Validation of the operational scenario

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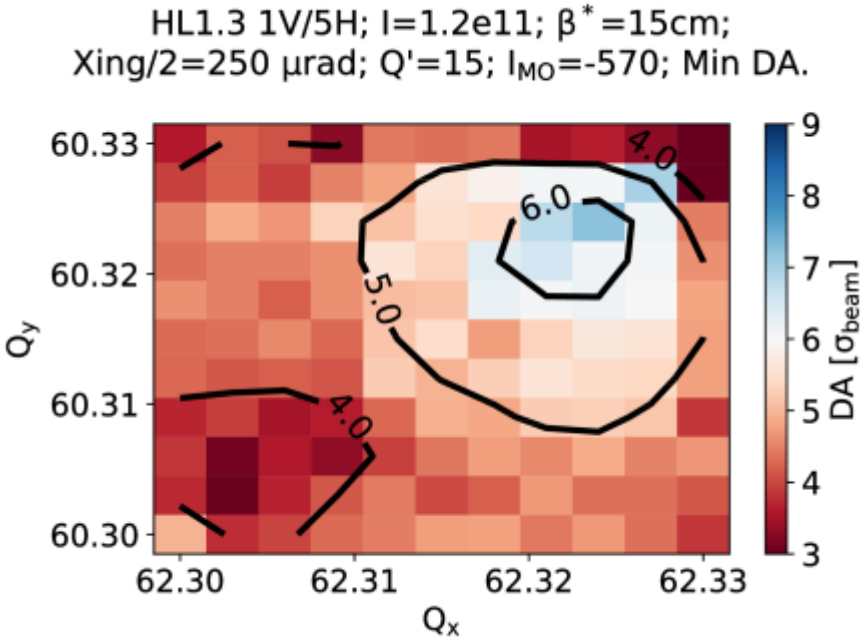
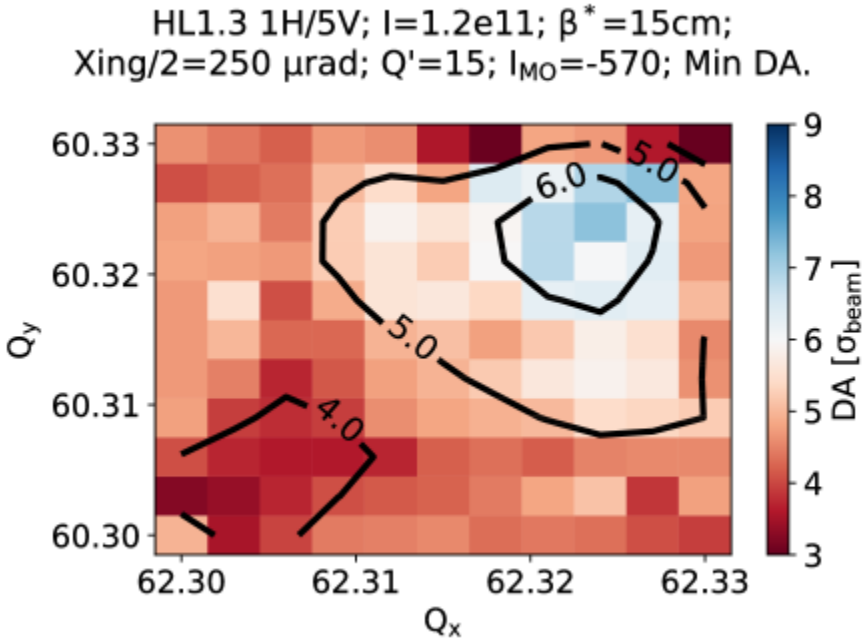
Simulation Setup

- HLLHC V1.3
- 1e6 turns, max crabbing half angle 190μrad
- LHCb b*=3m, offset levelled @ 2e33
- ALICE halo collisions at 5 sigma

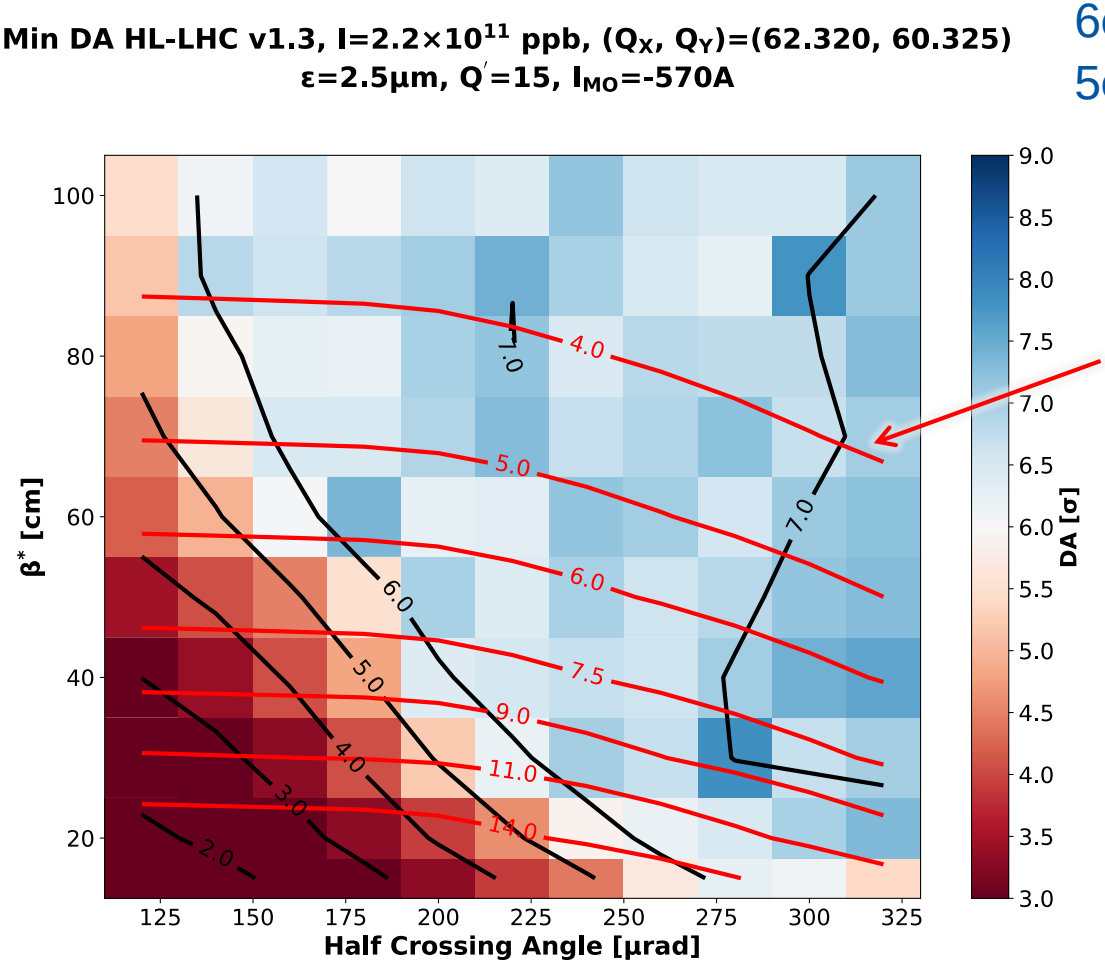
Tune Settings – HV vs VH





- No significant differences between VH and HV
- Very limited tune space! The nominal tune does not work (see also 94th WP2)
- (62.320, 60.325) already identified for full intensity, is used also at the end of leveling.

