JINR 1956-2006 DUBNA

JOINT INSTITUTE FOR NUCLEAR RESEARCH

The NICA/MPD Project at JINR (Dubna)

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on behalf of the NICA/MPD working group

Nuclotron-based Ion Collider fAcility
Multi-Purpose Detector

- JINR: Synchrophasatron – Nuclotron –NICA
- Goals of the NICA/MPD project
- NICA scheme and layout
- Multi-Purpose Detector
- The project milestones

The Joint Institute for Nuclear Research (JINR) in Dubna is an international research organization established in accordance with the intergovernmental agreement of 11 countries in 1956. At the present time, eighteen countries are the JINR Member States and five more countries have the associated member status.

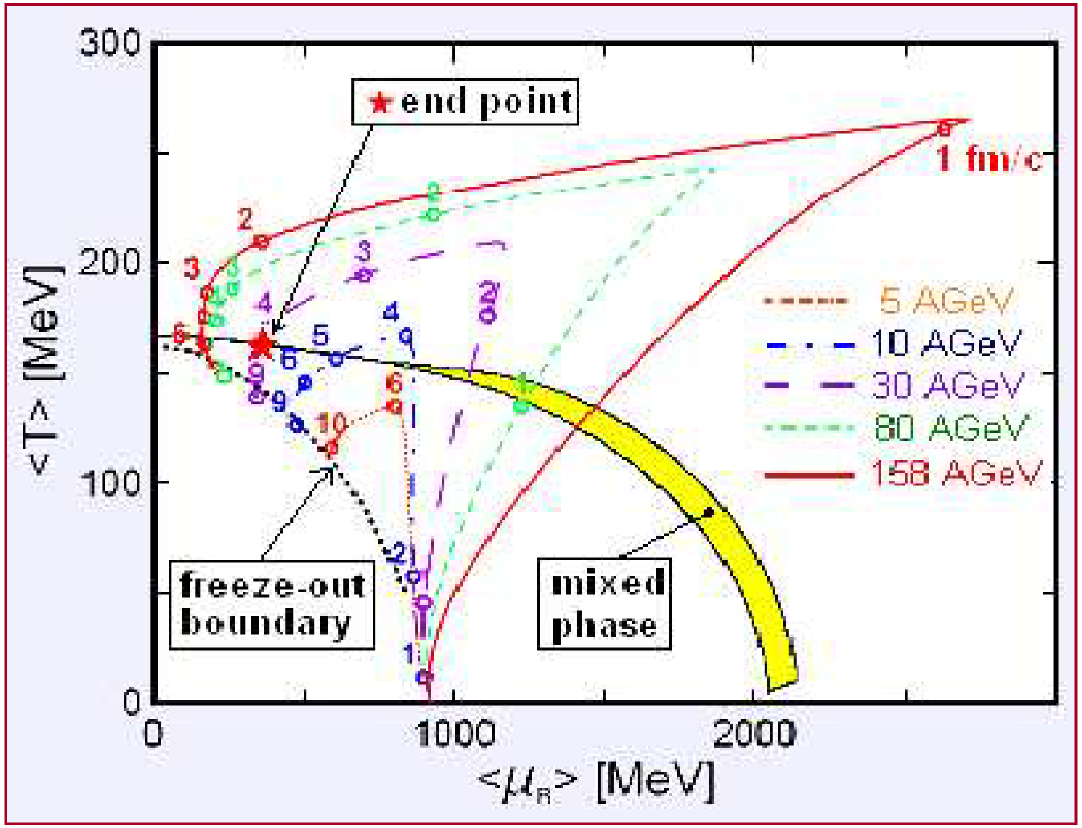
The Synchrophazotron:

1970 observation of dd $\Rightarrow$ π-jet – first cumulative effect (V.Sviridov, V.Stavinsky)

The first relativistic nuclear beams with the energy of 4.2 AGeV were obtained at the Synchrophasotron in 1971. Since that time the study of relativistic nuclear physics problems has been one of the main directions of the JINR research program.

The Nuclotron

6 A·GeV synchrotron based on unique fast-cycling superferric magnets, was designed and constructed at JINR for five years (1987-1992) and put into operation in March 1993. The annual running time of 2000 hours is provided during the last years.



Dynamical trajectories for central (*b* = 2 fm) Au+Au collisions calculated within the relativistic 3-fluid hydrodynamics with hadronic EoS. Phase boundary is estimated in a two-phase bag model taking into account the conservation of baryon and strangeness charges. The critical end point is calculated in the lattice QCD.

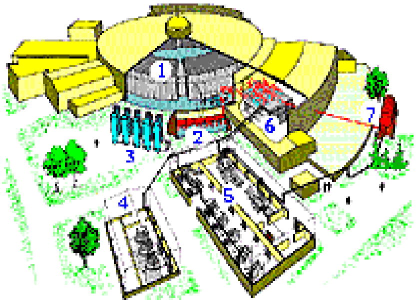
JINR Joint Institute for Nuclear Research

Round Table Discussion

Searching for the mixed phase of strongly interacting matter at the JINR Nuclotron

July 7 - 9, 2005

Progr



Organizing Committee

Talks

Photographs

Research Program & Expert's Report

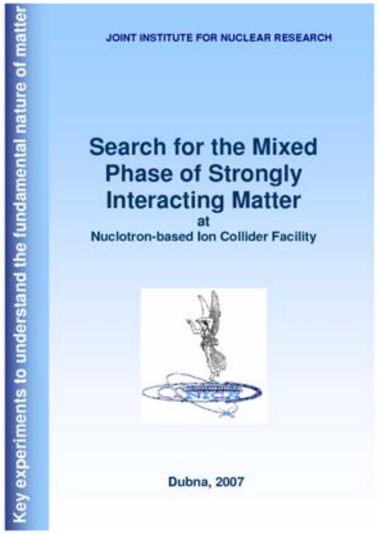
http://theor.jinr.ru/meetings/2005/roundtable/

JINR — Joint Institute for Nuclear Research

Round Table Discussion II

Searching for the mixed phase of strongly interacting matter at the JINR Nuclotron:
Nuclotron facility development

JINR, Dubna, October 6-7, 2006



Conceptual project

Design and construction of
Nuclotron-based Ion Collider fAcility (NICA)
and Multi-Purpose Detector (MPD)

http://theor.jinr.ru/meetings/2006/roundtable/booklet.html

http://theor.jinr.ru/meetings/2006/roundtable/

NICA goals and physics problems

Study of in-medium properties of hadrons and nuclear matter equation of state, including a search for possible signs of deconfinement and/or chiral symmetry restoration phase transitions and QCD critical endpoint in the region of $\sqrt{s}_{NN}$=4-9 GeV

by means of careful scanning in beam energy and centrality of excitation functions for

the first stage

- ♣ Multiplicity and global characteristics of identified hadrons including multi-strange particles
- ♣ Fluctuations in multiplicity and transverse momenta
- ♣ Directed and elliptic flows for various hadrons
- ♣ HBT and particle correlations

the second stage

- ♣ **Electromagnetic probes (photons and dileptons)**

Required mean luminosity is about 10^{27} $cm^{-2}s^{-1}$

Collider Luminosity Limitations

1) Multibunch regime – storage and exchange "bunch by bunch".

