DFM Functional specification

Y. Leclercq on behalf on WP6a DFM team development

CDR DFM 21 June 2019

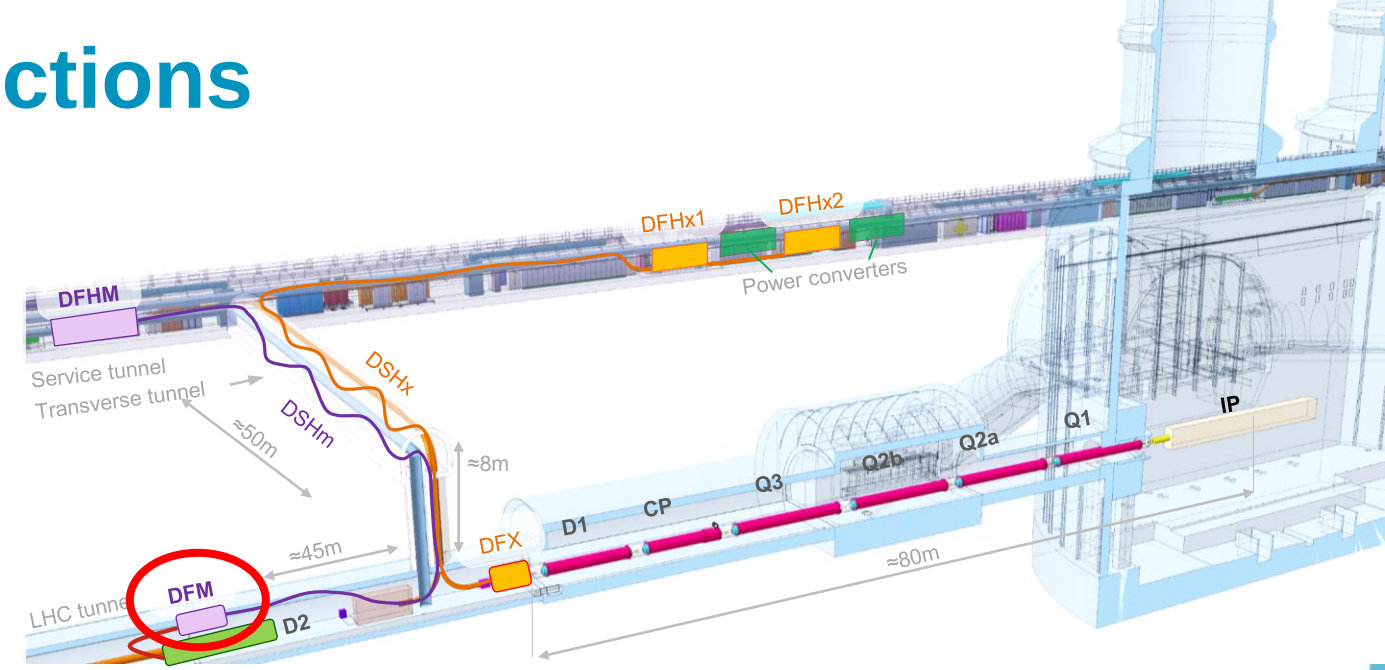
Context : DF boxes key functions

Each IP1 and IP5 sides equipped with 2 cold powering chains of cryostats

- Matching sections : DFHm – SC Link - DFM

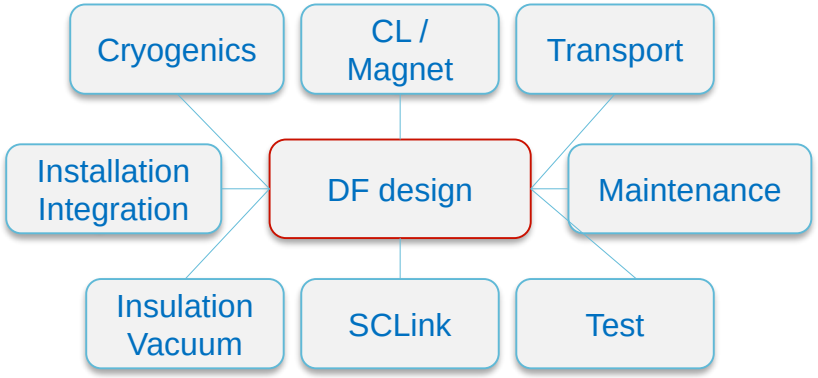
DFM basic functions:

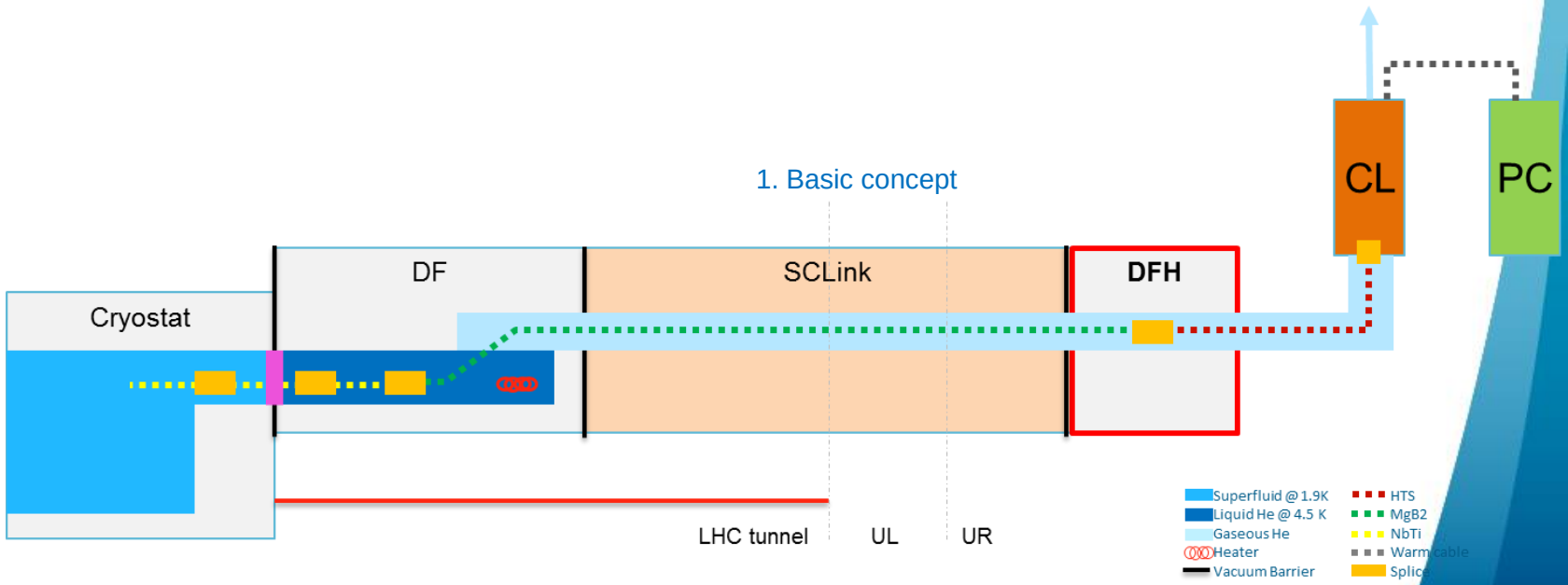
- Electrical interface between SC Link and superconducting magnets
- Supply cryogenics to the SCLink



DFM functional specification and interface definition EDMS 2052614

DF system interfaces





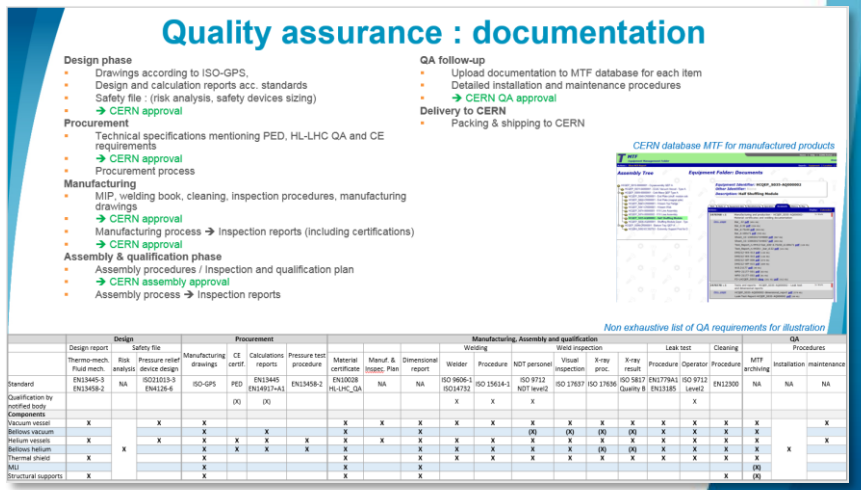
General requirements

- DFM installed in LHC machine
  - ➔ Comply with CERN rules
    - CERN Safety Rules
    - GSI-M-4 - Cryogenic equipment :

> GSI-M4: “The manufacture […] by collaborating institutions, of all new cryogenic equipment shall comply with the applicable CERN Safety Rules, European directives and harmonised standards”.

