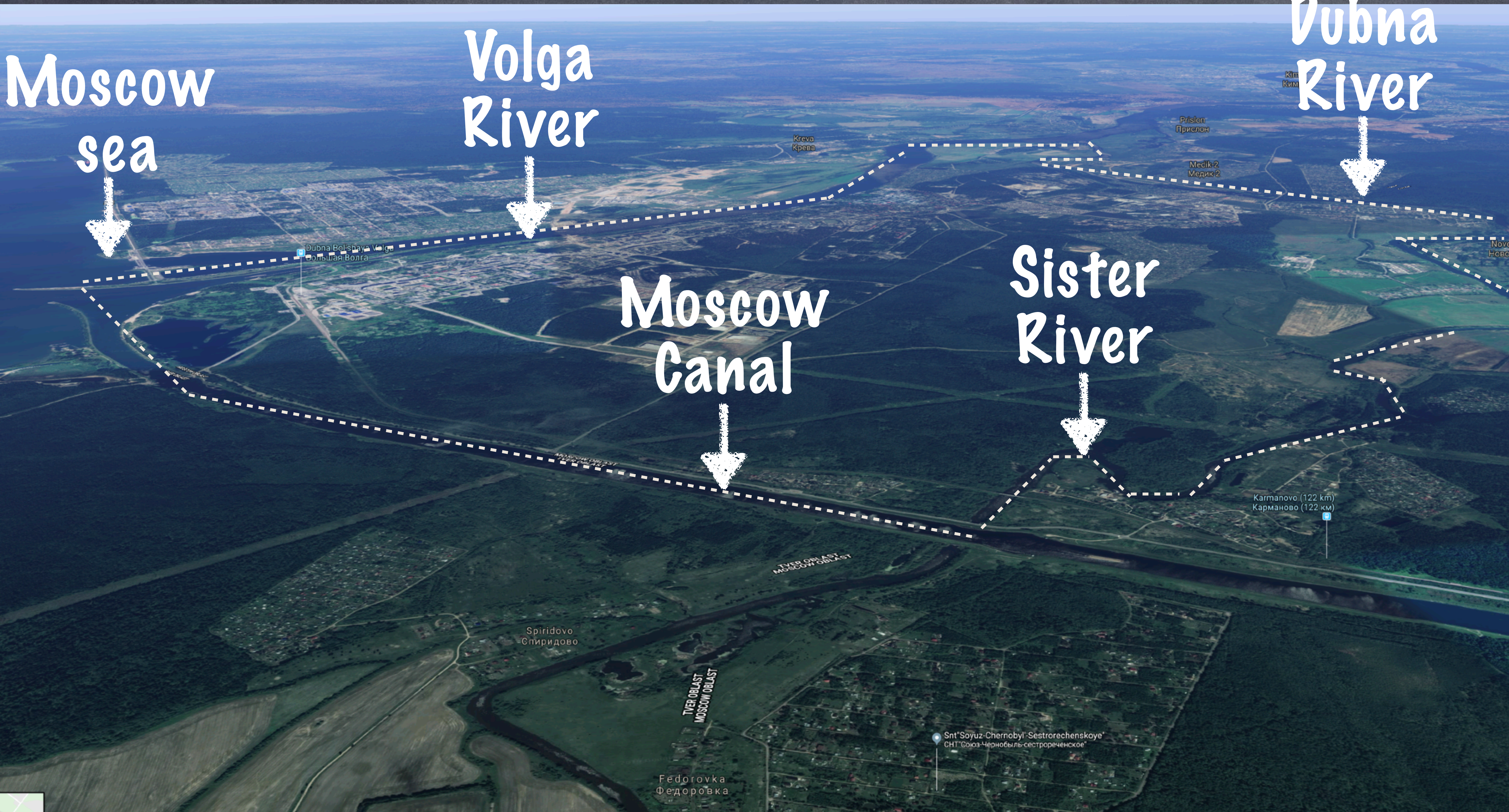
Joint Institute for Nuclear Research

Baksan School on AstroParticle Physics
April 17, 2019

Dmitry V.Naumov

Dubna



A magic island

Dubna. JINR. DLNP Campus

Dubna. JINR. VBLHE Campus

JINR

- New elements 102, {103, 104, 105(Db), 107}, 114, 115, 116, 117, 118
- Hypothesis of neutrino oscillations (1957). {NP: 2015}
- Discovery of new particle: anti-sigma-minus hyperon
- And many other discoveries

JINR

- Employed ~ 5000: 1200 - scientists, 2000 - engineers
- 7 labs. Each as a big institute
- 18 countries member-states and 6 associated
- 1500 science papers/year
- Collaboration with 800 scientific centers in 64 countries
- 1, 5 billions USD. Budget for 2017-2023

- Laboratory of high energy physics
- Laboratory of nuclear problems
- Laboratory of nuclear reactions
- Laboratory of neutron physics
- Laboratory of information technologies
- Laboratory of theoretical physics
- Laboratory of radiation biology

JINR

Short History

History

- May, 7 1946. First discussion of «construction of a power cyclotron» at special committee of the government
- 18 August 1946. Soviet government approved the proposal of Academician Igor Kurchatov to construct in USSR „the installation M" for fundamental studies in nuclear physics.
- 14 December 1949. The 480 MeV proton synchrocyclotron started operation at the Hydrotechnical Laboratory in Dubna, the most powerful accelerator in the world at that time.
- Electrophysical lab lead by Veksler worked on proton accelerator with 10 GeV energy
- 26 March 1956. On the basis of two labs JINR founded.

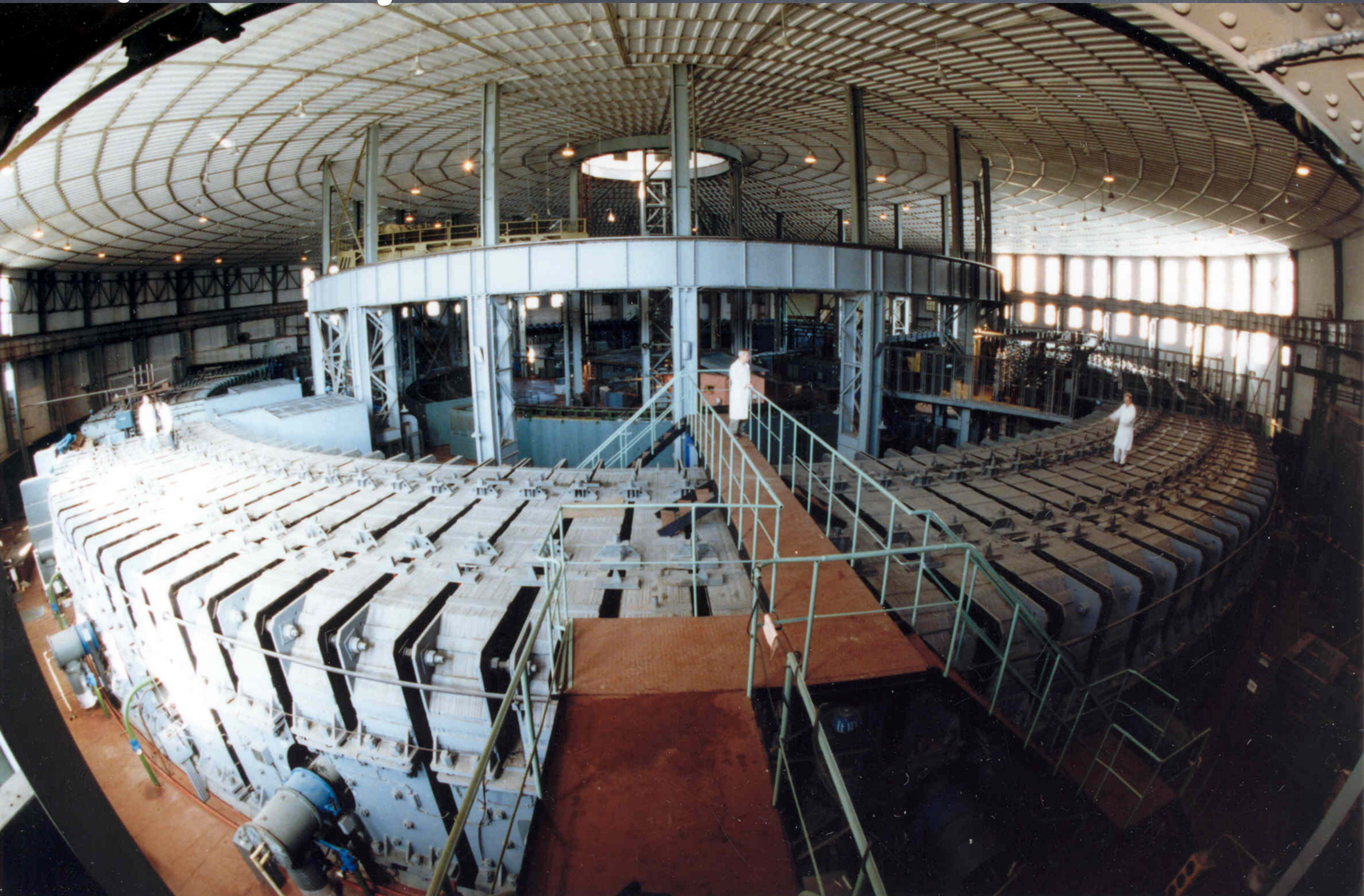
Synchrocyclotron of DLNP JINR

Synchrocyclotron. 680 MeV (1953)

M.G.Mecheriakov

Synchrophasotron. VBLHEP JINR

Synchrophasotron. VBLHEP JINR



Two facts

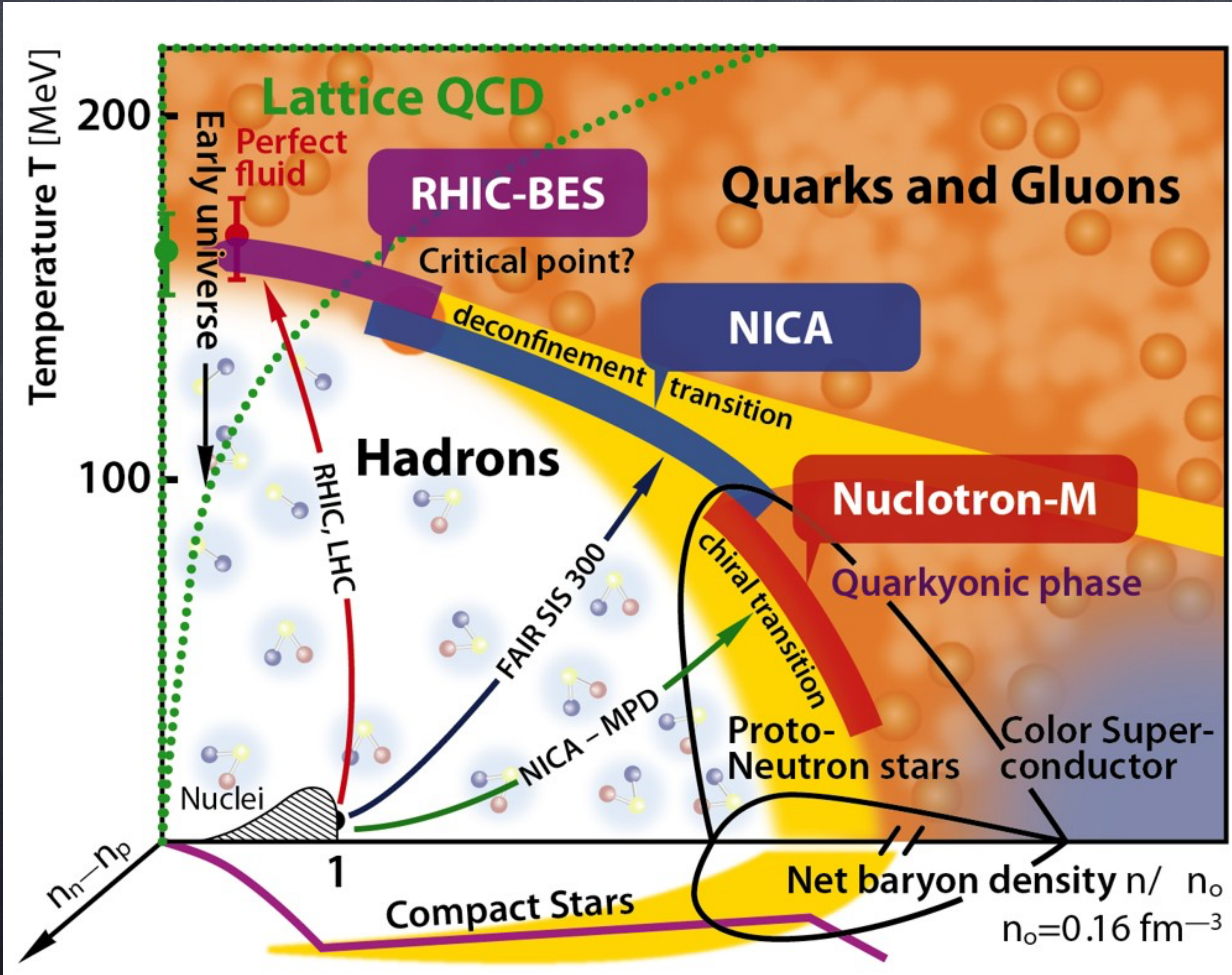
- Half of discoveries in nuclear physics belongs to JINR (37)
- 15 belongs to DLNP JINR

VBLHEP

Veksler and Baldin Laboratory of High Energy Physics

http://lhe.jinr.ru/index_rus.html

NICA - Nuclotron-based Ion Collider fAcility
Flagship project of VBLHEP and JINR
Mega-Science project of Russia



Temperature T [MeV]
200
100
Lattice QCD
Perfect fluid
Early universe
RHIC-BES
Critical point?
Quarks and Gluons
NICA
deconfinement
transition
Hadrons
RHIC, LHC
FAIR SIS 300
NICA – MPD
Nuclotron-M
chiral transition
Quarkyonic phase
Proto-
Neutron stars
Color Super-
conductor
Nuclei
1
$n_n - n_p$
Compact Stars
Net baryon density n/ n_o
n_o=0.16 fm^{-3}