2) Bunch number is limited by parameters of the injection/extraction system:
at realistic kicker pulse duration ~ 100 ns one can have $\odot$ 10 bunches/ring if $C_{collider}$ = 250 m.

3) Bunch intensity is limited by space charge effects:

"Lasslett tune shift" $\Rightarrow$ $\Delta Q = 0.05$ for $N_{ion/bunch} = 3 \cdot 10^9$, l_{bunch} = 0.33 m

Beam-beam effect $\Rightarrow$ $\xi = 0.009$ at the same bunch parameters

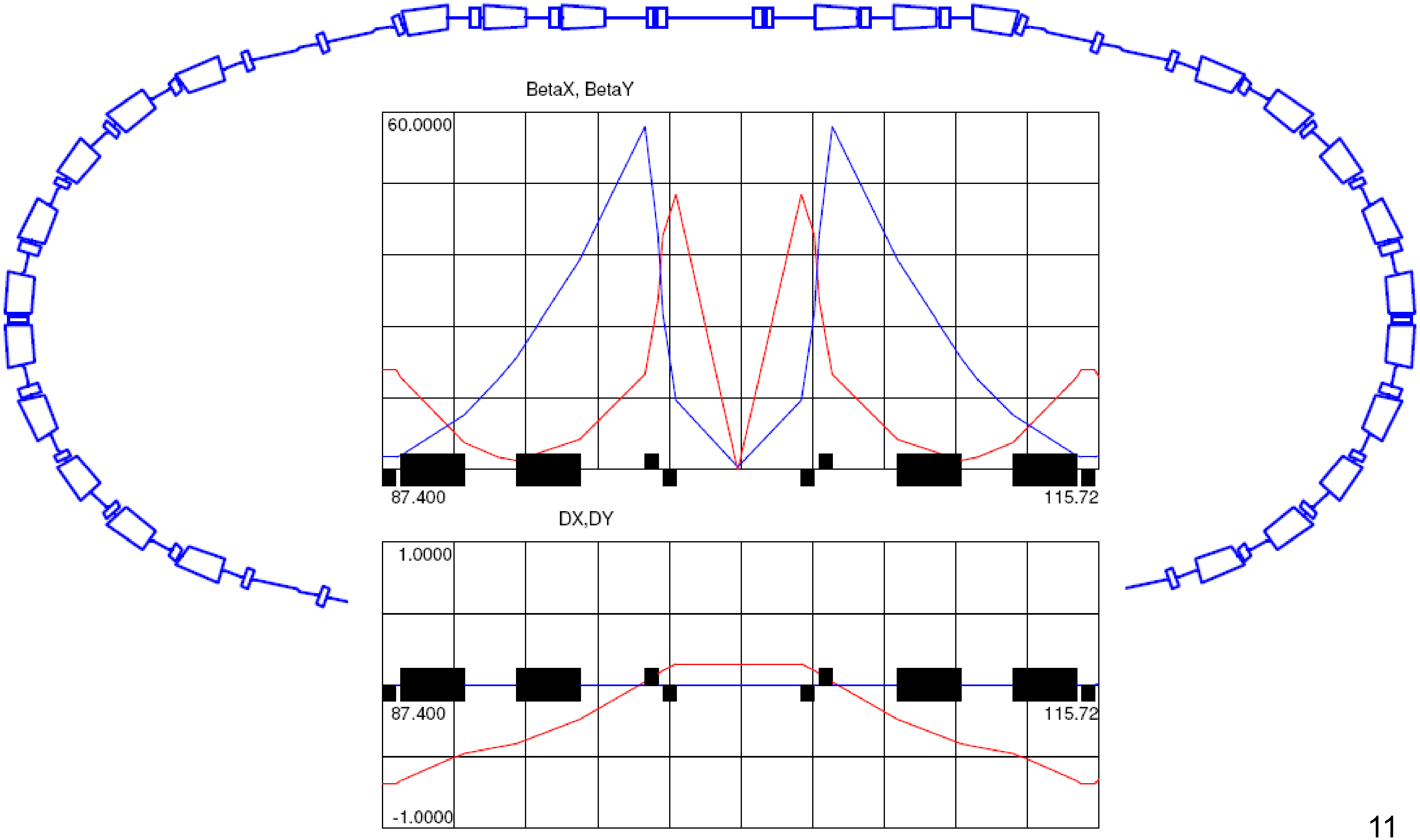
4) Additional limitations of the beam intensity:

Electron cloud, coherent instabilities, multibunch instability

Collider general parameters

Ring circumference, m	250
Ion kinetic energy, min/max E [GeV/u]	1 ÷ 3.5
Particle number per bunch, $N_{ion/bunch}$	3.5×10^{9}
Bunch length, m	0.33
Bunch number, n_{bunch}	10
Horizontal emittance, ε [π mm mrad]	0.7
Momentum spread, $\Delta p/p$	0.001
IBS growth time [sec]	50
Beta function at interaction point, β^*	0.5
RF voltage, U_rf [kV]	200
Laslett tune shift, ΔQ	0.05
Beam-beam parameter	0.009
Peak luminosity (at 3.5 GeV/u), L [$cm^{-2}s^{-1}$]	2×10^{27}
Average luminosity (at 3.5 GeV/u), L [$cm^{-2}s^{-1}$]	$(1\div1.5)\times10^{27}$

