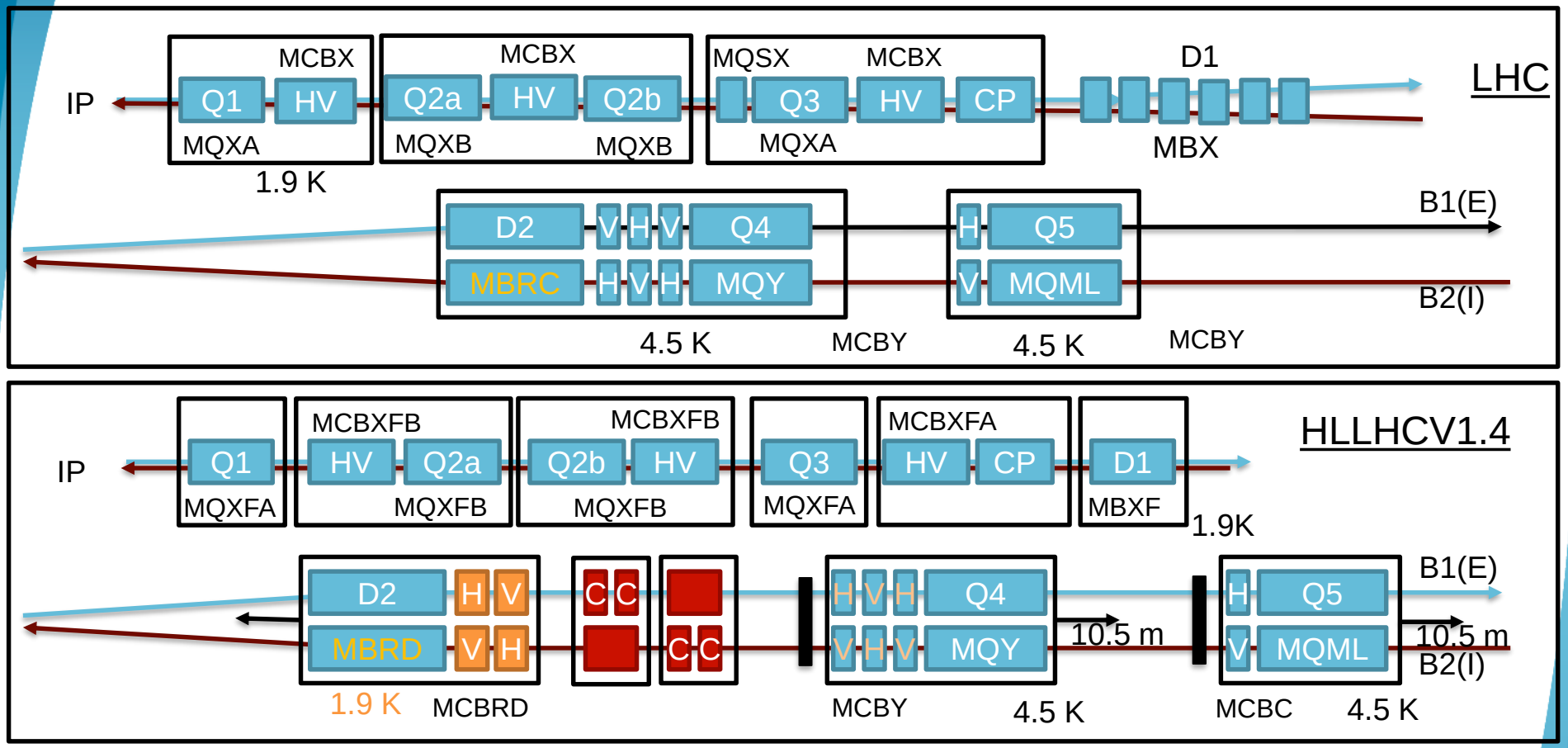
HL-LHC layout and optics

R. De Maria
Thanks to M. Deile, P. Fessia

Forward physics 19/12/2018

Layout main changes



Main changes:
New triplets, cold D1, D2-Q4 separated, orbit correctors and crab cavities inserted, Q4-Q5 displaced, mask inserted.

