



# DFM Functional specification

Y. Leclercq on behalf on WP6a DFM team development

***CDR DFM 21 June 2019***

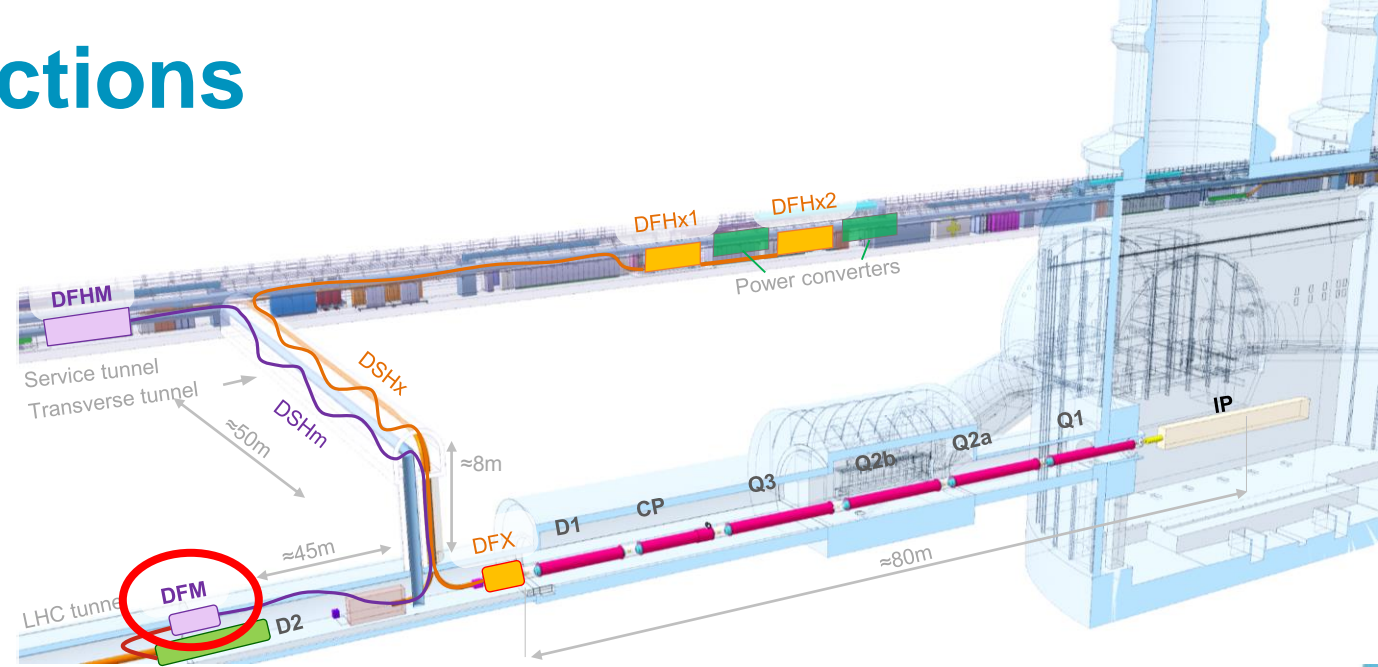
# Context : DF boxes key functions

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

- Matching sections : DFHm – SC Link - DFM

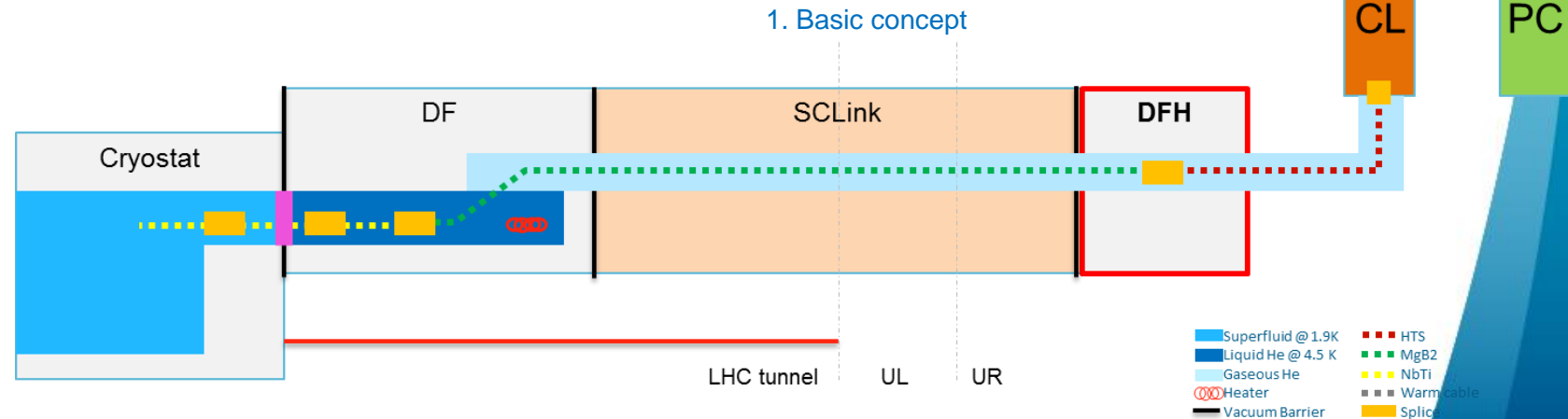
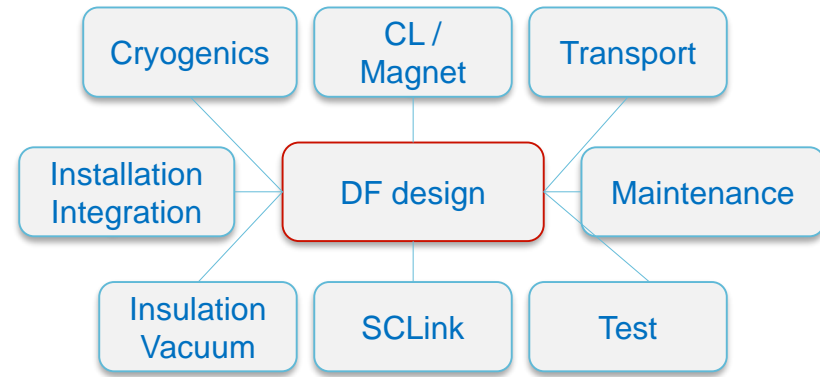
DFM basic functions:

- 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*

### Quality assurance : documentation

**Design phase**

- Drawings according to ISO-GPS.
- Design and calculation reports acc. standards
- Safety file : (risk analysis, safety devices sizing)
- CERN approval

**Procurement**

- Technical specifications mentioning PED, HL-LHC QA and CE requirements
- CERN approval
- Procurement process

**Manufacturing**

- MIP, welding book, cleaning, inspection procedures, manufacturing drawings
- CERN approval
- Manufacturing process → Inspection reports (including certifications)
- CERN approval

**Assembly & qualification phase**

- Assembly procedures / Inspection and qualification plan
- CERN assembly approval
- Assembly process → Inspection reports


**QA follow-up**

- Upload documentation to MTF database for each item
- Detailed installation and maintenance procedures
- CERN QA approval

