Magnet powering for Hi-Lumi LHC

4th LHC Parameter and Layout Committee
26/03/2013

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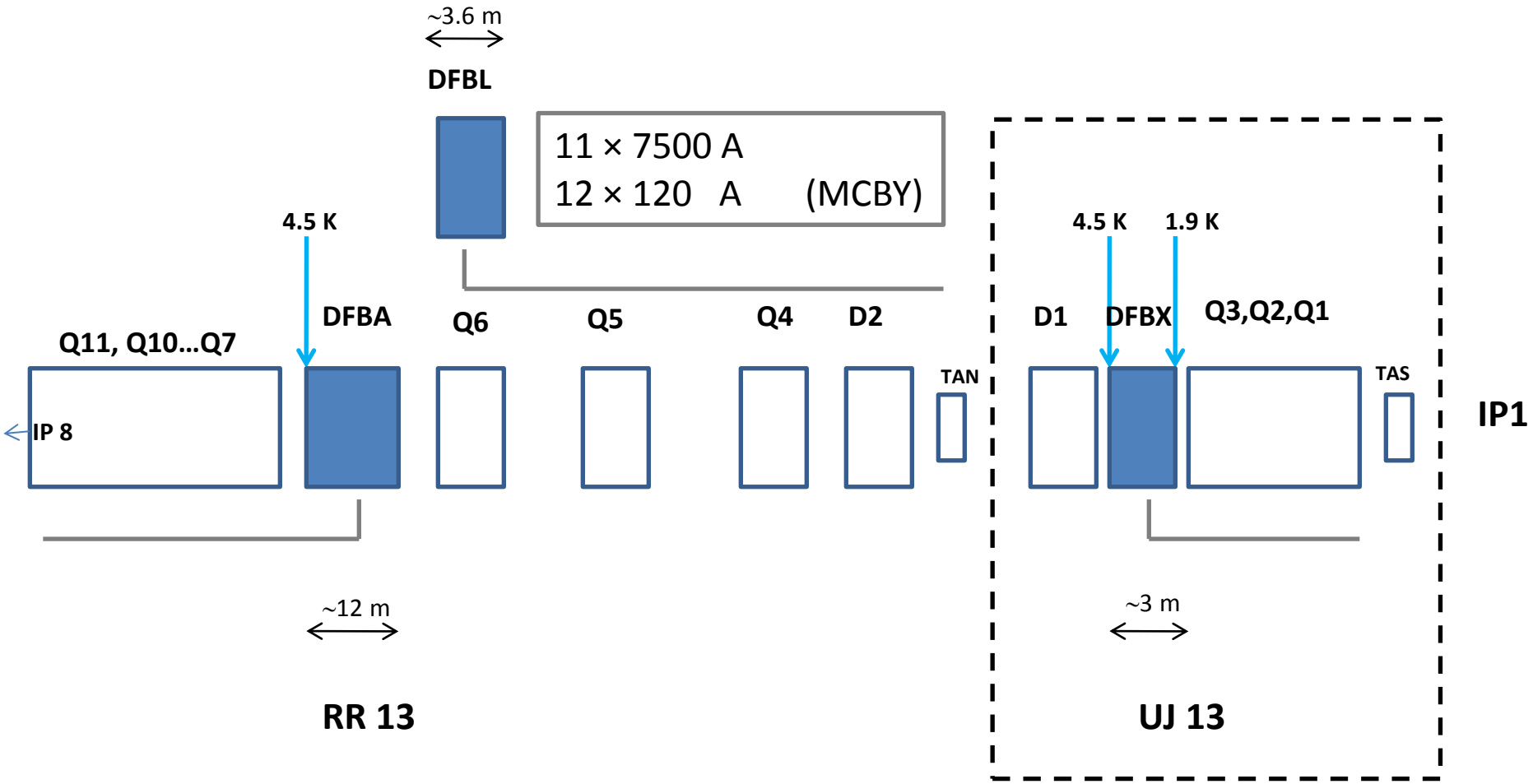
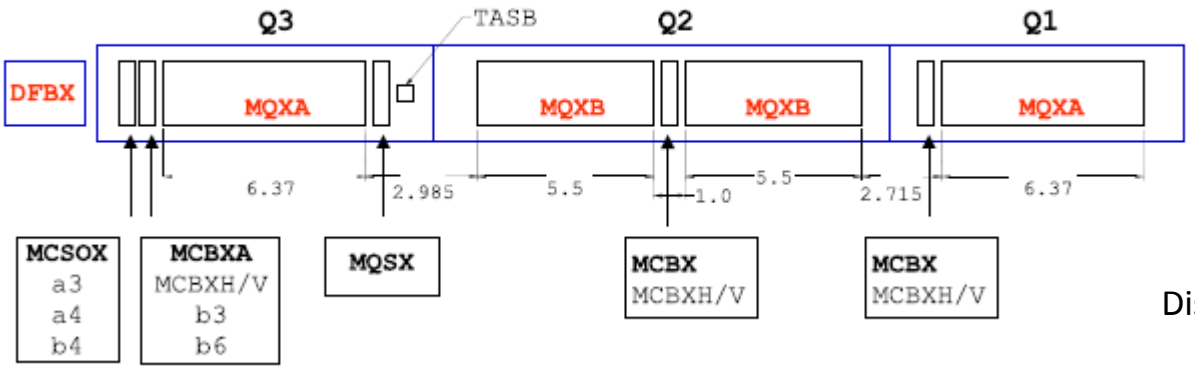
Outline

