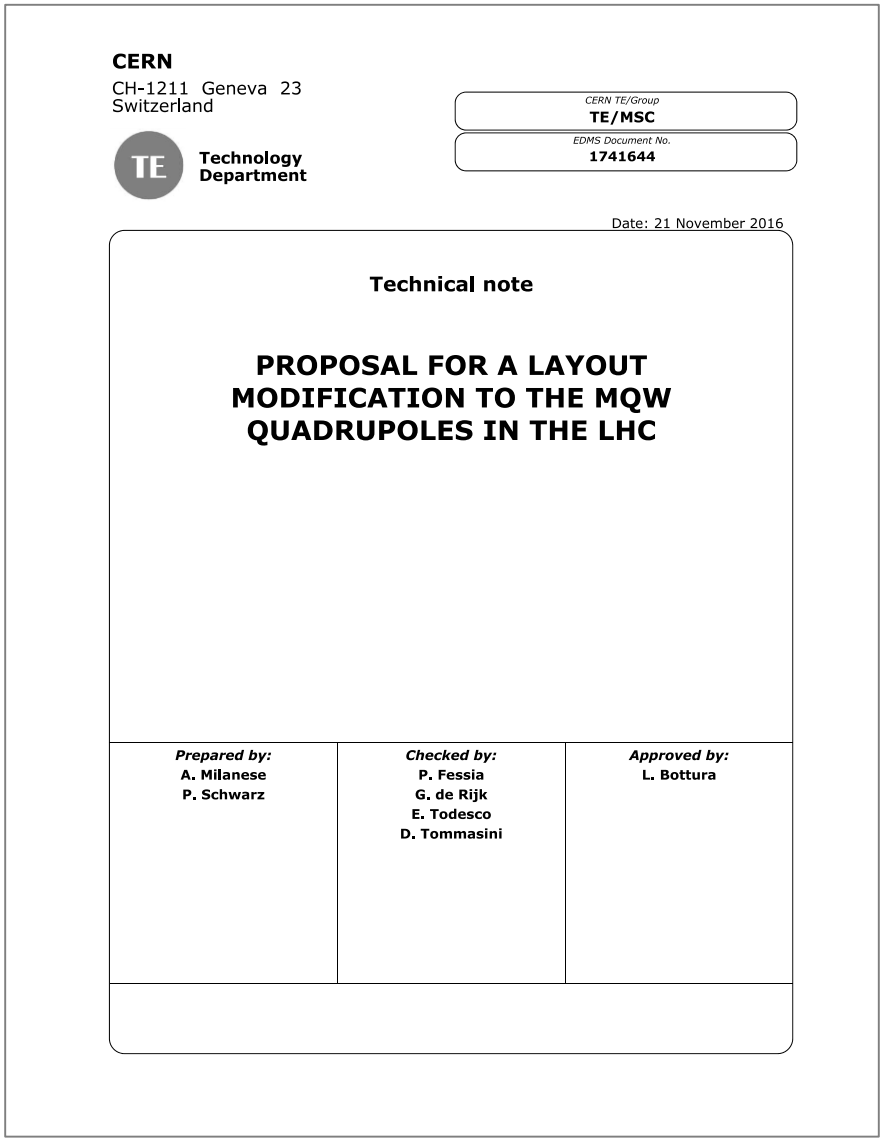
Complementary actions for the MQWs:
- to double the spares (without new ones)
- to further reduce the dose
(at limited cost)

Attilio Milanese

10 May 2017

This is an overview of a proposal put forward some time ago, more details can be found in that note



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EDMS Document No.
1741644

Date: 21 November 2016

Technical note

PROPOSAL FOR A LAYOUT MODIFICATION TO THE MQW QUADRUPOLES IN THE LHC

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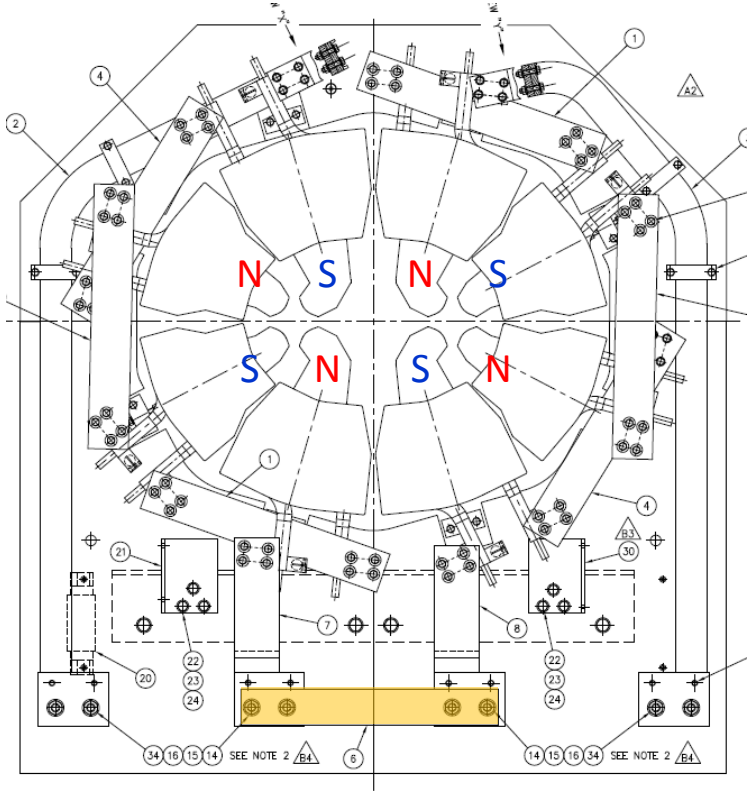
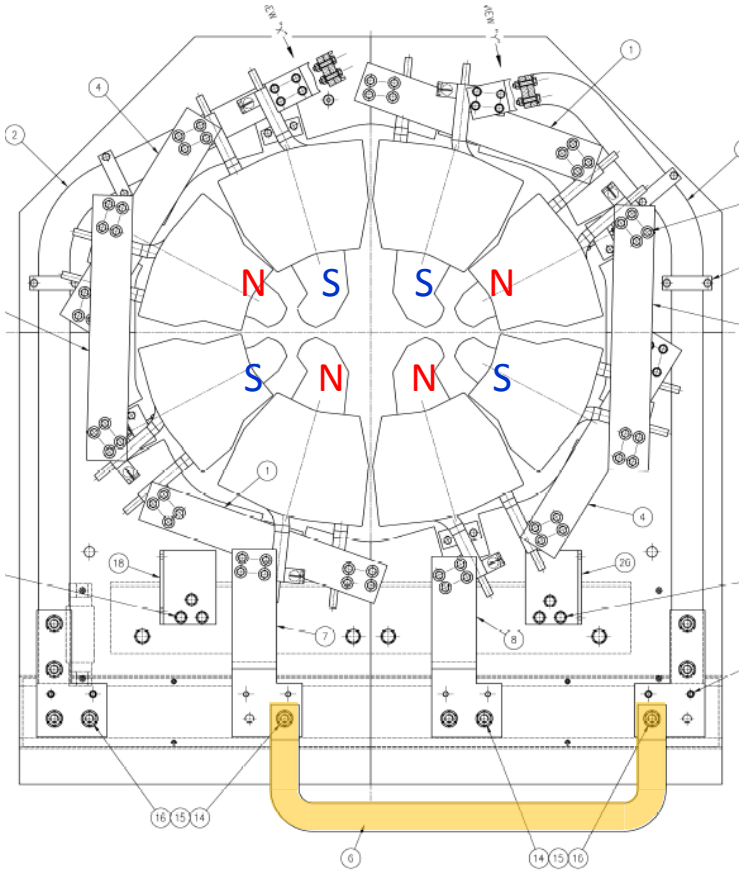
The MQWs come in two families: MQWA & MQWB

