HiLumi
HL-LHC PROJECT

V1.2 reevaluation of collision debris impact on the IT region - and matching section -. The role of IT interconnections and BPM.

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CERN EN STI FLUKA

WP10
Energy deposition & R2E

5th HL-LHC TCC   Mar 31, 2016

OUTLINE

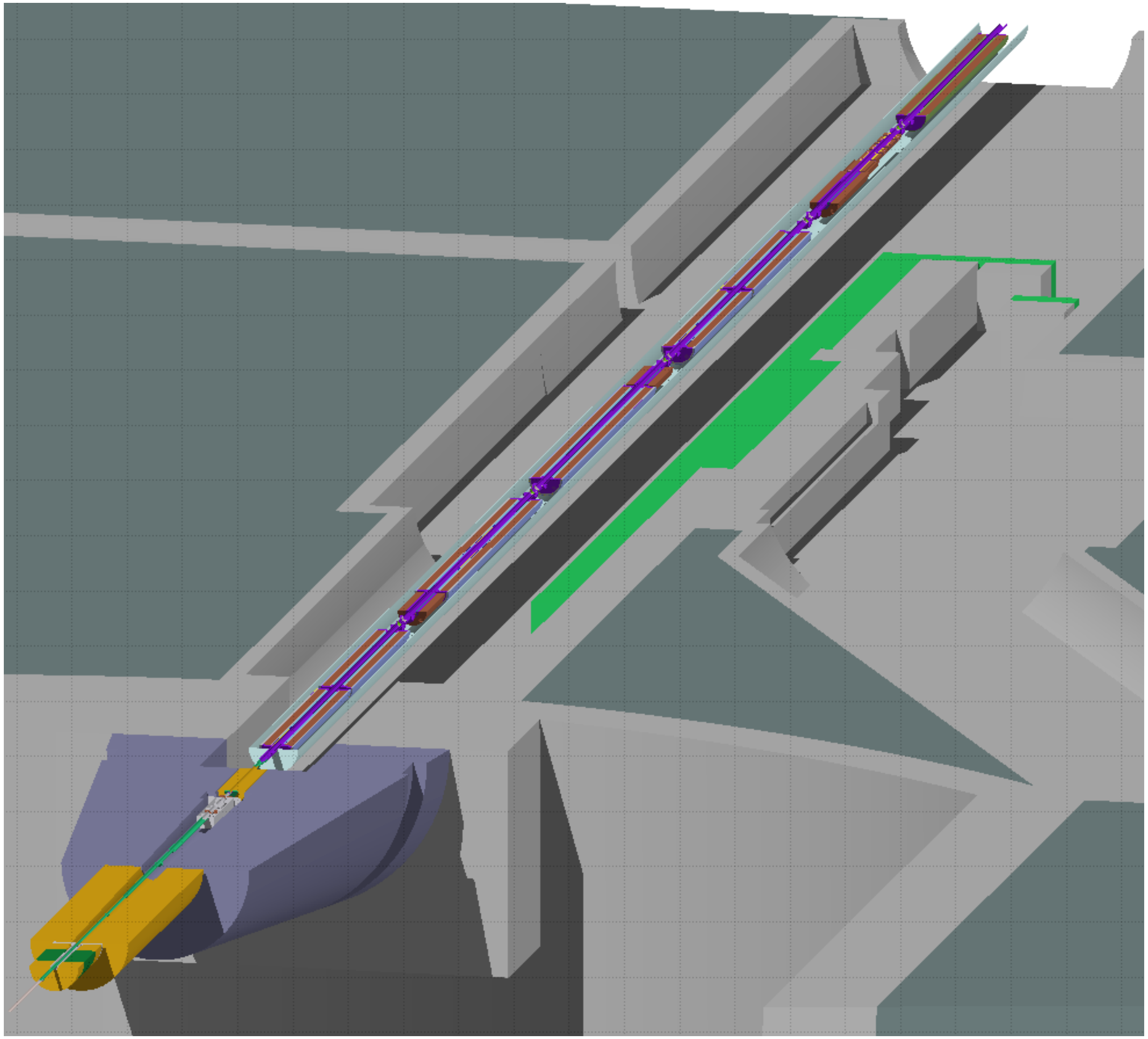
Updated impact on the IT-D1 region for vertical (IR1) and horizontal (IR5) crossing

