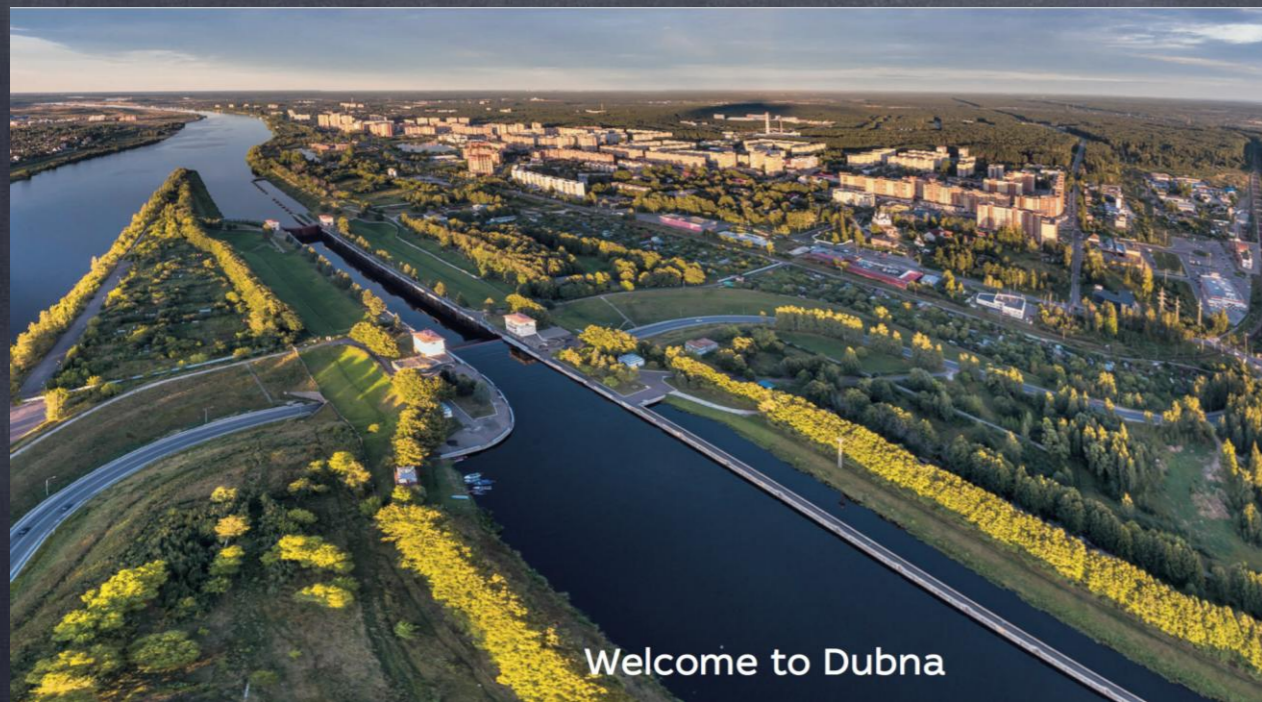


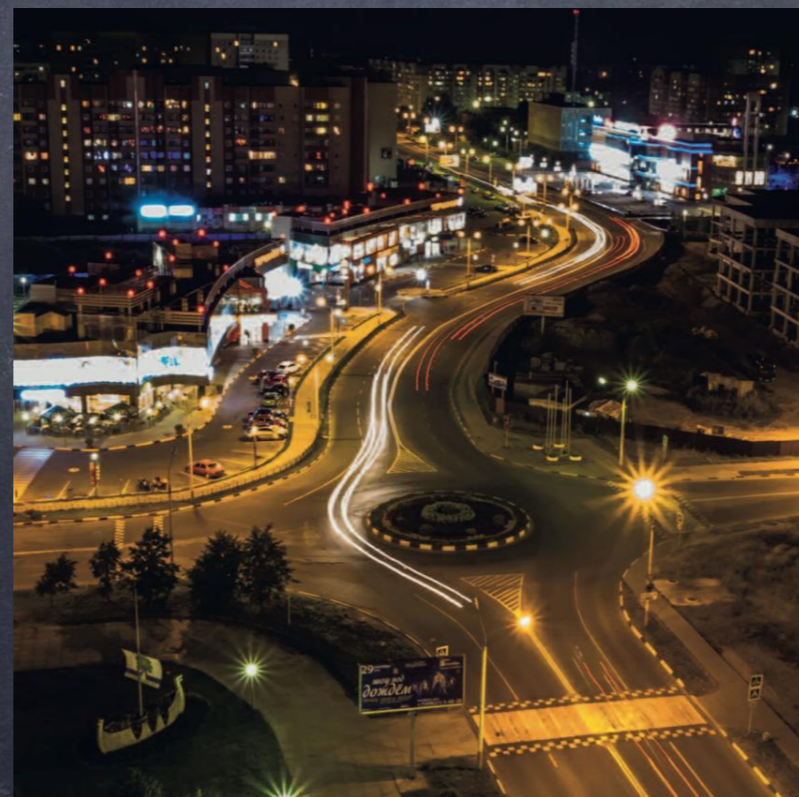
Dzheleпов Laboratory of Nuclear Problems

Dmitry V. Naumov

Dubna



Welcome to Dubna



JINR

- New elements 102, {103, 104, **105(Db)**, 107}, 114, 115, 116, 117, 118 are synthesized
- Hypothesis of neutrino oscillations (1957г.)
- New particles: anti-sigma-minus hyperon
- And many other discoveries



JINR

- Employed ~ **5000**: 1200 - scientists, 2000 - engineers
- **7 labs**. Each lab is as a big research institute
- **18 member-states and 6 associated members**
- **1500 scientific publications**
- Collaboration with **700 scientific centers and universities in 64 countries**
- Expected budget in 2017-2023 **1, 472 billion USD**

JINR Laboratories:

JINR comprises 7 Laboratories, each being comparable with a large institute in the scale and scope of research performed.



