DALI2+ at the RIKEN Nishina Center RIBF

I. Murray,*1,2 F. Browne,*2 S. Chen,*3,2 M. L. Cortés,*2 P. Doornenbal,*2 H. Sakurai,*2,7 J. Lee,*4 M. MacCormick,*1 W. Rodriguez,*5 V. Vaquiero,*6 D. Steppenback,*2 and K. Wimmer*7

The utilization of large arrays of sensitive γ-ray detectors in combination with fast beams and a reaction target, is a powerful approach to interrogate nuclear structure.1) This technique, known as in-beam γ-ray spectroscopy and often in association with additional particle detectors, permits access to observables such as excited state energies, transition probabilities, exclusive and differential cross-sections, deformation lengths and parameters, state lifetimes and exclusive parallel momentum distributions. Highlights of RIKEN in-beam γ-ray spectroscopy results can be found in the references.2–4)

The Detector Array for Low Intensity Radiation (DALI) was constructed in 1995 for observing nuclear reactions with a low yield.5) DALI originally consisted of $60 \times 6 \times 12 \text{cm}^3$ thallium-doped sodium iodide (NaI(Tl)) scintillators arranged around a reaction target to cover a large solid angle. The granularity of the detector array permitted a correction to the Doppler shifted γ-rays at RI beam velocities of $v/c \sim 0.3$.

DALI was supplemented with additional NaI(Tl) detectors up to a total of 186 in 20026) and renamed DALI2. With the opening of the RIBF facility, where the RI beam velocities are $v/c \sim 0.6$, DALI2’s greater angular resolution and detection efficiency was integral to its continuing success.

In the spring of 2017, DALI2 was further upgraded to DALI2+ by the inclusion of additional new detectors to the array, bringing the total to 226. Poorly performing older detectors were substituted. A rendering of the new arrangement is shown in Fig. 1. Additional support structures were fabricated to accommodate the new detectors. The simulated total energy resolution of the DALI2 and DALI2+ configurations for various photon energies (in a centre-of-mass (CM) frame) are listed in Table 1. The beam pipe, shield, target thickness, beam velocity distribution and individual detector resolutions are not included in the simulations. The γ-rays are emitted isotropically in the CM frame and Doppler corrected.

The small reduction in FEP efficiency of the DALI2+ configuration is a consequence of the reduced angular coverage. The smaller opening angles of the detectors lead to an increase in inherent energy resolution because of Doppler correction.

DALI2+ was employed for the first time for the third SEASTAR campaign.7–9) It surrounded the liquid hydrogen target of MINOS10) which was situated between BigRIPS11) and SAMURAI12) spectrometers.

References
7) S. Chen et al., in this report.
8) M. L. Cortés et al., in this report.
9) H. N. Liu et al., in this report.