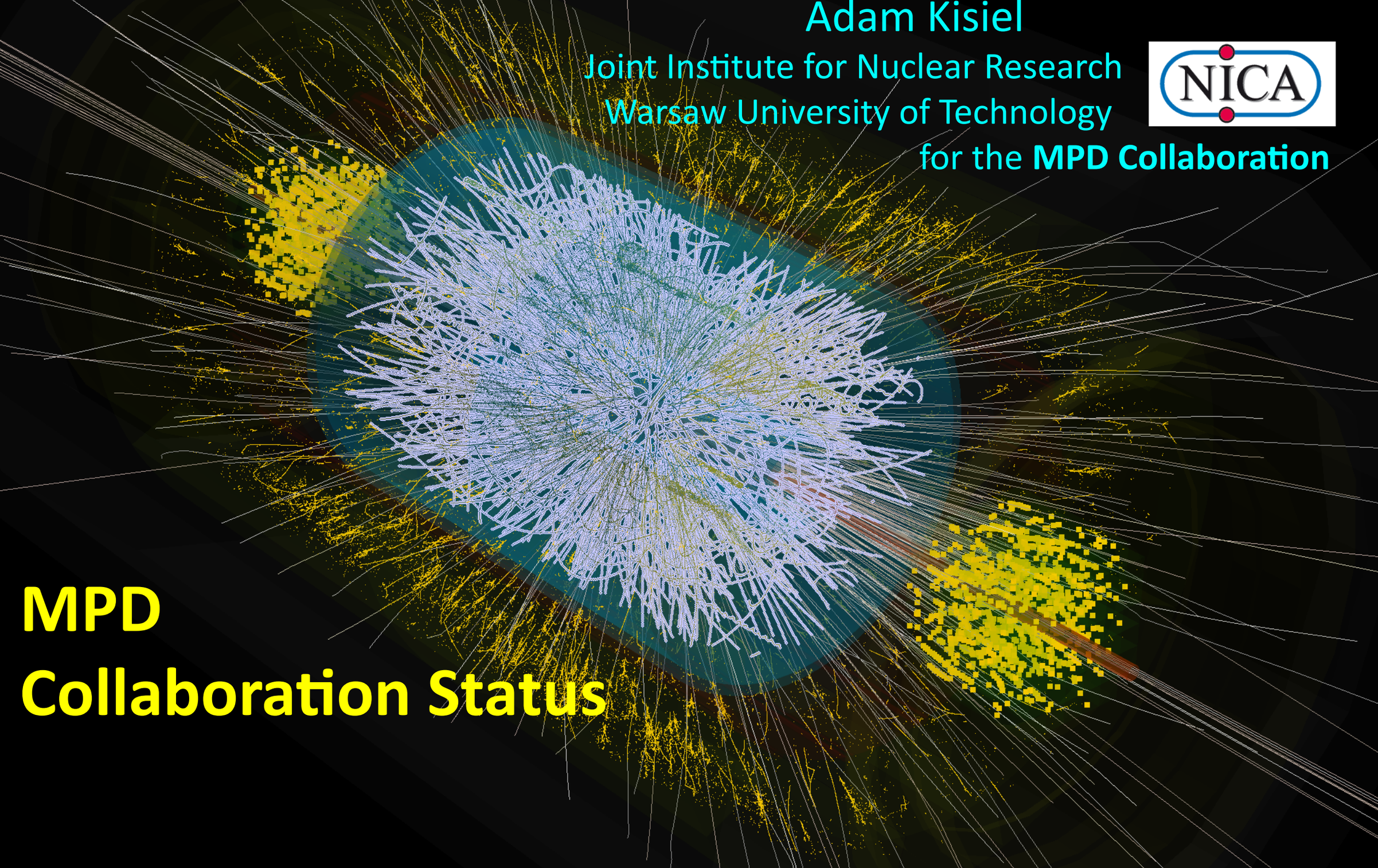
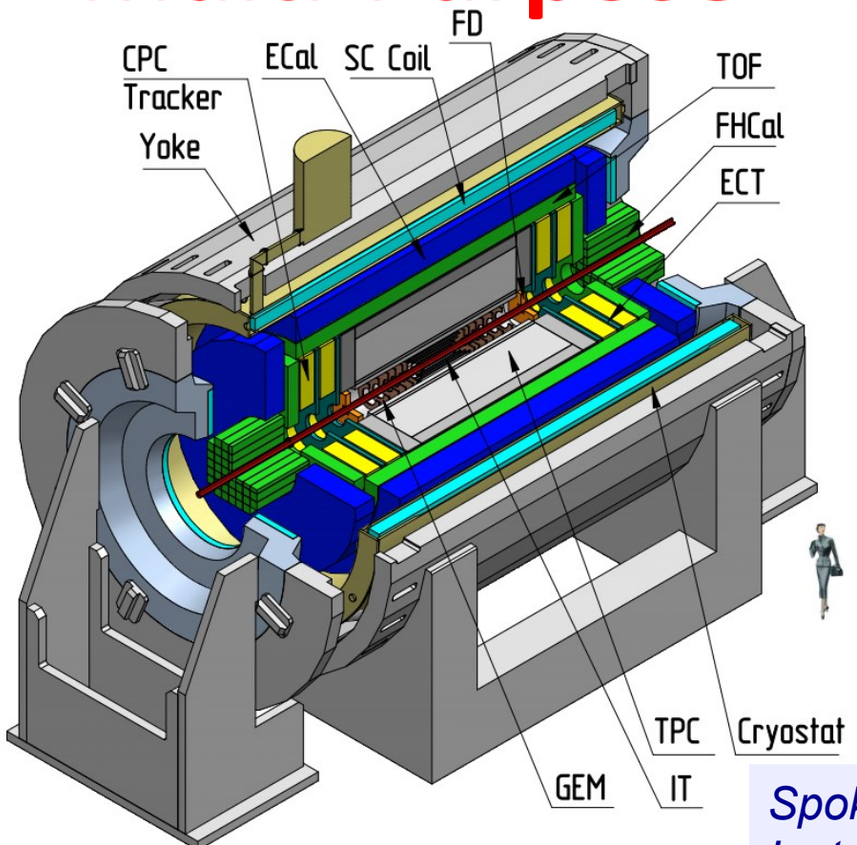
Adam Kisiel
Joint Institute for Nuclear Research
Warsaw University of Technology
for the **MPD Collaboration**



MPD Collaboration Status

Multi-Purpose Detector (MPD) Collaboration



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

NICA

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

Deputy Spokespersons:
Victor Riabov, Zebo Tang

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, Huizhou, ***China;***
Institute of Nuclear and Applied Physics, CAS, Shanghai, ***China;***
Central China Normal University, ***China;***
Shandong University, Shandong, ***China;***

IHEP, Beijing, ***China;***
University of South China, ***China;***
Three Gorges University, ***China;***
Institute of Modern Physics of CAS, Lanzhou, ***China;***
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;***

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, **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
- Recently prepared MoUs: **Armenia:** A. Alikahnyan National Lab of Armenia, **Poland:** University of Silesia, **Czech Republic:** Palacki University, Olomouc
- Progress on the MoU with Chinese Institutions (agreement with Chineese MOST)

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 First Physics Document

- Report on expected physics results on the first run of MPD
- Initial running plan for the NICA Complex (Bi+Bi@$\sqrt{s_{NN}}$=9.46 GeV, Au+Au up to 11 GeV)
- Status of the readiness of the MPD detector subsystems
- Calibration and computing readiness
- Selection of physics observables with largest discovery potential for the initial datasample
- Collaboration Review of the paper expected in the coming weeks
- Need to prepare Author List and Acknowledgments

First Physics with MPD Experiment at the NICA Accelerator Complex*

(Dated: October 26, 2020)

The Nuclotron-based Ion Collider fAcility (NICA) is in construction at the Joint Institute for Nuclear Research (JINR). The accelerator complex will consists 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 Nuclotron. The expected date of putting the NICA collider ring for commissionning is September of 2022. At the same time the Multi-Purpose Detector (MPD) has been designed to operate at NICA. Components of MPD are currently in production. The assembly of the detector on-site has started on July of 2020, while on November of 2021 the detector setup will start the commisioning, to be ready for datataking on first beam from NICA.

This documents details the preparation schedule for the construction and commisionning of MPD. It presents the plans for the first physics measurements at NICA and puts them into context of existing and planned physics experiments in the area of QCD phase diagram investigation.

CONTENTS

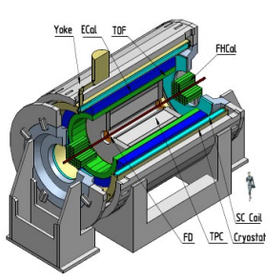
* A report for the NICA Supervisory Board and the JINR Committee of Plenipotentiaries

I. THE NICA COMPLEX CONSTRUCTION SCHEDULE AND EXPECTED INITIAL PERFORMANCE

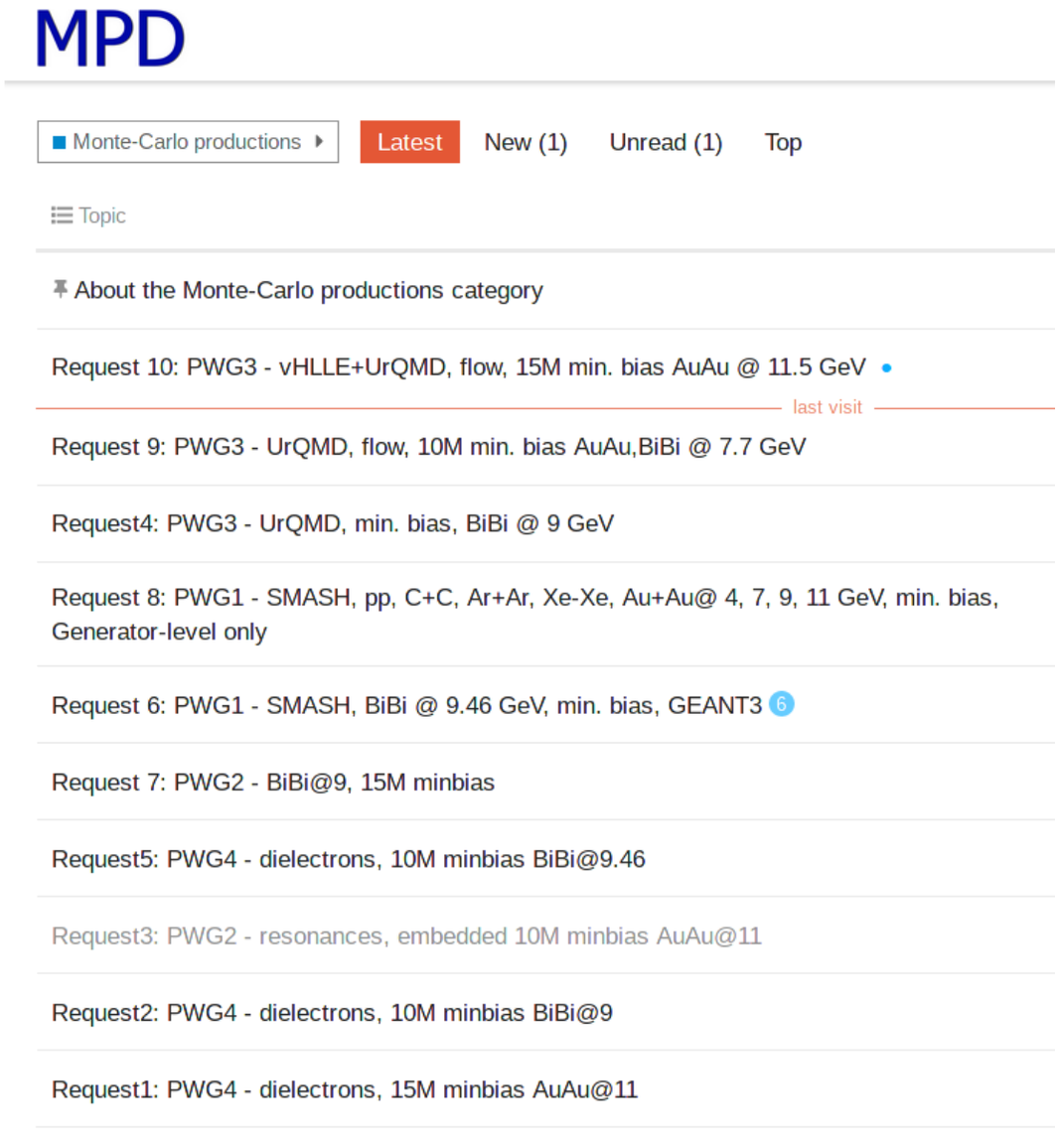
The NICA Accelerator complex progress is described in detail in XYZ. The expected date of the start of commissioning of NICA accelerator ring is September 2022. The initial luminosity is planned to be at least $10^{24}\ cm^{-2}s^{-1}$ with relatively quick increase to at least $10^{25}\ cm^{-2}s^{-1}$. Symmetric collisions of heavy ions will be performed in the initial stages of NICA operation. Several types of ions are under consideration for the initial NICA operation, including ^{197}Au ions, which were used in previous and ongoing experiments at RHIC in the Beam Energy Scan program, ^{208}Pb ions which were used for extensive data runs at SPS as well as ^{209}Bi ions, which are very similar to Pb ions, but provide more reliable operation of the NICA injection and acceleration complex at the commissioning and first running phase. The expected beam momentum provided by the Nuclotron will be in the range of 2.5 to 3.8 GeV/c^2. At the initial stage additional acceleration of the beams in NICA Collider is not foreseen. Therefore the initial collision energy $\sqrt{s_{NN}}$ may vary from 7 up to 9.46 GeV, with the maximum possible collision energy of 9.46 GeV being preferable.

