International large research infrastructure of JINR, Dubna.

Megaproject NICA: superconducting heavy ion collider.

G.Trubnikov on behalf of JINR Directorate, Dubna

VBLHEP Relativistic nuclear physics
Synchrophasotron – Nuclotron – NICA

1957 – 2002 Synchrophasotron

10 GeV proton accelerator – world leader in energy.

Beginning of era of high-energy physics

V.Veksler – phase stability principle discovery

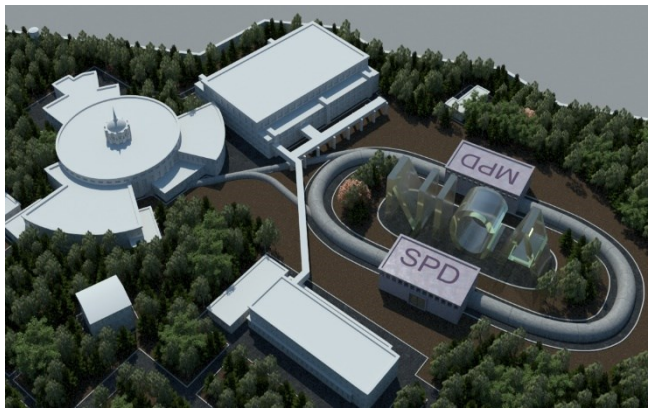
1993 – Nuclotron

First in the world Superconducting Synchrotron of heavy ions

A.Baldin –start of relativistic nuclear physics era

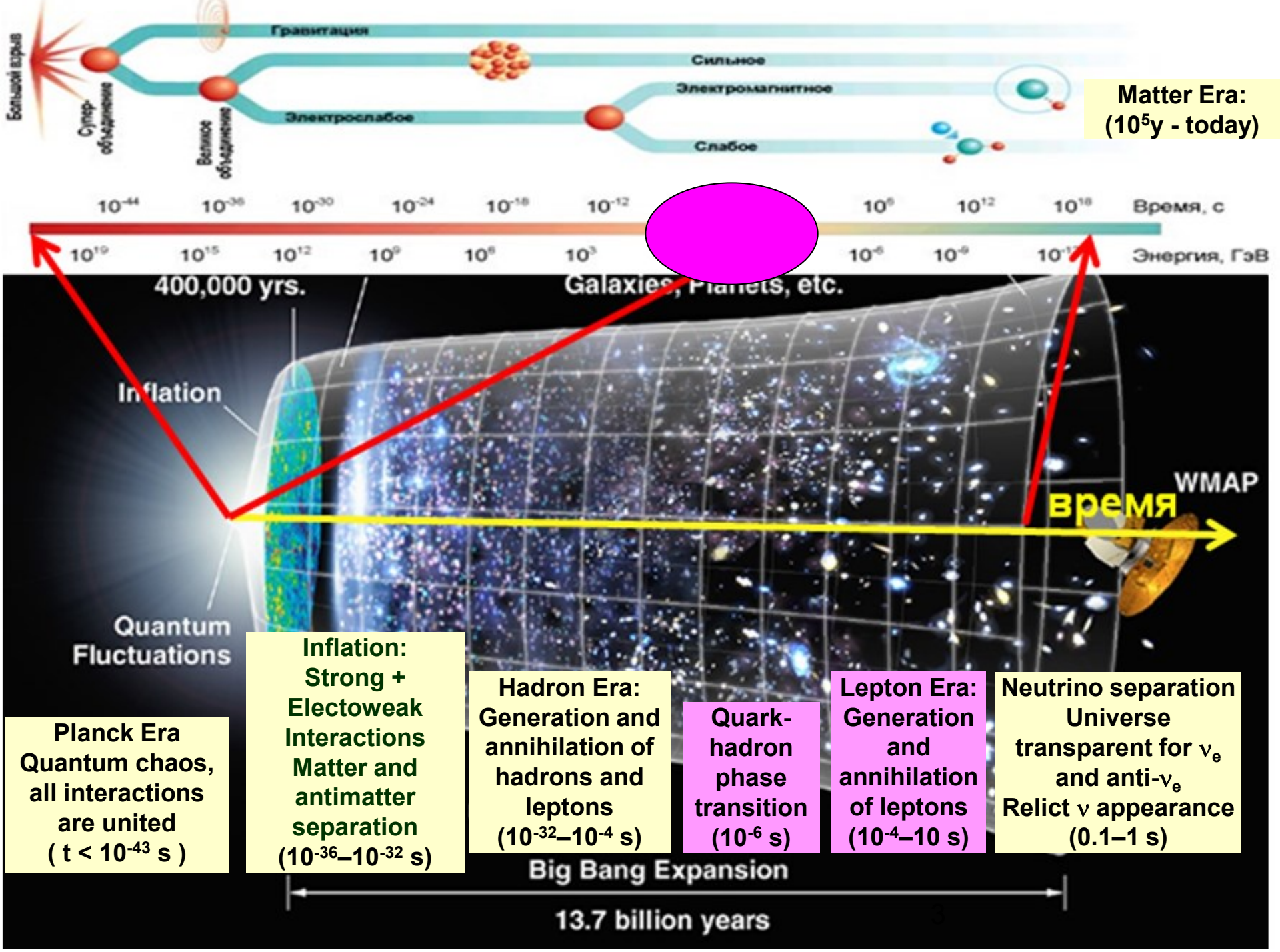
2019 – NICA

Superconducting collider of heavy ions



Study of baryonic matter at extreme conditions (max net baryon density)

The JINR 7-year plan for 2010-2016 approved by CPP:
NICA – the JINR flagship project in High Energy Physics


Гравитация
Сильное
Электромагнитное
Электрослабое
Слабое
Большой взрыв
Супер-объединение
Великое объединение
Matter Era:
(10^5y - today)
10^{-44} 10^{-36} 10^{-30} 10^{-24} 10^{-18} 10^{-12} 10^{6} 10^{12} 10^{18} Время, с
10^{19} 10^{15} 10^{12} 10^{9} 10^{6} 10^{3} 10^{-6} 10^{-9} Энергия, ГэВ
400,000 yrs.
Galaxies, Planets, etc.
Inflation
WMAP
время
Quantum Fluctuations
Planck Era
Quantum chaos, all interactions are united
(t < 10^{-43} s)
Inflation:
Strong + Electoweak Interactions
Matter and antimatter separation
(10^{-36}–10^{-32} s)
Hadron Era:
Generation and annihilation of hadrons and leptons
(10^{-32}–10^{-4} s)
Quark-hadron phase transition
(10^{-6} s)
Lepton Era:
Generation and annihilation of leptons
(10^{-4}–10 s)
Neutrino separation
Universe transparent for ν_e and anti-ν_e
Relict ν appearance
(0.1–1 s)
Big Bang Expansion
13.7 billion years

Question 1: What is dark matter?

