

Development of Magnetic Field Components for the Polarisation Option of the Neutron Spectrometer FOCUS

L. Holitzner¹, U. Filges¹, J.P. Embs², T. Fennell², T. Panzner¹

¹Laboratory for Developments and Methods, Paul Scherrer Institut, Villigen, Switzerland

²Laboratory for Neutron Scattering, Paul Scherrer Institut, Villigen, Switzerland

Abstract

Introduction:

Neutrons are part of the atomic nuclei. As neutrons are electrically neutral, they deeply penetrate into sample materials. Neutrons with a suitable velocity (resp. wavelength) are the perfect "detectives" to explore the dynamical and structural properties of materials. In addition neutrons have a spin. In a "normal" neutron beam these spins are orderless. When it succeeds to order the neutrons spin in the beam and to guide this "polarised" beam to the sample, we can also probe the magnetic properties of samples. The time-of-flight spectrometer FOCUS [1] at the spallation neutron source SINQ at Paul Scherrer Institut (PSI) can be extended by a polarisation option. Our current activities concentrate on the components for the primary polarisation: the polariser (to order the neutron spin), the magnetic guide field (to keep the beam polarised) and a spin flipper (which can invert the spin direction). These new components have to be implemented into the existing neutron spectrometer.

Use of COMSOL Multiphysics®:

Due to the space conditions in the existing spectrometer, the polariser has to be placed inside the rectangular hole of the monochromator shielding. The first challenge was, to create a relatively strong, homogeneous magnetic field for the polariser in direct neighbourhood to the field-disturbing iron elements of the shielding. As the spin flipper is located in the inhomogeneous stray field of the polariser field, it was a challenge to create the necessary magnetic zero-field inside the spin flipper. The next task was, to design the magnetic guide field in the transition region between polariser and spin flipper. This requires a clever adjustment of magnetic field gradients. The magnetic polariser field and the guide field were created by a set of permanent magnets, while the spin flipper is composed of rectangular magnetic coils. In the polarizer domain, COMSOL Multiphysics® provided the optimization of the magnetic field homogeneity by a parameter study of the best permanent magnets position. The neutron guide field properties were verified by calculating the neutron wavelength limit for adiabatic rotation, in the COMSOL Multiphysics® model defined as a variable in the neutron flight path domain. Finally, COMSOL Multiphysics® was used to improve the magnetic flux density distribution inside the spin flipper and to calculate the Joule heating in the coils.

Results:

We obtained very good magnetic field homogeneity in the polarizer magnetic field cross-section plane with an average angle deviation of 0.16° to the ideal field vector (Figure 1). The guide field is able to carry polarized neutrons with wavelengths > 1.2 Angstrom, which provides a safety factor of 3-5. The magnetic flip field inside the spin flipper meets the ideal value (e.g. 2.67 mT at 5 \AA) with a maximum deviation of 2%. The spin flipper coil temperature can be limited to $30\dots34^\circ\text{C}$ with thermal conductive cooling (Figure 2).

Conclusion:

We show a new, favourable space-saving method to host a neutron polarizer in the iron-containing monochromator shielding of a time-of-flight spectrometer for cold neutrons. In this poster you can learn e.g., how to create robust, homogeneous, rectangular magnetic fields.

Reference

[1] J.Mesot, S.Janssen, L.Holitzner, R.Hempelmann, J. Neutr. Res. 3 (1996) 293-310

Figures used in the abstract

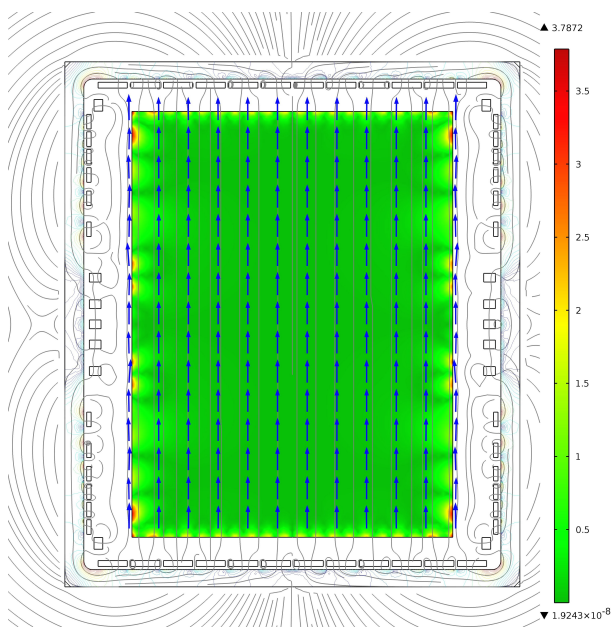


Figure 1: Field angle distribution in the polariser cross-section

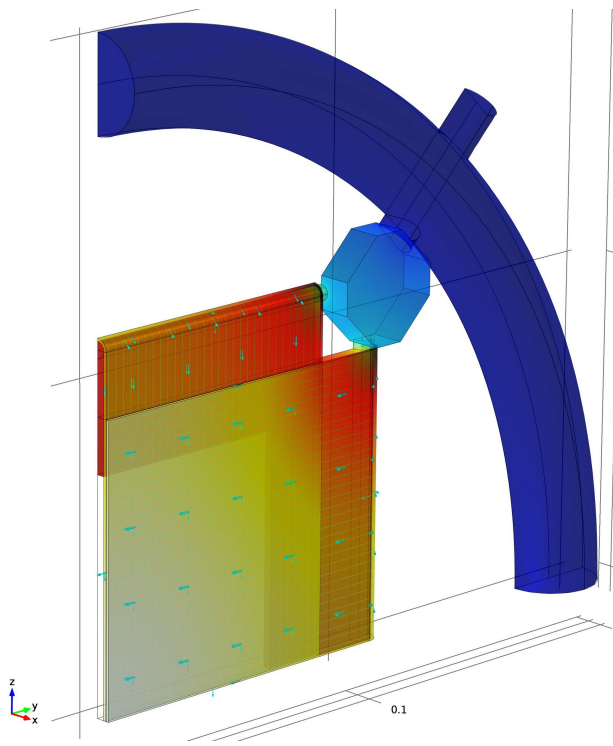


Figure 2: Temperature distribution in the spin flipper coils (support ring at 20°C)