II. READINESS OF THE MPD EXPERIMENT

The overall structure of the MPD detector in the first stage of data-taking (Stage 1) is shown in Fig. 1.

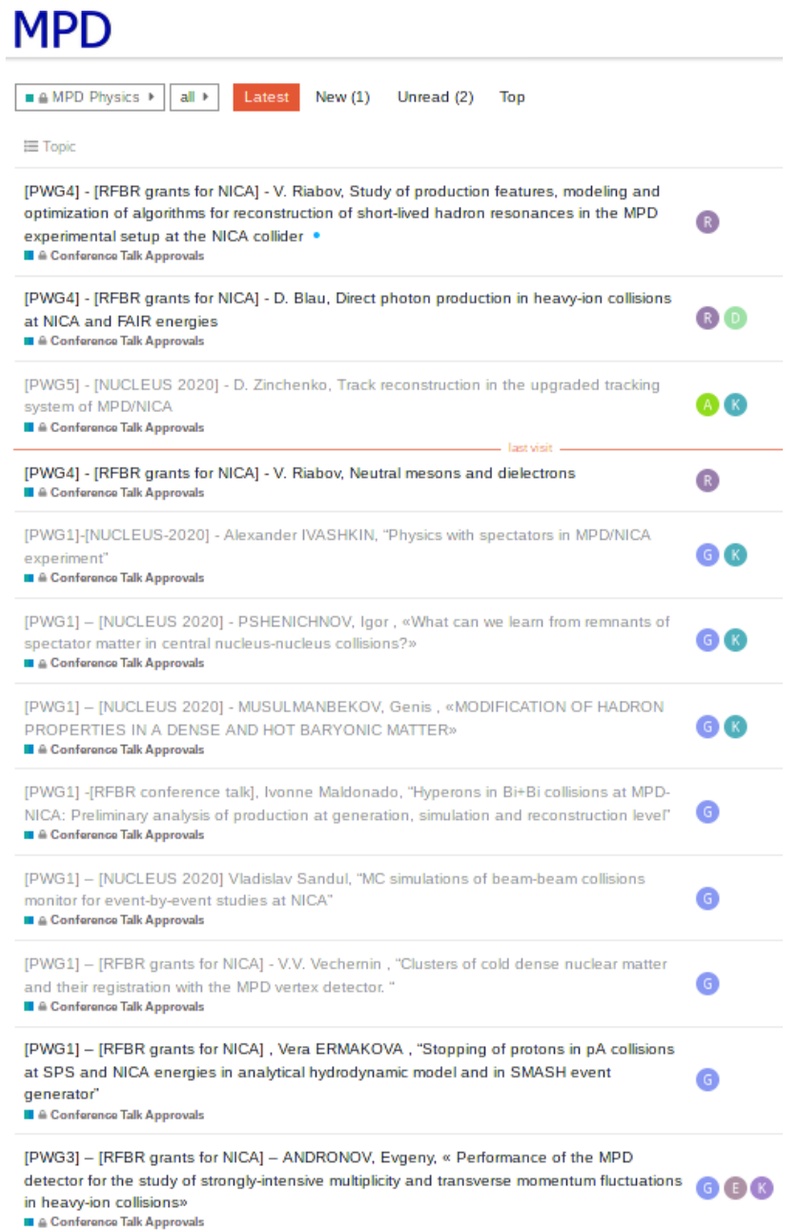


Monte-Carlo simulations, computing readiness



- Organized regular massive productions of Monte-Carlo simulations, using MPD computing resources
- Regular running of productions in HybryLIT (LIT laboratory cluster), use of DIRAC
- NICA Cluster at VBLHEP in routine operation for data analysis
- Established procedure for requests and validation of Monte-Carlo productions
- Extensive new requests in response to clarification of initial NICA beams

MPD Physics reports at Autumn conferences



- Three major conferences in Autumn 2020:
  - ICPPA 2020 (MePHI) Oct 5-9
  - Nucleus 2020 (SPSU) Oct 11-17
  - RFBR grants for NICA (JINR) Oct 20-23
- More than 40 reports (total) at the conferences, related to MPD
- Major effort to prepare up-to-date physics simulations for the talks
- Organized slides approval and talk rehearsals within MPD PWGs for the talks

MPD at “RFBR grants for NICA” conference

Plenary sessions:

A. Taranenko, *Collective Anisotropic Flows* (Wed)
L. Malinina, *Femtoscopy and correlations* (Wed)
G. Feofilov, *Initial states at NICA* (Wed)
A. Ivashkin, *Spectators in FHCAL* (Wed)
M. Martemianov, *ECal Calibration* (Wed)

E. Kryshen, *e+e- Conversion pairs* (Thu)
V. Kulikov, *ECal Simulations* (Thu)
A. Zinchenko, *Event reconstruction* (Thu)
V. Kolesnikov, *Strangeness in MPD* (Thu)
V. Riabov, *Hadronic Resonances in MPD* (Thu)

O. Rogachevsky, *Monte-Carlo modelling* (Fri)
V. Babkin, *MPD Time-Of-Flight* (Fri)
Y. Murin, *MPD ITS based on MAPS* (Fri)
V.I. Zherebchevsky, *Data analysis with ITS* (Fri)

Parallel sessions

D. Zinchenko, *Vector Finder Toolkit,* Thu, Parallel 1
D. Drnoyan, *Hyprnuclei in MPD,* Thu, Parallel 1
V. Kondratiev, *ITS simulations,* Thu, Parallel 1
I. Rufanov, *Electron ID in MPD TPC,* Thu, Parallel 1
A. Bychkov, *Calibration of TPC,* Thu, Parallel 1
A. Krylov, *Event display for MPD,* Thu, Parallel 1

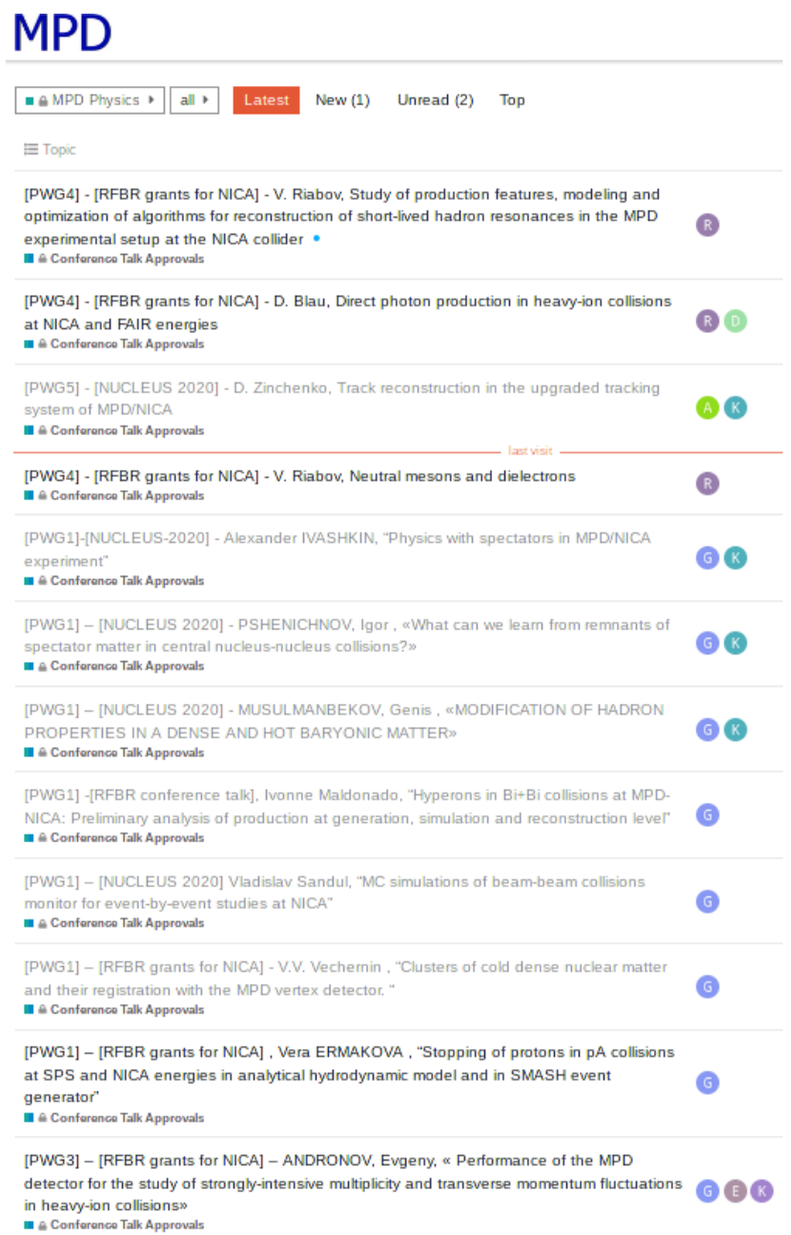
O. Kodolva, *Factorial Moments,* Thu, Parallel 2
D. Idrisov, *Methods for Anistotropic Flow,* Thu, Parallel 2
V. Riabov, *Neutral mesons and dielectrons,* Thu, Parallel 2
A. Mudrokh, *Event-by-evemt Fluctuations,* Thu, Parallel 2
D. Blau, *Direct photons,* Thu, Parallel 2

G. Nigmatkulov, *Data Formats,* Thu, Parallel 3

D.G. Nesterov, *MAPS construction for MPD,* Fri, Parallel 1

I. Maldonaldo, *Lambda Polarization,* Fri, Parallel 2
V.V. Vechernin, *Nuclear Clusters,* Fri, Parallel 2
A. Prokofiev, *MAPS test,* Fri, Parallel 2
A. Rakhmatulina, *Identification in MAPS,* Fri, Parallel 2

Talk rehearsals for MPD



- MPD Bylaws require approval and rehearsal of talks representing MPD at major conferences
  - Strict requirement so far only applies to talks presenting MPD data
  - Executive Council and Physics Council recommended the procedure for 2020 conferences to test the system, provide help to speakers and ensure consistent message
- Rehearsals conducted in Sep and Oct 2020
  - Organized by PWG convenors
  - Open to all Collaborators
  - Many thanks to all participants!

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 Vidyo conference platform) for planning, execution and archiving of MPD meetings
  - WebEX, Interprocom, ZOOM, 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” diskspace at JINR (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 Interprocom 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 10th - Solenoid is in Dubna
5. Nov-Dec - Assembling of Magnet Yoke and Solenoid at JINR

Year 2021

6. Jan- April - Preparation for switching on the Solenoid (Cryogenics, Power Supply et cet.)
7. May - June - Magnetic Field measurement
8. July - Installation of Support Frame
9. Jul- Dec - Installation of ECal and TOF, Electronics Platform, Cabling

Year 2022

11. Jan- Mar - Installation of TPC, Electronics Platform, Cabling
12. March - Installation of beam pipe, FHCal, Cosmic Ray test system
13. April-Dec - Cosmic Ray tests
14. December - Commissioning

Year 2023

15. March - Run on the beam

MPD Civil Construction status

- MPD Hall ready for limited scope of equipment installation, remaining works still ongoing

MPD Hall crane weight test

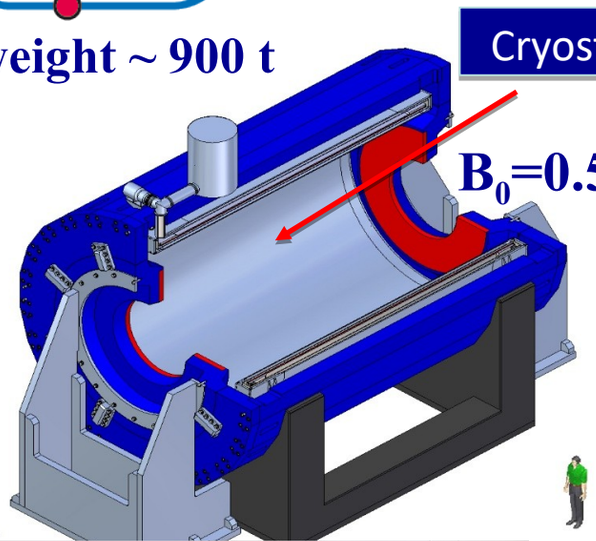
Exterior of the MPD Hall Building and high voltage connection housing

Epoxy floor finish ready in the MPD Hall

Magnet Yoke assembly

- Assembly of the magnet yoke started – 13 modules (out of 28) installed with average 200 µm precision
- Awaiting arrival of Solenoid and manufacturer team to finish procedure
- Critical assembly path commenced

Magnet fabrication



Assembled Solenoid

yoke control assembly at HM Vitkovice

- **Transportation**
- **The magnet is being transported via boat to Dubna**
- **Arrived in St. Petersburg end of last week – now needs to be delivered to Dubna via the Volga river**
- **Preparation for switching on the Solenoid at JINR**

To cool down the magnet the supply of LN and LHe from Collider lines was planned. However at the time of Solenoid cooling down the collider Cryogenics line will not have been yet available. Dedicated cryogenics needed

