Current Lead Heating System (CLHS) for HL-LHC circuits and Instrumentation Feedthrough System (IFS)

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Outline

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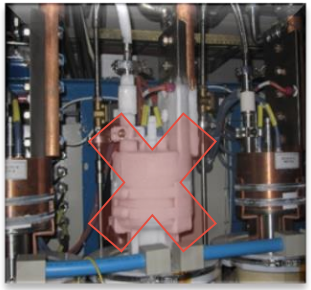
Scope of CLHS

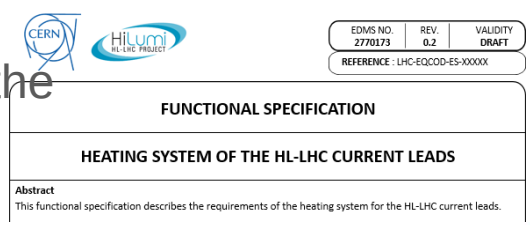
- Each superconducting circuits of the HL-LHC Inner Triplets and Matching Sections will be equipped with HL-LHC HTS current leads (600A to 18kA circuits). In order to ensure their safe operation, a current lead heating system (CLHS) is required.
- The CLHS avoids water condensation, ice formation and guarantees that the temperature at the top of the current lead stays above the dew point during machine operation.
- Each Current Lead Heating System is composed of a Heater Control Unit, a Heater Power unit , Heater Cartridges and Temperature sensor (thermocouple).




Example of existing CLHS system in the LHC machine

Introduction

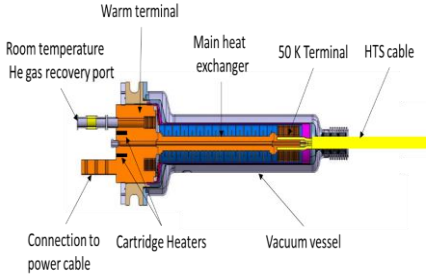
- Functional specification has been prepared by J. Fleiter, EDMS 2770173, WP6a, based on the existing CLHS in the LHC machine.
- Main specs:
  - **19 leads** for Inner Triplet circuits (DFHX) and **10 leads** for Matching Section circuits (DFHM), total of **29 leads**.
  - Heater cartridges powered 48 VAC (isolation transformer)
  - Specific power needed per current lead type:


EDMS NO. 2770173 | REV. 0.2 | VALIDITY DRAFT
REFERENCE : LHC-EQCOD-ES-XXXXX

FUNCTIONAL SPECIFICATION

HEATING SYSTEM OF THE HL-LHC CURRENT LEADS

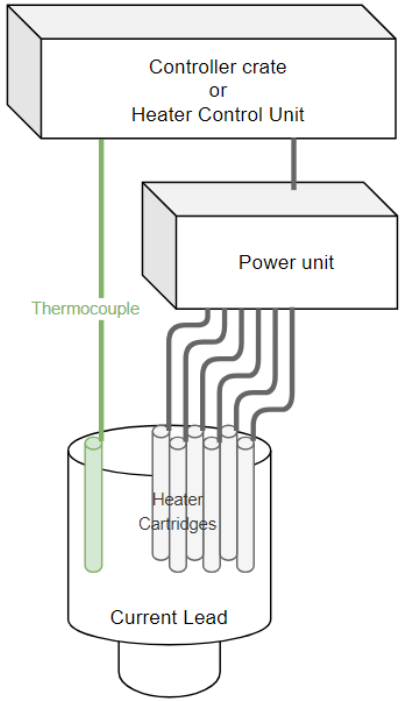
Abstract
This functional specification describes the requirements of the heating system for the HL-LHC current leads.