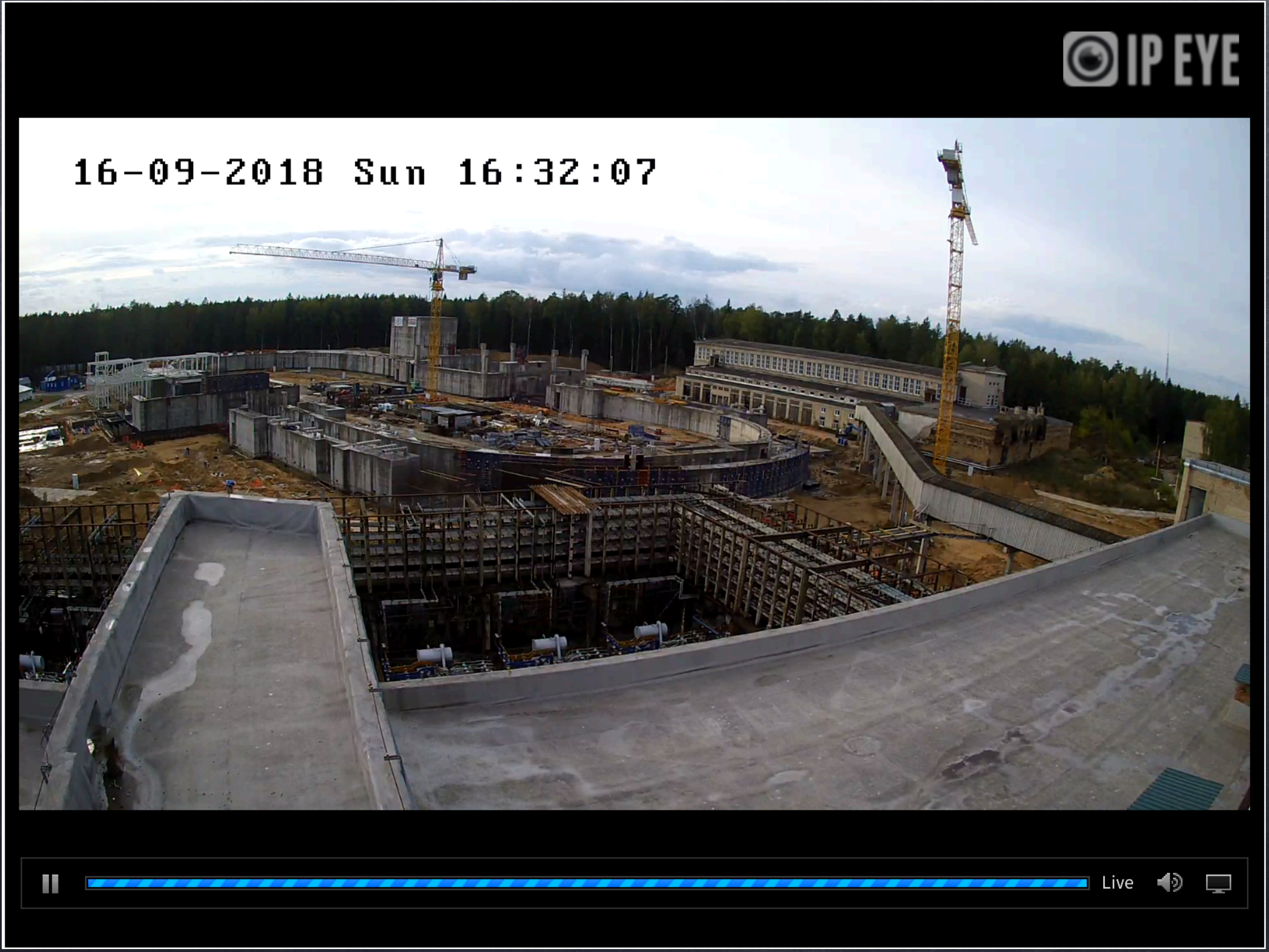
Observables

Sensitive to phase transitions

- Particle's yields and spectra
- Event-by-event fluctuations of multiplicity and pT
- Restoration of chiral symmetry -> modification of hadronic spectral functions
- Strangeness production enhancement

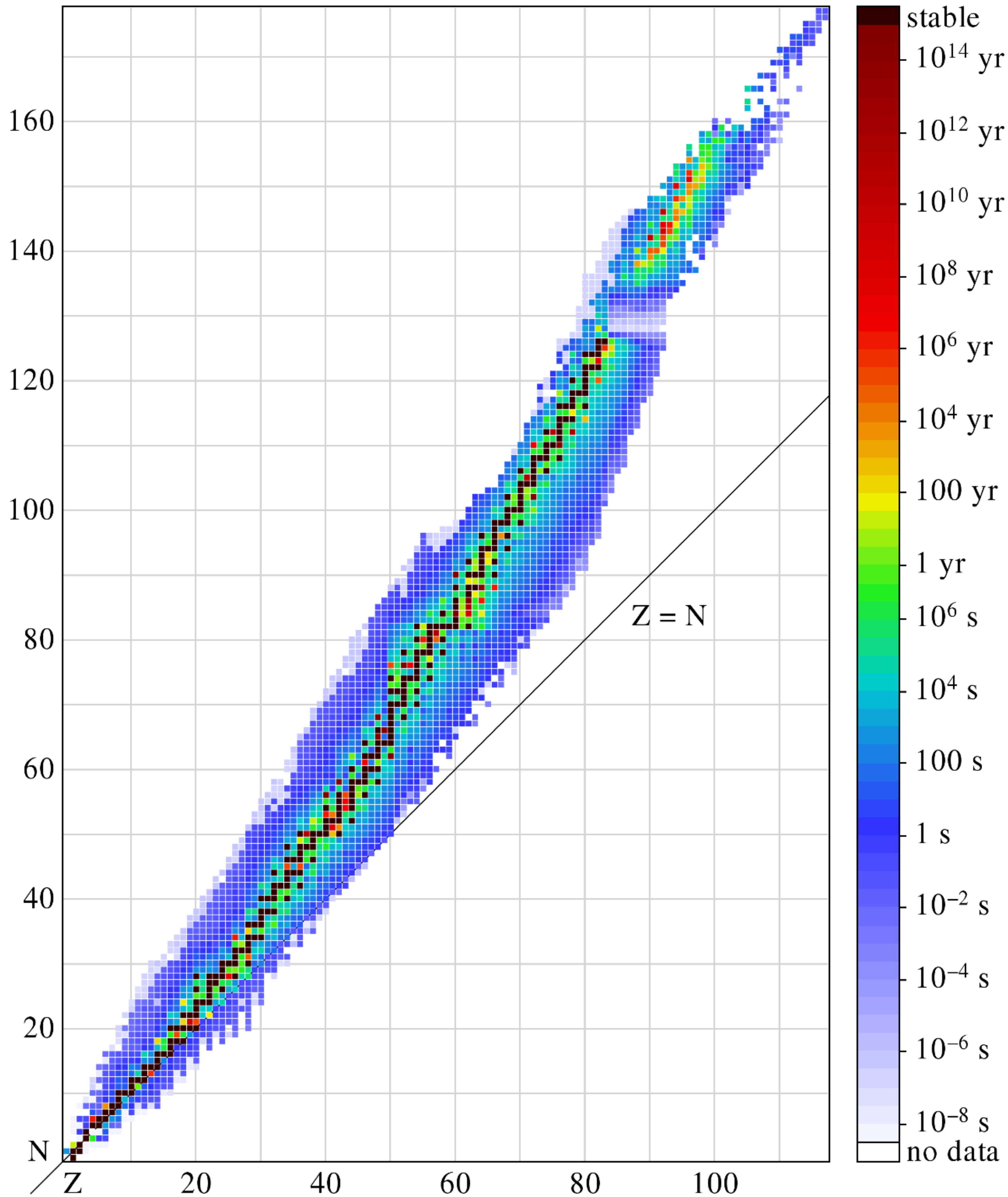
Строительство коллайдера NICA

http://nucloweb.jinr.ru/nucloserv/205corp.htm

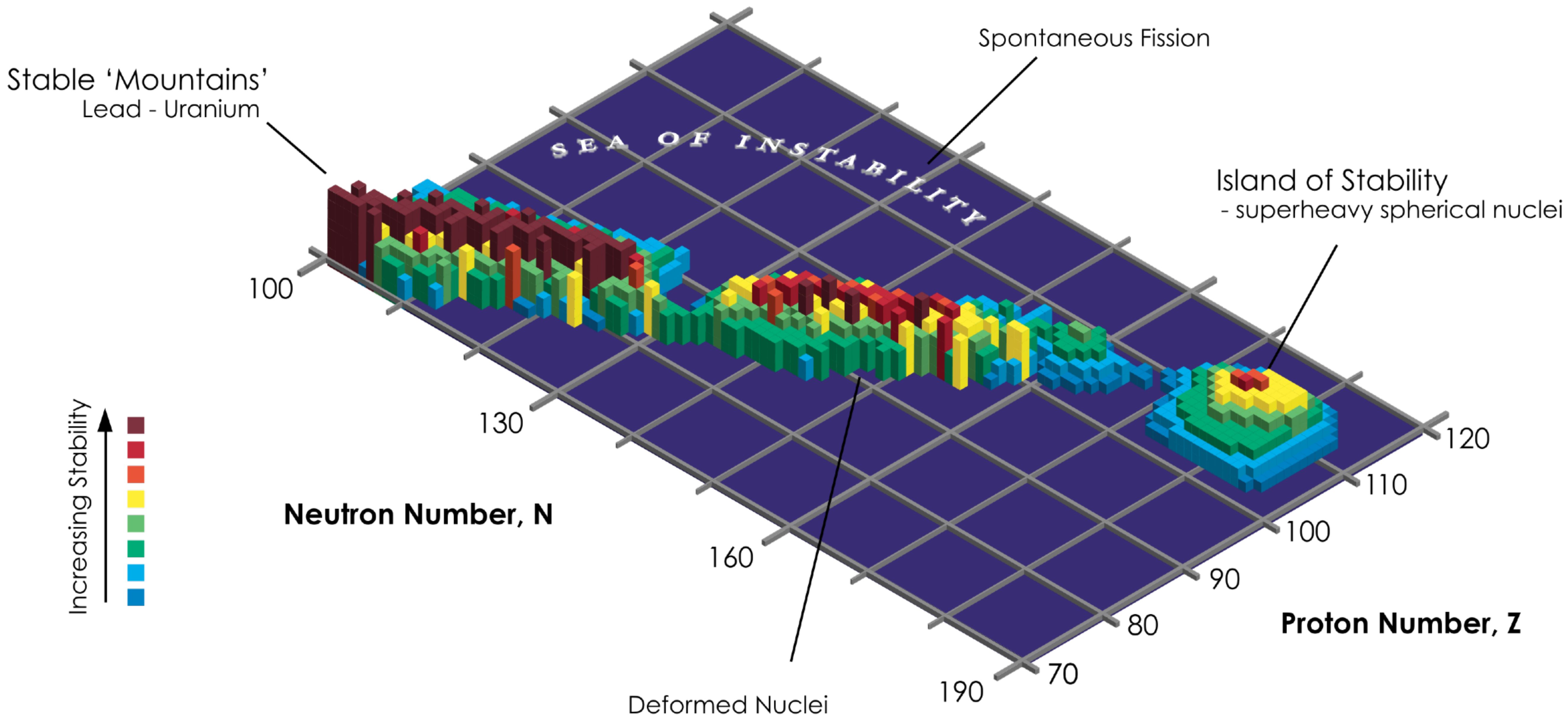


FLNR

Flerov Laboratory of Nuclear Reactions



- Nuclei become less stable with increasing Z and N
- Shell model —> new stability island with Z=114 and N=184



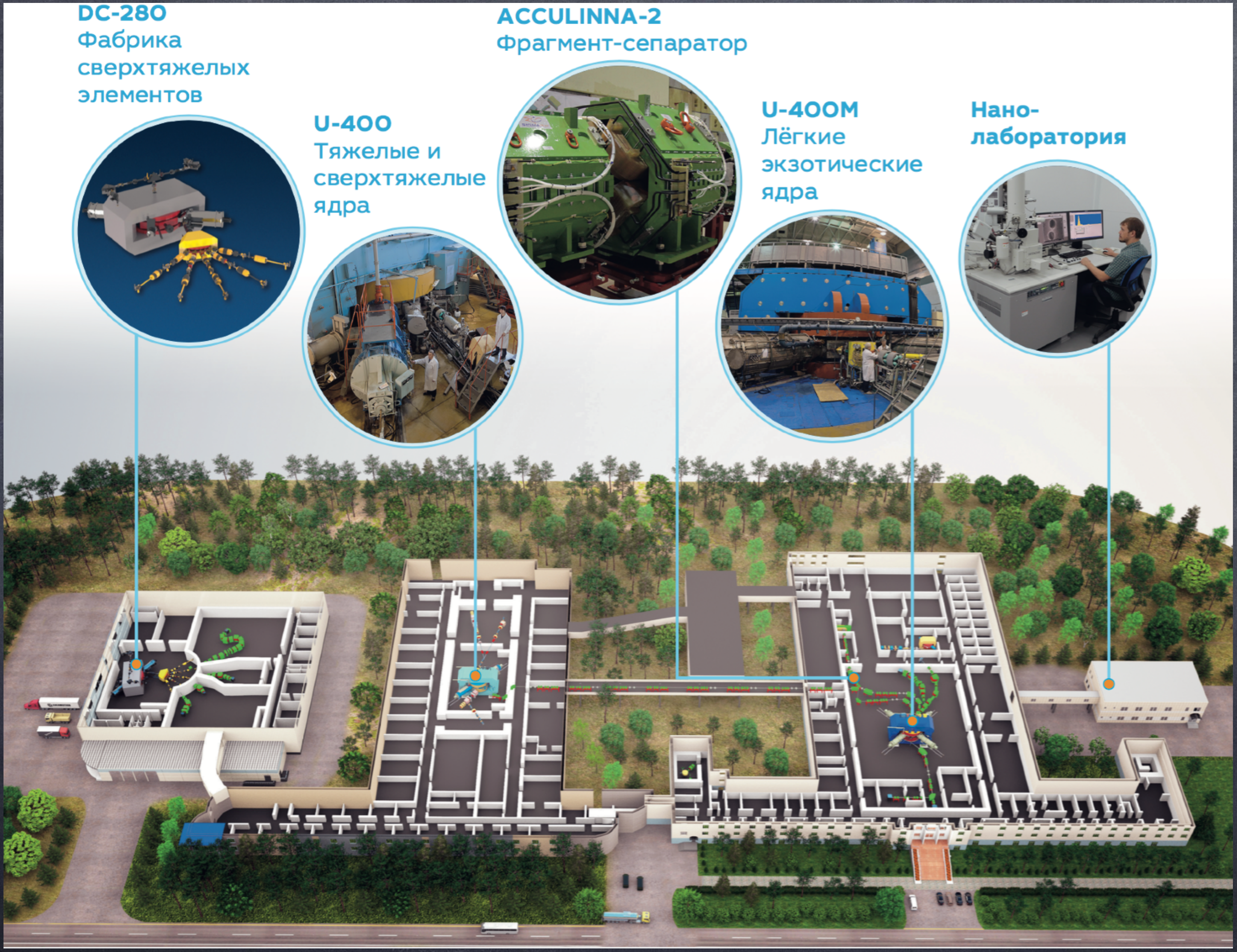
Stable 'Mountains'
Lead - Uranium
Spontaneous Fission
SEA OF INSTABILITY
Island of Stability
- superheavy spherical nuclei
100
130
160
190
Neutron Number, N
Increasing Stability
120
110
100
90
80
70
Proton Number, Z
Deformed Nuclei

