1st HiLumi LHC/LARP Collaboration Meeting: WP6 Cold Powering

Task 6.3. Electrical transfer and cryostats: thermo-electrical and mechanical models

Partners

CERN
University of Southampton (SOTON)

Main Activities in Task6.3

STUDIES: Thermal-electrical performance of HTS cables and links

Topics/parameters

- Conductors:

  MgB_2, BSCCO 2223 and YBCO

- Coolant:

  LHe, Supercritical Helium and LN_2

- Steady State Heat Transfer:

  Flow configurations and mass flow rates, background heat load (cryostat), reserved cooling capacity and heat transfer for HTS, thermal resistance of cable insulation

- Transient Heat Transfer:

  Define quench scenarios, stabilizing matrix, quench propagation in a temperature gradient, detection method and criterion

- Terminations:

  Contact resistances at Joints to LTS bus (~5K) and HTS current leads (20K+), splices(?), heat transfer considerations

Main Activities in Task6.3

STUDIES: Thermal-electrical performance of HTS cables and links

Methodology: Experimental (in 5m-20 cryostats)

Electrical Measurements (cables/links/joints/splices):

Ic(T), I-V and current sharing, uniformity and reproducibility, Contact resistance

Heat Transfer Measurements

Flow rate vs ΔT for h to cryostat and HTS for different flow configurations/insulation, Heat transfer requirements and HEX for terminations

Quench Measurements

Spatial-temporal measurements of temperature and voltages; Minimum quench energy and propagation velocity at different I, T, dT/dx, stabilizing matrix, and mass flow/(reserved) cooling configurations;

Main Activities in Task6.3

STUDIES: Thermal-electrical performance of HTS cables and links

Methodology: Data Analysis and Modelling

- Fundamental conductor properties
  - Ic(T) from specs and tests, I-V and current sharing, contact resistance, self/mutual inductance s
- Heat Transfer Models
  - Nu correlations for heat transfer configurations, application/adaptation of standard ones and CFD (Ansys) models for confirmation. Scaling analysis and model for different cables/links/cryostats
- Quench Models
  - Current sharing model based on I-V measurements; 1D quench model with lateral cooling (Matlab /Ansys/Opera); 2D model for quench propagation across the cable strands (Ansys/Opera)
- Circuit Model
  - *L-R network* model for the circuits and dynamic behaviour of nonlinear $R(T)$ at quench

Main Activities in Task6.3

STUDIES: Thermal-electrical performance of HTS cables and links

Methodology: Mock-up

- Real size mock-up of interface to HTS
  - 4x600A(?) current leads cryostat connected to 5m cable cryostat with interfaces for helium flow and cooling HEX for the joints.

Main Activities in Task6.3

DESIGNS: Concepts for cryostat and interface to current leads

Inputs

Task 6.1 , 6.2 and 6.3 studies

Output

Concepts address the requirements for the allowed maximum flow rate and temperature margin, flow and heat transfer configurations, cable installation/spooling/support, and mechanical considerations.

Drawings at conceptual level for system and sufficient details for key components

