

Effect of emittance blow-up on beam loss at collimators in the KLS storage ring

^{1,2}JunHa Kim, ²Jaehyun Kim*, ³G.S Jang, ²J.Seok, ²Kimoon Nam, ⁴M. Chung**

¹UNIST, Department of Physics

²PAL, Department of PLS-II Accelerator

³PAL, Department of EUV

⁴POSTECH, Department of Physics and Division of Advanced Nuclear Engineering

Abstract

Collimators in electron storage rings intercept lost electrons at designated locations to protect accelerator components, including vacuum chambers and insertion devices, and to control radiation and activation caused by beam losses. Particularly in low-emittance electron storage rings, RF beam dumps can concentrate particle losses on a small number of collimators, potentially causing damage through localized energy deposition. An effective dump strategy must therefore capture the lost particles while limiting excessive loss concentration at individual collimators.

This study investigates beam loss redistribution through emittance excitation before RF dumps in the Korea Light Source (KLS) storage ring. A horizontal kicker is used to increase the beam emittance before RF shutdown. Particle tracking simulations compare loss distributions for different kicker strengths against a reference case without horizontal excitation. We compare the number of lost particles, their loss turns, and their transverse phase-space distributions at each collimator for different kicker strengths. The results show that increasing the kicker strength makes the loss distribution more uniform among collimators. This suggests that emittance blow-up can reduce beam loss concentration during RF dumps.

