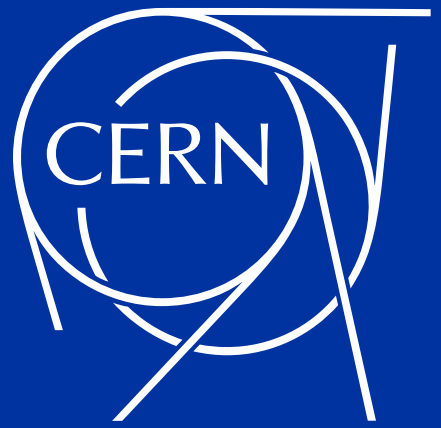


WED-OR3-503-05

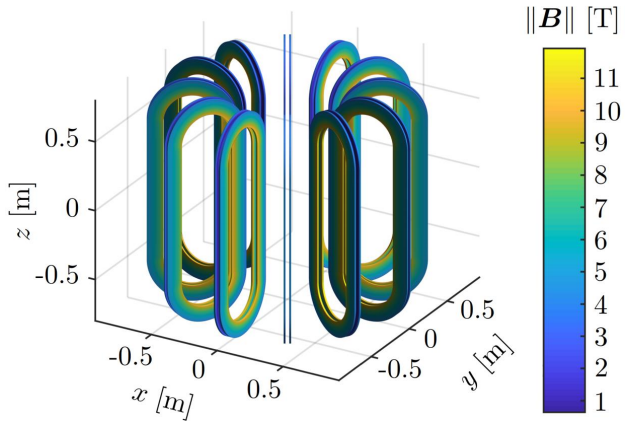
Design and manufacturing of AMaSED-2: A no-insulation HTS demonstrator coil for the space spectrometer ARCOS

Magnus Dam[1], William Jerome Burger[2,3], Rita Carpentiero[4], Enrico Chesta[5], Roberto Iuppa[6], Gijs de Rijk[5], and Lucio Rosso[1,7]

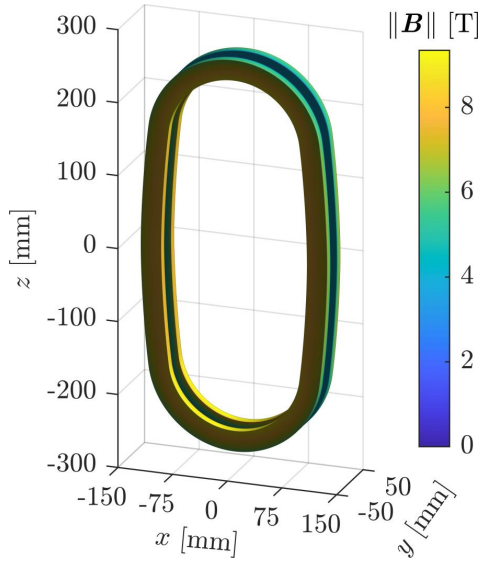
[1]INFN, [2]TIFPA, [3]CREF, [4]ASI, [5]CERN, [6]University of Trento, [7]University of Milan

The HTS Demonstrator Magnet for Space (HDMS) project goals

1) Conceptual design of a HTS magnet for the magnetic spectrometer in space ARCOS

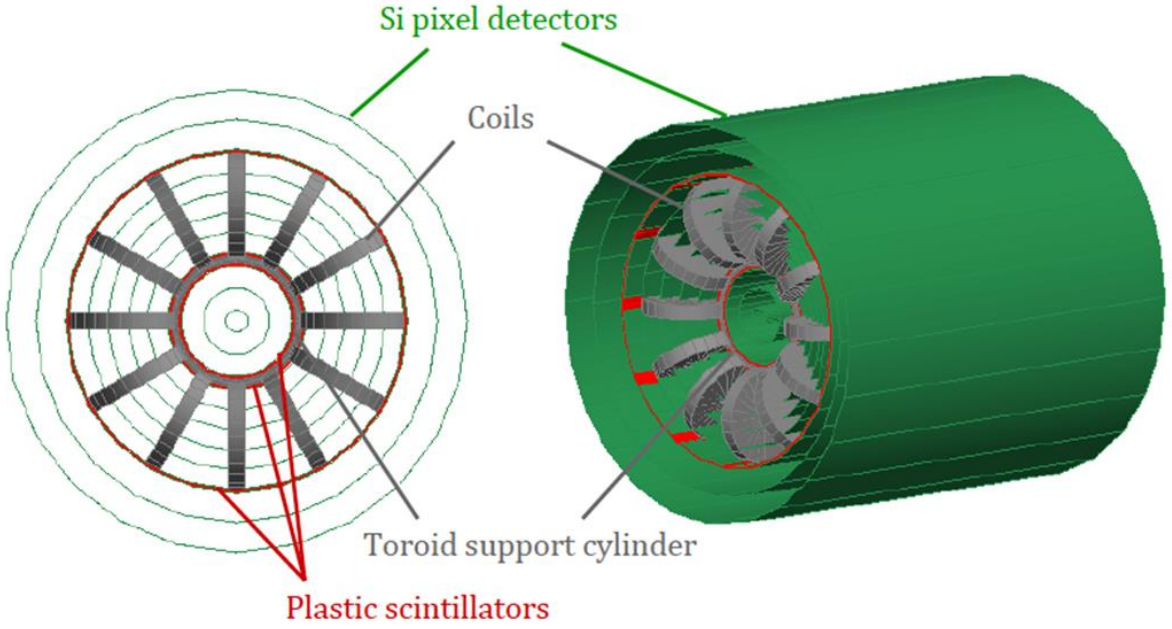


2) Design and manufacture a demonstrator coil AMaSED-2 for the ARCOS magnet



Astroparticle Research Compact Orbital Spectrometer (ARCOS)

- A toroidal high-field magnet
- A tracker, composed of silicon pixel detectors, which measures the charged particle trajectories in the magnetic field
- Plastic scintillators, which provide the trigger to select the desired event topologies.



Rigidity and bending strength

Rigidity:

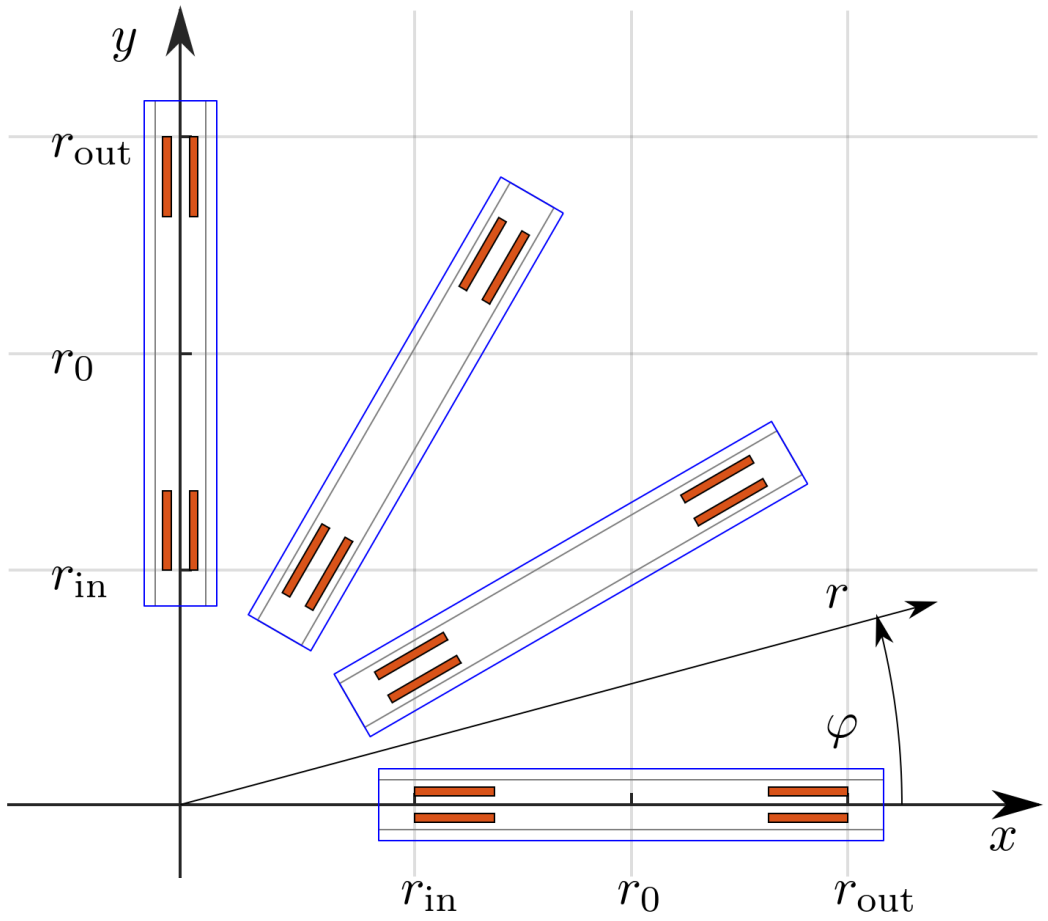
$$R = c\frac{p}{q} \quad [\mathrm{V}]$$

Bending strength:

$$\overline{B}_\varphi L(\varphi) = \int_0^L B_\varphi(r,\varphi)dr$$

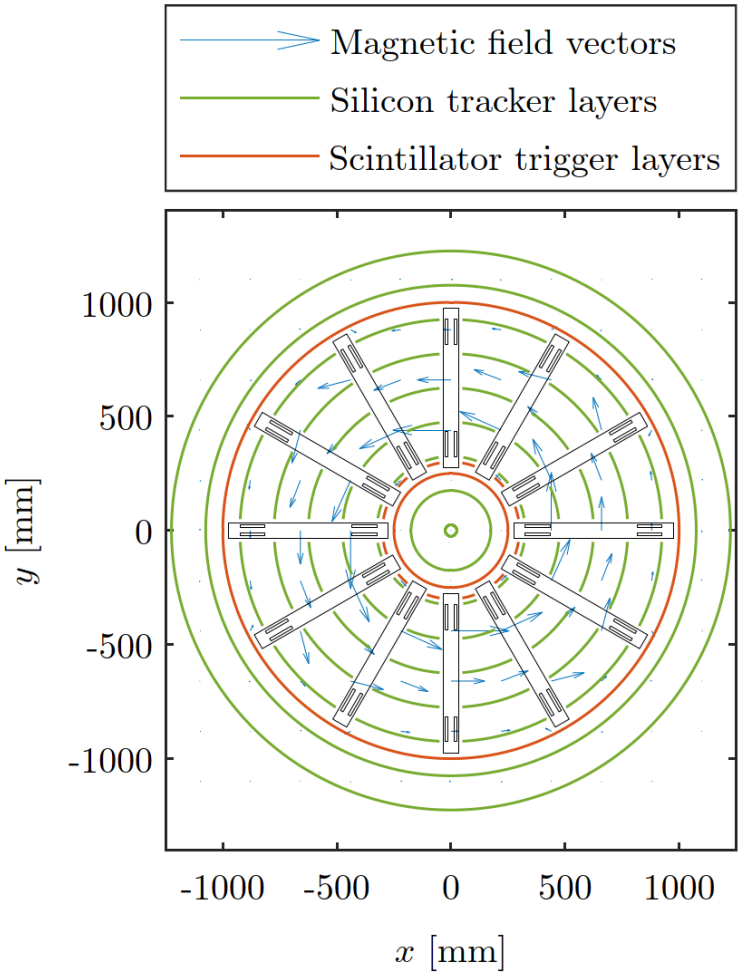
Average bending strength:

$$\langle \overline{B}_\varphi L \rangle = \frac{N}{\pi}\int_0^{\pi/N} \overline{B}_\varphi(\varphi) L d\varphi$$



Requirements for the ARCOS magnet

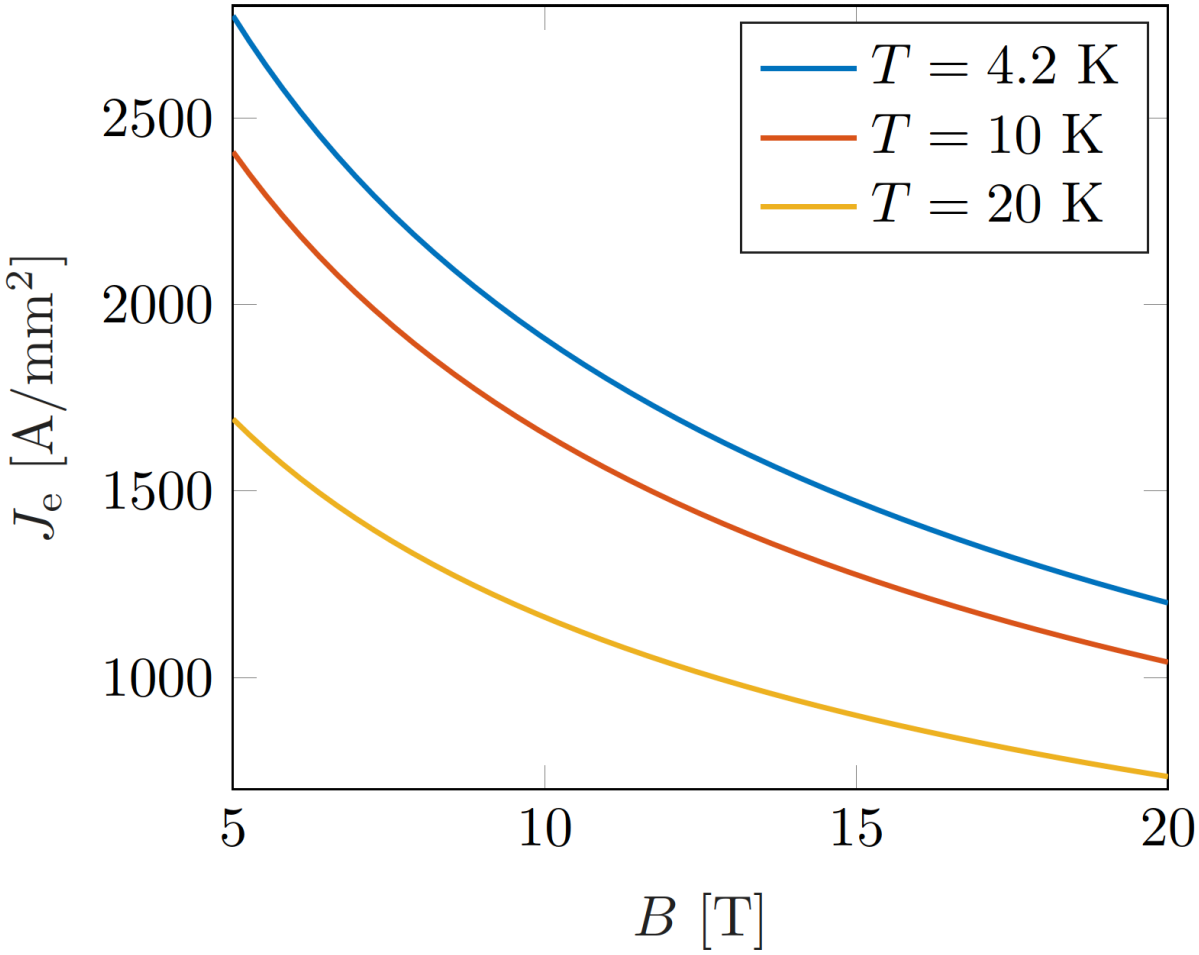
- Average bending strength: 3 T m
- Inner toroid diameter: 500 mm
- Outer toroid diameter: 2000 mm
- Straight coil segment height: 1000 m
- Operating temperature 20 K
- Conduction cooled by a cryostat
- Lightweight structure
- Sufficient space available for detectors



Conductor requirements for the ARCOS magnet

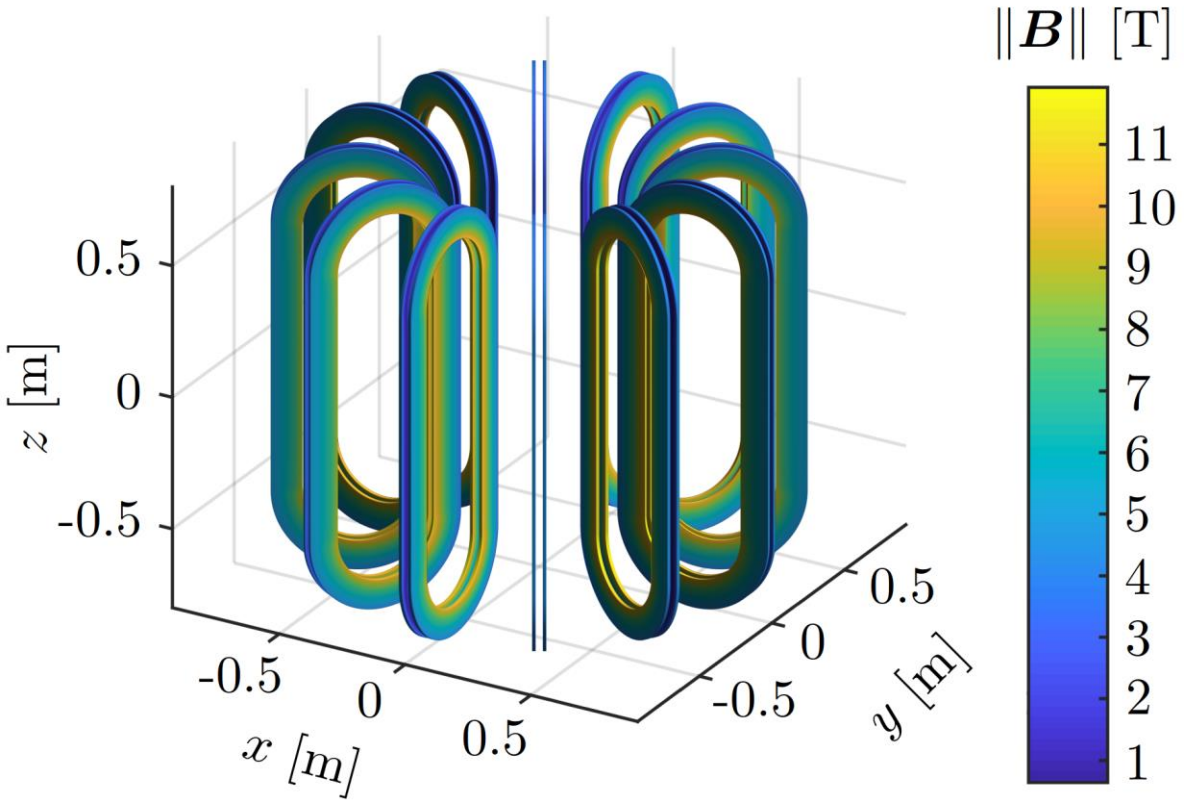
HTS ReBCO tape:

- 12 mm wide, 100 µm thick
- J_e = 1200 A/mm^2 at 4.2 K and 20 T
- Angle dependence: worst case conditions
- Field dependence: Fitting function

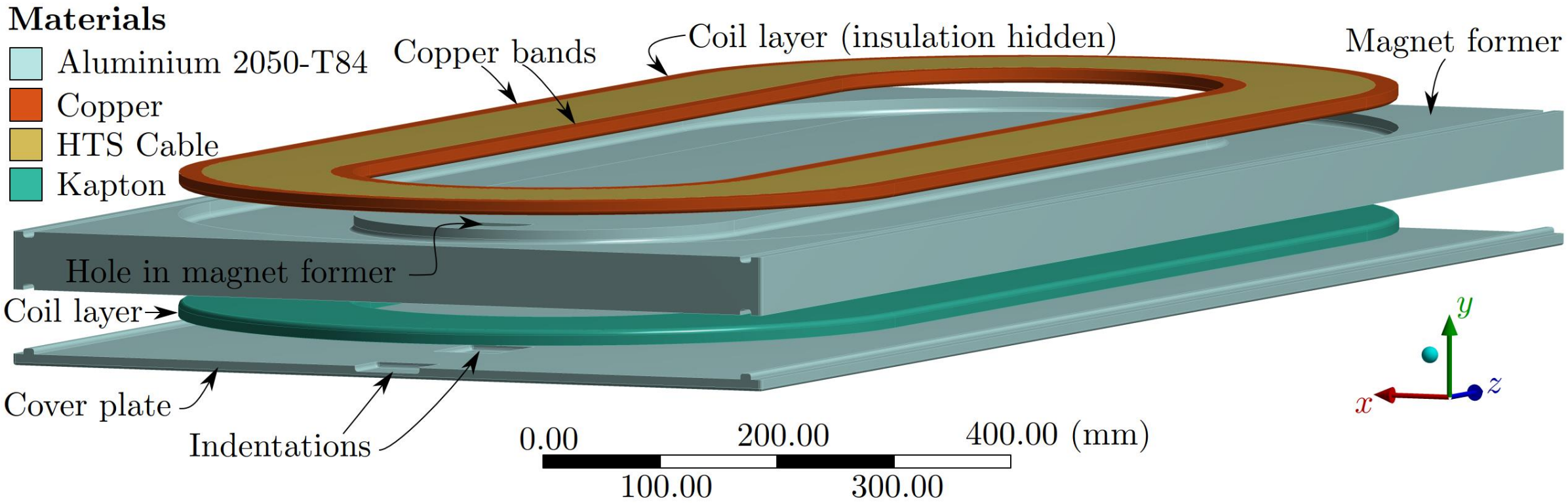


ARCOS magnet design

- 12 racetrack coil packs
- 2 winding layers per coil pack
- Engineering operating current density: 855 A/mm^2
- Peak field: 11.9 T
- Total HTS tape length: 62 km
- Stored magnetic energy: 39.6 MJ



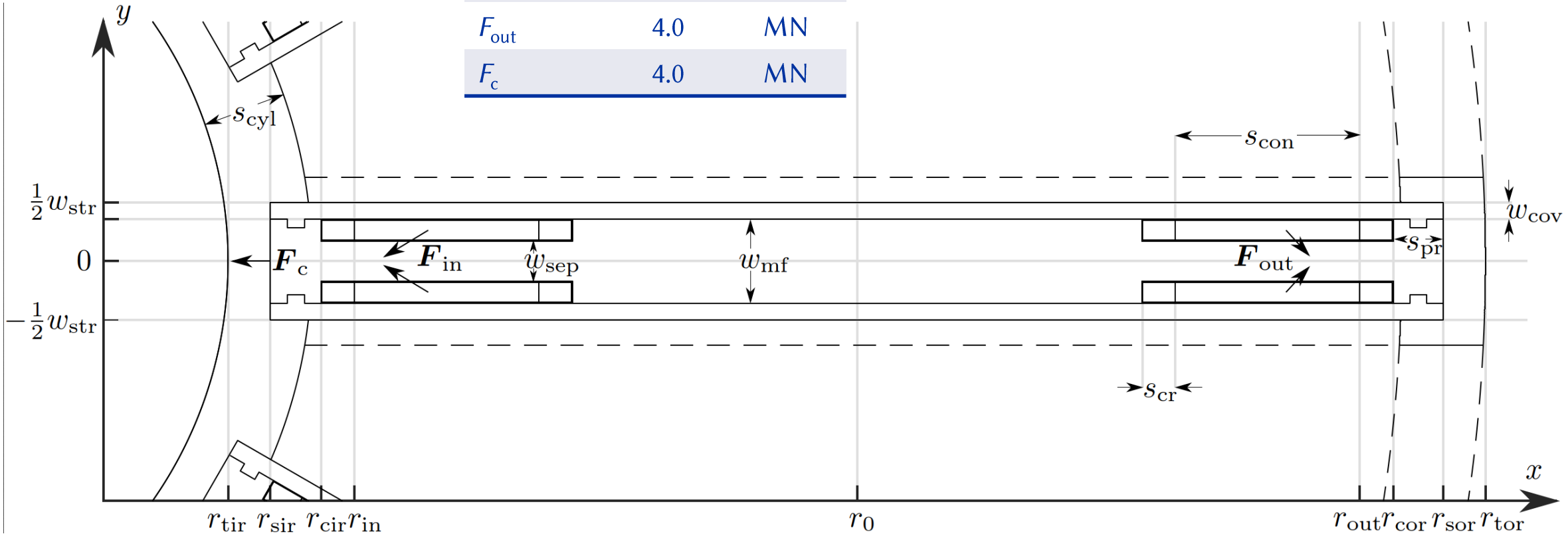
ARCOS coil mechanical structure



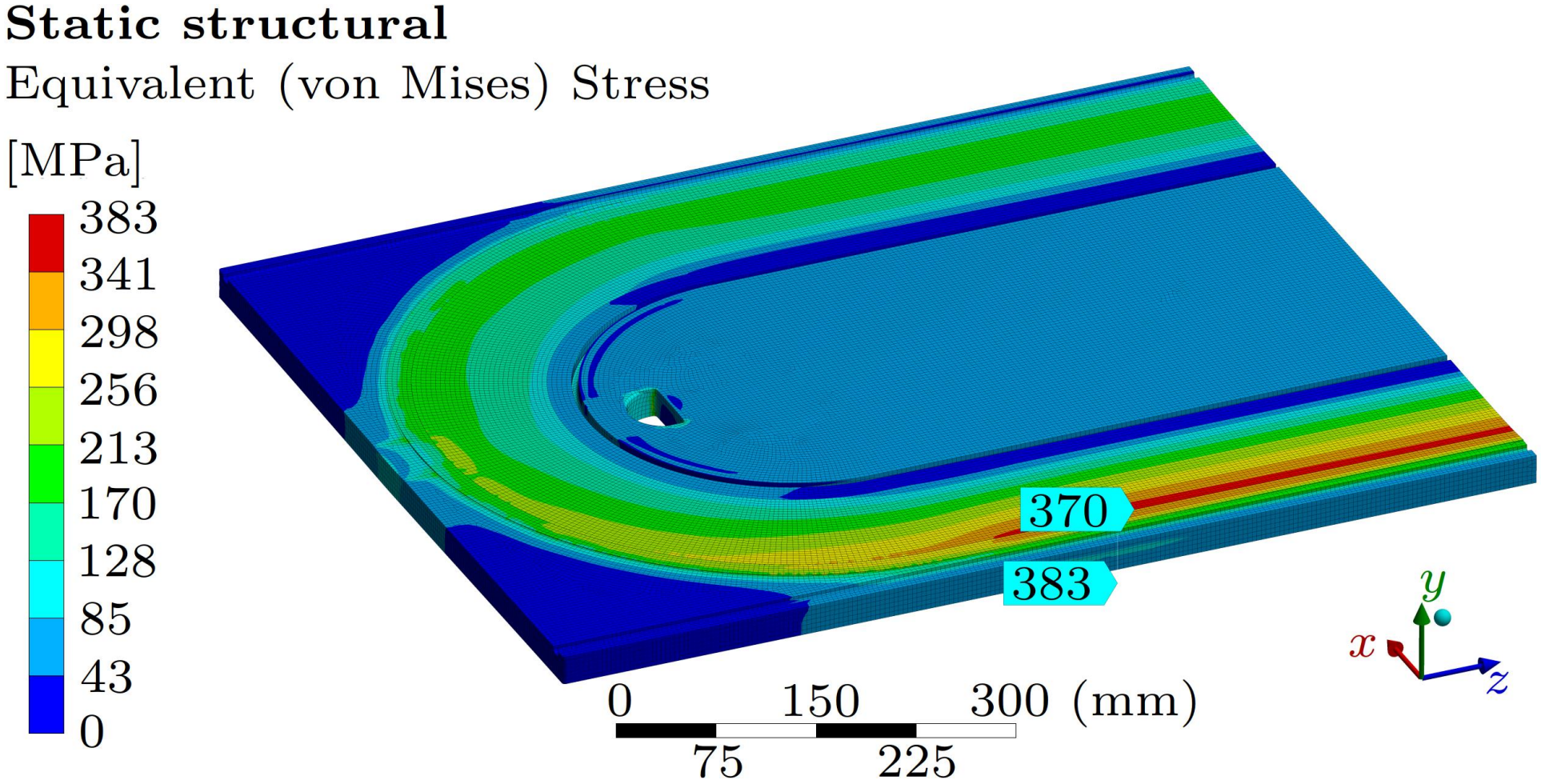
Note: Upper cover plate and insulation of upper winding layer are hidden in the figure

