INFN-GE CONTRIBUTION TO THE DEVELOPMENT OF THE PTOLEMY SC MAGNET

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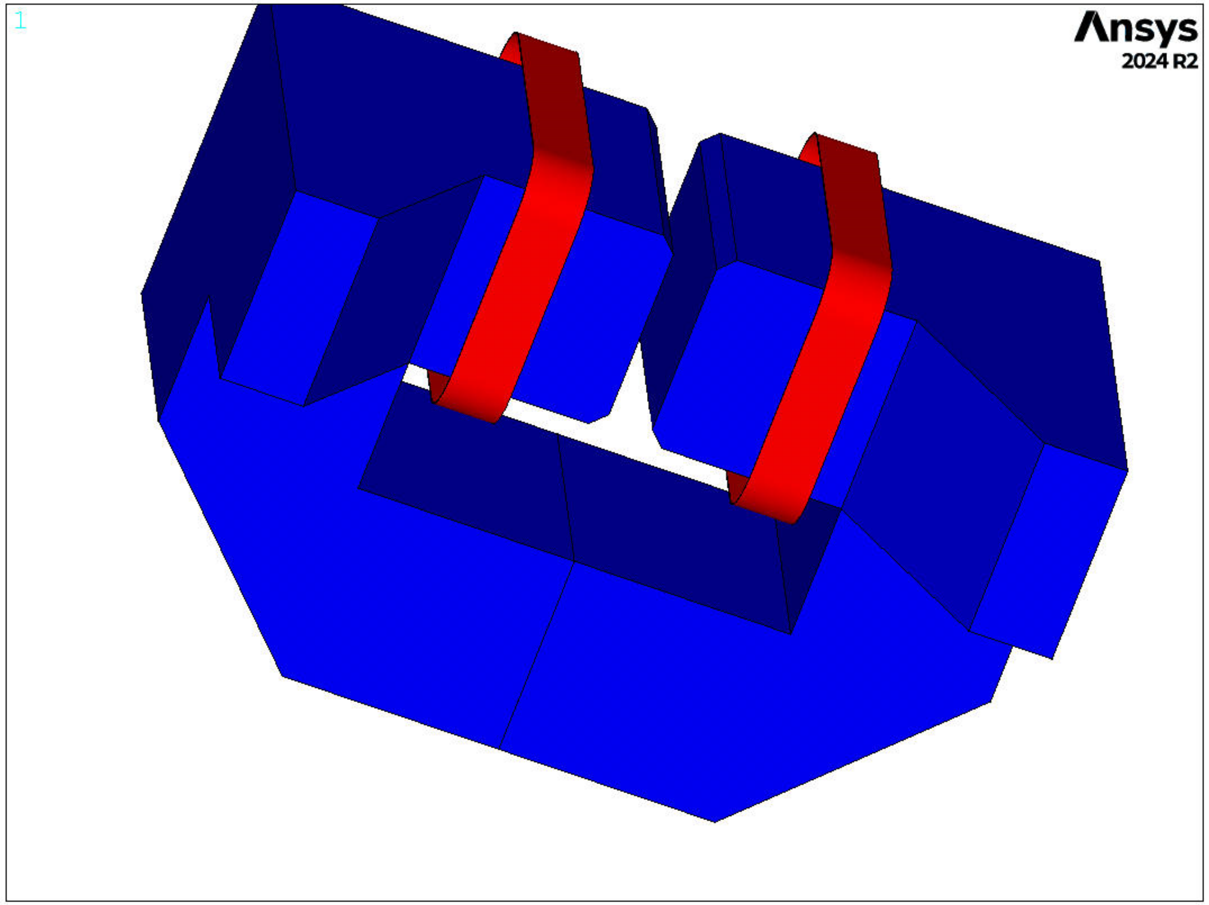
INTRODUCTION

- My personal interest in this project arises from the fact that PTOLEMY will host the first MgB_2 magnet dedicated to fundamental physics research.
- Additionally, I will be supervising a student, Gabriele Neri, for his Master's Degree thesis. In agreement with ASG, he will contribute to the development of the PTOLEMY superconducting magnet.

