



**JOINT INSTITUTE
FOR NUCLEAR RESEARCH**

International Intergovernmental Organization

Объединенный институт ядерных исследований сегодня

Владимир Кекелидзе

*Осенняя Школа по информационным технологиям ОИЯИ
Дубна, 16 октября 2023*

Joint Institute for Nuclear Research (JINR)

International Intergovernmental Scientific Organization,

founded in 1956 by agreement between 12 countries, located in Dubna, Moscow region

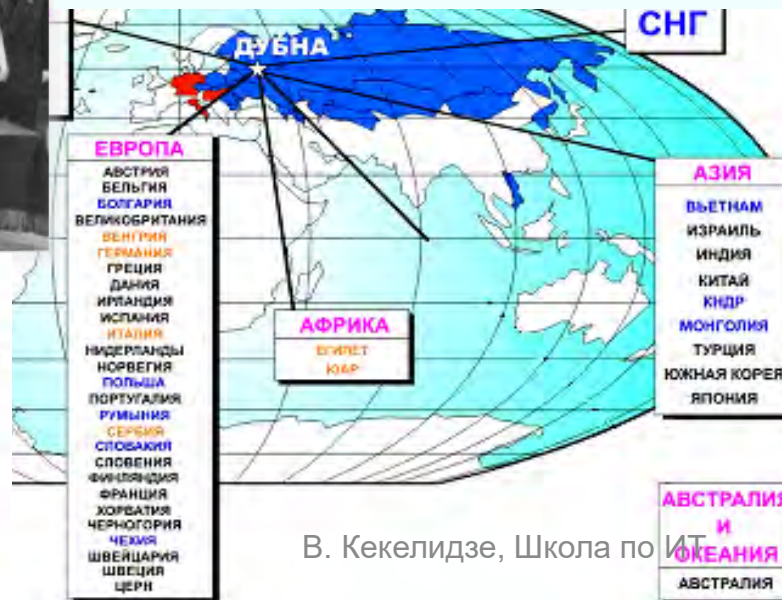
Registered in UN, the JINR charter - in the UN Secretariat (№3686, 01/02/1957)

JINR member states



26 March 1956

Cooperation with
~ 900 institutions
from ~ 70 countries



16 member states
+ 4 associated



В. Кекелидзе, Школа по ИТ

Bogolyubov Laboratory of theoretical physics (BLTP)

Theory of
Fundamental
Interactions

Theory of
Condensed
Matter

Theo
of Ato
Nucle

Mode
Mathem
Phys

*Н.Н. Боголюбов
Д.И. Блохинцев,
М.А. Марков,
А.А. Логунов,
А.Н. Тавхелидзе,
В.Г. Кадышевский,
В.А. Рубаков,
В.И. Огиевецкий,
А.В. Ефремов,
А.Т. Филиппов,
В.А. Соловьев,
...
..*



BLTP: ~240 staff, 20 countries, 300-350 articles + 150-250 proceedings, 10-12 conferences + 3-4 schools



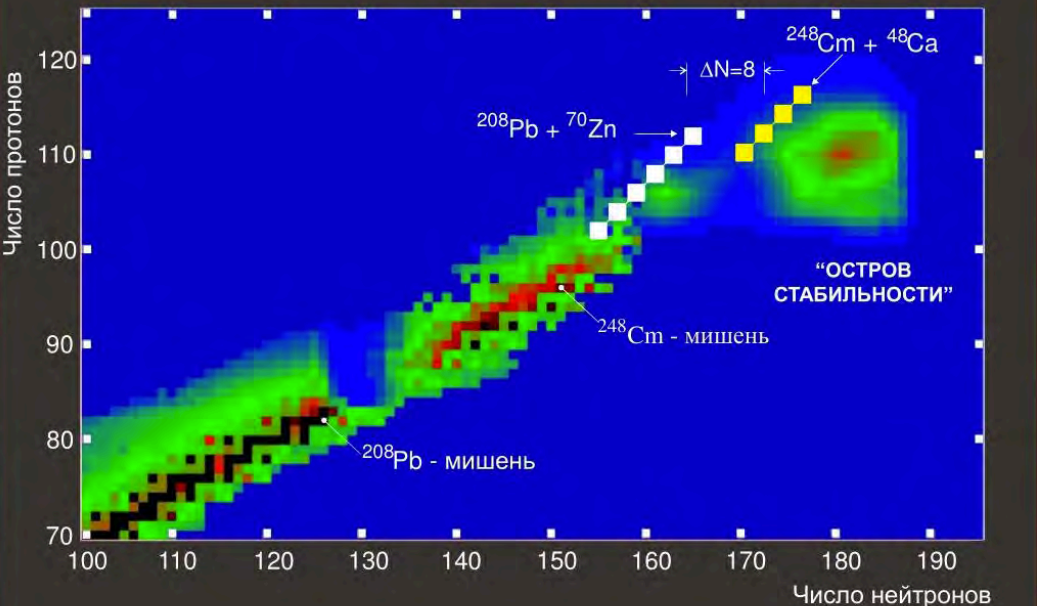
FLEROV LABORATORY of NUCLEAR REACTIONS

Периодическая таблица элементов Д.И. Менделеева

D.I. Mendeleev's Periodic Table of Elements

1																	18
IA																	VIIIA
1 H 1.00794 Hydrogen	2 He 4.0026 Helium											13 Al 26.981539 Aluminum	14 Si 28.0855 Silicon	15 P 30.97376 Phosphorus	16 S 32.06 Sulfur	17 Cl 35.4527 Chlorine	18 Ar 39.948 Argon
3 Li 6.941 Lithium	4 Be 9.01218 Beryllium	3 B 10.811 Boron	4 C 12.011 Carbon	5 N 14.0067 Nitrogen	6 O 15.9994 Oxygen	7 F 18.9984 Fluorine	8 Ne 20.1797 Neon	9 Na 22.989768 Sodium	10 Mg 24.3050 Magnesium	11 K 39.0983 Potassium	12 Ca 40.078 Calcium	13 Ga 69.723 Gallium	14 Ge 72.61 Germanium	15 As 74.92159 Arsenic	16 Se 78.96 Selenium	17 Br 79.904 Bromine	18 Kr 83.80 Krypton
19 K 39.0983 Potassium	20 Ca 40.078 Calcium	21 Sc 44.95591 Scandium	22 Ti 47.88 Titanium	23 V 50.9415 Vanadium	24 Cr 51.9961 Chromium	25 Mn 54.938045 Manganese	26 Fe 55.847 Iron	27 Co 58.9332 Cobalt	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	31 Ga 69.723 Gallium	32 Ge 72.61 Germanium	33 As 74.92159 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
37 Rb 85.4678 Rubidium	38 Sr 87.62 Strontium	39 Y 88.90585 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.90638 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98] Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.90550 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.8682 Silver	48 Cd 112.411 Cadmium	49 In 114.818 Indium	50 Sn 118.710 Tin	51 Sb 121.757 Antimony	52 Te 127.60 Tellurium	53 I 126.90447 Iodine	54 Xe 131.29 Xenon
55 Cs 132.90545 Cesium	56 Ba 137.327 Barium	57 La 138.9055 Lanthanum	58 Ce 140.12 Cerium	59 Pr 140.90765 Praseodymium	60 Nd 144.24 Neodymium	61 Pm [145] Promethium	62 Sm 150.36 Samarium	63 Eu 151.965 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92534 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.93032 Holmium	68 Er 167.26 Erbium	69 Tm 168.93421 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.967 Lutetium	72 Hf 178.49 Hafnium
73 Ta 180.9479 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.96654 Gold	80 Hg 200.59 Mercury	81 Tl 204.3833 Thallium	82 Pb 207.2 Lead	83 Bi 208.98037 Bismuth	84 Po [209] Polonium	85 At [210] Astatine	86 Rn [222] Radon	87 Fr [223] Francium	88 Ra [226] Radium	89 Ac [227] Actinium	90 Th [232] Thorium
89 Ac [227] Actinium	91 Pa [231] Protactinium	92 U [238] Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 Nh [289] Nihonium	103 Fl [289] Flerovium	104 Mc [289] Moscovium	105 Lv [293] Livermorium	106 Ts [294] Tennessine	107 Og [294] Oganesson
119	120																

РЕАКЦИИ СИНТЕЗА СВЕРХТЯЖЁЛЫХ ЭЛЕМЕНТОВ



Лантаноиды Lanthanoides

58 Ce 140.12 Cerium	59 Pr 140.90765 Praseodymium	60 Nd 144.24 Neodymium	61 Pm [145] Promethium	62 Sm 150.36 Samarium	63 Eu 151.965 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92534 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.93032 Holmium	68 Er 167.26 Erbium	69 Tm 168.93421 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.967 Lutetium
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Актиноиды Actinoides

