Production of ^{11}C Radioactive Nuclear Beam with MARS

X. D. Tang, A. Azhari, C. A. Gagliardi, T. Sandu, L. Trache and R. E. Tribble

In continuation of our nuclear astrophysics program we plan to use the proton transfer reaction (^{11}C,^{12}N) at about 10 MeV/nucleon in order to extract the astrophysical S-factor for the $^{11}C(p,\gamma)^{12}N$ radiative capture reaction using the ANC method. The measurement follows closely the methods and procedures we used in the last three years with the ^{7}Be beam [1,2]. This year we had two runs in preparation for this task. In the first we wanted to obtain the ^{11}C radioactive nuclear beam, to measure the production rate and to optimize the beam optics. In the second one we concentrated on obtaining a maximum intensity beam out of the cyclotron and onto the primary target. For the production of ^{11}C we chose the $H(^{11}B,^{11}C)n$ reaction. The ^{11}B beam produced by the superconducting cyclotron K500 impinged on a hydrogen gas cryogenic target. The recoiling ^{11}C nuclei were then separated with the Momentum Achromat Recoil Separator MARS [3]. A 155 MeV $^{11}B^{+2}$ beam hit the primary target gas cell that has 0.2 mil havar windows, is about 10 cm long and is cooled to liquid nitrogen temperature. It was operated at atmospheric pressure. A supplementary 0.5 mil havar foil behind the target cell dropped the energy of outgoing ^{11}C nuclei to 129 MeV. They entered MARS where they were first momentum separated by the first dipole D1 and a pair of slits, then mass separated by the combination velocity filter-dipole magnet D3 and refocused at the place of the secondary target at the back end of MARS.

In a two day run, we separated ^{11}C, transported and optimized it on the target. The beam properties where measured with a telescope of Si detectors dropped in at the position of the secondary target. It consisted of a 16 strips position sensitive detector, 105 μm thick that gives position information as well as energy loss information for particle identification, and of a 500 μm large area detector to measure the residual energy. Using a system of four pairs of slits that control the momentum and mass separation in MARS, we obtained a clean ^{11}C beam, with no primary beam admixture. The ^{11}C production rate at the position of the secondary target was determined to be about 10 kHz per particle nA of beam incident on the primary target. A small satellite group of ^{7}Be detected at the secondary target position was eliminated using the third pair of slits, situated behind the focusing quadrupole magnets at the end of MARS.

In the second run, in Feb. 1999 we obtained an intensity of 240 pnA of ^{11}B on the primary target and therefore we expect RNB intensities of about 10^6 particle/sec. This is satisfactory for the proton transfer reaction $^{14}N(^{11}C,^{12}N)^{13}C$ that we plan to study using a melamine secondary target.

References

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