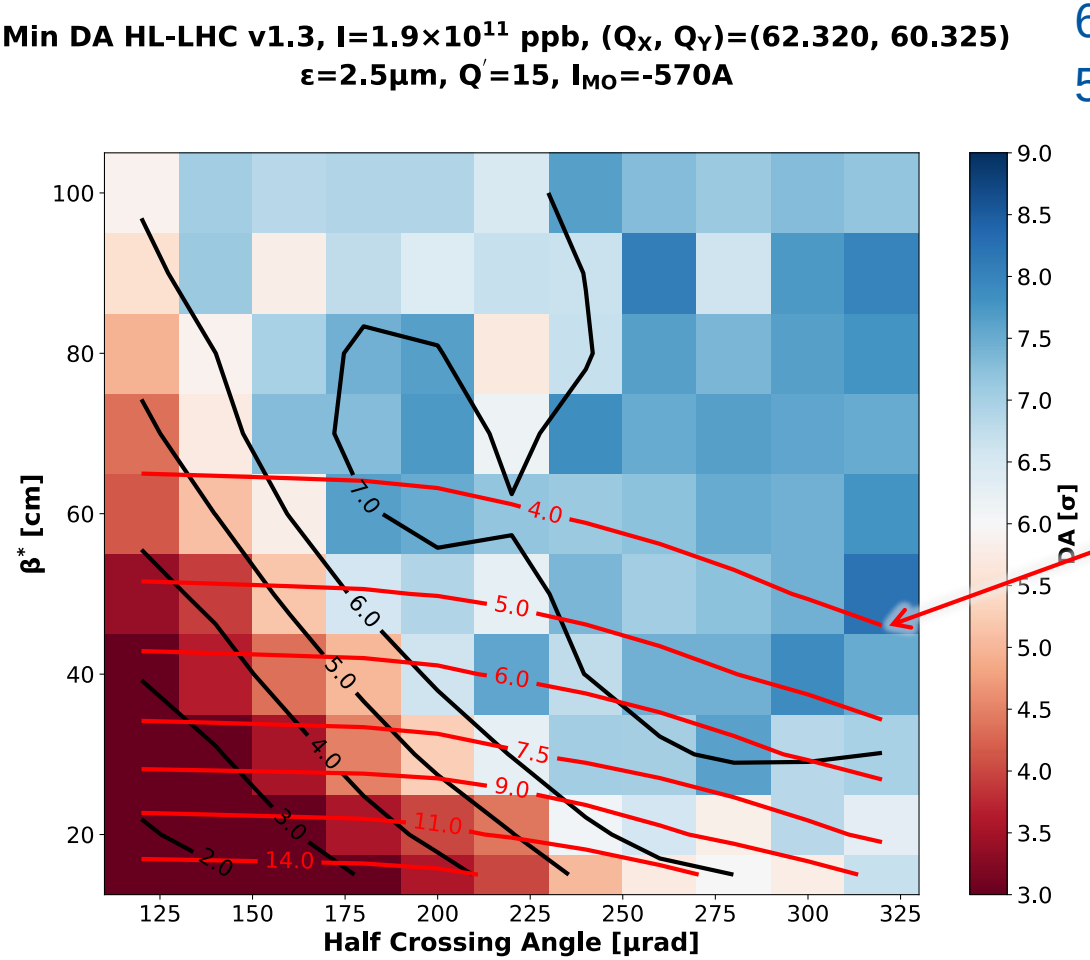
Levelling Path



6σ / 5lumi = (156.2 μrad, 69.0 cm)
5σ / 5lumi = (126.8 μrad, 69.4 cm)

Luminosity (10^{34} Hz/cm²)

Levelling Path

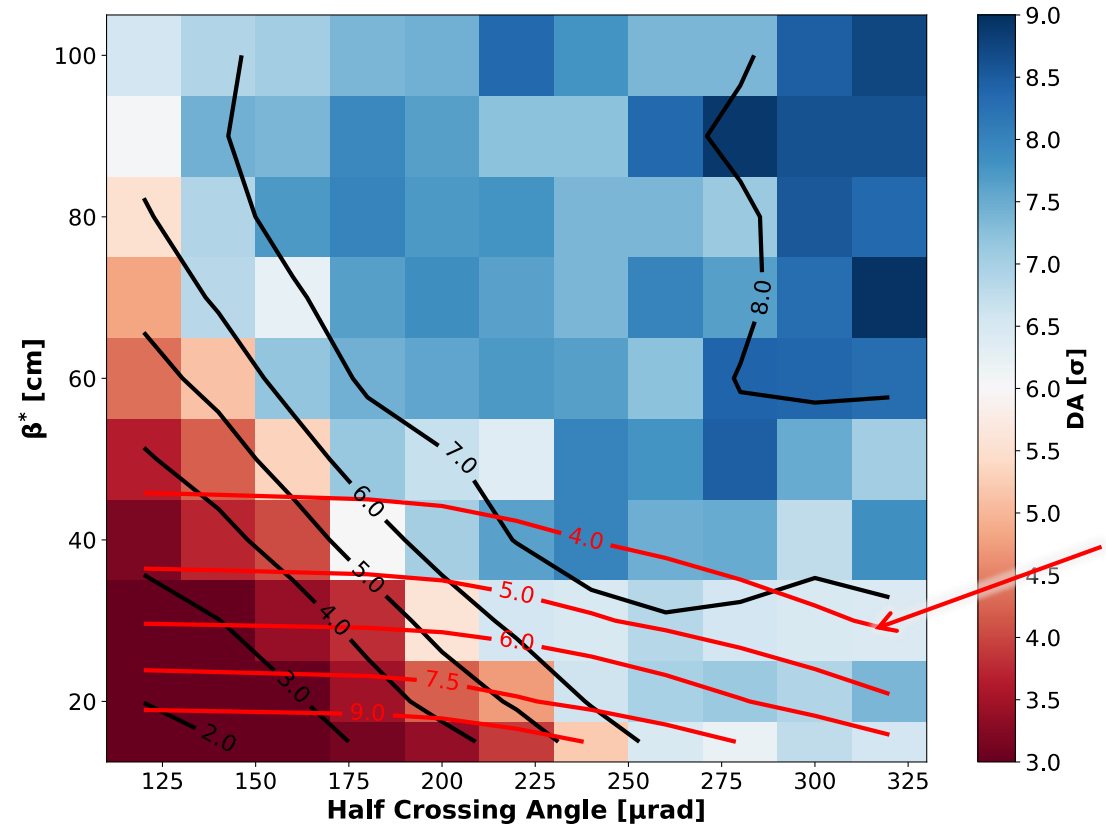


6σ / 5lumi = (174.7 μrad, 50.7 cm)

5σ / 5lumi = (154.0 μrad, 51.1 cm)

Luminosity (10^{34} Hz/cm^2)

