Model based systems engineering - software tools for design and measurements for HFM

Roxie

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Table of contents

New Roxie23 features

- Technical improvements
  - Dynamic memory allocation
  - Improved Iron and Mesh Generator
  - Structured XML output generation
  - Python API for communication with ROXIE
  - Containerization
- Coil geometries
  - CCT magnets
  - Wigglers and Undulators, Flex PCBs
  - Custom discretisation, for coil ends and straight section
  - Curved magnets
- Analysis settings
  - Zonal harmonics for solenoid design
  - K-values of search coils
  - Maxwell stress tensors
  - Quench Simulation (Adiabatic, 2.5D)

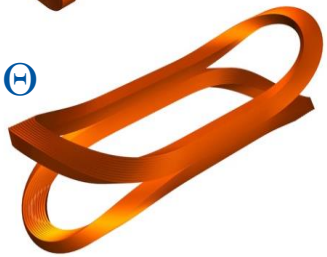
3D coil geometry macros

Bedstead

Cradl

Cranked sattle

Cos Θ



Flared

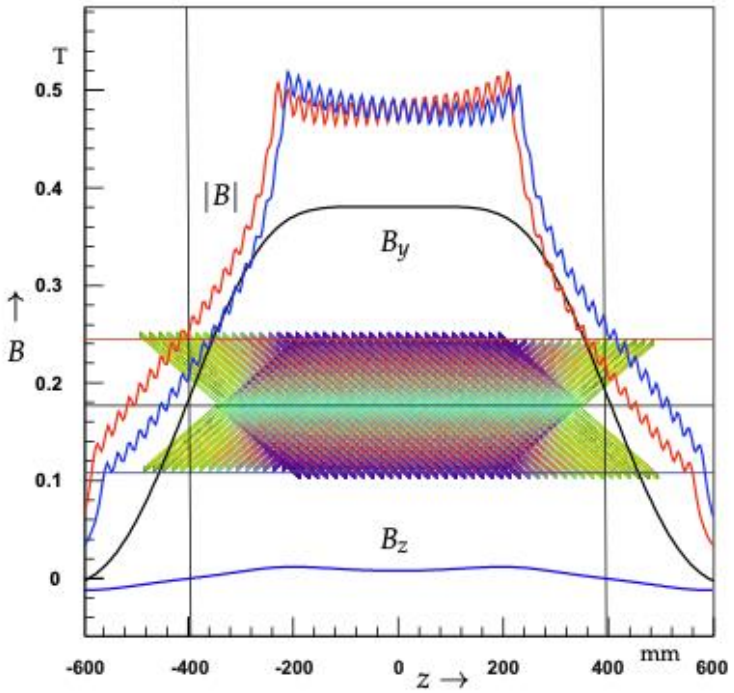
Flex PCB

Racetrack soft way

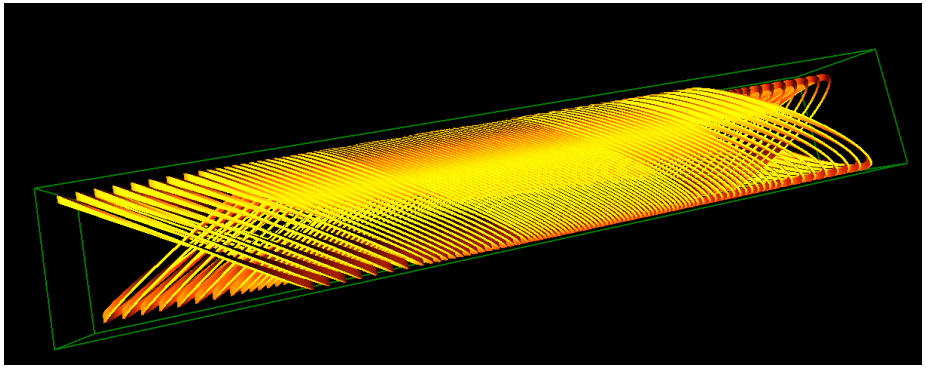
Racetrack hard way

CCT

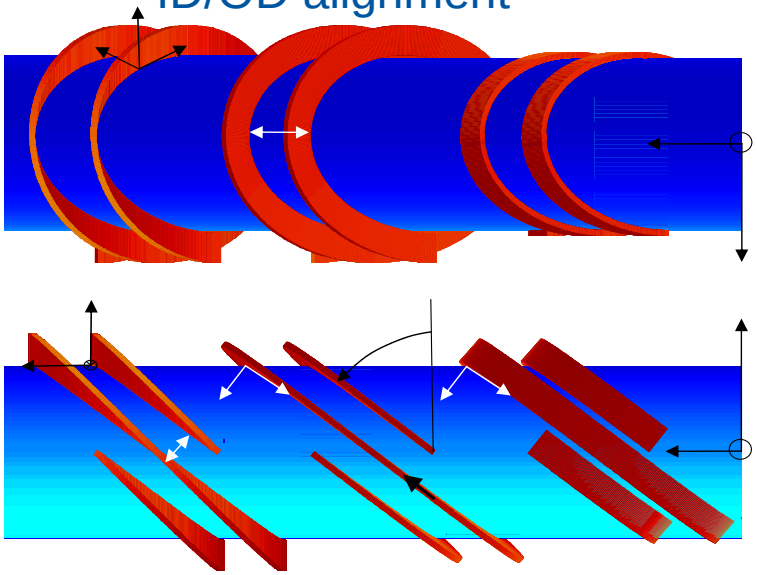
CCT coil macro



Pitch variation at the ends



Frenet and Darboux frames, ID/OD alignment

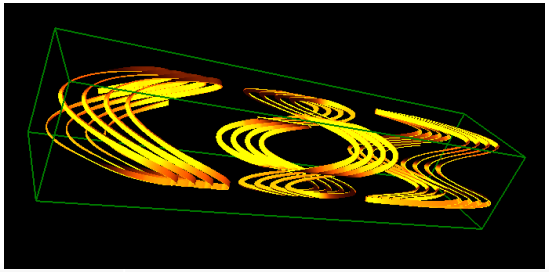


Darboux frame

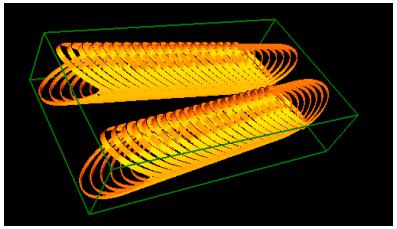
Frenet frame hard way

Frenet frame soft way

