



# Equipment safety & safety aspects in the LHC tunnel

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***Engineering Design Review of DFM 18.01.2022***

# Agenda

- Review of CDR close-out recommendations
- Conformity compliance strategy
- Radiation protection aspects
- Cryogenic safety aspects
- Electrical safety aspects
- Next steps

# Recommendations from the DFM CDR

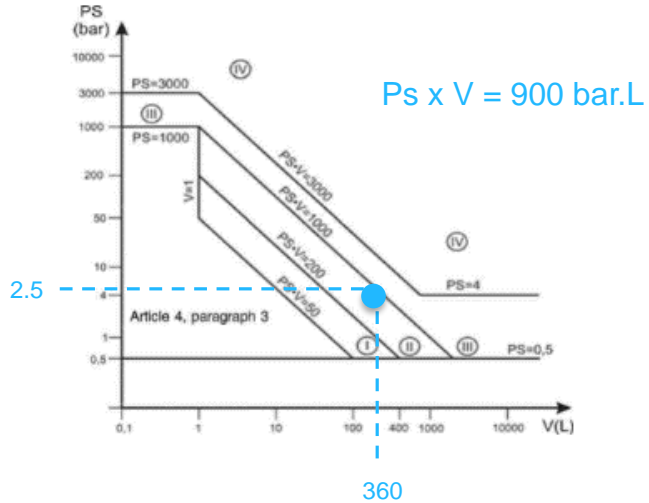
## ■ Recommendation #3

- [...] the radioprotection aspects make any intervention (apart from the first installation) critical for ALARA considerations.
- The plan for maintenance and reparation must be developed taking into account this aspects.
- More detailed sequence for all these operations are expected at the DDR review.
  - Detailed sequence for maintenance & repair will follow F2 test bench to include empirical knowledge (c.f. P.Cruikshank's talk #1)

## ■ Recommendation #4

- The DFM design and its technical documentation has to coherently address the point of the design standard applied (PED) and consequent requirements all along the procurement, assembly and testing phases.
  - ✓ Design standard will be presented and justified. Requirements will be addressed.
- The exact role of HSE should be identified and clarified.
  - ✓ HSE guidance used for the conformity compliance strategy. HSE's role is clear.
- The integration of burst disk, rated valve and relief plates must be done together WP15 and HSE.
  - ✓ Final integration of pressure safety devices made considering best safety practices.

# DFM PED category & requirements



PED Category	Conformity Assessment Module	Comment
SEP	N/A	Equipment must be designed and manufactured following sound engineering practice. No involvement of notified body.
Category I	Module A	CE marking with no notified body involvement, self-certifying.
<b>Category II</b>	<b>Module A2</b>	<b>Notified body performs unexpected checks and monitors final assessment.</b>
	Module D1	Notified body performs unexpected checks and assesses production QA.
	Module E1	Notified body performs unexpected checks and assesses final testing QA.
Category III	B1+F	Notified body approves the design, examines and tests the vessel.
Category IV	G	Further involvement of the notified body.

# Conformity compliance strategy

- Design made by CERN acc. to EN13445-3
- Manufacturing by SOTON via UK industrial partner (UK2 agreement)
- Manufacturer chooses the notified body as per Module A2
- Manufacturer responsible for the technical documentation, the final assessment and for drawing up the EU declaration of conformity for CE certification
- Notified body will confirm that the final inspection, the proof test and the safety devices are in line with Sec. 3.2 of the ESR (Annex I of the PED)
- No involvement of HSE before reception at CERN. Connection to the interfacing equipment in the LHC tunnel (DSHM, QXL, D2) under HSE supervision.

# Radiation protection safety

Area	Dose limit [year]	Ambient dose equivalent rate		Sign
		Work place	Low occupancy	
Non-designated	1 mSv	0.5 $\mu$ Sv/h	2.5 $\mu$ Sv/h	
Supervised	6 mSv	3 $\mu$ Sv/h	15 $\mu$ Sv/h	
Simple	20 mSv	10 $\mu$ Sv/h	50 $\mu$ Sv/h	
Limited Stay	20 mSv	2 mSv/h		
High Radiation	20 mSv	100 mSv/h		
Prohibited	20 mSv	> 100 mSv/h		

## Manufacturing

- Stainless steel cobalt content < 0.1 wt% where possible. Any deviation will be the subject of a derogation request.

