Update on the Inner Triplet Powering and Protection

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for the **Magnet Circuit Forum (MCF)**

8th HL-LHC Collaboration Meeting, CERN, 16th October 2018

Content

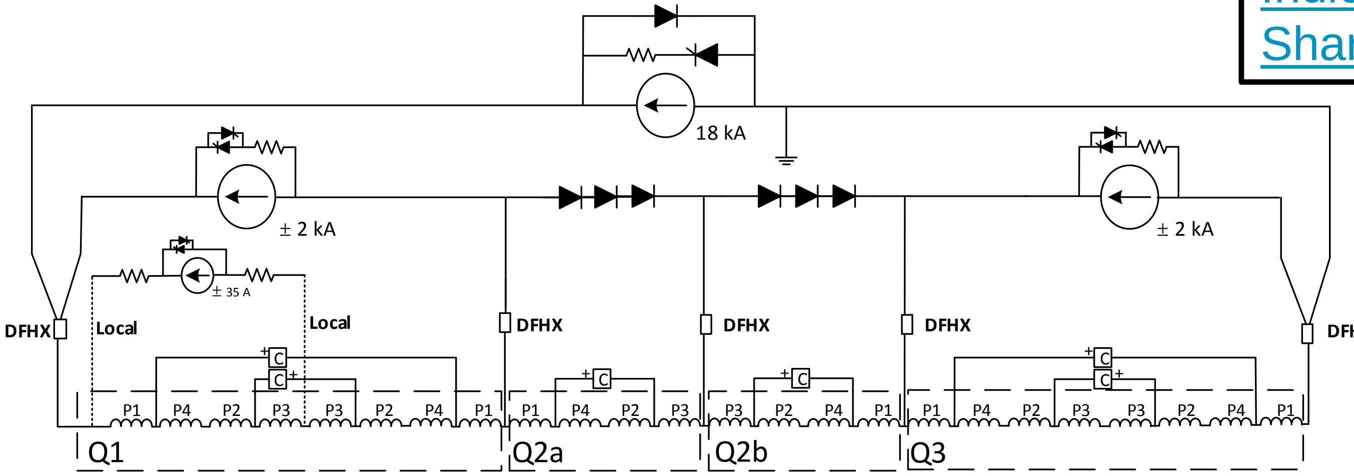
- Inner Triplet Circuit
- ECR on HL-LHC Circuits
- K-modulation Circuit
- Cold Diodes
- Quench Detection Instrumentation
- ECR on “*Local Powering*” of Corrector Package Circuits
- Disconnectors
- Conclusions

IT Circuit

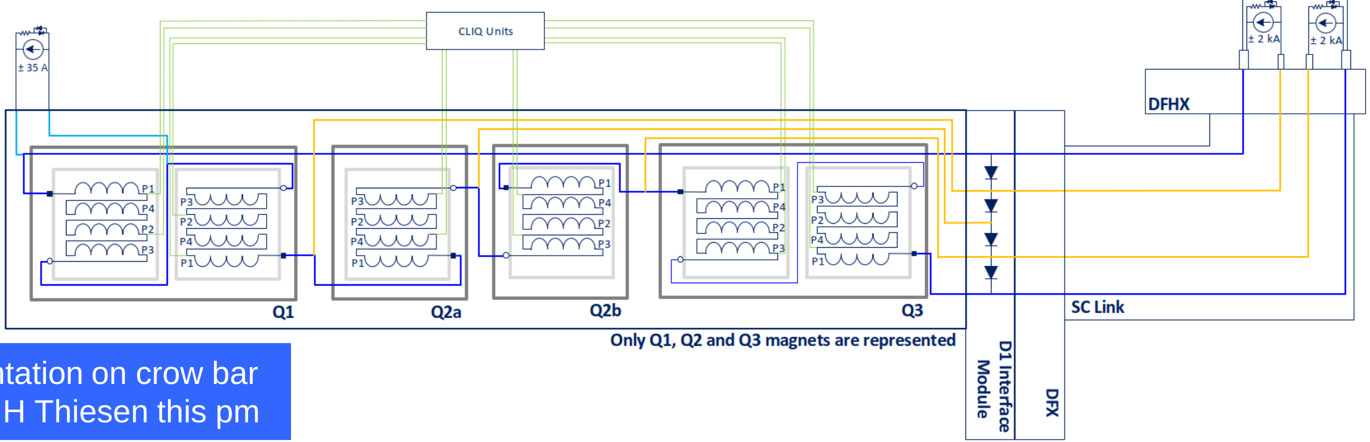
All the information is available from the Magnet Circuit Forum

[Indico](#)
[SharePoint](#)

