# Status of the scintillation experiment of the TAIGA astrophysical complex

E.A.Kravchenko on behalf of TAIGA collaboration

## TAIGA-Muon scintillation facility

**Description:**

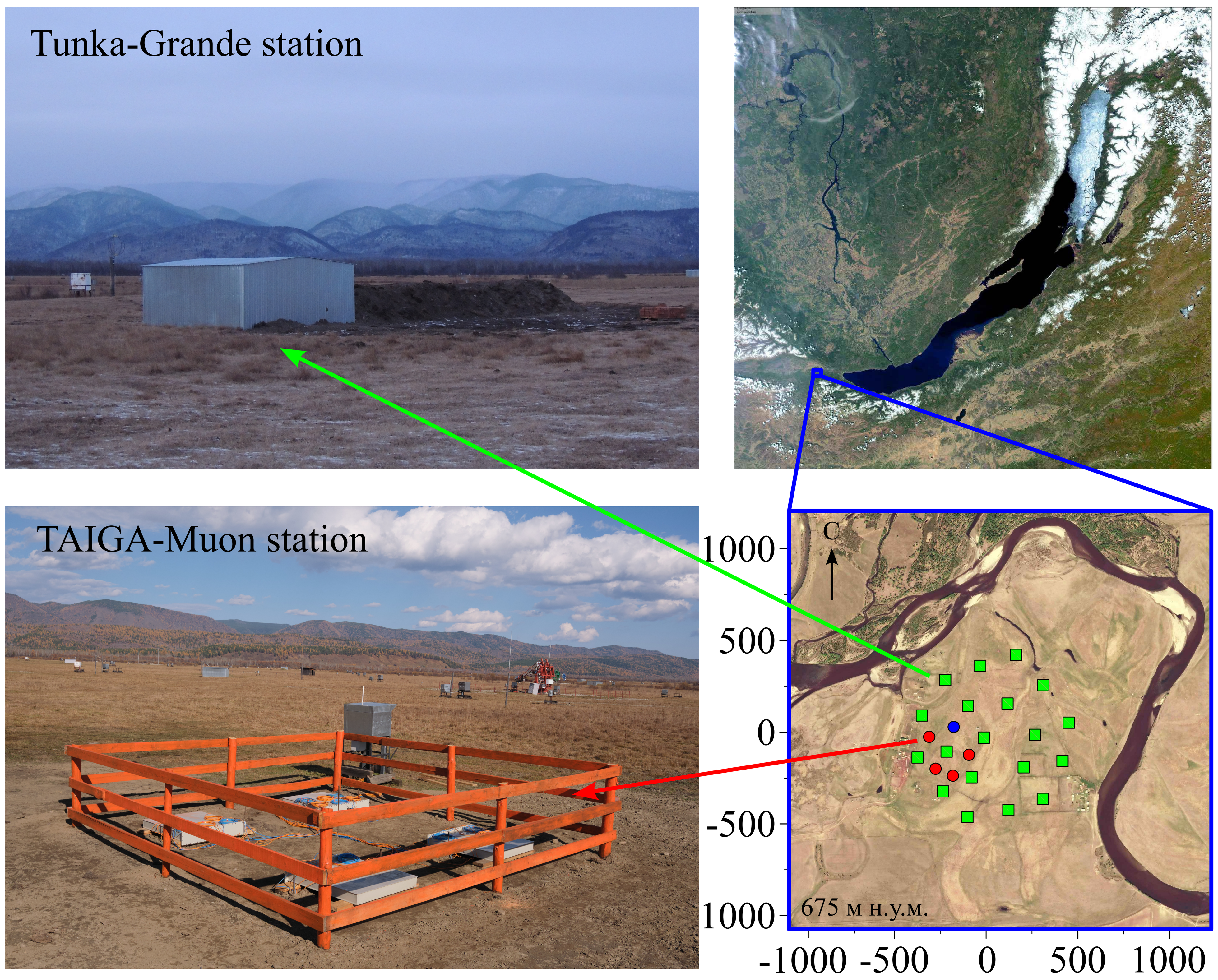
- It has been under construction since 2019 as an addition to the existing Tunka-Grande facility [1].
- It is located in the Tunka Valley, 50 km from Lake Baikal.
- It is part of the TAIGA astrophysical complex [2].
- Currently, 5 of the 10 stations have been deployed.
- Each station has a ground-based and an underground (soil layer ~ 1.7 m) parts.
- The ground-based part consists of 8 or 4 (new station design since 2022) detectors.
- The underground part consists of 8 or 16 (new station design since 2022) detectors.

