MEXnICA, Mexican group in the MPD-NICA experiment at JINR

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Autonomous University of Puebla
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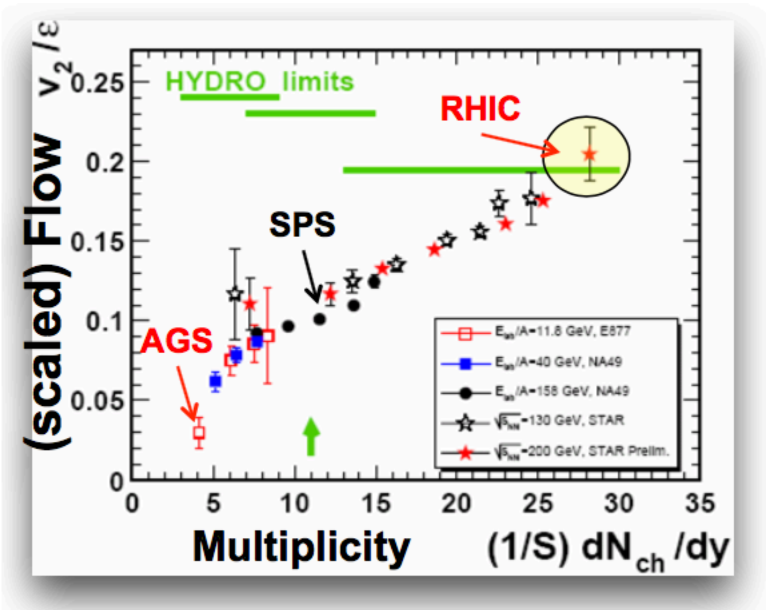
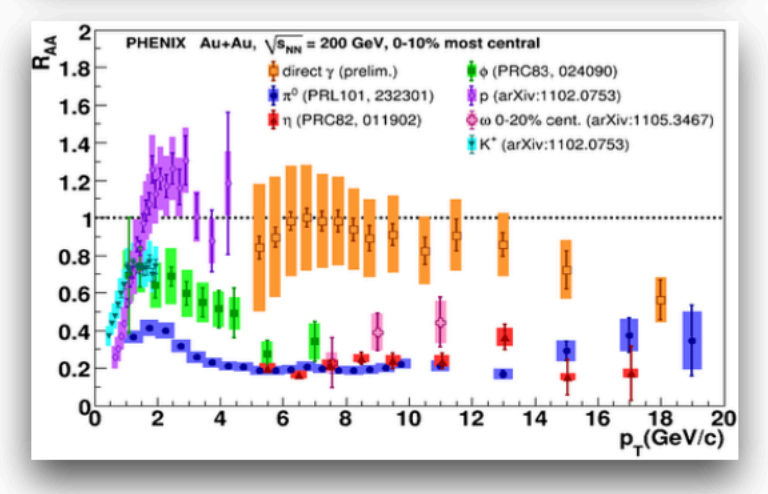
Plan of this talk

- Introduction
- MPD-NICA at JINR
- MEXnICA proposal
- Final comments

Introduction

Heavy-ion physics allows us to study QCD matter under extreme conditions of high temperature and energy density





Some signatures of the QGP in Heavy-ion collisions

- **collective flow** (radial and anisotropic)
- **long-range angular correlations** (hydrodynamical evolution of the medium)
- **suppression of high pT hadrons** (energy loss of partons in the medium)
- **enhancement of thermal photons and dileptons** (emission from the plasma)

Ok, maybe I can skip this. Irais just talked about this topic

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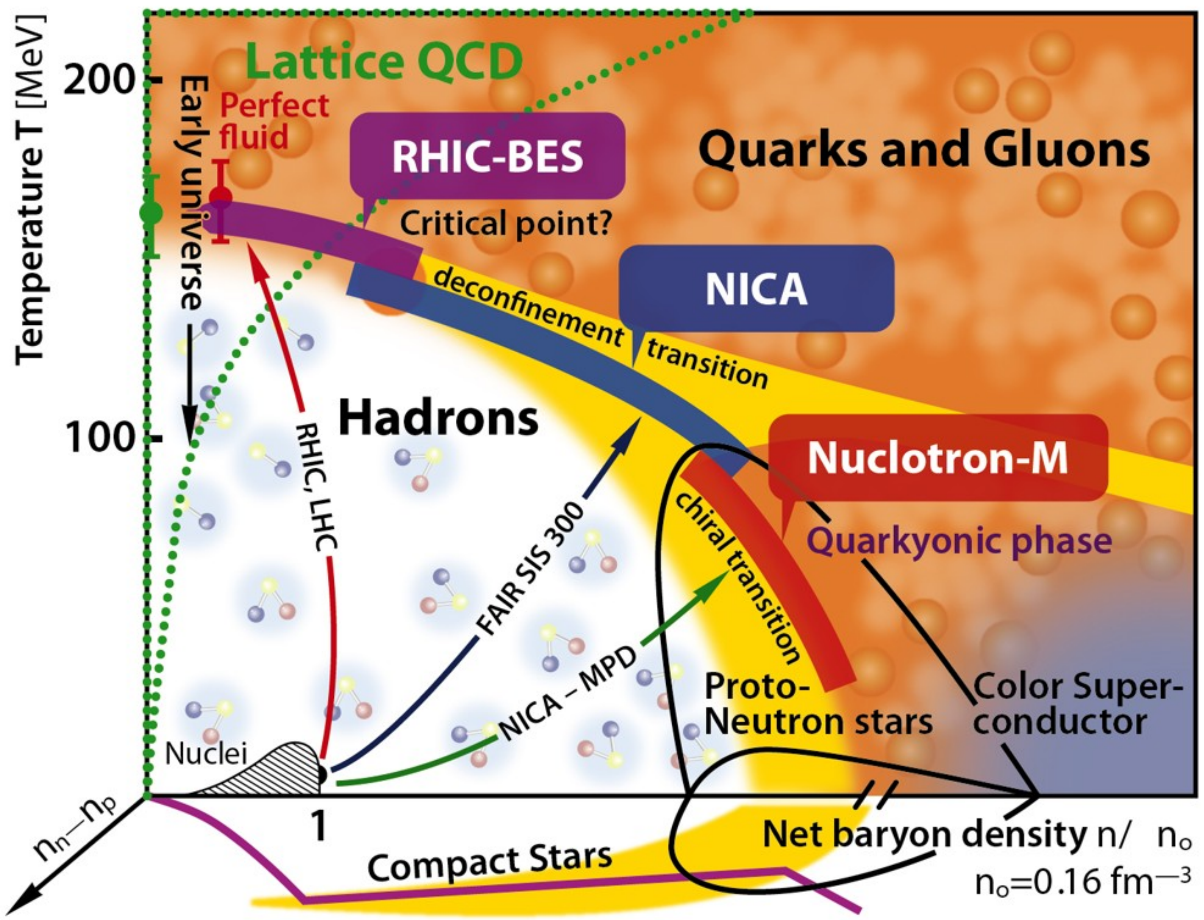

Feb 10, 2000:

"...The data provide evidence for colour deconfinement in the early collision stage and for a collective explosion of the collision fireball in its late stages. The new state of matter exhibits many of the characteristic features of the theoretically predicted Quark-Gluon Plasma."

.....

" The higher energies of RHIC and LHC are needed to complete the picture and provide a full characterization of the Quark-Gluon Plasma."

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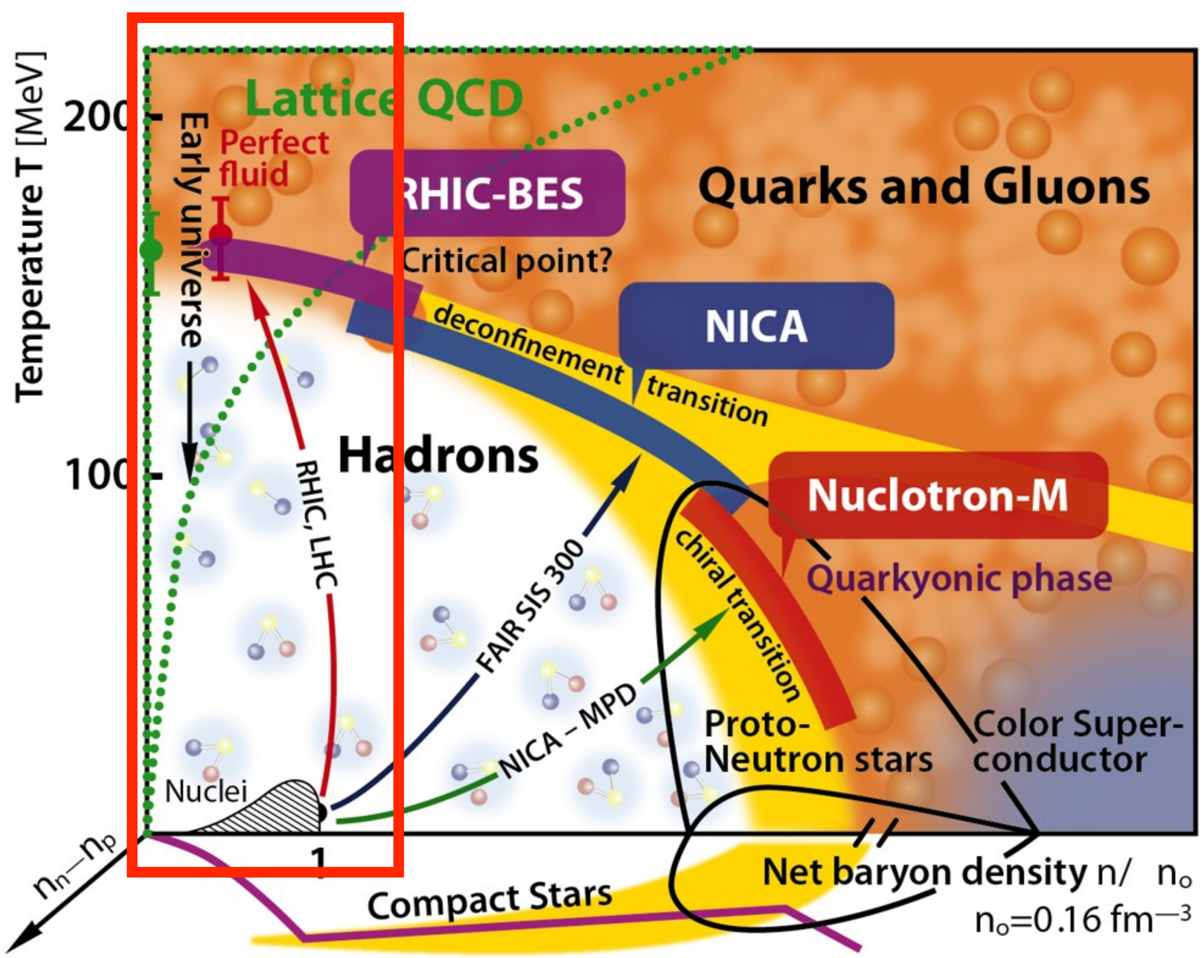

RHIC's results:

- **observation of strong "elliptic" flow** (Phys.Rev.Lett 86:402-407,2001)
- **observation of jet quenching** (suppression of hadrons with large pT, Phys.Rev.Lett.88:022301,2002)

LHC's results

- **observation of long-range, near-side angular correlations in PbPb and pPb collisions** (Phys. Lett. B (718) 795-814)
- **hot and dense matter created in HIC behaves like a fluid with almost zero friction** (constrain on n/s, PRL 105, 252302 (2010))
- **enhanced production of multi-strange hadrons in high-multiplicity p-p collisions** (proton collisions present similar patterns to those observed in HIC, doi:10.1038/nphys4111)

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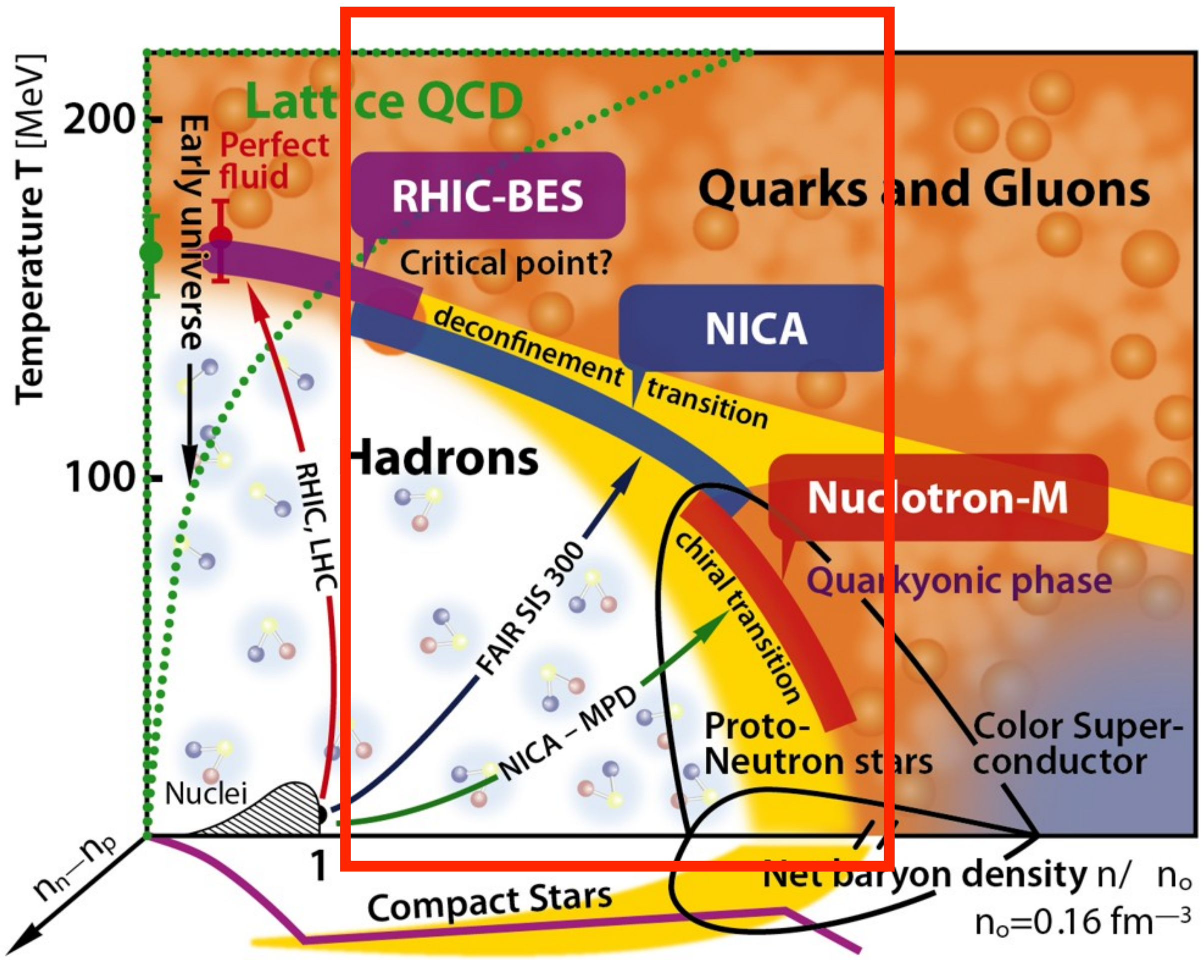

Main NICA targets

- **study of hot and dense baryonic matter**
- **investigation of nucleon spin structure, polarization phenomena**

Energy range of NICA **—> unexplored region of the QCD phase diagram**

- **highest net baryon density**
- **onset of deconfinement phase transition**

discovery potential

- **Critical End Point (CEP)**
- **Chiral symmetry restoration**
- **hypothetic quarkyonic phase**

complementary to

- **RHIC/BES, NA61/CERN, CBM/FAIR and Nuclotron-M experimental programs**

Comprehensive experimental program requires scan over the QCD phase diagram by varying collision parameters: system size, beam energy and collision centrality

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NICA

Nuclotron-based
Ion Collider fAcility

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NICA (Nuclotron-based Ion Collider fAcility) is a new accelerator complex designed at the Joint Institute for Nuclear Research (Dubna, Russia) to study properties of dense baryonic matter.

