JINR: State of Today and Perspectives

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(represented by A.Olshevskiy)

JINR, Dubna

European School of Hiigh Energy Physics 2014
(CERN/JINR School)

Almost 50 years long way from the theoretical hypothesis on the nature and mechanism of generation of masses of the heavy vector fields of the Electroweak Interactions (W,Z bosons) to the direct experimental observation at the Large Hadron Collider in CERN marked in 2012 by the Nobel Prize

What is the next?

At the border of the XX-XXI centures

Elementary Particle Physics, Nuclear Physics, Astrophysics and Cosmology

are developing in a close interrelation as a unique direction of the fundamental research on the edge frontier of the modern nature science =

the Fundamental Physics

whose goal is search of the primary unique universal laws of Nature which are governing phenomena in both – the micro and macro worlds and relate the deep structure of matter with evolution of our Universe as a whole.

Main Puzzles of Fundamental Physics in the new Millenium

What gave first push to our Universe birth?

Physics of the Big Bang and evolution of the early Universe:

*The Inflation hypothesis (exponentially fast expansion and generation of spectra of inhomogenities)

*Evolution of the Hot Universe

*Nucleosynthesis

*Acceleration of the Universe expanding

Very Broad Scientific International Cooperation in

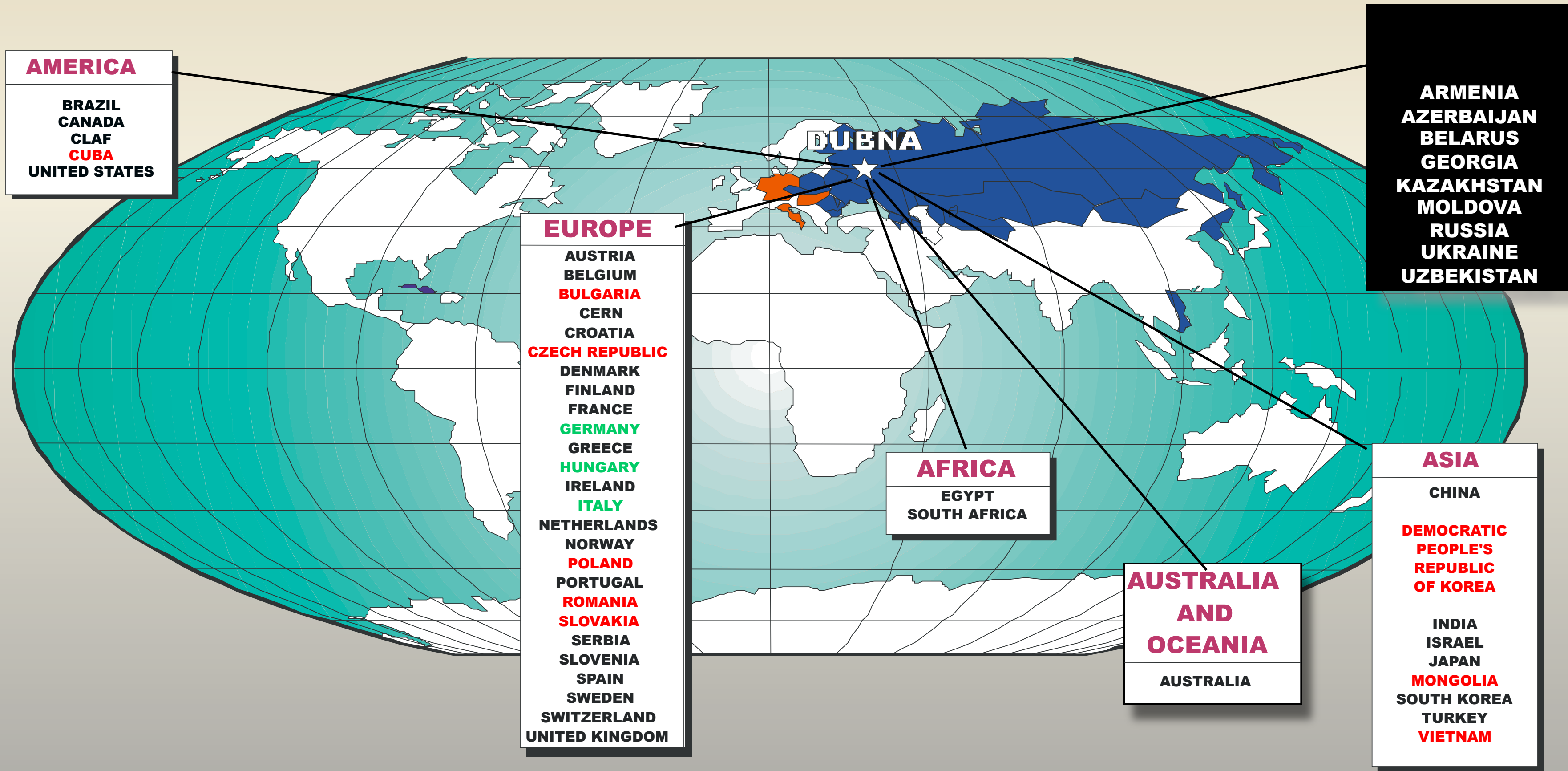
Energy & Intensity Frontiers

Europe, US & Latin America, Asia, South Africa

International labs: CERN (est. 1954) & JINR (est. 1956)

Where is JINR?

JINR Cooperation



JINR's partners are about 700 institutions located in 60 countries, including about 300 institutions and universities from the JINR Member States

JINR's Basic Scientific Directions

- High Energy Physics & Relativistic Heavy Ion Physics
- Nuclear Physics
- Condensed Matter Physics
- Radiation Biology & Astrobiology

- *Main Supporting Activities*
- **Theory of Pphys., Nphys., CMphys.**
- **Networking and computing**
- **Physics instruments and methods**
- **Training of young specialists**

JINR Research Facilities

- Complex Nuclotron-NICA (Mega-Science Project):
  High density & strong interacting matter search
- Pulsed reactor IBR-2: Condensed matter & Nuclear physics
-
- Accelerators Complex: New heavy elements synthesis
-
- Complex of computing & information technologies
- Accelerators complex: Applied and & medical sciences,
  proton therapy

High Energy Physics @ JINR

From Synchrophasotron to Nuclotron to NICA

1957 - Synchrophasotron

10 GeV proton accelerator – world leader in energy.

Beginning of era of high-energy physics

V.Veksler – phase stability principle discovery

1993 – Nuclotron

First in the world

Superconducting Synchrotron of heavy ions

A.Baldin –start of relativistic nuclear physics era

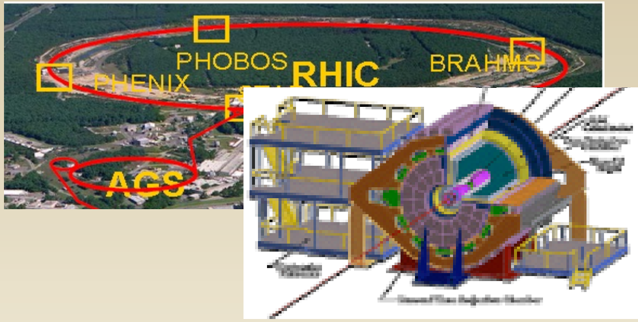
2019 – NICA

Superconducting collider of heavy ions

Study of baryonic matter at extreme conditions

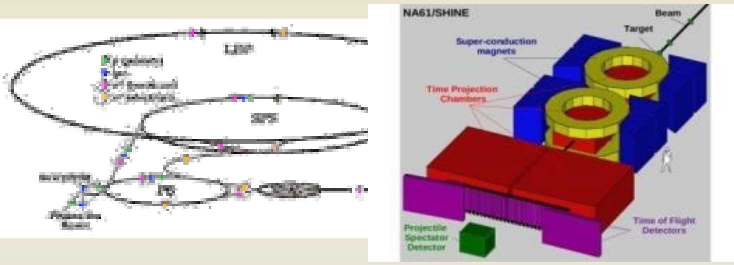
The JINR 7-year plan for 2010-2016 approved by CPP in 2009:

NICA – the JINR flagship project in HEP



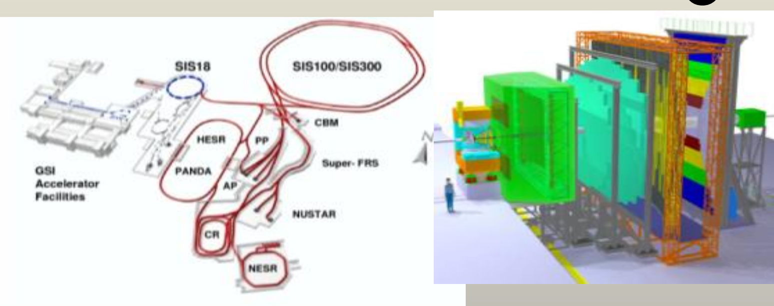
2^{nd} generation Heavy Ion experiments

STAR/PHENIX @ BNL/RHIC.
designed for high energy researches ($\sqrt{s_{NN}}$ > 20 GeV), low luminosity for LES program L<10^{26} $cm^{-2}s^{-1}$ for Au^{79+}

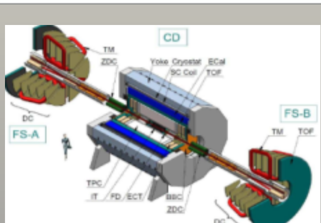


NA61 @ CERN/SPS.
Fixed target, non-uniform acceptance, few energies (10,20,30,40,80,160A GeV), poor nomenclature of beam species

3^{nd} generation Heavy Ion experiments



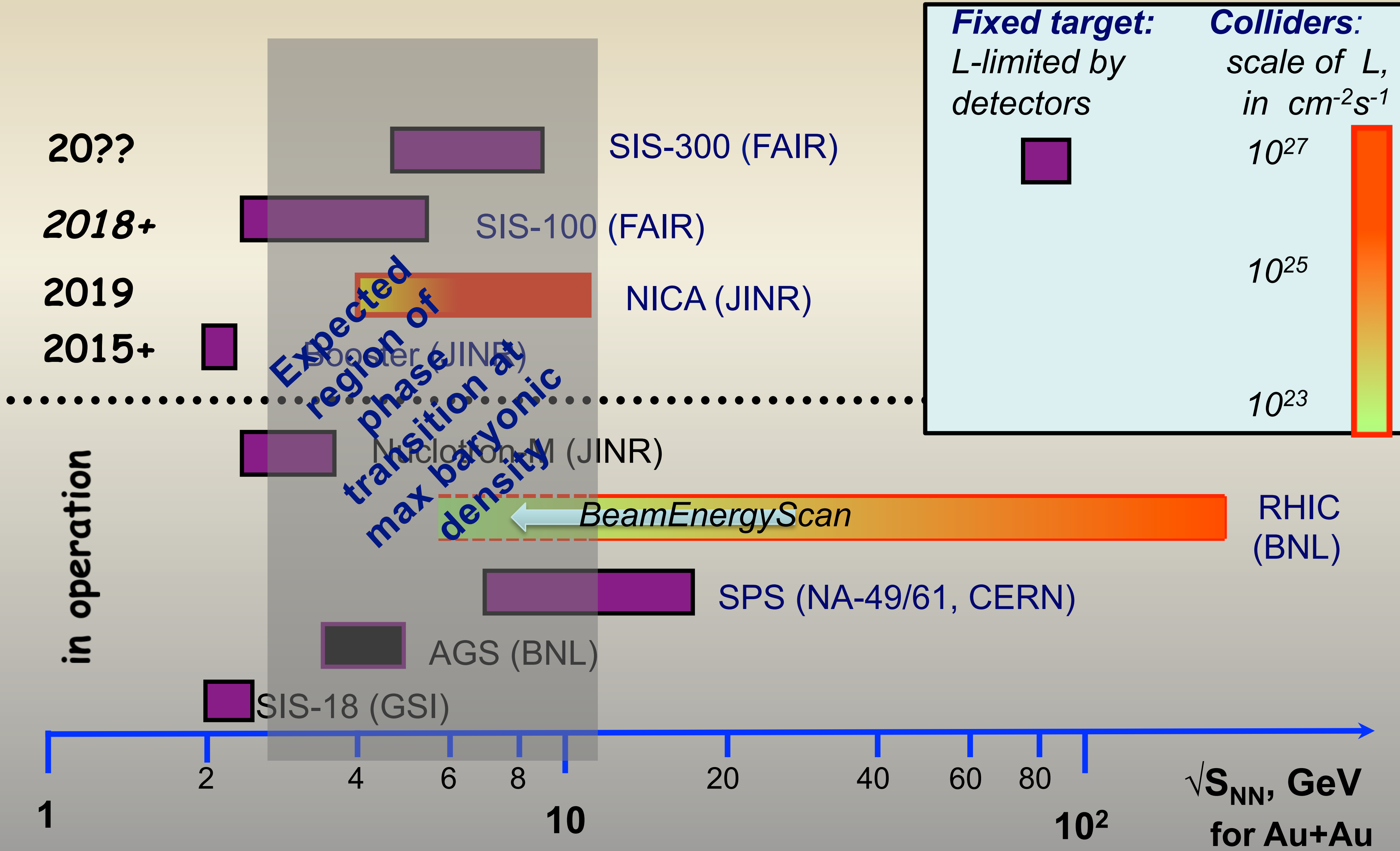
CBM @ FAIR/SIS-100/300
Fixed target, E/A=10-40 GeV, high luminosity



MPD & SPD @ JINR/NICA.
Collider, small enough energy steps in the range $\sqrt{s_{NN}}$ = 4-11 GeV, a variety of colliding systems, L~10^{27} $cm^{-2}s^{-1}$ for Au^{79+}

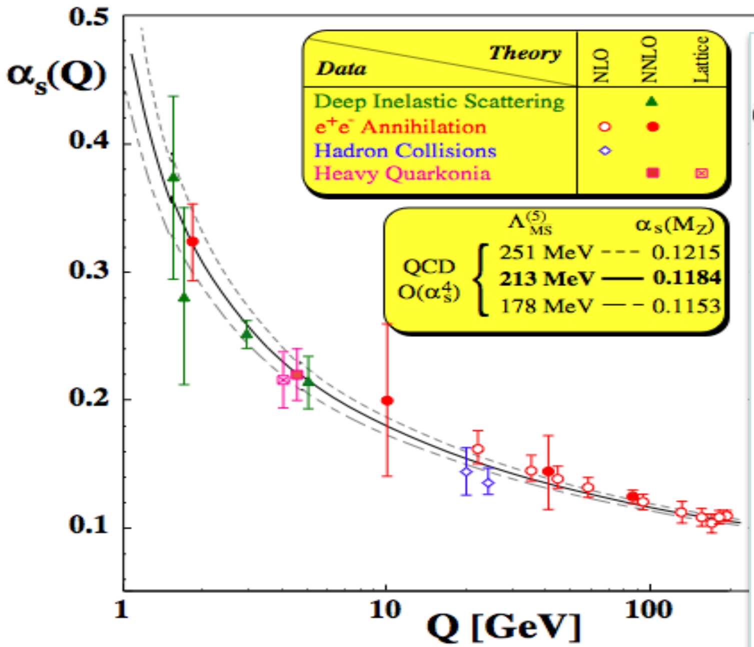
Common European Research infrastructure for Heavy Ion High Energy Physics: NICA + FAIR

