Dzhelepov Laboratory of Nuclear Problems

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

Science @DLNP

Neutrino Program

1. Baikal-GVD
2. SuperNEMO
3. GERDA-LEGEND
4. GEMMA (nuGEN)
5. DANSS
6. JUNO/DayaBay
7. NOvA/DUNE
8. BOREXINO
9. DsTAU
10. T2K

Particle Physics

1. ATLAS
2. BESIII/SCTF
3. MEG-II
4. SPD
5. COMPASS-AMBER
6. Mu2e
7. COMET
8. PANDA
9. ARIeL

Astroparticle

1. EDELWEISS-RICHOCHET
2. DarkSide
3. TAIGA

Nuclear Physics

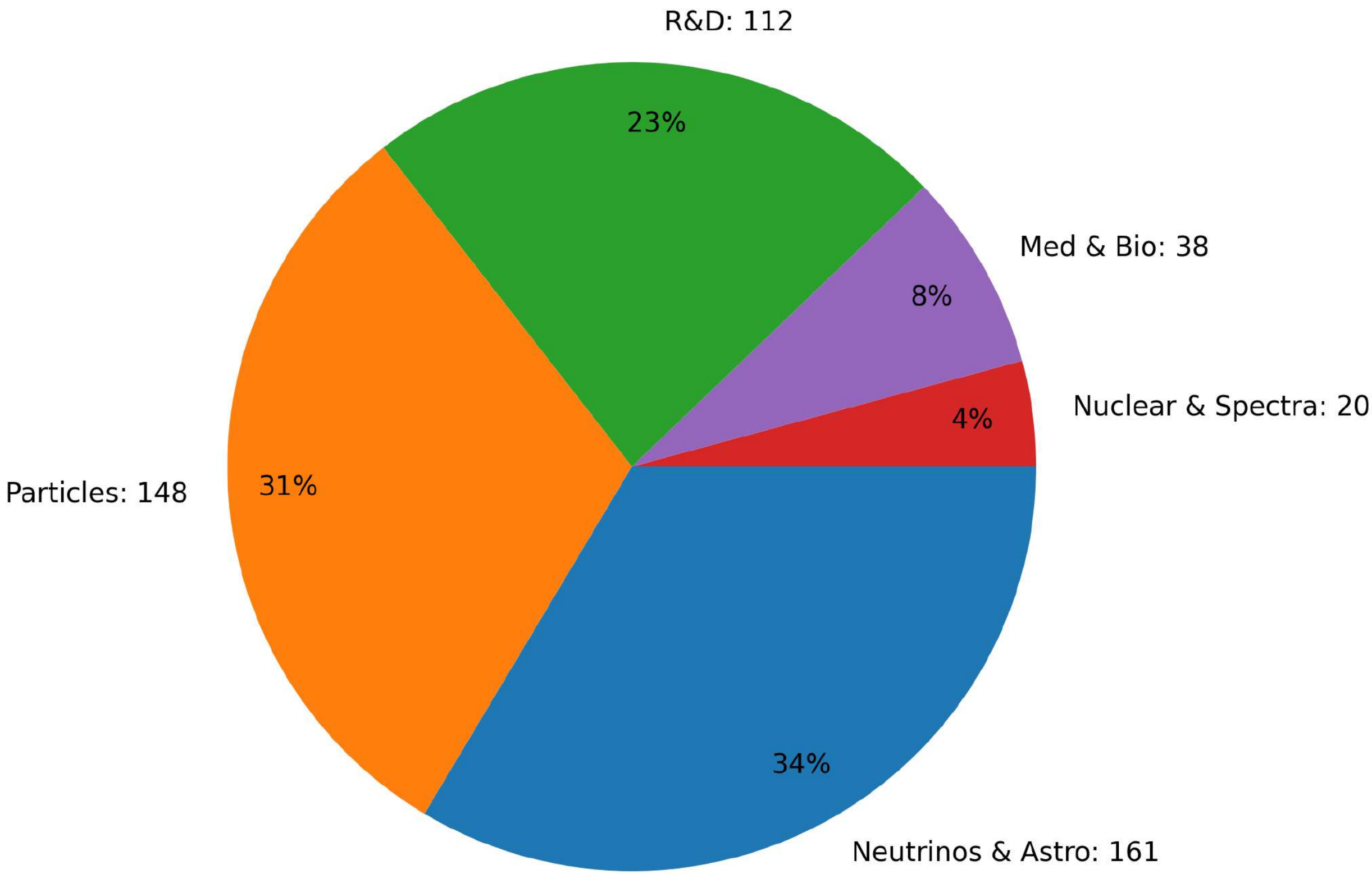
1. GDS-SPASCHARM
2. MONUMENT

Life Science

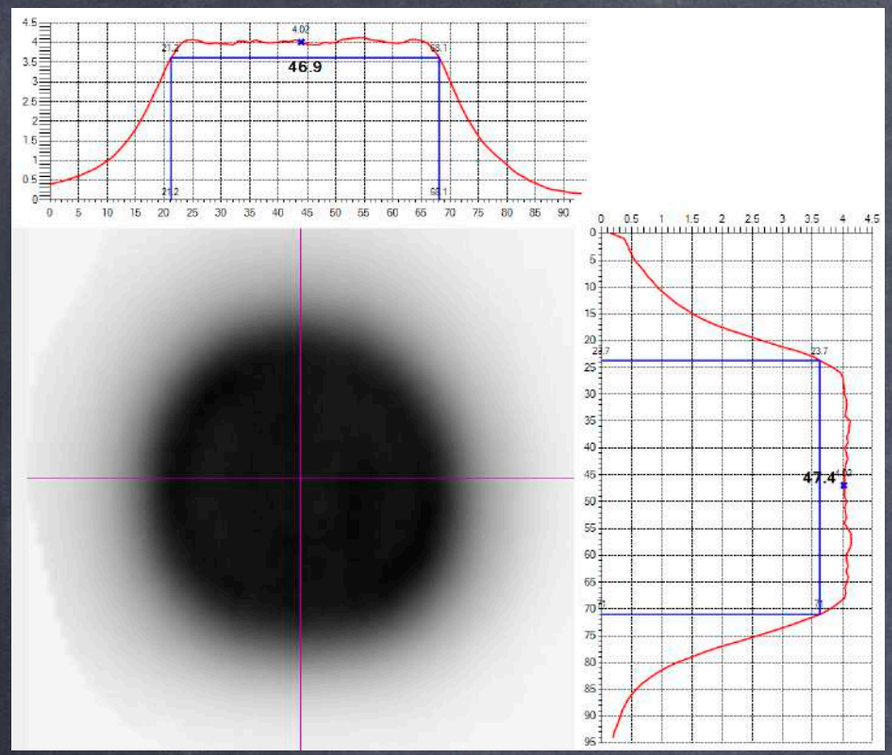
1. Proton Therapy
2. RADIOGEN
3. DSUP
4. MSC-230

Technologies

1.HPGe
2.Radichemistry
3. New SiPM
4. PLI
5. PAS
6.LINAC-200

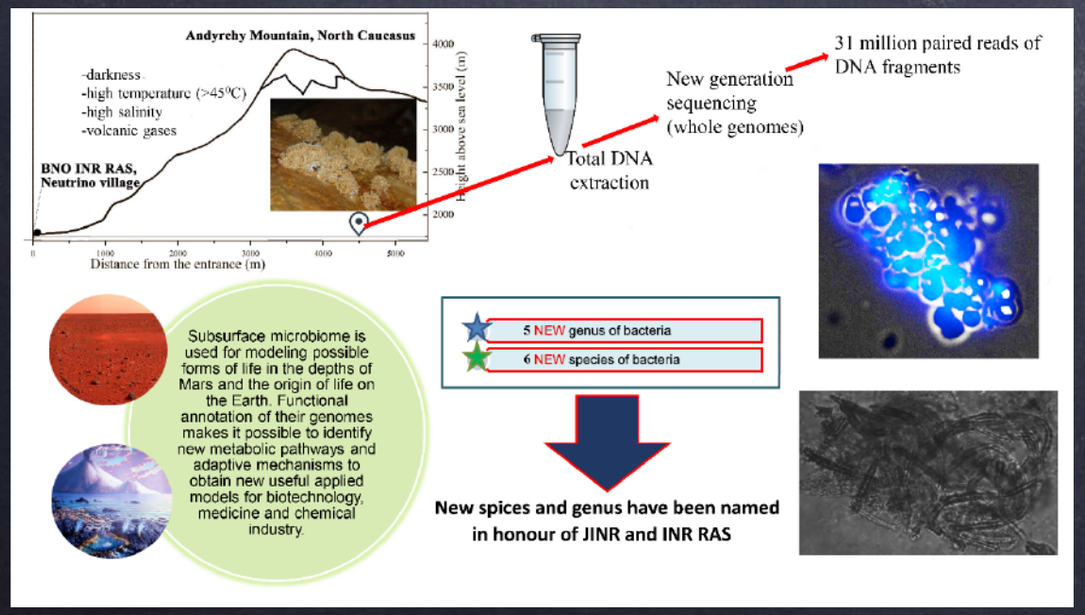

R&D: 112
23%
Med & Bio: 38
8%
Nuclear & Spectra: 20
4%
Particles: 148
31%
34%
Neutrinos & Astro: 161

