The Multi-Purpose Detector for JINR heavy ion collider

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on behalf of the MPD Collaboration at NICA

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Heavy ion physics at JINR

A new scientific program on heavy-ion physics is under realization at JINR (Dudna).

It is devoted to study of in-medium properties of hadrons and nuclear matter equation of state including a search for signals of deconfinement phase transition and critical end-point. Comprehensive exploration of the QCD diagram will be performed by a careful energy and system-size scan with ion species ranging from protons to $^{197}Au^{79+}$ over c.m. energy range $\sqrt{s_{NN}}$ = 4 - 11 GeV.

The future Nuclotron-based heavy Ion Collider fAcility (NICA) will operate at luminosity of $^{197}Au^{79+}$ ions up to 10^{27} $cm^{-2}s^{-1}$.

Main targets of the NICA accelerator facility:

- *study of hot and dense baryonic matter*

& nucleon spin structure

- *development of accelerator facility*

for HEP in JINR providing

*intensive beams of relativistic ions from **p** to **Au***

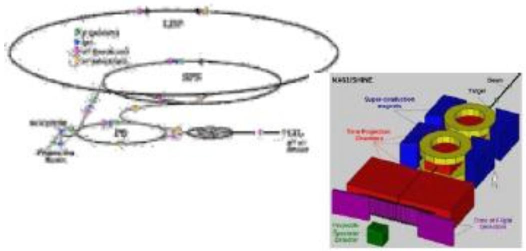
energy range $\sqrt{S_{NN}}$= 4..11 GeV (Au^{79+})

*and polarized **protons** and **deutrons***

(energy range $\sqrt{S_{NN}}$= 4..26 GeV for p)

2nd generation HI experiments

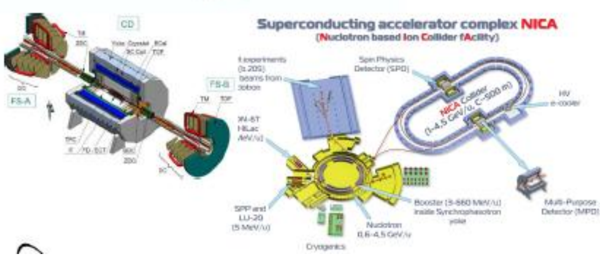
STAR/PHENIX @ BNL/RHIC. Originally designed for higher energies (s_{NN} > 20 GeV), low luminosity for LES program $L<10^{26}$ $cm^{-2}s^{-1}$ for Au^{79+}



NA61 @ CERN/SPS. Fixed target, non-uniform acceptance, few energies (10,20,30,40,80,160A GeV), poor nomenclature of beam species

3nd generation HI experiments

CBM @ FAIR/SIS-100/300
Fixed target, E/A=10-40 GeV, high luminosity

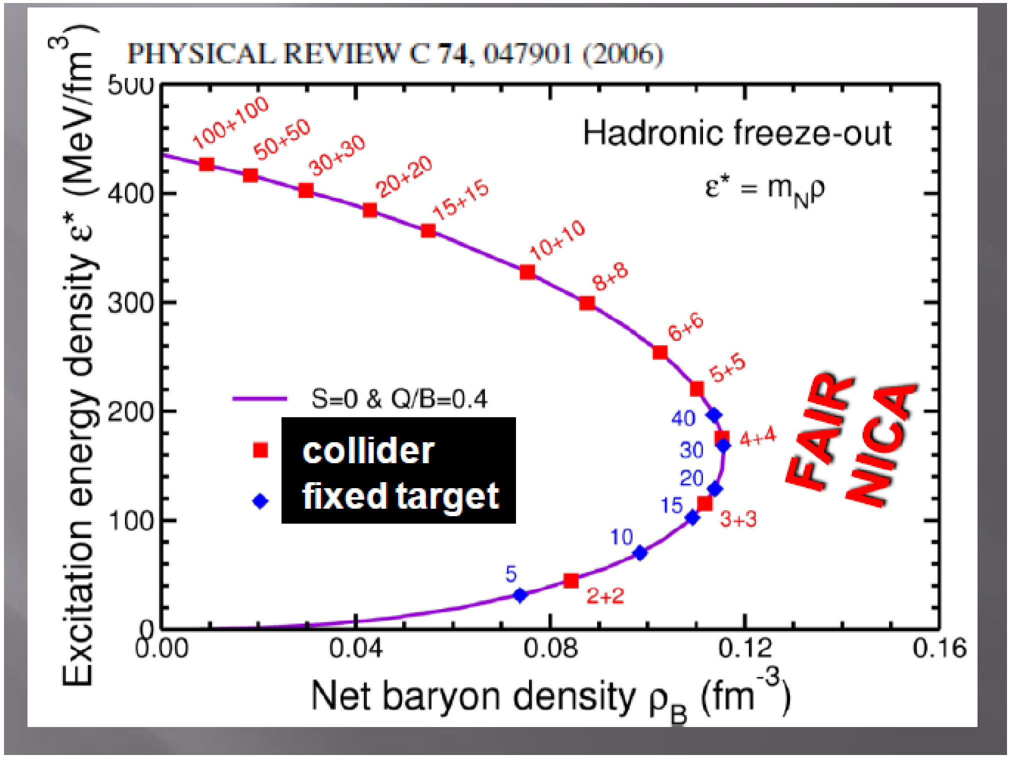


MPD & SPD @ JINR/NICA. Collider, small enough energy steps in the range s_{NN} = 4-11 GeV, a variety of colliding systems, $L\sim10^{27}$ $cm^{-2}s^{-1}$ for Au^{79+}

http://nica.jinr.ru

Scanning net baryon densities

J. Randrup and J. Cleymans



Energy Range of NICA

unexplored region of the QCD phase diagram:

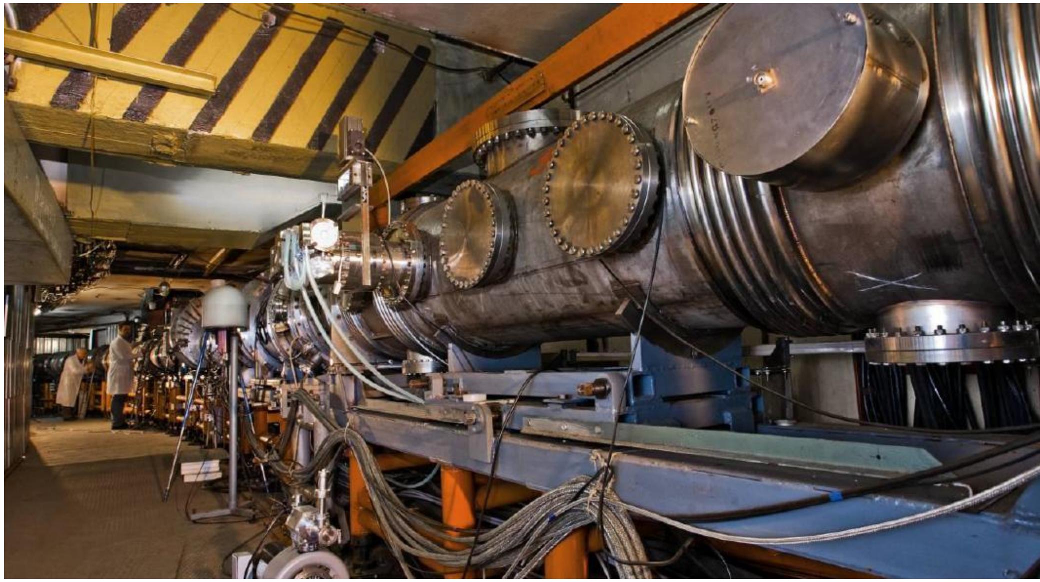
- **Highest net baryon density**
- **Onset of deconfinement phase transition**
- **Discovery potential:**
  a) Critical End Point (CEP)
  b) Chiral Symmetry Restoration
  c) Hypothetic Quarkyonic phase
- **Complementary to the RHIC/BES, NA61/CERN, CBM/FAIR and Nuclotron-M experimental programs**

Comprehensive experimental program requires scan over the QCD phase diagram by varying collision parameters: system size, beam energy and collision centrality. NICA provides capabilities for studying a variety of phenomena in a large region of the phase diagram.

Synchrophasotron (1957-2002)→ Nuclotron (1993)

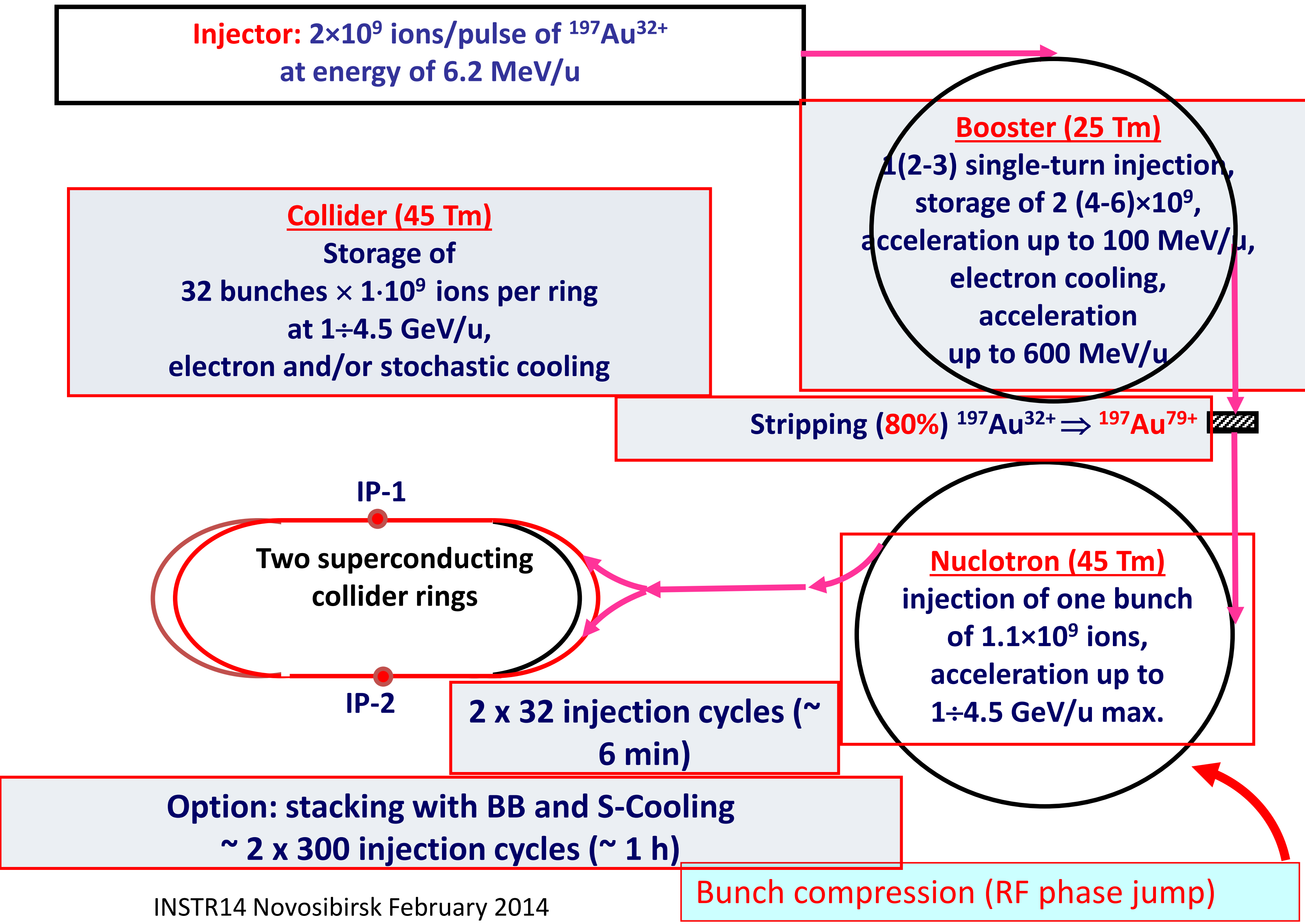
The Nuclotron is the basic facility of JINR for high energy physic research . Acceleration of proton, polarized deuteron and nuclear (or multi charged ion) beams can be provided at the facility. The maximum design energy is 6GeV/u for the particles with charge-to-mass ratio Z/A=½. The Nuclotron was built during 1987-92 and put into operation in 1993. This accelerator based on the unique technology of superconducting fast cycling magnetic system, has been proposed and investigated at the JINR

Parameter	working	planned
Accelerated particles	1<Z<36	1<Z<92
Max Energy (GeV/n)	4.2	6(A/Z=2)
Magnetic field (T)	1.5	2.0
Slow extraction system		
Time extraction (sec)	Up to 10	up to 10
Energy range (GeV/n)	0,2-2,3	0.2-6.0

