



# Plug development: status, plan and key milestones for intermediate validation, production plan

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***Conceptual design review of the DFX***



# DFX-Triplet plug specifications

- 19 bus bars through the plug:

		$I_{cable}$ [kA]	$N_{cables}$
MQXF	●	18	2
Trim Q1/Q2a/Q2b/Q3	●	7	3
MCBXF%	●	2	12
MBXF (D1)	●	18	2

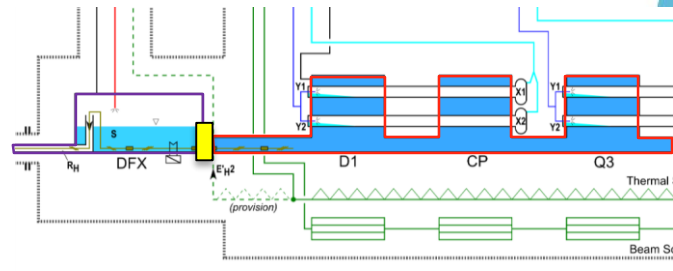
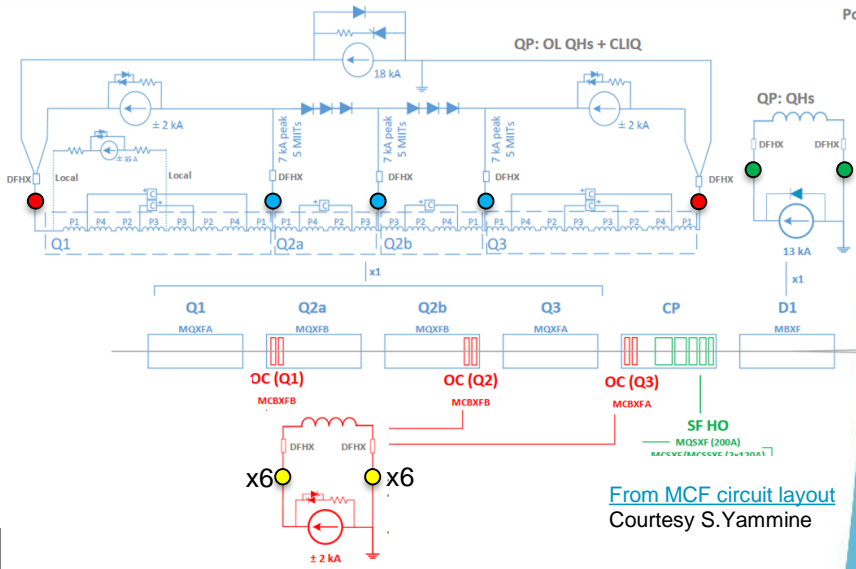
- Separates 2 Cryogenic volumes:

Helium volumes	Phase Nominal	$T_{nom}$ [K]	$P_{nom}$ [bara]	Design pressure PS [bar]
Triplet cold mass He enclosure	Superfluid	1.8	1.3	20
DFX - SCLink	Sat. liquid	4.5	1.3	3.5

Preliminary\_naming\_parameters\_and\_flow\_diagrams\_for\_HL-LHC  
 Courtesy D. Berkowitz [EDMS1573115](https://edms.cern.ch/record/1573115)

- Design requirements

		Specification
Overall leak rate (target)		$1.10^{-4}$ mbar.l.s <sup>-1</sup>
Insulation to ground/cable @ RT		4.6 kV
Thermal cycles		200
Maintainability		Replaceable
Radiation levels (1.6m distance from beam)	Dose Neutron fluence	100 kGy $2.10^{14}$ cm <sup>-2</sup>



From Process flow diagram of HL-LHC IT L5  
 Courtesy D. Berkowitz - M. Sisti - EDMS1963716

R.Garcia et al. "LHC and HL-LHC: Present and future radiation environment in the HL collision [...]" [CDS2310128](https://cds.cern.ch/record/2310128)



