

# Review of the situation without MS10 at the end of leveling with flat optics

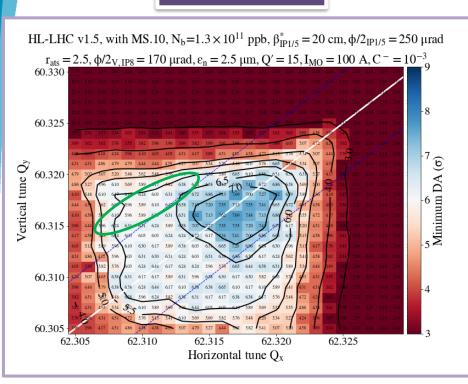
S. Kostoglou, H. Bartosik, R. De Maria, G. Sterbini

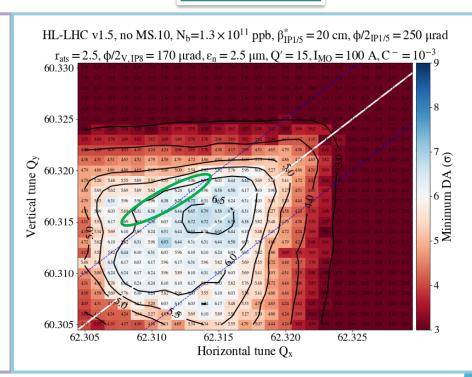
# Previous studies with round optics: e-3 r=2.5, $\beta^*=20$ cm, $I_{oct}=100$ A

C<sup>-</sup>=1e-3 on\_disp=1

#### With MS10

#### No MS10





#### Summary of findings with round optics:

- DA reduction in "No MS10" for EOL but DA target reached.
- Important to operate with on\_disp=1 in noMS10 scenario at EOL otherwise visible impact from chromatic coupling.



## $\beta^* = 7.5/30$ cm, no CC

C<sup>-</sup>=1e-3 on\_disp=1

#### With MS10

# HL-LHC v1.5, Flat optics, End of leveling $N_b = 1 \times 10^{11} ppb$ , $\beta_{x, 1P1}^* = 7.5$ cm, $\beta_{y, 1P1}^* = 3.0$ cm, $\phi/2_{1P1(v)/5(H)} = 250$ µrad CC OFF, $\sigma_z = 7.61$ cm, $\phi/2_{v, 1P8} = 170$ µrad, $\epsilon_n = 2.5$ µm, Q' = 15, $I_{MO} = 100$ A, $C^- = 10^{-3}$ $\frac{100}{100}$ $\frac{1$

