Development of a monitor for stored particles in the Rare RI Ring

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The precise mass measurements of neutron-rich nuclei are important for the study of the r-process and nuclear structure. The Rare RI Ring is a device for the precise mass measurements for short-lived nuclei.[1,2] In the mass measurements, the magnetic field in the ring is adjusted to be isochronous by using trim coils. Under this condition, the revolution time is constant and independent of the momentum of particles. This device determines the masses by comparing the revolution time of the reference particle with known mass and the particle of interest. First, we must optimize the septum magnets and the kicker magnet to enable the injection and storage of particles. For this purpose, a detector is needed to monitor the stored particle in the Rare RI Ring.

The required performance of a detector to confirm particle storage is high efficiency and low material density on beam line. In this report, we have developed a detector using a thin foil, scintillators and multi-pixel photon counters (MPPCs). This detector detects multiple turns by detecting secondary electrons including low-energy electrons to δ-rays using plastic scintillators and MPPCs. As a detector for the same purpose, a timing detector using a carbon foil and a micro-channel plate has been developed.[3] The advantage of the new detector is that it is free from the electrical noise of the kicker magnet because it uses a photo-sensor.

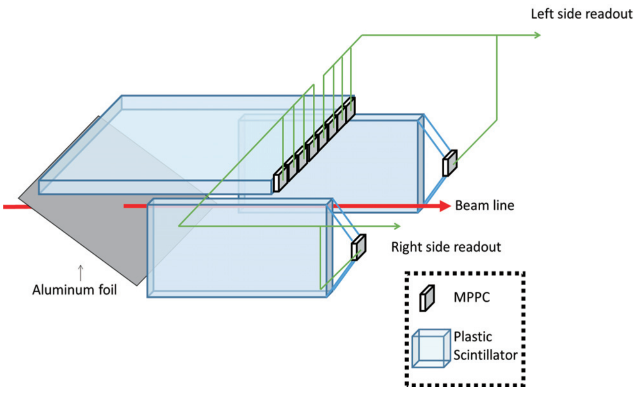

Fig. 1. Schematic view of the configuration of the δ-ray detector.

Figure 1 shows a schematic view of the developed detector. The thin foil consists of 3-μm-thick aluminum. The size of the top plastic scintillator is 100 × 100 mm^2 with 3-mm thickness. The size of plastic scintillators on both sides is 80 × 50 mm^2 with 3-mm thickness. We prepared ten MPPCs. Eight of them were connected to the upper side of the plastic scintillator and the other two were connected to the left and right sides. Ten MPPCs were divided into two units, the right half and the left half, and signals of five MPPCs are combined into one signal to reduce the number of readout channels. Hereafter, we refer to the developed detector as the δ-ray detector.

In November 2016, we conducted the third machine study of the Rare RI Ring[4] and measured revolution time using the δ-ray detector and the timing detector. In this experiment, we injected nuclei around ^{78}Ge with 175 MeV/nucleon. Figure 2(a) shows a histogram of the circulation of ^{78}Ge. This figure indicates the success of detection of circulating particles. The revolution time is calculated by the relationship between the turn numbers and total stored time (Fig. 2(b)). The revolution time measured by the δ-ray detector is consistent with the value measured by the timing detector. The precision of determining revolution time was 8×10^{-4}. The future development goal is the improvement of time resolution.

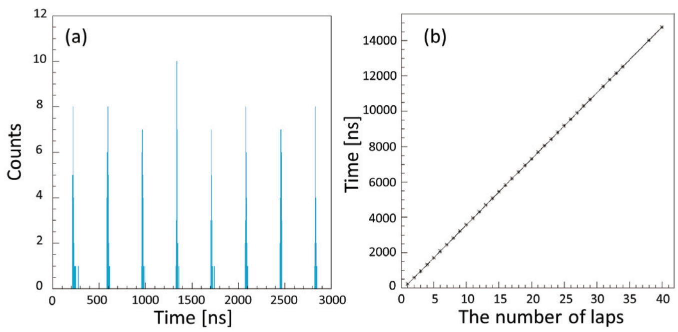

Fig. 2. (a) Zoomed histogram of the circulation of ^{78}Ge. (b) Time as a function of turn number, which is fit using a linear function.

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References
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