BASELINE

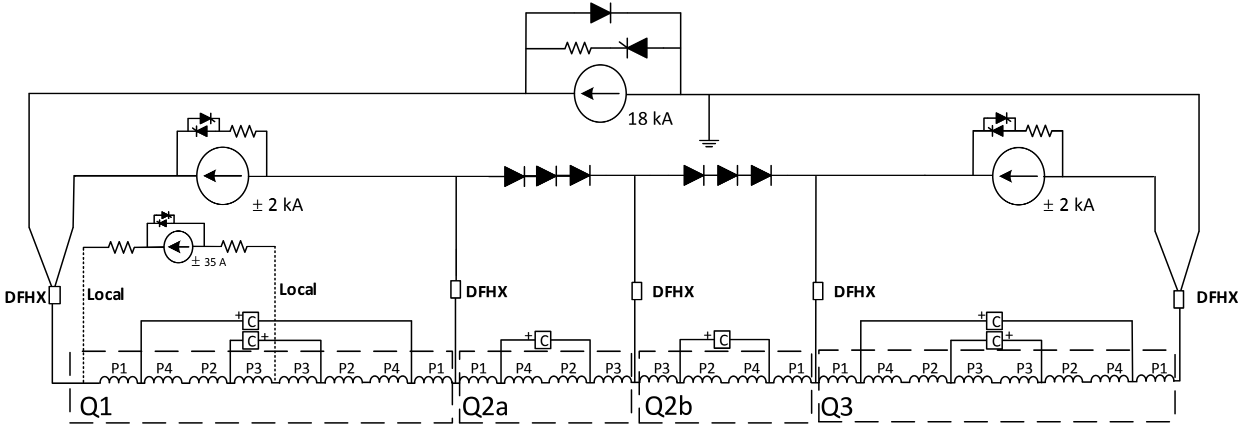


Option



See presentation on crow bar designs by H Thiesen this pm

Inner triplet as system



	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

ECR on HL-LHC Circuits

CERN HiLumi HL-LHC PROJECT

EDMS NO.	REV.	VALIDITY
1682952	0.9	DRAFT

REFERENCE : LHC-_-EC-0028

HL – LHC Engineering Change Request
New reference circuit baseline

ECR DESCRIPTION

WP Originator	Magnet Circuit Forum (MCF)	***Process***	Technical
Equipment	HL-LHC Superconducting Magnet Circuits	***Baseline affected***	Scope
Drawing		***Date of Issue***	2018-06-01
Document		***CI responsible***	F. Rodriguez Mateos (as MCF Chair)
WPs Affected	WP1, WP2, WP3, WP6a, WP6b, WP7, WP9, WP11, WP15, WP16, WP17	***Reference Document***	TDR Version 0.1

Detailed Description

Following the Internal Circuit Review that took place on 17th March 2017 [1], the baseline of the High-Luminosity Large Hadron Collider (HL-LHC) superconducting magnet circuits required some modifications. These modifications are presented through this document and will be divided in 3 different main chapters:

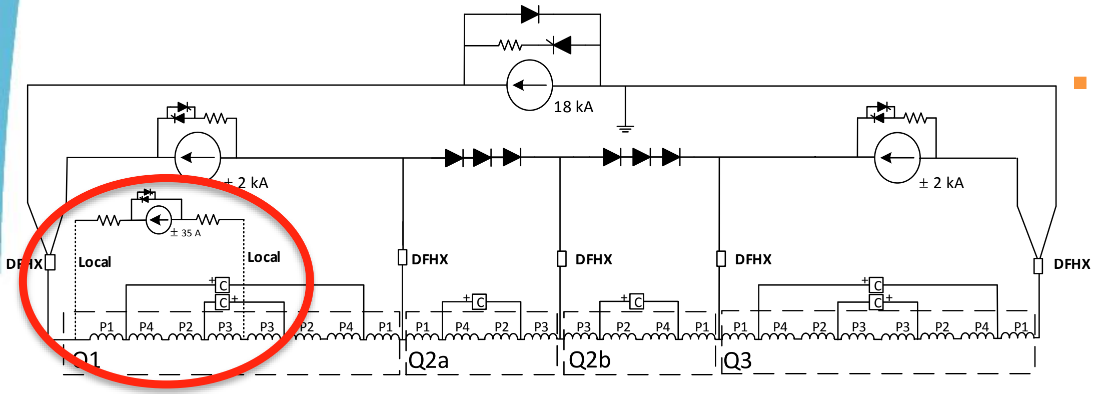
a) 11 Tesla Dipole and Trim Circuit,
b) Matching Section Circuits,
c) Inner Triplet and D1 Circuits.