- Powering layout of the LHC Triplets
- Proposed powering layout for the Hi-Lumi Triplets
- Modifications in the Matching Sections
- Conclusions

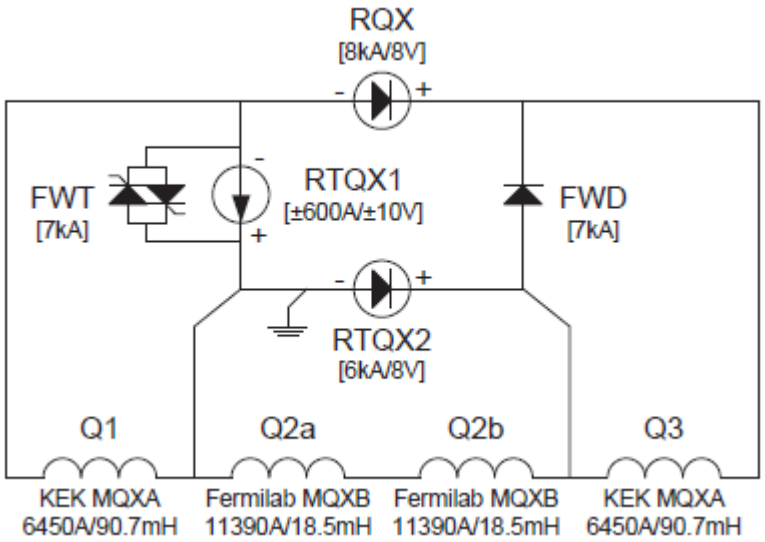
Powering of LHC Triplets



Powering of LHC Triplets



Distances in m



F. Bordy et al.

- **Nested circuits**
- **One trim** power converter (6 kA) on Q2
- **One trim** power converter on Q1 (0.6 kA)

Powering of LHC Triplets

D1 resistive magnet
Q1, **Q2** and **Q3**: four leads, each rated at **7500 A** DC
Corrector magnets: quadrupole, sextupole and octupole (120 A/600 A)

