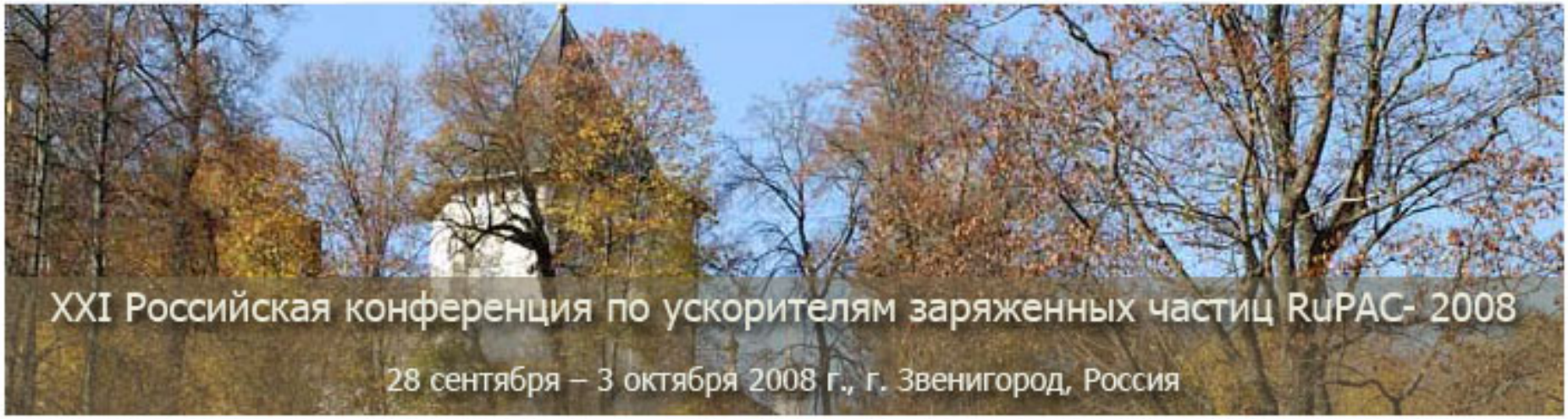


Project of the Nuclotron-based Ion Collider fAcility (NICA) at JINR

Anatoly Sidorin for NICA/MPD collaboration

JINR, Dubna

JOINT INSTITUTE FOR NUCLEAR RESEARCH

JINR

NICA

Nuclotron-based Ion Collider fAcility
Multi-Purpose Detector

- Search for the mixed phase of strongly interacted matter
- NICA/MPD concept
- NICA scheme and layout
- Injector
- Booster
- Nuclotron
- Collider
- Project milestones

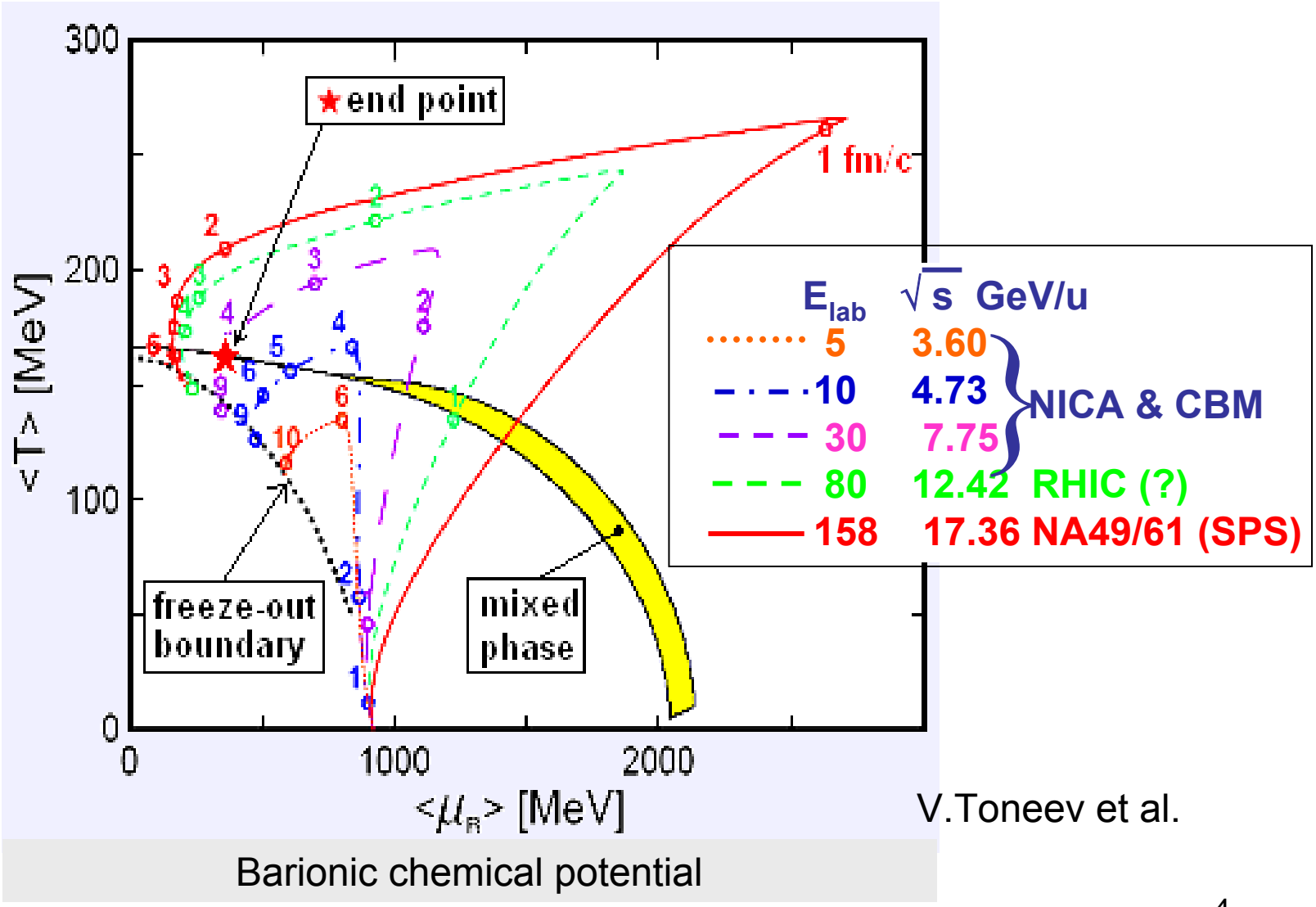
The Joint Institute for Nuclear Research (JINR) in Dubna is an international research organization established in accordance with the intergovernmental agreement of 11 countries in 1956. At the present time, eighteen countries are the JINR Member States and five more countries have the associated member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

1. Search for mixed phase of strongly interacting matter



V.Toneev et al.