  - ➔ European directives
    - Pressure Equipment Directive 2014-68-EU
  - ➔ HL-LHC QA requirements
    - ALARA principle
    - Material requirements
    - Documentation & MTF

HL-LHC documentation requirements
Details in spare slide



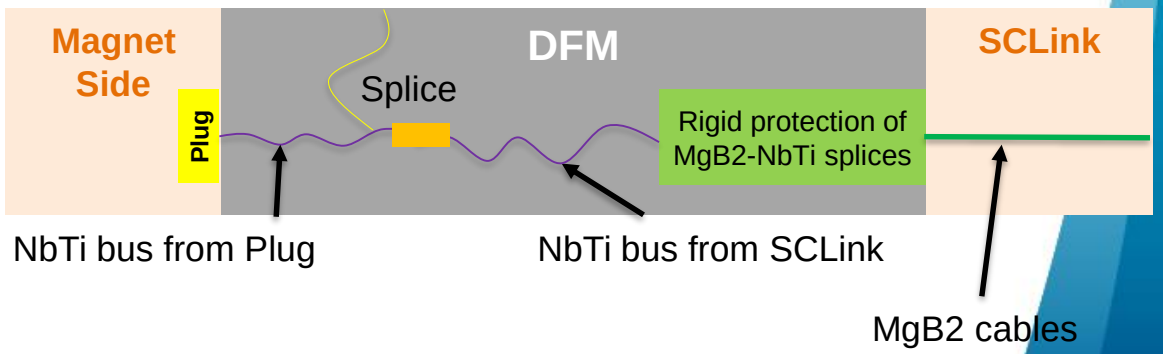
Electrical main specifications

- DFM shall ensure the electrical connectivity between the SCLink DSHM and D2 cables
- SCLink cables layout:
  - 10 MgB_2 conductors in SCLink
  - NbTi extensions soldered to MgB2 in protective rigid cylinder
  - Only NbTi extensions are accessible in DFM

- Magnet cables layout: 10 NbTi conductors from magnet side

- The NbTi extensions shall be routed and connected to the NbTi bus coming out of from the plug

- Instrumentation shall be routed to feedthroughs on a dedicated patch panel at the level of the vacuum vessel interface (no cold feedthroughs)