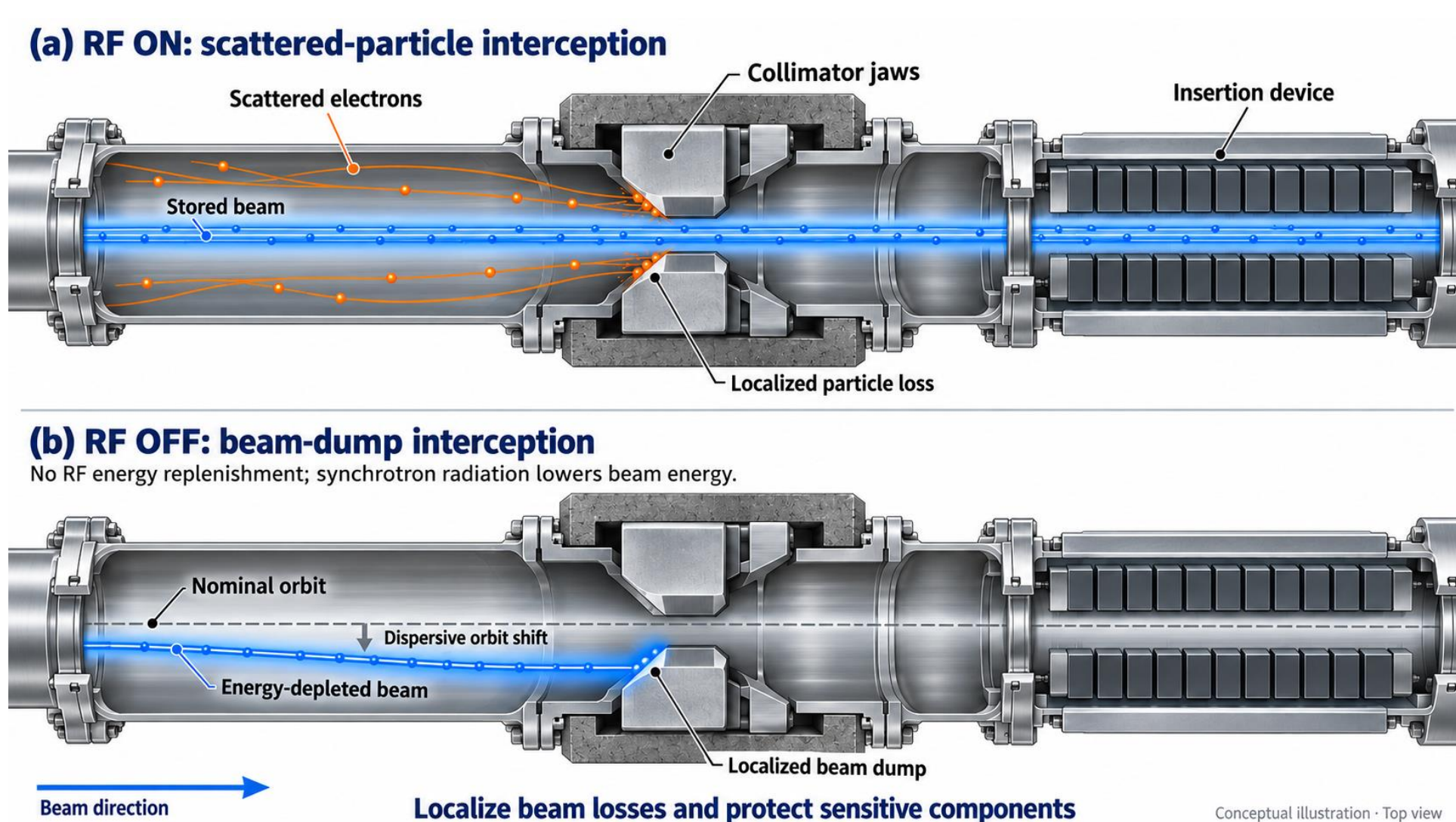
Role of Collimators

a) Normal operation :

- Collimators intercept scattered electrons.
- Protect accelerator components from the beam losses and radiation showers.

b) RF OFF:

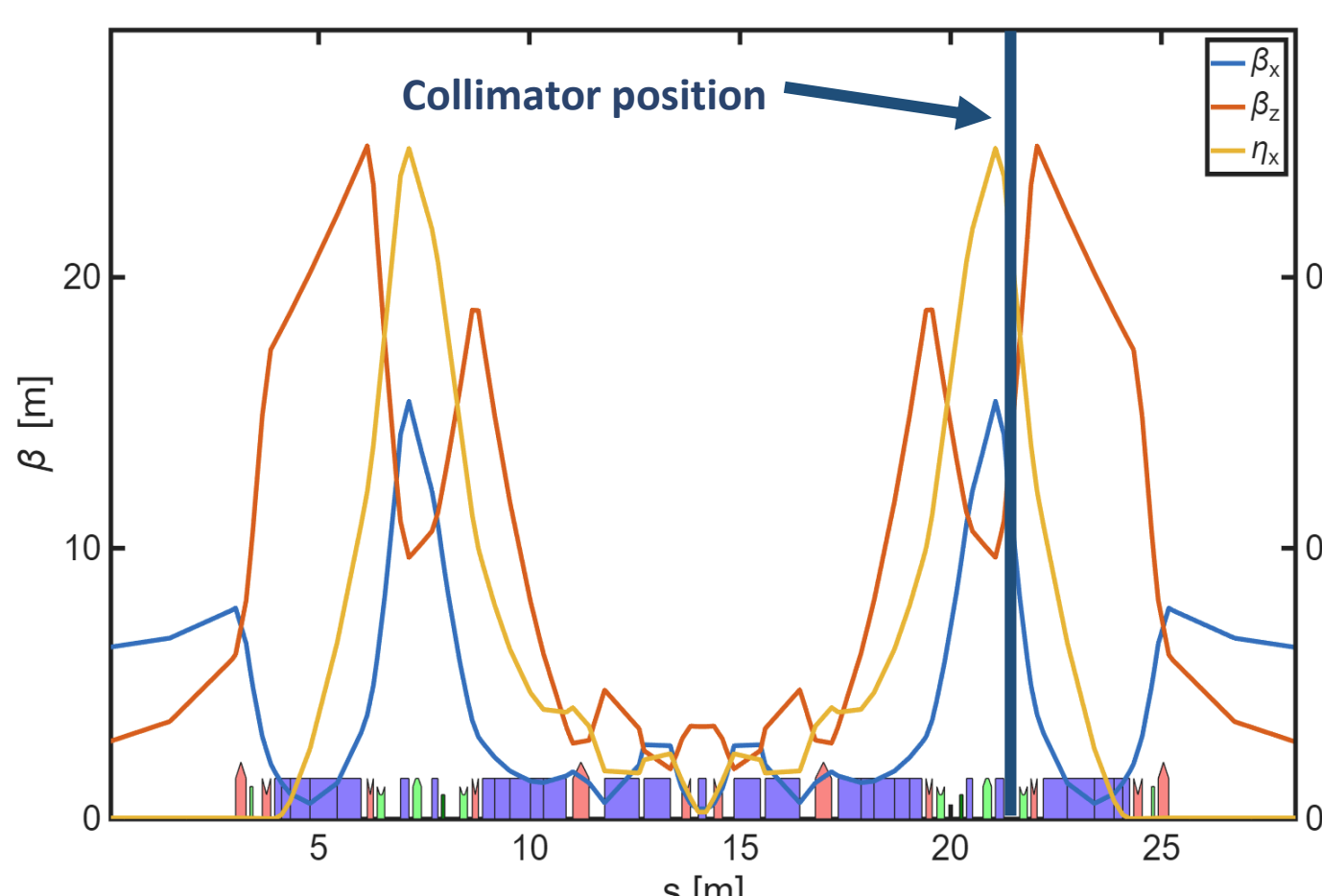
- Collimators intercept the energy-depleted beam.
- Localize beam losses for safe beam dumping.