Elements synthesized in Dubna

Z=114

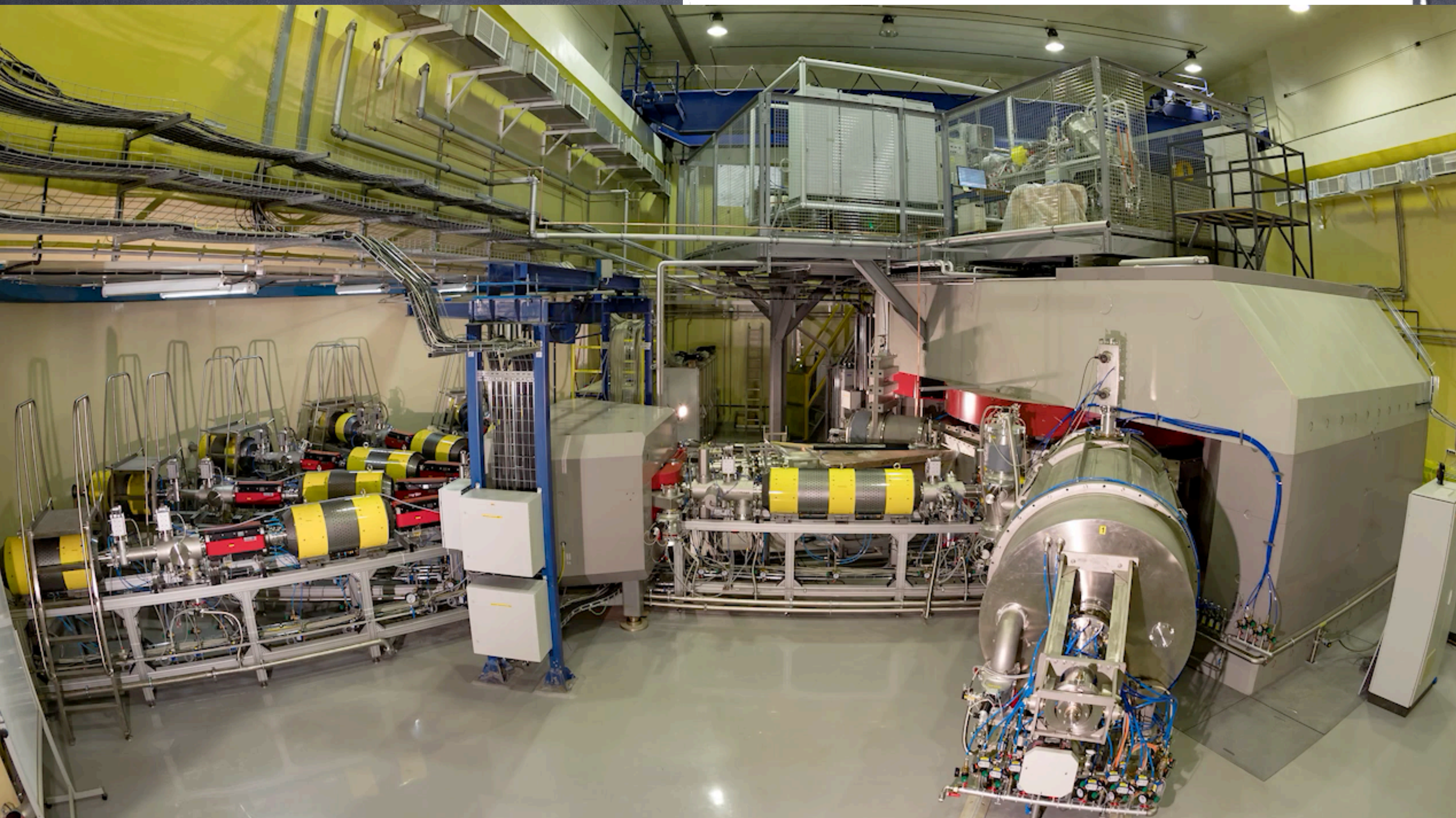
- The exact location of stability is not yet found
- The trend of increasing stability with N—> 184 is observed

SHE: Super-Heavy Elements factory



Кому Ruthenium. Moscovoium. Dubnium. Oganesson

Куда



FLNP

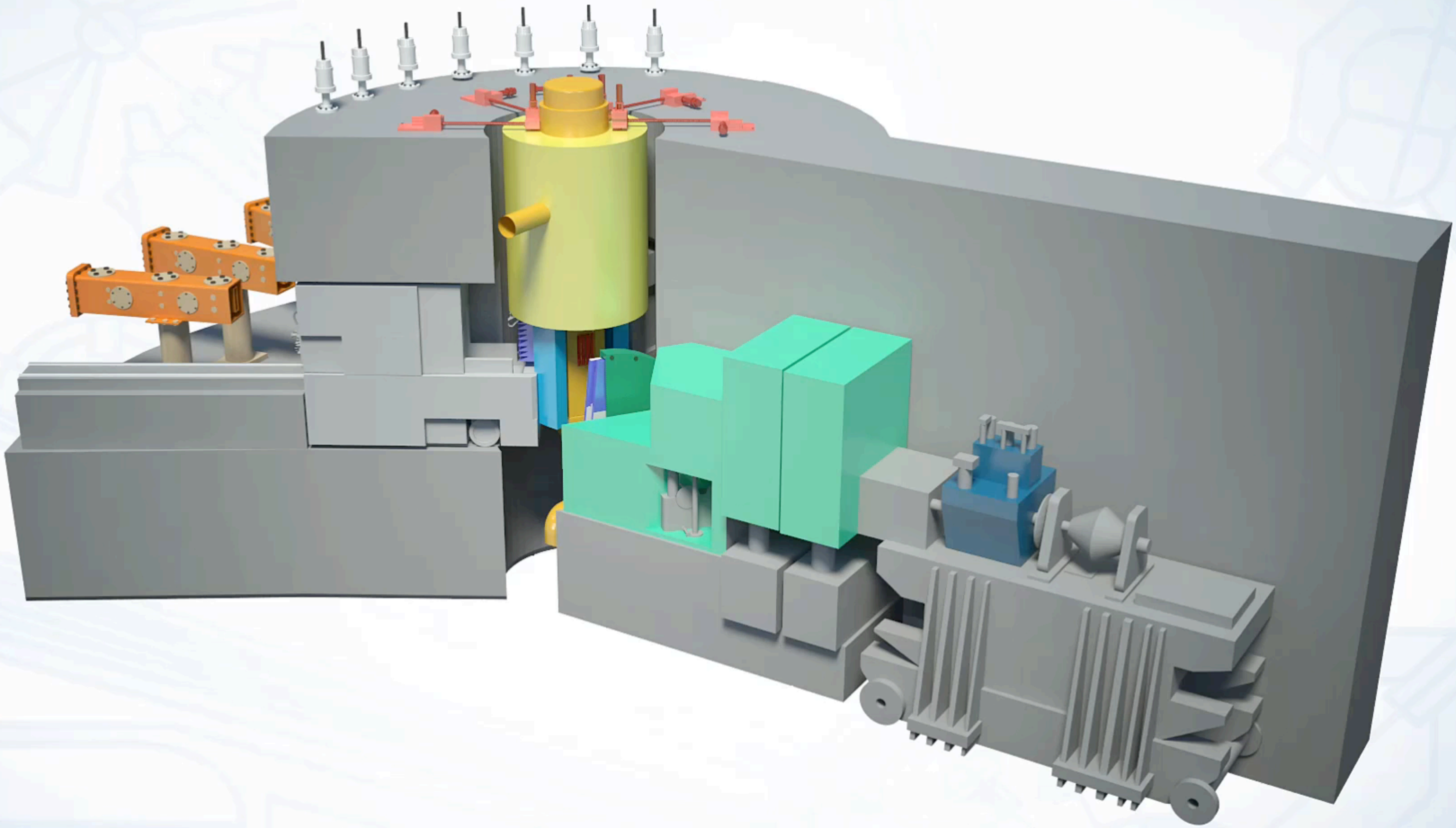
Frank Laboratory of Neutron Physics

http://flnph.jinr.ru/en/

Impulse fast reactor (IBR)

- End of 1955. Idea by D.I Blokhintsev during a seminar in Obninsk
- Mid of 1956. D.I. Blokhintsev was suggested to head JINR. His condition was — build IBR
- November 1960. I.M. Frank reported first results from newly constructed IBR.
- ...
- 2010. Upgraded IBR-2

IBR-2



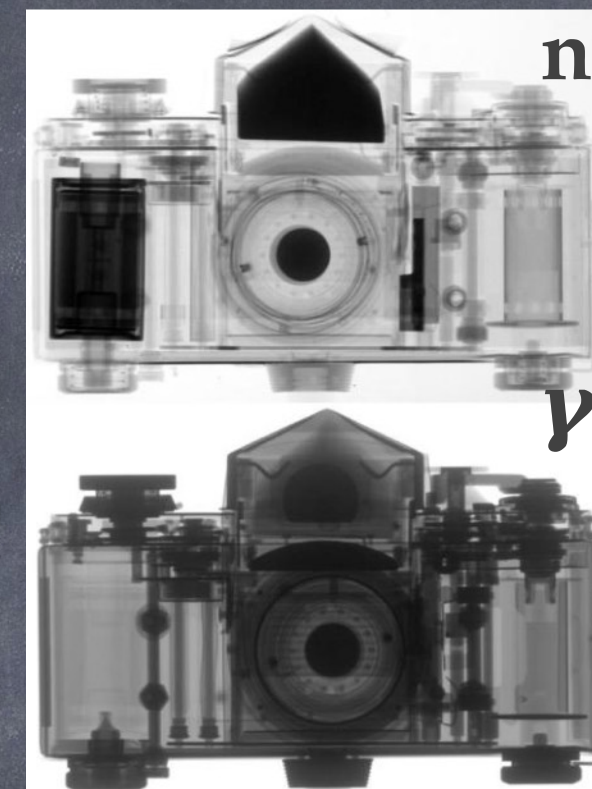
R&D for new most powerful neutron source

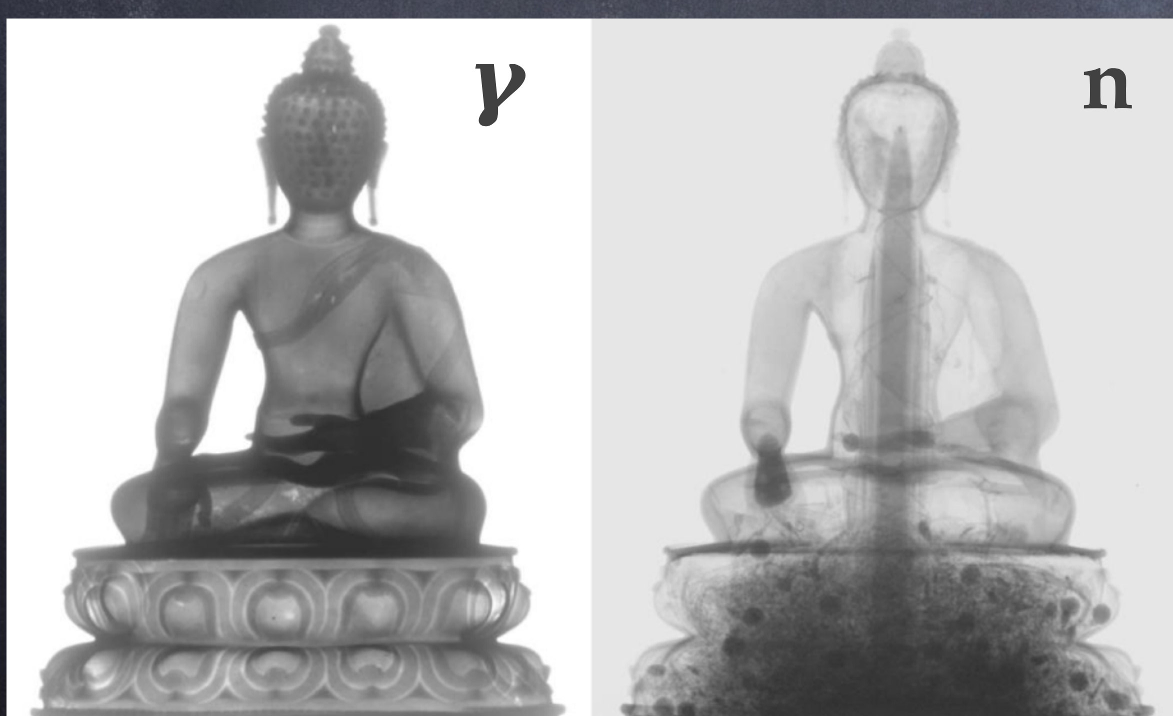
Wide research program

- Study neutron
- Study structure and dynamics of condensed matter
  - Crystals, nanosystems
  - Complex liquids, polymers, rock
  - Molecular biology and pharmacology
- Applied research

