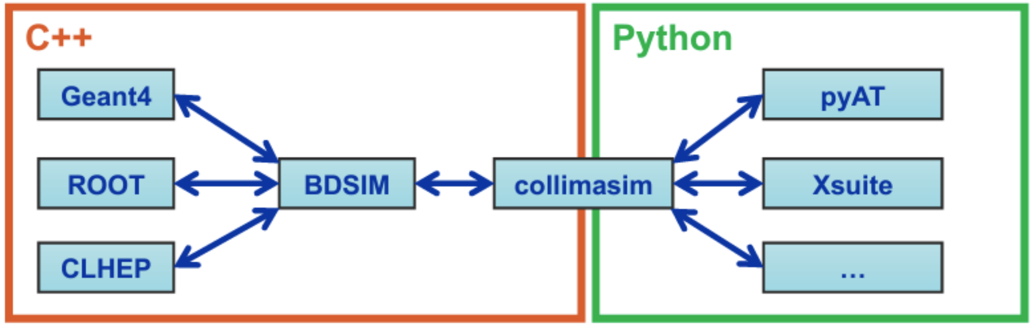
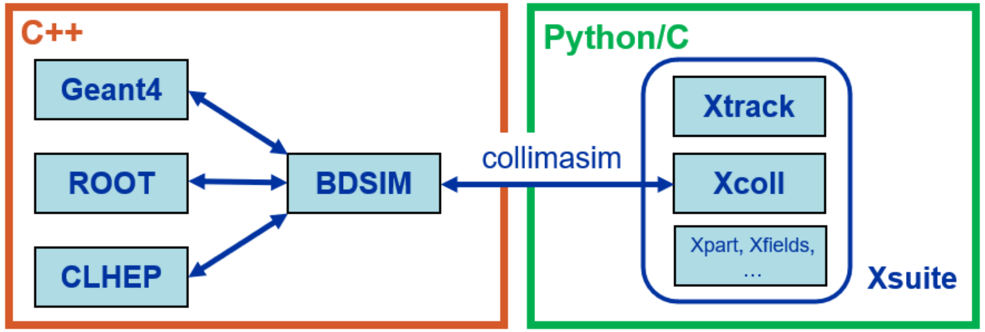
Impacts on BDSIM-Geant4 collimators

- **FCC-ee collimation simulations** are being performed with the **Xsuite-BDSIM coupling** simulation tool
  - First developed by A. Abramov for the FCC collimation simulation needs

- Xsuite-BDSIM now integrated and available with the **Xcoll** package
  - Xcoll is the collimation package belonging to the Xsuite collection of Python packages
  - Xcoll interface to BDSIM-coupling already used in full production for the latest FCC-ee collimation studies

