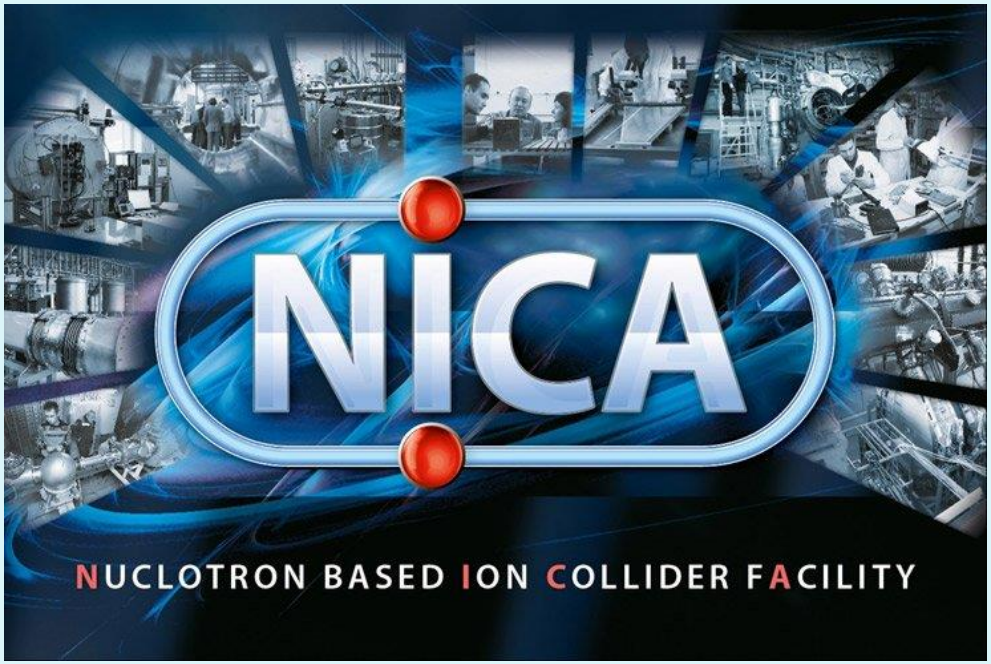
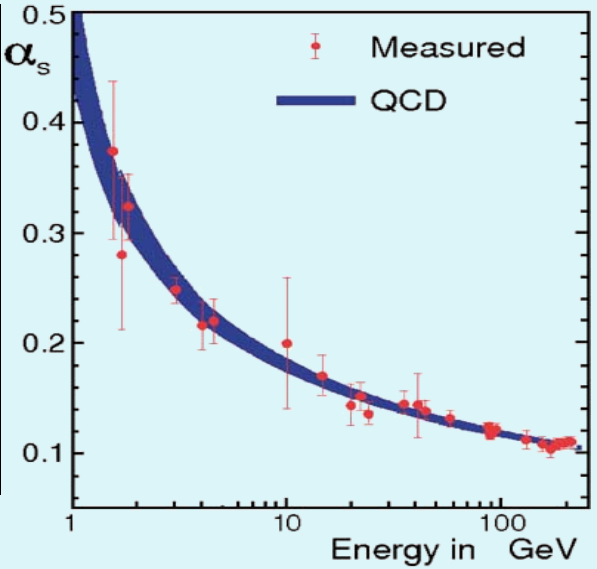
MultiPurpose Detector – MPD

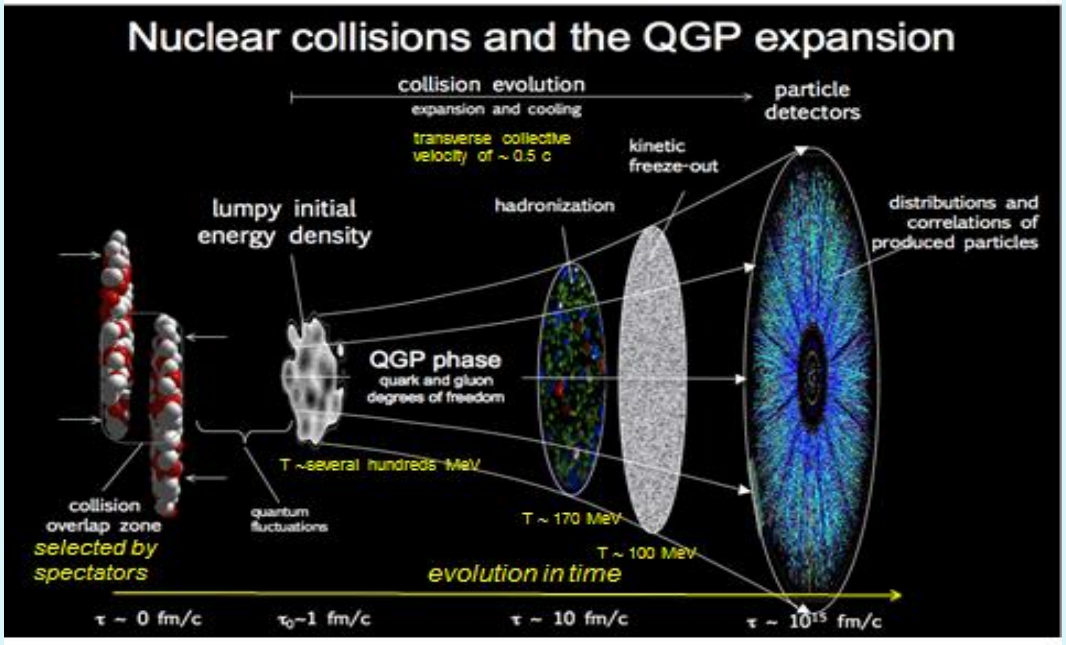


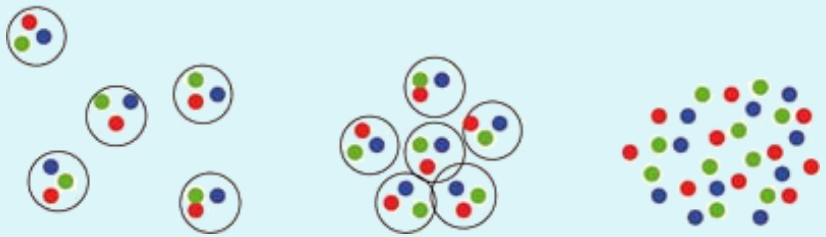
V.A. Babkin on behalf of the MPD/NICA collaboration

The problem of studying hot and dense baryonic matter



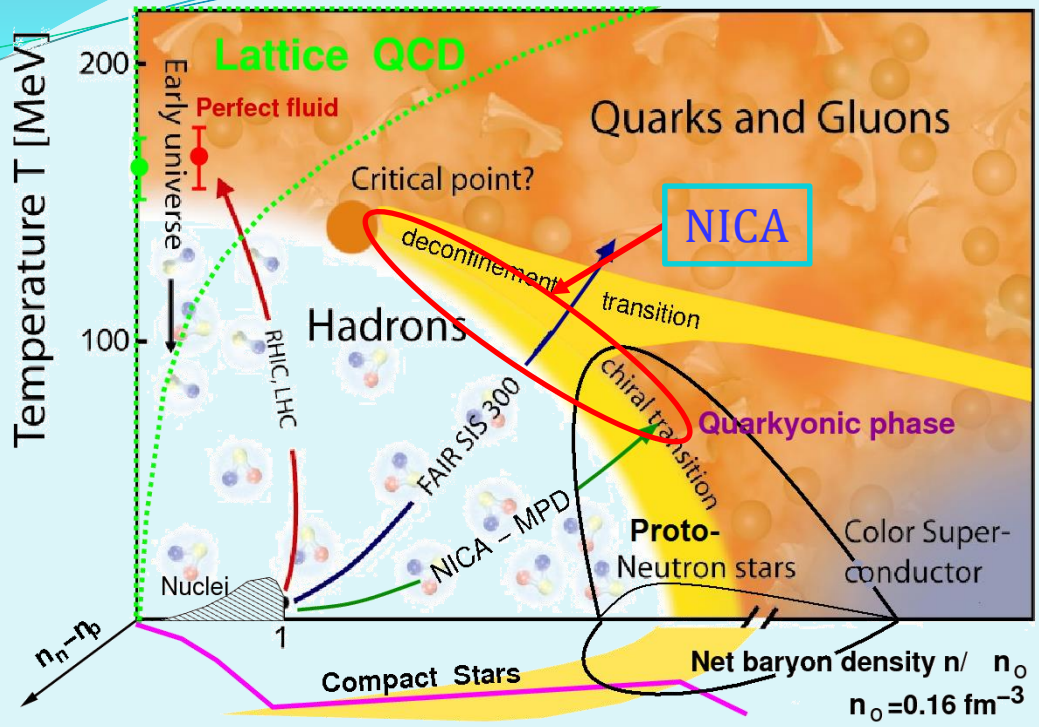
Asymptotic freedom of quarks. The strength of the coupling α_s decreases with increasing energy.