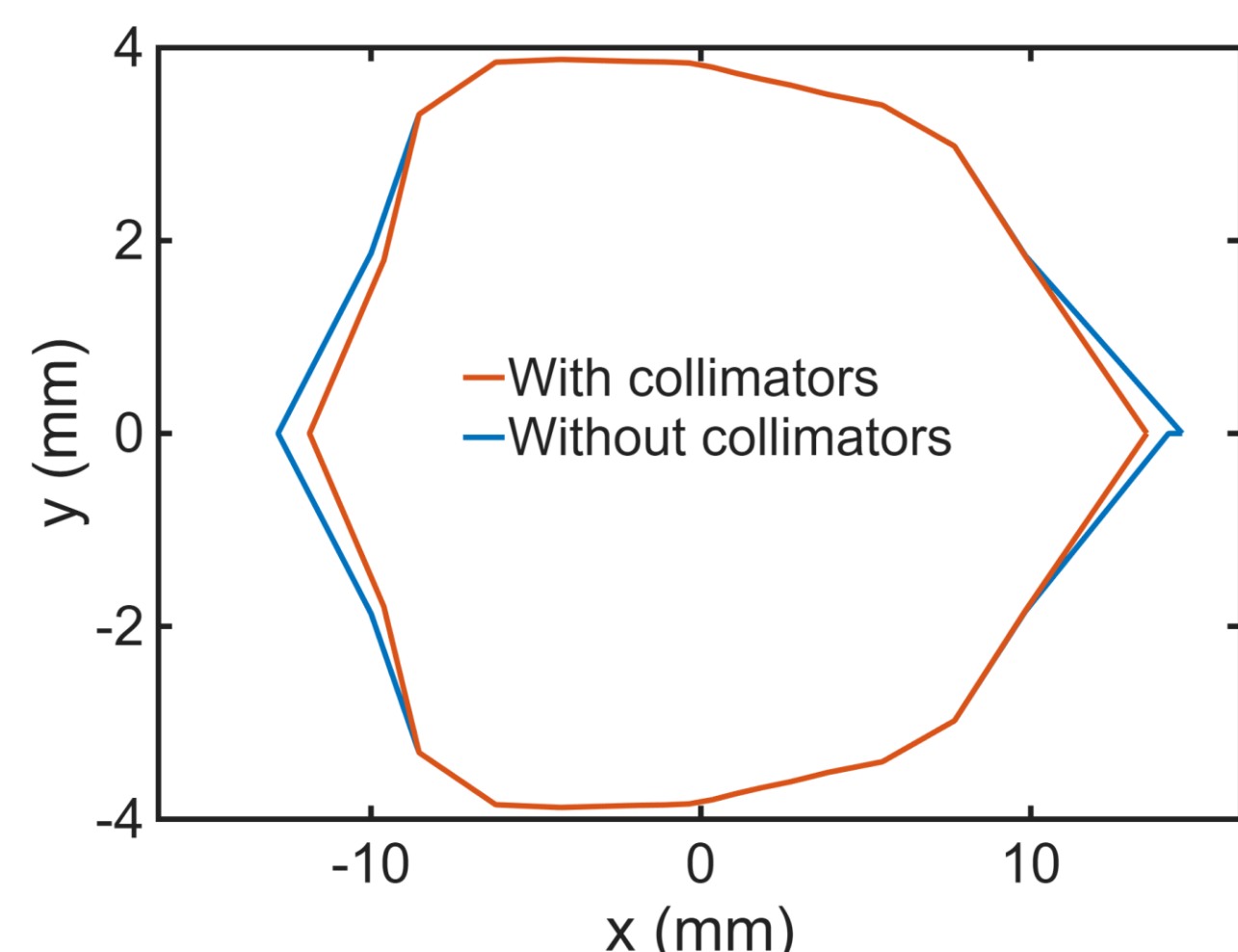
Role of collimators in a storage ring

Collimators in the KLS storage ring

- The KLS storage ring has 28 collimators, with one installed at the downstream dispersion bump in each unit cell.