DFBX

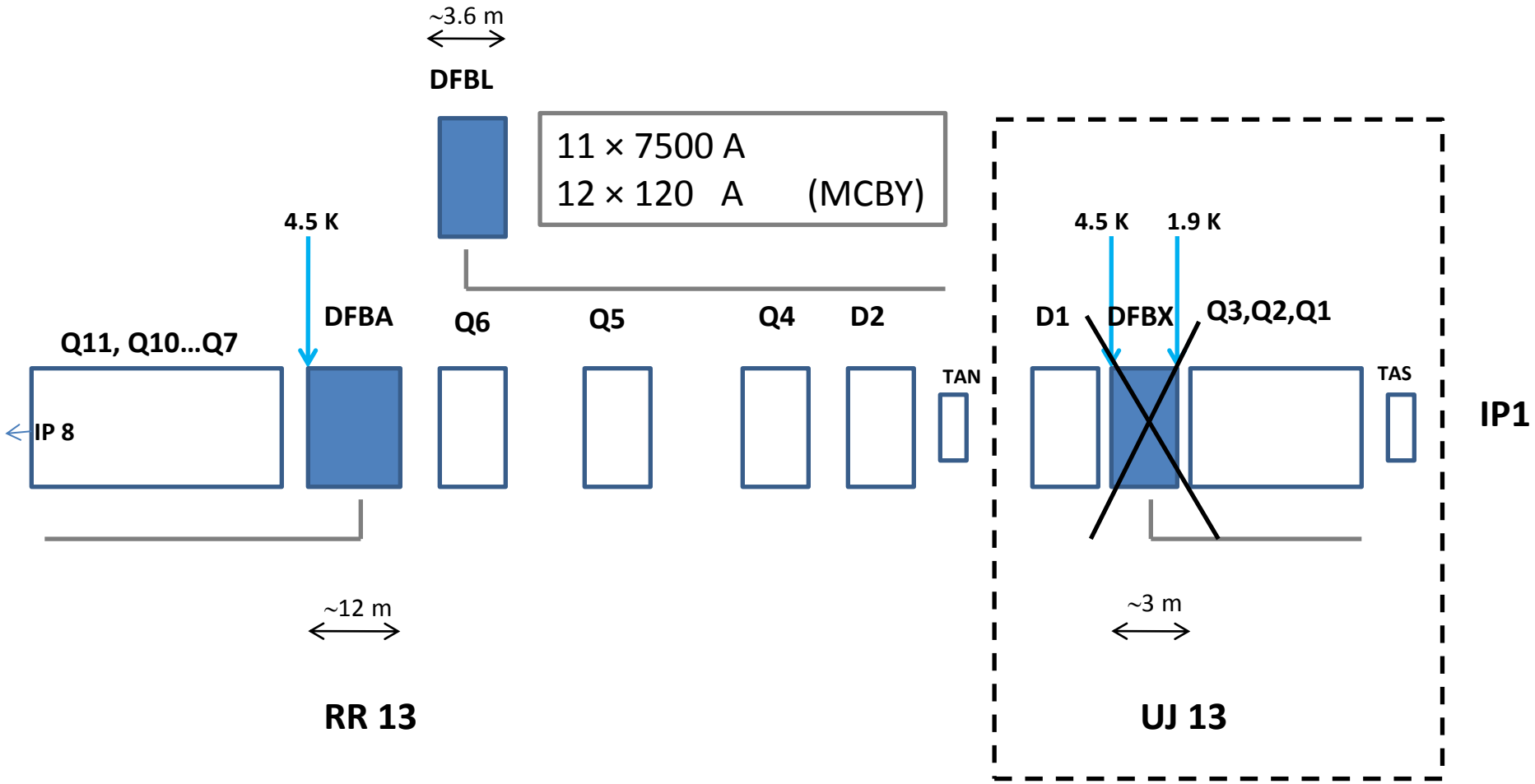
N. of leads	Rating (A)
10	120
14	600
4	7500