**Delivery to CERN**

- Packing & shipping to CERN

CERN database MTF for manufactured products



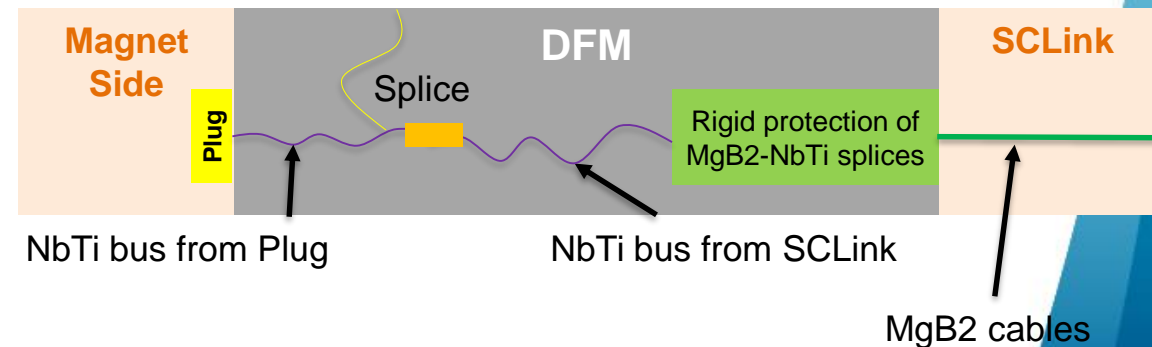
*Non exhaustive list of QA requirements for illustration*

	Design		Procurement				Manufacturing, Assembly and qualification										QA			
	Design report	Safety file	Manufacturing drawings	CE certifi.	Calculations reports	Pressure test procedure	Material certificate	Manuf. & Inspect. Plan	Dimensional report	Welding Procedure	Visual inspection	X-ray	X-ray result	Procedure	Operator	Procedure	MTF archiving	Installation	maintenance	
Standard	EN13445-1	EN13445-2	EN13445-3	EN13445-4	EN13445-5	EN13445-6	EN13445-7	EN13445-8	EN13445-9	EN13445-10	EN13445-11	EN13445-12	EN13445-13	EN13445-14	EN13445-15	EN13445-16	EN13445-17	EN13445-18	EN13445-19	EN13445-20
Qualification by certified body			(X)	(X)																
Components																				
Vacuum vessel	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Below vacuum					X															
Helium vessel	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Below helium					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Thermal shield					X															
MI					X															
Structural supports	X				X															



# Electrical main specifications

- DFM shall ensure the electrical connectivity between the SCLink DSHM and D2 cables
- SCLink cables layout:
  - 10 MgB<sub>2</sub> conductors in SCLink
  - NbTi extensions soldered to MgB<sub>2</sub> 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

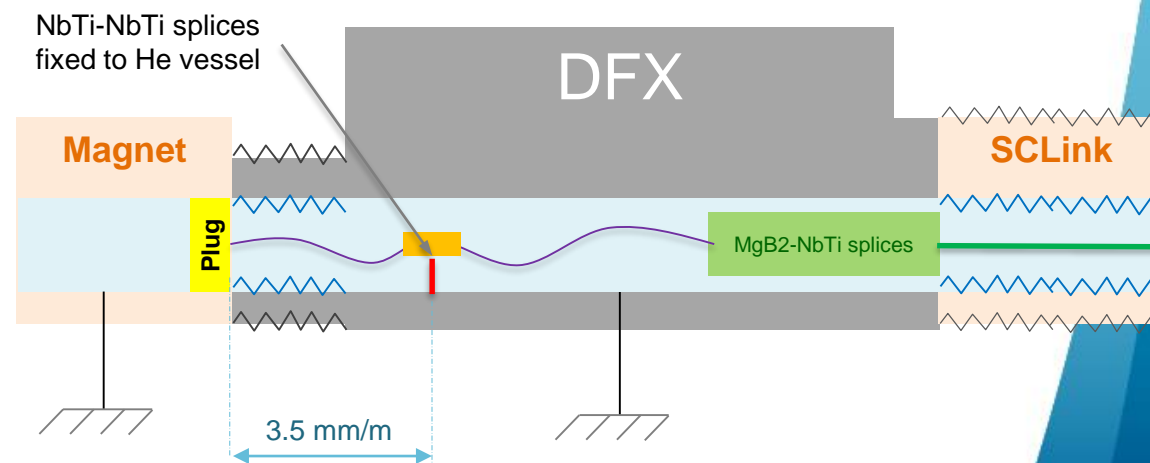
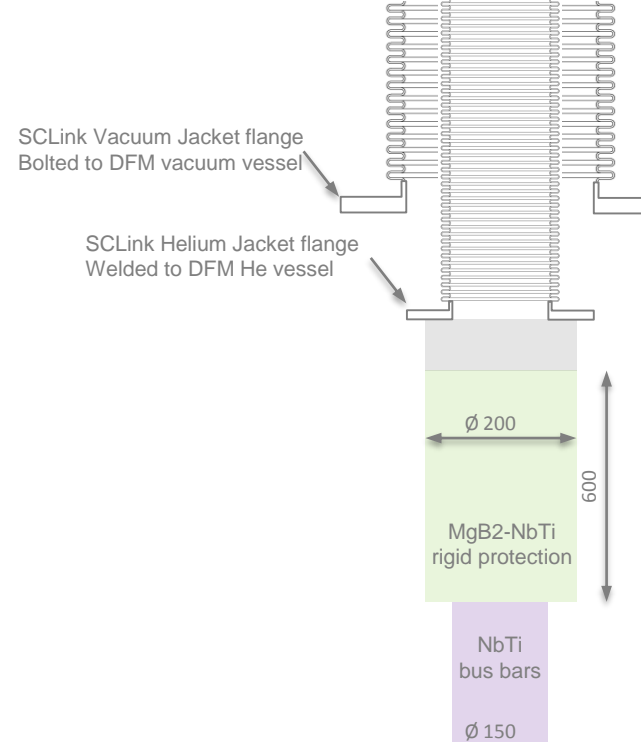
- Two independent flexible when installed
- Vacuum & helium jacket flanges fixed to DFM
- MgB<sub>2</sub>-NbTi splices contained in rigid protection fixed to He jacket flange
- Only NbTi extensions access the DFM He volume