Cooling tests

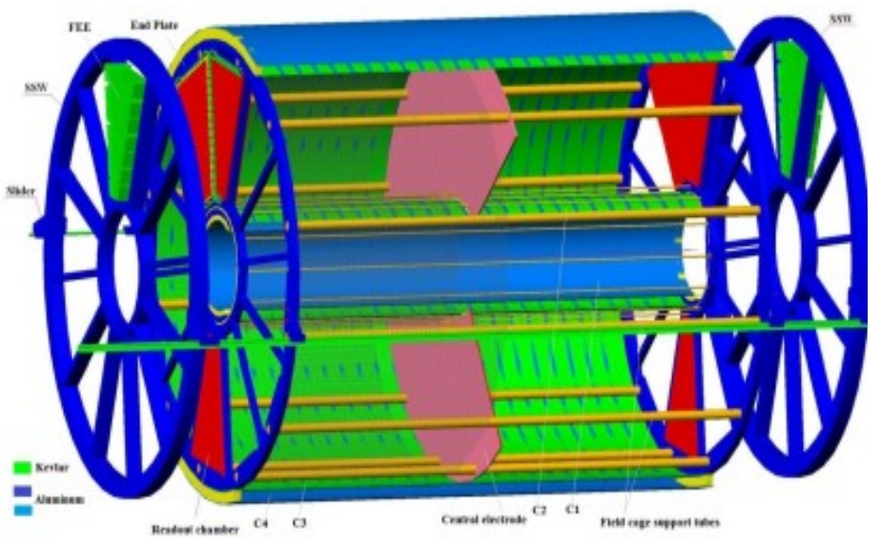
We expect results of low temperature (LN) tests at JINR under supervision of ASG (ITALY). Some reparation after Cooling down procedure of the Solenoid Coils may be needed (coil isolation cracks). Specialized area in JINR is prepared in case repairs are needed

Current lead

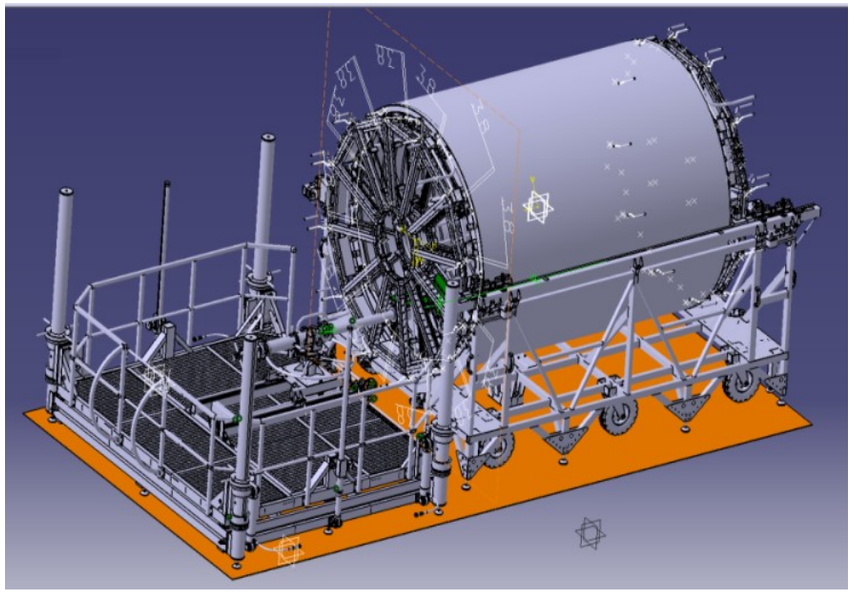
ASG decided to use current leads with glued fiberglass vacuum seals. Our experts suggest this is not a reliable solution. Several cycles of warming and cooling may cause the leakage in the vacuum system of the solenoid. We plan to replace current leads from Cryomagnetic Inc. company with those of Mark&Wedel.

MPD Time Projection Chamber

- **Sensitive length: 326 cm**
- **Radius: 34/133 cm**



Item	Dimension
Length of the TPC	340cm
Outer / Inner radius of vessel	140cm / 27 cm
Outer / Inner radius of the drift volume	133cm / 34cm
Length of the drift volume	163 cm (of each half)
Electric field strength	~ 140 V/cm
Drift gas	90% Ar+10% CH_4 / 80%Ar+20%CO_2
Gas amplification factor	~ 10^4
Drift velocity	5.45 cm/μs;
Drift time	< 30 μs;
Temperature stability	< 0.5°C
Number of readout chambers	24 (12 on each side)
Number of pads	95232
Maximal event rate	< 7 кHz (at Lum.= 10^{27})
Electronics shaping time	~180 ns
Signal-to-noise ratio	30:1
Signal dynamical range	10 бит
Signal sampling	10 МГц
Two-track resolution	~1 cm



Robot for ROC installation

TPC assembling didn't meet big problems. C3 and C4 cylinders are assembled, ROC chambers (12pc) are tested. ROC chambers installation with a special Robot is foreseen

MPD TPC FEE based on SAMPA

Item	Date	
Testing 512-channel system (FEC v1.0) finished	Jan. 2019	✓
Testing 256-channel system (FEC v2.0) finished	Feb. 2019	✓
Preproduction vervion FEC PCBs sent for fabrication	Mar. 2019	✓
Half-ROC readout system base design finished	Mar. 2019	✓
Receive SAMPA V4 chips at Dubna	Jul. 2019	✓
34 preproduction version FEC assembled and tested	Nov. 2019	✓
32 preprod. version FEC installed on Pilot 2048 ch. Syst.	Dec. 2019	✓
Instrumented Half ROC system testing	Feb. 2020	
Testing instrumented ROC finished	Apr. 2020	
Production vervion FEC PCBs ready	May 2020	
1st batch of prod.ver FEC (130 pcs) fabricated	Jul. 2020	
2nd batch of prod.ver FEC (800 pcs) fabricated	Sept. 2020	
3rd batch of prod.ver FEC (800 pcs) fabricated	Dec. 2020	

Test ROC with FECs (2048ch) –> Oct 2020

FECs mass-production –> 2021

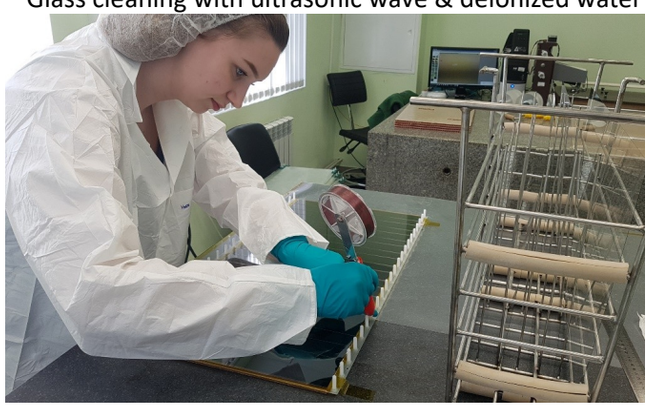
MPD Time-of-Flight

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

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

Glass cleaning with ultrasonic wave & deionized water

Automatic painting of the conductive layer on the glass



MRPC assembling

Soldering HV connector and readout pins

	Number of detectors	Number of readout strips	Sensitive area, m^2	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)

The current design of mRPC was used for TOF-BM&N and showed excellent characteristics. Time resolution - 60 ps

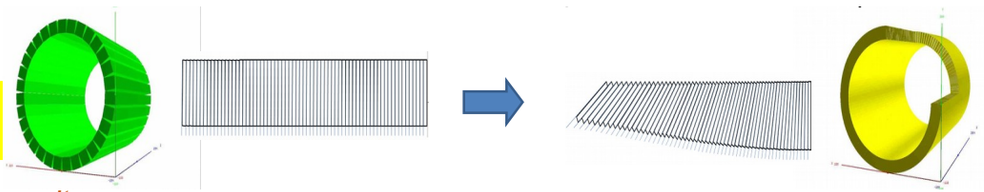
- However on the stage of mass production of RPCs for MPD we have observed a different electric properties of glass and higher dark current. Finding the problem and its solution required 4 months.
- Gas tightness of boxes requires a lot of effort. To lower the material budget we designed and produced low material-budget, non-enforced gas boxes.
- To diminish dead zones we left tight space between TOF modules in the MPD (5 mm). It may cause problems during installation.

Electromagnetic Calorimeter (ECAL)

ECal – THU – Tsinghua University., Yi Wang
SDU – Shandong University
HU – Huzhou University Fuqiang Wang
JINR – production in IHEP (Protvino) and Tenzor (Dubna)

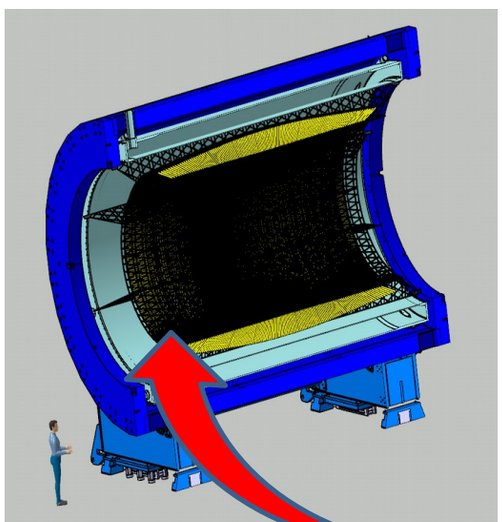
ECal is organized into 25 sectors (50 half-sectors). Each half-sector contains 48 modules.

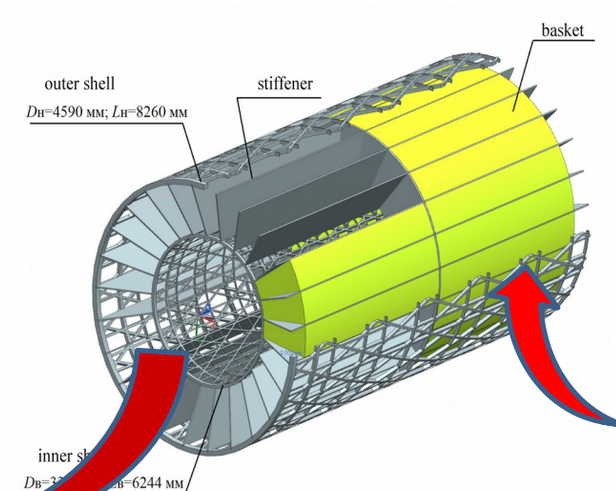
Barrel ECAL ~ 38400 ECAL modules

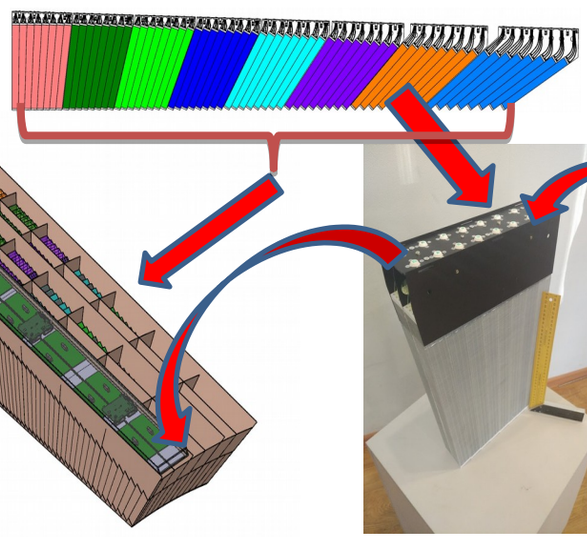


Container is made of Carbon composite

Total load of about 1.2 tons







We need Containers for sectors

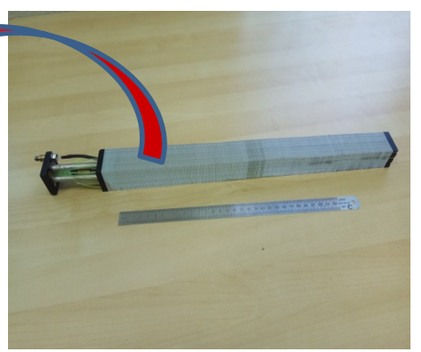
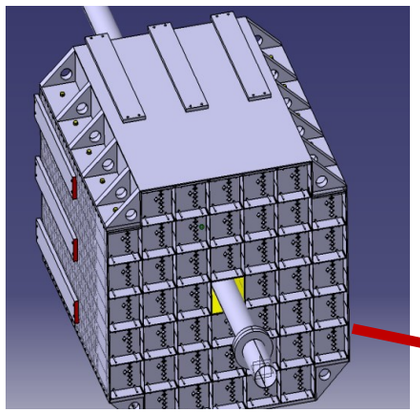
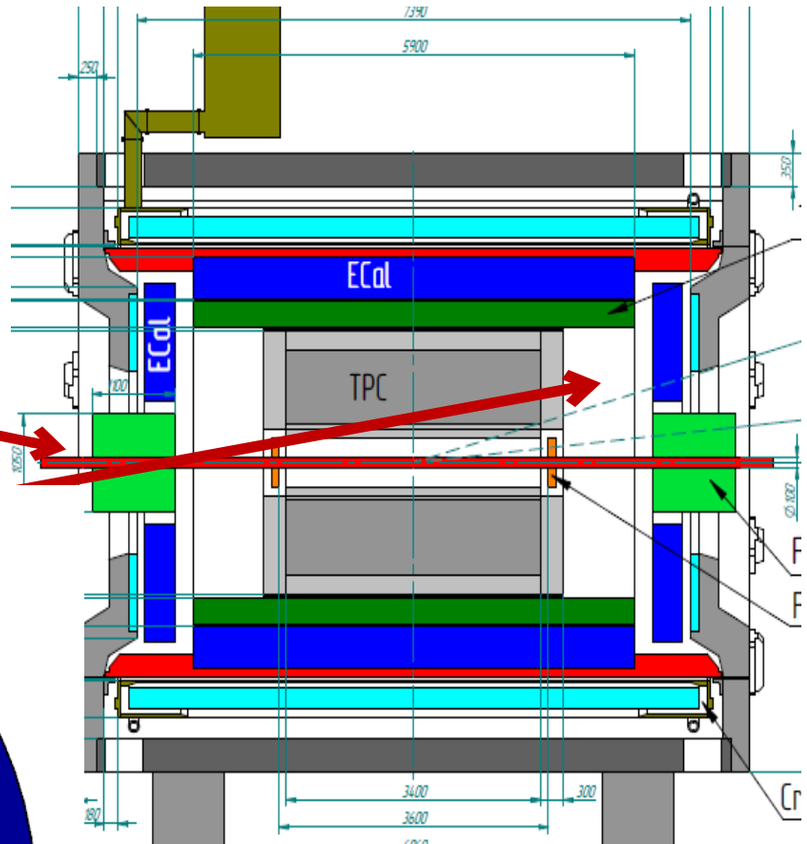


Photo of one element

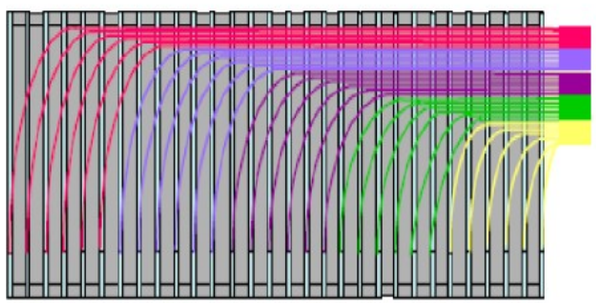
There was preliminary agreement that 25% of all modules are produced by JINR (production area in Protvino) and the rest - 75% in China. 3 sites are prepared for that in China Universities.
However at the beginning of this year the Ministry of Science and Education of China allocated funds for only for 25% all modules and electronics for them. We have to postpone the production of other 50% of Ecal modules to Stage II.
The positive news is that China Universities received funds in August 2020.