**Task:**

- Registration of the electron-photon and muon components of extensive air showers (EAS).

**Objective:**

- Study of the energy spectrum and mass composition of cosmic rays, as well as search for diffuse gamma radiation in the energy range of 1 - 1000 PeV.

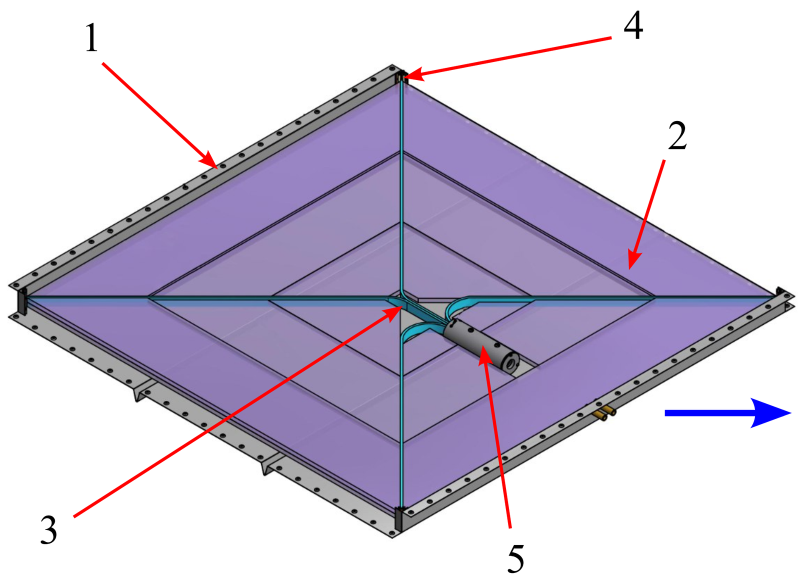


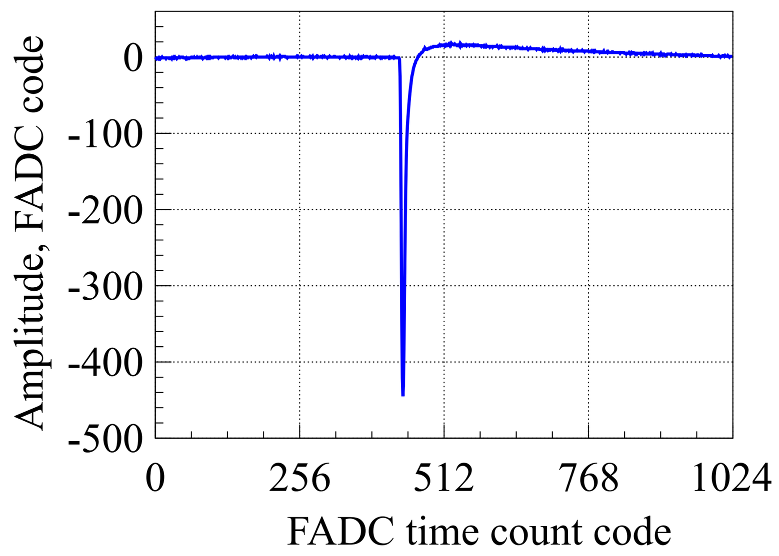

**Counter elements:**

1 - Stainless steel housing assembly.
2 - Variable-thickness scintillation plates (10 mm in the detector center and 20 mm on its periphery) based on polystyrene with the addition of 1.5% p-terphenyl and 0.01% POPOP.
3 – Wavelength shifting light guides with a cross-section of 5·20 mm2 (acrylic glass with the addition of BBQ dye).
4 - Mirror reflectors (special paint).
5 - FEU-85-4 photomultiplier tube, magnetic shield and signal preamplifier.