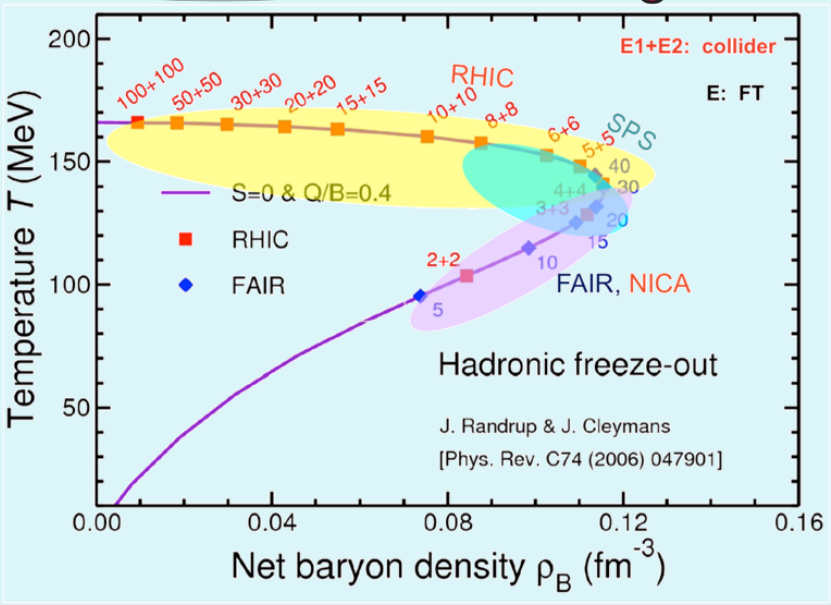




The transition from a hadron gas to a quark gluon plasma. The arrow indicates growing temperature and/or chemical potential for baryon density.

The problem of studying hot and dense baryonic matter





- Highest net baryon density
- Energy range covers onset of deconfinement
- Complementary to the RHIC, FAIR and SPS experimental programs

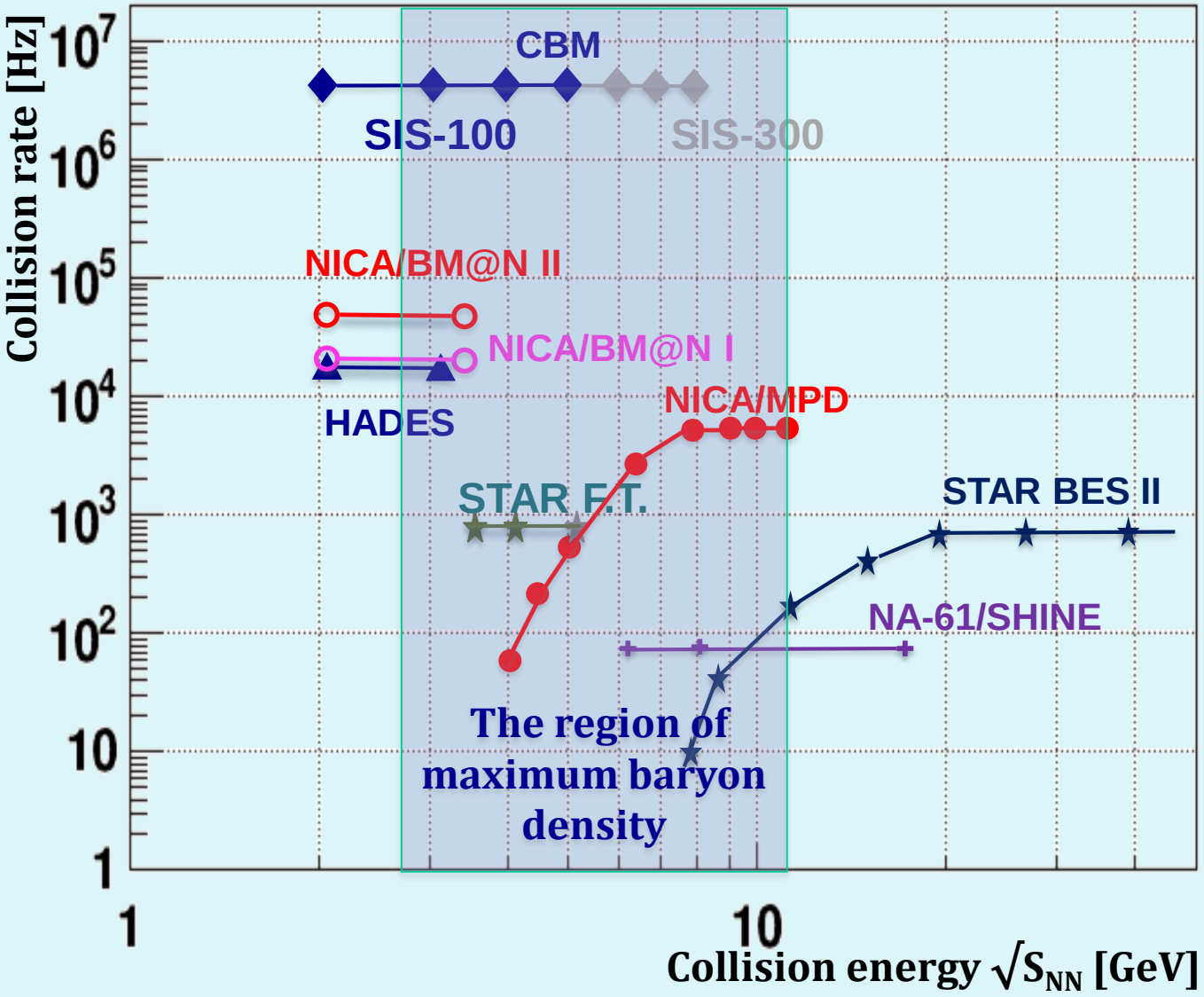
MPD/NICA heavy ion programm:

- **Main properties, EOS** – particle yields & spectra, ratios, femtoscopy
- **In-Medium modification of hadron properties** – onset of low-mass dilepton enhancement
- **Deconfinement (chiral) phase transition at high ρ_B** – enhanced strangeness production
- **QCD Critical Point** – event-by-event fluctuations & correlations
- **Y-N (hyperon-Nucleon)** interactions in dense nuclear matter - hypernuclei

To study properties of phase diagram it is important:

- to have possibilities of **fine scan** on collision energy;
- to have **variety** of beam nucleus.

