BAIKAL GVD*

Neutrino Telescope

*GVD = Gigaton-volume-detector

Status Report

May 6, 2020

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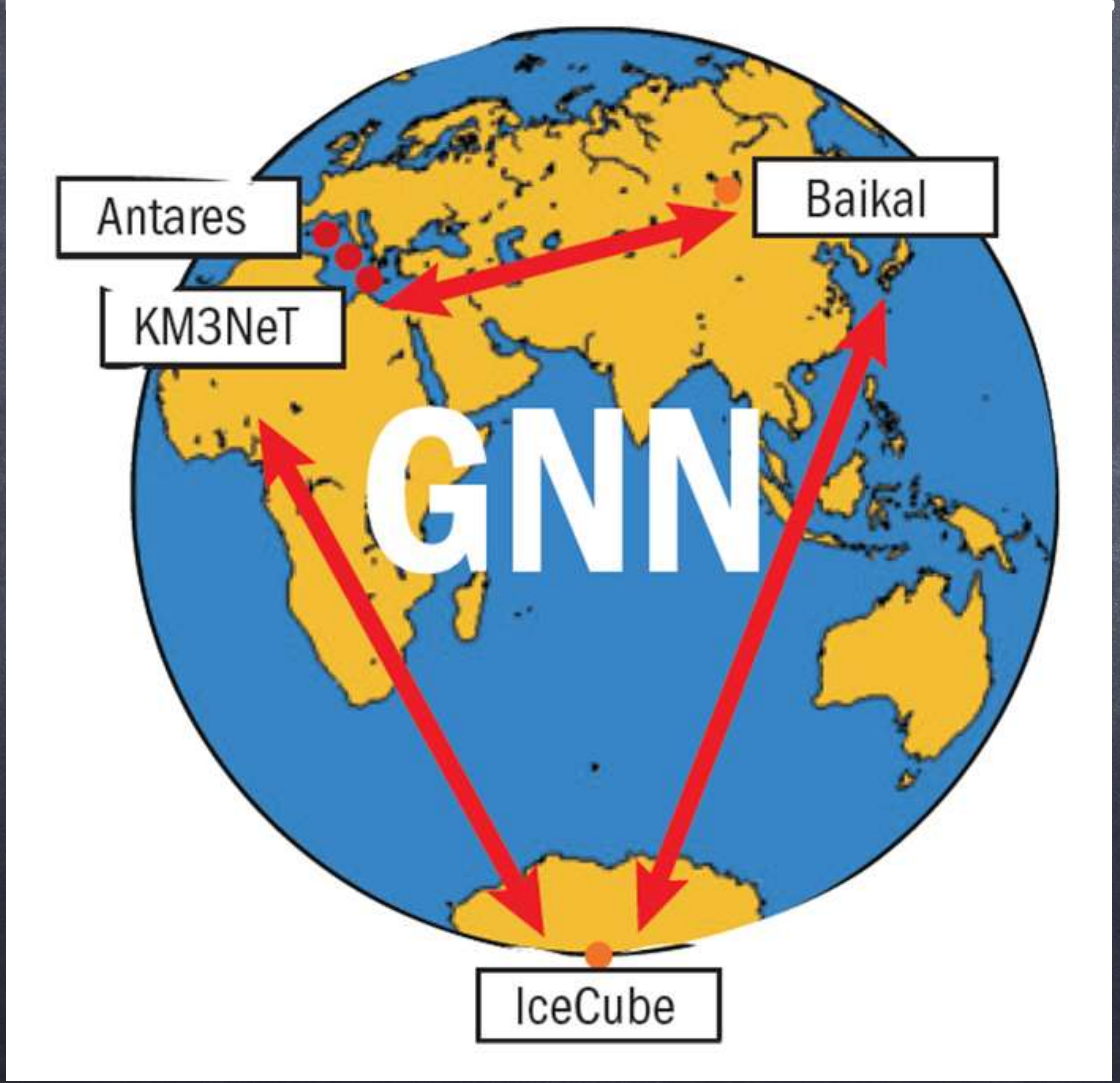
JINR, Dubna