Life Science

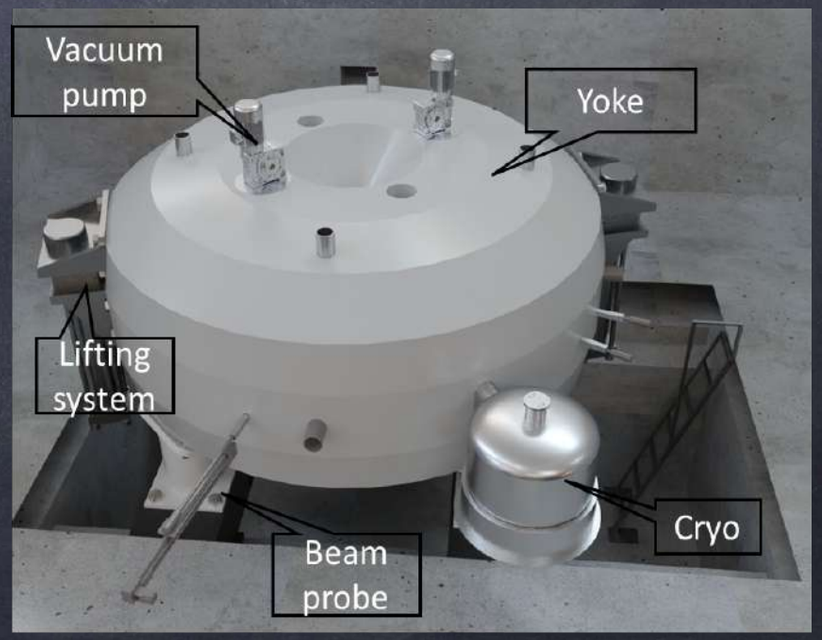


Proton beam profile (flash-therapy mode)

Radiogen



DSUP



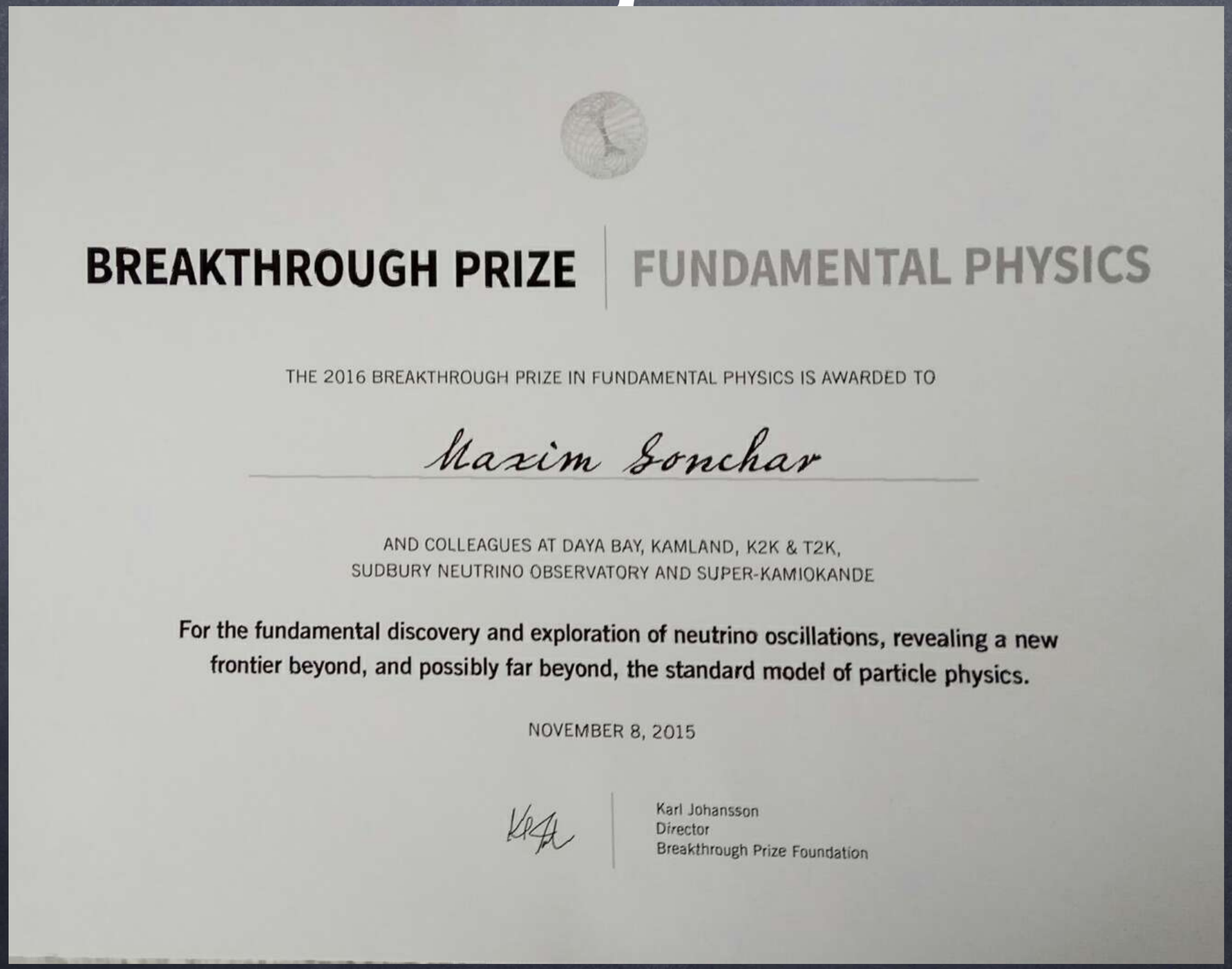
Neutrino Physics

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

Nobel Prizes for Neutrino Physics

- 1988. Discovery of muon neutrino.
- 1995. Discovery of electron antineutrino
- 2002. SN 1987A.
- 2015. 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 Sonchar

