The 4th International Conference on the Chemistry and Physics of Transactinide Elements

05 – 11 September, Sochi, Russia

# Prospects for JINR development

M.G Itkis

Acting Director of JINR

BİRLƏŞMİŞ NÜVƏ TƏDQİQATLARI İNSTITUTU

ՄԻՋՈՒԿԱՅԻՆ ՅԻԶԻԿԱՅԻ ՄԻԱՑՅԱԼ ԻՆՍՏԻՏՈՒՏ

АБ'ЯДНАНЫ ІНСТЫТУТ ЯДЗЕРНЫХ ДАСЛЕДАВАННЯЎ

ОБИДЕНЕН ИНСТИТУТ ЗА ЯДРЕНИ ИЗСЛЕДОВАНИЯ

VIỆN LIÊN HIỆP NGHIEN CỨU HẠT NHÀN

ᲒᲘᲐᲗᲘᲗᲣᲚᲘ ᲑᲐᲠᲔᲗᲔᲑᲘᲡ ᲒᲐᲔᲠᲗᲘᲐᲜᲔᲑᲣᲚᲘ ᲘᲜᲡᲢᲘᲢᲣᲢᲘ

БІРІККЕН ЯДРОЛЫҚ ЗЕРТТЕУ ИНСТИТУТЫ

련합원자력연구소

INSTITUTO UNIFICADO DE INVESTIGACIONES NUCLEARES

INSTITUTUL UNIFICAT DE CERCETARI NUCLEARE

ЦӨМИЙН ШИНЖИЛГЭЭНИЙ НЭГДСЭН ИНСТИТУТ

ZJEDNOCZONY INSTYTUT BADAŃ JĄDROWYCH

ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

INSTITUTUL UNIFICAT DE CERCETARI NUCLEARE

SPOJENÝ ÚSTAV JADROVÝCH VÝSKUMOV

ЯДРОВИЙ ТАДҚИҚОТЛАР БИРЛАШГАН ИНСТИТУТИ

ОБ'ЄДНАНИЙ ІНСТИТУТ ЯДЕРНИХ ДОСЛИДЖЕНЬ

SPOJENÝ ÚSTAV JADERNÝCH VÝZKUMŮ

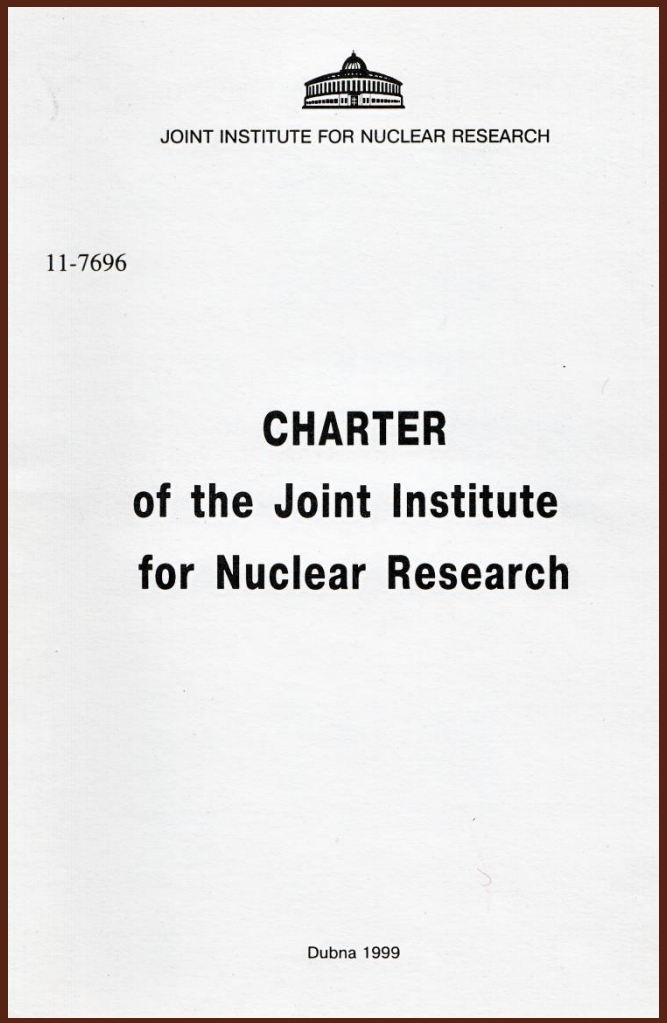
# CONTENTS

- **Introduction:**
  **preserving main traditions and further development of JINR**

- **JINR today and outlook for the future:**
  **Institute's research niche and competitiveness on the world scale**

- **Conclusion**

# FOLLOWING THE SPIRIT OF JINR CHARTER



JOINT INSTITUTE FOR NUCLEAR RESEARCH

11-7696

CHARTER

of the Joint Institute

for Nuclear Research

Dubna 1999

## CHAPTER I
## General provisions

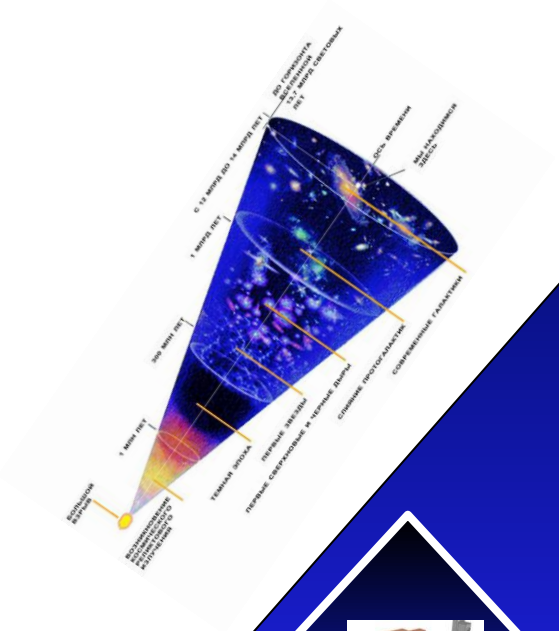
**Article 1**

The Joint Institute for Nuclear Research, is an international intergovernmental scientific research organization created in accordance with the Agreement on establishing the Joint Institute for Nuclear Research of 26 March 1956 and basing its activities **on the principles of its openness for participation to all the interested states, of their equal and mutually beneficial cooperation.**

**Article 4**

The Institute has been established with the aim of uniting the efforts, scientific and material potentials of the Institute Member States **for investigations of the fundamental properties of matter.**

# JINR science policy: preserving traditions and further development



## Fundamental Science

Particle Physics

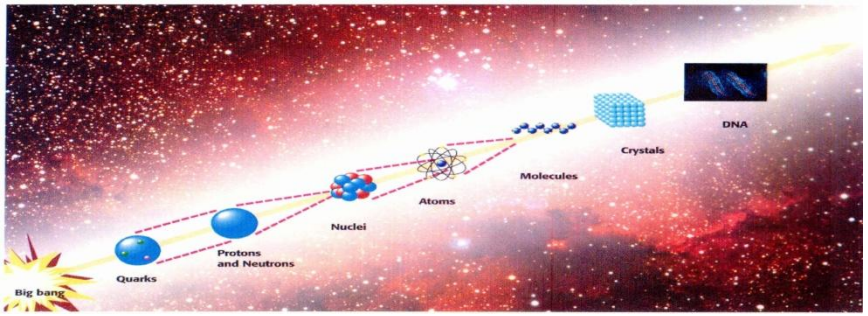
Nuclear Physics

Condensed Matter Physics

## Innovation Activities

## Educational Programme

Special Economic Zone, “DUBNA” Nanocentre




M. Itkis

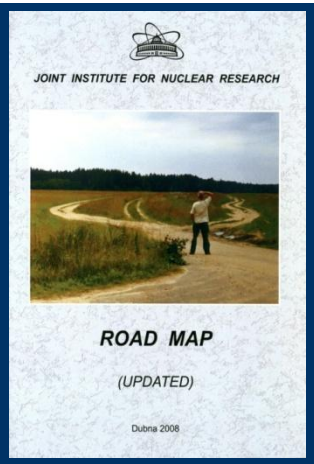
UC, DIAS-TH, International Univ. “Dubna”

# JINR science policy and development strategy

**It is expedient that the following supplements to the current seven-year plan should be worked out and published:**

- **on the main JINR projects with detailed information about implementation schedule, parameters, innovation and financial components, intelligible for a wide range of scientists, government officials, representatives of diplomatic corps, etc.**
- **on involvement of JINR in the programme of the LHC and its detectors development.**

