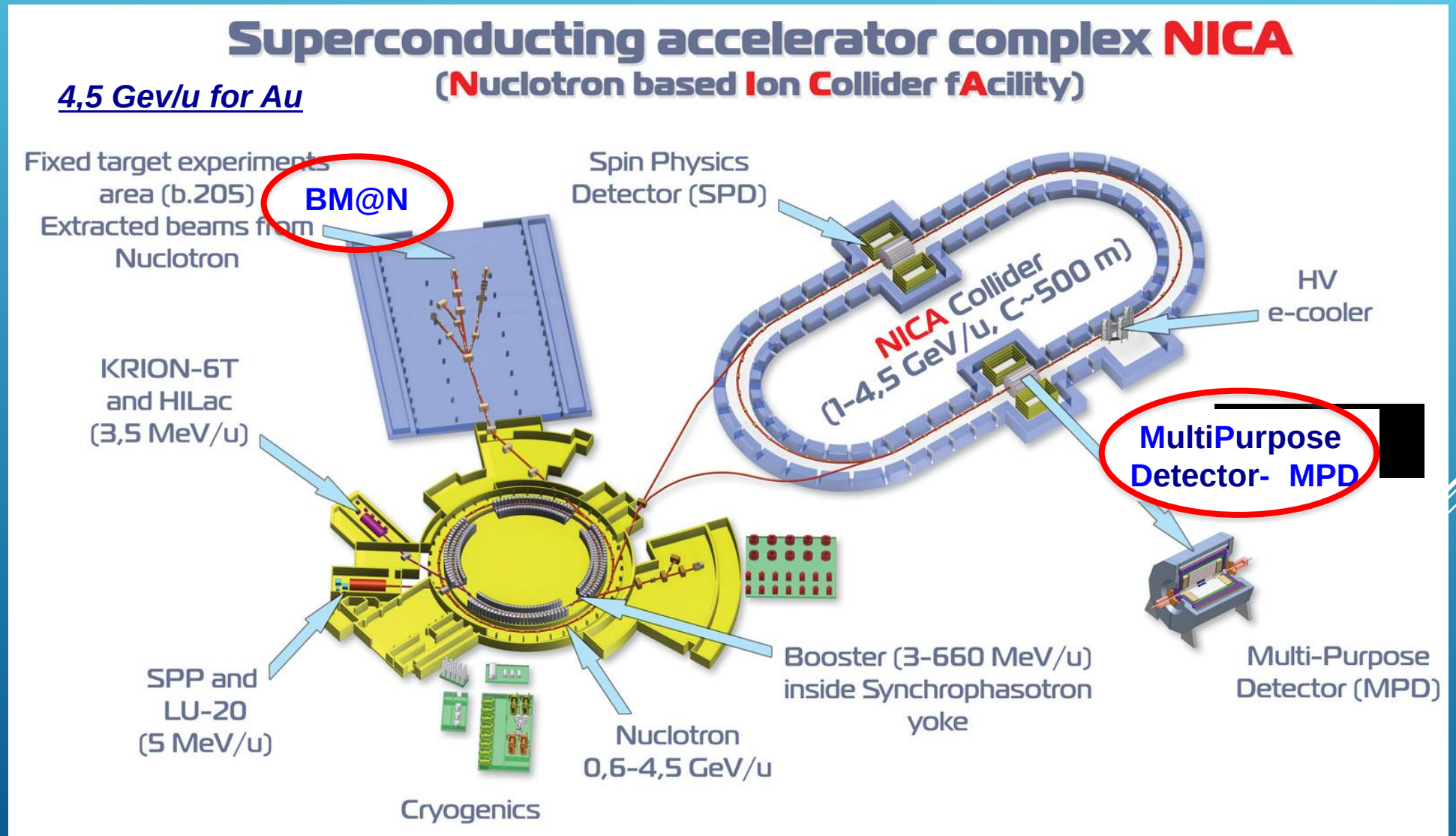
D. Dąbrowski, V. Golovatyuk, M. Kapishin, V. Kekelidze, M. Peryt, J. Pluta, O. Rogachevskiy, K. Rosłon,

Modular and Adaptable Control System for high-energy physics experiments/detectors BM@N and MPD at JINR in Dubna

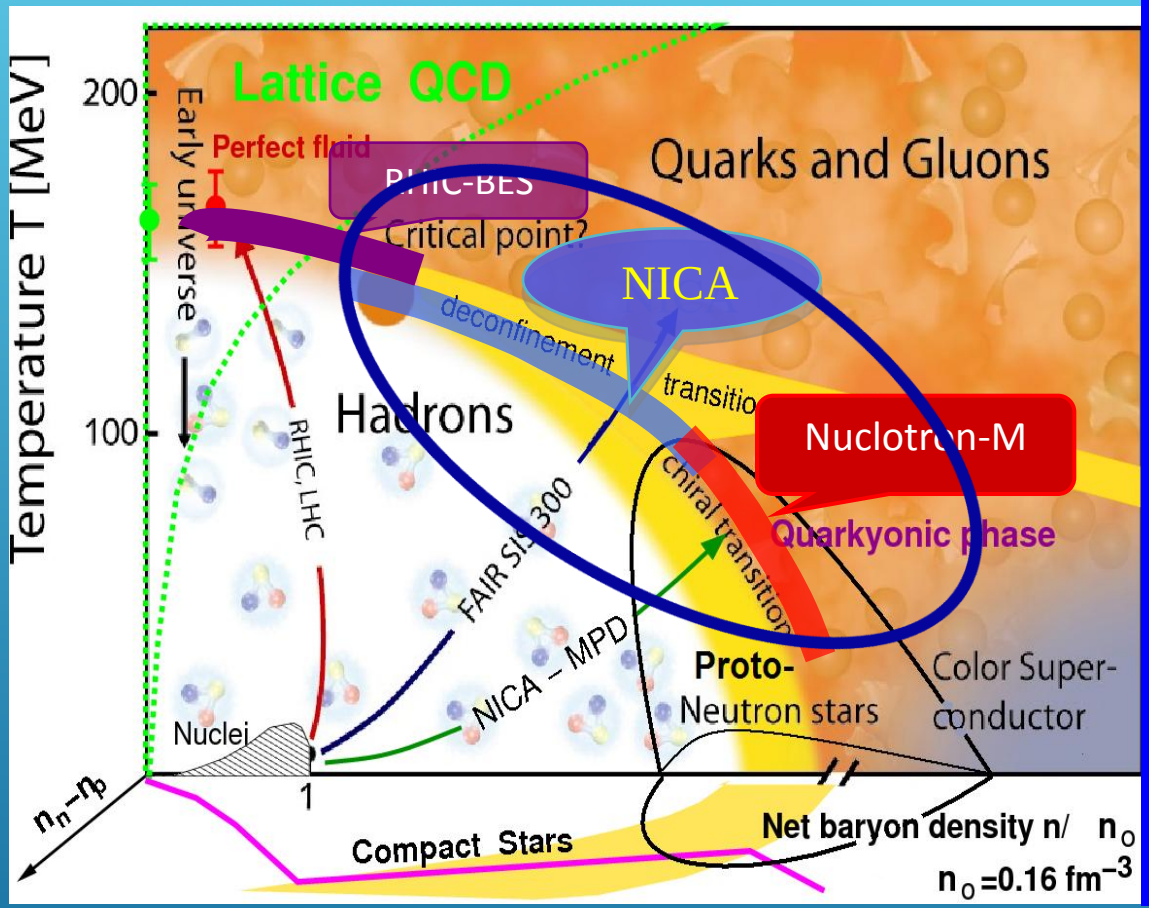


MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

Some abbreviations:

FP WUT – **F**aculty of **P**hysics, **W**arsaw **U**niversity of **T**echnology
V&BLHEP – **V**eksler & **B**aldin **L**aboratory of **H**igh **E**nergy **P**hysics
JINR – **J**oint **I**nstitute for **N**uclear **R**esearch
NICA – **N**uclotron-based **I**on **C**ollider f**A**cility
MPD – **M**ulti-**P**orpouse **D**etector
BM@N – **B**aryonic **M**atter **at N**uclotron

