# Impact of crab cavity bump non-closure on DA during collisions

**R. De Maria, G. Iadarola, S. Kostoglou, Y. Papaphilippou, G. Sterbini**

## Overview

- Simulation parameters
- Sanity checks
- Impact of CC bump non-closure on orbit, tune diffusion & DA

**185th Hi-Lumi WP2 meeting 24/11/2020**

# Simulation parameters

DA studies with beam-beam at the **end of β*-leveling**

| HL-LHC V1.5* | | | | | | |
|---|---|---|---|---|---|---|
| 7 TeV | $\beta^*$=15 cm | 1.2e11 ppb | $\varepsilon_n$=2.5 μm | $C^-$=1e-3 | $I_{oct}$=+300 A | Q'=15 |
| $N_{IP1}$, $N_{IP2}$, $N_{IP8}$ = 2748, 2494,2572 | | $\phi/2_{IP1}$= 250 μrad | $\phi/2_{IP8}$= -200 μrad Positive polarity | on_crab= -190 μrad | $(Q_x, Q_y)$ =(0.31, 0.315) | $V_{RF}$=16 MV |

*https://github.com/lhcopt/lhcmask/tree/master/python_examples/hl_lhc_collisions_python
https://gitlab.cern.ch/skostogl/crab-cavities-da-studies

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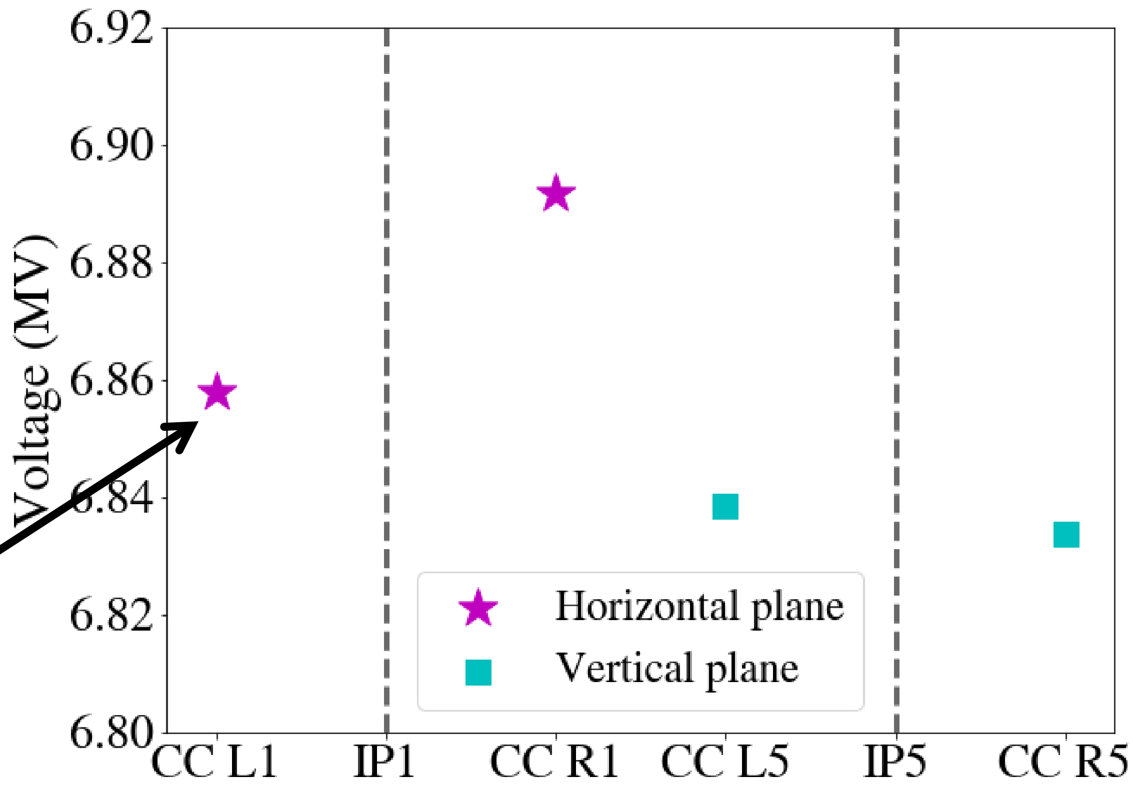
# Closed crab cavity bump

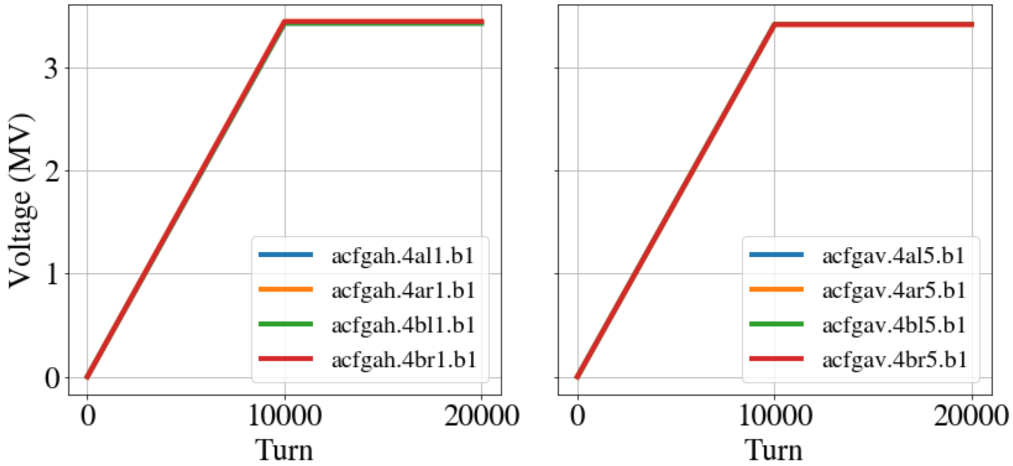
For on_crab1=on_crab5 **=-190 µrad**:




acfgah.4**a**l1
&
acfgah.4**b**l1

# Simulation parameters

- CC voltages are ramped adiabatically during **10 K turns** (~18 synchrotron periods).




Output of DYNK block SixTrack

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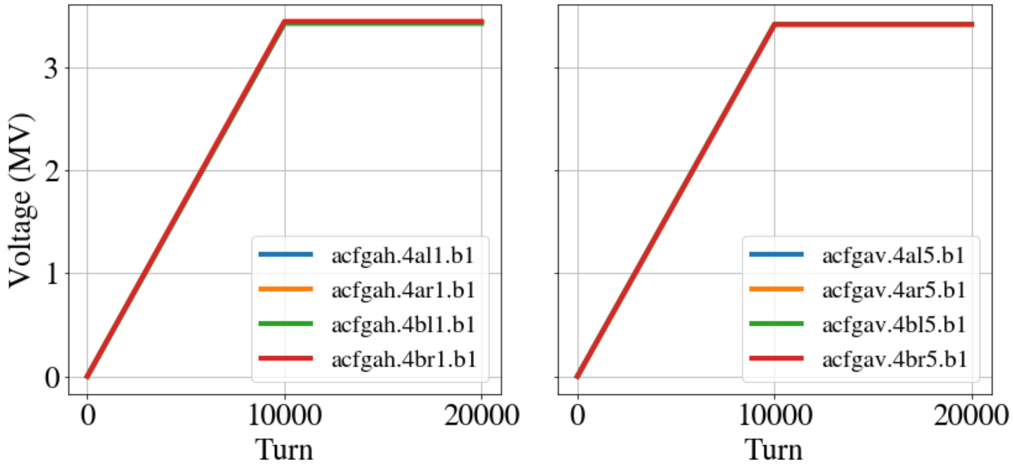
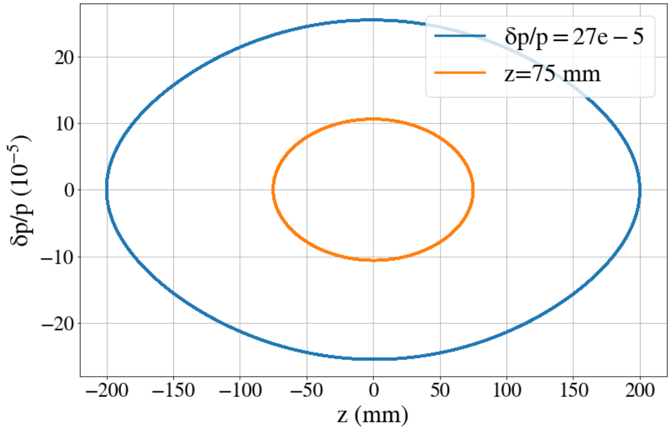



Output of DYNK block SixTrack

- δp/p=27e-5 (3/4 bucket height) in DA simulations→ **z~200 mm**. Studies also with z=75 mm.



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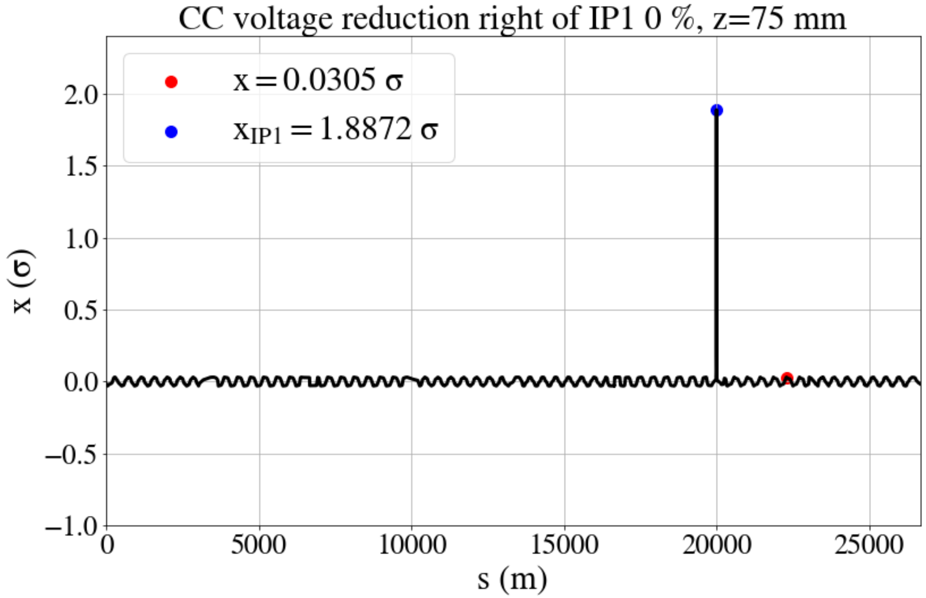
Orbit, z=75 mm



