Towards HL-LHCV1.4 (2)

R. De Maria, D. Gamba, F. Plassard

WP2 meeting 21/8/2018

Changes HLLHC1.3 → 1.4

Layout (IR1/5 when not specified):

- 2+2 crab cavities → 2 crab cavities only
- Q4: 4xMCBY+MQY 1.9K → 3xMCBY+MQY 4.5 K
- Q5: 3xMCBY+MQY 1.9K → 1xMCBC+MQML 4.5
- Q4, Q5 displaced towards the arc from 10.047 m, 11 m w.r.t LHC to 10.5 m w.r.t LHC
- Remote alignment system (i.e. machine can be realigned during beam commissioning)
- Extended D1 beam-screen
- New specification for TCTPV-TCTPH-TCLX stroke and apertures
- Changes length/position of correctors in CP
- IR7: MBH+TCLD, MQW (not the absorber)
- IR2: TCLD, TDIS
- IR8: TANB

Missing:

- Final positions of correctors in CP
- Comparison with mechanical drawings
- Agreement on design/nominal magnetic length on drawings
- Possible displacement BPM from IP side D2 to arc side
- Small change MCBRD positions

Changes HLLHC1.3 → 1.4

Optics:

- Crossing bumps re-optimized thanks to remote alignment system
- Dedicated optics for 7 TeV (using 7.5 TeV equivalent currents where needed)
- IR4 optimized for instrumentation and e-lens
- IR6 reviewed and re-optimized for TCDQ gaps, Q5 strengths
- IR8 β^*=1.5 m
- New aperture estimates thanks to remote alignment system
- Decision on crossing plane for Point 1/5
- Squeeze sequence with/without ATS in the ramp
- Update MS10 branch and follow-up of the DA studies.
- Optics optimization for forward physics.

Repository:

- Move LS2 changes from HL-LHC to RunIII repository
- Error tables, macros and script (e.g.. CP update)

Corrector package

Magnet name		Integrated field at R_{ref}=50 mm [T m]		Magnet coil length [mm]		Magnet length [1] [mm]		Magnetic [3] length [mm]	
		Base line	New value	Base Line [2]	New value	Baseline	New Value	TDR	New Value
Skew quadrupole	MCQSXF	1.000	0.700	728	528	814	614	807	462
Normal sextupole	MCSXF	0.063	0.095	132	192	194	254	111	171
Skew sextupole	MCSSXF	0.063	0.095	132	192	194	254	111	171
Normal octupole	MCOXF	0.046	0.069	119,6	169,6	183	233	87	151
Skew octupole	MCOSXF	0.046	0.069	119,6	169,6	183	233	87	151
Normal decapole	MCDXF	0.025	0.037	118,6	168,6	183	233	95	138
Skew decapole	MCDSXF	0.025	0.037	118,6	168,6	183	233	95	138
Normal dodecapole	MCTXF	0.086	0.086	490	490	575	575	430	465
Skew dodecapole	MCTSXF	0.017	0.017	135	135	200	200	89	92

Source: https://edms.cern.ch/document/1963788/1.0 HL-LHC ECR: WP3 CHANGE OF QUADRUPOLE, SEXTUPOLE, OCTUPOLE AND DECAPOLE CORRECTORS INTEGRATED FIELD

[1]: not the magnetic length; [2] values differ slightly from TDR;

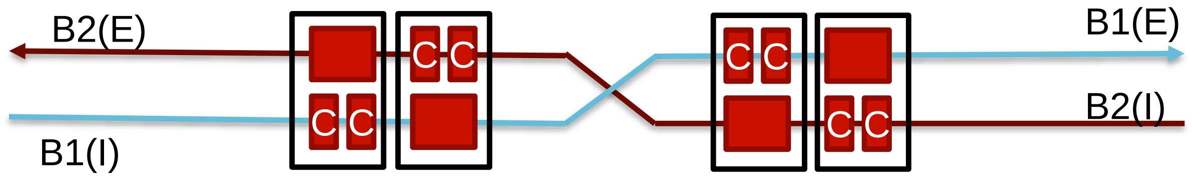
MQW

DCUM	Old slots	Old Circuit	New slots	New Circuit
19870.8	MQWA.A5L7	RQ5.LR7	MQWA.A5L7	RQ5.LR7
19867.0	MQWA.B5L7	RQ5.LR7	MQWA.B5L7	RQ5.LR7
19863.2	MQWB.5L7	RQT5.L7	MQWA.C5L7	RQ5.LR7
19859.4	MQWA.C5L7	RQ5.LR7	MQWA.D5L7	RQ5.LR7
19855.6	MQWA.D5L7	RQ5.LR7	MQWA.E5L7	RQ5.LR7
19851.8	MQWA.E5L7	RQ5.LR7	removed	removed
20117.5	MQWA.A5R7	RQ5.LR7	MQWA.A5R7	RQ5.LR7
20121.3	MQWA.B5R7	RQ5.LR7	MQWA.B5R7	RQ5.LR7
20125.1	MQWB.5R7	RQT5.R7	MQWA.C5R7	RQ5.LR7
20128.9	MQWA.C5R7	RQ5.LR7	MQWA.D5R7	RQ5.LR7
20132.7	MQWA.D5R7	RQ5.LR7	MQWA.E5R7	RQ5.LR7
20136.5	MQWA.E5R7	RQ5.LR7	removed	removed

Radiation Shielding Installation and Possible Optics Change for the MBW and MQW Magnets in IR 3 and 7 of the LHC. Second phase LS2 LS3 and HL-LHC. LHC-MW-EC-0002 v.1.1

Injection optics from R. Bruce, from a branch of HL-LHCV1.3.

Crabbing angle



Crab angle [μrad]	Q7 [T/m]	Same IR1/5 Optics	H Optimized Optics	V Optimized Optics
HL1.3	200	380	n/a	n/a
HL1.4	200	375	388	375
HL1.4	214	388	400	390

- 5 μrad lost due to Q4-Q5 displacement from HL1.3 to HL1.4.
- Higher than nominal Q7 current allow to increase crabbing angle
- Different optics for IR1/IR5 can optimize a given crabbing plane.
- With the present crab cavity layout (same for 1/5) H crossing is favored, therefore different layouts can still improve overall crab crossing.
- Crab cavity voltage optimization has some impact on aperture and forward physics.

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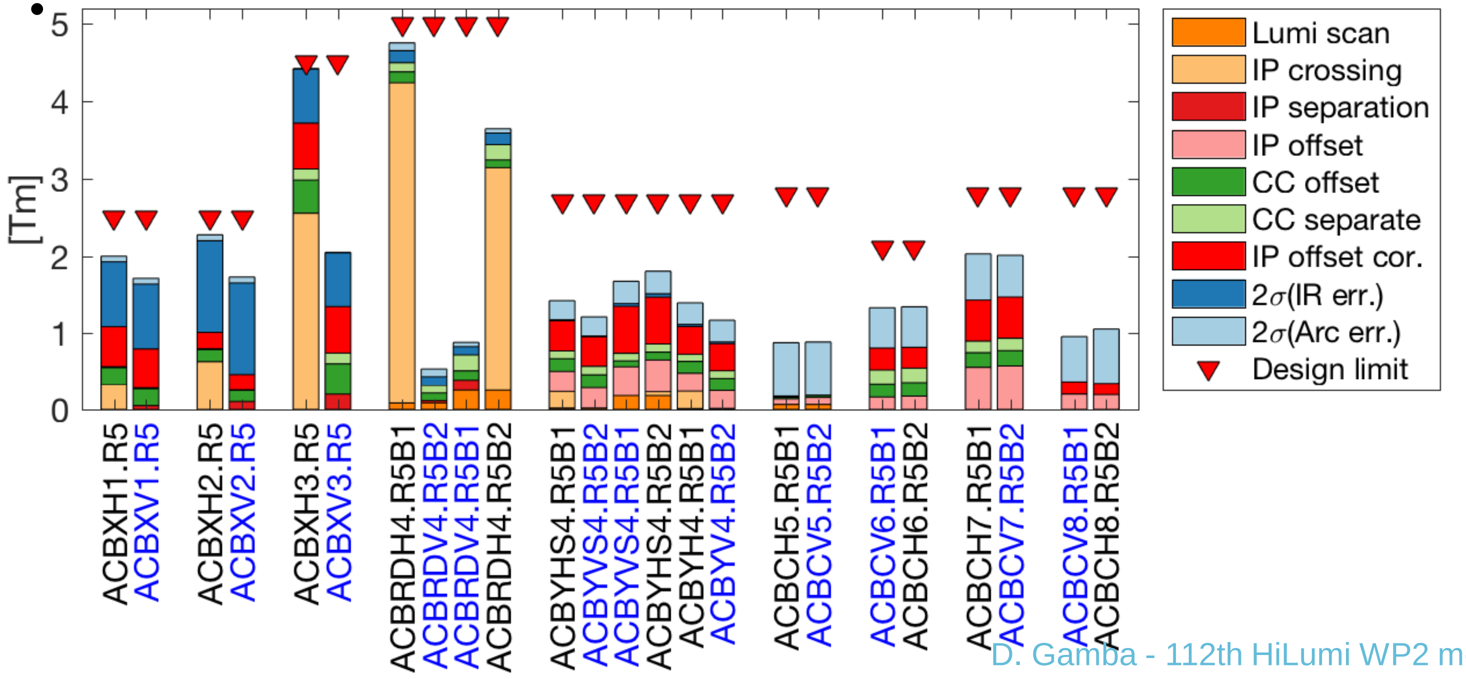
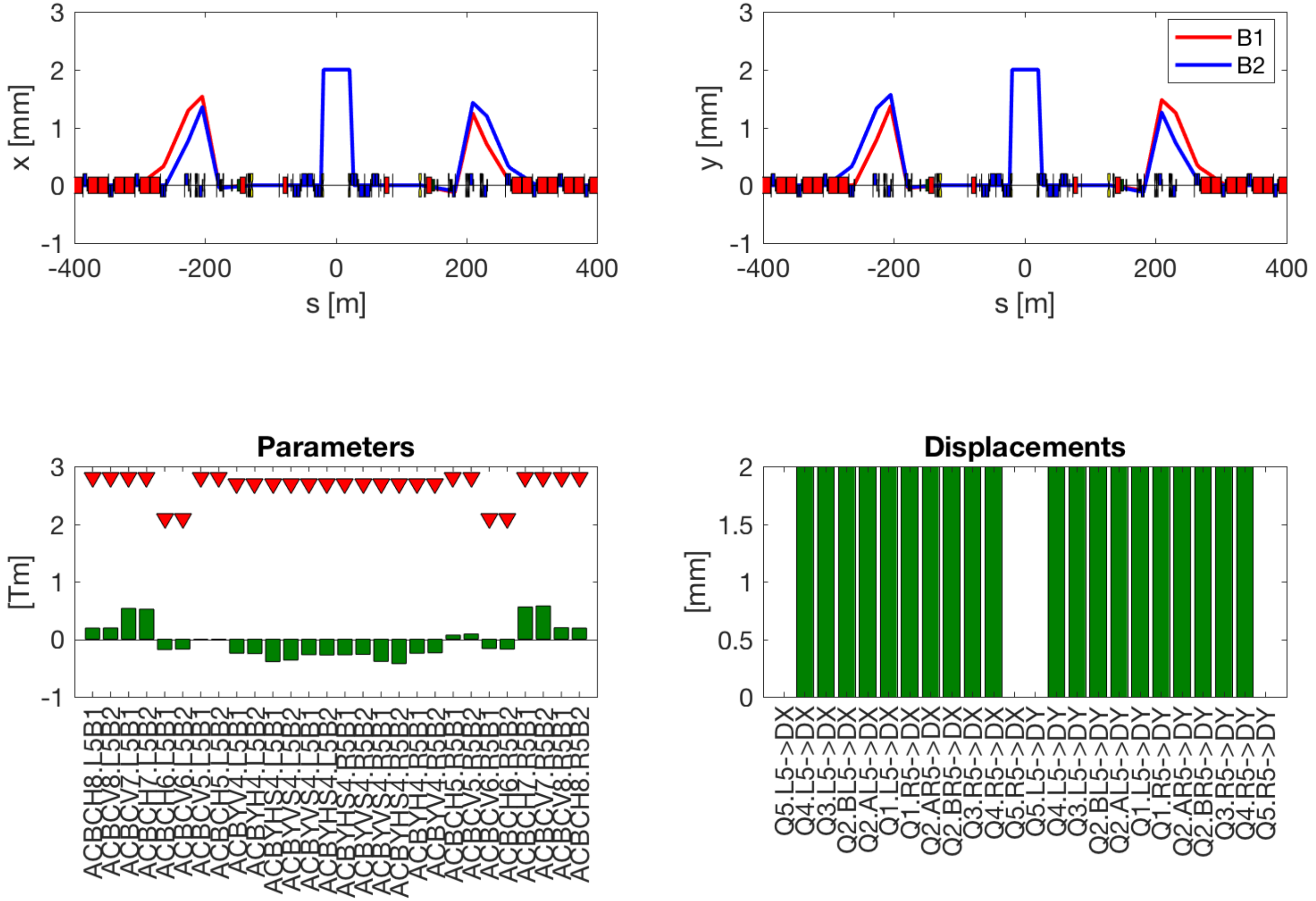
Summary of strengths with remote alignment

Knobs for:

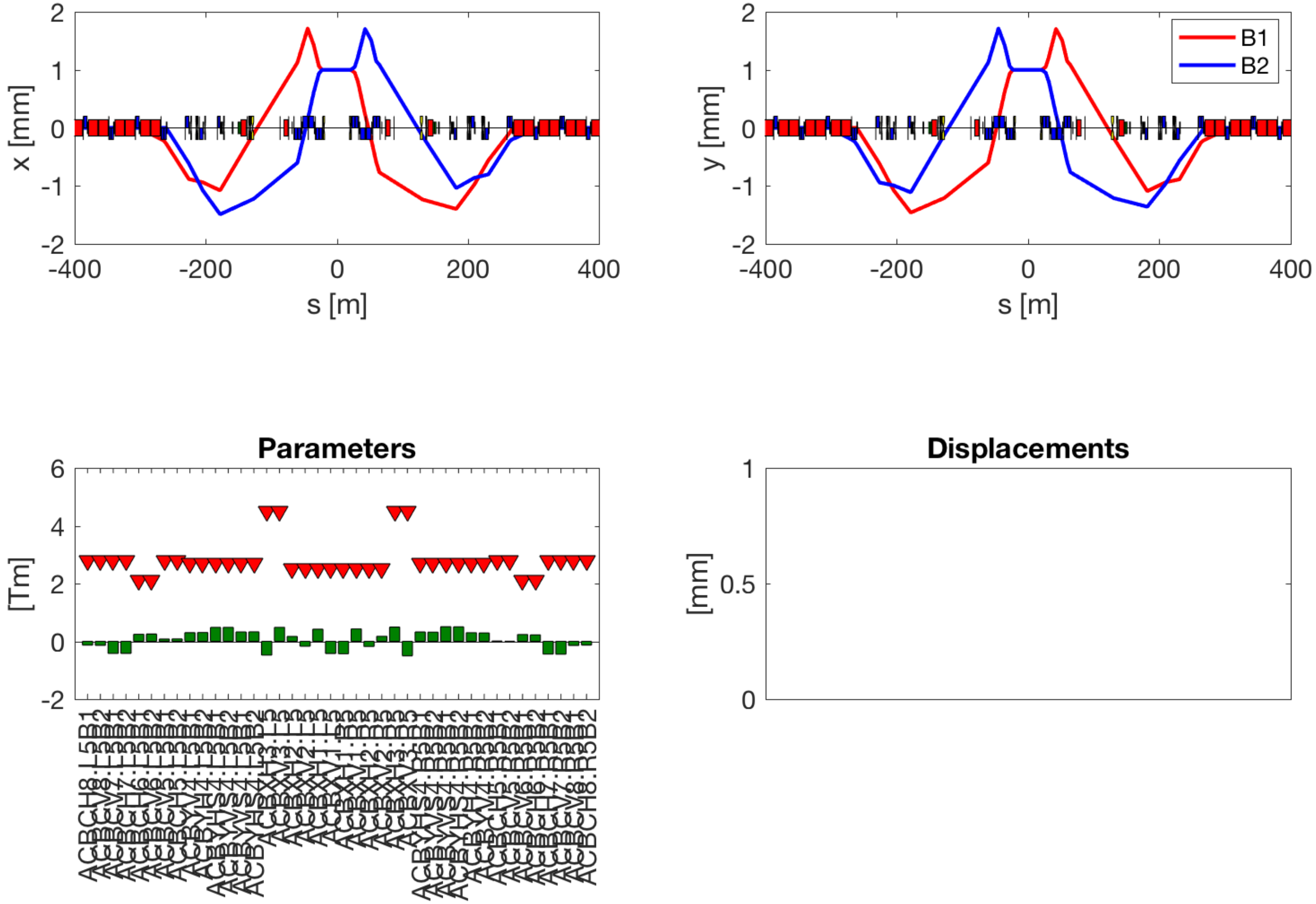
- ± 2 mm IP offset with correctors + Q1-Q4 displaced by 2 mm
- ±100 um IP movement independent for B1/B2 for lumiscan
- ±295 urad crossing angle in H plane
- ±0.75 mm separation in V plane
- ±500 um B1/B2 separation at CC
- ±500 um B1 and B2 orbit offset at CC
- ±1.2 mm of IP offset with correctors (fall-back for remote alignment loss of aperture)
-



IP offset with Q1-Q4 + correctors (+2 mm)

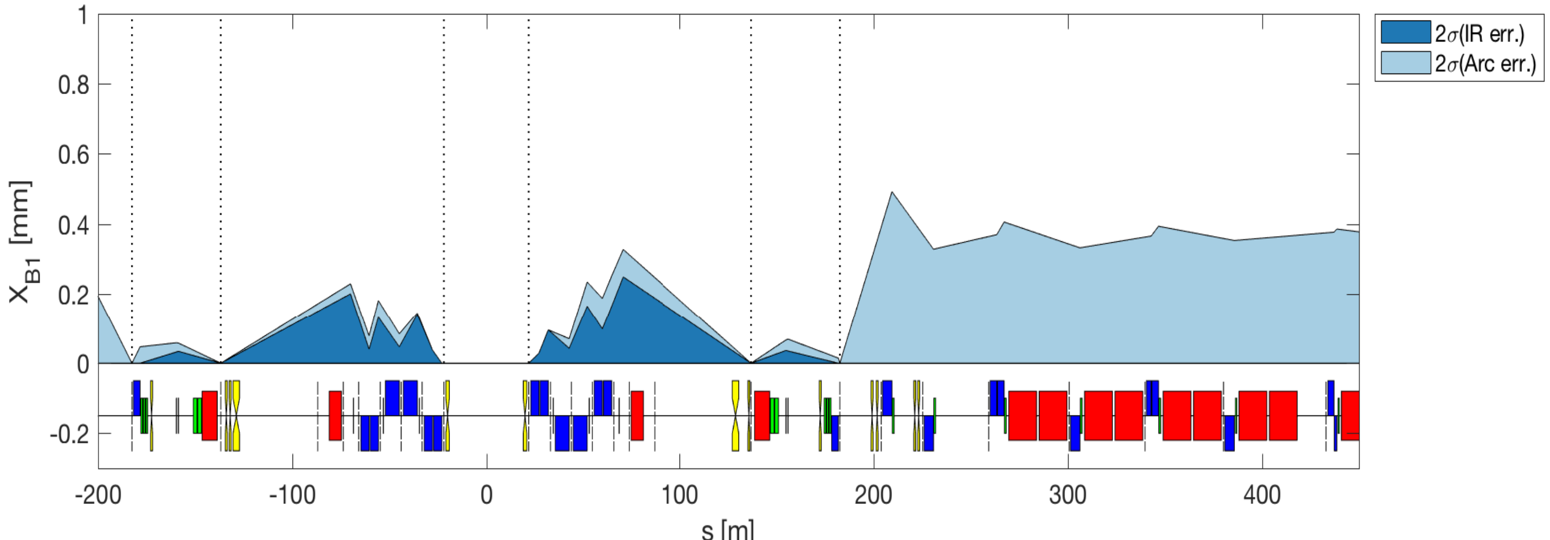


IP offset with correctors only (up to Q8) (+1mm)



Orbit corrected as usual at relevant BPMs

- Errors:
  - All square distributions
    - (i.e. if ±0.5 mm, then sigma = 0.5/sqrt(3) = 0.2887 mm)
  - Quadrupoles
    - ±0.5mm DX/DY, ~~±10mm DS, ±0.002 DKR1, ±1 mrad DPSI.~~
      - Presently considering only DX/DY on quadrupoles. Normally DS/DKR1/DPSI has minor impact.
      - To be repeated with "nominal" crossing condition.
  - Dipoles
    - ±10mm DS, ±0.002 DKR0, ±0.5 mrad DPSI.