Question 2: What is dark energy?

Question 3: How were the heavy elements from iron to uranium made?

Question 4: Do neutrinos have mass?

Question 5: Where do ultrahigh-energy particles come from?

Question 6: Is a new theory of light and matter needed to explain what happens at very high energies and temperatures?

Question 7: Are there new states of matter at ultrahigh temperatures and densities?

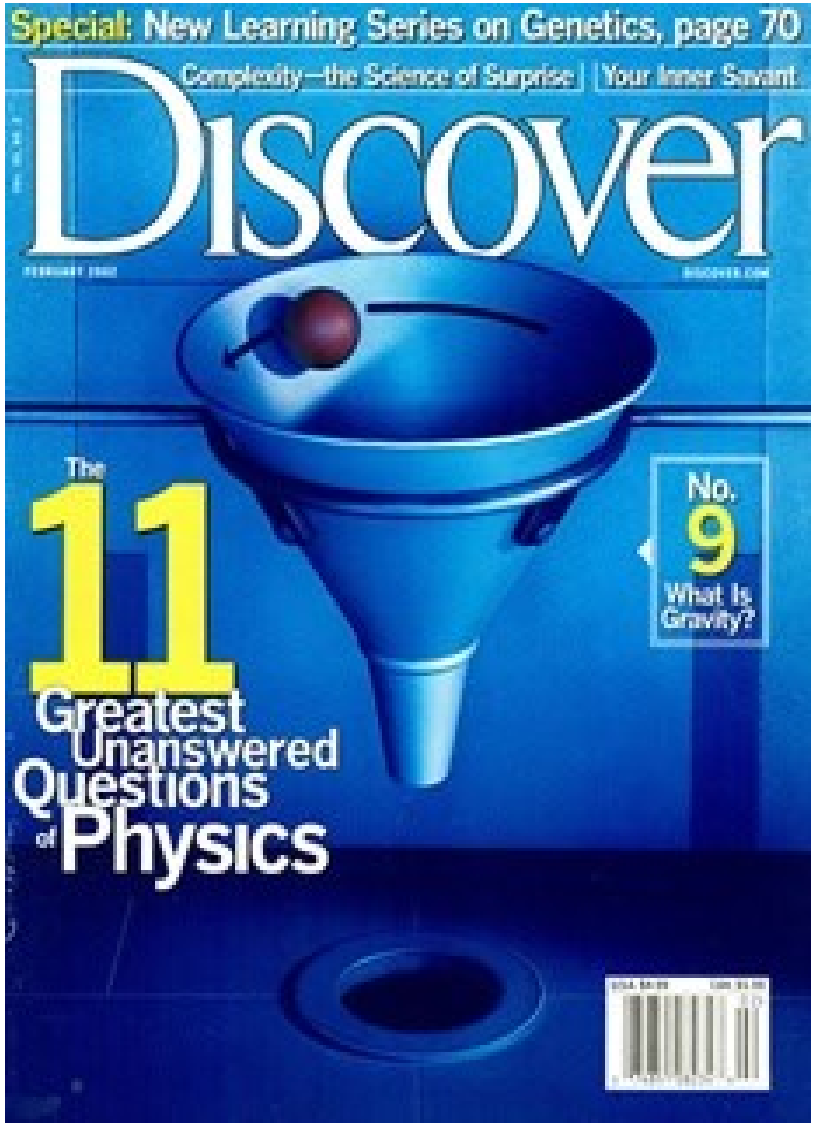
Question 8: Are protons unstable?

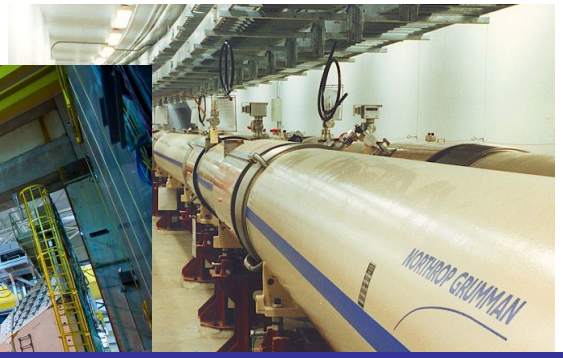
Question 9: What is gravity?

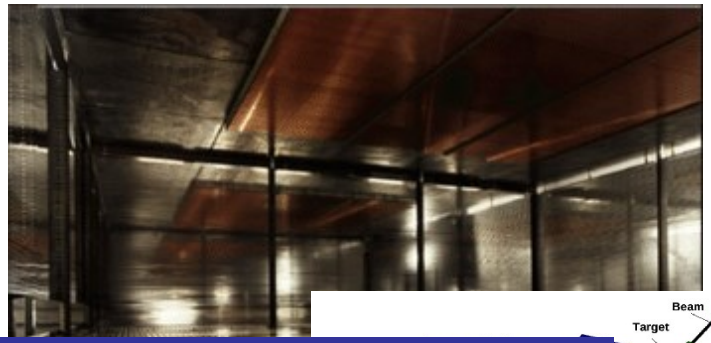
Question 10: Are there additional dimensions?

Question 11: How did the universe begin?

Ginzburg's List of fundamental questions:







STAR/PHENIX
designed for hig
low luminosity f

NICA/MPD will provide most precise results exploring the whole phase space region in the most interesting energy range

/SPS.
ance,
GeV)

MPD @ NICA.
Collider: $\sqrt{s_{NN}}$ = 4-11 GeV (~100 MeV/u energy step, variety of ions). L~10^{27} $cm^{-2}s^{-1}$ for Au^{79+}

CBM @ FAIR/SIS-100/300
Fixed target, $\sqrt{s_{NN}}$= 2-5(9) GeV, high luminosity

NICA injection complex (ion sources + HILac)