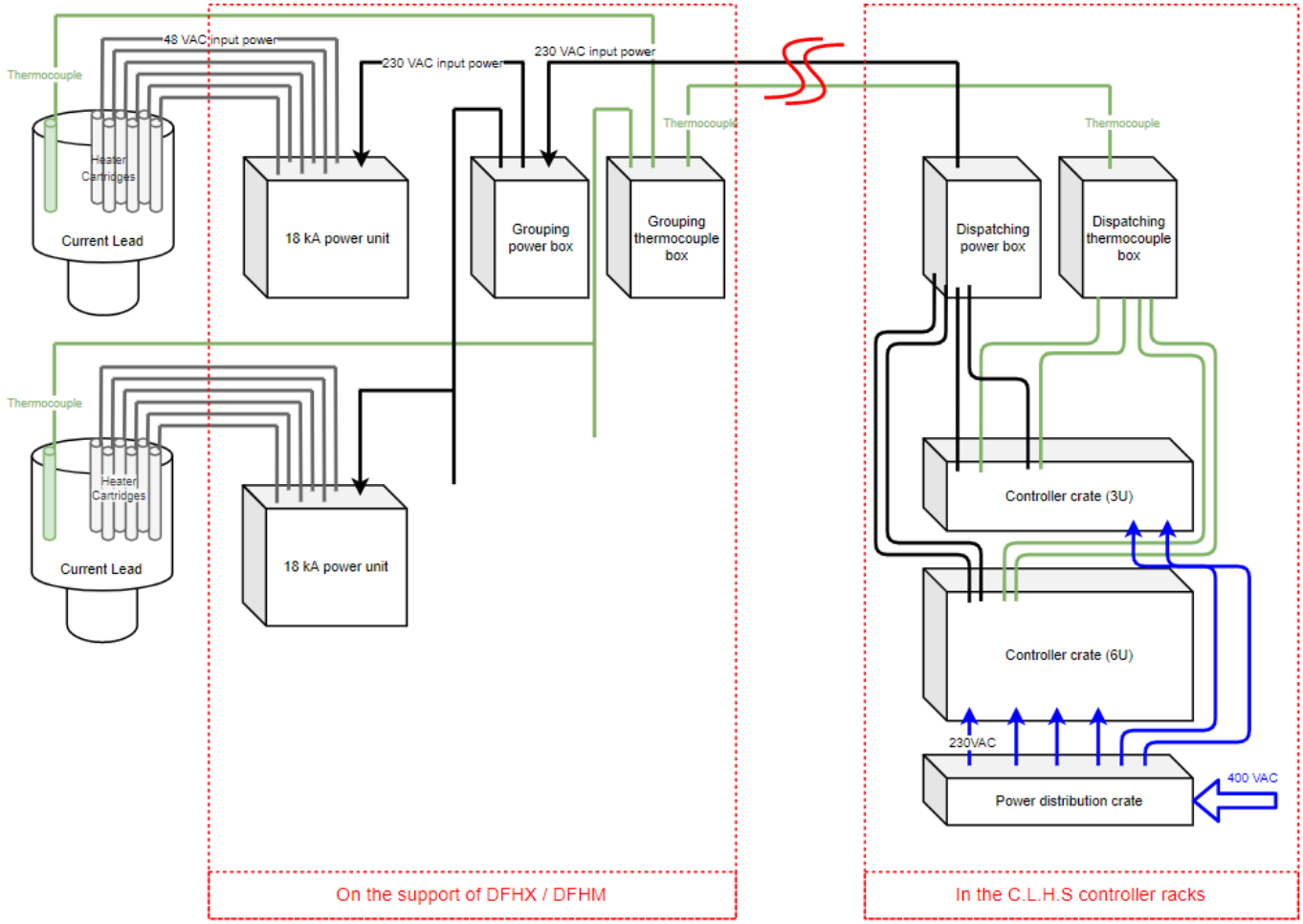
	Type of lead	Number of leads per system	Number of cartridge heater per lead	Maximum Power per lead [W]
Inner Triplet	18 kA	4	6	1800
	7 kA	3	2	250
	2 kA	12	2	250
Matching Section	18 kA	2	6	1800
	0.6 kA	8	1	125

Components of each heating system

- The heating system of each current lead is made of:
  - **Heater Control Unit**
    - Temperature regulation
    - Power electronic (SSR)
  - **Heater Power Unit**
    - Isolating transformer (3 kV) (230/48 VAC)
    - circuit breaker on secondary
  - **Cartridge Heaters:**
    - From 1 to 6 cartridges per lead, 48 VAC, 125 W to 300 W
  - **Temperature Sensor**
    - Thermocouple J-type installed on the warm terminal of each lead

