Introduction to the activities of the WP2.11 – at CEA

CEA-CERN HFM collaboration agreements (KE5647)

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OUTLINE

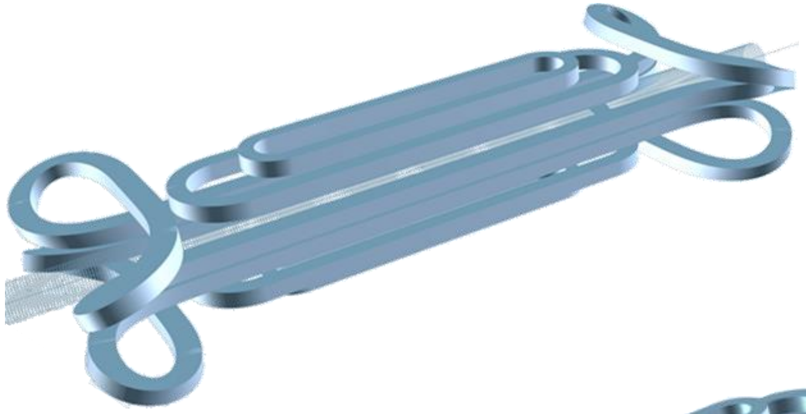
1. Introduction to KE5647 agreement Toward 16+ T HTS dipole magnet
2. Scope of the project
3. Electromagnetic and thermal modeling
4. Mechanical model
5. Conceptual model and technological developments
6. Thermal measurements

1. Introduction to KE5647 agreement Toward 16+ T HTS dipole magnet

Global roadmap phases

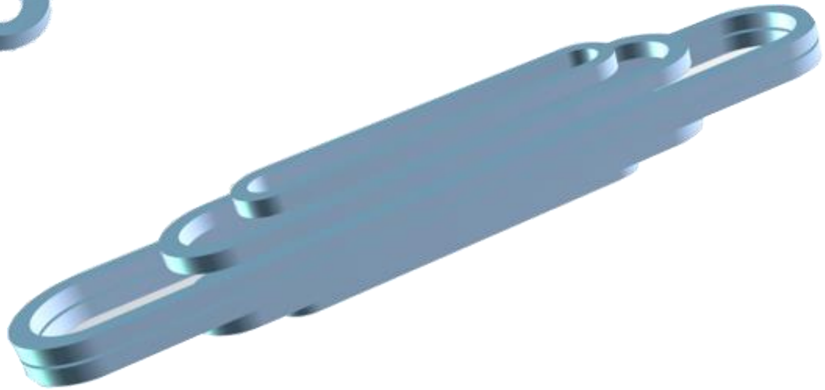
Phase 3 :

« EuCARD V3 »
MI cold bore 16 T+
magnet



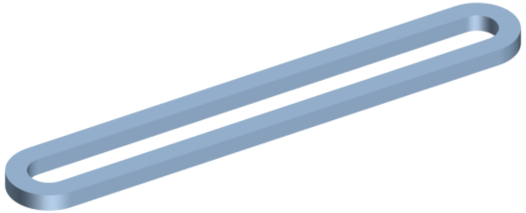
Aperture +
Field quality measurements

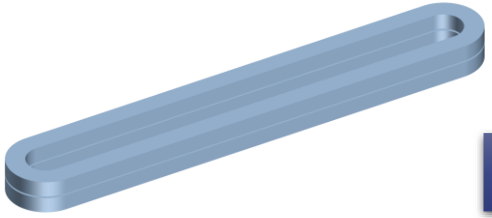
Phase 2 :
magnet MI 16 T+
« EuCARD V2 »