ARCOS force analysis

Symbol	Value	Unit
F_{in}	5.5	MN
F_{out}	4.0	MN
F_c	4.0	MN

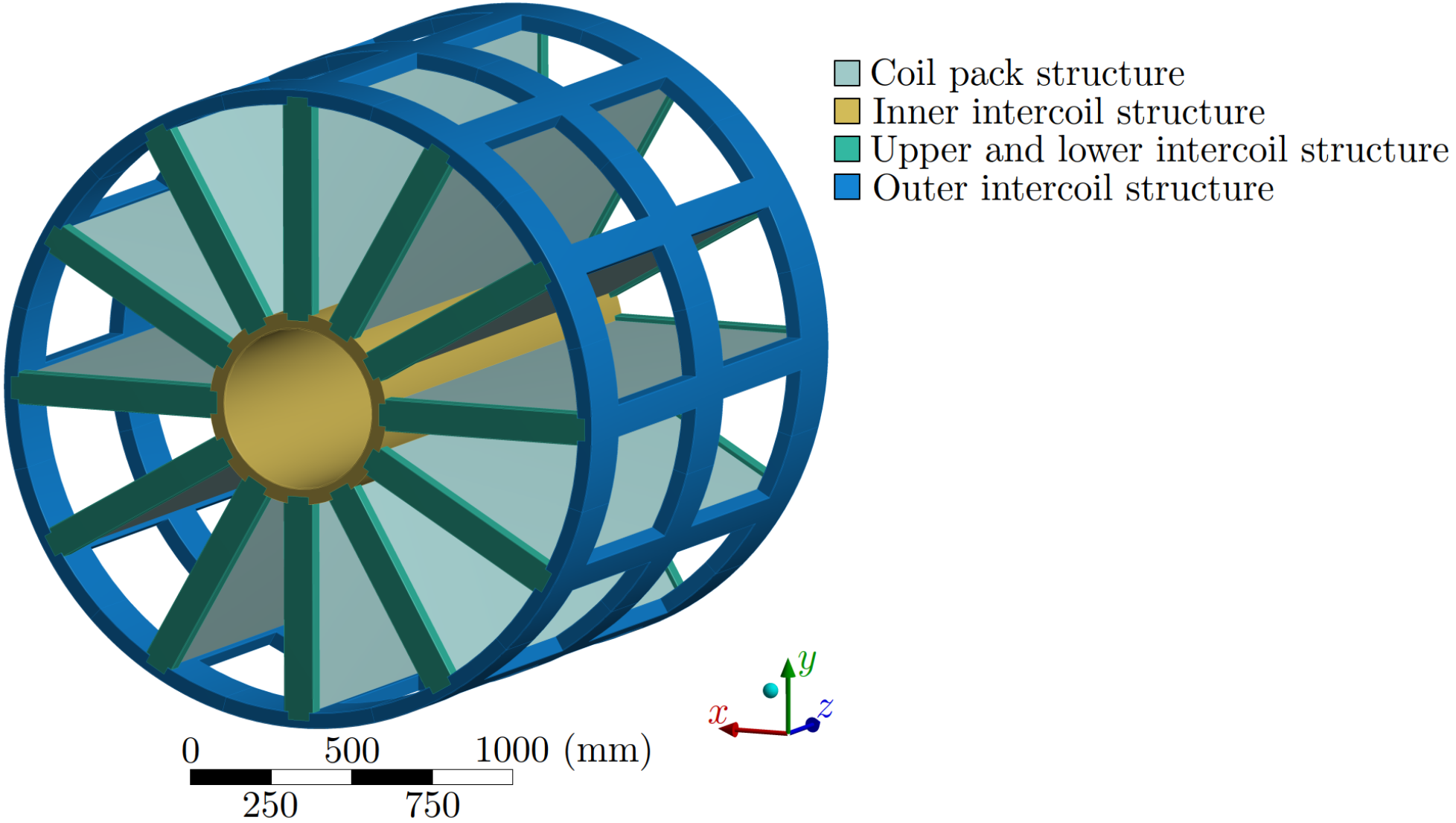


ARCOS mechanical analysis



Note: Due to symmetry only one quarter of a coil pack is shown. The cover plate and insulation are hidden in the figure.

ARCOS intercoil structure



Design and manufacture of AMaSED-2

AMaSED: **A**dvanced **Ma**gnetic **S**pectrometer **E**xperimental **D**emonstrator

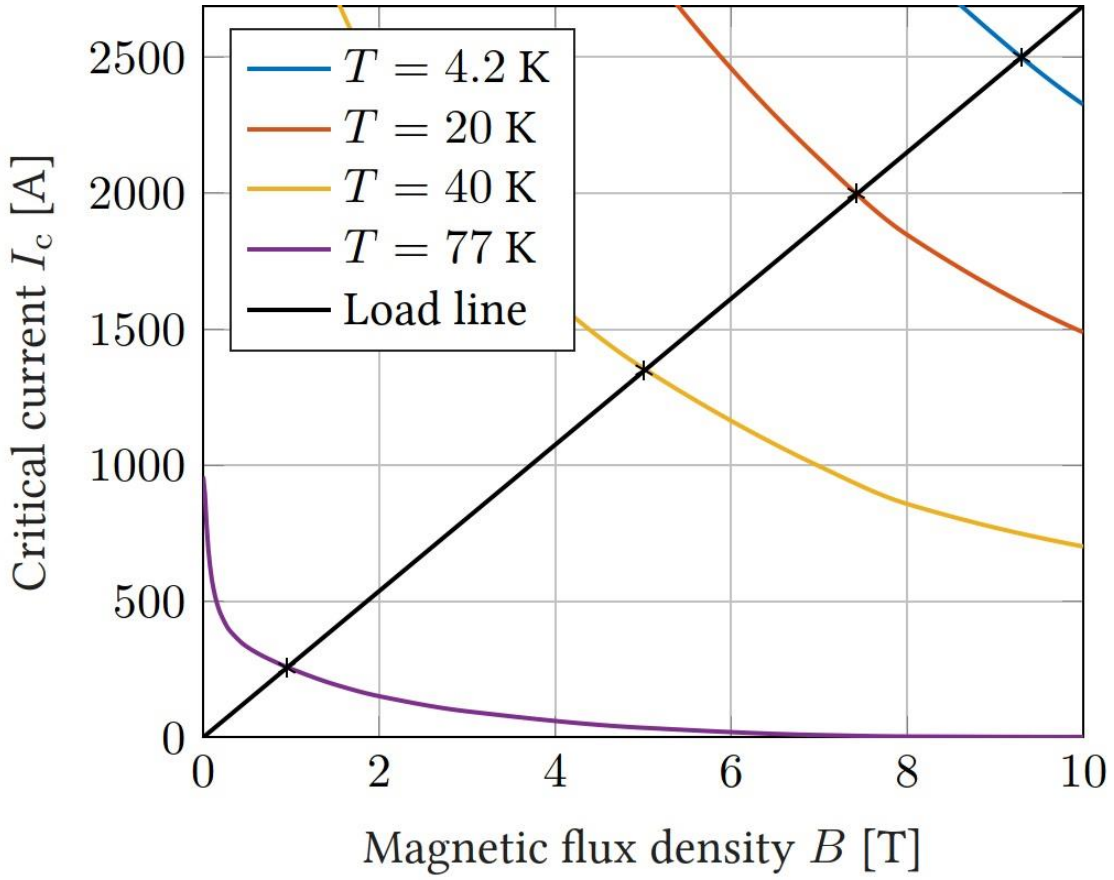
Main goals for the demonstrator:

- Copper bands as current leads and layer jumps
- Test medium sized no-insulation coil
- Test design of aluminum structure

