Energy deposition for HL-LHC v1.5: TAXN aperture study

Marta Sabaté-Gilarte, Francesco Cerutti

WP10

Energy deposition & R2E

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CONTEXT

Point 1 for HL-LHC machine

Horizontal crossing of 250 μrad

HL-LHC optics version 1.5 (end of May 2019)

Region of interest from Q1 to Q4

Mention to version 1.3 only for comparison reasons

OUTLINE

Updates in the layout since v1.3

Impact in the triplet+D1 region, and in the TAXN-Q4 region

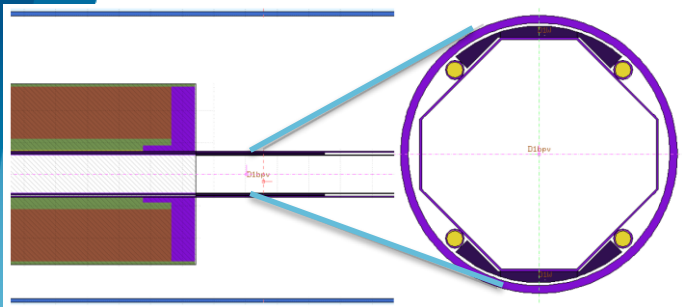
TAXN aperture considerations (85 vs 80 mm) for HL-LHC optics v1.5

Problem of the Dose to the Q4 MCBY correctors

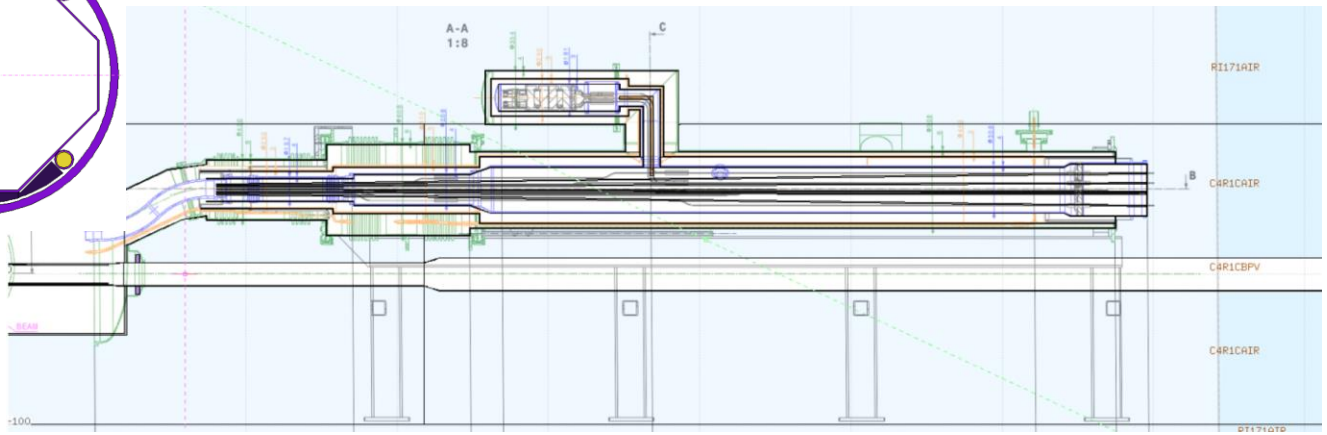
- **Updates in the layout since v1.3**

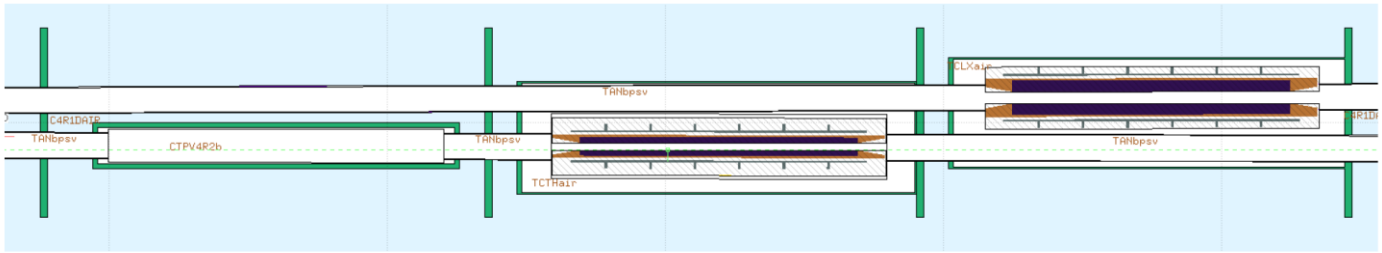
Updates in the layout since v1.3 for HL-LHC

- Focus on Horizontal Crossing: IP1 for v1.5.
- Revision of the **vacuum layout from TAXS to Q7**:
  - Additional modifications are expected at the end of D2 and from Q5 to Q7.
- Update on the triplet-D1 **IC** model.
- Inclusion of **end covers** of the thermal shield in the triplet+D1 and D2 cryostats.
- Update of the **CP** magnetic and mechanical lengths.
- **D1 beam screen**:
  - Prolongation of the beam screen: modification of the inermet shielding and the horizontal aperture.
- Inclusion in the geometry of the **Cold Diode at the end of D1**.
- Increase **TAXN beam separation** from 148mm-158mm to 151mm-161mm.
- Implementation of the full model of the **Crab Cavities Cryomodule.**
- **TCLM-masks on Beam2** before Q4 tentatively removed.



