Updated GHC collimation studies

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FCC-ee collimation meeting, 04/12/2025

Introduction

- **Extensive studies on FCC-ee GHC lattice performed on V25.2**
  - Studied losses from:
    - Generic beam halo, generic off-momentum, beam-gas, Touschek, beam-beam, top-up injection, generic failure, fast failure
  - Overview presented at the 216th FCC-ee Accelerator Design meeting
    - G. Broggi, FCC-ee collimation studies

- For the **GHC vs. LCC lattice comparison** GHC V25.4 (=V25.3) has been selected
  - Studies should be updated to V25.4 (but V25.4 is very similar to V25.2)
  - **Additional recent updates**: aperture of QC2 quadrupoles, beam parameters
  - Studies selected for the GHC vs. LCC lattice comparison
    - Generic beam halo
    - Slow blow-up
    - Generic off-momentum

    - Fast instability: in progress

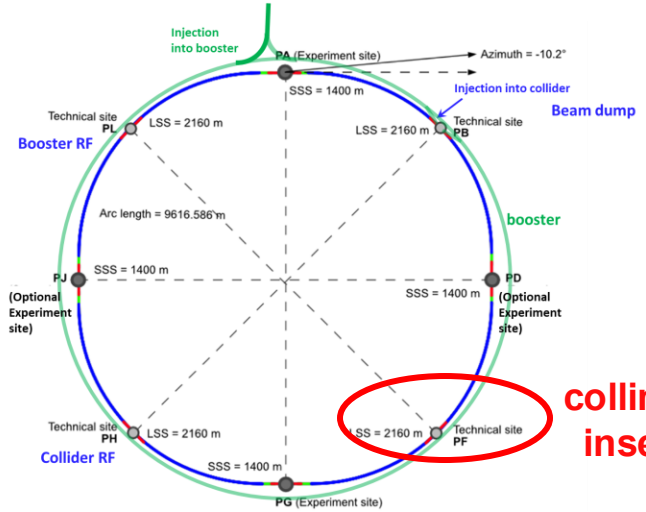
Recent updates

- **Aperture of QC2 quadrupoles increased from 20 mm radius to 25 mm radius**
  - M. Boscolo, Machine-detector interface: inputs for the FCC-ee beam-optics decision
  - Increases H-bottleneck from ~11.5σ to ~12.5σ
  - Horizontal collimator settings adapted accordingly

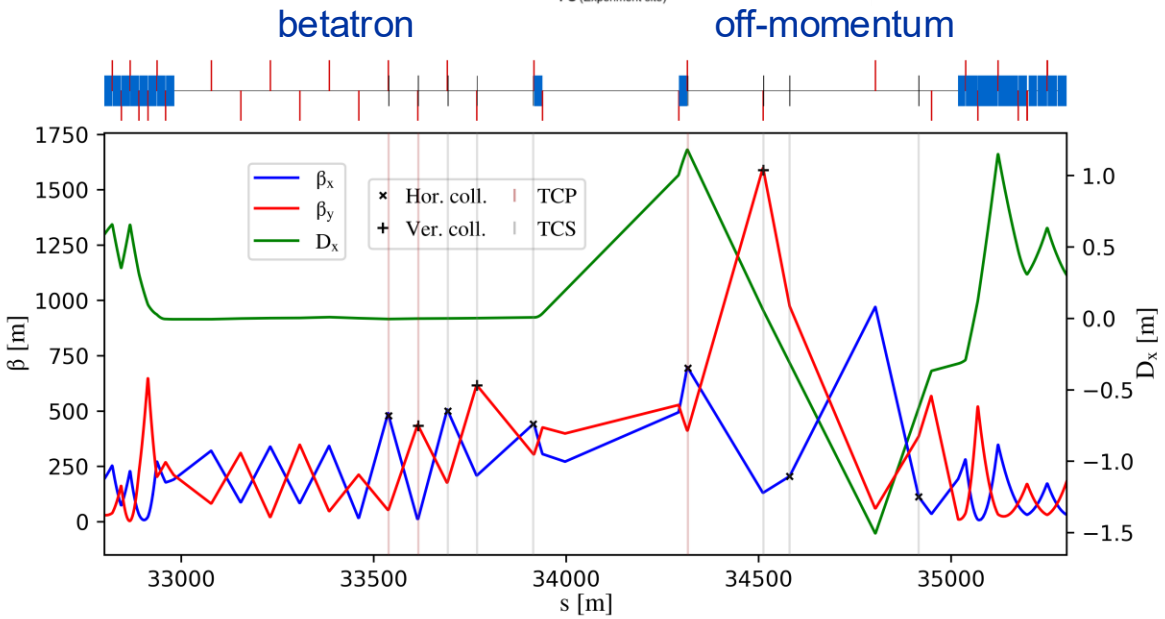
- **Beam parameters rediscussed several times over the last two weeks**
  - We decided to use the parameters in the first table presented in:
    - X. Buffat, Discussion on lattice comparison, presented at the beam-beam meeting on 18/11
    - Vertical emittance "in collision": 2.5 pm (GHC) 2.6 pm (LCC)