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

European Physical Society
PRIZE

The 2021 Giuseppe and Vanna Cocconi Prize

for an outstanding contribution to Particle Astrophysics and Cosmology

is awarded to the

Borexino Collaboration

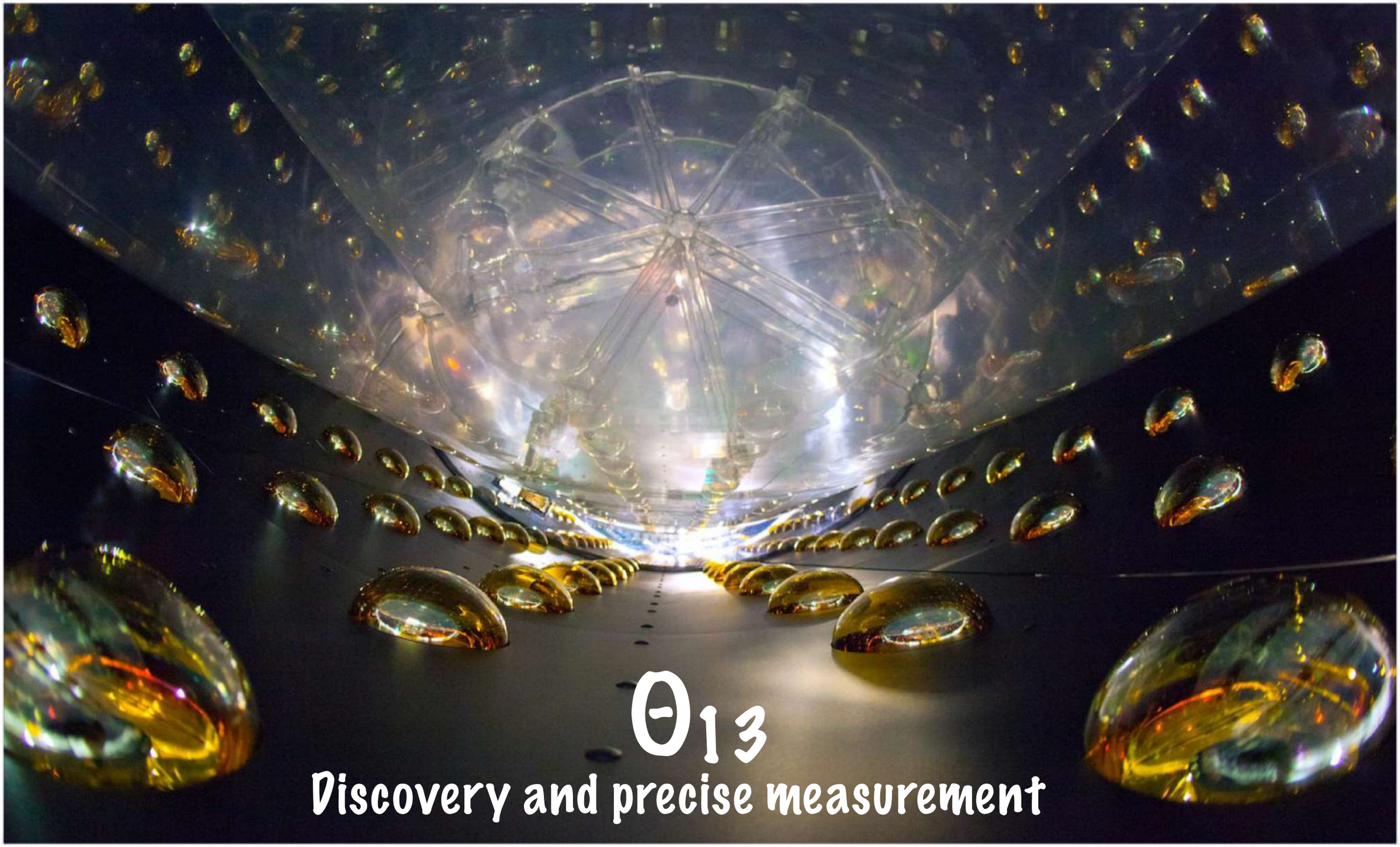
for their ground-breaking observation of solar neutrinos from the pp chain and CNO cycle that provided unique and comprehensive tests of the Sun as a nuclear fusion engine.

Luc Bergé
President
European Physical Society

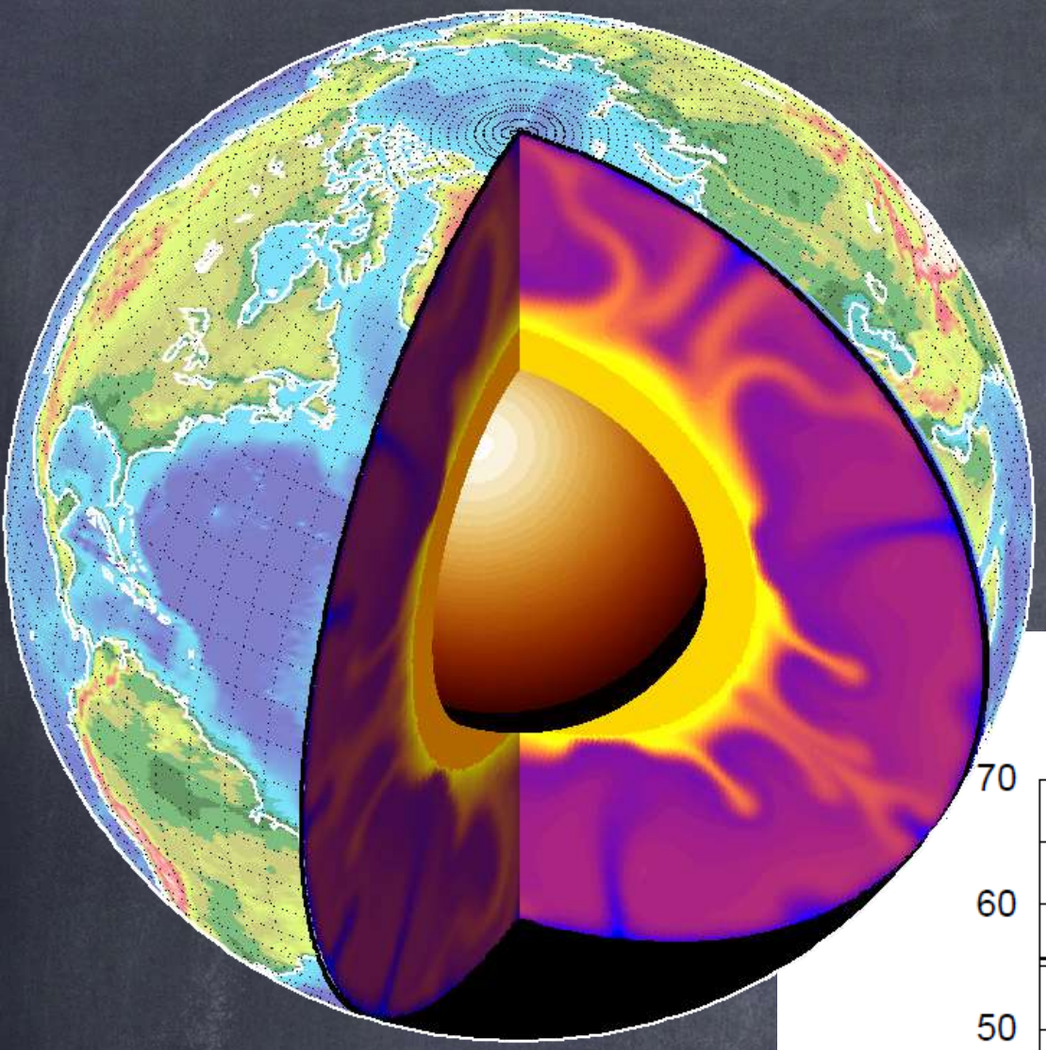
Thomas Gehrmann
Chair
EPS High Energy and Particle Physics Division

