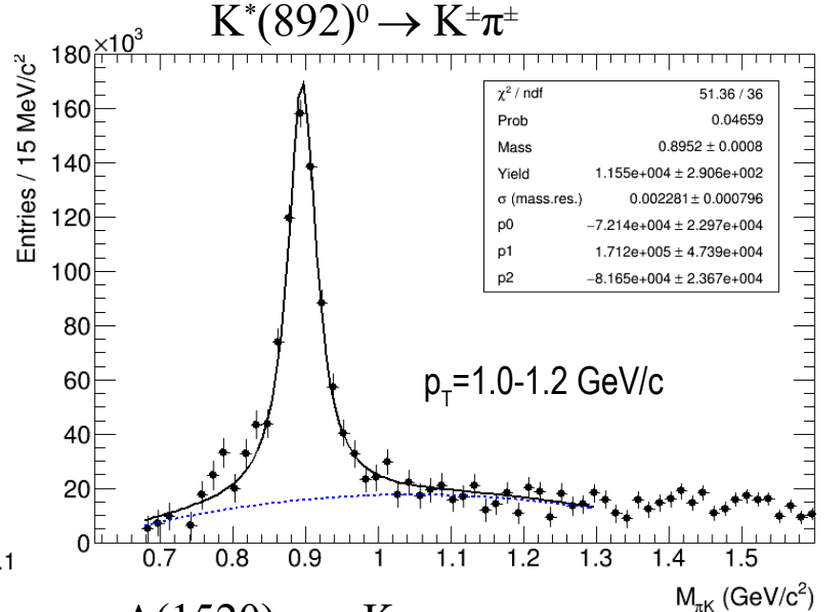
Resonances at MPD

· Minbias Au+Au@11 (UrQMD) · Full reconstruction and realistic PID · Topology cuts and secondary vertex · Event mixing for background

