The 2018 European School of High-Energy Physics

Maratea, Italy, 20 June - 3 July 2018

Physics at JINR

- JINR yesterday, today and tomorrow
  - Priorities of the 7-year plan
  - Basic science, Innovation and Education programs
  - JINR Long Range Strategy

V. Matveev

JINR, Dubna

"Science is essential to people. The country that does not advance it will inevitably turn into a colony"

Frédéric Joliot-Curie

On February 1 1957, JINR was registered by the United Nations

26 March 1956. Moscow, the conference hall of the Presidium of AS USSR.

12:45 – the fourth sitting of the meeting adopted a resolution:

"The Final Statement of the meeting on the issue of establishment of the Joint Institute for Nuclear Research".

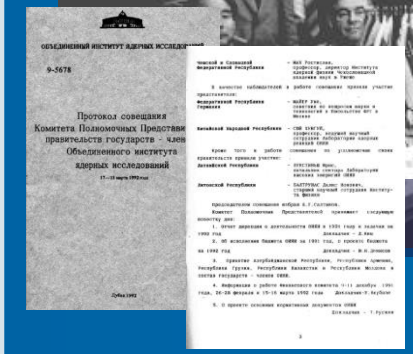
It says: "...it is provided by the Agreement to establish an international scientific research organization under the title "the Joint Institute for Nuclear Research" with the location area in the USSR..." .

The settlement Novo-Ivankovo on the bank of Volga - river. The 1950s.

The science city -"naukograd" Dubna today

1993–2018: **25 years of the new era of international cooperation for JINR**

Session of the Committee of Plenipotentiaries, Dubna, December 1991



Протокол совещания
Комитета Полномочных Представи
правительств государств - член
Объединенного института
ядерных исследований

- Membership of Belarus, Russia, Ukraine was approved at CP session in December 1991;
- Armenia, Azerbaijan, Georgia, Kazakhstan, Moldova – March 1992;
- Uzbekistan – June 1992;
- Czech and Slovak Republics – March 1993;
- Associate members: Germany (July 1991), Hungary (February 1993).

Early 1990-ies:

- ✓ Dramatic transformation of European and World socio-political landscape;
- ✓ Economies in transition in Central/Eastern Europe, Russia: social and economic challenges;
- ✓ New era of cooperation for JINR: new Member States and Associate Members.

JINR today

About 780 research partners in 62 countries

18 Member States (incl. 5 from EU):

Azerbaijan
Armenia
Belarus
Bulgaria
Vietnam
Georgia
Kazakhstan
Cuba
DPRK
Moldova
Mongolia
Poland
Russia
Romania
Slovakia
Uzbekistan
Ukraine
Czech Republic

6 Associate Members (incl. 3 from EU):
Hungary, Germany, Egypt, **Italy,** Serbia, SAR

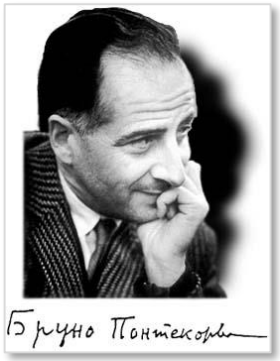
JINR–BMBF agreement: Germany is the first Associate Member of the Institute

On 15 July 1991, a bilateral agreement for the cooperation and using JINR facilities was concluded between the Joint Institute of Nuclear Research and the Federal Ministry of Education and Research (BMBF) of Germany authorized by FRG Government to represent Germany interests at JINR.

Dubna, 13-14 December 1992

Next year, the Workshop "Scientific cooperation between research centers of Germany and JINR" (Dubna, 13-14 December 1992) confirmed the efficiency of such cooperation

Cooperation between JINR and Italy



In the 80s-90s, JINR's and Italian scientists did research, which were a collective contribution to a more wide cooperation – to the projects of European organization of nuclear researches (CERN).

Consequently, bilateral treaties were made in relation to experiments at CERN.

- **15.12.1996** Agreement between INFN and JINR
- **10.06.1999** Agreement between University of Turin (Department of General Physics "A. Avogadro") and JINR on cooperation in research activities in the field of nuclear and sub-nuclear physics
- **01.01.1999** Agreement between INFN and JINR 02.06.1999 Protocol on Cooperation between FLNR JINR and LNS

. . .

JINR Director V. Matveev and INFN President F. Ferroni signed the new Agreement on INFN–JINR cooperation in the presence of President of the Italian Republic Signor S. Mattarella

Embassy of Italy in Moscow, 12 April 2017

JINR-UNESCO Round Table: 20 years of cooperation

An early bird event of the International Year of the Periodical Table of Chemical Elements

UNESCO Headquarters, Paris, 14 February 2018

UNESCO and the Joint Institute for Nuclear Research (JINR) celebrated 20 years of successful collaboration with a debate on current challenges in the basic sciences. The meeting was also an opportunity to explore areas for future partnership.

Speakers:
M. Itkis – JINR Vice-Director
Yu. Oganessian – FLNR Scientific Leader
N. Tarasova – Former IUPAC President
S. Pakuliak – UC Director

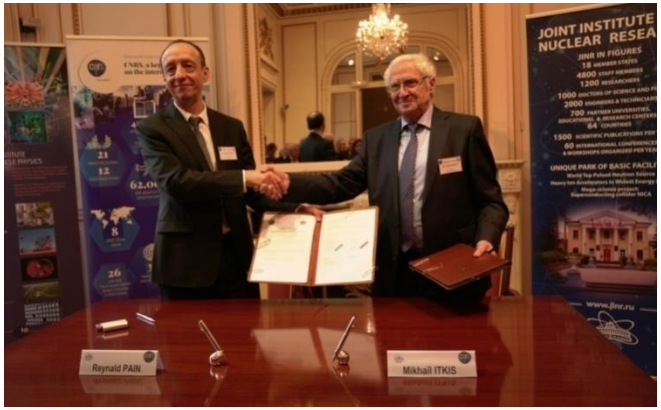
The event was led by Douglas Nakashima, Director of UNESCO's Division of Science Policy and Capacity-Building and moderated by Martiale Zebaze Kana, Chief of UNESCO's Section for Innovation and Capacity Building in Science and Engineering.

Cooperation with France: an important milestone

Day of JINR in France (Paris, 15 February 2018)

Alain Beretz - Director General for Research and Innovations the Ministry for Higher Education, Research and Innovation

Signing the Letter of Intent on concluding the MoU between the government of France and JINR. Deadline to agree on MoU text is 1 October 2018.



Reynald Pain - Director of IN2P3

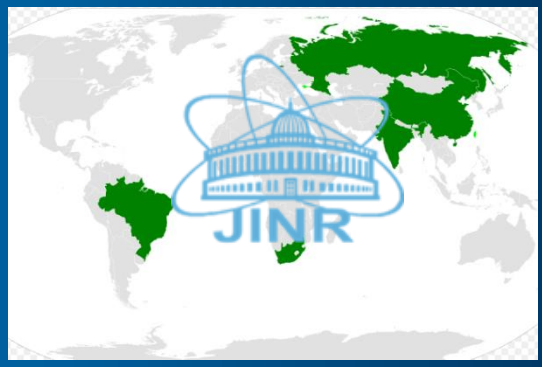
Signing the Agreement of cooperation in the field of research in nuclear physics and physics of particles between CNRS/IN2P3 and JINR for a period of five years

Prolongations of the collaboration agreements GDRI EUREA and LIA JoULE

IN2P3-JINR Joint Coordination Committee CNRS, 16 February 2018

Cooperation with BRICS

The 1st Meeting of BRICS Working Group
on Research Infrastructure and Mega-Science projects
15-16 May 2017, JINR, Dubna



Multidisciplinary Fora
«Frontiers in Nuclear,
Elementary Particle
and Condensed Matter Physics»
16-20 June 2014. India-JINR
15-19 June 2015. Brazil-JINR

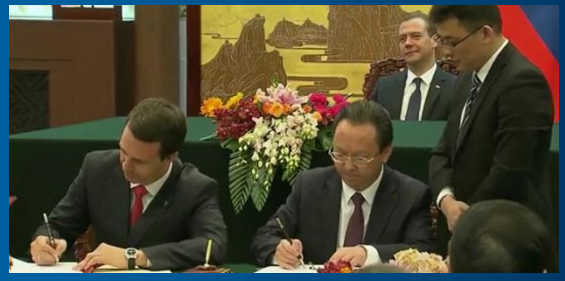
Draft Cooperation Agreements submitted
to DAE/India and to CNEN/Brazil in 2016

Ambassador of Brazil, Forum closing, 2015

Joint Secretary,
Department of Science & Technology of India
Forum follow-up visit. September 2014

The XIX meeting of the Russian-Chinese
Sub-Commission on scientific and technological cooperation
Co-chaired by the deputy ministers. 26 October 2015

20th Regular Meeting of Prime Ministers of Russia and China



Signing Quadripartite Protocol between
MES/Russia, MOST/China, CAS/China and JINR, 17 December 2015

JINR-Israel: opening a new page of scientific cooperation

21 February 2018

The framework agreement on cooperation between the Joint Institute for Nuclear Research and the Israel Academy of Sciences and Humanities represented by the Israeli Committees for High Energy Physics and Nuclear Physics was signed in the JINR Directorate.

The agreement for 5-year cooperation is focused on the fields of experimental and theoretical, astroparticle, nuclear and particle physics and related technologies.

The agreement also presupposes joint participation in projects of experiments and R&D efforts, exchange of information, technology and scientists, organization of joint seminars and schools.

Dubna, 21 February 2018

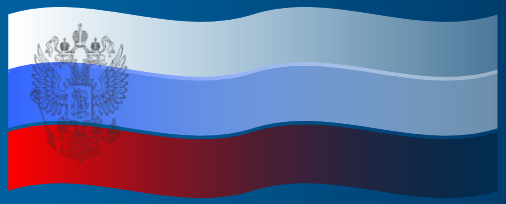
High representatives of the Israel Academy of Sciences who came to JINR for signing the agreement were Chairman of the Israel Committee for High Energy Physics **Eliezer Rabinovici** and Chairman of the Israel Committee for Nuclear Physics **Itzhak Tserruya** who is also Chairman of the JINR PAC for Particle Physics.

News from our colleagues from China

Prof. Gao Jie:

“I have attended the CPCC Conference which is like SENATE meeting in your country. I have made proposal to President Xi in a face to face meeting on suggestions including China should apply to Dubna associate membership. My written proposal has been deposited to MOST. We think it is good for China and Dubna”.

Ratification of the Agreement between the Government of the Russian Federation and the Joint Institute for Nuclear Research



In 2000, a Russian Federal Law, principally important for JINR, was signed by President Vladimir Putin

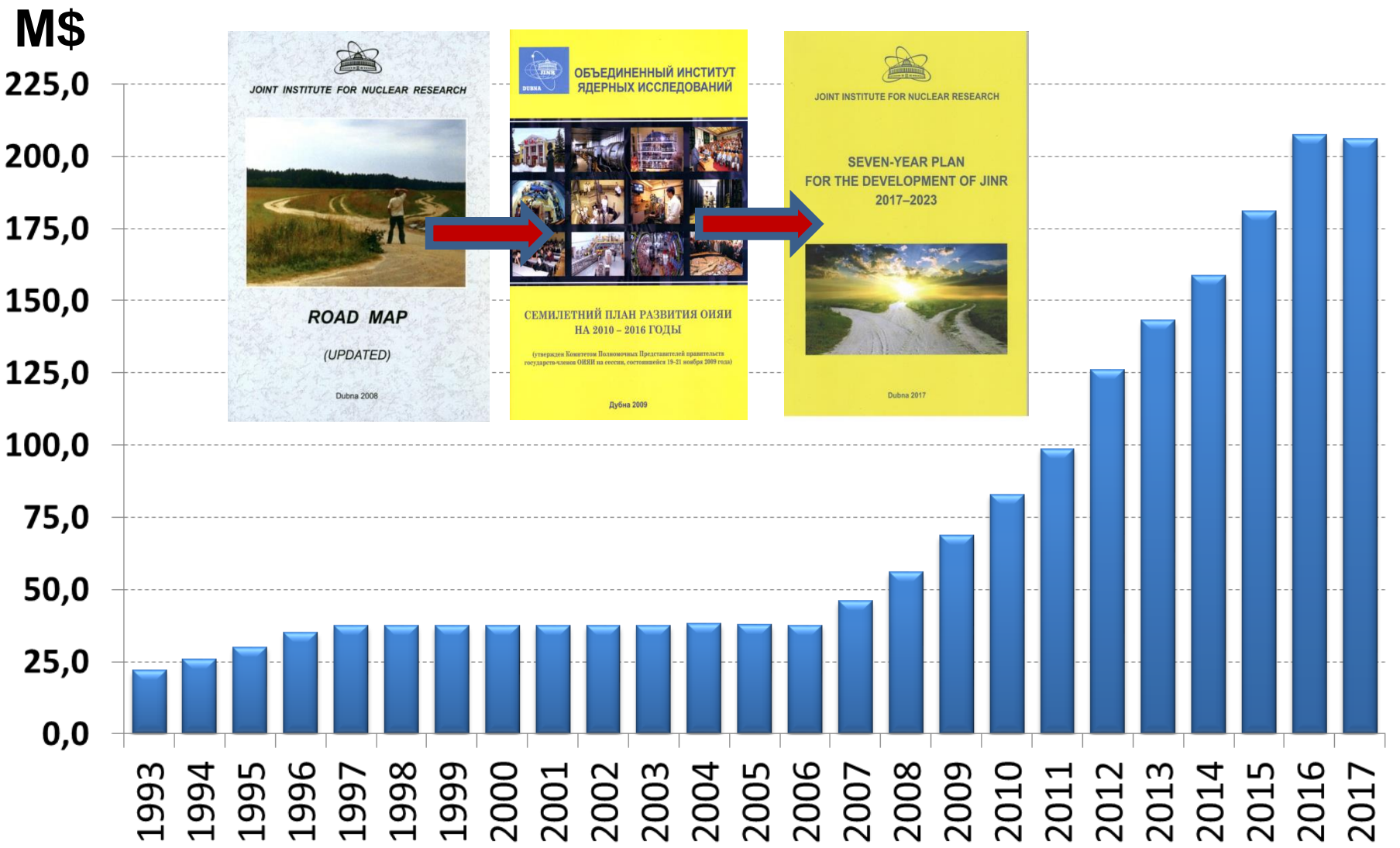
"The Agreement between the Government of the Russian Federation and JINR on the Location and Terms of Activity of JINR in the Russian Federation".

This Agreement grants privileges and immunities in accordance with established practice for international intergovernmental organisations.

The Agreement was signed by Vladimir Putin on his first working day in the new position: 02.01.2000

Committee of Plenipotentiaries of the JINR Member States Governments has approved in November 2016 the new 7-Year Plan for INR development in 2017-2023 with the goal of modernization of existing and creation of the new basic facilities for fundamental research in integration with the European and World research strategy programs.

JINR Budget 1993–2017 => “2017-2023”



JINNR Research Programme

High Energy Physics
Hadron Matter Physics
Relativistic Nuclear Pnysics

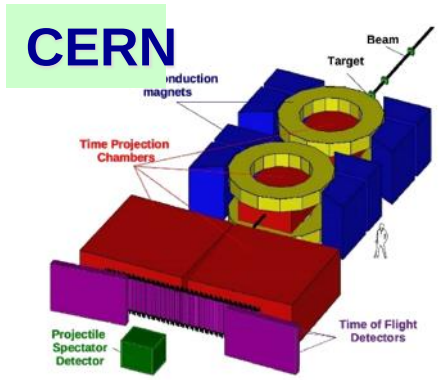
NICA (Nuclotron based Ion Colider fAcility)

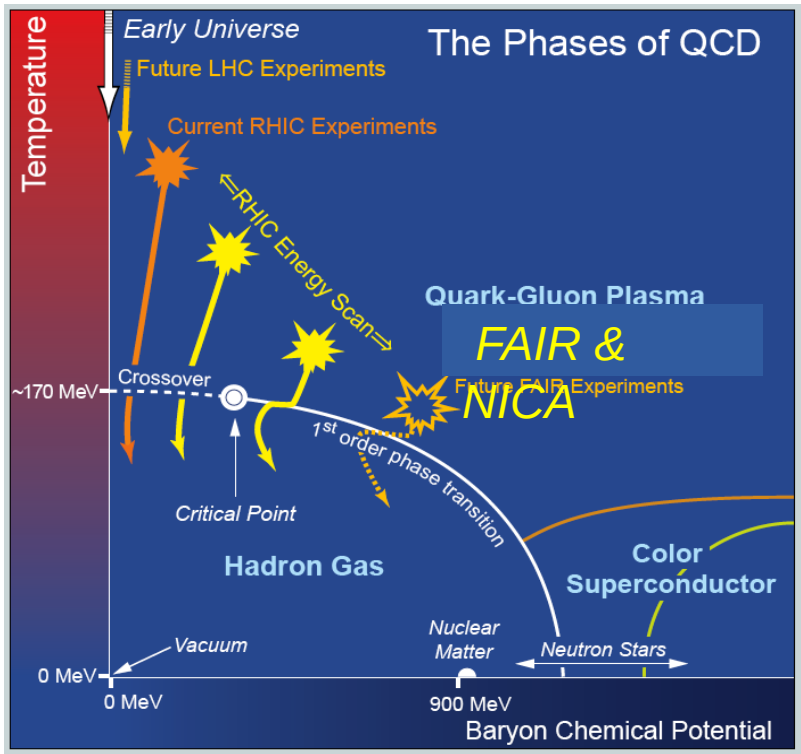
- development of accelerator facility for HEP @ JINR,
- construction of Collider of relativistic ions from p to Au, polarized protons and deuterons

with energies up to $\sqrt{S_{NN}}$ = 11 GeV (Au^{79+}) and = 27 GeV (p, d)

Mega-science project at JINR:
Nuclotron Based Ion Collider Facility (NICA)

25 March 2016
NICA “cornerstone” ceremony
The Veksler-Baldin Laboratory of HEP, JINR

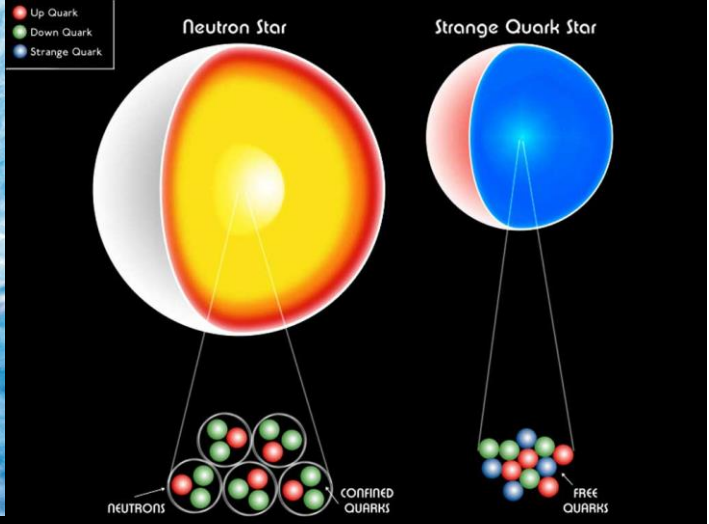




NICA has the most interesting energy diapason ($\sqrt{s_{NN}}$ ~ 10 GeV) corresponding to the region of the maximal density of baryonic or nuclear matter which nobody has had yet achieved in the laboratories. Main Goal - studying the critical phenomena and phase transitions happened to appear in the Early Universe and presumably existing in the Neutron Stars.

- ✓ ***FAIR (GSI, Darmstadt) – Fixed target experiments***
- ✓ ***NICA (JINR, Dubna) – Collider experiments***

The Neutron Star



- Highest density matter in the universe

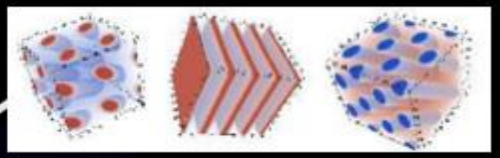
  $M = 1\sim2\ M_\odot$, $R \sim 10\sim20$ km

  $\Rightarrow$ Density of the core = $3\sim10\rho_0$ ($1\sim3$ Btons/cm^3)

  ρ_0: nuclear density

- Various forms of matter made of almost only quarks

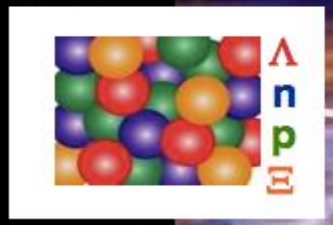
Nuclear "Pasta"



Nuclear + Neutron Matter

Neutron Matter

Superfluid



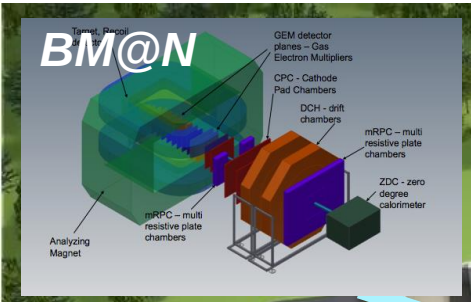
Strange Hadronic Matter ?

High density nuclear matter with hyperons (strange quarks)

Quark Matter ??

Deconfined quarks
Color superconductivity

basic facility



SPD

E-cooling

MPD (Detector)

BM@N (Detector)

Collider ring (c=503 m)

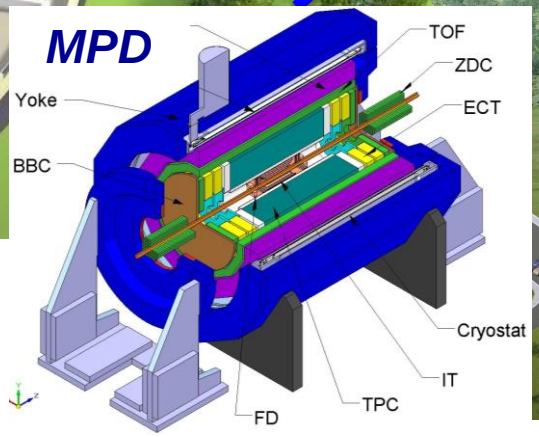
Injection Complex

Nuclotron

Booster

Nuclotron ring (c=251,5 m)

applied research area



Center NICA

NICA civil construction

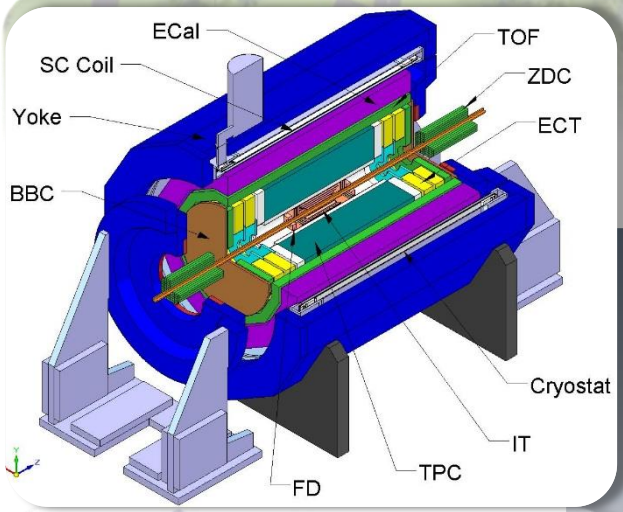
MPD Hall will be ready for equipment installation at the end of 2018

Conclusion

The NICA accelerator complex in the full configuration is scheduled to be put into operation in 2023 at JINR.

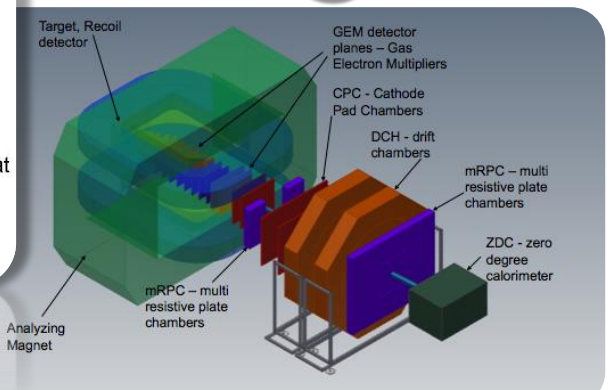
Status of the NICA complex realization (2017)

Nuclotron & channels	40%
Injection complex	49%
Booster	64%
Collider	18%
MPD	35%
BM@N	60%
SPD	2%
Infrastructure	39%
Innovation area	1%
IT & computing	25%



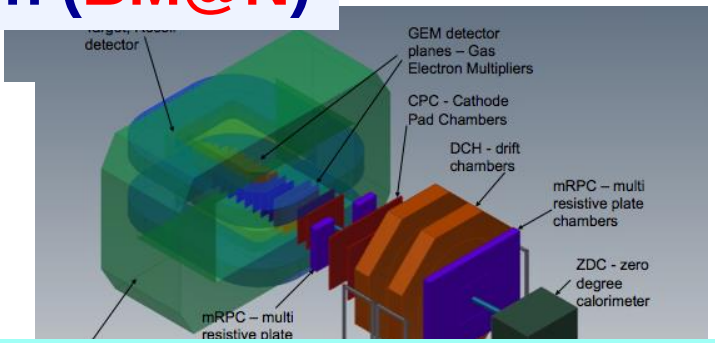
MPD

BM@N



NICA Center

Baryonic Matter at Nuclotron (BM@N)



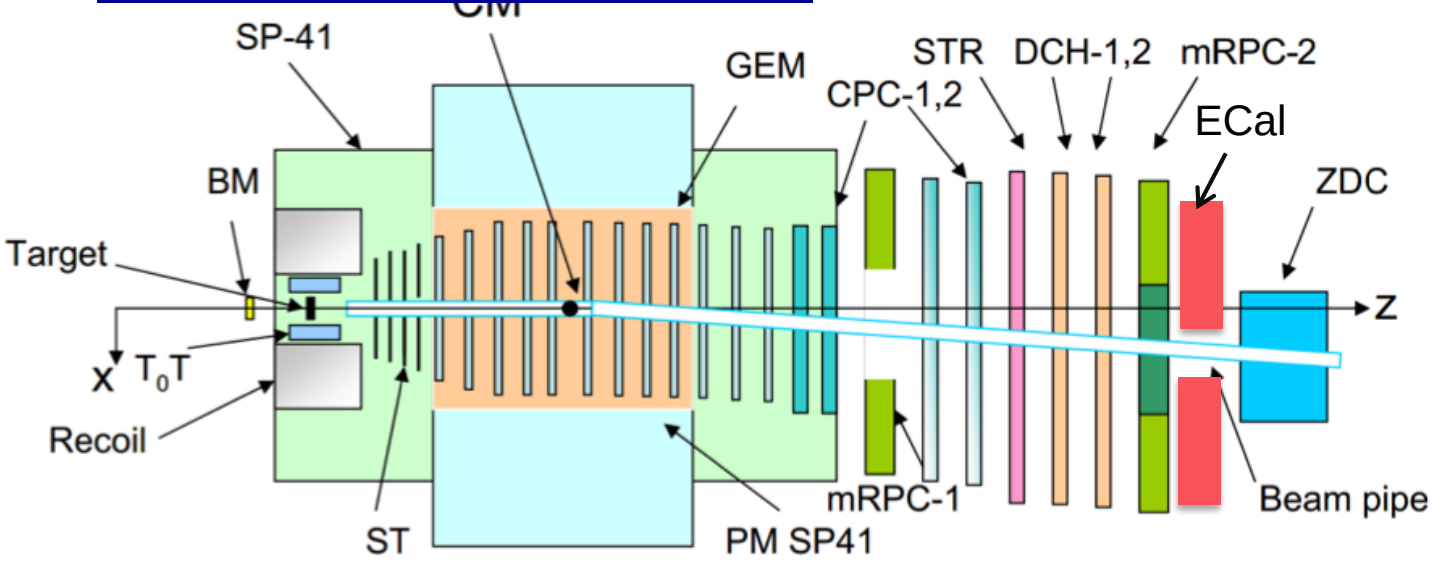
BM@N cooperation:

Russia: *INR RAS, MEPI, SINP MSU, ITEP KI, others*
Bulgaria: *Plovdiv University;*
China: *Tsinghua University, Beijin;*
Poland: *Warsaw Tech.Uni.*
Israel: *Tel Aviv Uni.,*
Germany: *Frankfurt Uni.; GSI*
USA*: MIT, FIU, ODU, PSU*
France: *CEA*

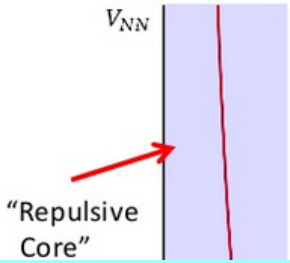
The first run has started on March 22, 2018:

- ***^{40}Ar beam 3,2 GeV/u;***
- ***targets: C - Pb***
- ***20M events already recorded.***

BM@N *schematic view*



The first experiment at BM@N :
"Probing the Short-Range Correlations"



2-pion exchange attractive; omega-exchange repulsive

$$V_{NN} = -g_\pi^2 \frac{e^{-2\mu_\pi r}}{r} + g_\omega^2 \frac{e^{-\mu_\omega r}}{r}$$

(Yukawa potentials!)

