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Production of high energy γ-ray by charged-particle bombardment on nuclei has been studied to test off-shell behavior of nuclear collision[1),2)]. The γ-rays of the present interest are those having energies which are comparable to or even greater than those which are available in the projectile and target system when we consider the energy as that per nucleon. For γ-ray production by intermediate-energy heavy ion collision, it is presently accepted that incoherent nucleon-nucleon collision (nucleon-nucleon bremsstrahlung) play an important role, where Fermi motion of nucleons in the nucleus is significant for explaining the entire energy spectrum. On the other hand, light ion induced γ-rays has been discussed in terms of nucleon-nucleon interaction in the projectile, especially the short range interaction among them. Thus, our scientific motivation for the present study is to examine the high-energy γ-ray production mechanism in the vicinity of light ion impact.

Since γ-rays are emitted from moving source, they are affected by Doppler shift. Thus it is expected that the velocity of the source may be deduced from the fore-aft anisotropy in the angular distribution of γ-ray for the laboratory frame, by assuming a reflection symmetric angular distribution in the source frame.

In this report we present preliminary results of measurement for the γ-ray spectrum produced by ^{3}He-particle bombardment on ^{9}Be, ^{12}C, and ^{208}Pb, detected at laboratory angles of 30°, 90°, and 135°.

The experiment was performed using 65 MeV ^{3}He from the AVF cyclotron at the Cyclotron and Radioisotope center, Tohoku University. The γ-rays were observed with newly developed detecting system by which measurement of the angular distribution of emitted g-rays was capable. Self-supporting foil of Be and C with their thickness of 18.5 and 22.5 mg/cm^2, respectively, were used as the target. Events were gated by the beam pulse interval of 1 nsec, thus Neutron events being rejected by means of the time of flight technique. Similarly, cosmic ray events being reduced to 1/3000 by combination of the time of flight technique and the detector hit-pattern analysis.[3)] Layout of the new system is shown in fig. 1. The target chamber and beam line are made of aluminum which yields the most energetic neutron-capture γ-ray of 7.6 MeV. The target holder is made of 0.2 mm thick aluminum. Note that it is important to remove thick materials from the target region to reject unwanted γ-rays due to the beam hallow.

The γ-ray is detected by the BaF_2 crystals, layout and performance of which have been reported previously[4),5)]. The detector system consists of seven BaF_2 crystals having the same sizes, one of which is located at the center and the other six crystals make a ring around it. The detector system is shielded with 15 cm-thick lead block at both sides, top and bottom. A 15 cm thick lead collimator is placed in front of the detector to define the solid angle. The whole assembly weight about 2.5 tons, is mounted on a turn table covering detection angles between 35 deg. and 145 deg with respect to the beam direction.

Figure 2 shows the energy spectra of high energy γ-ray measured at laboratory angle of 35°, 90°, 144° for the collision of ^3He on Be and C at E_h(lab.) = 65 MeV. The spectra show a tendency that in forward angles the highest energy limit moves toward higher energy side, while in backward angles it moves toward lower energy side. This evidence suggest the effect of Doppler shift due to the fact that γ-rays are emitted from the moving source. The observed γ-ray energy $E_{obs.}$ is related to the source-frame energy E_{source} by

$$E_{obs.} = \frac{(1 - \beta^2)^{1/2}}{1 - \beta cos\theta} E_{source} \quad , \qquad (1)$$

where β is the source velocity normalized by the light velocity, and θ is the observed angle. The source velocities for the cases of Be and C have been extracted by fitting equation (1) to the observed spectrum at higher energy region. The deduced source velocities thus obtained for Be and C were 0.09 and 0.1, respectively, which are consistent with the nucleon-nucleon center-of-mass velocity of 0.13 . As seen in fig. 2, the observed energy spectra extend over the relative kinetic energy of ^3He + nucleus system. Such s high energy γ-ray may be emitted when the incoming three nucleons stopped in a time.