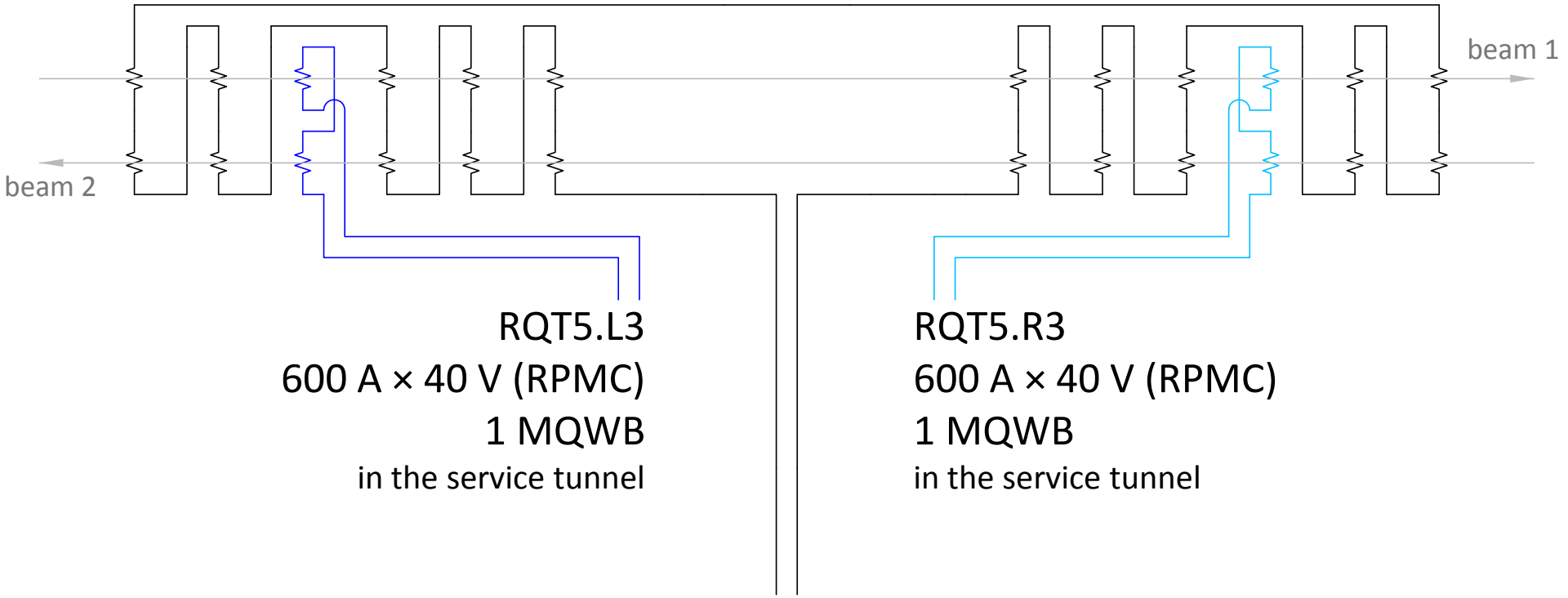
MQWA (F/D)



MQWB (F/F)



The circuits have 10 MQWAs in series, with the MQWBs used as trims: this is the (sketched) schematics for Q5 L/R 3



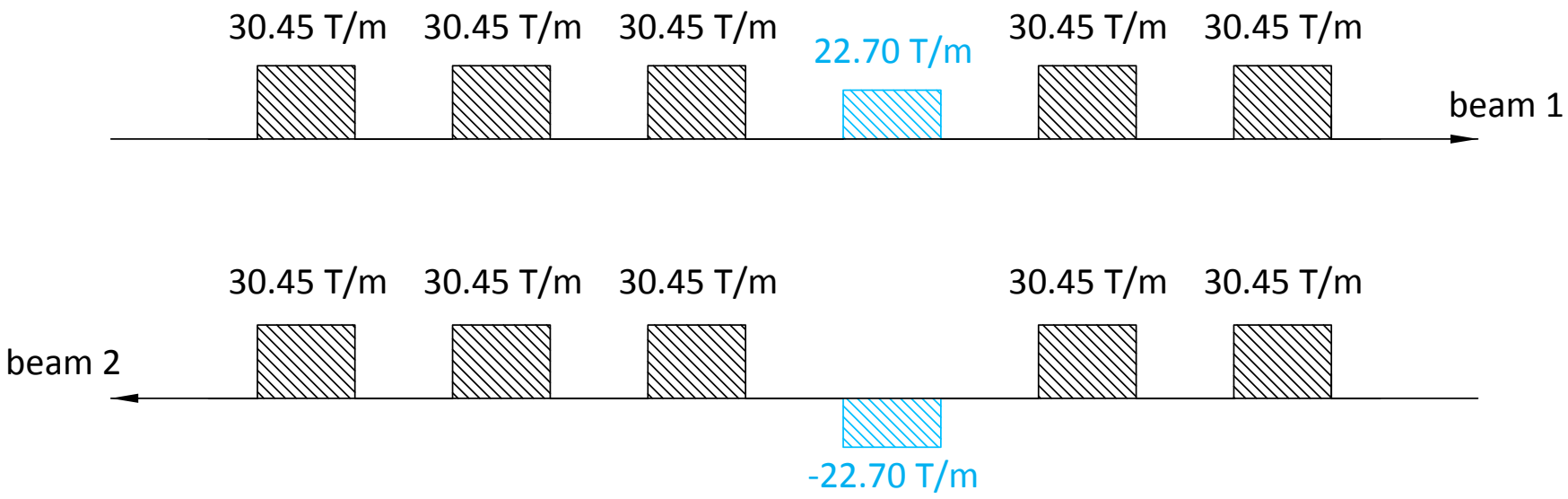
In total, there are 12 circuits, with 48 MQWs installed, plus 4 spares (with no radiation)