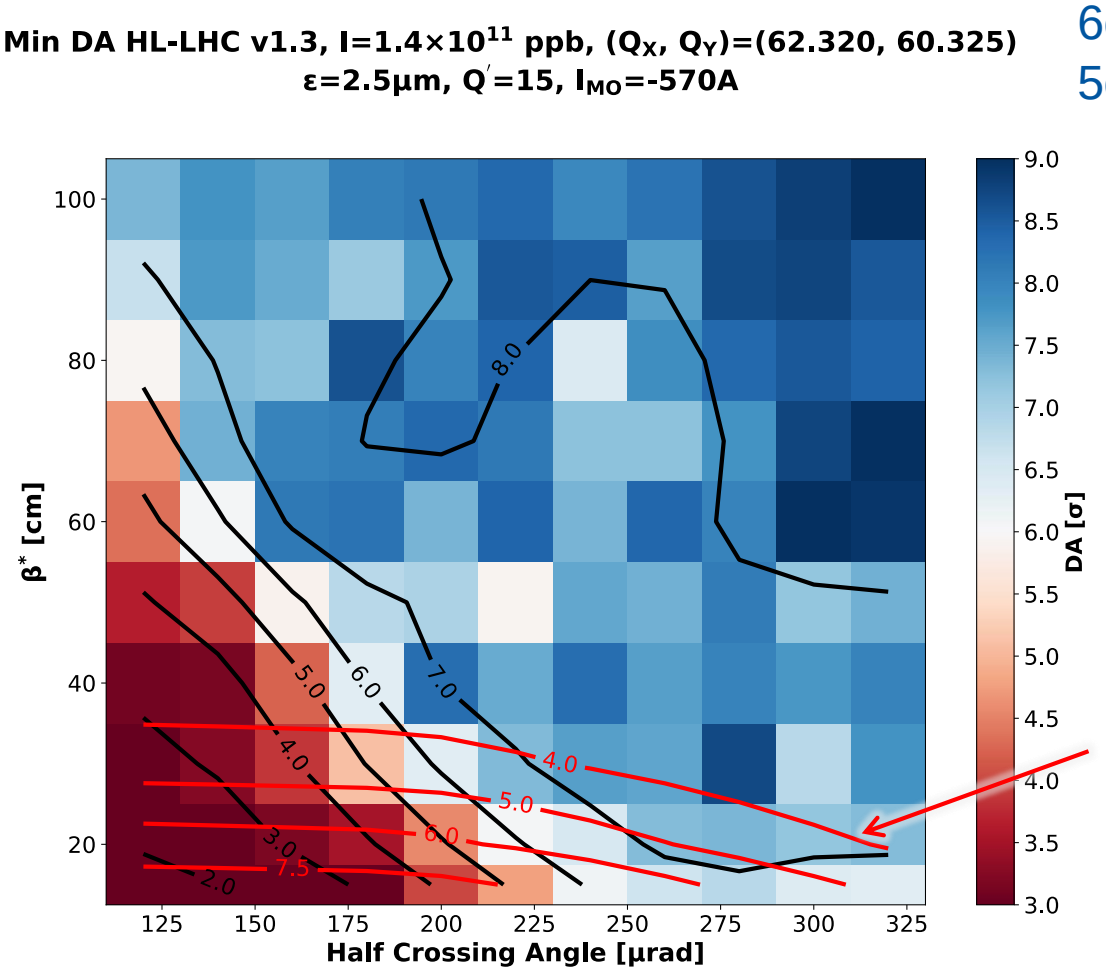
Levelling Path



6σ / 5lumi = (202.01 μrad, 34.8 cm)
5σ / 5lumi = (178.85 μrad, 35.7 cm)

Luminosity (10^{34} Hz/cm^2)

Levelling Path



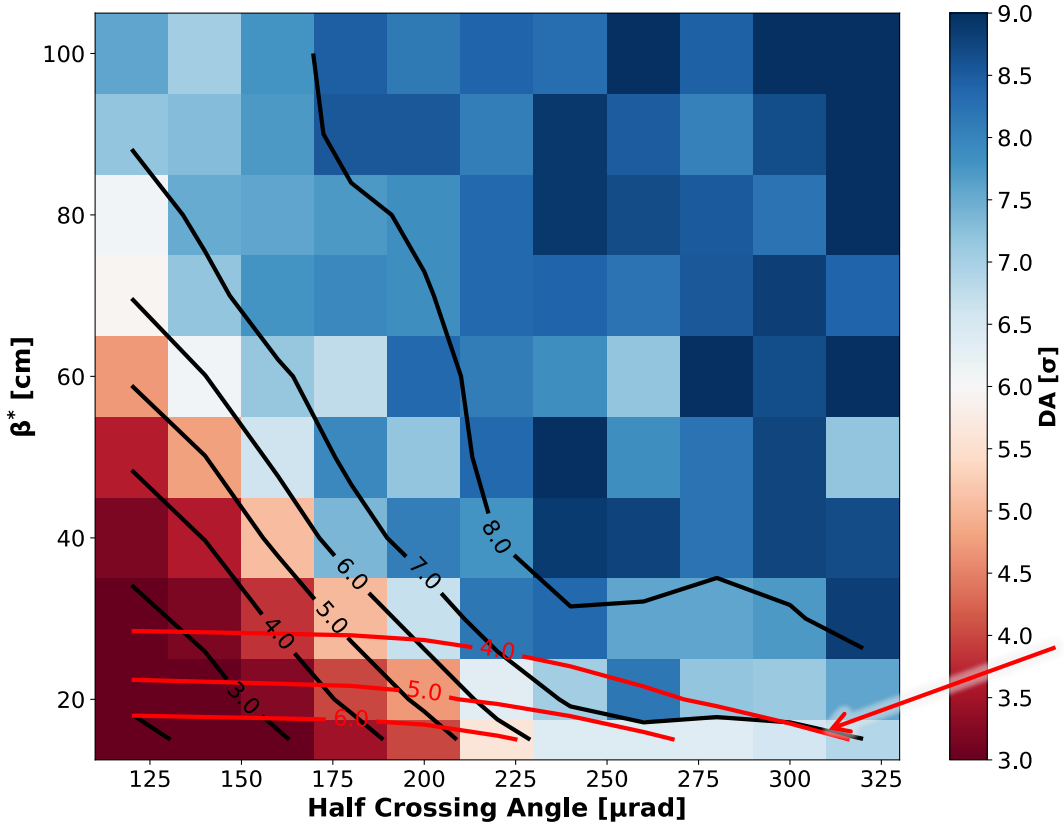
6σ / 5lumi = (207.34 μrad, 25.0 cm)
5σ / 5lumi = (186.50 μrad, 26.8 cm)

Luminosity (10^{34} Hz/cm²)

Levelling Path

Min DA HL-LHC v1.3, I=1.275×10^{11} ppb, (Q_X, Q_Y)=(62.320, 60.325)
ε=2.5μm, Q′=15, I_{MO}=-570A