Present and future heavy ion collider and fixed target experiments

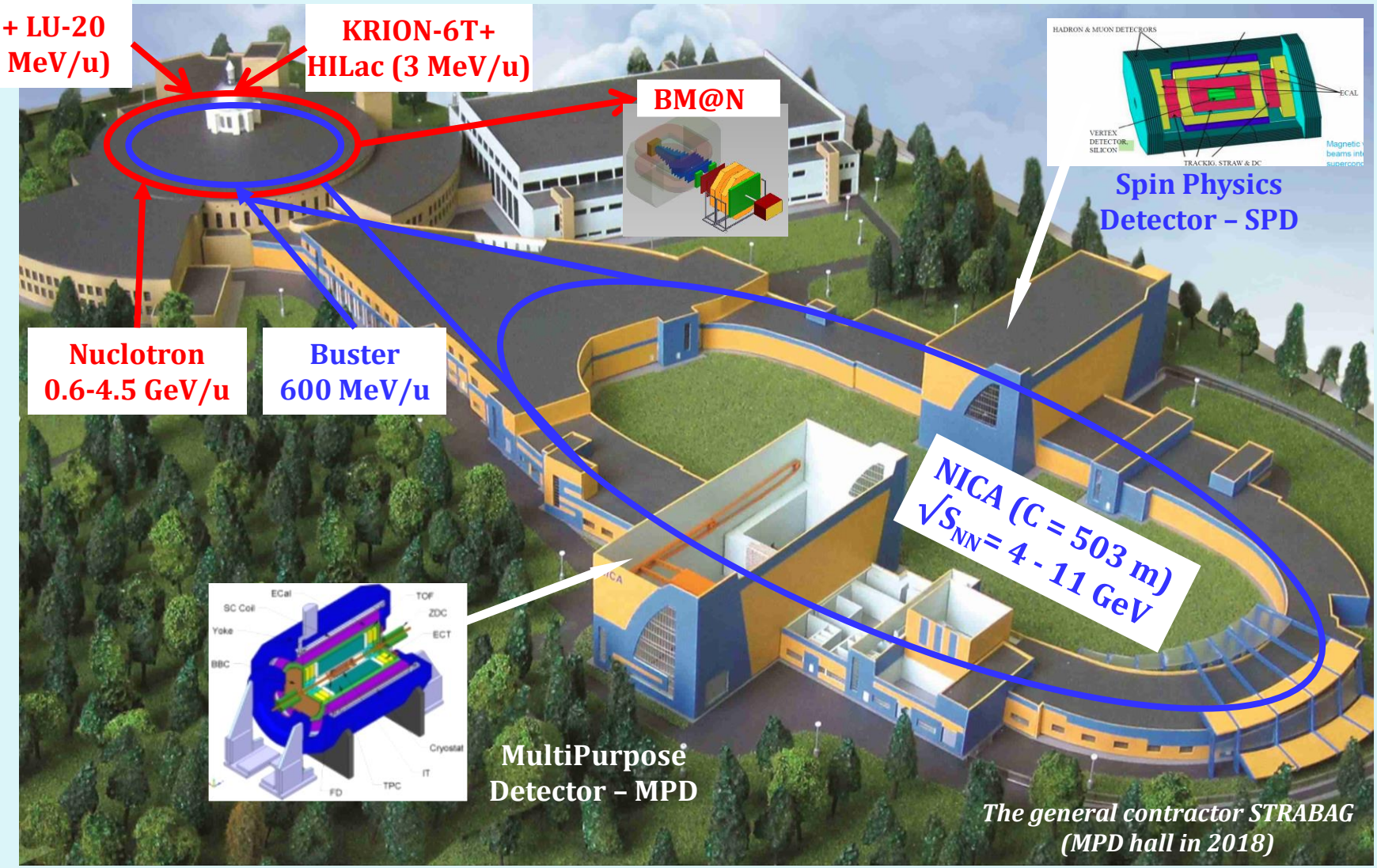


Nuclotron-based Ion Collider fAcility – NICA

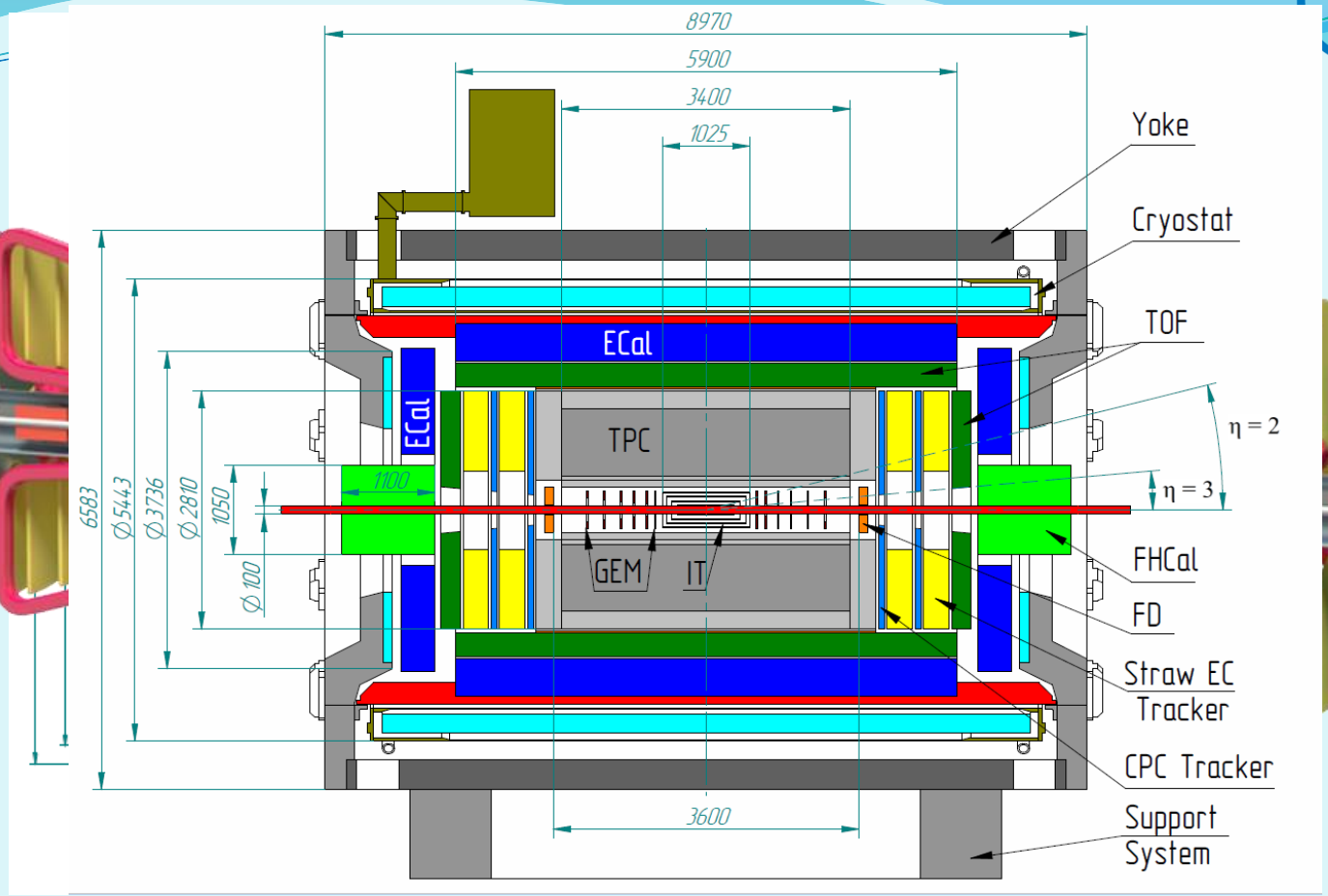
Main properties of the NICA collider:

$\sqrt{s_{NN}}$ = **4 - 11** GeV; ***ion beams*** **p ... Au** @ $L \sim 10^{27}$ cm^{-2} s^{-1} (**Au^{79+}**),

$\sqrt{s_{NN}}$ = **6 - 26** GeV; ***polarized beams*** **p↑** and **d↑** @ $L \sim 10^{32}$ cm^{-2} s^{-1}



Stages of the MPD commissioning



First stage (2019-2020): |η|<1.3

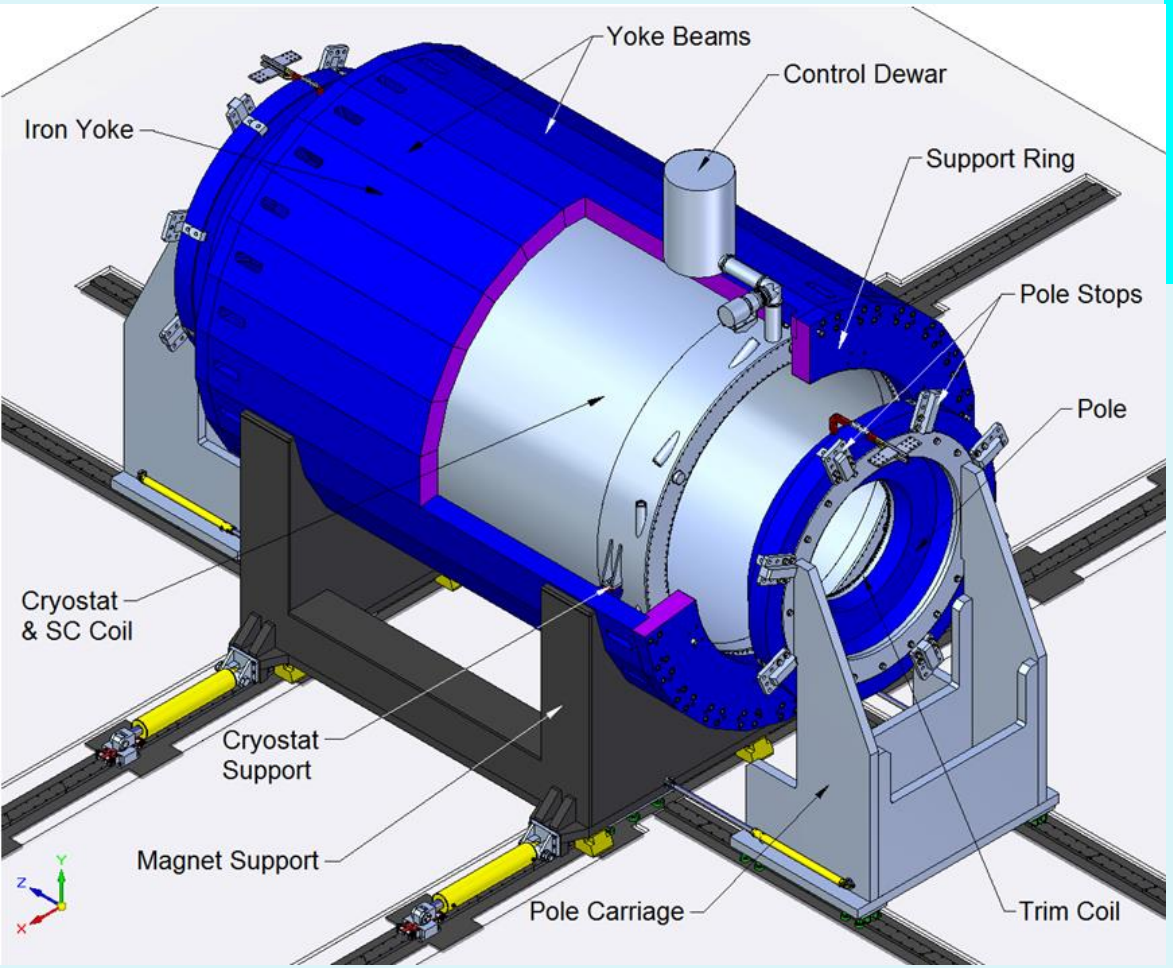
- Particle yields and spectra (p,K,p,clusters,L, X ,W)
- Event-by-event fluctuations
- Femtoscopy involving π, K, p, Λ
- Collective flow for identified hadron species
- Electromagnetic probes (electrons, gammas)