Major motivations

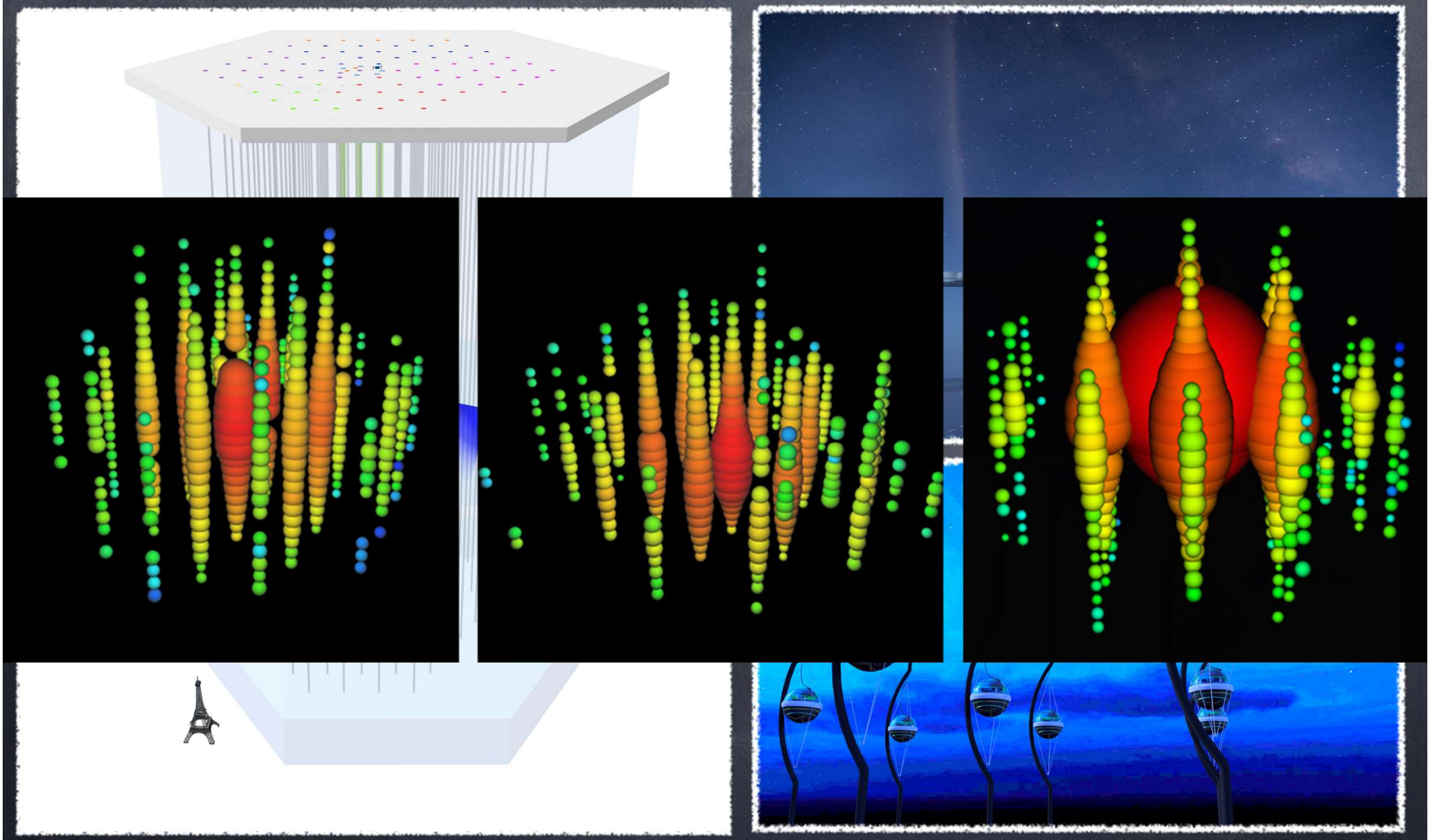
- Exploration and study of the Universe Evolution with ultra-high energy neutrino
- Sources of ultra-high energy particles

Neutrino Telescopes worldwide

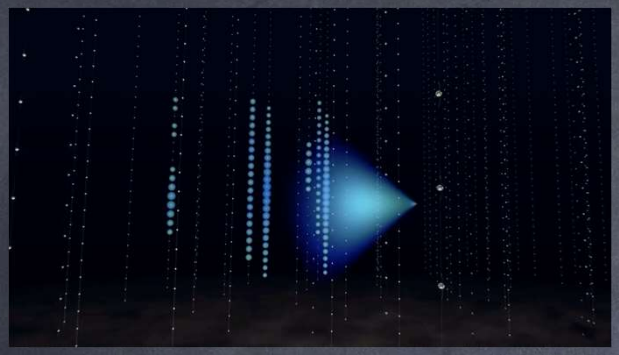
Global Neutrino Network



Solar, SN1987A … and finally astrophysical neutrinos @IceCube



Detection principles



Neutrino interactions

Muon track (ν_μ CC)

Shower e,τ, hadrons in CC & NC

Cherenkov light

δ(ln E_μ) = 0.25 Energy resolution δ(E_{sh}) = 0.1-0.2

$\delta\theta$ = 0.3-0.5° Angular resolution $\delta\theta$ = 2-3°

Why BAIKAL?

Light re-scattering in ice is large

Why BAIKAL?