Beam stay clear

Effective model of the beam stay clear region, assuming most pushed optics.

Beam stay clear =

$$1.1\ n_\sigma\ \sigma_{nominal} + 2\ mm$$

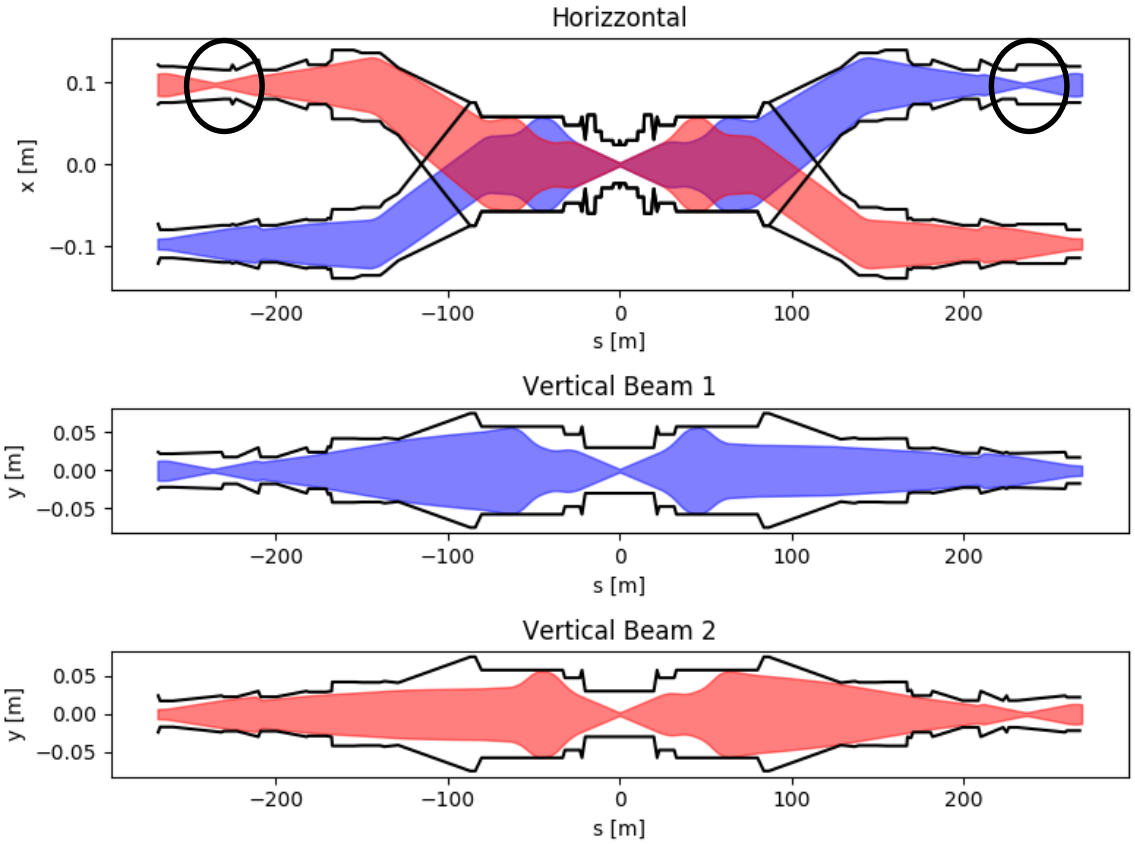
where:

n_σ = 13.25 up to D1

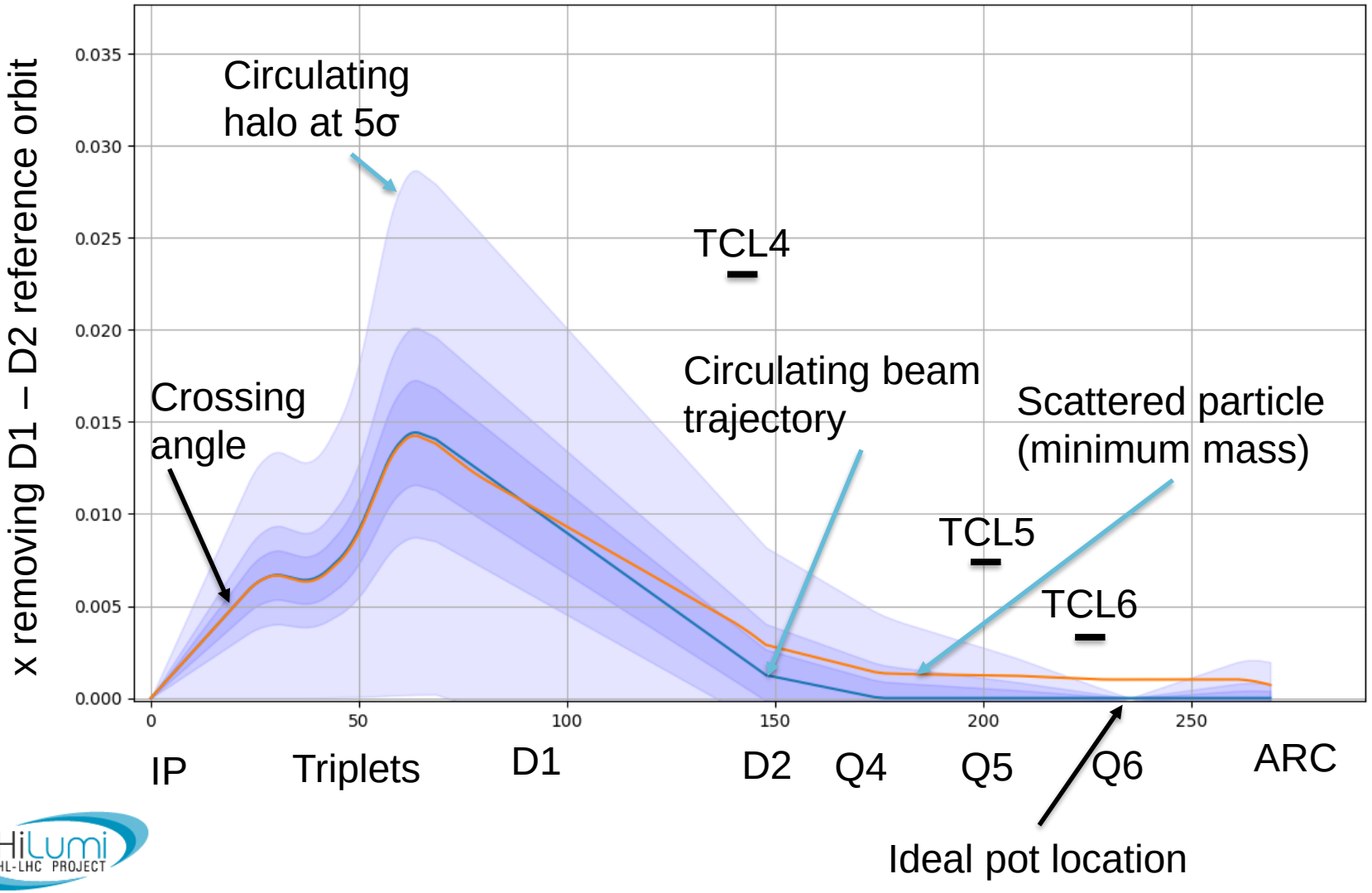
n_σ = 15 TAXN-Q5

n_σ = 20 sigma Q6 to Q7.

Table available here.