QCD phase diagram - Prospects for NICA



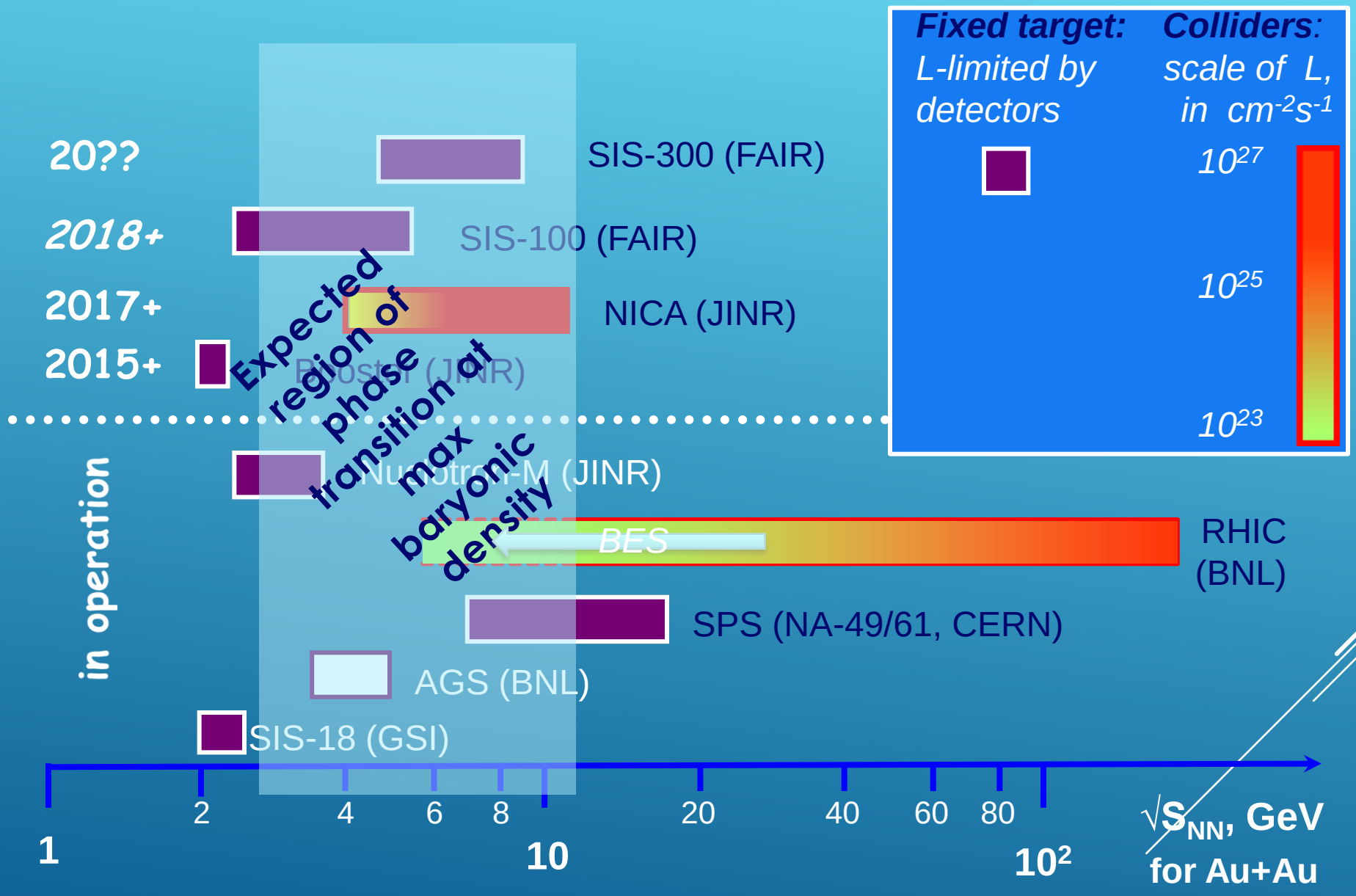
Energy Range of NICA

unexplored region of the QCD phase diagram:

- Highest net baryon density
- Onset of deconfinement phase transition
- Strong discovery potential:
  a) Critical End Point (CEP)
  b) Chiral Symmetry Restoration
- Complementary to the RHIC/BES, FAIR, CERN & Nuclotron-M experimental programs

NICA facilities provide unique capabilities for studying a variety of phenomena in a large region of the phase diagram

Present and future HI machines



The MultiPurpose Detector (MPD) project

- approved in 2010

The goal:

Search for the mixed phase and phase transition of strongly interacting matter in processes:

AA, pA and pp interactions

using variety of nuclei A (from p to Au)

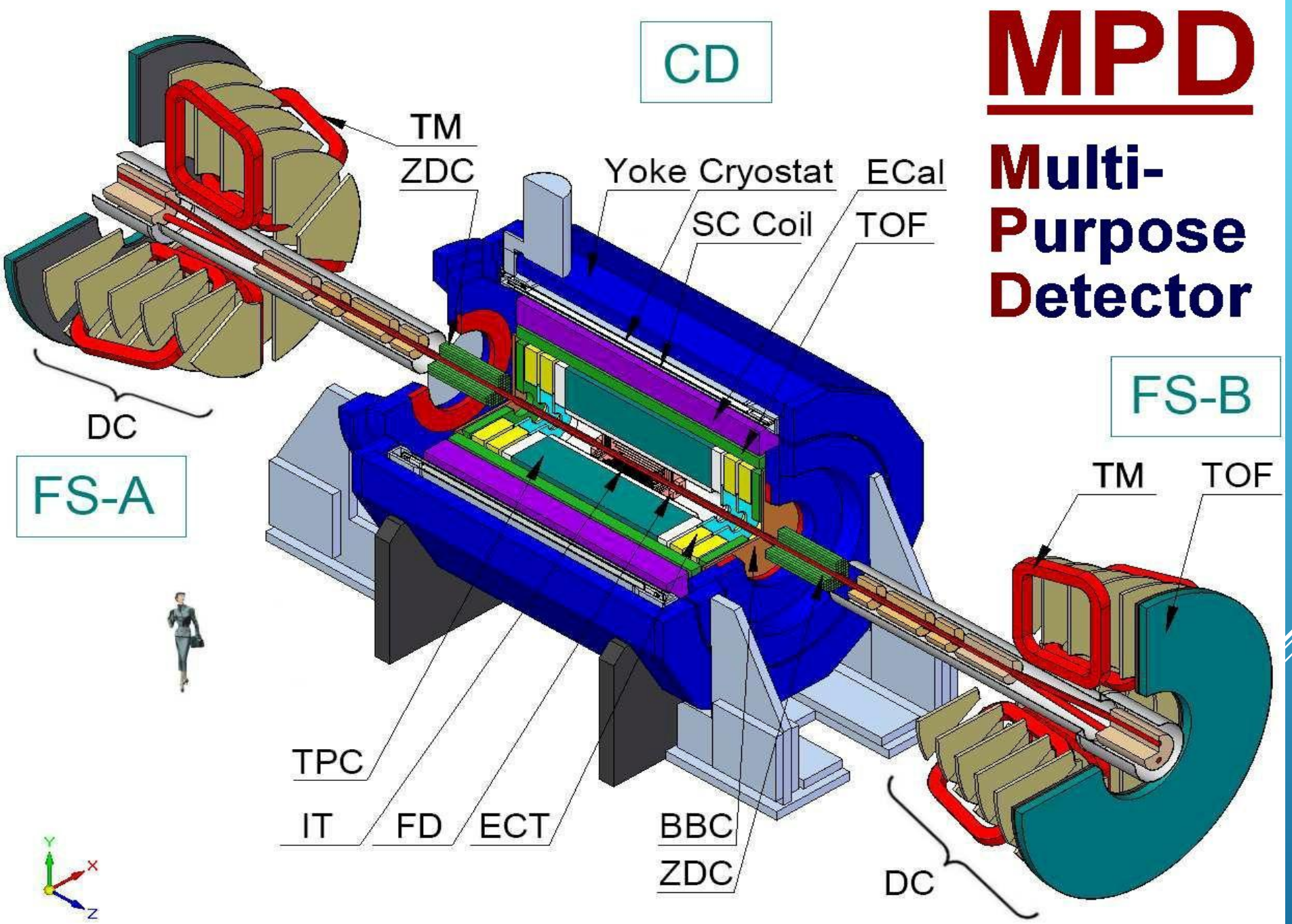
scanning over energy range: $\sqrt{s_{NN}}$ = *4 – 11 GeV*