Higher-order multipoles

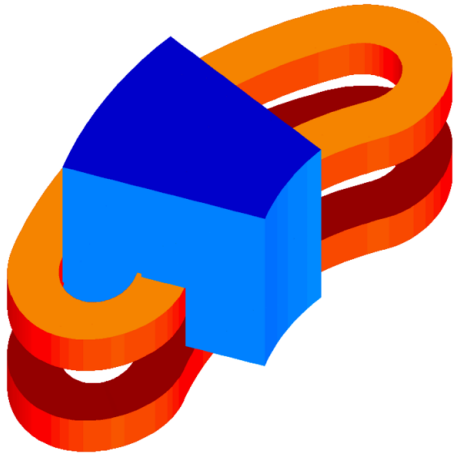


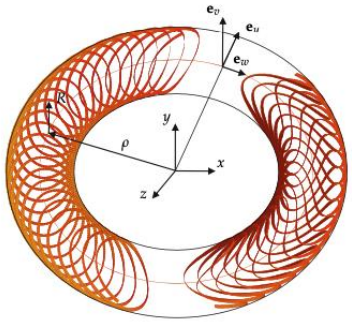
Transformations

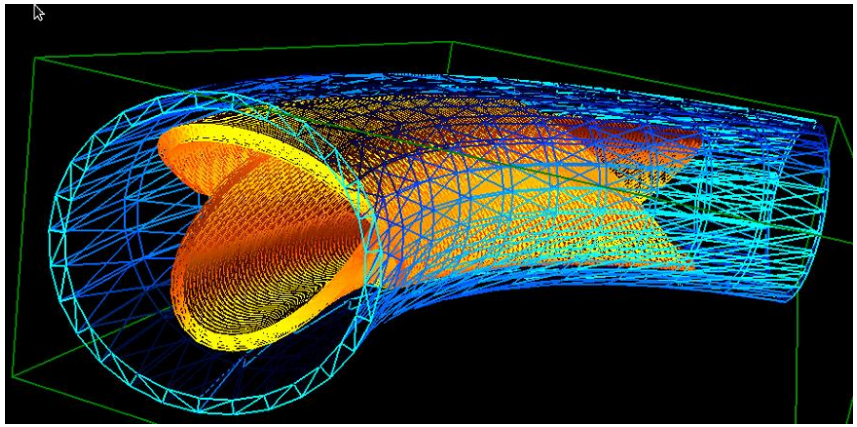


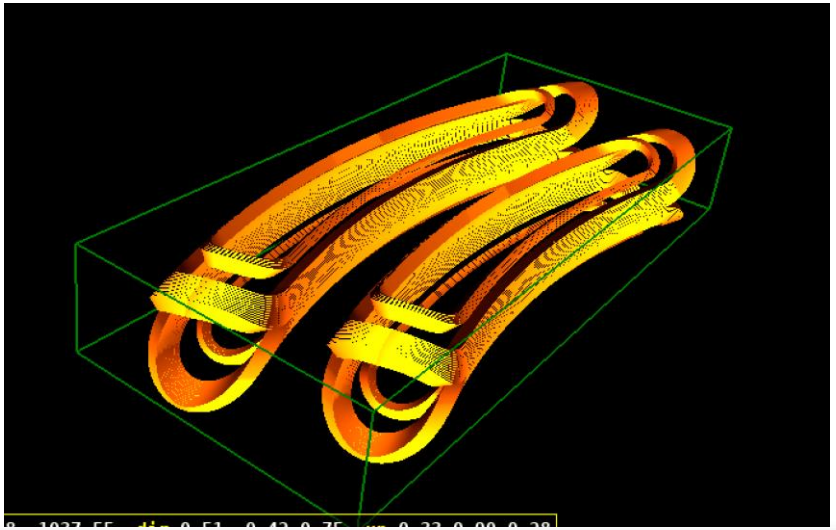
Curved Magnets

- On any geometry
- Simple curved Iron
- Special case - CCT



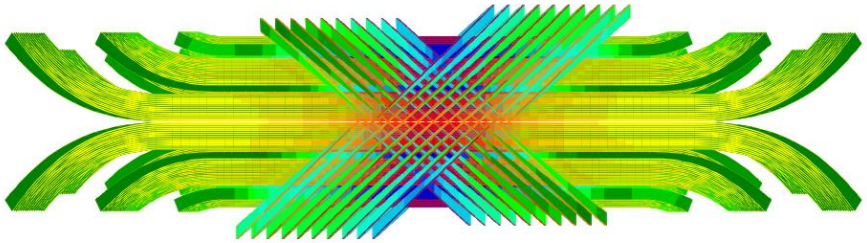




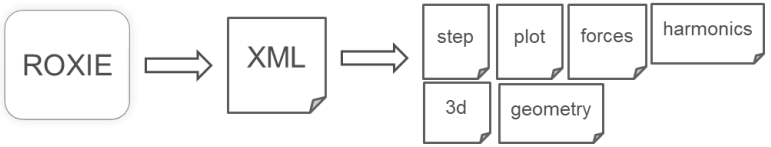


Technical Improvements

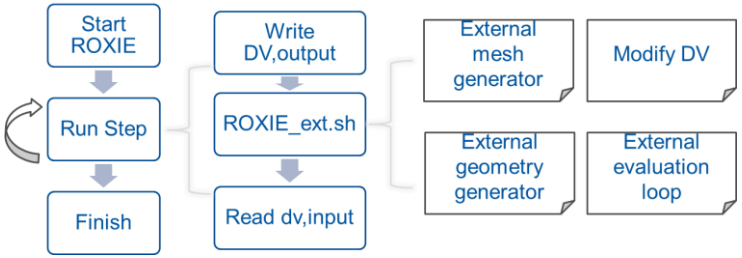
- Dynamic Memory Allocation
- Discretization per block
  - 30 elements in straight section
  - 25 elements in coil heads
  - 1500 elements in CCT coils



