STATUS OF FCC-EE COLLIMATION SYSTEM

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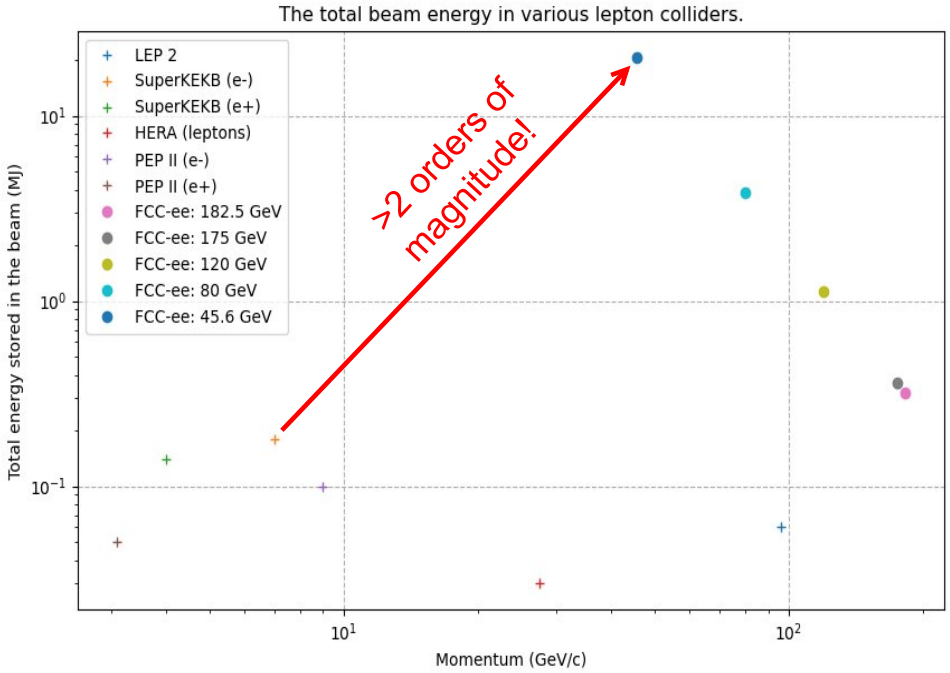
Outline

- Reminder: Motivation for FCC-ee collimation system
- Present system design
  - Layout, optics, settings, materials
- Beam loss scenarios
- System performance

Reminder: why do we need a collimation system in FCC-ee

- Up to 17.8 MJ stored beam energy in the FCC-ee
  - at Z-mode, 45.6 GeV
  - Comparable to LHC with ions!
- Beam losses can damage impacted elements
  - Damage to collimators observed at SuperKEKB, with factor ~100 less stored energy
- Collimation system needed to protect the machine, not only to control backgrounds
  - New regime compared to previous lepton colliders



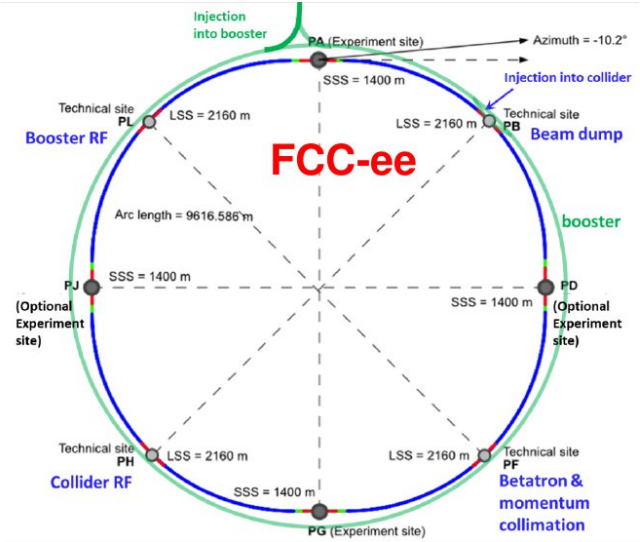
Collimation system design criteria

- Design criteria
  - Collimation system should be the aperture bottleneck of the ring intercepting primary losses
  - Total impedance of the collimators should stay within the allowed impedance budget
  - Collimation should
    - Suppress experimental backgrounds to tolerable levels
    - Suppress losses sufficiently so that any leakage out of the collimation system does not damage impacted machine components or quench superconducting elements for given “design beam losses“, nor should the collimators themselves be damaged

Collimation system layout

- **Several iterations on system design. Present version:**
  - PF dedicated to collimation, housing combined betatron and momentum cleaning
  - 2-stage system for H, V, off-momentum
    - 1 primary + 2 secondaries per case
  - Materials: MoGr primaries, Mo secondaries as tentative working assumption. Performance to be studied for other materials as parameters become available
  - In addition, set of dedicated synchrotron radiation collimators upstream of the IPs

