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Tunka-Rex: Status and results of the first measurements

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ABSTRACT

Tunka-Rex is the new radio extension of Tunka-133 located in Siberia close to Lake Baikal. The latter is a photomultiplier array registering air-Cherenkov light from air showers induced by cosmic-ray particles with initial energies of approximately 10^{16}–10^{18} eV. Tunka-Rex extends this detector with 25 antennas spread over an area of 1 km^2. It is triggered externally by Tunka-133, and detects the radio emission of the same air showers. The combination of an air-Cherenkov and a radio detector provides a facility for hybrid measurements and cross-calibration between the two techniques. The main goal of Tunka-Rex is to determine the precision of the reconstruction of air-shower parameters using the radio detection technique. It started operation in autumn 2012. We present the overall concept of Tunka-Rex, the current status of the array and first analysis results.

1. Introduction

Since the measurements of cosmic rays have reached the theoretical limit for energies [1,2], the main challenge for the physics of ultra-high cosmic rays is to increase the statistics and the measurement quality near the energy spectrum cut-off. To obtain a sufficient statistics from the surface of Earth we need to build economically reasonable large-area detectors with a high duty cycle. The radio detection could be one of the perspective techniques for future investigations of ultra-high energy cosmic rays.

Radio emission from extensive air showers was theoretically predicted [3–6] and first detected [7–9] about 50 years ago. The radio detection techniques became popular in the last decade again, because standard detection methods have reached technological and economical limits: measurements by surface particle detectors depend on models, whose accuracy is limited at high energies due to extrapolation; optical fluorescence and air-Cherenkov detectors are limited by their duty cycle due to night length and weather. Thus, a number of modern experiments [10–13] aim at obtaining the main properties of extensive air showers, such as arrival direction, energy, shower maximum, and primary particle[1] using the radio detection technique. These experiments proved that the radio emission can be detected from air showers with energies above 10^{17} eV, with an angular resolution for the arrival direction better than 1° [14].

The open question is the precision of the reconstruction for primary energy and shower maximum. Up to now, the experiments have given only upper limits for these quantities (20% for the energy and about 100 g/cm^2 for $X_{\max}$) [15–18]. In a very recent report of the LOFAR collaboration, there has been shown that the precision of the $X_{\max}$ reconstruction can reach up to 20 g/cm^2 for some events [19]. This precision would be comparable with the fluorescence technique. The current challenge is to reach a competitive precision with an economic radio array which can be scaled to very large areas.

The main goal of Tunka-Rex, the radio extension of the Tunka observatory for air showers, is to answer this question, i.e. to determine the precision for the reconstruction of the energy and the atmospheric depth of the shower maximum based on the

[1] The chemical composition of cosmic rays (i.e. the primary particles) can be reconstructed only by indirect methods from air-shower measurements, for example, by combining study of primary energy and shower maximum, which can be obtained by the optical detectors.

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