Production of Focussed Radioactive Beams

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journal or publication title	CYRIC annual report
volume	1989
page range	87-90
year	1989
URL	http://hdl.handle.net/10097/49517

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Properties of nuclei such as spin, radii, electromagnetic moment and different interactions between nuclei have been investigated for stable nuclei. Our present knowledge of nuclear structure and nuclear reaction mechanism are based essentially on experiments on stable nuclei. However, it is significant to extent studies to far from the stability line in order to obtain a deeper understanding of properties of nuclei and these reaction mechanism. Study of scattering and reactions using radioactive beams are important not only for production of new isotope nuclei but also for a precise understanding of the effective interactions in nuclei such as the isospin-dependent interaction and many-body effects.

One of the most significant contributions of heavy-ion scattering on nuclei, thus far, has been in providing great scope for the study of the properties which enhance the effects of the strong absorption, fusion, core exchange, and channel coupling so on. The systematic effects of these properties may be strongly dependent on the proton and neutron numbers of both projectile and target nuclei. The use of radioactive beams provides greater selection in both numbers.

On the other hand, in hot stars and in novas, low-energy nuclear reactions between unstable nuclei are known to be very important. However the reaction cross-sections on such unstable nuclei have not been measured because of difficulty to get low energy unstable beams.

In most case, heavy ions of energy higher than a few hundred MeV/nucleon are used for production of radioactive nuclei. In an experiment which requires low energy and better momentum resolution, the produced radioactive beam must be injected into a storage-cooler ring in which the beam is cooled down to a desired energy.

On the other hand, heavy ions of energy lower than ten MeV/nucleon are available to get focused radioactive beam from the reaction ^{1}H(HI, N_R)n$^{1)}$, where N_R is a produced radioactive nuclei. For the incident energy of a few MeV higher than threshold energy in this reaction, a velocity of produced radioactive nuclei very small in the center of mass system. However, a velocity of the center of mass determined by the incident heavy ions is very large. Thus a velocity coupling the center of mass velocity and the produced radioactive nuclei velocity in the center of mass system is nearly equal to the incident heavy ion velocity. Thus produced radioactive nuclei are emitted to within very small forward cone.

On present experiment, the ^{15}O beam as a radioactive beams have been obtained from the reaction $^{1}H(^{15}N, ^{15}O)n$ at incident energy of 85 MeV. $^{15}N^{5+}$ beam was provided from the Tohoku 680-cyclotron.2) The H_2 gas target is prepared at pressure of 0.5 bar. The produced ^{15}O beam is separated from ^{15}N primary beam using a small strong-field dipole magnet as a beam separator magnet installed in a large scattering chamber. The ^{15}O beam are also identified by ΔE-E counter telescope system which consists of two solid state detectors. Figure 1 shows the experimental arrangement. The result of the kinematical calculation for the reaction $^{1}H(^{15}N, ^{15}O)n$ at E = 85 MeV are shown Fig. 2. In this incident energy, the maximum angle of emitted ^{15}O cone is about 2.2° with the primary beam axis. The beam separation magnet is placed at 0°. By applying magnetic field of 10 kGauss, the primary beam of ^{15}N at 85 MeV and the secondary radioactive beam ^{15}O at 75 MeV must be in directions separated by about 2°. A beam slit placed in front of the magnet cut the secondary ^{15}O beam at the cone angle of about 1° with the primary beam axis. Thus a resolution of the secondary beam is determined by this beam slit as indicating by the dashed line in Fig. 2. A spectrum of the ^{15}O radioactive beam is shown in Fig. 3. Obtained energy resolution is about 1 MeV. Energies of two ^{15}O peaks indicated in Fig. 3 are about 10 MeV lower than the results of the kinematic calculation due to some energy loss in H_2 gas target and two 2.2 μm Favor window foils with a gas target chamber.

We are going to do the experiment to obtain some better secondary radioactive beams.

References

1) Hasegawa K., Seki H., Kotajima K., Yamaya T., Satoh O., Shinozuka T. and Fujioka M., CYRIC Annual Report 1986, p. 103.
2) Yamaya T., Shinozuka T., Kotajima K., Fujioka M. and Onodera T., Nucl. Instr. and Meth. **226** (1984) 219.