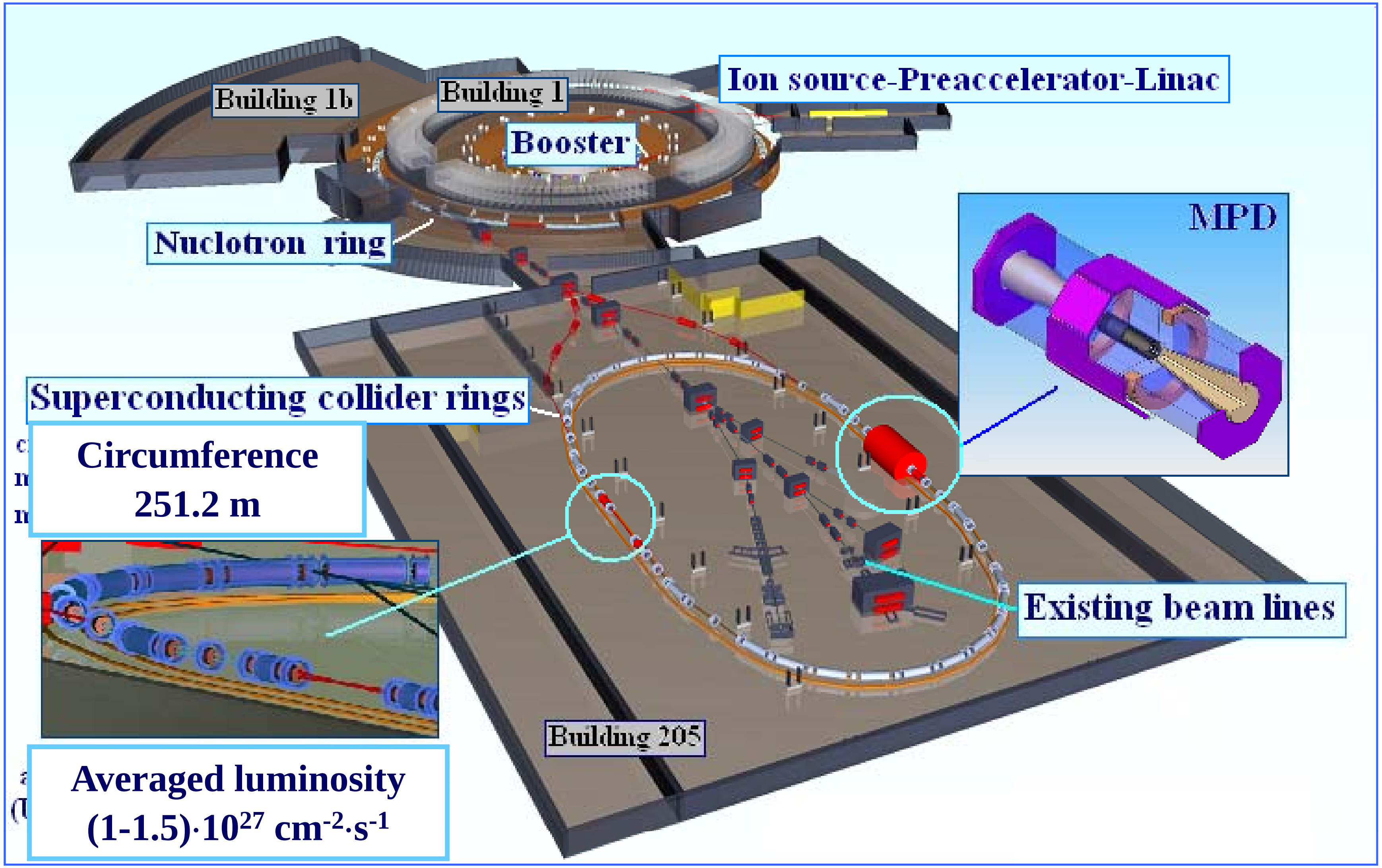
Collider ring optics and lattice functions at interaction point



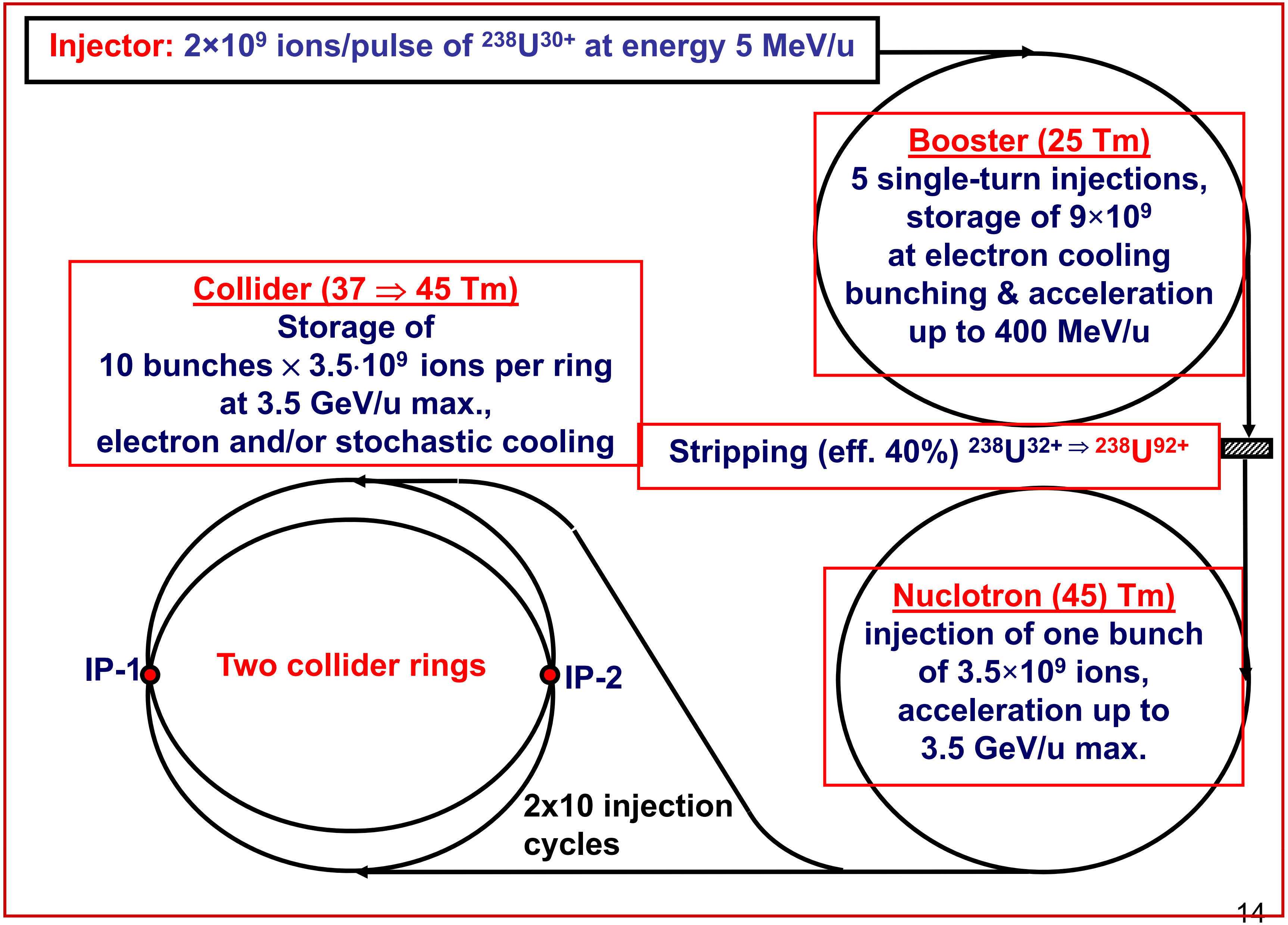
Collider General Parameters

Ring circumference, [m]	251.2
Bρ min/max (U92+), [T·m]	14.6/37.3 (⇒ 50.5)
Ion kinetic energy, [GeV/amu]	1.0 ÷ 3.5 (⇒ 5.0?)
Dipole field, [T]	1.5 ÷ 3.73 (⇒ 5.05?)
Long straight sections number / length, [m]	2 x 48.3
Short straight sections number / length, [m]	4 x 9.66
Vacuum, [pTorr]	100 ÷ 10

