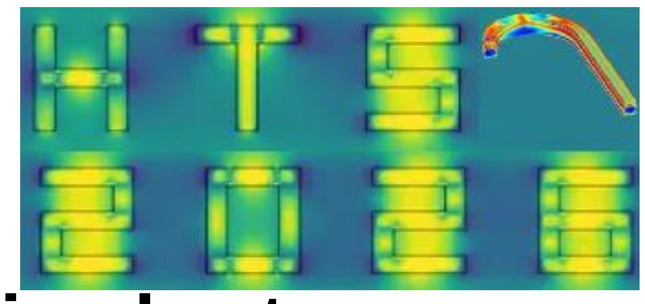

Transformer configuration for induced current in short-circuited multilayer CORC cable

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Remountable joints in fusion coils

- Building large-scale SC coils in segments → Easier transportation logistics
- Coils can be assembled at power plant site
- Facilitate fusion reactors maintenance

CORC cable sub-size experiment

- Goal: Measure CORC joint resistance along whole current capacity of CORC cable
- Experiment at operating temperature of HTS fusion magnet
- Completed resistance measurement at 77 K for straight CORC joint (up to 1.6 kA)

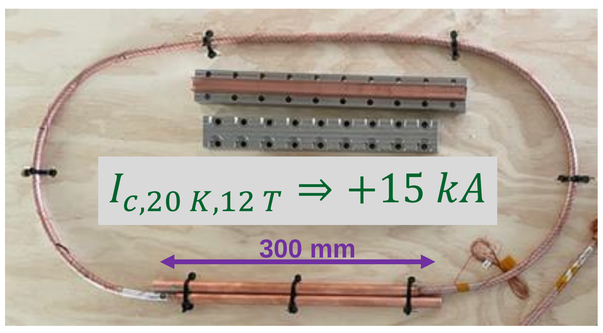
Joint requirements for HTS coil

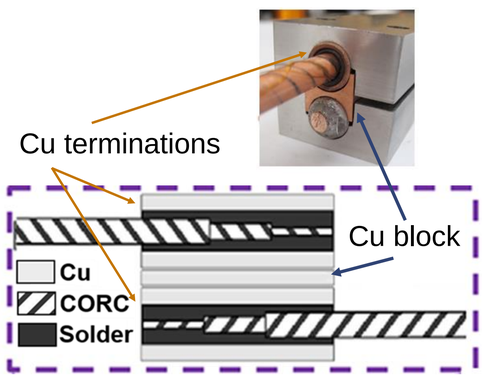
Operating Temperature	20 K
Nominal Current (I_{nom})	100 kA
Safety factor ($I_{nom}/I_{c,\,total}$)	0.9
(One-mount) Joint resistance	≤ 1 nΩ
Joint area	<10,000 mm^2
Magnetic Field	12 T

Characteristics for CORC cable and joint

- Tubular C101 copper terminations
- Staircase cut for HTS tape layers
- Void filled with solder, low-resistance connection to terminations [1]
- Between terminations, Cu block with circular grooves

Lenght between terminations [mm]	1250
Lenght termination [mm]	300
Diameter termination [mm]	12.3
Diameter CORC [mm]	8.5
Number of HTS tapes (Fujikura, 4 mm)	60
HTS tape layers	20

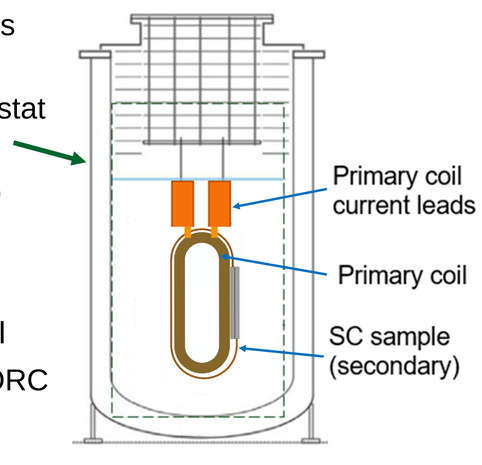


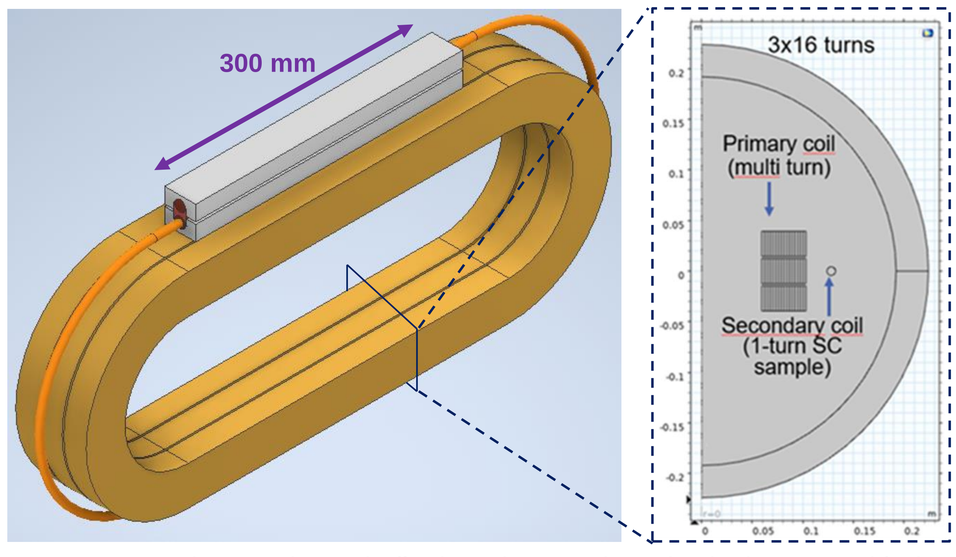


Left: CORC cable with steel blocks, in short-circuited configuration
Right: Longitudinal cut of joint, showing low-resistance to all HTS tape layers

