New Capabilities of the GRAND RAIDEN Spectrometer

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Recently the Grand Raiden High Resolution Spectrometer System has undergone significant upgrades and improvements, which allow to perform new and improved nuclear physics experiments using light ions, like p or ^{3}He, at intermediate energies available from the RCNP Cyclotron [1] complex.

A completely new, fully dispersion-matched beam line was designed and constructed [2,3] to realize experiments with resolutions up to the design resolving power limit of $p/\delta p = 37,000$ of Grand Raiden for a 1 mm object size. In order to allow reconstruction of the scattering angles from focal plane information, angular dispersion matching has also been implemented. This technique is particularly important in the extensively used 0° transmission mode experiments. Owing to the fast diagnostic method using faint beam [4], these matching conditions as well as proper monochromatic focusing on the target position of the spectrometer is reliably achieved.

An over-focus mode of the spectrometer [5] was introduced to improve the resolution of the vertical angle down to 4 - 7 mrad as compared to about 12 mrad when the vertical focal plane angle is used in the reconstruction. In this mode, the vertical scattering angle is reconstructed from the vertical ray position in the focal plane.

These upgrades and developments were implemented to perform a variety of high-resolution and good angle-resolution experiments [6] which were previously not possible. In (^{3}He,t) experiments at 140 MeV/nucleon performed at and near 0°, a resolution of 35 keV and an angle resolution of ≈ 5 mrad are realized in the range of $0° - 3°$. With this resolution, fine structure of states was clearly observed for the Gamow-Teller resonance in fp-shell nuclei [7], which was previously observed as a bump in pioneering (p,n) reactions. This has opened a new window in the study of strength distribution of spin nuclear excitations up to high excitation energies as well as in the fine structure study of giant resonances. By making level-by-level comparison with the results from high resolution inelastic proton scattering achieving 13 keV resolution even at the energy as high as 300 MeV [3], the identification of isospin values of high-lying states becomes possible. In the ^{16}O(^{3}He,t) reaction, the low-lying close triplet states in ^{16}F with spin-dipole nature, including "pion-like" 0^- state, were isolated for the first time in the intermediate charge-exchange reaction.

References

[1] The RCNP cyclotron, see Web Page http://www.rcnp.osaka-u.ac.jp/
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[3] T. Wakasa et al., Nucl. Instr. Meth. **A482** (2002) 79
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[6] Approved experiments, see RCNP Web Page http://www.rcnp.osaka-u.ac.jp/
[7] Y. Fujita et al., Eur. Phys. J. A **13** (2002) 411