## 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 :  $2 \text{ g}\cdot\text{s}^{-1}$  , design  $3 \text{ g}\cdot\text{s}^{-1}$
- GHe gaseous mass flow through the SCLink
- Design Pressure : 2.5 bara

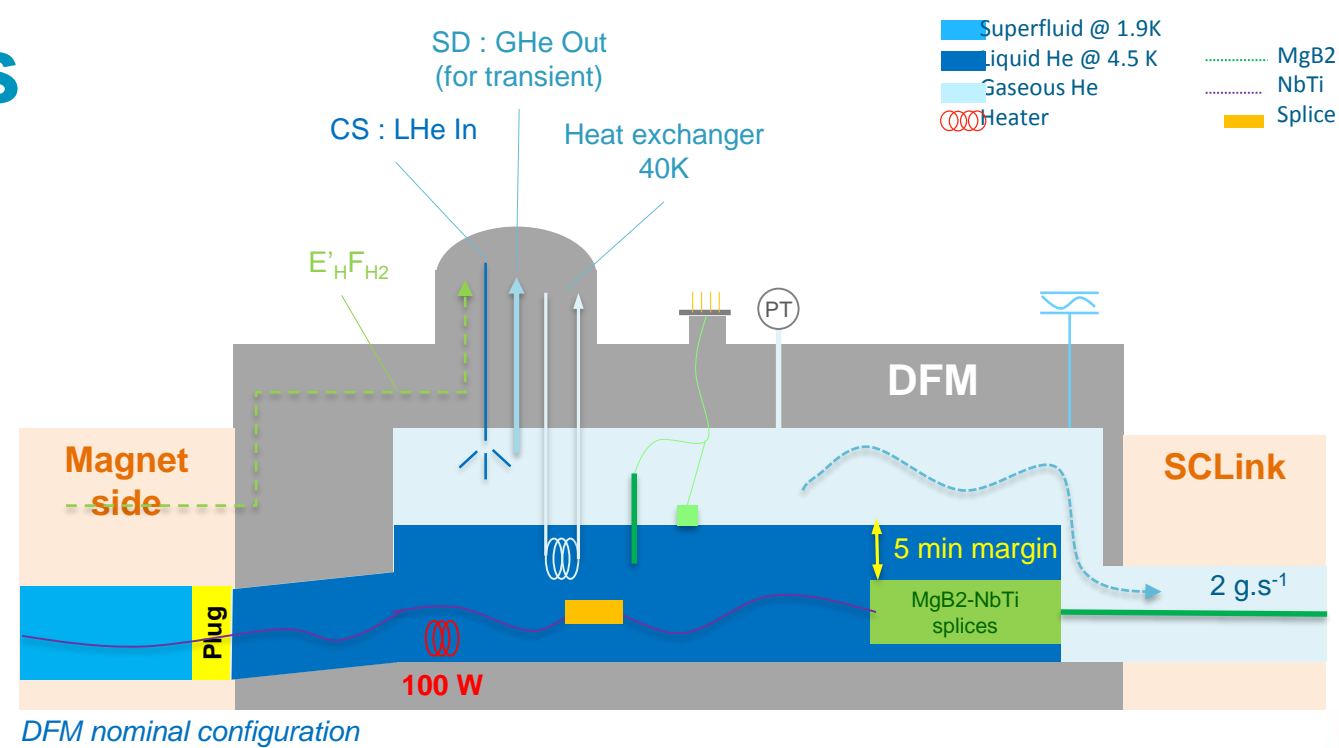
## Instrumentation:

- 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



# 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:

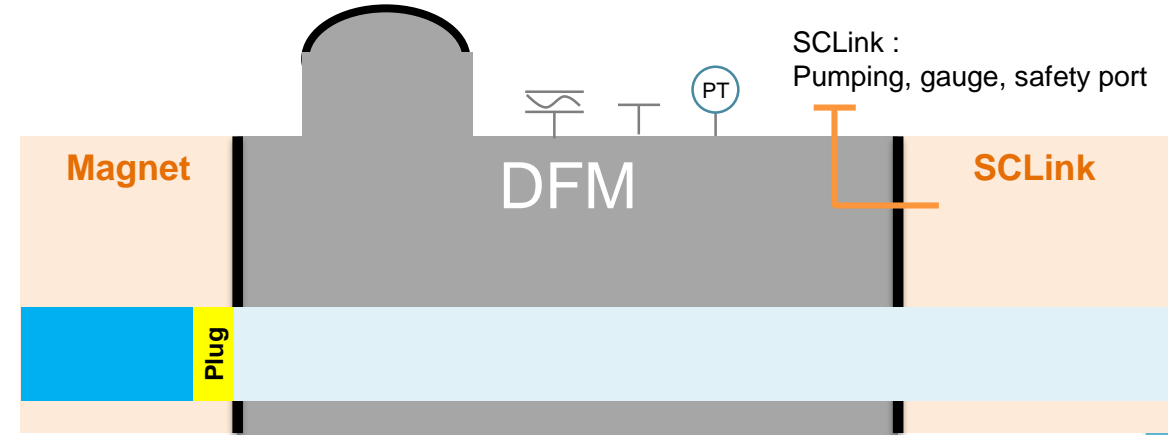
- The cryolines (not part of DFM)
- The SCLink (part of the DFM)
- The Connection to the D2 cryostat (not part of DFM)