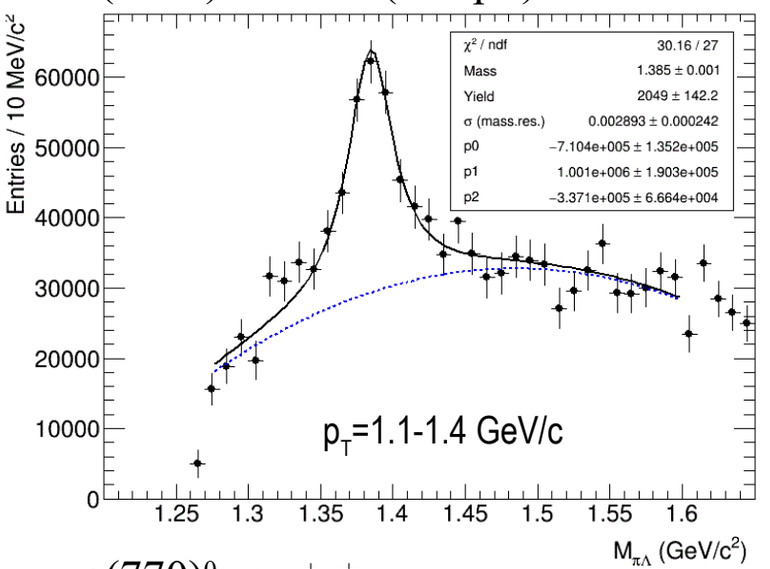
$\phi(1020) \rightarrow K^+K^-$



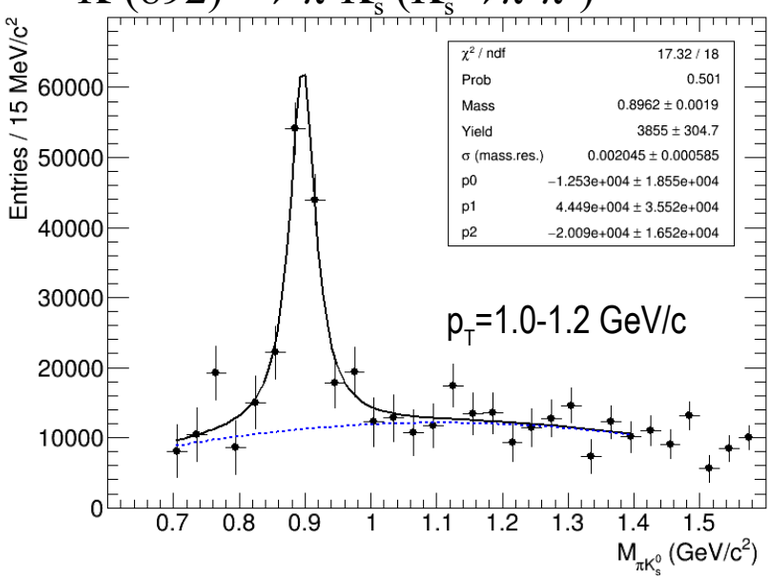
$K^*(892)^0 \rightarrow K^{\pm}\pi^{\pm}$



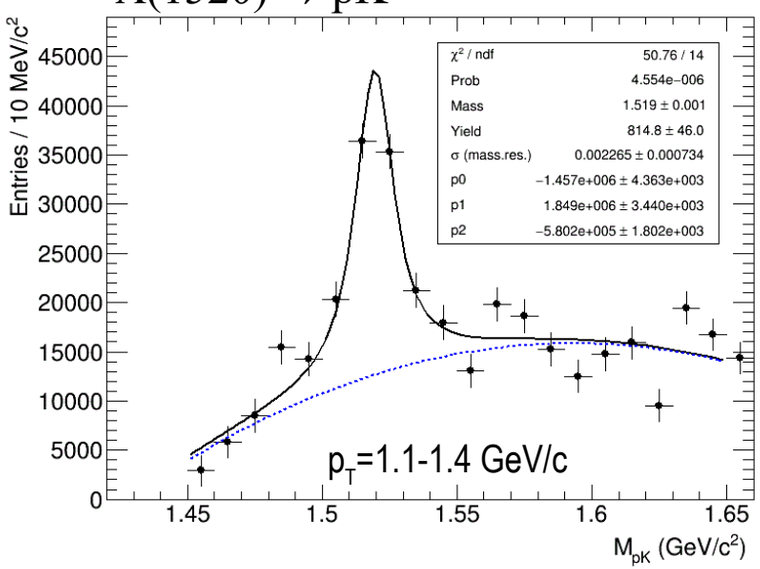
$\Sigma(1385)^{\pm} \rightarrow \pi^{\pm}\Lambda\ (\Lambda \rightarrow p\pi)$



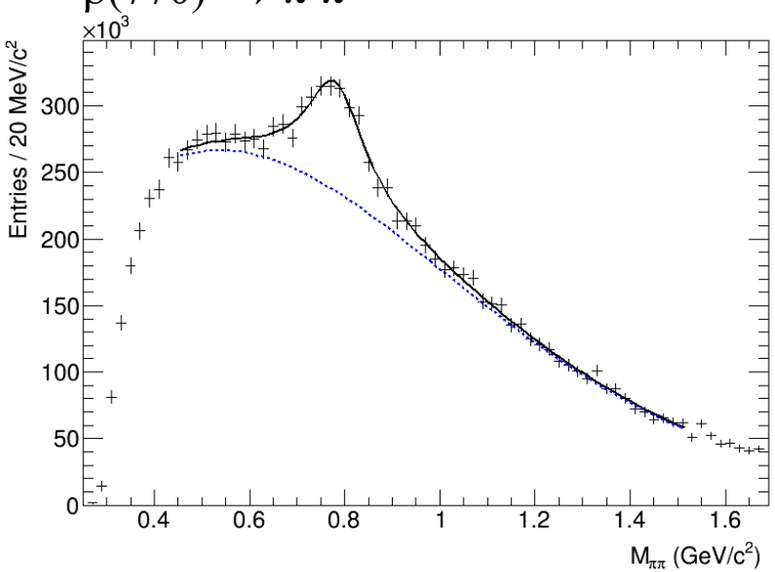
$K^*(892)^{\pm} \rightarrow \pi^{\pm}K_s\ (K_s \rightarrow \pi^+\pi^+)$



