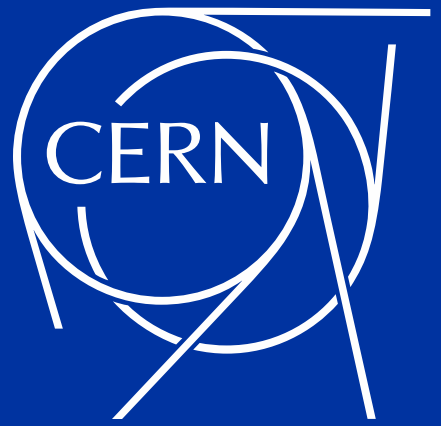


Velo aperture

B. Lindström, R. Bruce, M. Giovannozzi, S. Redaelli

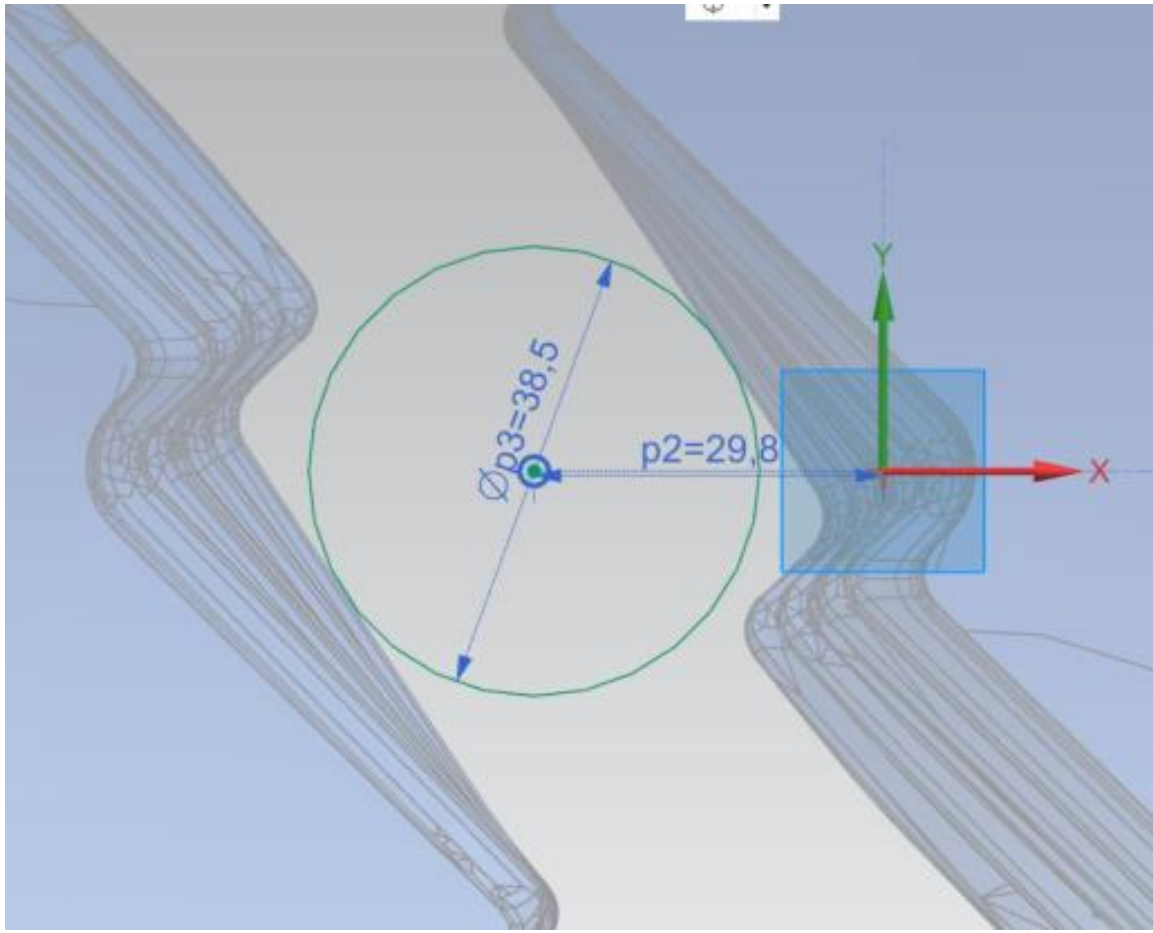
Acknowledgents: V. Coco, R. de Maria, I. Efthymiopoulos, S. Fartoukh, T. Persson, J. Sestak

10th March 2023 – Machine Protection Panel

LHCb VELO aperture bulging

- From LMC #450, VELO bulging reduces closed aperture at top energy from 3.5 mm to 2.9 mm
- During YETS, further deformation reducing aperture from 49 mm to 38.5 mm in open position
- **Compatible with injection beams?**
- **Compatible with collision and VdM optics/scans?**

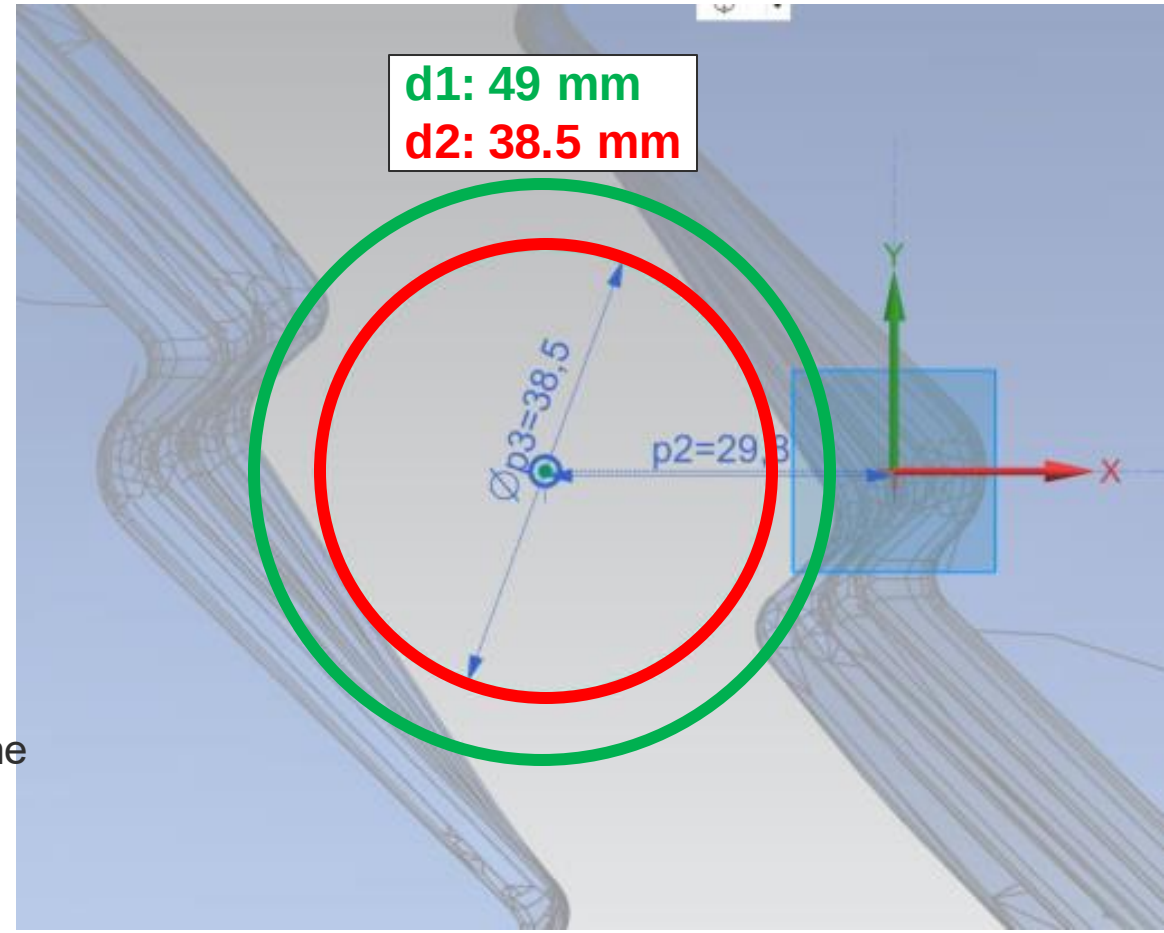
- Studied available aperture at the VELO with 2023 optics:
  - **injection – 10m β* in LHCb**
  - **collision – 2m β* in LHCb**
  - **VdM – 24m β* in LHCb**