105
Db
Dubnium
(268)

2023

Флеровий 114
Fl
Flerovium

Московский 115
Mc
Moscovium

Ливерморий 116
Lv
Livermorium

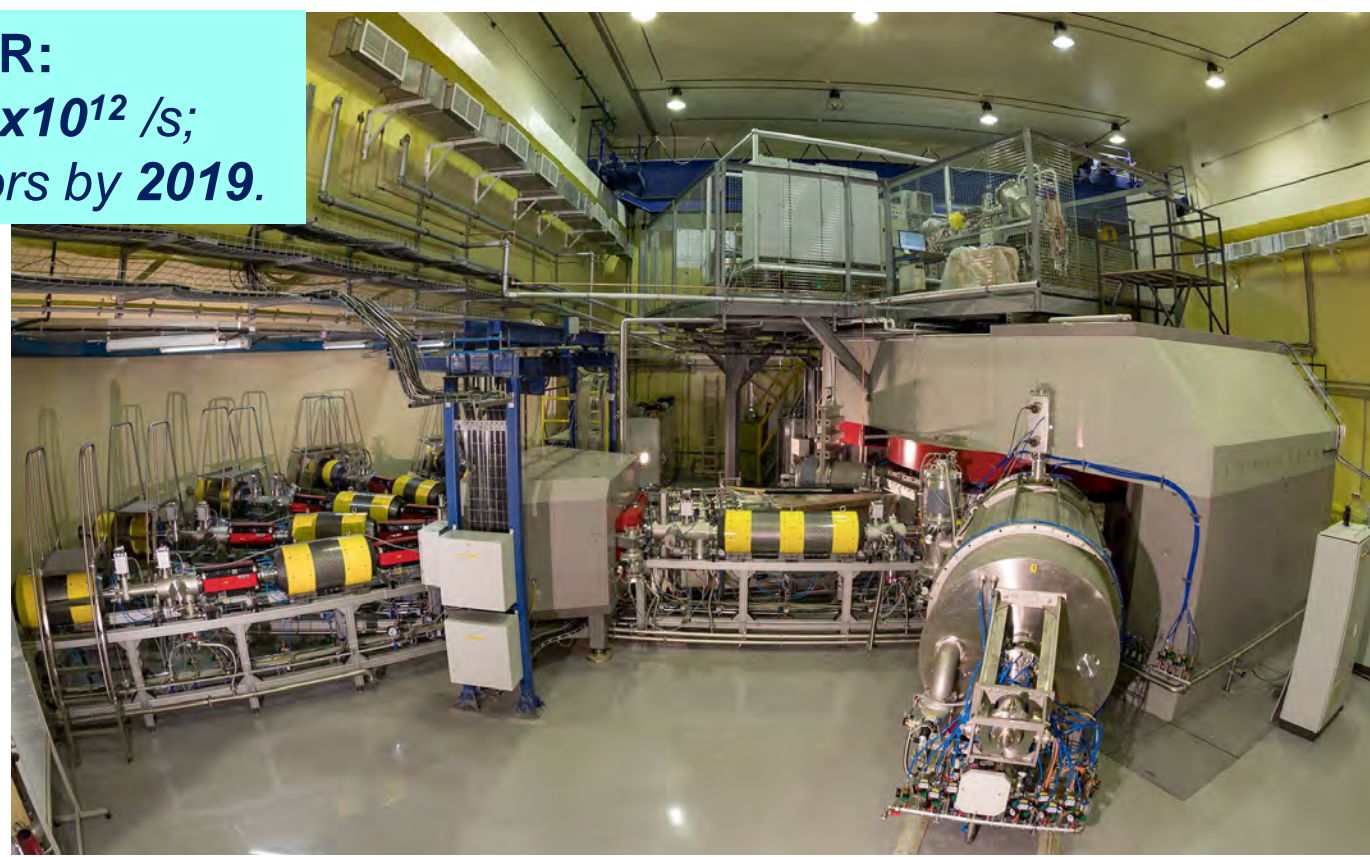
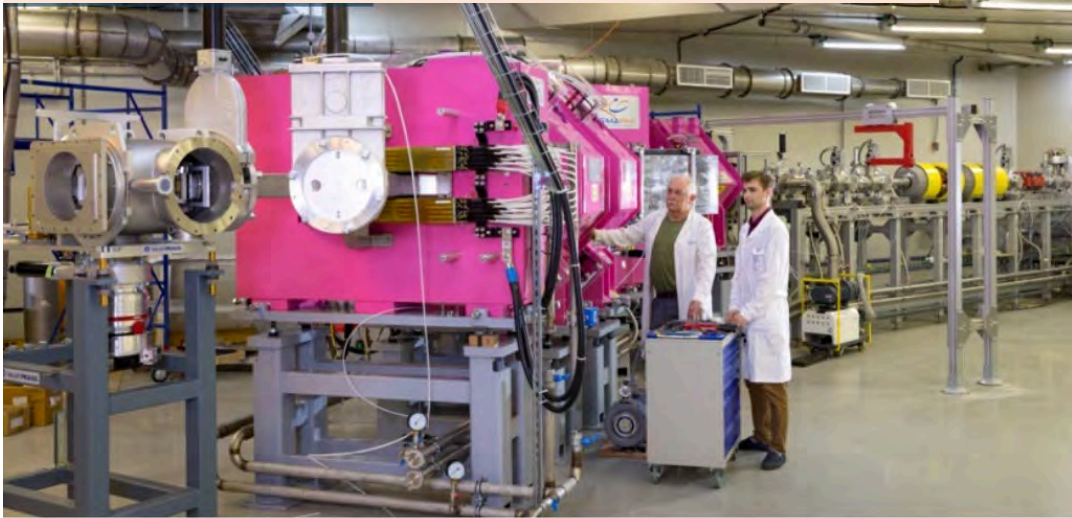
Теннессин 117
Ts
Tennessine

Оганесон 118
Og
Oganesson

DC-280 – Super heavy Elements Factory, LNR:

- project intensity of **Calcium-48** ion beam - 60×10^{12} /s;
- **10 times higher intensity than other accelerators by 2019.**

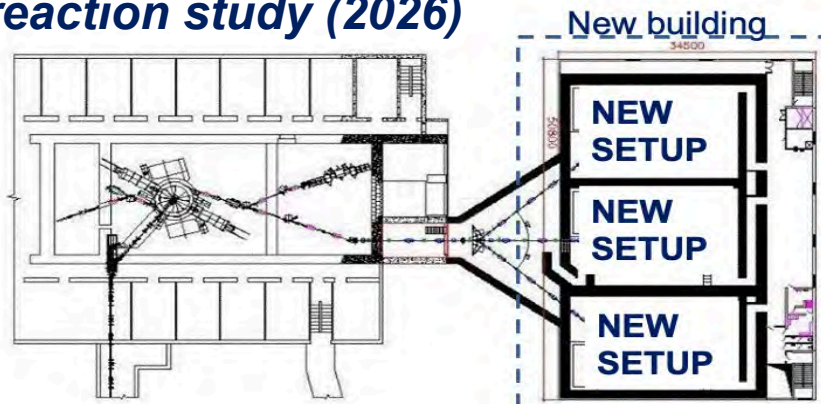
Dubna Gas Filled Recoil Separator



SHE Factory



U400R: up to 2.6 mA (U-beam) 10^{10-11} , smooth energy variation for nuclear reaction study (2026)

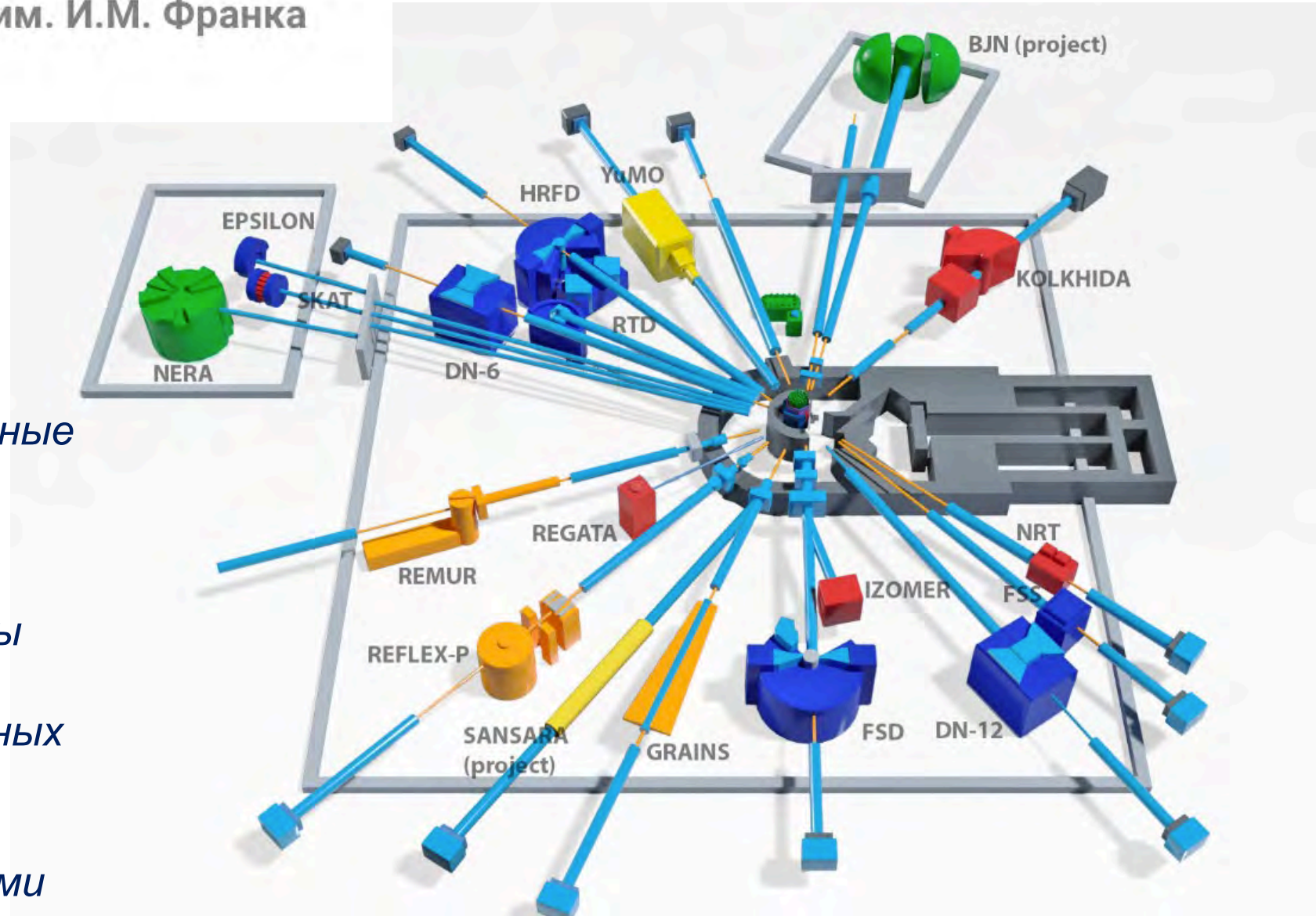


U400M: Radioactive Ion-Beam research (2023)