**A longer-term vision for JINR development up to 2030 should be worked out as well.**




- **Seven-year plans of JINR development: 2003 – 2009; 2010 – 2016**
- **Mid-term strategic plan of JINR development – Road Map: 2006 – 2018**

# Basic concept of the current Road Map

## JINR must be a world leader in specific scientific and innovation areas of research

- International staff of professionals
- Modern and ambitious scientific programme: theory and experiments, information support
- A suite of upgraded basic facilities
- A developed innovation belt around the Institute

# JINR's research niche offered by home facilities

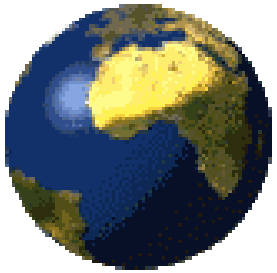
## Heavy Ion Physics

- **Heavy-Ion Physics at high energies:**
  **Nuclotron-M: up to 4.5 GeV/n (Au)**
  **In future NICA/MPD: $\sqrt{s_{NN}}$ = (4 – 11)GeV, $E_{lab.}$ ~ (8 – 60 GeV/n)**

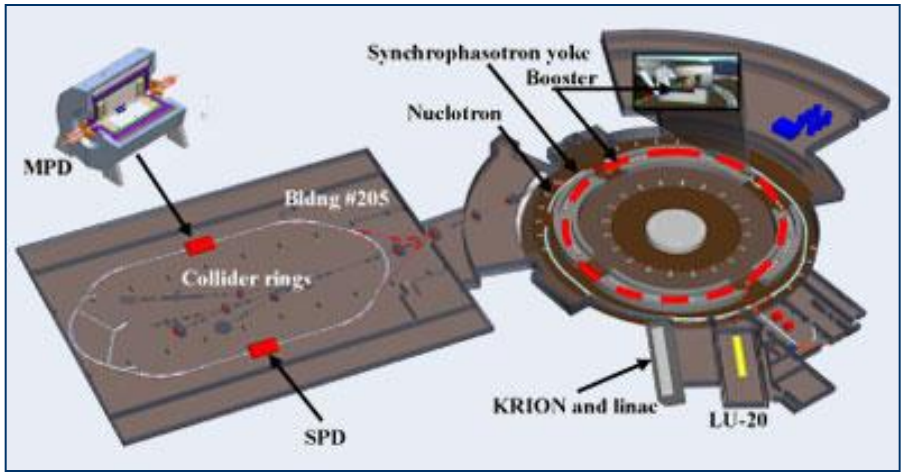
- **Heavy-Ion Physics at low and intermediate energies (5 – 100 MeV/n): U400M, U400, DRIBs**

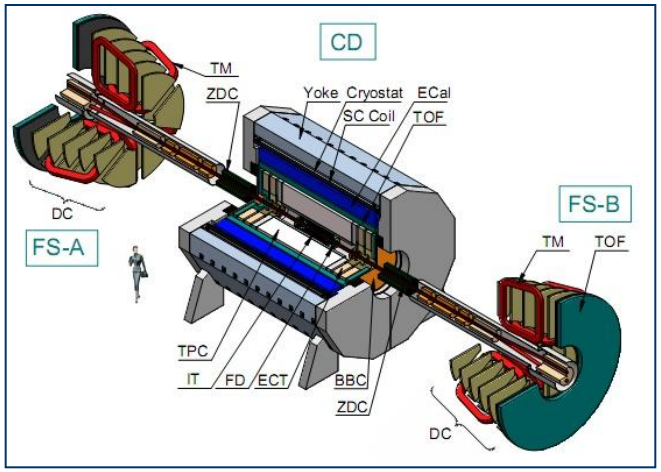
## Condensed Matter Physics using nuclear physics methods (neutron sources: IBR-2, IREN)

# JINR's niche in particle physics and competitiveness on the world scale.



# The new flagship of JINR in HEP: Nuclotron-based Ion Collider fAcility and MultiPurpose Detector (NICA / MPD) – 2015-2016


**The main goal of the NICA/MPD project is to start in the coming years experimental study of hot and dense strongly interacting QCD matter and search for a possible manifestation of the mixed phase formation and critical endpoint in heavy ion collisions.**

# Main scientific tasks of the NICA/MPD project

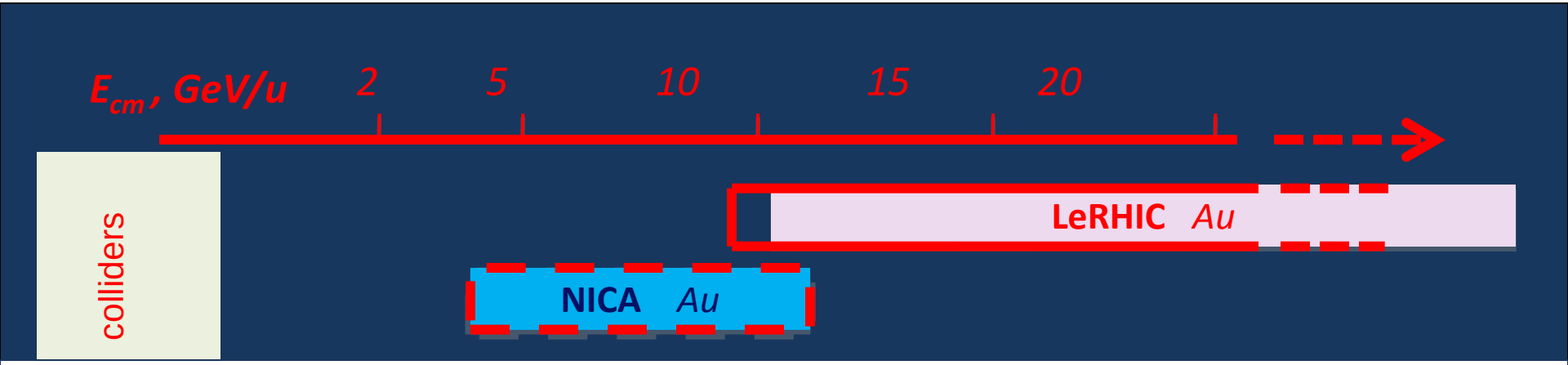
- **Studies of dense baryonic matter:**

  - ***properties of hadrons in medium and the equation of states in the nuclear medium***
  - ***deconfinement borders and restoration of chyral symmetry***
  - ***phase transitions, mixed phase and the critical point***
  - ***local parity violation in strong interactions***

- **Studies of nucleon spin structure:**

  - ***cast light on the origin and nature of spin***
  - ***defining the spin structure of the nucleon***

