



TCLPX4 settings effect on the matching section of IR1/5

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WP10 Energy deposition & R2E

Context

- TCLPX4 aperture needs to be modified to allocate the flat optics.
- Furthermore, it is important for PPS2 configuration in IR5.
- Study the impact of the TCLPX4 settings by looking at:
 - Peak dose on D2 and Q4 assemblies.
 - Loads on D2, Q4, TCLPX4 and TCLMB.
 - Radiation levels.
- Settings to be considered:

Half-gap	11.6 mm	14.2 mm	21.1 mm	24.7 mm	28 mm
IR1 - HC	x	x	<i>ref</i>		
IR5 - VC	x	x	<i>ref</i>	x	x

FLUKA simulations

- HL-LHC optics version 1.5 (Nov. 2019 released).
- Right side of the IP1/5.
- p-p collisions at 7 TeV.

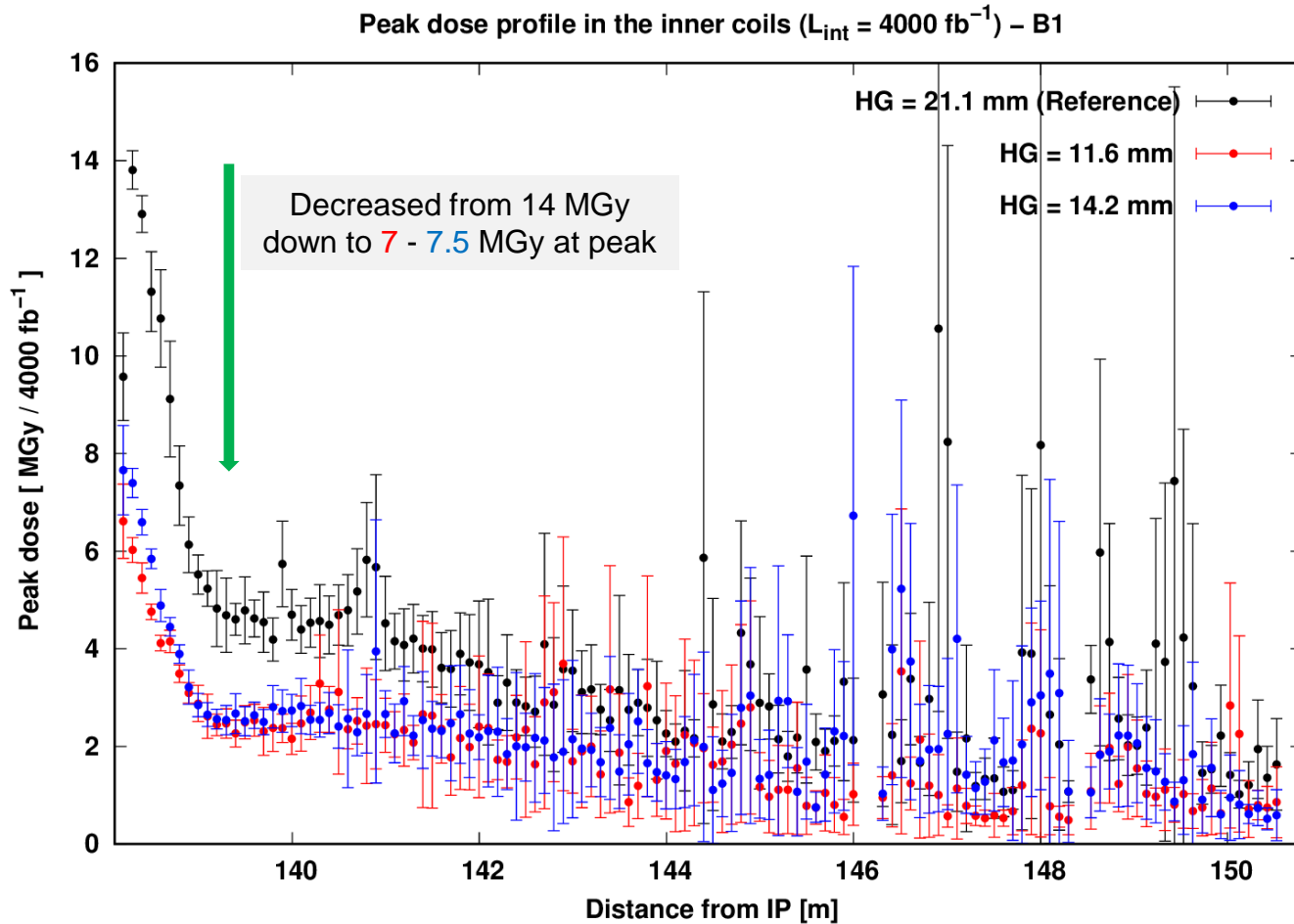
- IR1: 250 μrad crossing angle in the horizontal plane.
- IR5:
 - +250 μrad crossing angle in the vertical plane.
 - Mix polarity up/down combination.