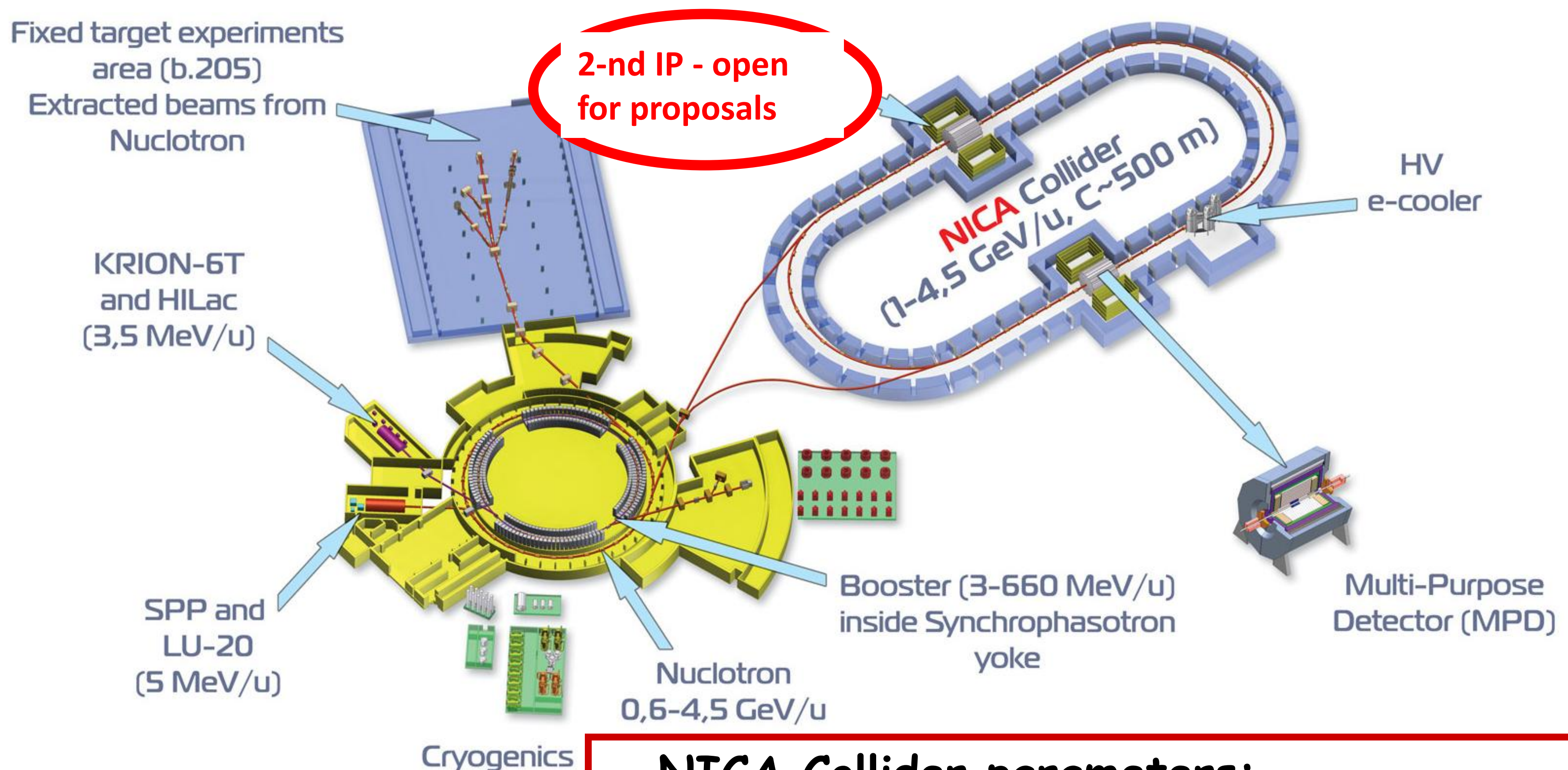


Nuclotron provides now performance of experiments on accelerated proton and ion beams (up to *Xe42+, A=124*) with energies up to 6 AGeV (Z/A = 1/2)

NICA operation regime and parameters

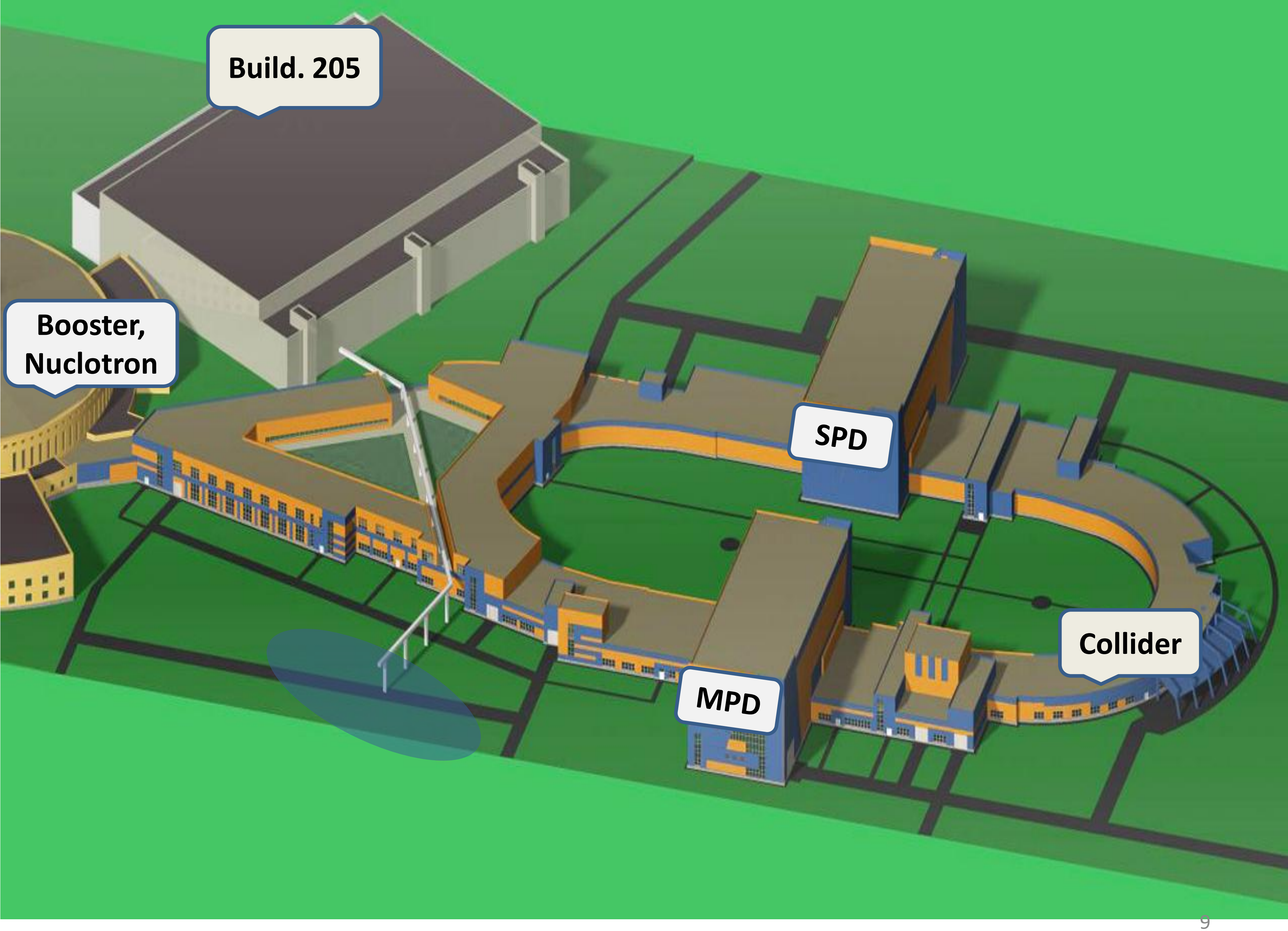


Superconducting accelerator complex NICA
(Nuclotron based Ion Collider fAcility)



NICA Collider parameters:

- Energy range: $\sqrt{s_{NN}}$ = 4-11 GeV
- Beams: from p to Au
- Luminosity: L~10^{27} (Au), 10^{32} (p)
- Detectors: MPD; SPD-> Waiting for Proposals


Build. 205
Booster,
Nuclotron
SPD
MPD
Collider

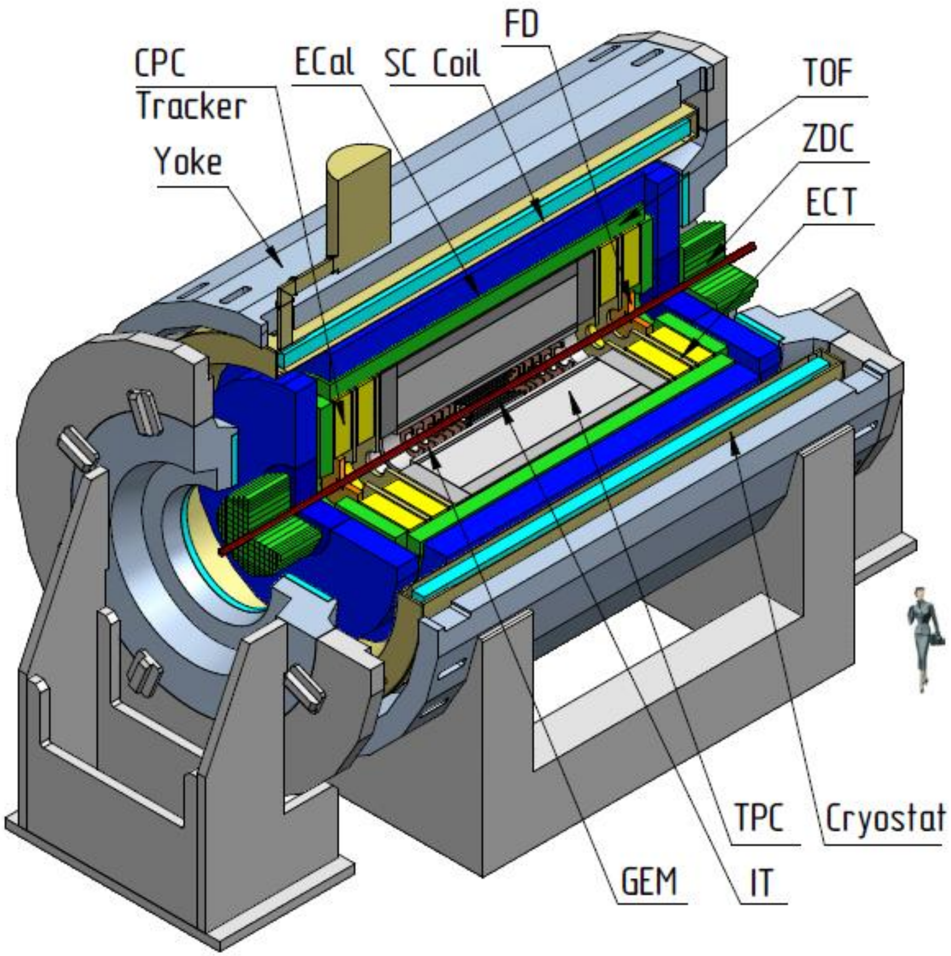
Detector overview

<u>Major physics point for the conceptual design:</u>

- deconfinement phase transition: measurements of hadron yields including multi-strange barions
- fluctuation and correlation patterns in the vicinity of the QCD critical end-point: solid angle coverage close to 4π, high level of particle identification
- in-medium modification of hadron properties: measurements of the dielectrons invariant mass spectra up to 1 GeV/c2

The MPD is designed as a 4π spectrometer capable of detecting of charged hadrons, electrons and photons in heavy-ion collisions in the energy range of the NICA collider. The detector will compromise 3D tracking system and high-performance particle identification system based on the time-of-flight (TOF) measurements and calorimetry. At the design luminosity the event rate in the MPD interaction region is about 7 kHz; total charge particle multiplicity exceeds 1000 in the most central AuAu collisions.

Start up configuration of the MultiPurpose Detector (MPD)