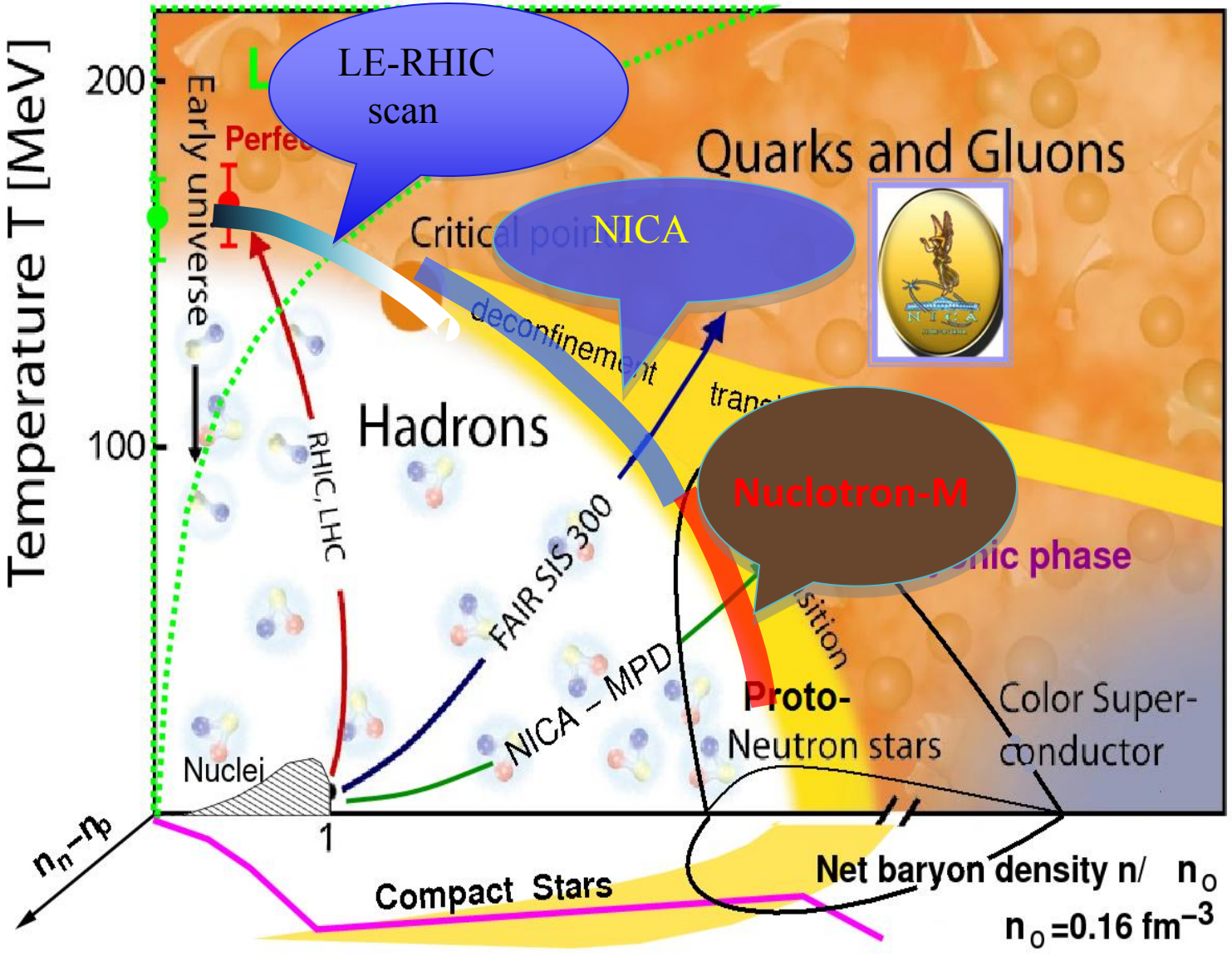
# Energy regions covered by present & future experiments and niche of the Nuclotron-M and NICA facilities




**In case of being accomplished in the scheduled time (2015-2016), the NICA project would provide JINR with a leading position in the international arena in a very exciting field of knowledge – nuclear physics of superdense matter.**

**Understanding of the properties of matter that exists in extreme conditions of high density is very important not only for nuclear physics but also for astrophysics, cosmology, condensed matter physics and development of new technologies.**

# QCD phase diagram
## of strong interactive (hadron) matter



# NICA WHITE PAPER

NICA

Draft v 4.01
January 24, 2011

SEARCHING for a QCD MIXED PHASE at the
NUCLOTRON-BASED ION COLLIDER FACILITY
(NICA White Paper)

**Editorial board:**

| | |
|---|---|
| A. Sorin | D. Blaschke |
| D. Kharzeev | O. Teryaev |
| V. Toneev | I. Tserruya |


JOINT INSTITUTE
JINR
FOR NUCLEAR
RESEARCH

**The final goal of the NICA White Paper is to address the following key topics:**

- Phases of dense QCD matter and conditions for their possible realization
- Characteristic processes as indicators of phase transformations
- Estimates of various observables for events
- Comparison with other experiments

**http://theor.jinr.ru/twiki-cgi/view/NICA/WebHome**

# External Activities in Particle Physics

**CERN, FNAL, BNL, DESY, GSI, IN2P3, INFN, RIKEN…**

**More than 70 Russian institutions**

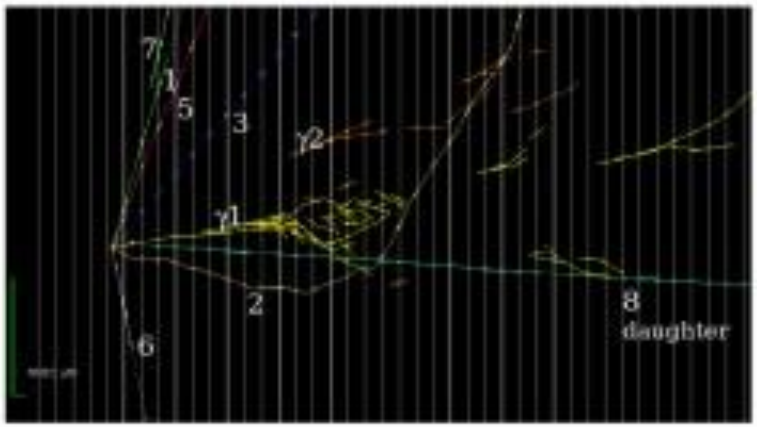
**About 100 institutions from Member States**

# Neutrino physics and rare phenomena

## OPERA experiment:

**Direct search for $\nu_\mu \rightarrow \nu_\tau$ oscillations**

### Observation of a first $\nu_\tau$ candidate event in the OPERA experiment



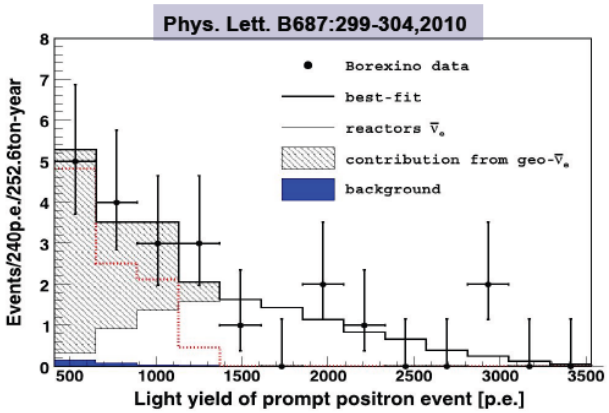

| | | | |
|---|---|---|---|
| **2009** | **$3.52 \times 10^{19}$** pot up to now (Sep 6th) | 3693 int. | Extrapolation is **$3.5 \times 10^{19}$** pot at end of the run. (~**2 tau expected** in total) |
| **2010** | $4.5 \times 10^{19}$ | 4500 int | ~10 tau decays are expected to be observed Less than 1 background after 5 years running |
| Nominal | $4.5 \times 10^{19}$ pot x 5 year. total $22.5 \times 10^{19}$ pot | | |

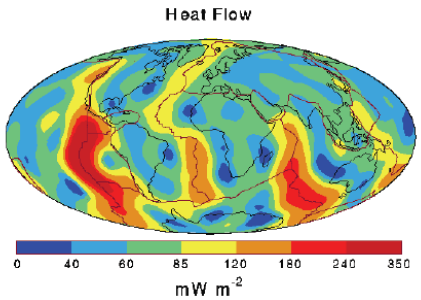
- First candidate of $\nu_\tau$ event was registered recently ( $\tau \rightarrow$ 1-prong hadron decay topology)

## BOREXINO experiment:

**Solar neutrino flux measurement**

### Detection of geoneutrinos with Borexino




$$N_{geo} = 9.9^{+4.1}_{-3.4}$$
$$N_{react} = 10.7^{+4.3}_{-3.4}$$

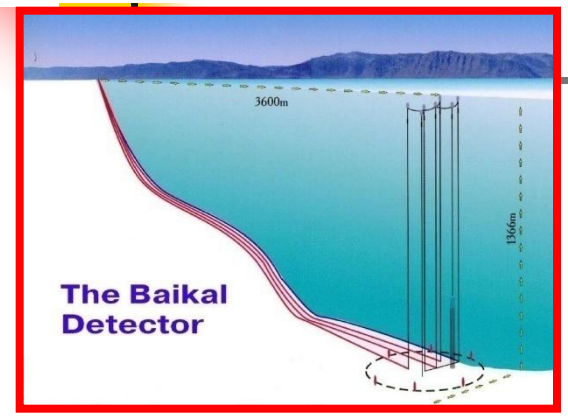
**Null hypothesis rejected at 99.997% C.L.**

