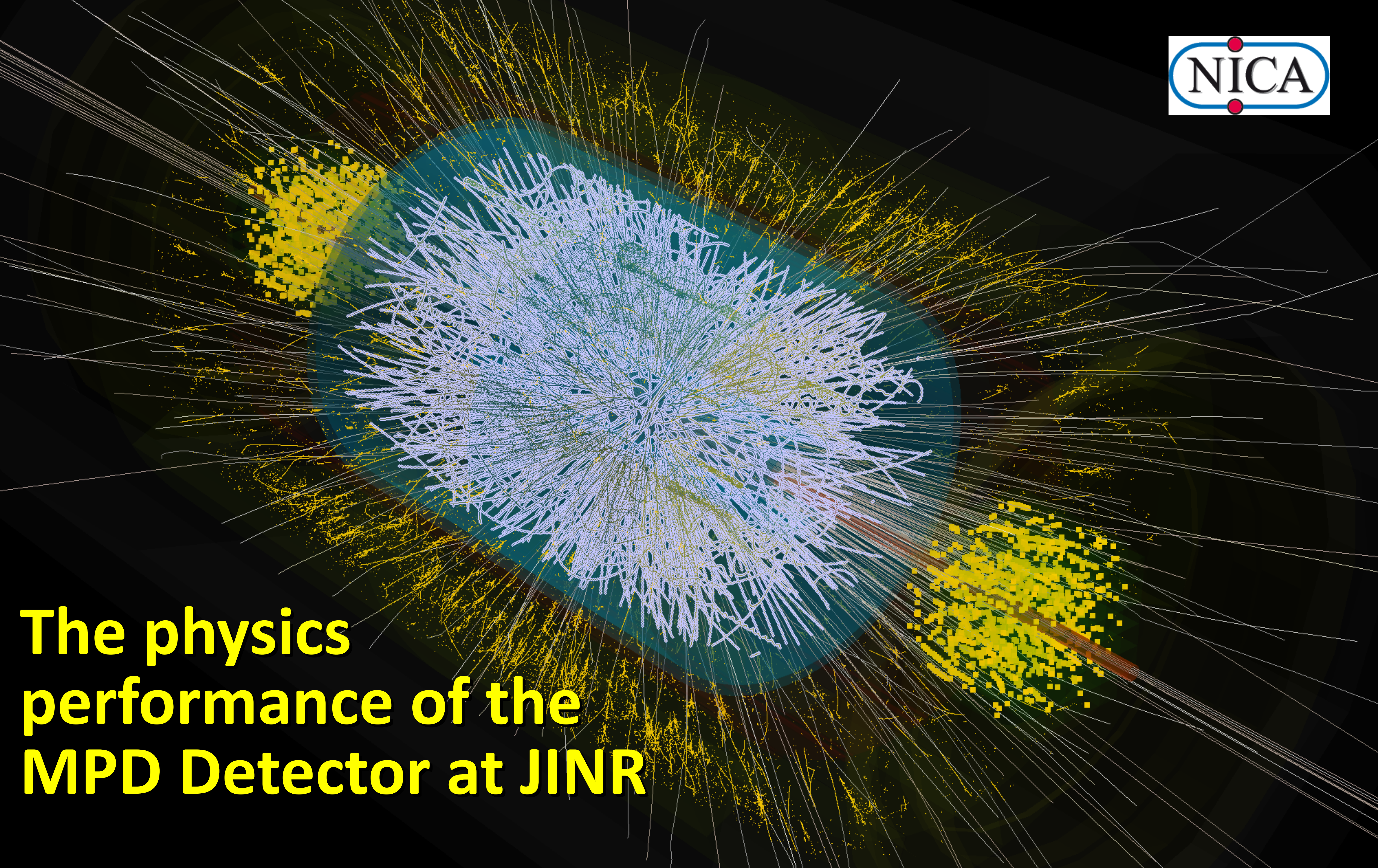
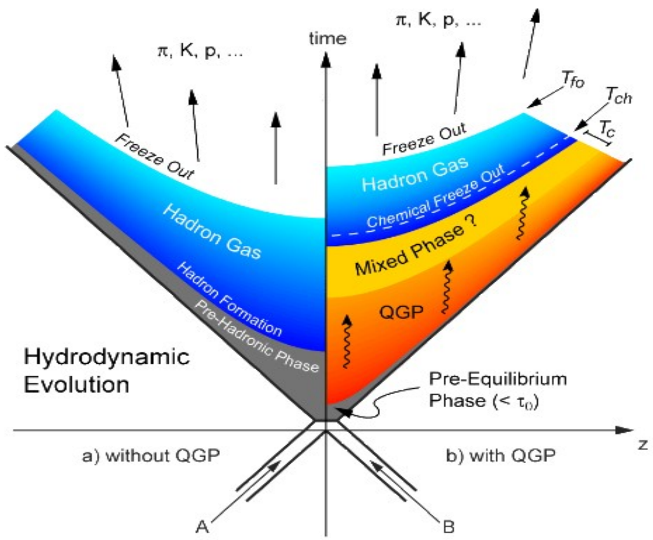


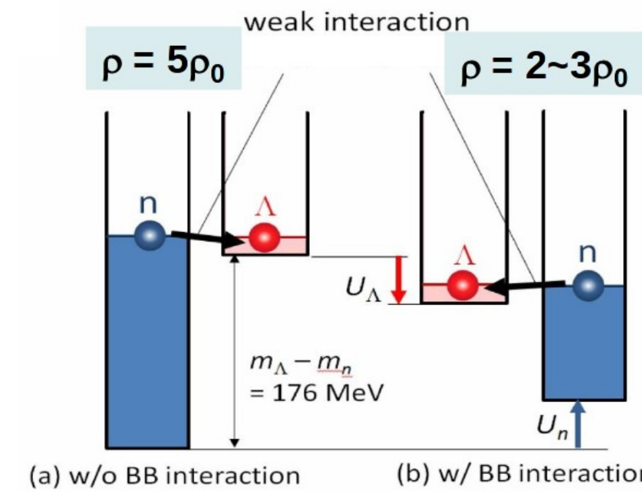
The physics performance of the MPD Detector at JINR

Unexplored phase space in QCD diagram

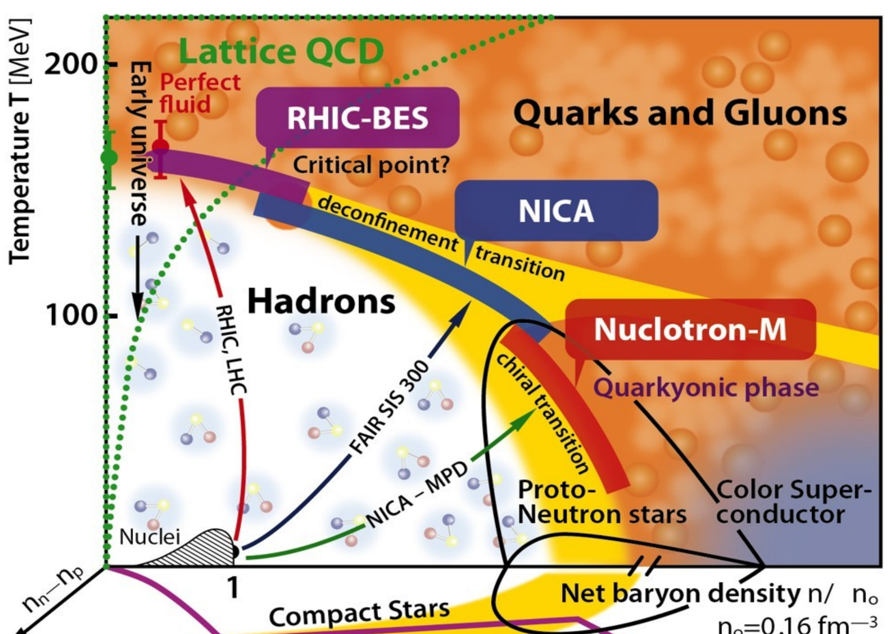


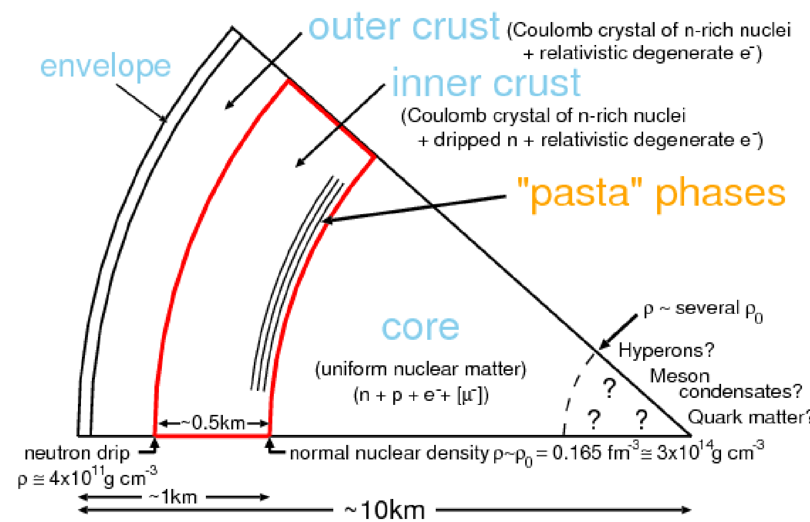
core of neutron stars reaches density several times nuclear density

