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LETTER TO THE EDITOR

CR-39(DOP) AS A RELATIVISTIC ^{238}U-ION DETECTOR

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CR-39(DOP) stack was exposed to 927 MeV/n $^{238}_{92}$U beam from the Lawrence Berkeley Laboratory (LBL) accelerator BEVALAC at an angle of 30^o to the detector surface. The chemically processed sheets were investigated using a Leitz Ortholux optical microscope. 644 etch pit cone lengths were measured and the track etch rate has been found to be (174 ± 11) μm/h. The present result is in accord with the data of Heyna et al. The estimated charge sensitivity has been found to follow the extrapolated results of Salamon et al. The present survey on the etch rate ratio has been found to increase faster than exponentially with Z/β and follows the relation $V_T/V_G = \exp[A + B(Z/\beta - 60) + C(Z/\beta - 60)^2]$ where $A = 1.623 \pm 0.064$, $B = -0.0444 \pm 0.0015$ and $C = 0.000506 \pm 0.000064$ for $27.6 \leq Z/\beta \leq 106.4$.

The dielectric track detectors have better charge resolution than ionization and semiconductor detectors and are sensitive to various kinds of energy transfers. Such detectors are also better than nuclear emulsions or organic scintillators which are very sensitive to high energy transfers.

In the earlier investigation, Salamon et al. [1] have measured charge resolution of CR-39(DOP) track detector using 1 GeV/n ^{197}Au ions and fragments, 1.28 GeV/n ^{139}La, 1.45 GeV/n ^{84}Kr and 1.7 GeV/n ^{56}Fe ions. These results are compared with our results for 1.88 GeV/n ^{56}Fe, 0.45 GeV/n ^{84}Kr and 1.015 GeV/n ^{197}Au ions [2-4]. These studies showed that the reduced etch rate for $Z/\beta \geq 60$ sharply increases with Z/β. Heyna et al. [5] have estimated the track etch rate of 0.41 GeV/n ^{238}U ions in CR-39 using LBL, BEVALAC beam and found a maximum value of track etch rate of about 180 μm/h for residual range 6000 μm before the stopping of ions was reached.

A stack of CR-39(DOP) plastic sheets, each of a thickness of 450 μm, was irradiated by 927 MeV/n ^{238}U ions from the LBL accelerator BEVALAC, at an angle of 30^o to the surface. The sheets were etched for one hour in a 6.25N NaOH solution at (70 $\pm$ 0.1) ^{o}C. The bulk etch rate of the detector material was $V_G =$ (1.36 $\pm$ 0.05) μm/h. The cone lengths of the etch pits on both surfaces have been measured by a Leitz Ortholux optical microscope with an X15 filar micrometer eyepiece and an X24 dry air objective. The finest division of the filar micrometer scale was 0.3 μm. 644 cone lengths were measured and the results are plotted in Fig.1.

