PSI

HFM High Field Magnets Programme

CHART Swiss Accelerator Research and Technology

Progress on the PSI Subscale Stress-Managed Common-Coils SMCC

Final Assembly and instrumentation

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WG Common-Coils, 19 June 2024

Agenda

- Magnet Parameters and Goals
- Instrumentation Overview
- Final Assembly (Pictures)
- Subscale SMCC and BigBOX tests

Subscale Stress-Managed Common-Coils (SubSMCC) | Acknowledgment

CHART: B. Auchmann, A. Brem, T. Michlmayr, C. Müller, J. Schmidt, A. Stampfli

PSI magnet section: R. Felder

LBNL: D. Arbelaez, I. Pong, P. Ferracin, S. Prestemon (Nb_3Sn cable)

CERN: E. Ravaioli, M. Wozniak, A. Verweij (protection studies)

CERN: T. Boutboul, S. Hopkins, A. Bonasia (Ic measurements from witness samples)

CERN: F-J. Mangiarotti, C. Petrone, J. Feuvrier, S. Russenschuck (testing, magnetic measurement)

CERN: F-O. Pincot, J-C. Perez, A. Haziot, E. Todesco, A. Milanese (reaction of two coils)

CERN: L. Gentini (magnet integration into the cryostat)

Subscale Stress-Managed Common-Coils (SubSMCC)

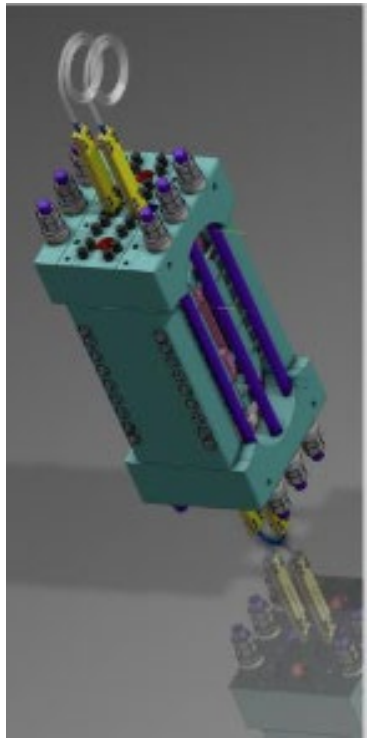
Validating manufacturing process and introducing advanced concepts: coil pre-load free, at room temperature; stress-management structure and splicing on the low-field region.

Fast turn-around platform for testing matrix systems; protection concepts and cooling options.

Possibility to test a Hybrid magnet with LTS (Nb_3Sn) Common-Coils and HTS racetracks

LTS (Nb_3Sn) conductor manufactured by LBNL (cct subscale cable)

Parameter	CCs
B_{0_ss} in T	5.1
B_{peak_ss} in T	6.3
I_{ss} in kA	9.2
E_{mag_ss} in kJ	16.4



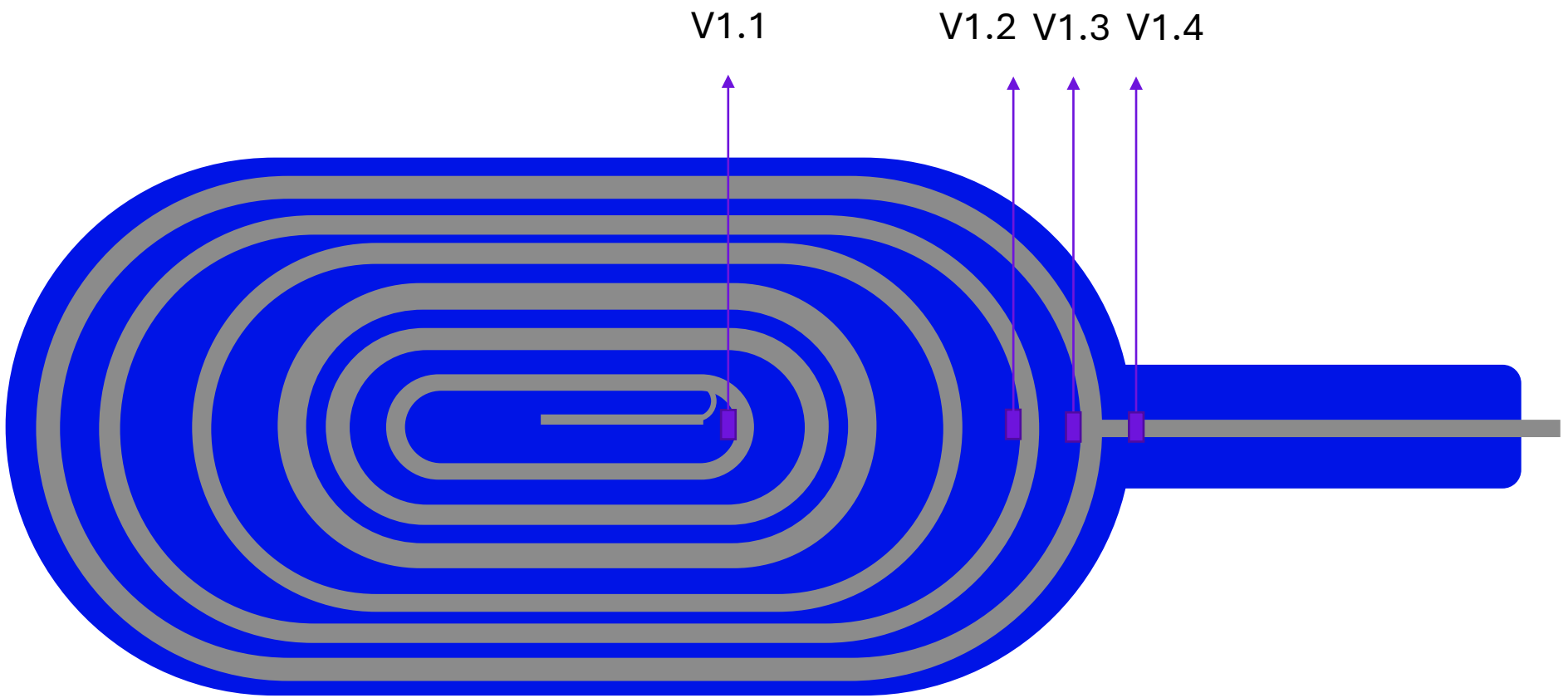
Number of turns	Wire type	N wire x dia in mm	Cu/nCu	Bare Cable dimensions in mm	Insulation thickness in mm
18 / layer	Nb_3Sn RRP® 132/169	11 x 0.6	1.17	3.8 x 1.3	0.155

T_{op}	I_{ss}*	B_{peak} in T	B_0 in T	J_{sc} in A/mm²	J_{cu} in A/mm²	J_{ov}** in A/mm²
4.5 K	9.2 kA	6.3	5.1	6418.9	5486.3	1390.3

* From 3D without including the self-field contribution

** Including insulation area

Instrumentation: Nomenclature of voltage taps (former 1)