Barionic chemical potential

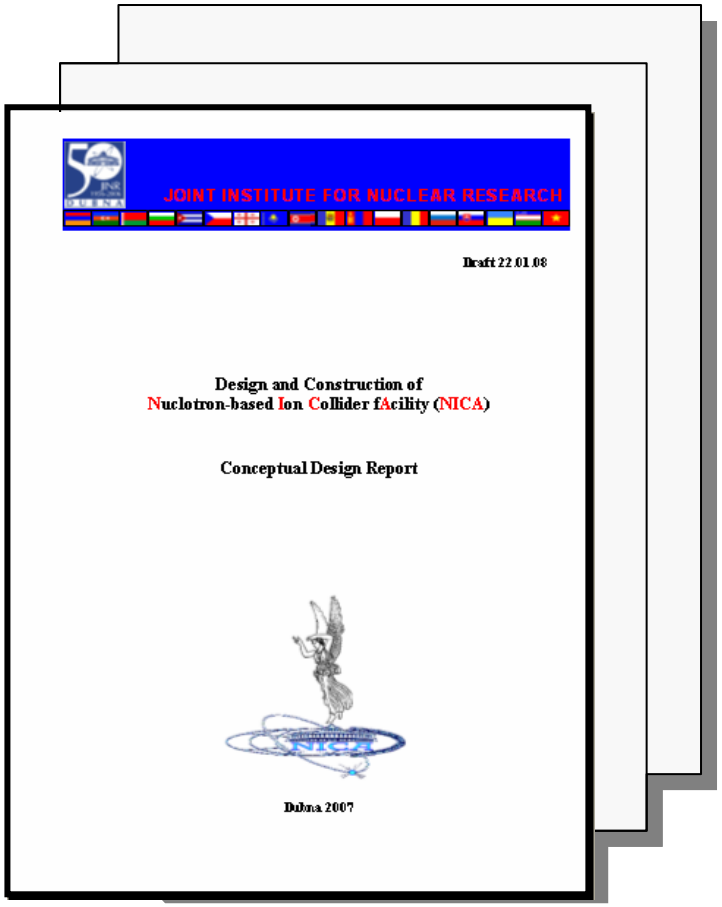
Complementary projects

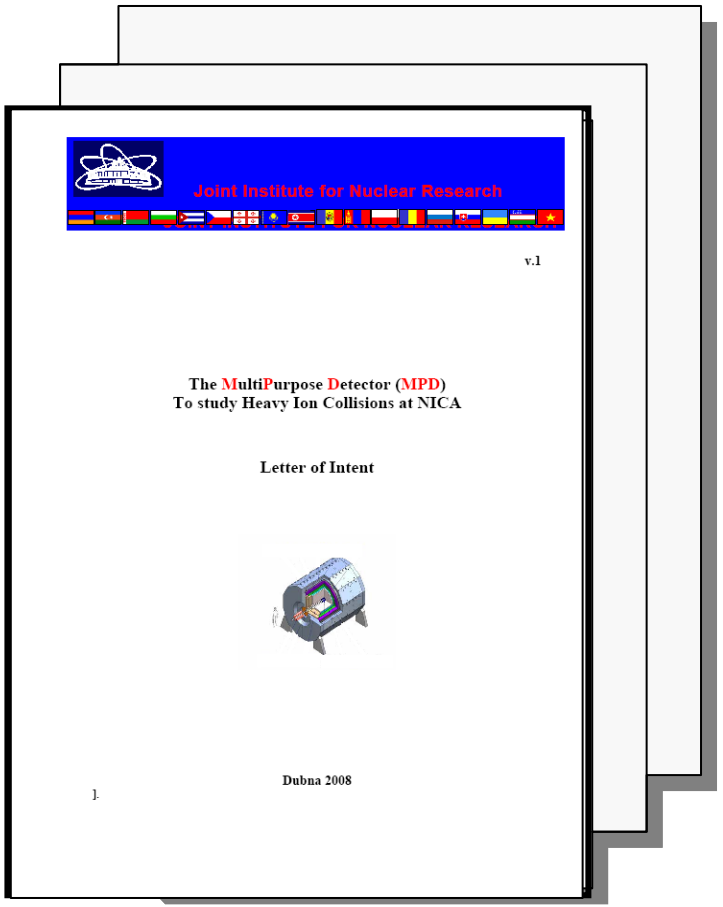
Facility:	SPS	RHIC	NICA	SIS-300
Exp.:	NA61	STAR PHENIX	MPD	CBM
Start:	2009	2010	2013	2015
Pb Energy: (GeV/(N+N))	4.9-17.3	4.9-50	≤9	≤8.5
Event rate: (at 8 GeV)	100 Hz	1 Hz(?)	≤10 kHz	≤10 MHz
Physics:	CP&OD	CP&OD	OD&HDM	OD&HDM

CP – critical point
OD – onset of deconfinement, mixed phase, 1st order PT
HDM – hadrons in dense matter

M. Gazdzicki

2. NICA/ MPD Concept





January 2008

The intention and the goal:

Development of the JINR basic facility for generation of intense heavy ion and polarized nuclear beams aimed at searching for the mixed phase of nuclear matter and investigation of polarization phenomena at the collision energies up to $\sqrt{s_{NN}}$ = 11 GeV/u, i.e. ^{238}U x ^{238}U in the energy range of 1 ÷ 4.5 GeV/u.

The polarized proton energy up to 13 GeV.

NICA heavy ion program

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 $\sqrt{s}_{NN}$=4-11 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} $cm^{-2}s^{-1}$ (at 3.5 GeV/u)

"The Basic Conditions" for the Project Development and Some Consequences

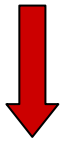
1. Minimum of R & D

2. Application of existing experience

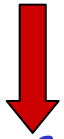
3. Co-operation with experienced research centers

"The Basic Conditions" for the Project Development and Some Consequences

4. Cost – as low as possible
5. Realization time – 4 – 5 years



Choice of an existing building for dislocation of the collider



Collider circumference is limited by ~ 250 m

Luminosity  High beam intensity,
multibunch regime,
low beta-function in Interaction Point,
.....

Luminosity of the collider, optimized for 3.5 GeV/u U

$$L = \frac{N_b^2}{4\pi\varepsilon\beta^*} F_{coll}\, f\left(\frac{\sigma_s}{\beta^*}\right)$$

$$F_{coll} = N_{bunches} F_{rev}$$

$$f\left(\frac{\sigma_s}{\beta^*}\right) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} \frac{\exp(-u^2)du}{\left[1+\left(\frac{u\sigma_s}{\beta^*}\right)^2\right]}$$

Short bunch length ~ 0.3 m
Momentum spread ~ 10^{-3}

Low beta function in the interaction point ~ 0.5 m.