$\mu_\pi = m_\pi/(\hbar c)$

$\mu_\omega = m_\omega/(\hbar c)$

$g_\omega^2/(\hbar c) = 29.6$

$g_\pi^2/(\hbar c) = 10$

BM@N collaboration +

***Israel**: Tel Aviv University*

***Germany**: TUD and GSI*

***USA**: FIU, MIT, ODU, PSU*

***France**: CEA*

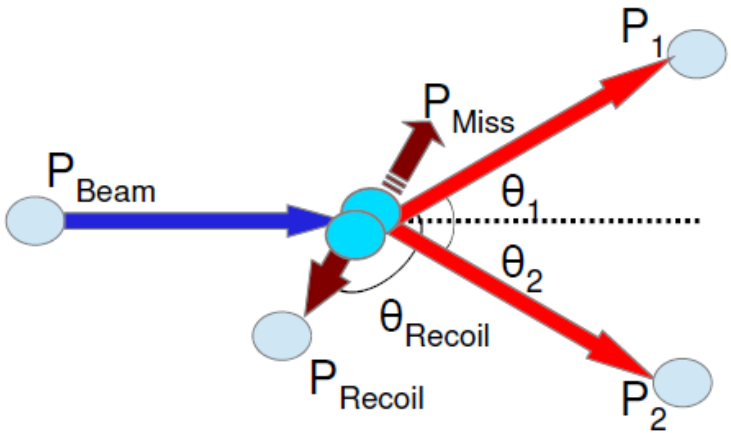
The first run on March 3-17:

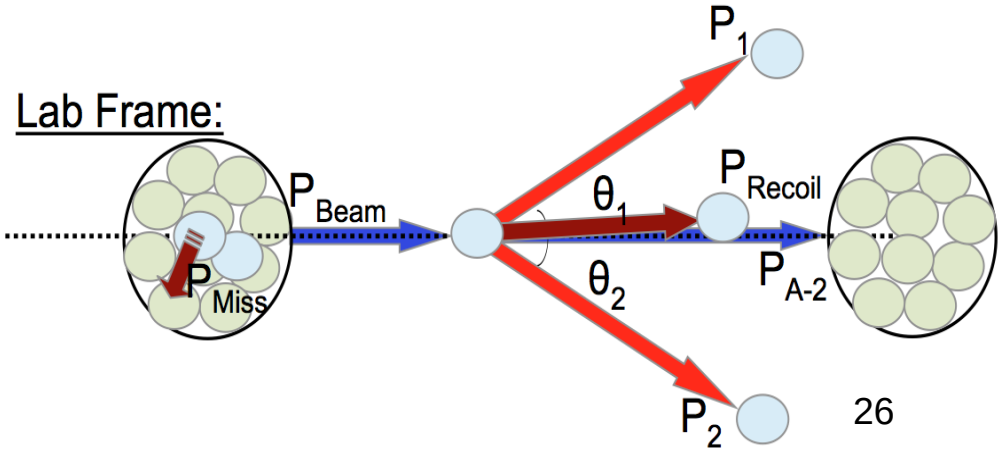
- ***^{12}C beam 4 GeV/u;***
- ***Hydrogen target;***
- ***time 324 hours;***
- ***20M events recorded (19Tb).***

$^{12}C + p \rightarrow 2p + {}^{11}_{5}B$ QE

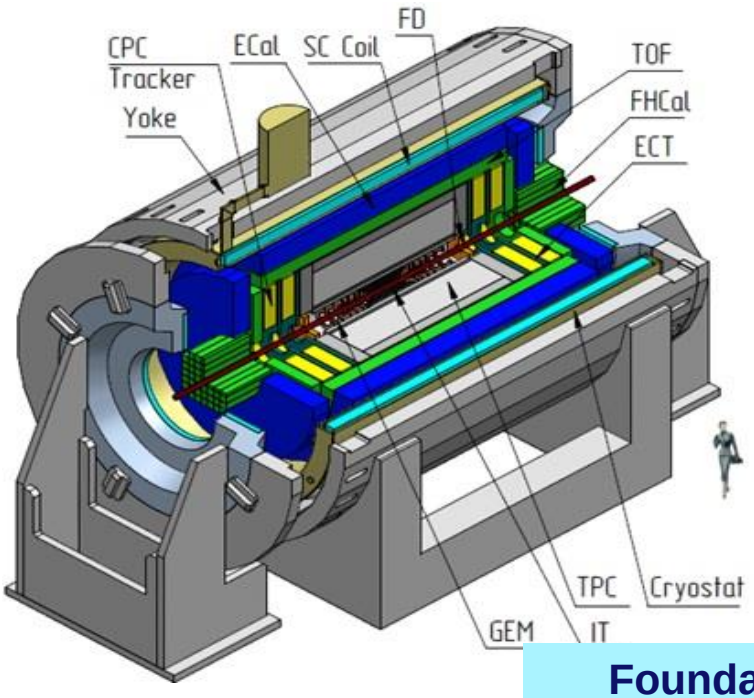
$^{12}C + p \rightarrow 2p + {}^{10}_{5}B + n$ np SRC

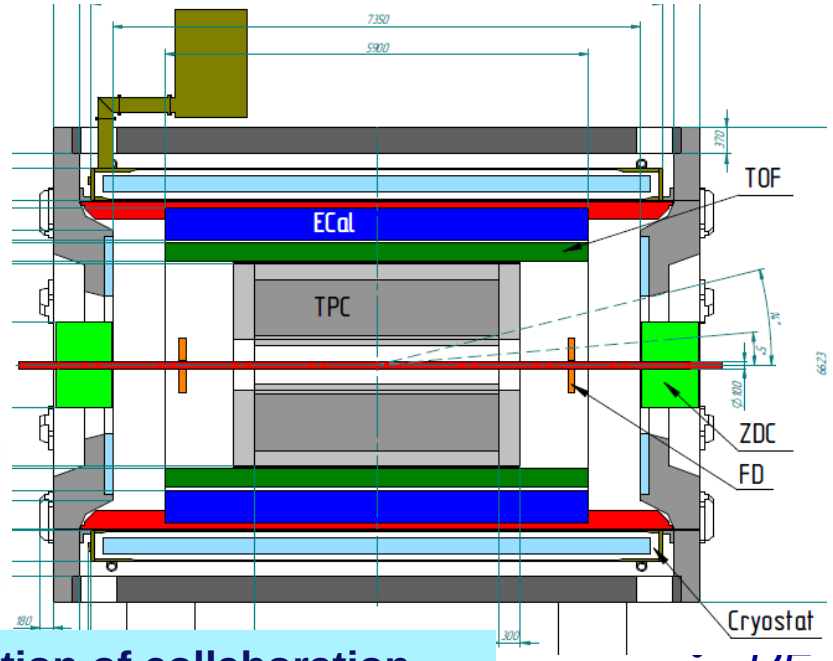
$^{12}C + p \rightarrow 2p + {}^{10}_{4}Be + p$ pp SRC





Multi Purpose Detector @ NICA





Foundation of collaboration
April, 2018

MPD Collaboration:

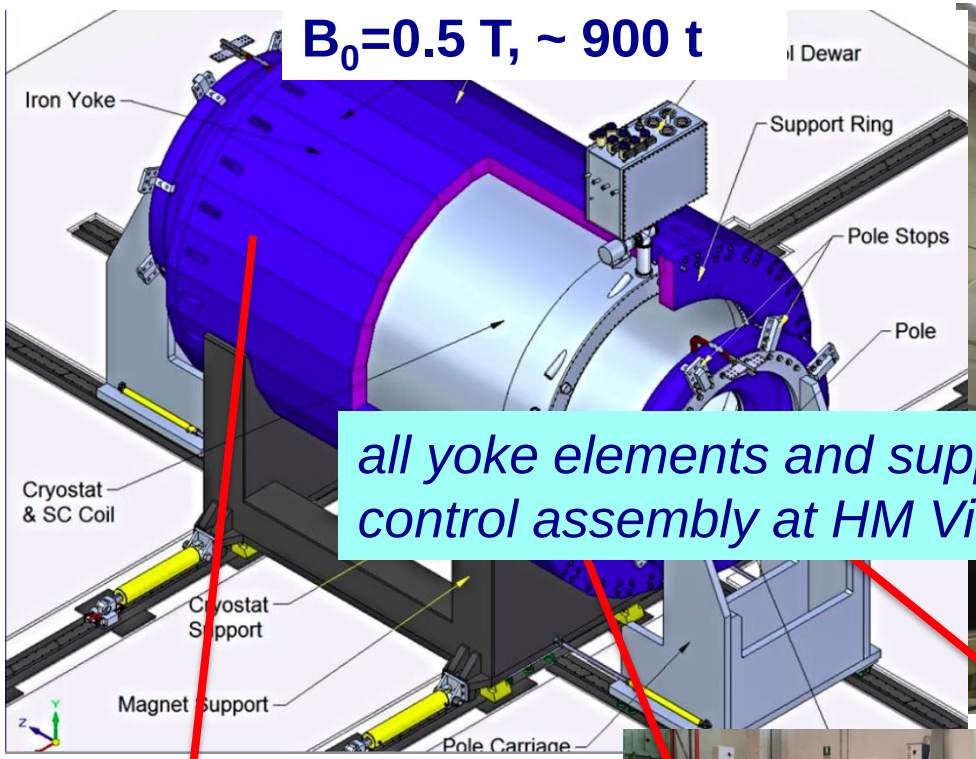
- *JINR, Dubna;*
- *Tsinghua University, Beijing, China;*
- *GSI, Germany*
- *MEPhI, Moscow, Russia.*
- *INR, RAS, Russia;*
- *PPC BSU, Minsk, Belarus;*
- *WUT, Warsaw, Poland;*

expression of interest:

- *CERN;*
- *DF, US, Mexico;*
- *ICN UNA; Mexico;*
- *DF, CIEA del I.P.N, Mexico;*
- *FCF-M UAS, Sinaloa, Mexico;*
- *FCF-MB UAP, Puebla, Mexico;*
- *PI Az.AS, Baku, Azerbaijan;*
- *ITEP, NC KI, Moscow, Russia;*
- *PNPI NC KI, Saint Petersburg, Russia;*
- *CPPT USTC, Hefei, China;*
- *SS, HU, Huzhou, Republic of South Africa.*

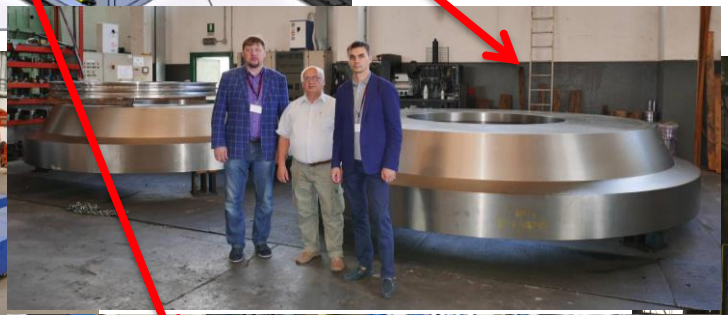
Magnet production: *at ASG (Genova) & Vitkovice HM*

B_0=0.5 T, ~ 900 t



the first SC coil winding has started

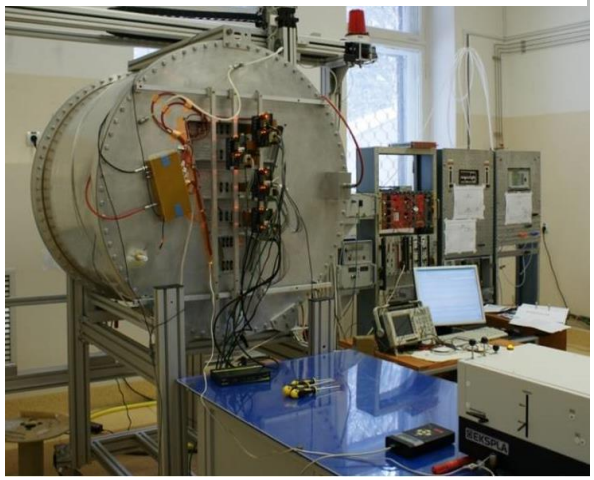
all yoke elements and support structure are produced; control assembly at HM Vitkovice will start soon



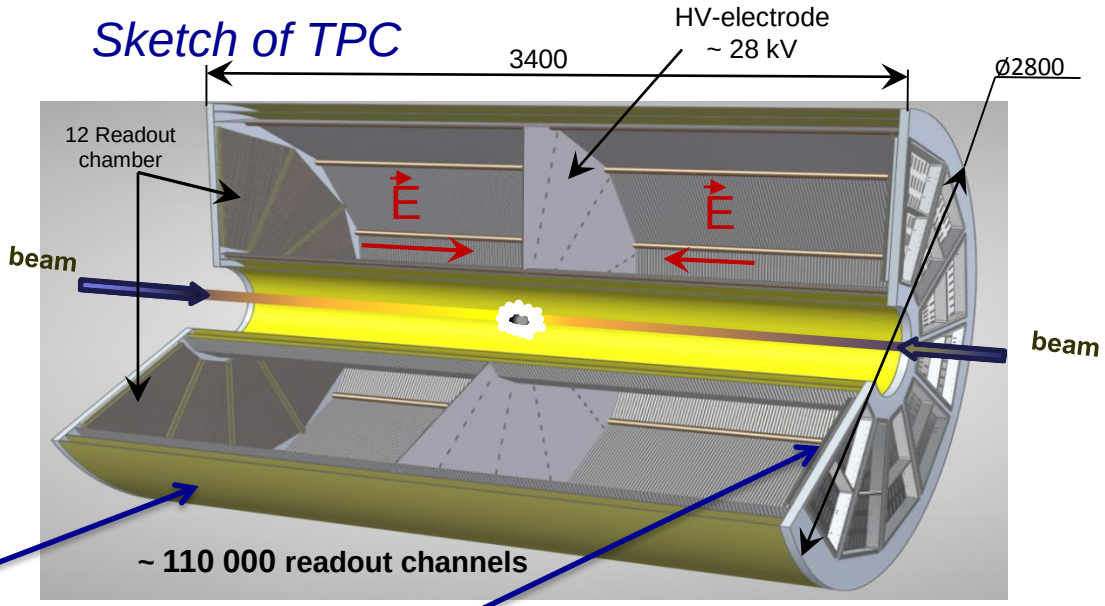
Time Projection Chamber

Leaders: *S. Movchan, Yu. Zanevsky*

TPC Prototype

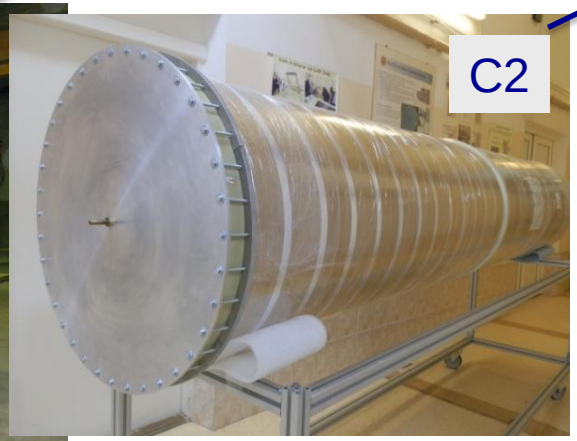


Sketch of TPC



C3

C2



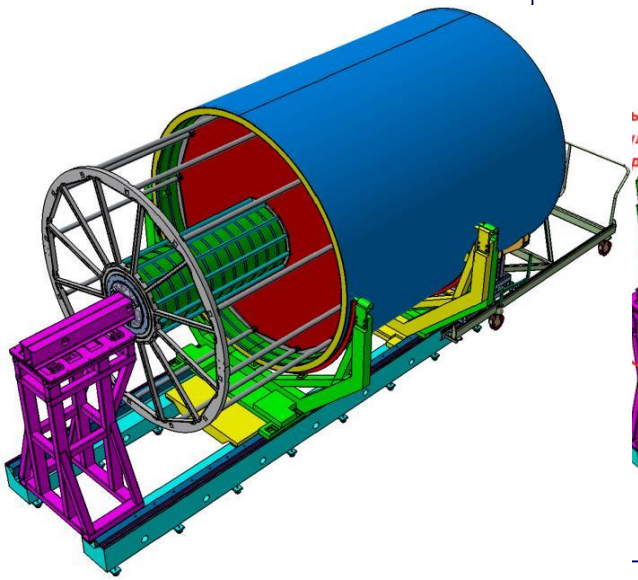
Project status:

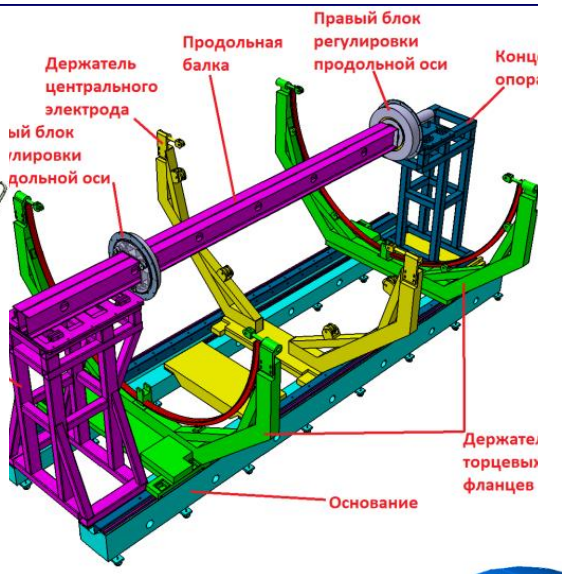
-basic R&D finished, (cont. alternative RO Ch.);

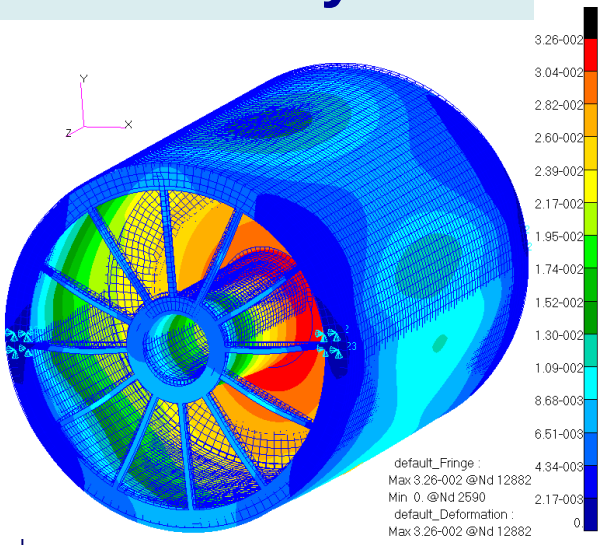
*-assembly workshop in preparation (readiness – IIq., **2016**)*

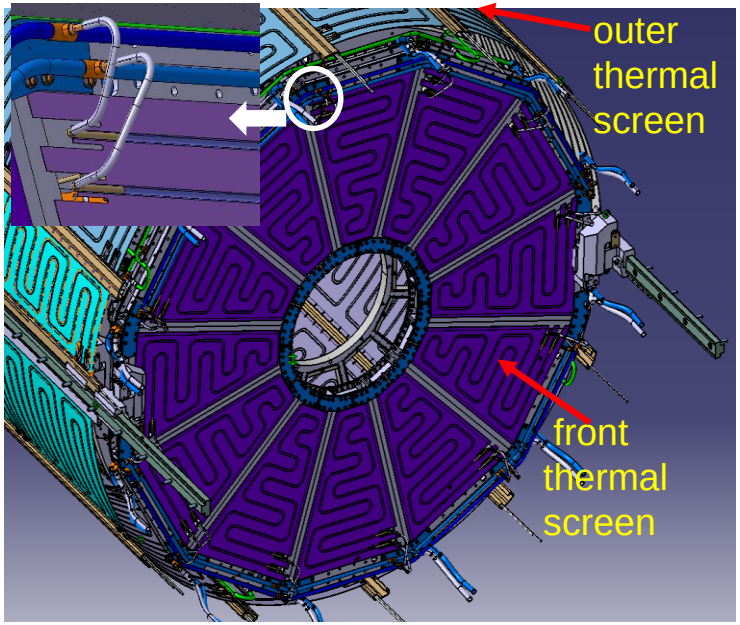
Works are going in accordance with the schedule

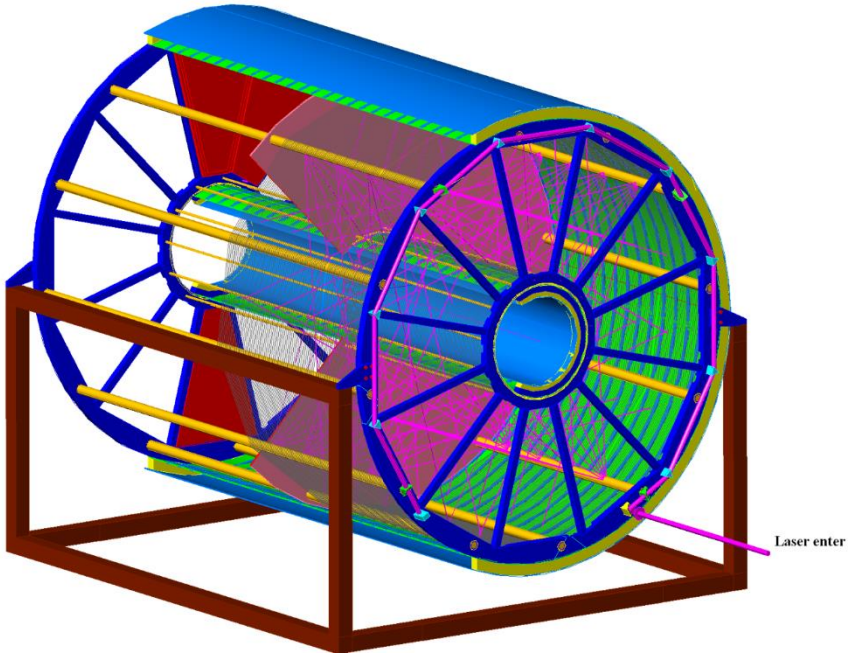
TPC assembly tools, cooling & laser calibration system





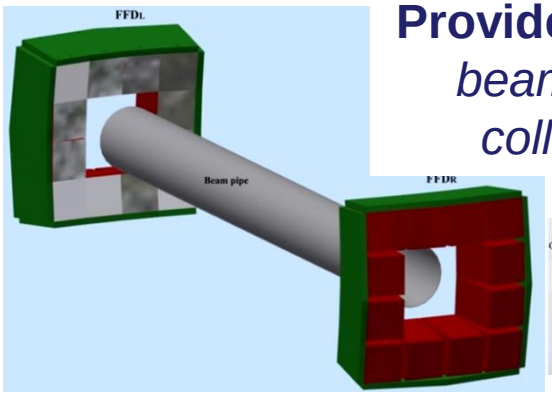




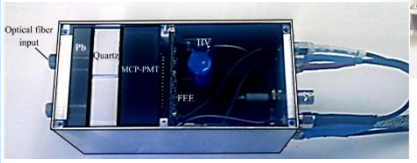


Time of Flight system (TOF)

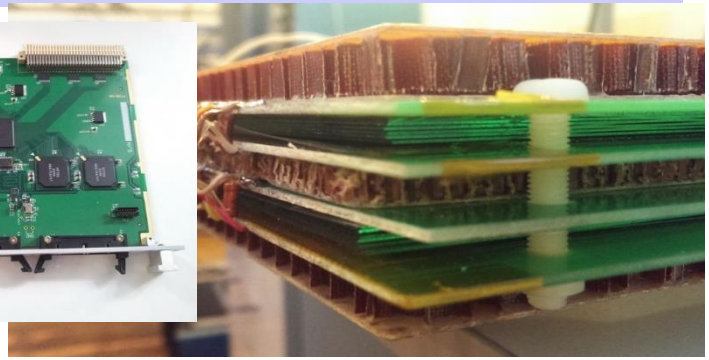
Fast Forward Detector (FFD): *production stage*



Provides: *T0 for TOF, beam adjustment & collision L0-trigger*

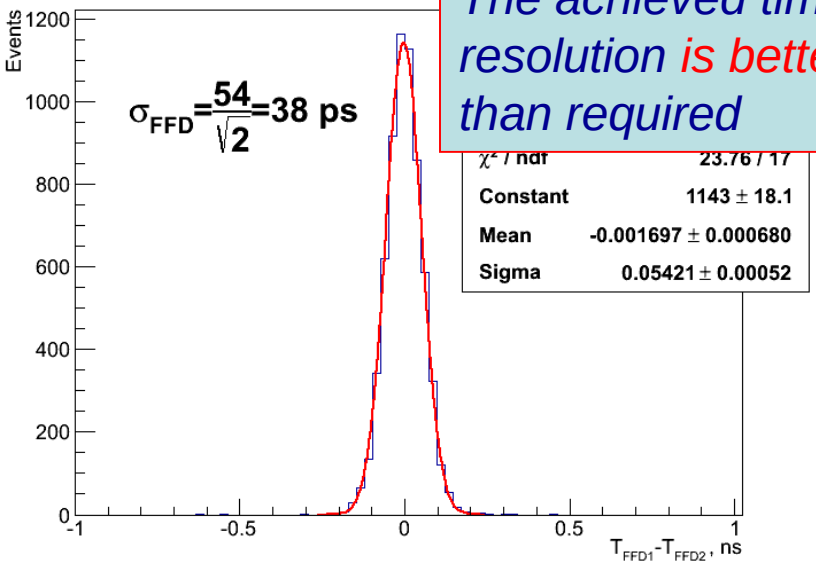


mRPC – TDR has been prepared, *ready for mass production*

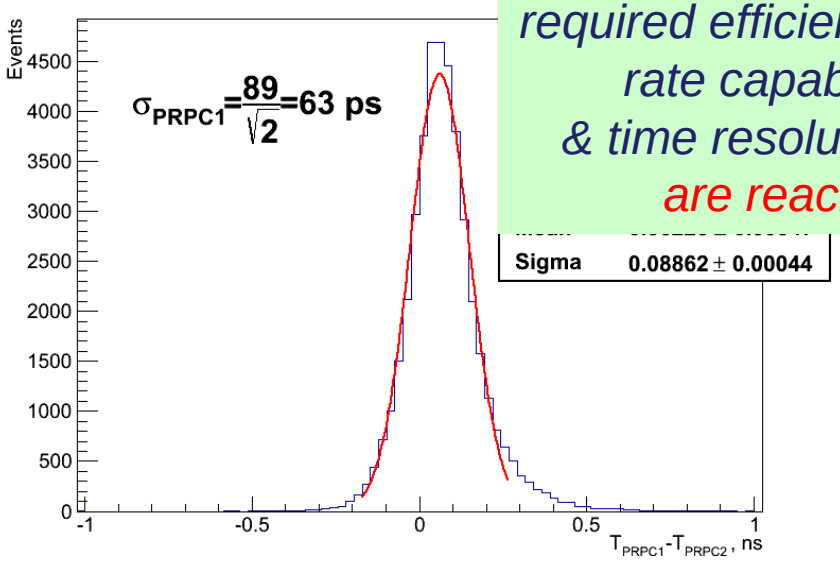


Zhu Weipinga, Wang Yi, Feng Shengqin, Wang Jingbo, Huang Xinjie, Shi Li, V. Babkin, V. Golovatyuk, M. Rumiantcev, G. Eppley, T. Nussbaum, ***NIM A 735, 277–282, 2014***

The achieved time resolution is better than required



required efficiency, rate capability & time resolution are reached

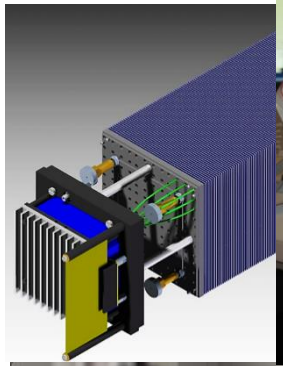


Calorimetry

ECAL – *TDR - in preparation*

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

Energy resolution **2.5% / √E**

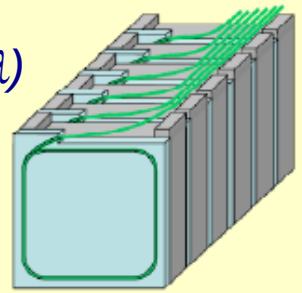


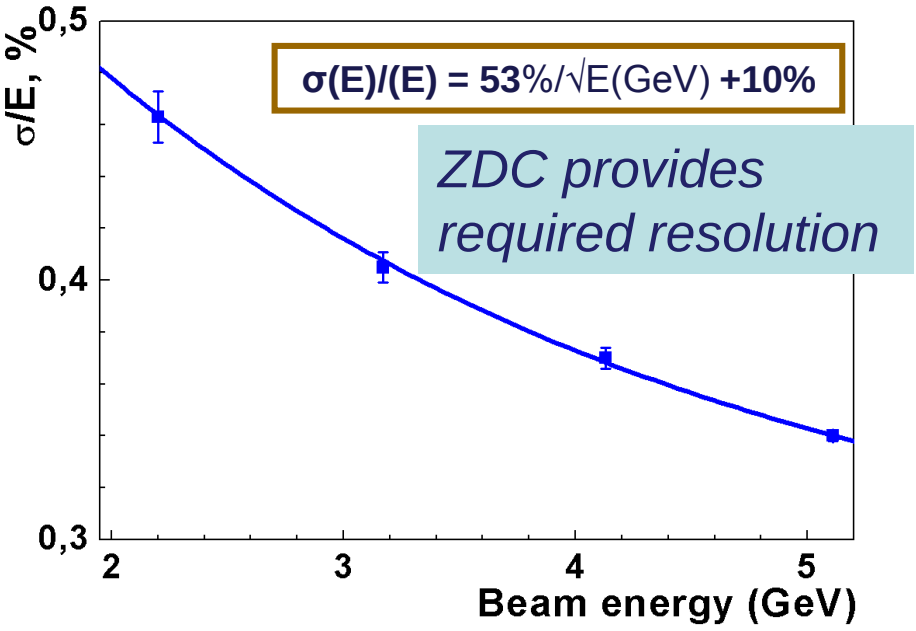
Preparation for tests with electron beams at DESY (December'13)

Zero Degree Calorimeter (ZDC): TDR stage

ZDC coverage: 3.2<|η|< 4.8

Pb-scintillator sampling (5λ)
Read-out: fibers + AvalanchePD





ZDC provides required resolution

Inner Tracking System

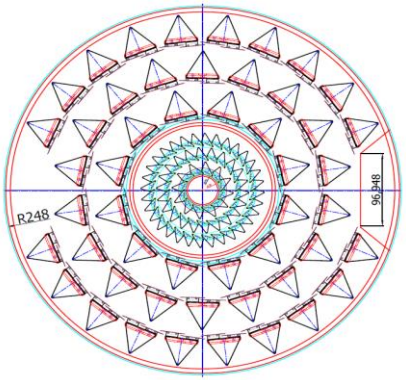
*cooperation with **CBM/FAIR**, **ALICE/CERN**:*