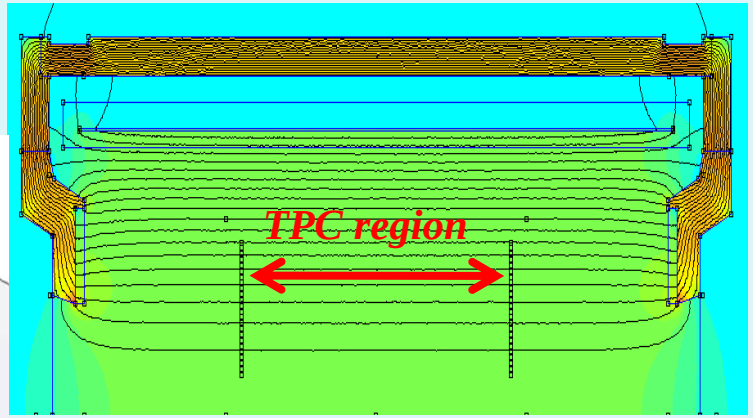
Second stage (2023): |η|<2 + IT

- Total particle multiplicities
- Asymmetries study (better reaction plane determination)
- Di-Lepton precise study (ECal expansion)
- Exotics (soft photons, hypernuclei)

Superconducting solenoid of the MPD

B_0=0.5 T (I=1.79 kA); SC cable: NbTi/Cu (T=4.5 K) weight ~ 900 t; L=8970 mm, Ø6583 mm





High level magnetic field homogeneity in the TPC region ~ **$3x10^{-4}$**

ASG superconductors (Genova, Italy)**:**

- *Cold Mass + Cryostat*
- *Vacuum System*
- *Trim Coils*
- *Control System*
- *General responsibility*

VHM *(Vitkovice, Czech Republic)*

- *Yoke production*

SPETSMASH *(Kazan, Russia)*

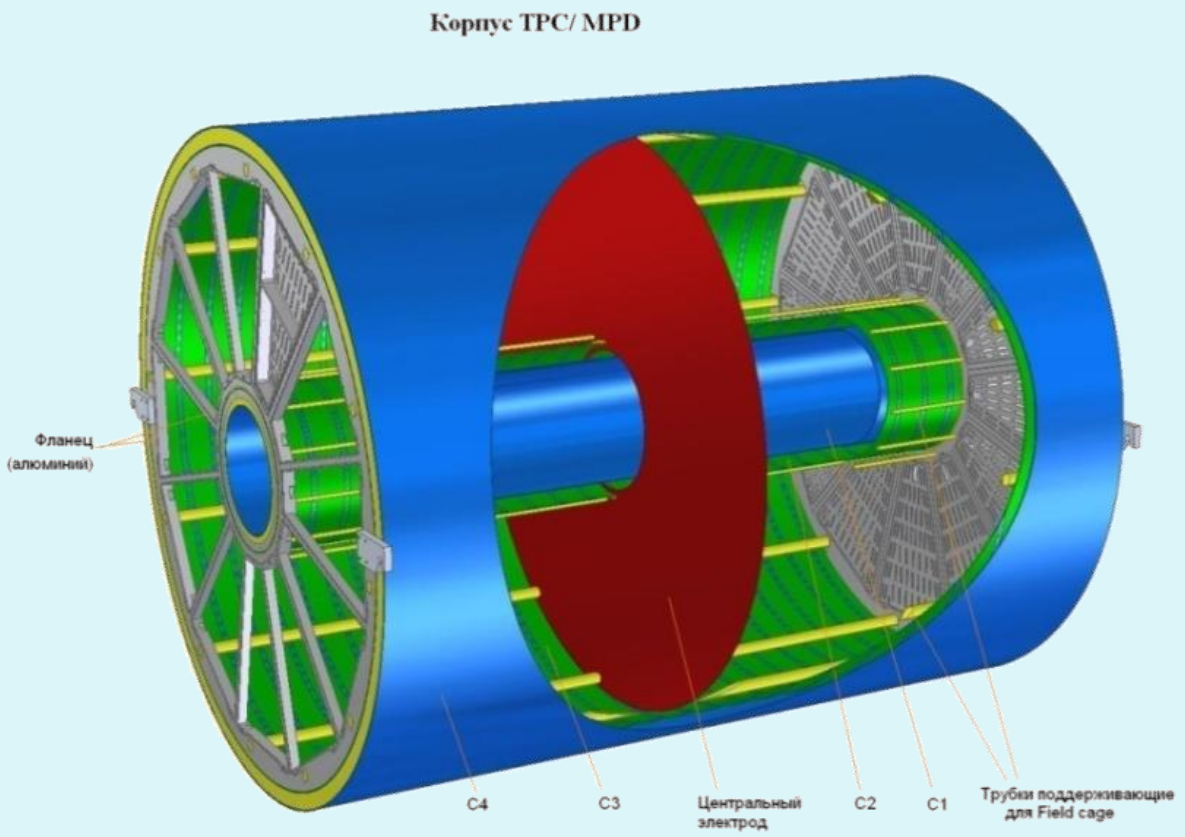
- *Forging (support rings, poles, plates)*

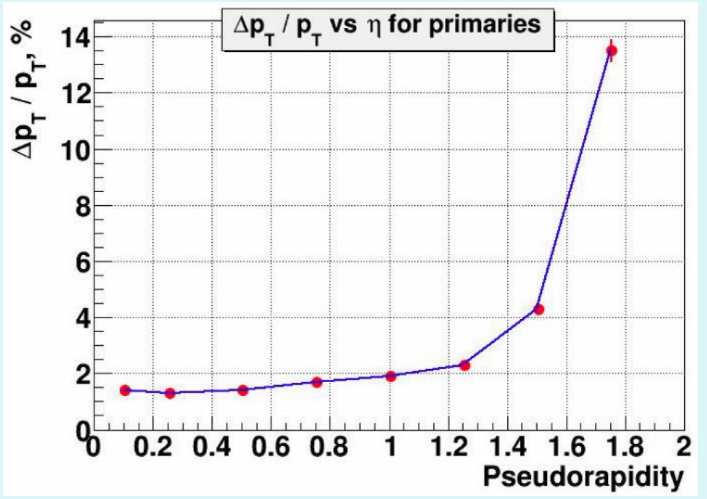
Time Projection Chamber (TPC)

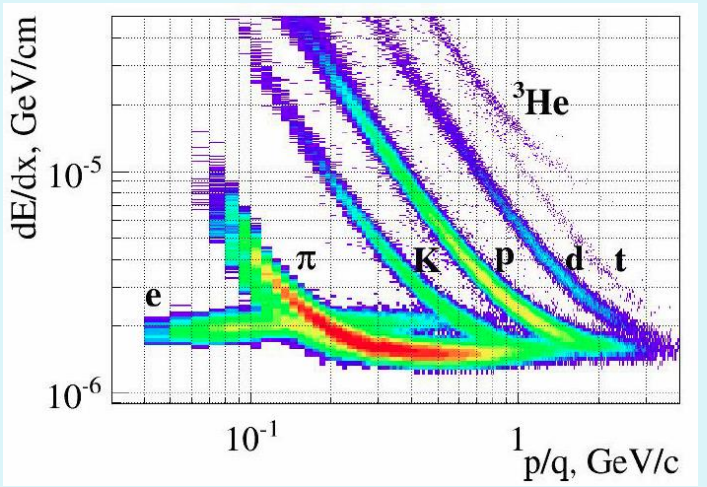
$R = 1400$ mm, $L = 3400$ m, $N_{pads} = 95232$

