IT orbit corrector preferable orientation and TAXN aperture

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WP10

Energy deposition & R2E

78th HL-LHC TCC Meeting CERN 4th July 2019

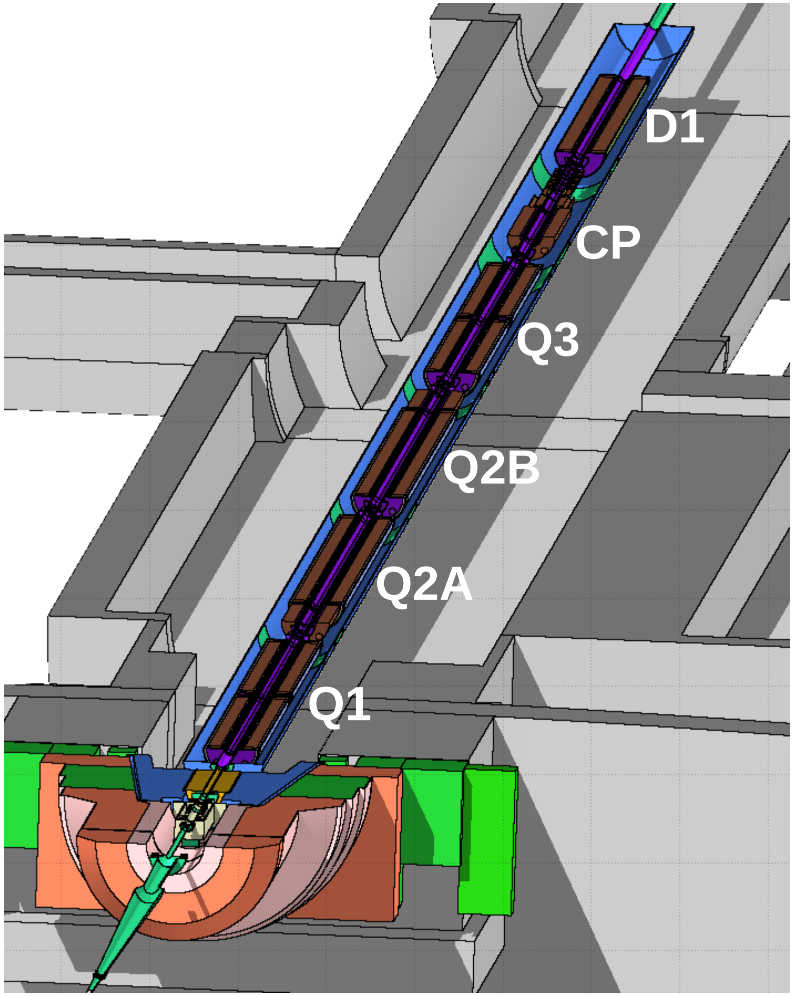
Outline

- IT orbit corrector preference orientation:
  - Exposure of the coils, including the return coils, for vertical and horizontal crossing.
- TAXN aperture:
  - Updates from HL-LHC optics v1.3 to v1.5 in the FLUKA layout.
  - Study the effect of reducing the TAXN twin aperture from 85 to 80 mm.
  - Impact on the matching section from D2 to Q4.

IT: Inner triplet

IT orbit corrector preference orientation

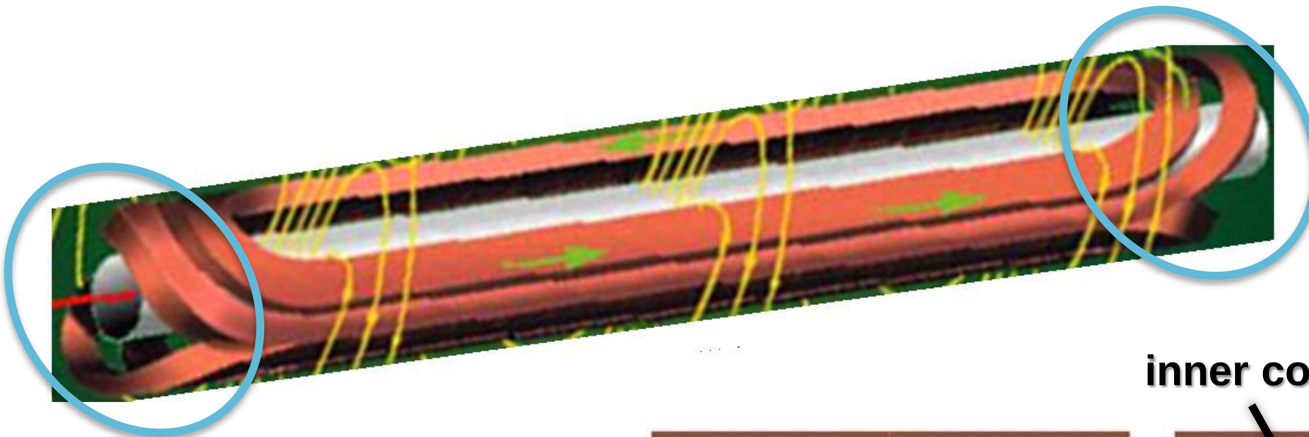
THE MODEL

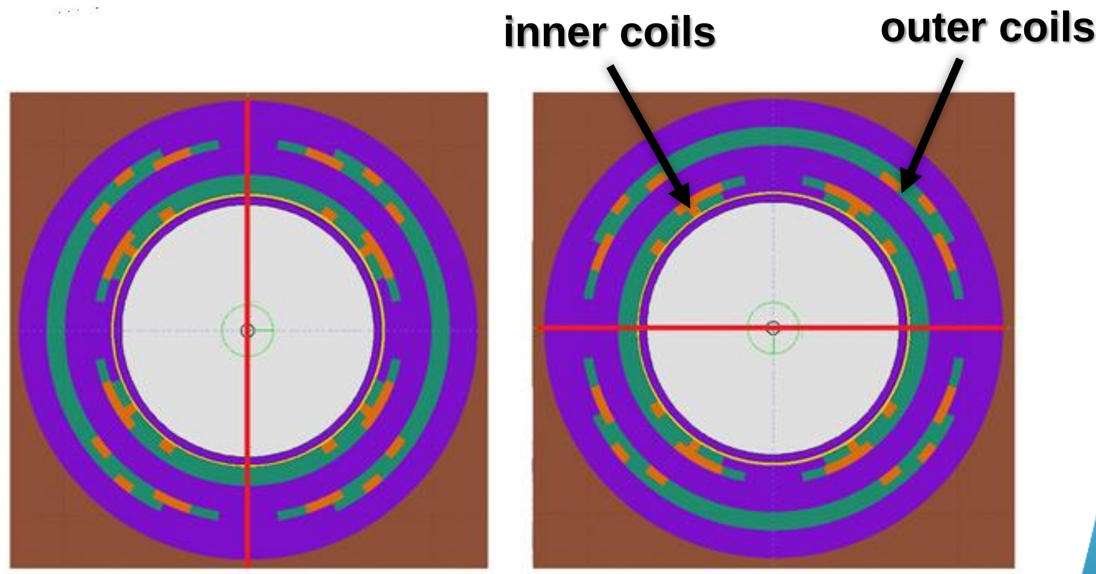


- IR5 / IR1
- Triplet - D1 region
- Horizontal/Vertical crossing of 250 μrad
- Optics: HL-LHC v1.3

Nested orbit corrector prototype

At the magnet ends, first and last 10 cm of the mechanical length, the return coils lay in the opposite plane: in the vertical plane for horizontal orientation and vice versa.

