Scientific Research Programme at JINR

DUBNA

" JINR:
Past, Present and Future"

V. Matveev (Director JINR)

CERN Council, 176th Session,
June 19th 2015

JINR is located in the city of Dubna in 120 km to the north from Moscow

JOINT INSTITUTE for NUCLEAR RESEARCH

International Intergovernmental Organization

The Agreement on the establishment of JINR was signed on 26 March 1956 in Moscow

" ATOM for PEACE "

The results of the researches carried out at the Institute can be used solely for peaceful purposes for the benefit of mankind

Founders of JINR

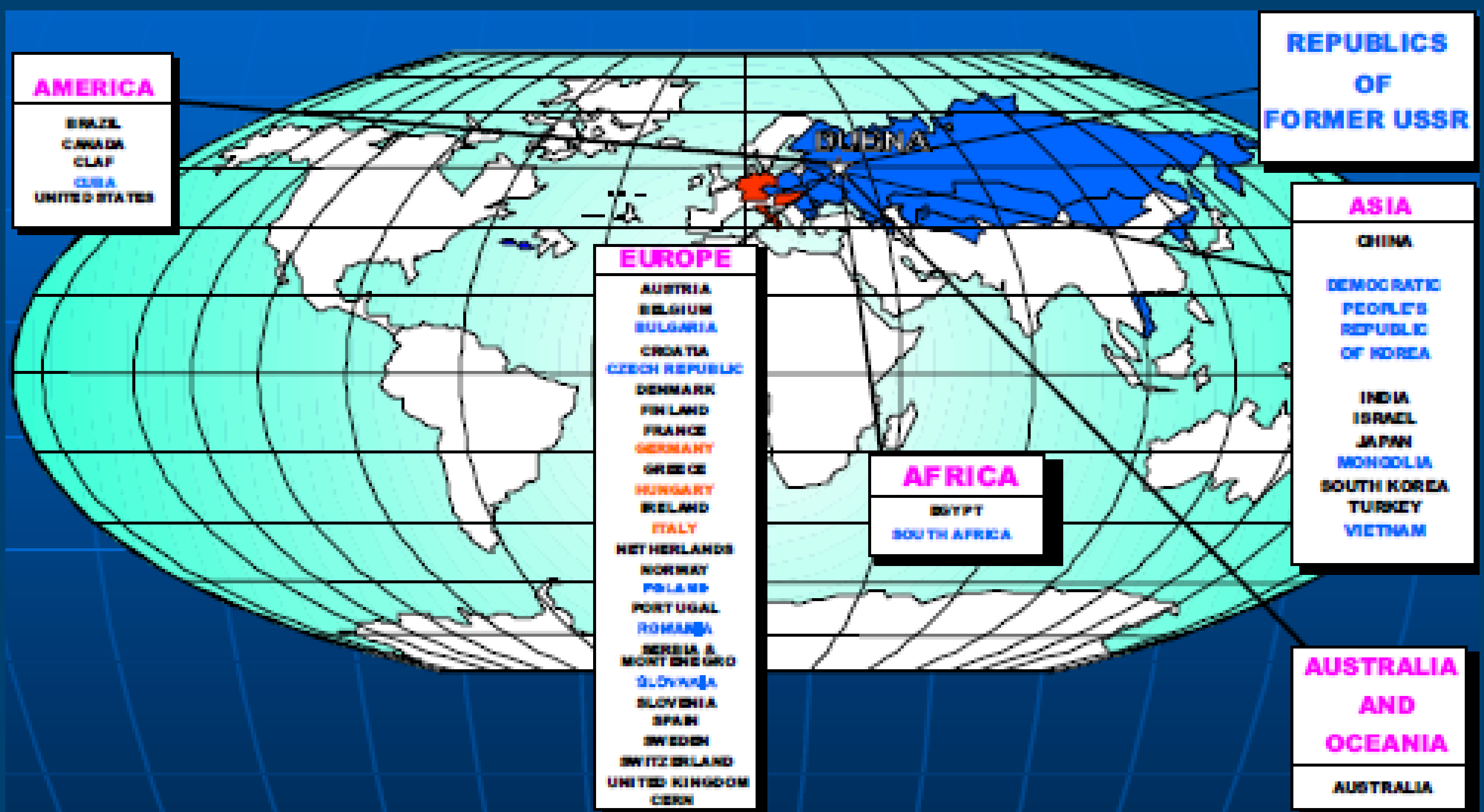
JINR has at present 18 Member States:

Armenia
Azerbaijan
Belarus
Bulgaria
Cuba
Czech Republic
Georgia
Kazakhstan
D. P. Republic of Korea
Moldova
Mongolia
Poland
Romania
Russian Federation
Slovakia
Ukraine
Uzbekistan
Vietnam

Participation of Egypt, Germany, Hungary, Italy, the Republic of South Africa and Serbia in JINR activities is based on bilateral agreements signed on the governmental level.

International collabiraton

JINR collaborates with more than 700 scientific centres and universities in 63 countries of the world.



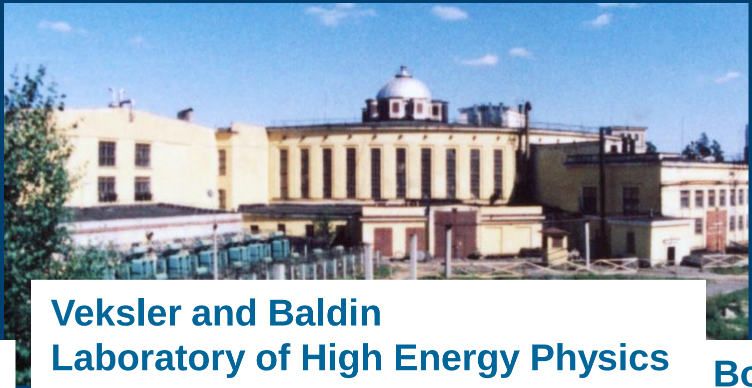
The Supreme governing body of JINR is the Committee of Plenipotentiaries of the governments of JINR Member States

In November 2014, the Committee of Plenipotentiaries decided to grant the European Organization for Nuclear Research the status of Observer at JINR, following a similar decision on the status of Observer of JINR at CERN taken earlier by the CERN Council.

The research policy of JINR is determined by the Scientific Council, which consists of eminent scientists from the Member States, as well as outstanding researchers from China, France, Germany, Greece, Hungary, India, Italy, and CERN

JINR comprises 7 Laboratories, each being comparable with a large institute in the scale and scope of investigations performed

Dzhelepov
Laboratory of Nuclear Problems



Veksler and Baldin
Laboratory of High Energy Physics

Bogoliubov
Laboratory of Theoretical Physics

Flerov
Laboratory of Nuclear Reactions

Frank Laboratory of Neutron Physics

Laboratory of Information Technologies

Laboratory of Radiation Biology

SOME OF THE MAJOR RESULTS OF JINR

Accelerators – Phase Stability Principle (Veksler);

Synthesis of the new supperheavy elements

“105”, “112-116”, “118”

and indications on the existence of the Stability Island

(Flerov, Oganesian);

Phenomenon of the Neutrino Oscillation (Pontecorvo);

Construction of the Impulse Breader Reactor IBR-2 (Blokhintsev, Frank, Shapiro);

First superconducting heavy ion accelerator (Baldin);

Development of the Basic Prinsiples of the Local Quantum Field Theory (Bogoliubov,Shirkov);

Hypothesis of the new quantum number of quarks (BST)

MAJOR DIRECTIONS OF JINR RESEARCH ACTIVITIES:

- ❒ BASIC PHYSICS RESEARCH
- ❒ EDUCATIONAL PROGRAMMES
- ❒ INNOVATION DEVELOPMENTS

Multidisciplinary researches:

Medicine physics, hadron terapy threatments

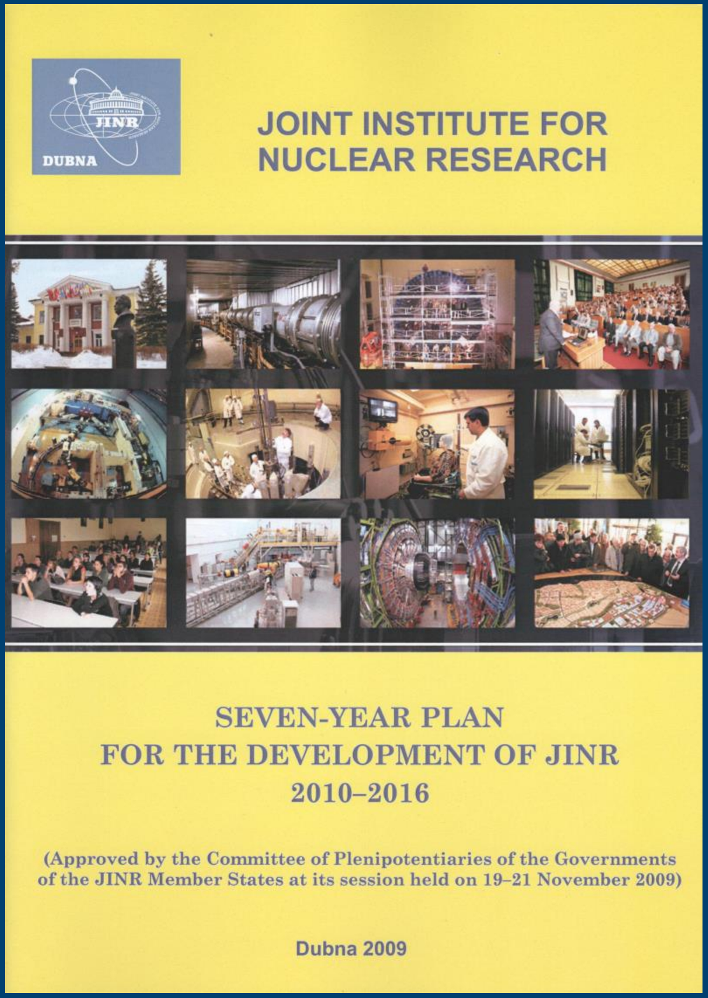
Nanotechnologies, treck membrane productions