$\sigma_x, \sigma_y, \sigma_z \sim 0.6$ mm, 1 mm, 2 mm

$\delta p/p < 2\%$, $dE/dX \sim 8\%$



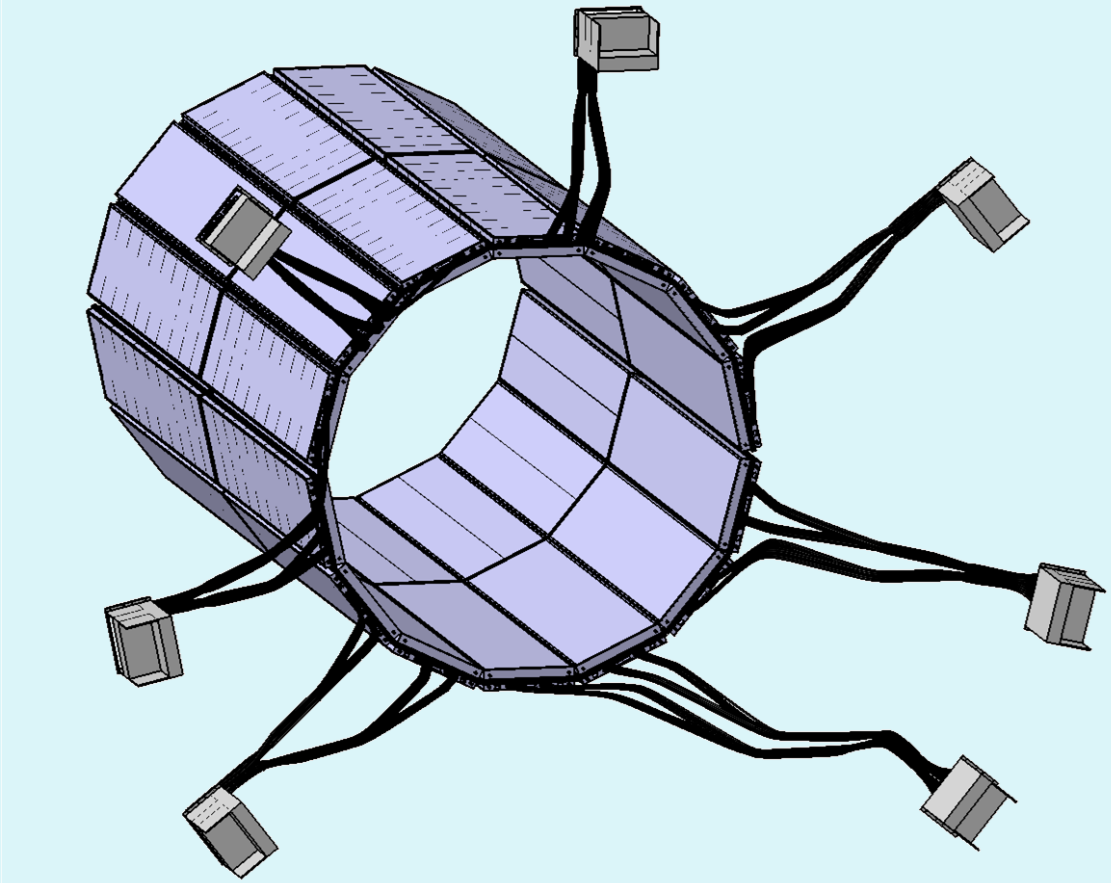


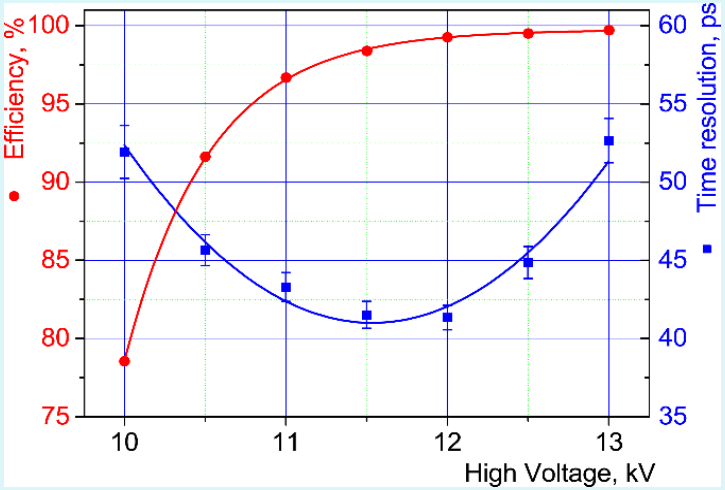


Detailed description of the TPC in the presentation of S. Vereschagin "Readout electronics for TPC…"

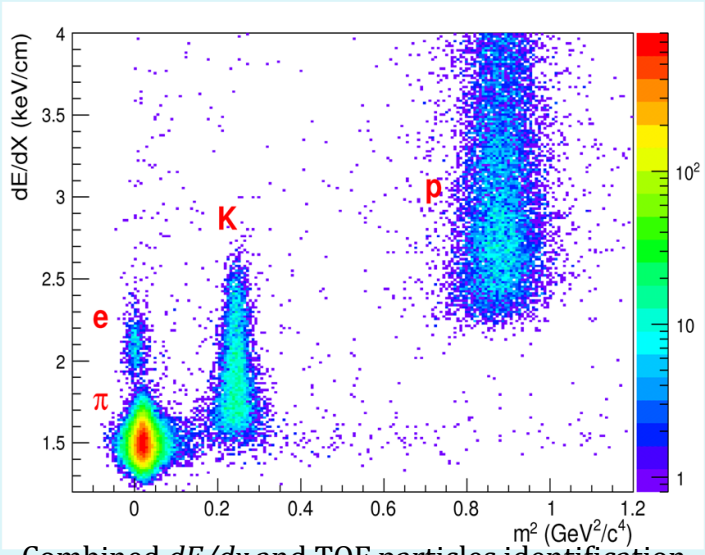
Time-of-Flight system (TOF)

D = 3200 мм, L = 5900 мм, 280 MRPCs
13 440 FEE (NINO) channels, σ_{tof} < 80 ps





Time resolution and efficiency of the MRPC

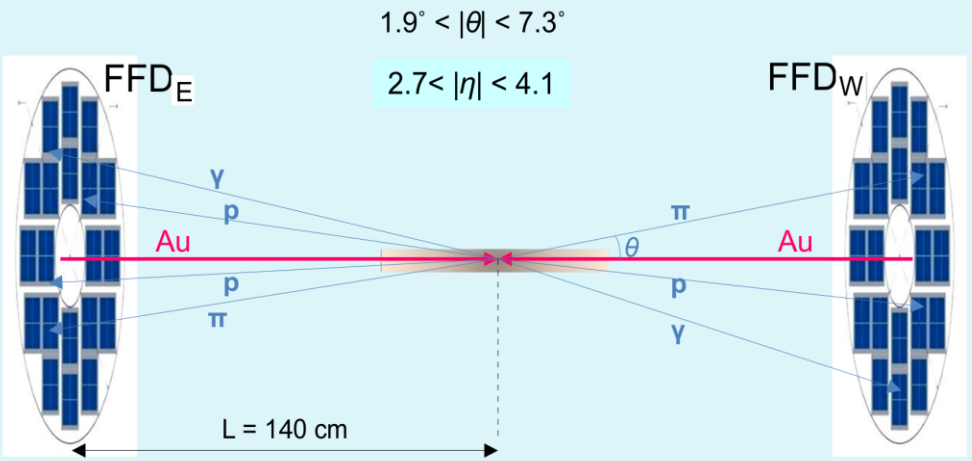


Combined *dE/dx* and TOF particles identification for 0.5 < *p* < 1 GeV/c

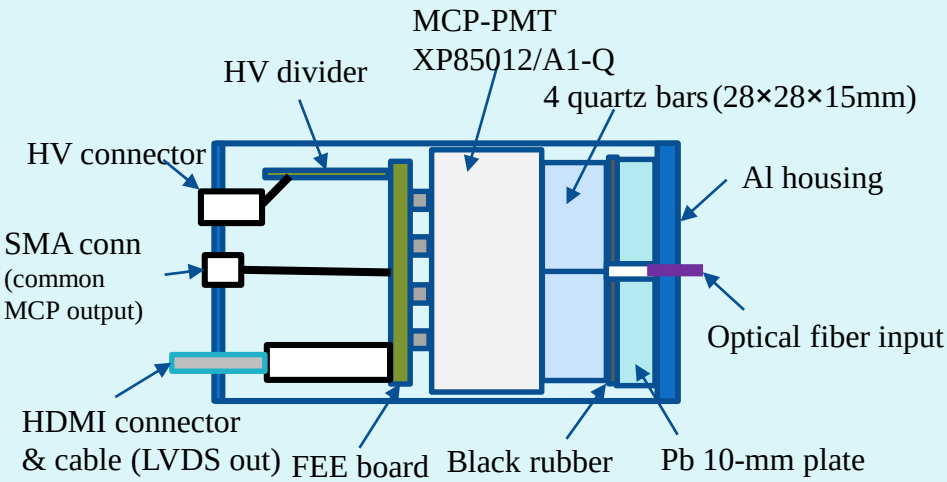
Detailed description of the TOF in the talk of A. Dmitriev "Control and readout electronics of the time-of-flight system…"

