



Connection and Integration of the Instrumentation in the Cold Powering System

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Outline

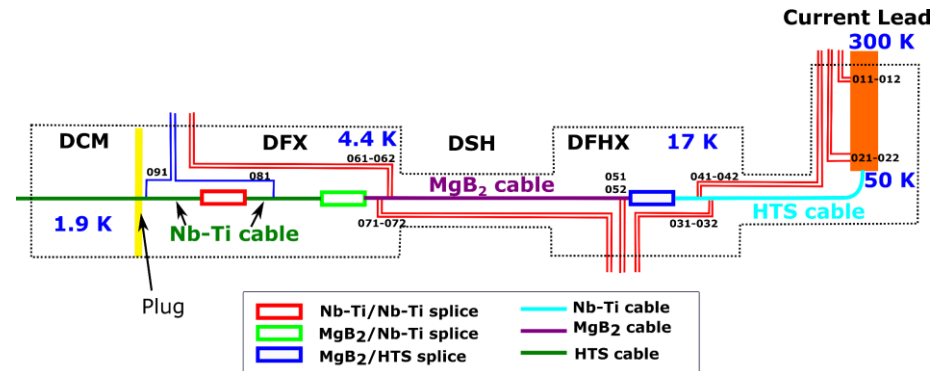
- **Overview of the cold powering system instrumentation scheme**
- Wires connection, routing and testing
- IFS flanges and splitting modules overview and validation
- Documentation of cold powering system instrumentation

SC-link Instrumentation Overview #1

Voltage taps:

- Triplets & Matching Sections identical approach
- Vtaps all along SC cables, splices & lead HEX:

- Current lead HEX
- HTS cable
- HTS – MgB₂ splice
- MgB₂ cable
- MgB₂ – NbTi splice + NbTi cable
- NbTi – NbTi splice (*monitoring only*)

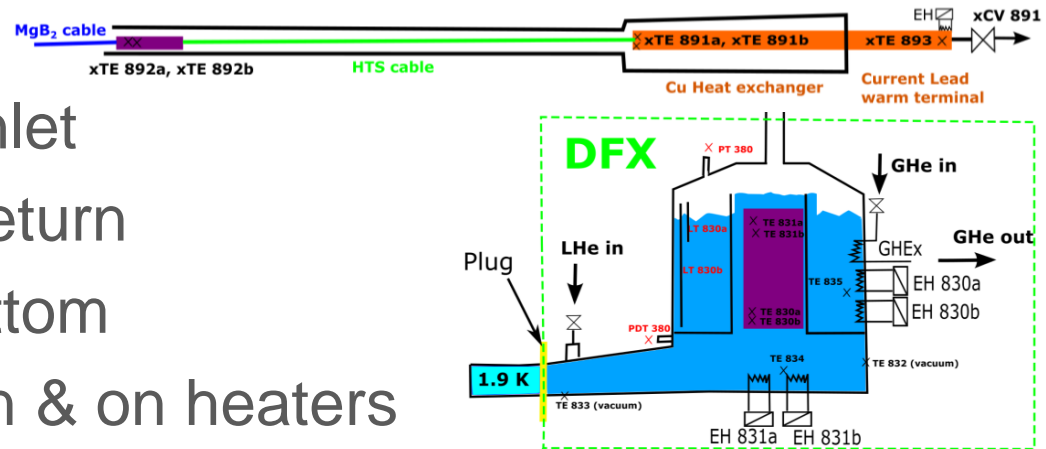


- All protection Vtaps doubled
- Identical on all circuits, named by Vtap number + circuit identifier: **EEA061**

SC-link Instrumentation Overview #2

Temperature sensors:

- Triplets & Matching Sections identical approach
- Temp. sensors all along SC cables & splices:
 - Current lead HEX: top & bottom
 - HTS – MgB₂ splice
 - DFHX/DFHM gas inlet
 - DFHX/DFHM gas return
 - DFX/DFM top & bottom
 - DFX/DFM insulation & on heaters
- All GHe control & SPA relevant sensors doubled
- Identical on all circuits, named by sensors number + circuit number + first/second: **1TE892a** first/second

