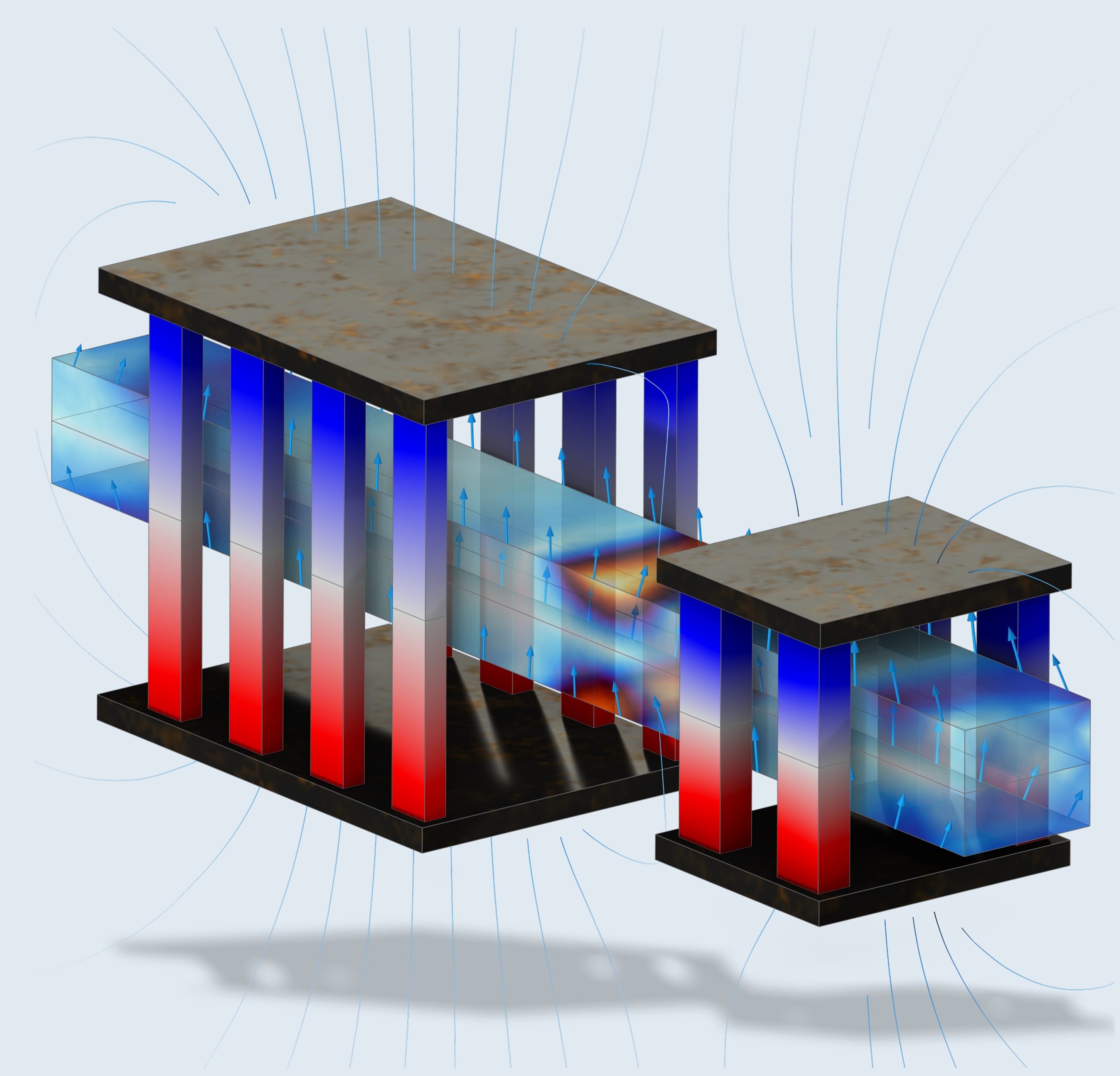

Engineering Tools for Neutron Instrumentation

Magnetic fields are frequently used in state-of-the-art neutron scattering experiments. Three apps are presented, using the AC/DC Module, which make sample environment and instrument design more efficient.