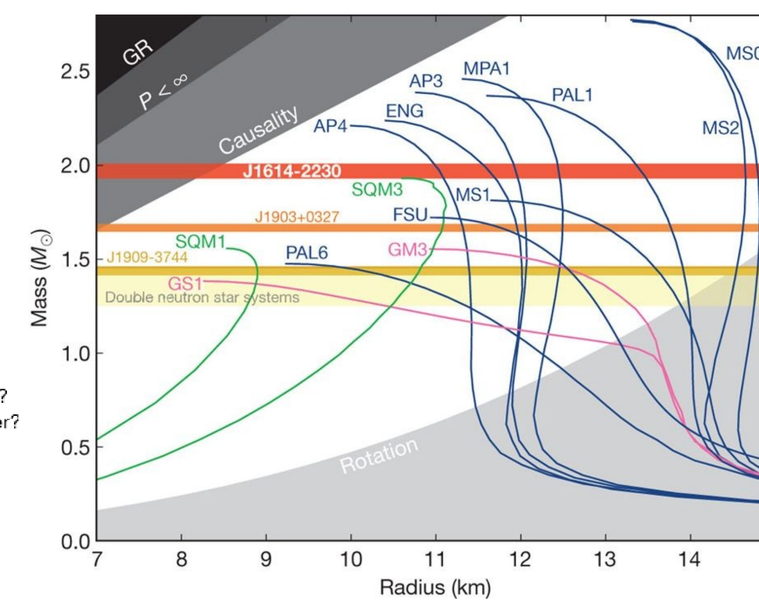
Credit: LIGO Collaboration



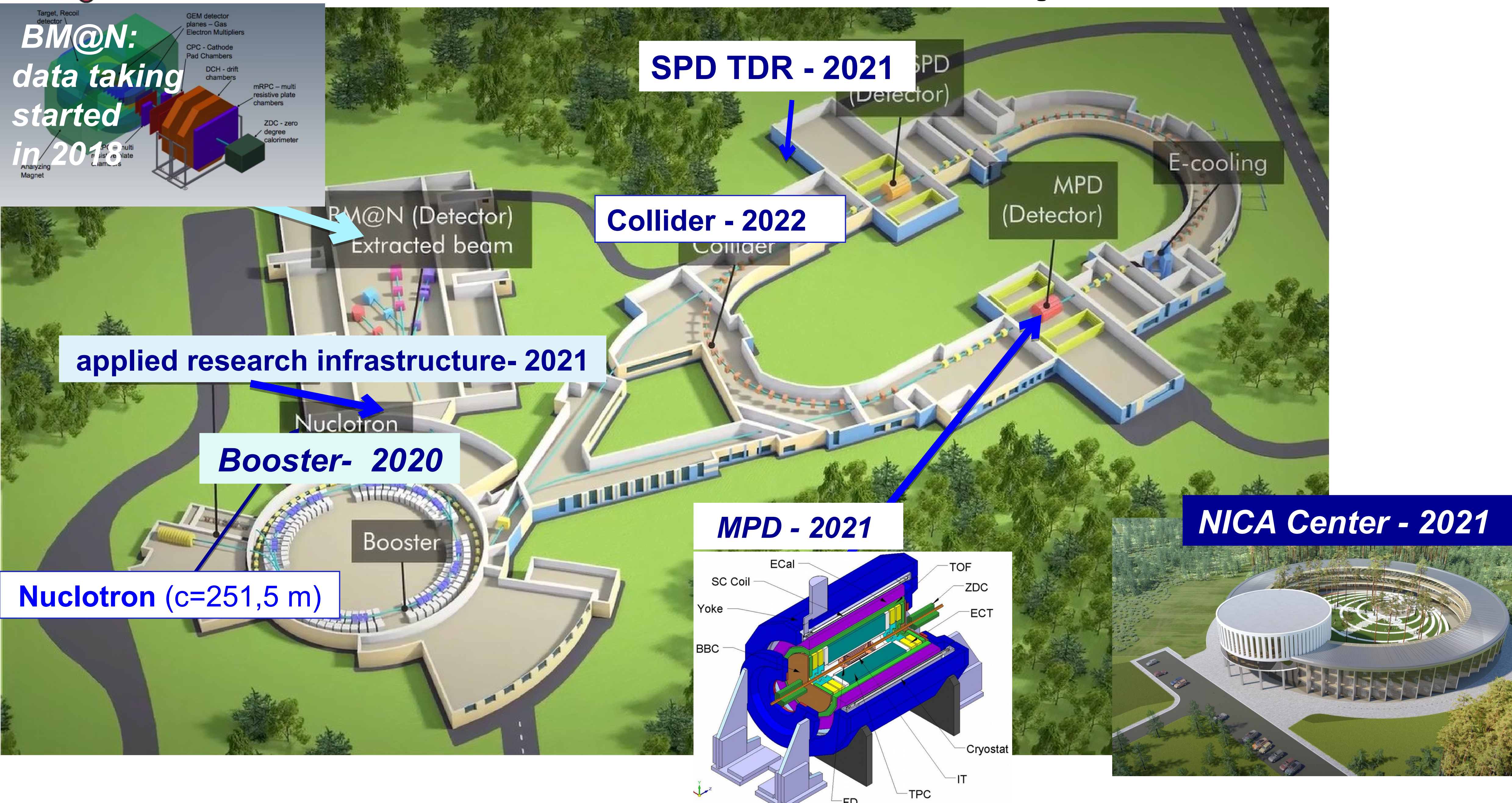
H. Tamura, Hadron 2017







NICA Accelerator Complex



Status of the Accelerator Complex

Linac HILac ← **KRION**

Linac LU-20 ← **Ion sources**

Booster (25 Tm)

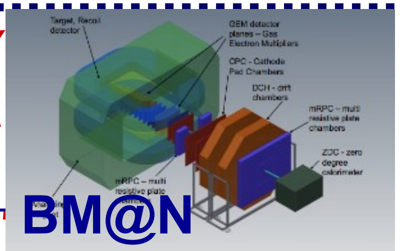
storage of $(2 \div 4)\times10^9$ ions, acceleration up to 600 MeV/u

Stripping (80%) $^{197}Au^{31+}$ => $^{197}Au^{79+}$

Nuclotron (45 Tm)

injection bunch ~ 2×10^9 ions acceleration up to ***1 - 4.5 GeV/u***

Fixed Target



BM@N

put in operation in 2018

Two SC collider rings

IP-2

$\sqrt{S_{NN}}$ = 4 – 11 GeV (Au+Au)

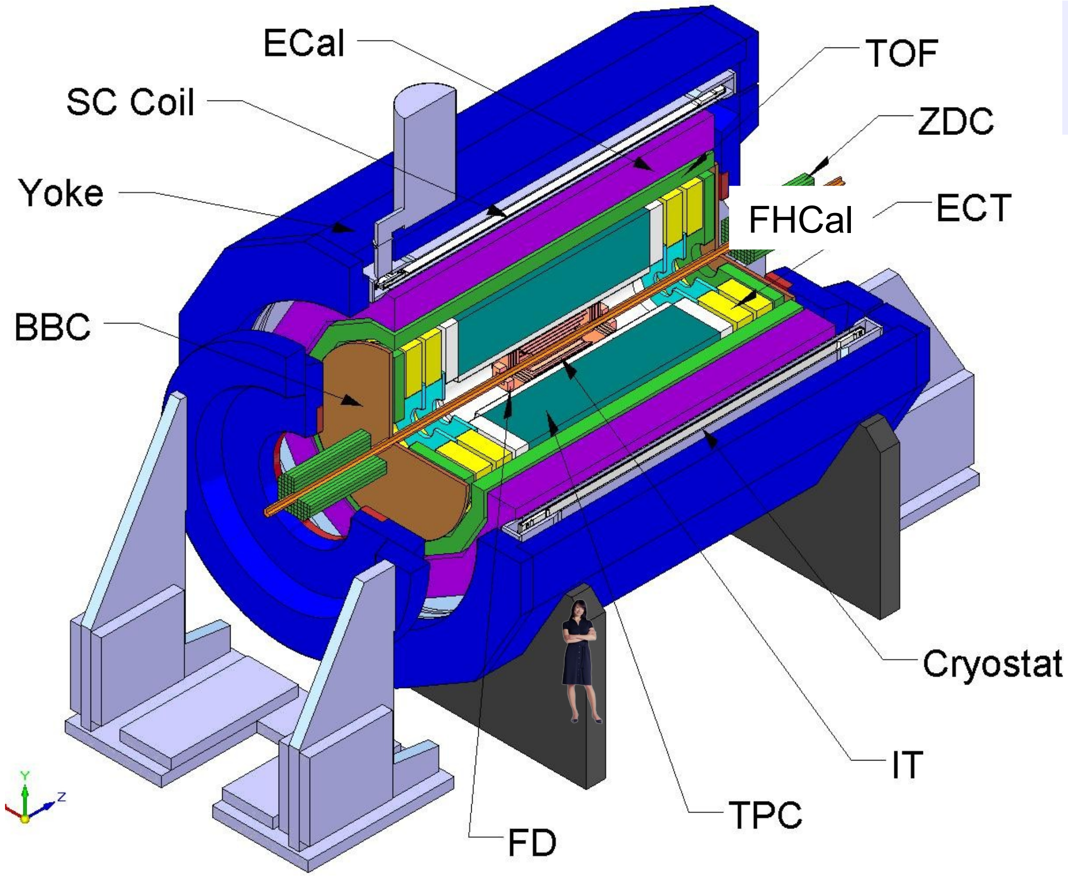
L = 1 x 10^{27} $cm^{-2} s^{-1}$

~ 2 x 22 injection cycles

22 bunches per ring

IP-1

Multi-Purpose Detector (MPD) Collaboration



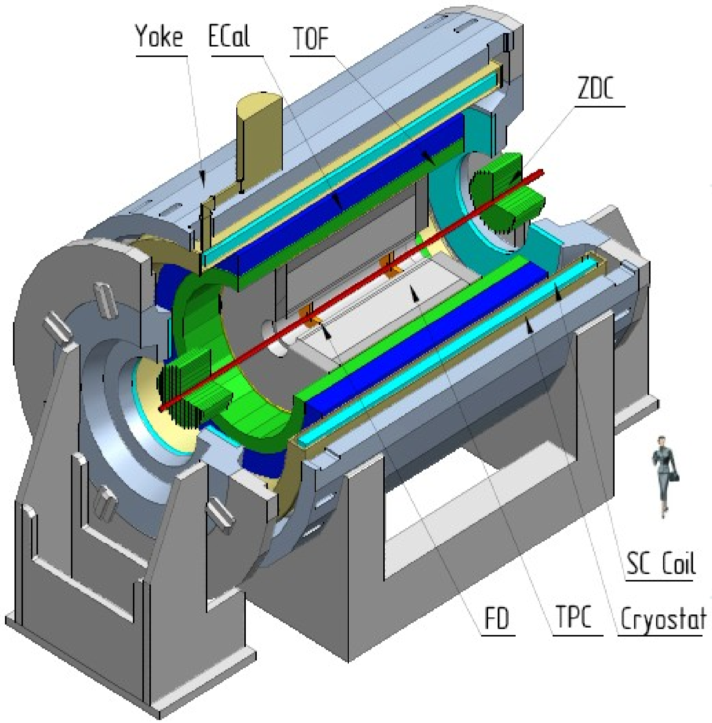
***11** Countries, **475** participants,*
33+5** Institutes and **JINR

