Scaling of DA with beam-beam effects (LR-HO): experience and simulations

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What I will cover:

- First results from simulations on HL-LHC v1.2 optics:
  - DA vs Chromaticity and Octupoles,
  - DA vs Crossing and Intensity.
- Experimental status and foreseen steps.

Simulation setup

Standard MADX-SixTrack-SixDesk environment:

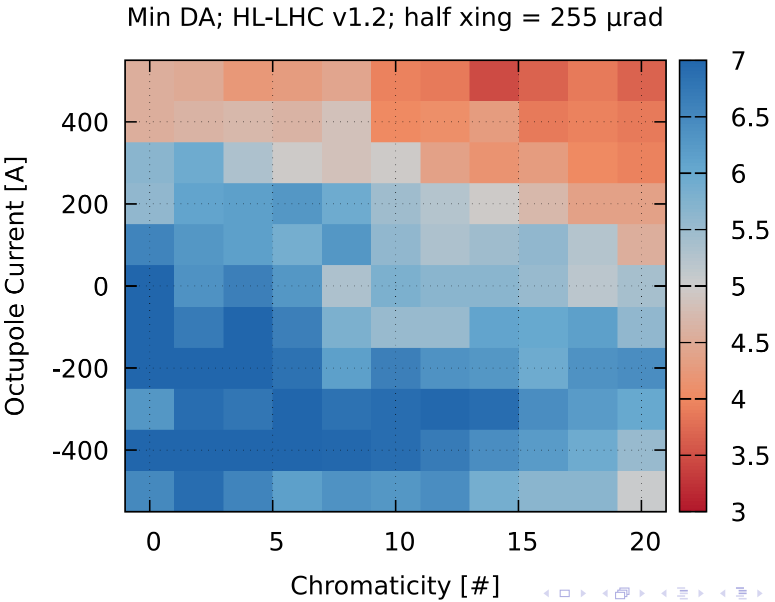
- HL-LHC optics v1.2 with standard beam parameters at the end of levelling (7 TeV, $\beta^* = 20\,\text{cm}$, $\varepsilon = 2.5\,\mu\text{m}$, $N = 1.275 \times 10^{11}$);
- Beam-Beam in weak-strong approximation (rigid kicks) in all IPs (5σ separation in IP2);
- Parasitic long-range interactions are taken into account up to the fifth one in the separation dipole (total of 20 per side);
- 6D tracking of 1M turns in the LHC ring.

- Initial longitudinal tracking condition: $(z, \delta)_0 = (0, 0.00027)$
- Dynamic aperture extracted by SixDesk for the standard 5 angles in the xy plane (15,30,45,60,75)[1];
- We considered the minimum dynamic aperture over the angles.

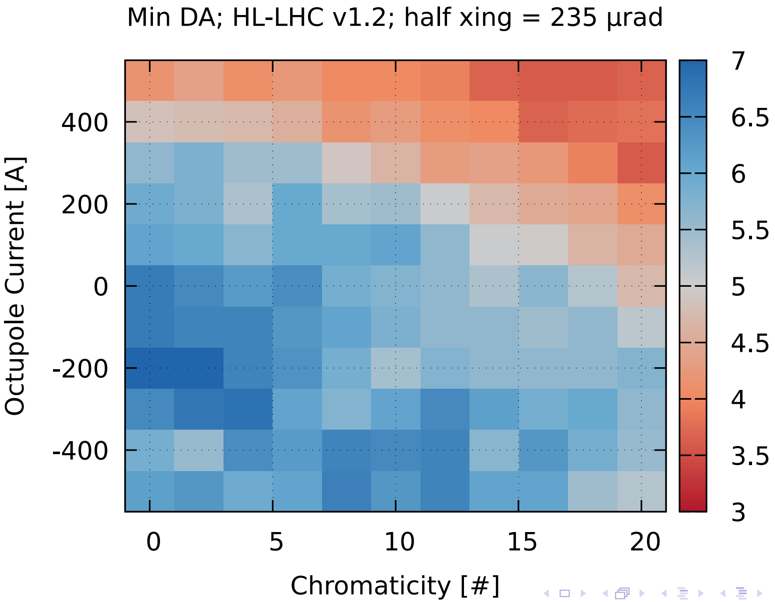
[1] sometime less than 5 due to nuisances from lsf