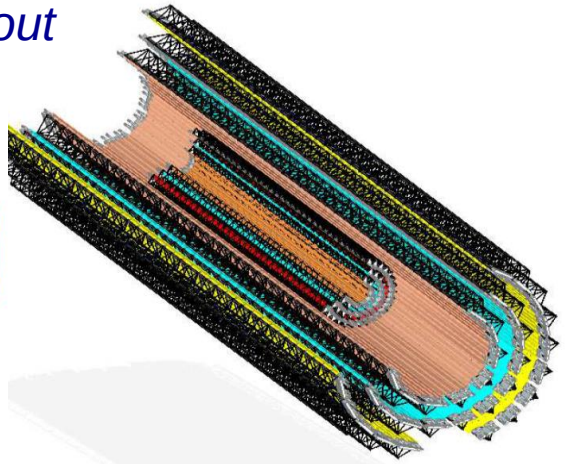
- *manufacturing the **ITS** carbon fiber space frames for **NICA** (BM@N & MPD)& **FAIR;***
- *construction of **ALICE type** (MAPS) **ITS***

*workshop for detector assembly & test was put in operation in **2015***

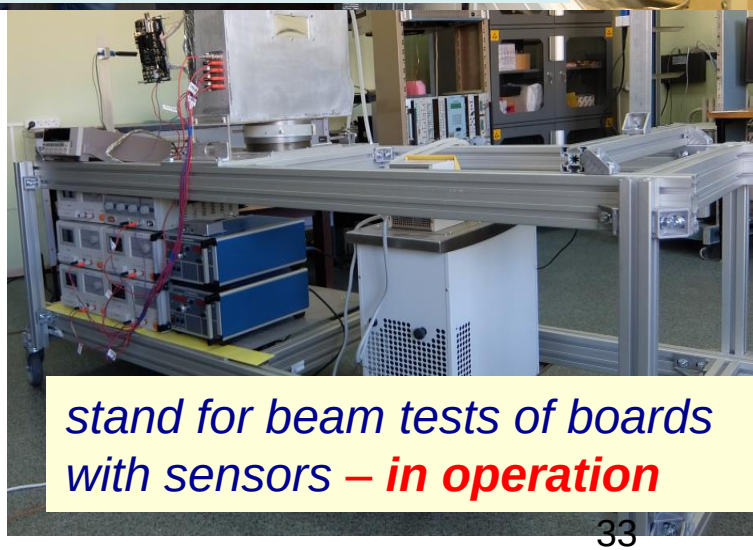
D. Gross in the workshop

***ITS MPD** layout*





# layer	R0 mm	Active l, mm	N of staves	N of chips / layer	active area, cm2	number of pixel cells,
1	24,4	542,4	12	216	889,9	113 246 208
2	42,0	542,4	22	396	1 087,7	207 618 048
3	60,0	542,4	32	576	1 582,1	301 989 888
4	107,	1477,5	12	2 352	4 845,1	1 233 125 376
5	156,5	1477,5	18	3 528	7 267,7	1 849 688 064
6	206,5	1477,5	24	3 920	9 690,2	2 055 209 960
Total:				10 988	25 362,7	5 760 877 544



*stand for beam tests of boards with sensors – **in operation***

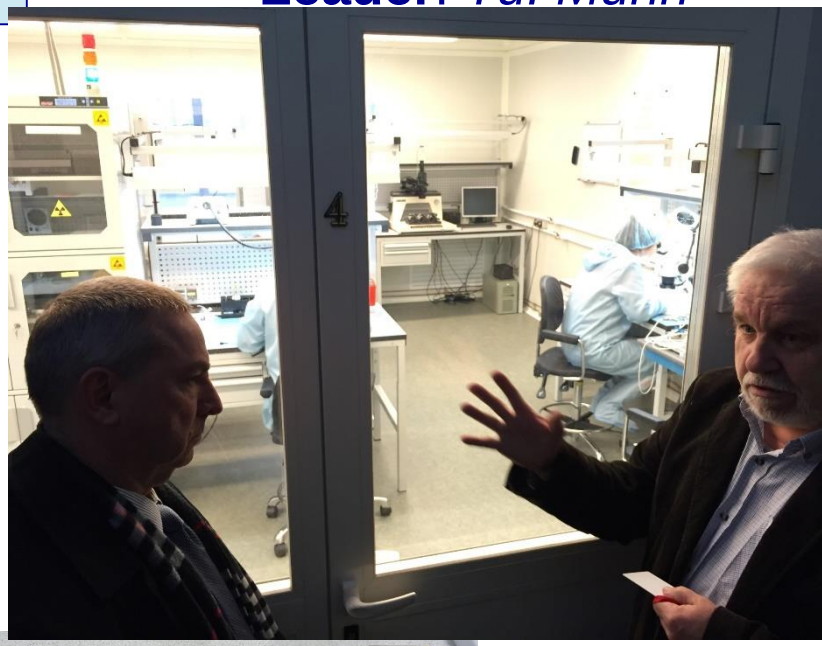
Workshop for microstrip detector assembly & test

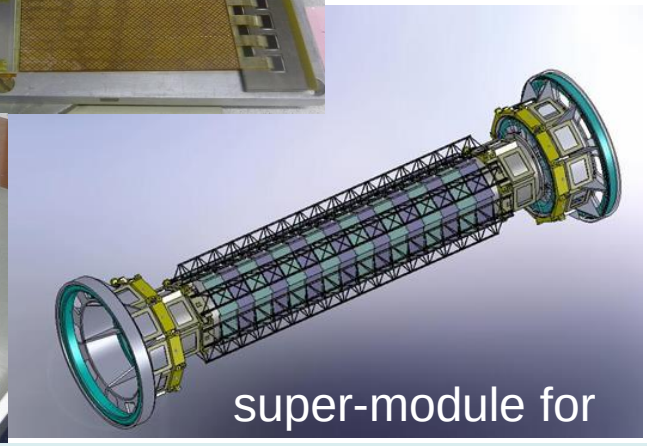
CBM-MPD Consortium

Leader: *Yu. Murin*

the clean workshop has started operation in 2015.

***CERN** & **JINR** have signed **MoU** for manufacturing the STS carbon fiber frames for **NICA** (BM@N & MPD) and **FAIR** (CBM)*





project is supported by the **CREMLIN** grant *(framework of HORIZON-2020)*

The kick-off meeting on formation of the MPD and BM@N Collaborations

took place in Dubna on 11-13 April, 2018.

detailed information about the meeting can be found at:
https://indico.jinr.ru/conferenceDisplay.py?confId=385

192 participants from 18 countries

Baku State University, National Nuclear Research Center, Azerbaijan;
University of Plovdiv, Bulgaria;
University Tecnica Federico Santa Maria, Valparaiso, Chili;
Tsinghua University, Beijing, China;
USTC, Hefei, China;
Huizhou University, Huizhou, China;
Shandong University, Shandong, China;
Institute of Nuclear and Applied Physics, CAS, Shanghai, China;
Central China Normal University, China;
Institute of High Energy Physics, Beijing, China;
University of South China, China;
Palacky University, Olomouc, Czech Republic;
Nuclear Physics Institute CAS, Rez, Czech Republic;
Tbilisi State University, Tbilisi, Georgia;
Tubingen University, Tubingen, Germany;
Tel Aviv University, Tel Aviv, Israel;
Institute of Physics and Technology, Almaty, Kazakhstan;

UNAM, Mexico City, Mexico;
Institute of Applied Physics, Chisinev, Moldova;
Warsaw University of Technology, Warsaw, Poland;
National Center for Nuclear Research, Otwock – Swierk, Poland;
University of Wroclaw, Wroclaw, Poland;
Jan Kochanowski University, Kielce, Poland;
INR RAS, Moscow, Russia;
MEPhI, Moscow, Russia;
PNPI, Gatchina, Russia;
Skobeltsin Institute of Nuclear Physics MSU, Moscow, Russia;
SPSU - Dept. of NP, St. Petersburg, Russia;
SPSU – Dept. of HEP, St. Petersburg, Russia;
Kurchatov Institute National Research Center, Moscow, Russia;
MIT, Cambridge, USA;

JINR, Dubna.

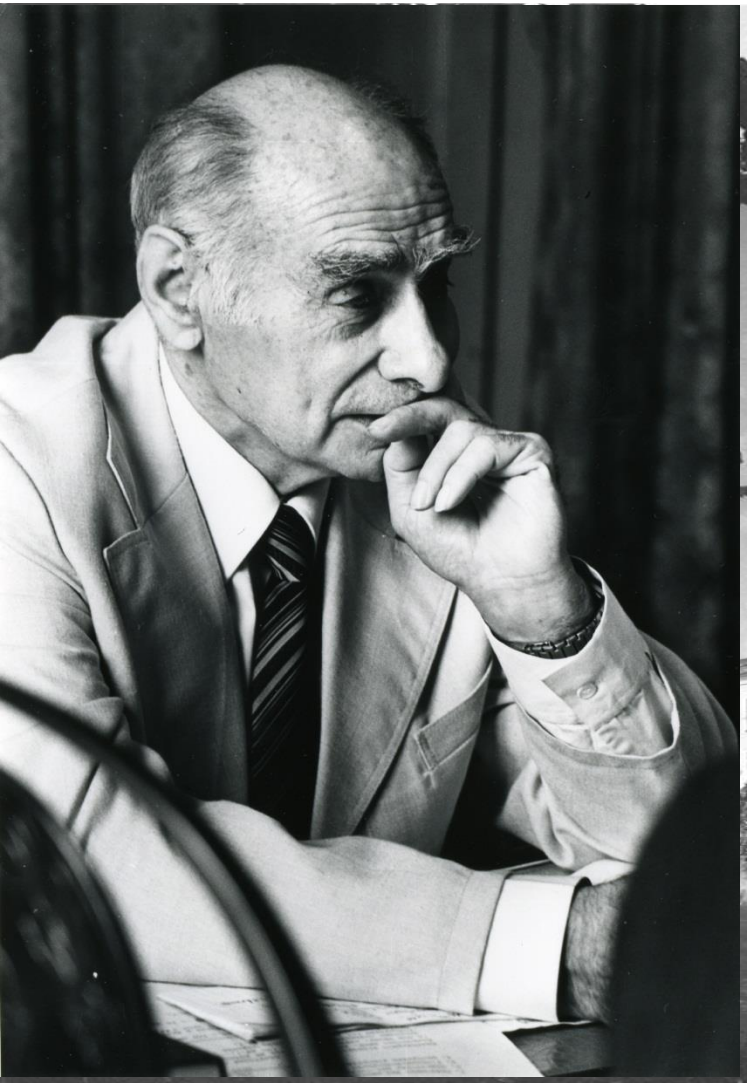
NICA the Basic configuration milestones

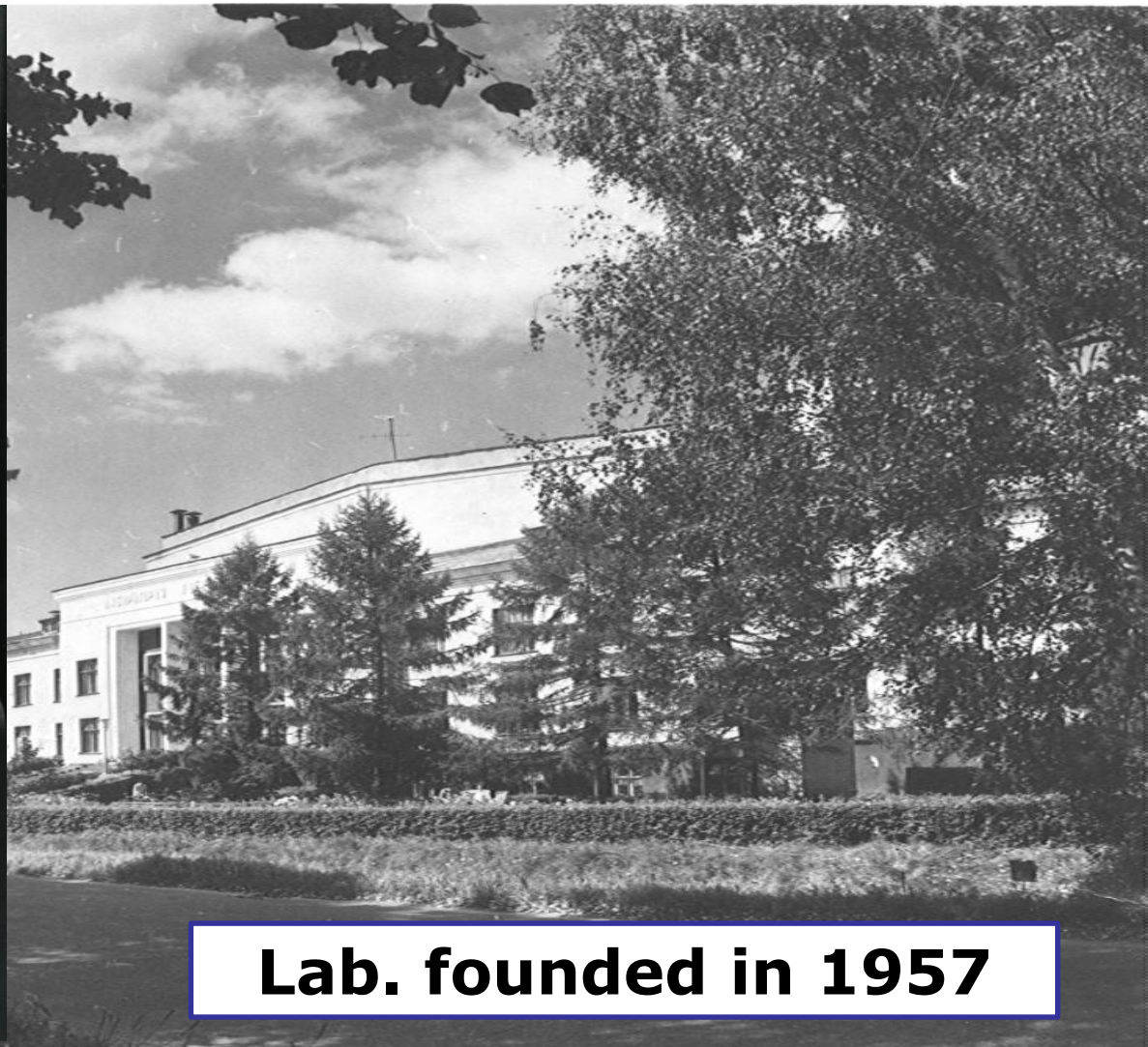
- ***2017*** *– start of* ***BM@N*** *experiment*
- ***2018*** *– start of* ***Booster*** *assembly*
- ***2019*** *–* ***MPD*** *magnet commissioning*
- ***2019*** *– start of* ***MPD*** *detectors assembly*
- ***2020*** *– completion of NICA civil constructions (****b. 17)***
- ***2020*** *– start of* ***Collider*** **assembly**
- ***2020*** *– start of* ***Collider*** *commissioning*
- ***2020*** *– start of* ***MPD*** *commissioning*
- ***2020*** *– completion of* ***«Center NICA»*** *construction*
- ***2020 –*** *start of assembly of* ***Computer center*** *elements*

«Center NICA» design

“NICA Center”
Contract for the design is concluded

Ac. G.N. Flerov, JINR Lab. of Nuclear Reactions under his name

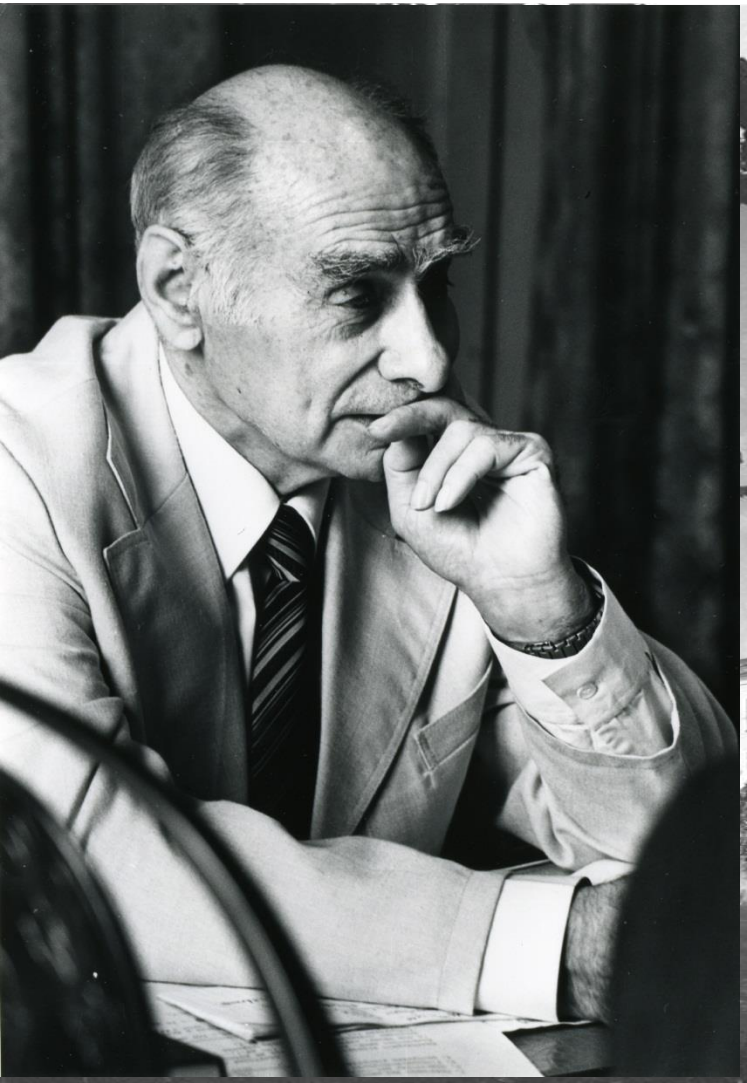




Lab. founded in 1957

FLEROV LABORATORY of NUCLEAR REACTIONS

Ac. G.N. Flerov, JINR Lab. of Nuclear Reactions under his name

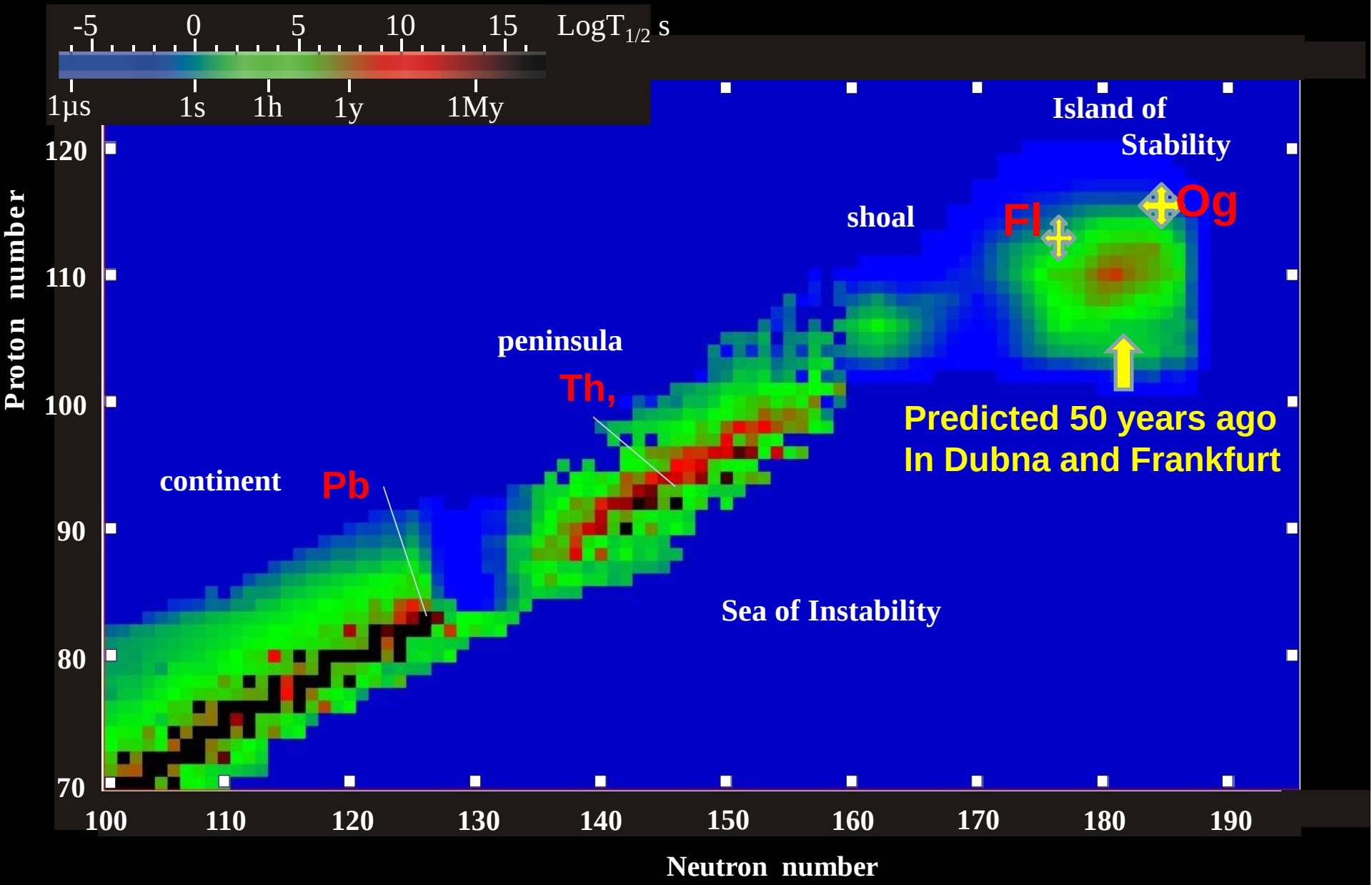


Nuclear Physics at low energies
Physics of Super heavy elements
Neutron rich Exotic nuclei
Extreme Coulomb fields
($\alpha Z > 1$)

Yuri Oganessyan

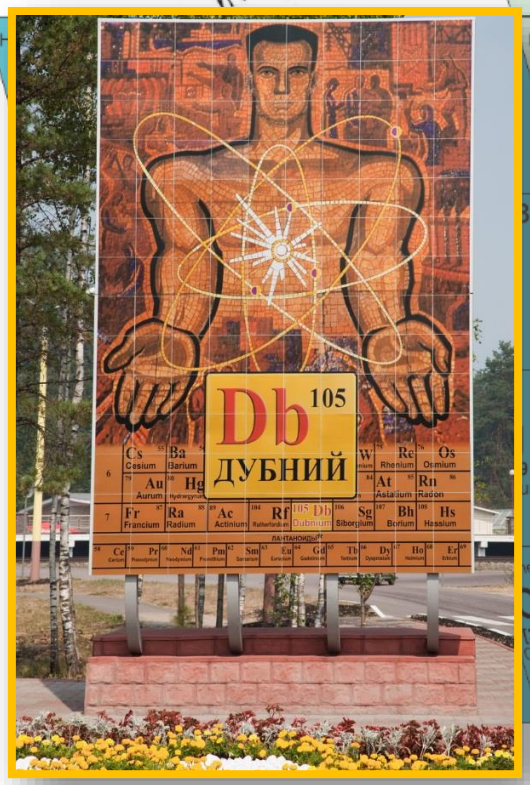
FLEROV LABORATO

New lands Search for new Island of Stability



D.I. Mendeleev's Periodic table of elements

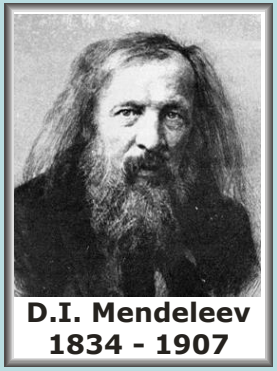
105
Db
Dubnium



Бор 5	Углерод 6	Азот 7	Кислород 8	Фтор 9	Неон 10
B 10,81 Boron	C 12,011 Carbon	N 14,007 Nitrogen	O 15,999 Oxygen	F 18,998 Fluorine	Ne 20,18 Neon
Алюминий 13	Кремний 14	Фосфор 15	Сера 16	Хлор 17	Аргон 18
Al 26,982 Aluminum	Si 28,085 Silicon	P 30,974 Phosphorus	S 32,06 Sulfur	Cl 35,45 Chlorine	Ar 39,948 Argon
Галлий 31	Германий 32	Мышьяк 33	Селен 34	Бром 35	Криптон 36
Ga 69,723 Gallium	Ge 72,630 Germanium	As 74,922 Arsenic	Se 78,971 Selenium	Br 79,904 Bromine	Kr 83,798 Krypton
Индий 49	Олово 50	Сурьма 51	Теллур 52	Иод 53	Ксенон 54
In 114,82 Indium	Sn 118,71 Tin	Sb 121,76 Antimony	Te 127,60 Tellurium	I 126,90 Iodine	Xe 131,29 Xenon
80	Таллий 81	Свинец 82	Висмут 83	Полоний 84	Астат 85	Радон
	Tl 204,38 Thallium	Pb 207,2 Lead	Bi 208,98	Po [209]	At [210]	Rn [222]
ерникий 112	Нихоний 113	Флеровий 114	Московий 115	Ливерморий 116	Теннессин 117	Оганесон 118
Cn [285] Copernicium	Nh [286] Nihonium	Fl Flerovium	Mc Moscovium	Lv Livermorium	Ts Tennessine	Og Oganesson

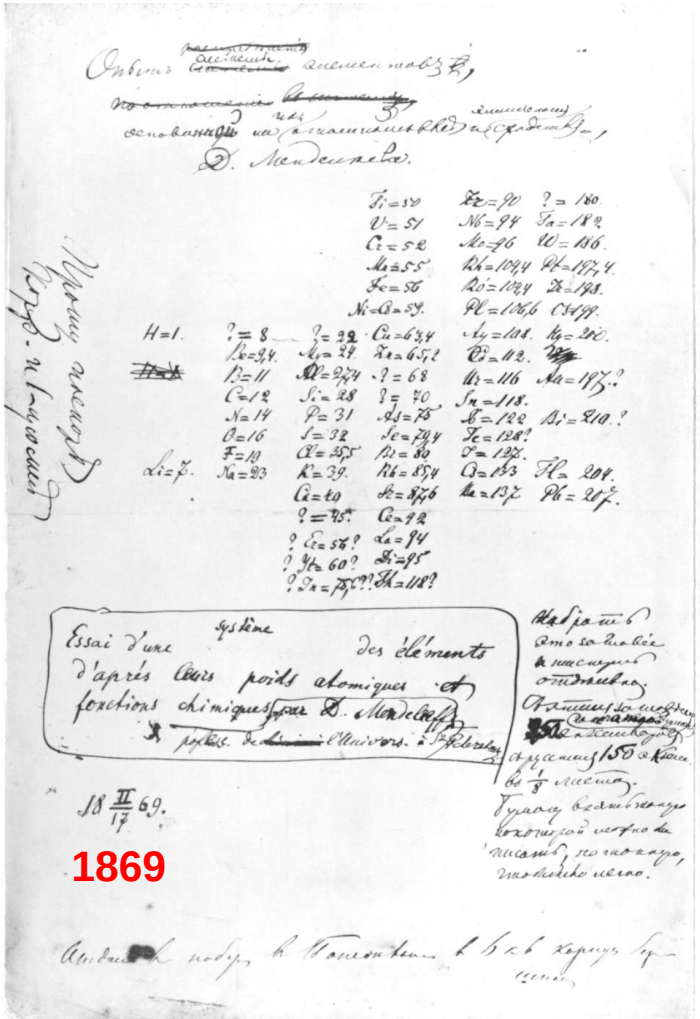
On 20 December 2017,
during its 74th Plenary Meeting the United Nations (UN) General Assembly 72nd Session

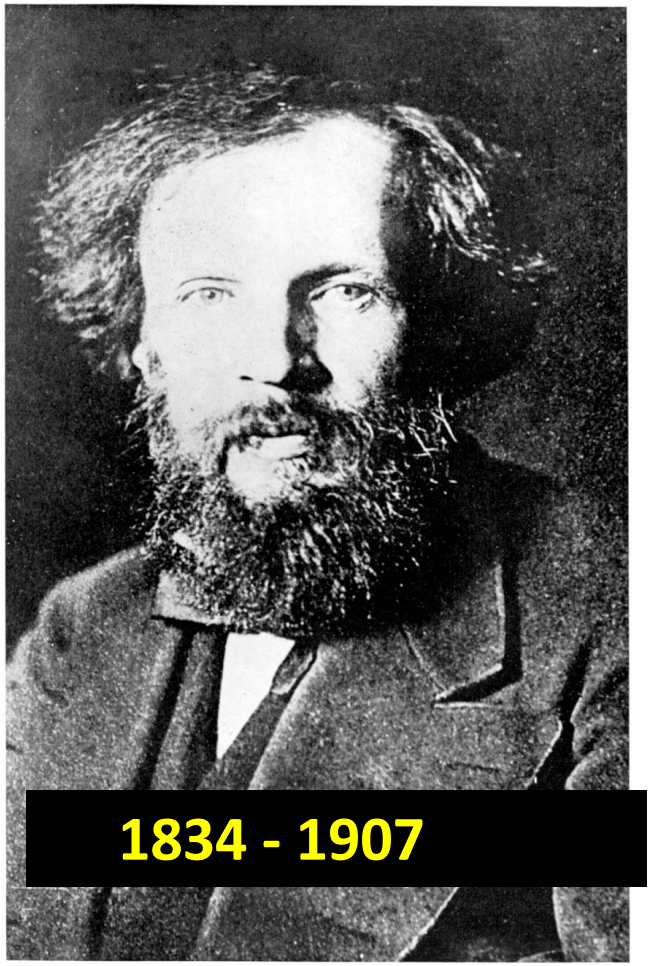
has proclaimed


D.I. Mendeleev
1834 - 1907

2019 as the International Year of the Periodic Table of Chemical Elements (IYPT 2019)

Physics of SHE – testing the triumph of Mendeleev Periodic Law connecting the chemical properties of elements with their atomic numbers