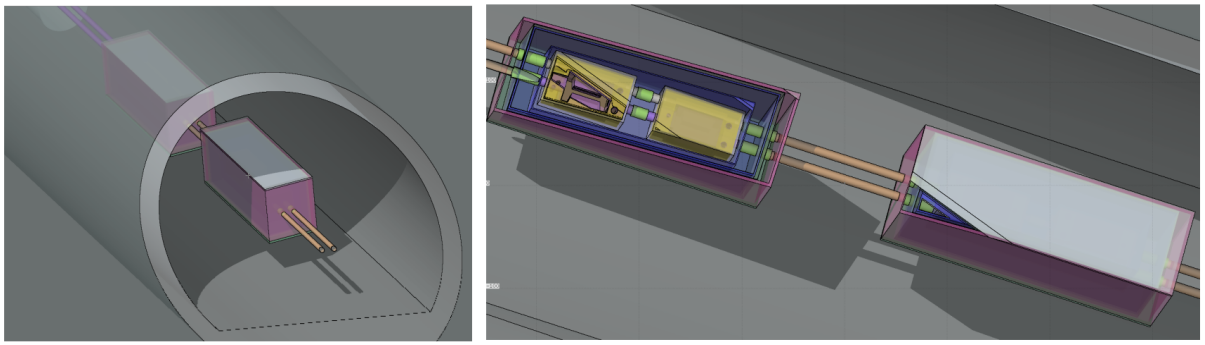
D1 beam screen extension and cold diode





FLUKA model of the collimators region between TAXN and D2.

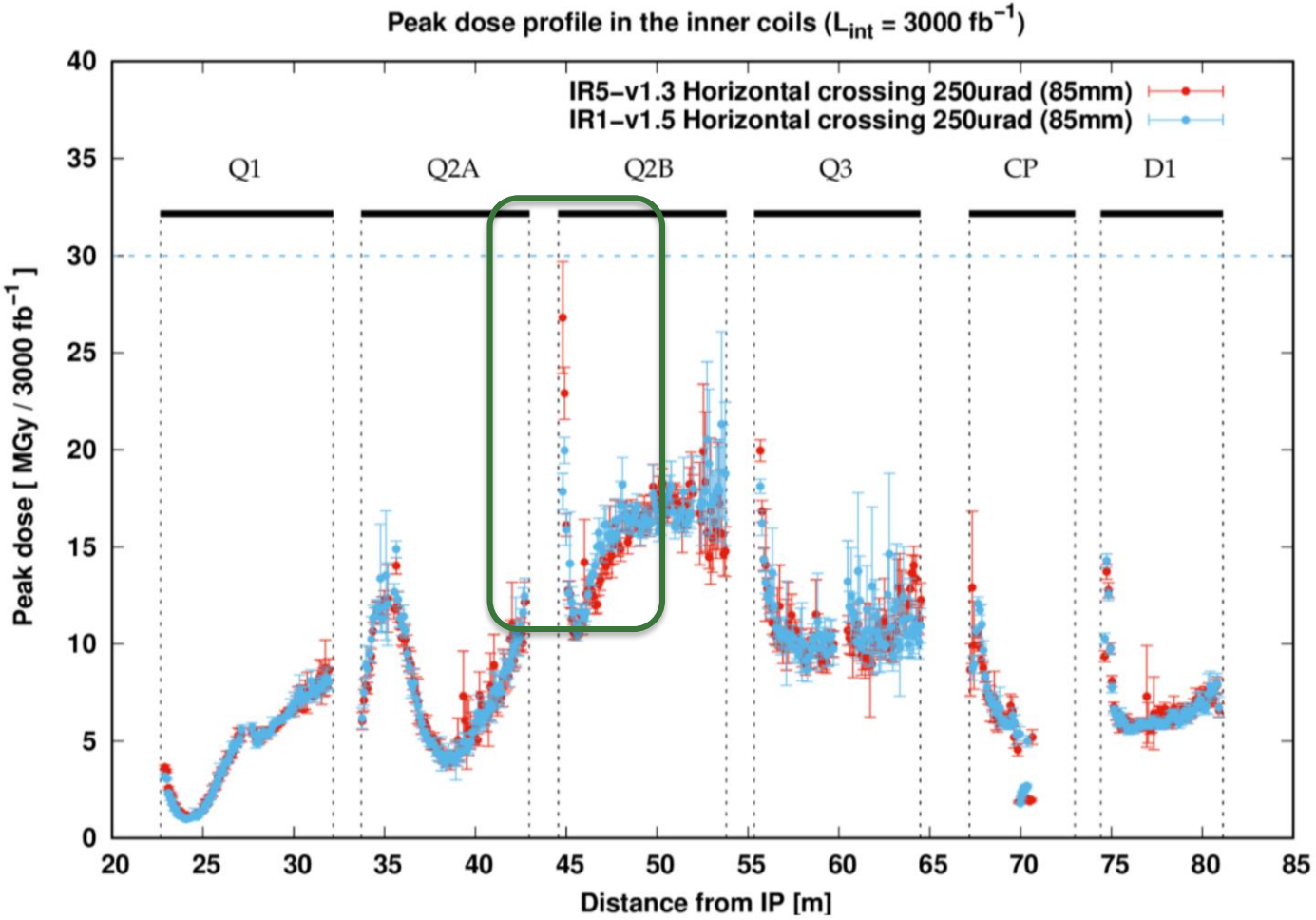
Tanks added



FLUKA prototype for the full crab cavities in the tunnel.