courtesy of V. Coco

Input tolerances for aperture calculations

- **Circular aperture inlayed – conservative yet robust**
- **VELO longitudinal extent: ± 800 mm from IP8**
- **mechanical tolerance: 5.5 mm / 50 µm**
- **spectrometer on**
- **injection optics (10 m β*)**
  - orbit error: 2 mm
  - separation: -3.5 mm y
  - beta beating: 15 %
- **collision optics (2 m β*):**
  - orbit + alignment error: 2 mm (open) / 300 µm (closed)
  - up to ± 3 σ (~93 µm) single beam displacement in vertical plane
- **VdM optics (24 m β*):**
  - orbit + alignment error: 2 mm (open) / 300 µm (closed)
  - up to ± 4.5 σ (~480 µm) single beam displacement in H/V
  - beta beating: 10 %



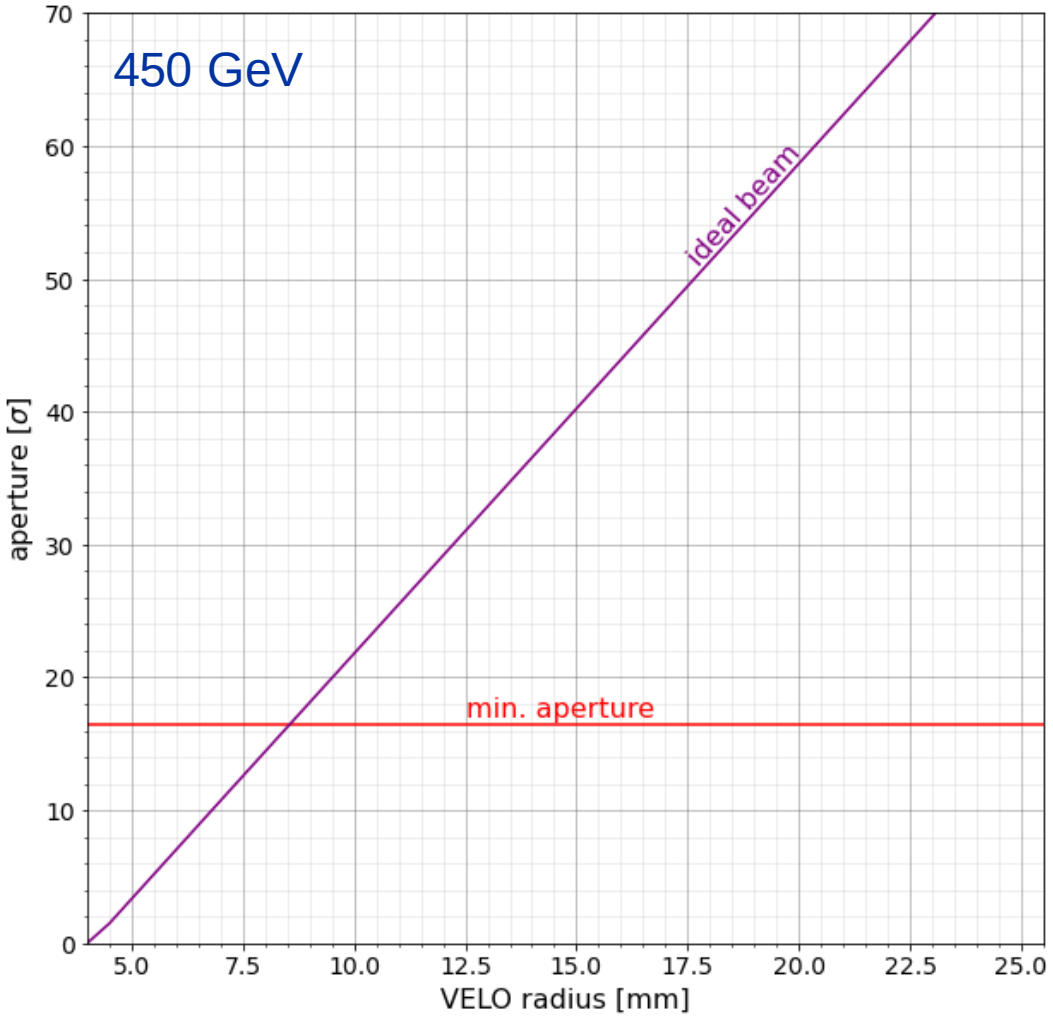
courtesy of V. Coco

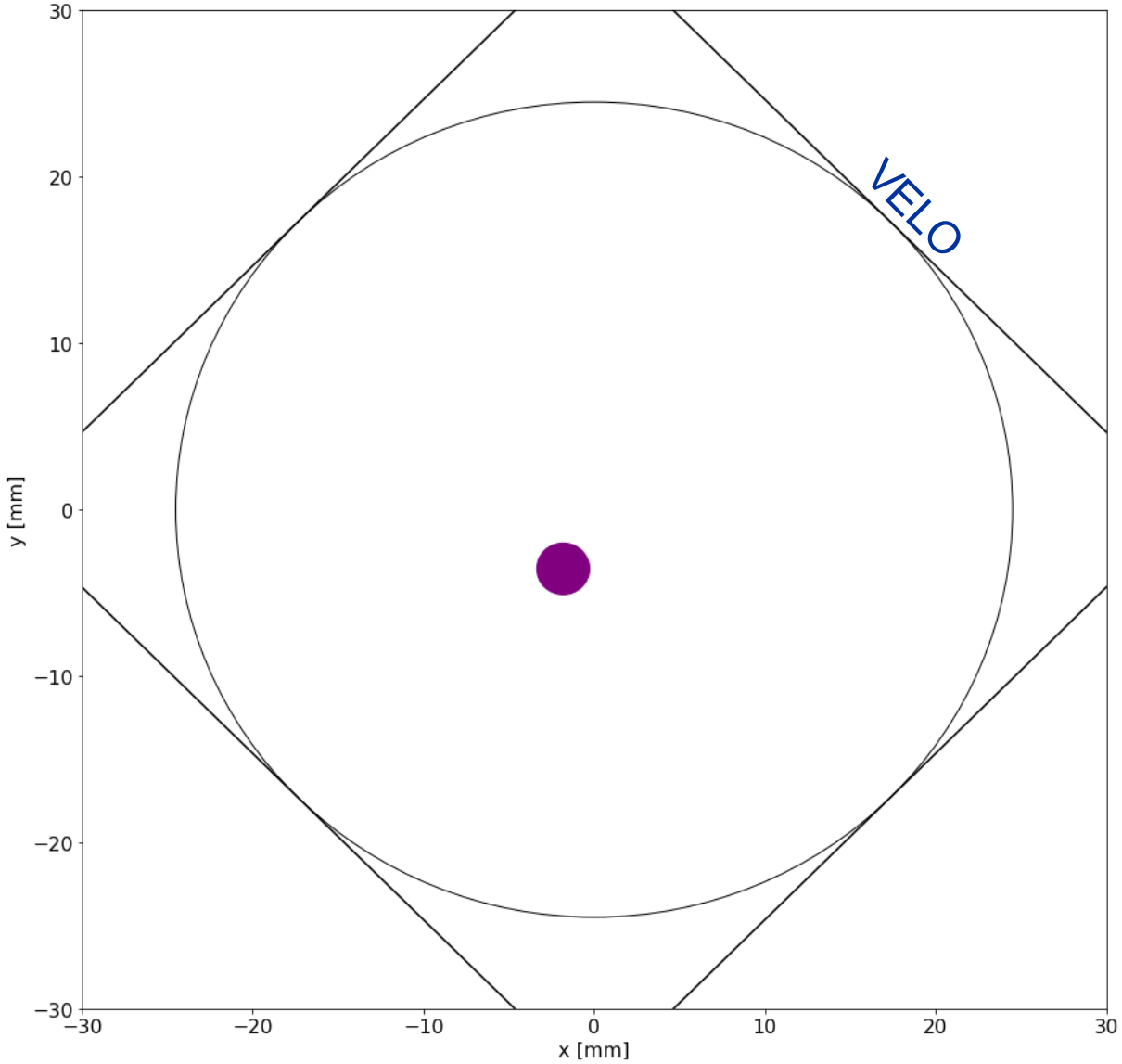
n.b. reference emittance is 3.5 µmrad

VELO aperture – 10m β*

*R. Bruce et.al., Updated parameters for HL-LHC aperture calculations for proton beams, https://cds.cern.ch/record/2274330?ln=en