Effect of optics variations

Interconnection optimization

Updated impact on the MS for vertical (IR1) and horizontal (IR5) crossing

(IR1) IT REGION



THE SHIELDING BACKBONE

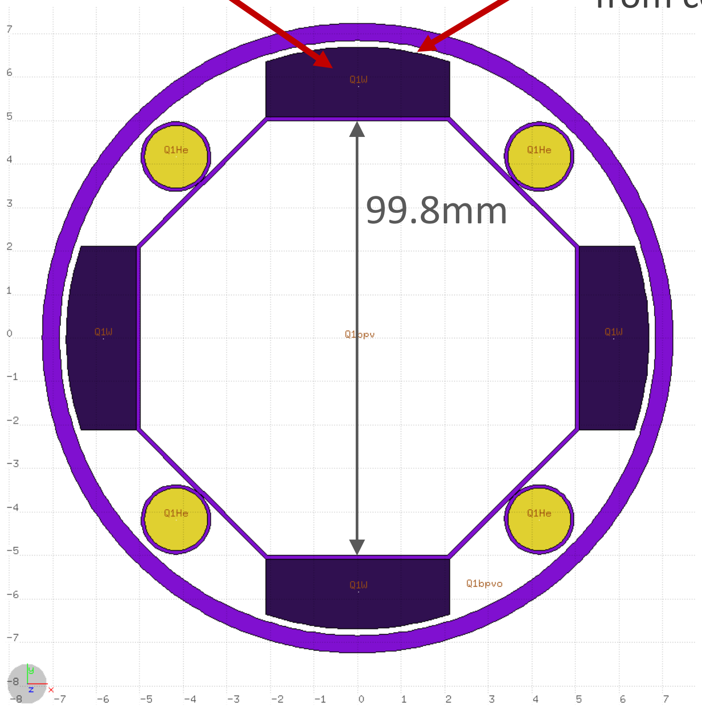
Q1

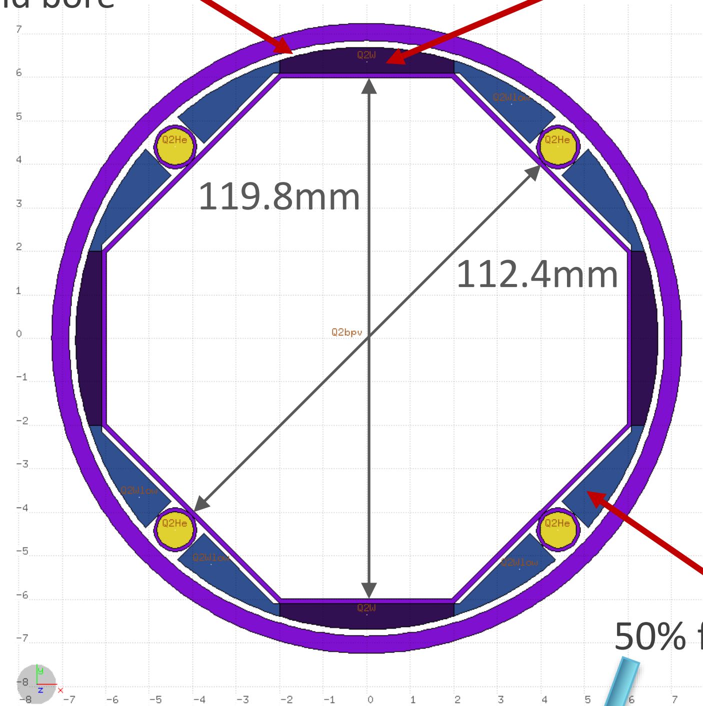
Q2 and beyond

d_{max} = 16mm

1.5mm clearance
from cold bore

d_{max} = 6mm





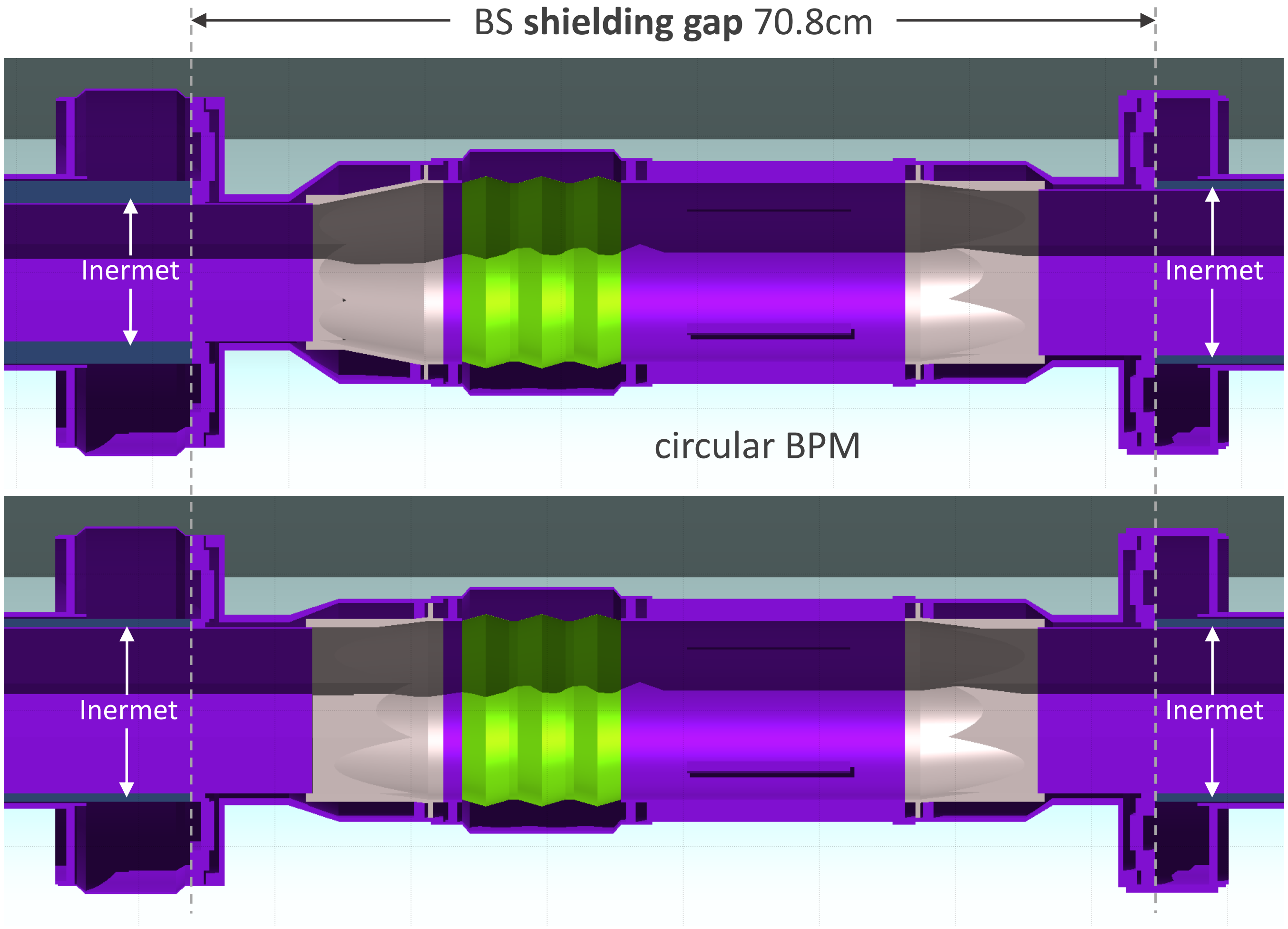
50% filling factor

later reduction to 20%,
with explicit alternation of 2cm inermet pieces
with 8cm gaps

THE WEAK POINT

Q1→Q2

Q2
and beyond



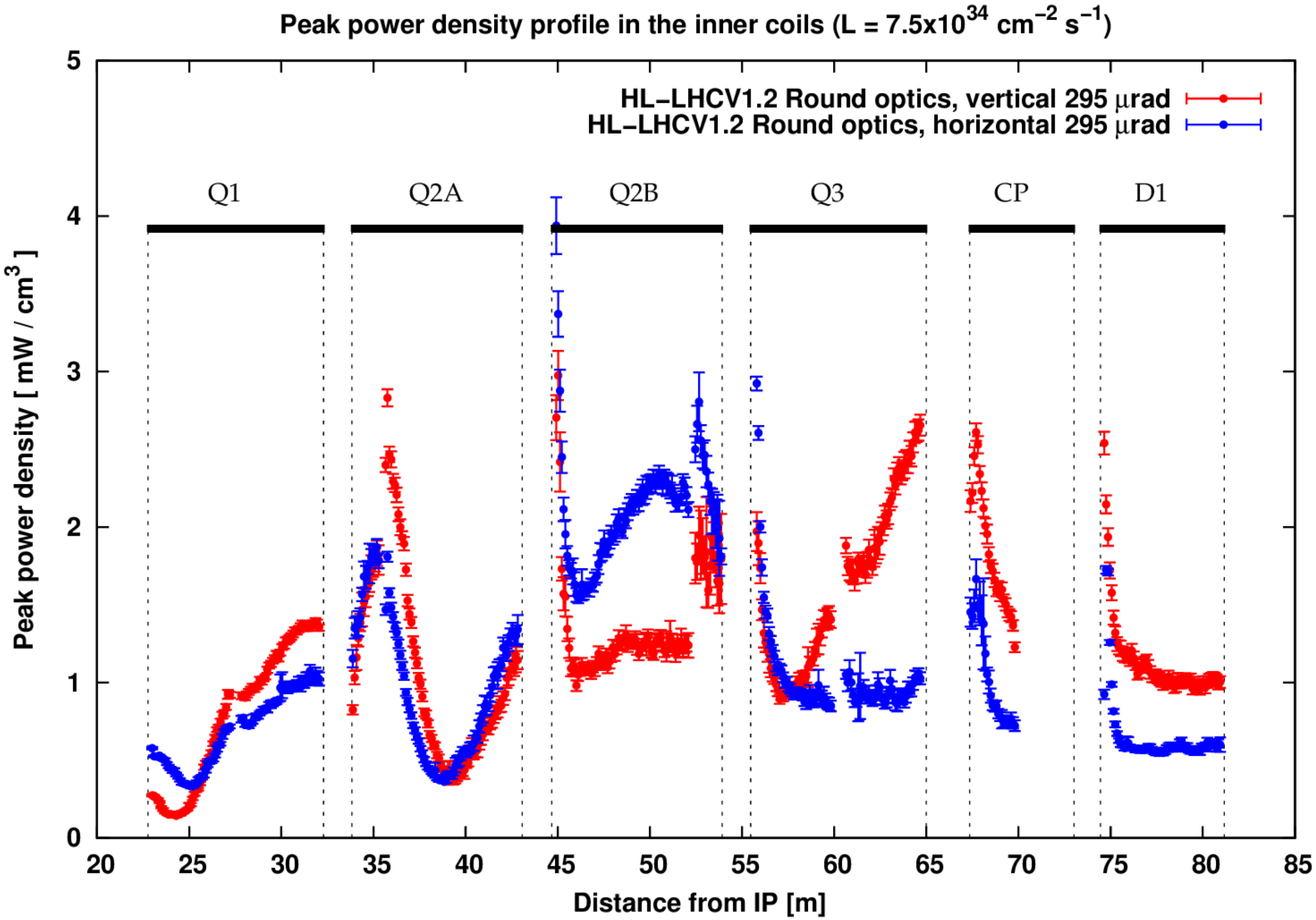
Design provided by R. Fernandez-Gomez, T. Lefevre

DEPOSITED POWER @ 7.5L_0

	Round vertical		Round horizontal		Round vertical V1.1	
	Magnet cold mass	Beam screen	Magnet cold mass	Beam screen	Magnet cold mass	Beam screen
	Power [W]					
Q1A + Q1B	167	251	176	257	140	210
Q2A + corr.	139	115	127	101	150	90
Q2B + corr.	170	147	178	153	165	100
Q3A + Q3B	186	153	160	125	220	105
CP	85	106	58	73	105	90
D1	113	107	92	84	135	80
TOTAL	**860**	**879**	**791**	**793**	**915**	**675**

- Extension of BS shielding towards poles (with a 50% filling factor!) re-balances loads between CM and BS
- Loads in horizontal crossing ~10% lower with respect to vertical crossing