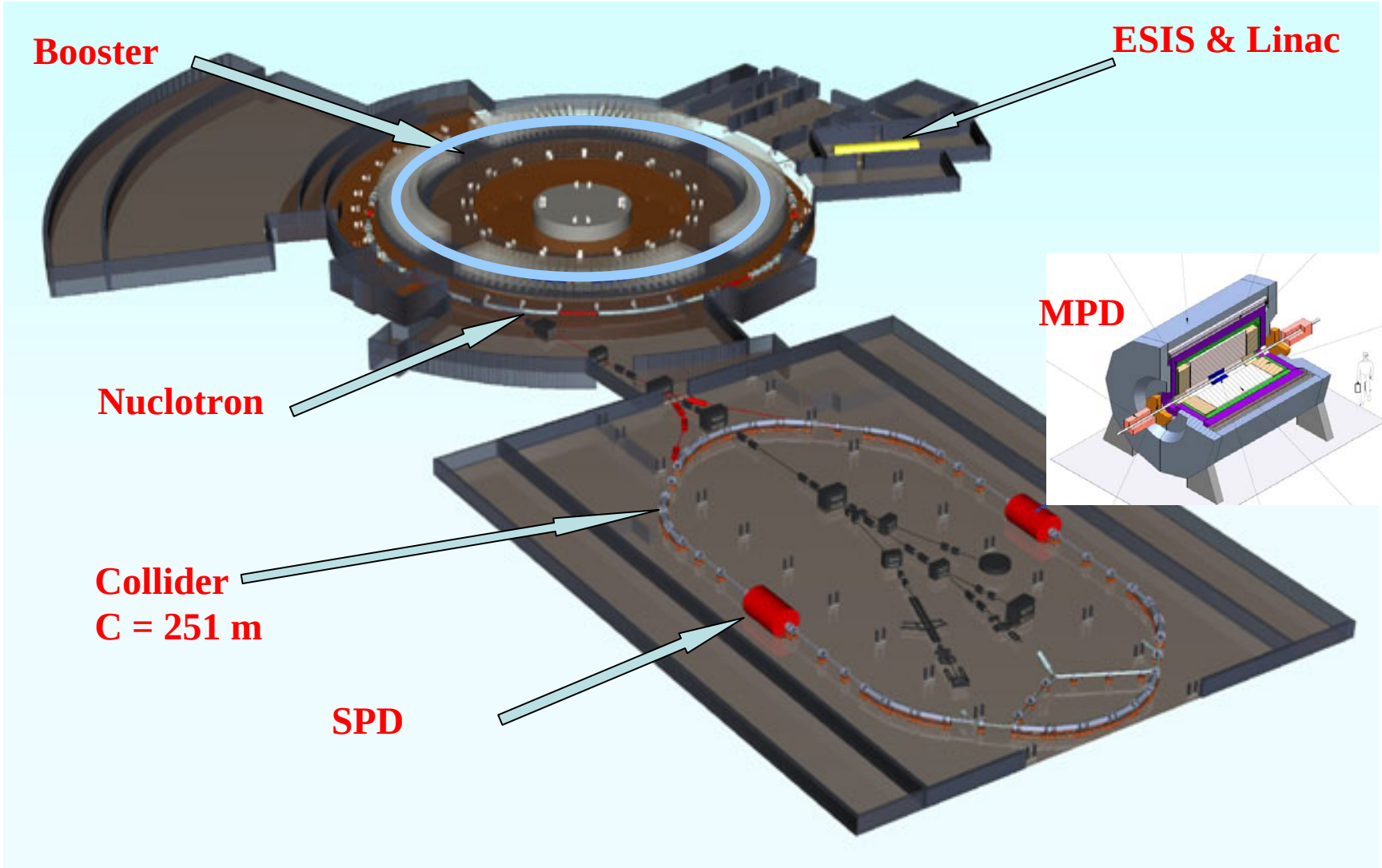
The beam emittance corresponding to the space charge limit.

Single bunch luminosity is about $7 \cdot 10^{25}$ $cm^{-2}s^{-1}$ at 10^9 ions

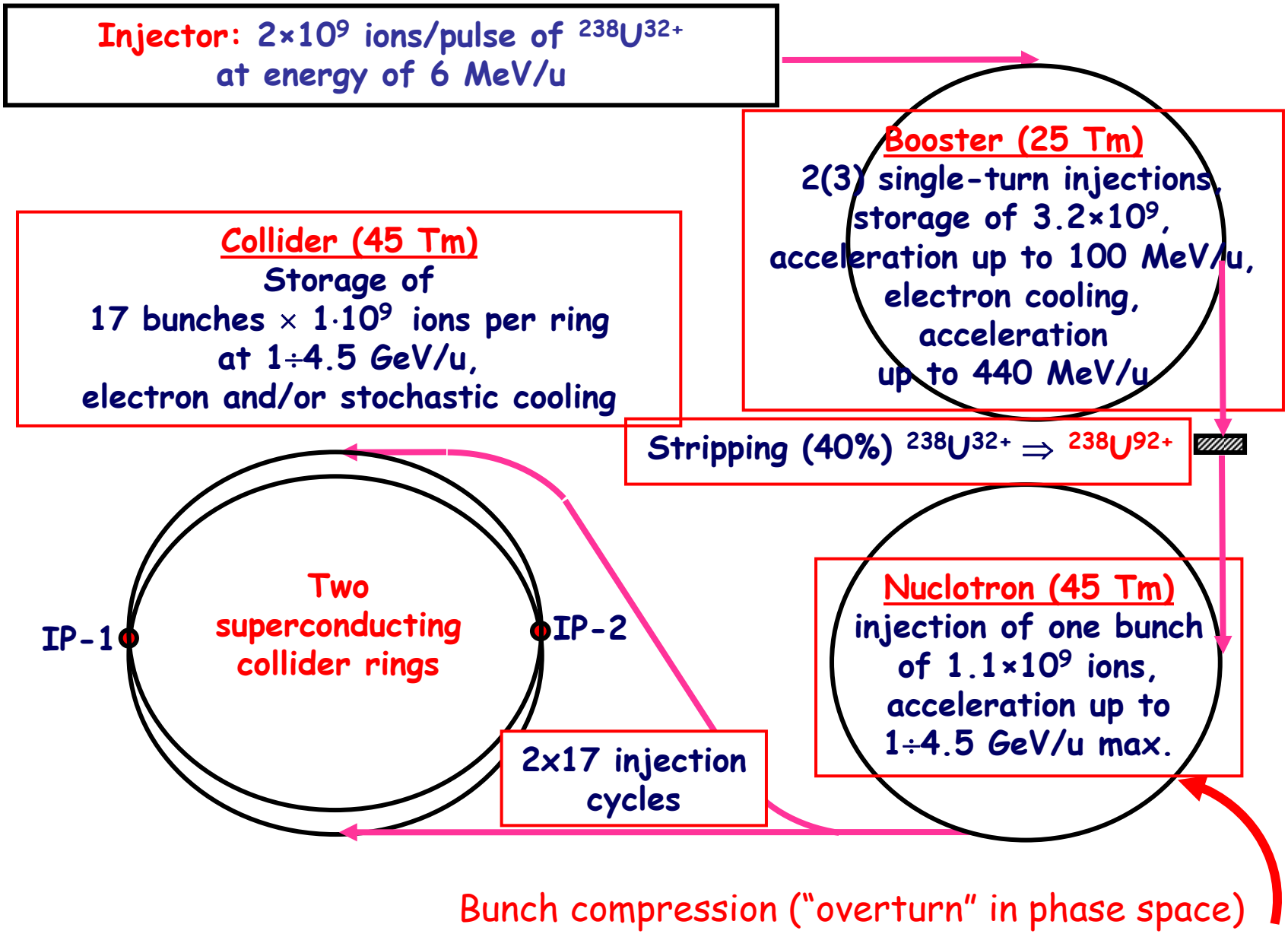
High collision repetition rate.