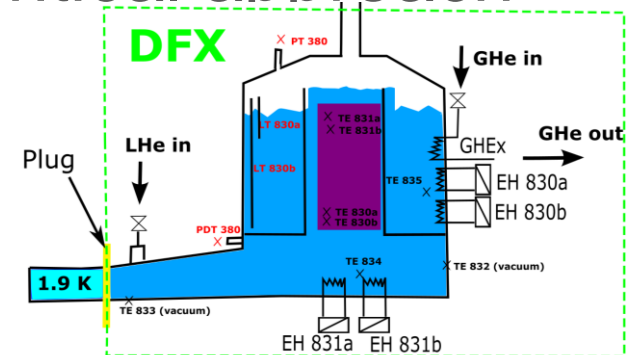


circuit number: 1 is a temp. sensor sensor number

SC-link Instrumentation Overview #3

Level sensors:

- Triplets & Matching Sections identical approach
- LHe level control in DFX/DFM:
 - 2x level gauge



Pressure sensors:

- Triplets & Matching Sections identical approach
- Pressure monitoring in DFX/DFM & DFHX & DFHM

Heaters:

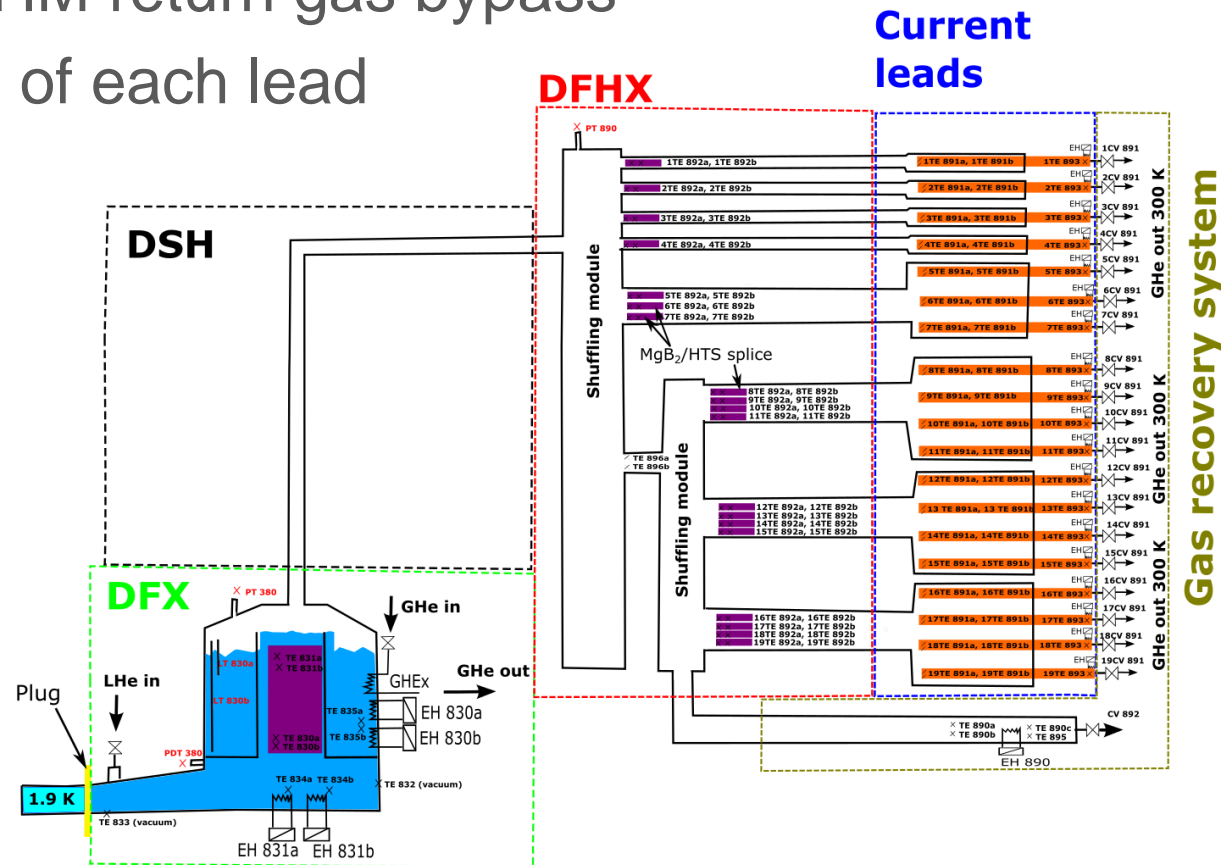
- Triplets & Matching Sections identical approach
- GHe flow generation in DFX/DFM & warmup:
 - 2x pairs of electrical heaters, temp. sensor monitored

