Swiss Accelerator
Research and
Technology

CHART MagNum - Sustainable and Consistent Integrated Modelling of Superconducting Magnets

Principal investigator: Dr. Jasmin Smajic

Project manager: Dr. Michal Maciejewski

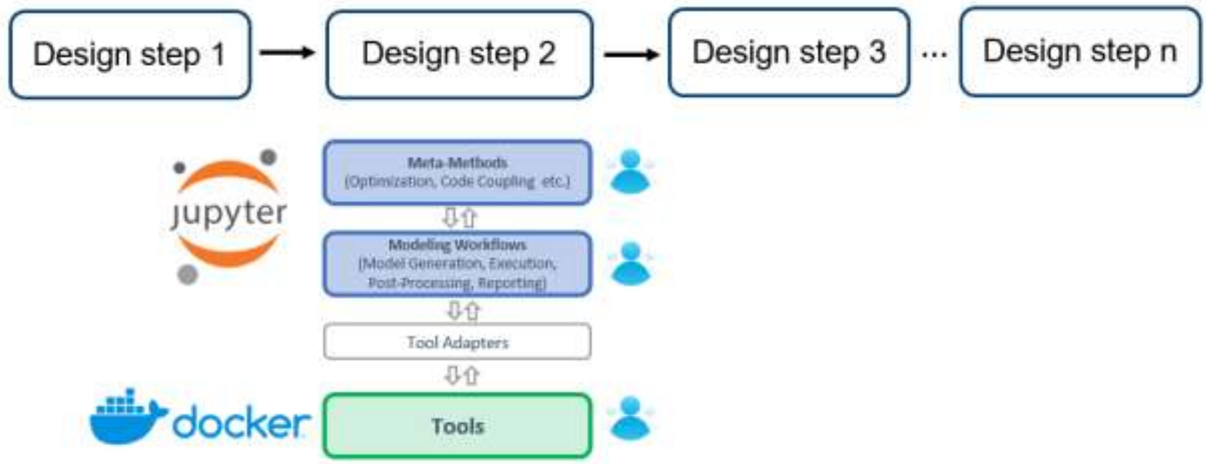
Timeframe: 04.2021 – 04.2023

Abstract: The MagNum project brings advanced techniques to multi-model and multi-scale numerical design of future superconducting high-field low and high-temperature superconducting magnets. We enhance the existing design methods with Model-Based System Engineering (MBSE) guidelines. A design process is divided into separate tasks. An individual design task is encapsulated in an interactive Jupyter notebook. Each notebook is based on a parametric input serving as a "single source of truth" for a magnet design version. Once a notebook is executed, it is persisted as a report to ensure design reproducibility and traceability. A design workflow constitutes concatenations of design steps, where the output of one step serves as input in the next, e.g., to perform multi-physics, multi-objective design optimization. Workflows are auto-executed regularly and in case of design changes to ensure their unbroken consistency. We propose to make innovative use of widely available infrastructure for software development (e.g., GitLab, Docker).

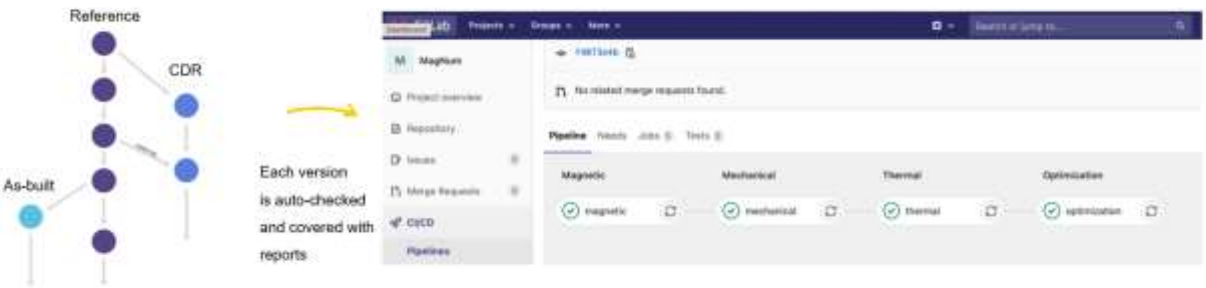
CHART MagNum - Sustainable and Consistent Integrated Modelling of Superconducting Magnets

Projects in superconducting magnet R&D for accelerators are intrinsically multi-stage, iterative processes involving various disciplines, changing teams of experts, and software tools that are subject to updates or replacement. With project durations from several years to several decades, a consistent, sustainable, and reproducible organization of numerical models, construction- and validation data, and tools used in the process, is of the essence.

The MagNum project brings advanced techniques to multi-model and multi-scale numerical design of future superconducting high-field low and high-temperature superconducting magnets. We enhance the existing design methods with Model-Based System Engineering (MBSE) guidelines. A design process is divided into separate tasks. An individual design task is encapsulated in an interactive Jupyter notebook. Each notebook is based on a parametric input serving as a “single source of truth” for a magnet design version. Once a notebook is executed, it is persisted as a report to ensure design reproducibility and traceability. A design workflow constitutes concatenations of design steps, where the output of one step serves as input in the next, e.g., to perform multi-physics, multi-objective design optimization.



Workflows are auto-executed regularly and in case of design changes to ensure their unbroken consistency. We propose to make innovative use of widely available infrastructure for software development (e.g., GitLab, Docker).



The project profits from a broad experience of the Institute of Electromagnetic Fields (IEF ETHZ) in modelling, simulation, and optimization of coupled multi-physics field problems. With this project we intend to solve the problem of sustainability and consistency in magnet design, while fostering innovation by ensuring maximum flexibility and cooperation for participating institutes (ETHZ, PSI, CERN, LBNL).

Work supported by the Swiss State Secretariat for Education, Research, and Innovation SERI.