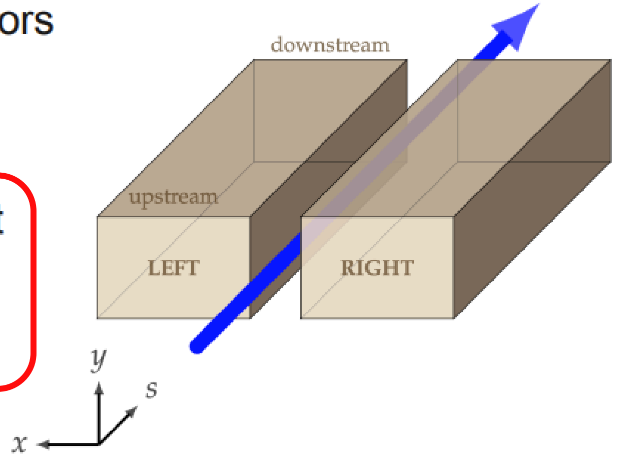


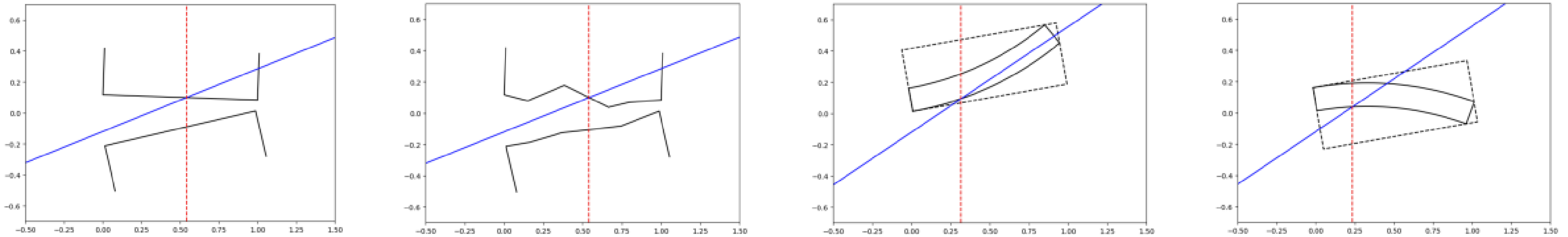


- ➢ Self-written functions (e.g., collimator installation, collimator settings assignment, generation of impacting distribution at the collimators, interpolation of loss location, …) replaced with standardized Xcoll functions
- ➢ Xcoll has a wider community of users
- ➢ Profit of features already available in Xcoll, e.g., **impact records**

Collimator Geometry

- Important emphasis on **geometry** when working with collimators
- Jaw position, angle around the beam axis, tilt around the transverse axis, non-standard jaw structure, ...
- Routines in C to define arbitrary shapes, and calculate impact and exit points
- Full **separation** between geometry and scattering



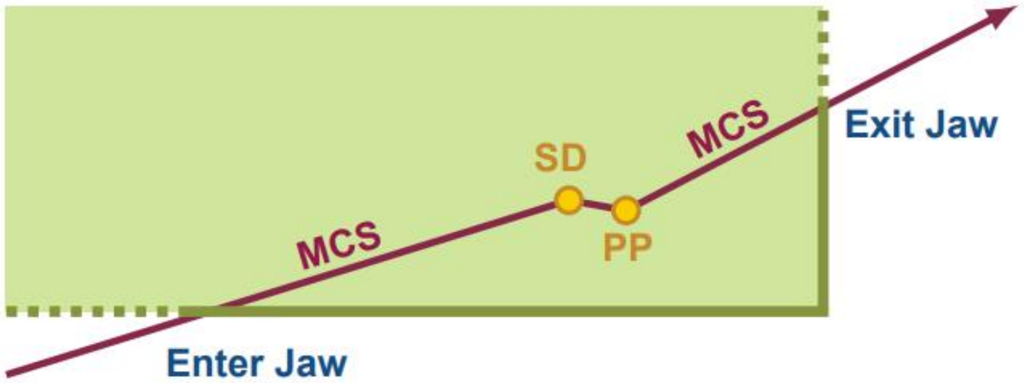


F.F. Van der Veken ICAP'24 *Introducing Xcoll* 11

- F. Van der Veken, Introducing Xcoll: A Streamlined Approach to Collimation and Beam Loss Simulations Using Xsuite, ICAP’24

Impact Table

- Table to log impacts, interactions, and exits
- **Full table** available in Everest
- **Impacts** available in Geant4 coupling
- WIP for a FLUKA table

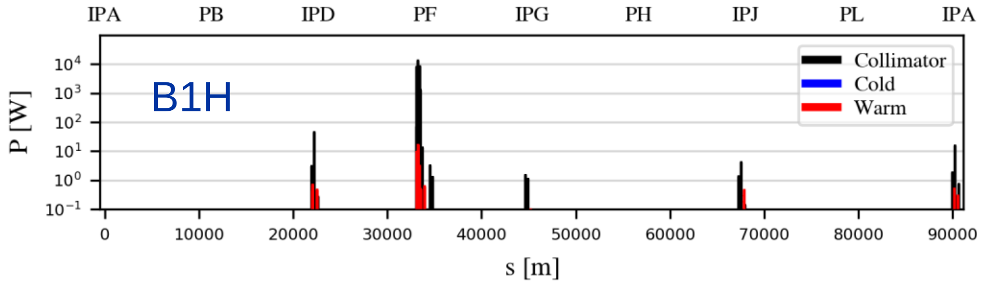


	interaction_type	id_before	s_before	x_before	px_before	id_after	s_after	x_after	px_after
6847	Enter Jaw L	2227	0.538346	0.000000e+00	0.000015	-1	-1.000000	-1.000000e+00	-1.000000
6848	Multiple Coulomb Scattering	2227	0.538346	0.000000e+00	0.000015	2227	0.574394	5.094311e-07	0.000013
6849	Single Diffractive	2227	0.574394	5.094311e-07	0.000013	2227	0.574394	5.094311e-07	-0.000007
6850	Multiple Coulomb Scattering	2227	0.574394	5.094311e-07	-0.000007	2227	0.580198	4.678767e-07	-0.000007
6851	PP Elastic	2227	0.580198	4.678767e-07	-0.000007	2227	0.580198	4.678767e-07	0.000024
6852	Multiple Coulomb Scattering	2227	0.580198	4.678767e-07	0.000024	2227	0.600000	9.381799e-07	0.000024
6853	Exit Jaw	2227	0.600000	9.381799e-07	0.000024	-1	-1.000000	-1.000000e+00	-1.000000