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

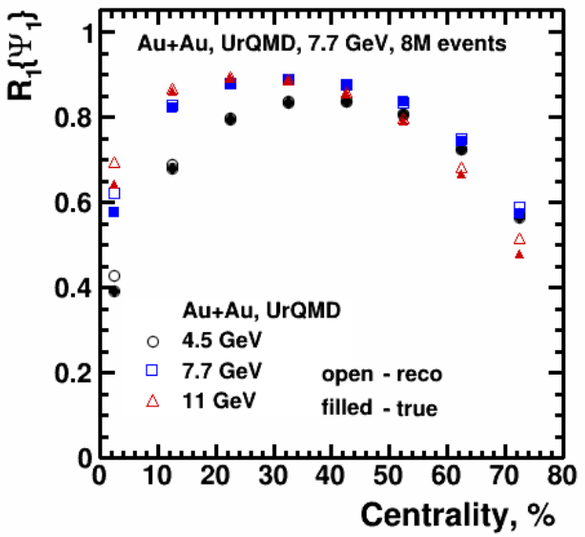


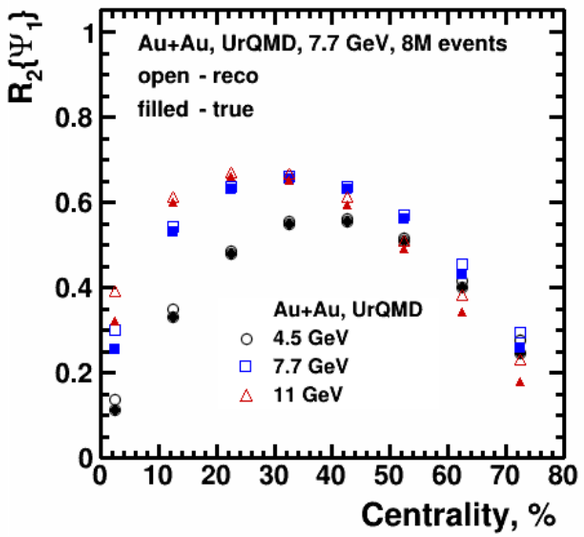
$\rho(770)^0 \rightarrow \pi^{\pm}\pi^{\pm}$