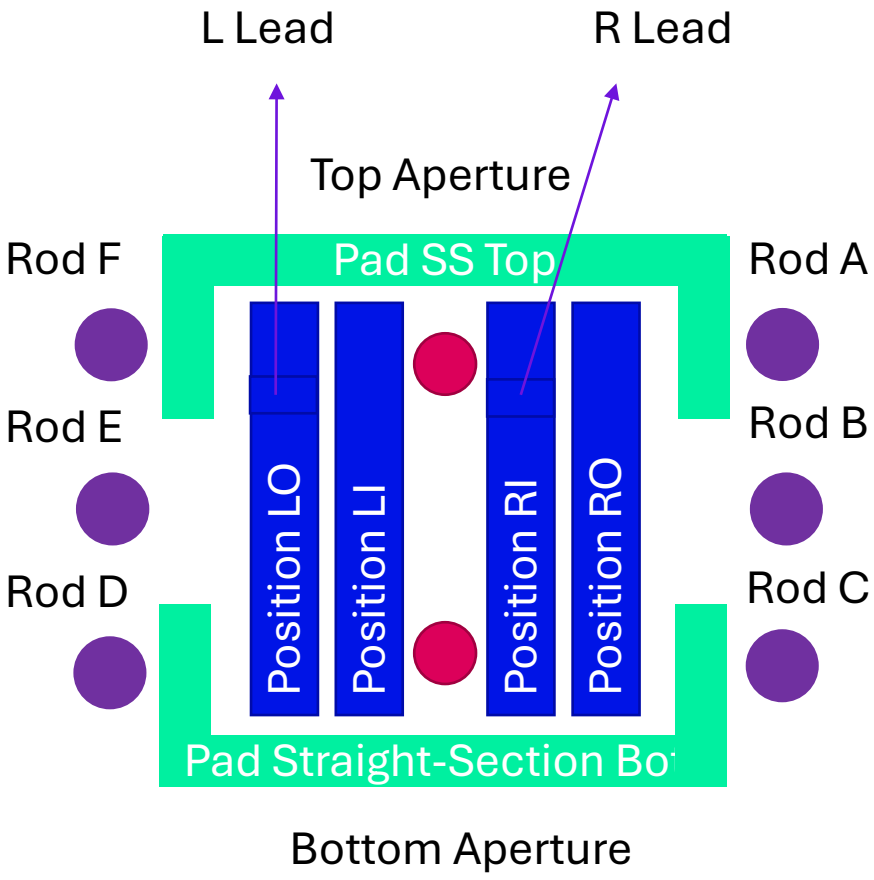


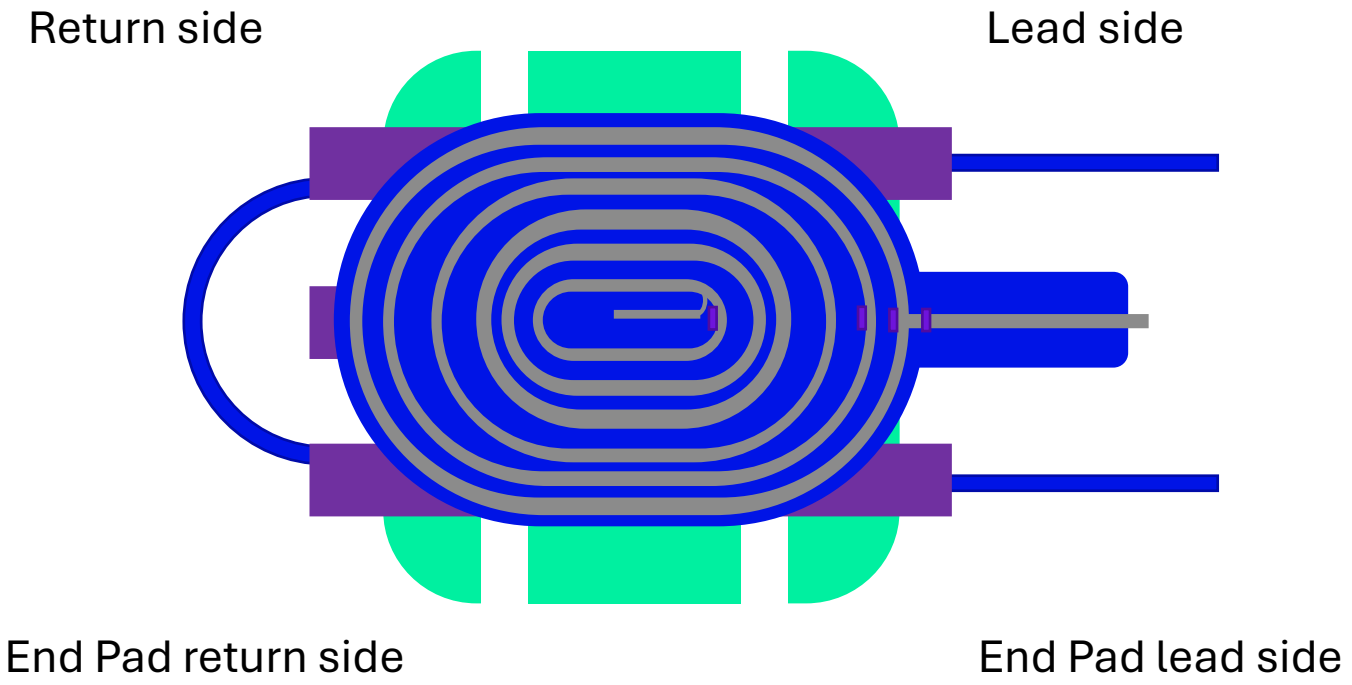
VF.P

Former number

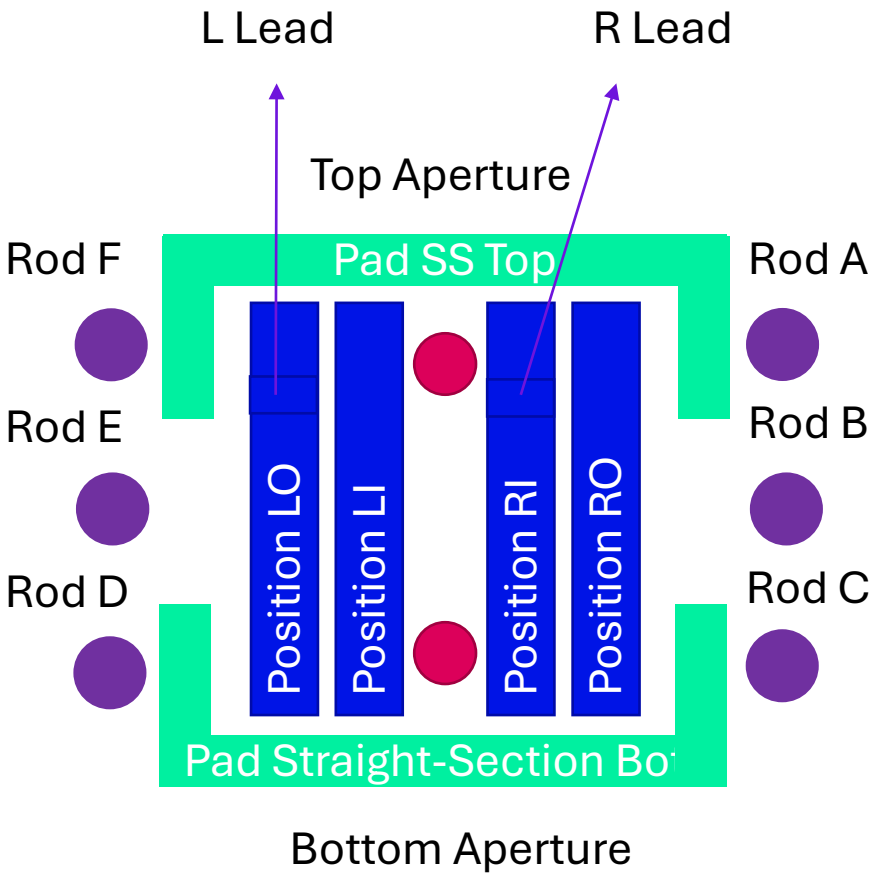
Position number

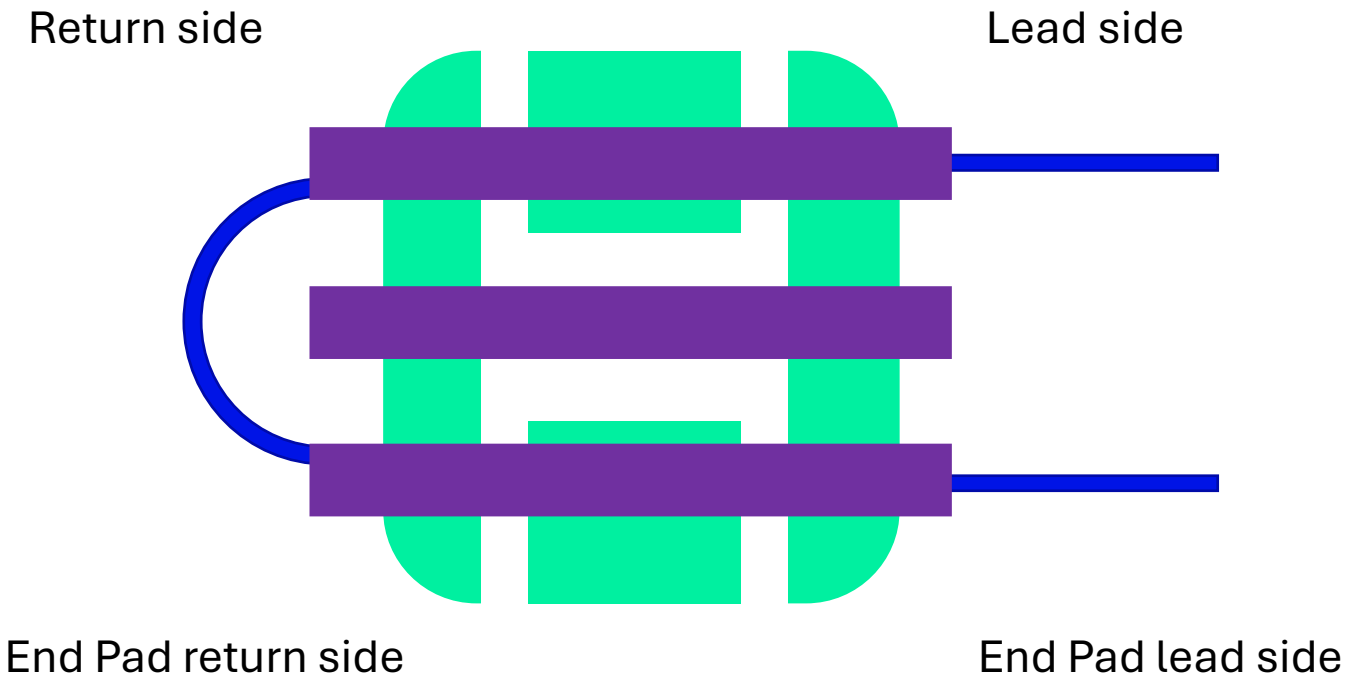
Instrumentation: Nomenclature of parts



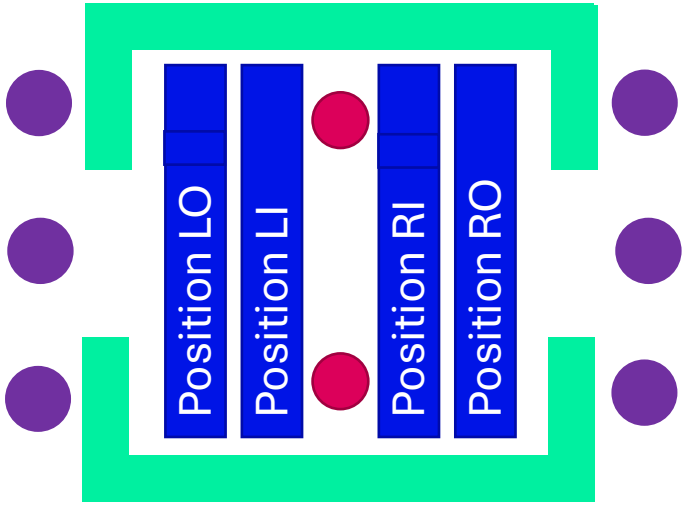


Instrumentation: Nomenclature of parts