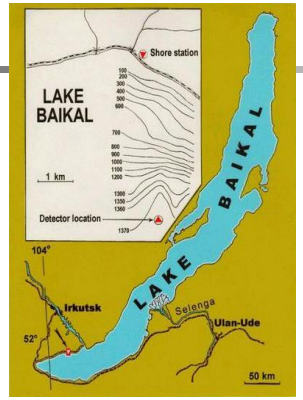
M. Itkis

# Dark Matter and Astrophysics

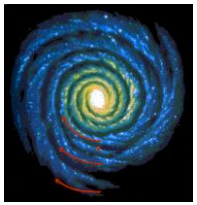
## BAIKAL experiment

**Deep underwater ν-detector**

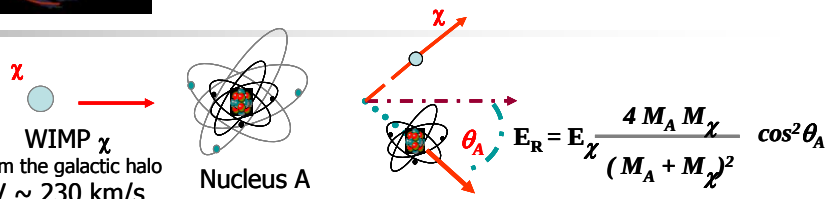


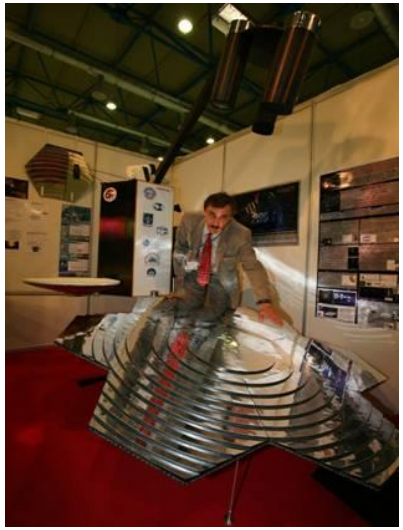

## EDELWEISS experiment



**Search for Cold Dark Matter**

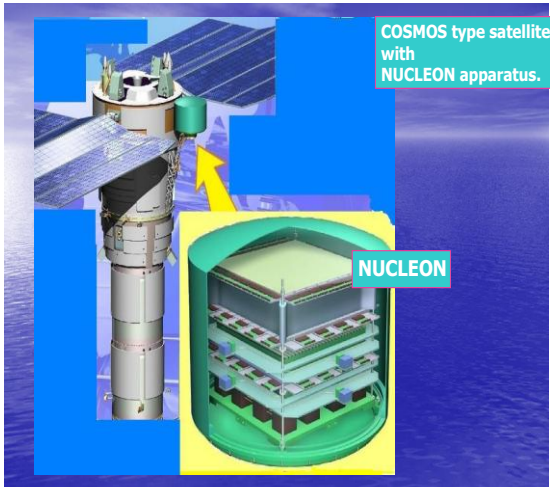



## TUS experiments



**Study the energy spectrum composition and angular distribution of the Ultra High Energy Cosmic Ray (UHECR) at E ≈ $10^{19}$ -$10^{20}$ eV (GZK cutoff region)**

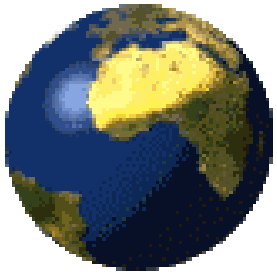
## NUCLEON experiments




**Measurement of cosmic rays flux in the energy range $10^{11}$-5x$10^{14}$ eV and charge range up to Z»30 in the near-Earth space**