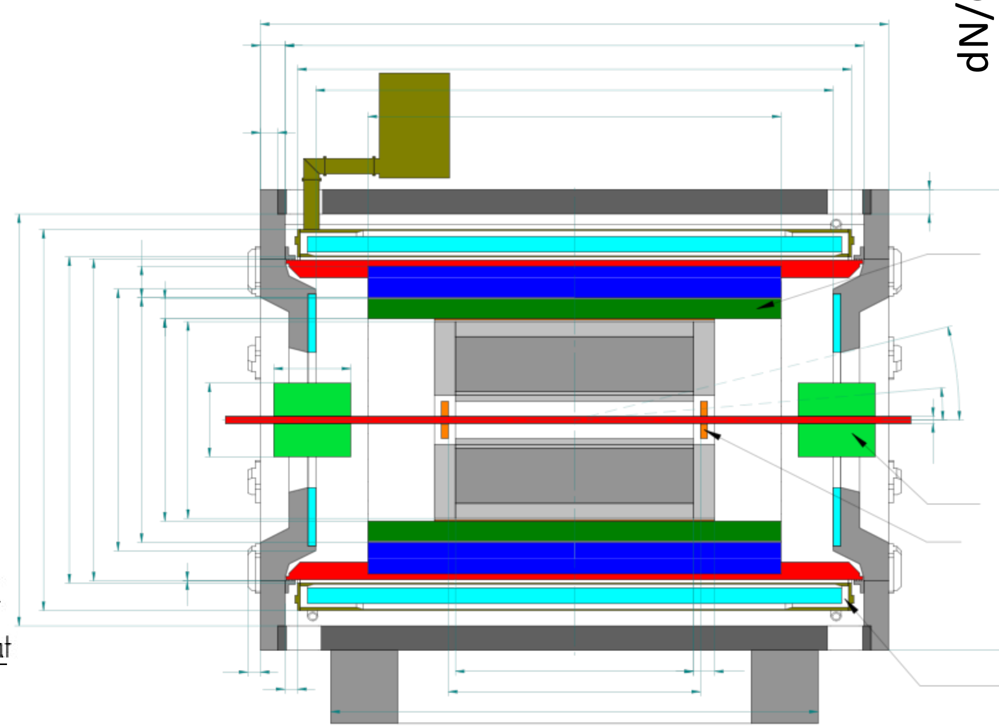
*AANL, Yerevan, **Armenia;***
*Baku State University, NNRC, **Azerbaijan**;*
*University of Plovdiv, **Bulgaria;***
*University Tecnica Federico Santa Maria, Valparaiso, **Chile**;*
*Tsinghua University, Beijing, **China**;*
*USTC, Hefei, **China**;*
*Huizhou University, Huizhou, **China**;*
*Institute of Nuclear and Applied Physics, CAS, Shanghai, **China**;*
*Central China Normal University, **China**;*
*Shandong University, Shandong, **China**;*

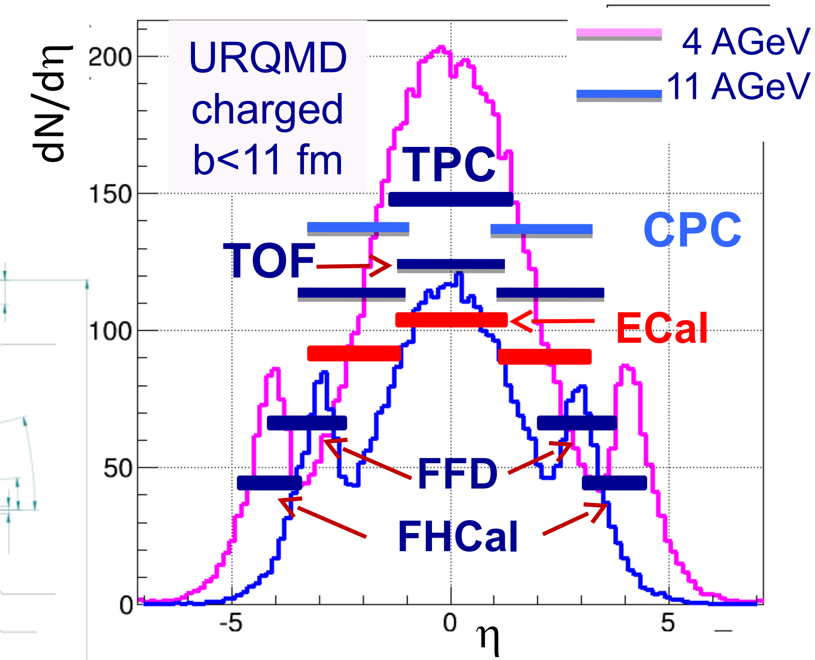
NICA

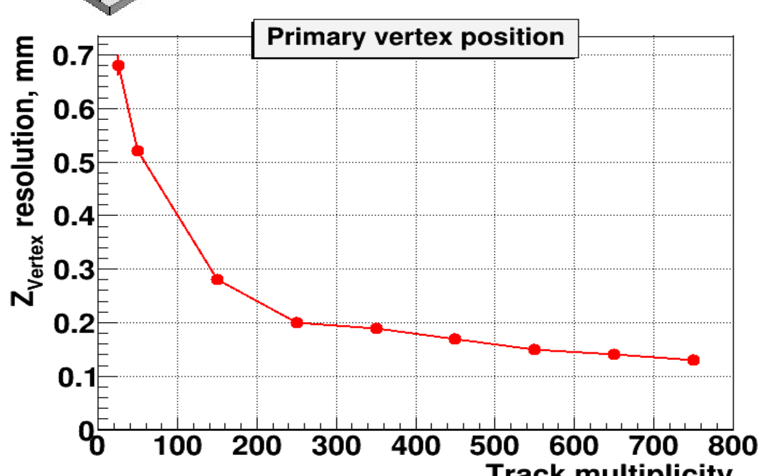
*IHEP, Beijing, **China**;*
*University of South China, **China**;*
*Three Gorges University, **China**;*
*Institute of Modern Physics of CAS, Lanzhou, **China**;*
*Palacky University, Olomouc, **Czech Republic**;*
*NPI CAS, Rez, **Czech Republic**;*
*Tbilisi State University, Tbilisi, **Georgia**;*
***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 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**;*
*SPSU - Dept. of NP, **Russia;***
*SINP, Moscow, **Russia**;*
*PNPI, Gatchina**, Russia**;*

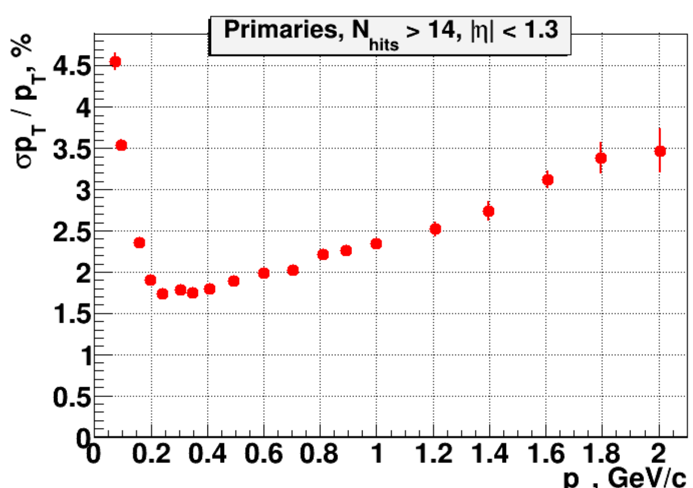
MPD 1st stage

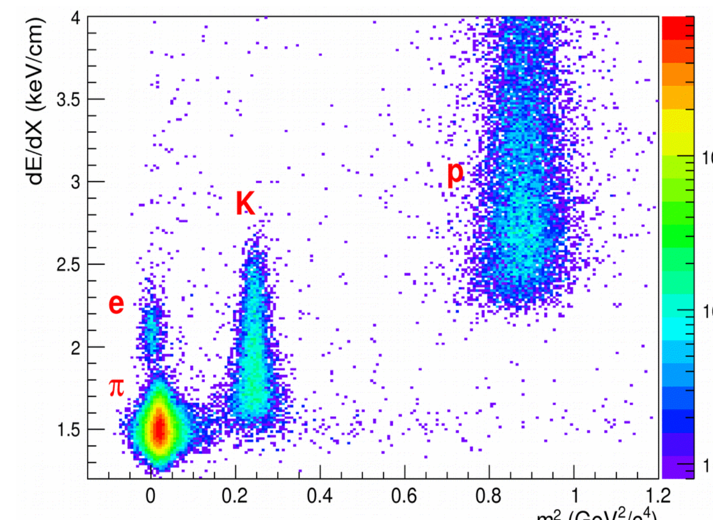












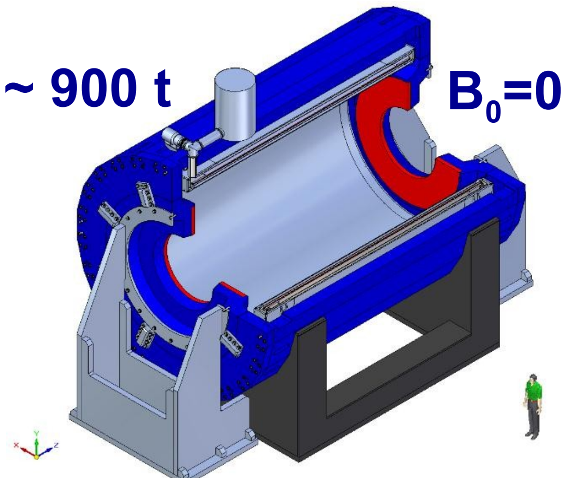
- 2π in azimuth, 3-D tracking (TPC), Powerful PID (TPC, TOF): - π/K up to 1.5 GeV/c, - K/p up to 3 GeV/c, Low material budget, High rate (<=6 kHz)