warm GHe circulation heater

SC-link Instrumentation Overview #4

GHe flow sensors:

- Triplets & Matching Sections identical approach
- GHe flow monitoring & return gas management:
 - DFHX/DFHM return gas bypass
 - return gas of each lead



Conduction cooled current leads #1

General information:

- Leads similar to LHC leads, 2 types: 60 A & 120 A
- Used for different circuit types:
 - 1x 60 A lead for 60 A circuits
 - 1x 120 A lead for 120 A circuits
 - 2x 120 A leads (in parallel) for 200 A circuits
- Connector + heat exchanger at warm end
 - connection to the RT power cables
 - limits the condensation (ventilation needs to be finalized)



Instrumentation:

- 1 pair of Vtaps per lead (1 doubled wrt. LHC)
- Current bias sensors in 200 A circuits

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Wires connection, routing & testing #1

Design voltages:

- Wires, leads, DFHX/DFHM & DFX/DFM designed for 5 kV (air) and 3.5 kV (GHe)
 - ≥ 30 mm creepage distance inside DFHX/DFHM
 - ≥ 25 mm creepage distance in HTS & MgB₂ cables
 - ≥ 25 mm creepage distance inside DFX/DFM
- All other instrumentation components (flanges and splitting modules) designed for 3.5 kV (air)

Test voltages:

- Wires, leads, DFHX/DFHM & DFX/DFM and cables tested at ≥ 5 kV & ≥ 3.5 kV (air & GHe)
- Other components tested at 3.5 kV (air)

Wires connection, routing & testing #2

Preformed tests on SC-link prototype system:

- MgB₂ cables + inst. wires
 - production: 10 kV (air) & reception: 10 kV (air)
 - after installation & shuffling: 5 kV (air)
- Current leads & HTS cables
 - production: 5 kV (GHe) & assembly: 5 kV (GHe)
- Round NbTi cables
 - production: 5 kV (air)

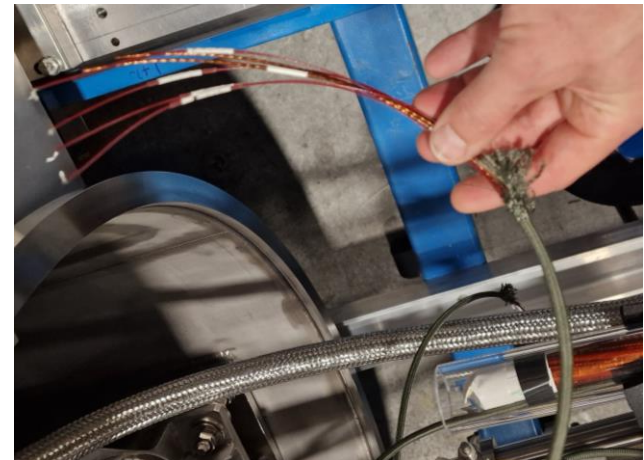
Planned tests for SC-link prototype system:

- MgB₂ cables + inst. wires + leads
 - on DFHX completion: 5 kV (air)
- MgB₂ cables + inst. wires + leads + NbTi cables
 - on DFX completion: 5 kV (air) & 3.5 kV (GHe)

Wires connection, routing & testing #3

Wires for voltage taps:

- Axon: Kapton + resin insulated wires
 - embedded as one/two instrumentation wire bundle(s) in the MgB_2 cable
 - used in the DFHX/DHFM & DFX/DFM
- All wires tested up to 5 kV (air) during production and after installation
- Routed in bundles, protected by Nomex sleeves in DFHX/DFHM & glass fiber sleeve in DFX/DFM
- Identified by shrink tube labels as: **0101**



plug number: 1 pin number: 1

Wires connection, routing & testing #4

Wires for temperature sensors:

- LHC type: 4-in-1, twisted, Kapton insulated wires
 - used in the DFHX/DHFM & DFX/DFM
- All wires tested up to 5 kV (air) after installation
- Routed in bundles, protected by Nomex & glass fiber sleeves in DFHX/DFHM & DFX/DFM
- Same identification method as voltage tap wires

Wires connection, routing & testing #5

Routing:

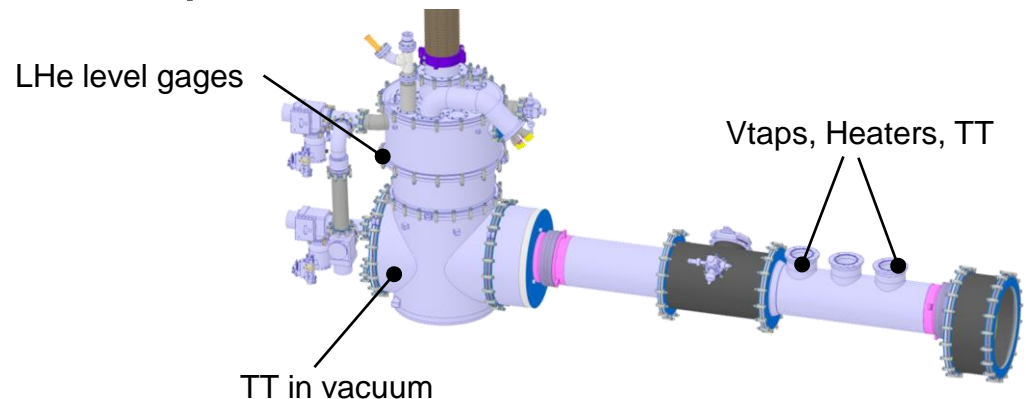
- DFX/DFM instrumentation wires routed to DFX/DFM IFS & other dedicated feedthroughs
- 2x2 Vtaps per circuit routed via MgB₂ cable instrumentation bundle to DFHX/DFHM IFS
- DFHX/DFHM instrumentation wires routed to DFHX/DFHM IFS
- Current lead + HTS cable instrumentation wires routed to 1x Fischer, 1x Lemo on each lead
- Instrumentation wire bundles protected with PE insulators in DFHX/DFHM & DFX/DFM routing

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IFS flanges & splitting module #1

DFX/DFM IFS:

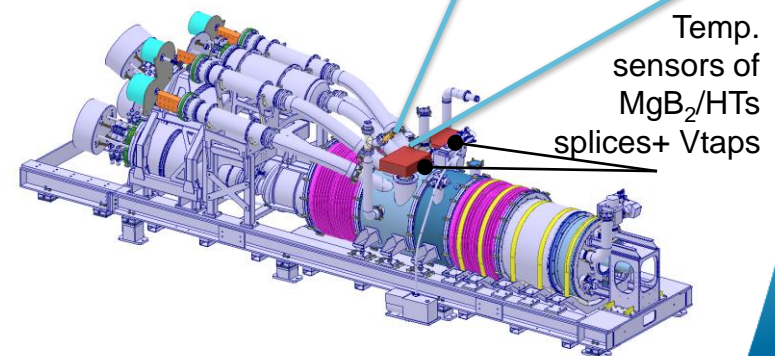
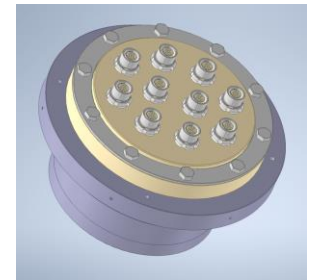
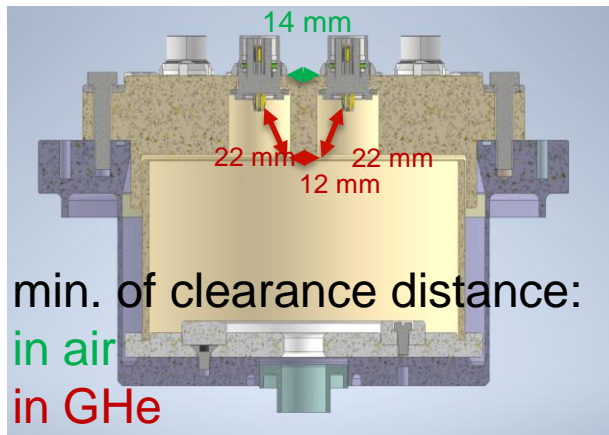
- Standard magnet type IFS + dedicated instrumentation feedthroughs
- High voltage rated
- Signals:
 - LHe level gauges
 - temp sensors. in vacuum
 - Vtaps, heaters and temp. sensor in He vessel