Veksler and Baldin Laboratory of High Energy Physics

<http://lhe.jinr.ru/index.html>



Dzhelepov Laboratory of Nuclear Problems

<http://dlnp.jinr.ru/en>



Bogoliubov Laboratory of Theoretical Physics

http://theor.jinr.ru/lab_en.html



Frank Laboratory of Neutron Physics

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



Flerov Laboratory of Nuclear Reactions

<http://flerovlab.jinr.ru/flnr/index.html>



Laboratory of Information Technologies

<http://lit.jinr.ru/index.php?lang=lat>



Laboratory of Radiation Biology

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



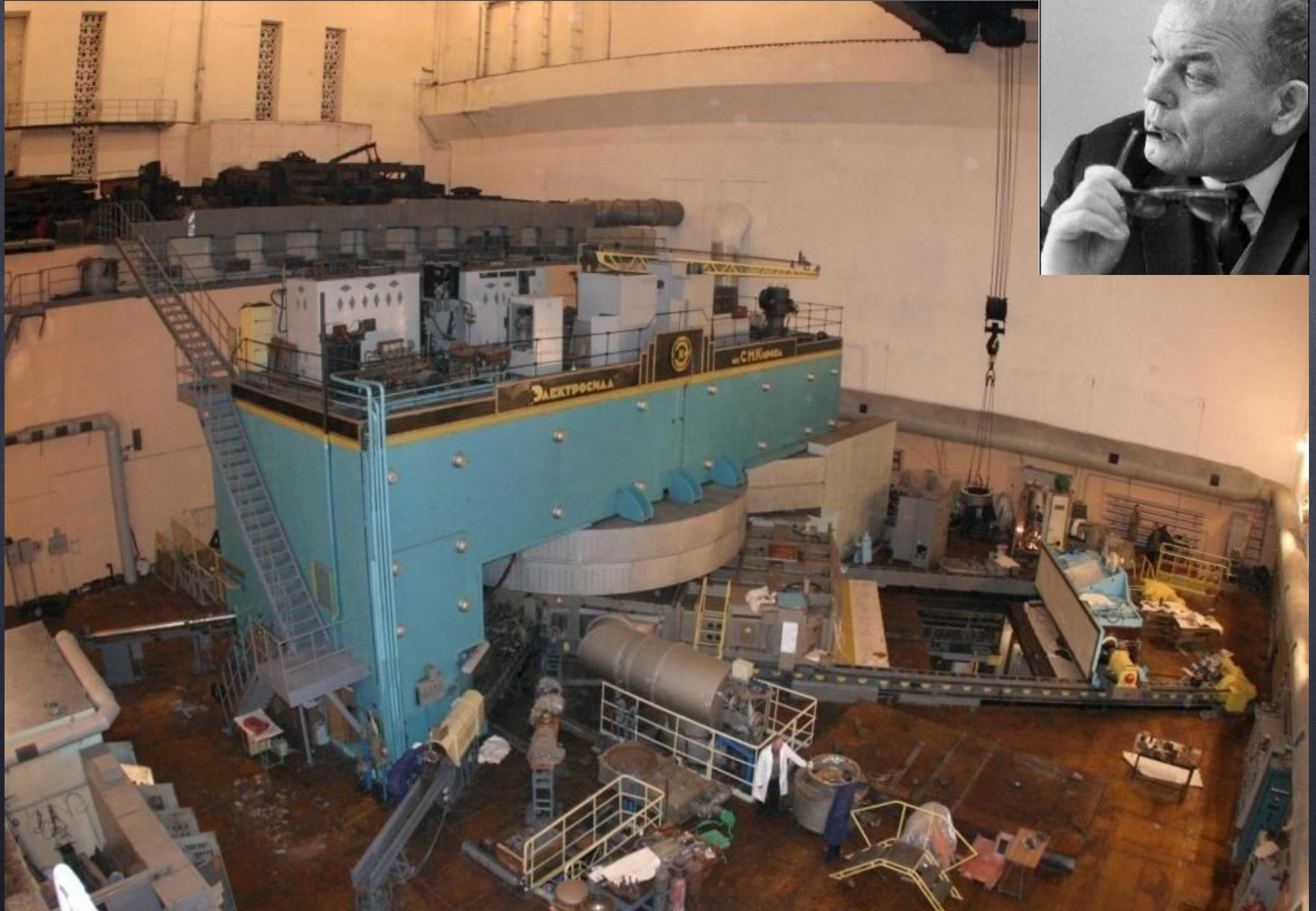
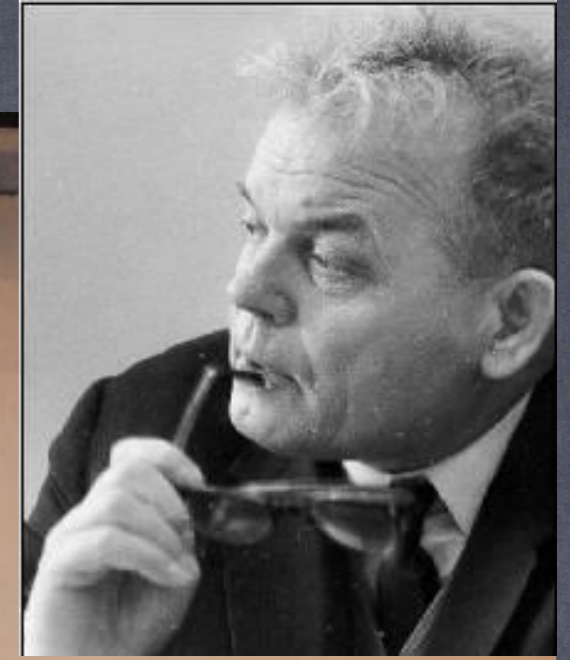
History

- **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.
- **26 March 1956.** Laboratory of Nuclear Problems of JINR has been founded.



Synchrocyclotron 680 MeV (1953)

M.G. Meshcheryakov



Discoveries

- Half of discoveries (37) in physics recorded in Soviet Union belongs to JINR
- 15 of these belongs to LNP
- Nowadays DLNP researchers are also awarded for important discoveries.

Discoveries → New Technologies → Discoveries

LNP a laboratory with largest diversity → origin of most of laboratories in JINR

Institute of Nuclear Problems (now DLNP) +
Electrophysical laboratory (now LHEP) → JINR

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

SCIENCE & TECHNOLOGIES

Particle Physics

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

Neutrino Physics & Astrophysics

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

Technologies

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

SCIENCE & TECHNOLOGIES

Medicine & Molecular Genetics

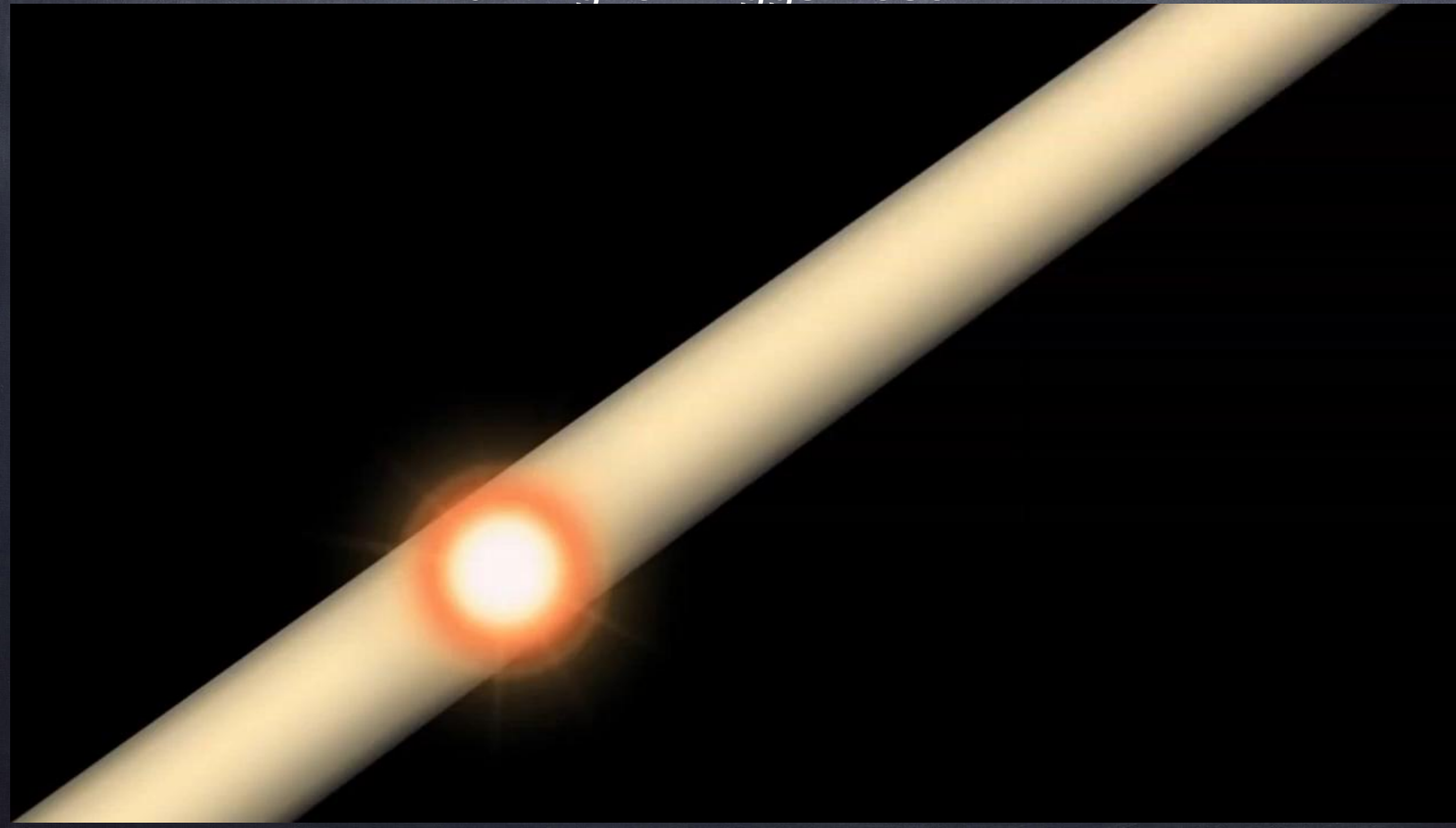
- Proton Therapy
- Medical-biological studies
- Radiation genetics