- Suppression of Q2a trim
- Additional Q1a k-modulation circuit
- Ratings of the superconducting elements of the inner triplet circuit
- Cold Diodes – still as option
- Circuit Disconnectors
- “Local Powering” of 120A/200A corrector circuits of the Inner Triplet

K-modulation Circuit

Impact of K-modulation Configuration (warm powering)

- K-modulation circuit has impacts to the following:
  - Current looping in sub-circuits
  - Decoupling matrix configuration
  - Power converters state management



See talk by L Williams on k-mod feeders this pm

- Disconnection and reconnection of the k-modulation circuit
  - Current looping is not a problem, but needs to be considered
  - Same configuration could be kept for the decoupling matrices (at a risk of additional instability - to be studied)
  - One software for state management could be maintained

A permanent configuration is preferable for development and complexity reduction

Impact of K-modulation Configuration on Protection

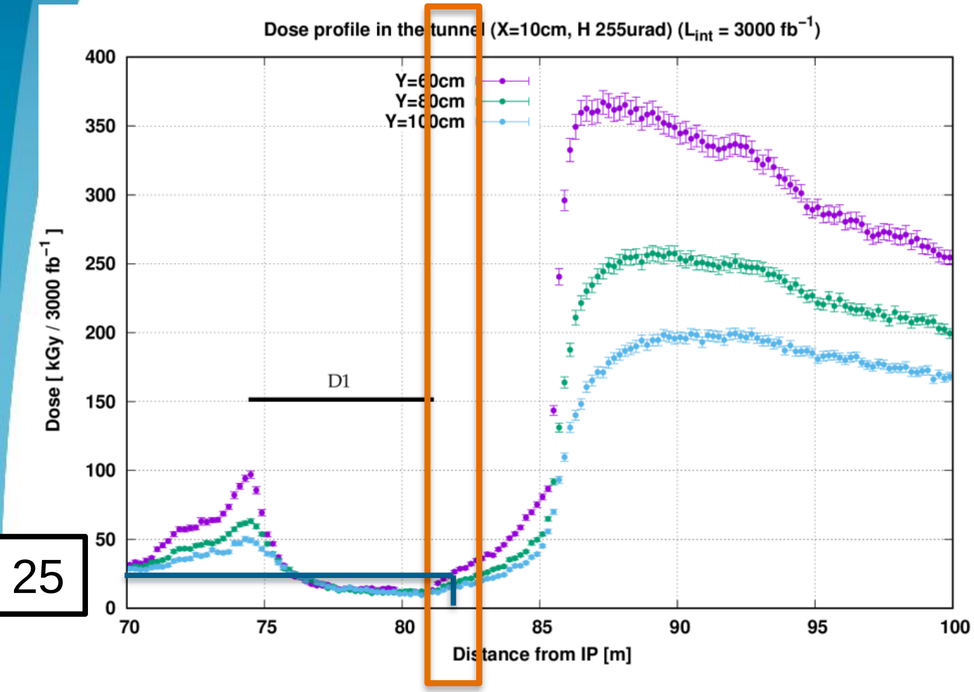
- k-modulation circuit seems to be beneficial in reducing the maximum voltages in case of imbalanced quench between Q1a and Q1b.
- In any case, Q3 has to undergo the quench discharges regardless of absence of k-modulation circuit.
- It is critical that during operation / quench, the 35 A trim circuit does not switch from connected to disconnected, as this would lead to very high voltages in the circuit

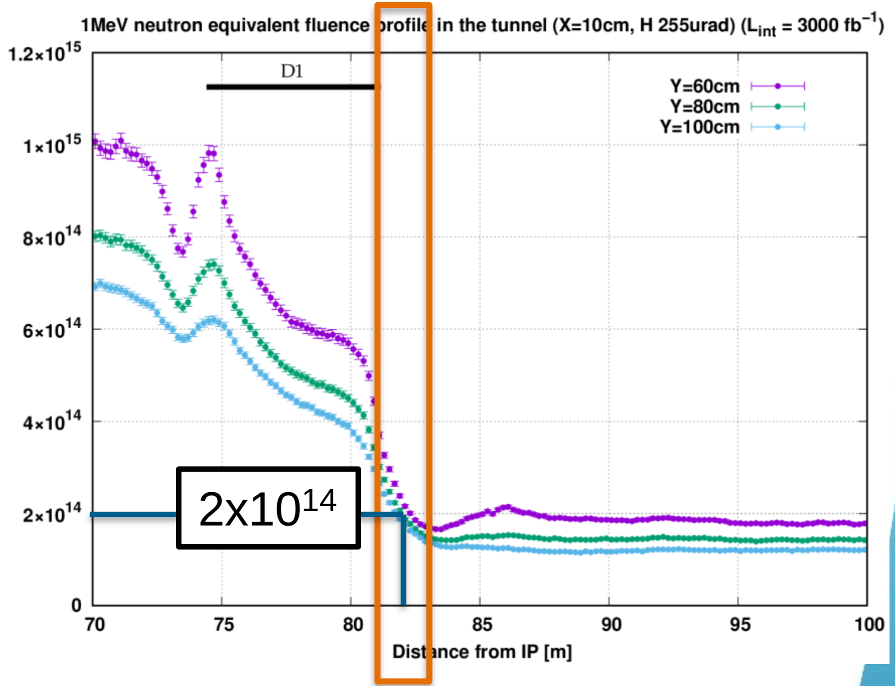
Both presence or absence of the k-modulation circuits are acceptable for WP7. However, it would be **preferable to keep one circuit configuration to limit complexity and help automated analysis**