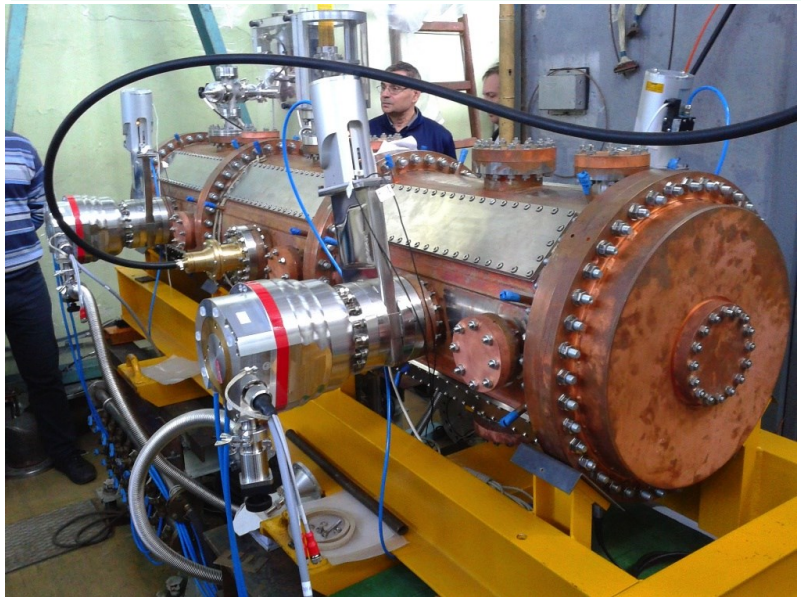
Source for polarized particles (SPP)

Source assembled in 2013 now is commissioned to achieve 10^{10} ppp.
First beam run in beg.2016

Heavy ion source: Krion-6T ESIS

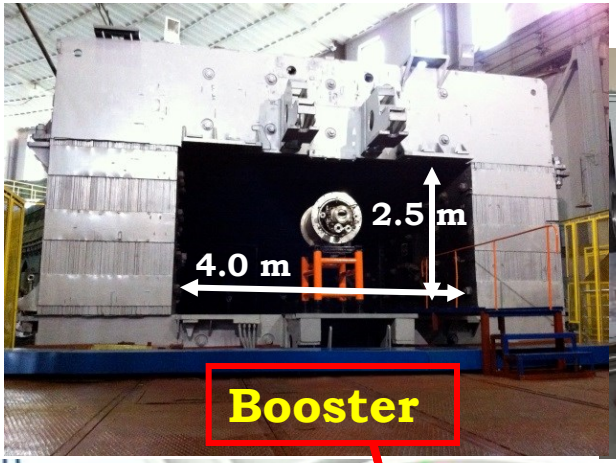
B= 5.4T reached. Test Au beams produced:
- $Au^{30+} \div Au32^{32+}$, 610^{8}, T_{ioniz}= 20 ms for
- Au^{32+} -> repetition rate 50 Hz.
- ion beams $Au^{51+} \div Au^{54+}$ are produced.

Heavy Ion Linac delivered to JINR.
Commissioning scheduled for Oct'15

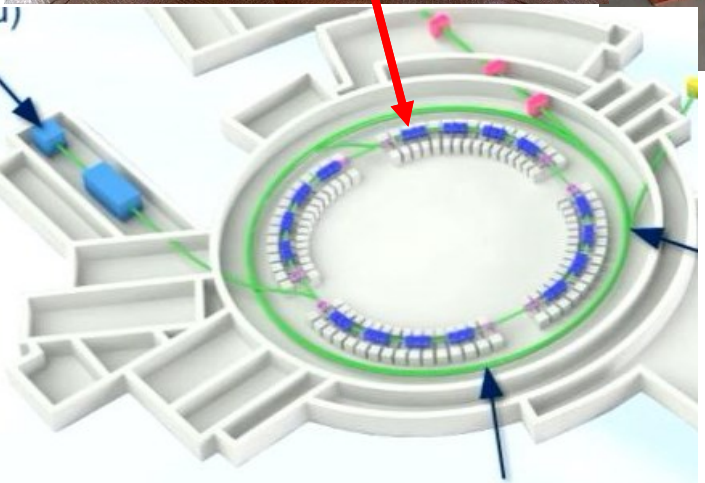


NICA light ion injector (LU-20): RFQ linac, 150 keV

Booster systems: progress is going



Booster RF system and RF test bench

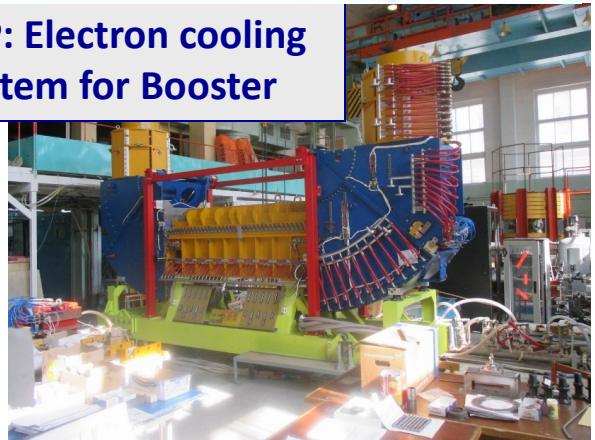


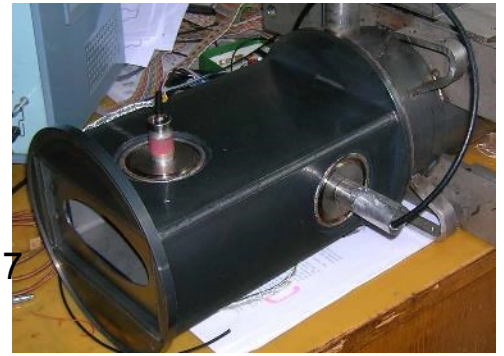
Serial production of cryostats and thermal shields – is in final stage at Poland.
Serial production of dipole and quadrupole magnets started in Dec'2014 – two years

*In October **2014 two RF** stations - delivered to Dubna, assembled and tested.*

First prototype of Booster PU-station tested in Bulgaria in Sept'15. Series starts fast