Light re-scattering in BAIKAL water is small

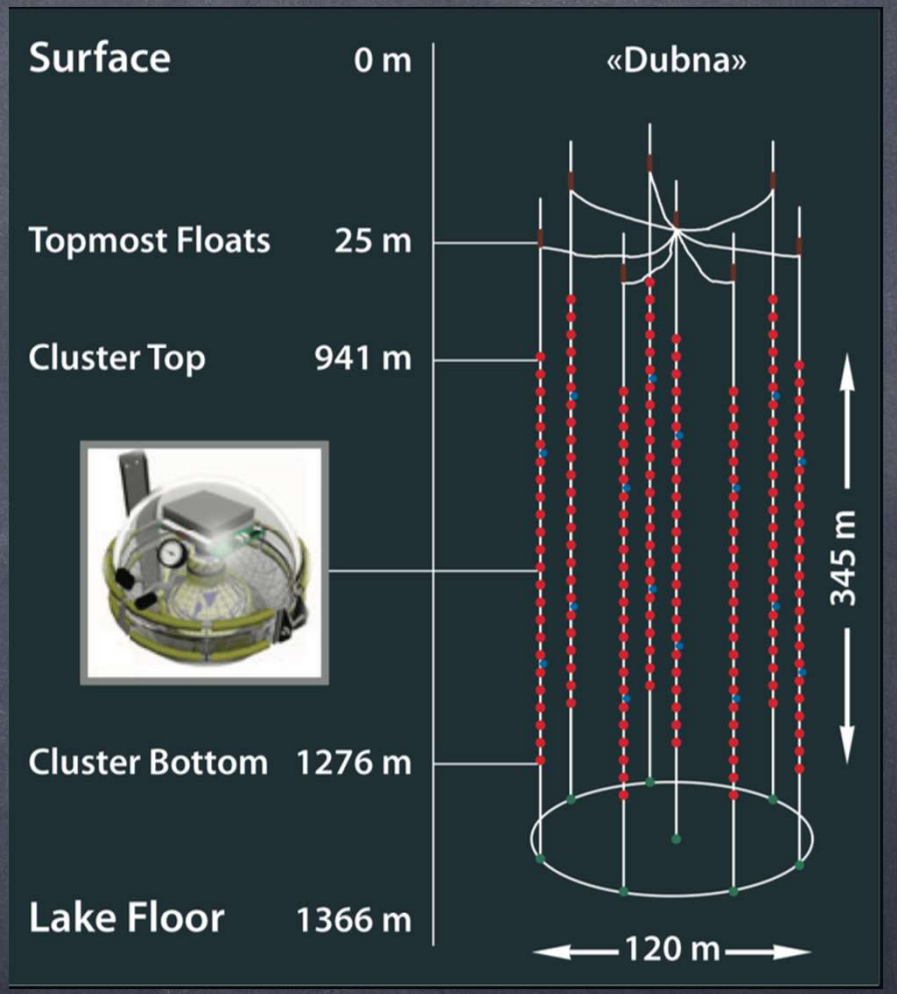
Why BAIKAL?

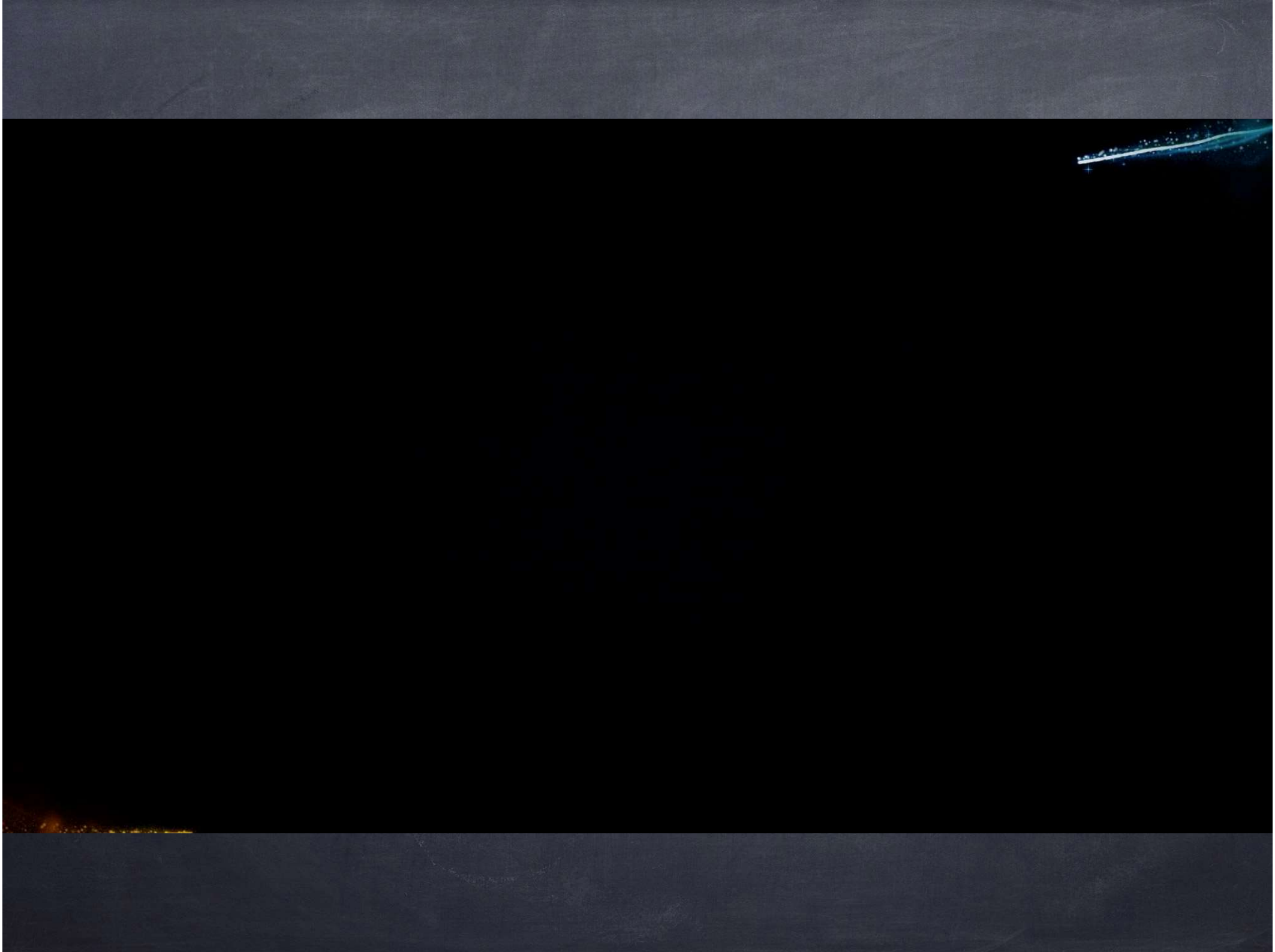
Experiment	Absorption Length, m	Scattering Length, m	Angular resolution muons	Angular resolution showers	Dark Rate, kHz
IceCube	40-150	0.4-2.4	0.5-1°	15°	0.3-0.6
KM3NET	50-70	30-60	0.2°	2°	30-50
BAIKAL GVD	22-25	30-50	0.3-0.5°	2-3°	15-30

