Beam-beam DA simulations with new operational scenario

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Overview

DA studies with beam-beam at:

1) Start of collisions for B1 & B2
   - $r=1, \beta^* = 1$ m, CC OFF, $I_{\text{oct}} = +510$ A
   - $r=1/2, \beta^* = 1$ m, CC OFF, $I_{\text{oct}} = -490$ A
   - $r=1/2, \beta^* = 1$ m, CC OFF, $I_{\text{oct}} = +470$ A
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2) End of $\beta^*$-leveling for B1 & B2
   - $\beta^*=15$ cm, CC ON, $I_{oct}=-300$ A
   - $\beta^*=15$ cm, CC ON, $I_{oct}=+300$ A
   - Chromaticity & octupole scan.
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Simulation setup:
- HL-LHC v1.5
- New pythonic masks (preliminary results for B2 & beam-beam)
- $C^- = 10^{-3}$
- $\Phi/2\text{IP1/5} = 250$ µrad, $\delta p/p=27 \times 10^{-5}$, 5 angles, 15 chroma
Start of collisions
r=1, β*=1 m, positive octupoles

**DA target:** Minimum DA > 6 σ for ΔQ ≥ 5 × 10⁻³.
r=1/2, $\beta^*=1$ m, positive octupoles

- Slight DA reduction with anti-telescope (although lower octupoles).
$r=1/2$, $\beta^*=1$ m, negative octupoles

Beneficial impact from negative octupoles.
For all 3 cases: several working points that meet the DA target.

DA of B2 slightly worse (~0.5 σ) than B1.
End of $\beta^*$-leveling
$$\beta^* = 15 \text{ cm, negative octupoles}$$

- Best working points throughout the whole collision process for B1 are (62.315, 60.320), (62.316, 60.321), (62.317, 60.322).
$\beta^* = 15 \text{ cm}, \text{ positive octupoles}$

- 1 working point for B2, marginal for B1 (without IP1-IP5 phase advance optimizations).
- More pronounced DA asymmetry between the two beams around coupling resonance.
For optimized working point (B1, EOL, negative octupoles, $DA_{\text{min}} = 6.21 \sigma$).
Summary

- Meeting DA target for all three scenarios at start of collisions including coupling and beam-beam both for B1 and B2.
- Preliminary DA results of B2 slightly worse than B1 (~0.5 σ), to further understand origin of asymmetry.
- Best working points for the whole collision process for B1 is (62.315, 60.320), (62.316, 60.321), (62.317, 60.322).
- No working point for B2 at the end of leveling with negative octupoles & 1 working point for positive octupoles with the present configuration.
- EOL & optimized working point, optimal regime for B1 $I_{oct} = -250$ to 150 A.
Summary

- Meeting DA target for all three scenarios at start of collisions including coupling and beam-beam both for B1 and B2.
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Next steps:
1. Further sanity checks and verification for Beam 2.
2. To identify origin of DA asymmetry between the two beams (especially around the coupling resonance at EOL).
3. Phase advance optimizations with beam-beam & complement no MS10 studies with beam-beam.
Backup
Chromaticity & octupoles scan

**B1 optimized WP**

HL-LHC v1.5, B1, Collisions, \( N_b = 1.2 \times 10^{11} \) ppb, \( \beta^*_{IP/AS} = 15 \) cm

\( \phi_{2/IPUS} = 250 \) μrad, \( \varepsilon_n = 2.5 \) μm, \((Q_x, Q_y) = (62.315, 60.321)\), \( C^- = 10^{-3} \)

**B1 nominal WP**

HL-LHC v1.5, B1, Collisions, \( N_b = 1.2 \times 10^{11} \) ppb, \( \beta^*_{IP/AS} = 15 \) cm

\( \phi_{2/IPUS} = 250 \) μrad, \( \varepsilon_n = 2.5 \) μm, \((Q_x, Q_y) = (62.31, 60.32)\), \( C^- = 10^{-3} \)
F. Plassard et al: *Sextupole scheme optimization for HL–LHC.*