- **Concepts of lattice vertical emittance and vertical emittance "in collision" recently rediscussed**
  - Artifical dynamic emittance effect caused by the fake vertical wigglers
  - X. Buffat, Lifetime and emittance growth comparison for GHC and LCC, presented at the beam-beam meeting on 02/12
  - For the future, need to discuss which vertical emittance to assume for collimation studies

GHC collimation: collimation insertion PF



collimation insertion



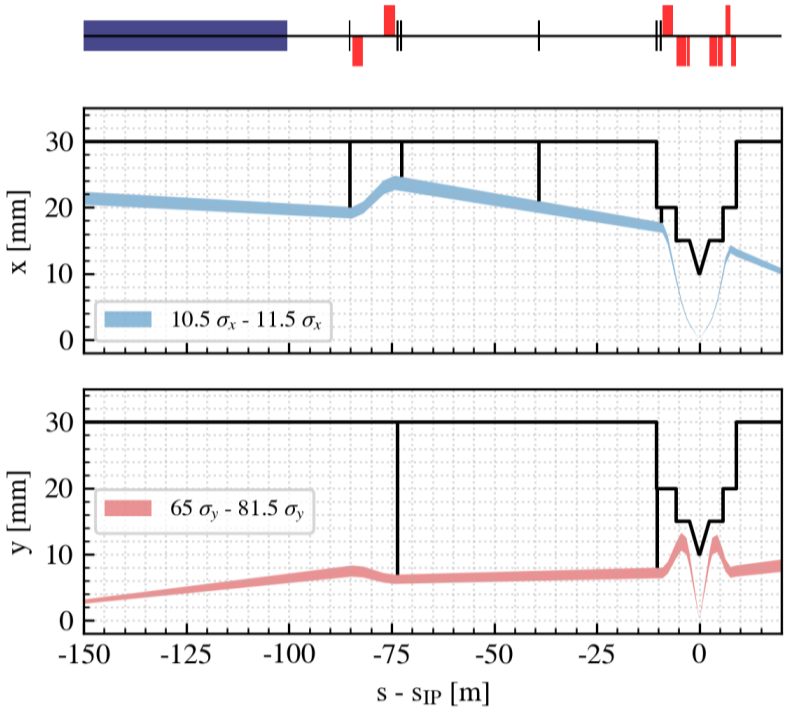
FCC-ee (*Z*) beam halo collimator parameters and settings (V25.4)

Name	Plane	Material	Length [cm]	Gap [σ]	Gap [mm]	δ_{cut} [%]
TCP.H.B1	H	C-based	25	10	6.0	-
TCP.V.B1	V	C-based	25	51.5	1.7	-
TCS.H1.B1	H	Mo-based	30	11.5	6.7	-
TCS.V1.B1	V	Mo-based	30	61.5	2.4	-
TCS.H2.B1	H	Mo-based	30	11.5	7.2	-
TCS.V2.B1	V	Mo-based	30	61.5	3.8	-
TCP.HP.B1	H	C-based	25	18	12.6	1.1
TCS.HP1.B1	H	Mo-based	30	28	11.4	3.5
TCS.HP2.B1	H	Mo-based	30	28	7.8	1.3

GHC collimation: SR collimation

- **Synchrotron radiation collimation**
  - 6 collimators and 2 masks upstream of the IPs
  - Designed to reduce SR-induced detector backgrounds and power loads in the inner beampipe