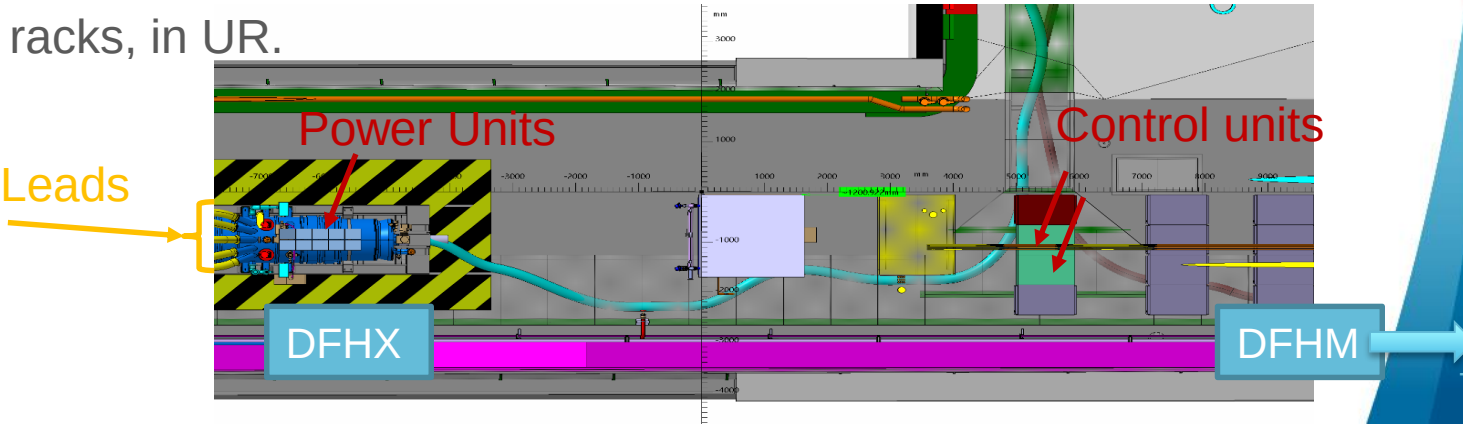


General overview of the C.L.H.S.