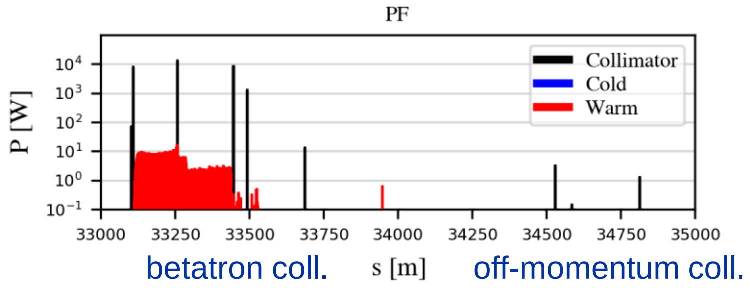
- F. Van der Veken, Introducing Xcoll: A Streamlined Approach to Collimation and Beam Loss Simulations Using Xsuite, ICAP'24

- **First FCC-ee impact tables produced for different beam loss scenarios**
  - Horizontal betatron losses of the positron beam (B1H) → provided to the FLUKA team (S. Marin, A. Lechner)

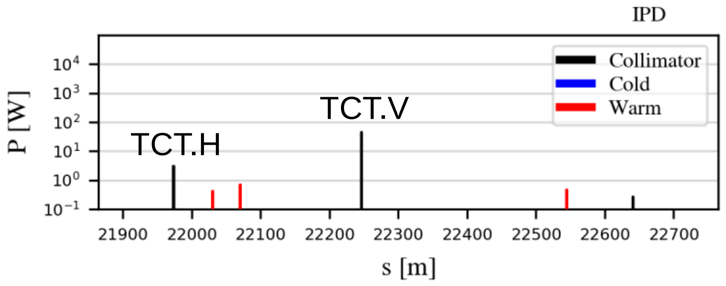