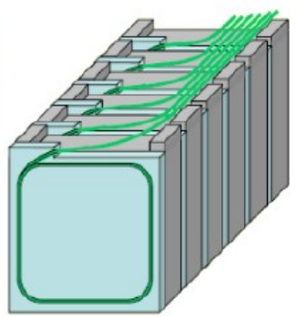
Forward Hadron Calorimeter (FHCal)

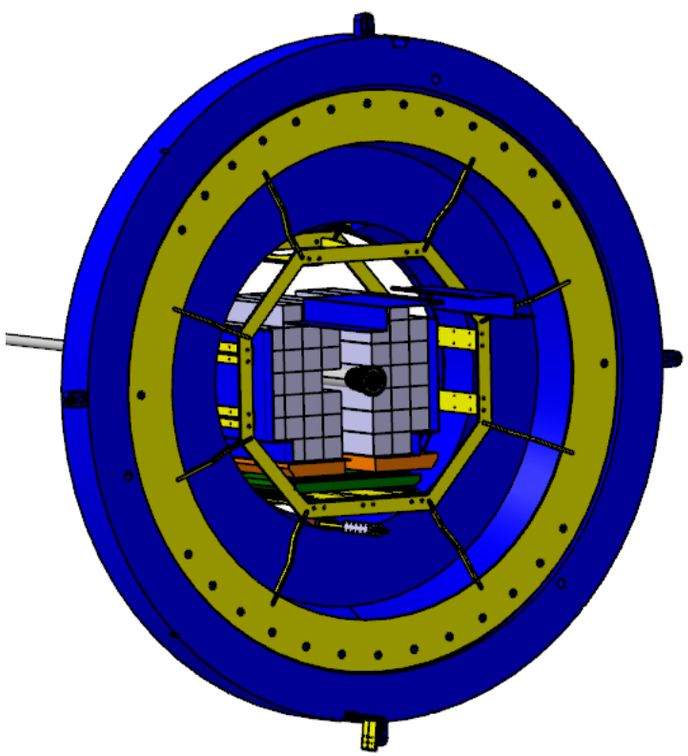




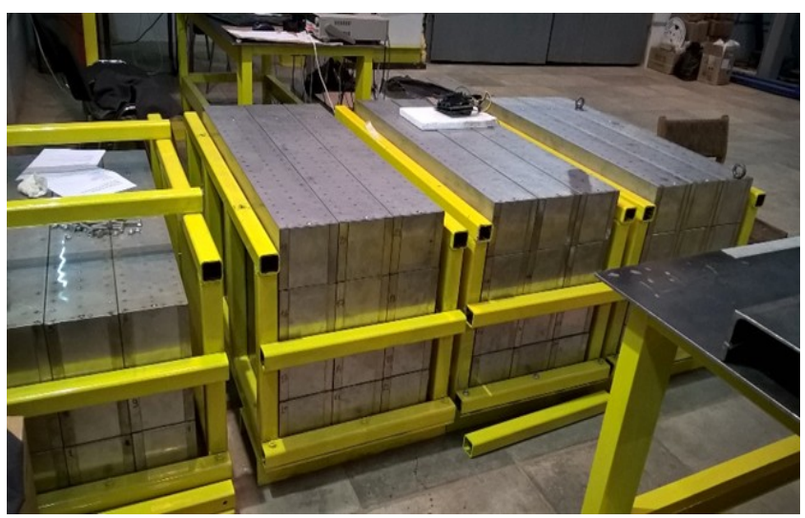
- Two-arms at ~3.2 m from the interaction point.
- Each arm consists of 44 individual modules.
- Module size 150x150x1100cm^3 (42 layers)
- Pb(16mm)+Scint.(4mm) sandwich
- 7 longitudinal sections
- 6 WLS-fiber/MAPD per section
- 7 MAPDs/module







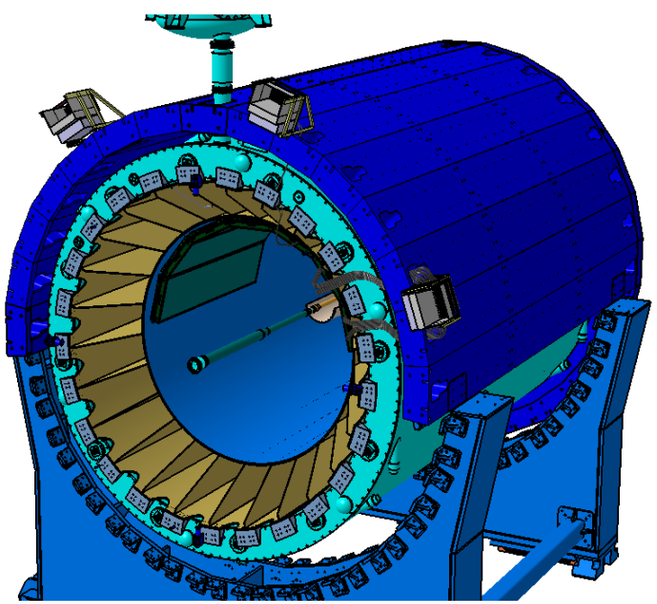
Design of the Support platform for FHCal is under development



Support Frame for detectors inside Solenoid

The structure of the Support Frame is made of carbon fiber which allows for deformation of less than 3 mm under the load with detectors (~80 T). The thickness of the walls is 2-4 mm.

Producer - The Central Research Institute for Special Machinery, Khotkovo, Moscow region is a leading Russian enterprise in design and production of structures on the basis of advanced polymer composite materials for rocket & space engineering, transport, power, petrochemical machinery and other industries.



- design is almost ready, we have to control the space for cabling
- the contract with the Company on the construction of the Support Frame is signed
- according to schedule the Frame will be transported to Dubna in April 2021
- Representatives of the Company will participate in the process of installation of Support Frame into MPD and its alignment

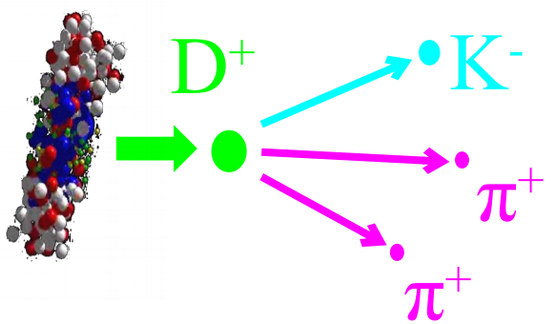
- **The rigs and tools for the installation of ECAl and TOF are still in the design stage.**

ITS for MPD Experiment

Consortium includes JINR, NICA (BM@N & MPD) , **FAIR, Russian, Poland and Ukraine Institutes + CCNU Central China Normal Univ – Wu Han and Feng Liu**

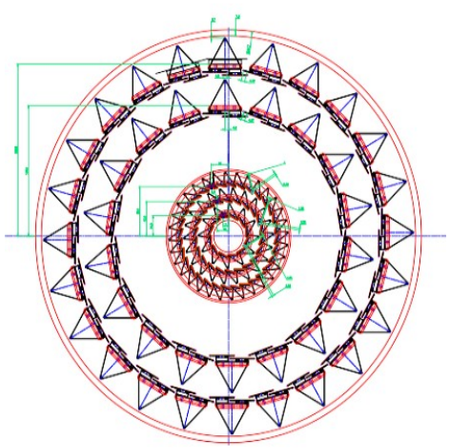
IMP – Institute of Modern Physics - Lan Zhou and Nu Xu

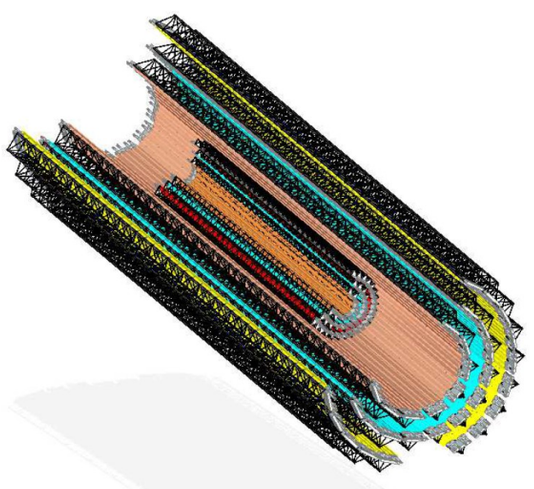
USTC – Hefei - Zebo Tang



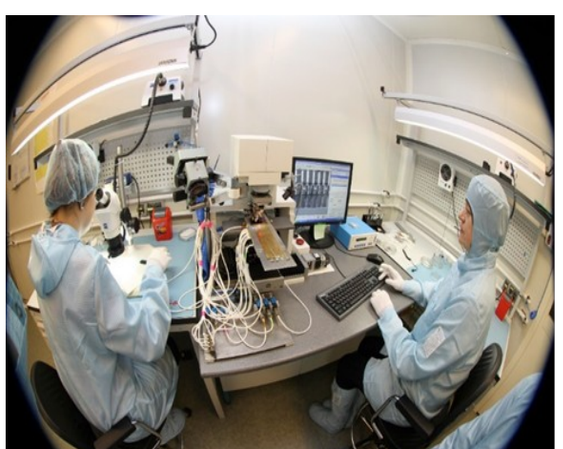
The status of the MPD ITS has changed from the moment when the Protocol # 134 between CERN and JINR stating the legal terms for transaction of CERN developed novel technology and the know-how for building the MPD-ITS on the basis of Monolithic Active Pixel Sensors *(the MAPS*) ALPIDE was signed in 2018.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

The ITS TDR is under preparation in the Collaboration

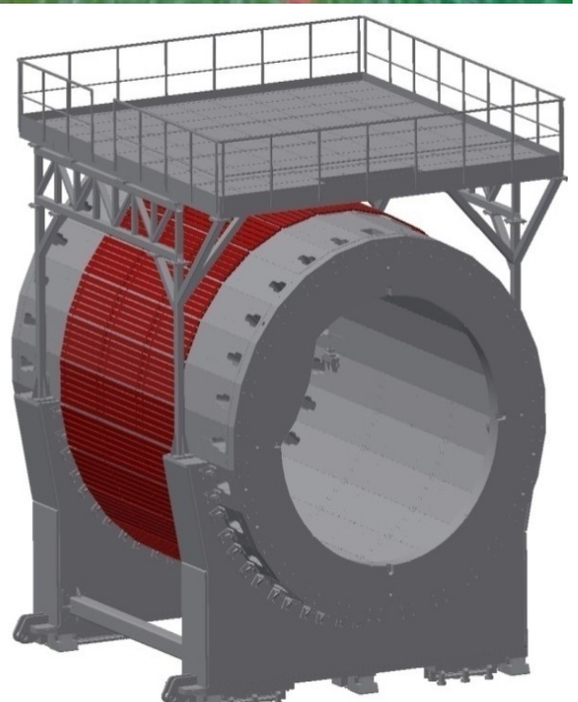




MPD ITS based on ALICE type staves



MPD Cosmic Ray Detector (MCORD)



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

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 March 2021

CDR for MCORD under evaluation of the MPD DAC

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

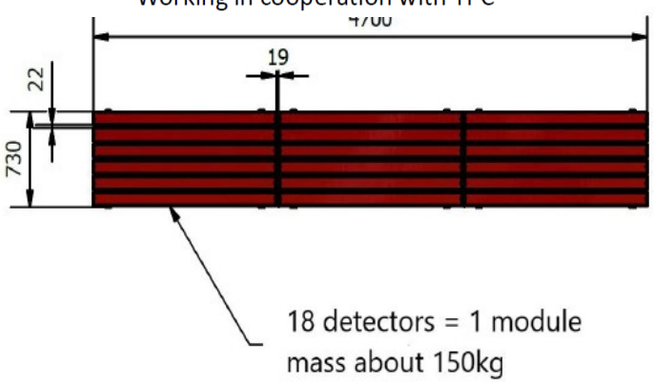
a) Trigger (for testing or calibration)
- testing before completion of MPD (testing of TOF, ECAL modules and TPC)
- calibration before experimental session