Long luminosity life-time – cooling during experiment.

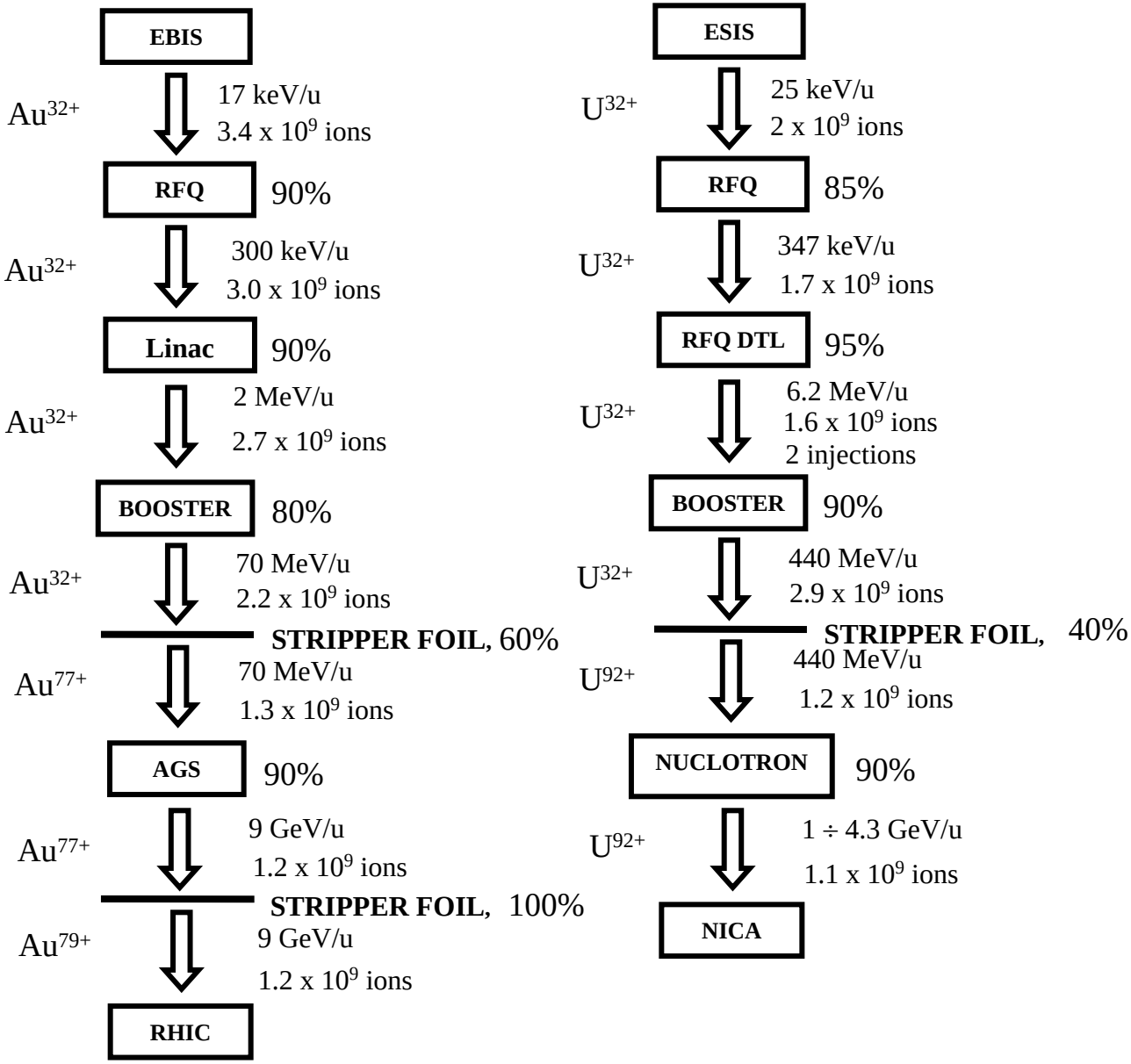
NICA general layout



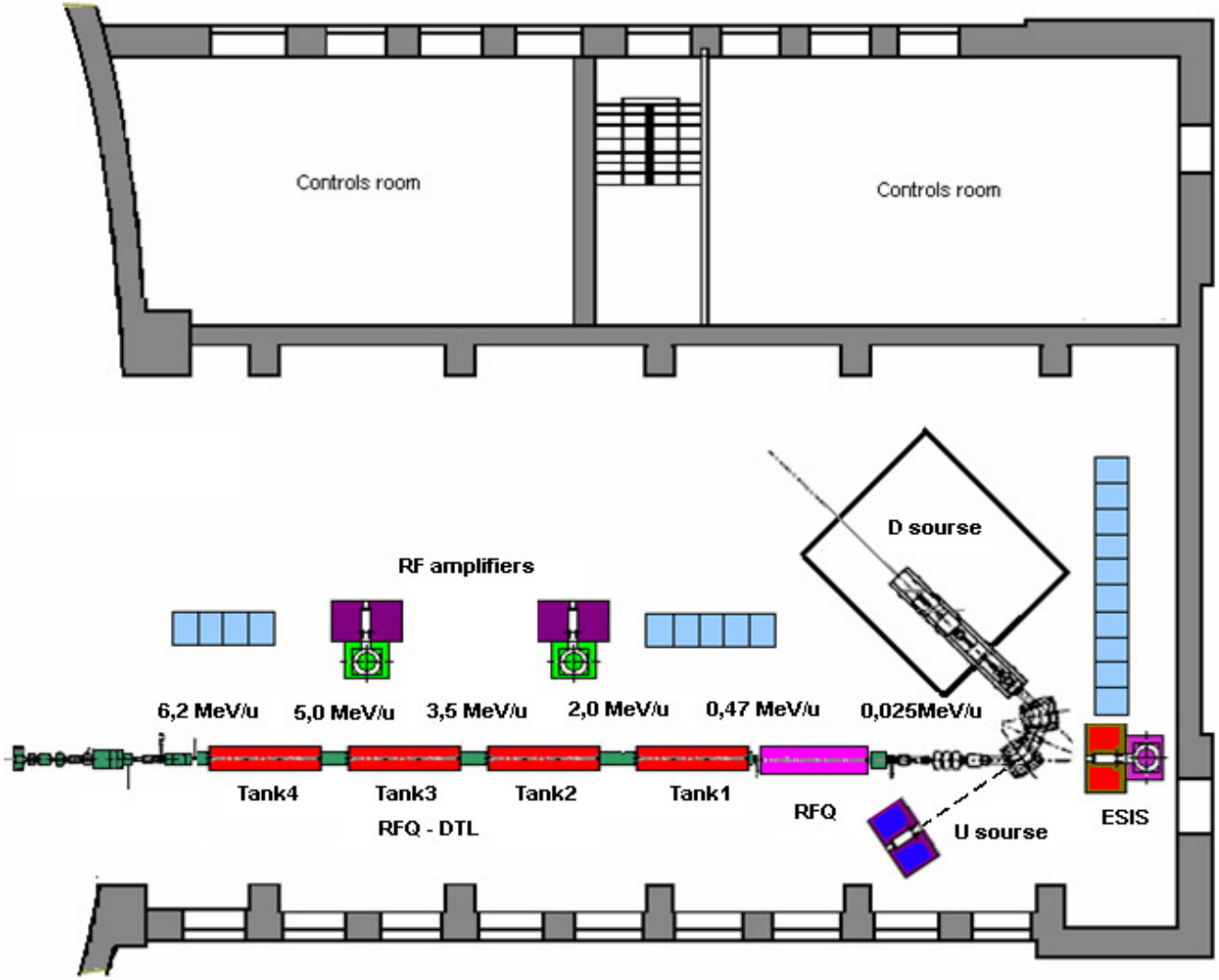
3. NICA Scheme and Operation Scenario