Itot from DFBX ~ 40 kA

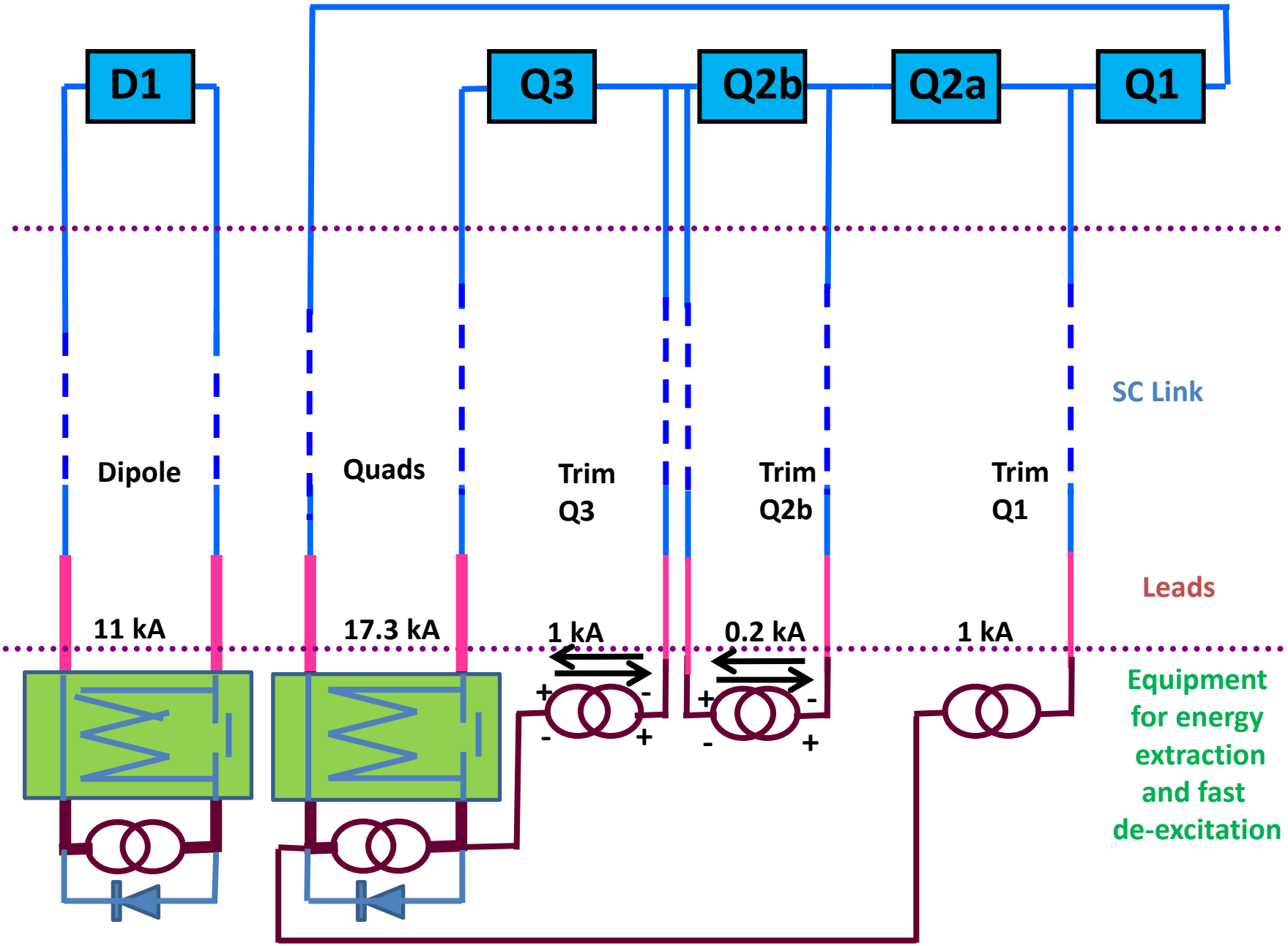
Baseline for powering the Hi-Lumi Triplets:

- DFBX moved to the surface;
- DFB and power converters in surface building;
- SC link transferring the current from the surface to the tunnel
- Cooling of DFB and SC link using new refrigerators

