Spectroscopy of single-particle states in oxygen isotopes via ${}^{A}\mathrm{O}(\vec{p}, pN)$ reaction with polarized protons

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The $(\vec{p}, pN)$ reaction is an effective spectroscopic tool to examine single-particle states. One can determine the spin-parity of single-particle states in nuclei from the momentum dependence of the cross section and the vector analyzing power without model dependence.[1)] In this experiment, our goal was to determine the spin-orbit splitting of the 1p spin doublet in oxygen isotopes as a function of their neutron number.

We performed ${}^{14,22-24}\mathrm{O}(\vec{p}, 2p)$ reaction measurements (SHARAQ04 experiment) with a polarized proton target at RIKEN RIBF to measure single-particle spectra and to determine spin-orbit splitting in ${}^{14,22-24}\mathrm{O}$. For the experimental setup, see refs.[2,3)]

Figure 1 shows the time-of-flight (TOF)-ΔE correlations for (a) incident and (b) residual particles in ${}^{14}\mathrm{O}$ runs. The particles are identified via the TOF-ΔE method on an event-by-event basis. For residuals, only their atomic numbers are identified. The proton separation energy (S_p) of the target nuclei can be obtained from the scattering angles and momenta of scattered protons:

$$S_p = (1-\gamma)\, m_p - \gamma\,(T_1 + T_2) + \beta\gamma\,(p_{1\parallel} + p_{2\parallel}),$$

where γ and β are the Lorentz factor and the velocity of the beam, respectively; m_p is the proton mass; T_1 and T_2 are the kinetic energies of the scattered protons; and $p_{1\parallel}$ and $p_{2\parallel}$ are the momenta of the scattered protons. In this formula, the momentum of the residual nucleus is ignored because its effect to S_p is negligibly small compared with the resolution of S_p. Figure 2 shows the separation energy spectrum for the ${}^{14}\mathrm{O}(p, 2p)^{x}\mathrm{N}$ reaction. Some amount of strength can be seen above the separation energy of ${}^{14}\mathrm{O}$ (4.627 MeV). However, it is difficult to distinguish excited states in the current result because of the small statistics. We intend to continue the analysis of these results by investigating different gating methods that may improve the efficiency, resolution, and S/N ratio.

The analysis for ${}^{22}\mathrm{O}$ and ${}^{24}\mathrm{O}$ beams is still ongoing.

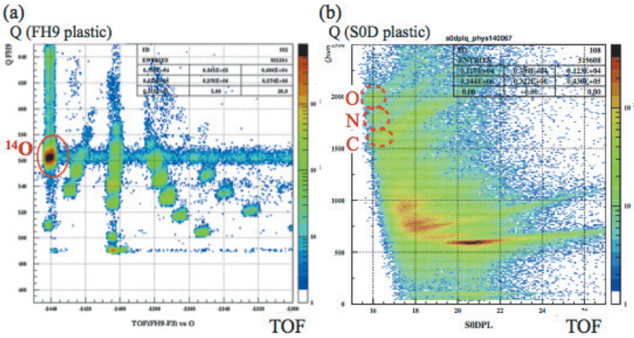

Fig. 1. TOF-ΔE correrations for (a) incident and (b) residual particles in ${}^{14}\mathrm{O}$ runs. TOF was measured by using plastic scintillators between (a) F3 and FH9 and (b) target position and S0 downstream.

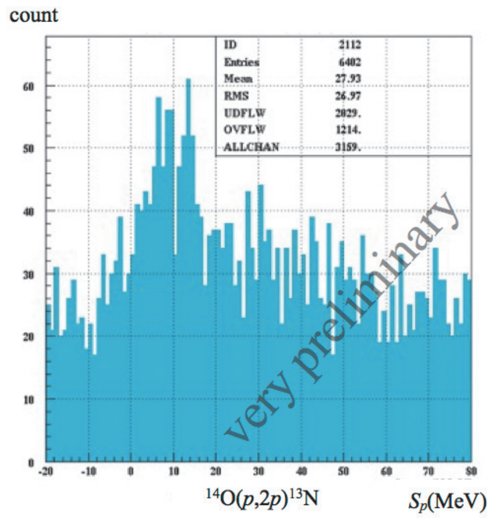

Fig. 2. Separation energy spectrum for ${}^{14}\mathrm{O}(p, 2p)^{x}\mathrm{N}$.

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