Education & Outreach

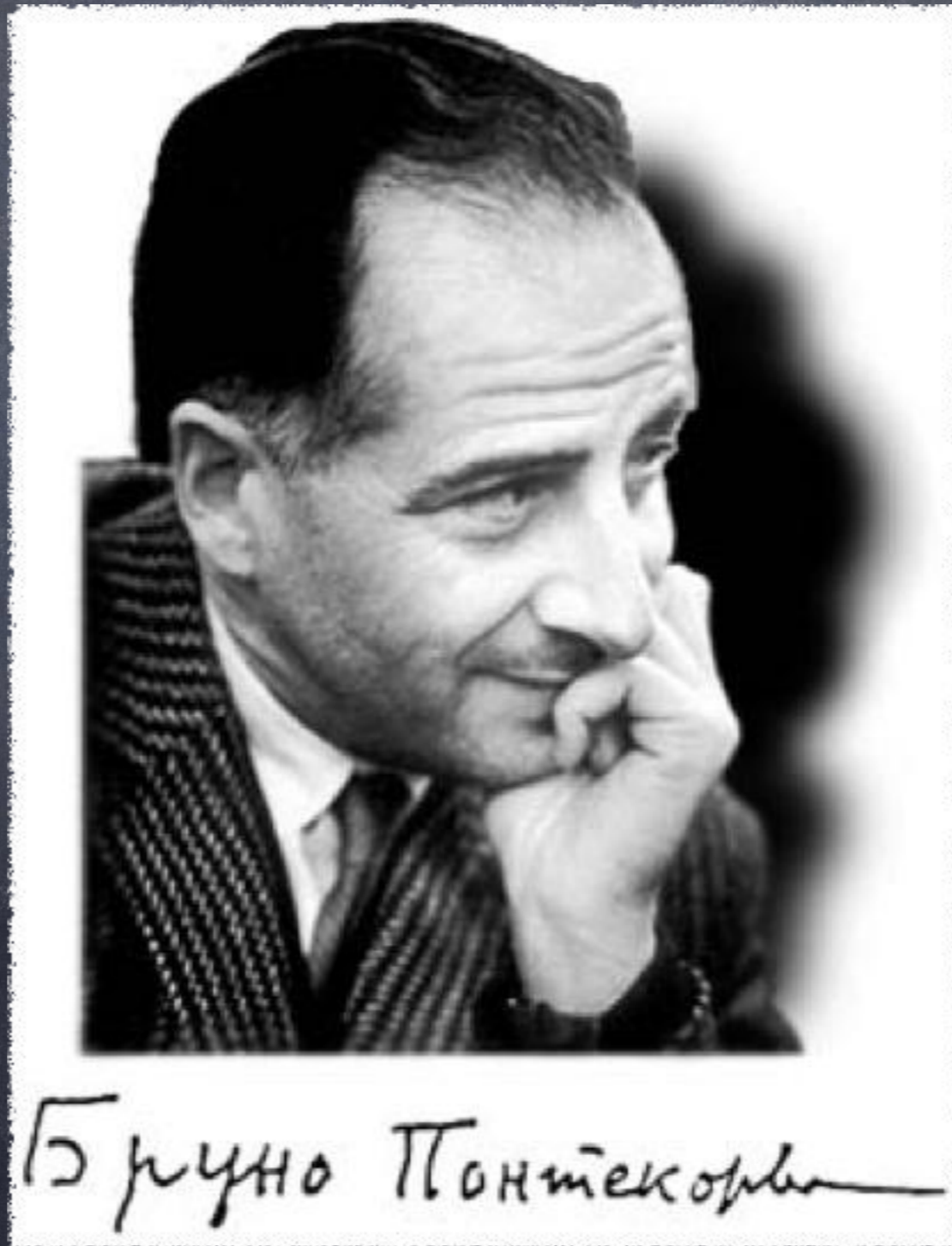
- Schools, conference, seminars
- Web-site of DLNP, social networks
- Lecturing at MSU, MIPT, «Dubna» University and others

ATLAS

Hunting for Higgs Boson



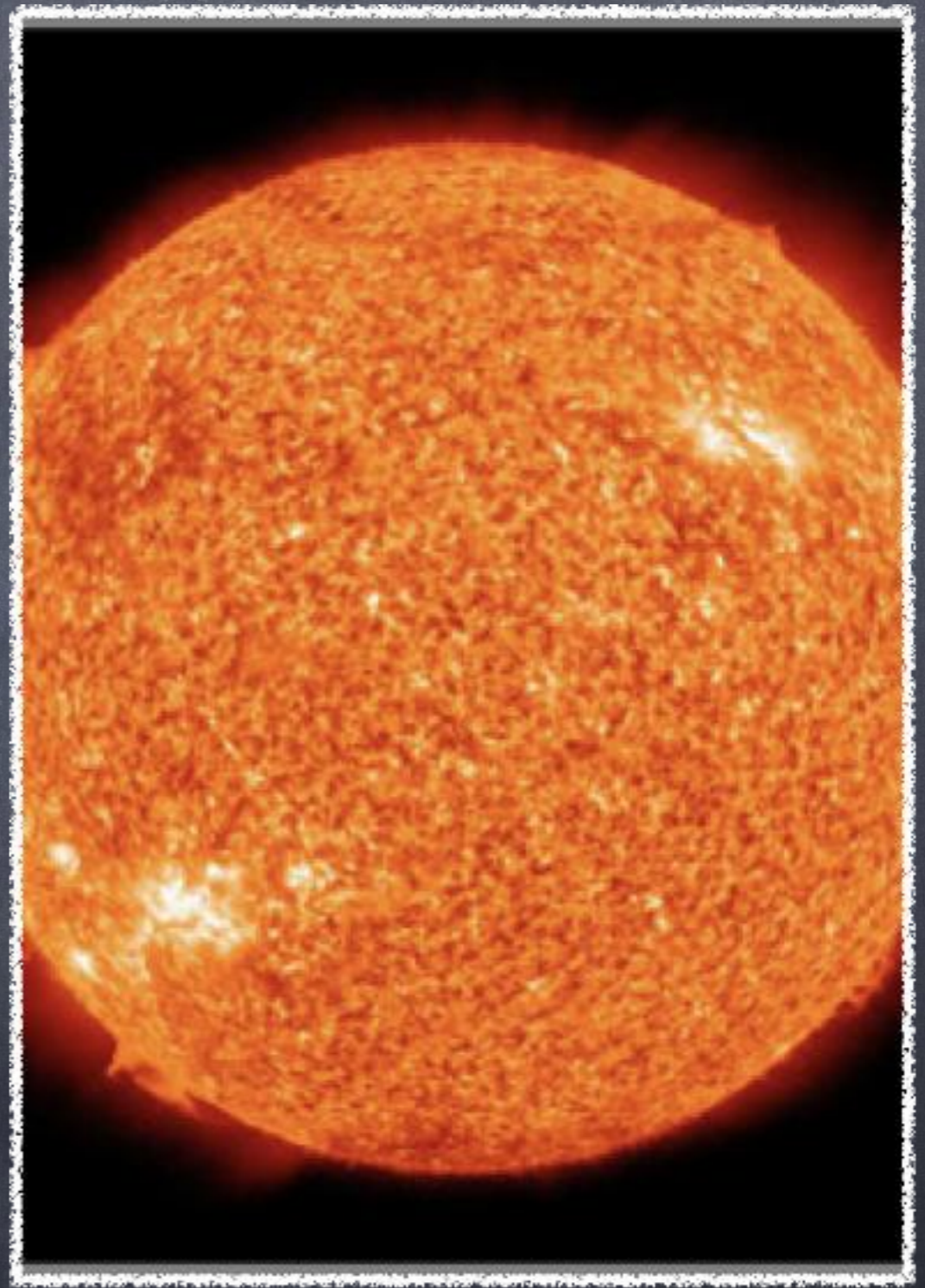
Bruno Pontecorvo worked in JINR (1950-1993) establishing a School of Neutrino Physics



Бруно Понтекорво

Why neutrino is an important particle?

Spin:
$$\underbrace{\frac{1}{2} + \frac{1}{2}}_{\text{even}} \rightarrow \underbrace{1 + \frac{1}{2} + \frac{1}{2}}_{\text{even}}$$



Why neutrino is an important particle?

Spin: $p + p \rightarrow d + e^+$

$$\underbrace{\frac{1}{2} + \frac{1}{2}}_{\text{even}} \rightarrow \underbrace{1 + \frac{1}{2}}_{\text{odd}}$$



Nobel Prizes for Neutrino Physics

- 1988 ([Leon M. Lederman](#), [Melvin Schwartz](#) and [Jack Steinberger](#)). Discovery of muon neutrino.
- 1995 ([Frederick Reines](#)). Discovery of electron antineutrino
- 2002 (Raymond Davis, Jr. и [Masatoshi Koshiba](#)). SN 1987A.
- 2015 ([Takaaki Kajita](#) and [Arthur B. McDonald](#)). Discovery of neutrino oscillations.