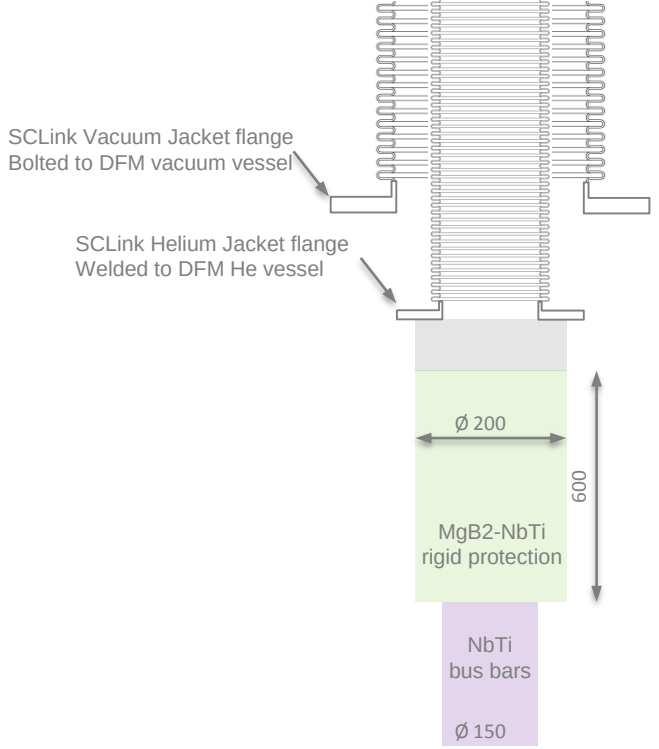


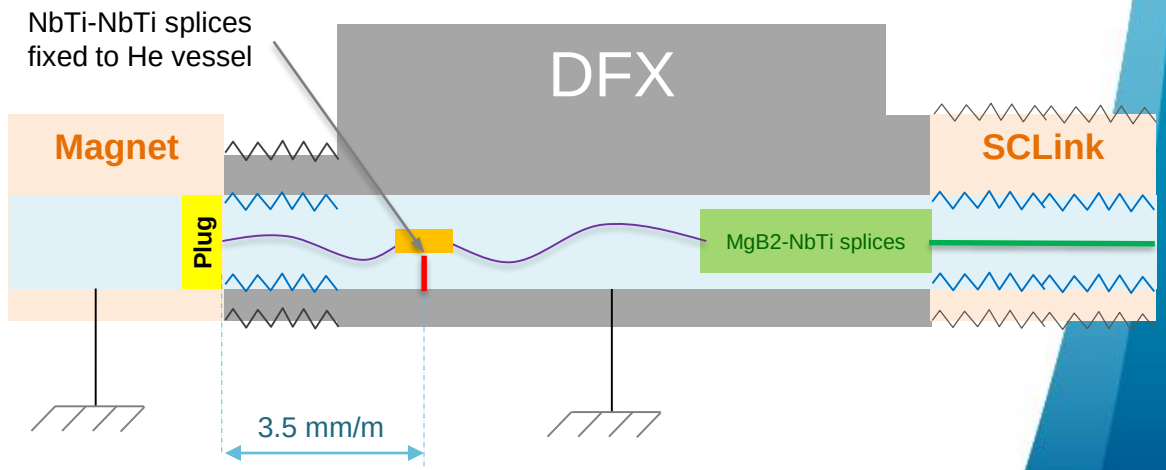
Mechanical interfaces

- SCLink mechanical interface
  - Two independent flexible when installed
  - Vacuum & helium jacket flanges fixed to DFM
  - MgB2-NbTi splices contained in rigid protection fixed to He jacket flange
  - Only NbTi extensions access the DFM He volume

- Magnet mechanical interface
  - Plug fixed to ground
  - DFM fixed to He/vacuum interfaces with bellows
  - Access to NbTi-NbTi splices granted during installation and maintenance

- Cables thermal contractions
  - NbTi-NbTi splices fixed to DFM He vessel
  - DFM covers internal contractions 3.5 mm/m





Cryogenics requirements

Dedicated presentations on Cryogenic scheme, operation, safety

Layout:
- Hydraulic plug separates triplet magnet & DFX-SCLink He volumes
- Dedicated DFX jumper

Electrical performance:
- NbTi cables & MgB2-NbTi splices immersed in LHe

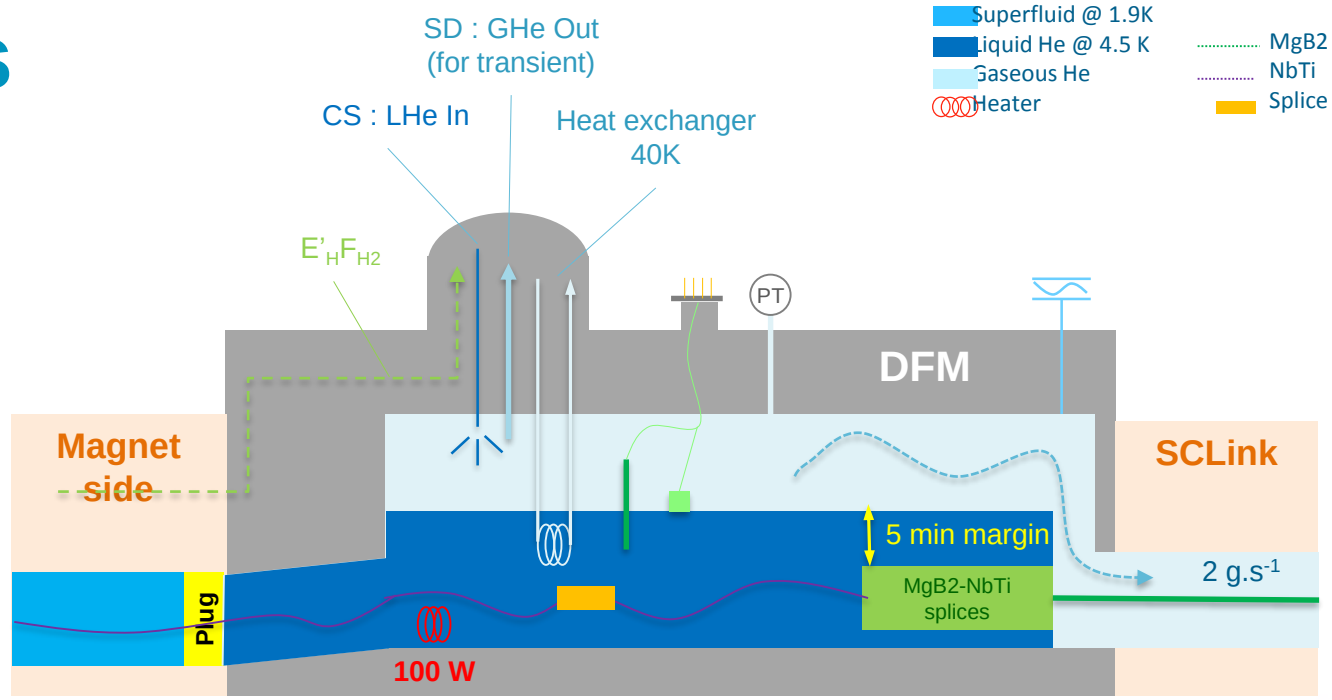
Cryogenic lines:
- LHe in, Ghe out, Outlet Magnet line, heat exchanger

