The wide-aperture gamma-ray telescope TAIGA-HiSCORE in the Tunka Valley: design, composition and commissioning.

Oleg Gress (for the TAIGA Collaboration)

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The new TAIGA-HiSCORE non-imaging Cherenkov array aims to detect air showers induced by gamma rays above 30 TeV and to study cosmic rays above 100 TeV. TAIGA-HiSCORE represents an integrating air Cherenkov detector stations with a wide field of view (0.6 sr), placed of 100 m from each other. They cover an area of initially ~ 0.25 km^2 (array prototype) to ~ 5 km^2 at the final phase of the experiment. Each station includes 4 neighbored PMTs with 20 or 25 cm diameter, equipped with light guides shaped as Winstone cones. We describe the design, specifications of the read-out, DAQ and control and monitoring systems of the array. The present 28 detector stations of the TAIGA-HiSCORE engineering setup are in operation since September 2015.

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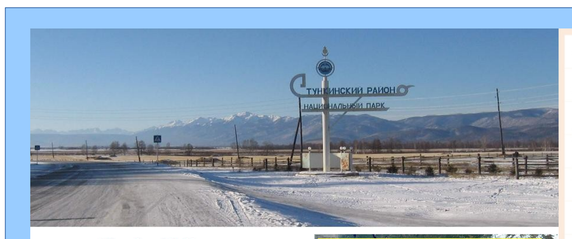
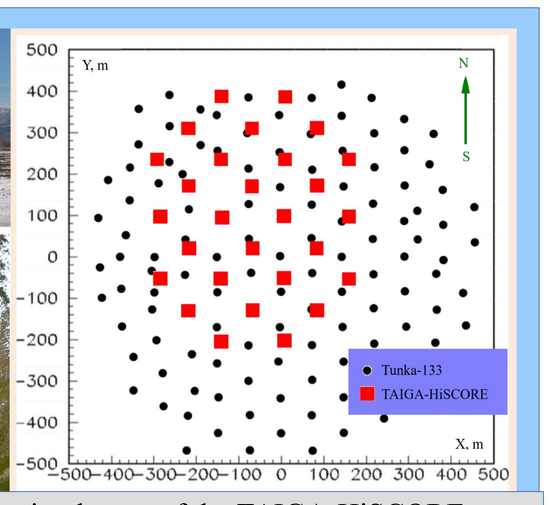
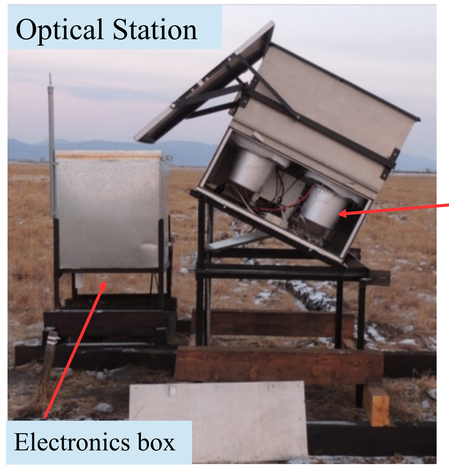
http://www.taiga-experiment.info



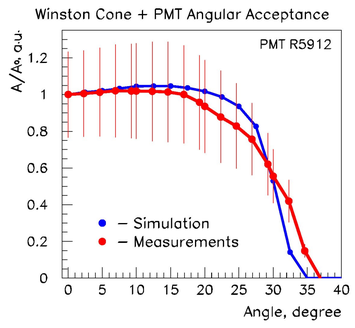


Station layout of the TAIGA-HiSCORE array.

