

Real-Time Follow-Up of Multimessenger Alerts at the Baikal-GVD Telescope

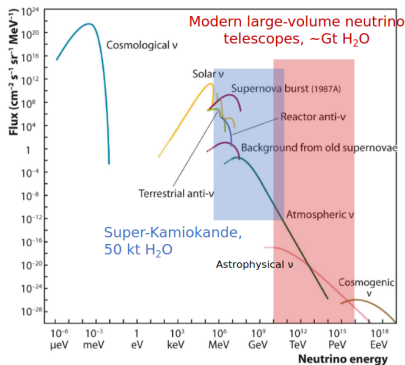
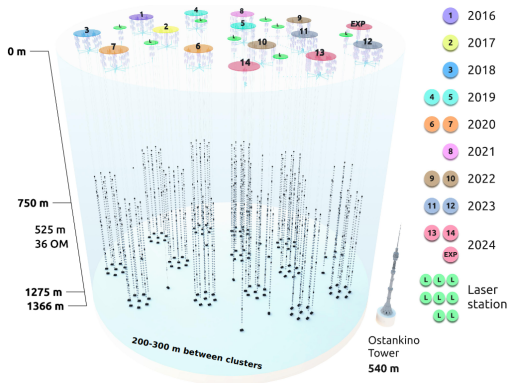
136th session of JINR Scientific Council

Viktoriya Dik
for the Baikal-GVD Collaboration

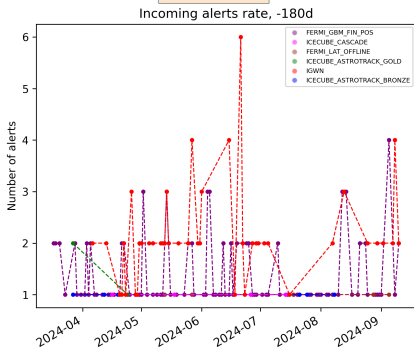
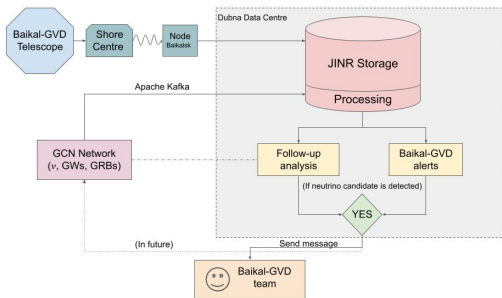
2024.09.13

Status of Baikal-GVD experiment

- ▶ The Baikal-GVD (Gigaton Volume Detector) is an underwater neutrino detector being constructed in Lake Baikal.
- ▶ Currently contains 3960 Cherenkov detecting optical modules with effective volume $> 0.6\text{km}^3$ for cascades $E > 1\text{PeV}$.
- ▶ The primary goal is the study of high-energy neutrino flux.



Baikal-GVD Real Time Processing and Follow-Up



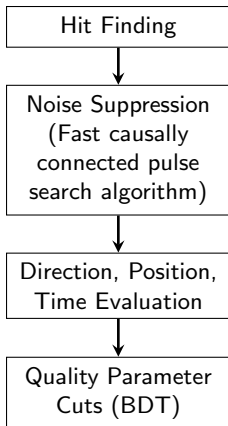
- ▶ BARS C++ programs are managed using PyBARS workflow built on the Luigi package.
- ▶ Data is saved with Influx, MariaDB.
- ▶ The delay between a Baikal-GVD event and a potential alert message is $\sim 3-10$ mins.
- ▶ Email in a MM standardized text format, along with a picture showing a potential coincidence, is sent to the Baikal-GVD working group.

Online Reconstruction

- ▶ Less precise coordinates and simplified calibration compared to offline.
- ▶ Single cluster reconstruction in parallel tasks, OM hits with charge $Q > 1.5$ p.e.

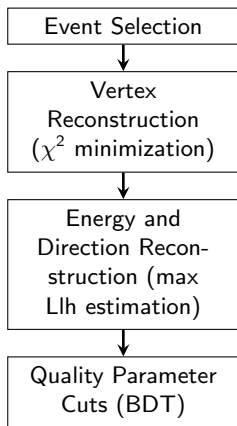
Tracks upgoing

(CC, ν_μ , ν_τ)
angular resolution is
 $\sim 0.3^\circ - 0.5^\circ$, energy
is 200–300%

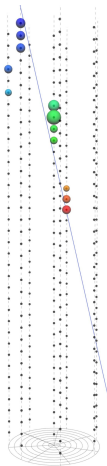


Cascades all sky

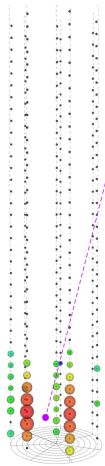
(CC ν_e , ν_τ , NC)
angular resolution is
 $\sim 3^\circ - 5^\circ$, energy is
5–30%