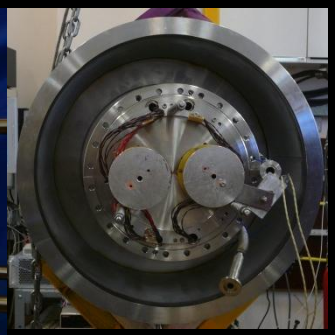
Main Activities in Task6.3

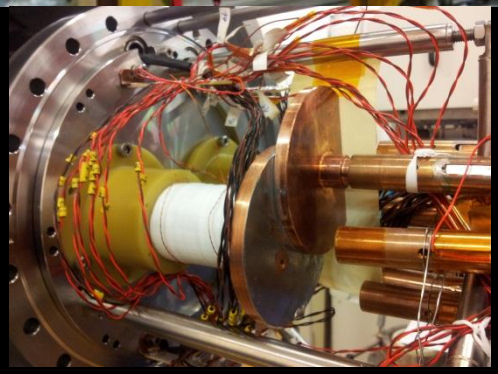
Infrastructure and Experience

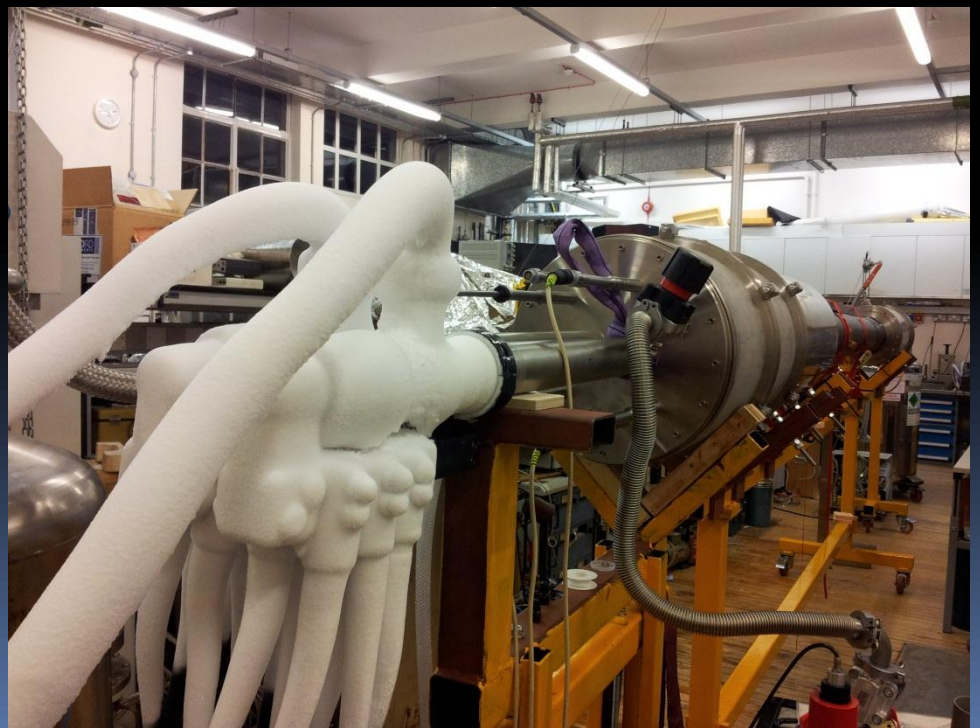
- Fabrication and Test of 600A twisted pair HTS cable and 25x2x600A HTS links
  - Progressed as planned in EuCARD
- Existing Facilities
  - 2m LHe (4.2K) test setup at CERN
  - 1m LN_2 (77K) test setup at CERN
  - 2m GHe (5K-100K) test setup with 2.5kA HTS current leads for twisted-pair cables at SOTON
  - 5m GHe (5K-100K) test setup with CryoFlex and 2.5kA HTS current leads for multi-cable links at SOTON
- Facilities to upgrade
  - 20m LHe/GHe test setup with CryoFlex at CERN for multi-cable links
  - 5kA current leads upgrade at SOTON

Main Activities in Task6.3

5m GHe Test Setup at SOTON







Deliverables

D6.2) Preliminary report on results of thermo-electrical studies: first analysis of performance of cables operating in transient mode and cooled with different coolants. (Task 6.3) [month 24]

D6.5) Thermo-electrical studies: detailed study of thermo electrical performance is described in a document and modelling codes are made available (Task 6.3) [month 42]

D6.7) Cryostat drawings and report: Conceptual drawings of cryostat and report on cryostat thermal and electrical functionalities (Task 6.3) [month 45]

D6.8) Final design report: final design report with design of the cryostat incorporating the current leads and report on thermal performance (Task 6.3) [month 46]

Milestones

Milestone name	Work package(s) involved	Expected date	Means of verification
Cryogenic scenarios	6 (Task 6.2)	M18	Preliminary Report
Thermo-electrical models	6 (Task 6.1 using input from 6.3)	M24	Preliminary Report
Energy deposition	6 (Task 6.4)	M24	Preliminary Report
Cryogenic scenarios	6 (Task 6.1 using input from 6.2 and 6.3)	M30	Report
Cryostat for current leads	6 (Task 6.3)	M40	Report
Thermo-electrical models and cryostat conceptual design	6 (Task 6.3)	M42	Report and Codes
Energy deposition studies	6 (Task 6.4)	M42	Report
Material studies	6 (Task 6.4)	M44	Report