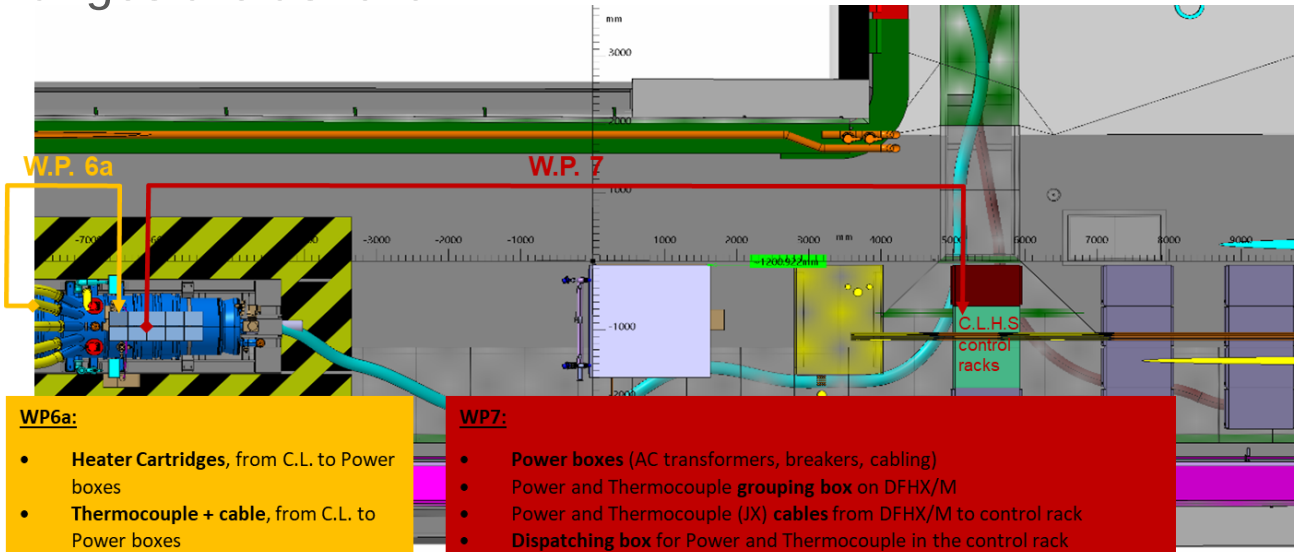
Integration in the HL-LHC machine

- The integration of the components of the CLHS in HL-LHC gallery is as follow:
  - Power units and grouping box are installed close to current leads, on top of the DFHX / DFHM in individual box.
  - Heater cartridges and thermocouple are mounted on the current leads, equipped with their cable running on cable trays installed on top of the DFHX / DFHM.
  - Heater control units installed at about 15 m from the current leads in dedicated racks, in UR.



Responsibilities

- There is an agreement between WP6a and WP7 regarding the responsibilities for the HL-LHC CLHS.
- Engineering Change Request in under preparation and will be circulated soon.
- Proposed changes are as follow:



WP6a:

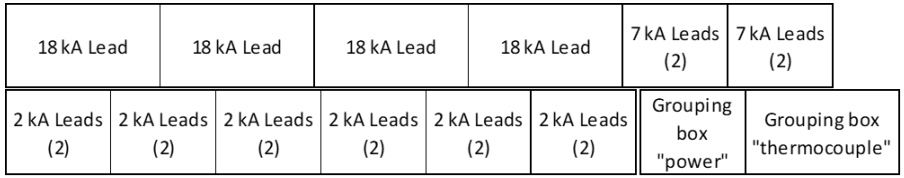
- **Heater Cartridges**, from C.L. to Power boxes
- **Thermocouple + cable**, from C.L. to Power boxes
- **Support** for Power boxes and distribution box on DFHX and DFM

WP7:

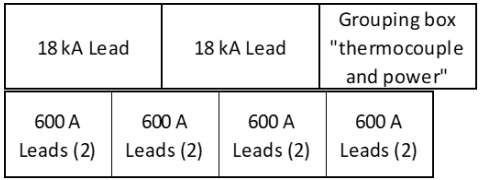
- **Power boxes** (AC transformers, breakers, cabling)
- Power and Thermocouple **grouping box** on DFHX/M
- Power and Thermocouple (JX) **cables** from DFHX/M to control rack
- **Dispatching box** for Power and Thermocouple in the control rack
- **Control crates** for DFHX/M
- **Power distribution crate**

Overview of the boxes needed at the DFHX/ DFHM

- DFHX:
  - 4 Large power boxes for 18 kA lead
  - 8 Medium power boxes for 7 / 2 kA lead
  - Grouping box for power (230 VAC)
  - Grouping box for thermocouple signals



- DFHM:
  - 2 Large power boxes for 18 kA lead
  - 4 Medium power boxes for 600 A lead
  - Grouping box for power (230 VAC) and thermocouple signals



The integration studies should be updated based this new layout that uses grouping/dispatching boxes.

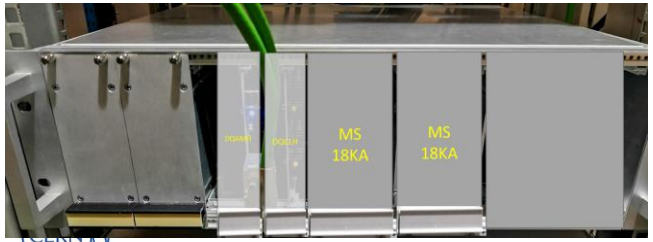
The design of the frame (WP6a) attached to DFHX/DFHM supporting the boxes should be further studied with inputs from WP7.