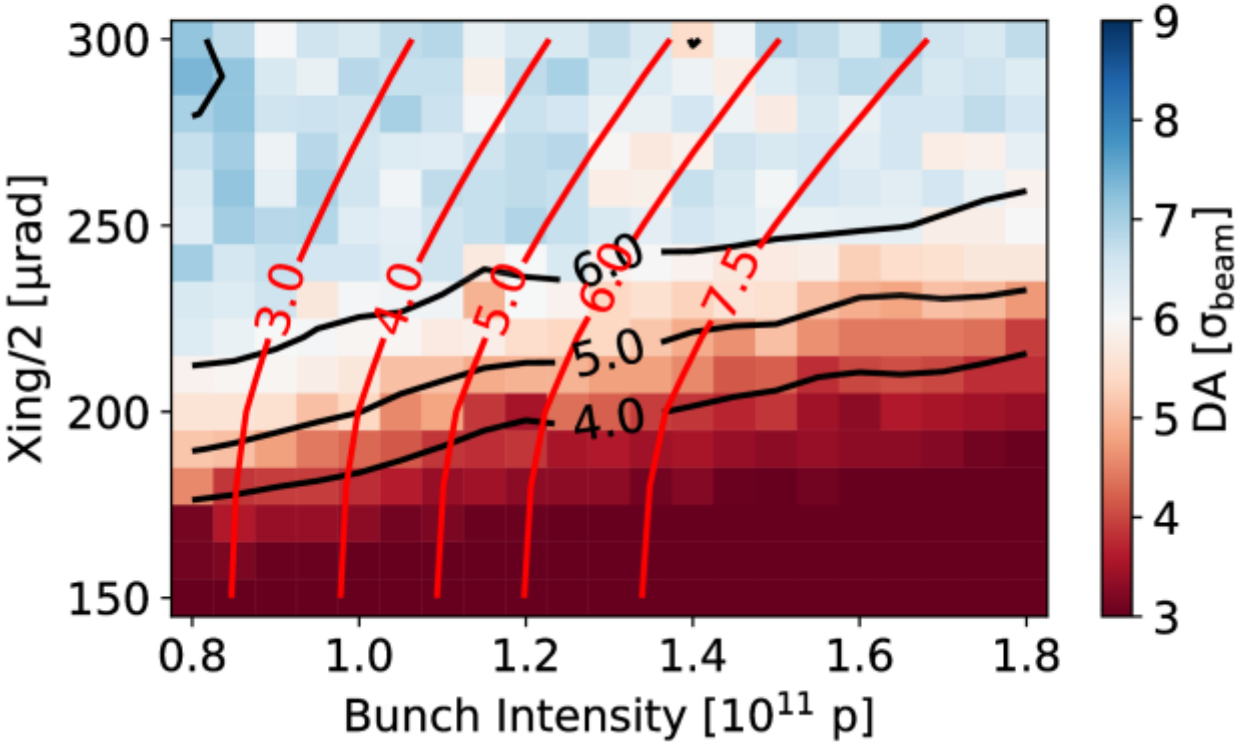
6σ / 5lumi = (214.3 μrad, 20.0 cm)
5σ / 5lumi = (193.2 μrad, 21.1 cm)



Luminosity (10^{34} Hz/cm^2)

End of Leveling

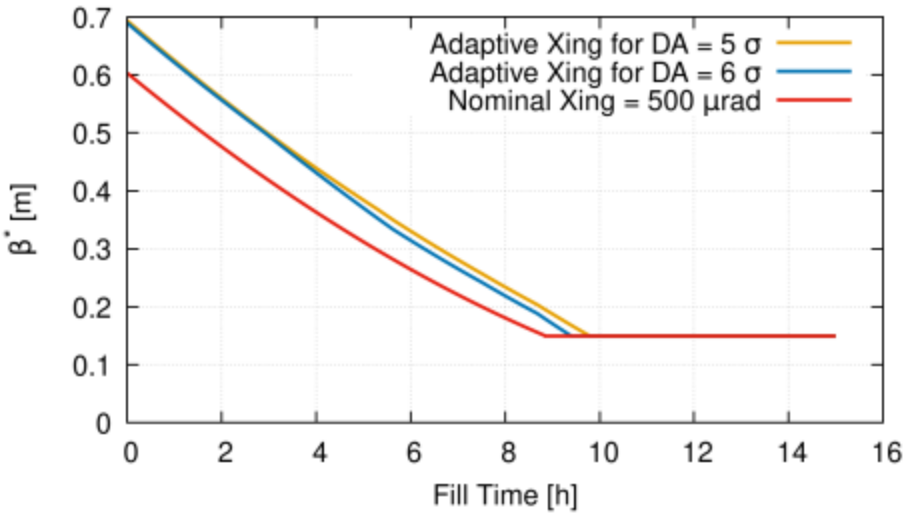
6σ / 5lumi = (237 μrad, 1.22e11 p)
5σ / 5lumi = (215 μrad, 1.14e11 p)

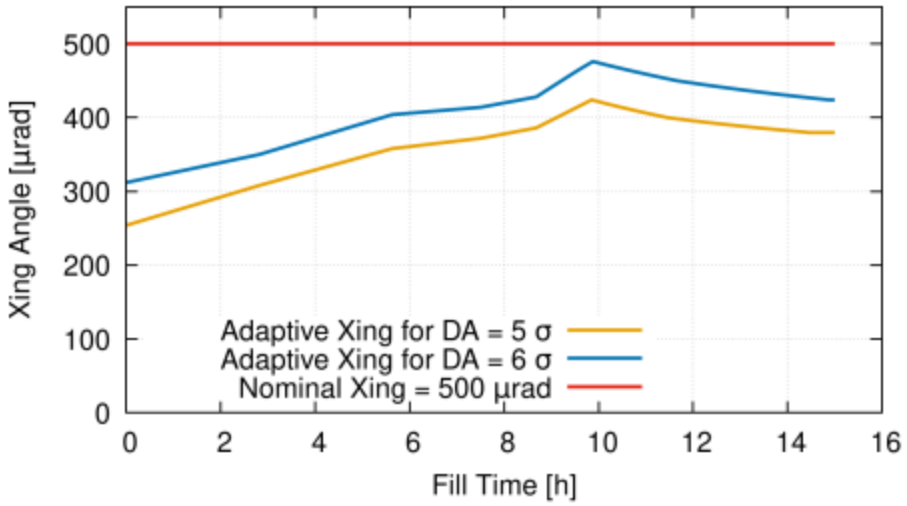


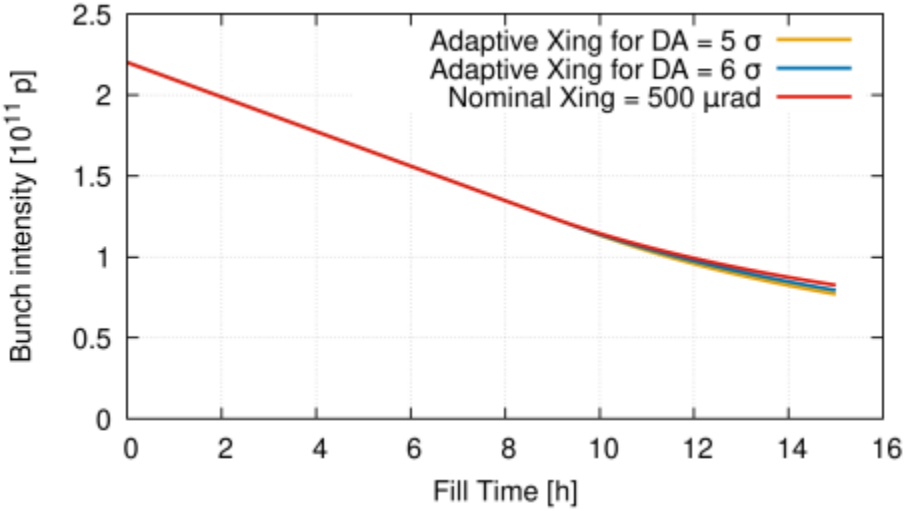
Can continue to "anti-level" with the crossing angle.