Breakthrough Prize for Neutrino Physics - 2015



BREAKTHROUGH PRIZE | FUNDAMENTAL PHYSICS

THE 2016 BREAKTHROUGH PRIZE IN FUNDAMENTAL PHYSICS IS AWARDED TO

Maxim Gonchar

AND COLLEAGUES AT DAYA BAY, KAMLAND, K2K & T2K,
SUDBURY NEUTRINO OBSERVATORY AND SUPER-KAMIOKANDE

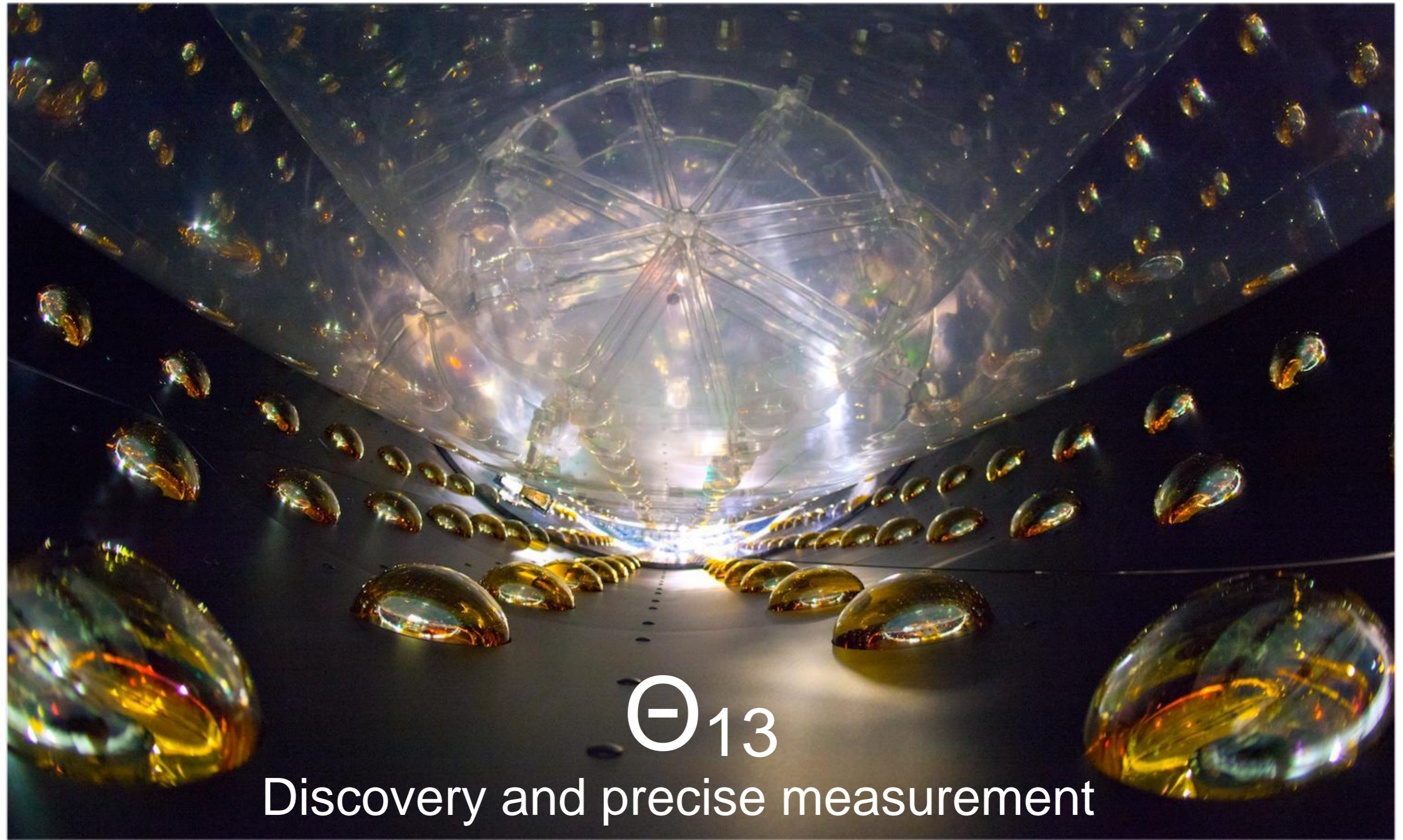
For the fundamental discovery and exploration of neutrino oscillations, revealing a new
frontier beyond, and possibly far beyond, the standard model of particle physics.

NOVEMBER 8, 2015

Karl Johansson
Director
Breakthrough Prize Foundation

Neutrino Physics

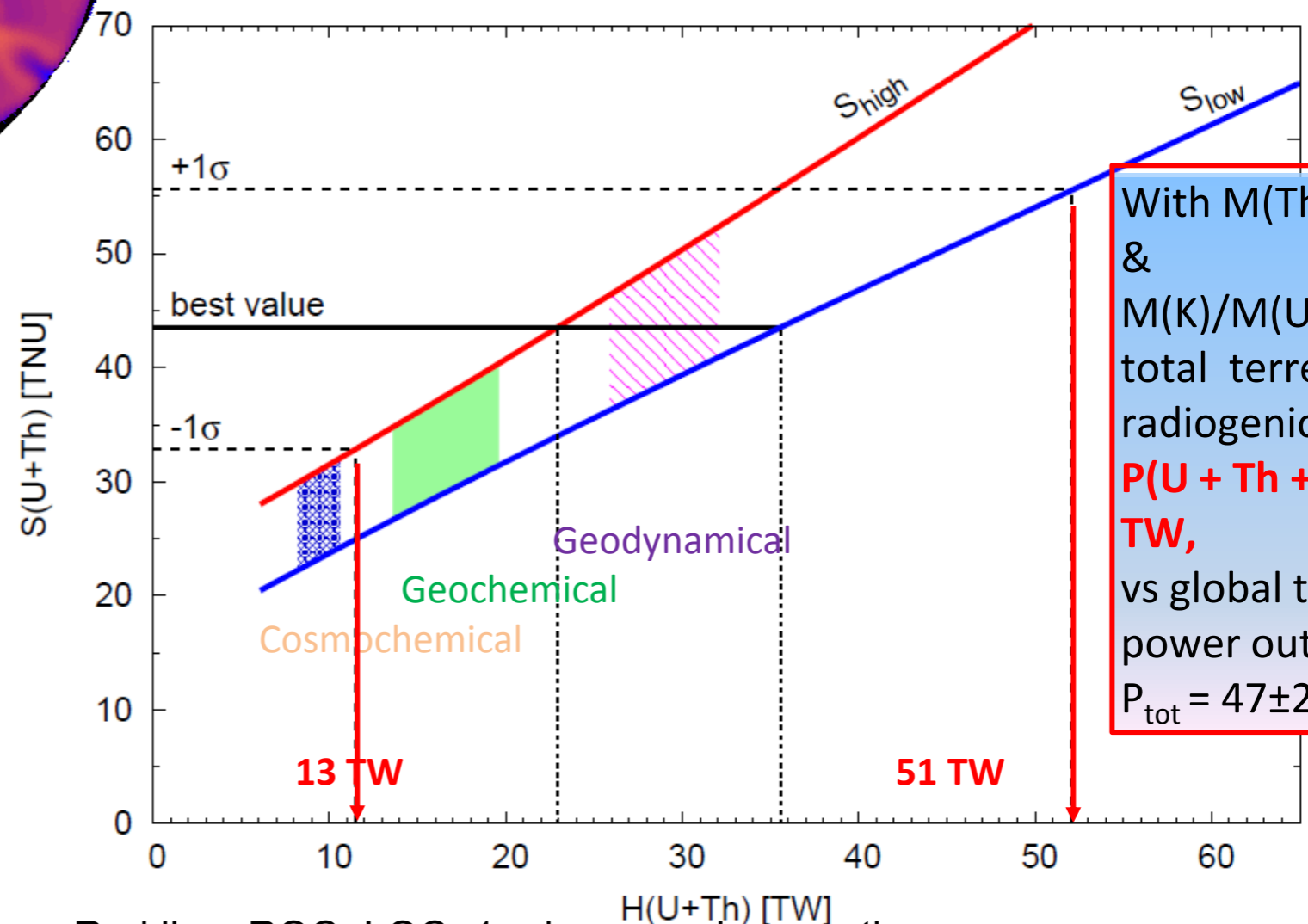
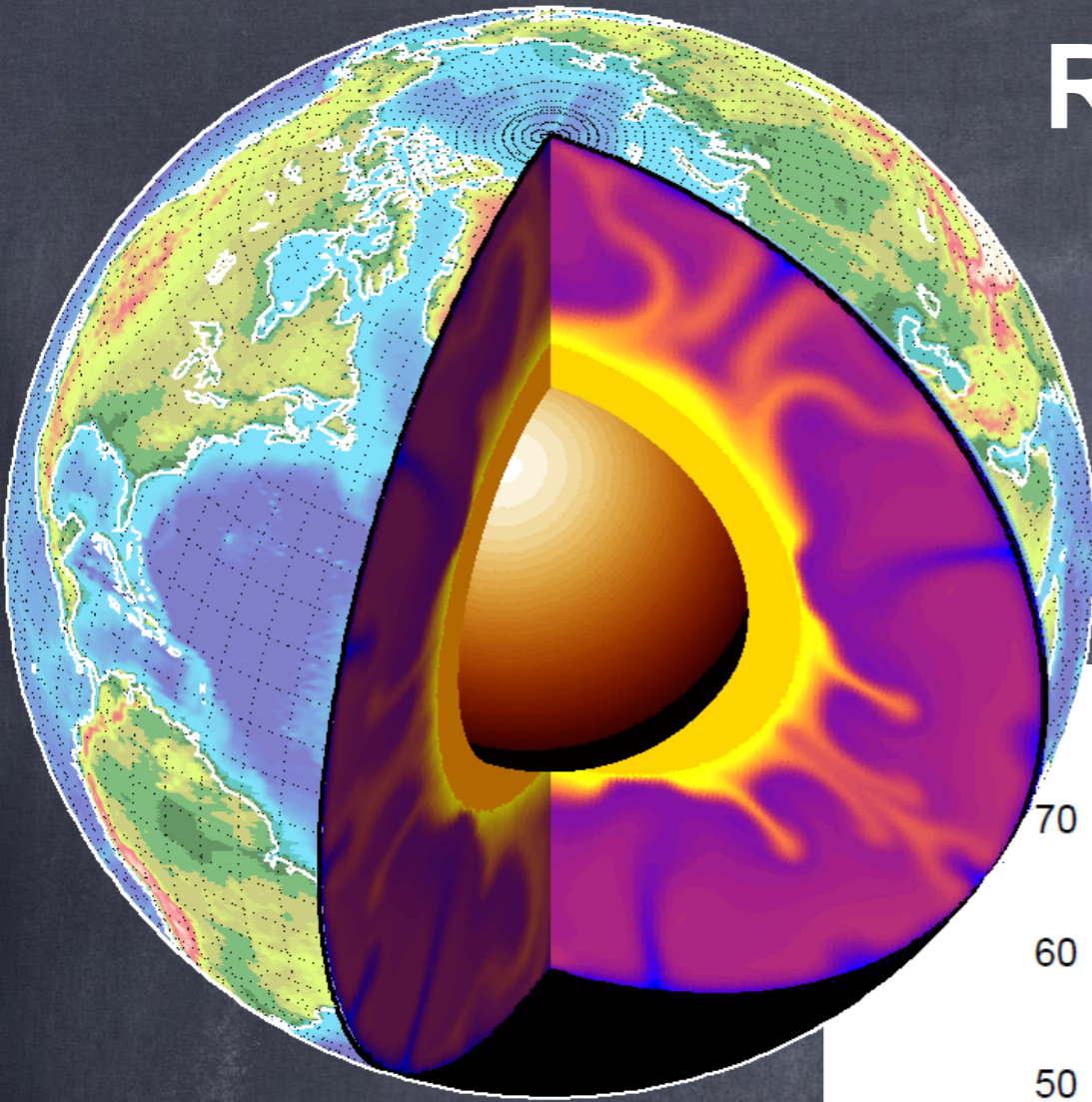
Daya Bay experiment



