# Development of a timing detector for decay spectroscopy in conjunction with MRTOF-MS

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The KEK Isotope Separation System (KISS)[1] has been used to perform the $\beta$-$\gamma$ decay and laser spectroscopy of heavy neutron-rich nuclei of refractory elements. In most scenarios, we had isobar and isomer (or ground state) contaminants owing to the limited mass resolution of a dipole magnet ($A/\Delta A \sim 900$). The isobar contaminants are the survival ions extracted from an argon gas cell, and isomer (or ground state) contaminants originate from the element-selective laser ionization at the exit of the Ar gas cell. The isobar and isomer contaminants often complicate[2] analyzing $\gamma$-ray energy spectra and decay half-lives. Therefore, for the spectroscopy of a single nuclide identified precisely using a multi-reflection time-of-flight mass spectrograph (MRTOF-MS), we will install a $\beta$-$\gamma$ time-of-flight (TOF) detector that provides a stop signal of the MRTOF-MS for a time-correlated measurement between the MRTOF-MS and $\beta$-$\gamma$ detectors.

The current $\beta$-$\gamma$ detector station consists of an aluminized Mylar tape transport system placed at the center of the detector station, a proportional gas counter,[3] and germanium detectors. To perform the decay spectroscopy in conjunction with the MRTOF-MS, the decay station must be installed downstream of the MRTOF-MS, and the $\beta$-$\gamma$ TOF detector must be installed at the front of the gas counter. The start timing of the TOF measurement is the timing of the ions injected into the MRTOF. The secondary electrons (SEs) emitted from the aluminized Mylar tape in the injection of mass-separated ions are detected by an annular-type MCP detector to supply the stop timing of the MRTOF-MS. We call the MCP detector the $\beta$-$\gamma$ TOF detector. We report the simulation results of the SEs detection using the $\beta$-$\gamma$ TOF detector.

Figure 1 shows the cross-sectional view of the setup for the detection of SEs. The setup consists of a solenoid coil with a length of approximately 54 mm, an electrode for the SEs transport to the MCP, and a metal plate with a thin pipe shielding the electric fields of the MCP for the ion transport. The mass-separated ions from the MRTOF-MS are accelerated up to 20 keV/$q$ using a pulse drift tube and impinged on the tape, as shown at the bottom of Fig. 1. The SEs emitted from the surface of the tape (GND) are accelerated toward the solenoid coil by a potential of +370 V and transported upstream with a sufficiently small orbital radius by a magnetic field inside the solenoid coil and by the upstream electrode (+600 V). Subsequently, the SEs hit the front surface of the MCP, and the TOF stop signal

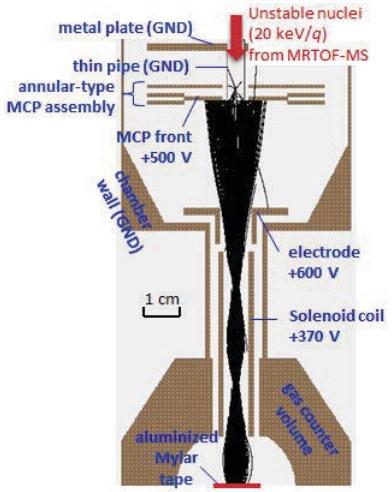


Fig. 1. Simulated trajectory (black line) of SEs emitted from the surface of an aluminized Mylar tape.

is obtained.

The SEs trajectories simulated using SIMION[4] are indicated by black lines in Fig. 1. In the simulation, SEs were generated at the tape position with the Gaussian distribution of 1 mm in standard deviation, and the initial emission angle was assumed to be uniform in $2\pi$. The initial kinetic energy was assumed to be an order of 1 eV, which is the typical order of the energy for SEs. The simulated transport efficiency of a single electron from the tape position to the MCP surface was 77% and the time resolution was approximately 0.5 ns in FWHM. We expect the number of SEs of ~2.8 on average, which was the measured value in a previous study via a bombardment of $W^+$ ions (15 keV) on an $Al_2O_3$ target.[5] Therefore, we can expect a detection efficiency of as high as 90%. The simulated time resolution of the electron transportation, ~0.5 ns, is sufficiently small considering the typical TOF of approximately 15 ms and the contribution to the mass resolving power is smaller than 3%.

The offline study is ongoing. The setup will be installed early next fiscal year.

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