Radiobiology, cosmic medecine, ecology

Astrobiology,

Information technologies

7-Year Plan (2010 – 2016)



The concept of the Seven-Year Plan is based on the concentration of resources to update the accelerator and reactor base of the Institute. The key elements of the qualitative improvement of the research infrastructure are the following basic facilities:

– the ion collider NICA (Nuclotron-based Ion Collider fAcility) for research in the field of high-energy heavy-ion physics ;

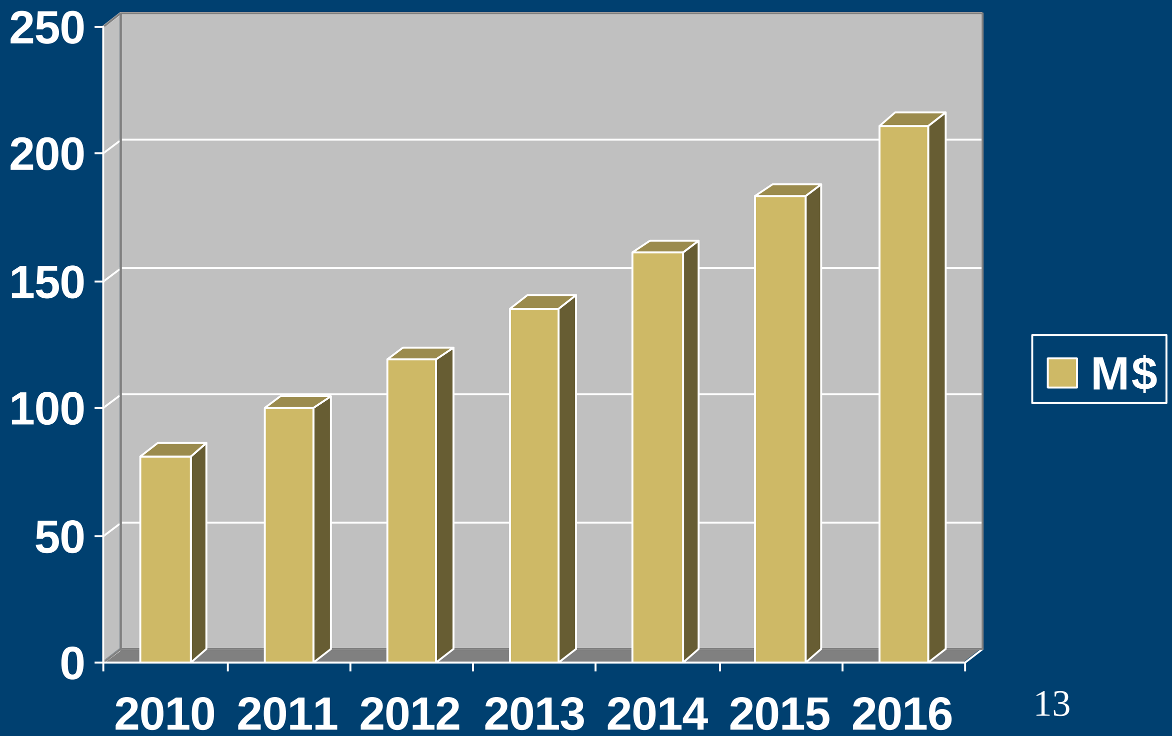
– the cyclotron complex DRIBs-III (Dubna Radioactive Ion Beams) for the search for new superheavy elements of Mendeleev’s Periodic Table and for studies of the properties of radioactive and exotic neutron-rich nuclei;

– the modernized reactor IBR-2M for research in condensed matter physics and particularly in the fields of nanoscience and nanotechnology.

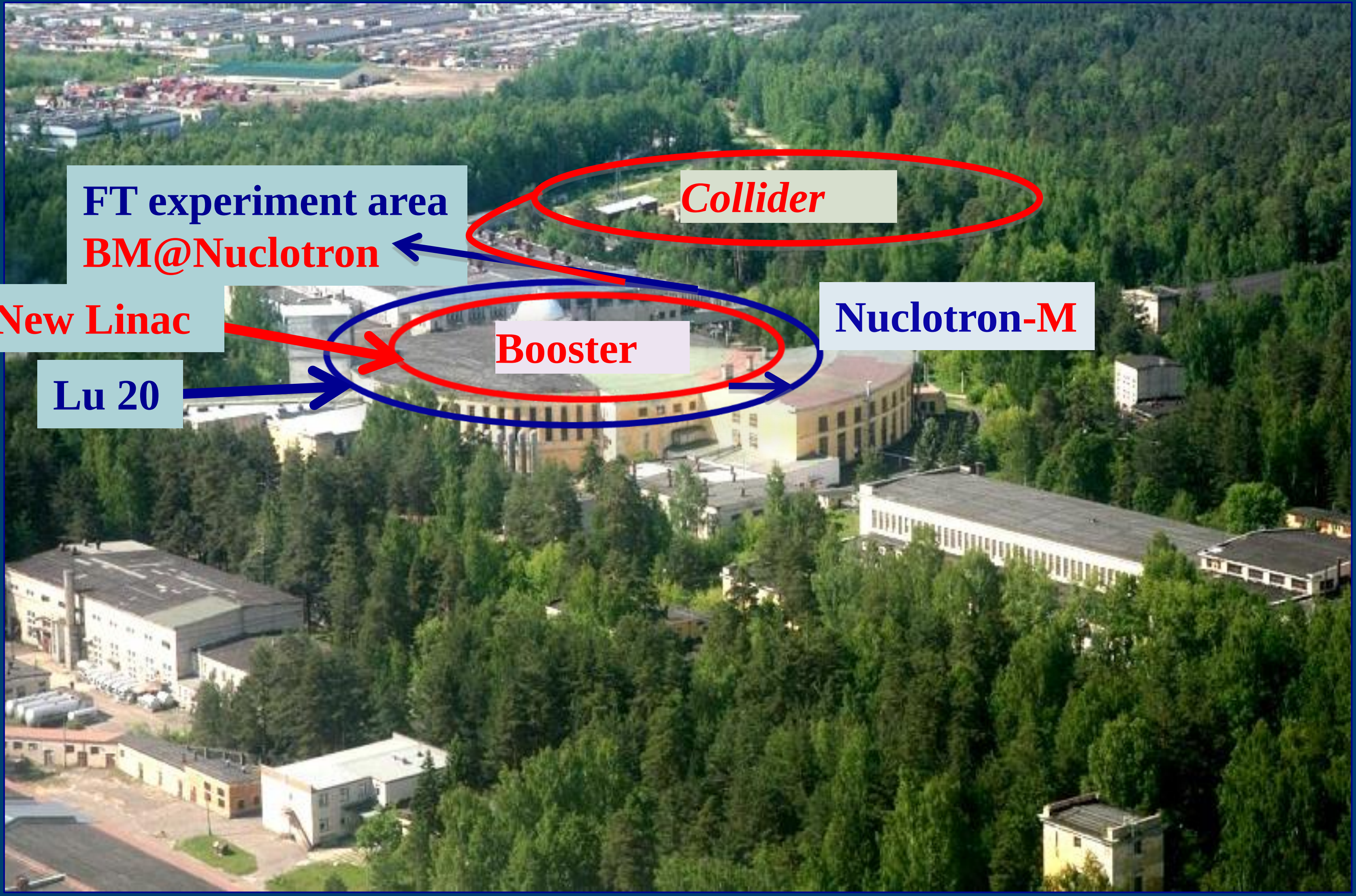
JINR in some figures

- **JINR's staff members ~ 4500**
- **Researchers ~ 1200**
  including from the Member States (but Russia) ~ 400
- **Full Doctors and PhD ~ 1000**

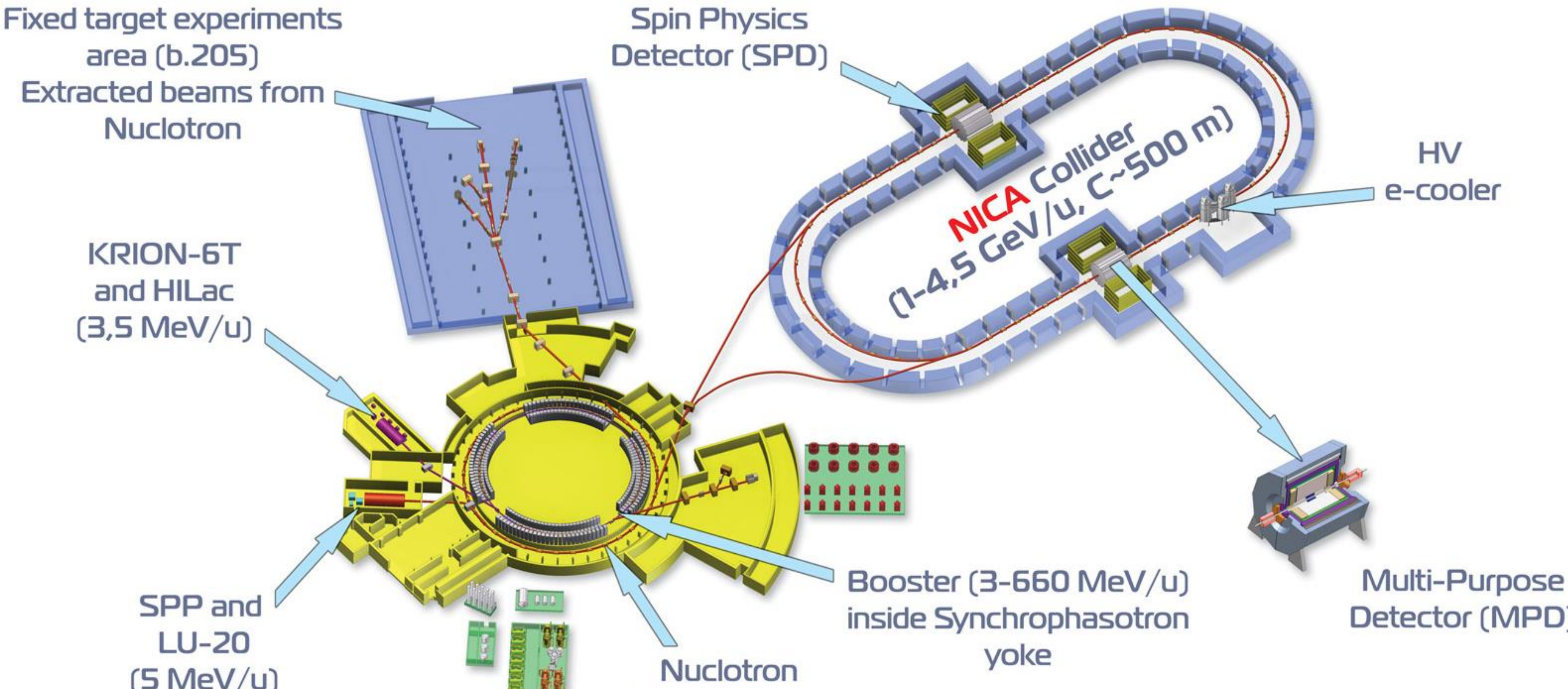
JINR Budget (actual and foreseen in the 7-year Plan)