Do not include BPM errors, but to be compared with 2 mm budget in aperture calculations.

IR4 optics actions from BI

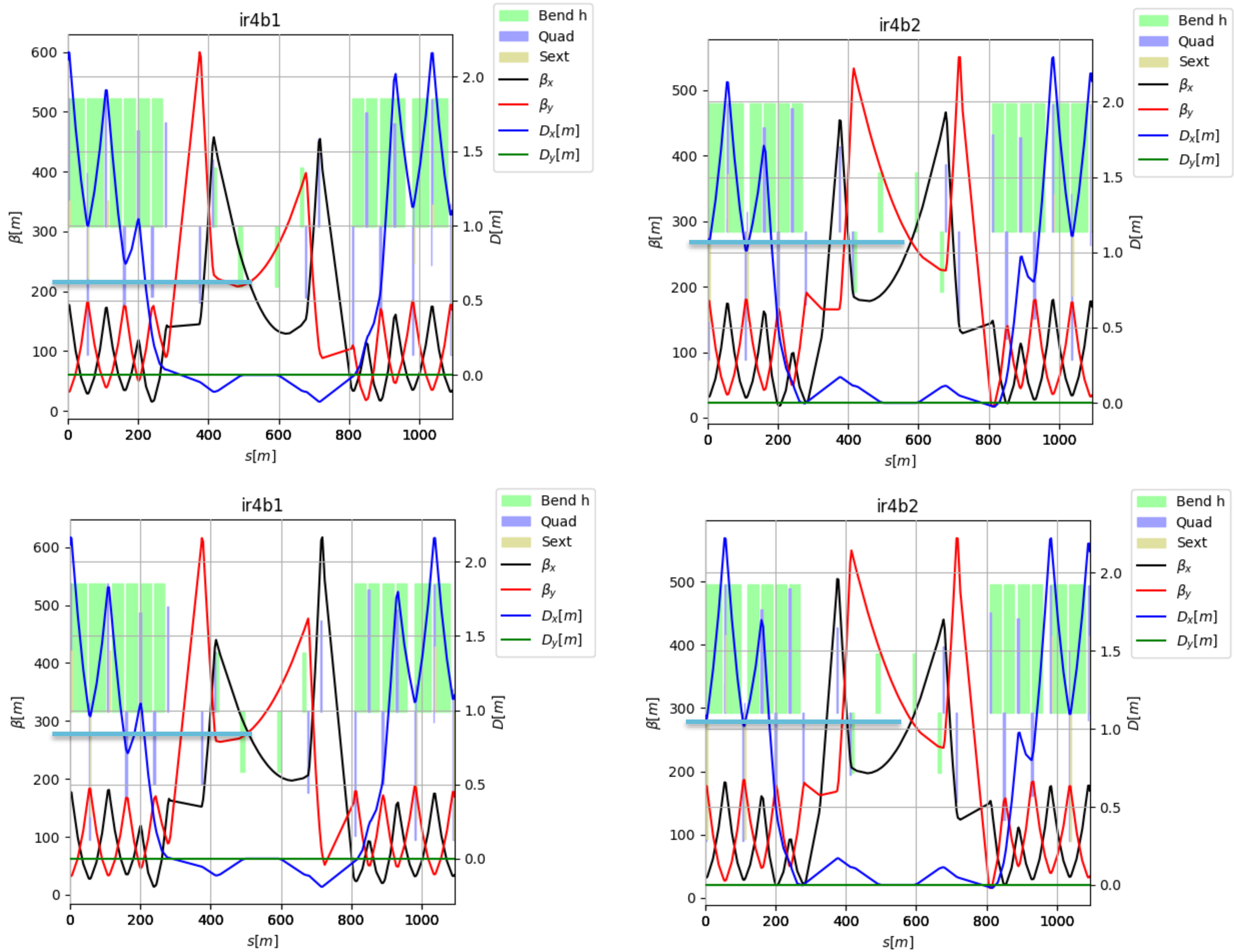
Follow-up from 115 WP2 meeting:

- Use improved injection optics without optics change during the ramp (for the time being)
- Increase the minimum beta at the BSRT above 200 m while keeping the beta at HEL bigger than 250 m.
- Reduce β-ratio between for Shottky monitors
- Study reducing the aperture of the HEL (below 50 mm)
- Optics parameters should be estimated at the location of BGV and new BSRT using the light from D4
- Implications of the issue with imbalance of currents on Q8.L4.B1
- Review BQK
- Provide dispersion correction in IR4 (on-going)

New IR4: No Optics changes during ramp

HL1.3

HL1.4



Increased beta and rounded in B1, more round in B2

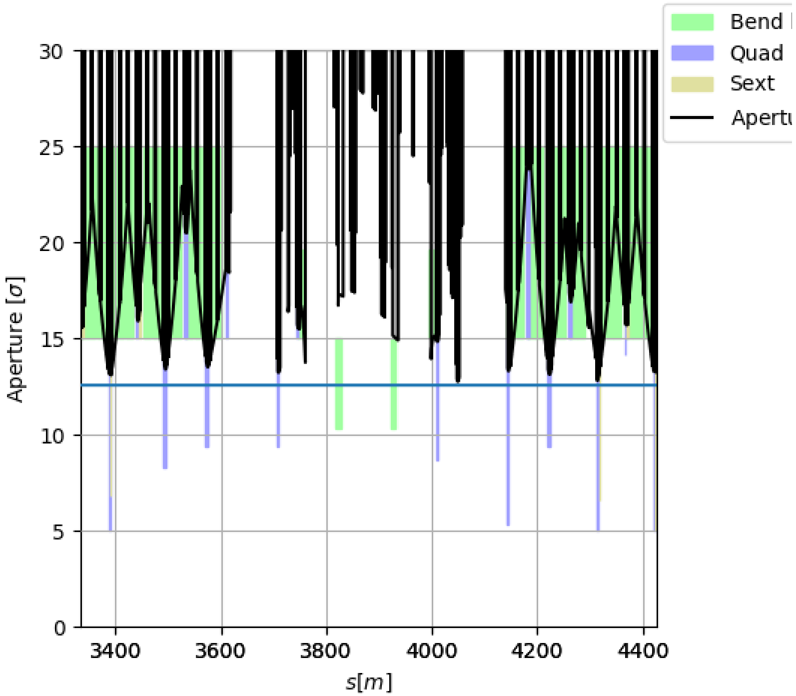
New IR4: No Optics changes

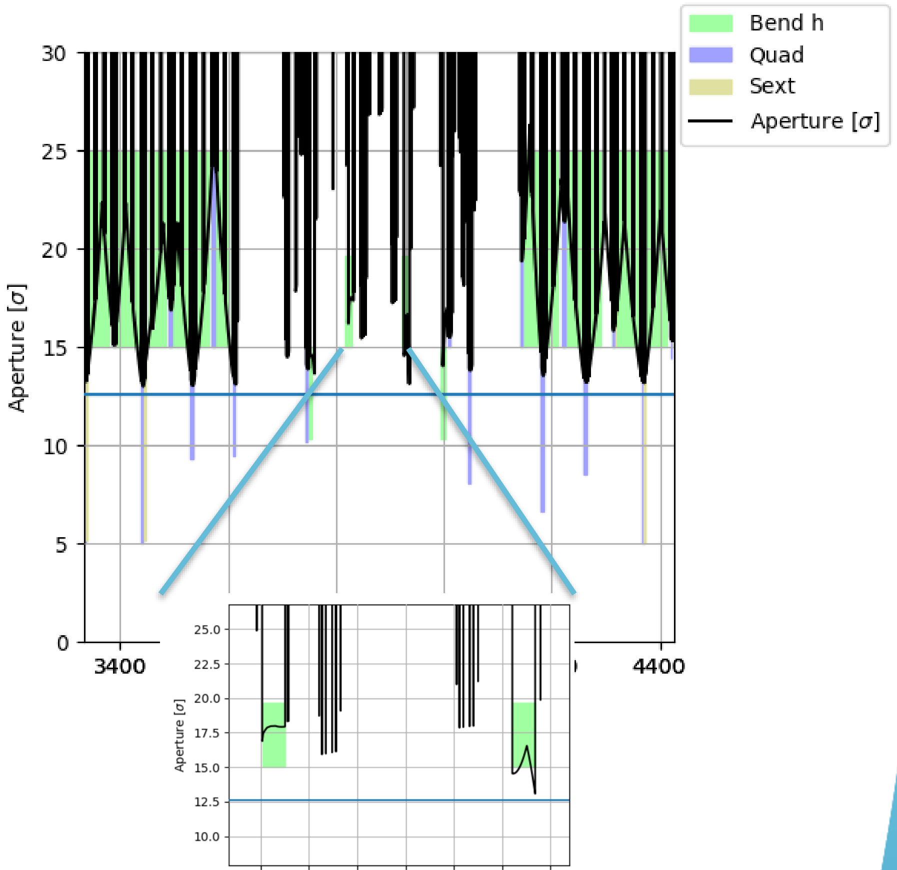
β_{xB1}/β_{yB1} β_{xB2}/β_{yB2}[m]	Pos.	HLLHC <=V1.3 (inj.)	HLLHC 1.4 Inj	LHC 1.4 Round 15cm
e-lens	D3	232/212/281/263	280/280/280/280	280/280/280/280
BSRT/I	D3	136/270/191/365	206/351/206/384	206/351/206/384
BGI	D3-4	279/208/321/245	314/270/314/262	314/270/314/262
WS	D3-4	130/320/178/435	197/402/197/453	197/402/197/453
BQSH	Q5-7	426/ 92/425/226	577/ 58/405/240	515/109/405/240
BQSV	Q5-7	142/371/130/491	201/451/124/506	201/451/ 76/559
BPLH1	Q5-7	400/135/420/256	543/117/396/270	481/165/387/276
BPLH2	Q5-7	403/ 89/431/165	543/ 51/479/168	492/104/432/230
BPLV	Q5-7	193/337/180/500	260/389/201/517	251/405/201/517
BQLV2	Q5-7	-/-/129/470	-/-/124/483	-/-/ 73/530
BPLX	Q5-7	277/234/296/356	375/246/280/371	346/283/251/397

Flat 30/7.5 cm and 18/7.5 cm optics are also possible.

- Work in progress to get a smooth squeeze:
  - issue with B1 for round squeeze (needs phase advance re-optimization
- Then analysis in Q5-Q7 can continue based on more realistic squeeze
  WP13 Meeting scheduled on 3/9 to discuss in more detail.

New IR4 Injection Optics





Aperture at injection above the target of 12.6 σ using HL-LHC aperture tolerances.

Aperture margin for e-lens available, to be evaluate with detailed drawings

IR6 TCDQ Constraints

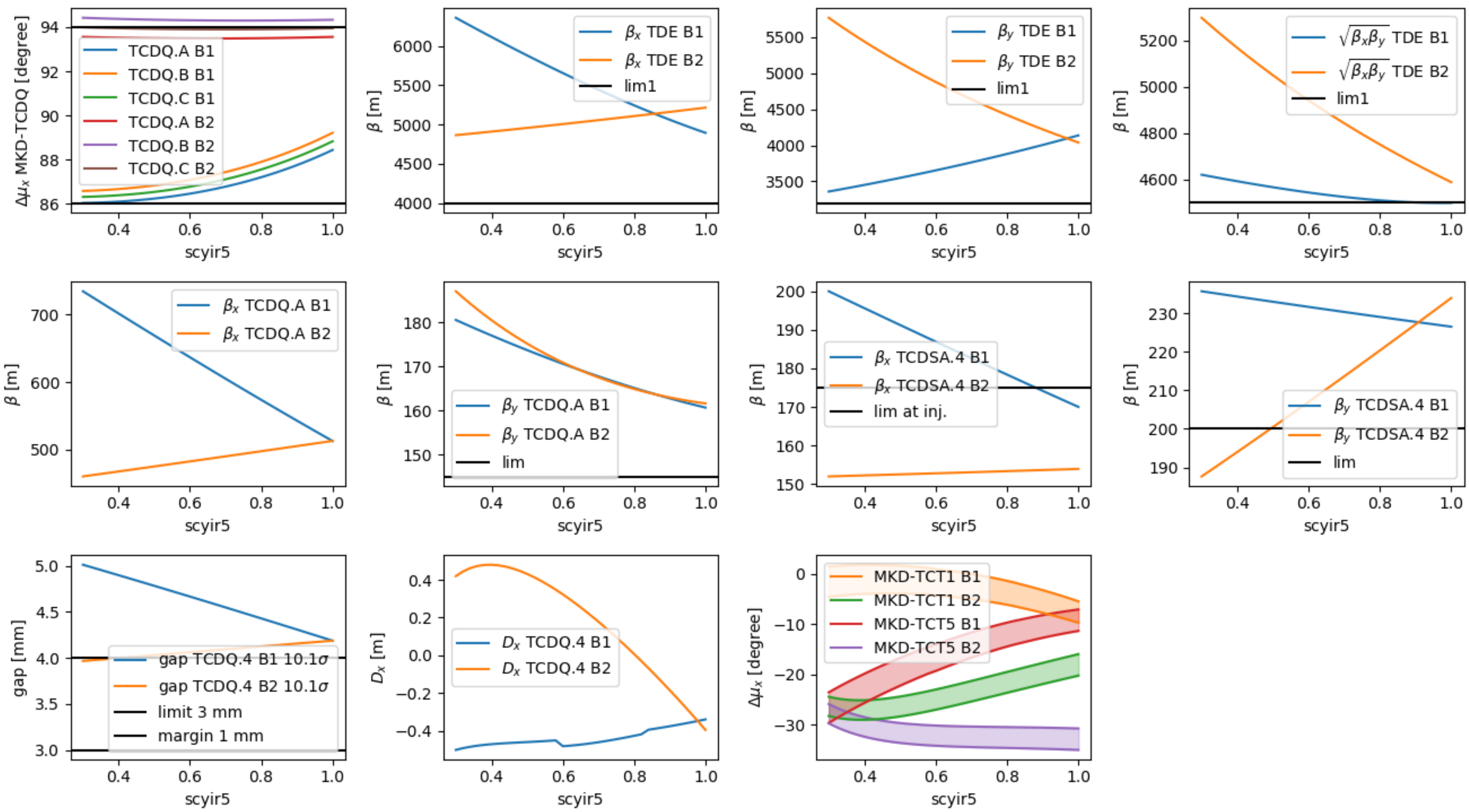
TCDQ gaps	Old [mm]	New[0] [mm]
Min real gap	3	3[1]
Interlock	1.2	0.8-0.5[2]
Position accuracy, β-beat	0.3	0.3
Dispersion δ =2e-4	0.4[3]	0.1[4]
Total margin	1.9	0.9-1.2

[0] Meeting WP2-WP5-WP14 23/1/2018
[1] Base on present FLUKA and ANSYS studies at 2.2 10^{11}. Lower for lower ppb?
[2] Based on studies with DOROS TCSP BPM. J.W. 0.5 mm in LCR3 meeting.
[3] Dx = 2 m very large
[4] Dx = 0.5 m should be sufficient

BETS: fixed gap at flat top in mm.
Implies gap chosen to be the one for the ideal setting (10.1 σ or +1 from TCS) at the end of the squeeze.
Settings HLLHC1.3:

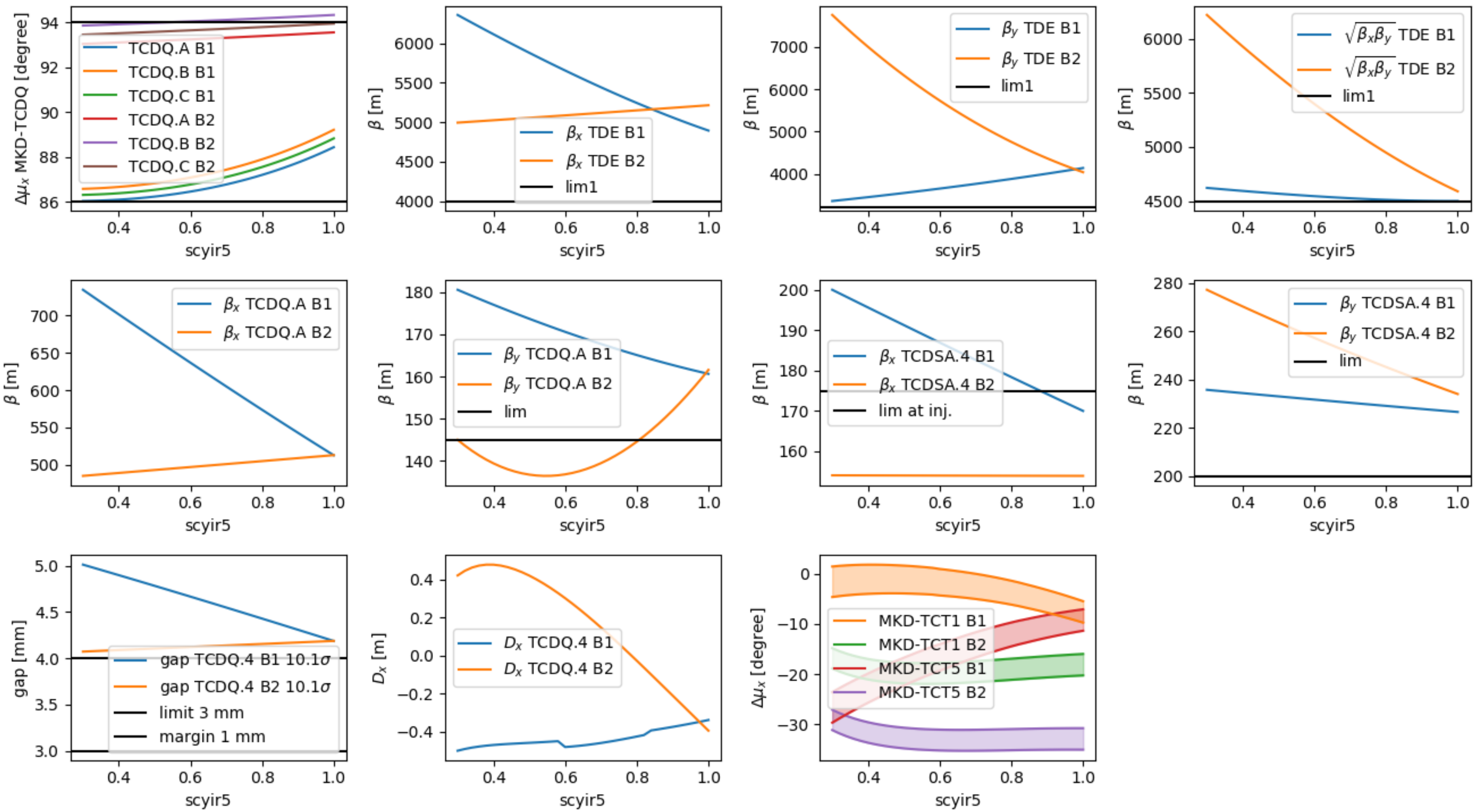
- Beam1: 5 mm: from 12.3σ →10.1 σ: β increases during the squeeze
- Beam2: 3.9 mm: from 9.6 σ → 10.1 σ. β decreases during the squeeze