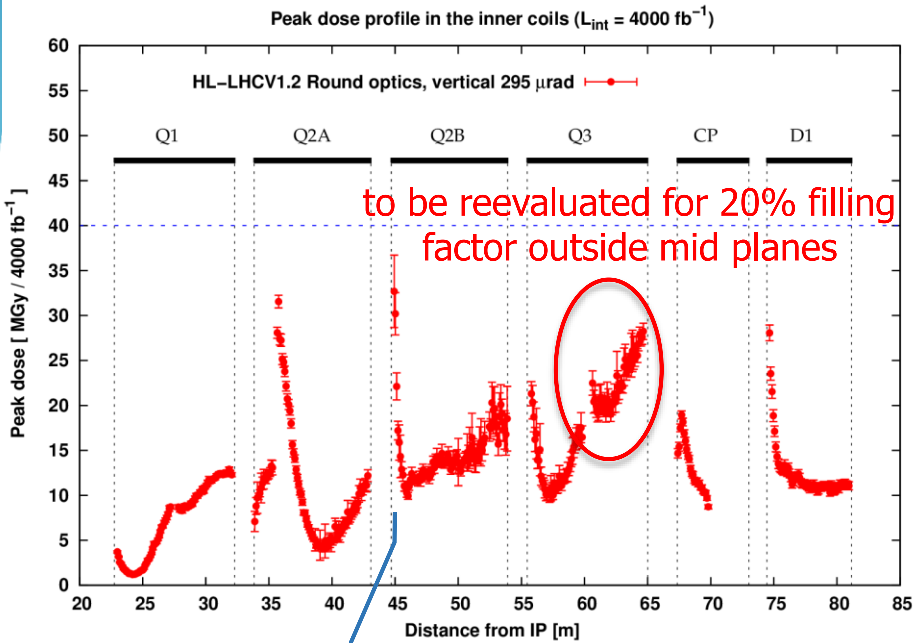
COIL PEAK POWER DENSITY @ $7.5L_0$

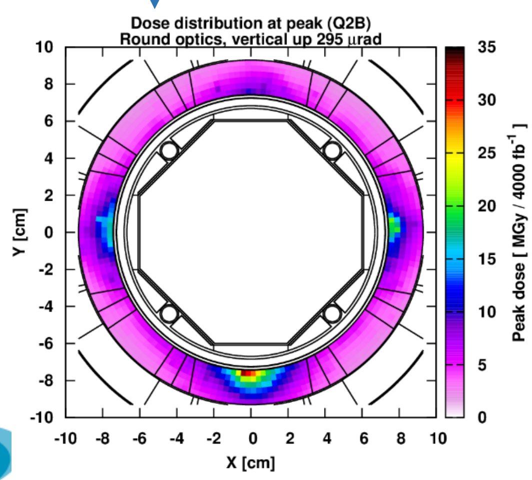


- Peak power density well below design values overall
- There is an important effect on the IP-faces due to shielding gap in the interconnect, especially for horizontal crossing