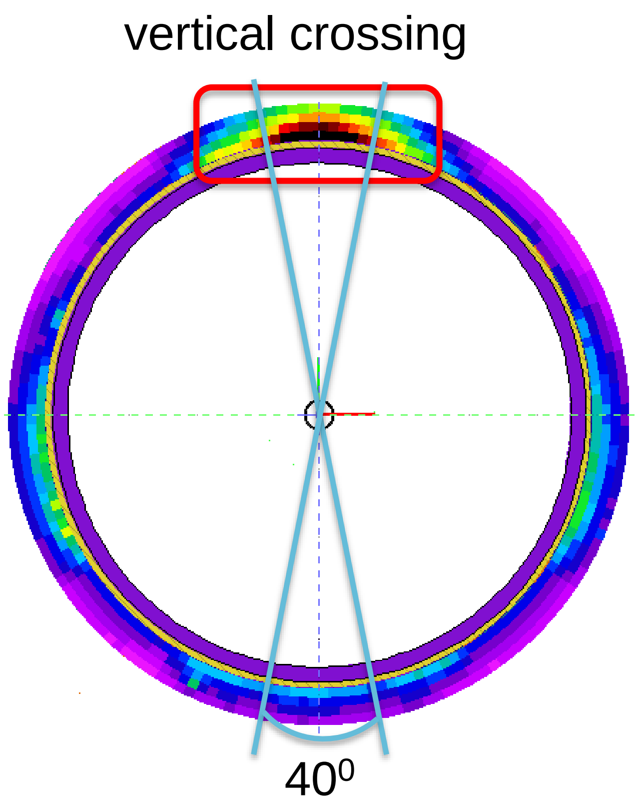


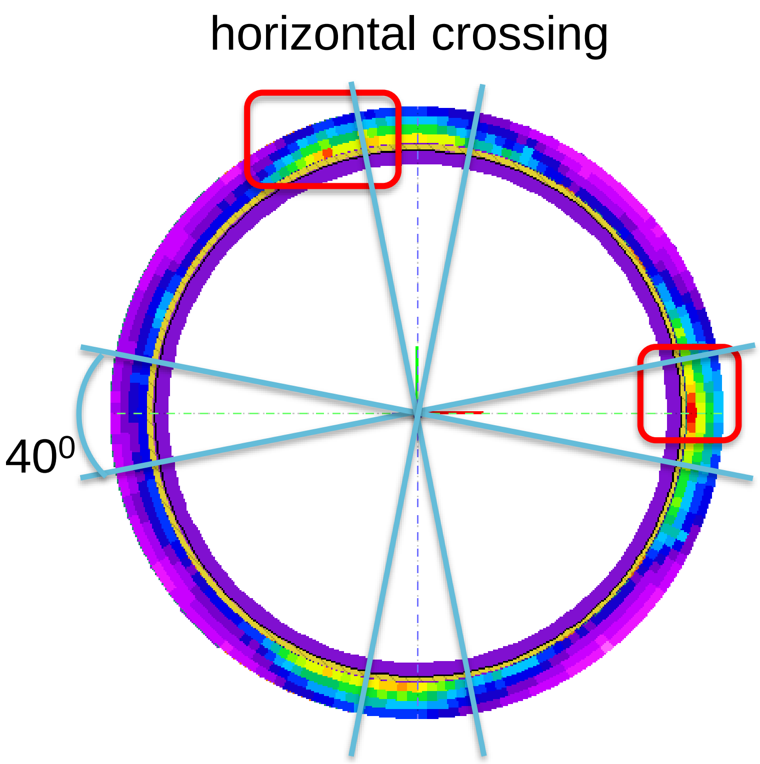


vertical orientation **horizontal orientation**

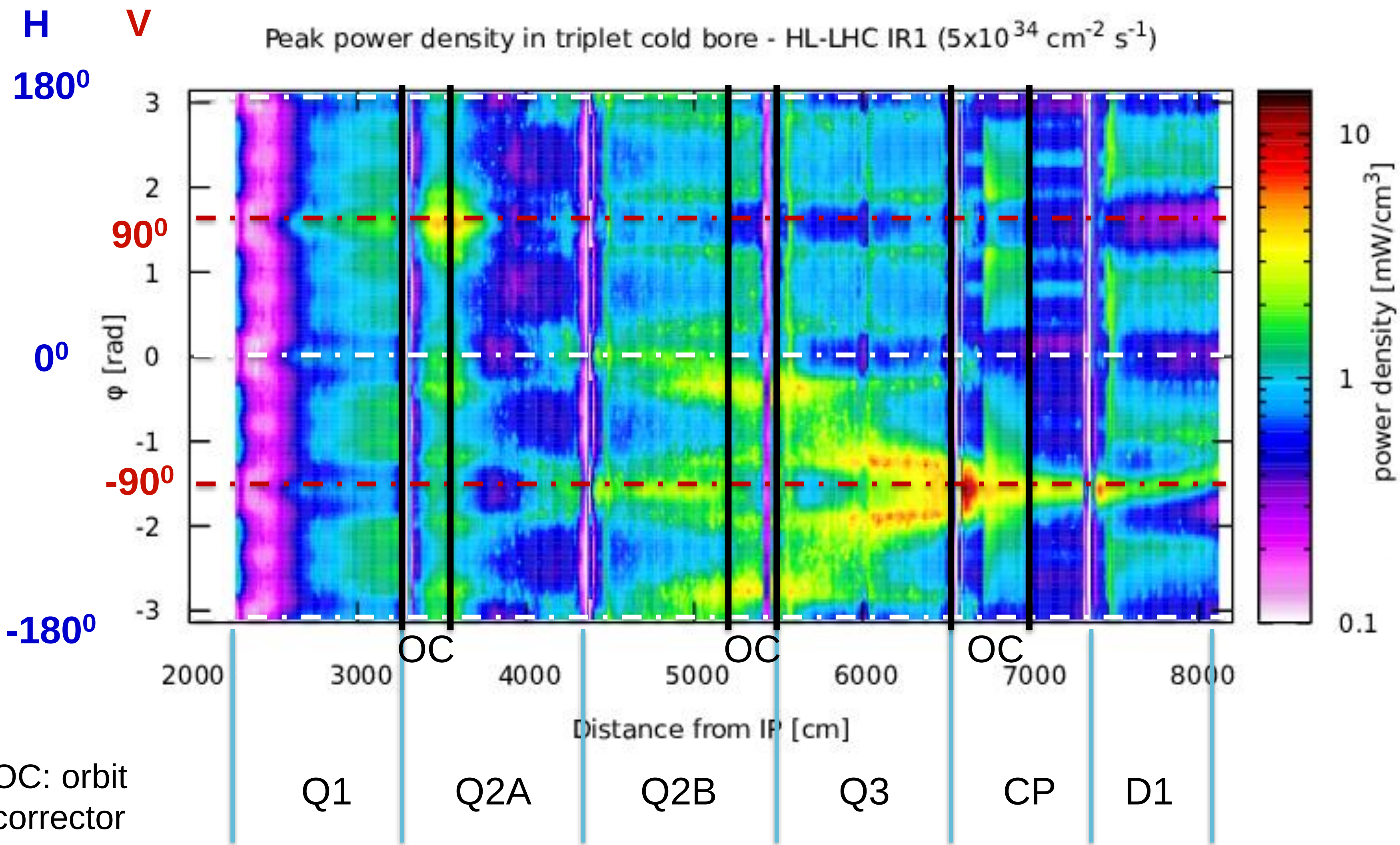
Dose distribution around the inner coils