Area of Nuclotron-NICA Facility



Superconducting accelerator complex NICA
(Nuclotron based Ion Collider fAcility)



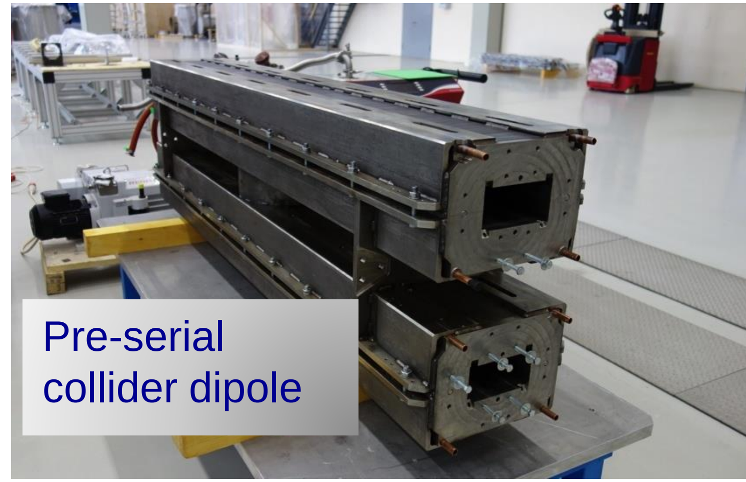
Preparatory works are completed ~60 000 m²!

NICA parameters:

- Energy range: $\sqrt{s_{NN}}$ = 4-11 GeV
- Beams: from p to Au
- Luminosity: $L \sim 10^{27}$ (Au), 10^{32} (p)
- Detectors: MPD (ions), SPD (spin physics)

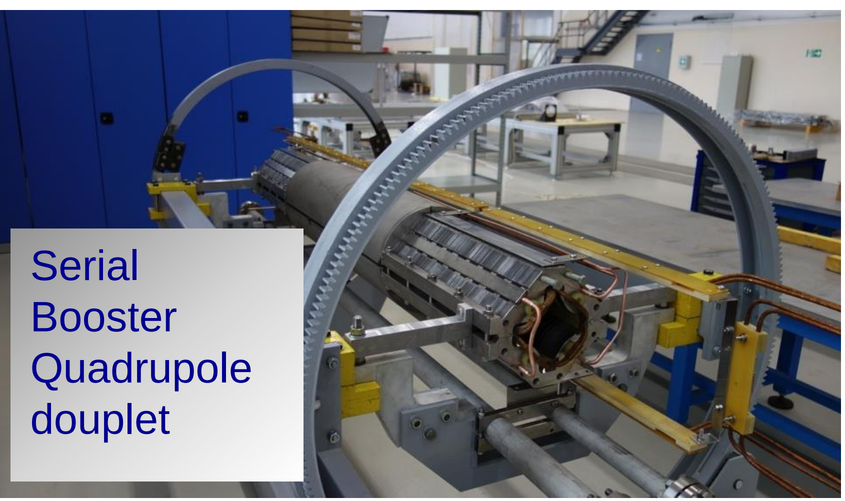
Test Facility for SC magnets of NICA and FAIR: excellent collaboration of JINR and Germany (BMBF). Start of operation – December'14. Serial assembly and cold tests (6 arms) – December 2015

1st cold test of Booster dipole with magnetic measurements made in December'14
Cold test of serial quadrupole duplet – Feb-March 2015



Pre-serial collider dipole

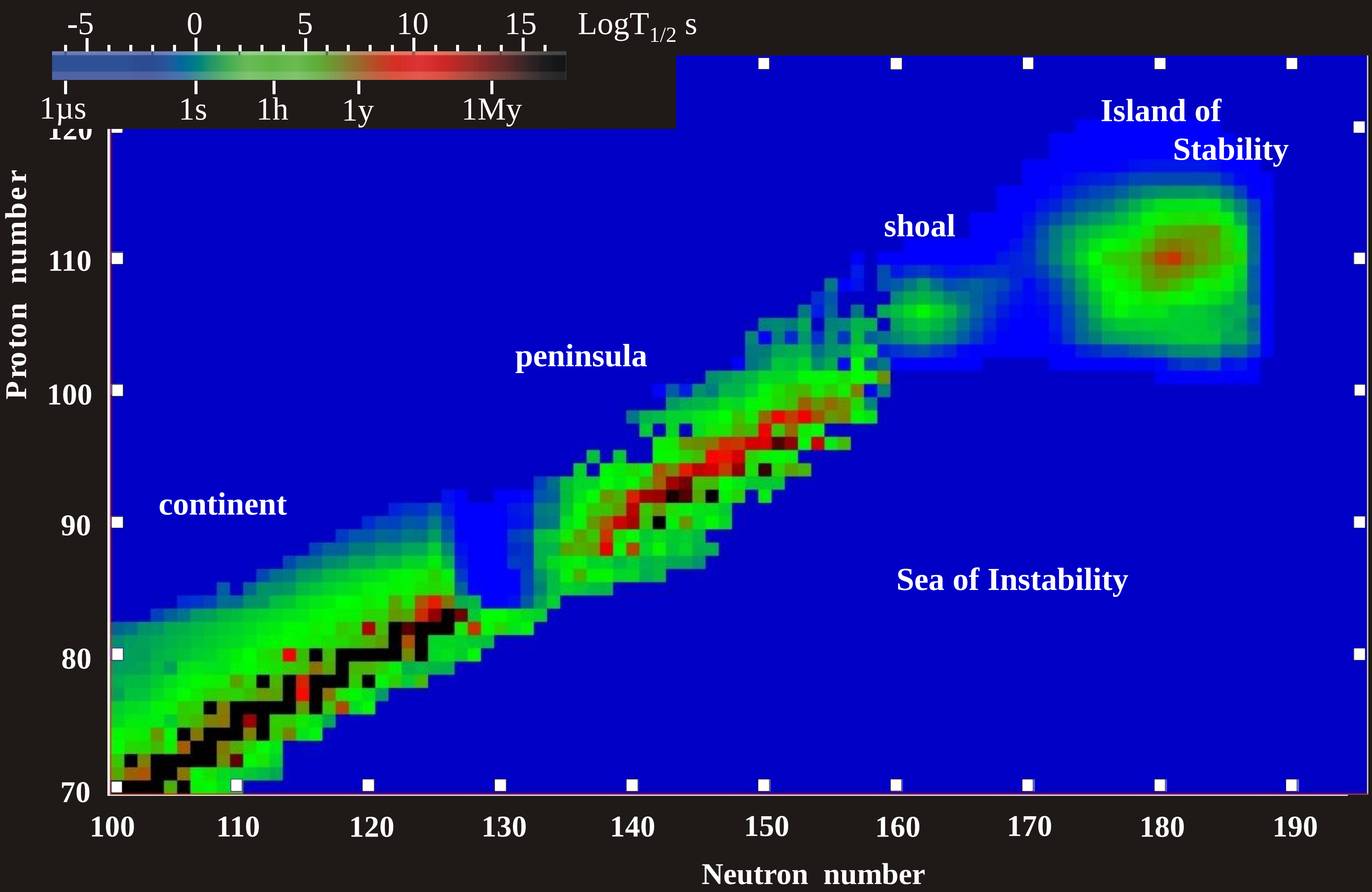
Serial production of Booster dipoles and quadrupoles started in Oct 2014