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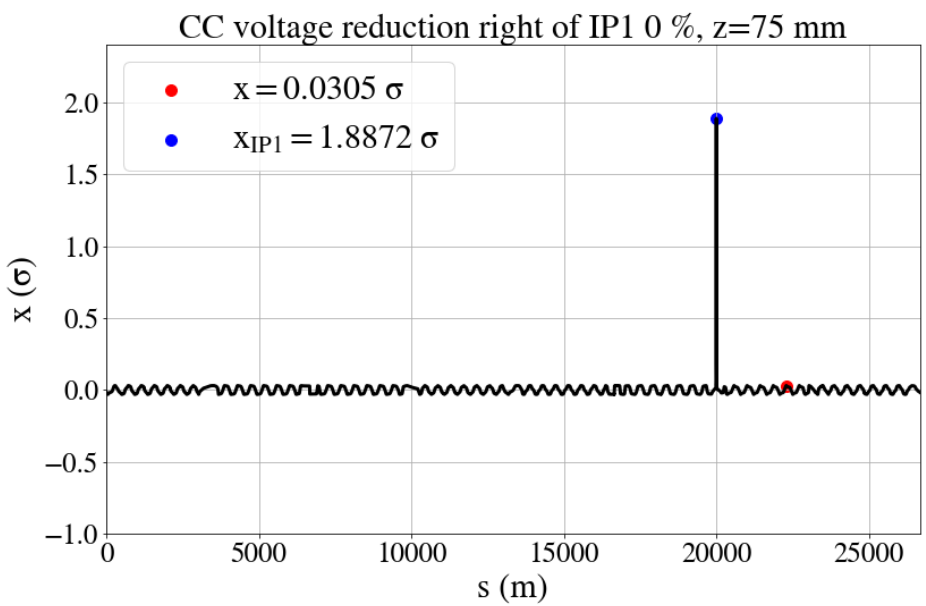
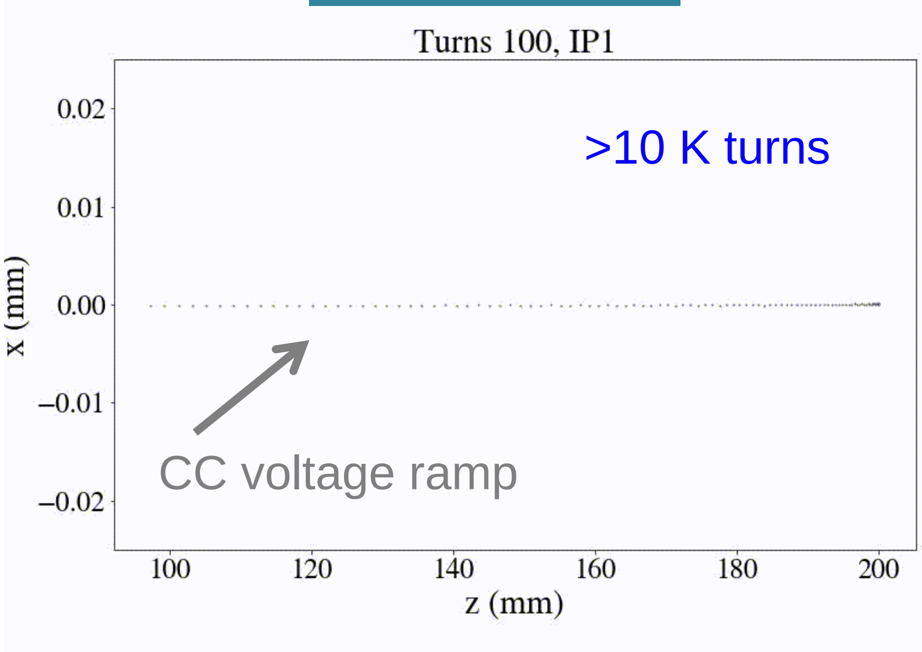



IP1, z=200 mm



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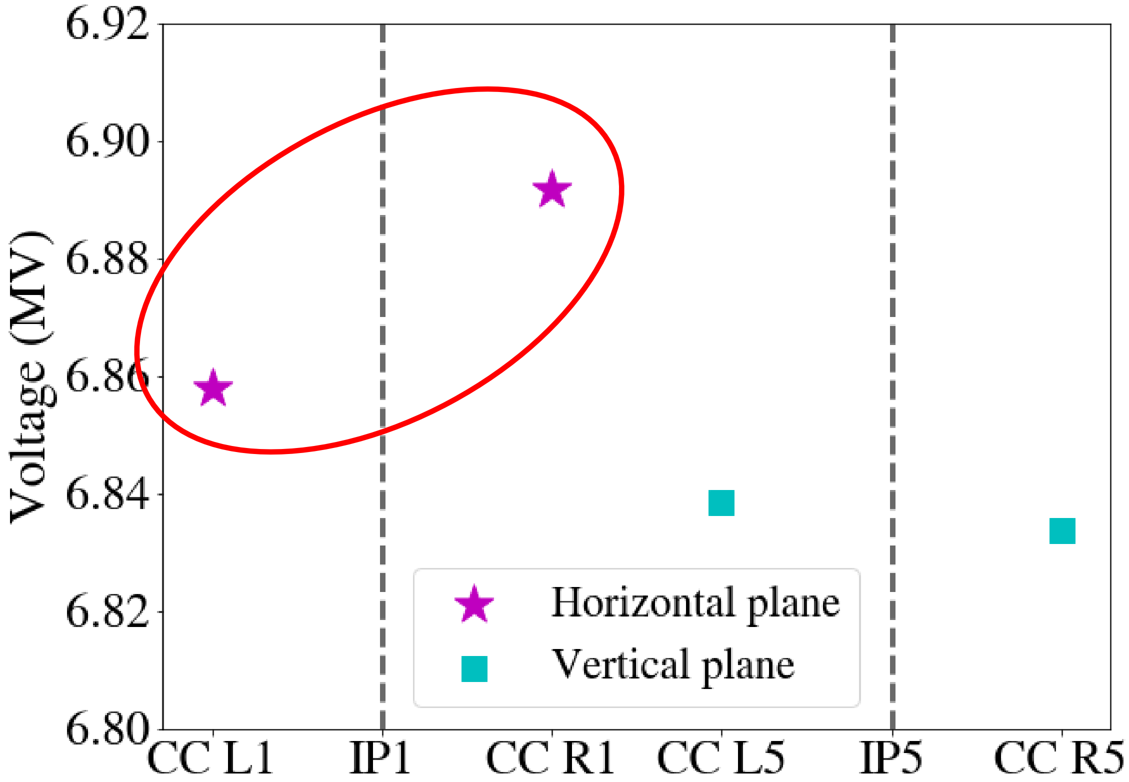
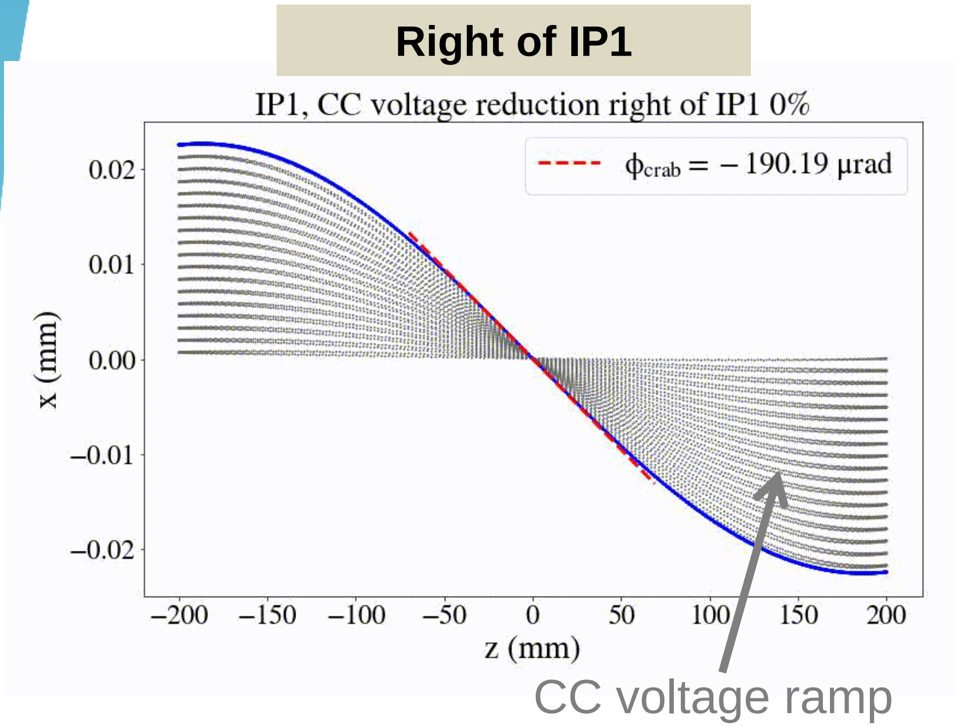
For on_crab1=on_crab5 =**-190 µrad**:




Modify the CC voltage right (or/and) left of IP1 with the formula:

$$\mathbf{V_{err} = V_{closed} \times (1\text{-}error)}$$

# CC bump non-closure: Impact on crabbing angle

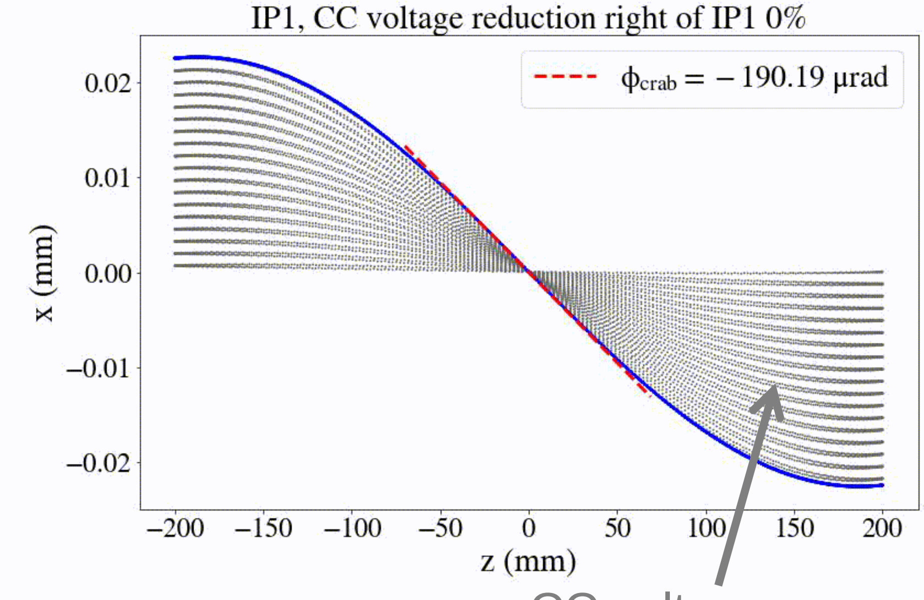



Minimum crabbing angle for **200%** reduction of voltage right of IP1

# CC bump non-closure: Impact on crabbing angle

GIF

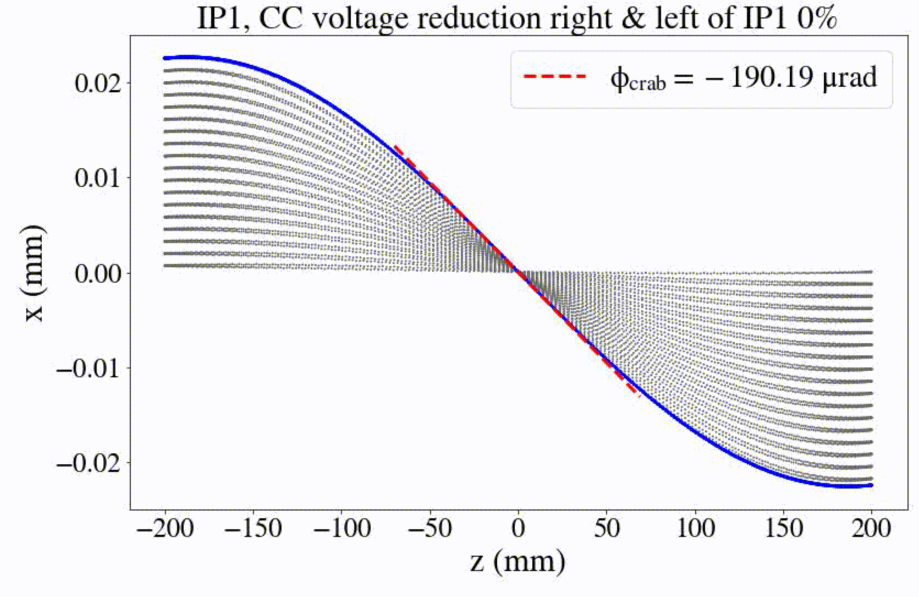
**Right of IP1**




CC voltage ramp

Minimum crabbing angle for **200%** reduction of voltage right of IP1

**Right & left of IP1**




Minimum crabbing angle at **100%** reduction of voltage right & left of IP1

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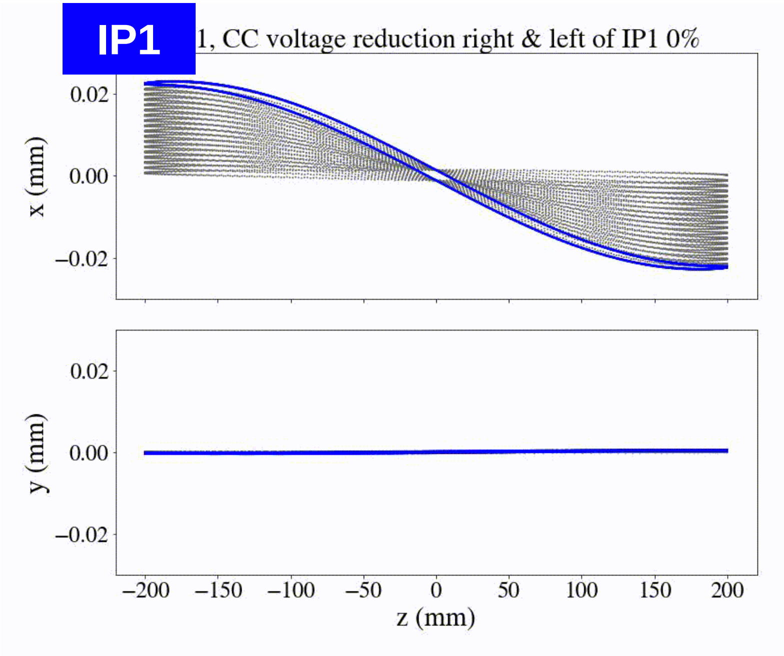
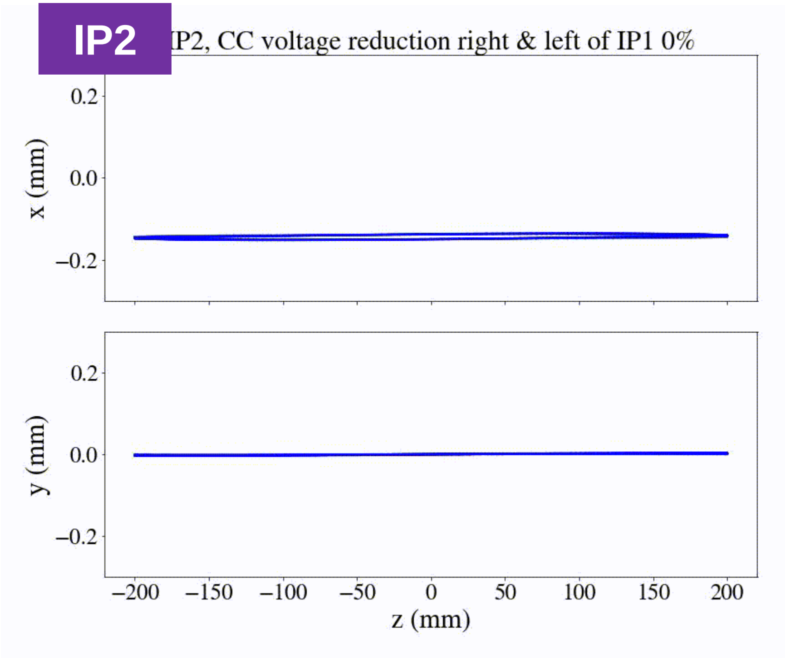
# CC bump non-closure: Impact on other IPs



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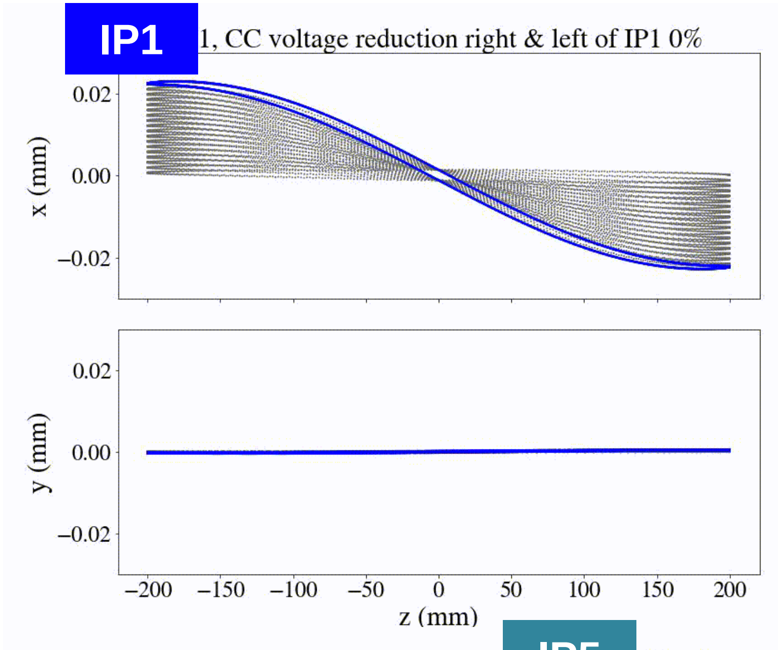
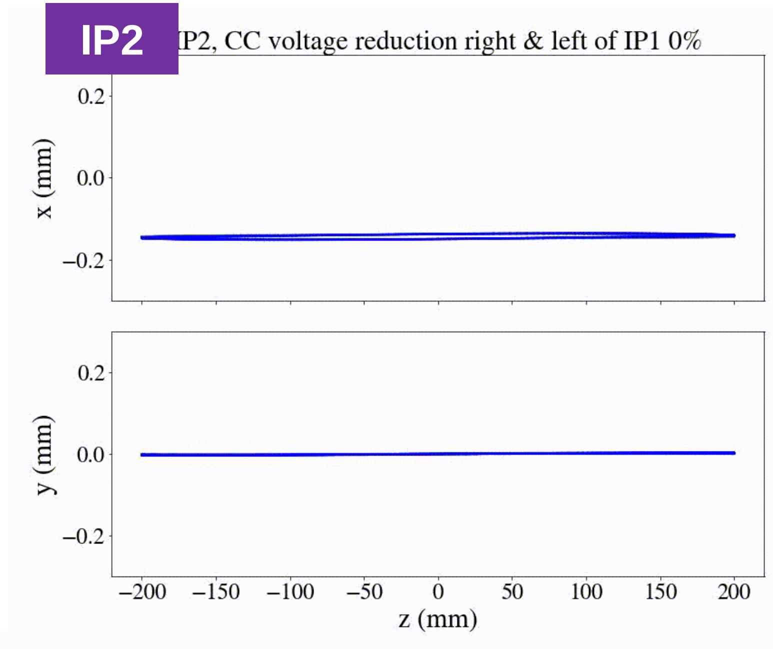
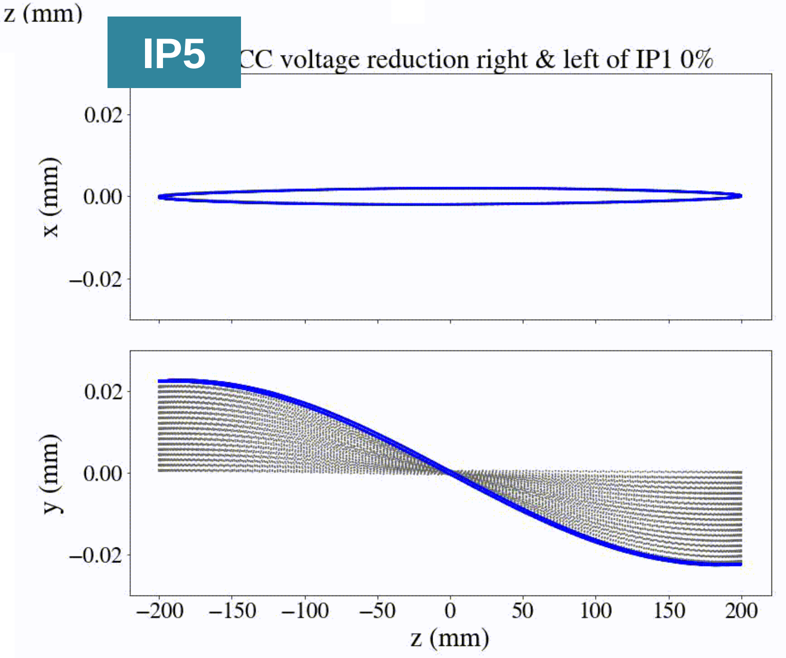


