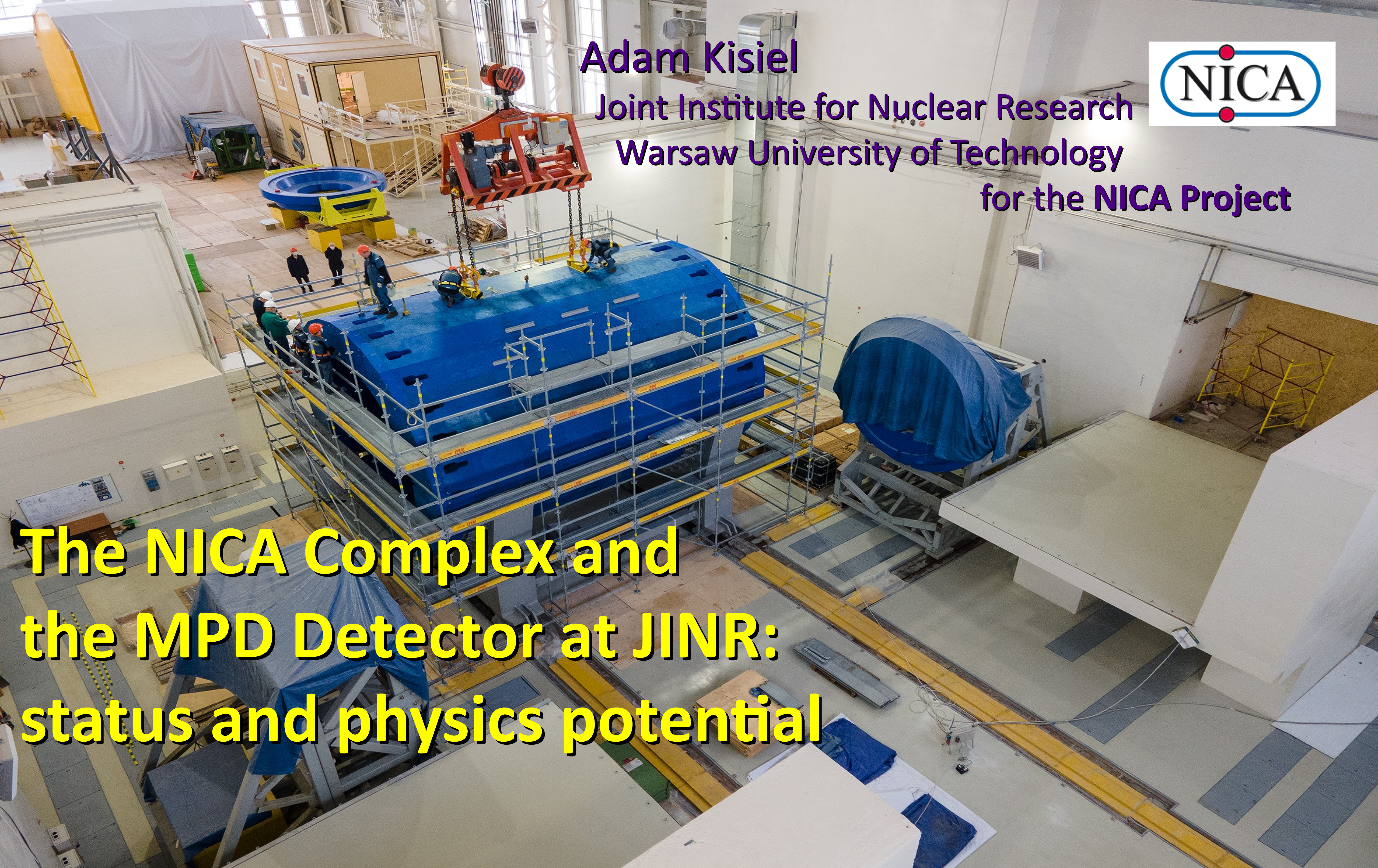


Adam Kisiel
Joint Institute for Nuclear Research
Warsaw University of Technology
for the NICA Project

The NICA Complex and the MPD Detector at JINR: status and physics potential

The Host Institute

JOINT INSTITUTE FOR NUCLEAR RESEARCH
SCIENCE BRINGS NATIONS TOGETHER
1956

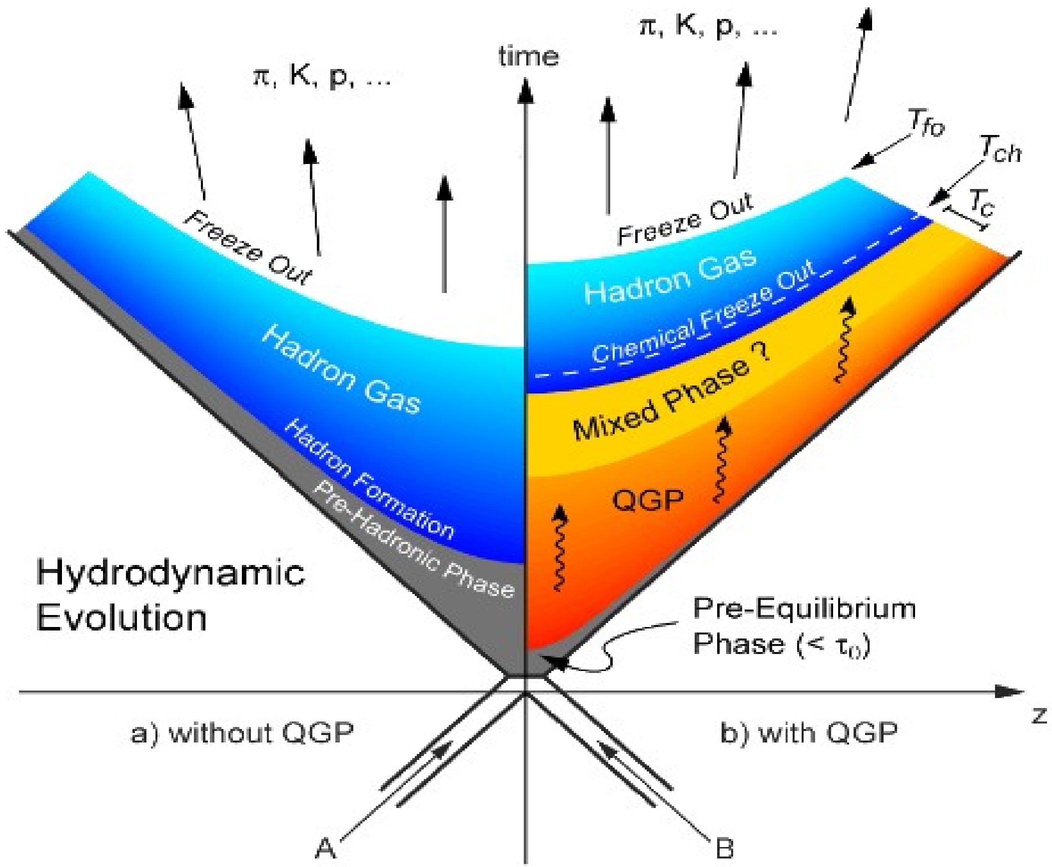
Joint Institute for Nuclear Research (JINR) –
International Intergovernmental Organization established through the Convention of March 26, 1956 by 11 founding States and registered with the United Nations on 1 February 1957

Governed by the **Committee of Plenipotentiaries** *representing governments of* ***18*** *countries*

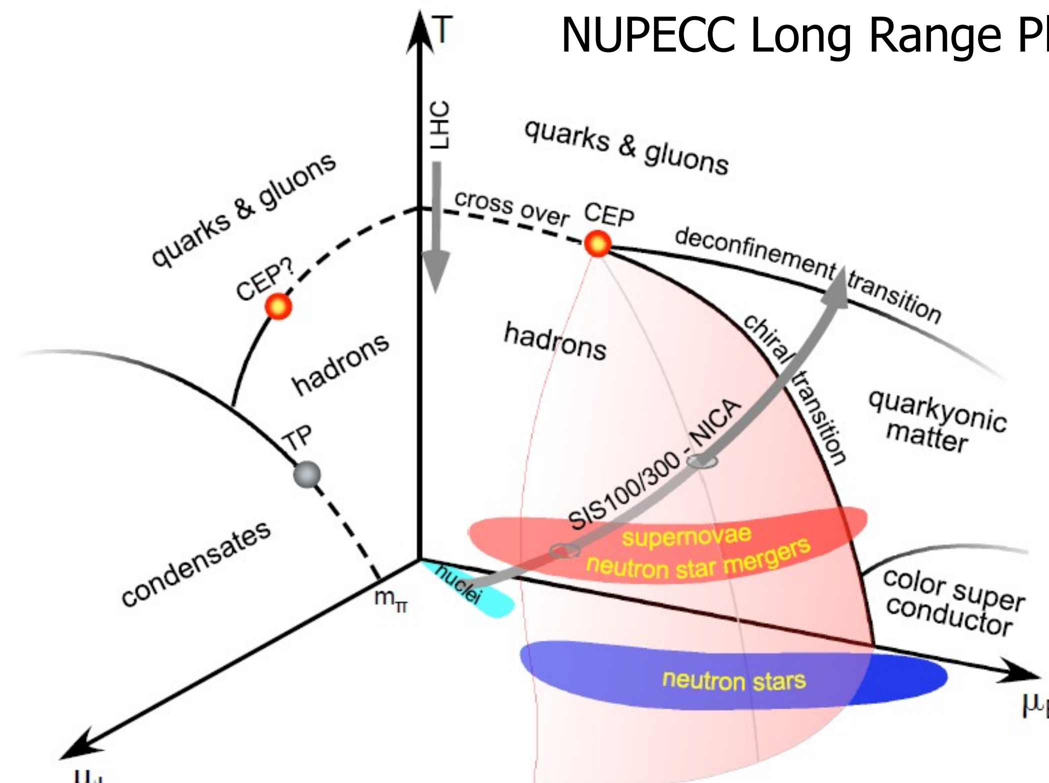
CERN *and* ***JINR*** *have reciprocal* ***observer status***

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

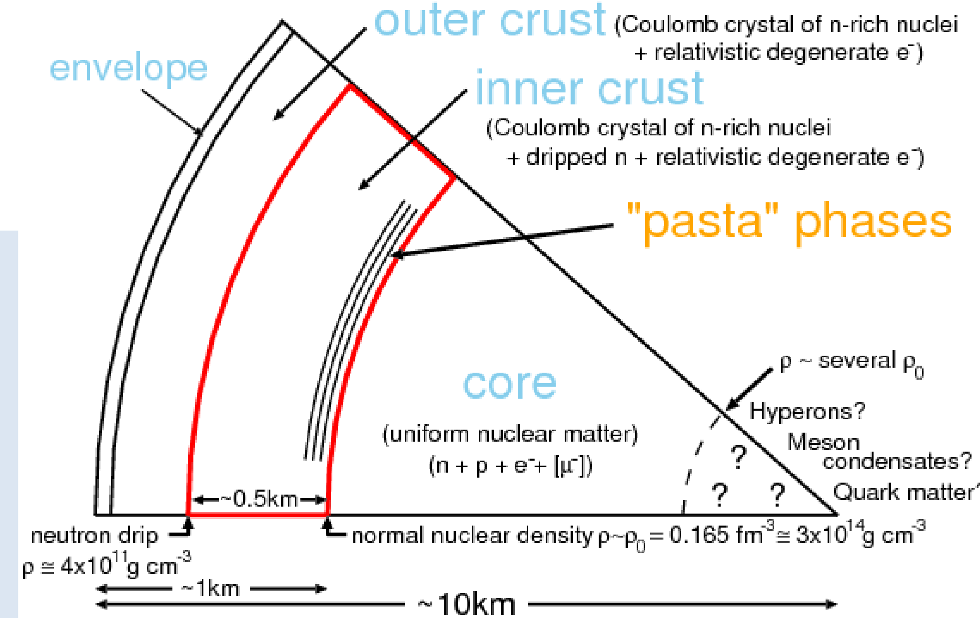


Access neutron star matter in laboratory

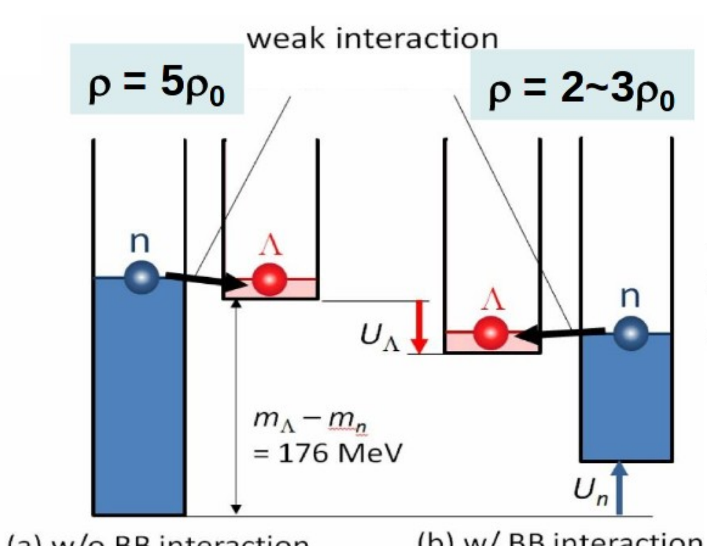
core of neutron stars reaches density several times nuclear density

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

Credit: LIGO Collaboration

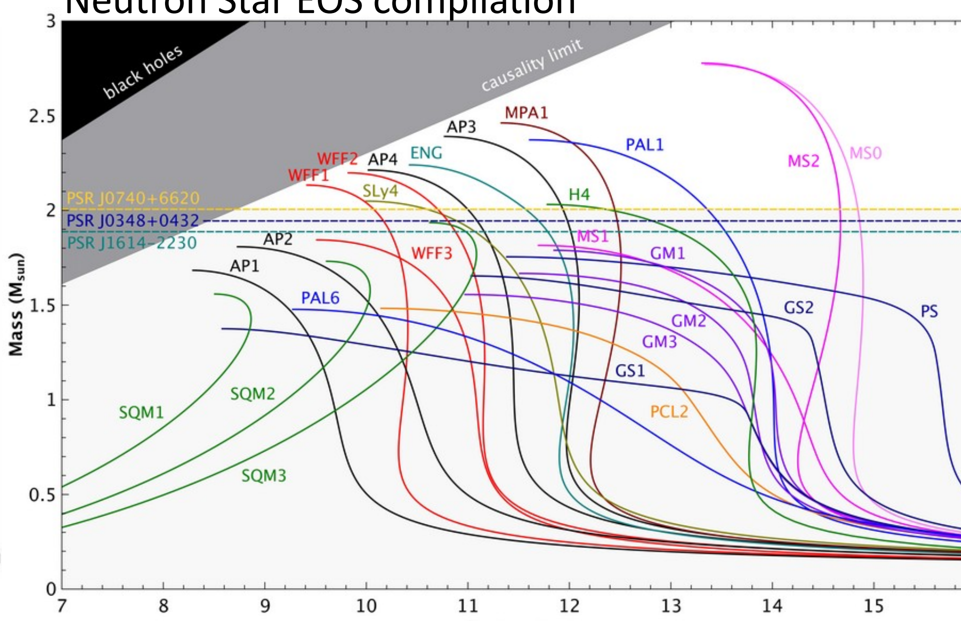


Demorest et al., Nature 467, 1081

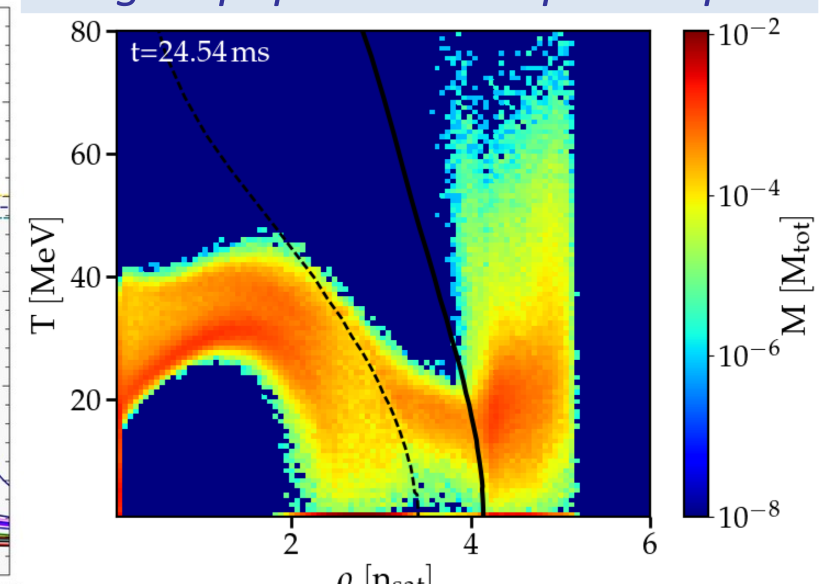


H. Tamura, Hadron 2017

Neutron Star EOS compilation



mergers populate NICA phase space



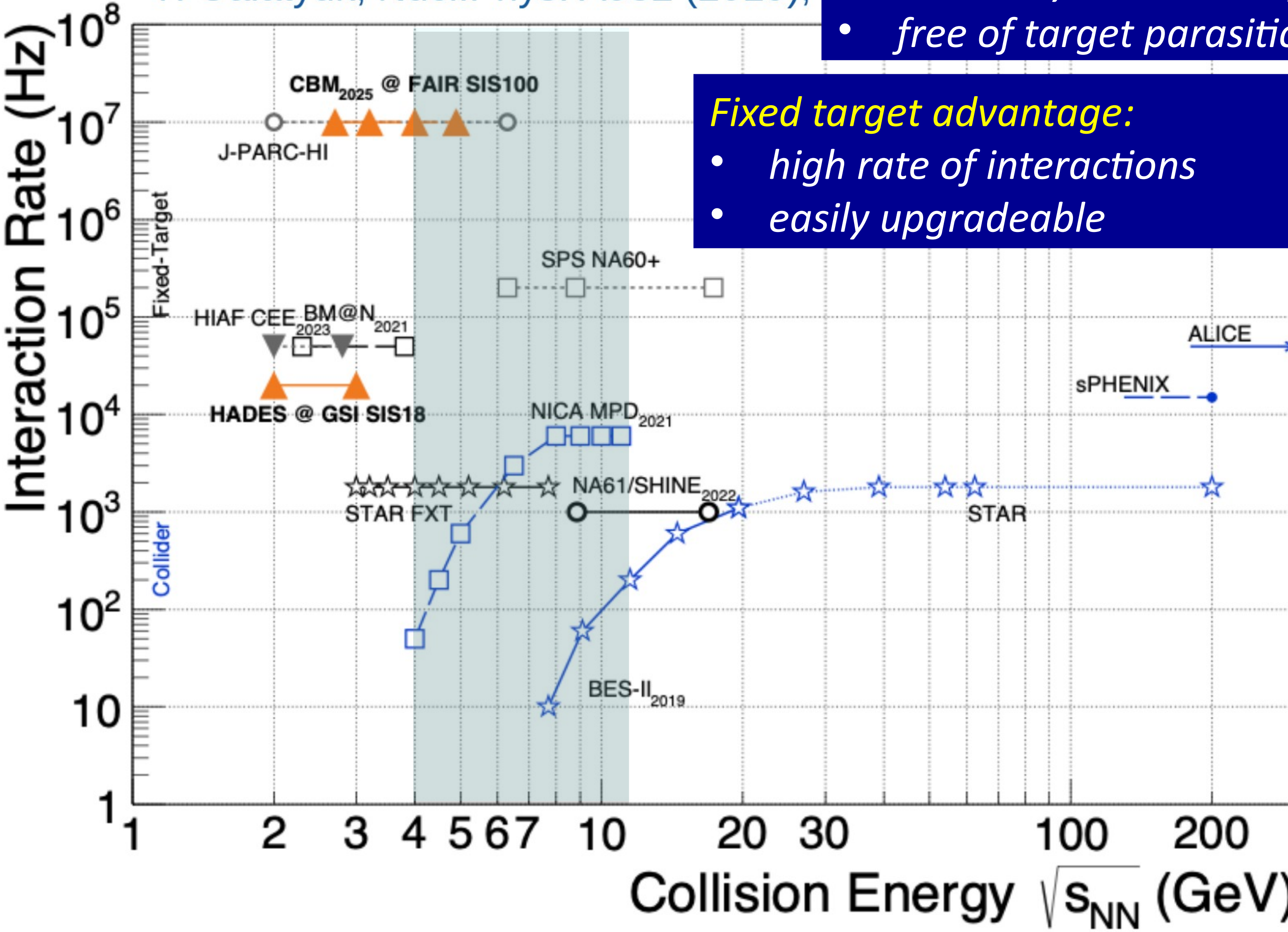
Blacker et al., Phys. Rev. D 102, 123023

NICA: Unique and complementary

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

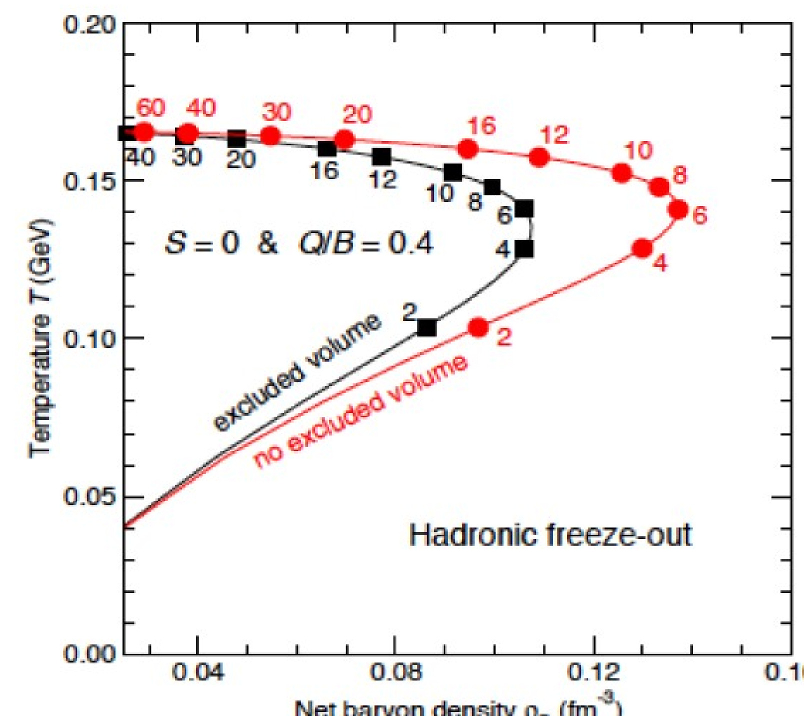
Collider advantage:
- *coverage of max. phase space*
- *minimally biased acceptance*
- *free of target parasitic effects*

