Measurement of ^{4}He(^{8}He,^{8}Be) reaction for verifying tetra-neutron resonance

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The existence of nuclei composed only of neutrons has been discussed for over half a century, but it has not been confirmed yet. In 2002, a candidate bound state of the tetra-neutron, which consists of four neutrons, was reported.[1)] An *ab-initio* calculation suggested that there might be a tetra-neutron ($4n$) resonance, but a bound $4n$ was not reproduced.[2)] An experimental search for the $4n$ resonance state conducted using the exothermic double charge exchange (DCX) ^{4}He(^{8}He,^{8}Be)$4n$ reaction was performed at the SHARAQ spectrometer in RIBF[3)]. As a result, four candidate events were found with a 4.9σ significance level, and the energy of the $4n$ resonance was determined as $E_{4n} = 0.83 \pm 0.65(\text{stat.}) \pm 1.25(\text{syst.})$ MeV. To confirm the existence of $4n$ resonance, we performed a new measurement with higher statistics and with smaller energy uncertainty.

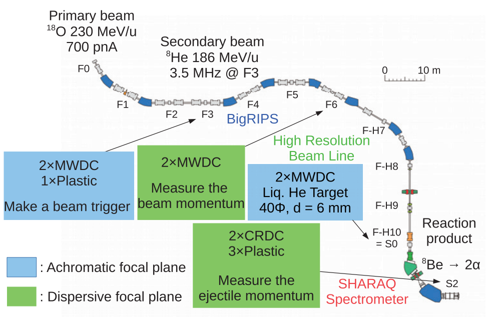

Fig. 1. Detector setup of BigRIPS/SHARAQ beam line.

Figure 1 shows a schematic view of the setup for this experiment. A primary ^{18}O beam was accelerated to about 230 MeV/nucleon by AVF+RRC+SRC. The intensity of the primary beam was about 700 particle nA. The energy of the secondary ^{8}He beam was about 186 MeV/nucleon. The beam intensity was increased from that in the previous experiment. The rate of the secondary beam at F3 was increased from about 2.0 MHz to 3.5 MHz. Six low-pressure multi-wire drift chambers (LP-MWDCs) were installed for tracking the beam. "F6" was set as a dispersive focal plane, so that the momentum of the beam could be measured by the focus position. At "S0," a liquid He target system (CRYPTA) was installed. At the final focal plane, "S2," 2 α particles from the decay of outgoing ^{8}Be were detected using 2 cathode readout drift chambers (CRDCs).

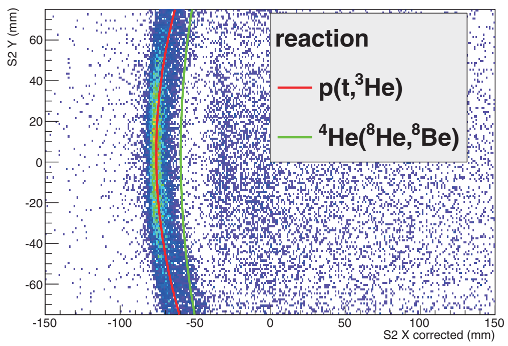

Fig. 2. A preliminary hit pattern of the ^{1}H(t,^{3}He) reaction at S2 for the energy calibration with a reaction kinematics curve. The X and Y axes represent the missing momentum and the vertical scattering angle, respectively.

In the present experiment, the method of missing-momentum calibration was changed to reduce the systematic error of the $4n$ energy. As a reference for the energy, the ^{1}H(t,^{3}He) reaction was measured with a triton beam that has the same magnetic rigidity as the ^{8}He beam (8.3 Tm). The energy can be calibrated without changing the magnetic settings. Figure 2 shows an S2 image of outgoing ^{3}He particles from the ^{1}H(t,^{3}He) reaction. The red line indicates the fitted kinematics curve of the reaction. The threshold energy of the $4n$ state can be determined from the curve. Further analysis is now in progress.

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