Tunka-Rex Virtual Observatory.



D. Kostunin for the Tunka-Rex collaboration Data Life Cycle in Physics 2020, Karlsruhe/Moscow/Irkutsk – virtual





The radio detection techniques is successfully applied to ultra-high energy particle physics since first decade of this century.

A number of detectors are in sucessfully operation, next-generation prototypes are on the construction stage

Huge amount of data acquired by radio detectors aimed at air-shower experiments are left unused

 \Rightarrow We combine the experience gained by the radio astronomers and astroparticle physicists to publish the radio data in multi-purpose *Virtual Observatory*

All-component values of a radio field recorded with high-resolution timing bring us to the following science cases:

- Studies of the radio background in the frequency band of 30-80 MHz
- Searching for radio transients
- Training of neural networks for background tagging
- Outreach and education

Tunka-Rex instrument is an ideal testbench to try this approach \Rightarrow Tunka-Rex Virtual Observatory (TRVO)

Tunka-133 ightarrow TAIGA

Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy



= 3 km² covered by:

Cosmic ray detectors < EeV

- Tunka-133 air-Cherenkov
- Tunka Radio Extension (Tunka-Rex)
- Tunka-Grande scintillators

Gamma ray detectors >TeV

- TAIGA-HiSCORE
- TAIGA-IACT
- TAIGA-muon

Tunka-Rex at a glance



- 7 Optical Modules + on/under-ground scintilators + 3 antennas
- Combined measurements (e/μ , $\gamma_{\rm c}$, radio) of E > 100 PeV
- Total 19 (dense) + 6 (satellite) clusters located on 3 km²
- Operation since 2012 till 2019



- Measurement season from October to April
- Starting from 2015 Tunka-Rex reached 85% uptime
- Second most cited experiment in Tunka (after MASTER)

Tunka-Rex and cosmic-ray science



TRVO data structure

Data Layers (DL)

- DL0: raw traces recorded by the ADCs
- DL1: traces containing voltages at the antenna stations
- DL2: traces containing values of electrical field at the antenna stations ⇒ DL2-AIRSHOWER, DL2-ASTRONOMY, DL2-OTHER
- DL3+ will contain high-level reconstruction of radio data

Antenna station data

- Trace ID
- Antenna ID
- Timestamp
- Version
- Traces
- Flags

Calibration data

- Commission
- Decommission
- Antenna ID
- LNA ID
- Filter ID
- X, Y, Z
- Alignment

Air-shower data

- UUID
- Timestamp
- Theta, Phi
- X, Y, Z
- Energy
- Xmax
- Particle

TRVO Implementation and performance

Prototype status

- 3 TB MySQL database with 100M events (DL1) deployed at IKP KIT
- Processing of 1k events/s
- Almarac (Tien-Shan radio array) DB is deployed at API ISU
- Integration with GRADLCI services

Preparation for release

- Funding for hardware upgrade are secured from KIT side
- Human resources are provided from ISU side

Thank to self-trigger group we found a bug which descreased timing resolution in billion times (oops), i.e. from ns \rightarrow sec \Rightarrow interferometry/short transients are disabled, but the rest is fine \Rightarrow database is need to be re-installed

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Conclusion

Prototype applications

- Storage of data itself
 - Tunka-Rex data (done + extension)
 - Almarac data (testing stage)
 - Tunka-21cm data (in preparation)
- Studies of the radio background
 - RFI library module for TRVO
 - Module for 21cm cosmology tasks
- Outreach and education
 - Hackaton during first workshop of math. center @NSU

Future steps

- Server (hardware and software) upgrade
- Implementation of common user interface
- Integration with KCDC/GRADLCI

Release

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