Status HLLHCV1.5

R. De Maria

Thanks to J. Andersson, R. Calaga, F. Cerutti, P. Fessia, L. Fiscarelli, D. Gamba, L. Gentini, M. Giovannozzi, M. Gonzalez, M. Krupa, H. Mainaud Durand, M. Modena, J. Oliveira, F. Plassard, H. Prin, R. Revo, M. Sabate Gilarte.

WP2 Meeting 23/7/2019

Optics And Layout versions

	Optics Files	Drawings	Comments
HLLHCV1.3	Apr. 2017	Apr 2017	Last approved layout drawings
HLLHCV1.4 Official release	Sep. 2018	Not released	Used in TDR, aperture calculations, DA studies, operational scenarios, ramp&squeeze, LHCb upgrade studies
HLLHCV1.5rc0 Pre-release	Mar. 2019	Not released	Used for energy deposition studies new TAXN-Q4 area
HLLHCV1.5rc1 Pre-release	Jun. 2019	Not released	Used for energy deposition studies on rotated Q4
HLLHCV1.5 Official release	Expected October	Expected October	

HLLHCV1.5 layout modifications

Point 1,5:

- TAXS: Some changes expected to cope with pre-existing non conformities, area not fully integrated yet.
- Q1-D1: small variation of positions of all elements (take into account thermal contraction)
- CP: changes in position and magnetic lengths of HO correctors
- D1: elongated beam screen + warm BPM new position
- TAXN-D2: new positions TAXN-TCT/L-D2, D2 BPM relocation, TCTPV increased stroke
- Crabs: Changed position, different location between Point 1 and 5 due to internal cryostat differences between H(RFD) and V(DQW) cavities, new beam screen in non-crabbing pipe
- Re-location for APWL and BTPX (close to crab cavities)
- Change of names for BPM, tertiary collimators and crab cavities.
- Possible rotation of Q4. Possible new position for TCT6.

Layout pending decisions

Quantities still pending studies and decision

- TAXS position and lengths
- TAXN copper length
- D2 BPM length and position
- Position of APWL (wall current monitor) BTPX (BPM for experiments)
- Rotation of Q4 (only blocking point)
- Position of TCT6 protecting Q5

Ideally the solution should allow the release of optics and layout before the annual meeting.