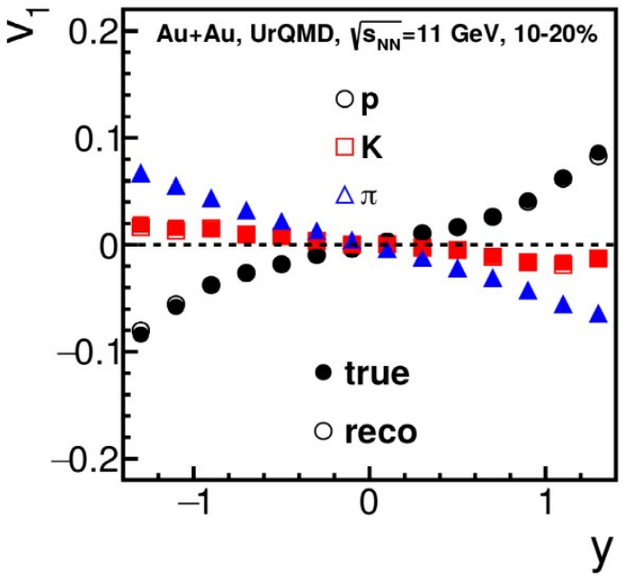


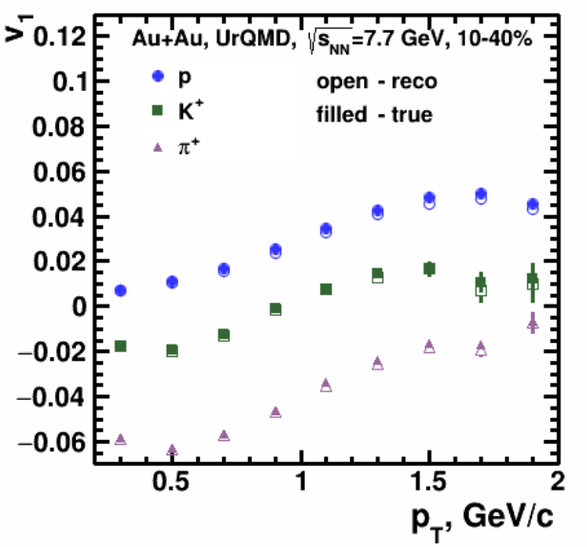
Performance of collective flow studies

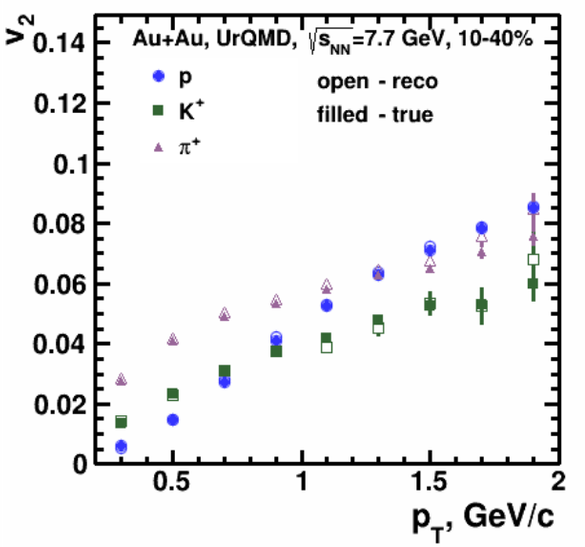
Au+Au, $\sqrt{s_{NN}}$ = 7.7, 11 GeV, UrQMD, GEANT3 + MPDRoot reco.