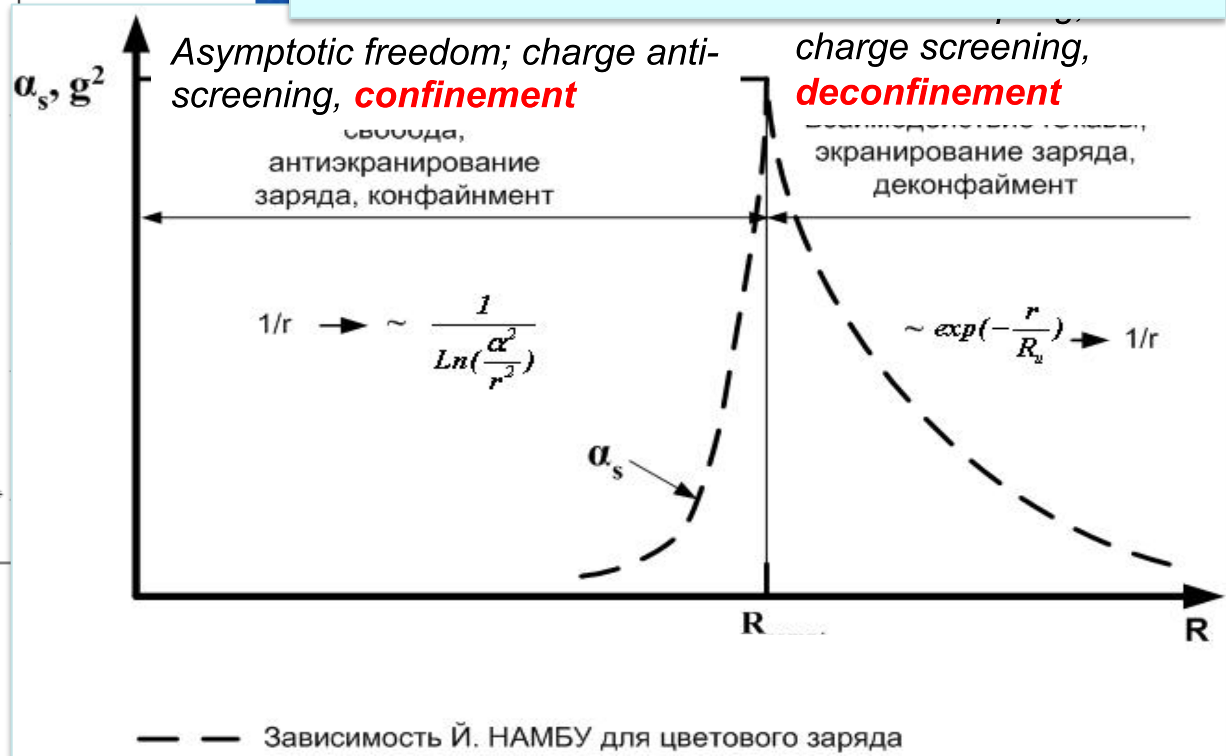
Present and future HI machines



BASIS: Asymptotic freedom of quarks

N.Bogolyubov, D.Shirkov
D.J.Gross, H.D.Politzer, F.Wilczek
A.Tavkhelidze, B.Struminsky, V.Matveev



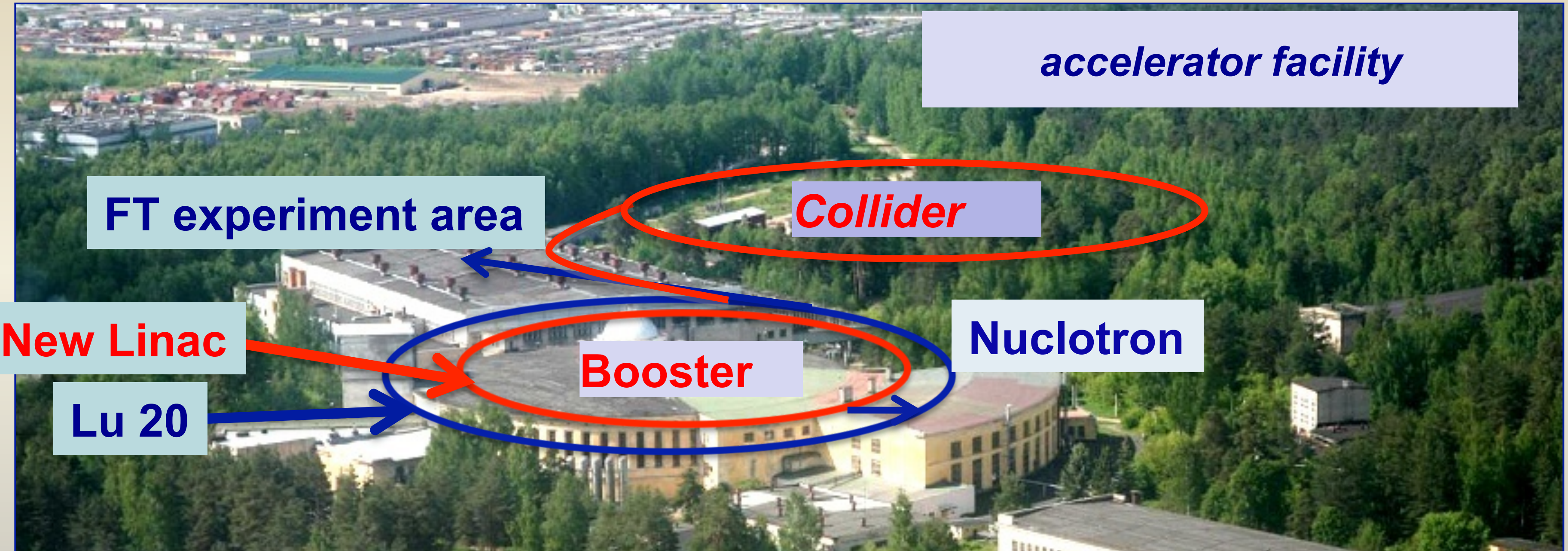


the access to "asymptotically free" regime in hard processes

and in **super-dense matter**
(inter-particle distances ~ 1/T)

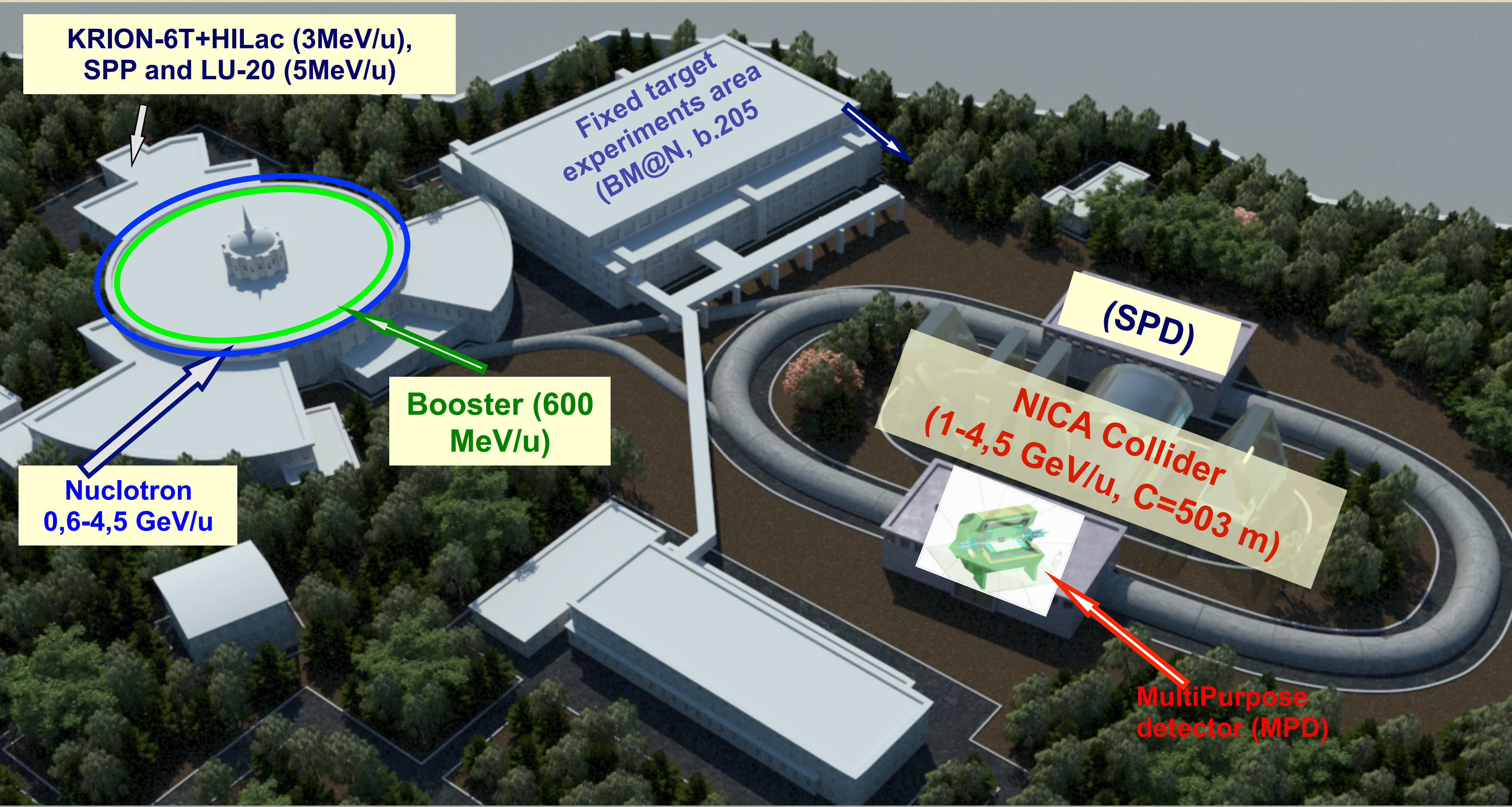
super-dense matter *could be obtained in heavy ion collisions*

Complex NICA @ JINR

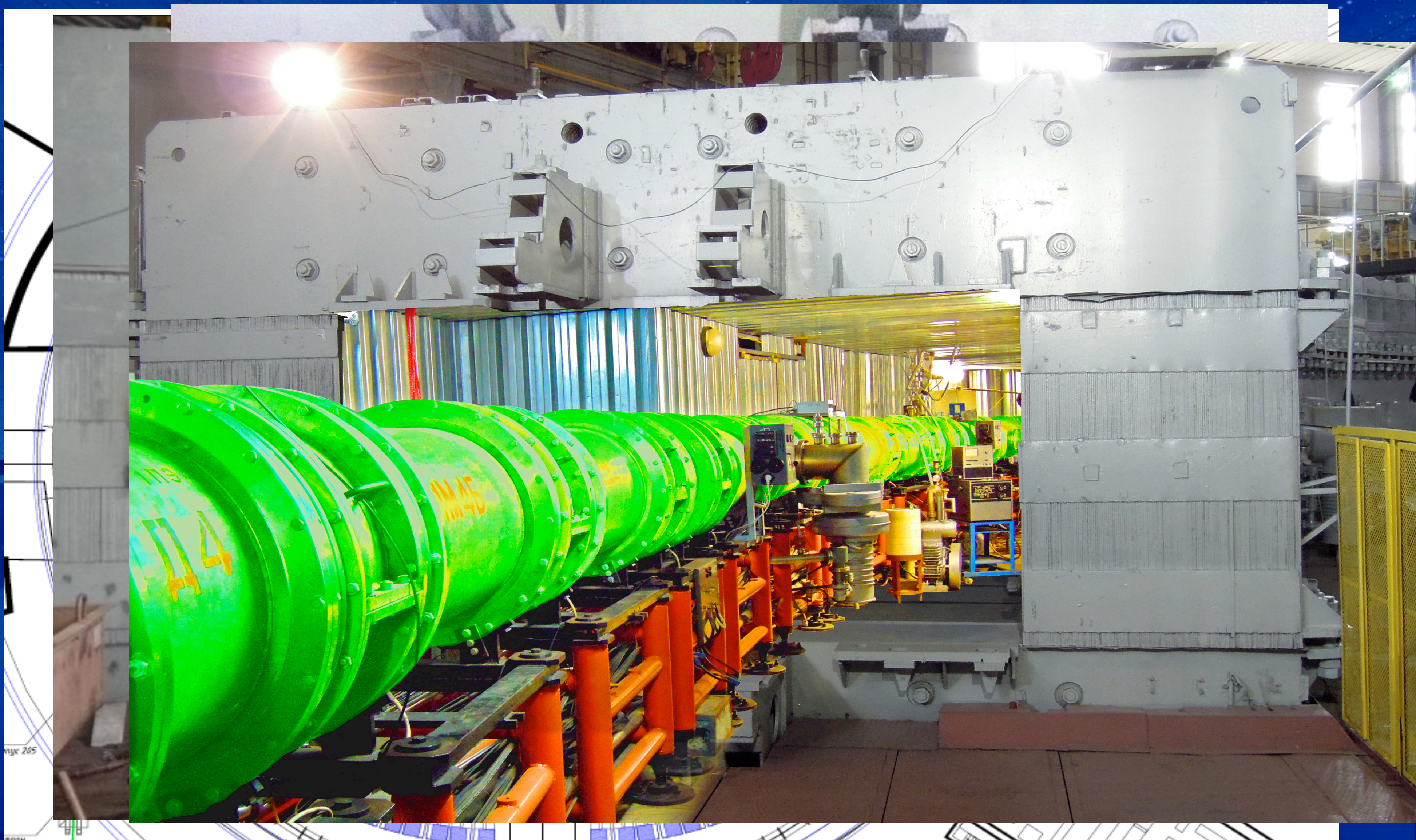


JINR NICA -
in the list of international Mega-science projects in RF area

Superconducting accelerator complex NICA
(Nuclotron based Ion Collider fAcility)