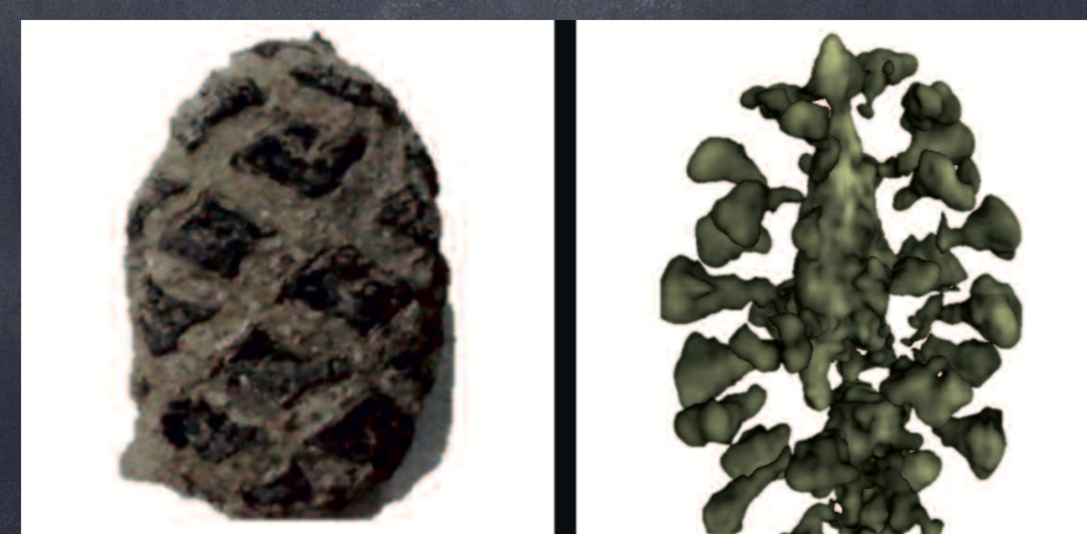
Neutron radiography

- Organic structure is better seen with help of neutrons
- Gamma is sensitive to density only



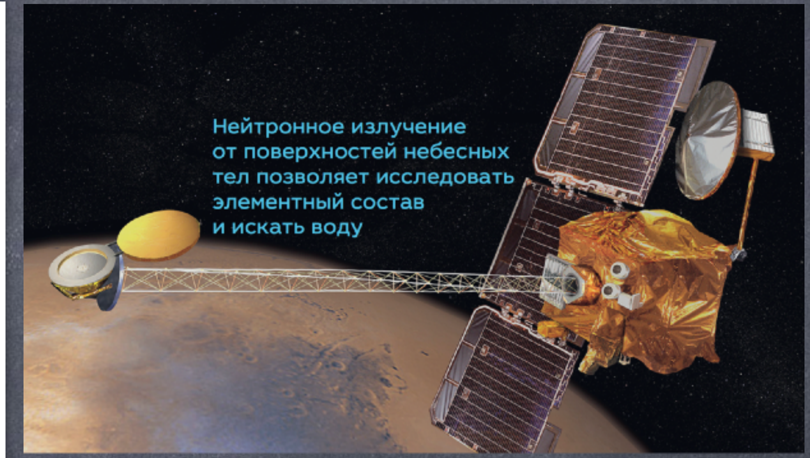


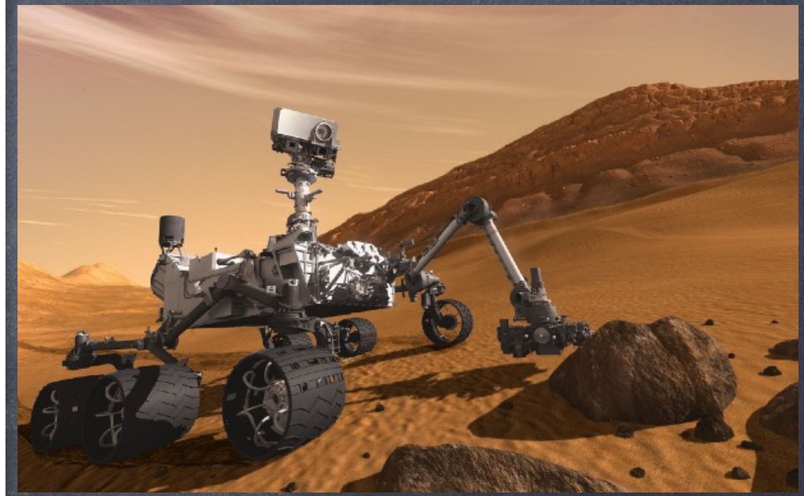
Effective for paleonthology

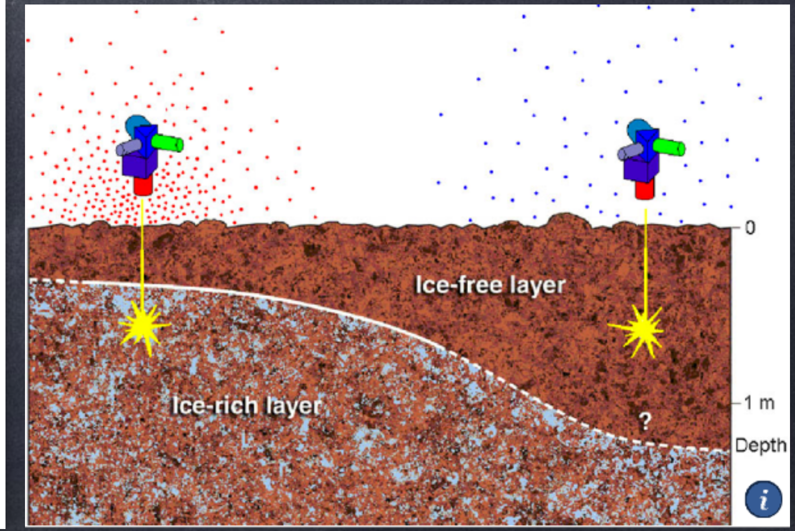


Search for water on Mars

- Mars Odyssey 2001 is on Mars orbit from 2002.
- Neutron detector HEND (with help of JINR) is onboard .
- Source and detector of neutrons DAN (JINR) is onboard of Mars rover «Curiosity Rover»







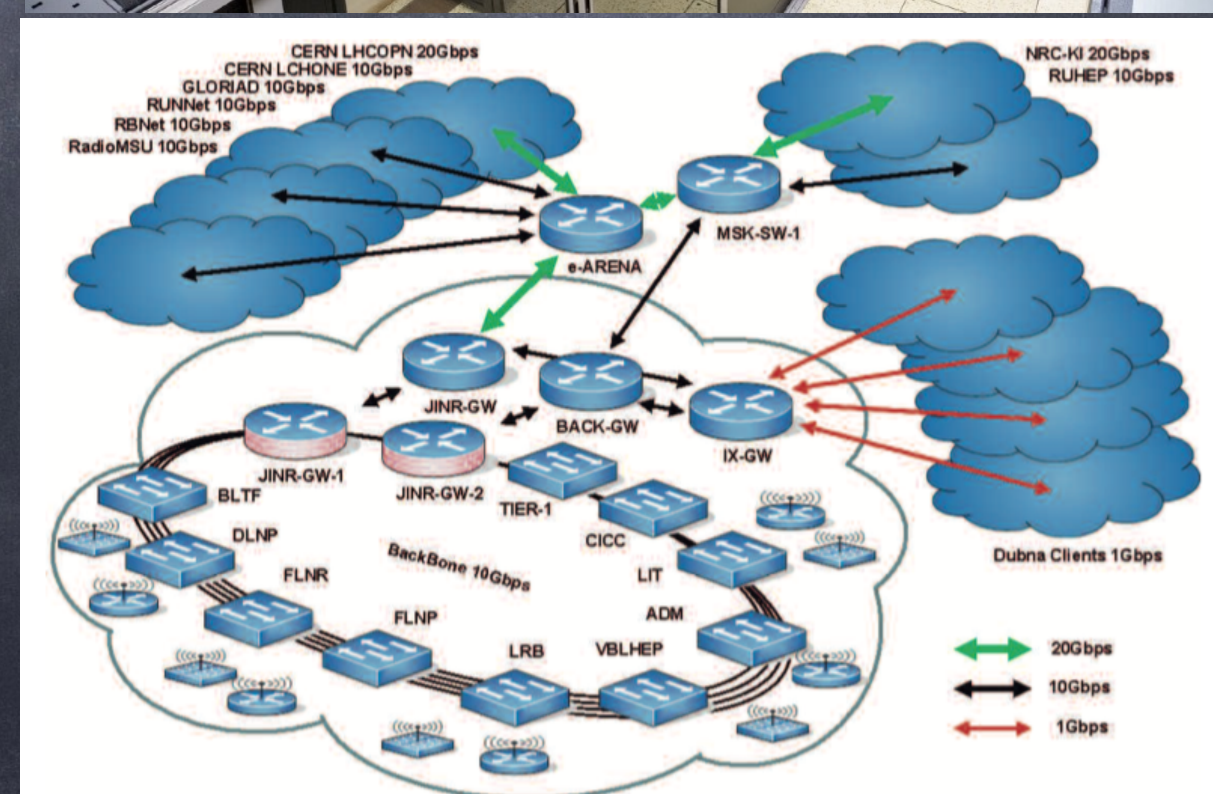
LIT

Laboratory of information technologies

http://lit.jinr.ru

Computing cluster

- Included in computing network GRID
- Used by leading centers: CERN, IHEP, Fermilab...
- More than 6000 CPU units
- Heterogeneous cluster (GPU)
- 4.2 petabytes of disk space
- 5 petabytes on robotic tapes
- Support 24/7



BLTP

Bogoliubov Laboratory of Theoretical Physics

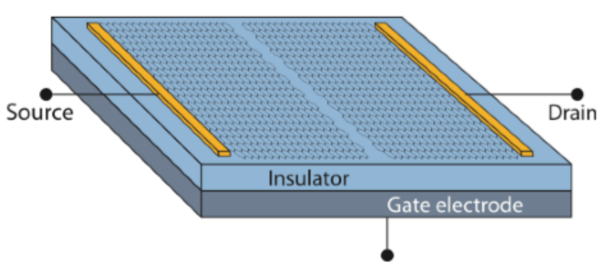
http://theor.jinr.ru/lab_rus.shtml

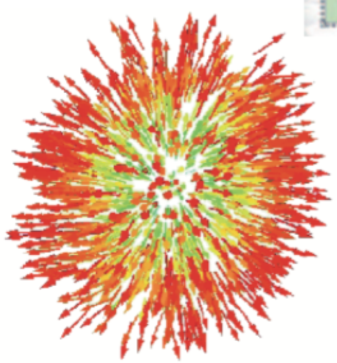
Theoretical studies

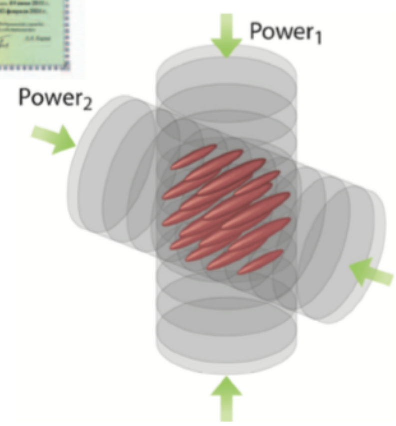
- The largest theory lab
- Theory support of experiments : NICA, SHE, neutrino physics, etc.
- Collaboration with: CER, DESY, KEK, Fermilab and many others
- Fellows from 20 countries, 1/3 are young fellows
- Research in:
    - Condense matter
    - Fundamental interactions
    - Elementary particles
    - Nuclear physics
    - Modern math physics

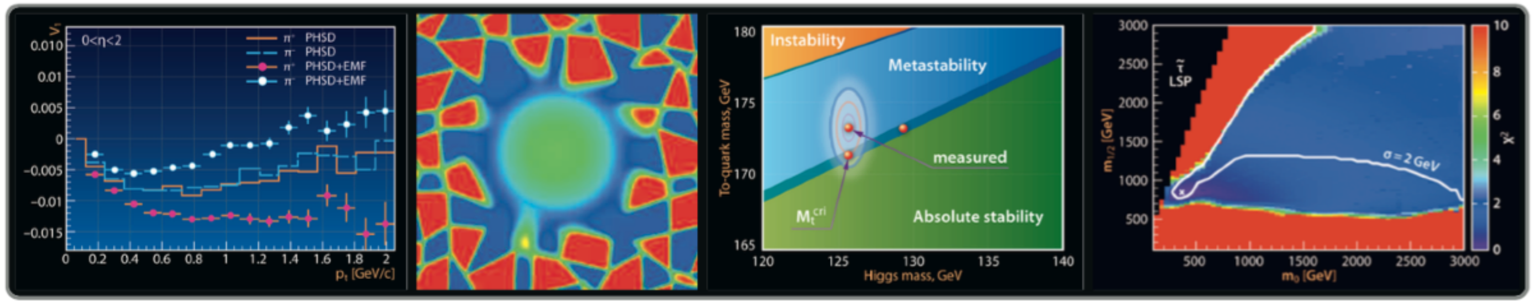
BLTP Publications (2012–2016)

Year	2012	2013	2014	2015	2016	Total
Journal Publications	382	363	364	356	370	1835
Conference Proceedings	97	122	131	142	165	657
Total	479	485	495	498	535	2492









LRB

Laboratory of Radiation Biology

http://lrb.jinr.ru/new/olab/olab_en.shtml

DLNP

Dzhelepov Laboratory of Nuclear Problems

http://dlnp.jinr.ru

Structure of DLNP

- Particle Physics
- Accelerator Technologies
- Neutrino Physics & Astrophysics
- Radiation Medicine, Genetics, Molecular Genetics
- Radiochemistry & Nuclear Spectroscopy
- IT, design office, workshop, services, etc
- Education & Outreach

- about 650 employees
- among them about 500 scientific staff

SCEINCE & TECHNOLOGIES

Particle Physics

- ATLAS
- Mu2e, g-2
- COMET
- BES-III
- PANDA

Neutrino Physics & Astrophysics

- BAIKAL GVD
- Daya Bay/JUNO
- NOVA
- BOREXINO
- DANSS
- GERDA
- GEMMA/νGEN
- SuperNEMO
- TUS/Nucleon/TAIGA
- EDELWEISS

Technologies

- Precise Laser Metrology
- New semiconductor detectors
- Ultra cold temperatures

Underlined astrophysical experiments

SCEINCE & TECHNOLOGIES

Medicine & Molecular Genetics

- Proton Therapy
- Medical-biological studies
- Radiation genetics

Education & Outreach

- Schools, conference, seminars
- Web-site of DLNP, social networks
- Lecturing at MSU, MIPT, «Dubna» University and others

Bruno Pontecorvo worked in JINR (1950-1993) establishing a School of Neutrino Physics

