

15 cm beta* round optics for crab-cavity using SLHCV3's techniques. DRAFT

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Content

An sLHCv3.0 optics for round beams (15cm beta*, 580urad crossing angle) suitable for crab cavities. The crab cavities are then installed after D2 in order to have 194mm separation and large beta function.

Not covered:

- ▶ crab orbit leakage (not an ideal pi-bump)
- ▶ field quality issues of the crab kick
- ▶ orbit variation due crossing scheme
- ▶ field quality of new magnets
- ▶ beam beam non linearities

What is sLHCv3?

New optics for the LHC with limited layout changes.

It fully exploit the $\pi/2$ cells with interleaved sextupoles families up to 60cm beta* restoring the "right" phase advances for beta beating correction using 2 sectors per IP.

It then continue the squeeze using the neighbor insertions with a perturbation that reduce beta* without altering the chromatic correction (arcs and IR1 IR5 are not changed nor perturbed, only boundary conditions are changed).

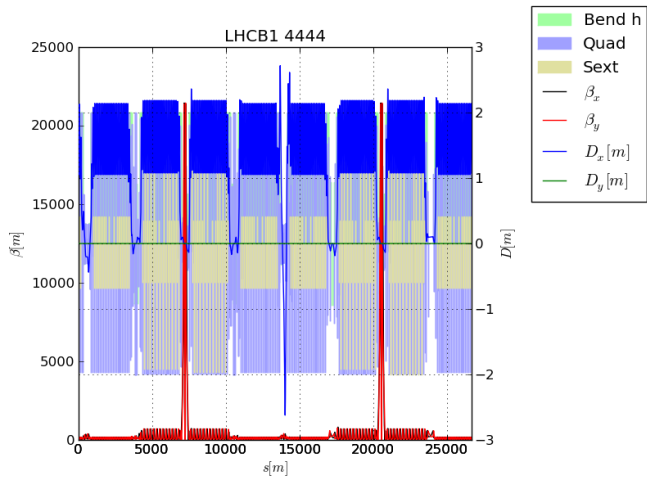
Spurious dispersion is corrected with closed orbit bumps in the arcs.

Layout changes are needed to accommodate larger beta* close to the high lumi IP and in IR6 to recover some flexibility.

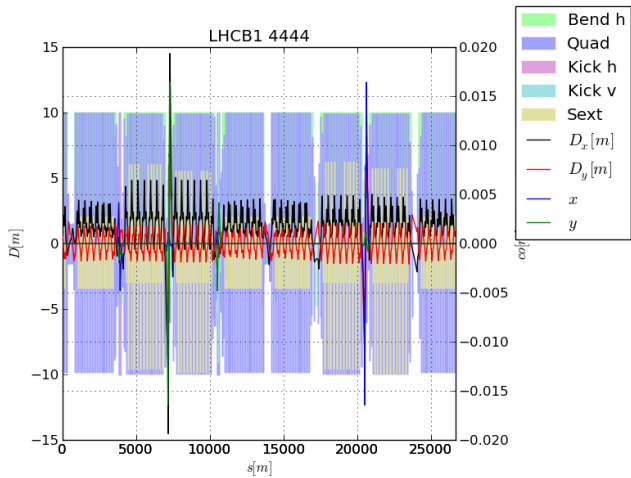
The "right" phase advances are not really the best and they open a problem with possible solutions (rephasing the IR, adding a sextupole, disabling a sextupole)

The scheme is consistent with the machine as specified. Todo: field quality specification of new elements, impact of linear imperfections, beam beam, impedance, operation and protections checks.

