Production of a ^{7}Be implanted target

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The beam system for reaction of isotope of long-life with light-ions applying normal kinematics and implanted target (BRILLIANT) is a project to realize light-ion reaction with implanted targets. The first application is for ^{7}Be to measure the ^{7}Be(d, p) reaction for studying the primordial ^{7}Li production in Big-Bang nucleosynthesis (BBN).

The overestimation of primordial ^{7}Li abundance in the standard BBN model is one of the known and unresolved problems in nuclear astrophysics. The latest theoretical BBN model prediction of the primordial ^{7}Li abundance is still 3 times higher than the recent precise observation.[1)] A key to solve the discrepancy is the destruction of ^{7}Be, for which the ^{7}Be(d, p)^{8}Be and ^{7}Be(n, α)^{4}He reactions are two promising processes. It is suggested that the contribution from ^{7}Be(d, p)^{8}Be is larger than that from ^{7}Be(n, α)^{4}He.[2,3)] We focus on the ^{7}Be(d, p)^{8}Be reaction. Present available data are insufficient in terms of the accuracy or energy range.[4,5)] We develop an unstable ^{7}Be target for a high-resolution measurement of the ^{7}Be(d, p)^{8}Be reaction in normal kinematics, which is a great technical challenge. We call the technique "implantation method." The ^{7}Be particles are implanted in a host material. Our goal is to implant 1×10^{12} ^{7}Be /mm^{2} in 29 h.[6,7)]

We performed an experiment in June 2016 to create the ^{7}Be target at CRIB. The primary beam was ^{7}Li^{2+}, and the secondary beam was produced by the ^{1}H(^{7}Li, ^{7}Be) reaction. The ^{7}Be beam energy was 4.0 MeV/nucleon. We used a 10-μm-thick Au foil as the host material after a 15-μm-thick Au foil as an energy degrader and a 2-mmφ collimator (Fig. 1).

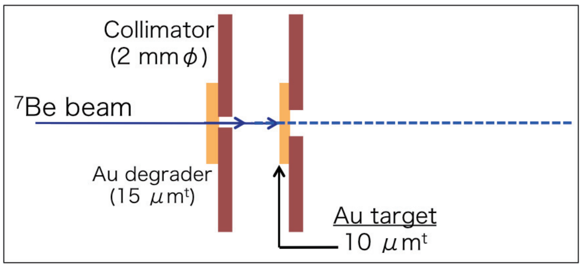

Fig. 1. Set up in the CRIB F2 chamber.

We checked the beam focus and position with the F2 PPAC detector when the beam intensity was about 10^{4} pps at F2. The beam diameter at F2 was 10 mm. We implanted ^{7}Be for 19 h after increasing the beam intensity to 1.1 eμA.

The amount of implanted ^{7}Be was measured by detecting the 477-keV γ-rays from the electron-capture decay of ^{7}Be using a LaBr$_{3}$ detector. Thus, we could achieve the implantation of 4×10^{10} ^{7}Be/mm^{2} in the first experiment.

The number is still smaller than the goal. We suspect that the beam-spot size and the beam position at F2 were not fully optimized for the high-intensity beam and not maintained well during the long irradiation time.

As a next step, we plan to have a development beam time to satisfy those conditions for producing a high-intensity ^{7}Be beam at CRIB.

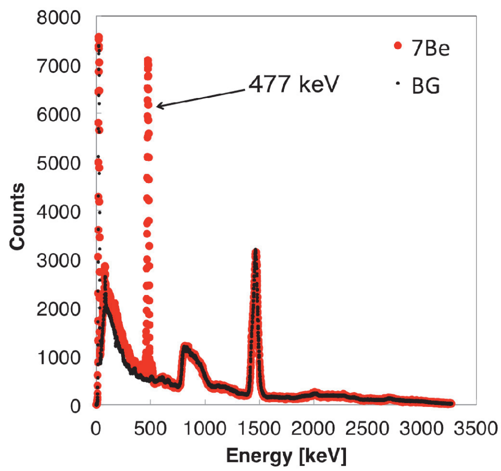

Fig. 2. Comparison between the γ-ray measurement of the implanted target and the background. An obvious 477-keV peak appeared after the irradiation.

References
1) R. H. Cyburt et al., J. Cosmol. Astropart. Phys. **11**, 012 (2008).
2) S. Q. Hou et al., Phys. Rev. C **91**, 055802 (2015).
3) T. Kawabata et al., Phys. Rev. Lett. **118**, 052701 (2017).
4) R. W. Kavanagh et al., Nucl. Phys. **18**, 493 (1960).
5) C. Angulo et al., Astrophys. J. **630**, L 105 (2005).
6) H. Yamaguchi et al., Nucl. Instr. Meth. A **589**, 150 (2008).
7) G. Amadio et al., Nucl. Instr. Meth. A **590**, 191 (2008).

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