Mechanics + high field +
Quench + assembly

Phase 1 (KE5647) **2023-2025**:
Simple or double Racetrack MI





Models + techno

1. Introduction to KE5647 agreement Toward 16+ T HTS dipole magnet

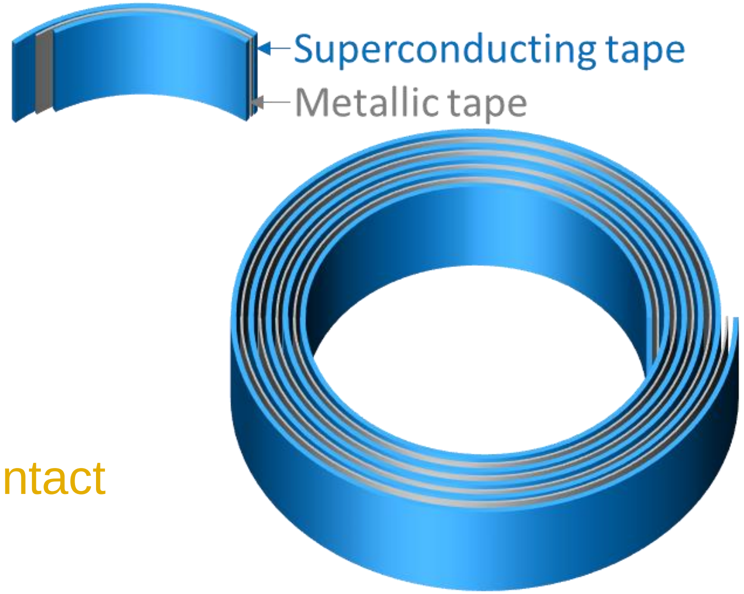
Philosophy

- **Feedback from previous programs**

→ HTS cables : Field quality / stability BUT Cost / supply / modeling

→ Insert : High Field with limited conductor BUT OD limit / higher risk / specific test station

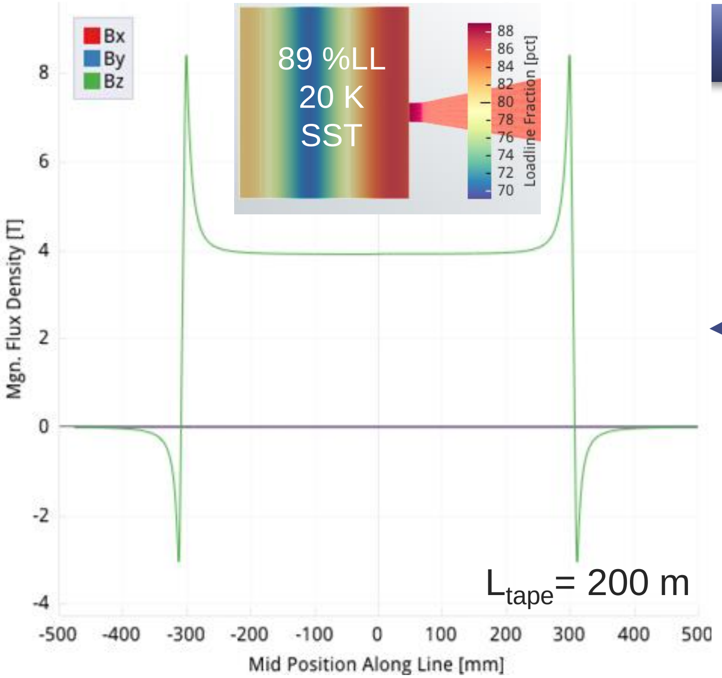
→ Metal as Insulation (**MI**) technology **on solenoids**
  → Hot spot protection BUT mechanics problem are possible
  → Good charging BUT losses to consider + transient field quality
  → Good steady state field BUT transient more complexe
  → R_{ct} tuning



