ECR related to 120A/200 A HL-LHC circuits

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With contributions from:

WP3 (Magnets): E. Todesco, D. Ramos, V. Parma, H. Prin, L. Bottura

WP6b (Warm powering): M. Martino

WP7 (Machine Protection):D. Wollmann

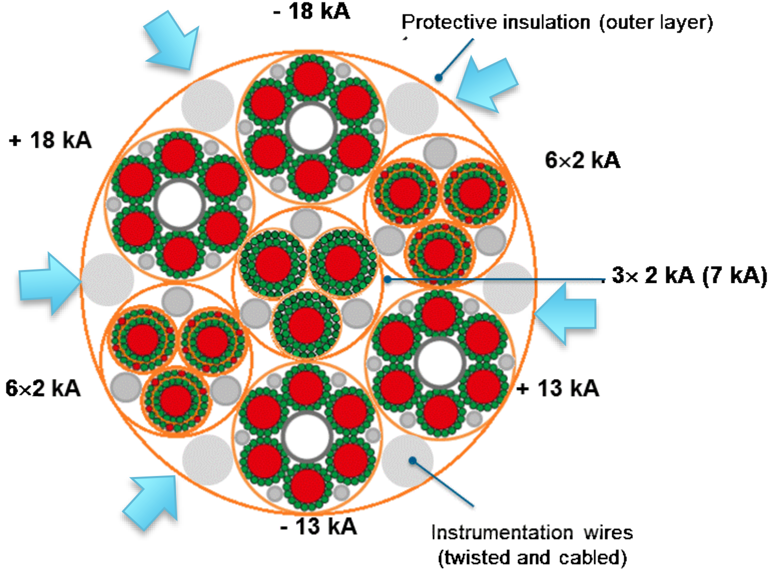
WP 9 (Cryogenics): S. Claudet

WP15 (Integration): P. Fessia,

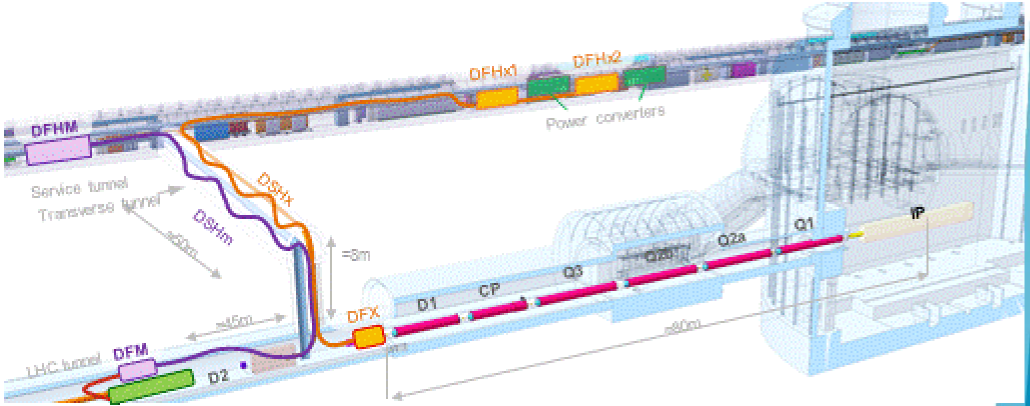
WP17 (Infrastructure): J. C. Guillaume

The proposal

120 A Leads (16) + 200 A Leads (2)



MgB$_2$ cable assembly



120 A Leads removed from SC Link and locally integrated in the magnets' cryostat
This is the solution adopted for LHC

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The advantages for WP6a

- **Elimination** of the about **100 m long electrically insulated MgB2 cables**, rated for DC currents of 200 A or 120 A, housed inside the superconducting link (eighteen cables per Triplet);
- **Simplification** of the **cabling process** related to the assembly of the 200 A/120 A MgB2 cables in the final MgB_2 cable assembly;
- **Elimination** of the 200 A/120 A gas **cooled High Temperature Superconducting (HTS) current leads** located in the – replaced by conduction-cooled current leads;
- **Elimination** of the **control valves and warm recovery lines** associated with gas-cooled current leads;
- **Elimination** of the **protection equipment needed for the superconducting part of the circuit, i.e. for the MgB_2 cables and for the HTS part of the leads** (each requiring dedicated protection with different voltage thresholds);
- **Reduction of the number of the electrical splices** in the Cold Powering System, i.e. elimination - per Triplet- of eighteen HTS to MgB_2 splices in the DFH cryostat and eighteen MgB2 to Nb-Ti splices in the DFX cryostat;
- **Simplification of DFH cryostat** by reduction of number of HTS cables routed out of it and of number of splices it shall host.
- Simplification of the **plug** in the DFX cryostat.