## Assembly & integration

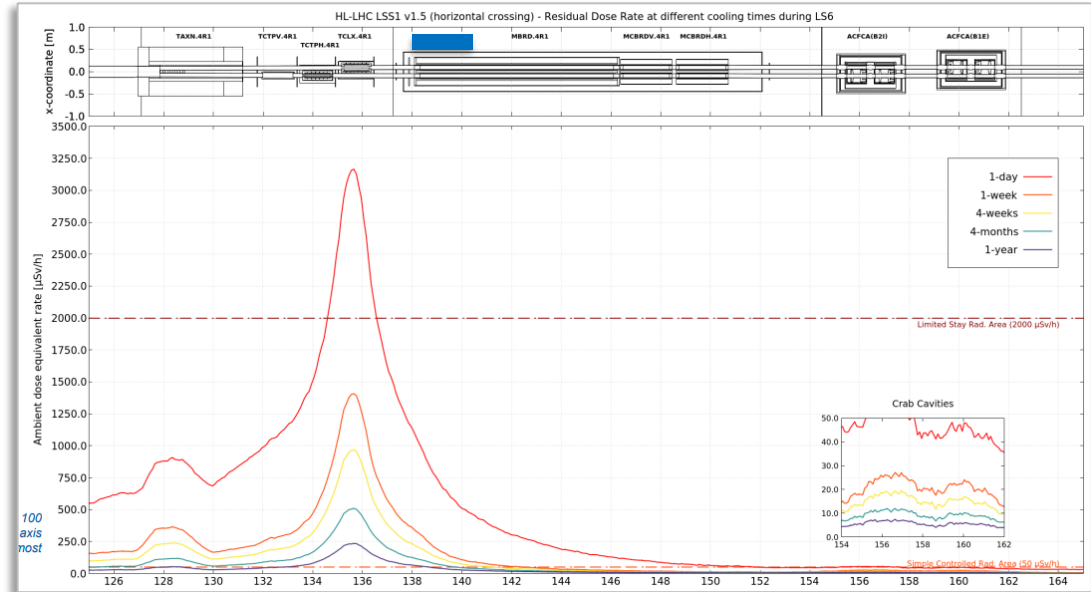
- Highly integrated zone of the tunnel with no margin to locate DFM elsewhere.
- Assembly procedures will be developed following ALARA recommendations.

## Maintenance & repair

- Only very urgent interventions after 1 week cooldown.
- Complex environment above D2 will anyway require a mock-up where intervention procedures (including ALARA) can be optimised.

## Dismantling

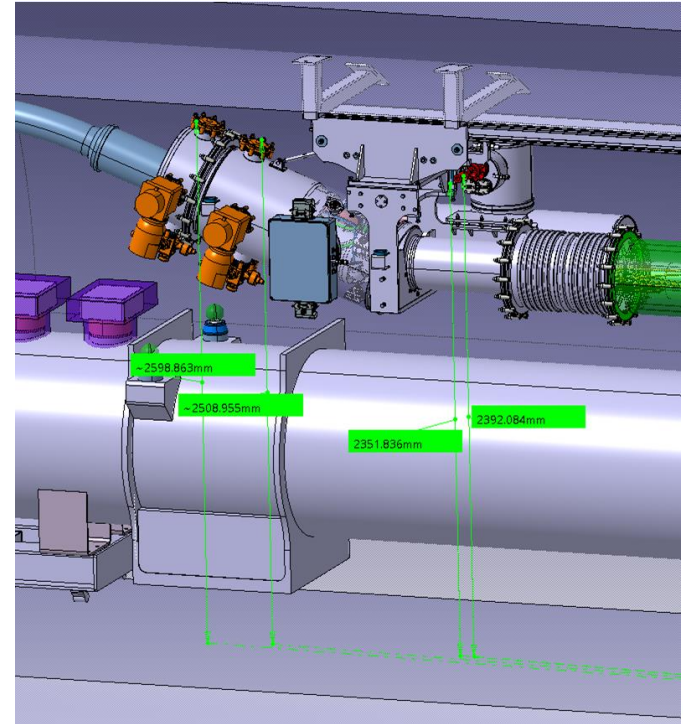
- Disassembly procedure will be developed following ALARA.
- Collimators removed first, D2 removal prior to DFM dismantling preferred.
- Not very time-critical