Off-momentum orbits



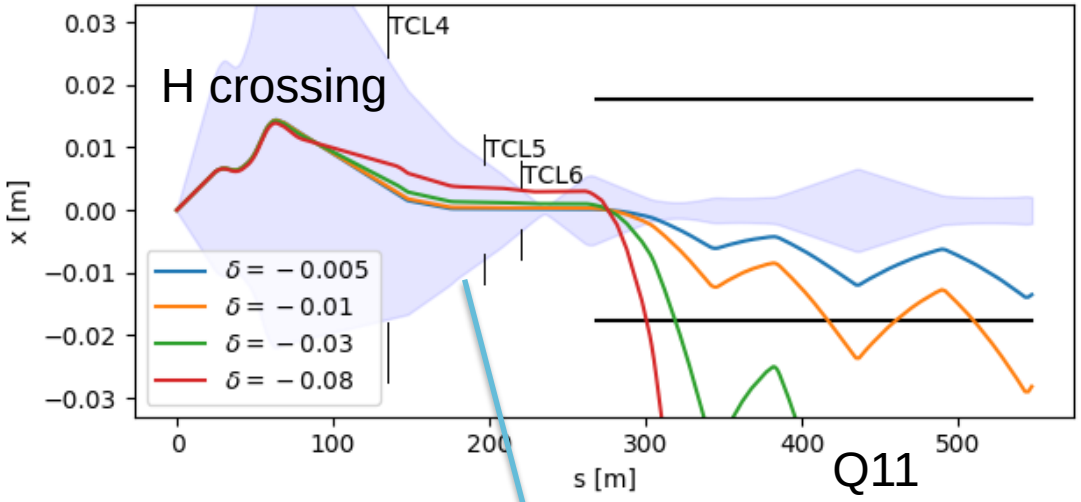
Crossing plane off momentum trajectories

Crossing plane change off momentum trajectories.

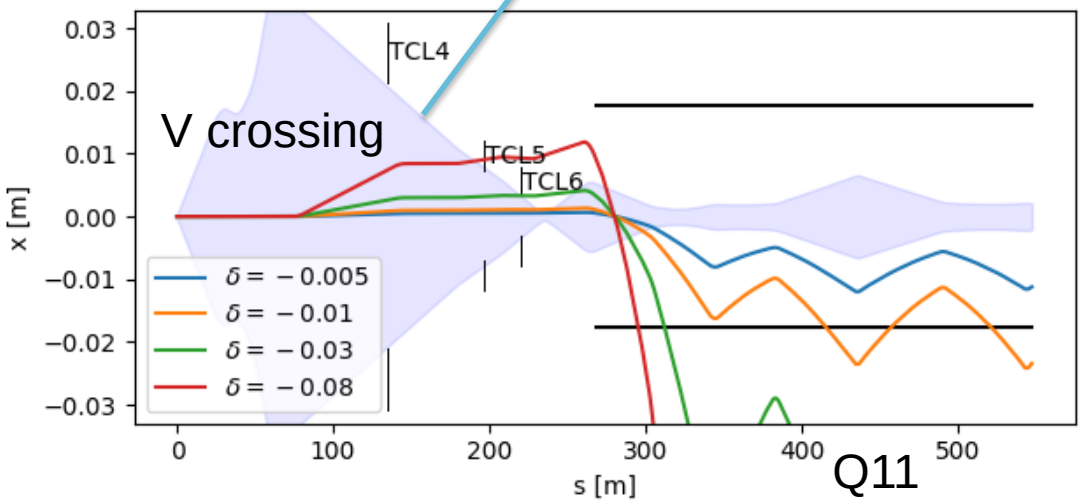
Crossing plane choice is under study:

- Baseline: H (Point 1) and V (Point 5) better for round optics.
- Option: V (Point 1) and H (Point 5) better for flat optics.

Choice cannot be (easily) changed after crab cavities installation.



Halo: (nTCT+3) σ + 0.3 mm



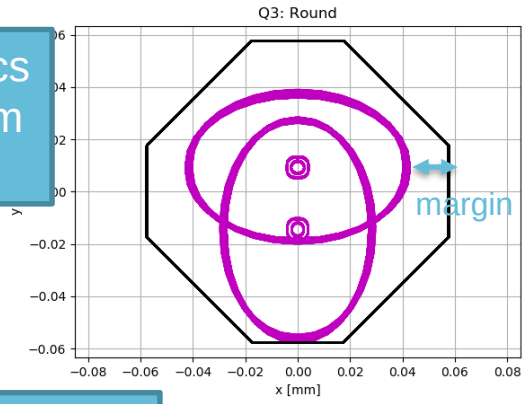
Crossing plane choices

- Crab cavities act on either H or V plane and cannot easily exchanged. Decision 2019.
- MKD failure scenario and TCT damage threshold reduce the horizontal aperture margins in Point 5.