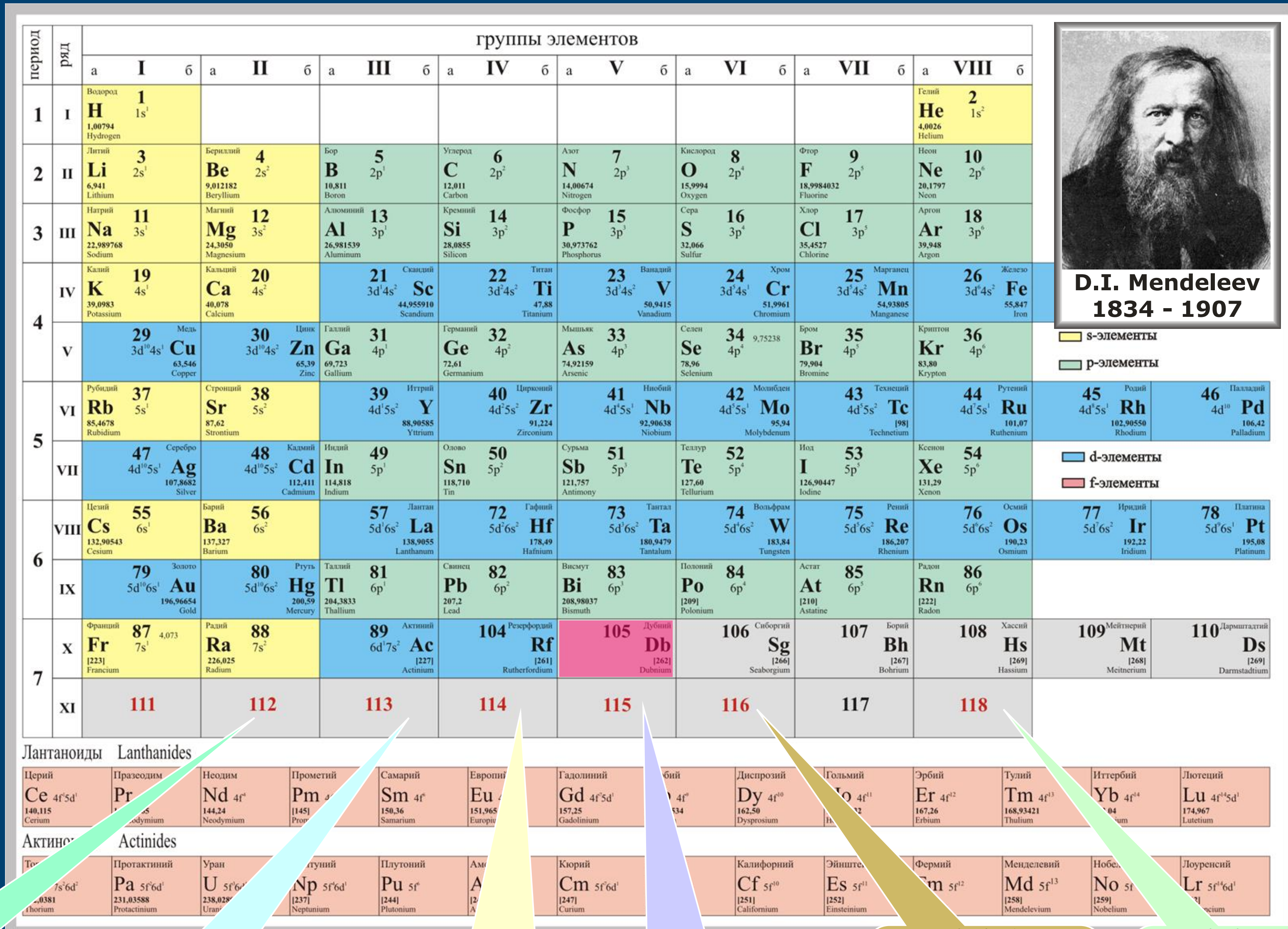
Serial Booster Quadrupole douplet

		2015				2016				2017				2018				
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I
Booster																		
dipoles	40+3	■	■	■	■	■	■	■										
quadrupoles	48+6	■	■	■	■	■	■	■	■									
multipole correctors	40+4					■	■	■	■									
Collider																		
dipoles	80+5					■	■	■	■	■	■	■	■	■	■	■	■	
quadrupoles	86+5					■	■	■	■	■	■	■	■	■	■	■	■	
multipole correctors																		
nonstructurals																		

New lands



-5
0
5
10
15
LogT1/2 s
1µs
1s
1h
1y
1My
Island of Stability
shoal
peninsula
continent
Sea of Instability
Proton number
120
110
100
90
80
70
100
110
120
130
140
150
160
170
180
190
Neutron number



112
Chemical identification in 2006

113
Discovered at JINR in 2003

114
Discovered at JINR in 1999

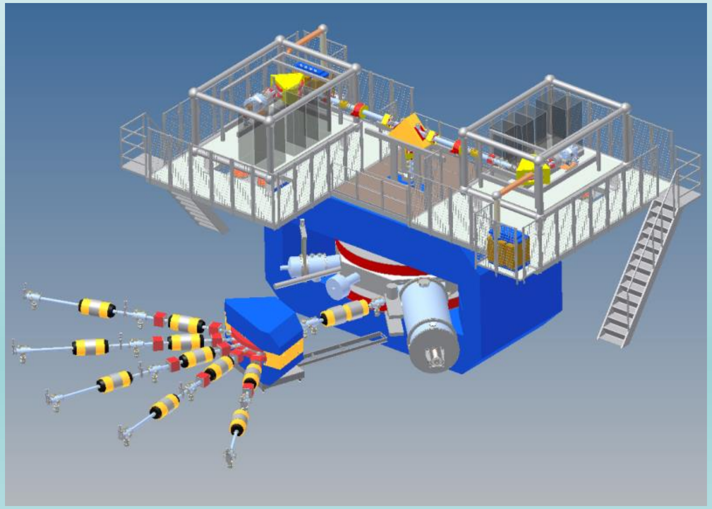
115
Discovered at JINR in 2003

116
Discovered at JINR in 2000

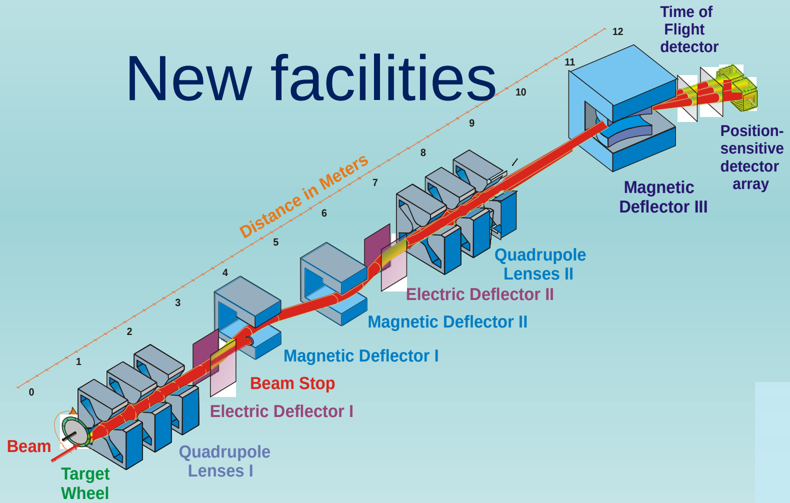
118
Discovered at JINR in 2001

Super Heavy Elements (SHE) Factory

High-current cyclotron DC-280



New facilities



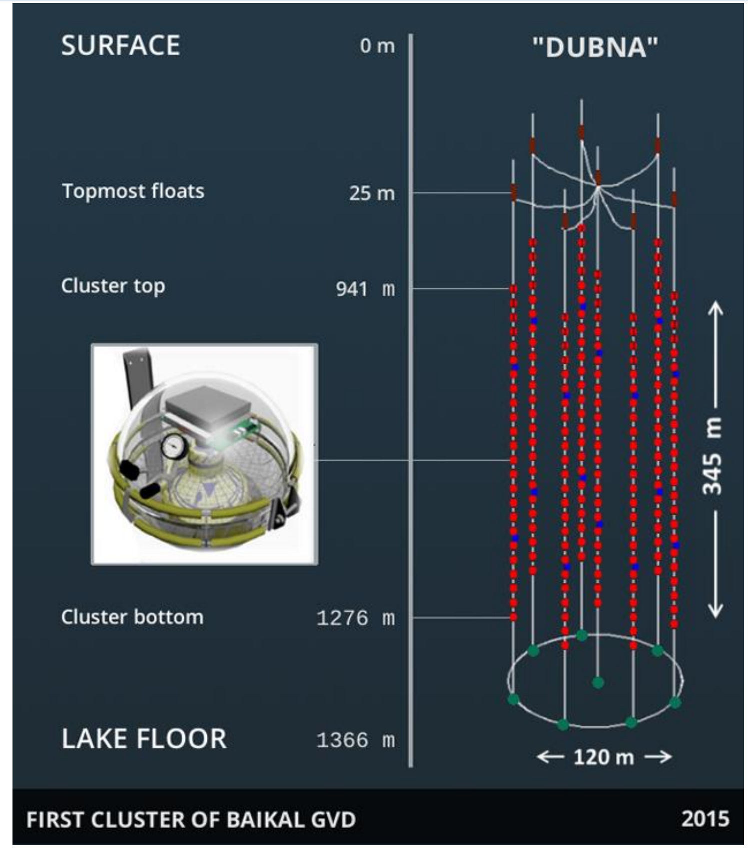
New experimental hall

DC280-cyclotron – SHE-factory

- Synthesis and study of properties of superheavy elements.
- Search for new reactions for SHE-synthesis.
- Chemistry of new elements.

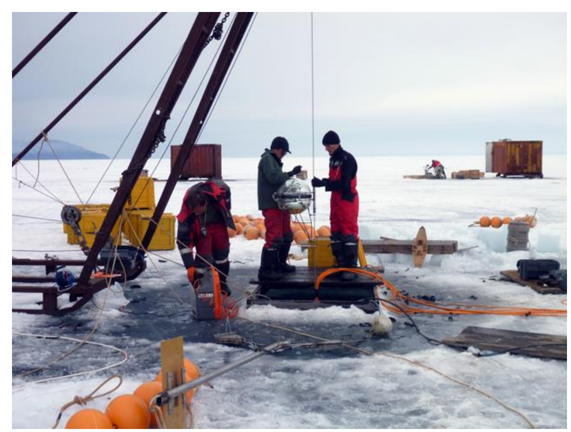
DC280 (project) E=4÷8 MeV/A		
Ion	Ion energy [MeV/A]	Output intensity
^{7}Li	4	1×10^{14}
^{18}O	8	1×10^{14}
^{40}Ar	5	6×10^{13}
^{48}Ca	5	$0,6\text{-}1,2\times10^{14}$
^{54}Cr	5	2×10^{13}
^{58}Fe	5	1×10^{13}
^{124}Sn	5	2×10^{12}
^{136}Xe	5	1×10^{14}
^{238}U	7	5×10^{10}

Baikal project: Gigaton Volume Detector (GVD)