Dose distribution transverse section at the Q2A orbit corrector:



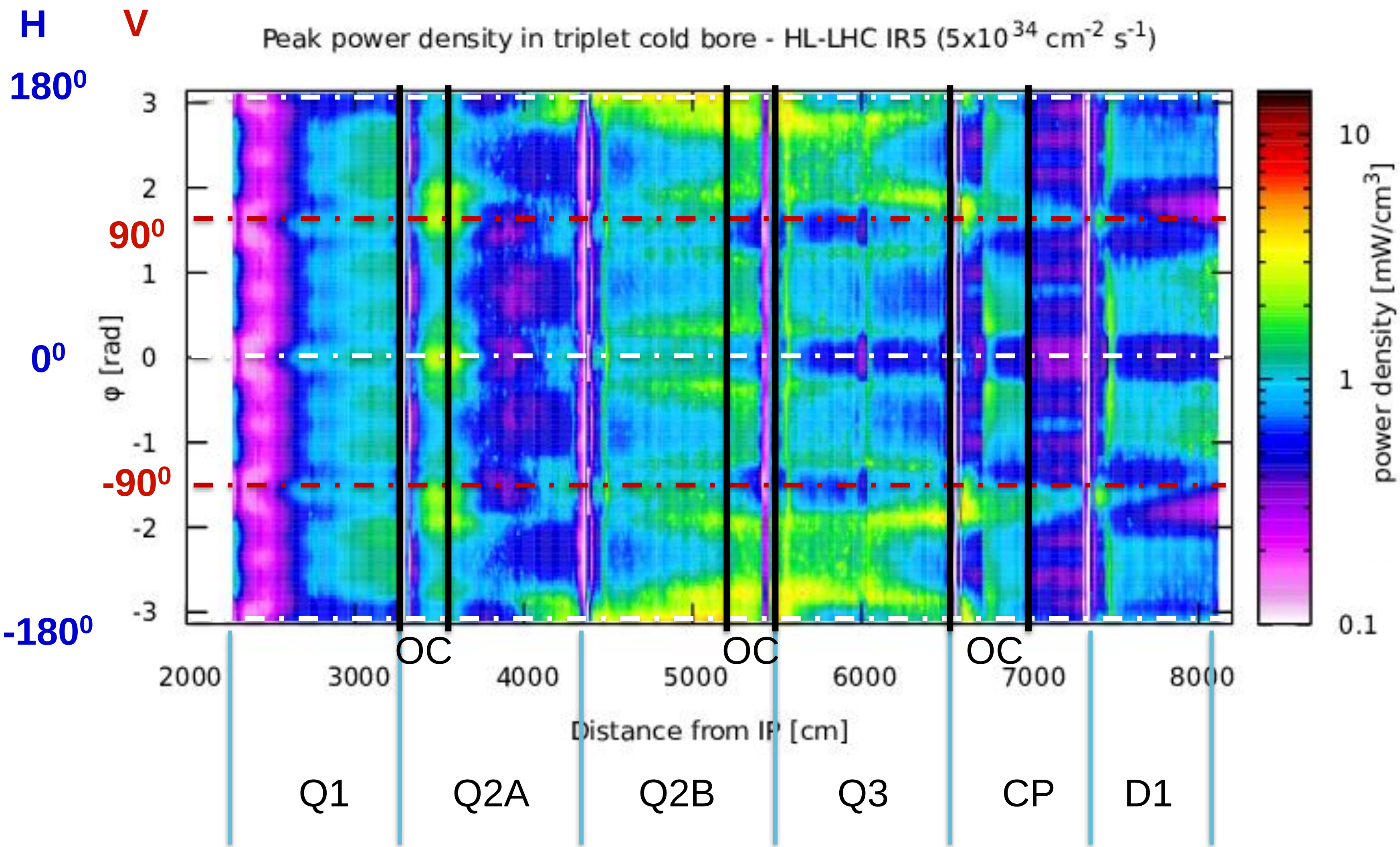


Peak power density in the triplet: vertical crossing

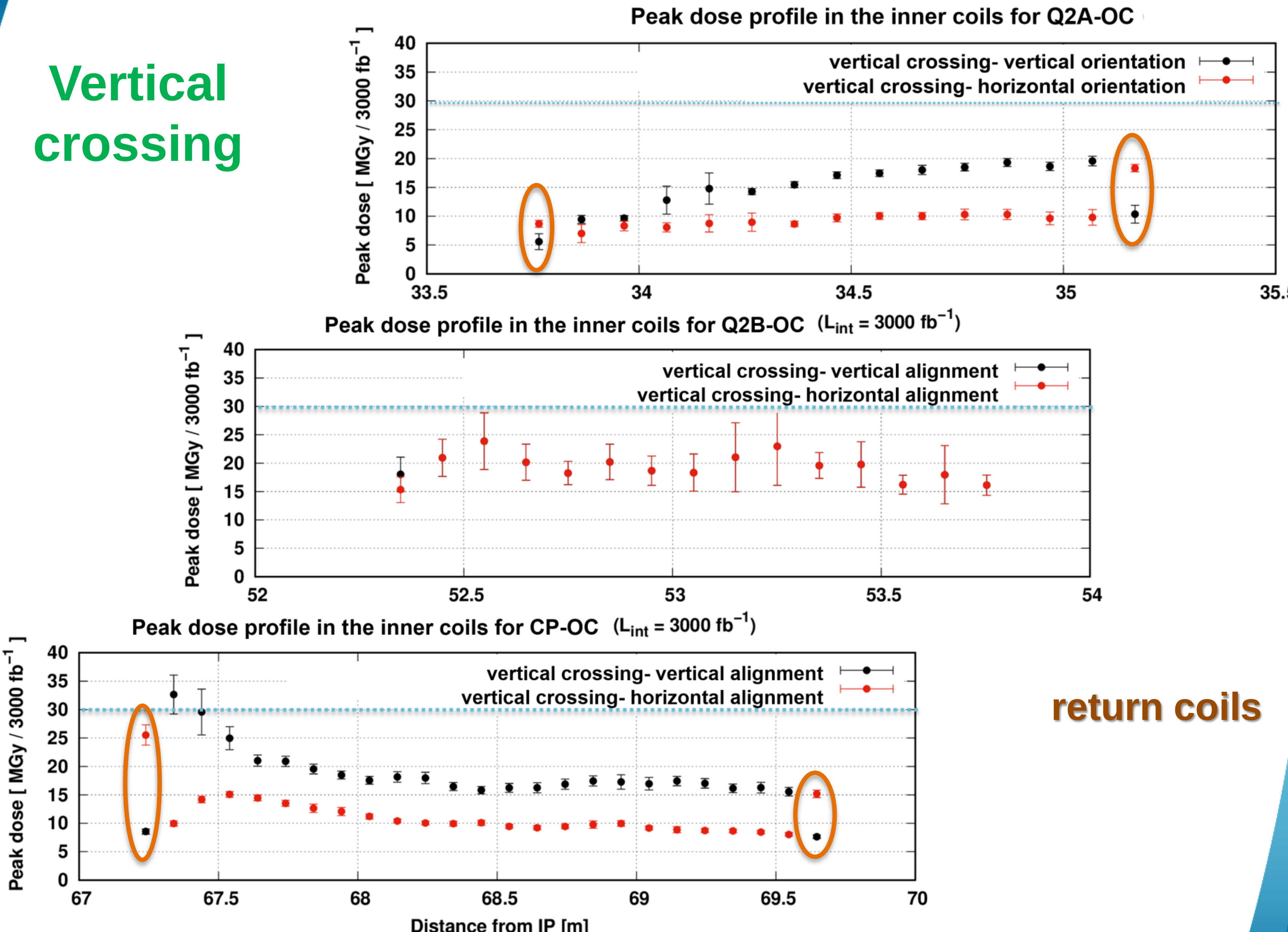


