Detection of Heavy Cosmic Ray Particle (Z > 20) at Hanle, Ladakh at an Altitude of 4.5 km a.s.l. using SSNTD.

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Abstract: To detect exotic events, like strangelets, expected to be present in the cosmic ray flux at high altitude, we have placed Solid State Nuclear Track Detectors of the material Polyethylene Terephthalate (PET) with a high detection threshold along with standard CR-39 at different mountain altitudes. Geographical locations chosen are Darjeeling (Latitude - 28° N, Longitude - 88° E and Altitude 2.13 km), Ooty (Latitude - 11°24'N, Longitude - 76°42'E and Altitude 2.23 km) and Hanle (Latitude- 32°42'N, Longitude- 79°04'E, Altitude 4.5 km).The flux of recorded tracks at Hanley is ~10^{-5}/ (cm^2/s/sr) on PET and flux observed in CR-39 ~ is 10^{-3}/ (cm^2/s/sr); both these values are consistent with the fluxes obtained at other locations. These tracks are due to mainly protons and low energy ions. One high energy heavy ion Z > 20 has been recorded at Hanley which punched through 0.7mm thick CR-39 plate. Track parameters and the ratio of track etch rate and bulk etch rate (Vt/Vg) for this event are remarkably different from those of the other tracks, making it a candidate for exotic event.

Keywords: Strangelet search at high mountain altitude

1. Introduction

Search for massive exotic particles in cosmic rays is an active field of research in cosmic ray studies at present. Quite a few reported observations of massive particles in cosmic rays by different groups have been repoted. Several authors have suggested that these could be possible candidates of strange quark matter (SQM) or strangelets. A theoretical study by Banerjee et al [1] suggested the possible existence of strangelets in cosmic rays even at mountain altitudes with extremely low abundance (5-10/100m^2/year) compared to that of primary cosmic rays. The authors of ref.1 have pointed out that under suitable conditions, small strangelets of initial mass A~64 amu and charge Z~2 arriving at the top of the terrestrial atmosphere with β~0.6, could grow to A~300-400 and Z~10-20 at mountain altitude ~3-4 km and be left with a β~0.01.

To investigate this type of rare events one requires a large area detector array. We have plan to setting up a 400 m^2 detector array at Sandakphu (altitude ~ 3.6 km) in the Eastern Himalayan Range in India. The suitable choice of detector for such large area cosmic ray exposure at high altitude is polymer or plastic detectors, called Solid State Nuclear Track Detectors or SSNTD.
We have standardized and calibrated a plastic detector Polyethylene terephthalate (PET) (2,3) for detection of strange lets or any exotic event which have high Z/β threshold. Available standard solid state detectors, CR39(DOP 1%) with

Z/β~6 , CR39(HCB 0.5%) with Z/β~10 and Lexan Polycarbonate with Z/β~57 , as compared to the predicted Z/β range of 1000-2000 for strangelets, these detectors will record a huge low-Z particles which is most undesirable in a search for these type of rare events. A detector, which is sensitive only to higher values of Z/β, therefore, is of prime importance in the search for strange quark matter.

2. Experiment and results

We have exposed several sets of PET & CR39 detectors at different mountain altitudes Darjeeling, Ooty and Hanley. Processing and scanning is described in ref (3). Data recorded on PET and CR39 at Darjeeling are reported (4). At Ooty charged particle flux recorded with CR-39 detector is 4.7 x 10^{-5}/(cm^2.s.sr) and at Hanle flux obtained is 5.77x10^{-4}/(cm^2.s.sr) are consistent with that observed at Darjeeling (1.05x10^{-3}/(cm^2.s.sr). Photograph of tracks are shown in fig 1. Track parameters of the tracks observed are measured for both side of the CR-39 plate. One un-usually heavy ion track is observed on the bottom side of a CR-39 plate. Photograph of track is shown in fig.2a. It has passed through the CR-39 plate and entered the PET film and then stopped after a few microns. CR-39 plate was placed on top of a stack of PET films. Track image on PET is shown in fig 2b. Size of each frame is 116 μm x 87 μm.

From the measurements of track parameters of the track found on PET that particular heavy ion is identified with the help of our calibration curve (3). Identification also made with the help of our internal calibration curve for CR-39 from the track parameter. This heavy ion has Z=26 ± 2. It has punched through the plate 700 μm thick CR-39 before impinging on PET. Energy of the ion when it impinges CR-39 is ~ 1.70 GeV calculated using SRIM (5). The ion was incident on the plate at an angle of 60° with the plate, which in turn was placed in the direction facing towards south with 10° off from east and inclined at an angle of 30° with the horizontal. Distribution major axis diameters of tracks observed on top surface with that of heavy ion are shown in Fig 3. It is clearly different from other tracks. Further analysis is under way.