Study of heavy and supe-rheavy elements in the world

1 Berkeley National Laboratory, USA

2 GANIL, Caen, France

3 Helmholtz Centre GSI, Darmstadt, Germany

4 JINR, Dubna, Russia

5 IMP, Lanzhou, China

6 RIKEN, Wako, Japan

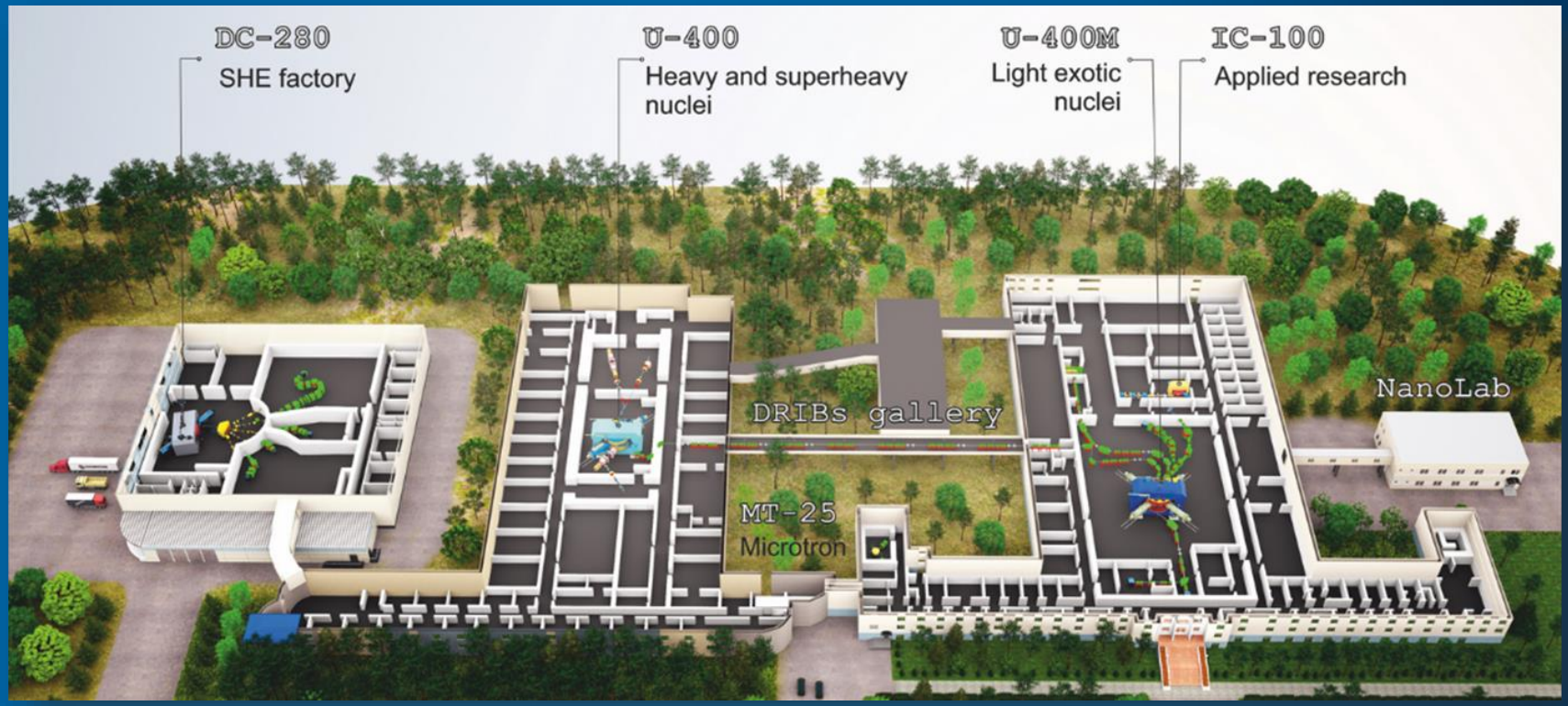
Advantages of JINR:

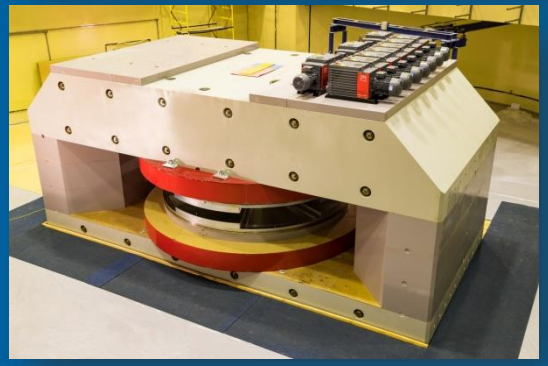
- wide range of accelerated ions (deuterium up to uranium);
- availability of actinide isotopes for targets;
- Long-standing traditions and a scientific school;
- full-time availability of an accelerator complex – SHE-Factory.
- broad international cooperation (JINR Member States; Livermore & Oak Ridge National Laboratories, Vanderbilt University, Univ. of Tennessee, USA; Paul Scherer Institute, Switzerland, Univ. Louis Pasteur, Univ. Paris Sud, GANIL, France; IMP, Lanzhou, China);

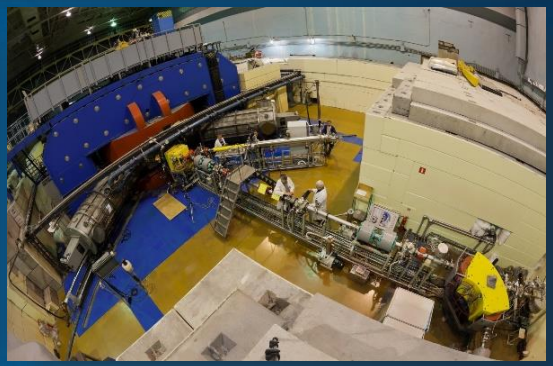
Constructing the SuperHeavy Elements (SHE) Factory

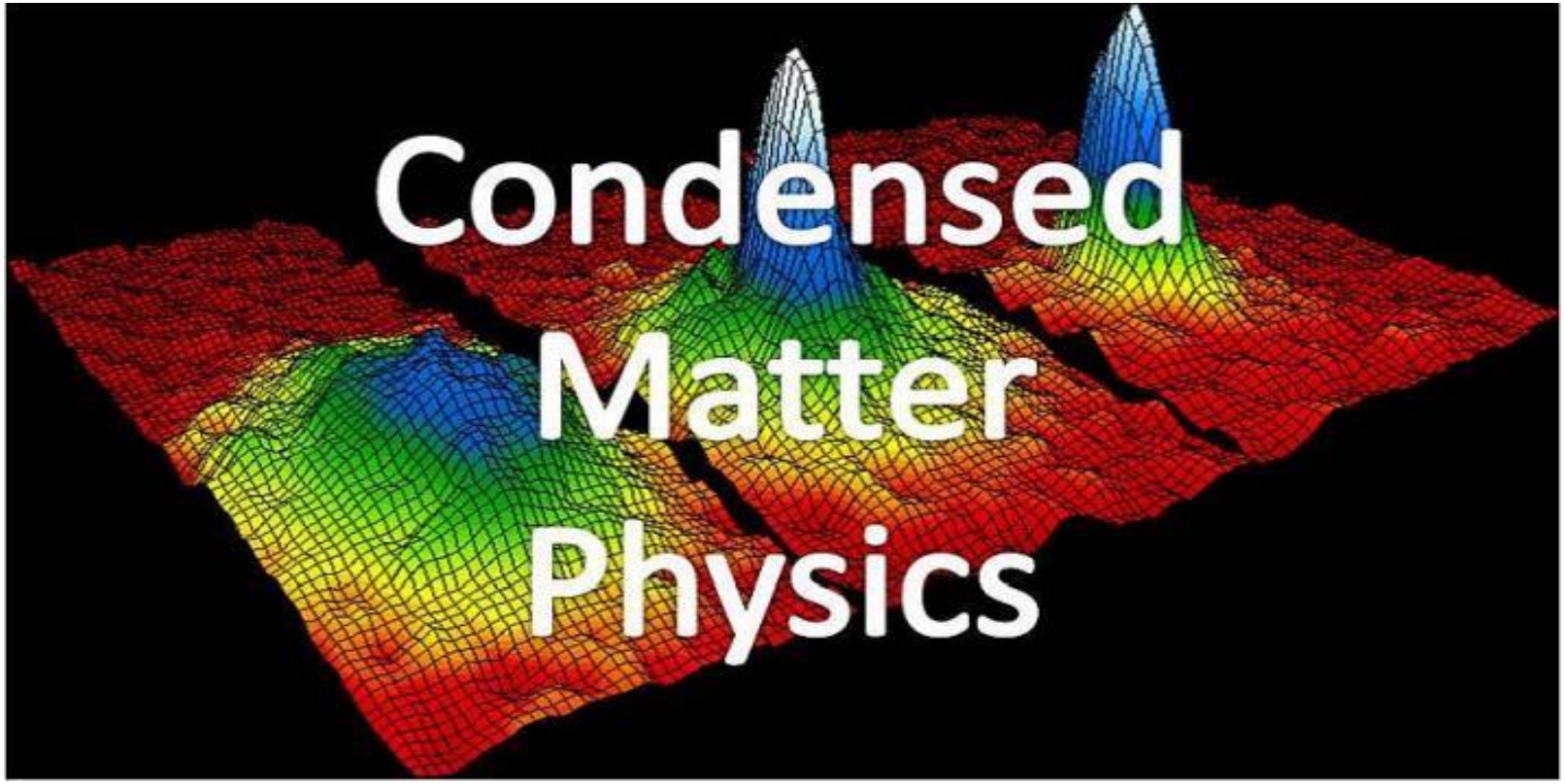
- Completion of the SHE Factory building and its engineering systems (*April 2018*)
- Assembling the DC-280 cyclotron. Installation of new Gas-Filled Recoil Separator (*April – July 2018*)
- First experiments (*2018*)

Dubna Radioactive Ion Beam accelerator complex (DRI







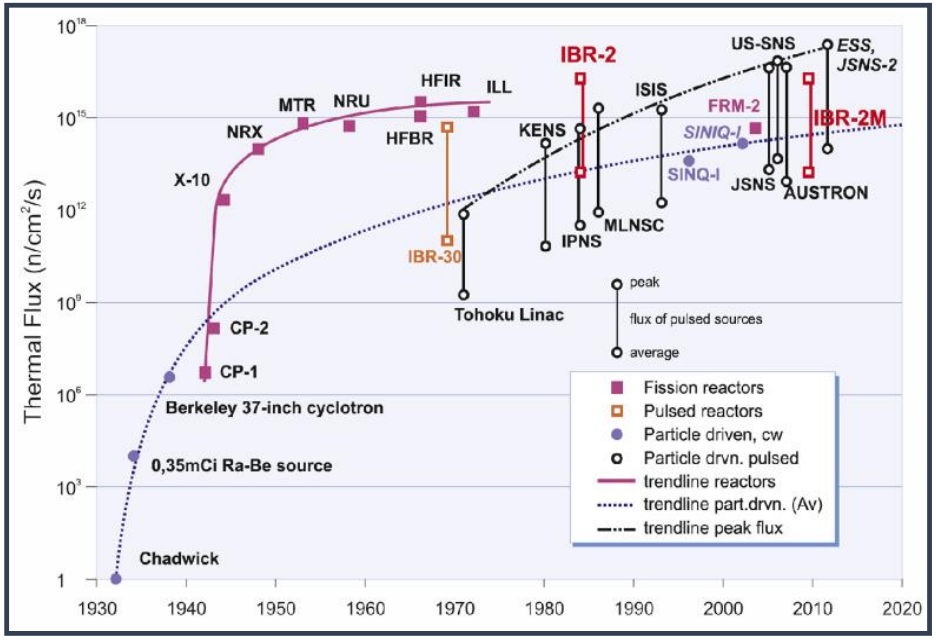


Neutron scattering & Nuclear Structure
Life Science Problems
Radiobiology & Astrobiology
Nuclear Ecology & Cosmic Medicine

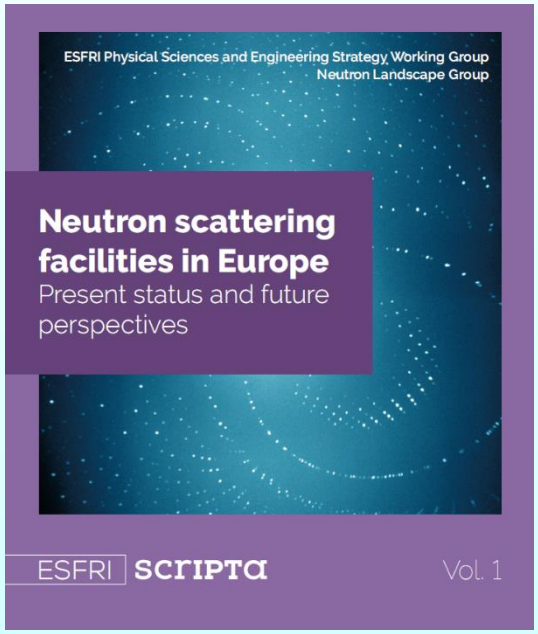
IBR-2M pulsed research reactor

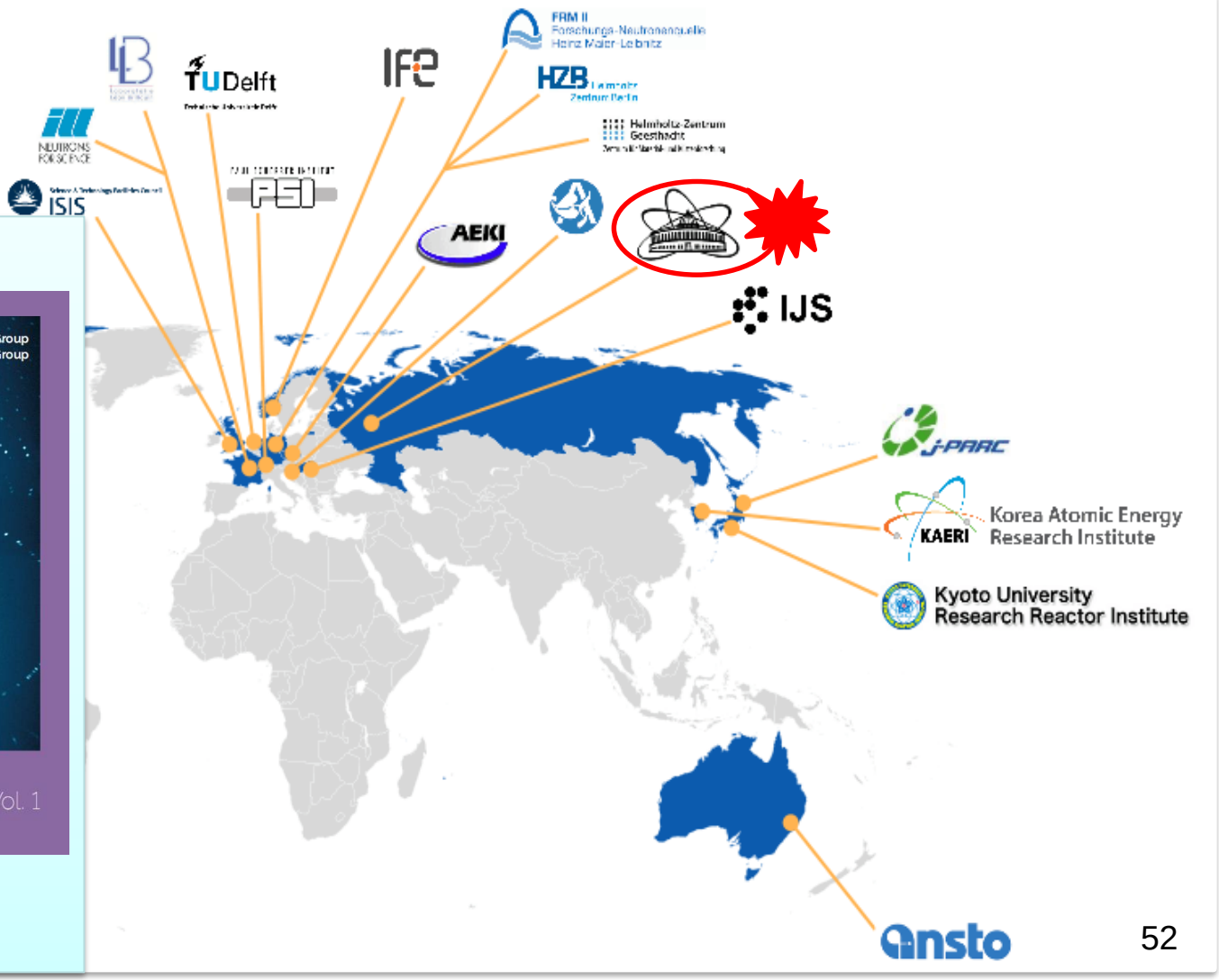
mean power: ***2 MW***
pulse frequency: ***5 Hz***
pulse width for fast neutrons: ***200 μs***
thermal neutrons flux density on the moderator surface: ***10^{13} n/cm^2 /s***
maximum in pulse: ***10^{16} n/cm^2 /s***

IBR-2 is included in the 20-year European strategic research program in the field of neutron scattering

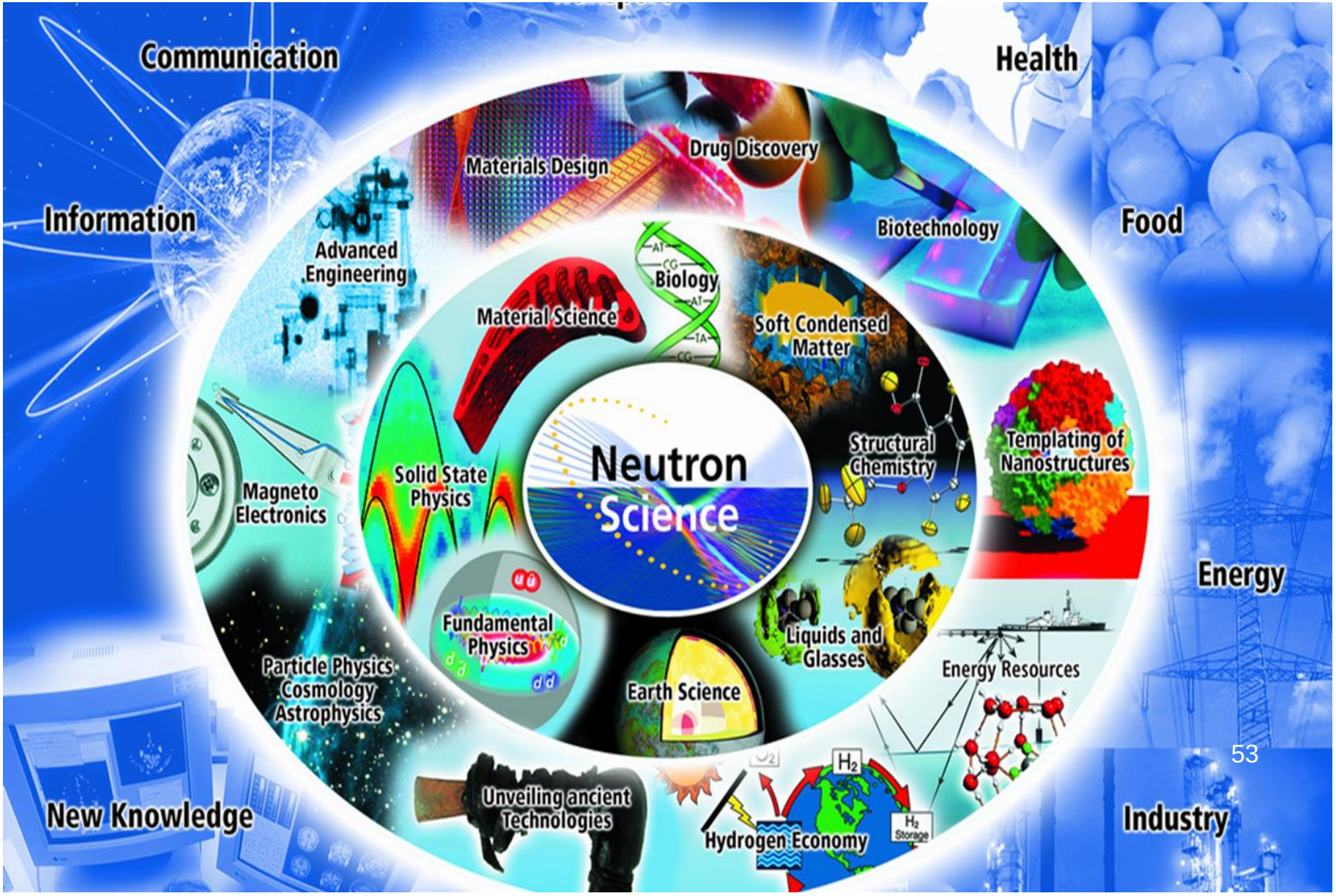


IBR-2M is one of the best sources of the thermal neutrons and its program is a part of the European strategic research program in the field of neutron scattering.



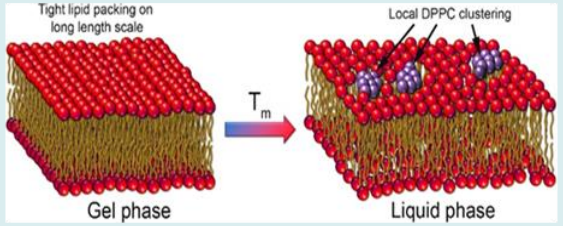


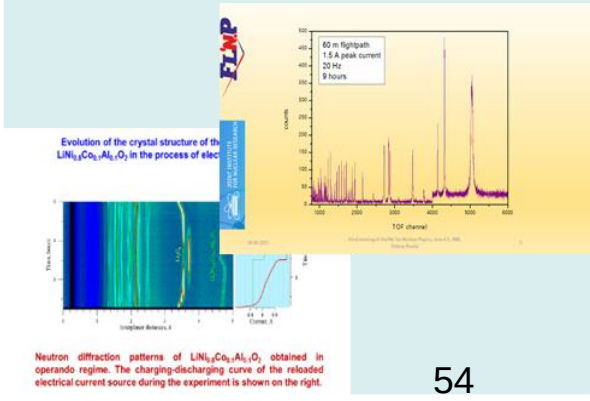
Neutron science in our life



Condensed matter physics at JINR

- Physics and Chemistry of Novel Functional Materials;
- Physics of Nanosystems and Nanoscale Phenomena;
- Physics and Chemistry of Complex Liquids and Polymers;
- Molecular Biology and Pharmacology;
- Materials and Engineering Sciences;
- Neutron Radiography and Tomography
- Neutron Ecological studies
- Neutron beams as the method for solving problems of Life Science

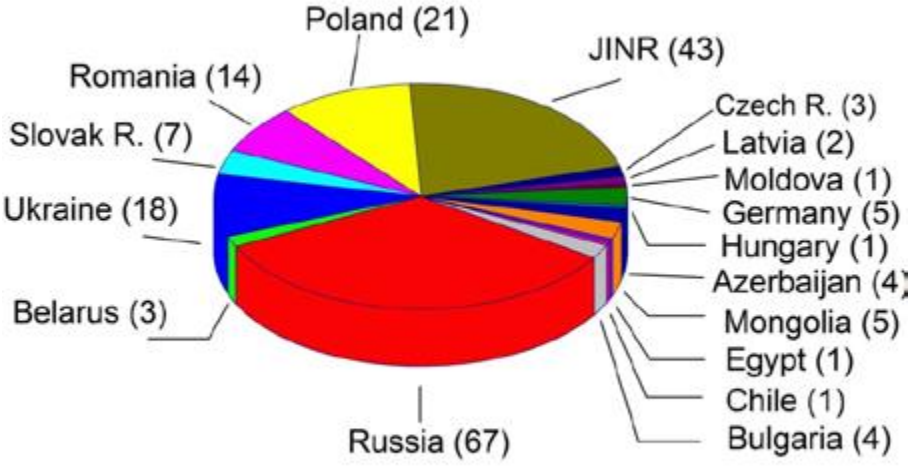




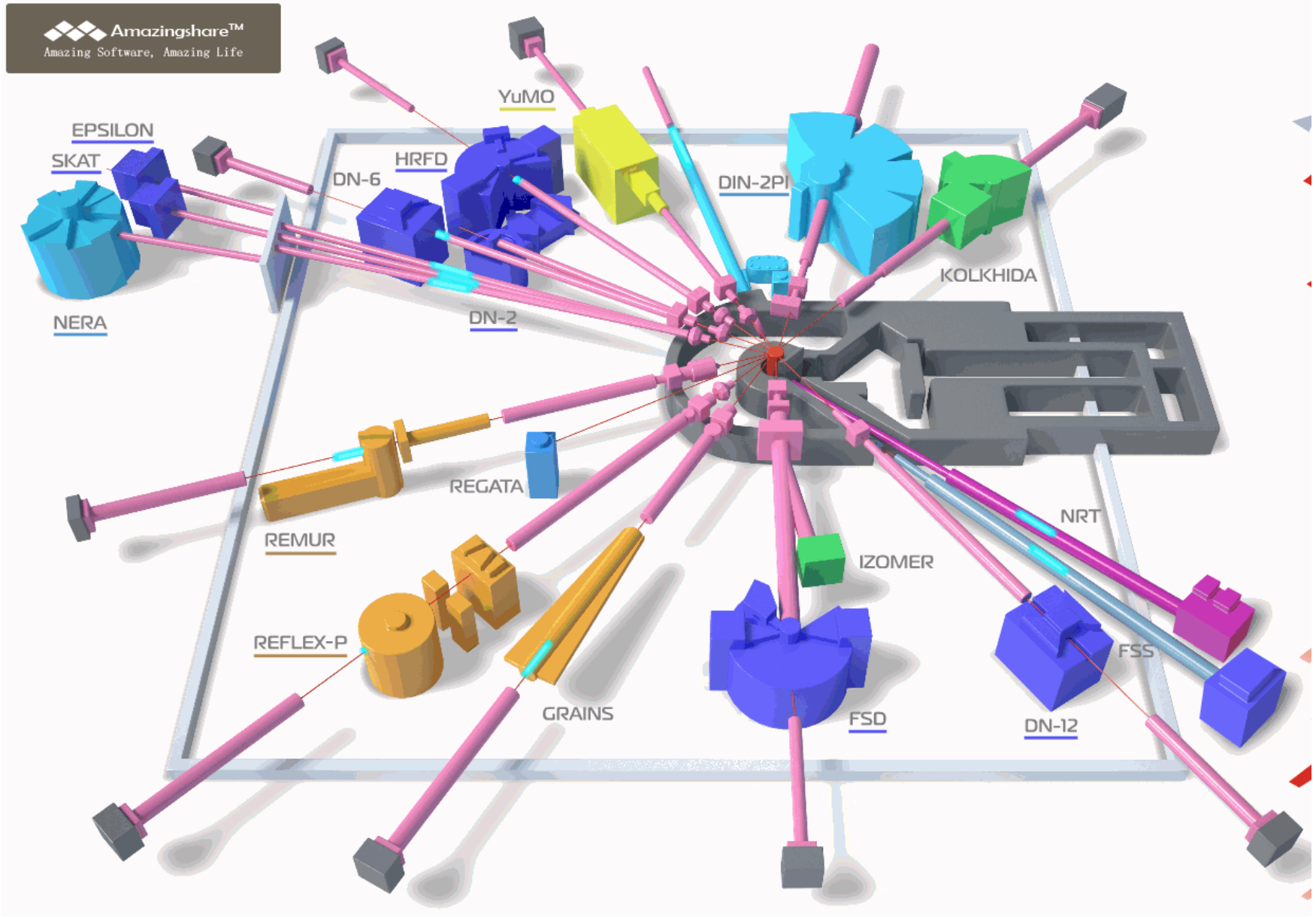
FLNP User Programme

The User Programme at the spectrometer complex of the upgraded IBR-2 reactor is implemented successfully. At the reactor, specialists from many countries conduct experiments in physics, material science, biology, geology, etc.