After puting the NICA collider into operation JINR scientists will be able to create in the Laboratory a special state of matter in which our Universe stayed shortly after the Big Bang – the Quark-Gluon Plasma (QGP).

Start of the construction: 2013.
Commissioning: 2020.

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NICA will provide beams of ions over a wide range of atomic masses (from p to Au) at average luminosity of 10^{27} $cm^{-2}s^{-1}$ for gold-gold collisions and 10^{32} $cm^{-2}s^{-1}$ for proton-proton collisions. The center-of-mass energy will be between 4 to 11 GeV for Au+Au and up to 27 GeV for p+p.

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Experimental data on hadron production properties at SPS suggest that this transition occurs within the NICA energy range.

Theoretical calculations indicate that the deconfinement phase transition can be accomplished by partial restoration of the chiral symmetry in heavy-ion collisions leading to possible modifications of hadronic spectral functions in dense hadronic matter.

Introduction

NICA
Nuclotron-based
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After the collision of two heavy-ion nuclei,

- the matter behaves as a thermalized system
- the hot fireballs cools down —> particle production tracing a trajectory on phase diagram (maybe close to the critical point)
- key study —> event by event fluctuations of physical observables of particles in its final state.

Introduction

Nuclotron-based
Ion Collider fAcility

Physics tasks of the NICA Heavy-ion program

- event-by-event fluctuation in hadron productions (multiplicity, Pt etc.);
- femtoscopic correlation;
- directed and elliptic flows for various hadrons;
- multi-strange hyperon production (including hypernuclei): yield and spectra (the probes of nuclear media phases);
- photon and electron probes
- charge asymmetry

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Where would this happen ?

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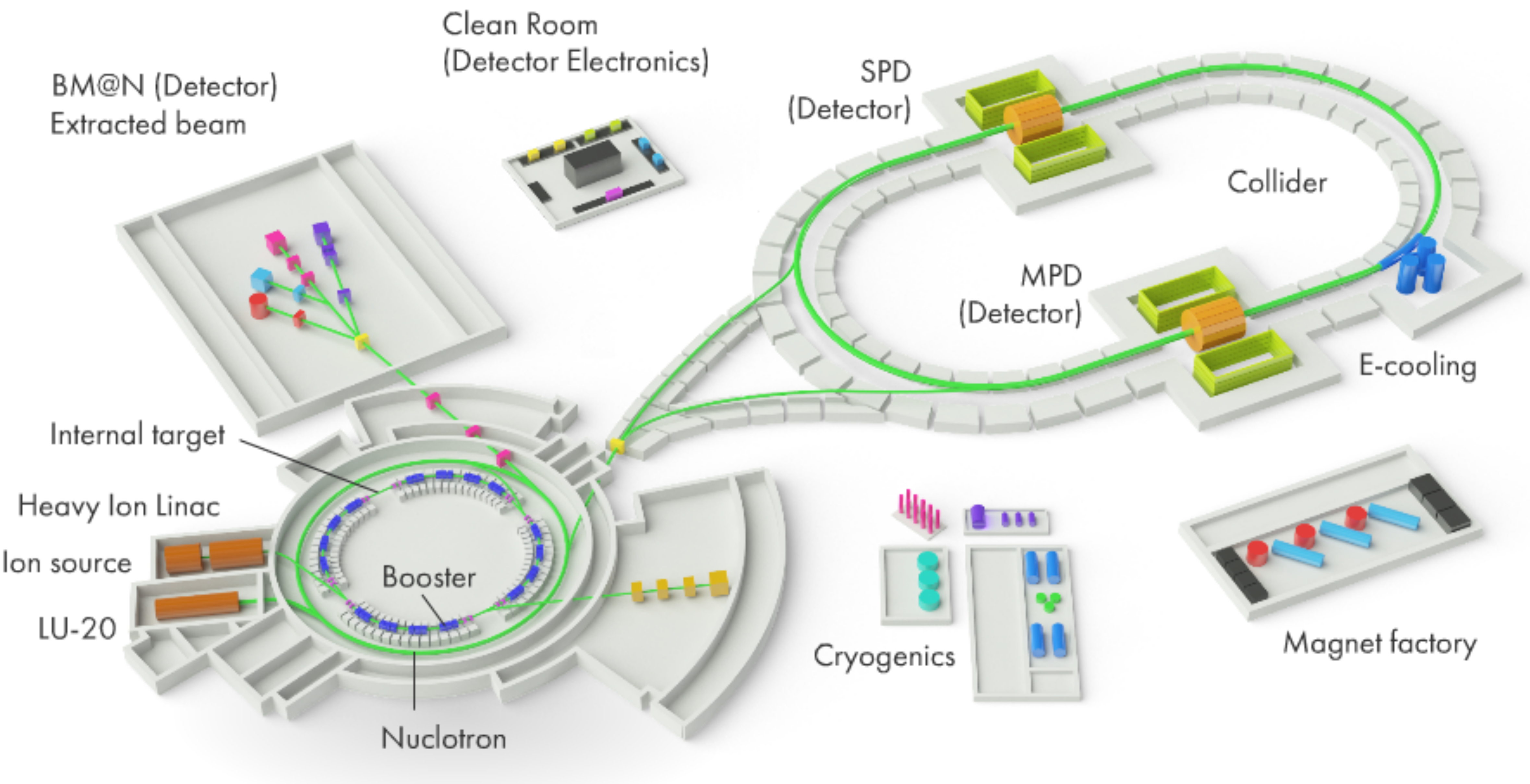

MPD-NICA at JINR

MPD: **M**ulti-**P**urpose **D**etector (typically cylindrical particle detector)

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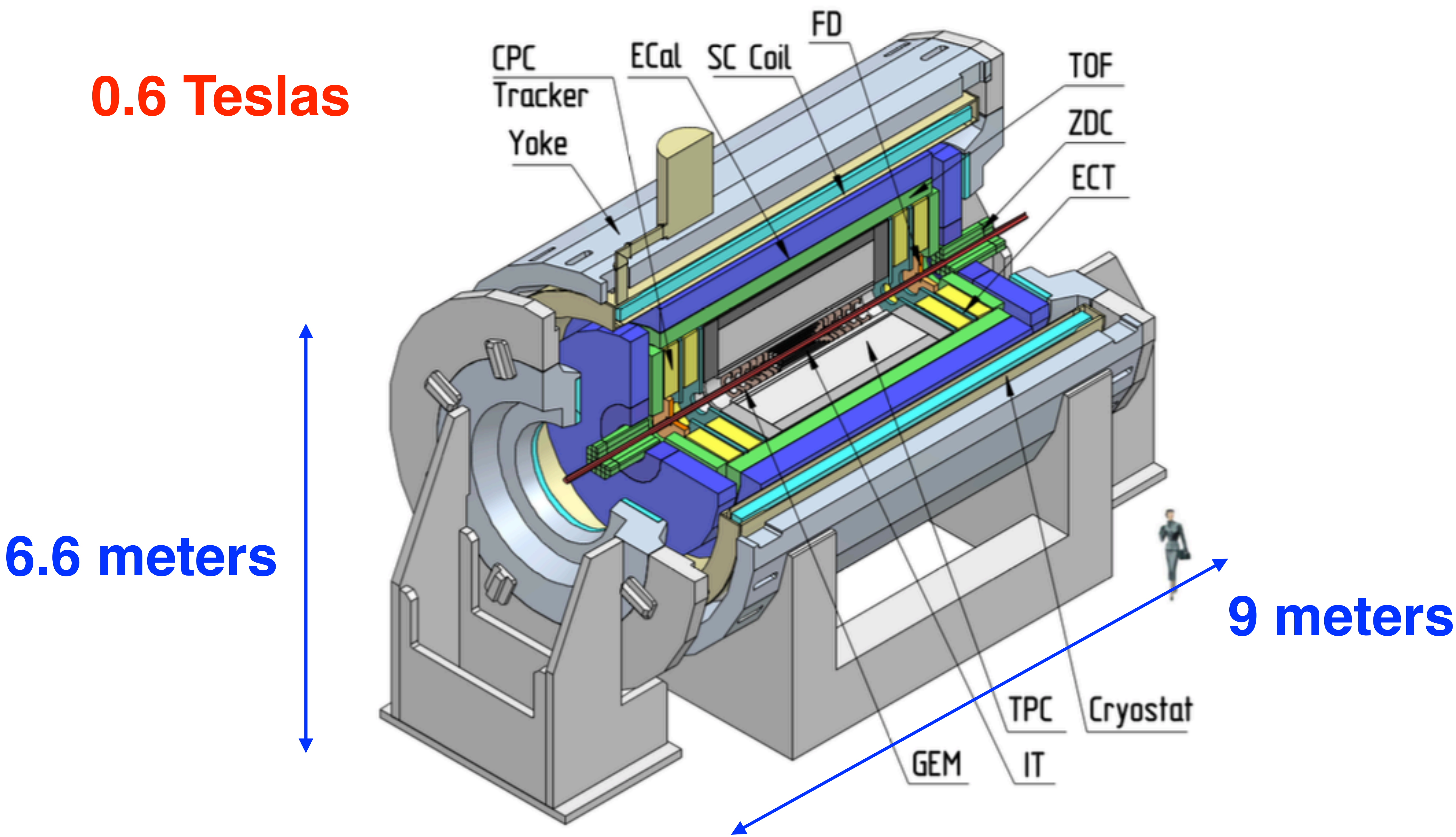

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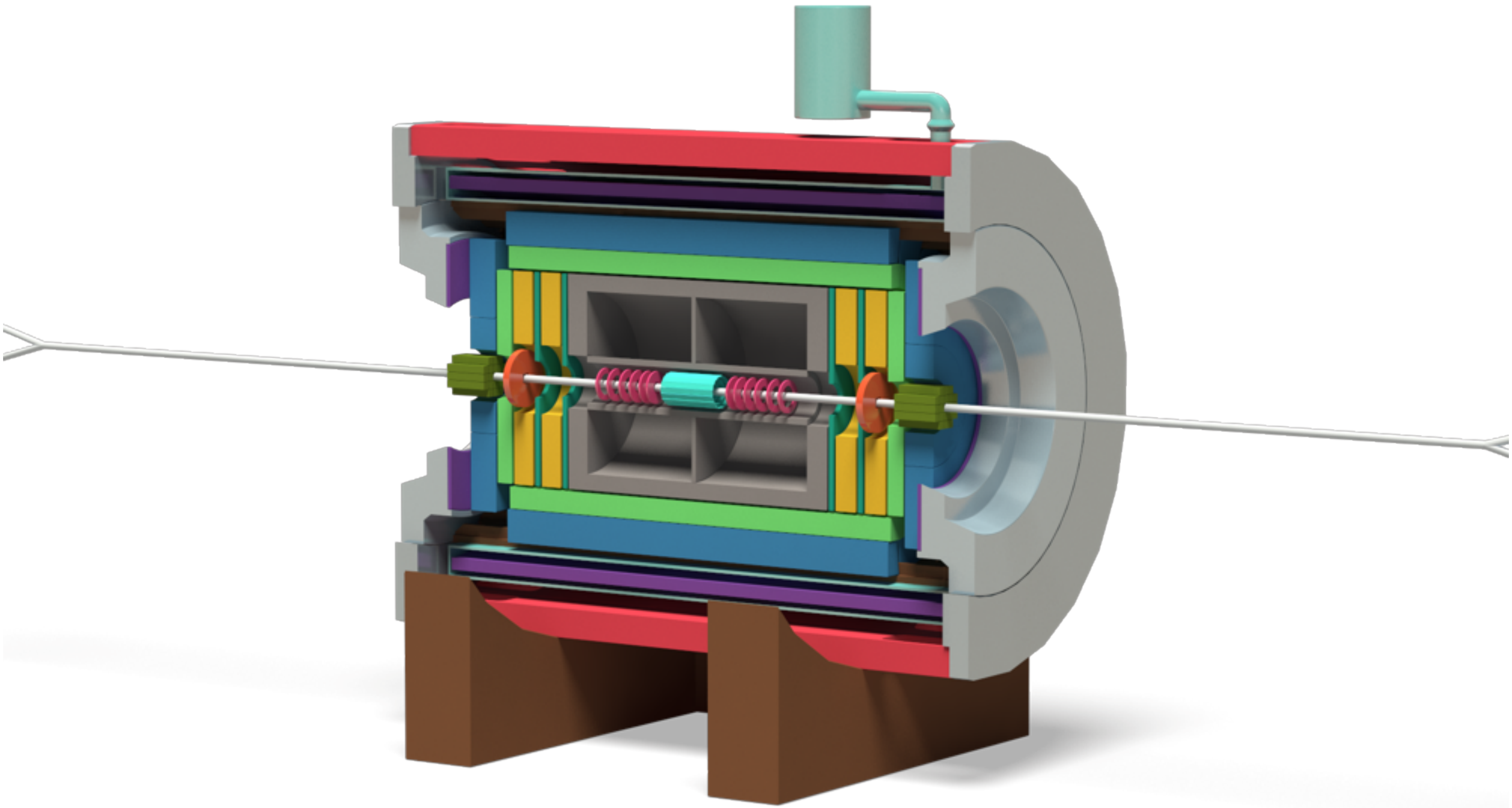