Magnet: *0.6 T SC solenoid*

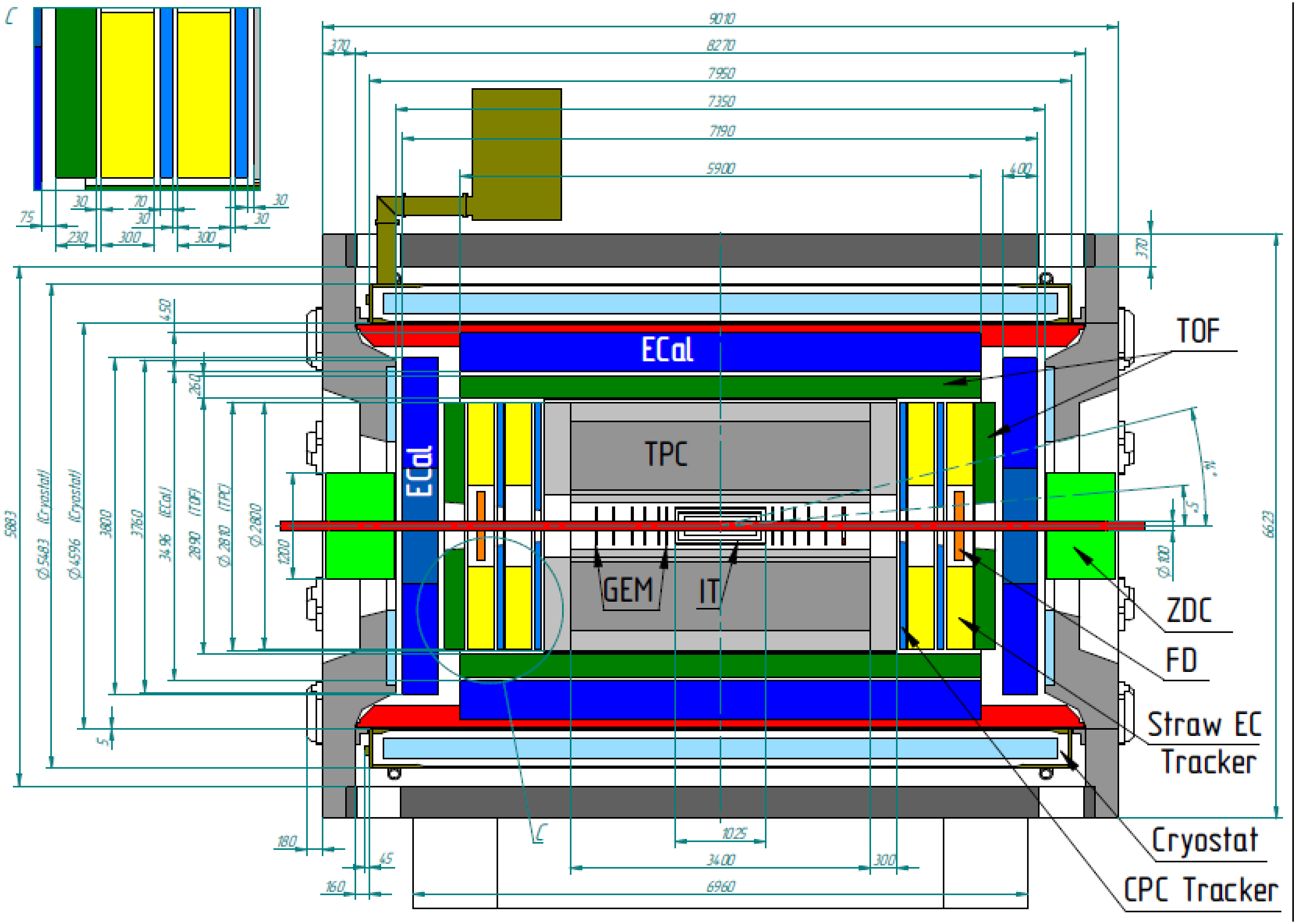
Basic tracking: **TPC**

ParticleID: **TOF, ECAL, TPC**

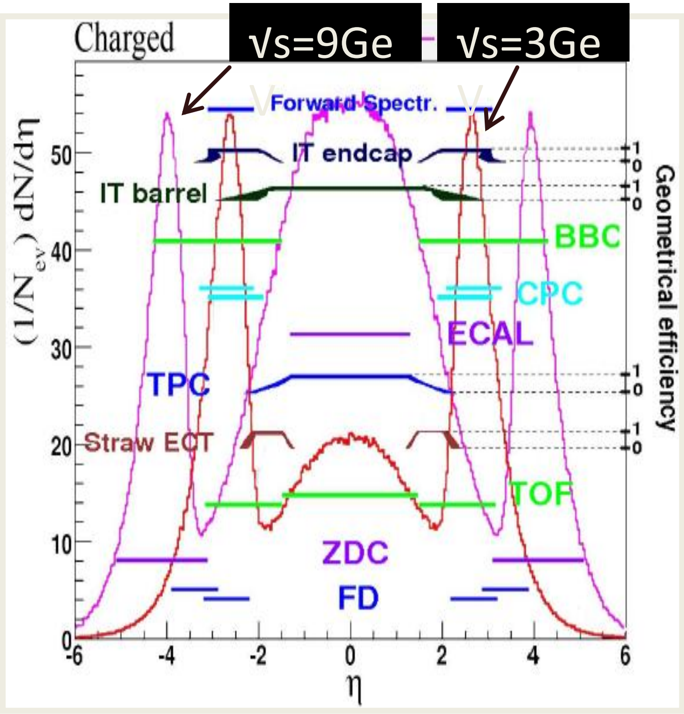
T0, Triggering: **FFD**

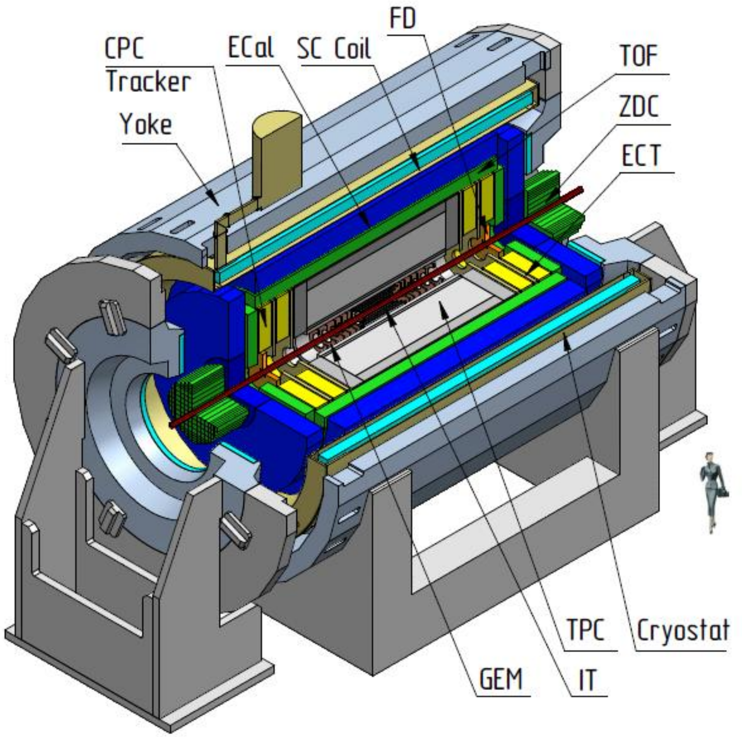
Centrality, Event plane: **ZDC**

- *hermetic and homogenous acceptance (2π in azimuth), low material budget,*
- *good tracking performance and powerful PID (hadrons, e, γ),*
- *high event rate capability and detailed event characterization*


ECal
ECal
TPC
GEM
IT
TOF
ZDC
FD
Straw EC
Tracker
Cryostat
CPC Tracker

The scientific program of the MPD includes the following topics:
> Particle yields and spectra (π, K, p, clusters, Λ, Ω)
> Event-by event fluctuation
> Femtoscopy with π, K, p, Λ
> Collective flow of identified hadron species
> In-medium modification of vector mesons





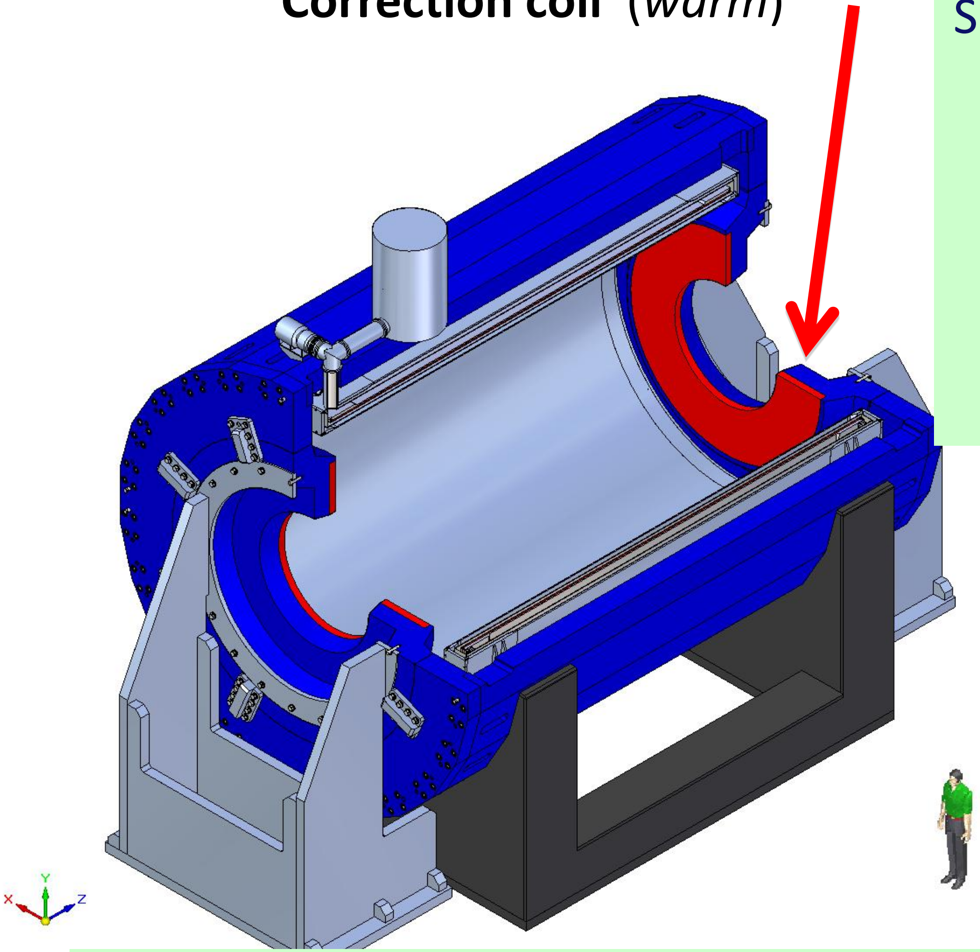
Observables	Detectors in use
Yields & spectra	TPC, ZDC, barrel TOF & ECAL end-cap tracker + end-cap TOF & ECAL
Di-leptons	TPC, barrel TOF & ECAL end-cap tracker + end-cap TOF & ECAL
Event-by-event fluctuations	ZDC, barrel TOF & ECAL end-cap tracker + end-cap TOF & ECAL
Flow	TPC,TOF, event plane detector (extended ZDC) end-cap tracker + end-cap TOF & ECAL
Hyperons, hyper-nuclei, charm	TPC, IT

MPD Superconducting solenoid: challenging project

- to reach high level (~ 10^{-4}) of magnetic field homogeneity

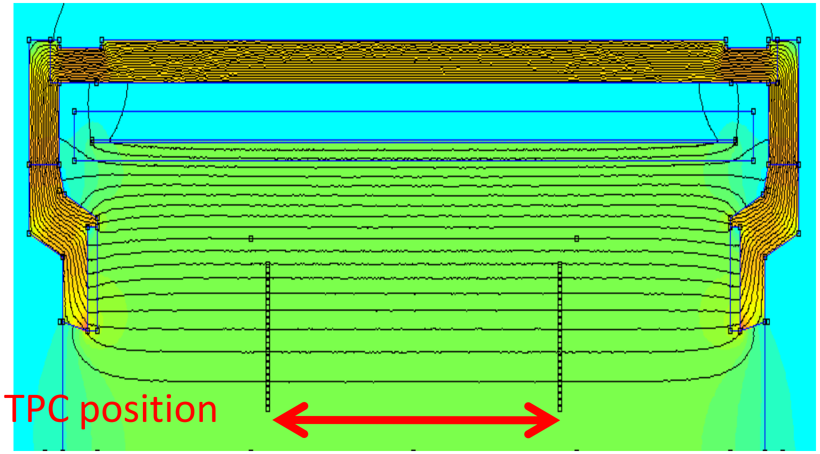
B_0=0.66 T

Correction coil (*warm*)



The design – close to completion;
Survey for contractors:

the cold coil / cryostat;
cryo infrastructure;
engineering infrastructure:
the yoke;
the warm coil
PS etc.



simulated map of magnetic field

Design by "Neva-Magnet" (***Russia***)

Basic parameters of the MPD TPC:

TPC length – 340cm
Outer radius – 140cm
Drift volume outer radius – 133cm
Inner radius – 27cm,
Drift volume inner radius – 34cm
Length of drift volume – 170cm
Electric field strength – 140V/cm
Magnetic field strength – 0.5 Tesla
Drift gas – 90% Argon + 10% Methane

Readout: 2x12 sectors (MPWC cathode pads
Number of pads ~ 100000
Pad size – 5x12mm, 5x18mm

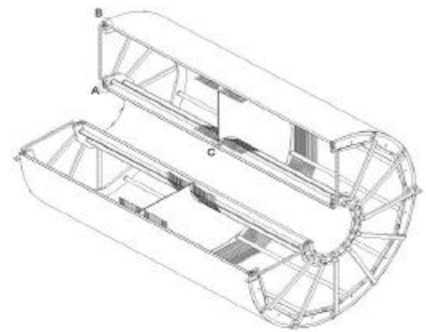


Fig.2a. Inner view of the TPC

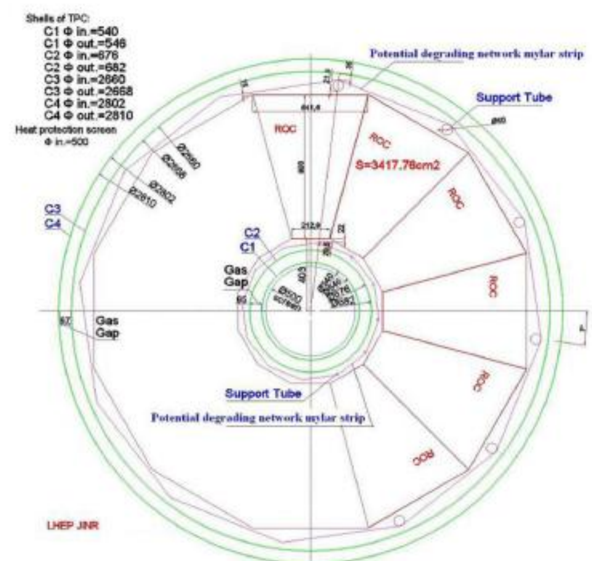
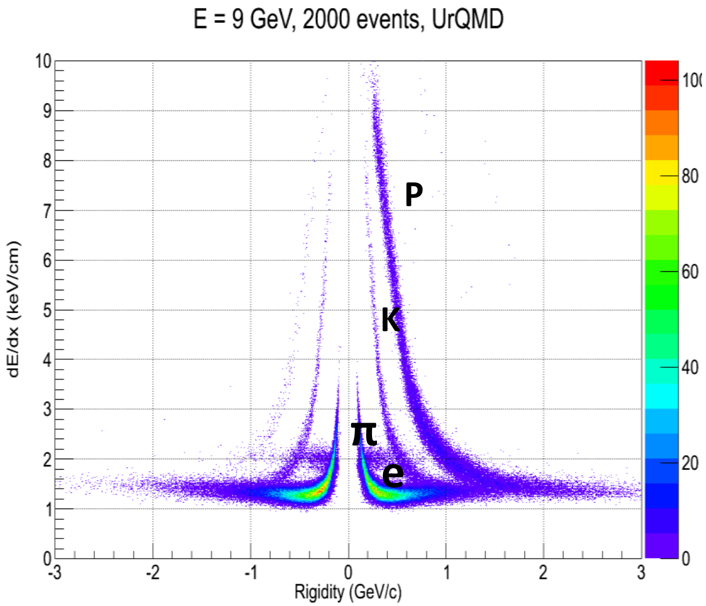
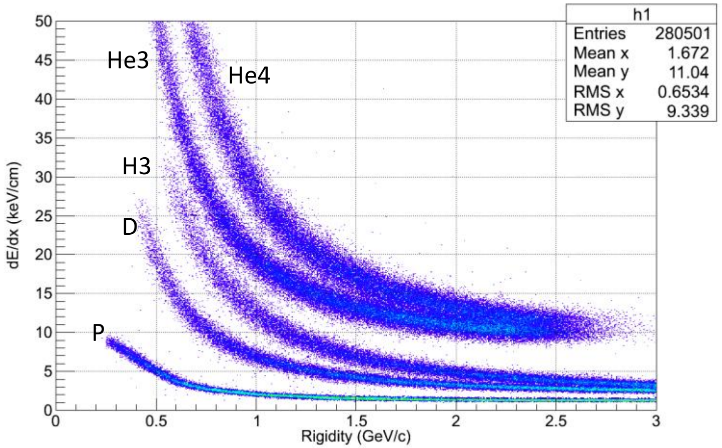