- **Applying MI technology to racetrack bloc dipole magnet**

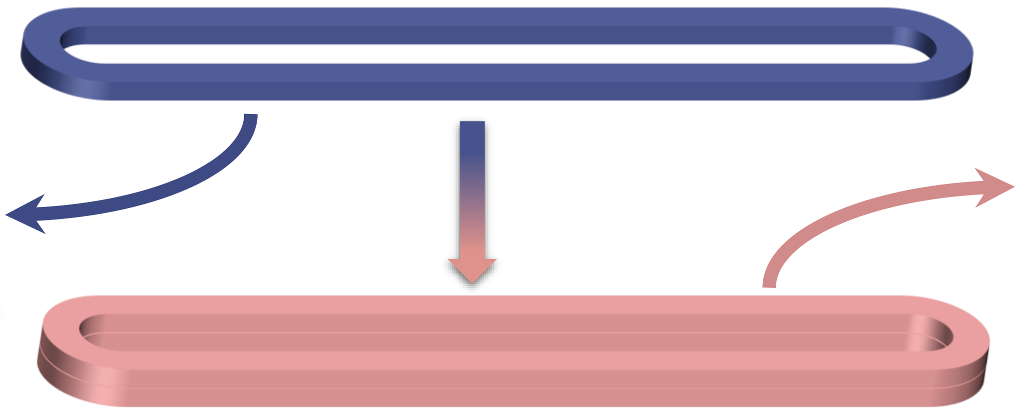
→ Racetrack bloc magnet experience BUT need reliable turn-to-turn contact
→ Tape based winding
→ Evaluate the magnet without hotspot risk in case of quench

