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

Y.Leclercq, JB. Deschamps on behalf of the Plug development team : 31 Jan. 2019

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:

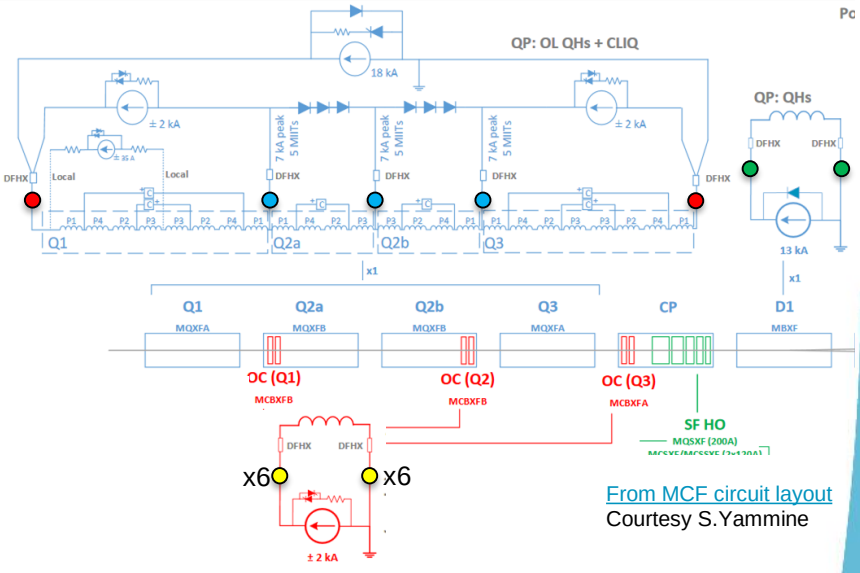
Helium volumes	**Phase Nominal**	T_{nom} [K]	P_{nom} [bara]	**Design pressure PS** [bar]
Triplet cold mass He enclosure	Superfluid	1.8	1.3	20
DFX - SCLink	Sat. liquid	4.5	1.3	3.5

Preliminary_naming_parameters_and_flow_diagrams_for_HL-LHC
Courtesy D. Berkovitz EDMS1573115

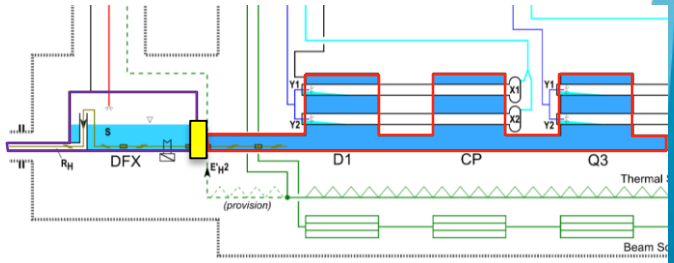
- Design requirements

		Specification
Overall leak rate @ RT (target)		1.10^{-4} mbar.l.s^{-1}
Insulation to ground/cable @ RT		4.6 kV
Thermal cycles		50
Radiation levels (1.6m distance from beam)	*Dose* *Neutron fluence*	*100 kGy* *2.10^{14} cm^{-2}*

R.Garcia et al. "LHC and HL-LHC: Present and future radiation environment in the HL collision […]" CDS2310128



From MCF circuit layout
Courtesy S.Yammine



From Process flow diagram of HL-LHC IT / 5
Courtesy D. Berkowitz - M. Sisti – EDMS1963716

DFX-Triplet plug conceptual design

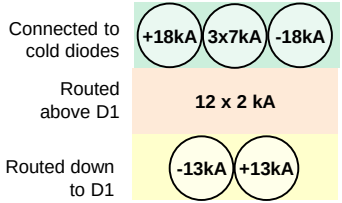
- Bus bars configuration
- ➔ 2 different plugs 18 kA & 2 kA

- Physical layout proposal

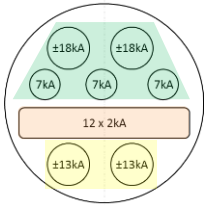
- Plug LHC inspired design proposal:
  - From 13 kA LHC plug
  - From 3 x 6kA LHC plug