MPD Systems in production

SC Solenoid

~ 900 t

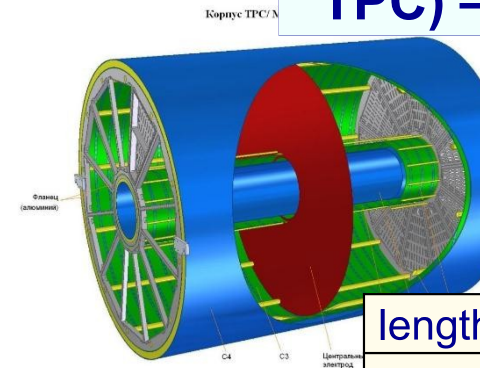
B_0=0.5 T

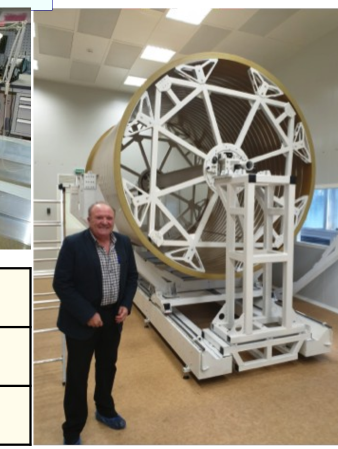


Yoke – produced & delivered

cryostat with SC coil - ready for cold tests

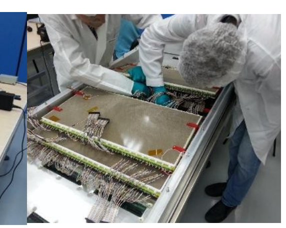
TPC) – basic tracker





length	*340 см*
out Radii	*140 см*
N chan.	***95 232***

TOF system

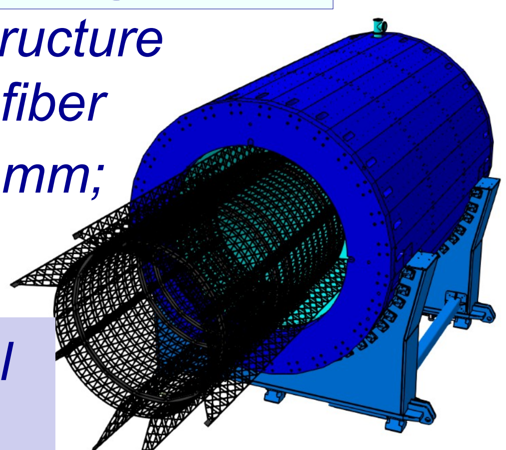


Integration

support structure of carbon fiber

sagite ~ ***5*** *mm;*
0,13 X_0

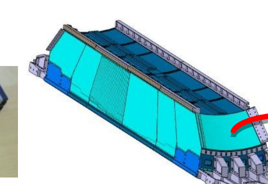
***ECal** barrel*
~ ***100*** *t*

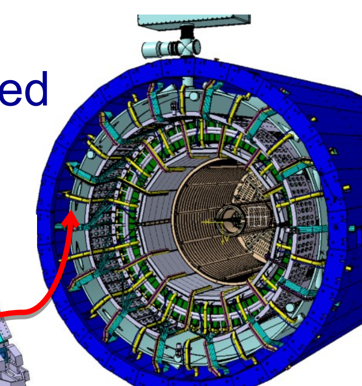


ECAL

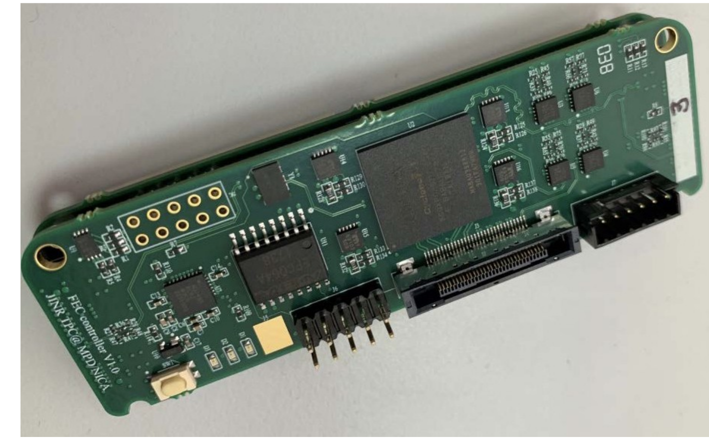
~ **43 000** modules to be produced

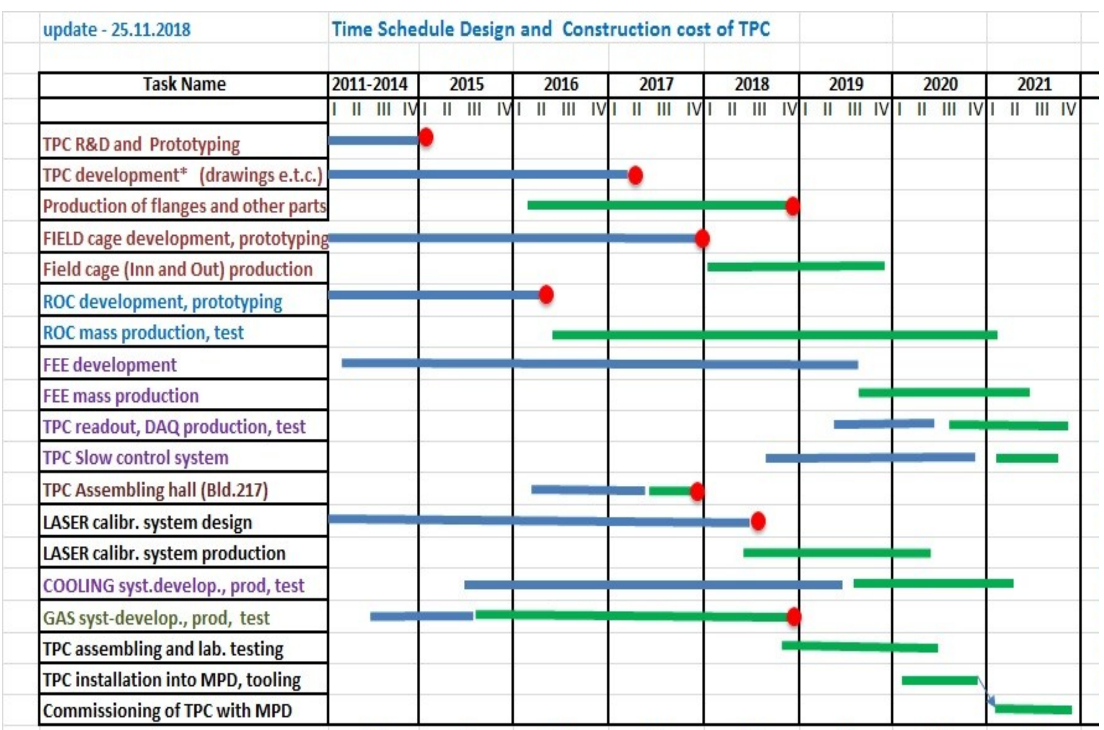
a module: Pb+Sc "shashlyk" type Ecal





MPD Time Projection Chamber

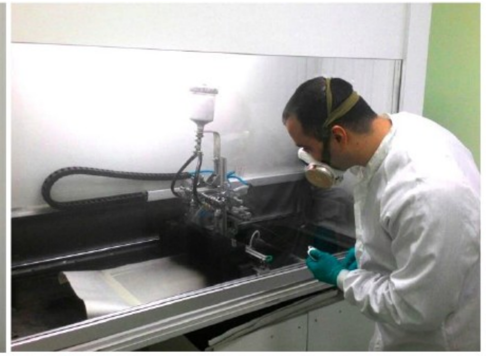




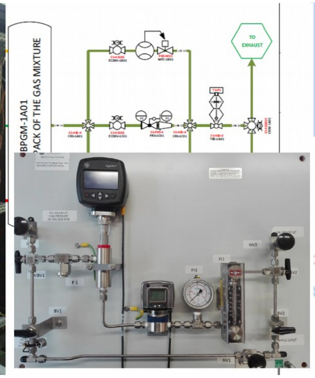
item	Date
Testing FEC v1.0 finished	Feb. 2019
Receive SAMPA V4 chips at Dubna 4500 (all)	June 2019
32 preproduction vervion 2.1 FE Card assembled (1/2ROC)	Jul. 2019
Testing of half ROC equipped with FE Cards	Aug. – Dec.2019
Production FE Cards for 1 ROC and Testing 2020	Dec. 2019-Apr.
Instrumentation and test ROC 2, 3, 4	May 2020
Production FE Cards for the first 10 ROCs (Total 14)	July 2020
Production FE Cards for the second 10 ROCs (Total 24)	August 2020

MPD Time-of-Flight

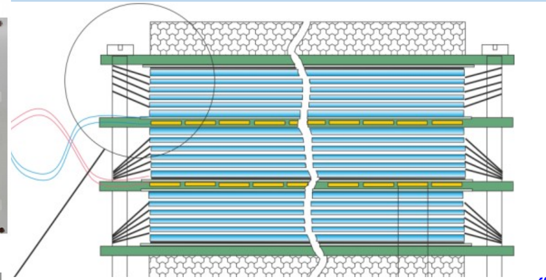

Ultrasonic wave glass cleaning


Painting of the HV conductive layer


MRPC assembling

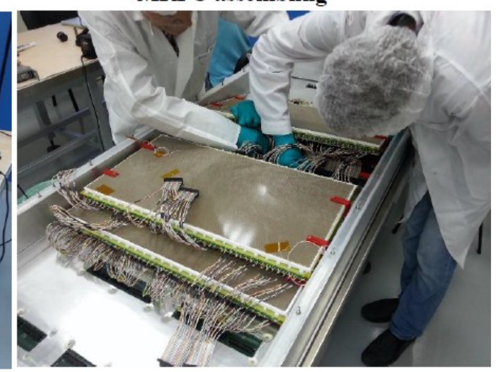


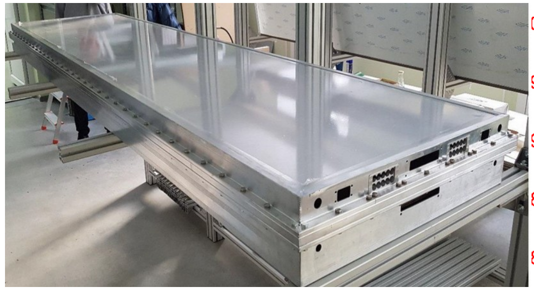
Dimensions of sensitive area
600 x300 mm^2

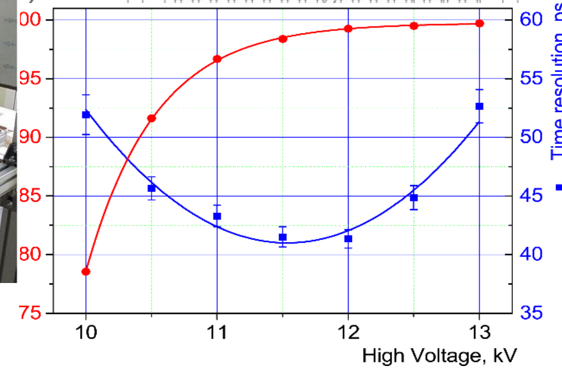



Optical quality control


Cables and connectors soldering


Detectors installation to the TOF box

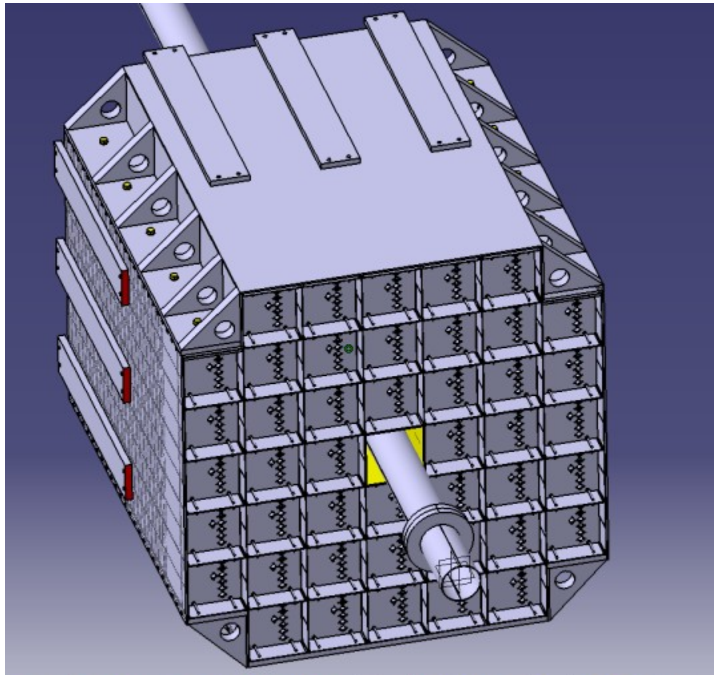


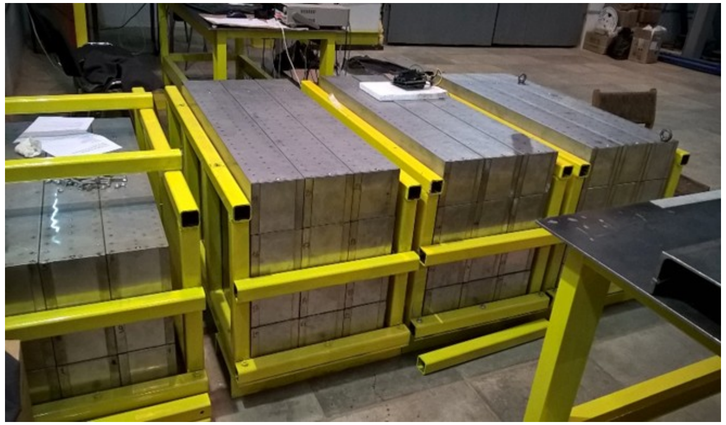


	Number of detectors	Number of readout strips	Sensitive area, m^2	Number of FEE cards	Number of FEE channels
MRPC	1	24	0.192	2	48
Module	10	240	1.848	20	480
Barrel	280	6720	51.8	560	13440 (1680 chips)