Лаборатория предлагает :

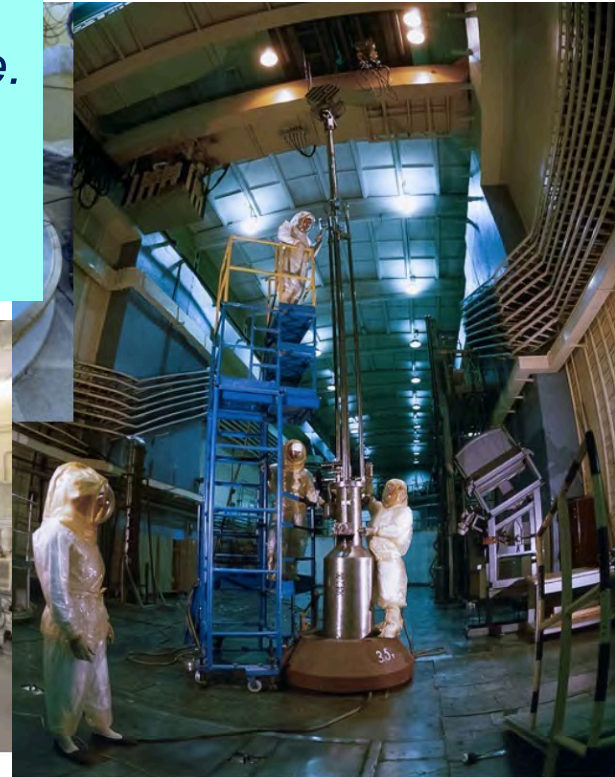
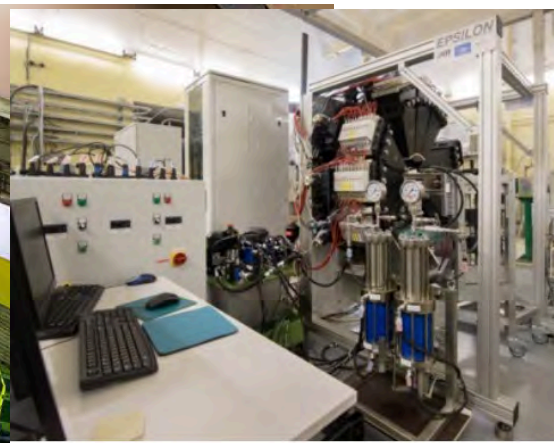
- широкий круг исследований, центральное место среди которых занимают нейтронные методы;
- пользовательские программы User Club, открытость к работе с коллегами из смежных областей науки и гибкие форматы работы с промышленными партнерами



Frank Laboratory of Neutron Physics

IBR-2 - Fast Pulse Reactor with periodic activity:

- neutron fluxes at the moderator surface $\sim 2,4 \times 10^{16}$ n/cm²/s; 1850 MW in pulse.
- frequency – 5 Hz; pulse width (WN) – 320 mksec;
- study neutrons & condense matter properties;
- user policy: ~ 250 experiments / year by researches from up ~ 30 countries





Лаборатория ядерных проблем им. В. П. Дзелептова



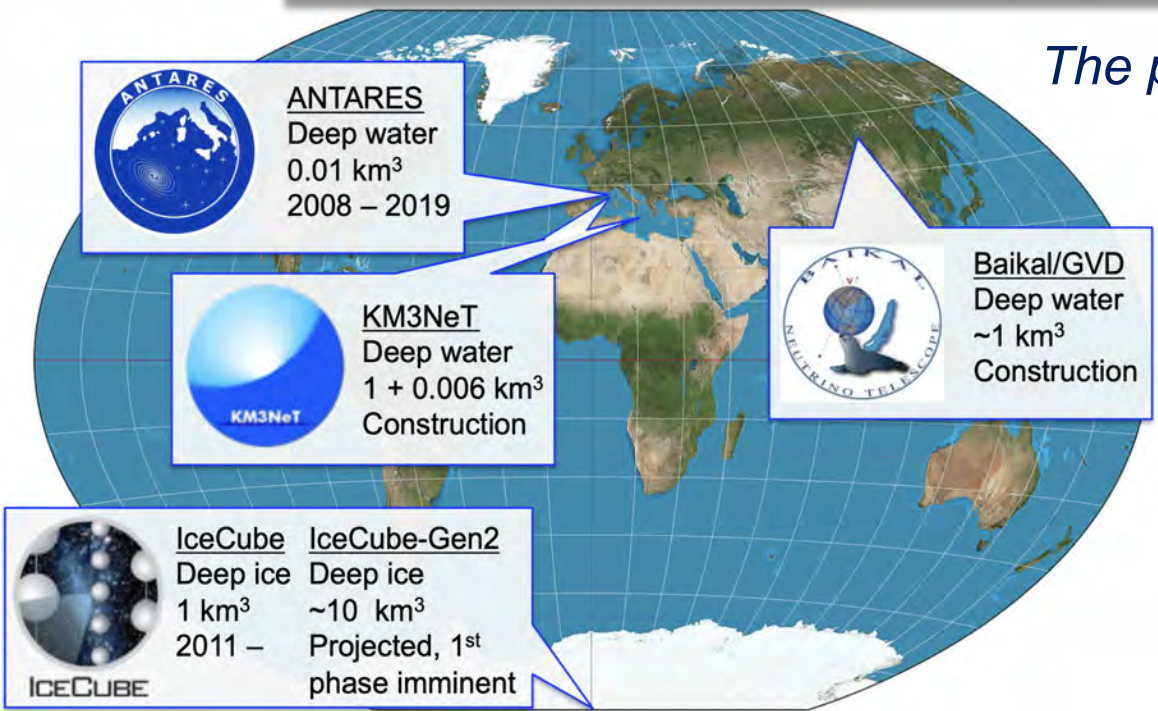
14 декабря 1949 г. произошло историческое событие — состоялся запуск синхроциклотрона, первой базовой установки ОИЯИ,

Основные направления исследований Лаборатории ядерных проблем (ЛЯП):

- *физика **нейтрино** и астрофизика;*
- *исследования по физике частиц высоких энергий;*
- *разработка и создание современной измерительной аппаратуры;*
- *прикладные исследования, в частности, протонная терапия и разработка медицинского ускорительного комплекса.*

Изучение свойств нейтрино

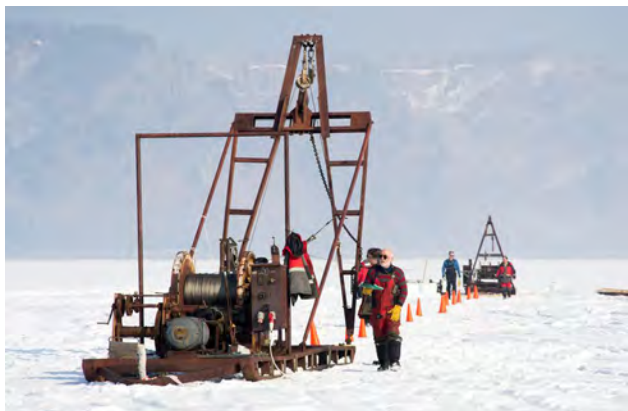
– традиционная область исследований в **ЛЯП**, основанная **Бруно Понтекорво**.



The project is aiming to identify of **astrophysical sources** of ultra-high energy (exceeding **tens of TeV**) neutrinos. *Actuality: their sources are **still unknown**.*

The identification of sources will help to elucidate mechanisms of **galaxies creation and evolution**.