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

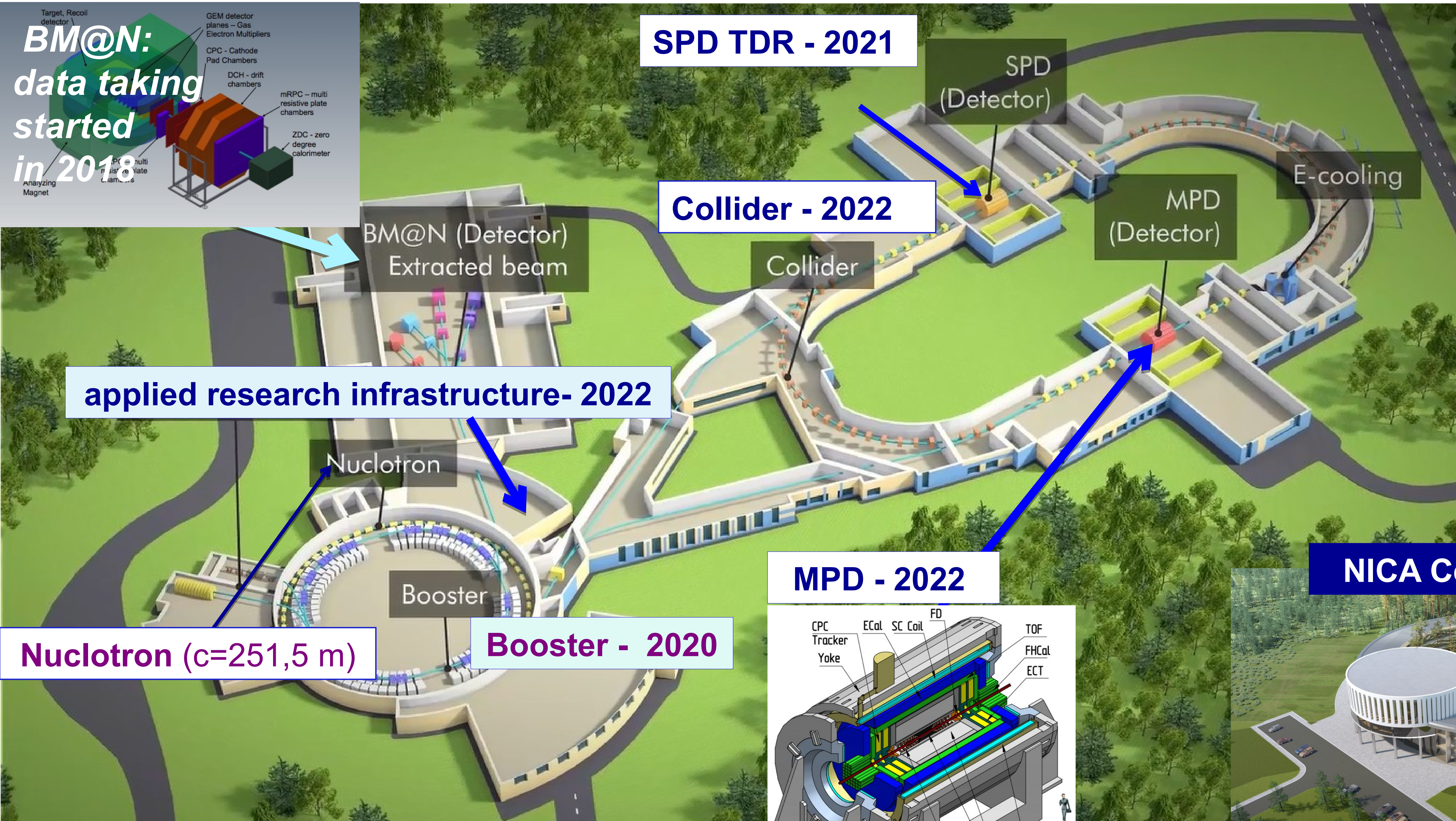


In NICA Collider energy range maximum possible net-baryon density is reached

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



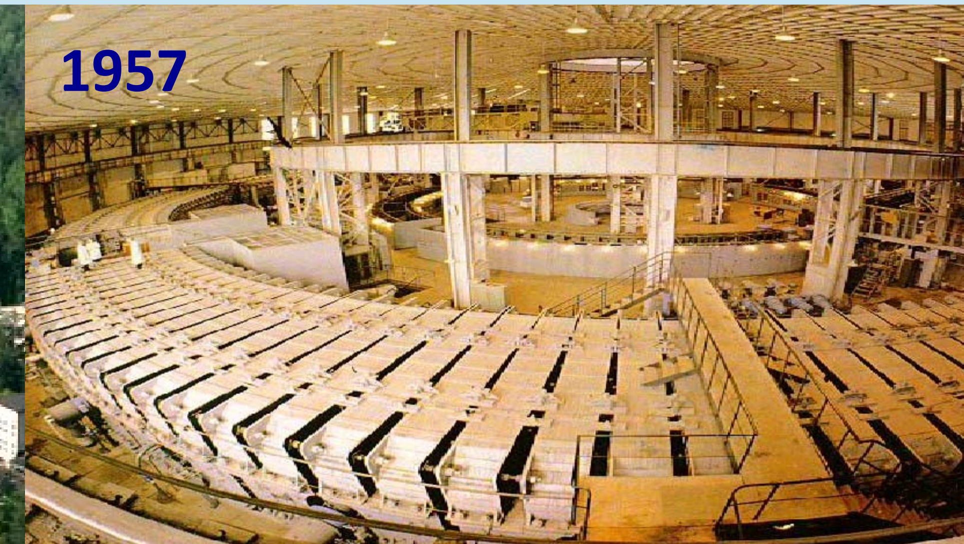
NICA Accelerator Complex in Dubna



Budget: approx. 500 MUSD

History of NICA Accelerator Complex

Synchrophasotron –10 GeV proton synchrotron (1957)
pioneering research in RNP since '70-ties;

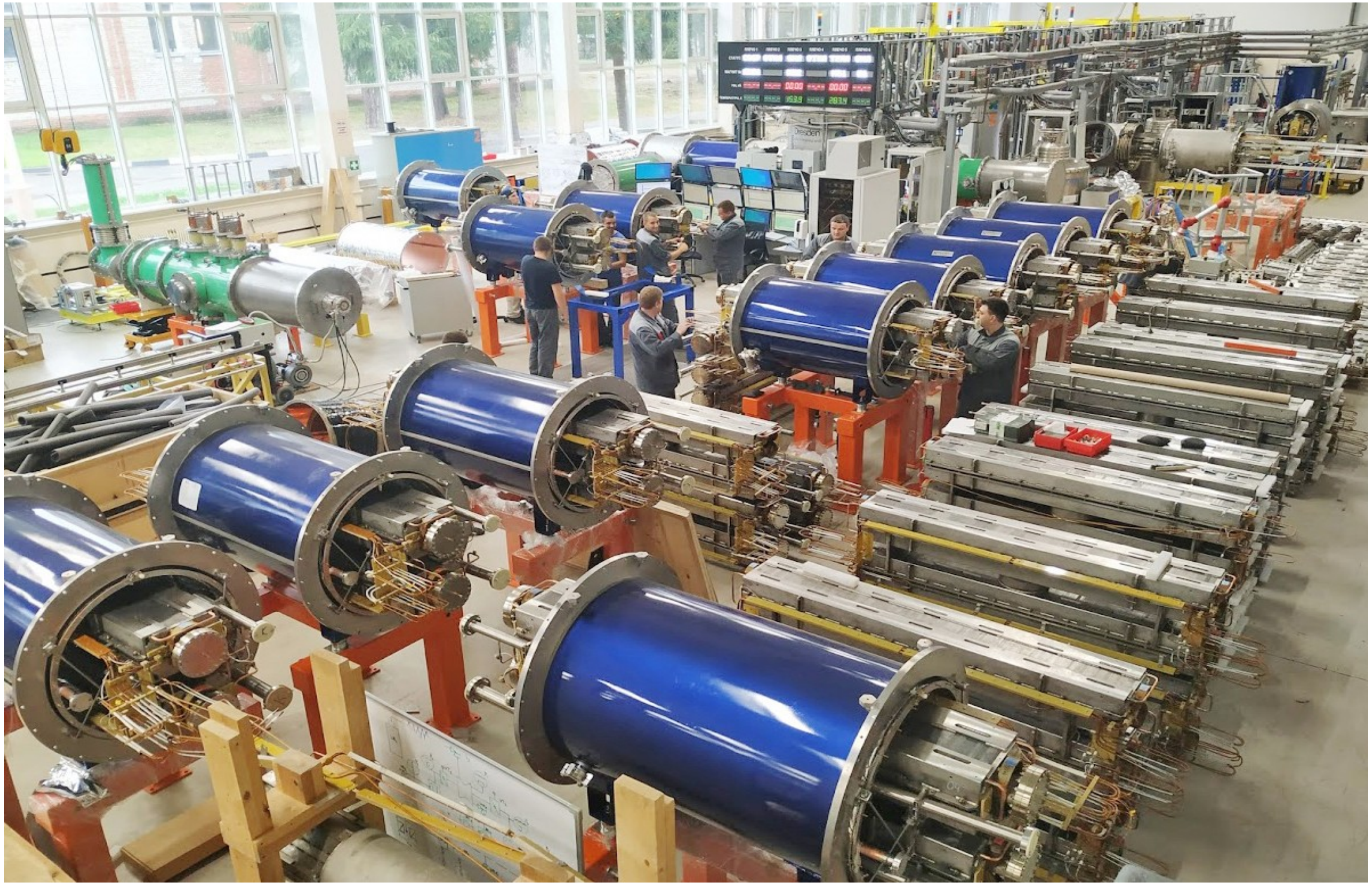


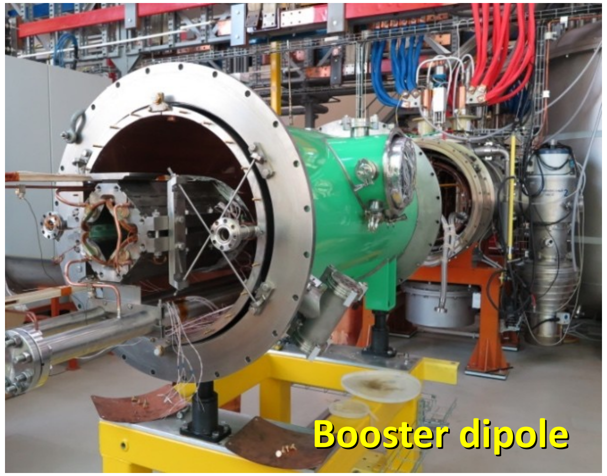
*Nuclotron ring (c= **251,5** m)*

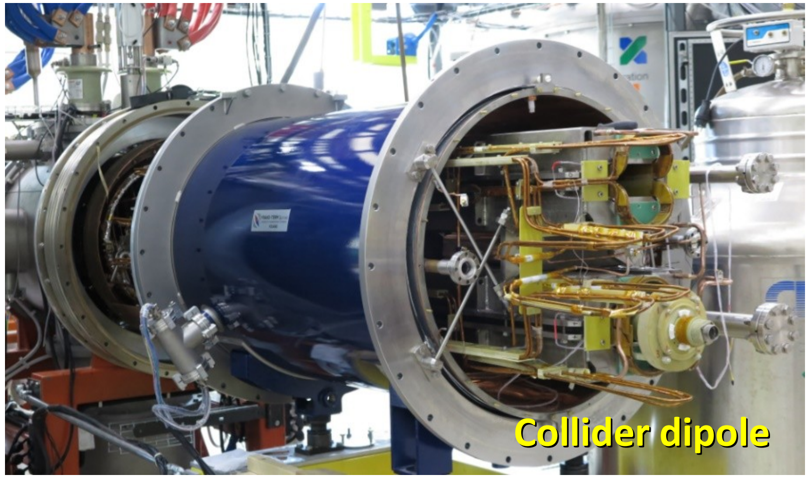
SC synchrotron- **Nuclotron (1993)** *based on*
*superconducting fast cycling magnets developed at **LHE JINR***

JINR Magnet Factory

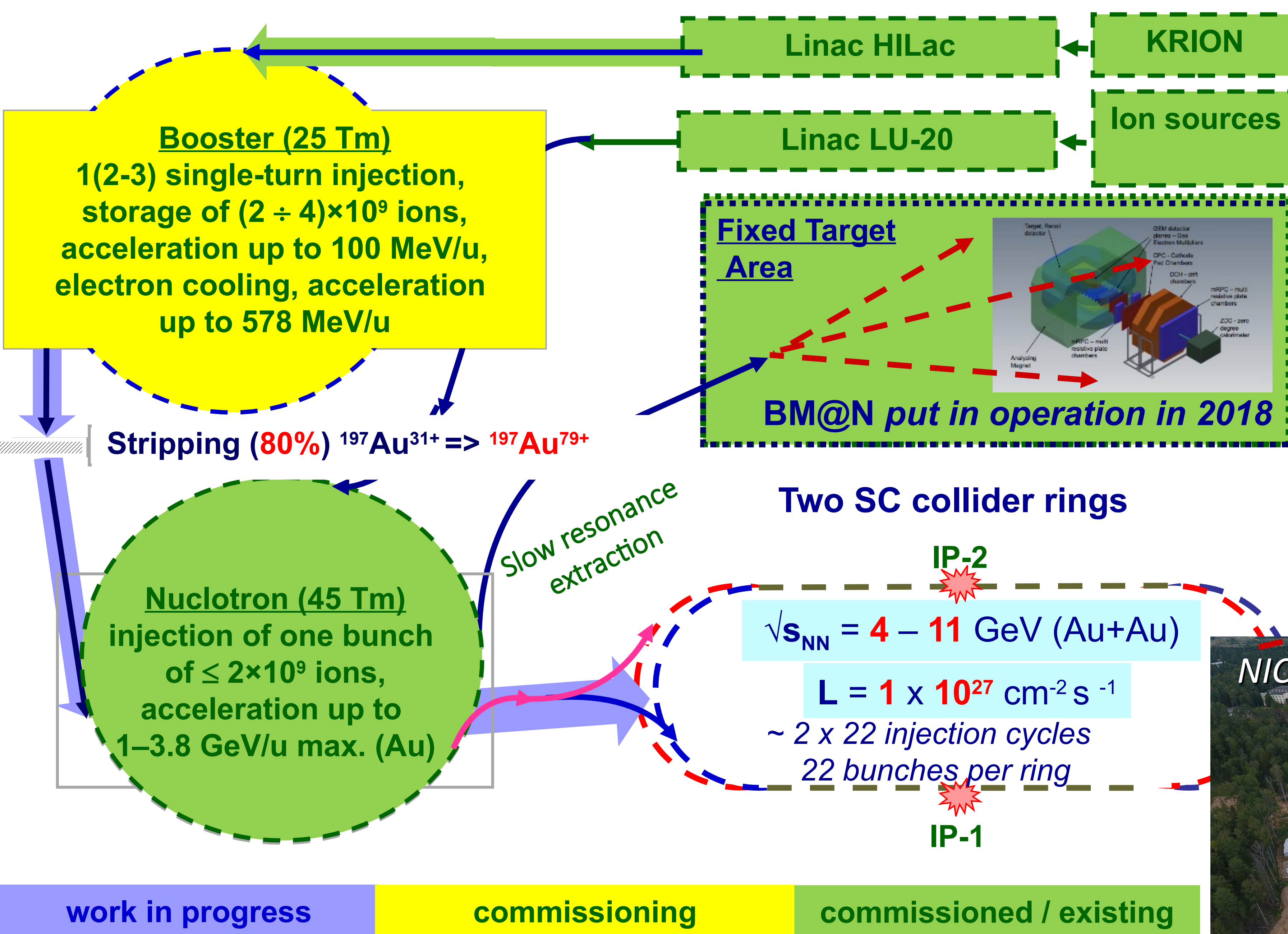
Production and cold tests of superonducting magnets for Booster, NICA and FAIR at VBLHEP







Status of the Accelerator Complex



Recent video from NICA: https://youtu.be/mfOLT9XZOj0

NICA construction live

Main parameters of accelerator complex

Nuclotron

Parameter	**SC synchrotron**
particles	↑p, ↑d, nuclei (Au, Bi, ...)
max. kinetic energy, GeV/u	10.71 (↑p); 5.35 (↑d) **3.8** (Au)
max. mag. rigidity, Tm	38.5
circumference, m	251.52
vacuum, Torr	10^{-9}
*intensity, **Au** /pulse*	1 10^{9}

Booster

	value
ion species	A/Z ≤ 3
max. energy, MeV/u	**600**
magnetic rigidity, T m	1.6 – 25.0
circumference, m	210.96
vacuum, Tor	10^{-11}
*intensity, **Au** /p*	1.5 10^{9}

The Collider

Design parameters, Stage II

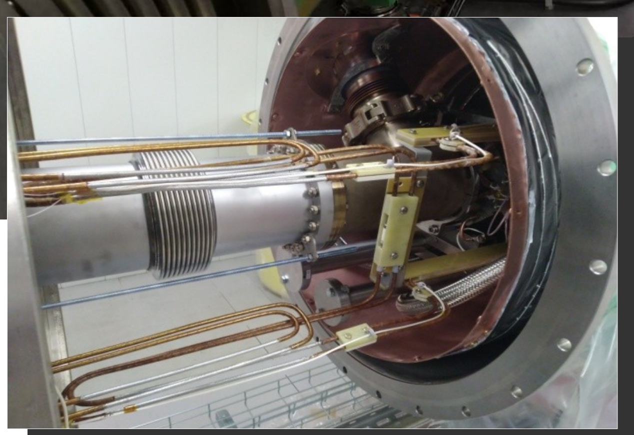
45 T*m, 11 GeV/u for Au^{79+}

Ring circumference, m	**503,04**
Number of bunches	**22**
r.m.s. bunch length, m	**0,6**
β, m	**0,35**
Energy in c.m., Gev/u	**4-11**
r.m.s. Δp/p, 10^{-3}	**1,6**
IBS growth time, s	**1800**
Luminosity, cm^{-2} s^{-1}	**$1x10^{27}$**

Stage I:
- ***without ECS in Collider, with stochastic cooling***
- ***reduced number of RF***
- ***reduced luminosity***

Collision system limited by source. *Now Available: C(A=12), N(A=14), Ne(A=20), Ar(A=40), Fe(A=56), Kr(A=78-86), Xe(A=124-134), Bi(A=209)*

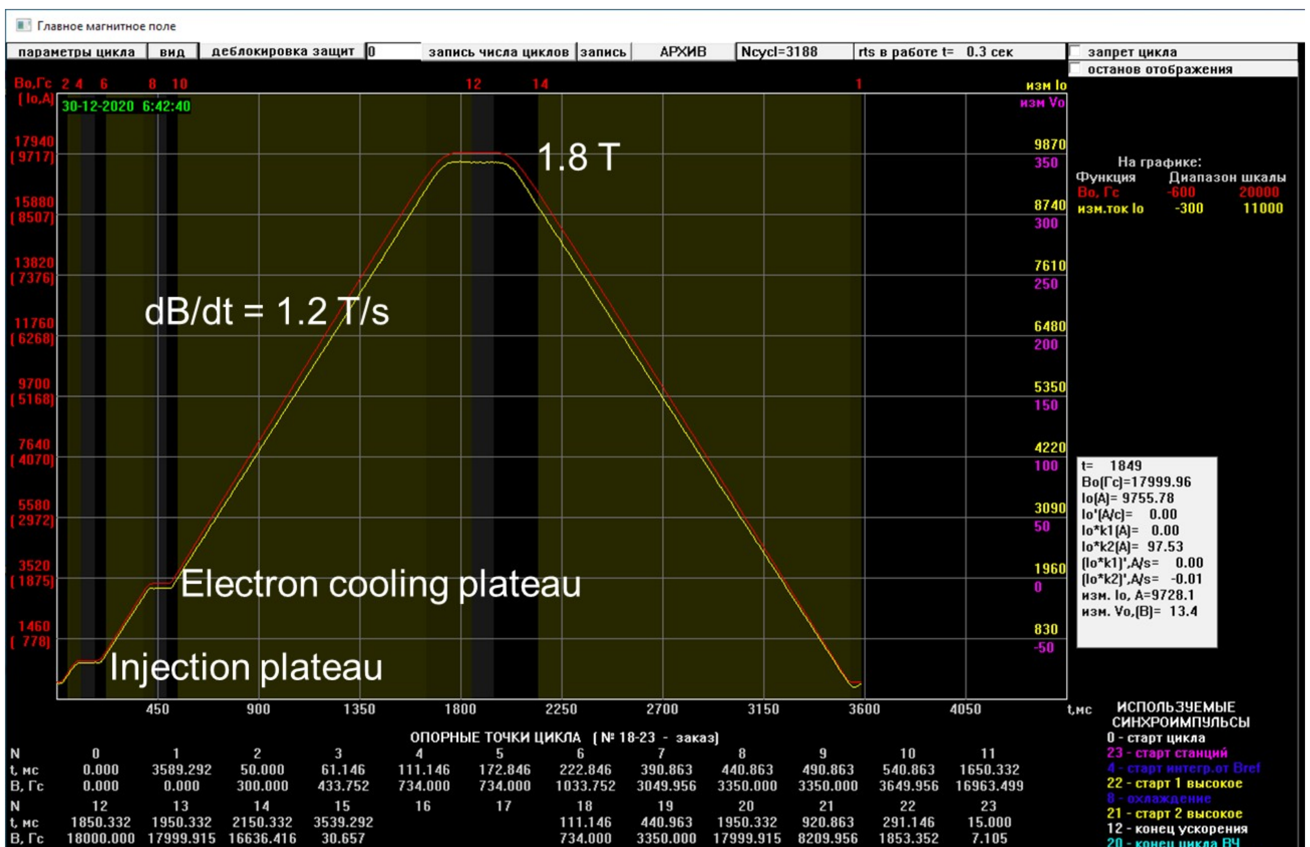
Booster operational



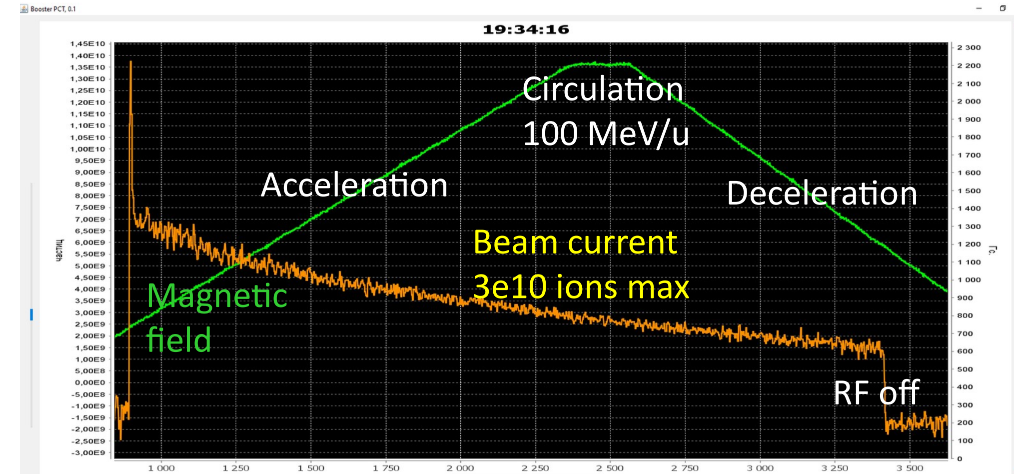
- ✓ ***<u>Booster fully assembled in the tunnel</u>***
- ✓ ***<u>Commissioning and test ongoing for beam diagnostics, beam acceleration, electron cooling, power supply, magnets, cryogenics</u>***

First Booster run – Dec 30th, 2020

Booster – the first technical run:
Injected He^{1+}, 3,2MeV/u, 6,5*10^{10} ppp
Accelerated up to 100 MeV/u
(project 600 MeV/u)

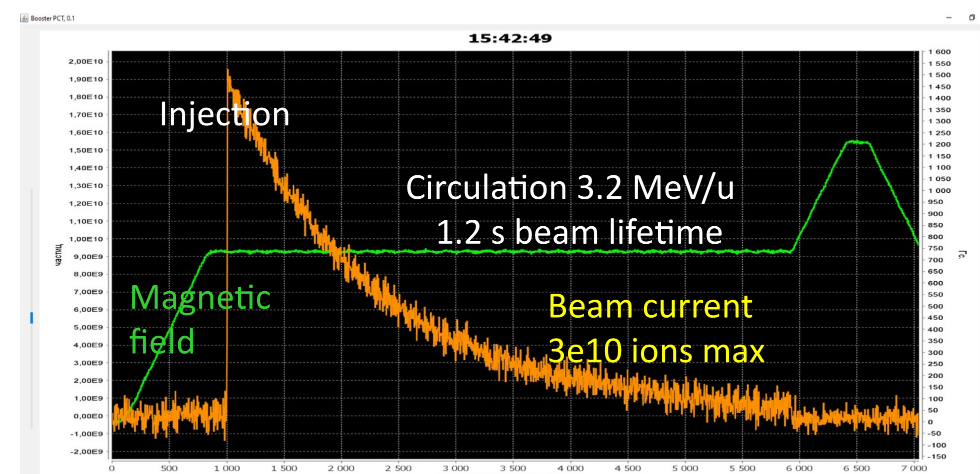


operation at design magnetic field & ramp rate



FCT signal when injecting into rising field, capturing (~60%), accelerating & decelerating:

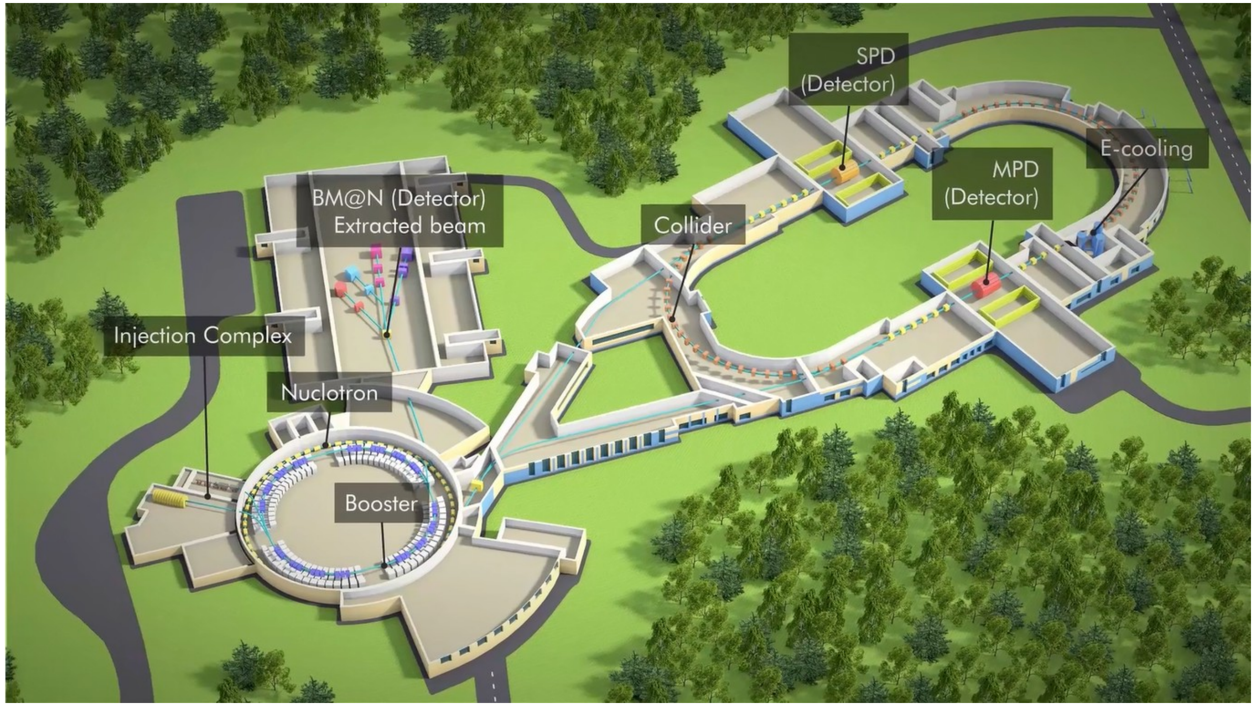
no transient losses on the MF table & after.



