Physics program of the Baksan Neutrino Observatory of the INR RAS

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Laboratories

L. of Baksan Underground Scintillation Telescope (BUST)

Investigations of cosmic rays

L. of Gallium-Germanium Neutrino Telescope (GGNT)

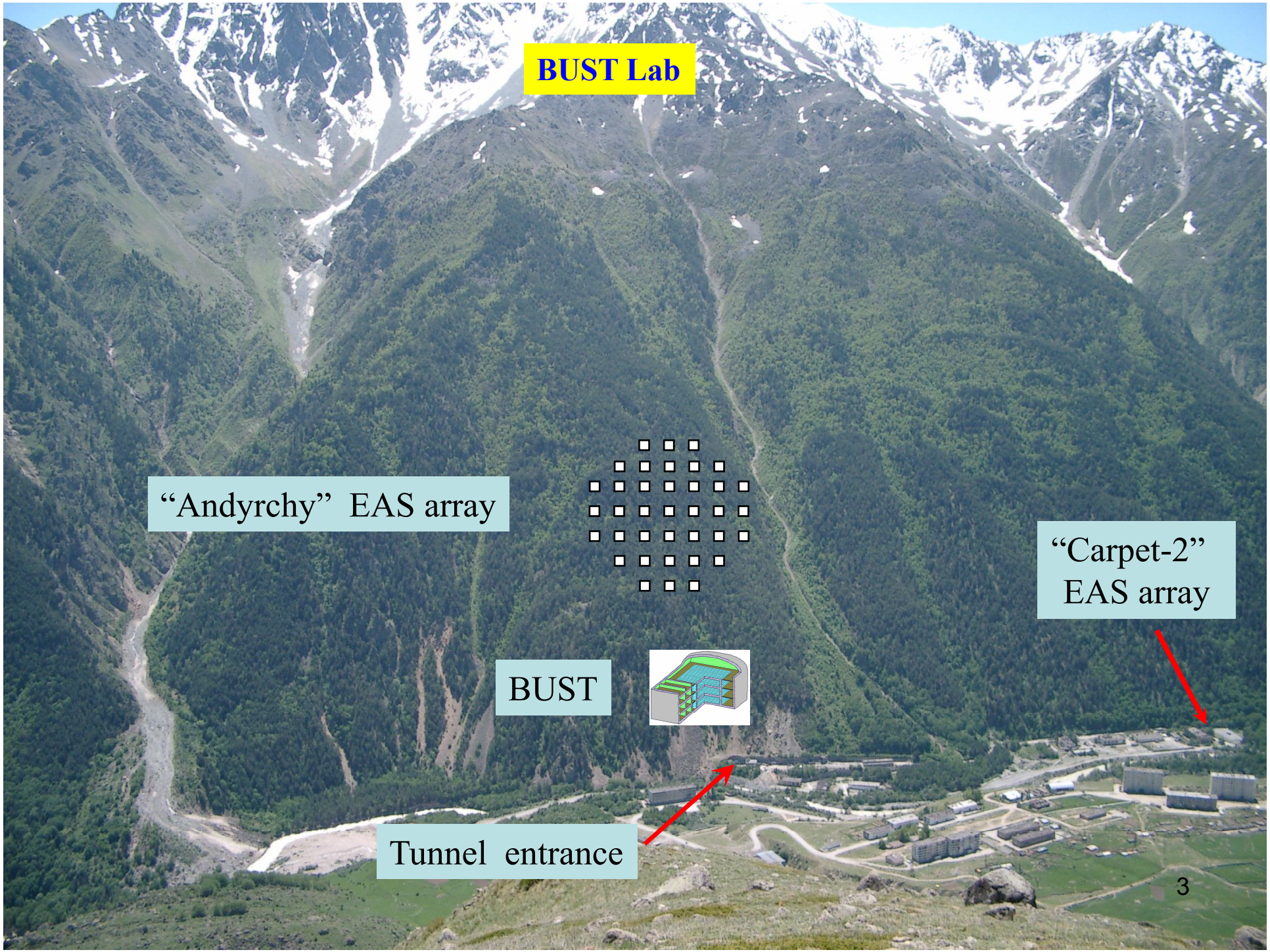
Measurement of Solar neutrino flux

L. of Low Background Researches (LBR)

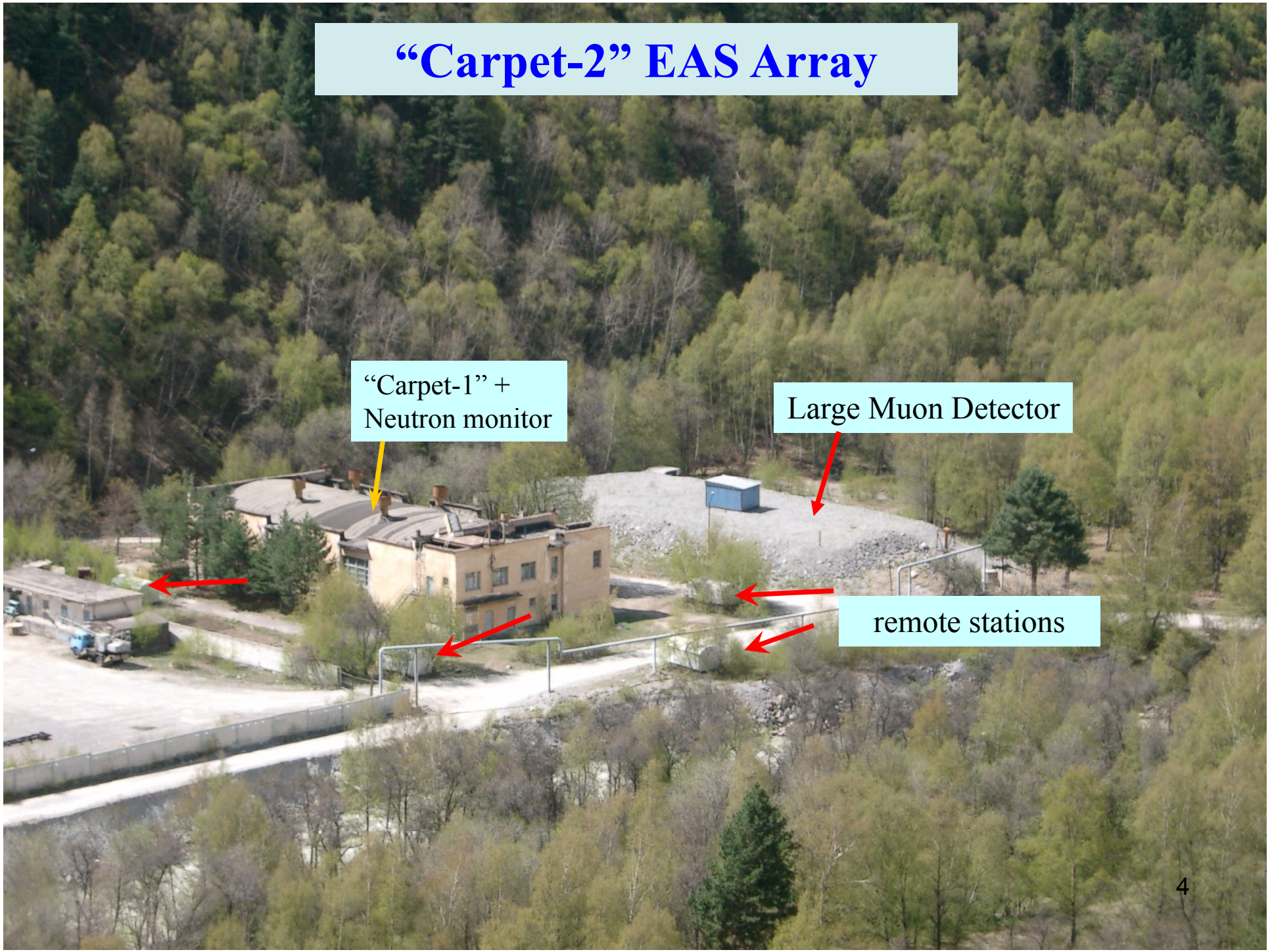
Investigations of rare decay processes (double β-decay, dark matter search)