Cold Diodes

Radiation levels at the cold diodes position

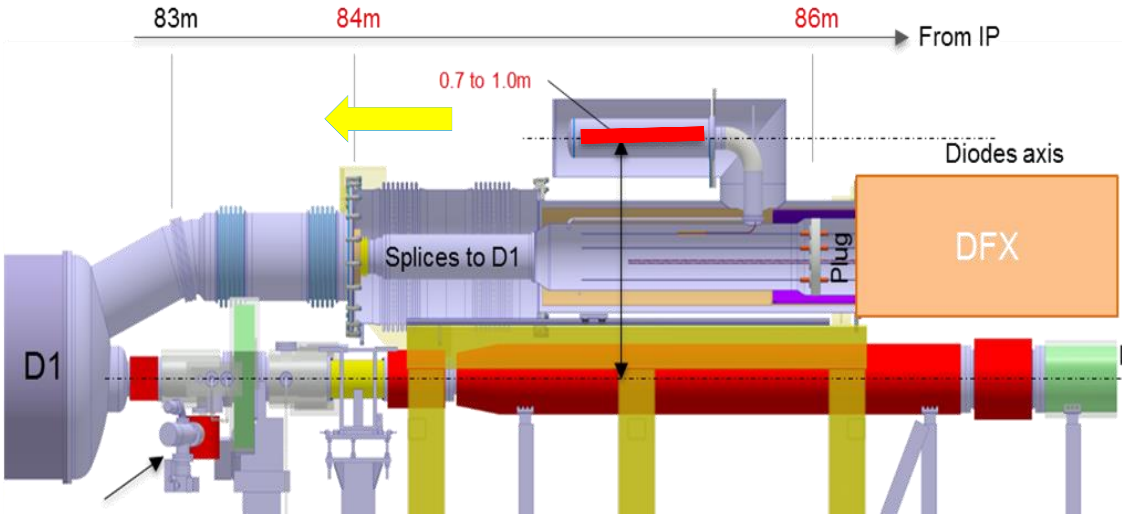
Ruben Garcia Alia et al.





See plenary talk by Giorgio D'Angelo and session on Wednesday am about radiation levels and effects, test results so far, etc

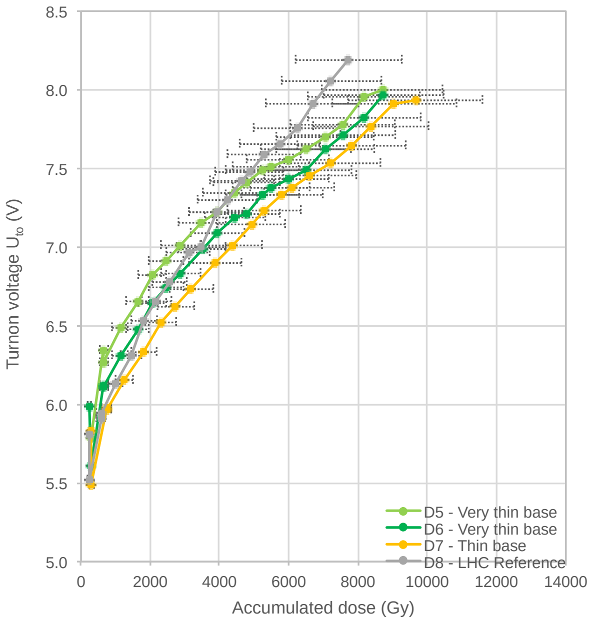
Position to place the cold diodes

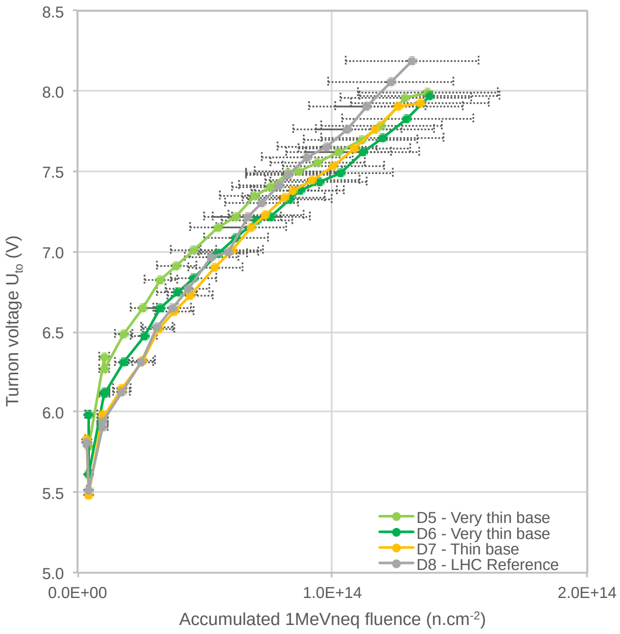


Integration studies on going

See slides by Y Leclercq

Vto vs dose/fluence for diodes at CHARM





Open questions:

a) margins in terms of Vto, Vfwd, Vrev, C
b) effects of annealing

See slides from G D'Angelo and A Monteuuis

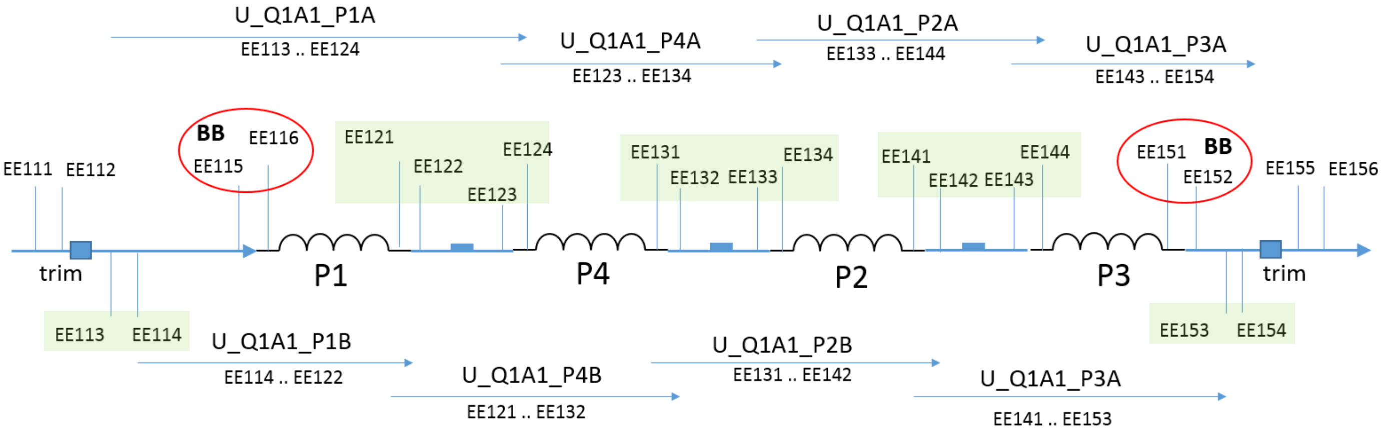
Instrumentation for Quench Detection

Quench Detection Baseline

- Recall on **quench protection strategy**
- Every pole of the magnet is instrumented
- QD system measures the voltage over each pole of a magnet using an isolated channel
- Internal magnet bus bars are covered by the pole voltages
- Bus bars between magnets and magnets to link are covered by dedicated, isolated channels

QD instrumentation

J Steckert, H Prin et al



QD algorithm

Asymmetric BoxA: UP1A – UP4A, UP2A – UP3A
BoxB: UP1B – UP4B, UP2B – UP3B

Symmetric BoxA: (UP1A+UP4) – (UP2A + UP3A)
BoxB: (UP1B+UPB) – (UP2B + UP3B)

Endorsed by MP3

- Vtaps with unique names
- Vtaps in the trims are not needed
- Vtaps needed before the DFX

