LAYOUT AND OPTICS FOR A COLLIMATION SECTION IN FCC-EE

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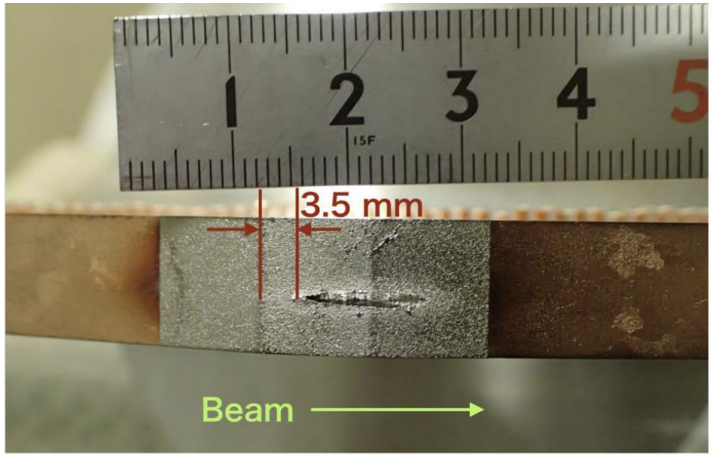
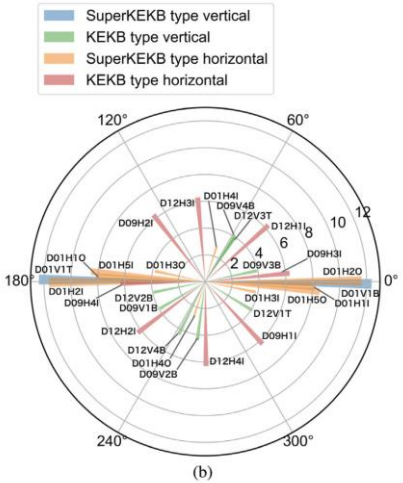
Motivation

- FCC-ee will push boundaries in many aspects, among which beam energy and stored energy
- Collimation system to protect sensitive hardware and suppress background in experiment
  - Optics is one of the key ingredients in collimation performance
- Process for optics design and outline of this presentation:
  - Review the systems in other machines
    - Decide on implementation in FCC-ee
      - Optics integration respecting constraints
        - Collimator settings and placement

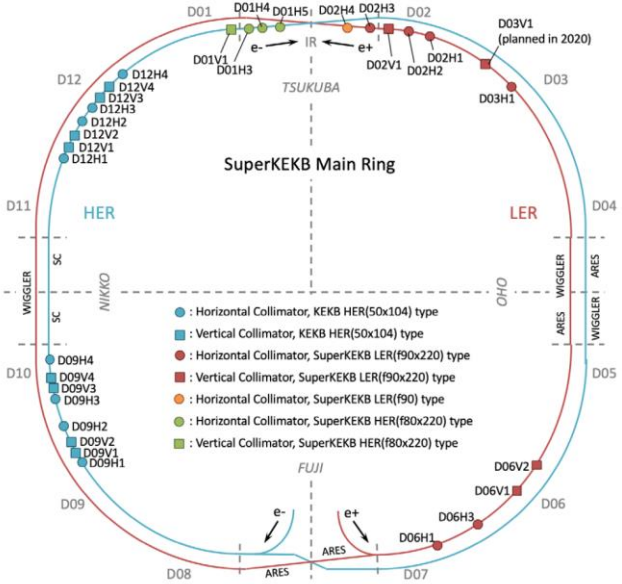
Collimation in other (circular) lepton collider

- Dedicated presentation on Thu, 12:10 CET
- In SKEKB, collimation system in the arcs
  - Phasing between single sided collimator and to final focus quadrupole
  - Damage potential