AMaSED-2 conductor requirements

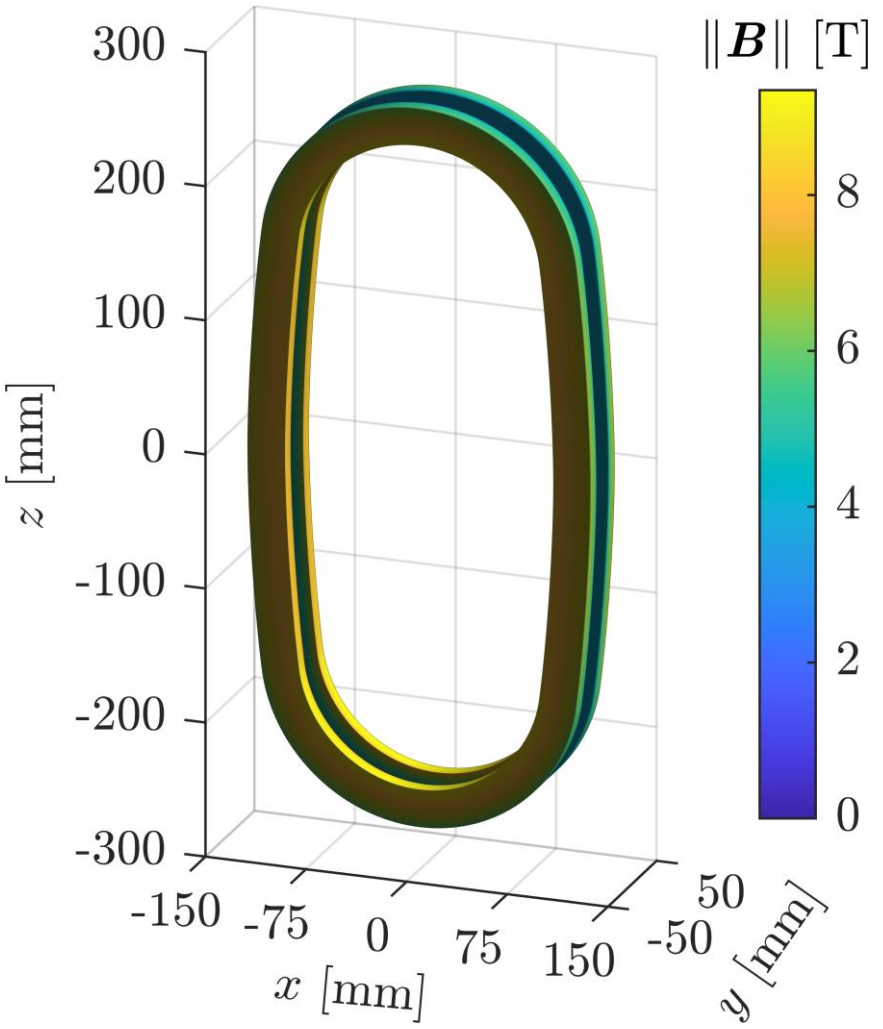
HTS ReBCO tape:

- 12 mm wide, 100 µm thick
- J_e = 600 A/mm^2 at 4.2 K and 20 T
- Angle dependence: worst case conditions
- Field dependence: Robinson Research Institute HTS Wire database, extrapolated to lower temperatures and higher flux densities

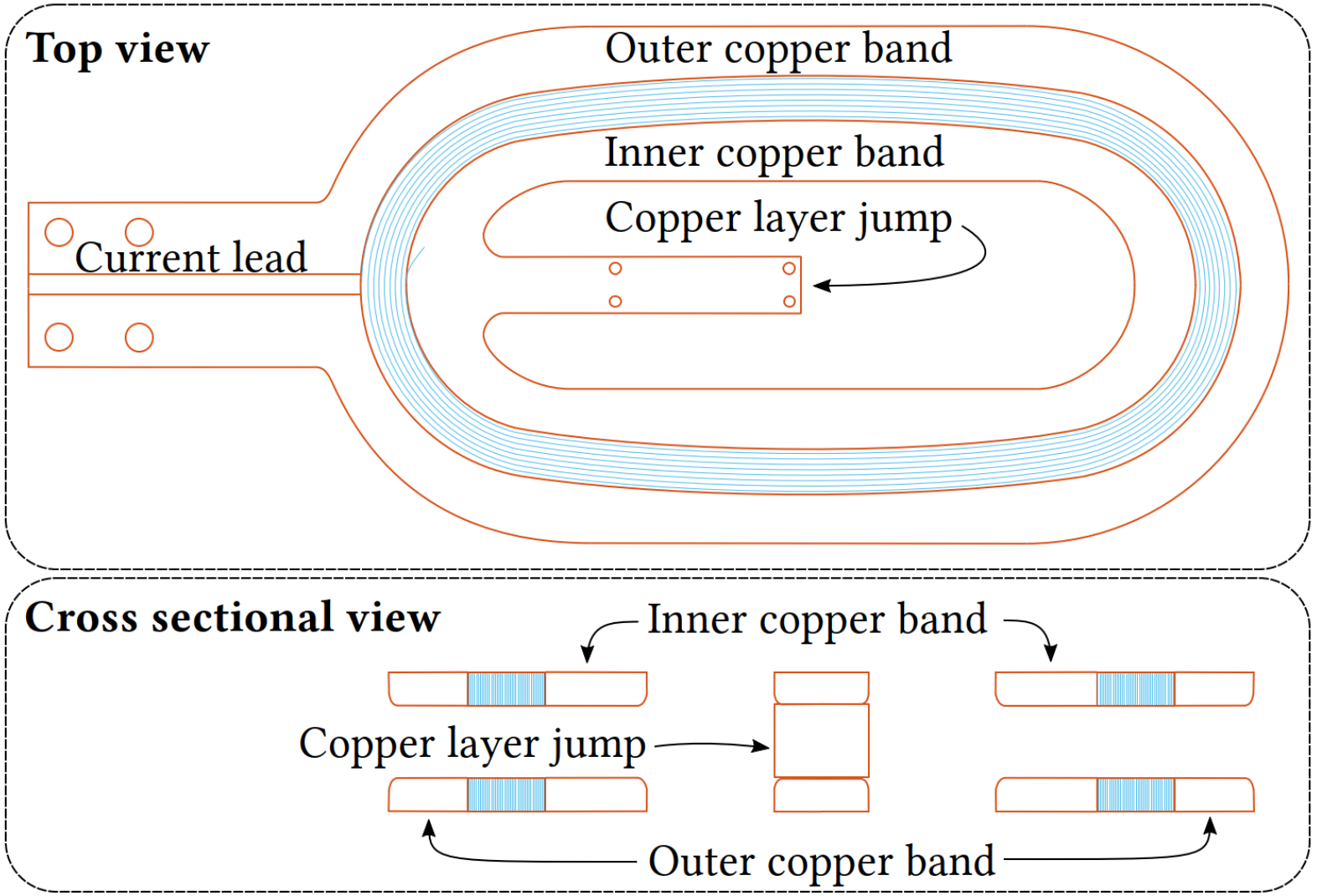


AMaSED-2 coil design

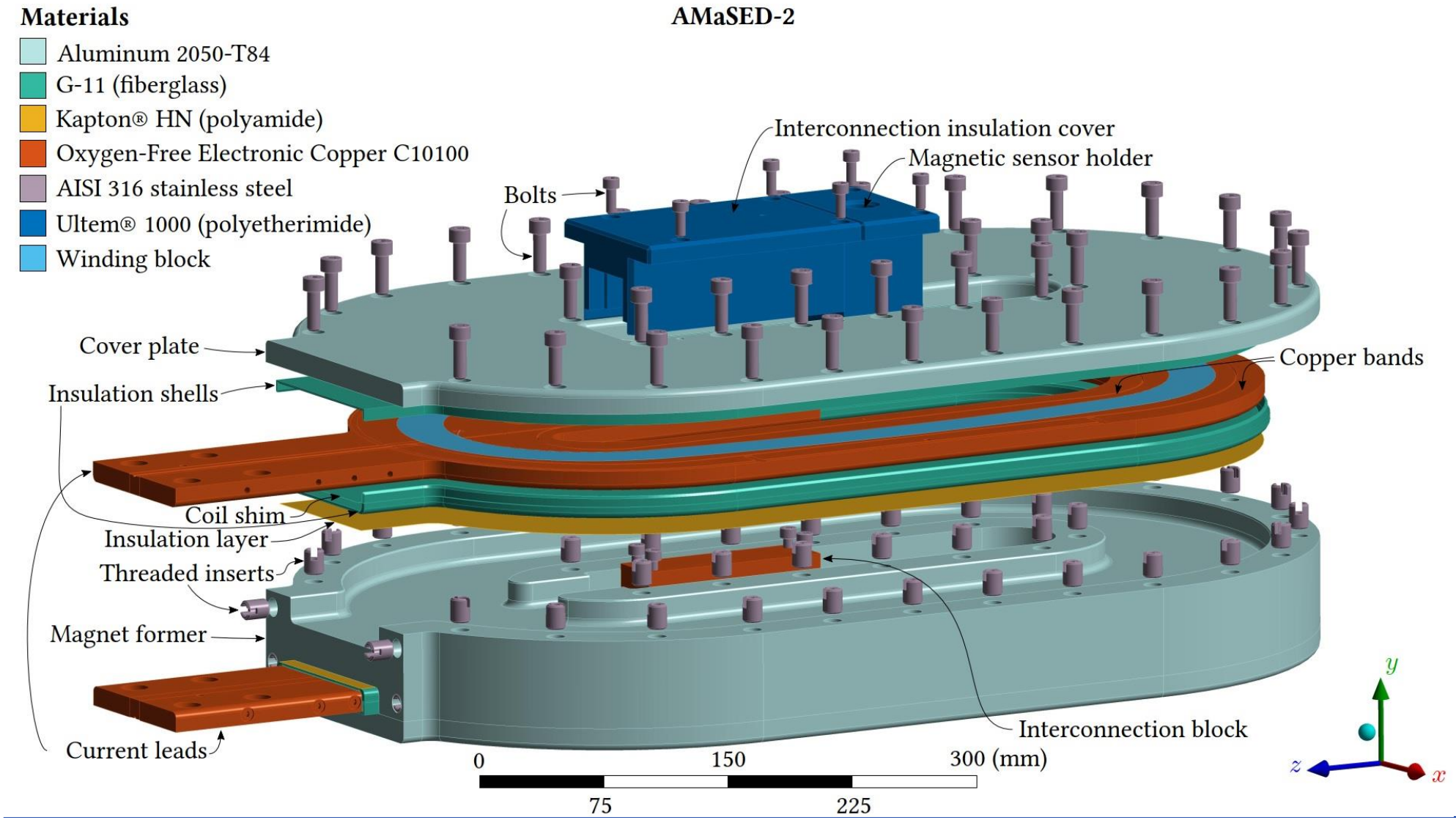
- Racetrack-like shape, size: 480 mm x 256 mm
- No-insulation coil, two HTS tapes (face-to-face)
- 724 m of 12 mm wide SuperPower HTS tape
- Theoretical maximum operating current: 2480 A at 4.2 K, and peak magnetic flux density of 9.3 T
- Stored energy: 143 kJ
- Inductance: 47 mH
- Central magnetic flux density: 2.8 T