Round



Possible improvement: increase TCDQ gap in B2

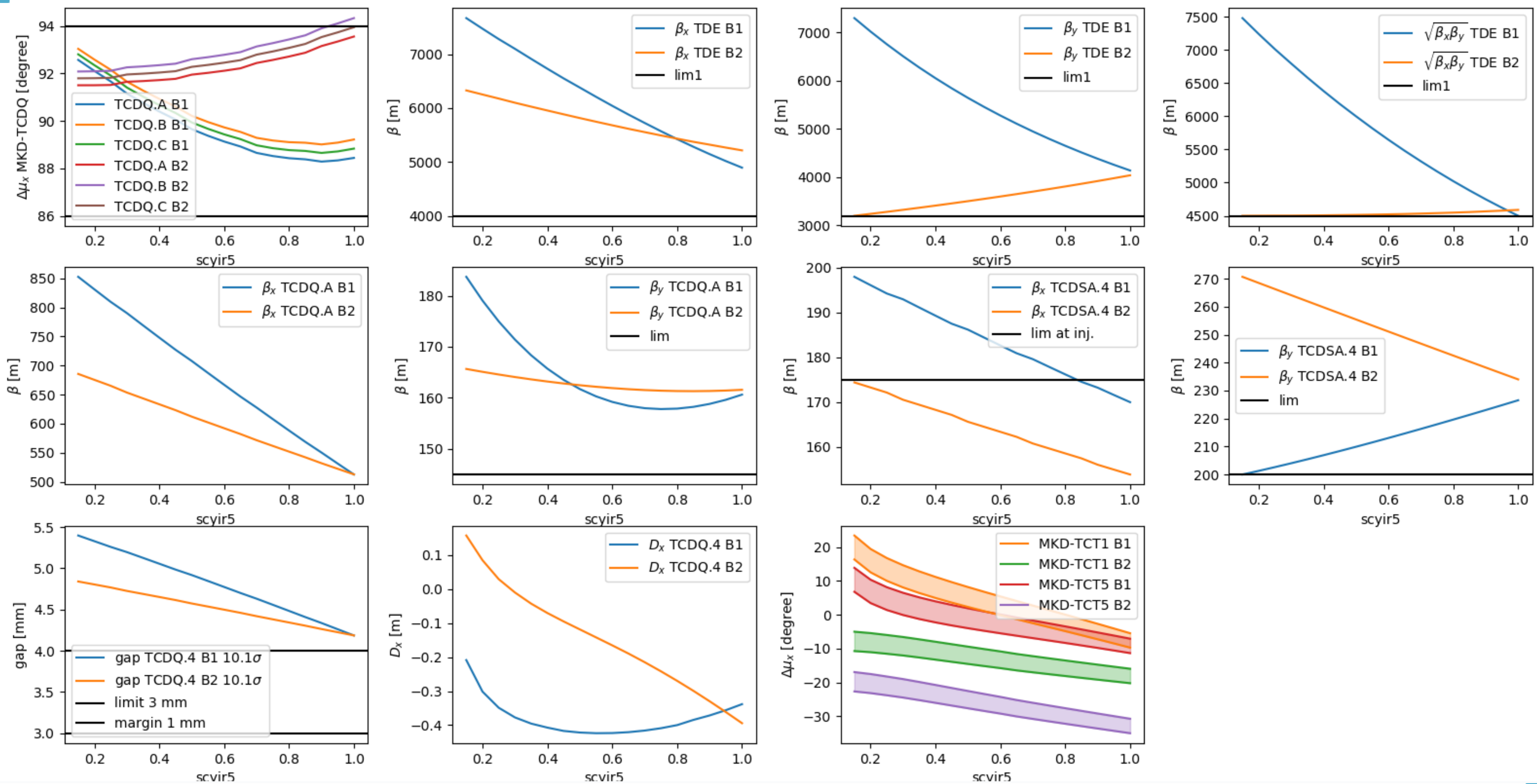
Round (V2)



Possible improvement: increase TCDQ gap in B2.

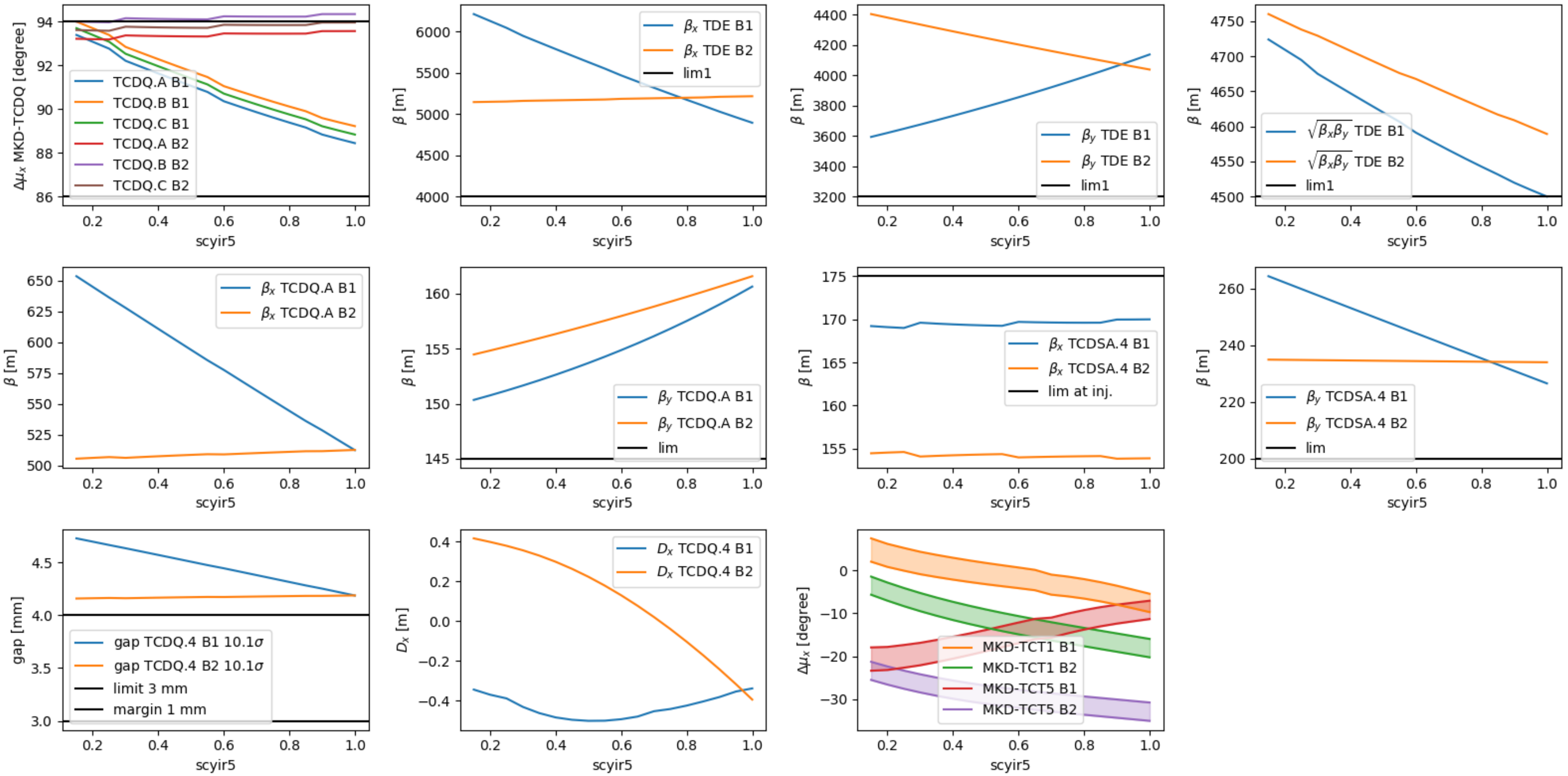
Important to know if we need to increase the gap during the ramp.

Flat (7.5/30 cm)



MKD-TCT1 could be further improved, not strictly needed.

FlatCC (7.5/18 cm)



IR6 Current

- Latest measurements, LMC 21/3/2018, A. Ver

	Current [A]	Gradient [T/m]
Nominal	3610	160.0
Ultimate	3900	172.8
SS Limit 4.5K	4200	186.1
SS Limit 1.5K	5800	257.0
Training	3950	175.0

	HLLHCV1.4 @ 7TeV		
	Round	FlatCC	Flat
β* Xing/Sep [cm]	15/15	18/7.5	30/7.5
Q5.L6 [T/m]	163/165	160/167	148/171
Q5.R6 [T/m]	159/151	160/150	161/147

Few T/m reduction w.r.t HL1.3 in particular for Q5.R6

NoMs14 branch to be done.

One needs to add 1% margin for optics correction + 50 amps.
7.5 TeV operation should guaranteed for Run V.

Aperture Margins: Round 15 cm, 10.5 σ

	Bare	Mech	Beam	Crab	Offset
TAXS	25.1	22.6	18.5	18.5	16.3
MQXFA.[AB]1	22.1	20.5	17.4	17.4	16.2
MQXF[AB]..[23]	16.5	15.5	13.2	13.1	12.0
MBXF	17.2	16.3	13.9	13.7	12.9
TAXN	22.9	21.6	18.4	17.9	16.2
MBRD	25.6	22.7	19.0	18.1	15.5
MCBRD	26.9	24.0	20.1	19.1	16.3
TCLMB.4	25.3	23.0	18.8	17.9	14.5
MCBY[HV].[AB]?4	26.6	24.3	19.9	18.8	15.3
MQY.4	29.0	26.8	22.0	21.0	17.3
TCLMB.5	36.1	33.9	28.3	28.2	24.8
MCBY[HV].[AB]?5	37.3	35.2	29.4	29.3	26.2
MQY.5	39.2	37.1	31.0	31.0	27.9
TCLMC.6	36.6	34.2	28.0	28.0	25.5
MCBC[HV].6	37.7	35.5	29.0	29.0	26.4
MQML.6	38.1	35.4	29.0	29.0	26.8

Aperture in σ at 2.5 μm/γ at 7 TeV

θ_c= ± 250 μrad;
d_{sep}= ± 0.0 mm;

Bare: best possible aperture, everything nominal
Mech: aperture reduce due to mechanical tolerance, ground motion and fiducialization,
Beam: beam imperfection introduced
Crab: Orbit adjustment at CC with orbit correctors
Offset: IP Shift with orbit correctors. Not applicable to with R.A. from Q1 to Q4.

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Aperture Margins: Flat 18/7.5 cm, 11.3 σ

θ_c= ± 240 μrad; d_{sep}= ± 0.0 mm;

	Bare	Mech	Beam	Crab	Offset
TAXS	21.0	19.1	15.8	15.8	14.0
MQXFA.[AB]1	19.4	18.2	15.7	15.7	14.8
MQXF[AB]..[23]	15.4	14.7	12.7	12.6	11.8
MBXF	15.7	15.0	13.0	12.8	12.3
TAXN	18.1	17.1	14.6	14.3	13.0
MBRD	19.4	17.6	15.0	14.5	13.0
MCBRD	21.3	19.3	16.4	15.9	14.1
TCLMB.4	18.0	16.4	13.4	12.7	10.4
MCBY[HV].[AB]?4	19.0	17.3	14.1	13.4	10.9
MQY.4	20.5	19.0	15.5	14.8	12.2
TCLMB.5	25.5	24.0	20.0	19.9	17.7
MCBY[HV].[AB]?5	26.4	24.9	20.8	20.7	18.5
MQY.5	27.7	26.3	21.9	21.9	19.8
TCLMC.6	26.0	24.3	19.8	19.8	18.0
MCBC[HV].6	26.9	25.2	20.6	20.6	18.8
MQML.6	27.0	25.1	20.5	20.5	19.0

Aperture could still improve if ground motion tolerances and BPM accuracy improve.

TAXN few mm reduction possible:
evaluate impact in energy deposition studies

Aperture in σ at 2.5 μm/γ at 7 TeV

Protected Apertures

$\Delta\mu_x$ MKD-TCT [°]	Aperture [σ@2.5μm]
0-20	11.2
30	11.9
40	12.9
50	13.8
60	14.5
70-90	14.6
No TCT	19.4
Injection	12.6

Parameter	7 TeV	0.45 TeV
Radial CO [mm]	2	
Mom offset	$2\ 10^{-4}$	
Dispersion	0.1	
Beam size	1.1	1.025

In addition there is:

- Ground motion and fiduciliaztion ~2.5 mm
- Shape tolerances ~1-3 mm

Depends on the equipment and it is being reviewed with ossible gains.

R. Bruce et al. CERN-ACC-2017-0051

Figure of merit of optics options

	Baseline HL1.3			No MS10/14F HL1.3		
	Round	FlatCC	Flat	Round	FlatCC	Flat
β* Xing/Sep [cm]	15/15	18/7.5	30/7.5	15/15	18/7.5	30/7.5
Xing angle [μrad]	±250	±240	±245	±250	±240	±245
Max MSD Current [A]	550	550	550	580	580	580
TCDQ gap[1)] B1/B2 [mm]	5.0/4.0	4.7/4.2	5.4/4.8	4.2/4.0	4.3/4.2	3.9/4.3
Q5.L6 [T/m]	163	167	175	162	170	174
Q5.R6 [T/m]	159	166	165	164	170	168
MKD-TCT5 [°]	30	27	27	36	33	31
Protected H[2)] Ap. P5 [σ]	11.9	11.8	11.8	12.5	12.2	12
Protected V[2)] Ap. [σ]	10.4-11.2	10.4-11.2	10.4-11.2	10.4-11.2	10.4-11.2	10.4-11.2
Crossing plane	V or H	H	H	V or H	H	H
Aperture[3)] Xing [σ]	13.2/12.0	14.2/10.4	15.6/10.4	13.2/11.9	14.2/10.4	15.6/10.4
Aperture[3)] Sep [σ]	16.5/14.5	12.7/10.3	12.9/10.4	16.5/14.4	12.7/10.3	12.9/10.4

1) 3 mm minimum gap assumed (C. Bracco 5.2 mm requested)
2) assuming different settings for TCTH and TCTV, which is under study (R. Bruce)
3) with/without fully remote alignment

Figure of merit of optics options

	Baseline HL1.4			No MS10/14F HL1.3		
	Round	FlatCC	Flat	Round	FlatCC	Flat
β* Xing/Sep [cm]	15/15	18/7.5	30/7.5	15/15	18/7.5	30/7.5
Xing angle [μrad]	±250	±240	±245	±250	±240	±245
Max MSD Current [A]	550	550	550	580	580	580
TCDQ gap[1)] B1/B2 [mm]	5.0/4.0	4.7/4.1	4.7/4.5	4.2/4.0	4.3/4.2	3.9/4.3
Q5.L6 [T/m]	165	167	171	162	170	174
Q5.R6 [T/m]	159	160	161	164	170	168
MKD-TCT5 [°]	30	22	25	36	33	31
Protected H[2)] Ap. [σ]	11.9	11.4	11.7	12.5	12.2	12
Protected V[2)] Ap. [σ]	10.4-11.2	10.4-11.2	10.4-11.2	10.4-11.2	10.4-11.2	10.4-11.2
Crossing plane	V or H	H	H	V or H	H	H
Aperture[3)] Xing [σ]	13.2/12.0	14.2/10.4	15.6/10.4	13.2/11.9	14.2/10.4	15.6/10.4
Aperture[3)] Sep [σ]	16.5/14.5	12.7/10.3	12.9/10.4	16.5/14.4	12.7/10.3	12.9/10.4

1) 3 mm minimum gap assumed (C. Bracco 5.2 mm requested)
2) assuming different settings for TCTH and TCTV, which is under study (R. Bruce)
3) with/without fully remote alignment

Free choice of crossing plane:
HV give more margin for round, but strongly limits FlatCC

Preview Next steps

To release version 1.4:

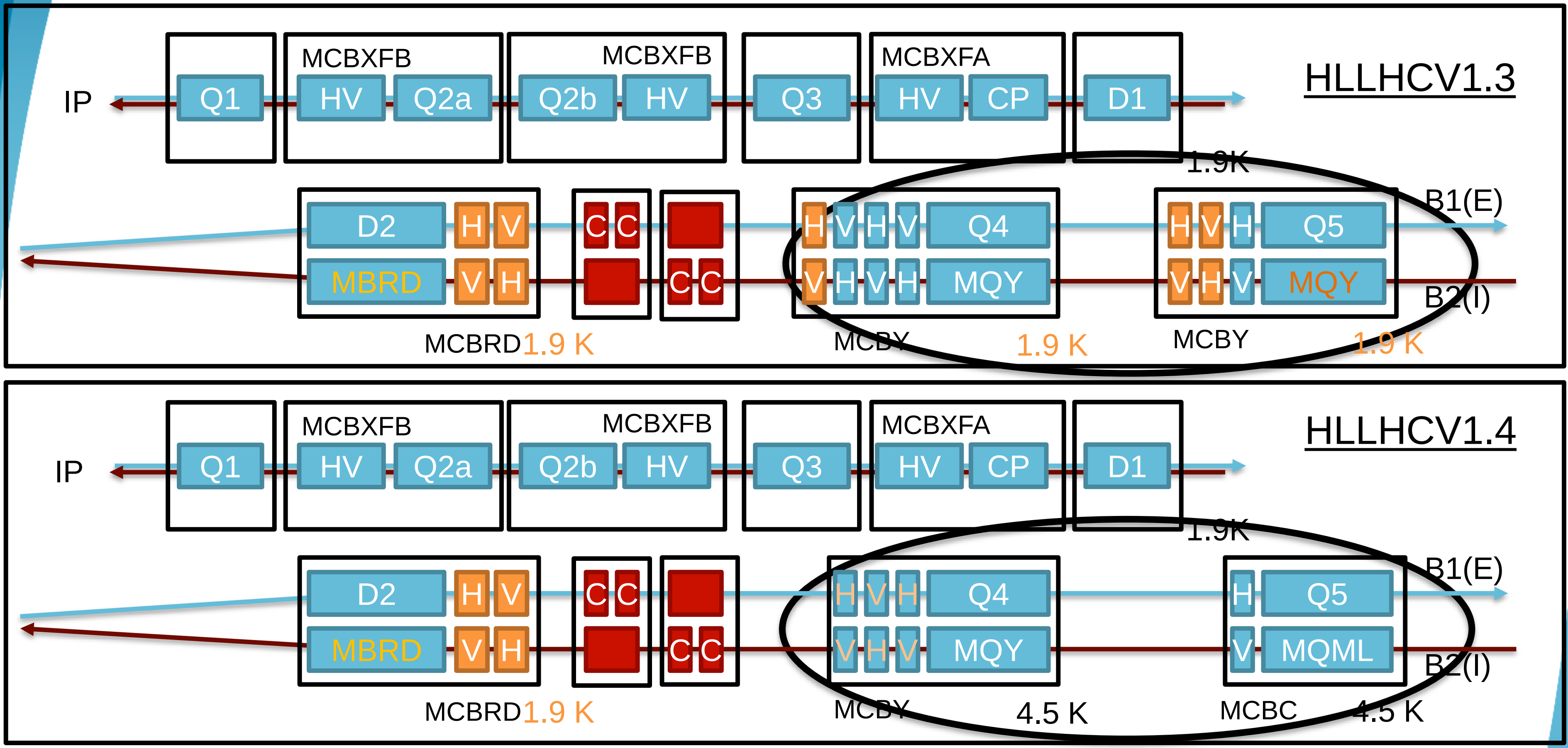
1. Decision or study new position for Q4/Q5 for cryogenic integration. [Done]
2. Decision on how to gain 30 cm in between D2/crab cavities. [Done]
3. Consistency check between drawings and optics model. [On going]
4. Optimization crossing schemes and other orbit bumps. [Done]
5. Finalization IR6 optics and IR4 optics. [On going]
6. Freeze mechanical, ground motion, fiduc. tolerances. [On going]
7. Computation aperture margins and phase advance tunability. [On going]
8. Evaluation/choice of crossing planes. [On going]