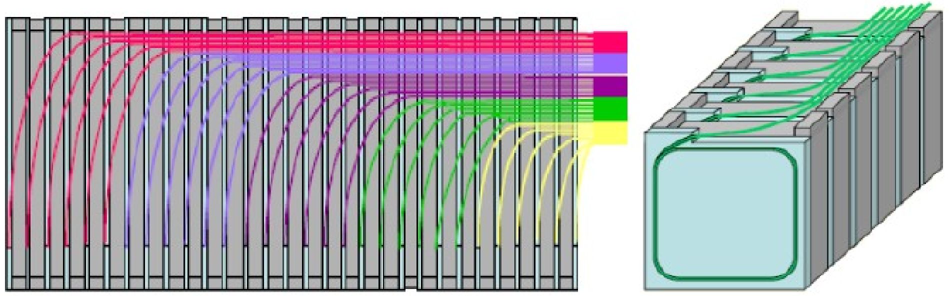
So far 20% of all mRPCs are assembled
At the end of October 2020 all mRPCs will be assembled.
Problems with leaks of gas box has been solved.
Assembled half sectors of TOF are under Cosmics tests

Forward Hadronic Calorimeter



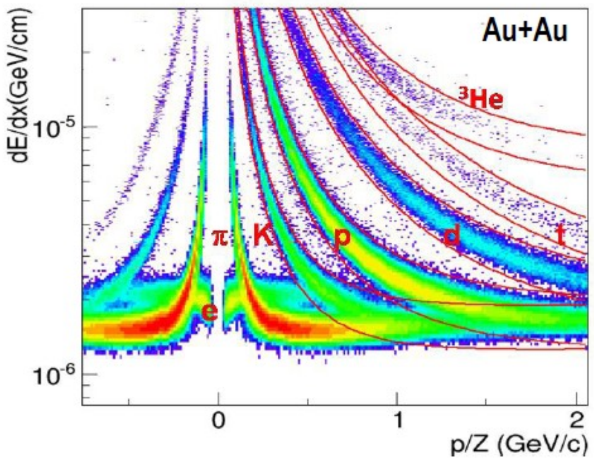


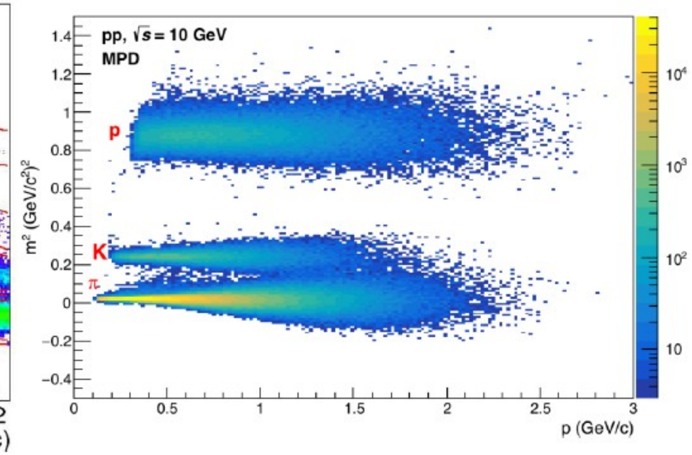
- Two-arms at ~3.2 m from the interaction point.
- Each arm consists of 45 individual modules.
- Module size 150x150x1100cm^3 (55 layers)
- Pb(16mm)+Scint.(4mm) sandwich
- 7 longitudinal sections
- 6 WLS-fiber/MAPD per section
- 7 MAPDs/module

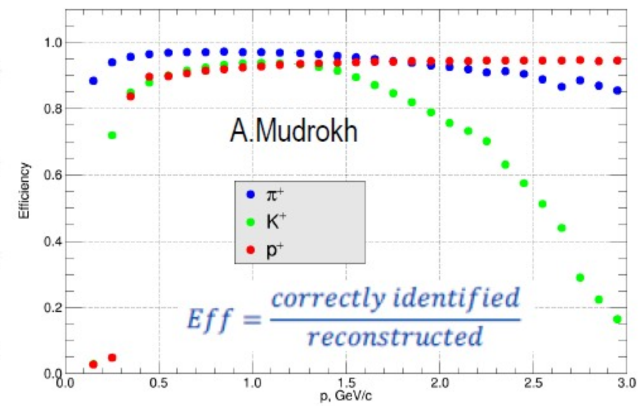


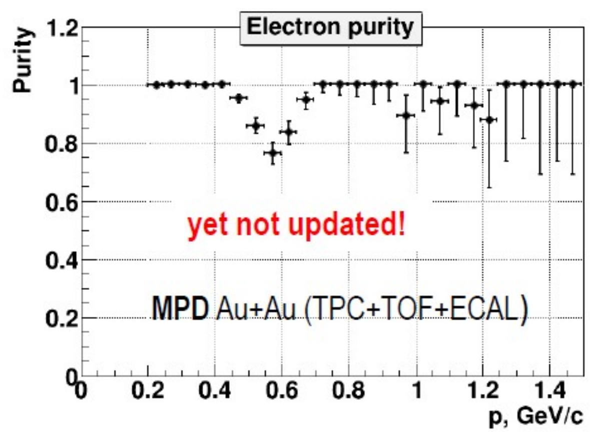
1. We have 80 modules ready (need 88)
   Plan to have 100 modules in September 2019
   Produced modules are under test on Cosmic
2. FE Electronics is under production – will be ready at the end of 2019
3. Design of the Support platform for FHCal is under way

PID Performance in MPD







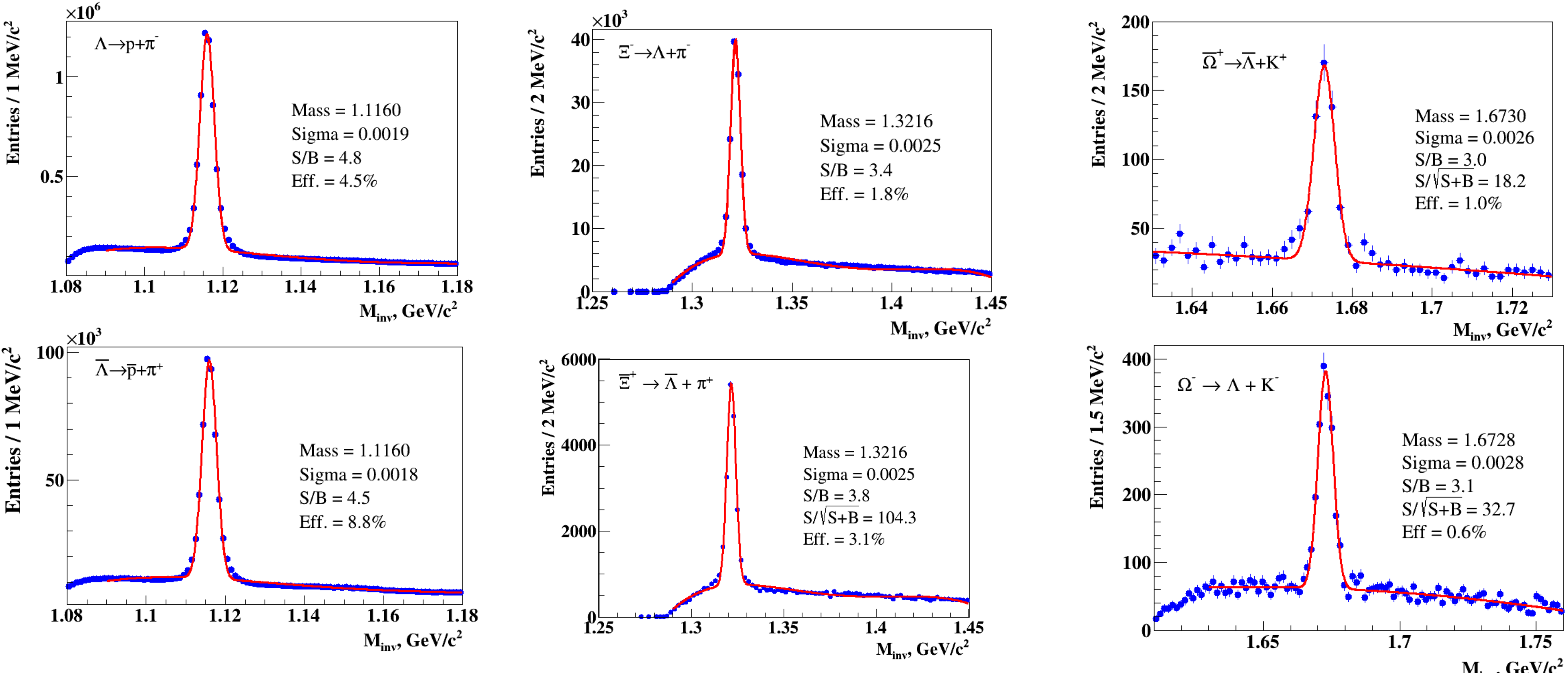


- Combined (dE/dx+TOF) PID for hadrons provides π/K up to 2 GeV/c and K/p up 3 GeV/c
- An extra hadron suppression in the electrons will be provided by ECAL