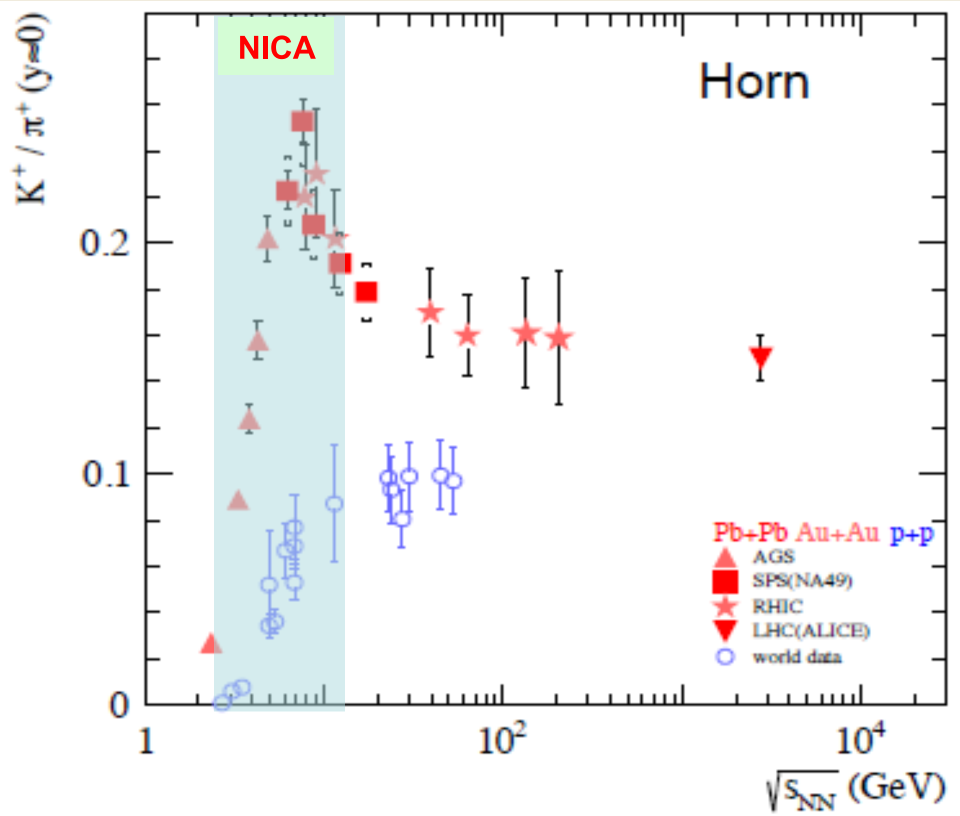
Booster synchrotron



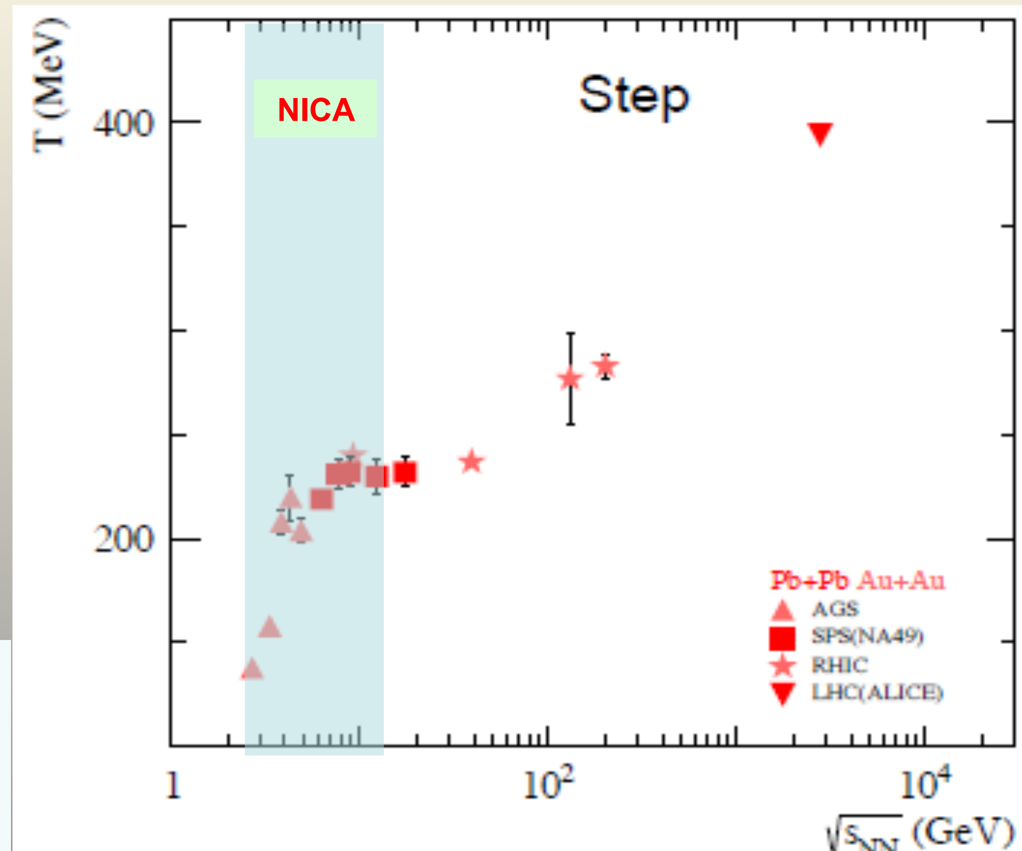
Main observables @ NICA detector MPD

- *Hadron multiplicities (4π particle yields : π, K, p, Λ, Ξ, Ω)*
- *Event-by-event fluctuations*
- *BE & FD correlations: Femtoscopy involving π, K, p, Λ, others*
- *Collective flow for identified hadron species and resonances*
- *Electromagnetic probes:*
  electrons, photons, vector meson decays
- *Hyper Nuclei & other exotic states*

Towards the "deconfinement" & mixed phase



- **Non-monotonic energy dependence of the K+/π+ ratio ("Horn") – onset of deconfinement?**



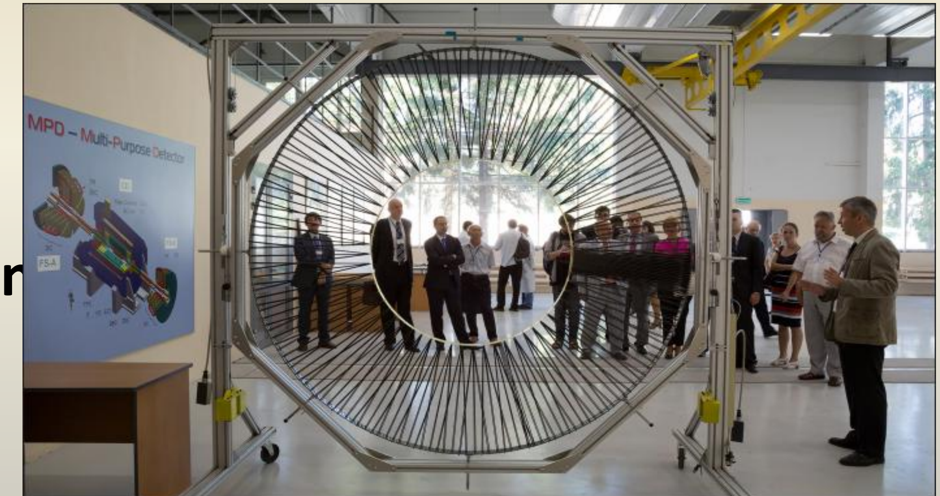
Plateau in the apparent temperature of the kaon spectra ("Step") – signal of the mixed phase?

NICA Mega-Science Project International Consortium

6 countries

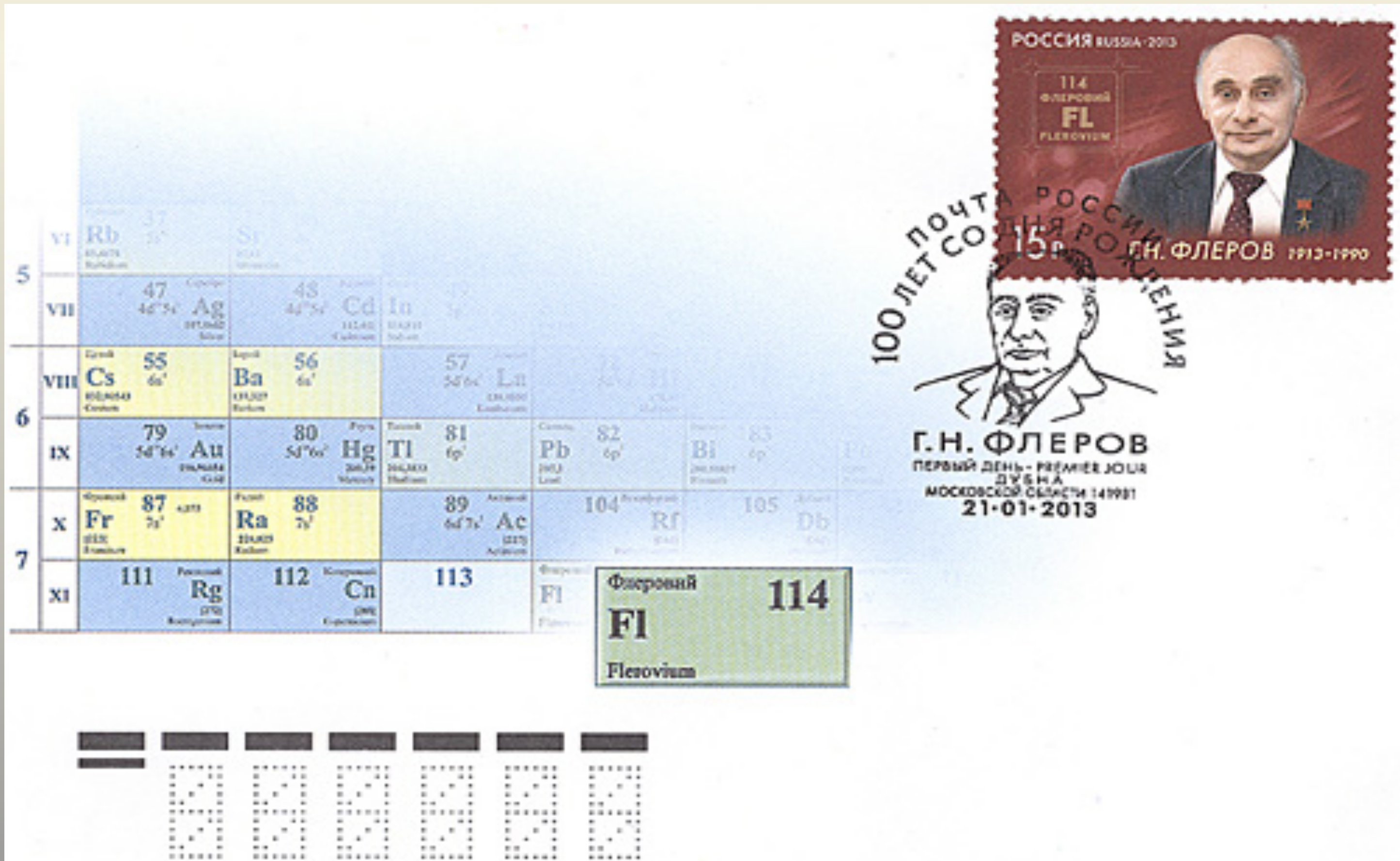
- **Protocol** signed by:
- Belarus, *Bulgaria,* Germany, Kazakhstan
- Russia, Ukraine

Dubna, August 08, 2013.



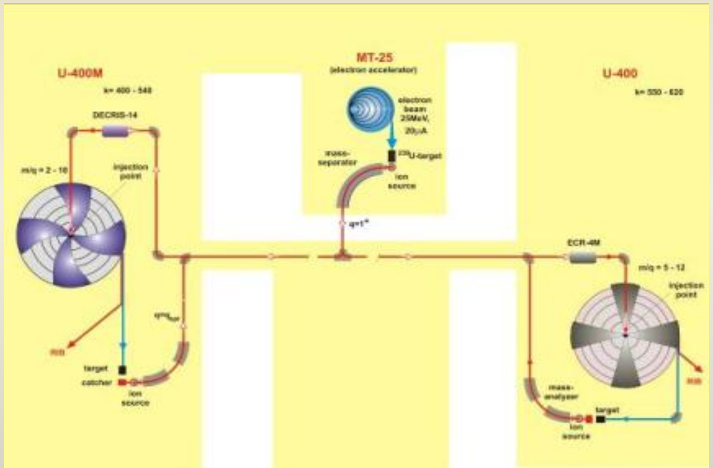
Scientific cooperation @ NICA projects

Super-Heavy Elements

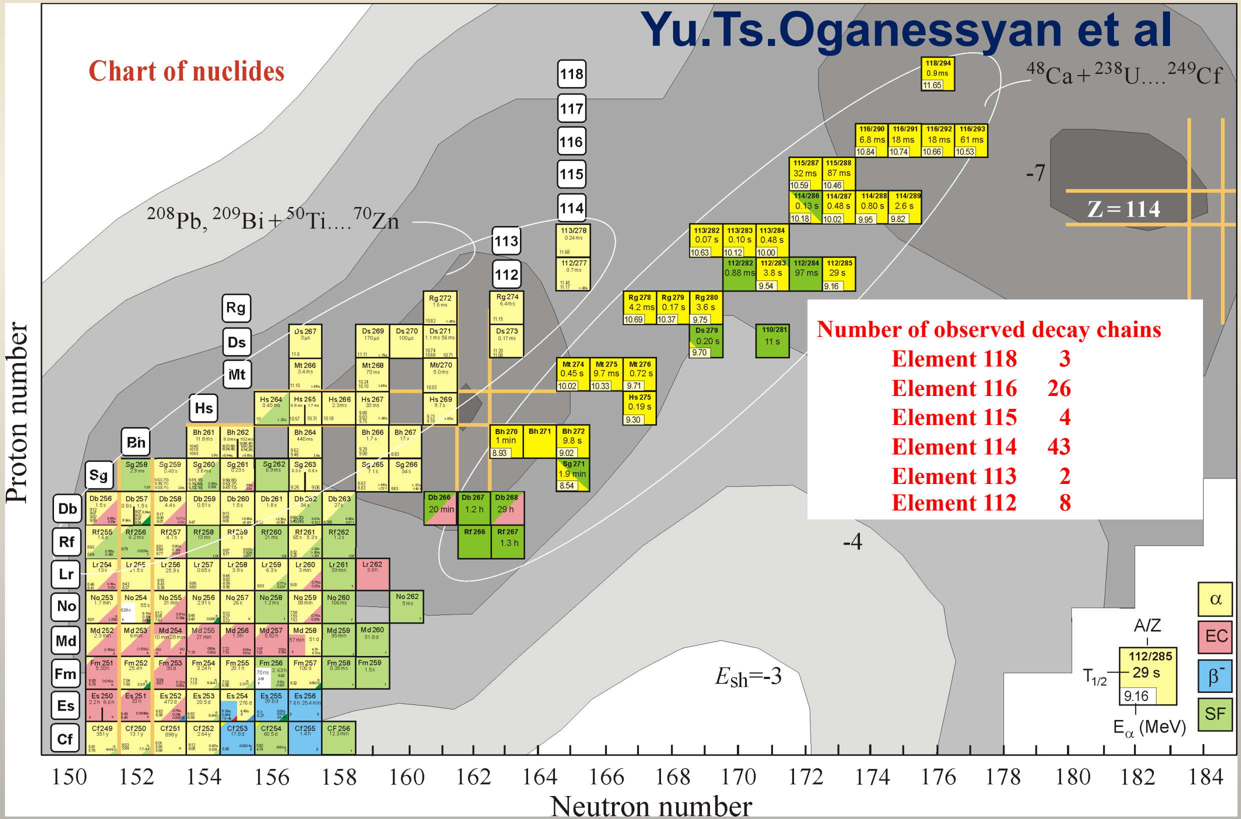


Super Heavy Elements (DRIBs-III project)