K. Andre's design

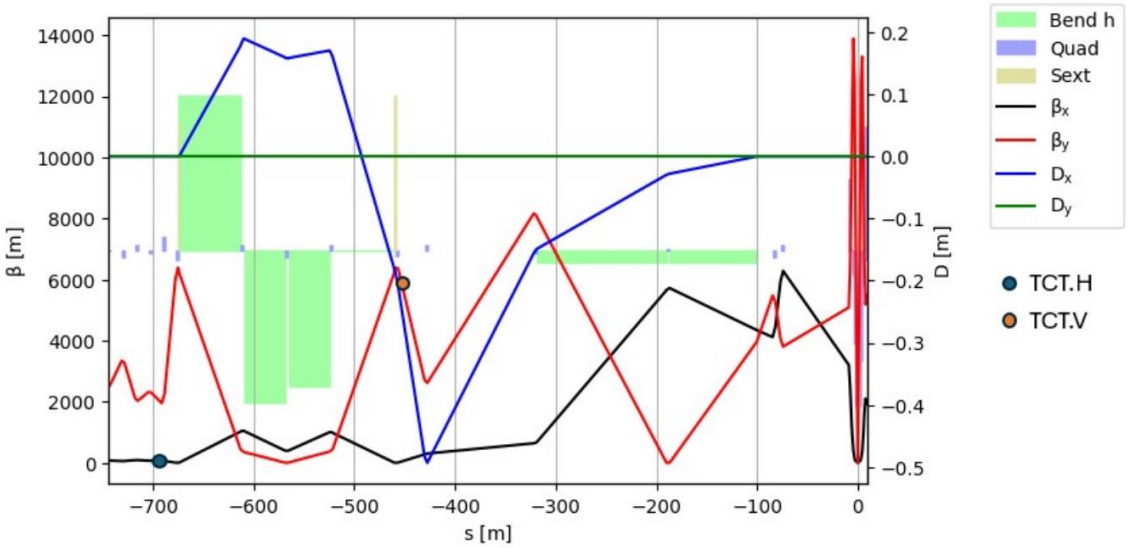


FCC-ee (*Z*) SR collimators parameters and settings (V25.4 GHC)

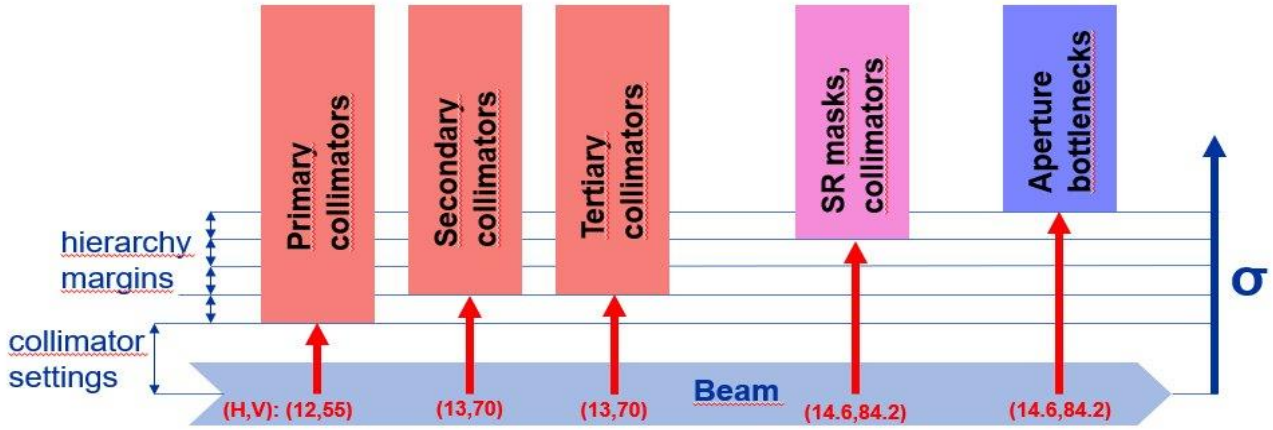
Name	Plane	Material	Length [cm]	Gap [σ]	Gap [mm]
TCR.H.WL.B1	H	W-based	10	12.5	21.8
TCR.V.C0.B1	V	W-based	10	71.5	7.0
TCR.H.C0.B1	H	W-based	10	12.5	26.8
TCR.H2.C0.B1	V	W-based	10	12.5	22.8
TCR.V.C2.B1	V	W-based	10	71.5	8.0
TCR.H.C2.B1	H	W-based	10	12.5	19.3