L. of Geophysics and Gravity (LGG)

Investigations of process in the Earth and search for GV in the Galaxy

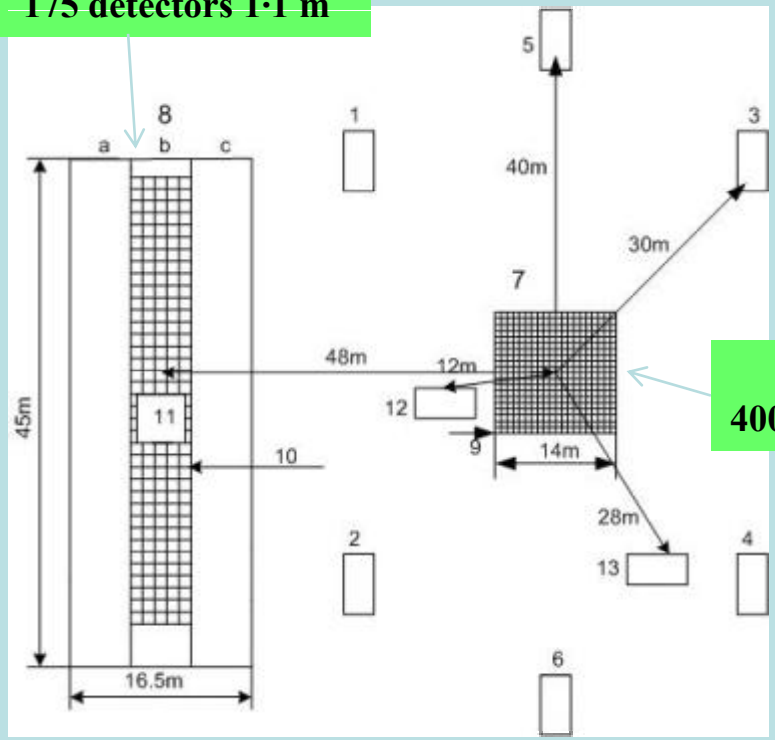

BUST Lab
“Andyrchy” EAS array
“Carpet-2” EAS array
BUST
Tunnel entrance

“Carpet-2” EAS Array



“Carpet-2” EAS Array

Large Muon Detector
175 detectors 1·1 m



“Carpet-1”
400 detectors 0.7·0.7 ·0.3 m

Scheme of the “Carpet-2”

“Carpet-2” EAS Array

View of the “Carpet-1”

“Carpet-2” EAS Array

View of the Muon Detector (section “C”)

“Carpet-2” EAS Array

The main task of the Carpet-2 Air Shower array is to study primary cosmic rays (c.r.) in the energy region of $5.7 \cdot 10^9$-$1 \cdot 10^{16}$ eV.

Basic researches carried out at the Carpet-2:

1. **Study of structure of the EAS central part;**
2. **Study of cosmic ray variation;**
3. **Study of c.r. anisotropy;**
4. **Gamma-ray astronomy of ultrahigh energies;**
5. **Study of atmospheric neutrino flux variation;**
6. **Study of muon component in EAS;**
7. **Study of chemical composition of primary c.r. of $E \geq 10^{14}$ eV.**

“Carpet-2” EAS Array

Some results

1. The first evaluation of a cross section of generation of particles with large transversal momentum in hadron-hadron interactions with c.m. system energy of $\sqrt{S} \sim 500$ GeV.
2. High-precision evaluation of c.r. intensity dependence on meteoeffects.
3. Pioneer observations of particles with energy of $\sim 10^{10}$ eV generated in solar flares.
4. Discovery of anisotropy ($0.057 \pm 0{,}005$) in cosmic rays with $\sim 10^{13}$ eV.
5. Pioneer registration of Crab Nebula burst on February 23, 1989.

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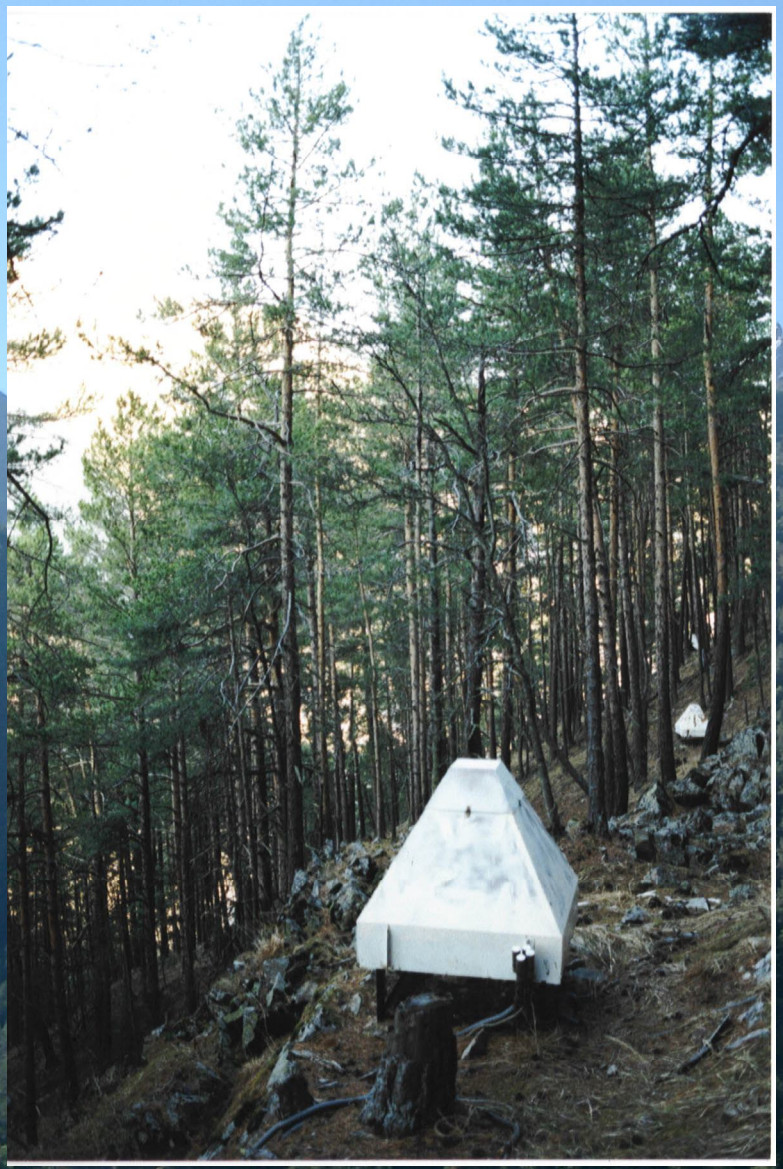
“Andyrchy” EAS array