- **16.4 σ is the general aperture limit for unprotected elements***

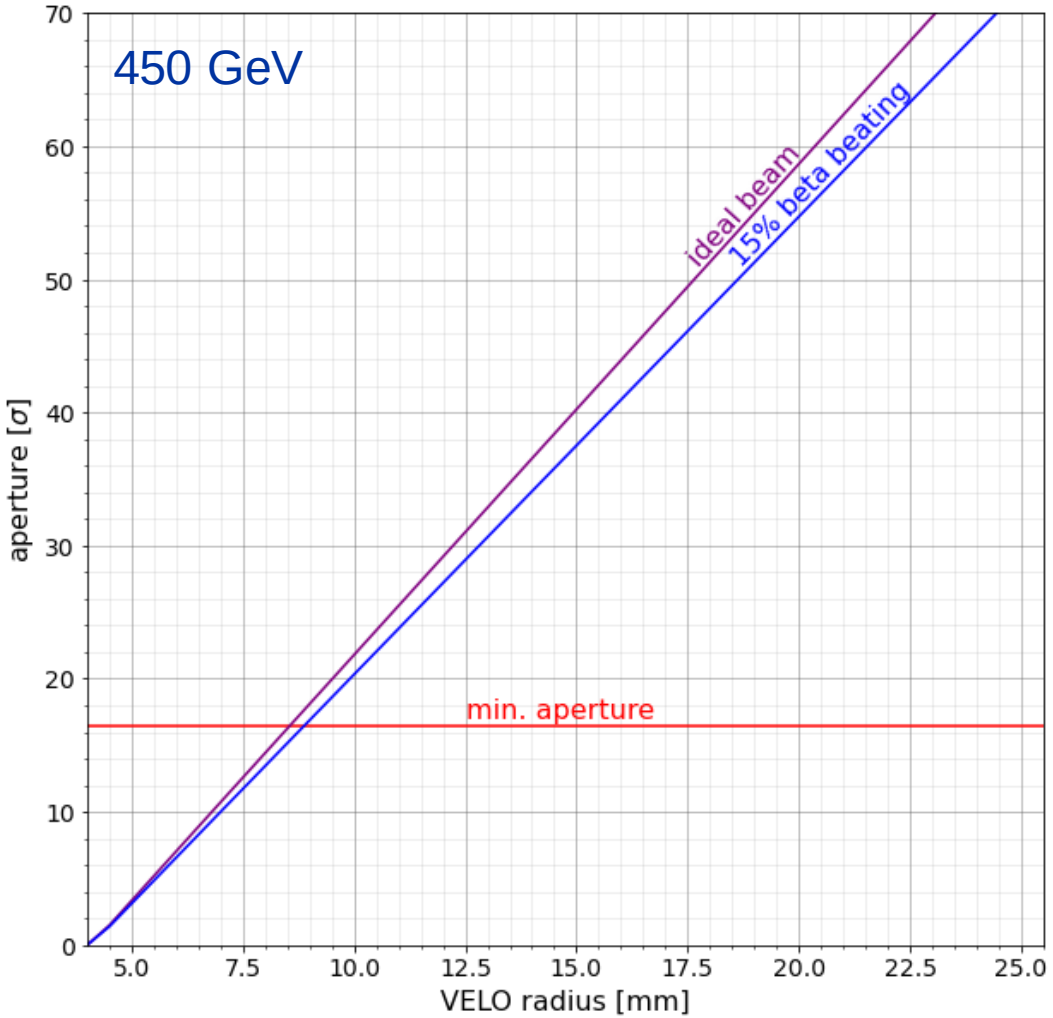


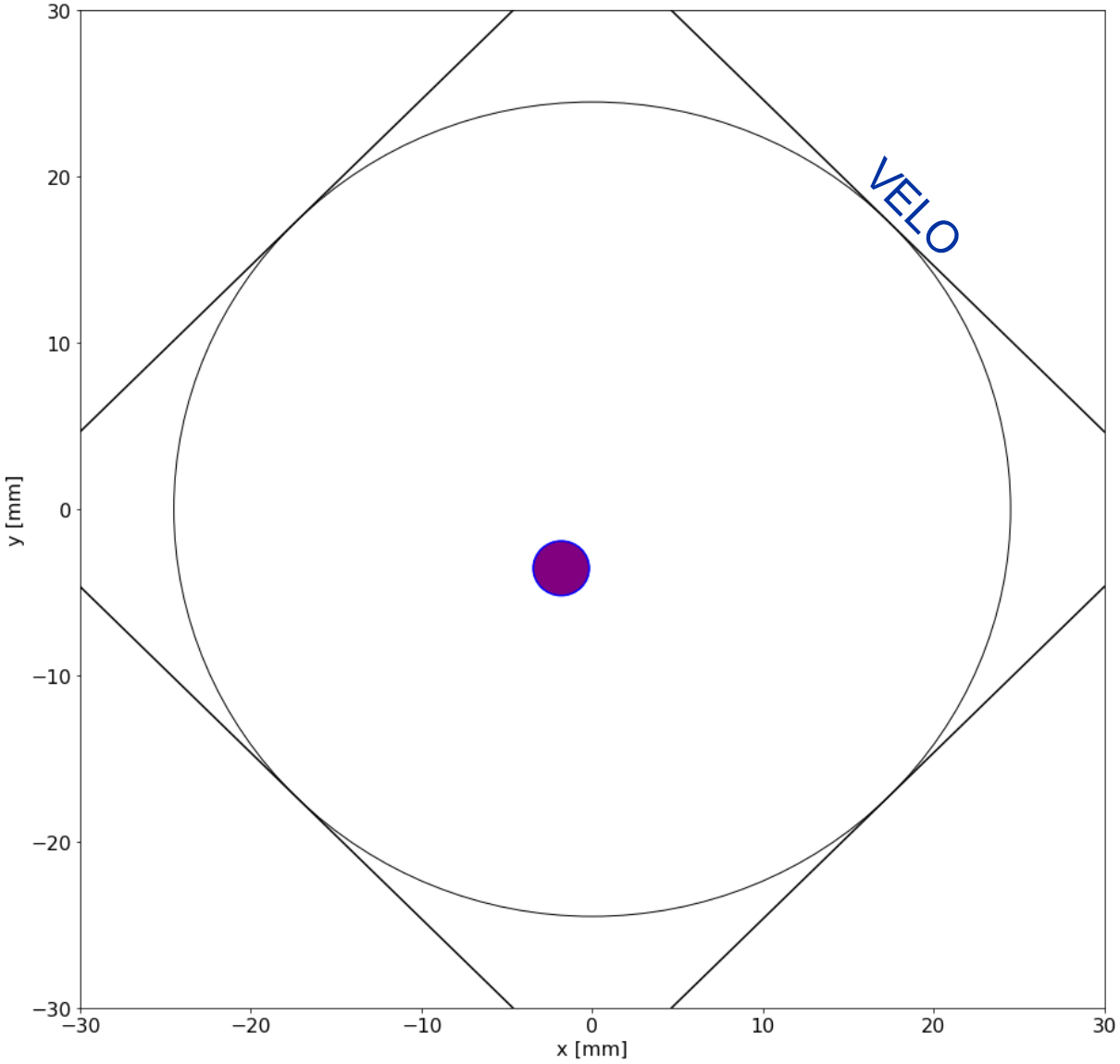


VELO aperture – 10m β*

*R. Bruce et.al., Updated parameters for HL-LHC aperture calculations for proton beams, https://cds.cern.ch/record/2274330?ln=en