Fig.2b.The front view of the TPC

ENERGY LOSS



The energy loss distribution in the MPD TPC



TPC FEE input full scale amplifier ~ 200 fC
It is ~ 30-40 MIP energy loss

QGSM Au+Au central collision
9 GeV, b=1fm

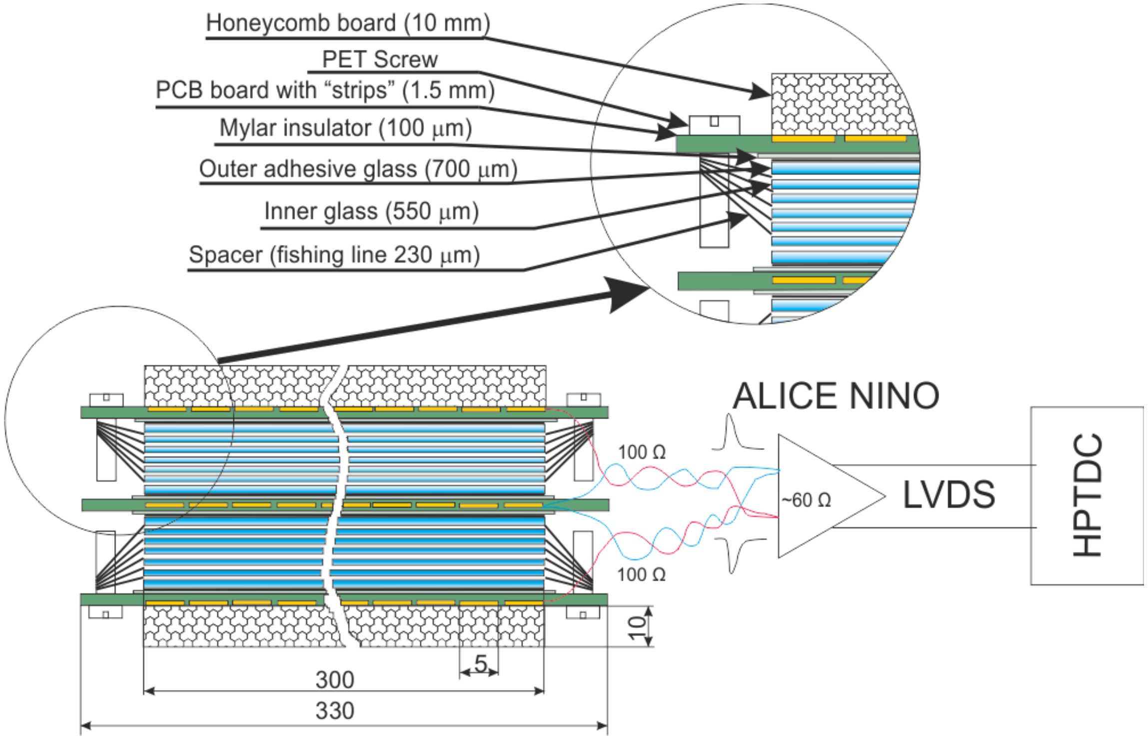
PID: Ionization loss (dE/dx)
Separation:
- e/h – 1.3..3 GeV/c
- π/K – 0.1..0.6 GeV/c
- K/p – 0.1..1.2 GeV/c

Time-of-Flight System

The TOF system is intended to perform particle identification
with total momenta up to 2 GeV/c. The system includes the barrel part
and two endcaps and covers the pseudorapidiry $|\eta| < 2$. The TOF is based
on Multigap Resistive Plate Chambers with high timing properties and
efficiency in high particle fluxes. The 2.5-m diameter barrel of TOF has
length of 500cm and covers the pseudorapidity $|\eta| < 1.4$.
All MRPC are assembled in 12 azimuthal modules providing the overall
Geometric efficiency of about 95%.

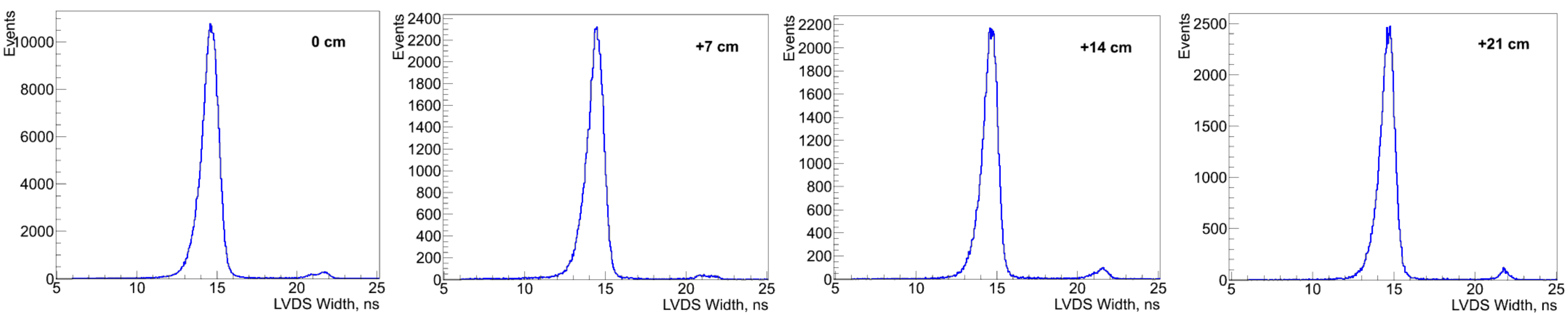
The Fast Forward Detector (FFD) will provide TOF system with the start signal.

Double stack MRPC with 5 mm strip readout



Double stack prototype characteristics:

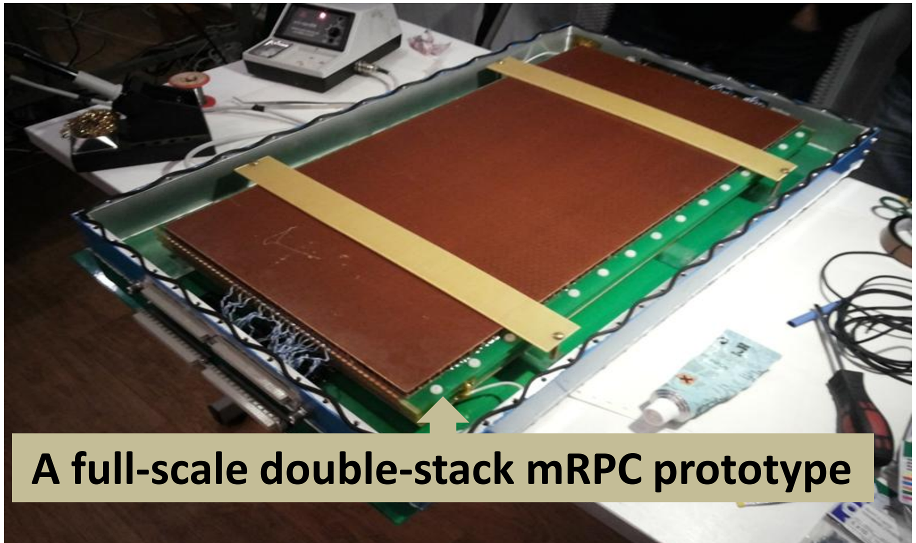
Overall dimensions	**700x400 mm**
Active surface	**600x300 mm**
Channels number	**48**
Strip dimensions	**600x5 mm**
Thickness of glass (inner, outer)	**550, 700 μm**
Gaps number (2 stack)	**6x2 = 12**
Gap width	**230 μm**



Width spectra for **double stack** MRPC with **5 mm** strip readout (over double parallel twisted pair). The chamber moved perpendicular to the beam on four positions 0 , +7, + 14 and +21 cm.

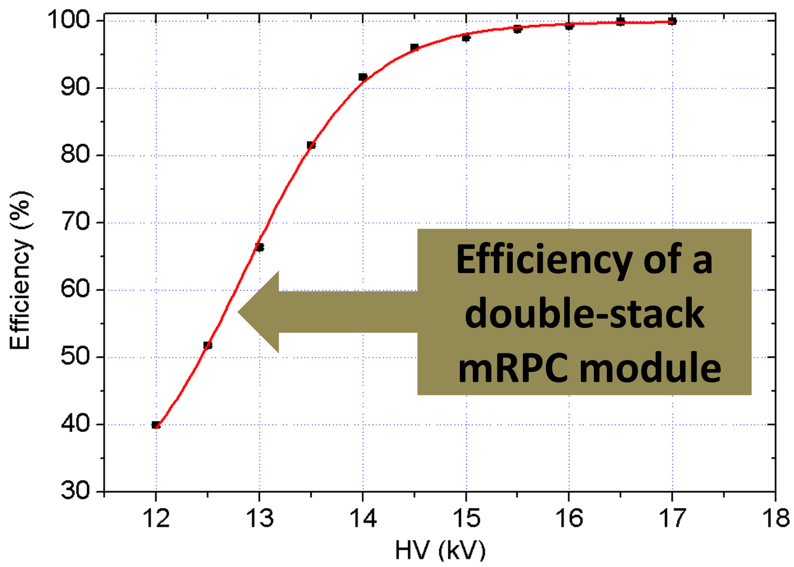
Main goals in 2013:

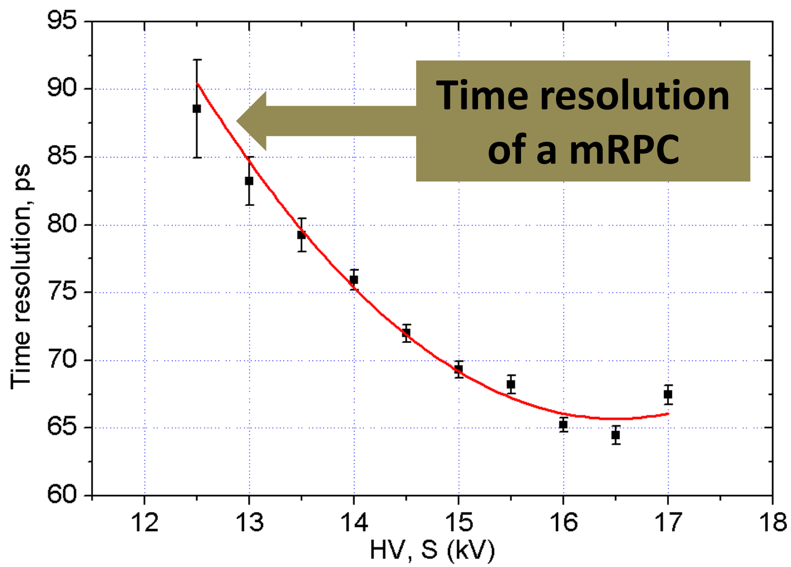
- Optimization of the TOF geometry and read-out scheme
- Technological development aimed in achieving better mRPC performances
- Experimental study of rate capability for several prototypes of TOF modules
- TOF TDR finalizing (draft is ready)

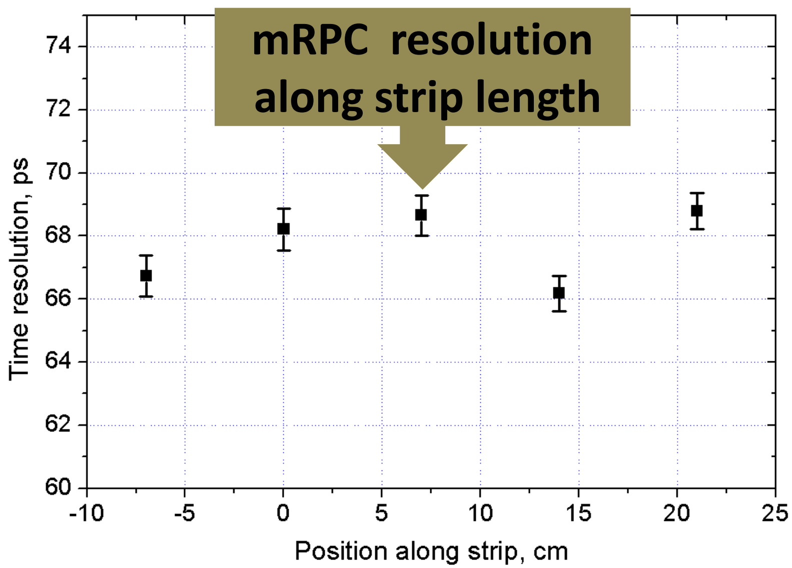


A full-scale double-stack mRPC prototype

Experimental setup for mRPC tests (March’13, Nuclotron))





