Recap on mitigation options if the MS in Q10 will not be installed.

R. De Maria

Using material from F. Plassard from 2019

Past references

In the years we studied potential mitigation for the absence of MS in Q10, which is the topic of the following slides. A report (F. Plassard et al) has been approved waiting to be uploaded to CDS.

Thursday, 29 April 2021 MS10 options for Run4 (S. Kostoglou)

Tuesday, 06 April 2021 Review of the situation without MS10 at the beginning of collisions and at the end leveling (S. Kostoglou)

Tuesday, 25 February 2020 Update on the No MS10 status for HL-LHC (F. Plassard)

Tuesday, 10 September 2019 No MS10 studies (F. Plassard)

Tuesday, 19 March 2019 Possibility to suppress the installation of MS in Q10 in IR1 and IR5 (F. Plassard)

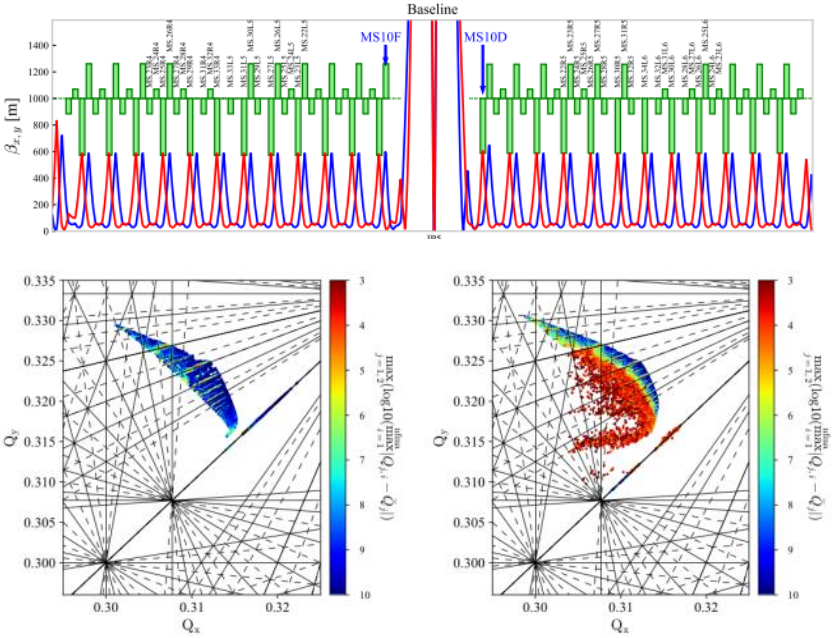
Tuesday, 07 November 2017 MS10: can we do without it? Cases without and with beam-beam (R. De Maria)

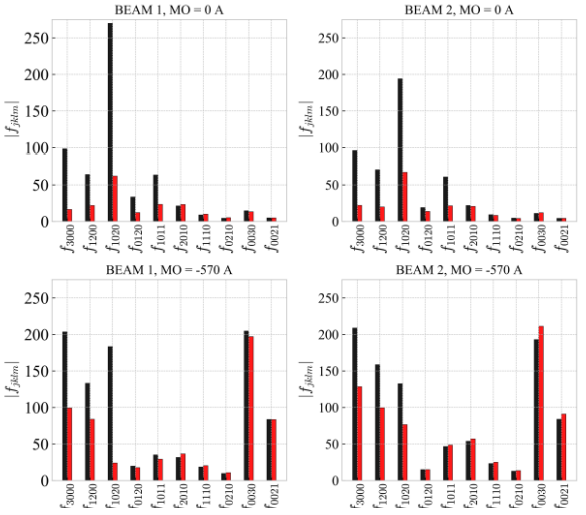
The message HAS NOT CHANGED:

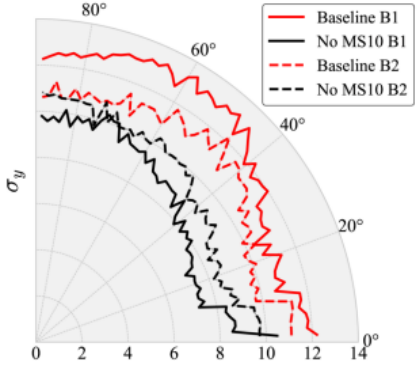
1) The additional MS in Q10 improves DA, in particular, for low β*.
2) The absence of MS in Q10 increases the risk of not being able to use the triplet aperture to increase the luminosity due to poor beam lifetime.