BINP: Electron cooling system for Booster



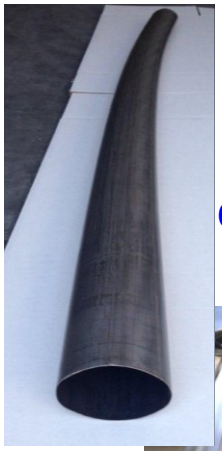


Ultra-high vacuum

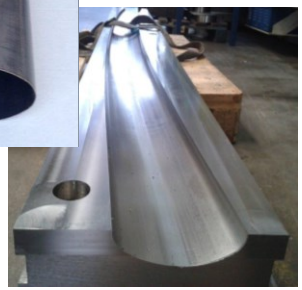
Collider pre-serial dipoles

High-temp Superconductivity

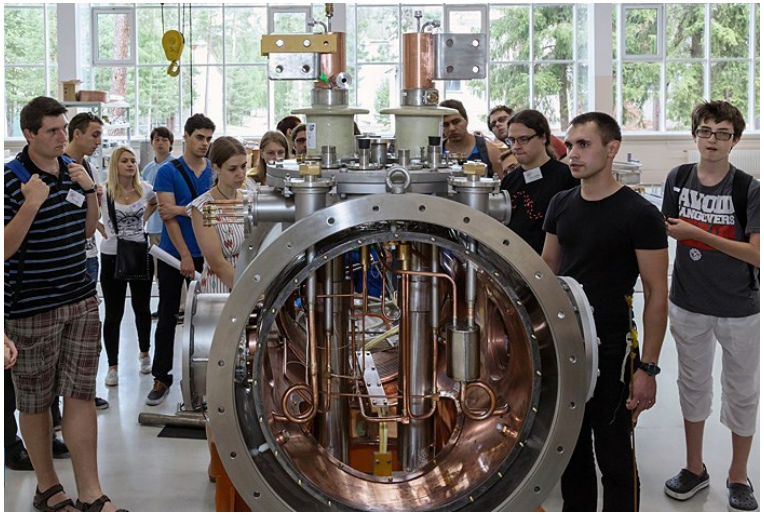
R&D for Collider and Booster



Curved UHV chambers



Vacuum cryostats and SC twin quadrupole

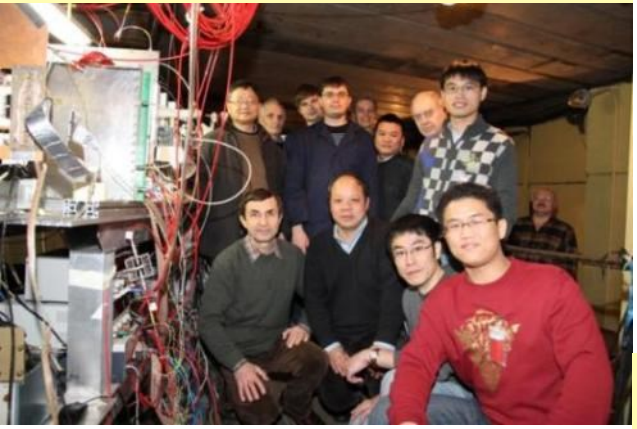


Magnetic measurements

Support of President, Presidential Council, Ministry, NRC KI, Russian institutes, European and Asian Agencies

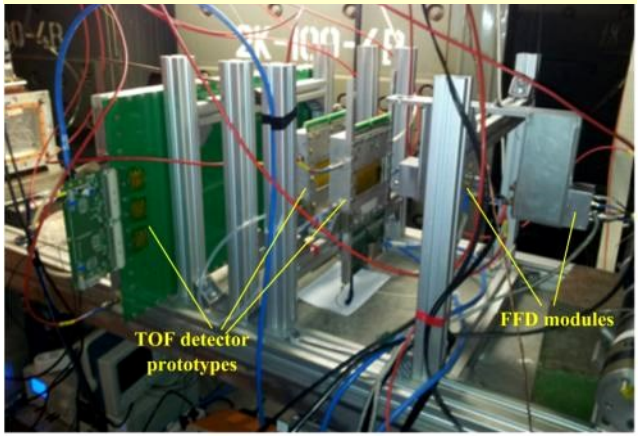
NICA

RPC deam test at NUCLOTRON: cooperation with SPb, China



Preproduction ECAL prototypes: co-operation with ISM *(Kharkiv, Ukraine)*

FFD tested with beam: achieved time resolution (38 ps) is better than required

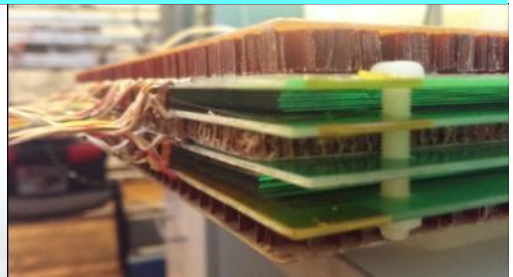


TPC: Cylinder C3 manufactured in Dec' 13

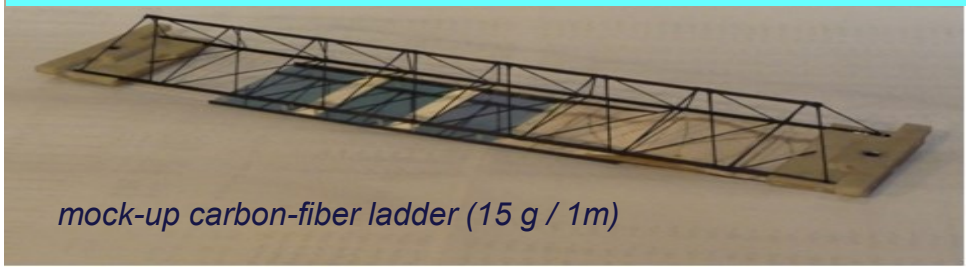
ZDC coverage confirmed: 2.2<|η|< 4.8

Readout Electronics developed for *TPC, TOF, and ECAL* (64 ch,13-bit,65 MSPS)

RPC performance : *required efficiency, rate capability & time resolution (63 ps) are reached*



The CBM - MPD consortium: *development & production of STS for **CBM** (FAIR), **MPD** & **BM@N***



NICA Civil Construction

Contract for Working Documentation signed in Aug'14. Ready WDR – mid' 15

Signed!

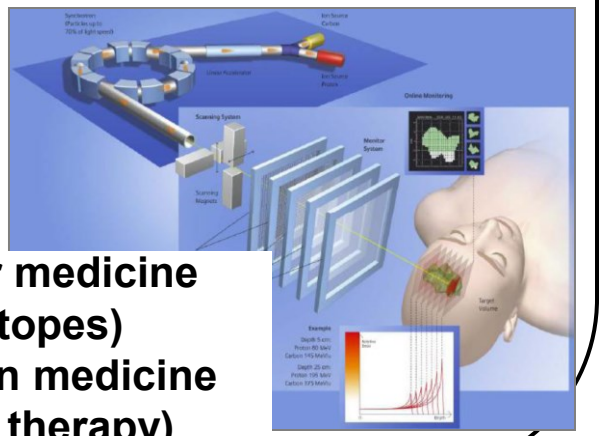
MEGAPROJECT NICA

Innovative Perspectives

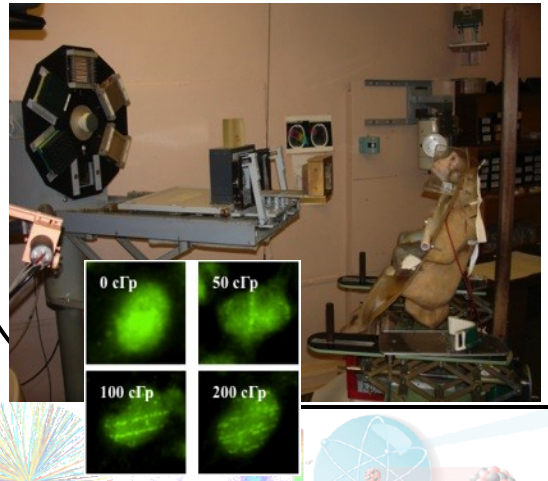
Power saving, nuclear energetics, industrial accelerators, ecology

Security

Space Technologies



Nuclear medicine (isotopes)
Radiation medicine (beam therapy)



Radiobiology

European commission on Russian mega-science projects (May-Dec 2013)

The fact that NICA/JINR are part of the EU research infrastructures landscape has already been recognized by ESFRI. The Expert Group (EG) recommends that the NICA project be fully taken into account in the forthcoming discussions on the next update of the ESFRI Roadmap.
The EG encourages JINR to continue actively develop new and extended cooperation with potential European partner institutions. The exceptional opportunities available in Dubna to young scientists and engineers should be more widely promoted.