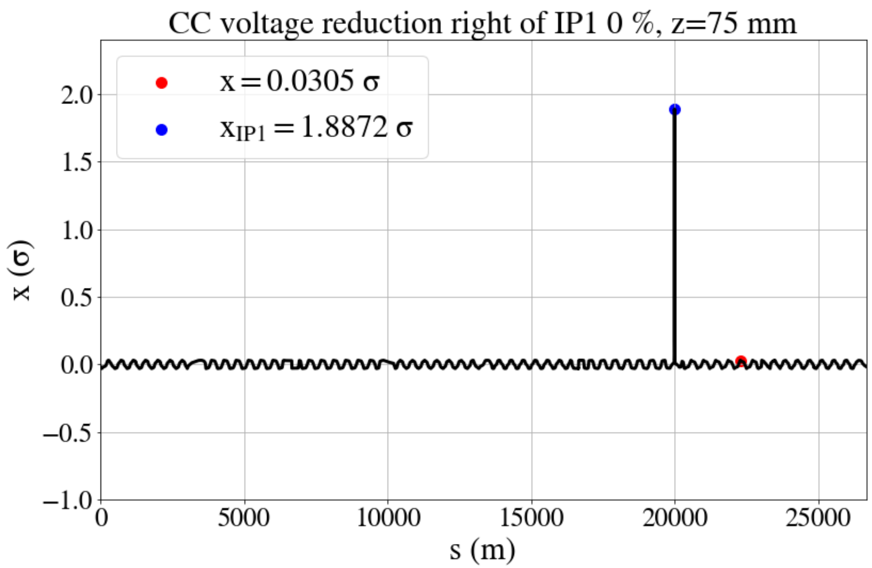



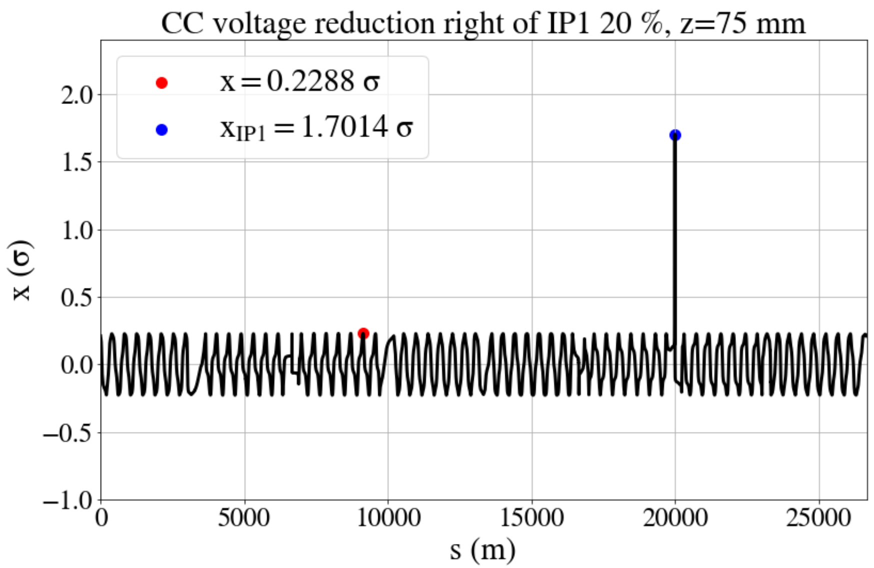

Visible crabbing in IP2




Crabbing in H plane of IP5

# CC bump non-closure: Impact on orbit



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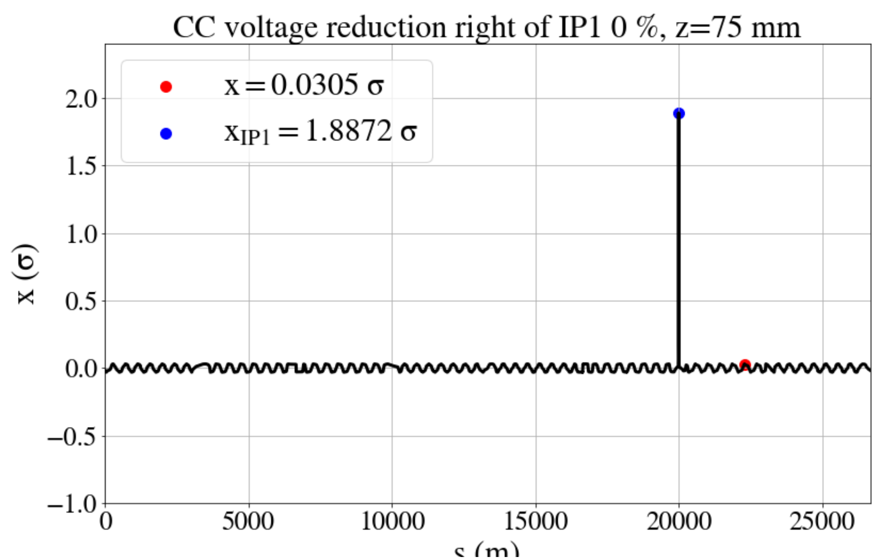
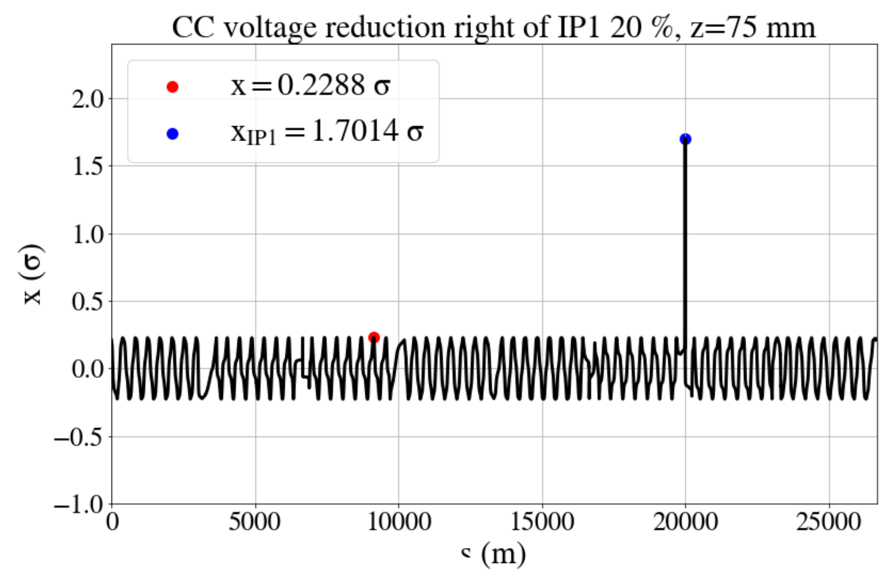
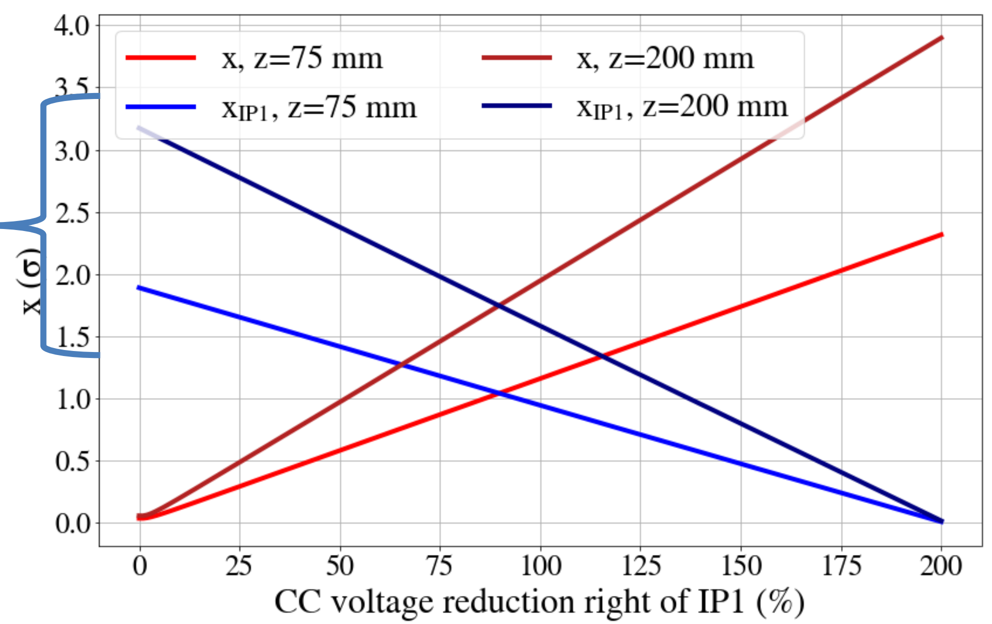



