3D magnetic field measurement of the SCRIT electron spectrometer

H. Wauke,[*1,*2] T. Aoyagi,[*1,*2] A. Enokizono,[*1] Y. Honda,[*1,*2] K. Kurita,[*1,*3] S. Sato,[*1,*3] T. Suda,[*1,*2] S. Takagi,[*1,*4] S. Takayama,[*1,*2] D. Taki,[*1,*2] T. Tamae,[*2] K. Tsukada,[*1,*2] T. Ohnishi,[*1] M. Wakasugi,[*1,*4] and M. Watanabe[*1]

Window-frame Spectrometer for Electron Scattering (WiSES)[1)] is an electron spectrometer for Self-Confining Radioactive-isotope Ion Target (SCRIT)[2)] experiment. WiSES consists of a dipole magnet,[3)] two drift chambers at the entrance and exit of the magnet, a helium bag installed between the two drift chambers to reduce the multiple scattering effect, and two scintillation counters used for trigger generation. The solid angle of the spectrometer is about 80 msr, covering a wide range of scattering angles, *i.e.*, from 30° to 60°. A typical momentum resolution of $\Delta p/p \sim 10^{-3}$ for an electron energy in the range of 150–300 MeV is required to separate elastic and inelastic scattering with WiSES. It was found that the momentum resolution evaluated in past elastic scattering experiments did not reach the design value. One possible cause was that the map calculated using OPERA3D to reconstruct the trajectories of the scattered electrons had not accurately reproduced the WiSES magnetic field.

The scattered electrons passing through WiSES experience strong vertical focusing due to B_z, which is a horizontal component of the fringing field.

In order to check the calculated map, we measured the 3D magnetic field of WiSES with the measured accuracy $\Delta B/B \sim 10^{-3}$. The magnetic field strength was 0.4–0.8 T, which corresponds to an electron beam energy of 150–300 MeV in the experiment. In 2018, we developed a triaxial probe made from three Hall probes to measure three field components simultaneously.[4)] The measurement resolution of these probes is about 10^{-6} T. In addition, we developed a 3D driving device consisting

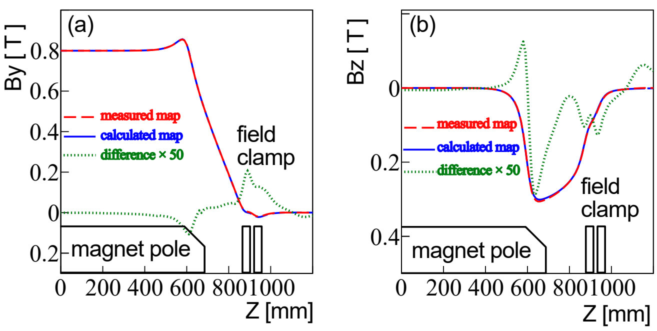

Fig. 1. Comparison between the measured map and the calculated one near the magnetic pole. The strength of the magnetic field was 0.8 T. (a) shows vertical component B_y and (b) shows horizontal component of the fringing field B_z. The red line is the measured map, blue line is the calculated one, and green line shows 50 times the difference between the two maps.

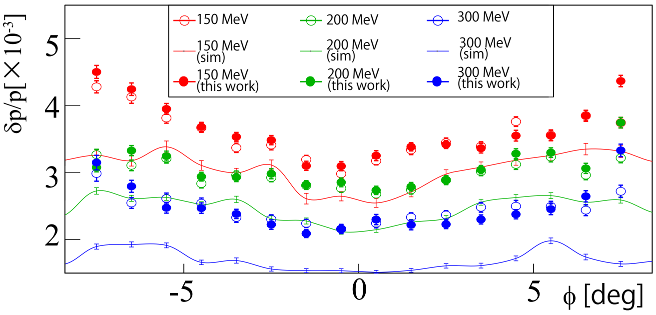

Fig. 2. Comparison of the momentum resolution between the measured map and the calculated one. The solid lines show the simulation results, the open circles show the results obtained with the calculation map, and the filled circles show the results obtained with the measured map. Red indicates the results with 150 MeV, green indicates the results with 200 MeV, and blue indicates the results with 300 MeV.

of three electric sliders that move in a large measurement area. The 3D driving device was controlled by a LabVIEW program. The program also read the field values from the Hall probes and the absolute magnetic field of the WiSES magnet from nuclear magnetic resonance (NMR).

Figure 1 shows the vertical component B_y and the horizontal component of the fringing field B_z of the measured map and the calculated one. The structure of the measured magnetic field is similar to the calculated one even at about 1 cm from the magnet pole. Over the entire measurement area, the difference between the two maps was $\sim 10^{-3}$ T for both B_y and B_z. Similar results were obtained for other magnetic field strengths.

In November 2019, an electron scattering experiment using a carbon target was conducted.[5)] The momentum resolution is the width of the elastic scattering peak obtained in the experiment. The resolution was obtained using the above two maps and compared. Figure 2 shows the result. ϕ is the azimuth angle of the scattered electrons as viewed from the target. The width of the elastic scattering peak obtained in the experiment was used as the momentum resolution. At three electron energies, the momentum resolutions obtained from the measured map in this study were almost the same as that obtained from the calculated one.

We need further consideration to explain the difference of the WiSES momentum resolution between the simulated and experimental values.

*1 RIKEN Nishina Center
*2 ELPH, Tohoku University
*3 Department of Physics, Rikkyo University
*4 Institute for Chemical Research, Kyoto University

References

1) T. Adachi *et al.*, RIKEN Accel. Prog. Rep. **45**, 144 (2012).
2) M. Wakasugi *et al.*, Phys. Rev. Lett. **100**, 164801 (2008).
3) T. Suda *et al.*, RIKEN Accel. Prog. Rep. **46**, 184 (2013).
4) H. Wauke *et al.*, RIKEN Accel. Prog. Rep. **52**, 144 (2018).
5) K. Tsukada *et al.*, in this report.