OC: orbit corrector

Peak power density in the triplet: horizontal crossing

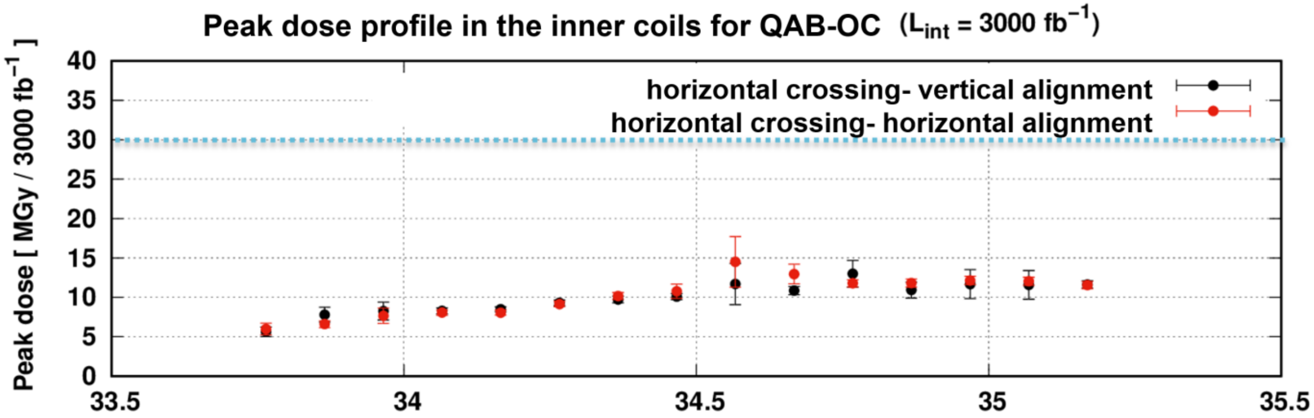


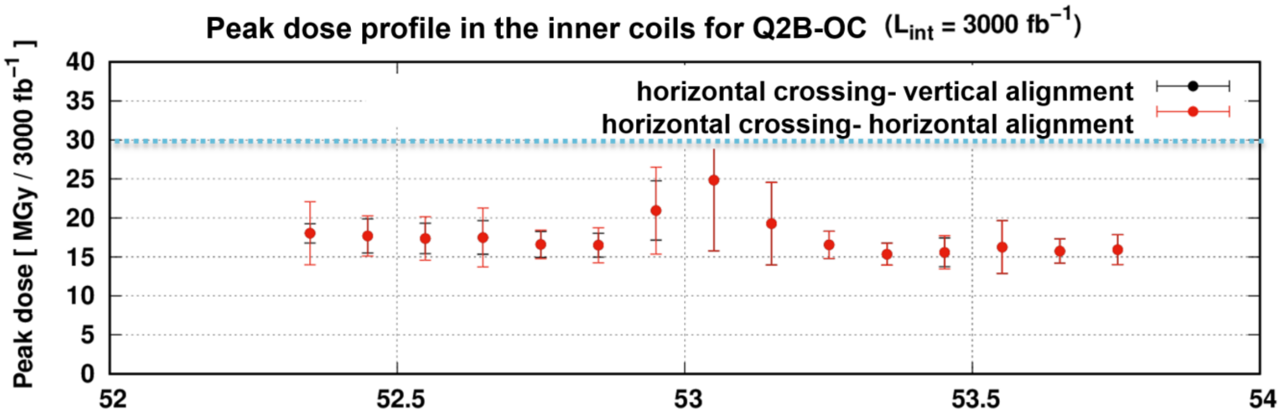
Vertical crossing

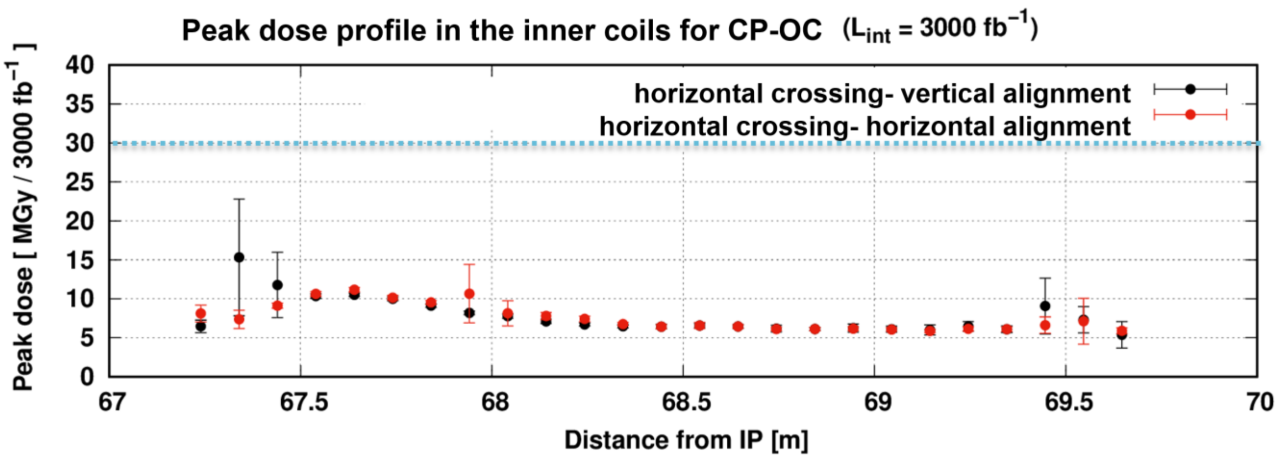