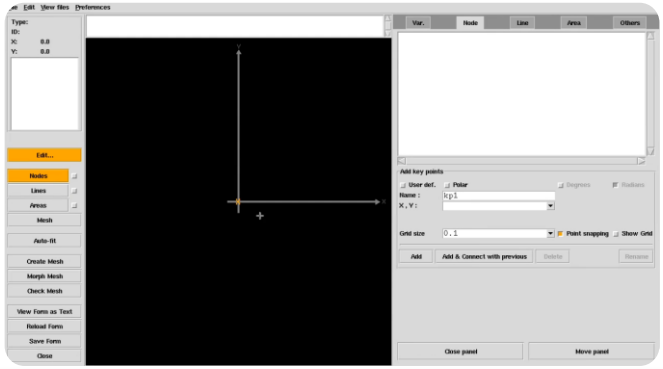
Structured XML output



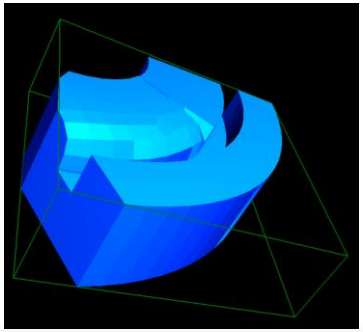
Hook into optimization loop (WIP)



Improved Iron file editor

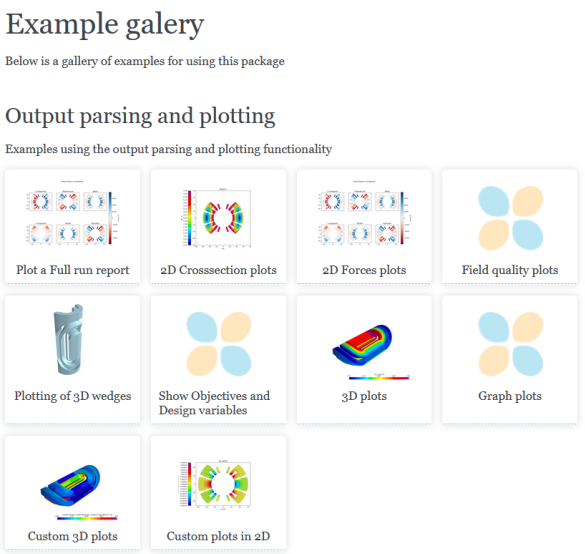


- Use of external meshes
  - *.hmo
  - *.hmascii (Hypermesh)

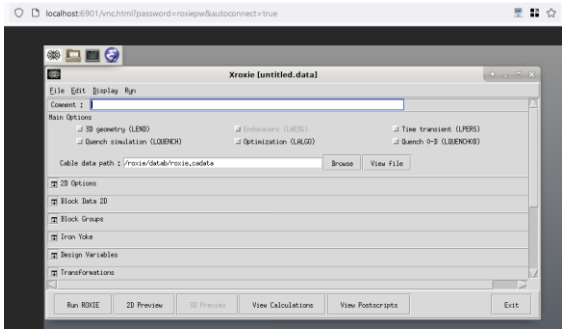


Scripting and Interfaces

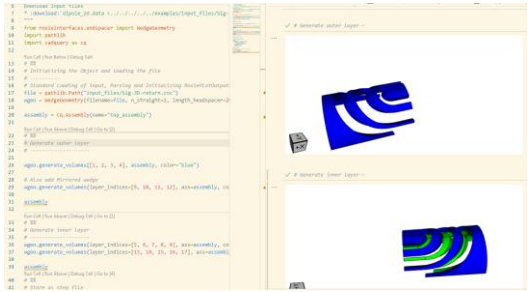
- Python API: roxie-api
  - Input file handling
    - Load existing files
    - Update tables, change flags
  - Output file handling
    - Parsing of XML output
    - Generation of plots/tables
  - Execution
    - Run ROXIE from python script
    - Execute on remote machine (REST)