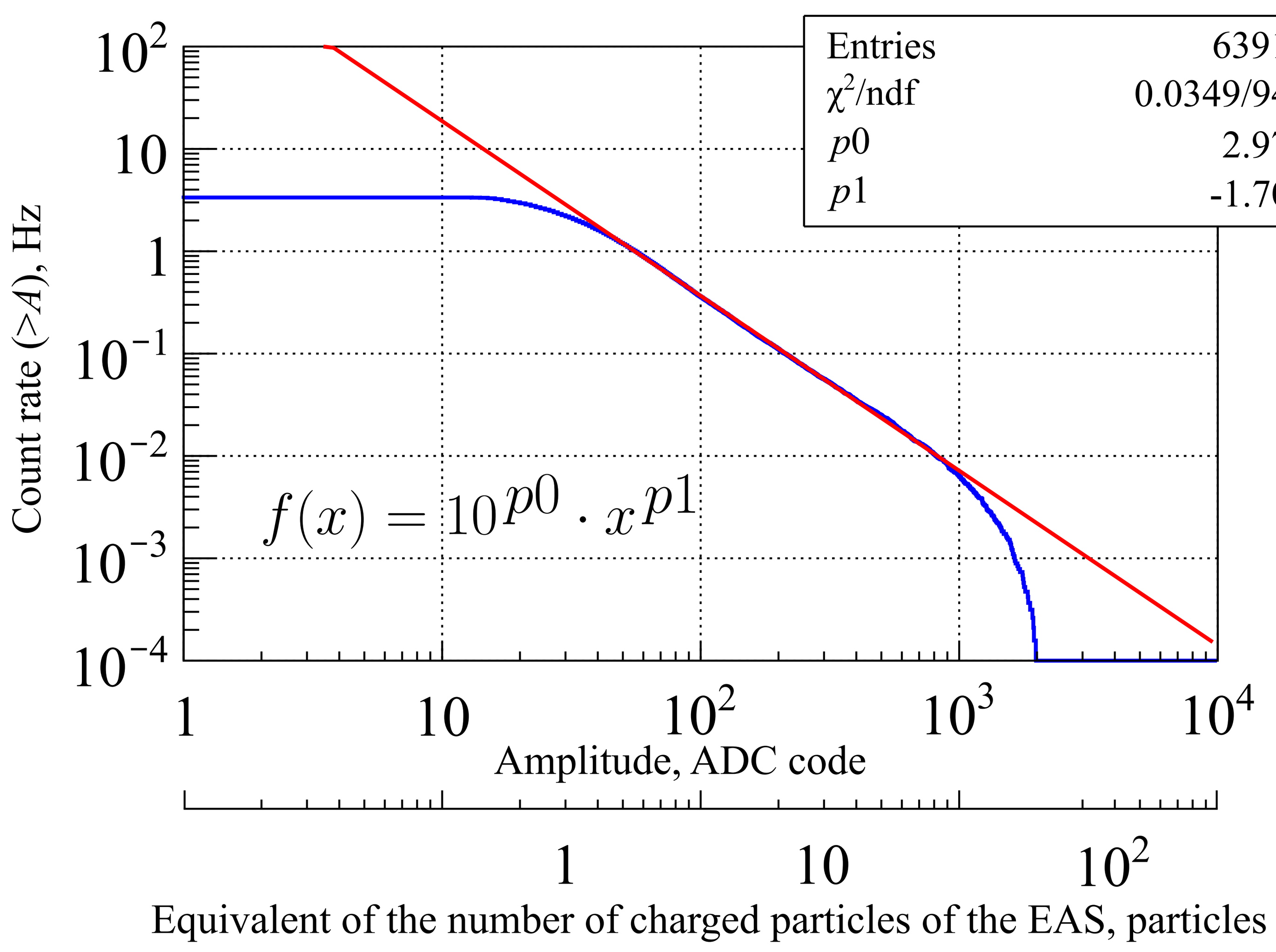
**Data acquisition system parameters:**

- ADC sampling frequency 200 MHz, digitizer bit depth 12 bits.
- Station time synchronization accuracy 10 ns.




## EAS particle density spectrum based on experimental data from scintillation counters




## Reconstruction of EAS parameters

**Parameters reconstruction:**

θ, φ - zenith and azimuth angles of the EAS axis; x, y - coordinates of the position of the EAS axis in the plane of the facility; Ne, Nμ - the total number of particles in the electron-photon and muon components of the EAS; s - the EAS age parameter.