Fast Forward Detector (FFD)

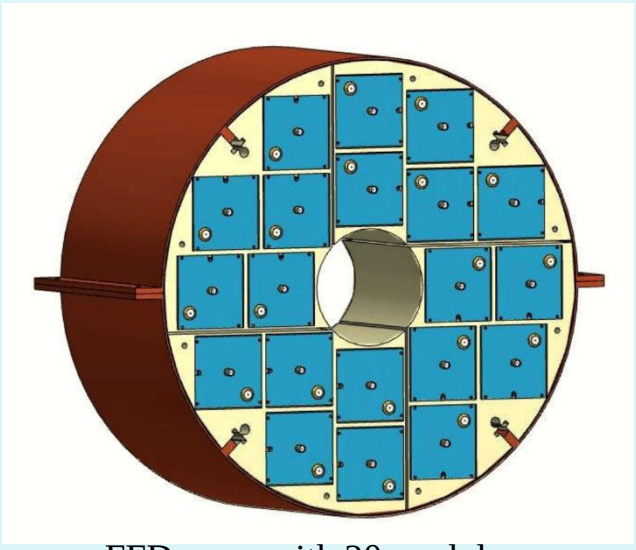
160 channels (two arms of 40 modules), σ_t<50 ps



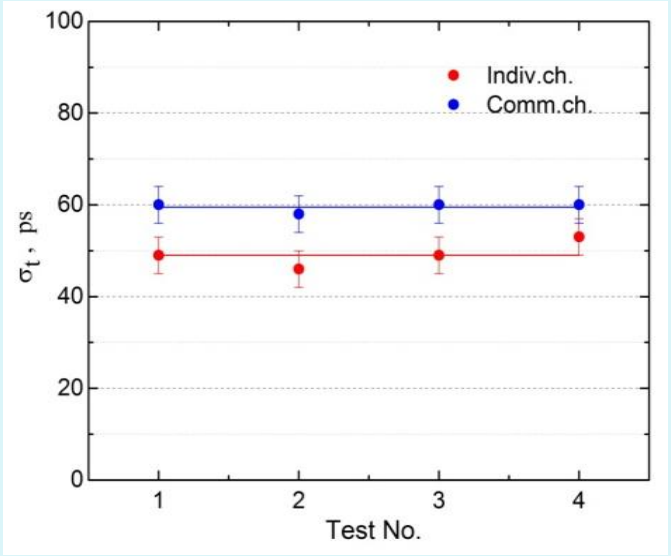
Distribution of the FFD modules around the beam line



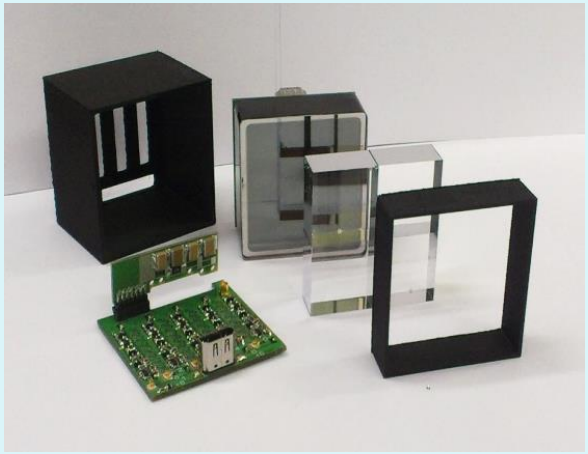
FFD module size: 66 × 66 mm^2



FFD array with 20 modules
and 80-channel granularity

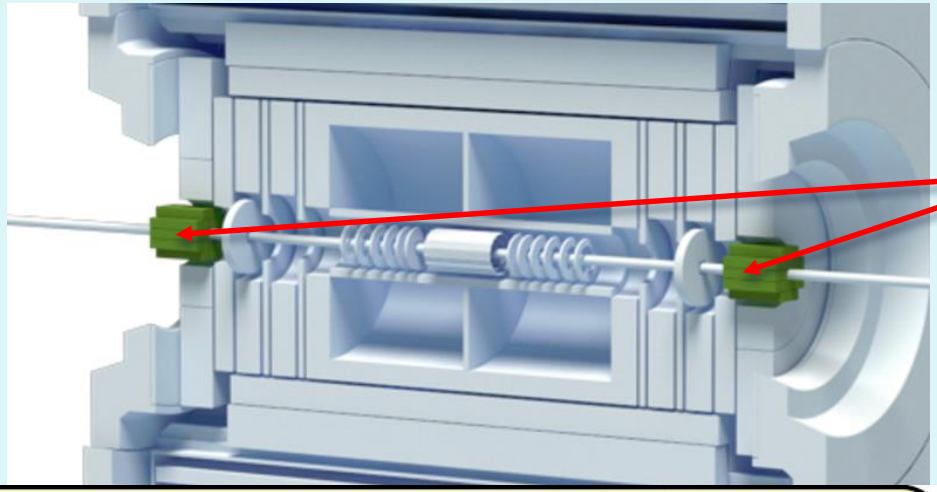


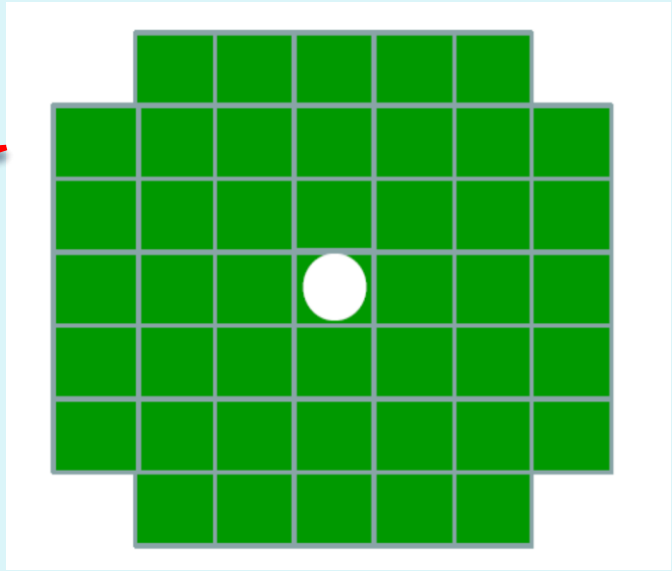
Time resolution of different FFD modules

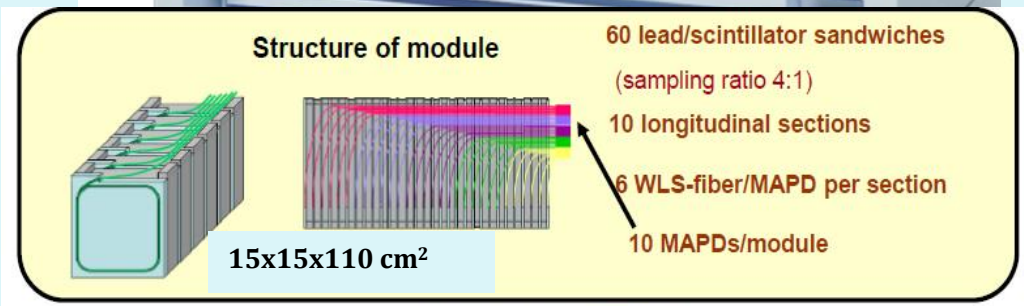


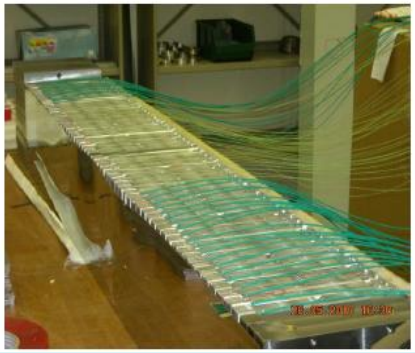
Forward Hadron Calorimeter (FHCal)

