Study of νp-process nucleosynthesis at OEDO

D. Suzuki,[*1] B. Mauss,[*2] N. Imai,[*3] S. Michimasa,[*3] D. Beaumel,[*4,*1] K. Y. Chae,[*5] S. Cherubini,[*6] T. Chillery,[*3] M. Dozono,[*7,*1] M. Egeta,[*8,*1] F. Endo,[*8,*1] N. Fukuda,[*1] T. Haginouchi,[*8,*1] S. Hanai,[*3] S. Hayakawa,[*3] Y. Hijikata,[*7,*1] J. W. Hwang,[*9] S. Ishio,[*8,*1] N. Iwasa,[*8,*1] S. Kawase,[*10,*1] K. Kawata,[*3] R. Kojima,[*3] S. Kubono,[*1] M. La Cognata,[*6] J. Li,[*3] N. Nishimura,[*1] K. Okawa,[*3] M. Oishi,[*10,*1] H. J. Ong,[*11,*1,*12] S. Ota,[*12] S. Palmerini,[*13,*14] R. Pizzone,[*6] T. Saito,[*3] H. Sakurai,[*1] S. Shimoura,[*3,*1] Y. Shimizu,[*1] T. Sumikama,[*1] H. Suzuki,[*1] H. Takeda,[*1] H. Tanaka,[*15,*1] M. Tanaka,[*1] X. Tang,[*12] T. Teranishi,[*15,*1] Y. Togano,[*1] A. Tunimo,[*6] Y. Wang,[*16] K. Yako,[*3] K. Yahiro,[*7,*1] H. Yamaguchi,[*3] R. Yokoyama,[*3] K. Yoshida,[*1] R. Yoshida,[*7,*1] and M. Yoshimoto[*1]

Neutron-deficient stable isotopes, referred to as p-nuclei, are known to be produced by p process nucleosynthesis. However, certain lighter p-nuclei, *e.g.* Mo and Ru, are significantly underproduced in the present astrophysical scenario. The νp process[1)] ascribes their origin to core-collapse supernovae, wherein the availability of neutrons aids the flow to bypass the waiting point ^{56}Ni on the synthesis path. The neutron capture cross section of ^{56}Ni, howeve, remains experimentally unknown because both the neutron and ^{56}Ni are short-lived. To evaluate the cross sections, we applied the surrogate method[2)] to the (d, p) reaction by using an energy-degraded ^{56}Ni beam at OEDO.

The experiment was performed at the OEDO beam line of RIBF. The secondary beam was produced by the projectile fragmentation reaction of a ^{78}Kr beam at 345 MeV/nucleon and purified by the BigRIPS fragment separator. The total beam intensity at F3 was measured to be about 500 kpps (particles per second) with a purity of about 30% for ^{56}Ni. The impurities included ^{55}Co (50%) and ^{54}Fe (10%), both isotones of ^{56}Ni with $N = 28$. The energy of ^{56}Ni transmitted from BigRIPS to OEDO was about 113 MeV/nucleon. The beam energy was degraded at FE9 by an angle-tunable wedge-shaped degrader (3 mm in central thickness) together with a flat degrader (0.3 mm in thickness),[3)] both made of aluminum. The angle of the former was set to 4 mrad to obtain a desired beam energy. The beam energy of ^{56}Ni was estimated to be 15.1(10) MeV/nucleon based on the time of flight measurement from FE9 to FE12. The RF deflector at FE10 was operated at 100 kV to reduce the spot size of ^{56}Ni. The phase shift of RF was optimized to increase the transmission through the target frame aperture of 50 mm in diameter (Fig. 1). The transmission from F3 to FE12 was about 75% with a total rate of 370 kpps at FE12. CD_2 targets of 285 and 644 μg/cm^2, provided by INFN, were set at S0 about 1 m downstream of FE12. The incident position and angle of the secondary beam were deduced by a pair of SR-PPACs[4)] in the vacuum chamber of FE12. The recoiling protons were detected by the silicon and CsI detectors array TiNA.[5)] Missing mass spectra are deduced from the scattering angle and total kinetic energy measured by TiNA. The scattered particles were transmitted to a QQD spectrometer at zero degrees for the particle identification, which facillitated the determination of the decay channels. The spectrometer was equipped with a pair of SR-PPACs followed by an ionization chamber with CF_4 gas at 100 Torr. The transmission through the spectrometer was roughly 50%.

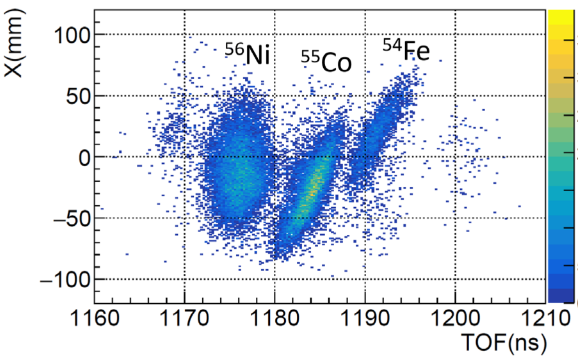

Fig. 1. Horizontal position at S0 vs. TOF from F3 to FE9 of the secondary beam with the optimal RF settings.

The data analysis is underway. The current focus is directed towards the beam tracking detectors.

References
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*1 RIKEN Nishina Center
*2 CEA-DAM
*3 Center for Nuclear Study, University of Tokyo
*4 IJClab, IN2P3, CNRS
*5 Department of Physics, Sungkyunkwan Unviversity
*6 INFN Laboratori Nazionali del Sud
*7 Department of Physics, Kyoto University
*8 Department of Physics, Tohoku University
*9 CENS, Institute for Basic Science
*10 IGSES, Kyushu University
*11 Institute of Modern Physics, Chinese Academy of Sciences
*12 Research Center for Nuclear Physics, Osaka University
*13 INFN Sezione di Perugia
*14 Department of Physics, University of Perugia
*15 Department of Physics, Kyushu University
*16 Department of Physics, Tsinghua University