Sub-size joint element: Short-circuited CORC cable

- One-turn racetrack CORC coil, by joining its terminations
- CORC coil to be mounted at in-house cryostat (VATESTA)
- Conduction cooling with cryocoolers (20 K)
- Reach +10 kA current in CORC
- Current induced via 48-turn primary Cu coil
- Voltage taps to track induced current in CORC cable





Left: 48-turn, 3 pancake Cu primary (yellow), and 1-turn short circuited CORC cable (orange)
Right: Cross-section of transformer setup, at middle of the joint length

Transformer approach: Primary coil design (copper)

- Braided Cu cable allow:
  - Compact pancakes
  - Sufficient current density
- Primary coil operated in short pulses:
  - Limited joule heating
  - Sufficiently high-current in CORC
- Installed power supply in VATESTA cryostat: 1.6 kA, 20 V

Coils and coupling specs

(Turns/pancake) × pancakes	16 × 3
Cu cross-section area (A_{cc}) [mm^2]	50
Braid Cu dimensions [mm]	25 × 2.6
Inductance primary coil (L_p) [µH]	1637
Inductance CORC coil (L_s) [µH]	1.694
Mutual inductance (M) [µH]	29.01
Coupling factor (*k*)	0.55
Length cable [m]	62.56
Weight primary coil [kg]	28.02
Resistance primary coil $R_p(300K, 77K, 20K)$ [mΩ]	21, 1.8, 1.1

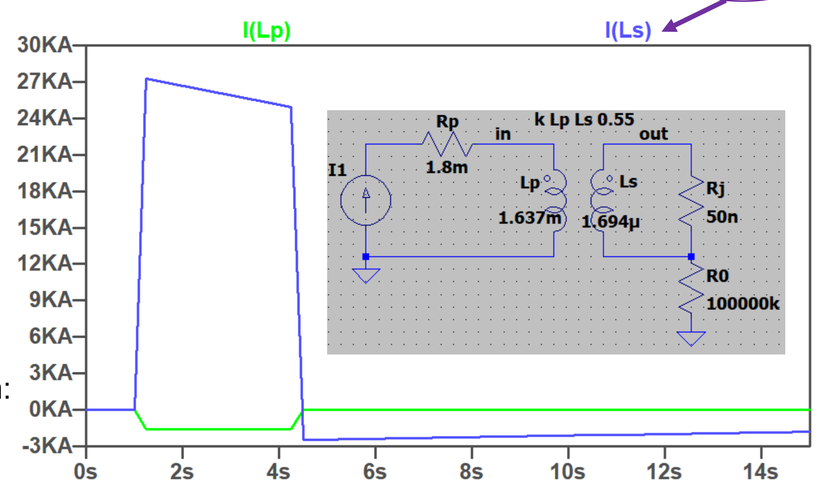
Simulation: Voltage and Temperature Rise in primary Cu coil

- Primary coil best operated at 77 K:
  - Small temperature rise
  - Coil voltage lower than power supply voltage rate

I_primary [A]	Flat-top [s]	Ramp time [s]	Joule heating during flat-top (300 K, 77 K, 20 K) [kW]			ΔT increase (300 K, 77 K,20 K) [K]			Voltage at ramp (300 K, 77 K, 20 K) [V]			I_peak in CORC (20 K) [kA]
800	3	0.25	13.5	1.2	0.64	3.9	0.82	9.3	21.9	6.51	5.9	13.6
800	3	1	13.5	1.2	0.64	4.8	1.1	11.5	18.1	2.8	2.1	13.5
1600	3	0.25	53.8	4.8	2.6	15.6	3.28	37.2	43.7	13.1	11.7	27.3
1600	3	1	53.8	4.8	2.6	19.2	4.1	45.8	36.2	5.51	4.11	26.8

Joint resistance:

- Experiment for straight CORC joint (77 K): $R_j \approx 100\ \mathrm{n\Omega}$
- Under preparation in parallel for 20 K test
- As resistance decreases from 77 K to 20 K, assumption for simulation: $R_j = 50\ \mathrm{n\Omega}$



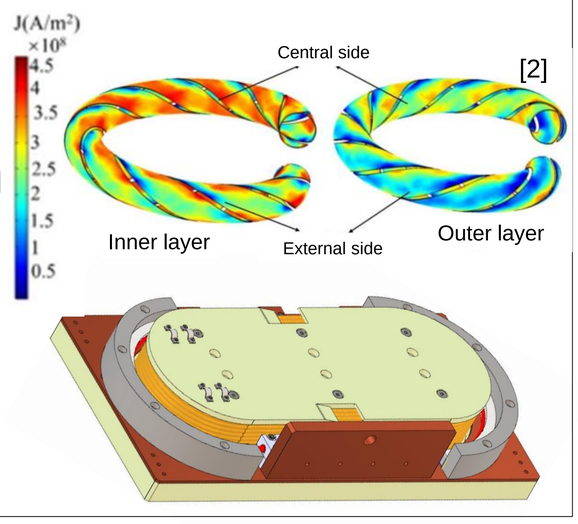
Outlook on next steps for simulation

Current behavior analysis

- Secondary coil assumed as single filament
- Current distribution in HTS tapes influenced by resistance tape to tape and magnetic field
- May maximum current for multilayer CORC cable be the same?

Mechanical analysis

- At +10 kA, electromagnetic forces may be significant
- Structural support in coils required
- Explore mechanical design integrity



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