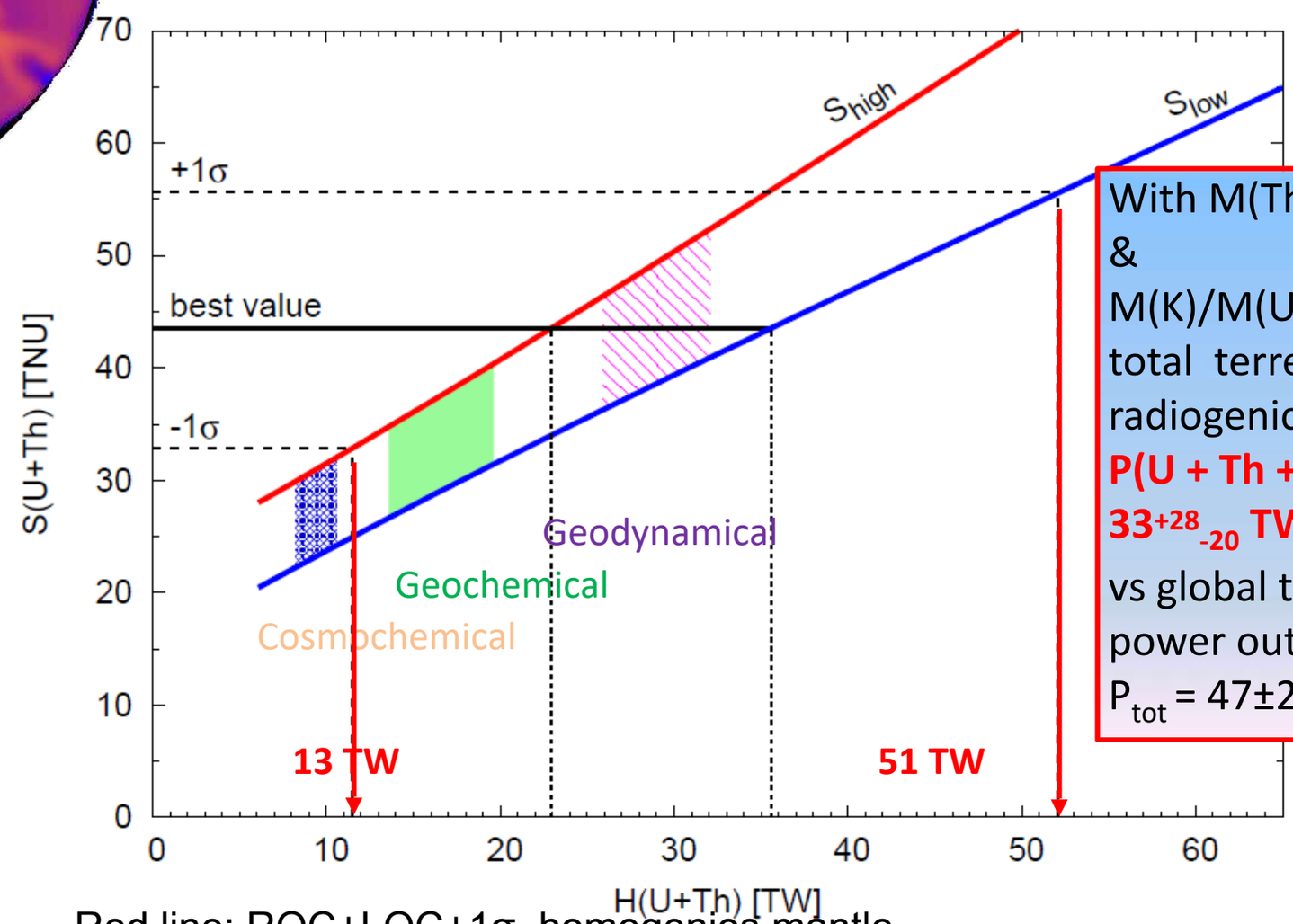
Mulhouse, France, 26 July 2021

Daya Bay experiment



Radiogenic heat: Borexino





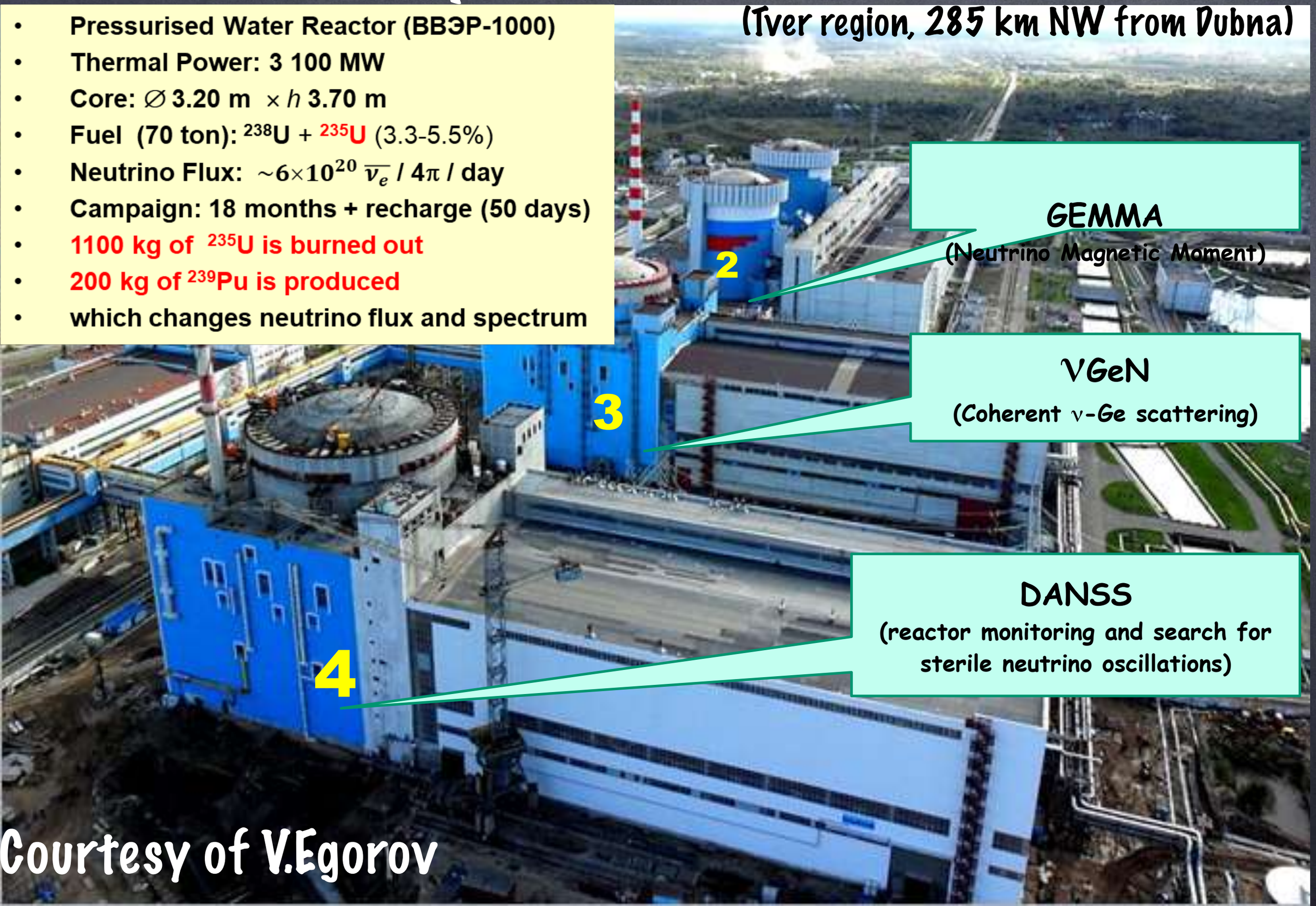
With M(Th)/M(U)=3.9 &
M(K)/M(U) = 10^4 the total terrestrial radiogenic power :
$P(U + Th + K) = 33^{+28}_{-20}$ TW,
vs global terrestrial power output
P_{tot} = 47±2 TW

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

Neutrino experiments at the Kalinin NPP

(Tver region, 285 km NW from Dubna)

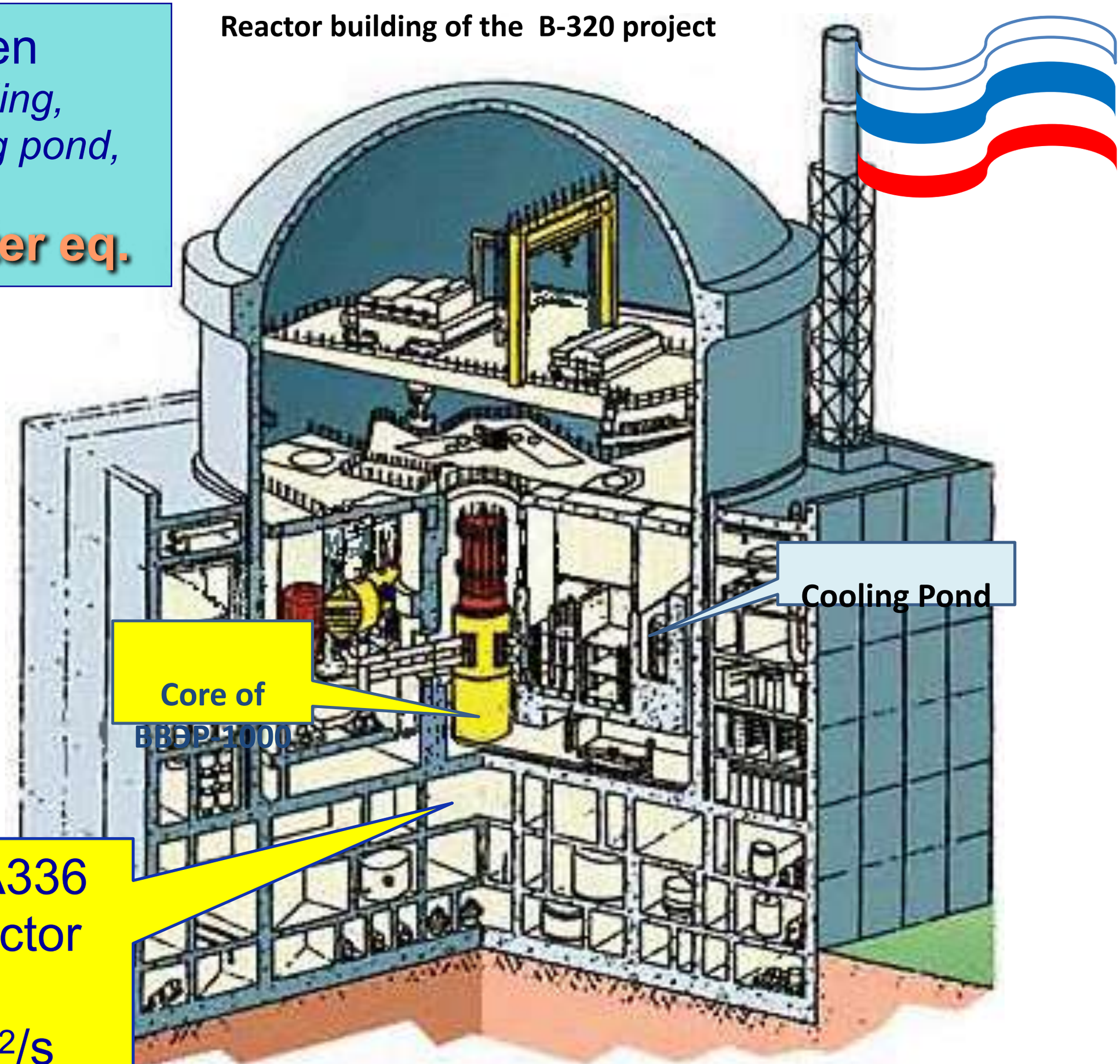
- Pressurised Water Reactor (ВВЭР-1000)
- Thermal Power: 3 100 MW
- Core: ∅ 3.20 m × *h* 3.70 m
- Fuel (70 ton): ^{238}U + ^{235}U (3.3-5.5%)
- Neutrino Flux: $\sim 6\times10^{20}\ \overline{\nu_e}$ / 4π / day
- Campaign: 18 months + recharge (50 days)
- 1100 kg of ^{235}U is burned out
- 200 kg of ^{239}Pu is produced
- which changes neutrino flux and spectrum



Courtesy of V.Egorov

Overburden
(reactor, building, shielding, cooling pond, etc.):
~50 m of water eq.