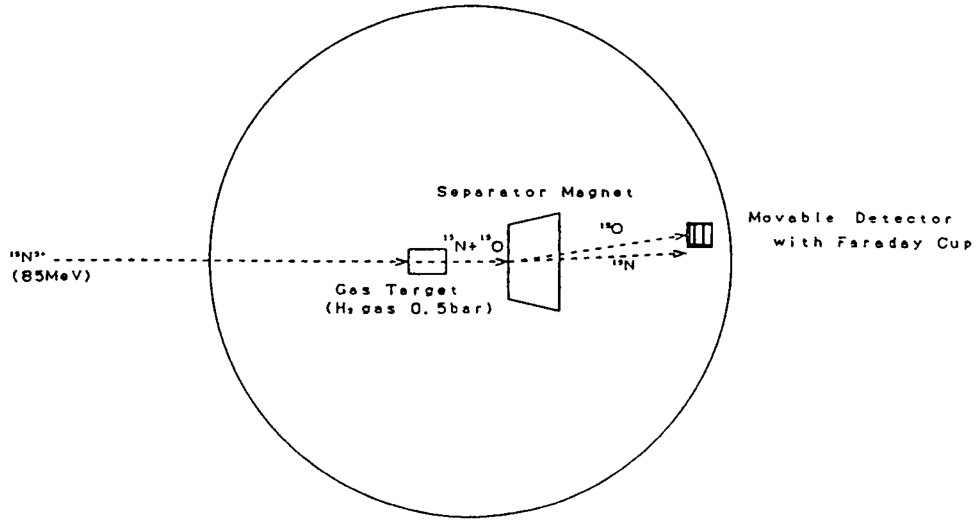

Fig. 1. Experimental arrangement in a large chamber.

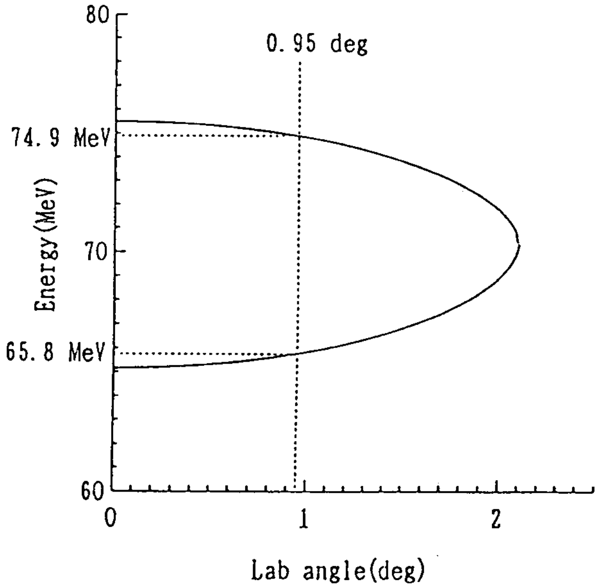

Fig. 2. Energies of ^{15}O via angles in the reaction (^{15}N, ^{15}O) on ^{1}H.

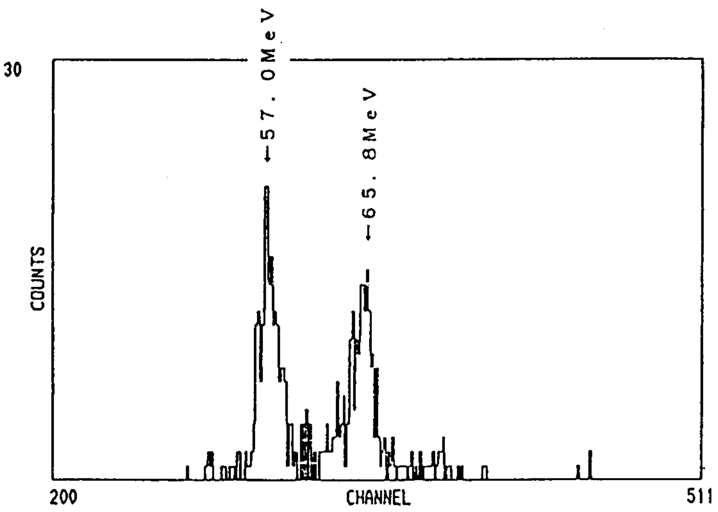

Fig. 3. Spectrum of ^{15}O from the reaction (^{15}N, ^{15}O).