Studies in parallel:

- Study optics at 7 TeV with ultimate currents in Q7 (more urgent if we want to ask for an hardware test at the end of the run). [Done]
- Update MS10 branch and follow-up of the DA studies. [On Going]
- Optics optimization for forward physics. [On Going]

Backup

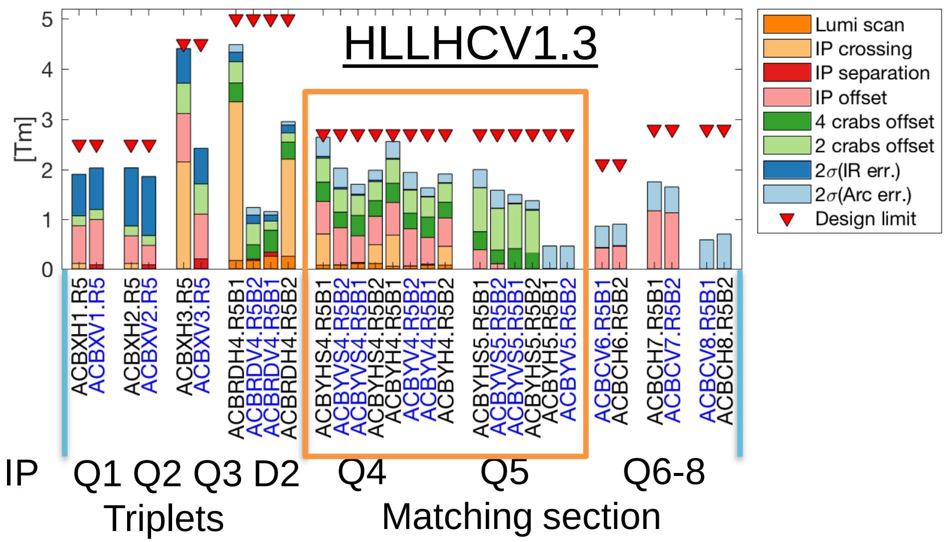
Layout changes



Changes with respect to the baseline:

- Q4: reusing existing cold mass (3 correctors instead of 4), no need of 1.9 K.
- Q5: reusing existing Q5 cold mass (1 corrector instead of 3), no need of 1.9 K.
- Full deployment of remote alignment system to be used with safe beam.

Orbit corrector strength budget



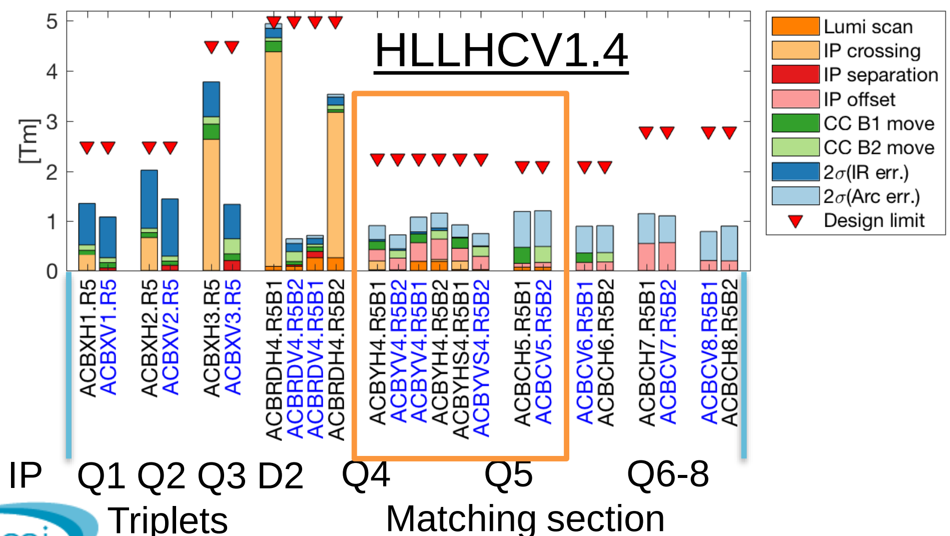
Right Point 5, H crossing.

The following symmetries apply:

- Left B1 -> Right B2,
- Left B2 -> Right B1
- H Point 5 -> V Point 1

HLLHCV1.4:

- orbit bumps reduced at the crab cavities
- IP offset performed by remote alignment
- Limited crab beam adjustment still possible



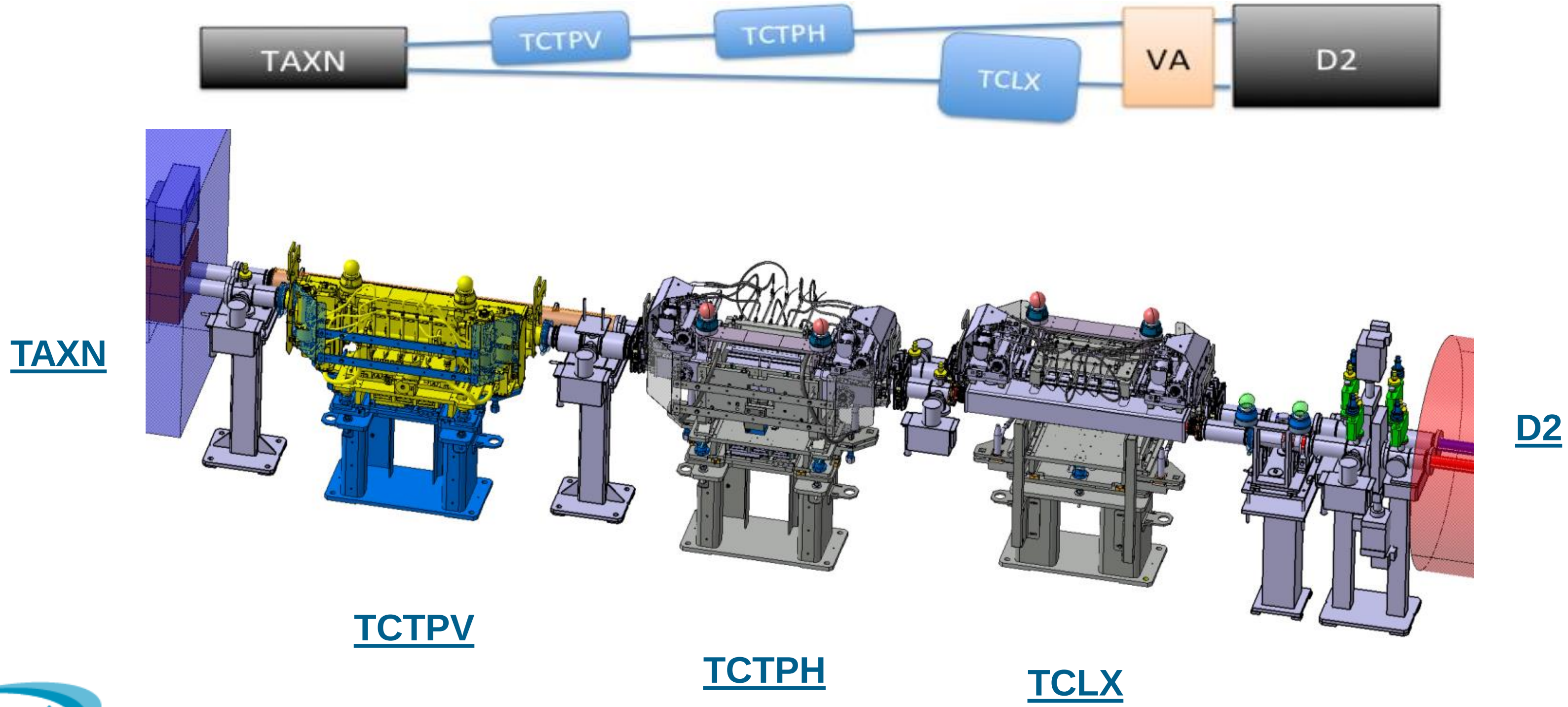
Crossing: ±295 μrad
Separation: ±0.75 mm
IP Offset: ±2.0 mm with re-alignment
Luminosity scan: ±100 μm
Crab knobs: ± 0.5 mm (baseline only)
Imperfection (2σ): from uniform distribution of mainly ±0.5 mm quad. alignment and 0.5 mrad / 20 units dipole errors.

HiLumi HL-LHC PROJECT

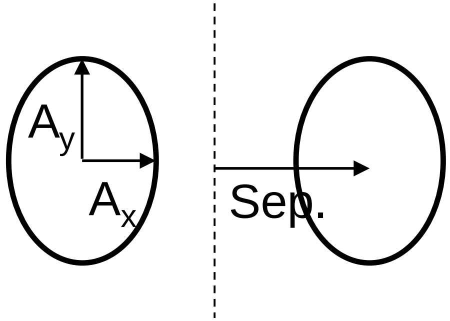
TCLX – TCPH issues in HLLHC

- Beam size in between TAXN – D2 is much larger than LHC due to lower β* and D2 closer to the triplet, beam separation smaller than LHC because D1 – D2 distance is shorter.
- TCLX needs thicker internal jaw to provide dose protection to D2

-> Larger stroke in less space.

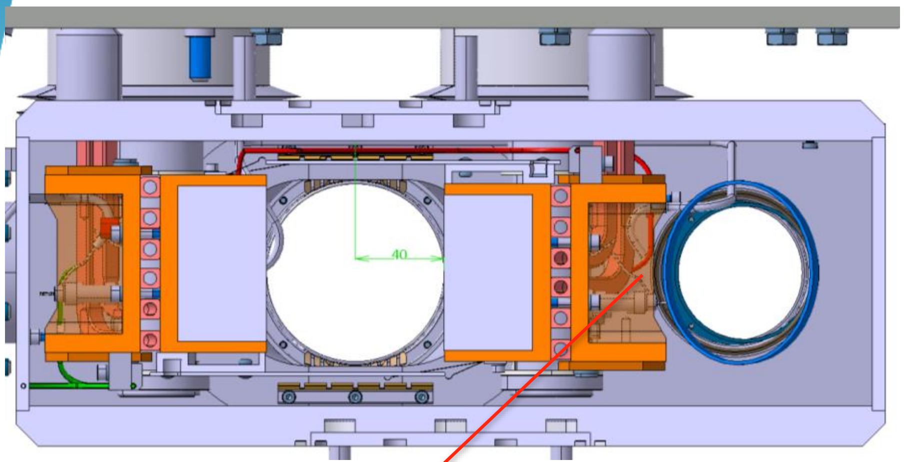


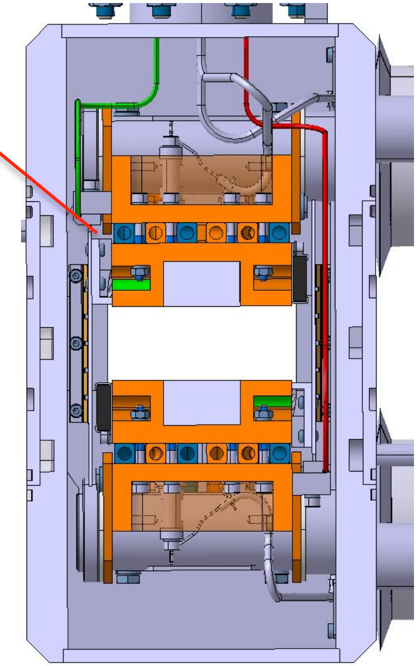
TCL-TCT Aperture specifications

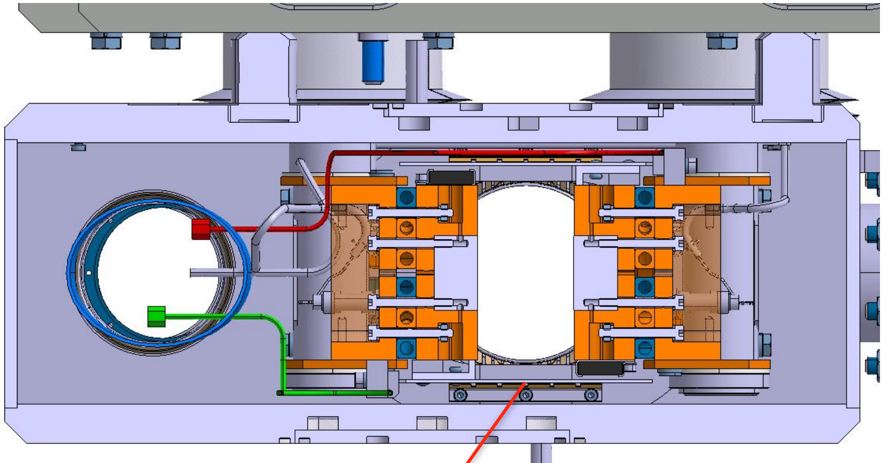


Offset (X,Y)	Baseline		Remote alignment		
Ground Motion + Fiduc.	~2 mm		~0.5 mm		
Orbit Error + crab adj.	2.5 mm		2.5 mm		
Collimator stroke	15 σ + 10 % (β-beat)		15 σ + 10 % (β-beat)		
Protected aperture	12 σ + 10 % (β-beat)		12 σ + 10 % (β-beat)		
2 mm IP shift	With orbit correctors		With re-alignment		
Round 15 cm	**A_x [mm]**	**A_y [mm]**	**A_x [mm]**	**A_y [mm]**	**Sep. [mm]**
TCLX	36.4	27.9	31.9	26.1	86.0-87.5
VTCLX	28.0	36.4	26.1	31.9	86.0-87.5
TCTPH	28.5	37.1	26.5	32.7	83.4-84.9
VTCTPH	37.0	28.1	32.5	26.4	83.4-84.9
TCTPV	28.9	38.0	26.9	33.7	80.4-81.9
VTCTPV	38.1	28.7	33.7	26.9	80.4-81.9
Flat 7.5/18 cm	**A_x [mm]**	**A_y [mm]**	**A_x [mm]**	**A_y [mm]**	**Sep. [mm]**
TCLX	42.8	33.8	38.3	32.0	86.0-87.5
VTCLX	33.9	42.9	32.1	38.4	86.0-87.5
TCTPH	34.2	43.5	32.3	39.1	83.4-84.9
VTCPTH	43.3	34.0	38.8	32.2	83.4-84.9
TCTPV	34.5	44.3	32.6	39.9	80.4-81.9
VTCTPV	44.2	34.5	39.8	32.5	80.4-81.9

New design proposal







	Stroke	Chamber
TCLX	40 mm	65/80 mm
TCTPH	32.5 mm	80/65 mm
TCTPV	40 mm	n/a

Remote alignment meeting, L. Gentini, 31/5/2018

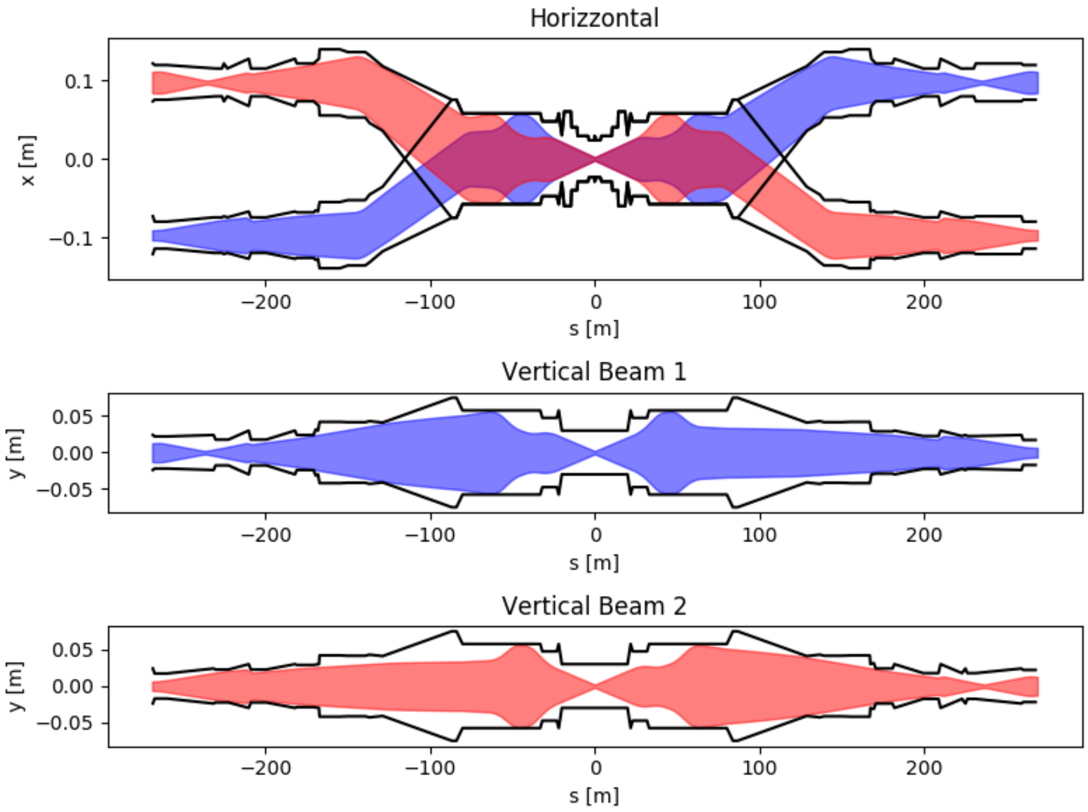
Aperture for vacuum layout

WP12 asked beam envelope without mechanical, alignment and fiducialization tolerances to specify vacuum apertures.
The request inverts the typical work flow because mechanical, alignment and fiducialization are not finalized.