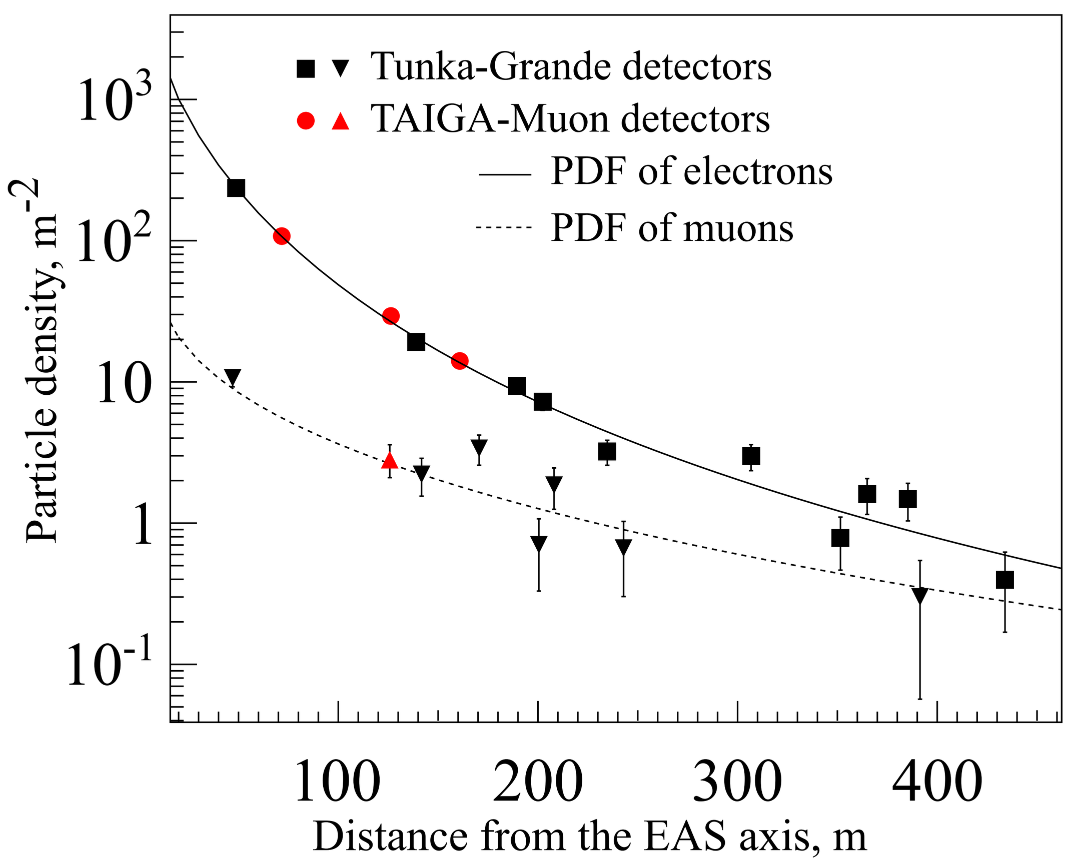
**Electron spatial distribution function:**

$$\rho_e(r) = N_e \cdot f_e(r) = N_e \cdot C_{norm} \cdot \left(\frac{r}{80}\right)^{s-2} \cdot \left(1 + \frac{r}{80}\right)^{s-4.5}$$

**Muon spatial distribution function:**

$$\rho_\mu(r) = N_\mu \cdot f_\mu(r) = N_\mu \cdot C_{norm} \cdot \left(\frac{r}{180}\right)^{-0.61} \cdot \left(1 + \frac{r}{180}\right)^{-b},$$

where b is a variable parameter with a mean value of 2.6.