- SR collimator apertures = estimated aperture bottlenecks

GHC collimation: TCTs for local protection



- TCT.H ~700 m upstream of the IPs (2π phase advance from H-SR-collimators and H-bottleneck)
- TCT.V ~460 m upstream of the IPs (π phase advance from V-SR-collimators and V-bottleneck)



FCC-ee (Z) collimation hierarchy

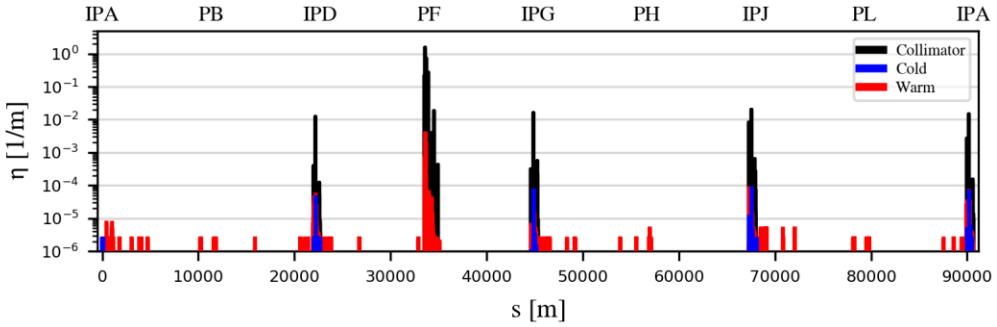
- Hierarchy margins set to 100-300um
  - ~1 $\sigma_{\beta x}$, ~10 $\sigma_{\beta y}$

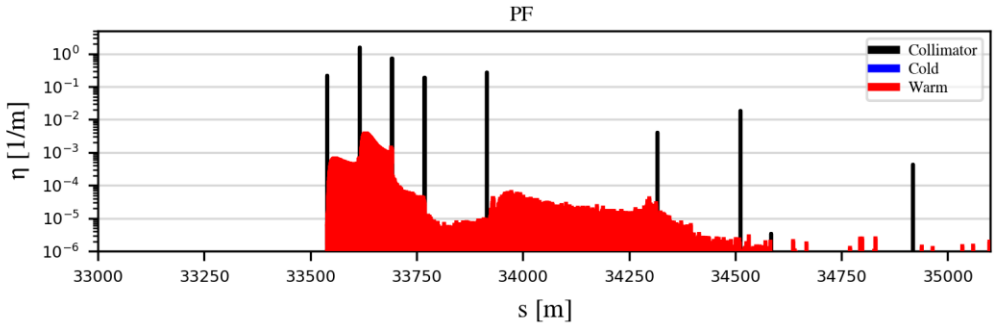
Name	Plane	Material	Length [cm]	Half-gap [σ]	Half-gap [mm]
TCT.H.B1	H	C-based	25	11.5	2.6
TCT.V.B1	V	C-based	25	61.5	7.7

Generic halo losses for the Z mode

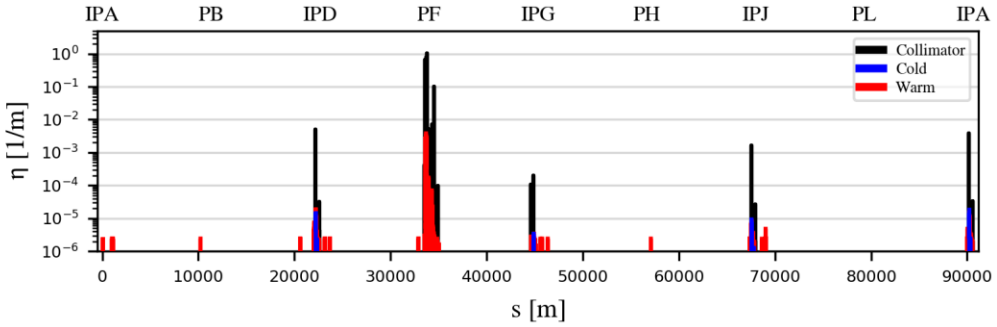
- **Generic halo losses**: pencil beam directly impacting TCP, 1 um impact parameter

