Commissioning of the Si-CsI array TiNA for direct reactions at OEDO

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The energy-degrading beamline OEDO is operating at RIBF to expand the scope of reaction studies for radioactive nuclei.[1] TiNA is an array of Si and CsI detectors for direct reaction studies at OEDO to address a wide range of objectives in nuclear structure and astrophysics.[2] The first version of the detector has been used in several transfer experiments.[3,4]

The TiNA detector was upgraded in 2020 to increase the solid angle and improve the resolution in angle and energy.[5] The upgraded TiNA consisted of two types of detector assemblies. Four square telescopes with a first stage of double-sided strip silicon detectors (DSSD) and a second stage of CsI detectors were arranged in a barrel configuration and placed just beyond the reaction target. The second detector assembly is a lampshade array consisting of six trapezoidal telescopes with a first stage of single-sided strip silicon detectors (SSSD) and a second stage of CsI detectors. The total angular coverage by the entire telescope ranges from 10° to 80° in the laboratory frame.

For the data taking, two different systems were unified. The DSSDs were connected to the General Electronics for TPCs (GET), an integrated system allowing the processing of a total of 1024 channels. The test of the GET electronics has been reported in a previous study.[5] The signals from the rest of the detectors, including the CsI crystals and SSSDs, were fed into standard analog amplifiers and digitized by VME-standard ADC modules. Triggers from both systems were merged in a trigger module. A common trigger is sent to both DAQs and synchronizes the event number.

The detector was commissioned in-beam at the tandem accelerator facility of the Center for Accelerator and Beam Applied Science, Kyushu University in January 2021. The aim of this commissioning was to measure the performances in terms of energy and angular resolutions, particle identification for light ions, and DAQ capabilities.

A 14 MeV deuteron beam impinged on a 1 mg/cm^2 thick ^{12}C target provided by the RCNP, Osaka University. At this beam energy, elastic scattering, inelastic scattering to excited states, and transfer (d, p) and (d, α) reactions are allowed. The preliminary results give an energy resolution of 125 keV FWHM for the elastic scattering events measured by the DSSDs. Figure 1 shows the excitation energy for the (d, p) transfer reaction. The protons were selected by the $E - \Delta E$ method using the CsI crystals and DSSDs. The excitation energy resolution is approximately 330 keV FWHM for proton energies around 14 MeV. Analysis is still ongoing to improve the resolution.

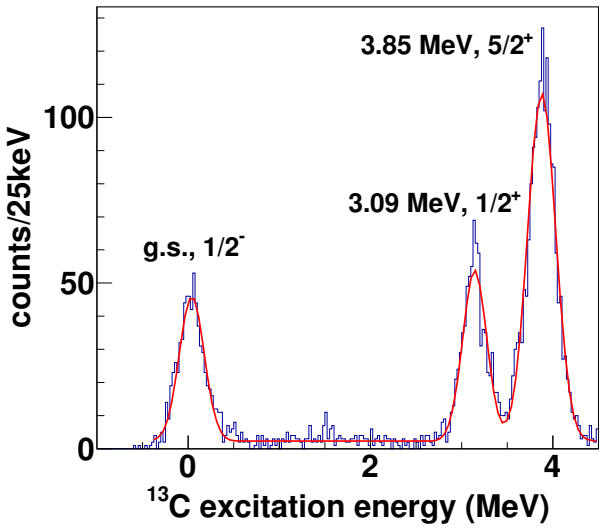

Fig. 1. Excitation energy spectrum for the ^{12}C$(d, p)^{13}$C transfer reaction using a 14 MeV deuteron beam.

In conclusion, the full setup of the TiNA detector was successfully commissioned at the tandem accelerator facility of the Kyushu University. The event correlation between the two independent data acquisition systems was validated; however, some DAQ capabilities should be improved in the future. The analysis is ongoing with encouraging preliminary results.

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