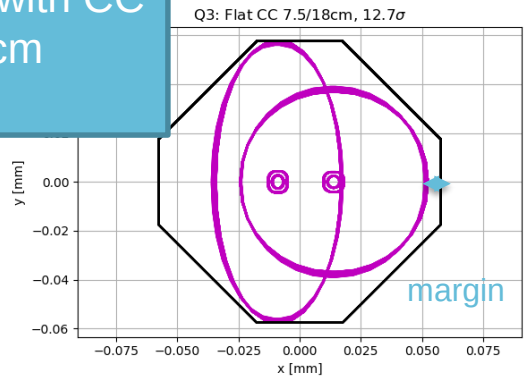
- Round optics have larger aperture margins in the parallel separation plane. Vertical crossing is best in Point 5.
- Flat optics have larger aperture margins in the crossing angle plane. Horizontal crossing is best in Point 5 (also because this improves TCDQ gaps).
- Wire compensator (not baseline) needs to be close to beam in the crossing plane. Vertical crossing is overall best in Point 5 [S. Fartoukh].

Baseline assumes vertical crossing in Point 5 based on the round optics scenario.

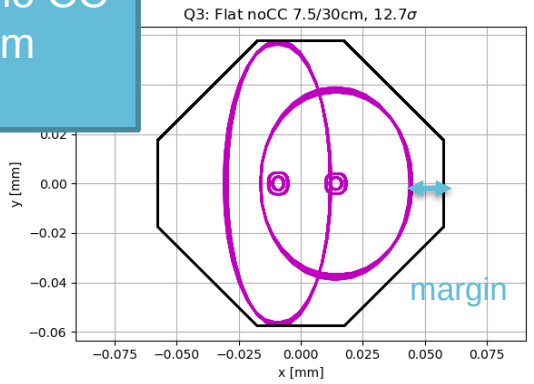
Round optics
β*=15/15 cm
V crossing