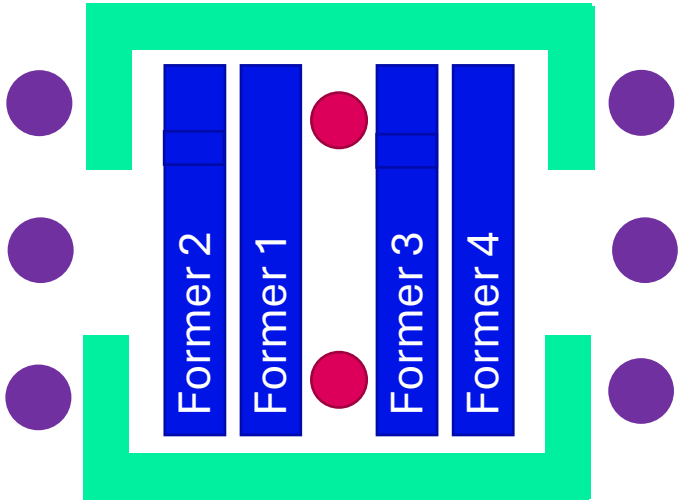




Instrumentation: voltage taps pairs



Test configuration



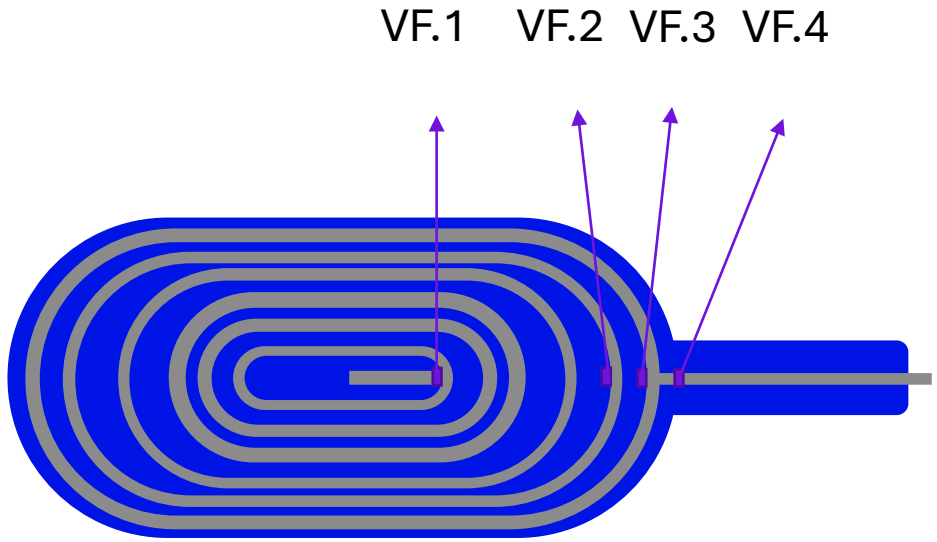
Twisted Pairs

	Right Side	**Left Side**
	V3.4 – V3.3	V1.4 – V1.3
	V3.3 – V3.2	V1.3 – V1.2
	V3.2 – V3.1	V1.2 – V1.1
Layer jump	V3.1 – V4.1	V1.1 – V2.1
	V4.1 – V4.2	V2.1 – V2.2
	V4.2 – V4.3	V2.2 – V2.3
	V4.3 – V4.4	V2.3 – V2.4