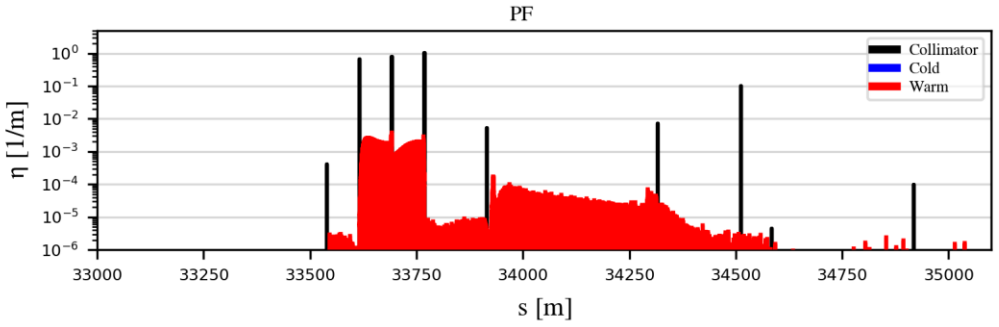
$$\eta = E_{loss,\Delta s} \,/\, (E_{loss,tot}\Delta s)$$





B1H



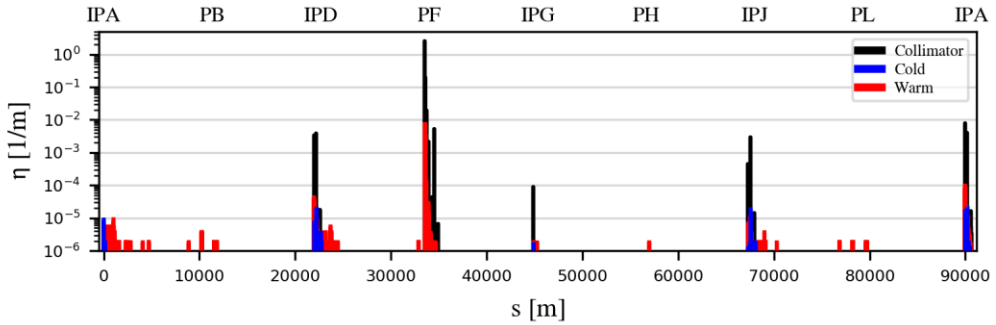


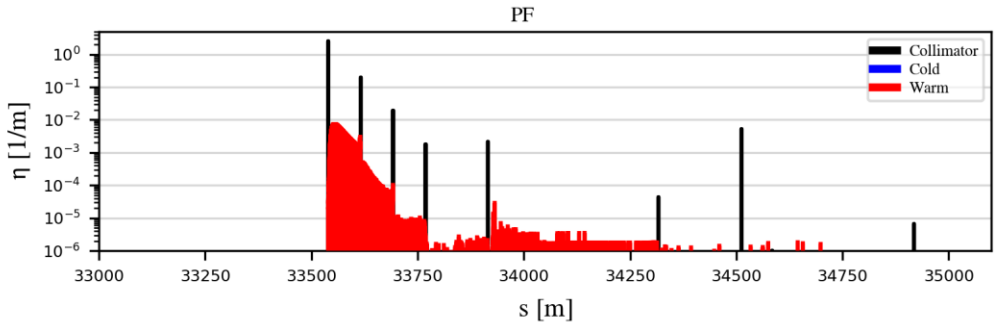
B1V

Slow blowup losses for the Z mode

$\eta = E_{loss,\Delta s} / (E_{loss,tot}\Delta s)$

- **Slow blowup**: distributed horizontal/vertical blow-up over 1500 turns
  - ½ of the beam lost in ~750 turns, ~20% of the beam surviving after 1500 turns
  - First slow blowup simulation on GHC lattice