Powering of LHC Hi-Lumi Triplets



Powering layout 1 – past proposal, not retained



Powering layout 1 – original baseline, not retained

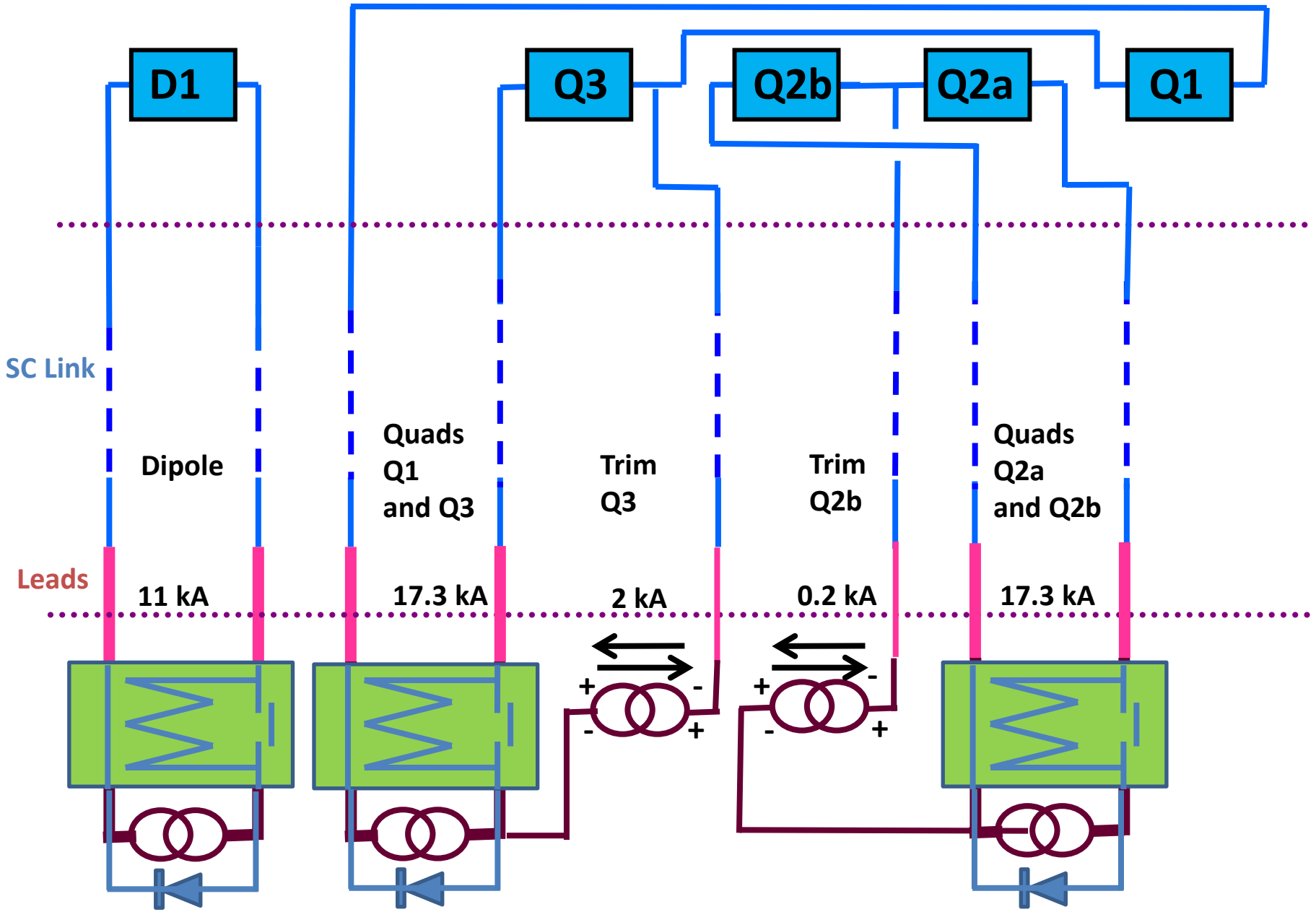
All quadrupoles in series with trims
Trims on Q3, Q1 and Q2b
τ for fast discharge < 7 s

+ Least investment for powering equipment

- Quench of all quadrupoles if one magnet quenches -unless use of cold diodes installed in non-radiation area or specifically developed with radiation hard characteristics

- Feasible, but more complicated for power converters (regulation and diagnostic)

Powering layout 2 –proposed baseline



Powering layout 2 – proposed new baseline

Two pairs of quadrupoles in series with trims

This layout assures:

- Full flexibility for the optics

When compared to Powering layout 1:

- Reduced constraints for magnet protection;
- Reasonable compromise for cold powering system (**+** 2×17.3 kA);
- Preferred solution for the power converters

Final location of 2 kA trim - Q3 or Q1 – to be defined at later stage

Corrector magnets

Nine circuits of **non-linear correctors** (MQSX)
9 PCs
18 leads, 18 SC cables in the link
Imax=100 A

Three times two circuits of **dipole correctors** (MBCX)
6 PCs
12 leads, 12 SC cables in the link
Imax=2400 A

Maximum Operating Current of Magnets and Powering Equipment*

Magnet type		Magnet current		Powering equipment current	
Quadrupoles	MQXF	17.3	kA	20	kA
Trim on Q3	Trim	± 2	kA	± 2.4	kA
Trim on Q2b	Trim	± 0.2	kA	± 0.24	kA
Dipole	D1	11	kA	13	kA
Non linear Correctors	MQSX	0.1	kA	0.12	kA
Dipole Correctors	MBCX	2.4	kA	3	kA