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



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

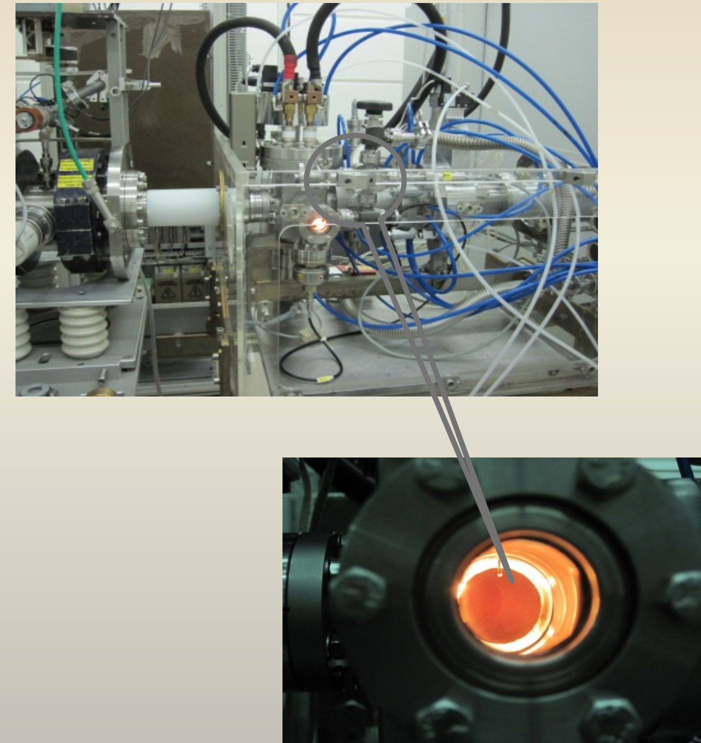


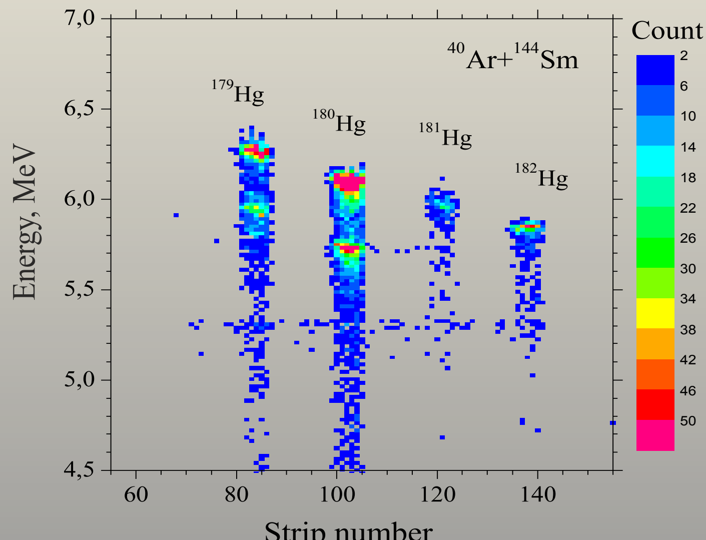
U400 and U400M isochronous cyclotrons are combined into the accelerator complex – project DRIBs which deals with the production of beams of exotic light neutron-deficient and neutron-rich nuclei in reactions with light ions.

MAss-Separator of Heavy Atoms - “MASHA”

Mass-separator “MASHA” at the beam of U-400M

Hot catcher





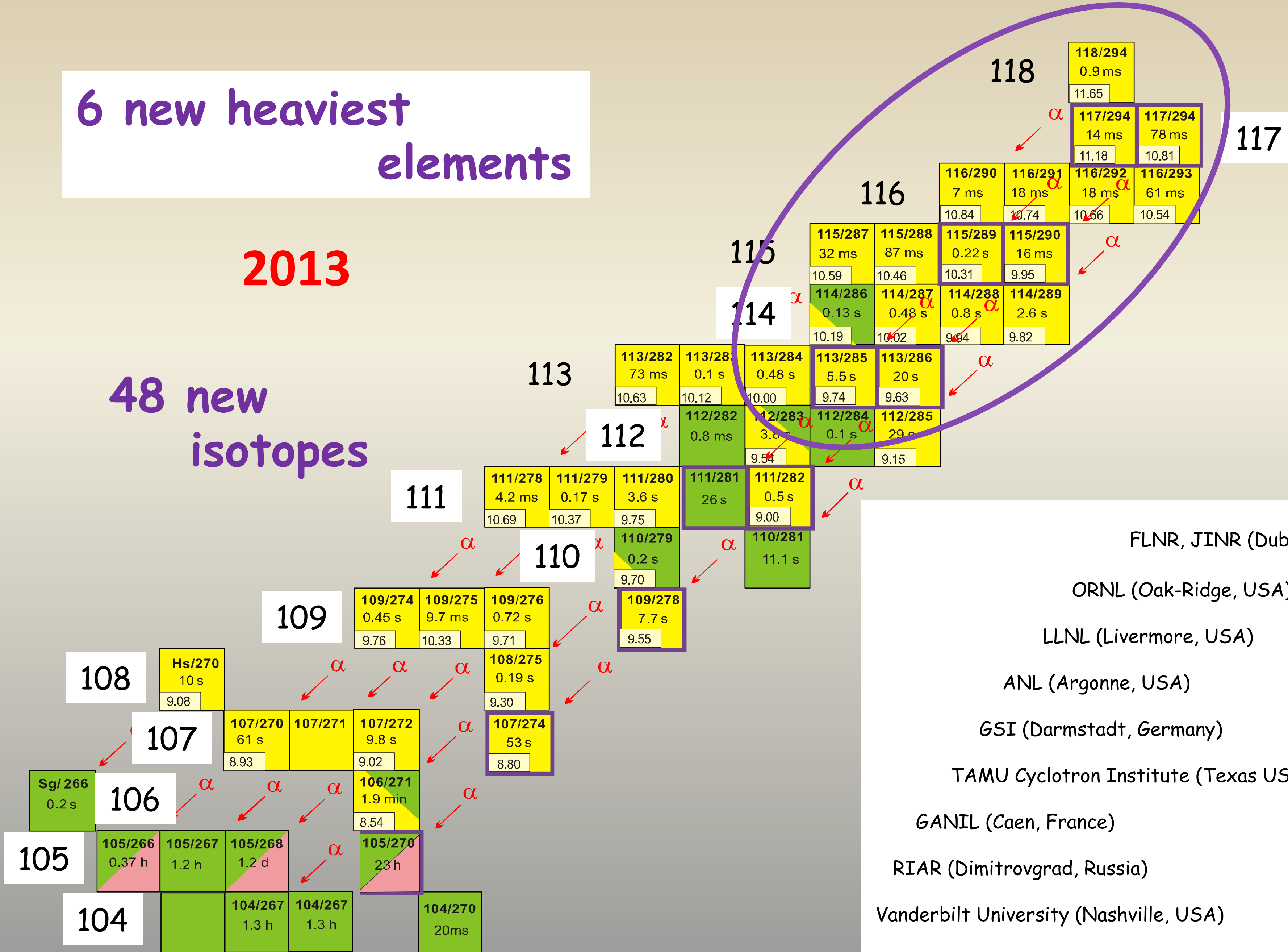
Detection of mercury isotopes at the focal plane

Mass measurement of ^{283}Cn in reaction $^{48}Ca+^{238}U$ started

6 new heaviest elements

2013

48 new isotopes



FLNR, JINR (Dubna)

ORNL (Oak-Ridge, USA)

LLNL (Livermore, USA)

ANL (Argonne, USA)

GSI (Darmstadt, Germany)

TAMU Cyclotron Institute (Texas USA)

GANIL (Caen, France)

RIAR (Dimitrovgrad, Russia)

Vanderbilt University (Nashville, USA)

Two new elements in the Table

What is beyond 118 element?

Heaviest target: $^{249}Cf \rightarrow Z_{max} = 118$

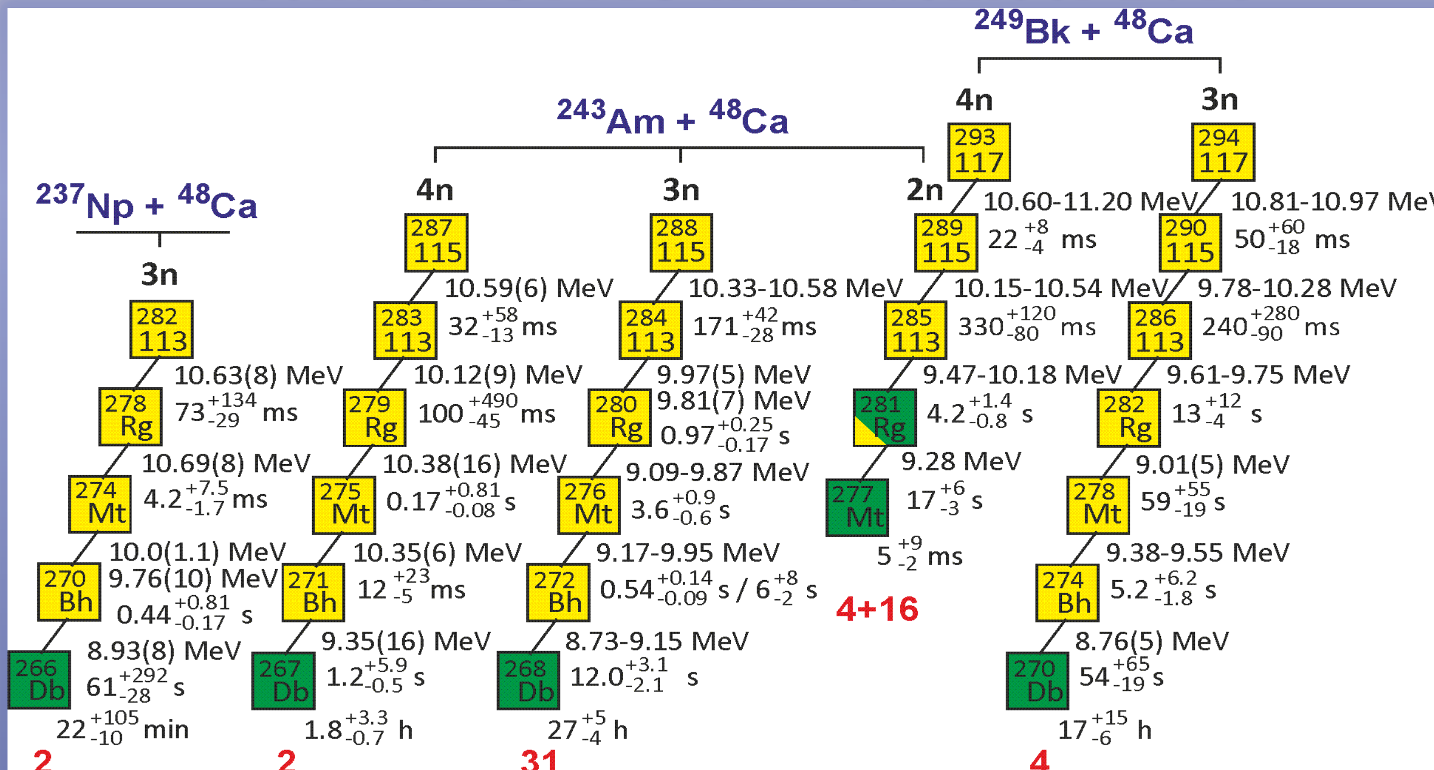
↓

- **Heavier projectiles (^{50}Ti, ^{54}Cr, ^{58}Fe, ^{64}Ni)**
- **Heavier targets (^{251}Cf, ^{254}Es -???);**
- **Symmetric reactions: $^{136}Xe+^{136}Xe$, $^{136}Xe+^{150}Nd$, $^{150}Nd+^{150}Nd$;**
- **Nucleon transfer reactions ($^{136}Xe+^{208}Pb$, $^{238}U+^{248}Cm$).**

Preparation to study $^{48}Ca + ^{251}Cf$ reaction (Spring 2014)

ODD SUPERHEAVIES: 113, 115, 117

Application for recognition of these discoveries is sent to IUPAC in November 2013



Russian Information Agency has recently published the result of widely distributed questionnaire about most significant discoveries by Russian researchers over last two decades.