HiLumi HL-LHC PROJECT

ECR on “local powering” of the corrector package circuits

EDMS NO.	REV.	VALIDITY
1832068	0.1	DRAFT

REFERENCE : LHC-D-EC-0002

HL – LHC Engineering Change Request

LOCAL POWERING OF THE TRIPLET CORRECTOR CIRCUITS

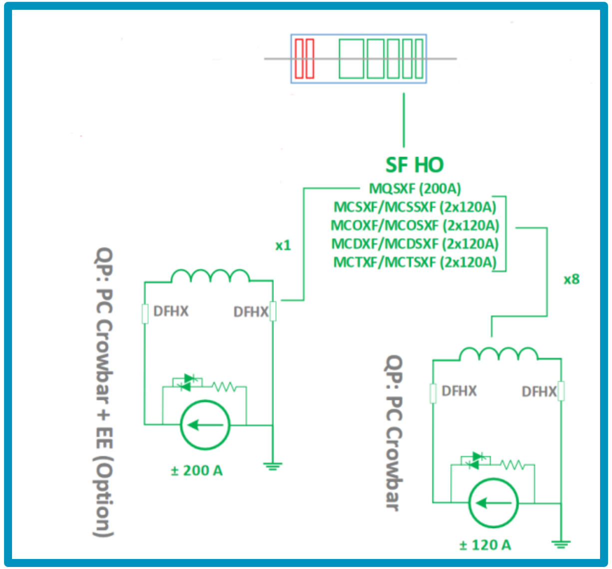
ECR DESCRIPTION

WP Originator	WP6a	***Process***	Design
Equipment	DSH, DFX, DFH,	***Baseline affected***	Cost
Drawing	NA	***Date of Issue***	2018-09-21
Document		***CI responsible***	
WPs Affected	WP3, WP6a, WP6b, WP7, WP9, WP15, WP17	***Reference Document***	TDR Version 0.1

Detailed Description

The HL-LHC Cold Powering baseline envisages powering the Triplet correctors circuits rated at 200 A and below [1] via the HL-LHC MgB_2 based Superconducting Link and associated cryo-electrical equipment. The present ECR proposes local powering of the Triplet corrector circuits, rated at 200 A and below, via LHC-type conduction-cooled current leads integrated in the magnet cryostats [2]. The proposed change enables simplification of the Cold Powering system. The global impact of the change is described in detail in this document. More specifically, local powering of the corrector circuits can be achieved by either leaving the concerned power converters in the present baseline location, i.e. in the UR (case A), or by re-locating the power converters in the UL14, UL16, UL557 and USC55 (case B). The second solution enables reduction of the length of the room temperature cables connecting the power converters to the current leads. Potential impact on performance, schedule and cost is estimated for both case A and case B.

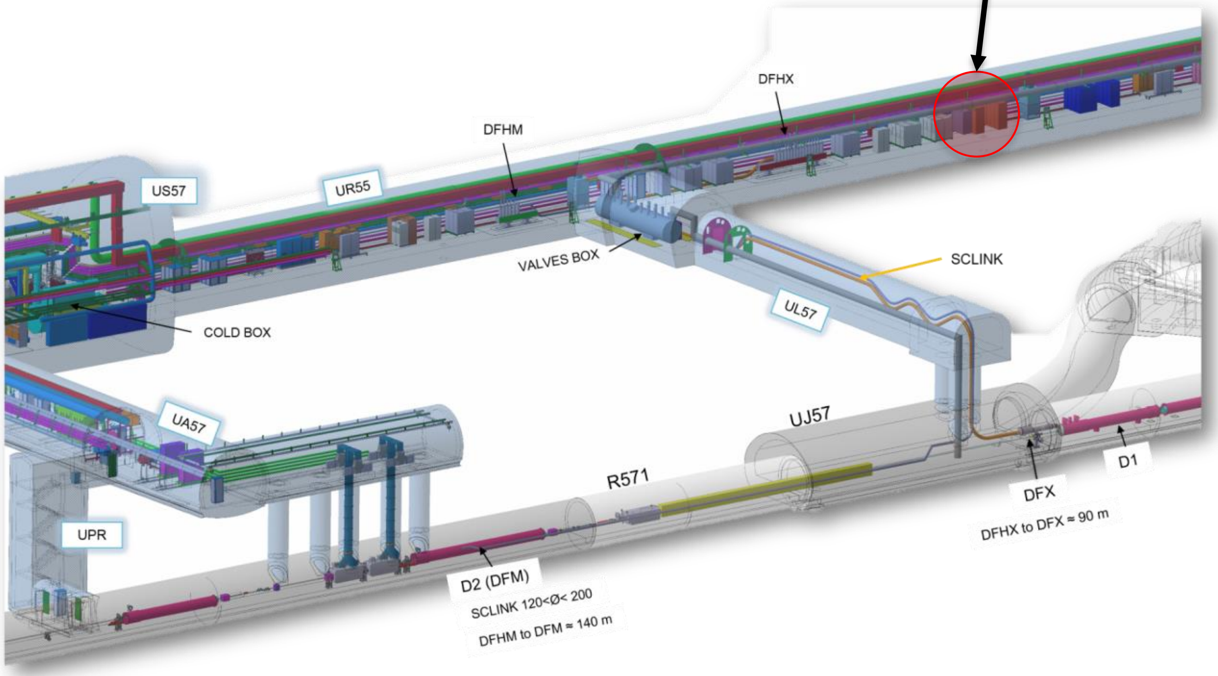
See presentation on this topic this afternoon