In 2017:
203 proposals for experiments came from 17 countries

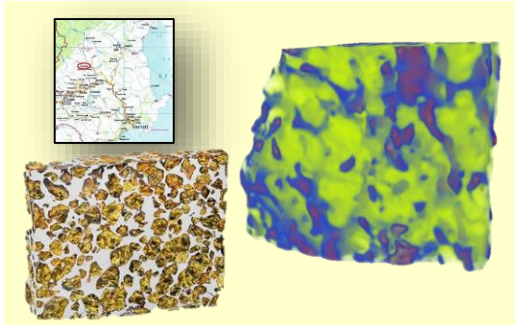


Neutron source channels at IBR-2M

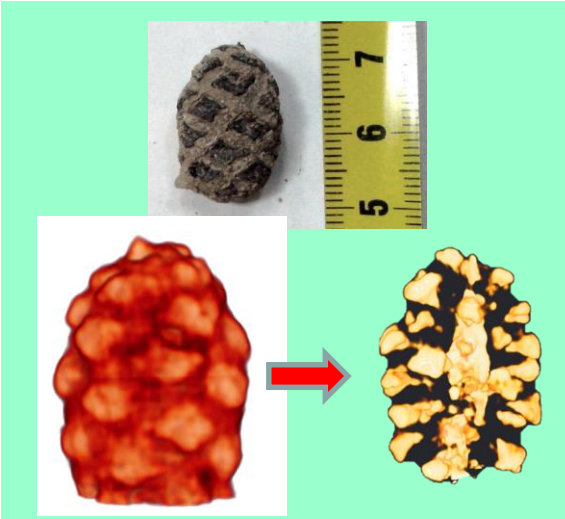


Development of neutron imaging techniques at IBR-2 and applications to natural heritage objects

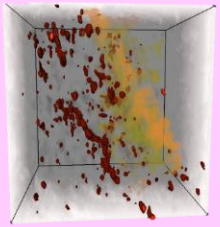
Neutron imaging instrument: Sample and detector position

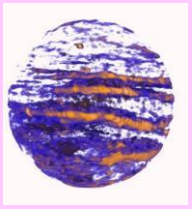


3D reconstruction of Fe-Ni alloy distribution in Seimchan meteorite from neutron tomography data



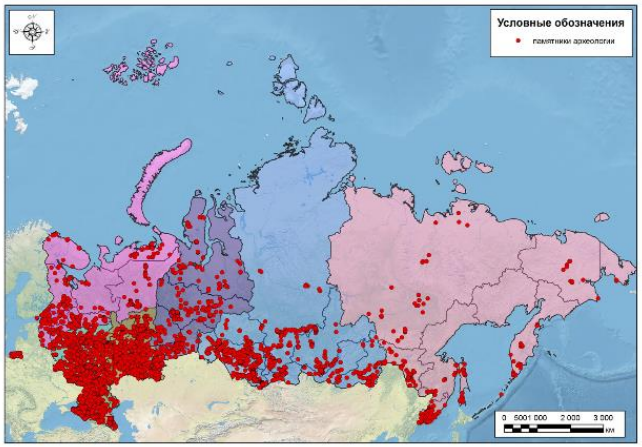
3D reconstruction of internal structure of Protosequoia cone (cretaceous period) from Paleontological Institute RAS using neutron tomography data



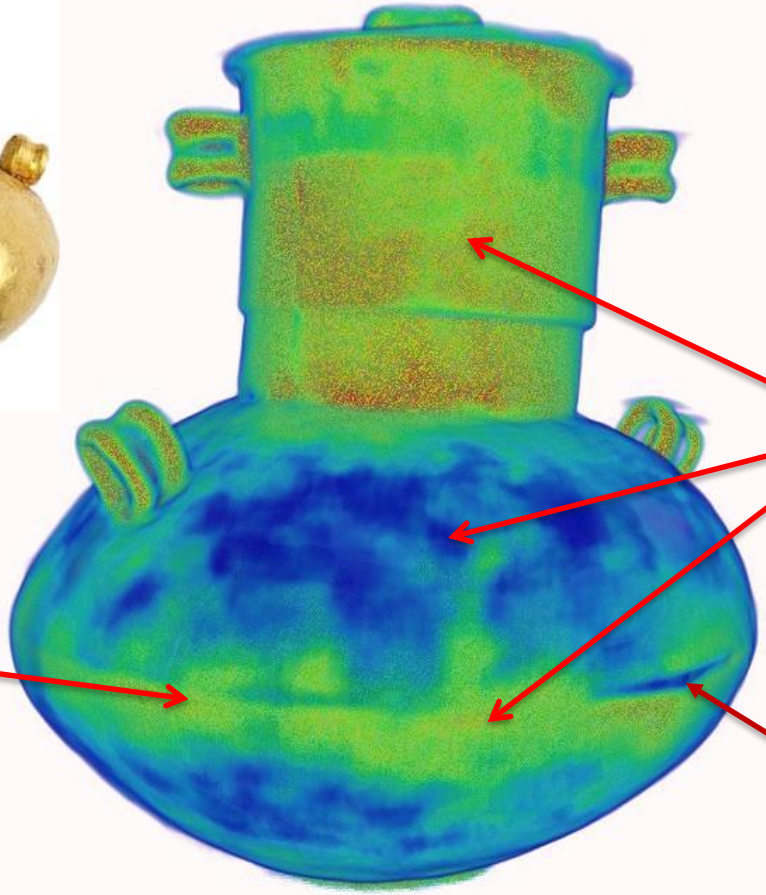


3D reconstruction of internal structure of the biotite gneiss sample from Kola Superdeep Borehole, depth 8802 m and its surface analogue using neutron tomography data

Neutron radiography and tomography at the Beam #14 are used to study archeological objects, especially metallic artifacts



Neutron radiography and tomography used to study archeological objects, especially metallic artifacts



Areas with other composition of gold

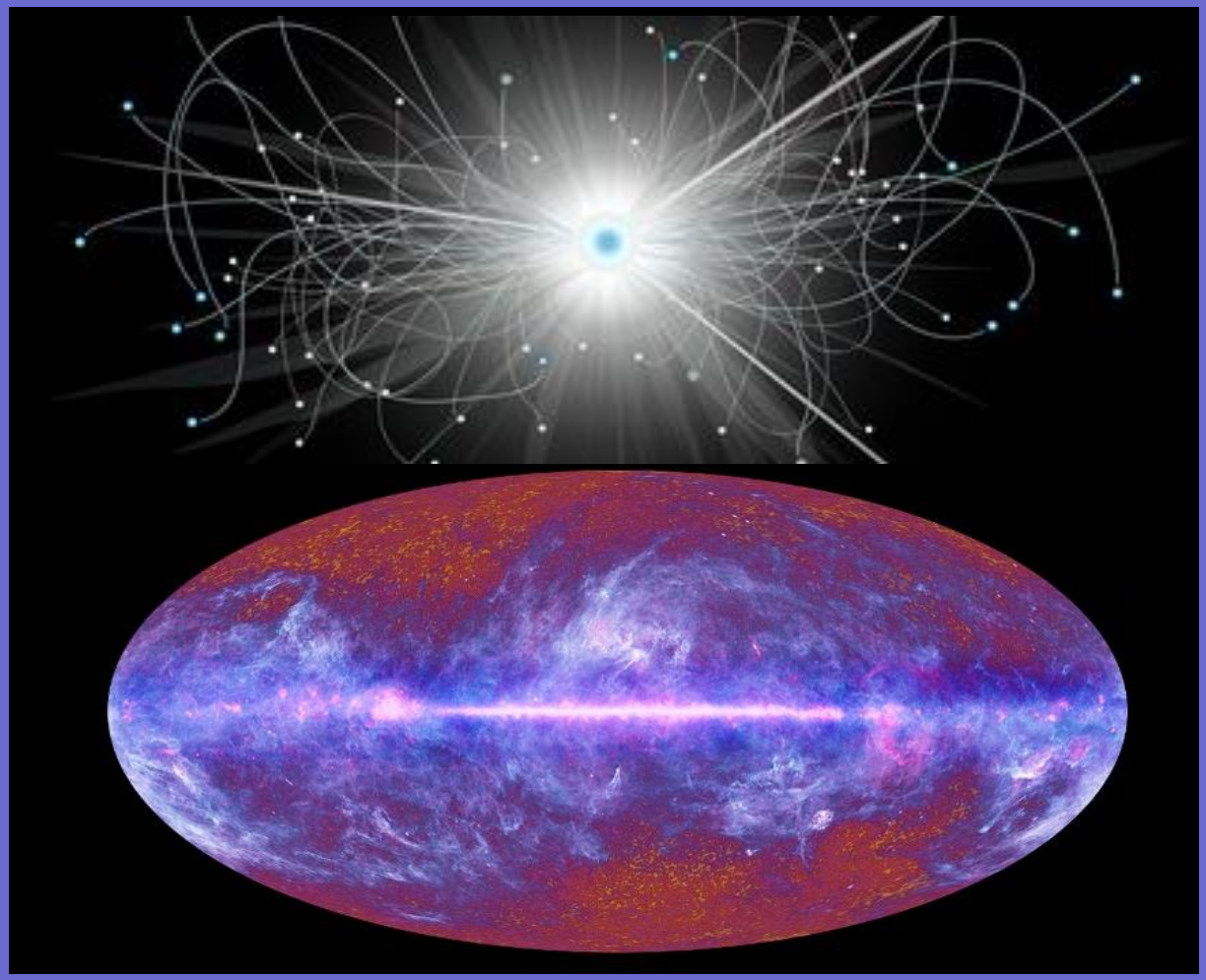
traces of concealment of a joint

Site of dispersed joint

IBR-2 Future

- **Short term perspectives:**
  - **Development and upgrade of the IBR-2 instruments. Already now there are examples at JINR of more than 10-fold increase in efficiency**
  - **Startup of the IREN source at designed parameters;**
- **Long term perspectives – new accelerator based neutron source in order to replace IBR-2 after the end of its lifetime > Superbooster NEPTUN**

Particle Physics and Astrophysics



Neutrino

JINR Neutrino program:

- neutrino physics and astrophysics,
- basic and applied research with reactor antineutrino beams.

JINR in the Global Neutrino Projects

- **BAIKAL-GVD: detection of ultrahigh-energy cosmic neutrinos. Search for local astrophysical sourses.**

  Phase-1 goal: an increasing of the observable volume up to 0.4 km^3 in parallel with data taking is foreseen during 2017–2023.

- **JUNO and NOvA experiments: the mass hierarchy and CP violation problems.**

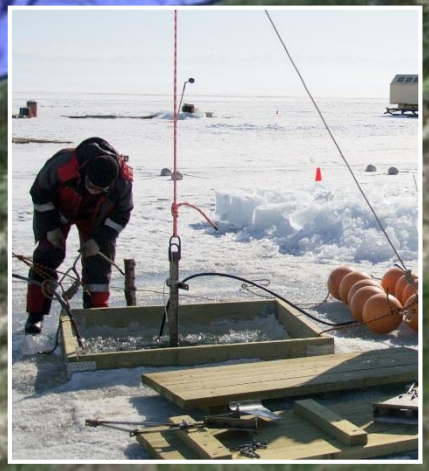
  JINR: to complete its major contribution to the construction of the JUNO experiment, to maintain the NOvA remote control room and to perform physical analysis.

- **During 2019–2023: R&D work on the calorimetry of the DUNE detectors based on the unique experience of JINR in collaboration with FNAL and CERN.**

- **Experiments at Kalinin Nuclear Power Plant: search for sterile neutrinos, neutrino magnetic moment and coherent neutrino scattering (DANSS, GEMMA, NuGEN)**

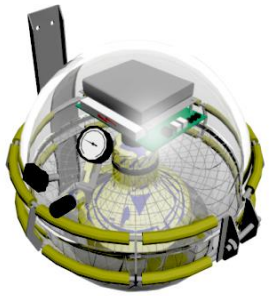
Lake Baikal, East Siberia

Baikal-GVD



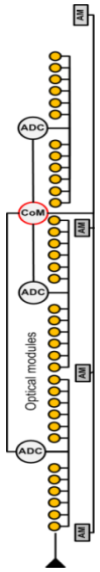
JINR Neutrino programme

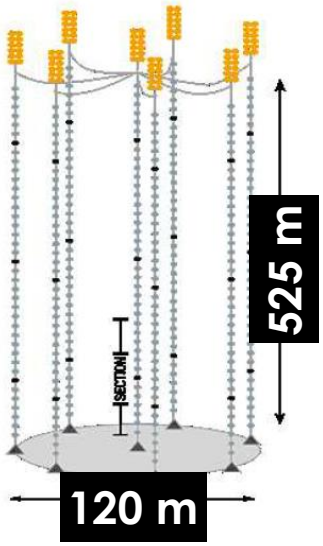
Baikal-GVD: Phase 1 (before 2020)



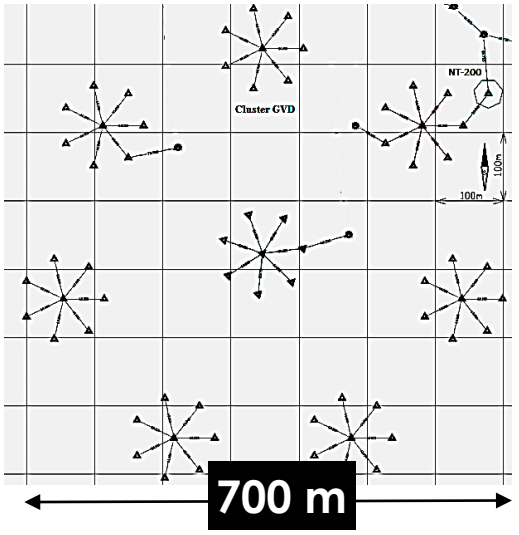
Optical module

String: 36 OMs





Cluster: 8 strings



GVD-1: 8 clusters

	GVD-1
OMs	2304
Clusters (8 Strings)	8
Depths, m	750 – 1275
Eff. Volume (E_{SH} > 100 TeV)	0.4 km^3

Directional resolution

Cascades: ~3°
Muons: 0.25° – 0.5°

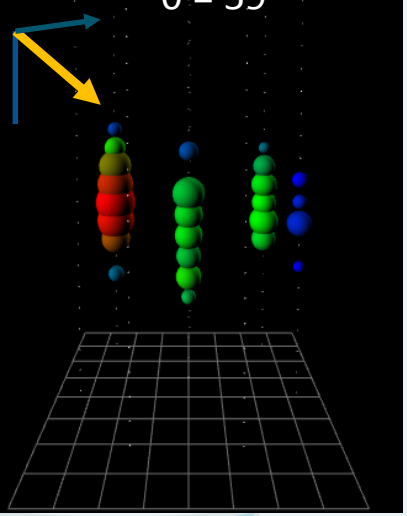
Present and future of the BAIKAL-GVD

~2300 OM (2020)
8 clusters

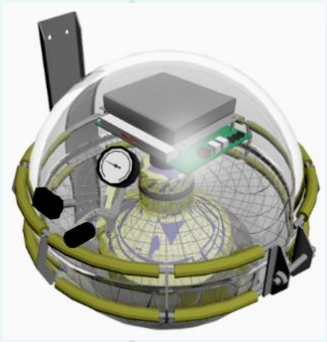
300 m

The first Nu - shower event

E = 158 TeV,
θ = 59°



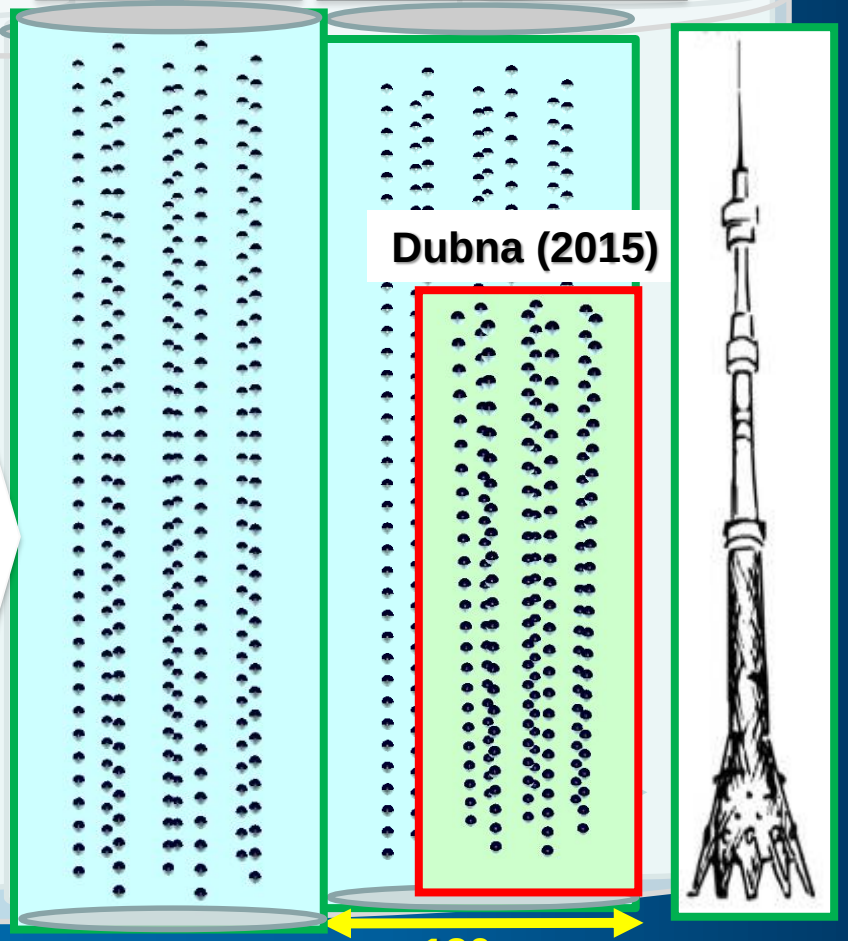
April 2018, new cluster assembled



April 2017, data taking

Since April 2016 taking data

Dubna (2015)



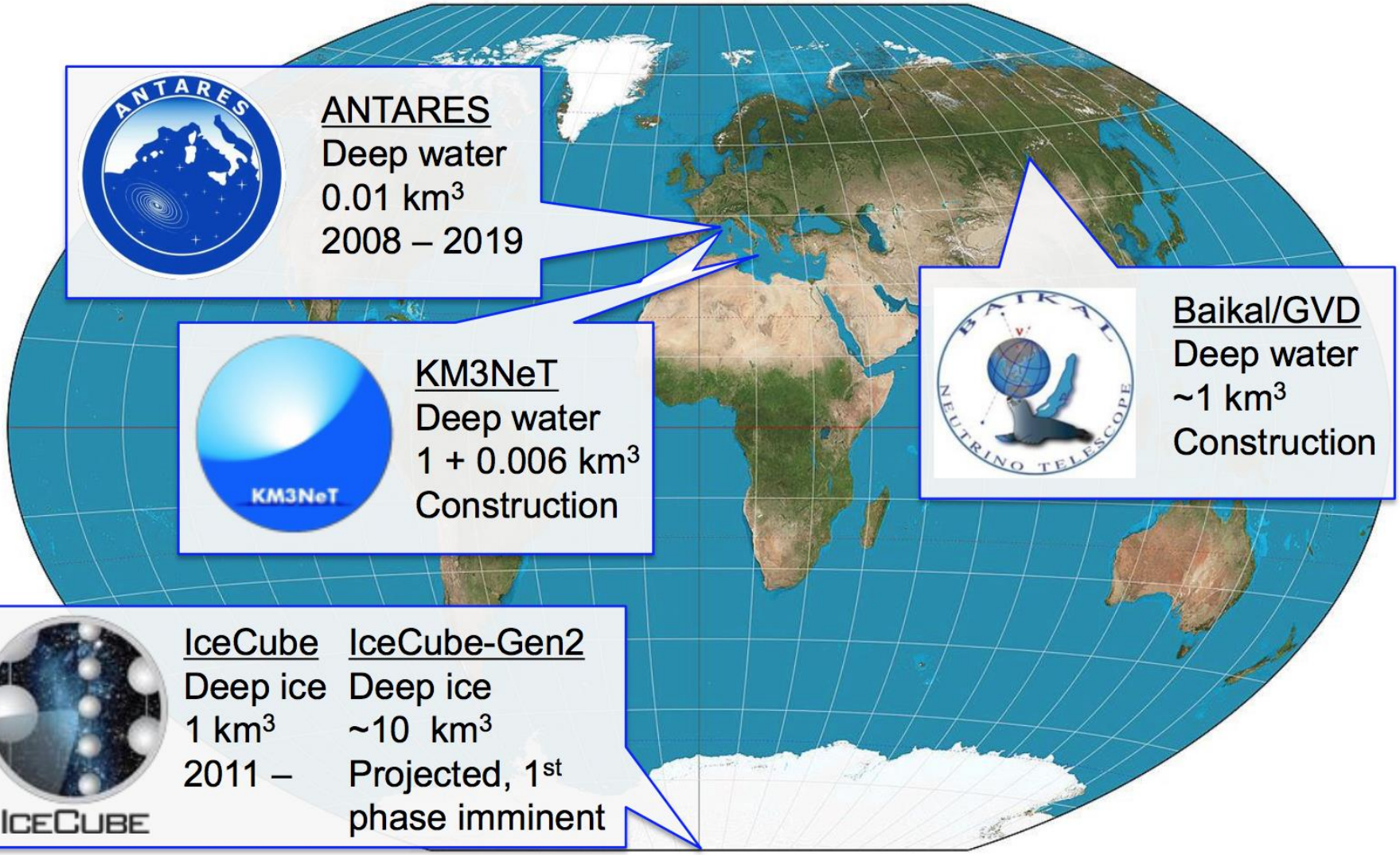
~600 m

120 m

~1 km

The neutrino telescope world map 2018

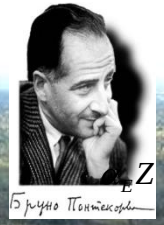
ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS



Neutrino experiments at Kalinin APS

(Tver region, 285 km from Dubna)

Pressurised water reactor;
Termal power 3 100 MW;
Neutrino flux ~ 6 10^{20} ν_e



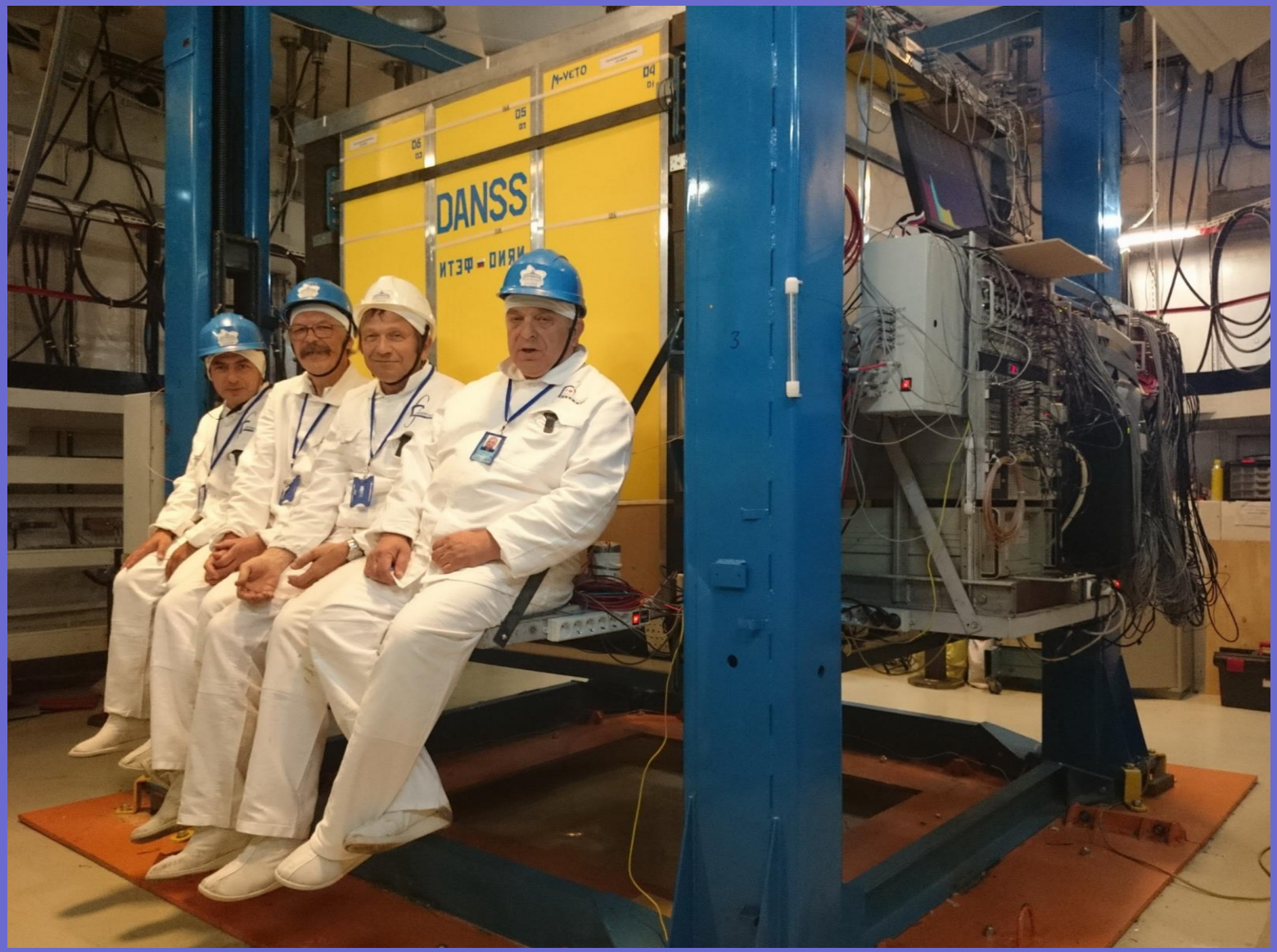
$Z \geq 1$

GEMMA (Neutrino Magnetic Moment)

νGeN (Coherent ν-Ge scattering)

DANSS (reactor monitoring and search for sterile neutrino oscillations)

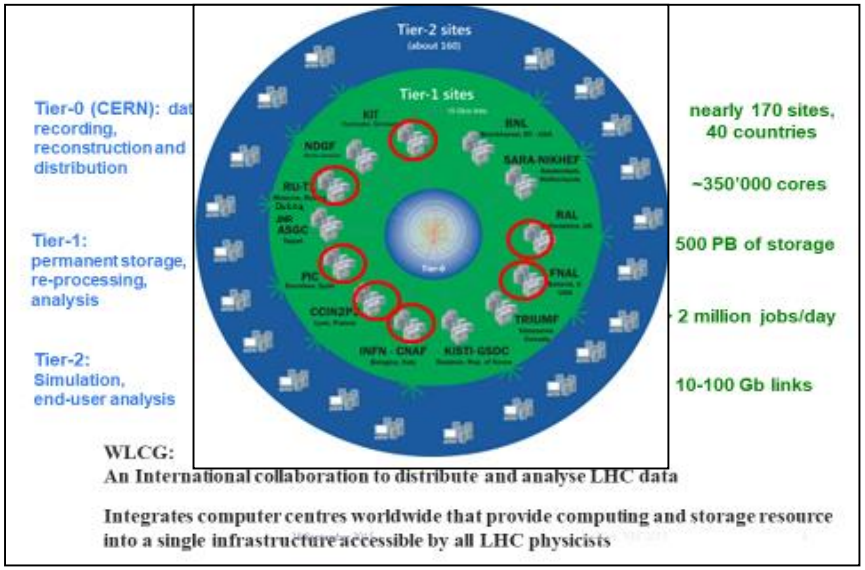
DANSS Results were presented at NEUTRINO2018



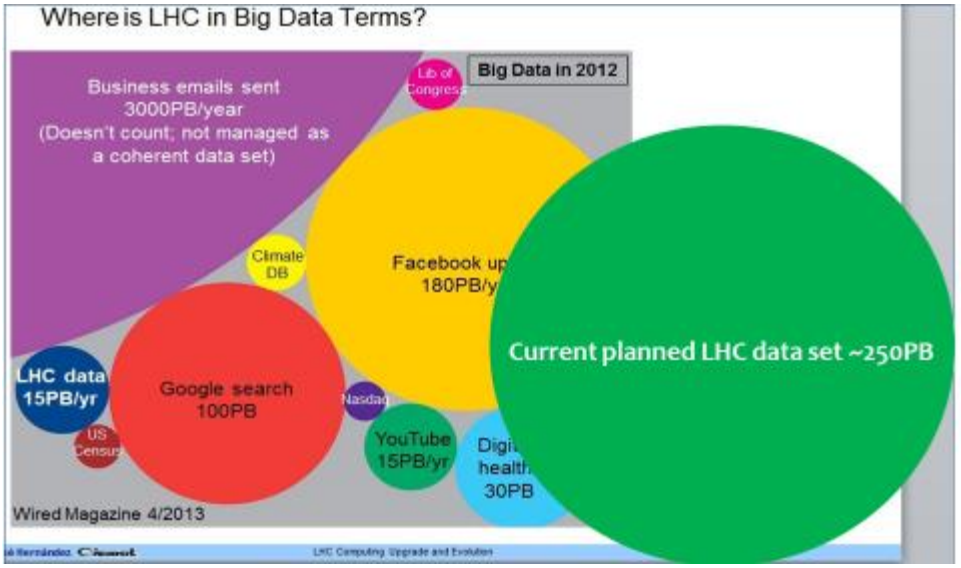
Modern Computing in HEP

Nowadays, any large-scale project will fail without a distributed infrastructure and Big Data Analytics for data processing.

The Worldwide LHC Computing Grid (WLCG)



Entry into the Big Data era

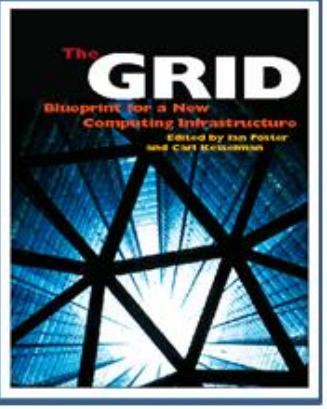


On a festivity dedicated to receiving the Nobel Prize for discovery of Higgs boson, former CERN Director-General Prof. Rolf Dieter Heuer directly called the grid-technologies one of three pillars of success (alongside with the LHC accelerator and physical installations).