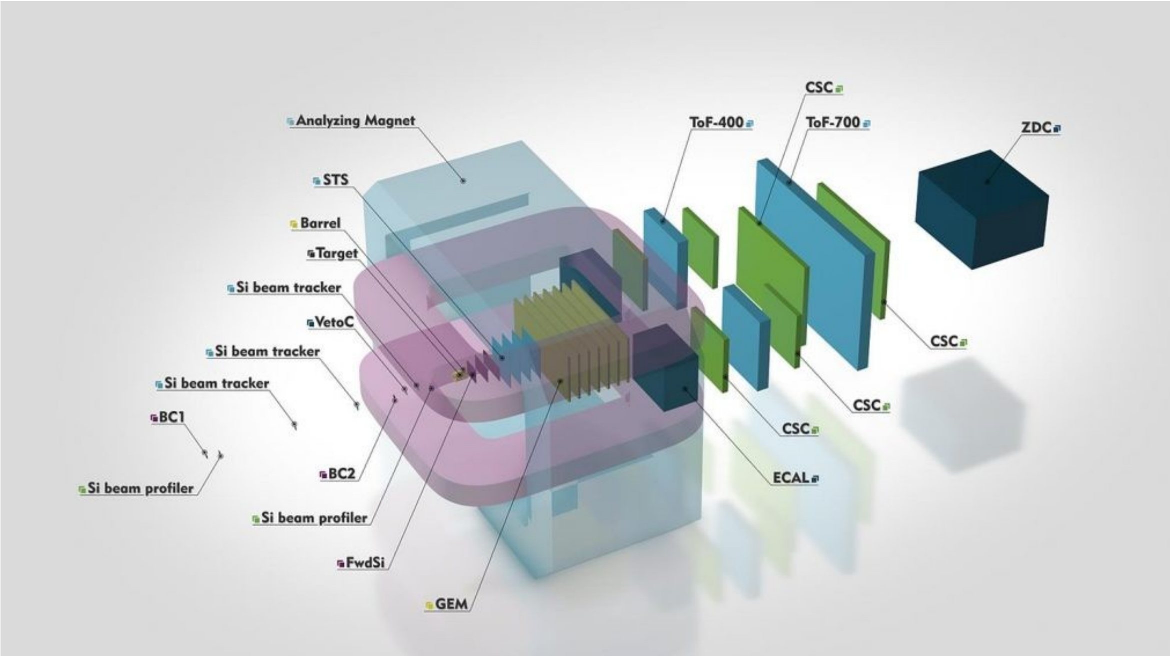
*Beam loss indicated the integral pressure in the beam pipe ~ 2-3 * 10^{-10} Torr*

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}
- **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



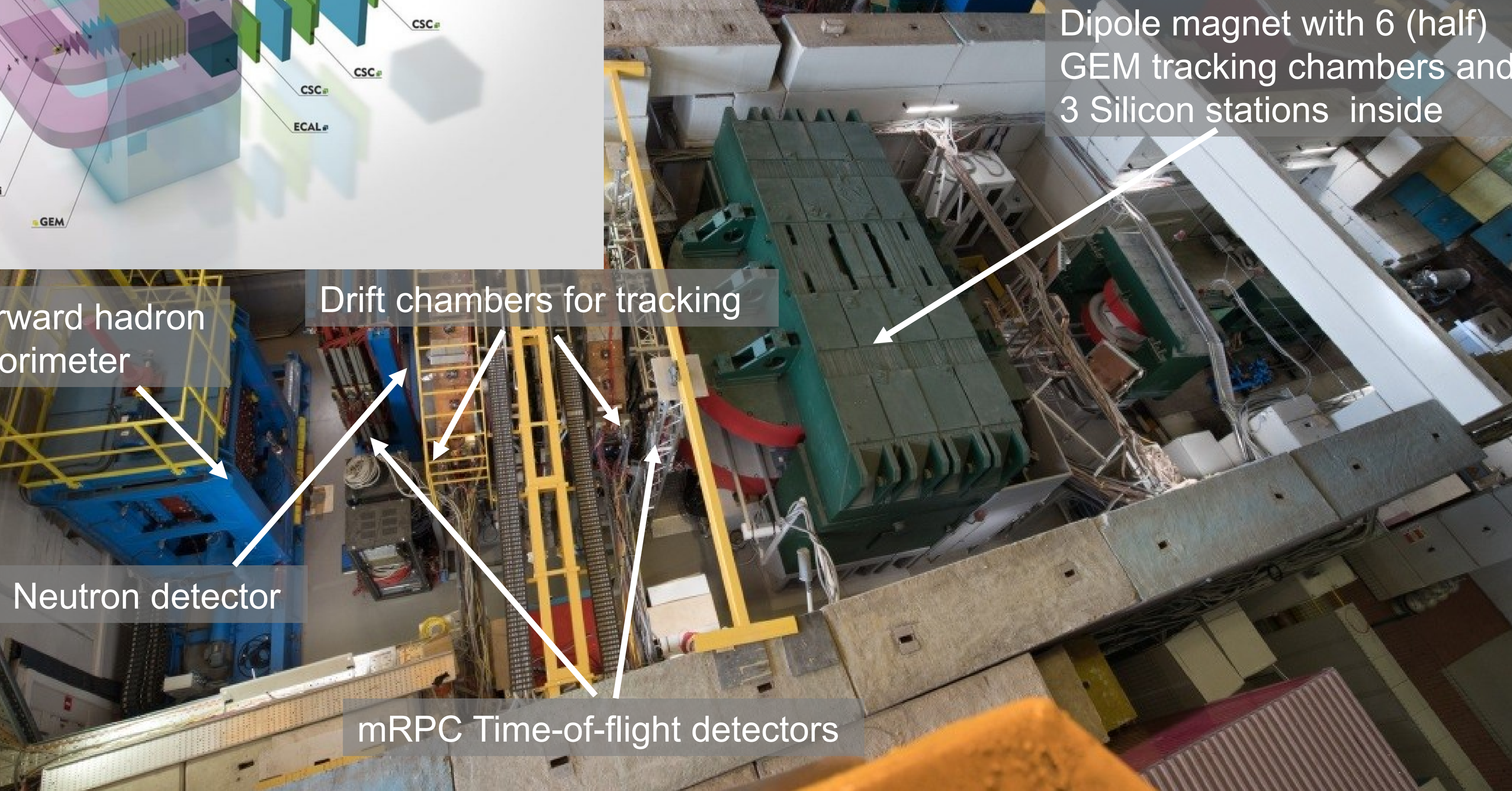
First physics from BM@N at NICA



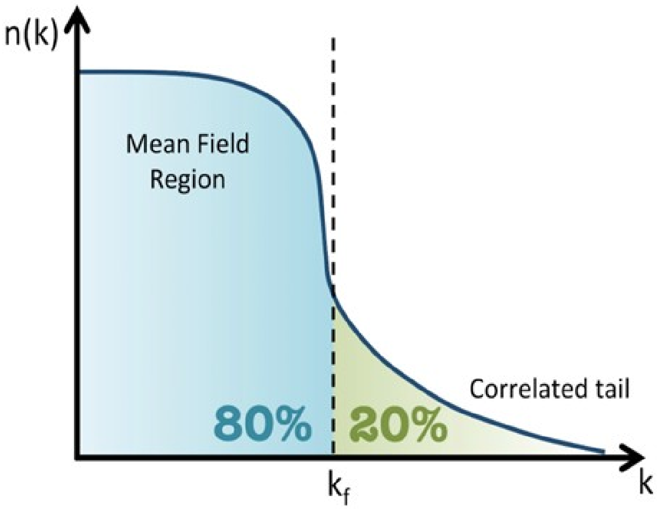
Baryonic Matter @ Nuclotron (BM@N)

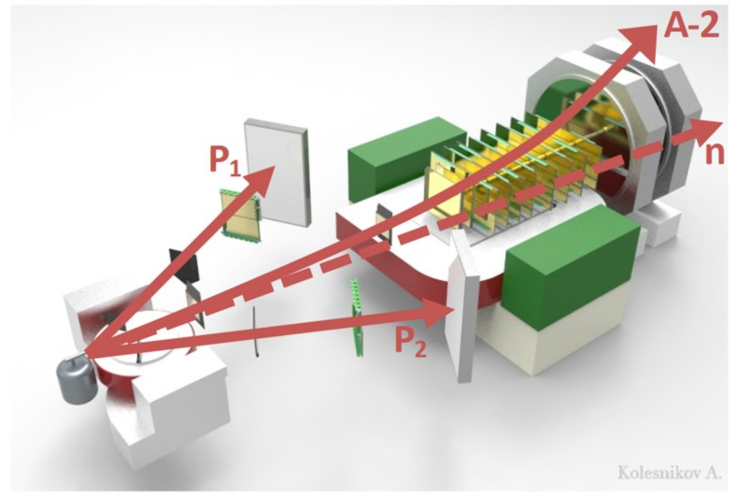
10 countries, 20 institutions,

246 participants



Experiment with BM@N: Short-Range Correlations (SRC)





Experiment at BM@N with a 4A GeV C-beam:

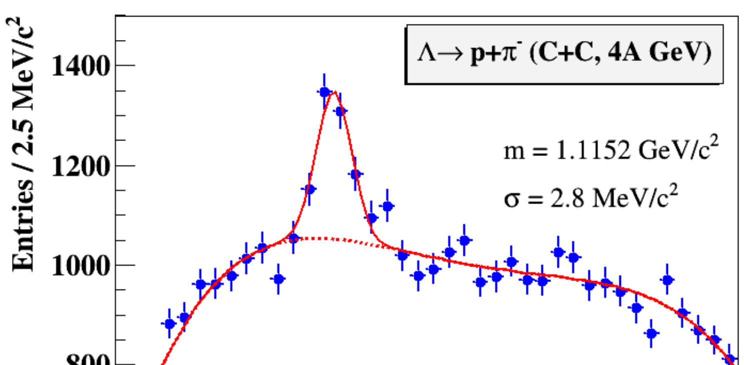
$^{12}C + p \rightarrow 2p + {}^{10}{}_{4}Be + p$ (pp SRC)

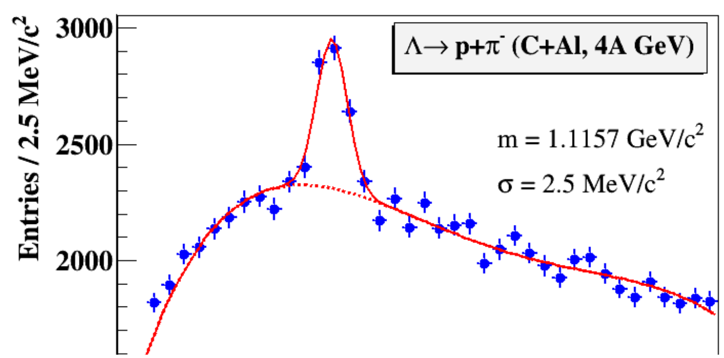
First fully exclusive measurement in inverse kinematics probing the residual A-2 nuclear system!

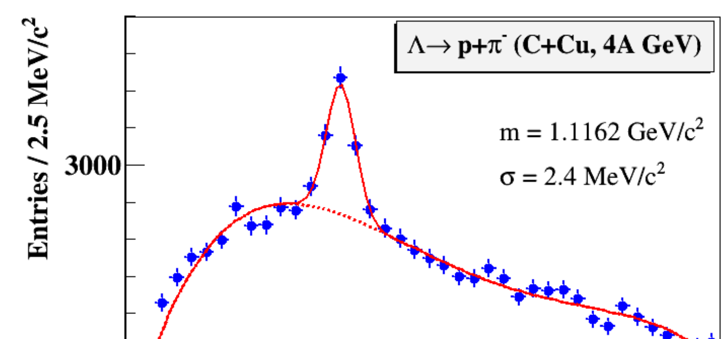
M. Patsyuk et al., arXiv:2102.02626

Accepted for publication in **nature physics**

Experiment with BM@N: Λ's in C + C, Al, Cu at 4A GeV



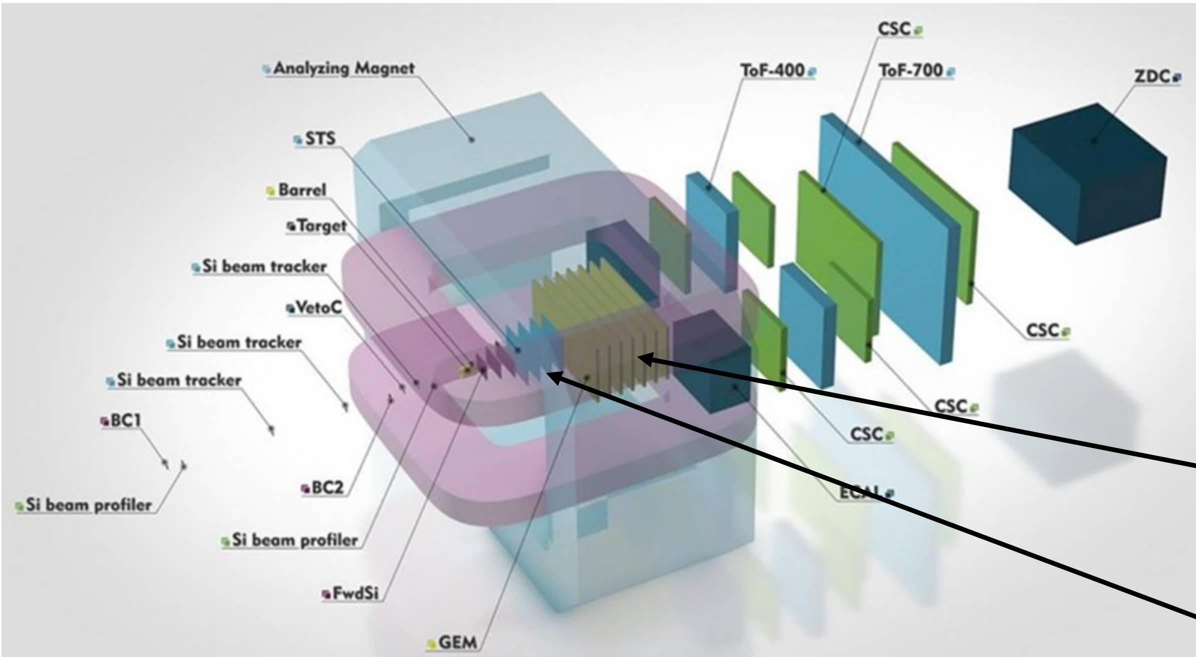


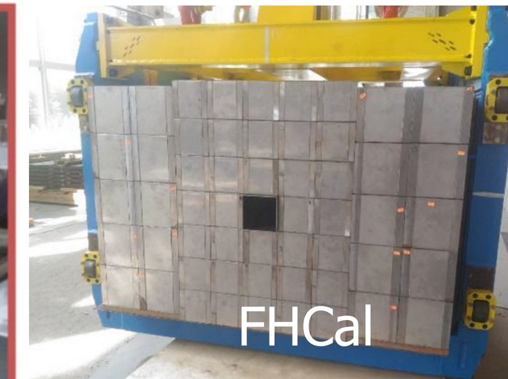


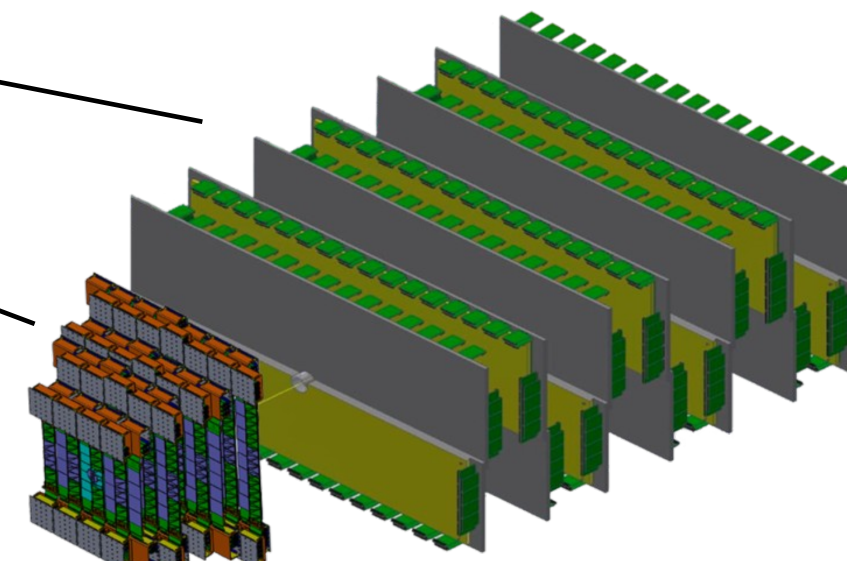
Present experimental limitations:

- low granularity tracking systems (small S/B ratio)
- air gaps in beam line from Nuclotron (low beam quality)
- no vacuum beam pipe in BM@N (large background)

BM@N setup for heavy-ion run







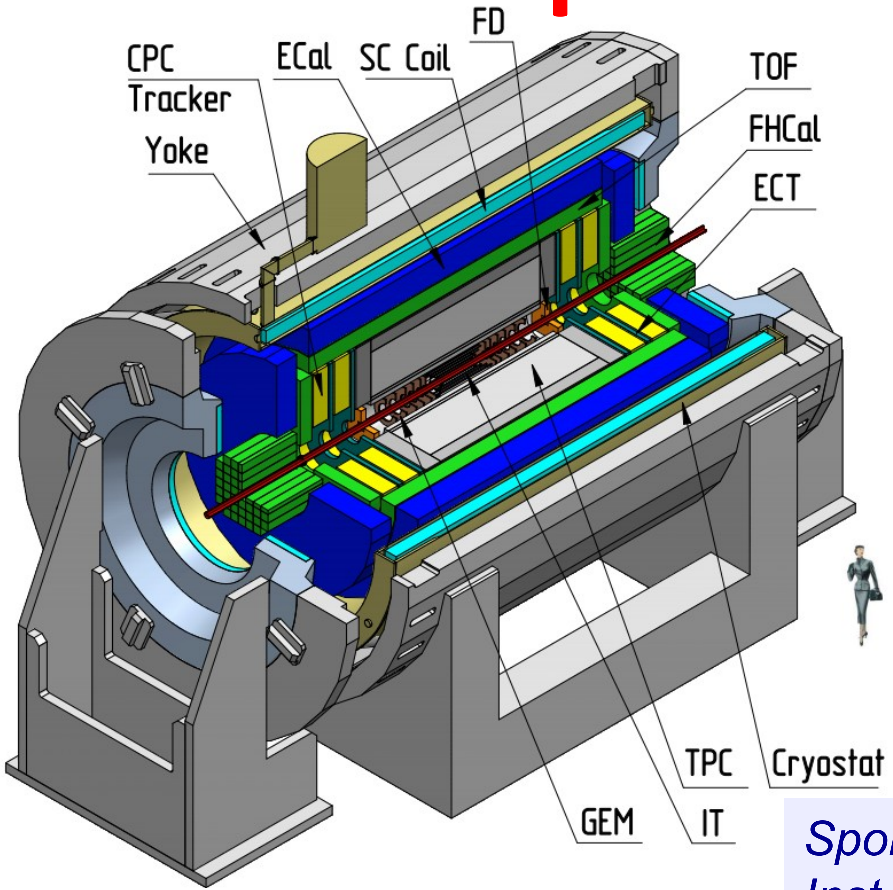
Upgrade:

- 4 Silicon Tracking Stations (STS)
- 7 full stations Gas-Electron-Multiplier (GEM) chambers
- Forward Hadronic Calorimeter (FHCal)
- Vacuum beam pipe in front and inside BM@N

STS development in close collaboration with CBM groups at FAIR

courtesy of the BM@N experiment

Multi-Purpose Detector (MPD) Collaboration



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

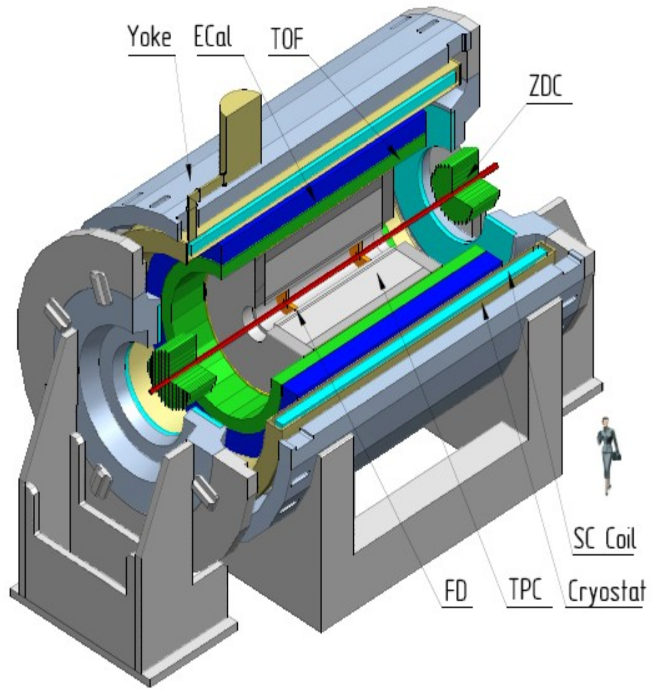
NICA

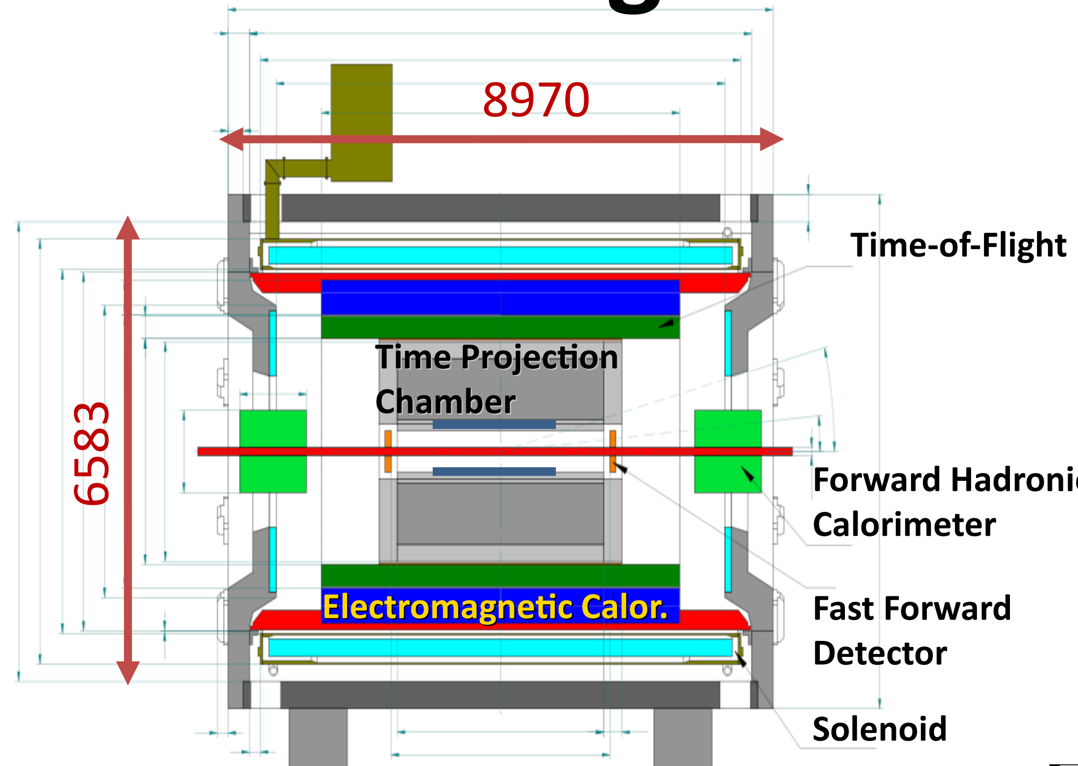
Spokesperson: ***Adam Kisiel***
Inst. Board Chair: ***Fuqiang Wang***
Project Manager: ***Slava Golovatyuk***

