HL-LHC Optics and layout update

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Status HLLHCV1.3 repository

/afs/cern/eng/lhc/optics/HLLHCV1.3

- Layout and drawings update
- Optics repository
  - Crossing angle knobs
  - Crab cavities
  - Masks for studies
- Optics update
  - IR6 phase advances
  - IR1/5 new phase and MS in Q10

Layout updates

Approved drawings in the WP15 website:

Point 1,2,5,7

Layout and drawings conforms:

- MBH in IR7: scripts to install elsewhere
- Crab cavity: 1st set as crabcavities, 2nd set as markers + plus script to modify the setup
- Still no wire, e-lens installed.
- TANB should be available from RunIII sequence (under development)

Optics file changes

- New sets of orbit knobs (crossing, separation, offset, angular offset in both planes for all IRs)
- Orbit knob use new LHC conventions:
  - Normalization to 1µrad, 1mm positive for Beam1
  - Names examples on_x5h, on_sep1v, on_a8v, etc…
- Compatibility layer with all definitions:
  - on_x5h: on_x5*cos(phi_ir5*180/pi);
  - on_dx5h: on_disp*on_x5;
- Crab cavity orbit knobs now fully independent.
- New commands added in MadX to add knobs in the model
- Latest (to be released next week) madx release needed.

Mask file

- Mask file available for HLLHCV1.2 (Frederik) and it would be the same for HLLHCV1.3
- Crab cavities supported for the weak beam

Optics

Collision round 15cm with improved phase:

	IP1	IP5
$\Delta\mu_x$ MKDo → TCT B1	29	27
$\Delta\mu_x$ MKDa → TCT B1	38	37
$\Delta\mu_x$ MKDo → TCT B2	21	25
$\Delta\mu_x$ MKDa → TCT B2	24	29

Q6	T/m at 7TeV
Q5.L6B1	170
Q5.L6B2	162
Q5.R6B1	163
Q5.R6B2	150

Optics without Q10

New phase for IR1/5: muy 2.642 –> 2.392 .

Arc	MS14	MS13	MS12	MS11
B1: 81,45	F1(9)	D1(12)	F2(10)	D2(12)
B2: 81,45	D1(11)	F1(10)	D2(12)	F2(10)
B1: 12,56	D2(11)	F2(10)	D1(12)	F1(10)
B2: 12,56	F2(9)	D2(12)	F1(10)	D1(12)

Arc	MS14	MS13	MS12	MS11
B1: 81,45	F1(8)	D1(12)	F2(10)	D2(12)
B2: 81,45	D1(11)	F1(10)	D2(12)	F2(10)
B1: 12,56	D2(11)	F2(10)	D1(12)	F1(10)
B2: 12,56	F2(8)	D2(12)	F1(10)	D1(12)

Pre-squeeze, VDM, Injection available.

Work in progress to build optics tools to generate ATS optics.

Validate with tracking.

Backup

IR6 Optics constraints

- Q4 RB1, LB2 gradient: ±1 %
- $\Delta\mu_x$ MKD(mid) to TCDQ (mid): 90º ± 4º
- TCDS: β_y > 200 m (170 m still ok)
- TCDQ: β_y > 145 m, β_x > 630 m (430 m with SIS at 0.5 mm), $|D_x|$<0.2 m (under discussion with WP5)
- TDE: $(\beta_x\ \beta_y)^{1/2}$>4.5 km, β_x>4 km, β_y>3.2 km
- TCDS-MSD: β_x< 175 m (at injection)
- $\Delta\mu_x$ MKD(mid) to TCT (mid): mod 180º ± 10º (under discussion with WP5)
- TCDQ monotonic retraction (under discussion with WP5)

C. Bracco, A. Lechner, M. Fraser

Impact of phase advance on protected aperture

Strictly from CERN-ACC-2014-044 and ColUSM website:
TCP7 6.7 σ, TCS7 9.1 σ, TCS6 10 σ, TCDQ6 10.6, TCT15 12.9, Aperture 14.5 σ.

A better phase advance can reduce the TCT-TCS7 retraction.

$\Delta\mu_{x\ MKD-TCT}$(1) [degree]	TCTH [σ]	Aperture [σ]
90	12.9	14.6
70	12.7	14.6
60	12.4	14.5
50	11.8	13.8
40	10.9	12.9
30	9.8	11.9
20-0	9.8	11.2

There is not much gain below 9.8 σ under 2016 assumption on TCT position in cleaning hierarchy (may also depend on possibility to close TCDQ further).

Assuming TCTV=TCTH.

Estimates R. Bruce et al. to be plublished.

(1) To be calculated assuming $\delta=\pm 2\ 10^{-4}$ and a margin from optics correction and drifts.