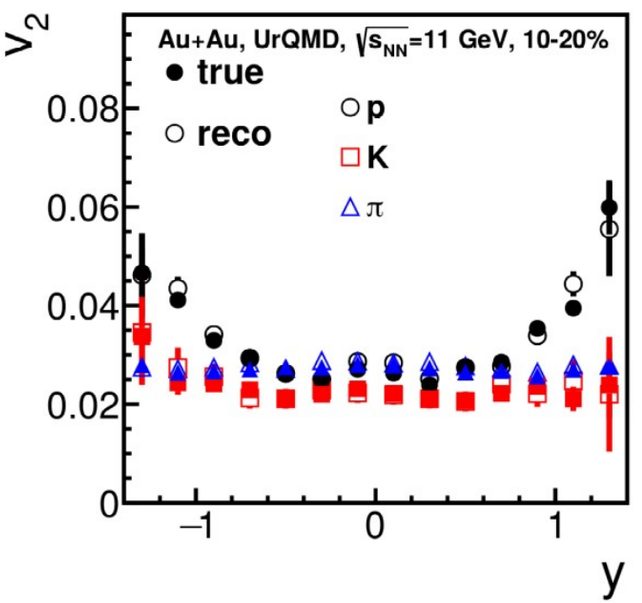








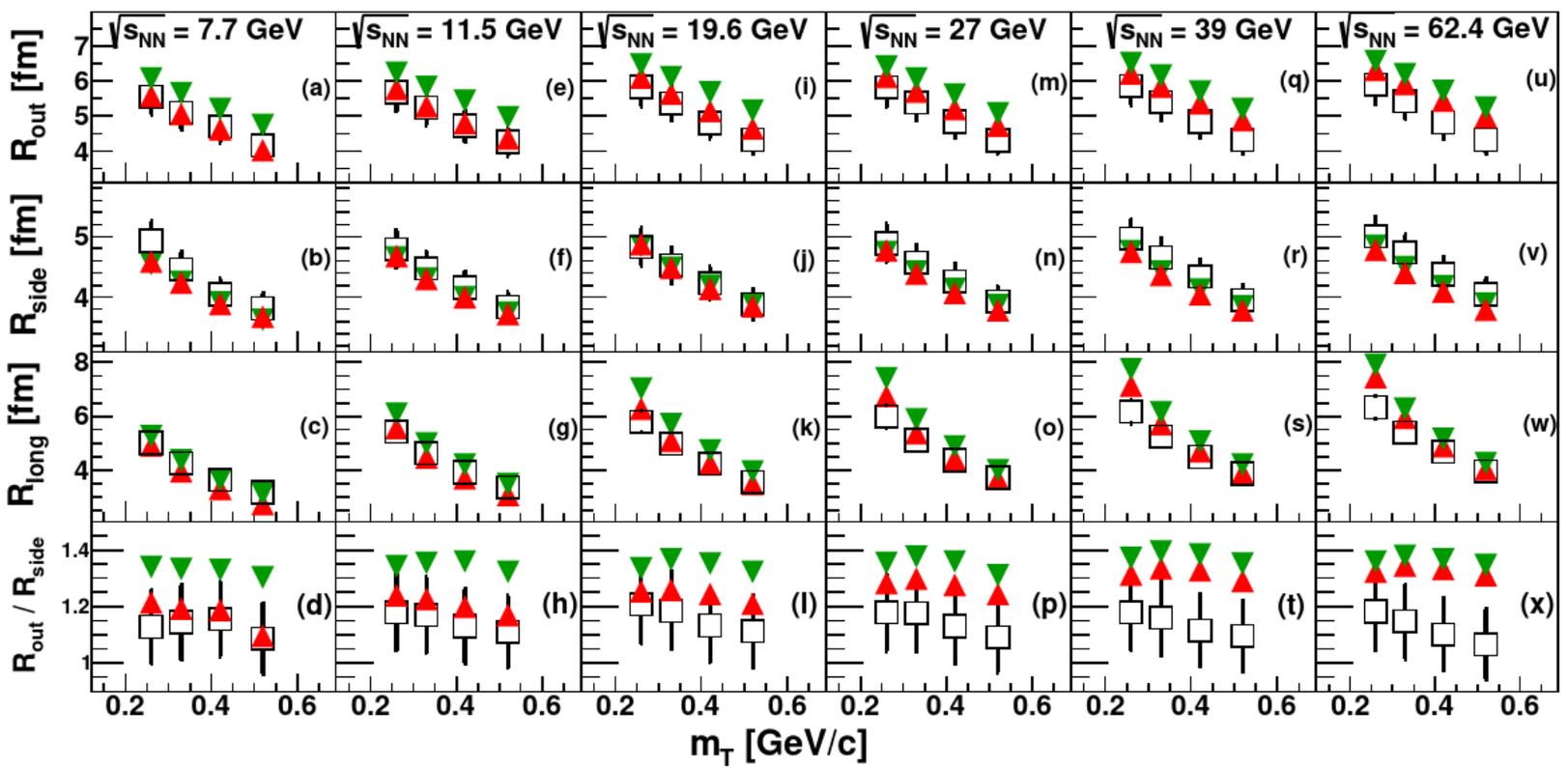




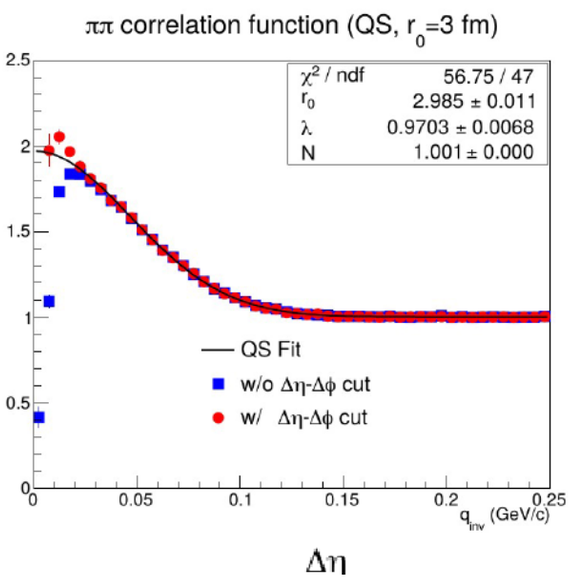
Collective flows a unique and direct way to probe EOS of QCD matter. Excellent flow measurement capabilities in MPD

System size sensitive to phase transition

- Femtoscopy based on two-particle correlation technique (similar to HBT effect in astronomy) probes system size in HIC
- Measurement for pions straightforward and robust, large discovery potential in correlations for kaons and protons, as well as correlations including hyperons