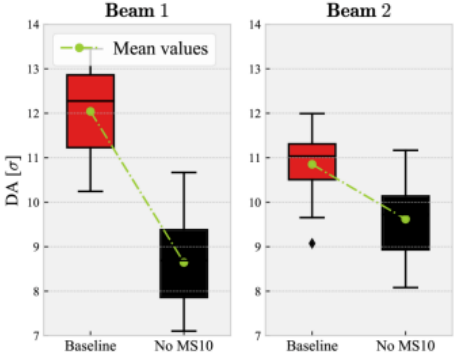
MS10 vs no MS10

Additional MS cures resonance created by uncompensated MS









No imperfections, 10^6 turns

Mitigations

- IP1-IP5 phase advance optimization
  - Compensate dangerous resonances between IP1 and IP5
  - Risks:
    - 1) not enough optics flexibility to apply it (thanks to decision to not build CuCD collimators HL has less optics flexibility)
    - 2) the phase advance that cures DA may conflict with the phase advance that cures other effects (beam-beam orbit, etc..)
    - 3) the optimal phase advance on paper, may not exists in presence of uncompensated field imperfection
- Remove one sextupole in Q14:
  - Eliminate one odd sextupole and change one strong family
  - Risks:
    - It reduces arc correction capabilities: more off-moment beta-beating (worse cleaning), more dispersion (less aperture more cold losses) or larger beta in the arcs (less aperture, worse DA) for the same beta*
    - It increases octupole resonances which make DA worse therefore it needs phase-advance optimization bearing the risks
- Remove two sextupoles:
  - Elimitate two odd sextupoles without changes families
    - It further reduces arc correction capabilities more than above
    - It solve octupole resonances of above

Cutting MS 14

Condemning sextupoles should be possible and restore pair cancellations. Is it reversible, at what cost? WP3 to clarify or costly.

Two options: NoMS14F, NoMS14F&D

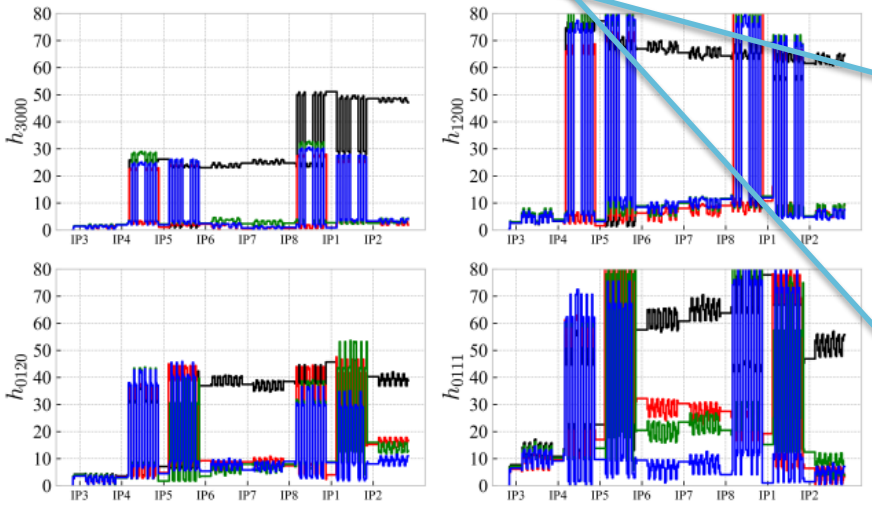
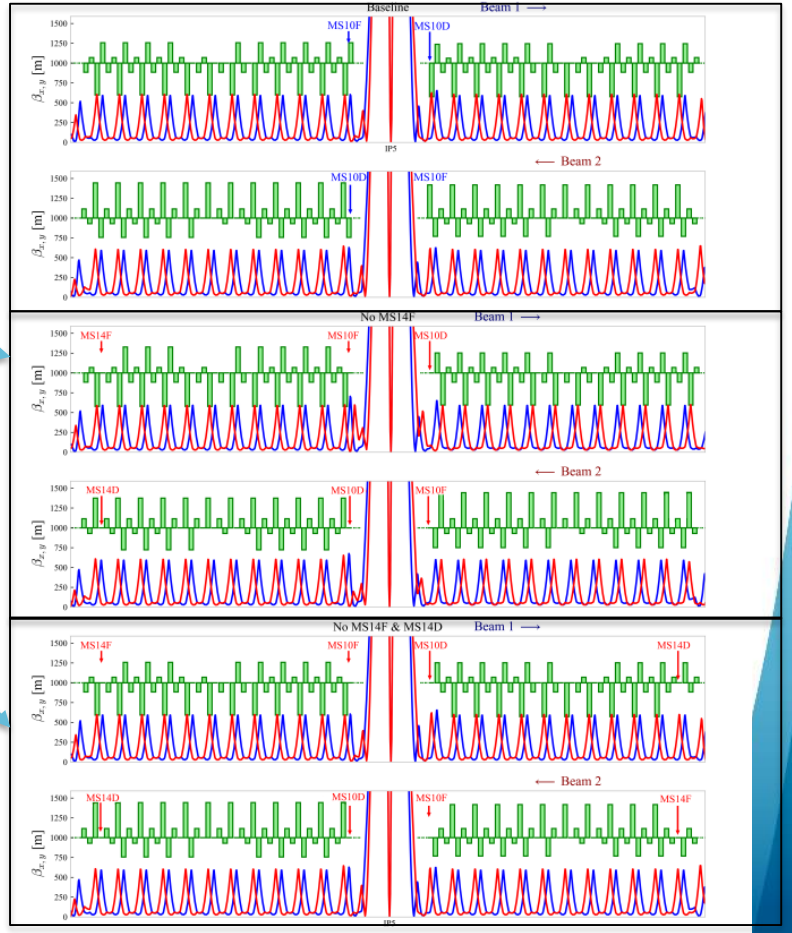


