Status and prospects of the TAx4 experiment

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Abstract. The TAx4 experiment is a project to observe highest energy cosmic rays by expanding the detection area of the TA experiment with newly constructed surface detectors (SDs) and fluorescence detectors (FDs). The construction of both SDs and FDs is ongoing. New SDs are arranged in a square grid with 2.08 km spacing at the north east and south east of the TA SD array. Field of view of new FDs overlaps the detection area of new SDs to observe SD FD hybrid events. New SDs are planning to be deployed early next year. The first light with new FDs was already observed on February 2018. Especially the hotspot and energy spectrum anisotropy are expected to be understood in more detail from the implications obtained by the TA experiment.

1 Introduction

Telescope Array (TA) is the largest cosmic-ray observatory in the Northern Hemisphere. The TA experiment has 507 surface detectors (SDs) on a square grid with 1.2 km spacing covering approximately 700 km^2. The SDs are surrounded by three fluorescence detector (FD) stations (12, 12 and 14 telescopes). The duty cycle of the SD array is greater than 90% throughout 10-year observation period, whereas the FD duty cycle is about 10% because the data is taken only on moonless clear nights. The locations of the detectors of TA are shown in Fig. 1. in Ref. [1]. The latitudes and the longitudes of the detector sites are around 39.30°N and 112.91°W in Utah in the USA.

The hotspot was observed in the arrival directions of 72 cosmic rays with energies above 57 EeV [2]. The data used in the analysis was obtained by observing with TA SD for 5 years. The chance probability to exceed the obtained maximum significance (5.1 σ) in an isotropy sky is estimated to be 3.4 σ in Ref. [2].

The SD array of the TAx4 experiment was designed to study cosmic rays with energies especially above 57 EeV. The spacing of TAx4 SD array is sparser than TA SD to obtain larger detection area. The spacing of the array is 2.08 km. Cosmic rays with higher energies make larger number of SDs triggered and the sparse array does not lose the quality of event reconstructions very much at the higher energies. Reconstruction efficiency of the SD array is expected to be more than 95% above 57 EeV. 500 TAx4 SDs cover about 3 times larger area than 507 TA SDs and the combined coverage of TAx4 SDs with TA SDs is about 3000 km^2. Fig. 1. in Ref. [1] also shows the locations of TAx4 detectors. 2 FD stations of the TAx4 experiment were also designed. The field of view of FDs covers the detection area of SDs to observe SD FD hybrid events.

The implications of the energy spectrum anisotropy were recently observed by the TA experiment [3–5]. The difference between the energy spectrum within 30 degrees from the supergalactic plane and the energy spectrum in the other part of the sky region was implicated in Ref. [3]. The statistical significance of the difference was estimated to be 3.2 σ. The difference between the energy spectra above and below the declination $\delta = 24.8°$ was also implicated in Ref. [4]. The statistical significance of the difference of the break points of the energy spectra was estimated to be 3.5 σ. The energy spectrum anisotropy above $E = 10^{19.2}$ eV was implicated in Ref. [5]. The post-trial significance of the anisotropy was estimated to be 3.74 σ. These implications were obtained using TA SD data which was obtained from the observation for 5-7 years, and the implications are expected to be confirmed by the TAx4 experiment.

Construction of the TAx4 detectors is now ongoing. The status of the construction of detectors is shown in the section 2. Prospects of the observation are shown in the section 3.

2 Construction

The status of the construction of SDs and FDs is shown in the section 2.1 and the section 2.2, respectively.

2.1 Construction of SDs

The detailed structure of SDs is shown in Fig. 2 in Ref. [1]. The assembly of scinitillator boxes of SDs was started in 2015. The scintillator boxes were assembled in Japan every year and transported to the USA. The assembly in South Korea was also started in 2018. The quality of scintillator boxes is almost same as shown in the section 3 in Ref. [1]. SDs were assembled with the transported scintillator boxes were in Delta, Utah. Fig. 1 shows assembled SDs in Delta, Utah.

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Figure 1. Picture of assembled SDs. These SDs will be deployed in the observation sites.

Figure 2. Picture of assembled 4 telescopes in the FD station at the north site of the TAx4 experiment.

2.2 Construction of FDs

2 FD stations are being constructed using transported telescopes of the HiRes experiment. North FD station was constructed, and the first light was observed on Feb. 16, 2018. Fig. 2 shows constructed north FD station. 4 and 8 telescopes are instrumented in the north and south FD station, respectively. Construction of the south FD station is ongoing.

3 Prospects

More than half of 500 SDs will be deployed in the observation sites early 2019. The observation of SDs will be started after that. North FD station was already constructed, and the south FD station will be constructed soon.

The hotspot and energy spectrum anisotropy will be studied with 4 times larger statistics than TA SDs if the full operation is started. The full operation of the TAx4 experiment will provide about 3 times larger number of SD FD hybrid events than the TA experiment at the highest energies. Mass composition of cosmic rays will be studied in detail with the hybrid events.

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