Structure of Borromean nuclei around N=16 and 20 shells

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Nuclei near the neutron drip line provide the opportunity to investigate unusual properties that depend on isospin. The emergence of nuclear halos[1),2)] and changes of nuclear shell structure[3)-6)] are some of the dramatic unexpected effects resulting from the large neutron/proton asymmetry. Nuclear halos arise from the one- or two-outermost neutrons forming a low-density extended neutron surface. Identifying and characterizing the neutron halos require knowledge of their matter and proton radii. Information on occupancy of nuclear orbitals sheds light on the evolution of nuclear shells. Two-neutron halos in Borromean nuclei have been identified in the *p-sd* shell in ^{6}He, ^{11}Li, ^{14}Be, ^{17,19}B and ^{22}C but its occurrence in the conventional *pf*-shell is still unknown. The breakdown of the N=20 shell closure has been observed in Mg-Ne isotopes, and one-neutron halo formation was found in ^{31}Ne.[7)]

In a recent experiment performed at the BigRIPS[8)] and ZeroDegree Spectrometer (ZDS) facilities at the RIKEN RI Beam Factory we aimed to investigate the structure of the Borromean N=20 drip line nucleus, ^{29}F. ^{29}F nuclei were produced via the fragmentation of a ^{48}Ca primary beam with a Be production target. The BigRIPS fragment separator and particle detectors were used to separate ^{29}F from the contaminants. The energy loss in the ionization chamber placed at the F7 achromatic focus provided Z identification. Time of flight was measured with scintillator detectors placed at F3 and F7 foci. Position sensitive PPAC detectors were used to determine the magnetic rigidity. This information led to an event by event identification of ^{29}F as shown in Fig. 1. A carbon reaction target placed at the F8 focus was surrounded by the DALI2 gamma detector array.[9)] Gamma rays from the de-excitation of the two-neutron removal fragment were detected in coincidence with ^{27}F.

The ZDS was used to transport and identify the fragments or the beam at the final achromatic focus, F11. The time of flight with scintillators placed at F11 and F8 together with position information is used to determine the momentum distribution from the two-neutron removal process. At F11 a second carbon reaction target was placed for measuring the charge changing cross section using multi sampling ionization chambers[10)] placed before and after this second reaction target. The measured interaction cross section is expected provide the matter radius of ^{29}F while the charge-changing cross section will yield a measure of its proton radius. Charge-changing cross sections were measured for the drip-line C and B isotopes as well.

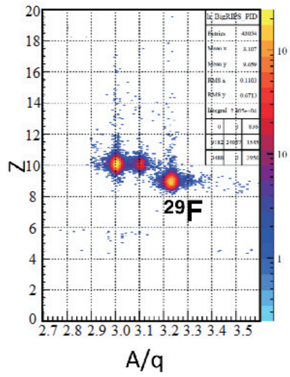

Fig. 1. Particle identification spectrum for detection of ^{29}F.

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