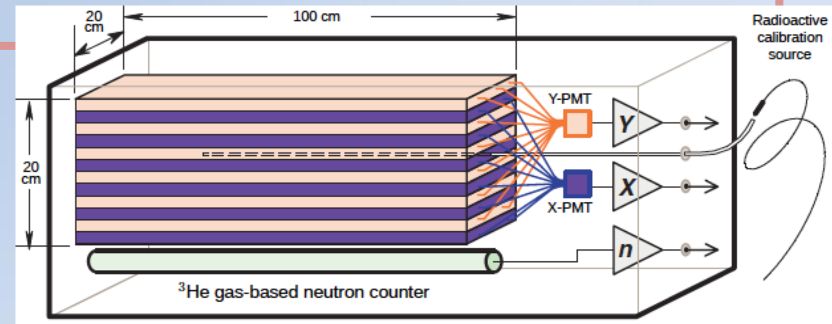
Central Physics Goals:

- Investigate Galactic and extragalactic neutrino "point sources" in energy range > 3 TeV
- Diffuse neutrino flux – energy spectrum, local and global anisotropy, flavor content
- Transient sources (GRB, …)
- Dark matter – indirect search
- Exotic particles – monopoles, Q-balls, nuclearites, …

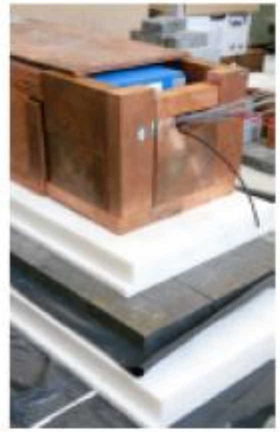


Neutrino physics

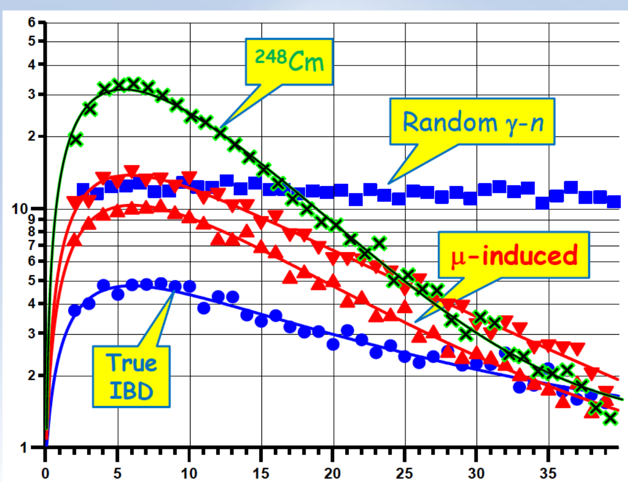
DANSS experiment at the Kalinin APS

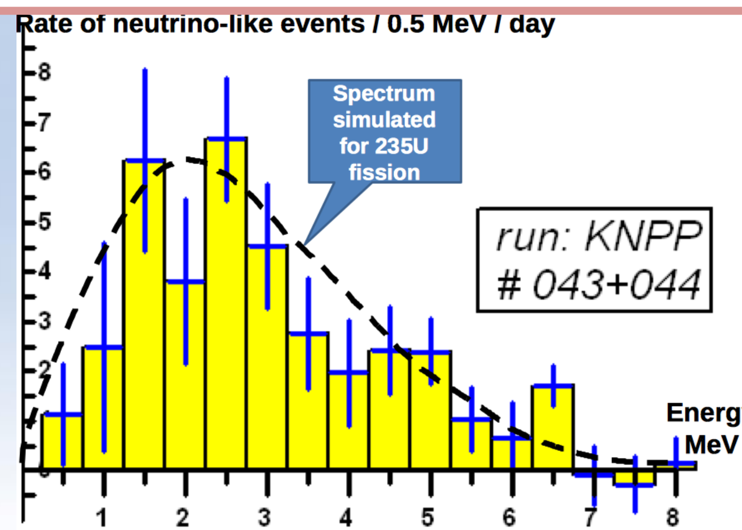


To check the DANSS design, a pilot version
DANSSino (DANSS/25) was created !



Measured reactor $\bar{\nu}$-spectrum!

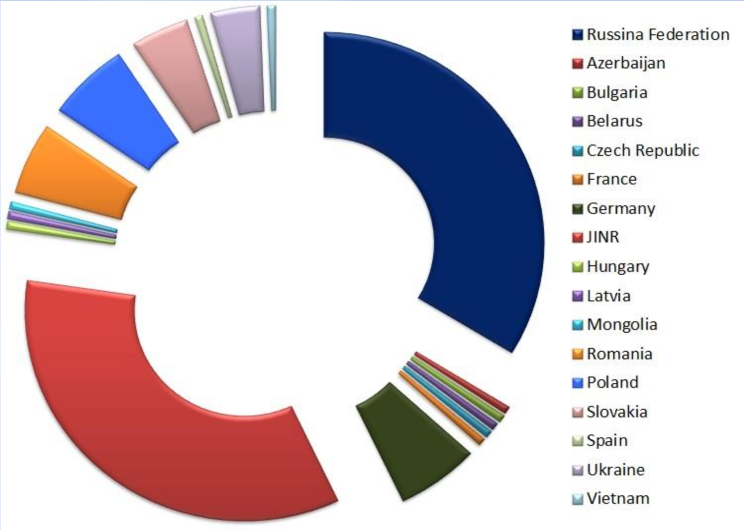




IBR-2: Pulsed reactor with fast neutrons

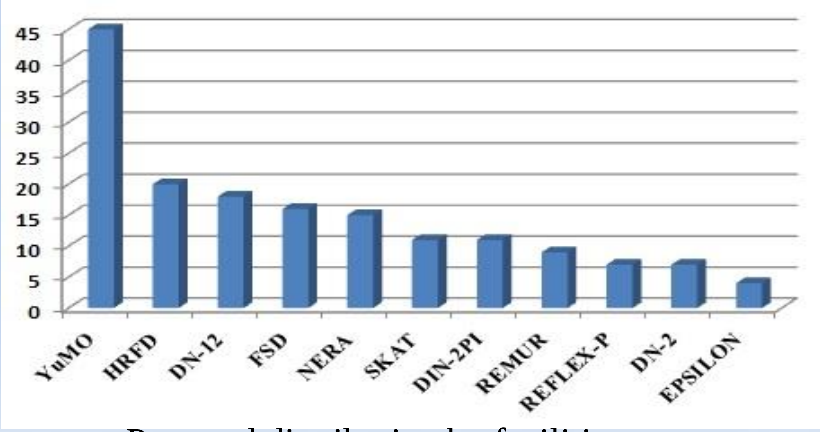
mean power 2 MW
pulse frequency 5 Hz
pulse width for fast neutrons 200 μs
thermal neutrons flux density on the moderator surface: 10^{13} n/cm^2/s
maximum in pulse: 10^{16} n/cm^2/s

User policy at the IBR-2 (2014)

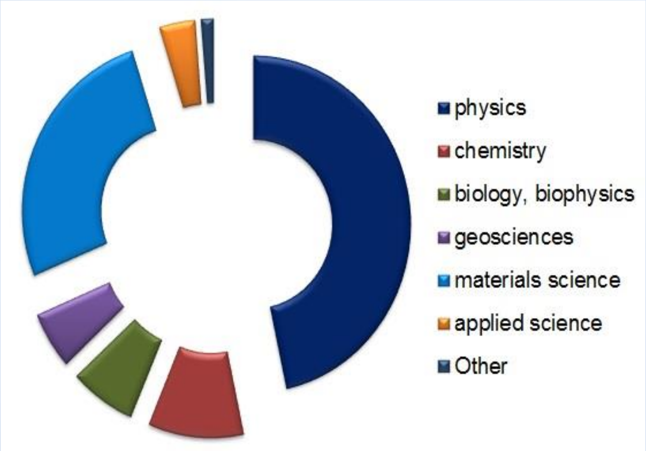


Proposal distribution by applicant's affiliation

163 proposals were received in total
150 proposals accepted for realization



Proposal distribution by facilities



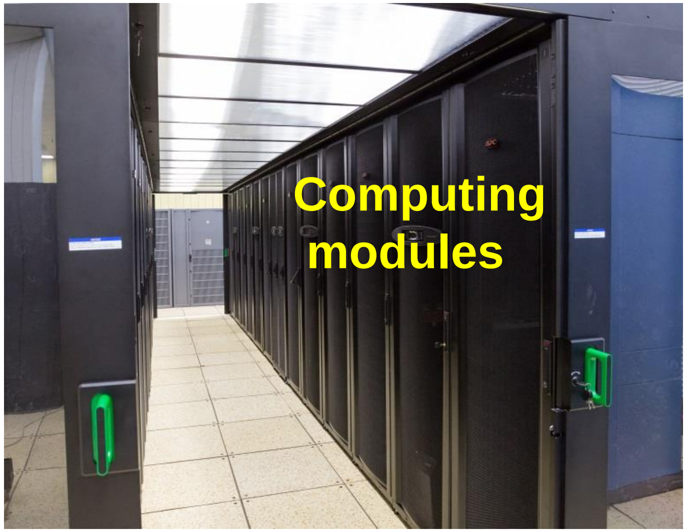
Proposal distribution by science

In 2014 the IBR-2 reactor operated for 2,492 hours for experiments.

JINR Multifunctional Centre for Data Storage, Processing and Analysis

Start Tier-1 at 26 March 2015

- Grid-Infrastructure at Tier1 and Tier2 Levels
- General Purpose Computing Cluster
- Cloud Computing Infrastructure
- Heterogeneous Computing Cluster HybriLIT
- Education and Research Infrastructure for Distributed and Parallel Computing



BLTP Bogoliubov Laboratory of Theoretical Physics

Publications, 2014
Journals & Conf. Proc
~ **490**

Conferences and Schools
Total - **16 (~ 1000 participants)**
DIAS-TH and Helmholtz Schools - **4**
> 20 countries were represented

Educational Activity
More than **40 lecture courses** at JINR UC, DIAS-TH, Moscow U., Dubna U., MPTI, etc

JINR Educational Programs

At present **340** graduate students are taking part in various JINR educational programs. According to the law "On Education in RF" a new JINR **PhD program** has been started in 2015.