Baseline/recommendations

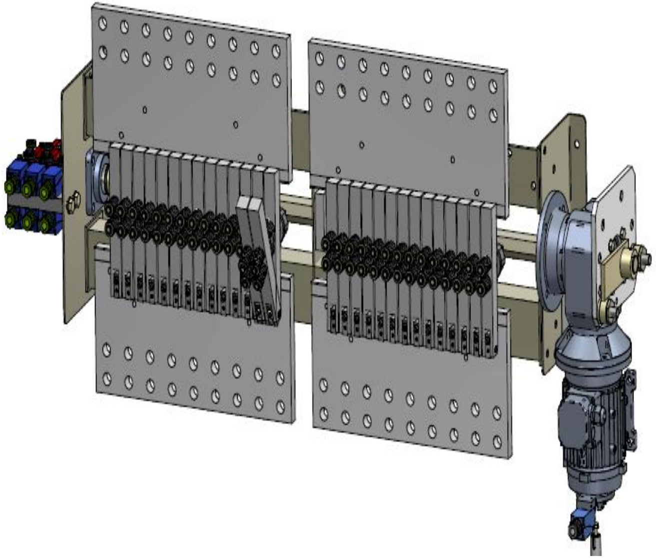
120A/200A circuits powered with sc link

Power convertors location



Recommendations by TCC

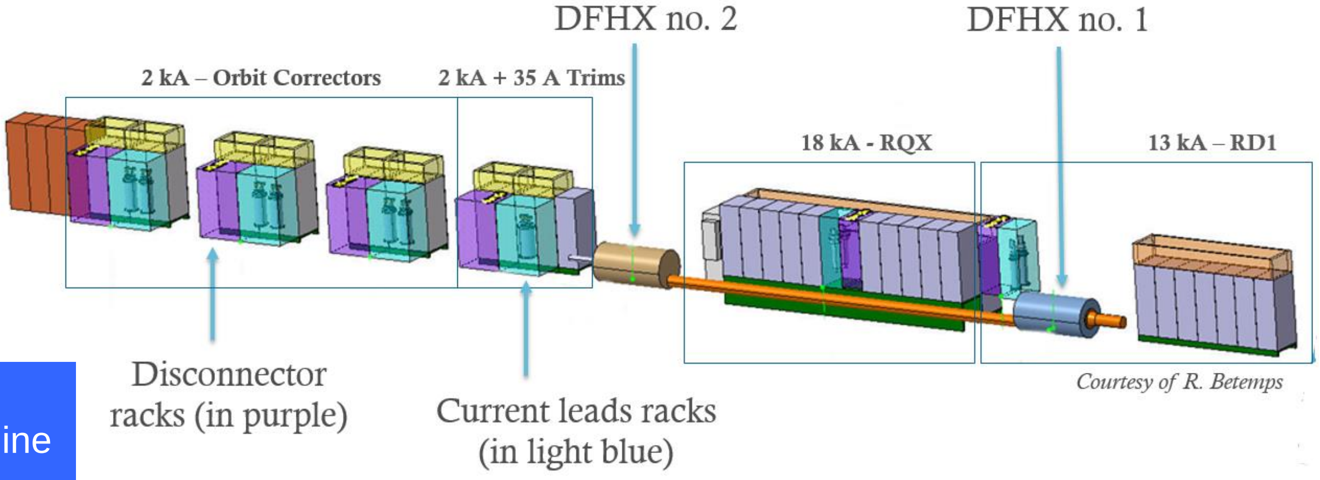
- To decouple the decision on the sc link from location of power converters
- Approve the changes to the link
- Study on going to keep converters in UR