The list of those discoveries is opening with ***SHE synthesis at JINR.***

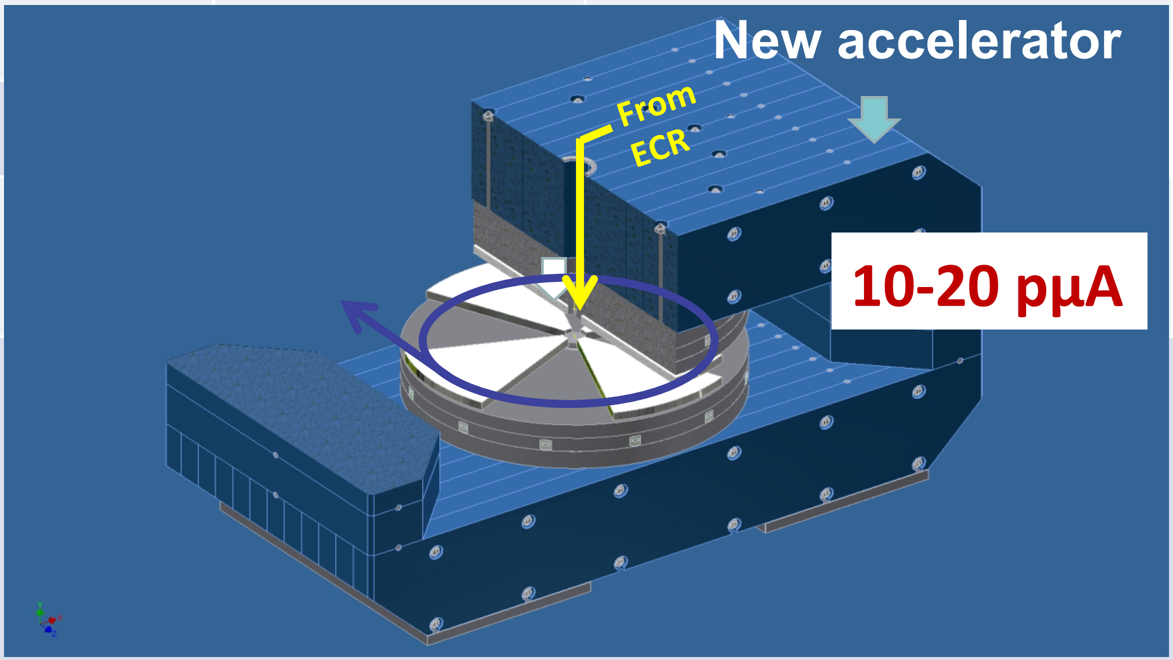
Super-Heavy Elements Factory – «SHEF»

Production

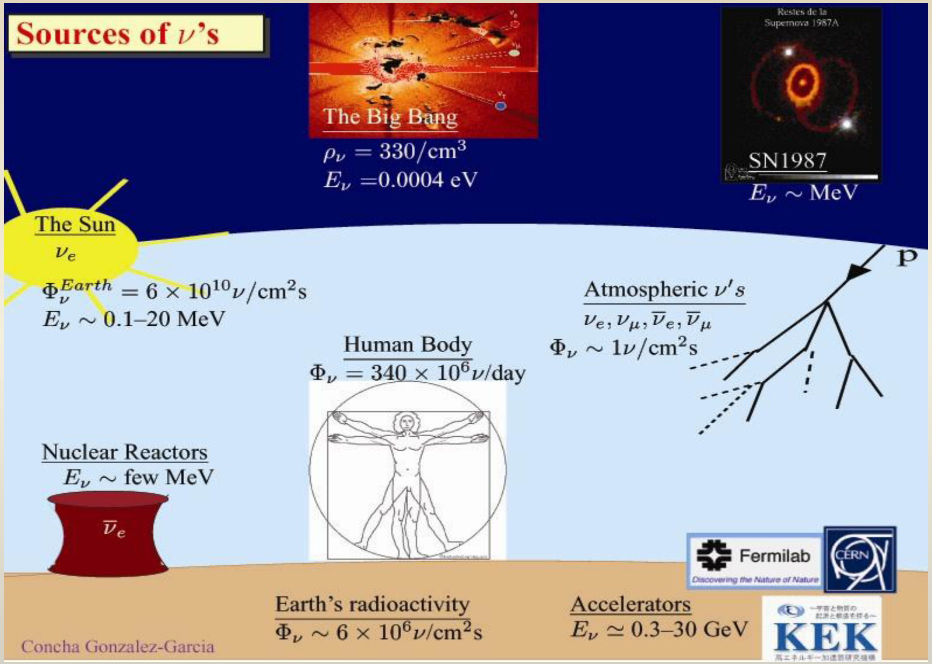
Today: ~ $5 \cdot 10^{19}$ **With SHEF: $1.5 \cdot 10^{21}$**

factor: 30

Increased	**Intensity beam**	&	**Beam time**
			SHEF
			~ 7000 h/year



Neutrino Physics



F. Reines, *Ann. Rev. Nucl. Sci.* **10** (1960) 1–26.

- ✓ fission reactors are the best source of low energy antineutrinos
- ✓ muon-neutrinos can be produced by allowing pions to decay in flight
- ✓ the Sun is a "most copious source of neutrinos"
- ✓ cosmic rays striking the Earth's atmosphere should produce a significant flux of neutrinos from pion decay
- ✓ high-energy neutrinos produced by astrophysical objects would provide information not available from cosmic rays

B.Pontecorvo:

- ✓ proposed the first (radiochemical) method of neutrino detection and possibility of reactor experiments.
- ✓ was the first who came to an idea of *μ − e universality of the weak interaction.*
- ✓ proposed the experiment with accelerator neutrinos to prove that ***ν_μ* and *ν_e* are different particles.**
- ✓ was the first who came to idea of neutrino oscillations and proposed many experiments to check it.

New frontier

A lot more to learn

- Majorana or Dirac masses? $\Longrightarrow$ $2\beta 0\nu$-decays
- Absolute mass scale $\Longrightarrow$ Katrin + cosmology + $2\beta 0\nu$
- Direct or inverse chierarchy $\Longrightarrow$ Long baseline accelerator and reactor neutrino experiments
- CP-violation $\Longrightarrow$ Long baseline accelerator experiments
- Electromagnetic properties $\Longrightarrow$ Search for neutrino magnetic moment
- Sterile neutrinos?

JINR is an important player in nearly all of this

NEMO $\Longrightarrow$ SuperNEMO, GERDA $\Longrightarrow$ GERDA/Majorana
Daya Bay $\Longrightarrow$ JUNO, NOνA
GEMMA
DANSS

60 years of reactor neutrino physics

2011/2012 - The year of θ_{13}

2008 - Precision measurement of Δm_{12}^2. Evidence for oscillation

2003 - First observation of reactor antineutrino disappearance

1995 - Nobel Prize to Fred Reines at UC Irvine

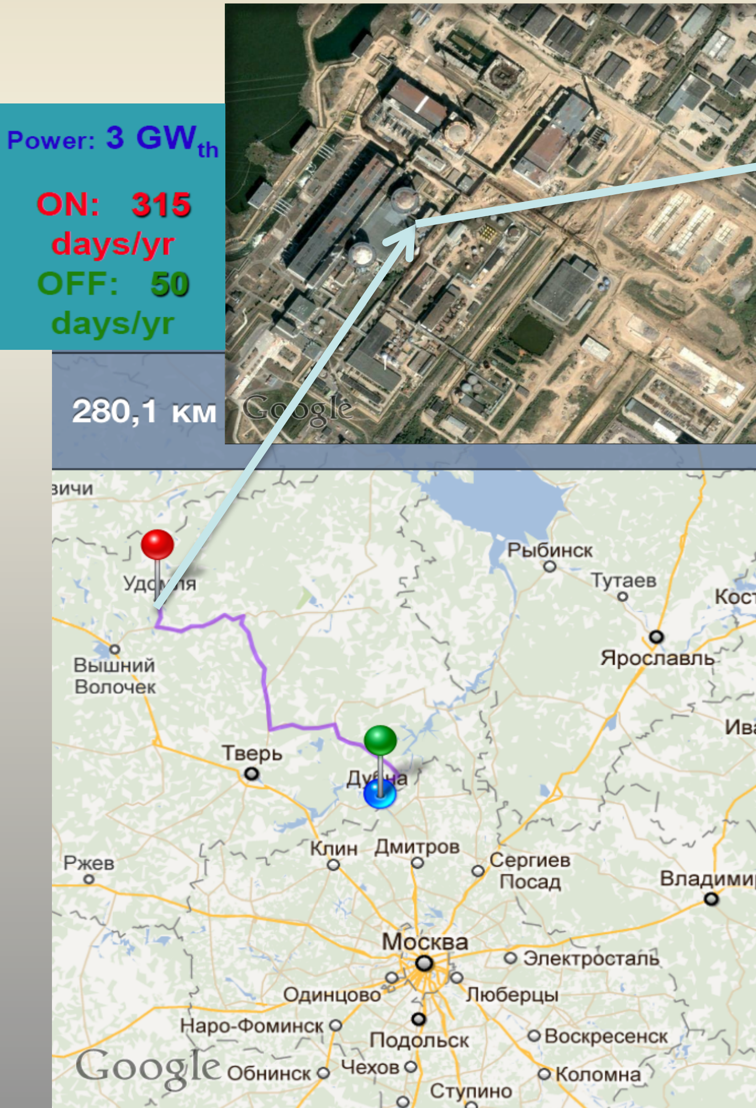
1980s & 1990s - Reactor neutrino flux measurements in U.S. and Europe

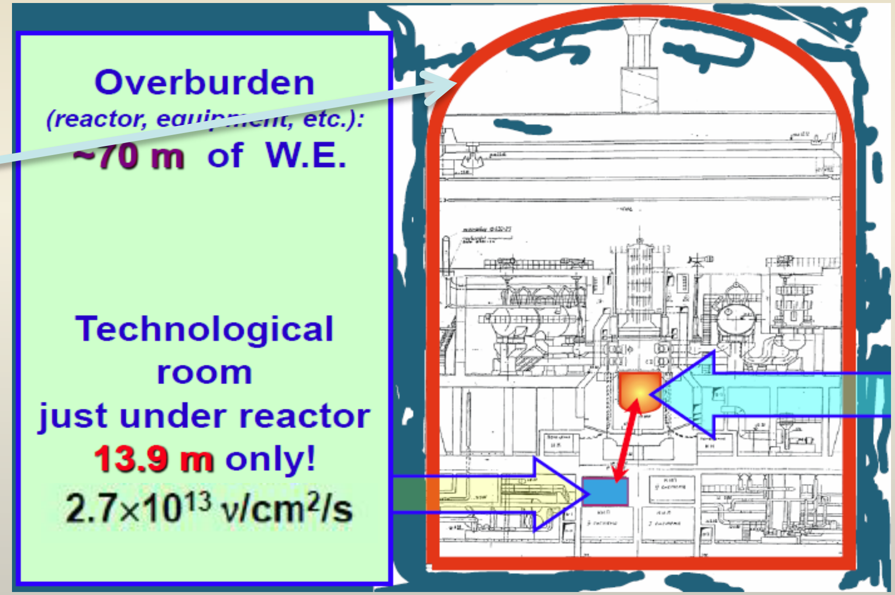
1956 - First observation of (anti)neutrinos

Past Reactor Experiments
Hanford
Savannah River
ILL, France
Bugey, France
Rovno, Russia
Goesgen, Switzerland
Krasnoyark, Russia
Palo Verde
Chooz, France

1953 – first experiment at Hanford

Experiments at Kalinin NPP

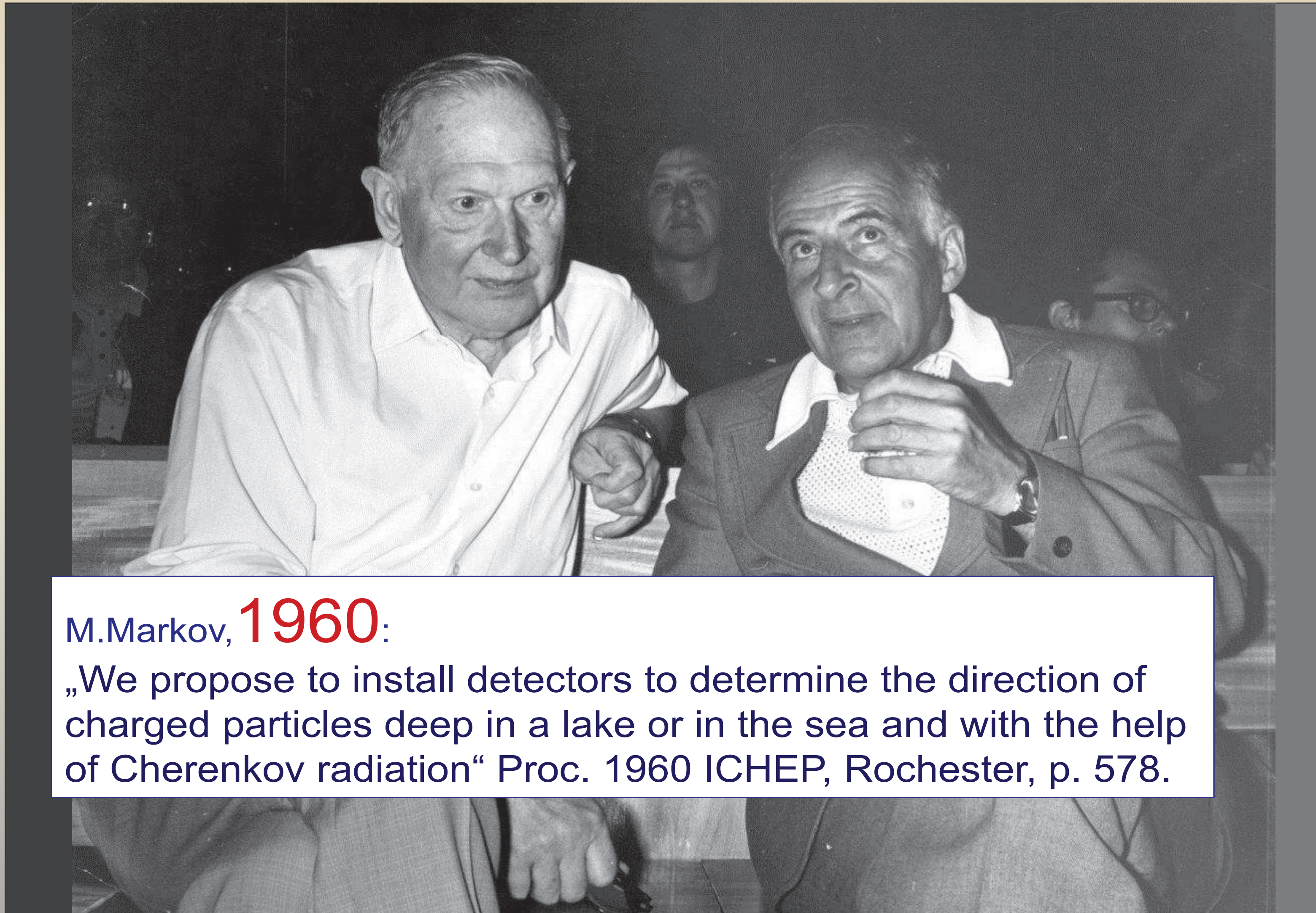




Fundamental and Applied Research:

- ✓ Search for Neutrino Magnetic Moment
- ✓ Measurement of Neutrino Fluxes and Spectra
- ✓ Search for Sterile Neutrino States

High energy neutrinos: Prolegomenon



M.Markov, 1960:

„We propose to install detectors to determine the direction of charged particles deep in a lake or in the sea and with the help of Cherenkov radiation“ Proc. 1960 ICHEP, Rochester, p. 578.

Neutrino Astronomy

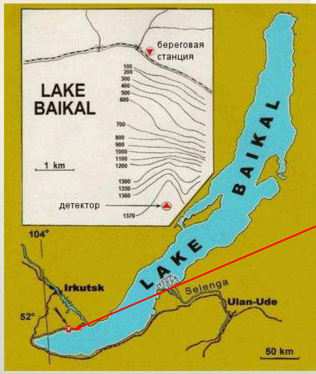
Among others, underwater/under-ice detectors are special

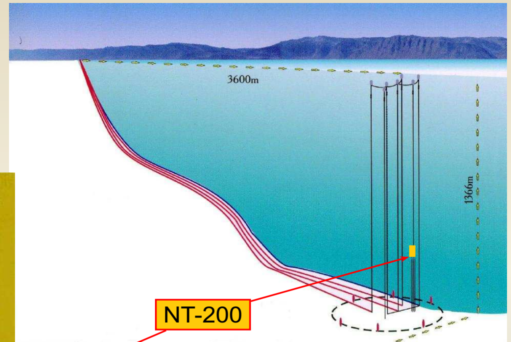
Main advantage: large scale.