NICA general layout

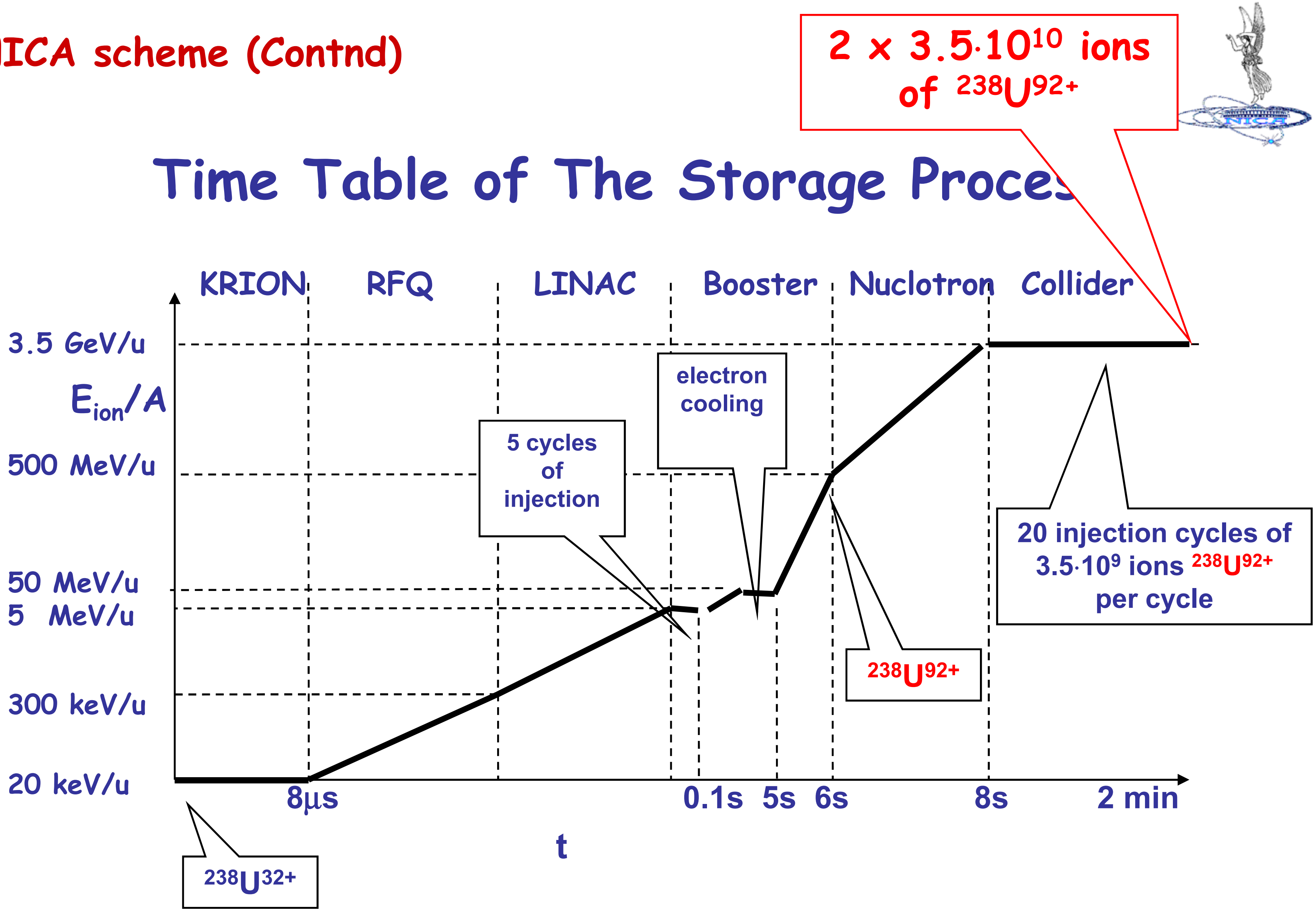


NICA scheme


Injector: 2×10⁹ ions/pulse of ²³⁸U³⁰⁺ at energy 5 MeV/u
Booster (25 Tm)
5 single-turn injections,
storage of 9×10⁹
at electron cooling
bunching & acceleration
up to 400 MeV/u
Collider (37 ⇒ 45 Tm)
Storage of
10 bunches × 3.5·10⁹ ions per ring
at 3.5 GeV/u max.,
electron and/or stochastic cooling
Stripping (eff. 40%) ²³⁸U³²⁺ ⇒ ²³⁸U⁹²⁺
IP-1
Two collider rings
IP-2
Nuclotron (45) Tm)
injection of one bunch
of 3.5×10⁹ ions,
acceleration up to
3.5 GeV/u max.
2x10 injection
cycles

NICA scheme (Contnd)

Time Table of The Storage Process



ESIS-type Ion Source

Ion Sources comparison

(Experimental results)

Ion source	KRION, Au^{30+}	ECR, Pb^{27+}
Peak ion current, mA	1.2	0.2
Pulse duration, μs	8	200
Ions per pulse	2×10^{9}	1×10^{10}
Ions per μsec	$2.5\mathrm{x}10^{8}$	$5\mathrm{x}10^{7}$
Norm. rms emittance, [π mm mrad]	0.15÷0.3	0.15÷0.3
Repetition rate, Hz	60	30

Crucial parameter: Ions per μsec!

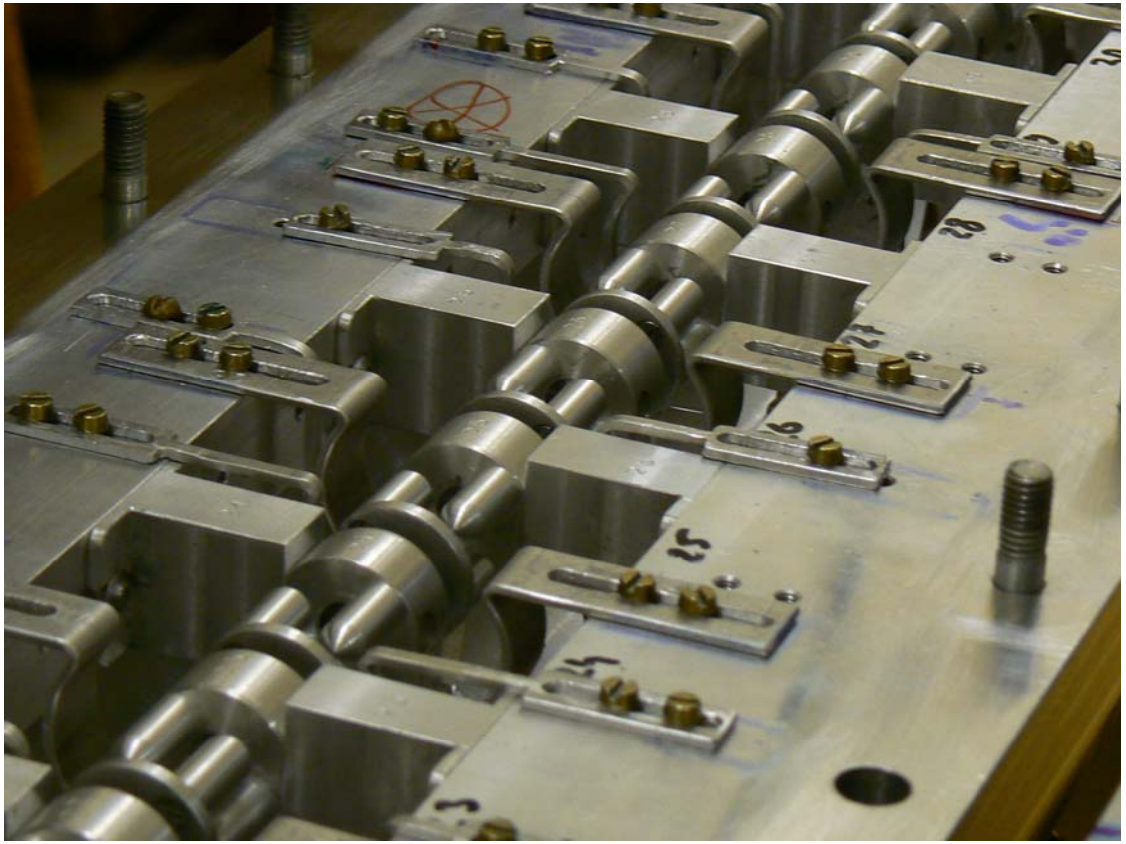
Thus, KRION has a very significant advantage!