- **Impact in the triplet+D1 region**

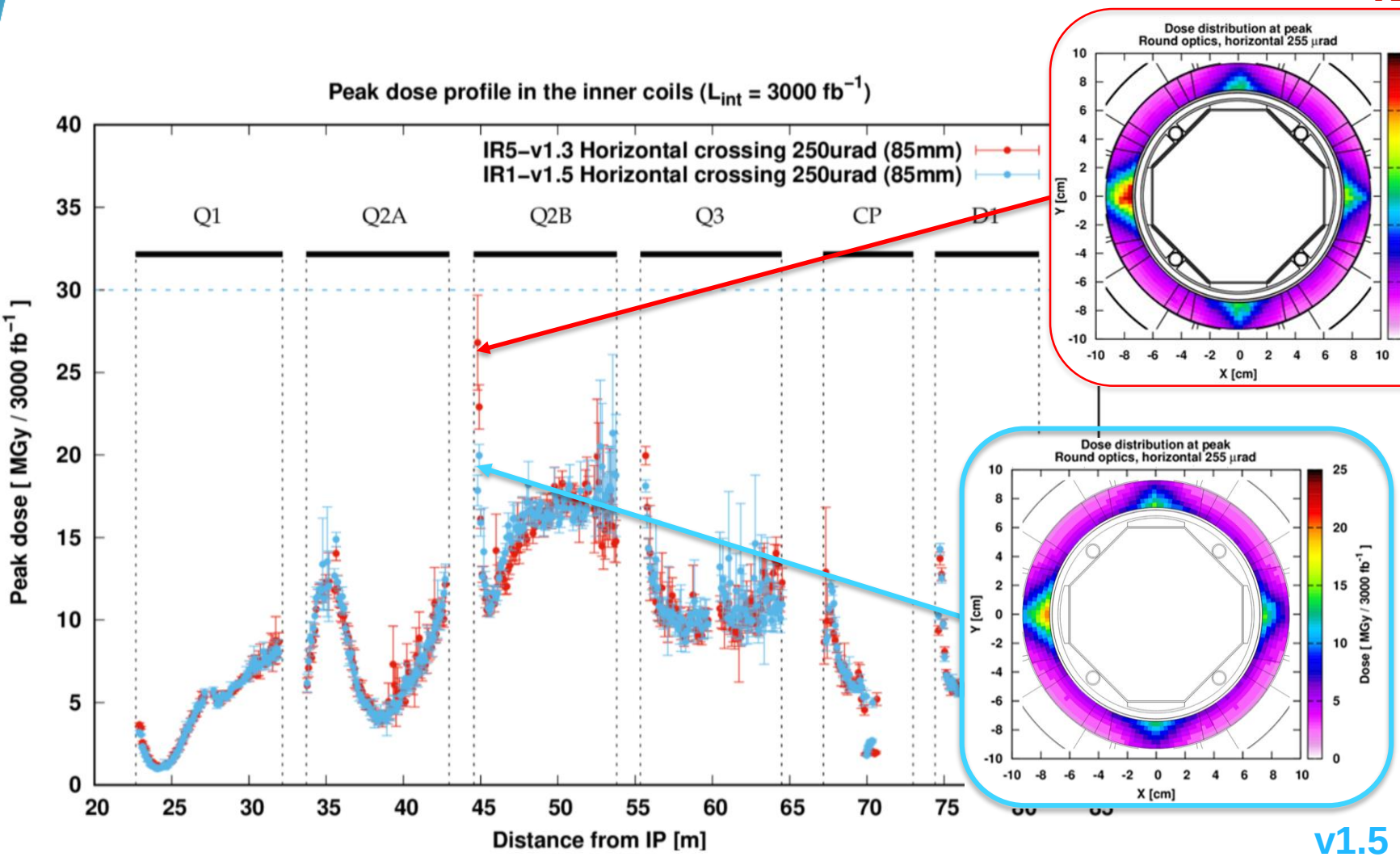
Impact in the triplet+D1 region



v1.3 Horizontal crossing in IP5

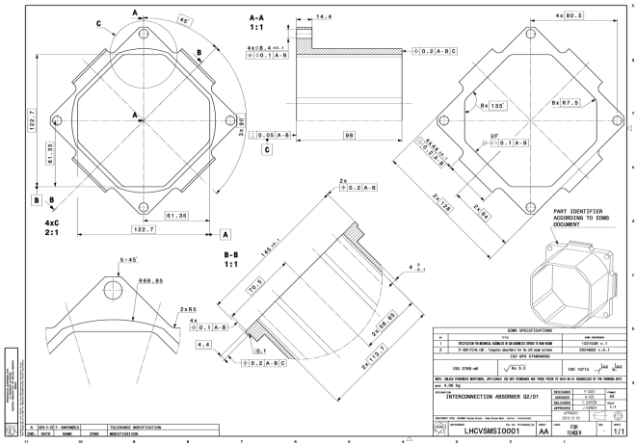
v1.5 Horizontal crossing in IP1

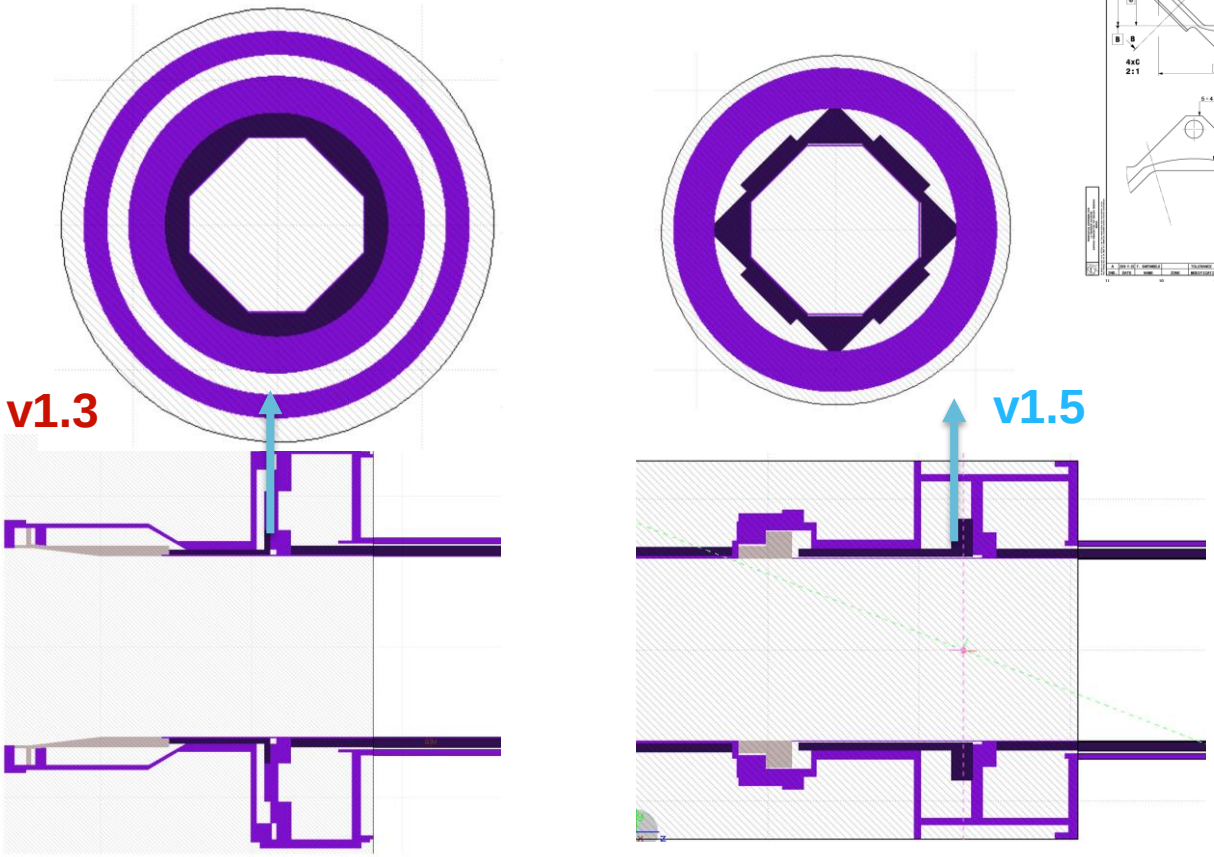
Impact in the triplet+D1 region



The reason behind

- The 11.5cm inermet block on the non-IP side of the IC is as follow:





- **Impact in the TAXN-Q4 region**

v1.3 vs. v1.5: Total Power from TAXN to the Q4

	v1.3	v1.5
TAXN	819	929
D2	30.9	22.5
D2 H corr.	1.32	1.08
D2 V corr.	0.95	0.98
Q4 corr.	5.06	4.04
Q4	3.1	3.4
TCLX4-int	155.6	151.0
TCLX4-ext	88.5	104.9

Beam separation:

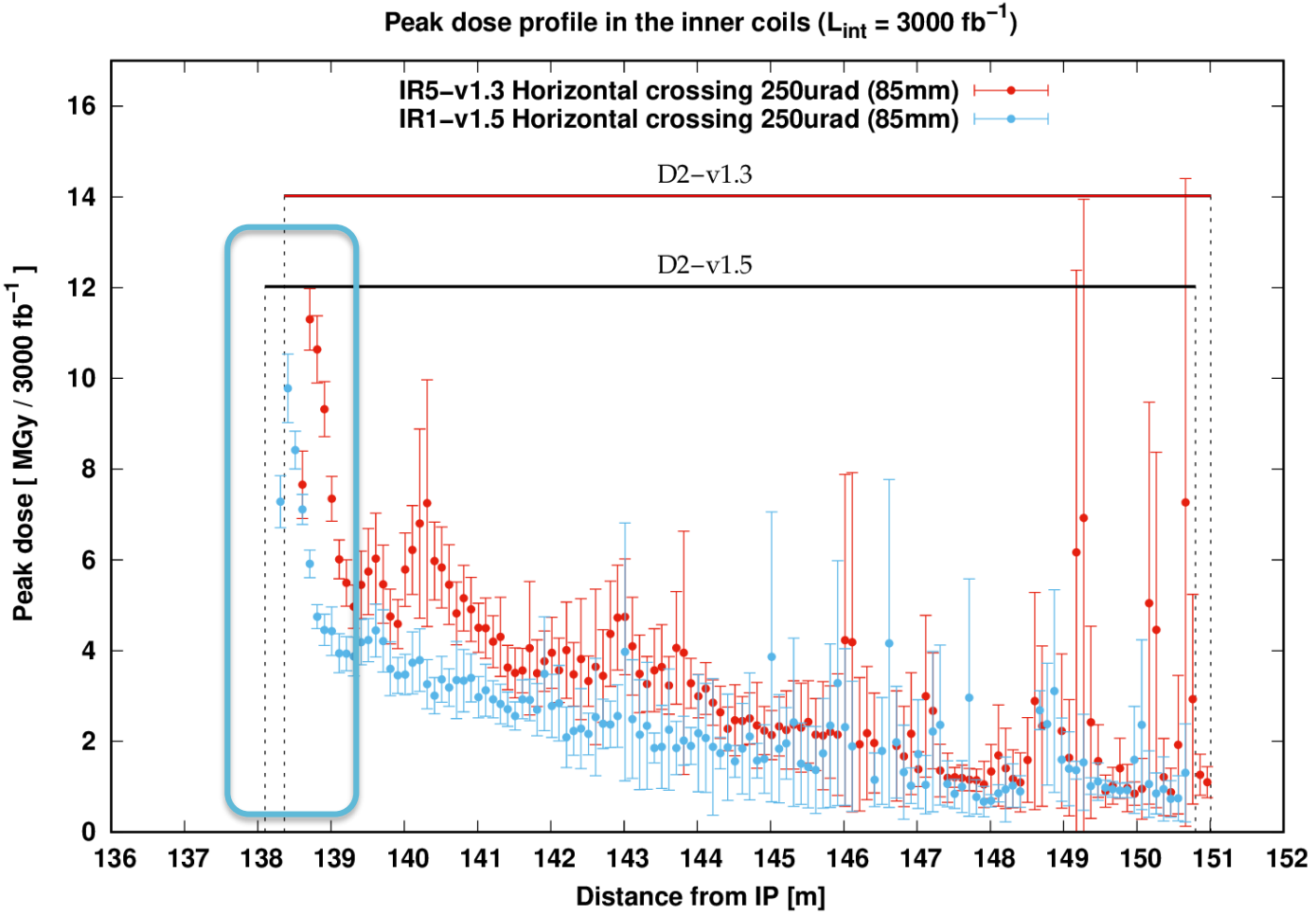
148mm-158mm (v1.3)

151mm-161mm (v1.5)

