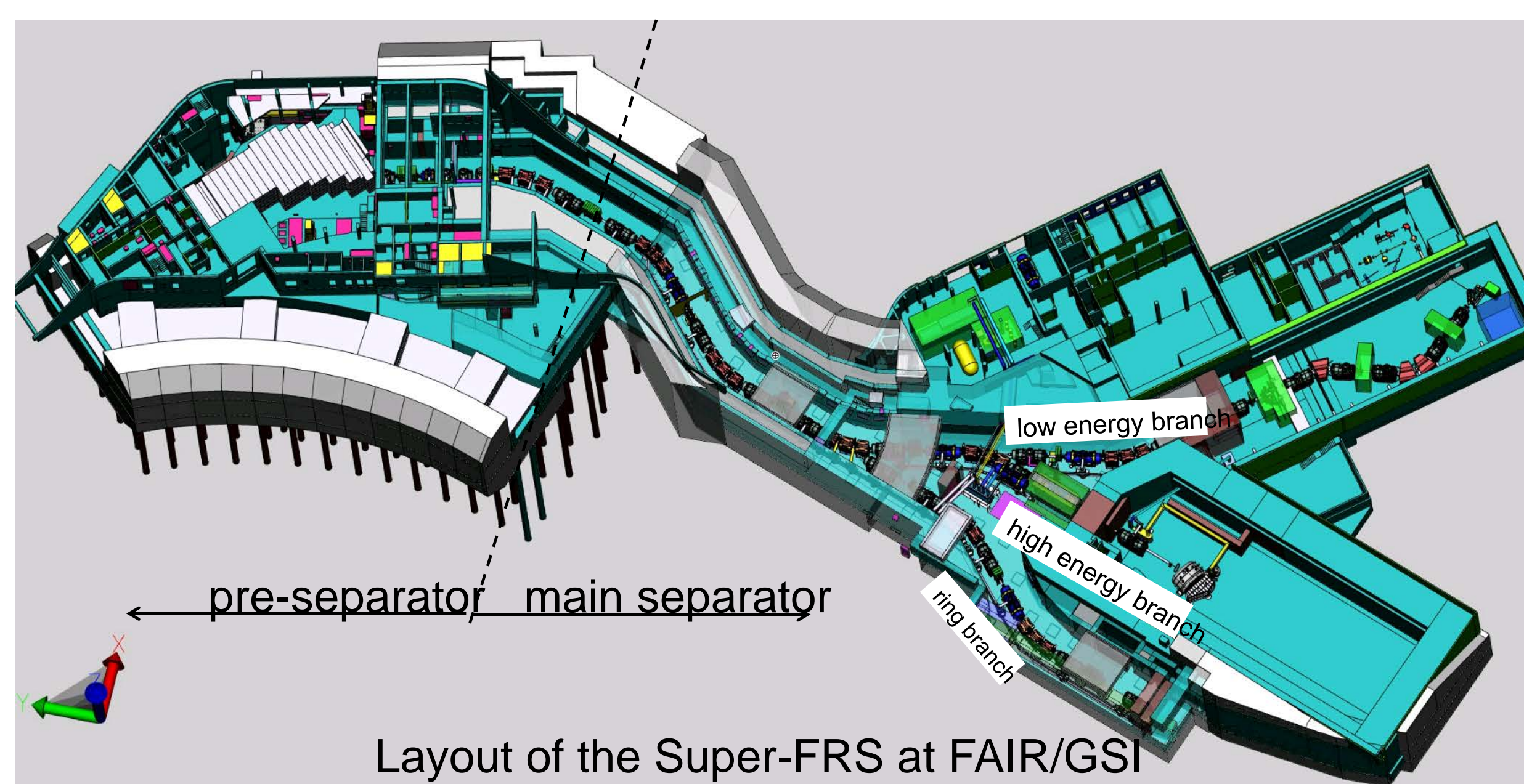


Superconducting Fragment Separator

The **Super-FRS (Superconducting FRagment Separator)** at FAIR aims at production and separation of rare isotopes. It is a two stage in-flight separator (pre- and main stage) with three branches, a low energy, a high energy and a ring branch connecting different experimental areas. The Super-FRS comprises 24 super conducting dipoles and 30 multiplets.