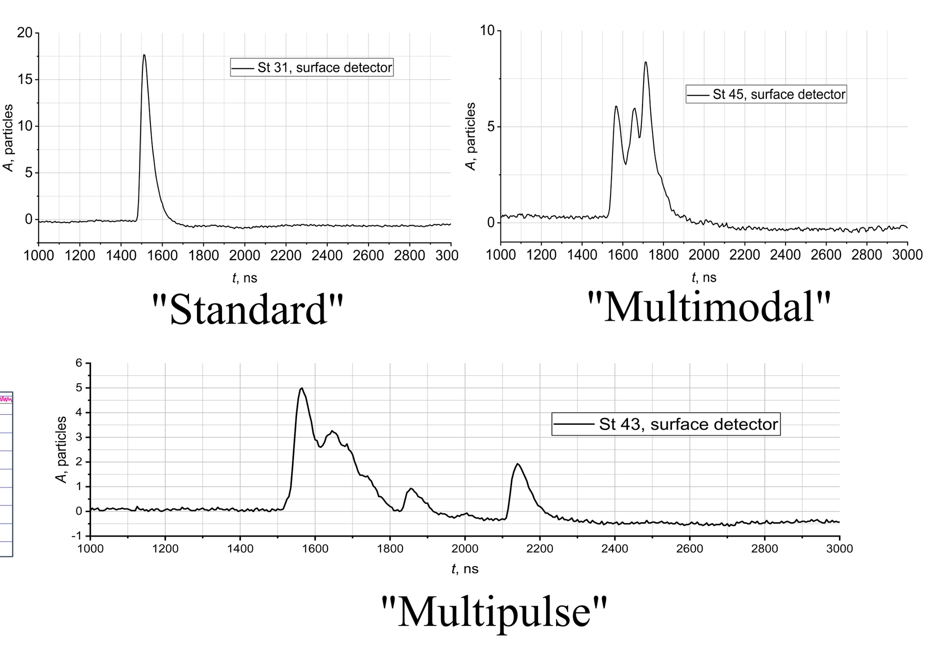

An example of the spatial distribution of EAS particles based on experimental data from the Tunka-Grande and TAIGA-Muon installations