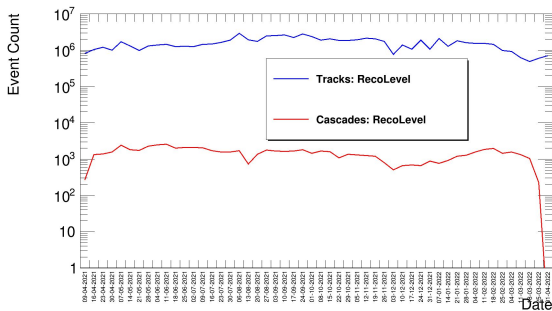
Track-
like, data
2019



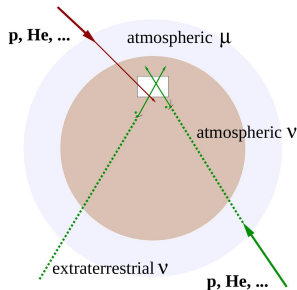
Cascade-
like, data
2022



Reconstructed Events in Processing



Baikal-GVD 2021 season



Majority of the reconstructed events is background atmospheric muons and muon groups.

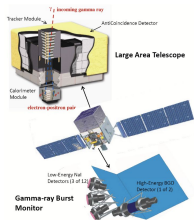
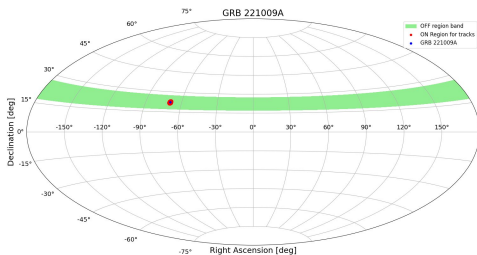
The goal of selection is the suppression of muon background.

- ▶ V.M. Aynutdinov et al. PoS ICRC2023 (2023) 1001 - tracks
- ▶ V.M. Aynutdinov et al. PoS ICRC2023 (2023) 986 - cascades

Baikal-GVD and Follow-Up with GCN Kafka

Search for online coincidences:

- ▶ ON/OFF method
- ▶ ON region includes 90% localization errors
- ▶ OFF is extended within a ± 5 dec band
- ▶ OFF is evaluated using real data from previous seasons



Fermi-GBM/LAT:

- ▶ $[T_0 - 1d, T_0]$
- ▶ $[T_0 - 1d, T_0 + 12h]$
- ▶ $[T_0 - 1d, T_0 + 1d]$

LIGO-Virgo-KAGRA:

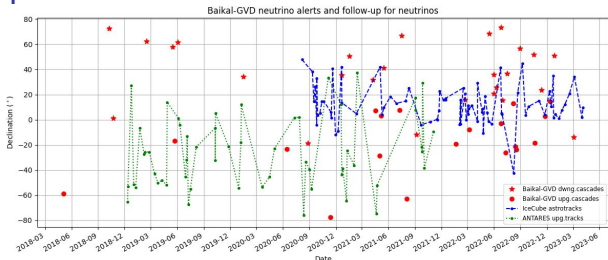
- ▶ $[T_0 - 1000s, T_0 + 1000s]$
- ▶ $[T_0 - 1000s, T_0 + 14d]$

IceCube:

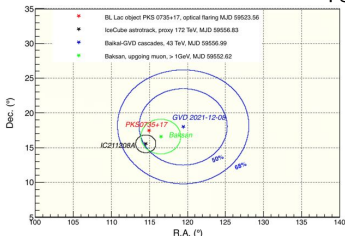
- ▶ $[T_0 - 1h, T_0 + 1h]$
- ▶ $[T_0 - 1d, T_0 + 1d]$

Neutrino Follow-Up

- ▶ 2018 - 2 cls
- ▶ 2019 - 3 cls
- ▶ 2020 - 5 cls
- ▶ 2021 - 8 cls
- ▶ 2022 - 10 cls
- ▶ 2023 - 12 cls

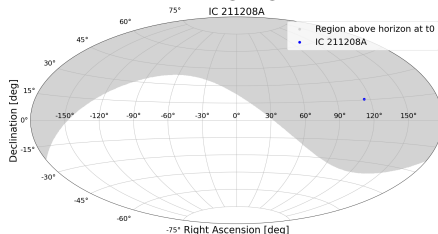


Upgoing events: $E > 15$ TeV, Downgoing: $E > 60$ TeV




GVD211208A & PKS0735+17
Astrotelegram # 15112

Upper limits on the neutrino fluence $E^2 \cdot \Phi_\nu(E)$ for one cluster for $1\text{TeV} < E < 10\text{PeV}$ in cascade mode are found to be from 1 to 3 GeV/cm^2 within ± 12 hours.



IC211208A localization for Baikal

A serene night landscape featuring a full moon in a dark blue sky, its light reflecting on a calm body of water. In the distance, a range of mountains is visible under the twilight sky. The foreground shows a grassy slope and a dark railing, suggesting the viewer is looking out from an elevated position. The overall mood is peaceful and quiet.

Thank you for your attention!