Development of position detector for luminosity monitor in the SCRIT electron scattering facility

M. Tachibana,[*1] S. Iimura,[*2] T. Ohnishi,[*3] R. Ogawara,[*3] Y. Kikuchi,[*4] R. Kagami,[*1] H. Kobayashi,[*1] Y. Saito,[*1] K. Tsukada,[*1,*5] K. Hotta,[*6] Y. Honda,[*6] Y. Maeda,[*1] H. Matsubara,[*2] T. Yamauchi,[*6] M. Wakasugi,[*1,*5] and M. Watanabe[*3]

Investigation of the internal structure of atomic nuclei is extremely important for verifying nuclear theory models. We aim to conduct electron scattering experiments targeting unstable atomic nuclei using the self-confining RI ion target (SCRIT) method[1] to form internal targets in the electron storage ring. At the SCRIT facility, we count the scattered electrons with the scattered electron spectrometer and measure luminosity by counting the number of bremsstrahlung photons emitted from the target-electron interaction to determine unknown electron scattering cross-sections. The error on the luminosity directly affects the accuracy of the cross-section. We need electron scattering data at different electron beam energies to cover a wide momentum transfer region. Therefore, comparing luminosity among the data is crucial for normalization of the cross-section.

The luminosity measurement system, called luminosity monitor (LMon), consists of a position detector and a calorimeter array. The position detector measures the spatial distribution of electron-positron pairs produced from bremsstrahlung photons. In this study, we newly developed a position detector (Fig. 1) to improve luminosity measurement accuracy. The position detector consists of two sets of 64 scintillation fibers, each with a cross section of 1×1 mm^2, one set measures the horizontal distribution and the other measures the vertical distribution. We improved the position resolution by using thinner scintillation fibers compared to the previous detector with a cross section of 3×3 mm^2.[2] And MPPCs were adopted instead of PMTs for signal amplification to improve the detection efficiency. We confirmed that the developed position detector operated correctly and checked the uniformity of each scintillation fiber gain using a radiation source (^{90}Sr). We also verified the systematic error in counts for each channel of the position detector and found it to be about 4%.

Additionally, to evaluate the performance of the luminosity monitor, electron scattering experiments targeting ^{208}Pb and ^{132}Xe were conducted at the SCRIT facility. The luminosity for the ^{208}Pb target experiment can be predicted using the charge density distribution of ^{208}Pb, which was precisely measured in past experiments.[3] In Fig. 2, the experimental results (blue dots) showing the spatial distribution of bremsstrahlung photons are compared with Geant4 simulation results (red line). It is difficult to reproduce the spatial distribution by the simulation, as shown in Fig. 2, resulting large ambiguity of luminosity values.

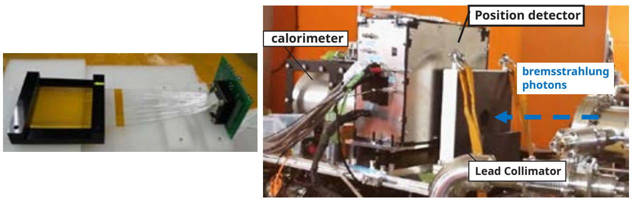

Fig. 1. A set of scintillation fibers (left), LMon (right).

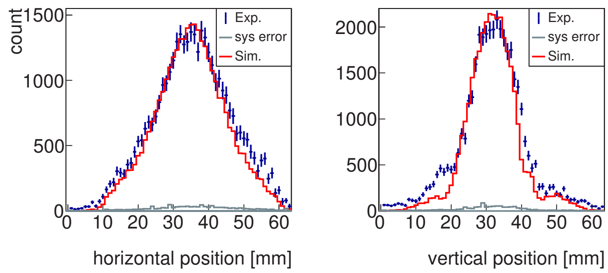

Fig. 2. Spatial distribution of bremsstrahlung photons for ^{208}Pb target and $E_e = 250$ MeV, blue dots are experiment, gray line is systematic error, red line is simulation scaled to the experimental results.

This result may be due to the lack of detailed information about the obstacles between the internal targets and LMon. The acceptance of LMon with the developed position detector needs further investigation. Additionally, we need to verify the reliability of the luminosity monitor by comparing the luminosity obtained from LMon with that derived from the scattered electron spectrometer. In the future, we aim to provide accurate luminosity during electron scattering experiments targeting ^{132}Sn.

References
1) M. Wakasugi *et al.*, Nucl. Instrum. Methods Phys. Res. A **532**, 216 (2004).
2) T. Fujita *et al.*, RIKEN Accel. Prog. Rep. **50**, 188 (2016).
3) H. De Vries *et al.*, At. Data Nucl. Data Tables **36**, 495 (1987).

*1 Department of Physics, Kyoto University
*2 Department of Physics, Rikkyo University
*3 RIKEN Nishina Center
*4 Department of Physics, Saitama University
*5 Institute for Chemical Research, Kyoto University
*6 Reserach Center for Accelerator and Radioisotope Science, Tohoku University

DOI:10.34448/RIKEN.APR.58-215