with a fine steps

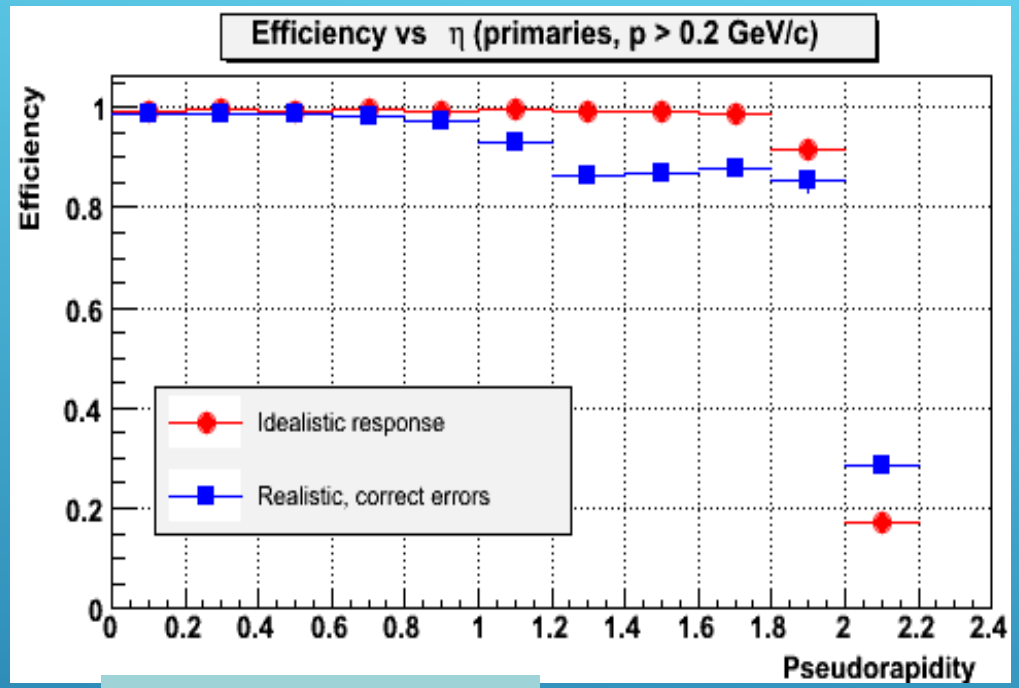
Strategy: detailed energy & system size scan

with a step ~ 10 MeV/u in selected regions

at high **L** allowing the high statistic (*precision*) studies

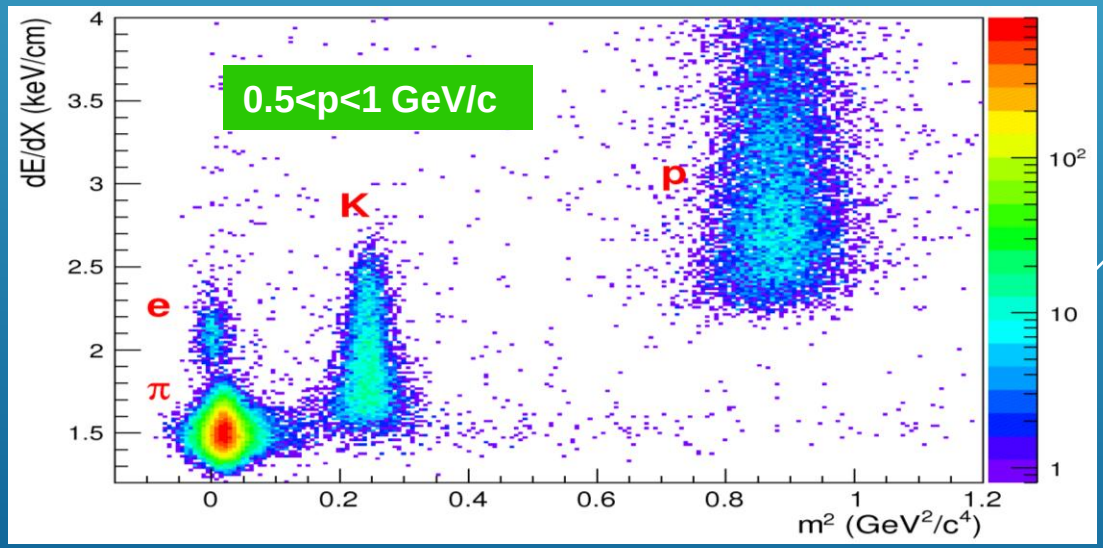

MPD
Multi-
Purpose
Detector
CD
FS-A
FS-B
TM
ZDC
DC
Yoke Cryostat
SC Coil
ECal
TOF
TM
TOF
TPC
IT
FD
ECT
BBC
ZDC
DC

MPD performance

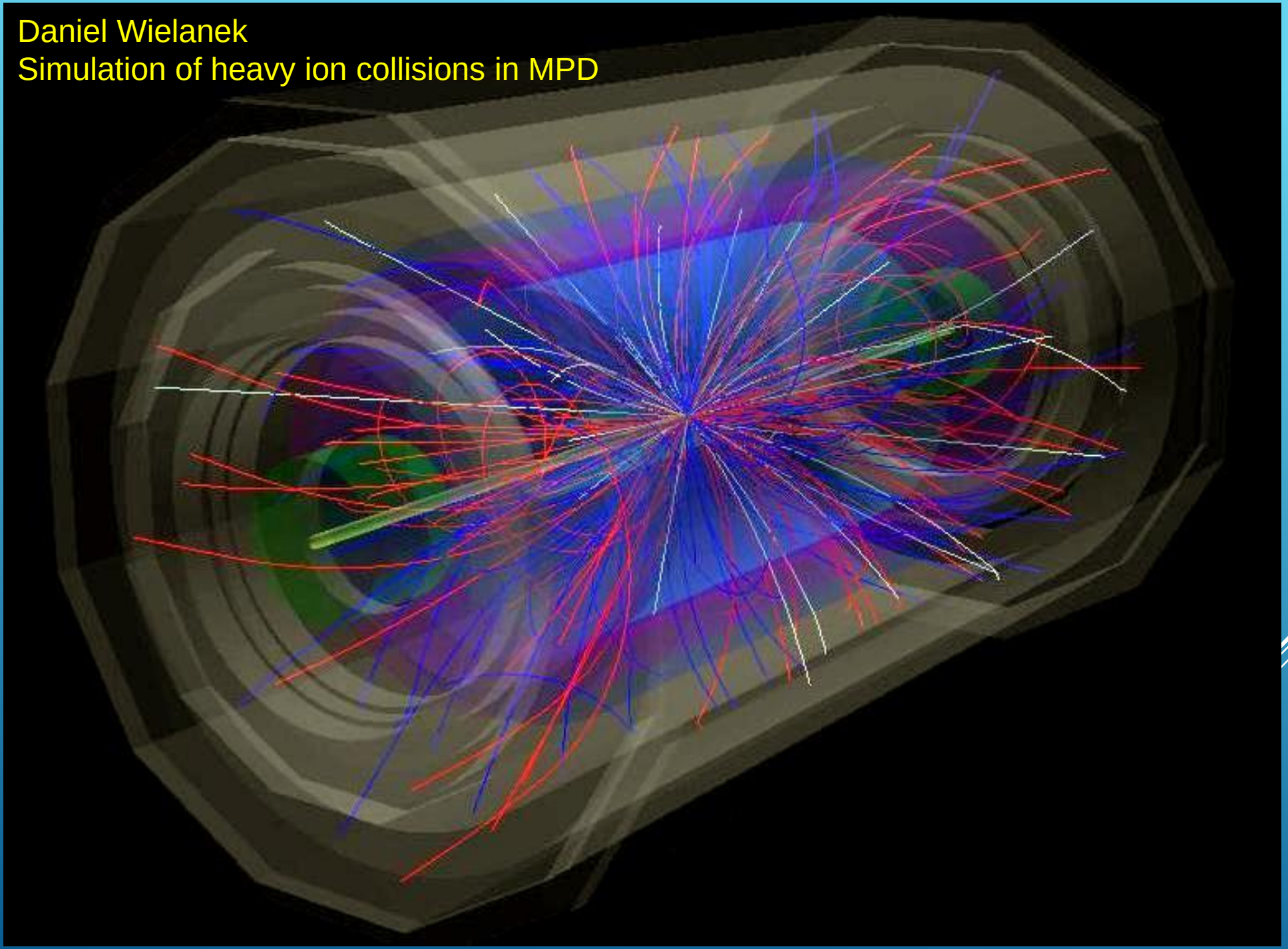


Tracking: *up to |η|<2 (TPC)*
PID: *hadrons, e, g (TOF, TPC, ECAL)*

PID: TOF, TPC, ECAL

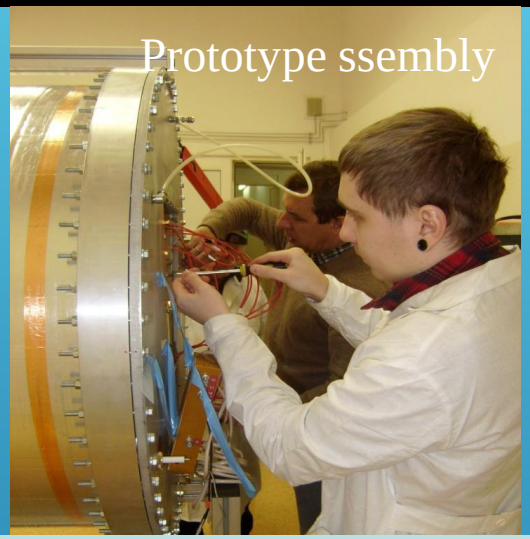


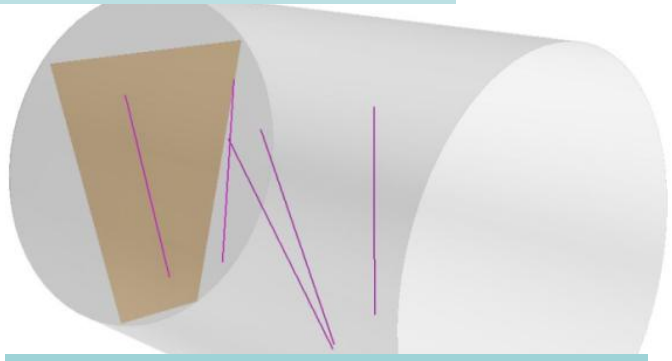
Daniel Wielanek
Simulation of heavy ion collisions in MPD