circuit	MQWA	MQWB	current [A] 7 TeV FiDeL
RQ4.LR3	10	-	561
RQT4.L3	-	1	313
RQT4.R3	-	1	-313
RQ5.LR3	10		593
RQT5.L3	-	1	-441
RQT5.R3	-	1	441
RQ4.LR7	10		598
RQT4.L7	-	1	152
RQT4.R7	-	1	-152
RQ5.LR7	10		610
RQT5.L7*	-	1	17
RQT5.R7*	-	1	-17

* to be removed in LS2

The two beams can see different ∫B': this is Q5.L3, the location where the difference is larger

values for 7 TeV
from FiDeL

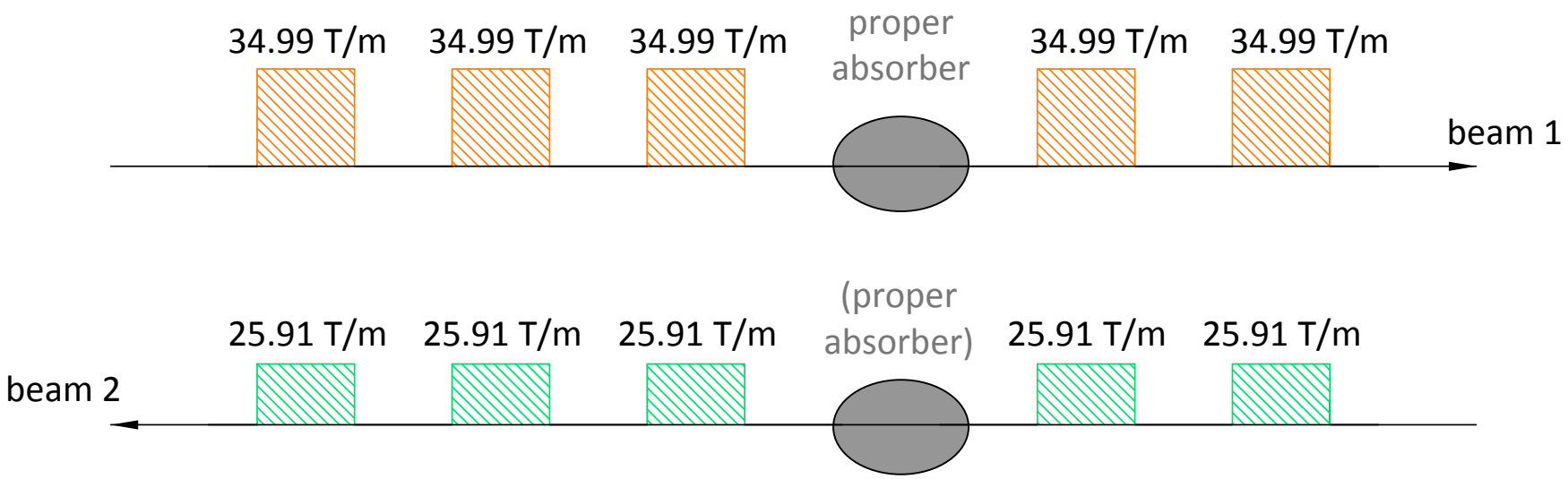


$$\int B'_{\text{beam 1}} = (5 \times 30.45 + 1 \times 22.70) \times 3.108 = 543.74 \text{ T}$$

$$\int B'_{\text{beam 2}} = (5 \times 30.45 - 1 \times 22.70) \times 3.108 = 402.64 \text{ T}$$

$$\int B'_{\text{beam 2}} / \int B'_{\text{beam 1}} = 0.74$$

The *same* effect can be achieved by powering the apertures independently, which also allows to remove 1 out of 6 units