However, the maximum beam current is 10 – 30 mA

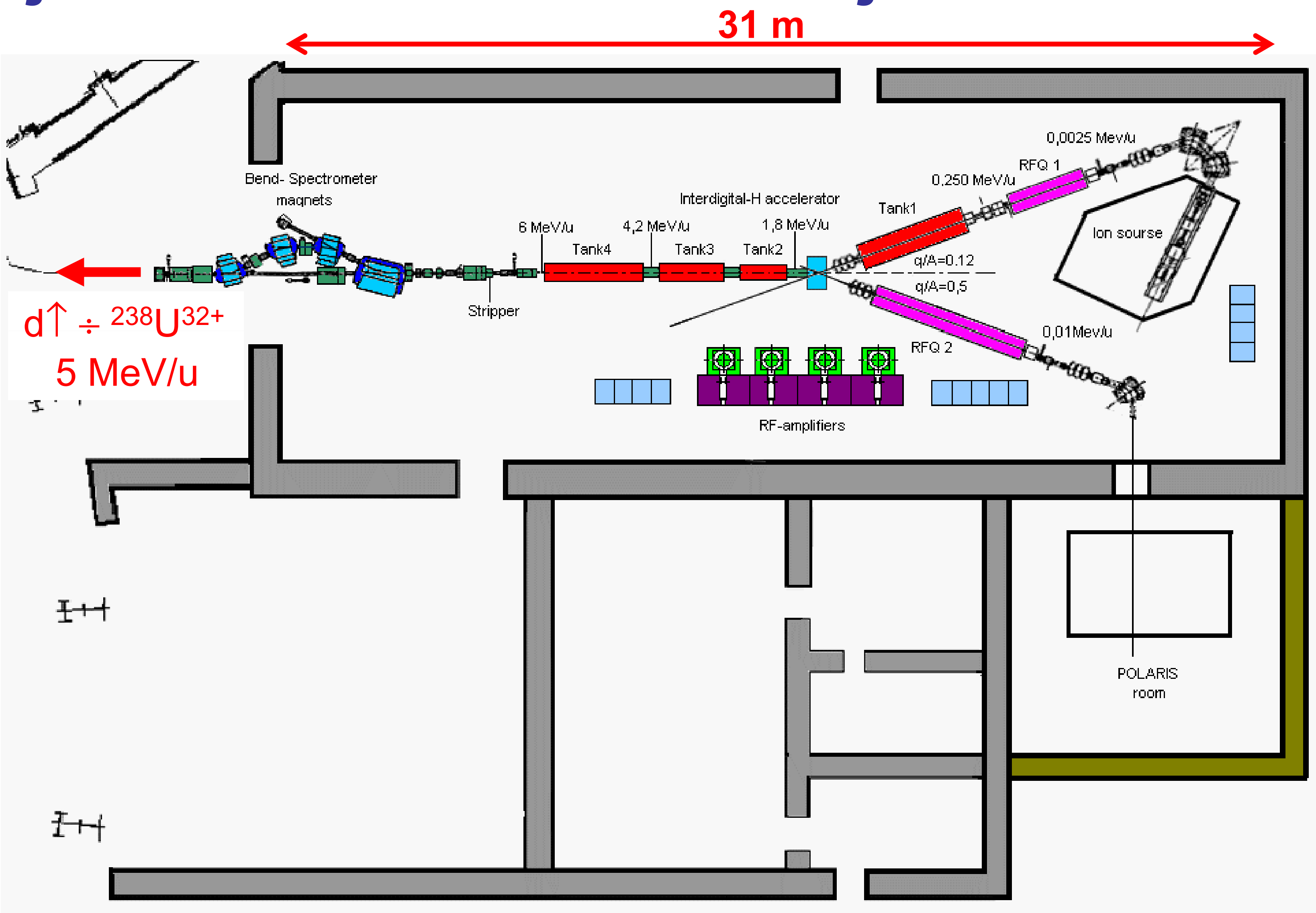
RFQ + RFQ-DTL

Designed in IHEP (Protvino)