IFS flanges & splitting module #2

DFHX/DFHM IFS:

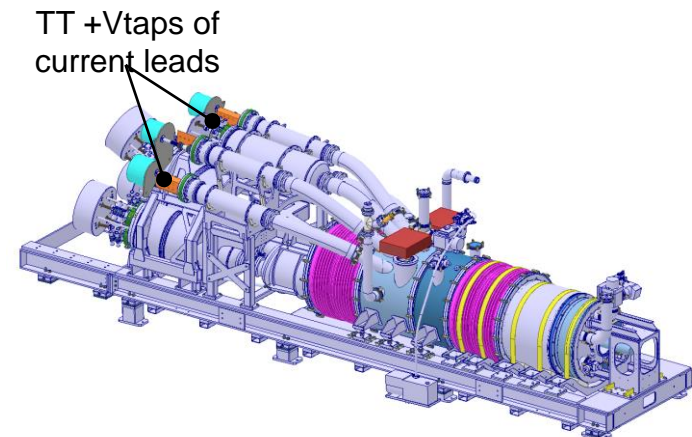
- Standard magnet type IFS not feasible due to high number of signals
- Temp. sensors & Vtaps of same circuit grouped into one Fischer S105A058 connector
 - no high voltage between the pins
 - creepage distances:
 - in air: 14 mm & in GHe (RT, 1 ATM): 66 mm



IFS flanges & splitting module #3

Current lead IFS:

- On each current lead:
 - 1x temp. sensors & Vtaps Fischer connector
 - 1x temp. sensors Lemo connector
- No high voltage between the pins
- Connector assumed to be on the potential of the circuit → shield in RT cable not connected



IFS flanges & splitting module #4

Splitting modules:

- Splitting modules that separate different signals
 - Cryogenic instrumentation
 - Vtaps
 - Temperature switches for current leads
- Groups signals per circuit
- HV compatible Harting connectors
- Different splitting modules for SC-link prototype system test and IT string
 - additional instrumentation (more than baseline) available for prototype test: additional Vtaps on HTS cables, additional temp. sensors in current leads

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Documentation #1

Cold powering system documentation:

- Documentation in engineering check on EDMS
- Will be finalized after prototype system check
- Component specific documentation:
 - DFHX / DFHM / DFX / DFM & current leads
- Global cold powering system documentation

1. IFS Design for DFHX and DFHM: <https://edms.cern.ch/document/2510343/1.0>
2. Technical Design of DFHX/M Instrumentation Flanges: <https://indico.cern.ch/event/1170478/#1-technical-design-of-the-inst>
3. Splitting Modules Interfaces: <https://edms.cern.ch/document/2784361/0.3>
4. Engineering Specs of Cold Powering Instrumentation :
 - a. <https://edms.cern.ch/document/2512704/0.3>
 - b. <https://edms.cern.ch/document/2591698/0.3>
5. DFX IFS interface : <https://edms.cern.ch/document/2896457/0.1>
6. DFM IFS interface: <https://edms.cern.ch/document/2896453/0.1>
7. General Instrumentation Layout for the inner triplets: <https://edms.cern.ch/document/2893121/AA>
8. General Instrumentation Layout for the matching sections: <https://edms.cern.ch/document/2893067/AA>
9. General Quench Detection Representation : <https://edms.cern.ch/document/2896468/AA>

DFX/DFM heaters & temp. sensors