The simplifications listed above favour reliability of the circuits during machine operation

HiLumi HL-LHC PROJECT

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Impact on WP3 and WP9

- **WP3**. Integration feasible. Integration of feedthroughs feasible in the CP cryostat (extra cost of ~ 95 kCHF). Heat sink will be at 60 K-80 K. In addition, savings because of reduced work for interconnections (~ 40 kCHF). Saving also because availability of local leads in CP cryostat enables a) reduced number of cool-downs (factor 3) for test of magnets in the SM-18 and b) reduction of related connection work, which is a significant percentage of the test preparation (this saving has not been quantified in kCHF).

- **WP9**. Integration feasible. Total saving (suppression of He valves and warm recovery lines) ~ 60 kCHF. Estimated also for information impact on operational cost during 10 years of operation (20 kCHF per point, for a total of 80 kCHF). The estimation has been done by considering the heat load at 1.9 K of the conduction-cooled leads -10 mW/A (thermalization at 60 K- 80 K).

Impact on WP6b

- **WP6b**. Integration feasible. Two possibilities studied:
  - Case A. Warm powering remains in the URs. No extra-cost.
  - Case B. Warm powering moved to UL14, UL16, USC55, UL557. Radiation hard power converters – 200 A - to be made (including spare units). Limited access not considered of big impact. Extra cost of 75 kCHF (including adaptation of control infrastructure).

Impact on WP7

- **WP7**. Integration feasible
- Case A: no changes. About 25 kCHF cost reduction (reduced number of quench detection systems).
- Case B: need of moving the MQSXF quench detection and energy extraction system (space found). Additional signal cables from power converters. No cost reduction.

Impact on WP 17

- **WP17**. Integration feasible
- Case A: DC cables power dissipation in the vertical shaft to be verified. Cross section of cables to be increased
- Case B: Partial re-use of existing infrastructure and cable trays.

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Impact on WP 15

- WP 15. Integration feasible
- CASE A: Installation of Cu cables in // with the rest of the cabling campaign. Extra element in the plan
- CASE B: Provision of 100 kCHF (25 kCHF per IP) for modification of existing infrastructure. To be transferred to WP15 only in case of need

Cost evaluation

	CASE A	CASE B
WP3	- 40 kCHF	+ 95 kCHF
WP6a	- 450 kCHF	
WP6b	No extra cost	+ 75 KCHF
WP7	- 25 kCHF	No extra cost
WP9	- 60 kCHF	
WP15	Minor impact	**+ 100 kCHF**
WP17	+ 330 kCHF	+ 62 kCHF

Plus saving in magnet test (not quantified)

Operational cost + 80 kCHF

Provision in case of need

Total saving	CASE A: 575 kCHF
	CASE B: 550 kCHF
Total extra-cost	CASE A: 425 kCHF
	CASE B: 232 kCHF

Net saving	CASE A: 150 kCHF
	CASE B: 318 kCHF

Conclusions

- Local powering feasible
- Impact on different WPs evaluated
- In view of the feasibility and advantages for:
  - the Cold Powering System system
  - the related cryogenic/electrical/protection systems
  - the testing of the CP magnets
  - the costs

… the MCF recommended (meeting on 18/09/2018) to go ahead with ECR to TCC for approval

- Finally: the ECR has been written and is ready for being circulated

Solution for Q1 Trim (EDMS 1821907)

	Magnet	Cold Powering			
	I_{ult}(kA)	I_{peak}(kA)	I_{lead} (kA)	I_{cable}(kA)	N_{leads}/N_{cables}
MQXF	17.82	-	18	18	2
Trim Q1	2	2.4	2*	7	1
Q2a/Q2b	Protec.	5.6	2*	7	1
Trim Q3	2	6.8	2*	7	1
MCBXFB	1.73	-	2	2	2+2
MCBXFB	1.59	-	2	2	2+2
MCBXFA	1.73	-	2	2	2
MCBXFA	1.59	-	2	2	2
MQSXF	0.2	-	0.2	0.2	2
MCSXF/MCSSXF	0.12	-	0.12	0.12	2+2
MCOXF/MCOSXF	0.12	-	0.12	0.12	2+2
MCDXF/MCDSXF	0.12	-	0.12	0.12	2+2
MCTXF/MCTSXF	0.12	-	0.12	0.12	2+2
D1	12.96	-	18	18	2

Table 1: Number of current leads and of MgB_2 superconducting cables inside the link (N_{leads}/N_{cables}), design current rating of the current leads (I_{lead}) and of the MgB_2 superconducting cables (I_{cable}), ultimate current of the HL-LHC magnets (I_{ult}) and peak current during transient modes (I_{peak}) following triggering of the MQXF magnets' quench protection system.

k-modulation Trim on Q1a: part of WP3. Local powering - via leads of CLIQ type.