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

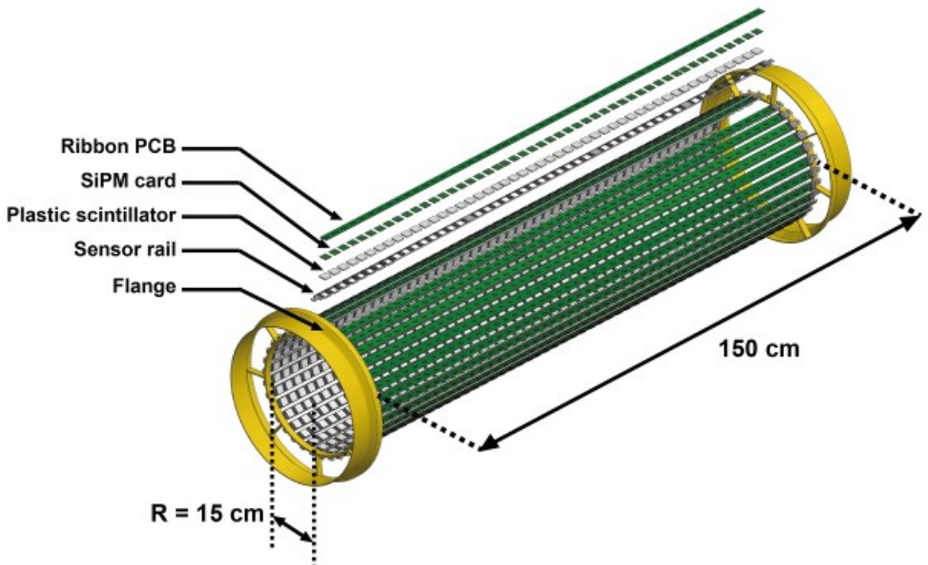
RESOLUTION

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%

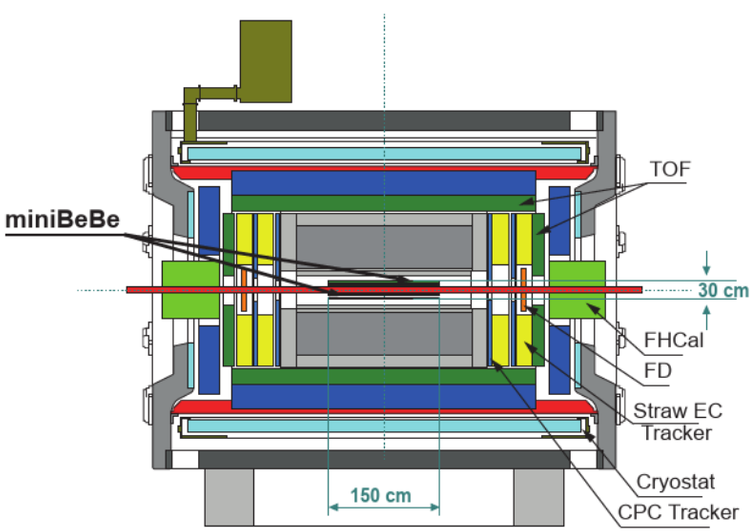
MiniBeBe (Mini Beam-Beam Counter)

MexNICA Collaboration



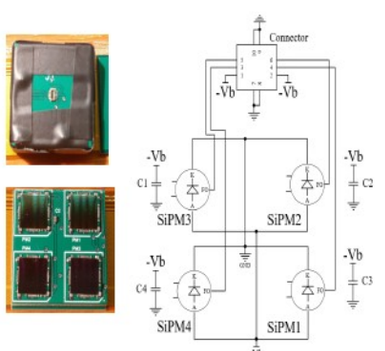
Main requirement:

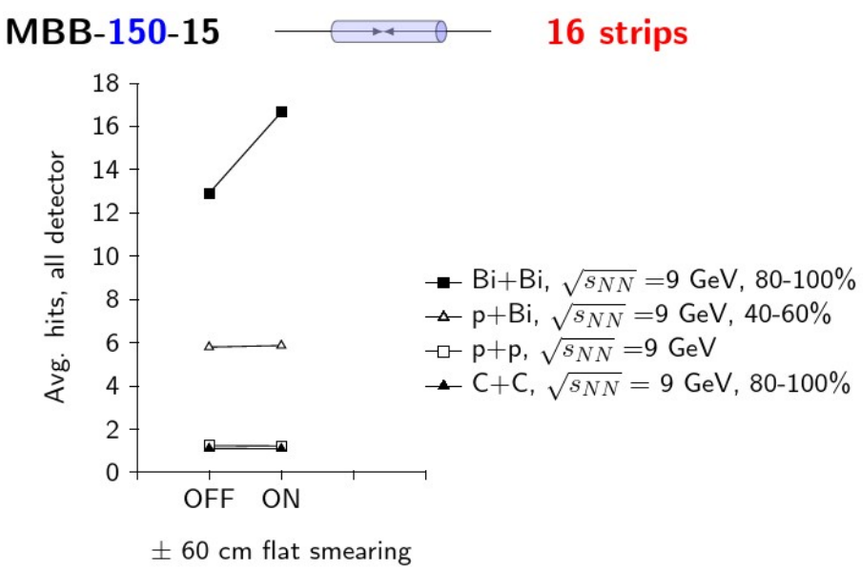
- Provide fast wake-up signal for TOF and reference time for TOF measurement with time resolution of ~30 ps
- Improve trigger efficiency for p+p, p-A and low multiplicity A-A
- Provide possibility to perform luminosity measurements at Phase 0 of NICA operation



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



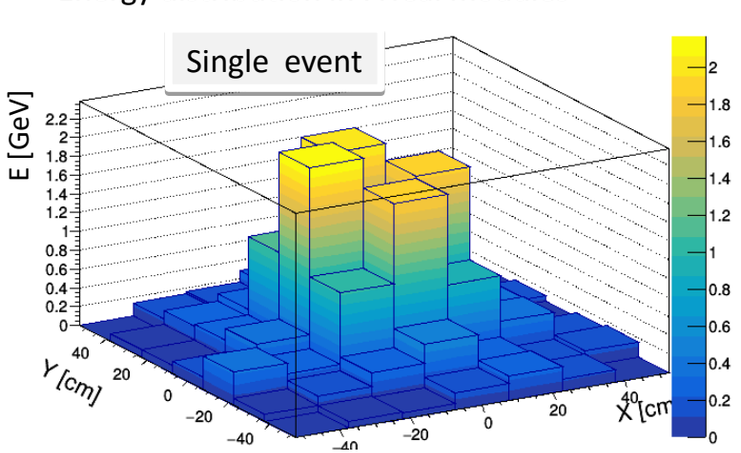


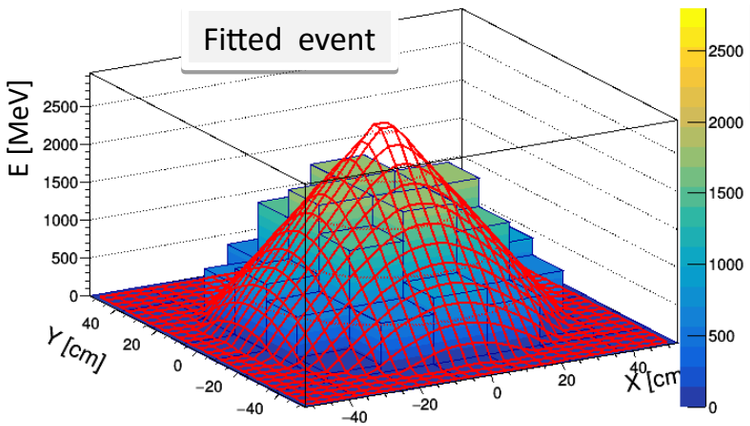
Recent MPD status reports

- Recent reports on the status of the MPD realization:
  - The Program Advisory Committee for Particle Physics (07.2020)
    - Support for the extension and budget for the JINR MPD project for 2021-2025
  - The Cost & Schedule Review Committee of JINR (09.2020)
    - Positive assessment of progress for MPD assembly
    - Identification of Magnet assembly as critical for timeline
    - Support for plans for cosmic ray test period and the development of the physics program (First Physics document)
  - The Detector Advisory Committee of MPD (10.2020)
    - The CDR for MCORD under consideration for approval
    - Guidance on critical points for MiniBeBe CDR

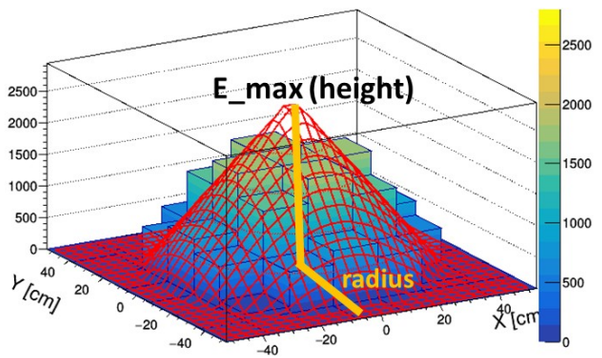
Centrality and reaction plane in FHCal

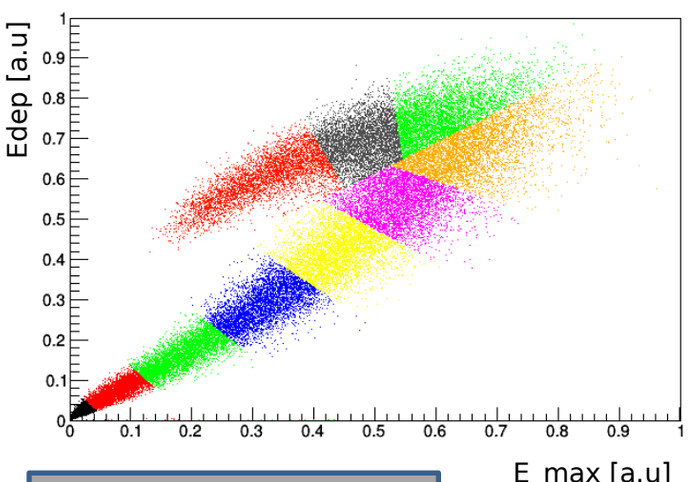
Energy distribution in FHCal modules



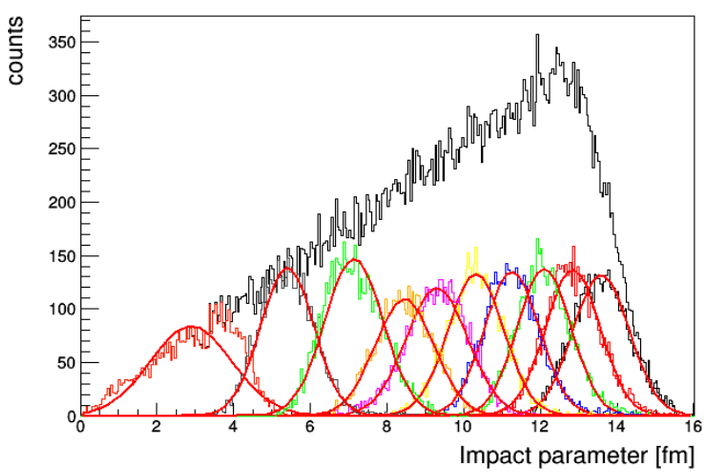


Initially we have experimental energy deposition E_{dep} in FHCal.

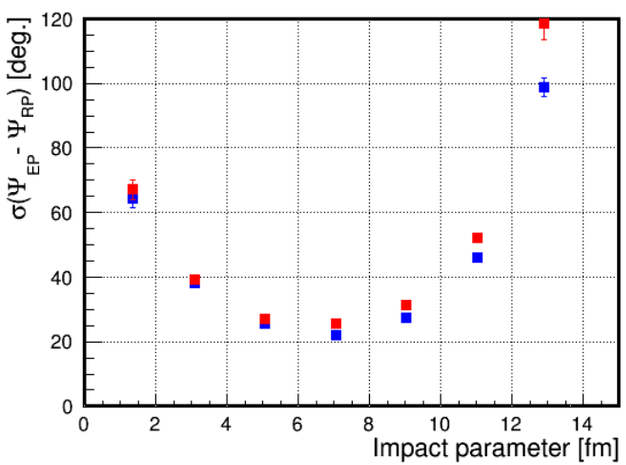




Each color bin is 10% fractions of the total number of events.