Return Side **V_{tot}**

V4.4 – V1.4 V3.4 – V2.4

Magnet Structure: V MS

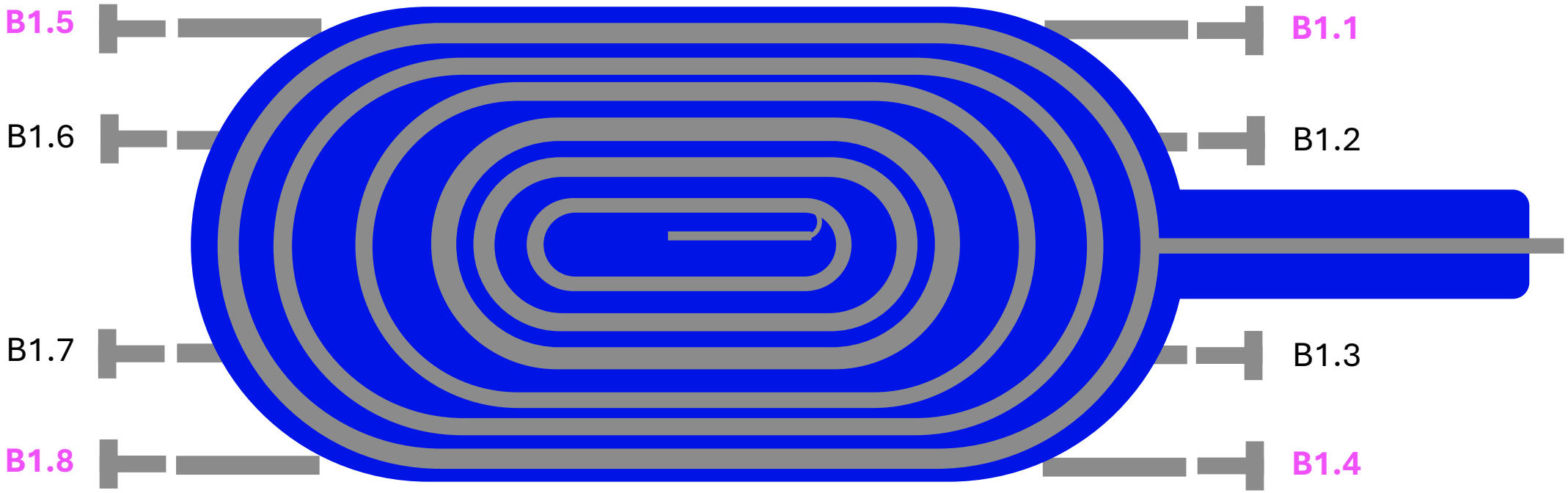


VF.P

Former number

tap Position

Instrumentation: bullets (former 1)



16 x Bullets (mainly for pre-load at room temperature)

- SG uarter-bridges
- Cr – Ni / Polyimide TML CFLA-1-350-17
- Direction: Z
- Channels: 16