TPC- *technical project approved, production stage*

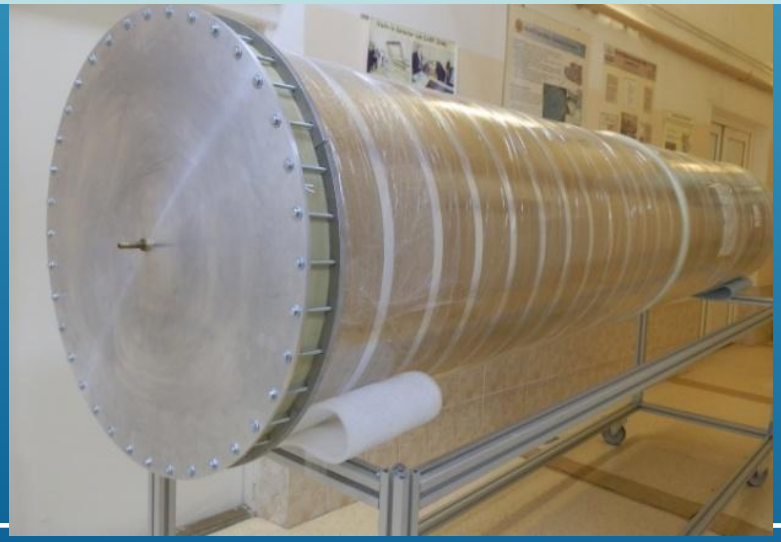
*Team leader - **Yu. Zanevsky** (VBLHEP)*





Prototype1: UV laser tracks - reconstructed

Cylinder C2, preparation for vacuum tests

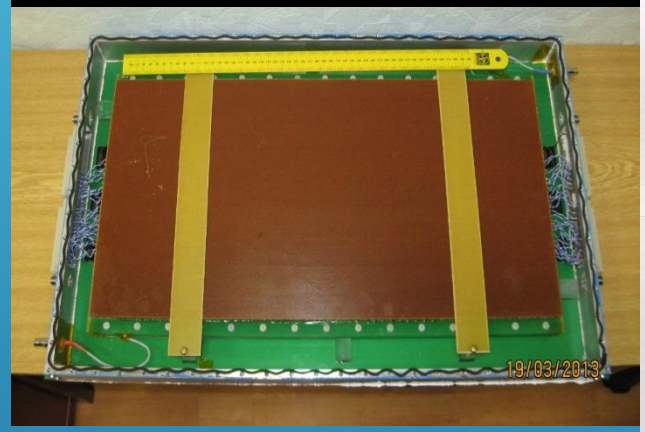


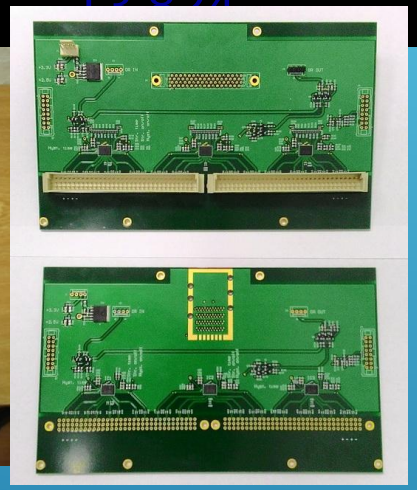
C3 manufactured in Dec. 2013

TOF Barrel Design

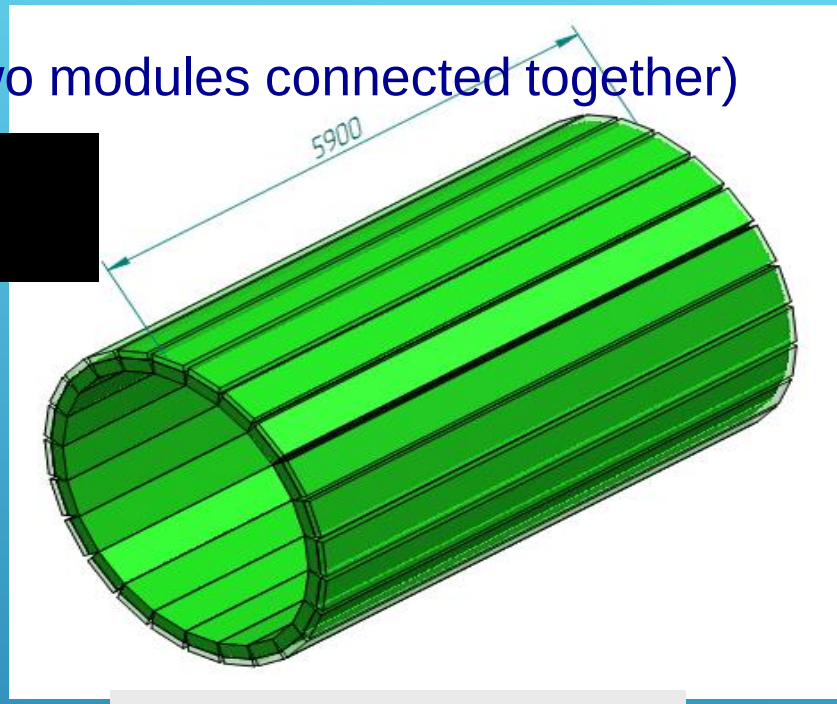
The barrel consist of 12 super-modules (two modules connected together)

Active area of TOF barrel	~56 m^2
Number of channels	13 824





mRPC full scale prototype
& 24 ch. FEC based on NINO

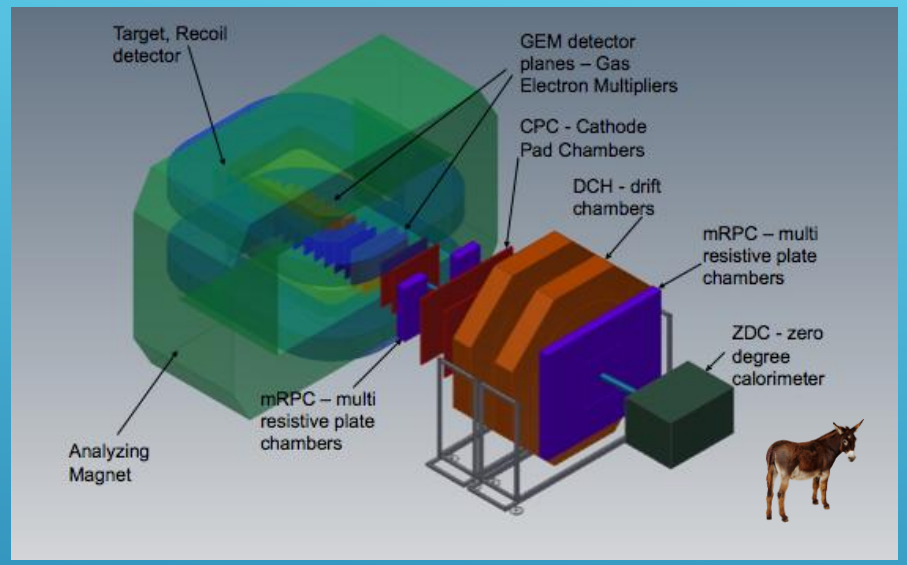


electronic test bench

Project status:

- *R&D and tests of prototypes are finished,*
- *80% readiness for the mass production*