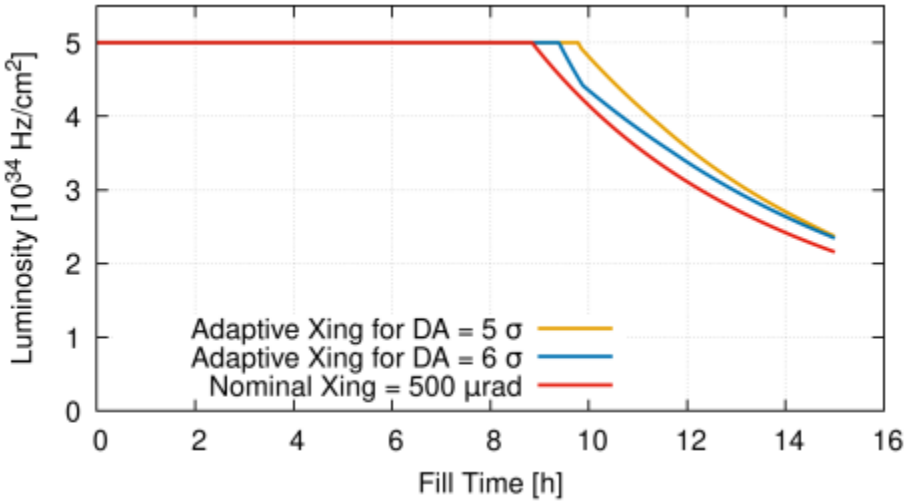
Parameter Evolution (I)

81 mb cross section assumed



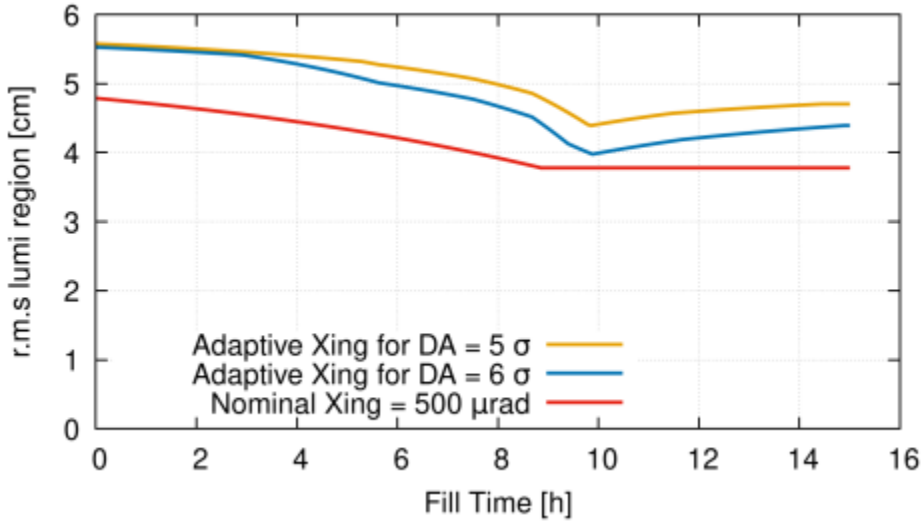


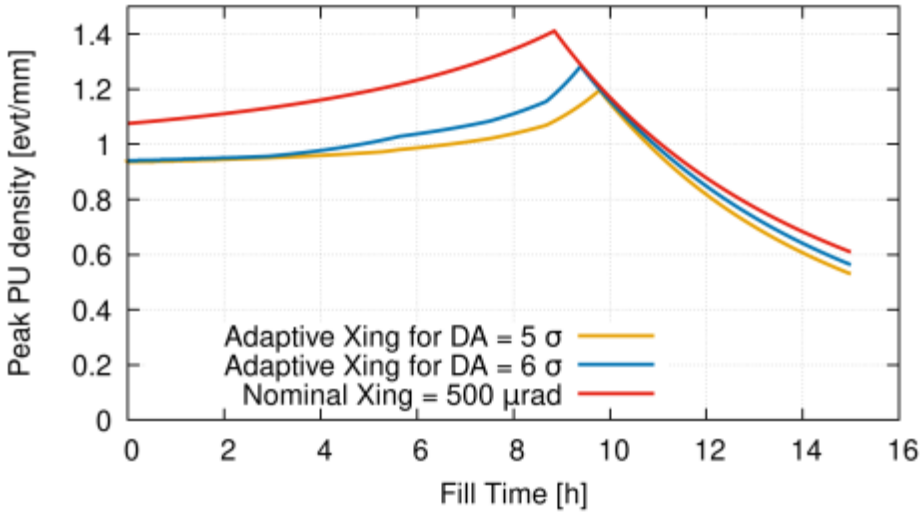


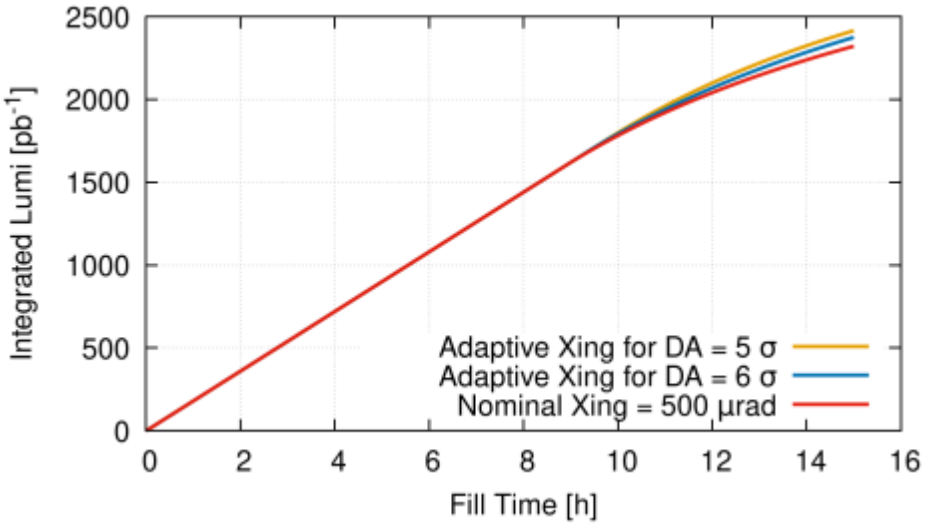


Parameter Evolution (II)