BF.P

Former number

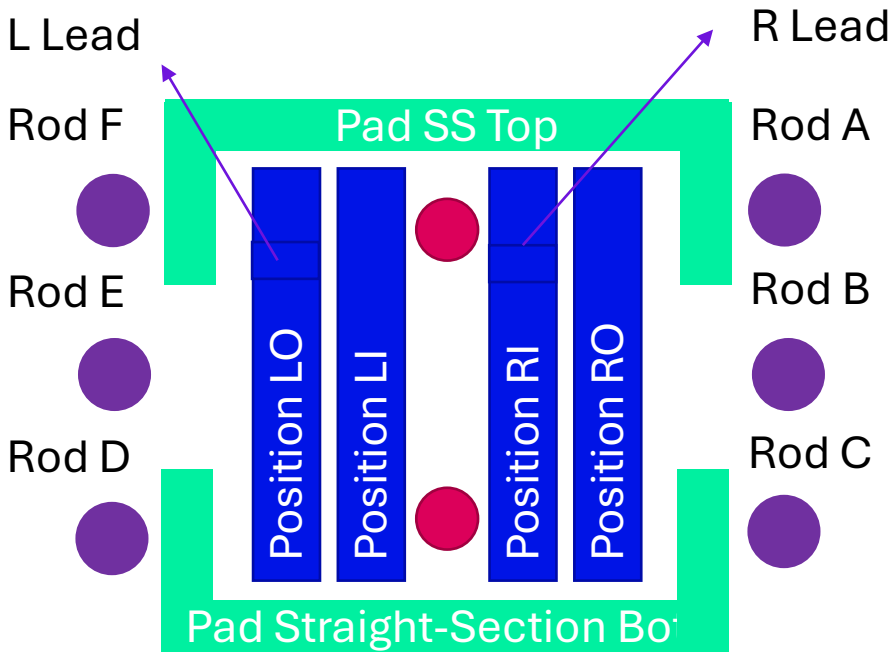
Bullet Position

Instrumentation: Strain gauges

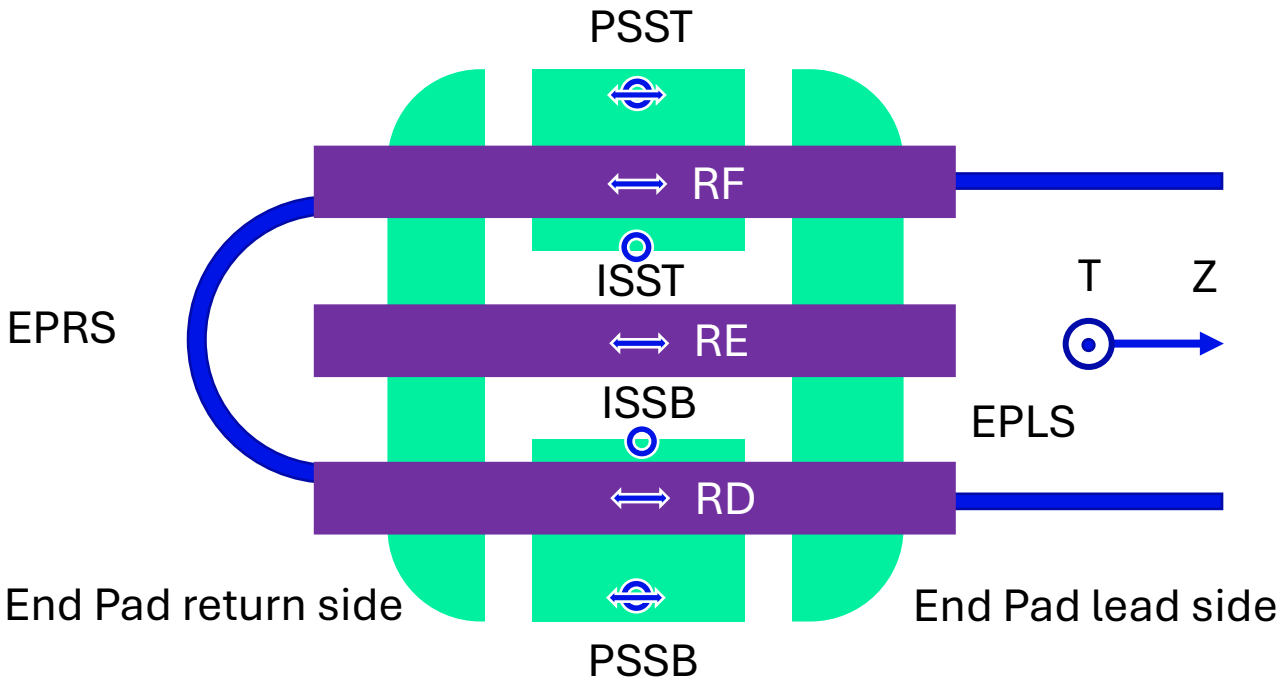
Z: longitudinal, T: transversal

6 x Rods (RA, RB, RC, RD, RE and RF)

- SG full bridges
- Cr – Ni / Polyimide HBM XC11-3/350
- Direction: Z
- Channels: 6



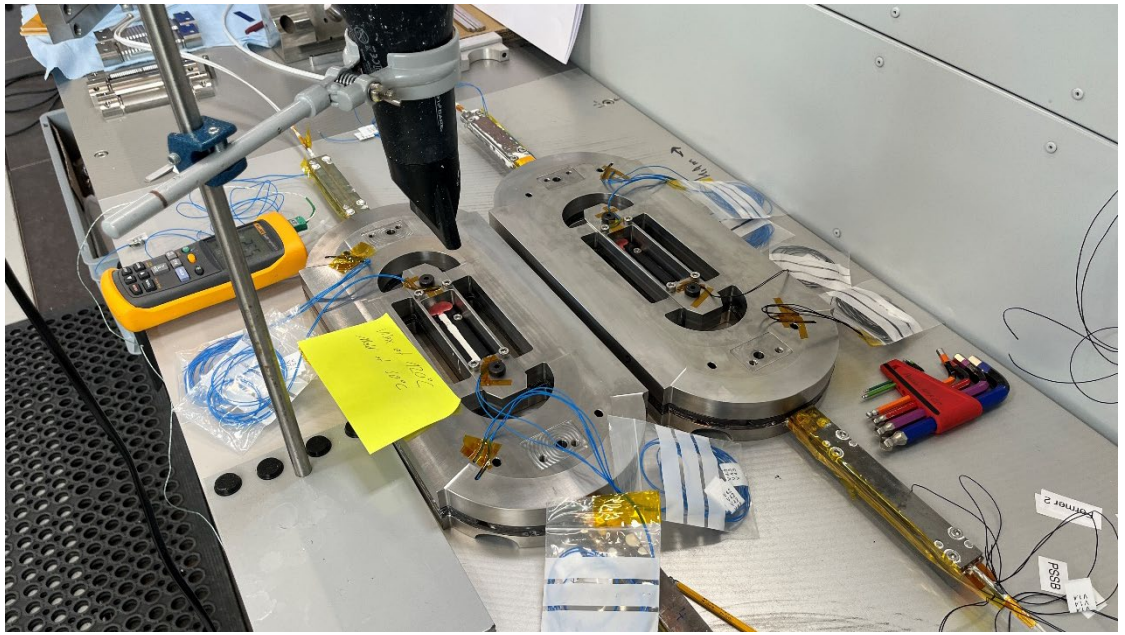
- 4 x Pads (PSST, PSSB, ISST, ISSB)
  - SG quarter bridge, T compensated (dummy) or double quarter bridge
  - Cr – Ni / Polyimide HBM XC11-3/350
    Direction: Z and T for PSS and T for ISS
  - Channels: 6



Final Assembly

Splicing of pancakes

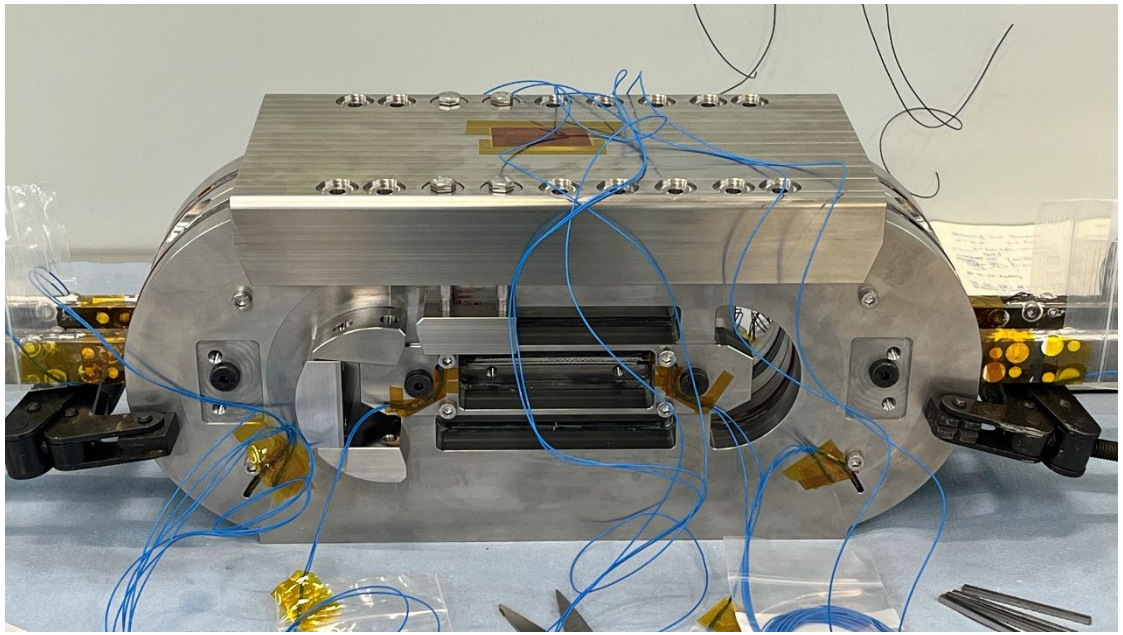
Filling the splicing region with filled wax