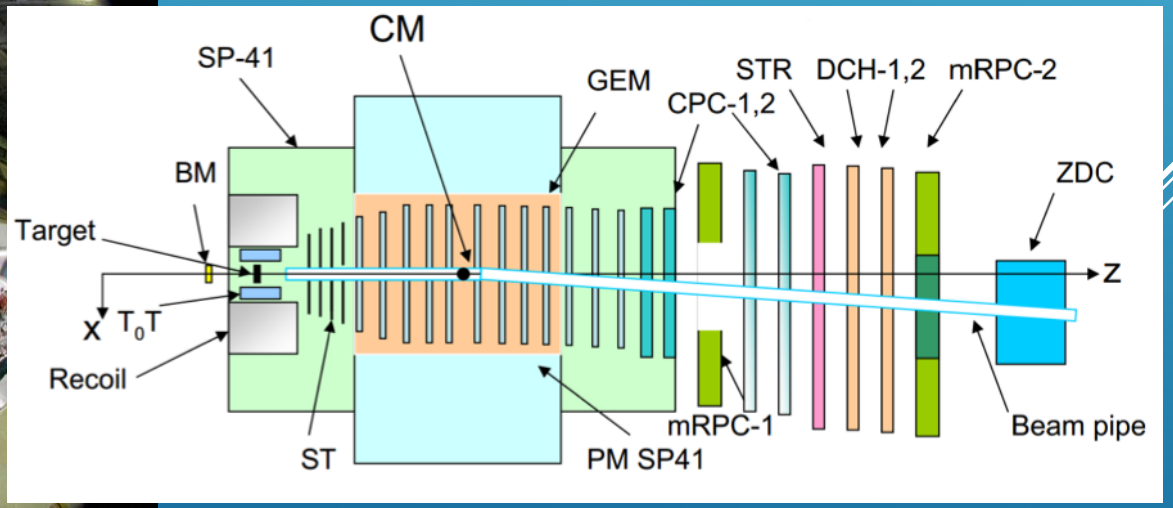
BM@N: *the 1st stage*



Collaboration of scientific centers:
IN, SINP MSU, IHEP + S-Ptr Univ. (RF);
GSI, Frankfurt U., Gissen U. (Germany):
+ CBM-MPD IT-Consortium,

Physics:
- ✓ *hyperon production*
- ✓ *hadron femtoscopy*
- ✓ *in-medium effects for strange & vector mesons*
- ✓ *electromagnetic probes (optional)*

BM@N *schematic view*



charged particle collisions :

- protons *(hydrogen nucleus)*
- heavy ions (*nuclei*)

$M^2 = S_{NN} = (E_1+E_2)^2 - (\vec{p}+0)^2$
$= (p + m)^2 - p^2 =$
$2pm$

fixed target (BM@N):

p = **10** GeV

$\vec{p}$, m → target → $\vec{0}$, m

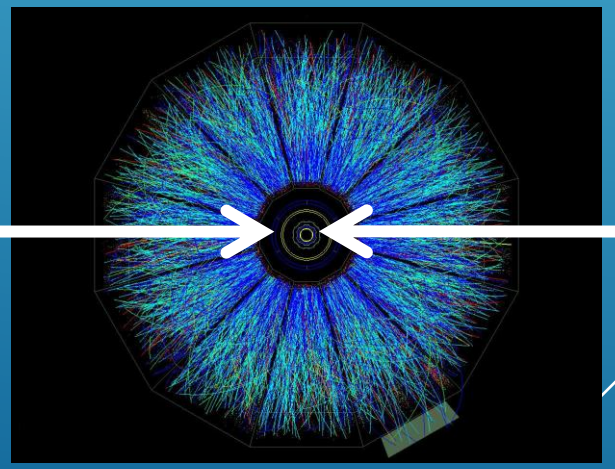
$\sqrt{S_{NN}} = \sqrt{2pm} =$ **4,3** GeV

1eV = **1.6×10^{-19}** J

1GeV=10^9 eV≈ m_p

Collider (MPD):

$\vec{p}$, m → ← $-\vec{p}$, m



$\sqrt{S_{NN}} = 2p =$ **20** GeV

MODULAR and ADAPTABLE CONTROL SYSTEM

for HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

BM@N and MPD at JINR in Dubna

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

PROJECT DESCRIPTION – BASIC ASSUMPTIONS (1)

The measuring systems of high energy physics experiments typically consist of multiple sub-systems, enabling registration of large number of particles and measurement of very different physical properties, which implies the diversity of measurement techniques: solid-state position detectors, time projection chamber, time of flight detectors, electromagnetic and hadron calorimeters, transition radiation detectors, threshold Cherenkov detectors, etc.

PROJECT DESCRIPTION – BASIC ASSUMPTIONS (2)

Each of these measurement techniques require specific conditions for operation: the type and pressure of the gas in the measuring chamber, voltage stability and power supply, cooling system and temperature stability, synchronization of data acquisition processes, etc. A variety of used equipment (hardware) is huge, and it requires a large diversity in computer techniques used to control of the equipment activity (software).

PROJECT DESCRIPTION – THE IDEA

The question arises:
is it possible to create a system that will follow this diversity? Also, if necessary, is it possible to create a system for fast customization of the service? The need for rapid modification also requires quick access to the system. Timing of these modification can be hard to predict in advance by the specialists, since they are not always close to the apparatus at a given moment.

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

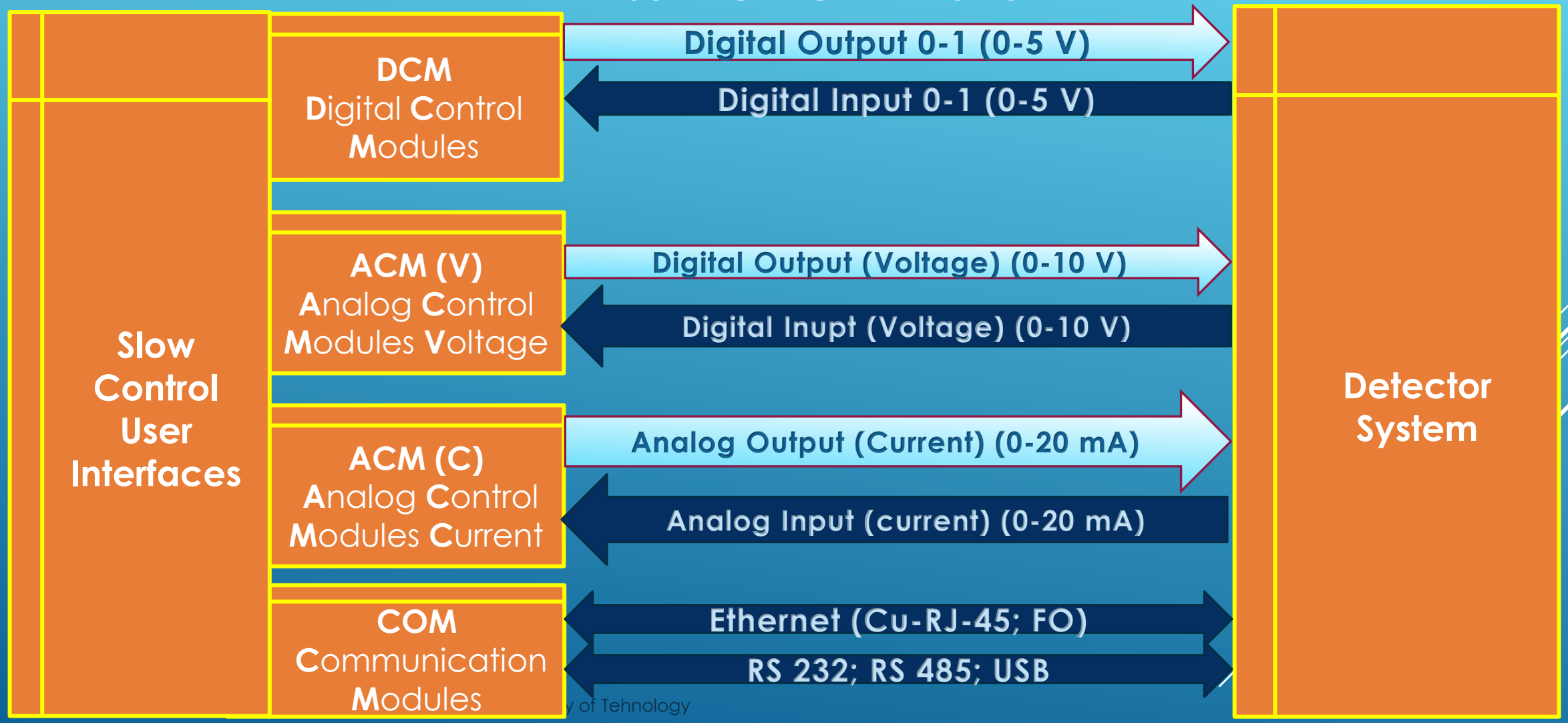
WHAT IS GOING TO BE BUILD?

Modular and **A**daptable Detector **C**ontrol **S**ystem for BM@N and MPD with the possibility to be adapted for other **s**cientific or **i**ndustrial **a**pplications.