81 mb cross section assumed







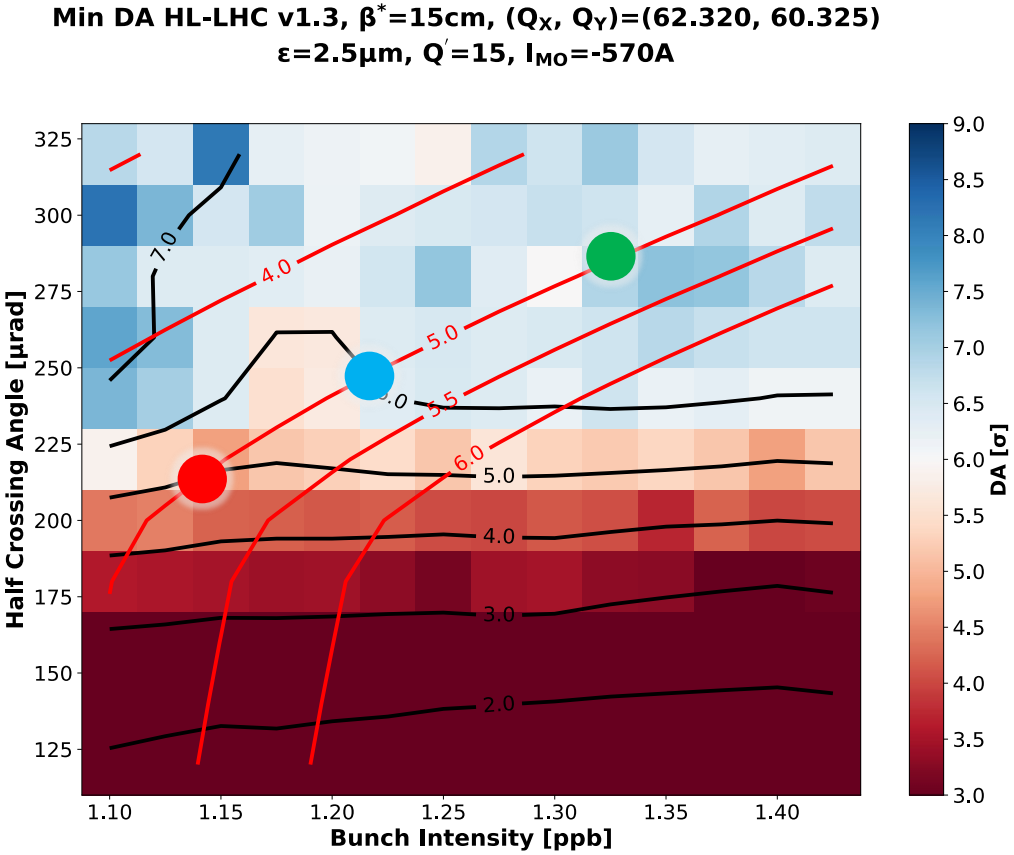
Operational Scenario - Summary

- High negative octupoles and chroma are impossible with nominal tunes.
- The optimised tunes (62.320, 60.325) allow for a significant DA recovery, the scenario appears **feasible**.
- Can reach **15 cm** with less than 250 urad.
- **Adaptive crossing** still in place for significantly reduced pileup density.
- Need to check **pacman** and **8b4e**. The latter were simulated in the LHC, resulting in an improved DA, as observed in the machine.
- **HV** and **VH** crossing result in almost identical DA.

Impact of Errors

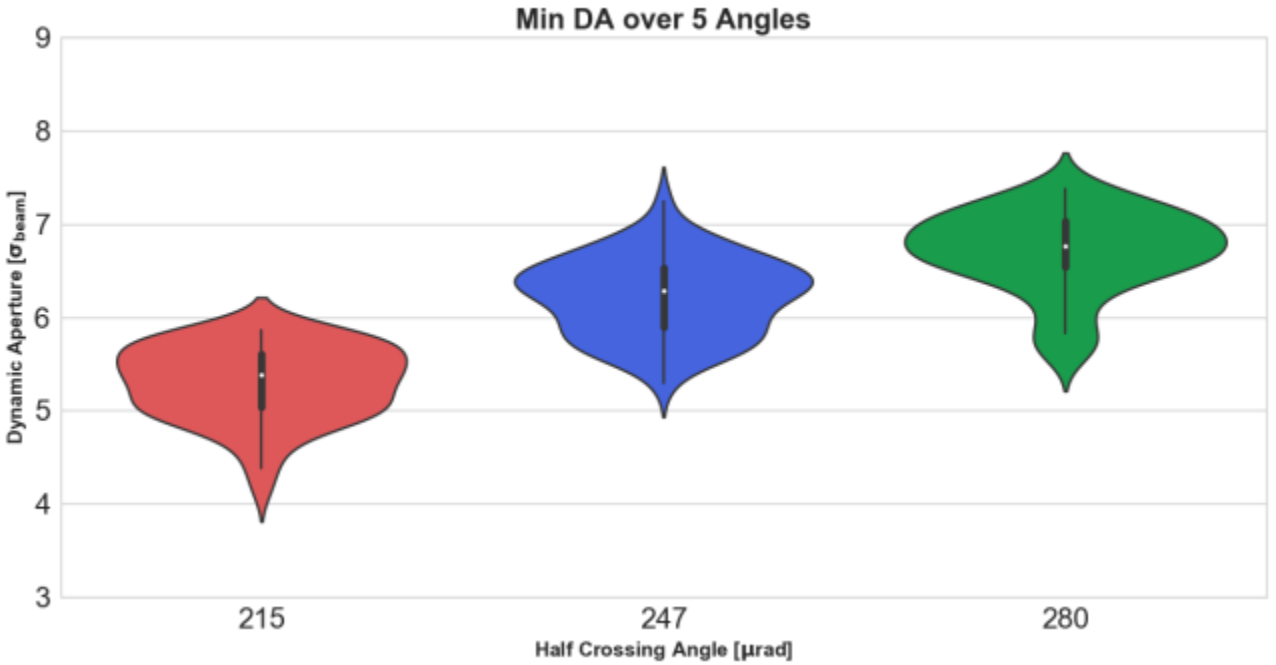
- 60 machine realisations of the machine, applying Field Errors from errortable v5.
- Running along the 5e34Hz/cm² line for a few points.

End of Leveling



EoL: Errors for Field Quality

For each seed the **minimum** DA over the angles is collected and plotted.