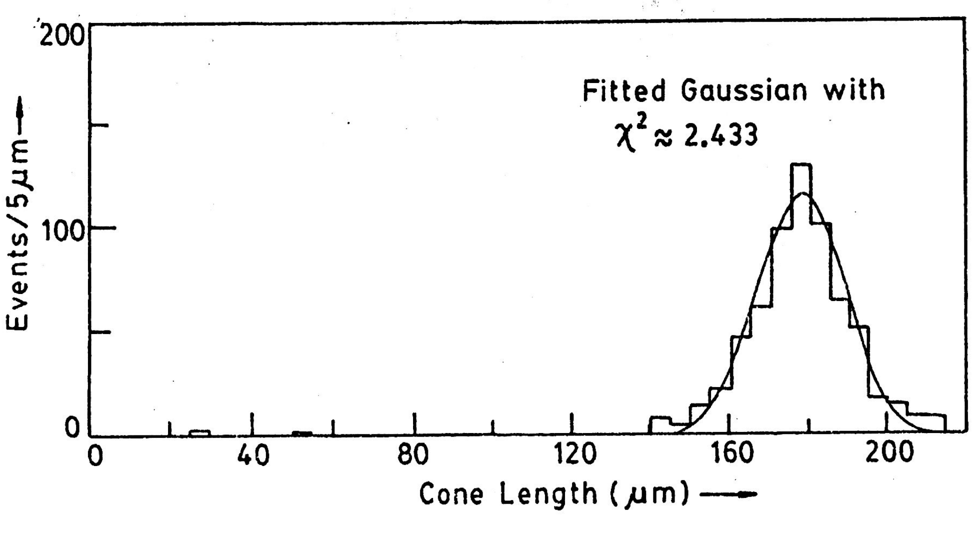

Fig. 1. Cone length distribution of 927 MeV/n ^{238}U*-ion tracks in* CR-39(DOP) *detector.*

The average value of the measured cone lengths has been estimated and has been found to be (174 ± 11) μm. The track etch rate has also found to be $V_T = (174 \pm 11)$ μm/h. The present estimate is in an approximate agreement with the observations of Heyna et al. [5] in the low energy region with 0.41 GeV/n ^{238}U ions in CR-39 non DOP dielectric nuclear track detector.

The estimated charge sensitivity of the CR-39(DOP) detector for registering U-ions at near relativistic energy has been found to be $V_T/V_G = 128 \pm 11$. The present results for ^{238}U ions is shown in Fig. 2 along with the earlier CR-39(DOP) detected data of Salamon et al. [1] and our results [2-4] for ^{197}Au, ^{84}Kr and ^{56}Fe ions.