full 90 km ring



collimation insertion



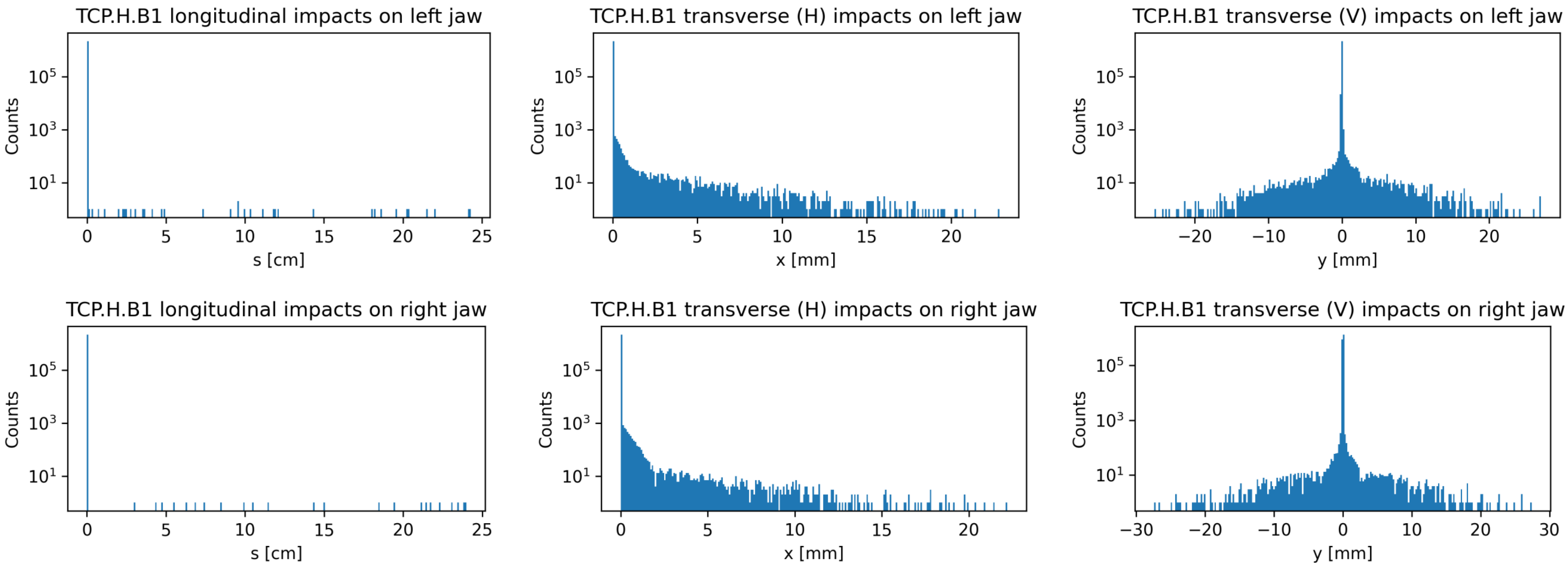
most exposed IP



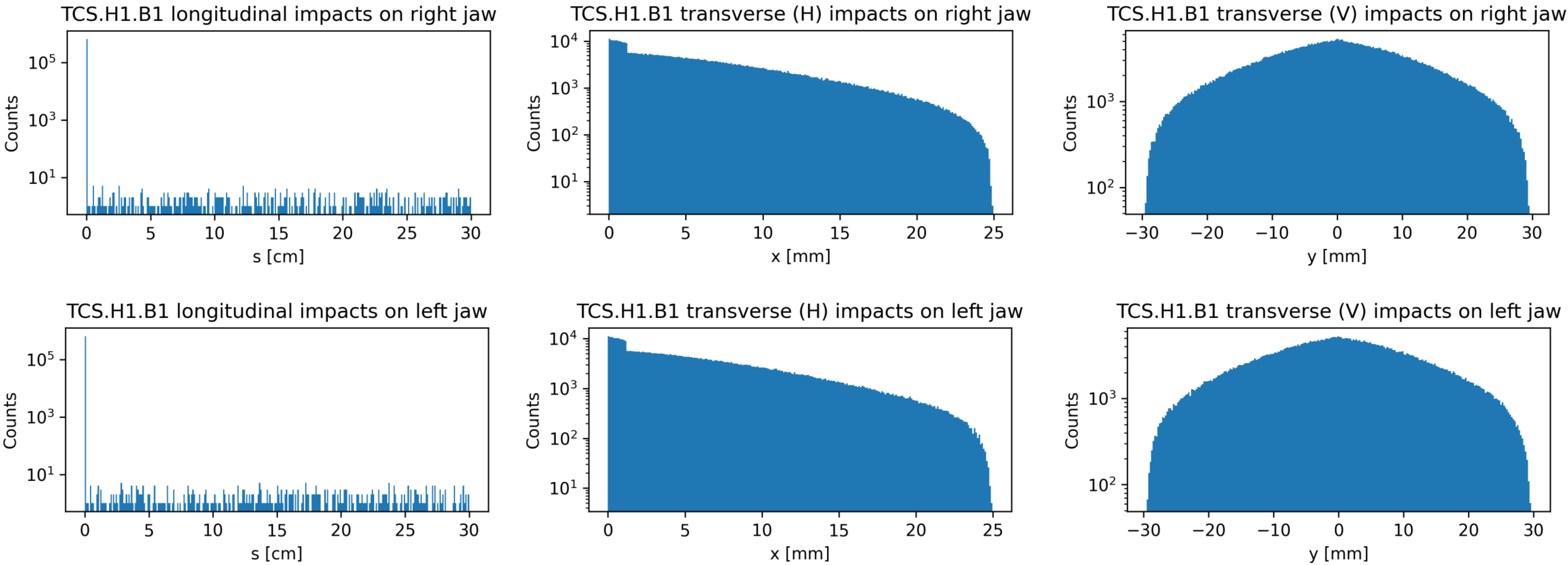
  - Vertical betatron losses of the positron beam (B1V)
  - Beam-gas (bremsstrahlung) losses of the positron beam

  - Spent beam losses for the positron beam
    - ➢ Likely not realistic impacts due to large vertical emittance blow-up – detailed checks ongoing