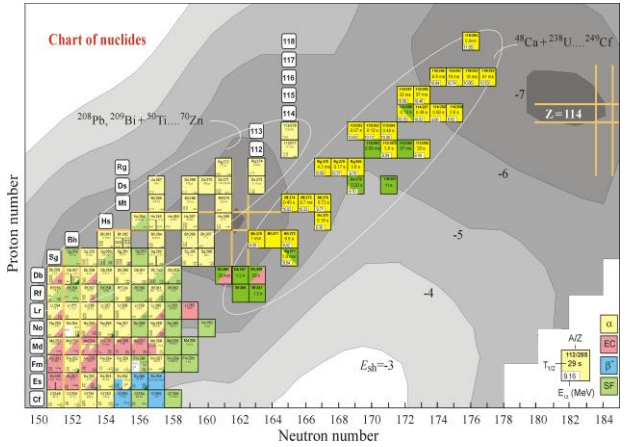
M. Itkis

# JINR's niche in Heavy Ion Physics at Low Enegies & competitiveness on the world scale.

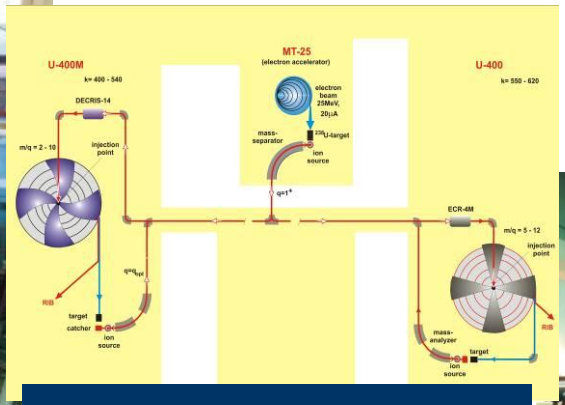


# JINR's Large-Scale Basic Facilities

**For the last decade JINR has become one of the world's leading scientific centres in low-energy heavy-ion physics.**




U400 isochronous cyclotron




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

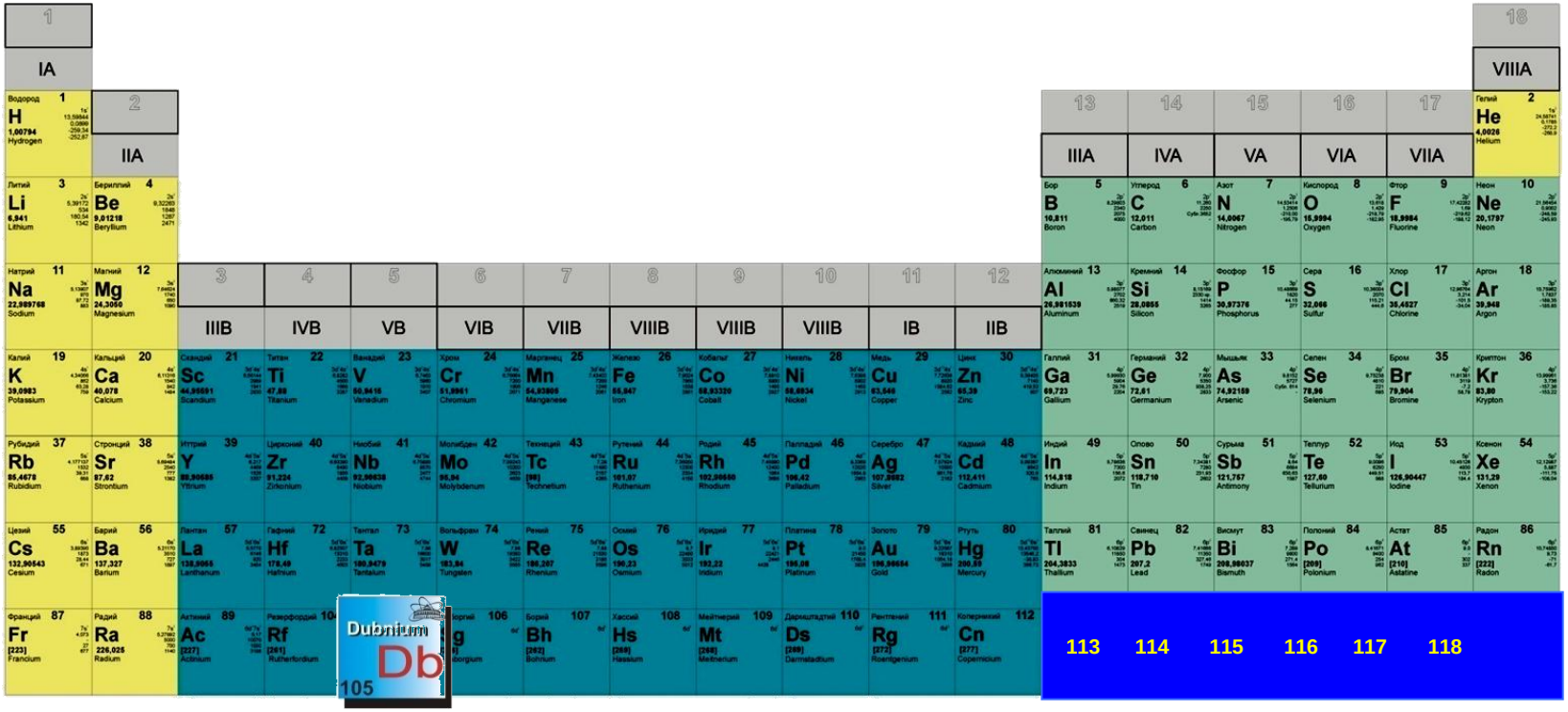
U400MR isochronous cyclotron

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

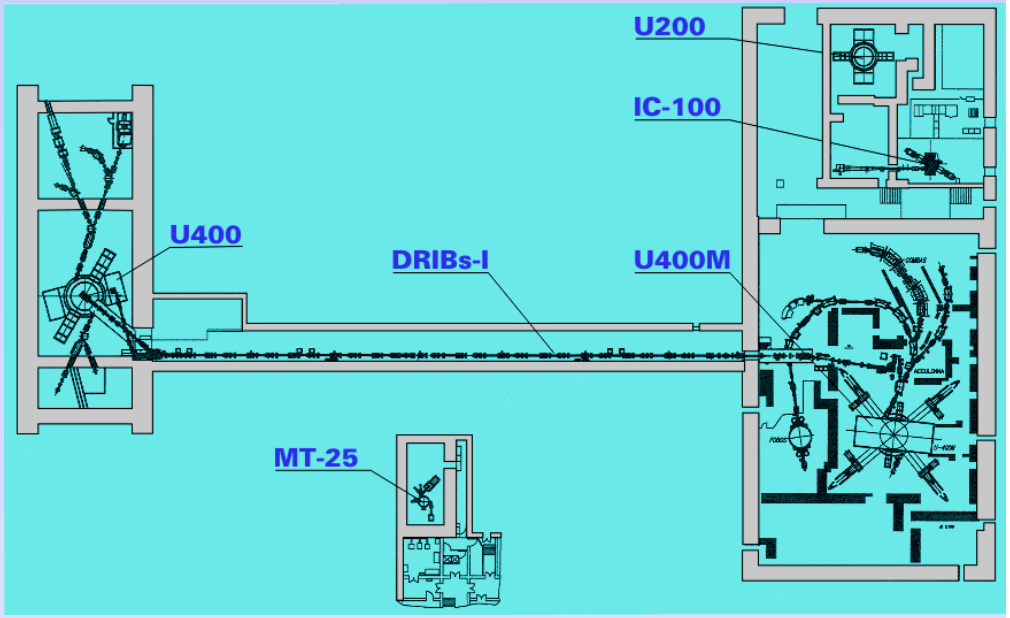
# Achievements in the last decade: new elements, 49 new isotopes



## Mendeleev periodic table of the elements



# JINR's advantages




- Unique beams of heavy ions: $^{48}Ca$ - $^{58}Fe$, $^{6}He$, $^{8}He$
- Beam on target time up to 12,000 hours/year
- Unique actinide targets $^{237}Np$ – $^{249}Cf$
- Cryogenic D-T- target
- Advanced experimental set-ups
- Highly-qualified scientists and engineers

**Broad international cooperation:**

**JINR Member States, Germany, the USA, Finland, France, Italy, Japan, Switzerland, etc.**

# PROSPECTS

## Road map
## Superheavy elements (SHE)

- Nuclear structure and properties of SHE
- Chemical properties of SHE
- Electron structure of SH atoms
- Search for new nuclear shells
- Search for SHE in nature.

## Project «DRIBs-III»
## experimental base

- Upgrade of the running accelerators U400 and U400M
- Construction of the new experimental hall (≈ 2600 м$^2$)
- Development and construction of the next-generation set-ups
- Development of high current heavy ion accelerator.

# NEW FLNR ACCELERATOR – CYCLOTRON DC280

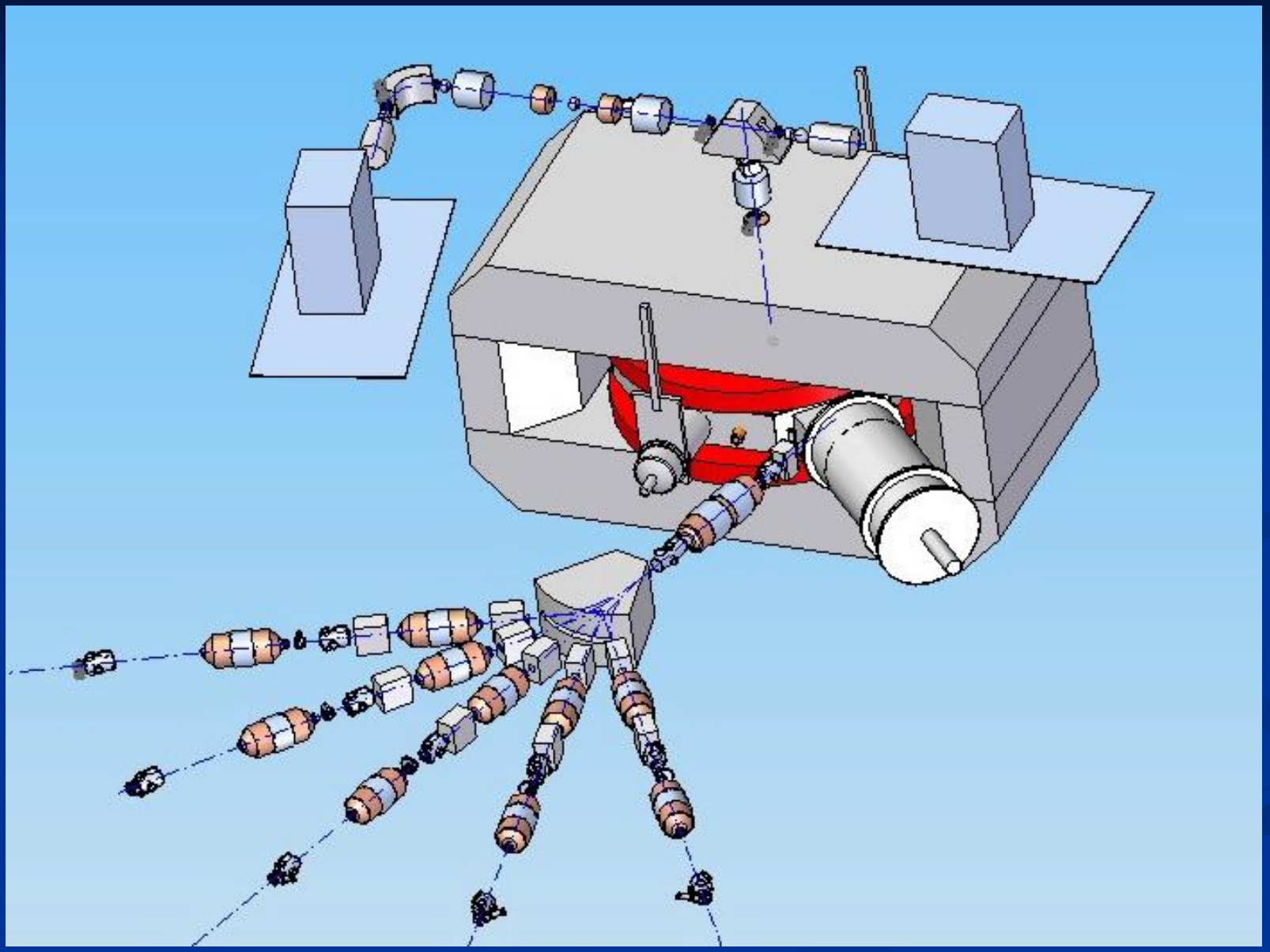
In order to improve efficiency of the experiments for the next 7 years it is necessary to obtain the accelerated ion beams with following parameters.

| | |
|---|---|
| Energy | 4 8 MeV/n |
| Masses | 10 238 |
| Intensity (up to A=50) | 10 pμA |

Beam emittance less 30 π mm·mrad

Efficiency of beam transfer >50%

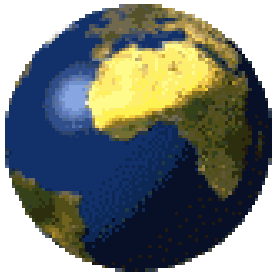
# DC-280 cyclotron



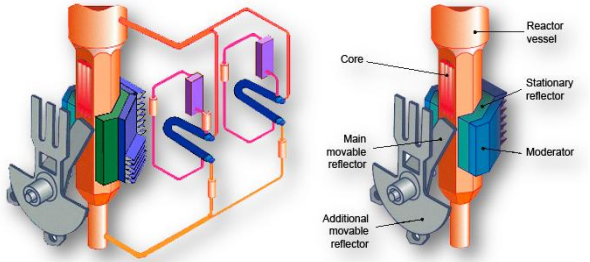
# DC-280.
## Main Parameters

| | |
|---|---|
| Ion source | DECRIS-4 - 14 GHz<br>DECRIS-SC3 - 18 GHz |
| Injecting beam potential | Up to 100 kV |
| A/Z range | 4 7 |
| Energy | 4÷8 MeV/n |
| Magnetic field level | 0.6 1.35 T |
| K factor | 280 |
| Gap between plugs | 400 mm |
| Valley/hill gap | 500/208 mm/mm |
| Magnet weight | 1000 t |
| Magnet power | 300 kW |
| Dee voltage | 2x130 kV |
| RF power consumption | 2x30 kW |
| Flat-top dee voltage | 2x14 kV |