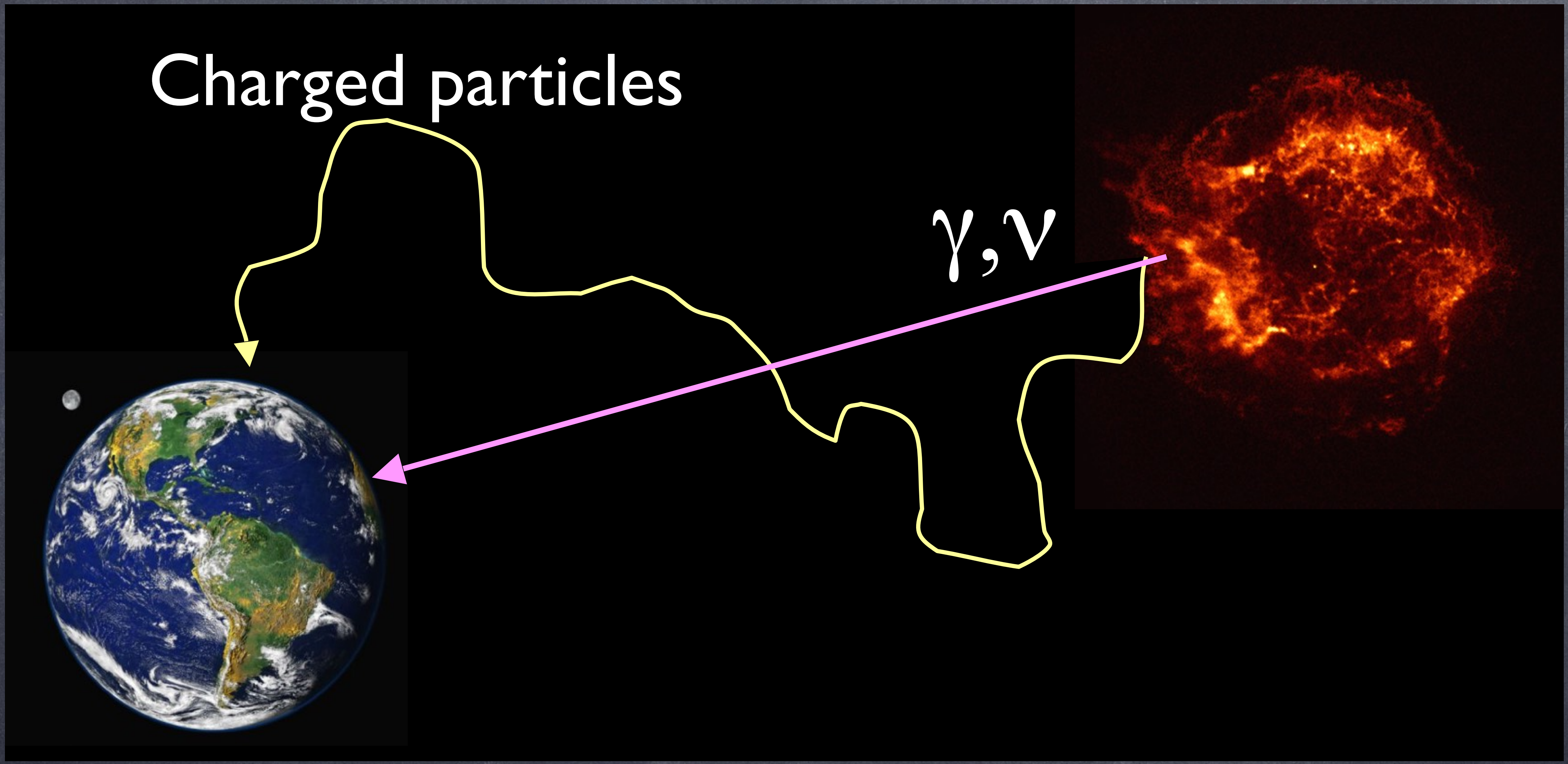
Main objective:

Astrophysical Catastrophes in the Universe

- Sources of ultra-high energy particles

- We are made of star dust
- Modern stars are already of the third generation

Why Neutrino?



- Charged particles loose direction and energy
- Photons get absorbed
- Neutrino astronomy is possible because of weak interaction neutrino

There is no sunrise and sunset with neutrinos

https://www.youtube.com/watch?v=mu7IYTXP-hI

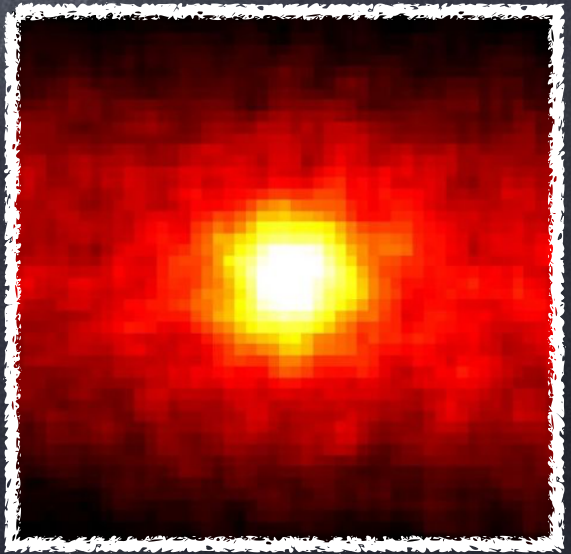


Image of Sun with Neutrinos by SuperKamiokande

Credit: R.Svoboda, K.Gordan (LSU)

Short History of Neutrino Telescopes

M.A. Markov. 1960

«We propose to install detectors deep in a lake or in the sea and determine the direction of charged particles with the help of Cherenkov radiation».
ICHEP, Rochester. p578

Short History of Neutrino Telescopes

1960 - M.Markov - main idea.

1976 - Discussions of DUMAND project

1980 - Start of works on construction of BAIKAL Detector lead by G.V.Domogatsky

1993 - NT-36 (36 OM) @BAIKAL

1996 - NT-96 (96 OM)

1997 - AMANDA B10 (302 OM) @SouthPole

1998 - NT-200 (192 OM)

2000 - AMANDA II (677 OM)

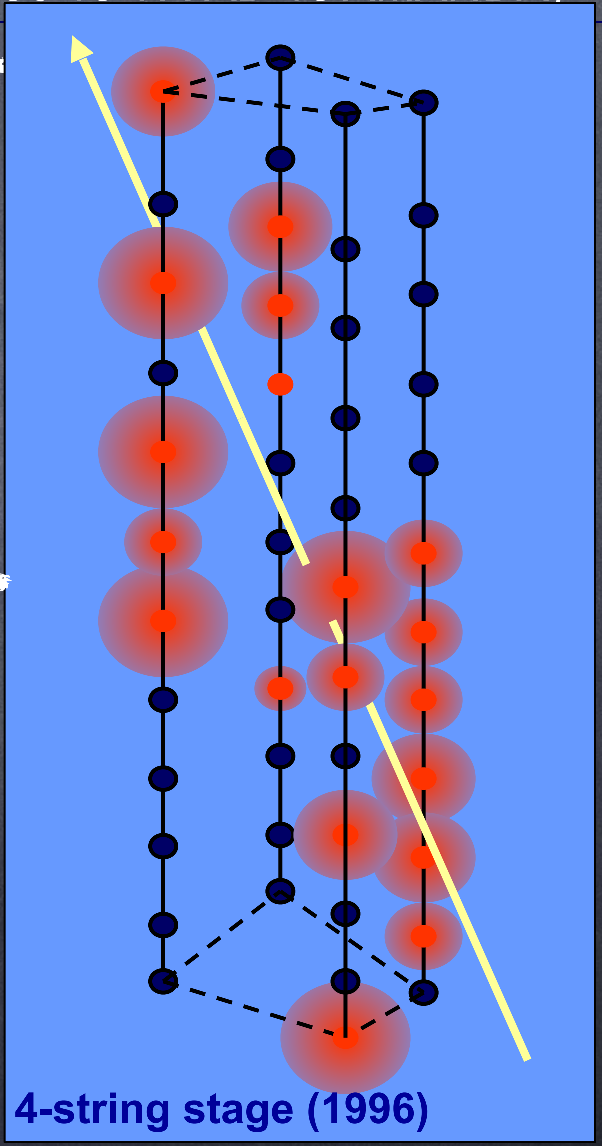
2005 - NT-200+ (228 OM)

2005 - IceCube (first string)

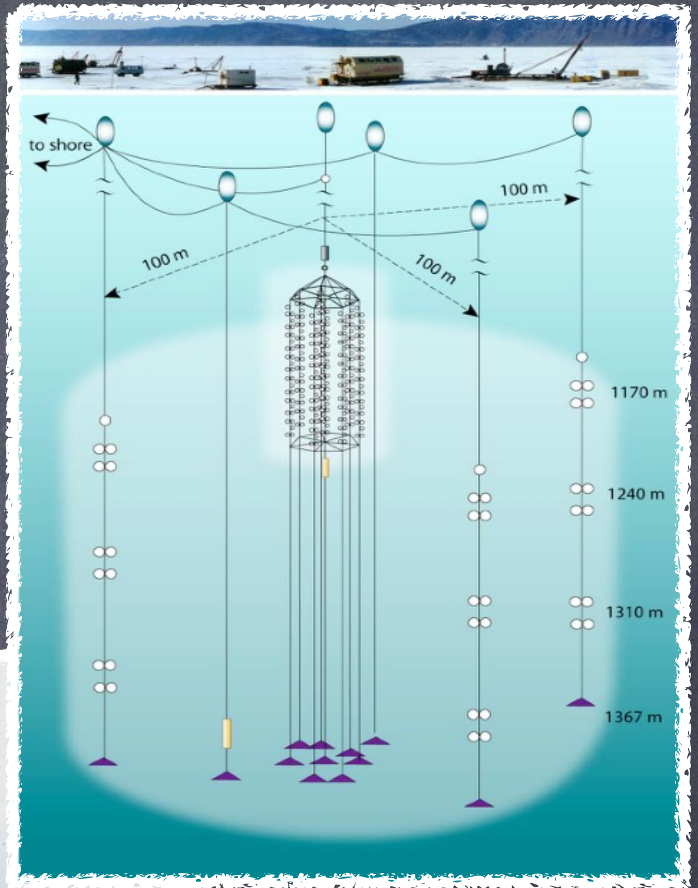
2010 - IceCube (last string)

2015 - BAIKAL GVD («Dubna» cluster)

J. Learned to C.Spiering:
„Congratulations for winning the 3-string race!“
(NT-36 vs TRIAD vs AMANDA)



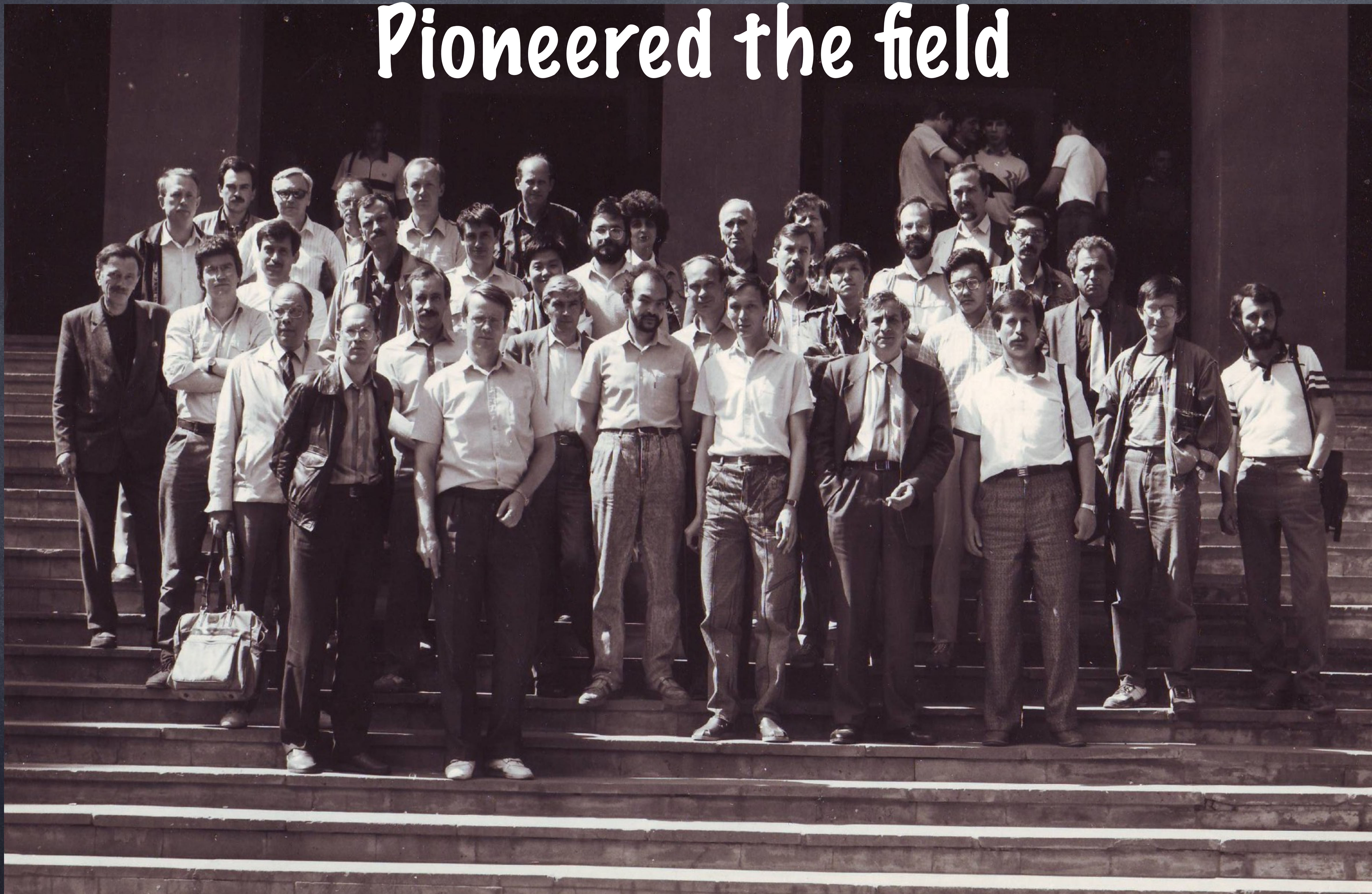
BAIKAL Neutrino Telescope Pioneered the field

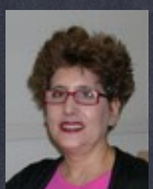
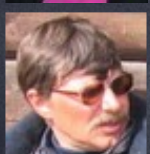