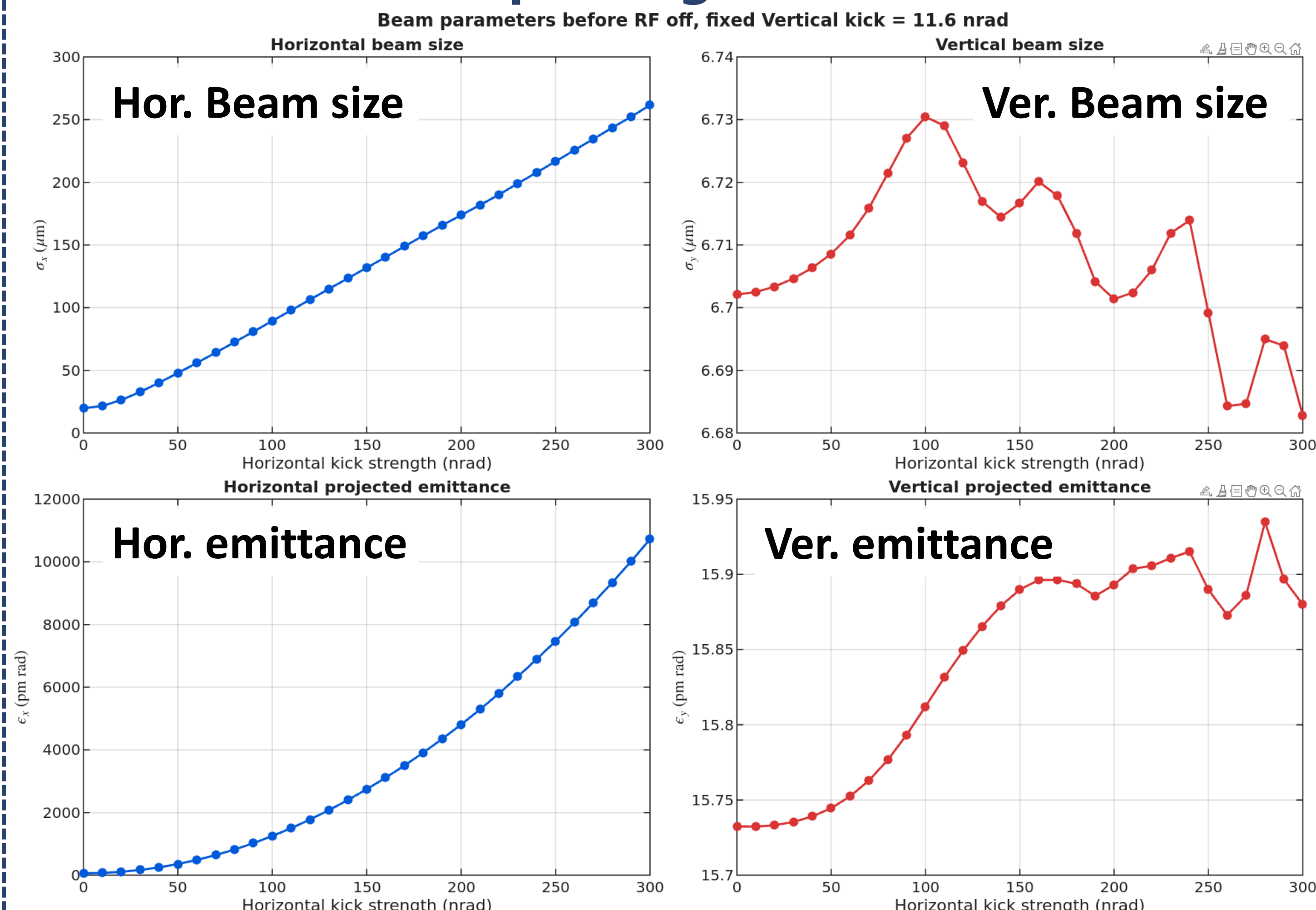


Unit cell of the KLS storage ring



DA comparison with/without collimators

Emittance blow-up using the PPRE method



Simulation setup

- 10,000 particles were tracked for 10,000 turns using a one-turn map