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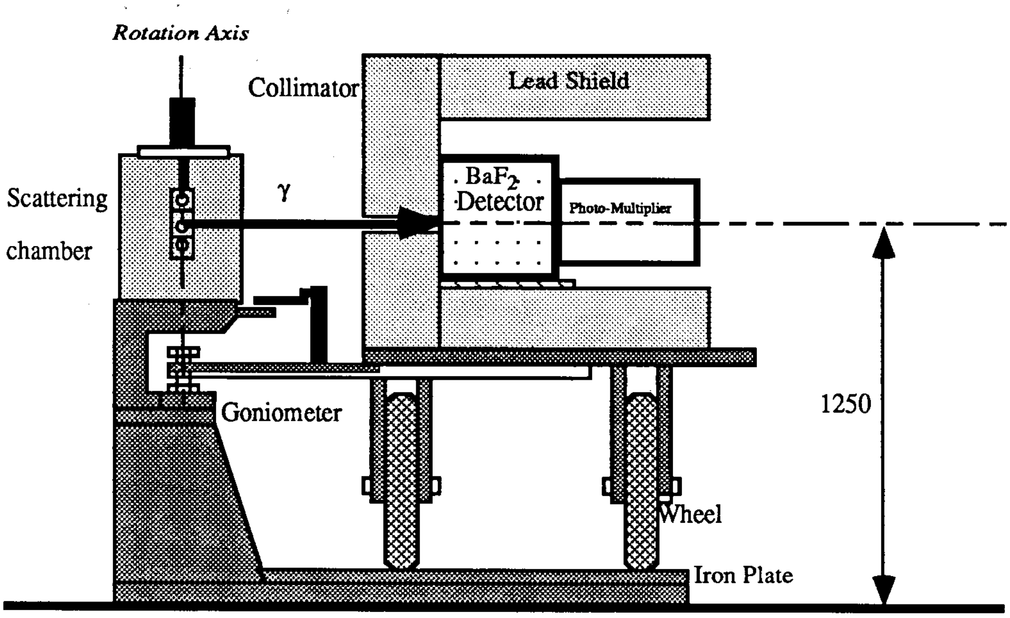

Fig. 1. Layout of the γ-ray detecting system.

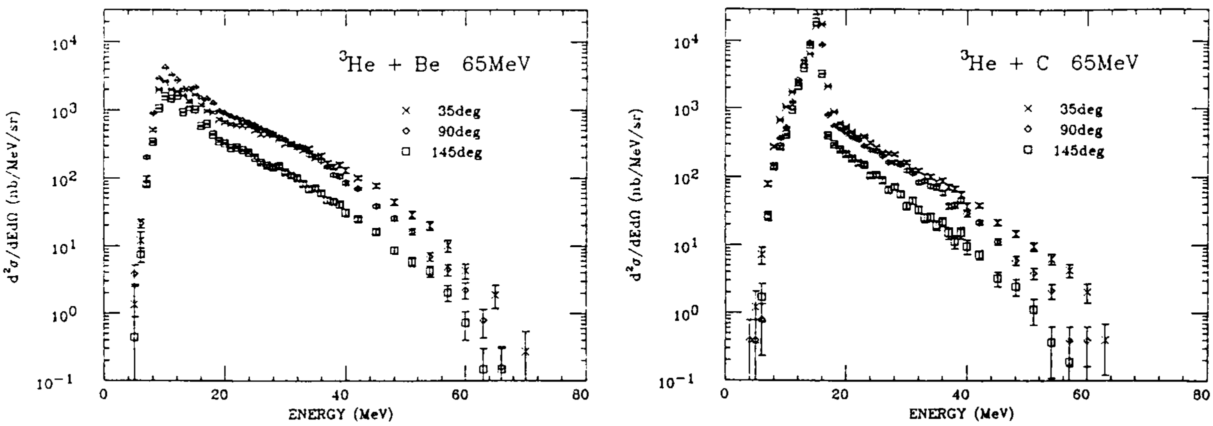

Fig. 2. γ-ray energy spectra in the laboratory frame for Be (left frame) and C (right frame) at measured angles of 35°, 90°, 145°.