Reactor building of the B-320 project



Techn. room A336
just under reactor
9 m only!
5×10^{13} ν/cm²/s

BAIKAL GVD
Neutrino Telescope

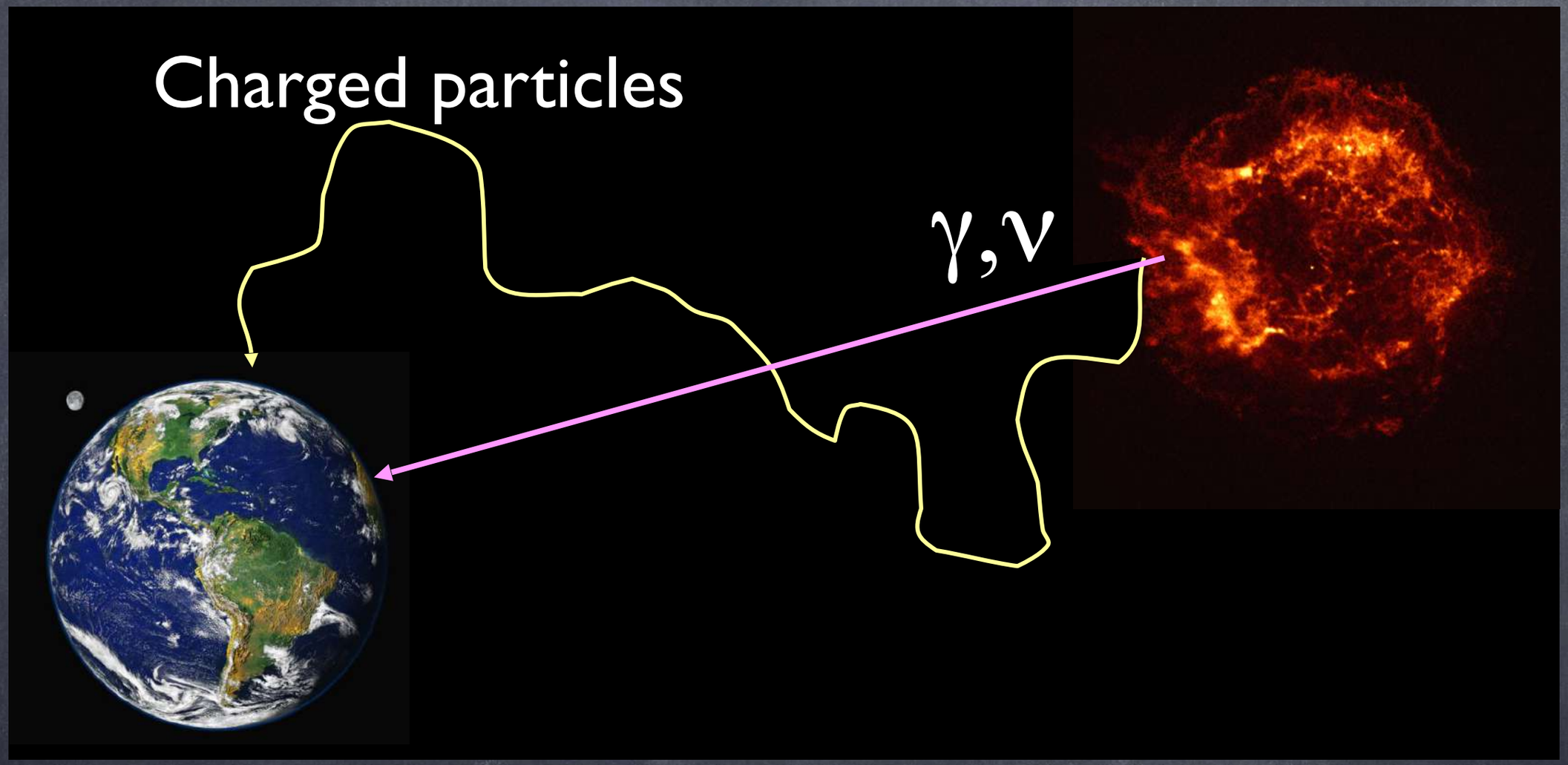
GVD = Gigaton-volume-detector

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?



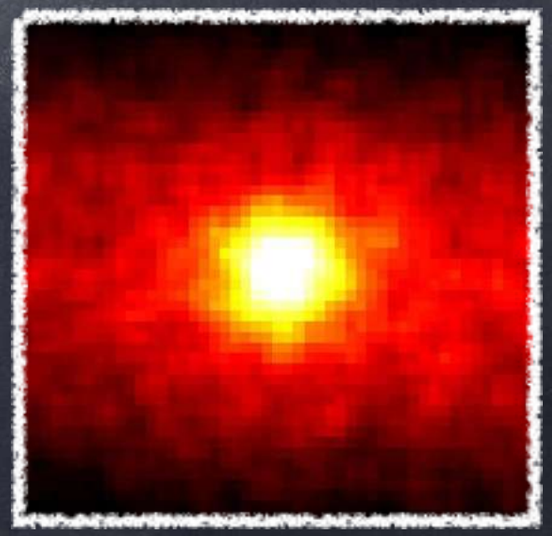
- Charged particles loose direction and energy
- Photons get absorbed
- Neutrino astronomy is possible because of weak interaction neutrino