08 Aug'13: Representatives of 13 countries

HORIZON – 2020
ESFRI RoadMap Update 2016
BRICS global RI

08 Aug'13: Representatives of 13 countries, 6 signed (**Belarus, Bulgaria, Germany, Kazakhstan, RF, Ukraine**). China and South Africa – are ready to join.

Germany (BMBF, GSI) – to the Test Facility for SC magnets and STS (> 15MEuro); **MoU**
China (ASIPP) – to the HTSC current leads, SC magnets, vacuum systems (> 2M$); **MoU**
USA (FNAL) – to the NICA collider stochastic and electron cooling systems (~ 6M$) ; **MoU**
CERN – to the BM@N and MPD elements (drift chambers, MM systems…, (~ 2MCHF); **MoU**
Rep. of South Africa – cryostats, diagnostics for SC ion source, cryogenics (~0.3M$). **MoU**

NICA International collaboration

JINR-France (IN2P3) MoU

Megaprojects: Workshop in Dubna (Italy, Germany, France, China, Egypt, SAR, RF)

ESFRI European Strategy Forum on Research Infrastructures

17 July 2015

Invitation for NICA Hearing – ESFRI 2016 Roadmap Update

In its final stage NICA will represent high scientific excellence, pan-European relevance and a socio-economic impact

*since the **NICA** will be the only facility providing*

- *heavy ion collisions at the collider mode in the **energy range** of **maximum baryonic density**;*
- *collisions of protons & deuterons with all combinations of transversal and longitudinal polarizations;*
- *variety of extracted heavy ion beams for applied researches.*

NICA construction already involves Russian and European companies in active works for several years

Proposal for some megascience rules:

The experiment running expenses will be covered by the corresponding collaborations, normally through a Common Fund.

Beams will be provided by the JINR for free for the basic researches.

For commercial applications special agreements will be drawn up.

Proposal for some megascience rules:

*The main incentive for engaging of new users will be a unique nomenclature of ion and neutron beams and a scientific infrastructure created at the **JINR, Dubna, RF**.*

Good visibility creates interest of new potential users of the facility.

*The requirements and procedure how to use the facility is regulated by the **JINR rules** of proposal consideration and approval:*
http://www.jinr.ru/section.asp?sd_id=220&language=eng

*We anticipate increasing of the user base from ~ **400-450** users now to more than **1500**, when all facilities are constructed and fully operational.*

International cooperation

- *The wide cooperation has been established for the development of the NICA accelerator and detector complexes, and for the theoretical support. This cooperation will be expanded taking into account the growing experimental collaborations;*

- *The inclusion of the NICA complex and other Russian megascience projects to the ESFRI and BRICS RI Road Maps will give a boost in attracting scientists all over the world for participation in the our project;*

- *The development of the legislative base for international collaborations around Russian megaprojects has been started. NICA – is ideal example of existing RI;*

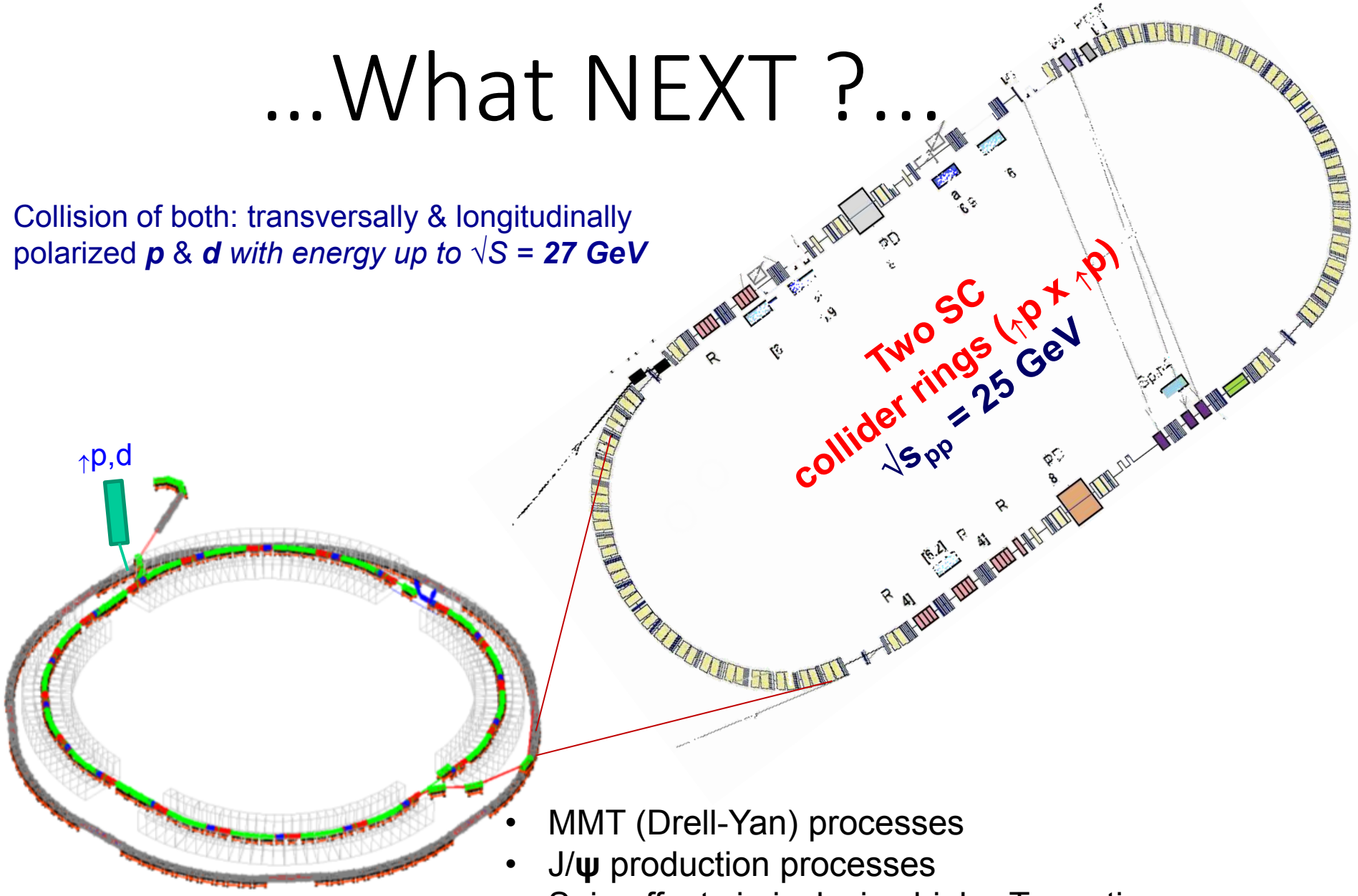
- *The development of proper social infrastructure is required to give new attraction to Russian megaprojects. State programs could be a good support.*