NICA collider Injection chain



Injector: Ion Sources + Linac

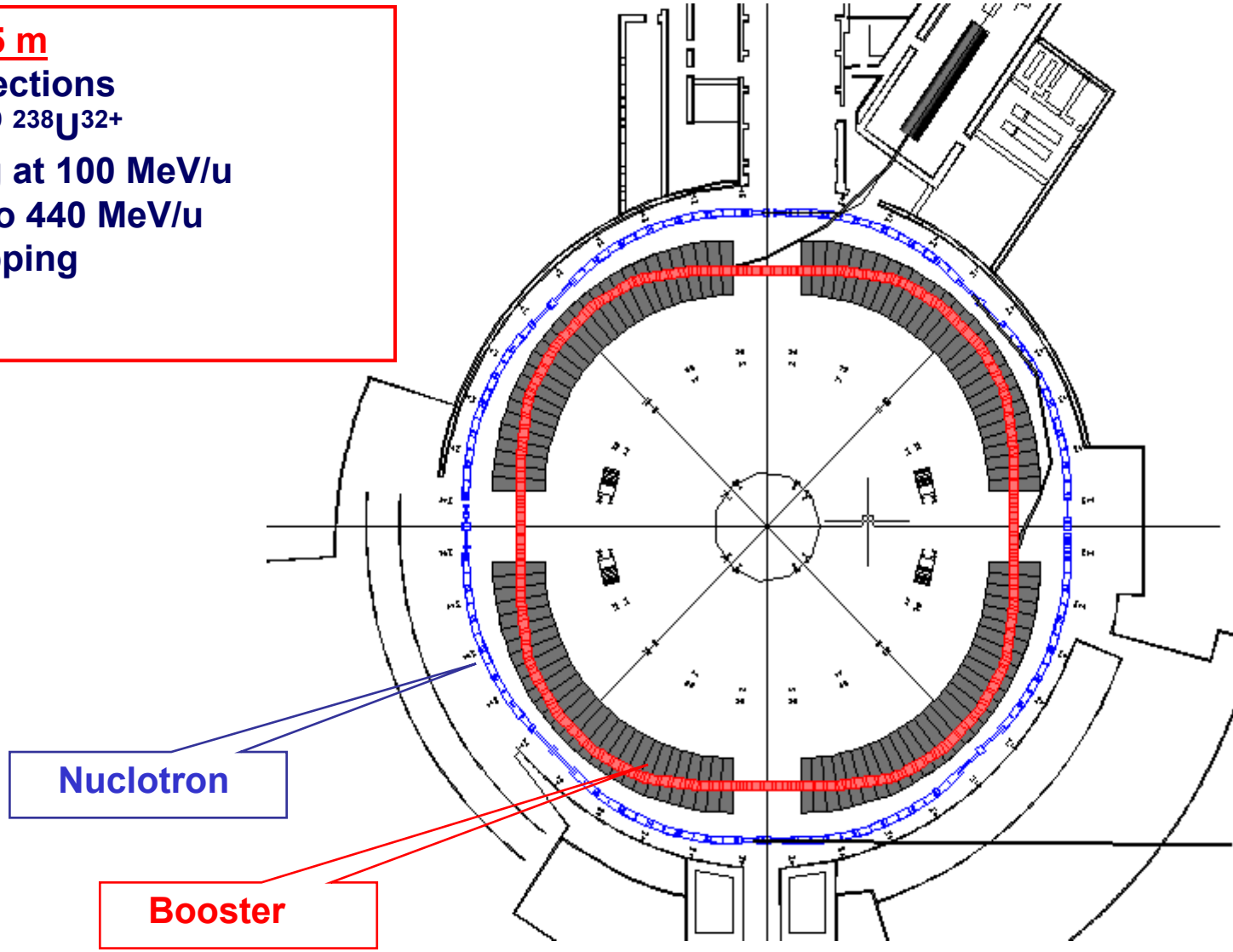


V.Kobets, Heavy ion injector for NICA/MPD project, Стендовая сессия "B" (вторник, 30 сентября 2008, 17.20-18.50)