Powering layout 2 –proposed baseline

* Current Leads, HTS cables in SC link and power converters

DFBX

N. of leads	Rating (A)
10	120
14	600
4	7500

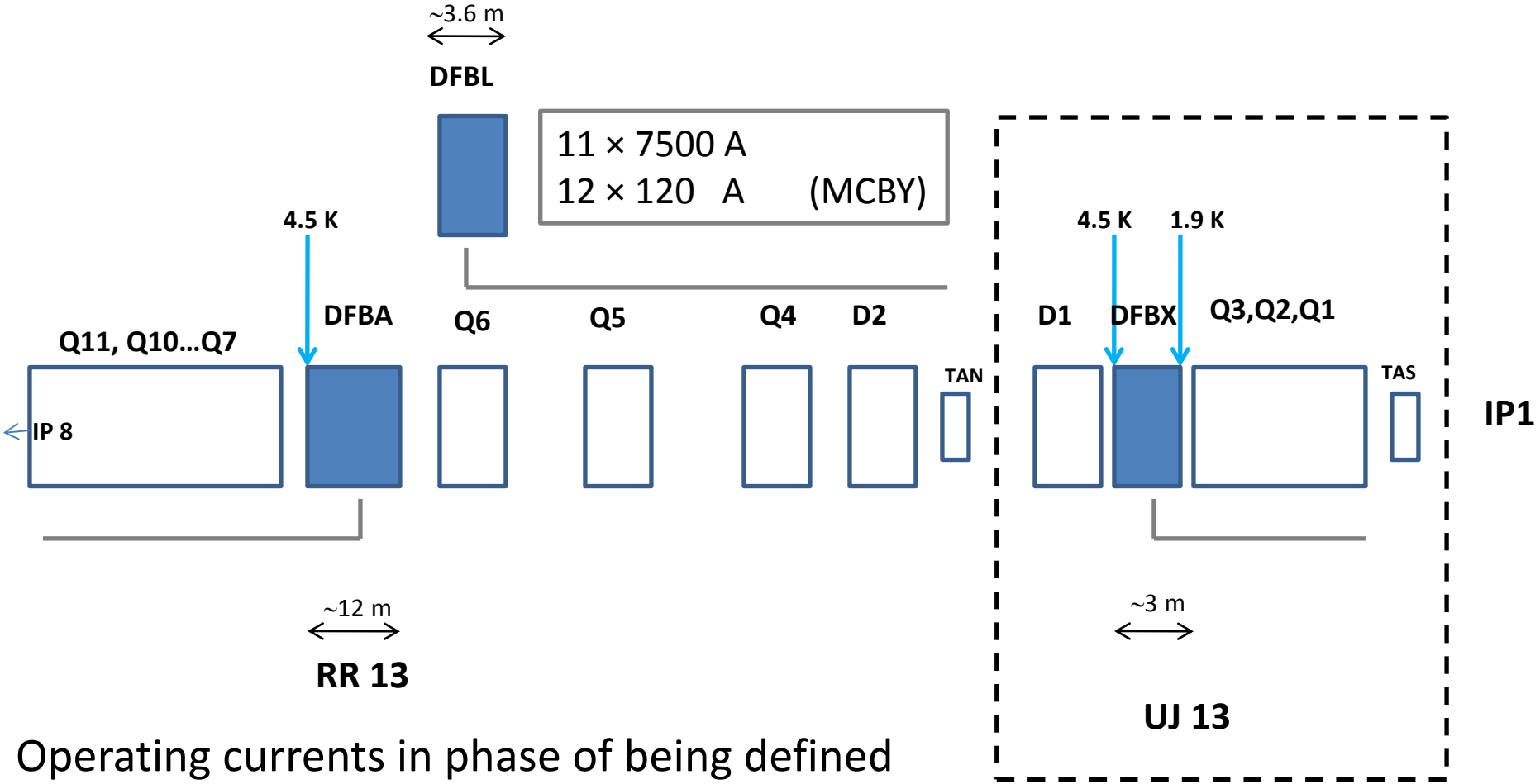
Itot ~ 40 kA

Hi-Lumi DFB and SC Link HTS cables

N. of leads	Rating (A)
18	120
12	3000
2	2400
2	400
2	13000
4	20000

Itot ~ 150 kA (!)