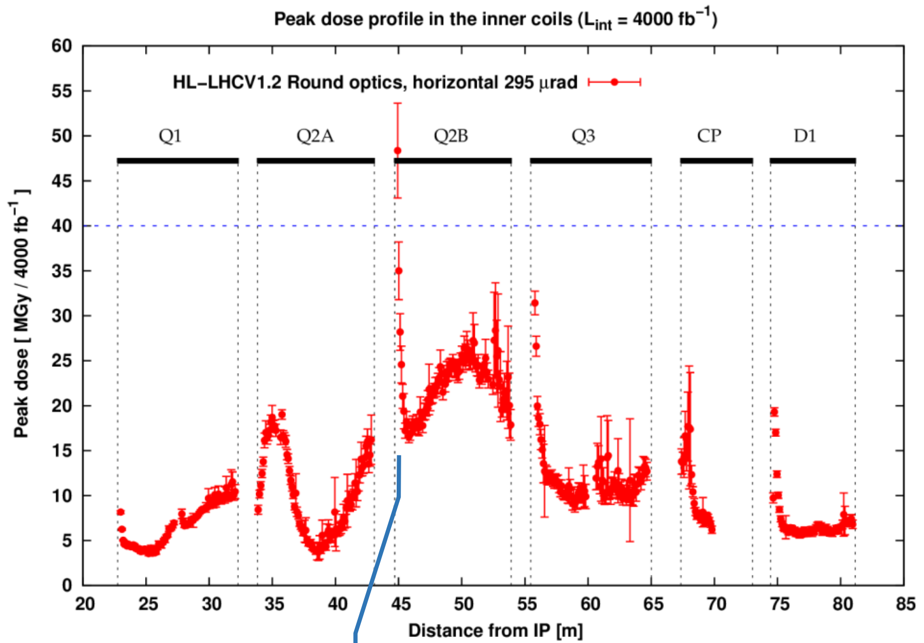
COIL PEAK DOSE FOR 4ab^{-1}

Vertical crossing

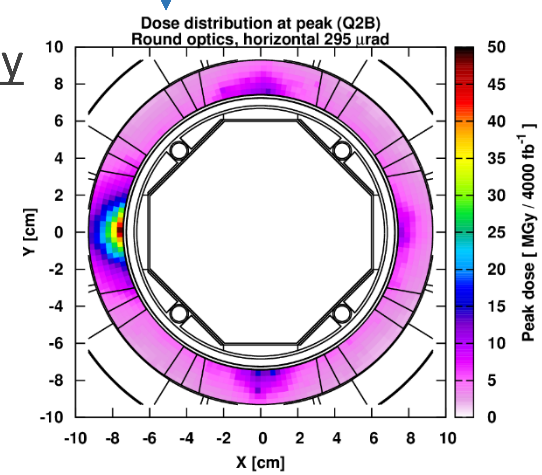




Horizontal crossing



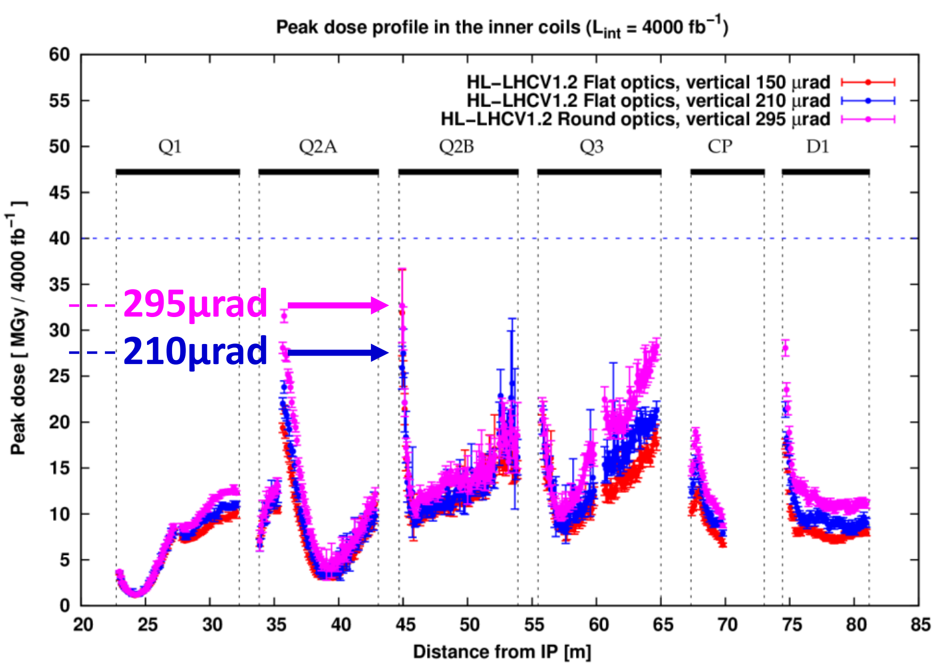
50 MGy



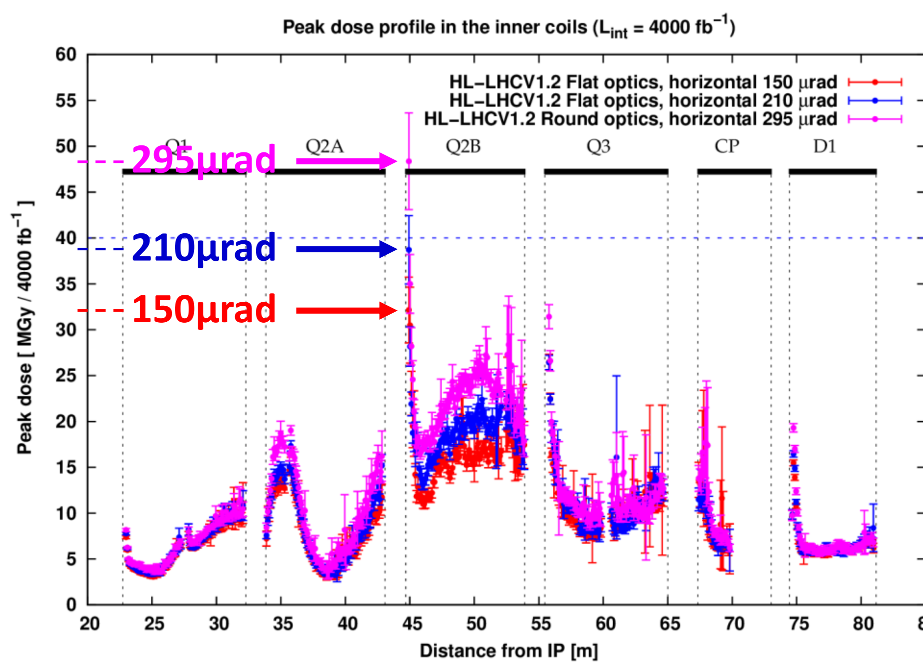
FLAT OPTICS BENEFITS

- Two flat optics scenarios were also studied for both vertical and horizontal crossing
  - 150μrad half-crossing angle, β^*_x / β^*_y = 40 / 10 cm
  - 210μrad half-crossing angle, β^*_x / β^*_y = 40 / 10 cm
- Sensitivity of results to changes in bunch length and beam divergence is limited
- On the contrary, the crossing angle plays an important role
  - Lower dose for lower crossing angle

Vertical crossing



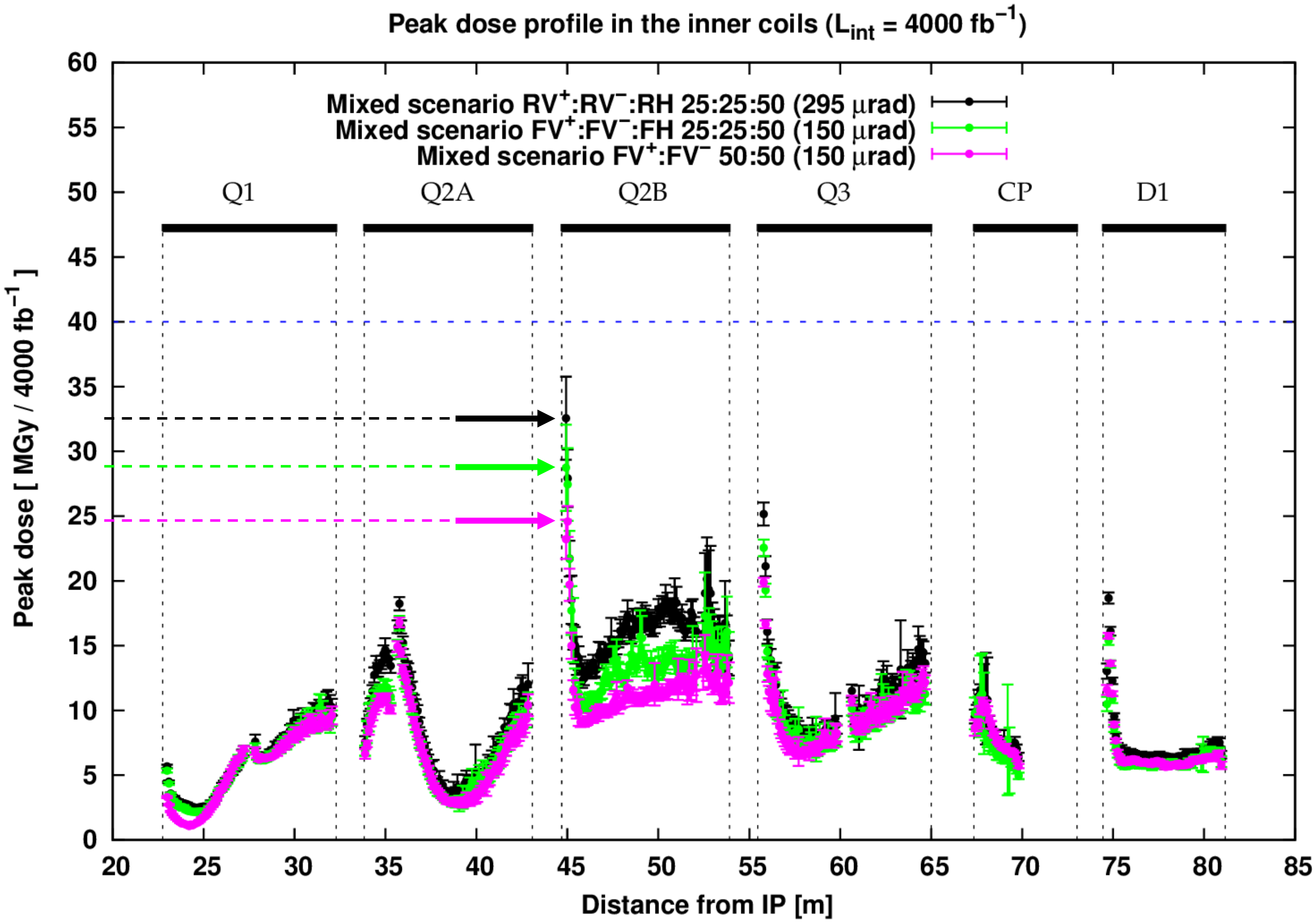
Horizontal crossing



PEAK DOSE MINIMISATION SCENARIOS

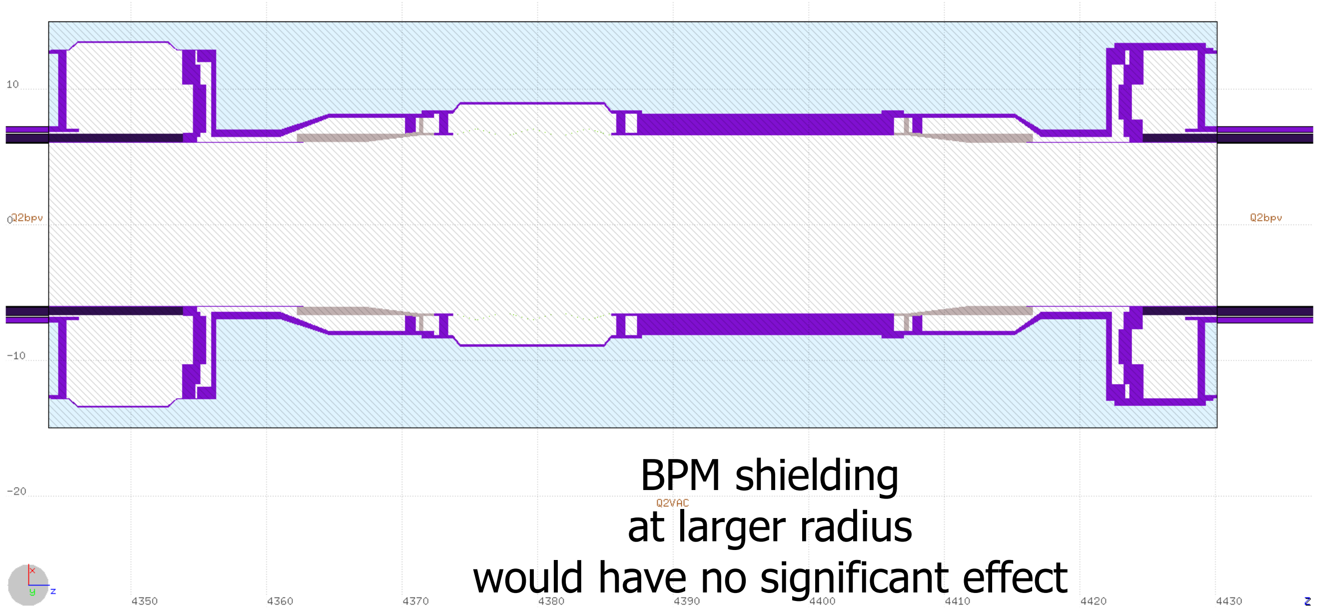
with S. Fartoukh (BE-ABP)

