Neutron drip-line search using 48Ca beam

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A neutron drip-line has been determined till O[1] of which mass number(A) is 24, three times the atomic number(Z). However for F, Ne and Na isotopes with A=3Z+4 were found[2]. The sudden increase in neutron numbers suggests that there might be a change in the nuclear structure of F. The drip-line search is important to investigate how many neutron number increases and determination of the drip line gives some constraints to nuclear models.

The drip-line search was performed by using the BigRIPS[3] with a 345 MeV/u ^{48}Ca beam of high intensity (> 400 particle nA). In the search, we used two settings of the BigRIPS for ^{33}F and ^{36}Ne&^{39}Na. In the two settings, magnetic rigidities before a degrader located at F1 were the same (9.385 Tm) but those after it were different. The magnetic rigidities were determined so that ^{33}F for the former and center of ^{36}Ne and ^{39}Na for the latter became a central orbit. Radioactive isotopes were produced by the 20 mm Be target. The thickness of the degrader at F1 was 15 mm. A rather thick target and degrader were used so as not to be over the maximum magnetic rigidities of both the first and second stage in the BigRIPS. Another degrader at F5 (7 mm) was used to remove light particles such as triton. Widths of momentum slits at both F1 and F5 were ±120 mm and those of both F2 and F7 slits were ±20 mm. A collimator made using iron was located upstream of F2 to remove triton, ^{6}He of long stopping ranges that could not be removed by the F2 slit. The length of the collimator for beam direction was 450 mm and the opening widths were ±35 mm at the entrance and ±20 mm at the exit. In order to study yield systematics, we measured the yields of $^{23\sim31}$F, ^{34}Ne, and ^{37}Na using the same settings of the target, degraders, and slits as the drip-line search. We also studied the secondary reaction effect in the target wherein isotope A is produced in 2 steps via a different isotope B (Here A is produced by ^{48}Ca->B->A). In this study we measured target thickness dependence (Be 5 mm, 10 mm and 20 mm) of the production yields using ^{37}Na.

Particle identification (PID) was performed by determination of Z and A/Z event by event using the ΔE-TOF-Bρ method. The ΔE was measured using four 300 μm Si stacks, the MUSIC, and plastic scintillators at F7 redundantly. TOF was measured using 2 plastic scintillators at F5 and F7. Bρ was determined by track reconstruction using positions and angles measured by PPACs located at F5 and F7. Because around Z=10, efficiency of the PPAC was not 100 %, we also measured the positions using the plastic scintillators. In the drip-line search, A/Z was determined for only the second half (from F5 to F7) in the second stage due to large contaminants at F3 (> 1 MHz), which is mainly triton.

Figure 1 shows a PID plot for the setting of the drip-line search of ^{33}F with a running time of 14.3 hours. In this measurement live time of data acquisition was 74.5 % and the intensity of ^{48}Ca beam was 415 particle nA on average. As shown in Fig. 1, ^{31}F was clearly seen but there is no event in the ^{33}F area although an expected value of ^{33}F are 20.7 counts if we assume a production cross section of ^{33}F predicted bv EPAX 2.15[4].

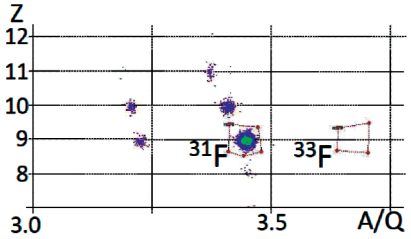

Figure 1 A/Q vs Z plot for the drip-line search of F.

Figure 2 shows the yield systematics of F isotopes with prediction of EPAX 2.15 (solid line). The measured yields are in good agreement with those of EPAX2.15.

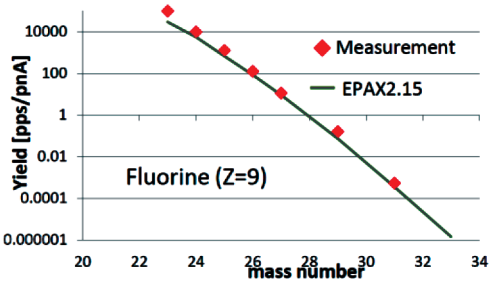

Figure 2 Yield systematic of F isotopes.

We estimated probability that ^{33}F is 0 count in the measurement by applying the expected value (20.7 counts) to the Poisson distribution. The estimated probability is 0.000000103 % and this implies that the probability that ^{33}F is unbound is 99.999999897% in this assumption. In the study of the secondary reaction effect, we did not observe a large enhancement at the thick target as expected. Detailed analysis including the ^{36}Ne&^{39}Na setting is in progress.

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