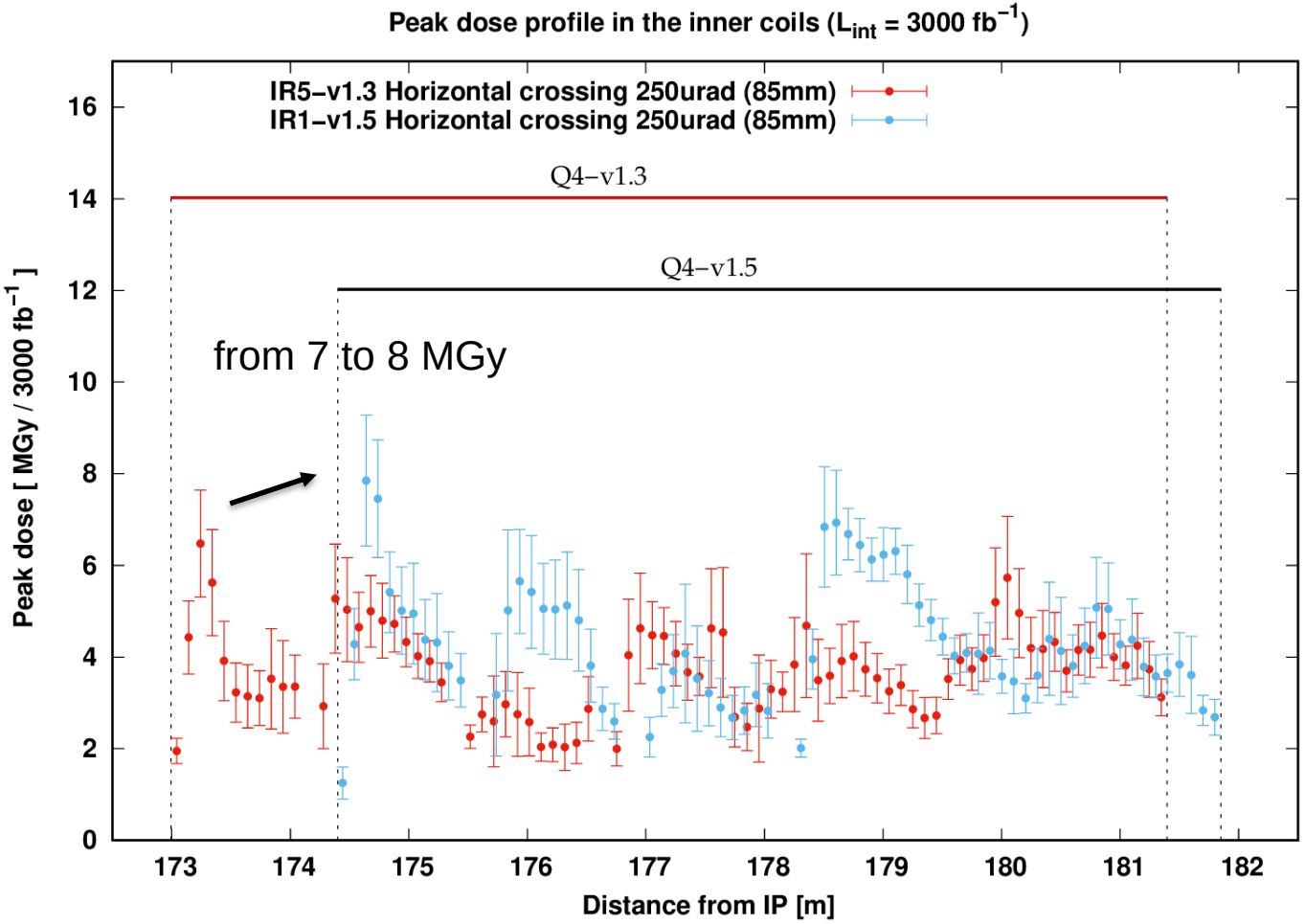
Power in W $L_{int}=5\cdot10^{34}$ (cm^{-2} s^{-1}) and σ(p-p collision) = 85 (mb)

v1.3 vs. v1.5: Impact in D2

15% reduction (from 11.5 to 10 MGy)