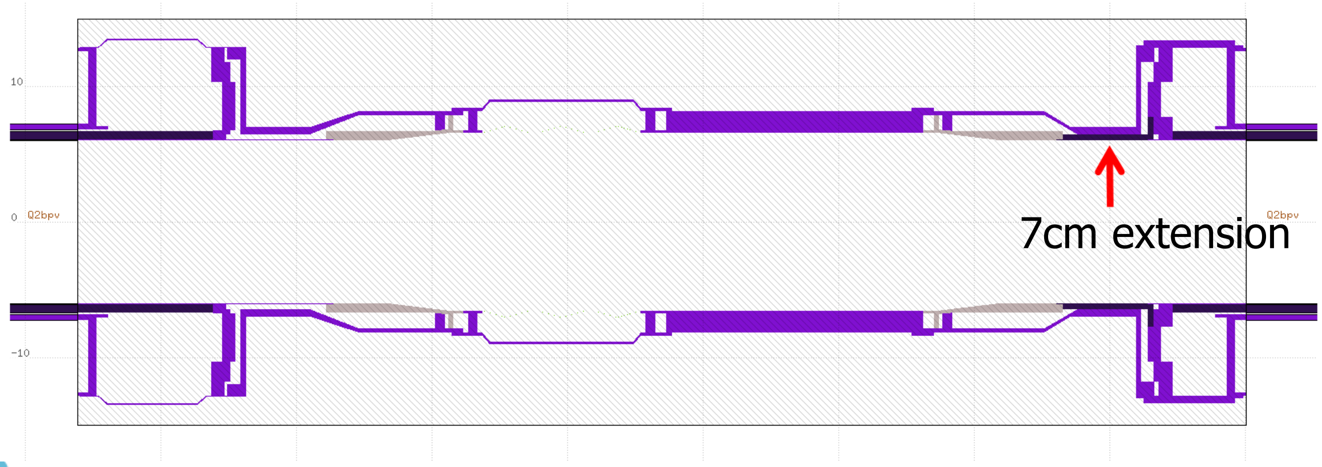
- Regular vertical crossing angle polarity inversion in IR1, as endorsed for the present LHC, is not a solution: 50 MGy are left in IR5 with horizontal crossing
- Allowing for regular crossing plane exchange or even same crossing plane in both IRs:



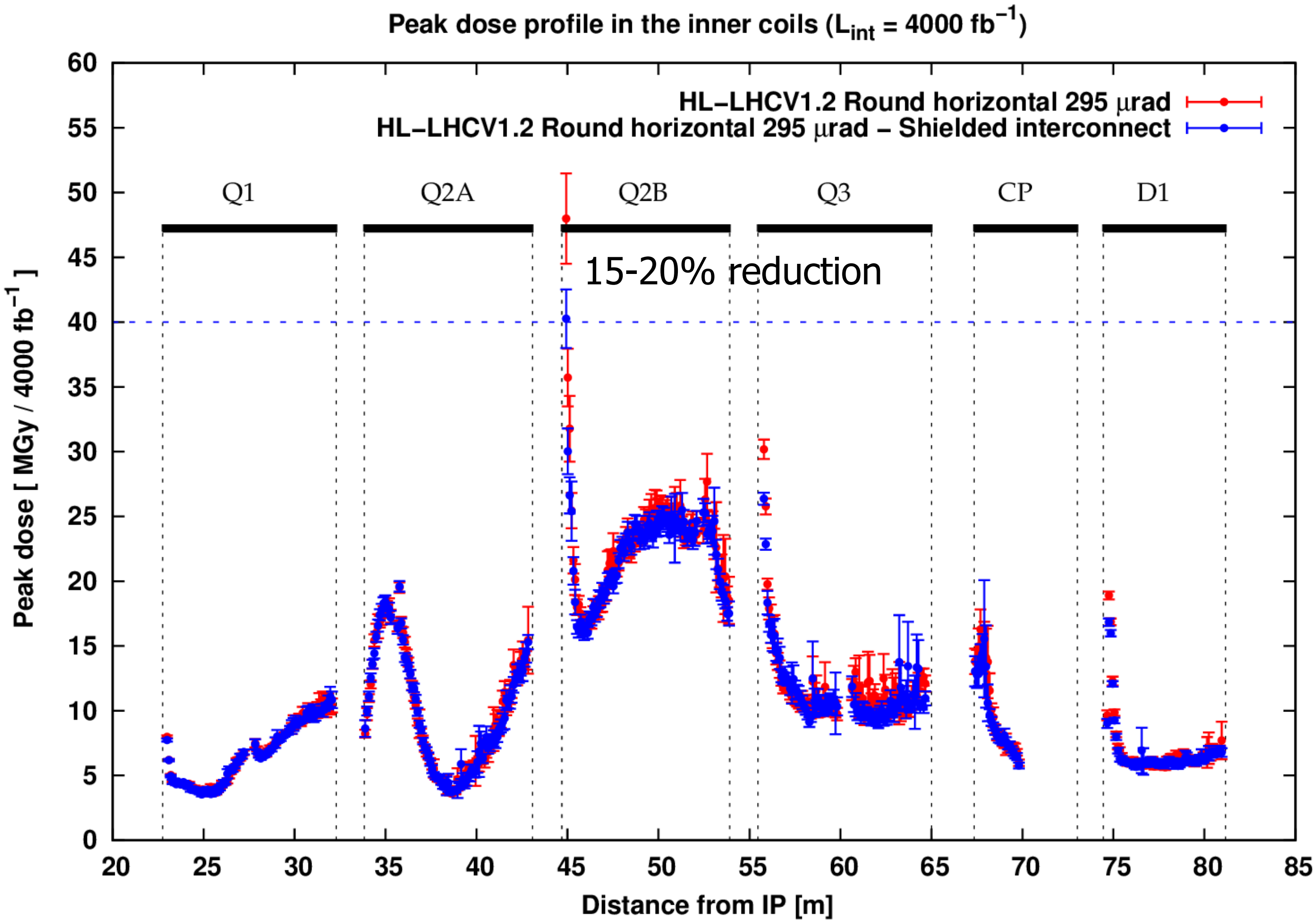
IC SHIELDING IMPROVEMENT

with R. Fernandez-Gomez, C. Garion, R. Kersevan (TE-VSC)





A GOOD GAIN



Peak dose profile in the inner coils (L_{int} = 4000 fb^{-1})
HL−LHCV1.2 Round horizontal 295 μrad
HL−LHCV1.2 Round horizontal 295 μrad − Shielded interconnect
Q1
Q2A
Q2B
Q3
CP
D1
15-20% reduction
Peak dose [MGy / 4000 fb^{-1}]
Distance from IP [m]
0
5
10
15
20
25
30
35
40
45
50
55
60
20
25
30
35
40
45
50
55
60
65
70
75
80
85

SHIELDING DEGRADATION?

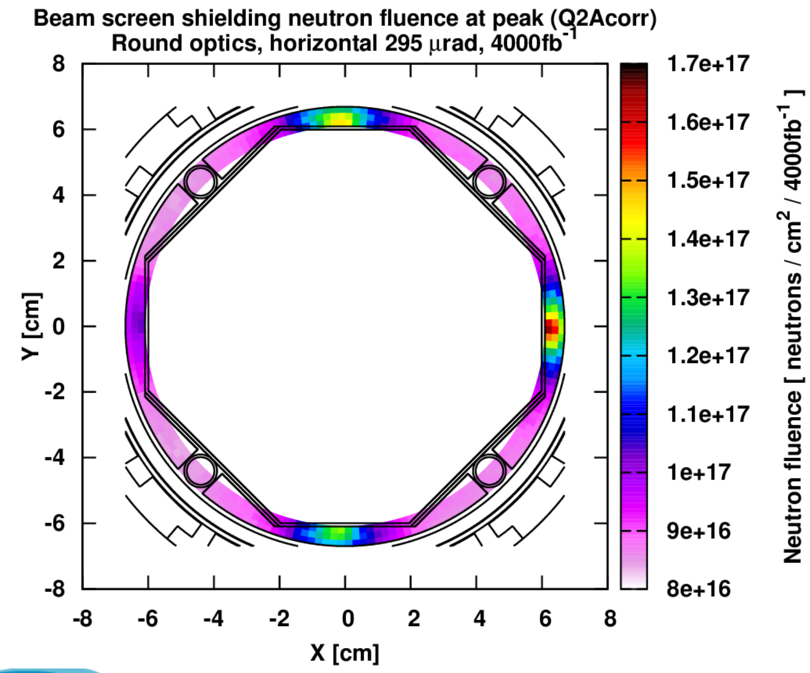
with C. Garion, M. Morrone (TE-VSC), M. Calviani (EN-STI)