Modern Computing at JINR

Grids

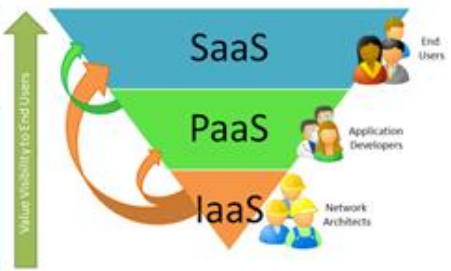
- Collaborative environment
- Distributed resources



Supercomputers

Titan System (Cray XK7)			
Peak Performance	27.1 PF 18,688 compute nodes	24.5 PF GPU	2.6 PF CPU
System memory	710 TB total memory		
Interconnect	Gemini High Speed Interconnect	3D Torus	
Storage	Lustre Filesystem	32 PB	
Archive	High-Performance Storage System (HPSS)	29 PB	
I/O Nodes	512 Service and I/O nodes		

Clouds



Big Data

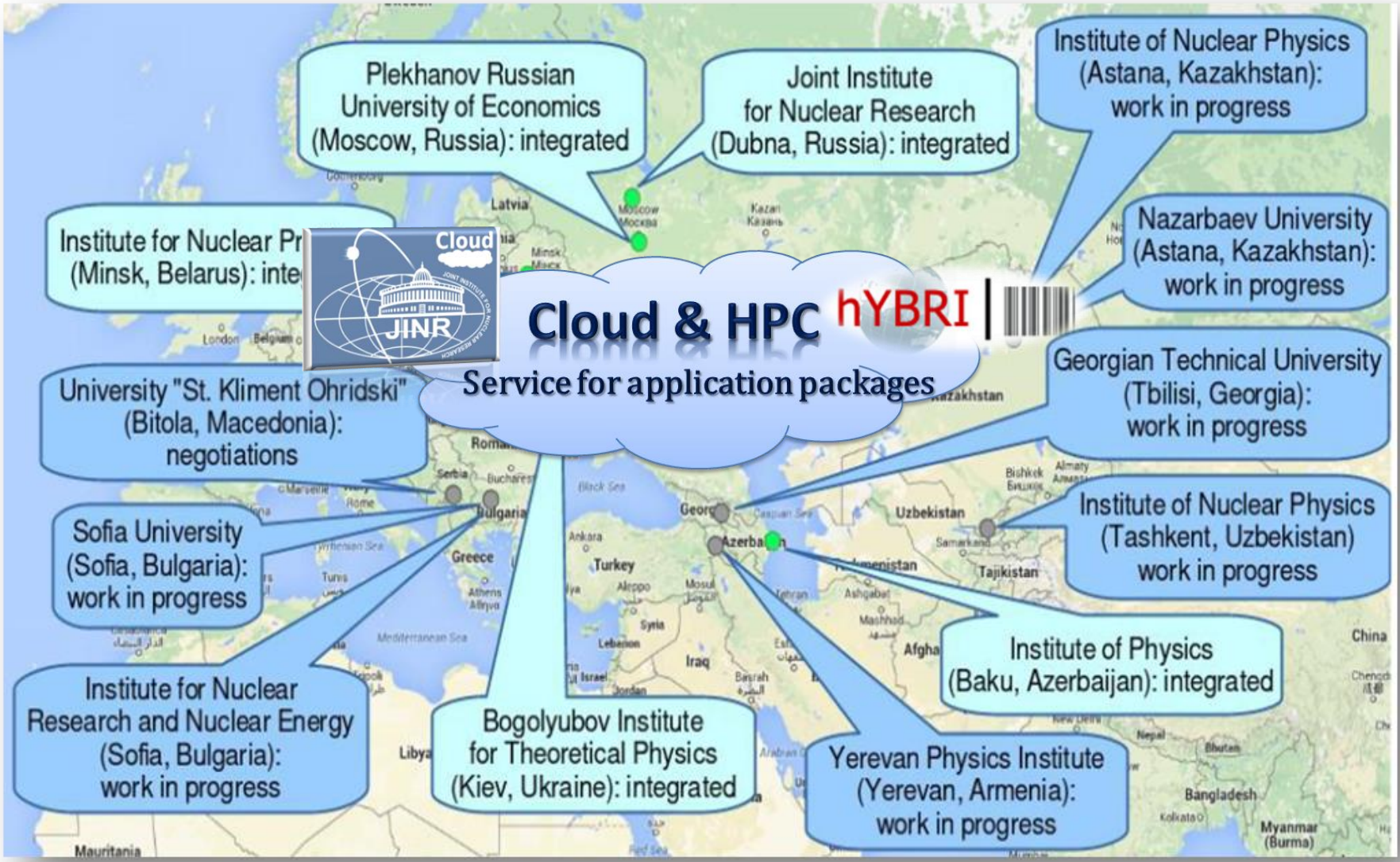
- *Volume*
- *Velocity*
- *Variety*

JINR Multifunctional Information and Computing Complex

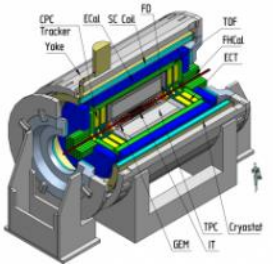
IT-infrastructure is the one of JINR basic facilities

JINR Cloud + HPC

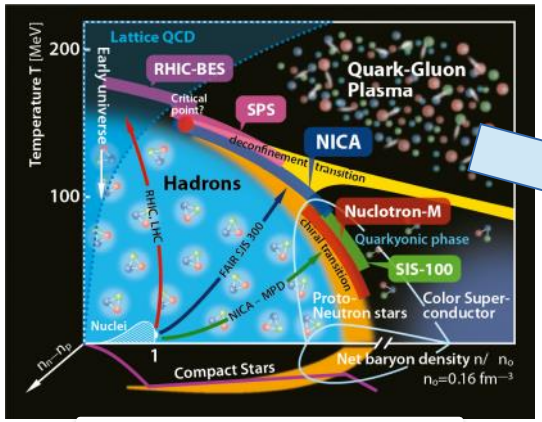
New challenge – integration JINR Member States cloud to supercomputer using JINR Cloud and containers



NICA computing challenge

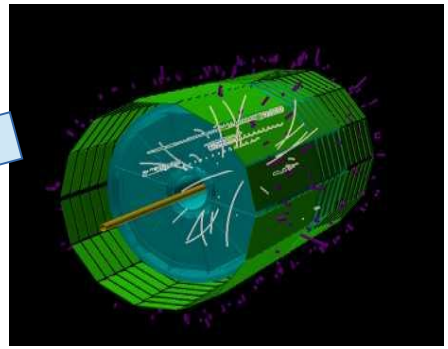


MPD experiment

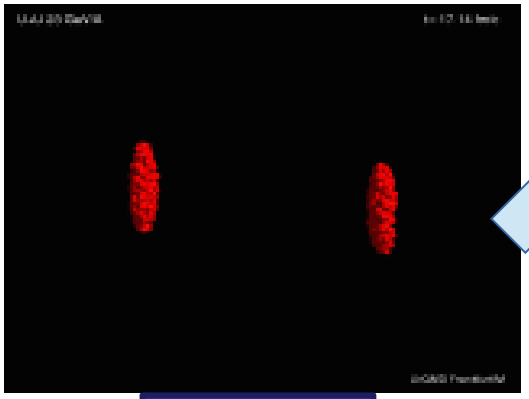


QCD phase diagram

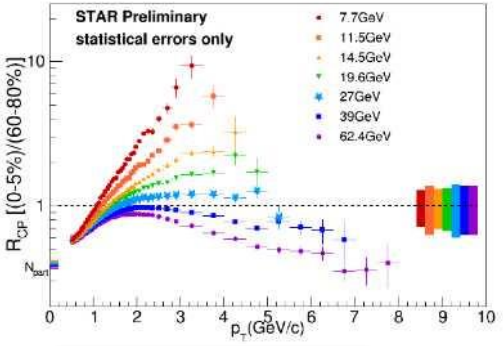
Super-Computer
" N.GOVORUN "



Events reconstruction



Simulations



Physics analysis

Supercomputer at JINR

The aims:

- Increase of computational power for massive parallel computations required for acceleration of complex theoretical investigations held at LTP in frames of **"Hadronic matter under extreme conditions"**, theme 01-3-1113, "Theory of fundamental interactions"

- Development of a testbed for study into the feasibility of use of the newest computation platforms for computing on **NICA** project

Total performance: 1 Pflops (x10)

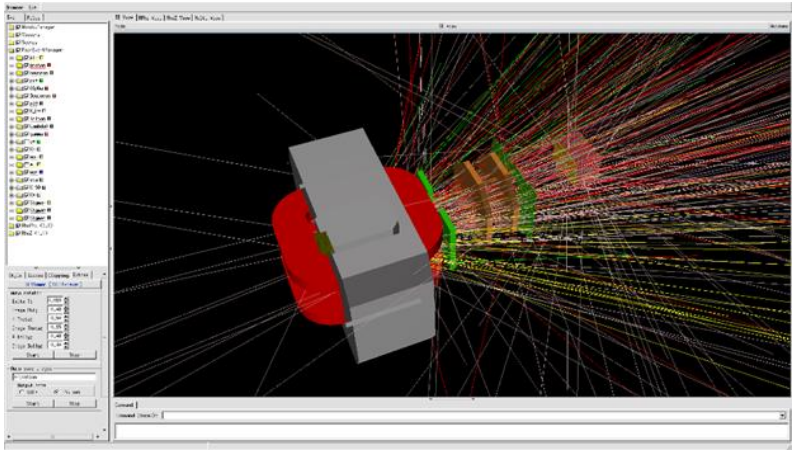
Putting into operation: March 27, 2018

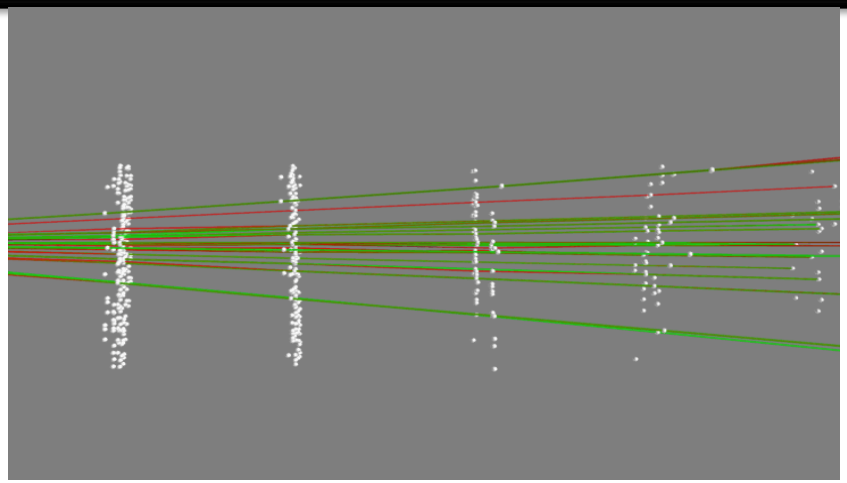
LIT BLTP NICA hYBRI

ML Tracks Reconstruction BM@N

Machine learning algorithms bring a lot of potential to the tracks reconstruction problem due to their capability to learn effective representations of high-dimensional data through training, and to parallelize on HPC architectures.

Simulation data





Input data for the first step algorithm were simulated by GEANT in MPDRoot framework for the real BM@N configuration.

Real track

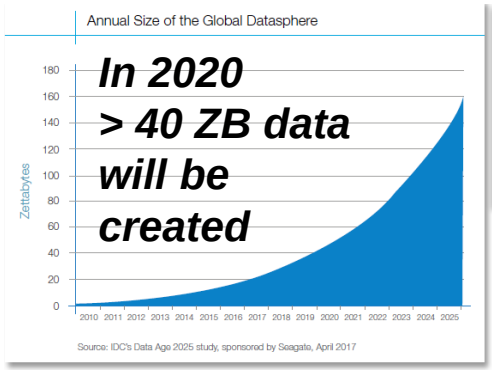
True found track

Ghost track

White dots are both hits and fakes

Efficiency 97,5%

Big Data + HPC (HPDA - High Performance Data Analysis)

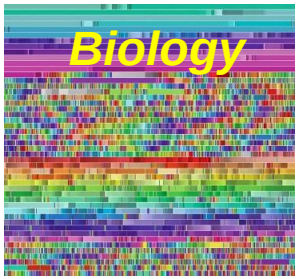


Annual data production follows to exponential law.

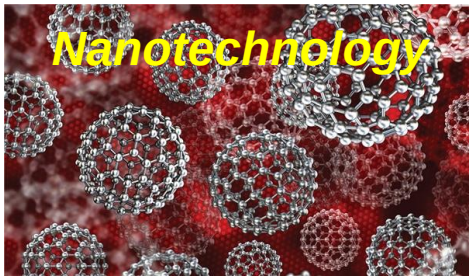
High Energy Physics

CERN

Biology



Nanotechnology

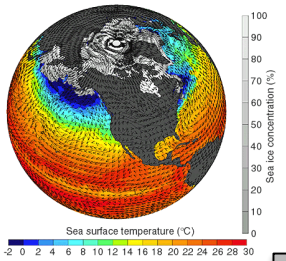


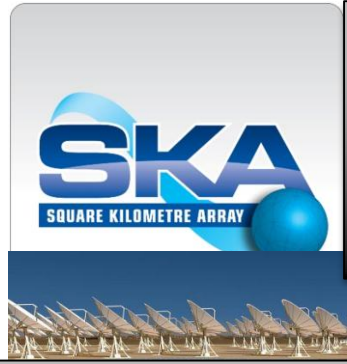
Science

CERN Large Hadron Collider
> 20 Pb/Year, > 200 Pb stored

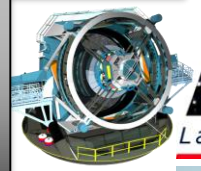
Astrophysics

Climate

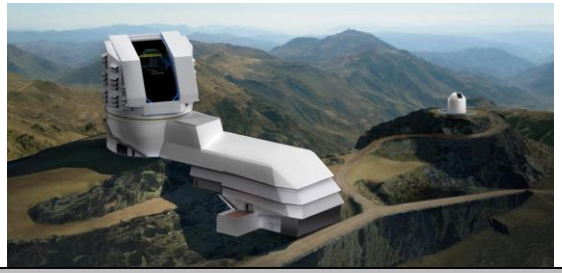




Square Kilometre Array radio telescope (SKA)
> 20 Pb/Day (estimation)



LSST
Large Synoptic Survey Telescope



An International radiotelescope for the 21st century

...et cetera

Large Synoptic Survey Telescope (LSST)
> 10 Pb/Year (estimation)

Theoretical Physics at JINR

Multidisciplinary research:

- Theory of Fundamental Interactions
- Theory of Nuclear Structure and Nuclear Reactions
- Theory of Condensed Matter
- Modern Mathematical Physics: Strings and Gravity, Supersymmetry, Integrability

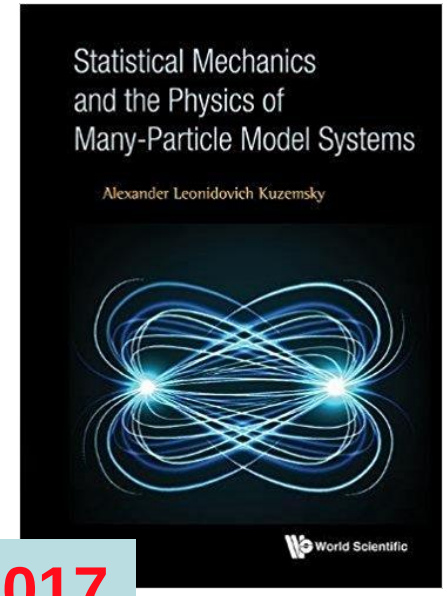
- Research and Educational Project “Dubna International Advanced School of Theoretical Physics” (DIAS-TH)

Publications 2017:
Journals (390) & Conf. Proc. (170) ~ 560
Monographs - 4

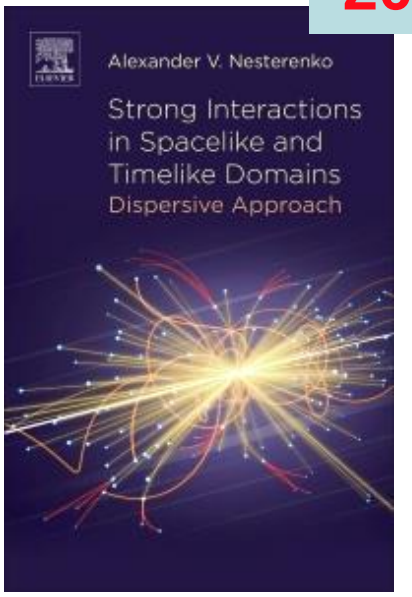
Conferences and Schools, 2017:
Total - 18 (> 900 participants)
DIAS-TH and Helmholtz Schools - 4

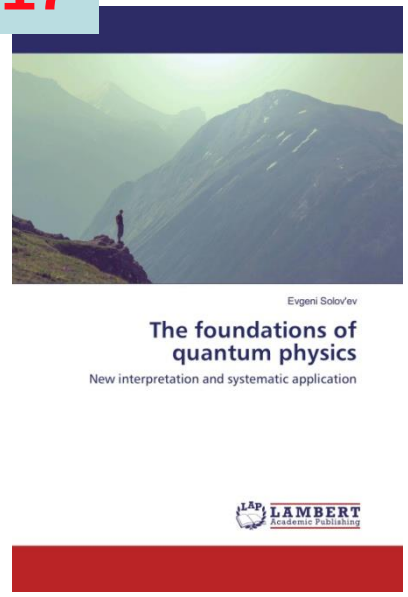
Educational Activity:
More than 40 lecture courses at UC JINR, DIAS-TH, Moscow U., Dubna U., MIPT, etc.

Workshop on Classical and Quantum Integrable Systems (BLTP and HSE, 2017)
dedicated to the memory of L.D. Faddeev



2017

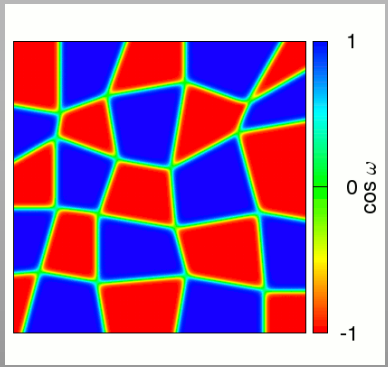




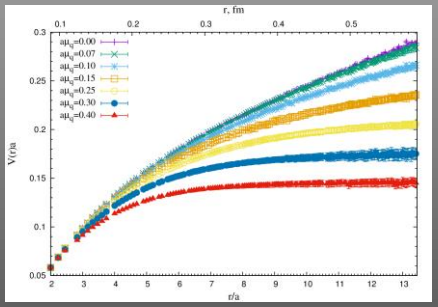
Hot theoretical physics topics for HPC

THEORY OF HADRONIC MATTER UNDER EXTREME CONDITIONS

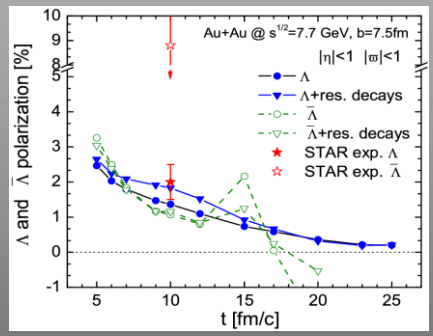
(In theoretical support of NICA and other relativistic heavy-ion physics experiments)



Parallel computing for Lattice QCD, functional RG, statistical and hydrodynamical models of HIC, sophisticated models of QCD vacuum, strongly correlated systems in condensed matter physics



Critical phenomena in hot dense hadronic matter in the presence of strong electromagnetic fields, deconfinement and chiral symmetry restoration:



QCD Phase diagram
Thermodynamics of N_f=2+1+1 QCD
Real-time spectral properties of thermal QCD
Transport properties of hadronic matter
Properties of cold dense SU(2) QCD through lattice calculations
Anderson transition in the N_f=2+1+1 QCD
Z(N) symmetry & meta-stable states

Supercomputing Hybrid Cluster at JINR will tremendously increase efficiency of theoretical investigations

Modern trends in radiobiology

Fundamental radiobiological research: *studying mechanisms of radiation action at the molecular, cellular, tissue, and organismal levels of biological organization*

Radiation and nuclear medicine: *refinement of tumor radiation therapy techniques (proton and carbon therapy); designing new radiosensitizers and radioprotectors; extension of the list of the radionuclide pharmaceuticals for diagnostics and treatment*

Radiation safety of deep space flights: *refinement of the approaches to human protection from heavy charged particles*

JINR's Laboratory of Radiation Biology

Origin of Life on the Earth

Applied radiation technologies: *development of methods of raising crop capacity and improvement of agricultural product quality; elimination of pathogenic micro- and macroflora; disinfection of agricultural waste, etc.*

Fundamental aspects of radioecology: *research at the level of ecosystems and populations*

Radiobiology research in JINR & RAS

New concept of radiation risk

Ac. E.A. Krasavin

Ac. A.M. Sergeev

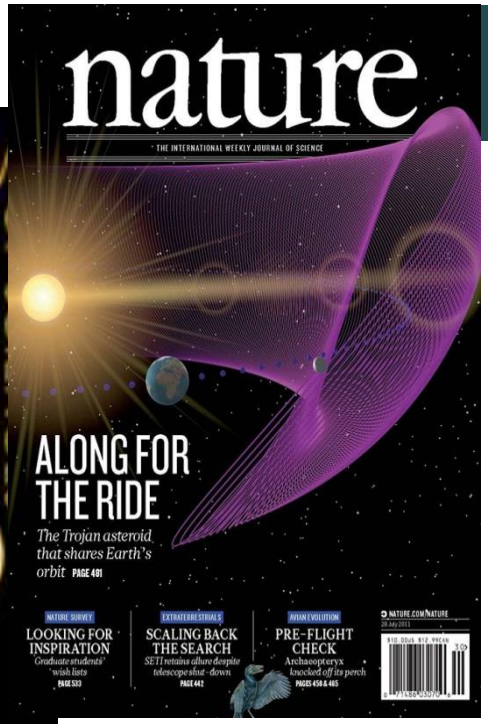
- A new concept of radiation risk for manned interplanetary flights has been proposed and substantiated.
- The notion of the ***successful mission accomplishment probability*** has been introduced.
- Radiation damage is considered mainly as a result of the action of galactic cosmic rays' heavy nuclei on **the central nervous system structures,** which may lead to changes in the higher integrative functions of the brain, causing degradation of space crew's operator functions.

19th Meeting of the Russia/U.S. Joint Working Group with JINR participation on Space Biomedical and Biological Sciences Research
4–6 December 2017, Moscow, Russia

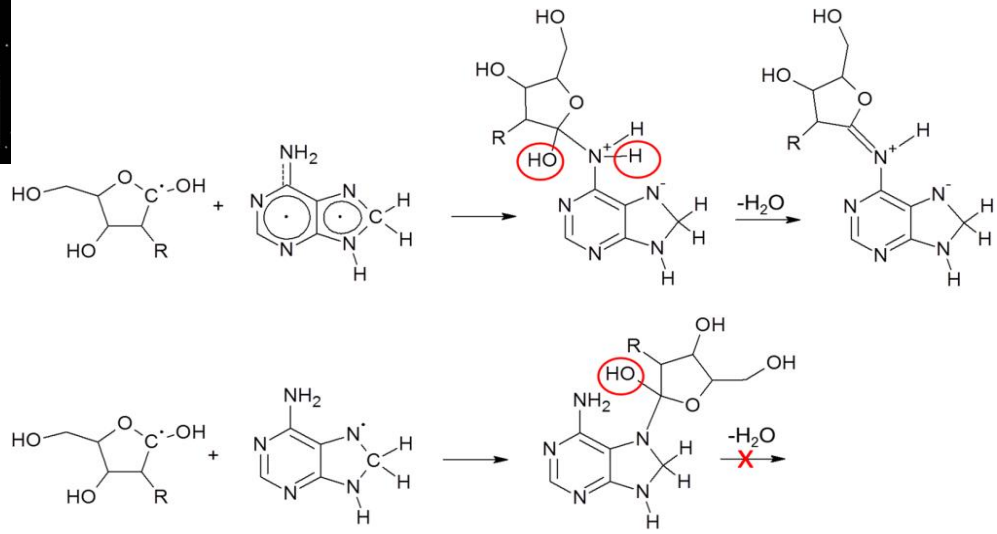
From the Protocol of the 19th Joint Working Group:

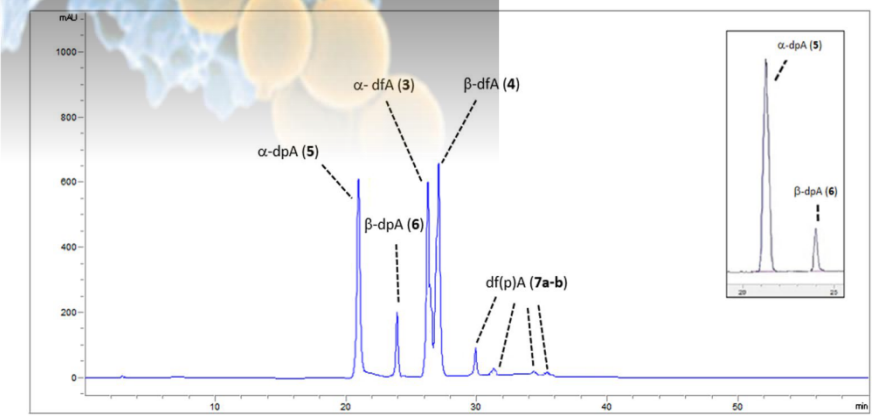
The Russian and U.S. (NASA) sides considered the programs of research on cosmic radiation in connection with the danger of irradiation in manned flights. The sides stressed the importance of studying the biological effects of heavy particles of galactic cosmic radiation, primarily on the central nervous system. ***The Russian side presented the results of experiments performed at JINR's accelerators, indicating a behavior disorder in monkeys after irradiation.*** **The American side reported a similar study, which revealed changes in behavioral responses and the structure of the central nervous system *in rodents*. The sides agreed to consider the possibility of implementing a *joint project* to investigate the effects of cosmic radiation on the central nervous system.**

Astrobiology @ JINR



Proton irradiation: a key to the challenge of N-glycosidic bond formation in a prebiotic context





HPLC chromatographic profile for the irradiation of adenine (1) and 2-deoxyribose (2)

N^6-glycosidation of nucleobases by a C1-centered ribose radical

Technology transfer to JINR Member State

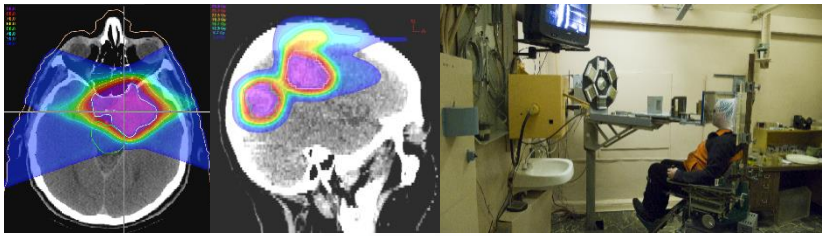
CYCLOTRON CENTRE IN ASTANA (KAZAKHSTAN) LAUNCHED IN 2006

- **2003:** Government decision on the creation of a cyclotron center in Astana
- **2004–2005:** Designing and manufacturing of equipment of the DC-60 cyclotron
- **2006:** Delivery of equipment to Astana; mounting, tuning and adjustment; first beam generation

Radiation Medicine at JINR

Radiation medicine methods are being developed at JINR on the basis of JINR's long-term experience in proton therapy and in the frames of the Agreement between JINR and Federal Medical-Biological Agency of Russia

Superconducting cyclotron for proton therapy: Cooperation between JINR and ASIPP (China)



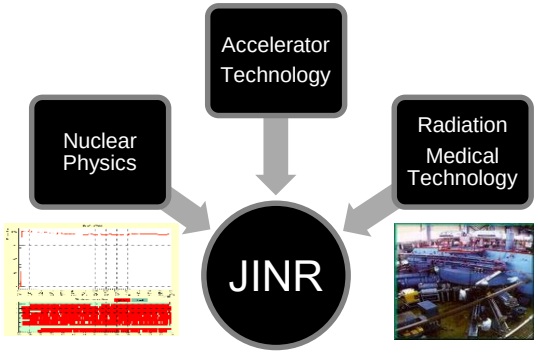
- Design project is successfully finished
- Current status: production

A new cyclotron is expected to be merged with the **existing beamlines** and radiotherapy cabins of the JINR **Phasotron** after its shutdown.

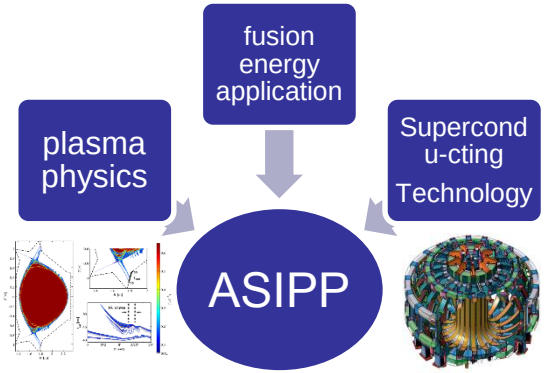
SC200 = Superconducting Cyclotron 202 MeV

Radiation Medicine at JINR

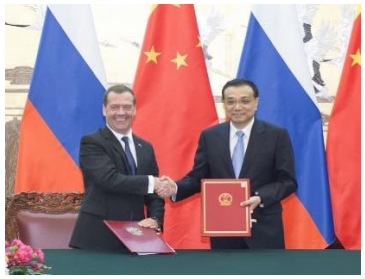
JINR–ASIPP collaboration background



Collaboration

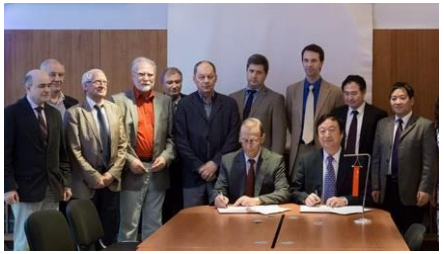


China-Russia joint statement in 2014

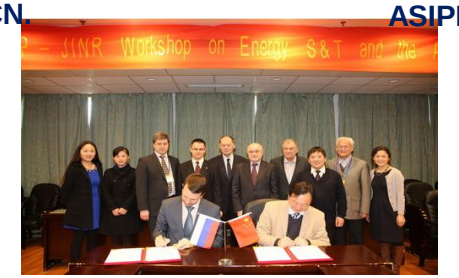


20th and 21st Prime Minister Regular Meeting btw RU. and CN.

Russian Prime Minister Dmitry Medvedev visited ASIPP



Memorandum of Cooperation between NICA and FAST



1st ASIPP&JINR workshop on Energy S&T and the Applications

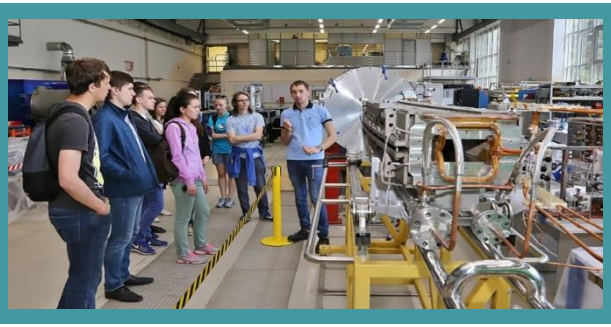
JINR-ASIPP Superconducting Proton Therapy Joint Research Center

SC200 Cooperation btw JINR & CIM

JINR UC Educational Programmes

and 7-year Plan for the Development of JINR

Implementing the goal "Attracting Youth to Science"


Major JINR UC educational activities:

- Outreach programmes for school students and teachers;
- Preparation of qualification works at Bachelor, Master, or PhD level;
- International Student Practices at JINR;
- Summer Student Programme;
- Training programmes for engineers, etc.

- In 2017 JINR has addressed the Russian Government to join the system of defending theses at JINR and assigning the JINR PhD degree.
- JINR is intend to establish a special fund to support JINR postdoc positions.

JINR UC outreach activity

- **Scientific Schools for physics teachers at CERN and JINR (started in 2009); http://teachers.jinr.ru/**
- **Visits to the JINR laboratories for school and university students;**
- **Festivals of sciences, etc.**

NEW !

Dubna School of Engineering: joint initiative of JINR and Dubna State University

School's Objectives:

to meet challenges in realizing present and future JINR projects

✓ ***attracting most talented students***

✓ ***modern technical education and hand-on training of engineers***

Guidelines of the School:

PRACTICAL and FUNDAMENTAL education: ***broad practical skills, deep math, IT, training to work at JINR present and new basic facilities***

ELITE education: ***selection of most talented students of Dubna University***

INTENATIONAL education: ***attraction of students from JINR Member States***

HIGH-LEVEL teaching staff ***from JINR and leading universities***

Creation of MODERN educational INFRASTRUCTURE:
joint efforts of JINR and Dubna University, using dedicated JINR facilities at UC

Supported by JINR Scientific-Technical Council 16.06.2017, by Scientific Council of Dubna State University 26.01.2018

Joint programme by Dubna city and JINR under support of the Moscow region government

NEW ! Organizing in Dubna an International Lyceum for gifted school children with the strong learning courses on physics, mathematics, IT and biology

- First lyceum in Russia with bilingual education.
- Unique modern training laboratories with the newes equipment.
- Teachers are world-class specialists practicing in physics, mathematics, information technology, biology.

