Large-acceptance achromatic mode with mono-energetic wedge degrader for ZeroDegree spectrometer

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An experiment was proposed to achieve the online commissioning of the SLOWRI gas catcher and multi-reflection time-of-flight (MRTOF) mass measurements symbiotically with in-flight experiments using the ZeroDegree spectrometer.[1)] A 50-cm-long cryogenic He gas cell will be placed downstream of the F11 chamber to provide low-energy radioactive isotopes from the energetic radioactive isotope (RI) beams of ZeroDegree. For ZeroDegree, the typically used large-acceptance achromatic (LAA) mode provides beams with a large energy spread at the F11 focal plane, resulting in a relatively low stopping efficiency (∼1%) in the gas cell. In order to improve the stopping efficiency, mono-energetic beams are prefered. Two ion optic settings were proposed to make such beams: the large-acceptance dispersive (LAD) mode[2)] and the LAA mode with a mono-energetic wedge degrader (LAAmono). The transmission efficiencies and particle identification resolutions were investigated for both modes. Herein, we report the results of the LAAmono mode.

A test was performed with a typical experimental condition for an in-beam gamma-ray experiment. A combination of a 345 MeV/nucleon ^{238}U primary beam and a 4-mm-thick ^{9}Be target was used to produce radioactive beams around ^{79}Cu at ∼270 MeV/nucleon. Both BigRIPS and ZeroDegree were tuned for the ^{80}Zn isotopes. The LAA and LAAmono mode were applied in turns for the ZeroDegree spectrometer. In the LAAmono mode, an Al wedge degrader with an angle of 20.8 mrad and a center thickness of 2.85 mm was employed at the momentum-dispersive focal plane (F10) of the standard LAA mode, as shown in Fig. 1(a). The energy distribution of ^{80}Zn isotopes after the wedge degrader [Fig. 1(b) right] shows a good mono-energetic property. A stopping efficiency of ∼5% in the gas cell was estimated from this distribution.

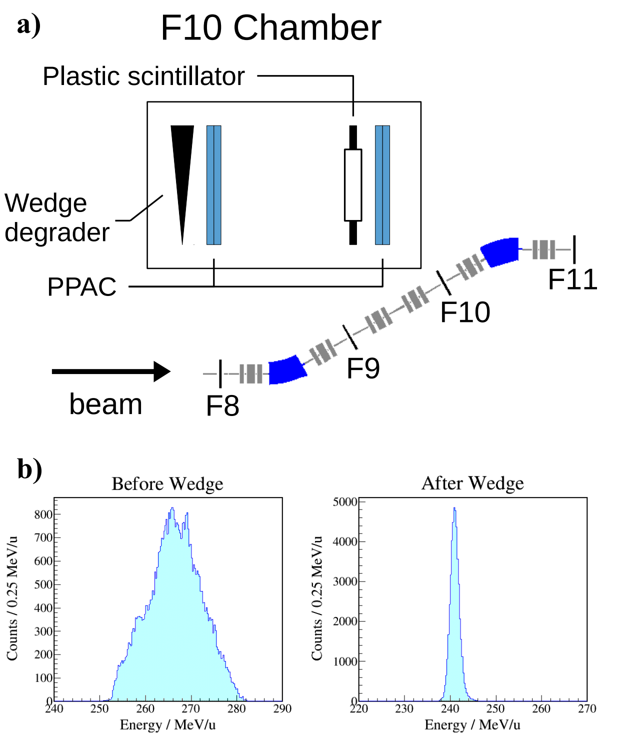

Fig. 1. (a) ZeroDegree setup for the LAAmono mode. (b) Energy distributions of ^{80}Zn before (left) and after (right) the F10 wedge degrader.

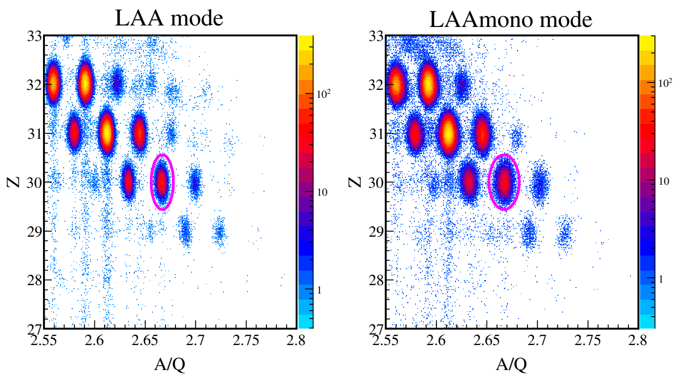

Fig. 2. Particle identification plots from the LAA mode (left) and LAAmono mode (right). The ^{80}Zn isotopes are indicated by the red ellipse in both plots.

The particle identification (PID) for both modes was performed using the time of flight from F8 to F11, reconstructed $B\rho$ between F8 and F10, $B\rho$ between F10 and F11, and $\varDelta E$ measured using the F11 ionization chamber. The PID plots from both modes are shown in Fig. 2. The one from the LAAmono mode exhibits a resolution slightly worse than the one from the LAA mode, but the resolution was sufficient to separate all the different isotopes well. The transmission efficiencies of ZeroDegree were studied by comparing the statistics of the ^{80}Zn isotopes in BigRIPS and ZeroDegree PID plots. The LAAmono mode keeps 95% efficiency in comparison with the standard LAA mode in this test experiment. This efficiency is consistent with the value estimated from LISE++ calculations, which suggests that the main loss originates from the reaction losses in the wedge degrader.

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References

1) M. Wada, RIKEN Proposal NP1912-RIBF176.
2) H. Takeda, in this report.