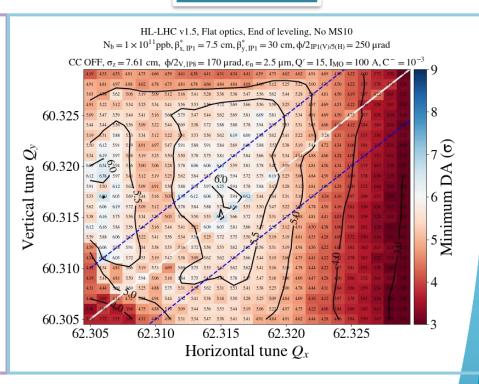
62.315

Horizontal tune  $Q_x$ 

62.320

62.325

#### No MS10





60.305

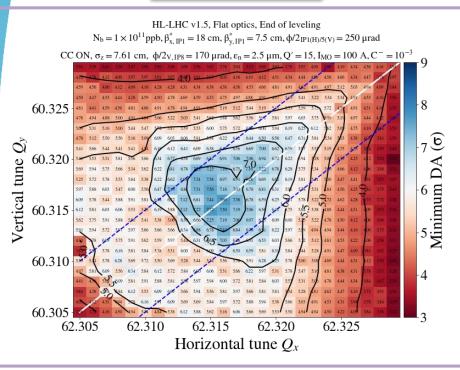
62.305

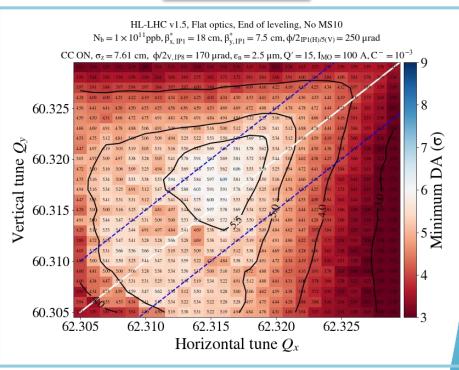
## $\beta^*$ =7.5/18 cm, with CC, H/V

C<sup>-</sup>=1e-3 on\_disp=1

#### With MS10







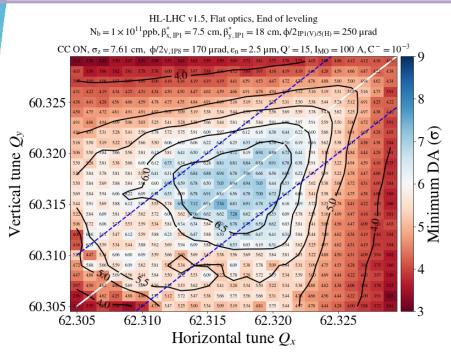


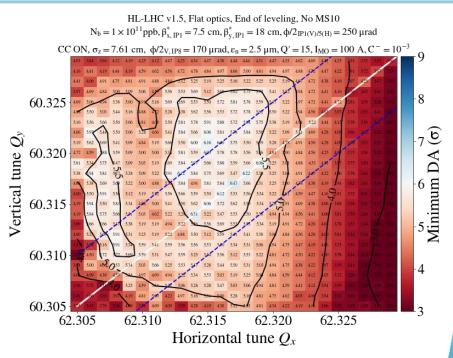
## $\beta^* = 7.5/18$ cm, with CC, V/H

C<sup>-</sup>=1e-3 on\_disp=1

#### With MS10

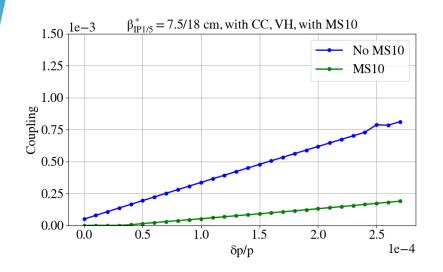


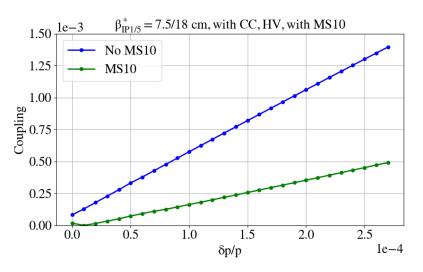


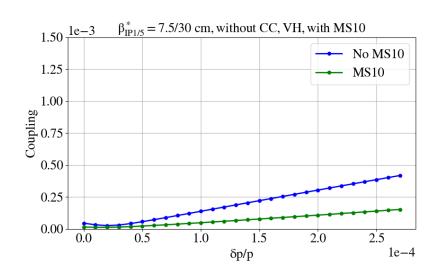




# Chromatic coupling, w/o BB





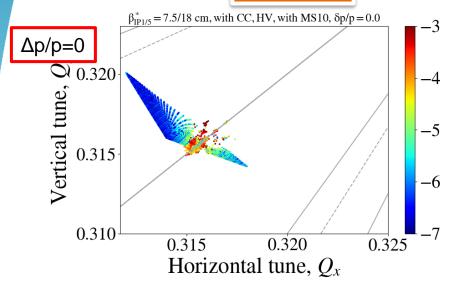


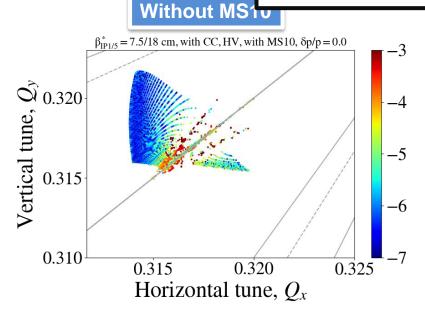


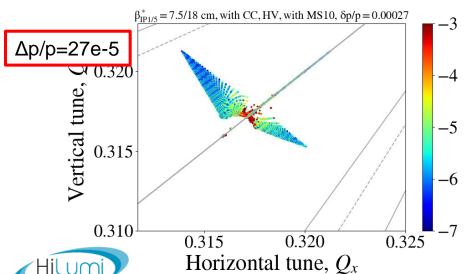
β\*=7.5/18 cm, HV, with CC
Without beam-beam

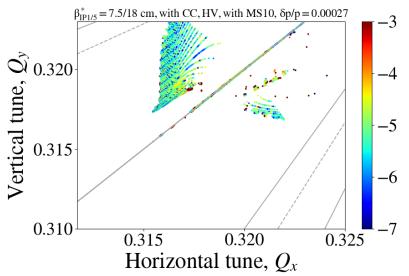












β\*=7.5/18 cm, VH, with beam-beam With MS10 Without MS10  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, with MS10,  $\delta p/p = 0.0$  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, with MS10,  $\delta p/p = 0.0$ Vertical tune,  $Q_y$ 0.315 0.300 0.315 0.315 0.300 0.300 Horizontal tune,  $Q_x$ Horizontal tune,  $Q_x$  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, with MS10,  $\delta p/p = 0.00027$  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, with MS10,  $\delta p/p = 0.00027$ Vertical tune,  $Q_v$  008.0 -6 0.300

0.300

0.315

Horizontal tune,  $Q_x$ 

 $\Delta p/p=0$ 

Vertical tune,

Δp/p=27e-5

Vertical tune, 0.300

0.300

0.315

Horizontal tune,  $Q_x$ 

0.315

## **Summary**

# Studied impact of "noMS10" on DA with flat optics for EOL:

- Studies with 7.5/30 cm without CC and 7.5/18 cm with CC (HV & VH crossing).
- Important DA degradation: from a situation where the DA target was comfortably achieved for all optics to a situation where a a limited number or no working point can be found that meets DA target → Absence of M10 more important for flat optics than round.
- As was done with round optics, investigated the role of chromatic coupling: without BB, increase of chromatic coupling in "noMS10", visible impact on FMAs. No clear impact of chromatic coupling with BB, DA degradation to be further understood.