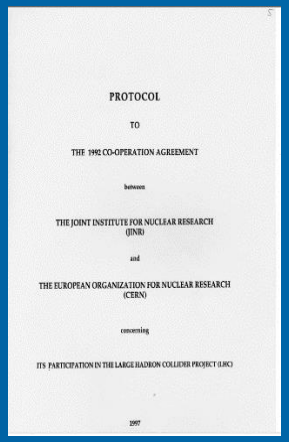
Cooperation with CERN

The history of cooperation between CERN and JINR spans over 50 years

CERN is JINR's main partner in Particle Physics.
20 CERN projects, including 3 LHC experiments & LHC itself
CERN and JINR are both observers in each lab.

JINR physicists are widely involved in a number of CERN projects including ATLAS, CMS, ALICE, LHC/Damper, NA48/1/2, NA58, NA61, NA62, NA64, and others

CERN – JINR Agreement updating


PROTOCOL

TO

THE 1992 CO-OPERATION AGREEMENT

between

THE JOINT INSTITUTE FOR NUCLEAR RESEARCH (JINR)

and

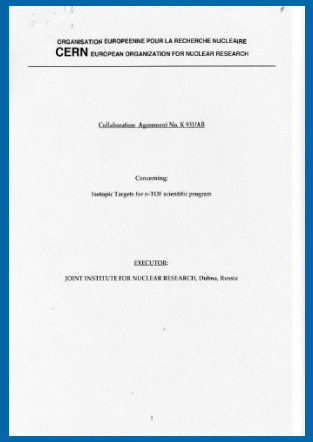
THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

concerning

ITS PARTICIPATION IN THE LARGE HADRON COLLIDER PROJECT (LHC)

1997

1997


ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Collaboration Agreement No. K 930/AB

Concerning:

Isotopic Targets for n-TOF scientific program

EXECUTOR:

JOINT INSTITUTE FOR NUCLEAR RESEARCH, Dubna, Russia

2003


AGREEMENT

Between

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

And

JOINT INSTITUTE FOR NUCLEAR RESEARCH (JINR)

2007

2007


AGREEMENT

Between

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

And

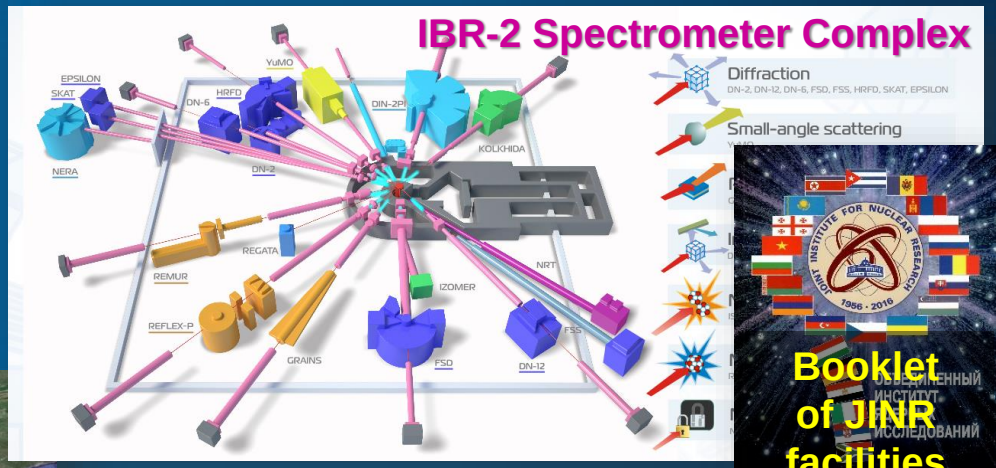
JOINT INSTITUTE FOR NUCLEAR RESEARCH

2010

JINR – CERN strategic partnerships

- JINR actively participates in the LHC programmes including the ATLAS, CMS , ALICE and the Collider itself and planning to contribute to the LHC detectors upgrade.
- Besides, JINR participate in the four SPS projects:
- Compass-II (NA58) – nucleon spin structure, hadron spectroscopy (with interests to future SPD at NICA);
- NA61 – (intersects with BM@Nuclotrone and MPD);
- NA62 – CP-violation and rare decays;
- NA64 – search for the dark sector;
- Accelerator development: **HL-LHC CLIC**,**ILC LHeC**, **FCC**, Precise laser metrology (super sensitive inclinometr) ,
- Computing and Information Technologies, **WLCG, Tier-1,2**
- Neutrino platform, DUNE; other - nTOF, DIRAC,
- Education and Teachers programs etc.

JINR: A look into the future



- *Implementing megascience projects;*
- *Integrating into the global physics landscape;*
- *Establishing new international ties;*
- *Long-term strategy planning.*

JINR Future:

Long Range Strategy Plan for up to 2030

(International working groups on different directions should present first reduction pf the plan at the end of 2019)

- NICA – II and III (SC Nuclotrone, HL-NICA)
- DRIBS-III (Dubna Radioactive Beam Complex)
- DERICA (Dubna Electron Radioactive Ion Collider fAcility)
- Physics with the ultracold neutrons at IBR-2M
- Super booster NEPTUNE (SC proton initiated pulsed Np-237 breeder Neutron Reactor)
- Baikal –GVD –II Neutrino Telescope
- Hadrons Therapy research complex

Acknowledgements

to the organizers of the CERN-JINR School

Thank you!

Acknowledgements

to the organizers of the CERN-JINR School

Thank you!

Acknowledgements

to the organizers of the CERN-JINR School

Thank you !

Спасибо !

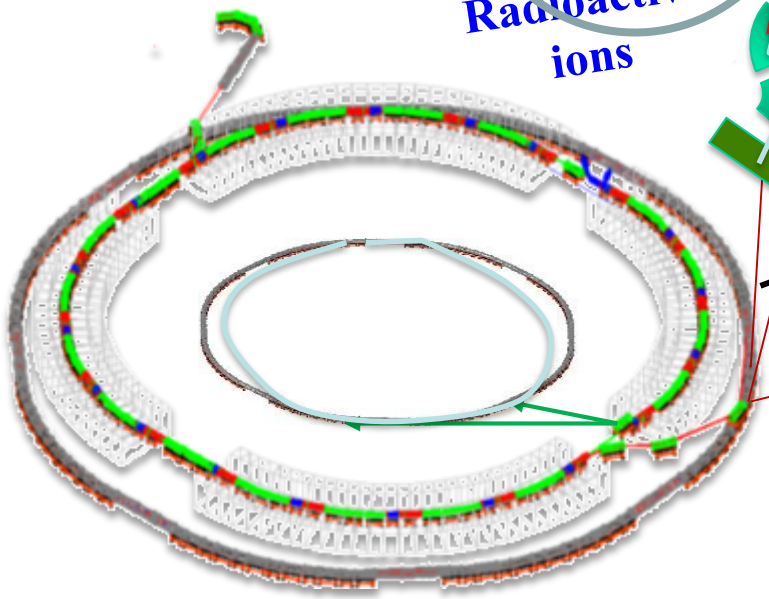
Our colleagues in member–states are saying:
“JINR in Dubna – it is our common house on the banks of the great Russian river Volga”

Welcome to JINR!

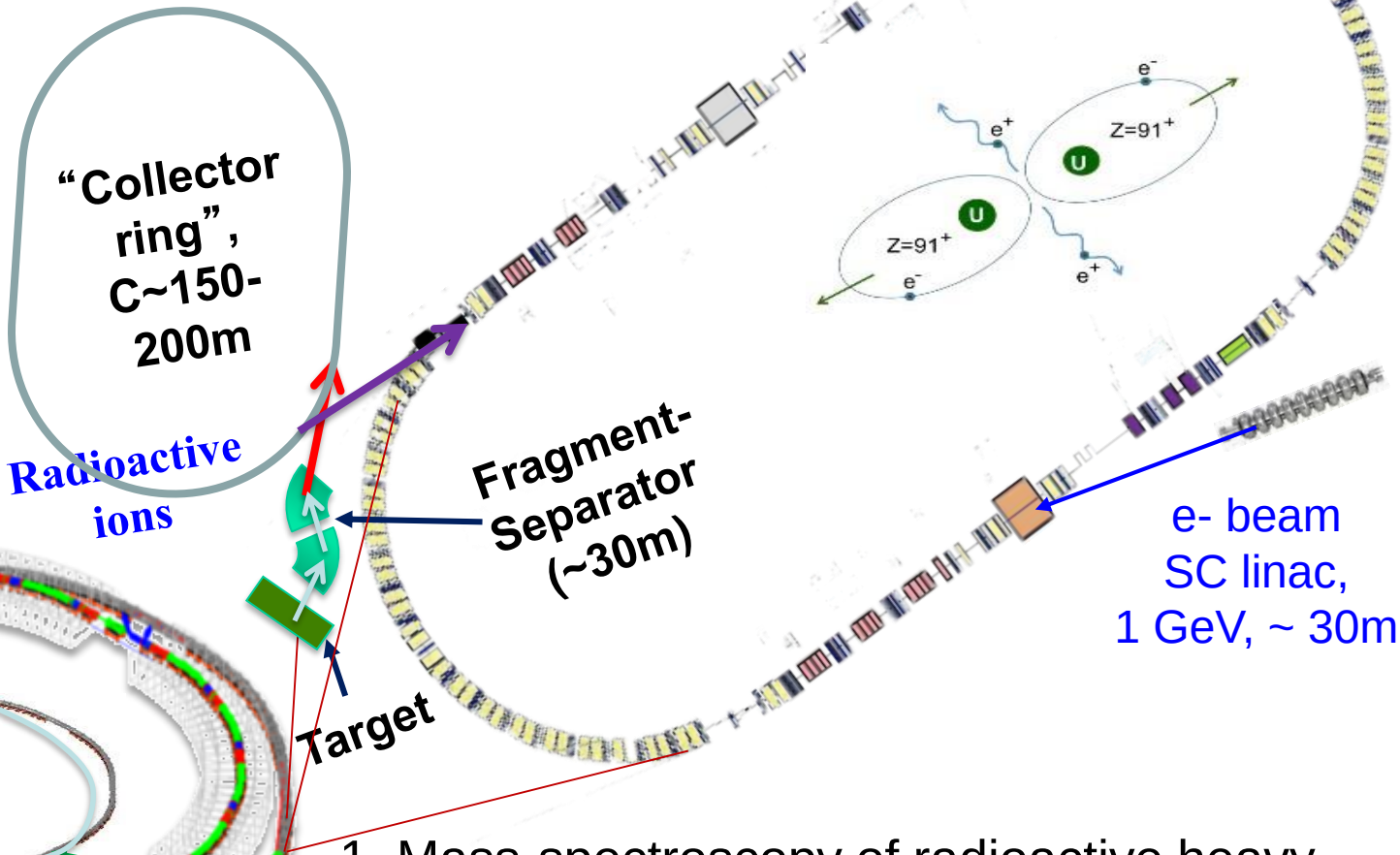
Thank you!

…What NEXT ?…

Creation of supercritical Coulomb fields with merging two bare Uranium beams)



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



1. Mass-spectroscopy of radioactive heavy ion beams in isochronous mode (using collider ring);
2. Merging of RI fragments in the collider ring
3. Scanning of massive nuclei PDF with colliding electron beam (up to ~ 1 GeV);

Superheavy and Radioactive Ion Beam (RIB) research at Dubna

The map of nuclides :

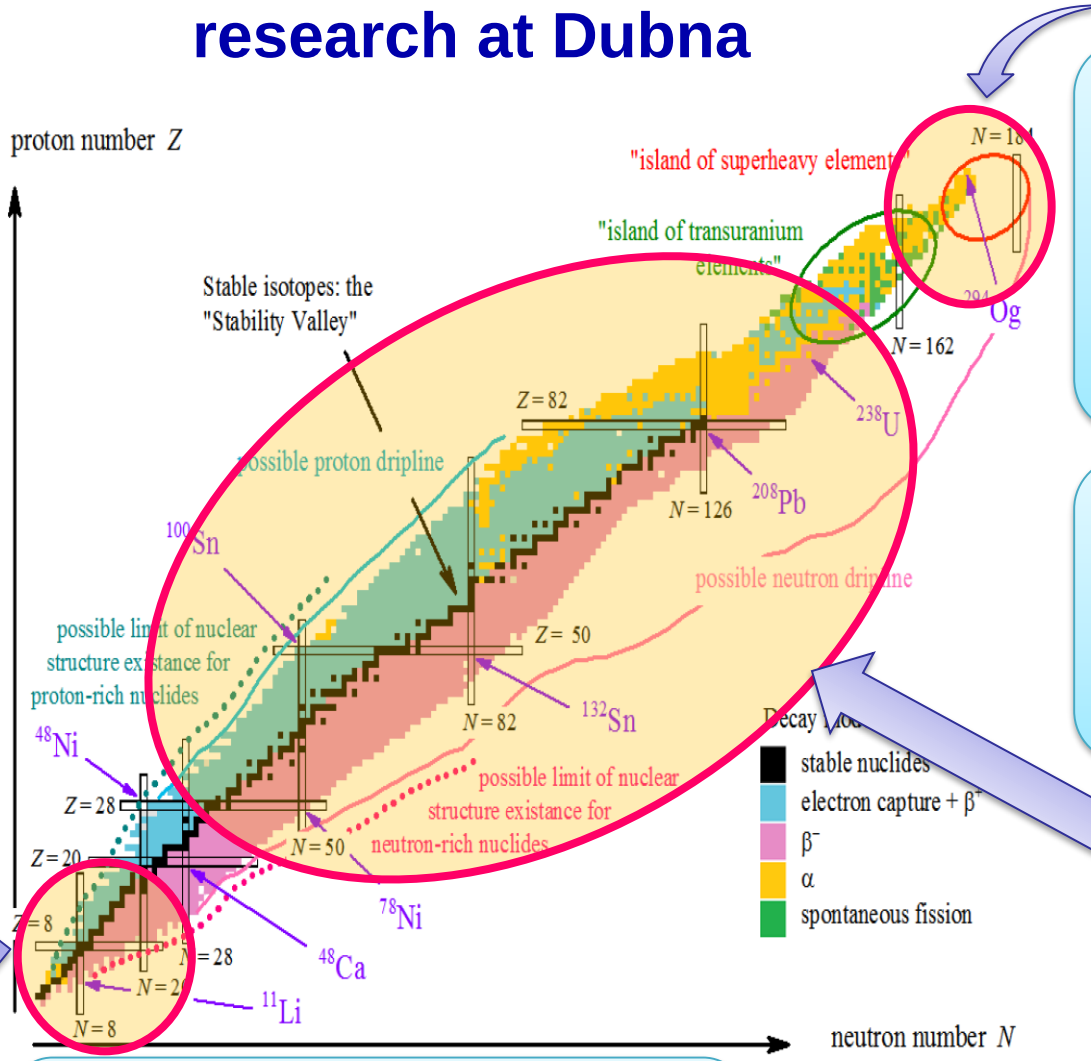
- 254 stable nuclides
- 339 found in nature
- More 3100 RI are known
- ~2000 to be discovered

Neutron dripline: Achieved and studied for N<20

Proton dripline: Achieved and studied for Z<32

Limits of nuclear structure existence: Are known only for the lightest nuclei

"Isle of stability" for superheavies: We just "touched" a bit of its "shore"…



Elements 102 - 108 and 113 - 118 were synthesized at FLNR JINR. Superheavy "isle of stability" discovered

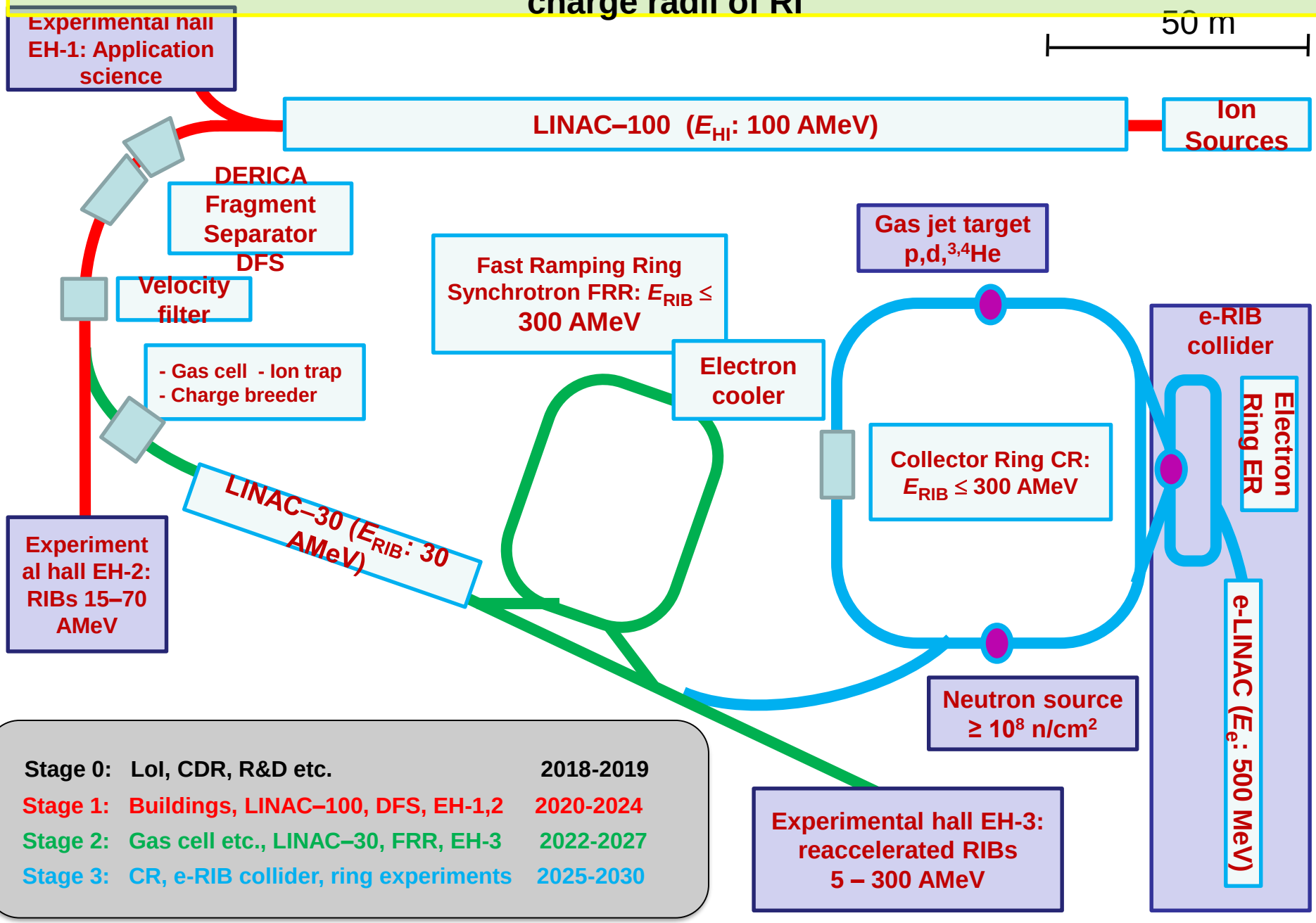
"Factory of superheavy elements" is in commissionin g

DERICA project

Fragment-separator ACCULINNA: Studies of the light RIBs. The only facility for RIB studies in Russia, CIS, and Easten Europe

Facility based on upgraded U-400M + ACCULINNA-2" is in commissioning

Main goal of DERICA (Dubna Electron – Radioactive Ion Collider fAcility): charge radii of RI



Stage 0:	LoI, CDR, R&D etc.	2018-2019
Stage 1:	Buildings, LINAC–100, DFS, EH-1,2	2020-2024
Stage 2:	Gas cell etc., LINAC–30, FRR, EH-3	2022-2027
Stage 3:	CR, e-RIB collider, ring experiments	2025-2030

Electron scattering as a tool for RIB studies

Robert Hofstadter 1915-1990,

1961 Nobel Prize "for his pioneering studies of electron scattering in atomic nuclei and for his consequent discoveries concerning the structure of nucleons.."

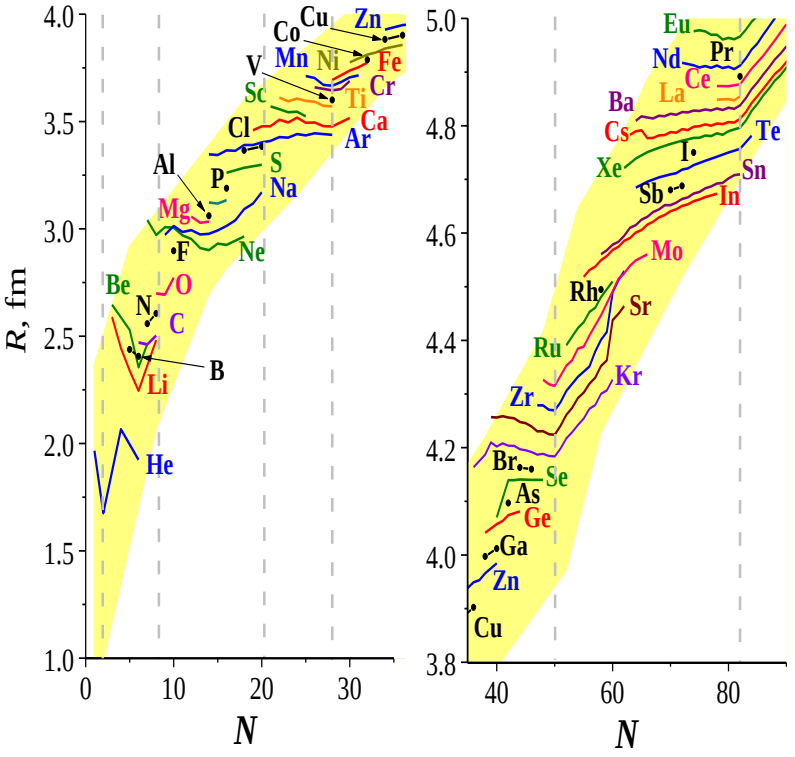
After masses, the radial properties are the most important characteristics of nuclei

Electromagnetic probe is the most reliably established

Status of nuclei radii studies

For 3100 known nuclear-stable isotopes only 900 radii are known

Some isotopic chains are well studied – some not at all

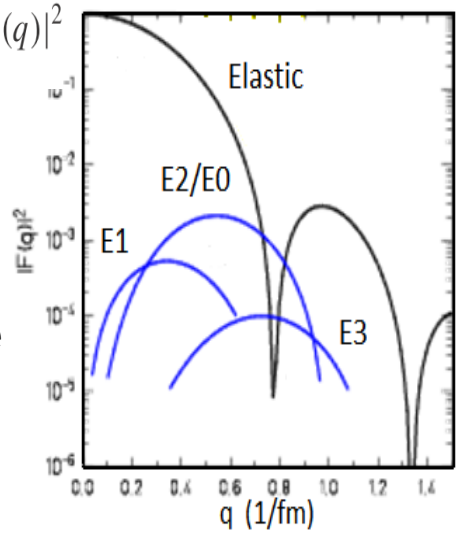


- Fast electrons, the first Born

$$\left(\frac{d\sigma}{d\Omega}\right)_{PWBA} = \frac{\sigma_M}{1+(2E/M_A)\sin^2(\theta/2)}|F_{ch}(q)|^2$$

$$\sigma_M = (e^4/4E^2)\cos^2(\theta/2)\sin^{-4}(\theta/2)$$

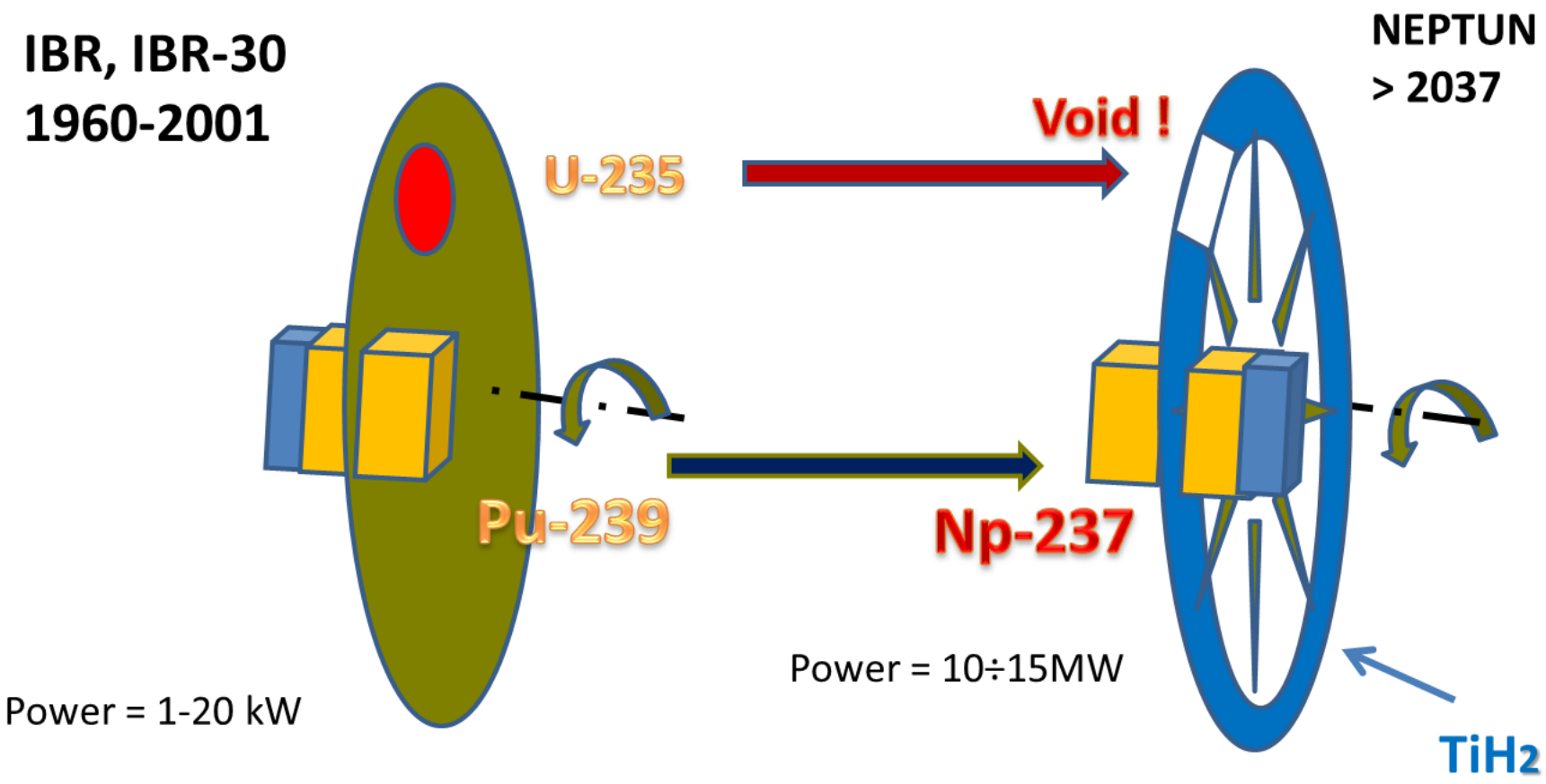
$$q = 2k\sin(\theta/2)$$



- $F_{ch}(q) = 4\pi \int_0^\infty dr r^2 j_0(qr)\rho_{ch}(r)$ ge

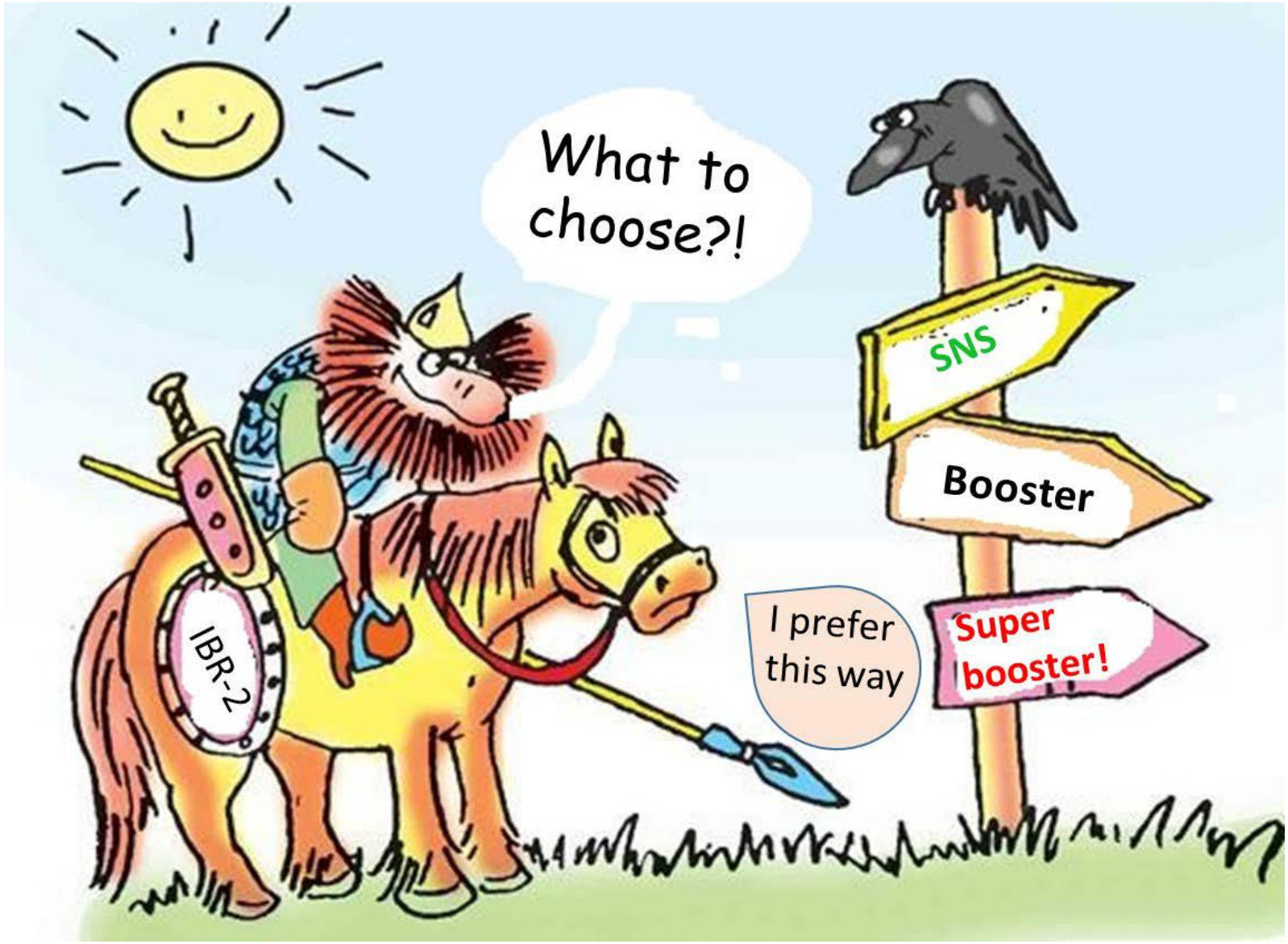
$$F_{ch}(q)/Z = 1 - \frac{q^2}{6}\langle r_{ch}^2\rangle + \cdots$$

e-RIB collider can fill gap in knowledge about nuclei radii in long isotopic chains