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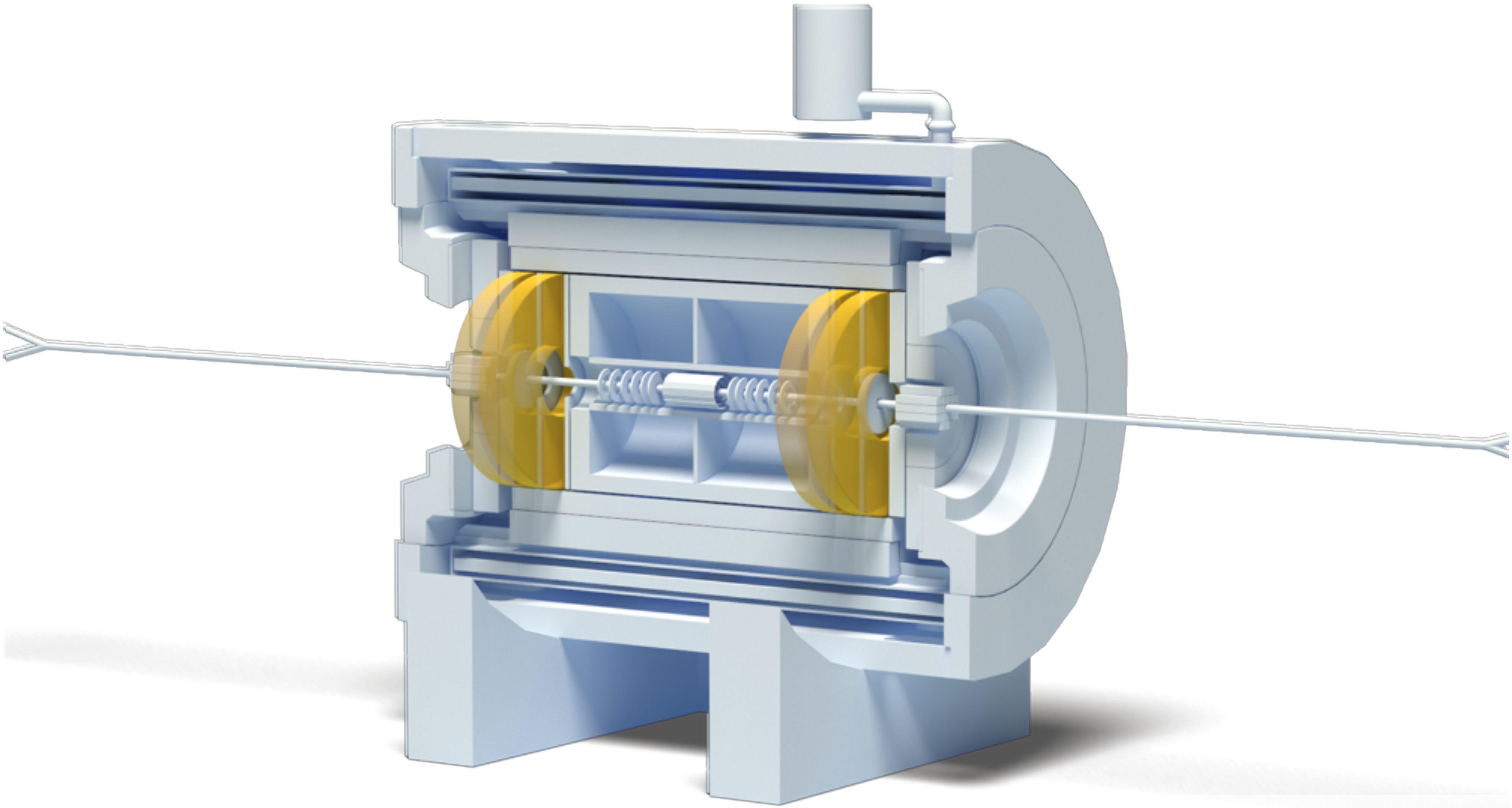
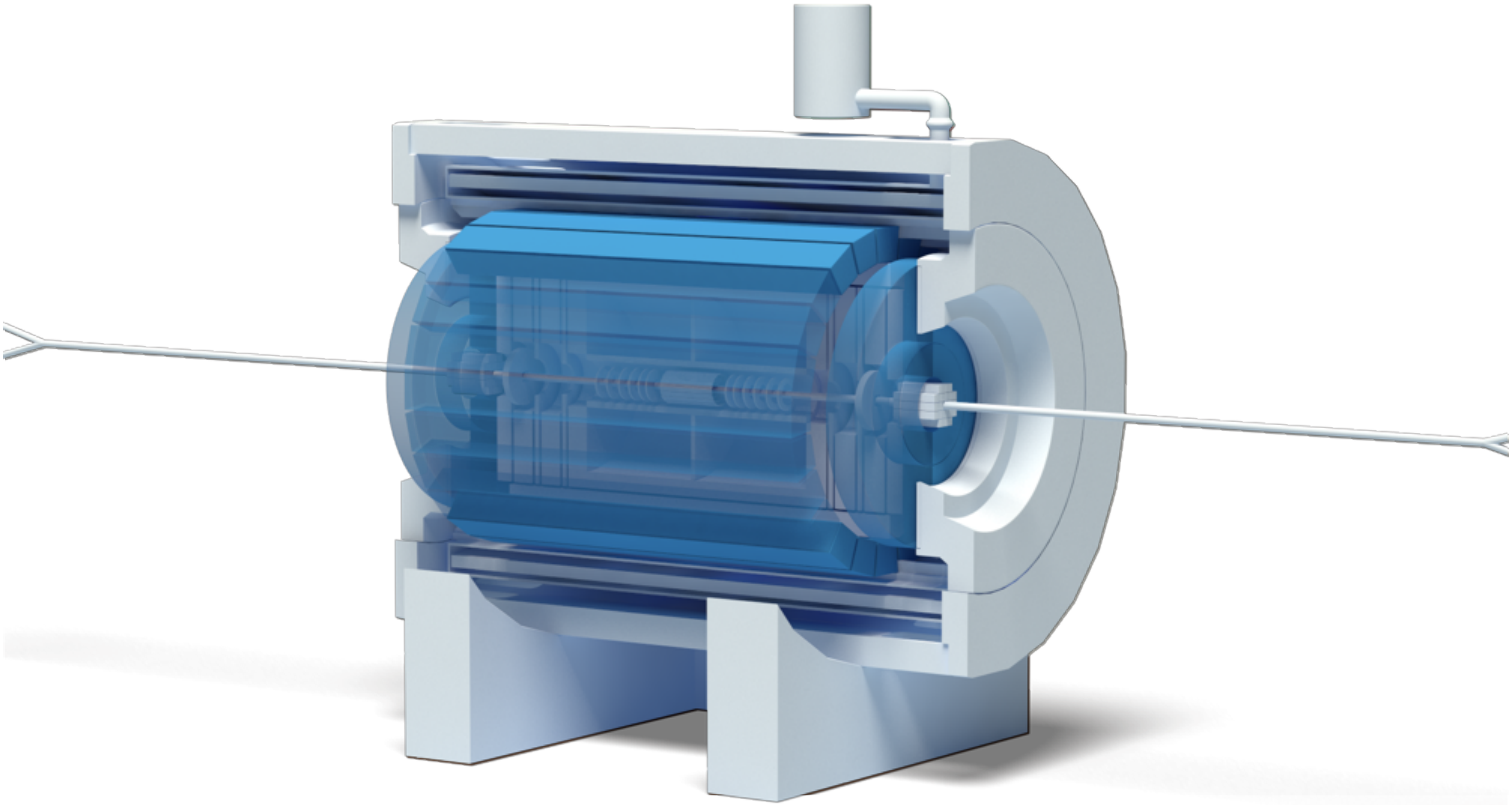


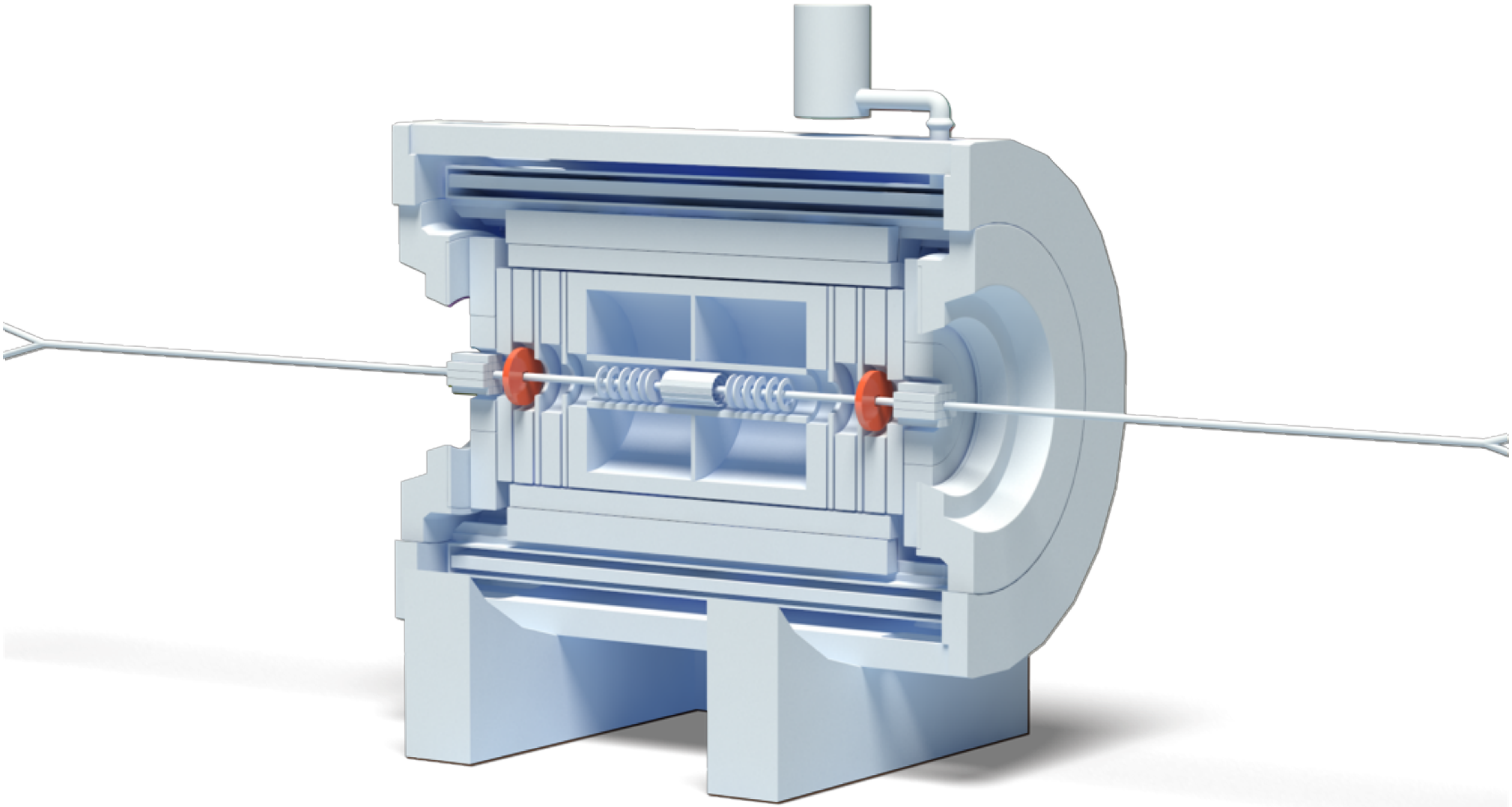
CPC tracker: wheel -like tracking detectors. It will provide tracking information for particles traveling at small radii for which the TPC has poor reconstruction ability

MPD-NICA at JINR



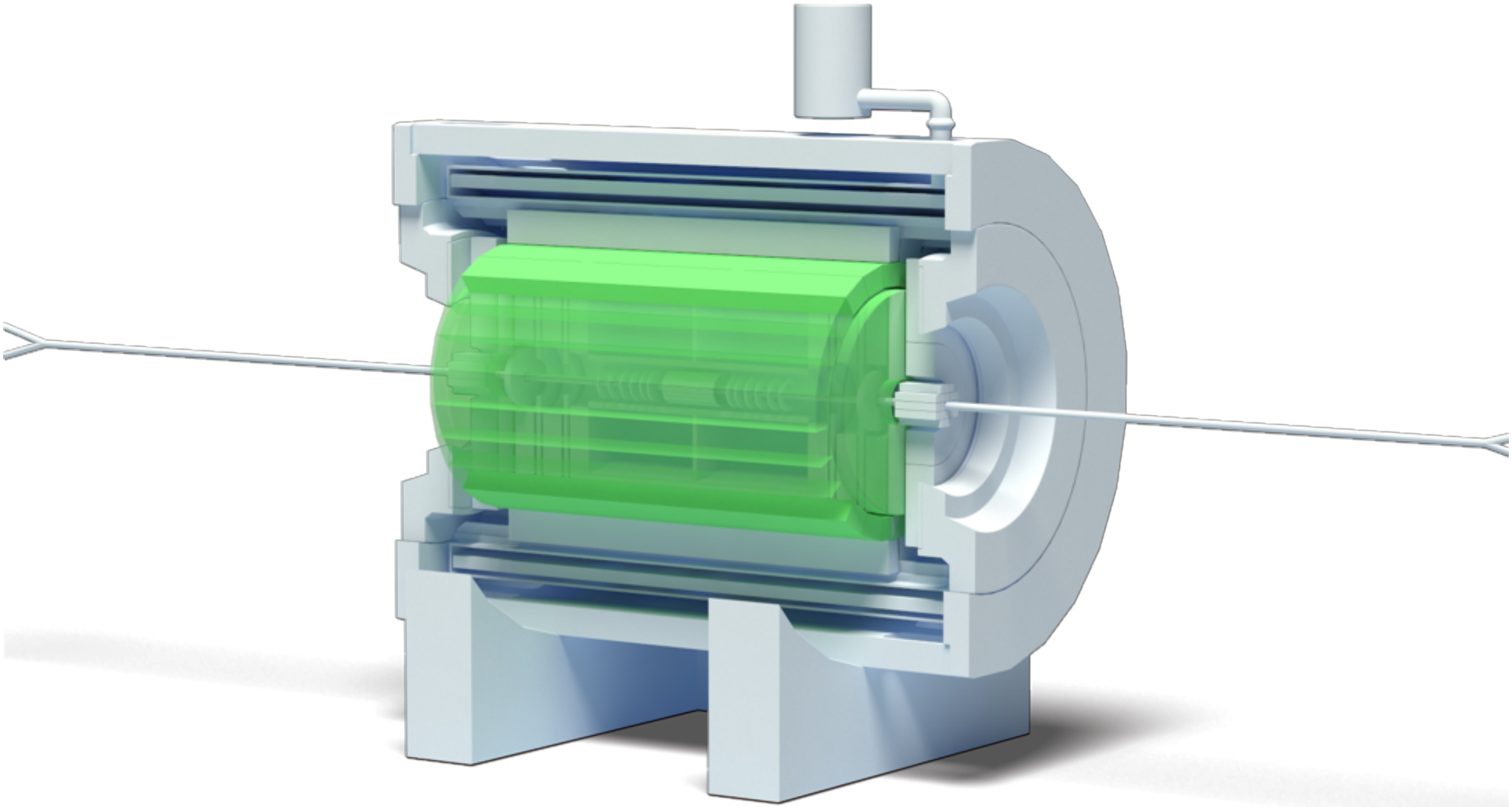
ECAL: electromagnetic calorimeter. Design to measure the spatial position and energy of the electrons and photons