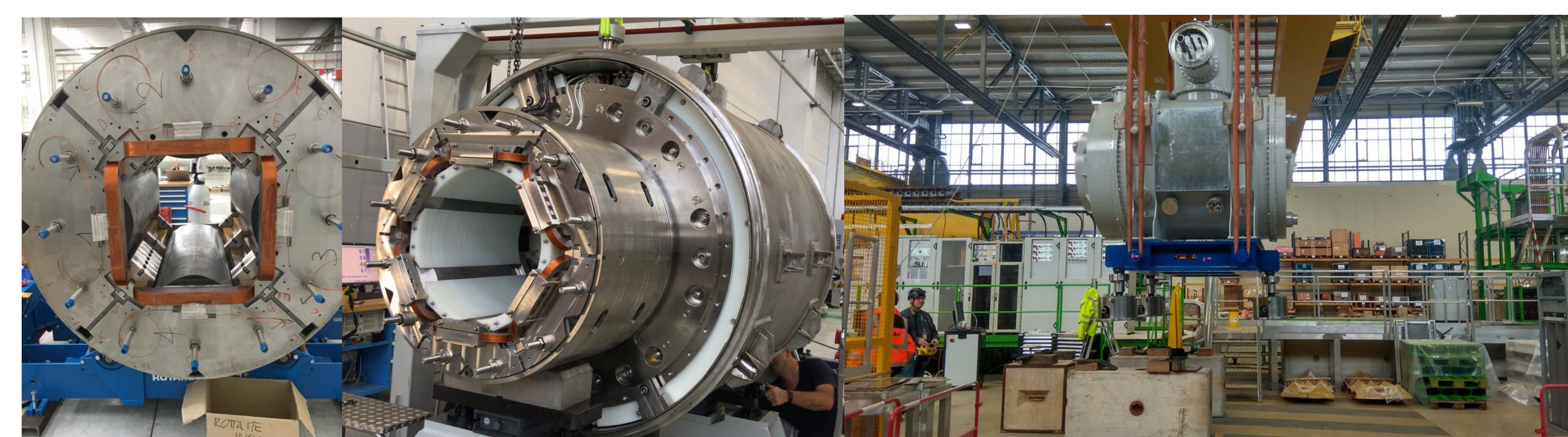
- large momentum and angular acceptance ($\Delta p/p = \pm 2.5\%$, $f_x = \pm 40$ mrad and $f_y = \pm 20$ mrad)
- The maximum beam rigidity is 20 Tm.



The First Unit of the Series (FoS) Multiplet

- 2.6 m x 2.7 m x 4.2 m (W x L x H) and 28 tons.
- The 19 tons of cold mass with one sextupole and one quadrupole magnet
- Cooled by LHe (~ 800 liters) in the common He bath (design pressure, 20 bars)
- Superferric magnets (magnetic field shaped by iron)
- Self-protecting
- Warm beam pipe

| | Length of iron | Pole tip radius | Warm bore radius | g_{max} | I_{nom} | Inductance @ I_{nom} | Stored Energy @ I_{nom} | B_{peak} @ I_{nom} | Number of Turns | Cu/Sc ratio | RRR |
|------------|----------------|-----------------|------------------|---------------------|-----------|------------------------|---------------------------|------------------------|-----------------|-------------|-----|
| Quadrupole | 1200 mm | 250 mm | 190 mm | 10 T/m | 300 A | 21 H | 952 kJ | 4.2 T | 1248 | 3.5 | 100 |
| Sextupole | 500 mm | 250 mm | 190 mm | 40 T/m ² | 297 A | 0.88 H | 37 kJ | 1.9 T | 242 | 3.5 | 100 |