Recipe given:

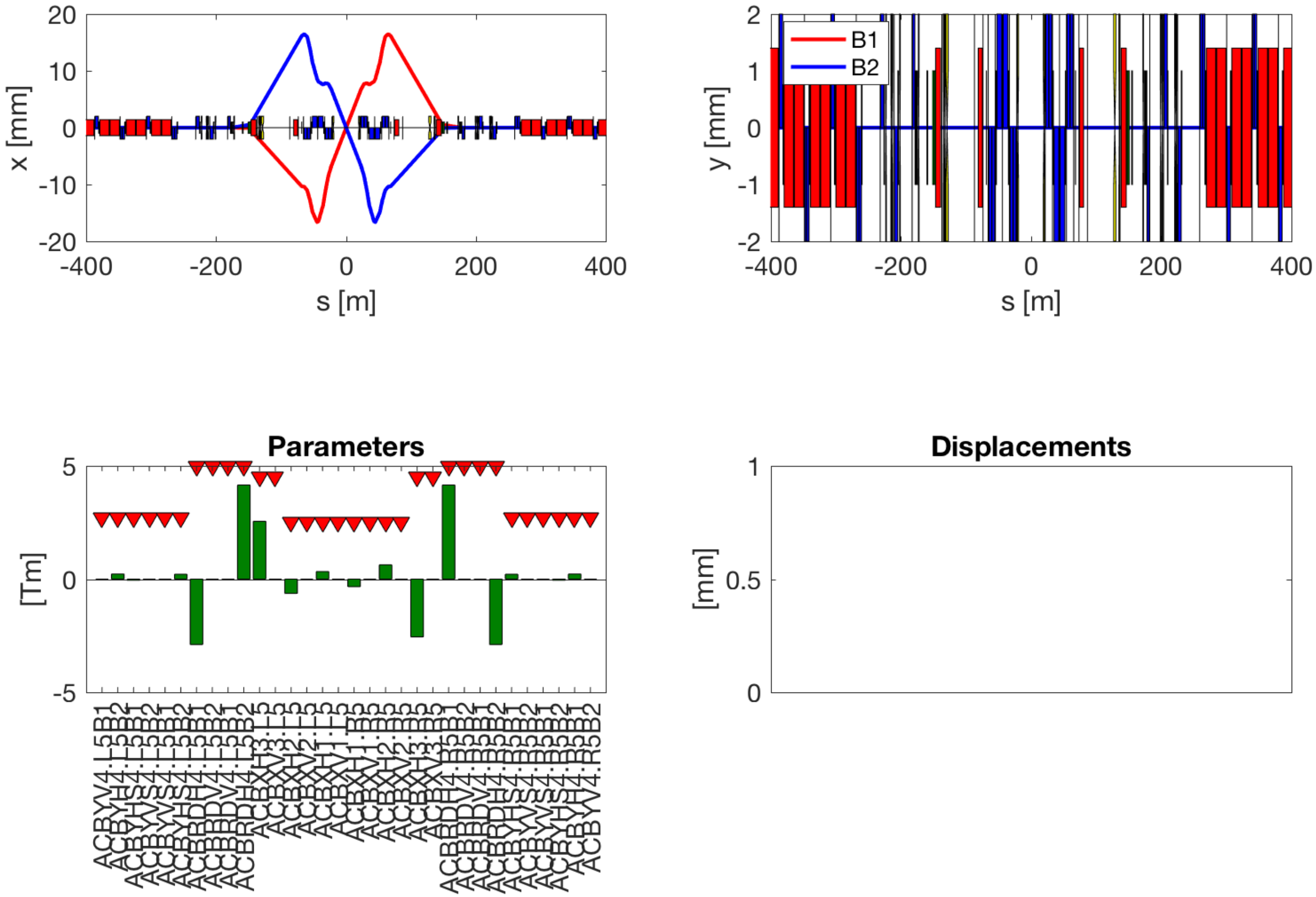
Beam stay clear =
$1.1\, n_\sigma\, \sigma_{nominal} + 2$ mm
where:
$n_\sigma = 13.25$ up to D1
$n_\sigma = 15$ TAXN-Q5
$n_\sigma = 20$ sigma Q6 to Q7.

In addition, new vacuum aperture should always have larger margins than those found in the triplet.
Table available here.

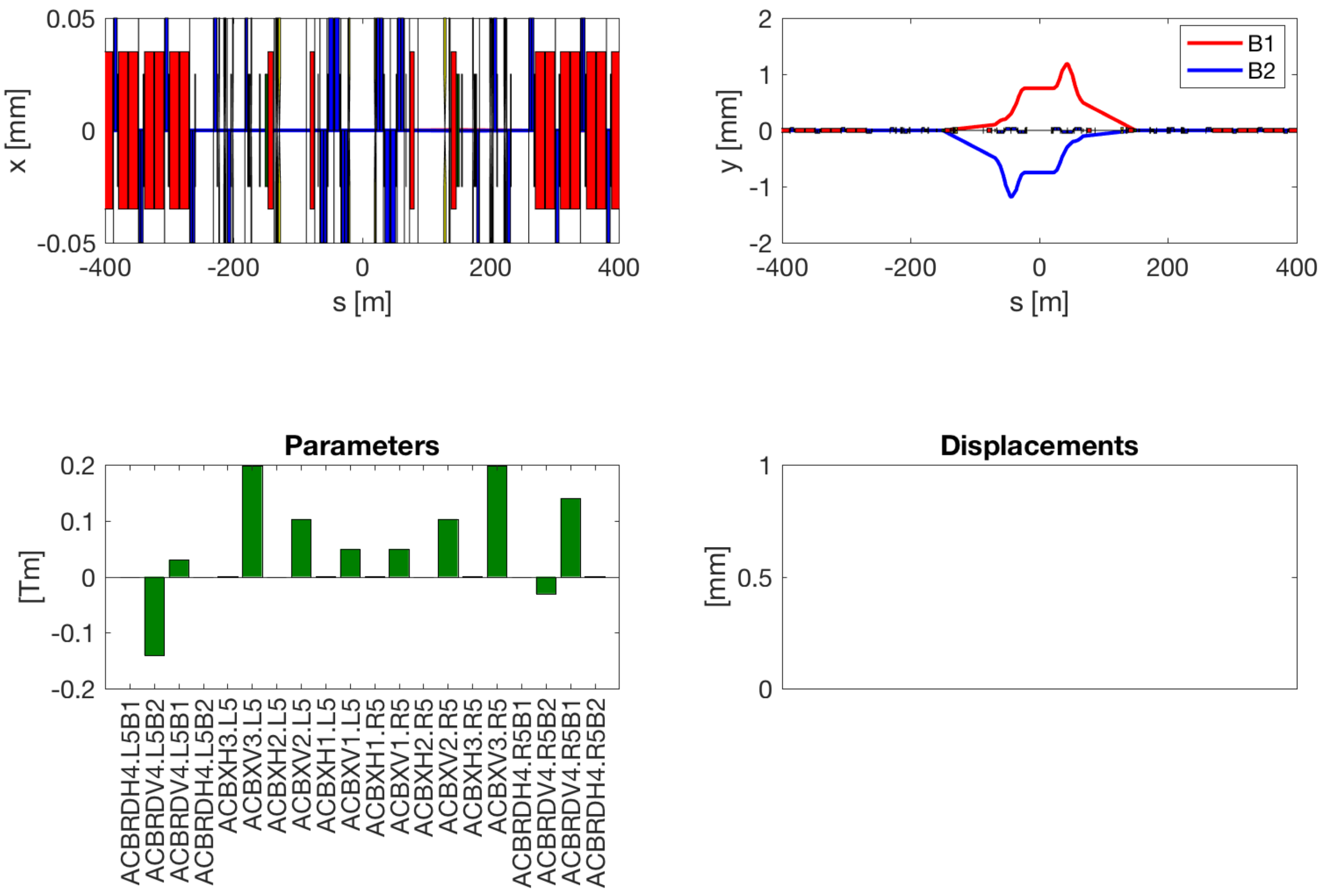


Consistent with present hardware and avoid additional aperture bottleneck.

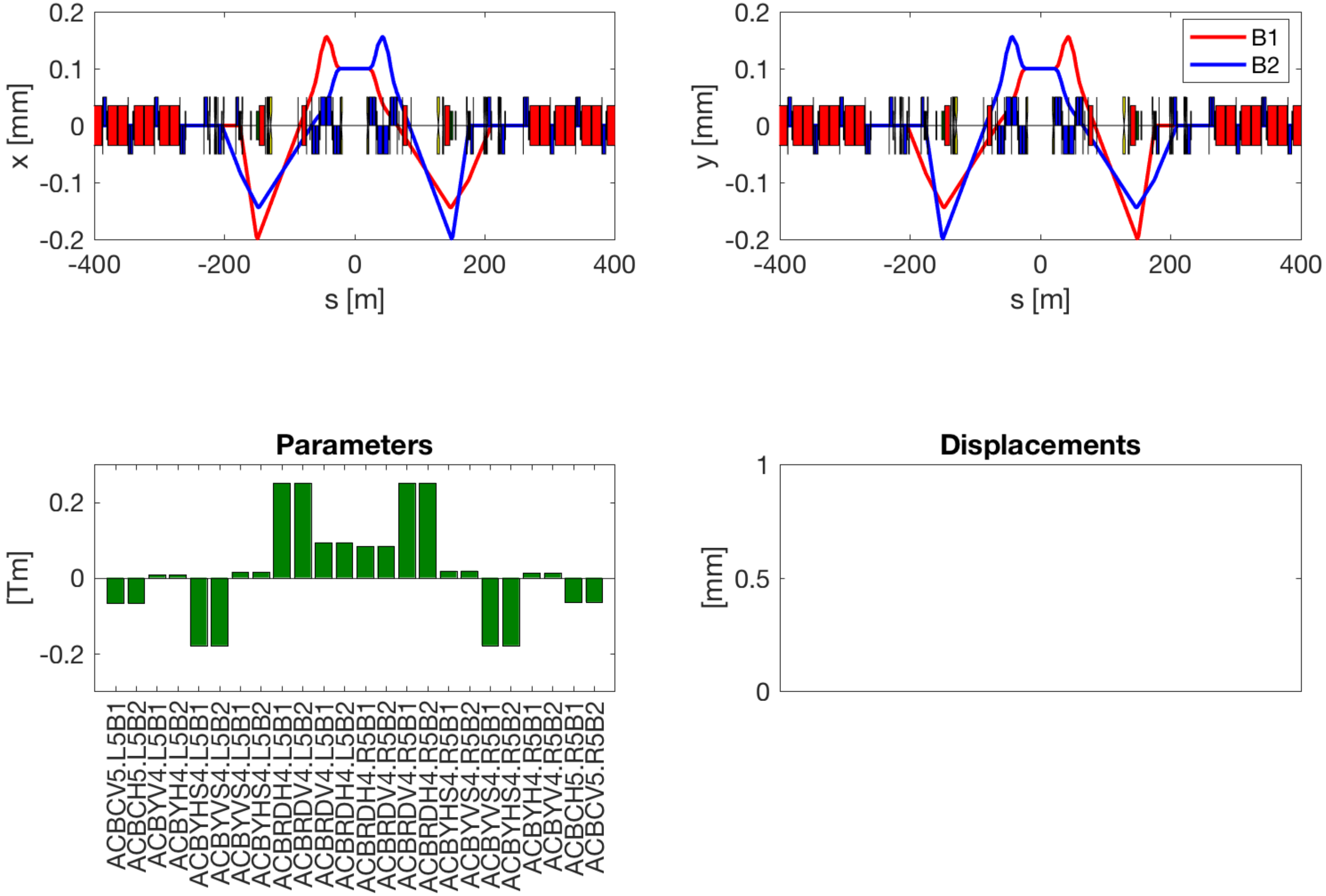
IP crossing (+-295 urad)



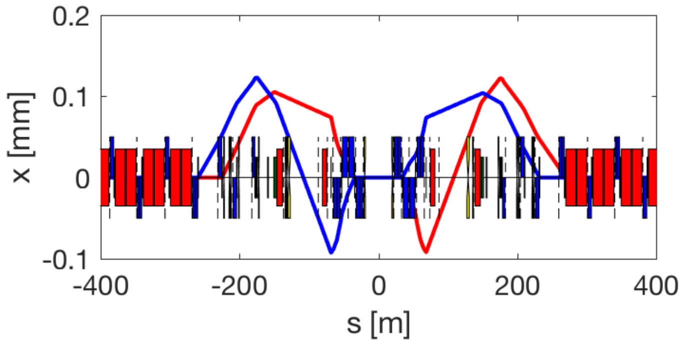
IP separation (+- 0.75 mm)

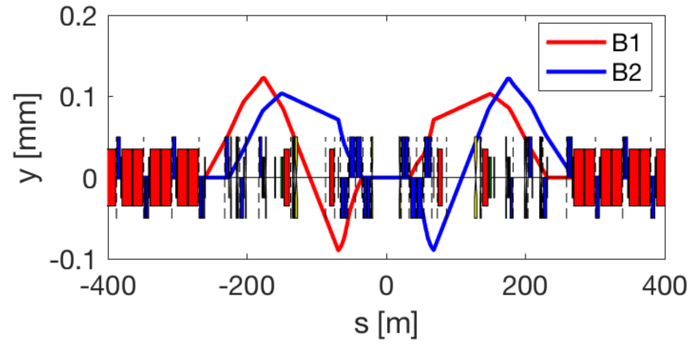


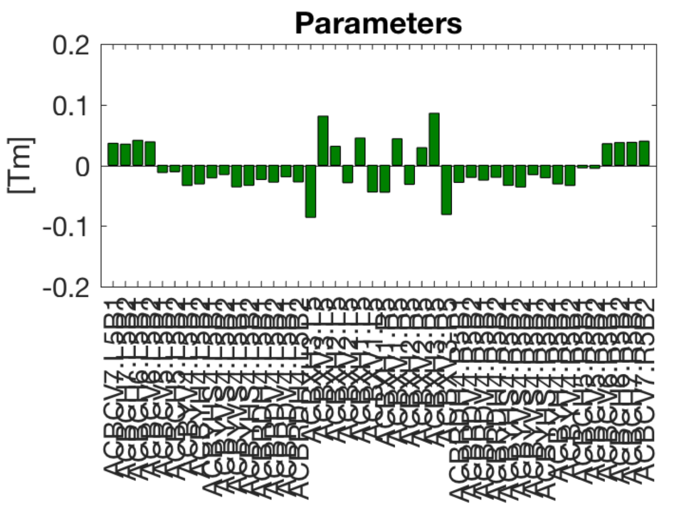
Lumiscan (+- 100 um)

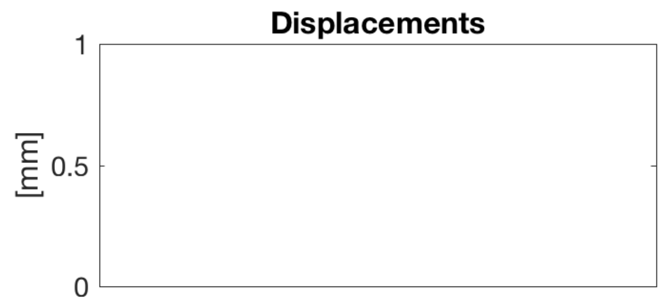


CC offset (100 um)

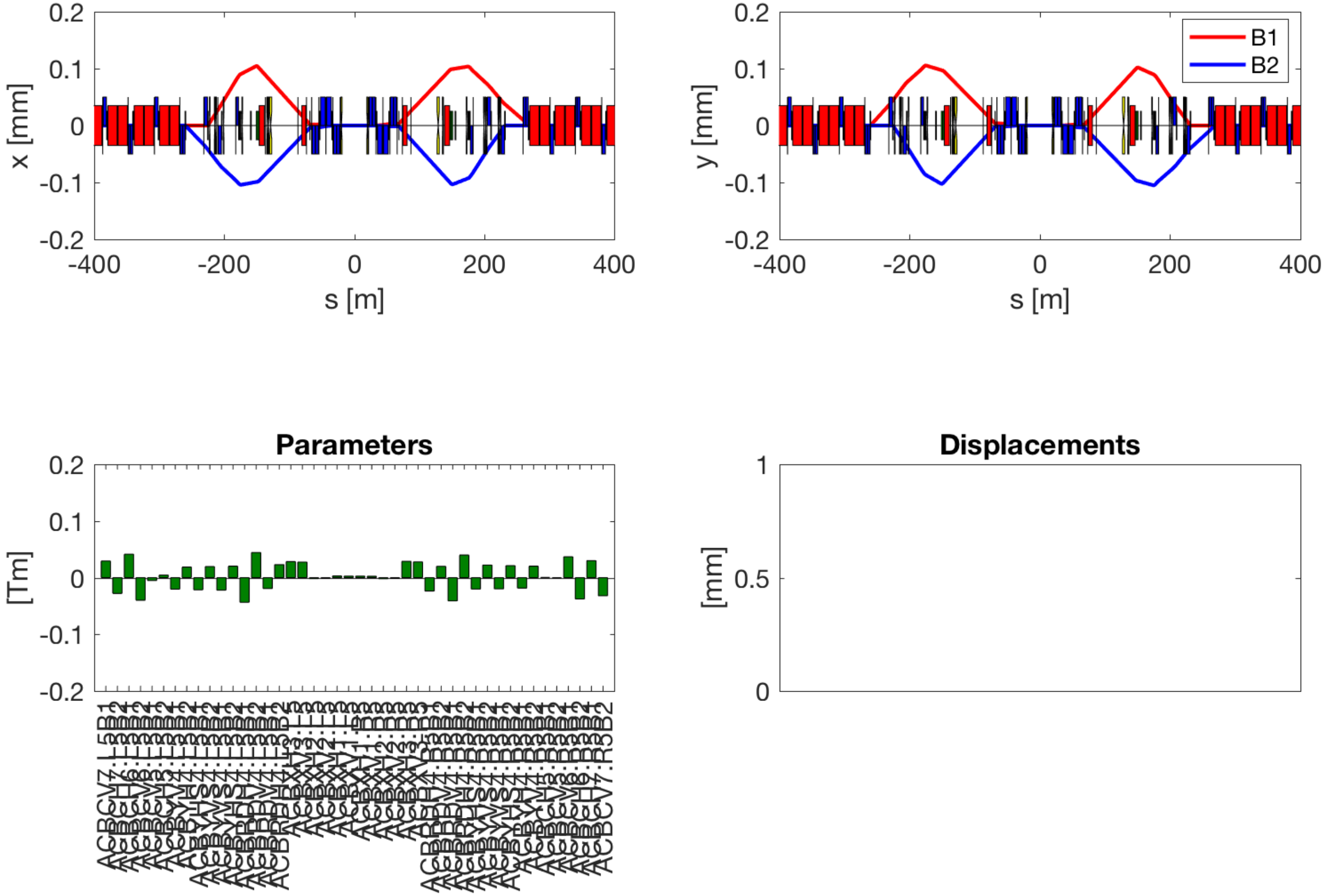








CC separation (+- 100 um)