There is no sunrise and sunset with neutrinos

https://www.youtube.com/watch?v=mu7lYTXP-hI

Image of Sun with Neutrinos by SuperKamiokande

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

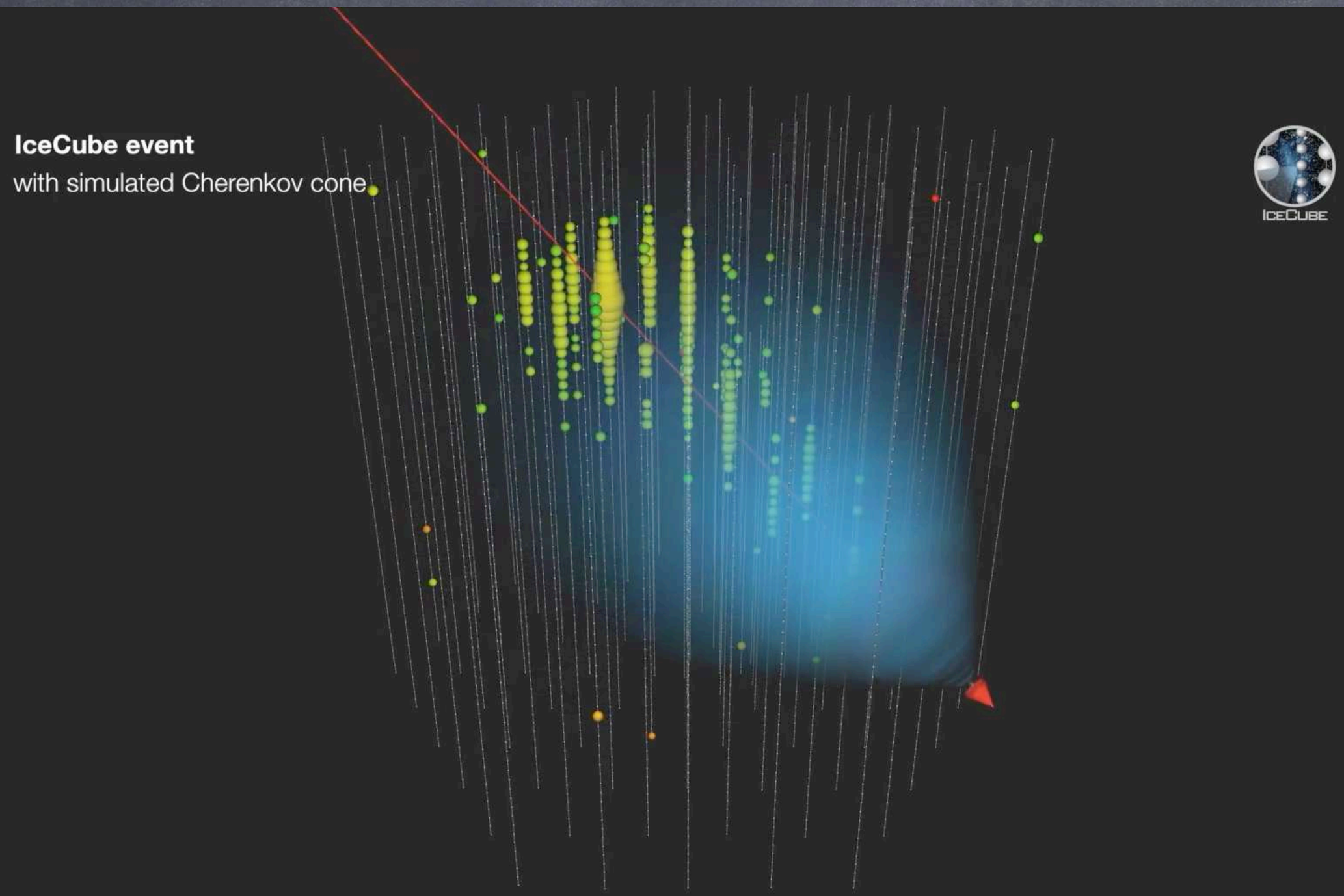


Short History of Neutrino Telescopes

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

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



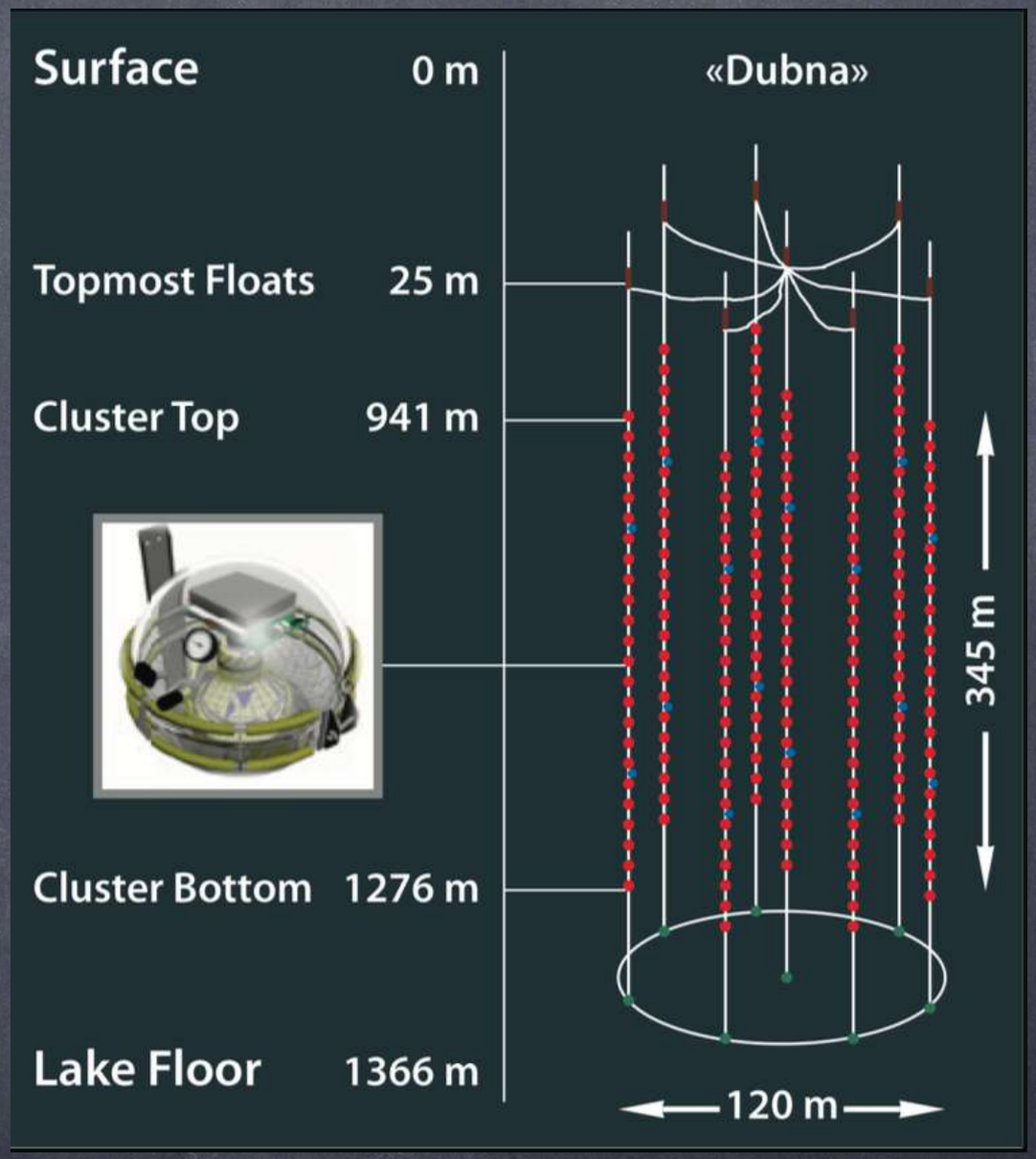
Why BAIKAL?