Sensitivity to Galaxy Center

The Plan

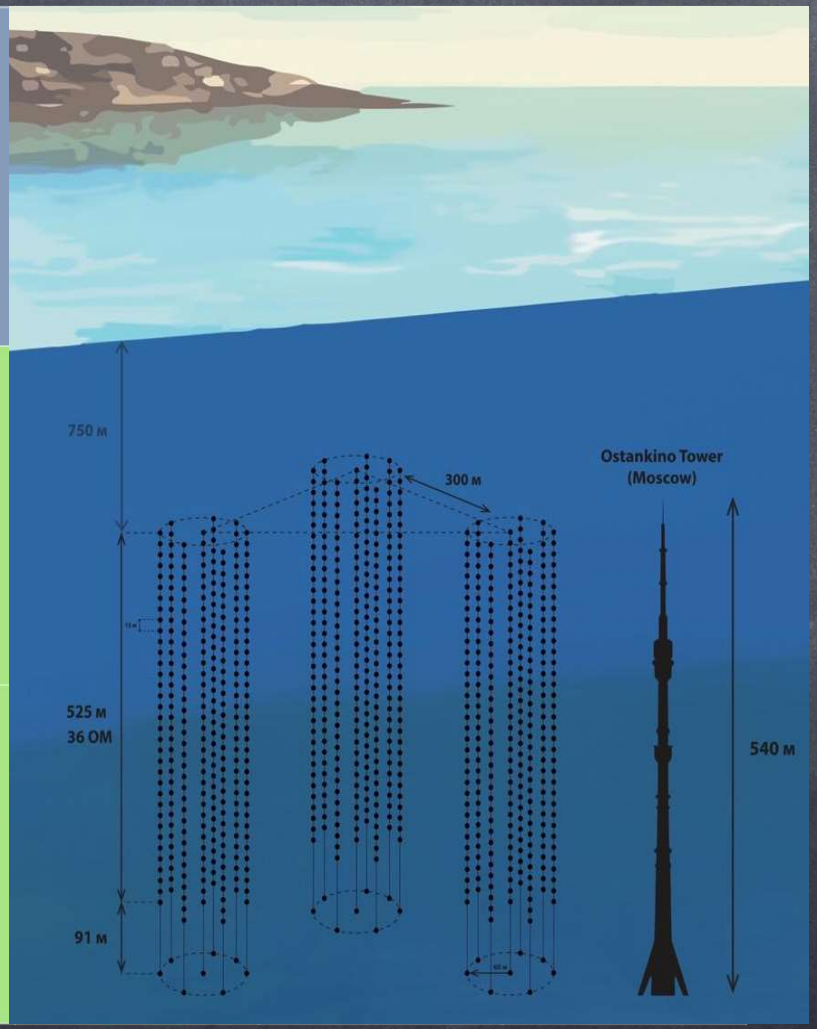
- Main Goal
  - Point sources of UHE neutrino
- 3D Array of photo-sensors
  - Phase I: 0.45 km3 (by 2021)
  - Phase II: 1.35 km3 (by 2027)
- Installation site
  - South Baikal
  - Depth 1.4 km
  - Distance from shore 3.5 km
- Requirements
  - Adjustable structure
  - Synchronization < 1ns