- The bunch was excited using zero-length kicker with sinusoidal kick angle

$$\theta_h = A_h \cos(2\pi f_{ext1} t)$$

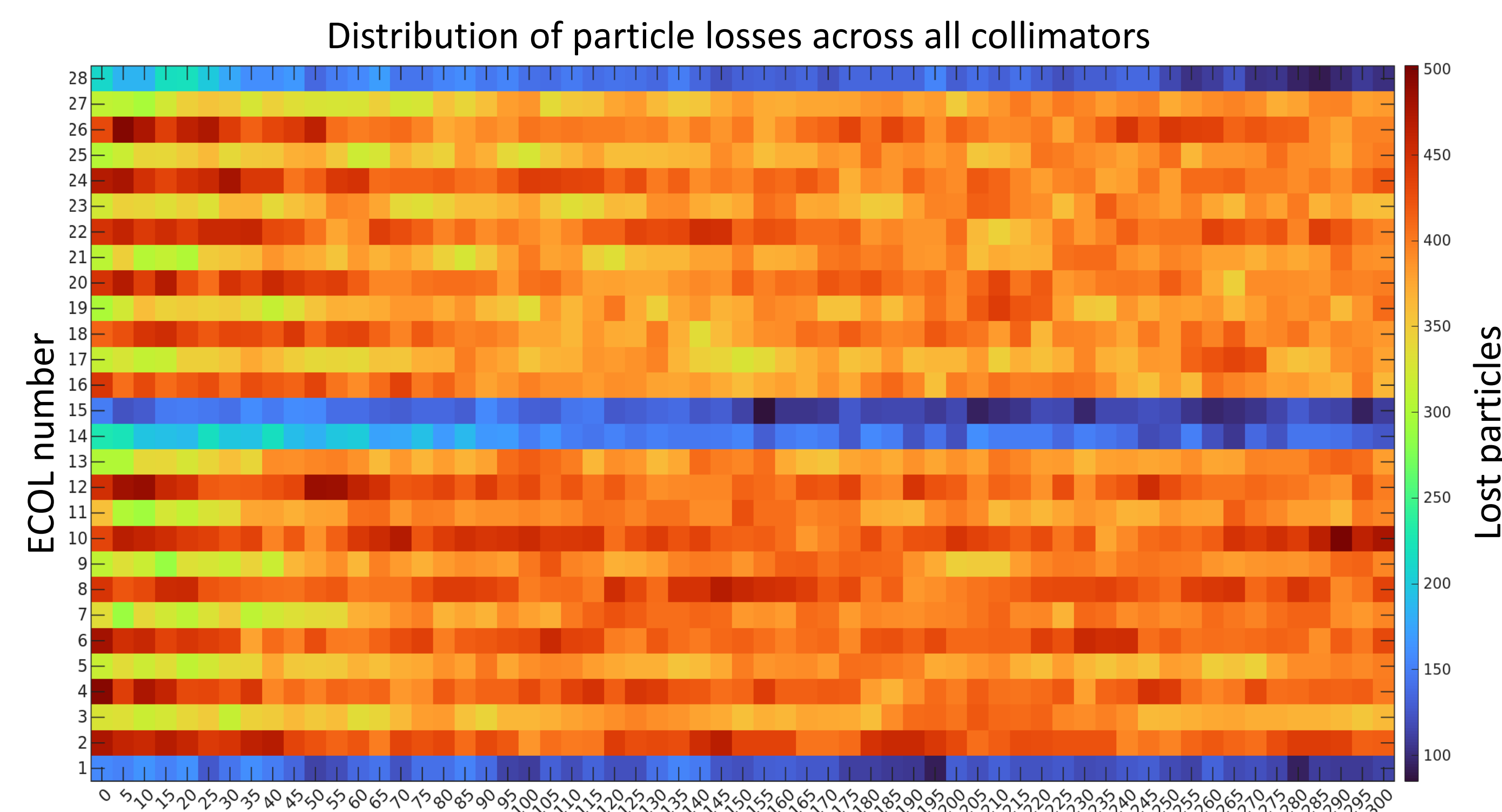
$$\theta_v = A_v \cos(2\pi f_{ext2} t)$$