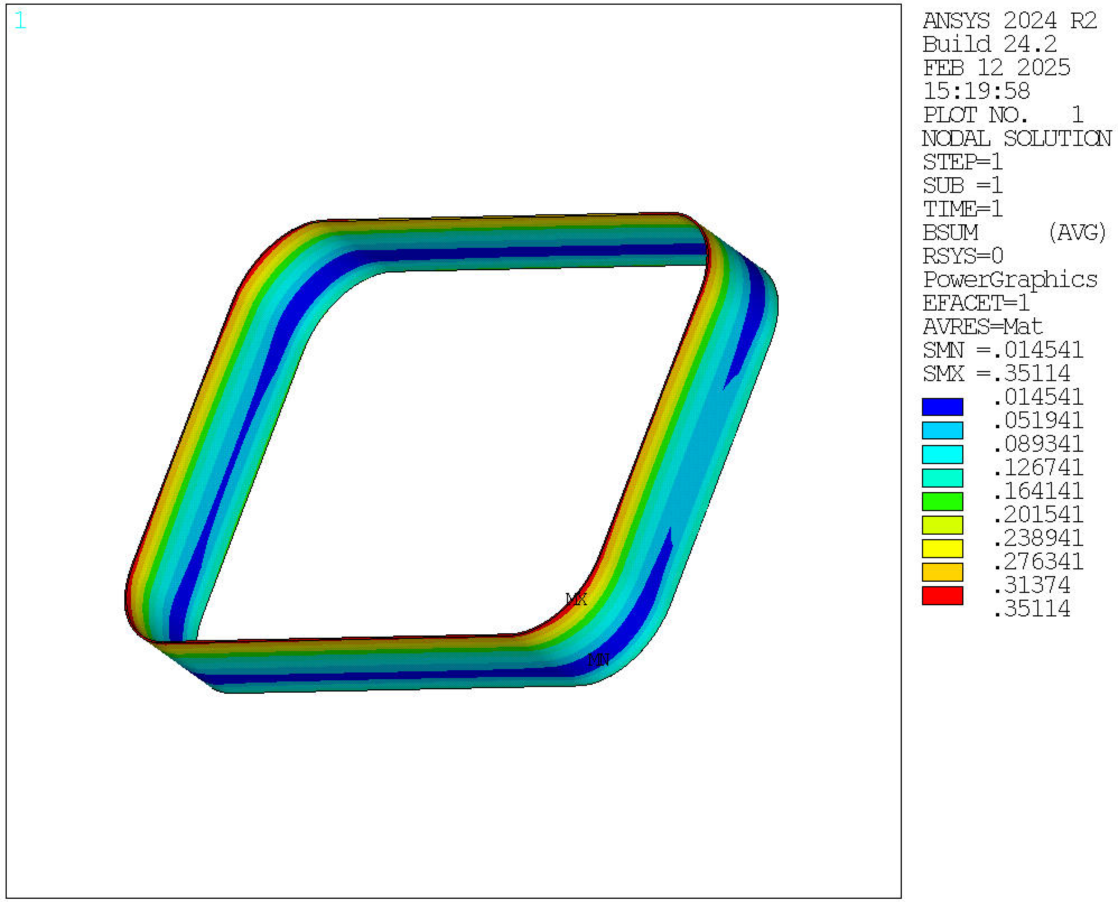
3D ELECTROMAGNETIC MODEL

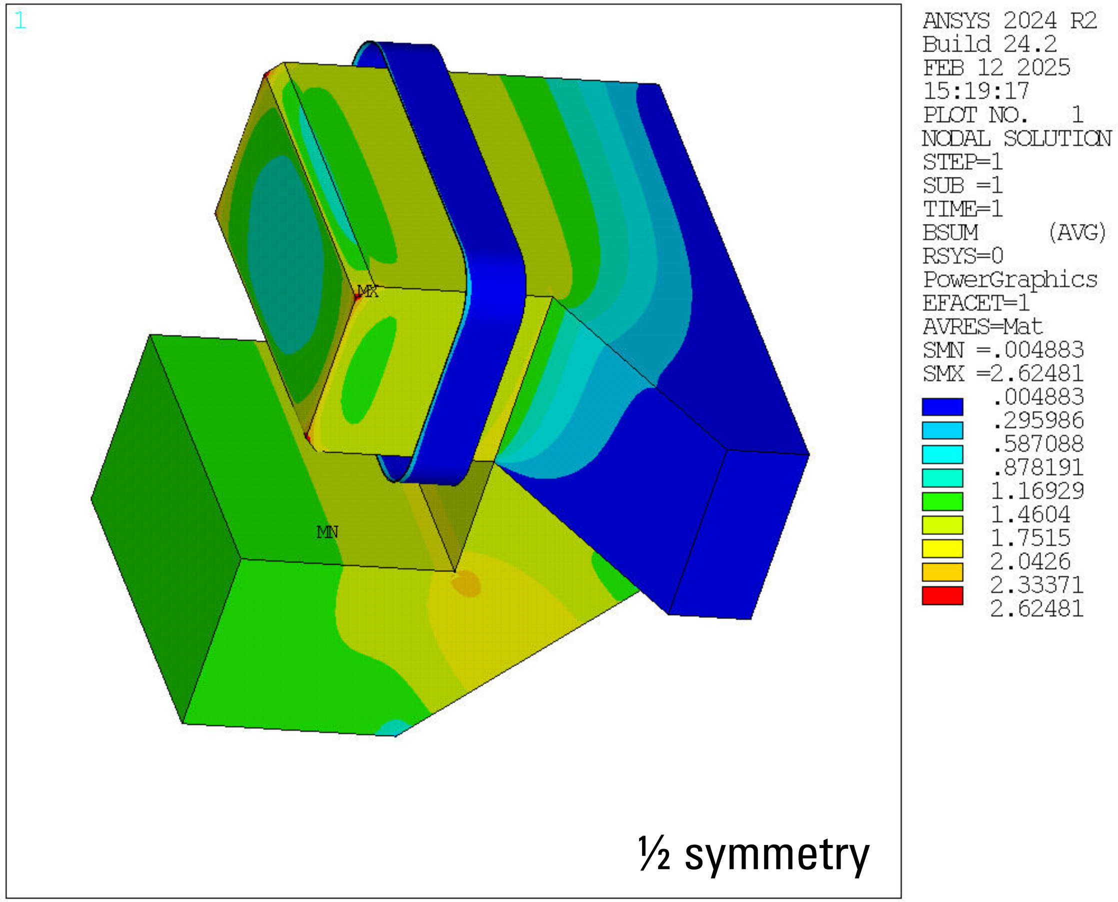
- I developed the 3D finite element model of the Ptolemy magnet system using ANSYS.
  - This software differs from the one used by ASG, providing a valuable cross-check.
- The model will serve as a basis for next Gabriele's work.

Iron yoke mass	27 tons
Min air gap	130 mm
Operating current	140 A
Current density	100 A/mm²
Operating temp	20 K