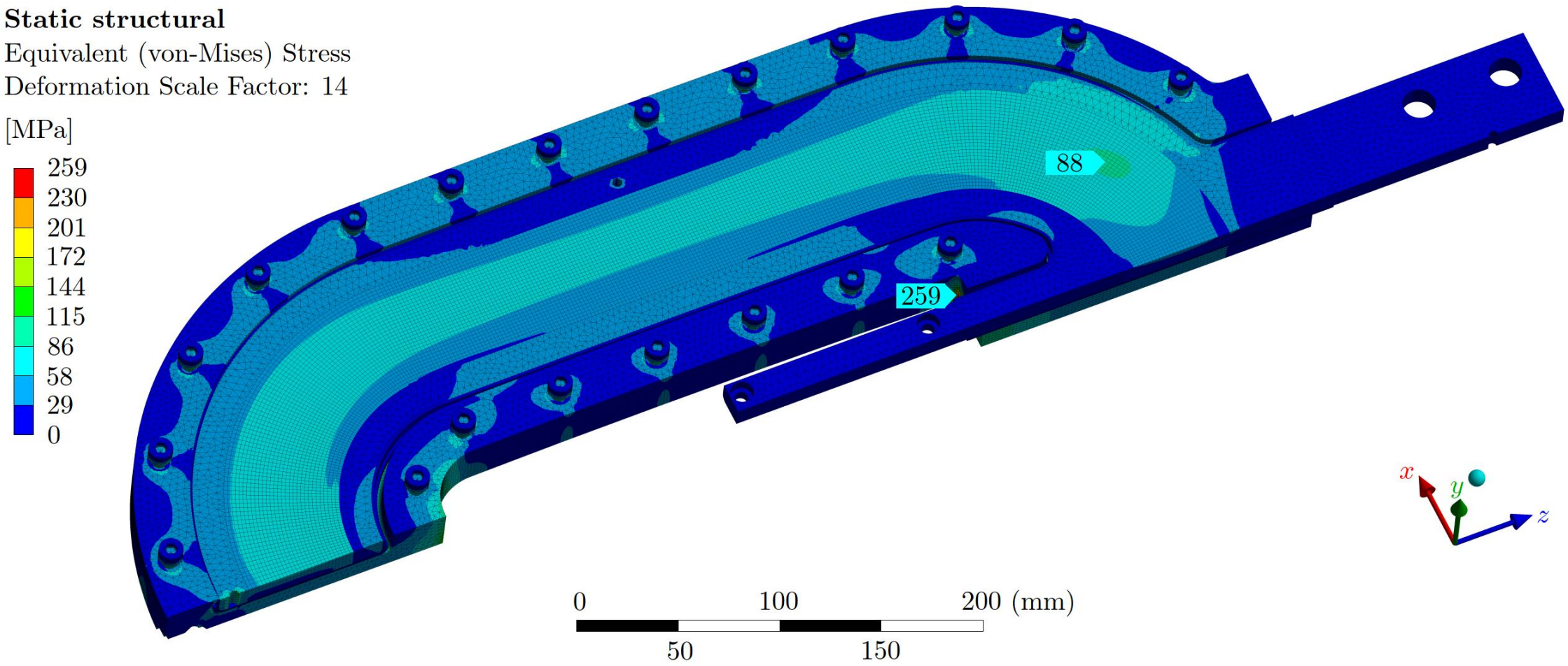
AMaSED-2 coil configuration



AMaSED-2 mechanical structure



AMaSED-2 mechanical analysis



Magnet manufacturing overview

The following coils have been built:

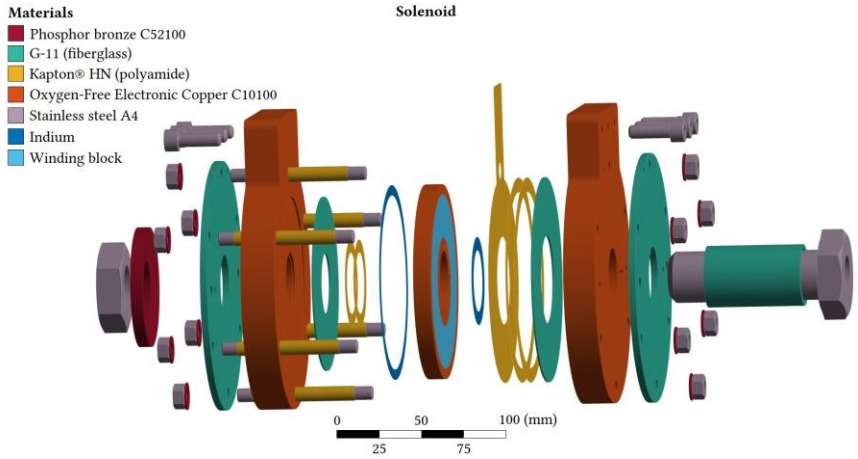
1) Small solenoids: Three configurations to test cable and solder configurations and charging/discharging behavior. Each coil uses 50-60 m of HTS tape

2) AMaSED-0: Mechanical model coil using copper coated stainless steel tape instead of HTS tape. Cable consists of two identical tapes.

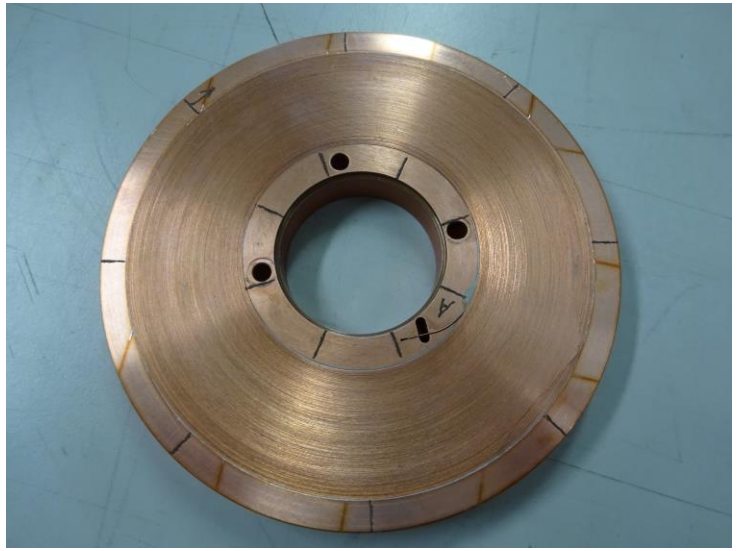
3) AMaSED-1: Single pancake practice coil using 380 m of THEVA HTS tape. Cable consists of a two-tape stack.

4) AMaSED-2: Final demonstrator coil using 724 m SuperPower HTS tape. Cable consists of a two-tape stack.