- Normalization factor:
 - 4000 fb^{-1} integrated luminosity.
 - 7.5 L0 instantaneous luminosity.

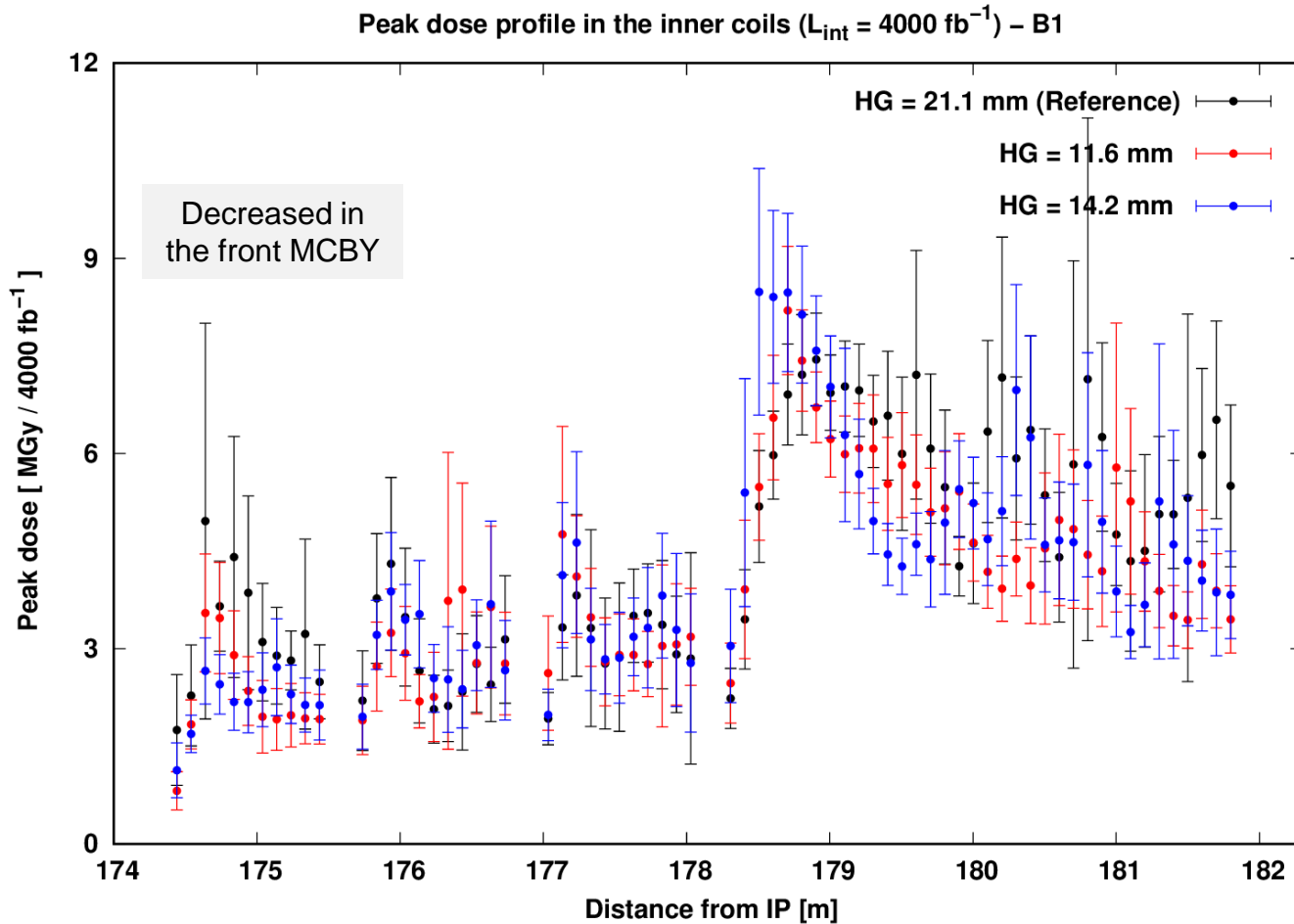
IR1

Horizontal crossing

HC: peak dose distribution in D2 assembly

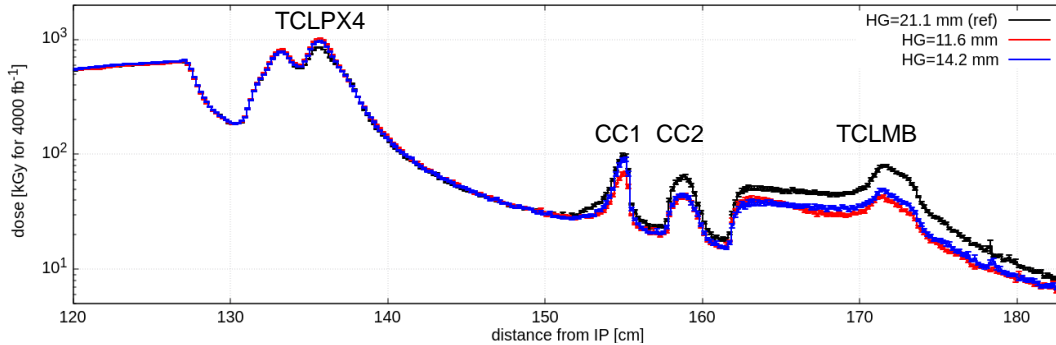


HC: peak dose distribution in Q4 assembly



Horizontal Crossing: dose levels

dose profile integrated over [-20 cm < transverse < 20 cm] and [-90 cm < height < -70 cm]



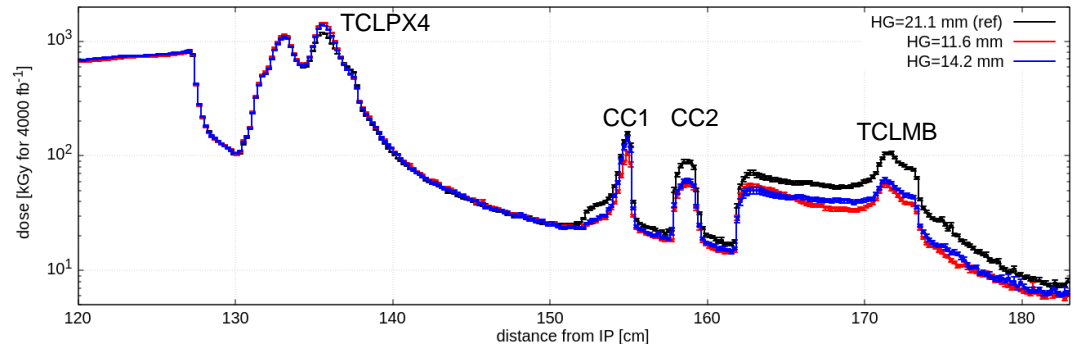
Around TCPLX4

11.6 / 14.2 mm: increased by a factor 1.2

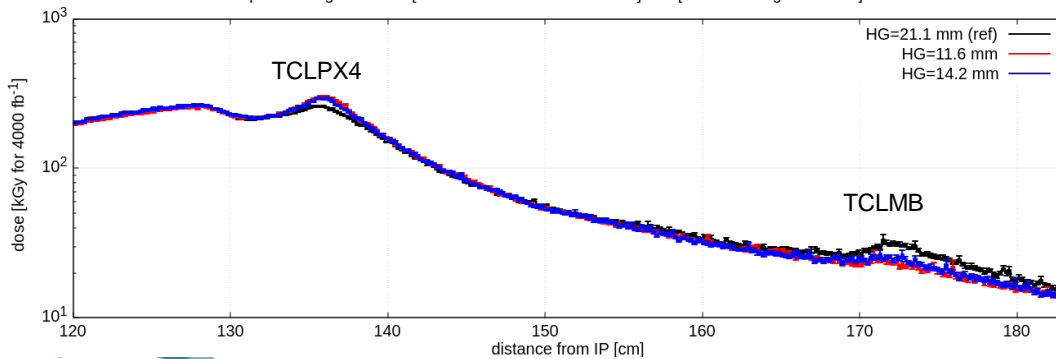
Around Q4-assembly:

11.6 / 14.2 mm: decreased by a factor 0.6

dose profile integrated over [-20 cm < transverse < 20 cm] and [-70 cm < height < -50 cm]



dose profile integrated over [160 cm < transverse < 180 cm] and [-10 cm < height < 10 cm]: cables



Horizontal Crossing: Total power (W) for 7.5 L0

Half gap (mm)	D2	D2 Hcorr	D2 Vcorr	Q4 - CM MCBYs	Q4 - CM	TCLPX inner	TCLPX outer	TCLMB B1
11.6	24.2	0.9	0.8	3.3	3.7	303.5	288.2	13.7
<i>Ratio wrt ref</i>	<i>0.9</i>	<i>0.5</i>	<i>0.5</i>	<i>0.6</i>	<i>0.8</i>	<i>1.3</i>	<i>1.8</i>	<i>0.5</i>
14.2	26.7	1.05	1.04	3.6	3.9	277.8	256	15.7
<i>Ratio wrt ref</i>	<i>0.9</i>	<i>0.6</i>	<i>0.7</i>	<i>0.7</i>	<i>0.8</i>	<i>1.2</i>	<i>1.6</i>	<i>0.5</i>
21.1 - ref	28.3	1.8	1.5	5.3	4.8	230.1	162.4	29.1

The collimator design, including the thermomechanical studies, is based on the loads corresponding to the reference settings.

