Impact of Coupling and its correction to collective effects (The DA part)


WP2 Meeting
17.09.2019
Usual DA simulations (1M turns, 0-10σ, 5 angles) have been employed to identify the available parameter space at the start of collisions, taking into account:

- Start of leveling $\beta^*$: 0.4 m, 0.6 m
- Start of leveling telescopic index: 1.7, 1.9, 2.2, 2.5
- Octupole polarity
- WP & Tune Split: 5e-3, 6e-3, 7e-3, 10e-3
- Start of leveling bunch intensity: 1.7 - 2.2e11 ppb
Quick Look at $I_{MO}>0$
\[ \beta^* = 0.4 \, \text{m} \, , \, I_{\text{MO}} = 570 \, \text{A} \]

- Bit pessimistic since the full 570A of octupole current are used in both cases.
$\beta^* = 0.6 \text{ m}, \ I_{\text{MO}} = 570 \text{ A}$

Min DA HL-LHC v1.3, Collisions, $r_{\text{ATS}} = 1.0$, $N_b = 2.2 \times 10^{11} \text{ ppb}$

Min DA HL-LHC v1.3, Collisions, $r_{\text{ATS}} = 1.7$, $N_b = 2.2 \times 10^{11} \text{ ppb}$

$\beta^*_{\text{IP1/5}} = 0.6 \text{ m}, \ \phi / 2_{\text{IP1/5}} = 250 \text{ mrad}, \ \epsilon_n = 2.5 \text{ mm}, \ Q^* = 15, \ I_{\text{MO}} = 570 \text{ A}$
Summary on $I_{\text{MO}} = 570$ A

Max/Min DA HL-LHC v1.3, Collisions, $N_b=2.2 \times 10^{11}$ ppb

$\beta_{\text{IP}_{1/5}} = 0.6$ m, $\phi/2\beta_{\text{IP}_{1/5}} = 250$ µrad, $\epsilon = 2.5$ µm, $Q' = 15$, $I_{\text{MO}} = 570$ A

Single point otherwise 5.6
The points (circles) show the minimum DA along the diagonal with a given $\Delta$.

The diamond show the maximum minimum DA found in the subset, with the associated $\alpha=0.05$ confidence level (95% CI) (errorbar).
Summary on $I_{MO} = 570$ A
I_{MO} < 0
$\beta^* = 0.4 \text{ m}, I_{\text{MO}} = -570 \text{ A}$
$\beta^* = 0.6 \text{ m}, \ I_{MO} = -570 \text{ A}$

Min DA HL-LHC v1.3, Collisions, $r_{ATS} = 1.7$, $N_0=2.2 \times 10^{11}$ ppb, $\beta^*_{p1/p5}=0.6 \text{ m}, \phi/2\pi p_{1/5}=250 \mu \text{rad}, \epsilon_u=2.5 \mu \text{m}, Q=15$, $I_{MO}=-570 \text{ A}$

Min DA HL-LHC v1.3, Collisions, $r_{ATS} = 1.9$, $N_0=2.2 \times 10^{11}$ ppb, $\beta^*_{p1/p5}=0.6 \text{ m}, \phi/2\pi p_{1/5}=250 \mu \text{rad}, \epsilon_u=2.5 \mu \text{m}, Q=15$, $I_{MO}=-570 \text{ A}$

Min DA HL-LHC v1.3, Collisions, $r_{ATS} = 2.2$, $N_0=2.2 \times 10^{11}$ ppb, $\beta^*_{p1/p5}=0.6 \text{ m}, \phi/2\pi p_{1/5}=250 \mu \text{rad}, \epsilon_u=2.5 \mu \text{m}, Q=15$, $I_{MO}=-570 \text{ A}$

Min DA HL-LHC v1.3, Collisions, $r_{ATS} = 2.5$, $N_0=2.2 \times 10^{11}$ ppb, $\beta^*_{p1/p5}=0.6 \text{ m}, \phi/2\pi p_{1/5}=250 \mu \text{rad}, \epsilon_u=2.5 \mu \text{m}, Q=15$, $I_{MO}=-570 \text{ A}$
Asynchronous Collapse & CC

Both IPs HO & CC on

Min DA HL-LHC v1.3, Collisions, \( r_{ATS} = 2.5, N_b = 2.2 \times 10^{11} \) ppb
\( \beta_{IP1/5}^* = 0.6 \text{ m}, \phi/2_{IP1/5} = 250 \mu\text{rad}, \epsilon_s = 2.5 \mu\text{m}, Q' = 15, I_{MO} = 570 \text{ A} \)

Still a bit tight, but almost +1σ in the worst case.

The increased opening up the available DA space.

Both IPs HO & CC off

Min DA HL-LHC v1.3, Collisions, \( r_{ATS} = 2.5, \) No CC, \( N_b = 2.2 \times 10^{11} \) ppb
\( \beta_{IP1/5}^* = 0.6 \text{ m}, \phi/2_{IP1/5} = 250 \mu\text{rad}, \epsilon_s = 2.5 \mu\text{m}, Q' = 15, I_{MO} = 570 \text{ A} \)
Summary of $I_{MO} = -570$ A

Max(Min) DA HL-LHC v1.3, Collisions, $N_b=2.2 \times 10^{11}$ ppb

Not really representative of the overall contours.
Summary of $I_{\text{MO}} = -570$ A

Overall the 5, 6 and 7e-3 behave quite similar. 1e-2 is almost out of the question in all configurations.

N.B.: Notice the larger “error bars”.
Summary of $I_{MO} = -570$ A

Min DA HL-LHC v1.3, Collisions, $N_t = 2.2 \times 10^{11}$ ppb

$\beta_{IP1/5} = 0.4 \text{ m}, \quad \phi_{2IP1/5} = 250 \mu \text{rad}, \quad \epsilon_\phi = 2.5 \mu \text{m}, \quad Q' = 15, \quad I_{MO} = -570$ A
Bunch Intensity Limit
$\beta^* = 0.4 \text{ m}$
$\beta^* = 0.6 \text{ m}$

$\text{r}_{ATS} = 1.7$

$\Delta = 5\times 10^{-3}$

$\text{r}_{ATS} = 1.9$

$\Delta = 6\times 10^{-3}$

$\text{r}_{ATS} = 2.2$

$\Delta = 7\times 10^{-3}$

$\text{r}_{ATS} = 2.5$

$\Delta = 1\times 10^{-2}$
• A $\Delta=1e^{-2}$ is **not favorable** for DA under any configuration.

• For the same $\Delta$ a **limit on intensity** can be found selecting the tele-index
  
  • In most cases adjusting the WP we regain the lost DA.
  
  • **No significant problems** with tele-index of $1.7$ and $\Delta < 1e^{-2}$
  
  • We can also survive with tele-index of $1.9$ and $\Delta < 5-6e^{-3}$, without sacrificing bunch intensity.
  
  • A tele-index of $2.2$ yields restricted area of DA which is very sensitive on the tune and even more on the tune split.

• Variation of DA along the same configuration reveals the impact of the **head-on**
  
  • Moving the tune along $y$ (instead of along the diagonal) could result in increased DA.

• **N.B.:** What has been presented so far has a **hard assumption** on a minimal effect of the **coupling** on the overall result (level, shape, area and position of the iso-DA contours). A closer look with the additional coupling knob would provide more precise results.