"Andyrchy" EAS array

The Andyrchy EAS array consists of 37 scintillation detectors, 1 m^2 each, evenly spaced (40 m) over the area of ~ $4.5 \cdot 10^4$ m^2. The Andyrchy EAS array is aimed to register air showers of energy > 10^{14} eV independently and in coincidence with the BUST.

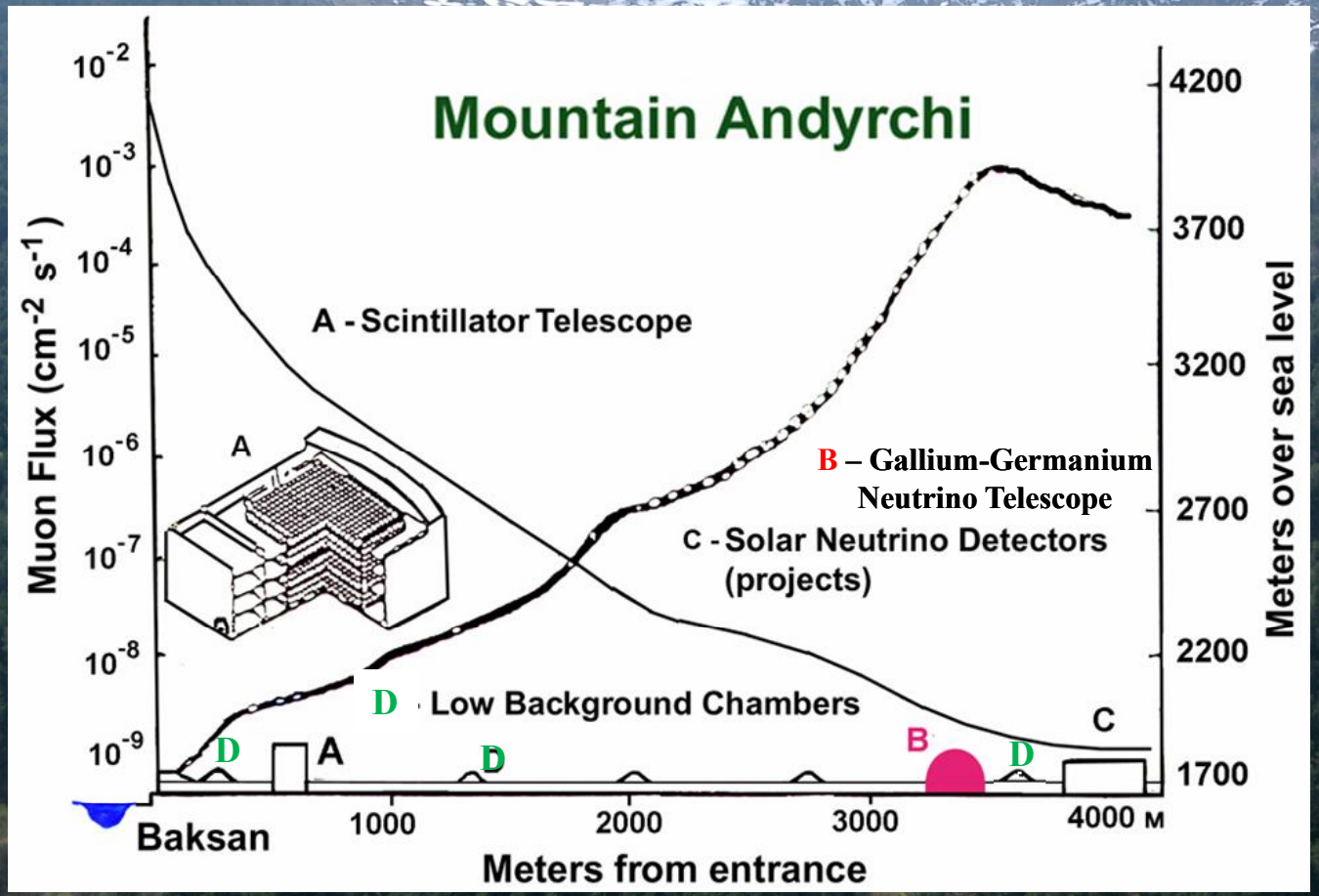
Researches carried out at the Andyrchy EAS array