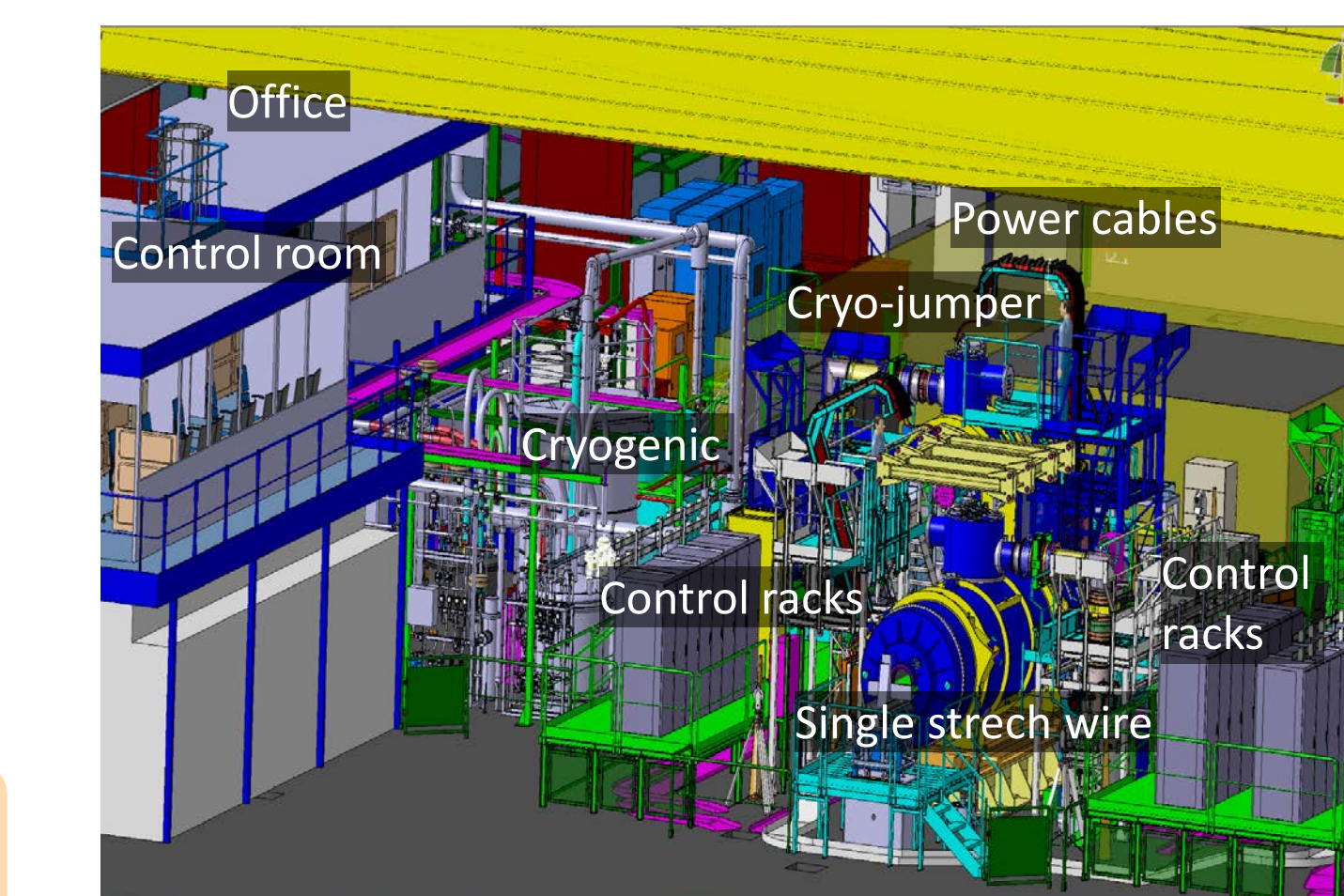
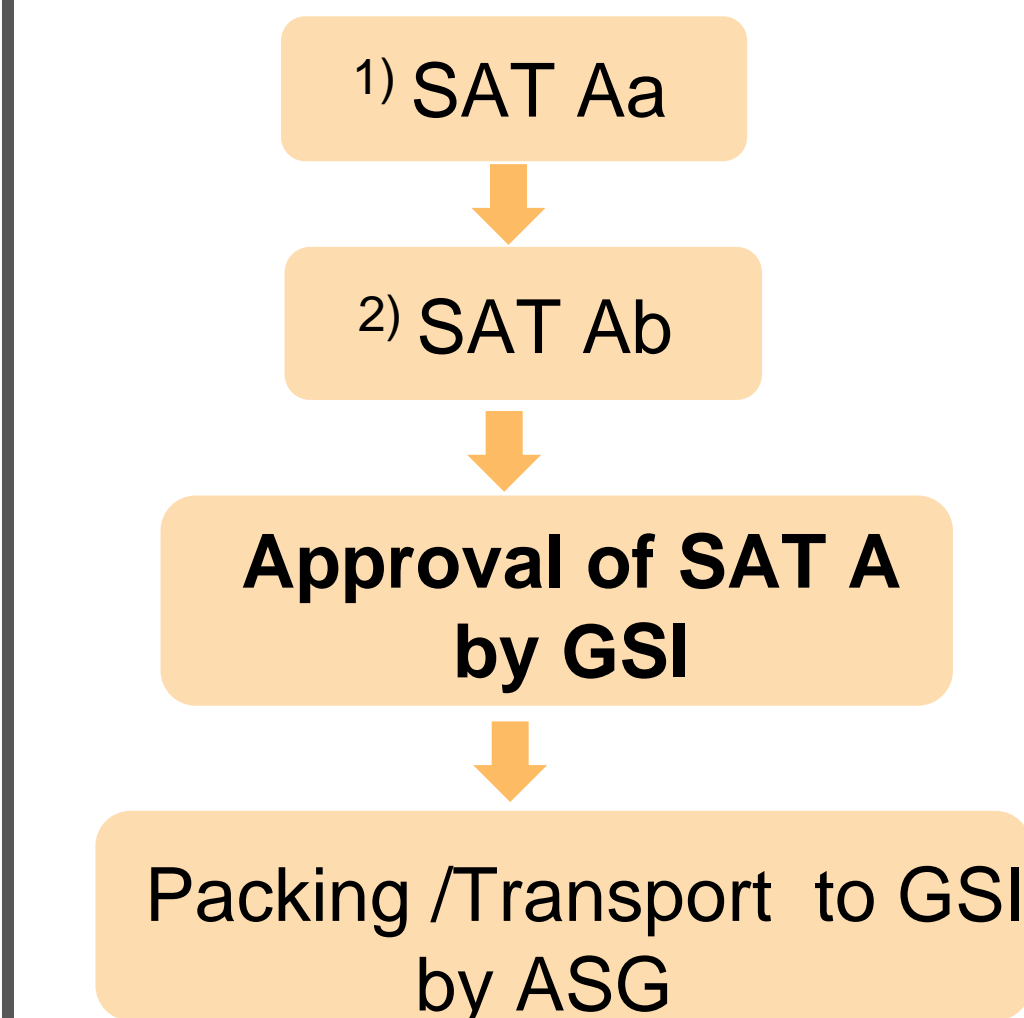
(a) The quadrupole magnet assembly. (b) The cold mass assembly. (c) Transportation of the FoS multiplet to the test bench in the Building180 (B180) at CERN.

