MAY 29 - JUNE 02
FCCWEEK2017
BERLIN, GERMANY
fccw2017.web.cern.ch

Ref: 2TUP19

Test of HTS Demonstrator Coils in the 11 T Background Field of the SULTAN Facility

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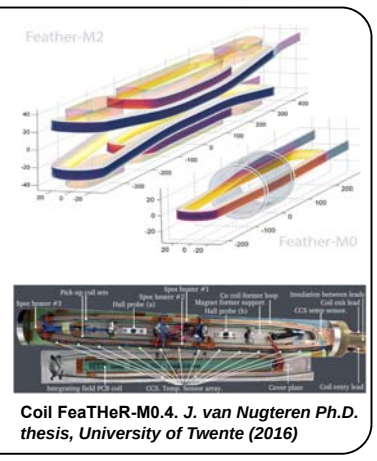
SULTAN facility

- Field generated by 3 pairs of **split solenoids**:
  - B_{max} **= 10.905 T** in test well
  - Homogeneity (2%) along ±200 mm
- **Test samples**:
  - Typically **cable-in-conduit conductors**
  - Inserted through a vertical test well (144 mm × 94 mm rectangular pipe)
  - Nb-Ti trafo supplies I_{sample} **≤ 100 kA**

FeaTHeR coils

- **FeaTHeR-M0** and **FeaTHeR-M2** are two sets of HTS insert-magnets produced at CERN and wound with **ReBCO-Roebel cable**
- FeaTHeR-M0s are **sub-scale planar racetrack coils**
- **FeaTHeR-M0.4:**
  - Successfully tested as a **stand-alone coil** at CERN
  - Will be the first of these demonstrator coils to be tested at **variable temperature** in the **11 T** background field of SULTAN

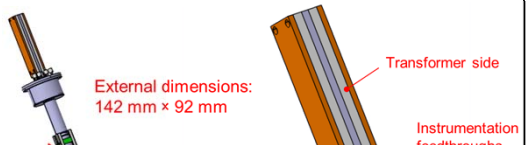


Coil FeaTHeR-M0.4. ***J. van Nugteren Ph.D. thesis, University of Twente (2016)***

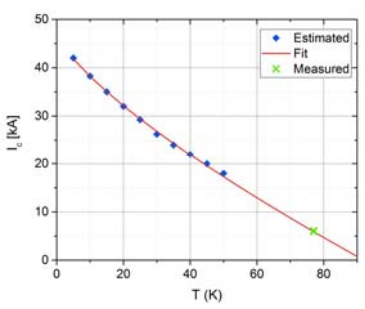
Required upgrades in SULTAN

Sample cryostat

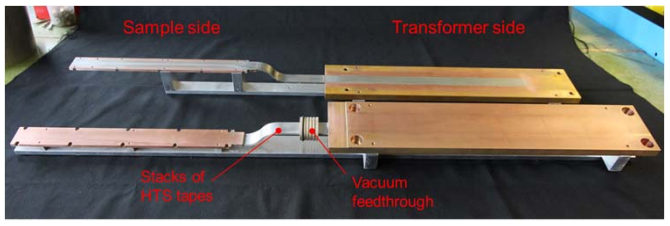
- Confines flow of He in a volume where **temperature is regulated**: 4.5 to 50 K
- **HTS current adapter** between HTS coil and Nb-Ti trafo
- Consists of a 2880 mm-long cylindrical stainless steel chamber (OD = 88.9 mm, ID = 83.7 mm)
- The cryostat is already built, but one of the current feedthroughs is **not helium tight**



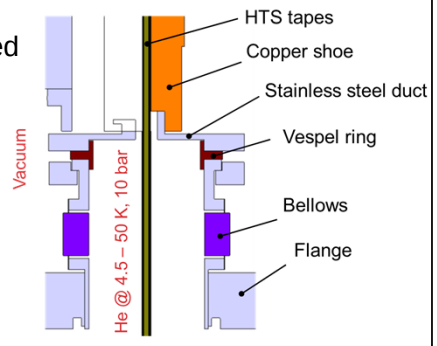
- Each leg of the **HTS adapter** consists of:
  - 2 copper plates
  - Connected by 2 parallel stacks of:
    - 8× ReBCO tapes +
    - 9× brass stripes
  - Splices: staircase profile machined in the Cu
  - Stray field ~0.25 T (mostly parallel to tapes)



Current feedthroughs. Old design



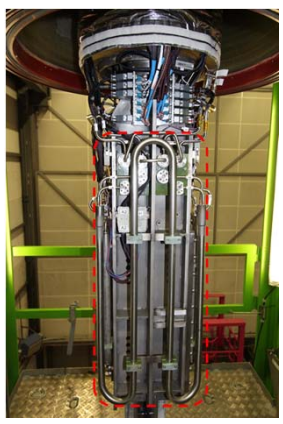
- **Current feedthroughs:**
  - Old design based on a **heat-shrink cup** filled with stycast was **not leak tight at cold**
  - **New alternative** is under fabrication:
    - HTS tape will be encapsulated in a stainless steel pipe
    - Electrical insulation provided by a Vespel ring



