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HiFiMagnet: a toolchain for the design and simulation of high field magnets

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The Laboratoire National des Champs Magnetiques Intenses (LNCMI) [1] is a French large scale facility enabling researchers to perform experiments in the highest possible magnetic field. This facility is a member of the European Magnetic Field Laboratory (EMFL). DC magnetic fields up to 37 T are provided at the Grenoble site and pulsed fields up to 100 T at Toulouse. To design efficiently such magnet multi-physics models are mandatory.

HiFiMagnet is a toolchain actively developed in collaboration with the technological platform, Cemosis, in mathematics of Uni. Strasbourg. It covers a large range of tools from semi-analytical to full scale 3D non-linear multi-physics models of our latest 37 Tesla magnet including thermal, mechanical and electromagnetic modeling [2]. The automatic generation of the 3D magnet geometry and mesh is performed with Salome. The 2D axi and 3D simulations are carried out with our in-house developments based on the Feel++ [3] library. This allows us to take full advantages of the HPC facilities provided by this library and to carry out detailed analysis of our magnets at a reasonable computational cost. More advanced numerical and analysis methods (like reduced basis methods) are also used to investigate parameters sensitivities and to estimate impacts of uncertainties mostly on materials physical properties.

In this work, we present the platform that has been designed to federate HiFiMagnet developments and usage with a direct connection to the data from the magnet control and monitoring system. The goals of this platform are to:

- Provide tools for the magnet designer not familiar to running simulation especially in a HPC context,
- Extract and setup HiFiMagnet simulation from an existing magnet in operating condition,
- Provide predictive behavior of the magnets from a control perspective,
- Help researchers by providing more accurate field maps to prepare, design and exploit their experiments.

More advanced features of HiFiMagnet are also available even if not fully integrated to the the platform. As an example, we present the use of Feel++ Reduced Basis framework to tackle the design of homogeneous magnet [4] for Solid State NMR physic applications.

REFERENCES

[1] The French High Magnetic Field Facility, Béard, J. and Debray, F., Journal of Low Temperature Physics 170 (2013) 541-552, DOI: 10.1007/s10909-012-0761-x

[2] Full 3D MultiPhysics Model of High Field PolyHelices Magnets, C. Daversin C Prudhomme and C Trophime, IEEE Trans. AppSup. 26 (4) (2016) 1-4, DOI: 10.1109/TASC.2016.2516241

[3] `http://www.feelpp.org`, `http://www.github.com/feelpp/feelpp`

[4] Optimization and control of high fields magnets, R. Hild, Phd thesis, Uni. Strasbourg, 2020