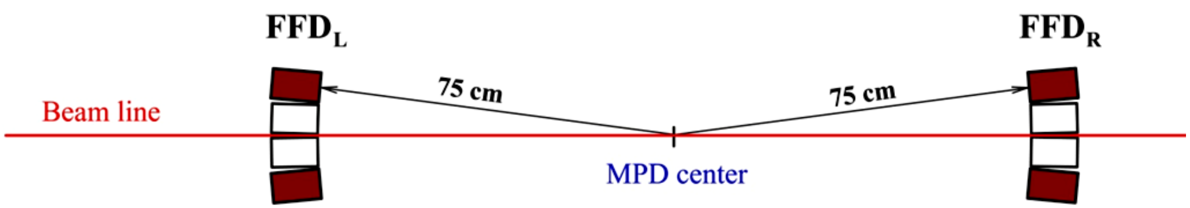


- Timing resolution σ < 70 ps achieved for a double-stack mRPC module
- The resolution does not depend on coordinate
- Results of the beam tests will be published soon

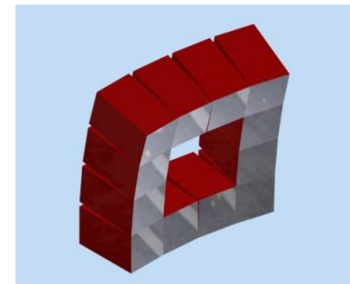
FAST FORWARD DETECTOR

FFD – two-arm picosecond Cherenkov detector of high-energy photons

2.3 < |η | <3.1



Each array consists of 12 modules based on MCP-PMT XP85012 (Photonis) and it has granularity of 48 independent channels



Granulated Cherenkov counters

Problem with ps-timing

Charged particle velocities $\beta < 1$ due to relatively low energies of NICA

Solution

Concept of FFD is based on registration of high-energy photons from neutral pion decays and it helps to reach the best time resolution

Similar fast detectors at RHIC and LHC:

PHENIX	BBC Cherenkov quartz counters	52 ps*
PHOBOS	Time-zero Cherenkov detectors	60 ps*
STAR	Start detector upVPD	80 ps*
ALICE	T0 Cherenkov detector	~30 ps*

* single detector time resolution

Detection of Cherenkov photons

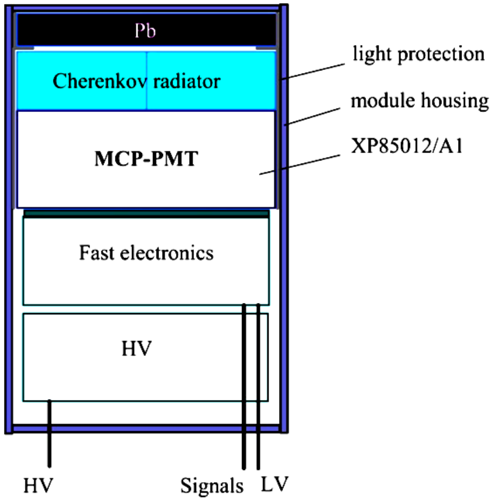
The high-energy photons are registered by their conversion to electrons inside a lead plate (1.5–2 X_0).
The Cherenkov light, produced by the electrons in quartz radiator, is detected by MCP-PMT XP85012/A1-Q (Photonis).

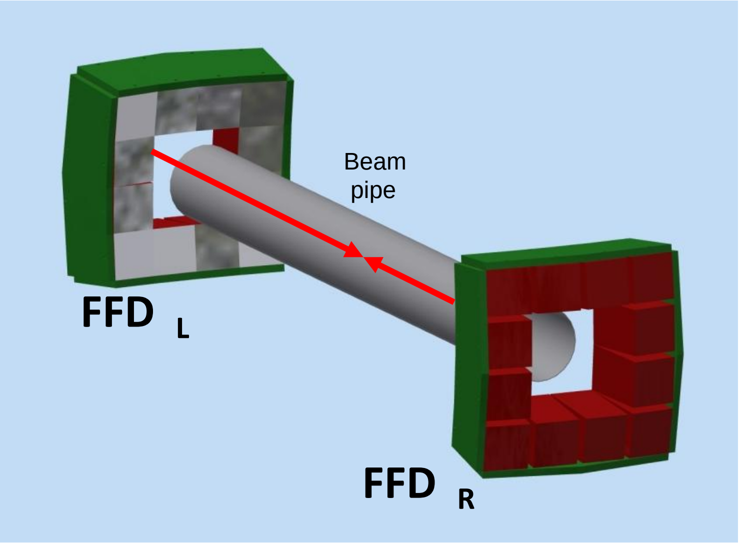
Planacon MCP-PMT XP85012 (Photonis)

- Photocathode of 53 × 53 mm occupies 81% of front surface
- Sensitive in visible and ultraviolet region
- 8 × 8 multianode topology
- Chevron assembly of two MCPs (25-μm)

- Typical gain factor of ~10^5 – 10^6
- Rise time 0.6 ns
- Transit time spread σ_{TTS} ~ 37 ps
- High immunity to magnetic field

FFD module

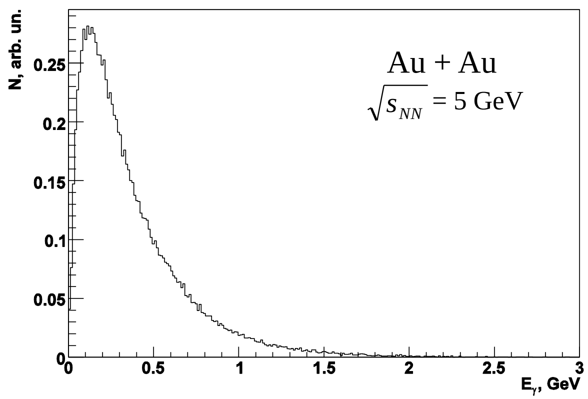




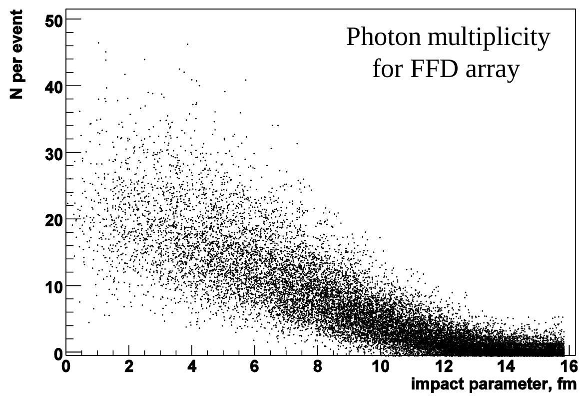
Two FFD arrays and beam pipe

Monte Carlo Simulation

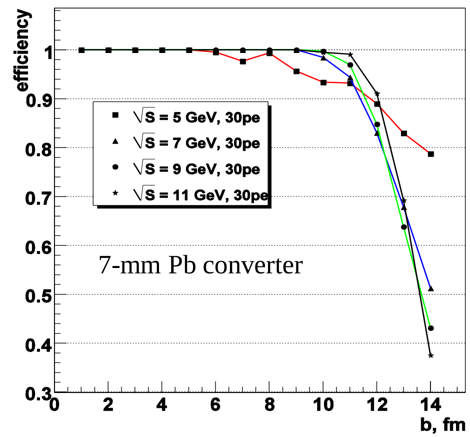
The UrQMD NICA plus GEANT3 code was applied for Monte Carlo simulation of Au + Au collisions for study of FFD performance.



Energy spectrum of photons in FFD acceptance



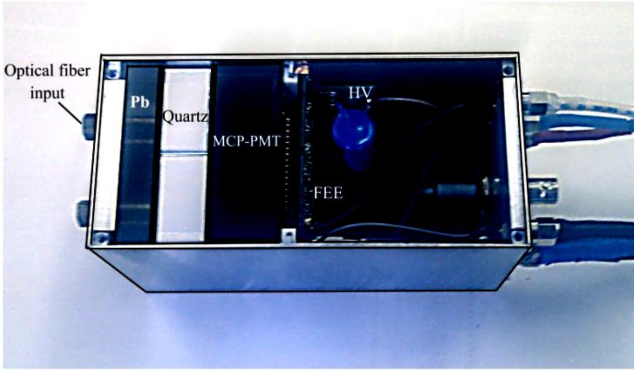
Distributions of photons in FFD acceptance as function of impact parameter for Au+Au at energy $\sqrt{s_{NN}}$ = 9 GeV



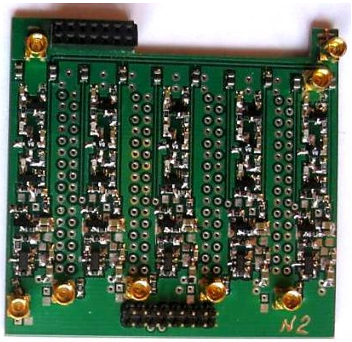
Efficiency of FFD array with bias of 30 pe as function of impact parameter at four different energies $\sqrt{s_{NN}}$ = 5, 7, 9, and 11 GeV

FFD module prototype

The module contains of aluminum housing, Pb converter with thickness of 7-10 mm, Cherenkov radiator with 4 quartz bars (bar dimensions 29.5 × 29.5 × 15 mm), MCP-PMT XP85012, FEE board, and HV divider.
The anode pads of XP85012 are joined into 2 × 2 cells.
The module FEE has 4 channels processing pulses from anode pads and single channel for pulse from MCPs output. Each the chain consists of amplifier, shaper, and discriminator and it produces output analog and LVDS signals.

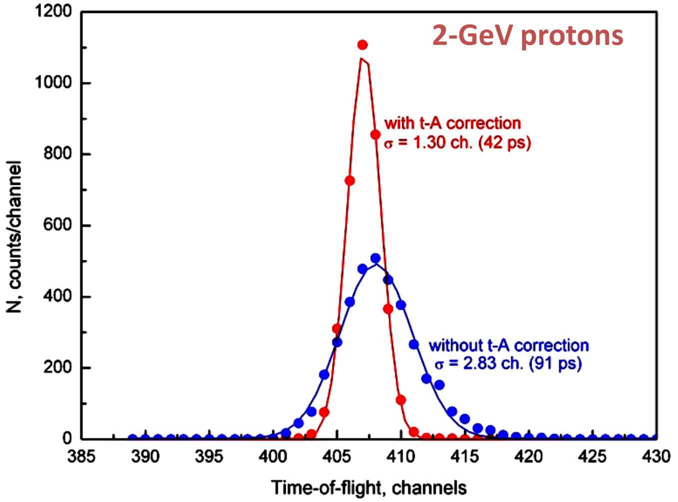


A view of FFD module

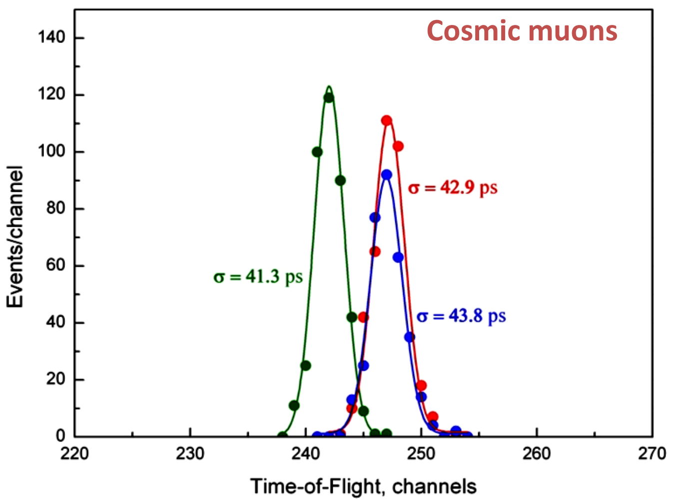


A view of FEE board

TOF measurements with two FFD modules



TOF distributions without and with *t* - *A* correction



TOF results for three different pairs of FFD channels

The time resolution $\sigma_t \approx$ 30 ps has been obtained for single channel in experimental tests with FFD prototypes. Better results are expected with new FEE in the nearest future.

Expected time resolution of start signal for TOF measurements

The time resolution of start signal depends on a number of independent channels of FFD arrays detecting photons in each event. For example, the FFD with 10-mm Pb converter for Au + Au collisions at $\sqrt{s_{NN}}$ = 9 GeV will provide the time resolution

Central collisions (*b* = 2 fm)	$< N_{ph} > \approx 28$	$< \sigma_t > \approx 5.7$ ps
Semi-central collisions (*b* = 7 fm)	$< N_{ph} > \approx 14$	$< \sigma_t > \approx 8$ ps
Peripheral collisions (*b* = 11 fm)	$< N_{ph} > \approx 3.5$	$< \sigma_t > \approx 16$ ps

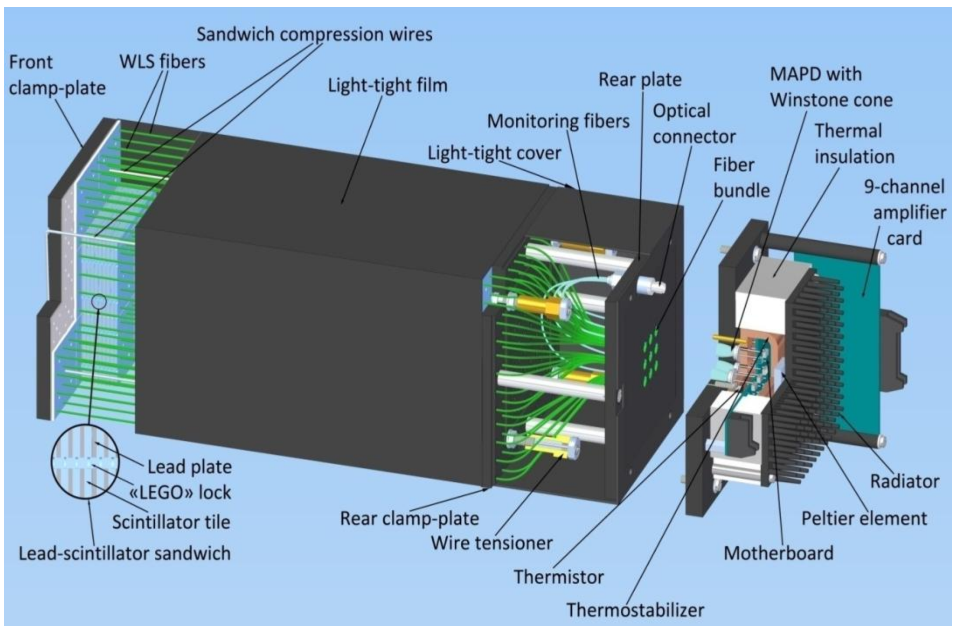
Electromagnetic Calorimeter

The main goal of EMC is to identify electrons, photons and neutral hadrons and measure their energy and position.
High multiplicity environment of heavy ion collisions implies a fine calorimeter segmentation (the transverse size of the cell should be of the order of the Moliere radius and cell occupancy nor more 5%).