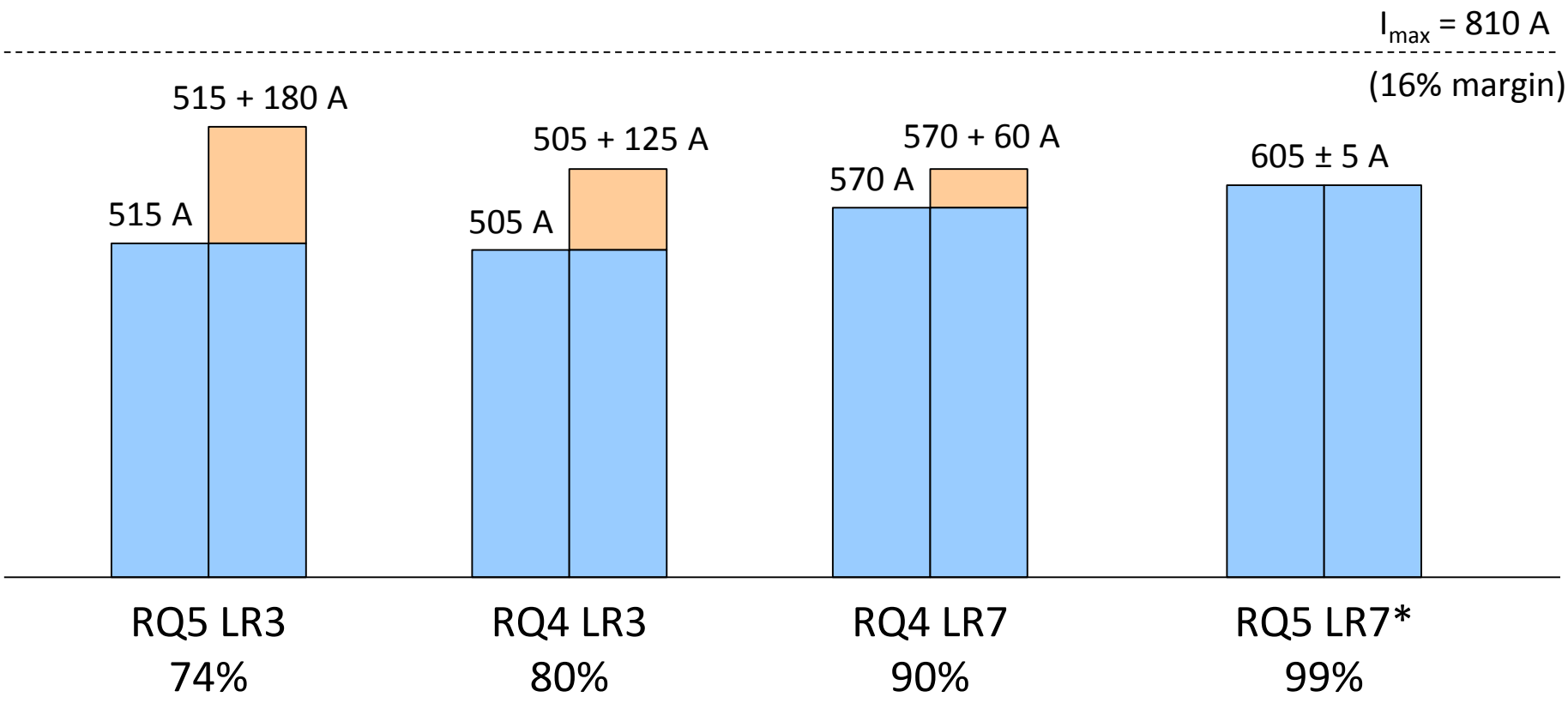
values for 7 TeV

$$\int B'_{\text{beam 1}} = 5 \times 34.99 \times 3.108 = 543.74 \text{ T}$$

$$\int B'_{\text{beam 2}} = 5 \times 25.91 \times 3.108 = 402.64 \text{ T}$$

$$\int B'_{\text{beam 2}} / \int B'_{\text{beam 1}} = 0.74$$

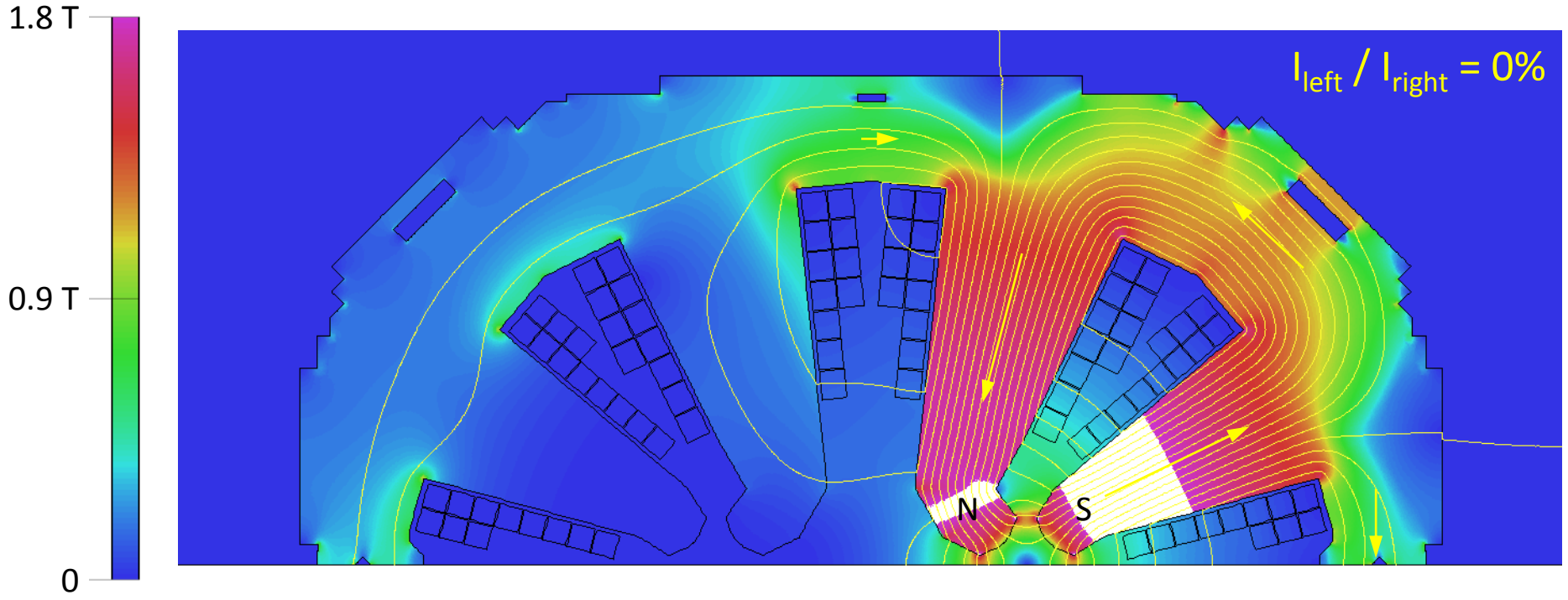
The ratios of ∫B' between the two apertures range from 74% to (almost) 100%