Lothar Holitzner
Laboratory for Neutron & Muon Instrumentation (LIN), Paul Scherrer Institut, Switzerland

Abstract

Our laboratory LIN develops unique scientific instruments, components and sample environment devices, mainly for the Swiss neutron spallation source SINQ. For this, sometimes FEM calculations are required. The following 3 apps have been developed.

A new cryomagnet can provide multi-extreme conditions (11 T vertical field magnet combined with a 8 kbar clamp pressure cell at temperatures down to 40 mK)[Ref.1]. The 1st app calculates the response of the cell to a sudden quench of the cryomagnet.

The 2nd app calculates forces around the cryomagnet and helps to make choices for the design of sample tables, for example.

The 3rd example supports the component design for new experiments with polarized neutrons. It numbers the neutron wavelength limit for adiabatic rotation in the magnetic guide field (Ref. 2), as well as the forces during installation.

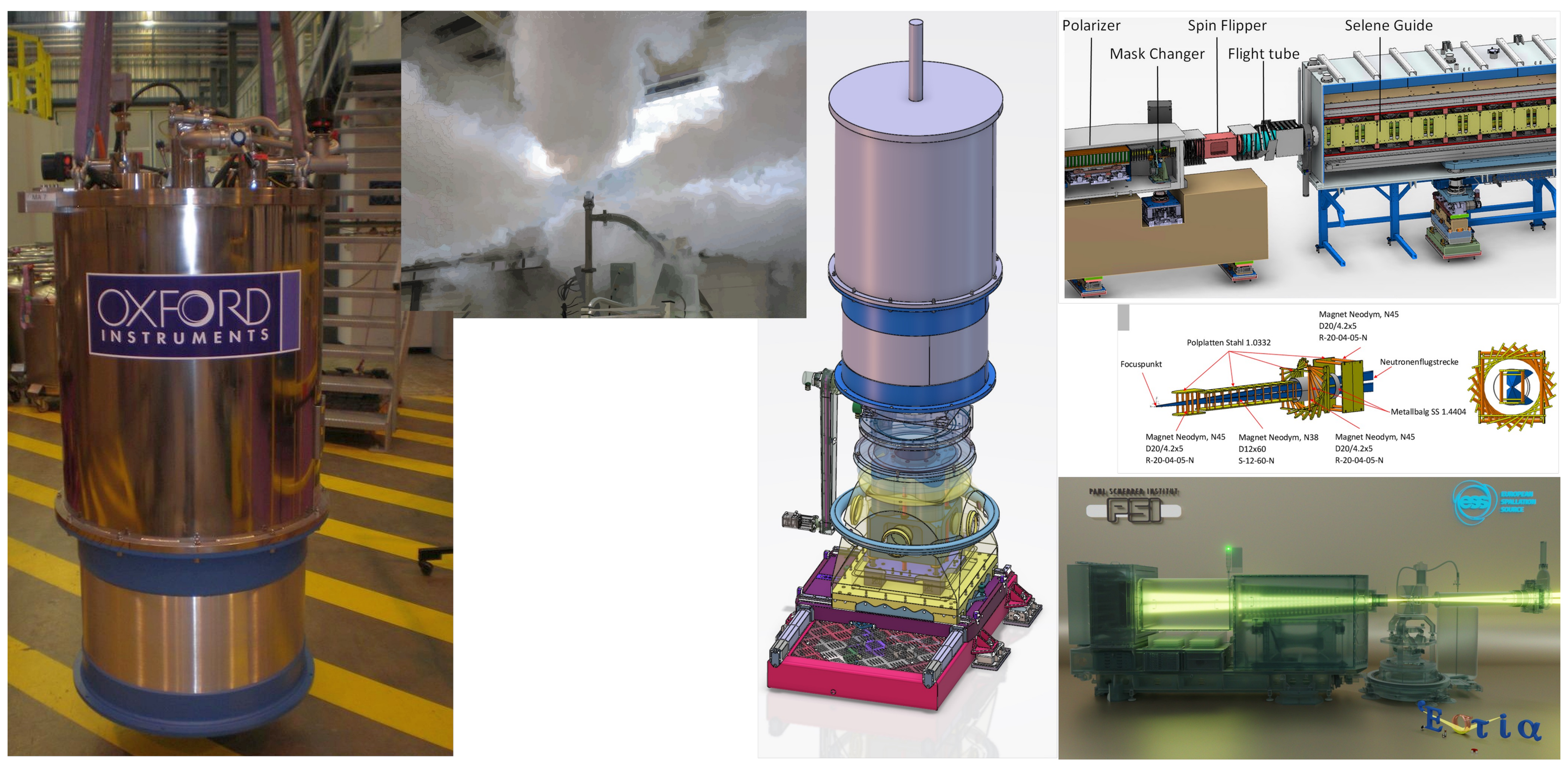

Figure 1. Left: Our cryomagnet MA7 (1.8 m high), a sudden cryomagnet quench (top). Middle: Model of a cryomagnet on the SANS-LLB sample table in the SINQ guide hall. Right: Design of the ESS (Lund, Sweden) instrument ESTIA (a Swiss in-kind contribution) with magnetic guide field for polarized neutrons. (Ref. 3)

Methodology

The 1st model (mf) calculates forces and heat dissipation (from eddy currents) as function of the time. It uses manufacturer specs (coil geometry, current densities) and a measured quench time constant.

The 2nd model (mfnc) uses an axial magnetized cylinder as a source to approximate the strayfield map, given by the manufacturer of the cryomagnet. This speeds up the force calculation on the surrounding steel components.

The 3rd model (mfnc) encloses a neutron beam with magnets and steel components, which create a static magnetic field. The wavelength limit for adiabatic rotation is calculated. One component is movable to imitate the installation process. This helps to estimate assembly forces.

Results

Common in all apps are the geometry import (step), the options to select/exchange components and to change material parameters.

In the 1st app, "Quench Simulation – Cryomagnet MB11 with Pressure Cell", you can adjust the cell position and get the resulting heat dissipation, axial and radial magnetic forces.

In the 2nd app, "Cryomagnet Strayfield Impact", you can select one of our 6 cryomagnets, change its orientation [°], define sensors and steel components. Force values are highlighted, if they are critical.

In the 3rd app, "Magnetic Guide Field for Polarized Neutrons", you can select magnetization and orientation of magnets, change the beam geometry and study a step-by-step component position shift.