corr = corrector
CM = cold mass

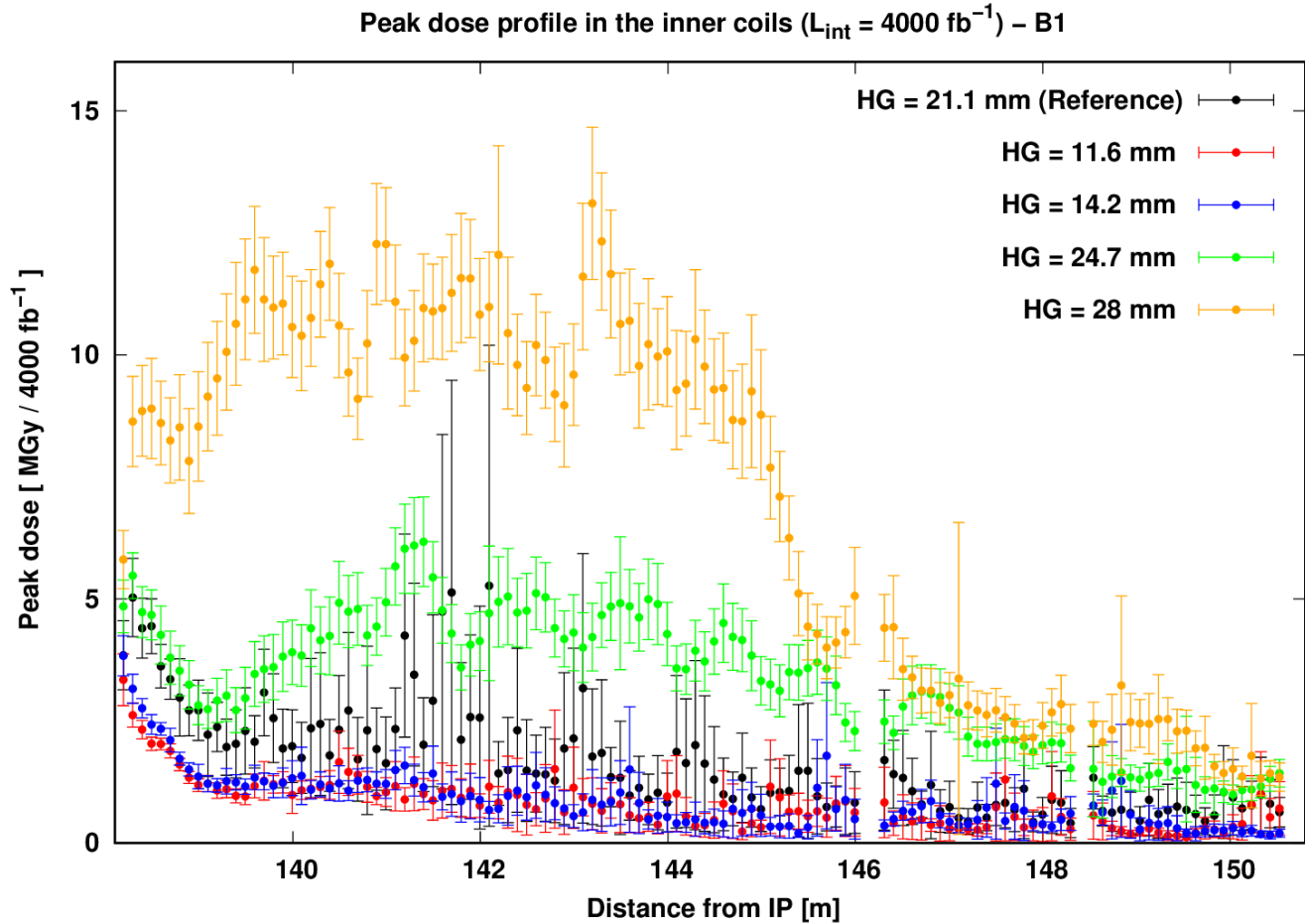
IR5

Vertical crossing

VC: peak dose distribution in D2 assembly

VC-up/down