2. Scope of the project

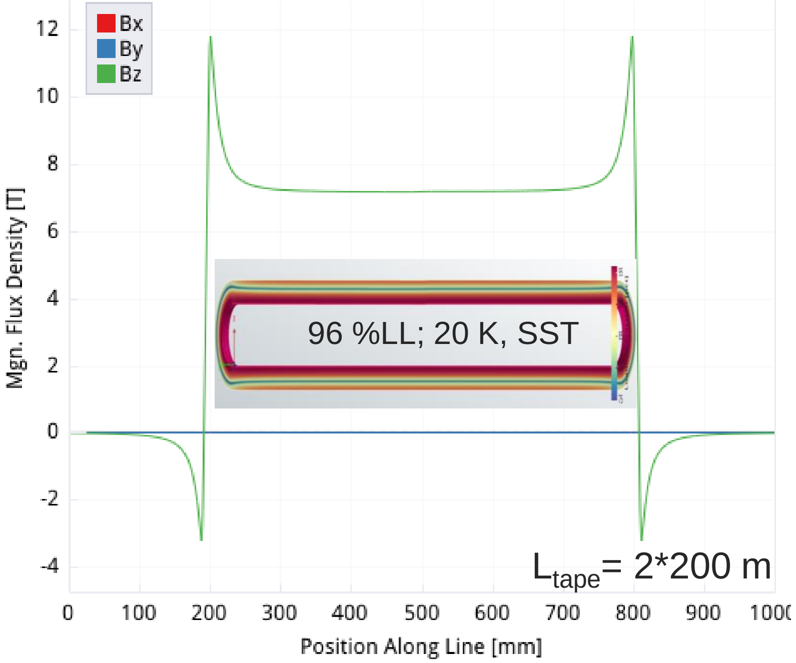


Design and fabricate a MI racetrack coil

Option 1 2000 A, 1 HTS tape, MI



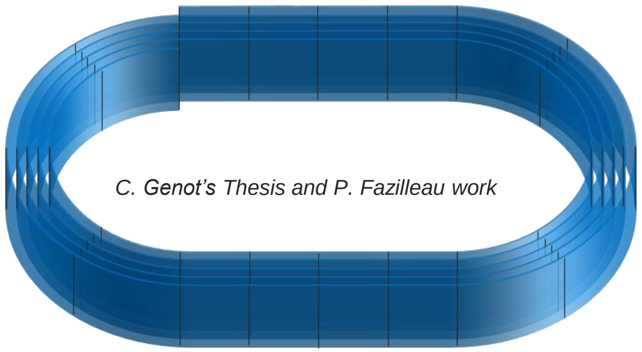
2000 A, 1 HTS tape, MI **Option 2**

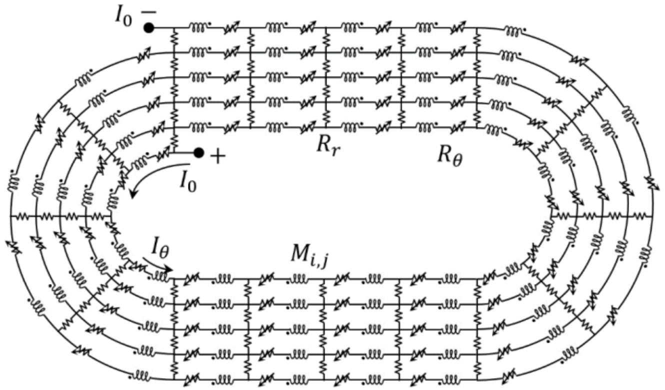


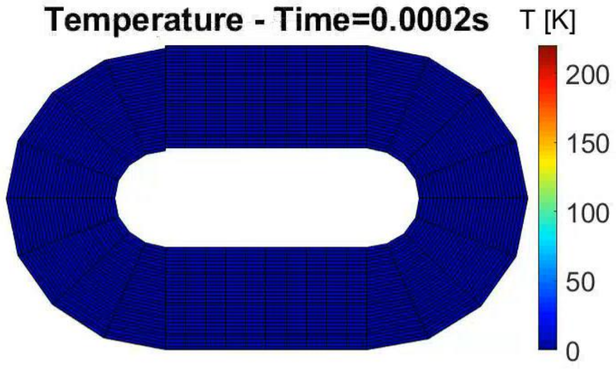
- **Electromagnetic MI model** (Existing PEEC model + updates –induced currents, optimization for faster simulation-)
- **Mechanical model** (CASTEM, ANSYS)
- **Conceptual and technological development** works (Structure, Winding, Electrical connection…)
- **Cryogenics and thermal model** (thermal properties measurements, evaluate the cryogen free solution)
- **Test station (**interfaces and thermal links)

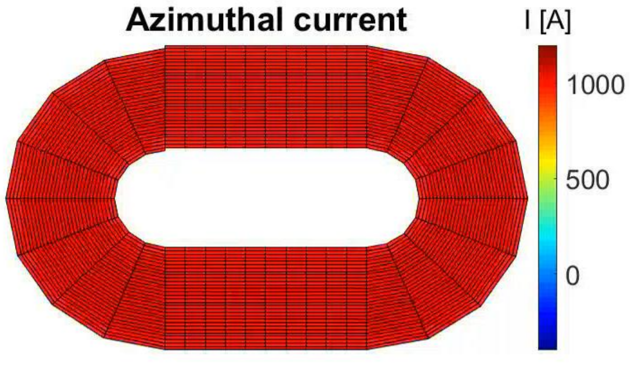
3. Electromagnetic and thermal modeling

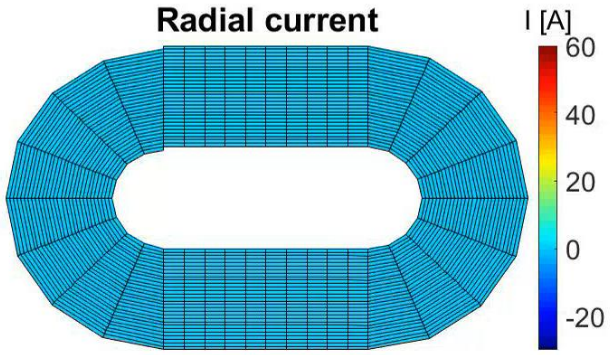
CEA PEEC model (initial development for solenoids)