The **Baikal-GVD** project is complementary to other neutrino telescopes, like the **IceCube**



- main advantage of Baikal-GVD:**
- pure and t-stable water;
 - angular resolution of muon tracks **0.3-0.5 grad** (IceCube: 0.5-1);
 - angular resolution of shower direction **2-3 grad** (IceCube: 15),





Baikal-GVD joined the Global Neutrino Network (GNN)

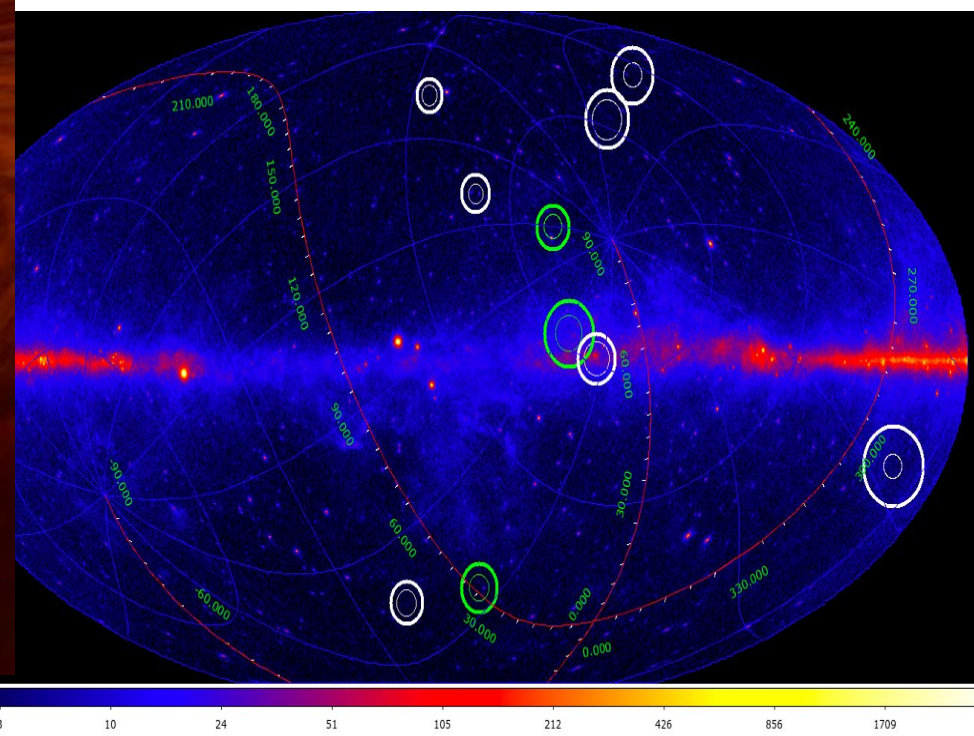


16 октября 2023

2020	7	2016
2021	8	2304
2022	10	2880
2023	12	3456
2024	14	4032

В. Кекелидзе, Школа по ИТ

First 10 events were selected as astrophysical candidates based on the **2018-2020** data



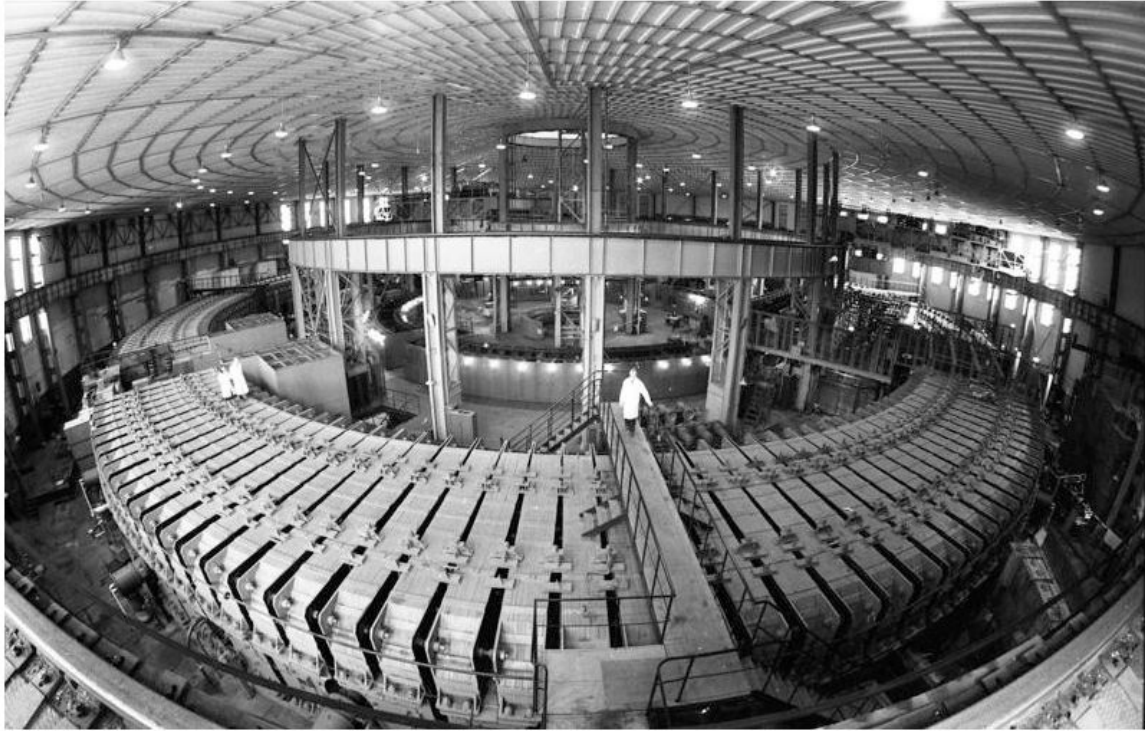
*Position of the first 10 candidates for astrophysical neutrino events on a celestial map with **FERMI-LAT** sources in the galactic coordinate system (the inner and outer circles correspond to the 50% and 90% detection probability).*



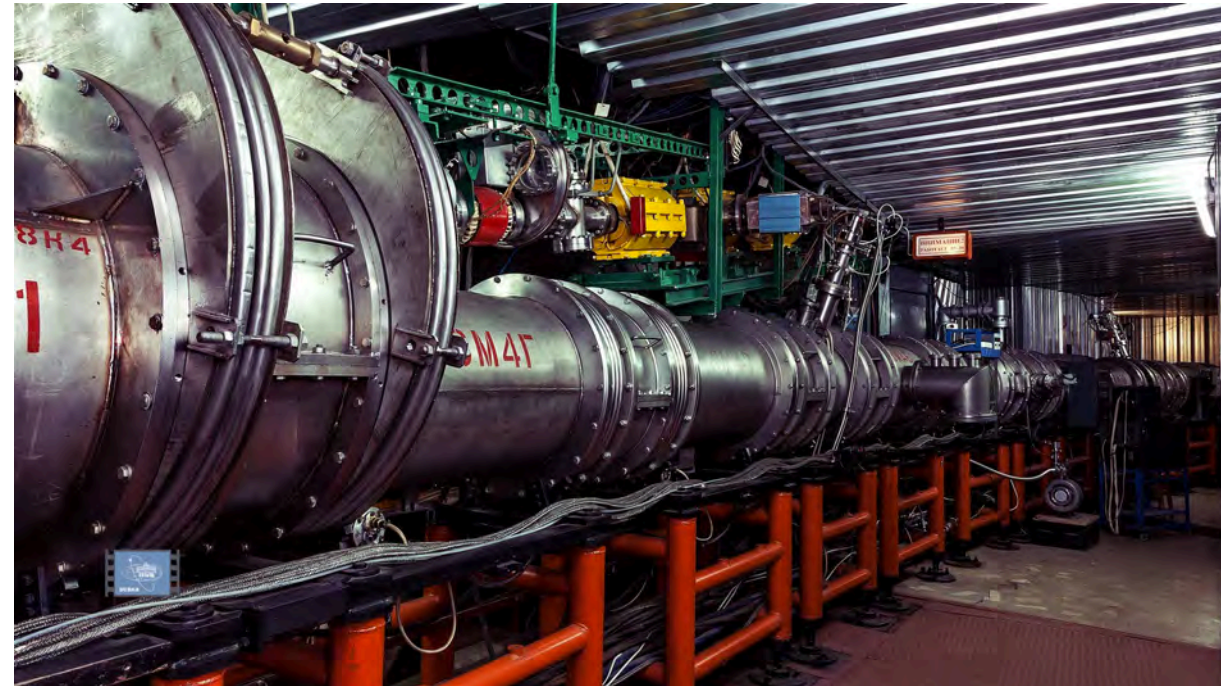
ЛАБОРАТОРИЯ ФИЗИКИ ВЫСОКИХ ЭНЕРГИЙ

ИМЕНИ В.И.ВЕКСЛЕРА И А.М.БАЛДИНА

Синхрофазотрон спроектирован и запущен в 1957 г. под руководством В.И. Векслера; впервые в истории энергия протонов – 10 ГэВ