# Backup slides



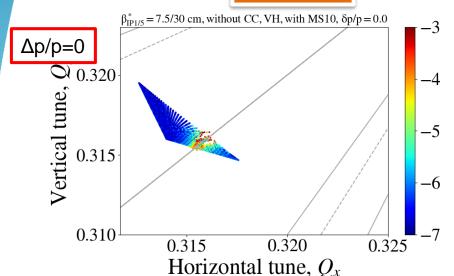
# FMAs without BB, with octupoles

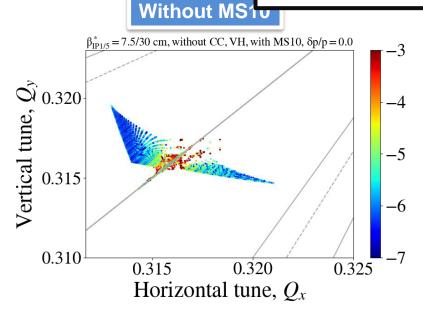


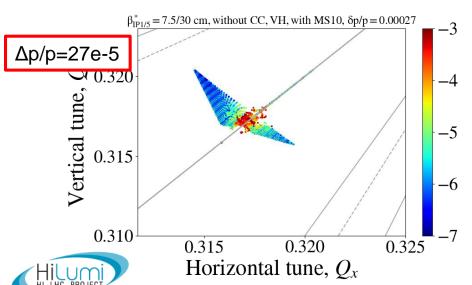
### $\beta^* = 7.5/30$ cm, no CF

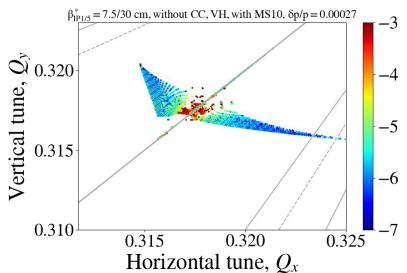
Without beam-beam





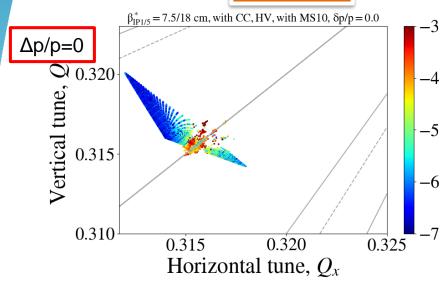


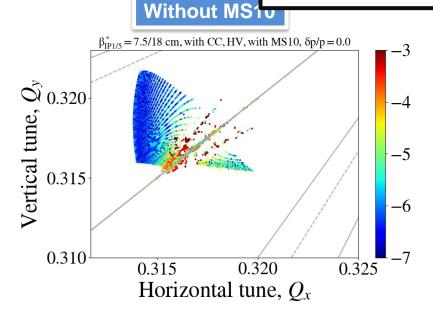


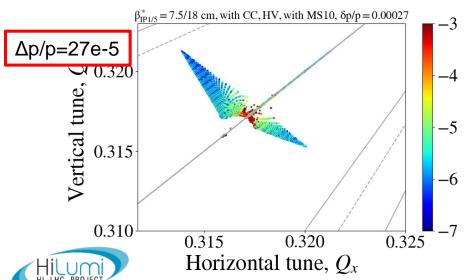


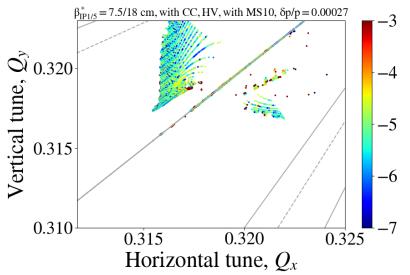
β\*=7.5/18 cm, HV, with CC Without beam-beam







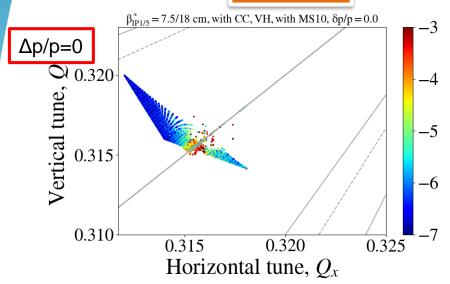


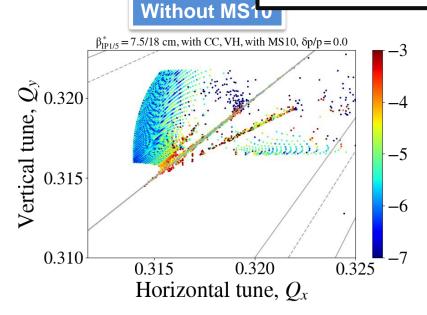


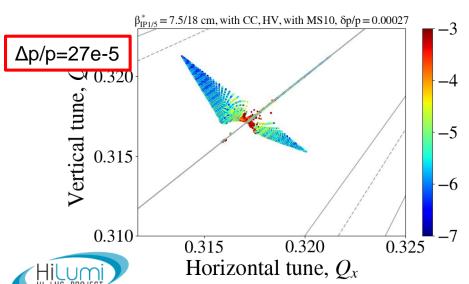
# β\*=7.5/18 cm, VH, with CC Without beam-beam