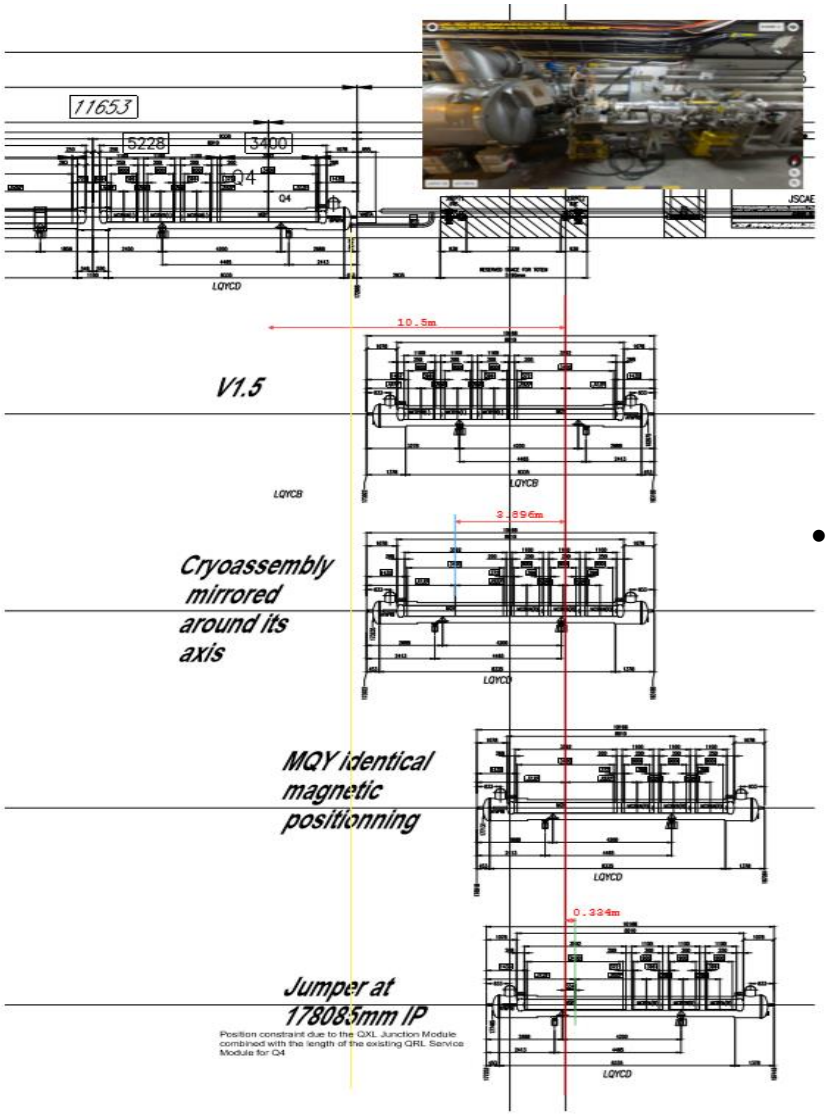
TAXN – D2 Area

- TAXN moved by 68 cm towards D2
- Change of inter-distance of TAXN and collimators (discussed by WP8 and MME)
- Better radiation shielding (see F. Cerruti)
- Proposal to increase TCTPV stroke from 40 mm to 42 mm (discussed by MME) to equalize aperture margins between all tertiaries.

Pos/Sep	HL1.4 [m/mm]	HL1.5 [m/mm]
D1	77.782	77.534
TAXN	128.801 / 148-158	*129.478 / 151-161*
TCTPXV	131.949 / 162	132.495 / 165
TCTPXH	133.950 / 168	134.028 / 170
TCLPX	135.707 / 174	135.614 / 175
D2	142.513 / 188	142.095 / 188
BPMQBCZA	136.7955 / 180	151.8475 / 194

New specifications provided to WPs

Q4 options



- Changes in optics e.g. max crab angle but not expecting major impact.

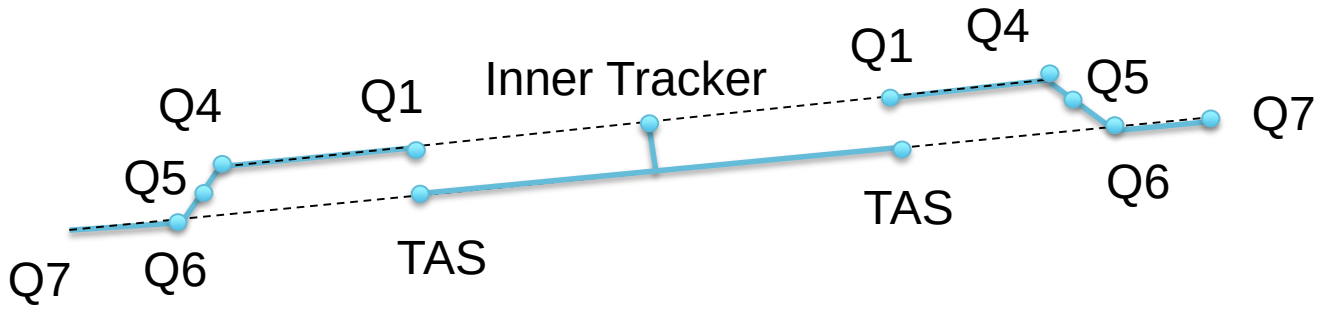
- Changes in orbit corrector budget, but not expecting major impact.
- Gain in aperture in Q4.
- Loss of long. space for wire unless they cound be put on the IP side…

On-going studies

- Alignment requirements for full remote alignment specifications
- Re-definitions of “mechanical” aperture tolerances
- Update of orbit corrector budget and BPM specifications
- Optics Optimization with/without MS10
- Ramp&squeeze scenarios, new flatCC scenario
- Increase beam size at the dump
- LS2 LHC sequence
- BGV location optimization