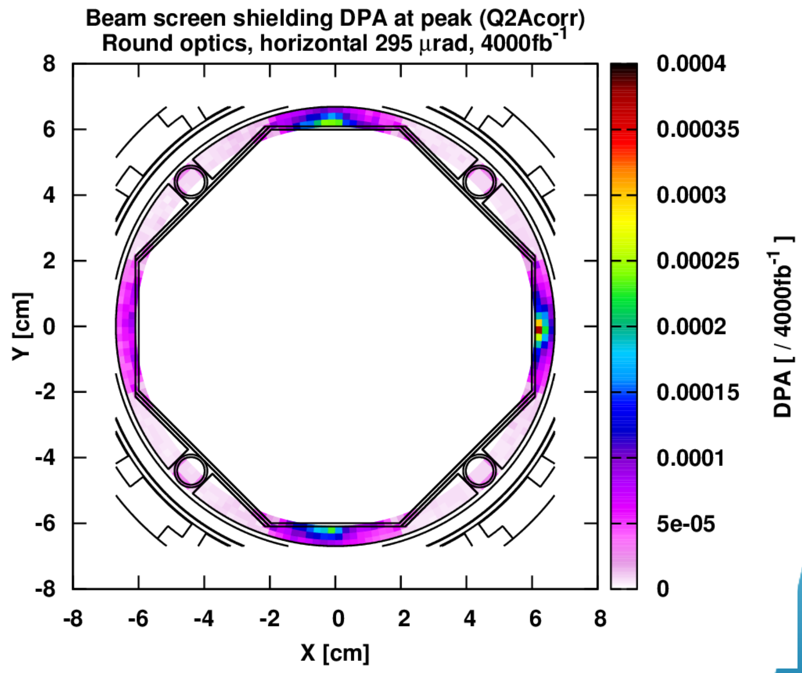
In the tungsten absorbers,

a neutron fluence of 10^{17}cm^{-2} and a DPA value of 10^{-4} are reached over 4ab^{-1}.

H and He gas production is of the order of 0.01-0.1 ppm.

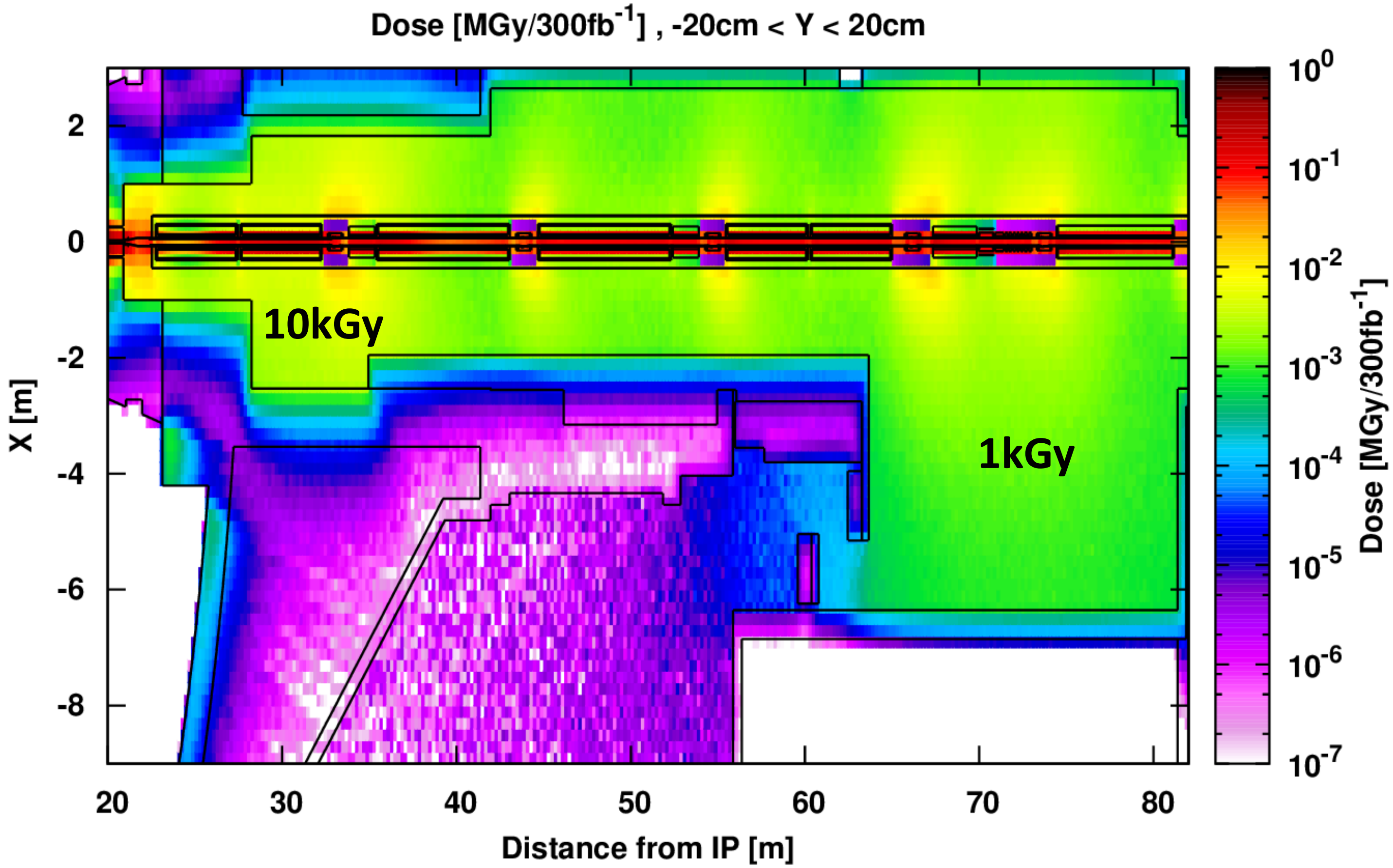
This is not expected to induce a significant alteration of relevant material properties.





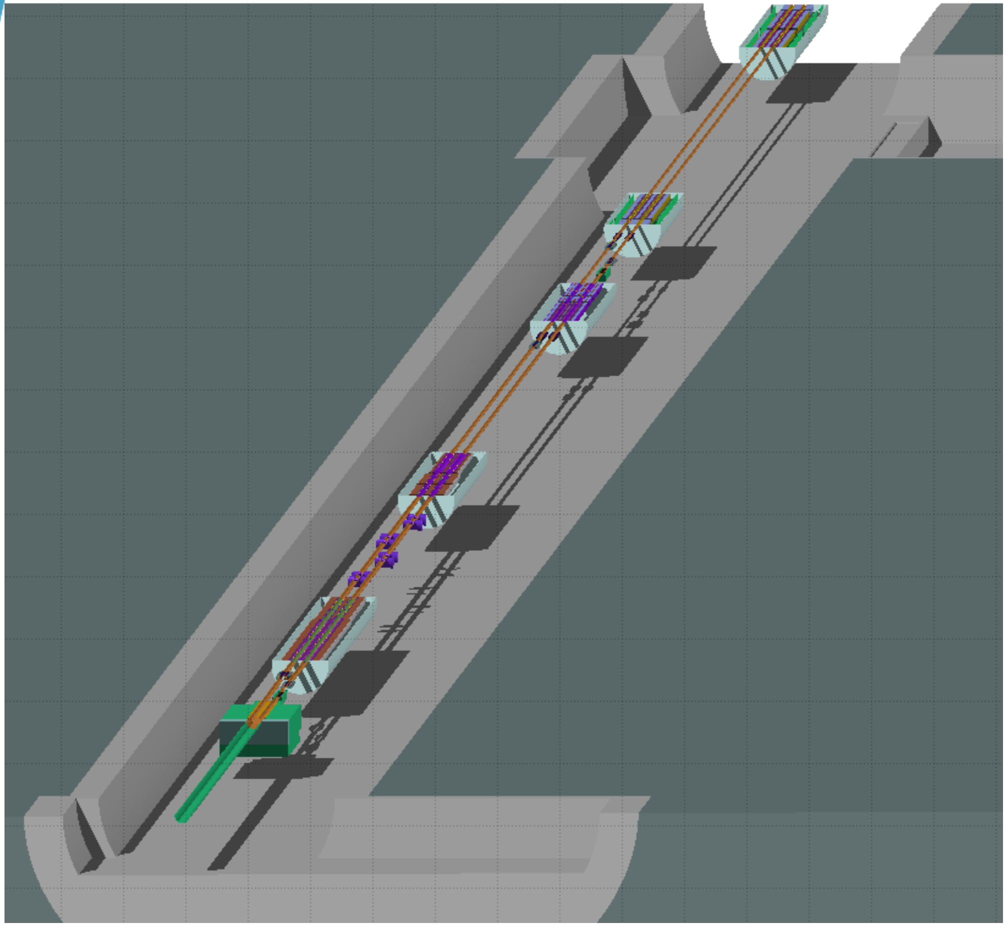
ANNUAL DOSE IN THE TUNNEL

- Relevant for vacuum and survey equipment, cabling etc.