Operation configuration
- Heaters (electrical & heat exchanger) vaporises helium
  - Nominal : 2 $g.s^{-1}$, design 3 $g.s^{-1}$
- Ghe gaseous mass flow through the SCLink
- Design Pressure : 2.5 bara

Instrumentation:
- Level gauges, Temperature sensors, Pressure gauge

Design requirements:
- Heat loads to LHe < 20 W
- No condensation on external surfaces and feedthroughs
- > 10 min of nominal supply GHE in case of liquid supply stop
- Constant slope between coldest point and LHE-GHE interface
- Safety relief devices to protect DFM+SCLink

Access to safety relief devices, instrumentation interfaces shall be granted for inspection and maintenance



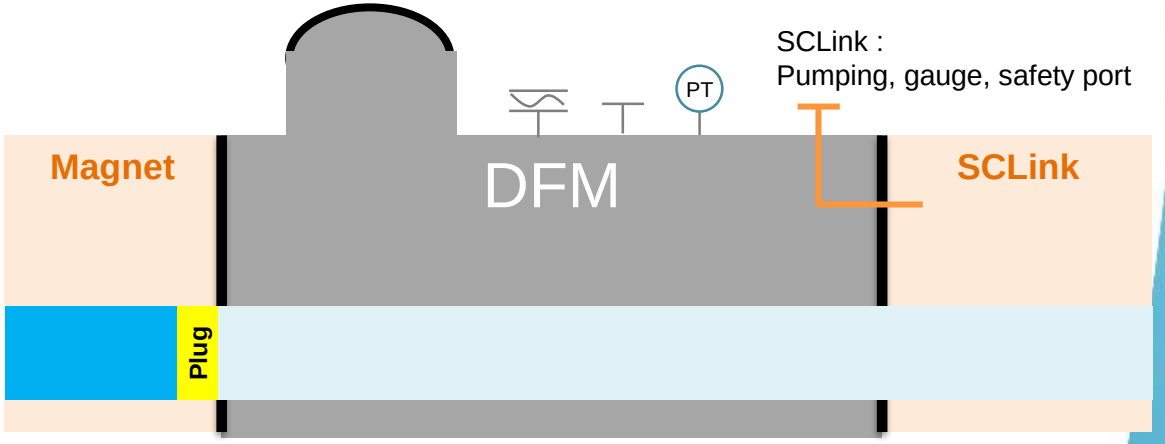
DFM nominal configuration

Insulation vacuum

- The DFM insulation vacuum shall be compatible with the General WP6a insulation vacuum layout EDMS 2048016
- The DFM insulation vacuum is independent to:
  - Allow local maintenance & leak detection
  - Minimise inter-dependence between helium volumes
- ➔ DFM presents vacuum barriers with:
  - The cryolines (not part of DFM)
  - The SCLink (part of the DFM)
  - The Connection to the D2 cryostat (not part of DFM)
- Interfaces:
  - Standard type flanges with elastomer seal
  - Ports for pumps and instrumentation for both DFM & SCLink
  - Pressure relief plate