Croma and Octupoles scan

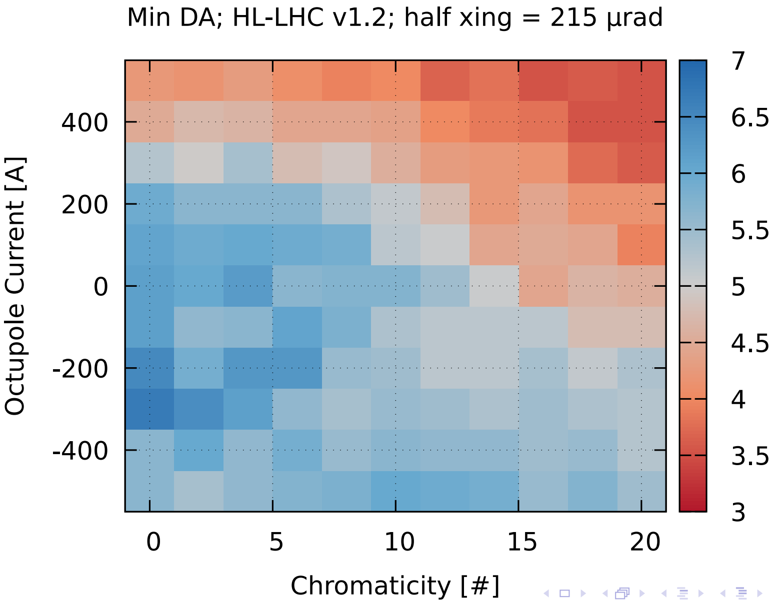
The Nominal Case, $N = 1.275 \times 10^{11}$



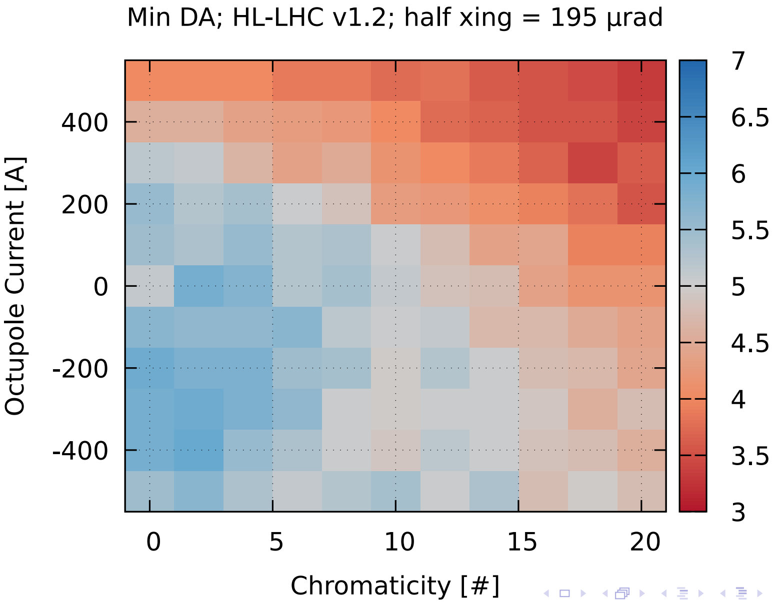
Reducing Crossing (I)



Reducing Crossing (II)



Reducing Crossing (III)