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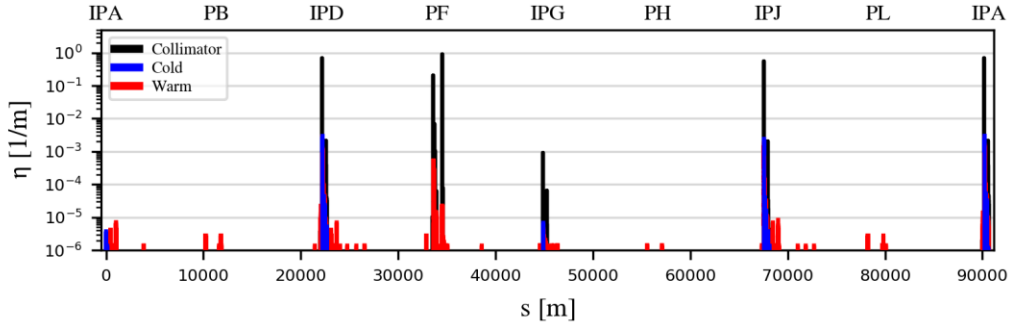
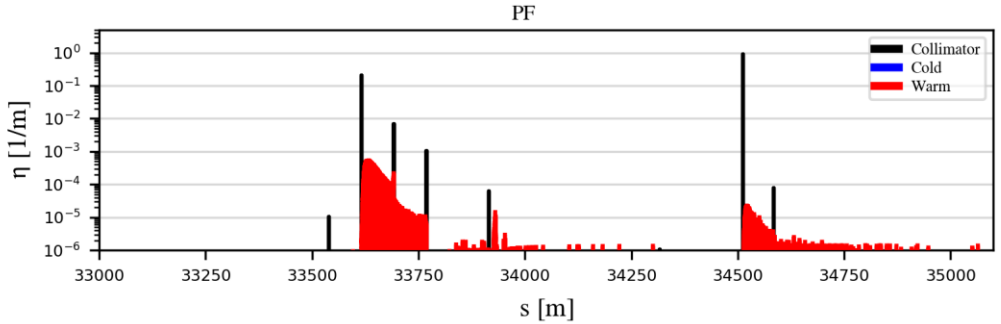


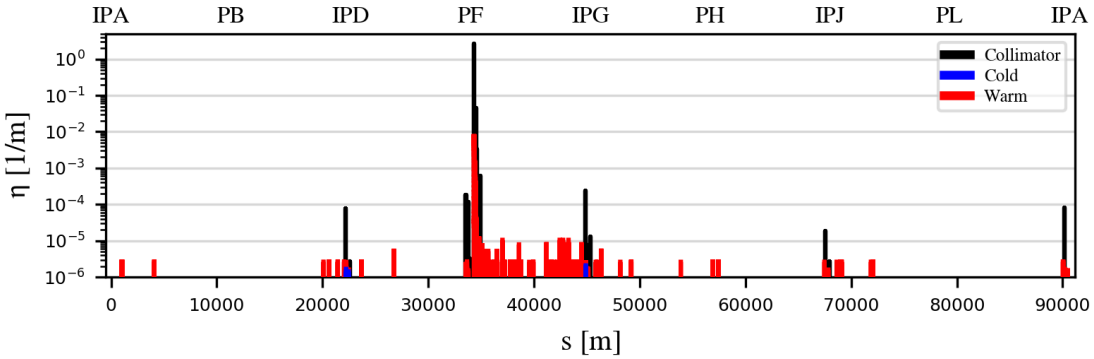


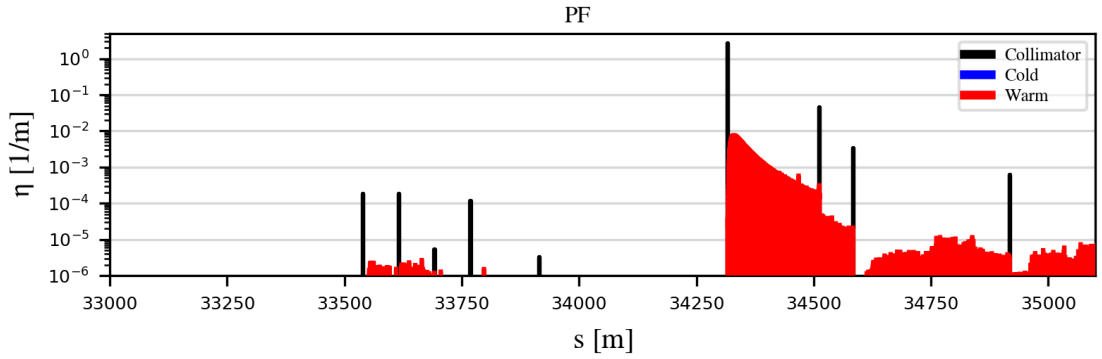
B1V

Off-momentum losses for the Z mode

$$\eta = E_{loss,\Delta s} / (E_{loss,tot}\Delta s)$$

- **Off-momentum losses**
  - Dedicated RF-sweep simulation progressively shifts the bunch central momentum (Δδmax ≈ –2.6%): simulates slow RF failures or other slow off-momentum loss scenarios





Thank you!