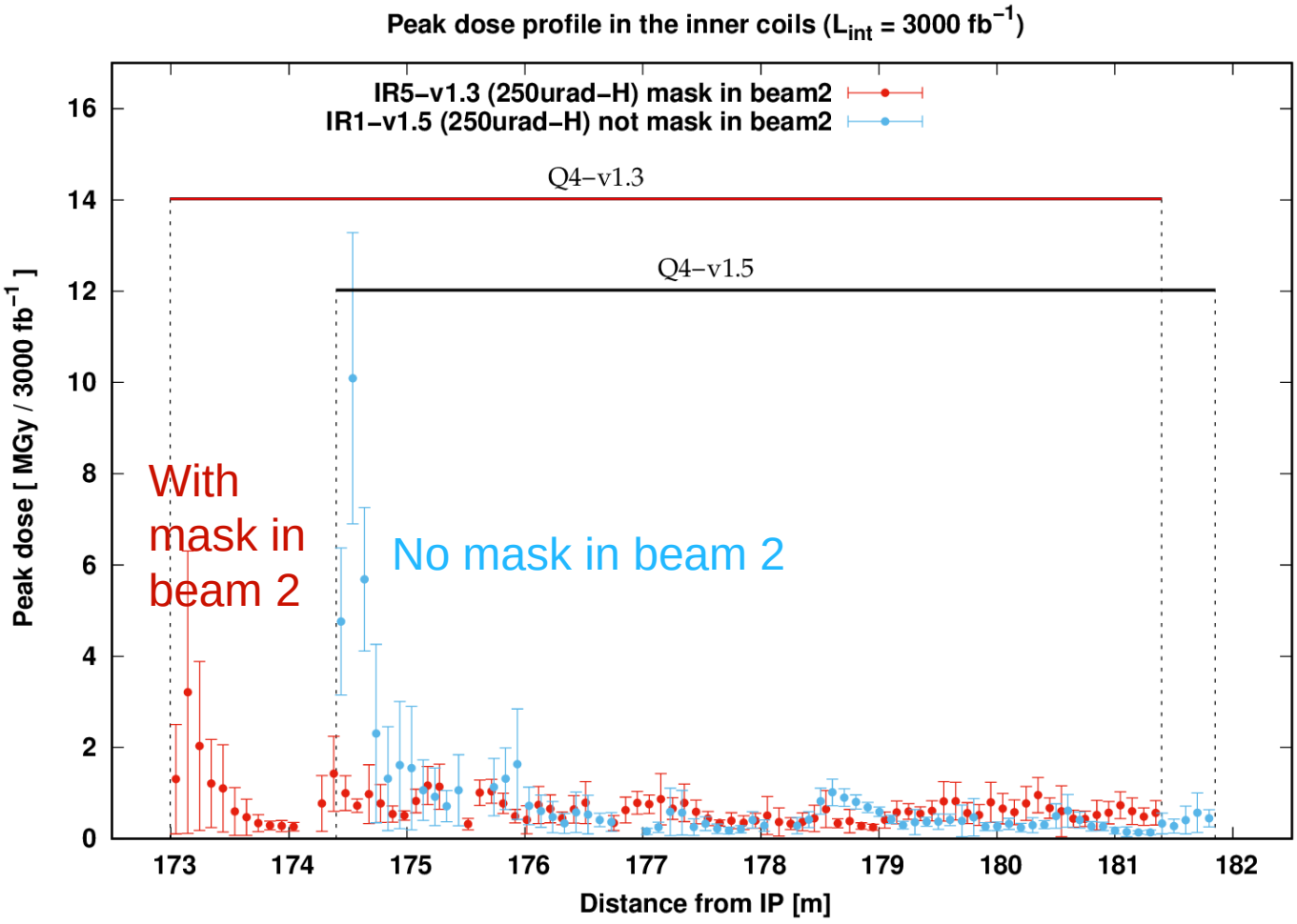


v1.3 vs. v1.5: Effect on Q4



Note:
4-corr. in v1.3
vs.
3-corr. in v1.5

Importance of the TCLM4-masks on B2



Indication of an important increment in the IP-side of the first MCBY

- **TAXN aperture considerations (85 vs 80 mm) for HL-LHC optics v1.5**

TAXN aperture considerations for HL-LHCv1.5

- Twin apertures of the Y-chamber of the TAXN: 85mm as reference.
- Study the impact on the D2 and Q4 when reducing the TAXN aperture down to 80mm.
- The vacuum layout between TAXN and D2 depends on the TAXN twin aperture: ID=90mm in case of 85mm or ID=80mm in case of 80mm. Except in the collimators and the sector valve.

Any benefit?

TAXN aperture considerations for HL-LHCv1.5

Total power

	85mm v1.5	80mm v1.5
TAXN	929	997
D2	22.5	20.5
D2 H corr.	1.1	0.7
D2 V corr.	1.0	0.7
Q4 corr.	4.0	4.2
Q4	3.4	3.7
TCLX4-int	151.0	97.2
TCLX4-ext	104.9	89.2

Aperture reduction (v1.5):

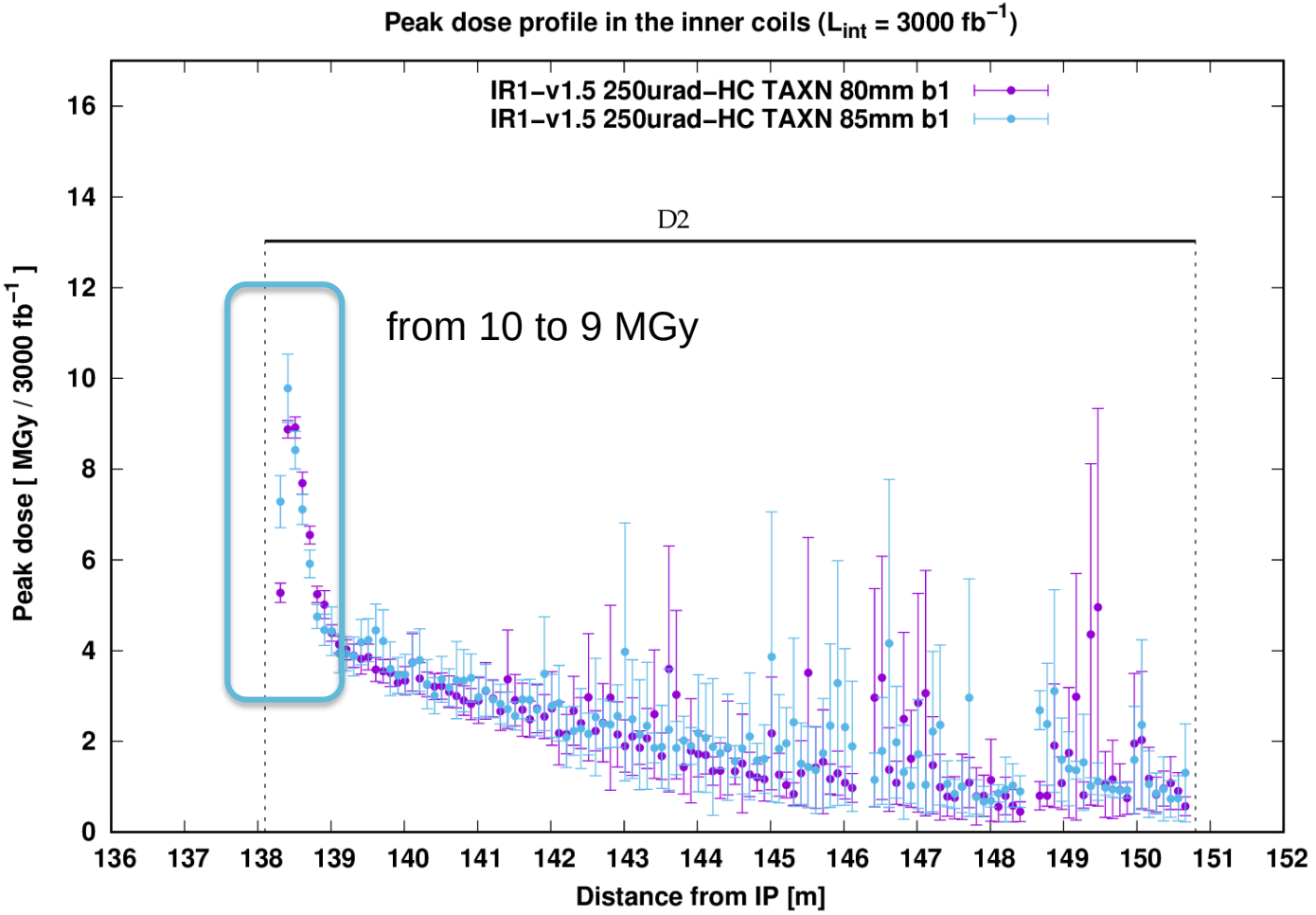
ID=90mm for 85mm

ID=80mm for 80mm

Power in W $L_{int}=5\cdot10^{34}$ (cm^{-2} s^{-1}) and σ(p-p collision) = 85 (mb)