Deputy Spokespersons:
Victor Riabov, Zebo Tang

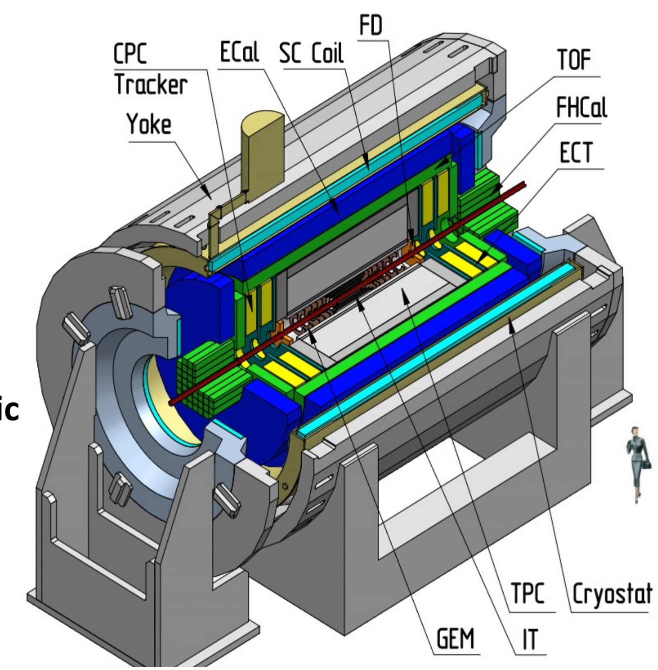
AANL, Yerevan, ***Armenia;***
Baku State University, NNRC, ***Azerbaijan****;*
University of Plovdiv, ***Bulgaria;***
University Tecnica Federico Santa Maria, Valparaiso, ***Chile****;*
Tsinghua University, Beijing, ***China****;*
USTC, Hefei, ***China****;*
Huzhou University, Huizhou, ***China****;*
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****;*

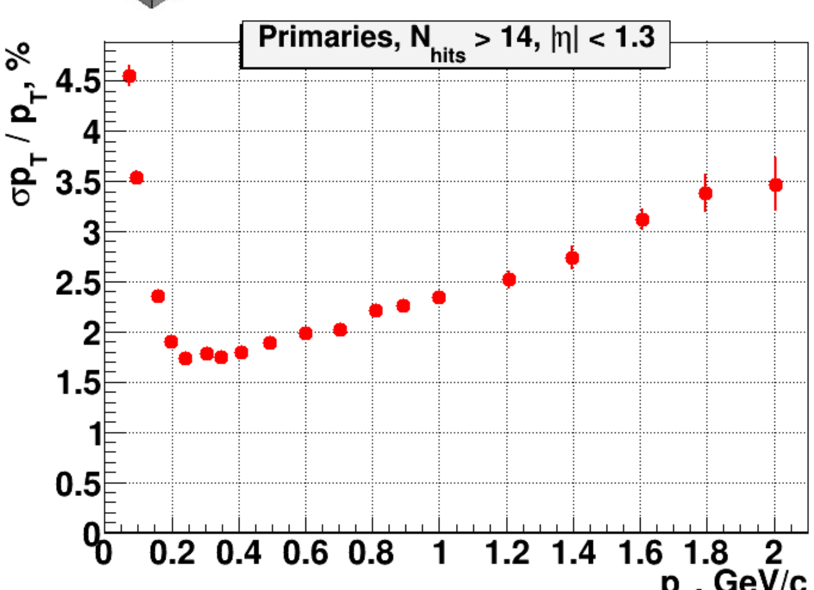
MPD - stage I and II



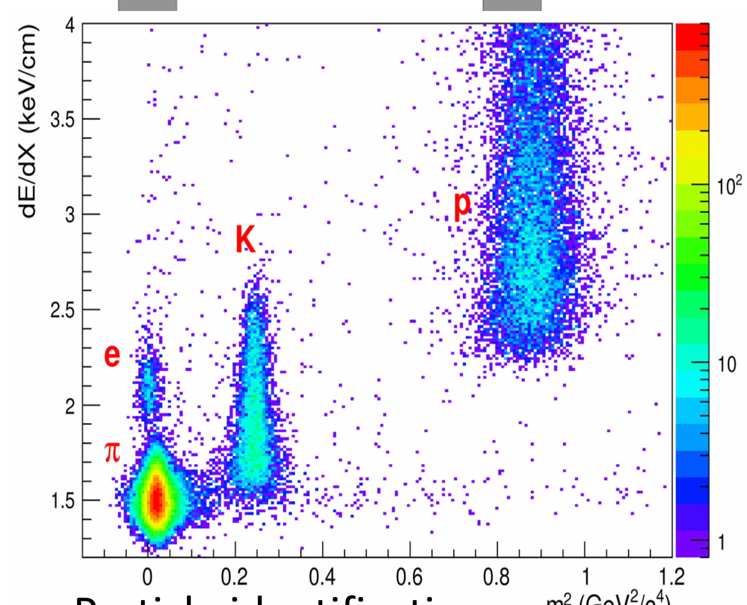


MPD - Stage II

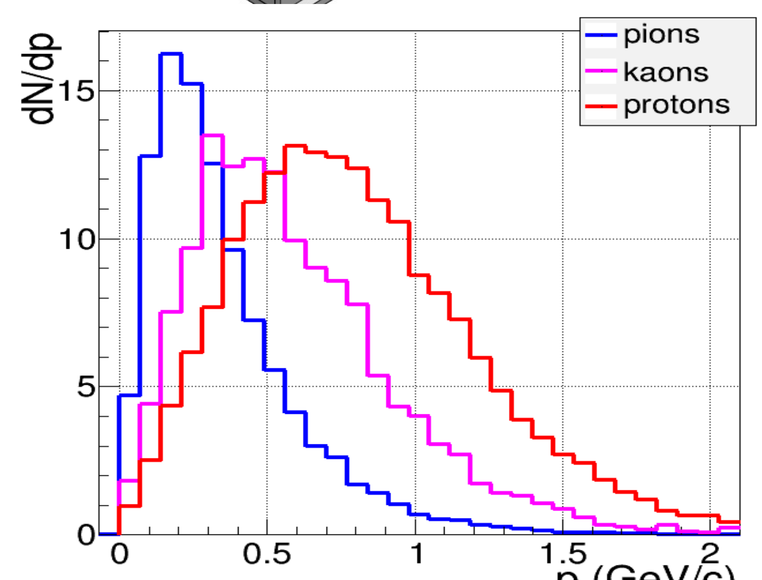




Momentum resolution with TPC



Particle identification



Momentum dist. of secondary particles

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

Transportation of MPD Magnet Yoke parts into the MPD pit (inside MPD Hall)

Magnet Yoke assembly

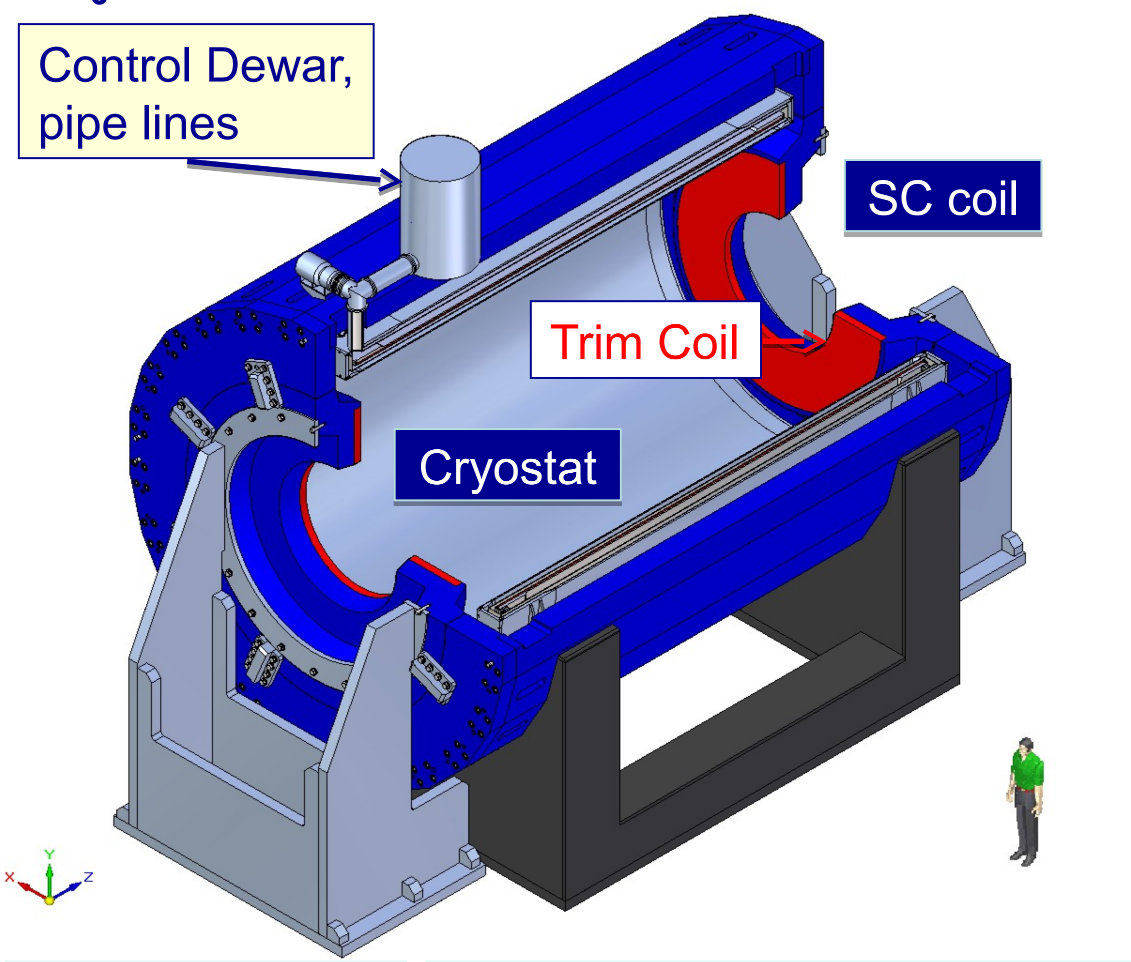
- Assembly of the magnet yoke – start with 13 modules (out of 28) installed with average 200 µm precision, full yoke done in Dec 2020
- Next step: assembly with solenoid in presence of manufacturer team
- Critical assembly path commenced

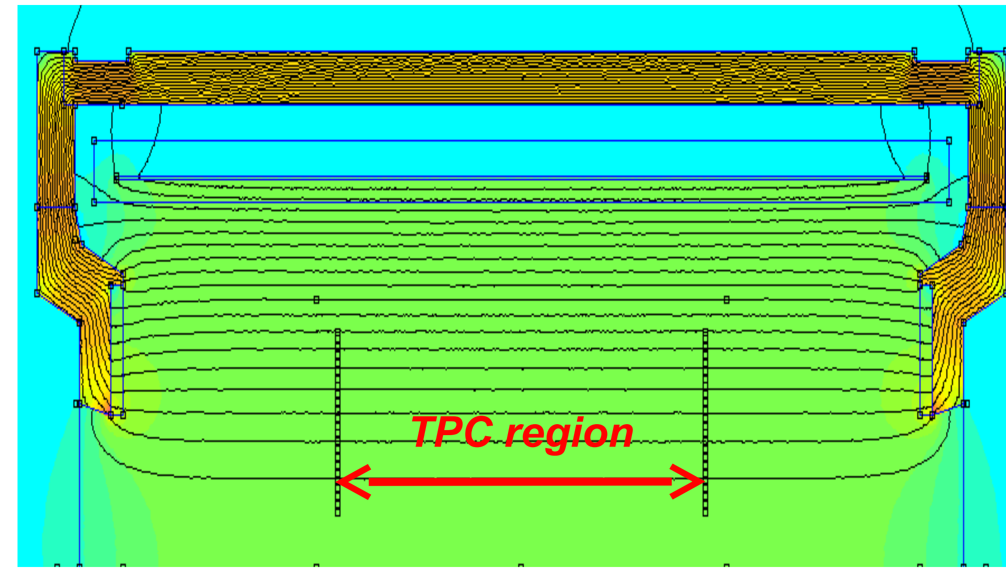
MPD Superconducting Solenoid

B_0=0.5 T

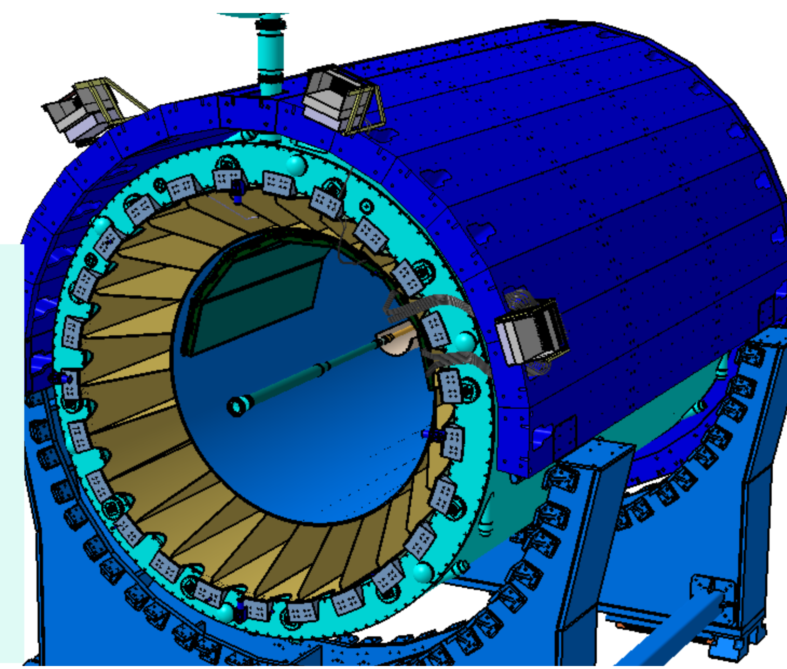
weight ~ **900 t**

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*

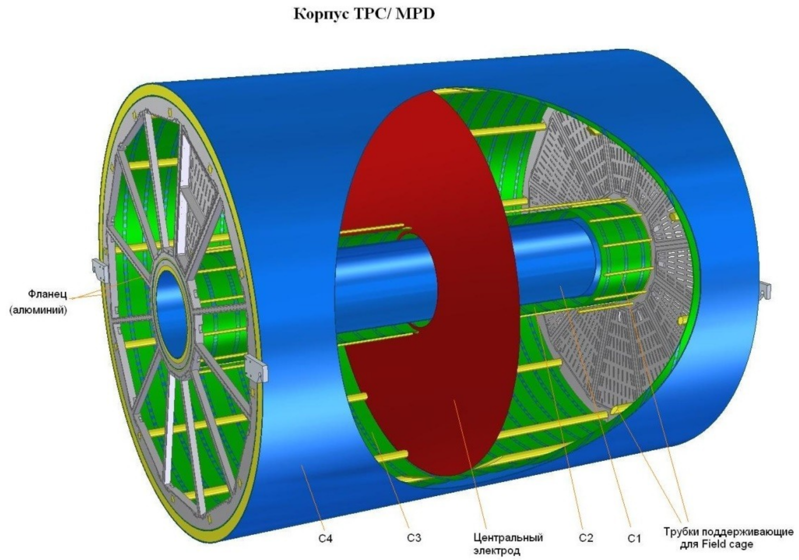
Solenoid in MPD Hall

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

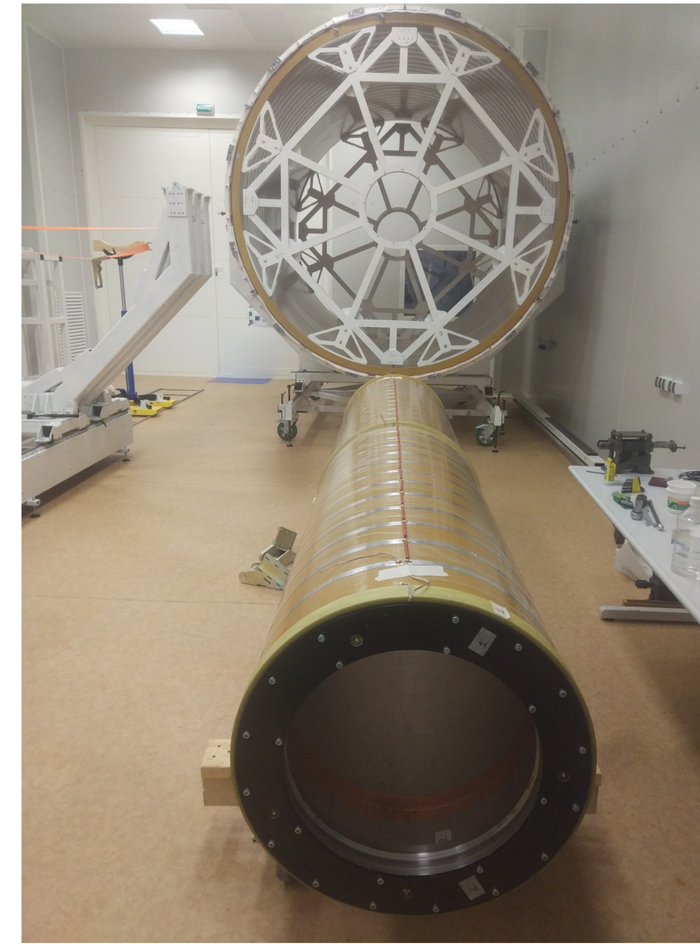
Interior of MPD Hall

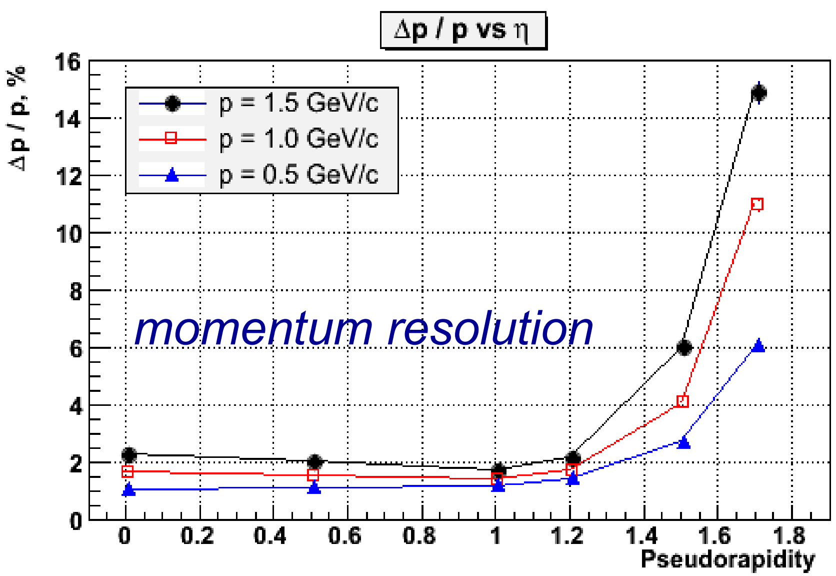
Opening of solenoid sarcophagus: Mar. 23rd

Time Projection Chamber (TPC): main tracker

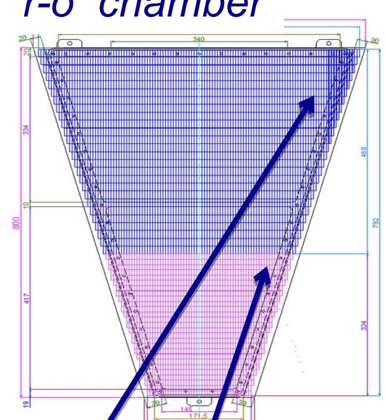


length	*340 см*
outer Radii	*140 см*
inner Radii	*27 см*
gas	*90%Ar+10%CH_4*
drift velocity	*5.45 см / μs;*
drift time	*< 30 μs;*
# R-O chamb.	*12 + 12*
# pads/ chan.	***95 232***
max rate	*< 7kGz (L= 10^{27})*





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*

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)

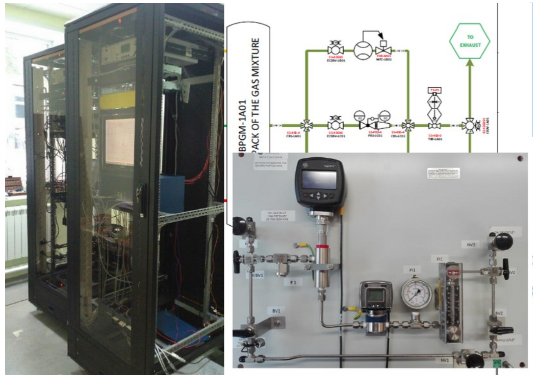
All procedure of detector assembling and optical control is performed in a clean rooms ISO class 6-7.

Glass cleaning with ultrasonic wave & deionized water

Automatic painting of the conductive layer on the glass

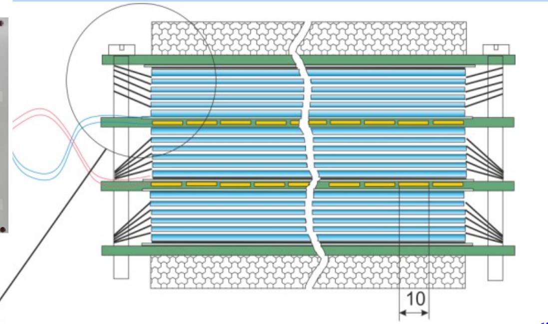
MRPC assembling

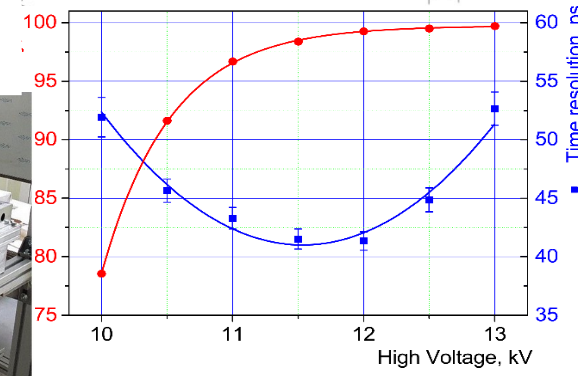
Soldering HV connector and readout pins

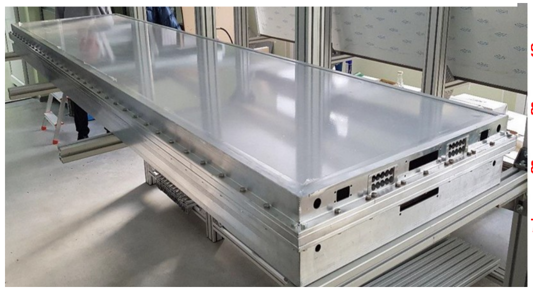


TOF gas system: Responsibility of the Polish group (WUT)

Dimensions of sensitive area 600 x300 mm^2







	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)

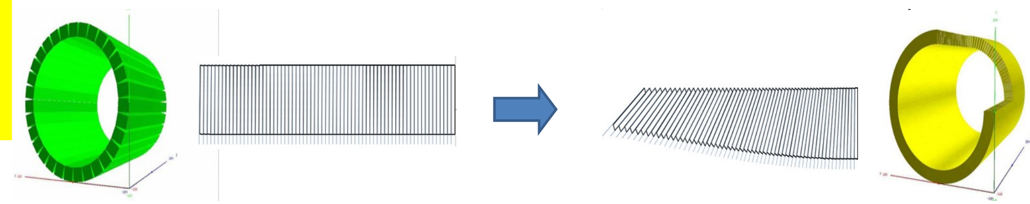
Single detector time resolution: 50ps

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)