Fig. 9: Comparison of the sextupole geometrical RDTs build-up along the ring for the *No MS10* (black lines), *Baseline* (red lines), *No MS14F* (green lines) and *No MS14F & MS14D optics* (blue lines) optics.



Cutting MS 14

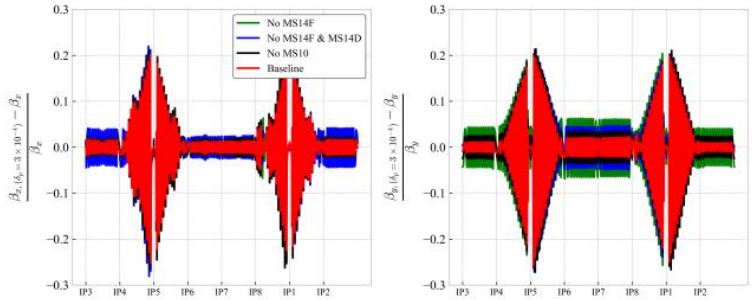


Fig. 12: Amplitude of the chromatic β-beating along the machine for the different sextupole lattice options.

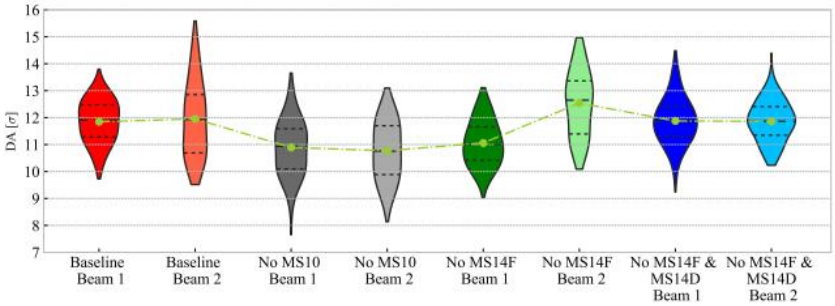


Fig. 14: Dynamic aperture comparison between all optics, with field imperfections and Landau octupoles set to I_{MO} = -570 A.

β*=15 cm
Errors v5, no MCBXF, MCBRD imperfections.
Present DA is worse in absolute.

MS10 overall better for DA and chromatic correction

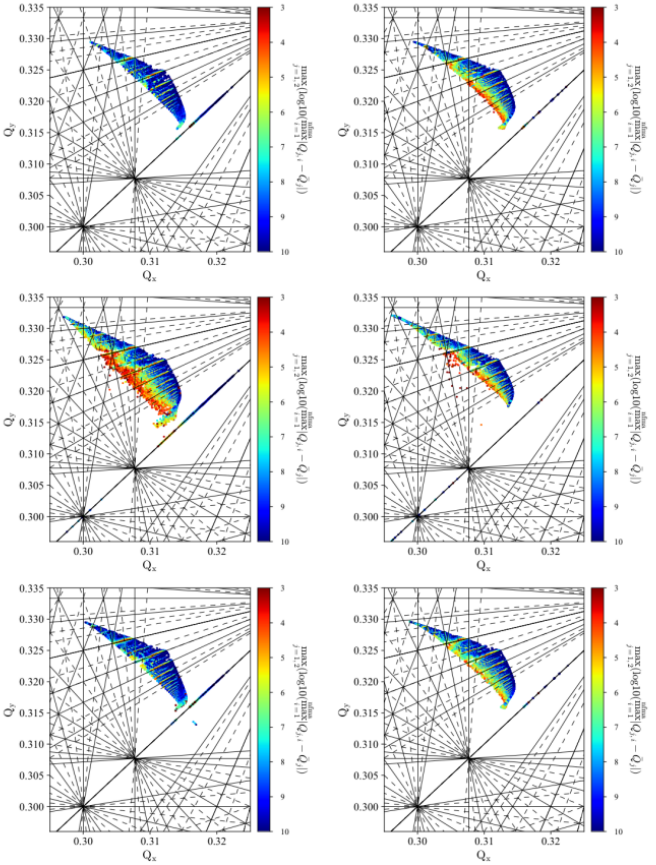
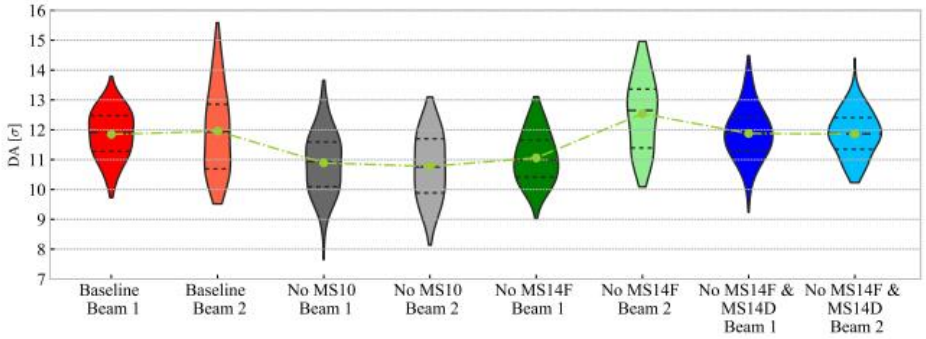