Prototype of the linac for CERN



Injector: Ion Source + Preinjector + Linac



Booster

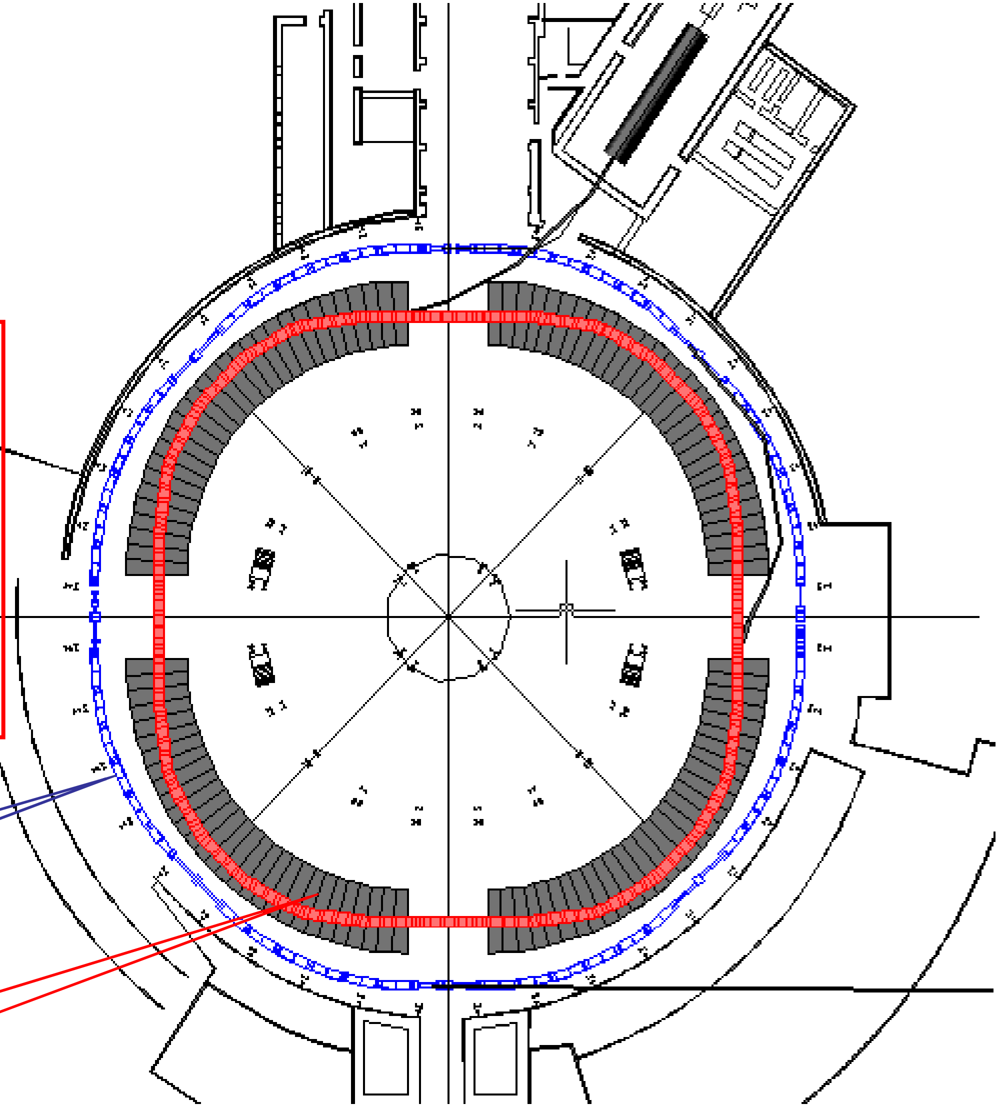
“Warm” booster

on base

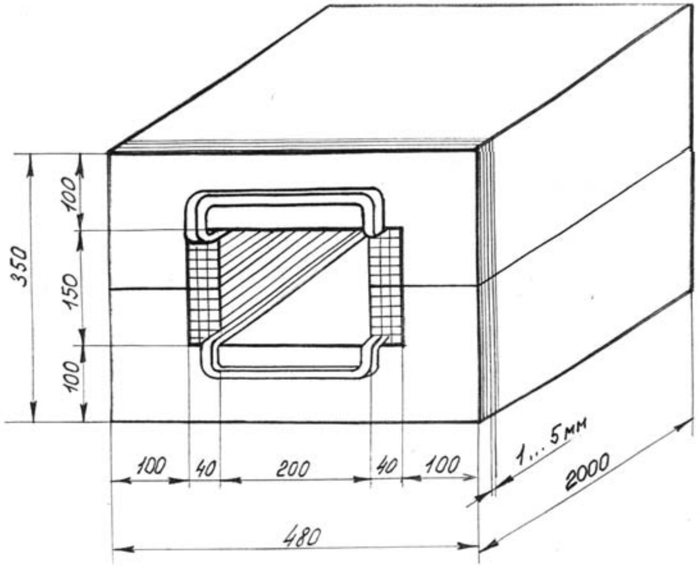
of the Synchrophasotron

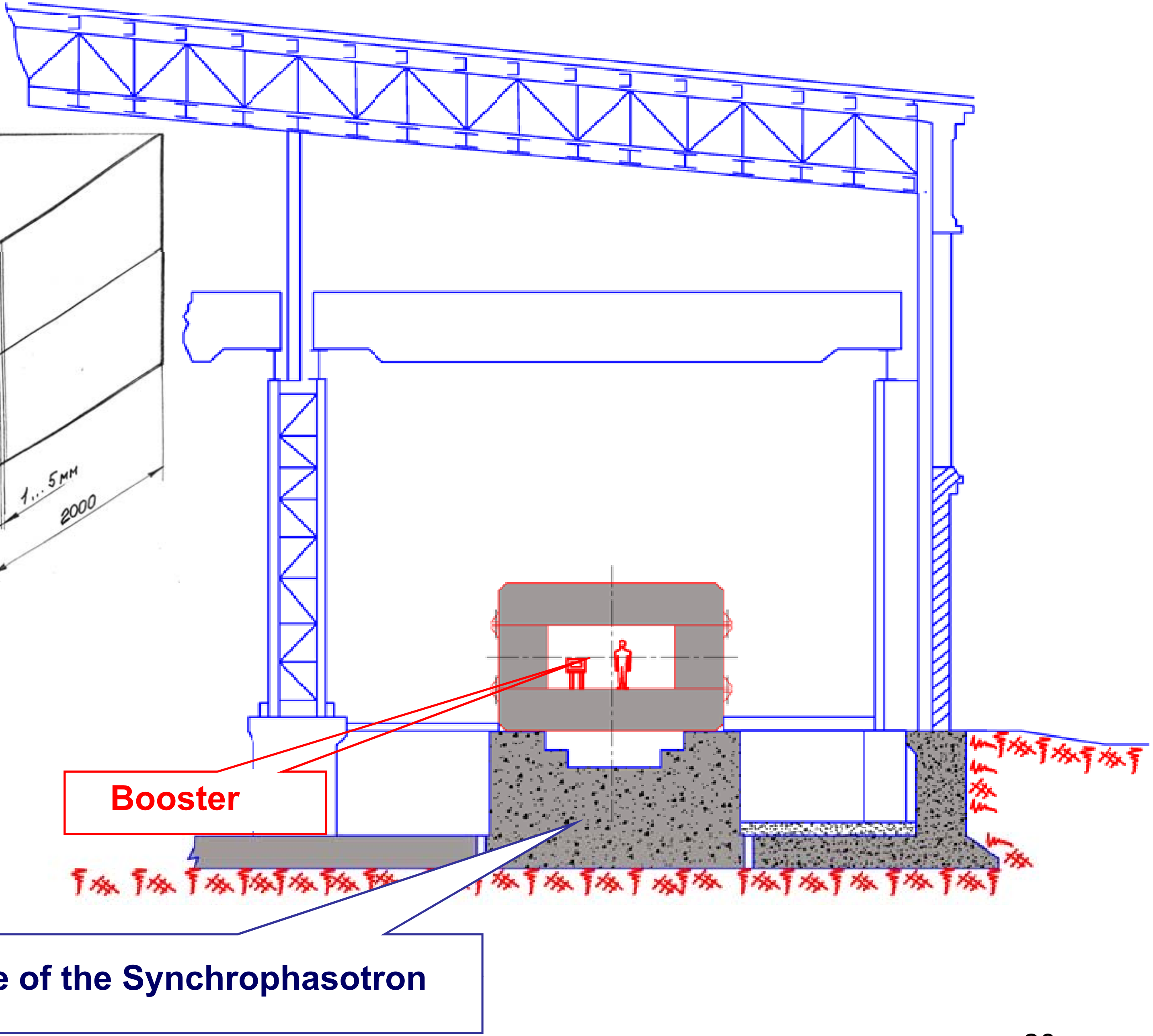
$B\rho$ = 25 T·m, C = 210 m

1) 5 single-turn injections
2) Storage of 9×10^{9} $^{238}U^{32+}$ at electron cooling
3) bunching
4) Acceleration up to 400 MeV/u
5) Extraction & stripping