MPD-NICA at JINR



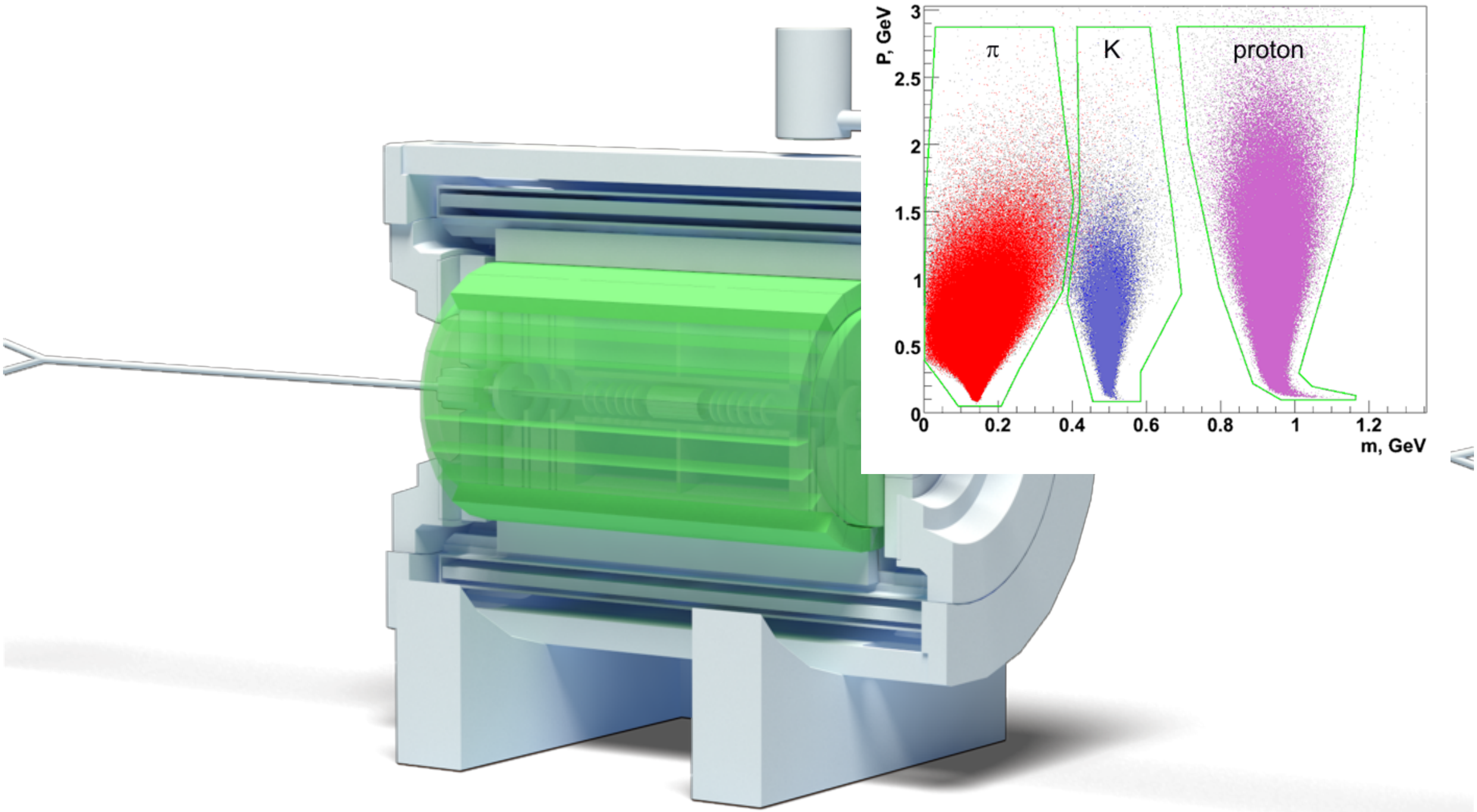
FD: fast determination of nucleus-nucleus interaction in the center of MPD setup.

MPD-NICA at JINR



TOF: Time of Flight. Particle Identification (PID).

MPD-NICA at JINR



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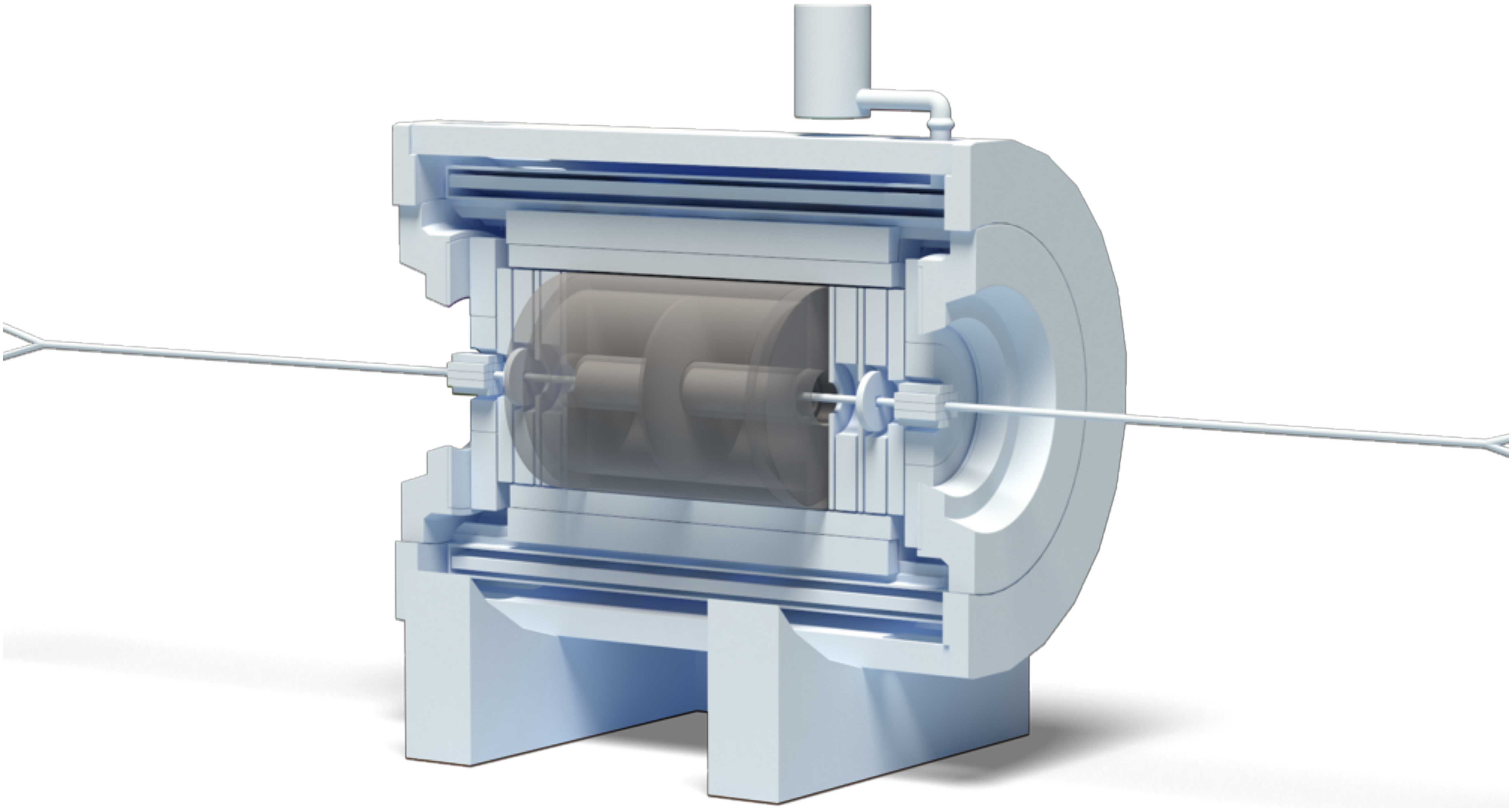
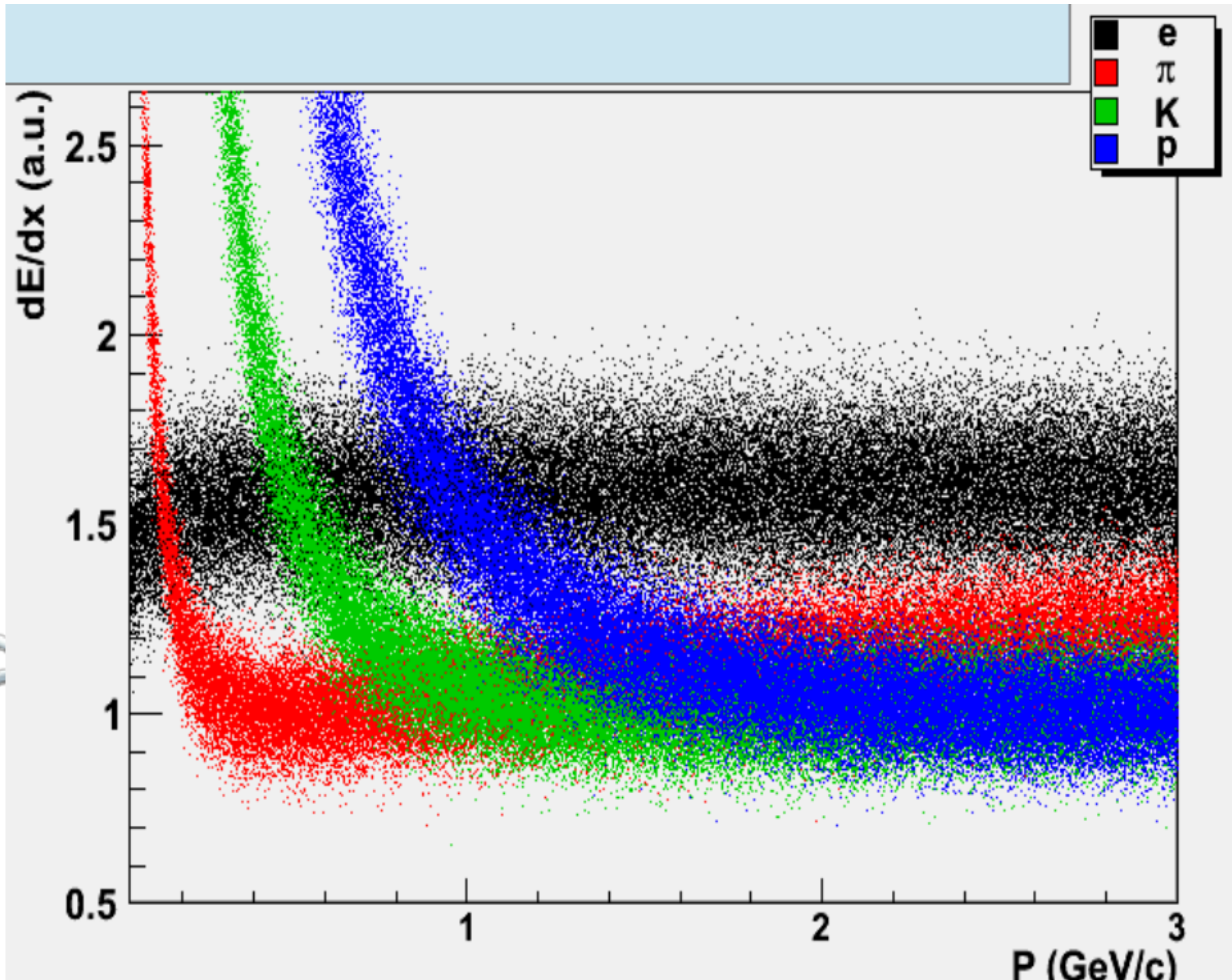
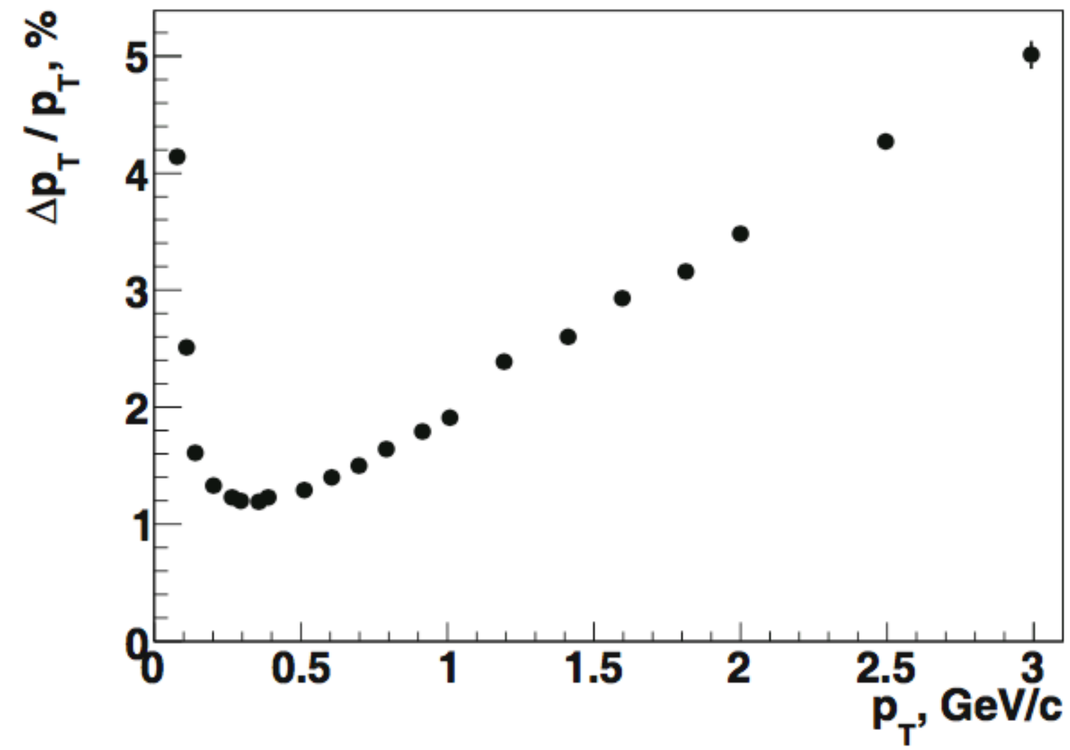
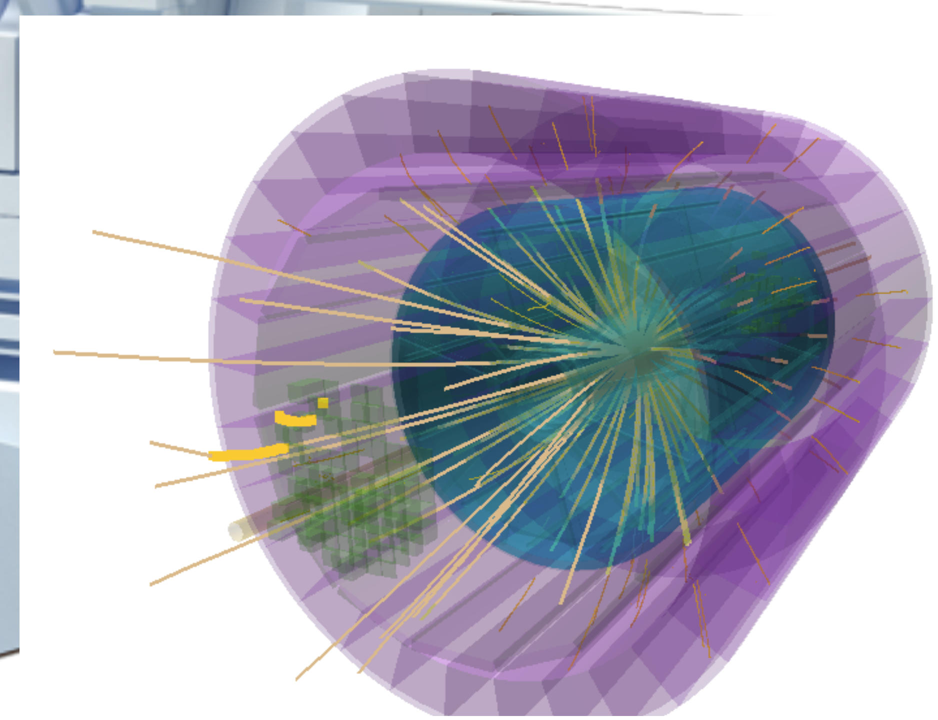