return coils

Horizontal crossing

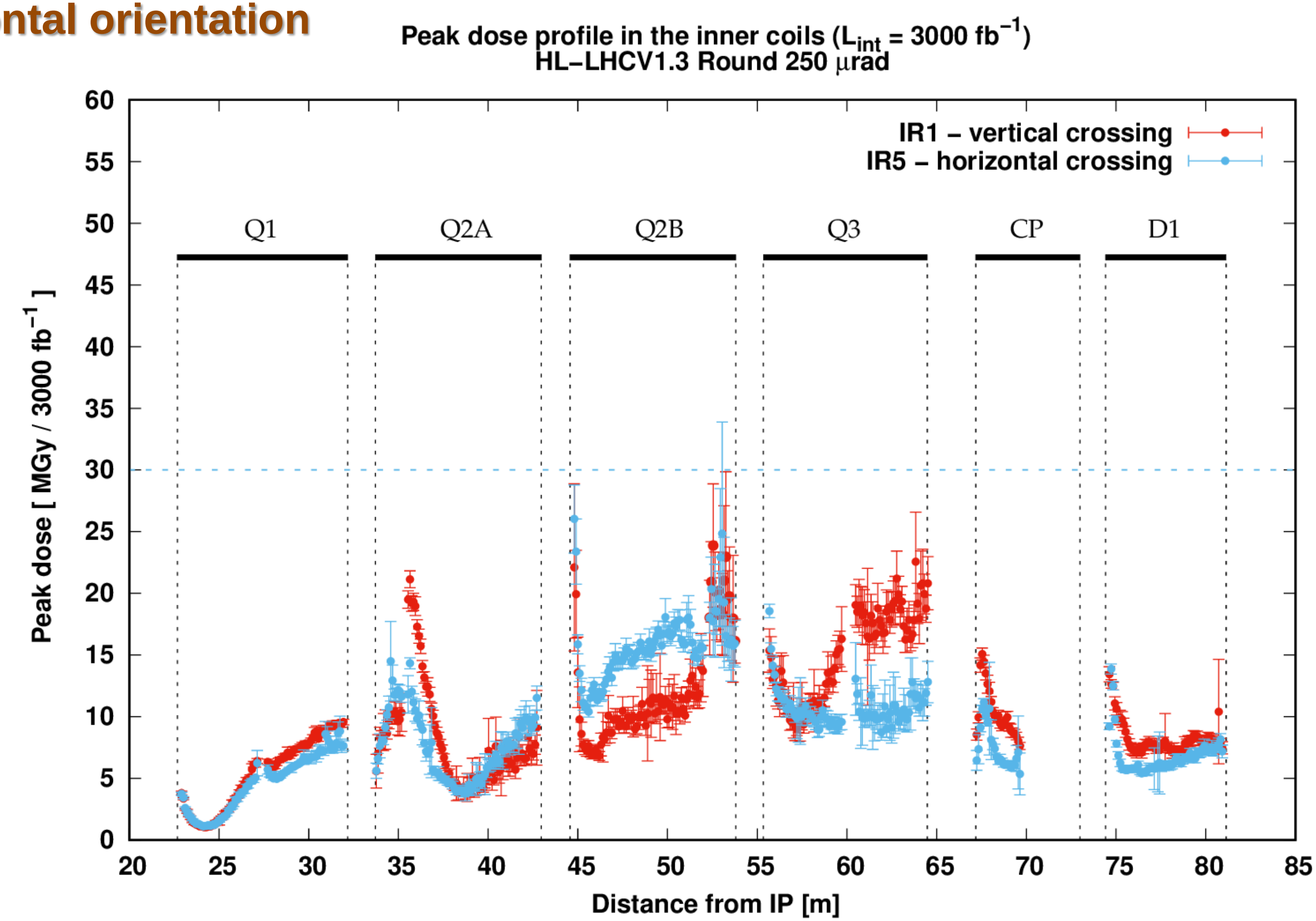






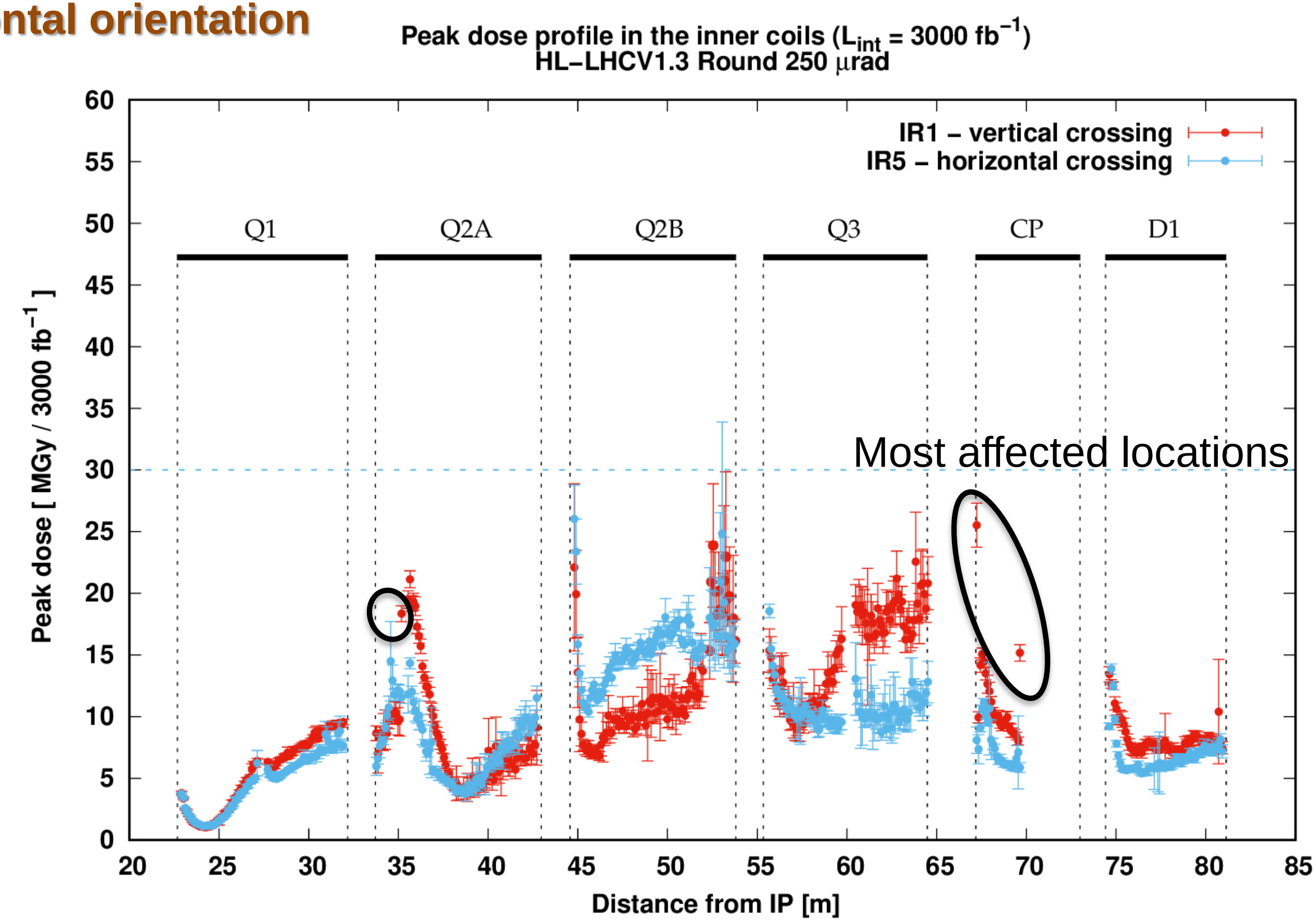
Peak dose profile in the inner coil for triple+D1 **without** the points for the return coils

