NICHE: Non-Imaging Cherenkov Light Observation at the TA Site

Yoshiki Tsunesada[1], Yugo Omura[1], BokKyun Shin[1], Douglas R. Bergman[2], John F. Krizmanic[3], and Toshiyuki Nonaka[4]

[1] *Department of Physics, Osaka City University, Osaka, Japan*
[2] *Department of Physics and Astronomy, University of Utah, Salt Lake City, Utah, USA*
[3] *Universities Space Research Association, Greenbelt, Maryland, USA*
[4] *Institute for Cosmic Ray Research, University of Tokyo, Kashiwa, Chiba, Japan*

E-mail: yt@sci.osaka-cu.ac.jp

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The Non-Imaging CHErenkov Array (NICHE) is a low energy extension to the Telescope Array and TALE using an array of closely spaced (70 ∼ 100 m) light collectors covering an area of up to a square km. The target is cosmic rays with energies above the *knee*, including the "transition region" above which Galactic cosmic rays are no more confined by the galactic magnetic field. It will be deployed in the field of view of TALE and will overlap it in energy range. TALE can observe events in the energy range 3 ∼ 30 PeV by non-imaging air-Cherenkov, so NICHE and TALE will observe imaging/non-imaging Cherenkov hybrid events. NICHE itself will use both the Cherenkov lateral distribution and the Cherenkov time-width lateral distribution in measuring air showers. These two methods will allow shower energy and Xmax to be determined to infer primary types of cosmic nuclei. A prototype of the array with 15 counters, called j-NICHE, is currently being built. We describe the design of the experiment and the status of the detector development.

KEYWORDS: Cosmic rays, Cherenkov light, mass composition

1. Introduction

The mass composition of cosmic rays is very important to clarify their origin, because it must be strongly related to their sites of origin, mechanisms of particle accelerations, and propagation from the sources to the Earth. There is a general agreement as regards cosmic ray composition that the fraction of the heavier component increases with energy around the *knee* region ($E = 10^{15} - 10^{16}$ eV, see [1] for review). In air shower experiments, the types of primary nuclei that induce air showers can be inferred from the longitudinal developments of the showers thanks to the differences in the interaction cross-sections with the atmosphere. The results from the previous experiments show that the cosmic-ray mass $\langle \ln A \rangle$ increases with energy indicating a heavy-dominant composition at the knee. This is consistent with the rigidity-dependent stochastic particle acceleration models for cosmic ray sources that predict the maximum reachable energies $E_{\rm max} \propto Z$. On the other hand, it has been predicted that galactic cosmic ray sources such as supernovae cannot accelerate particles to energies greater than $\sim 10^{18}$ eV, and therefore we conclude that cosmic rays with such high energies are of extra-galactic origin. In this case, protons and other lighter components would be dominant in this higher energy region, since heavier nuclei suffer from photo-disintegration processes by interaction with the cosmic microwave background photons during long distance propagation. In fact, from recent measurements of the cosmic ray composition in the ultra-high energy region ($E > 10^{18}$ eV) using the air fluorescence detection technique, a proton-dominant composition has been reported at 10^{18} eV [2–4]. Therefore, we can expect a drastic change in the cosmic-ray mass composition in the energy range of 10^{16} to