B' from 7 TeV values in FiDeL

* 2 MQWBs to be removed in LS2

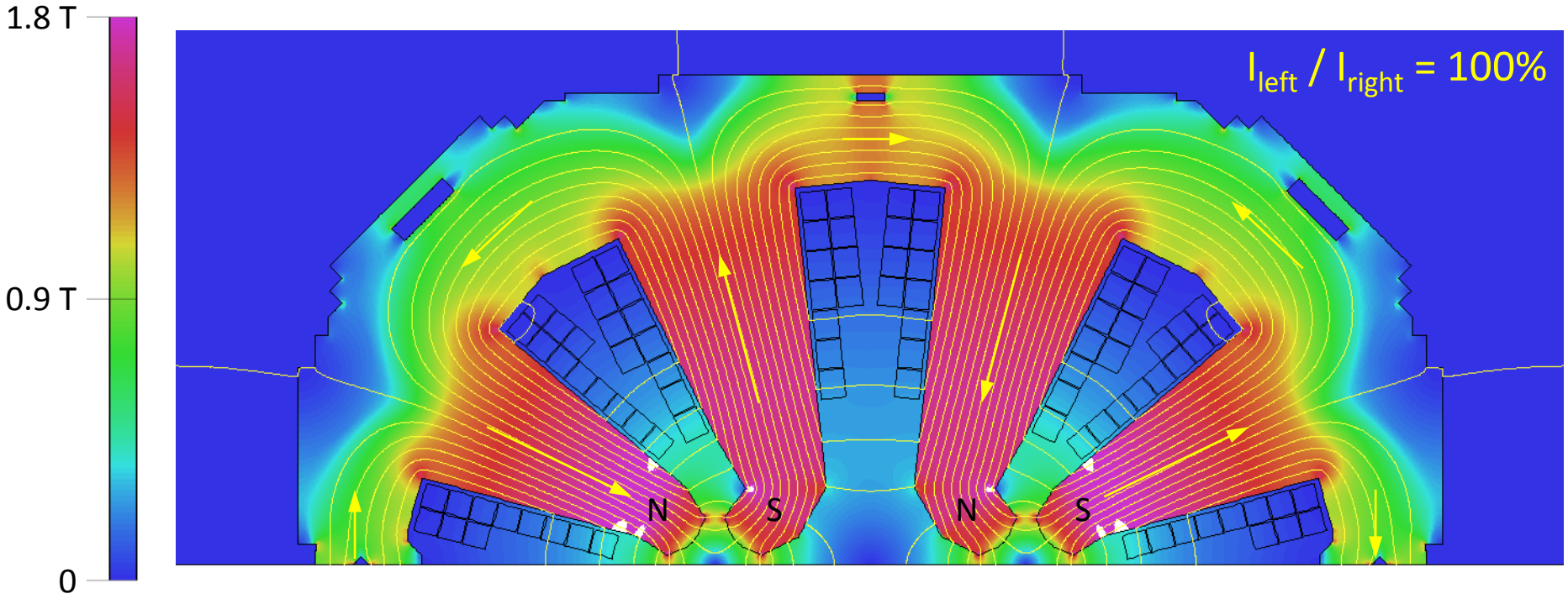
The MQWs have a peculiar magnetic design, still an unequal excitation in the apertures looks feasible: this is an extreme



I_{left} = 0% I_{lright}
B' = 0.0100 T/m

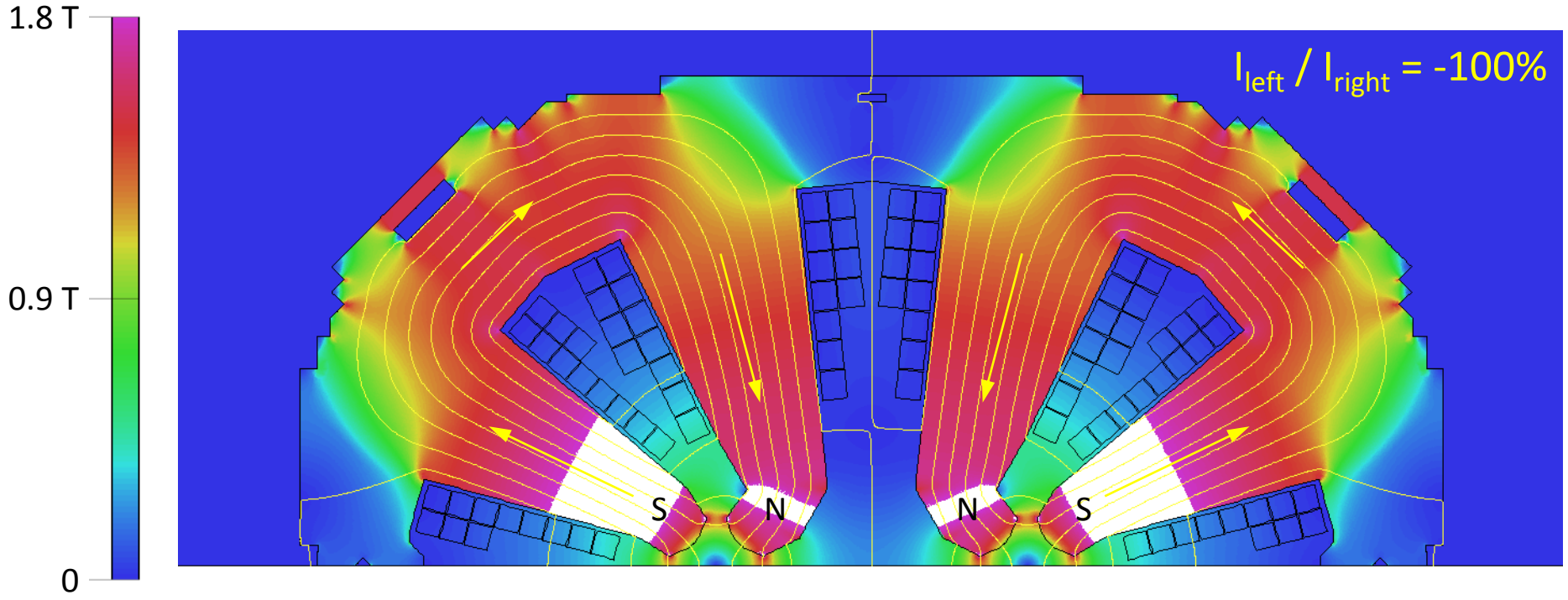
I_{right} = 710 A
B' = 35.7703 T/m
Δx = 0.15 mm
b_3 = -33, b_5 = -5, b_7 = 2

