Precise magnetic field measurement of electron spectrometer for the electron scattering off unstable nuclei experiment

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1 introduction

We have built the SCRIT(Self-Confining Radioactiv-isotope Ion Target)[1] electron scattering facility[2] at RIKEN RI Beam Factory in order to determine the charge density distribution of short-lived unstable nuclei by electron scattering. WiSES(Window-frame Spectrometer for Elecltron Scattering) is an electron spectrometer, which consists of a dipole magnet, two drift chambers at the entrance and the exit of the magnet, two scintillation counters for trigger generation, and a helium-gas filled bag installed between the two drift chambers as shown in Fig. 1. The momentum of the scattered electrons is determined by reconstructing the trajectories from the magnetic field(B-field) distribution of the magnet and information of the position and the angle of the scattered electrons obtained from two drift chambers.

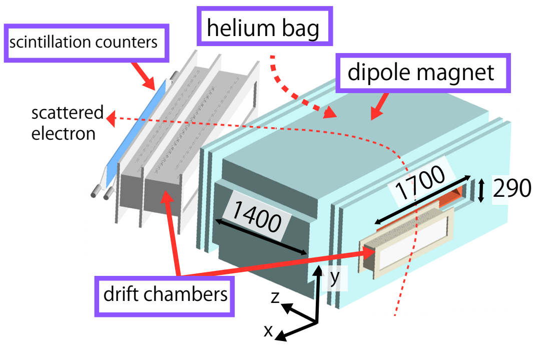

Figure 1: WiSES

In order to determine the charge density distribution of nuclei by elastic scattering, we need to identify the elastic and the inelastic scattering events by WiSES. The momentum resolution $\delta p/p$ of WiSES is necessary to be an order of 10^{-3} in the energy range of 150 to 300 MeV. But the past studies show that it has not been reached yet. One of the possible causes is the incomplete knowledge of the B-field distribution. The B-field distribution calculated by a finite element method program, TOSCA, has been used so far. I'm measuring the B-fields in order to improve the momentum resolution of the spectrometer.

2 experimental set up

I measure the B-field with $\delta B/B \sim 10^{-3}$ accuracy. The measurement area is $850(x) \times 130(y) \times 850(z)$ mm^3, which covers both the homogeneous and the fringing field area. In adddition, considering the symmetry of the B-field in the y and x directions, the B-field in a quarter of the aperture area is measured. The strength of the B-field is set to be 0.4 to 0.8 T, corresponding to the electron beam energy of 150 to 300 MeV. The absolute B-field value is monitored by a NMR positioned in the homogeneous field.

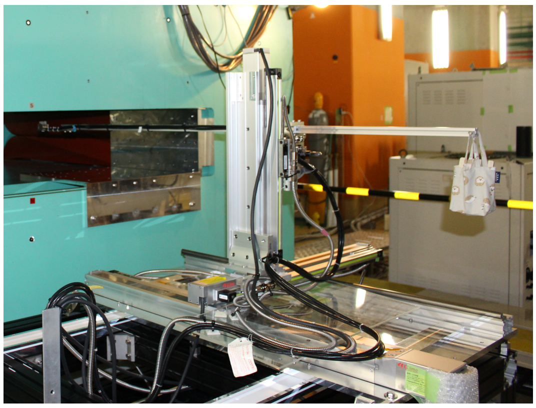

Figure 2: 3D B-field measurement system

I use three hall probes(Group3, LPT-141) mounted pependicular to each other on an aluminium cubic (ProbeHead) in order to measure the three components of the B-field simultaneously.

The ProbeHead is attached on the front edge of an 1.5 m aluminium bar, which is mounted on the 3D B-field mesurement system as shown in Fig. 2. At the tail edge of the bar, a 500 g weight is attached as a counter valance. The system has three motorized linear slides(Mitutoyo, EZS Ⅱ series) which are perpendicular to each other and remotely controlled. Furthermore, the position of the ProbeHead is measured by linear scale units (Mitutoyo, AT113 series).