TPC: Time Projection Chamber.

MPD-NICA at JINR







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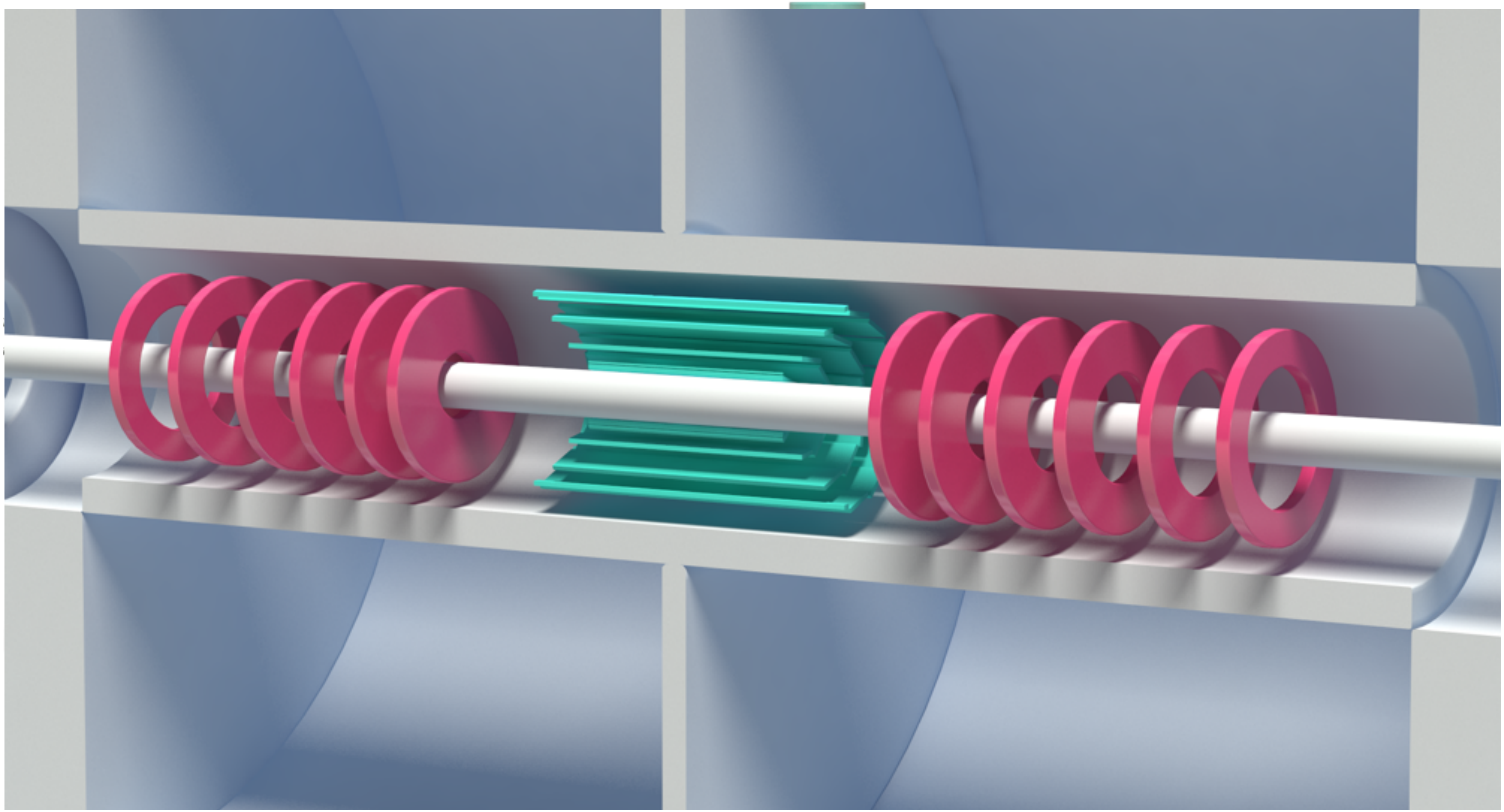
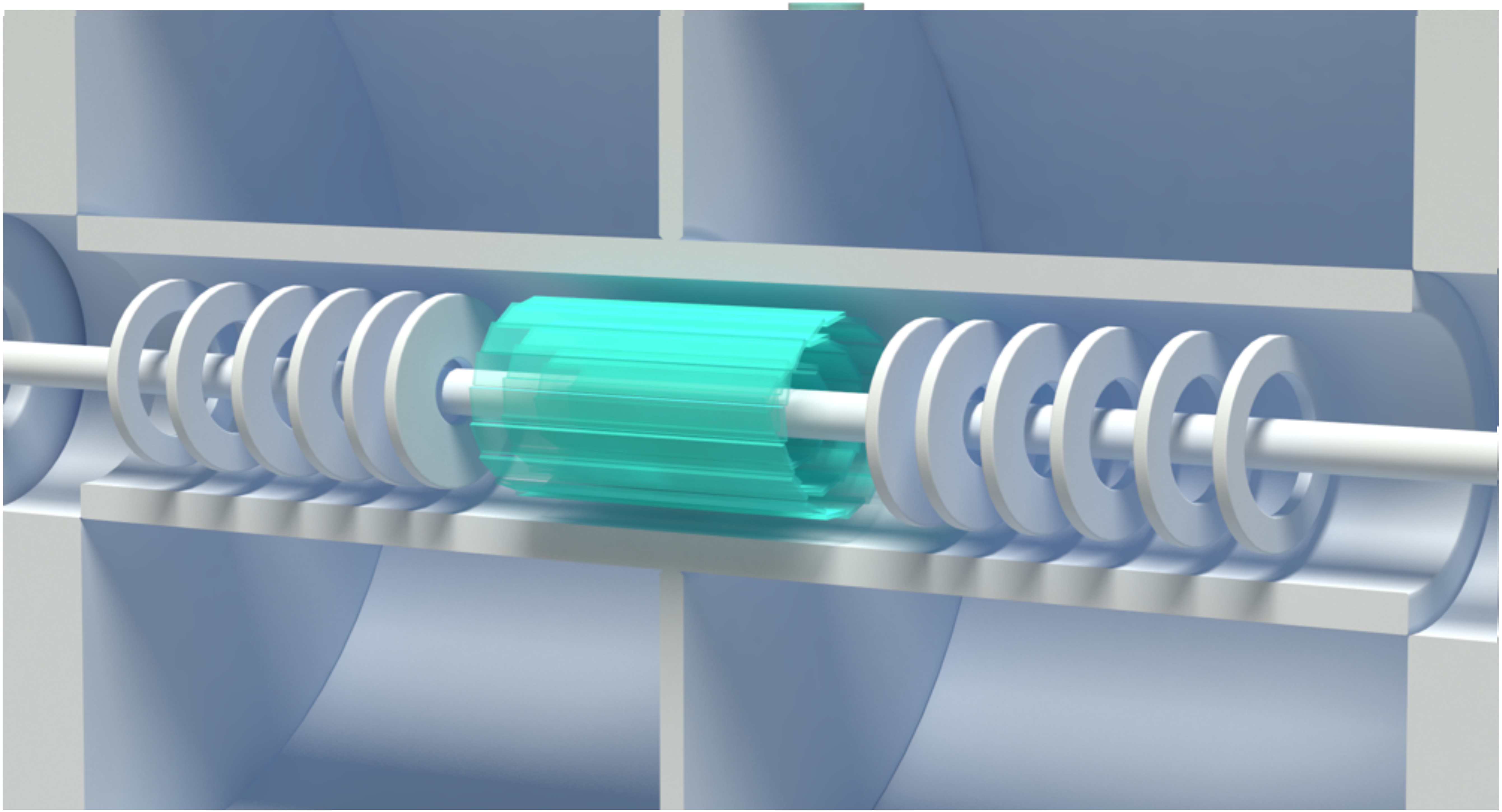


ITS: Inner tracking system

MPD-NICA at JINR



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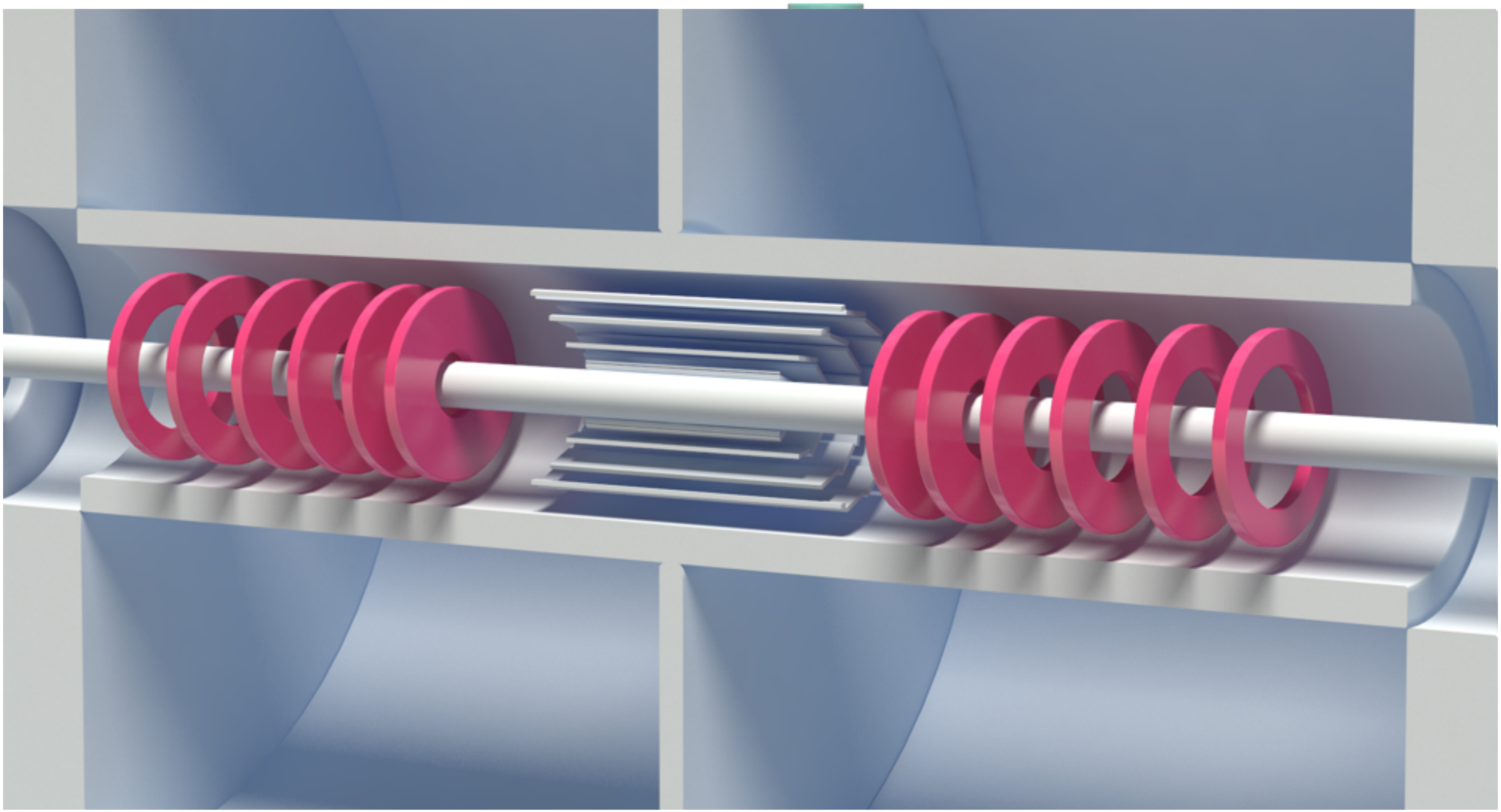