MAGNETIC FIELD IN COILS AND YOKE

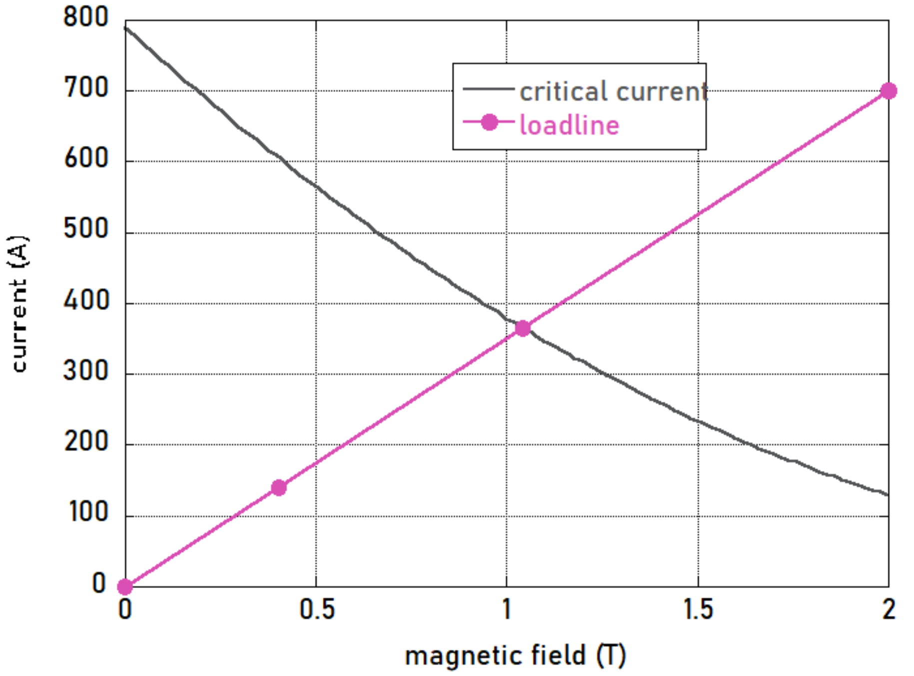




MAGNET MAIN PARAMETERS

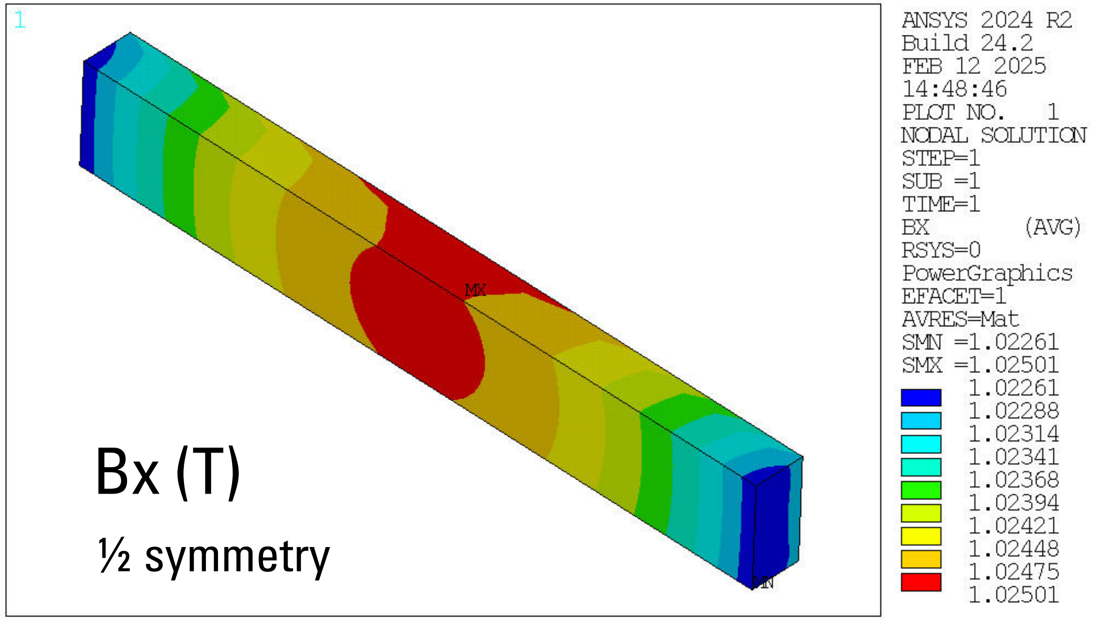
Gap field	1 T
Operating current	140
Operating temp	20
Peak field*	0.4 T
Magnetic energy	60 kJ
Inductance	6 H
Margin on the loadline	62%

*estimate including self-field



HOMOGENEITY

- In a specified volume, homogeneity is defined as: $H \equiv \max\left(\frac{B_x - \langle B_x \rangle}{\langle B_x \rangle}\right)$
- where: $\langle B_x \rangle = \frac{1}{l}\int_{-l/2}^{l/2} B_x \, dz$



Measuring volume (X × Y × Z)	Homogeneity (specified)	Homogeneity (calculated)
100 × 100 × 700	0.1%	0.15%
80 × 80 × 300	0.01%	0.025%