# DFX-Triplet plug proposal

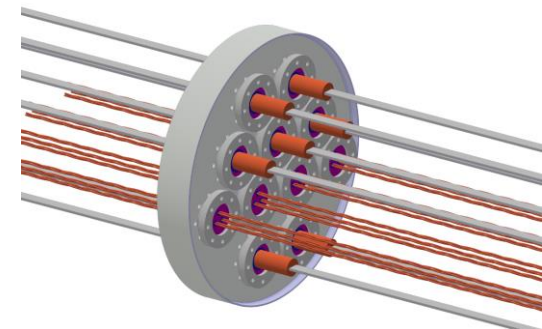
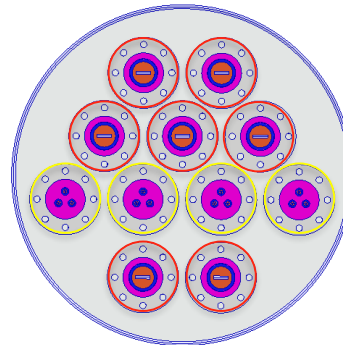
- Bus bars configuration
- 2 different plugs 18 kA & 2 kA

	$I_{\text{cable}}$ [kA]	$N_{\text{cables}}$	Triplet side	Cable type	
				Plug	DFX side
MQXF	18	2	18 kA Nb-Ti round	2 x MQXF leads	2 x MQXF leads
MBXF (D1)	18	2	13 kA Nb-Ti round		Not defined
Trims	7	3	18 kA Nb-Ti round	LHC 6 kA	Not defined
MCBXF%	2	12	2 kA Nb-Ti round		MCBXF + Cu

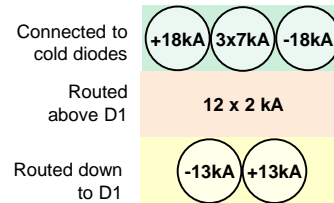
- Physical layout proposal

- Plug LHC inspired design proposal:

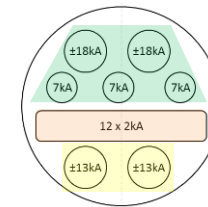
- From 13 kA LHC plug
- From 3 x 6kA LHC plug



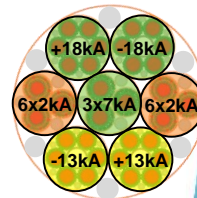
D1 interface configuration



Plug proposal



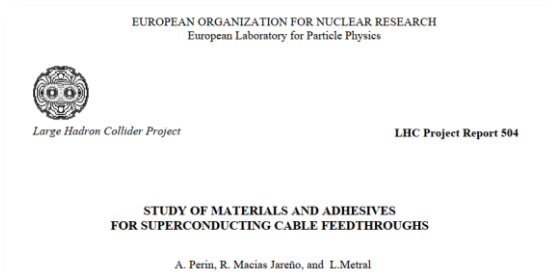
SCLink configuration



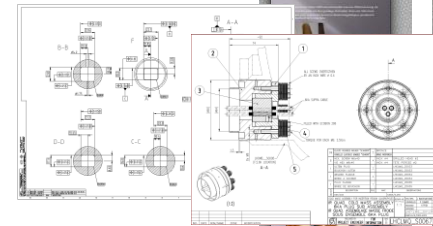
# Infrastructure & Know-How

Procedures 6kA, 13kA & N line LHC plugs

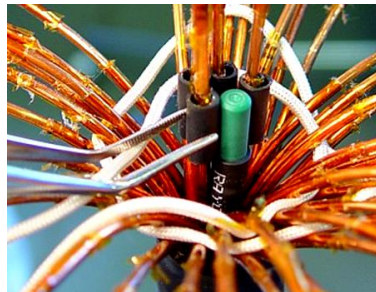
- Know-how from LHC experience
  - Various plugs types and technologies
  - Drawings, manufacturing procedure
  - Qualification procedures