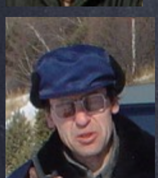
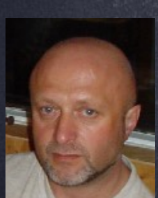
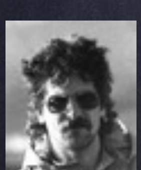
BAIKAL Neutrino Telescope
Pioneered the field

DESY was a major collaborator in BAIKAL in 90's

BAIKAL Neutrino Telescope
Pioneered the field



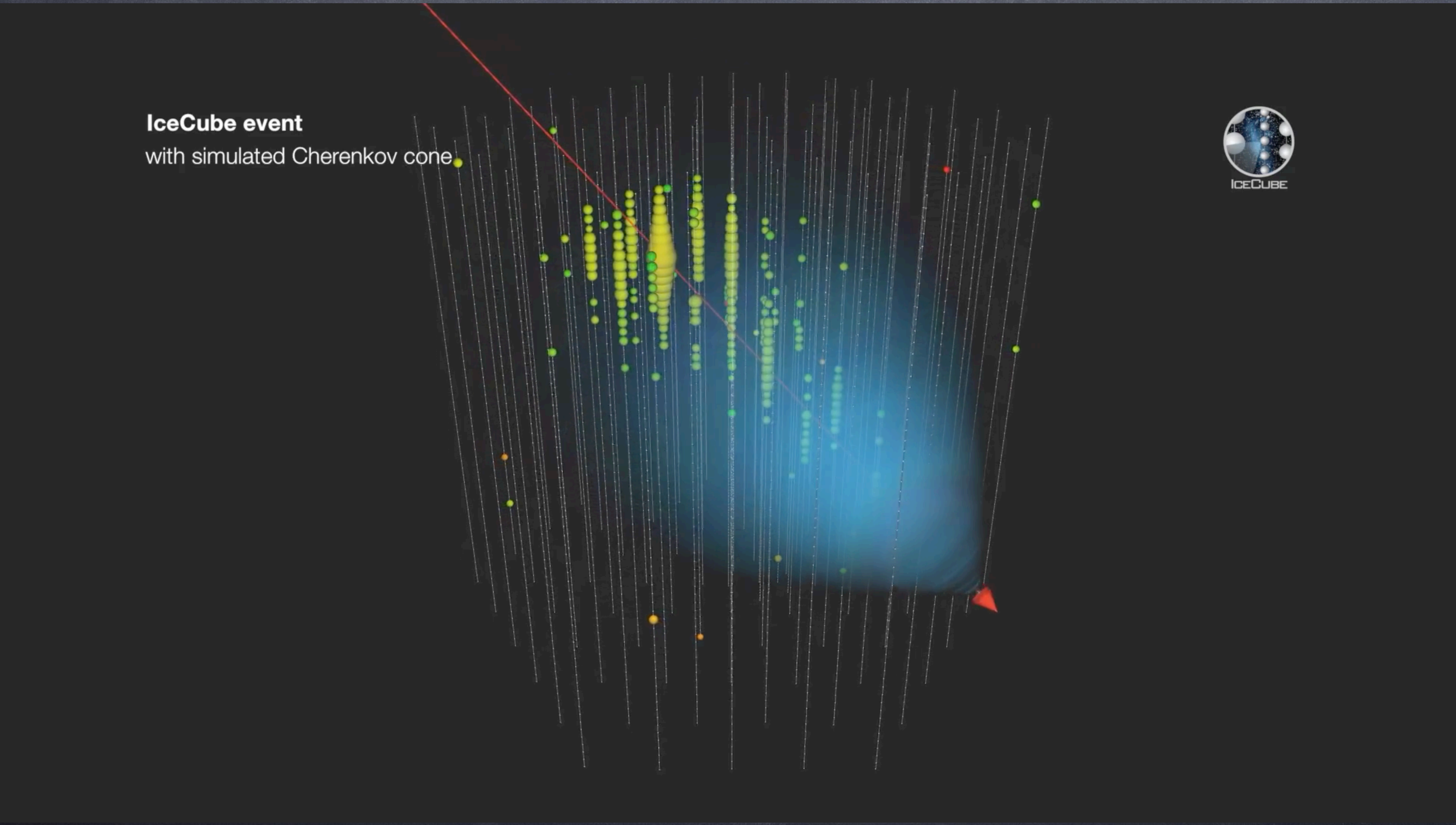





1990

A new boost in BAIKAL Neutrino Telescope history:

- Discovery of UltraHigh energy Neutrinos by IceCube (2014)
- JINR major contribution to construction of cubic-km BAIKAL GVD



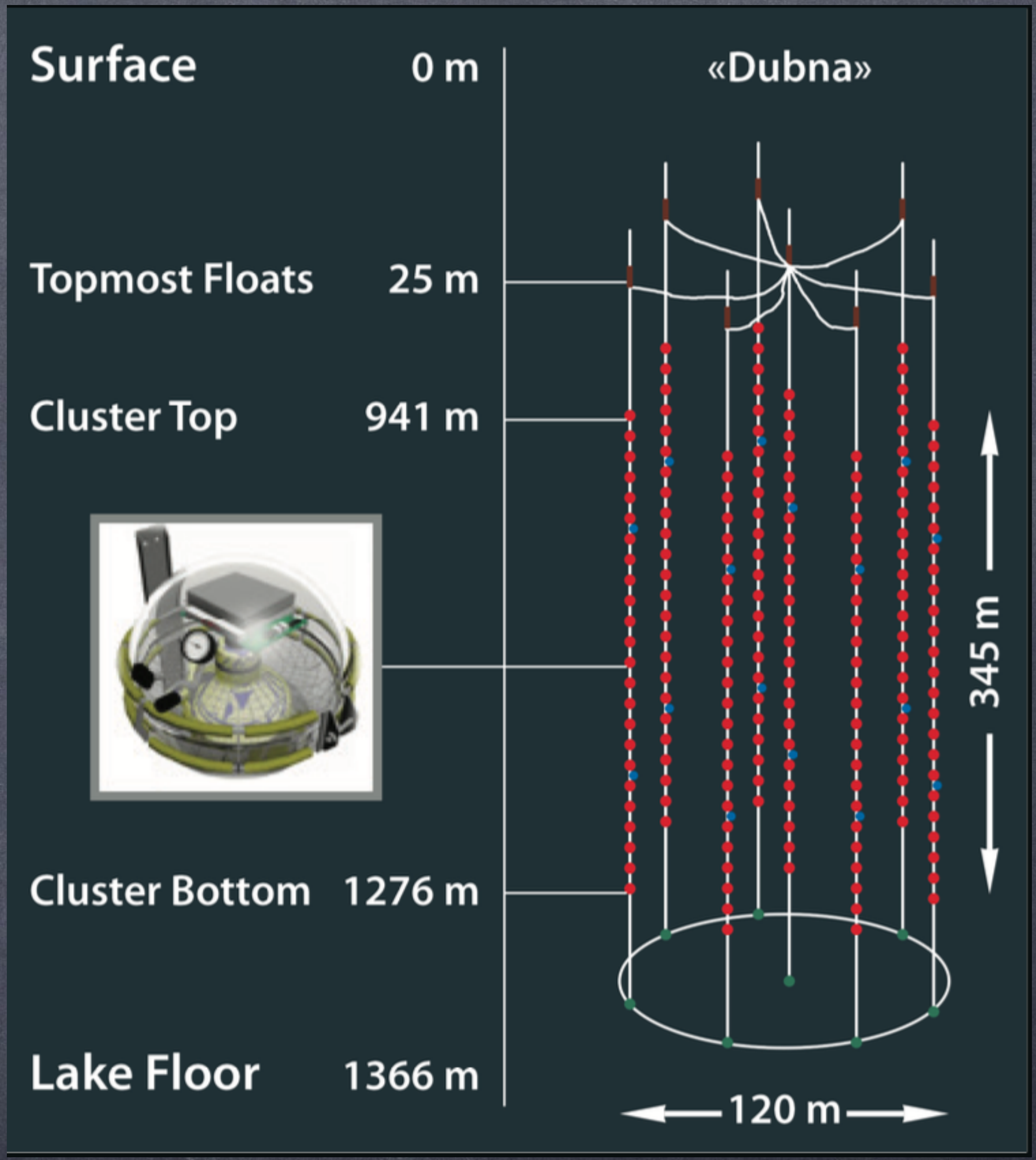
Why BAIKAL?

Accurate determination of arrival direction in BAIKAL water

Light re-scattering in ice is large

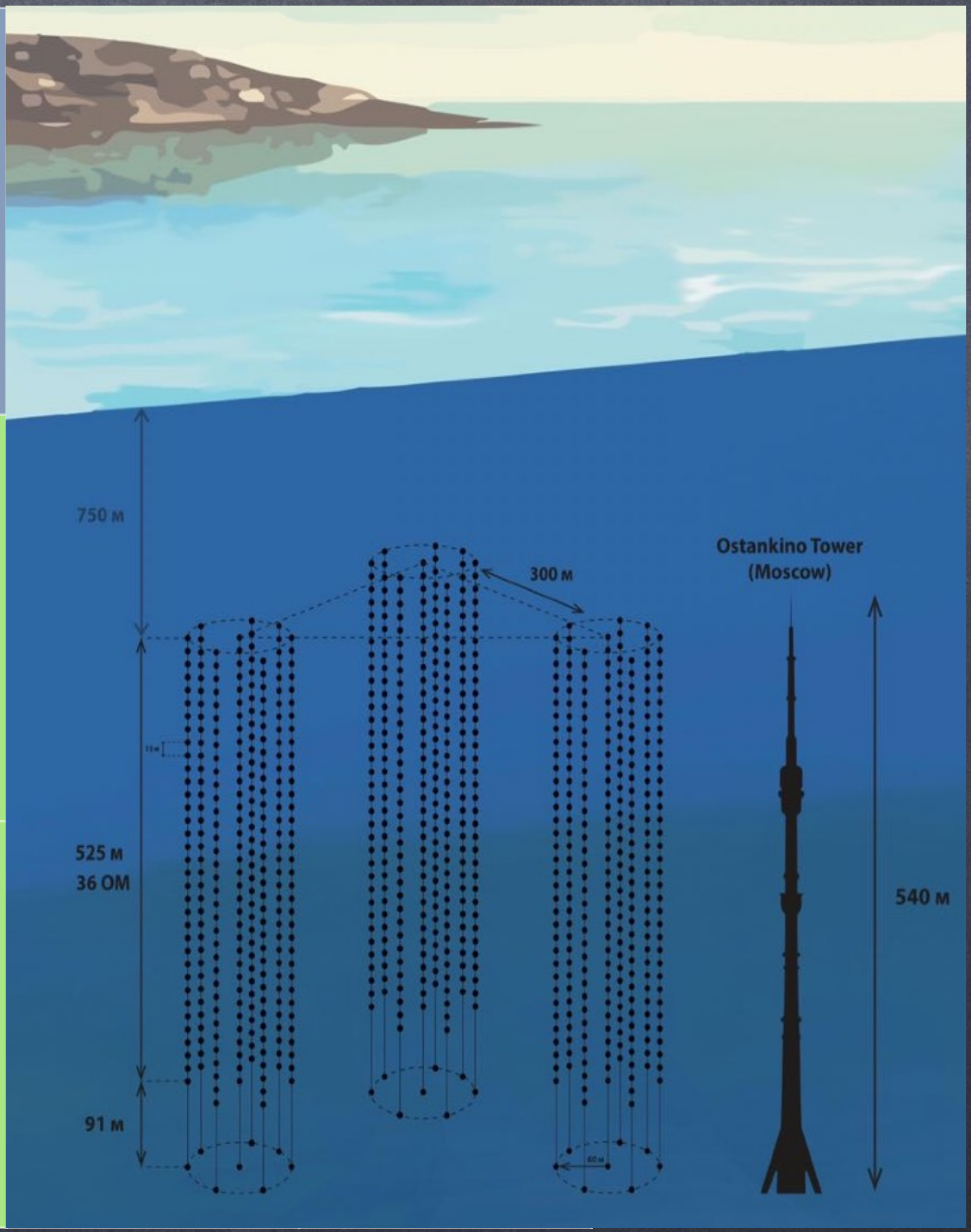
The Plan

- Main Goal
  - Point sources of UHE neutrino
- 3D Array of photo-sensors
  - Phase I: 0.4 km3 (by 2021)
  - Phase II: 1.5 km3 (by 2027)
- Installation site
  - South Baikal
  - Depth 1.4 km
  - Distance from shore 3.5 km
- Requirements
  - Adjustable structure
  - Synchronization < 1ns



Deployment status

	2015	2016	2017	2018
Number of clusters	≤1	1	2	3
Number of OM	192	288	576	864



The largest Neutrino Telescope in Northern hemisphere

Expedition 2019 Ongoing!