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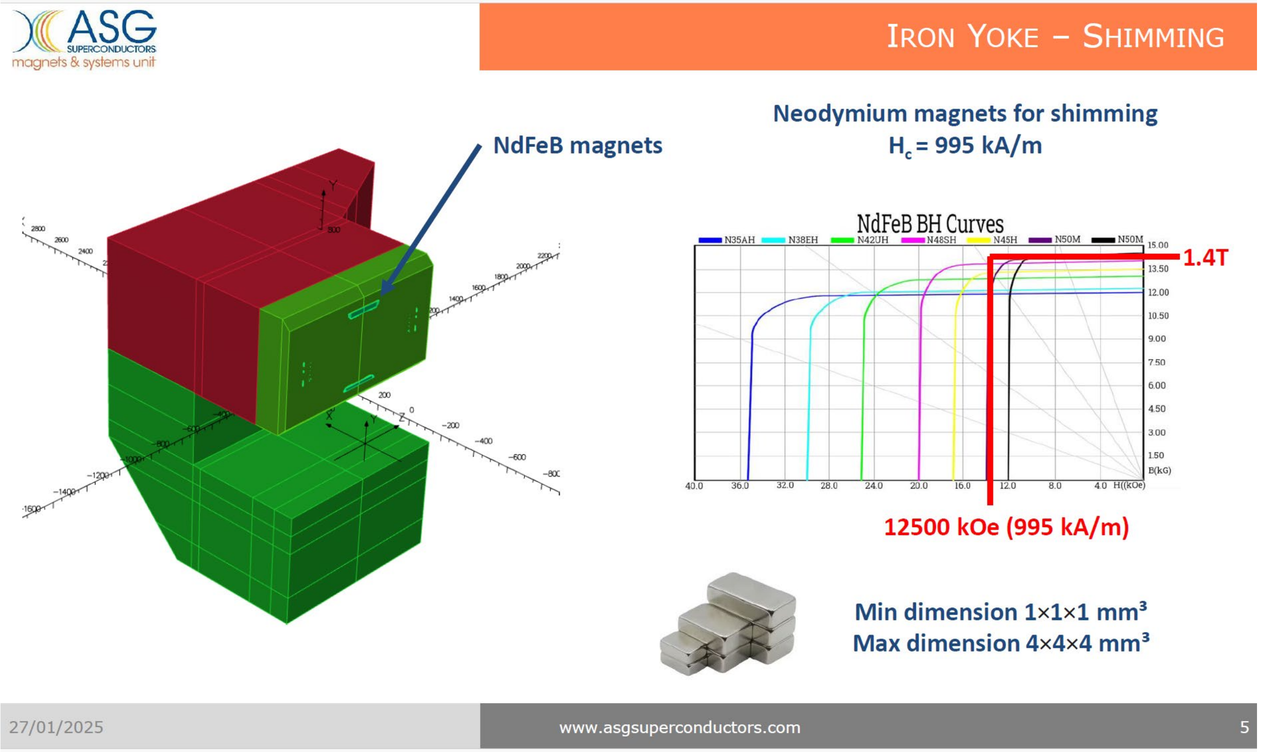
STATUS @ ASG SUPERCONDUCTORS

PTOLEMY

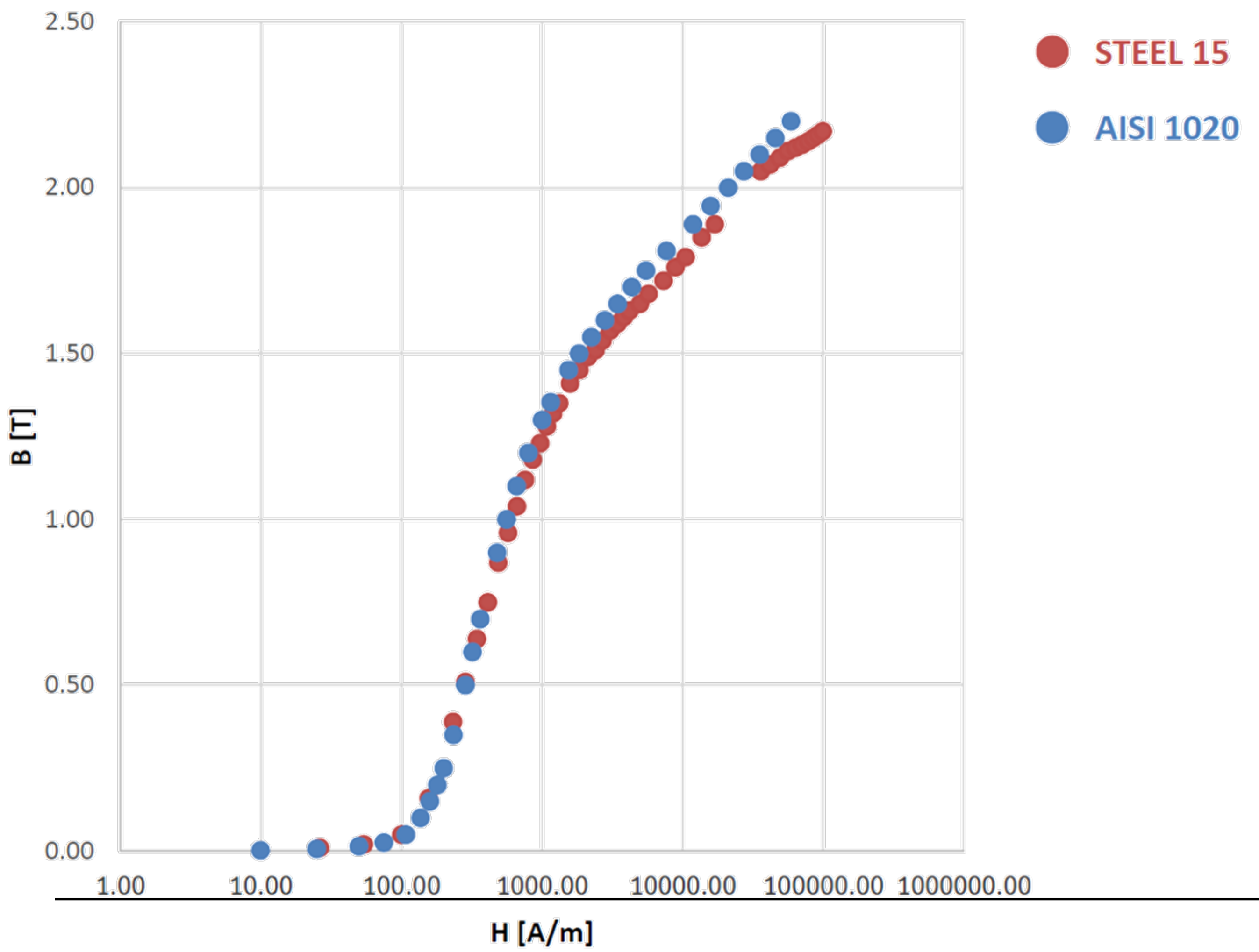
- Lorenzo Mauro provided me with the following updates:
  - Winding is set to begin next Monday.
  - Suprasys is nearing completion of the engineering design for the cryostat and suspension system.
  - The order for the iron yoke will be placed by the end of February, with priority given to the fastest supplier (most likely securing AISI 1020 forged rather than cast material).
  - The gap has been increased to 130 mm to accommodate permanent magnet shimming.