Thank you for your attention!

…What NEXT ?...

…What NEXT ?…

Collision of both: transversally & longitudinally polarized ***p*** & ***d*** *with energy up to* $\sqrt{S}$ = ***27 GeV***

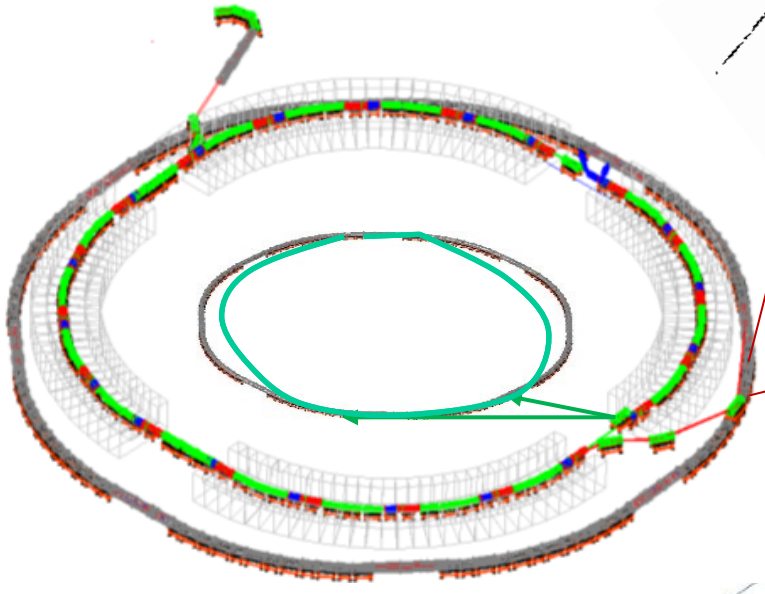


- MMT (Drell-Yan) processes
- J/ψ production processes
- Spin effects in inclusive high-pT reactions
- Spin effects in 1- and 2-hadron production processes
- Polarization effects in heavy ion collisions

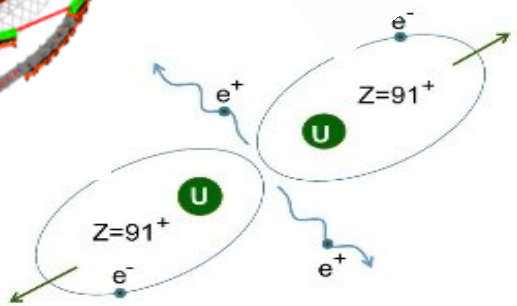
…What NEXT ?…

Experiments on the observation of spontaneous electron–positron pair creation in supercritical Coulomb fields (new 2 compact SC rings with merging bare Uranium beams)

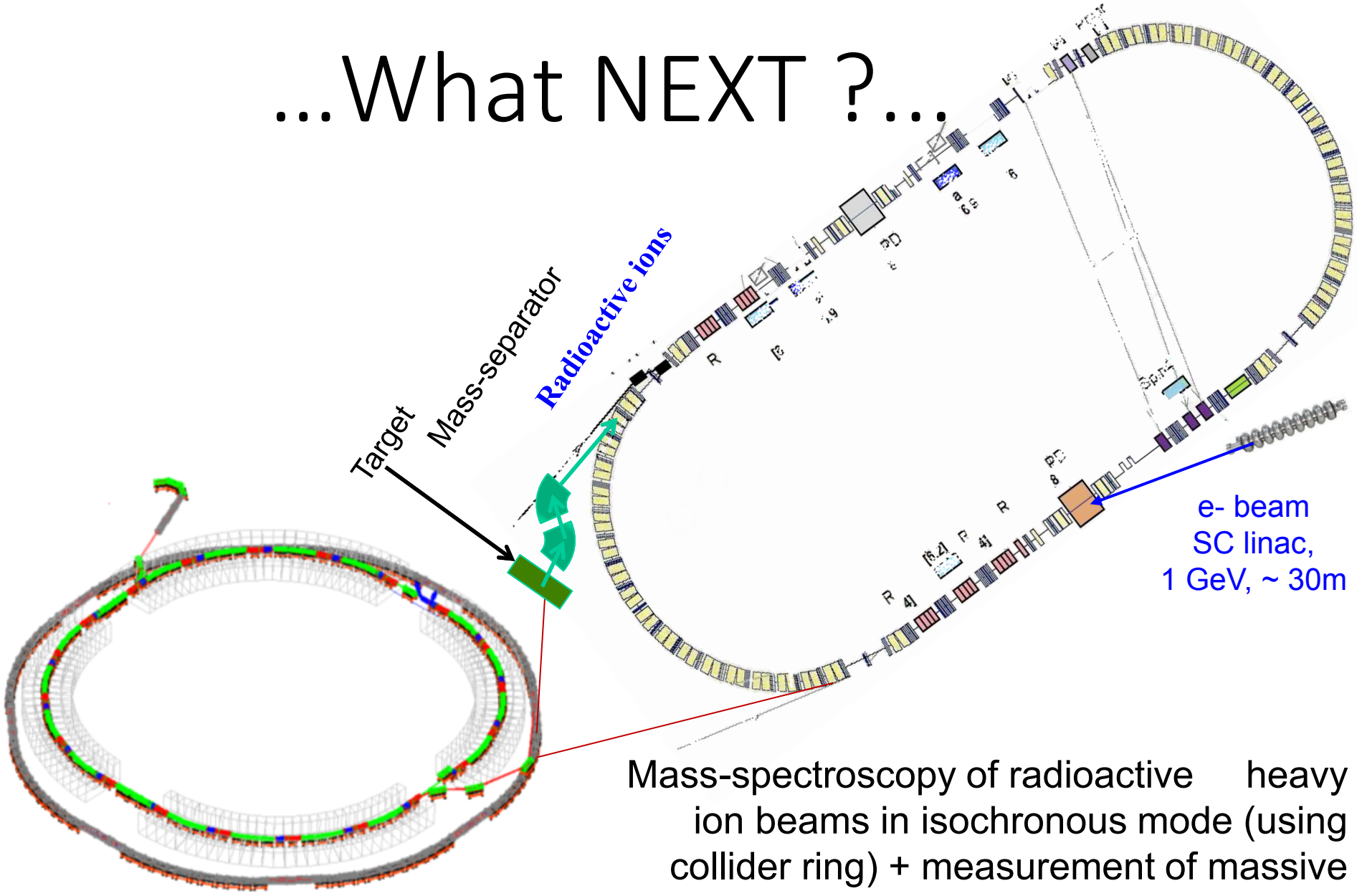
Formation of SUPERHEAVY “ATOM”