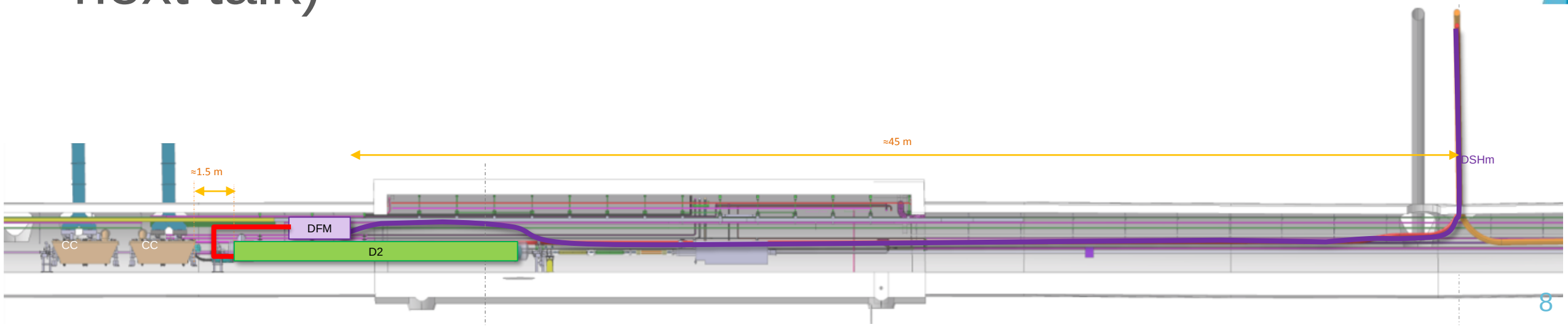
Table1 : Insulation vacuum requirements for WP6a components

Unit	Value
Insulation vacuum pressure level at ambient temperature	$< 1.10^{-4}$ mbar
Insulation vacuum pressure level in nominal operation	$< 1.10^{-5}$ mbar
Maximum allowed overall leak rate in nominal operation	$< 2.10^{-8}$ mbar.l.s^{-1}

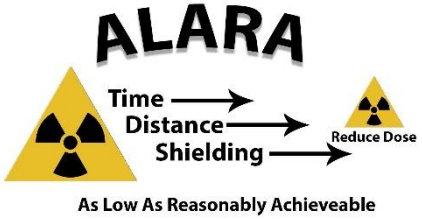


Integration specification

- On-going study to define Integration specifications
- Weekly meeting started under WP15 (Friday 10am) to define inputs leading to integration study.
- 1st Meeting on June 14.
- Preliminary studies led with DFX environment (see next talk)