6

Strange and multi-strange baryons

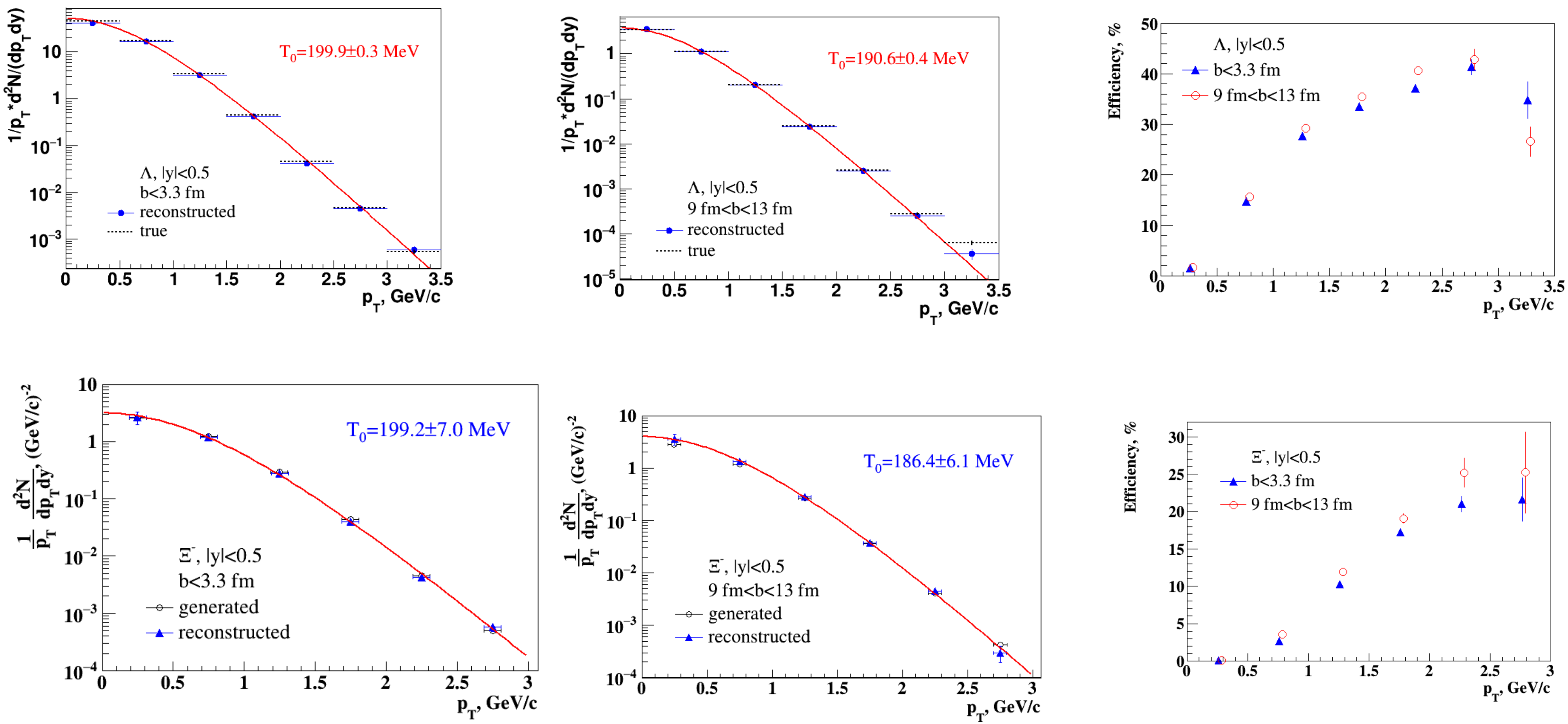
Stage'1 (TPC+TOF): Au+Au @ 11 GeV, UrQMD



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

NICA

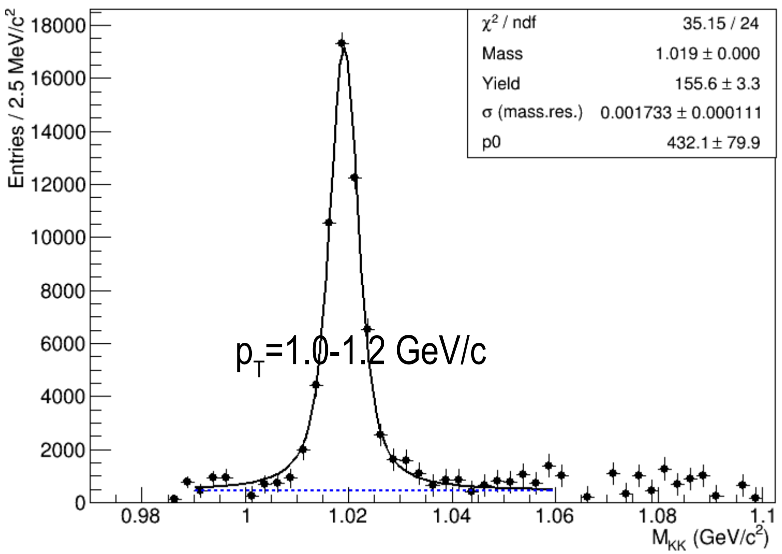
Efficiency and p_T spectrum



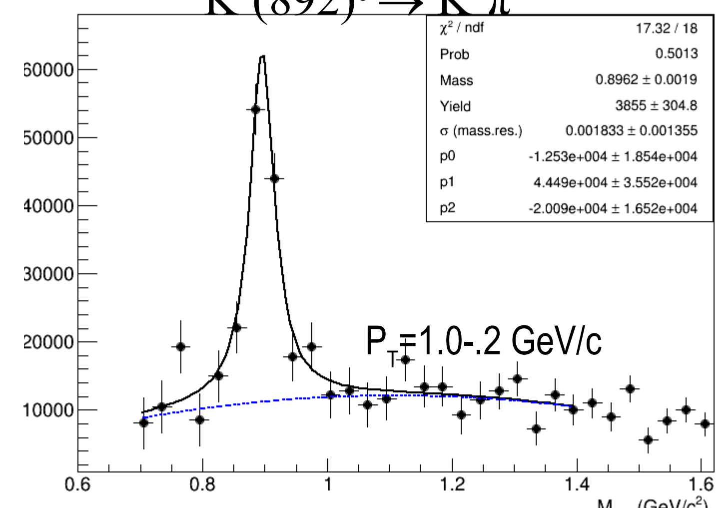
Resonances at MPD

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

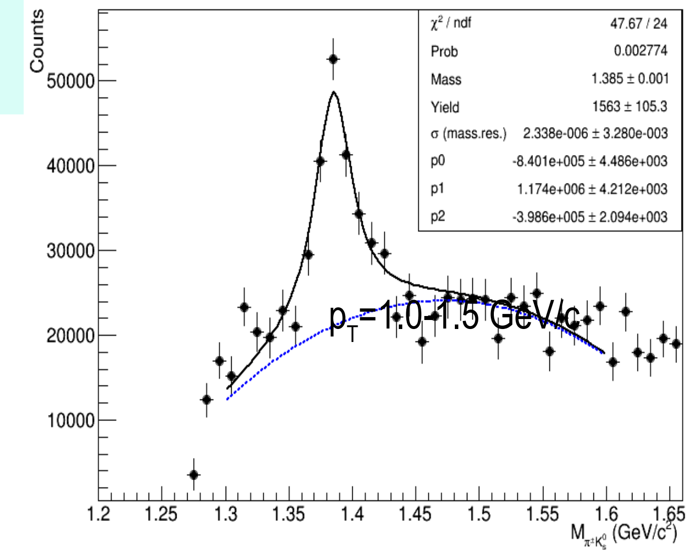
$\phi(1020) \rightarrow K^+K^-$,



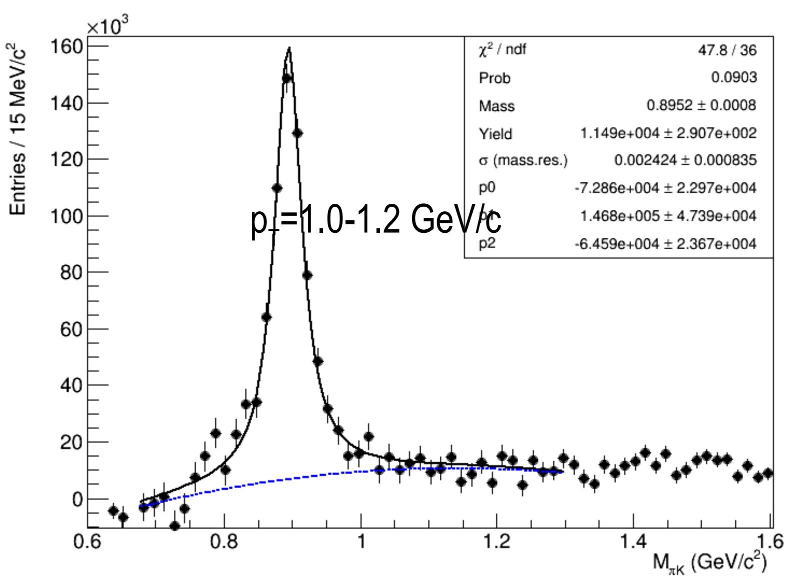
$K^*(892)^0 \rightarrow K^\pm\pi^\pm$



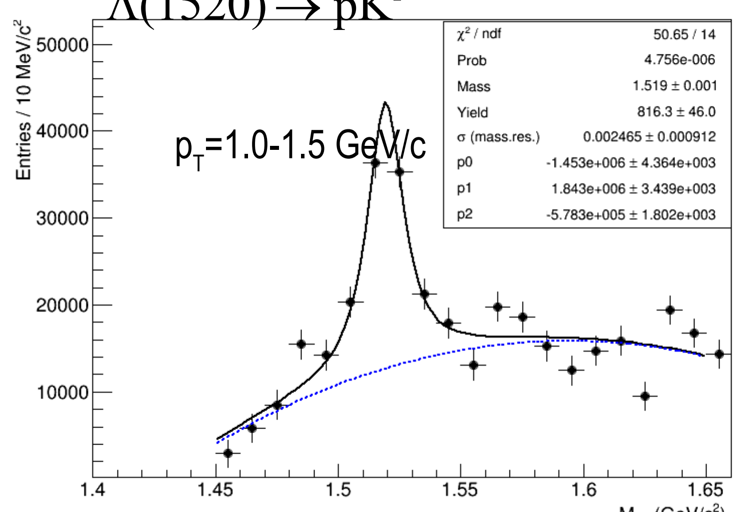
$\Sigma(1385)^\pm \rightarrow \pi^\pm\Lambda\ (\Lambda \rightarrow p\pi)$