x in IP1 for z=75 mm & z=200 mm

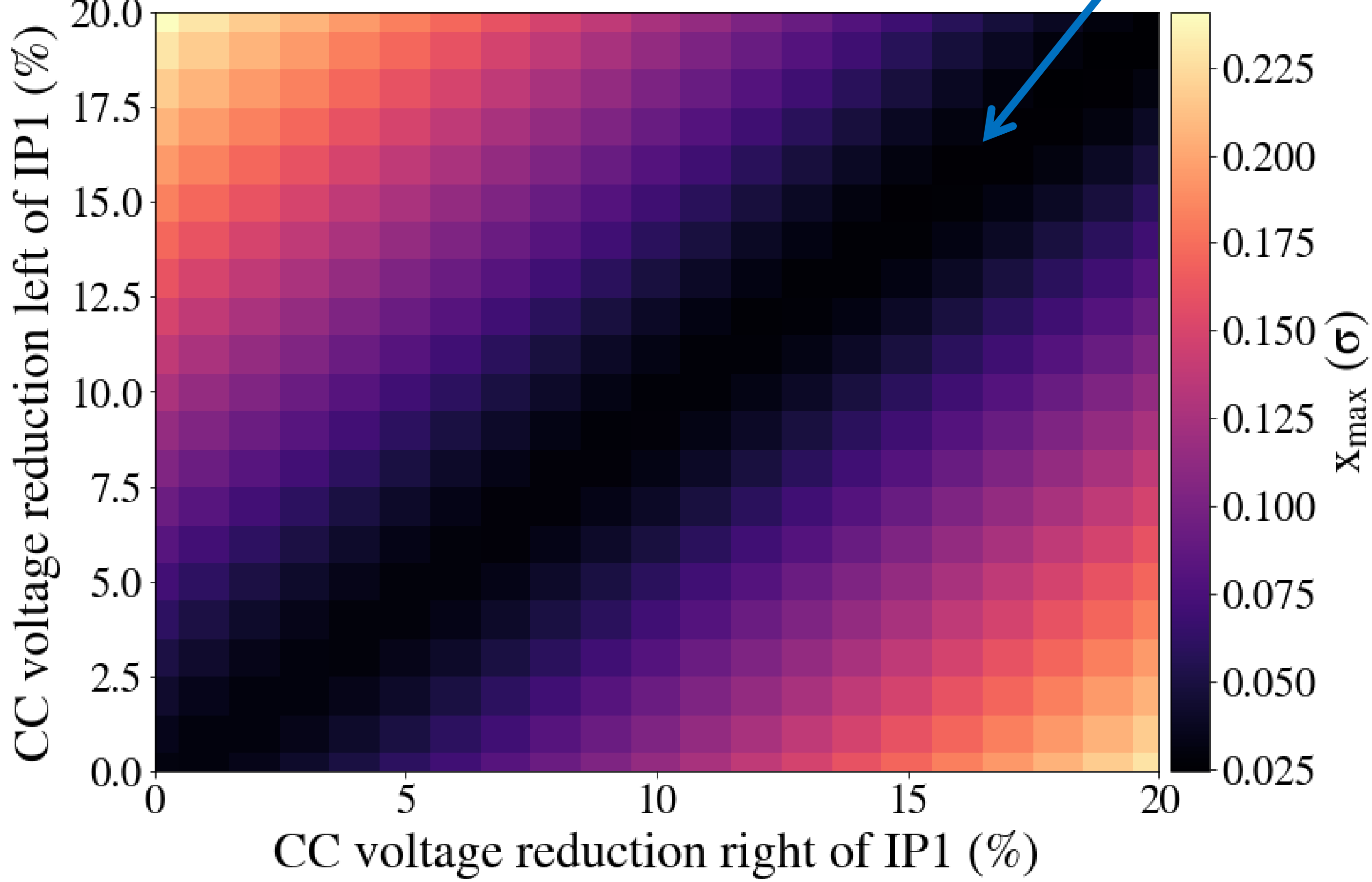



Max x in the ring for z=75 mm & z=200 mm

# CC bump non-closure: Impact on orbit

z = 75 mm,
Initial on_crab=-190 μrad

Closed CC bump, change in crabbing angle

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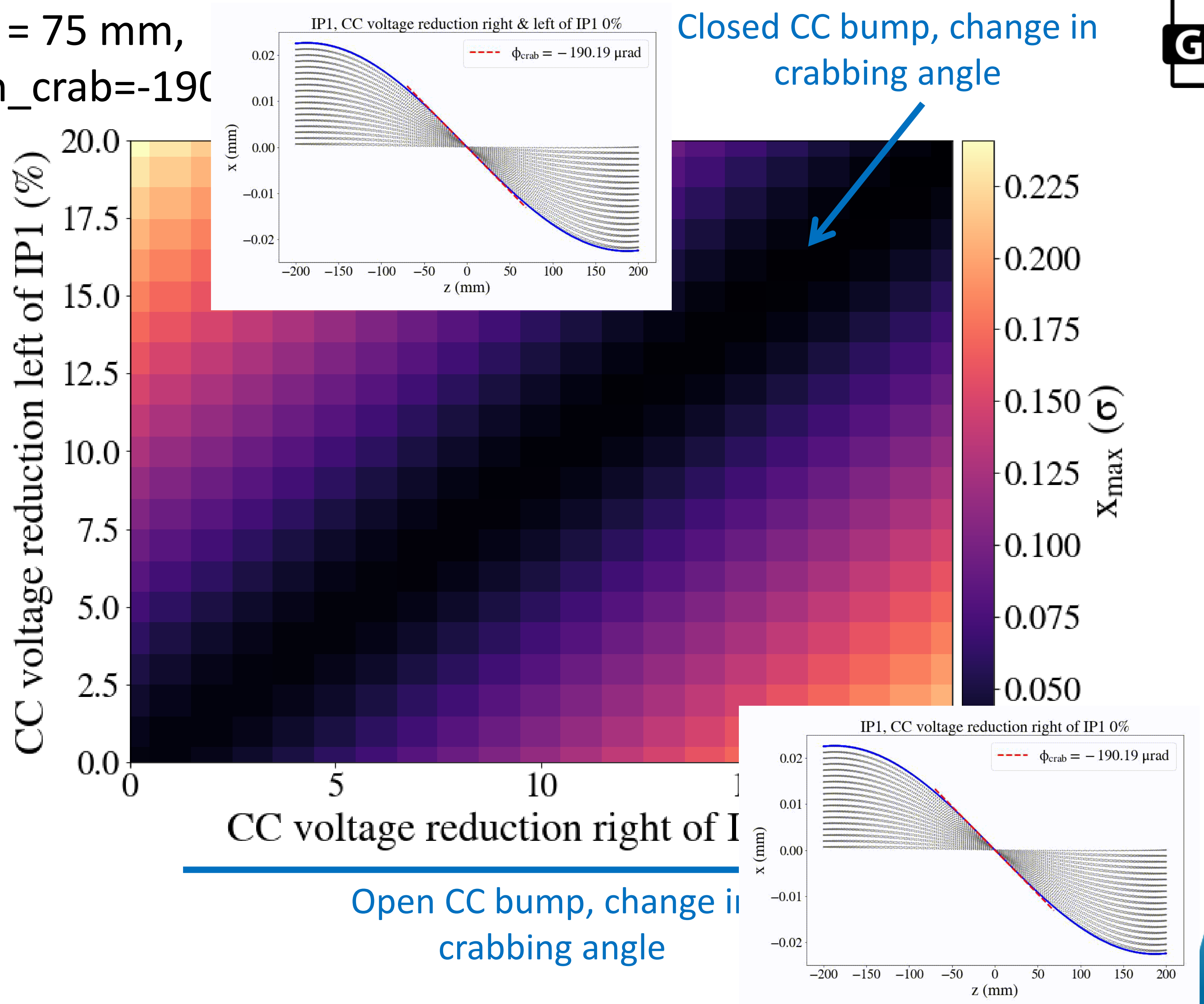
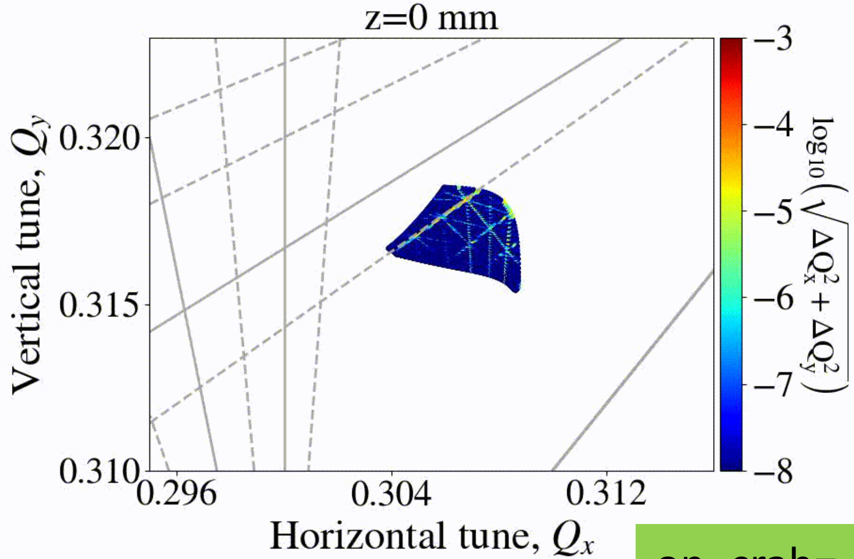
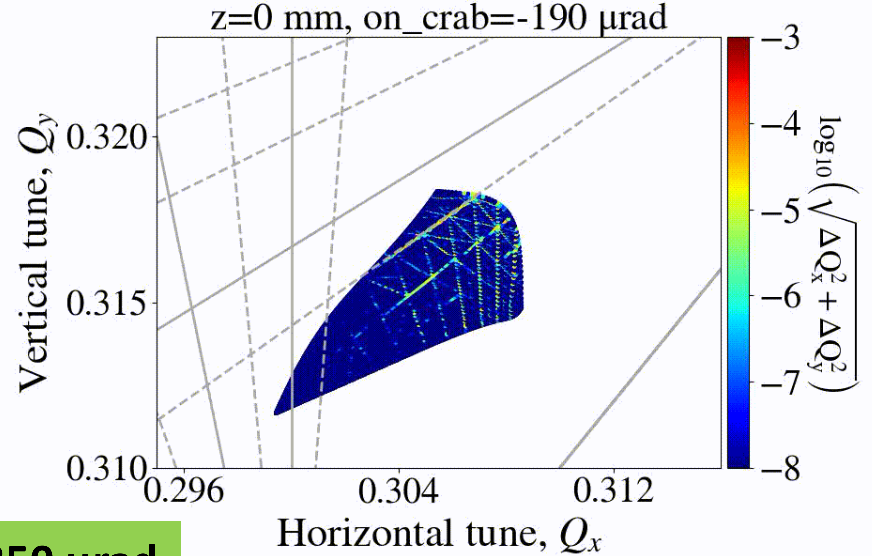