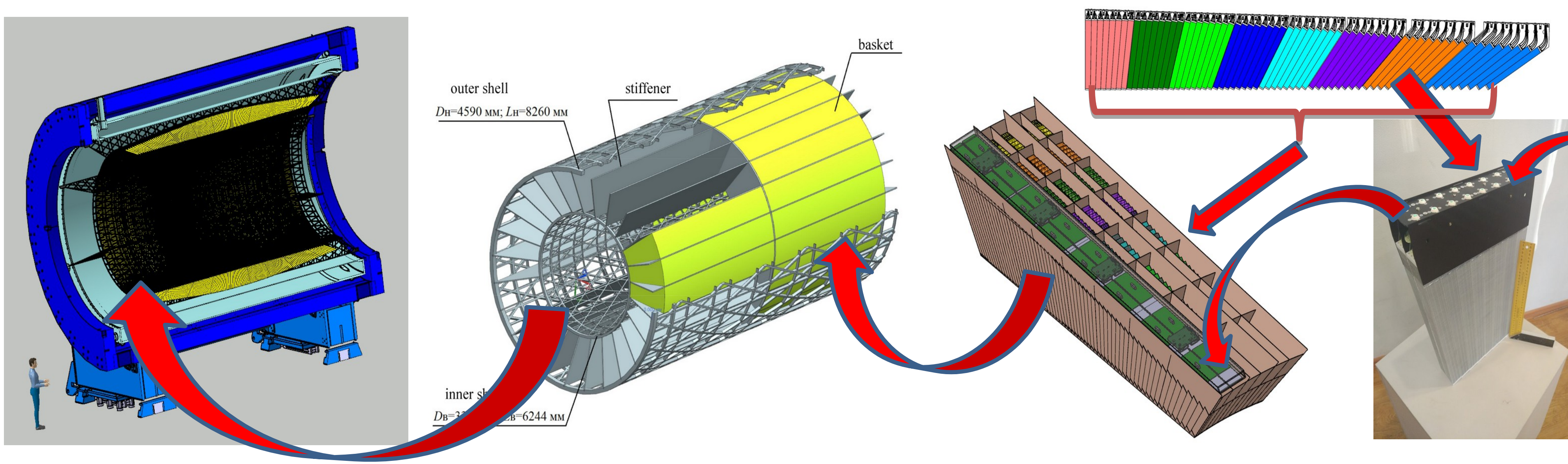
- *Pb+Sc "Shashlyk"* *read-out: WLS fibers + MAPD* *L ~35 cm (~ 14 X_0)*
- *Segmentation (4x4 cm²)* *σ(E) better than 5% @ 1 GeV* *time resolution ~500 ps*

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

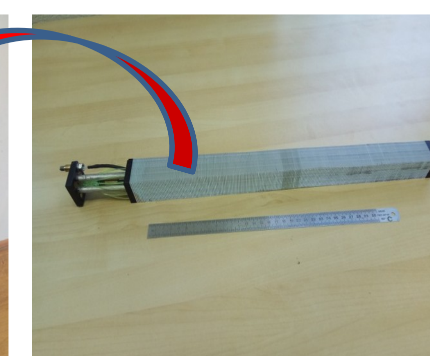
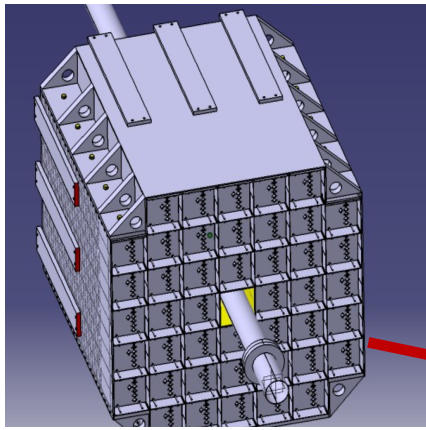
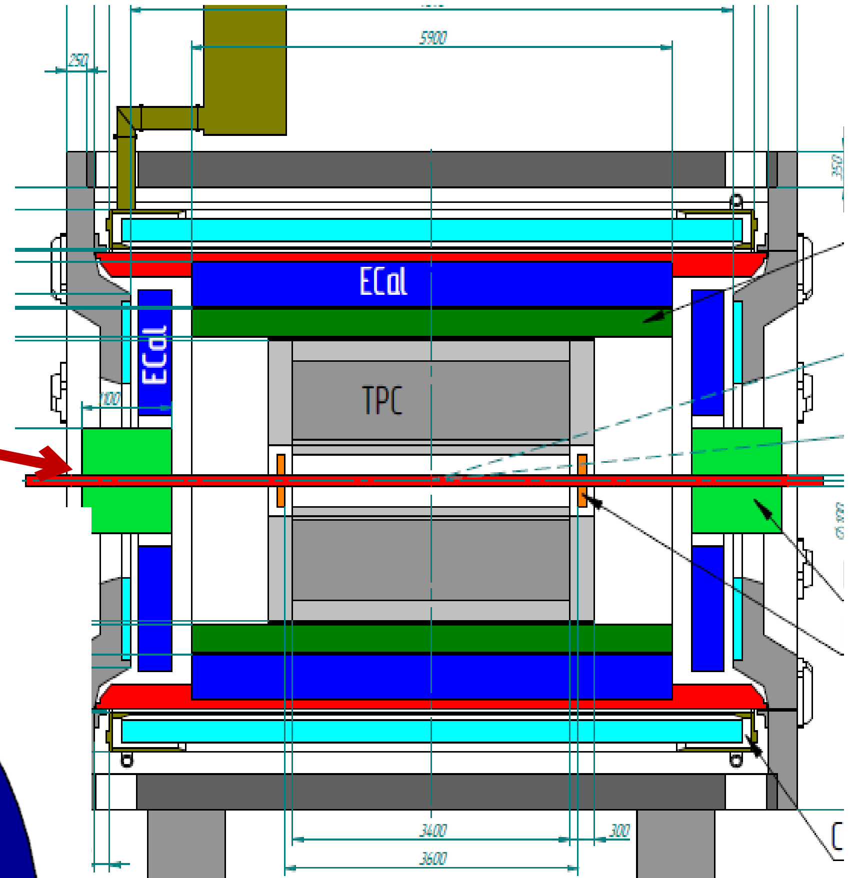
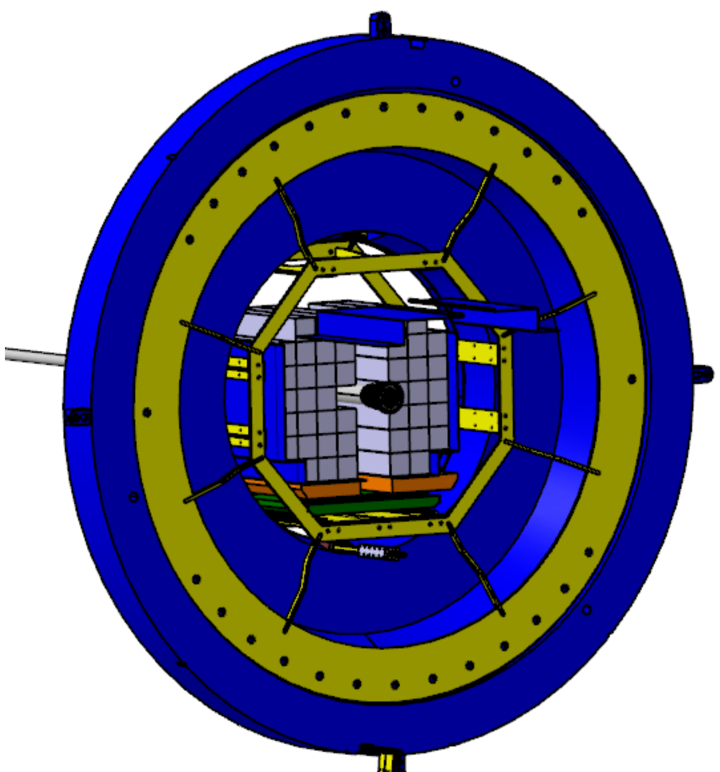


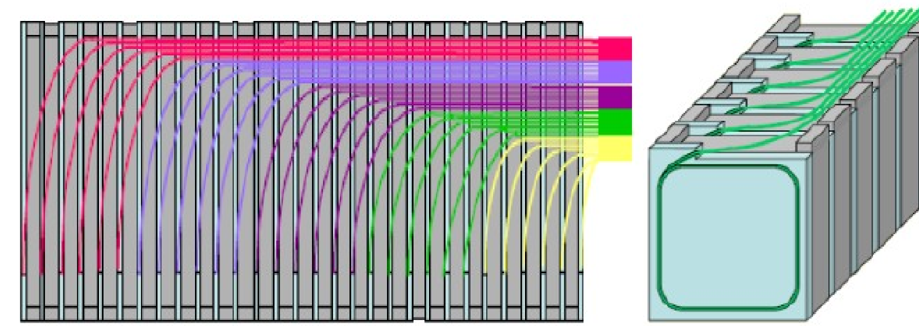
Photo of one element

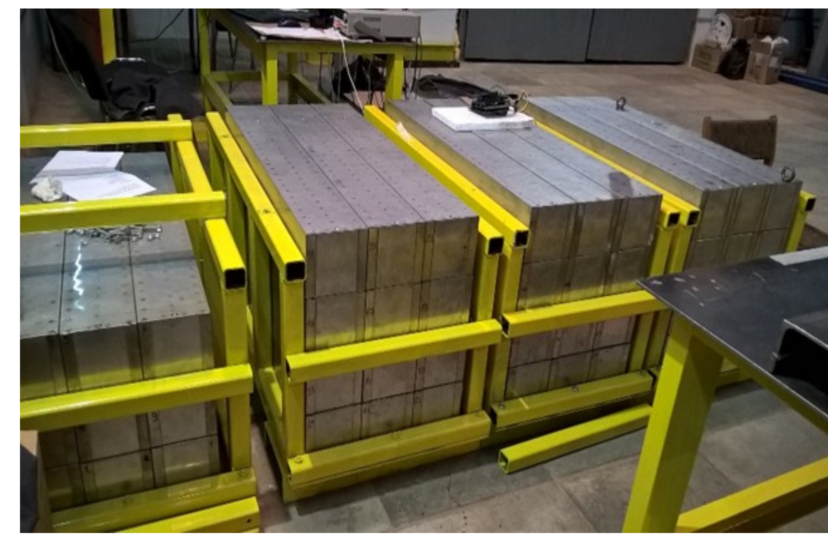
Forward Hadron Calorimeter (FHCal)





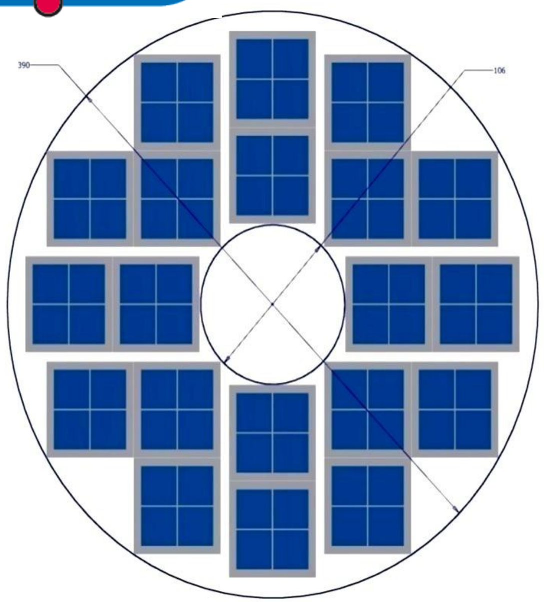


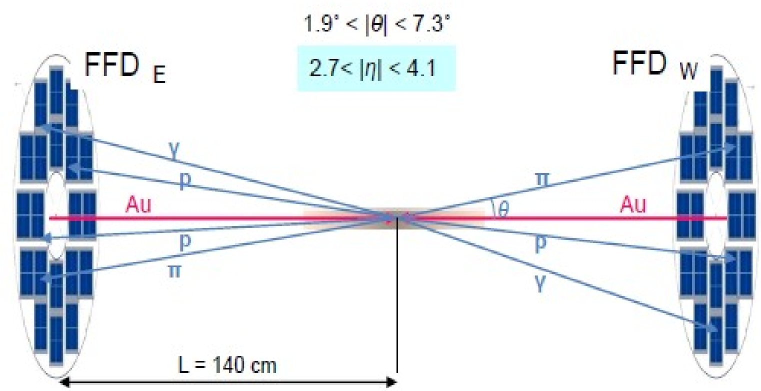




- Two-arms at ~3.2 m from the interaction point.
- Each arm consists of 44 individual modules.
- Module size 150x150x1100cm^3 (42 layers)
- Pb(16mm)+Scint.(4mm) sandwich
- 7 longitudinal sections
- 6 WLS-fiber/MAPD per section
- 7 MAPDs/module

FFD - Fast Trigger L_0 for MPD





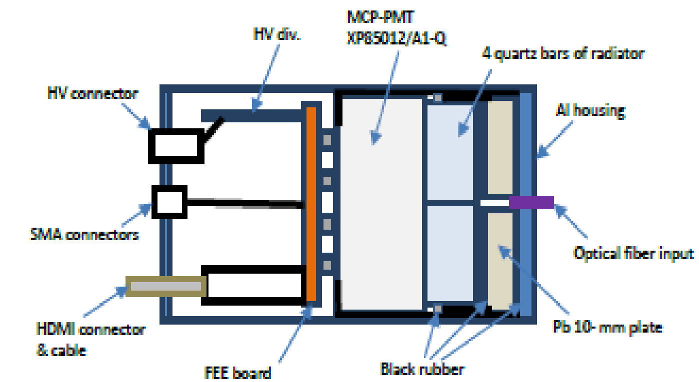


Fig. 4-1. A scheme of the FFD module.

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

MPD Cosmic Ray Detector (MCORD)

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

Project leader: 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 under evaluation of the MPD DAC

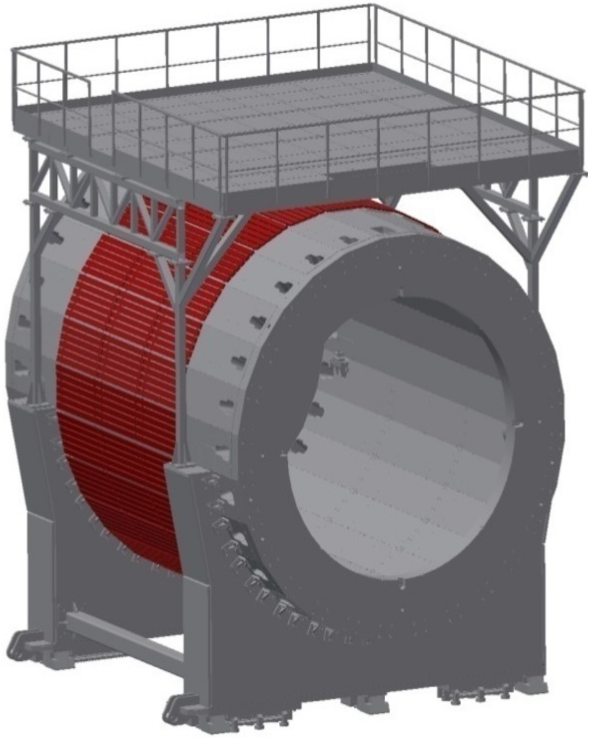
Cosmic Ray Detector consists of plastic scintillators with SiPM (Phototubes) light converters

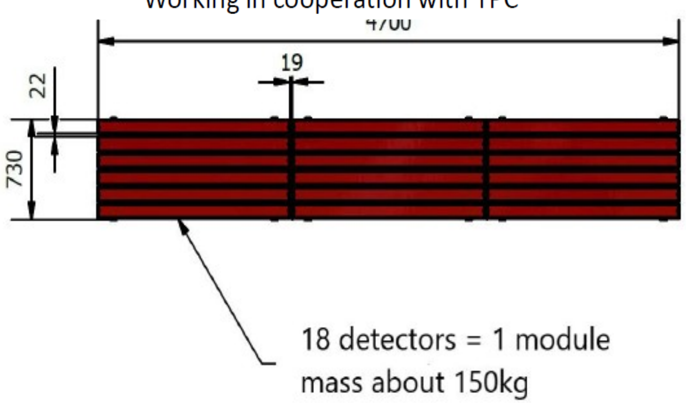
a) Trigger (for testing or calibration)
 - testing before completion of MPD
 (testing of TOF, ECAL modules and TPC)
 - calibration before experimental session

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

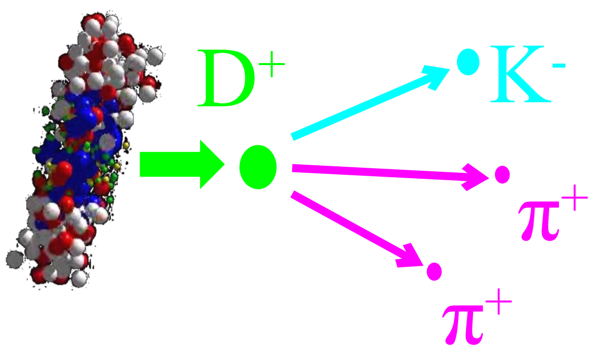
RESOLUTION

Position resolution: In X axis – up to 5 cm, In Y axis – 5-10 cm
Time Resolution – about 300-500 ps

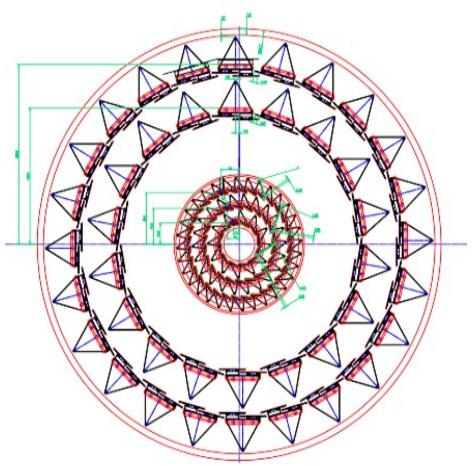
Number of events (particles):	about 100-150 per sec per m2
Calculated Coincidence factor:	about 98%

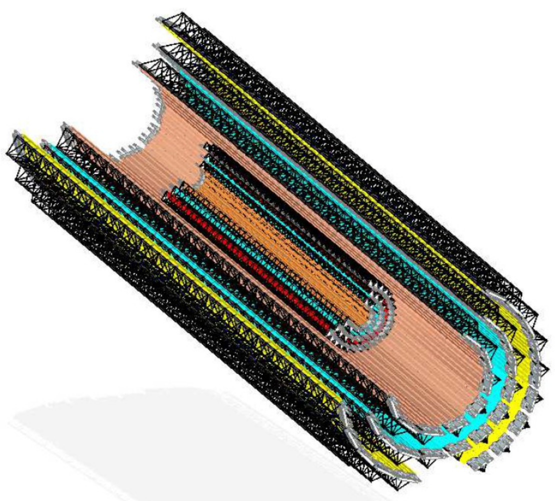
Inner Tracker System (ITS): precise tracking

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

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**

MPD Physics Programme

G. Feofilov, A. Ivashkin

Global observables

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

V. Kolesnikov, Xianglei Zhu

Spectra of light flavor and hypernuclei

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

K. Mikhailov, A. Taranenko

Correlations and Fluctuations

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

V. Riabov, Chi Yang

Electromagnetic probes

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

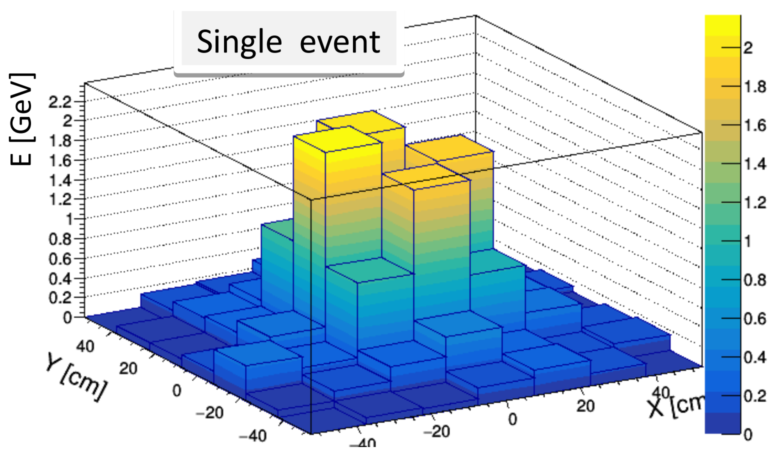
Wangmei Zha, A. Zinchenko

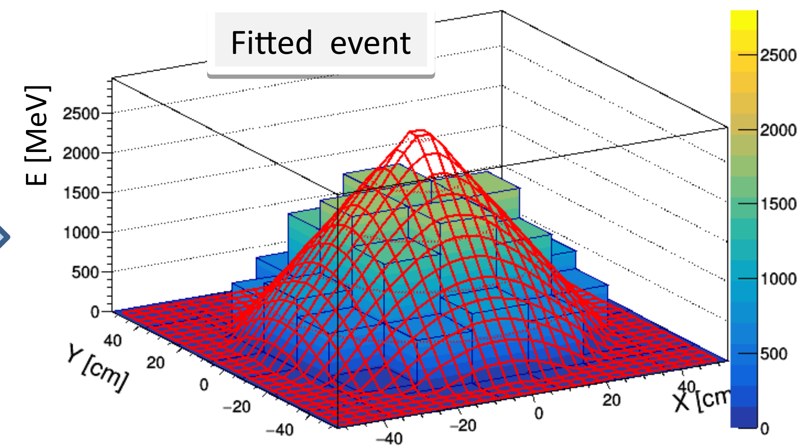
Heavy flavor

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

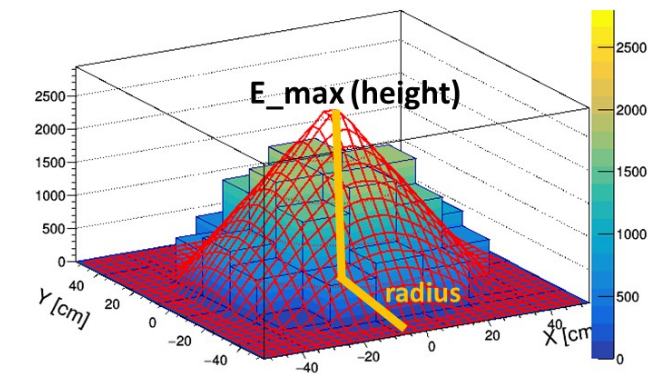
Centrality and reaction plane in FHCal

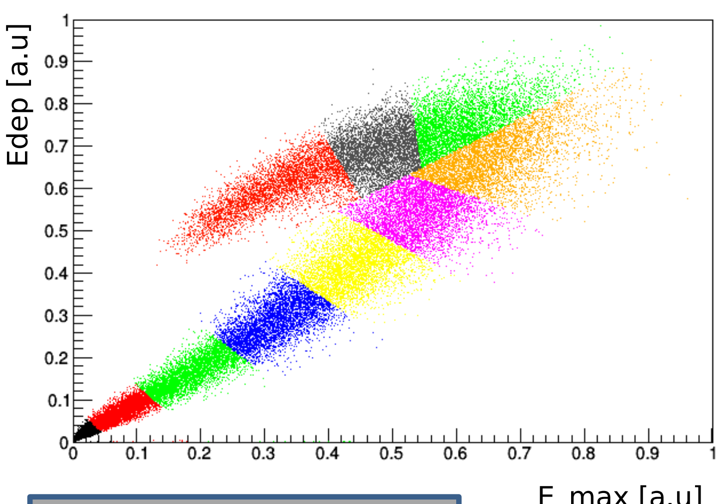
Energy distribution in FHCal modules



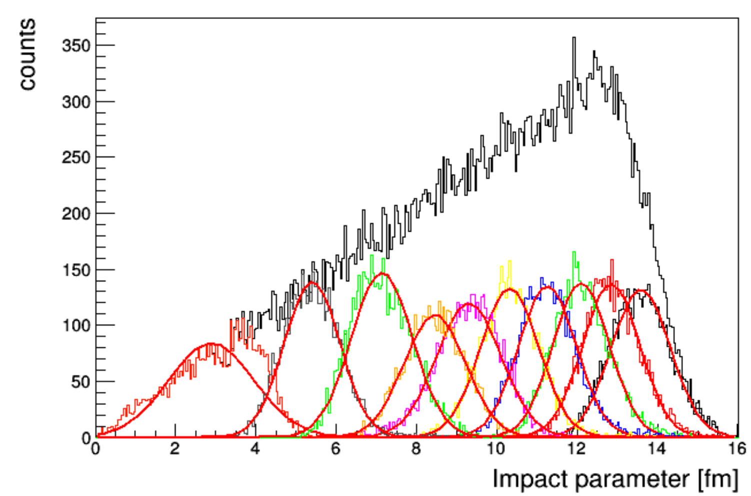


Initially we have experimental energy deposition E_{dep} in FHCal.

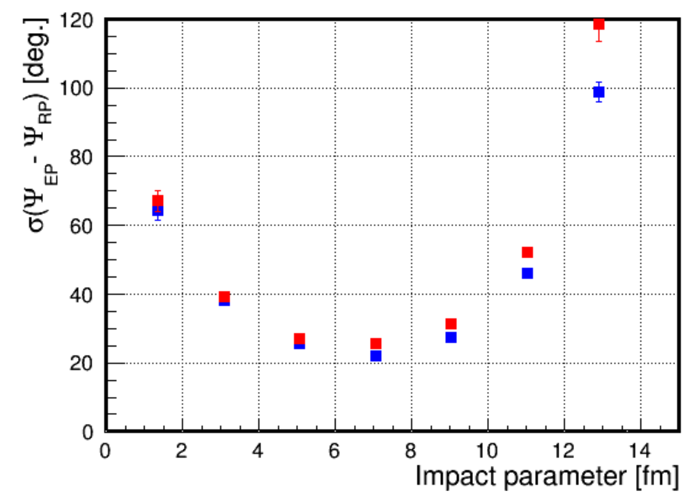




Each color bin is 10% fractions of the total number of events.