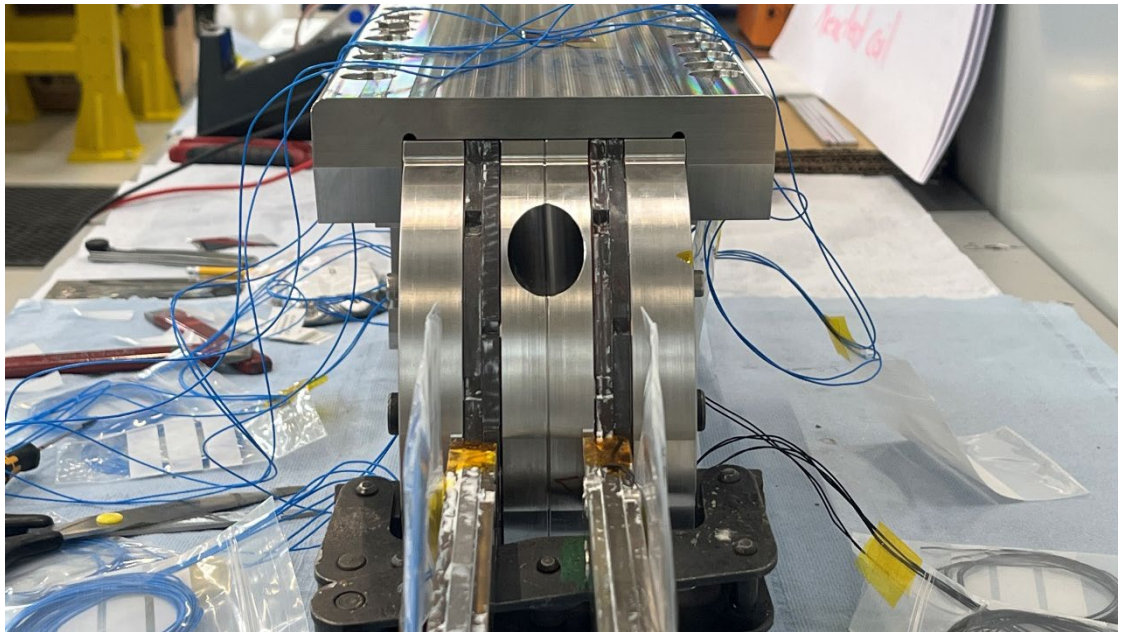
Two double pancakes prepared before assembly

Each pancake was spliced with NbTi leads

Final Assembly



Coils and plates assembled with one outer pad (straight section) and inner pads (ends)

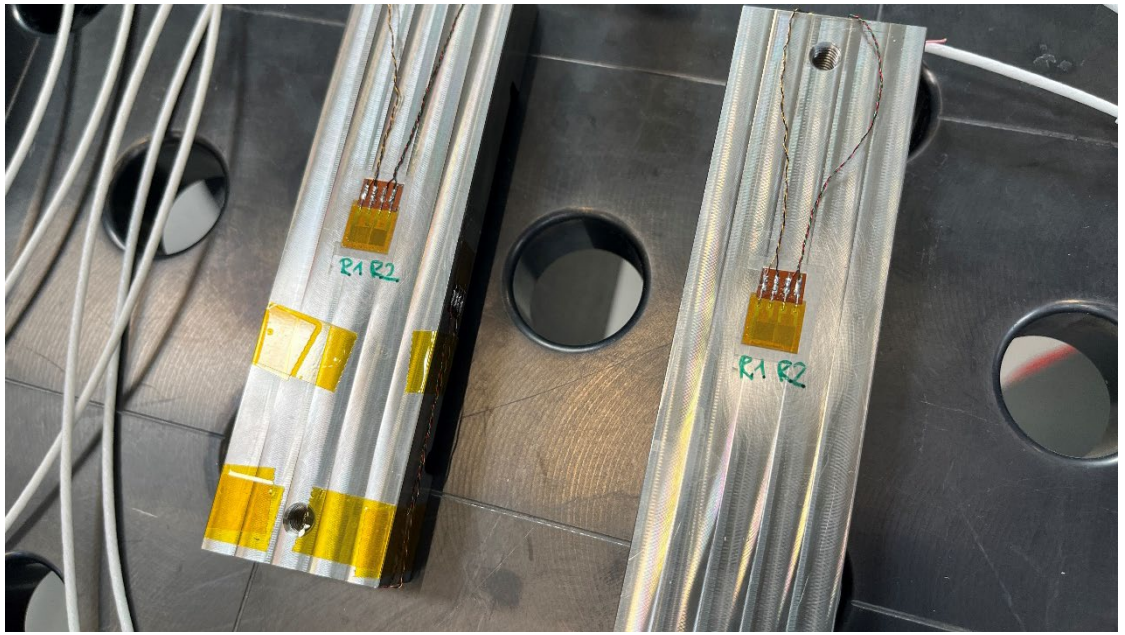


View of coils inner plates (forming the bore) and outer plates (to be removed for future tests)

Timelapse 1

Final Assembly

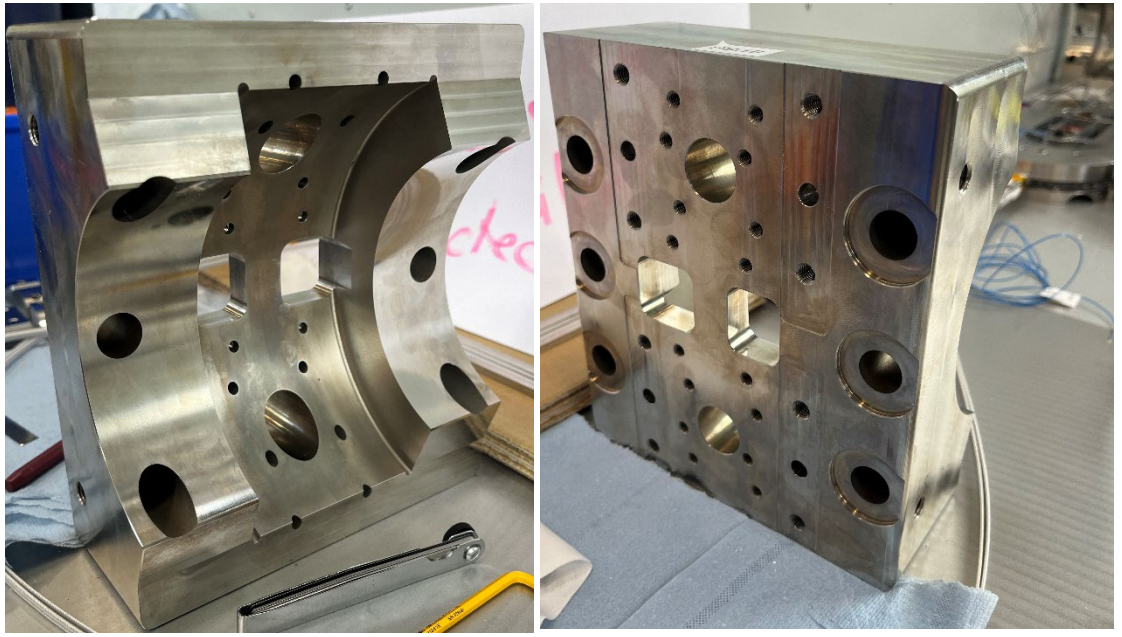
Outer pad (straight section) instrumented with strain gauges and field + temperature compensators (2 directions)