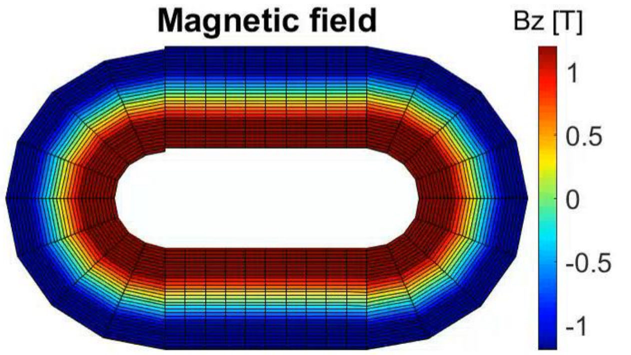












- **Parametric study** (R_{ct}, k_r, coil length, turn to turn pressure…)
- Implement a **multi-racetrack model**
- Include **magnetization** (possibility under consideration)
- Optimize the codes for **large coils** → effective protection methods → **local temperature**, **energy extraction**, **protection scheme**…

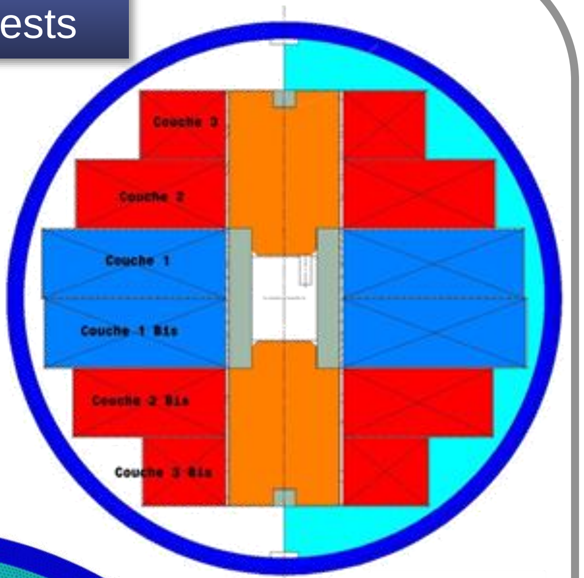
Not to scale: ID = 100 mm ; L = 200 mm

A. Blondelle and C. Genot with support of P. Fazilleau and N. Jerance