Accurate determination of arrival direction in BAIKAL water

Light re-scattering in ice is large

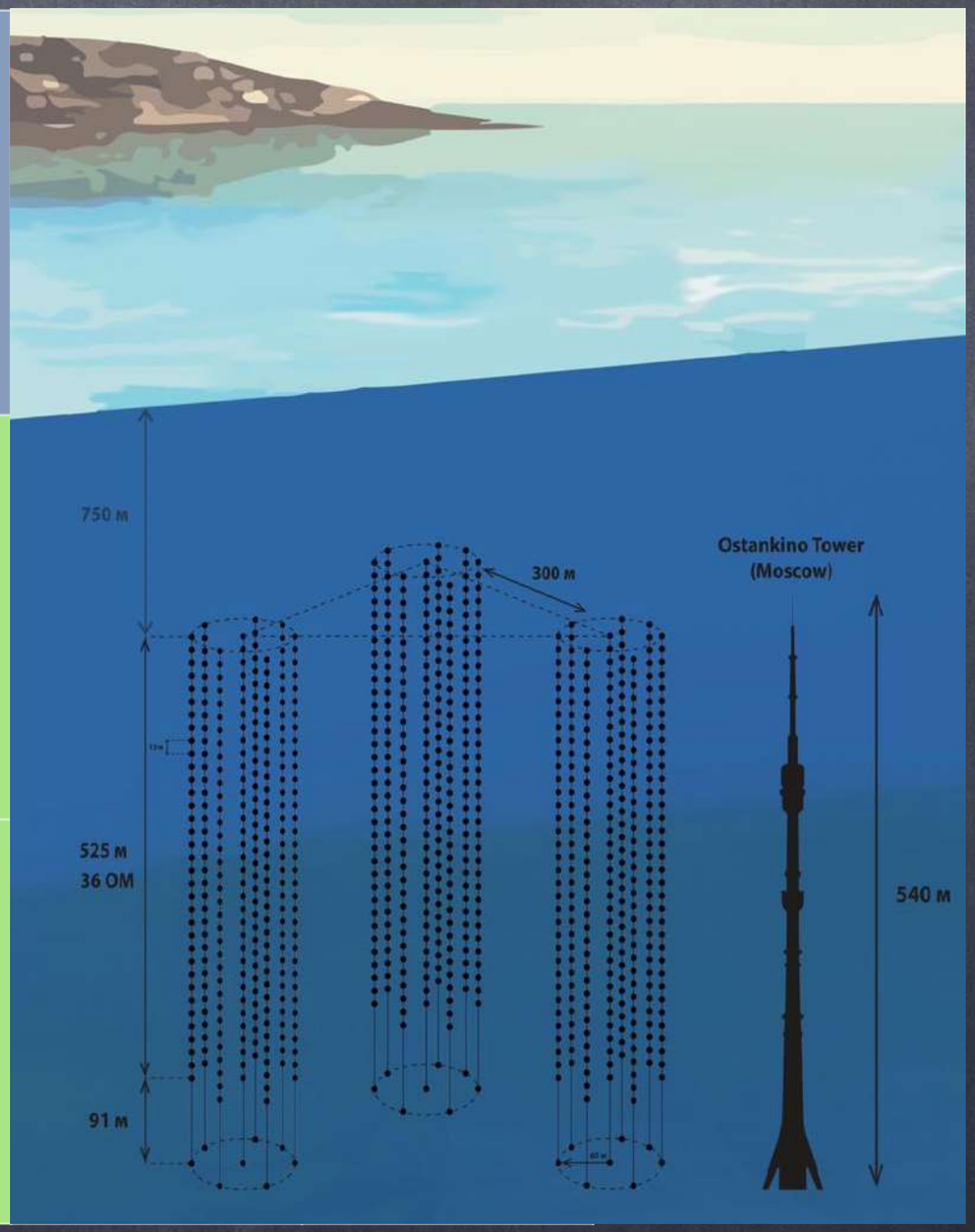
The Plan

- 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

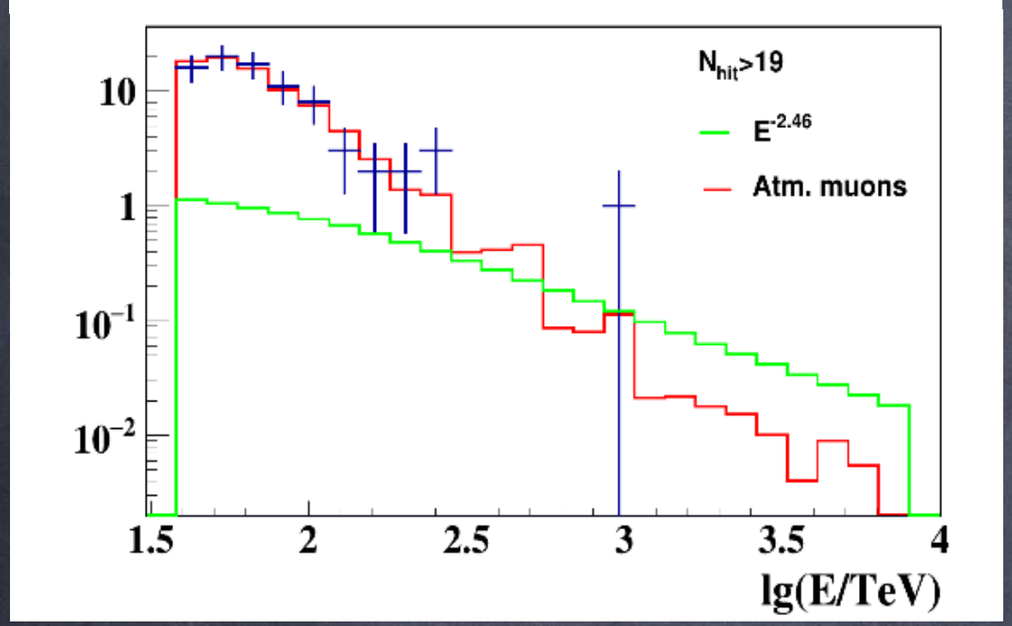
	2015	2016	2017	2018
Number of clusters	≤1	1	2	3
Number of OM	192	288	576	864



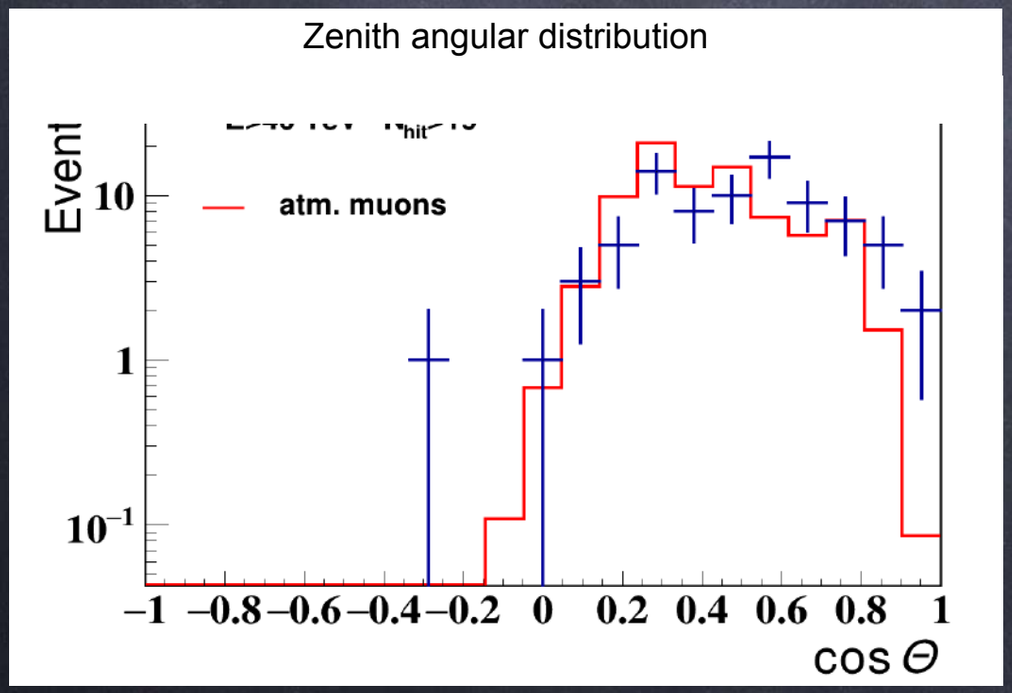
The largest Neutrino Telescope in Northern hemisphere

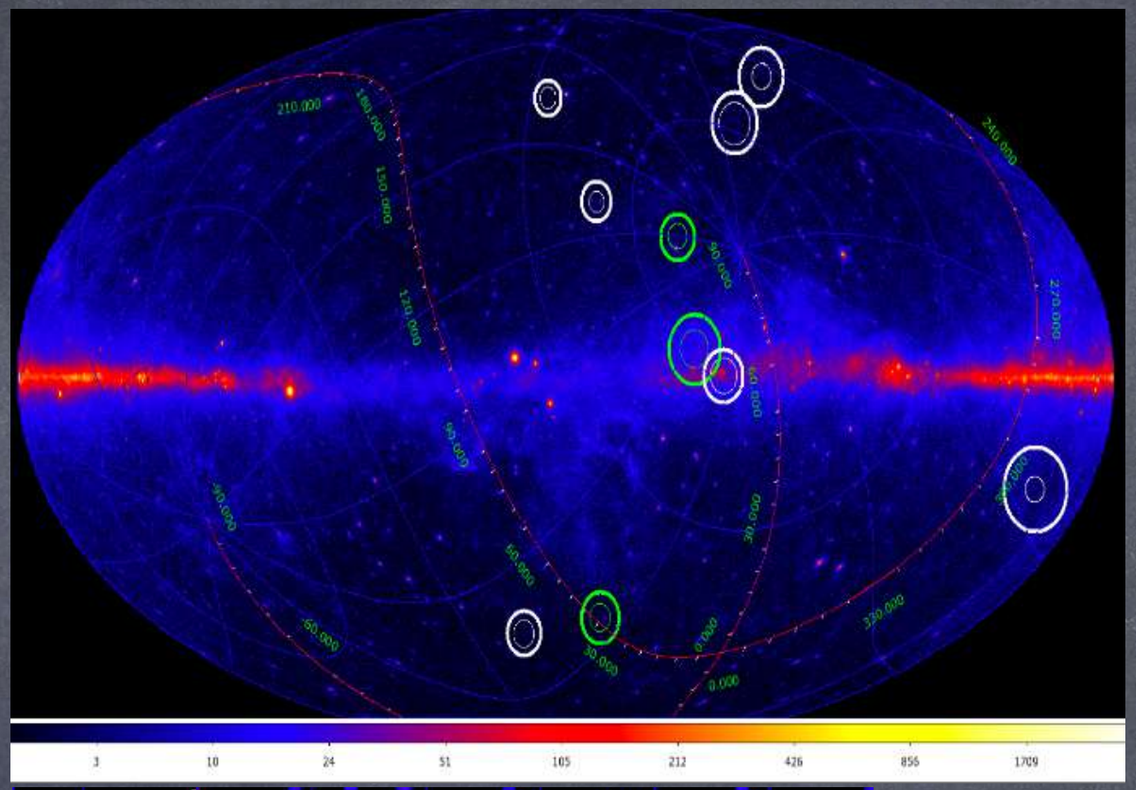
Events with a shower > 40 TeV before the final selection (muon signals search)