Centrality resolution



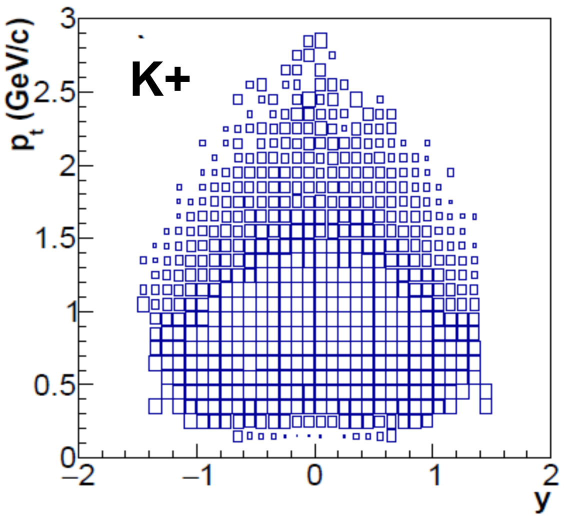
Reaction plane resolution

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**

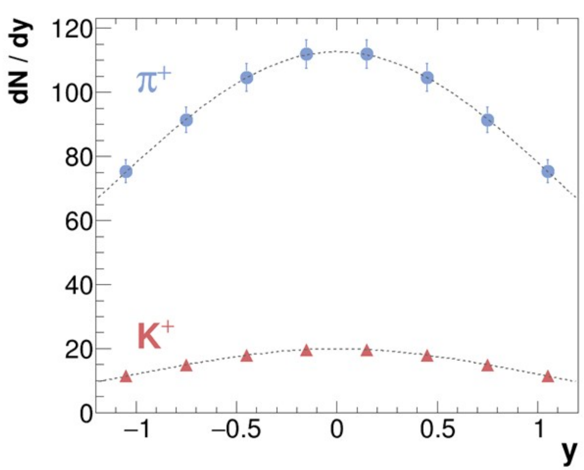
✓ *0-5% central Au+Au at 9 GeV from the PHSD event generator, which implements partonic phase and CSR effects*

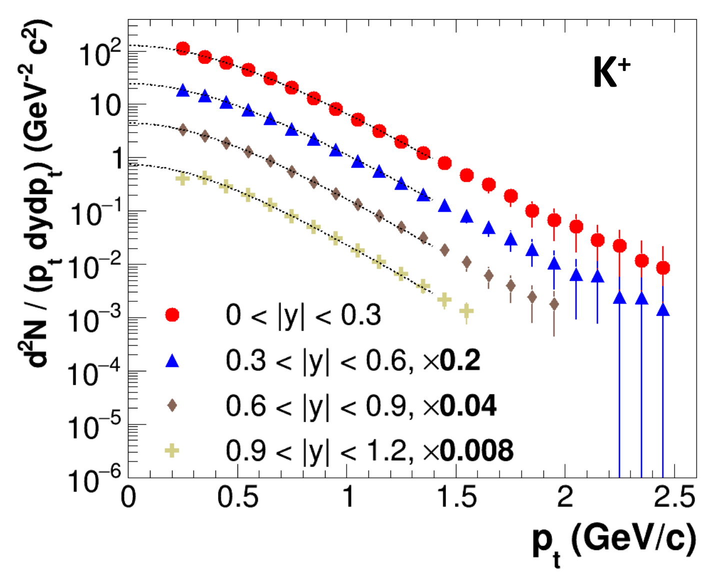
✓ *Recent reconstruction chain, combined dE/dx+TOF particle ID, spectra analysis*

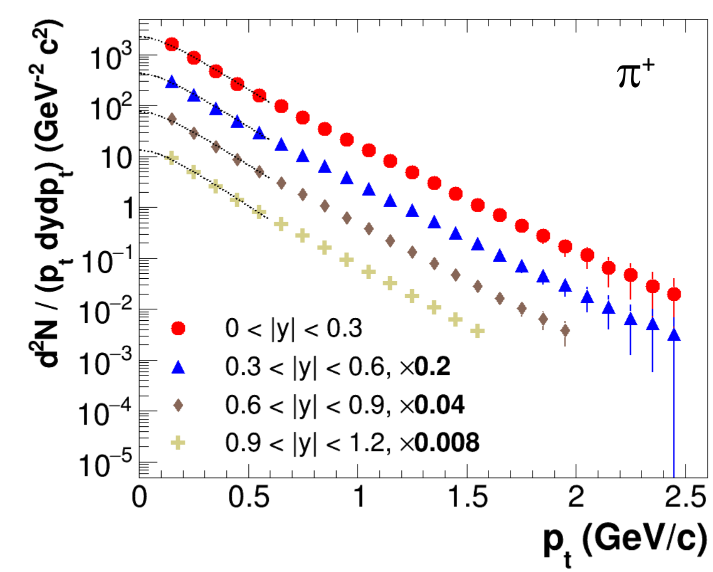


- MPD provides large phase-space coverage for identified pions and kaons (> 70% of the full phasespace at 9 GeV)
- Hadron spectra can be measured from p_T=0.2 to 2.5 GeV/c
- Extrapolation to full p_T-range and to the full phase space can be performed exploiting the spectra shapes (see BW fits for p_T-spectra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

Ability to cover full energy range of the „horn" with consistent acceptance

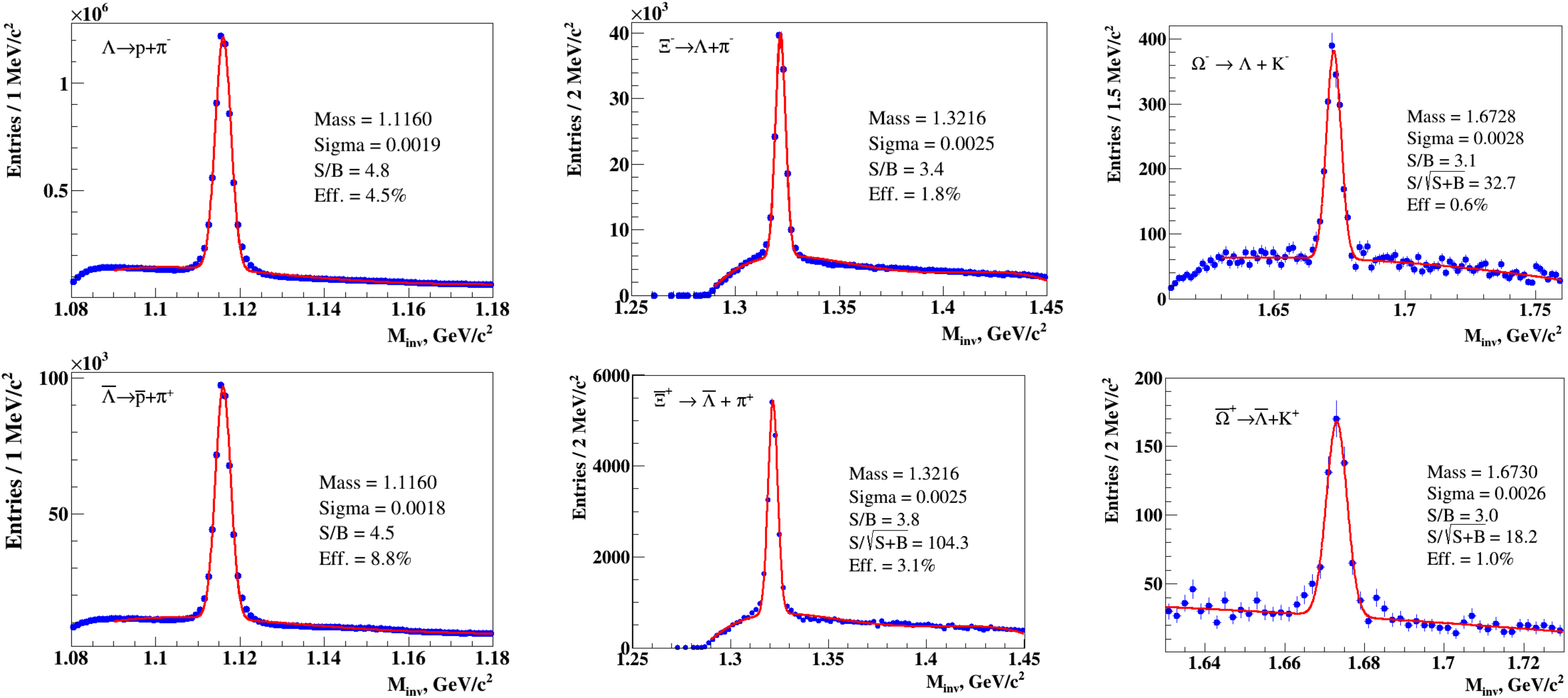






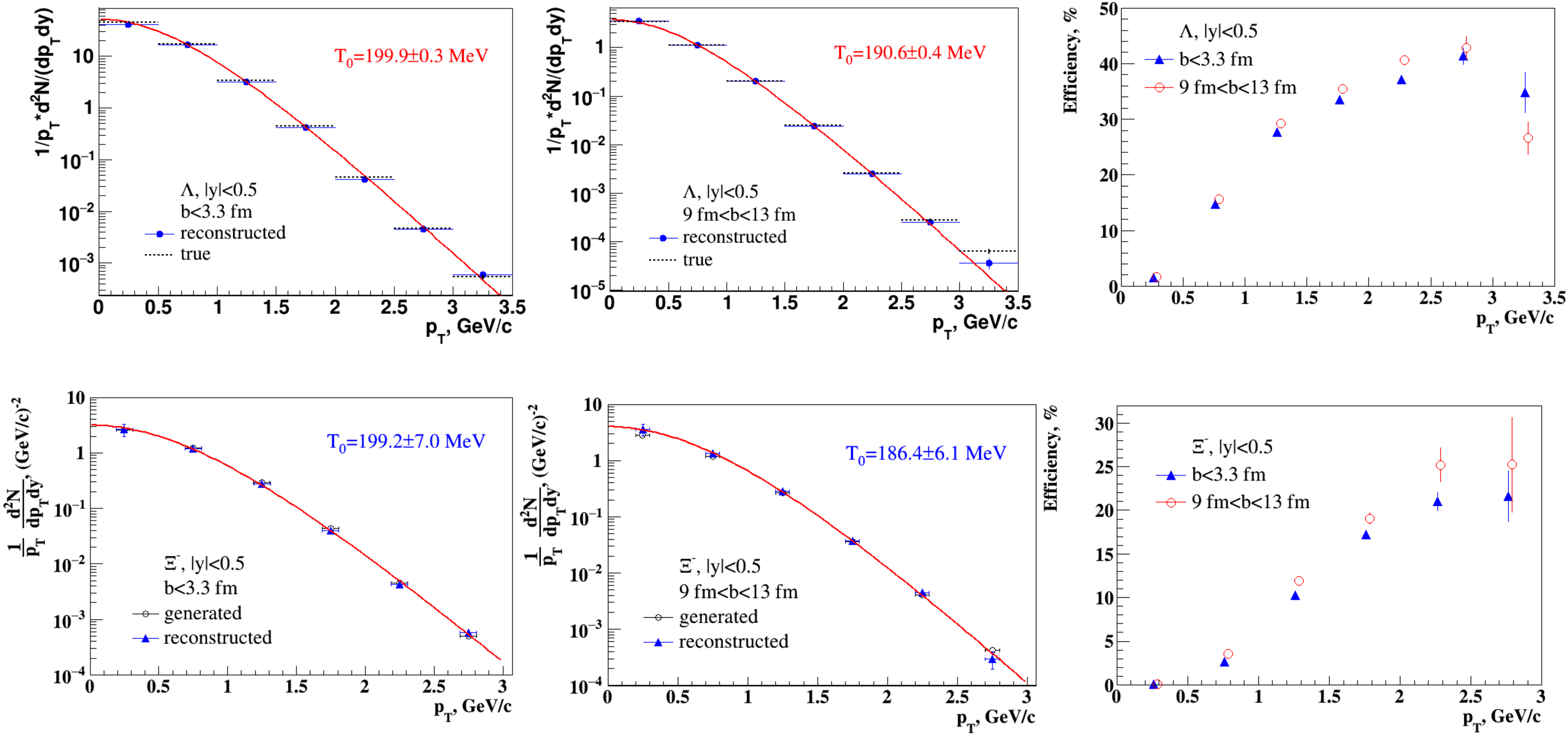
Strange and multi-strange baryons

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	$3 \cdot 10^8$	$3.5 \cdot 10^6$	$1.5 \cdot 10^6$	$8.0 \cdot 10^4$	$7 \cdot 10^4$	$1.5 \cdot 10^4$

Efficiency and p_T spectrum

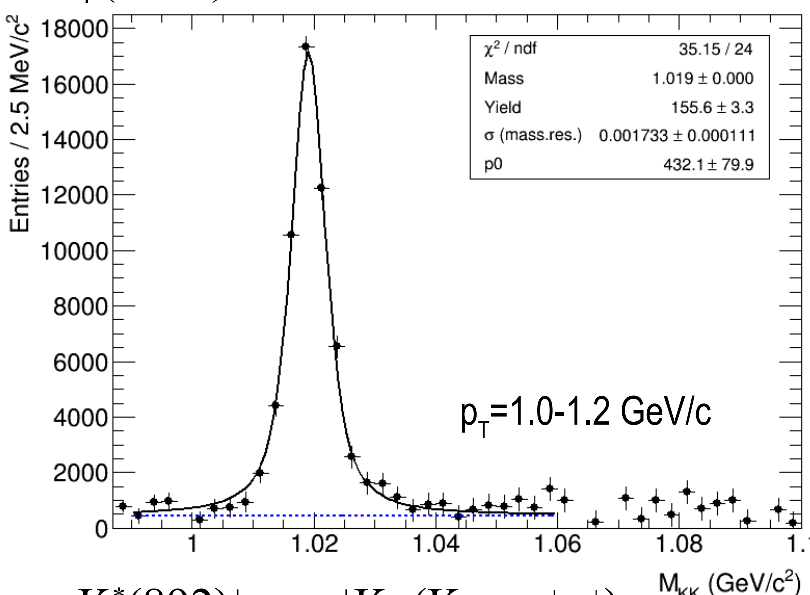


Full p_T spectrum and yield extraction, reasonable efficiency down to low p_T

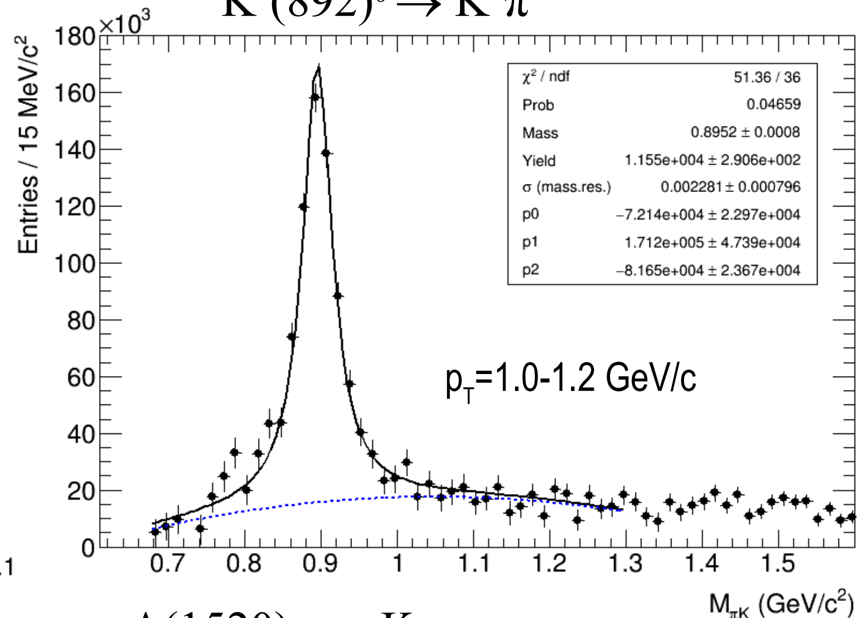
Resonances at MPD

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

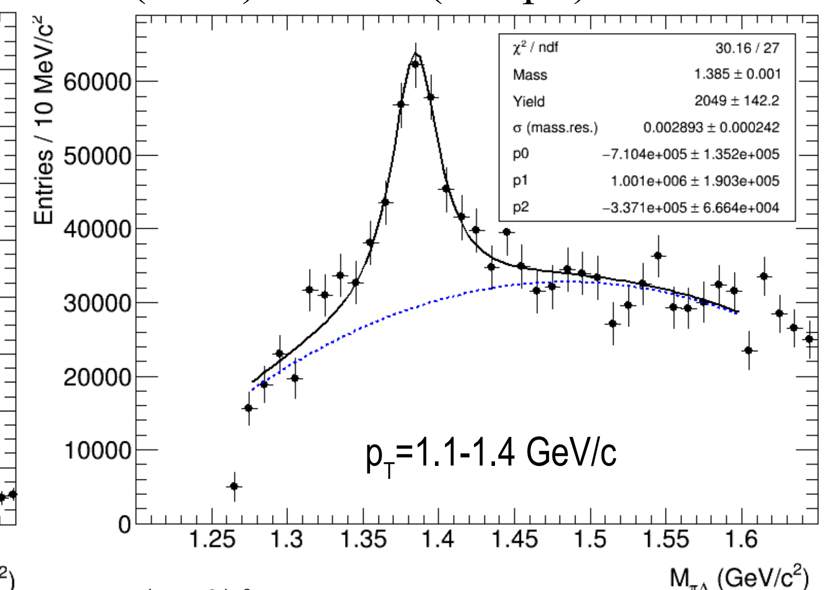
$\phi(1020) \to K^+K^-$



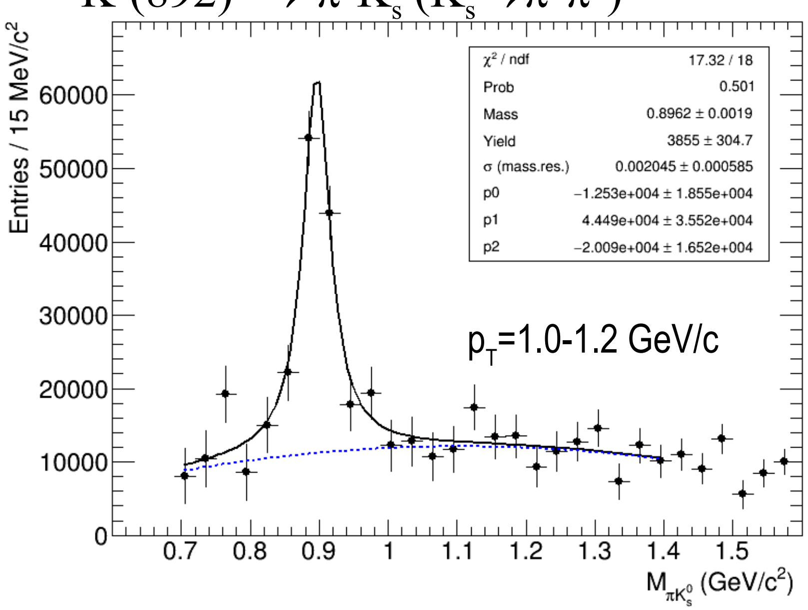
$K^*(892)^0 \to K^\pm\pi^\pm$



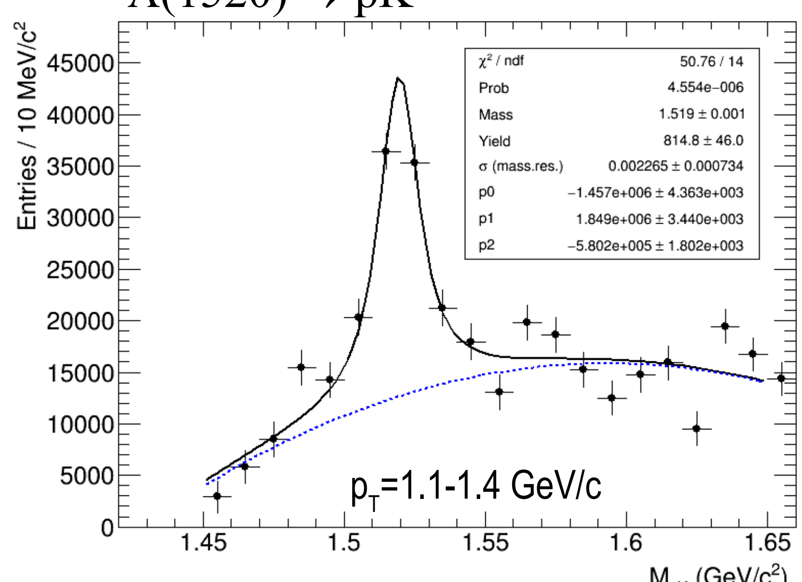
$\Sigma(1385)^\pm \to \pi^\pm\Lambda\ (\Lambda \to p\pi)$



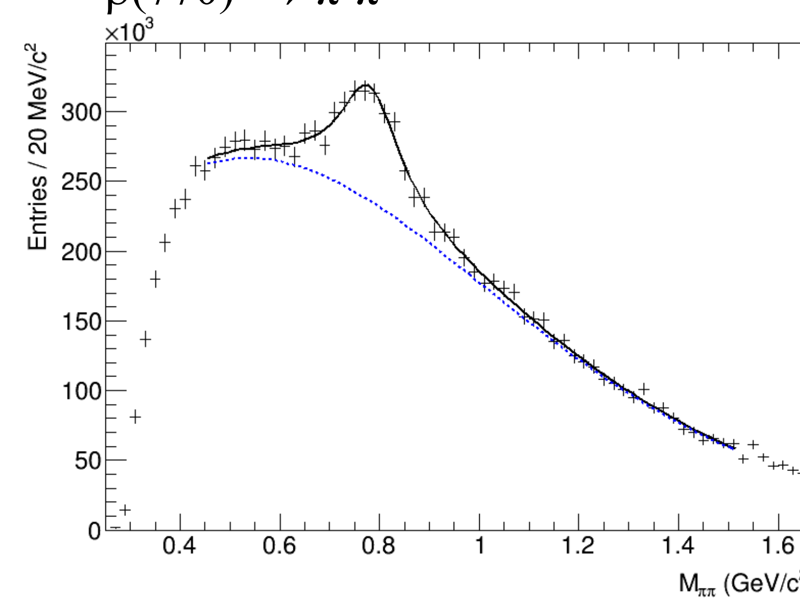
$K^*(892)^\pm \to \pi^\pm K_s\ (K_s \to \pi^+\pi^+)$