5σ / 5 lumi

Min = 4.2σ
Mean = 5.3σ
Max = 5.7σ
RMS = 0.4σ

6σ / 5 lumi

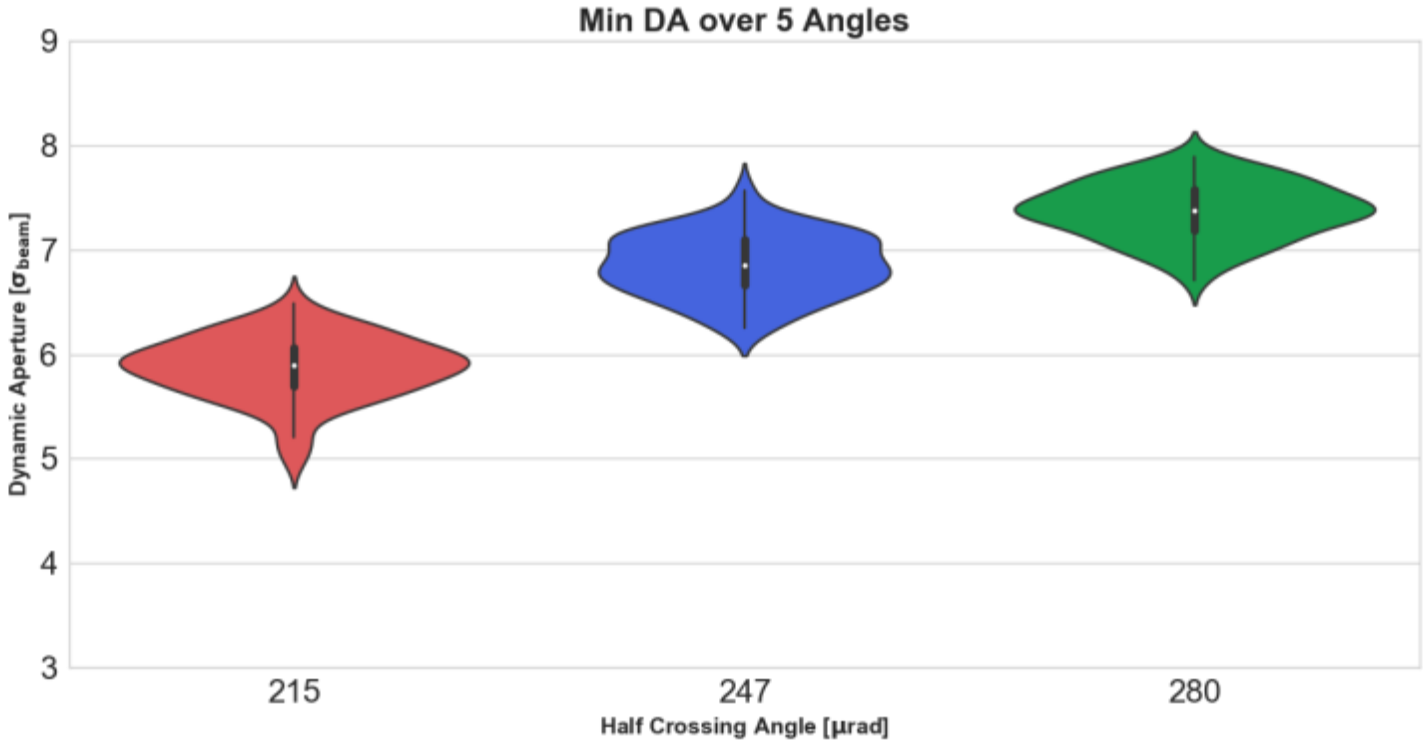
Min = 5.3σ
Mean = 6.2σ
Max = 7.2σ
RMS = 0.4σ

280μrad / 5 lumi

Min = 5.6σ
Mean = 6.7σ
Max = 7.4σ
RMS = 0.4σ

EoL: Errors for Field Quality (1.22e11)

For each seed the **average** DA over the angles is collected and plotted.



