 RIKEN Accel. Prog. Rep. 49 (2016)

Measuring luminosity of electron scattering from Xe isotopes at the SCRIT experiment

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The SCRIT (Self-Confining RI ion Target)[1] device has been developed to make the experiment of electron scattering off short-lived nuclei possible at high luminosity (10^{27}cm^{-2}s^{-1}). The charged density distribution of the target nucleus is derived from the angular distribution of elastic scattering cross-section of electrons. At the SCRIT experiment, the angle and momentum distributions of scattered electrons are measured by the electron spectrometer (WiSES), and the luminosity of the electron-nucleus scatterings is measured by the luminosity monitor (LMon). Here the luminosity is obtained by measuring photons from the bremsstrahlung process which is calculatable with less ambiguity even for previously unmeasured nuclei.

The LMon, which is located ~7 m downstream along the beam line from the electron-target interaction region, consists of 7 CsI calorimeters to measure the photon energy, and plastic fiber scintillators to measure the 2D hit distribution of photons[2]. In August 2015, a commissioning test using stable ^{132}Xe target was performed at the beam energy $E_e = 150$ MeV. In order to estimate the background from residual gases, the LMon measures photons for both periods with and without trapped ^{132}Xe.

Figure 1 shows the total energy distributions that are calculated by summing up energy deposits in the 7 CsIs. Each CsI energy was calibrated by using the cosmic data and GEANT4 simulation. The left panel of Figure 2 shows the photon hit rates measured run-by-run. Each run is typically ~20-30 min long. It is shown that the background photons from the residual gases (ION OFF) occupy the majority of the total event rate (ION ON), and the net photon event rate from Xe target (ION ON-OFF) is ~10-15 kHz. The run-by-run luminosities, as shown in the right panel of Fig. 2, are estimated as $L = N_{br}/t\sigma_{br}\epsilon$ where σ_{br} is the cross-section of the bremsstrahlung process for a given energy range[3] and ϵ is the detection efficiency evaluated by GEANT4. The net photon event rate (N_{br}/t) and the integral of σ_{br} are limited only above 50 MeV to avoid a huge background of low energy photons. The average luminosity during this commissioning experiment is estimated to be $(2.02\pm0.12)\times10^{26}$cm^{-2}s^{-1} including systematic uncertainties. The systematic error that originates in the CsI energy resolution is the largest contribution (2.8%). The energy pile-up contribution, which appears as entries above 150 MeV in Fig. 1 if more than two photons from independent bremsstrahlung processes hit CsIs within a trigger window, is found to be negligible.

In summary, we have performed a commissioning experiment for SCRIT using ^{132}Xe at $E_e = 150$ MeV, and demonstrated that the luminosity measured by LMon reached $\sim 2\times10^{26}$cm^{-2}s^{-1}. Since the background rate is found to be more than 3-4 times higher than the signal event rate, the next important step is to carefully investigate the background contributions by GEANT4 simulation. It should also be noted that more recent studies of the electron beam improved the luminosity by a couple of factors, and the result will be reported in near future.

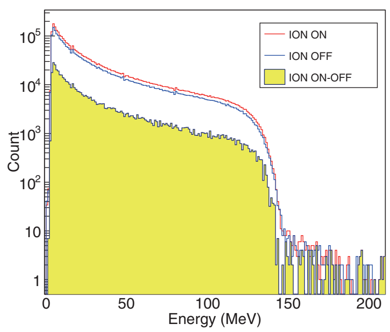

Fig. 1. Total energy distributions of CsI with Xe trap (ION ON), without Xe trap (ION OFF) and the difference between the two (ION ON-OFF).

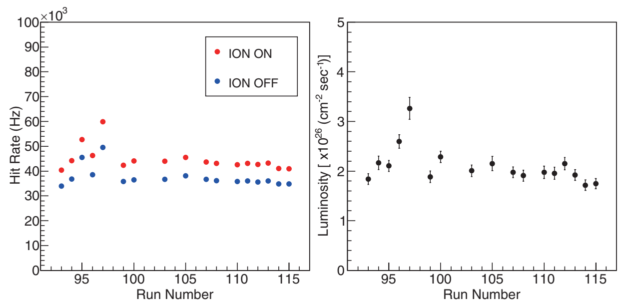

Fig. 2. Run dependence of photon hits rates at CsI (left), and the measured luminosity (right).

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References
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