1. Ultrahigh energy gamma astronomy.

2. Anisotropy of primary cosmic rays in the energy region of 10^{14}-10^{17} eV.

3. Gamma ray bursts of hard spectrum:

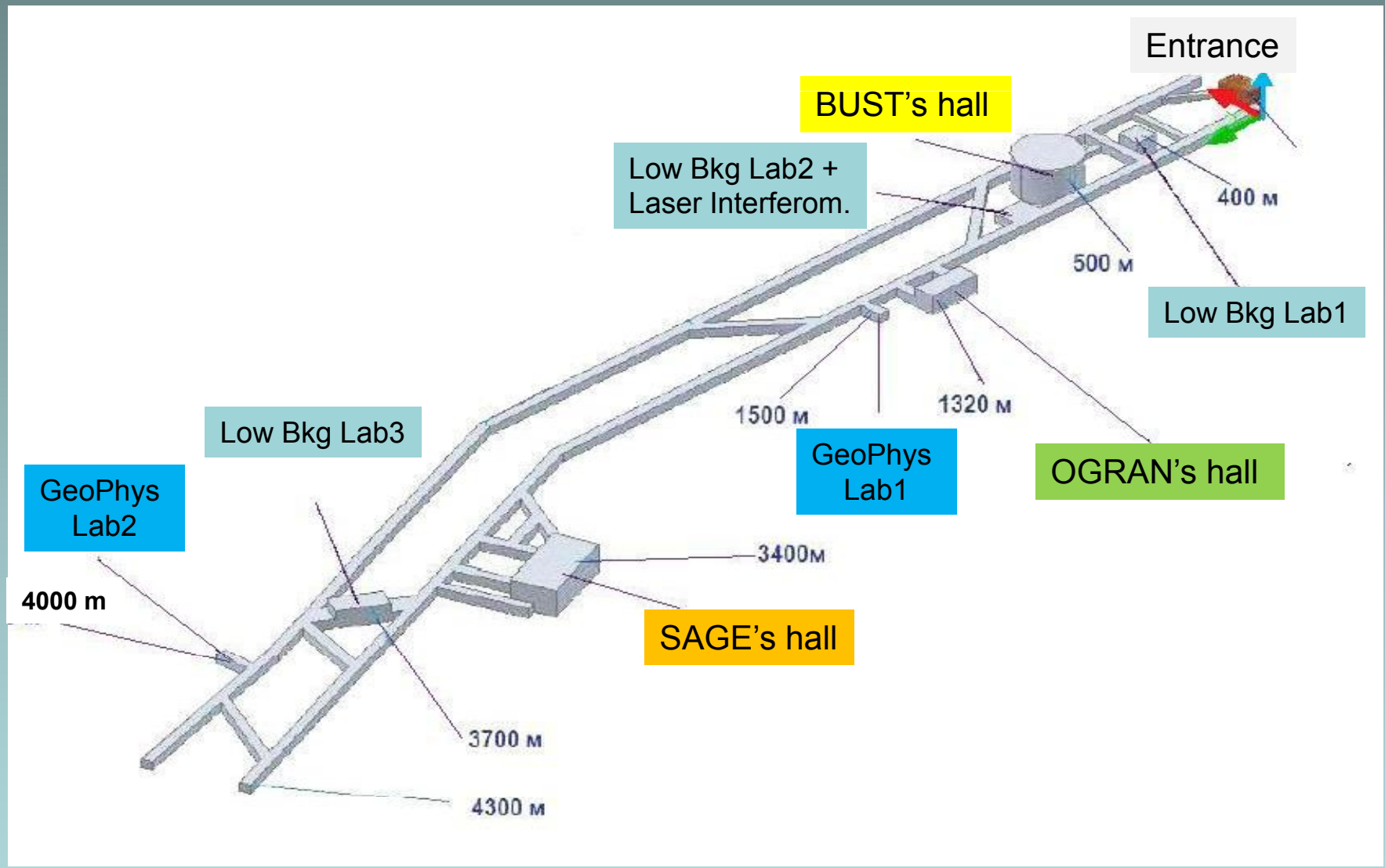
- data analysis for short gamma ray bursts for a period of 1996-2006 yrs yielded the excess of 24 s duration (in 5 s after the start of the event) over the background. Such an excess could be explained by extended gamma radiation of high energy.



Global Intensity of muons

$(3{,}0 \pm 0{,}15) \cdot 10^{-9}$ м $cm^{-2} \cdot s^{-1}$

~ 4800 m.w.e.

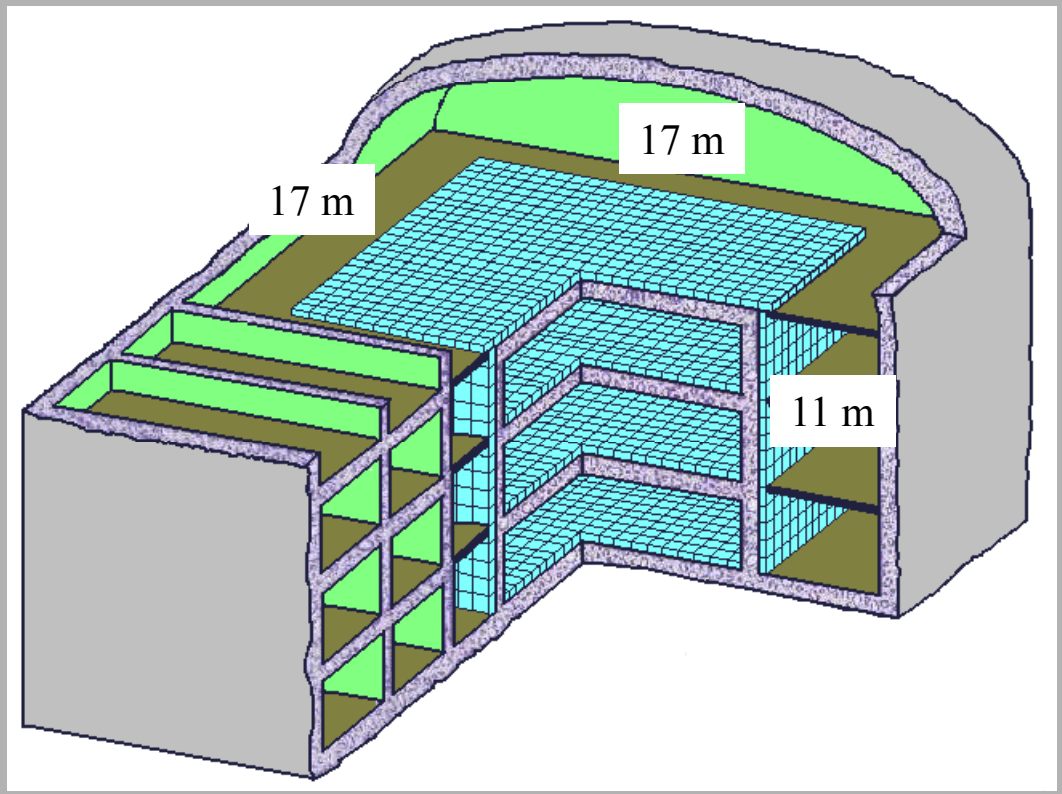


Underground Laboratories of the BNO INR RAS

Baksan Underground Scintillation Telescope

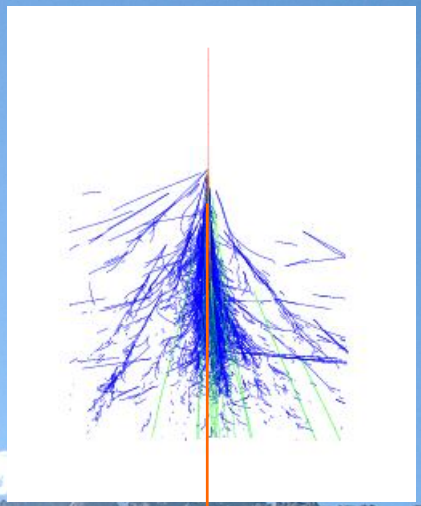
- Telescope construction completed **1977**

- *Depth: 850hg/cm^2*
- *Size: 17m×17m×11m*
- *Number of tanks: 3185*
- *Tank size: 70cm×70cm×30cm*
- *Angular resolution: 2^0*
- *Time resolution: 5 ns*
- *Trigger: 10Mev in any plane*
- *Rate: 17 Hz*
- *upward/downward: 10^{-7}*