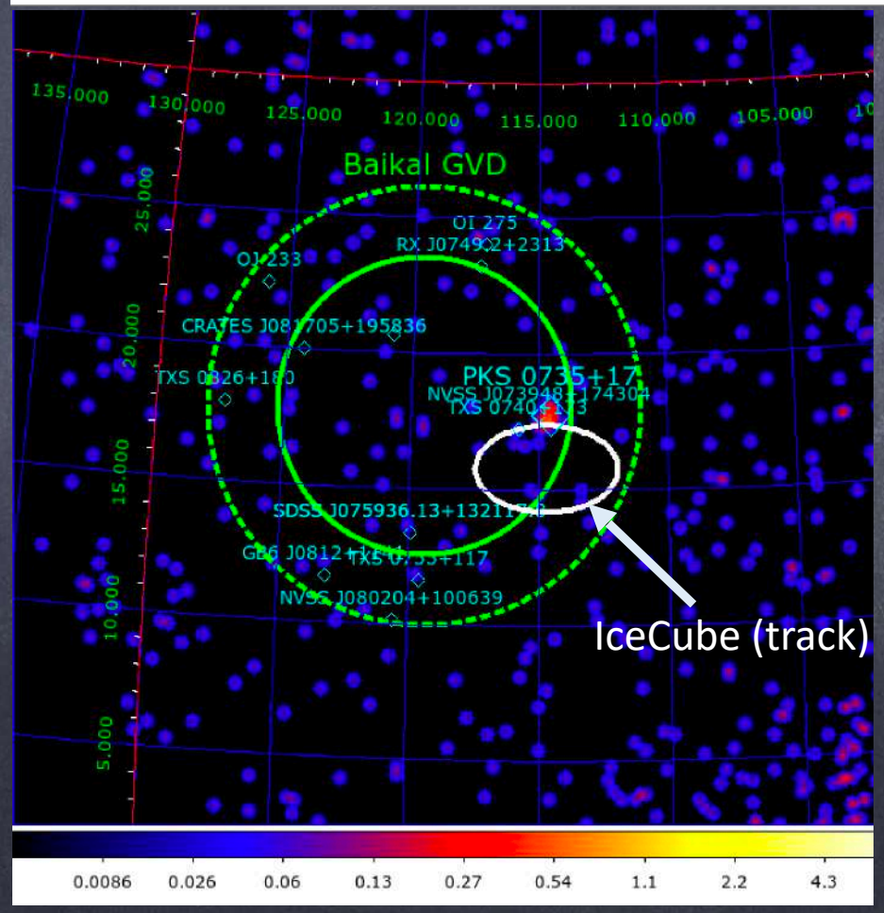
Energy distribution



Zenith angular distribution







08.12.2021:
IceCube + Baikal-GVD detected two neutrino events nearby radio-blazar PKS 0735+17

TAIGA: Ultra-high energy gamma

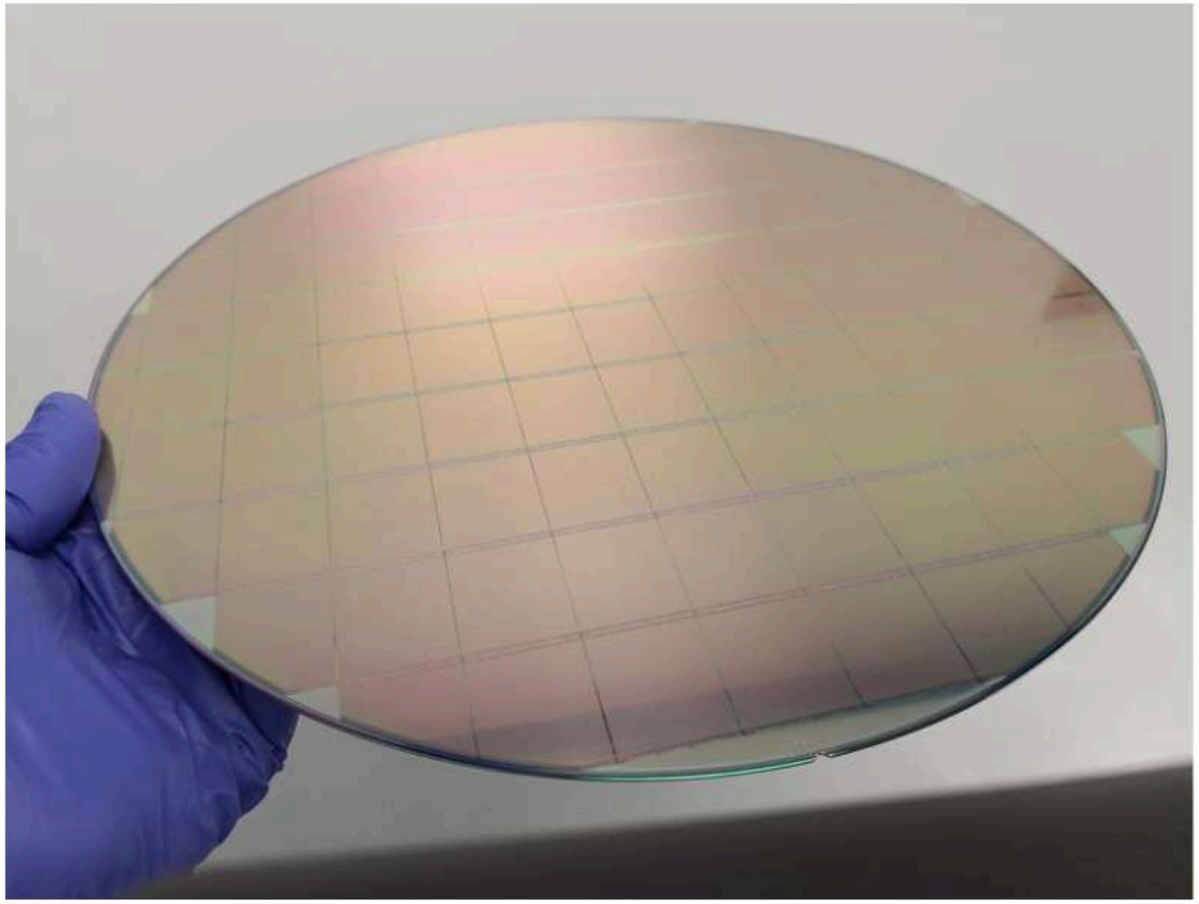
EDELWEISS: Dark matter and CEvNS

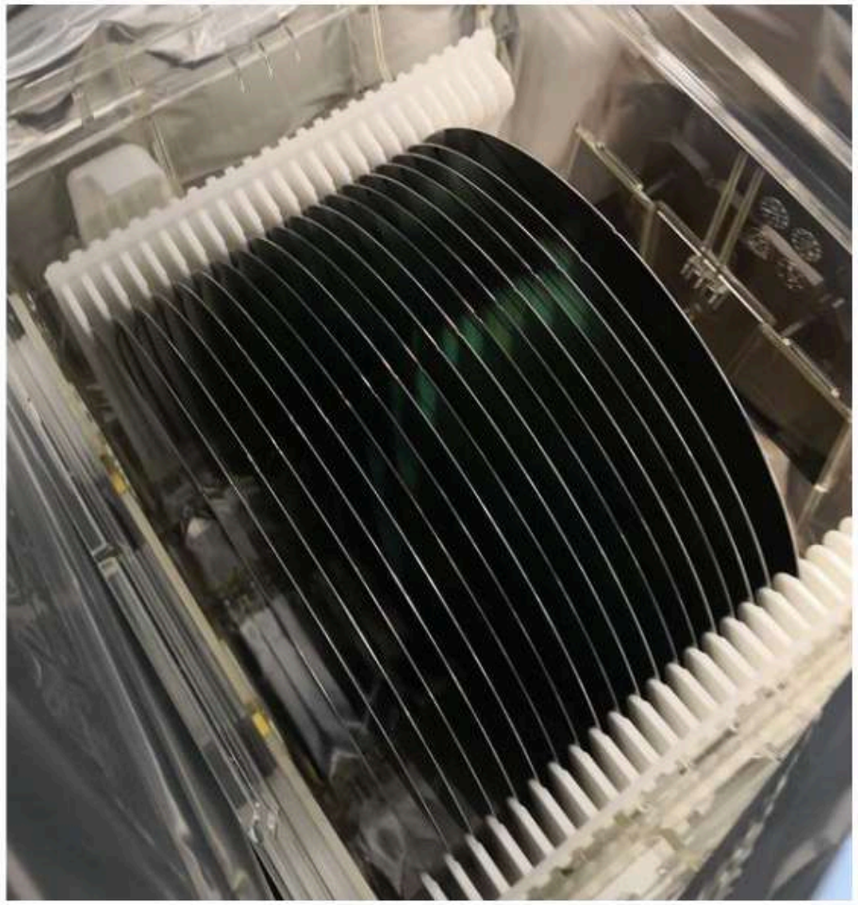
Medipix4

medipix collaboration

Timepix4 v2

- 19 wafers arrived last week
- 1 wafer sent for dicing → Expected to be back in ~2 weeks





LINAC200