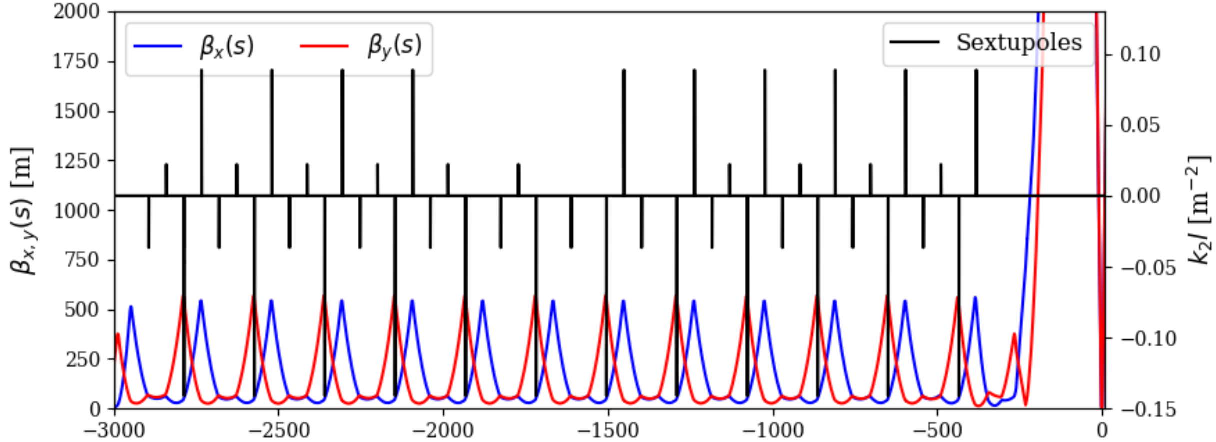


Sextupole MS10 RDTs study for HLLHC

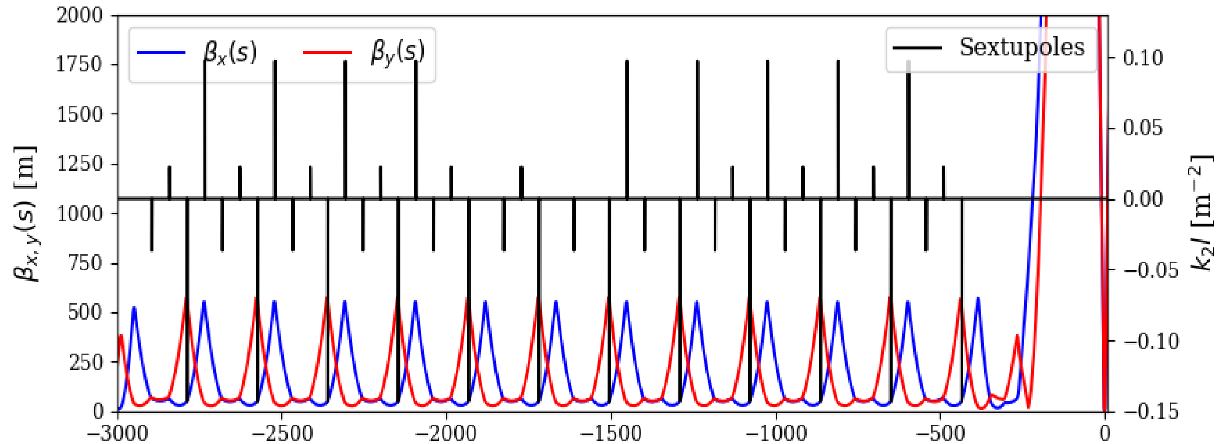
R. De Maria, F. Plassard

Meeting ?/?/2018

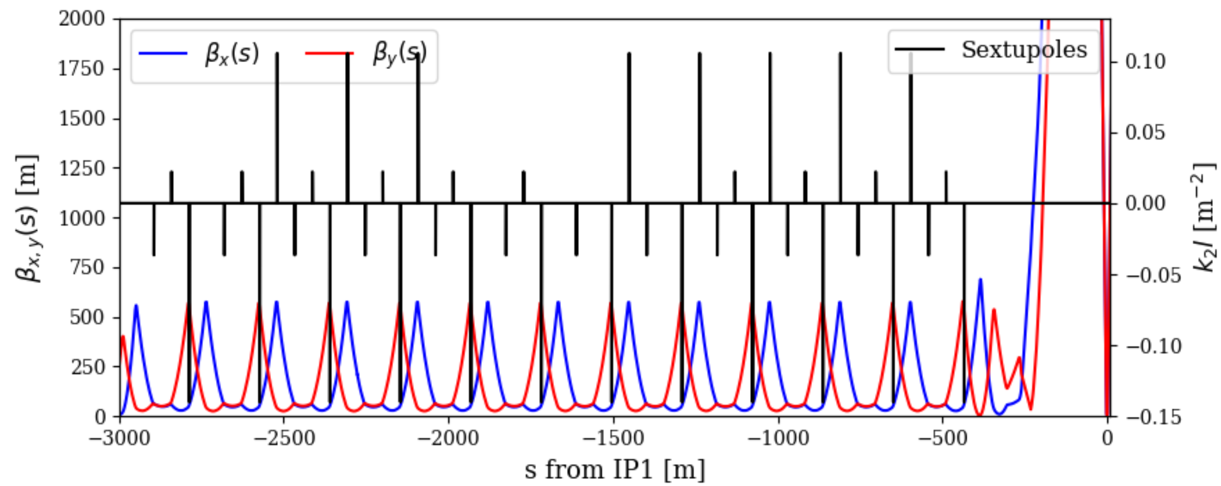
Baseline: add sextupole at Q10 (MS10)



noMS10: LHC-like configuration

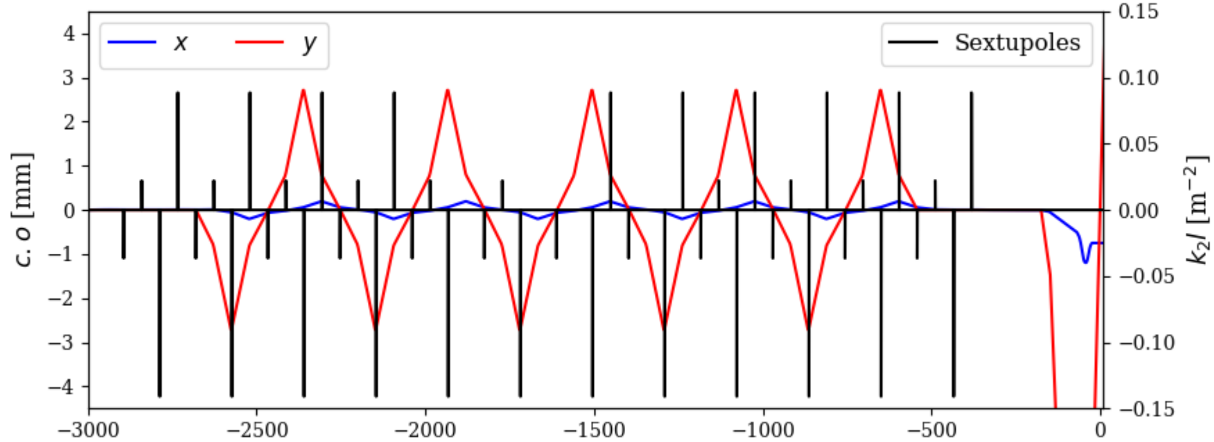


noMS14F: remove focusing MS14 (-1 sext. from LHC configuration)

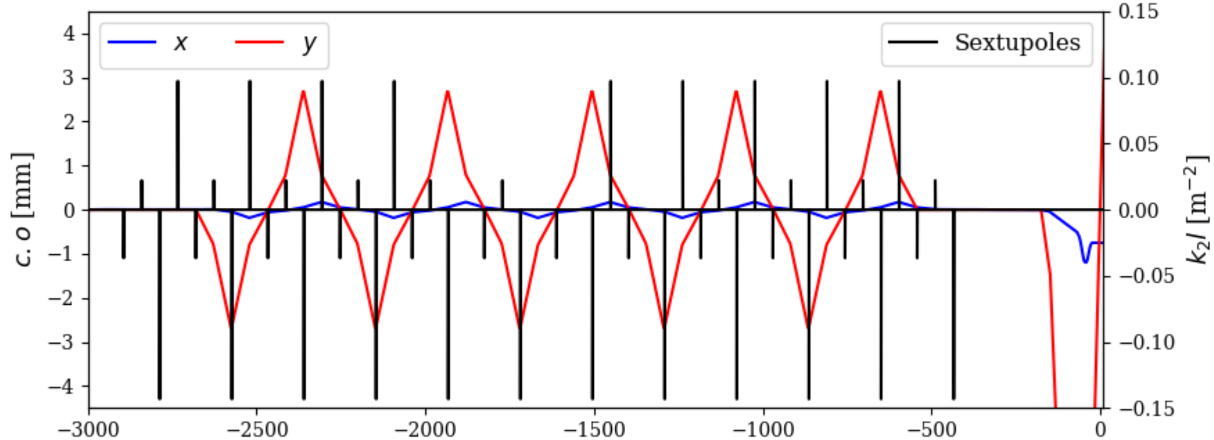


HiLumi HL-LHC PROJECT

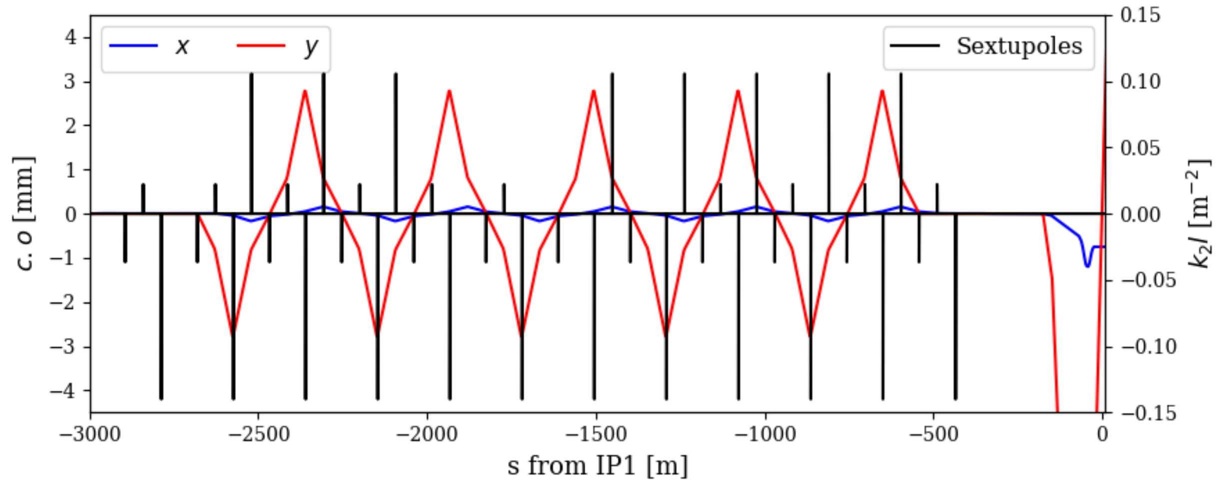
Baseline: add sextupole at Q10 (MS10)



noMS10: LHC-like configuration

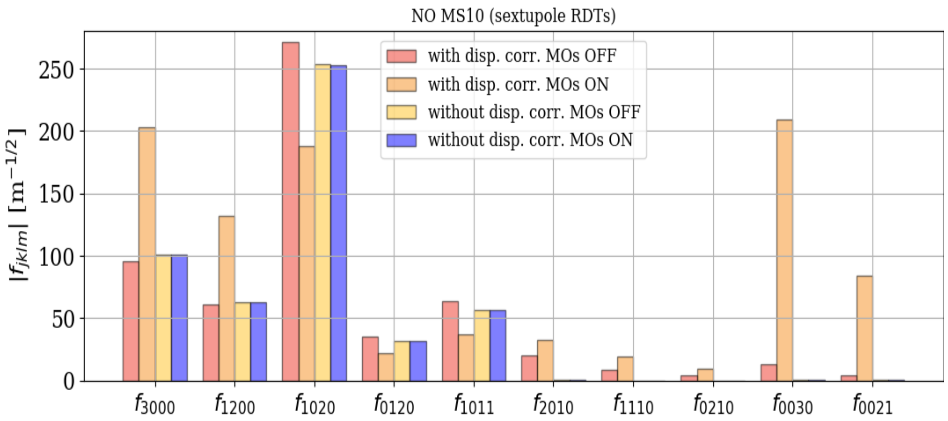


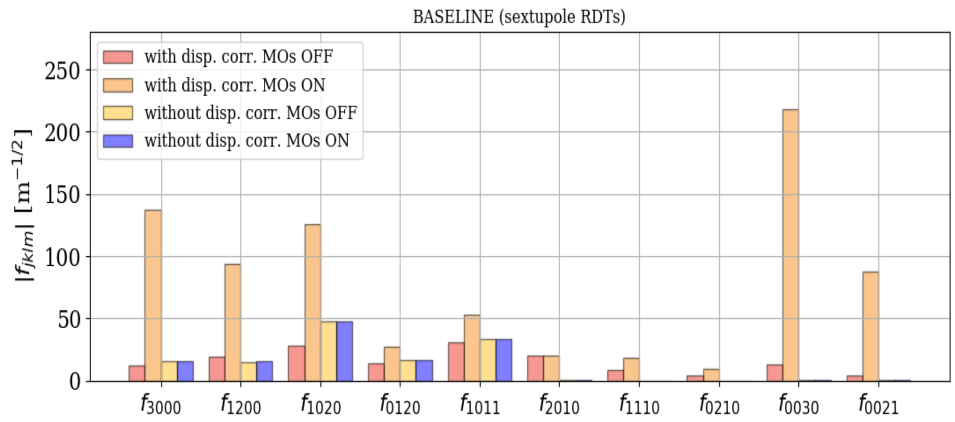
noMS14F: remove focusing MS14 (-1 sext. from LHC configuration)

