Stability limits with the new operational scenario

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➢ Updated stability limits and dynamic aperture
➢ On the limit with the negative polarity
➢ Probing the parameter space with the positive polarity
➢ Mitigation with a separation bump in the crossing plane
➢ Offset levelling in the low luminosity IPs
➢ Summary
### Updated stability limits

<table>
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<tr>
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(a) Positive polarity

(b) Negative polarity

Table 1: Stabilising octupole current together with the teleindex required to reach the equivalent detuning coefficient when operating the octupoles at the maximum of their capacity.
Updated stability limits

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(a) Positive polarity

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- It seems difficult to conciliate DA and stability requirement with the negative polarity, even with the new collimator settings.
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(b) Negative polarity

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- The old baseline was at the edge in terms of DA. The new collimator settings
Why is HL-LHC much more critical than LHC with the negative polarity

➢ The old baseline settings of HL-LHC are *comparable* to LHC 2016 settings*, a simple scaling for the octupole threshold (single beam) yields:

\[
200[A] \times \left( \frac{2.3 \cdot 10^{11}}{1 \cdot 10^{11}} \right) \left( \frac{2.0[\mu m]}{1.7[\mu m]} \right) \left( \frac{7[TeV]}{6.5[TeV]} \right) \approx 582[A]
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*Coll settings (3.5 µm) in 2016 : 5.5 / 7.5
HL-LHC nominal : 5.67 / 7.68
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➢ With the positive polarity, cutting the tails at 3σ results in an increase of the threshold by +25 % → 727 A (10 % from real estimate)

➢ With the negative polarity the increase due of the threshold to the cut tails reaches a factor 2, such that it is worse than the positive polarity by +30 % → 945 A (**less than half the estimate for two beams**)

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➢ There exists solutions to mitigate the minimum of stability at $1.5\sigma$
→ The most stringent limit is for separations $\sim5-7\sigma$ due to the **long-range contribution of the interaction at the IP**
Negative polarity : Speeding through the transient

- If we discard this transient unstable phase from the analysis (since it is shorter than the instability rise time), the requirement is reduced by approx. a factor 2 making it acceptable for DA

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(b) Negative polarity

Table 2: Stabilising octupole current together with the teleindex required to reach the equivalent detuning coefficient when operating the octupoles at the maximum of their capacity.

- Speeding through the minimum of stability at 1.5$\sigma$ was demonstrated in MDs in Run 2, a similar demonstration could be envisaged for the minimum at 6-8$\sigma$ in Run 3
Parameter space with the positive polarity

**Xing ⊥ sep. IPs 1 and 5**

**Xing ⊥ sep. IP 1 or 5**

**Xing || sep. IPs 1 and 5**

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Parameter space with the positive polarity

➢ Option 1 is feasible with various types of processes for the collapse of the separation bump
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➢ Option 2 (CC disabled during the collapse) is limited by the impact of the Piwiniski angle at separations $\sim1.5\sigma$. It is fully mitigated if a separation bump is introduced in the crossing plane.
Parameter space with the positive polarity and relaxed collimator settings

➢ Option 2 becomes doable with a asynchronous collapse of the separation bumps in IPs 1 and 5
Mitigation with a separation bump in the crossing plane: possible implementation

For a proper mitigation it is sufficient to implement the separation in the parallel plane for the last bit of the process (~6σ total separation)

- The existing 'lumiscan knobs' could do the job
Mode coupling instability of colliding beams with sep. // Xing

Sep. || Xing

Sep. ⊥ Xing

➢ The beam-beam forces differ significantly in the two configurations
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Offset levelling at the low luminosity IPs

➢ With both polarities of the spectrometer the Piwinski angle is low in IP2 ($\Phi = 0.16 / 0.38$). Operating with the positive polarity of the octupoles, there is no restriction on the separation (i.e. no need for a separation in the crossing plane)
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→ Operating with the positive polarity, it will lead to instabilities of the IP8 private bunches

- Get rid of IP8 private bunches when operating LHCb with the bad polarity (if they are problematic for operation)
- Level the luminosity a separation in the crossing plane
Summary

➢ The negative polarity is unfavoured by the long-range interaction at the IP during the collapse of the separation bump
  - The current required for Landau damping are not compatible with DA at the start of collision
  - The only possibility would be to rely on the speed of the collapse of the separation bump

➢ Option 1 (collision at $\beta^*=1.4$ with CC enabled) with the positive polarity features no reduction of Landau damping due to beam-beam through the cycle
  - The impact of crab cavity amplitude noise on non-colliding beams should be assessed (see. Sondre's talk)

➢ Option 2 (collision at $\beta^*=1.05$ with CC disabled) with the positive polarity features loss of Landau damping due to the offset interaction at the IP
  - The usage of the lumiscan knobs to introduce a separation in the crossing plane sounds offers a interesting alternative
  - Landau damping of a new type of mode coupling instability is under study
  - The speed of the collapse is also an possible alternative

➢ Without mitigation, IP8 private bunches may become unstable with the spectrometer polarity that enhances the crossing angle at the IP