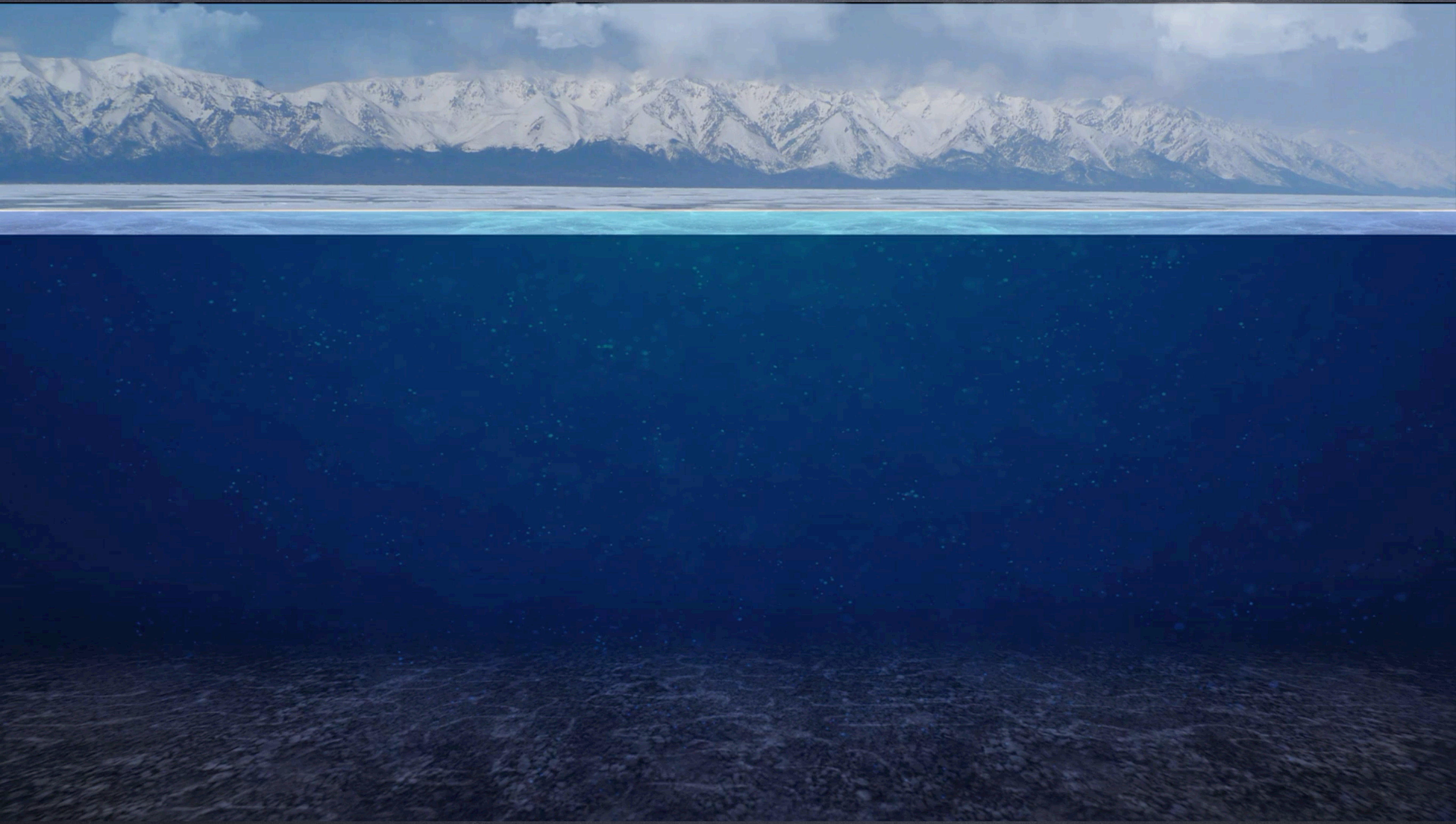
The goals:

- Install two more clusters
- Repair part of cluster #3

Hello from Baikal.
We are installing
two new clusters

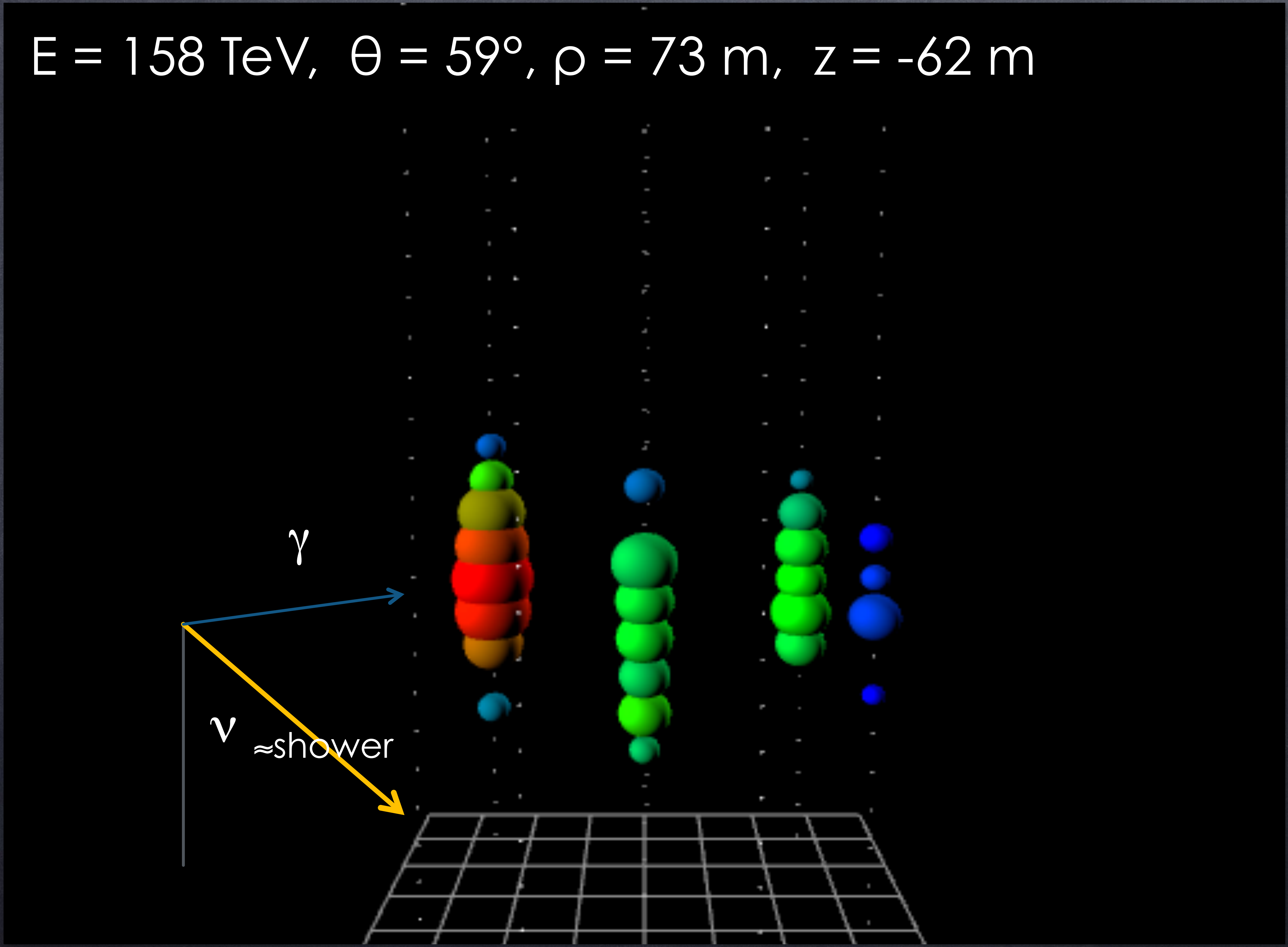
Two new clusters installed in 2019!

BAIKAL GVD
Construction



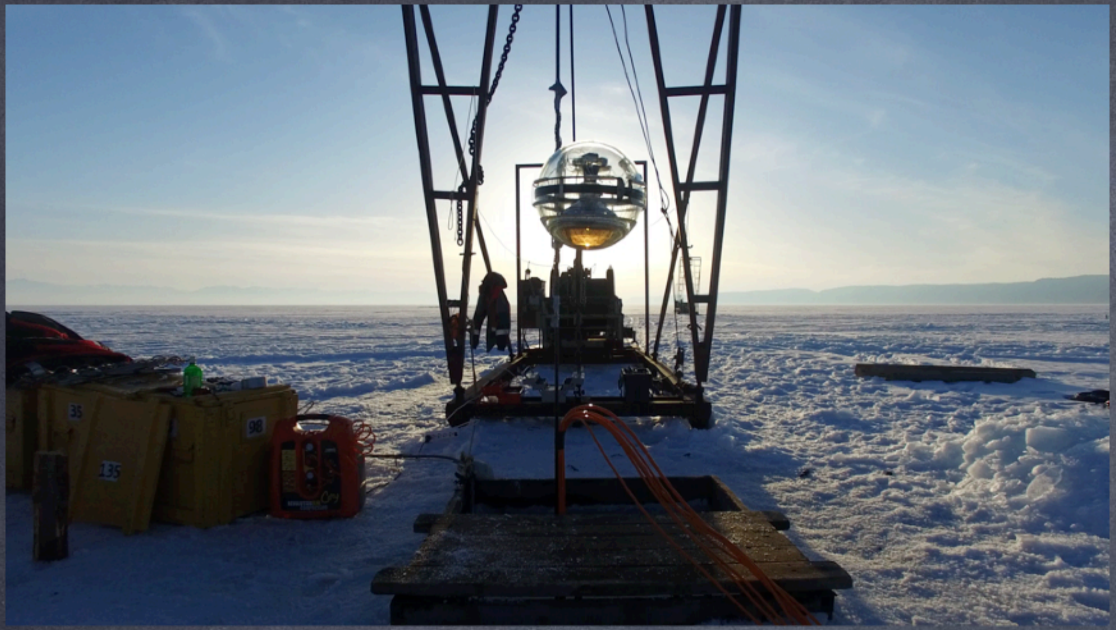
Physics

Neutrino candidate




Neutrino Astronomy unveiled

The most romantic experiment ever



Women's day!

Way for lunch

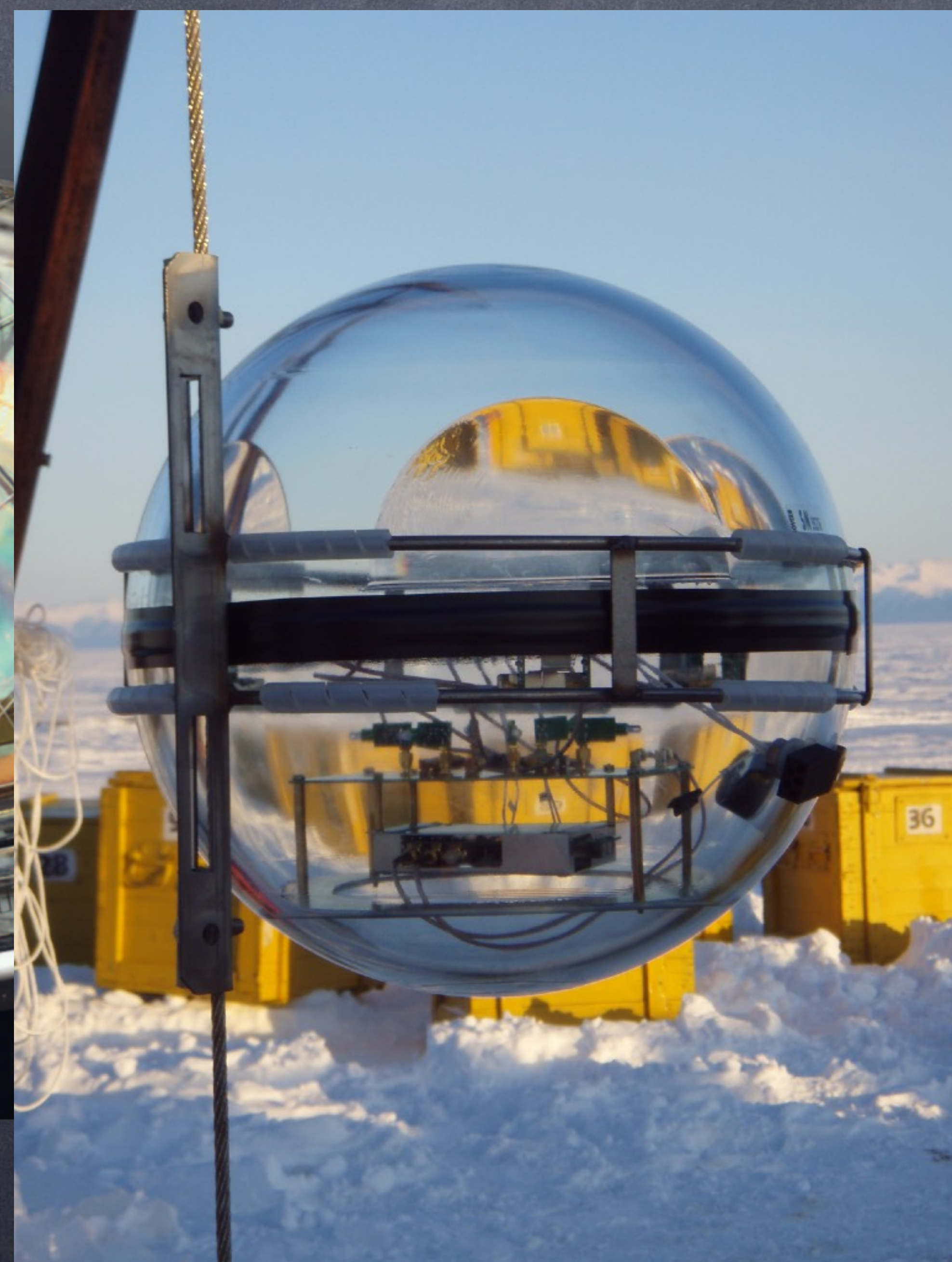
Enjoy more at http://dlnp.jinr.ru/ru/bajkalskij-dnevnik/bajkalskij-dnevnik-dmitriya-naumova

JINR


The End

Additional Materials

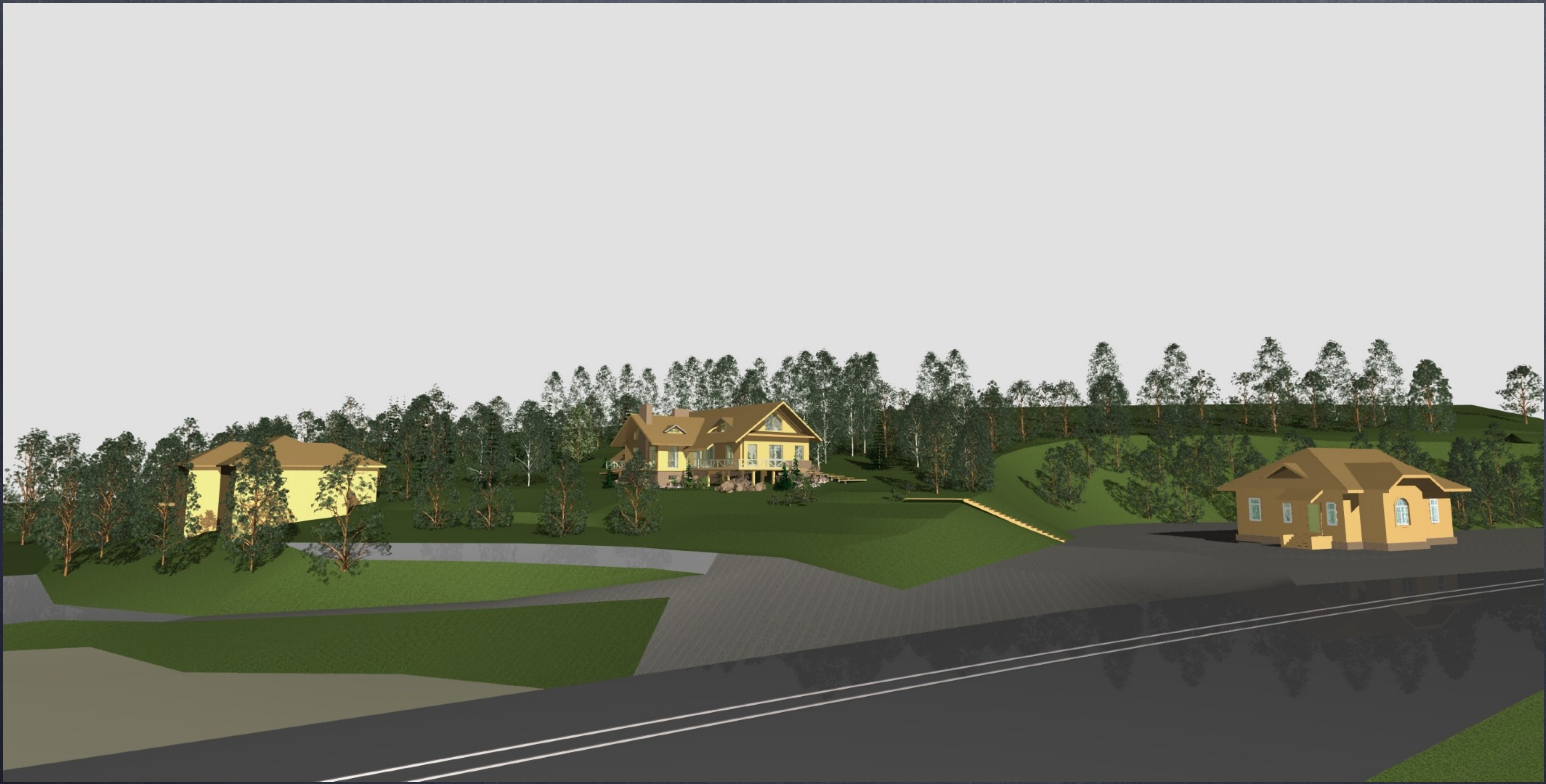
Baikal Optical Module (OM)