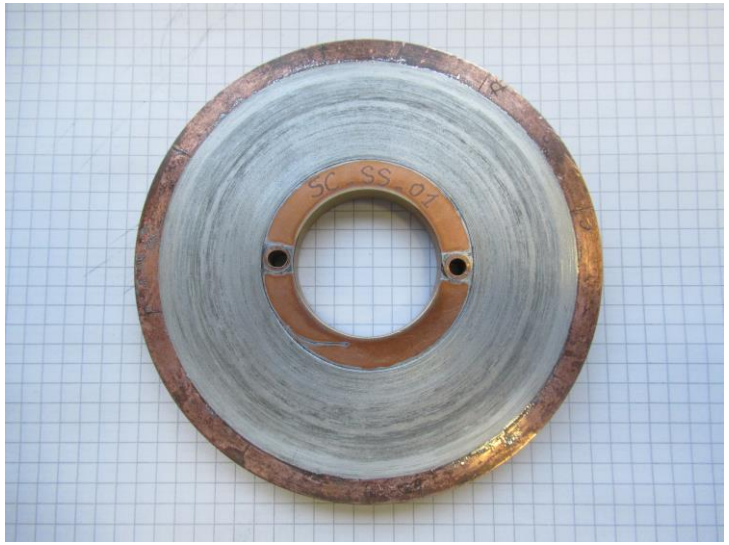
Small solenoids



1) Single HTS tape,
non-insulated, non-soldered

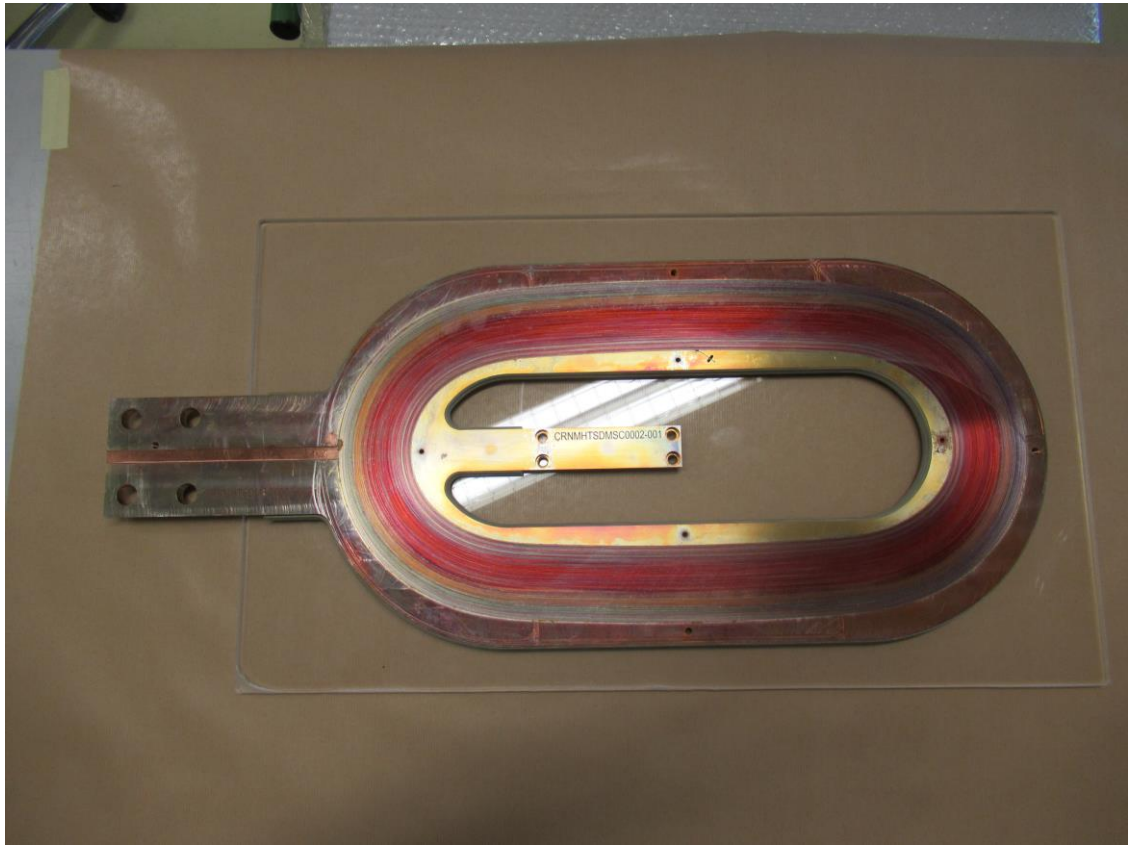


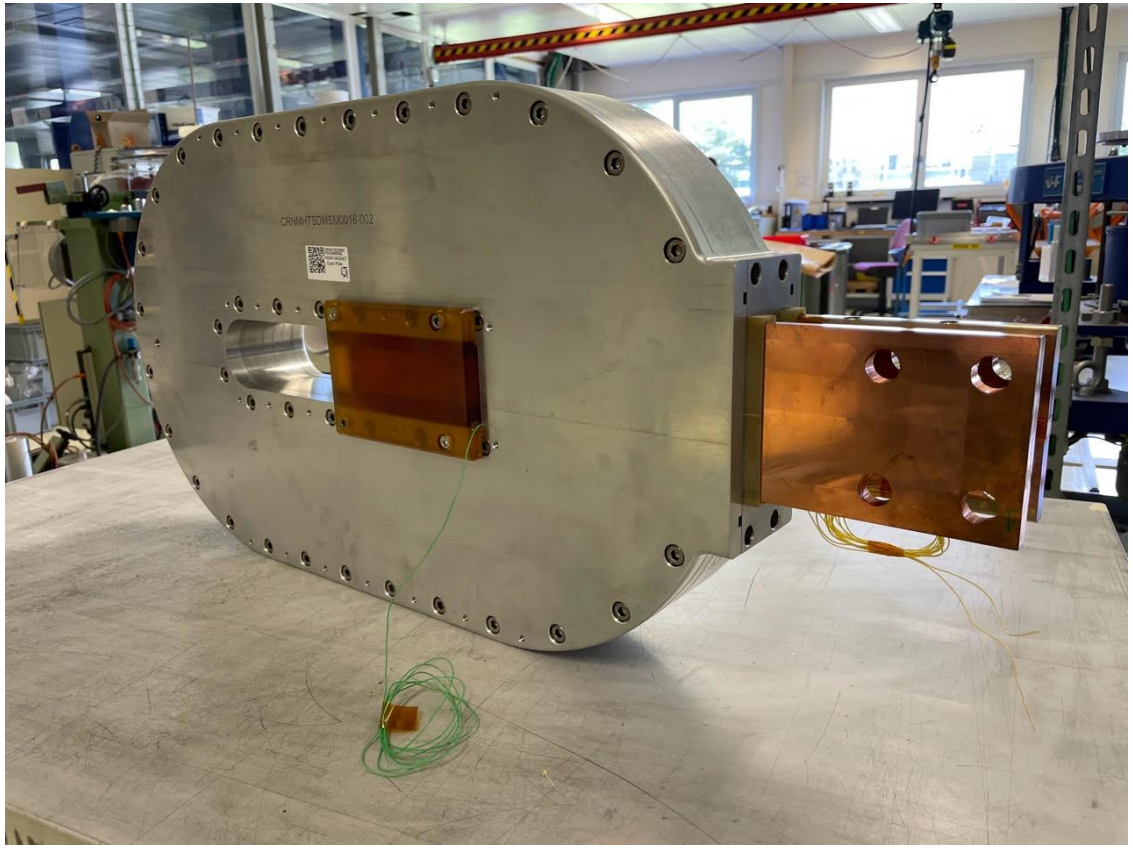
2) Single HTS tape,
non-insulated, soldered



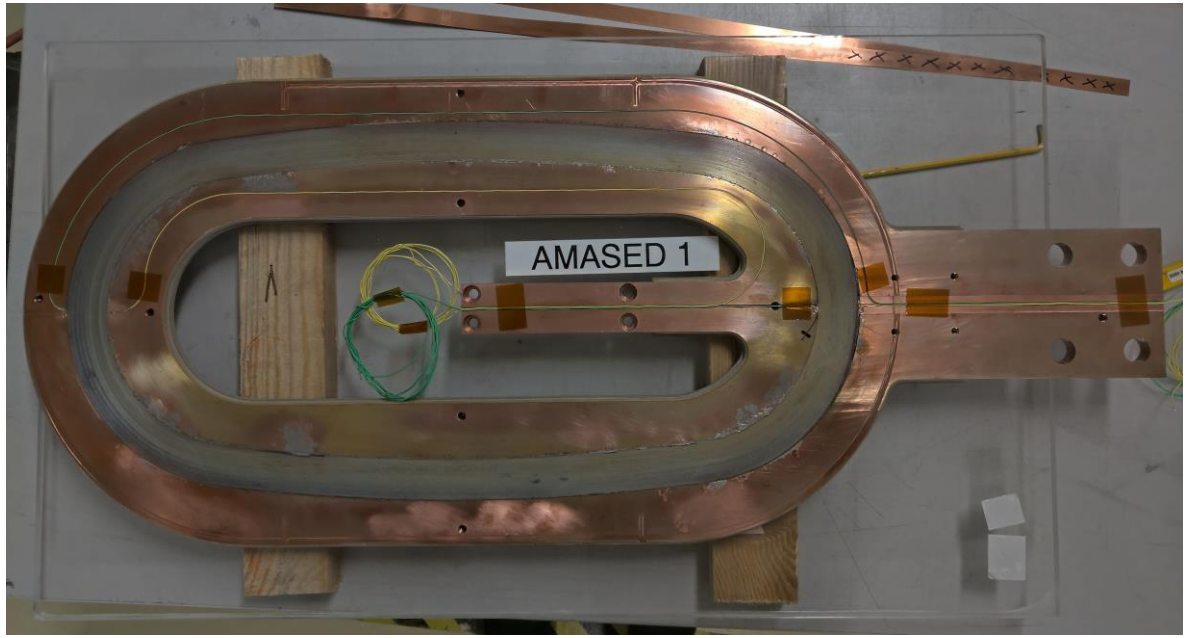
3) Two HTS tapes,
non-insulated, non-soldered