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

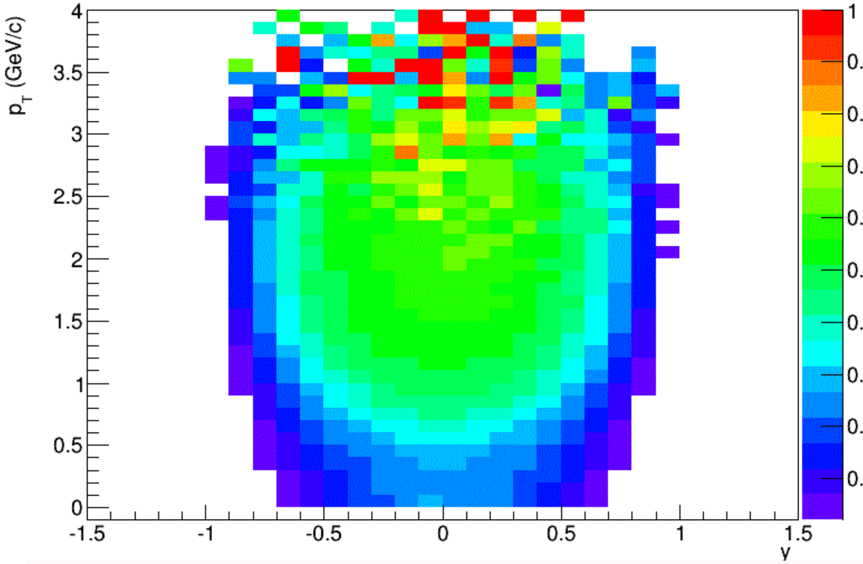


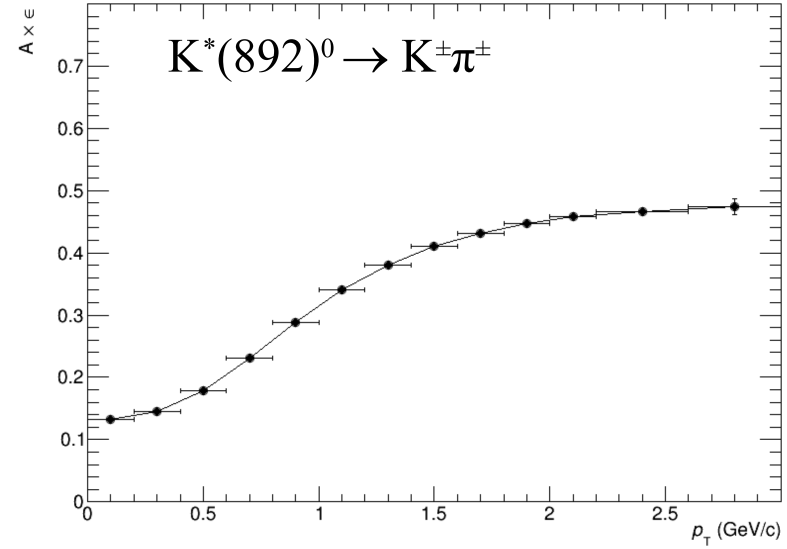
$\rho(770)^0 \to \pi^\pm\pi^\pm$

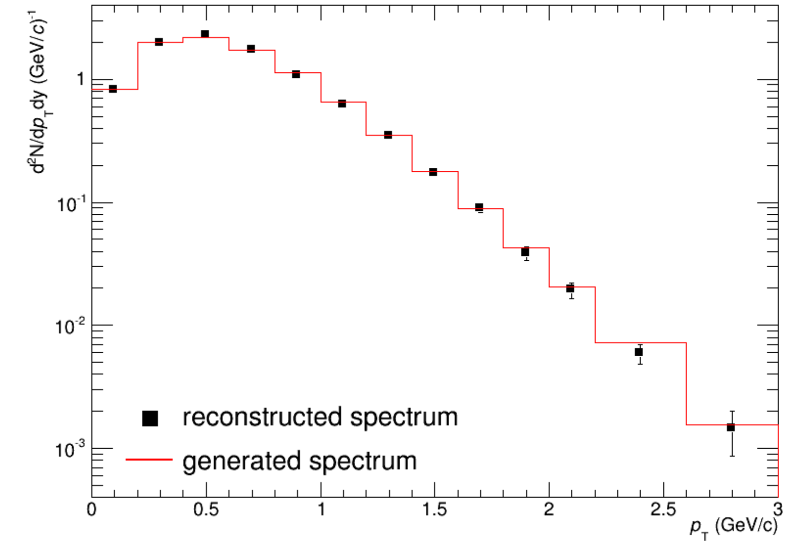


Efficiencies and closure tests examples

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

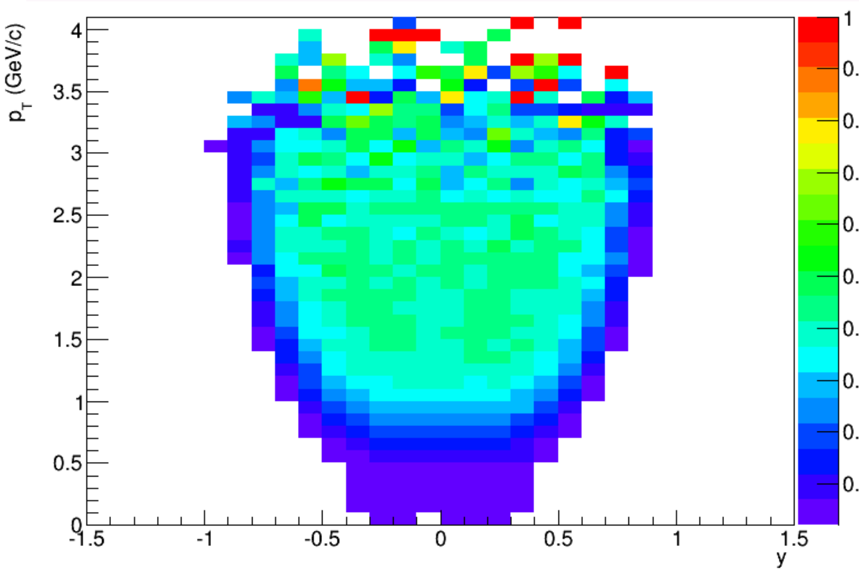


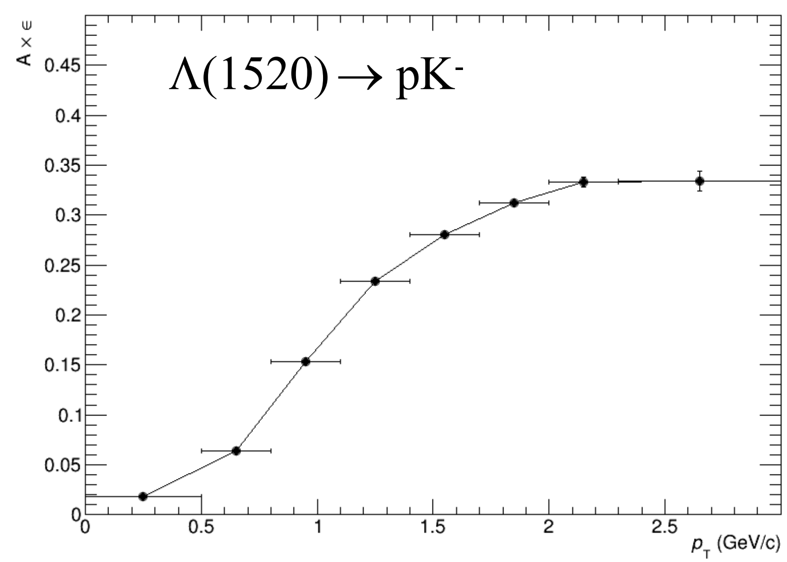


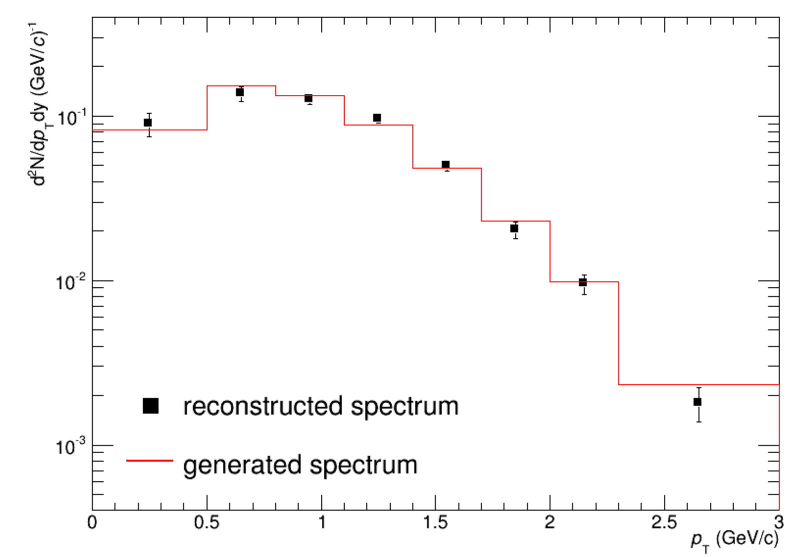


Reconstruction efficiency

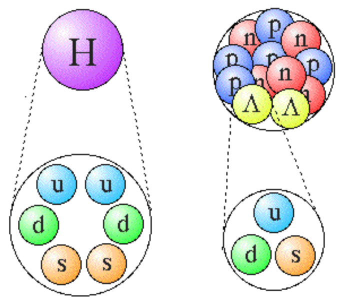
Closure Test







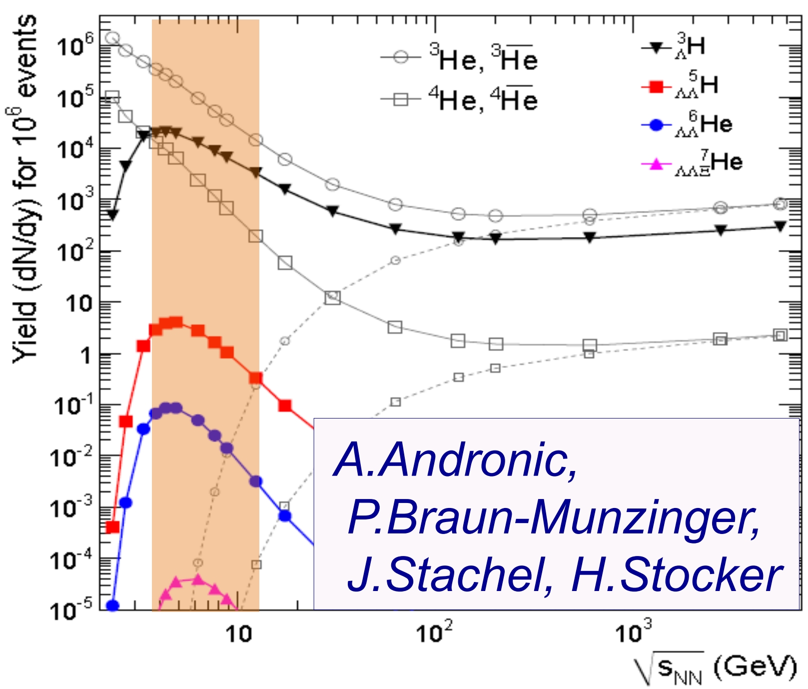
Hypernuclei at MPD

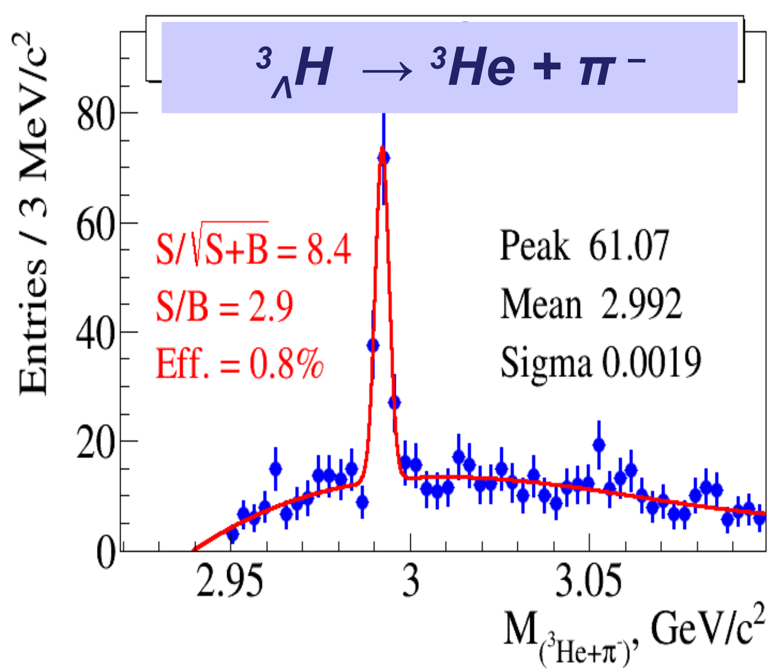


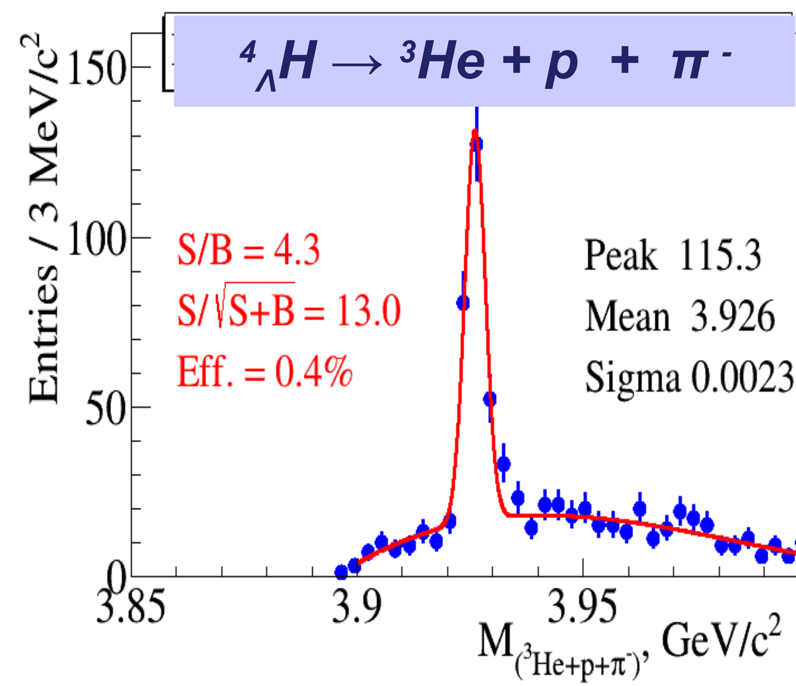
astrophysical research indicates the appearance of hyperons in the dense core of a ***neutron star***

Stage 2: *central* ***Au+Au @ 5*** *AGeV; DCM-QGSM*

hyper nucleus	yield in 10 weeks
$^{3}_{\Lambda}He$	$9 \cdot 10^{5}$
$^{4}_{\Lambda}He$	$1 \cdot 10^{5}$

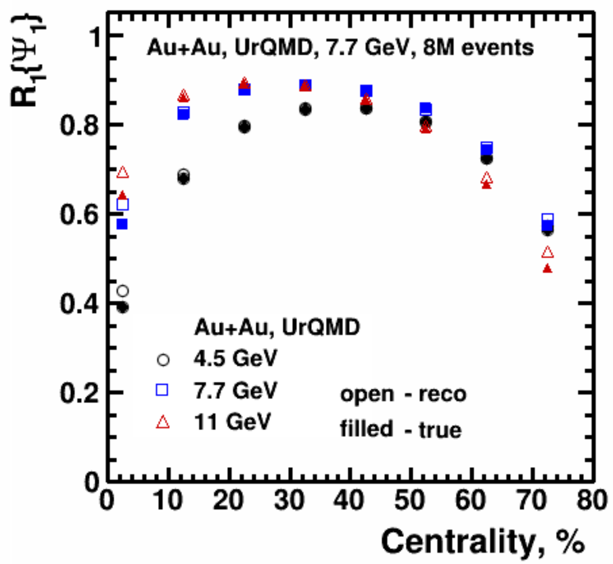


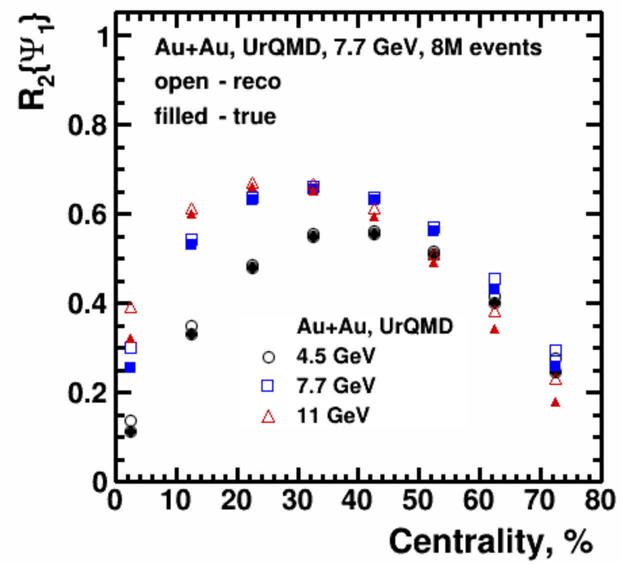


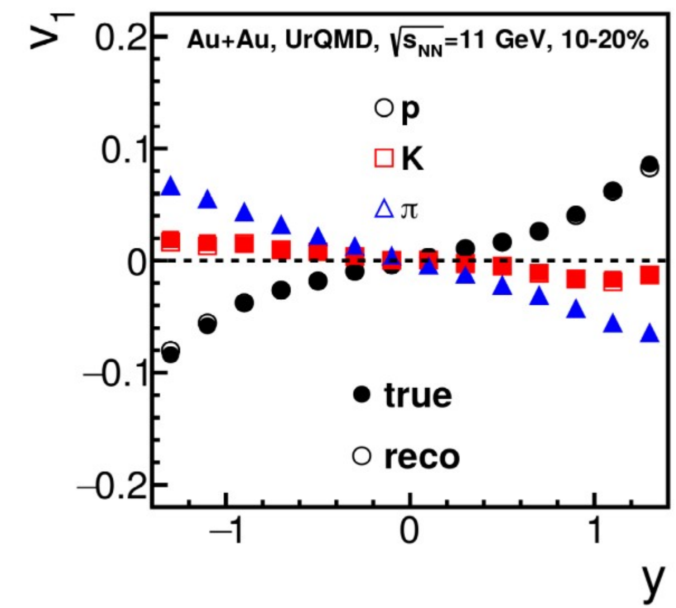


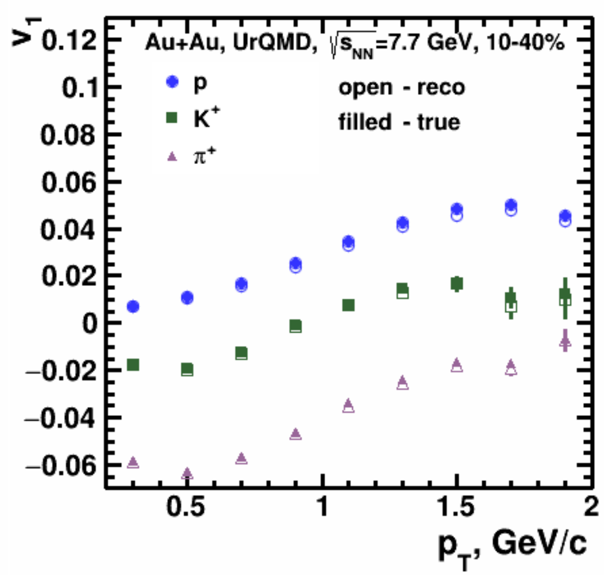
Performance of collective flow studies

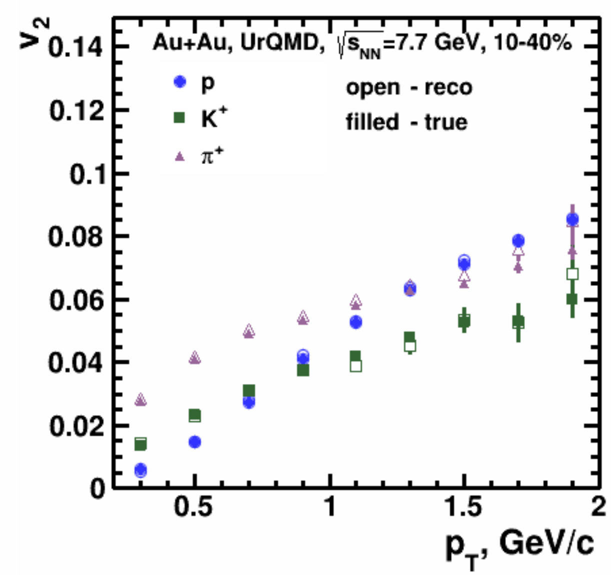
Au+Au, $\sqrt{s_{NN}}$ = 7.7, 11 GeV, UrQMD, GEANT3 + MPDRoot reco.

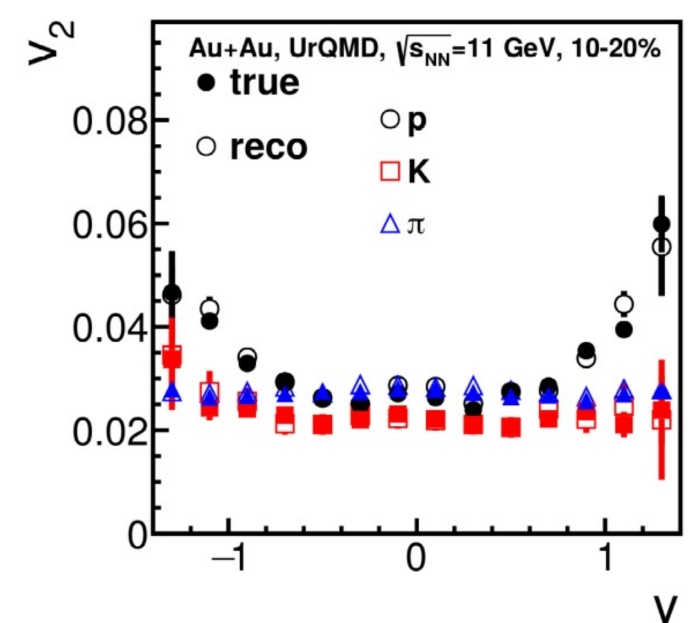












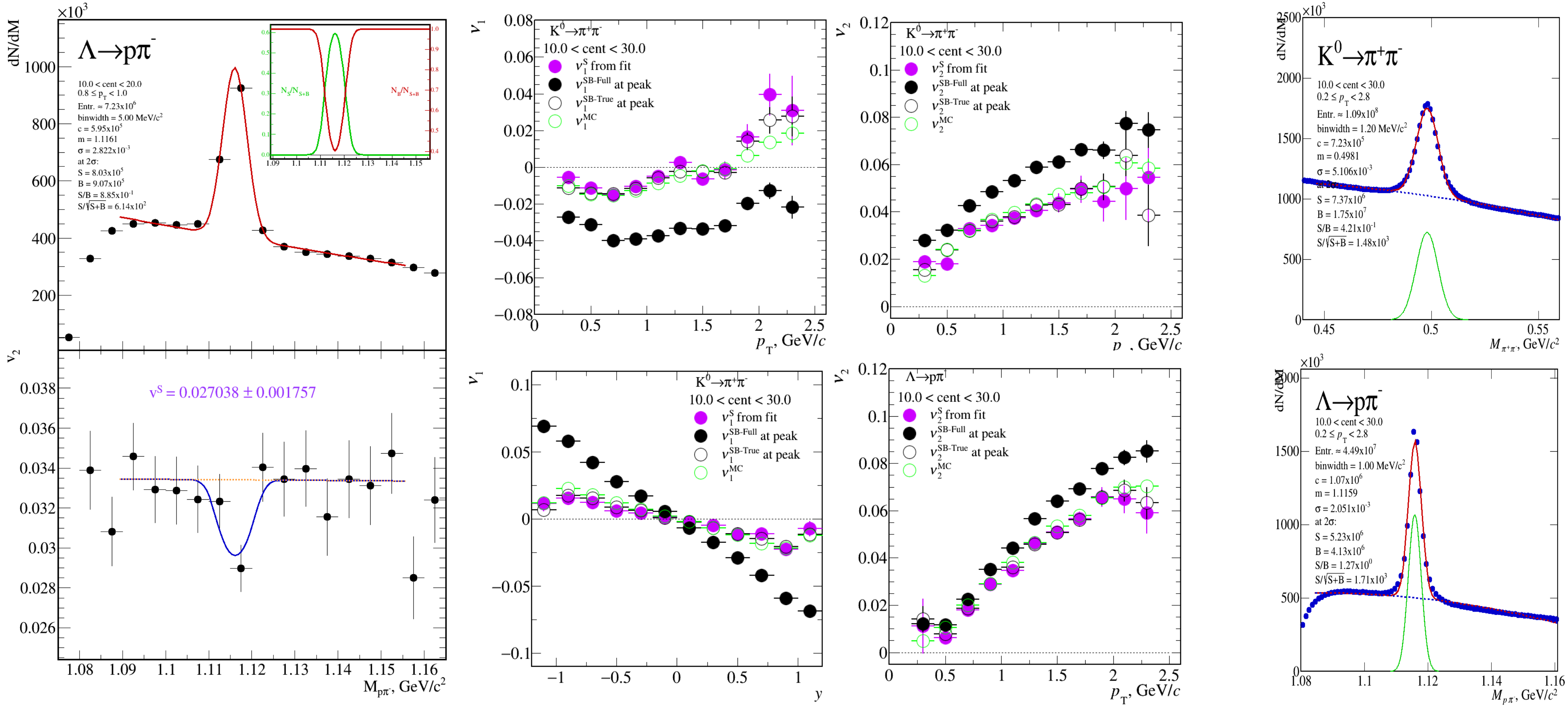
Collective flows a unique and direct way to probe EOS of QCD matter. Excellent flow measurement capabilities in MPD

Anisotropic Flow of Reconstructed Decays

$$v_2^{SB}(m_{inv},p_T) = v_2^S(p_T)\frac{N^S(m_{inv},p_T)}{N^{SB}(m_{inv},p_T)} + v_2^B(m_{inv},p_T)\frac{N^B(m_{inv},p_T)}{N^{SB}(m_{inv},p_T)}$$

Extracted flow signal after fit
Measured flow (s+bg) at peak region
Measured flow only for True
Measured flow from MC/model