Centrality resolution



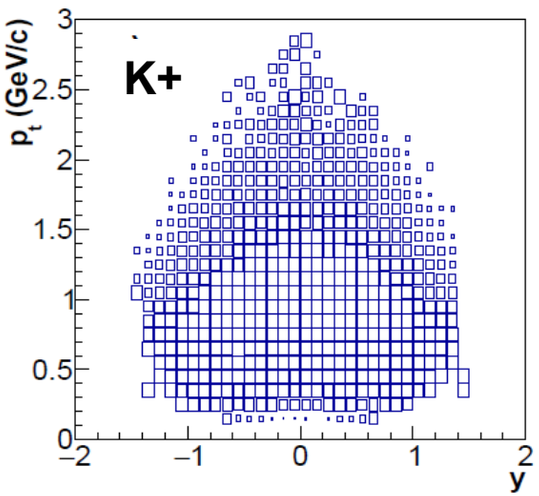
Reaction plane resolution

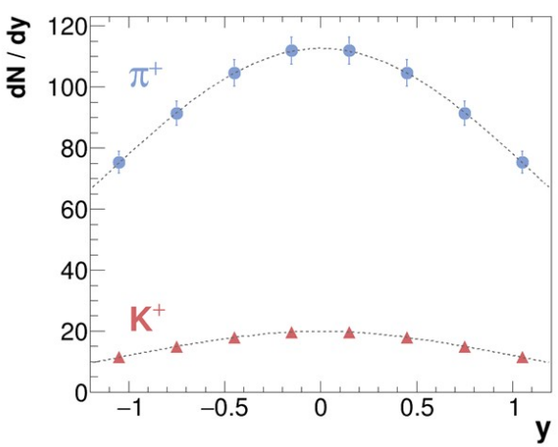
Hadroproduction with MPD

- **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**

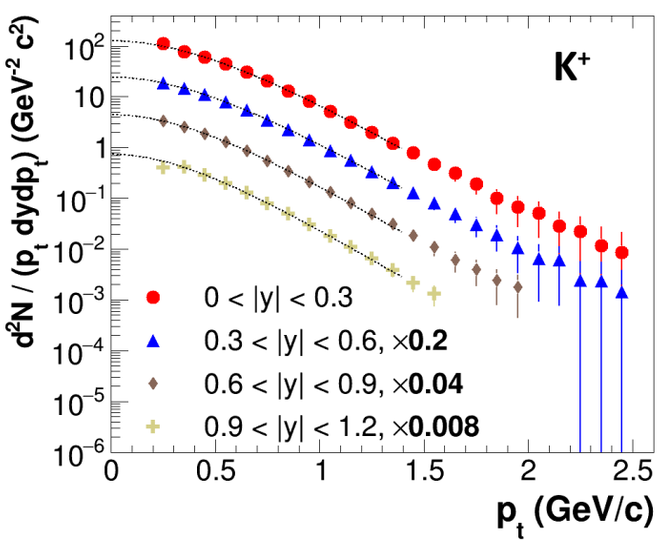
✓ *0-5% central Au+Au at 9 GeV from the PHSD event generator, which implements partonic phase and CSR effects*

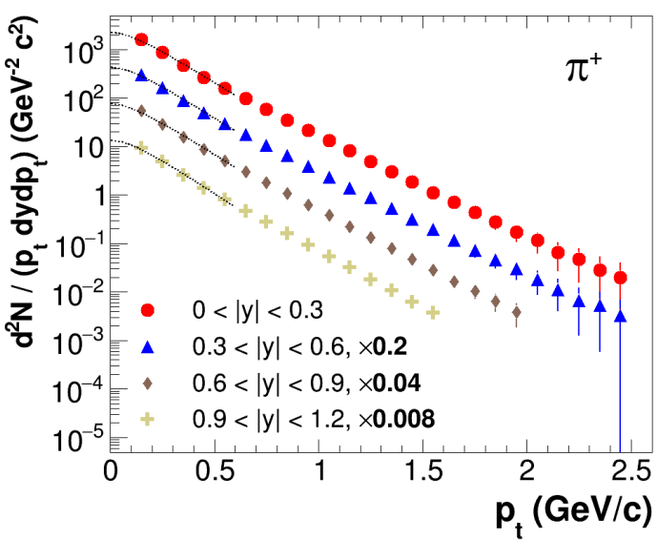
✓ *Recent reconstruction chain, combined dE/dx+TOF particle ID, spectra analysis*





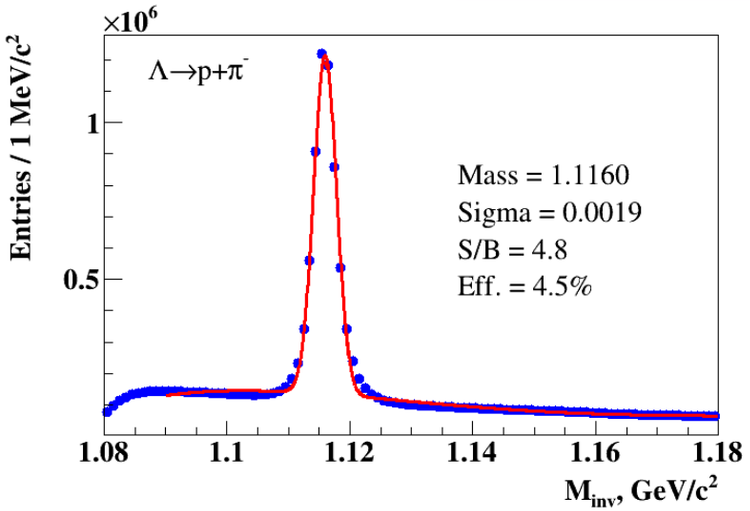
- MPD provides large phase-space coverage for identified pions and kaons (> 70% of the full phasespace at 9 GeV)
- Hadron spectra can be measured from p_T=0.2 to 2.5 GeV/c
- Extrapolation to full p_T-range and to the full phase space can be performed exploiting the spectra shapes (see BW fits for p_T-spectra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

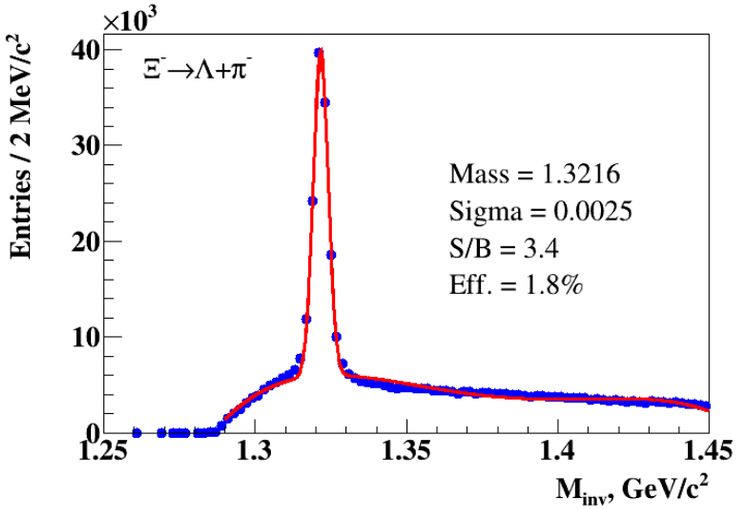


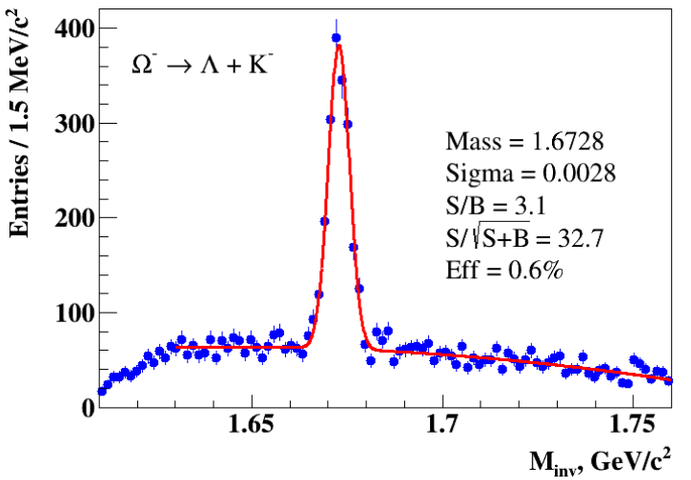


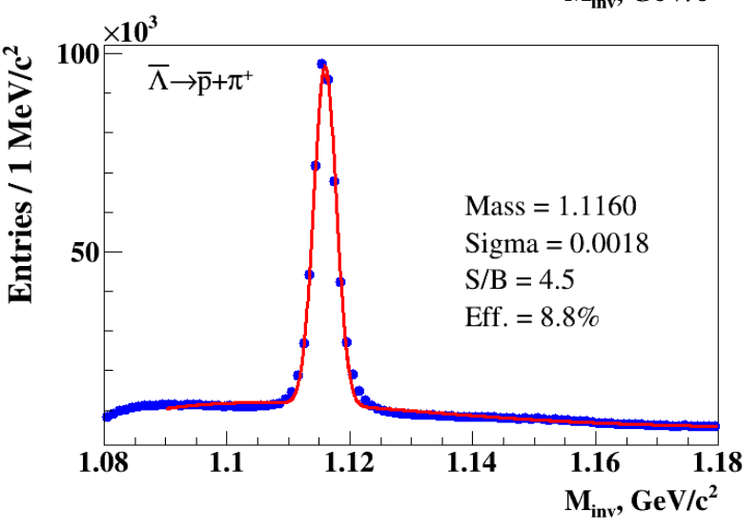
Strange and multi-strange baryons

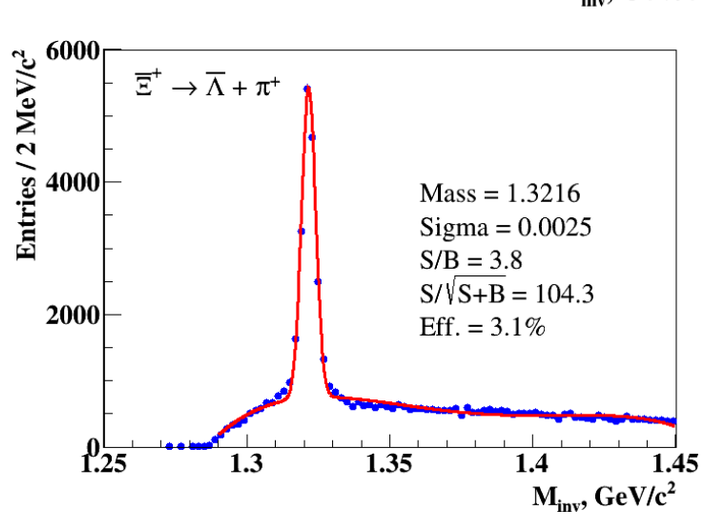
Stage'1 (TPC+TOF): Au+Au @ 11 GeV, PHSD + MPDRoot reco.

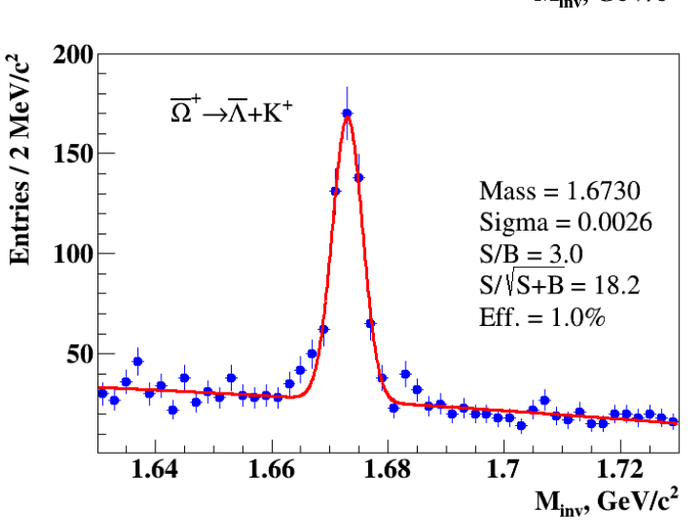










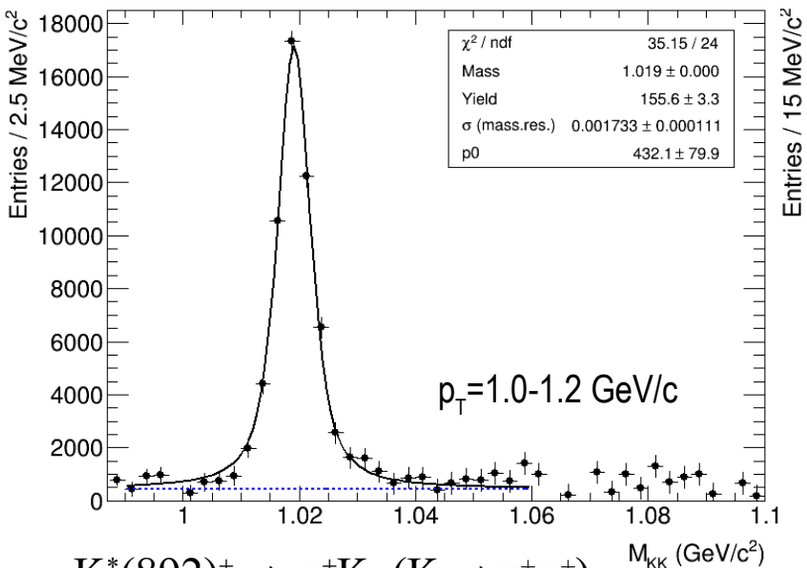


particle	Λ	anti-Λ	Ξ⁻	anti-Ξ⁺	Ω⁻	anti–Ω⁺
yield in 10 weeks	$3 \cdot 10^8$	$3.5 \cdot 10^6$	$1.5 \cdot 10^6$	$8.0 \cdot 10^4$	$7 \cdot 10^4$	$1.5 \cdot 10^4$