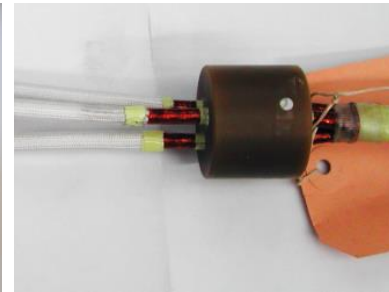
Drawings LHC plugs



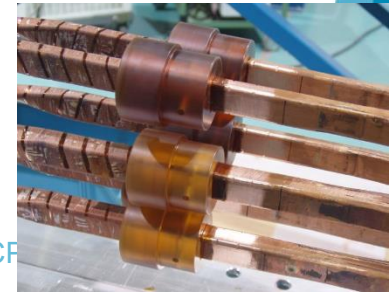
Line N LHC plugs



6 kA LHC plugs



13 kA LHC plugs



CF

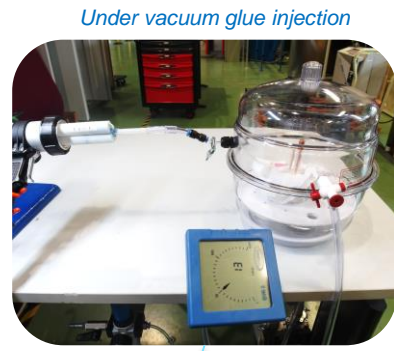
# Infrastructure & know-how

## Dedicated laboratory in SMI2

- Tooling & plug design area
- Preparation area
- Injection area
- Qualification area

## Train staff on LHC type plugs

- Design & manufacturing of tooling/plug
- Optimisation of manufacturing & QA procedures



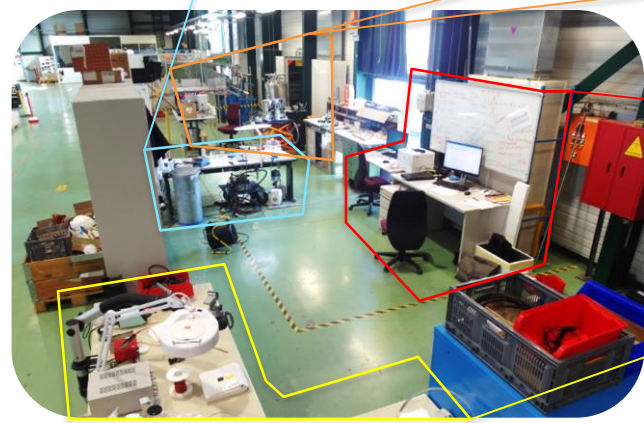
Under vacuum glue injection



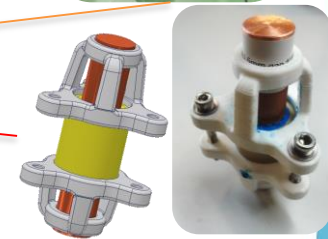
LN2 thermal cycling stand



Leak test equipment



SMI2 Plug lab

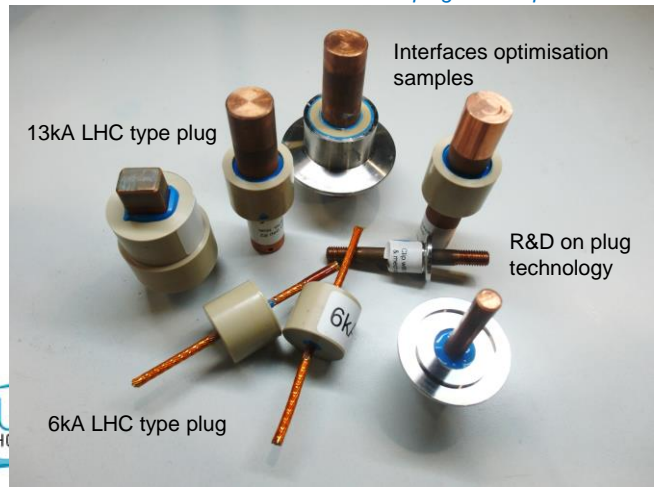


Plug & tooling design



Cable preparation

Some plugs developed at SMI2



Testing of various glues, polymers

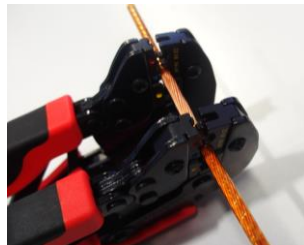
# Plug general manufacturing & qualification procedure

- Plug Cable preparation
- Soldering into copper structure
  - (if required)
- QA: leak test of soldered cable
- Surfaces preparation for gluing
  - Sand blasting, plasma treatment
- Parts preparation
  - Warm up & degassing
- Glue injection under vacuum
- QA: leak test @ ambient temperature
- QA: thermal cycling in LN2
- QA: final pressure and leak test tests