Qualification Process



Site Acceptance Test A (SAT A)

The SAT A at cold is performed at the dedicated CERN cryogenic magnet test facility (B180) in the framework of the GSI/CERN collaboration.

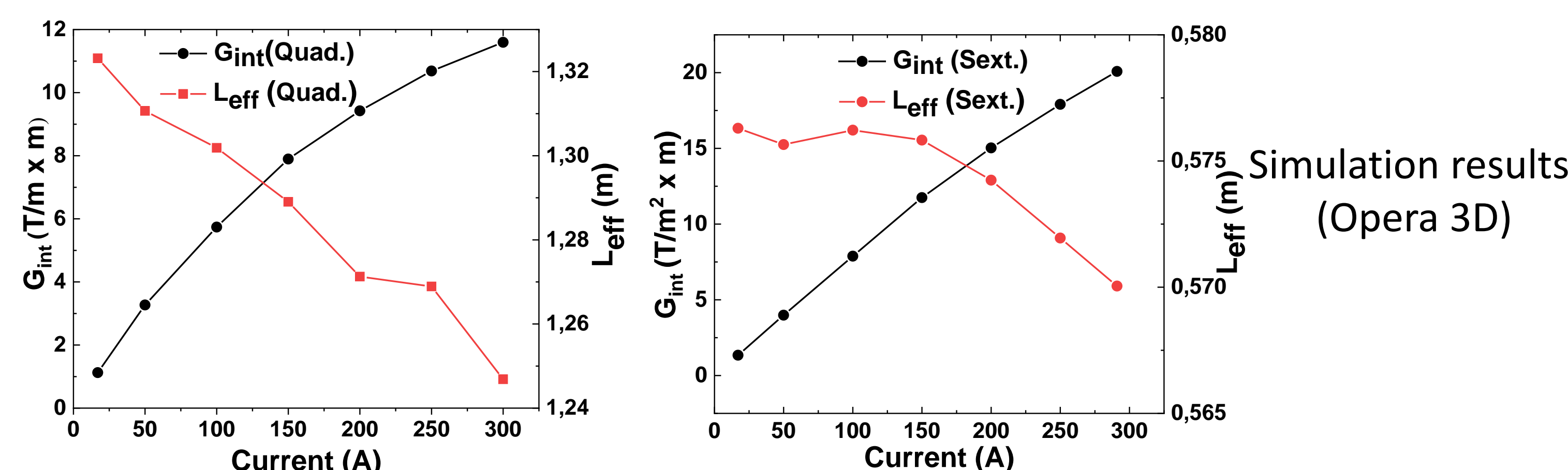


Courtesy by Antoine Kosmicki, CERN

¹ SAT Aa : on the lorry and at preparation area, ² SAT Ab : at the test bench (warm/cold/after warm-up)

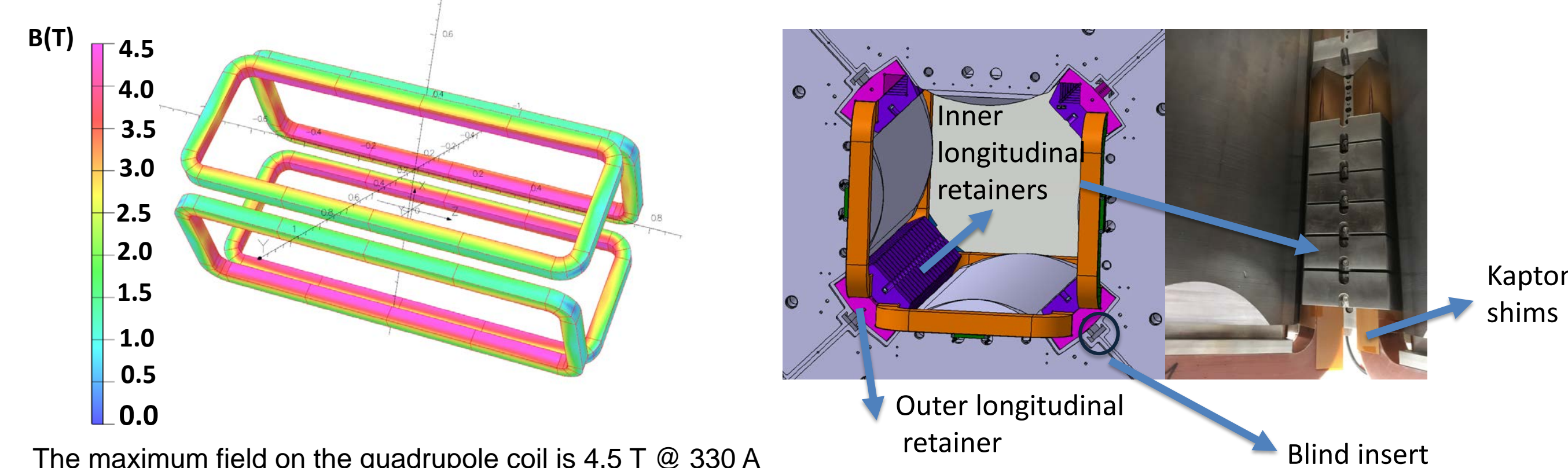
Goal of the SAT A

- **Verification of the magnetic design (gradient, L_{eff} and harmonics)**



- **Verification of the preventive measure to confine the quadrupole coil movement during the ramp-up to 330 A due to electric magnetic force.**

- The coils support structure against electromagnet force should work properly.
- Kapton shims placed between coil and retainer should work correctly so that coils cannot move due to electromagnetic force.

