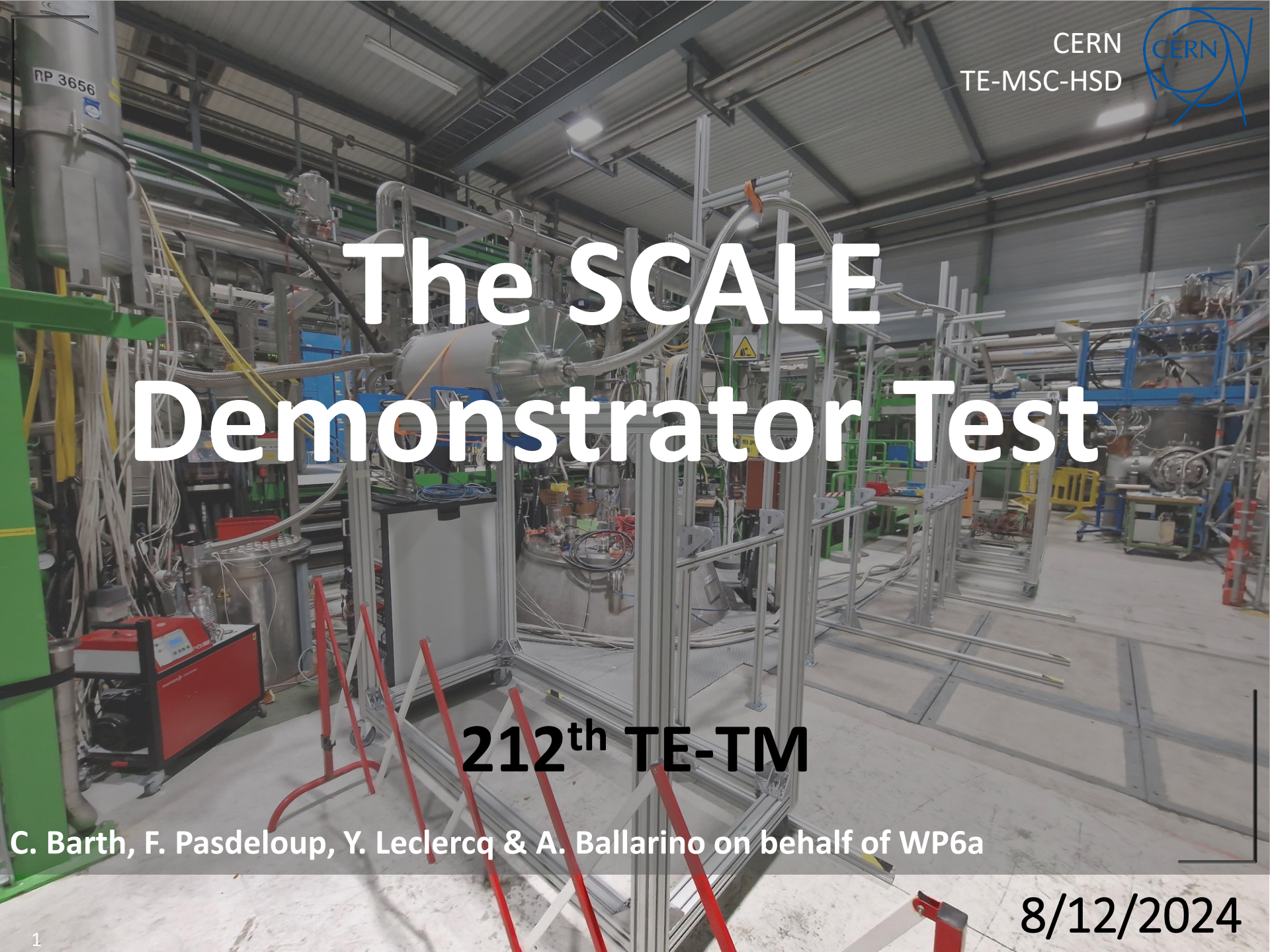


CERN
TE-MSC-HSD

The SCALE Demonstrator Test

212th TE-TM

C. Barth, F. Pasdeloup, Y. Leclercq & A. Ballarino on behalf of WP6a

8/12/2024

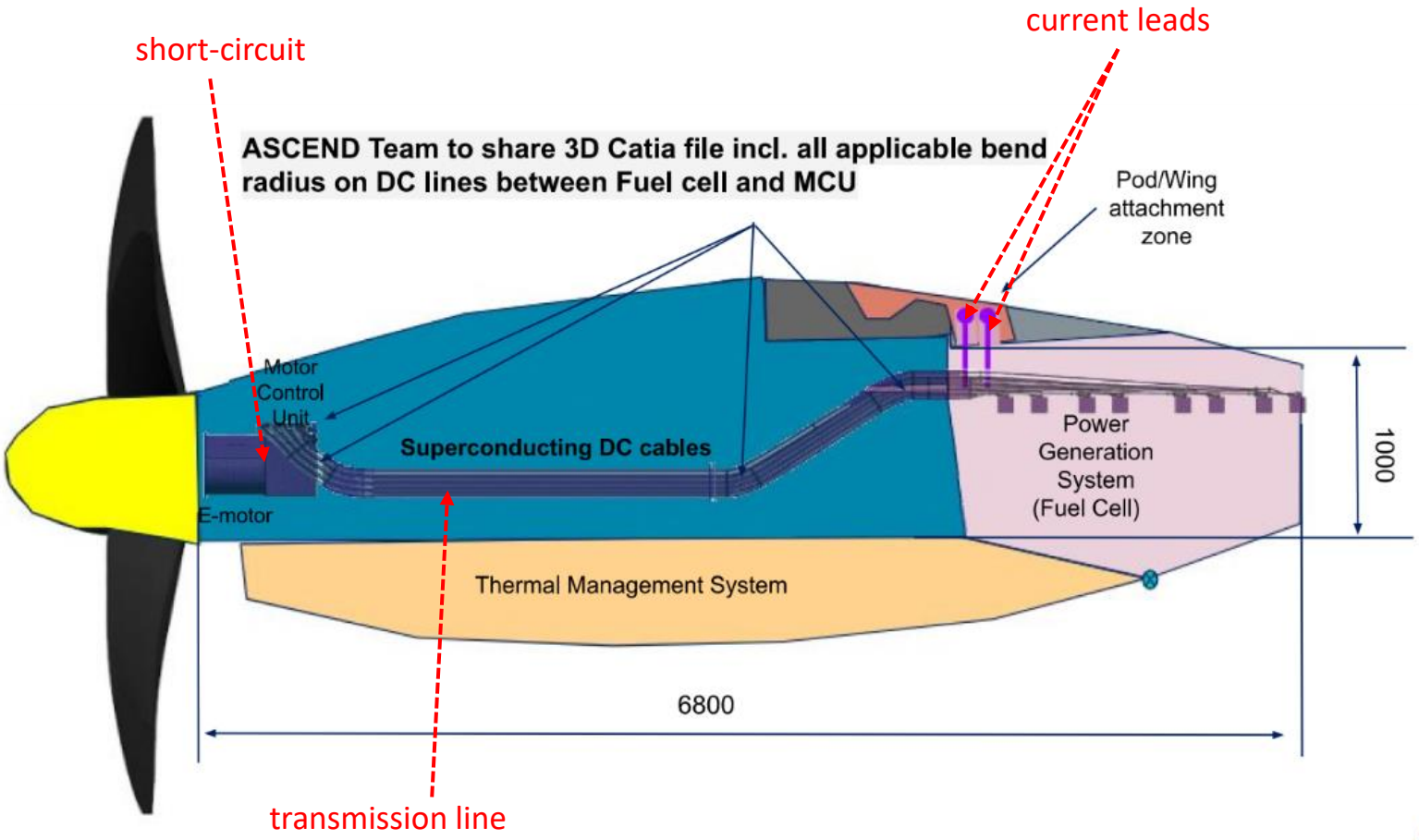
Motivation: SCALE

CERN & Airbus UpNext collaboration:

- 'Superconducting Technologies for Future Electric/Hybrid Planes Power Distribution Systems'
- Development, construction and test of a superconducting powertrain transmission line SCALE ('**S**uper-**C**onductors for **A**viation with **L**ow **E**missions')
  - rely on technologies of SC-link
  - ≈ 7 m flexible, coaxial transmission line with trajectory representative of usage in a plane
  - target performance: 0.5 – 1.0 kA in DC @ ≥ 20 K, 250 V – 500 V insulation voltage
  - optimize superconductor cable of transmission line for low weight

Motivation: SCALE

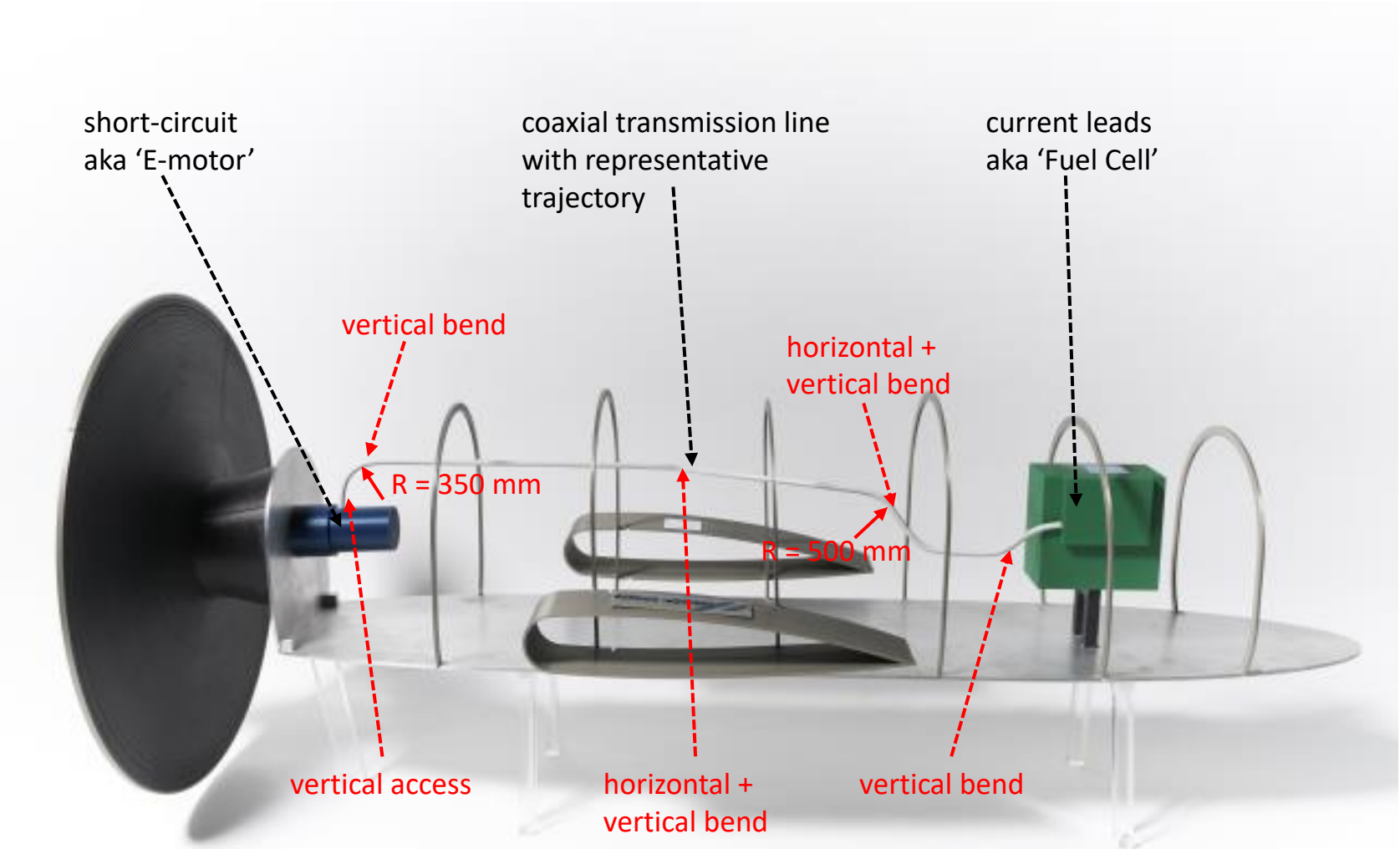
Components & trajectory of the power transmission line:



AIRBUS

Motivation: SCALE

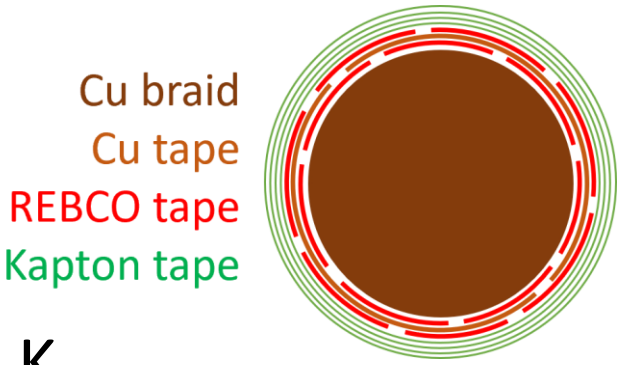
Mock-up of the power transmission line & trajectory:



SCALE HTS cable

Based on WP6a HTS cable:

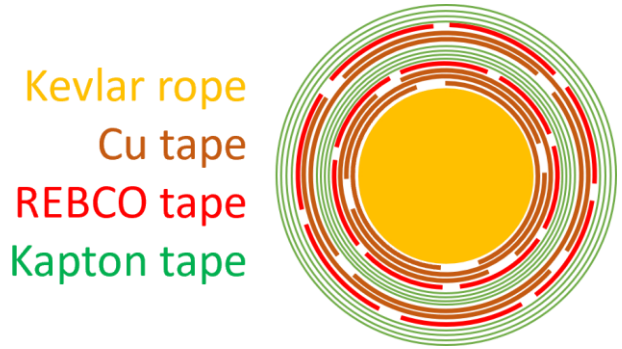
- Cu braid as core for stabilization
- 2 REBCO layers (7 tapes each), separated by Cu buffer layer: 3 kA @ 50 K
- Kapton tape layers for el. insulation (2 layers, each 50 % overlap): 10 kV air, 5 kV (gHe)



WP6a

Optimizations of HTS cable for SCALE:

- **Coaxial:** Kapton el. insulation layers between REBCO tape layers
- **Low weight:** Kevlar rope instead of Cu braid core, multiple Cu tape layers required for electrical & mechanical stabilization (winding direction change between layers)



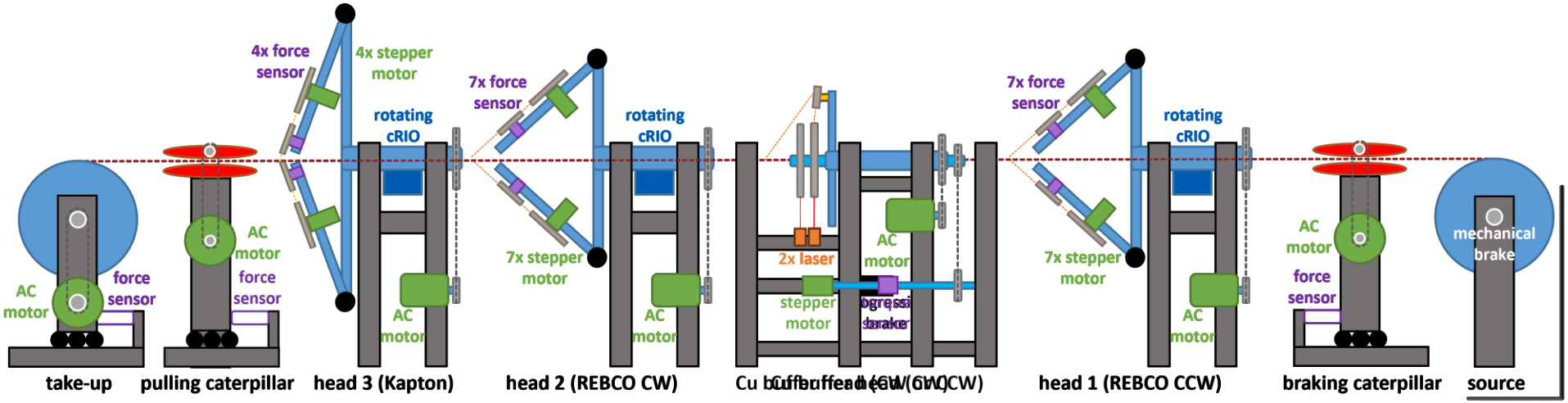
SCALE

SCALE HTS cable

Upgrade of HTS cabling machine:

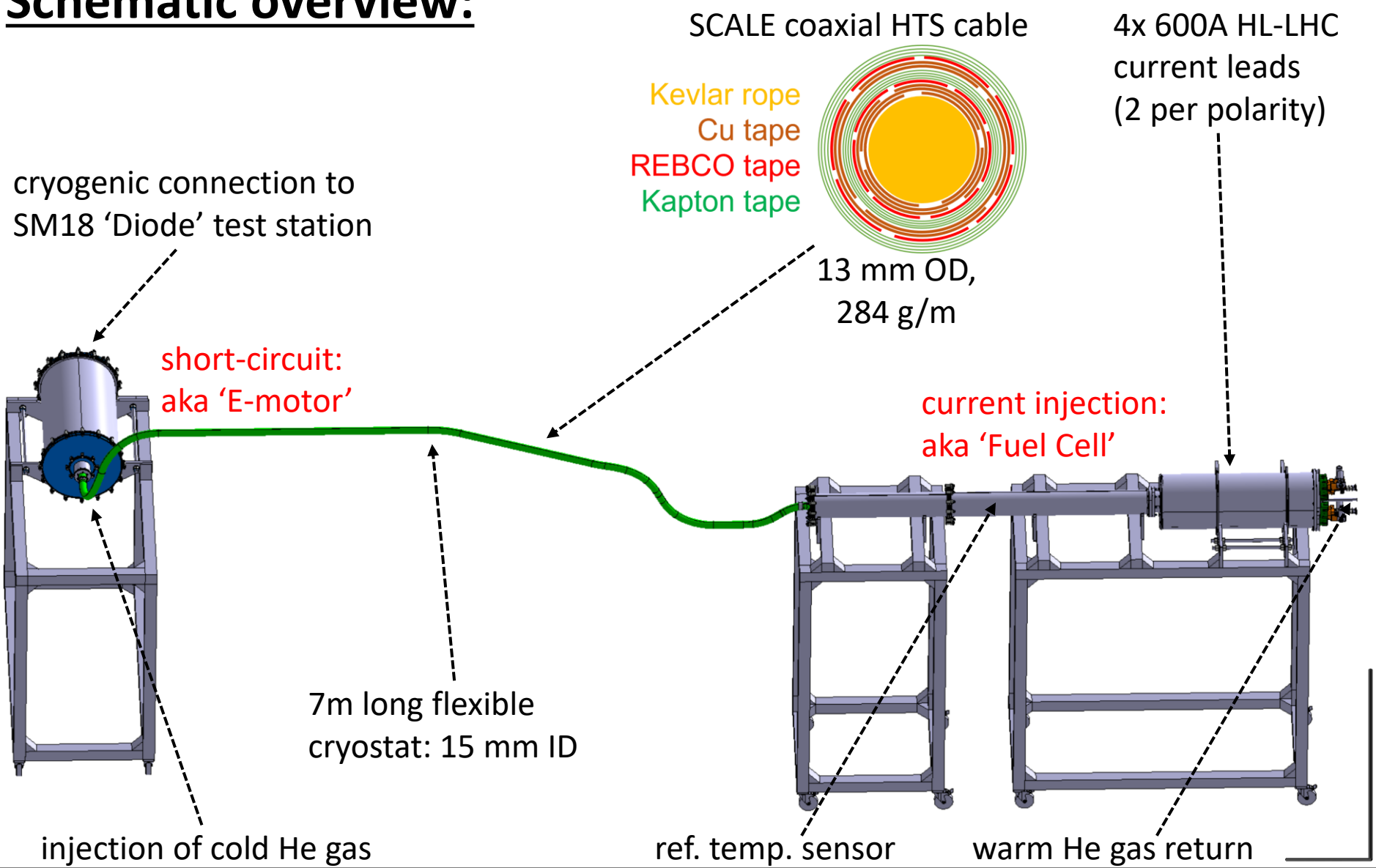
- **Multiple passes needed**: → full reel-to-reel operation
  - grooves in caterpillar belts
  - pulling caterpillar with force limiter

  → protect cable
- **CW & CCW Cu buffer layers:** → upgrade of Cu buffer head
  - 2x Cu tape source spools (CW & CCW), 2x radius measure laser
  - stepper motor + rotational torque meter instead of prop. brake → more precise tension control (while stationary & in rotation)



SCALE demonstrator

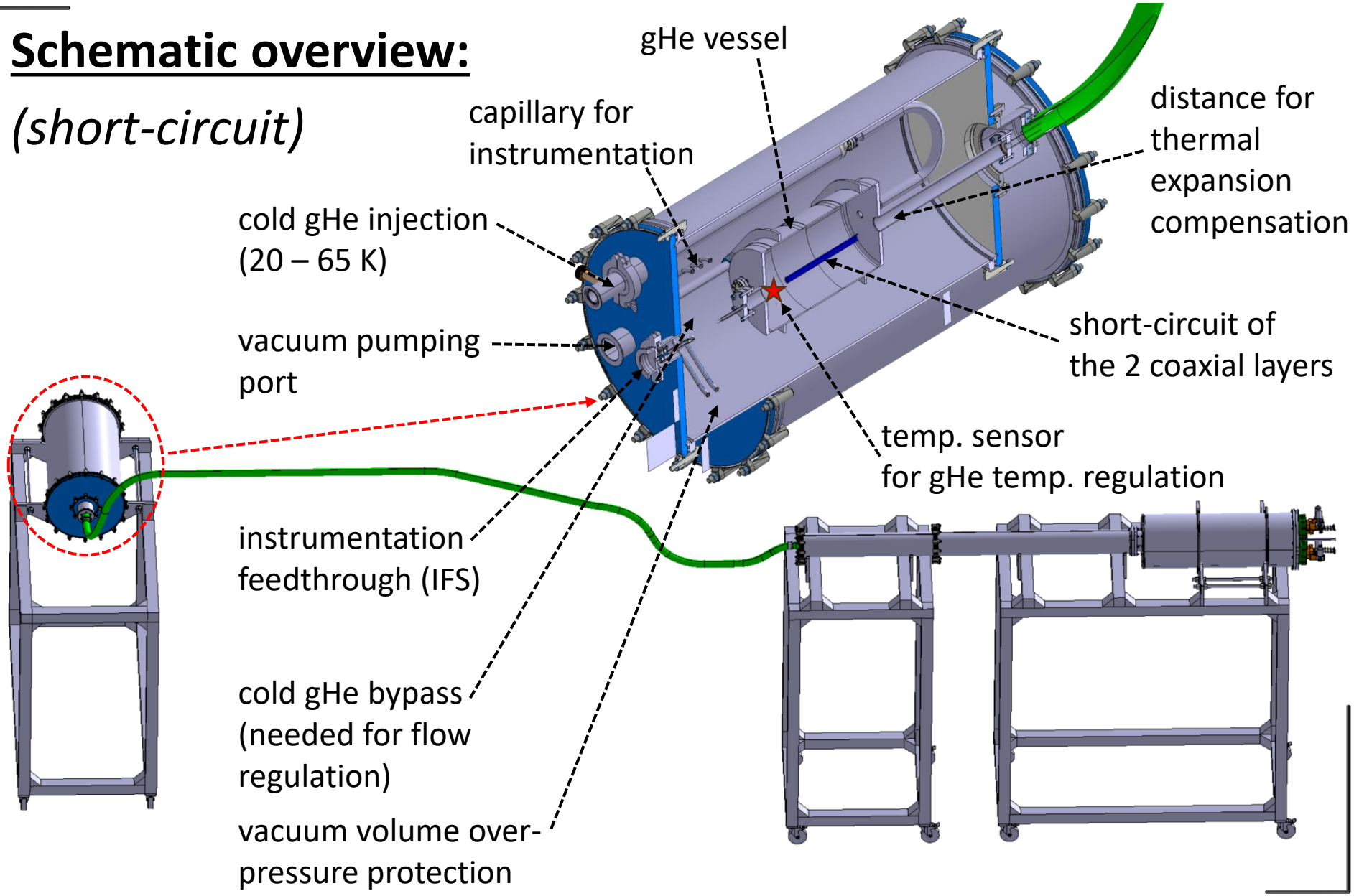
Schematic overview:



SCALE demonstrator

Schematic overview:

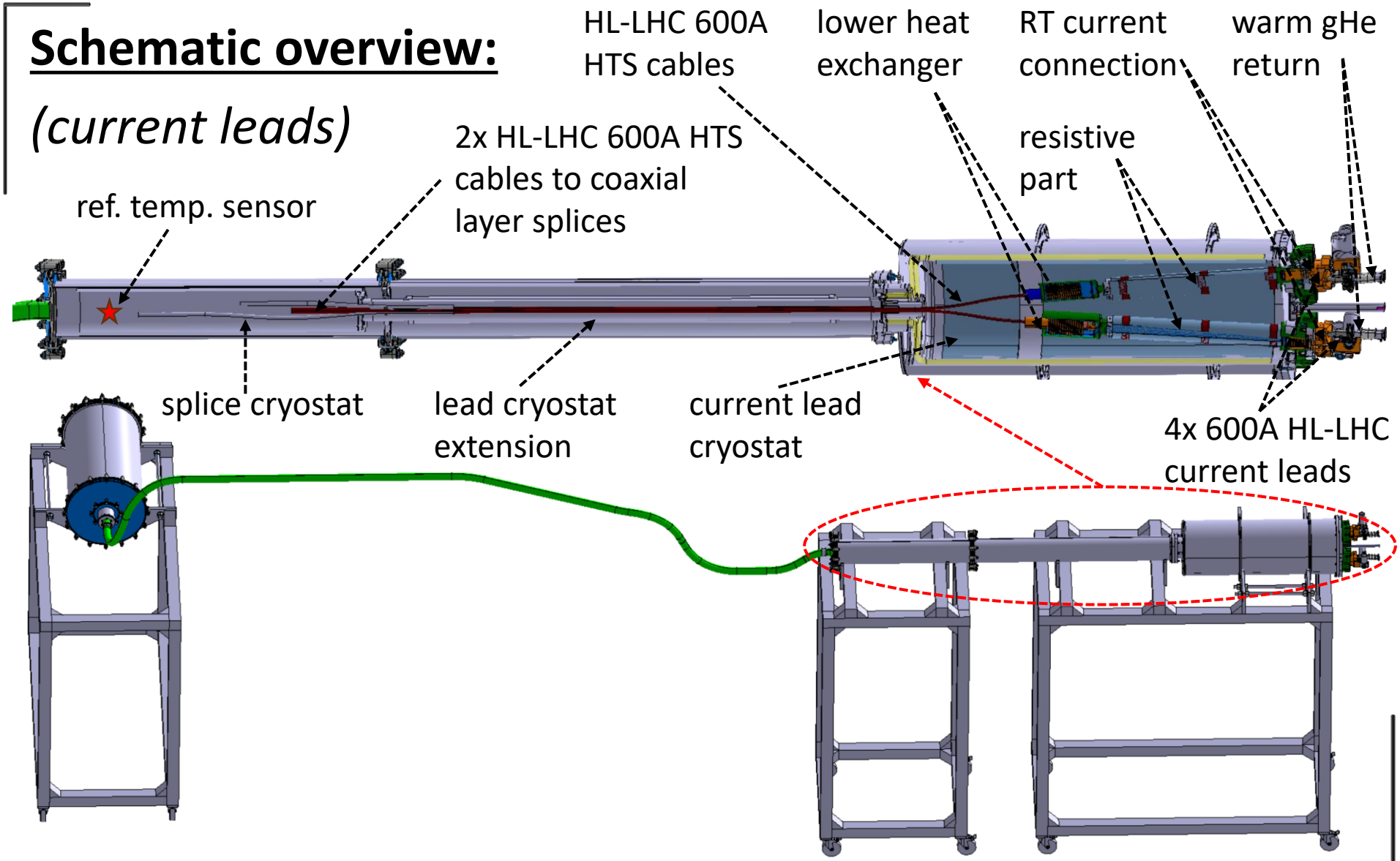
(short-circuit)



SCALE demonstrator

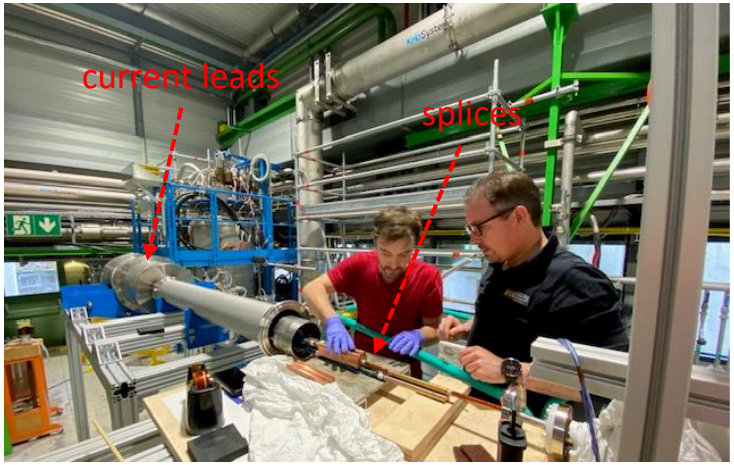
Schematic overview:

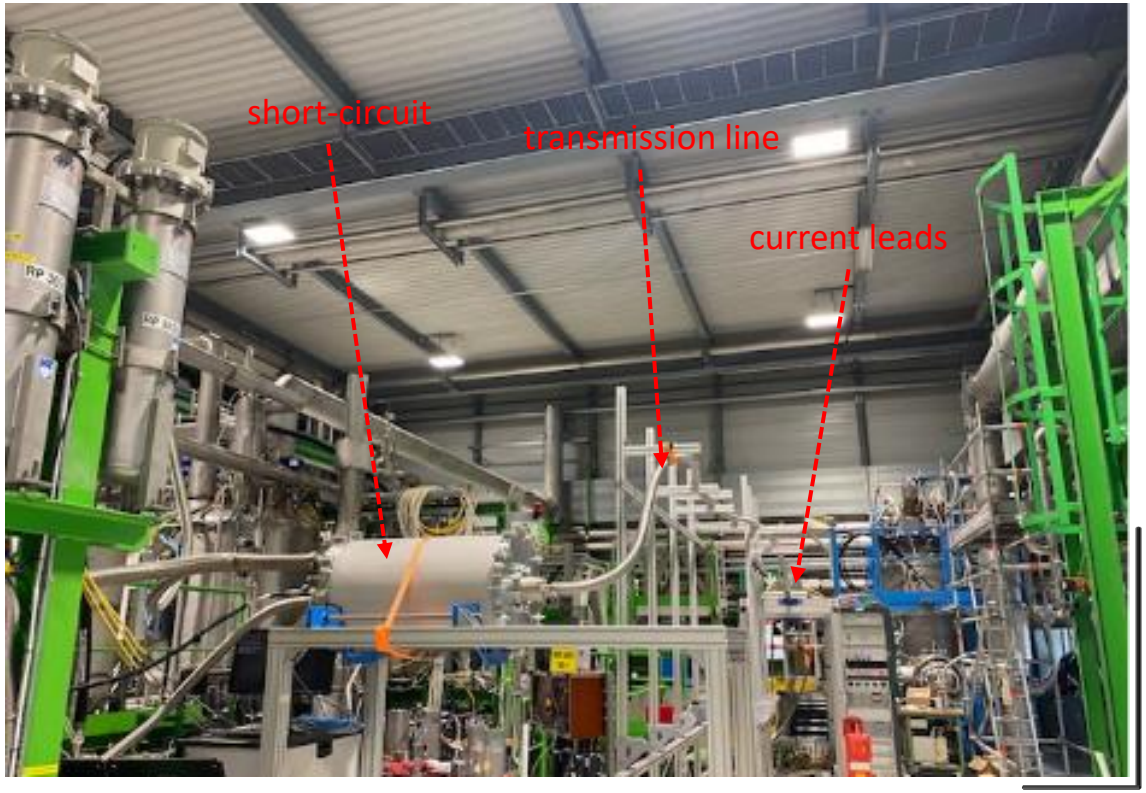
(current leads)