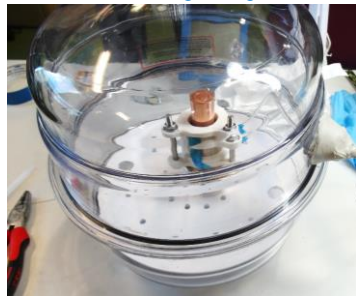
*Cable preparation*



*Parts warm up*



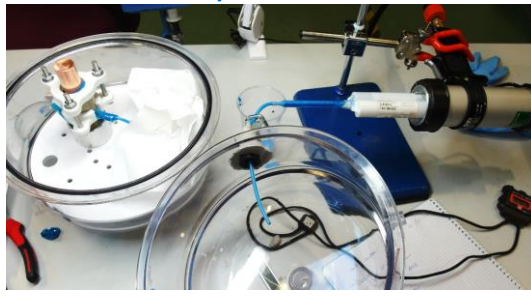
*Parts Degassing*



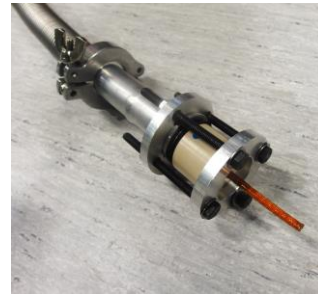
*Soldering cable to copper*



*Glue injection under vacuum*



*Glue tightness qualification*



*QA test for solder qualification*

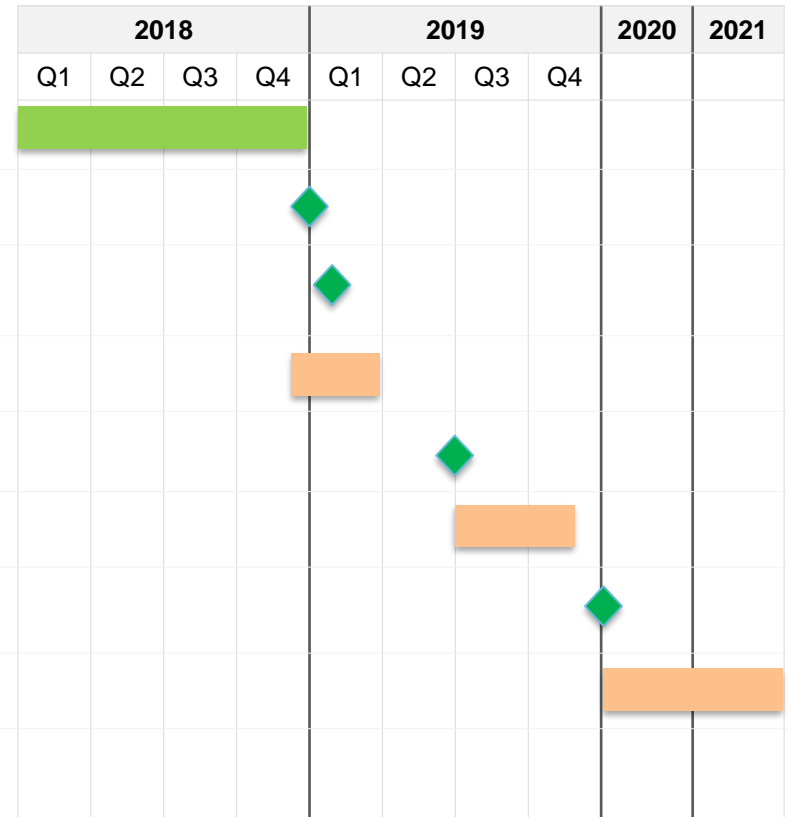


*Thermal cycling in LN2*



# Schedule & plan

- Equip Laboratory, Know-How & define procedures
- Bus bars definition
- Plug layout proposal
- Manufacture demonstrator
- Plug Design Review
- Prototype manufacturing & qualification
- Available for assembly in prototype test
- Series production (@ SMI2 ; 4 + 4 spares)



# Spare slides