GEM tracker: Inner tracking system

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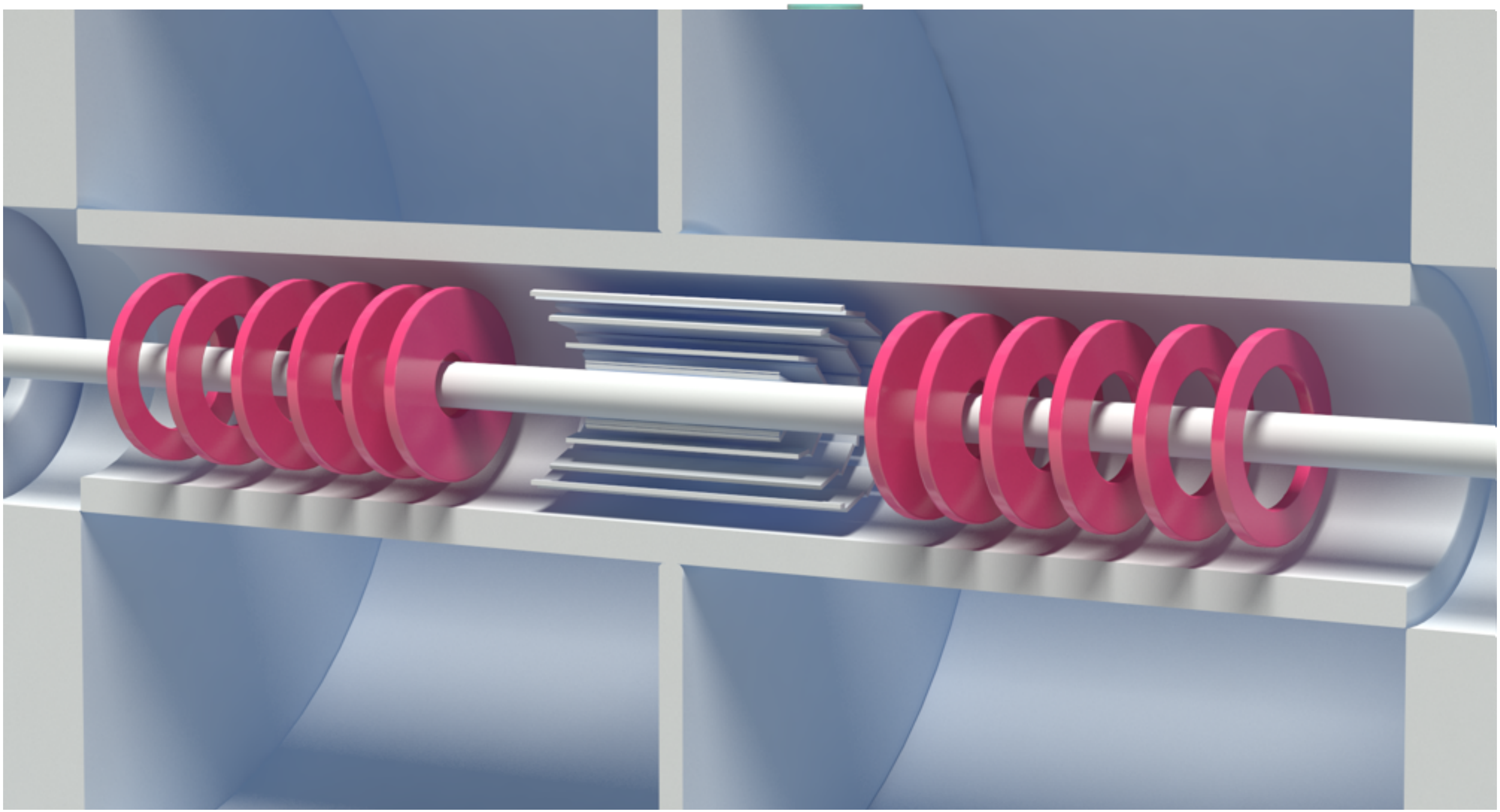

GEM tracker: Inner tracking system

MPD-NICA at JINR

Stage 1 (Mid-rapidity region, TPC, TOF, ECAL, ZDC, FD)

- Particle yields and spectra (pions, Kaons, protons, etc)
- Event-by-event fluctuations
- Femtoscopy involving pions, Kaons and protons
- Collective flow for identified hadrons
- Electromagnetic probes (electrons, gammas)

MPD-NICA at JINR

Stage 2 (Mid-rapidity region, TPC, TOF, ECAL, ZDC, FD + ITS)

- Total particles multiplicities
- Asymmetries study (better reaction plane determination)
- Di-lepton precise study
- Charm
- Exotic (soft photons, hypernuclei)

MEXnICA proposal

MEXnICA

Mexican group joining to the MPD-NICA efforts at JINR.

List of participants institutions (strict alphabetical order)

- BUAP
- CINVESTAV (Física)
- UAS
- UNISON
- UNAM (II, FC & ICN)

MEXnICA proposal

Main goal:

To contribute in the study of the QGP phase diagram (CEP)

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To study, from theoretical point of view, the mechanism responsible for the restoration of chiral symmetry.

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How?

To study, from theoretical point of view, the mechanism responsible for the restoration of chiral symmetry.

To study, from theoretical point of view, the QCD phase diagram at finite values of temperature and density.

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How?

To study, from experimental point of view, signatures that allows to locate the CEP.

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To contribute in the study of the QGP phase diagram (CEP)

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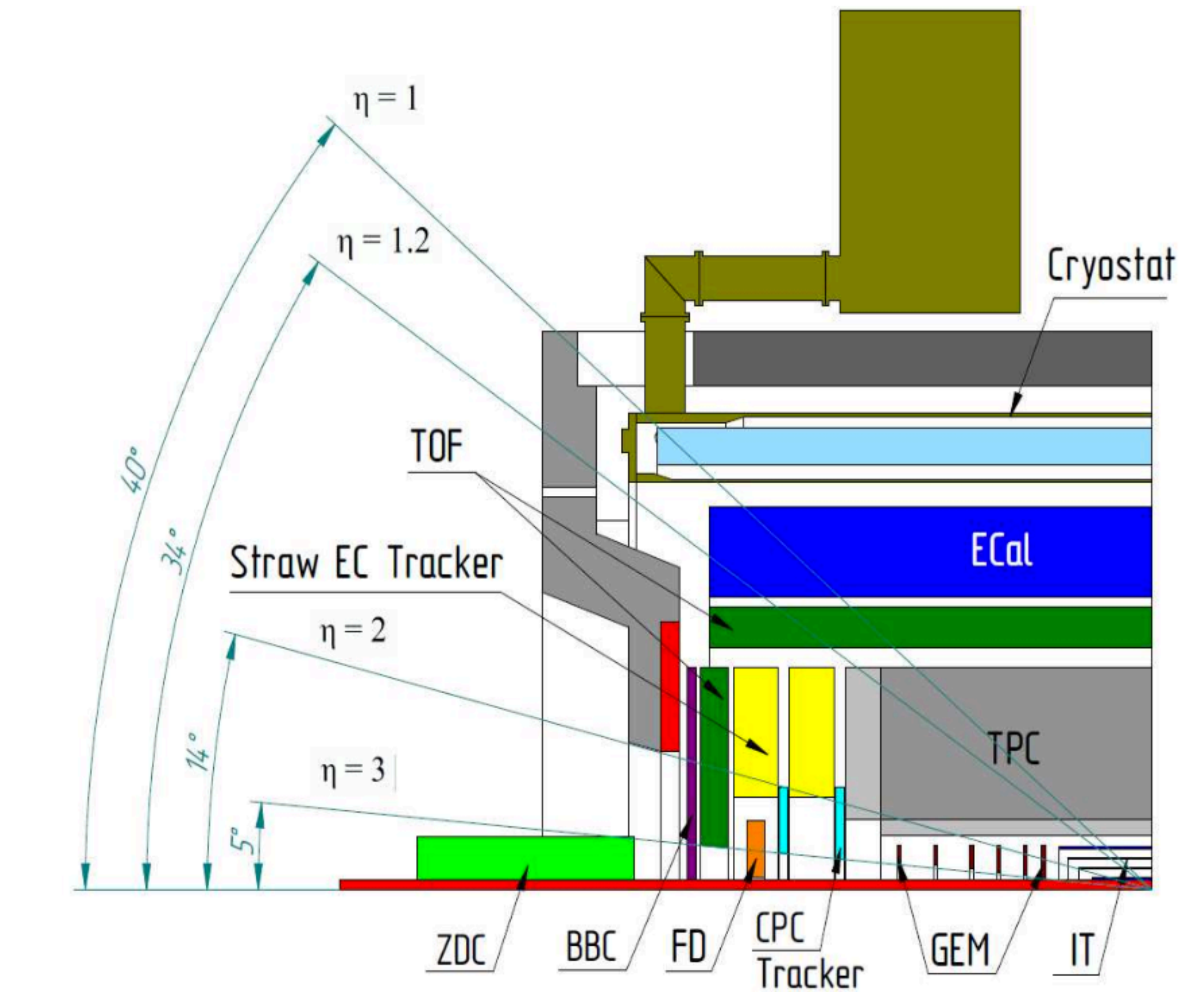
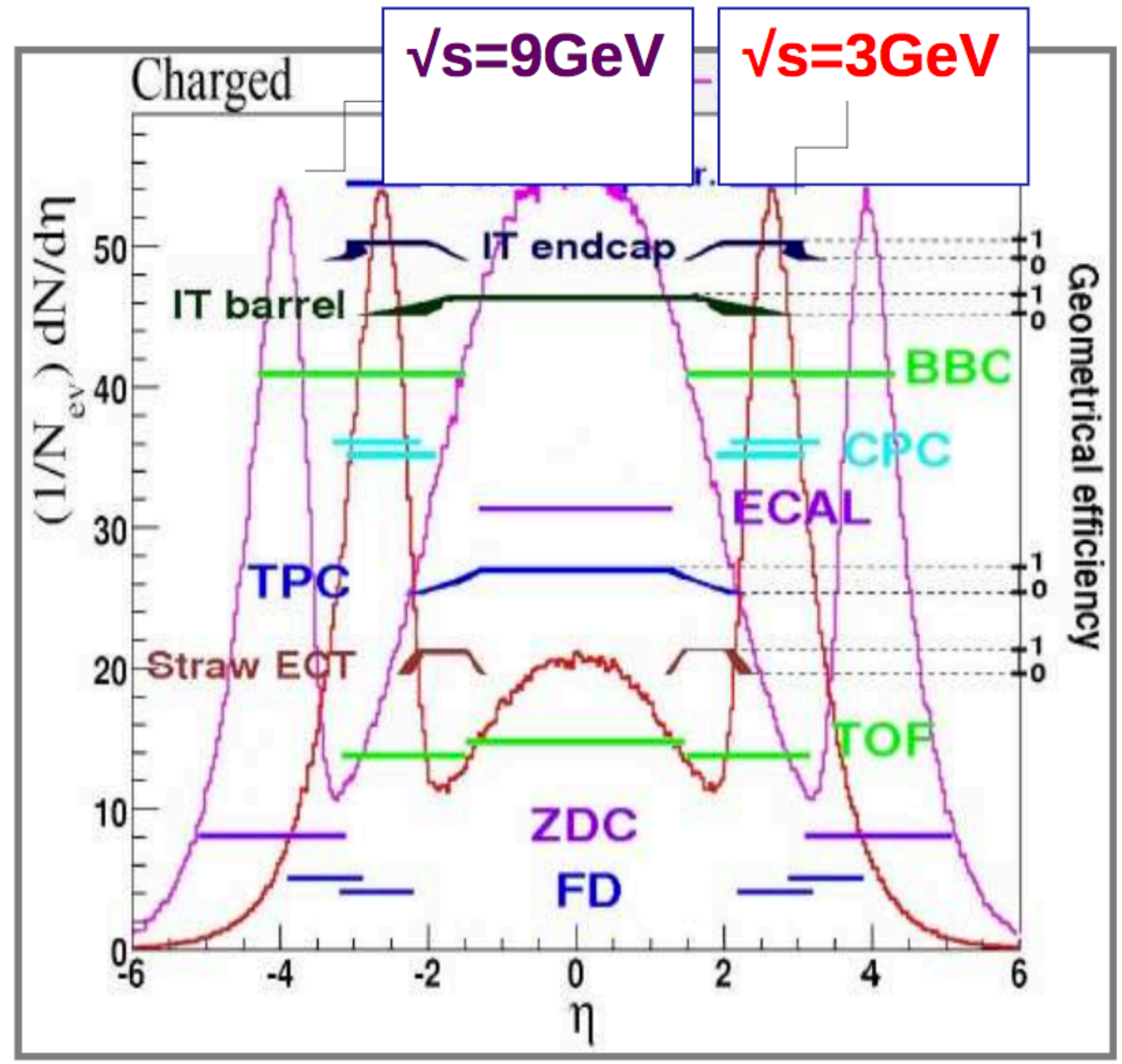
To study, from experimental point of view, signatures that allows to locate the CEP.