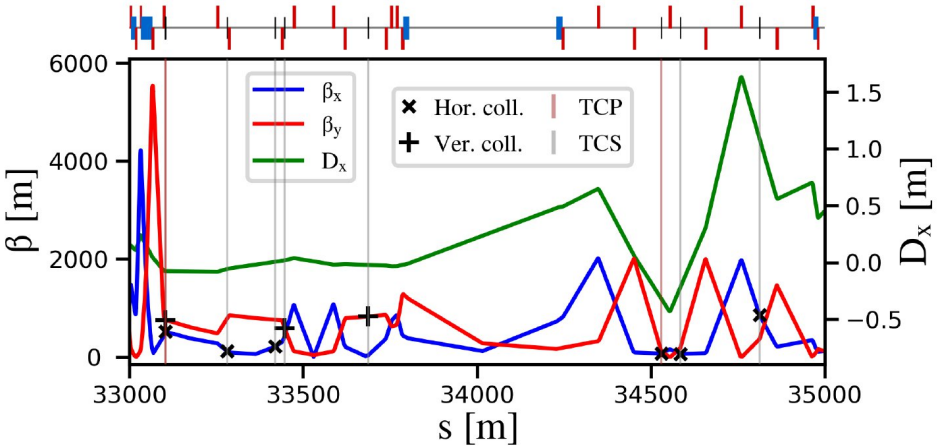
estimated aperture: 14.6 sig (H), 82 sig (V)



Type (#)	Plane	Material	Length [m]	Half-gap [σ (mm)]	δ_{cut} [%]
β prim. (1)	H	MoGr	0.25	11.0 (6.7)	8.9
β sec. (2)	H	Mo	0.3	13.0 (3.8, 5.1)	6.7, 90.6
β prim. (1)	V	MoGr	0.25	65.0 (2.4)	–
β sec. (2)	V	Mo	0.3	75.0 (2.5, 2.9)	–
δ prim. (1)	H	MoGr	0.25	18.5 (4.2)	1.3
δ sec. (2)	H	Mo	0.3	21.5 (4.6, 16.7)	2.1, 1.6

Collimation optics in PF

- Optimal phase advances primary-secondary, maximizing range of interception of scattering angles
- Presently implemented in “standard” optics, not yet in Pantaleo’s
- Collimation optics lives only in a development branch – should be integrated in main optics repository
- Some observations of degraded DA with collimation optics in place – to be investigated further to see if further optics changes are needed

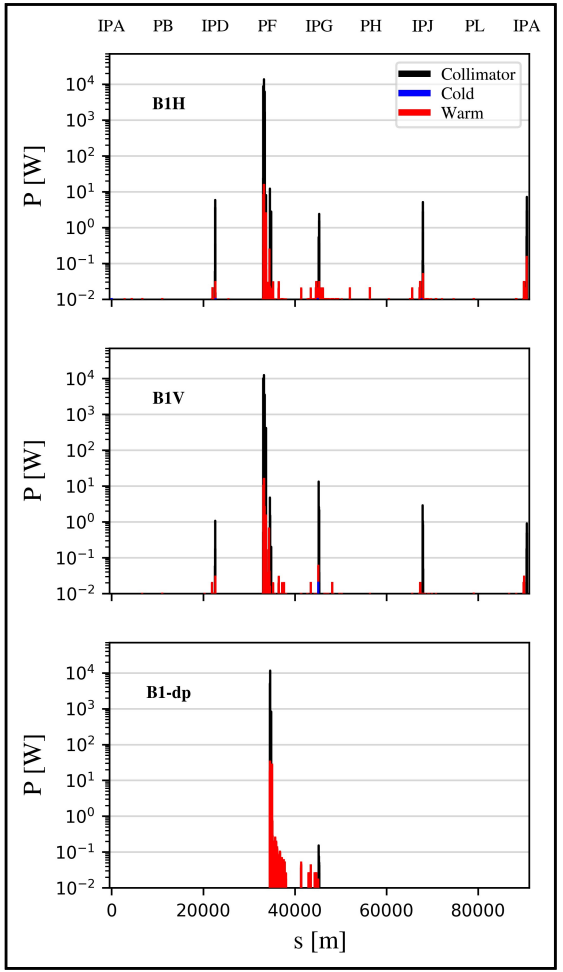


Collimation performance

- **Implemented simulation tool** combining multi-turn tracking of leptons (XSuite), particle-matter interactions (BDSIM), radiation damping, quantum excitation
  - Under development: beam-beam, beam-gas source term, Touschek source term, use of FLUKA as scattering engine

- For 1um impact parameter (generic direct halo, 5min lifetime, Z-mode), **achieve loss suppression of factor 10^3 on SR collimators, ~10^5 on other elements**
  - Need to study various machine tolerances to fully conclude on if performance is sufficient

- Note: impact parameter scan typically gives worse cleaning the smaller the impact parameter
  - Need to quantify realistic impact parameters – underway together with modelling of beam loss processes



Beam loss scenarios

- **Unavoidable sources of beam losses in regular operation**
  - Spent beam from collisions (beamstrahlung, Bhabha scattering) — work in progress
  - Beam-gas interactions
  - Losses during top-up injection
    - Looking at global leakage, not local protection at injection points
  - Scattering on thermal photons
  - Touschek scattering (probably less important)

  — not started

- **Irregular or accidental losses**
  - Generic 5-minute beam lifetime, could be caused by a number of processes — done
  - Injection failure
  - Extraction failure

    — Looking at global leakage, not local protection at injection points

  - Other failures: power supplies, RF, instabilities...
  - (“crazy beam“ a la SuperKEKB, 80% lost in 2-3 turns – not fully understood/modelled, presently not designing to sustain this)

  — not started - need inputs

- **Anything else?**