Inner pad (straight section) instrumented with strain gauges (1 direction)

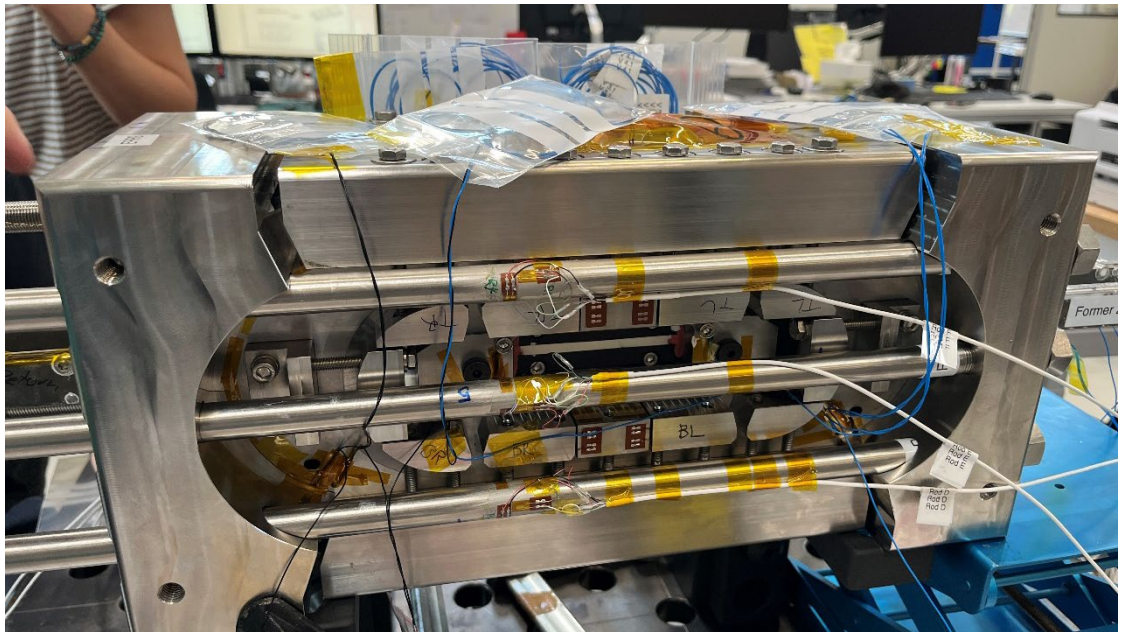
Final Assembly

6 x Instrumented stainless steel rods (compensation for bending)

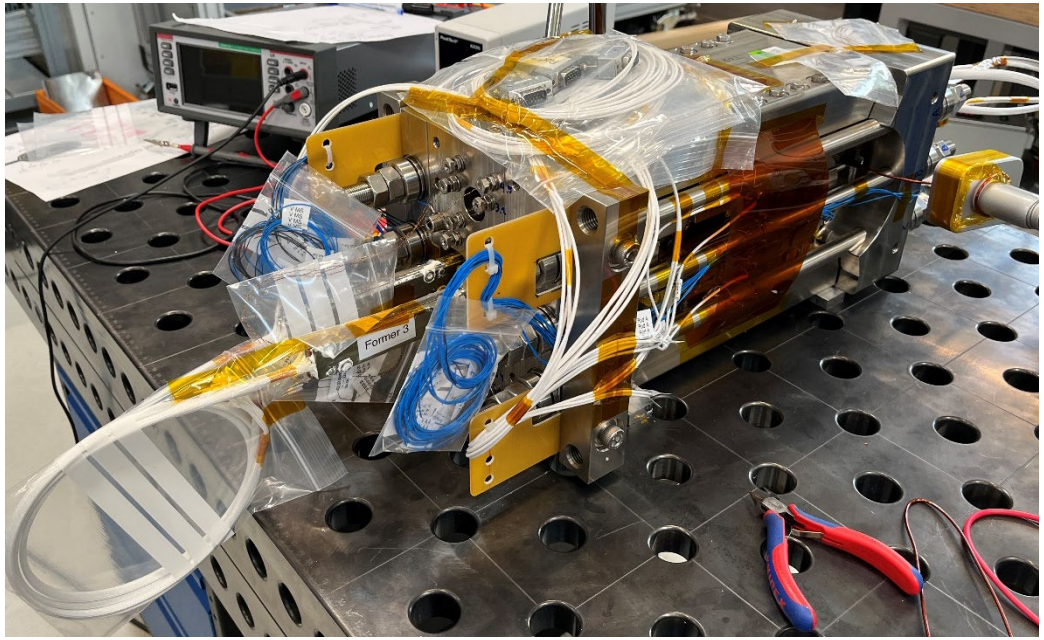


End-pads for return and lead side (holes for rods and bullets)

Final Assembly



End-plates and rods assembled before axial pre-load



After axial pre-load

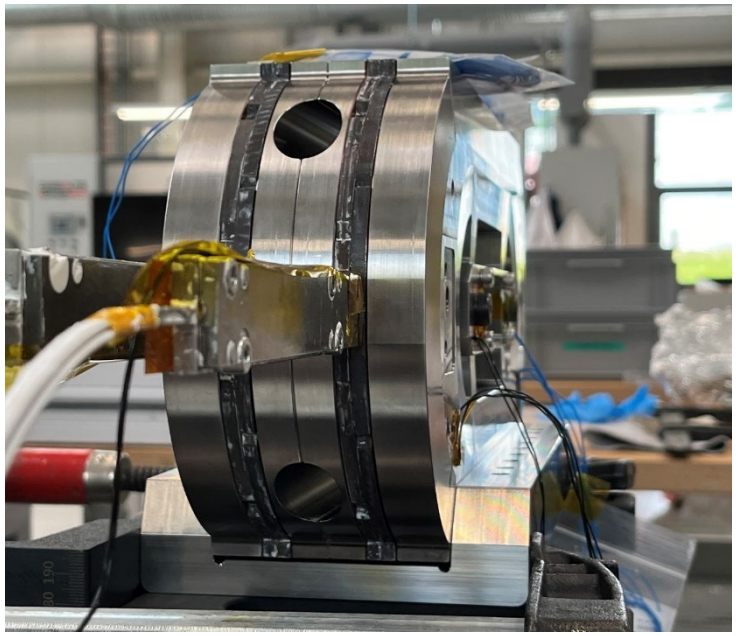
Secured instrumentation wires

Timelapse 2

Issues

- Required torque for the axial pre-load higher than expected
  - Share between transversal and axial pre-load (the bullets are to be in contact with formers “earlier”)
- Short-circuit between Voltage tap 4.3 and former
  - Additional electrical measurements have been performed to conclude that it is a single short
- Short-circuit on one of the bullets
  - They will be disconnected from the HBM unit before powering