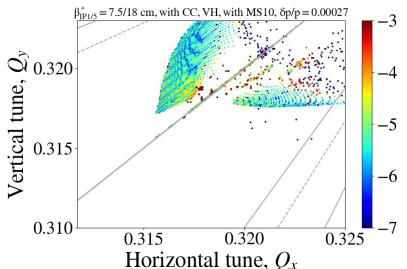












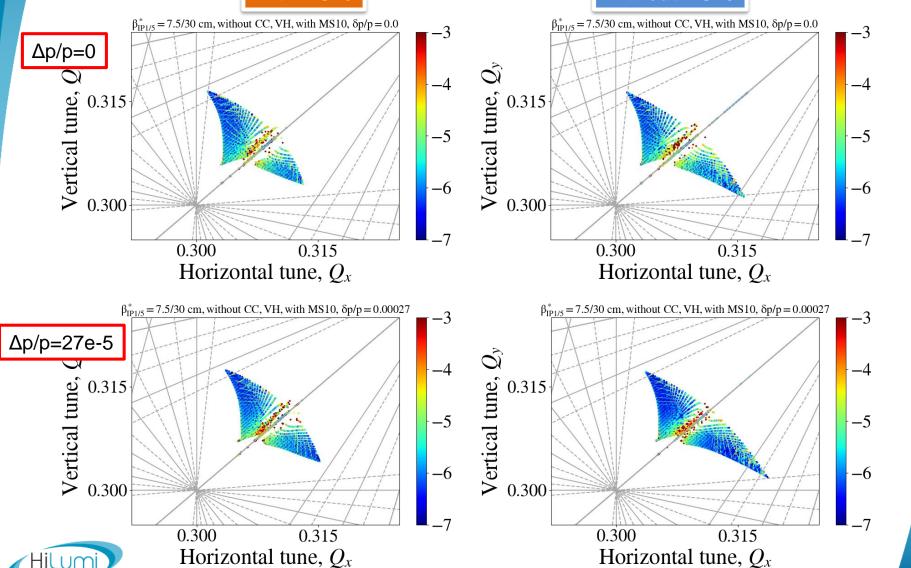
# FMAs with BB, with octupoles



# β\*=7.5/30 cm, no C With beam-beam



#### Without MS10



β\*=7.5/18 cm, HV, with CC With beam-beam With MS10 Without MS10  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, HV, with MS10,  $\delta p/p = 0.0$  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, HV, with MS10,  $\delta p/p = 0.0$ Vertical tune,  $Q_y$ 0.315 0.315 0.300 0.300 0.315 0.315 0.300 0.300 Horizontal tune,  $Q_x$ Horizontal tune,  $Q_x$  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, HV, with MS10,  $\delta p/p = 0.00027$  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, HV, with MS10,  $\delta p/p = 0.00027$ Δp/p=27e-5 Vertical tune,  $Q_y$  00000 Vertical tune, Co.300 0.300 0.300 0.315 0.300 0.315

Horizontal tune,  $Q_x$ 

 $\Delta p/p=0$ 

Vertical tune,

Horizontal tune,  $Q_x$ 

β\*=7.5/18 cm, VH, with beam-beam With MS10 Without MS10  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, with MS10,  $\delta p/p = 0.0$  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, with MS10,  $\delta p/p = 0.0$ Vertical tune,  $Q_y$ 0.3150.300 0.315 0.315 0.300 0.300 Horizontal tune,  $Q_x$ Horizontal tune,  $Q_x$  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, with MS10,  $\delta p/p = 0.00027$  $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, with MS10,  $\delta p/p = 0.00027$ Vertical tune,  $Q_v$  008.0 -6 0.300 0.300 0.315 0.300 0.315