Optical Station

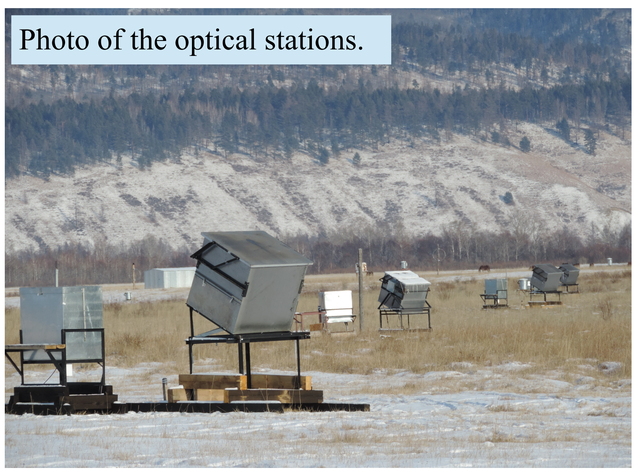


Winston cone

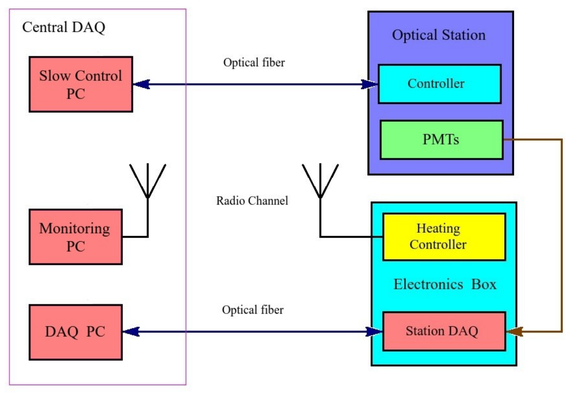


PMTs: EMI ET9352KB, Hamamatsu R5912 and R7081.
A single detector station consists of 4 PMTs with 6 dynodes that yield a gain 10^4 at a HV=1.4 kV. Each PMT is equipped with a light collector (Winston cone) made up of ALANOD 4300 UP material with a reflectivity of 80%.

Photo of the optical stations.

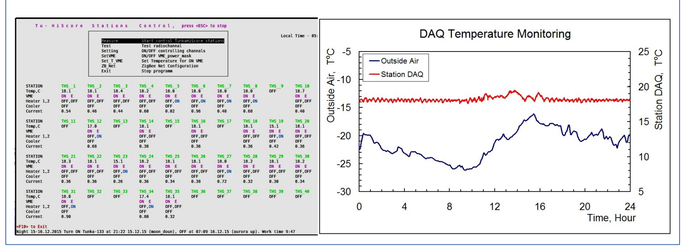


Schematic diagram of DAQ Electronics

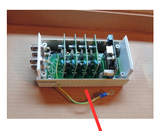


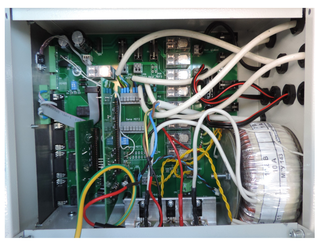
Monitoring of all Station DAQ:

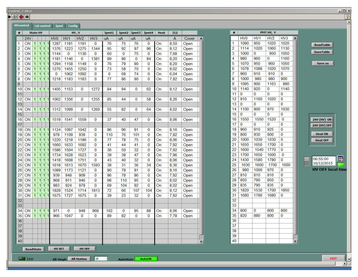
- Power Suplly AC 220V Switch-Off/On
- Thermostabilization mode control
- Display of the DAQ Temperature
- Load current monitoring