4. Mechanical model (CASTEM, ANSYS)

From EuCARD (5.4 T at 4.2 K) magnet studies : Feedback and optimization

Previous models and experimental tests



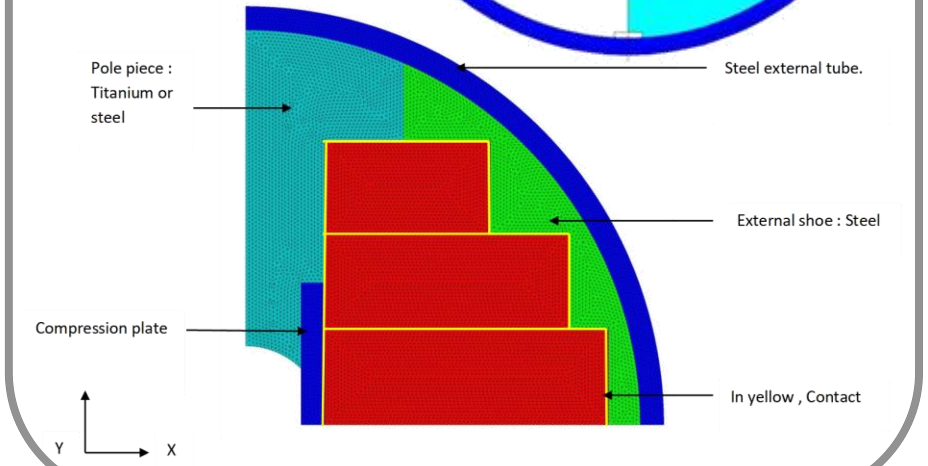
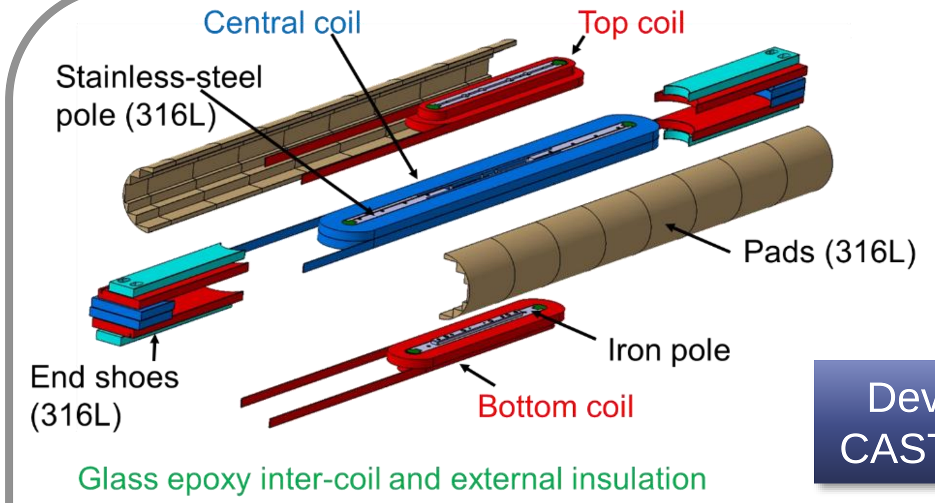
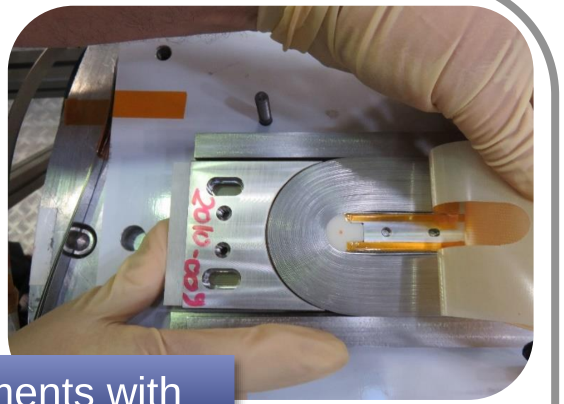


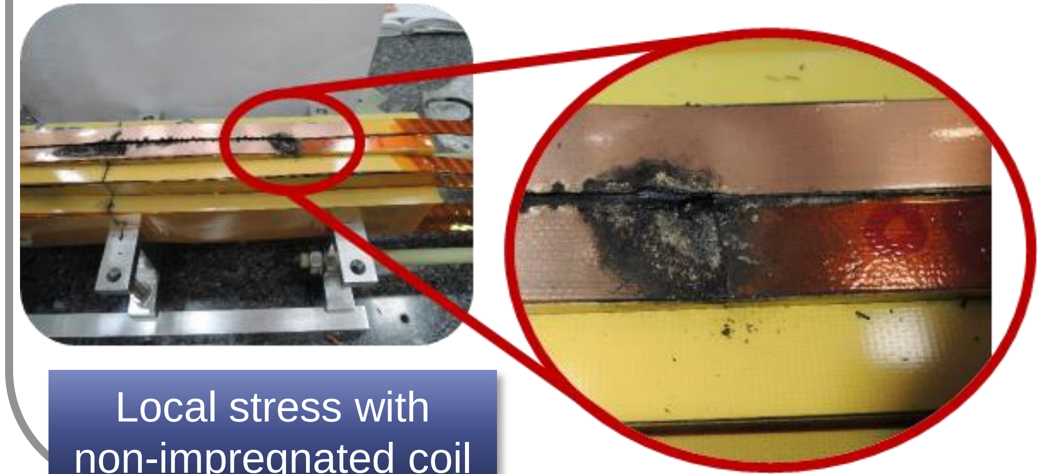
Figure 1 : Meshed model





Developments with CASTEM and ANSYS

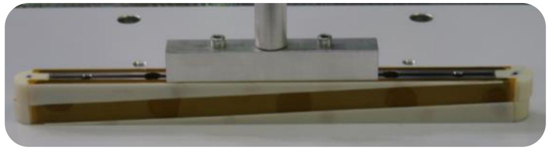
Mechanics around leads + insulation ?