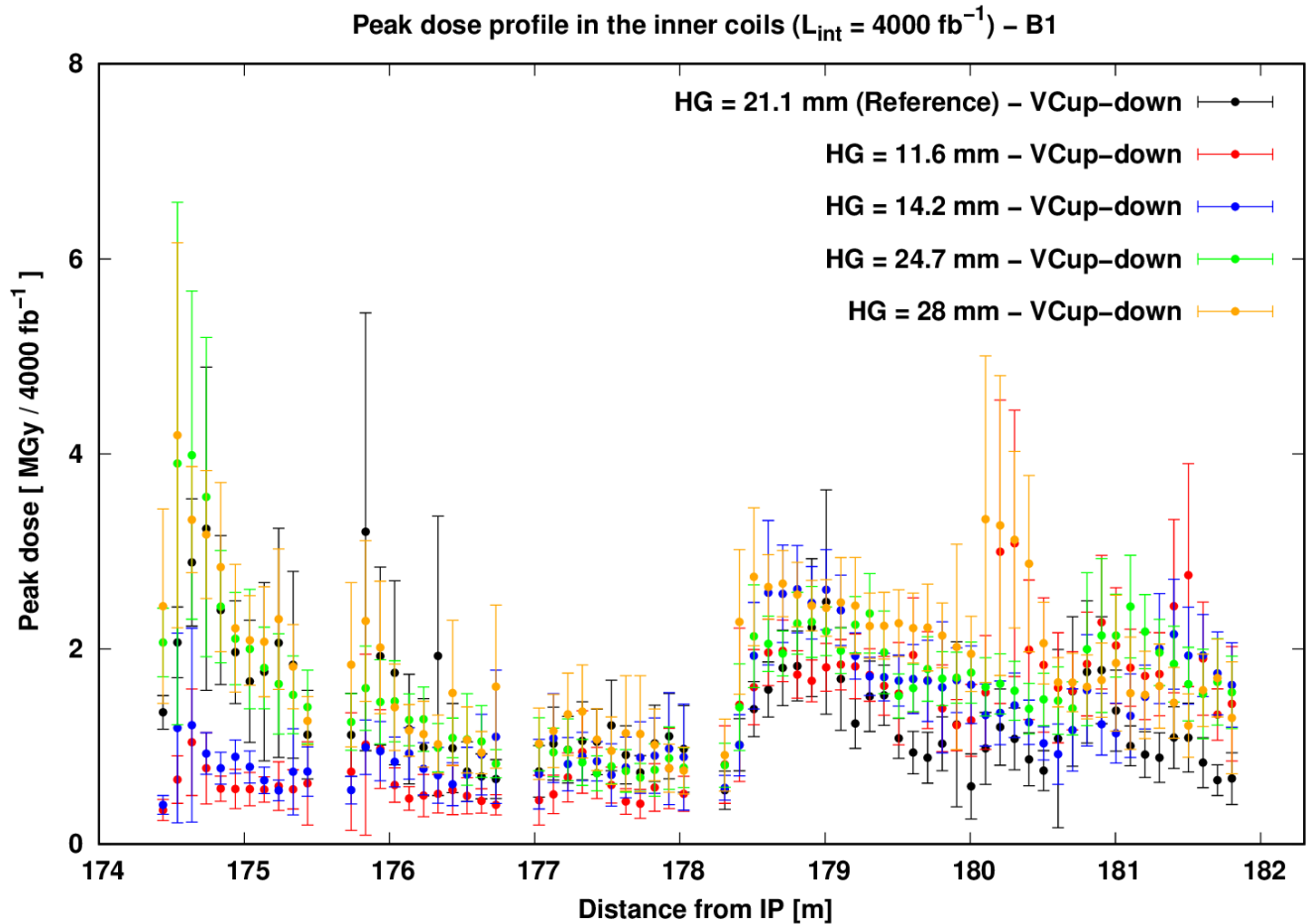
Half gap (mm)	Peak dose (MGy)
21.1 - ref	5
11.6	3.3
<i>ratio</i>	0.7
14.2	3.8
<i>ratio</i>	0.8
24.7	6
<i>ratio</i>	1.2
28	12 !
<i>ratio</i>	2.4