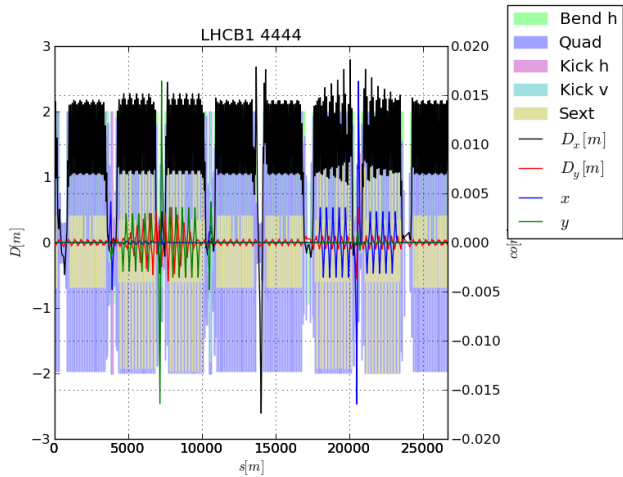
Optics



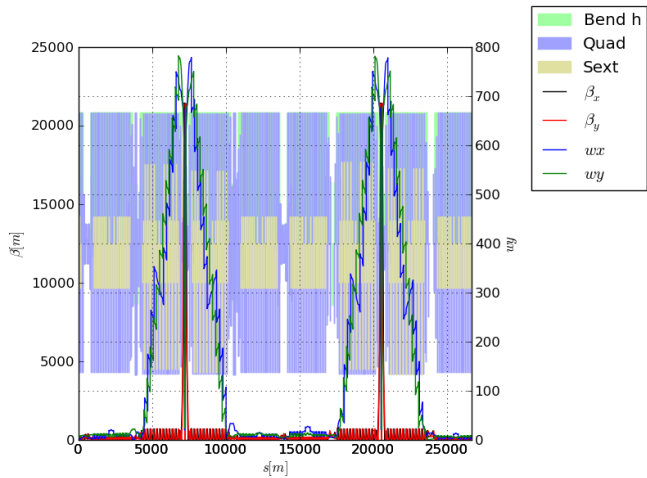
Optics



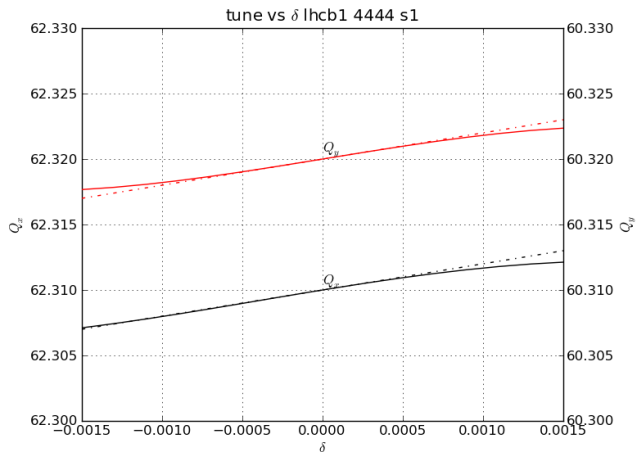
Optics



Optics



Optics



Layout changes

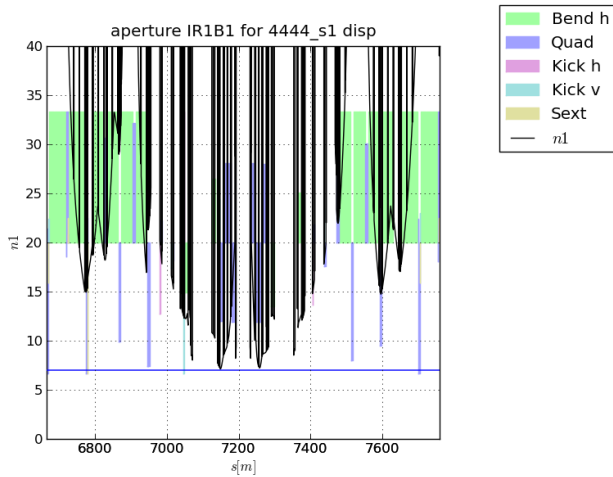
In IR1 and IR5

- ▶ new triplet 150mm
- ▶ new D1
- ▶ new D2 (bs 0.033500, 0.038500)
- ▶ new Q4, large aperture 2-in-1 (bs 0.030000 0.035000)
- ▶ new Q5, MQY type (bs 0.024000 0.028900)

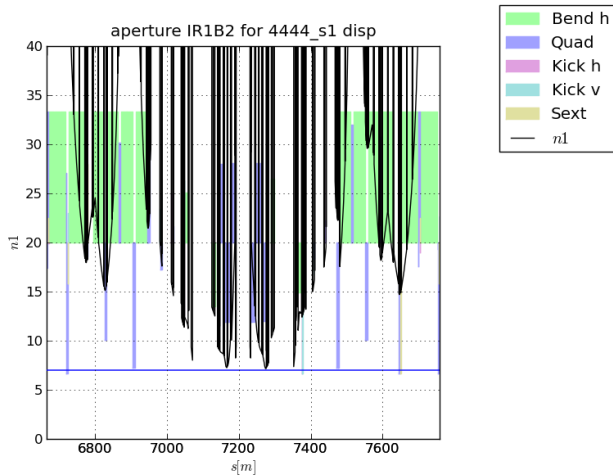
In IR6:

- ▶ additional Q5

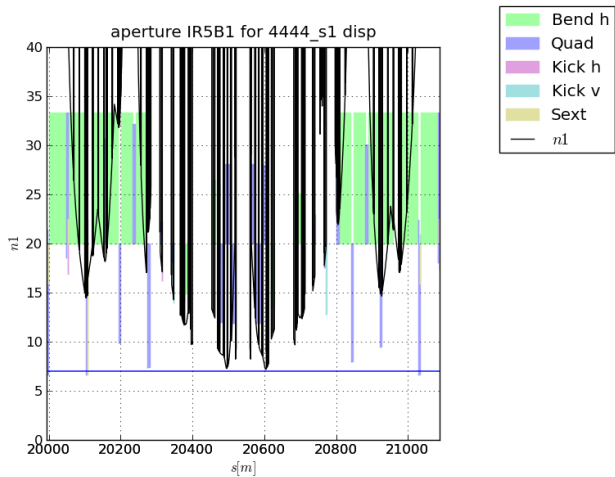
Aperture



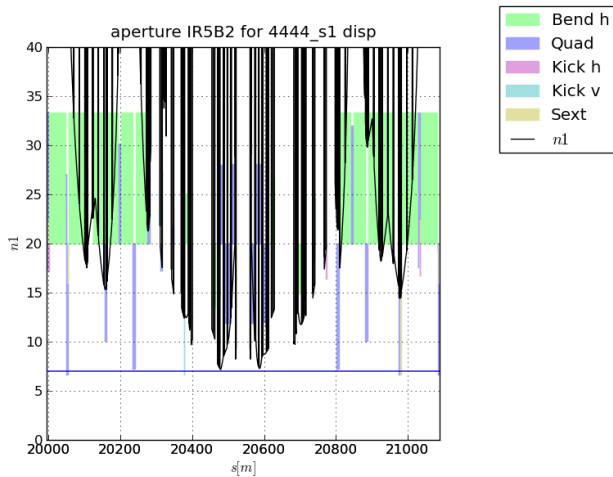
Aperture



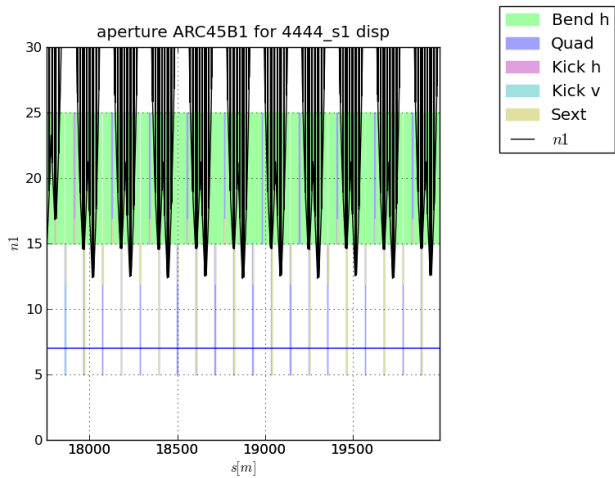
Aperture



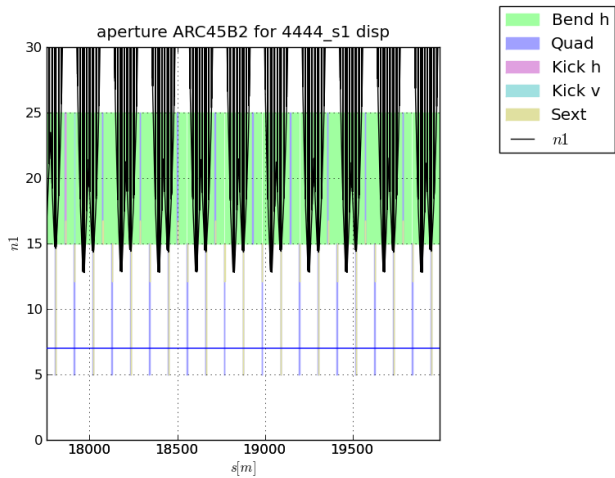
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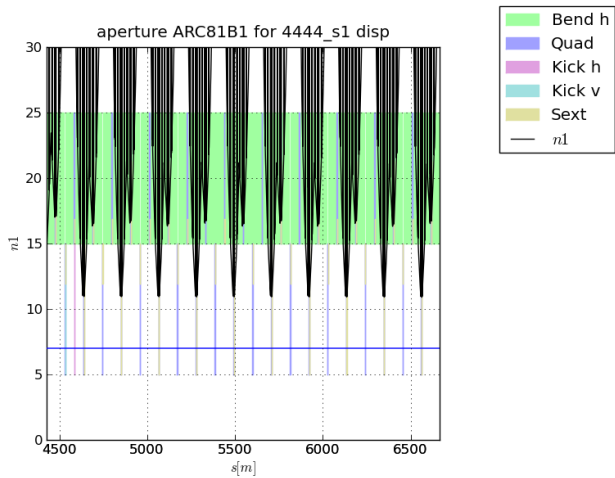
Aperture