PLANNED ACTIVITIES WITH ASG

- Validation of the yoke material
- Assessment of the ferrous material's impact on the central field
- Sensitivity analysis
  - Evaluation of yoke tolerances
  - Analysis of coil positioning
  - Coil manufacturing considerations
- Selection of magnetic field measurement points

VALIDATION OF THE YOKE MATERIAL



- Verify the magnetic field map of the Ptolemy magnet system against the measured B-H curve of the procured iron for the yoke.

ASG SUPERCONDUCTORS

CHEMICAL	PURE IRON	STEEL 15	AISI 1020
Carbon **C** [%]	0.0041	0.19	0.22
Manganese **Mn** [%]	0.298	0.61	0.55
Phosphorus **P** [%]	0.012	0.028	0.04
Silicon **Si** [%]	0.008	0.23	-
Sulfur **S** [%]	0.0084	0.033	0.05

PLANNED ACTIVITIES WITH ASG

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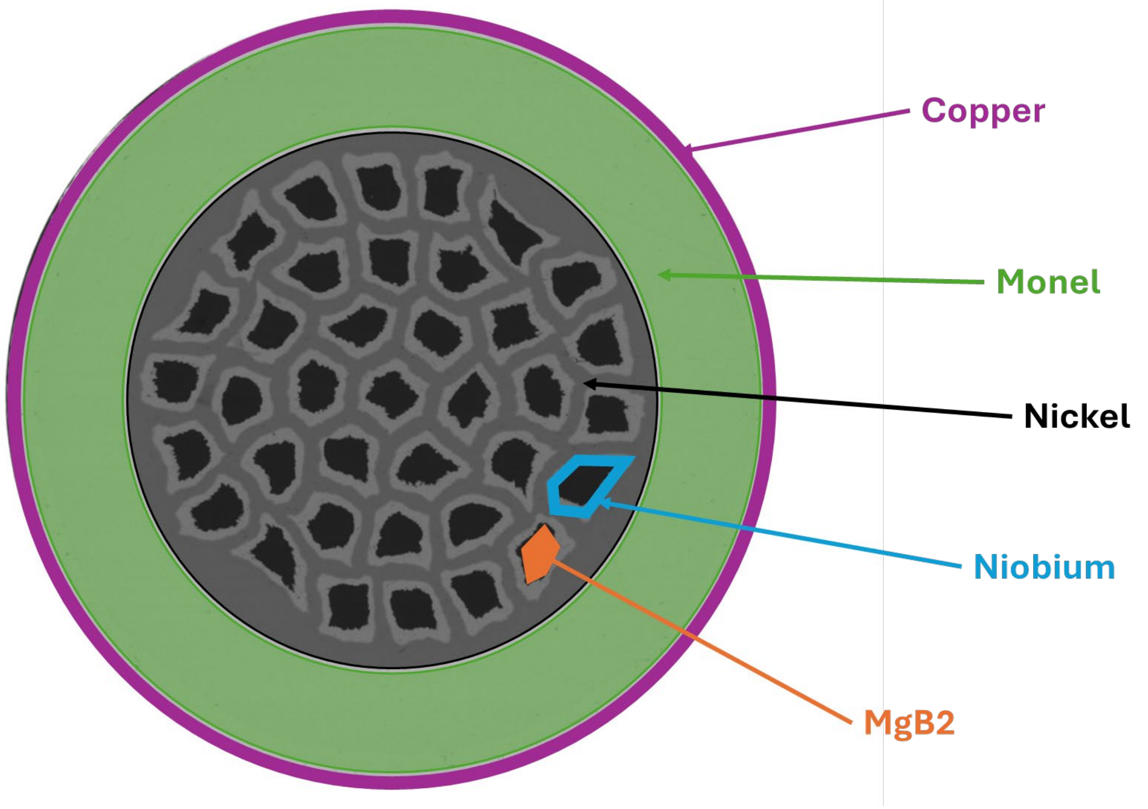
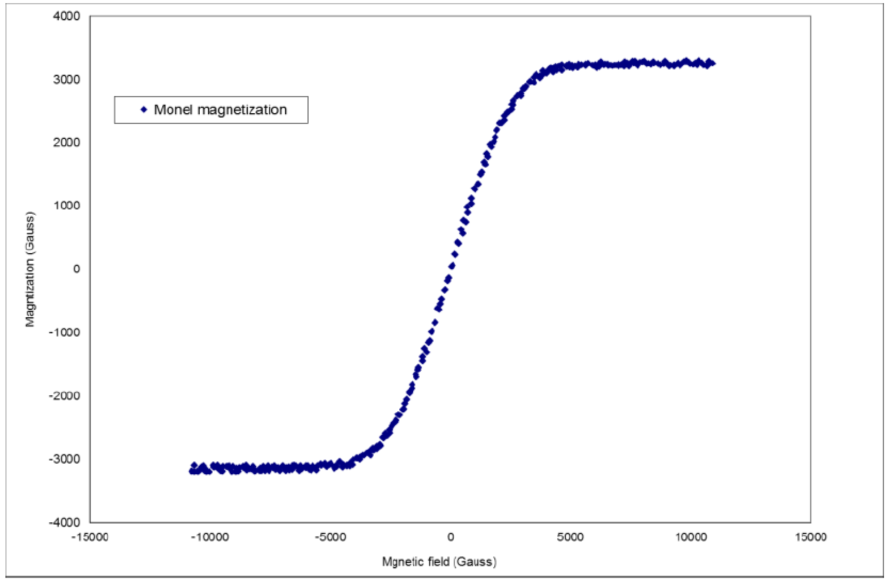
NICKEL AND MONEL SATURATION

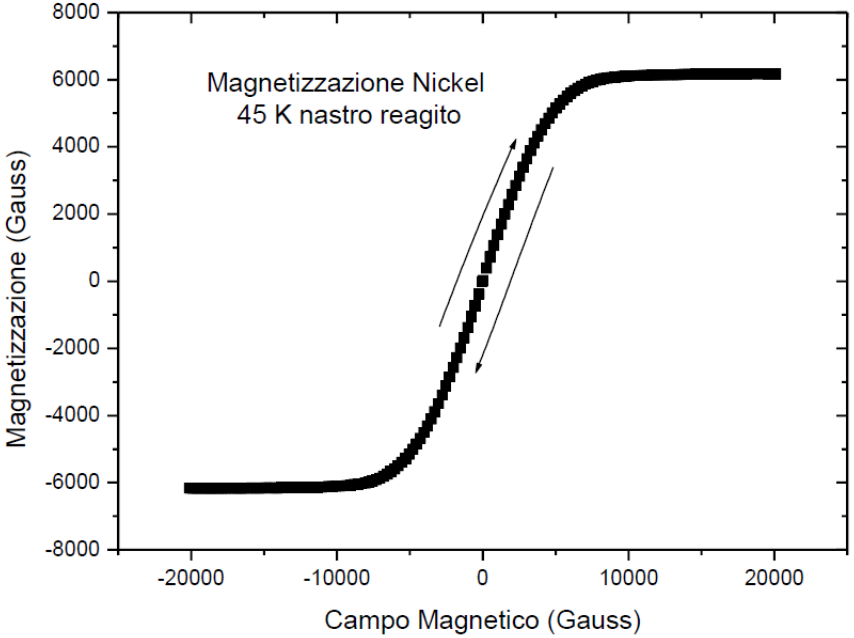
- In the MgB_2 conductor design, different materials are used to ensure protection and functionality:
    - the **Niobium** serves as a protective layer for the MgB_2,
    - the **MgB_2 filaments**, coated with Nb, are embedded in a **Nickel** matrix,
    - and the entire MgB_2-Nb-Ni assembly is enclosed within a **Monel** shell.
    - **Copper** forms the outer coating, allowing for easy soldering.
- **Nickel** and **Monel** are permeable materials.