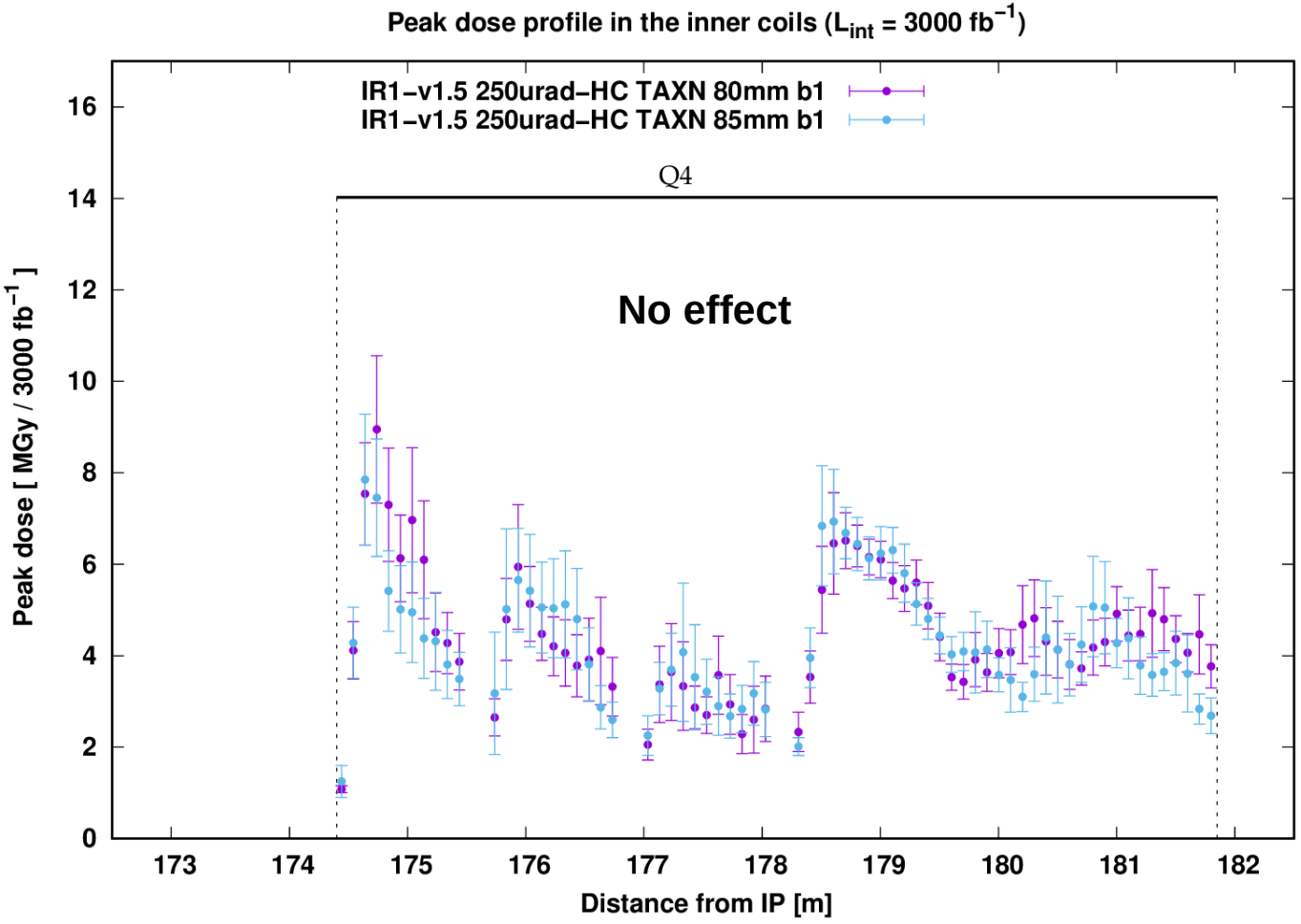
TAXN aperture considerations for HL-LHCv1.5