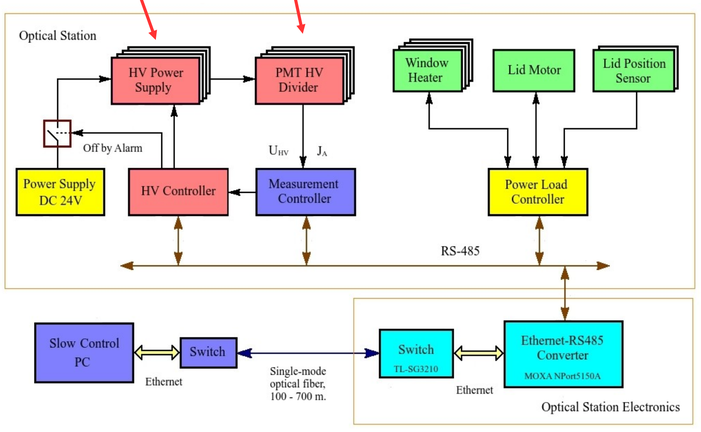
Command and Control System





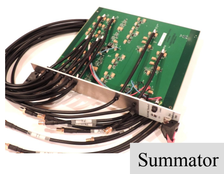


Slow Control PC Display

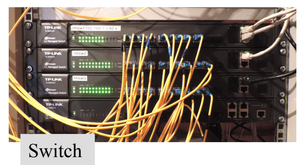


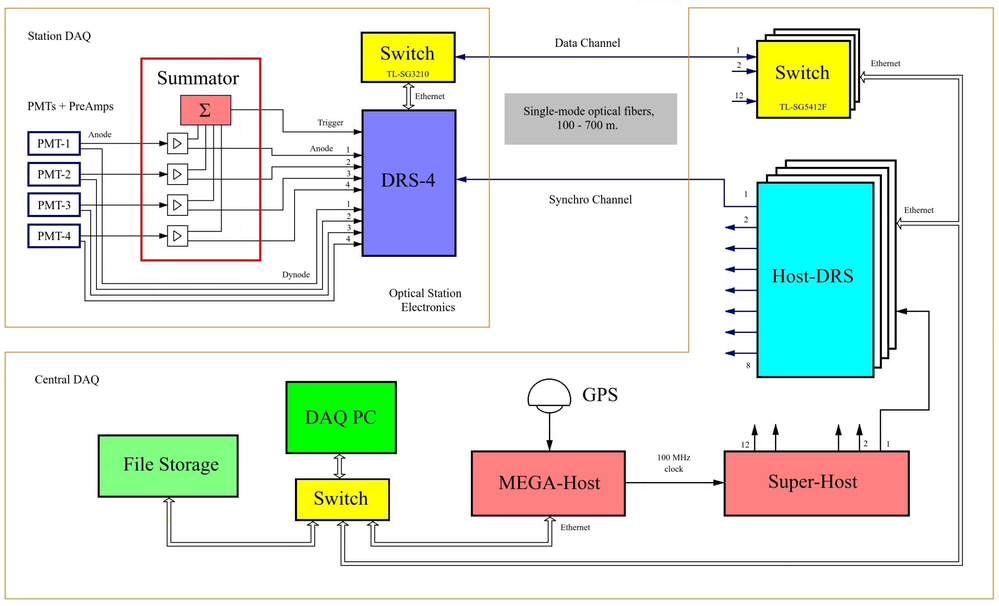
- Lid motor control, status
- HV setting, turn-off by overcurrent
- HV and PMT anode current monitoring
- Auto turn-off by time
- Configuration setting

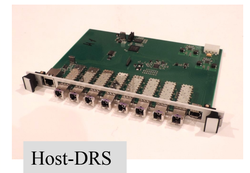
Data Acquisition System

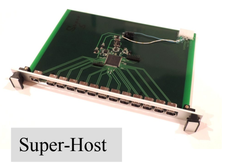

Summator

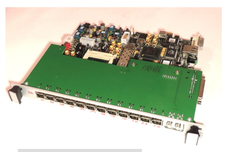

DRS-4


Switch




Host-DRS


Super-Host


MEGA-Host

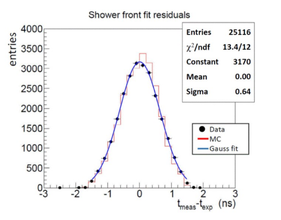
Events time synchronization methods

- A custom-made synchronization technique: distribution of 100 MHz clocks over separate optical fibers from the array center.
- Long-term verification with directly interfaced WhiteRabbit Nodes.

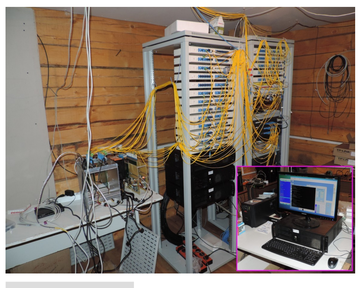
Perfect agreement of both timing methods.

Time synchronization accuracy ≤ 1 ns


Photo of DRS4 and WhiteRabbit System



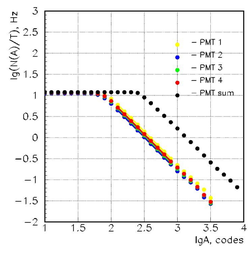
Experimental timing results after shower reconstruction. Distribution of fit residuals. Black dots: data; Red line: simulated events; Blue line: gaussian data fit.


Central DAQ

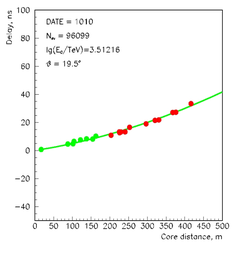

Station DAQ

- Trigger is based on summing PMT anode signals
- 8 channels DRS-4 board (DRS-4 chip and FPGA Xilinx Spartan-6)
- Sampling frequency - 2 GHz (0.5 ns/cell)
- Read-out window - 0.5 μs (1024 cells)
- Dead time ≤ 0.5 ms
- Soft: C++ on OS Linux

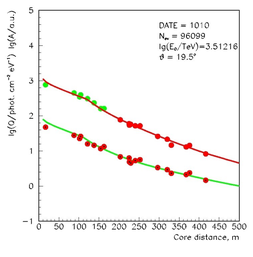
EAS events processing results



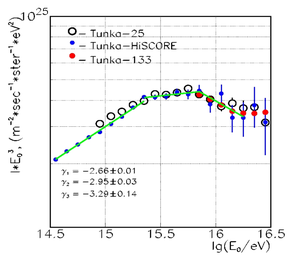
Amplitude Spectrum



Cherenkov Light Front



Cherenkov Light LDF



Cosmic Ray Spectrum

EAS events processing results

The TAIGA-HiSCORE array is part of the gamma-ray observatory TAIGA (Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy, → see: N.Budnev. Poster Board#: 3).

The non-imaging air Cherenkov technique is complementary to the standard imaging approach. It allows larger collection areas of several square kilometers at a comparatively moderate cost in number of read-out channels.
Its operating principle is based on the sampling of the density and timing (arrival-time and spread) of the air shower-front with distributed arrays of detector stations.
Goal: Search of the VHE gamma-ray sources as objects of the cosmic ray pevatrons, i.e. Galactic PeV accelerators.