Horizontal orientation



Peak dose profile in the inner coil for triple+D1 **including** the points for the return coils

Horizontal orientation



TAXN aperture study

Updates in the layout since v1.3 for HL-LHC_v1.5

- Focus on Horizontal Crossing: IP1 for v1.5.
- Revision of the **vacuum layout from TAXS to Q7**.
- Update on the triplet-D1 **IC** model.
- Inclusion of the thermal shield **end covers** in the triplet+D1 and D2 regions.
- 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 of the beam screen.
- 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.**

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

- Due to the increase of the beam separation in the TAXN by 3 mm, the total power delivered in the TAXN rises more than 100 W.

	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:

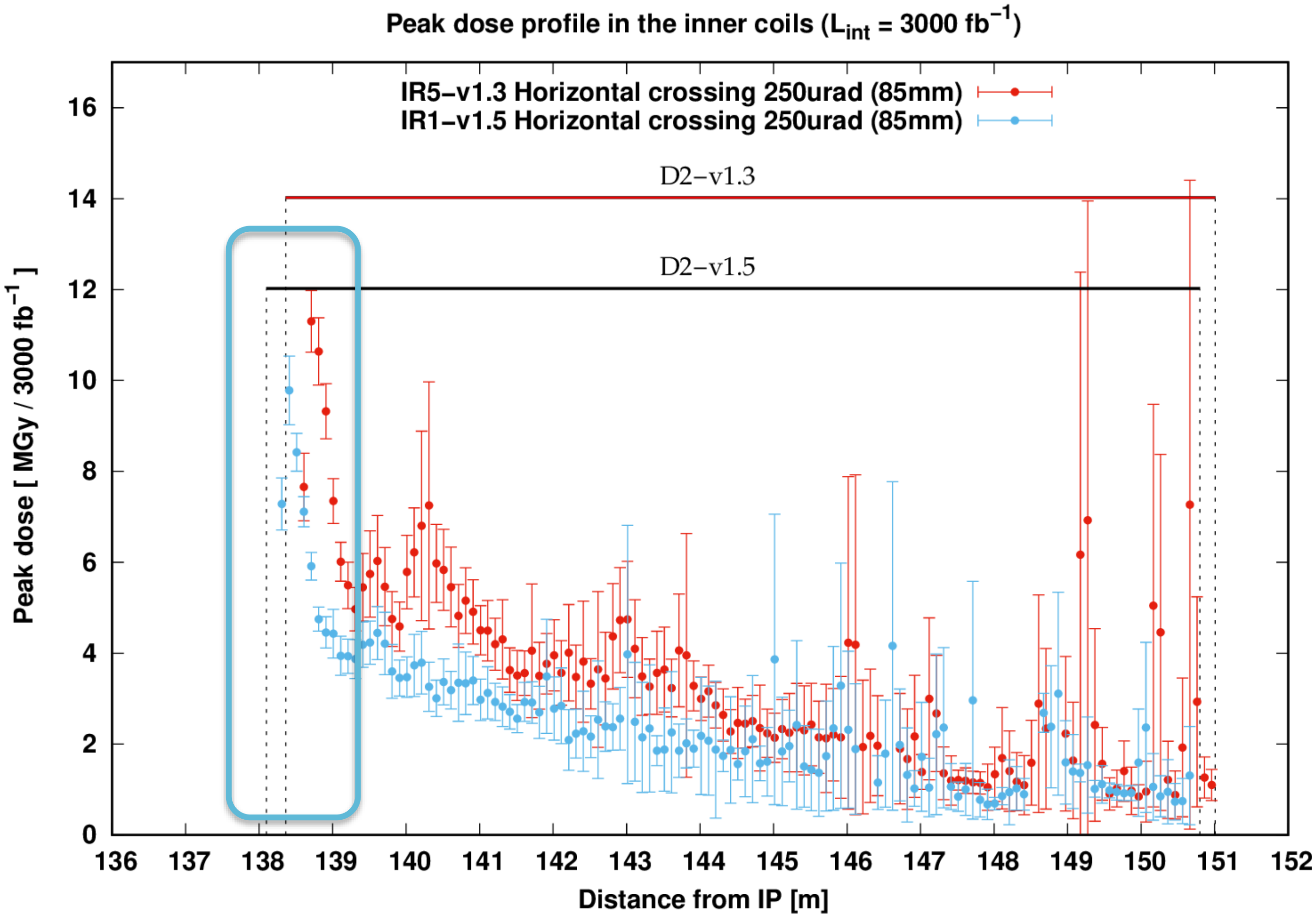
148mm-158mm (v1.3)

151mm-161mm (v1.5)