To study, from experimental point of view, the inclusion of a detector that allows to MPD increase its pseudorapidity acceptance.Bonus, optimization of event plane resolution, and trigger system

MEXnICA proposal





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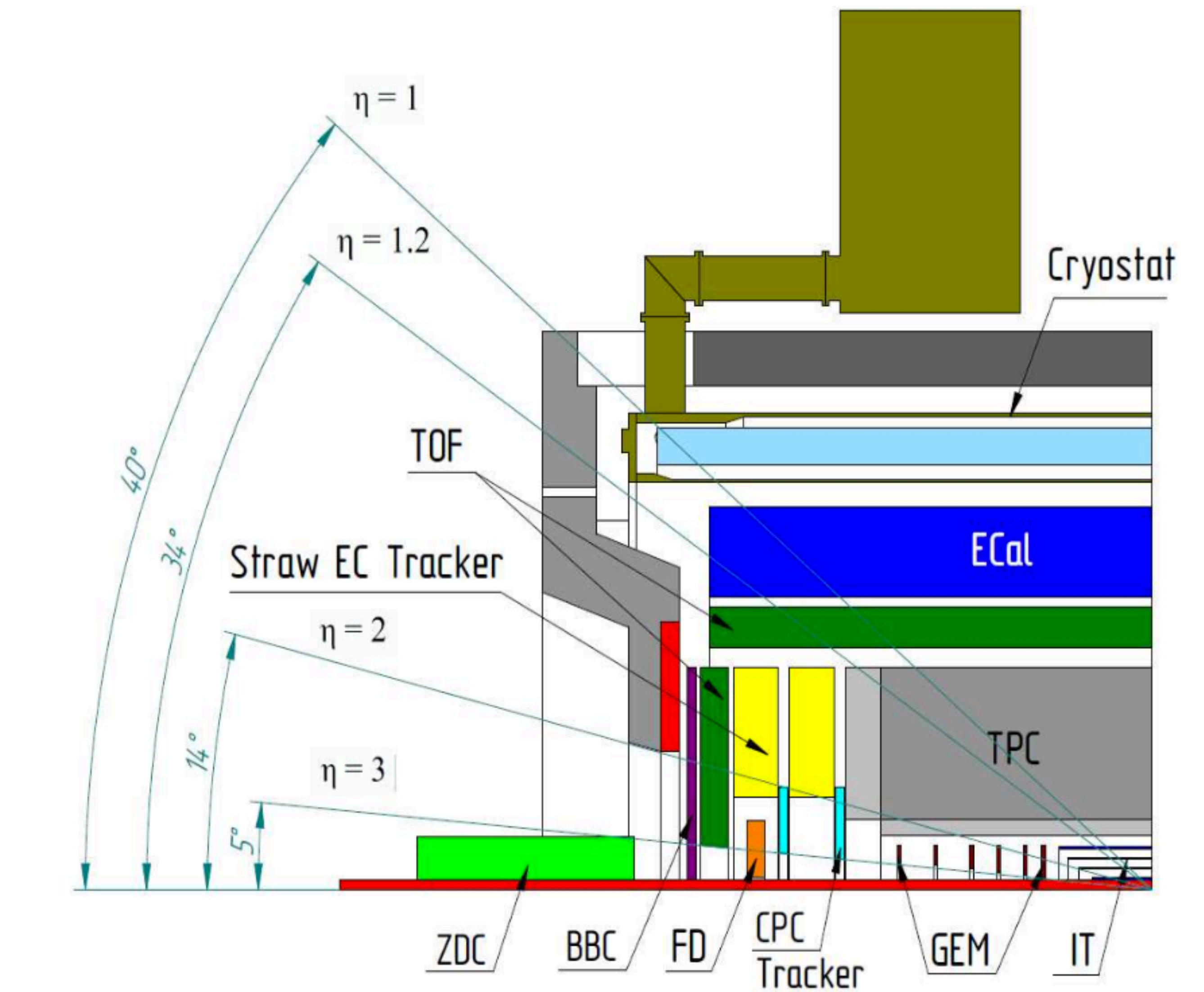

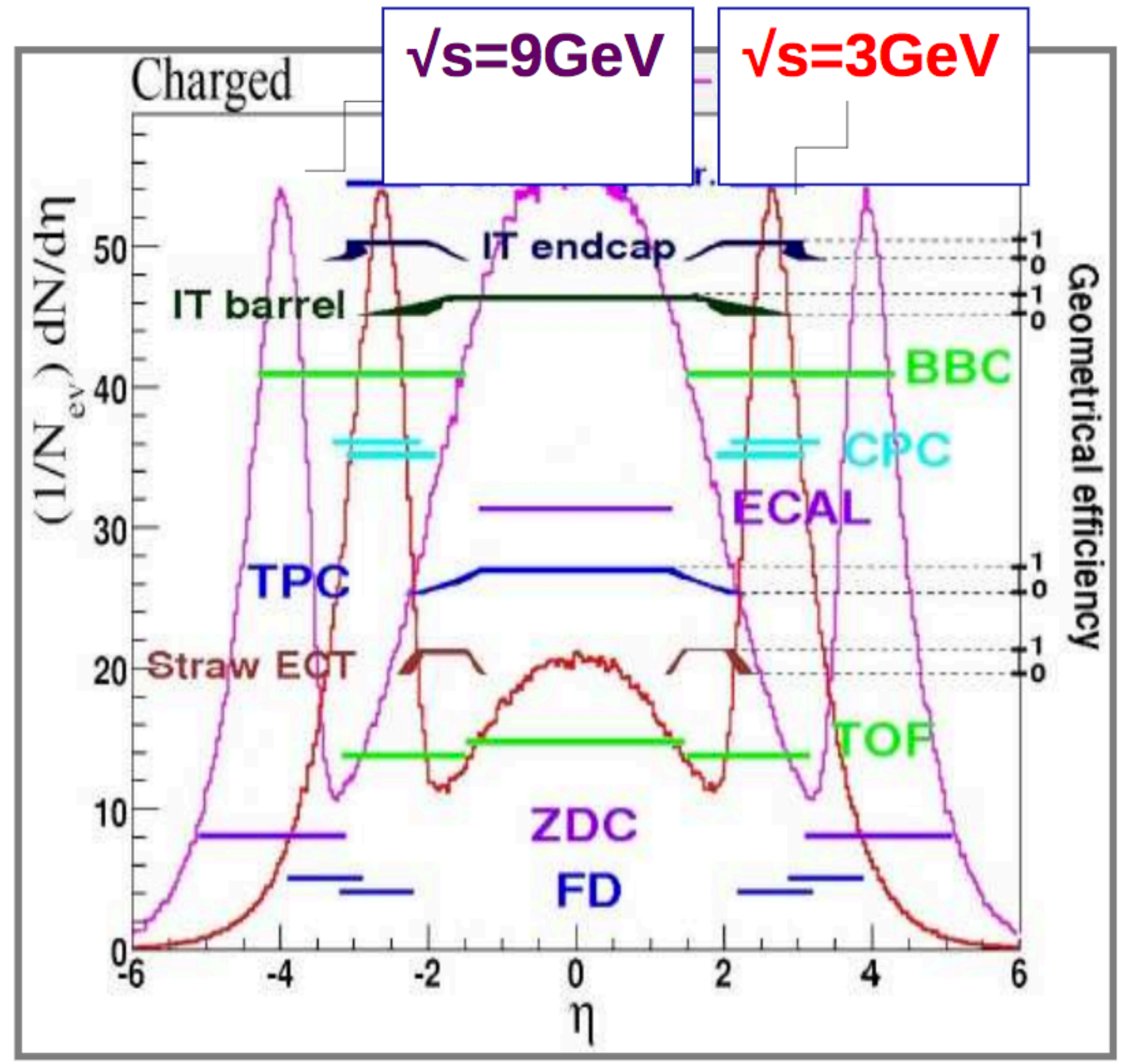

Beam Beam Counter(BBC) —> Beam Monitoring Detector (BMD)

MEXnICA proposal

The pseudorapidity region proposed for the BBC is $1.5 < \eta < 4.5$, which is outside the TPC acceptance, and therefore will not introduce a trigger bias to physics measurements which mostly rely on the $-1.0 < \eta < +1.0$ pseudorapidity region. A minimum bias trigger will require both the BBCs (east and west) to reduce beam gas background contamination.

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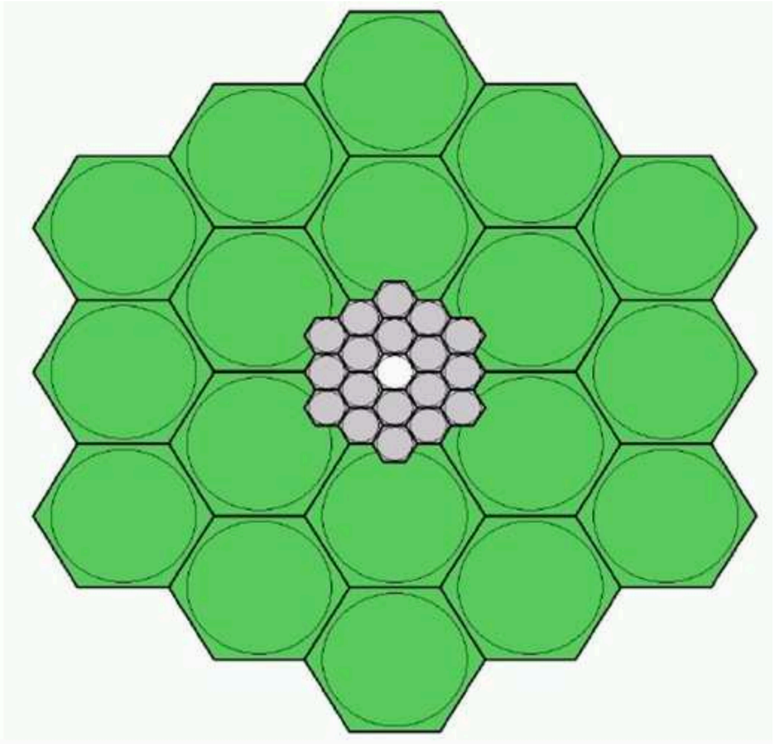

Fig. 2.112: Beam-Beam Counter front view. Small tiles can be inscribed in a circle with 12 cm diameter, large tiles are exactly four times larger. Inner empty space is left for the beam pipe.

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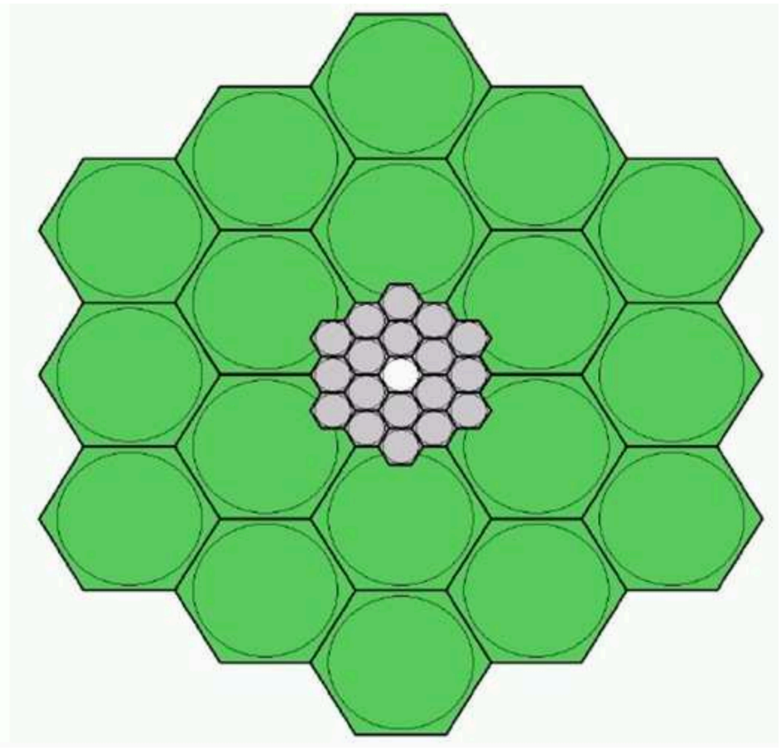

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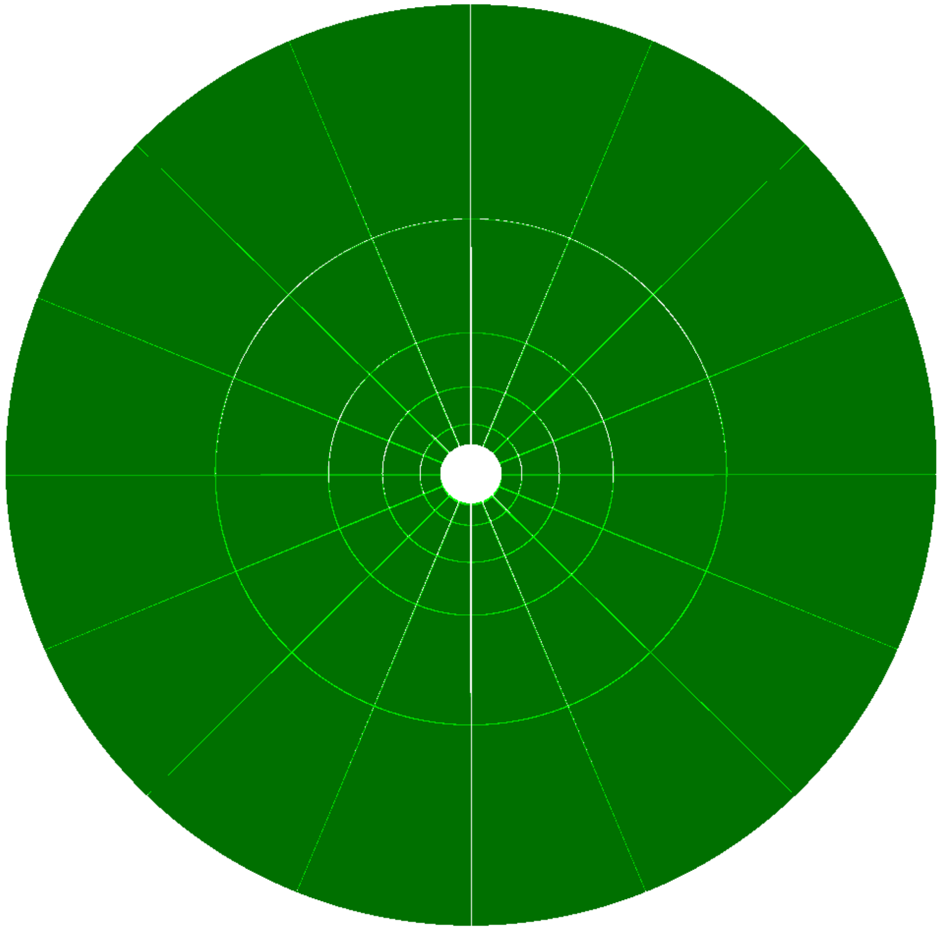

MEXnICA proposal

based on ALICE experience (see Lizardo Valencia slides)