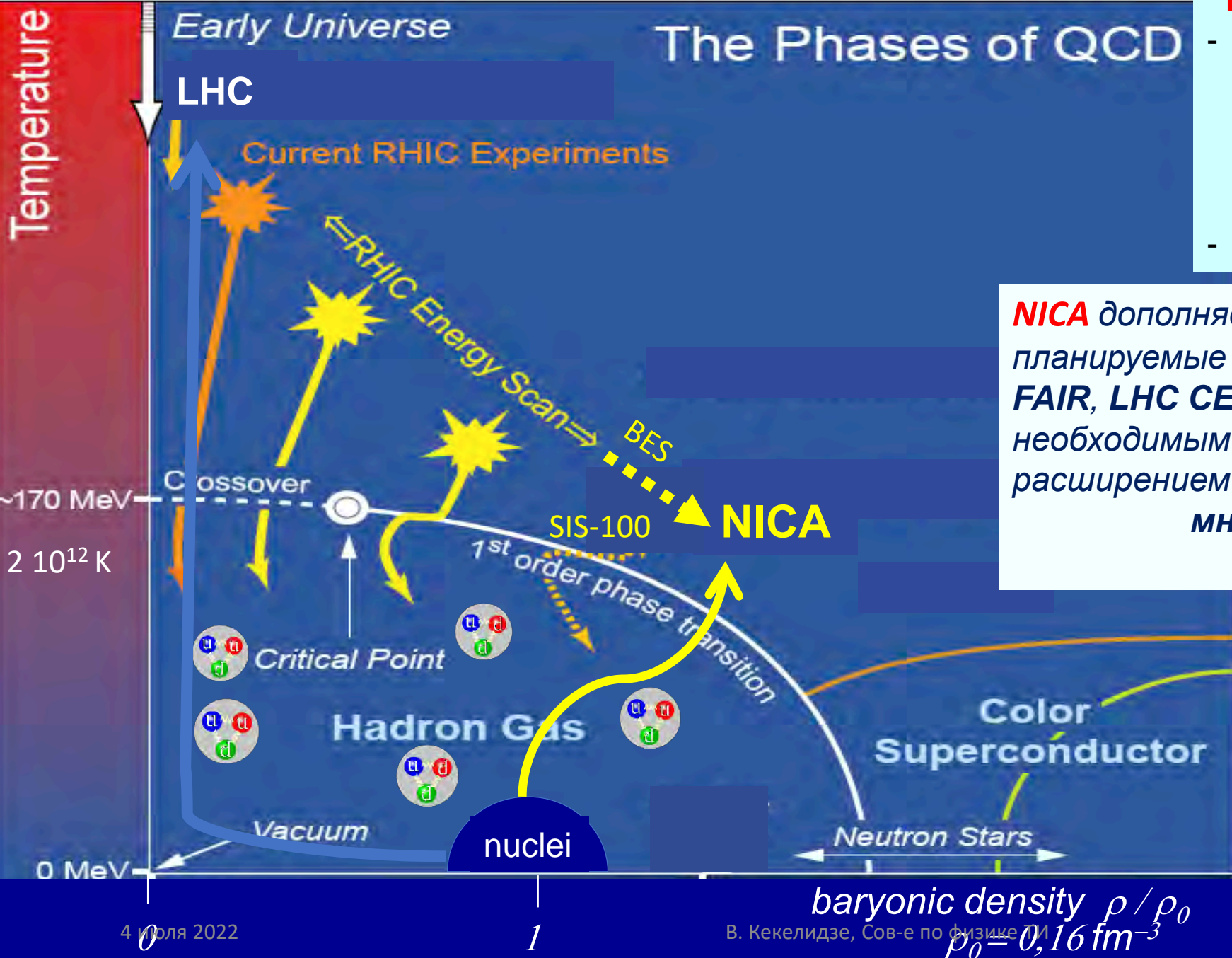
Нуклотрон – первый в России синхротрон на основе СП магнитов, разработанных в ОИЯИ и названных «Дубненскими»; построен по инициативе и под руководством А.М. Балдина; запущен в 1993 г.



16 октября 2023



Nuclotron based **I**on **C**ollider **f**Acility



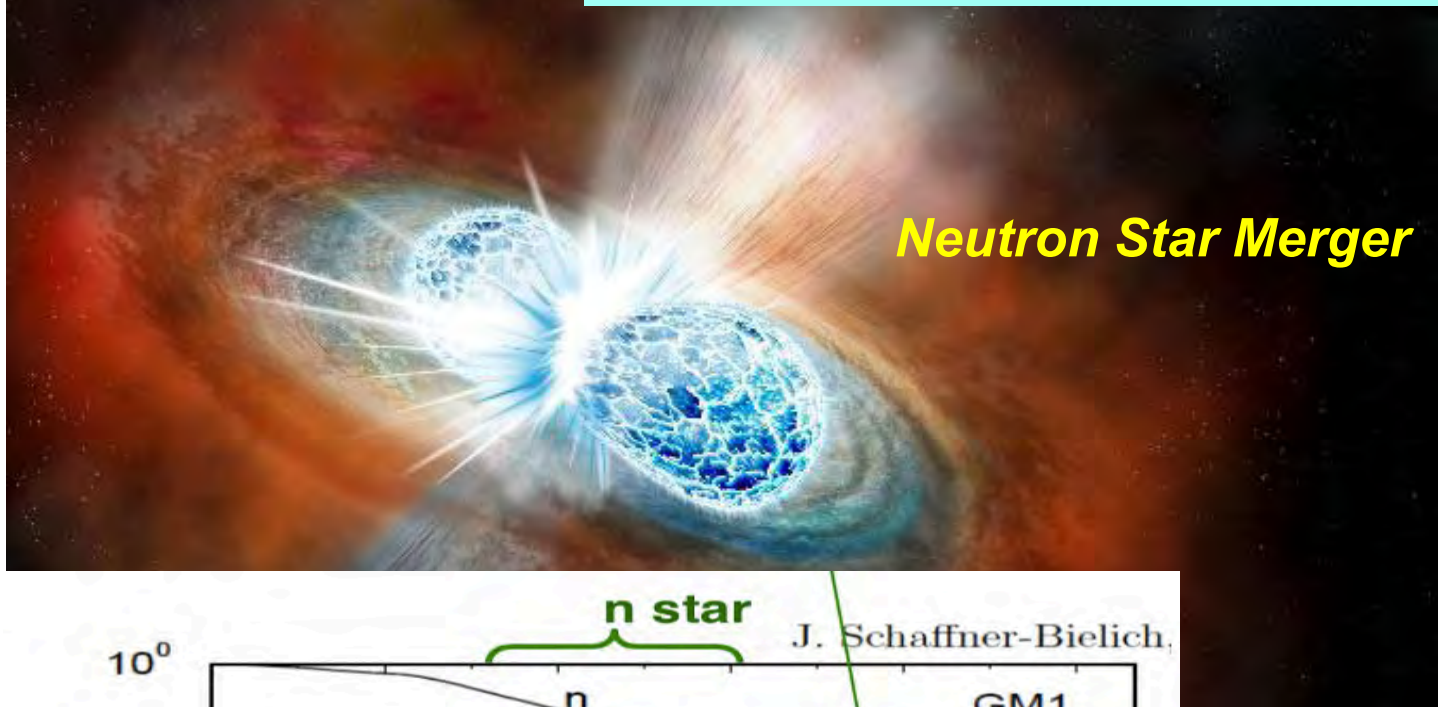
NICA нацелена на изучение:

- КХД диаграммы в наименее изученной области **большой барионной плотности**, где применение КХД на решетке не эффективно;
- спиновой структуры нуклонов.