- A_h : 0 ~ 300 nrad, A_v : 11.6 nrad

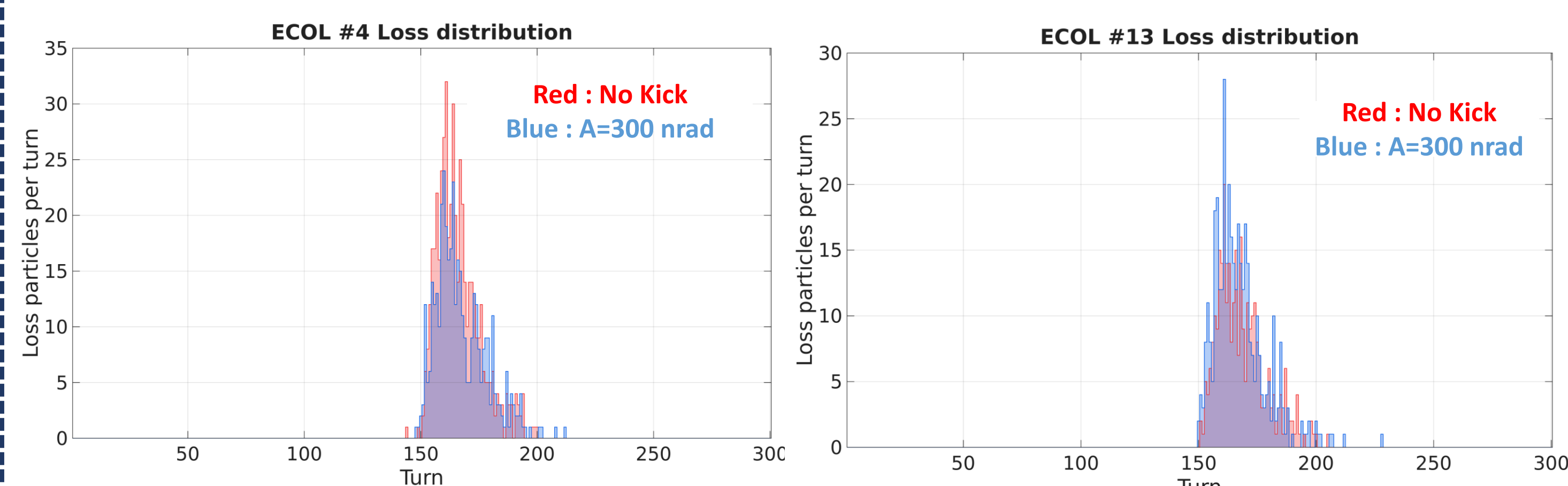
- f_1 : 67.19 kHz ($f_h + f_s$), f_2 : 98.7 kHz ($f_v + f_s$)