Courtesy A. Infantino

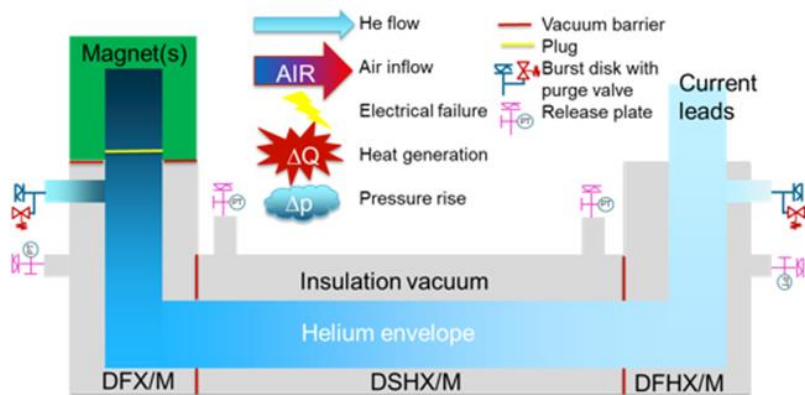
# Cryogenic safety

- Position of safety devices approved by HSE
  - Height of pressure relief devices wrt tunnel's floor between 2300 mm and 2600 mm: no risk of direct projection of cold helium gas on transport side.
- Safety relief device sizing (by Y.Leclercq)
  - Data
    - Cold surfaces exposed to Vacuum : 3.5 m<sup>2</sup> (2.2 m<sup>2</sup> wet surface)
    - 30 layers MLI on helium vessel
    - Helium volumes in nominal operation : 210 liters liquid + 150 liters gaseous
  - Input
    - Vacuum break on 30 MLI layers : 0.2 W/cm<sup>2</sup>
    - Power dissipated in liquid : 7 kW
  - Relief device sizing according to ISO21013-3
    - Qm = 0.5 kg/s (1.4 kg/s for 10 layers)
    - Drelief > 17 mm (28 mm for 10 layers)
- ✓ Sizing of DFM burst disk covers the dimensioning scenario with margin.
- ✓ Relief plates sizing checked at CDR: 2 DN100 on either side of the VB.
- Staggering protection concept (c.f talk of V.Gahier)

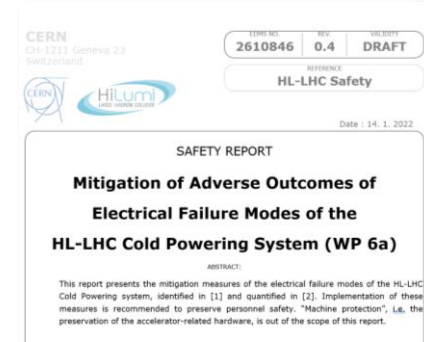
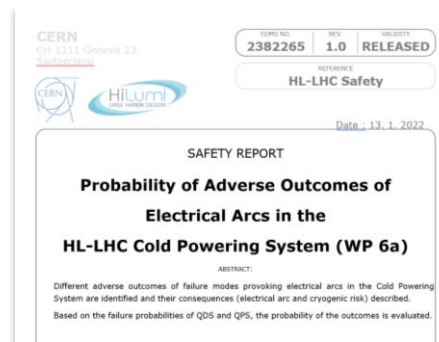


# Electrical safety aspects

- All failure modes identified & described in edms [2303664](#)
- All electrical failure modes quantified in edms [2382265](#) (risk assessment for DFX conservatively cover those for DFM)
- All electrical failure modes mitigated in edms [2610846](#) (mitigations for DFX conservatively cover those for DFM)



4.0 Symbols in Failure Mode Schematics





# Next steps

- Submit technical report with safety device calculation to HSE for approval.
  - Discuss and agree in advance who will be the designated notified body (e.g SOTON / External contractor).
- Detailed sequence for maintenance & repair to be finalised following F2 test bench.



**Thank you for your attention**