Θ_{13}

Discovery and precise measurement

Radiogenic heat: Borexino



With $M(\text{Th})/M(\text{U})=3.9$
 &
 $M(\text{K})/M(\text{U}) = 10^4$ the
 total terrestrial
 radiogenic power :
 $P(\text{U} + \text{Th} + \text{K}) = 33^{+28}_{-20}$
TW,
 vs global terrestrial
 power output
 $P_{\text{tot}} = 47 \pm 2 \text{ TW}$

Red line: ROC+LOC+1 σ , homogenios mantle

Blue line: ROC+LOC-1 σ , radiogenic material on the mantle/core interface

Neutrino experiments at the Kalinin NPP

(Tver region, 285 km NW from Dubna)

- Pressurised Water Reactor (BBЭP-1000)
- Thermal Power: 3 100 MW
- Core: \varnothing 3.20 m \times h 3.70 m
- Fuel (70 ton): ^{238}U + ^{235}U (3.3-5.5%)
- Neutrino Flux: $\sim 6 \times 10^{20} \bar{\nu}_e / 4\pi / \text{day}$
- Campaign: 18 months + recharge (50 days)
- **1100 kg of ^{235}U is burned out**
- **200 kg of ^{239}Pu is produced**
- which changes neutrino flux and spectrum

GEMMA
(Neutrino Magnetic Moment)

2

VGeN
(Coherent ν -Ge scattering)

3

DANSS
(reactor monitoring and search for sterile neutrino oscillations)

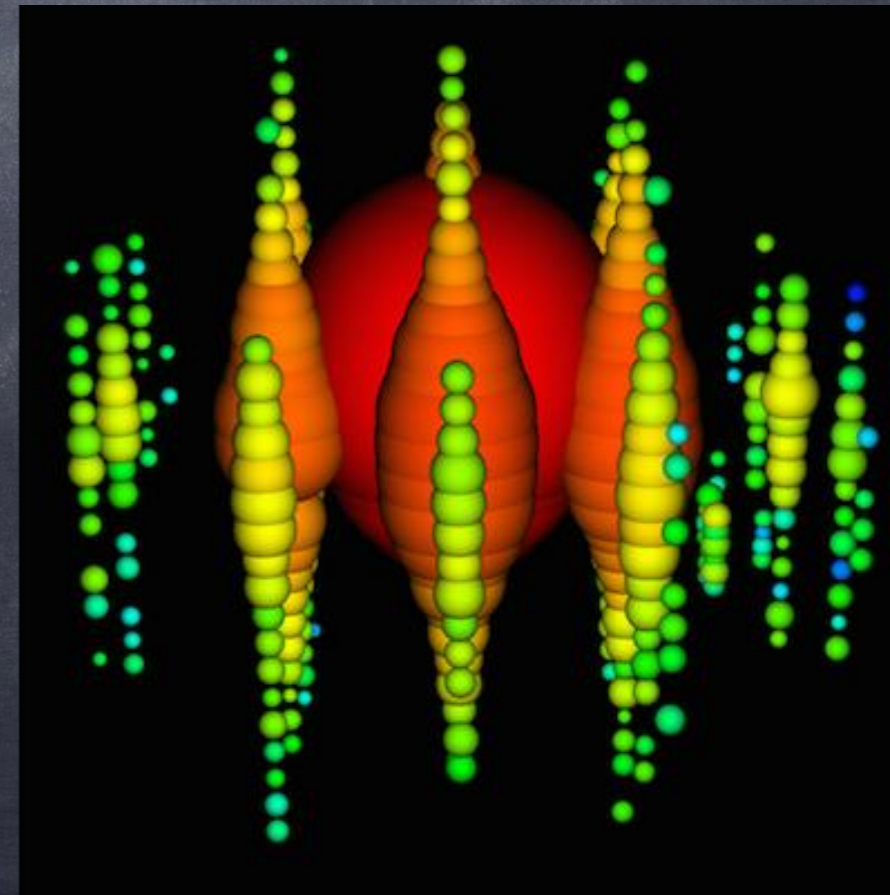
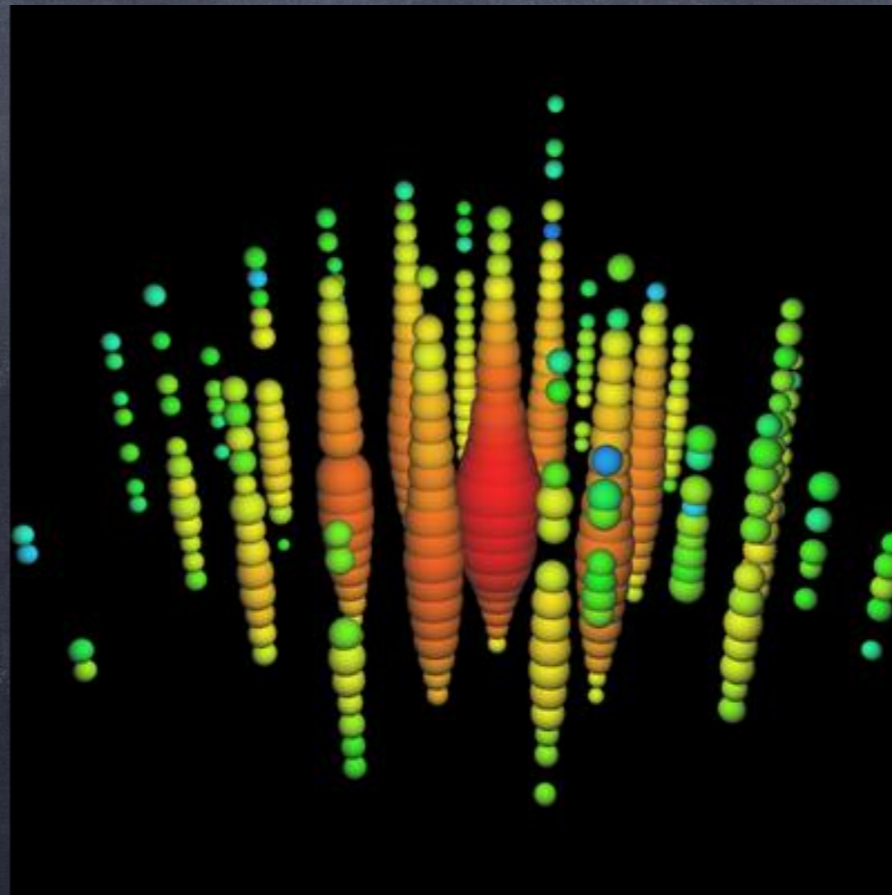
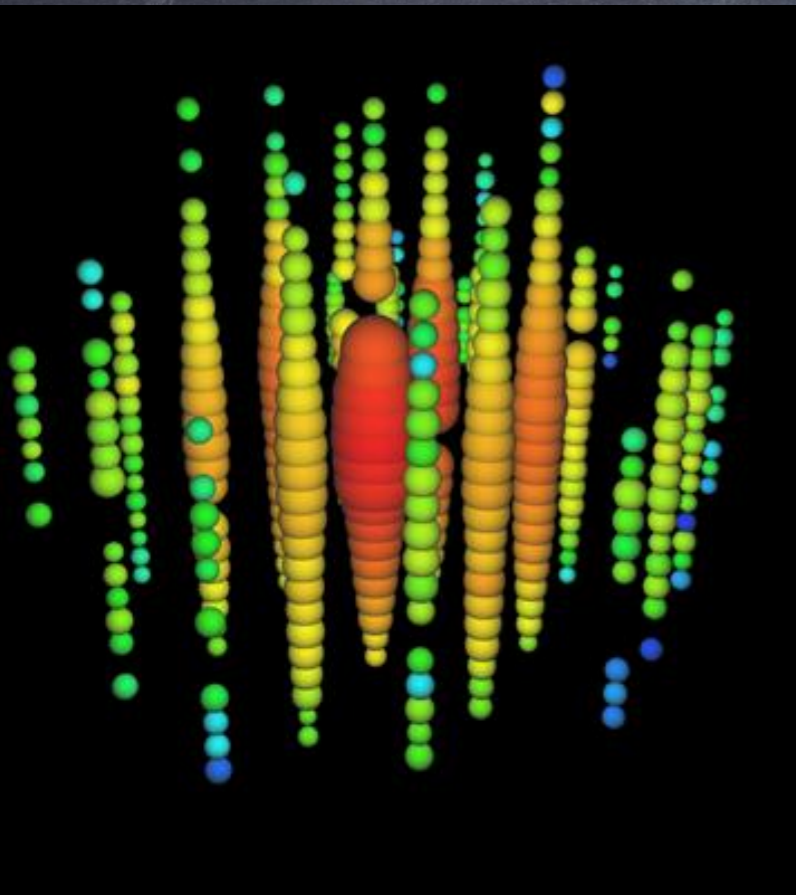
4