Requirements:
- high granularity, minimum dead space
- sufficient energy resolution
- low cost, flexible production

Chosen EMC technology (fulfills most of the requirements):

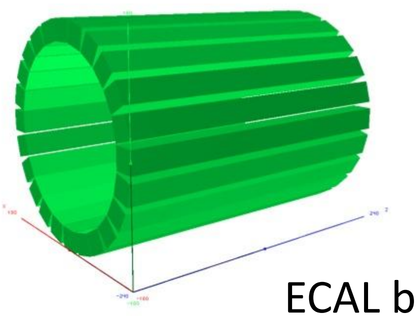
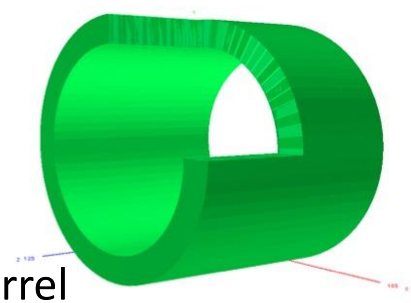
Shashlyk-type sampling Pb-Scint. calorimeter with WLS fibers and MAPD read-out



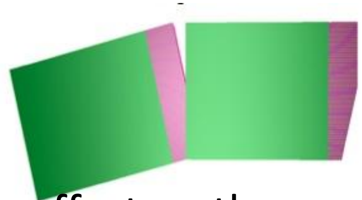
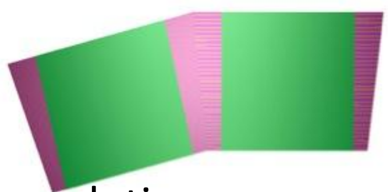
9 modules assembled in matrix 3x3	
Inner radius	1798 mm
Outer radius	2198 mm
Length «z»	5880 mm
Lead plate thickness	0.3 mm
Scintillator plate thickness	1.5 mm
Number of layers	221
Modul size	115 × 120 × 397.8 mm^3
Effective Moliere radius	$R_M = 31.88$ mm
Effective radiation length	$X_0 = 32.7$ mm
Total radiation length	$11.84\ X_0$

EMC geometry simulation

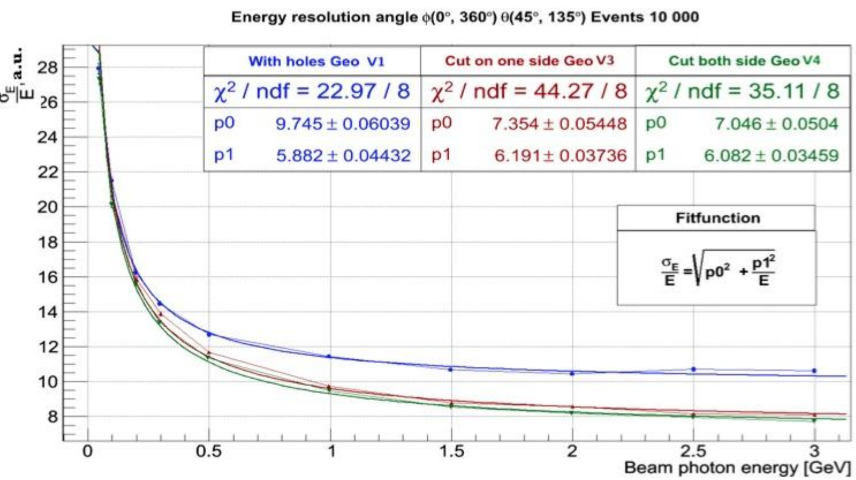
Rectangular (V1) | Trapeziform | Semi-Trapezoid (V3) | Trapezoid (V4)

ECAL barrel

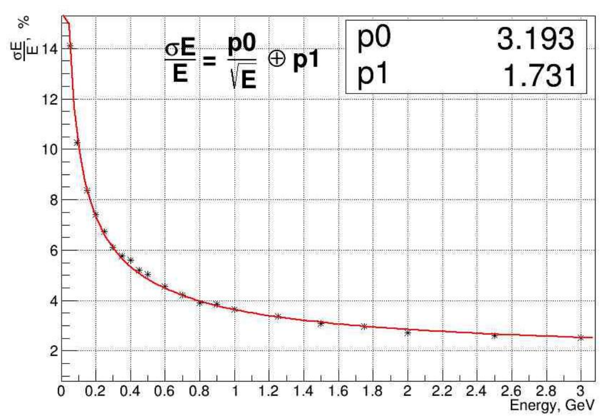



- Gaps affect on the energy resolution
- Semi or full trapezoid shape - is not significant!
- ISMA can product trapezoidal modules!



Geant 3

Geant 4



INSTR14 Novosibirsk February 2014

MPD ECAL. Progress in 2013

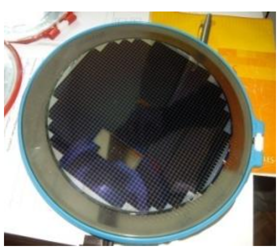
Injection-molding of scintillation plates

Painting of scintillators

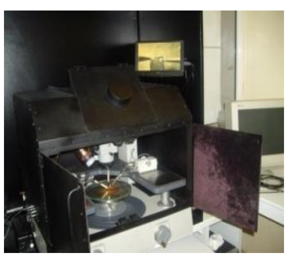
A trapezoidal ECAL

Assembling of ECAL modules

- **Manufacturing facility has been established by JINR and Institute for Scintillation Materials (Kharkov, Ukraine)**
- **Technology for production of trapezoidal EMC modules has been proven**
- **Certification procedure for MAPD wafers was developed**
- **Production of photo-detector units was organized**
- **Feasibility of mass production of EMC modules was investigated**
- **First study of EMC performance with particle beams and cosmic rays was performed**

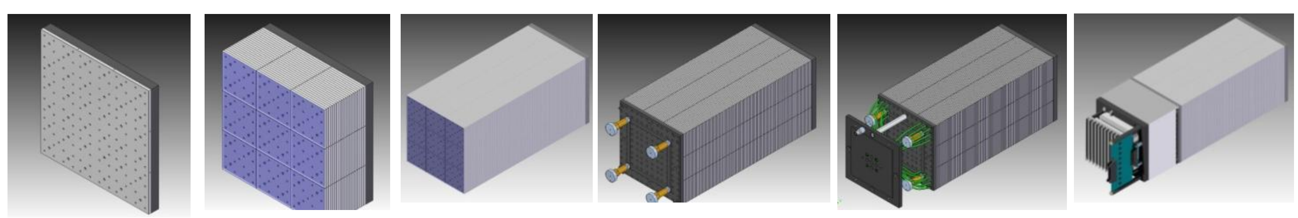


Wafer of MAPD-3N

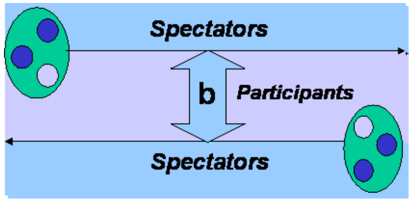


Setup for wafer tests

MPD EMC assembling (schematic)



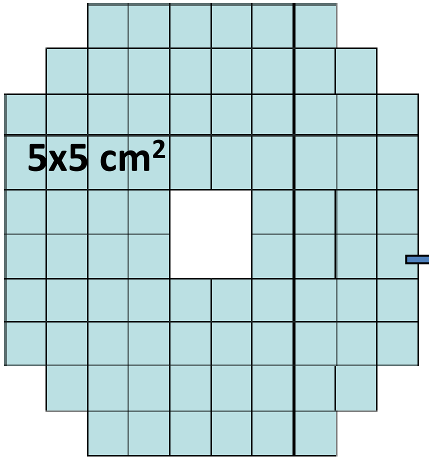
Zero Degree Calorimeter (ZDC)

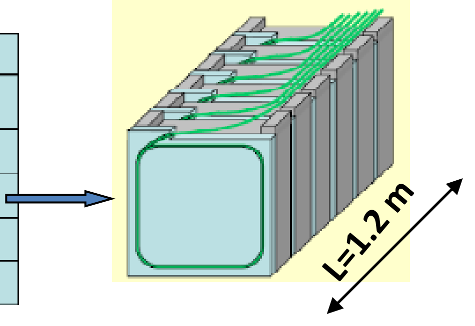


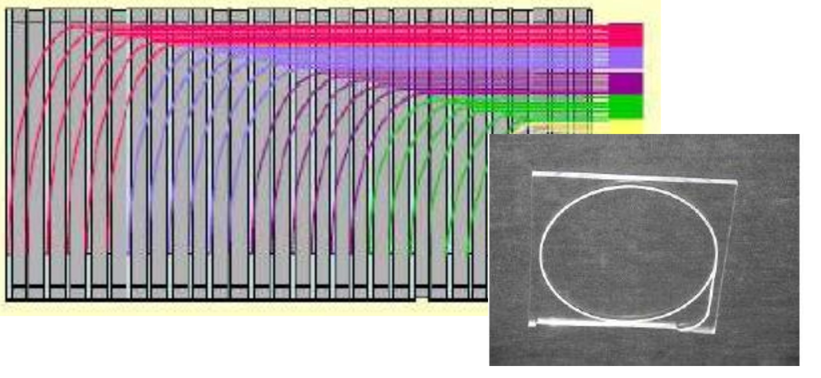
- measures the energy deposited by spectators.
- event centrality determination (offline b-selection)

Requirements:

- transverse dimensions determined by the spectator spot size (~ 40 cm at √s=9 GeV)
- measure of assymetry in athimuthal distribution → fine ϕ-segmentation
- energy resolution < 60%/ √E







- Pb(16mm)+Scint.(4mm) sandwich
- 60 layers of lead-scintillator (1.2 m, 6λ)
- 1 mm WLS fibers + micropixel APD
- produced by INR, Troitsk, Russia
- similar to ZDCs for NA61 and CBM

MPD Collaboration

The MPD Collaboration consists of 195 scientists from JINR (110) and other Institutions (85)

Participating Institutions : JINR + 18 Institutes from 9 countries

- The experienced persons from heavy-ion experiments at GSI, SPS, BNL (HADES, WA98, NA45, NA49, STAR, PHENIX, ALICE)
- Young scientists account for about 40% of th Collaboration

NICA priorities

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J. Randrup,[8] O. Rogachevsky,[9] O. Teryaev,[3] and V. Toneev[3]

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[2] *University of Wroclaw, Poland*

[3] *BLTP, JINR Dubna, Russia*

[4] *FIAS, Frankfurt, Germany*

[5] *GSI Darmstadt, Germany*

[6] *University of Frankfurt, Germany*

[7] *University of Kielce, Poland*

[8] *Lawrence Berkeley National Laboratory, USA*

[9] *Laboratory for High Energy Physics, JINR Dubna, Russia*

Therefore, the first round of NICA experiments should concentrate on a variety of diagnostic observables that have already been employed in experimental programs at RHIC (the beam energy scan) and the SPS; these are based on general considerations about phase changes and the associated different degrees of freedom. We recommend that the MPD detector at NICA will be optimized for the study of fluctuations and correlations of bulk event properties and that a primary goal will be to measure the excitation functions and the dependence of fluctuations and correlations on centrality and system size.