Deployment status

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



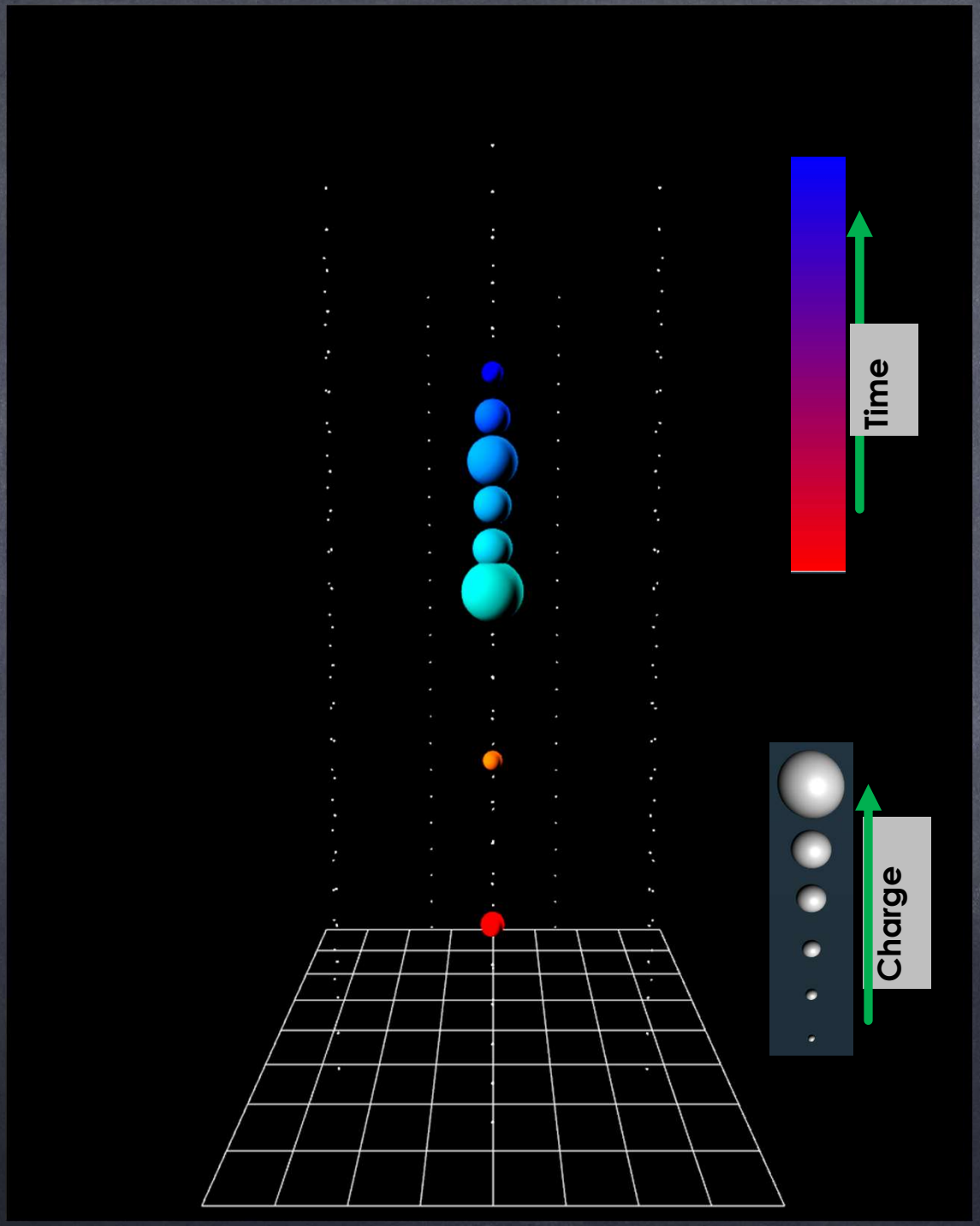
argest Neutrino Telescope in Northern hemisphere

What, where, when

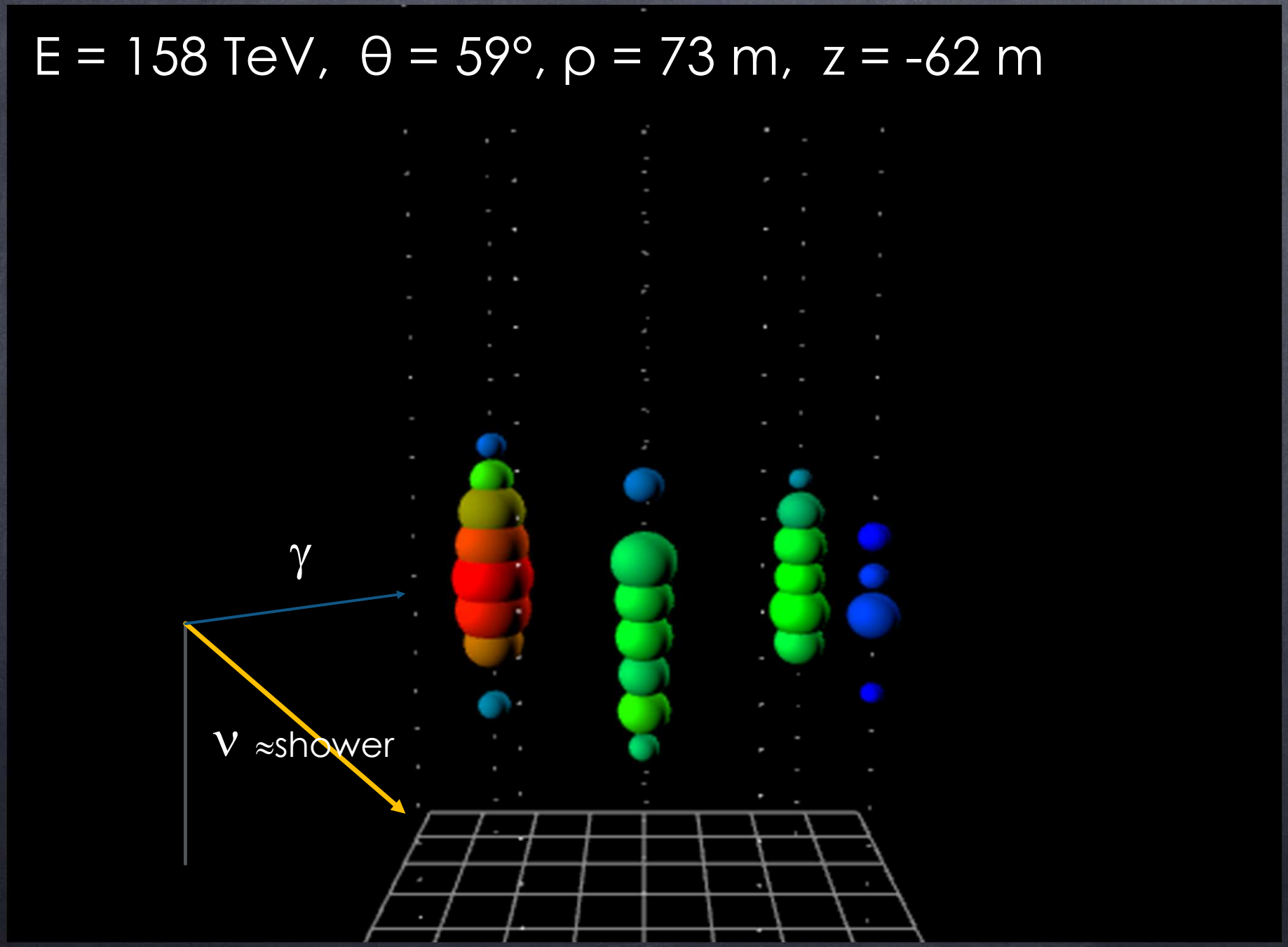
- Baikal Neutrino Telescope to explore the Universe
- Largest in the Northen Hemisphere.
  - Soon reaching the IceCube size
  - Better angular resolution —> better identification of sources
- The international collaboration lead by INR (Moscow) and JINR (Dubna)
- Milestones:
  - 2021: 0.45 km3
  - 2027: 1.35 km3