Multi-purpose

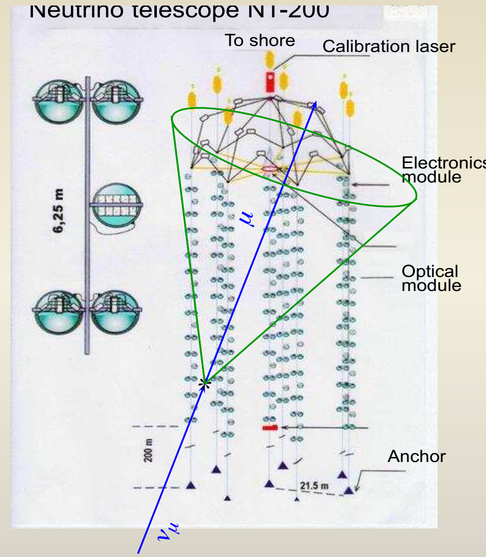
- Neutrino physics (in future) – mass hierarchy, CP-violation
  - With atmospheric neutrinos
  - Very long baseline experiments
- Search for dark matter: annihilations in the Earth and Sun
  $X + \bar{X} \to \pi^{\pm} + \cdots \to \nu, \bar{\nu}$
- Search for exotica (magnetic monopoles, quark nuggets, violation of Lorentz-invariance...)
- Cosmic ray physics
- Environmental studies
- Many more

Neutrino Astronomy

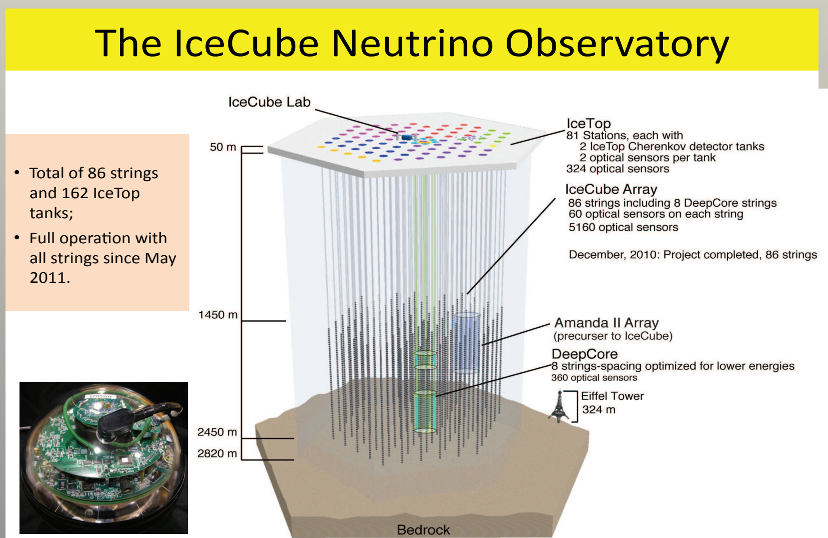




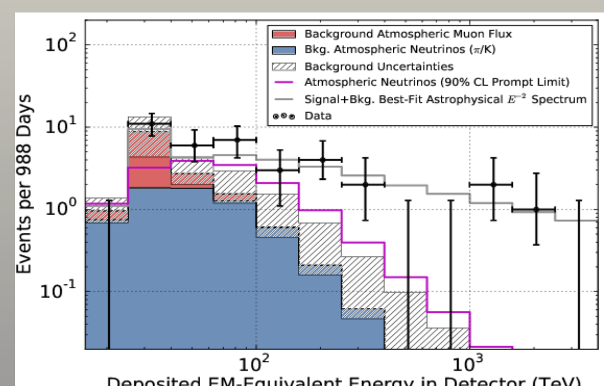
PROOF OF PRINCIPLE: BAIKAL



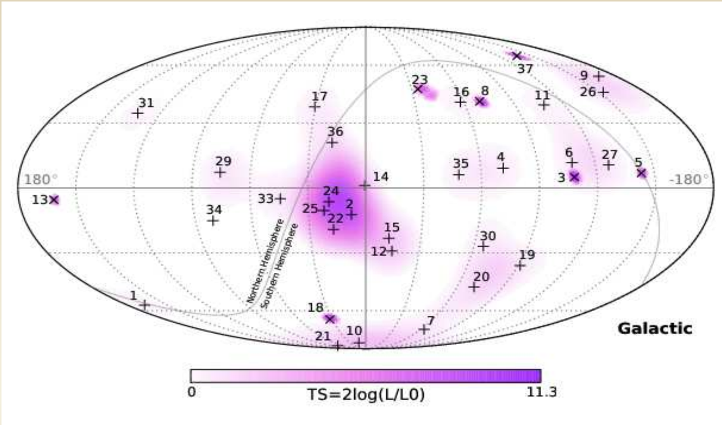
Newsmaker



First neutrinos of cosmic origin



Arrival directions



water, volume $\sim$ km^3

- Are there cosmic neutrinos indeed?
- Neutrinos from Galaxy or outside?
- Most likely from Galaxy, then
  - Point sources?
  - Galactic center (black hole)?
  - Fermi bubbles?

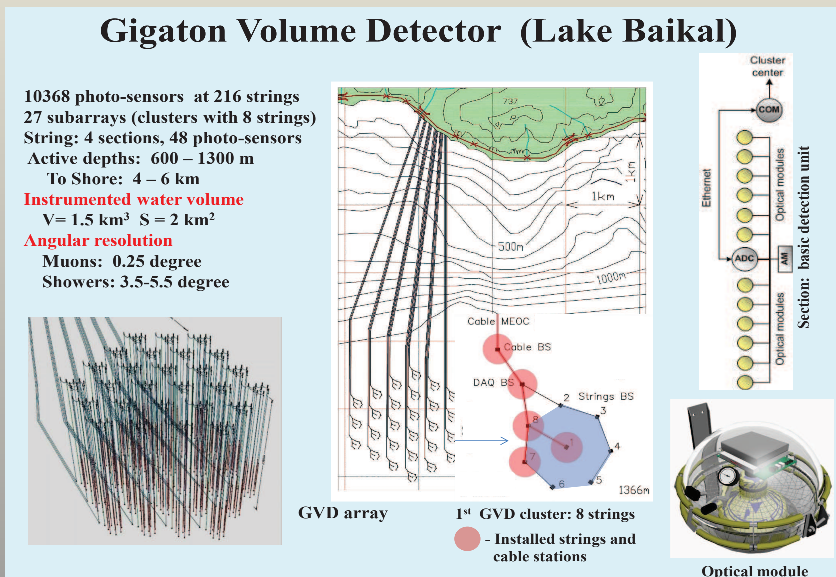
Key: angular resolution $\Longrightarrow$ water, not ice!

There must be hard gammas as well: both

$\pi^{\mp} \to \mu^{\mp} + \nu_\mu(\bar{\nu}_\mu)$, and $\pi^0 \to \gamma\gamma$

HiScore, HAWK, CTA

All this is within reach of Baikal GVD



Good company: GVD, IceCube, KM3Net

October 15, 2013. München. MoU signing.

From left to right: **Christian Spiering, Maarten de Jong, Tyce DeYoung, Zhan.-Arys Djilkibaev, Juan-Jose Hernandez-Rey, Paschal Coyle, Olga Botner, Uli Katz.**

Future of Daya Bay is JUNO, aimed at neutrino mass hierarchy. Apart from the mass hierarchy, with JUNO it would be possible to look for SN-neutrinos, geo-neutrinos, sterile neutrinos and may be even CP-violation … White Book and D.Naumov's talk

Reach physics goals

- Supernova neutrinos (less than 20 events so far)
  - $\bar{\nu}_e + p \to n + e^+$, $\sim$ 3000 correlated events
  - $\bar{\nu}_e + {}^{12}\mathrm{C} \to {}^{12}\mathrm{B}^* + e^+$, $\sim$ 10-100 correlated events
  - $\nu_e + {}^{12}\mathrm{C} \to {}^{12}\mathrm{N}^* + e^-$, $\sim$ 10-100 correlated events
  - $\nu_x + {}^{12}\mathrm{C} \to {}^{12}\mathrm{C}^* + \nu_x$, $\sim$ 600 correlated events
  - $\nu_x + p \to \nu_x + p$, single events
  - $\nu_x + e^- \to \nu_x + e^-$, single events
- Geoneutrinos
  - 10 times more than recorded by BOREXINO and KamLAND
  - Difficult on systematics
  - Background to reactor antineutrinos

Tasks to be solved

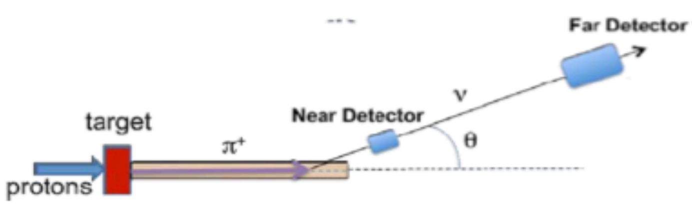
- Large detector (20 kt of LS): design, mechanics, chemistry, stability
- Energy resolution $3\%/\sqrt{E}$ (1200 p.e./MeV)
  - — Highly transparent LS
  - — High light yield
  - — High (80%) PMT covarage
  - — High QE PMT (40-50%) $\to$ a number of new problems to solve

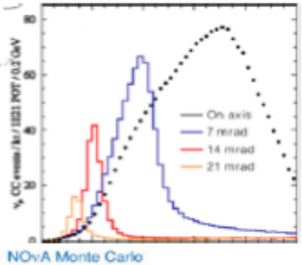
JINR possible contribution:

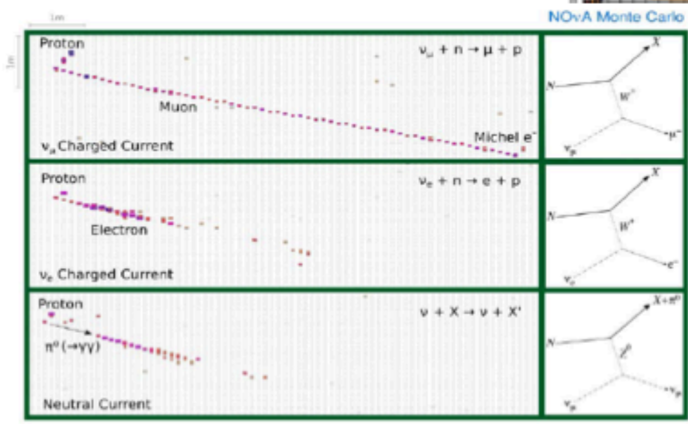
— Intelligent HV system
— PMT protection against Earth magnetic field
— Construction of a dedicated laboratory for large PMT tests and LS studies
— μ-veto based on OPERA plastic scintillator
— Detector design
— Simulation and reconstruction
— Data analysis

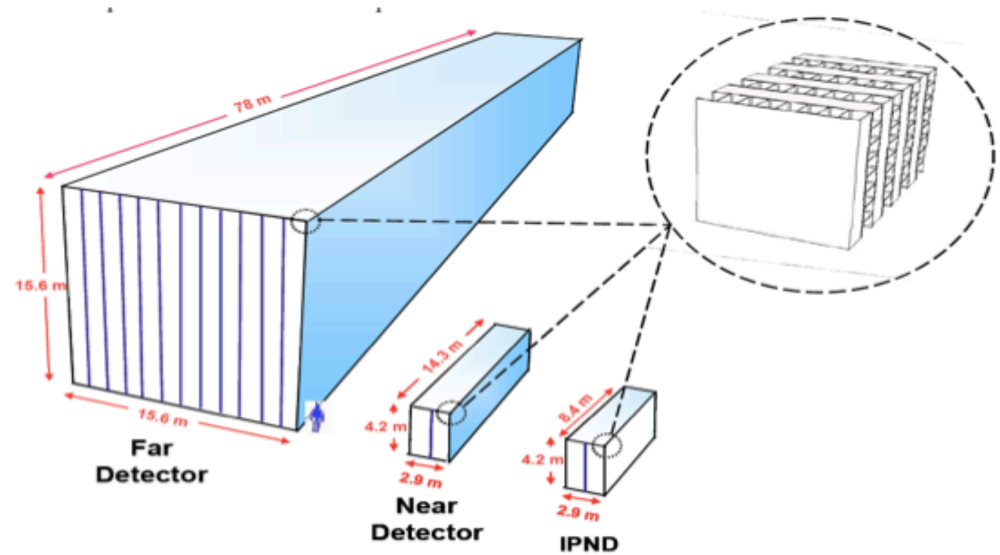
NOvA (NuMI Off-Axis ν_e Appearance) — a new generation accelerator long baseline experiment for study $\nu_\mu \to \nu_e$ oscillations.

The goal is to precisely measure the parameters of the neutrino mixing matrix, the neutrino mass hierarchy and CP violation effects in the lepton sector.





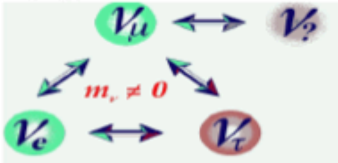




The NOvA apparatus consists of a Near Detector (220 ton) on the Fermilab site where the ν_μ-s are produced, and a Far Detector (14 kton) 810 km distant, both filled with liquid scintillator, have similar construction and situated 14 mrad off-axes to the ν beam. Detectors will be ready to reach full data-taking capability in 2014. The following 6 years of data taking are optimized for running with ν and $\bar{\nu}$ beams.

Neutrino history in Dubna — B. Pontecorvo and M.Markov!

About 55 years ago the idea of neutrino oscillation was born in Dubna!



$$\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix} = \begin{pmatrix}1 & 0 & 0\\ 0 & c_{23} & s_{23}\\ 0 & -s_{23} & c_{23}\end{pmatrix}\begin{pmatrix}c_{13} & 0 & s_{13}e^{-i\delta}\\ 0 & 1 & 0\\ -s_{13}e^{-i\delta} & 0 & c_{13}\end{pmatrix}\begin{pmatrix}c_{12} & s_{12} & 0\\ -s_{12} & c_{12} & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}\nu_1\\ \nu_2\\ \nu_3\end{pmatrix}$$

Weak eigenstates — Atmospheric ($c_{ij}=\cos\theta_{ij}$, $s_{ij}=\sin\theta_{ij}$) — CP phase — Sub-dominant θ_{13} oscillations — Solar — Mass eigenstates

Bruno Pontecorvo:
"The oscillations are very simple trick: 1–2–3 and … all OK!"