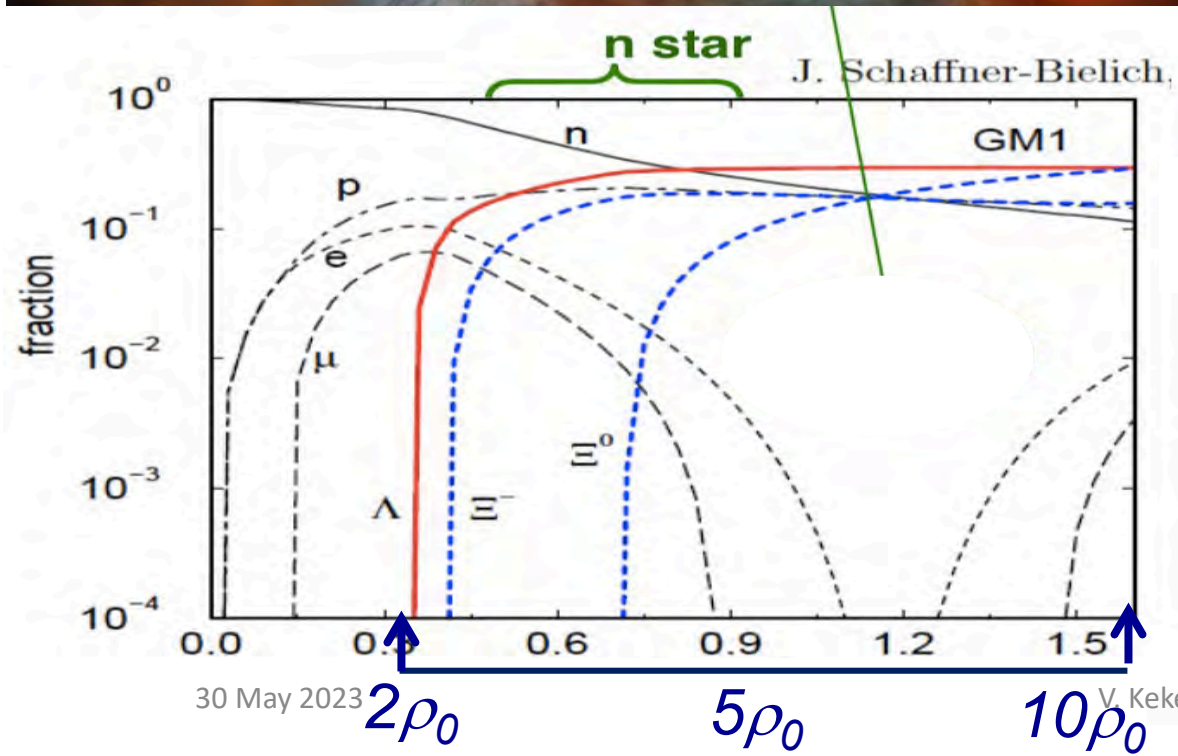
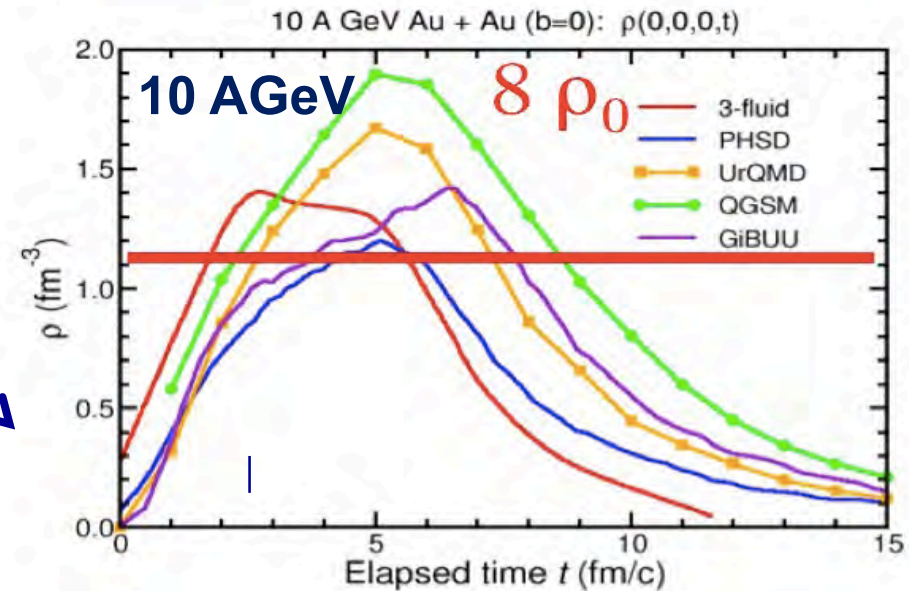
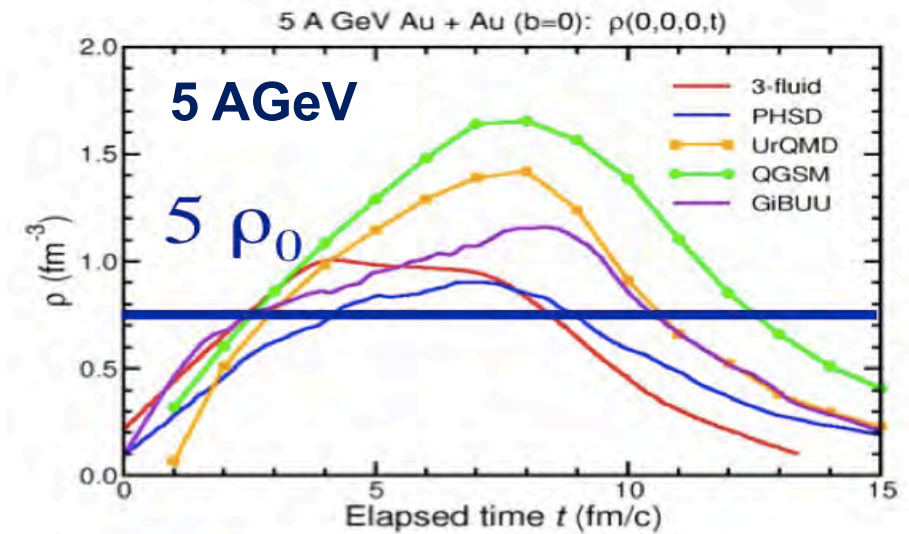
NICA дополняет существующие и планируемые установки в мире (**SIS-100 FAIR, LHC CERN**) и будет необходимым продолжением и значительным расширением исследований на **RHIC BES**: **многообразие систем и энергии, точность.**

Все это также связано с **астрофизическими** исследованиями, которые интенсивно развиваются и могут ставить нам **новые вопросы.**

Similarity of Stellar Objects & Heavy Ion Collisions



net baryonic density in Au + Au coll.



Bauswein et. al.,
arXiv:1809.01116

V. Kekelidze, UNAM, Mexico

I.C. Arsene et al., Phys. Rev. C75 (2007) 24902.

**Baryonic Matter
@ Nuclotron (BM@N)**

**Spin Physics
Detector (SPD)**

**Multi Purpose
Detector (MPD)**

Injection Complex

Collider

Nuclotron (c=251,5 m)

Booster

**Booster, 2020;
SC synchrotron**

- ◆ модернизация ускорительного комплекса
- ◆ создание **Коллайдера** (c= 503 м) для столкновений
 - ионов от **p** до **Au** при энергиях $\sqrt{S_{NN}} = 4 - 11$ ГэВ
 - поляризованных **p** и **d** до энергии $\sqrt{S} = 27$ ГэВ (p)

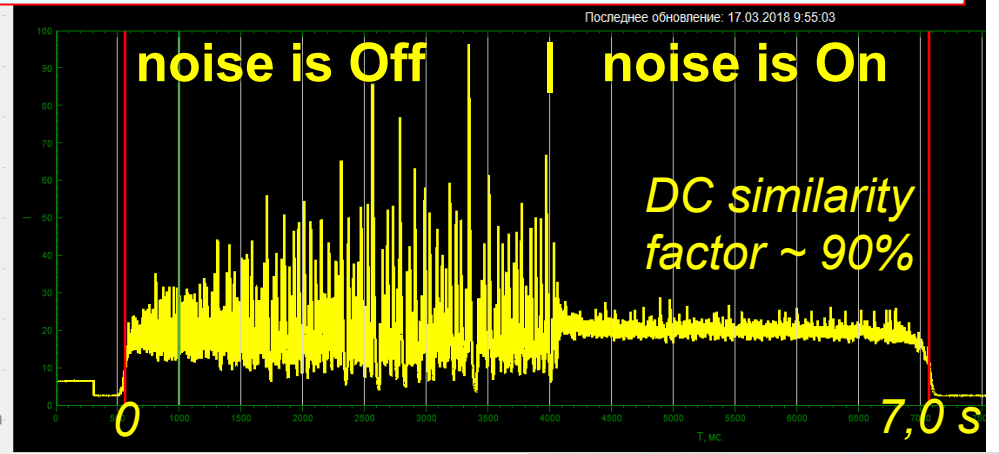
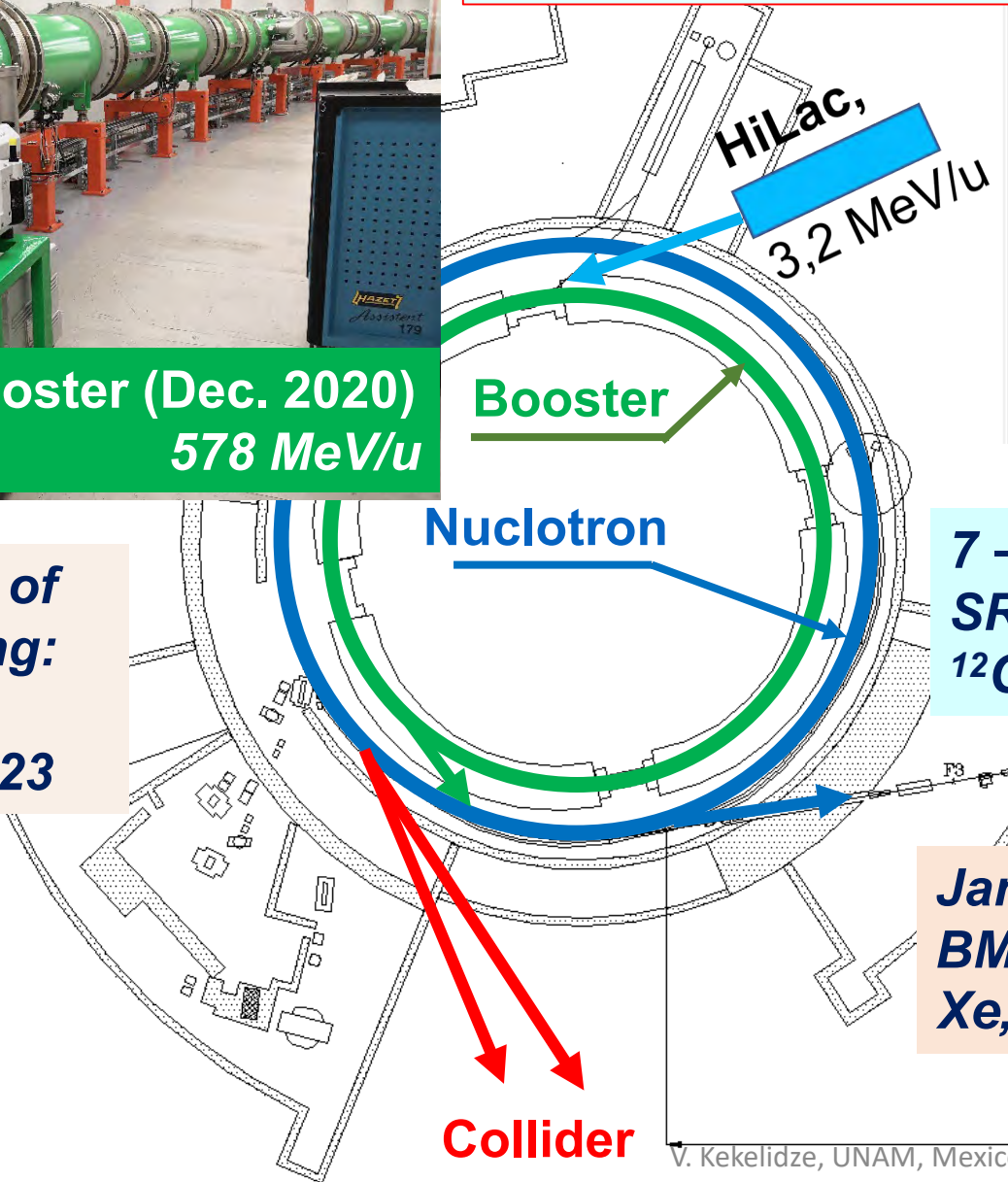
Accelerator chain - **Injection System** – is constructed & commissioned!