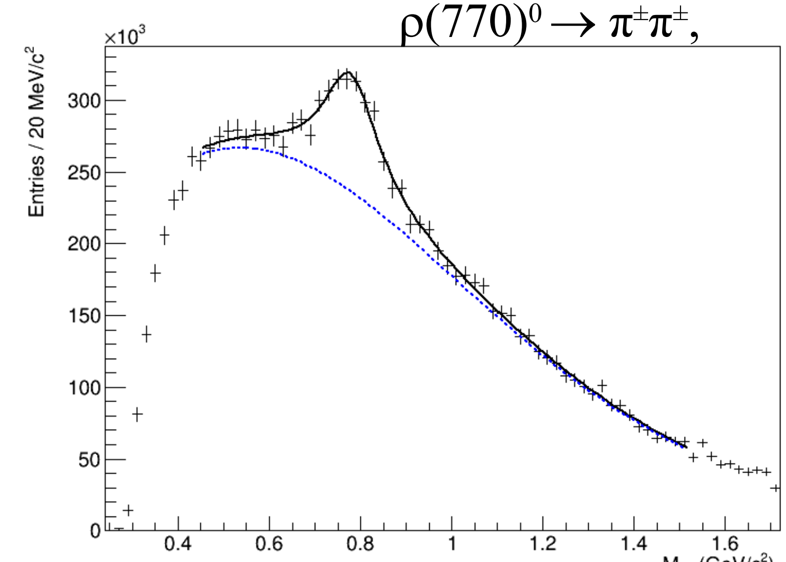
$K^*(892)^\pm \rightarrow \pi^\pm K_s\ (K_s \rightarrow \pi^+\pi^+)$



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

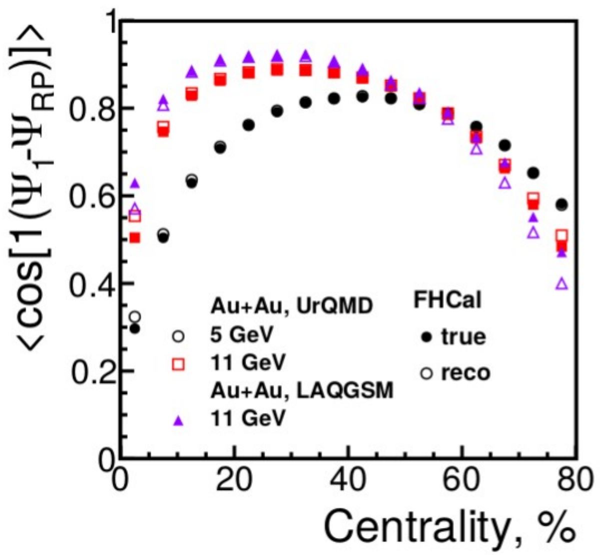


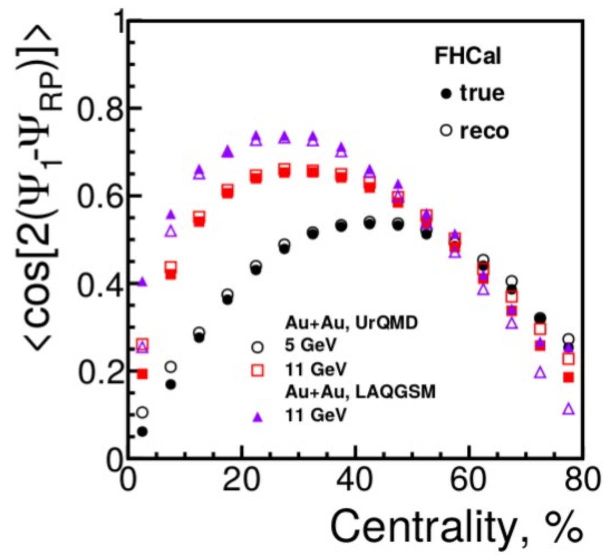
$\rho(770)^0 \rightarrow \pi^\pm\pi^\pm$,

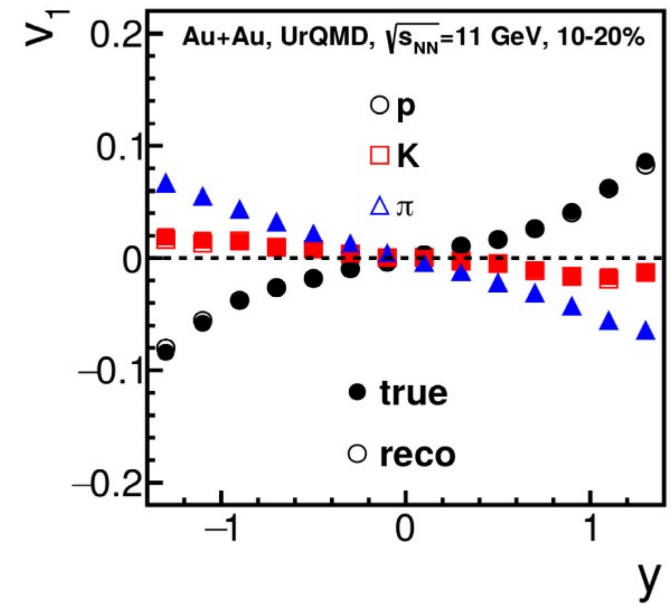


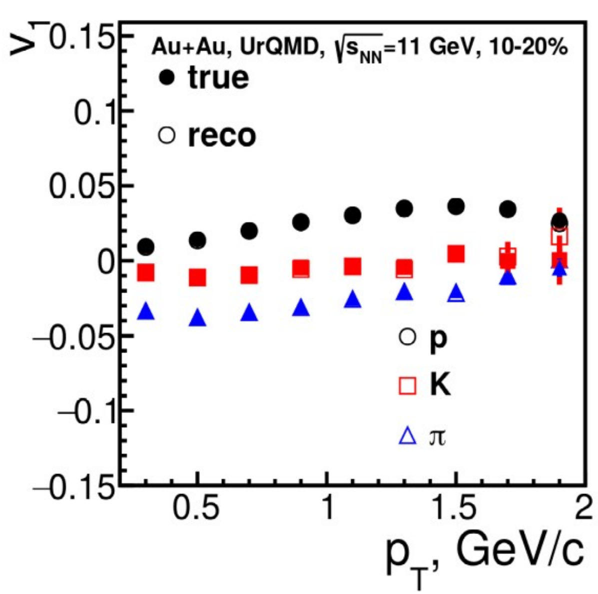
Performance of collective flow studies

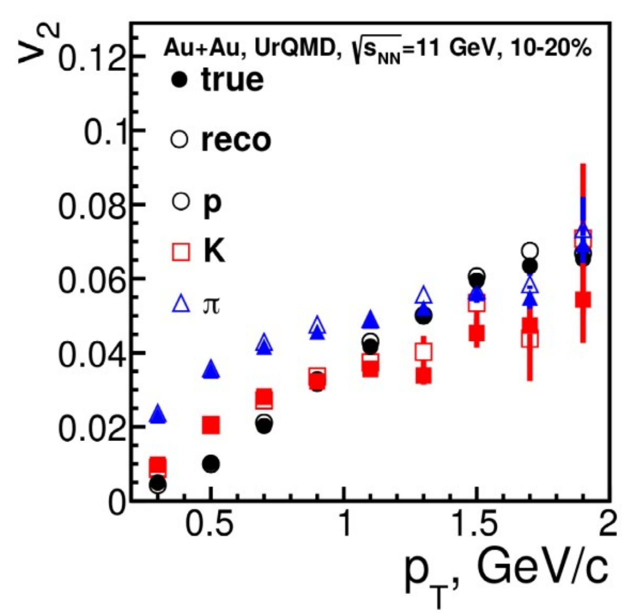
Au+Au, $\sqrt{s_{NN}}$ = 11 GeV, UrQMD, GEANT3

