Characterization of the MARS velocity filter for low-velocity ions

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Physical separation of evaporation residues produced in fusion reactions is necessary to remove the unwanted reaction products and beam particles from the heavy element of interest. A velocity filter uses crossed electric and magnetic fields to select ions of a specific velocity. The MARS velocity filter has been used in past experiments to select ions in the range of 8% to 30% of the speed of light, *c*. Fusion reactions produce heavy elements at much lower velocities, in the range of 1.5% to 2% of *c*. To calibrate the velocity filter in this range, offline experiments were preformed using an alpha source, ^{241}Am, to simulate the products of a beam experiment. The source was covered with 45-µg/cm^2 ^{nat}C cover foil to prevent contamination. Aluminum degraders of various thicknesses (0, 6.1, 12.3, and 18.4 µm) were used to decrease the velocity of the alpha particle to 5.33%, 4.92%, 4.20%, and 3.20% of *c*, respectively.

A silicon strip detector was placed at the focal plane of MARS to detect the alpha particles that passed through the separator. For the different velocities of alpha particles, the optimum electric and magnetic field ratio was determined for the MARS velocity filter. This was done by first turning off the velocity filter and tuning the rest of MARS for the maximum rate. Next the velocity filter was turned on, the electric field was set, and the rate was determined as a function of magnetic field; this was repeated for a total of five different electric field settings. This complete process was repeated for the four alpha particle velocities.

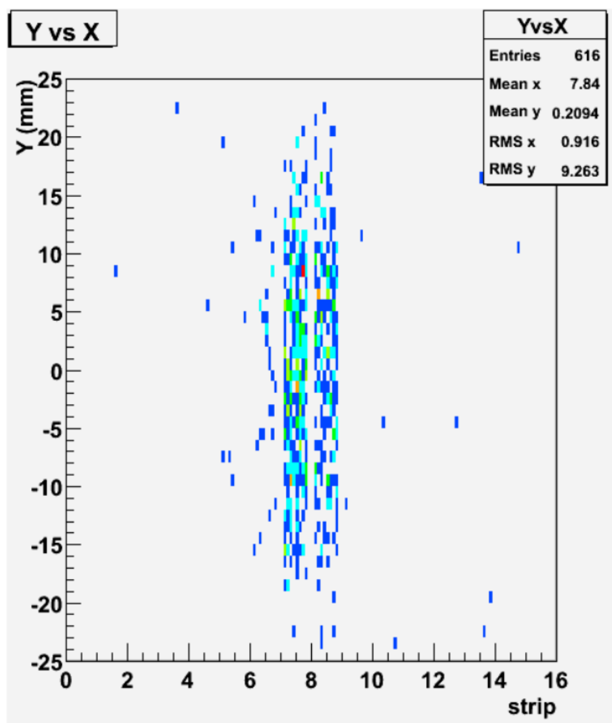

FIG. 1. Position spectrum of the alpha particles implanted on the detector.

A representative distribution of the alpha particles that reached the end of MARS can be seen in Fig. 1. As expected, the acceptance decreased as the electric field increased (Table I). Overall, the data showed a slight positive deviation in the calibration when compared to the calibration used in past experiments. This means a larger magnetic field is needed to compensate. The results were confirmed in a beam experiment with the detection of ^{199}At (~1.9% of *c*); results of this experiment are discussed in a separate contribution to this annual report.

TABLE I. The acceptance as a function of electric field and alpha velocity. Velocities of alphas are shown in the parentheses.

Electric Field (arbitrary units)	No Degrader (5.33% of *c*)	6.1μm Degrader (4.92% of *c*)	12.3μm Degrader (4.20% of *c*)	18.4μm Degrader (3.20% of *c*)
13.3	12.51%	12.29%	7.46%	4.34%
18.3	10.56%	8.05%	4.88%	4.62%
23.3	6.99%	6.99%	4.63%	4.61%
33.3	6.00%	4.43%	3.99%	4.33%
43.3	4.36%	3.90%	3.87%	—