Horizontal tune,  $Q_x$ 

 $\Delta p/p=0$ 

Vertical tune,

Δp/p=27e-5

Vertical tune, 0.300

Horizontal tune,  $Q_x$ 

0.315

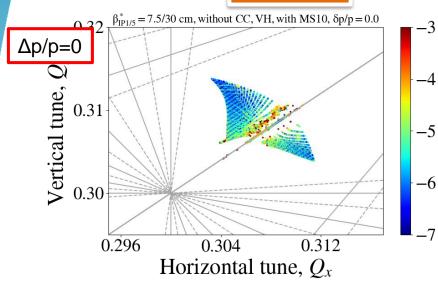
# FMAs with BB, without octupoles

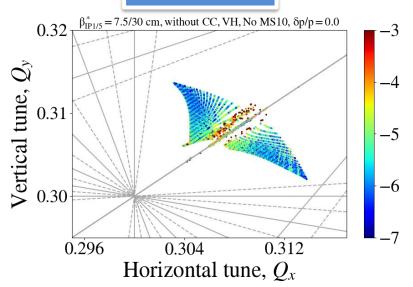


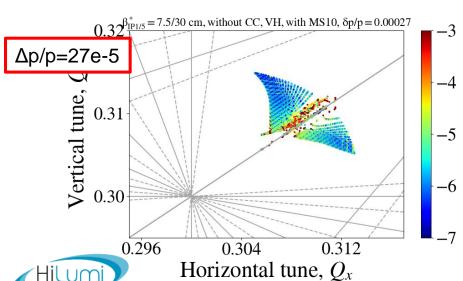
# β\*=7.5/30 cm, no C With beam-beam

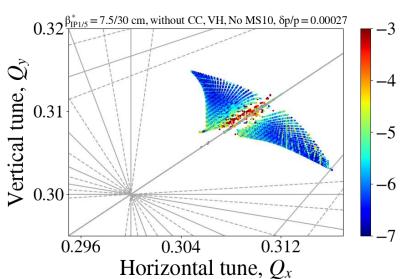


#### Without MS10









#### β\*=7.5/18 cm, HV, with CC With beam-beam With MS10 Without MS10 $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, HV, with MS10, $\delta p/p = 0.0$ $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, HV, No MS10, $\delta p/p = 0.0$ 0.32 $\Delta p/p=0$ Vertical tune, $Q_y$ Vertical tune, 0.31 0.31 **-**5 0.30 0.30 0.304 0.312 0.296 0.304 0.312 0.296 Horizontal tune, $Q_x$ Horizontal tune, $Q_x$ $0.32 \frac{\beta_{IP1/5}^* = 7.5/18 \text{ cm}, \text{ with CC, HV, with MS10, } \delta p/p = 0.00027}{\delta p/p} = 0.00027$ $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, HV, No MS10, $\delta p/p = 0.00027$ Δp/p=27e-5 Vertical tune, $Q_y$ Vertical tune, 0.31 0.31 **-**5 0.30 0.30

0.296

0.304

Horizontal tune,  $Q_x$ 

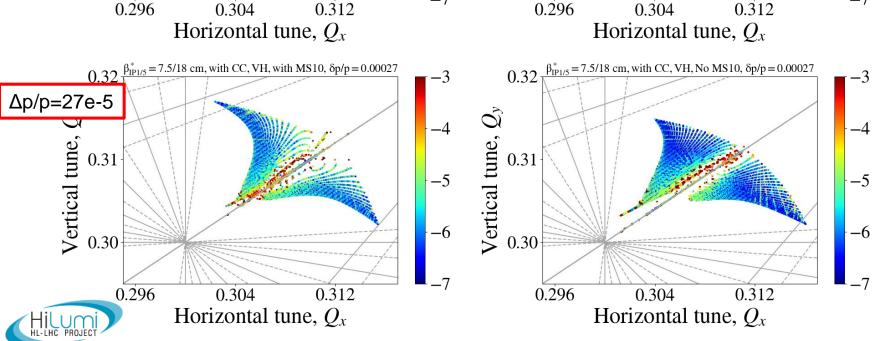
0.312

0.296

0.304

Horizontal tune,  $Q_x$ 

#### β\*=7.5/18 cm, VH, with beam-beam With MS10 Without MS10 $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, with MS10, $\delta p/p = 0.0$ $\beta_{\text{IP1/5}}^* = 7.5/18 \text{ cm}$ , with CC, VH, No MS10, $\delta p/p = 0.0$ 0.32 Vertical tune, $Q_y$ 0.31 **-**5 0.30 0.304 0.312 0.296 0.304 0.312 Horizontal tune, $Q_x$



 $\Delta p/p=0$ 

Vertical tune,

0.31