Stability diagrams and critical factors during the squeeze and adjust in 2016
X. Buffat, T. Pieloni, C. Tambasco

Thanks to N. Biancacci for providing the real tune shifts from DELPHI, based on the LHC 2016 impedance model at flat top

- Stability diagrams, coherent tune shifts and the critical factor
  - Squeeze
  - Adjust
- Summary
The stability diagram is defined by the tune spread (octupole, beam-beam and others)

The coherent tune shifts are defined here by the impedance

→ The ratio $b/a$ (≡ the critical factor) describes the stability of a mode in a given machine and beam configuration

- In configurations where the tune spread is only due to the octupoles, the critical factors corresponds to the margin in octupole current
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We characterize a machine and beam configuration with the largest critical factor among all the modes.
Current operational configuration $\rightarrow \sim 12 \, \sigma$ long-range beam-beam separation at the end of the squeeze (185 $\mu$rad)

With the positive polarity, the stability diagram increases during the squeeze

With the negative polarity, a minimum would be reached at $\sim 10.5 \, \sigma$
Without damper, only high chromaticity and positive octupole polarity remains stable through the squeeze.

With damper, the configurations with negative chromaicity have a reduced margin around 10-11 \( \sigma \) long-range beam-beam separation.
The stability diagram has a minimum at about 1.5 $\sigma$, leading to a peak of the critical factor.

- The most critical moment remains at large separation → end of the squeeze
The minimum of stability is visible for all chromaticities and damper gain.

- Without transverse feedback, most configurations are unstable.
- With high feedback gain, the configurations with high chromaticities are at the edge.
- The stability diagram has a minimum at about 1.5 σ, leading to a peak of the critical factor.
  - Overall it remains well below the instability threshold.
The minimum of stability is visible for all chromaticities and damper gain

- With $Q'>5$, all configurations are stable (except for the minimum of stability, without transverse feedback)

- In addition, the stability of coupled beam-beam impedance modes is not ensured without transverse feedback
Without feedback, all configurations go through an unstable point during the adjust process.

With 50 turns damping time, all configurations are stable, nevertheless the margin is larger for strong positive octupoles.
Summary

- **Negative octupole polarity:**
  - The stability diagram shrinks during the squeeze to reach a minimum at about 10.5 \( \sigma \) long-range beam-beam separation.
  - It shrinks again during adjust at about 1.5 \( \sigma \) separation at the IP.
  - Most robust solution with the negative octupole would be with a small positive chromaticity (~2 units) and large damper gain (~50 turns) → Not very robust operationally due to the required control on the chromaticity.

- **Positive octupole polarity:**
  - Robust in all configurations, except at the minimum of stability reached during adjust without transverse feedback.
  - There is a critical point in adjust for all configurations without transverse feedback.