The system will be seen via the Internet network.

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

MAJOR TECHNICAL FEATURES



MAJOR TECHNICAL FEATURES - Equipment Database (EqDb)

All the equipment components will be stored in the Equipment Database, recording their status and properties, the measurement's information, the necessary signals for testing, the operating points of the individual components etc.

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

WHY the EqDb must work on-line?

Precise conditions of electrical power, electronic parameters, gas preasure and temperature, humidity, and many others, are required and will be stored as well. These values must be compared with measured values all the time and in the case of emergency, a proper action should be taken.

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

HARDWARE FEATURES:

1. Scalability, the system is built in cabinets telecommunications.
2. Each of them has its own system access control, fire protection, power control etc.
3. Each cabinet has its own Ethernet in copper and FO technology.
4. One of them is separated as a master and has special register, which allows operator to manage hardware by software (remotely).

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

Master Rack Slow Control under construction on control position - BM@N - DUBNA

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

The added values of the project

1. **Lowering the cost by**:

- reduction of the unnecessary purchases of apparatus,
- reduction of the travel costs, by real access to programming apparatus through a virtual Internet network,
- reduction of the cost of servicing the equipment built by experts in many laboratories in the world (the specifics of scientific collaboration).

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

The added values of the project

2. **Possibility of a completely new education quality**, available for university students', with a use of the Internet technology (on-line laboratories) on High-Energy Physics real experiments.
3. **Popularization of science and technology**, with virtually no additional resources and funding.

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

CONCLUSION

The Project is a part of the current educational needs of the Department of Physics and other universities in Poland, and JINR scientific research. Moreover, the Project combines innovation features with highly advanced technologies and investments in Human Capital. It is open to the implementation and education.

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

Thank you for your attention

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

Backup slides

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

Master & Slave Racks
Slow Control Run Start System BM@N

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

Block level measurement gas distributor

Slave Rack
Slow Control

MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

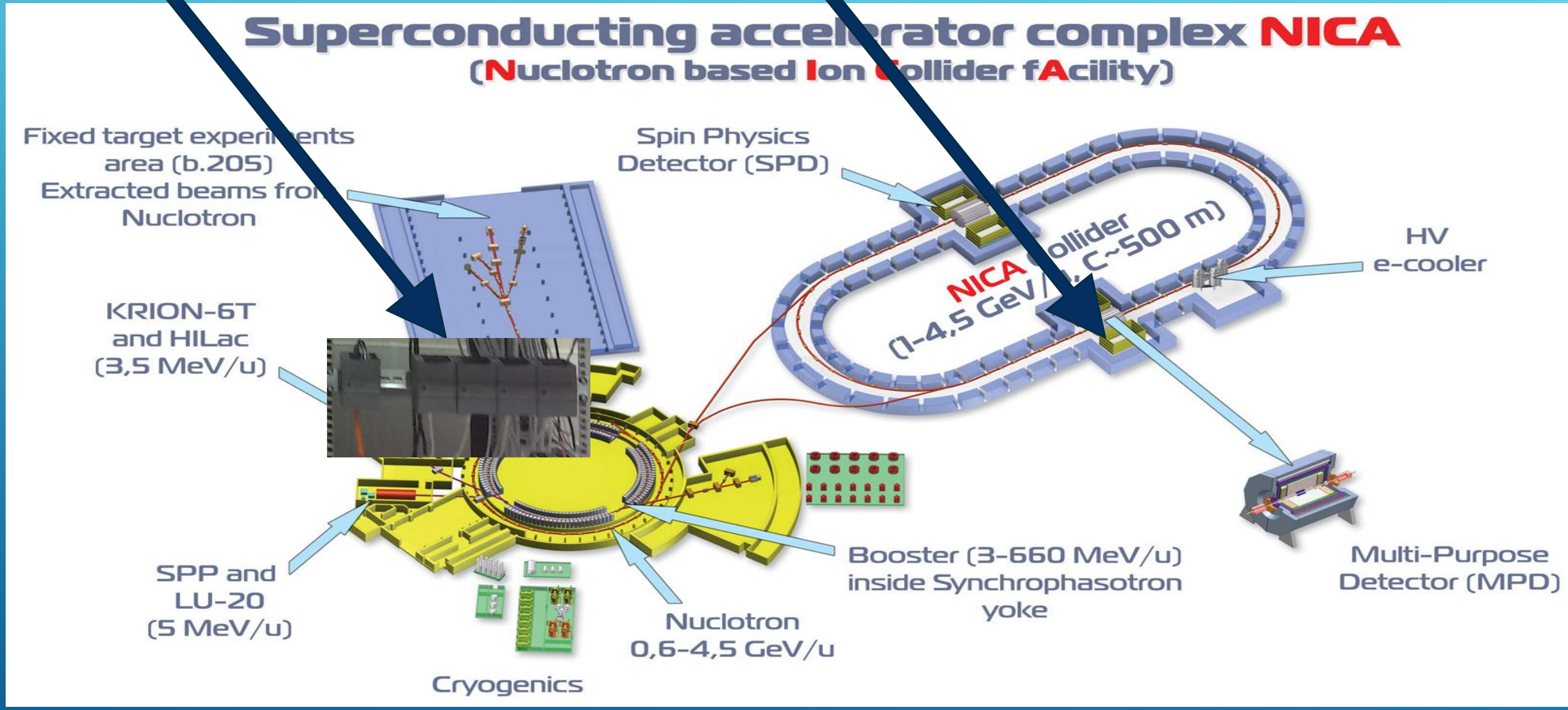
Hardware marked with a red ellipse is moved to a new location, connected via RS-485 or Ethernet Control Slow system. The system continues to be uniform, but measuring module has been elevated to another advantageous location.

Block level measurement gas distributor

Slave Rack
Slow Control

The old location of the Bloc measuring the level of gas in the distributor

The new location of the Bloc measuring the level of gas in the distributor



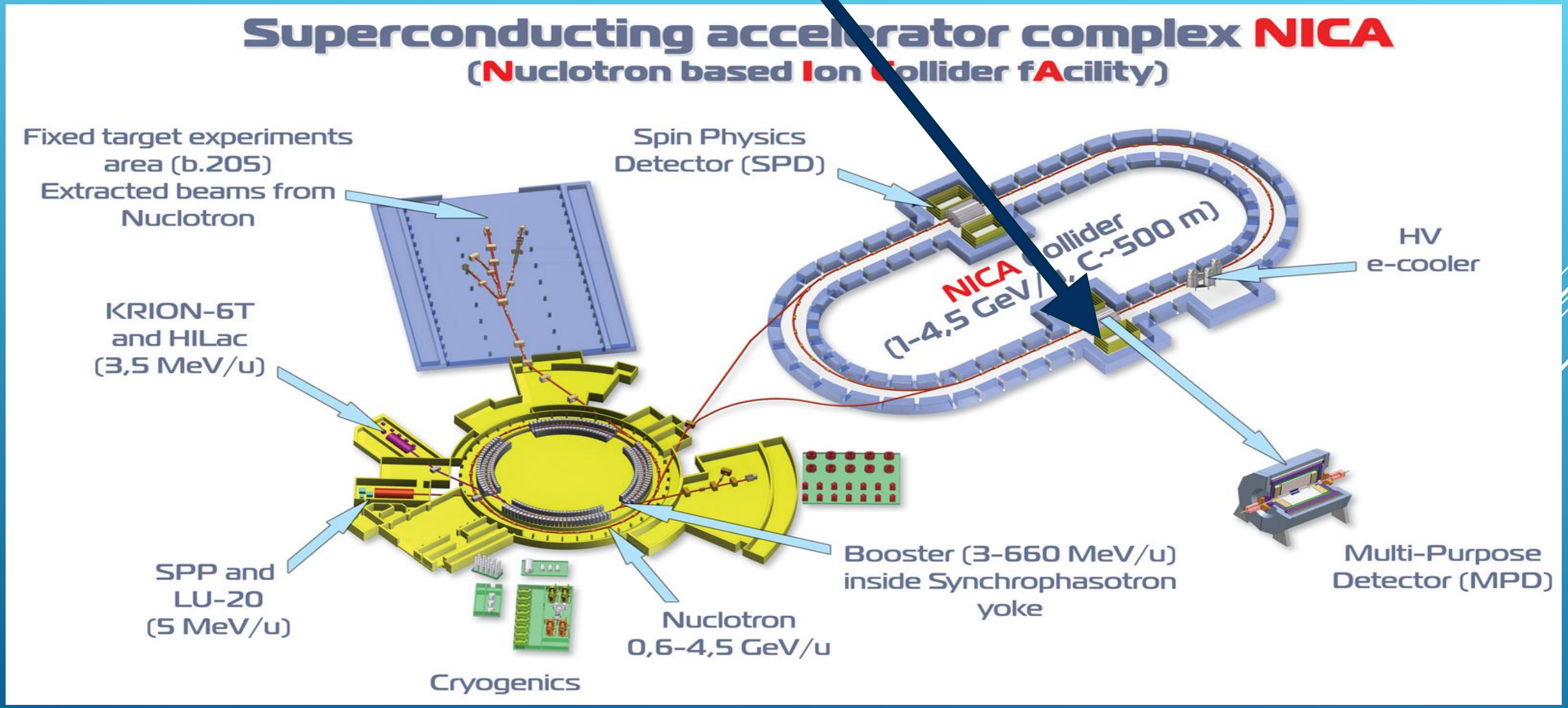
MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

Hardware marked with a red ellipse can be enhanced with new hardware modules, eg .: in order to increase the number of inputs (channels) measurement. Such a change in the system of scaling (adaptation) is possible also at the level of hardware and software.