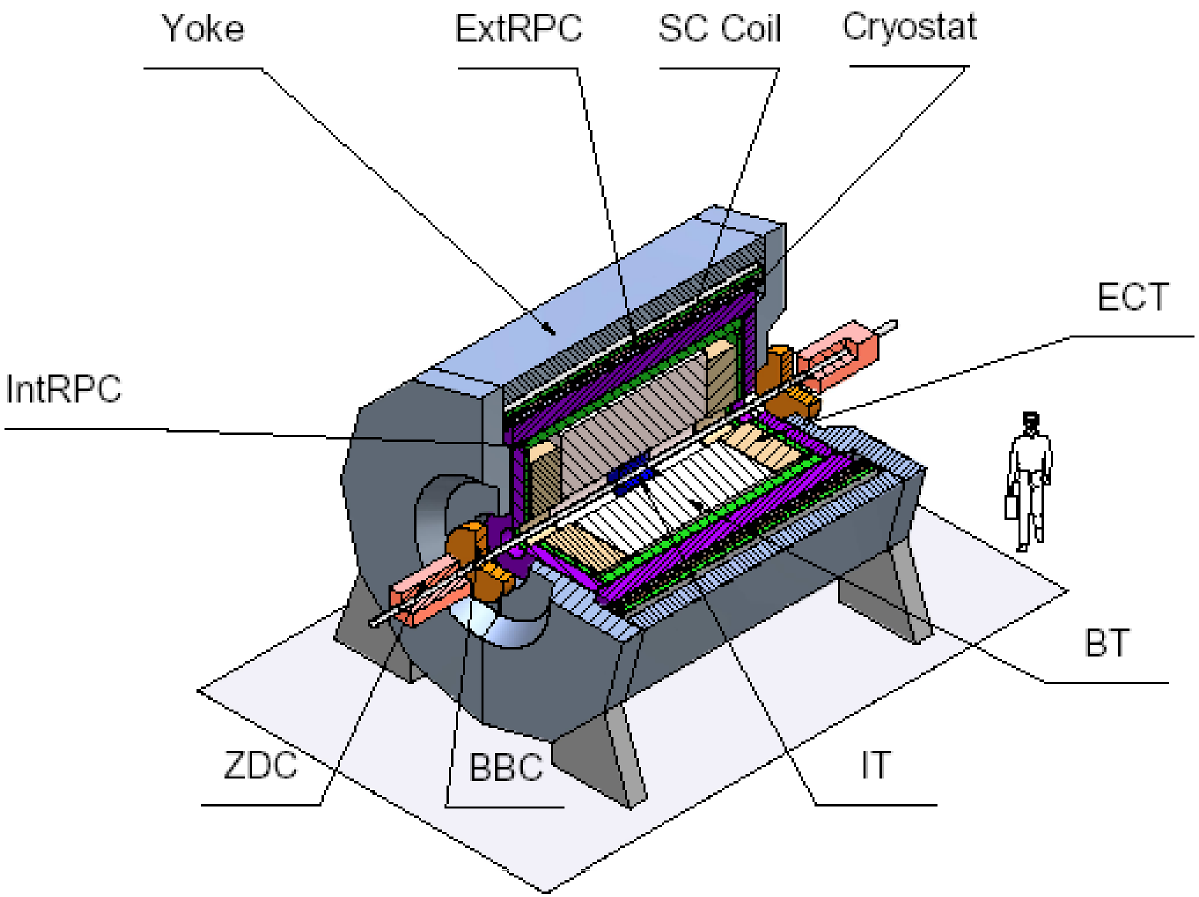


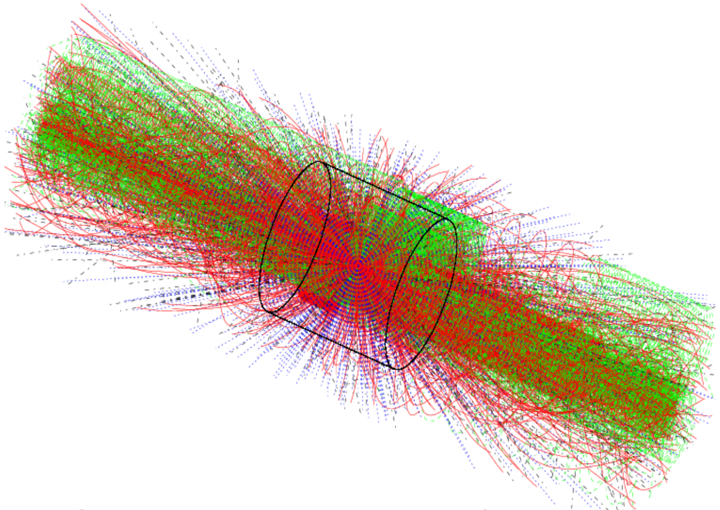
Booster (Contnd)





MPD general layout





Simulated tracks from U+U collision with $\sqrt{s_{NN}}$= 9 GeV energy with UrQMD model.

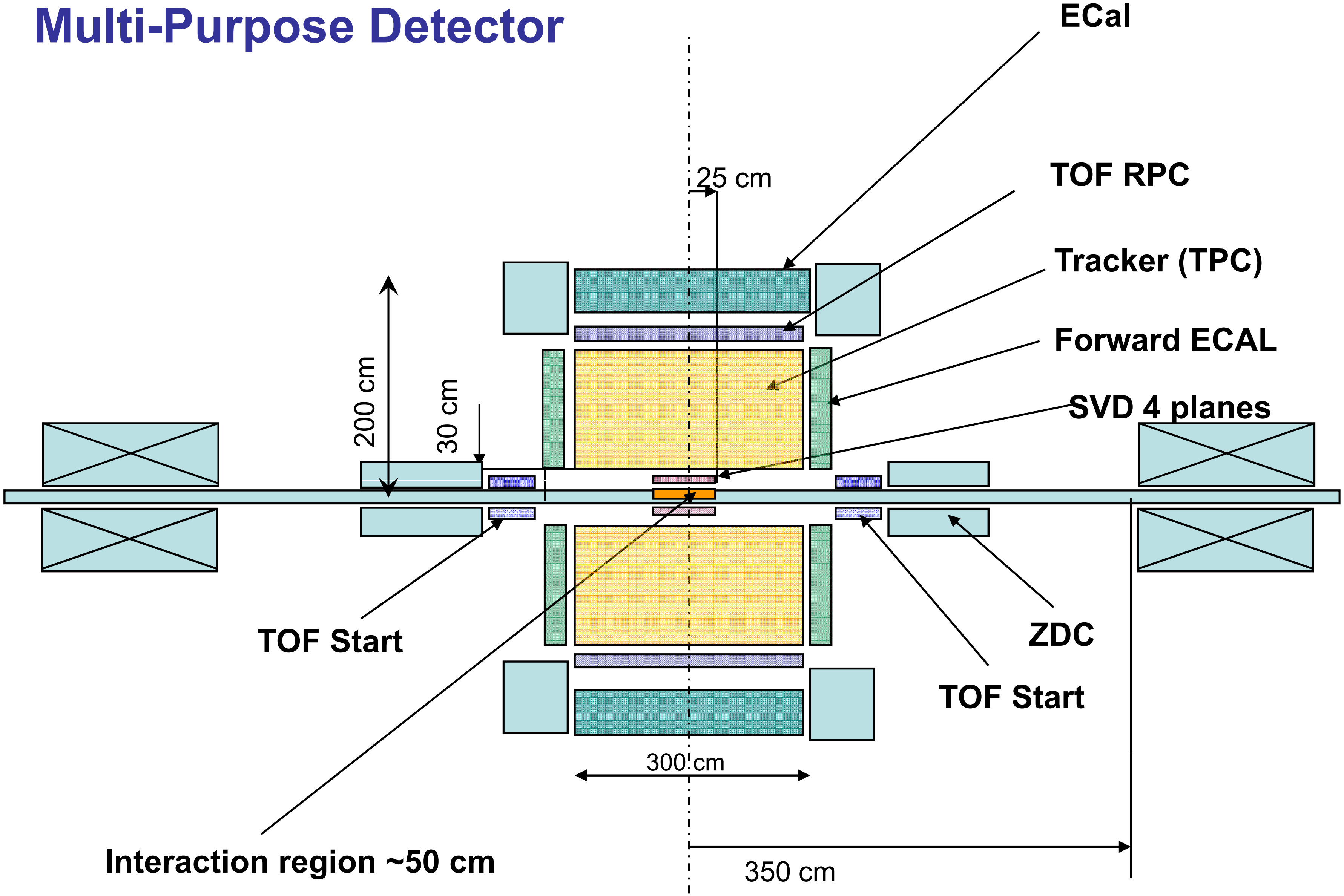
MPD dimension:

Along the beam – 8 m.

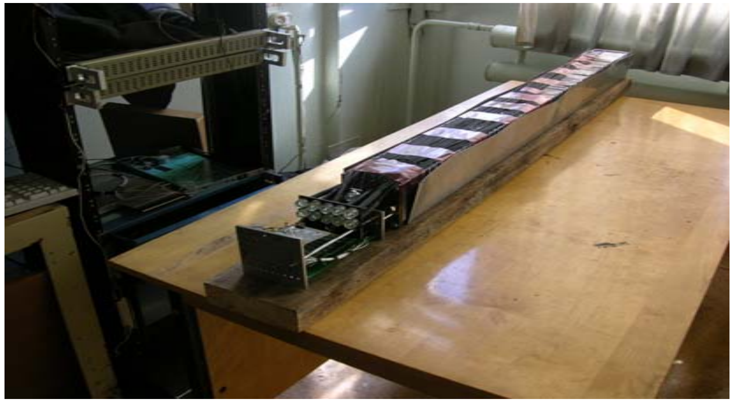
Diameter – 5 m.

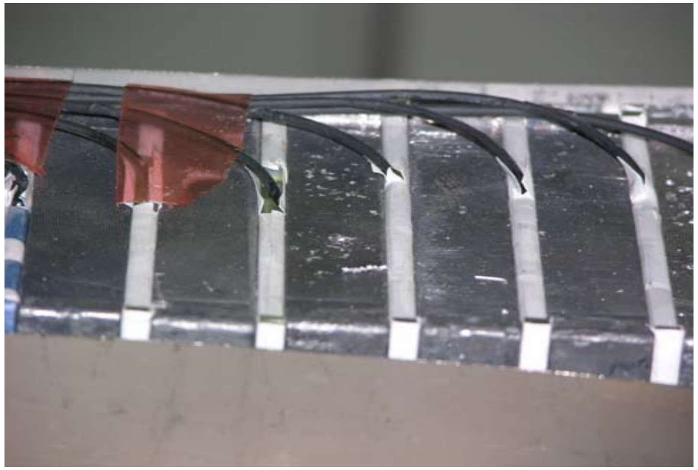
Tracking detectors are situated in the magnetic field of ~0.5 T .

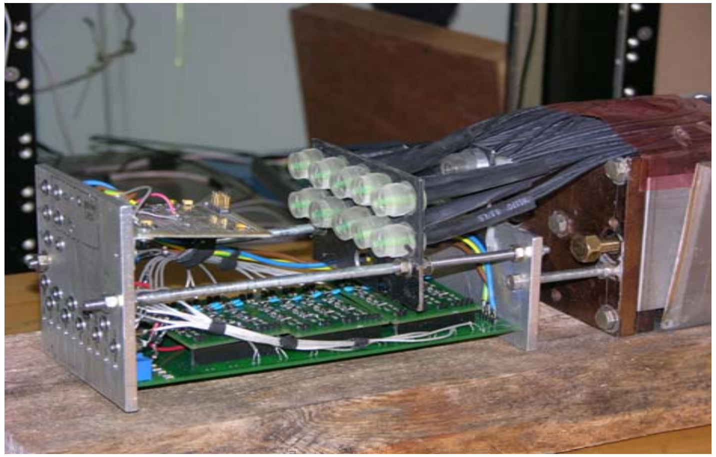
Multi-Purpose Detector



Assembling of the ZDC at INR (Troitsk)







Required MPD parameters

- $|y|<2$ acceptance and 2π continuous azimuthal coverage
- High tracking efficiency
- Adequate track length for tracking, momentum measurement and particle identification
- Momentum resolution $\Delta p/p<0.02$ for $0.1< p<2$ GeV/c
- Two-track resolution providing a momentum difference resolution of few MeV/c for HBT correlation studies
- Determination of the primary vertex better than 200μm for high momentum resolution to be able to identify particles from the primary interaction
- Determination of secondary vertices for detecting the decay of strange particles such as Λ, K^0_s, $\Xi^{\pm}$, Ω^-
- The fraction of registered vertex pions > 75%

Funding of the project

Cost saving factors:

- **No new buildings, no additional power lines.**
- **No extra heat, water cooling power.**

Estimated cost is of the order of 100 M€ (very preliminary)

Cooperation with main Russian scientific centers:
-Linear injector – IHEP,
-ZDC – INR,
-Superconducting magnets – BINP(?)

We hope for wide international cooperation

The Project Milestones

- **Stage 1: years 2007 – 2009**

- Upgrate and Development of the Nuclotron facility
- Preparation of Technical Design Report
- Start for prototyping of the MPD and NICA elements

- **Stage 2: years 2008 – 2011**

- Design and Construction of NICA and MPD detector

- **Stage 3: years 2011 – 2012**

- Assembling

- **Stage 4: year 2013**

- Commissioning

Round **Table Discussion III,** ***Searching for the mixed phase of strongly interacting QCD matter at the NICA/MPD*** **(JINR,Dubna) January, 2008**

Project Work Organization

Project leaders A.Sissakian, A.Sorin

NICA Steering Committee

NICA/MPD Center

Theory
A.Sorin,
V.Toneev

NICA
A.Kovalenko,
I.Meshkov

MPD
V.Kekelidze

Computing
O.Rogachevsky

VBLHE + LPP
Accelerator division
G.Trubnikov

VBLHE + LPP
R.Lednitsky/V.Kekelidze

THANK YOU
FOR ATTENTION !