Plans @SITE

- Canteen
- Restore Houses
- Sewage & Water supply
- Cable channel
- Rennovate Houses
- Pier for 2 boats
- Property

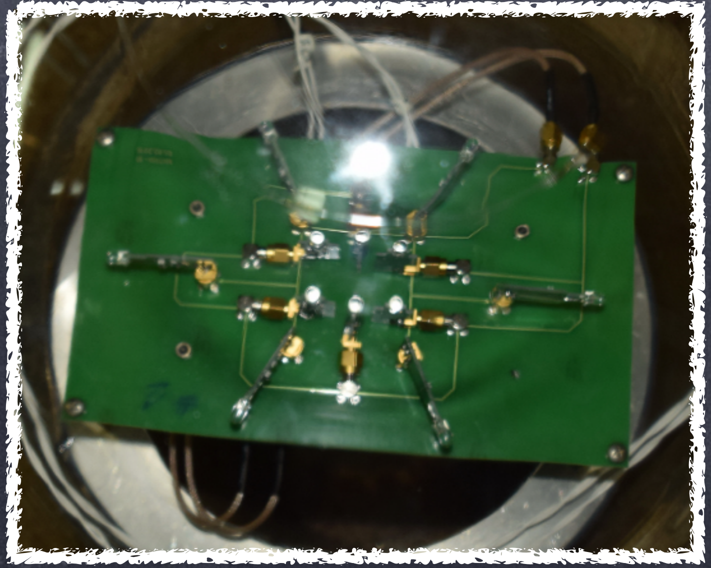
Design view @ 106 km



Detector performance

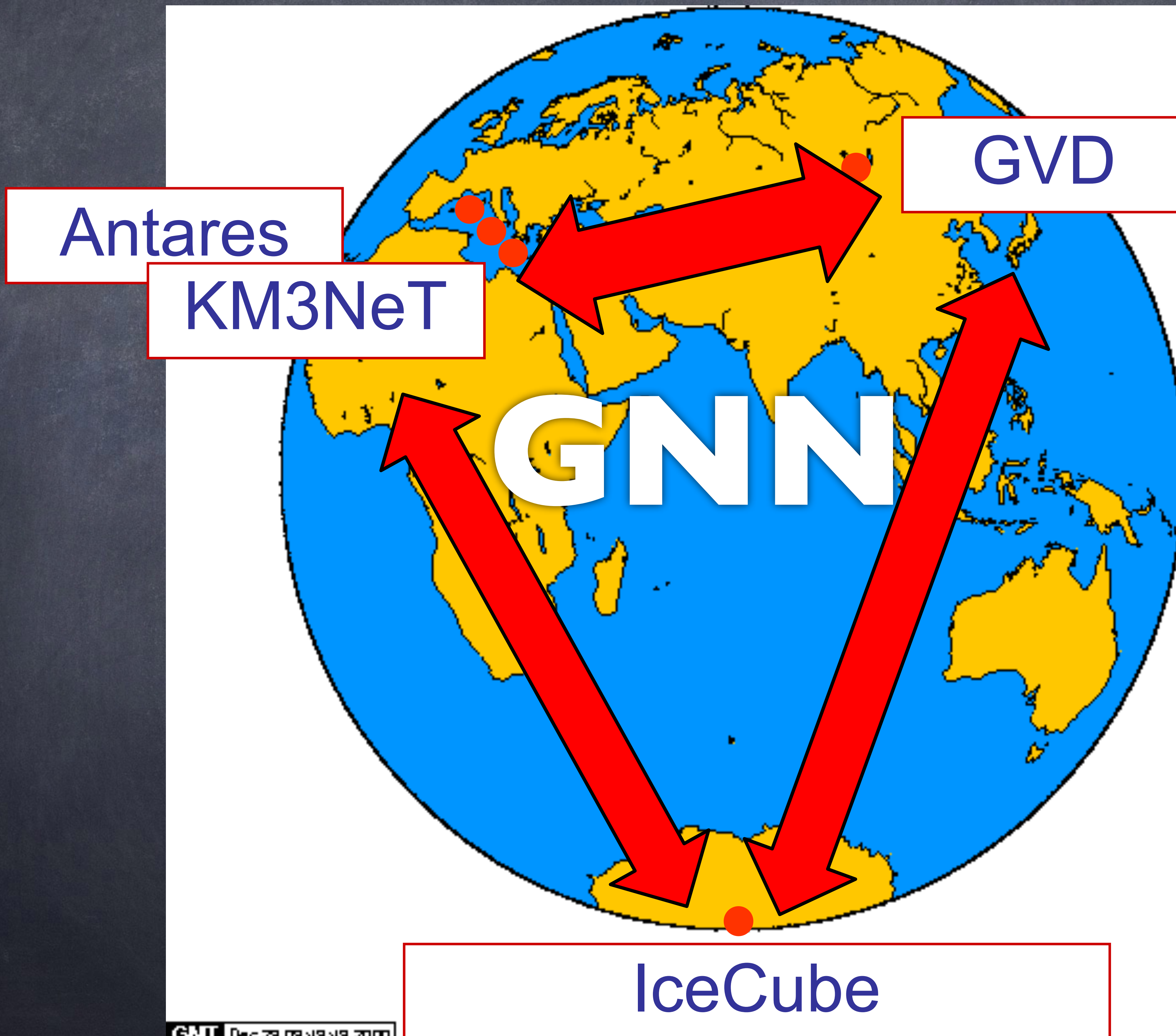
- Position of OMs
  - Acoustic system (few cm)
- Time synchronization between OMs @same cluster &between clusters
  - Laser
  - LED matrix

} 1-2 ns

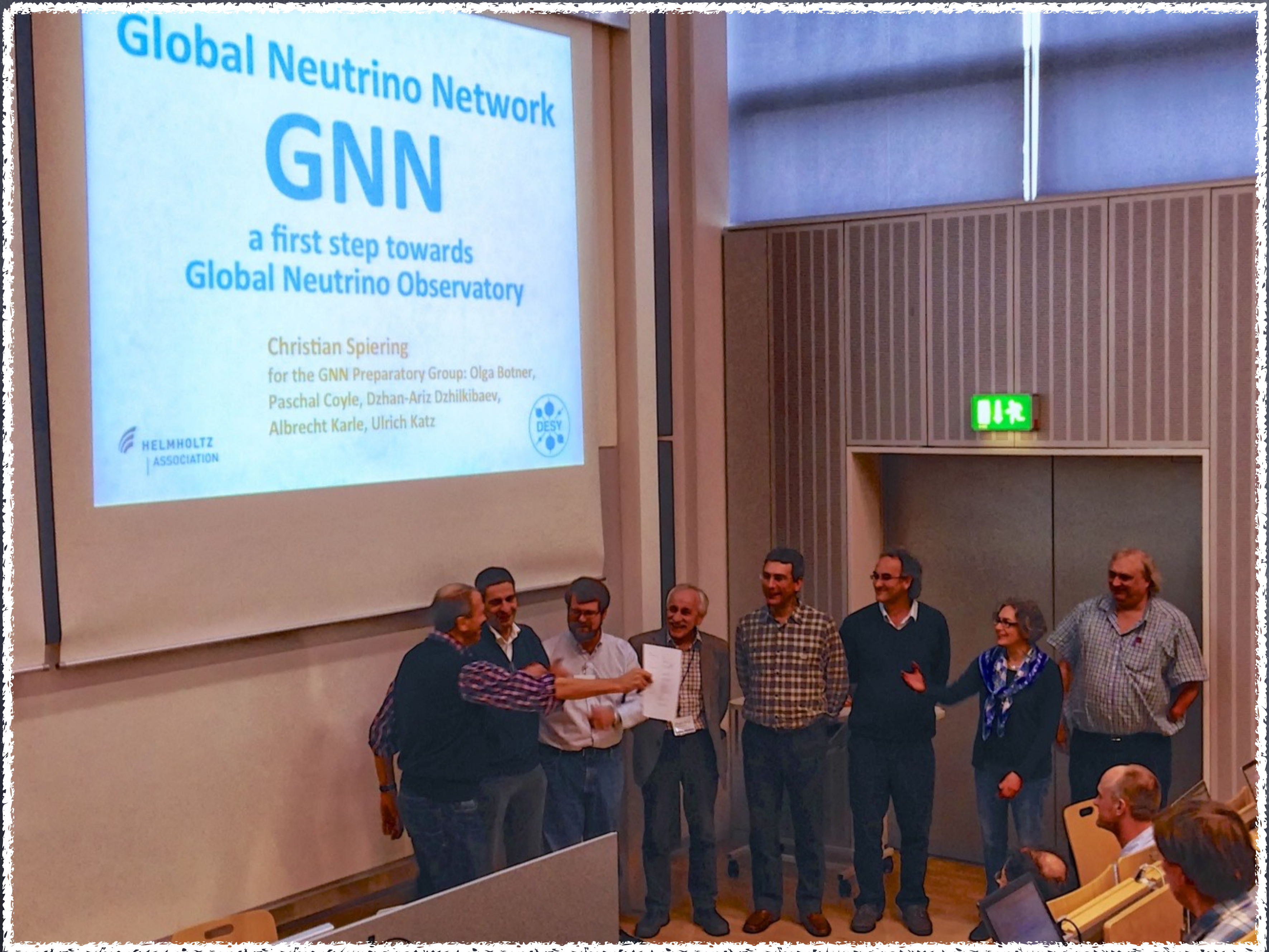


BAIKAL GVD in global context

Global Neutrino Network



The Global Neutrino Network



Oct. 2013, Munich

- Antares
- Baikal
- IceCube
- KM3NeT

http://www.globalneutrinonetwork.org/

Infrastructure upgrade

OM assembling hall @DLNP JINR

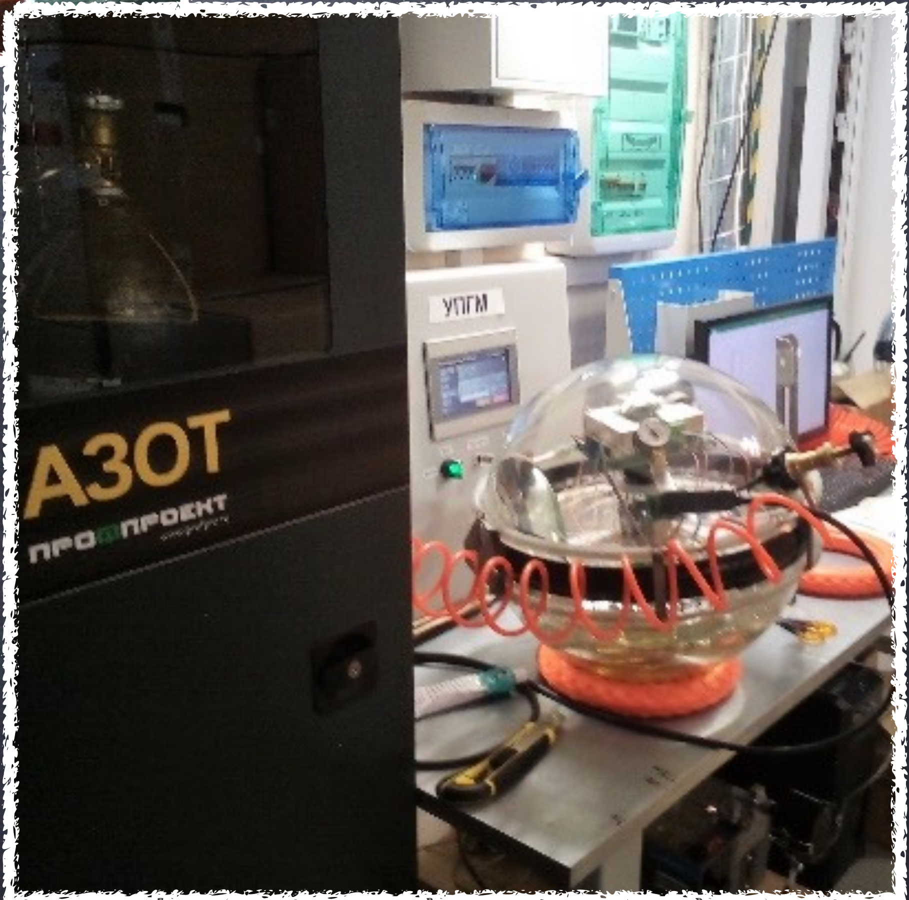
12 OM/day

JINR facilities

Vacuuming

Full testing

Nitrogen drying



DAQ testing @INR

Long-term testing @JINR

- Long term tests
- All cluster components
- Full power load

@SITE

New data taking center

Purchased storage building @ Baikalsk

New shore lab

New living boxes

@SITE
Transportation issues solved