- **16.4 σ is the general aperture limit for unprotected elements***

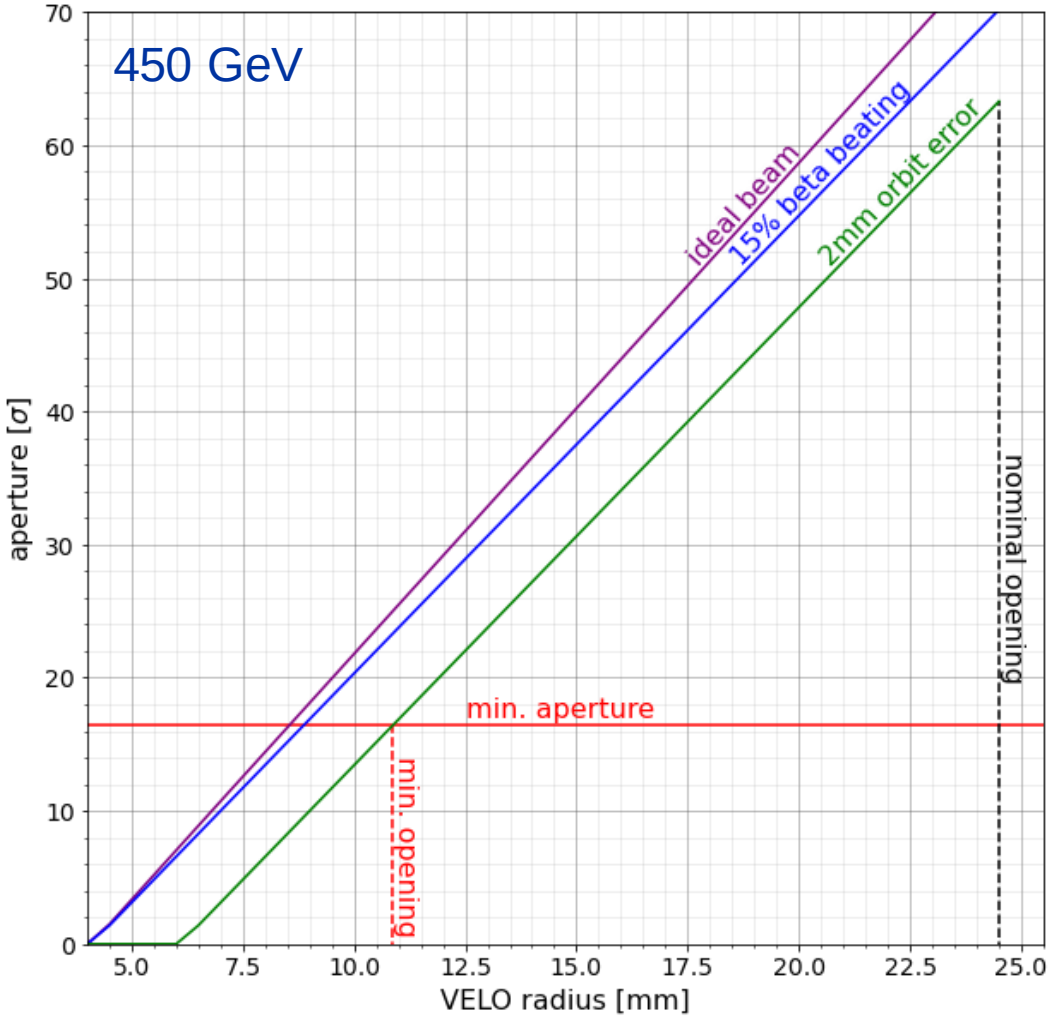


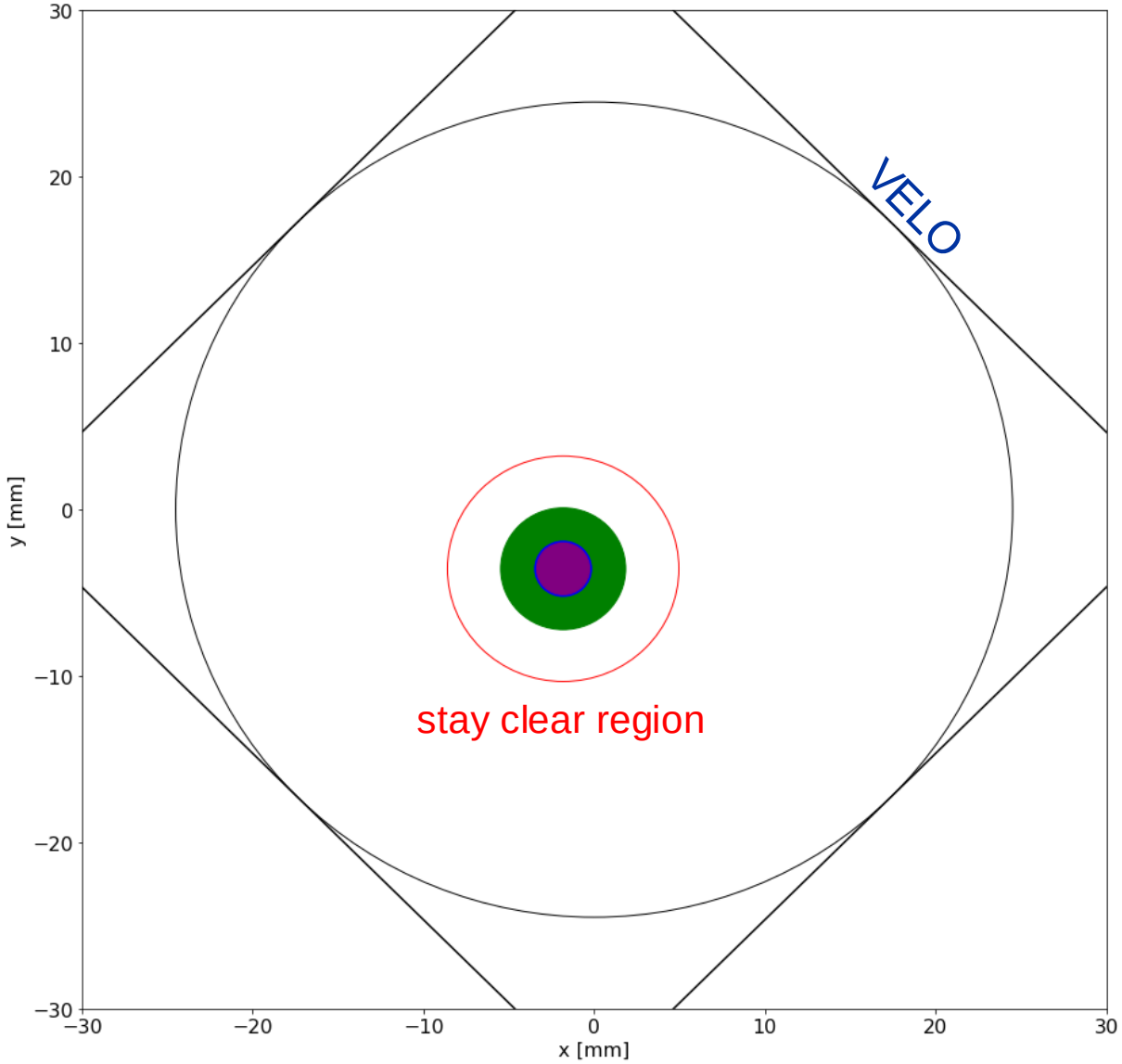


VELO aperture – 10m β*

*R. Bruce et.al., Updated parameters for HL-LHC aperture calculations for proton beams, https://cds.cern.ch/record/2274330?ln=en