Cuts not optimised for S/B

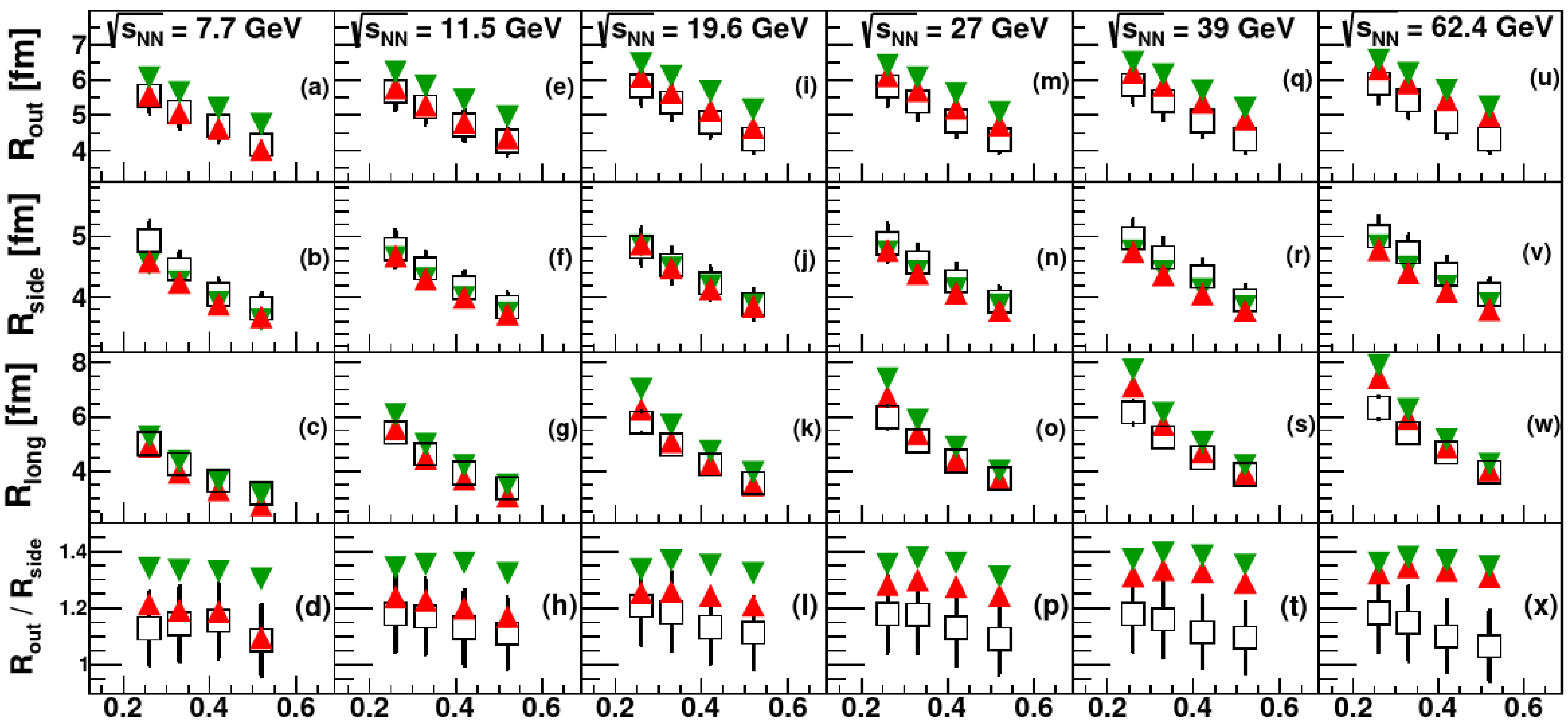


Performance of the MPD Detector for the Study of Multi-strange Baryon Production in Heavy-ion Collisions at NICA

N. Geraksiev, V. Kolesnikov, V. Vasendina,
A. Zinchenko for the MPD Collaboration

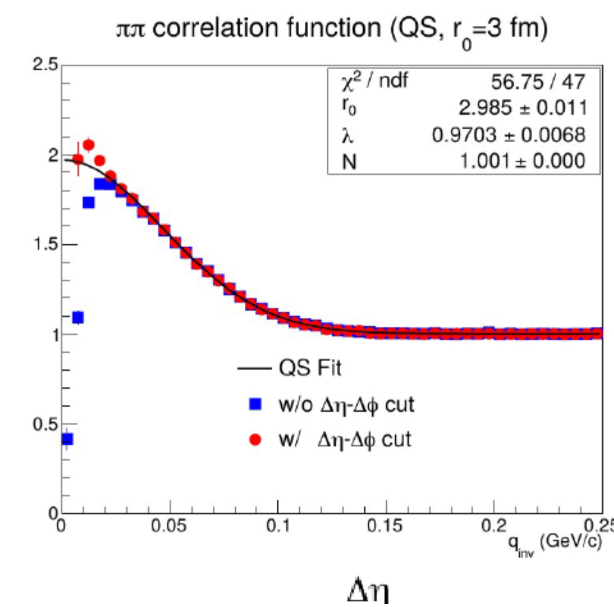
System size sensitive to phase transition

- 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



Phys.Rev.C 96 (2017) 2, 024911 m_T [GeV/c]

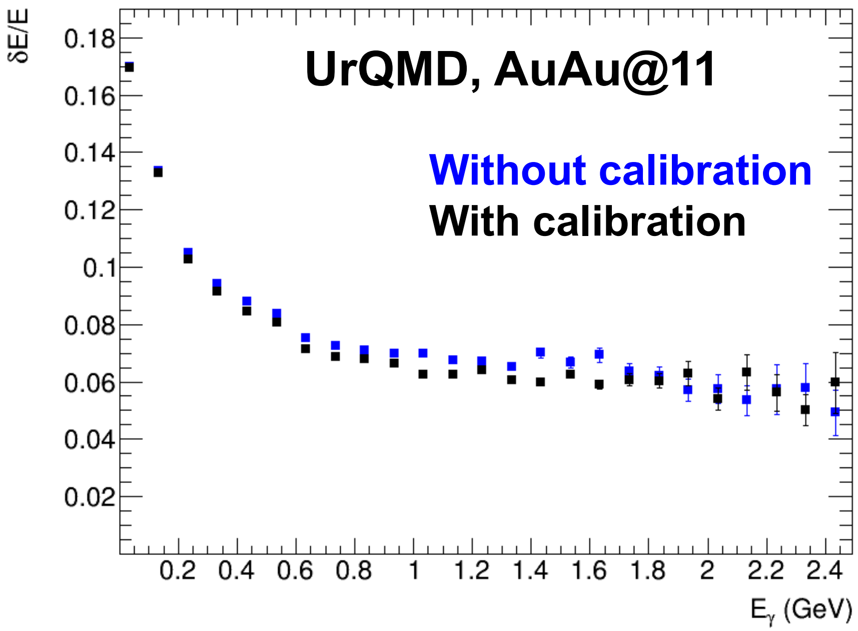
1st order phase transition
cross-over transition

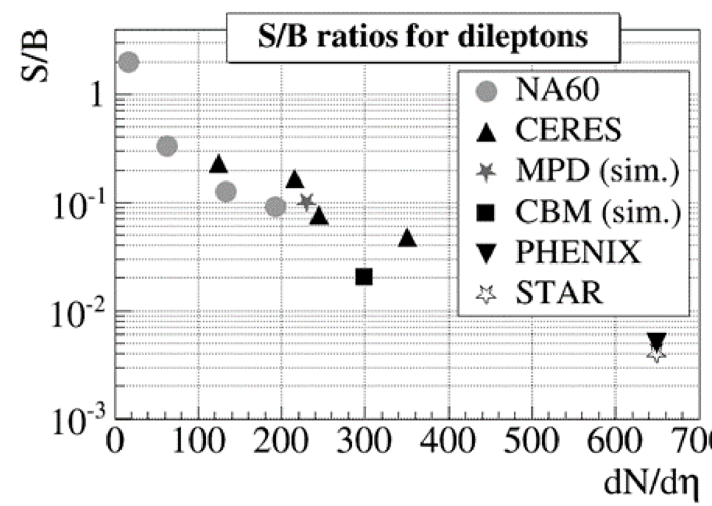


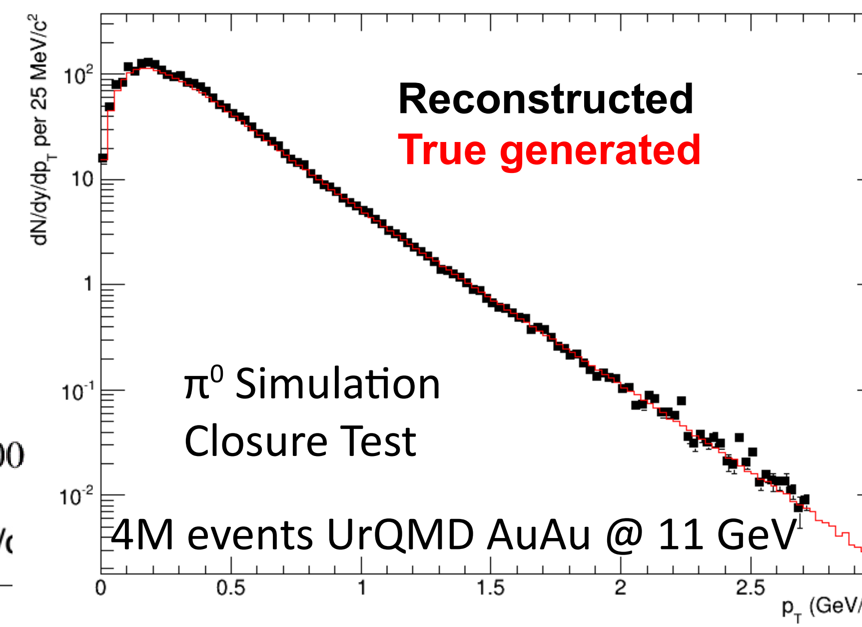
- Clear sensitivity of pion source size to the nature of the phase transitions
- Important and sensitive cross-check of detector performance (two-track resolution)

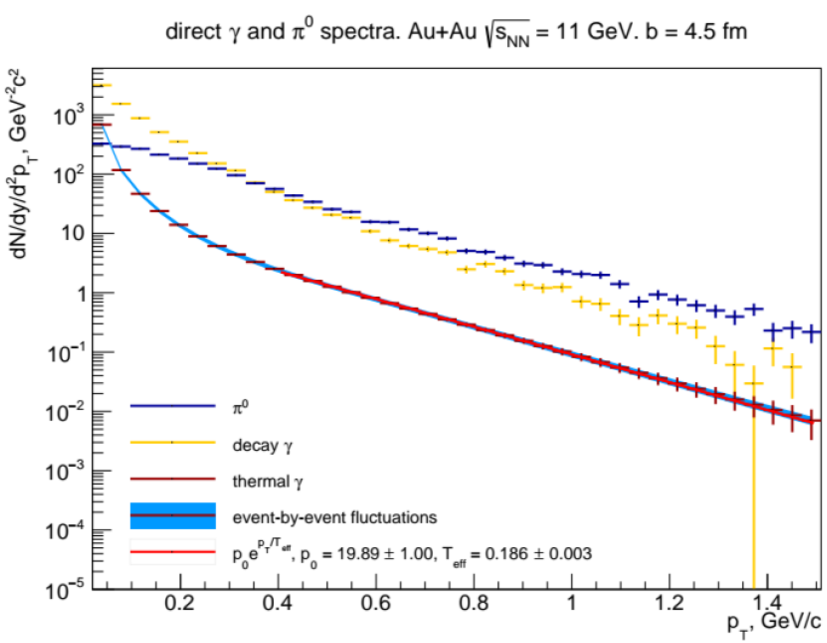
Electromagnetic probes in ECAL

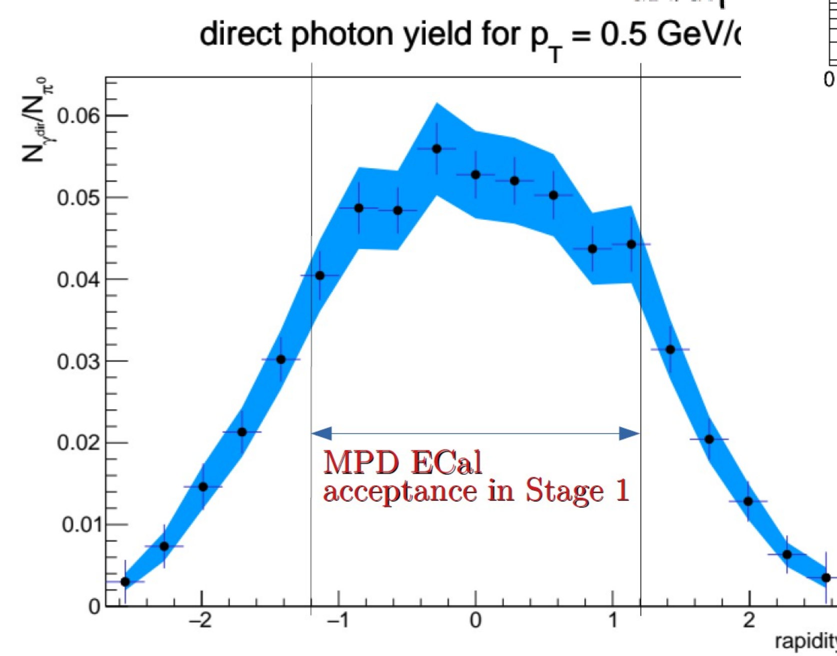
- Realistic ECAL reconstruction & analysis – large acceptance ECAL with good energy resolution: ideal tool for measurement of neutral mesons in a wide momentum range









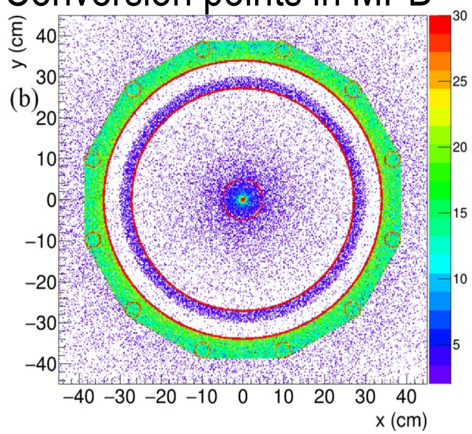


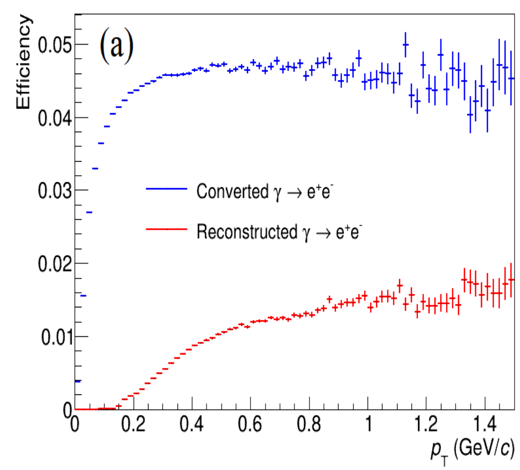
- Promising feasibility studies for prompt photon measurements in MPD

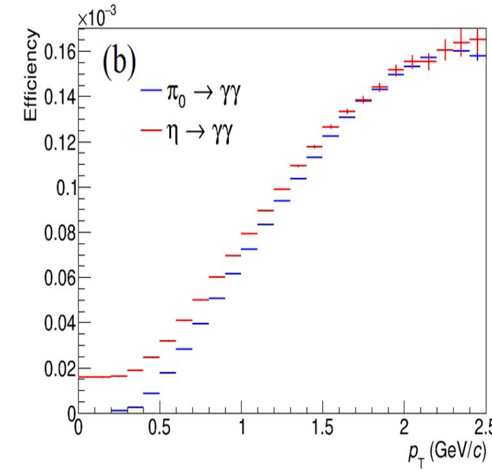
π^0 and η Reconstruction via conversion

- Photon reconstruction, complimentary to ECAL
- Direct photons, neutral mesons, geometry scan etc …
- Minbias AuAu@11, UrQMD - conversion on the beam pipe and inner layers of the TPC

Conversion points in MPD



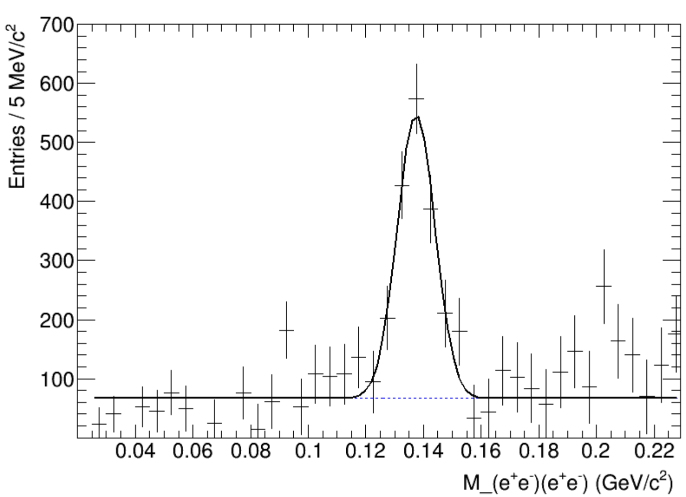




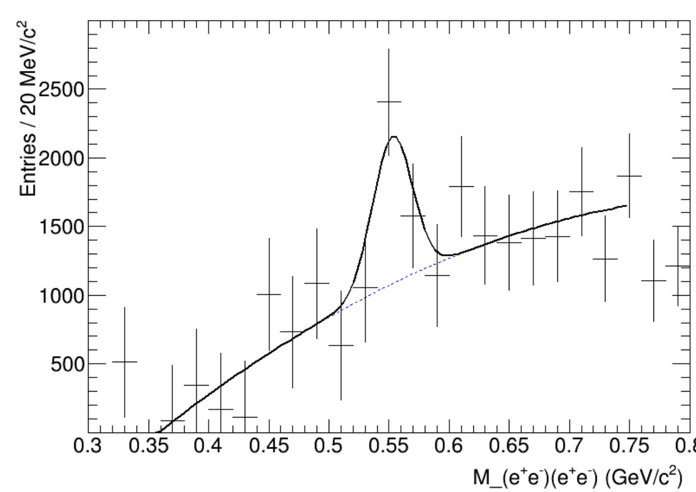
α) γ-conversion efficiency in the beam pipe & TPC vs p_T

b) MPD efficiency for π^0 and η reconstruction vs meson's p_T

$\pi^0 \rightarrow \gamma\gamma \rightarrow (e^+e^-)(e^+e^-)$



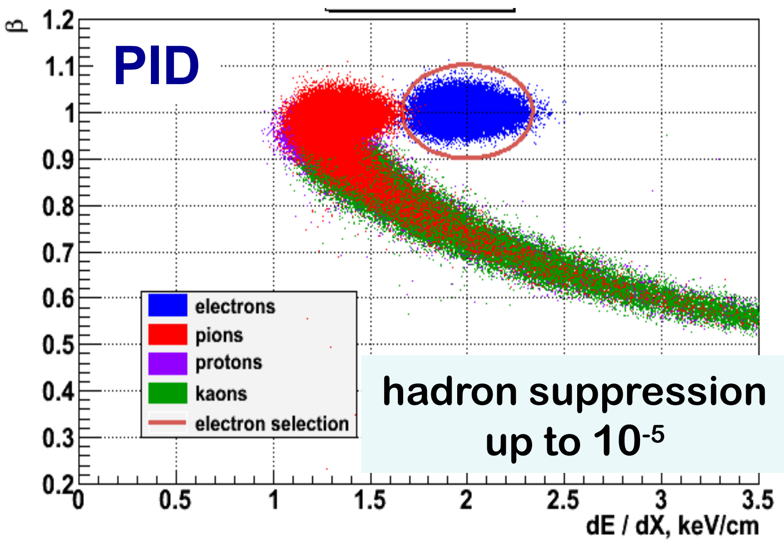
$\eta \rightarrow \gamma\gamma \rightarrow (e^+e^-)(e^+e^-)$

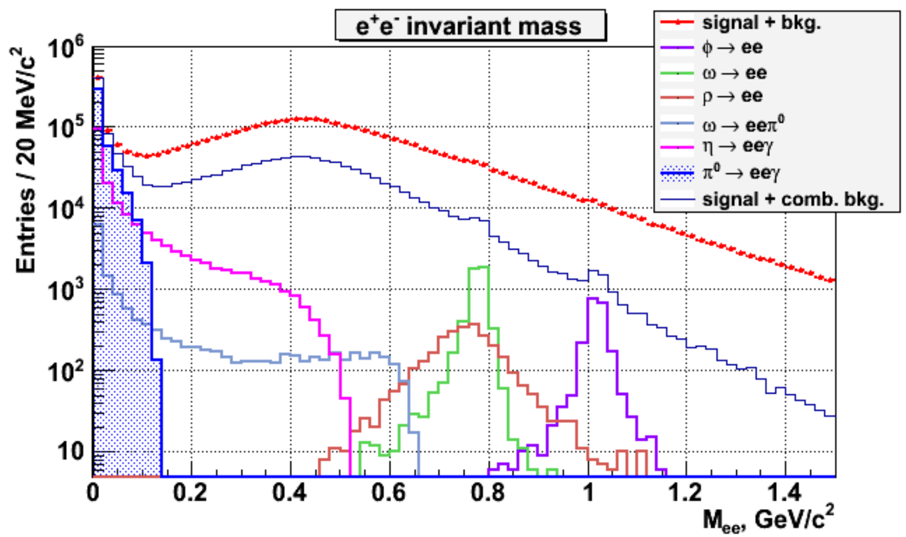


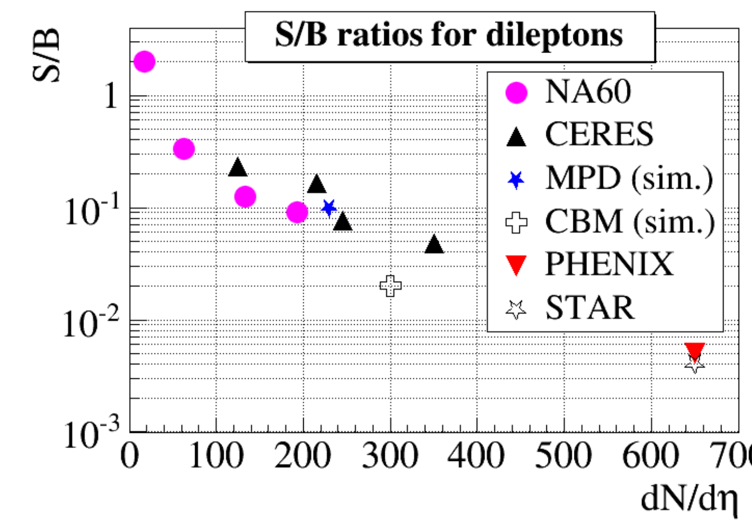
- Standard MPD configuration allows to reconstruct π^0 and η via conversion pairs

Prospects of dilepton studies

- **Event generator:** *UrQMD+Pluto (for the cocktail) central Au+Au @ 8 GeV*
- **PID**: *dE/dx (from TPC) + TOF (σ ~100 ps) + ECAL*

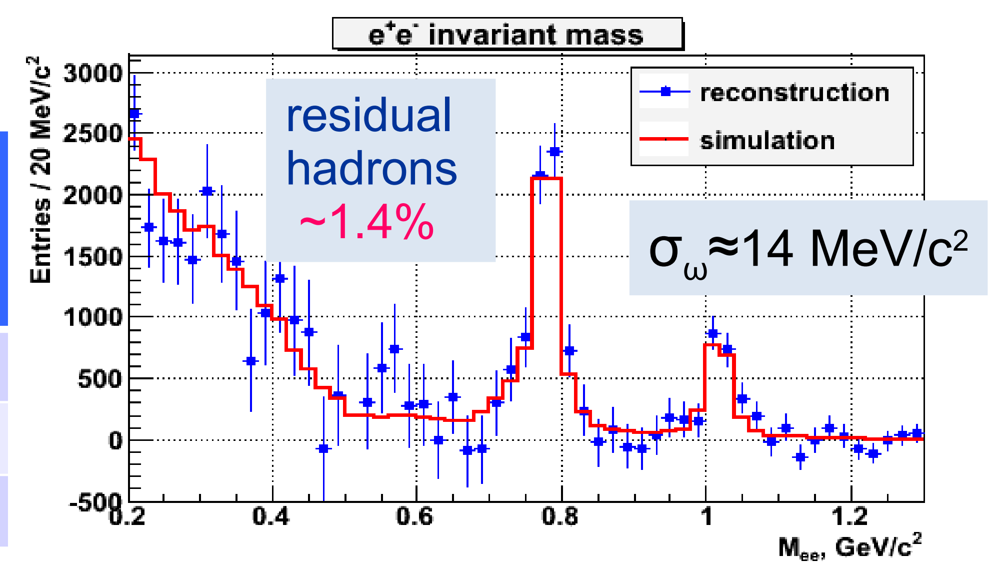






Yields, central Au+Au at $\sqrt{s_{NN}}$ = 8.8 GeV

Particle	Yields		Decay mode	BR	Effic. %	Yield /1 w
	4π	y=0				
ρ	31	17	e+e-	$4.7 \cdot 10^{-5}$	35	$7.3 \cdot 10^{4}$
ω	20	11	e+e-	$7.1 \cdot 10^{-5}$	35	$7.2 \cdot 10^{4}$
ϕ	2.6	1.2	e+e-	$3 \cdot 10^{-4}$	35	$1.7 \cdot 10^{4}$



Summary

- The NICA Accelerator Complex in construction with important milestones achieved and clear plans for 2021 and 2022
- All components of the MPD 1st stage detector advanced in production, commissioning expected for 2021 and 2022
- Intensive preparations for the MPD Physics programme with initial beams at NICA