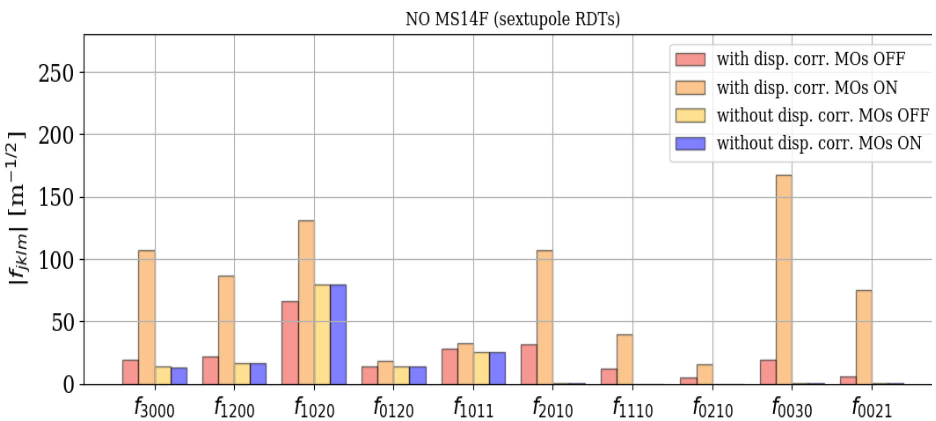


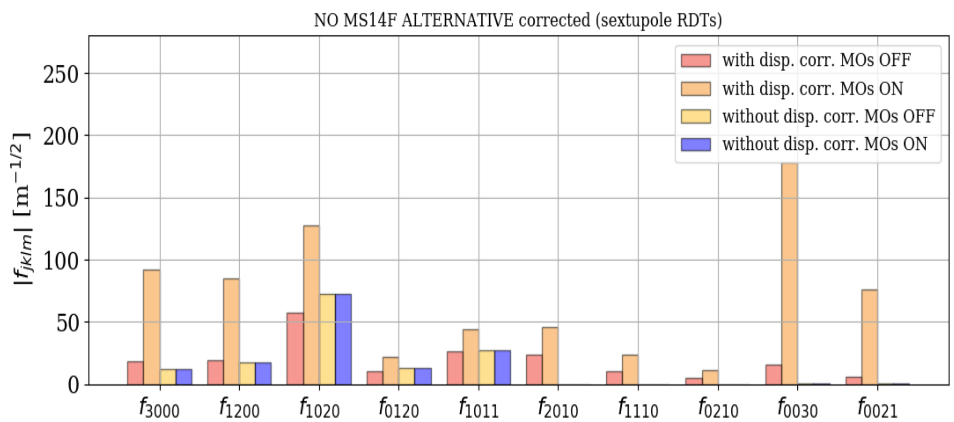
HL-LHC V1.3 : NO IMPERFECTIONS

Sextupole RDTs





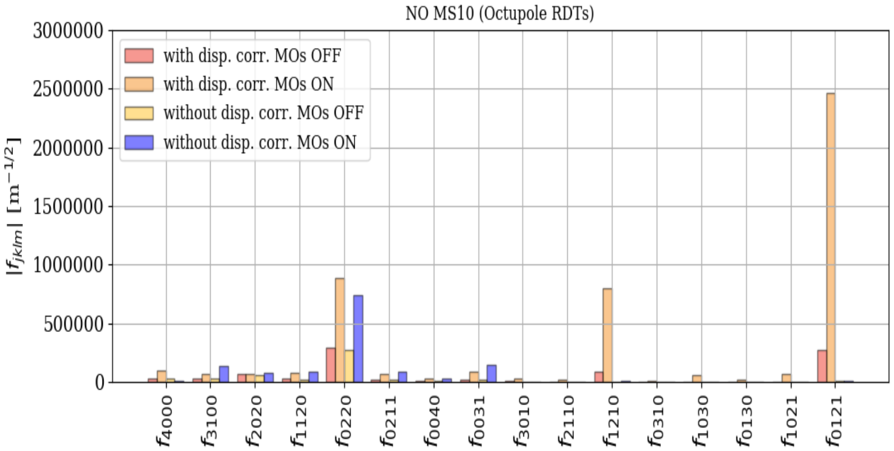


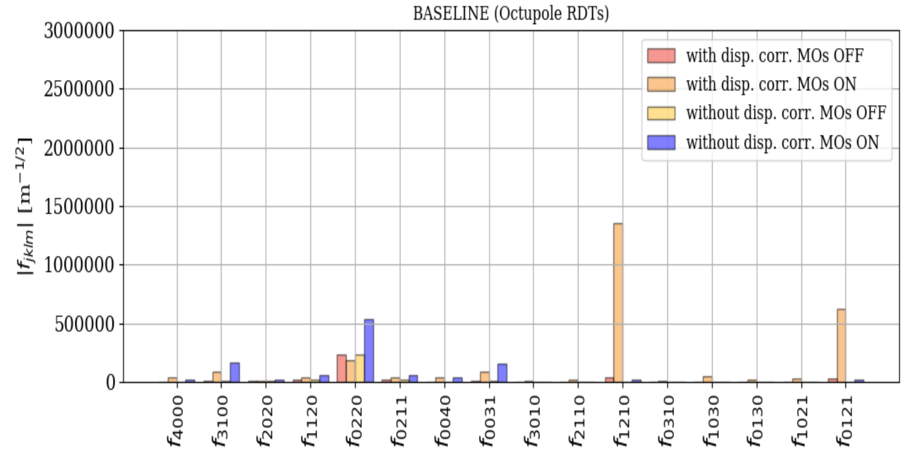


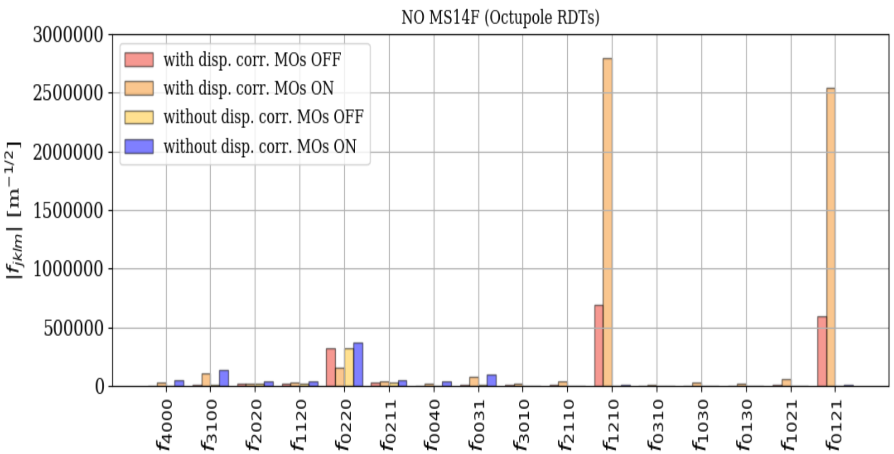
HiLumi HL-LHC PROJECT

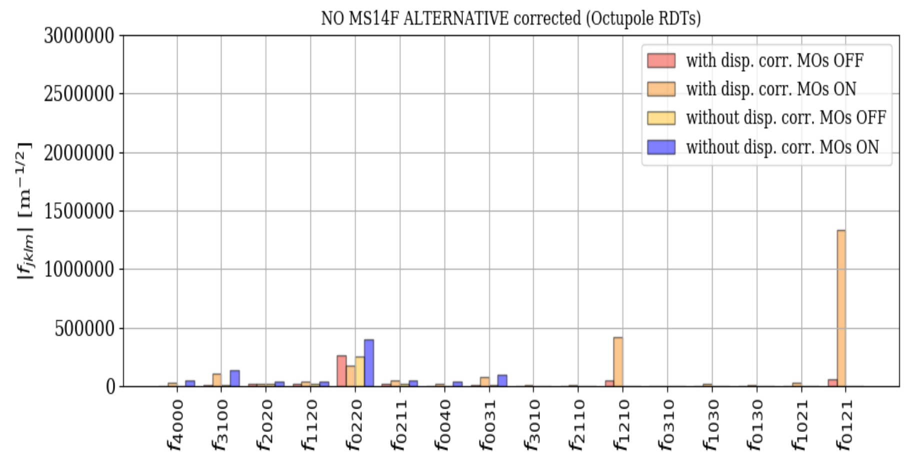
HL-LHC V1.3 : NO IMPERFECTIONS

Octupole RDTs





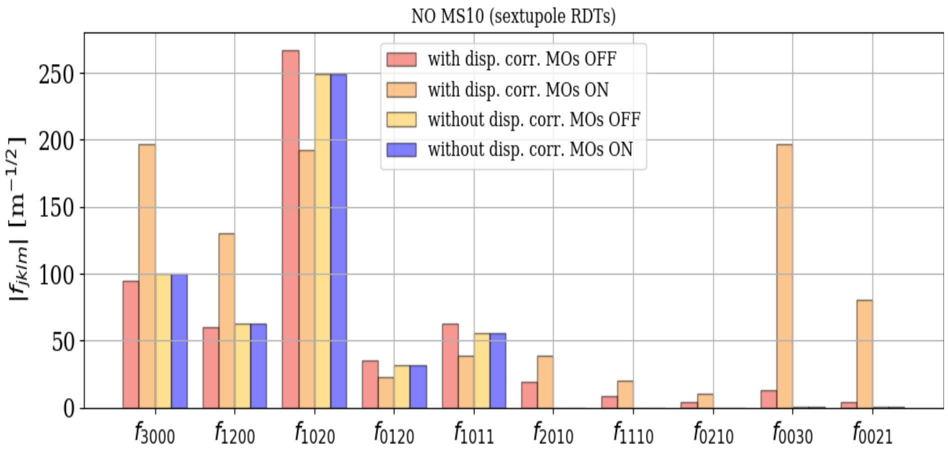


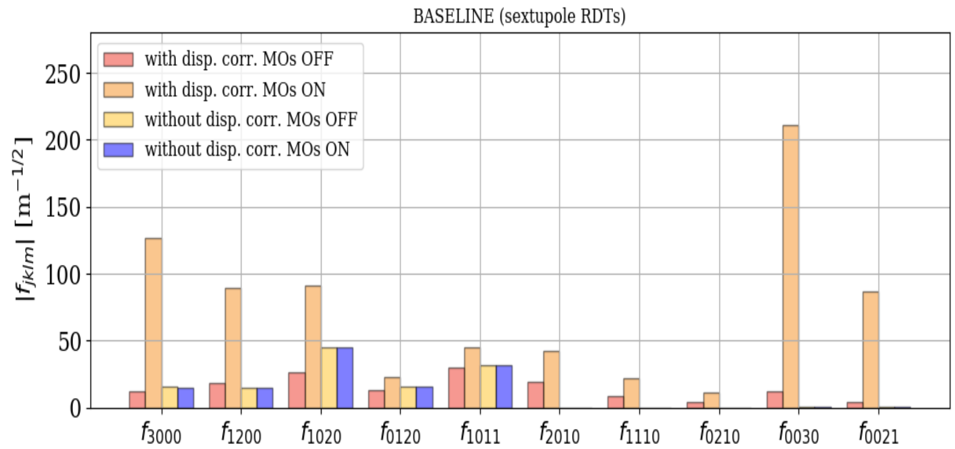


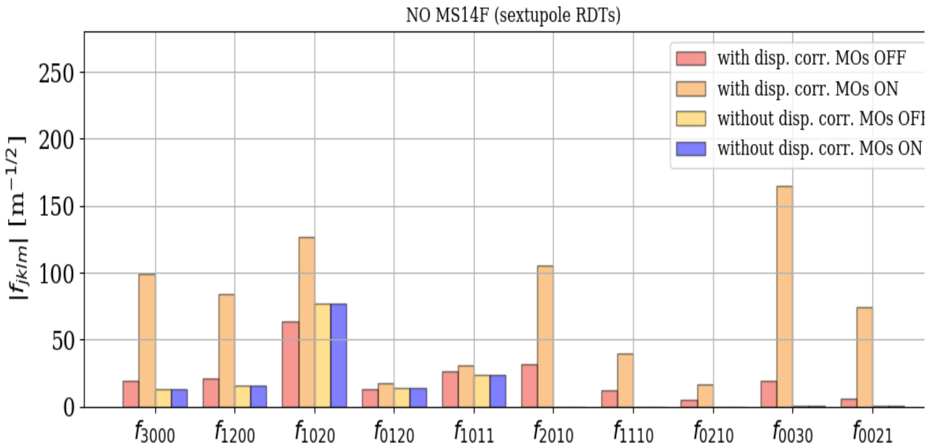
HiLumi HL-LHC PROJECT

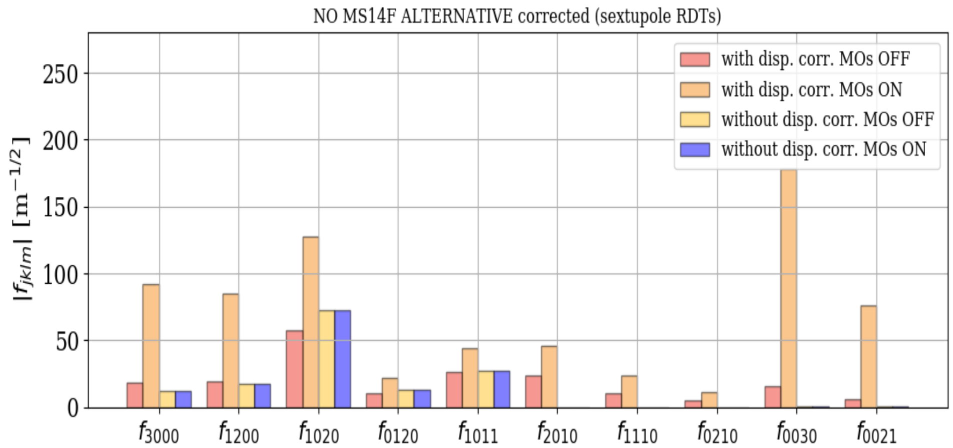
HL-LHC V1.3 : WITH IMPERFECTIONS

Sextupole RDTs



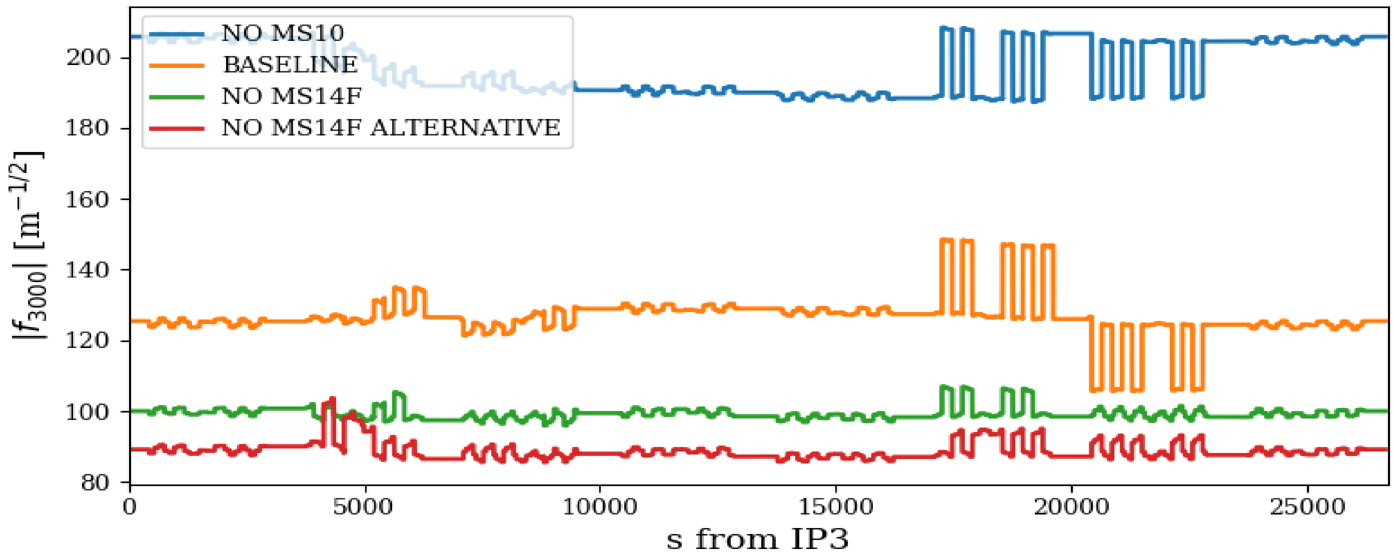


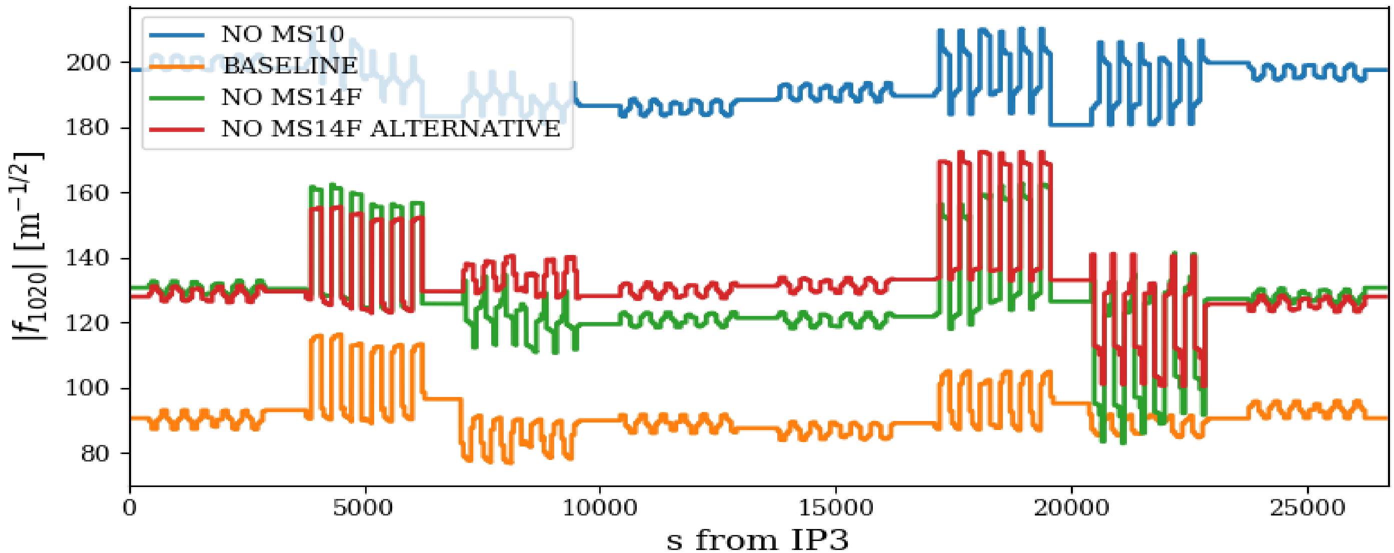




HiLumi HL-LHC PROJECT

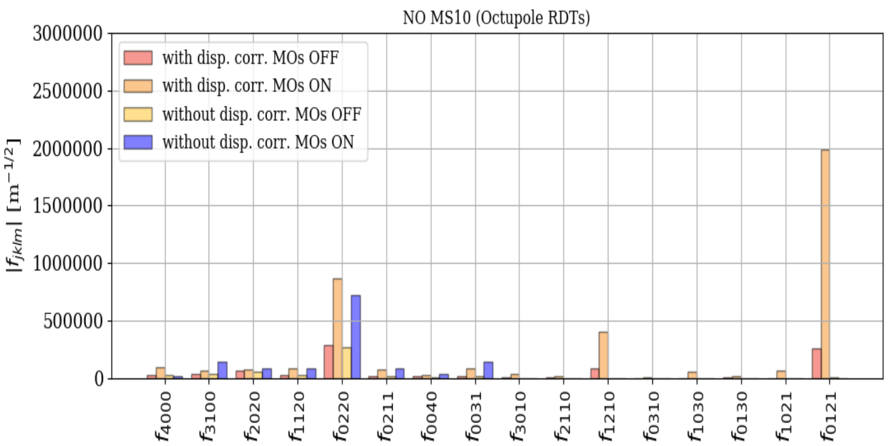
Sextupole RDTs

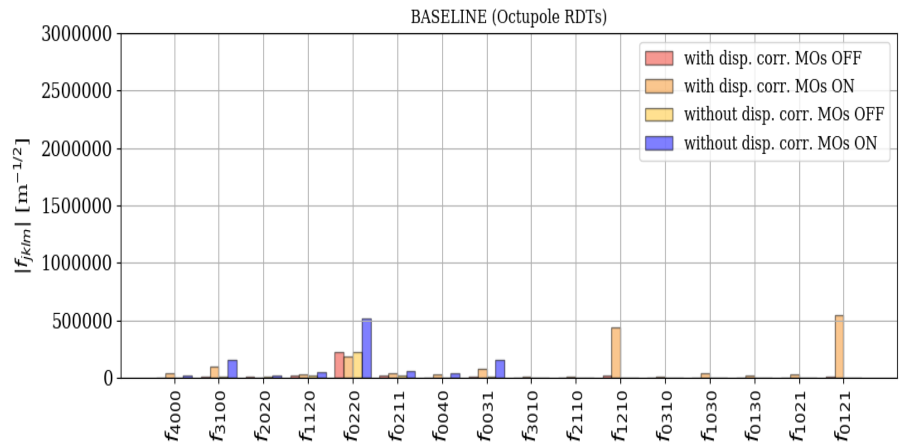


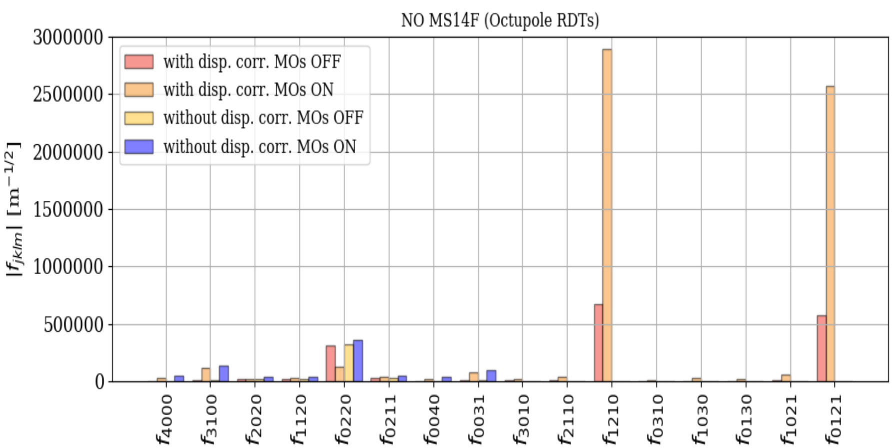


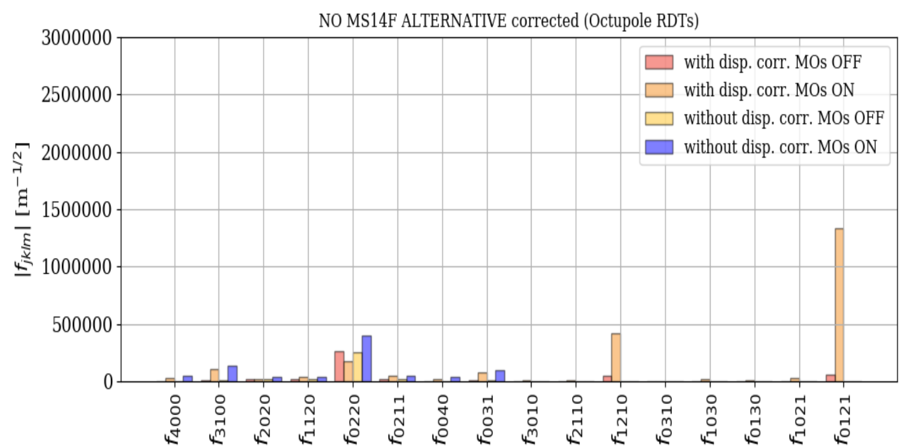
HL-LHC V1.3 : WITH IMPERFECTIONS

Octupole RDTs



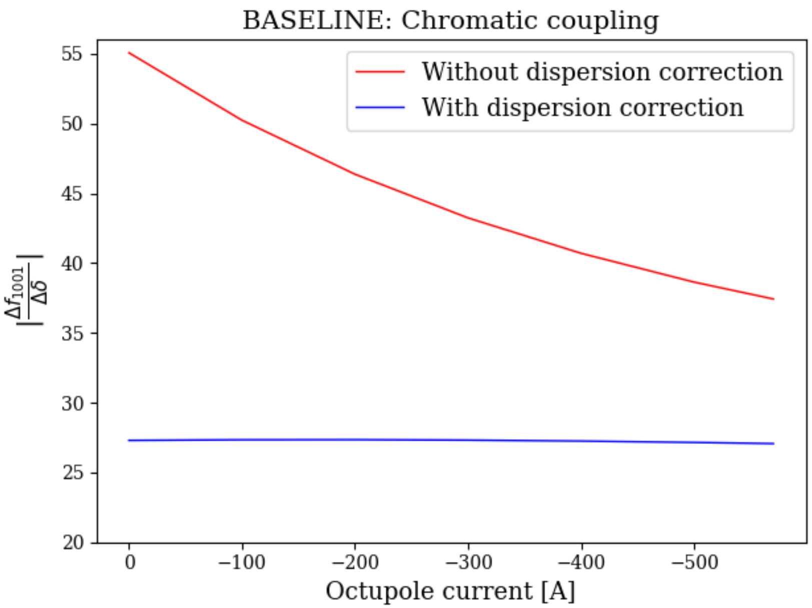