			Cable type		
	I_{cable} [kA]	N_{cables}	**Triplet side**	**Plug**	**DFX side**
MQXF	18	2	18 kA Nb-Ti round	2 x MQXF leads	2 x MQXF leads or round
MBXF (D1)	18	2	13 kA Nb-Ti flat		
Trims	7	3	18 kA Nb-Ti round		1 x MQXF lead or round
MCBXF%	2	12	6 kA Nb-Ti round	LHC 6 kA	MCBXF + Cu or round

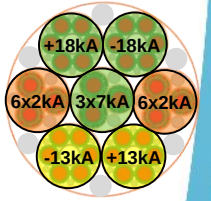
D1 interface configuration

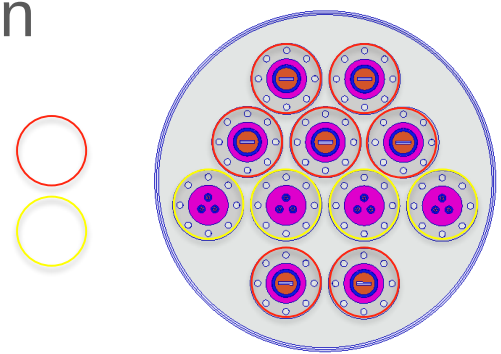


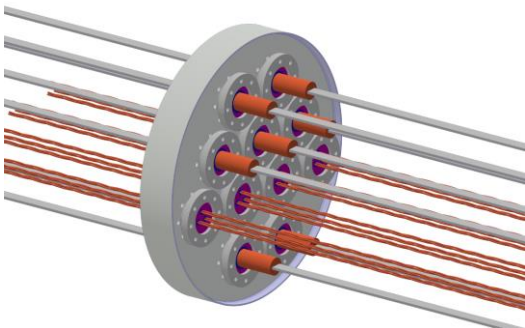
Plug proposal



SCLink configuratio







Bus-bar design

			Cable type		
	I_{cable} [kA]	N_{cables}	**Triplet side**	**Plug**	**DFX side**
MQXF	18	2	18 kA Nb-Ti round	2 x MQXF leads	2 x MQXF leads or round
MBXF (D1)	18	2	13 kA Nb-Ti flat		
Trims	7	3	18 kA Nb-Ti round		1 x MQXF lead or round
MCBXF%	2	12	6 kA Nb-Ti round	LHC 6 kA	MCBXF + Cu or round

Nb-Ti bus: same amount of Cu stabilizer in cable on magnets side, in cable in plug and in cable in DFX

Nb-Ti to Nb-Ti splices: specific development - with associated measurement campaign

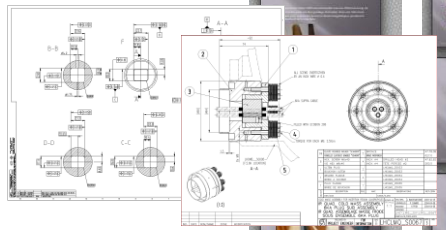
Infrastructure & Know-How

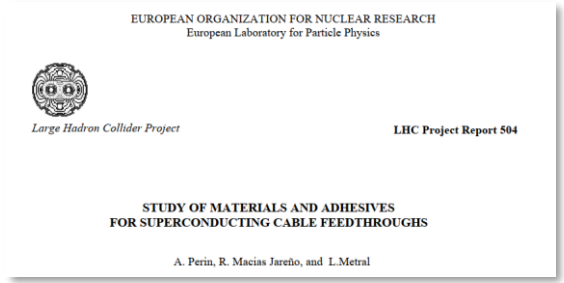
- Know-how from LHC experience
  - Various plugs types and technologies
  - Drawings, manufacturing procedure
  - Qualification procedures

Procedures 6kA, 13kA & N line LHC plugs

Step	Description	Reference/picture/drawing
25	Straighten the 20 wires of the outer layer by hand.	
26	Cut off the Kapton insulation of all wires of the outer layer using the custom made cutting pliers (table 7.1, No. 2) at the marked in the step 21 locations and 9,5 mm further away from thermal shrink sleeves. Turn pliers with the angle of 360°. (This is possible in one go.)	Marked position
27	Remove the Kapton insulation of all wires between the two cut locations with the custom made stripping pliers (table 7.1, No. 3). Make sure that the insulation is completely removed over the whole 9,5 mm distance.	Marked position

Drawings LHC plugs





EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
European Laboratory for Particle Physics

