DETECTOR CALIBRATION OF THE INDIAN COSMIC RAY EXPERIMENT (IONS) IN SPACE-SHUTTLE SPACELAB-3

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ABSTRACT

In IONS experiment in Spacelab-3 we intend to study nuclei upto iron in low energy cosmic rays, using CR-39 (DOP) detectors. We have exposed CR-39 (DOP) to He^4, C^{12}, O^{16}, Ne^{20}, Si^{28}, Ar^{40}, Cr^{52} and Fe^{56} accelerated beams from various accelerator facilities available around the world. We have used different beam energies and exposure angles. From these exposures, we have studied the charge resolution and energy resolution for our detector in the region of our interest. We have also studied the effect of pre-annealing and depth on the response of our detector. For isotopic resolution, we have exposed the detector samples to Ne^{20} and Ne^{22} accelerated beams. We have also kept samples of CR-39 (DOP) exposed to different accelerated heavy ions in our detector module to take into account the effect of ambient conditions on detector response during the flight.

1. Introduction. The passive track detectors provide the advantage of high geometrical factor to study low intensity cosmic rays. CR-39 plastic detectors are the most sensitive among passive detectors.[1] However, CR-39 has following disadvantages: (1) Its surface becomes frosty after etching for long time, and (2) It shows track response variation along the depth of detector samples. The first problem makes the multisheet measurements difficult while second problem affects directly track identification and hence the resolution of the detector. Both these problems are very important for cosmic ray studies. These problems are overcome by using long curing cycle and adding 1% dioctyl phthalate in CR-39 monomer (CR-39 [DOP]).

We are using CR-39 (DOP) detectors in our cosmic ray experiment in Space Shuttle Spacelab-3.[2] This plastic (of thickness $\sim 250\mu m$) is prepared by Pershore Moulding Ltd., UK, using 32 hours of curing cycle. We have studied the response of this plastic detector using different heavy ion exposures. In this paper, the results of this study are presented.

2. Experimental Details and Results. Indian cosmic ray experiment in Space Shuttle Spacelab-3 has been designed to perform the measurements of the ionization states, flux and energy spectra of elements from alpha particles to iron ions in the low energy region below 100 MeV/N. We have exposed CR-39 (DOP) samples to different heavy ions in this charge region. The exposure details are given in Table 1.

Table 1 : Exposure Details

Ion Beams	Energies MeV/N	Angle of Exposure
He	1.0, 2.1, 7.5 and 10.5	90^o
C	1.75, 3.5, 4.5, 7.0 & 8.8	30^o and 60^o
N	3.2 and 10.4	-do-
O	1.1, 4.2, 5.4 and 8.8	-do-
Ne^{20}	1.4, 7.3, 8.0 and 9.1	30^o, 60^o and 90^o
Ne^{22}	2.65, 4.6 and 7.5	-do-
Si	6.5	30^o
Cr	6.5	10^o, 20^o, 30^o, 45^o, 60^o and 90^o
Ni	6.0	30^o
Fe	$\leq$ 300	60^o

The exposures to alphas are obtained from Variable Energy Cyclotron (VEC), Calcutta, India. The exposures to iron beam (all energies below 300 MeV/N) are obtained from Berkeley, USA. All other exposures are obtained from Joint Institute for Nuclear Research, Dubna, USSR.

All the exposed samples are etched in 6.25 N NaOH at 70^oC simultaneously for different etching times. Different track parameters are measured to obtain the etch rate ratio for different particles of different energies. Different sets of four parameters are used to calculate the actual track length in order to cross check the values so obtained [3]. This method also gives the parameters with the least percentage errors in different etch rate ratio regions. The measured values of etch rate ratio are plotted as a function of dE/dX as well as $(Z_{effective}/\beta)^2$ calculated using different relations for energy loss and range [4]. Fig. 1 shows log-log plot between etch rate ratio and dE/dX (from Mukherjee and Nayak relations) [4]. The experimental data from other studies for relativistic ions are also included. It is clear from the figure that in low energy loss region, etch rate ratio is a linear function of energy loss. However, in high energy loss

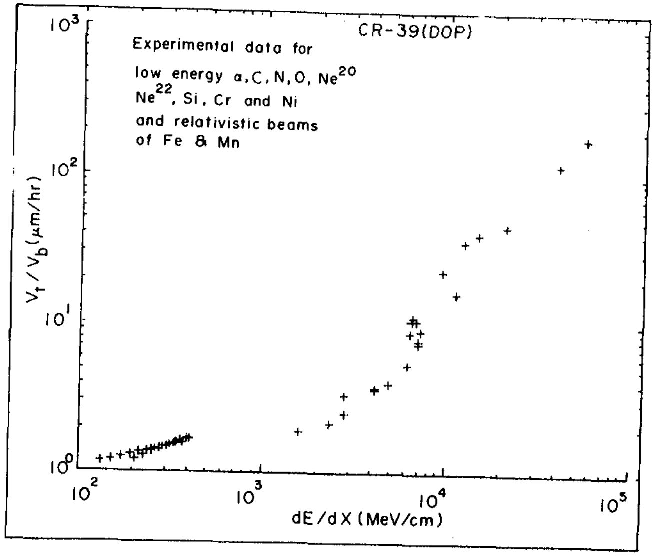

Fig. 1 Track response of CR-39 (DOP)

region, etch rate ratio is a power function of energy loss. A polynomial of the form

$$V_t/V_b = A + b\ (dE/dX) + c\ (dE/dX)^d$$

is fitted to data points (not shown in the figure). From response curve, we have generated curves between Vt/Vb versus residual range for different ions. From these curves, we have studied the charge resolution of CR-39 (DOP) in terms of standard deviation in measurements. The accuracy of the charge resolution turns out to be about 0.2 charge unit.

Isotopic resolution is studied from Ne^{20} and Ne^{22} exposures. The depth dependence of detector response of this plastic is studied from 6.5 MeV/N Cr exposures (range $\sim$ 95 μm). The track length measurements for different exposure angles, on both sides, do not show any difference beyond experimental error. We also do not find any significant effect of annealing on track response of this plastic.

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