Physics

#3101111 - ν candidate

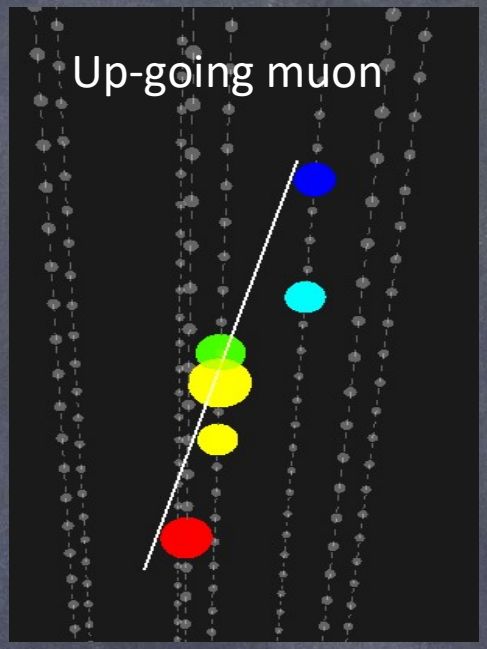


Neutrino candidate



Spectacular events

Neutrino signals



Backgroun
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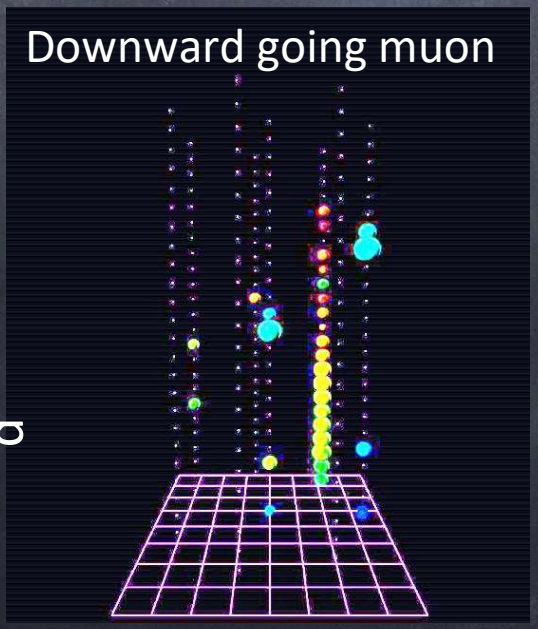
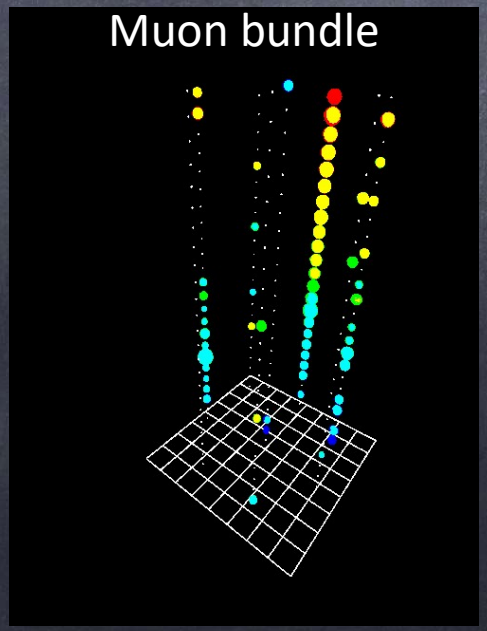
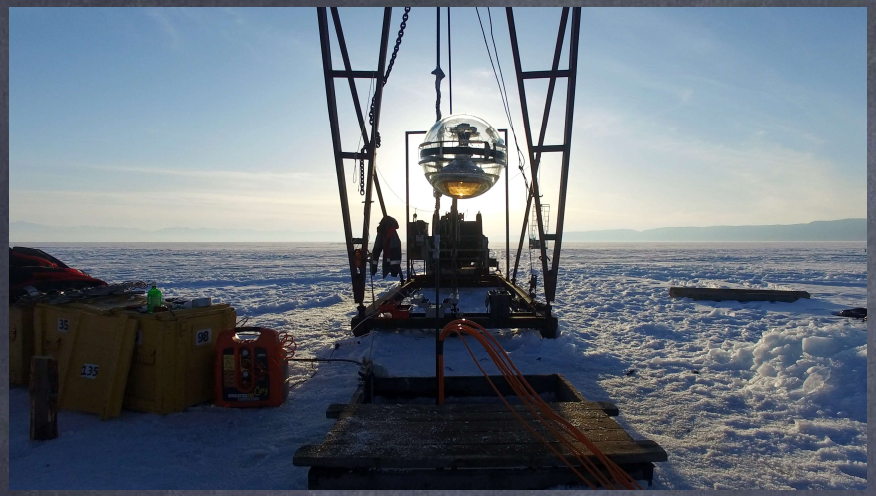
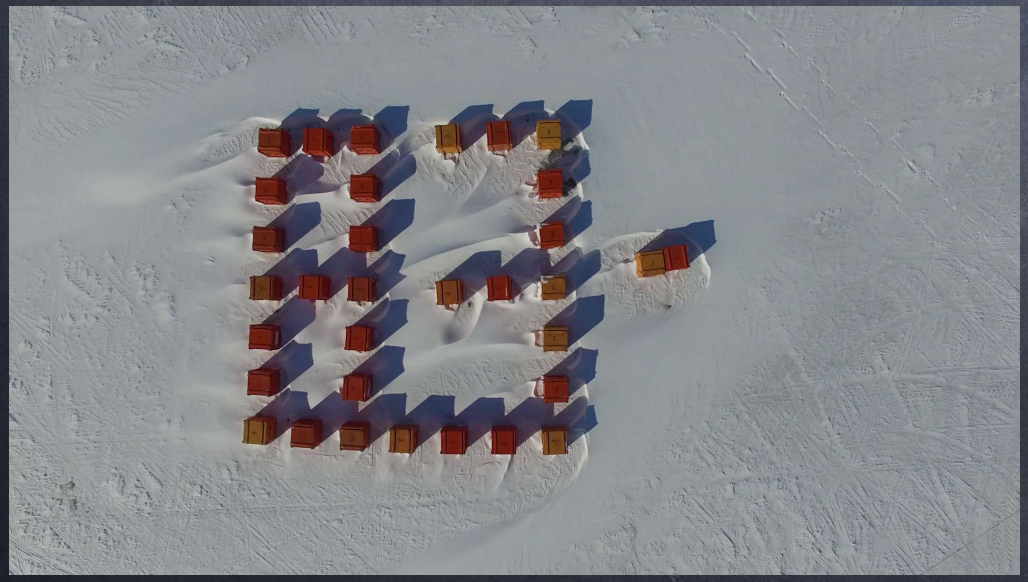