The observables include event-by-event fluctuations of multiplicity and transverse momentum of charged particles and identified particles (p,K,π) as well as the corresponding joint distributions. The correlations include long-range angular correlations like the transverse Fourier components v_1 and v_2 of identified particles (p,K,π, Λ), their antiparticles, and light clusters, three-body correlations (which are necessary for studying the chiral magnetic effect), as well as short-range two-particle correlations (for the studies of the system size). We recommend that the coverage in rapidity and transverse momentum should be as large as possible. The measurements should be made as a function of collision energy for the

Concluding Remarks

- The MPD/NICA program is well integrated into world experimental high energy ion investigations
- The MPD collaboration is growing and getting international recognition
- MPD project is well progressing: main goals of the R&D stage achieved
- Continuation of detailed project evaluation by MPD Detector Advicery Committee

Status of the MPD TDR

Completed (under evaluation) : **TPC, FFD**

Under completion : **TOF, ECAL, ZDC**

Link: *http://nica.jinr.ru/files/MPD/mpd_tdr.htm*

Thank you for attention

Back up slides

Experiments on dense nuclear matter

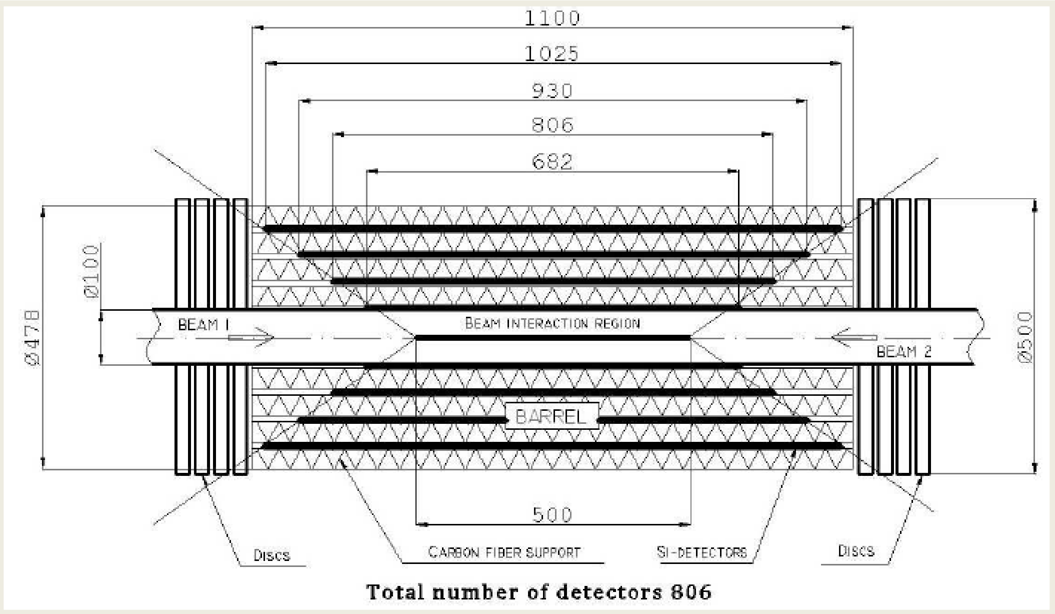
Experiments	Energy range (Au/Pb beams)	Reaction rates Hz
STAR@RHIC BNL	$\sqrt{s_{NN}}$ = 7 – 200 GeV	1 – 800 (limitation by luminosity)
NA61@SPS CERN	E_{kin} = 20 – 160 A GeV $\sqrt{s_{NN}}$ = 6.4 – 17.4 GeV	80 (limitation by detector)
MPD@NICA Dubna	$\sqrt{s_{NN}}$ = 4.0 – 11.0 GeV	~7000 (design luminosity of 10^{27} $cm^{-2}s^{-1}$ for heavy ions)
CBM@FAIR Darmstadt	E_{kin} = 2.0 – 35 A GeV $\sqrt{s_{NN}}$ = 2.7 – 8.3 GeV	$10^5 – 10^7$ (limitation by detector)

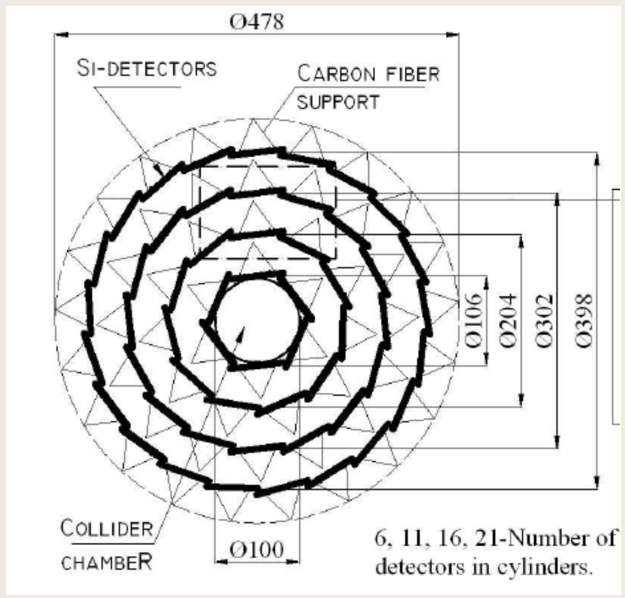
MPD Collaboration

http://nica.jinr.ru/MPD_CDR

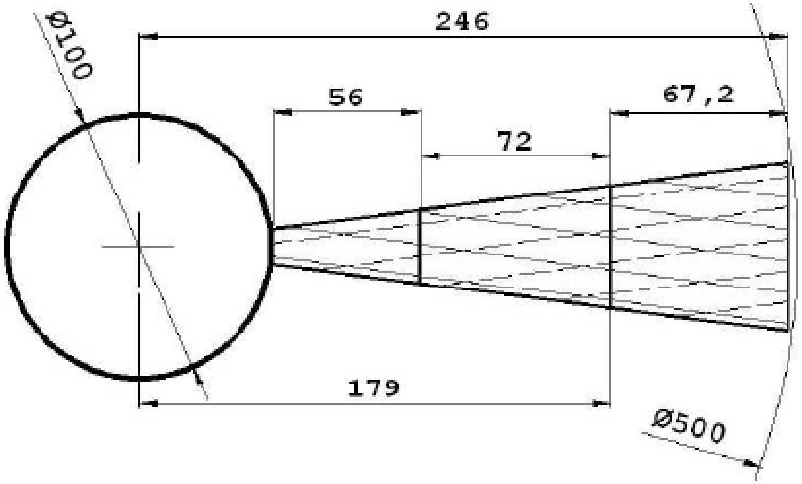
1) Joint Institute for Nuclear Research (Dubna, Russia)
2) Institute for Nuclear Research (Troitsk, Russia)
3) Institute of Nuclear Physics (Moscow, Russia)
4) Institute for Theoretical Experimental Physics (Moscow, Russia)
5) St.Petersburg State University (St.Petersburg, Russia)
6) Radium Institute (St.Petersburg, Russia)
7) “Neva-Magnet” S&E, Ltd. (St. Petersburg, Russia)
8) Department of Engineering Physics, Tsinghua University (Beijing, China)
9) Center of Particle Physics and Technology of the University of Science and Technology of China (Hefei, China)
10) Warsaw University of Technology (Warsaw, Poland)
11) Institute of Physics &Technology Mongolian Academy of Sciences (Ulan Bator, Mongolia)
12) Institute for Nuclear Research & Nuclear Energy (Sofia, Bulgaria)
13) Plovdiv University (Plovdiv, Bulgaria)
14) National Institute of Physics and Nuclear Engineering (Bucharest, Romania)
15) Bogolyubov Institute for Theoretical Physics (Kiev, Ukraine)
16) Institute for Scintillation Materials (Kharkiv, Ukraine)
17) State Enterprise Scientific & Technology Research Institute(Kharkiv, Ukraine)
18) Particle Physics Center of Belarusian State University (Minsk, Belorussia)
19) Physics Institute Az. AS (Baku, Azerbaijan)

Inner Tracker (IT)



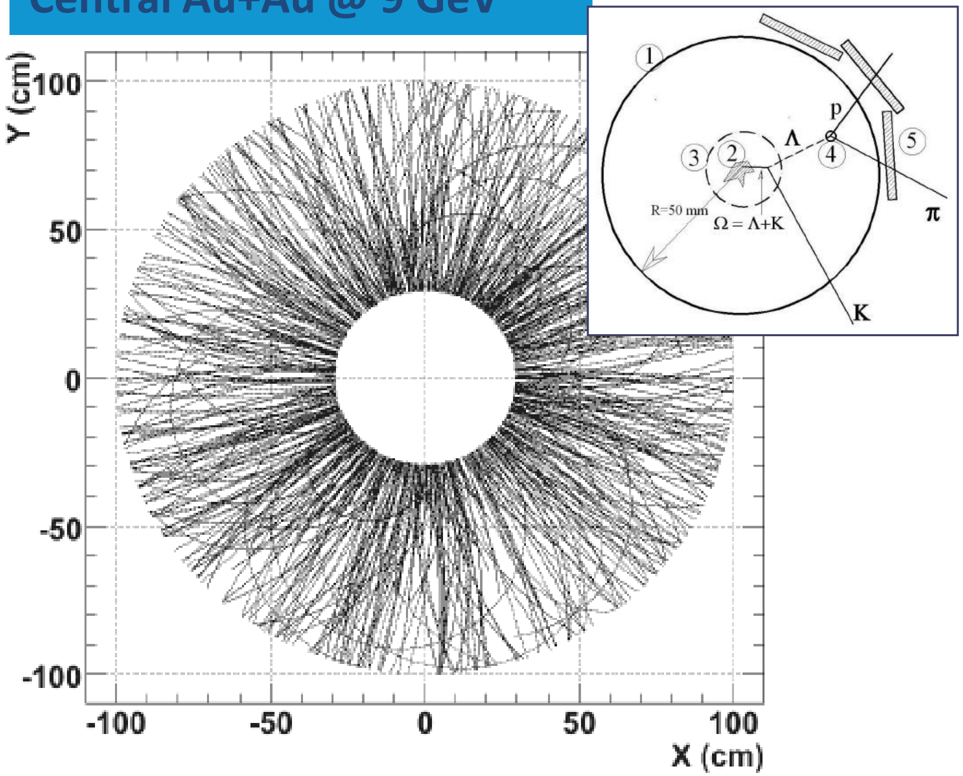


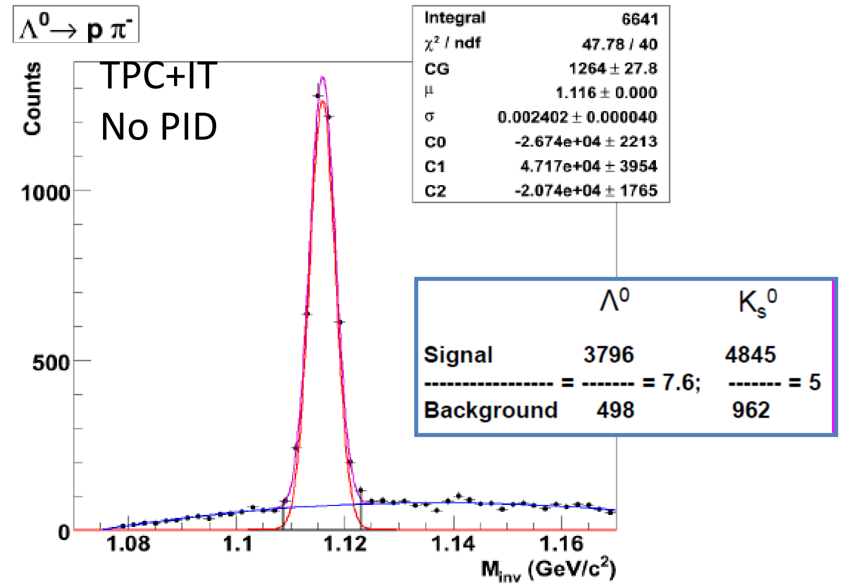
- 4 cylindrical & disk layers
- 300 μm double-sided silicon microstrip detectors, pitch = 100 μm
- Thickness/layer ~ 0.8% X_0
- Barrel: R=1- 4 cm, coverage |η|<2.5
  806 sensors of 62x62 mm²
- Disks: design under optimization
- resolution: σ_z = 120 μm, $\sigma_{r\phi}$ = 23 μm

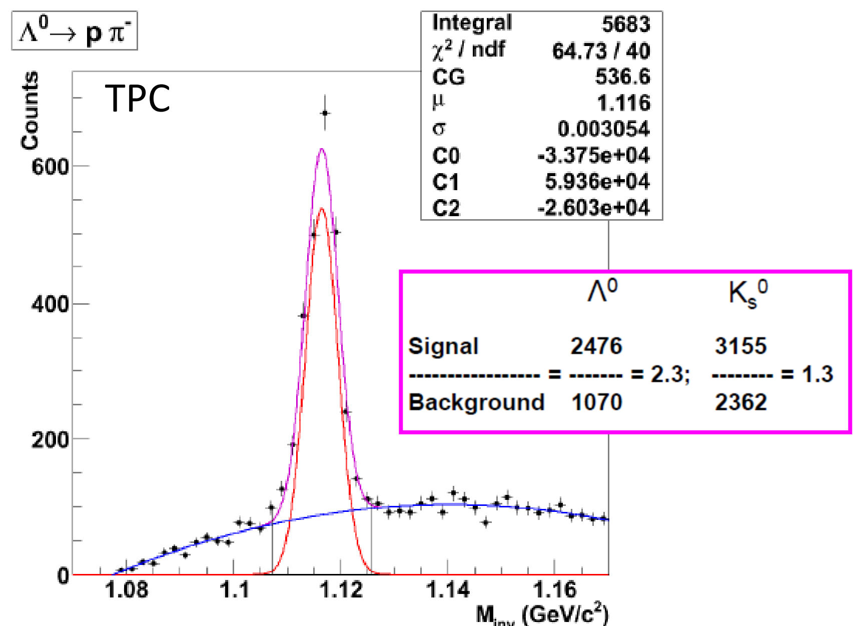


V0 performance (TPC+IT)

Central Au+Au @ 9 GeV







- **Improved Signal-to-Background ratio (S/B) with the vertex IT detector**

EndCap Tracker

The tracking capability of the TPC for the pseudorapidity $|\eta| > 1.2$ will be enhanced by an endcap tracking system.
The straw tube EndCap Tracker located between the TPC and endcap TOF is considered as an option. The ECT consist of 2x60 layers of 60 cm length straw tubes and covers the pseudorapidiry region $1 < |\eta| < 2.5$.