Astrophysical sources

BAIKAL GVD

Astrophysical neutrinos of Ultra High Energies (UHE) do exist (IceCube)

- Bert, Ernie, Big Bird with energies 1, 1.1 and 2.2 PeV
- Followed by several dozens of less energetic but astrophysical neutrinos
- UHE Neutrino Astronomy was born

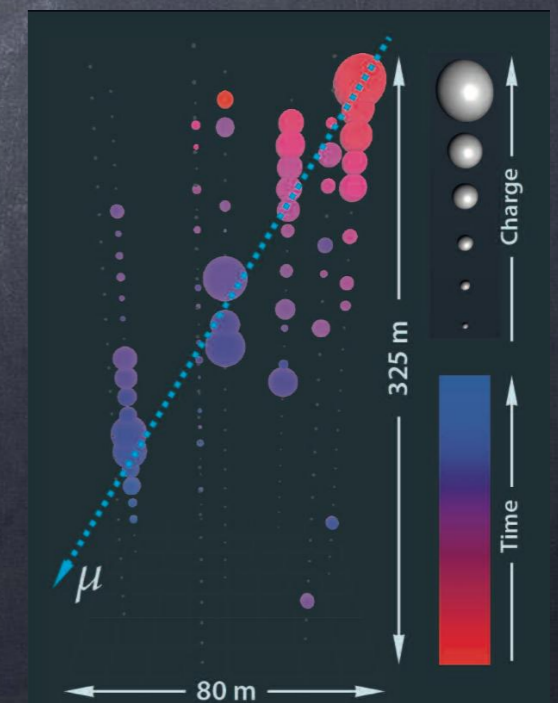
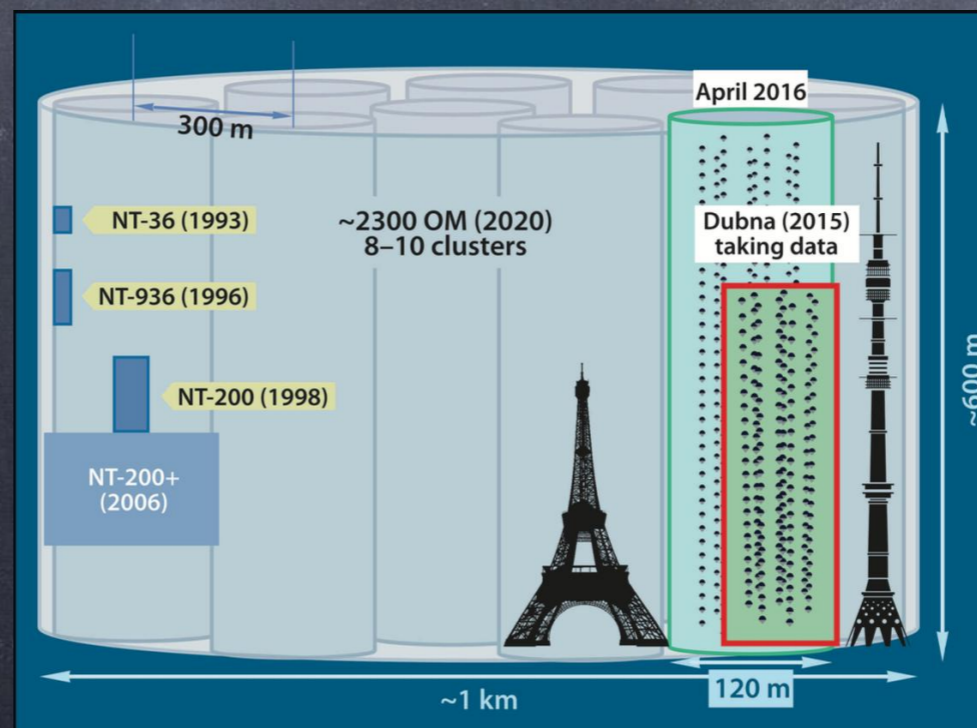
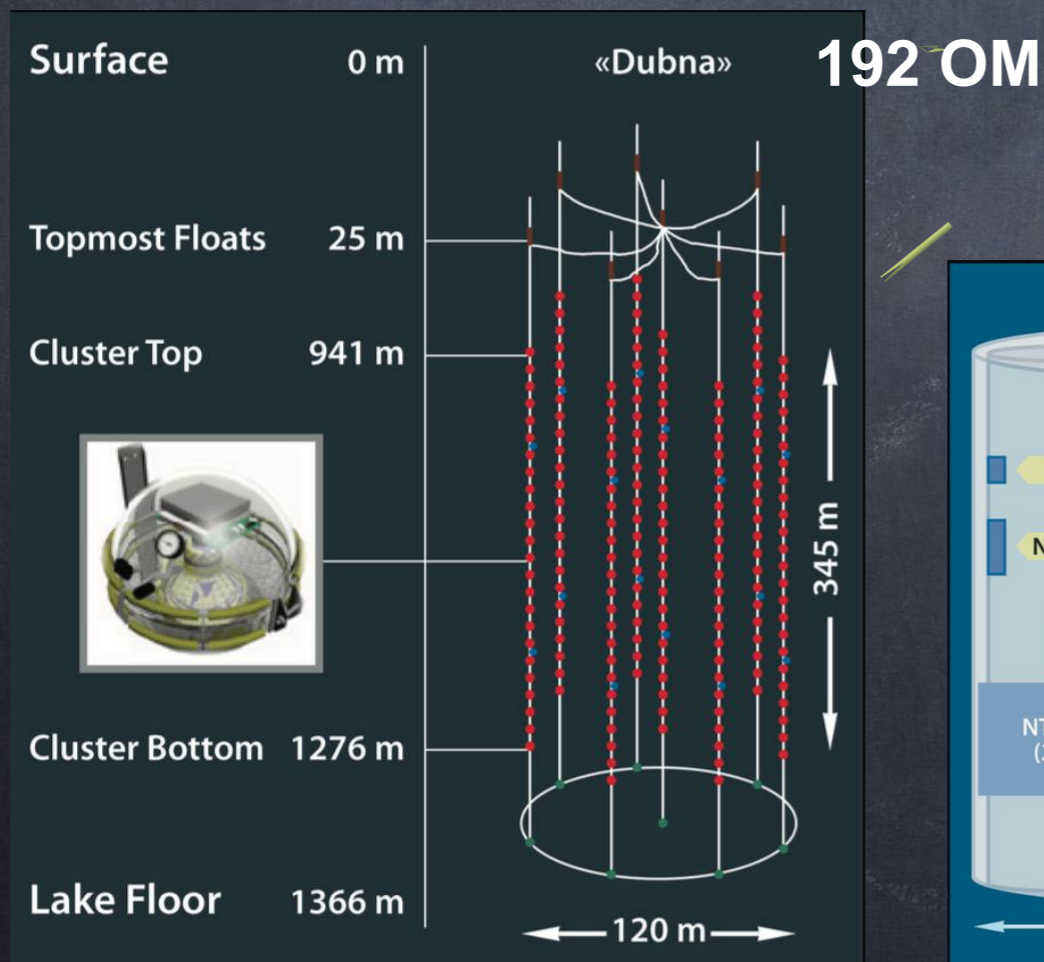
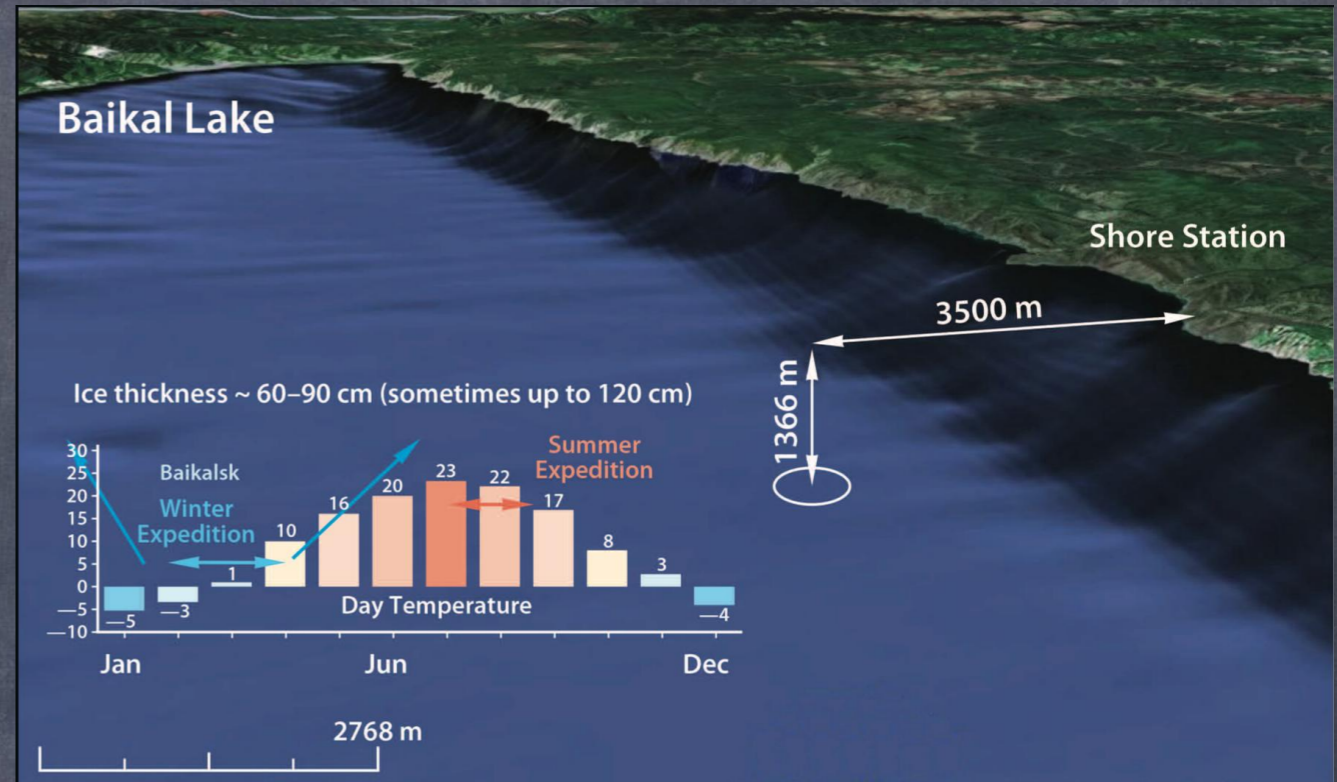