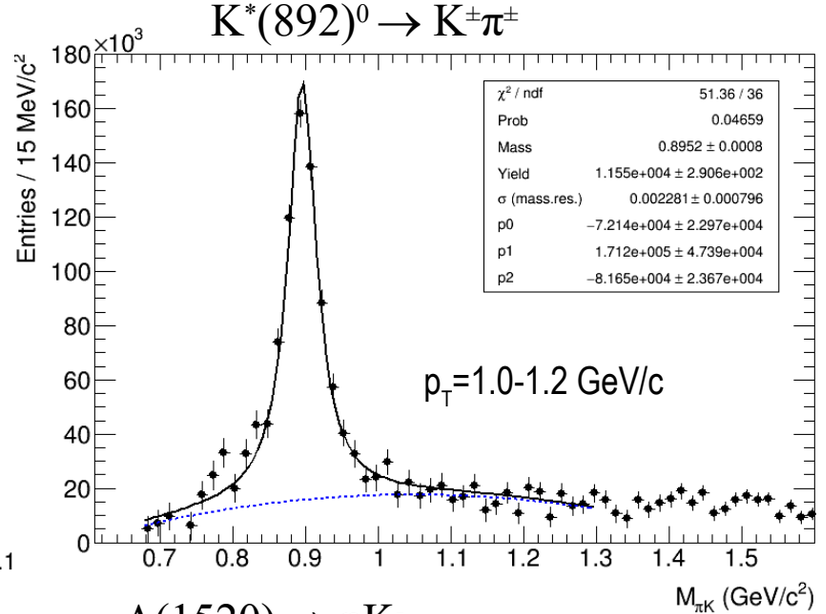
Resonances at MPD

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

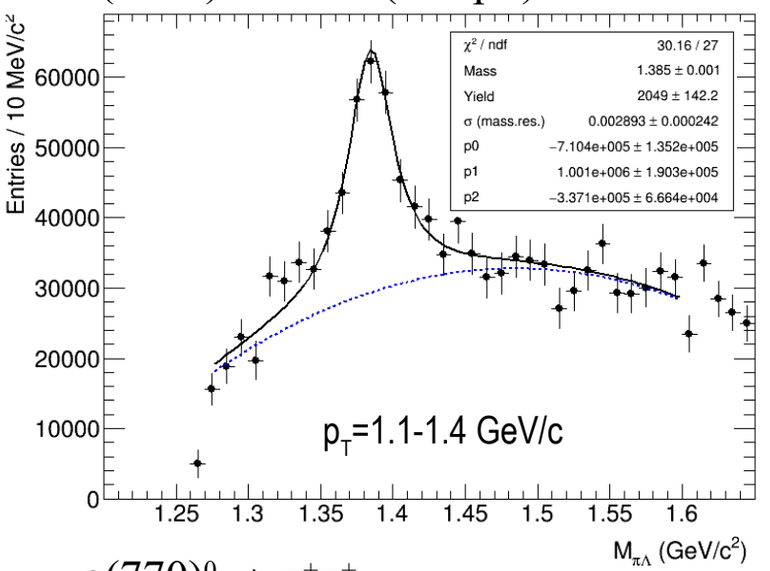
$\phi(1020) \rightarrow K^+K^-$



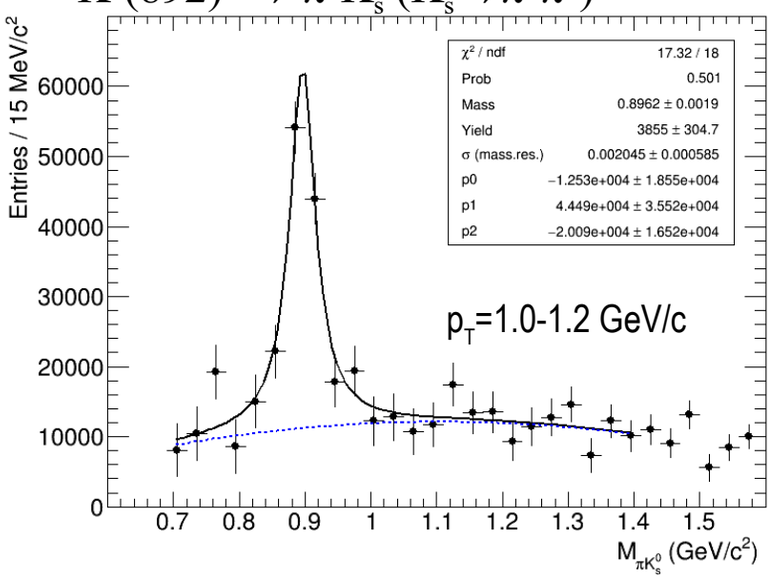
$K^*(892)^0 \rightarrow K^{\pm}\pi^{\pm}$



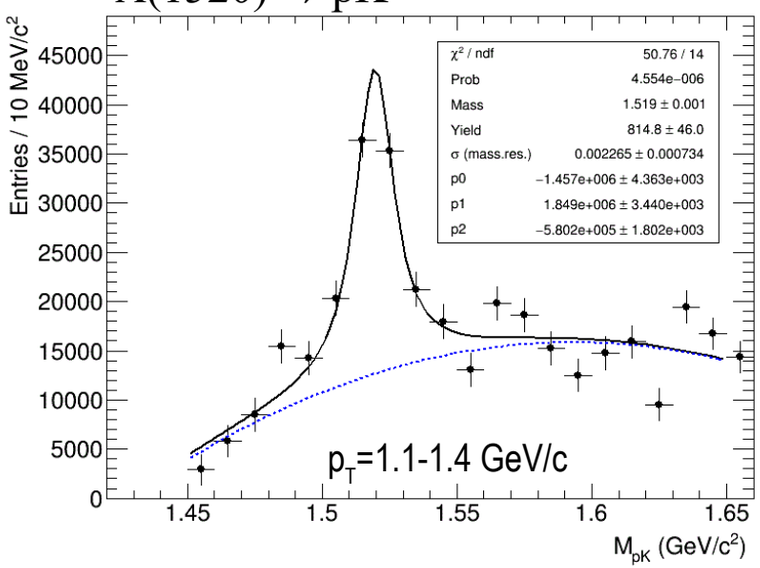
$\Sigma(1385)^{\pm} \rightarrow \pi^{\pm}\Lambda\ (\Lambda \rightarrow p\pi)$



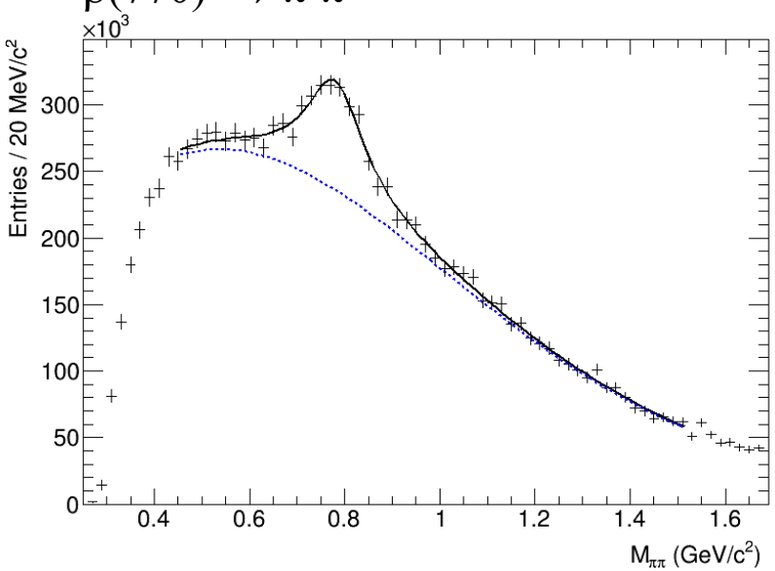
$K^*(892)^{\pm} \rightarrow \pi^{\pm}K_s\ (K_s \rightarrow \pi^+\pi^+)$



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

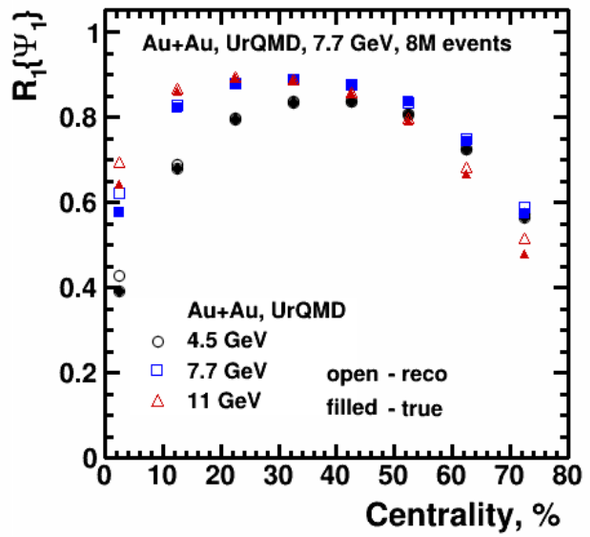


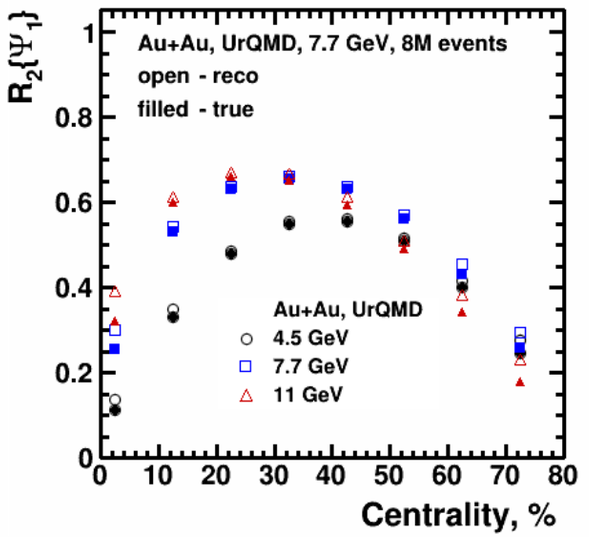
$\rho(770)^0 \rightarrow \pi^{\pm}\pi^{\pm}$

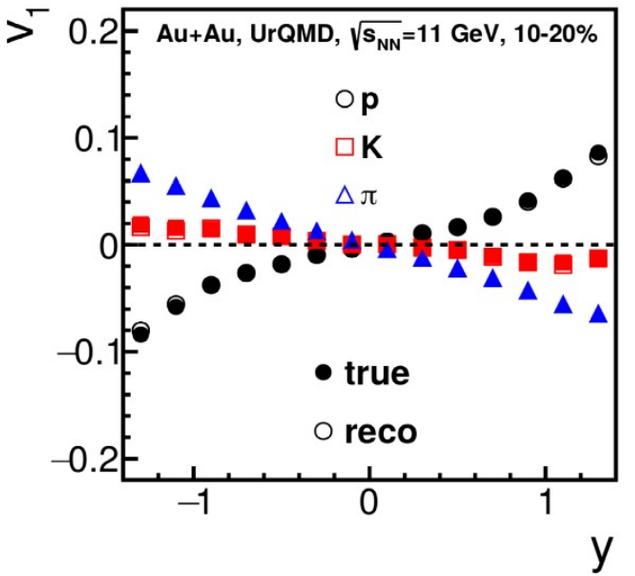


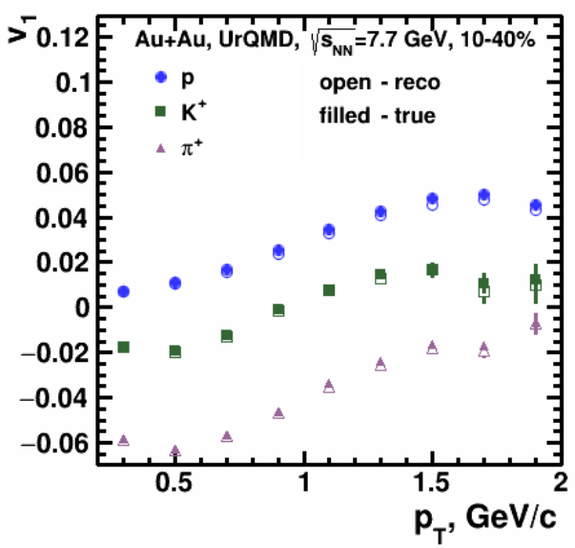
Performance of collective flow studies

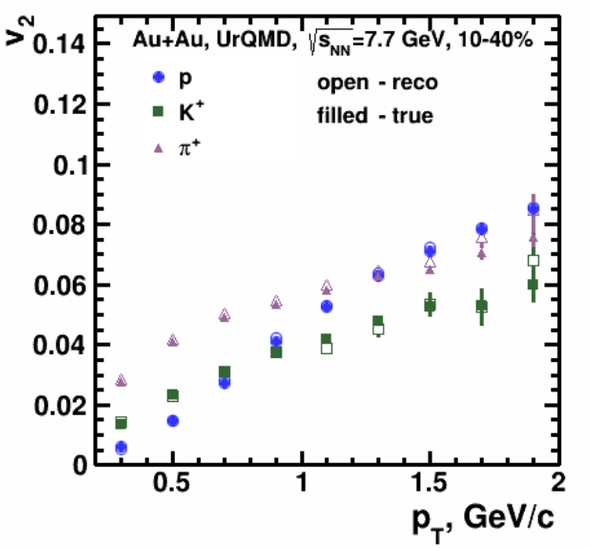
Au+Au, $\sqrt{s_{NN}}$ = 7.7, 11 GeV, UrQMD, GEANT3 + MPDRoot reco.