Flat optics with CC
β*=18/7.5 cm
H crossing

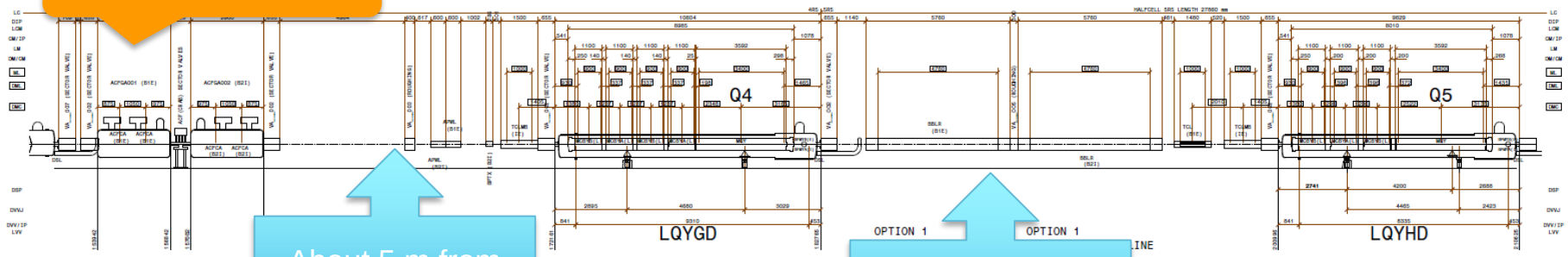


Flat optics no CC
β*=30/7.5 cm
H crossing



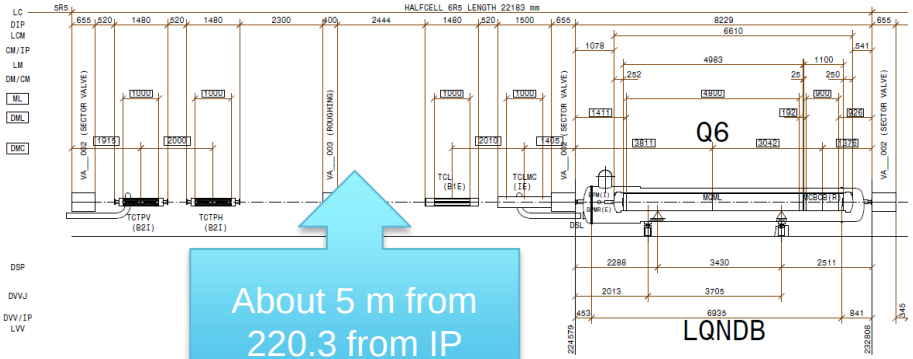
Possible layout location

Crab cavities



About 5 m from 165 m from IP

About 5 m from 190 m from IP

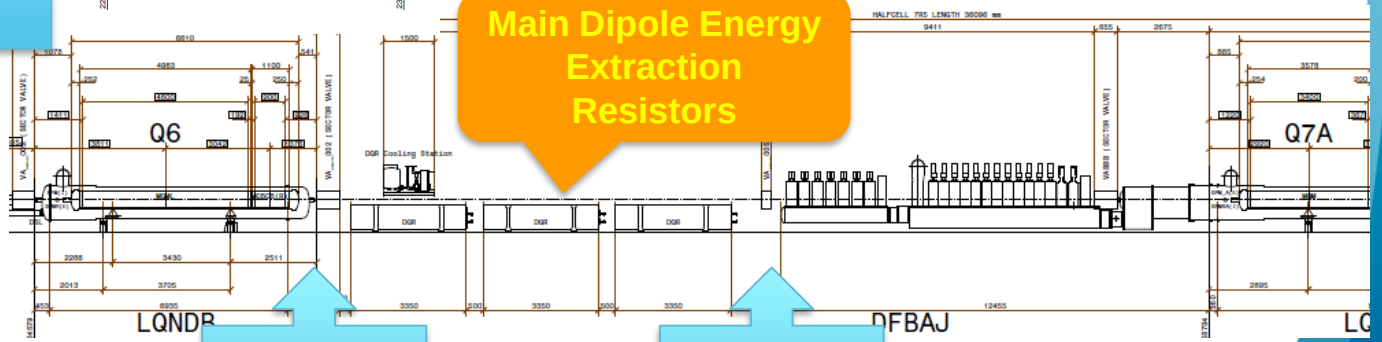


About 5 m from 220.3 from IP

Layout being reviewed:

- Possible displacement of the CC
- Q4 – Q5 slightly displaced

Main Dipole Energy Extraction Resistors



233 m from the IP

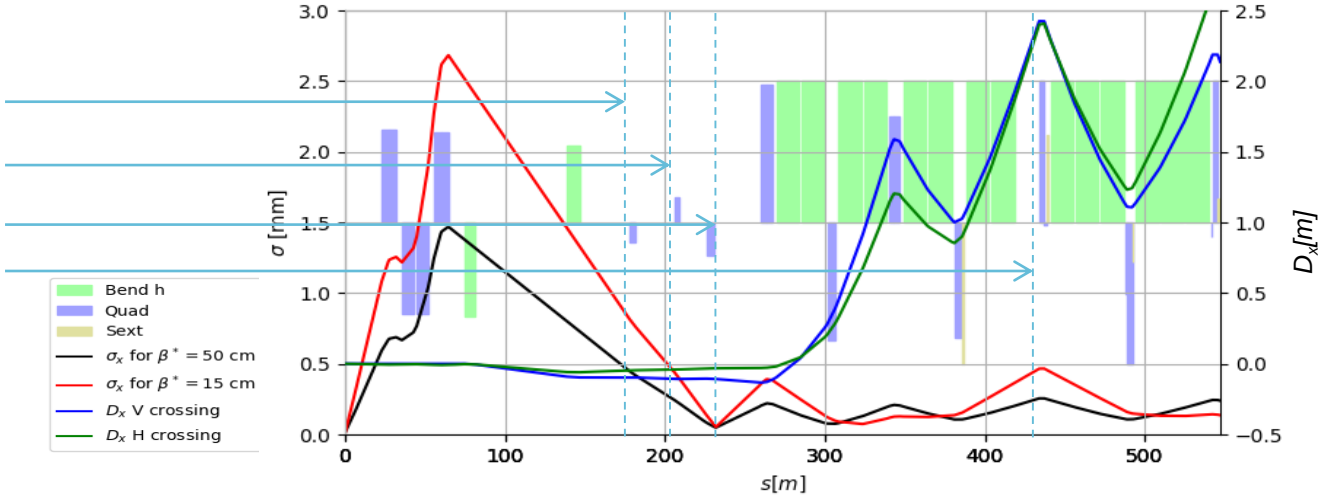
245 m from the IP

Forward Physics in HL-LHC

Proposed pot location:

- in between Crab-Q4,
- in between Q4-Q5,
- in between Q6-Q7,
- Q11 empty-cryostat.

P. Fessia, coordination meeting, 5/6/2018



Comments:

- Matching section optics and layout under review.
- Beam size and dispersion in Q6 are subject to changes and cannot be easily optimized.
- TCL settings: can reduce acceptance, TCL4 (TCLX) critical for D2 protection (assumed 13.5 σ F. Cerutti annual meeting 14/7/2017, 14.2 σ for collimation studies (D. Mirarchi, colUSM, 24/2/2017)
- No request of high-beta optics (VDM optics β*=30 m).

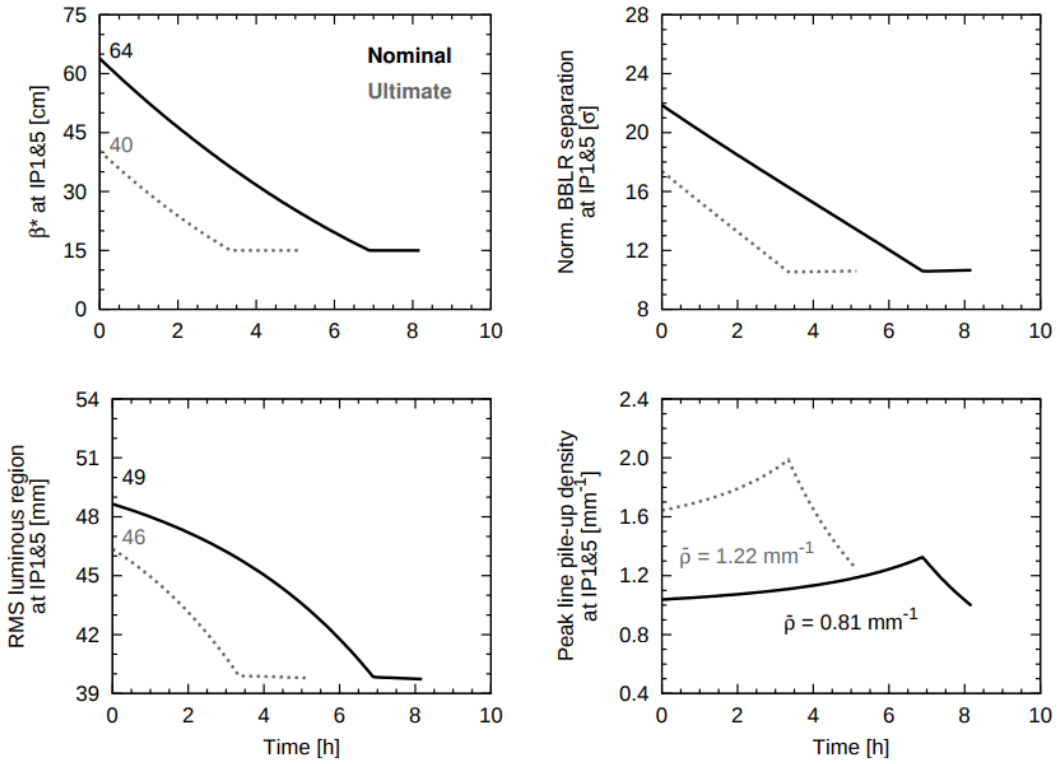
Operational scenario

Baseline levelling	Begin	End
Bunch population	2.2 10^{11}	1.1 10^{11}
β*	64 cm	15 cm
Crossing angle	500 µrad (21.8 σ)	500 µrad (10.5 σ)

Main scenario: β* levelling, 250 fb^{-1}/year, 7h levelling time, round β*.