Dose to the D2



TAXN aperture considerations for HL-LHCv1.5

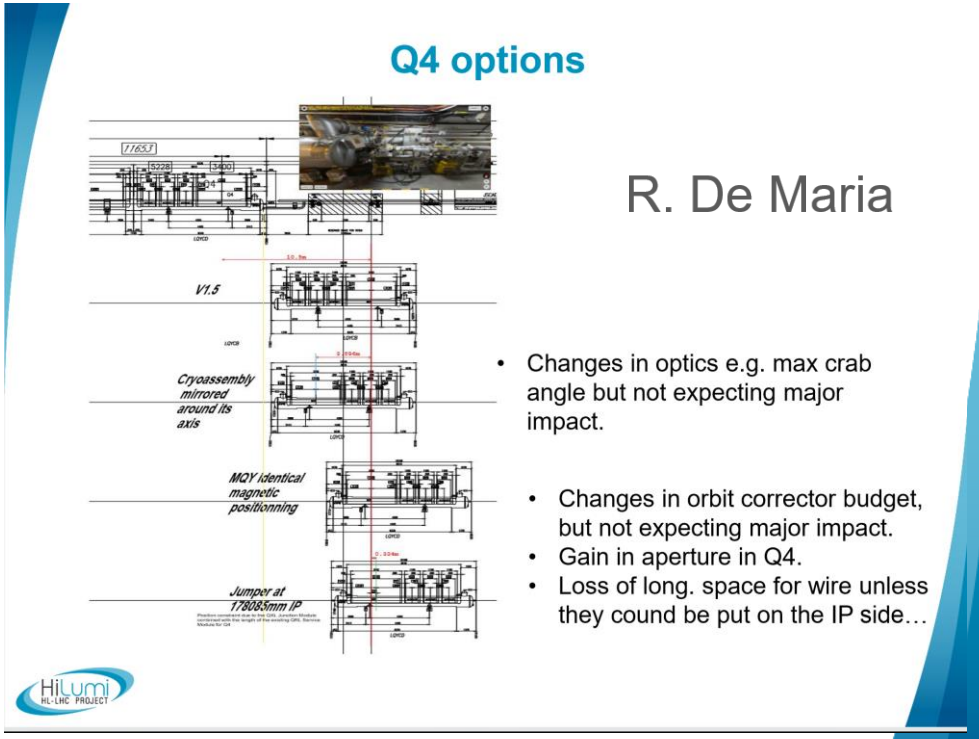
Dose to the Q4 assembly



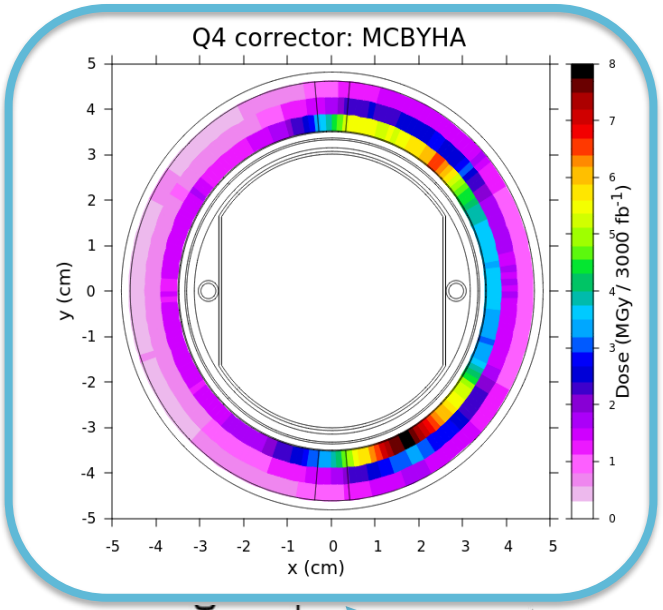
- **Problem of the Dose to the Q4-correctors**

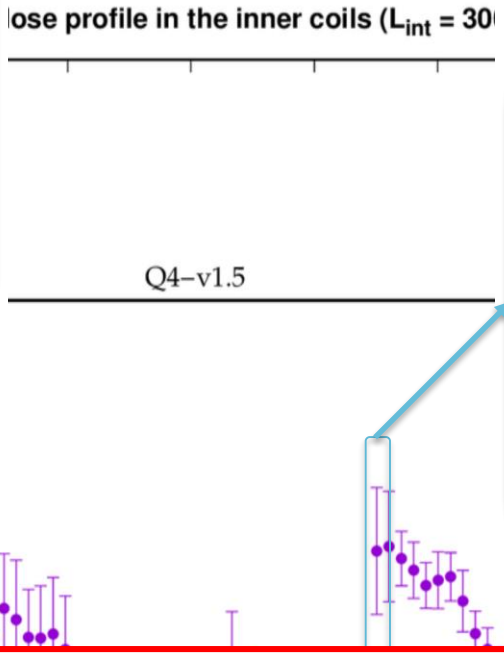
Problem of the Dose to the Q4-correctors

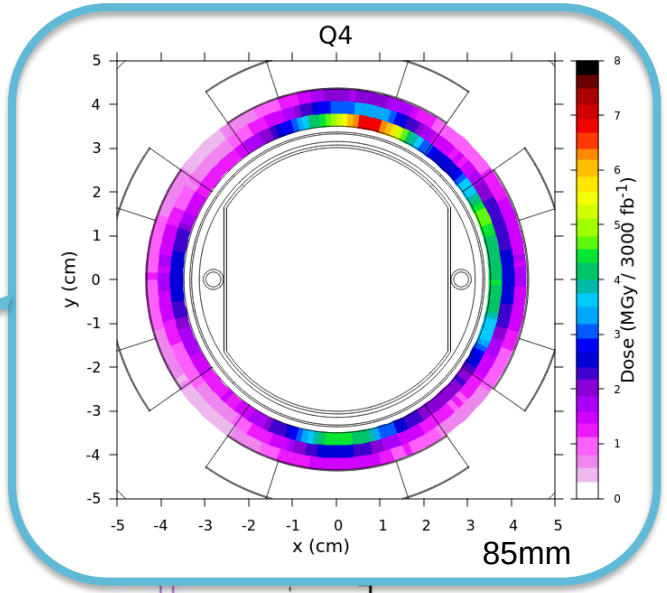
- The proposed rotation of the Q4 cryostat could help to protect the MCBYs in a limited way:
  - Q4 (MQY) identical magnetic position BUT the drift before the cryostat will increase its length → the expected dose at the from face of Q4 may be higher than 8 MGy.
  - The Q4-corr. (MCBYs) will be more protected BUT the dose could not go below 2 MGy.



ıe Dose to the Q4-correctors







In order to grant a major reduction of the MCBY corrector dose, an internal shielding should be considered, although sacrificing a fraction of the 70 mm coil aperture.

Distance from IP [m]

85mm

Summary and Conclusions

Summary and Conclusions (I)

v1.5 impact in the triplet+D1 region and in the TAXN-Q4 region

- The inclusion of the most updated model of the interconnect in the triplet+D1 region shows an improvement in the dose, especially at the entrance of Q2B, where a reduction of the maximum value from 26 to 20 MGy was obtained.
  (With the total power in the cold mass and beam screen remaining unchanged).

- The increase of the beam separation in the TAXN for v1.5 with respect to v1.3 entails a rise in the total power taken by the TAXN (110 W more) together with a reduction of the D2 load (max dose down to 10 MGy and 25% less power).

- Indication for the need of the TCLM4-mask on beam 2, to limit the respective dose on the front face of the first MCBY.

Summary and Conclusions (II)

TAXN aperture reduction study for HL-LHCv1.5 from 85mm to 80mm:

- With a 80 mm twin aperture, the total power in the TAXN increases by ~70 W, which are removed from the TCLX4 jaws.
- Minor beneficial effect on D2: the max dose at the IP-side is reduced by 10% and the total power (~20 W at nominal HL lumi) decreases by 10%.
- No effect on Q4 and its MCBYs.

Problem of the Dose to the Q4-correctors

- Evidence of the fact that all along the Q4 assembly the peak dose in the coils remains above 2 MGy. Therefore, the rotation of the Q4-cryostat could help only to a rather limited extent.
- To significantly change the picture, one needs internal shielding.