# JINR's niche in Condensed Matter Physics & competitiveness on the world scale.



# JINR's Large-Scale Basic Facilities




## IBR-2 Parameters

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

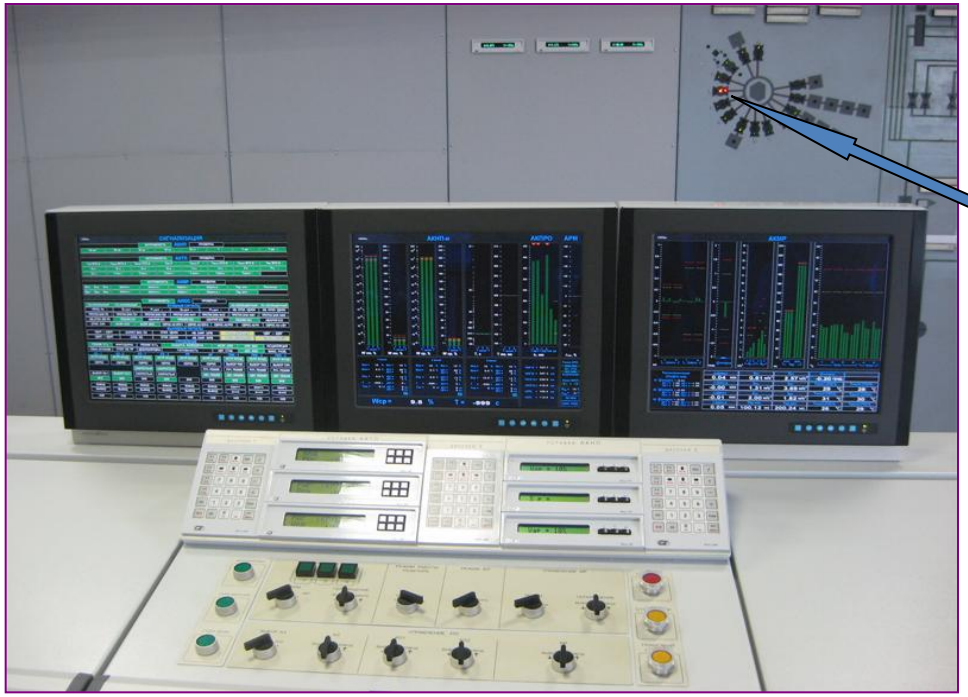
**Fundamental and applied research in condensed matter physics and related fields — biology, medicine, material sciences, geophysics, engineer diagnostics — aimed at probing the structure and properties of nanosystems, new materials, and biological objects, and at developing new electronic, bio- and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

# 9 June 2011: the works on the IBR-2 reactor physical start-up were successfully completed

**29 June 2011: State Acceptance Commission devoted to the start-up readiness of the IBR-2 reactor took a decision:**

**“The modernized IBR-2 reactor is ready for the power start-up”.**

**5 July 2011:**
**the works on the power start-up were started**



**8 July 2011:**
**Mean power (W) = 300 kW**

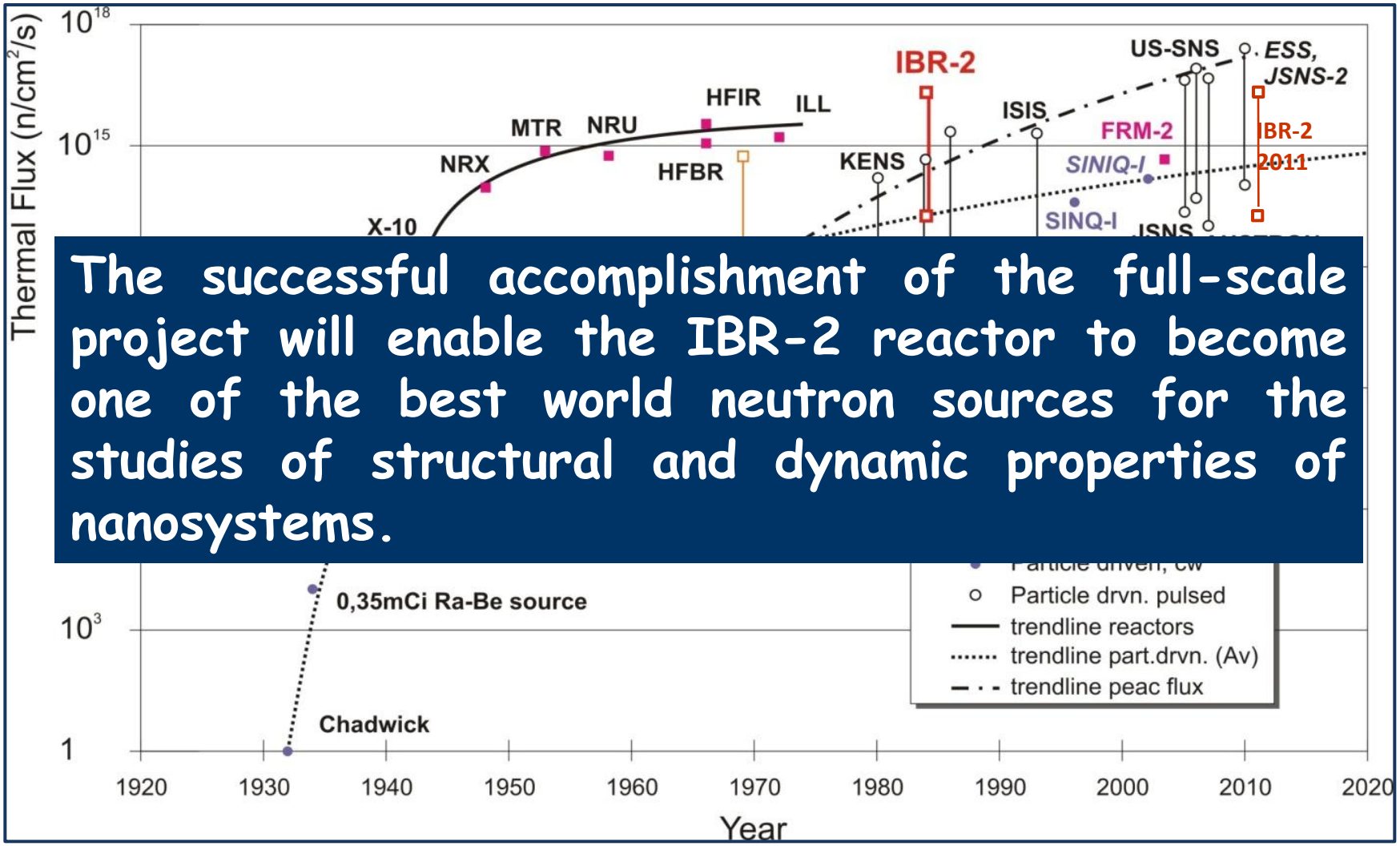
**Indication of the beams shutters at the operator control desk. Beam 5 is open.**

**For the first time since December 2006 a beam line is open!**

**21 July 2011:**
**Mean power (W) = 1 MW**

# The physical start-up of the IBR-2 reactor began on 17 December 2010 in accordance with schedule

## Competitiveness



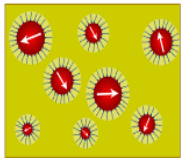

The successful accomplishment of the full-scale project will enable the IBR-2 reactor to become one of the best world neutron sources for the studies of structural and dynamic properties of nanosystems.