The event has been identified as candidate belonging to iron group according to charge identification. Flux of iron at the altitude of Hanley is ~10^{-20} /cm^2/s, which is less than 1 particle per square km/century (6). We have observed this event after searching an area of ~50 cm^2, which has exposed for 2.77x 10^7 sec (~ one year). Calculated flux over this area is 7.2x10^{-10} /cm^2/s. It is very rare and may be an exotic event which is important information in cosmic ray physics.

3. Figures

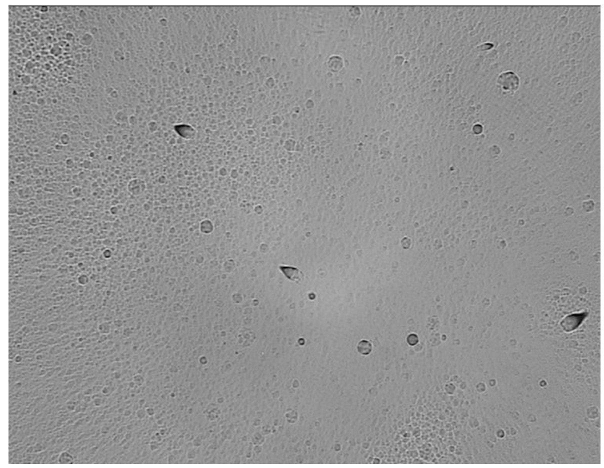

Figure1. General feature of tracks observed on CR-39 top surface after two hours of etching

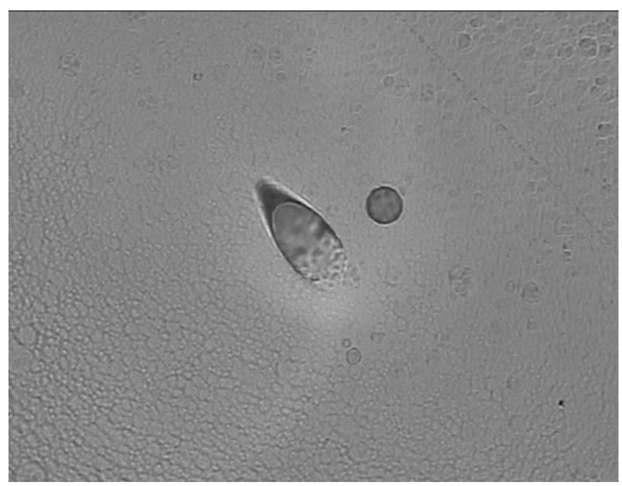

Figure 2a. Big size track observed on bottom side of the same plate after two hours of etching.

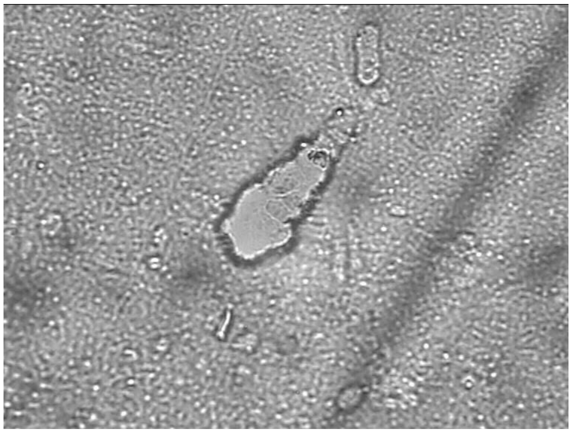

Figure 2b. Track observed on PET which is continuation of track shown in fig2a.

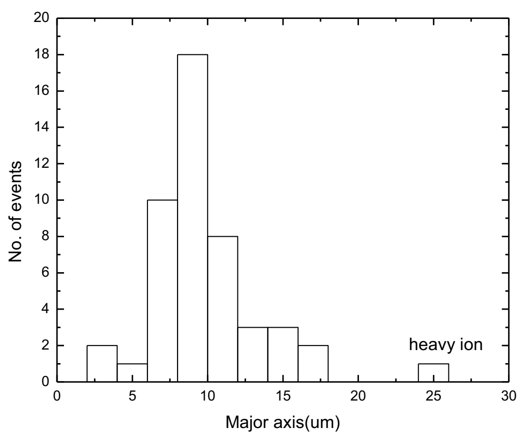

Fig.3. Major axis diameter distribution.

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