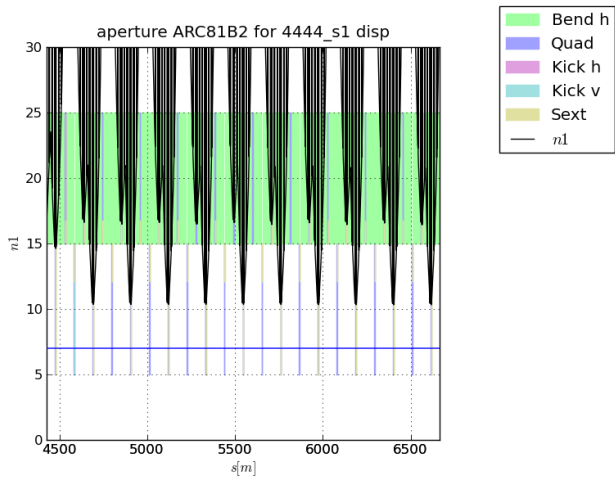
Aperture



Aperture



Aperture



Tracking studies

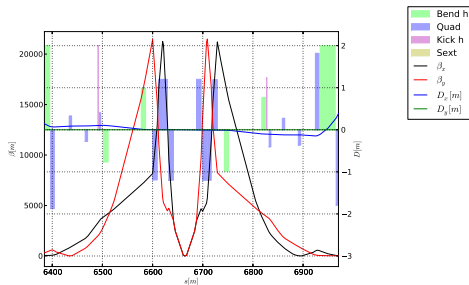
- ▶ tune (62.28,60.31), (62.31,60.32)
- ▶ using $\delta = 0.00027 = (2.5\sigma_\delta)$
- ▶ include multipole error a,b from 2 to 15 order for: MB, MBRB, MBRS, MBX, MBW, MBXW
- ▶ include multipole error a,b from 3 to 15 order for: MQW, MQTL, MQMC, MQX, MQM, MQML, MQ
- ▶ exclude: MQY, new MQX, new D1/D2
- ▶ correct triplet error:
 - ▶ A2(1,-1), A3(2,1)(1,2) partial with MQSX
 - ▶ A3(0,3)(3,0), with MCSSX
 - ▶ A4(1,3), A4(3,1), with MCOSX
 - ▶ B4(4,0), B4(0,4), B4(2,2) partial with MCOX
 - ▶ B3(3,0)(0,3) partial, B3(1,2)(2,1) with MCSX
 - ▶ B6(6,0), B6(0,6), B6(4,2) partial, B6(2,4) partial, with MCTX
- ▶ correct arcs errors:
 - ▶ beta beating and tune with MQT weak sector
 - ▶ correct coupling with MQS
 - ▶ chromaticity with MS weak sector
 - ▶ chromatic coupling with MSS
 - ▶ b3 dipoles with MCS
 - ▶ b4 dipoles with MCO full strength
 - ▶ b5 dipoles with MCD

ms (no imperfection), mb (imperfection excluding new elements),
mbdc (with dispersion correction)

jobslhc3_1_4444_ms_v1	min	[	27.42	25.68	24.58	17.99	22.56]
jobslhc3_1_4444_mbdc_v1	min	[	16.85	17.17	16.32	13.42	14.19]
jobslhc3_1_4444_mb_v5	min	[	15.72	16.41	15.86	13.25	14.48]
jobslhc3_1_4444_mbdc_v1	avg	[	17.46	17.9	17.11	14.31	14.64]
jobslhc3_1_4444_mb_v5	avg	[	16.75	18.38	17.14	14.25	15.28]
jobslhc3_1_4444_mbdc_v1	max	[	18.21	18.87	18.08	14.97	15.21]
jobslhc3_1_4444_mb_v5	max	[	17.79	22.15	18.2	14.96	16.05]
jobslhc3_2_4444_ms_v1	min	[	25.65	-28.	26.12	-28.	-28.]

Crab cavity integration

Crab cavities can be used at best when β^* is small and the crossing is large.



For a local scheme they are ideally placed at -1, but to accommodate the necessary beam separation the needs to be put after d_2 (or in a dogleg as proposed by Rogelio).

crab beta and voltage

```
crab.l5b1.beta =          3374.869887 ;
crab.r5b1.beta =          2843.001687 ;
crab.l1b1.beta =          2842.746364 ;
crab.r1b1.beta =          3374.652147 ;
crab.l5b2.beta =          2843.001686 ;
crab.r5b2.beta =          3381.651178 ;
crab.l1b2.beta =          3381.433017 ;
crab.r1b2.beta =          2842.746362 ;
crab.l5b1->volt =         10762241.54 ;
crab.r5b1->volt =         11725805.68 ;
crab.l5b2->volt =         11725805.69 ;
crab.r5b2->volt =         10751445.25 ;
crab.l1b1->volt =         11726332.25 ;
crab.r1b1->volt =         10762588.73 ;
crab.l1b2->volt =         10751792.08 ;
crab.r1b2->volt =         11726332.26 ;
```