Straw full sector prototype

EMC tests with beams and cosmic rays

Preparation for tests with electron beams (DESY, December'13)

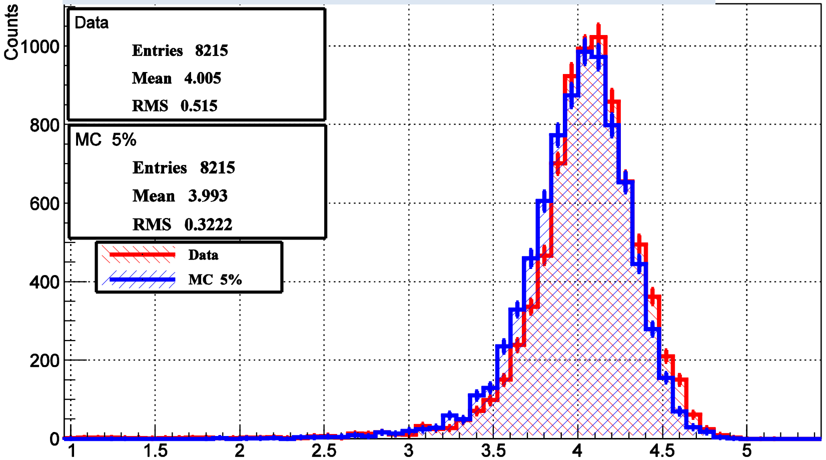
Test of EMC modules with cosmic rays

Program of EMC beam tests:

- Performance study of two EMC modules with different WLS-fibers
- Tests of the EMC read-out electronics (amplifiers and ADCs)
- Energy scan with electrons (E_e = 1..6 GeV)

Analysis of the data recorded in beam tests is ongoing

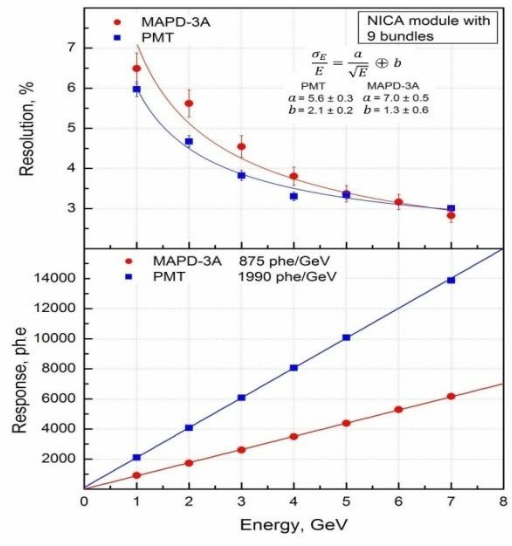
EMC response to 4 GeV electrons



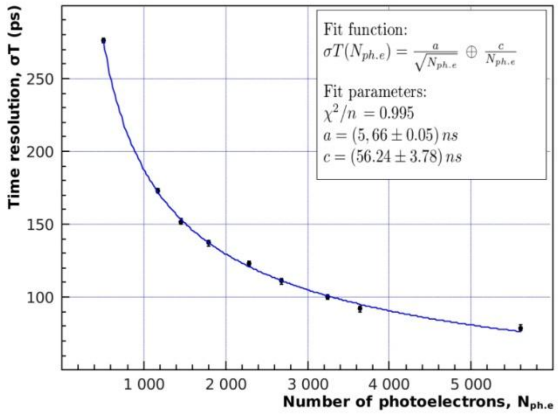
ECAL – "shashlyk" type modules with APD readout

(Lead plates (0.275 мм) and plastic scintillator (1.5 мм), the radiation length of tower $18X_0$ (40 см))
The active area of APD- 3x3 мм; Density of pixels in APD – 10^4/мм^2

The primary role of the electromagnetic calorimeter is to measure the spatial position and energy of electrons and photons produced in heavy ion collisions. It will also play a major role in particle identification due to high time resolution. The first prototype of EM-module (shashlyk type) for EMC MPD-NICA with MAPD readout on beam tests at CERN and at DESY are presented. The MAPD combines a lot of advantages of semiconductor photodetectors: it is insensitive to magnetic field and has a compact dimension. It also has a high gain which is close to that of the PMT. Novel types of MAPD with deep micro-well structures have super high pixel densities of up to 40000 mm^{-2} which provides wide dynamic range and high linearity. The main characteristics of the novel deep micro-well MAPD which are Gain and Photon Detection. Energy and time resolution of individual EM-module with MAPD readout were measured and also presented. The EM-module with the MAPD readout looks very promising. With some improvements it will serve as an EMC of the future detector MPD for NICA experiment. We used ADC with 12 bits and 100 MHz.

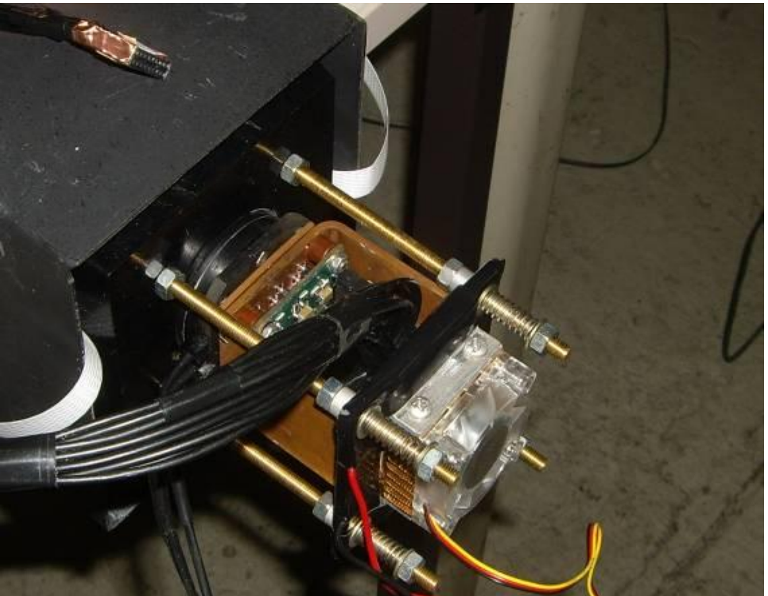


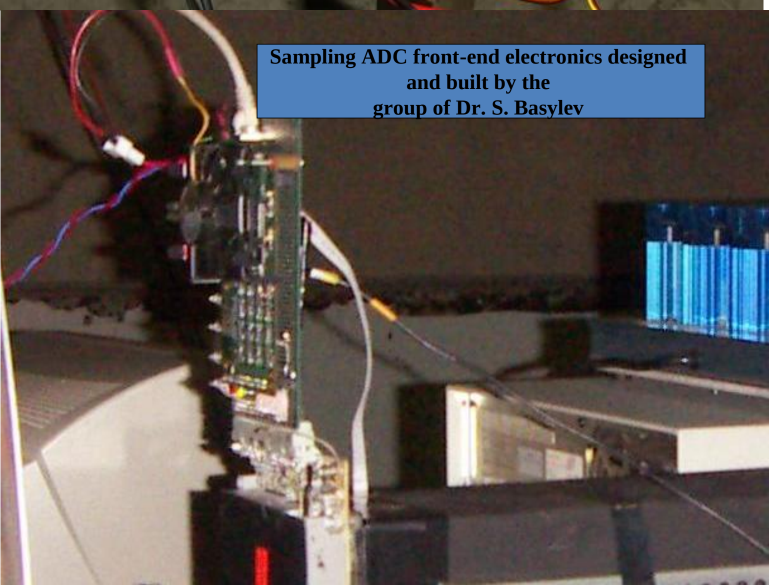
Responses and energy resolutions of the prtototype NICA module readout by PMT EMI 9814B and MAPD-3A at T=15º C versus electron beam energy.



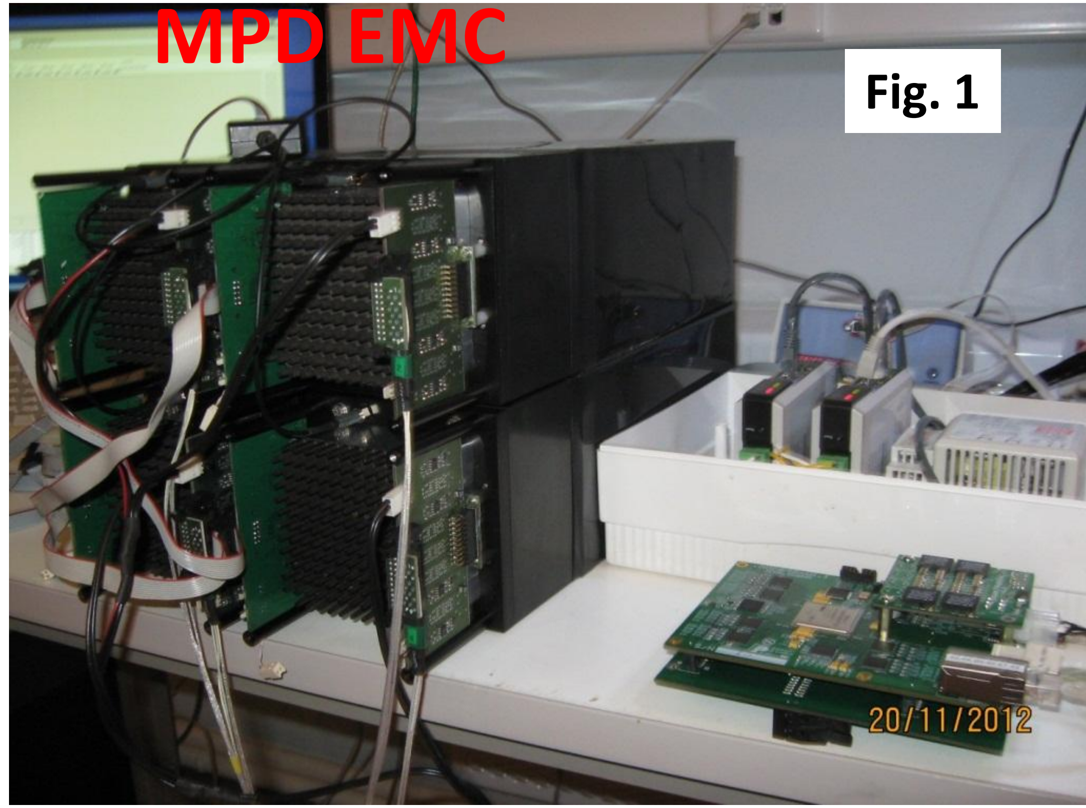
Time resolution of the prototype NICA module readout by MAPD-3A versus the number of collected photoelectrons (Nph.e)

EMC-ReadOut





MPD EMC



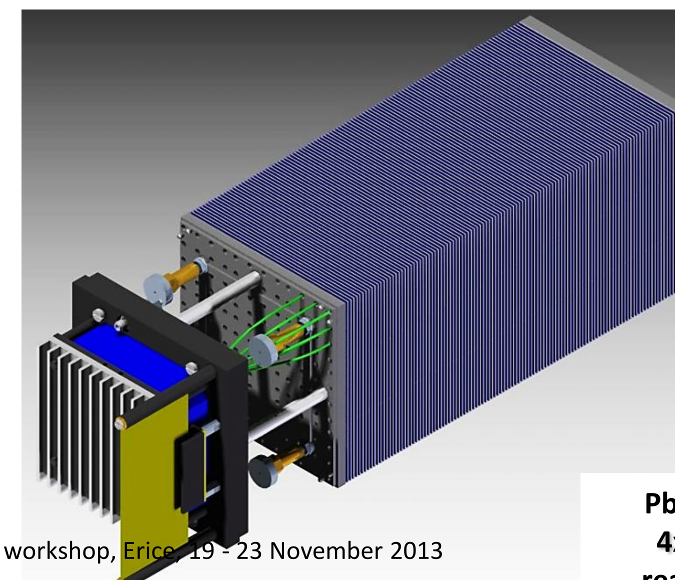
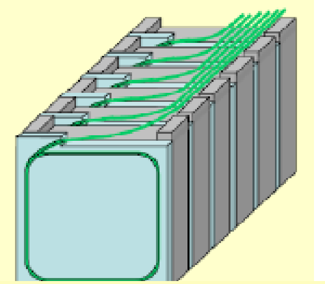
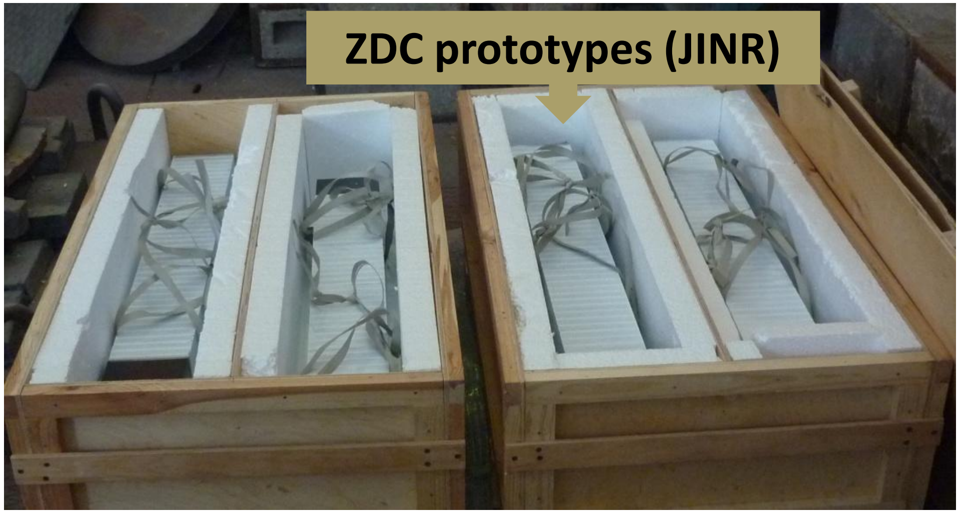


Fig. 2

Fig.1. Design of the EMC module
Fig.2. ECAL “tower”
Fig.3. Setup for testing ECAL prototypes

Pb(0.35 mm)+Scint.(1.5 mm)
4x4 cm^2 , L ~35 cm (~ 14 X_0)
read-out: WLS fibers + MAPD





Pb-scintillator sampling (5λ)
Read-out: fibers+ AvalanchePD
ZDC coverage: 2.2<|η|<4.8

<u>2013 - 2014</u>

- Construction of several ZDC modules at INR and JINR
- Preparation for beam tests @ Nuclotron
- Extensive ZDC simulation
- ZDC TDR finalizing (draft is ready)