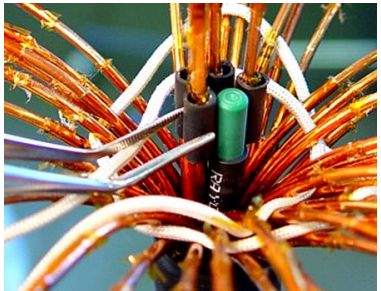
Large Hadron Collider Project

LHC Project Report 504

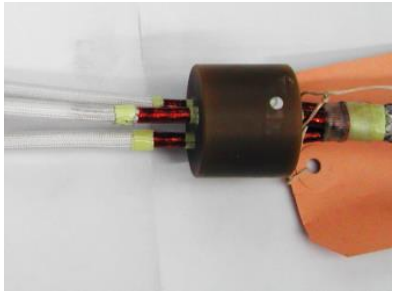
STUDY OF MATERIALS AND ADHESIVES FOR SUPERCONDUCTING CABLE FEEDTHROUGHS

A. Perin, R. Macias Jareño, and L.Metral

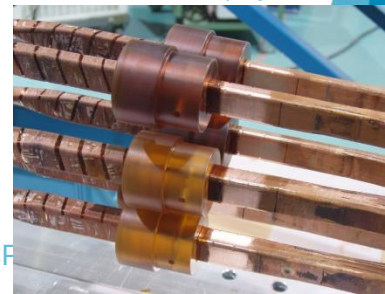
Line N LHC plugs



6 kA LHC plugs



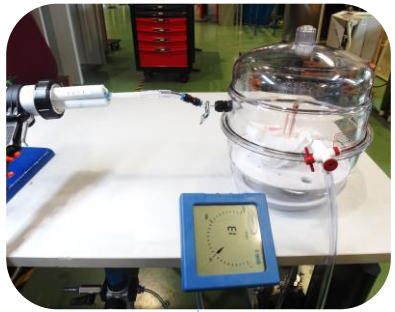
13 kA LHC plugs



Infrastructure & know-how

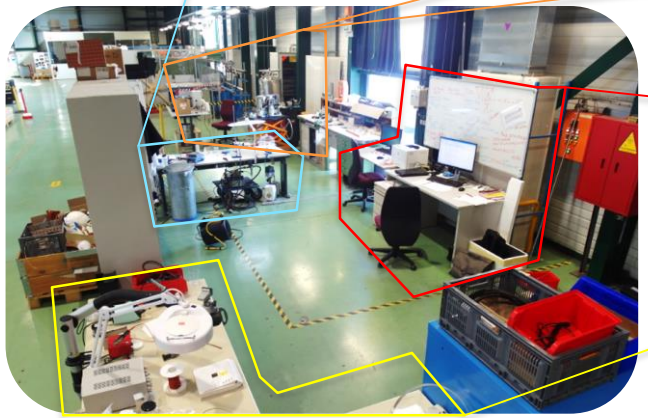
- Dedicated laboratory in SMI2
  - Tooling & plug design area
  - Preparation area
  - Injection area
  - Qualification area
- Train staff on LHC type plugs
  - Design & manufacturing of tooling/plug
  - Optimisation of manufacturing & QA procedures