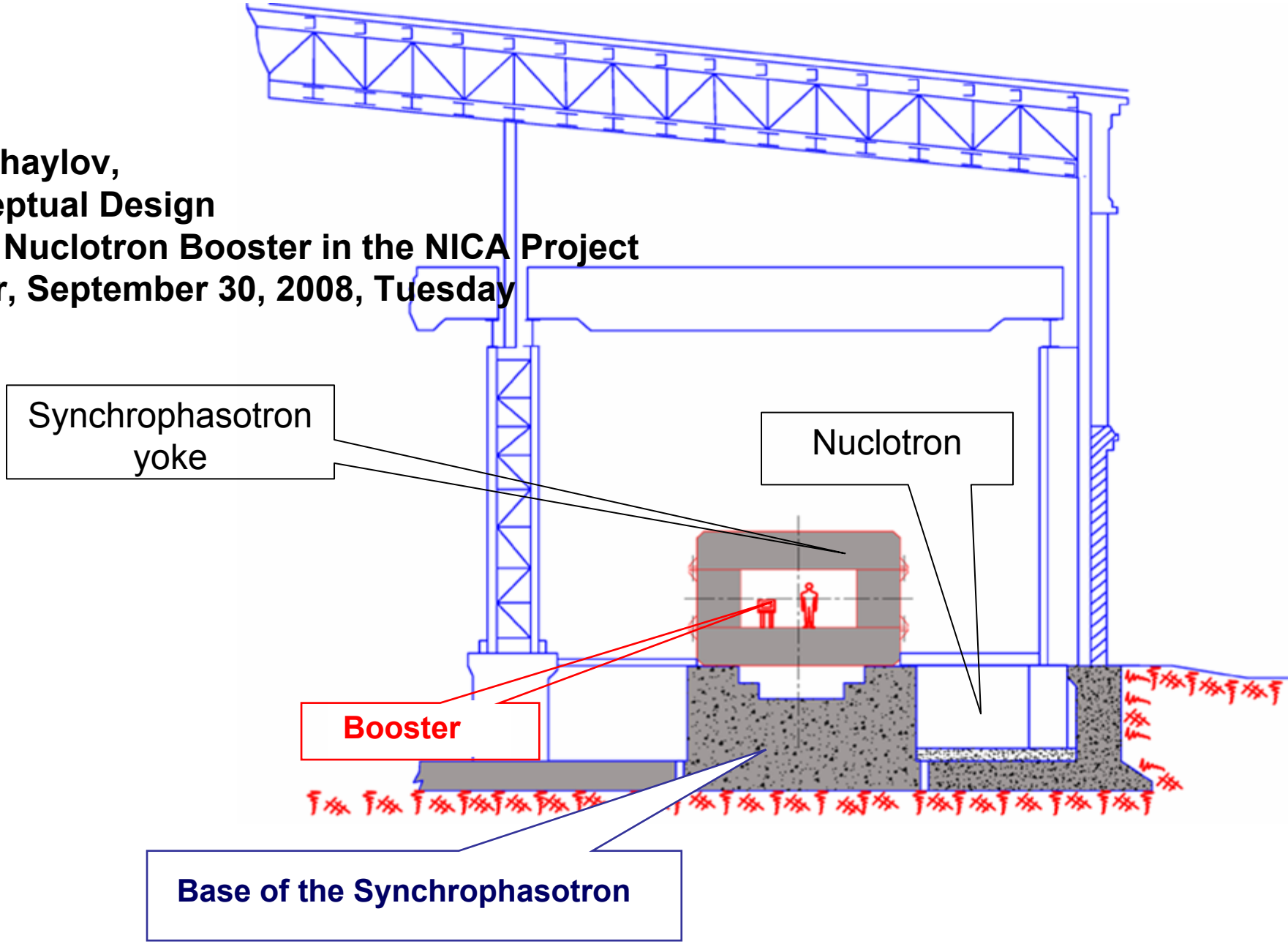
Booster

$B\rho$ = 25 T·m, C ≈ 215 m

1) 2 single-turn injections
2) Storage of 3×10^9 $^{238}U^{32+}$
3) Electron cooling at 100 MeV/u
4) Acceleration up to 440 MeV/u
5) Extraction & stripping



V. Mikhaylov,
Conceptual Design
of the Nuclotron Booster in the NICA Project
Poster, September 30, 2008, Tuesday



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.

Nuclotron upgrade program (has been started this year):
by fall of 2009 to accelerate 10^8 Au up to 3.5 GeV/u at dB/dt $\geq$1 T/c

Nuclotron upgrade program

Development of the ion sources

Sufficient improvement of the vacuum conditions in the Nuclotron ring and linear injector.

Development of the Nuclotron power supply system in order to reach magnetic field in dipole magnets of 1.8 - 2 T.

Upgrade of the Nuclotron RF system.

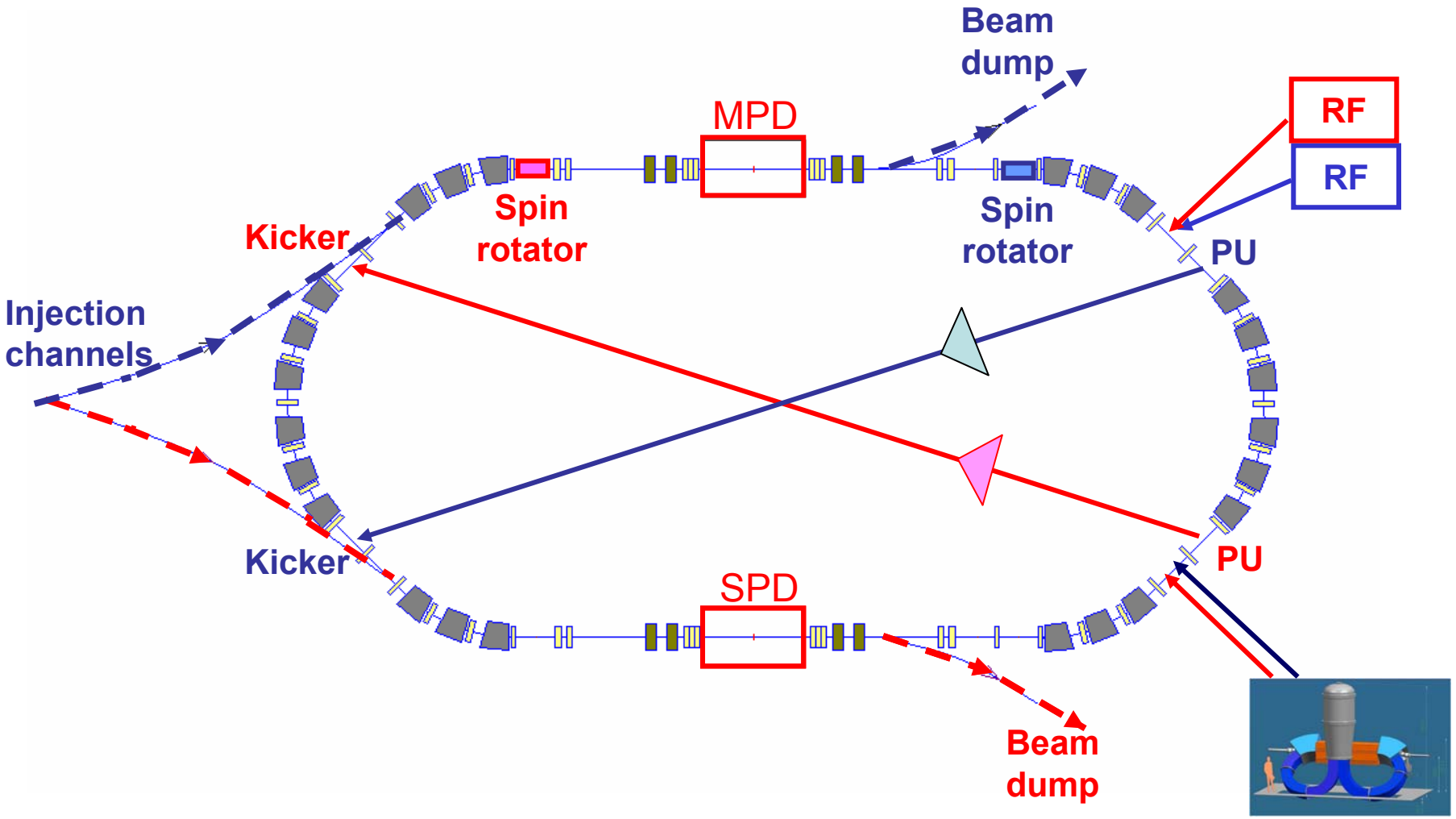
Beam dynamics studies,
minimizations of the particle loss at all stages of the acceleration.

Design of new injector (existing injector accelerates the ions at $q/A \geq 0.33$).