- Averaged over ±20cm from the beam height
- ~1kGy in the tunnel, except in the TAS-Q1 region
- a few tens of kGy at the interconnects

(IR5) MATCHING SECTION



All collimators in place:

- TCLX.4R5.B1
- TCL.5R5.B1/6R5.B1
- **TCTP.4R5.B2 (V&H)**
- TCT.6R5.B2 (V&H)
- no tank for the horizontal ones (missing space)
- Settings (R. Bruce):
  - TCLs @ 12σ
  - TCTs @ 10.9σ

Q5 and Q6 masks

TAXN

- 85mm ID aperture and 3.33m length

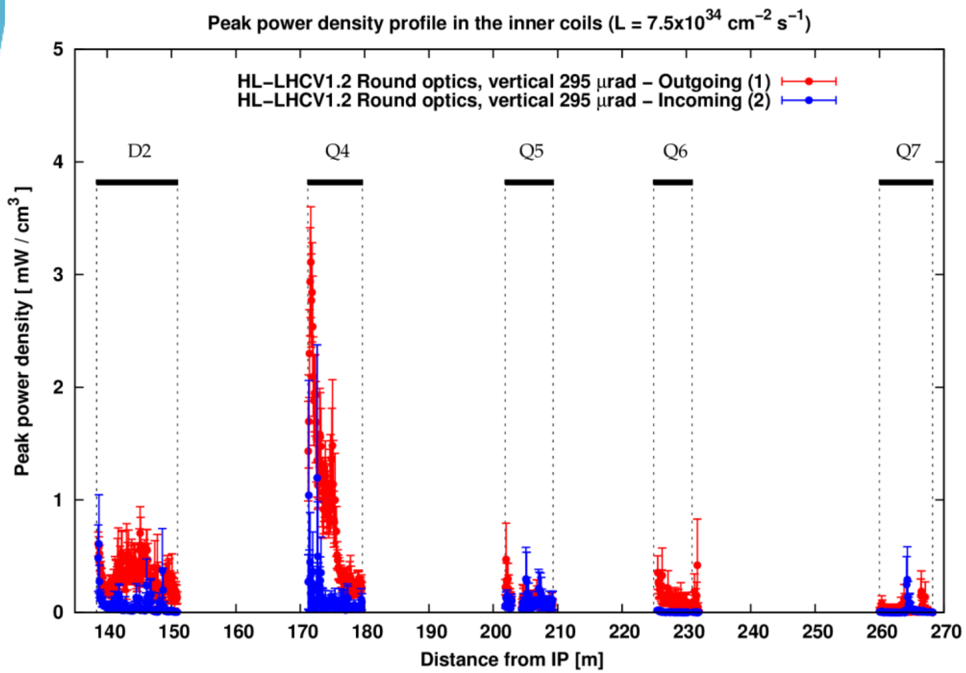
DEPOSITED POWER @ 7.5L_0

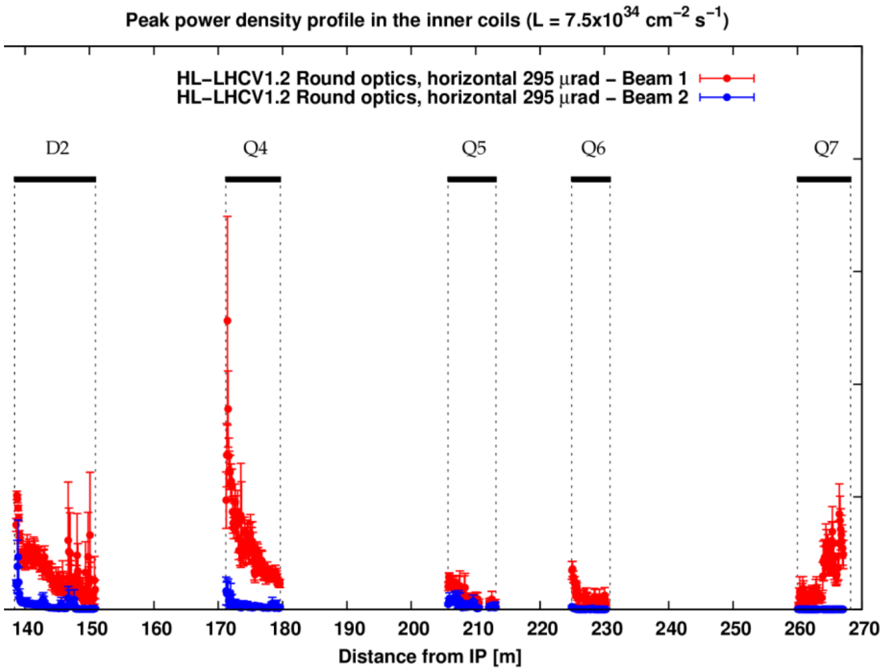
	Round vertical		Round horizontal	
	Magnet cold mass	Beam screen (b1/b2)	Magnet cold mass	Beam screen (b1/b2)
Magnet	Power [W]			
D2	24	1.3 / 0.1	50	2.5 / 0.1
D2c H	1.8	0.2 / 0.005	2.2	0.2 / 0.005
D2c V	1.6	0.2 / 0.005	1.4	0.2 / 0.004
Q4 H	10	1.4 / 0.06	11	1.3 / 0.03
Q4c V	5.4	0.6 / 0.07	4.6	0.8 / 0.03
Q4c	7.3	0.8 / 0.1	10	1.4 / 0.1
Q5 + 3 Q5c	8.5			
Q6 + Q6c	3			

- Larger leakage from TAXN for horizontal crossing
- Crab cavities: 140-170 mW (b1), ~35-45mW (b2) but significant dependence on the upstream vacuum chamber profile details, not yet defined

COIL PEAK POWER DENSITY @ 7.5L_0

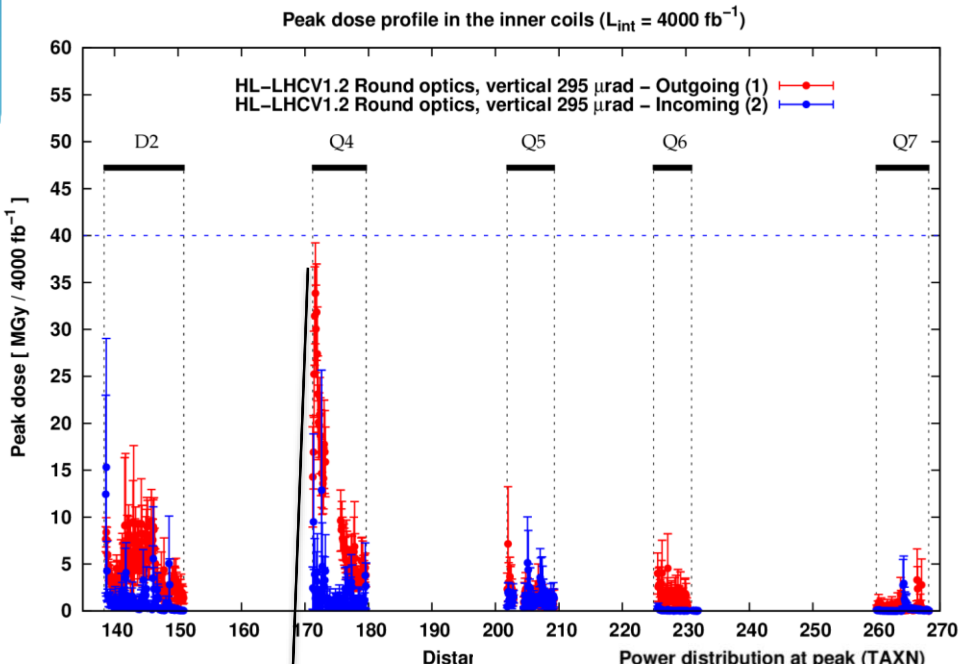
Vertical crossing | **Horizontal crossing**