Scripting and Interfaces

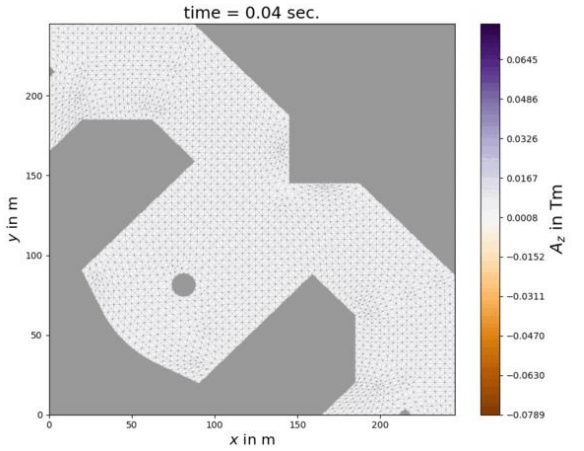


- Fully self-contained Docker Image
  - Terminal + Remote desktop (GUI)
  - Rest API for programmatic access
  - Runs on any machine
- ROXIE Interfaces package: roxie-interfaces
  - Collection of scripts and tools for IO file translation
    - Roxie output to step file (End spacers)
    - Mesh files to Roxie hmo



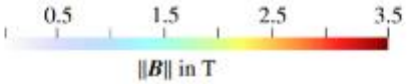
Prototyping Platform

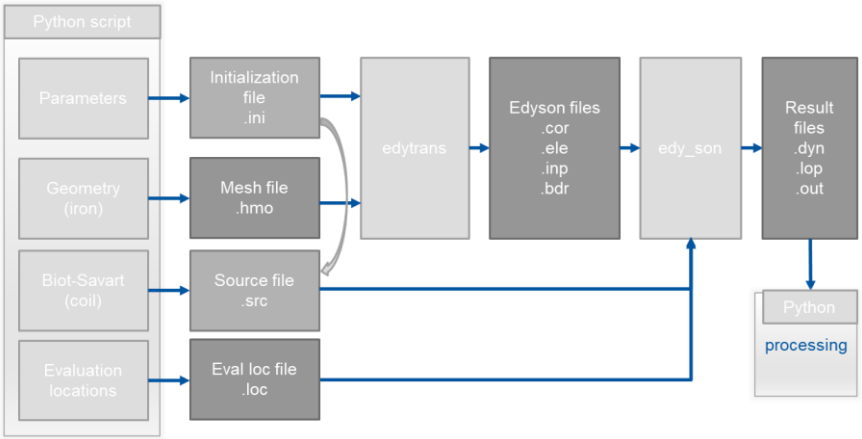
- Prototype new functionality in Python
- Fast turnaround; integrate once matured
  - Core code
  - Script
- Examples:
  - RoxCCT, Eddy current solver



Eddy current solver

Differential geometry generation module, example CCT (python API)





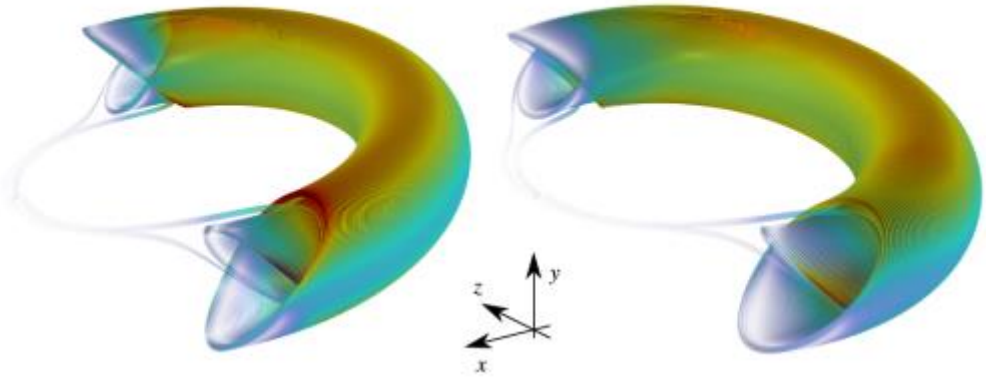


Figure 1: Conductor peak fields in curved CCT magnets. Left: constant pitch. Right: Pitch faded in the magnet ends.