- **16.4 σ is the general aperture limit for unprotected elements***

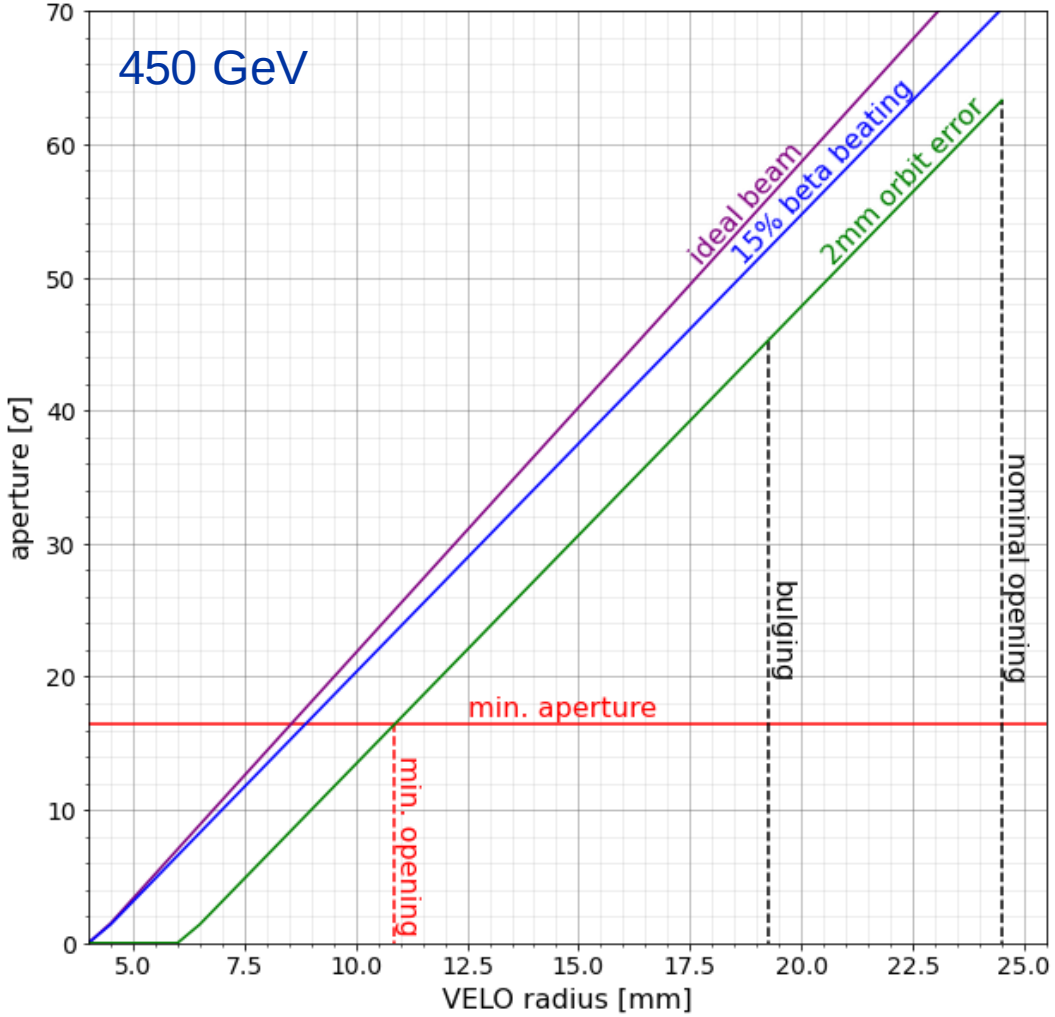


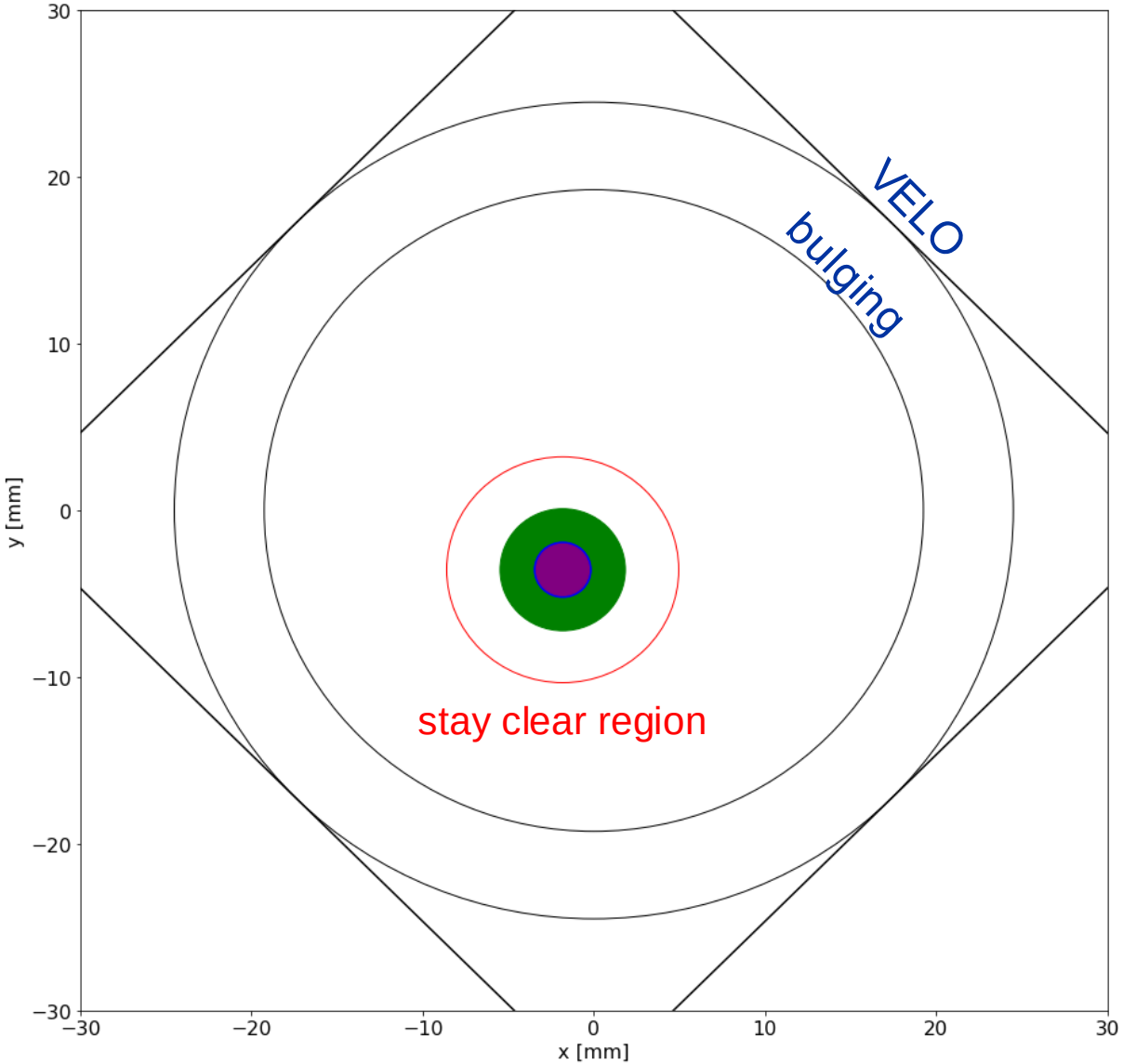


VELO aperture – 10m β*

- **16.4 σ is the general aperture limit for unprotected elements***

*R. Bruce et.al., Updated parameters for HL-LHC aperture calculations for proton beams, https://cds.cern.ch/record/2274330?ln=en