VC: peak dose distribution in Q4 assembly

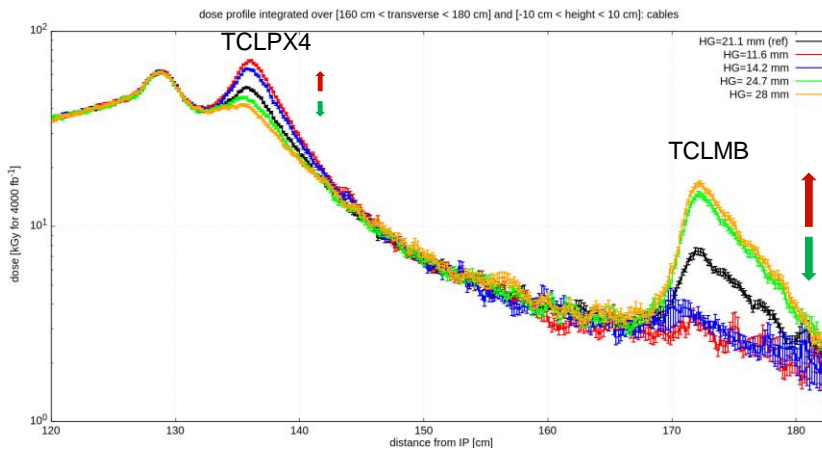
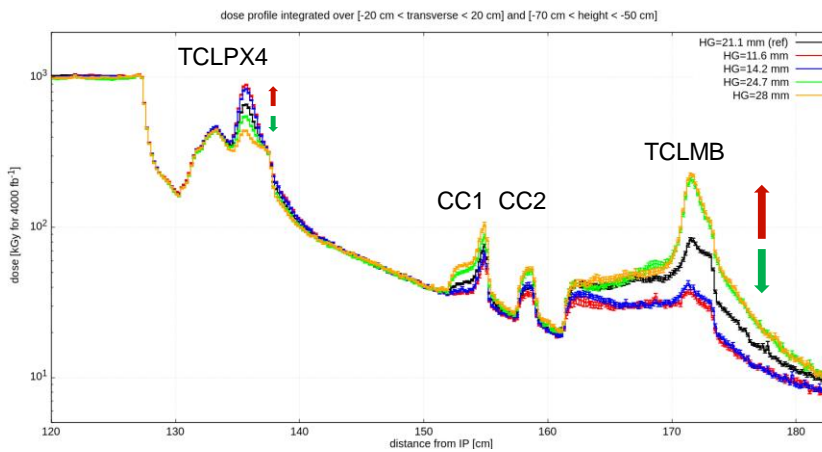
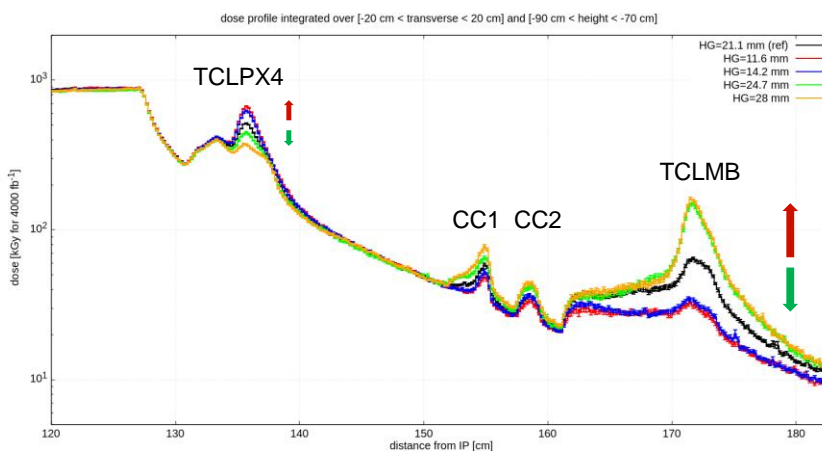
VC-up/down

