Study of the performance of the SCRIT rear drift chamber

S. Matsuo,[*1,*2] A. Enokizono,[*1,*2] K. Kurita,[*1,*2] Y. Moriya,[*2,*3] T. Suda,[*2,*3] T. Tamae,[*2,*3] K. Tsukada,[*2,*3] T. Tsuru,[*2,*3] and S. Yoneyama[*2,*3]

The SCRIT electron spectrometer called WiSES (Window-frame Spectrometer for Electron Scattering) consists of a dipole magnet, front and rear drift chambers (FDC and RDC, respectively), a helium bag to reduce multiple scattering and plastic scintillators for event triggering. To obtain charge density distributions of unstable nuclei, the angular distributions of differential cross sections have to be precisely measured using elastic electron scattering. Thus, the WiSES is required to achieve a good momentum resolution ($\Delta p/p \approx 10^{-3}$) for a wide momentum range[1)], and the position resolution of the RDC is required to be ∼150 μm to achieve the momentum resolution. A newly developed electronics module (RAINER) is employed to read data for the RDC[2)]. In this article, we report performances of the RDC and RAINERs, which were examined using a tungsten wire target experiment in December 2014[3)].

Since the RDC and RAINERs are installed very close to the RF power source for the electron storage ring, the background noise effect must be carefully investigated. Although the RF noise test has been performed using a small prototype DC with RP1212 (an old version of RAINER) which showed a good performance[4)], the actual RF effect on the RDC is still uncertain. Therefore, we repeated the same RF noise test using the RDC and RAINERs prior to the wire target experiment. As shown in Fig. 1 (a), the noise level was found to be slightly larger than that observed in the previous report but still less than ∼800 mV in the worse case. Fig. 1 (b) shows the comparison of noise counts between the RF off and on cases as a function of the threshold voltage (V_{th}) for the ASD chip in RAINER. There is basically no difference in the noise rate for the RF on/off conditions at V_{th} > 800 mV, and the rate reduces to zero for V_{th} > 2200 mV. For the wire target experiment, V_{th} is set to 1500 mV, where the noise rate is still much smaller than the event rate (a few hundred hertz) and such a low-rate random background could be eliminated in the tracking.

The RDC consists of 10 layers as VV′UU′XX′VV′UU′ and the tracking is performed using the following iterative algorithm. First, the U and V planes are determined using the hit position information for every four layers. Here, the initial hit position in each cell is calculated using TDC and a roughly estimated $x - t$ (space-time) calibration parameter. Second, a track is determined by combining the V/U planes and the hit positions in the remaining two X layers by minimizing χ^2/ndf. Then, the residual distributions between the initial hit positions and the track intersection on the layer planes and the $x - t$ calibration parameters are re-evaluated for each layer. The procedure is iterated (typically 4-5 times) until the widths of the residual distributions converge to the minima. The position resolution and efficiency per layer of the RDC were determined from the wire-target experimental data. Fig. 2 shows the converged residual distribution for a given V layer without the hit information of the layer. The rms was found to be ∼200 μm.

In summary, we conducted a wire target experiment for SCRIT WiSES and obtained calibration parameters for the RDC. Some efforts to improve the tracking algorithm are underway by tuning the calibration parameters to obtain a better position resolution.

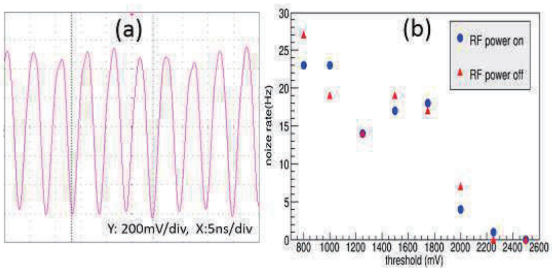

Fig. 1. (a) RF noise level measured at the ASD chip in the RAINER card. (b) Noise count rates as a function of V_{th} with/without RF power.

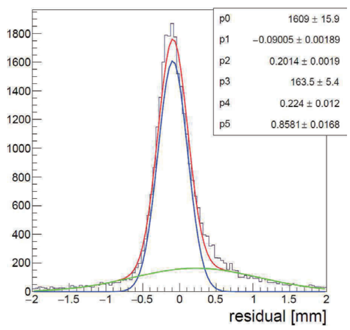

Fig. 2. Residual distribution of a V layer of the RDC

*1 Department of Physics, Rikkyo University
*2 RIKEN Nishina Center
*3 Research Center for Electron-Photon Science, Tohoku University

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