Overview of the control crates in the UR

IT 18 kA: based on the future 3U – 6 kA in LHC

IT 2 kA / 7 kA and MS 600 A: based on the future 6U – 600A in LHC

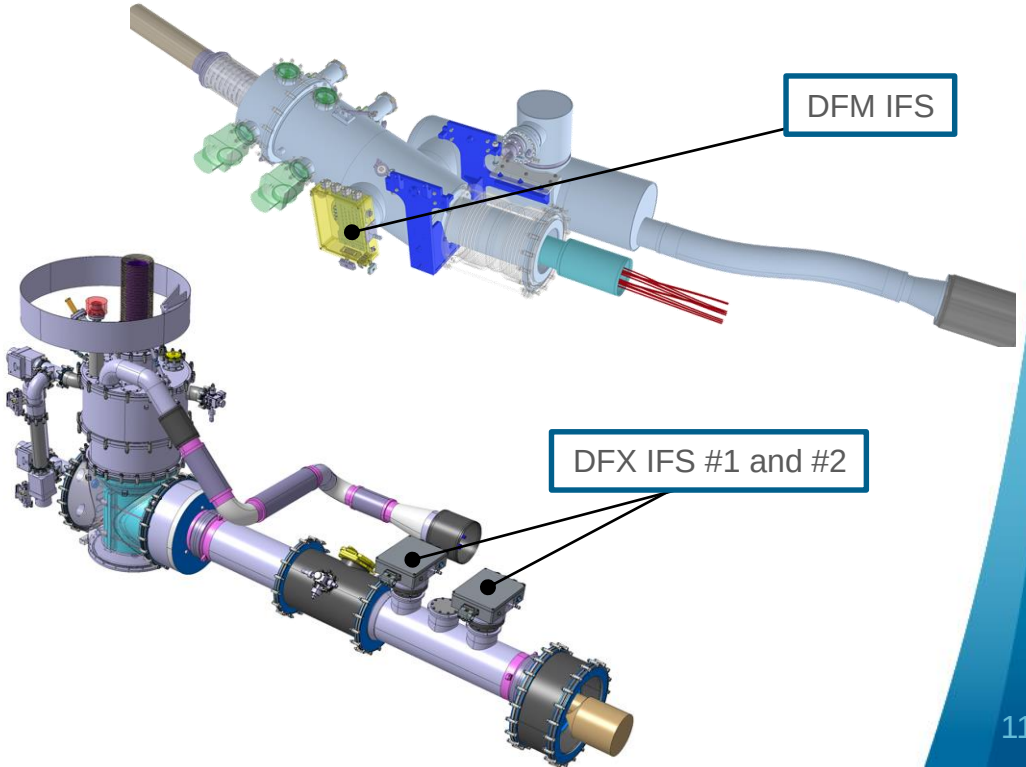
MS 18KA: based on the future 3U - 13KA in LHC



- WP7 will use heater control units developed for the RRs in LHC.
- For Inner Triplet leads:
  - 3U crate:
    - 4 x “cassettes” for 18 kA leads (1 “cassette” = 1 lead of 1800 W), D1 and RQX.
  - 6U crate :
    - 1 x “cassettes” for 7 kA leads (1 “cassette” = 4 leads of 250 W)
    - 3 x “cassettes” for 2 kA leads (1 “cassette” = 4 leads of 250 W)
- For Matching Section leads:
  - 6U crate : same crate as for IT leads
    - 2 x “cassettes” for 600 A leads (1 “cassette” = 4 leads of 125 W)
  - 3U crate:
    - 2 x “cassettes” for 18 kA leads (1 “cassette” = 1 lead of 1800 W)

IFSs of WP6a on DFX and DFM

- Following careful integration studies and for standardisation purpose it was decided to use HL-LHC I.F.S. boxes and flanges also in DFX and DFM.
- The signals routed are:
  - Vtaps of SC busbars
  - Cryogenic Heaters (EH)
  - Temperature sensors
  - Each IFS Type L could route:
    - 42 HV signals (Vtaps and EH)
    - 4 LV signals (TT sensors)
  - 2 IFS boxes already prepared for DFX test on bench F2