Scenarios Option:

- Ultimate luminosity -> shorter levelling time
- Flat optics -> smaller crossing angle

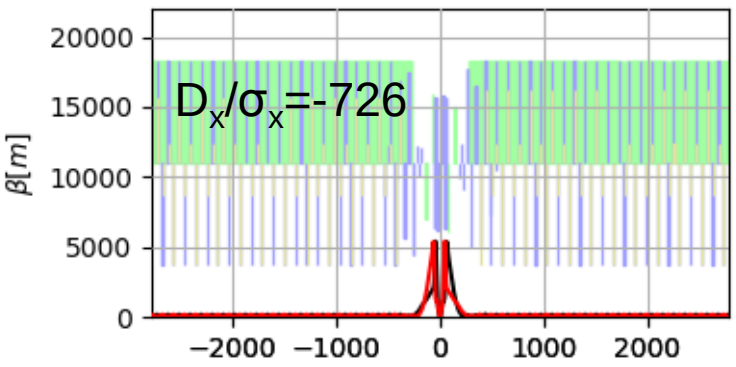


[Update of the HL-LHC operational scenarios for proton operation](), CERN-ACC-NOTE-2018-0002

Optics scenario

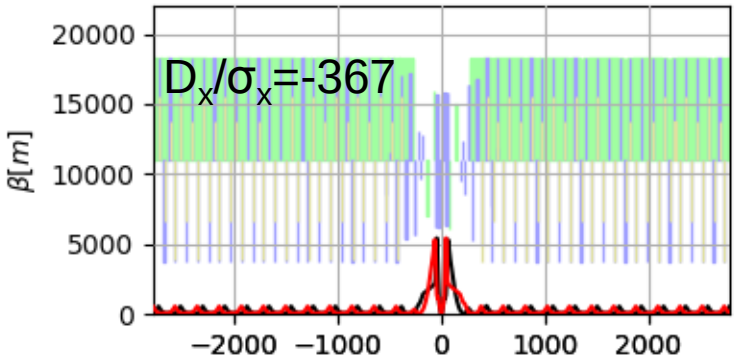
Two possible scenarios for β* levelling

IR1/IR5 squeeze during ramp

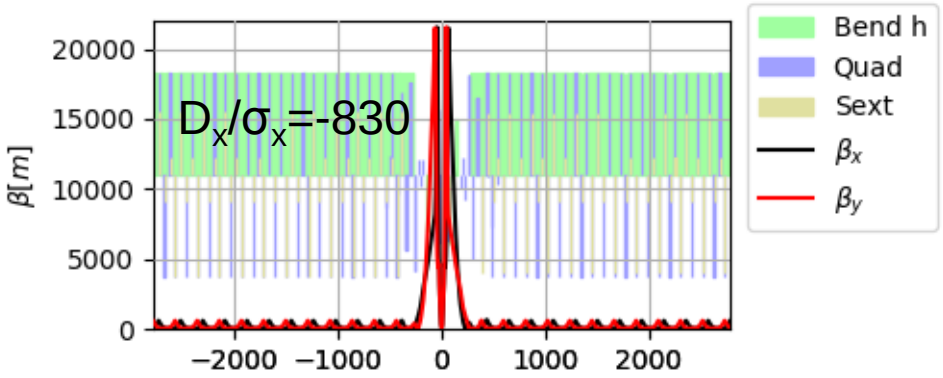


Final squeeze with ATS

IR1/IR5 partially squeezed and ATS fully deployed during the ramp.



Final squeeze with IR1/IR5



Choice has an impact on normalized dispersion (e.g. at 233 m)

Conclusion

Parasitic forward physics will be more difficult in the HL-LHC due to many constraints:

- Layout is has less available space.
- Optics is more constrained.
- Crossing plane constrained by crab cavities.
- TCL settings (in particular TCLX) cannot be easily relaxed.

Location around Q6 seems the most promising.

Specific optics optimization can be further attempted but probably at the expenses of crab cavity efficiency.