Available Aperture in Triplets IP1 and IP5

*for optics version 6.500, updated aperture files*

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Motivation

At injection and during most of the squeezing steps the aperture bottle-neck is in the arc ($\approx 27.79\sigma$), but at the end of the squeeze the triplets in the high luminosity insertion will become the aperture bottle-neck. Therefore the tertiary collimators have to be in place to limit the aperture in the triplets.
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Calculating the Available Aperture

used input:
- LHC optics V6.500
- aperture information provided
  
  /afs/cern.ch/eng/lhc/optics/V6.501/aperture

- \( dp = 0.86 \cdot 10^{-3} \) (for top energy)
- radial closed orbit 3 mm

MADX command:

```madx
aperture, range=MBRC.4L1.B1/MBRC.4R1.B1,
cor=0.003, spec=7, interval=1.0, dp=0.00086,
file="apert_tripletIP1_b1_V6.5.data";
```
Collision Optics (IR1)

left of IR

right of IR

beam 1

beam 2

min. aperture: beam 1 $n_1 = 7.34\sigma$ , beam 2 $n_1 = 7.04\sigma$
Collision Optics (IR5)

min. aperture: beam 1 $n_1 = 7.35\sigma$, beam 2 $n_1 = 6.93\sigma$
Flat Optics (IR1)

left of IR

right of IR

beam 1

beam 2

min. apeture: beam 1 \( n_1 = 7.98\sigma \), beam 2 \( n_1 = 7.98\sigma \)
Flat Optics (IR5)

min. aperture: beam 1 $n_1 = 7.99\sigma$ , beam 2 $n_1 = 7.99\sigma$

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Summary

- **flat optics**
  - minimal $n_1 = 7.98\sigma$ in IP1 (beam 1 and beam 2)
  - start closing tertiary collimators at $\beta^* \approx 5\text{ m}$

- **collision optics**
  - minimal $n_1 = 6.92\sigma$ in IP5 (beam 2)
  - start closing tertiary collimators at $\beta^* \approx 5\text{ m}$

- **difference between two beams:** since layout around insertion is symmetric the available minimal optics should be the same for both beams. Difference in $\beta$-function are in the $O(\text{cm})$ and for the orbit $O(\mu\text{m})$ cannot explain $0.3 - 0.5\sigma$