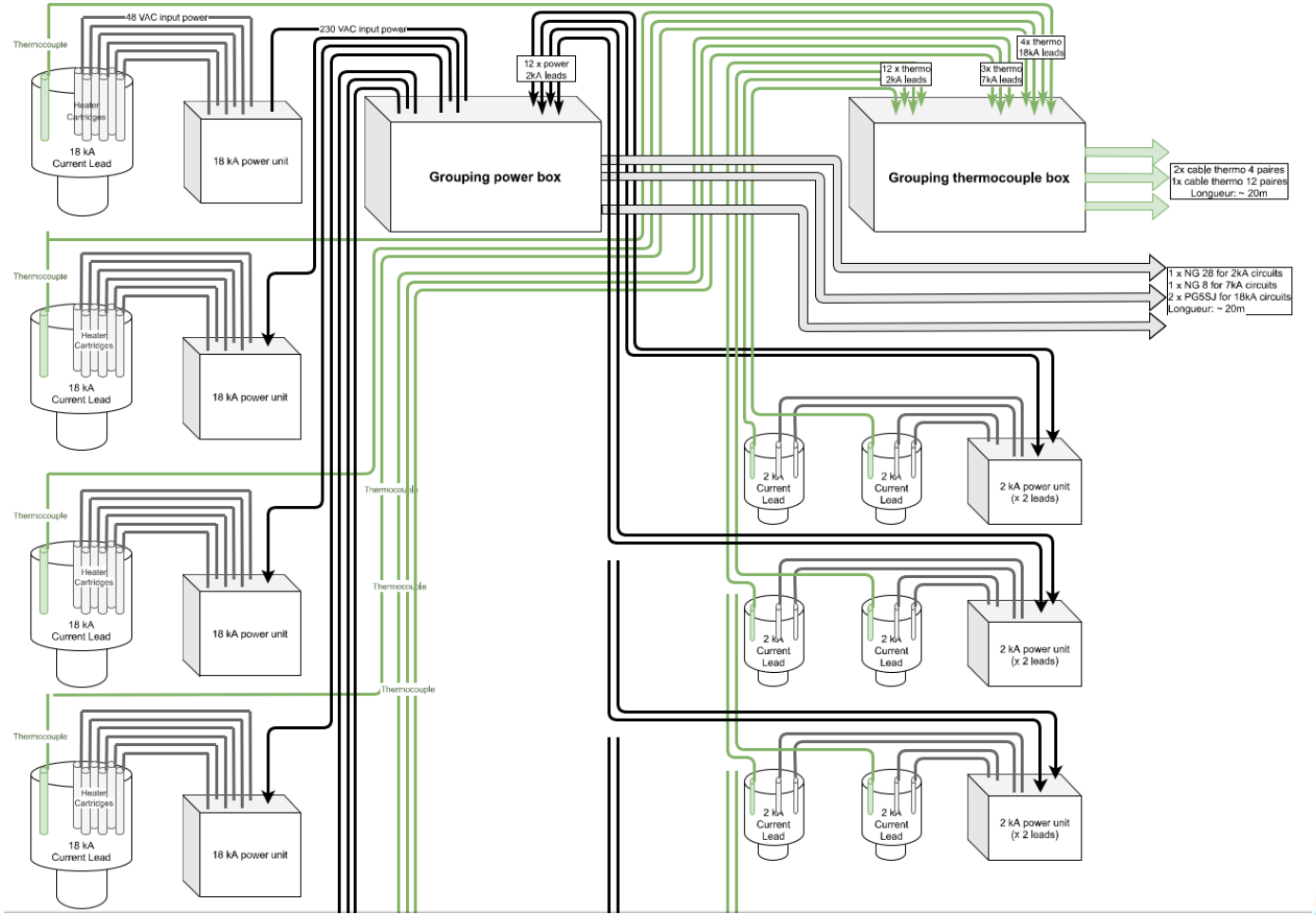
Conclusions

- Functional specification for HL-LHC CLHS has been prepared by J. Fleiter (WP6a), EDMS 2770173.
- Proposed technical solution by WP7 has been presented and should be describe in a dedicated document.
- Integration studies have started, however they should be finalized according to the updated design by WP7.
- WP7 will use the updated control units developed for the LHC in RRs.
- Responsibilities of the current lead heating system for HL-LHC have been discussed and agreed. The ECR will formalized responsibilities and budget allocation.
- WP6a profits from the design of the HL-LHC I.F.S. and flanges to route part of the instrumentation of the DFX and DFM.
- Prototype HL-LHC I.F.S. boxes have been prepared for the type test of the DFX on bench F2 (SM18).

Thank you for your attention !

Backup slides

Overview of the C.L.H.S. for IT circuits



Overview of the C.L.H.S. for MS circuits