- 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

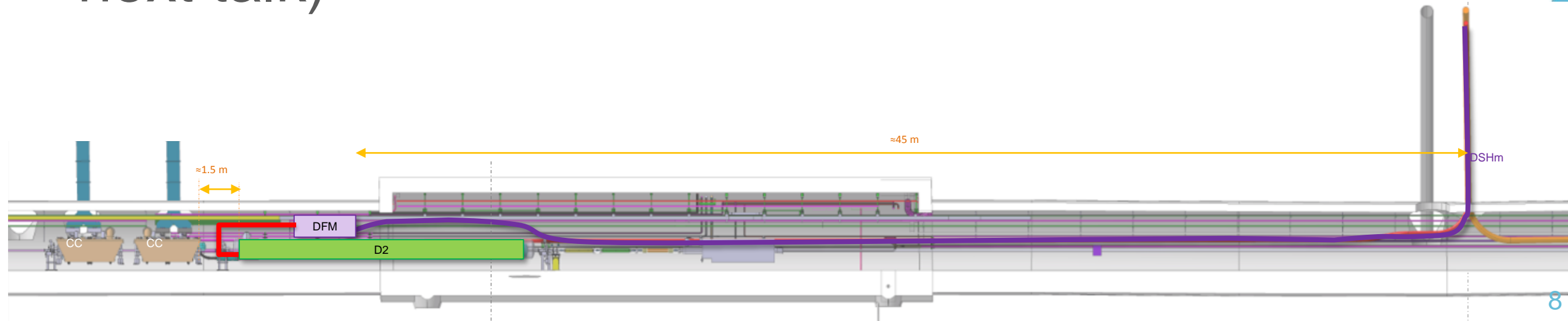
Unit	Value
Insulation vacuum pressure level at ambient temperature	$< 1.10^{-4}$ mbar
Insulation vacuum pressure level in nominal operation	$< 1.10^{-5}$ mbar
Maximum allowed overall leak rate in nominal operation	$< 2.10^{-8}$ mbar.l.s <sup>-1</sup>





# Integration specification

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





# Preventive maintenance and repairs

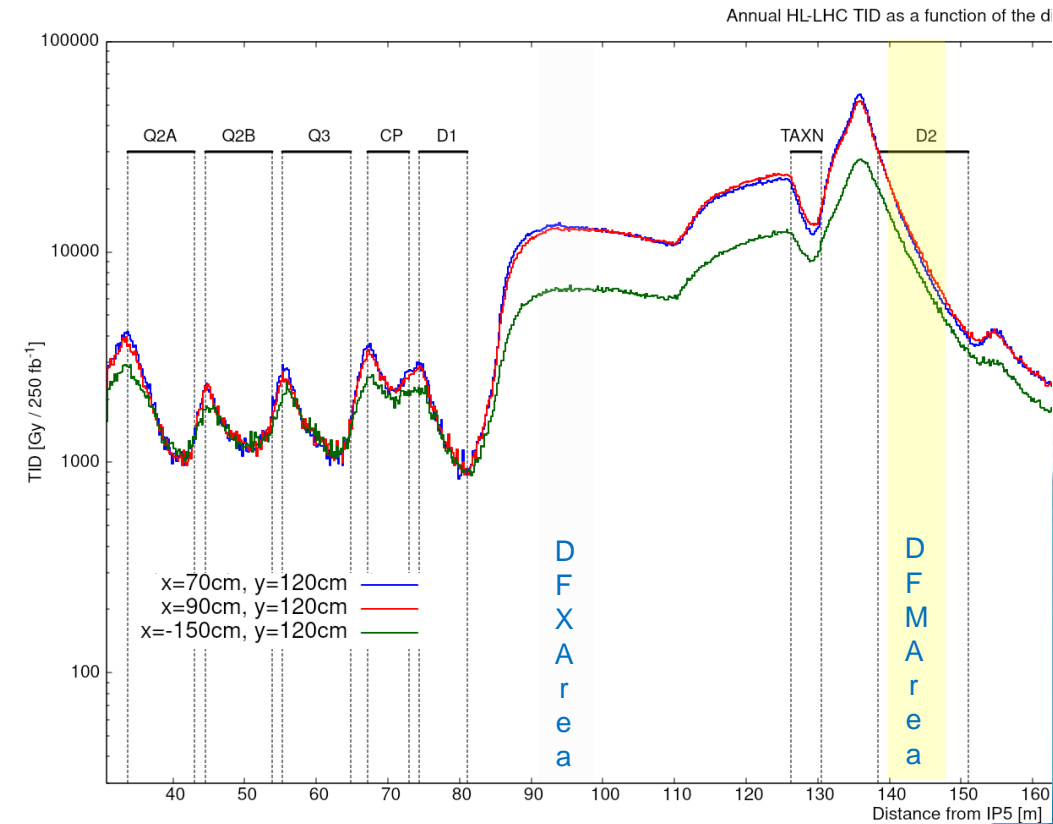
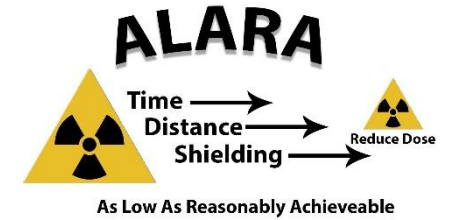
Dose up to 1 MGy over HL-LHC life time at D2 end, Neutron f.  $\approx > 1.10^{15} \text{ cm}^{-2}$ , up to 25 mSv/h