Local stress with non-impregnated coil

5. Conceptual model and technological developments

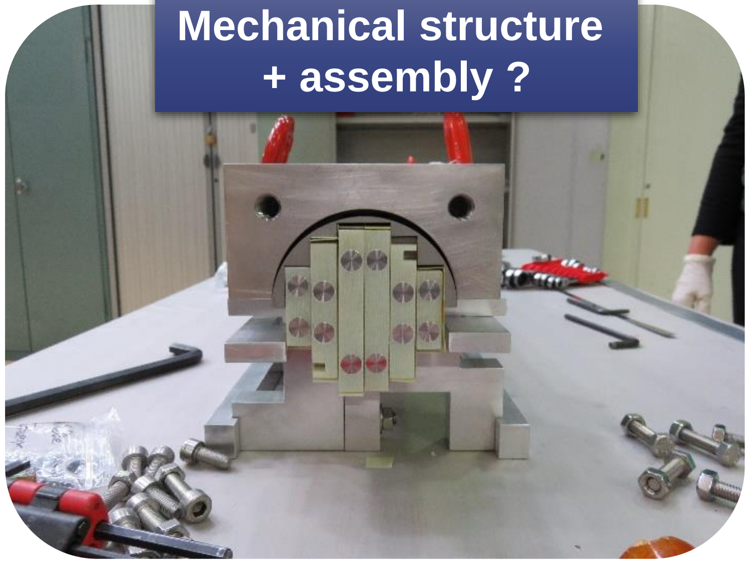
From EuCARD (5.4 T at 4.2 K) magnet studies : Feedback and optimization



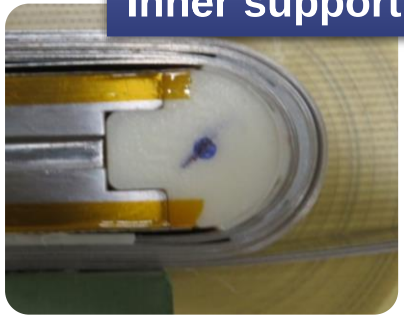
Layer jump vs joint ?

Smooth Winding of cowound tapes ?

Mechanical structure + assembly ?



Inner support ?



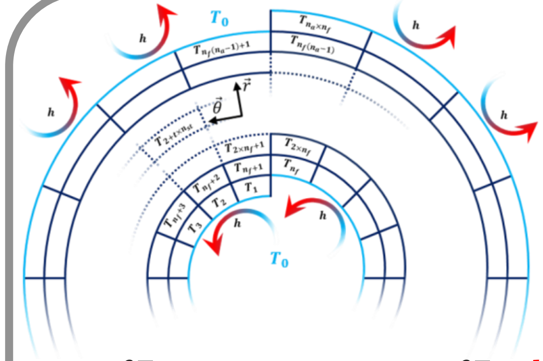
Leads + edge support ?

Insulation system?