Powering of the Matching Sections



Operating currents in phase of being defined

D2, Q4, Q5, Q6 > 7500 A ? Powering via DFBL

Q7 = ? Powering via DFBA

Implications of any change are huge

Conclusions

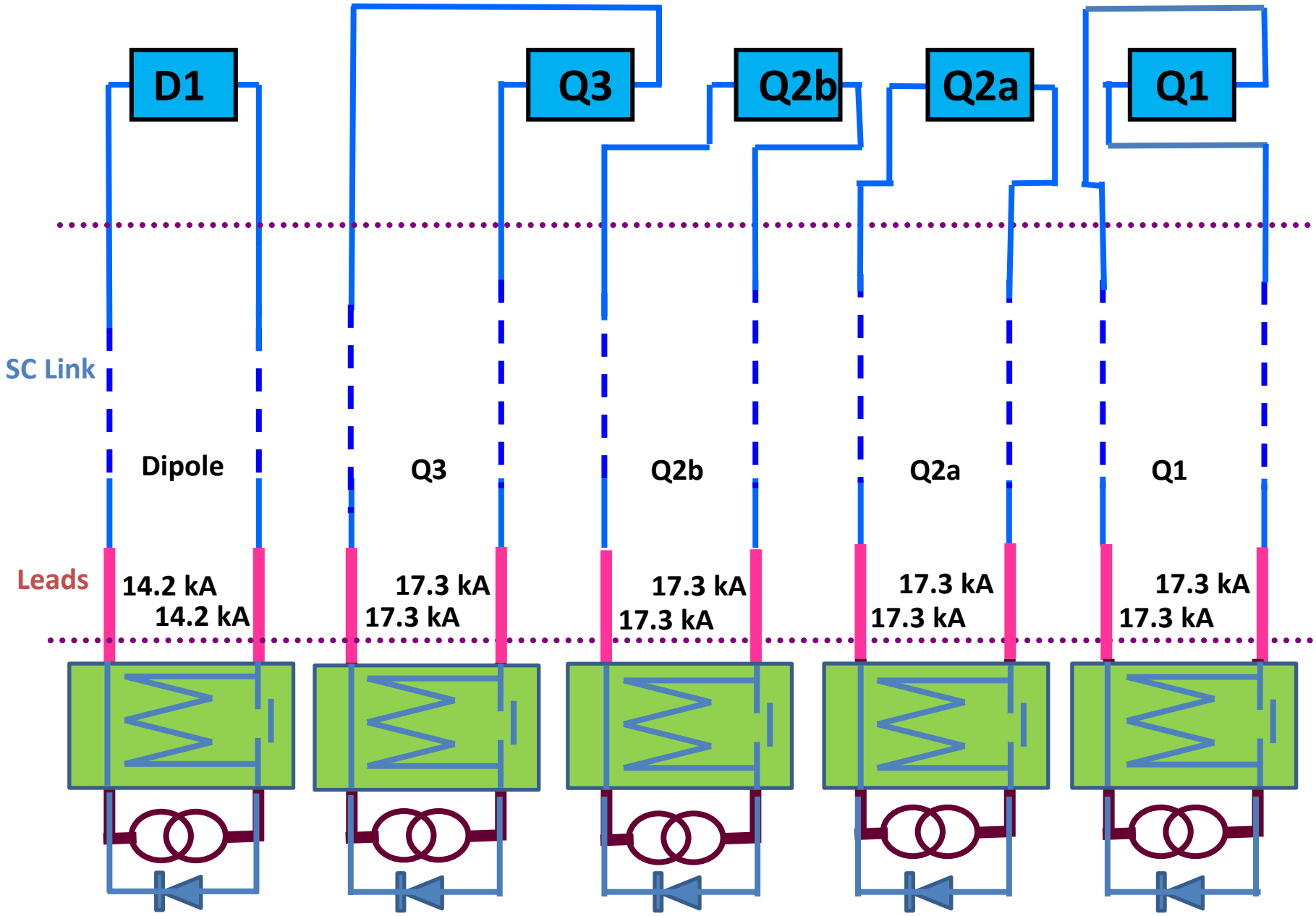
- The proposed powering layout for the Hi-Lumi Triplets meets requirements from optics, magnet and powering systems

- With a baseline for the powering layout, we (WP6) can start the design of the SC-link system

  In the meantime, we developed a round MgB_2 superconducting wire (CERN/Columbus Superconductor), tested first short lengths of MgB_2 cables at up to 10 kA @ 4.2 K, and developed, assembled and commissioned in the SM-18 a novel test station incorporating a 20 m long SC-link cryostat – for the measurement of superconducting HTS lines operated up to 20 kA in He gas at variable temperatures

- Changes in the MS – operating currents- have strong implications on the system (DFBA and DFBL)

SC-Link Test Station (SM-18)


D1
Q3
Q2b
Q2a
Q1
SC Link
Dipole
Q3
Q2b
Q2a
Q1
Leads
14.2 kA
14.2 kA
17.3 kA
17.3 kA
17.3 kA
17.3 kA
17.3 kA
17.3 kA
17.3 kA
17.3 kA