In the MQWAs, flux is shared between the two halves



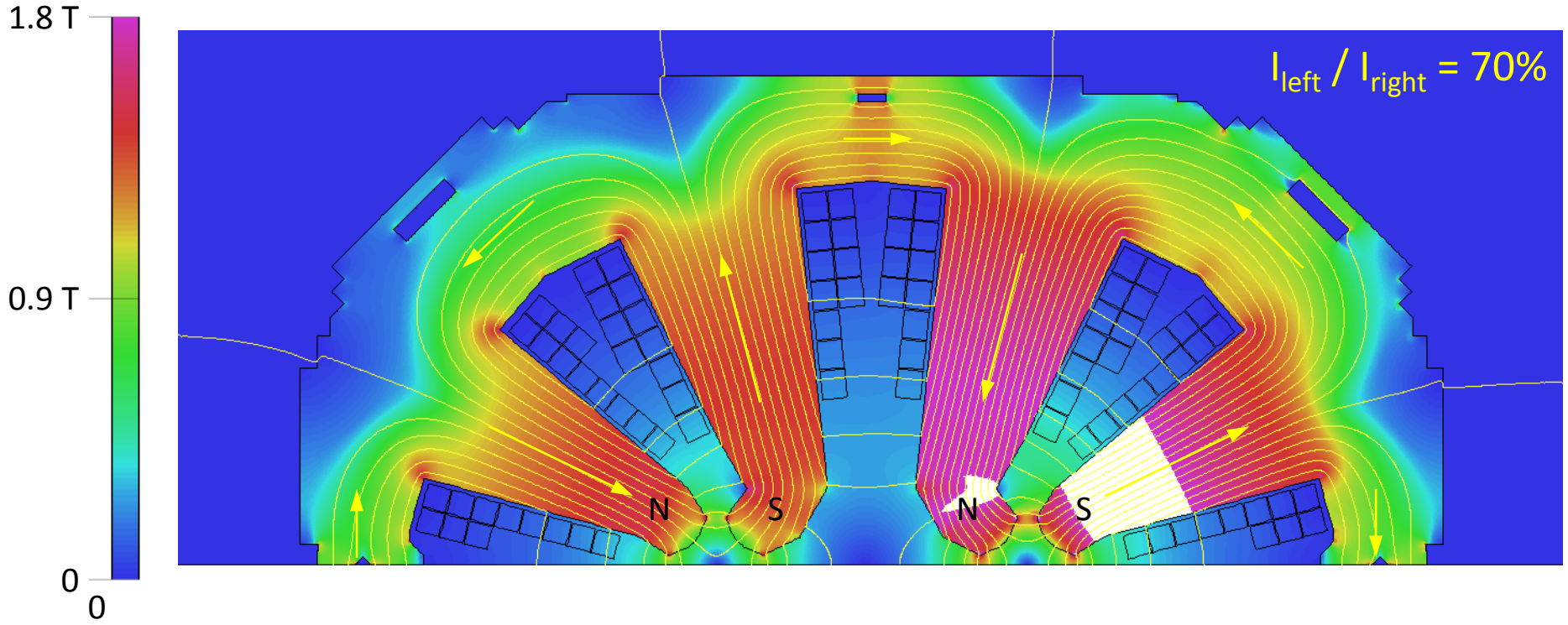
I_{left} = 100% I_{lright}	I_{right} = 710 A
B’ = 35.5244 T/m	B’ = 35.5233 T/m
Δx = -0.05 mm	Δx = 0.05 mm
b_3 = 7, b_5 = 3, b_7 = -1	b_3 = -7, b_5 = -3, b_7 = 1

The MQWBs, on the other hand, look like two figure-of-8 quadrupoles side by side



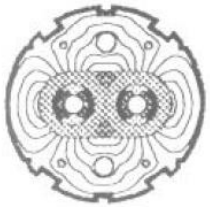
I_{left} = -100% I_{Iright}	I_{right} = 710 A
B’ = -35.8428 T/m	B’ = 35.8418 T/m
Δx = -0.18 mm	Δx = 0.17 mm
b_3 = 40, b_5 = 5, b_7 = -2	b_3 = -40, b_5 = -5, b_7 = 2

The situation is in between for a hybrid powering: 70% is the maximum expected difference, with some margin



I_{left} = 70% I_{Iright}	I_{right} = 710 A
B' = 25.7597 T/m	B' = 35.6204 T/m
Δx = 0.01 mm	Δx = 0.09 mm
b_3 = -6, b_5 = 2, b_7 = -1	b_3 = -18, b_5 = -4, b_7 = 1

This is not a new idea, simulations were done 20 years ago…
but finally a different scheme was retained



LHC Project Note 100

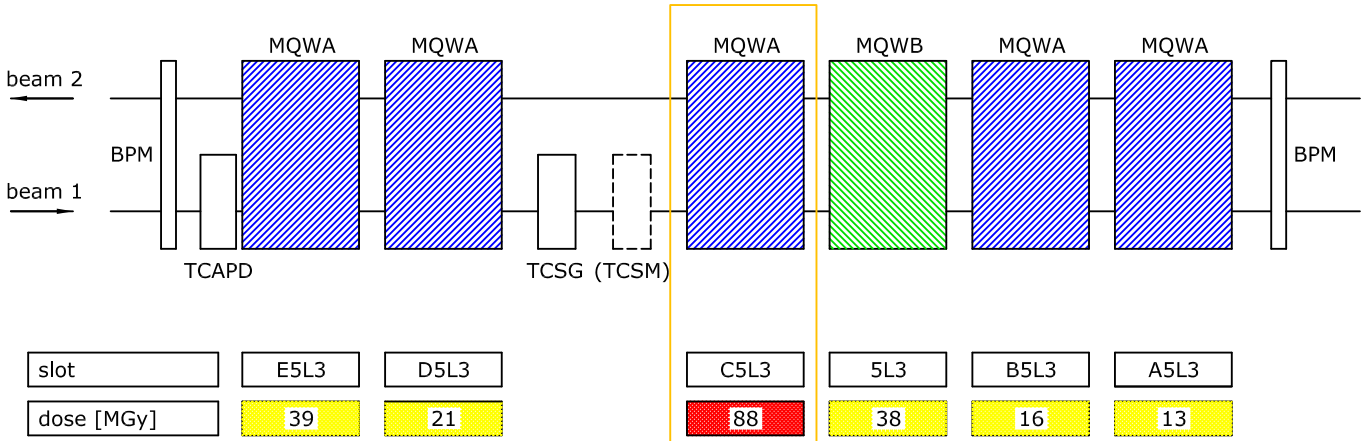
August 13, 1997

Gijs.De.Rijk@cern.ch

Magnetic Field quality for MQW cleaning insertion quadrupole with unequal excitation in the two apertures

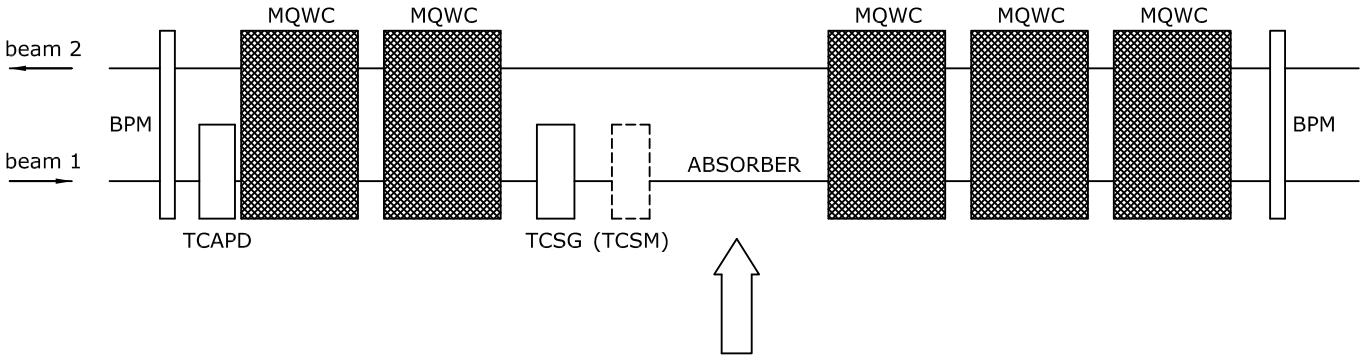
G. de Rijk

We could remove the most exposed unit in each block of 6, putting a proper absorber in space: ex. Q5.L3, from the note

