Research Report
ICRR Inter-University Research Program 2020

Research Subject: Neutrino Telescope Array Light Collector Prototype Test

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Summary of Research Result :
The origin of the Pevatron has not been revealed yet. ν production is closely related to that of gamma-rays (γ's) in photo-meson and hadro-nuclear reactions. Independently, HESS reported observation of a hard power-low spectra of γ's from the region surrounding the supermassive black hole Sgr A* at the Galactic Center with arcminute angular resolution. This also indicates a Pevatron candidate. Combined detection of PeV ν's and γ's from an accelerator would provide indispensable identification of the location and the physics mechanism. Such a "multi-particle" detection can be performed uniquely by NTA with a single detector system for imaging Cherenkov and fluorescence light from air-showers induced by Earth-skimming ν's and primary γ's in the air surrounding Mauna Loa (Fig.1). NTA offers point-back accuracy below 0.2°, covering the field of view (FoV) above π steradians as well as sufficient sensitivity to identify cosmic hadron accelerators clearly as PeV ν and γ objects. If "cosmic hadron accelerators" are discovered, the "cosmic beam of ν's and γ-rays" can allow for tests of Lorentz invariance, extra-dimensions, cosmic photon fields, and so on. NTA has potential impact on fundamental science. The technology was already developed and demonstrated by Ashra-1 in Japan and with Hawaii Island as an excellent site.

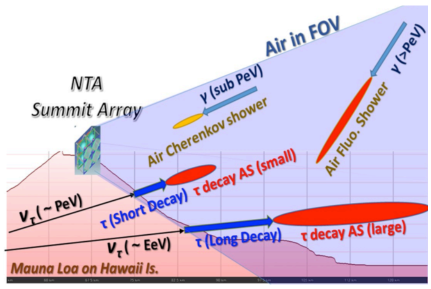

Fig.1: NTA detection concept.

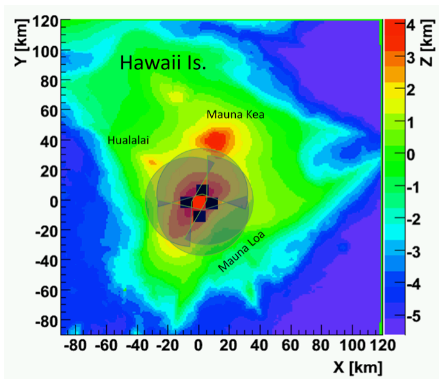

Fig.2: Four Sites on Mauna Loa.

The full NTA would consist of four observation sites at 3000-3500m a.s.l. on Mauna Loa to efficiently watch the entire air volume surrounding Mauna Loa above ground or sea (Fig.2). The core collaboration described in this proposal is an important step in that direction.

The Japanese side of Ashra/NTA collaboration has already set up the prototype test facility with a Nd-YAG laser and two prototype light collectors (LCs) of NTA at the

Akeno observatory(Fig.3). It is currently being used to develop more sophisticated trigger logic mainly for fluorescence detection of gamma-ray and neutrino showers.

The US side plan to (1) develop the automatic operation and the solar power generation system for a detector unit at each of four sites, which are indispensable in the real operation of the Ashra system on Mauna Loa, (2) new image readout system based on the SiPM technique, which we expect more stable production and operation of the photoelectric imager of NTA and which would be more cost-effective and (3) examination of radio detection options.

For the aims of the above R&D programs of (1) and (2), the US members are working together with the Japanese collaborators to discuss the design, to make plans, to perform the related laboratory tests at ICRR and prototype tests in Akeno. Since we have no budget for the local expenses to stay at ICRR and the Akeno Observatory due to difficulties associated with the COVID-19 pandemic situation, we have concentrated on the site investigation, discussion of the NTA design and collaboration organization with online meeting system.

We also discussed on how to organize the presentations at International Cosmic Ray Conference and Very High Energy Particle Astronomy (VHEPA) Workshop to be held in 2021 together with Japanese side collaborators.

Another collaborating work that the US side has done is cleaning up the debris left on the Mauna Loa site as requested by the State of Hawaii with hauling tracks (Fig.4 and 5).

Fig.3: NTA prototype in Akeno.

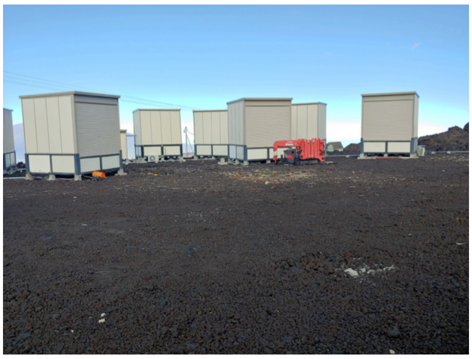

Fig.4: View of the Mauna Loa site after cleaning up the debris.

Fig.5: Hauling track with debris.