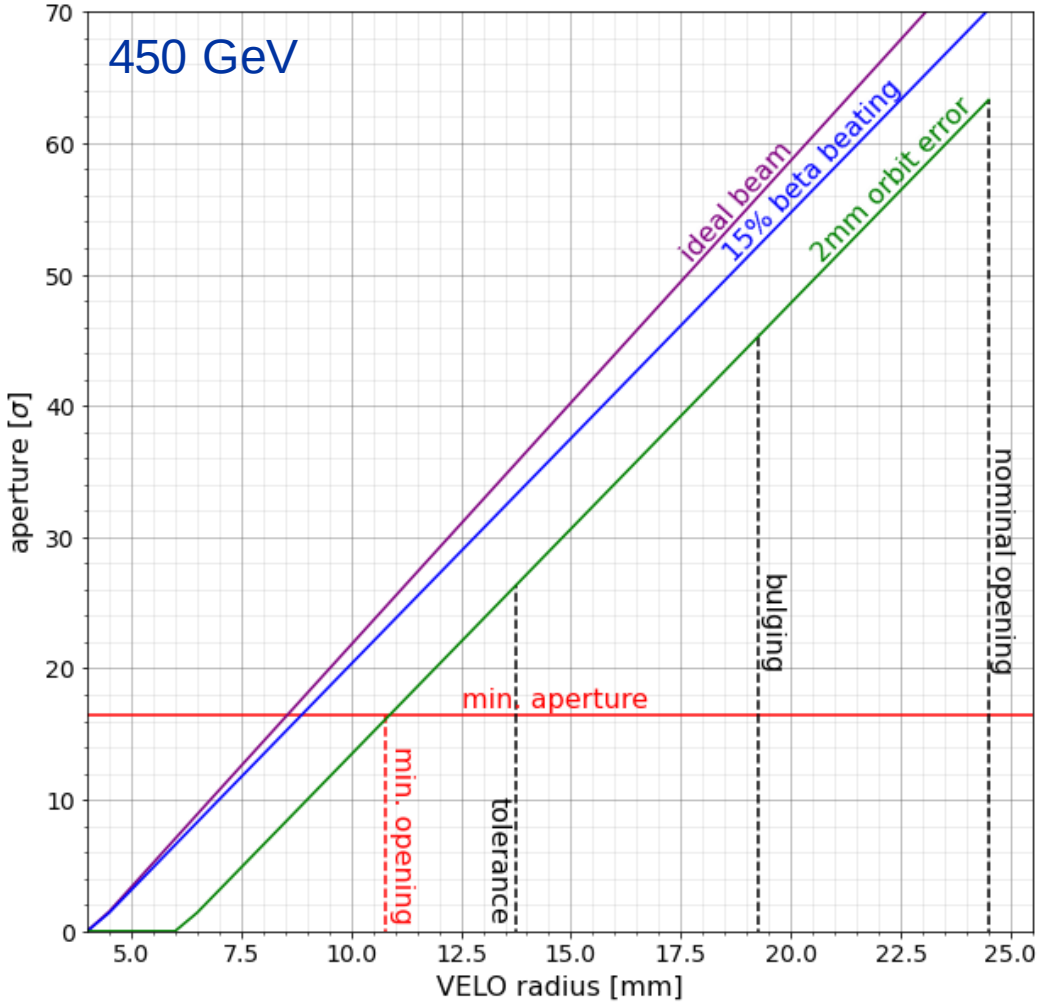


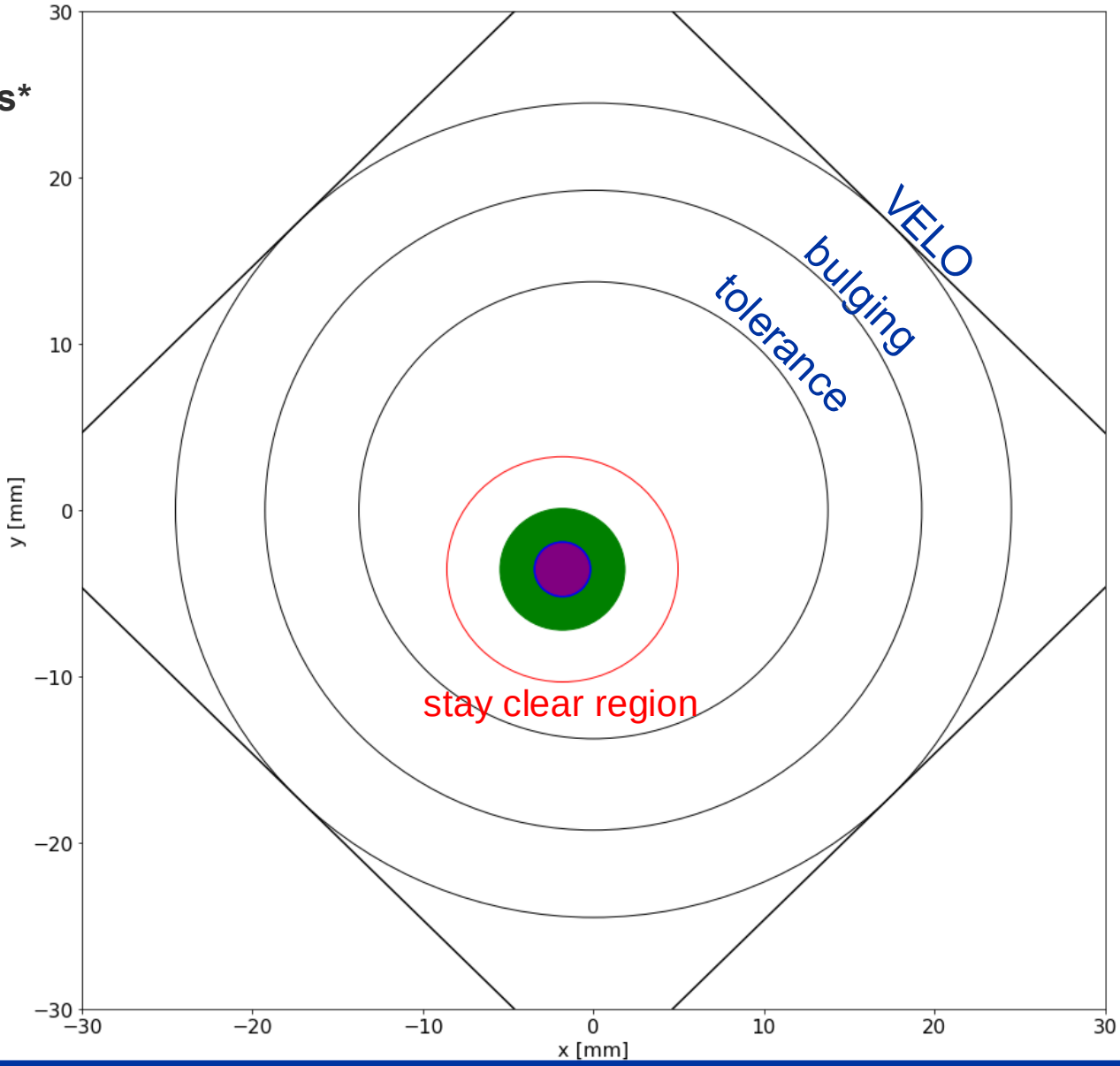


VELO aperture – 10m β*

- **16.4 σ is the general aperture limit for unprotected elements***

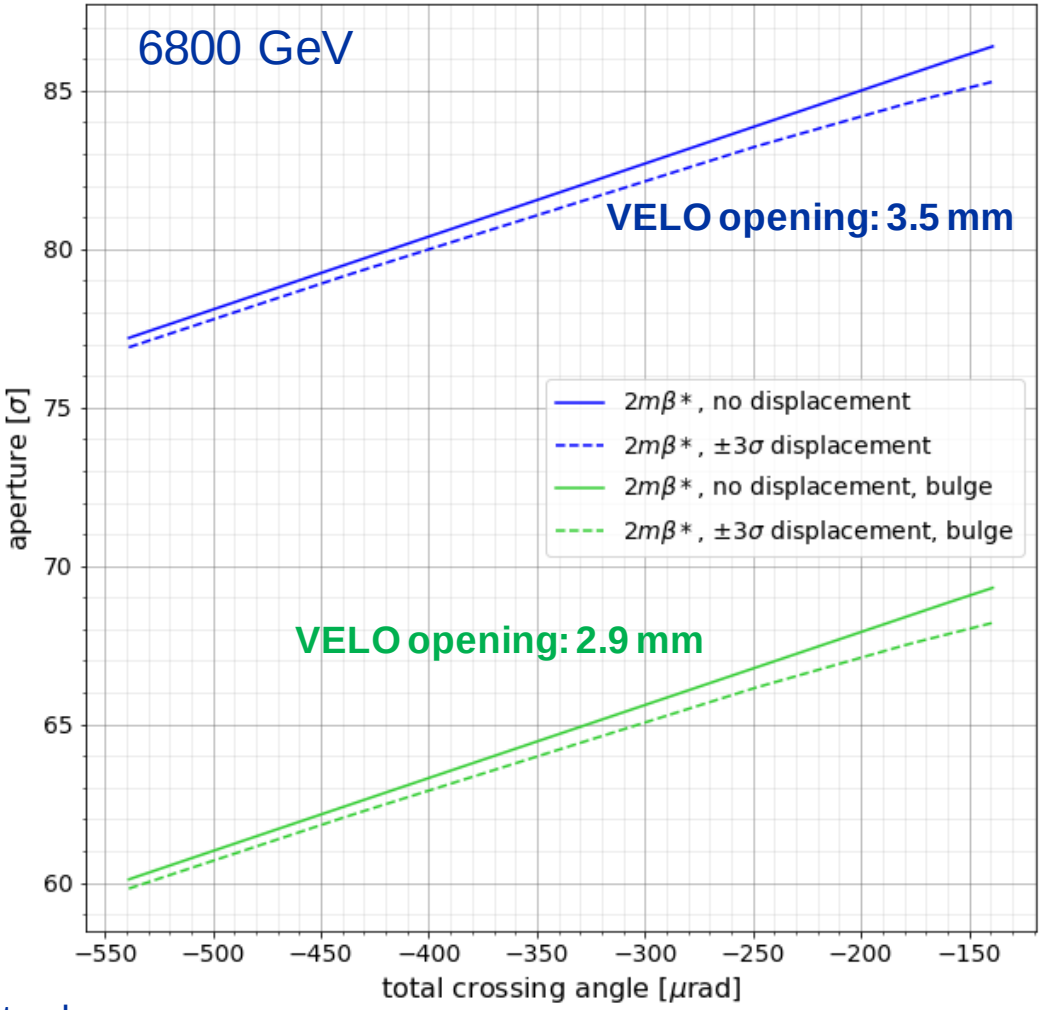
*R. Bruce et.al., Updated parameters for HL-LHC aperture calculations for proton beams, https://cds.cern.ch/record/2274330?ln=en





VELO aperture – 2m β*

- **Aperture margin is large due to small beam size**
- **Fully open, deformed, VELO ok**
  - Aperture > 300 σ
- **Deformed VELO can be centered around the beam and closed to an effective opening of 3.5 mm**
- **Minimum opening to be defined after VELO shape measurements and a definitive decision on xing angle**