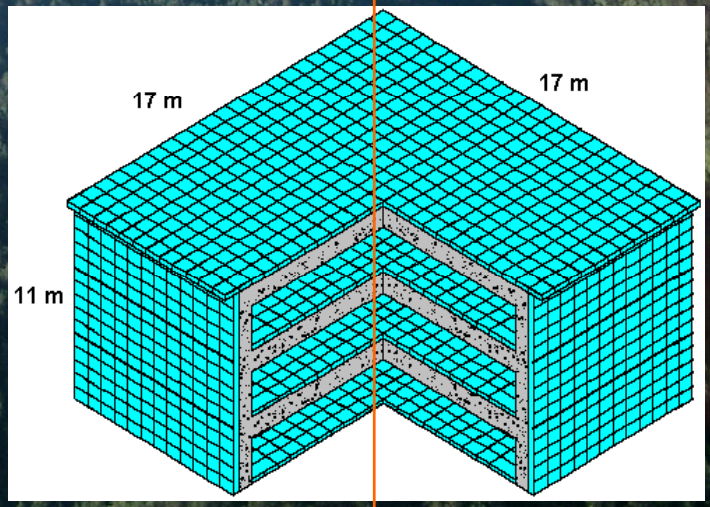


$E_\mu \geq E_{th}(x)$

$x = x(\theta,\varphi)$



$(E_{th})_{eff} = 0.22$ TeV



The Baksan Underground Scintillation Telescope

Researches carried out at the BUST

1. Measurement of muon flux generated high-energy neutrinos.
2. Search for neutrino bursts from the galactic star collapses.
3. Search for anisotropy of c.r. ($>10^{12}$ eV).
4. Study of chemical composition of c.r. (10^{12} - 10^{16} eV).
5. Study of muons interactions ($>10^{12}$ eV).

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The Baksan Underground Scintillation Telescope

Some results

1. **Limit obtained for the high energy neutrino flux due to local sources in the galactic plane [$F_\nu \leq 4 \cdot 10^{-14}$ cm^{-2}sec^{-1}cp^{-1}].**
2. **Amplitude [$(12.3 \pm 2.0) \cdot 10^{-4}$] and phase [1.6±0.8] measured for the first harmonic of anisotropy in sidereal time.**
3. **Search carried out for 29 years for neutrino burst from the gravitational collapse of the stars in the Galaxy.**
4. **……..**

The Baksan Underground Scintillation Telescope

An upper bound on the mean frequency of gravitational collapses in the Galaxy for BUST's data (at 90% CL)

year	LIVE TIME (years)	UPPER BOUND (90%CL)
1983	**2.2**	**0.33/year**
1993	**11.0**	**0.21/year**
2000	**17.6**	**0.13/year**
2011	**26.2**	**0.088/year**

BUST + “Andyrchy” EAS array: simultaneous operation

BUST – “Andyrchy” joint research

1. **Study of composition spectrum and anisotropy of galactic c.r. of (10^{13} – 10^{17}) eV**
2. **Study of EAS spectra in the knee region.**
3. **Study of c.r. interactions with matter. Search for new particles.**
4. **Study of c.r. intensity variations.**
5. **Gamma-ray astronomy (E_γ = 10 GeV – 100 TeV).**

The SAGE Collaboration

Measurement of the Solar Neutrino Capture Rate with gallium metal

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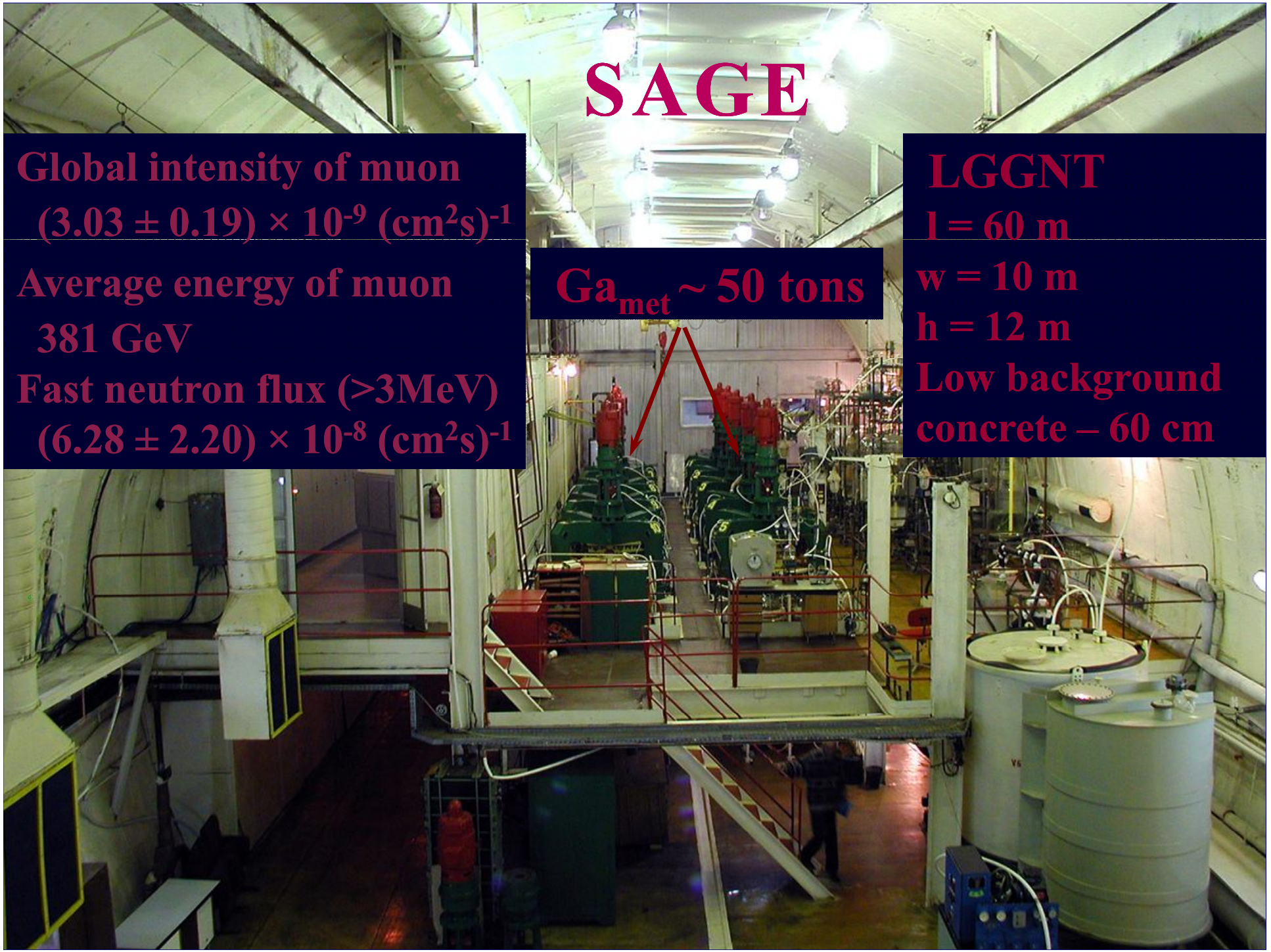
SAGE