The beginning of neutrino astrophysics …

M.A.Markov had proposed for the first time to define incoming directions of a cosmic ray charged particle in water by means of its Cherenkov radiation.
The first realization of this idea was the Baikal neutrino telescope NT-200. This is foundation of the IceCude success of today!

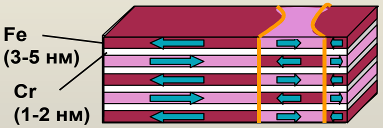
M.Markov, 1960:
„We propose to install detectors to determine the direction of charged particles deep in a lake or in the sea and with the help of Cherenkov radiation" Proc. 1960 ICHEP, Rochester, p. 578.

Opening of the monument to Bruno Pontecorvo and Venedict Dzhelepov at Dubna on 20 September 2013

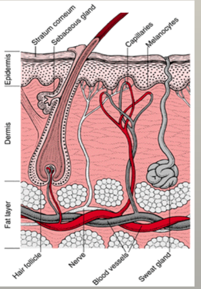
Condensed Matter Physics

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

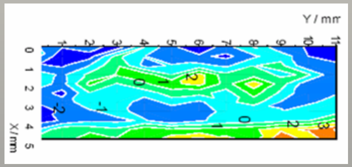
Nanosystems and Nanotechnology



Biomedical research



New materials



Diagnostics. Earth science.

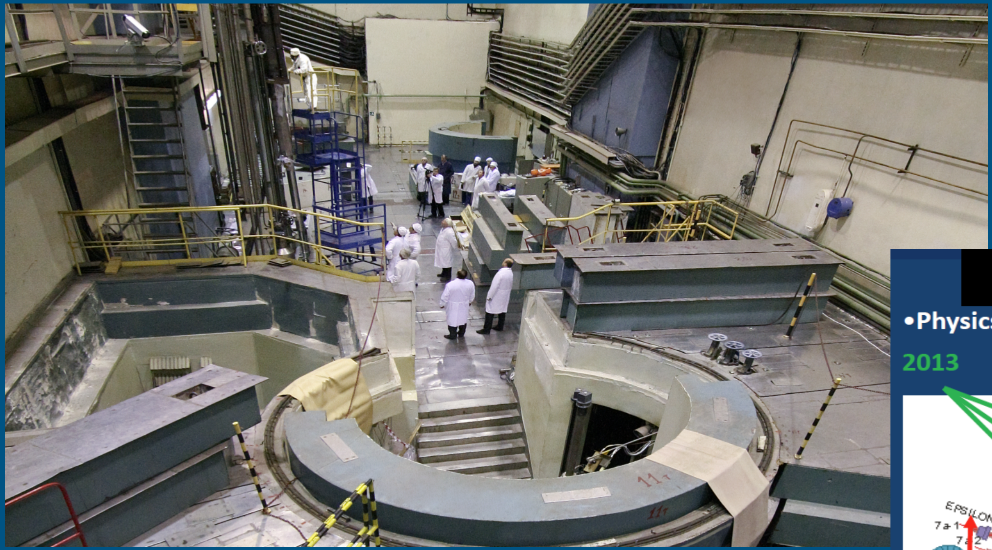
IBR-2

- Physics of high-temperature superconductivity
- Geological texture research
- Nanotechnology

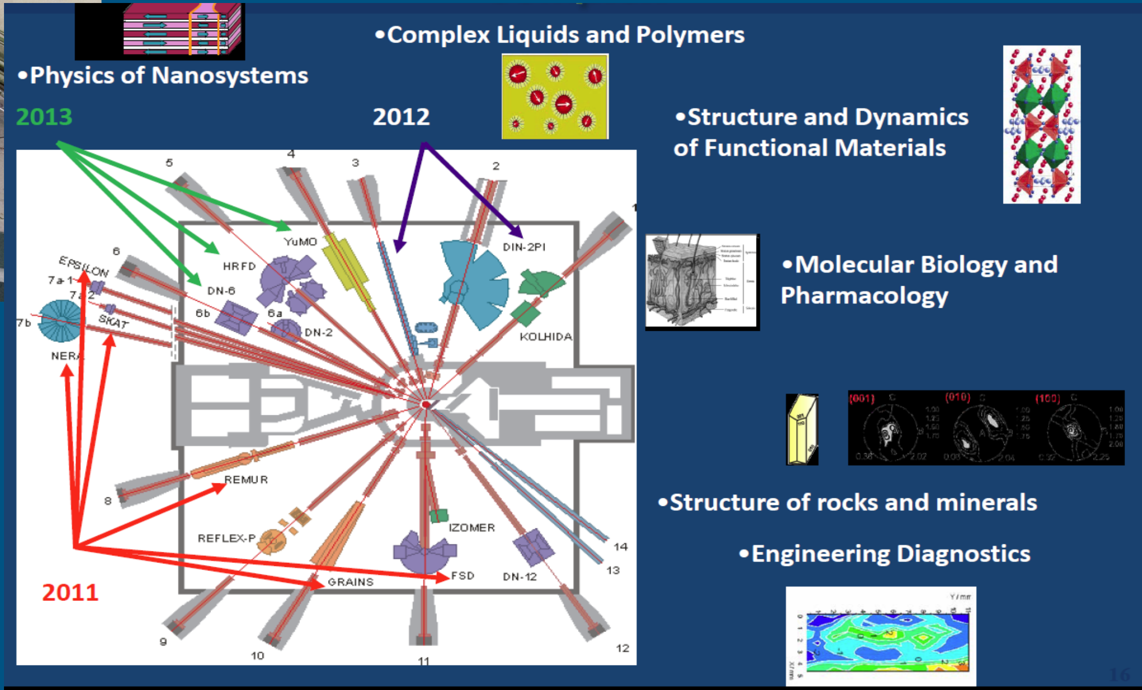
Upgraded IBR-2

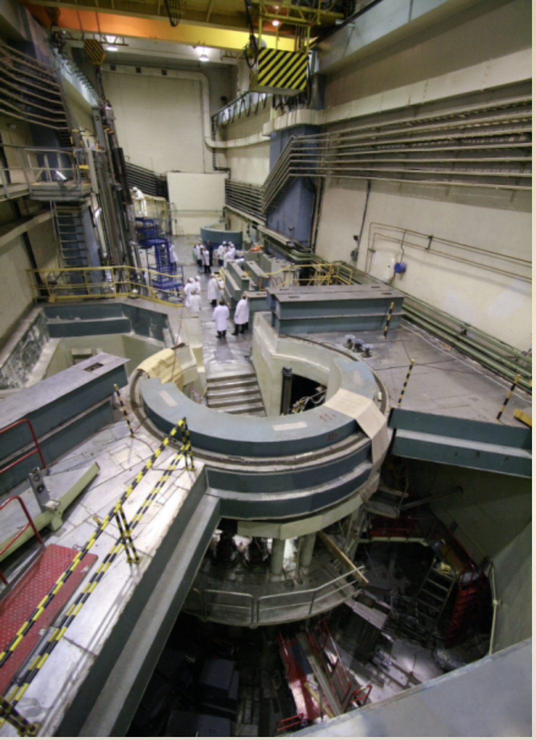
Pulsed reactor with fast neutrons

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



and spectrometer complex

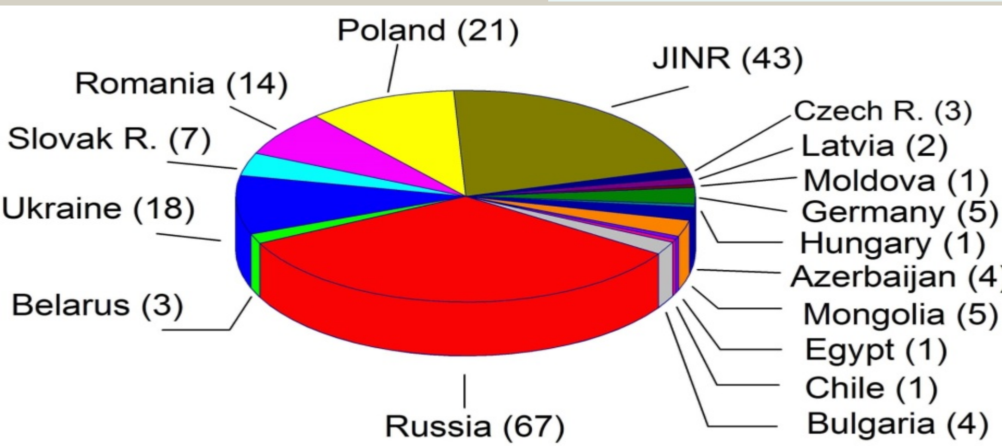


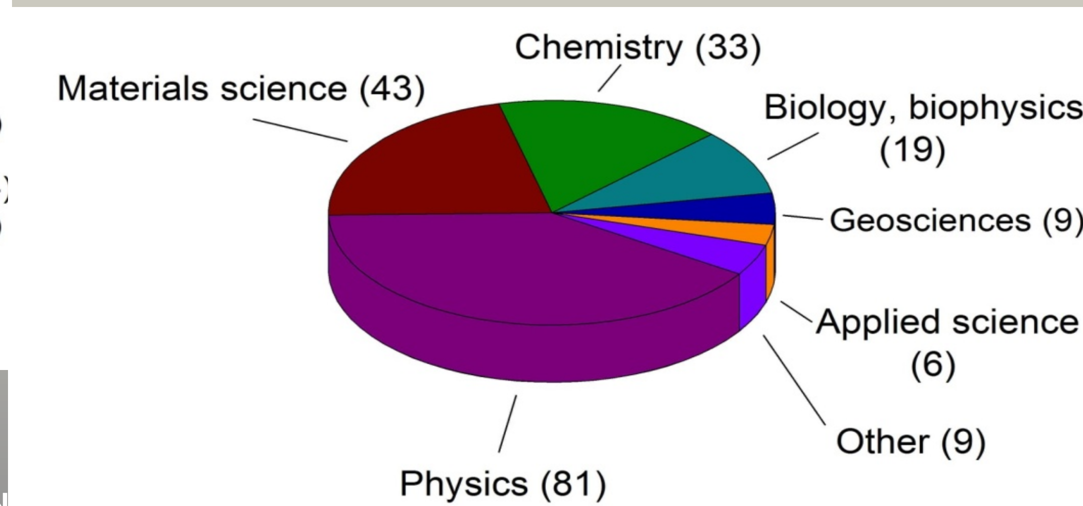


IBR-2

2578 hours for physical experiments, 12 cycles:
7 – water moderator, 6 – cryogenic moderator

- **195 proposals received for realization in 2013 during two calls**
- **70% accepted for realization according to recommendations of Expert Committees**
- **118 visits in the FLNP**





THEORETICAL PHYSICS @ JINR

Main fields of research

- ❑Theory of Elementary Particles and Fields
- ❑Nuclear Theory, Nuclear Structure and Dynamics
- ❑Theory of Condensed Matter and New Materials
- ❑Modern Mathematical Physics
- ❑Research and Education Project "Dubna International School of Theoretical Physics (DIAS-TH)"

Conferences and Schools

Every year (> 1000 participants)

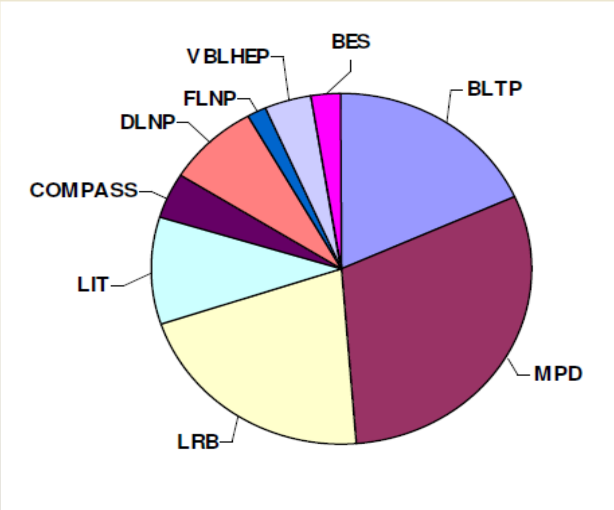
DIAS-TH and Helmholtz Schools (> 20 countries represented)

Educational Activity

Lectures courses at JINR UC, DIAS-TH, Moscow U., Dubna U., MPTI, etc.

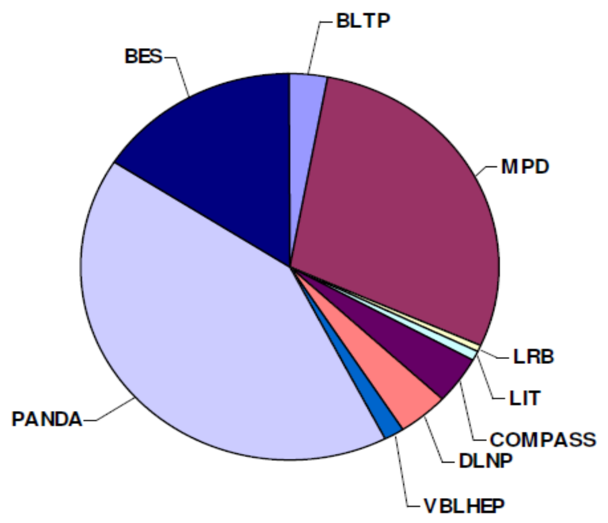
JINR Central Information and Computing Complex

Local users (no grid)



JINR CICC
Normalised CPU time share: JINR Laboratories and experiments in 2013.