Why BAIKAL GVD?

- UHE neutrinos exist. Their sources are unknown. Angular accuracy does not allow yet to identify the sources

Experiment	Absorption Length, m	Scattering Length, m	Angular resolution muons	Angular resolution showers	Dark Rate, kHz
IceCube	40-150	0.4-2.4	0.5-1°	15°	0.3-0.6
KM3NET	50-70	30-60	0.2°	2°	30
BAIKAL GVD	22-25	30-50	0.3-0.5°	2-3°	15

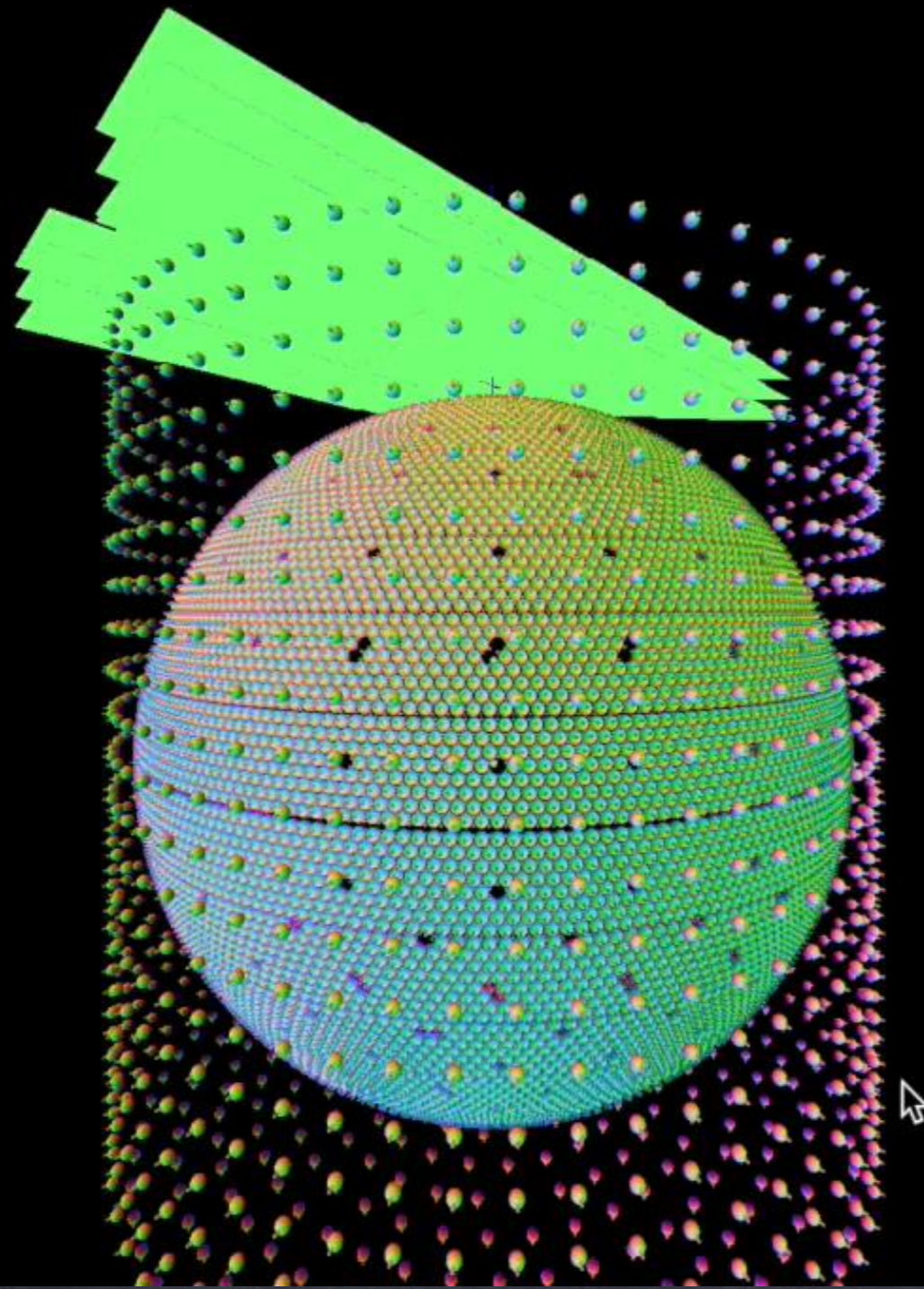
BAIKAL Gigaton Volume Detector



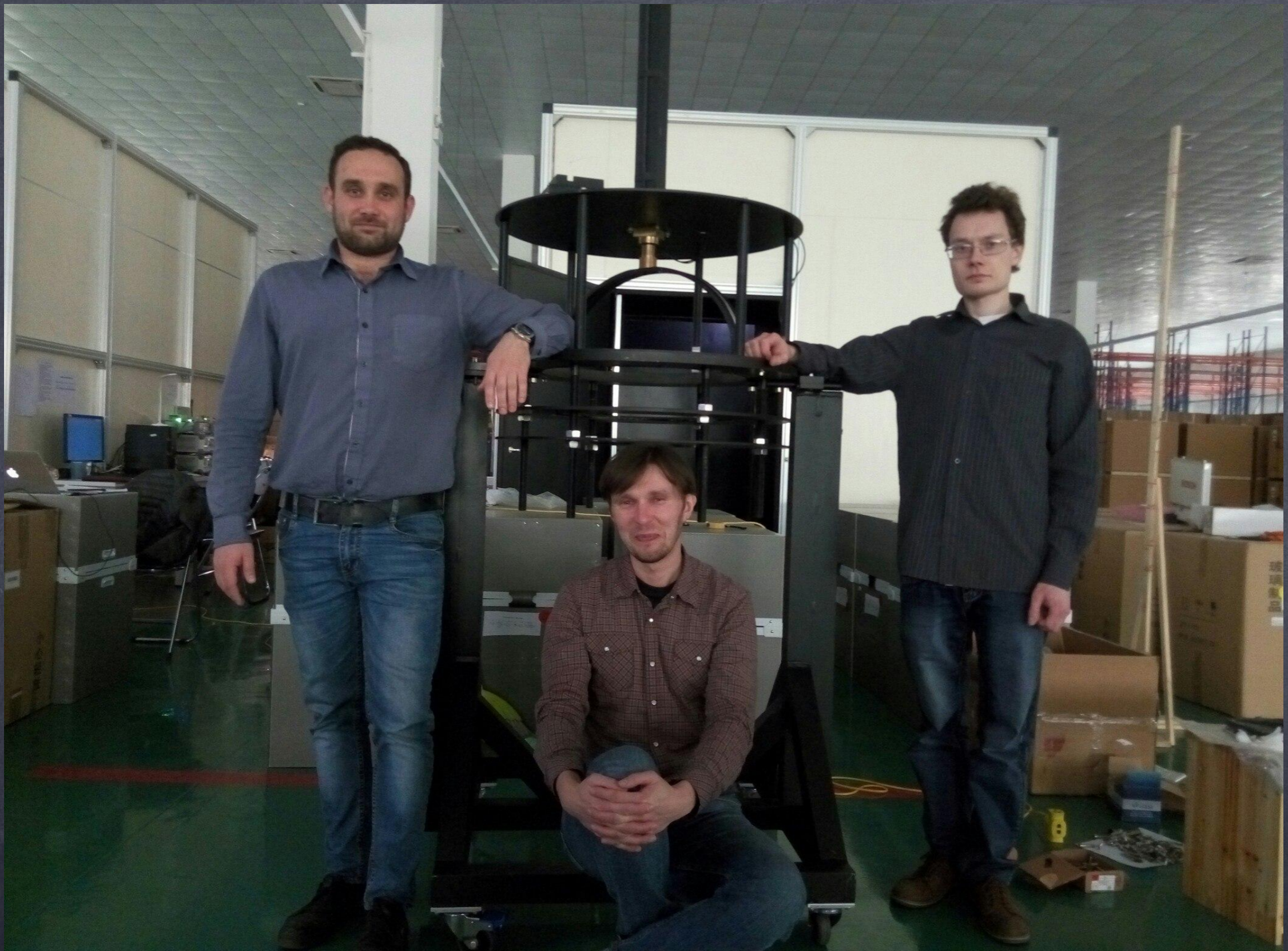
BAIKAL Gigaton Volume Detector