Under vacuum glue injection

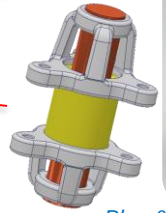


LN2 thermal cycling stand

Leak test equipment



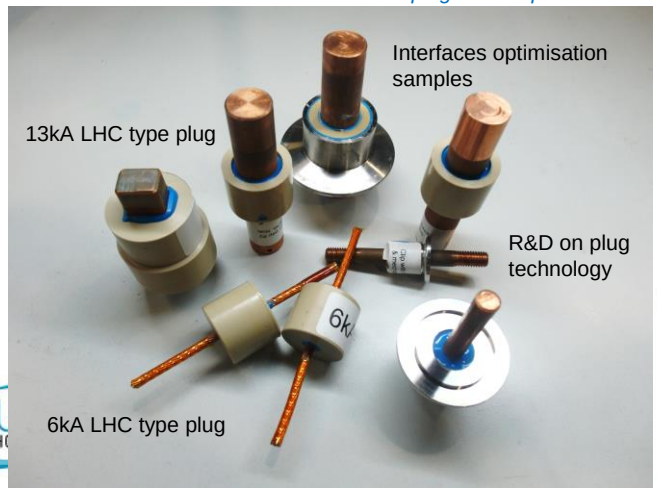
SMI2 Plug lab



Plug & tooling design

Cable preparation

Some plugs developed at SMI2



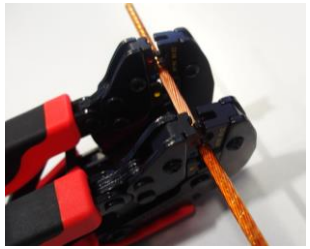
MY750 *Eccobond* *Araldite*

Testing of various glues, polymers

Plug general manufacturing & qualification procedure

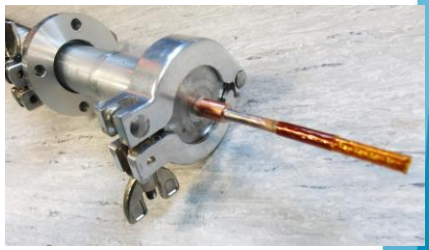
- Plug Cable preparation
- Soldering into copper structure
  - (if required)
- QA: leak test of soldered cable
- Surfaces preparation for gluing
  - Sand blasting, plasma treatment
- Parts preparation
  - Warm up & degassing
- Glue injection under vacuum
- Qualification
  - Leak test @ RT : 1.10^{-4} mbar.l.s^{-1}
  - 10 x thermal cycling in LN2
  - Pressure test (EN13458-2)
  - Leak test @ RT : 1.10^{-4}mbar.l.s^{-1}

Cable preparation



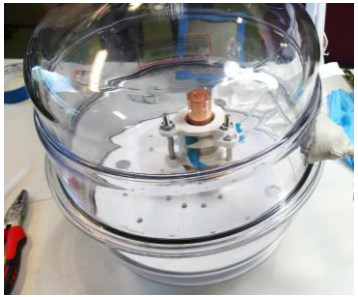
Soldering cable to copper

QA test for solder qualification



Parts warm up

Parts Degassing



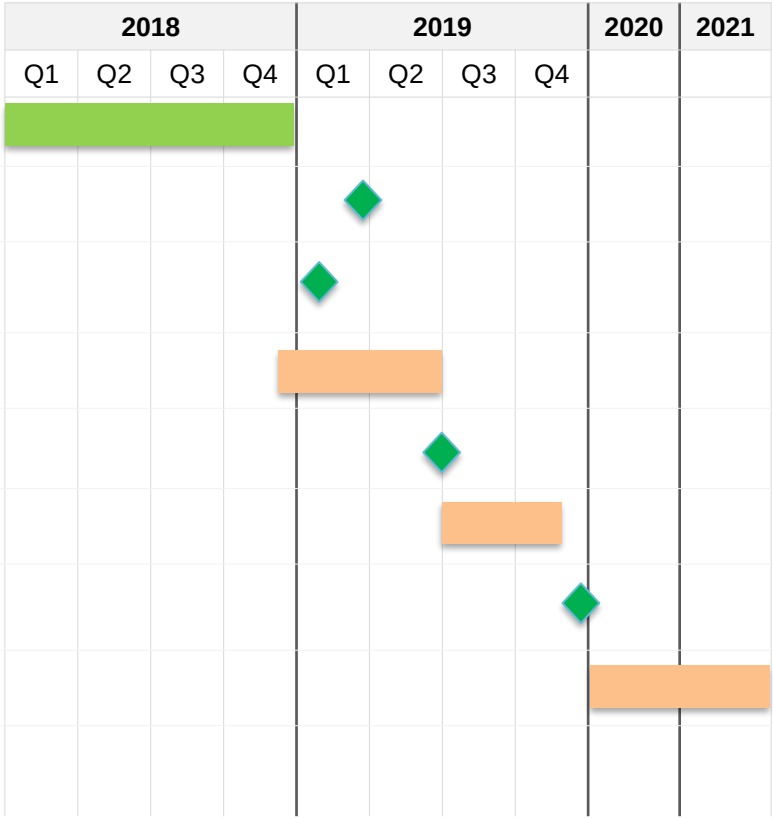
Glue injection under vacuum

Glue tightness qualification

Thermal cycling in LN2

Schedule & plan

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



Spare slides