International Student Practice (ISP) and JINR Summer Student Program (SSP) in 2015

University Center is ready to run ISP in 2015 in three stages. Participation of students from 9 JINR MS is expected. The call for applications for SSP-2015 was launched on January 15.

JINR Outreach Activity in 2014-2015

Outreach programs for teachers and school students from JINR Member States at CERN and JINR have been continued in cooperation with the Centre of National Intellectual Reserve of Moscow State University.

Teacher Programs (CERN & JINR)

http://teachers.jinr.ru/

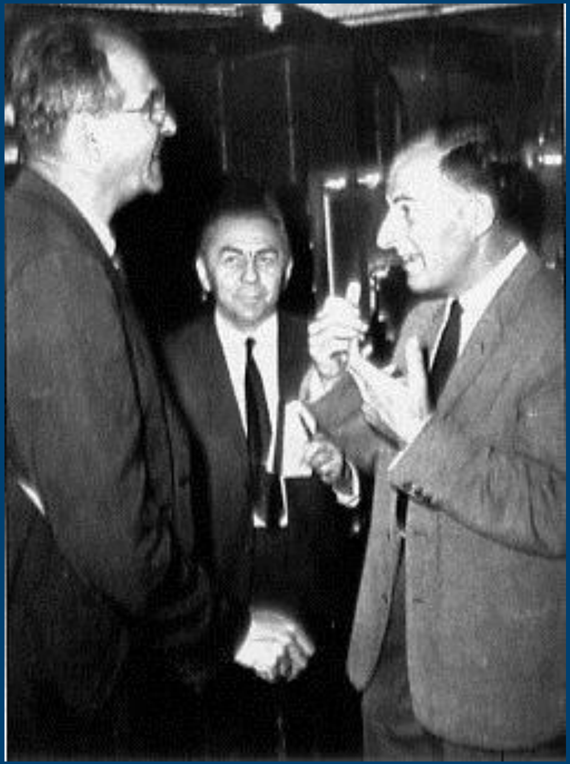
First School held in 2009

Seven Schools at CERN (260 part.)

Five Schools at JINR (210 part.)

Back to the beginning…

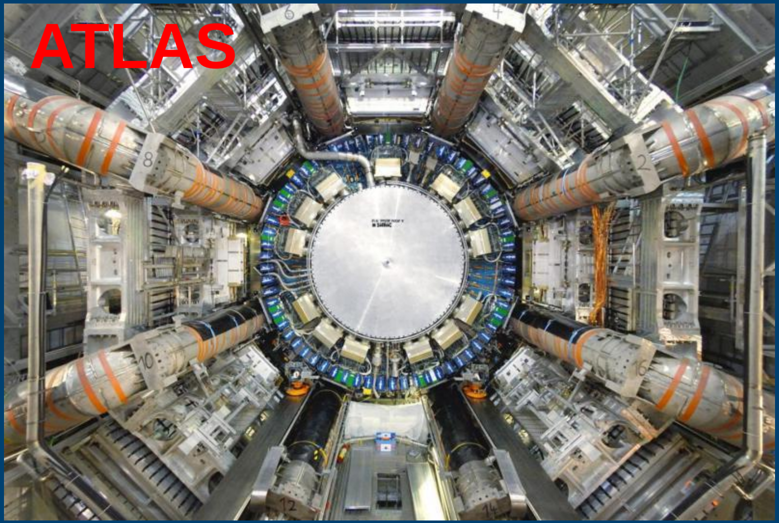
1957 – first contacts between CERN/JINR scientists
1962 – up to now: CERN-JINR Schools series on High-Energy Physics
1963 – first formalized agreement between JINR and CERN

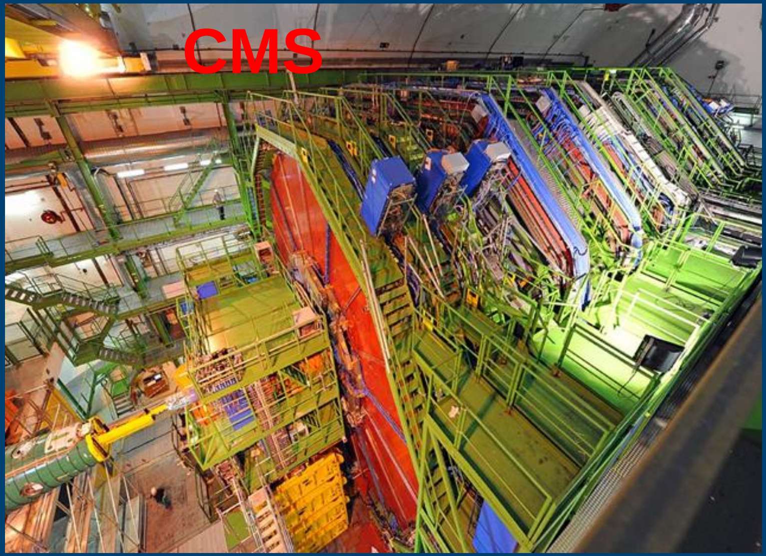


1963:
V. Weisskopf
V. Dzhelepov
B. Pontecorvo

1971:
W. Jentschke, N. Bogoliubov

1992 - CERN-JINR co-operation agreement on JINR's participation in the construction of the LHC and the ALICE, ATLAS and CMS detectors and in other experiments at CERN SPS and PS, as well as in information technologies





The last co-operation agreement between the JINR and CERN was signed in January 2010. This agreement foresees both, the continuation of JINR contribution to the CERN research program, and the help of CERN to the NICA complex construction.

2014:
CERN–JINR reciprocal Observer status

"… the reciprocal granting of Observer status by CERN and JINR, as proposed by JINR, would further strengthen the close ties between the two organisations. The improved exchange of information and mutual consultation on programmes and strategies would create new synergies and provide a basis for even more intense and successful co-operation in the future ..."

CERN Council September 2014

CERN – JINR Long Year Partnership

Committee of the Plenipotentiaties of the governments of the JINR Member States 25-26 March 2015 :

We were happy to welcome in Dubna

the President of Council of CERN

Prof. Agnieszka Zalewska

and the Head of the International Department of CERN,

Dr. Ruediger Voss

as the high representatives of the European Organization for Nuclear Research (CERN) at the JINR

For many years from the very beginning of JINR organization we have enjoyed close partnership relations between CERN and JINR.

Today, two new Protocols to the 2010 Cooperation agreement will be signed, concerning

PARTICIPATION BY JINR IN THE LARGE HADRON COLLIDER PROJECT (LHC)

and

COLLABORATION AND COMMON DEVELPOMENTS IN THE AREA OF NUETRINO PHYSICS AND TECHNOLOGY,
AS WELL AS IN RELATED FIELDS

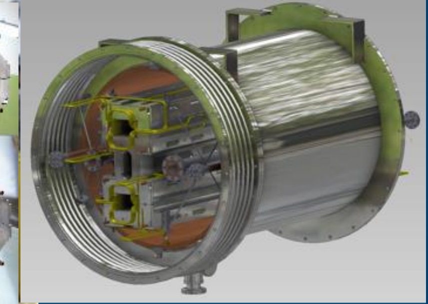
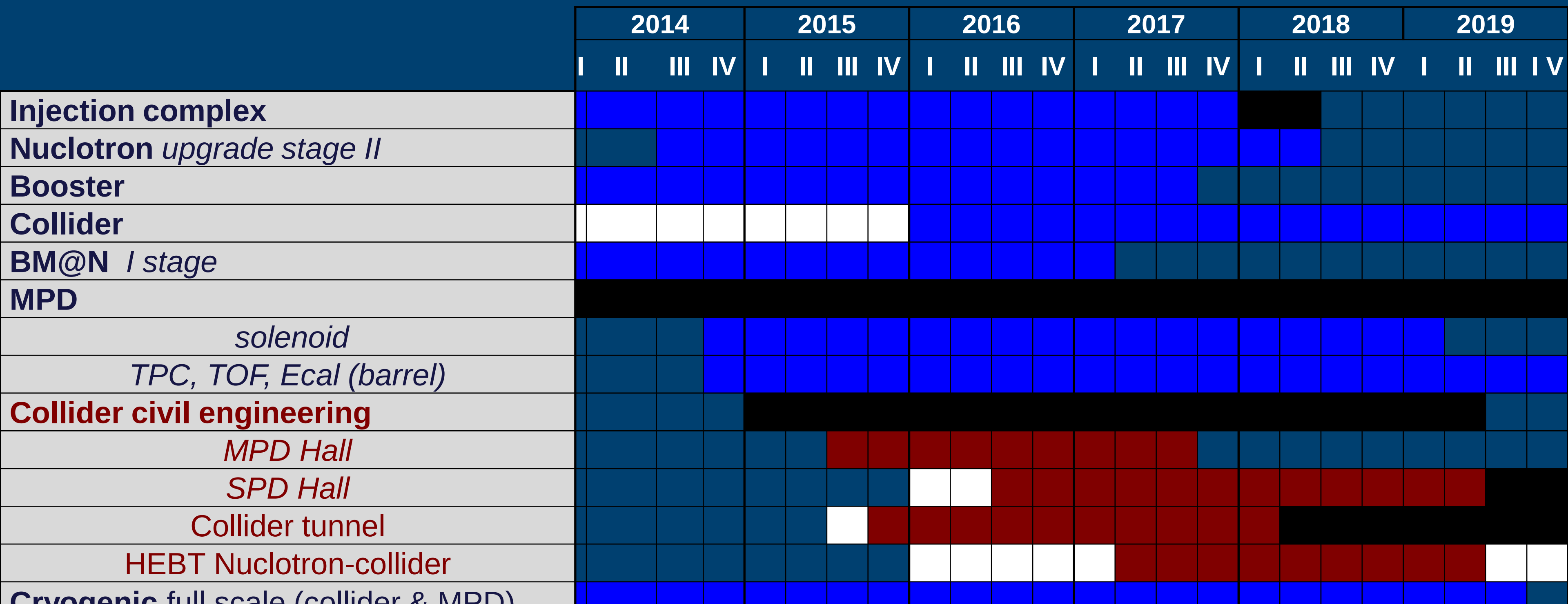
All these creates very efficient basis for the continues fruitful cooperation beneficial for the both sides and contributes to the scientific progress.