I have developed LabVIEW programs which automatically operate the linear slides to scan the whole volume to be measured. In addition, the programs can read and record the position values from the linear scale units, the B-field values from the tesla-meters and NMR. After moving the ProbeHead, it is necessary to wait for 20 sec so that the read value form the tesla-meter stabilizes.

The position of the ProbeHead relative to the magnet are calibrated using iron pins with a neodymium magnet attached as shown in Fig. 3.

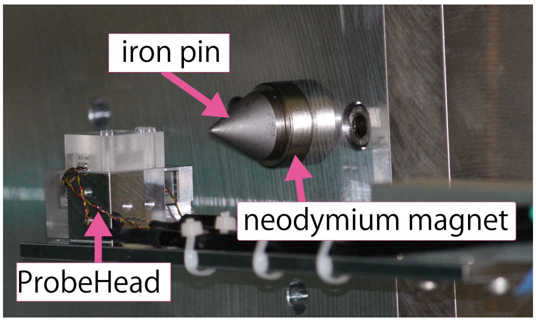

Figure 3: The iron pin and the ProbeHead in WiSES

3 present status

I have been in RIKEN since 9th September for preparations of the B-field measurements. The measurement of the B-field distribution started last week. So far, a half of the measurement has been carried out.

Figure. 4s show the z-dependence of B_y and B_z. Each color corresponds to the y-position from -60 to 110 mm. The geometries of the magnet are over drawn.

Near the field clamp, both B_y and B_z change largely. The y-dependence of B_y is not so large except for y=110mm, where characteristic peaks are observed as expected from the TOSCA calculation. On the other hand, The B_z distributions show large y-dependences. In addition, the sign of B_z is reversed at y=0. For example, the absolute values of B_z at $y = -60$ and 60 mm are almost the same. These results are generally similar to the calculation results altough corrections from the relative angles among the linear slides and ProbeHead are not taken into account. In the future, it will be necessary to conduct analysis in consideration of these parameters.

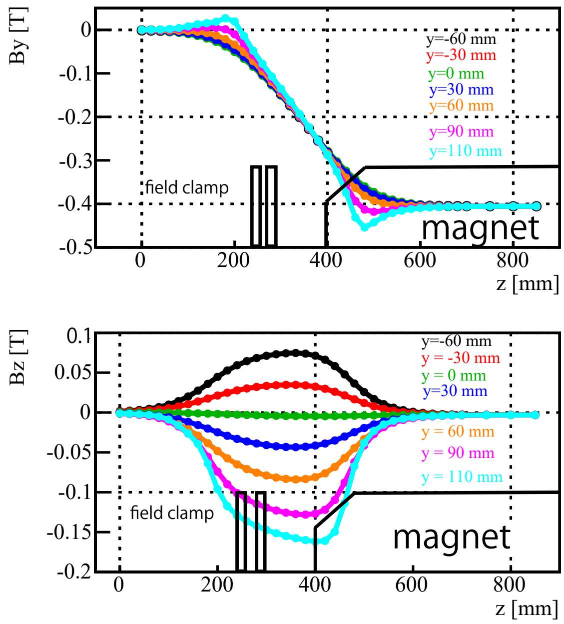

Figure 4: The result of the z-dependence of the B_y and B_z of WiSES.

4 summary and future

We have built the SCRIT electron scattering facility in order to conduct the world's first electron scattering off unstable nuclei. In order to improve the momentum resolution of the electron spectrometer WiSES, I'm performing the precise B-field measurement. I have developed a 3D B-field measurement system that can measure B-fields with $\delta B/B \sim 10^{-3}$ accuracy. The measurement is ongoing now.

The measured field maps will be analyzed and compared with a calculated map. Furthermore, electron scattering expriment with the carbon target will be performed to evaluate the momentum resolution of WiSES using a new field map.

[1] M.Wakasugi *et al* : Nucl. Instr. Meth. **A532**, (2004), 216-223

[2] T.Suda *et al* : Prog. Theor. Exp. Phys. **03C008**, (2012)