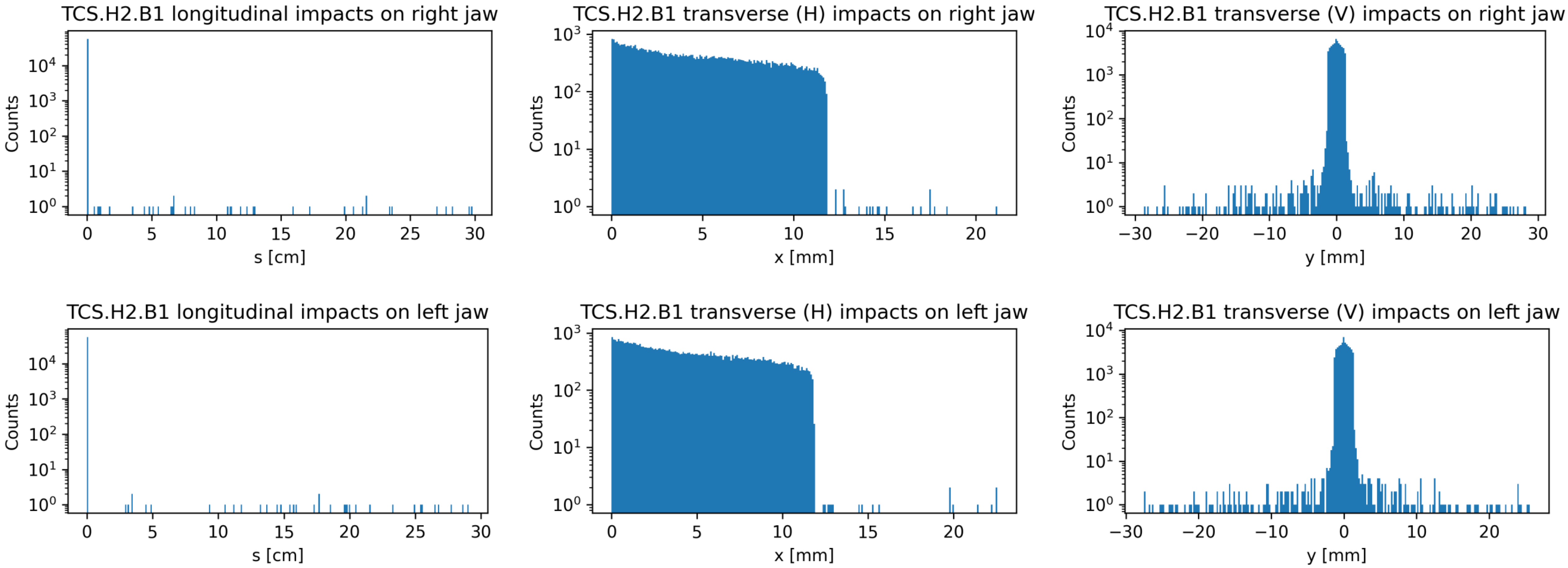
- Horizontal betatron losses of the positron beam (B1H) : horizontal primary collimator **TCP.H.B1**



- Horizontal betatron losses of the positron beam (B1H) : horizontal secondary collimator **TCS.H1.B1**



- Horizontal betatron losses of the positron beam (B1H) : horizontal secondary collimator **TCS.H2.B1**



Update on vertical beam size blow-up with beam-beam and collimation insertion optics

FCC-ee *Z* spent beam losses: results

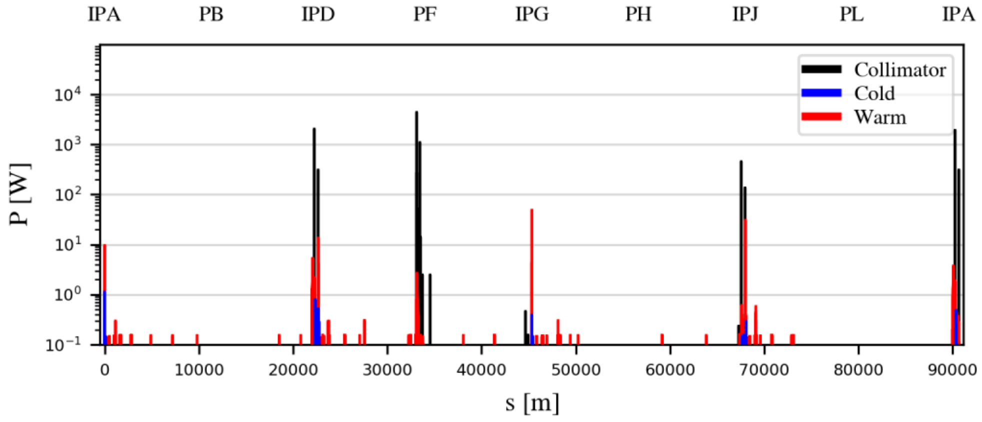
Lifetime for the *Z* mode [32]