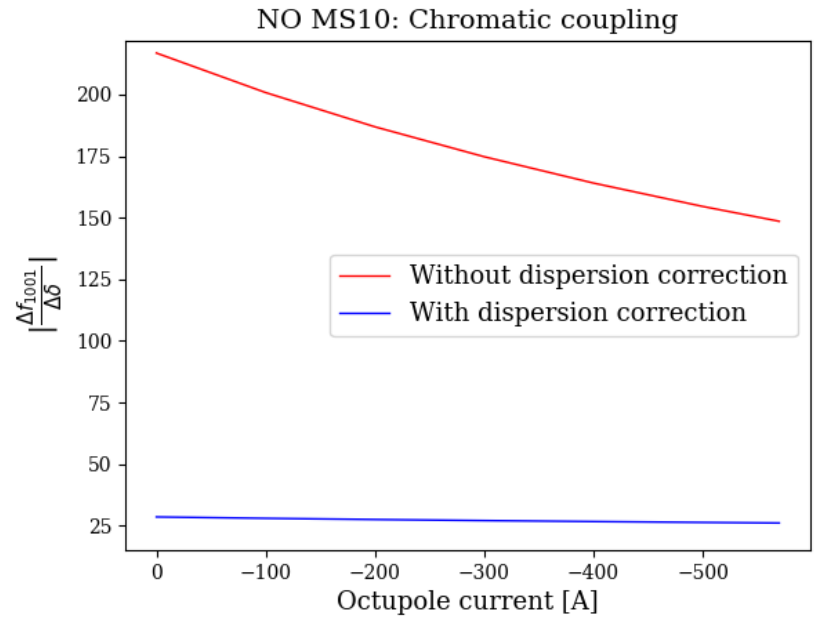


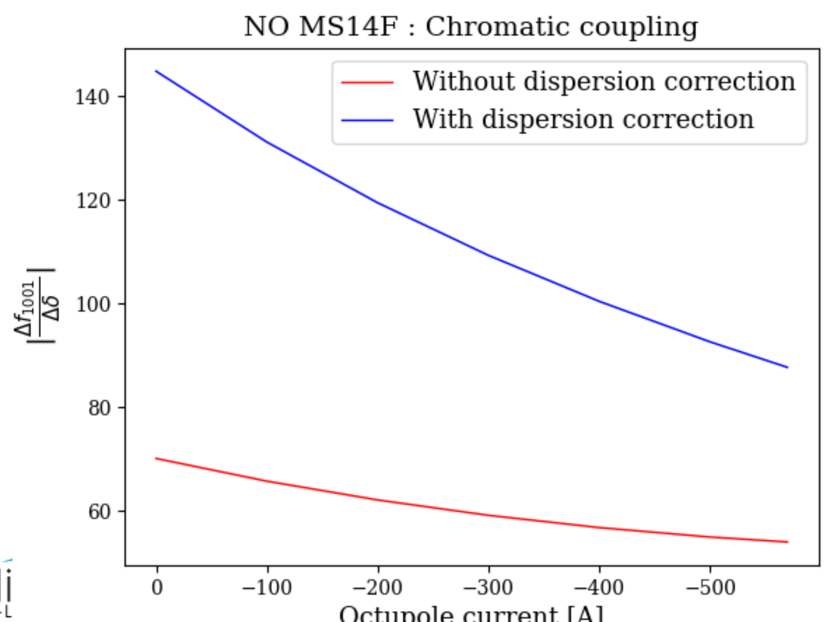


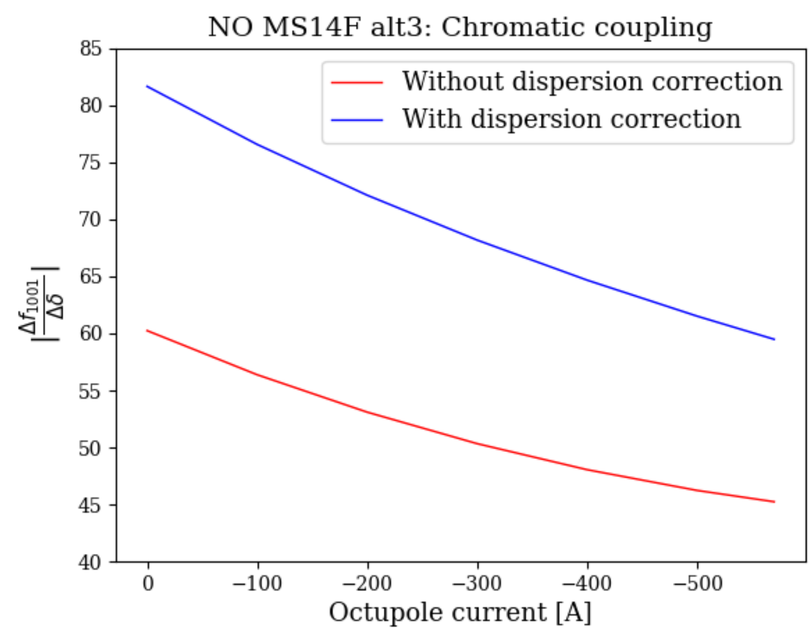
HiLumi HL-LHC PROJECT

HL-LHC V1.3 : CHROMATIC COUPLING

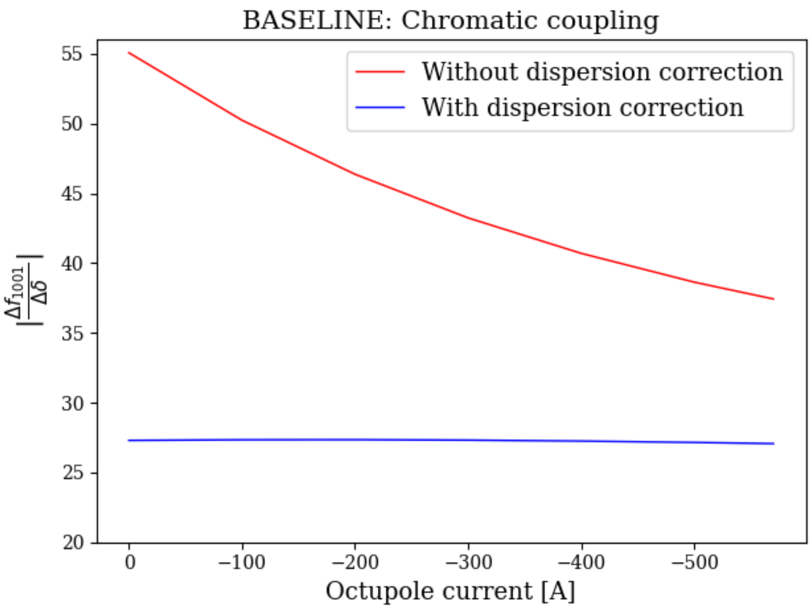


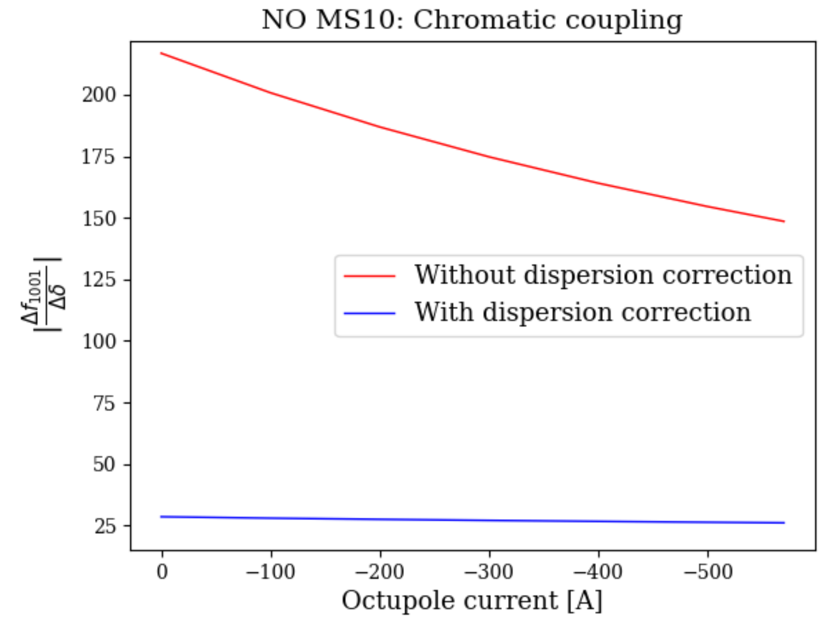


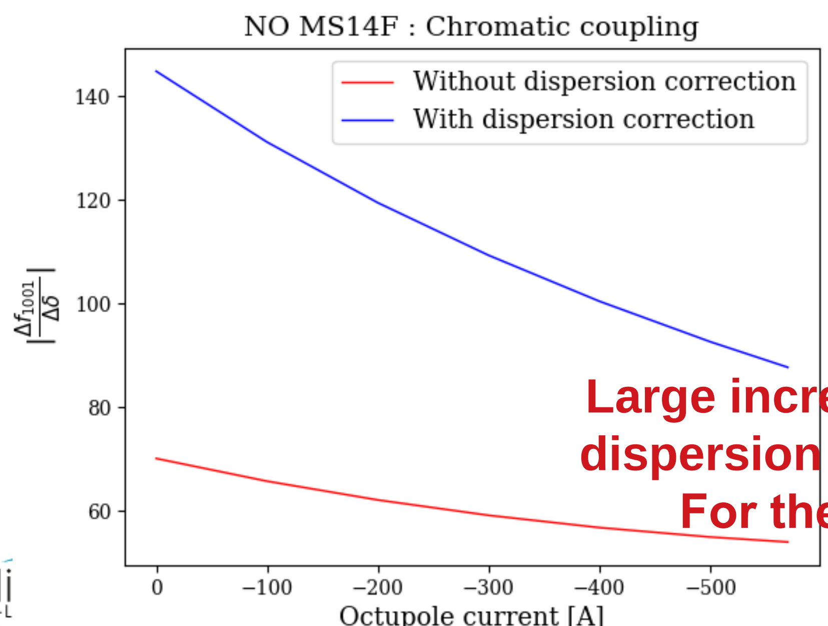


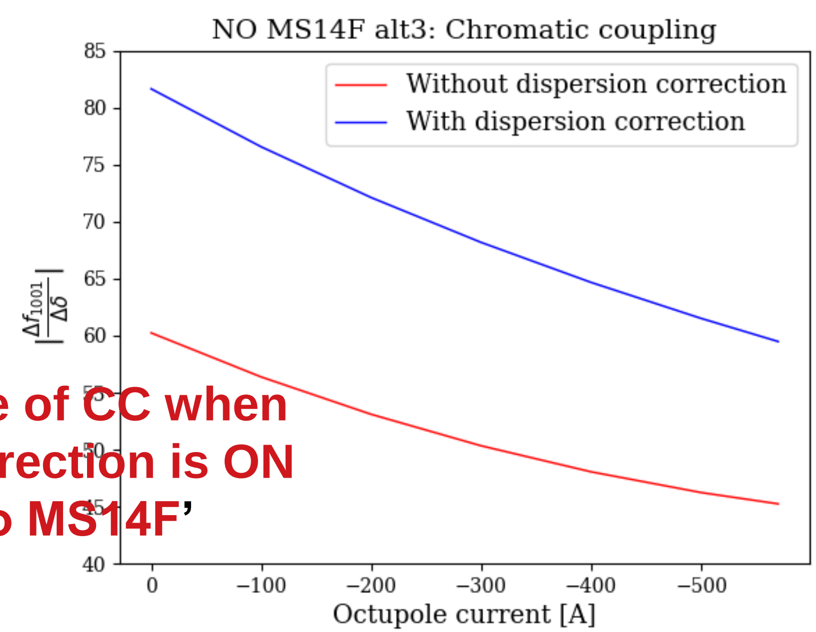


HL-LHC V1.3 : CHROMATIC COUPLING







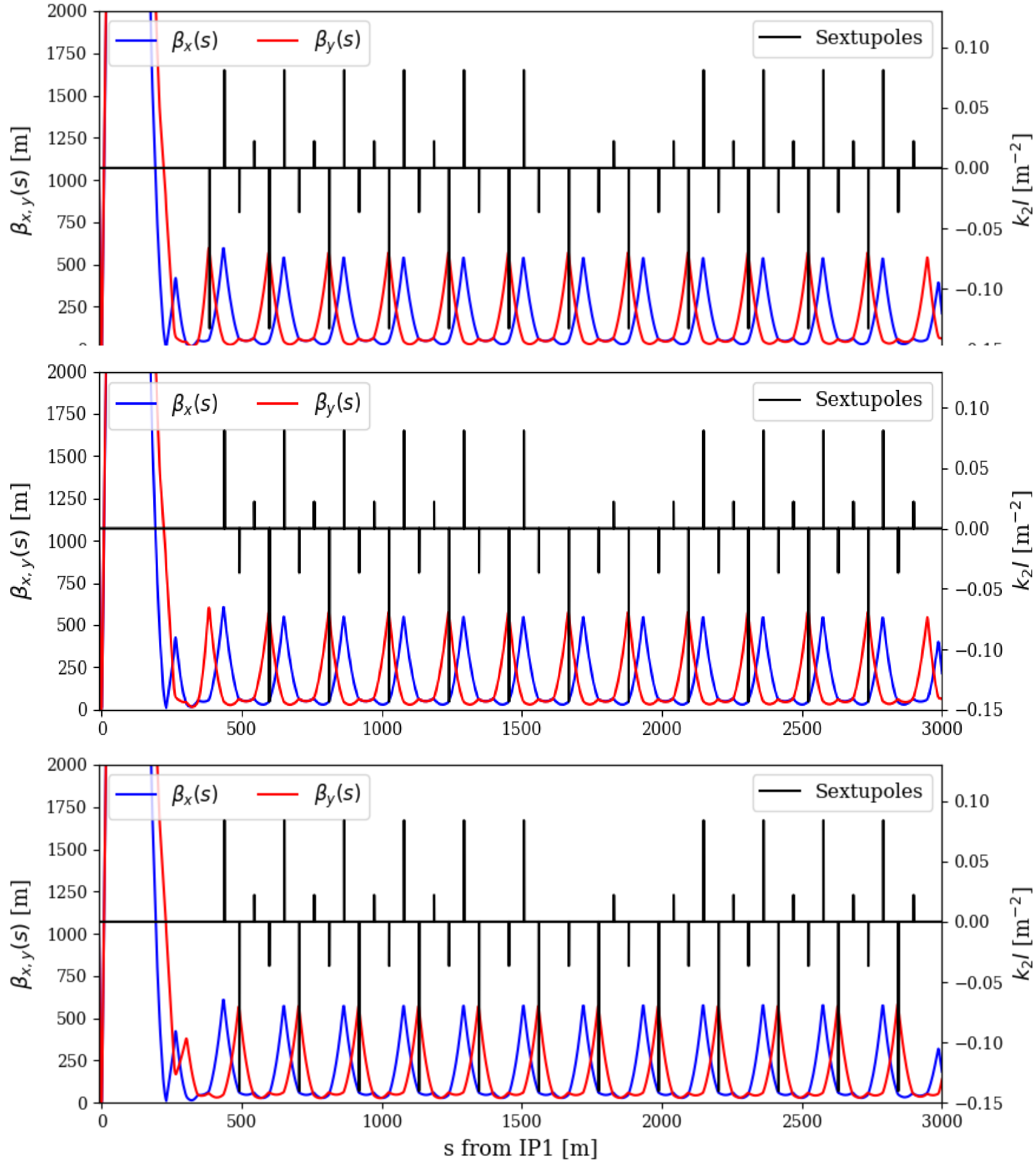


Large increase of CC when dispersion correction is ON For the 'no MS14F'

Baseline: add sextupole at Q10 (MS10)

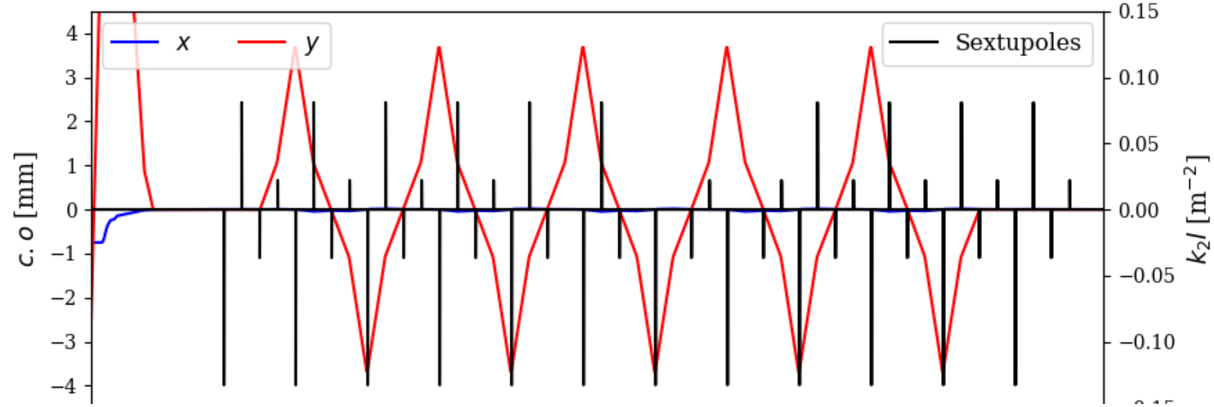
noMS10: LHC-like configuration

noMS14F: remove focusing MS14 (-1 sext. from LHC configuration)

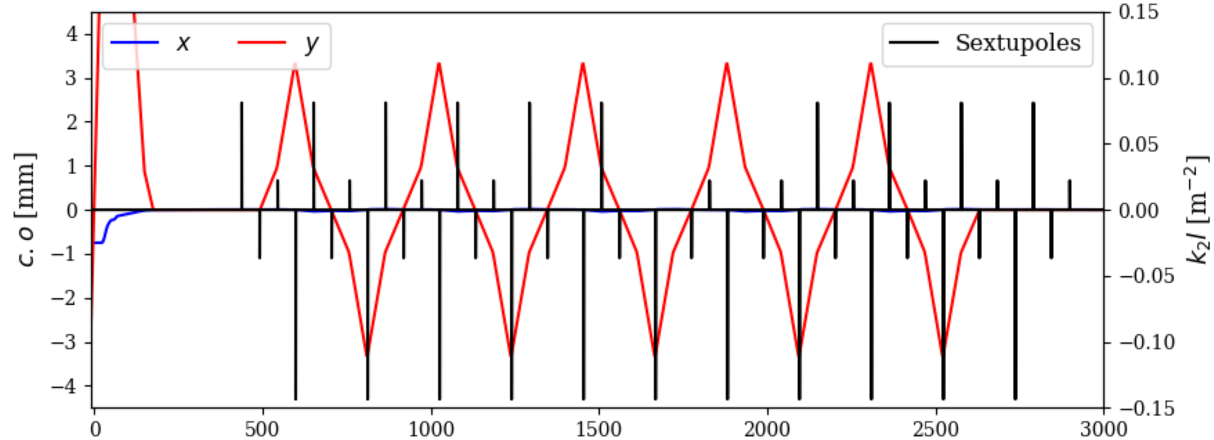


HiLumi HL-LHC PROJECT

Baseline: add sextupole at Q10 (MS10)



noMS10: LHC-like configuration



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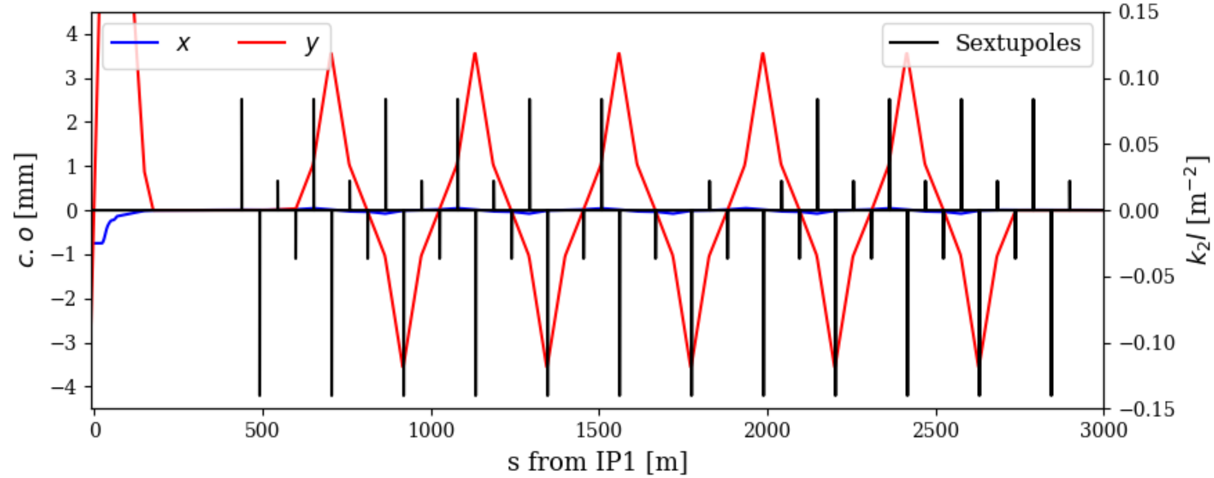

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