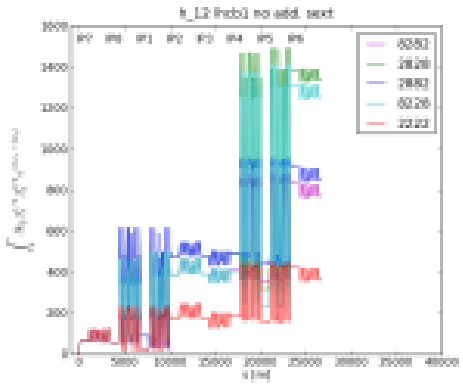
Constraints

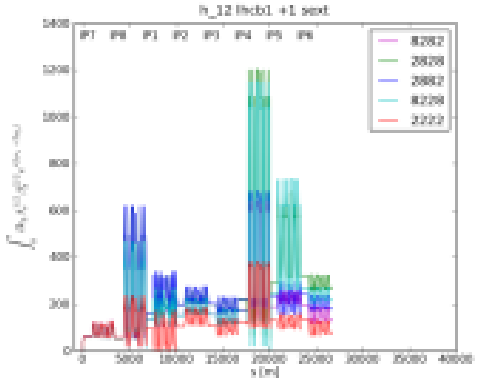
	Target	HL 1.2 15 cm	HL 1.2 30/7.5 cm	ATS-LHC 12 cm	Pushed
$\Delta\mu_{x,MKD-TCDQ}$	90º ± 4º	94.0	93.78	94.0	93.9
$\beta_{y,TCDS}$ [m]	200(170)	176	176	243	233
$\beta_{x,TCDQ}$ [m]	630(430)	716	486	474	470
$\beta_{y,TCDQ}$ [m]	145	157	176	150	160
$\|D_x\|_{,TCDQ}$ [m]	0.2	0.2	0.48	0.7	0.35
$\beta_{x,TDE}$ [km]	4	6.6	6.2/5(vh)	5	4.9
$\beta_{y,TDE}$ [km]	3.2	3.7	3.7	3.7	5.1
$(\beta_x\beta_y)^{½}_{,TDE}$ [m]	4.5	5.1	4.8/4.4(vh)	4.3	5.0
$\Delta\mu_{x,MKD-TCT,5B2}$ [º]	||<30º	-82º	-89/-66(hv)	-35º	-28º
$I_{Q5,\ L/R}$[T/m]	160	170/158	183(hv)/166(vh)	165/154	B2 <160
$k_{Q4,\ L6B1,R6B2}$ [$10^{-2}m^{\wedge 2}$]	4.88/4.83	4.88/4.83	4.88/4.83	4.88/4.83	4.88/4.83

Possible strategies for HL-LHC:

- copy ATS-LHC optics with minor phase adjustment
- explore more pushed option towards the target (need to study full squeeze though)

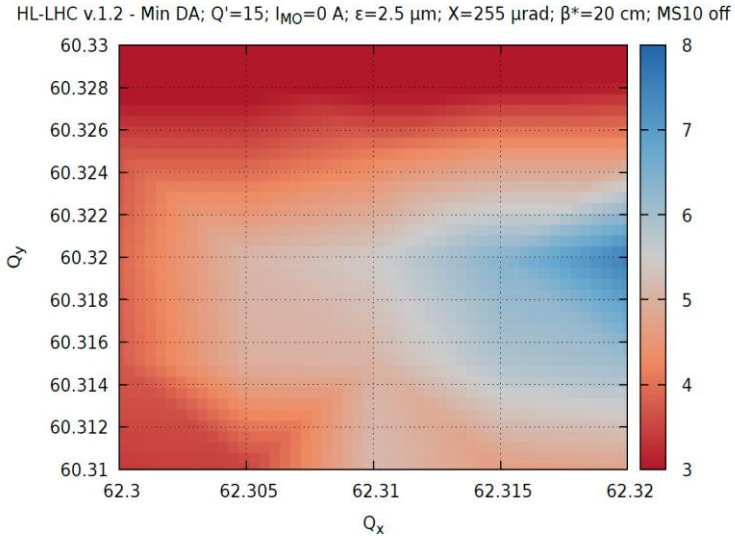
Additional MS10 Sextupole

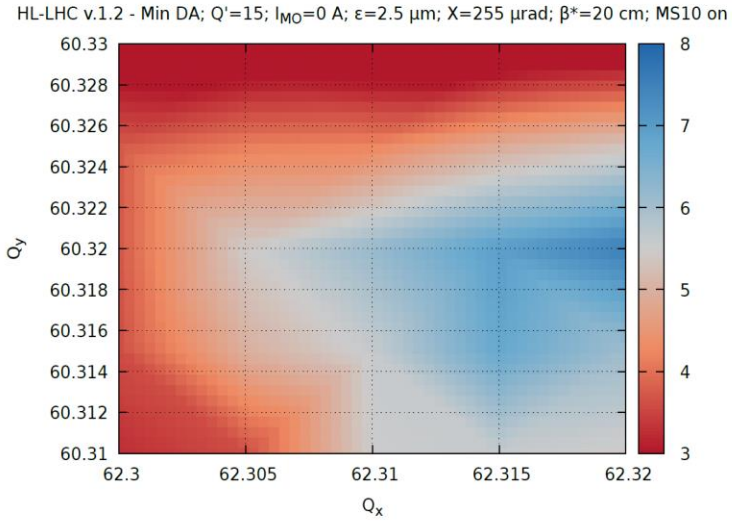




D. Pellegrini,
N. Karastathis

First Results





Beam-beam simulations confirm the losses in DA for β*=20 cm (worst case scenario). Severe loss of margins. Worse DA reduction expected for smaller β* and flat beams.