Current feedthroughs. New design

Heat exchanger

- He must return to the cryo-plant as cold gas (T < 20 K)
- **Counter flow** exchanger made of **2 copper pipes** fitted inside an outer **stainless steel tube**
- Already installed in the SULTAN transformer

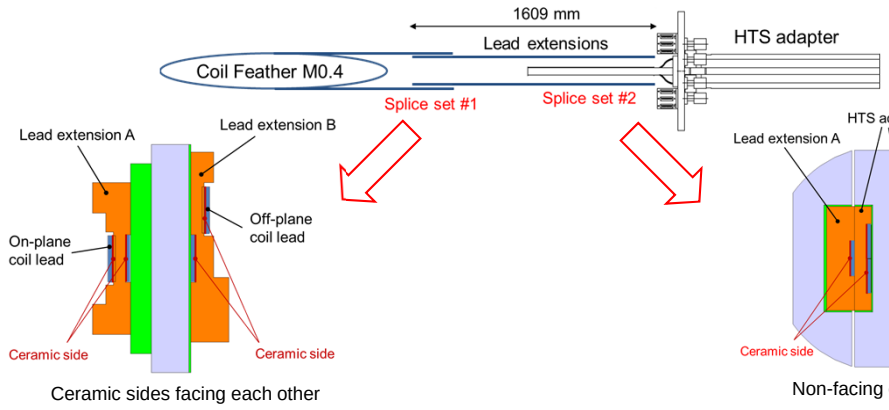


Required changes in the coil: lead extensions

- The lead extensions of FeaTHER M0.4 have to be **unsoldered** and **replaced** by **~1.6-m-long leads** to test the coil in the high field region

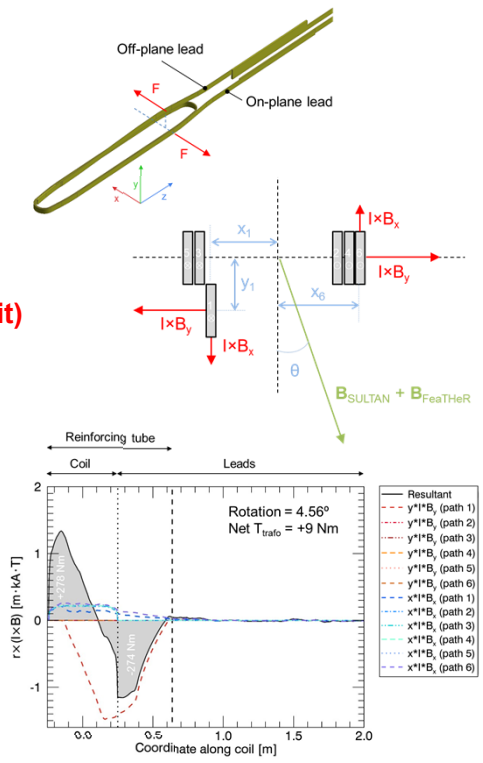
• *Electrical considerations:*

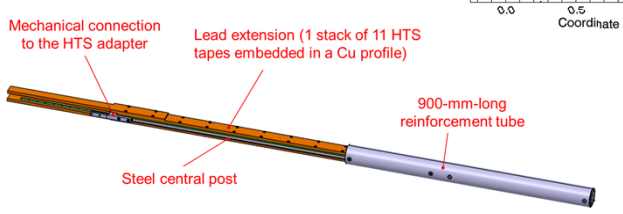
- Each lead extension is made of 11×12-mm-wide tapes embedded in a Cu profile
- **Splices:** staircase profile machined in each end of the lead extensions
  - **Splice set #1** (coil to lead extension): Roebel to copper
  - **Splice set #2** (lead extension to HTS adapter): Copper to copper



• *Mechanical considerations:*

- Cryostat (and coil) are hanging from the SULTAN transformer
- Efforts transmitted to the trafo:
  - Vertical load: **-2.5 kN (if centered)** ✔
  - Torque: **600 Nm** ✘ **(due to non-symmetric current lead exit)**
- The **net torque in the trafo cancels** if the coil is rotated **~4º**
- Still, the coil+lead assembly experiences an **internal torque**
- A ~1.2-m-long stainless steel post will set the coil in the high field region
  - Flexible to accommodate an 1º error
- A rigid 900-mm-long tube will hold the internal torque





Conclusions

- Progress towards the test of the coil **FeaTHeR M0.4** at **variable temperature** and **high magnetic field** in SULTAN is on-going
- Several **modifications** are **required** for these tests:
  - In the SULTAN facility:
    - A **sample cryostat** will enable the tests at **variable temperature**
    - A **heat exchanger** (already installed in SULTAN)
  - In the FeaTHeR M0 coils:
    - The **lead extensions** have to be **unsoldered** and **replaced**
    - A design is presented that **holds the internal torque** in the coil+leads assembly and **minimizes the net torque** in the **SULTAN trafo**