Source: IAEA-TECDOC-1439, February 2005

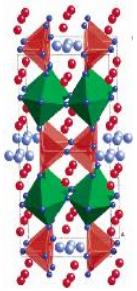
# Future: upgrade and development of the IBR-2 spectrometer complex


- Physics of Nanosystems

- Complex Liquids and Polymers

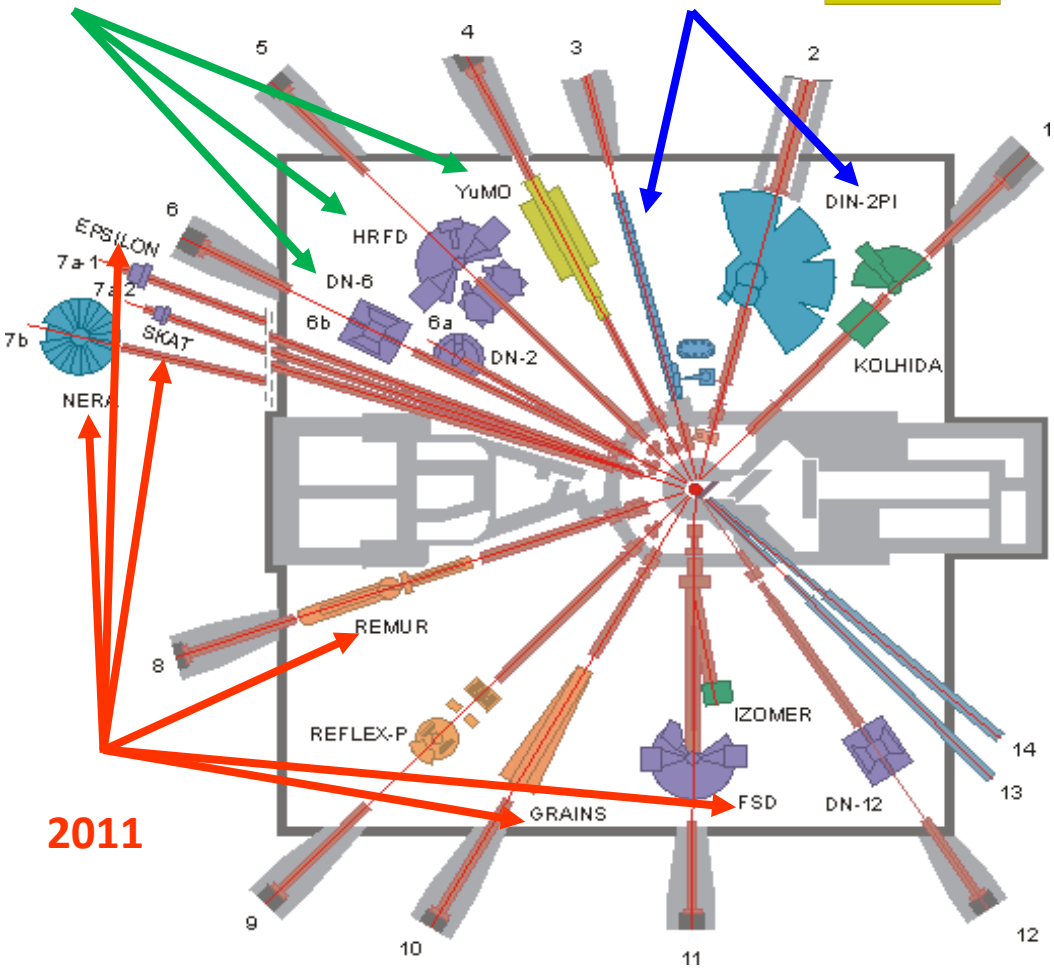


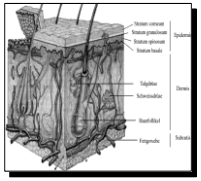
- Structure and Dynamics of Functional Materials



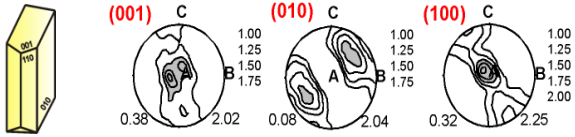
2013

2012



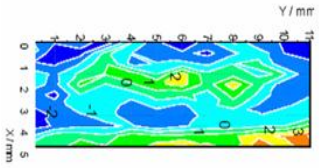



- Molecular Biology and Pharmacology



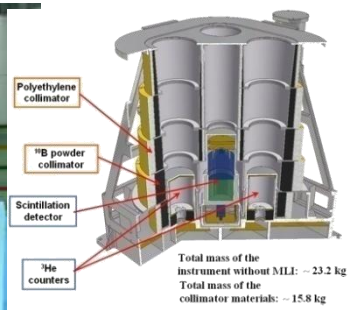

- Structure of rocks and minerals

- Engineering Diagnostics



2011

# Development of IREN and its detector complex



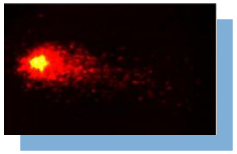

Calibration of the Lunar Exploration Neutron Detector (LEND)

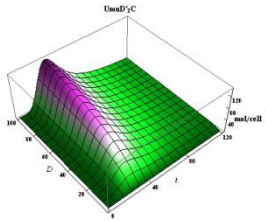


# Radiation Biology at JINR

Based on experiments at JINR's accelerators, the LRB resolved one of the central issues of radiobiology: the problem of the genetic effectiveness of ionizing radiations.

## Outlook for research



- study of the regularities and mechanisms of the effect of heavy charged particles on ***eye structures:*** the lens and retina;

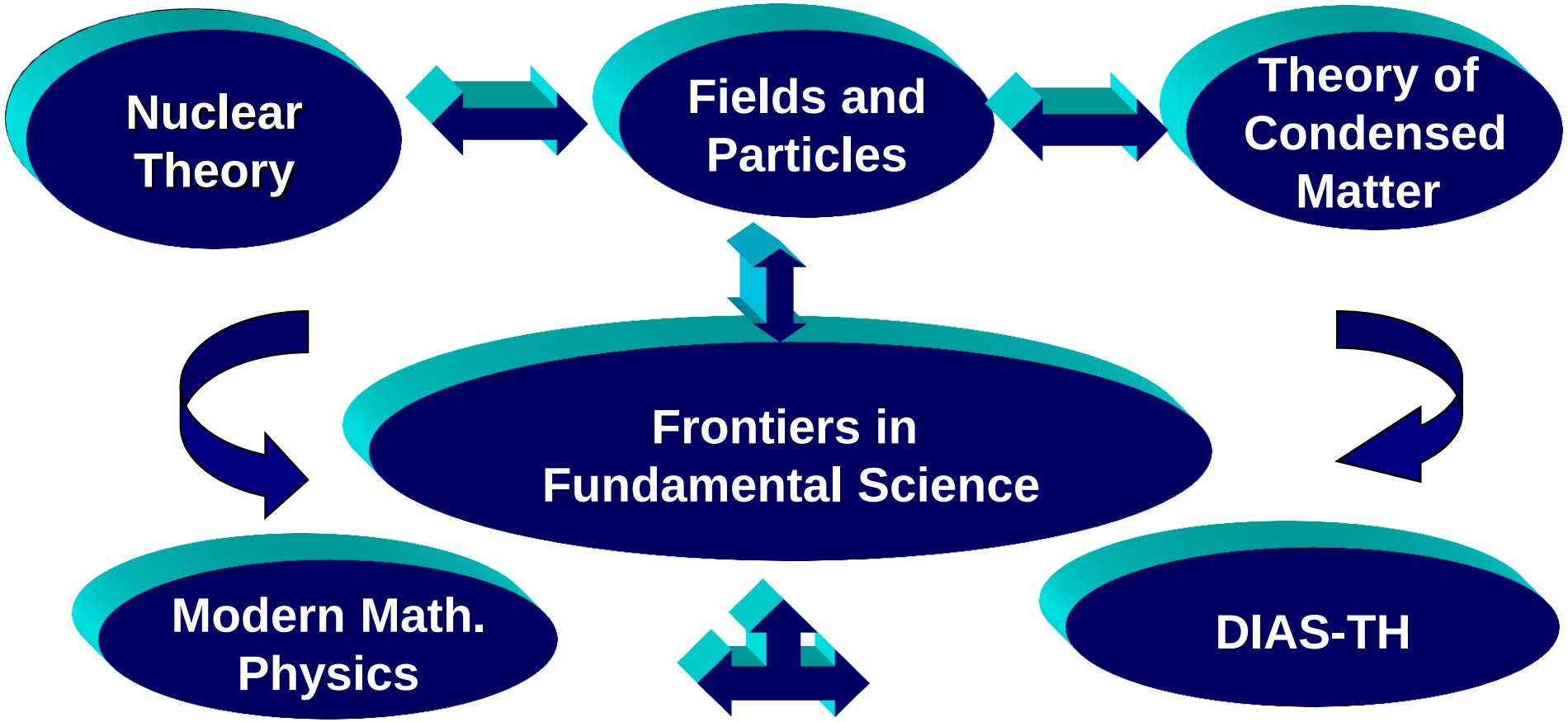
- evaluation of the risk of the damaging effect of ionizing radiations with different physical characteristics on ***the nervous system and higher nervous activity*** (regularities of nervous cell death; impairments of the intercellular signal transmission; and disorders in mental functions: learning, memory, behavior, and consciousness);