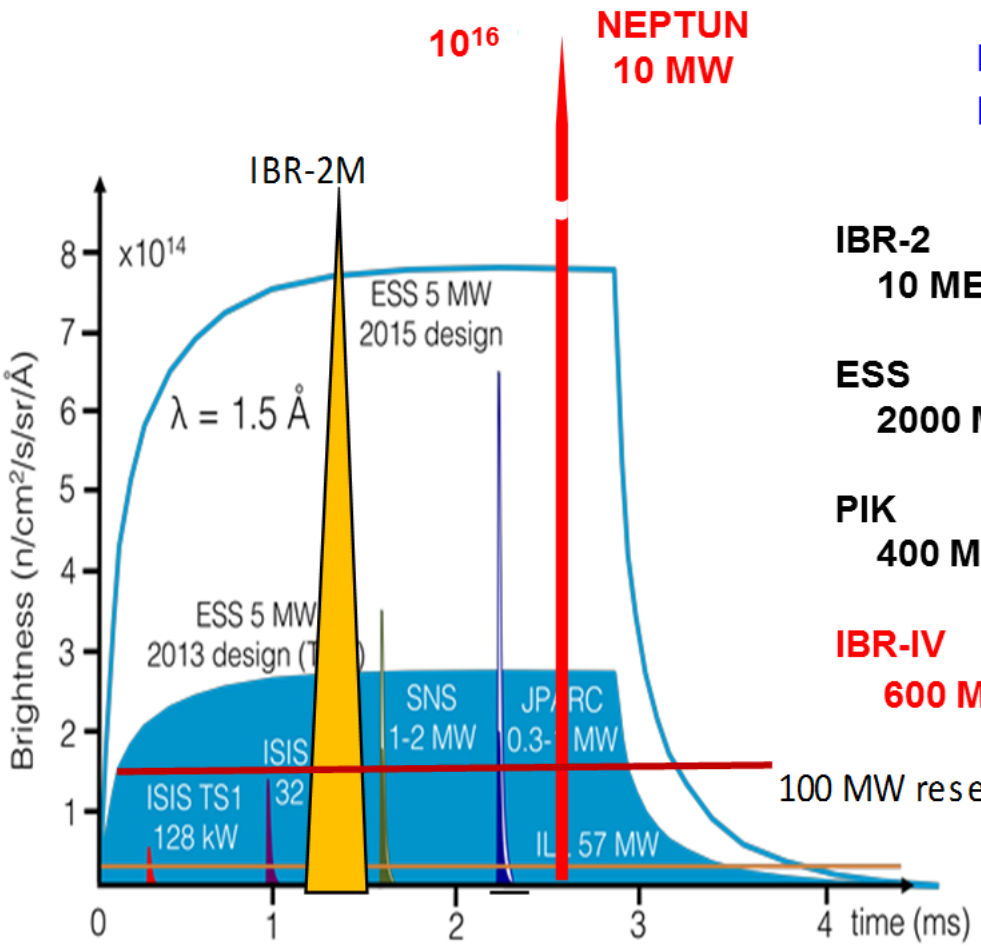


Evolution & Continuity

Why a superbooster



Comparison of NEPTUN with other sources (basic figure from the ESS report).



	Brightness, peak × 10^{14}	Flux density, time aver.
IBR-2 10 MEu	9	0.1
ESS 2000 MEu	8	2
PIK 400 MEu	2	14
IBR-IV 600 MEu	100	3

Data $\times 10^{14}\ [n \cdot cm^{-2} \cdot s^{-1}]$

Understanding the nucleus

Probing exotic (n-rich) nucleus

Nuclear Structure (nuclear models)

Phase Transitions in nuclei

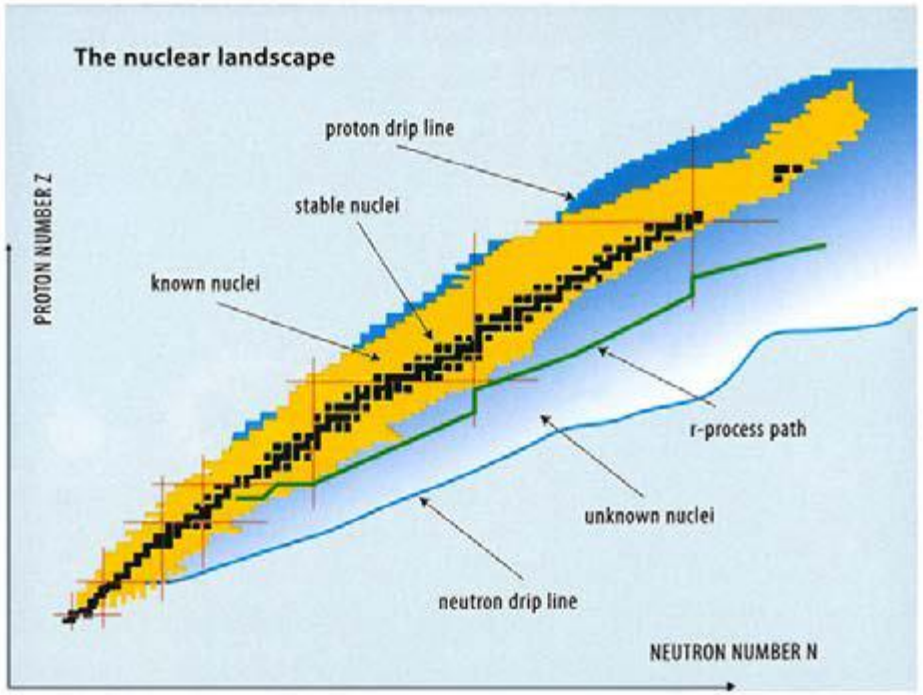
Fission Physics

Nuclear Data

Astrophysics (where do the heavy elements come from?)

Superheavy elements

Stability Island



2016:

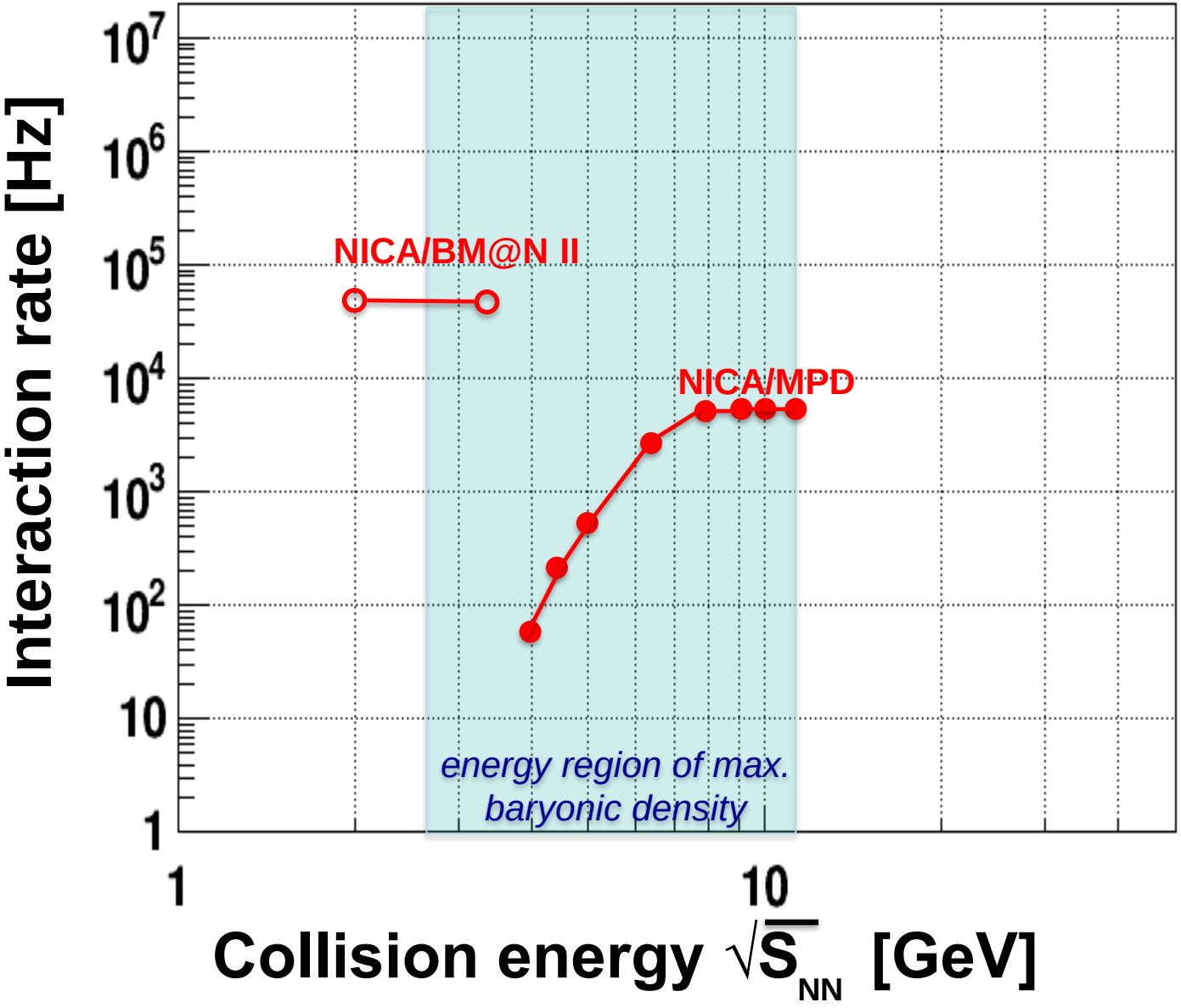
113 - Nihonium (Nh),

115 - Moscovium (Mc),

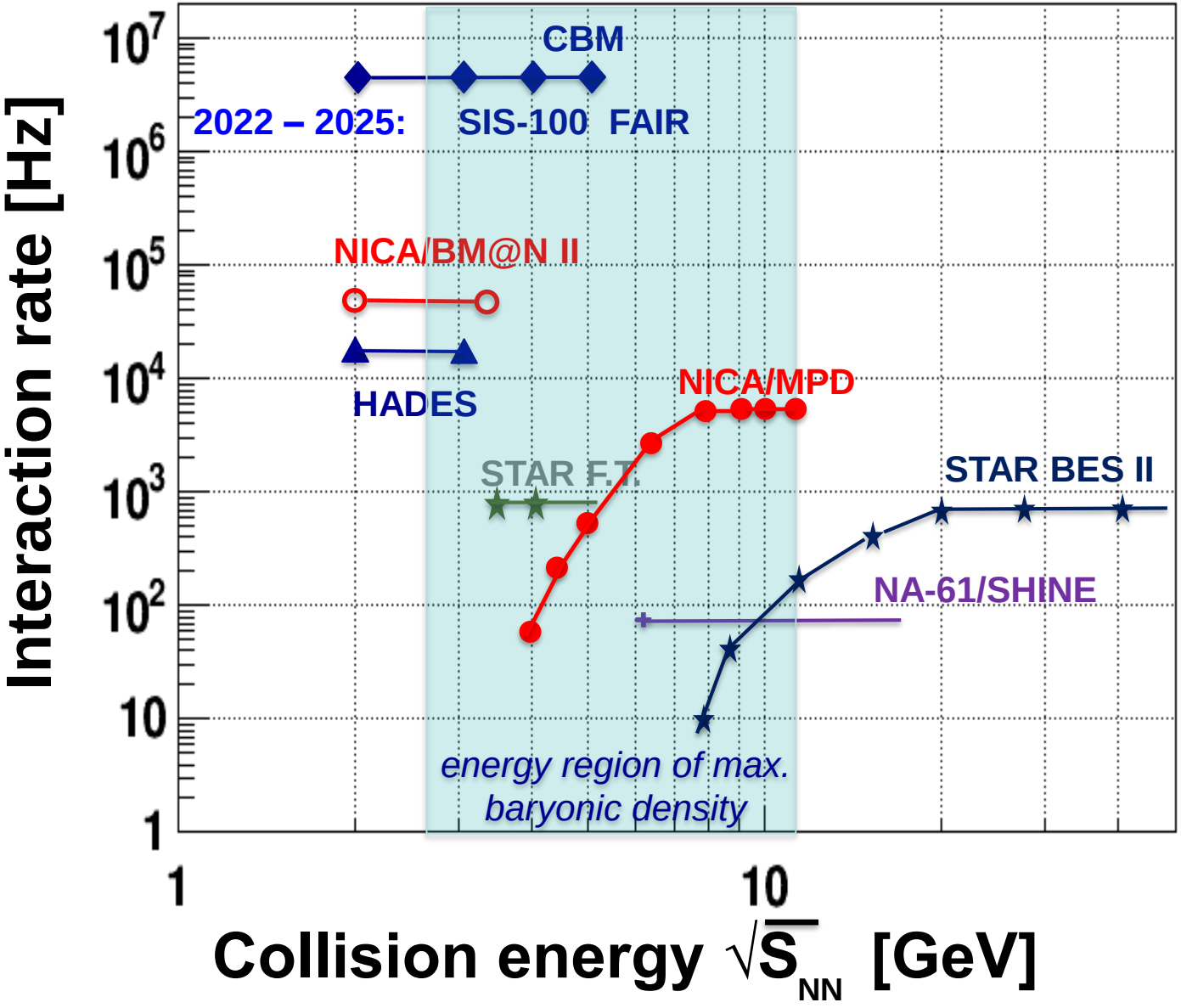
117 - Tennessine (Ts),

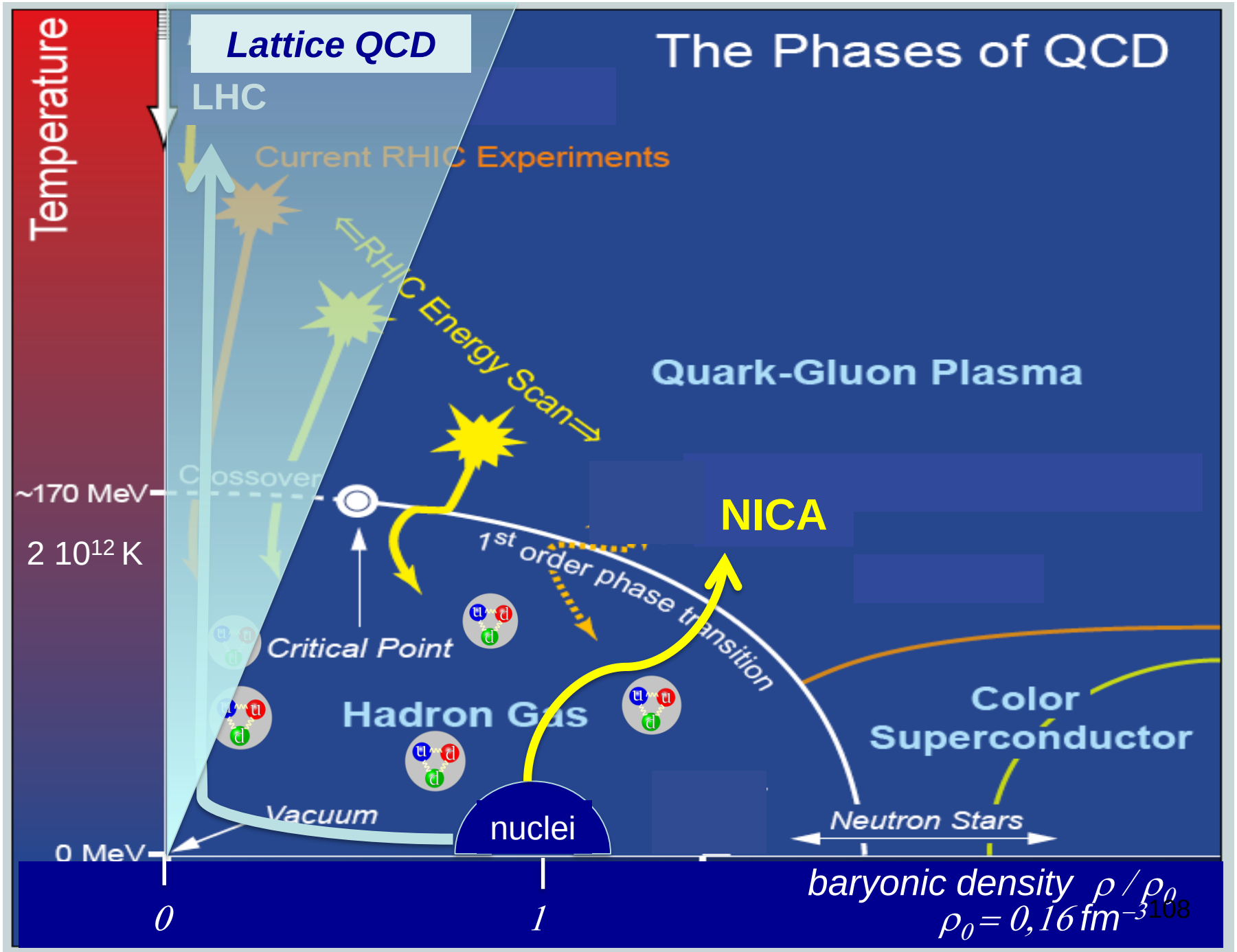
118 - Oganesson (Og)

Present and future HI experiments



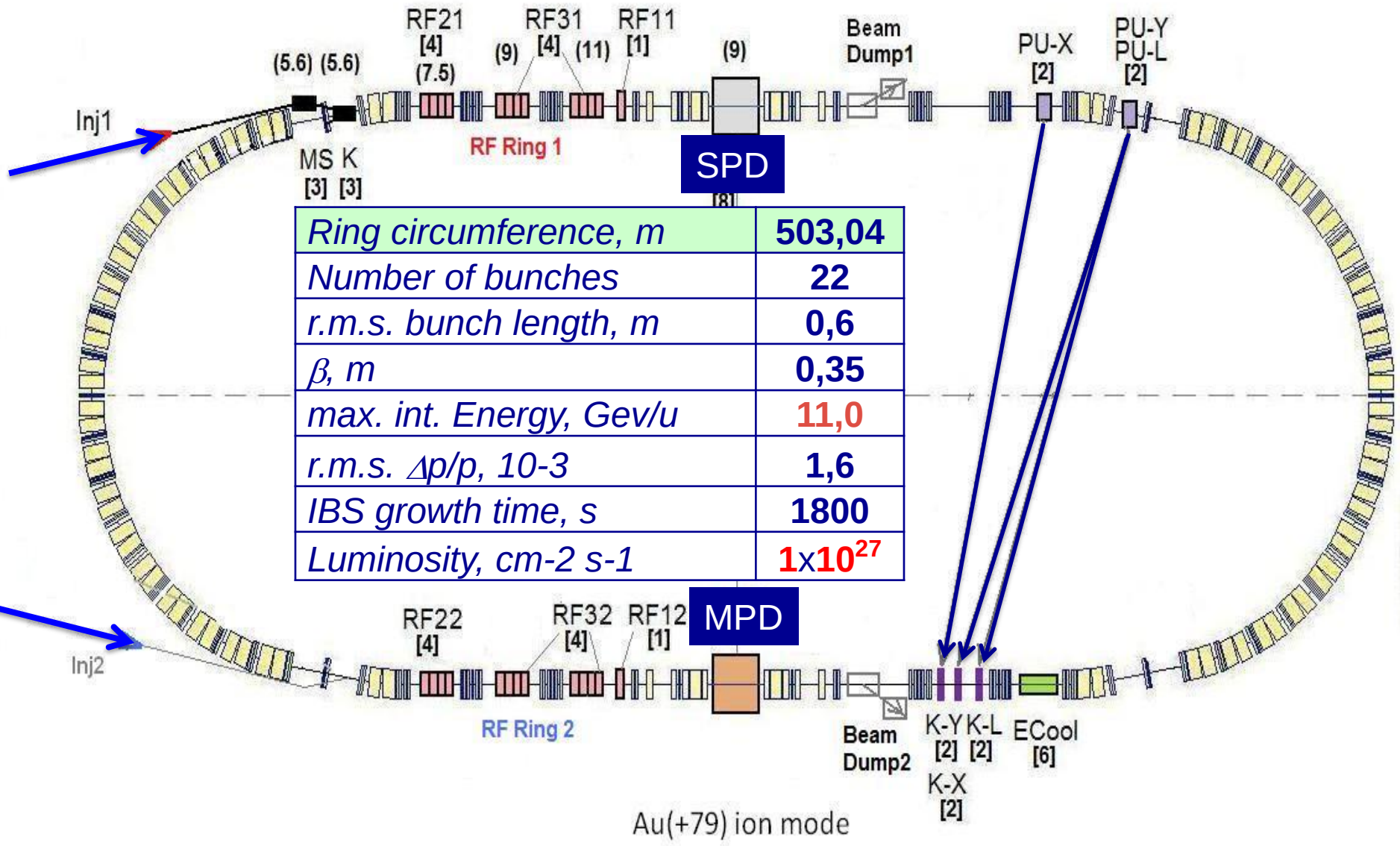
Present and future HI experiments




Lattice QCD
The Phases of QCD
Temperature
LHC
Current RHIC Experiments
⇐RHIC Energy Scan⇒
Quark-Gluon Plasma
Crossover
~170 MeV
2 10^12 K
NICA
1st order phase transition
Critical Point
Hadron Gas
Color Superconductor
Vacuum
nuclei
Neutron Stars
0 MeV
0
1
baryonic density ρ / ρ0
ρ0 = 0,16 fm−3

Collider

45 T*m, *4.5 GeV/u for* ***Au***$^{79+}$



Gigaton Volume Detector (GVD, Baikal Lake)

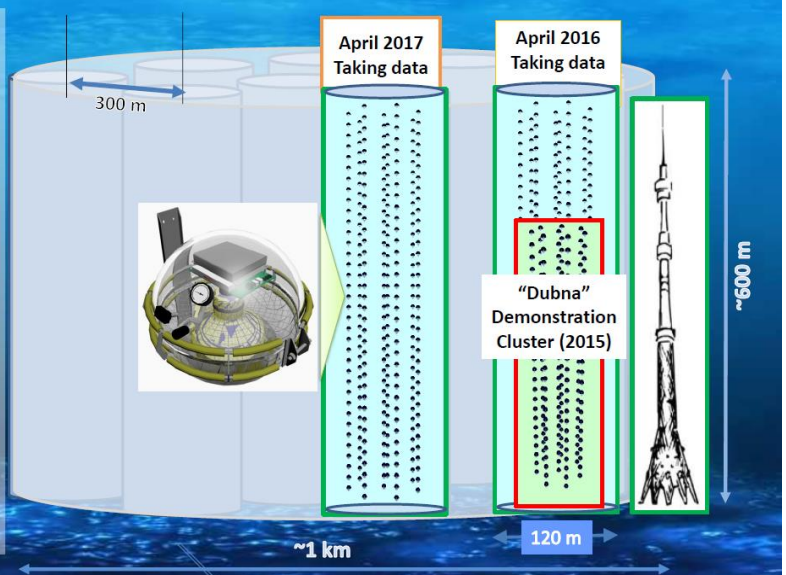
BAIKAL-GVD-1

2304 light sensors combined in 8 clusters of vertical strings at 750 – 1300 m depths.

Detection volume 0.4km^3

Objectives:

- Neutrino astrophysics above few TeV
- Dark matter – indirect search
- Exotic particles – monopoles, Q-balls, nuclearites, …



GVD-1 timeline

2009-2010: R&D with single prototype strings
2011-2014: R&D with prototype cluster of 3 to 5 strings
2015: *Dubna* Demonstration cluster

Cumulative number of full clusters vs. year

Year	2016	2017	2018	2019	2020
Cluster- 288 OM	*1* *288*	*2* *576*	*4* *1152*	*6* *1728*	*8* *2304*

data taking

Effective volume GVD-1 (cascades) ~ 0.4 km^3

Collaboration

1. Institute for Nuclear Research, Moscow, Russia.
2. Joint Institute for Nuclear Research, Dubna.
3. Irkutsk State University, Irkutsk, Russia.
4. Skobeltsyn Institute of Nuclear Physics MSU, Moscow, Russia.
5. Nizhny Novgorod State Technical University, Russia.
6. Saint Petersburg State Marine University, Russia.
7. Institute of Experimental and Applied Physics, Czech Technical University, Czech Republic.
8. Comenius University, Bratislava, Slovakia.
9. EvoLogics GmbH, Berlin, Germany.

Infrasructure





Strategic goals of

Particle Physics and Astrophysics

М.А. Марков

Achieving the integral picture of the World

DLNP

Direct search for New Physics at the LHC

Indirect search for New Physics (flavor sector)

Neutrino physics and astrophysics

Cosmology (dark matter and dark energy)

Perturbative and nonperturbative QCD studies

Relativistic physics of atomic nuclei (heavy ions)

List of tasks for the Seven-year Plan 2017 – 2023

Neutrino: Most important results

(by JINR or with JINR active involvement)

- Precise measurement of θ_{13} and Δm^2_{32} (Daya Bay)
- Discovery of geo-neutrinos (BOREXINO)
- Observation of $\nu_\mu \rightarrow \nu_\tau$ oscillations (OPERA)
- Best limits on existence of sterile neutrino (Daya Bay)
- First hints for neutrino mass hierarchy (NOvA)
- Best limits on neutrino magnetic moment (GEMMA-2)
- Best limits on Majorana neutrino mass (Super NEMO, GERDA)
- Three GVD complexes have already been installed at Baikal. First astrophysical event UHE (BAIKAL GVD)
- Progress of works at the NuLab at the Kalinin APS

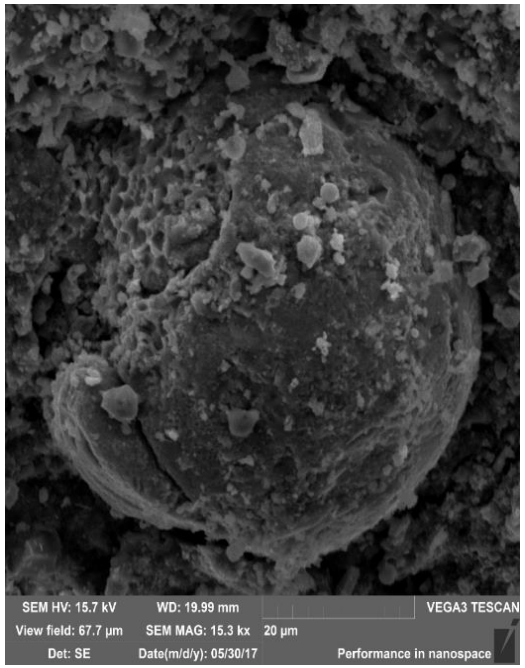
Search for Sterile Neutrino at JINR

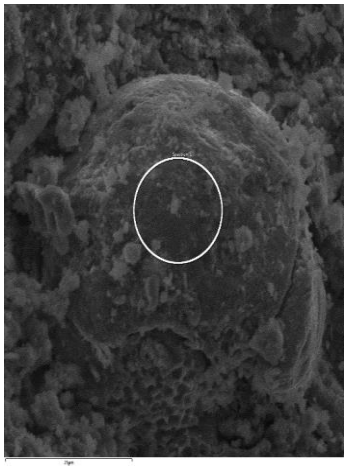
- DANSS will continue data taking at KNPP
- NEUTRINO4 project performs measurements at CM3 research reactor in Dimitrovgrad (point-like core)
- Possible new measurements at Baksan with neutrino source and new experimental setup are discussed (Brudanin, Serebrov)
- (Any questions can be addressed to Alexander Olshevsky at this School)

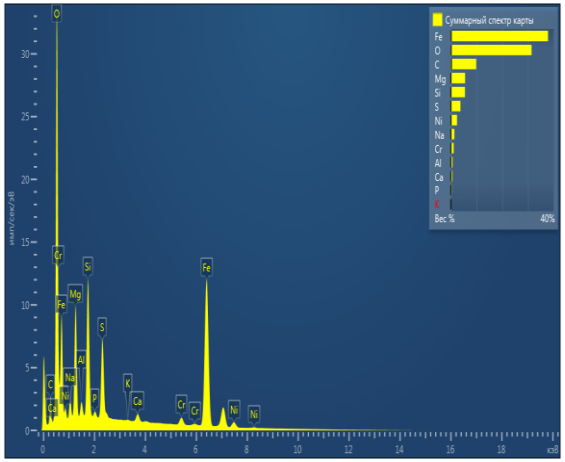
JINR Supercomputer

JINR super-computer “N.Govorun” revolutionary ultra-high dense HPC solution

Studying microfossils in meteorites







A prasinophyte alga in the Murchison meteorite. The absence of nitrogen in the spectrum indicates that this object is not a modern biocontamination.

A cyanobacterial thread with an apical heterocyst; bacterial sheaths and a framboid (the Orgueil meteorite)

“Where there is unity there is always victory.”

Publilius Syrus