In 2016 JINR will celebrate its 60th anniversary. You all are welcome to take part in this remarkable event !

Thank you and welcome to Dubna!

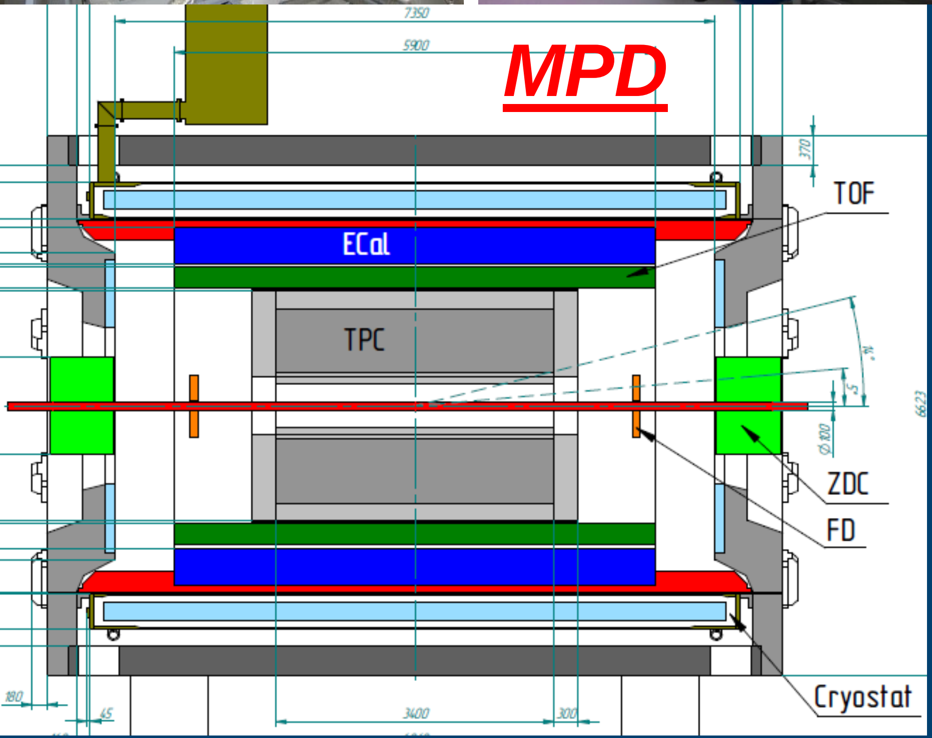






2014
2015
2016
2017
2018
2019
I II III IV I II III IV I II III IV I II III IV I II III IV I II III IV
Injection complex
Nuclotron upgrade stage II
Booster
Collider
BM@N I stage
MPD
solenoid
TPC, TOF, Ecal (barrel)
Collider civil engineering
MPD Hall
SPD Hall
Collider tunnel
HEBT Nuclotron-collider
Cryogenic full scale (collider & MPD)



STRABAG
PSJ
budostal 3sa



Detailed <u>energy & system size scan</u> <u>*with a step ~ 10 MeV/u in selected regions*</u> with a high **L** aimed in a search for anomalies:

- in particle production in the vicinity of the critical point,

- signatures of in-medium modification of the vector-spectral functions,

- study of the properties of the mixed phase of strongly interacting matter.

CERN: drift chambers, SC solenoid

INR RAS: ZD, RP calorimeters

GSI: silicon tracker

Ukraine: EM calorimeters

BNL :

- Key accelerator and detector technologies in NICA/NA61/CBM/BES at the frontier level are driven by challenging requirements of experiments and could be obtained fast only with our common efforts: intellectual exchange and sharing of resources

- Long successful experience of CERN-JINR collaboration in large projects and international scientific expertise allows to our member-countries support new mega-experiments.

- NICA project has tough schedule but it is realistic if supported by international scientific community, high-level expertise and actively working collaborations. Promised State support very important and needs constant assurance from international community.

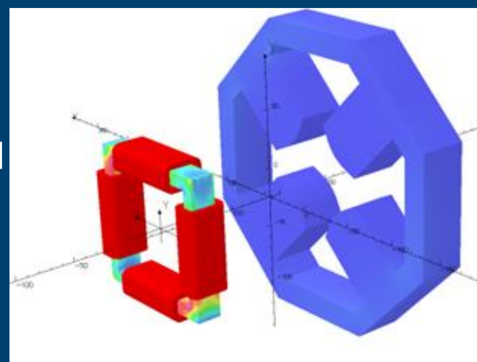
- International common efforts and complementarity of our experiments give us a strong argument in building European (global) distributed scientific infrastructure for heavy ion physics

MAGNETS

Contributions on magnetic design

- Electromagnetic design and analysis of complete magnets. Ex: the magnet for the AWAKE electron line.
- Advanced optimization of field quality in 3D. Ex: the magnets for the Hie-Isolde project.
- Contributions on the development of novel concepts of permanent and of hybrid magnets. Ex the hybrid magnets for CLIC and ILC (in particular the hybrid permanent magnets concept).

AWAKE: coupling of magnetic field between corrector and quadrupole



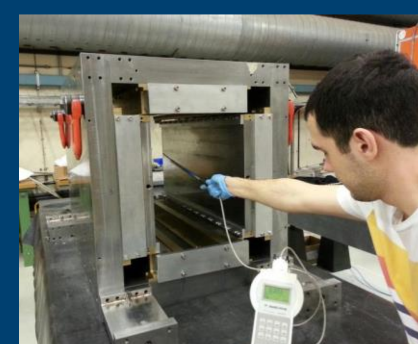
Hybrid final focusing permanent magnet quadrupole for linear colliders

Constributions on constructional design

- Design of advanced manufacturing tooling. Ex: the stack assembly of the sextupole magnets for Sesame.
- Design of different types of magnets for accelerators and experiments. For example the large permanent magnet spectrometer for n-TOF.

Advanced tooling for precision stacking of the laminations for the Sesame sextupole magnets

large permanent magnet spectrometer for n-TOF



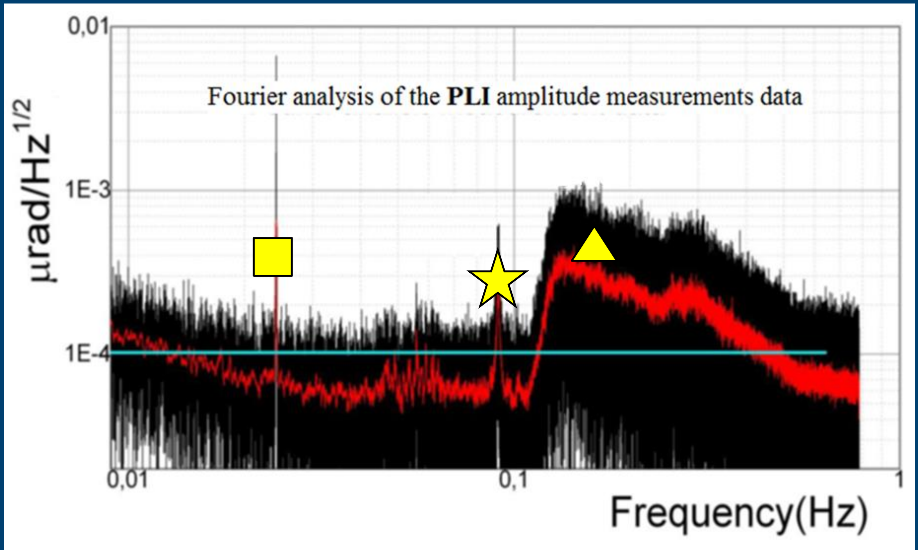
THE PRECISION LASER INCLINOMETER (PLI)

Reported on the CLIC Workshop 2015, January 26-30, CERN by N.AZARYAN, V.BATUSOV, J.BUDAGOV, V.GLAGOLEV, M.LYABLIN, G.TRUBNIKOV, G.SHIRKOV (JINR) and B. DI GIROLAMO, J.-C.GAYDE, D.MERGELKUHL, M. NESSI (CERN)

The **PLI** uses the GRAVITY vector as a stable reference line with angular variation $<10^{-10}$ Rad. The resolution of **PLI** is ~ 10^{-10} Rad enables it to discover and detect the SUPERWEAK GROUND ANGULAR MOTION.