Lifetime (q + BS + lattice)	[sec]	10000
Lifetime (lum)[b]	[sec]	1330

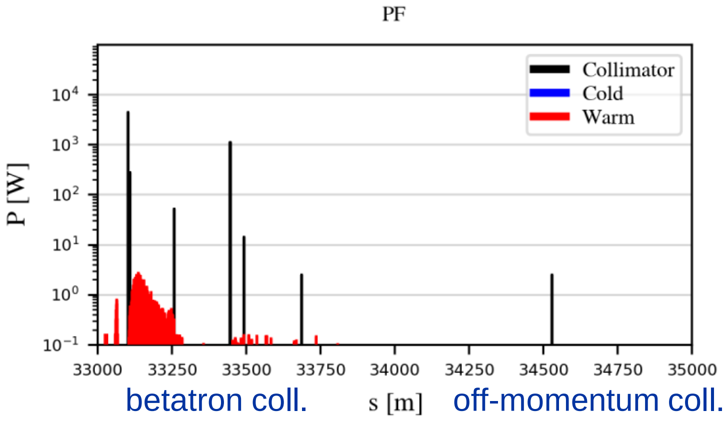
- The loss maps are scaled to the **combined nominal beam lifetime** from lattice, SR, beamstrahlung and luminosity

$$\tau = \left(\frac{1}{\tau_{q+BS+lattice}} + \frac{1}{\tau_{lum}}\right)^{-1} \cong 1174\ s$$