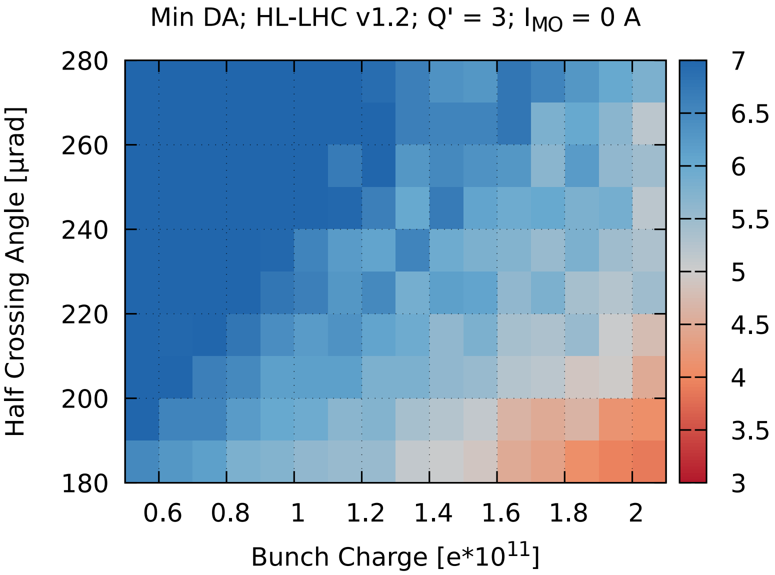


Some observations

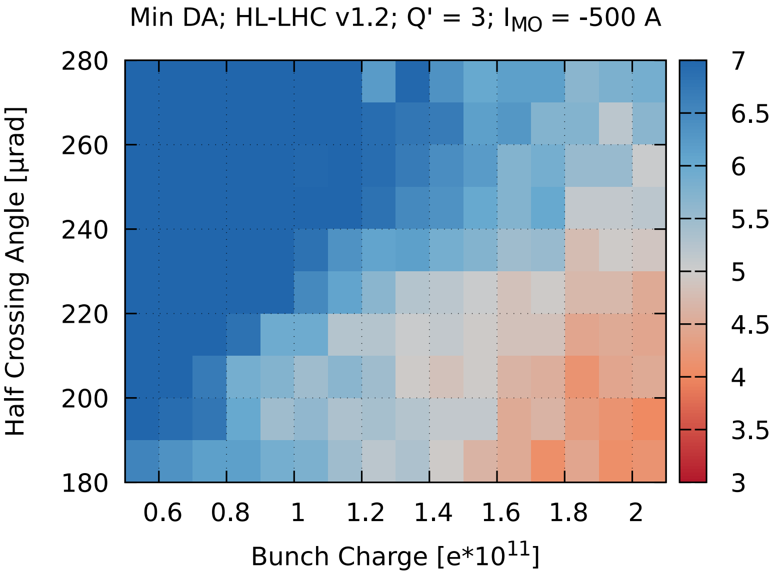
- The nominal setting for the crossing looks quite conservative,
- Good DA is maintained when reducing the crossing angle,
- Negative (or moderate) octupoles allow to run with high chromaticity,
- The best DA is obtained for negative octupoles: LR compensation.

Intensity and Crossing Scan

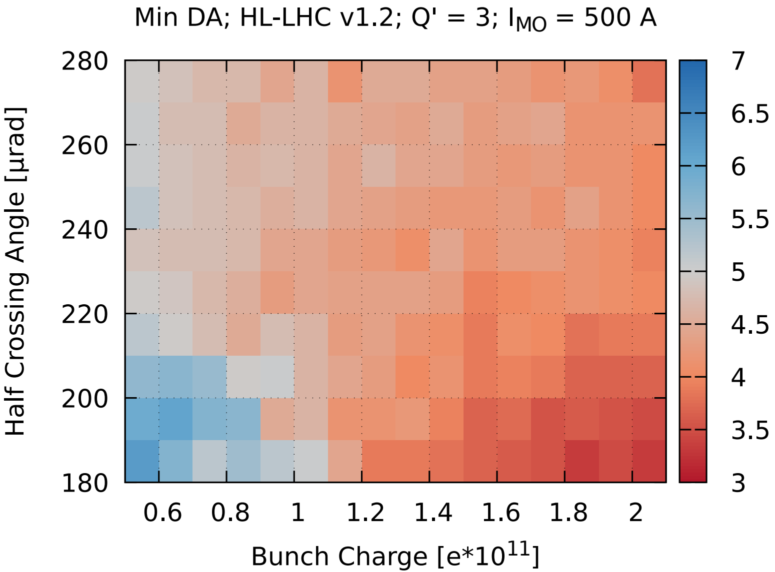
The Nominal Case



Negative Octupoles



Positive Octupoles



Some observations

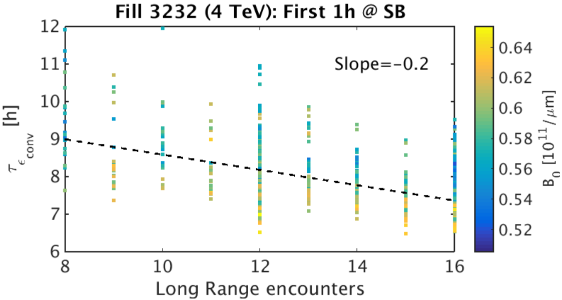
- The I-X scan shows margin as well: can reduce the crossing or increase intensity,
- Negative octupoles make the DA transition sharper: better DA around the nominal working point,
- Cannot run with positive octupoles.