# 6D FMAs: Scan in z

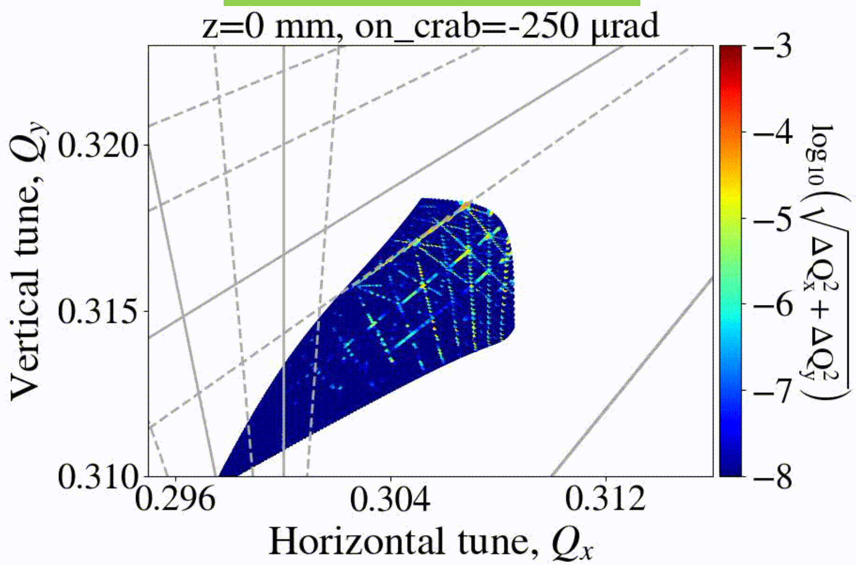
on_crab=**0 µrad**




on_crab=**-190 µrad**




on_crab=**-250 µrad**



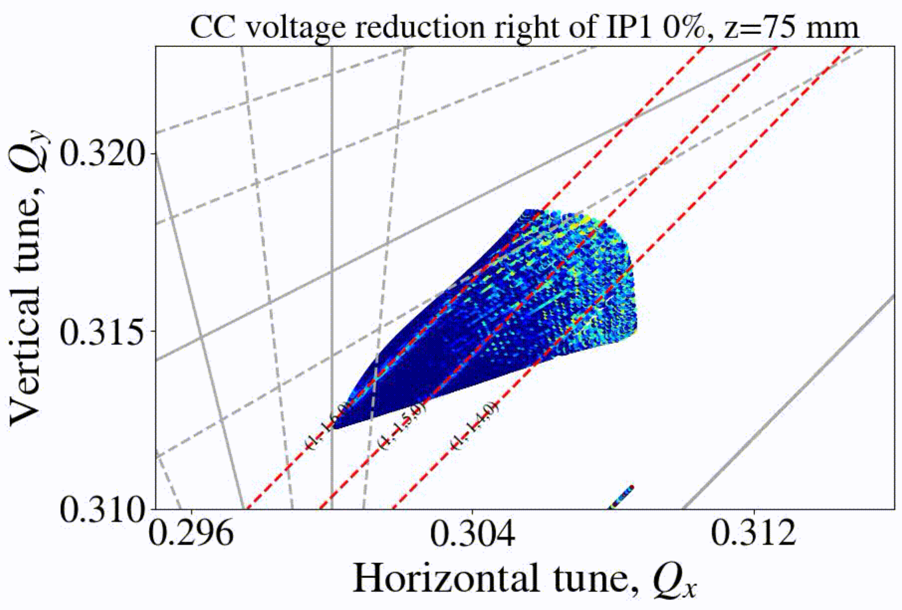

$\phi/2_{IP1}$=250 µrad, only HO, Q'=0, $I_{oct}$=0 A, distribution up to 6 σ

Synchrotron sidebands

# 6D FMAs: CC bump non-closure

z = 75 mm,
Initial on_crab=-190 μrad

**Open CC bump strong beam (B2)**



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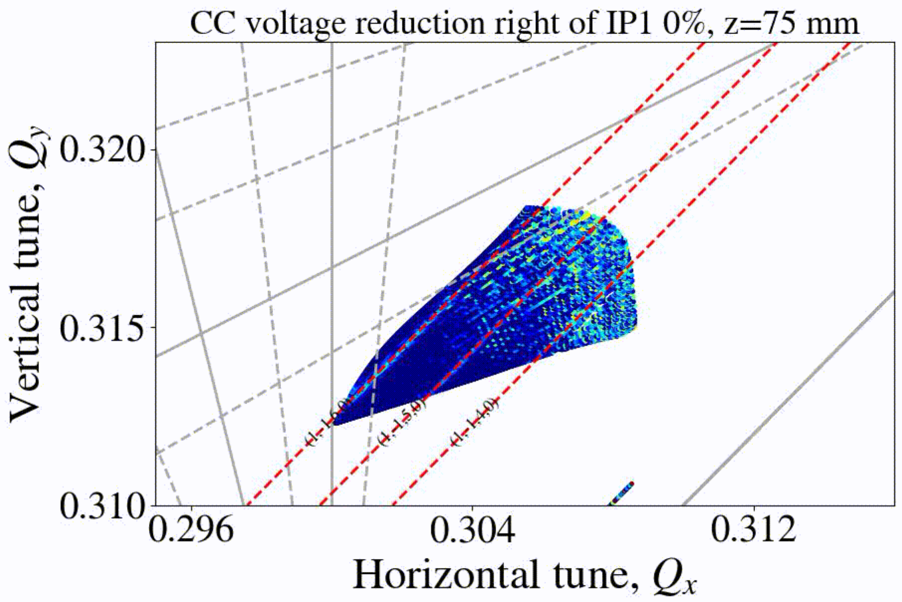
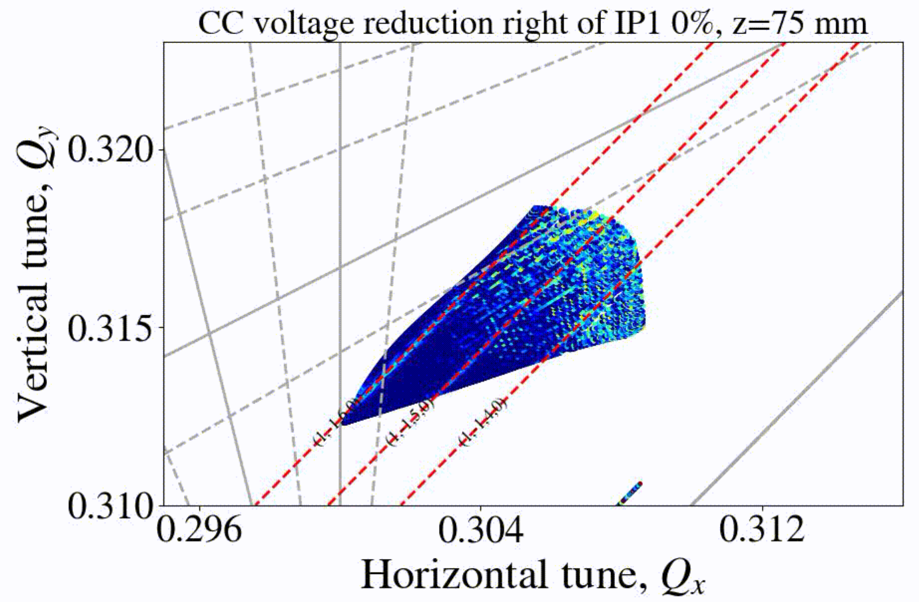



**Open CC bump weak beam (B1)**




When including imbalance in both beams, main contributor is the weak beam (see also appendix).

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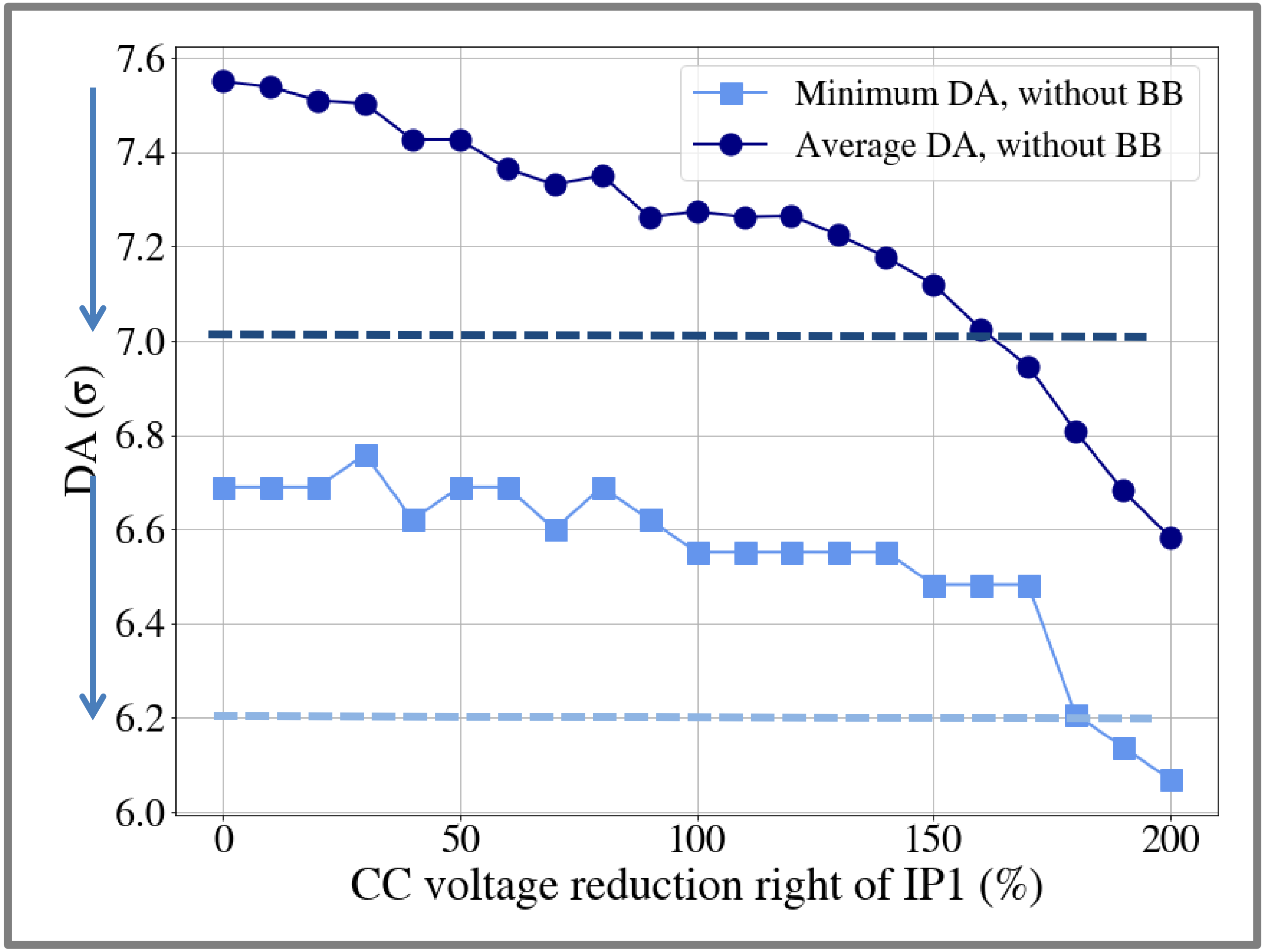
# Impact of CC bump non-closure on DA without BB