Fig. 13: Frequency Map Analysis on Beam 1 (left plots) and Beam 2 (right plots) for the Baseline (top), No MS14F (middle), and No MS14F & MS14D (bottom) optics.

Phase advance optimization



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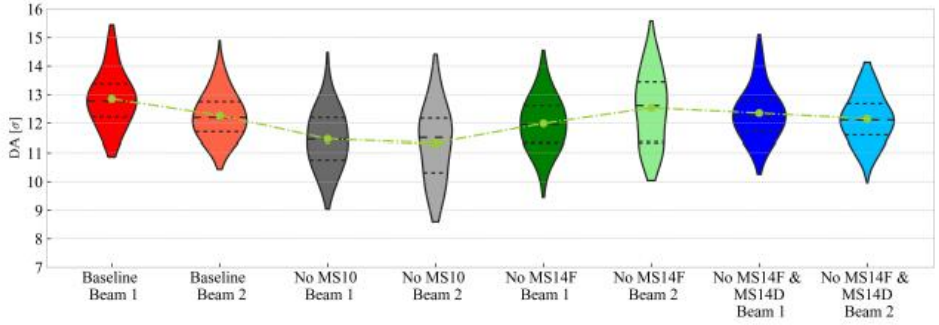

Fig. 19: Dynamic aperture comparison between all optics, with field imperfections, after $\Delta\mu_{x,y}^{IP1-5}$ phase optimisation and with Landau octupoles set to I_{MO} = -570 A.

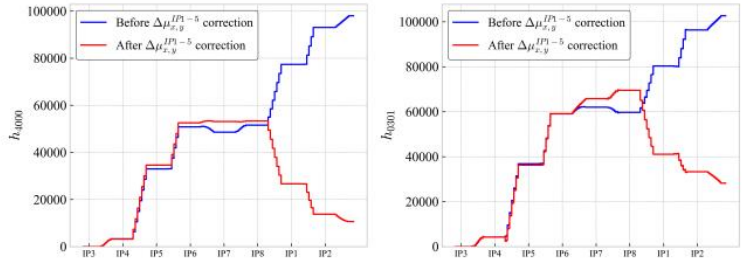

Fig. 15: Example of self-compensation of octupolar RDTs (h_{4000} and h_{0301}) between IR1 and IR5 after $\Delta\mu_{xy}^{IP1-5}$ phase optimisation (Baseline optics).

- Phase advance optimization can cure DA in particular for no MS14F.
- Still we do not know if this holds:
  - With recent field quality
  - With flat optics

NB Relying of phase advance is risky and not good for a baseline

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- Remove one sextupole in Q14 (noMS14F):
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  - Risks:
    - It reduces arc correction capabilities: more off-moment beta-beating (worse cleaning), more dispersion (less aperture more cold losses) or larger beta in the arcs (less aperture, worse DA) for the same beta*
    - It increases octupole resonances which make DA worse therefore it needs phase-advance optimization bearing the risks
- Remove two sextupoles (noMS14F&D):
  - Eliminate two odd sextupoles without changeing families
    - It further reduces arc correction capabilities more than noMS14F degrading same figures
    - It solve octupole resonances of option above noMS14F, giving overall better DA

Conclusion

- Install MS 10 to keep β* reach capabilities of the triplets.
- If not possible to install MS in Q10 (please WP3 and project management clarify if there are cost, schedule, technical risk issues):
  - accept the risk of not fully exploiting aperture for reducing β*;
  - work on schedule, cost, technical risk issues if any;
  - Shifting resources to support WP2/WP5 for additional mitigation studies: flat optics, collimation efficiency, impact of field imperfections, non-linear correction algorithms.