The most romantic experiment ever



Women's day!



Way for lunch

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

BAIKAL Collaboration

65 physicist & Engeneers

1. Institute for Nuclear Research, Moscow, Russia
2. Joint Institute for Nuclear Research, Dubna, Russia
3. Irkutsk State University, Irkutsk, Russia
4. Skobeltsyn Institute of Nuclear Physics MSU, Moscow, Russia
5. Nizhny Novgorod State Technical University, Russia
6. Saint Petersburg State Marine University, Russia
7. Institute of Experimental and Applied Physics, Czech Technical University, Prague, Czech Republic
8. Comenius University, Bratislava, Slovakia
9. EvoLogics GmbH, Berlin, Germany
10. Krakow Institute of Nuclear Physics PAN, Poland

2c. Facility uniqueness: hardware and adjacent research opportunities

Baikal-GVD possesses a set of unique, purpose-designed components that includes:

1. A network of hydroacoustic positioning devices.
2. Impulse light sources.
3. Hardware for measuring hydrological and optic properties of the Baikal water.
4. Hardware for measuring variation in the natural electric fields.

These instruments are used by Russian and foreign organizations for their own research under the umbrella of the Baikal Neutrino Observatory. Besides its primary function as a neutrino detector, Baikal-GVD provides a unique opportunity for research in hydrology, limnology, geophysics, hydrooptics, hydroacoustics and hydrobiology.

3. Facility access

The collaboration researchers have all means of access to the facility:

1. Winter expeditions provide researchers with direct access to the underwater hardware and to the shore facilities.
2. The detector is operated by a shifter from the shore station via a 6 km underwater optoelectric cable. Shifters live on the shore station and have a 24/7 access over a period of their shift (typically, 3 weeks).
3. The shore station is located on the shore of Lake Baikal, next to a railway stop and is available by a regular train service. Depending on a season, it can also be accessed by a car or a boat.
4. The shore station is connected to the internet via a radio link to the Baikalsk city. This allows for data transfer to the storage in JINR, Dubna, and for authorized personnel to access the detector and the shore station remotely.

4. Regulated access to the facility

Facility access procedures are regulated by:

1. The code of the Baikal Collaboration (the updated version will be approved in May - early June 2020 and will be published on the websites of the INR RAS (www.inr.ru), JINR and other members of the collaboration).
2. Access and services regulations of the Center for Collective Use "Baikal Neutrino Observatory" (published on www.inr.ru and www.inr.ac.ru)
3. Direct contracts and agreements with the head institute of the collaboration (INR RAS).

The facility does not provide open access to the general public.

5. Procedures and internal access policies for external users, availability of special type visa

1. Foreign users can apply for a special long-term research visa through the Joint institute for Nuclear Research (JINR) in Dubna . JINR is a full member of the Baikal-GVD project.
2. The list of long-term collaboration members includes researchers from Czech Republic, Slovakia, Poland and Germany.
3. The project is dedicated to the policy of attracting both domestic and foreign talent.