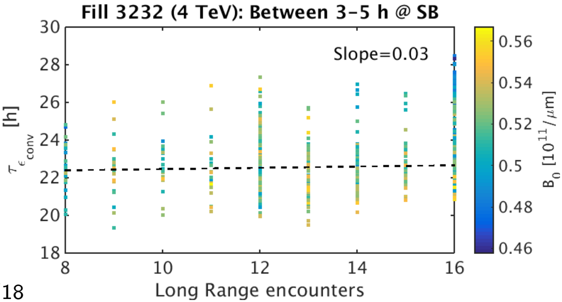
Outlook

- Improvements to the simulation: errors.
- Explore the levelling alternatives from an incoherent point of view:
  - Beta*,
  - Separation,
  - Crossing.

Experimental status: Work In Progress

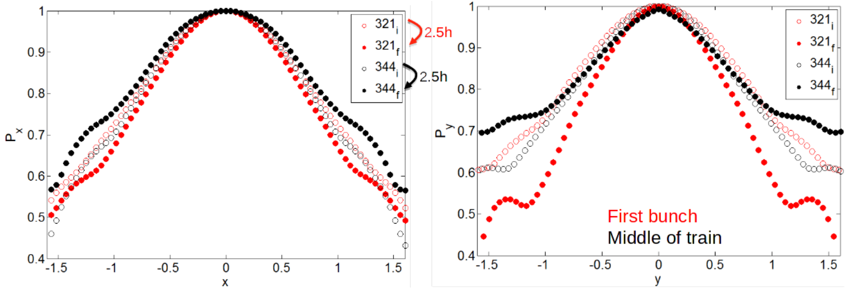
Effect of number of LRs on emittance growth





- Convoluted emittance growth (extracted from luminosity) vs number of LRs color-coded with brightness.
- Dependence on both number of LRs and brightness for 1st h in SB.
- Dependence on LRs is lost between 3-5 h in SB.
- Consistent trend over different 2012 fills.
- Need to verify if still present.

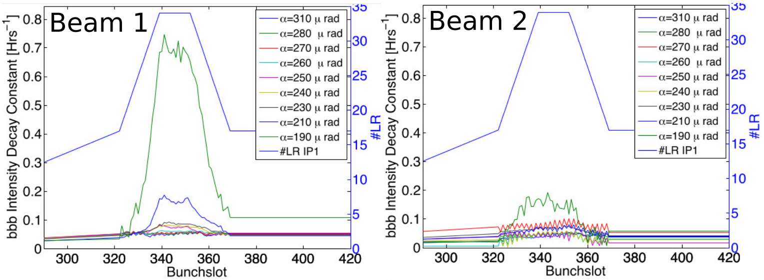
Profiles from BSRT



- The first bunch of the train (with less LRs) has less tails after 2.5 h → radiation damping?
- The middle bunch of the train (with more LRs) has more tails after 2.5 h → diffusion mechanism?
- The behaviour is not always consistent for different trains.

Asymmetry between the two beams

- Since 2016 B1 has a systematically smaller lifetime in all the conditions, from injection to dump, even with ATS optics!
- B1 showed signatures of LR interactions in the MD while B2 almost did not.



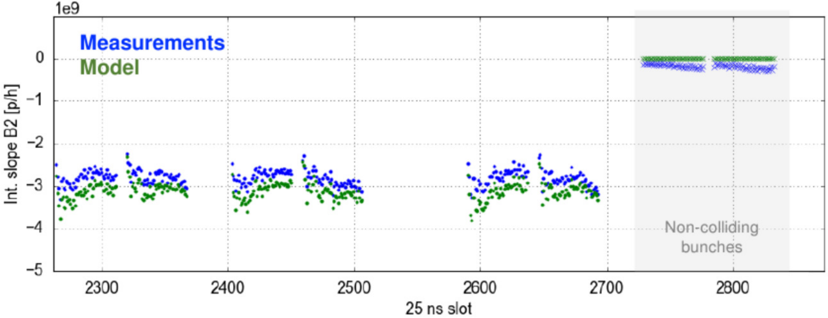
[2]

Are we in a weak-strong regime: B1 less bright than B2?

- Can we reproduce the observations in simulation, starting from the measured beam parameters?
- Different phase advances between the two IPs for the two beams, does this have an impact?

[2] T. Pieloni et al.

Is there a multibunch effect?



- More losses are seen for the bunches in the tails of trains (similar trends for the emittance blowup).
- True for both colliding and non-colliding trains: e-cloud? ADT?
- How does this effect couples with beam-beam? Can we disentangle them?
- Can this mask the signatures of LR interactions?

Conclusions

- Progresses are being made with the performance prediction and identification of working point for HL-LHC;
- Initial DA simulations have been performed and results are promising;
- Big efforts are being invested for a better understanding of the LHC.