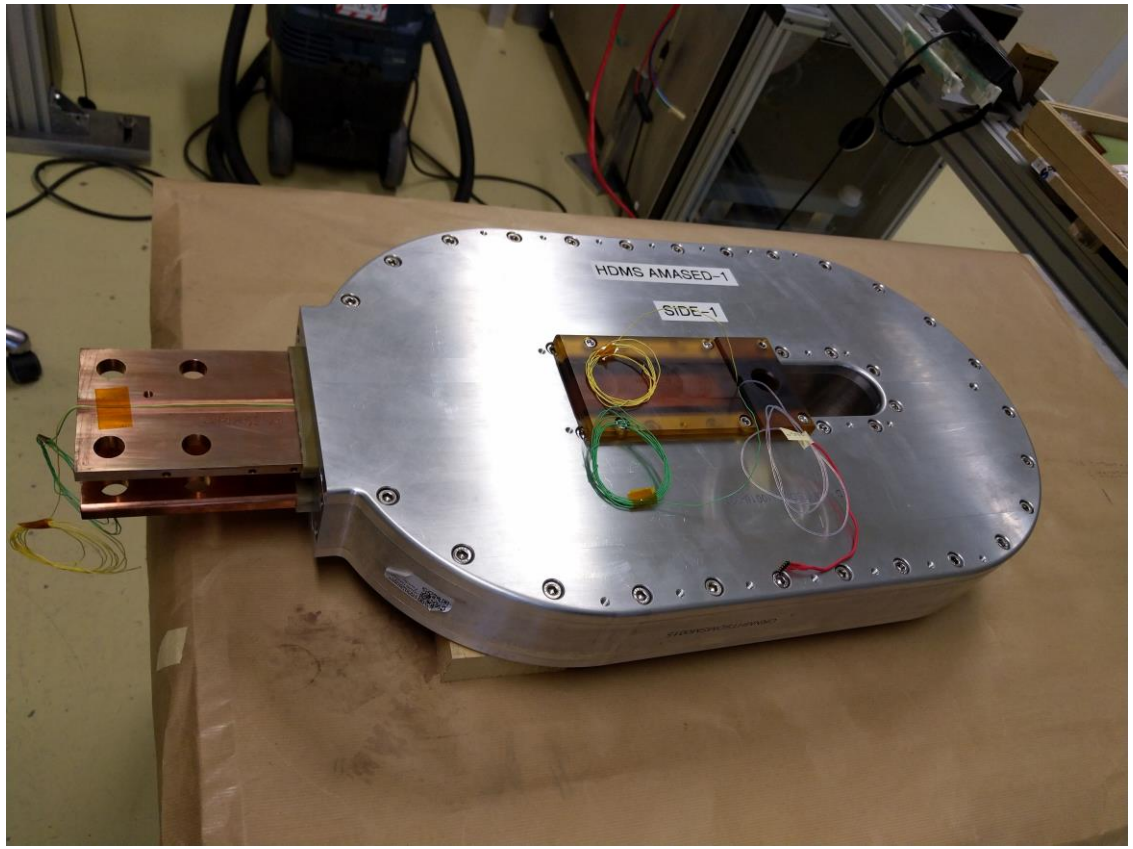
AMaSED-0



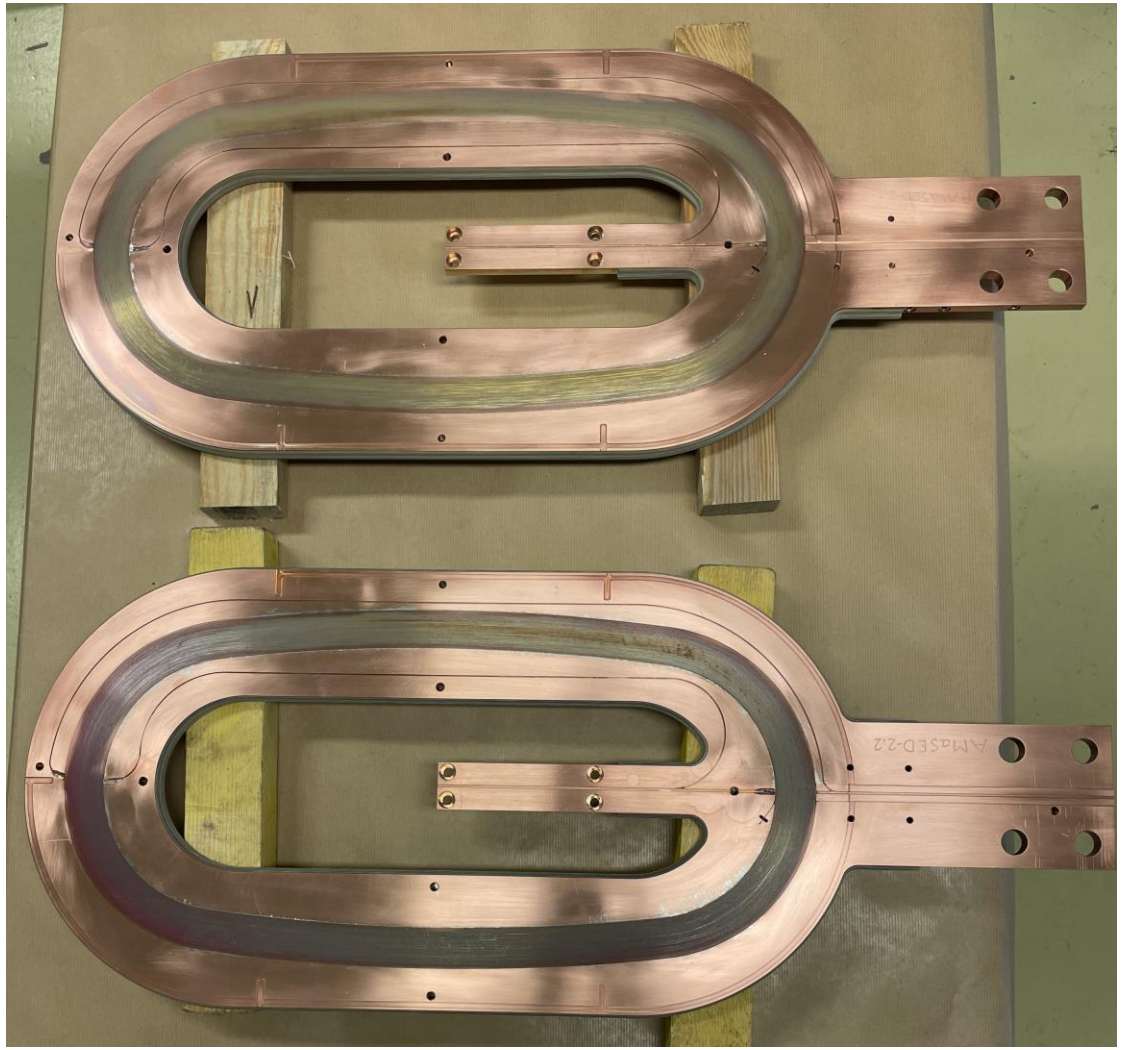


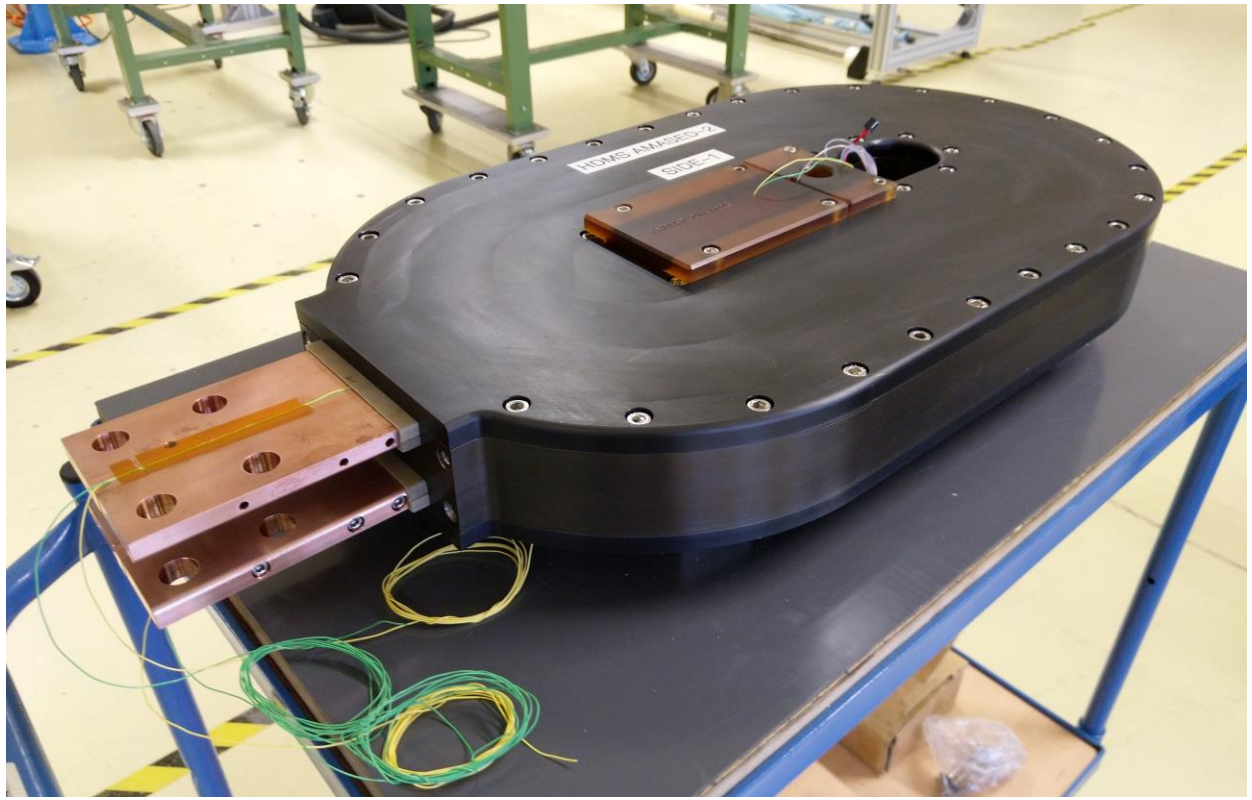
AMaSED-1





AMaSED-2





Summary of the HDMS project

Part 1: Conceptual design of the ARCOS magnet

- 12 racetrack-shaped coil packs
- Bending strength: 3 Tm, peak field: 11.9 T
- Lightweight aluminum structure

Part 2: Design and manufacture of AMaSED-2

- Small-scale version of a single coil pack of the ARCOS magnet
- No-insulation coil
- Status: AMaSED-2 has been manufactured, awaiting cold test