Program of fixed target experiments has *started* !



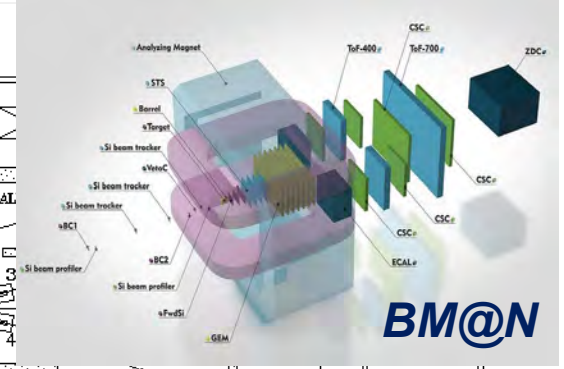
Booster (Dec. 2020)
578 MeV/u

resent stages of commissioning:
Jan –Mar '22;
Nov '22- Feb '23



7 – 29.03.2022
SRC experiment:
 ^{12}C , ~ 3 AGeV

Jan 2023
BM@N experiment:
Xe, 3,8 AGeV



Bld. 205 (10 000 m²)

~160 m



May 2022

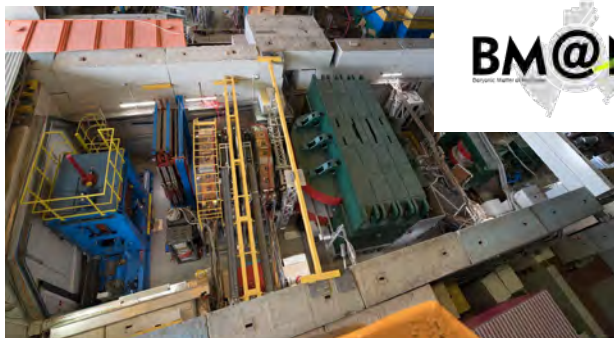


MPD

SPD



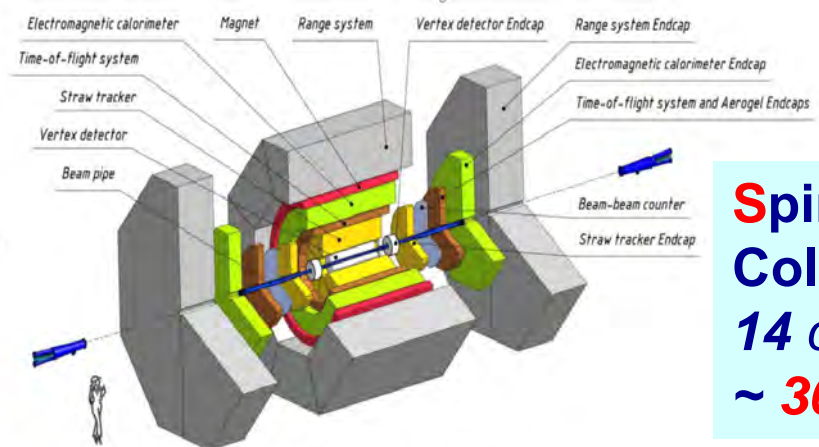
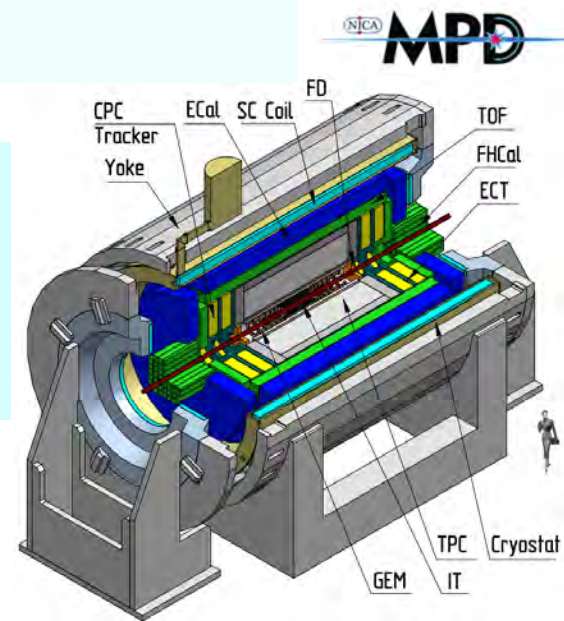
This basic facility should be utilized by a **global scientific community** of users from the **JINR member states** and the **others**.



BM@N

Baryonic Matter at Nuclotron (BM@N) Collaboration:
7 Countries, 15 Institutions, 222 participants

Multi Purpose Detector (MPD) Collaboration:
11 countries + JINR, 37 Institutes, > 500 participants



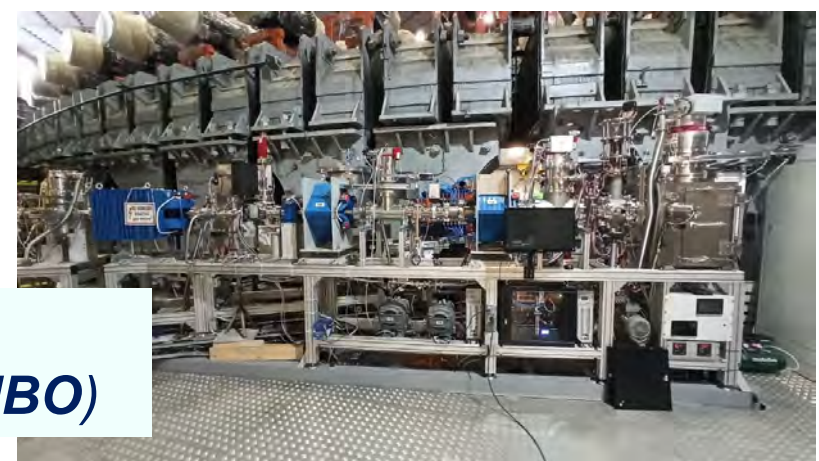
Spin Physics Detector (SPD) Collaboration:
14 countries, 32 Institutes, ~ 300 participants

ARIADNA



Applied Research Infrastructure
 for Advanced Developments at NICA facility

- *Station Of Chip Irradiation (SOChI)*
- *Setup for Investigation of Medical Biological Objects (SIMBO)*



CONCEPT

*of the development of **IT technologies & scientific computing** is aimed at solving the strategic tasks of JINR through **advanced IT solutions** integrated into a **unified computing environment** that combines a variety of solutions, concepts and methods.*

*It will be **steady implementation / upgrades** of **Networking** (**Tb/s** range), Computing infrastructure within the **Multifunctional Information & Computing Complex (MICC)** and **“Govorun” Supercomputer**, **Data center infrastructure**, **Data Lake & long-term storage** for all the experiments.*

*A variety of means will be used for **IT specialists upskilling.***

Supercomputer “Govorun” Current status:

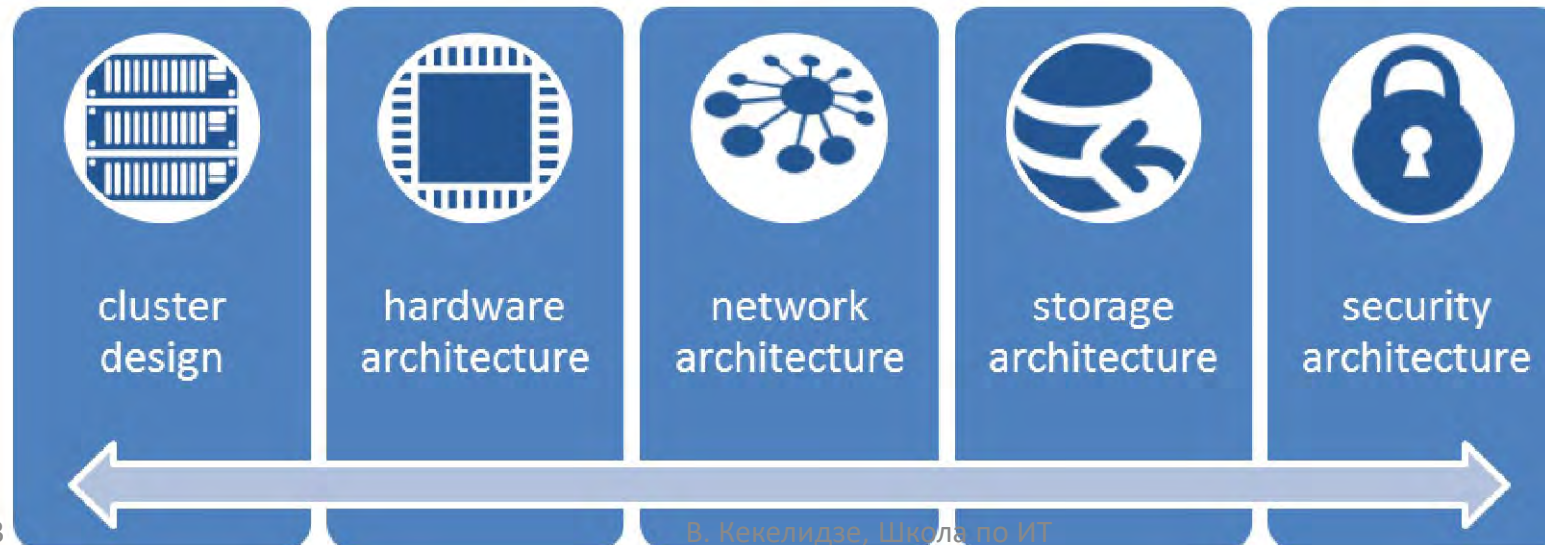


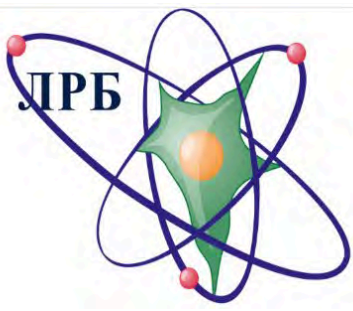
138 hyperconverged nodes;
40 GPU accelerators;
Total peak performance:
1.1 Pflops DP; 2.2 PFlops SP
Total capacity of Hierarchical Storage: **8.6 PB**
Data IO rate: **300 Gb/s**

- **HEP projects** deal with a huge amount of experimental data.
- **Distributed heterogeneous computing** will be used in future to support all the projects.

Computing needed for: **NICA Tier0 – Tier1 – number of Tier2**
Baikal-GVD, NOVA, JUNO – all types of resources
LHC@HL-LHC – Tier1 for CMS, Tier2 for ATLAS, ALICE

Big Data strategy at JINR





Лаборатория радиационной биологии

Объединенный институт ядерных исследований

Научные исследования :

- молекулярная радиобиология;
- медицинская радиобиология;
- математическое моделирование;
- радиационная генетика;
- радиационная физиология;
- радиационные исследования;
- радиационная цитогенетика;
- радиационная нейродегенерация;
- астробиология.

Развитие вивария, визуализации и томографии животных, микроскопии сверхвысокого разрешения; оборудование для мульти-OMICS исследований; строительство лабораторных блоков III радиохимического класса; исследования и разработки компактных облучателей для исследований клеток.



University Centre



- **International Student Practice in JINR Fields of Research** - a three-week program aimed at attracting talented young people to the Institute;
- **START Program for students - Student Advanced Research Training** - helps to find a supervisor for future BSc, MSc, or PhD theses, & increased the chances to join the international team of JINR;
- **International Remote Student Training (INTEREST)** - new online program for science / engineering / IT students (starting from their 2nd year) & postgraduates from all over the world intended to help to choose a research project in one of the science fields at JINR and facilitate communication with project supervisors;
- **Engineering and Physics Training** - staff for the Institute & the Member States at the currently operating modern physics facilities. The key feature of EPT is the opportunity to do hands-on work using real equipment.
- **Programmes for physics teachers** - the aim is to reduce the distance between School & fundamental science, to promote scientific knowledge among general public



INNOVATIONS: International Centre for Nuclear Technologies Research

OMICS@LRB: *neuroradiobiological studies; radiation neuroscience; approaches to increase radio-sensitivity: pharmaceuticals, transgene systems, targeted delivery (molecular vectors) & radionuclide;*

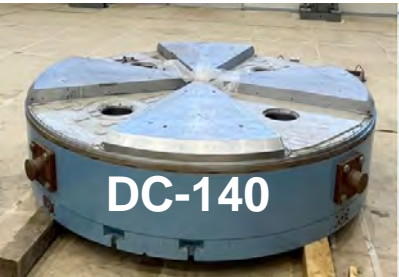
ARIADNA: *applied beams@NICA (ions from MeV/u to GeV/u): radiobiological studies (400-800 MeV/n); radiation testing of micro-electronics (3; 150- 350 MeV/n); nuclear physics @ 1-4.5 GeV/n. SOCHI is ready; full-scale **2024**;*



New with **DC-140 cyclotron** for electronic component testing, radiation material science, track pore membrane research and production, etc. ; **(2021 - 23)**;

New research **proton cyclotron MSC-230** for R&D in beam therapy: treatment planning; radio-modifiers for photon & proton therapy, flash-therapy, pencil beam (10 μ A, >5 Grey/liter target @ 50 ms pulse); a pilot facility for future medical centre **(2021– 24)**.

Radiochemical Laboratory Class-I for production of radioisotopes (Ac225, 99mTc) for nuclear medicine in photonuclear reactions @ 40MeV Rhodotron accelerator **(2022–27)**.



MAP of the JINR International Scientific Expertise



ряд знаковых событий

Сессия КПП в Болгарии (ноябрь 2021):
принята Софийская Декларация



President Rumen Radev at CP session

Сессия КПП в Египте (ноябрь 2022):
представлен 7-летний план развития ОИЯИ



Декларация о кооперации ОИЯИ –Мексика
подписанная на 133 сессии УС



первое заседание
координационного комитета **Китай-ОИЯИ**

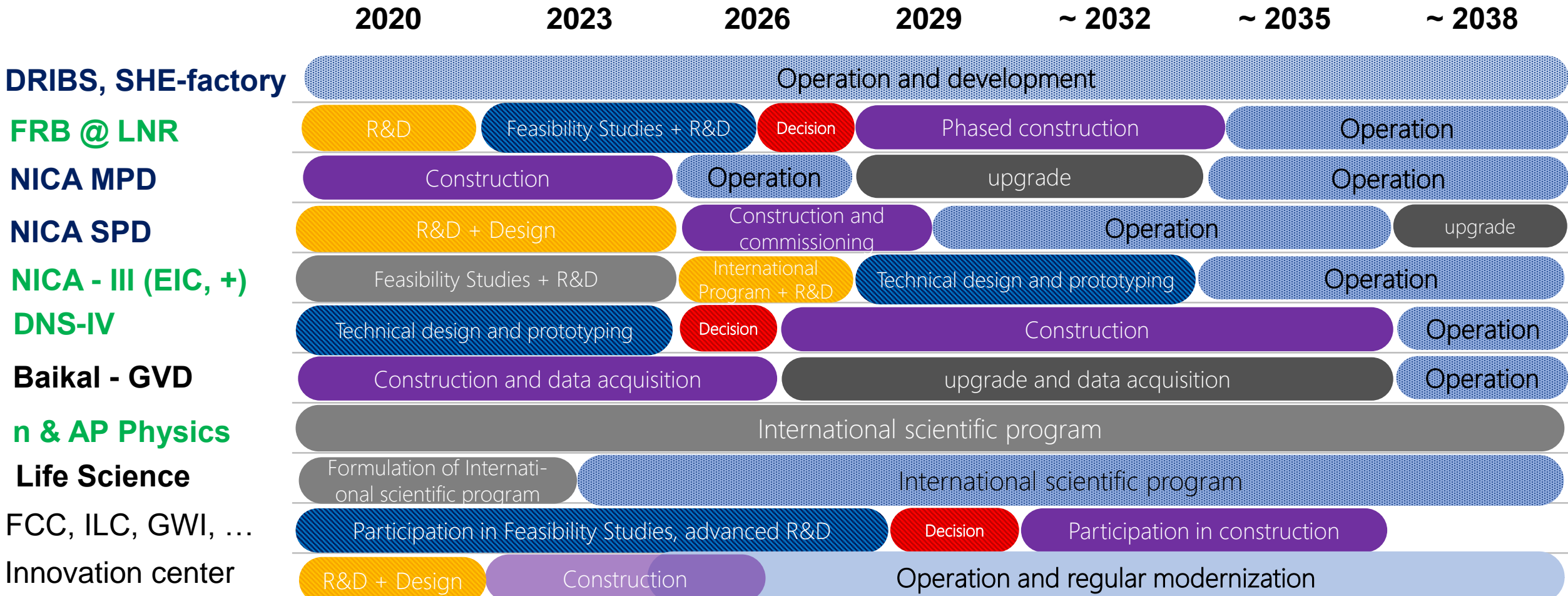
На **134** сессии Ученого Совета ОИЯИ (сентябрь 2023г.) был представлен и одобрен **7-летний** план развития Института



The 7-year plan (2024 – 2030) was approved at the CP session

The long-term development strategic plan of JINR up to 2030 & beyond, along with the improvement of the research infrastructure & the formation of an advanced multidisciplinary scientific programme is aimed at the comprehensive development of intellectual potential & strengthening of the Institute as an international scientific organization.

Matrix of JINR Key Projects





Спасибо за внимание