2018: Three clusters installed



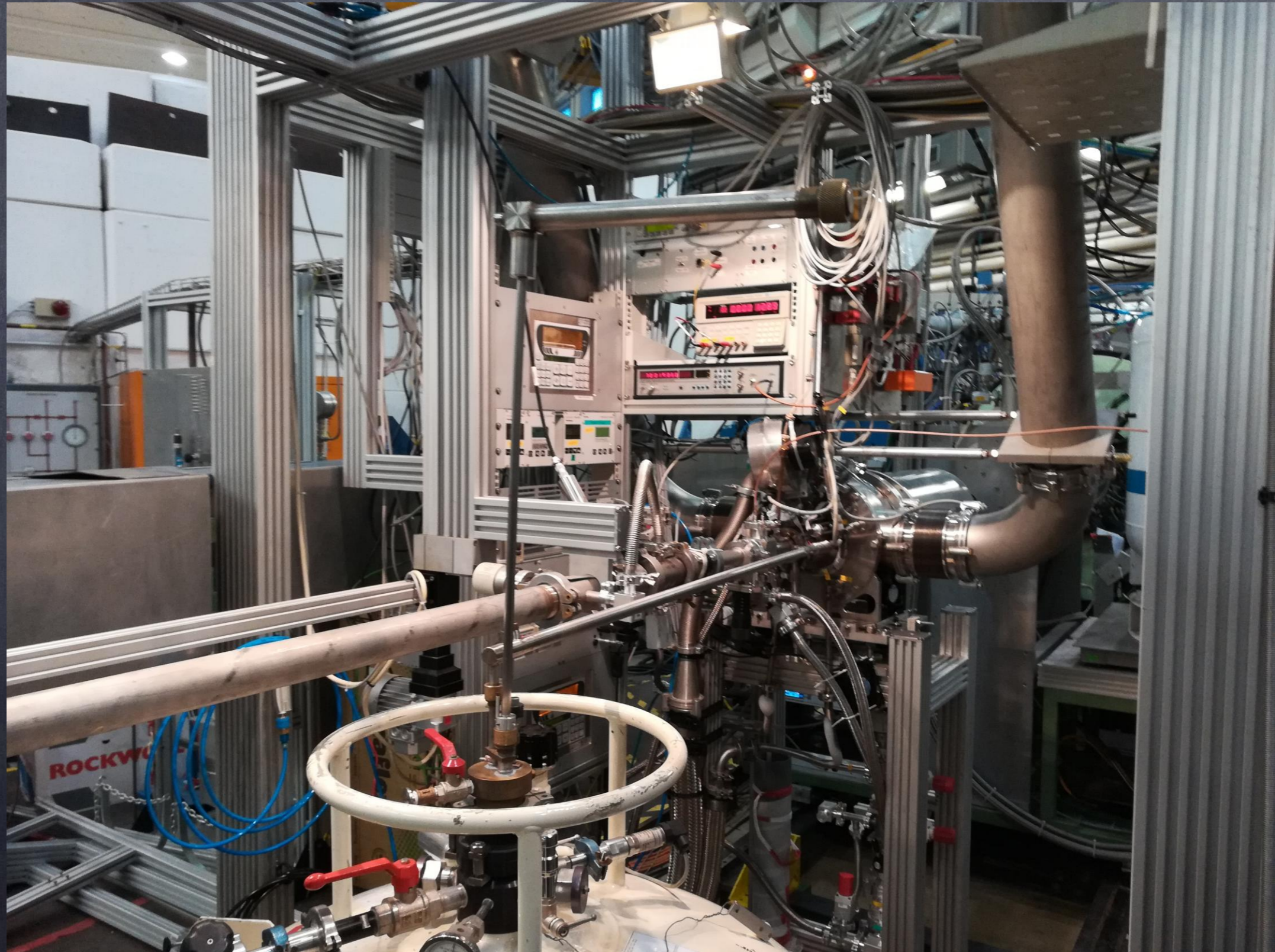
JINR is a major foreign contributor to
JUNO.



PMT Scanning Stations

And its team

Ultracold temperatures



Education & Outreach



We organize

- International Pontecorvo School on Neutrino Physics
- International Baikal Summer School on Physics of Elementary Particles and Astrophysics
- New Trends in High Energy Physics
- NANP
- Valday



Ren
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