Model Based Systems Engineering

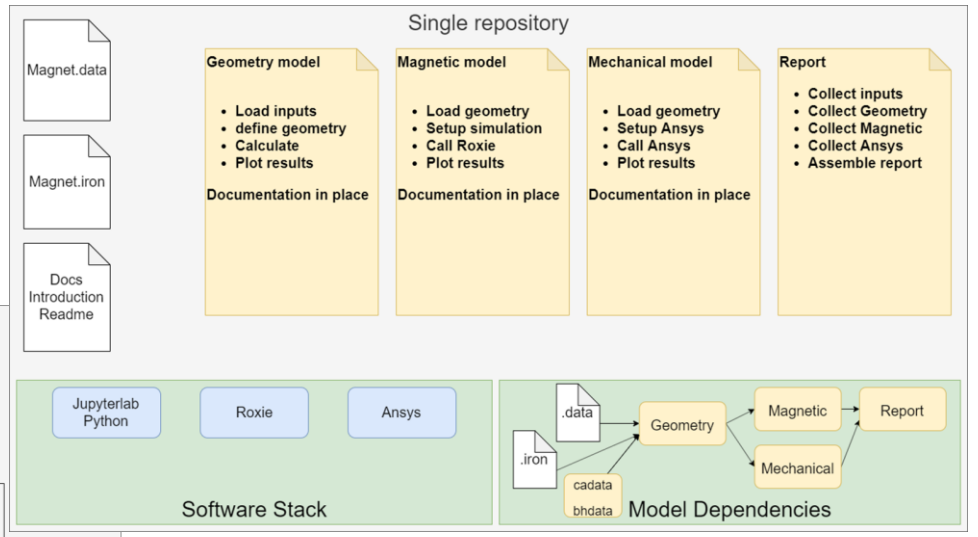
- Multiple Domains, Tools, Data Sources
- Complex information exchange

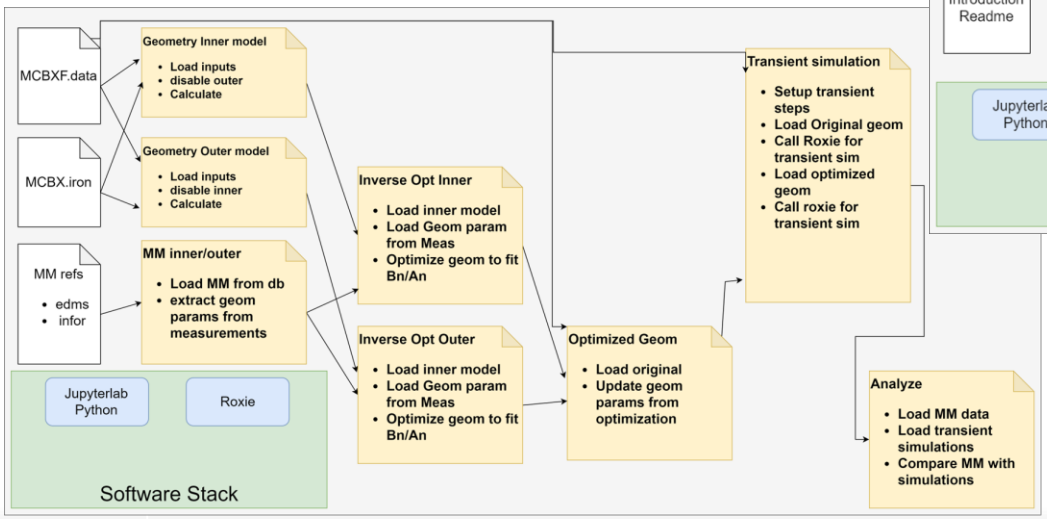
- Magnet Design as a system of domain models
  - Each model within its domain
  - Constraints, inputs, dependencies, sources
- Models as base of information exchange
  - Artefacts, queries
  - Repeatable, traceable, adaptable

Model Based Systems Engineering

- pyMBSE, self-contained multi-model execution
  - different models (geometry, magnetic, mechanic)
  - Cross-dependencies
  - dependent execution
  - Optimisation