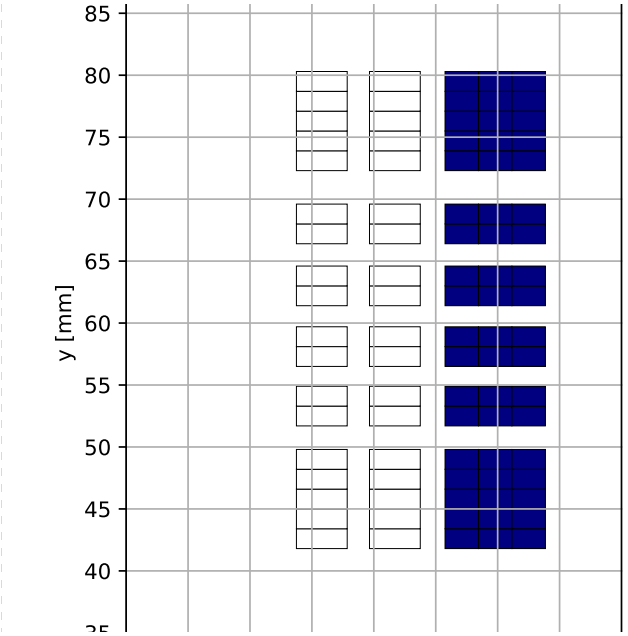
Subscale Stress-Managed Common-Coils (SubSMCC) | CHART/MagDev 2: 3 tests



Version: SubSMCC1

Description: LTS Nb_3Sn – Filled Wax

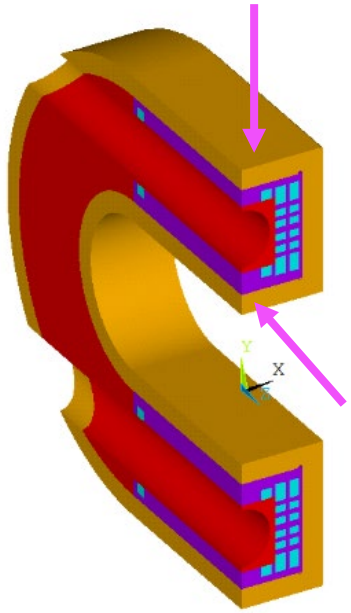
Goals: SMCC concept validation, first stand alone filled wax impregnated magnet



Version: SubSMCC1ESC

Description: Same 4 superconducting coils + **6 copper coils**

Goals: Test the Energy Shift with Coupling protection method

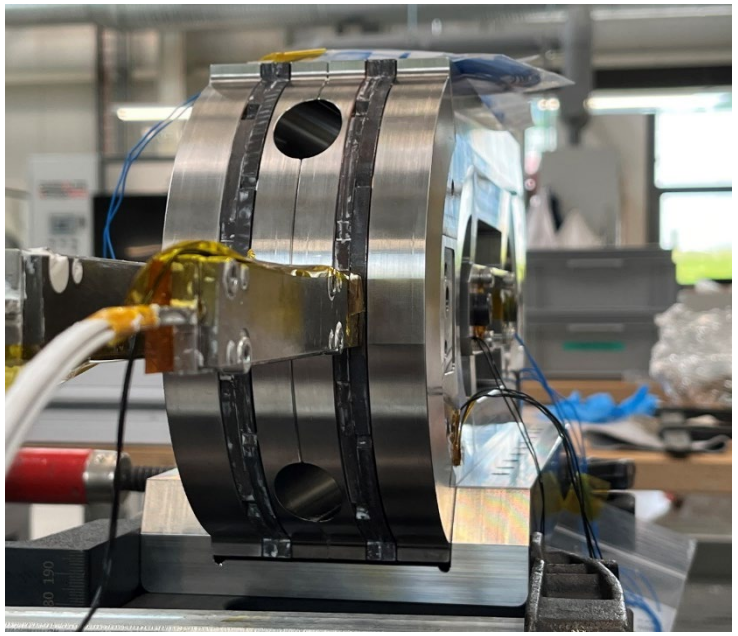


Version: SubSMCC1HTS

Description: Same 4 LTS superconducting coils + 4 (2?) **HTS ReBCO coils**

Goals: Test the Hybrid LTS/HTS configuration

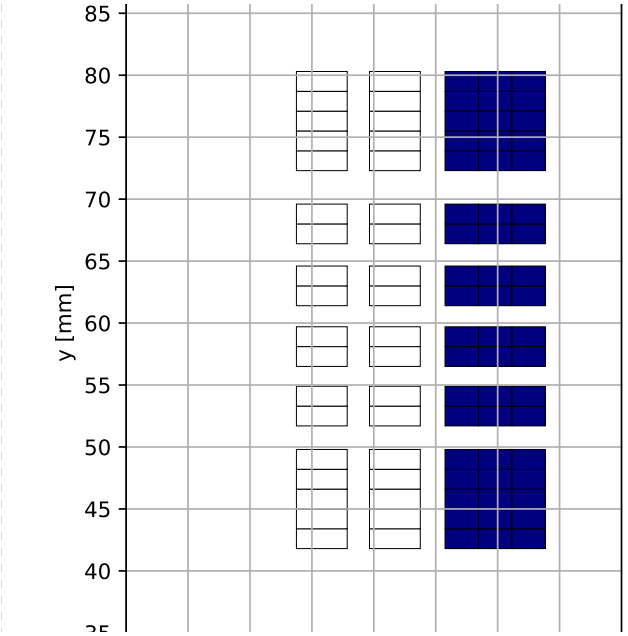
Subscale Stress-Managed Common-Coils (SubSMCC) | CHART/MagDev 2: 3 tests



Version: SubSMCC1

Description: LTS Nb_3Sn – Filled Wax

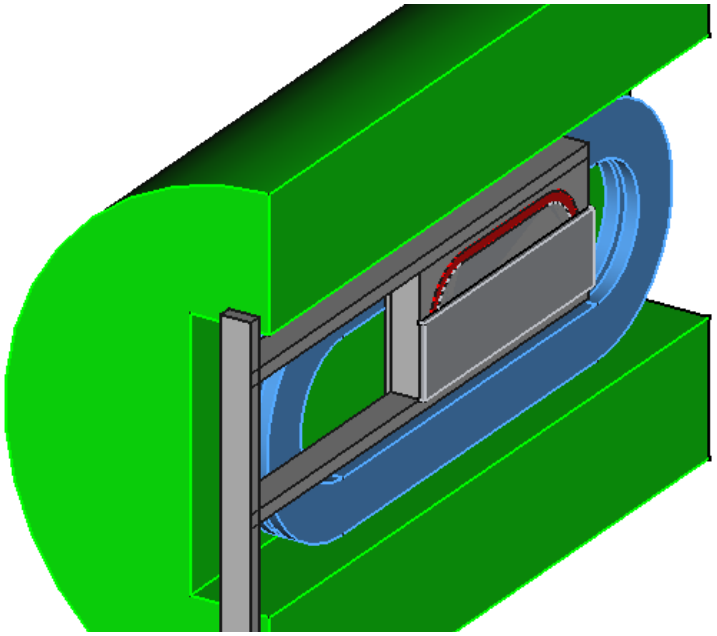
Goals: SMCC concept validation, first stand alone filled wax impregnated magnet



Version: SubSMCC1ESC

Description: Same 4 superconducting coils + **6 copper coils**

Goals: Test the Energy Shift with Coupling protection method



Version: BigBOX2

Description: **13 turns Nb_3Sn coil** tested under background field at BNL

Goals: Test the permanent degradation of filled wax in coil configuration