# Spectroscopy of unbound oxygen isotopes II

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The NP1312-SAMURAI21 experiment, entitled "Spectroscopy of unbound oxygen isotopes II", was carried out in November-December 2015, aiming at identifying resonance states of the extremely neutron-rich oxygen isotopes $^{27}$O and $^{28}$O, following the NP1106-SAMURAI02 experiment for $^{25}$O and $^{26}$O[1)] in 2012. The motivation for this series of experiments is exploring the shell evolution towards the possibly doubly magic nucleus $^{28}$O ($Z$=8 and $N$=20), which is essential to understand the mechanism of the sudden change of the neutron drip line from oxygen to fluorine ($Z$=9), called "oxygen anomaly."[2)] The invariant mass method is applied to reconstruct the decay energies of $^{27}$O and $^{28}$O, produced by two- and one-proton removal reactions from $^{29}$Ne and $^{29}$F, respectively.

The experiment was performed using the SAMURAI facility[3)] at RIBF. The secondary beams of $^{29}$Ne and $^{29}$F were produced by the projectile fragmentation of a $^{48}$Ca primary beam at 345 MeV/nucleon on a 15-mm thick beryllium target, and they were purified by BigRIPS. In addition to a 15-mm thick aluminum degrader at the first momentum dispersive focal plane (F1) of BigRIPS, a 7-mm thick aluminum degrader was installed at the second dispersive focal plane F5 to reduce the large amounts of light-ion background in the secondary beam. Plastic scintillators with a thickness of 3 mm were installed at the focal planes F3, F5, and F7 for particle identification.

A 15-cm length MINOS[4)] target cell filled with liquid hydrogen was installed 4.4 m upstream from the center of the SAMURAI magnet, surrounded by the MINOS TPC and the DALI2 $\gamma$-ray detector array.[5)] The incident beam was detected by two 1-mm thick plastic scintillators (SBTs) and two drift chambers (BDC1 and BDC2) placed before the MINOS target. The outgoing charged particle and neutrons were separated by the SAMURAI dipole magnet with a 2.9 Tesla field at the center. Standard drift chambers (FDC1 and FDC2) and a plastic scintillator hodoscope (HODF24) were used for the detection of charged fragments. HODF24 was expanded from the existing hodoscope (HODF) by adding eight new paddles, to cover the whole effective area of FDC2. For neutron detection, NeuLAND[6)] (new Large Area Neutron Detector for R3B at FAIR) was combined with NEBULA to increase the efficiency for multiple neutron detection.

Data analysis is now in progress.

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