Modernization of the Nuclotron is one of the key points of the NICA project

A.Butenko, **September 30, 2008, Tuesday**

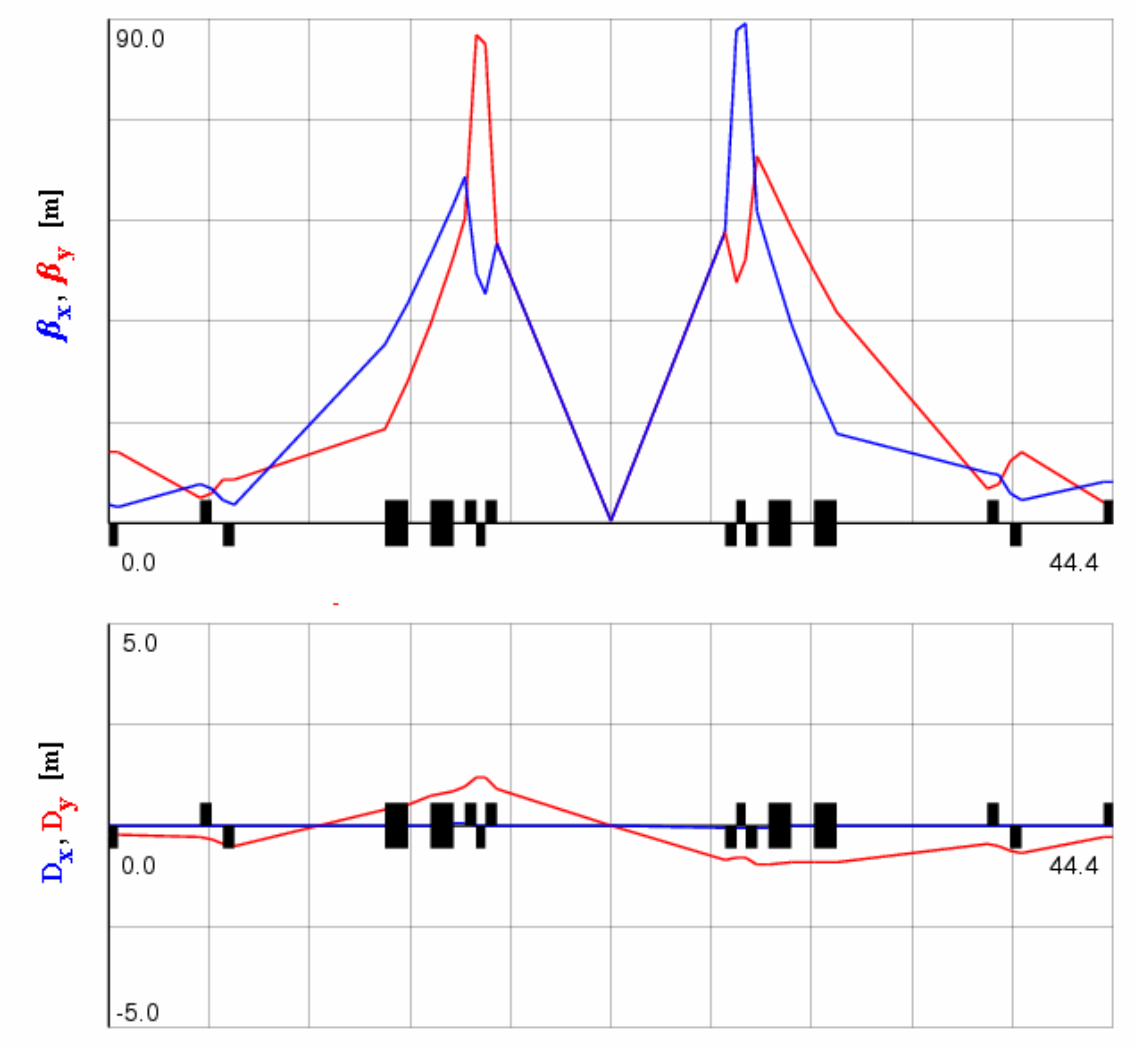
Collider Structure



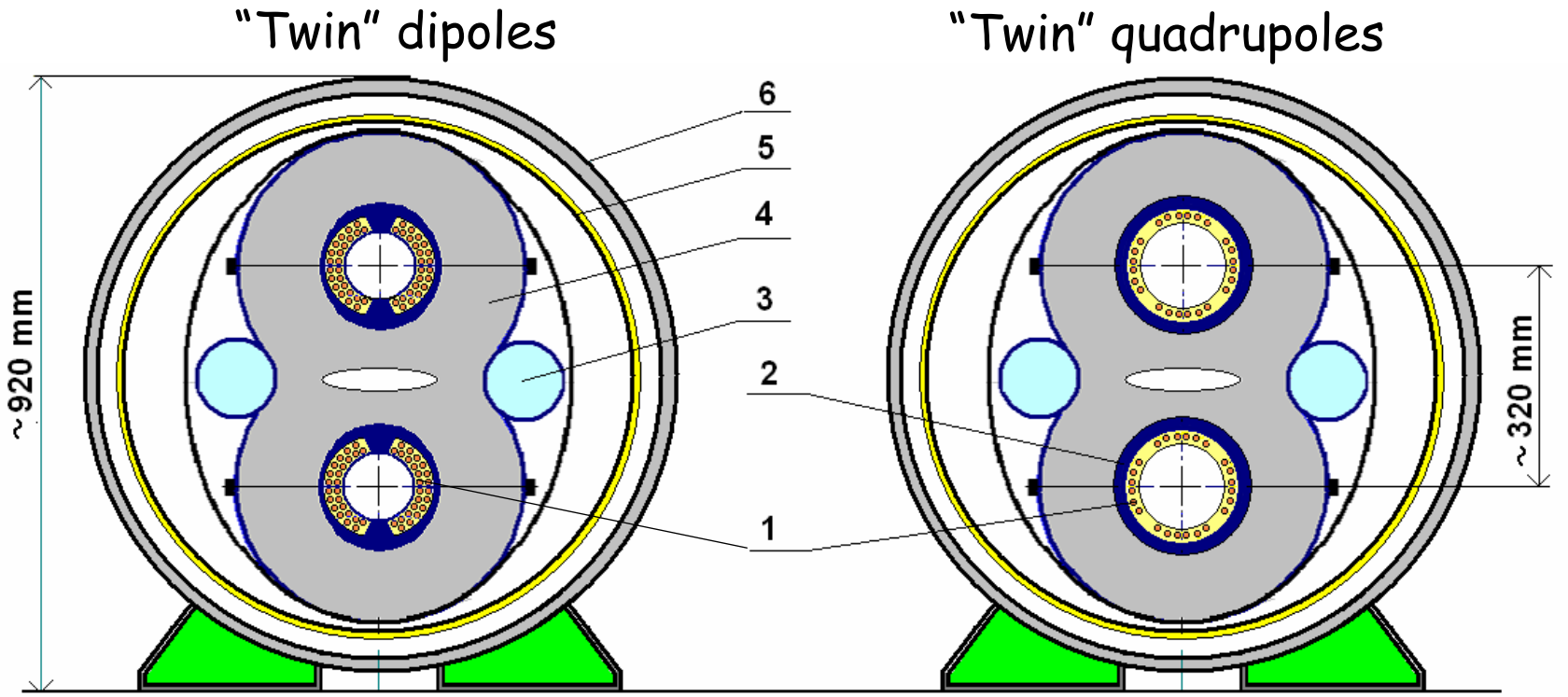
Collider beam parameters and luminosity

Energy, GeV/u	1.0	3.5
Rms bunch length, m	0.3	0.3
RF harmonics / amplitude, kV	102 / 100	102 / 100
Beta function in IP, m	0.5	0.5
Number of ions in the bunch	$1 \cdot 10^9$	$1 \cdot 10^9$
Rms unnormolized beam emittance, $\pi \cdot$mm mrad	3.8	0.3
Rms momentum spread	0.001	0.001
Luminosity per one IP, $cm^{-2} \cdot s^{-1}$	$0.75 \cdot 10^{26}$	$1.1 \cdot 10^{27}$
Number of bunches	17	17
Incoherent tune shift ΔQ_{bet}	0.056	0.047
Beam-beam parameter ξ	0.0026	0.002