- The third-harmonic cavity (3HC) was included in the lattice model

Beam loss simulation with RF off

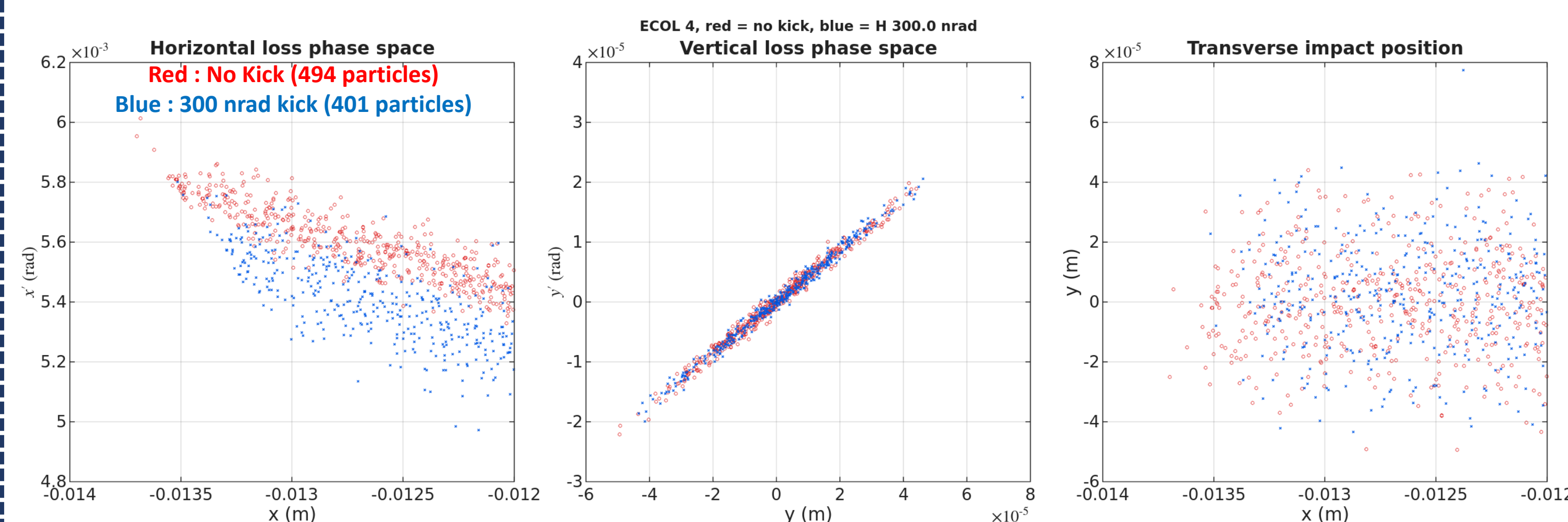


Horizontal Kick amplitude (nrad)



- At low horizontal kicker strengths, particle losses were concentrated at specific collimators (e.g., ECOLs 2, 4, 6, 8 ...)
- As the horizontal kicker strength increased, the loss distribution across the collimators became flatter and more uniform.
- ECOLs 14, 15, 28, and 1 are located downstream of the high-beta straight sections.

Distributions of lost particles at collimators



Phase-space and spatial distributions of lost particles at collimator 4

- Horizontal emittance blow-up before RF shutdown changes the (x') distribution of lost particles, while their (x) distributions remain similar.
- The change in impact angles may reduce peak energy deposition density and the risk of collimator damage during RF dumps.

Conclusion

- Horizontal emittance blow-up before RF shutdown redistributes particle losses and reduces loss concentration at the initially dominant collimators.
- At collimators, the horizontal impact-position distributions remain similar, while the x' distribution changes.
- Emittance blow-up may reduce collimator damage during RF dumps.

References

- [1] H.Ghasem, J.Kallestrup, I.P.S. Martin, Performance of the DIAMOND-II storage ring collimators, in Proceedings of the 13th International Particle Accelerator Conference, IPAC-2022, Bangkok, Thailand
- [2] M.A. Jebramick *et al.*, "Collimation Strategy for the Low-Emitance PETRA IV Storage Ring", in *Proc. IPAC'22*, Bangkok, Thailand, Jun. 2022, pp. 1445-1448. doi:10.18429/JACoW-IPAC2022-TUPOM5019
- [3] H. Ghasem *et al.*, "Collimator study for the Diamond-II storage ring", in *Proc. IPAC'24*, Nashville, TN, May 2024, pp. 1250-1253. doi:10.18429/JACoW-IPAC2024-TUPG19