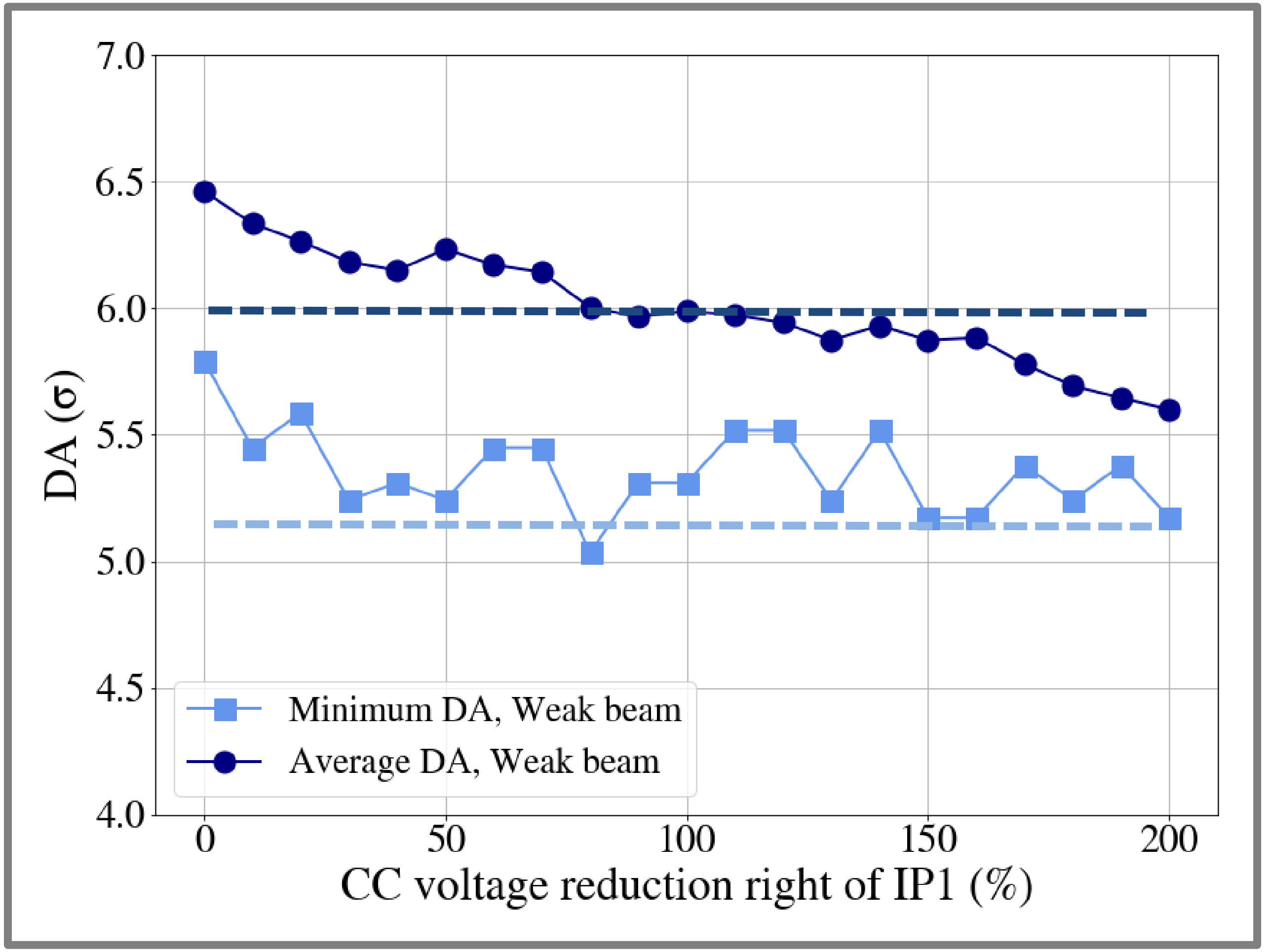

> 0.5 σ reduction

δp/p = 27e-5,
Initial on_crab=-190 μrad

**200%** reduction right of IP1:

- Average DA from **7.5 to 6.6 σ**
- Minimum DA **from 6.7 to 6.1 σ**

# Impact of CC bump non-closure on DA with BB

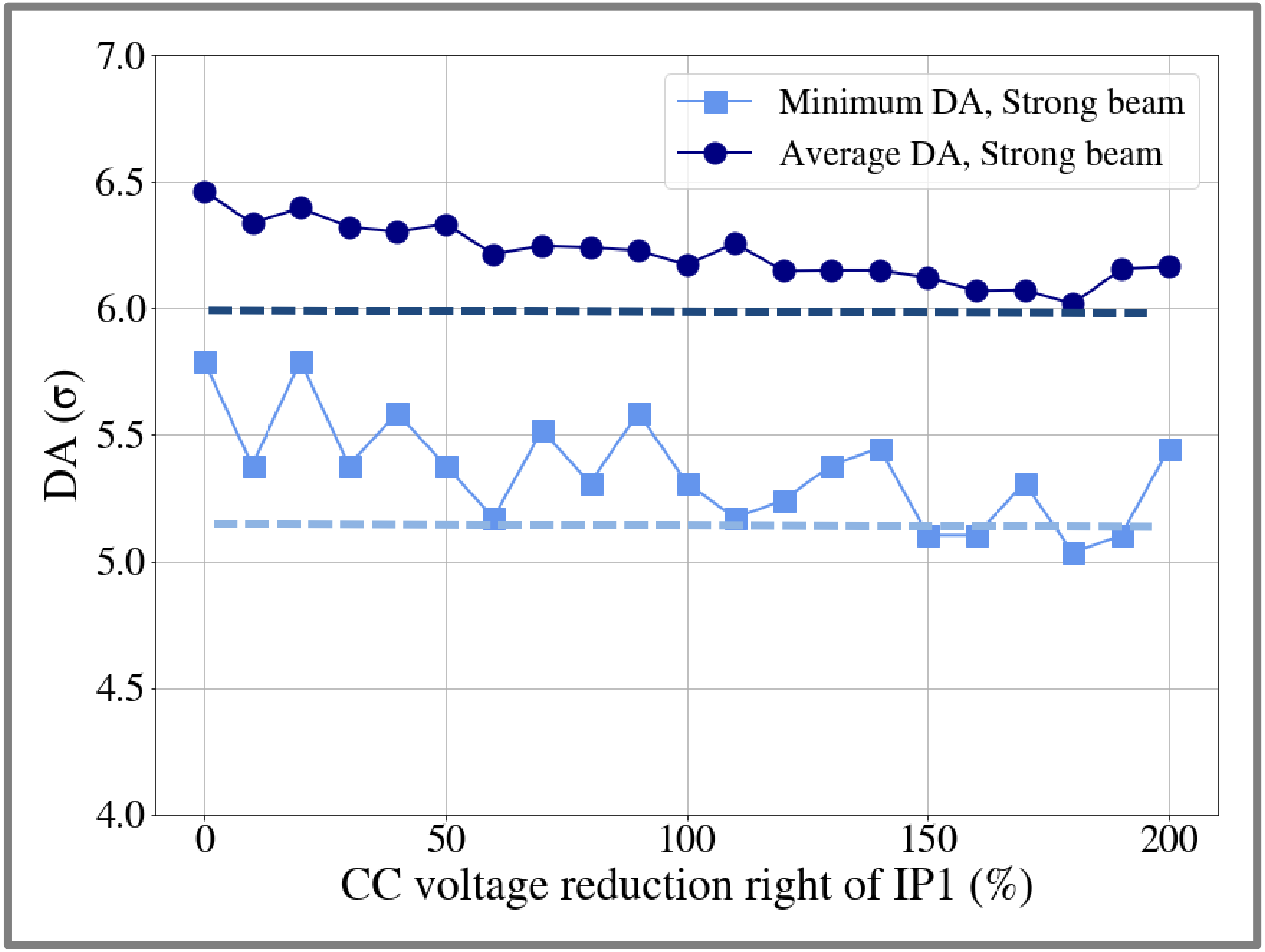



Non-ideal crabbing in the **weak beam (B1)**

**200%** reduction right of IP1:

➢ Average DA from **6.5 to 5.6 σ**

# Impact of CC bump non-closure on DA with BB

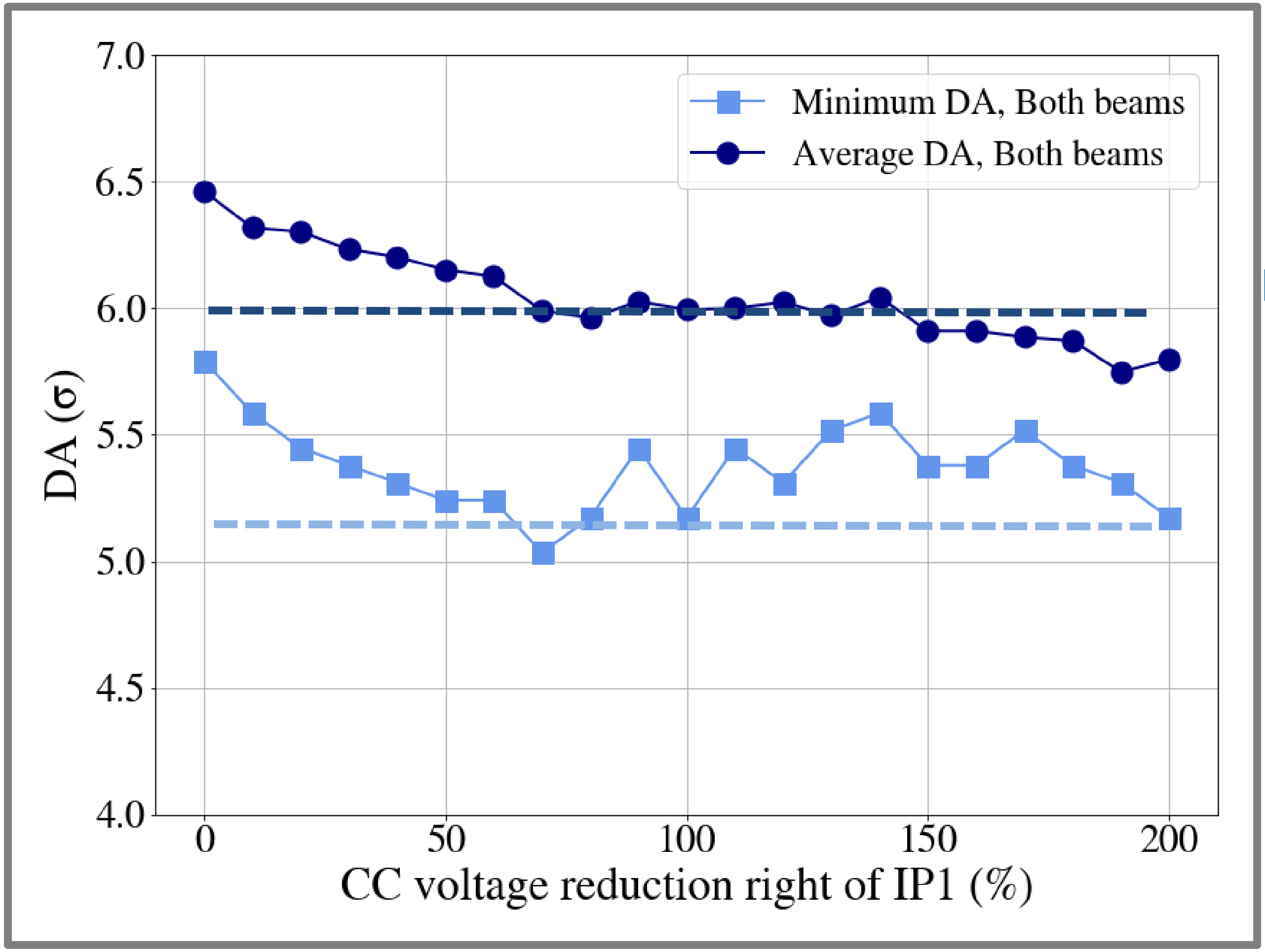



Non-ideal crabbing in the **strong beam (B2)**

**200%** reduction right of IP1:

- Average DA from 6.5 to 6.2 σ

# Impact of CC bump non-closure on DA with BB




Non-ideal crabbing in **both beams**

**200%** reduction right of IP1:

➢ Average DA from 6.5 to 5.8 σ

# Summary

- Investigated impact of CC bump non-closure on tune diffusion & DA at the end of the $\beta^*$-leveling for HL-LHC v1.5.
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  Without beam-beam (& up to 200% CC voltage reduction right of IP1):

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- Considered non-perfect crabbing for weak and/or strong beam.
- **Weak beam (B1)**: from 6.5 to 5.6 σ average DA (6D FMAs: HO tune spread ↓ as crabbing angle ↓ & ↑ of tune diffusion due to synchro-betatron sidebands)
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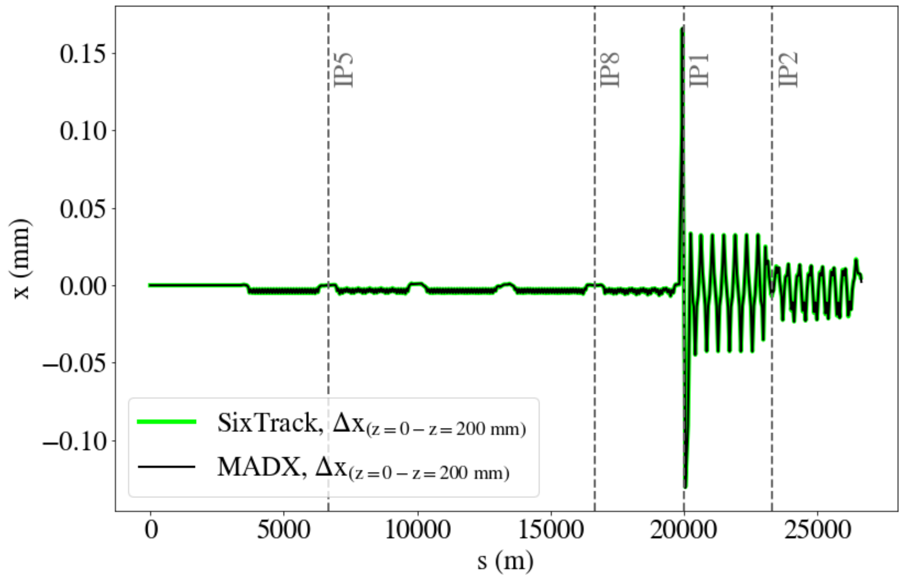
➢ **Next steps**: Include CC multipolar components.

# Backup

# Closed crab cavity bump

Sanity check MADX-SixTrack:

**ho_ip8=0, ho_ip1=0**




Initial conditions
$(x, p_x, y, p_y)=(0,0,0,0)$, z=0 and z=200 mm.

