Design of a Deflector to separate the recoil products in a nuclear reaction

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Introduction

In off-line experiments using radioactivity, radioactive isotopes of interest are produced in an accelerator facility by bombarding a chosen target with a beam and recoil reaction products are collected in a catcher foil placed behind the target. At VECC, various radioactive nuclei are being studied by off-line techniques to find the medium effects on nuclear decay, material properties using perturbed angular correlation studies etc which are being produced by bombarding suitable target with alpha and proton beam from K-130 cyclotron. It is required that the recoil reaction products are collected in a suitable catcher placed behind the targets. However, energy of the available beam from cyclotron being above coulomb barrier, primary beam as it traverses the catcher placed behind the target also produces unwanted activity which remain deposited in the catcher along with the required recoil radioactive nuclei. Sometimes these unwanted radioactive products cannot be removed even by radiochemical separation technique resulting unwanted background counts in the spectra. So, we designed a small electrostatic deflector so that comparatively heavy recoil products are separated from light primary beam and get deposited in different portions of the catcher. Thus portion of the catcher implanted with required radioactive isotope can be separated easily and unwanted activity can be reduced. In this work we have studied the simulation results of recoil ^{111}In produced by ^{109}Ag(^{4}He,2n)^{111}In reaction which is required to be separated from primary alpha beam having 30 MeV energy using the electrostatic deflector designed.

Design of the electrostatic deflector

The deflector designed has two parallel plates each having a width of 12 mm and thickness 5mm separated by a distance of 12 mm as shown in Fig 1. The upper plate is of length 12 cm and lower plate is of length 8 cm will placed symmetrically about the central axis of the beam pipe as shown in Fig 1(a). The catcher foil is placed at the end at a distance of 16.5 cm from the edge of the upper deflector plate. We applied 10 KV to the upper plate w.r.t lower plate and studied the effect of the designed deflector on the recoil reaction product ^{111}In and primary alpha beam using SIMION 8 [1].

Simulation, Results and Discussion

In this simulation we have considered a target of ^{109}Ag of thickness 100 μg/cm^2 being bombarded by a 30 MeV alpha beam having a energy variation of ±1 MeV. So, ^{111}In particles were projected with energy varying from 0.45 MeV to 1.28 MeV as ^{111}In would be produced at different regions of the target. Thus it would lose different amount of energy while traversing the target. We found primary alpha beam loses insignificant amount of energy while traversing the target as expected and hence variation in particle energy of alpha was not considered. Both primary beam and recoil ^{111}In beam size of 2mm diameter was considered and ion trajectory after passing through the designed deflector is shown in Fig 1(b) and 1(c). The simulation results under these considerations show that the recoil ^{111}In is well separated from the primary beam and distribution of particle in Y-Z plane is shown in Fig 1 (d).

However, there will be coulomb scattering of the primary beam particle and the recoil

products. If the target with 2mm collimator in front is placed at a distance of 15 mm from the deflector as shown in Fig 1, a substantial number of coulomb scattered alpha particles would strike the upper deflector plate leading to discharge process. In order to avoid this, target with collimator was placed at a distance of 10 cm from the deflector plates. This reduces the probability of primary alpha beam striking the deflector plate to ~1 in 10 min. This adversely affects implantation rate of recoil ^{111}In in the catcher reducing the production rate substantially. Design of electrostatic deflector for optimum performance is being studied.

References

[1] SIMION 8.0 user manual.

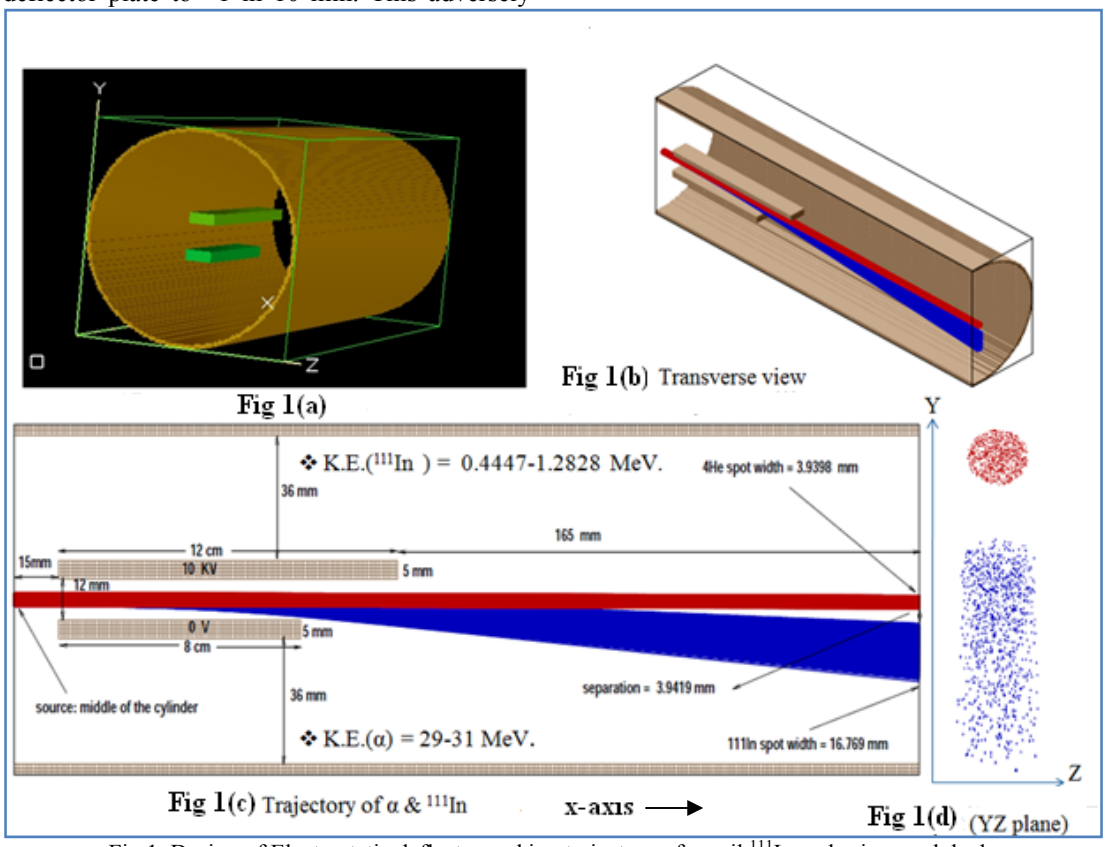

Fig 1. Design of Electrostatic deflector and ion trajectory of recoil ^{111}In and primary alpha beam