- Racetrack vs double racetrack
- Insulation scheme
- Current injection + internal joints
- Dry winding vs impregnation
- Smooth winding with thin tapes
- …

6. Thermal measurements

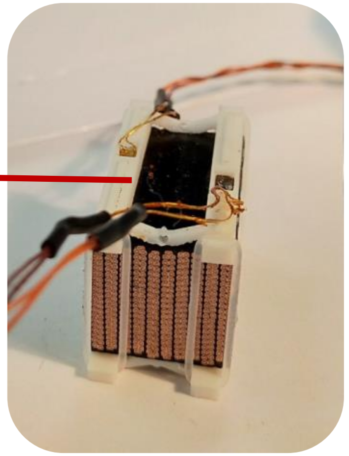
Transverse thermal conductivity measurement (k_r) versus temperature and pressure



PEEC model : thermal equations

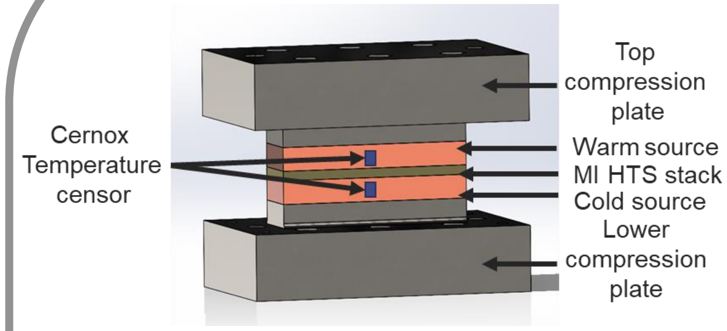
$$\rho C_p \frac{\partial T}{\partial t} = div(k\nabla T) + S \rightarrow \rho C_p \frac{\partial T}{\partial t} = \frac{k_r}{r}\frac{\partial T}{\partial r} + k_r \frac{\partial^2 T}{\partial r^2} + \frac{k_\theta}{r^2}\frac{\partial^2 T}{\partial \theta^2} + S$$

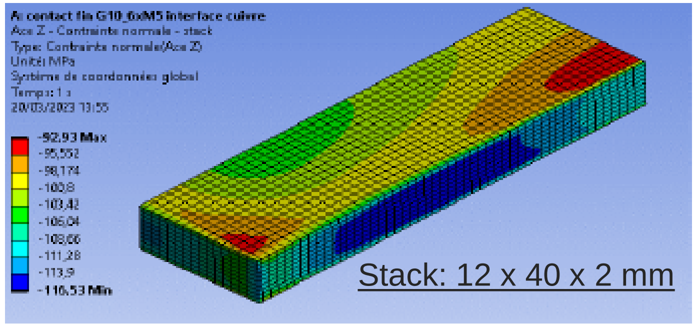
Existing test station (MECTIX)
(development through previous collaboration)

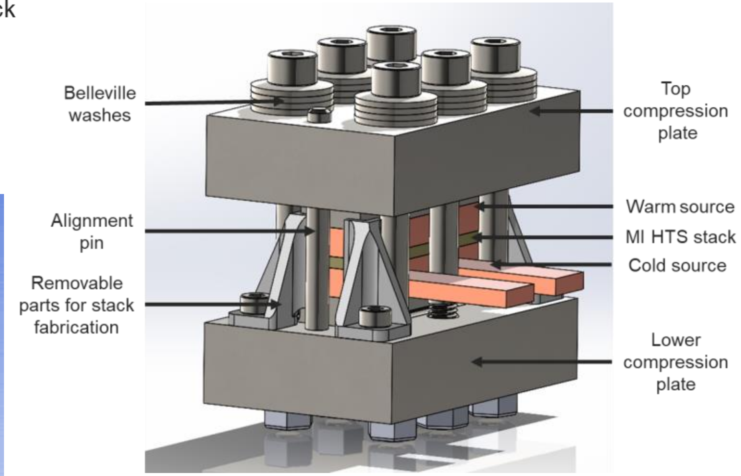


Example Nb_3Sn
10 stack sample

Need a specific sample for HTS MI







- Pressure uniformity (ANSYS model)
- Pressure study up to 100 MPa
- 5 samples to be made (time/cost driven)

- First sample structure procurement ongoing

Thank you

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