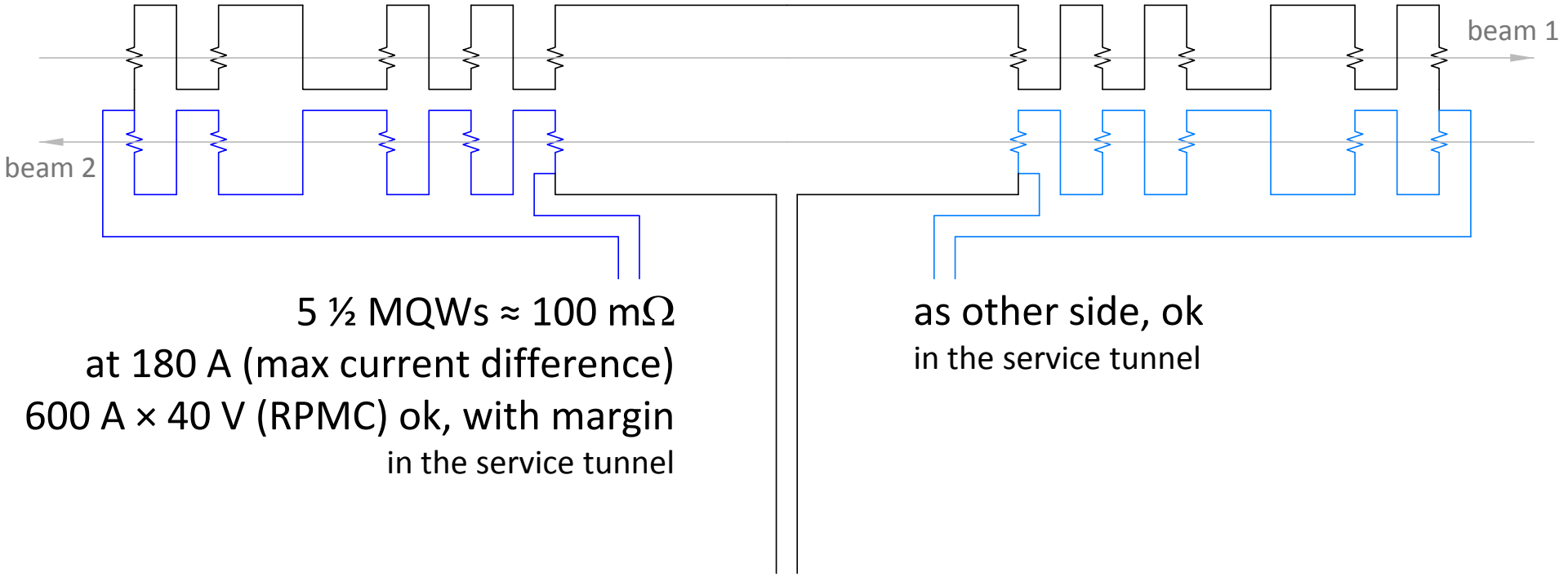


possibly a spare, if removed early enough

doses for 4000 fb^{-1}, without the updates from the eYETS16-17 readings of the dosimeters



A possible circuit implementation involves using the same converters and some re-cabling (in the tunnel only) without losing any degrees of freedom for the beam