Global intensity of muon
$(3.03 \pm 0.19) \times 10^{-9}$ $(cm^2 s)^{-1}$

Average energy of muon
381 GeV

Fast neutron flux (>3MeV)
$(6.28 \pm 2.20) \times 10^{-8}$ $(cm^2 s)^{-1}$

$Ga_{met} \sim 50$ tons

LGGNT
l = 60 m
w = 10 m
h = 12 m
Low background
concrete – 60 cm

SAGE

BNO INR RAS
V. N. Gavrin

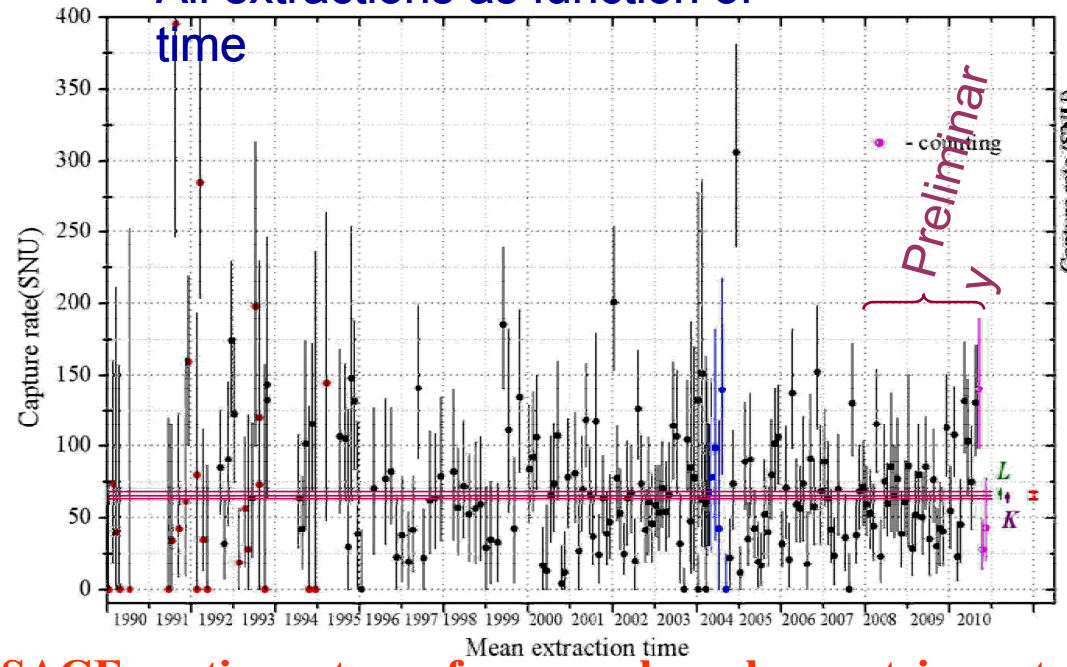
Presently SAGE is the only experiment sensitive to the *pp* neutrinos

It has the longest almost uninterrupted time of measurements among operating solar neutrino experiments

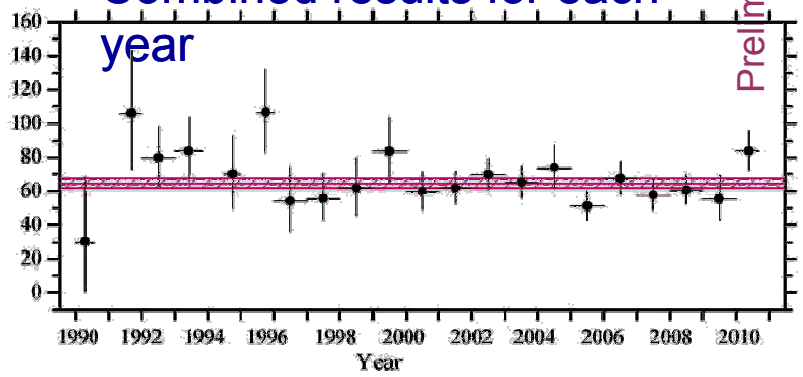
20.6 year period (1990 – 2010): 200 runs, 374 separate counting sets

$$\text{Result}: \quad 64.6\ ^{+2.7}_{-2.6}(\text{stat})\ ^{+2.6}_{-2.8}(\text{syst})\ \text{SNU}$$