SCALE demonstrator

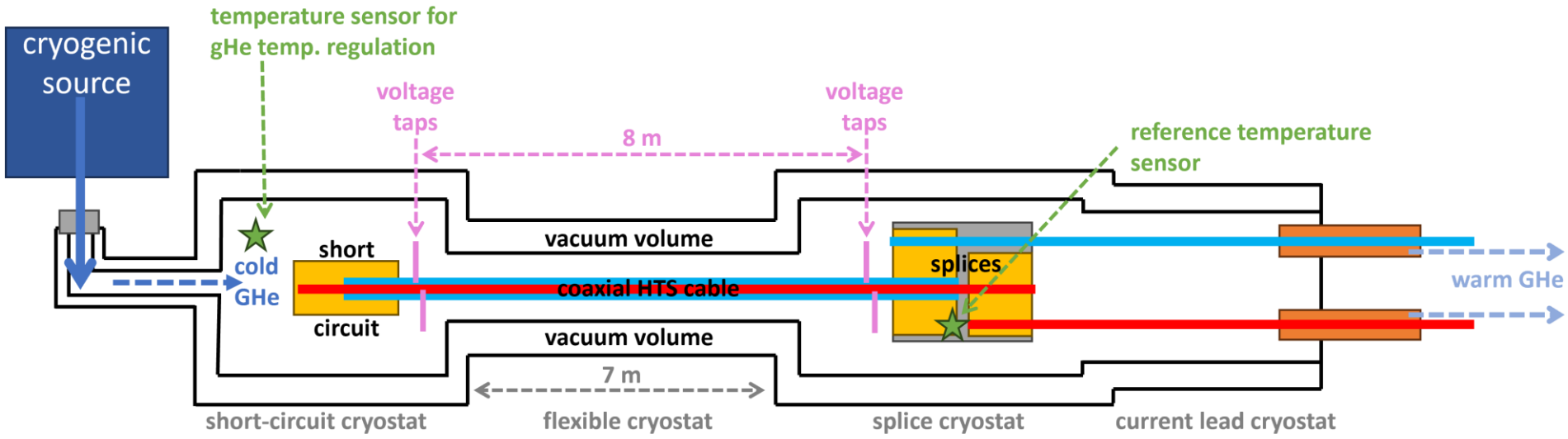
Realization:





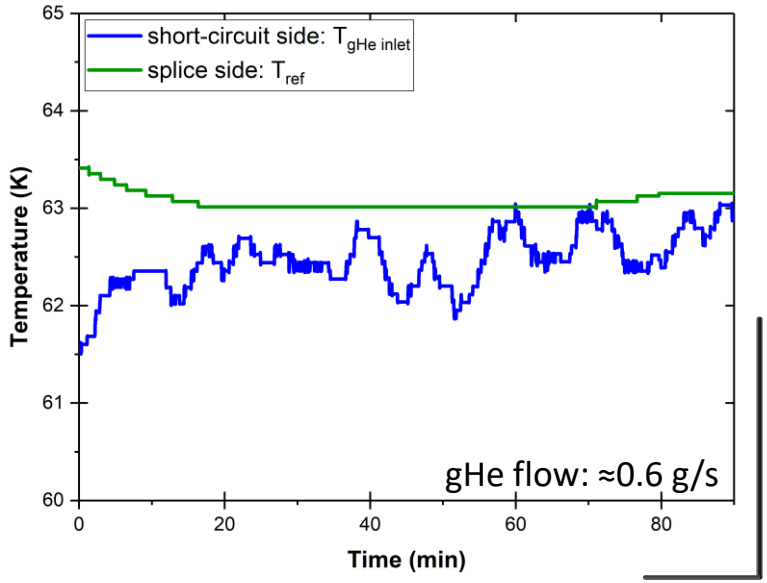
SCALE demonstrator

Simplified schematic overview:



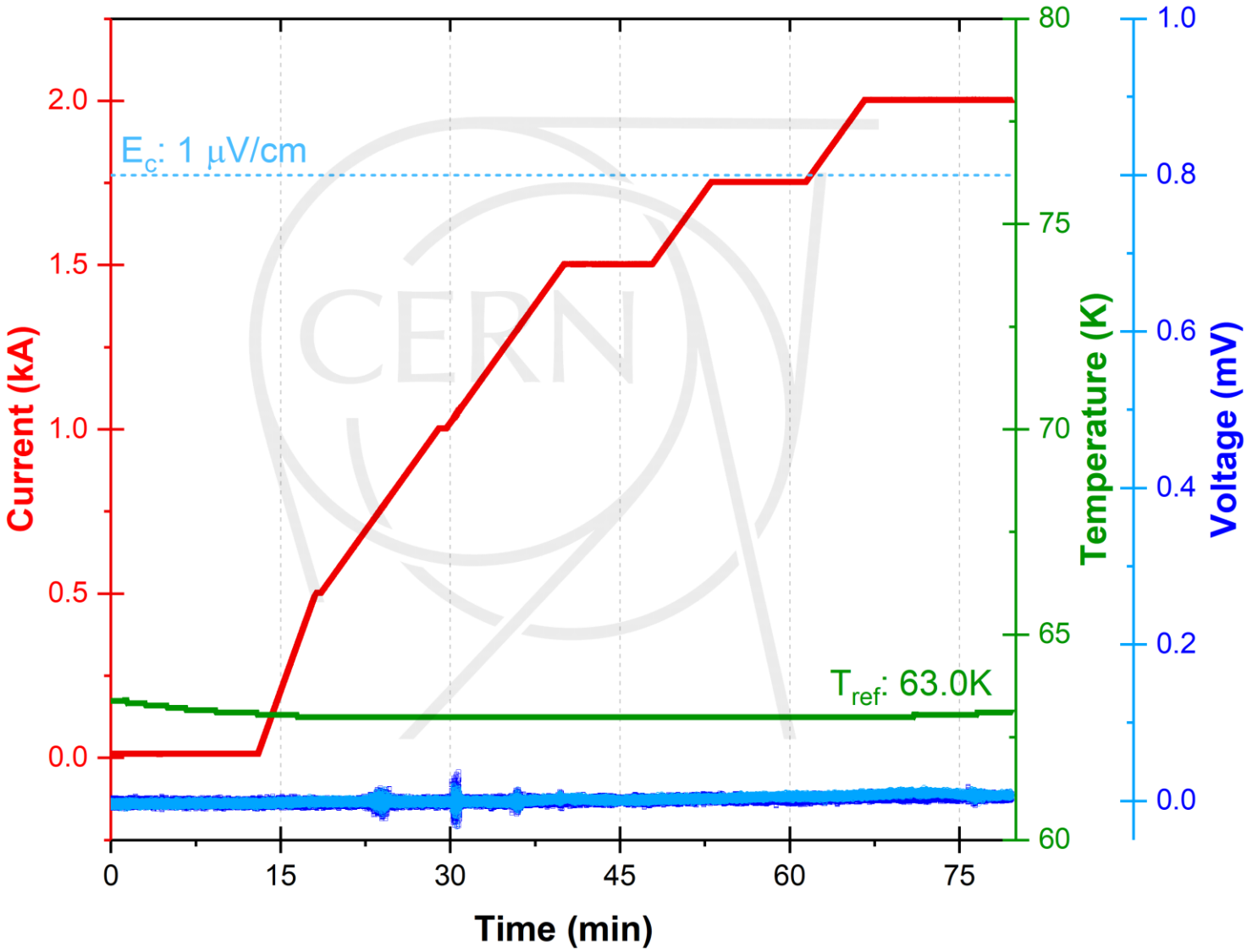
gHe temperature:

- Oscillations on short-circuit side due to gHe temp. regulation
- Splice side temp. (T_{ref}) stable
- <1 K temp. gradient along flexible cryostat (@ ≈0.6 g/s)



Test results

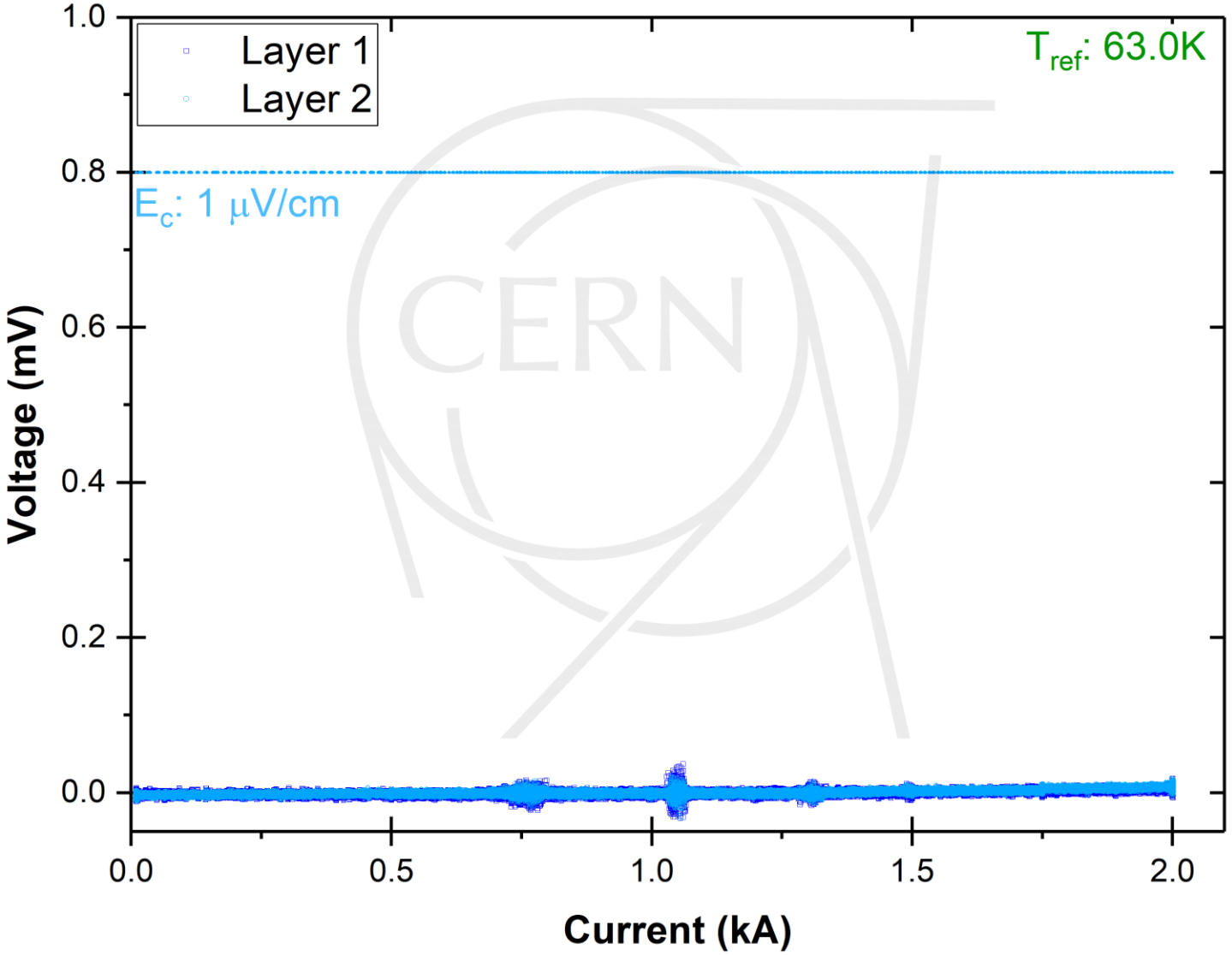
Reference temperature of 63 K:



Test results

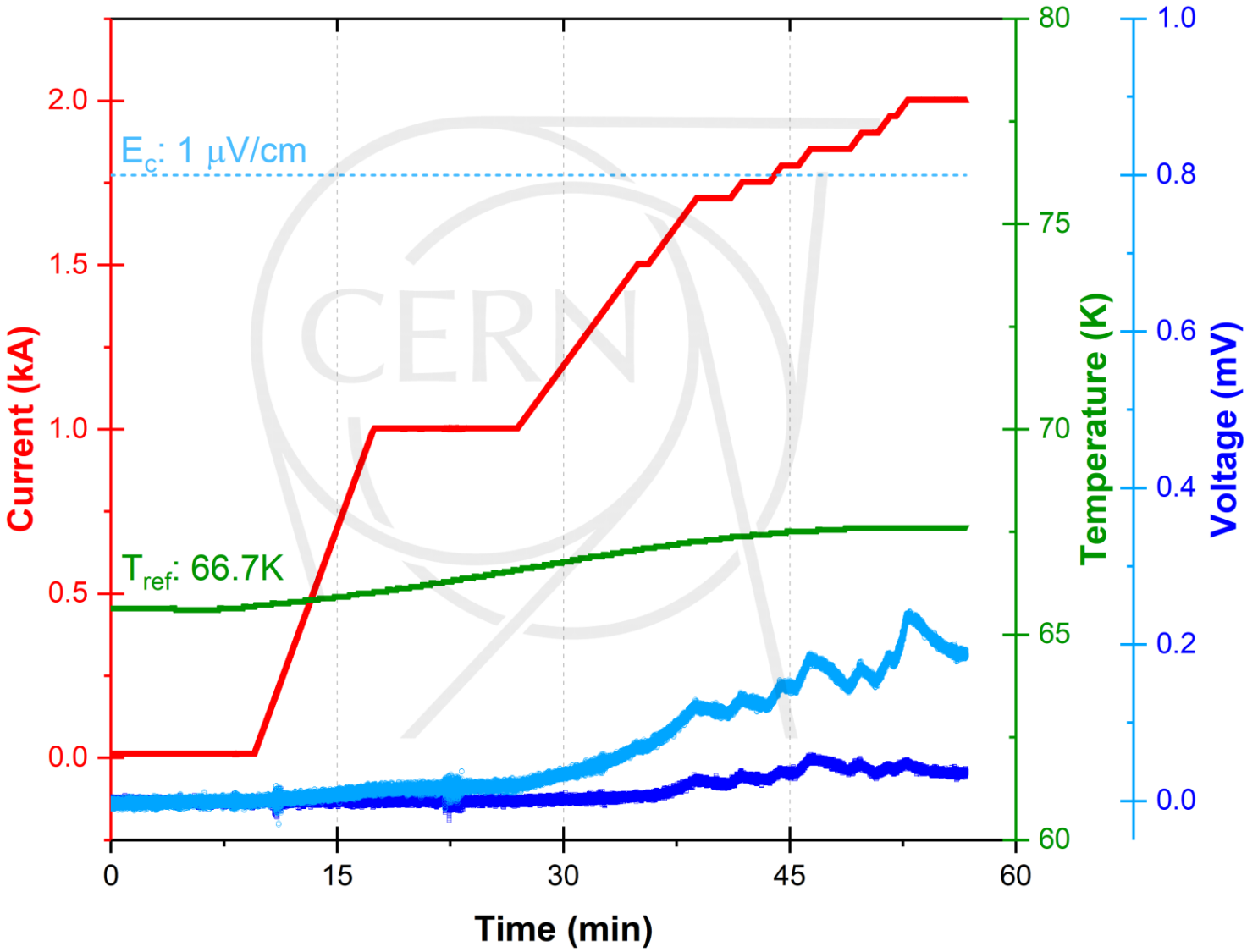
No voltage at 2 kA

Reference temperature of 63 K:



Test results

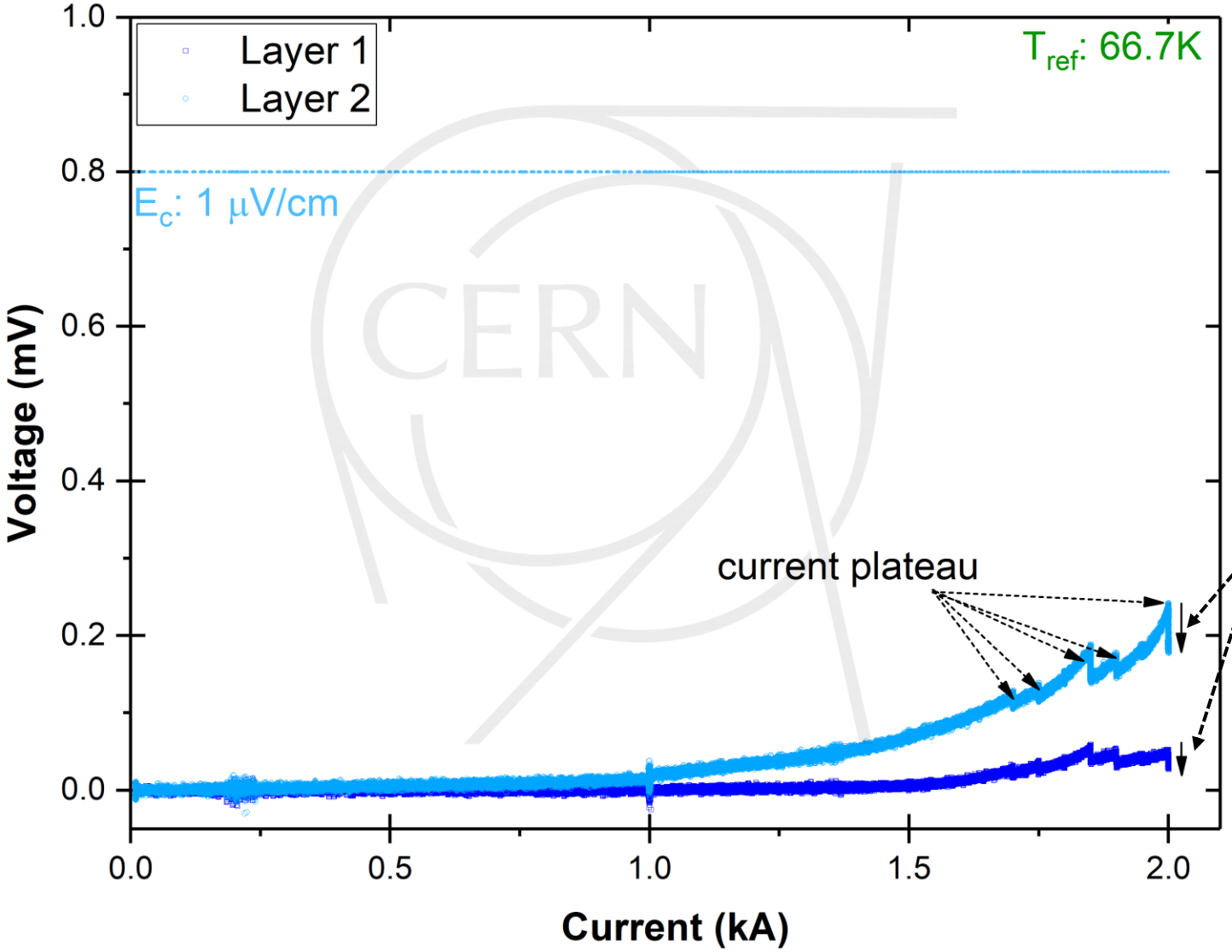
Reference temperature of 66 K:



Test results

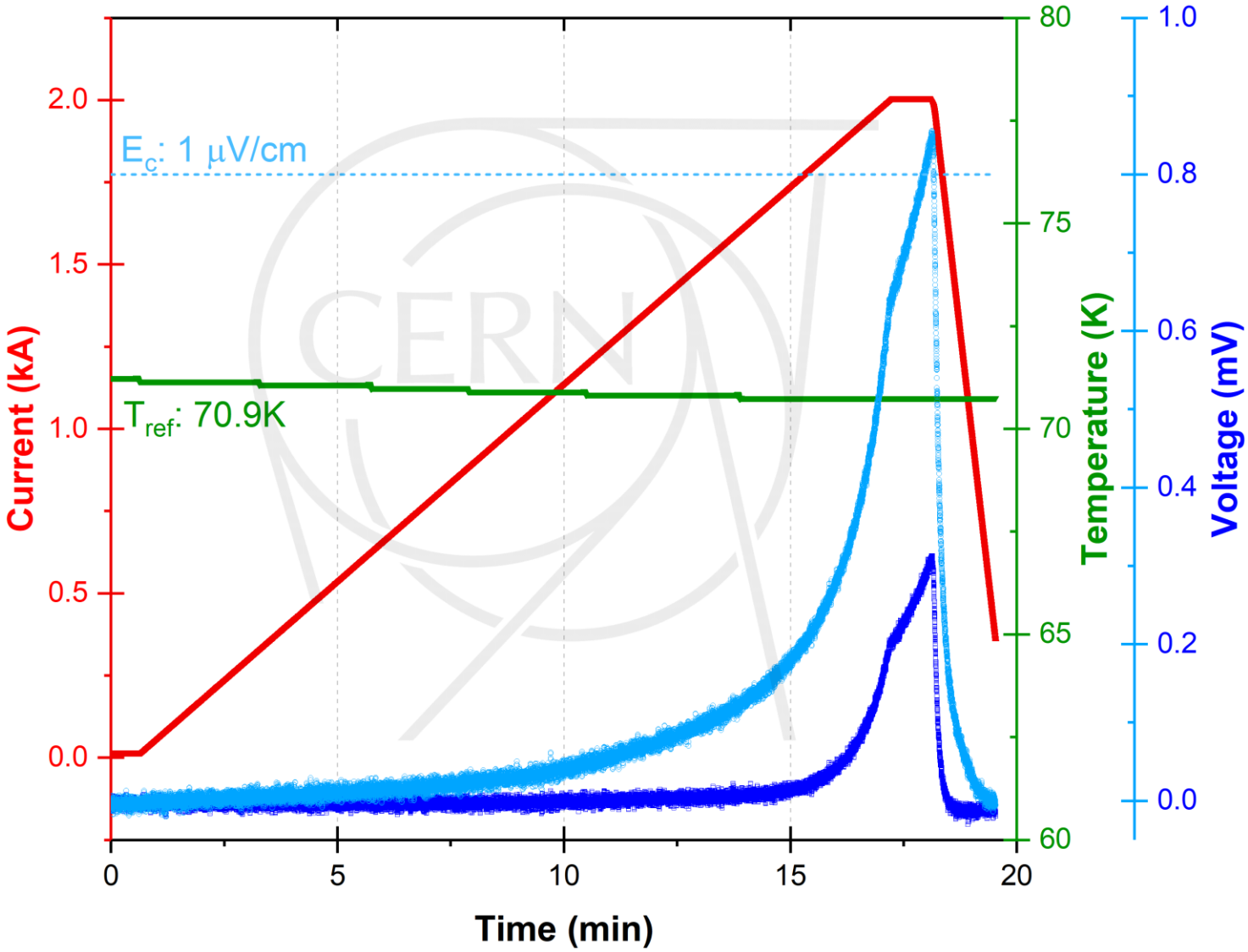
Reference temperature of 66 K:

Stable at 2 kA



Test results

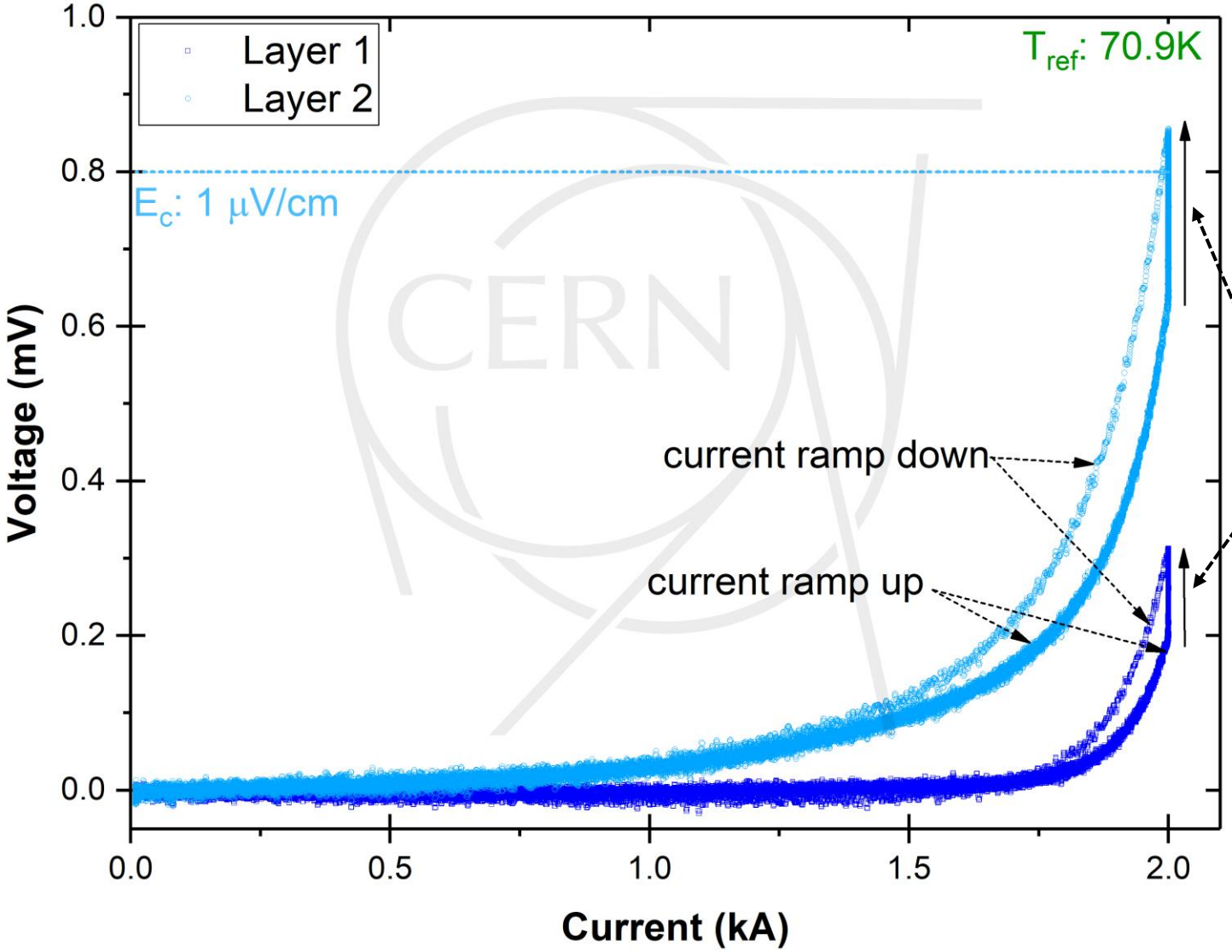
Reference temperature of 70 K:



Test results

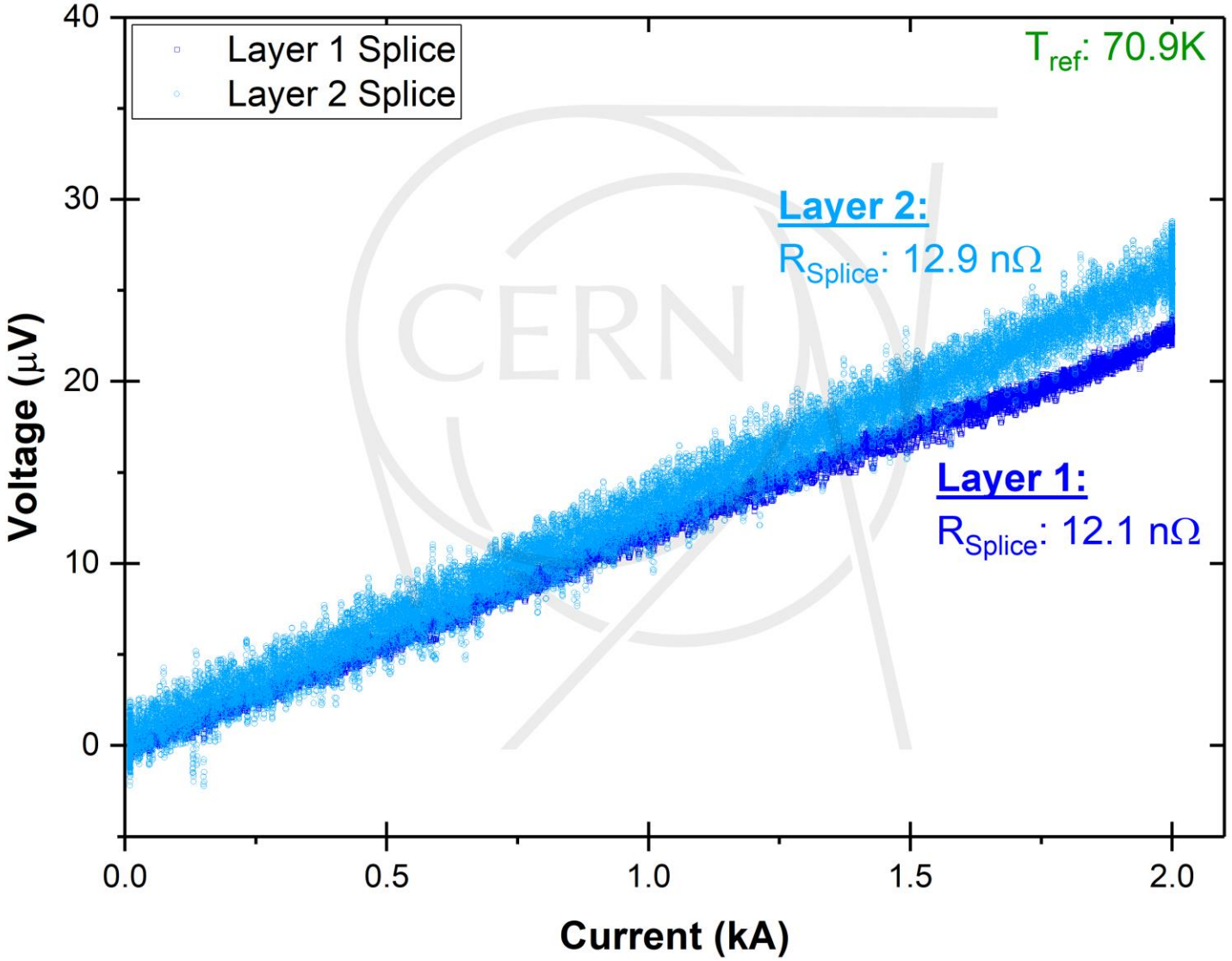
Unstable at 2 kA

Reference temperature of 70 K:



Test results

Splice resistance:



Summary

Successful cold powering test of SCALE demonstrator that by far exceeded the performance targets:

- Low cable weight: 284 g/m
- Homogenous resistance splice resistances <13 nΩ
- 63 K reference temperature (temperature of the splices on the current lead side): no voltage on the coaxial HTS cable at 2 kA
- 66 K reference temperature: ≈0.25 µV/cm on the coaxial cable, stable at 2 kA current plateau (voltage is slowly decreasing due to current re-distribution)
- 70 K reference temperature: ≈0.9 µV/cm on the coaxial cable after ramp to 2 kA (20 A/s), unstable at 2 kA current plateau (voltage is increasing due to local heating)

Thank you for your attention

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