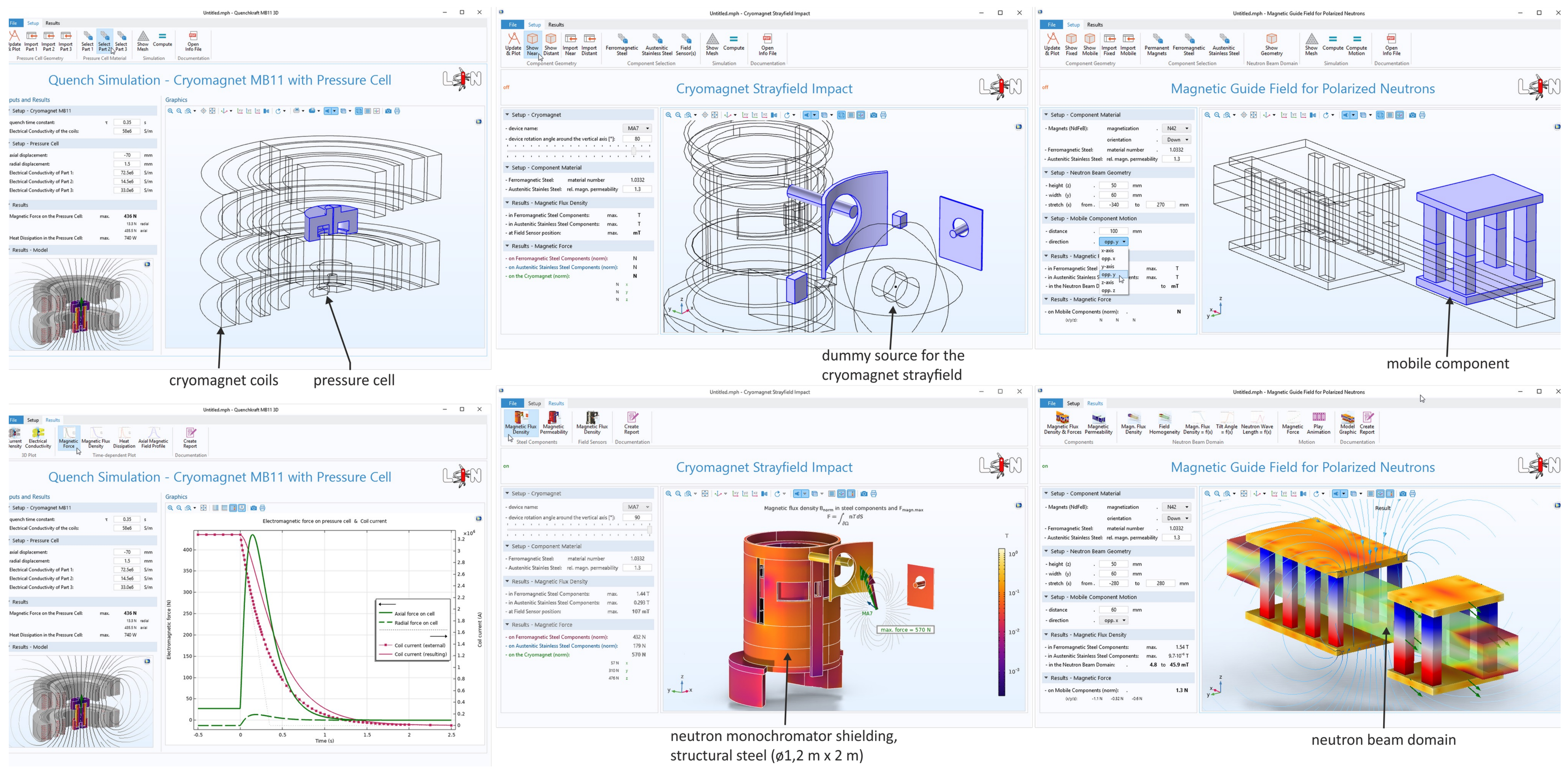

FIGURE 2. Screenshots of the proposed 3 apps from LIN, exemplary with a setup tab (top) and a results tab (bottom). The result tabs show Left: The time-dependent axial and radial force progression on the pressure cell. Middle: The magnetic flux density in steel parts and force arrows. Right: The magn. field homogeneity in the encased neutron beam.

REFERENCES

1. New equipment for sample environment, PSI Facility Newsletter IV/2021, Dec. 2021, #51; https://www.psi.ch/sites/default/files/videos/facility_newsletter/iv_21.html
2. L. Holitzner, "Development of Magnetic Field Components for the Polarisation Option of the Neutron Spectrometer FOCUS", Comsol Conference Rotterdam, 2013; https://www.comsol.com/paper/development-of-magnetic-field-components-for-the-polarisation-option-of-the-neutron-spectrometer-focus-15663
3. Glavic, A., Stahn, J., & Schütz, S. (2016). Estia: design of the polarized, small sample reflectometer at ESS. Swiss Neutron News (48), 6-16. https://www.dora.lib4ri.ch/psi/islandora/object/psi%3A27312; https://www.psi.ch/en/lns/estia