5σ / 5 lumi

Min = 5.0σ
Mean = 5.9σ
Max = 6.5σ
RMS = 0.3σ

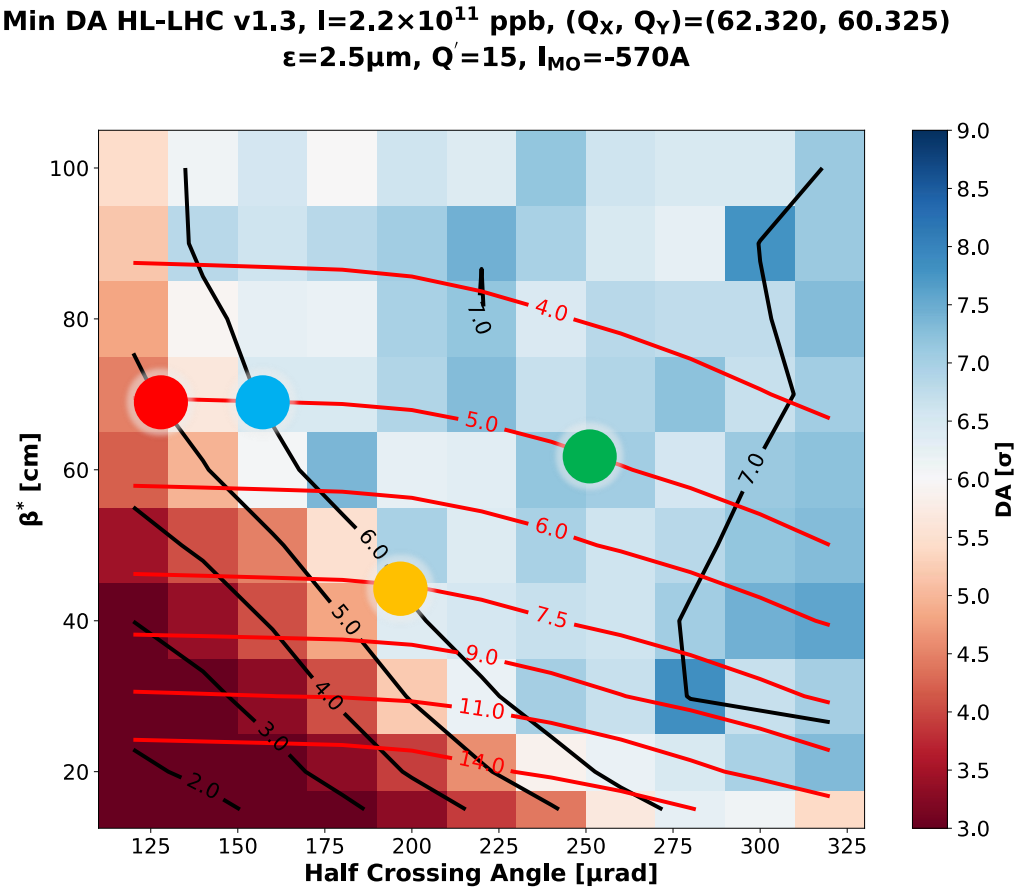
6σ / 5 lumi

Min = 6.2σ
Mean = 6.8σ
Max = 7.6σ
RMS = 0.3σ

280µrad / 5 lumi

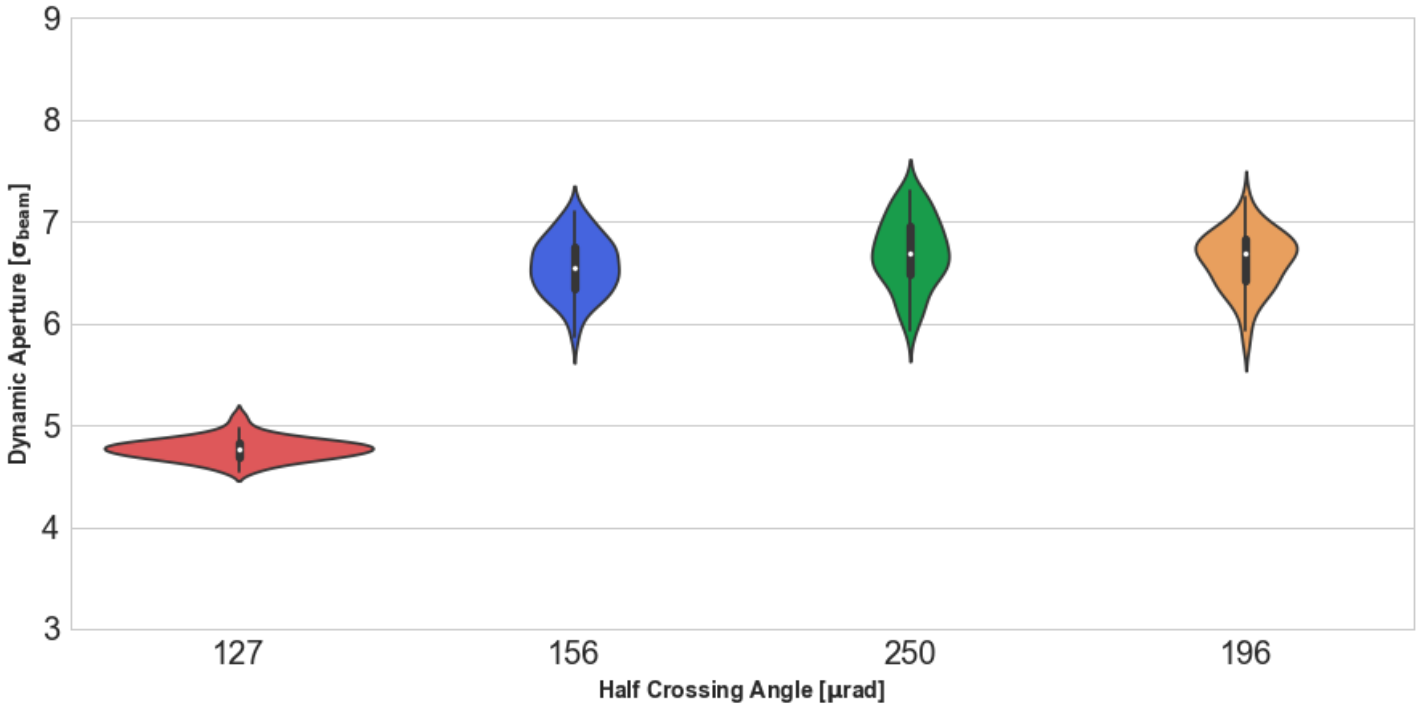
Min = 6.7σ
Mean = 7.4σ
Max = 7.9σ
RMS = 0.3σ

Start of Leveling



SoL: Errors for Field Quality (2.2e11)

For each seed the **minimum** DA over the angles is collected and plotted.



5σ / 5 lumi
Min = 4.5σ
Mean = 4.8σ
Max = 5.1σ
RMS = 0.1σ

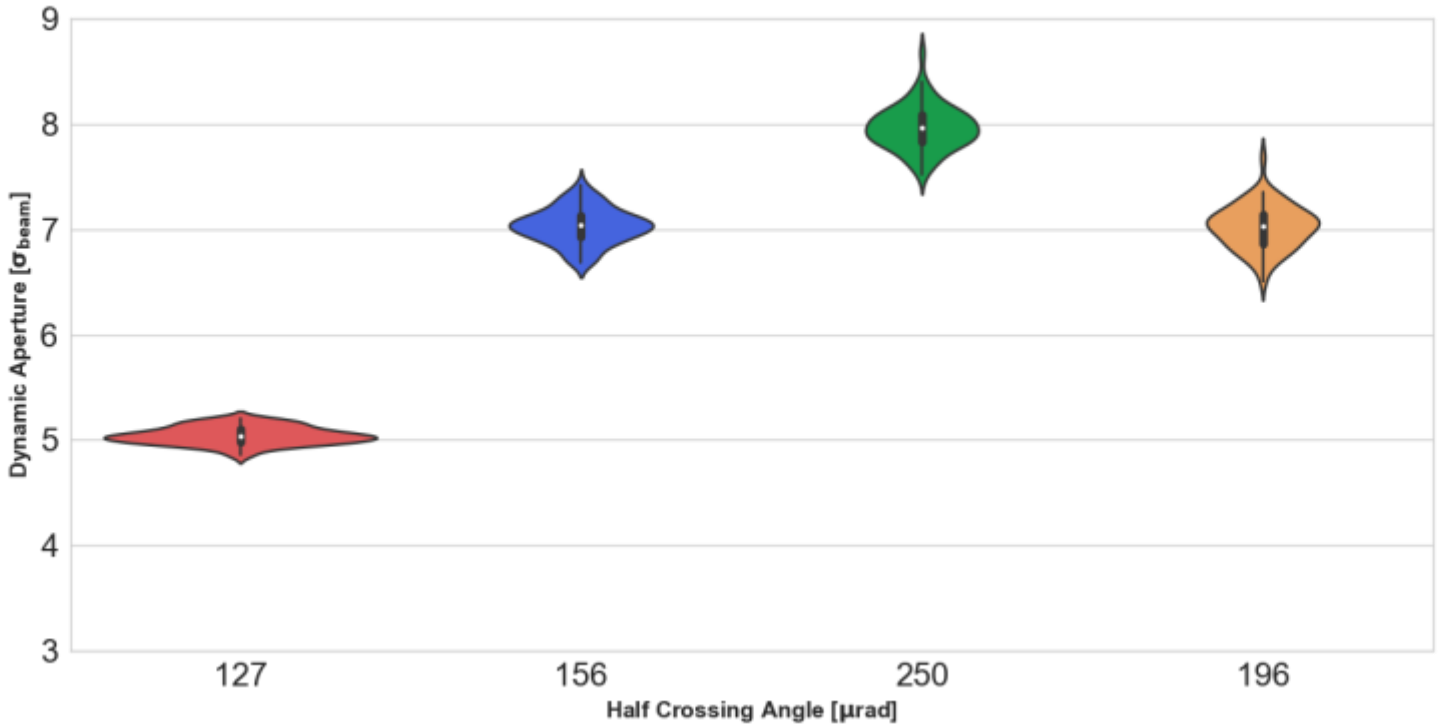
6σ / 5 lumi
Min = 5.8σ
Mean = 6.5σ
Max = 7.1σ
RMS = 0.3σ

250μrad / 5 lumi
Min = 5.9σ
Mean = 6.7σ
Max = 7.3σ
RMS = 0.3σ

6σ / 7.5 lumi
Min = 5.8σ
Mean = 6.6σ
Max = 7.2σ
RMS = 0.3σ

SoL: Errors for Field Quality (2.2e11)

For each seed the **average** DA over the angles is collected and plotted.



5σ / 5 lumi
Min = 4.8σ
Mean = 5.0σ
Max = 5.2σ
RMS = 0.1σ

6σ / 5 lumi
Min = 6.7σ
Mean = 7.0σ
Max = 7.4σ
RMS = 0.2σ

250μrad / 5 lumi
Min = 7.5σ
Mean = 8.0σ
Max = 8.7σ
RMS = 0.2σ

6σ / 7.5 lumi
Min = 6.5σ
Mean = 7.0σ
Max = 7.7σ
RMS = 0.2σ

Conclusions on Errors

- **For minimum DA:**
  - *Start of levelling :* DA spread : 0.3σ
  - *End of Levelling :* DA Spread : 0.4σ
- **For average DA :**
  - *Start of Levelling:* DA spread : 0.2σ
  - *End of Levelling :* DA spread : 0.3σ

- The specified field quality appears adequate.
- Errors remain in the shadow of beam-beam.