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*

	<b>INSTRUCTION DE SÉCURITÉ SAFETY INSTRUCTION</b> Mandatory as defined in SAPOCO/42	<b>IS41 Rev. 1</b>
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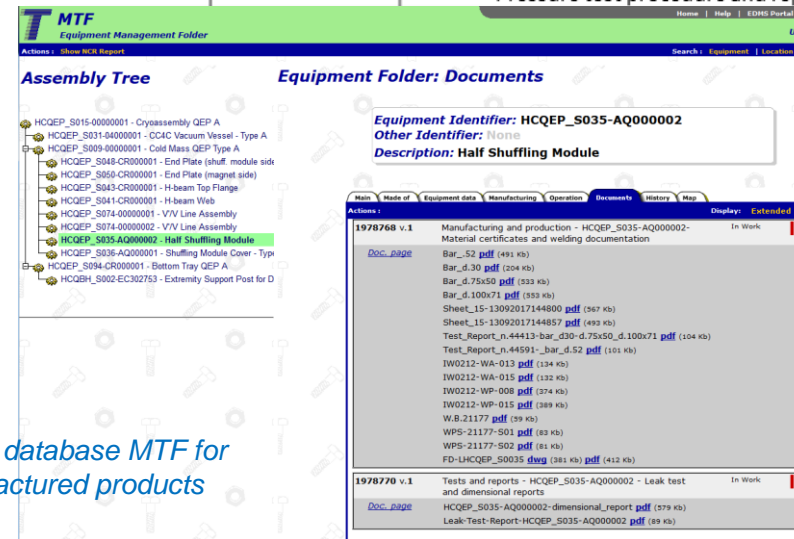
Issued by: SC-GS

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	<ul style="list-style-type: none"> <li>- Specification drawings according to ISO-GPS;</li> <li>- Design and calculation reports according to applicable standards;</li> <li>- Safety file as defined in [2];</li> </ul>
Procurement	<ul style="list-style-type: none"> <li>- Technical specifications with certification requirements;</li> </ul>
Manufacturing	<ul style="list-style-type: none"> <li>- Manufacturing drawings to ISO-GPS standards;</li> <li>- Manufacturing and Inspection plan;</li> <li>- Welding book</li> <li>- Welder certifications (ISO9606-1)</li> <li>- Weld qualification (ISO 15614-1)</li> <li>- Welds visual and radiographic inspection reports (ISO 17637, ISO 17636-1)</li> <li>- NDT operator certification (ISO 9712 NDT level2)</li> <li>- Cleaning procedure and reports</li> <li>- Pressure test procedure and reports</li> </ul>



The screenshot shows the MTF interface with an 'Assembly Tree' on the left and 'Equipment Folder: Documents' on the right. The assembly tree lists various components like 'Cryoassembly QEP A', 'Cold Mass QEP Type A', and 'Half Shuffling Module'. The document list includes files like 'Bar\_d\_30.pdf', 'Sheet\_15-13092017144850.pdf', and 'Test\_Report\_n.44413-bar\_d30-d.75x50\_d.100x71.pdf'.

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)