Amplitude and dispersion functions in the long straight section



"Twin bore" magnets for NICA collider rings

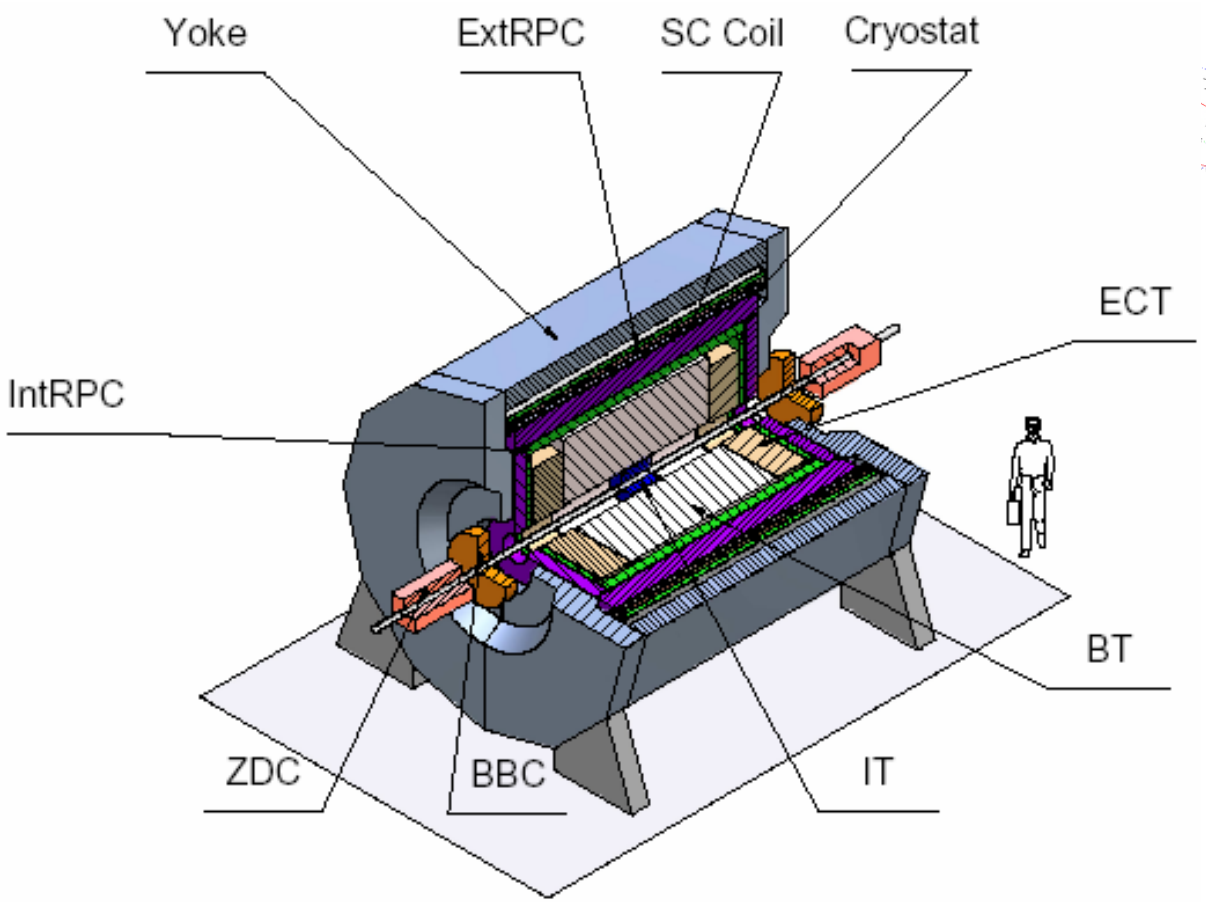


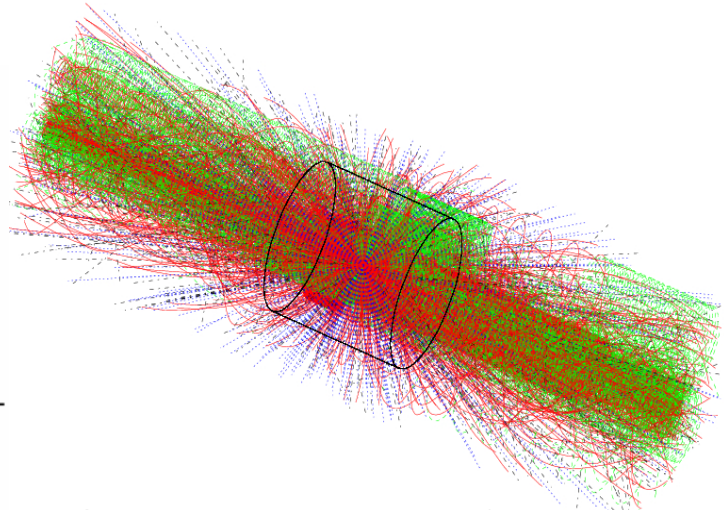
1 – Cosθ coils, 2 – "collars", 3 – He header, 4 – iron yoke,

5 – thermoshield, 6 – outer jacket

Dipole magnetic field ~ 4 T

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 .

9. Project Milestones

- **Stage I** *Nuclotron-M subproject and infrastructure development* *(2008-2010)*
  R&D programs
  Technical Design Reports on NICA and MPD
- **Stage II** *Design and manufacturing of NICA & MPD elements* *(2008-2012)*
  Infrastructure development
- **Stage III** *Construction and assembling of NICA & MPD* *(2010-2012)*
- **Stage IV** *NICA commissioning, MPD start-up* *(2013-2014)*

NICA Collaboration

Budker INP

- ✓ Booster RF system
- ✓ Booster electron cooling
- ✓ Collider RF system
- ✓ Collider SC magnets (expertise)
- ✓ HV electron cooler for collider
- ✓ Electronics (?)

IHEP (Protvino)

Injector Linac

FZ Jűlich (IKP)

HV Electron cooler

Fermilab

HV Electron cooler

BNL (RHIC)

Stoch. Cooling

GSI/FAIR

SC dipoles for Booster/SIS-100

SC dipoles for Collider/SIS-300 (?)

THANK YOU
FOR ATTENTION !