CHART
Swiss Accelerator Research and Technology
MagNum

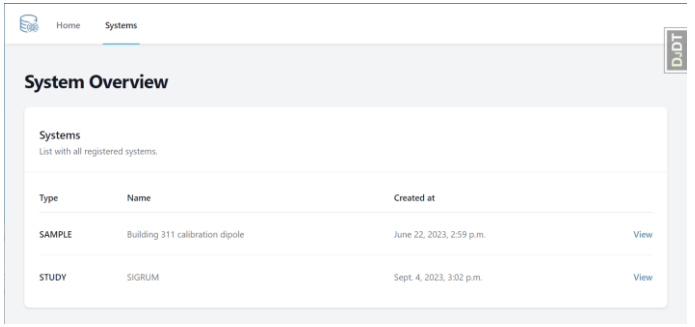


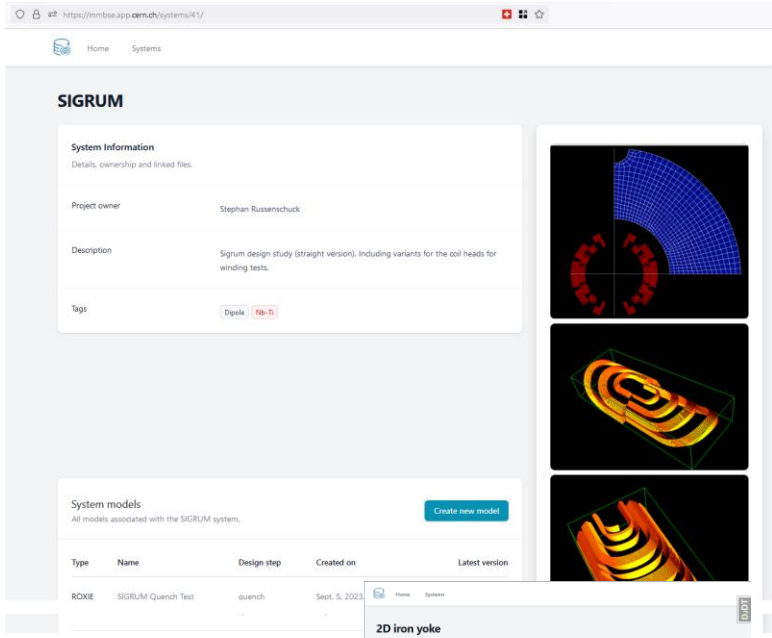


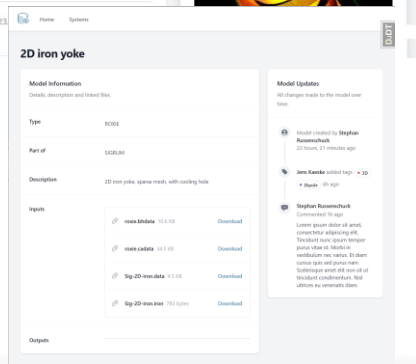
MMBSE

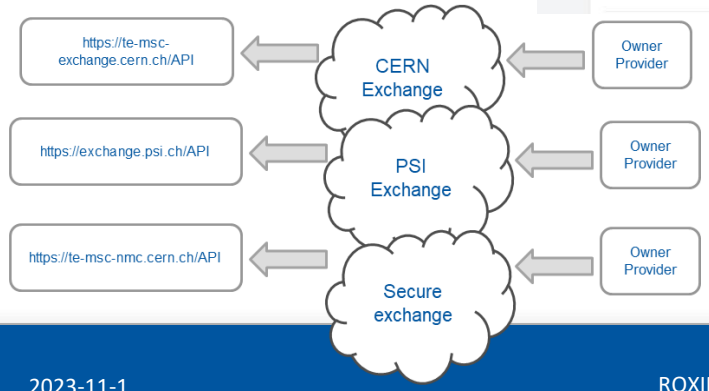
Database with Magnets / Systems

- Different models for a magnet
- Cover design process
- Define checks, verification
- REST API to access models
  - Inputs/Outputs
  - Reports
  - Versions
  - Scriptable









Summary - Outlook

- Re-established know-how to develop ROXIE
  - Core extensions
  - Interfaces (python, scripting, data)
  - Platform for integrating new features (ROXIE core or scripts)
  - Interdependend model execution
- Next steps
  - Magnet Database, Magnet Design Workflow
  - Eddy current integration in Xroxie
  - HTS
  - Ease of use

HFM

High Field Magnets

Links

- Roxie: https://roxie.docs.cern.ch/
- Roxie-Api: https://roxie-api.docs.cern.ch/
- Roxie-interfaces: https://roxie-interfaces.docs.cern.ch