- research on the mechanisms of the ***genetic effect*** of radiations with different physical characteristics (formation and repair of different DNA lesions; programmed cell death mechanisms; and genetic instability);

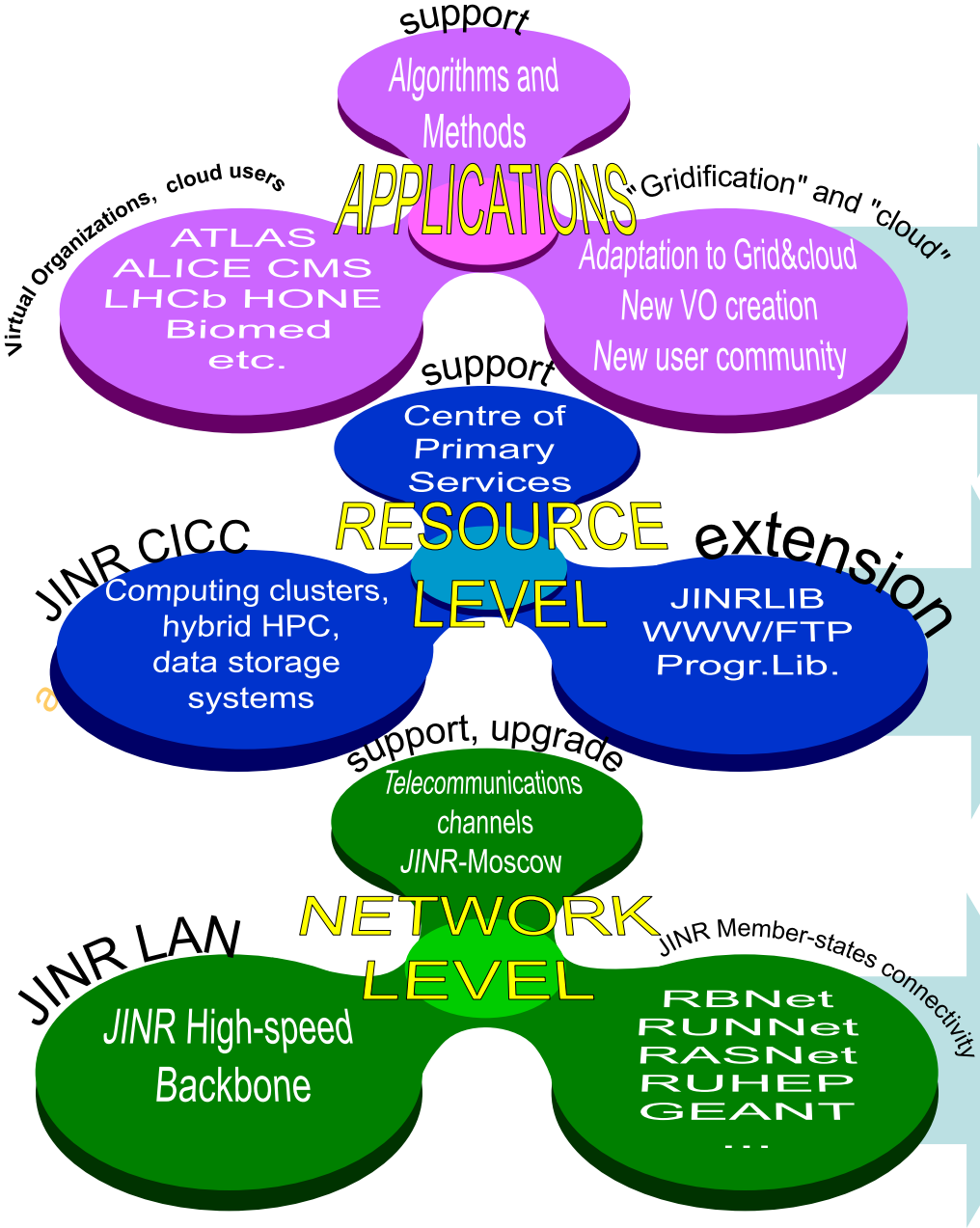
- ***mathematical modeling*** of biophysical systems.

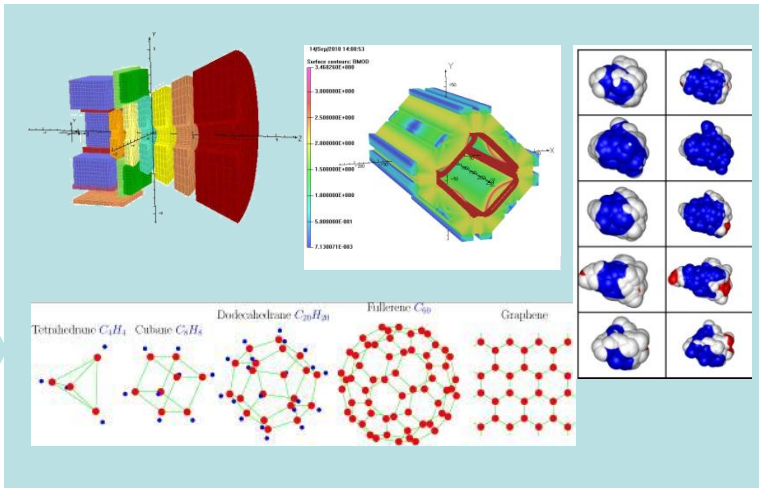
# Theory: Science Policy

- Support of the **JINR Experimental Programme;**
- Development of research in **Theoretical Physics** on the basis of **Advanced Mathematics;**
- Strengthening of the **efficiency of scientific staff** through the interplay of **research and education.**

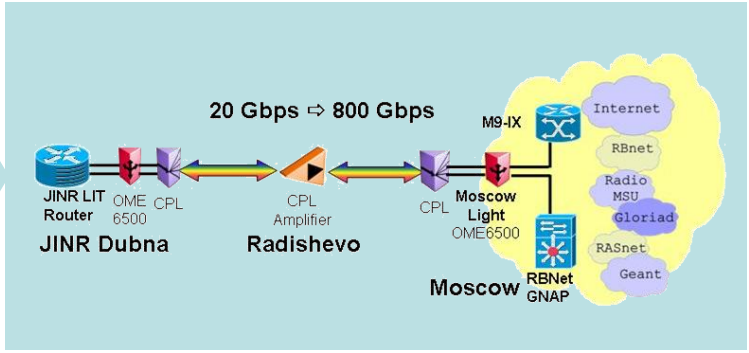


# E-infrastructure of JINR







# Educational programme at JINR

More students from JINR Member States participate in educational programs at JINR

Very successful Program at JINR and CERN for teachers from JINR Member States should be further developed

Research and educational dual-use equipment for the implementation of modern educational projects and applied research has to be installed

M. Itkis

# European Union - JINR

## Steps towards integration into the European Research Infrastructure

- In line with previous SC and CP recommendations, JINR is strengthening its ties and networking within EU Research Framework.
- In 2010, a number of positive consultations with European Commission officials took place, especially with German (BMBF) and French (IN2P3) authorities, as well as with the Russian Ministry of Education and Science .

**Short-term tasks:**

- Applications for membership (observer status) to European International organizations as **NuPECC** (**Nuclear Physics European Collaboration Committee**), **NuPNET (Net for Nuclear Physics Infrastructures)**, **Helmholtz International center for FAIR.**

**Long-term targets:**

- Joining **ESFRI** (the European Strategy Forum on Research Infrastructures) through establishing an **ERIC** – European Research Infrastructure Consortium;
- Developing the idea (firstly expressed by GSI Director H. Stöcker) of establishing the **collaborative framework between International Laboratories in Europe** (CERN, JINR, FAIR, GANIL, …).

36

# Conclusion

- Publication of a number of addenda to the current Seven-Year Plan and development of a longer-range Road Map of JINR until the year 2030.
- Support of the JINR finance policy, approved by the CP and aimed at achieving the main goals of the JINR Seven-Year Development Plan for 2010-2016.
- Enhancement of JINR's attractiveness for the Member States.
- Involvement of new economically developed countries-partners is a task of strategic importance.
- Considerable increase in recruitment of young scientists and specialists from all the Member States.
- Social policy to be oriented at securing of a favourable environment for the life and work of JINR staff members.


# Thank you!