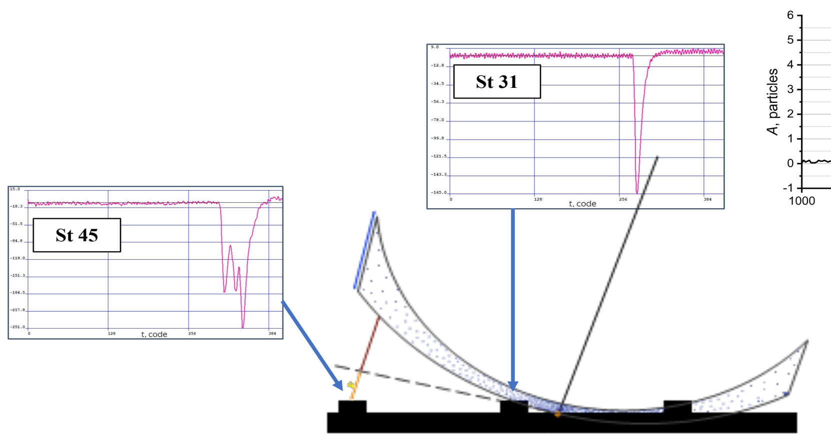
$lg(N_e) = 7.04$, $\theta = 27.35°$

## Study of EASs with non standard spatiotemporal structure

**Pulse type classification:**

- Standard, multimodal, multipulse;
- Leading pulses and dalyed or after-pulses

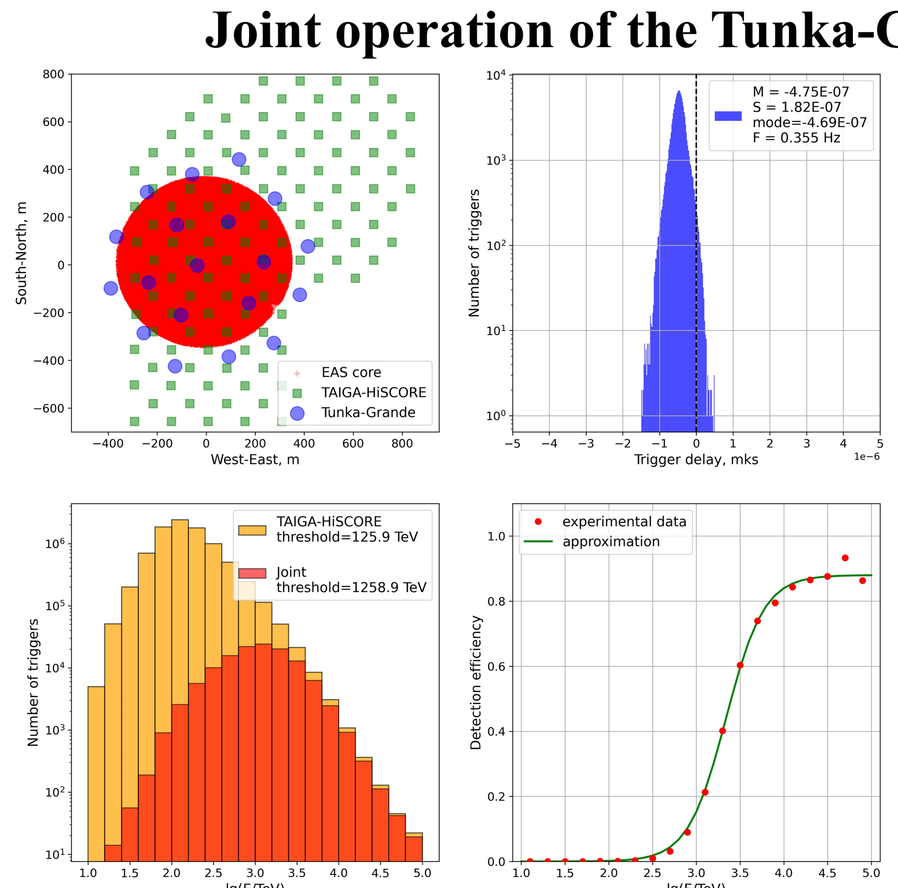



**Conclusions:**

- Multimodal pulses are associated with an increase in the thickness of the shower disk with increasing distance from the EAS axis.
- Statistical analysis shows that the origin of leading pulsus is coincedence with single muons.
- The delayed pulses have several contributions is provide: single muons, photomultiplier after-pulses, delayed particles.

## Joint operation of the Tunka-Grande and TAIGA-HiSCORE



**Event selection:**

- Position of the EAS axis, angles and energy of the primary particles are reconstructed using data from the TAIGA-HiSCORE detectors;
- Coincidence time ±5 μs;
- Number of Tunka-GRANDE stations in the event:≥3, ≥2, ≥1;
- EAS axis is inside a circle with a radius of 350 min the center of the Tunka-GRANDE installation

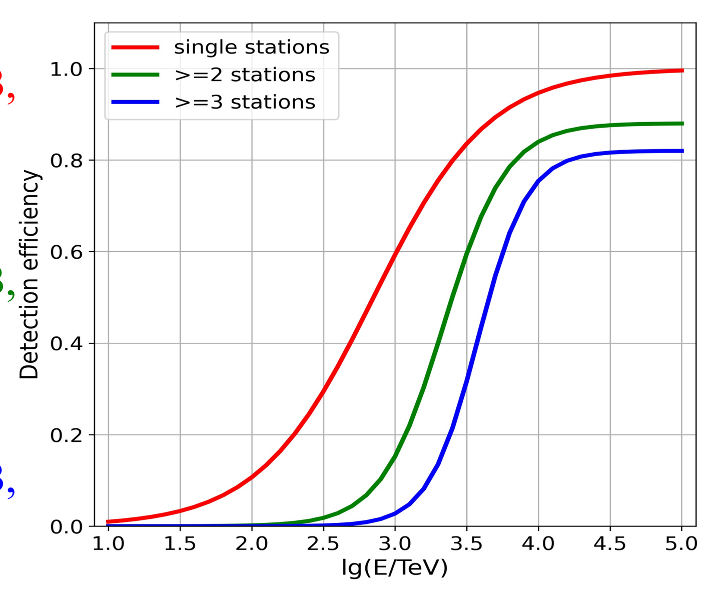
**Preliminary results:**

- The efficiencies of EAS joint registration for different modes were determined;
- Estimates have been made of the possible number of registered gamma-quanta from the Crab Nebula in one season for different operating modes.

≥1 station, $E_{thr} = 10^{14.3}$ эВ, $N_\gamma = 2.6$

≥2 stations, $E_{thr} = 10^{15.1}$ эВ, $N_\gamma = 0.26$

≥3 stations, $E_{thr} = 10^{15.5}$ эВ, $N_\gamma = 0.04$




**Acknowledgments:** The work was supported by the Russian Science Foundation, project 23-72-00054.

**References:**

1. Monkhoev R. et al. 2023 Izv.RAN.Ser.phys. T.87 No.7 P.954
2. Kuzmichev L. et al. 2020 Phys.At.Nucl V.83 №9 P.1375
3. Astapov I. et al. 2019 Nucl.Instr.Meth. V.936 P.254