NICKEL AND MONEL SATURATION

- Nickel and monel saturation properties could have an impact on the magnetic field





Saturation property

M(H>0.5T) ≈ 0.33T

Saturation property

M(H>0.5T) ≈ 0.60T

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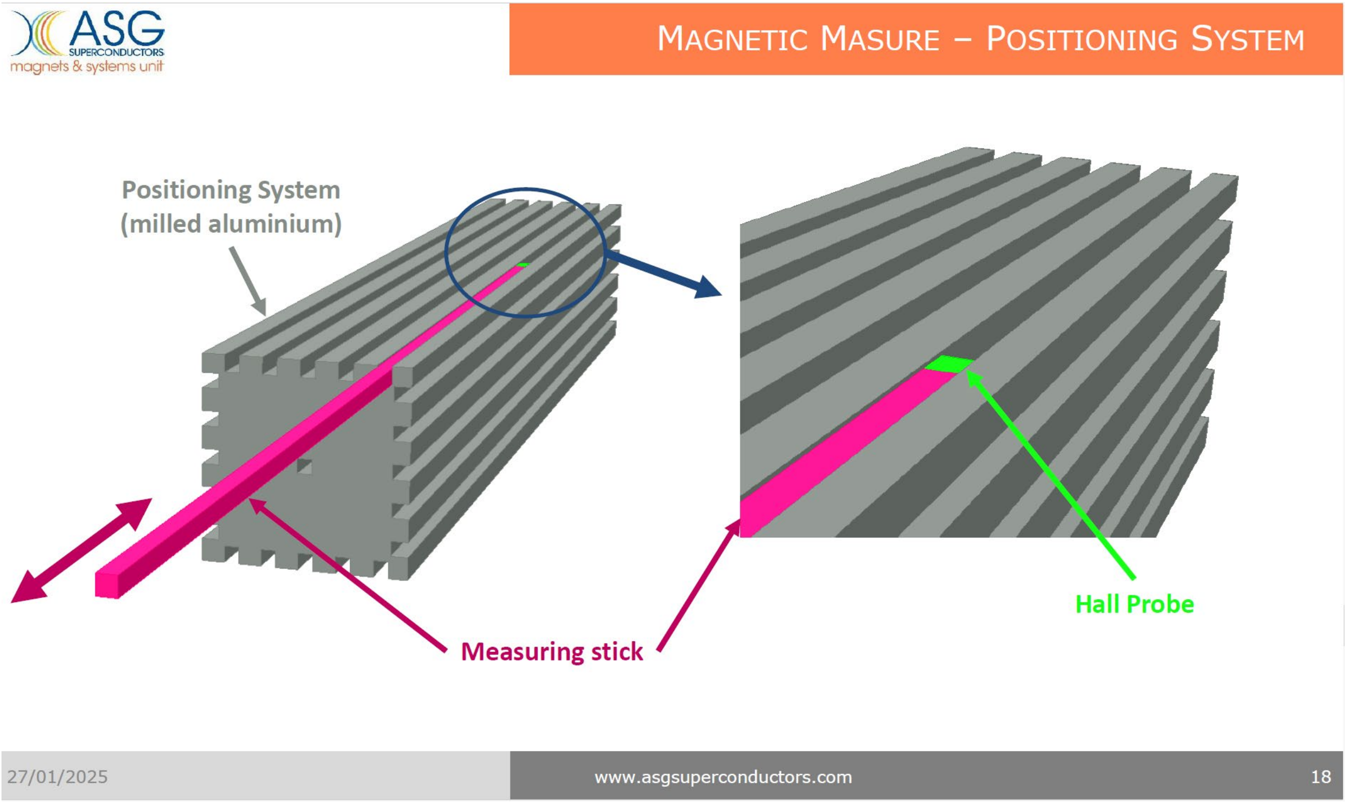
MEASUREMENT POINTS

- Optimize the tool for measuring the field map in the gap.
- Evaluate the measurement error by considering the tolerances of both the tool and its positioning.



POSSIBLE ADDITIONAL ACTIVITIES

- Participation in the field mapping at CERN
- ???