All extractions as function of time



Combined results for each year

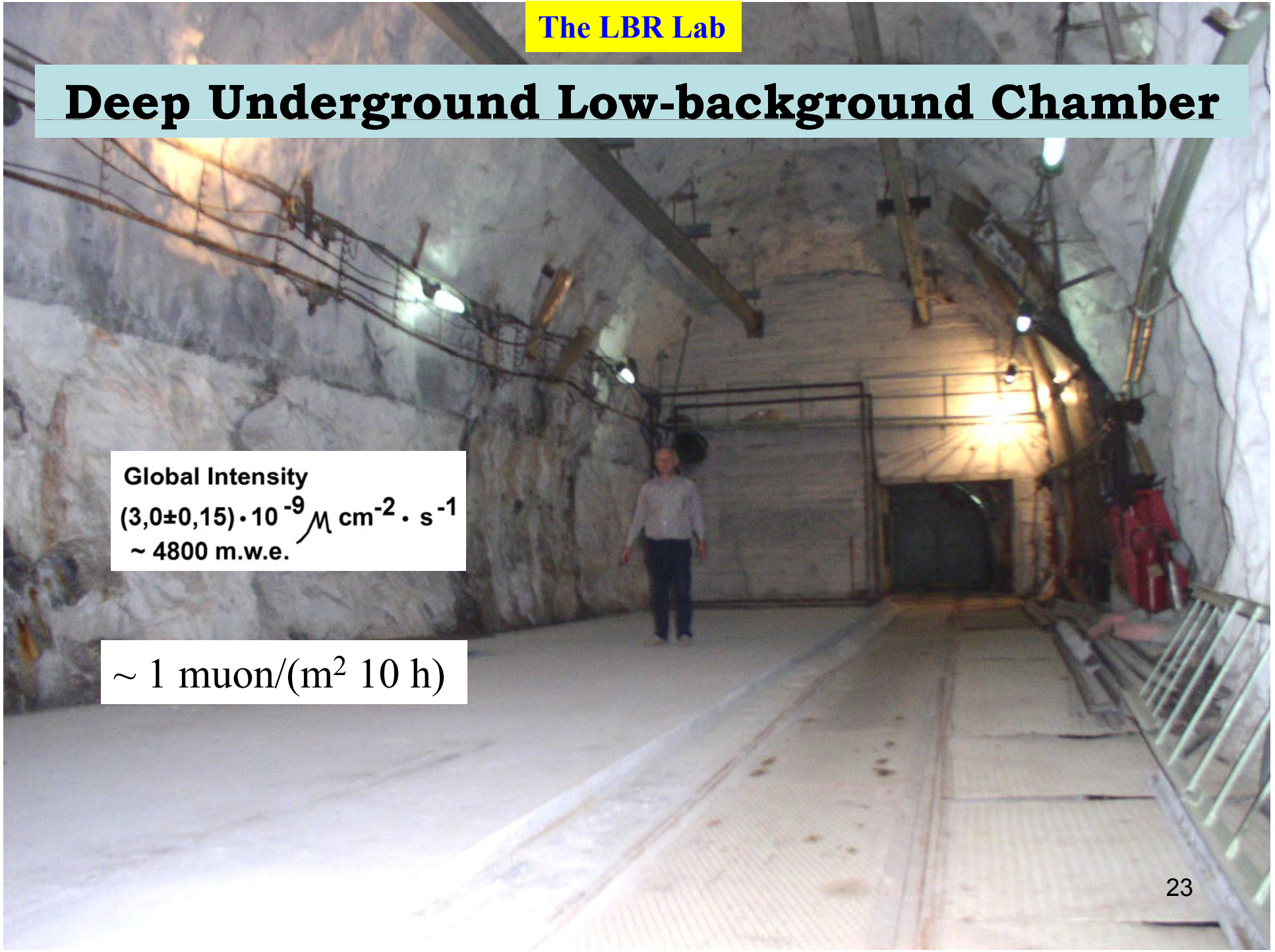


$$\text{or}\quad 64.6\ ^{+3.7}_{-3.9}\ \text{SNU}$$

[*pp*|Ga] = 39.9 ± 5.2 SNU

SAGE continues to perform regular solar neutrino extractions every four weeks with ~50 t of Ga

Deep Underground Low-background Chamber



Deep Underground Low-background Chamber

The wall 25 cm polyethylene + 0.1 cm Cd + 15 cm Pb

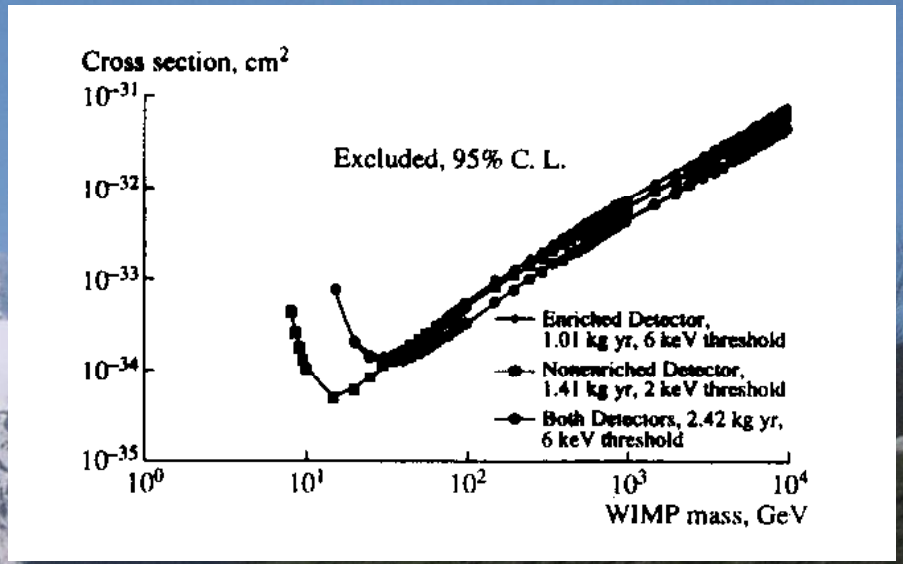
Low-background Deep-laid Chamber

Search for rare processes

(Low-background Chambers)

Nuclear physics:

- search for Superdense Nuclei and Electron Stability
- double beta decay search (Nd-150, Mo-100, Xe-136...)
- search for 2k-capture (^{78}Kr and ^{124}Xe)



Astrophysics:

search for Dark Matter particles

(WIMP – Weak Interaction Massive Particle)