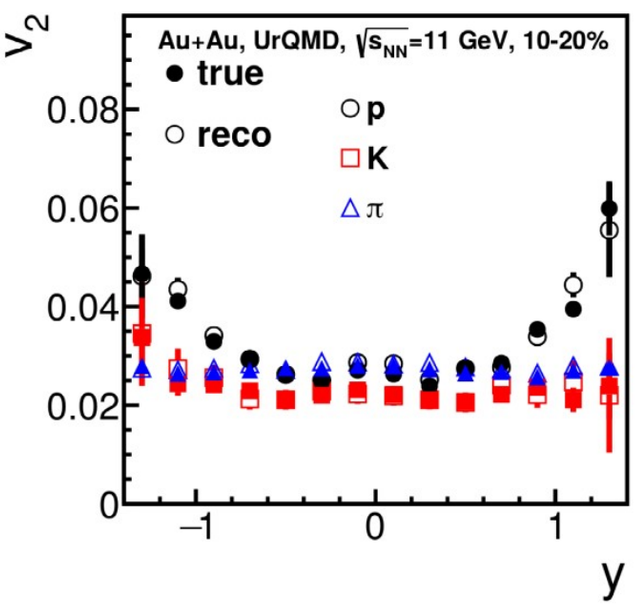








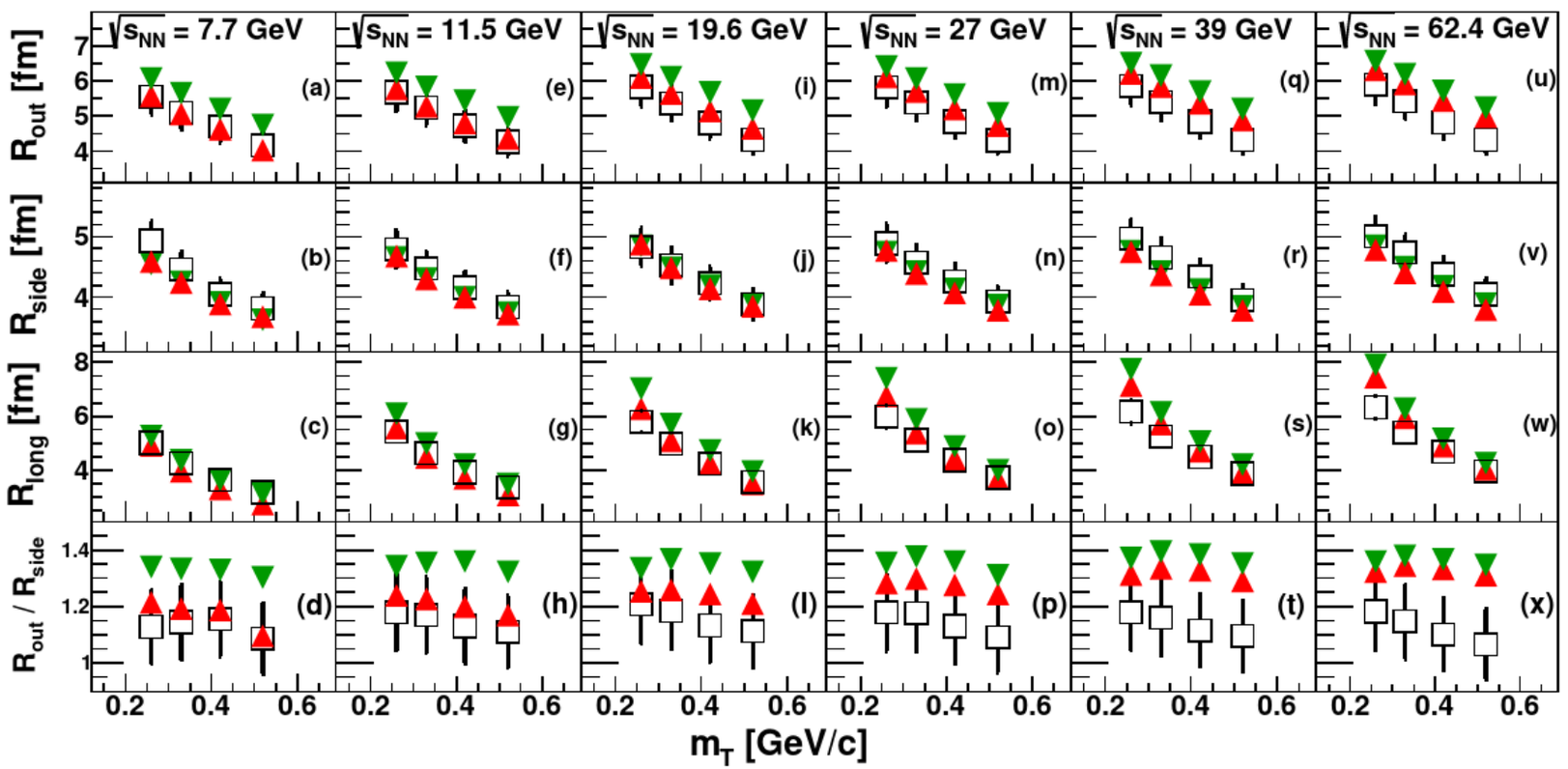




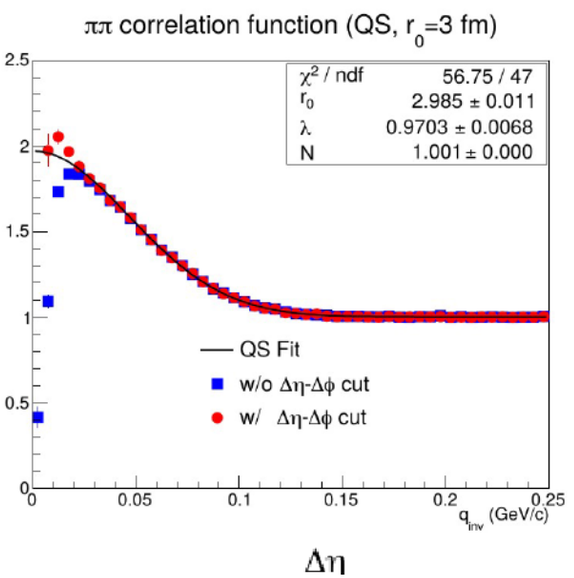
Collective flows a unique and direct way to probe EOS of QCD matter. Excellent flow measurement capabilities in MPD

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

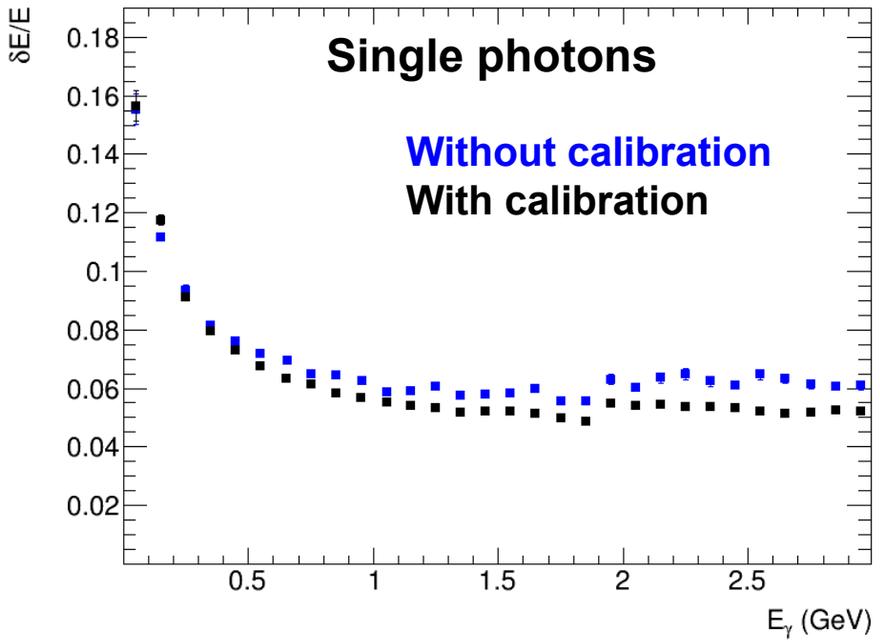


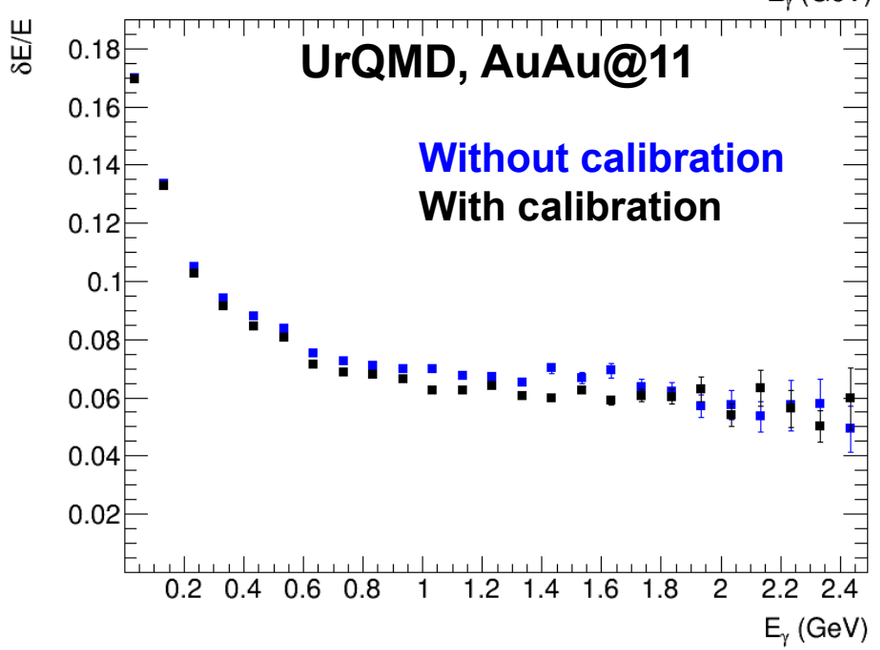
Δη

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

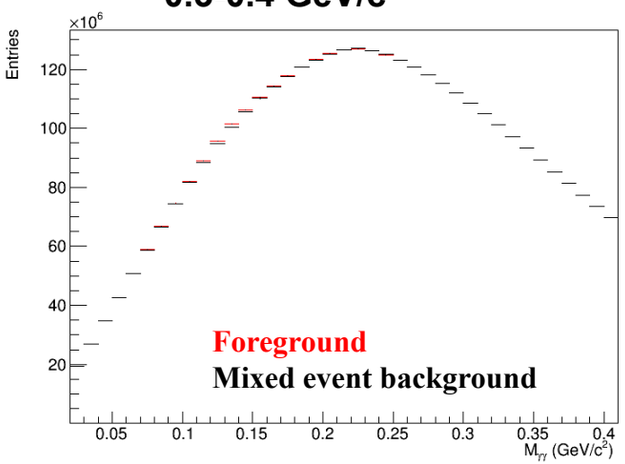
Electromagnetic probes in ECAL

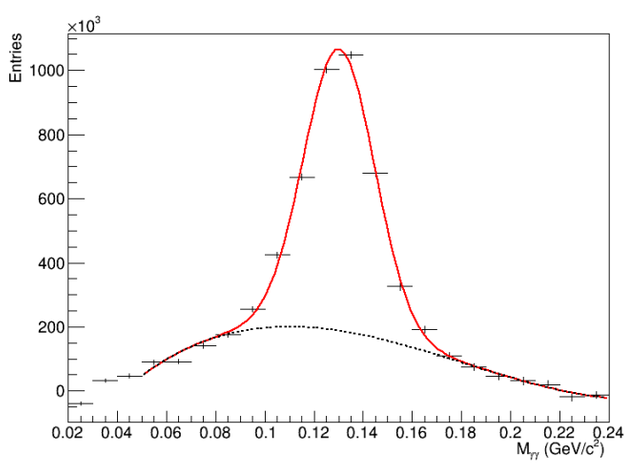
- Realistic ECAL reconstruction & analysis – large acceptance ECAL with good energy resolution: ideal tool for measurement of neutral mesons in a wide momentum range

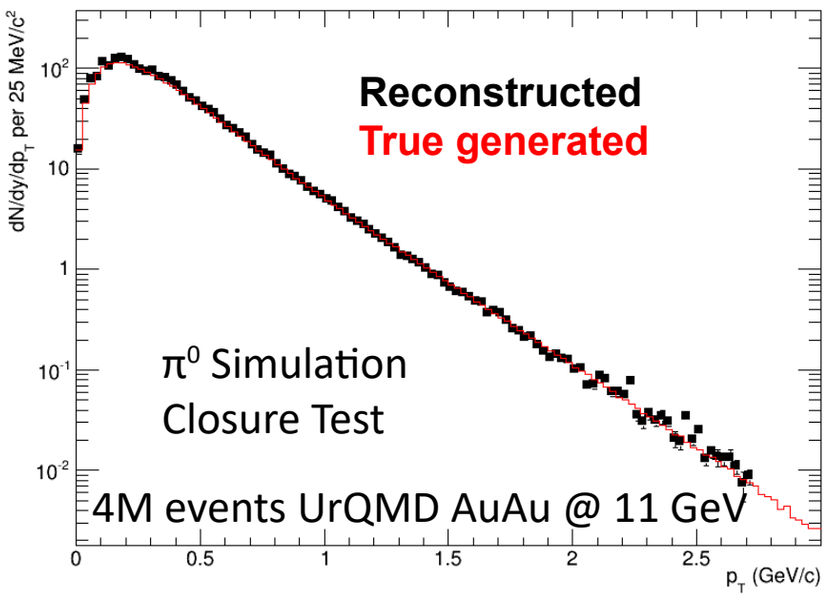


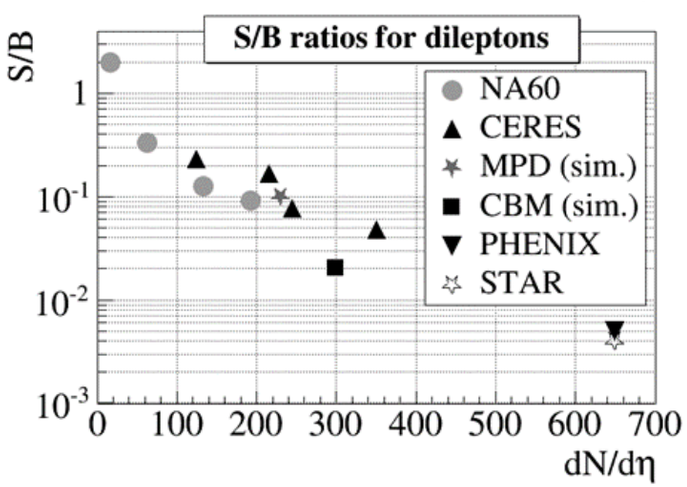


π^0-meson in central Au+Au









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