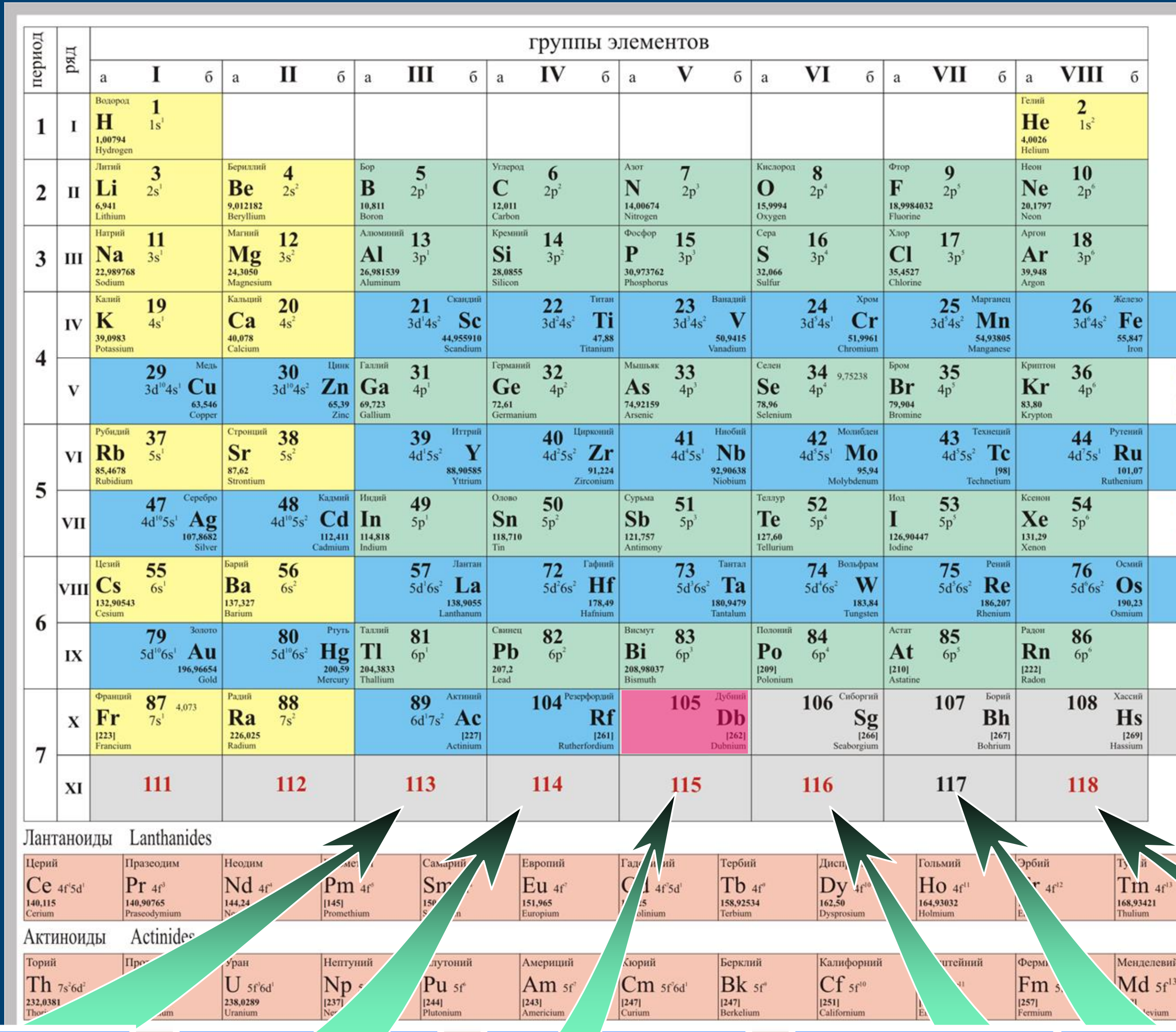
On the PICTURE – the **PLI** frequency spectrum with signals:

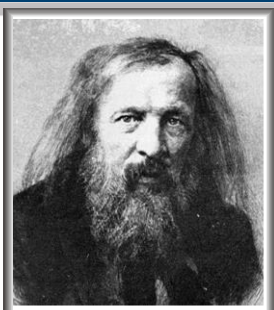
- ■ for instrumental calibration frequency;
- ★ for the tunnel-boring machine in Alpes;
- ▲ for the experimental observation of Microseismic Peak detected as ground ANGULAR motion caused by ocean water oscillations.



The **PLI** data can be used for stabilization of the space location of the Long Laser Fiducial Line for Multy-TeV Accelerators & Detectors

Currently in the CERN Transport Tunnel #1 the long-term tests of the two-coordinates PLI are in progress. The PLI signals are being online registered in the Laboratory of Nuclear Problems, JINR.



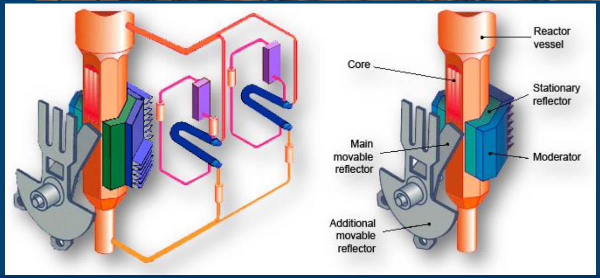


D.I. Mendeleev
1834 - 1907

113 **Discovered at JINR in 2003**	**114** **Discovered at JINR in 1999**	**115** **Discovered at JINR in 2003**	**116** **Discovered at JINR in 2000**	**117** **Discovered at JINR in 2009**	**118** **Discovered at JINR in 2001**

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.



Parameters

Fuel	PuO_2
Active core volume	22 dm^3
Cooling	liquid Na
Average power	2 MW
Pulsed power	1500 MW
Repetition rate	5 s^{-1}
Average flux	$8 \cdot 10^{12}$ n/cm²/s
Pulsed flux	$5 \cdot 10^{15}$ n/cm²/s
Pulse width (fast / therm.)	215 / 320 μs
Number of channels	14

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.

Web of Science®

JINR	CERN
2011-2013	
Total number of publications: 2897 Total number of citations: 34079 Average citations per article: 11.76 h-index: 52 budget (2013): ≈ 143.2 million USD	Total number of publications: 3561 Total number of citations: 48012 Average citations per article: 13.48 h-index: 79 budget (2013): ≈ 1 264 million USD
2014	
Total number of publications: 897 Total number of citations: 1149 budget (2014): ≈ 158.7 million USD	Total number of publications: 1240 Total number of citations: 3216 budget (2014): ≈ 1 125 million USD

Due to collaboration between CERN and JINR at LHC and other facilities a considerable part of publications in experimental elementary particle physics is joint. However above statistics (total number of publications and citations as well as h-index) of JINR includes also serious contribution related to nuclear and neutrino physics, condensed matter physics and biophysics, theoretical physics.

Both organizations look comparably efficient in terms of bibliometry. In terms of human and finance resources (JINR has 2 times less number of scientists and 7 times smaller budget) the publication activity of JINR is quite impressive.

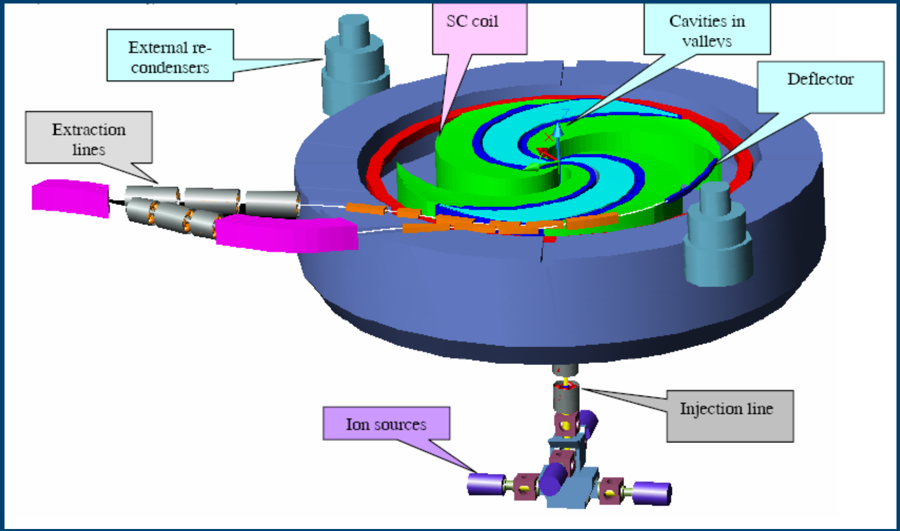
Proton therapy and medical accelerators

Proton Therapy at JINR's Phasotron

- Unique in Russia experience of application of conformal 3D therapy method
- About 100 patients per year since 2000
- Development of the project of PT Center

C400 SC Cyclotron Project for p & C Therapy

(together with IBA, AFK "Sistema", …)



The analysis of medicinal plants using neutron activation analysis at the IBR-2 reactor

Sanguisorba officinalis

International Journal of Medicinal Plants. Photon 106 (2014) 481-492
https://sites.google.com/site/photonfoundationorganization/home/international-journal-of-medicinal-plants
Original Research Article. ISJN: 6672-4384: Impact Index: 3.12

International Journal of Medicinal Plants

Photon

Investigation of Elemental Content of Some Medicinal Plants from Mongolia

Nyamsuren Baljinnyam[a*], Nanzad Tsevegsuren[b], Baasanjav Jugder[c], Marina Vladimirovna Frontasyeva[a], Sergey Sergeevich Pavlov[a]

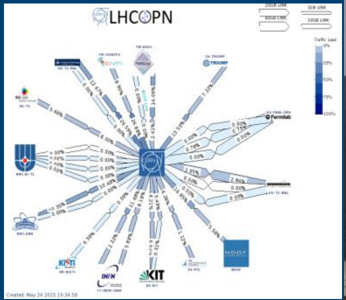
Carduus crispus

The authors receive Thomas Edison Award-2014 in the domain of Medicinal Plants for Inspiration and Knowledge Distribution among young research scholars.

Tier-1 (CMS)

Start - March 2015

- LHCOPN
- 2400 cores (~ 30 kHS06)
- 5 PB tapes (IBM TS3500)
- 2,4 PB disk
- Close-coupled, chilled water cooling InRow
- Hot and cold air containment system
- MGE Galaxy 7000 – 2x300 kW energy efficient solutions 3Ph power protection with high adaptability



CERN – JINR Partnership

Committee of the Plenipotentiaties of the governments of the JINR Member States 25-26 March 2015 :

We were happy to welcome in Dubna

the President of Council of CERN

Prof. Agnieszka Zalewska

and the Head of the International Department of CERN,

Dr. Ruediger Voss

as the high representatives of the European Organization for Nuclear Research (CERN) at the JINR

For many years from the very beginning of JINR organization we have enjoyed close partnership relations between CERN and JINR.

Astrobiology

Collaboration: University of Viterbo, Sapienza Università of Rome (Italy) and LRB (JINR)

Meteorite-catalyzed syntheses of nucleosides and of other prebiotic compounds from formamide under proton irradiation