Results of 2β-decay experiments

- **Nd-150:** $T_{1/2}(2\nu)=(1.9^{+0.7}_{-0.4})*10^{20}$ y,

  $T_{1/2}(0\nu)\geq 1.7*10^{21}$ y

- **Ge-76:** $T_{1/2}(2\nu)=(9.0\pm1.0)*10^{20}$ y,

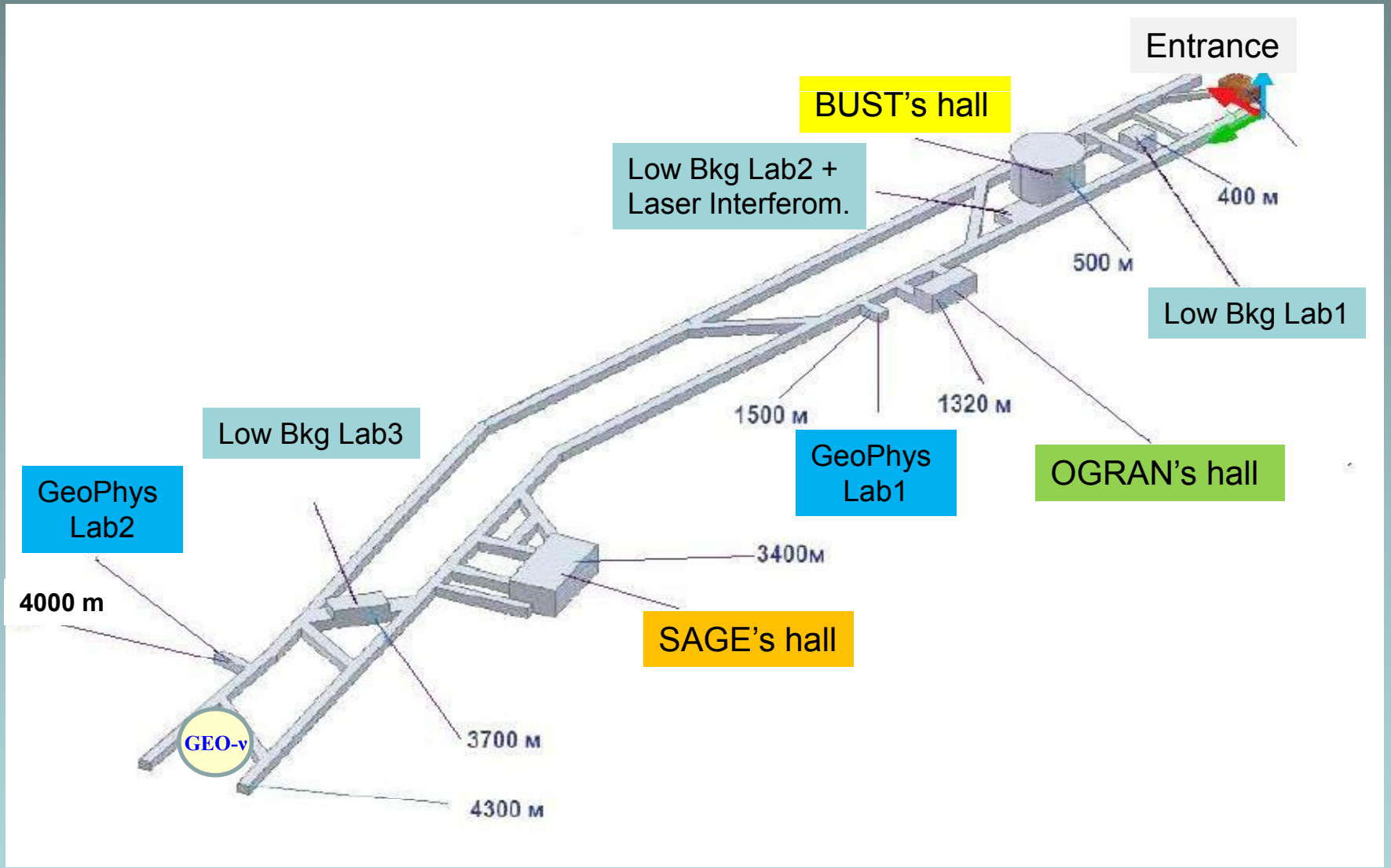
  $T_{1/2}(0\nu)\geq 1.6*10^{25}$ y

- **Xe-136:** $T_{1/2}(2\nu)= (5.5^{+4.6}_{-1.7})\cdot10^{21}$ y (year 2011)

- **Kr-78 (2K-capture):**

  $T_{1/2}(2K, 2\nu+0\nu)=(1.4^{+2.2}_{-0.7})\cdot10^{22}$ y (90% c.l.) (year2011)

Participation in GERGA and AMORE



Underground Laboratories of the BNO INR RAS

Laboratory of Geophysics and Gravity

1. Laser Interferometer - MSU
2. Geo Physical Laboratories I and II - IEP RAS + GS RAS + KBSU
3. Optical–Acoustic Gravitation Antenna with cryogenic sensitivity – INR RAS+MSU+ILPh SD RAS

Researches carried out at the LGG

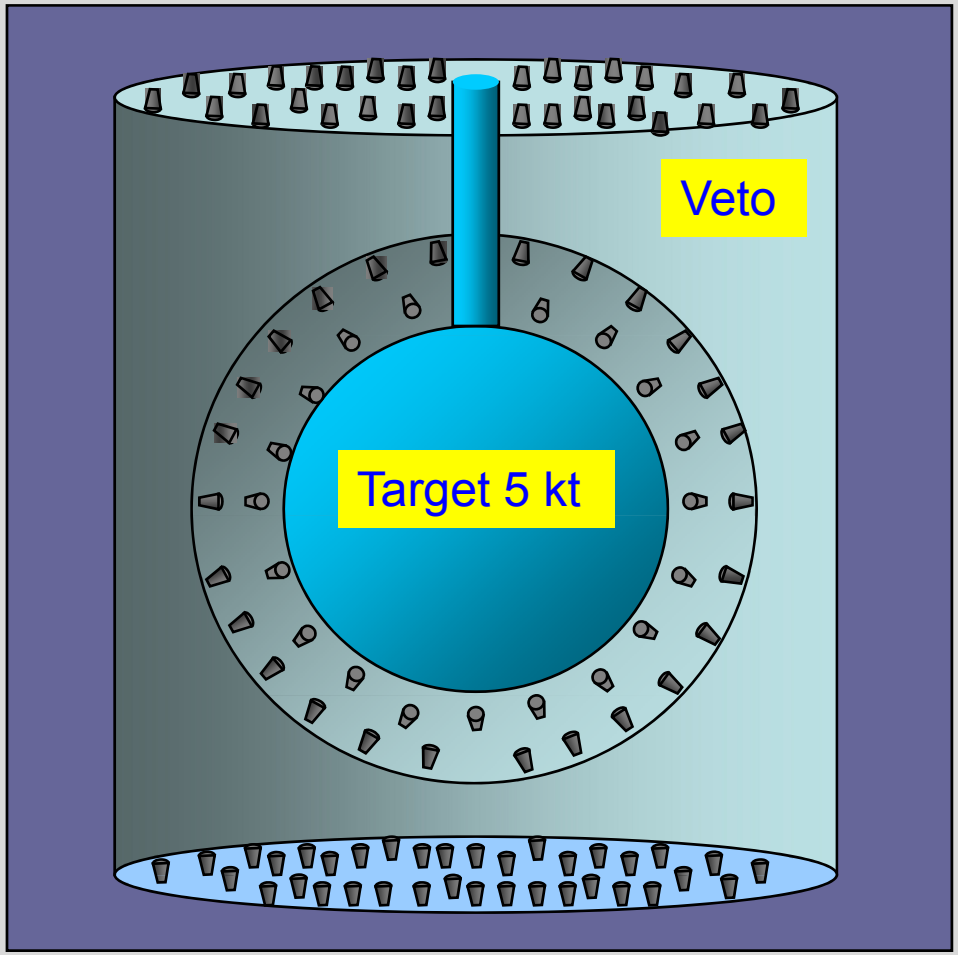
1. Monitoring of the Earth magnetic field.
2. Monitoring of a drift of lithosphere plate.
3. Seismic monitoring.
4. Preparation of the OGRAN.

Geophysics and Gravity

View of the GeoPhys Lab1

A large volume Baksan scintillation detector for GEO-neutrino proposed in 2006

G. Domogatsky, V. Kopeikin, L. Mikaelyan and V. Sinev, Phys. of At. Nucl., 69, iss. 11,(2006) 1894.



Geoneutrino effect (1/year) in 1 kt (10^{32} H) at known sites and its ratio to Nuclear reactors background

Site	Mantovani et al, 2004	Enomoto 2005	Sinev et al., 2009	With the core	$R=N_{geo}/N_{reactor}$
Hawaii	**12.5**	**13.4**	**15.99**	**20.8**	**0.1**
Kamioka	**34.8**	**36.5**	**33.2**	**38.2**	**6.7**
Gran Sasso	**40.5**	**43.1**	**41.7**	**47.1**	**0.9**
Sudbury	**49.6**	**50.4**	**52.2**	**57.5**	**1.1**
Pyhäsalmi	**52.4**	**52.4**	**55.4**	**60.5**	**0.5**
Baksan	**51.9**	**55.0**	**55.1**	**61.8**	**0.2**
Himalaya	**60.0**	**-**	**72.8**	**83.2**	**-**