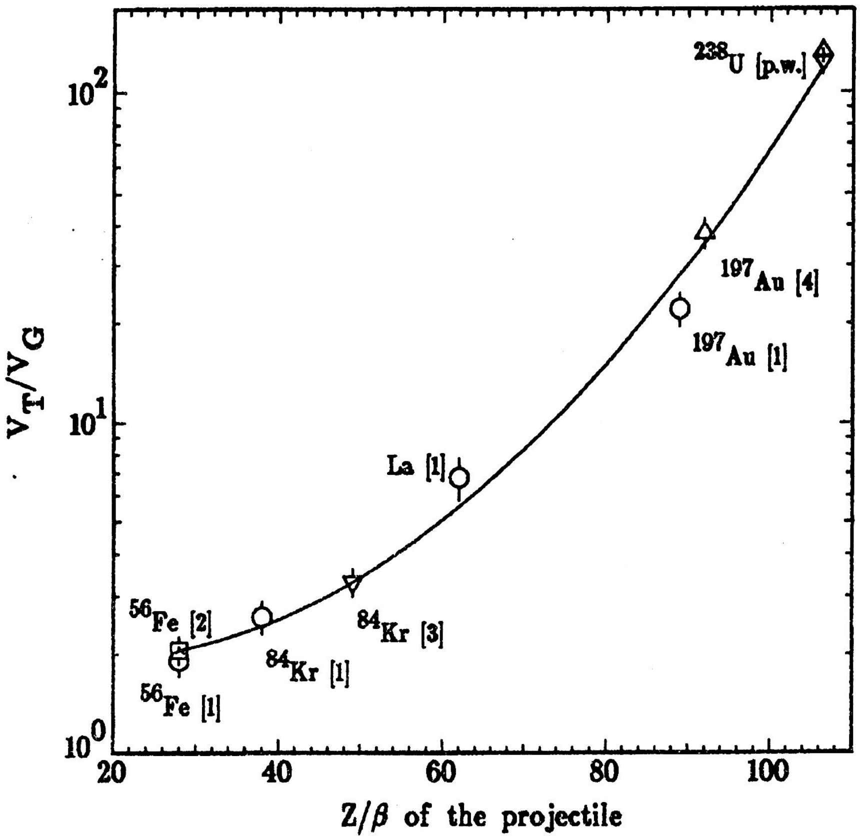

Fig. 2. The charge sensitivity V_T/V_G, plotted as a function of Z/β for various heavy ions in the CR-39(DOP) *detector:* ○ – *1.70* GeV/n ^{56}Fe *[1],* ○ – *1.45* GeV/n ^{84}Kr *[1],* ○ – *1.28* GeV/n ^{139}La *[1],* ○ – *1.00* GeV/n ^{197}Au *[1],* □ – *1.88* GeV/n ^{56}Fe *[2],* $\bigtriangledown$ – *0.45* GeV/n ^{84}Kr *[3],* $\triangle$ – *1.015* GeV/n ^{197}Au *[4] and* $\diamond$ – *0.927* GeV/n ^{238}*U (present work). Full curve is a fit to the data in the range* $27.6 \leq Z/\beta \leq 106.4$.

The full curve in Fig. 2 is the least-square fit to the data in the range $27.6 \leq Z/\beta \leq 106.4$ and the curve follows the relation:

$$V_T/V_G = \exp[A + B(Z/\beta - 60) + C(Z/\beta - 60)^2] \qquad \text{for} \qquad 27.6 \leq Z/\beta \leq 106.4$$

where the estimated values of the fitting parameters A, B and C have been found to be 1.623 ± 0.064, -0.0444 ± 0.0015 and 0.000506 ± 0.000064, respectively. The fit to the data in Fig. 2 indicates that in the range $25 \leq Z/\beta \leq 110$ the charge sensitivity V_T/V_G of the CR-30(DOP) Pershore increases with Z/β faster than exponentially. This fact indicates that such solid state nuclear track detector can register projectiles at relativistic energies with wide ranges of charges viz. from ^{56}Fe to ^{238}U.

The near relativistic U-ions can be detected by CR-39(DOP) solid state nuclear track detector. The estimated etch rate ratio for U-ions is in accord with the earlier results of Heyna et al. for 0.41 GeV/n ^{238}U ions.

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References

1) M. H. Salamon, P. B. Price, M. Tincknell, Guo Shi-Lun and G. Tarle, Nucl. Instrum. and Methods **B6** (1985) 504;

2) D. P. Bhattacharyya, B. Basu, P. Pal, R. Rakshit, S. Chakrabarty, S. Biswas and N. Durgaprasad, Nuovo Cimento **15C** (1992) 11;

3) D. P. Bhattacharyya, B. Basu, P. Pal, R. Rakshit, S. Chakrabarty and I. Hunyadi, Nucl. Instrum. and Methods **B61** (1991) 197;

4) D. P. Bhattacharyya, S. Chakrabarty, R. Rakshit B. Basu, P. Pal and S. Biswas, Nucl. Instrum. and Methods **B73** (1993) 308;

5) U. Heyna, W. Enge, G. Sermund and R. Beaujean, Nucl. Tracks and Radiat. Measurements **12** (1986) 33.

CR–39(DOP) KAO DETEKTOR RELATIVISTIČKIH IONA ^{238}U

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Slog CR–39(DOP) listova bio je izložen snopu iona $^{238}_{92}$U energije 927 MeV/nukleon u akceleratoru BEVALAC, u Lawrence Berkeley laboratoriju, pod kutom od 30° prema površini tih detektorskih listova. Listovi su kemijski obrađeni i ispitani pomoću optičkog mikroskopa Leitz Ortholux. Premjereno je 644 koničnih rupica nastalih prolaskom iona, i određena je brzina jetkanja oko tragova iona od (174±11) μm/h. Ovi su rezultati u skladu s rezultatima Heina i suradnika. Ocjenjena nabojna osjetljivost je u skladu s ekstrapoliranim rezultatima Salamonova i suradnika. Utvrđeno je da brzina jetkanja raste brže nego eksponencijalno o Z/β, i može se opisati relacijom $V_T/V_G = \exp(A + B(Z/\beta - 60) + C(Z/\beta - 60)^2)$, gdje je $A = 1.623 \pm 0.064$, $B = -0.0444 \pm 0.0015$ i $C = 0.000506 \pm 0.000064$, za $27.6 \leq Z/\beta \leq 106.4$.