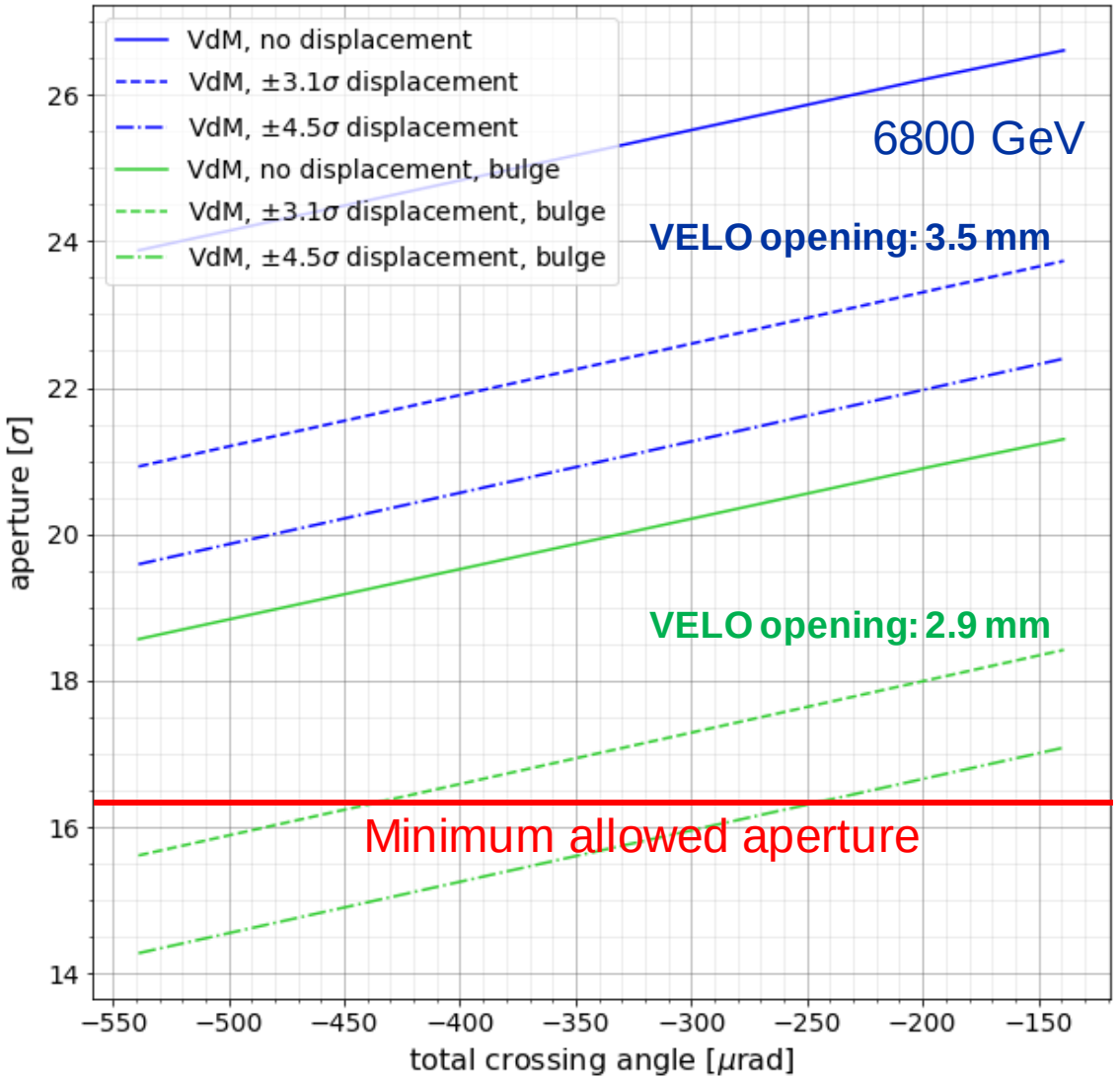


*R. Bruce et.al., Updated parameters for HL-LHC aperture calculations for proton beams, https://cds.cern.ch/record/2274330?ln=en

VELO aperture – 24m β*

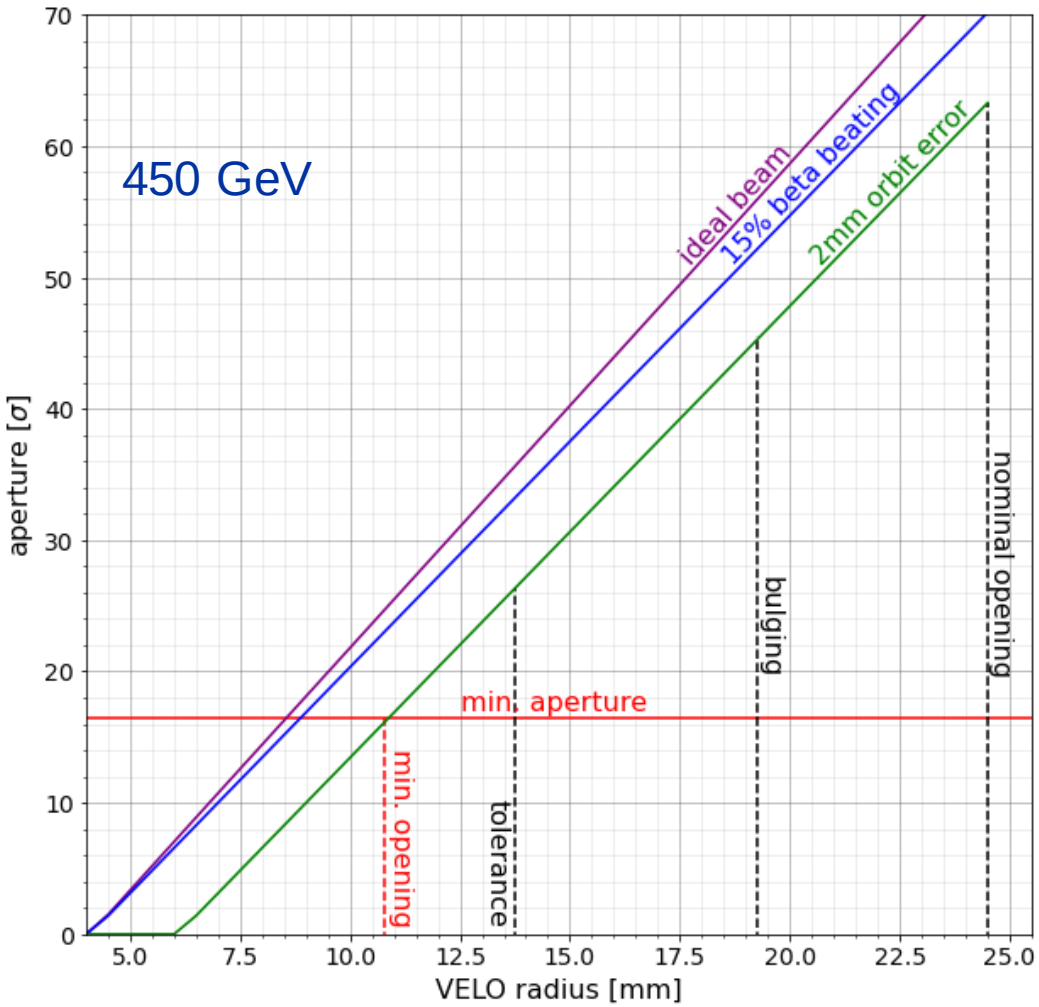
- **Aperture calculated for three scenarios:**
  - No beam displacement
  - ± 3.1 σ for the Van der Meer scan
  - ± 4.5 σ for the length scale calibration scan

- **Deformed VELO can be centered around the beam and closed to an effective opening of 3.5 mm**
  - Aperture for open, deformed, VELO > 90 σ
  - Minimum opening to be defined after VELO shape measurements and a definitive decision on xing angle / VdM scan ranges



Conclusions

- **Aperture deformation was simulated – no measurement available at the moment.**
- **In aperture calculations, VELO was open to 28.15 / 25.85 mm, opening to 29.8 / 29.8 mm provides further margin**
- **1st phase: Assessment of the injection feasibility:**
  - Aperture is compatible with this
- **2nd phase: Assessment of the operations feasibility with VELO fully open:**
  - Aperture is compatible with this, even with VdM scans up to 4.5 σ (> 90 σ aperture)
- **3rd phase: Assessment of the operations feasibility with VELO moving:**
  - Aperture is compatible with this
  - VELO should be centered around beam and can be closed to a min gap
  - Aperture measurements will provide important input for defining this range



more details: LNO-NDC section meeting
https://indico.cern.ch/event/1254790/