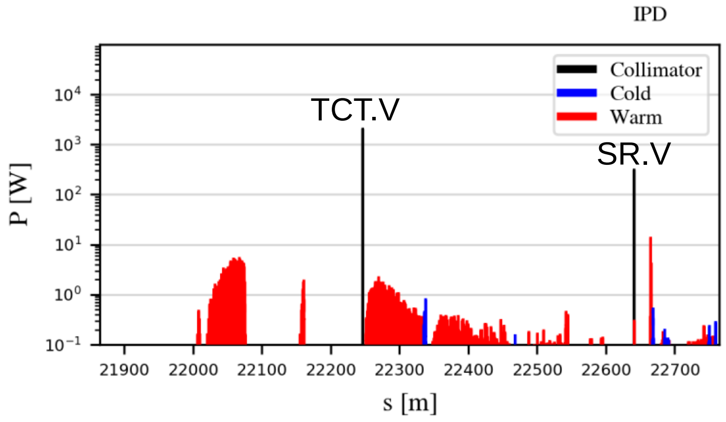
full 90 km ring



collimation insertion



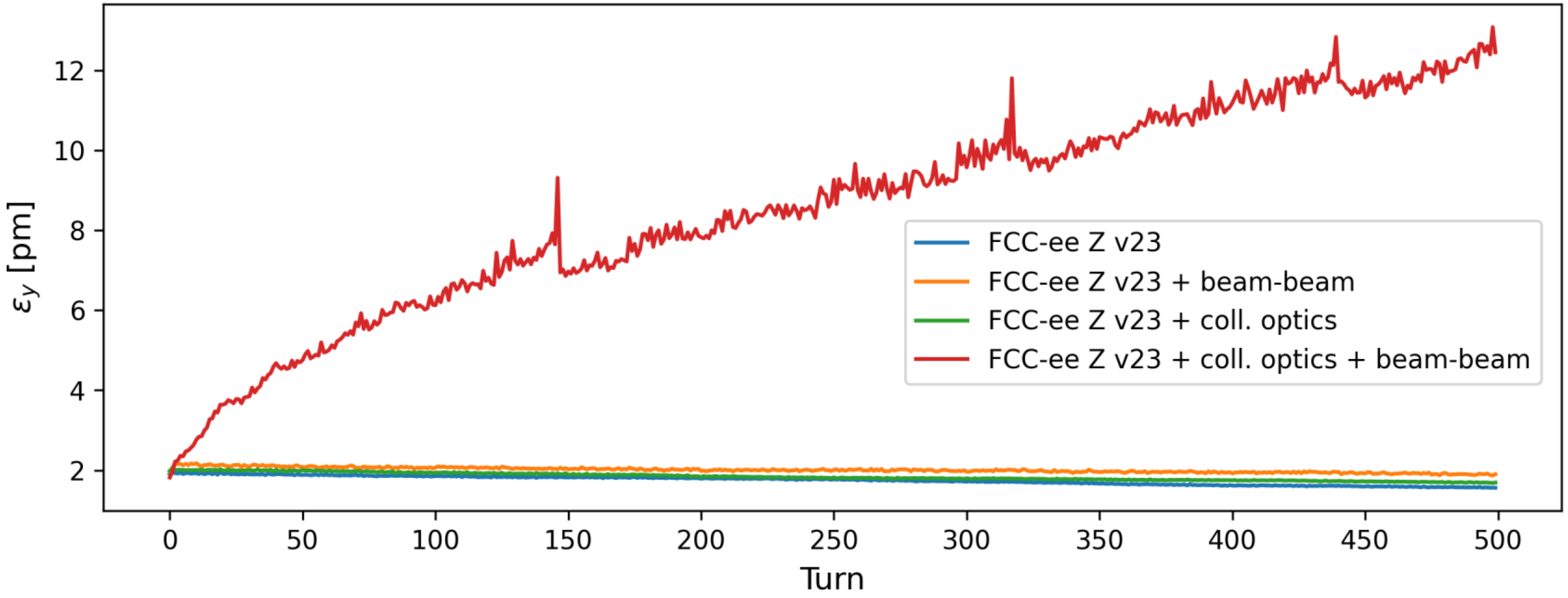
most exposed IP



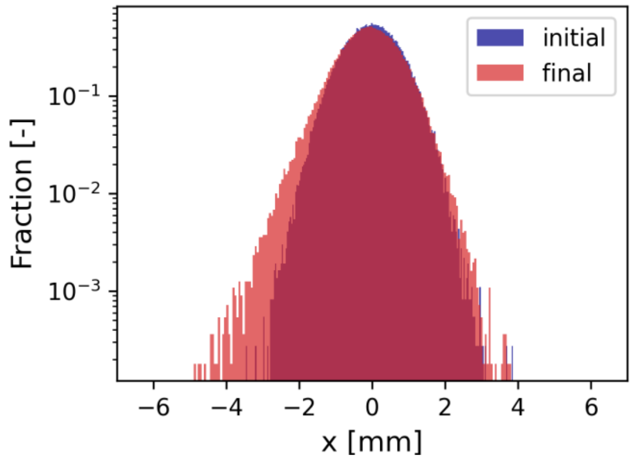
- Losses intercepted by betatron collimators in PF (43%)
- Large losses on the TCT.V and SR.V collimators in IPD, IPA and IPJ with minimal losses in IPG
  - Up to 2.1 kW on a vertical TCT and 300 W on a vertical SR collimator
  - Likely single-pass losses that cannot be intercepted by the halo collimation system in PF
    - Physics debris collimators (like in the CERN LHC) might be an option

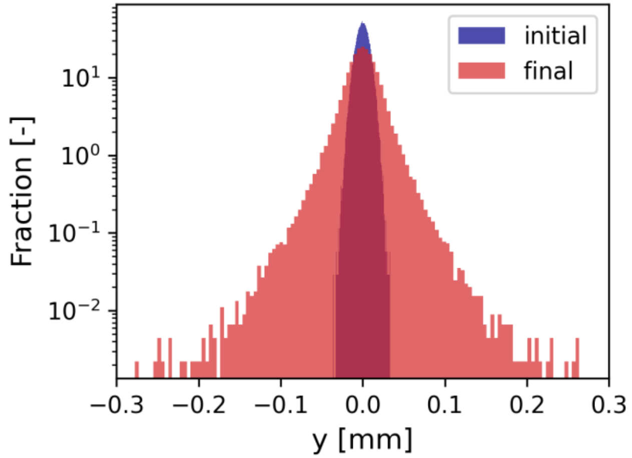
FCC-ee *Z*-mode spent beam losses: results

- High losses observed in the V plane
  - ➢ Driven by a vertical emittance blow-up due to an interplay between the collimation insertion optics and beam-beam interactions



Transverse distribution after 500 turns





- Inclusion of collimation insertion optics breaks the super-periodicity of the lattice
  - ➢ New resonance lines appear
- Because of beam-beam interactions a larger region of tune space is probed
- Avoiding such new resonances might become an additional design constraint for collimation optics