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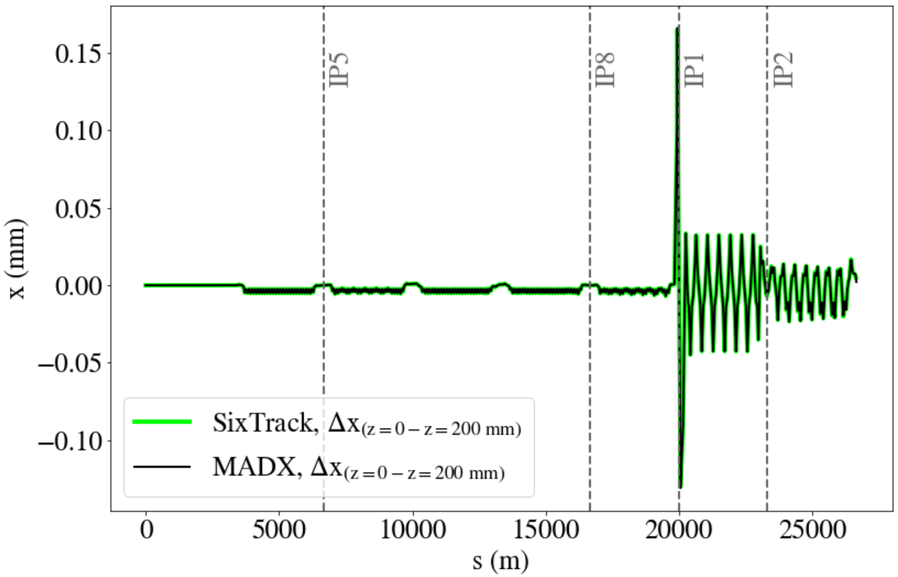
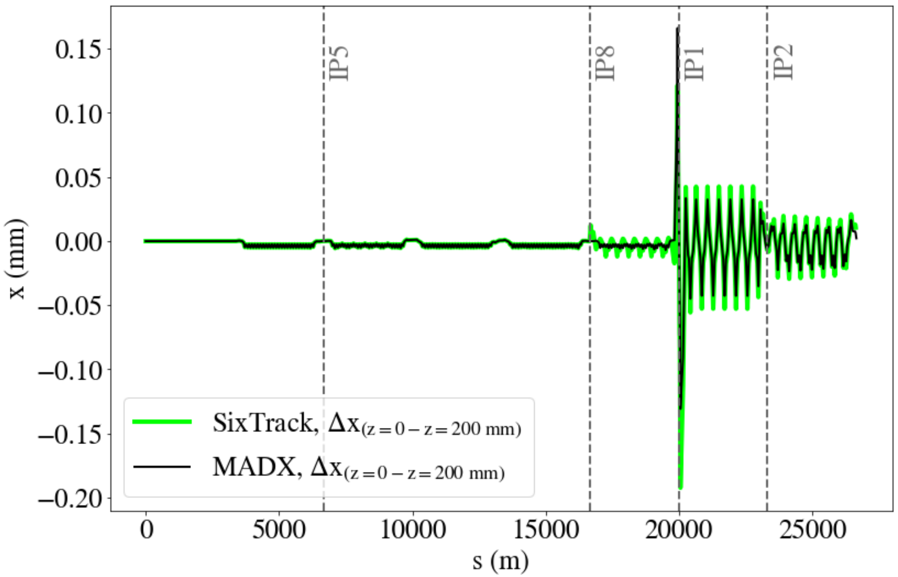



ho_ip8=1, ho_ip1=1

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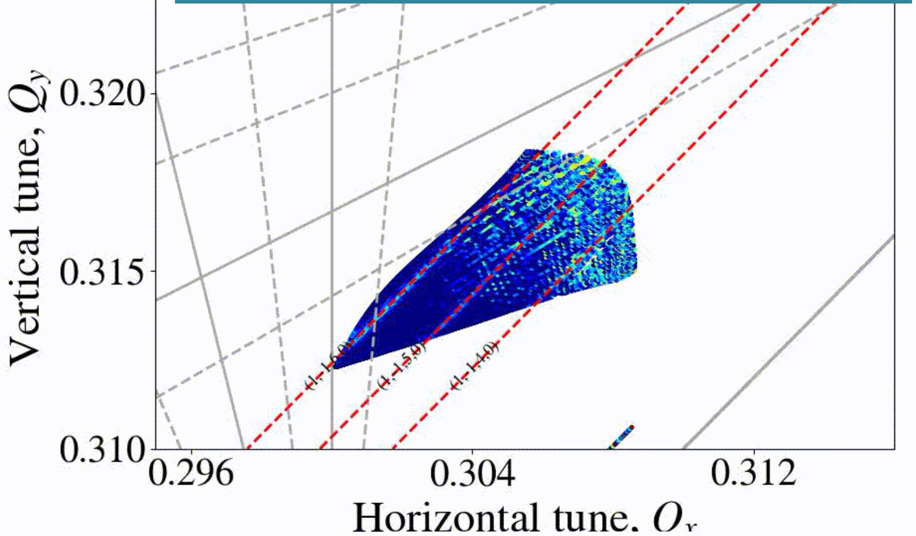
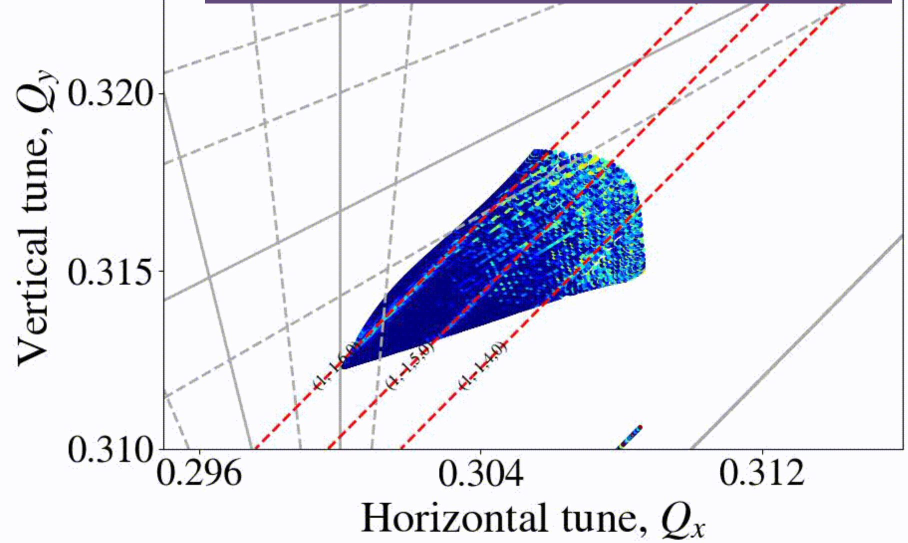
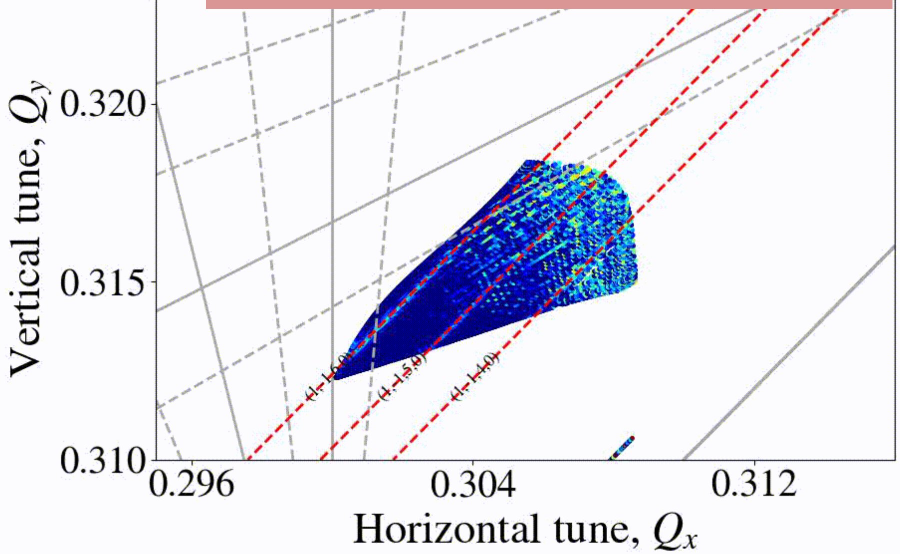



Open CC bump weak beam (B1)




Both weak & strong



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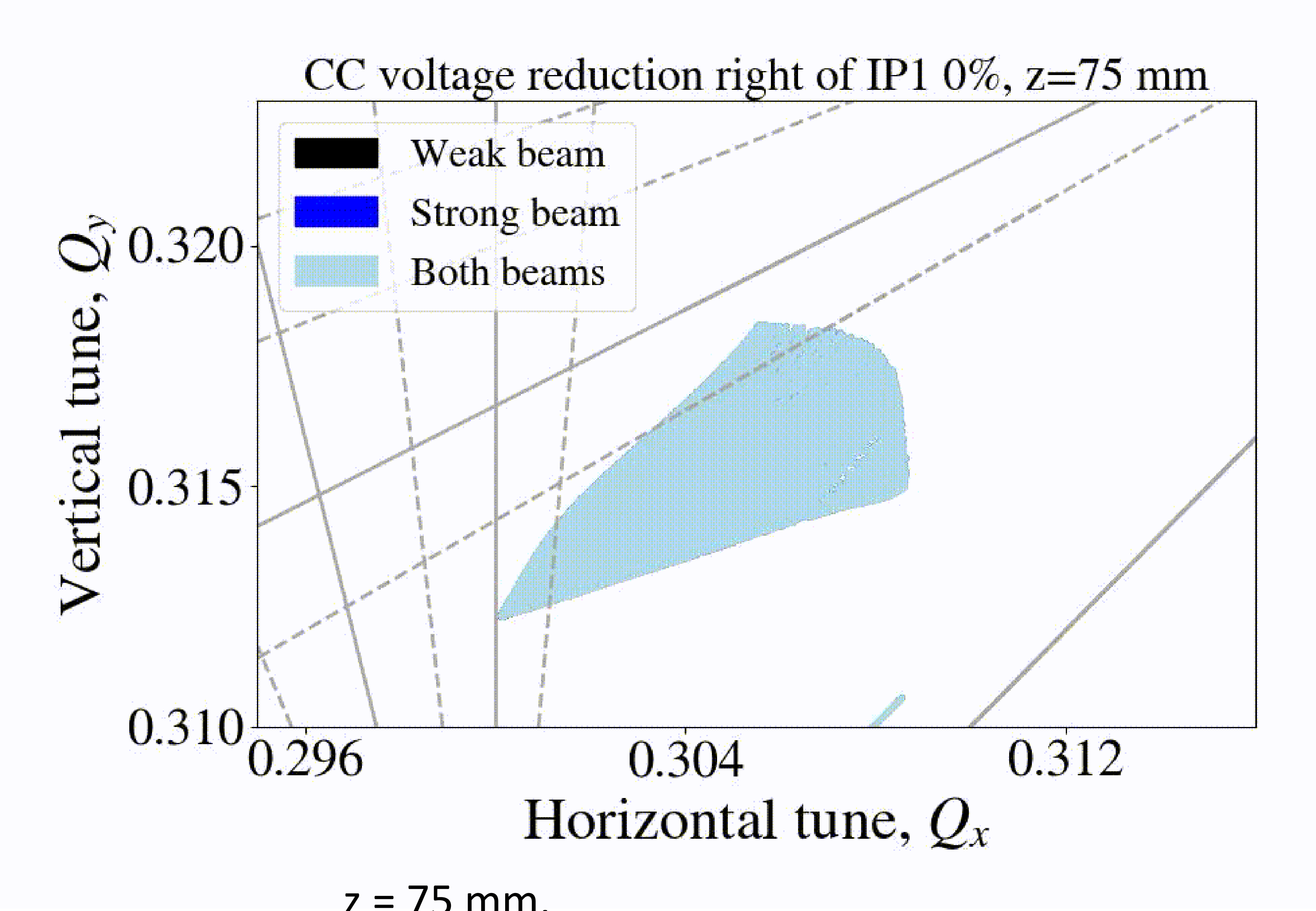



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