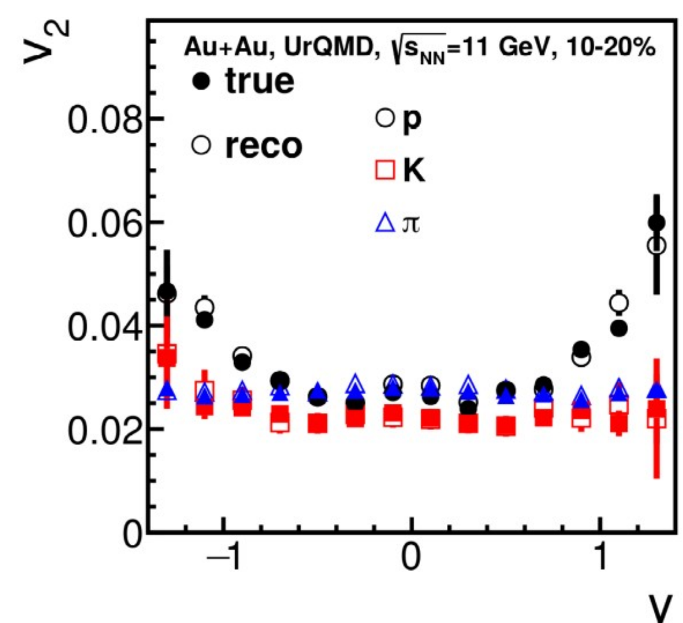












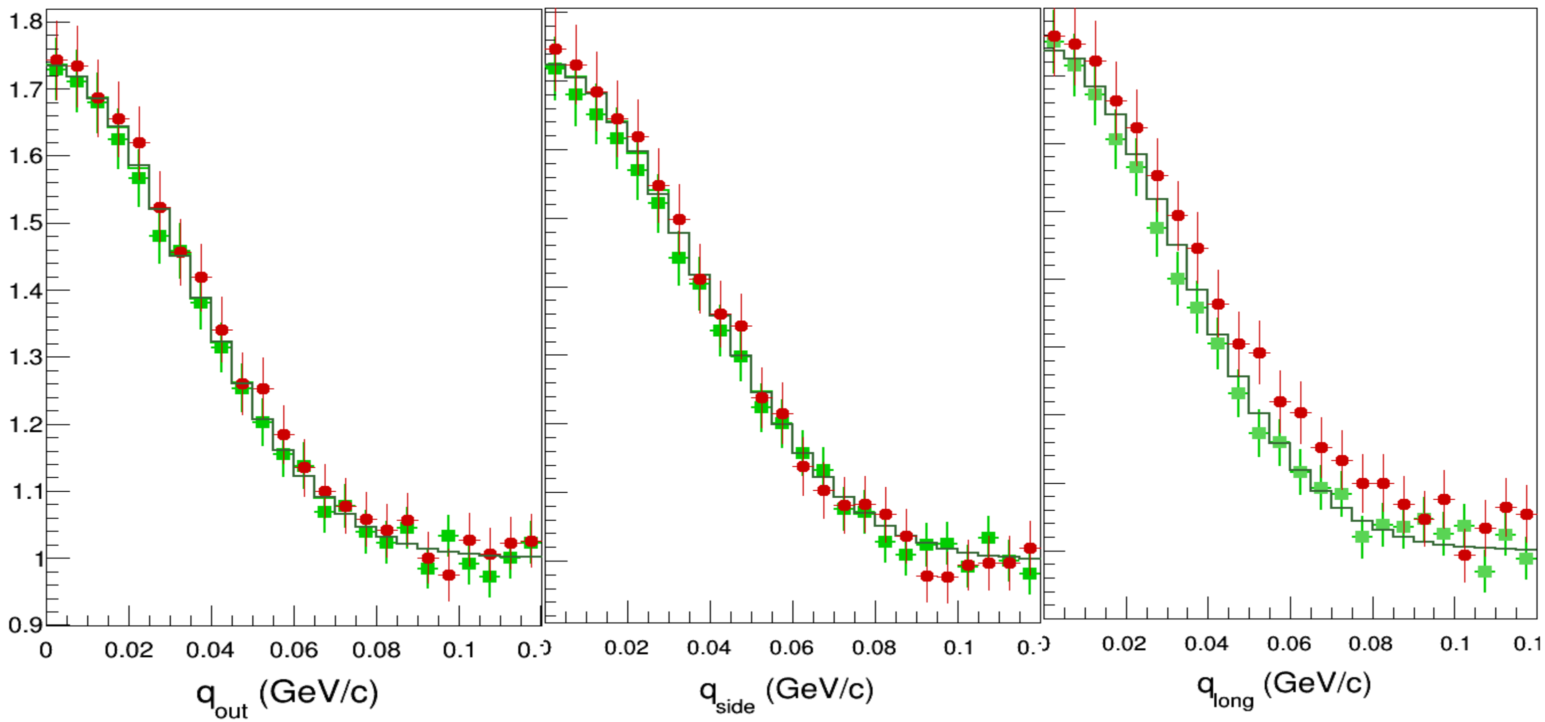
Femtoscopy in MPD

Study of collective effects, space-time characteristics of the emitting source at kinetic freeze-out, collision dynamics and quark-hadron phase transitions via femtoscopic correlations of hadrons at NICA energies

- MC input: vHLLE+UrQMD model implements hydro stage with different EoS, tuned to reproduce experimental data
- Data set : Au+Au collisions at 11 GeV, MPD full reconstruction chain
- Kaon particle ID and Correlation Function (CF) reconstruction

Projections of 3D kaon CF on the Out-Side-Long directions

Green – first order phase transition (1PT), **Red** – crossover (XPT)

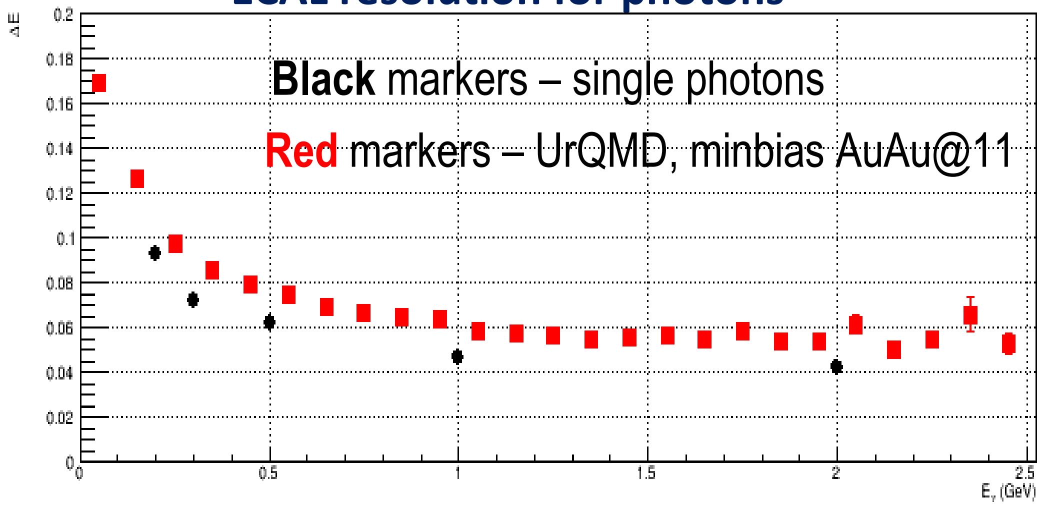


- **Gaussian shapes for kaon 3D CF**
- **"Long" CF projections for kaons differ for 1PT and XPT**

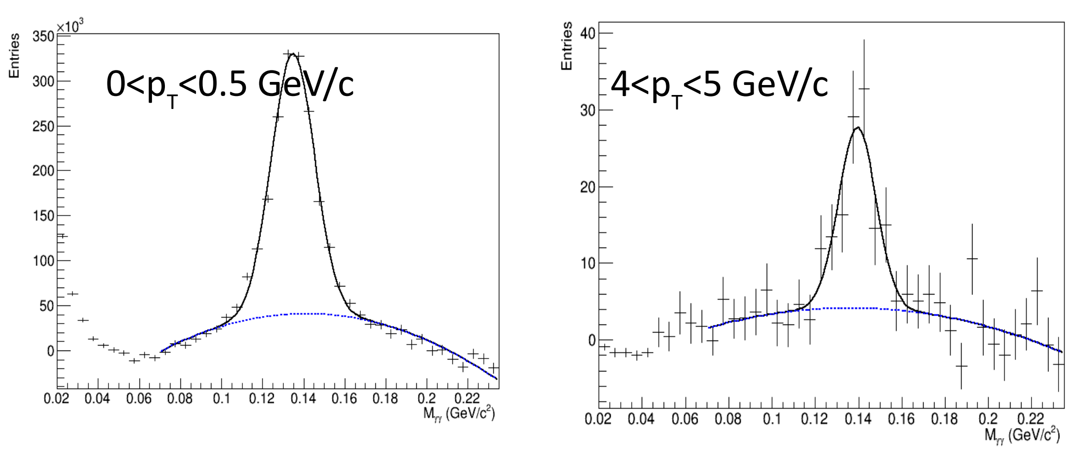
Electromagnetic Calorimeter simulation

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

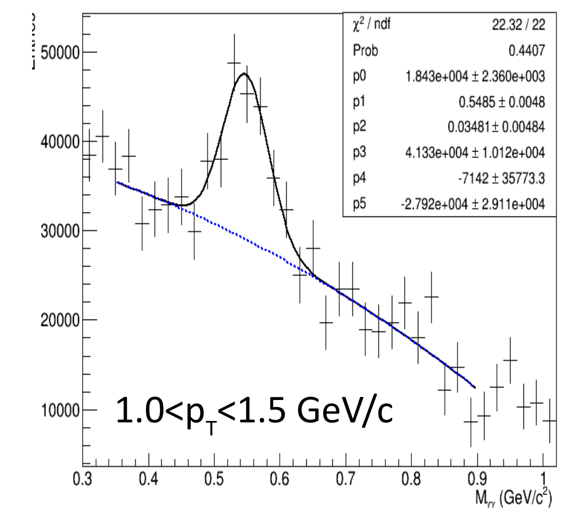
ECAL resolution for photons



π^0-meson in central Au+Au



η-meson in minbias Au+Au

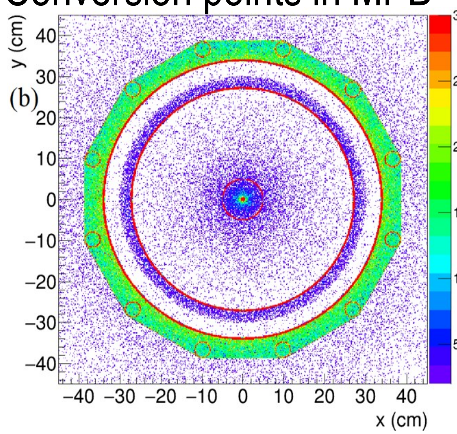


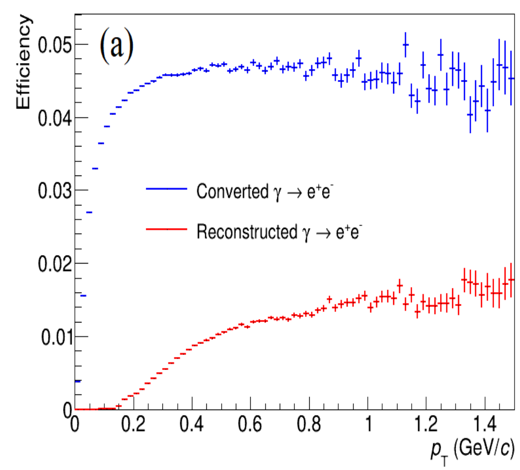
- **π^0 (η) reconstruction in MPD ECAL – feasible!**

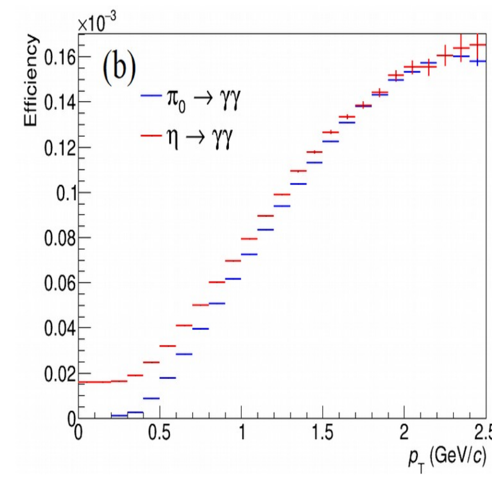
π^0 and η Reconstruction via conversion

- 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



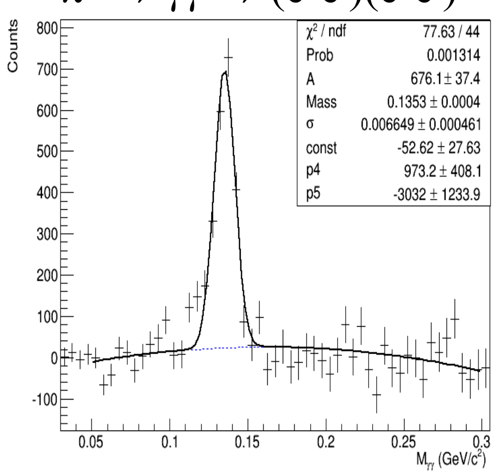




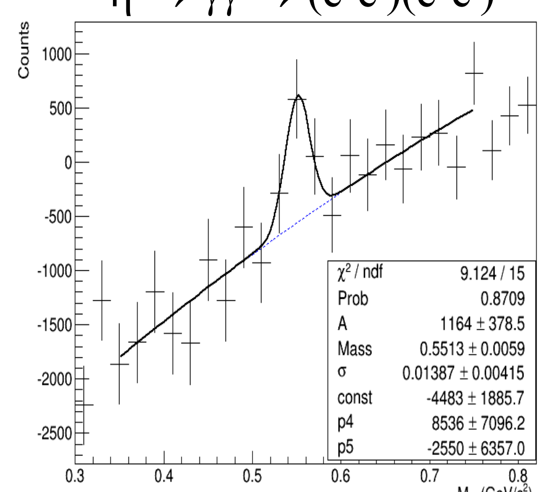
α) γ-conversion efficiency in the beam pipe & TPC vs p_T

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

Summary