Test of new readout card for the SCRIT drift chamber

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The SCRIT electron spectrometer[1)2)] consists of a set of dipole magnets, the front and rear drift chambers (DC), and plastic scintillators for event triggering. The rear DC has a volume of 274 cm x 36 cm x 78 cm, and it has a total of 5 layers of UVX consisting of 1130 channels, which have an intrinsic 150-μm position determination capability with 1-ns timing resolution. It covers a solid angle of 100 mSr for scattered electrons to achieve a good momentum resolution ($\Delta p/p \sim 10^{-3}$) with a wide scattering coverage (30°-60°) . We employed a new TDC card (RINEI RP1212) based on SiTCP technology[3)] for DC data readout. In this article, we report the results of readout tests of RP1212 using the actual experimental setup.

RP1212 has dimensions of 150 mm x 190 mm, and it is capable of processing ADC and TDC data for 64 channels. TDC is implemented in FPGA (Xilinx Kintex7) with 1-ns timing resolution. It is directly attached to the DC, and signals are immediately digitalized by FPGA on the board. The data is transmitted to a PC via Gigabit Ethernet. An advantage of using RP1212 is that the path length of the analog signal can be minimized such that the data is less influenced by analog noise as compared to the earlier readout system using the ASD card and TDC module. Nevertheless, since the DC and RP1212 will be located very close to the RF power source for the electron storage ring[4)], the background effect that originates from the RF noise was investigated.

Figure 1 (A) shows a typical β ray signal (^{90}Sr) using prototype DC and RP1212 under the RF environment. The top panel indicates that the pulse height of the β signal is ~800mV, and the bottom panel in a different time scale clearly illustrates 5-nsec-period oscillation, which is apparently caused by the 191-MHz RF noise. The noise amplitude is less than ~150 mV, which is much smaller than that of the β signal, at the full RF power condition. Fig 1 (B) shows the comparison of noise counts between RF off and on cases as a function of the threshold voltage for the ASD discriminator (Vth). The noise count is zero at Vth ~200 mV, while the noise rate is not negligible below a Vth of 150 mV when RF is on. In fact, the count at Vth = 100 mV is rather dominated by noise from powerline of RP1212. Since a typical height of a β signal with no angle is 600 mV to 800 mV, we found that the appropriate Vth is 400 mV to 500 mV, which is sufficient to trigger a β signal and eliminate RF noise simultaneously.

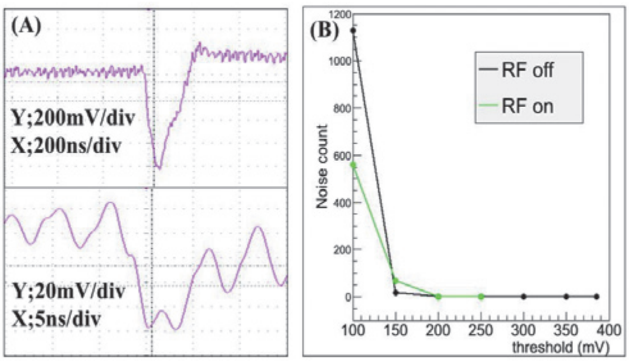

Fig. 1. (A) The top panel shows an analog signal for a beta ray measured with RP1212, and the bottom panel shows the RF noise in expanded scale for both time and pulse height. (B) Noise count rate as a function of threshold value for ASD chip on RP1212.

We measured the timing distribution of β signals using RP1212 and the actual SCRIT-DC for He+CH_4 (50:50) gas mixture. We examined the plateau region of detection efficiencies and then found that the operational voltage range for good efficiency is 2550 V to 2800 V. Therefore, the normal operation voltage is set at 2750 V.

Figure 2 shows the timing distribution of β signals. For better statistics, the histogram adds up TDC data from 64 channels. Since RP1212 has a common stop trigger, which is provided by a trigger scintillator, the right edge of distribution originates from β signals that were received near the anode wire. Since the rising edge is clear, we can use it as a calibration point. We are working on the timing calibration to achieve ~150 μm position resolution.

In 2014, we will proceed to developments of calibrations and tracking framework aiming at the first result of the ^{132}Sn electron scattering experiment.

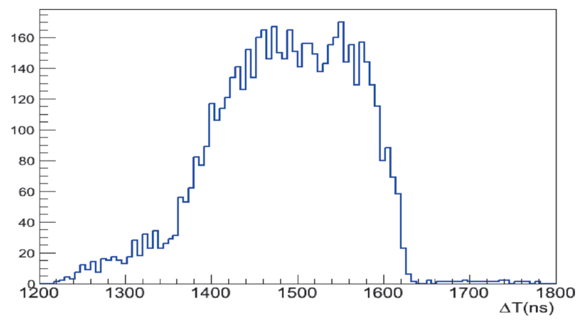

Fig. 2. The timing distribution of the beta signal.

References
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