1st order phase transition
cross-over transition

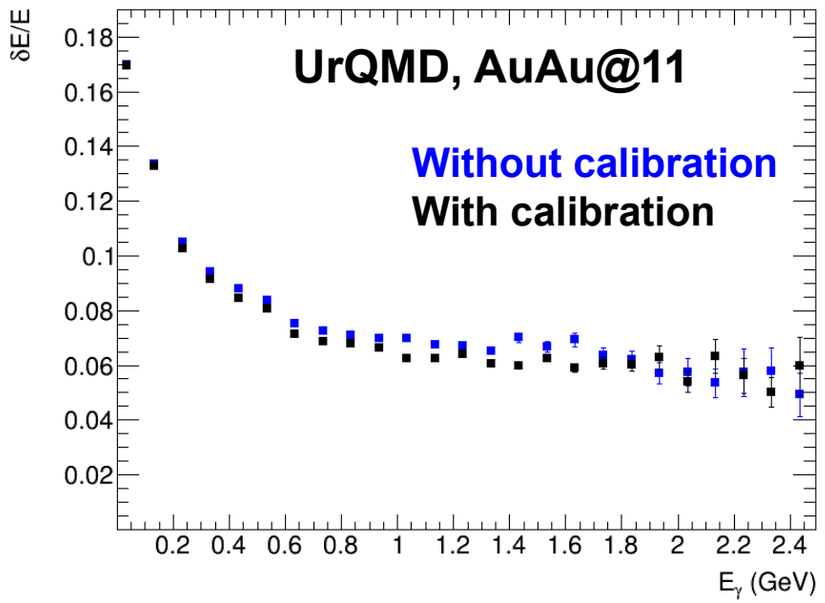


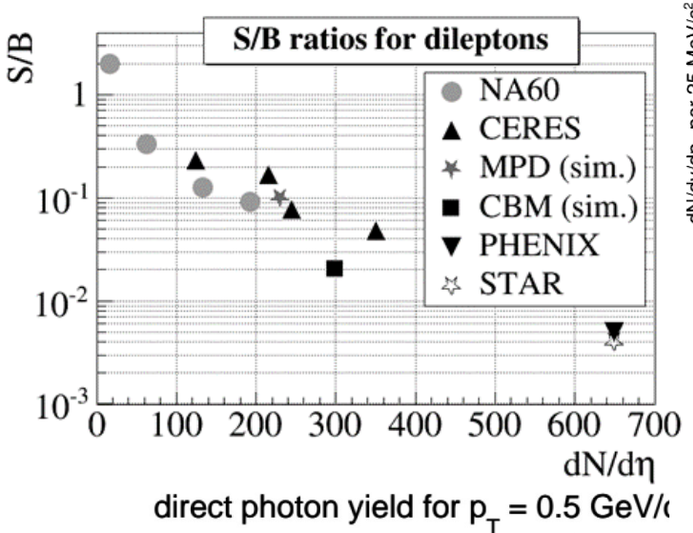
Δη

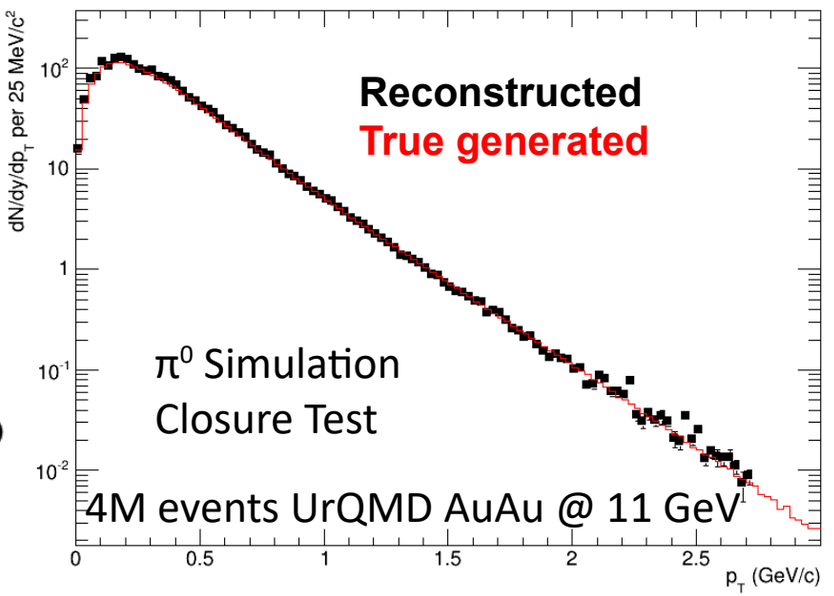
- Clear sensitivity of pion source size to the nature of the phase transitions
- Important and sensitive cross-check of detector performance (two-track resolution)