Merging $^{92+}U^{235}$ beams
E~ 0,6 GeV/u
~ 11 Tm ring



…What NEXT ?…



Mass-spectroscopy of radioactive heavy ion beams in isochronous mode (using collider ring) + measurement of massive nuclei PDF with colliding electron beam (up to 1 GeV)

Dzhelepov Laboratory for Nuclear Problems.

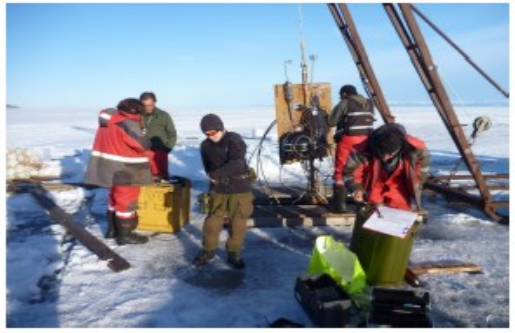
Neutrino Physics Program

Astrophysical neutrino sources (**BAIKAL GVD**)
Sterile neutrino searches (**DANSS/KNPP**)
Coherent neutrino-nucleus scattering (**vGEN**)
Precise measurements of neutrino oscillations (**Daya Bay, BOREXINO, OPERA**)
Neutrino mass hierarchy (**JUNO, NOVA**)
Dirac or Majorana? (**SuperNEMO, GERDA, Majorana**)

Kalinin Nuclear PP

Бруно Понтекорво

BAIKAL

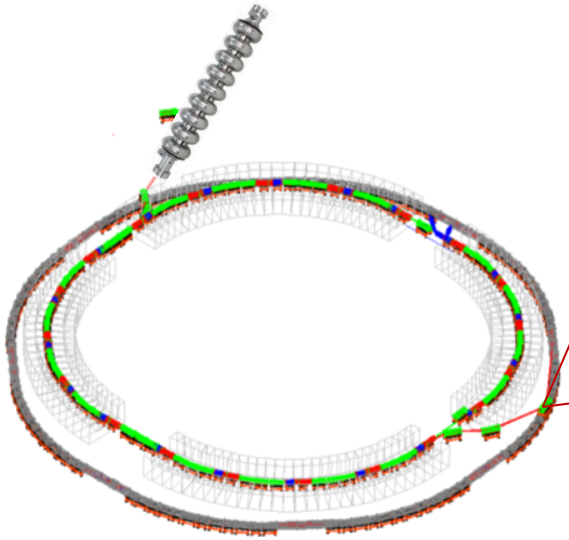


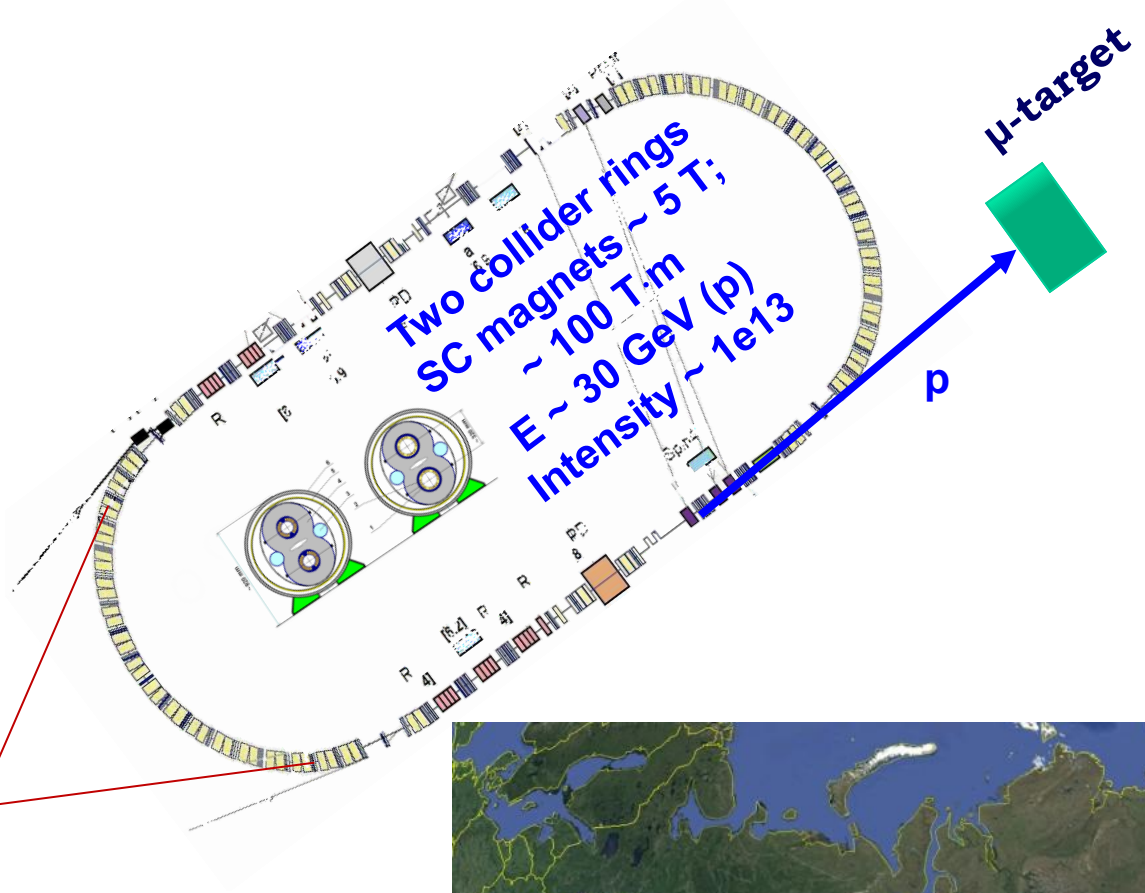
Solar
Reactor
Accelerator
Astrophysical
Atmospheric