Block level measurement gas distributor

Slave Rack
Slow Control

The new location of the Bloc measuring the level of gas in the distributor



MODULAR AND ADAPTABLE CONTROL SYSTEM FOR HIGH - ENERGY PHYSICS EXPERIMENTS / DETECTORS:

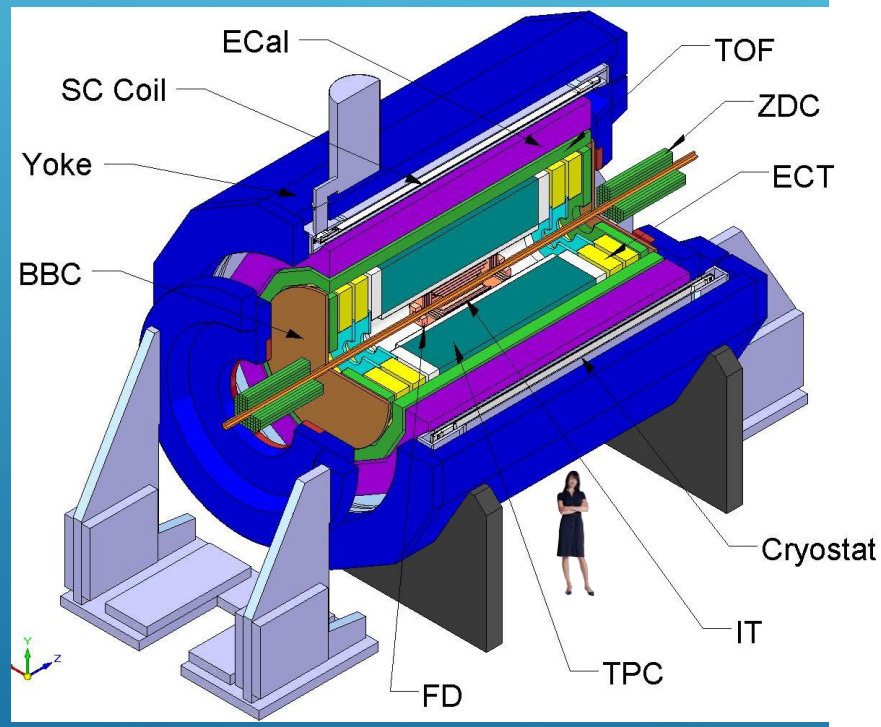
The origins of this Project are the result of the existing scientific cooperation between **FP WUT** and **V&BLHEP JINR** Project **TEBD**,
and a recent extension of this collaboration on issues of control
and measurement process.
Initially it was about **MPD** detector measurements with future collider **NICA**.
In last year, **V&BLHEP JINR** has been intensifying preparations
for the **BM@N** experiment.
Group of **FP WUT** became officially a part of the **BM@N** cooperation.

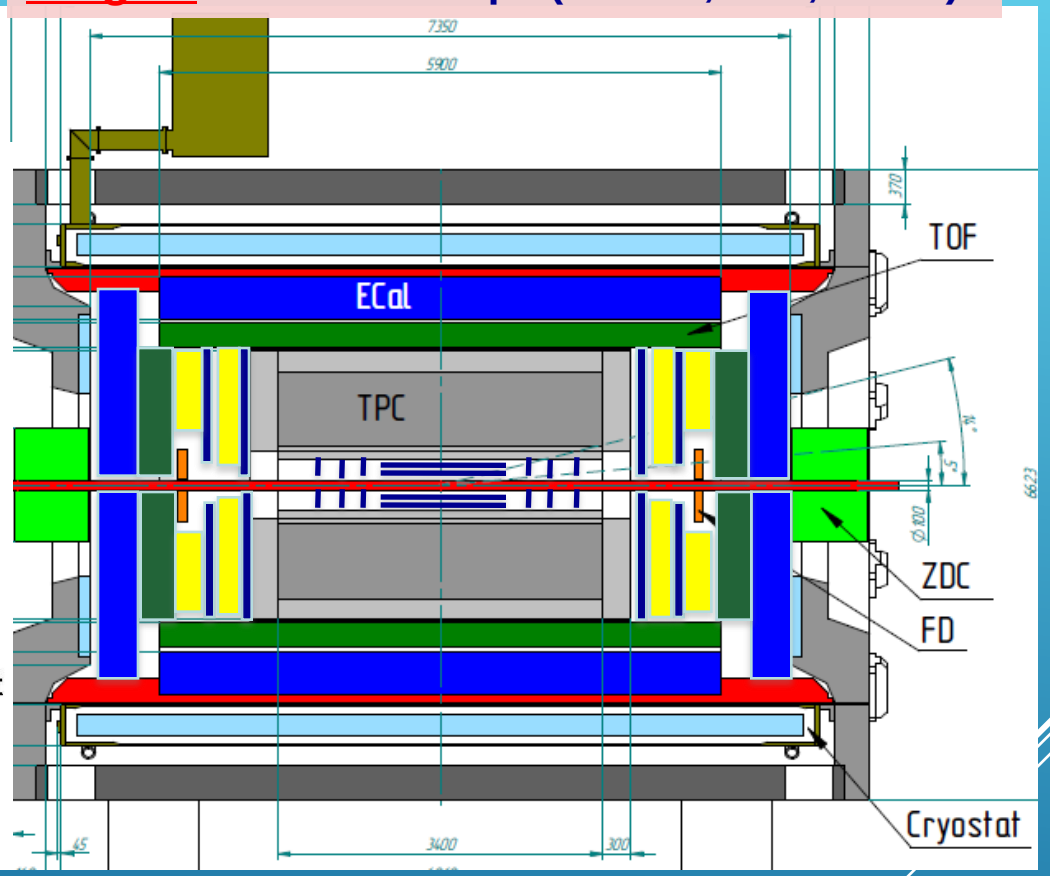
MPD detector for Heavy-Ion Collisions @ NICA

Tracking: up to |η|<2 (TPC)
PID: hadrons, e, γ (TOF, TPC, ECAL)
Event characterization:
centrality & event plane (ZDC)

Stage 1: TPC, TOF, ECAL, ZDC, FD

Stage 2: IT + Endcaps (tracker, TOF, ECAL)





Status: *technical design and detector R&D – completed;*
Preparation for the mass production