Half gap (mm)	Peak dose (MGy)
21.1 - ref	3.2
11.6	1
<i>ratio</i>	<i>0.3</i>
14.2	1.2
<i>ratio</i>	<i>0.4</i>
24.7	4
<i>ratio</i>	<i>1.3</i>
28	4.2
<i>ratio</i>	<i>1.3</i>



VC dose levels

VC-up



Around TCPLX4:
24.7 / 28 mm: decreased by a factor 0.7-0.8
11.6 / 14.2 mm: increased by a factor 1.3

Around Q4-assembly:
24.7 / 28 mm: increased by a factor 2.5
11.6 / 14.2 mm: decreased by a factor 0.5

Vertical crossing: Total power (W) for 7.5 Lo

Half gap (mm)	D2	D2 Hcorr	D2 Vcorr	Q4 - CM MCBYs	Q4 - CM	TCLPX inner	TCLPX outer	TCLMB B1	TCLMB B2
11.6	13.7	0.4	0.5	1.8	1.8	58.3	170	5	0.63
Ratio	0.7	0.4	0.4	0.4	0.7	1.5	2	0.1	0.6
14.2	14.6	0.4	0.6	2.2	1.8	52.6	144.7	6.1	0.79
Ratio	0.8	0.5	0.5	0.5	0.8	1.4	1.7	0.2	0.8
21.1 - ref	18.8	1	1.2	4.6	2.4	38.7	85.5	35.7	0.98
24.7	31.8	2.1	3.3	5.3	2.3	30.8	59.3	44.7	0.9
Ratio	1.7	2.2	2.7	1.2	1	0.8	0.7	1.3	0.9
28	54	3	4.6	5.6	2.6	23.2	37.3	51.9	0.9
Ratio	2.9	3.1	3.8	1.2	1.1	0.6	0.4	1.5	0.9

TCLPX is designed to stand the maximum heat in IR1, > 200 W for a single jaw.

corr = corrector
CM = cold mass

Conclusions

- The effect of bigger and smaller aperture of the TCLPX collimator was explored for HC/VC.
- **Peak dose in D2/Q4 assemblies:**
 - A reduction in the aperture of the TCLPX4 implies a decrease in the peak dose in D2 and Q4-assembly.
 - A larger opening leads to a non-negligible increase in D2 (up to a factor 2) and Q4-assembly.
- **Total power:**
 - The impact of the TCLPX4 settings highly depends on the half gap and the crossing plane.
 - For horizontal crossing, an aperture of 11.6 mm half-gap implies that the loads in the inner jaw of the TCLPX4 will be ~304 W, 70 W above the values considered in the design.
 - In vertical crossing when opening the TCLPX4 to 28 mm half-gap, the loads in the D2, Q4 and TCLMB increase by a factor 2.9 (up to 54 W), 1.2 (5.6 W) and 1.5 (52 W) respectively.
- **Radiation levels:**
 - When opening the collimator there is a decrease by a factor ~0.8 in the surrounding of TCLPX4 and an increase by a factor 2.5 around Q4-assembly.
 - When closing the collimator there is an increase by a factor ~1.3 in the surrounding of TCLPX4 and a decrease by a factor ~0.5 around Q4-assembly.