Total CPU time -
4 580 752

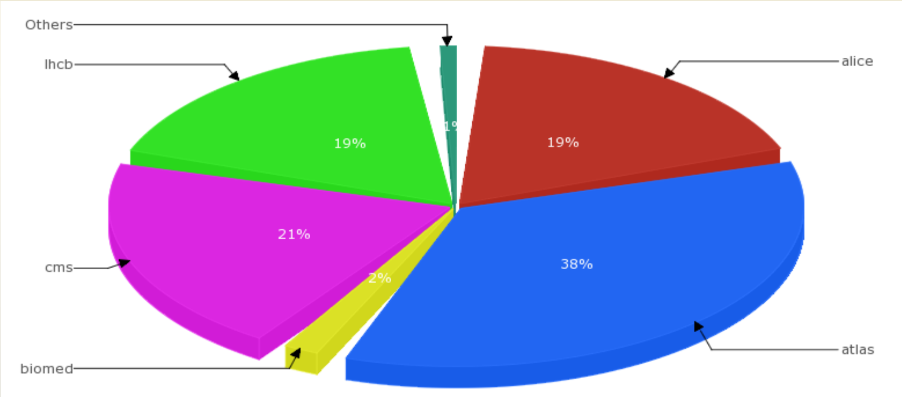


JINR CICC
Jobs executed for JINR Laboratories and experiments in 2013:

226 832

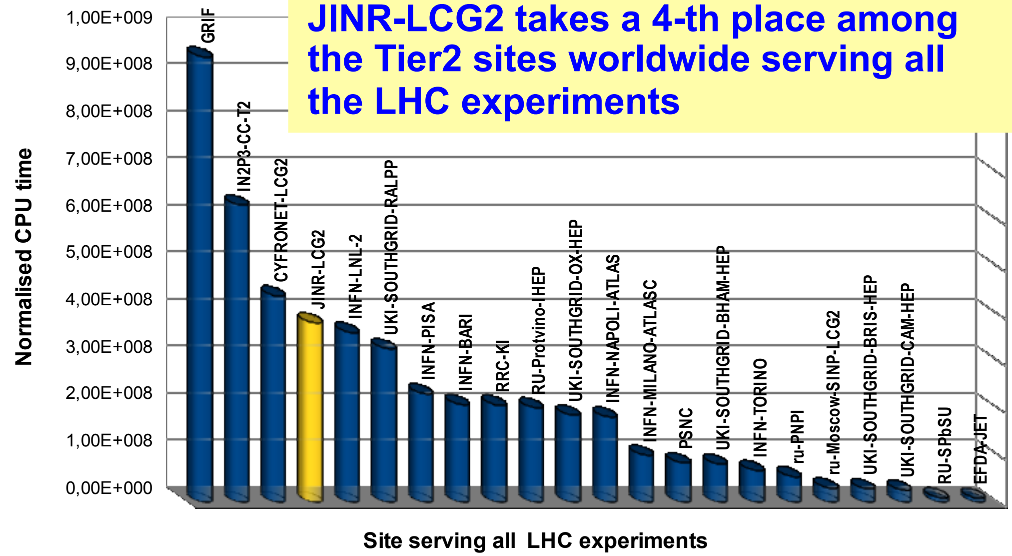
Grid users

JINR-LCG2 Normalised CPU time (2013)



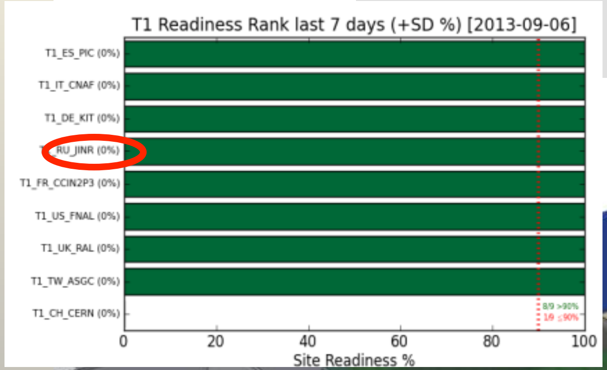
About 5 million jobs were executed

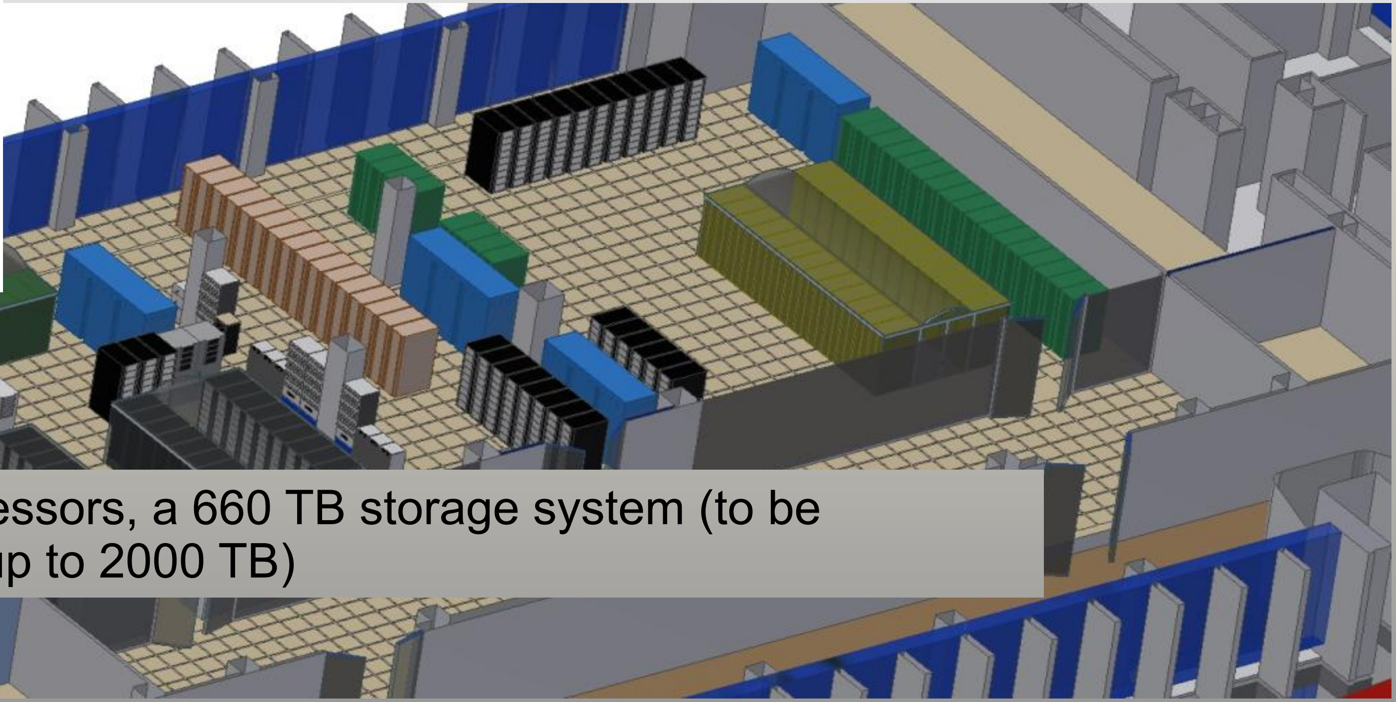
JINR-LCG2 takes a 4-th place among the Tier2 sites worldwide serving all the LHC experiments



CMS Tier-1 prototype

- Engineering infrastructure(uninterrupted power supply, climate-control);
- High-speed reliable network infrastructure with dedicated reserved data link to CERN (LHCOPN);
- Computing system and storage on the base of disk arrays and tape libraries of high capacity;
- Reliability and accessibility 100%





1200 64-bit processors, a 660 TB storage system (to be expanded soon up to 2000 TB)

JINR Educational Program

At the moment 354 graduate and 37 postgraduate students take part in various JINR educational programs. The JINR University Center keeps updating the training programs according to the goals of the JINR seven-year plan.

International Student Practice (ISP)

In total 129 students from 9 JINR Member States were participated during three stages of ISP-2013: ARE, Belarus, Bulgaria, Czech Republic, Poland, Romania, Slovakia, South Africa, Ukraine

JINR Summer Students Program (SSP)

http://students.jinr.ru/

New!

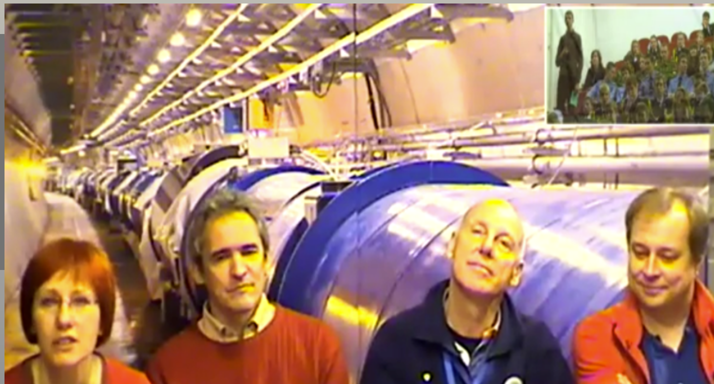
In 2014 JINR UC launches the Summer Student Program. Main distinction SSP from ISP is a selection of participants on a competitive basis. A special wed-site to coordinate this Program is already opened and we plan to start collecting applications for SSP-2014 by the mid of March.

JINR Outreach Activity

Programs at CERN and JINR started in November 2009 for the teachers from JINR Member States. Up to now 5 programs at CERN (193 participants) and 4 programs at JINR (176 participants)

New department "Development of the modern education programmes" was created at JINR University Center. One of the goals of this department is a creation of the educational programs to include current scientific data into the educational process, conduct virtual and online laboratory research based on information and communication technologies

UC continues organizing the video-conferences to promote achievements of modern science



Particle Physics (JINR outside)

JINR @ CERN, BNL, Fermilab, GSI/FAIR, KEK, China

Bright ex.: **DISCOVERY OF HIGGS–**
THE STANDARD MODEL TRIUMPH –HIGHEST ACHIEVEMENT OF MANKIND

JINR contribution: in **ATLAS** & **CMS** (experiments)

In theory:

- Transfer of spontaneous symmetry breaking phenomenon in condensed matter physics (N.N. Bogolyubov) to elementary particle physics.
- New quantum number of quarks (color) introduction.
- Renormalization principle in Quantum Field Theory.
- Renormalization group and "Asymptotic freedom" phenomenon.

Collaboration in Particle Physics
JINR @ CERN, BNL, Fermilab, GSI/FAIR, KEK, China

I. CERN (LHC): LHC development – consolidation of SC magnets;
CMS, ALICE and ATLAS – data taking & analysis;
upgrade of all 3 detectors – moderate ***additional resources***;

II. CERN (SPS):
COMPASS – finished 1st phase. Detector modification to measure GPD (DVCS) and polarized/unpolarized D-Y;
NA61 – neutrino and heavy-ion programs;
NA62 – measurement of extremely rare decays **($K^+ \to \pi^+ \nu\nu$)** ;
DIRAC – lifetime measurement of $\pi\pi$ and πK atoms completed at PS;
collaboration formed to continue at SPS;

III. BNL (RHIC):
STAR - energy scan HI program and physics with polarized beams
(important experience for future research at NICA)

IV. Fermilab: **NovA** neutrino program – in progress, Mu2e **($\mu \to e$)** – in discussion

V. GSI, FAIR (SIS-18/100/300): HADES – on the beam
CBM, PANDA – in preparation

VI. J-PARC & KEK: COMET **($\mu \to e$),** in progress

VII. China: Daya Bay Neutrino program new results in sin2Theta_13

CERN-JINR Partnership in Particle Physics

ICA-RU-0111

CO-OPERATION AGREEMENT

between

THE EUROPEAN ORGANIZATION
FOR NUCLEAR RESEARCH (CERN)

and

THE JOINT INSTITUTE FOR NUCLEAR
RESEARCH (JINR)

concerning

Scientific and Technical Co-operation
in High-Energy Physics

2010

Done at Geneva on 28 January 2010, in two copies in the English language.

For the European Organization for Nuclear Research (CERN) — Prof. Rolf-Dieter Heuer

For the Joint Institute for Nuclear Research (JINR) — Prof. Alexei N. Sissakian

28 January 2010, CERN
Signing of the Agreement between CERN and JINR

3.2 Possible projects at the date of this Agreement include:

- the commissioning and operation of the Large Hadron Collider ("LHC") at CERN, including the ALICE, ATLAS and CMS experiments using the LHC;
- upgrades of the Nuclotron and the construction, commissioning and operation of the NICA collider project at JINR, including the MPD and SPD experiments using NICA;
- upgrades of the LHC injector chain, including the Linac4, SPL and PS2 projects;

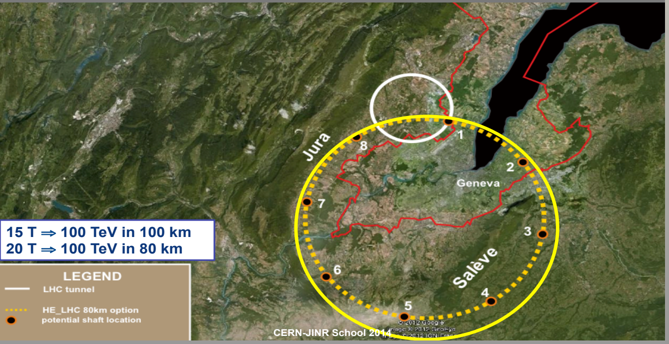
Strategy for Particle Physics

Future major facilities in Europe, Russia and elsewhere require collaboration on a global scale.

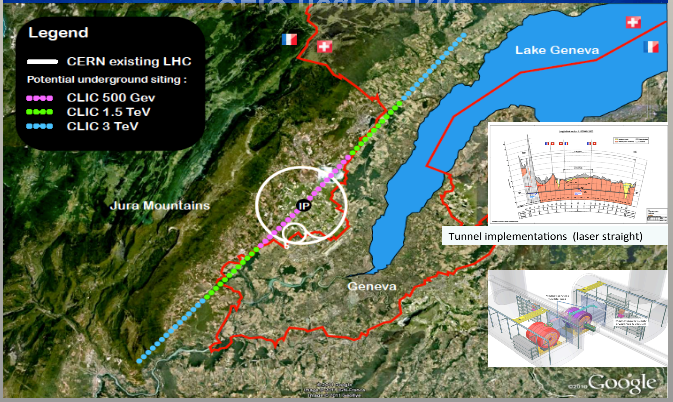
***CERN & JINR** combine the framework within which to organize a global particle & heavy ion physics accelerator projects in Europe & Russia, and should also be the <u>leading partners in global particle & heavy ion physics accelerator projects elsewhere.</u> Possible additional contributions to such projects from CERN's & JINR's Member and Associate Member States should be coordinated with CERN & JINR.*

Strategy comprises **high priority items**
for large-scale scientific activities which could/should
be organised as international projects

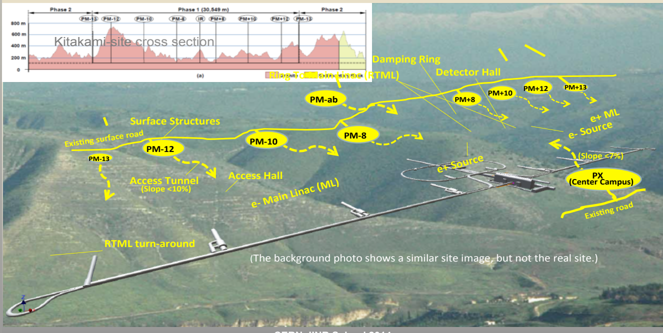
FHC: 80-100 km tunnel infrastructure in Geneva area – design driven by pp-collider requirements
with possibility of e+-e- (TLEP) and p-e (VLHeC)



CLIC near CERN



International Linear Collider (ILC): Site Specific Design
JAPAN



CERN-JINR School 2014

Summary: JINR World-Wide Collaboration

To realise our ambitious scientific plans based on the **home** and out of JINR large scale facilities and to fully exploit their excellent physics capabilities we suggest

- coherent and strong efforts of JINR member-states in all regions;

- long term stability and support in all regions;

- careful adjustment of schedules for these facilities

Global Partnership
with
long-term support

THANK YOU!