I. 2. Measurement of the α Decay from the Broad 10 MeV State in ^{12}C

Itoh M., Ando S., Aoki T., Arikawa H., Harada K., Hayamizu T., Inoue T., Ishikawa T., Kato K., Kawamura K., Sakemi Y., and Uchiyama A.

Cyclotron and Radioisotope Center, Tohoku University

The α cluster structure in the nucleus becomes one of active topics in recent years, again. Stimulating the concept of the α cluster gas as the Bose gas proposed by Tohsaki *et al.*[1], many researches have been performed theoretically and experimentally. The broad 10 MeV state in ^{12}C is considered to be one of the α gas-like states. According to the 3α orthogonality condition model with a complex scaling method, the broad 0^+ state around 10 MeV is considered to be a higher nodal of the second 0^+ state at 7.65 MeV in ^{12}C[2]. However, a variational calculation after spin-parity projection in the framework of antisymmetrized molecular dynamics indicates a linear-like 3α structure appears around 10 MeV in ^{12}C[3]. Recently, it was reported that the broad 10 MeV state consisted of two 0^+ components[4,5]. In this experiment, we investigated the decay property of the broad 10 MeV state in order to verify and study these two 0^+ states.

The measurement was performed with a large scattering chamber at the 41 course in CYRIC. The $^{12}C^{4+}$ beam accelerated up to 110 MeV bombarded the self-supported natural carbon foil with a thickness of 104 μg/cm^2. The experimental setup is shown in Fig. 1. The beam was stopped at a Neodymium magnet just in front of the silicon strip detector. Inelastically scattered ^{12}C beam, excited to the broad 10 MeV state, was immediately broken to three alpha particles. Since break-up three alpha particles had almost same kinetic energy per nucleons, they were easily detected even with a relatively small solid angle detector. Two double-sided silicon strip detectors (DSSD) were used as shown in Fig. 1. DSSD1 has horizontally 16 channels and vertically 16 channels with a size of 50 × 50 mm^2 and a thickness of 1500 μm. DSSD2 has horizontally 40 channels and vertically 40 channels with a size of 40 × 40 mm^2 and a thickness of 1000 μm. To reduce numbers of readout channels, two or

three strips were connected into a channel. Then, the total readout channels were reduced into 32 channels.

Figure 2 shows the energy spectrum around the broad 10 MeV state measured in this experiment. The center of mass angle for three break-up alpha particles was limited within 4.8 degrees. The prominent peak is the 9.641 MeV 3^- state. The broad hill at both side of the 3^- state is the broad 10 MeV state. The broad 10 MeV state was divided into four parts, as shown in Fig. 2, in order to see the energy dependence for the decay branch. In each energy region, the energy distribution of break-up three alpha particles was compared with those obtained in the Monte-Carlo simulation for two decay mechanisms as the decay through the ground state of ^{8}Be, ^{8}Be(g.s.), and that through the first 2^+ state of ^{8}Be, ^{8}Be(2^+). In this case, the direct 3α decay could not be distinguished from the ^{8}Be(2^+) channel. Figure 3 shows the preliminary results of the comparison between the experiment and the Monte-Carlo simulation. The experimental data are plotted with closed circles. The red dashed, the cyan solid, and the green dotted lines show the energy distributions obtained in the Monte-Carlo simulations for the ^{8}Be(g.s.), the ^{8}Be(2^+), and the sum of these two channels, respectively. The experimental energy distribution was reproduced well with the sum of the ^{8}Be(g.s.) and ^{8}Be(2^+) channels. The energy dependence for the branching ratio of the ^{8}Be(g.s.) channel is shown in Fig. 4. Open and closed circles indicate results of the RCNP experiment obtained in Ref. 5 and of the CYRIC experiment, respectively. While branching ratios of the ^{8}Be(g.s.) channel obtained in the RCNP experiment suddenly drop at the excitation energy of 10.8 MeV, those obtained in the CYRIC experiment gradually go down. Since the momentum transfer of the reaction in the CYRIC experiment was larger than that in the RCNP experiment, the energy spectrum at CYRIC in Fig. 1 contains higher multipole components, such as the 1^- state at 10.8 MeV and the 2^+ state at 10 MeV. According to the experiment by Alcorta *et al.*[6], the 1^- state at 10.8 MeV decays 100% through the ^{8}Be(g.s.) channel. Therefore, the branching ratio of the ^{8}Be(g.s.) channel around 11 MeV became nearly 90%. We need to estimate the contributions from higher multipole components, correctly. The estimations for the higher multipole contributions are in progress.