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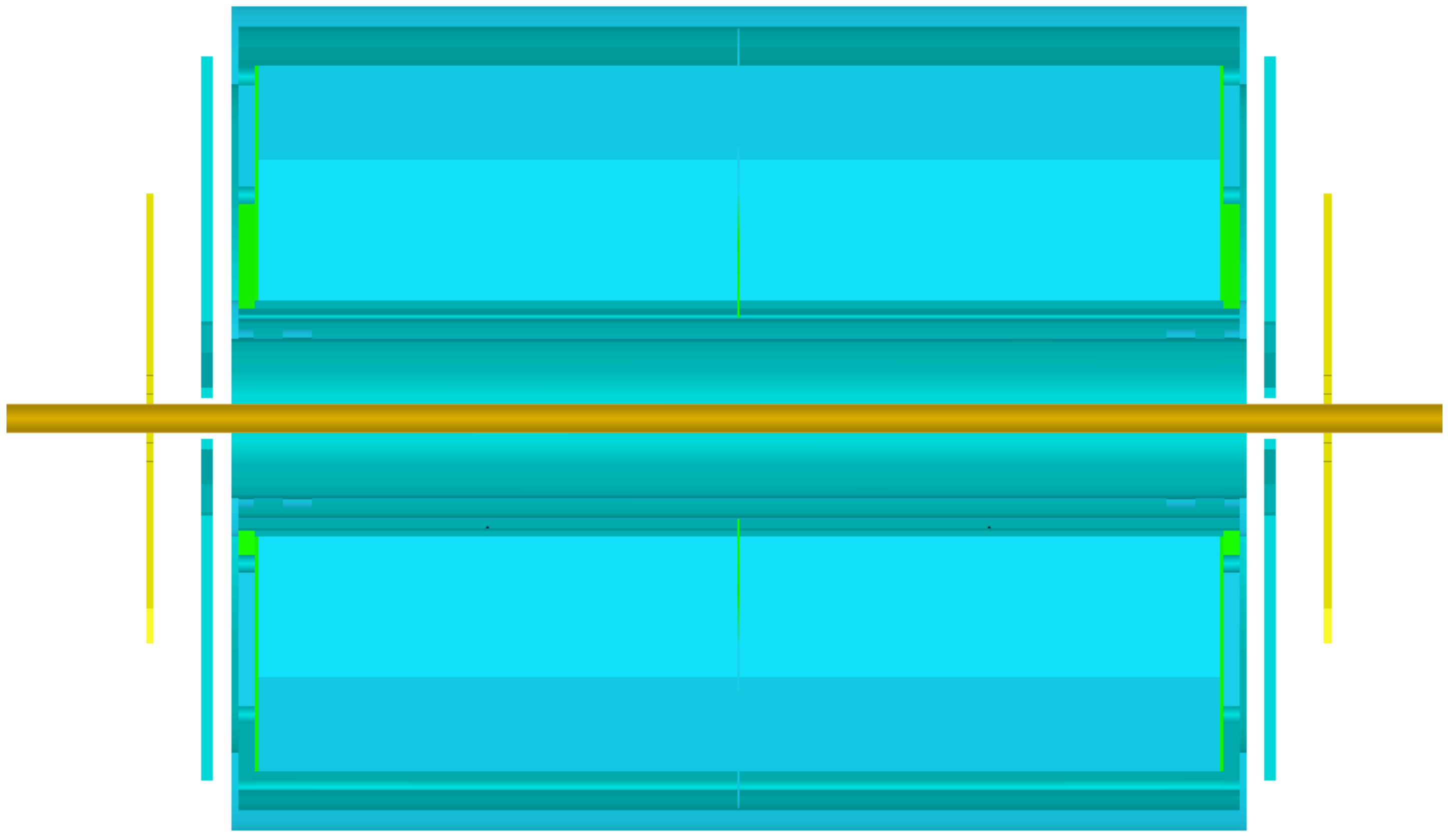

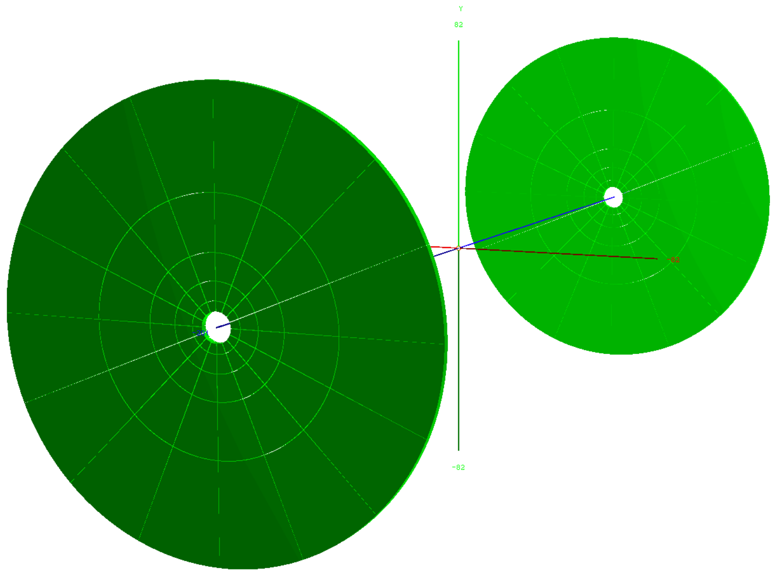

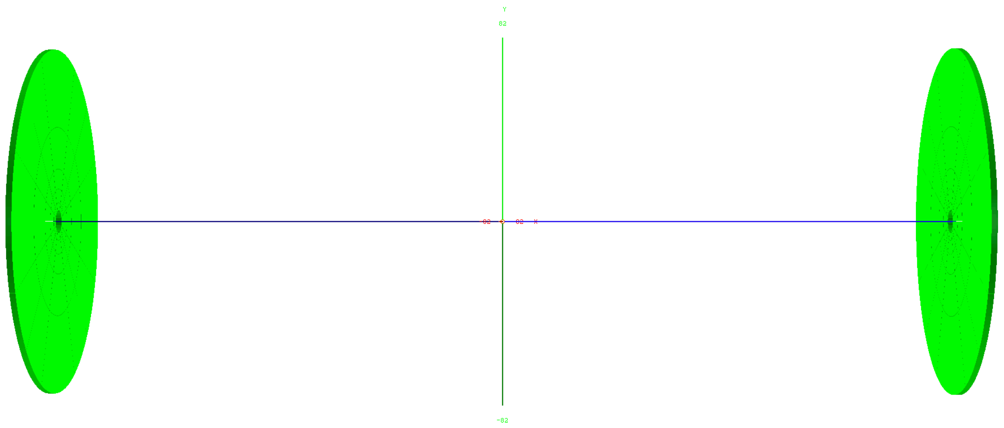

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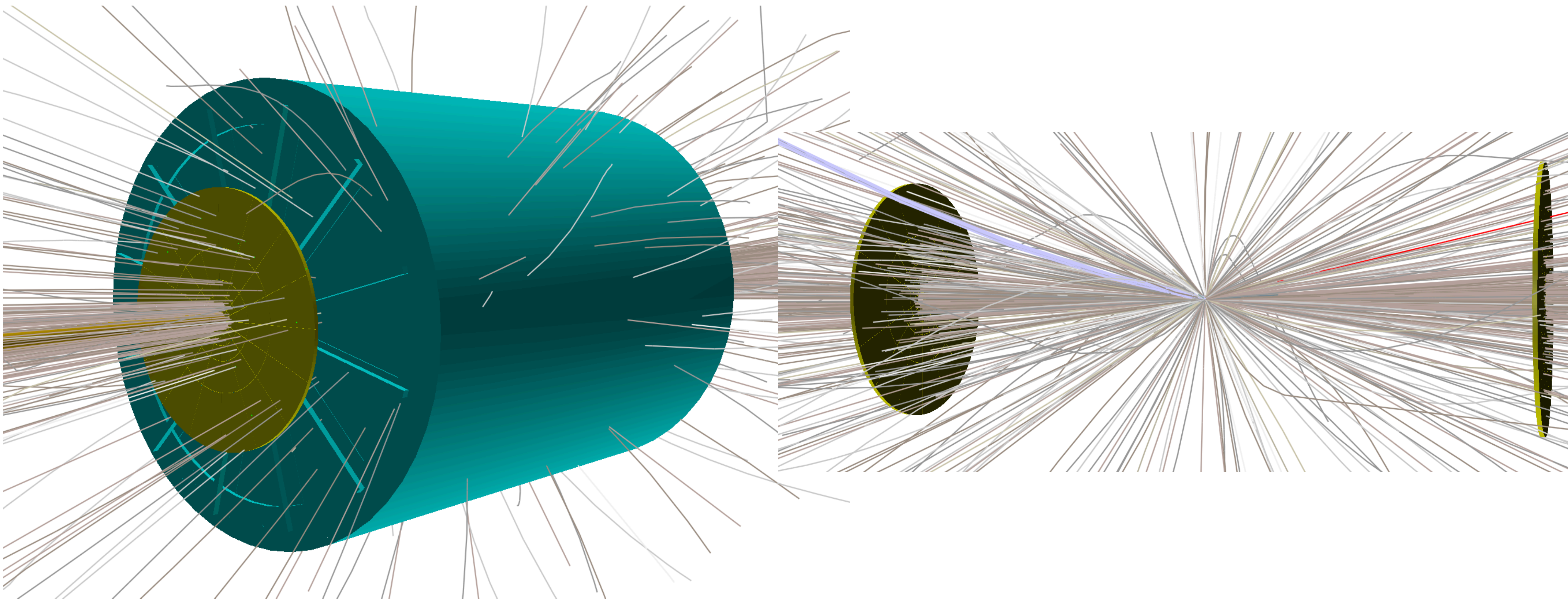

Final comments

NICA facility has the potential for competitive research in the field of dense baryonic matter

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The MPD detector has many advantages and meets all the ambitious physics requirements for exploring phase diagram of strongly interacting matter in a high track multiplicity environment.
The MPD detector covers a large phase space; it is functional at high interaction rates; comprises high efficiency and excellent particle identification capabilities; it is based on the recent detector developments and has comparatively reasonable cost.

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MEXnICA group plans

Conceptual design report of BMD is a work in progress. This material will be the input for a paper on this proposal

Final comments

MEXnICA group

Maria Elena Tejeda Yeomans
Isabel Dominguez Jiménez
Wolfgang Bietenholz
José Alejando Ayala Mercado
Roger Hernández Pinto
Luis Manuel Montaño Zetina
Luis Valenzuela
Heber Zepeda
Rodolfo Palomino
E. Moreno
Victor Manuel Velazquez Aguilar
Lauro Santiago Cruz
Sergio Solis
Pedro Gonzalez Zamora
Mario Rodríguez Cahuantzi

Back-up slides

Introduction

Ok, maybe I can skip this. Irais just talked about this topic

Quantum Chromodynamics (QCD) is the theory of Strong Interactions (forces between quarks, gluons, protons, neutrons ...)

Quarks and gluons remain confined (quarks and gluons cannot be isolated) inside hadrons (protons, neutrons)

Interaction becomes very weak at high energies/small length scales (2004 Nobel Prize to Gross, Politzer, Wilczek)

Under extreme conditions of high density and/or temperature there should be a deconfinement of quarks and gluons, and hadrons should undergo a phase transition.

Introduction

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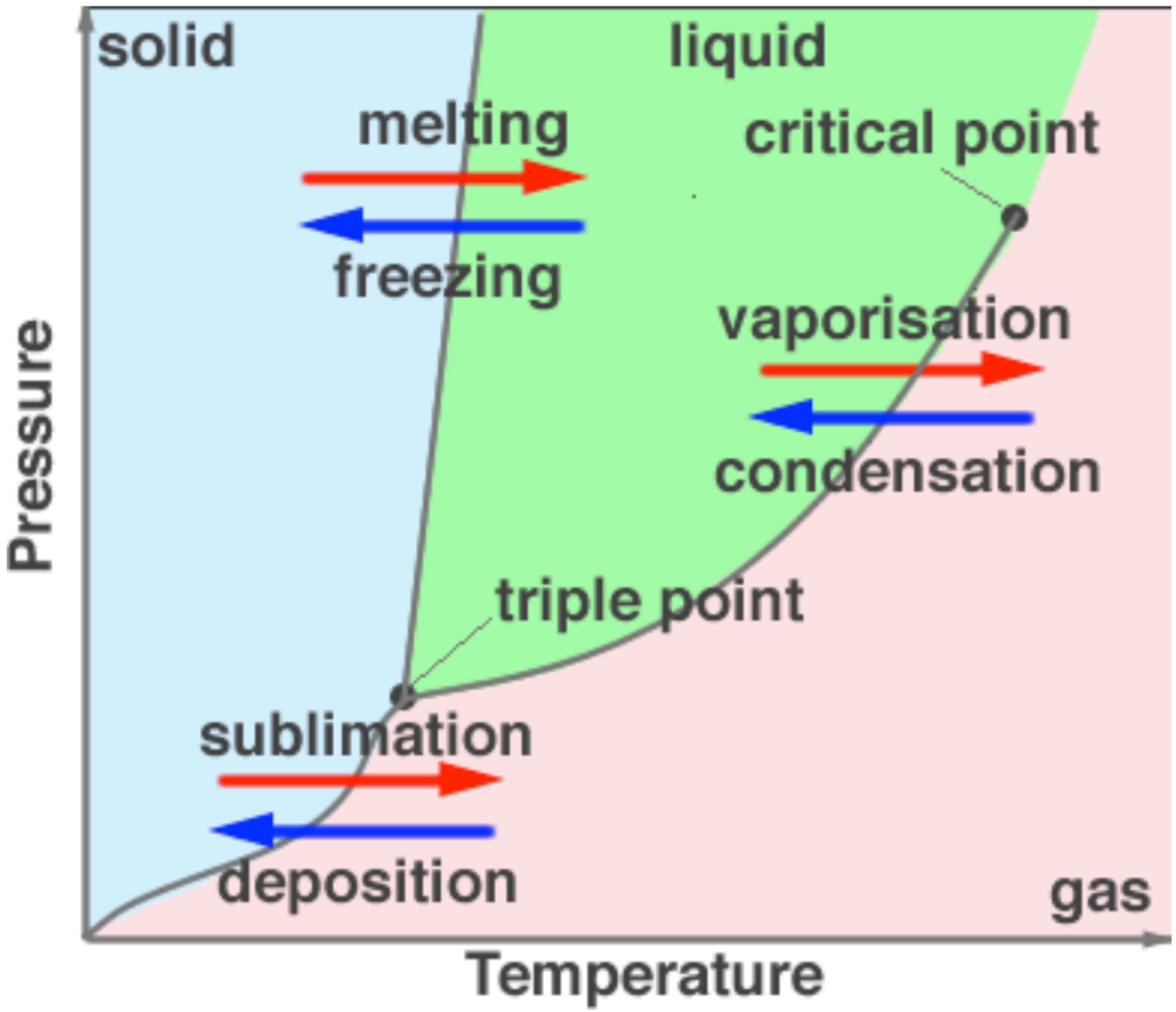

Example: Phase diagram of water

The ordinary matter can be observed in a variety of phases.

The matter can be transformed in different phases by changing external conditions such as Pressure and Temperature