6. Main users of the facility

1. Head institute: Institute for Nuclear Research of the Russian Academy of Sciences.
2. Joint Institute for Nuclear Research.
3. Irkutsk State University
4. Nizhny Novgorod State Technical University n.a. R.E. Alekseev

Foreign organizations:

1. Institute of Experimental and Applied Physics of the Czech Technical University in Prague
2. Faculty of Mathematics, Physics and Informatics of the Comenius University in Bratislava
3. The Institute of Nuclear Physics of the Polish Academy of Sciences (IFJ PAN) in Kraków
4. EvoLogics Gmbh, (Berlin)

7a. Cooperation with the European RI facilities

Baikal-GVD has a consistent history of cooperation with European neutrino telescopes, ANTARES and KM3Net:

1. Principal researchers of the European detectors have a permanent seat on the technical advisory board for Baikal-GVD.
2. Members of European collaborations are frequently invited to the collaboration meetings and workshops.
3. JINR regularly organizes international internships and schools for astrophysics, data analysis and other areas.

7b. Cooperation with the European RI facilities

GNN
The Global Neutrino Network

Baikal-GVD is a founding member of the Global Neutrino Network (GNN) - a collaboration of large volume neutrino detectors that includes members from United States (IceCube) and Europe (ANTARES and KM3Net). Following GNN memorandum, it has the goal of developing a coherent strategy to maximize the synergistic effects of exchanging information, analysis methods and scientists, of cross-checking results, and of defining common ways of presenting data.

GNN provides:

1. Annual dissertation prize for young scientists.
2. Regular workshops and conferences: MANTS (Mediterranean Antarctic Neutrino Telescope Symposium) and VLVnT (Very Large Volume Neutrino Telescopes).
3. Monthly review of the news from collaboration members.

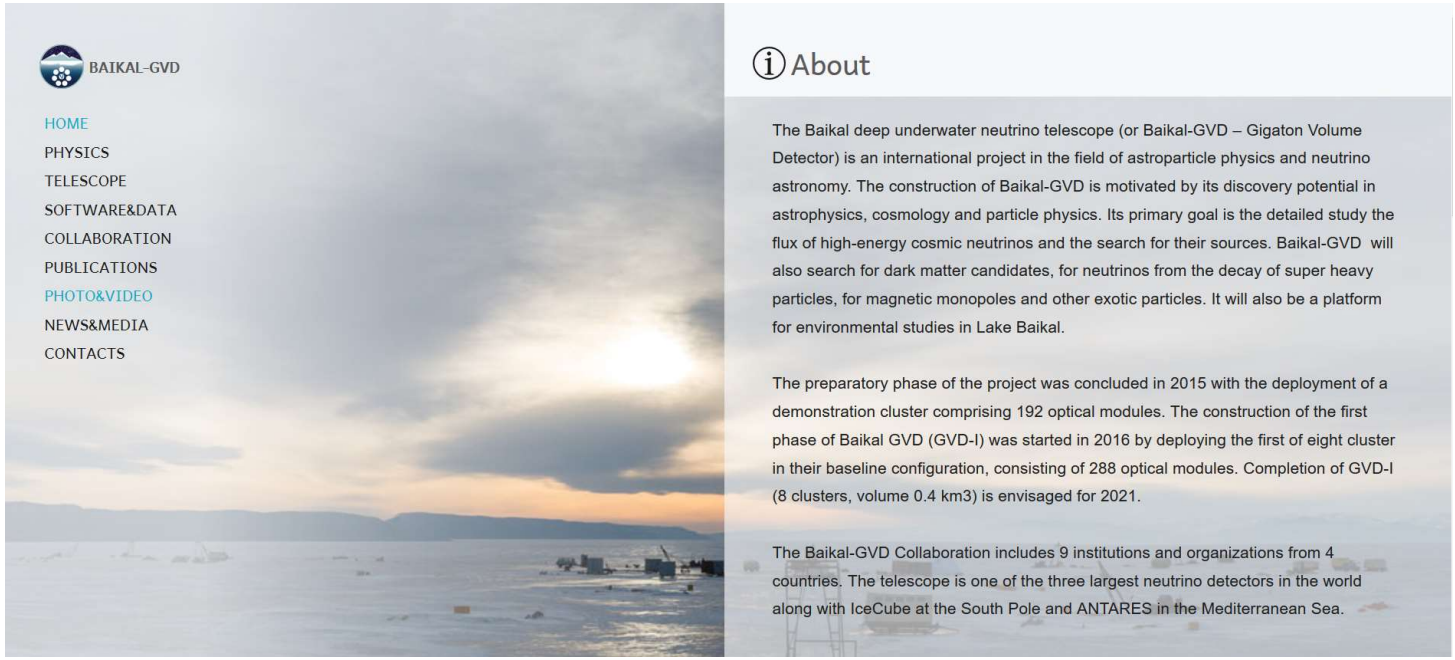
8. Brief analyses of the facility

Advantages of the facility were enumerated in sections 2a – 2c.

The primary venues for international collaboration are:

1. Data processing and visualization.
2. Unifying data formats among experiments and data sharing.
3. Developing new types of hardware for the next generation of neutrino detectors.
4. Hydrological, hydrooptic and hydroacoustic research.
5. Utilizing optical communications within clusters of Baikal-GVD
6. Advancing multi-messenger studies

9. Facility website screen shot and link



https://baikalgvd.jinr.ru

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