References

1) Tohsaki A, *et al.*, *Phys Rev Lett* **87** (2001) 192501.
2) Kurokawa C, Katō K, *Nucl Phys A* **792** (2007) 87; Kurokawa C, Katō K, *Phys Rev C* **71** (2005) 021301.
3) Kanada-Enyo Y, *Prog Theor Phys* **117** (2007) 655.

4) Itoh M, *et al*., *Phys Rev C* **84** (2011) 054308.
5) Itoh M, *et al*., *J Phys Conf Ser* **436** (2013) 012006.
6) Alcorta M, *et al*., *Phys Rev C* **86** (2012) 064306.

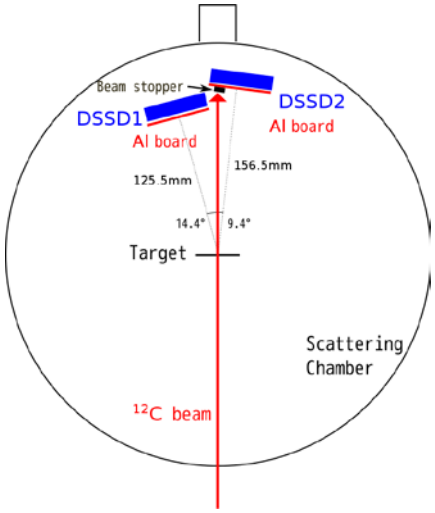

Figure 1. Experimental set-up.

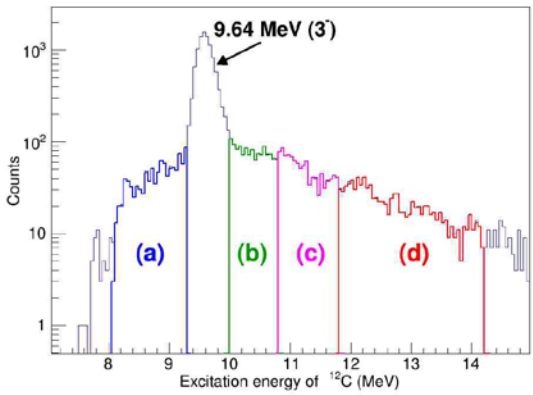

Figure 2. Energy spectrum around the broad 10 MeV state.

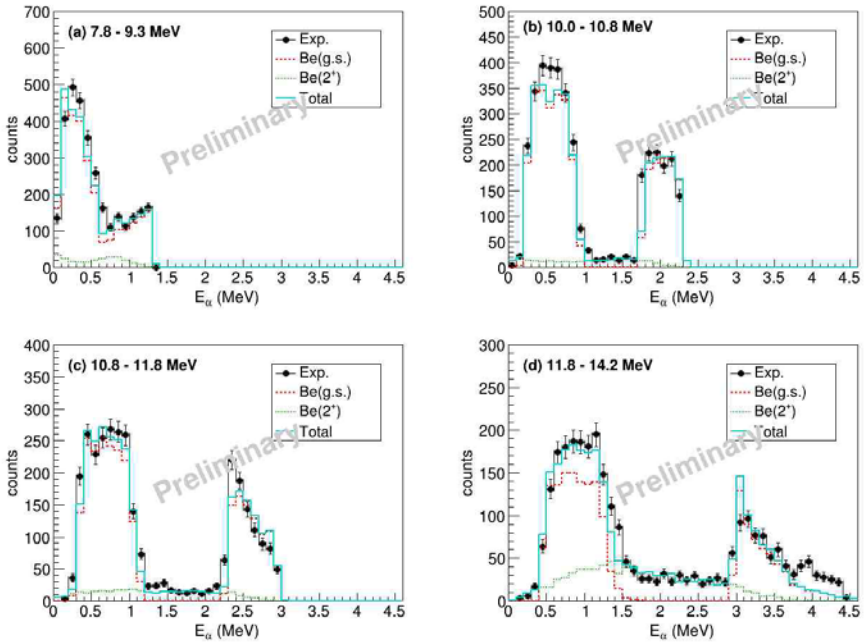

Figure 3. Energy distributions of decay α particles in the broad 10 MeV state.

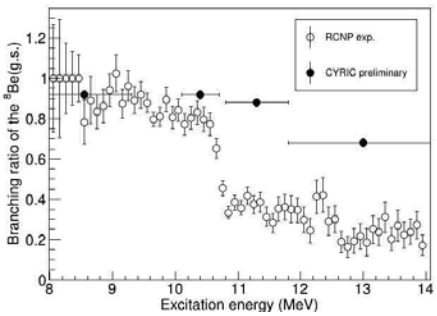

Figure 4. Energy dependence of the branching ratio to the ^{8}Be(g.s.) channel.