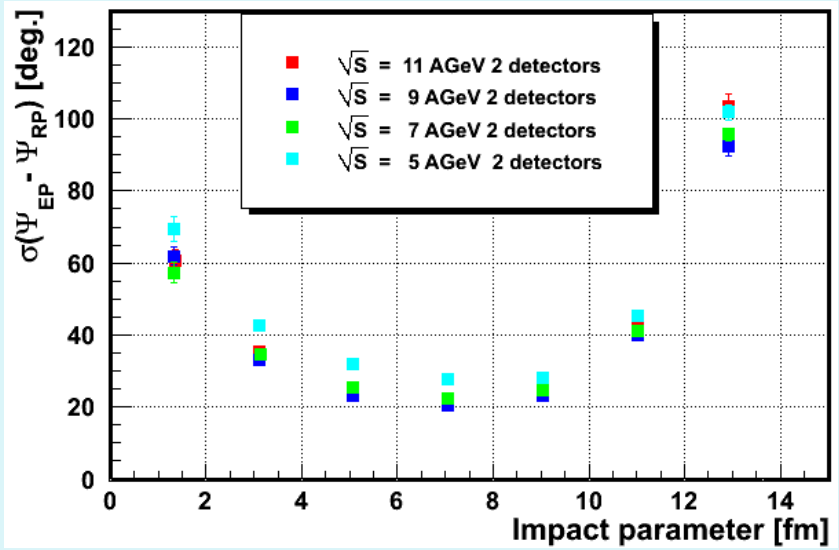
2 arms x 45 modules(~1 m^2)





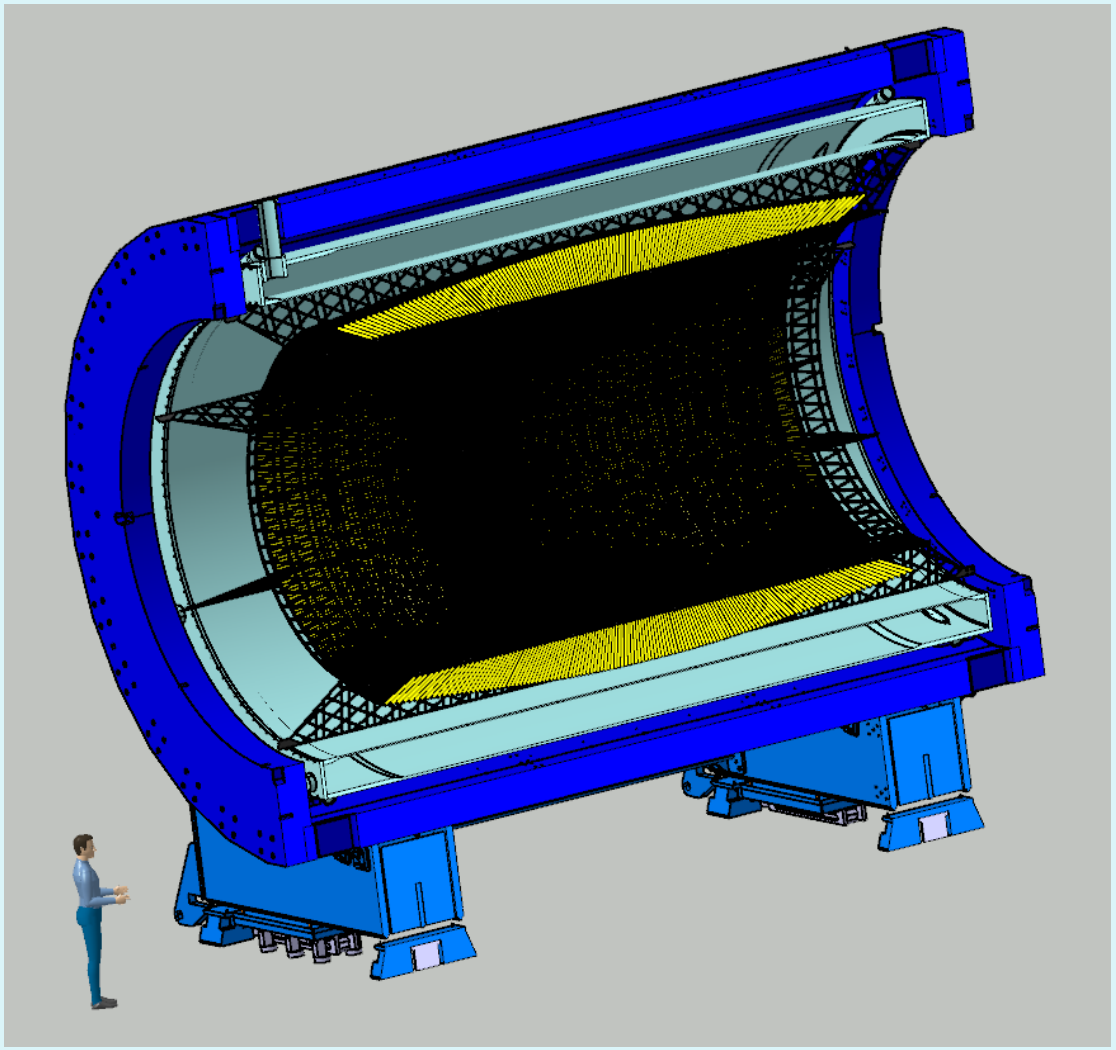


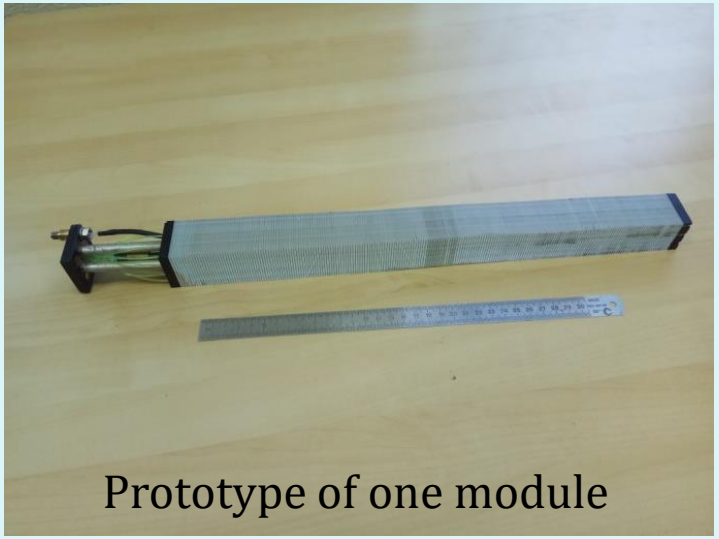


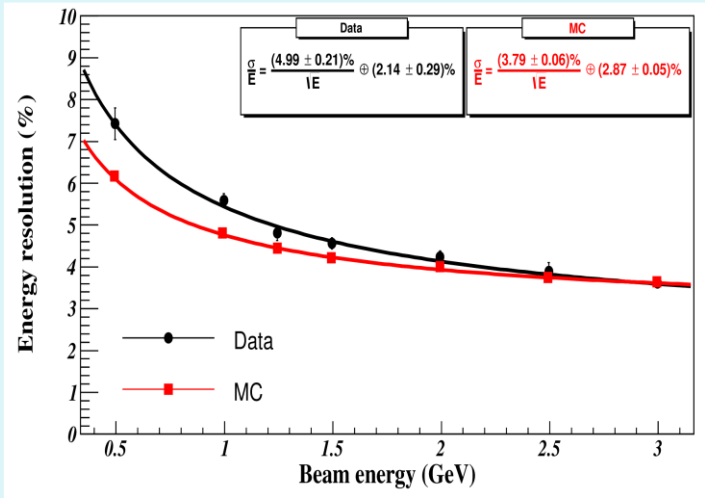


Electromagnetic Calorimeter (ECal)

"Shashlyk" type calorimeter: 43000 ECAL modules
Pb(0.3mm)+Scint(1.5 mm) (4x4 cm^2) Readout: WLS fibers + MAPD