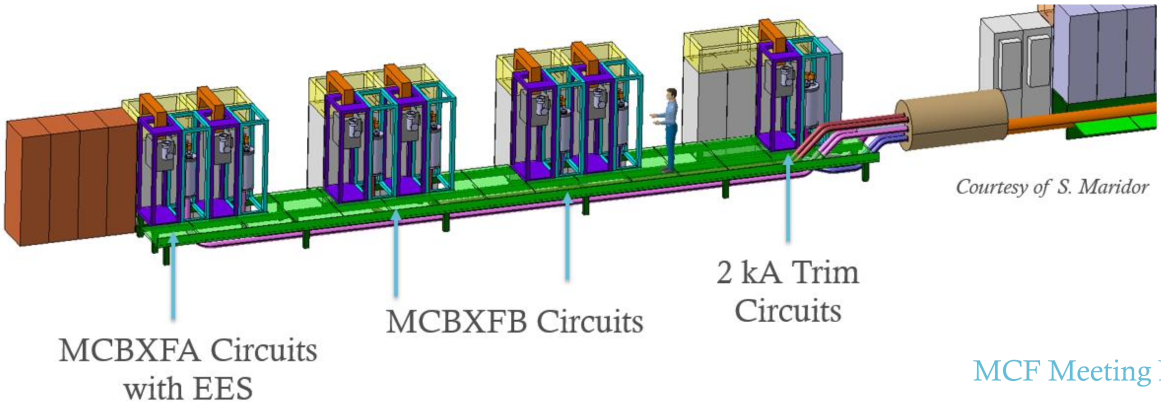
Disconnectors

Integration Concept in the UR (Q1→ D1) with CDBs

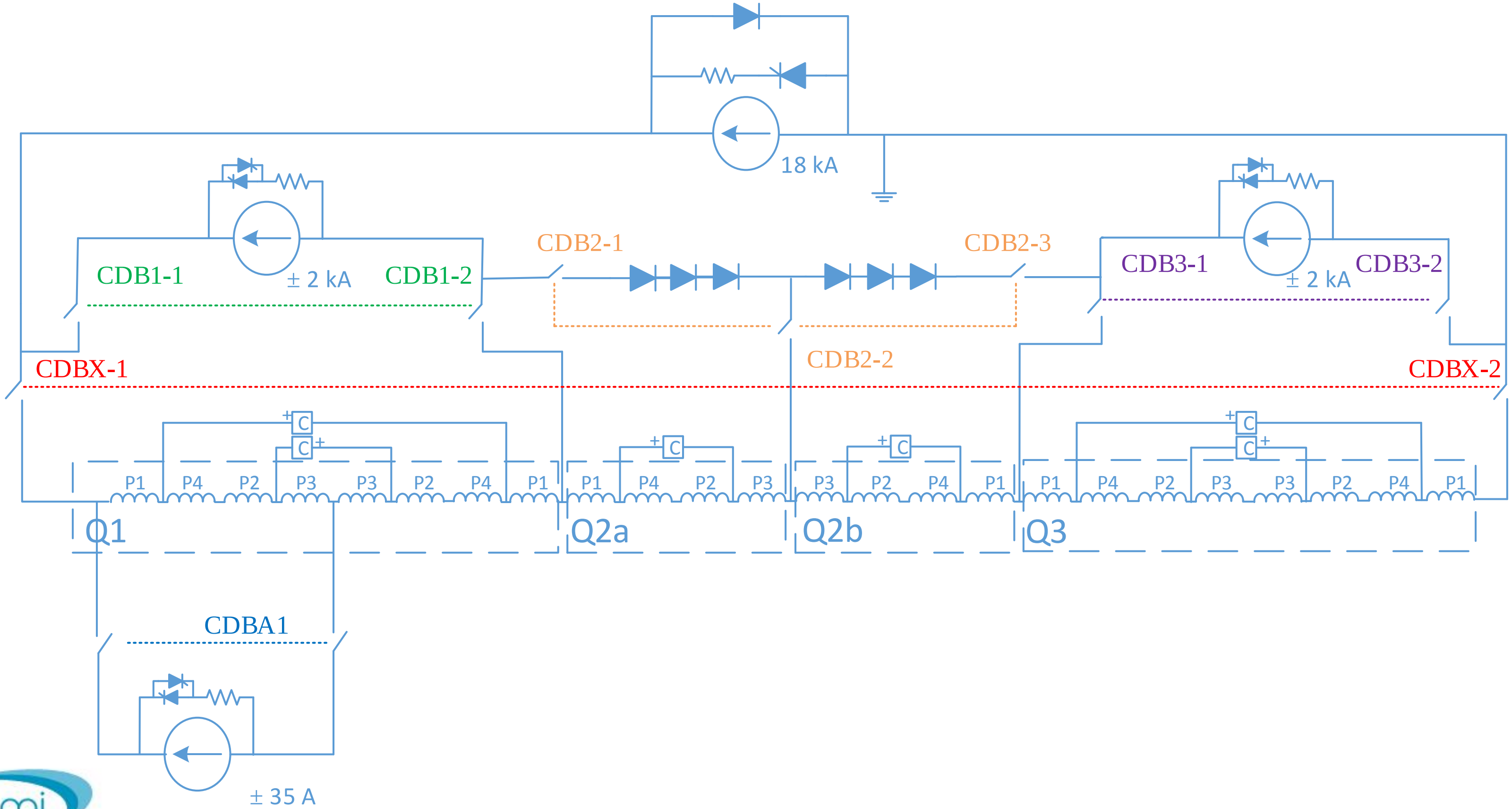
- Proposed integration concept with CDBs and distributed current leads



See talk by Samer Yammine on Thursday



Conceptual Solution for the IT Main Circuit



Conclusions

- Inner Triplet Circuit is consolidated (looking forward to include cold diodes in baseline)
- ECR on HL-LHC Circuits has been issued, documentation up to date
- K-modulation circuit is proposed to remain connected
- Cold Diodes – radiation tests ongoing, promising results
- Quench Detection Instrumentation – endorsed by MP3
- ECR on local powering, approved by TCC the changes on sc link, pending location of converters
- Disconnectors – final stage of study and approval by TCC

Thanks

Questions?