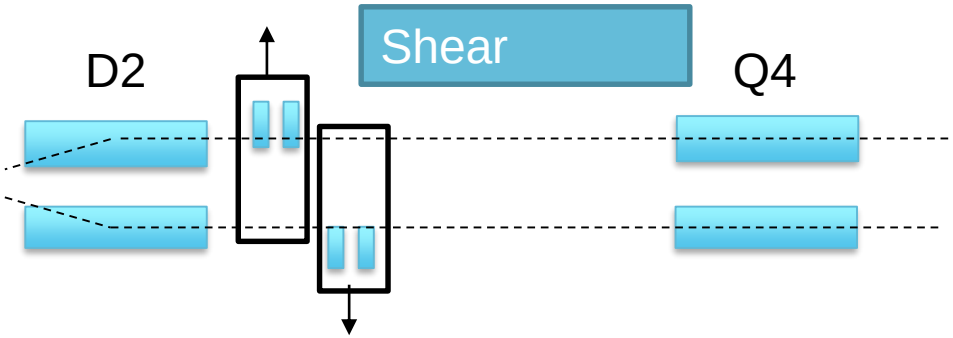
Transverse tolerances on Magnetic Fields

1. Orbit corrector budget assumes: quadrupole fields aligned to ±0.5 mm the "ideal" alignment line (blue in case of an IP shift).



2. Crab cavities will also need a small shear (from 0 to 0.8 mm) in the crossing plane depending on the available strength on the MCBRD and the chosen crossing angle

3. Crab cavities should be aligned to the specified position to ±0.5 mm.



4. The alignment priorities are IP and crab cavities, quadrupole fields and beam screens

Quantities to be reviewed from orbit correction studies for a consistent picture.

Alignment tolerances

Alignment tolerances are needed for WP2 to establish the maximum deviation from ideal alignment lines of magnetic fields and apertures.

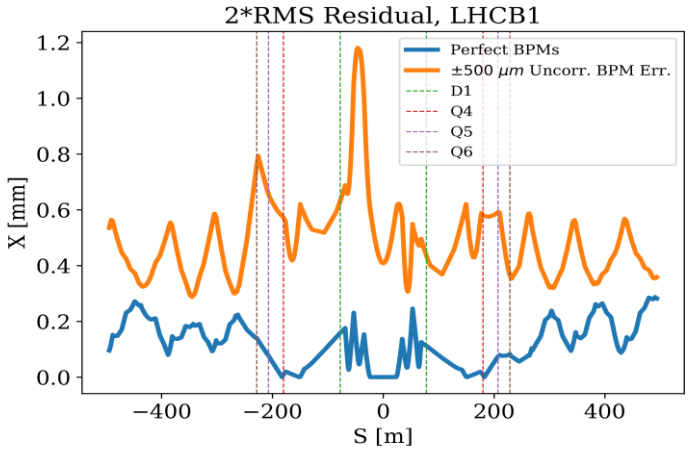
Components:

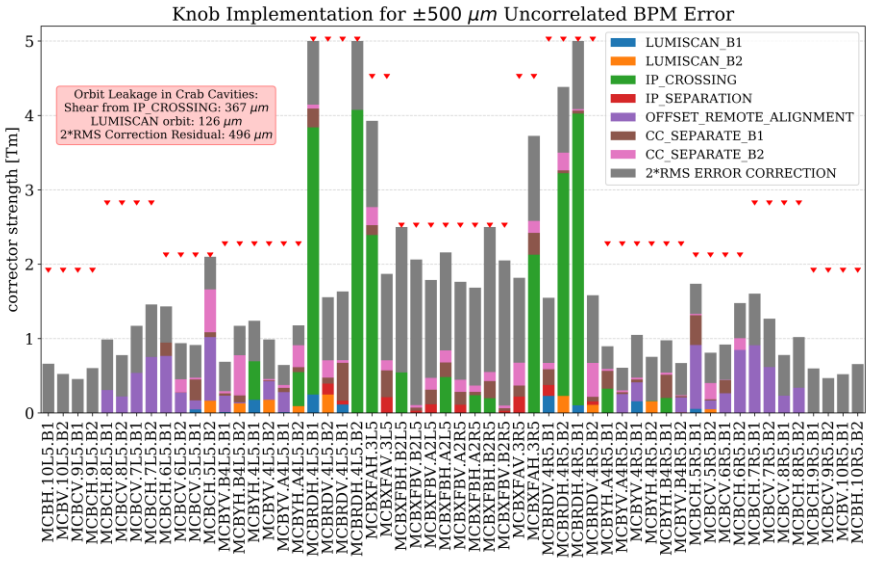
Components	WP
Ground motion from two alignment campaigns [ground motion]	15.4
Uncertainty of equipment fiducials to requested position [alignment error]	15.4
Uncertainty mechanical axis from fiducials [fiducialization]	15.4
Uncertainty magnetic/electric axis from mechanical axis [field error]	3/4/13
Uncertainty cold bore axis from mechanical axis [cold bore error]	3/4/8
Uncertainty beam screen position and shape from cold bore [b.s. errors]	12

Some of the quantities are already available, but not collected in a common sources.
WP2 and WP12 uses a mix LHC and HL-LHC quantities, but not the same mix.

Orbit correction and BPM error studies

- The budget of orbit corrector strength and residual orbit accounts for operational knobs and orbit correction due to element imperfections and misalignments
- A new study has been started to include:
  - orbit correction from BPMs under ground motion and alignment errors,
  - stability of residual orbit after luminosity and crab leakage optimization during a fill.
  - Realistic correction strategies.
  - Alignment requirements, BPM specifications, knobs optimization to stay within the orbit residual and corrector strength budget.





Presentation from Joel and Davide 27/8/2019

[J. Andersson, D. Gamba]

Optimization without MS10

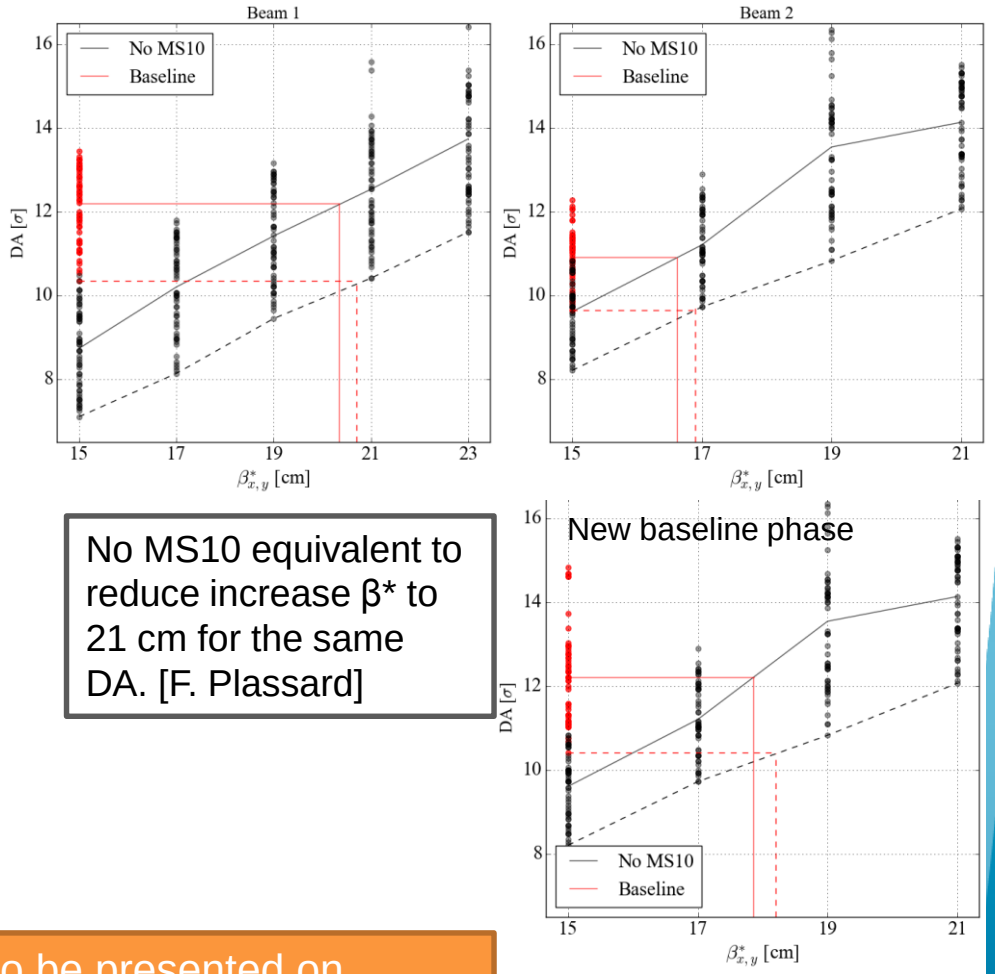
Studies have shown that:

- Baseline give always better DA
- Option without MS10 gives also worst DA

Mitigations:

- Cut MS14F and change vertical phase advances
- Cut MS14F&D and increase ATS factors
- [on going] Optimize IP1 to IP5 phase advance
- [on going] Optimize octupole families

DA with imperfections and -570 A, no BB



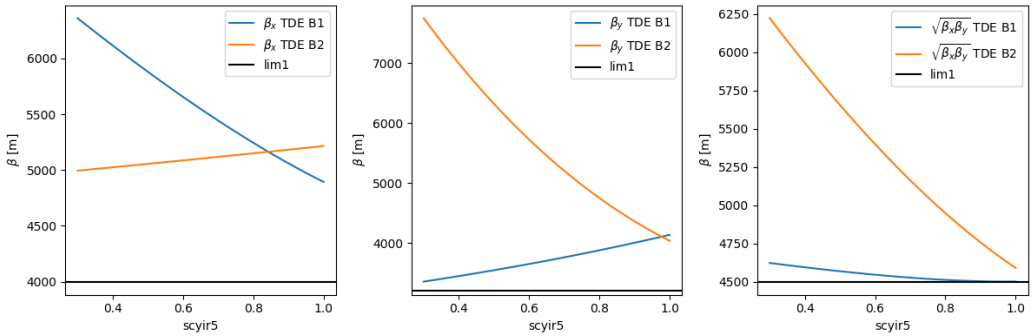
No MS10 equivalent to reduce increase β* to 21 cm for the same DA. [F. Plassard]

Work in progress to compare all options, to be presented on 27/8/2019 by Fabien.

IR6 Dump size optimization

- Increase spot size at the beam dump by relaxing MKD-TCT phase advance (not needed for round optics with V crossing in Point 5, or flat optics with H crossing in Point 5).

Status: spot size cannot be increased at injection due to aperture constraints, but can be done during ramp&squeeze



Nominal ramp and squeeze for round optics.

	Requirements	V1.4 round	First iteration
β_x[km]	>4	6.3/5.0	7.7/5.0
β_y[km]	>3.2	3.8/7.8	4.1/8.8
Sqrt($\beta_x\beta_y$) [km]	>4.5	4.6/6.2	5.6/6.6

Limits: non-conform mqtl11.r6b1, mqtl11.l6b2

First improvement 10% in beam size at the end of the squeeze [to be continued]

Conclusion

- HLLHCV1.5 optics should be released together with a new set of integration drawings
- Hardware integration is not completed yet
  - last blocking point is Q4 rotation
  - other modifications not involving magnets could be added in parallel with optics files generation
- This optics version aims at including an update of the aperture tolerance to refine aperture estimates.
- Several ongoing studies will be presented in August:
  - Orbit correction: strategy, corrector budget, BPM specifications
  - No MS10 studies
  - IR6 studies