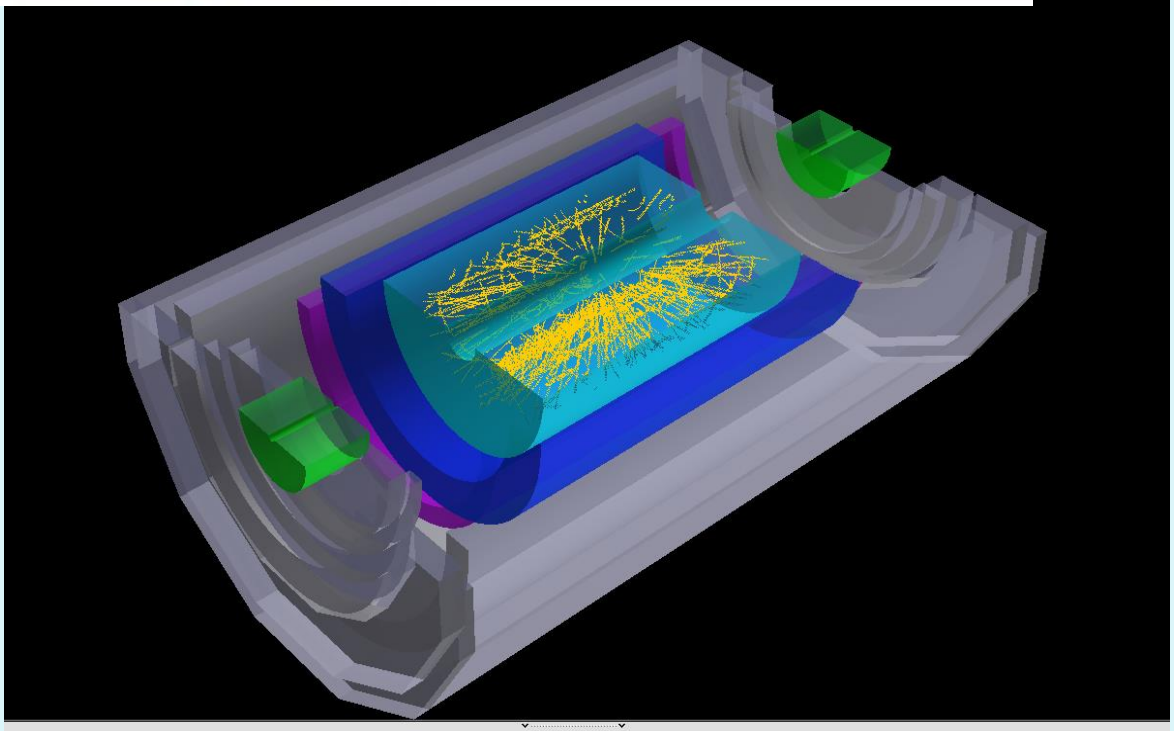




MPDRoot simulation framework

Event generators

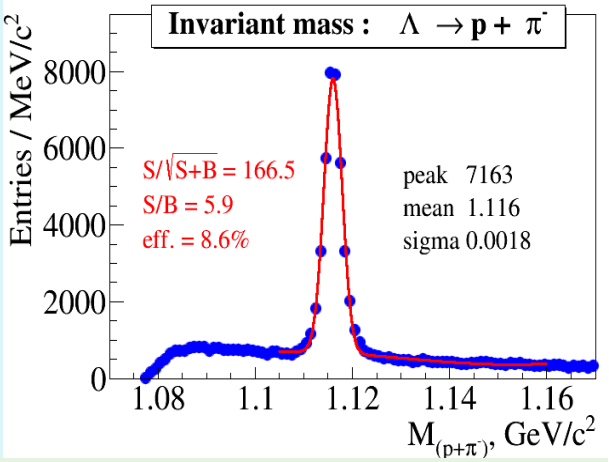
- ✓ *UrQMD 2.3*
- ✓ *LA QGSM*
- ✓ *SHIELD*
- ✓ *HSD*
- ✓ *UrQMD 3.4*
- ✓ *3FD + particlization*

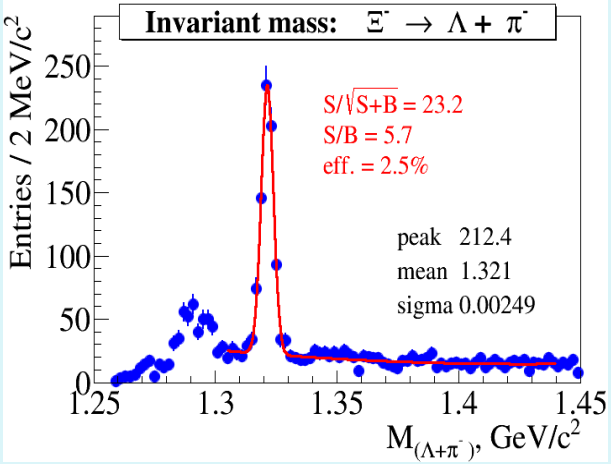


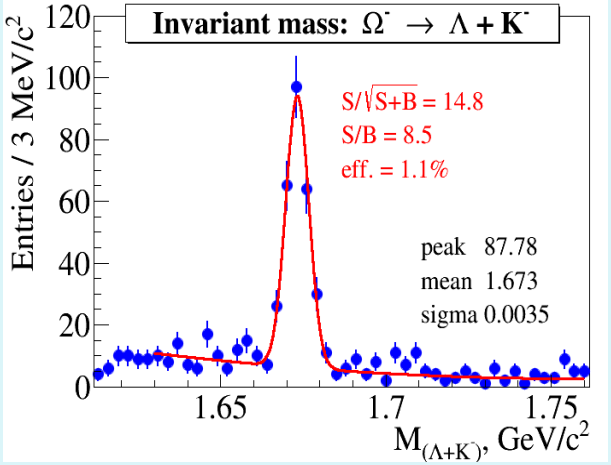
- *inherits basic properties from FairRoot (developed at GSI), C++ classes;*
- *extended set of event generators for heavy ion collisions;*
- *detector composition and geometry; particle propagation by GEANT3/4;*
- *advanced detector response functions, realistic tracking and PID included.*

Physical performance of the MPD

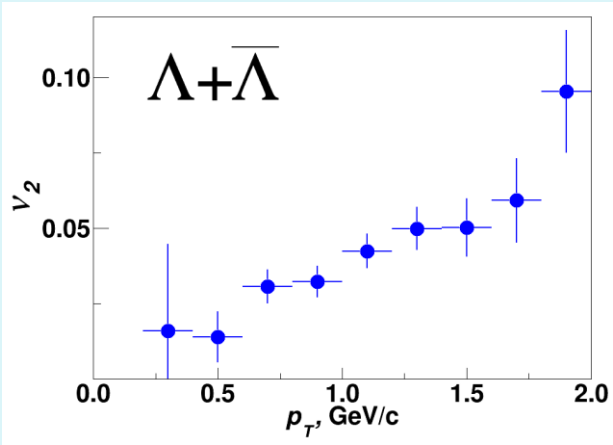
Production of multi-strange hyperons to study the properties of the strongly interacting system and signal for QGP



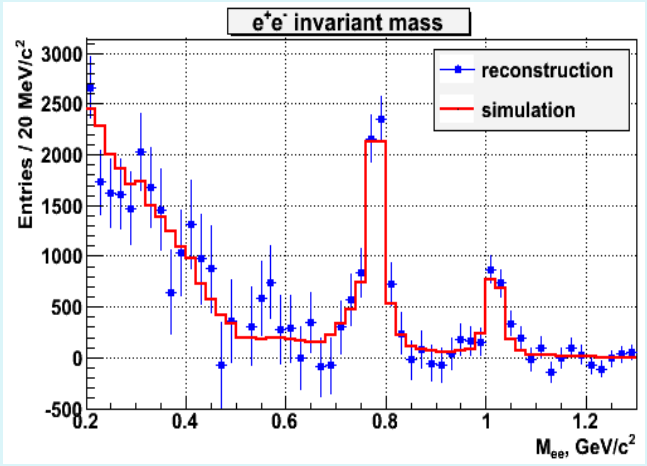




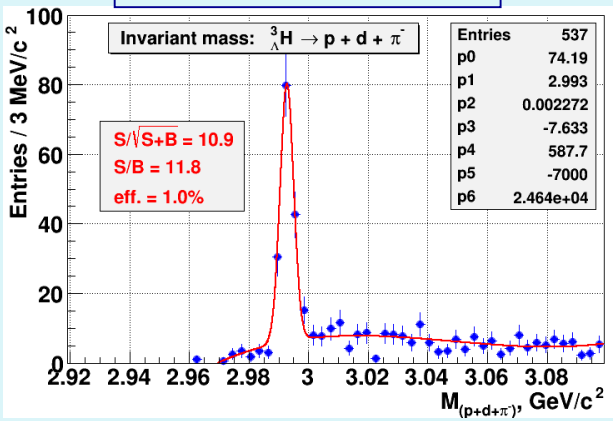
Momentum anisotropy (elliptic flow) originates from initial spatial anisotropy. v_2 depends on matter properties and EOS.



Dileptons - good probes to indicate medium modifications of spectral functions due to chiral symmetry restoration in A+A collisions; effect is proportional to baryon density



Hypernuclei @ MPD



Conclusions

- **Significant progress achieved in the MPD project realization**
- **MPD TDR preparation is being finalized**
- **Successful preparation for mass-production of MPD elements (TPC, TOF, FFD, FHCAL)**
- **The MPD is to be ready for physical data taking at 2021**

Thank you for the attention!