Daya Bay (China)

…What NEXT ?…

SC proton-linac (~10MV/m)

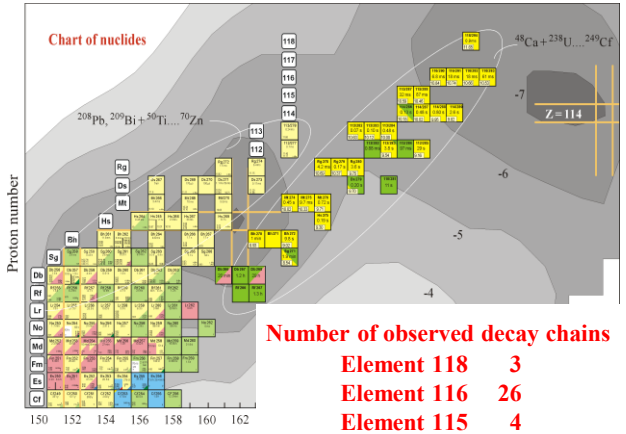




Goal: MW proton beam to the target, generating muon and neutrino fluxes

JINR's Large-Scale Basic Facilities

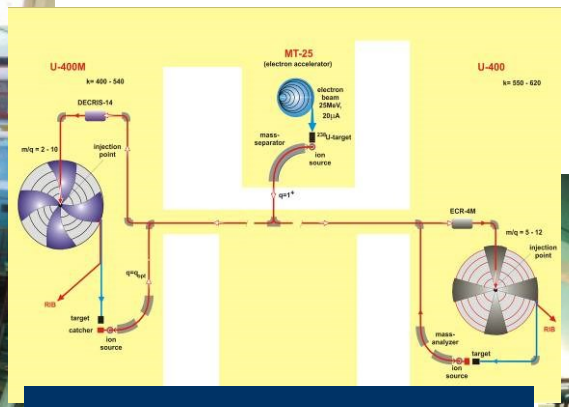
For the last decades JINR has become one of the leading scientific centers in the world in heavy-ion physics.



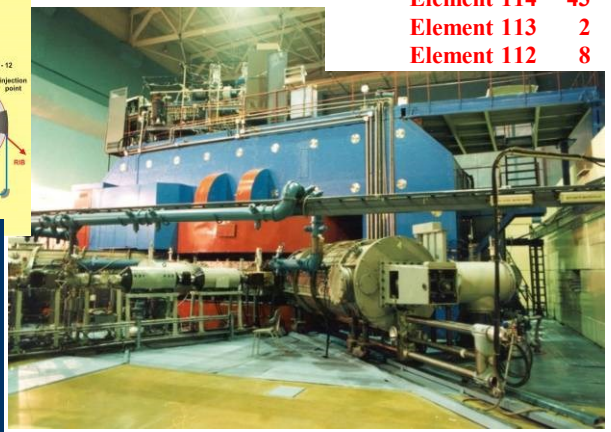
Number of observed decay chains

Element 118	3
Element 116	26
Element 115	4
Element 114	43
Element 113	2
Element 112	8

U400 isochronous cyclotron



DRIBs (I,II,III) – Dubna Radioactive Ion Beams



U400MR isochronous cyclotron

U400 and U400M isochronous cyclotrons (4 m diameter) are combined into the accelerator complex – project DRIBs which deals with the production of beams of exotic light neutron-deficient and neutron-rich nuclei in reactions with light ions.

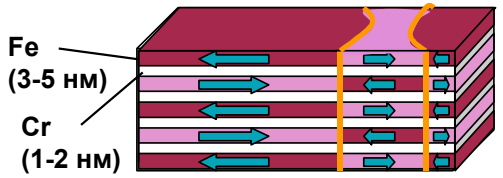
JINR's Large-Scale Basic Facilities

The IBR-2M pulsed reactor of periodic action is included in the 20-year European strategic programme of neutron scattering research.

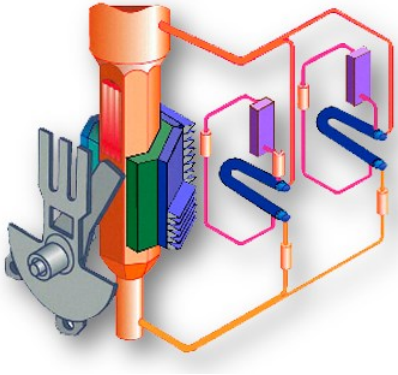
Fuel: PuO_2 , Average power: 2 MW ($8 \cdot 10^{12}$ n/cm^2/s), 5Hz, Pulsed power:1500 MW ($5 \cdot 10^{15}$ n/cm^2/s), width: 215/320 μs, 14 neutron channels.

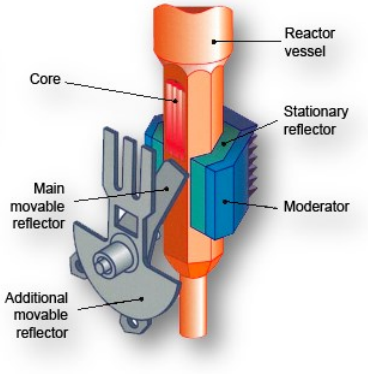
Nanosystems and Nanotechnologies

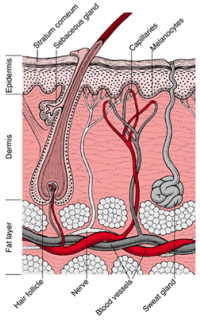
Novel Materials



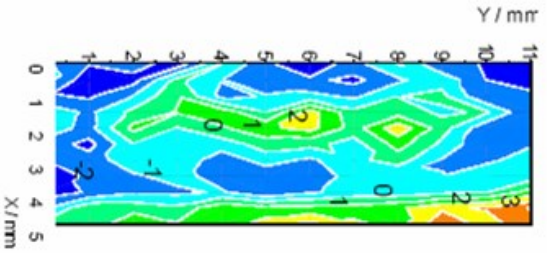
Biomedical Research







Engineering diagnostics. Earth Sciences



Fundamental and applied research in condensed matter physics and related fields: biology, medicine, material sciences, geophysics, engineer diagnostics - aimed at probing the structure and properties of nanosystems, new materials, and biological objects, and at developing new electronic, bio- and information nanotechnologies.