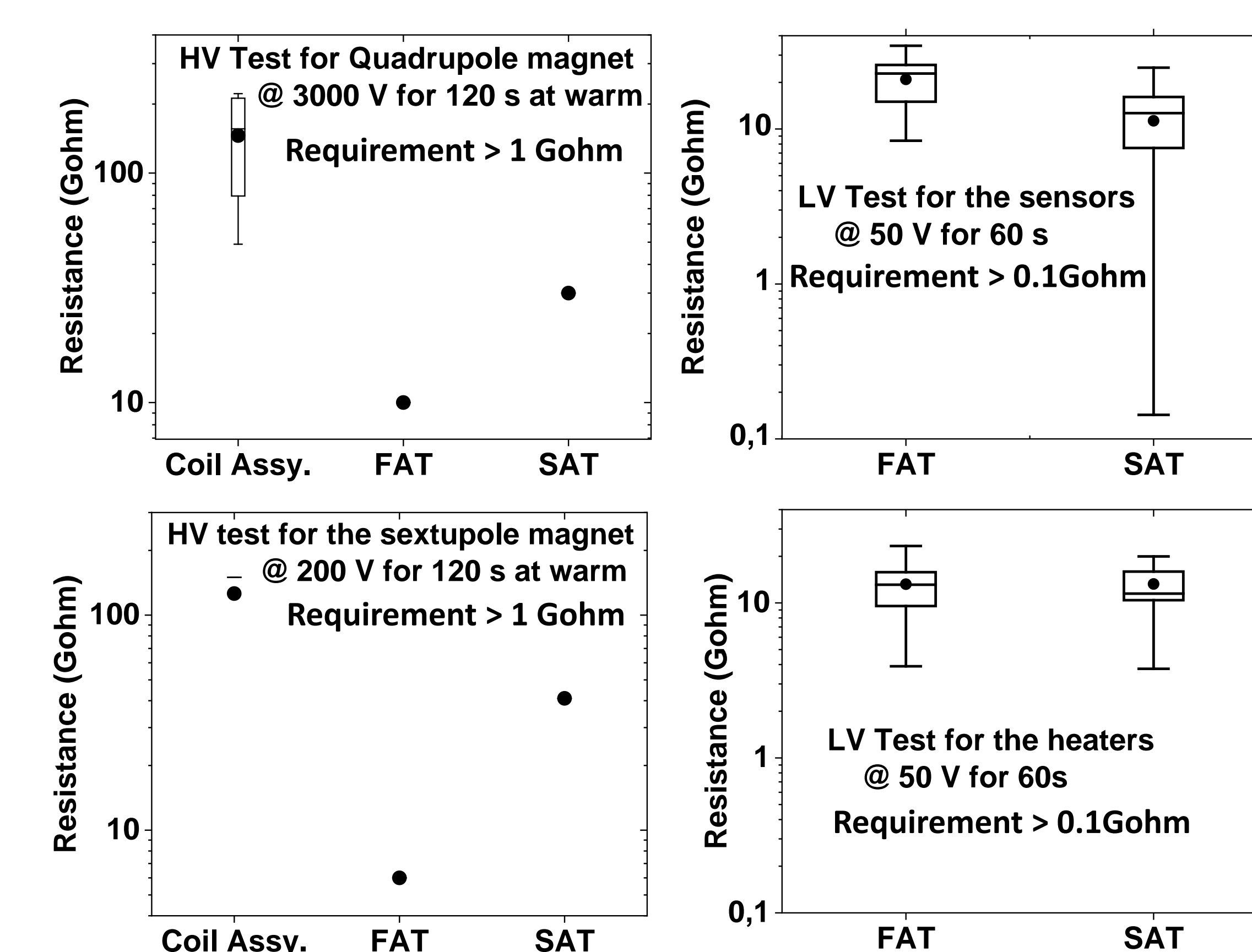


The Status of Testing and Results

- Insulation vacuum is ok ($< 1 \times 10^{-4}$ mbar).
- Leak rate is ok ($< 5 \times 10^{-6}$ mbar x liter /s).
- High and low voltage test results are ok.
- Sensor alive and continuity test results are ok.
- Powering test is in progress
 - Magnet excitation up to $1.1 \times I_{nom}$.
 - Pre-powering cycles up to I_{nom} .
- The remaining test programs
 - Magnetic field measurement.
 - Field mapping.
 - Crosstalk between the quadrupole and the sextupole magnet.
 - Heat load.
 - RRR.
 - Thermal cycles.



HV and LV Test Results



Summary and Outlook

This contribution presents the preliminary test results of the FoS multiplet. The qualification focuses on especially the magnetic design and the mechanical stability of the quadrupole magnets which are the main challenges during the design phase. After the series of the tests at warm, the magnets were cooled down successfully. The cold powering test is in progress followed by the magnetic field measurement. The completion of the test is scheduled for Q4, 2019.