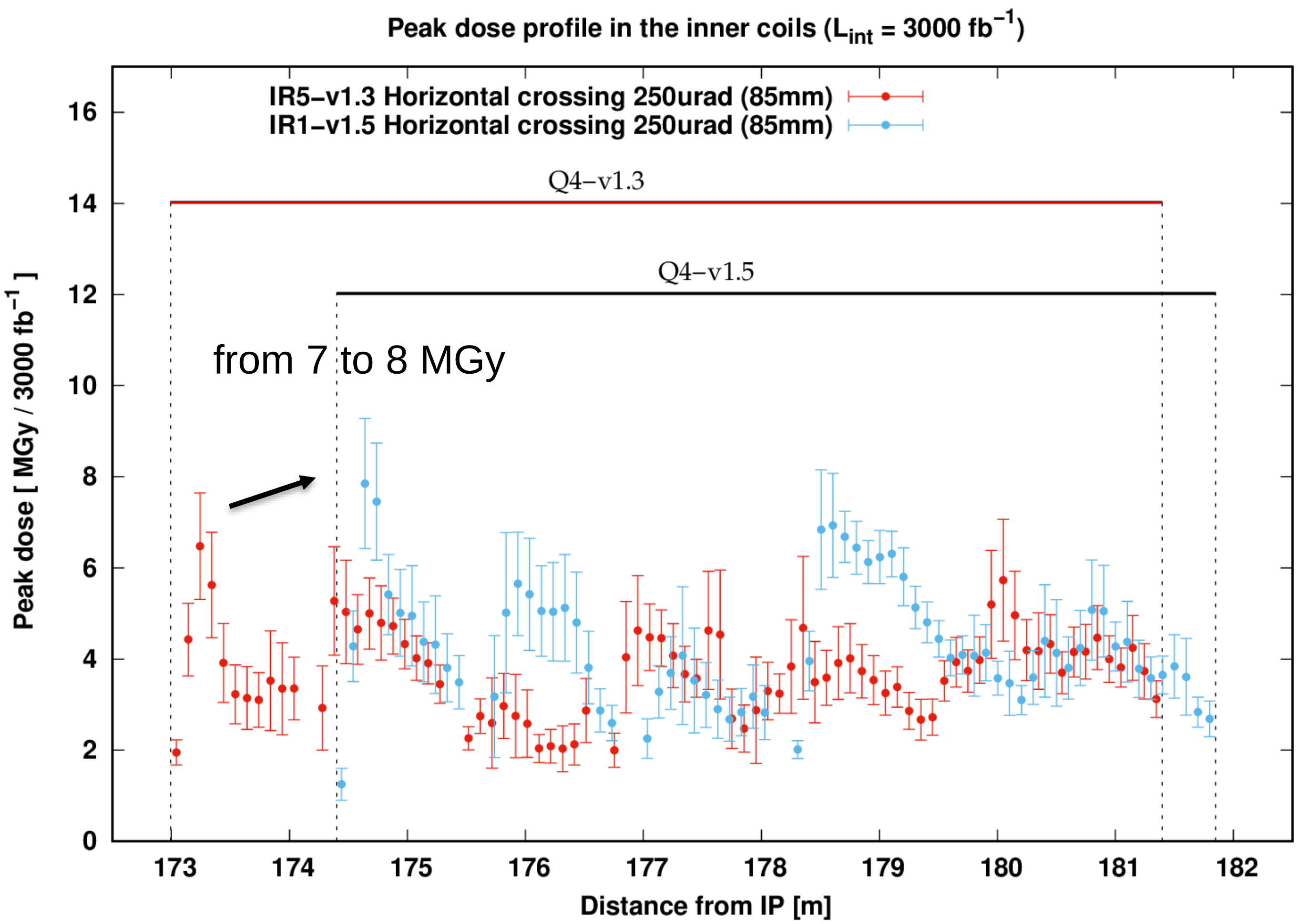
Power in W $L_{int}=5\cdot10^{34}$ (cm^{-2} s^{-1}) and σ(p-p collision) = 85 (mb)

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

TAXN aperture considerations

- Twin apertures of the Y-chamber of the TAXN: 85mm as reference.
- Horizontal crossing of 250 μrad (IP1 HL-LHC optic v1.5).
- 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.

Which is the effect?

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

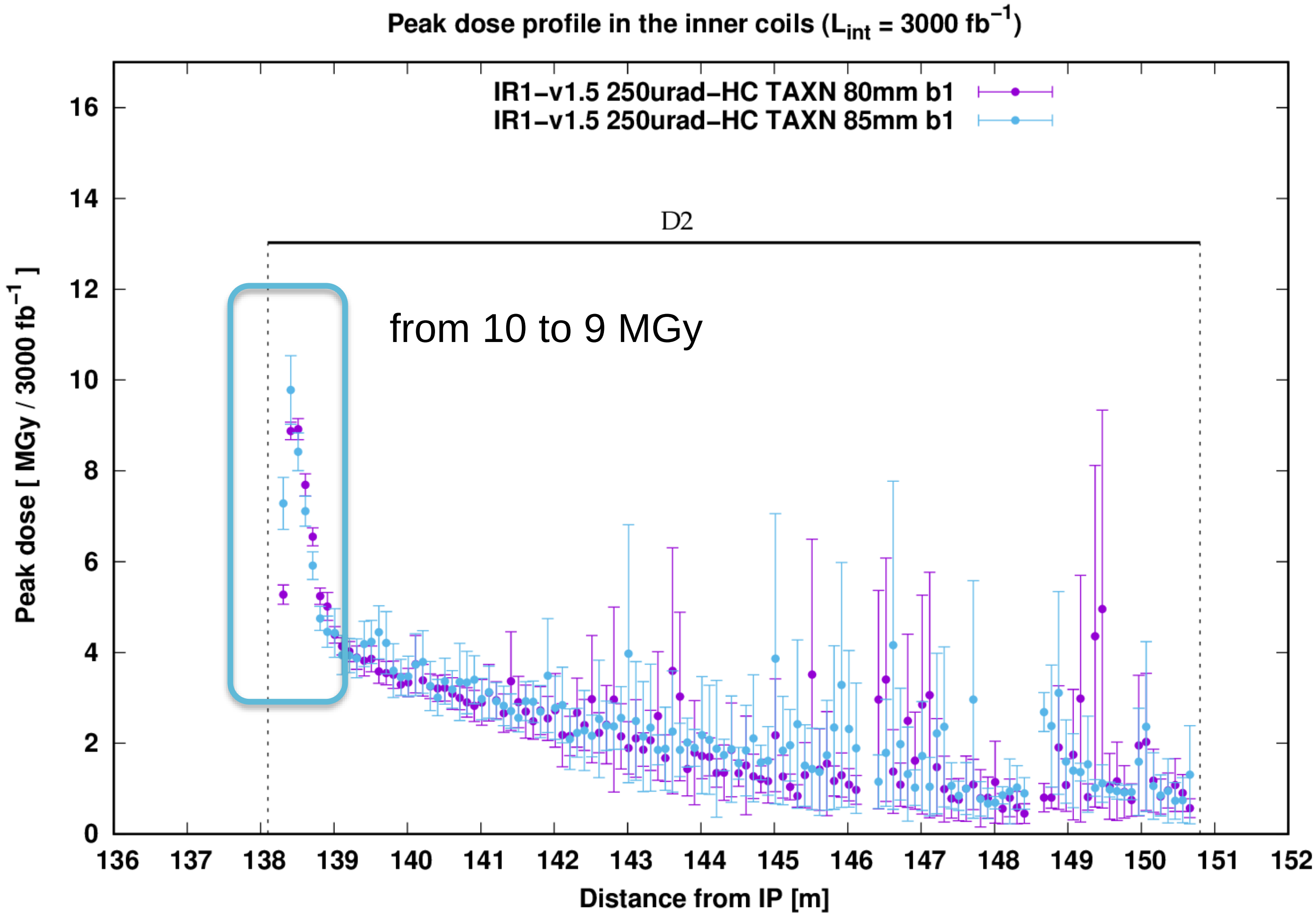
ID=80mm for 80mm

- Around 70 W taken by the TAXN and removed from the TCLX4 jaws.
- 10% reduction on the D2.
- No effect on Q4 nor in the MCBYs correctors.