BM@N setup

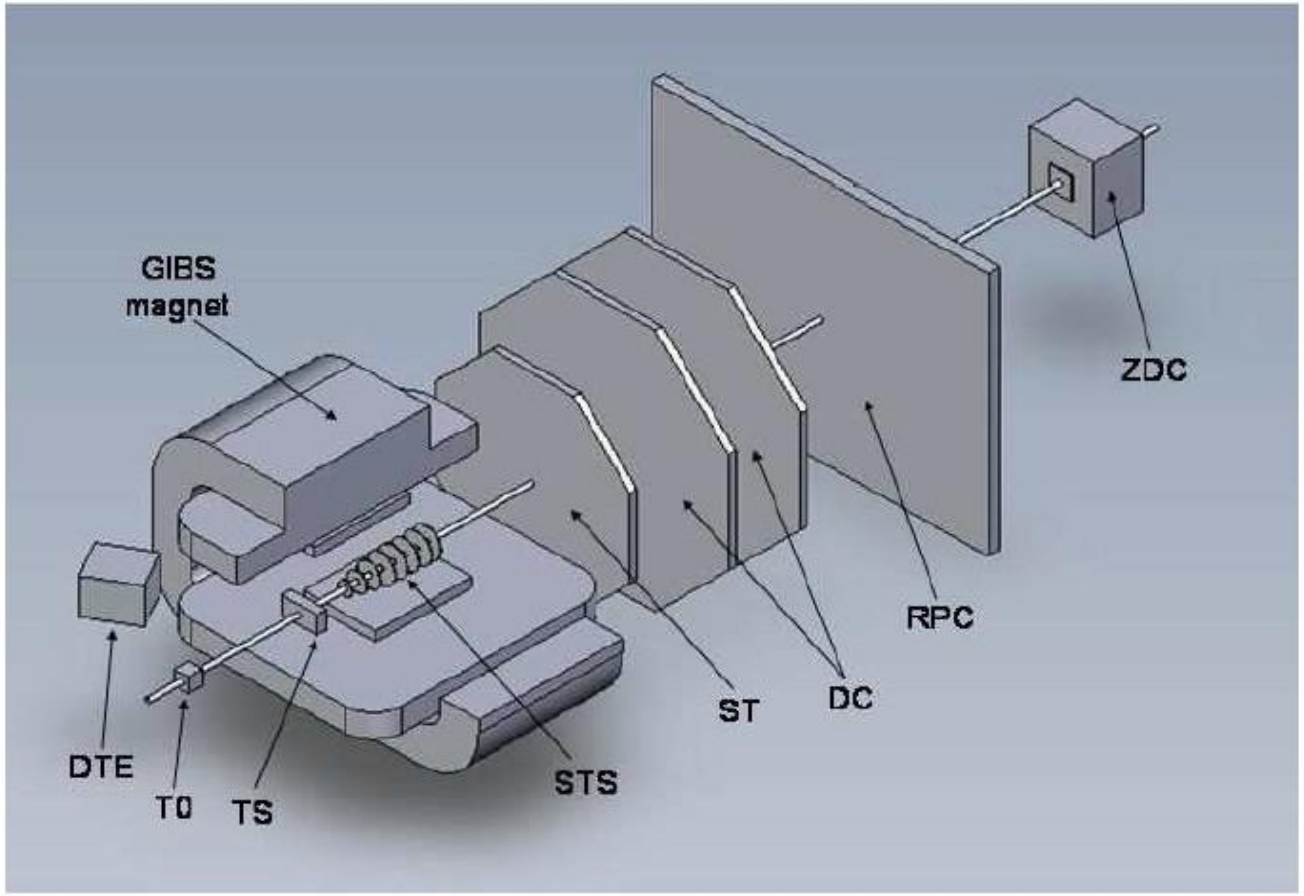
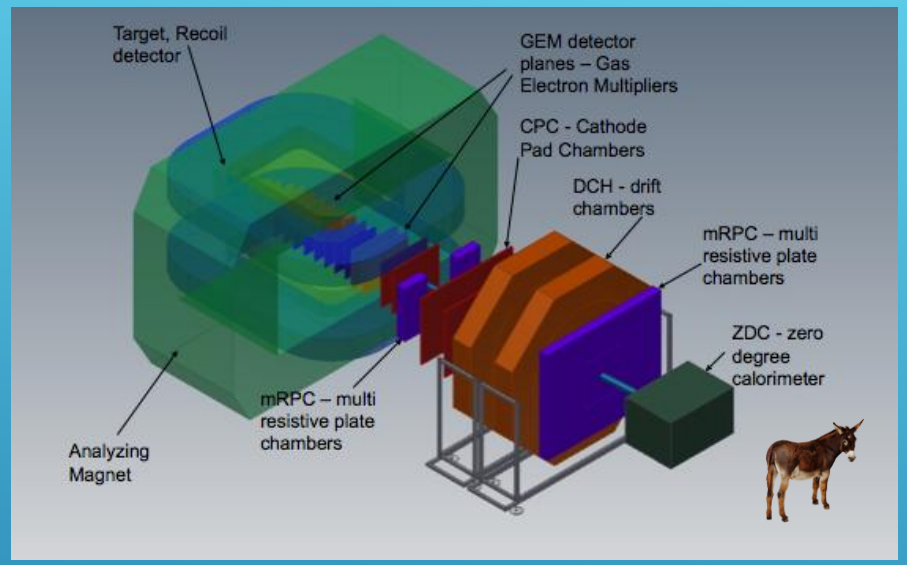


Figure 5.1: Schematic view of the setup with SP41 dipole magnet. TS — target station, T0 — start diamond detector (see section 5.4), STS — silicon tracker (5.2), ST — straw tracker (5.6), DC — drift chambers (5.5), RPC — resistive plate chambers (5.3), ZDC — zero degree calorimeter (5.8), DTE — detector of transverse energy (5.10).

BM@N: *the 1st stage*



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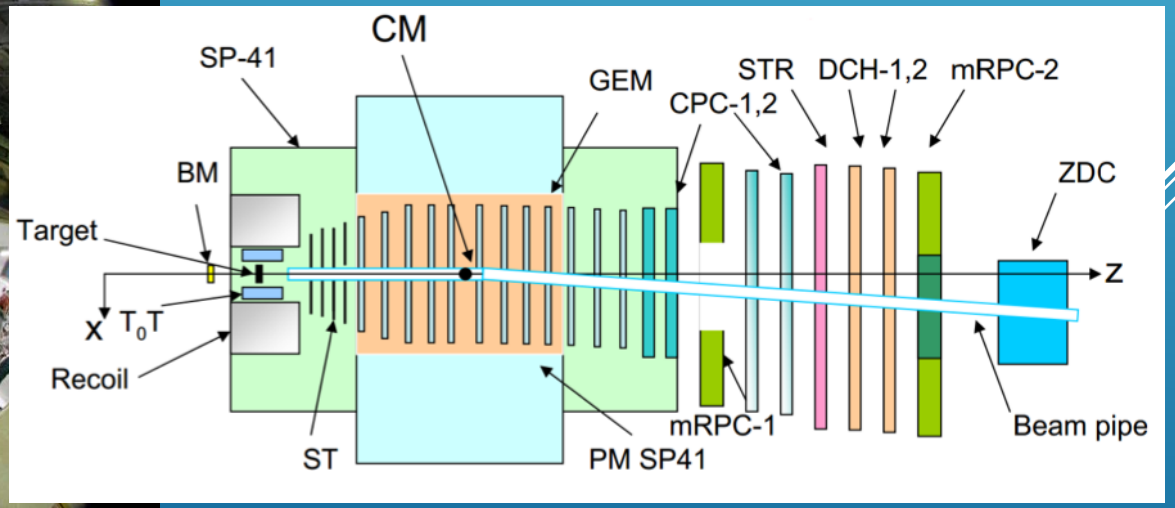
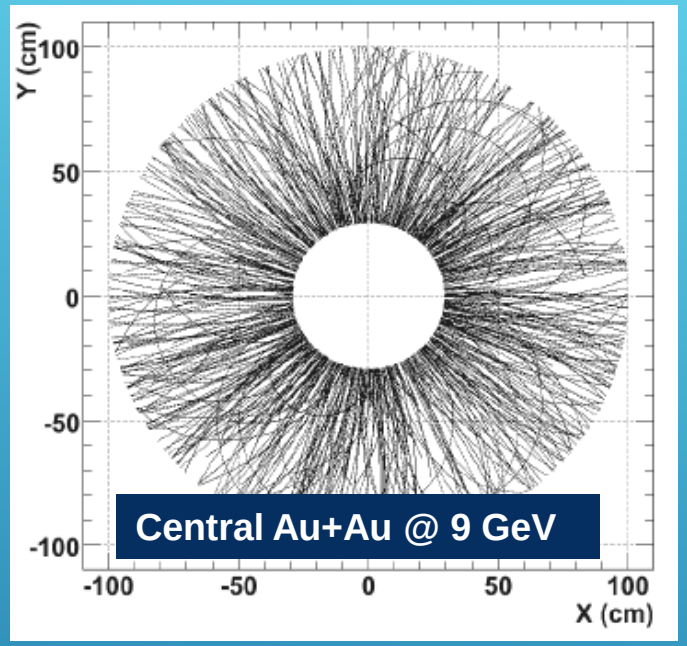
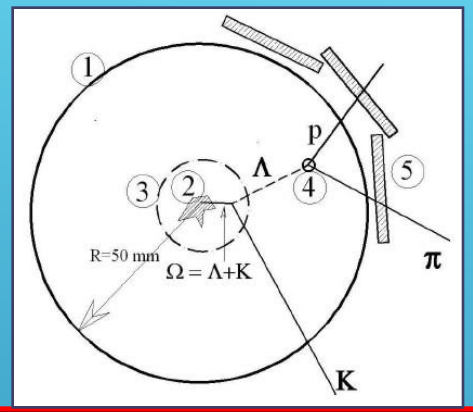
Physics:
- ✓ *hyperon production*
- ✓ *hadron femtoscopy*
- ✓ *in-medium effects for strange & vector mesons*
- ✓ *electromagnetic probes (optional)*

BM@N *schematic view*



V0 performance (TPC+IT)





Improved Sg-to-Bg ratio (S/B) with the vertex IT detector