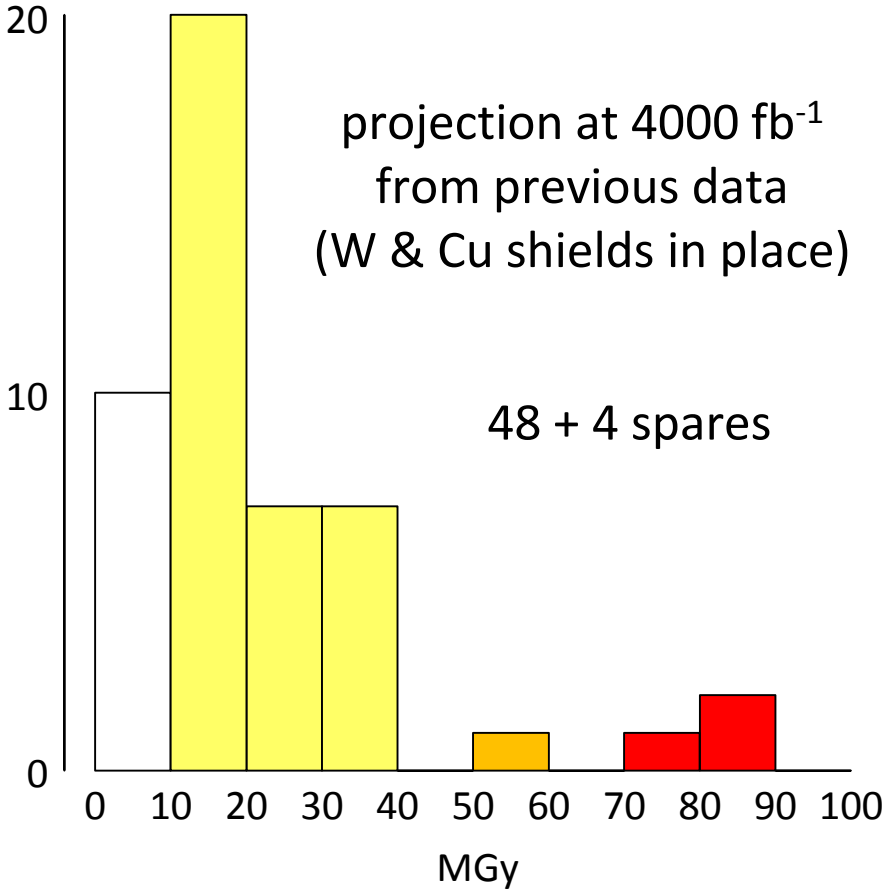


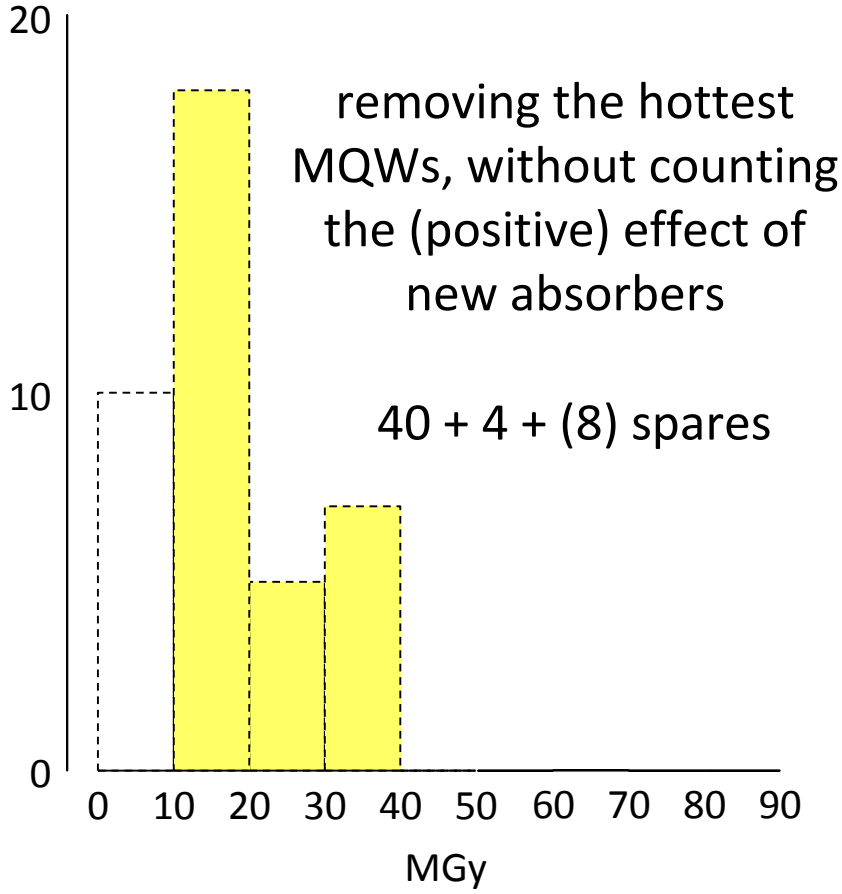
5 ½ MQWs ≈ 100 mΩ
at 180 A (max current difference)
600 A × 40 V (RPMC) ok, with margin
in the service tunnel

as other side, ok
in the service tunnel

10 MQWs, as today
810 A × 450 V (RPTF) still ok
at the surface

We would thus reduce the dose on the installed magnets and possibly increase the number of spares





We propose to further analyse this scheme, to complement the present baseline (W and Cu shields, radiation studies), and to revise the need of more spare magnets / coils

1. magnetic measurements — to do

   being organized with a subset of currents, to confirm magnetic coupling, field homogeneity and mutual inductances

2. beam optics / dynamics

   to be checked, in particular for the (small) longitudinal shift of the centre of the lenses, and for the higher harmonics

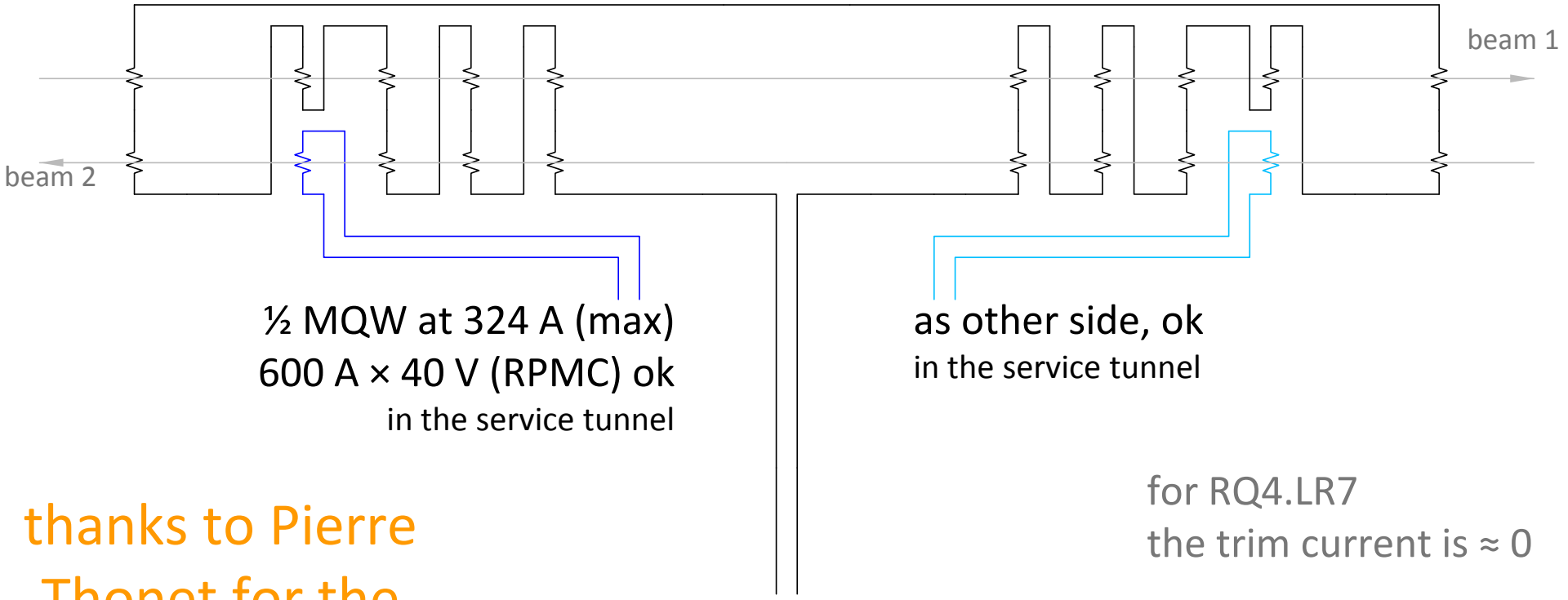
3. power converters & cabling

   re-configuration of the 600 A × 40 V as trims to be assessed / costed

4. radiation doses & absorbers

   projected doses at 4000 fb^{-1}, considering the latest readings of the dosimeters and dedicated absorbers to be installed (if needed) at the location of removed MQWs

This is another (last minute) layout – shall we look for the best option at the 4 different locations?



½ MQW at 324 A (max)
600 A × 40 V (RPMC) ok
in the service tunnel

as other side, ok
in the service tunnel

for RQ4.LR7
the trim current is ≈ 0

thanks to Pierre Thonet for the nice idea

8 MQWs + 2 ½ = 9, 1 less than today
810 A × 450 V (RPTF) ok
at the surface

thank you