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

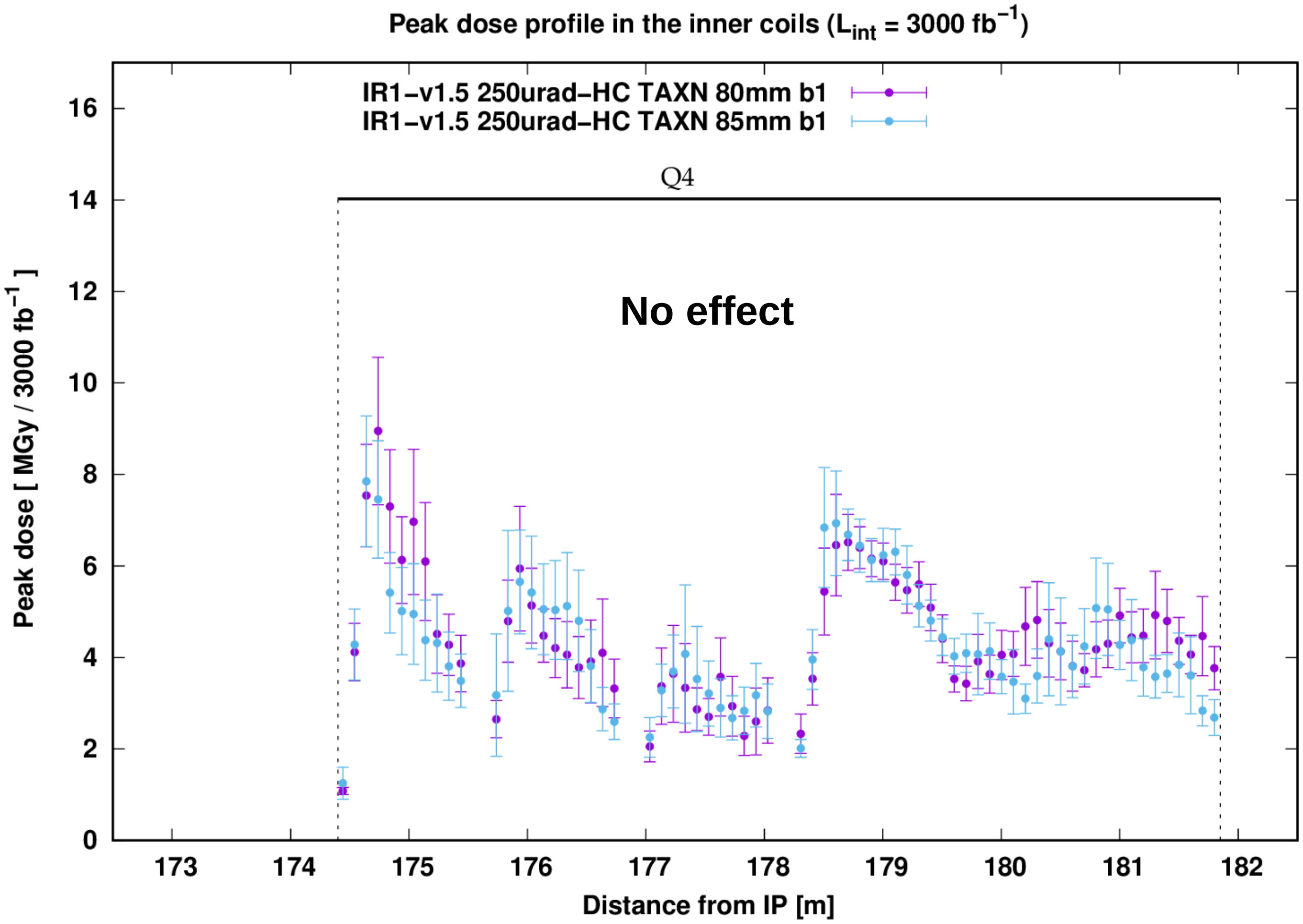
TAXN aperture considerations for HL-LHCv1.5

Dose to the D2



TAXN aperture considerations for HL-LHCv1.5

Dose to the Q4 assembly



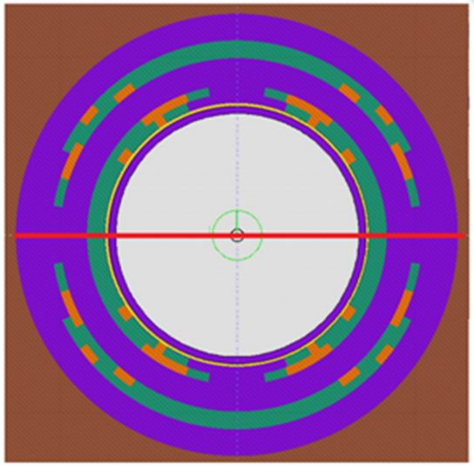
Summary and Conclusions

Summary and Conclusions (I)

Effect of the orbit correctors orientation on their exposure:

- The orientation of the nested orbit correctors affects the maximum dose their coils are exposed to.
- The recommended configuration is with the **inner layer giving a vertical field**, i.e. horizontal correction.
- This way, in the vertical crossing insertion the highest dose is only present in the return coils.

Recommendation



horizontal alignment

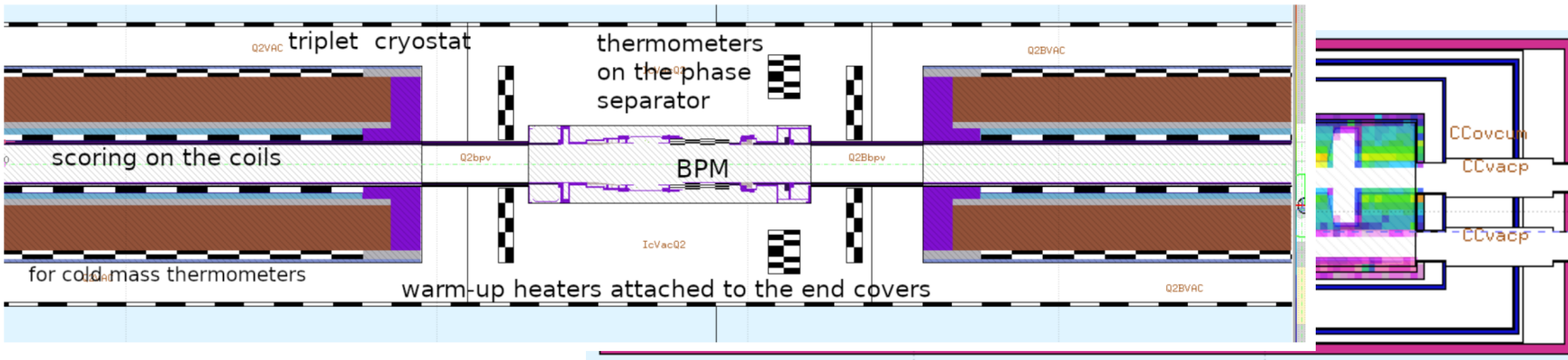
Summary and Conclusions (II)

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

- The reduction of the twin aperture moves 70 W from the TCLX4 jaws to the TAXN.
- The effect on the D2 is minor: a reduction of 10% in the max dose at the IP-side and a decrease of 10% in the total power (20 W at nominal for HL-LHC).
- No effect on Q4 and its MCBYs:
  - 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.
  - Internal shielding is needed to change the picture, if needed wrt the MCBY radiation resistance.

Extended dose evaluation for R2E/R2M considerations

New dedicated scoring implemented for energy deposition studies in specific equipment:



- Cryogenics equipment
  - IT/D2 cold mass thermometers in Q1, Q2, Q3
  - IT/D2 warm heaters: placed on the end cover eld.
  - IT thermometers on the phase separator.
  - IT/D2 beam screen heaters and thermometer
  - The results are being communicated to the c