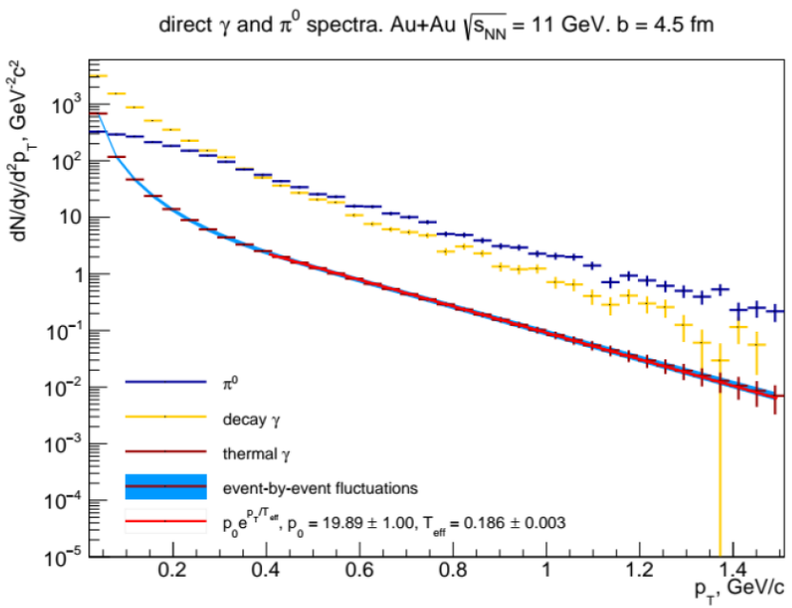
Electromagnetic probes in ECAL

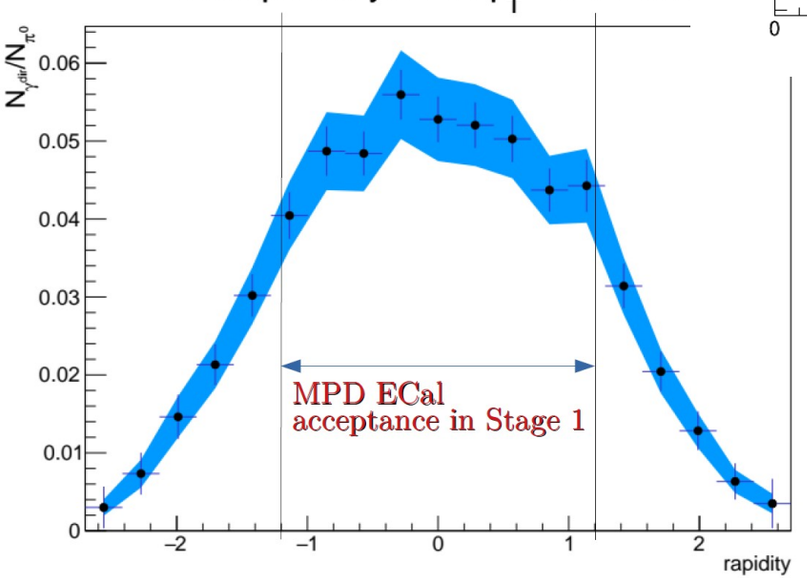
- Realistic ECAL reconstruction & analysis – large acceptance ECAL with good energy resolution: ideal tool for measurement of neutral mesons in a wide momentum range











- Promising feasibility studies for prompt photon measurements in MPD

Summary

- Increased effort on the preparation of the MPD Physics Programme, with connection to detector readiness
- Definition of formal deadlines for MPD project milestones
- All components of the MPD 1st stage detector advanced in production, commissioning expected for 2021