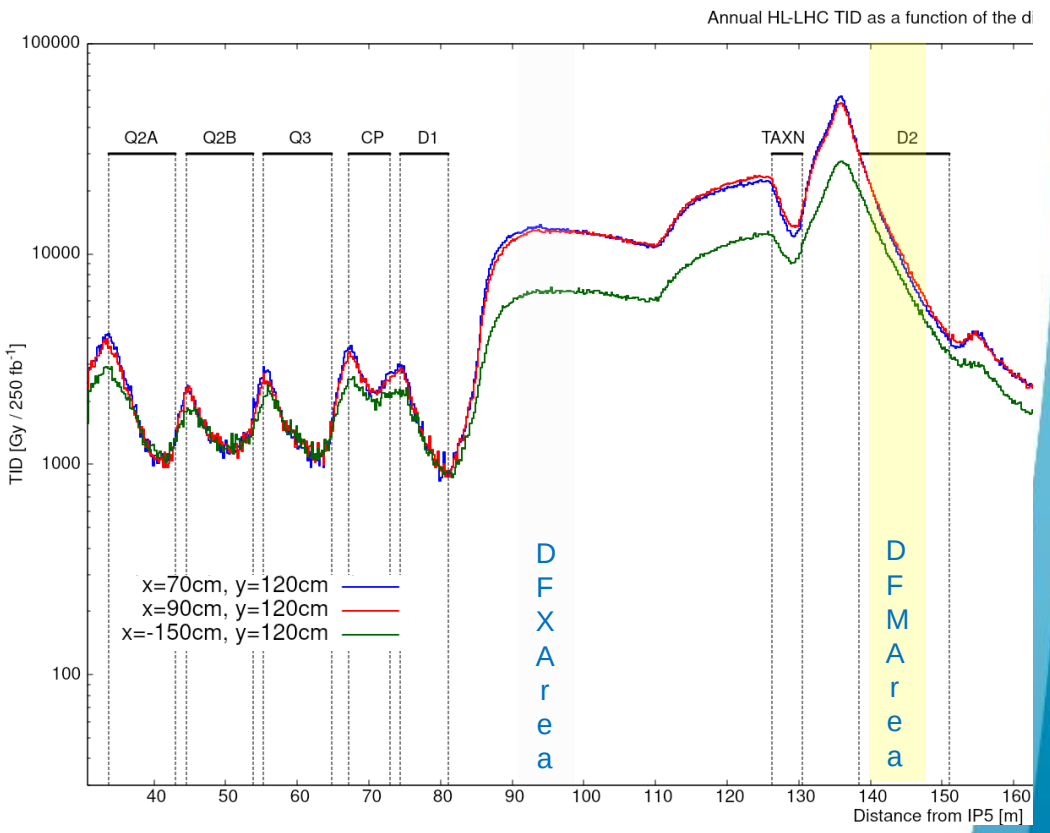
Preventive maintenance and repairs



- Dose up to 1 MGy over HL-LHC life time at D2 end, Neutron f. ≈ > 1.10^{15} cm^{-2}, up to 25 mSv/h

- All operations shall be designed from the ALARA point of view:
  - Minimise intervention time (access, automatic operation)

- Interventions
  - Unscheduled interventions for inspections and light work during Technical Stops (e.g. for electrical checks on patch panel)
  - Planned interventions for routine maintenance requiring warm up during YETS (e.g. replacement of burst disks)
  - Unscheduled medium repair work interventions requiring warm up during YETS (e.g. Nb-Ti/Nb-Ti repair)
  - Unscheduled heavy repair work interventions requiring warm up during EYETS or unscheduled extended machine stop (e.g. MgB2/Nb-Ti repair, plug replacement)



Annual HL-LHC TID at various location for illustration only. Courtesy G.Lerner

Manufacturing & Inspections

- Manufacturing & Inspections according to
  - Pressure Equipment Directive (PED)
  - HL-LHC QA requirements (see spec)

    - *Materials & Manufacturing specific requirements:*
      - *Compatible with Dose level over HL-LHC project period:*
      - *Cobalt content for stainless steel < 0.1%*
      - *Polymers according to IS41 EDMS335806*
      - *Vacuum vessel as PED CATI*
      - *Bellows specific welding interfaces*

    - *Inspections and certifications*
      - *Welding and welders*
      - *Leak tightness level, procedure and operators*
      - *Pressure testing according to PED*

    - *Documentation*
      - *Manufacturing procedures & qualifications*
      - *Inspection reports*
      - *CE certification*
      - *Upload into CERN database MTF*

CERN

INSTRUCTION DE SÉCURITÉ
SAFETY INSTRUCTION
Mandatory as defined in SAPOCO/42

IS41
Rev. 1

Issued by: SC-GS

Date of revision: November 2005
Original: English

The Use of Plastic* and other Non-Metallic Materials at CERN with respect to Fire Safety and Radiation Resistance

Table 4: Documentation

Phase	Requirements
Design	- Specification drawings according to ISO-GPS; - Design and calculation reports according to applicable standards; - Safety file as defined in [2];
Procurement	- Technical specifications with certification requirements;
Manufacturing	- Manufacturing drawings to ISO-GPS standards; - Manufacturing and Inspection plan; - Welding book - Welder certifications (ISO9606-1) - Weld qualification (ISO 15614-1) - Welds visual and radiographic inspection reports (ISO 17637, ISO 17636-1) - NDT operator certification (ISO 9712 NDT level2) - Cleaning procedure and reports - Pressure test procedure and reports - onnel certification (ISO 9712); edures; MTF, CERN database;

CERN database MTF for manufactured products

Summary

- Cryogenics, Electrical, insulation vacuum operating functional specifications are defined

- Integration and transport specifications still to be defined. Specific weekly meeting in place under WP15.

- Detailed technical and interfaces specifications to be studied (cryogenics connection, Electrical protection)