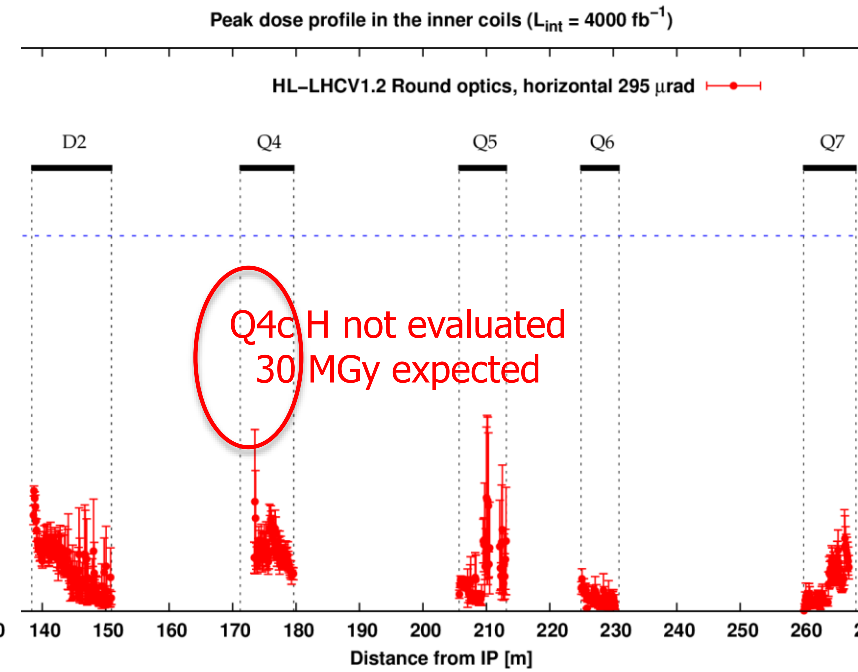


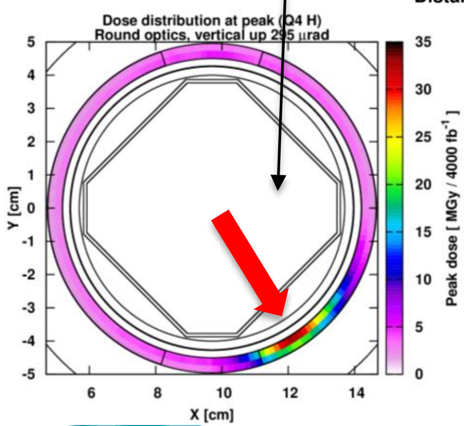
COIL PEAK DOSE FOR 4ab^{-1}

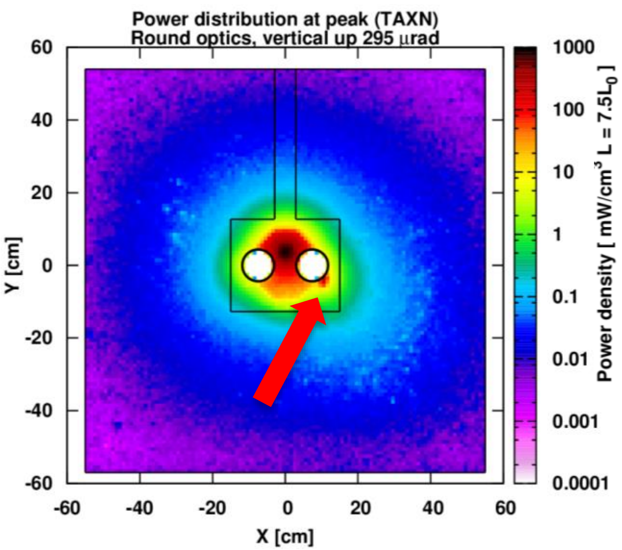
Vertical crossing



Horizontal crossing

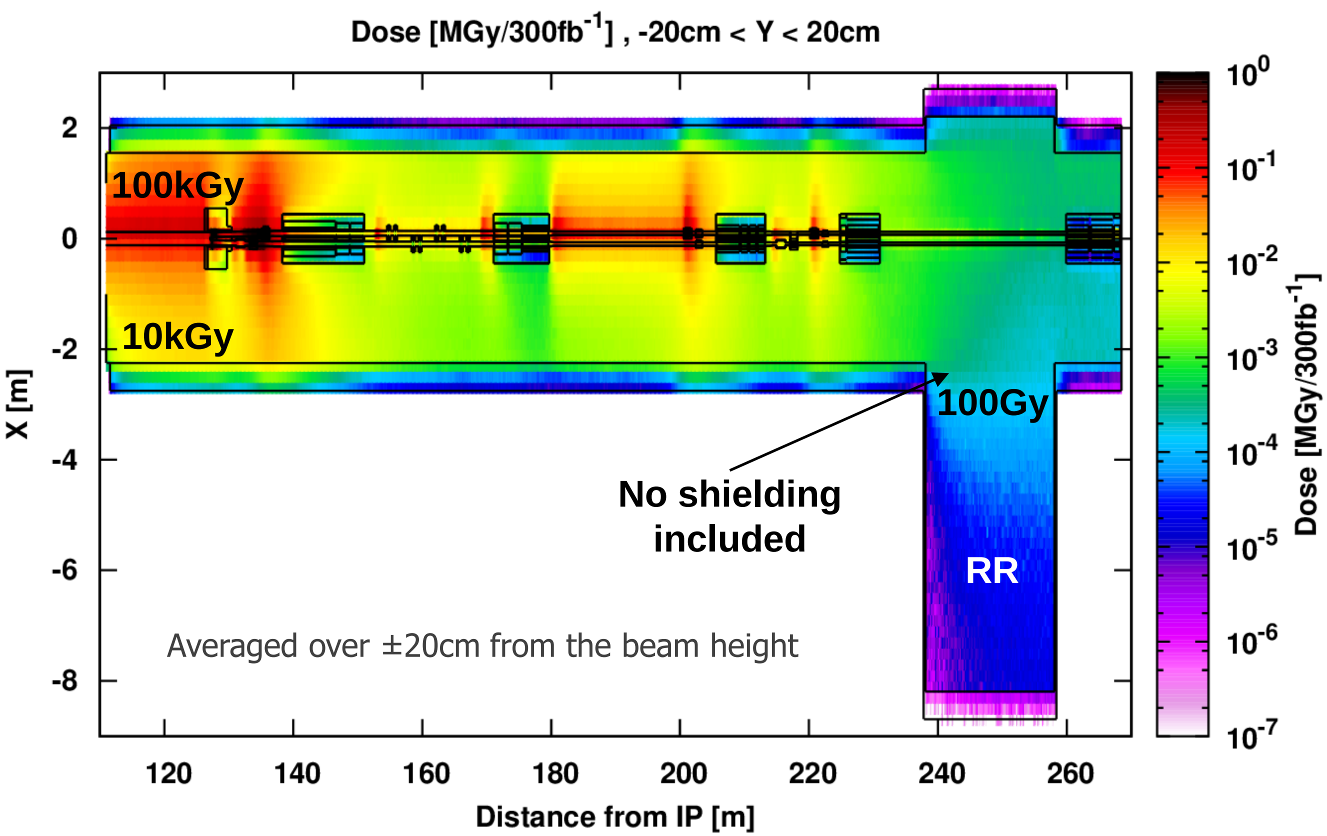






The *envisaged Q4 corrector aperture of 105mm* (here 90mm) would cure this hot spot allowing in addition to prevent its displacement to the Q4 front face by filling the 90-105mm aperture gap

ANNUAL DOSE IN THE TUNNEL



CONCLUSIONS

A consistent picture of the collision debris impact up to Q7 has been given for V1.2.

The shielding extension in [on the non-IP side of] the interconnections is recommended, while a BPM design embedding absorbers at a larger distance from the axis is not worthwhile.

Dose mitigation could be provided by optics flexibility (flat i.e. crossing angle reduction, crossing plane exchange, polarity inversion, unique crossing plane).

A coil aperture of 105mm for Q4 correctors is helpful, implying to use the aperture gap for Q4 shielding.

Possible removal of TCT4 (which are there for other purposes, namely triplet/experiment protection from incoming beam losses) has to be evaluated with respect to the implied internal bore exposure to TAXN leakage.