Phase advance to final focus quadrupole in HER

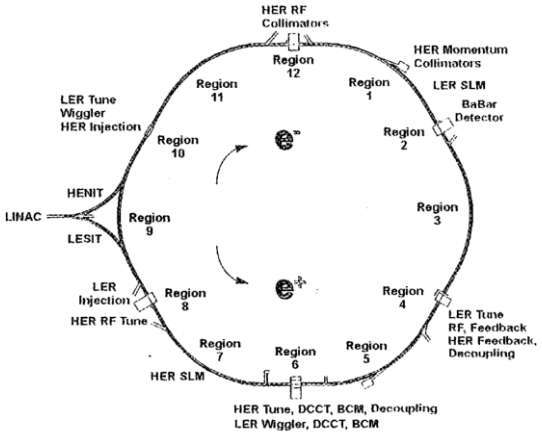


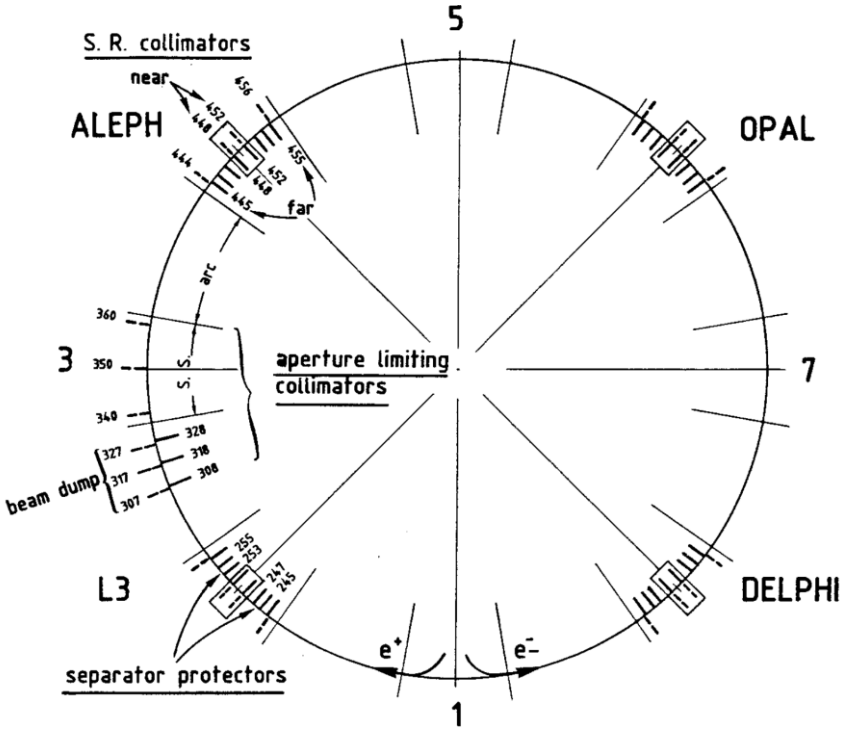
See **PRAB 23, 053501**

Collimation in other (circular) lepton collider

- In LEP, two stage collimation system (hor.) in a low-dispersion straight section
  - Additional hor. and ver. collimators in arc

- Similar setup in PEP-II

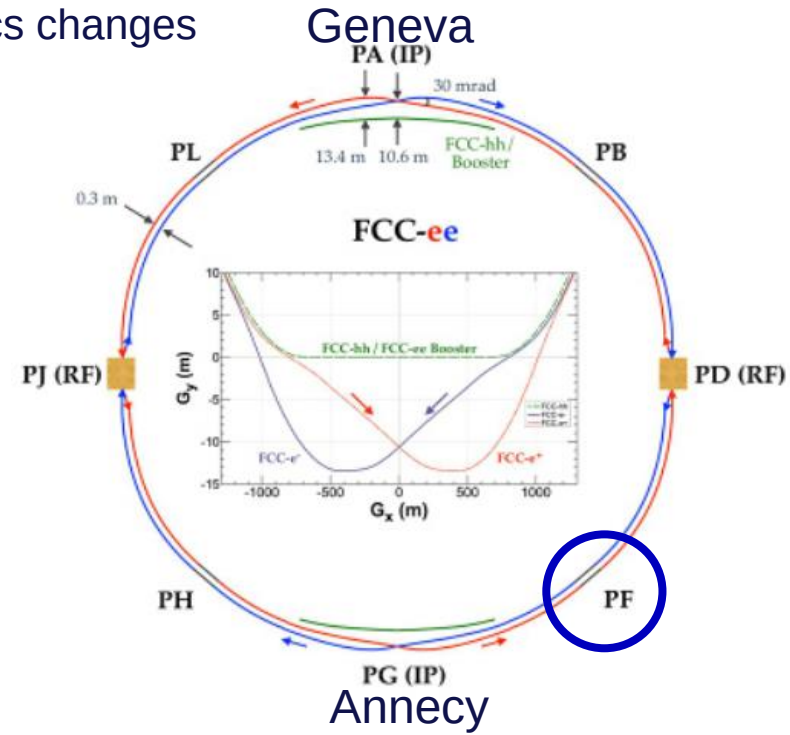




From CERN-LEP-BI-87-03

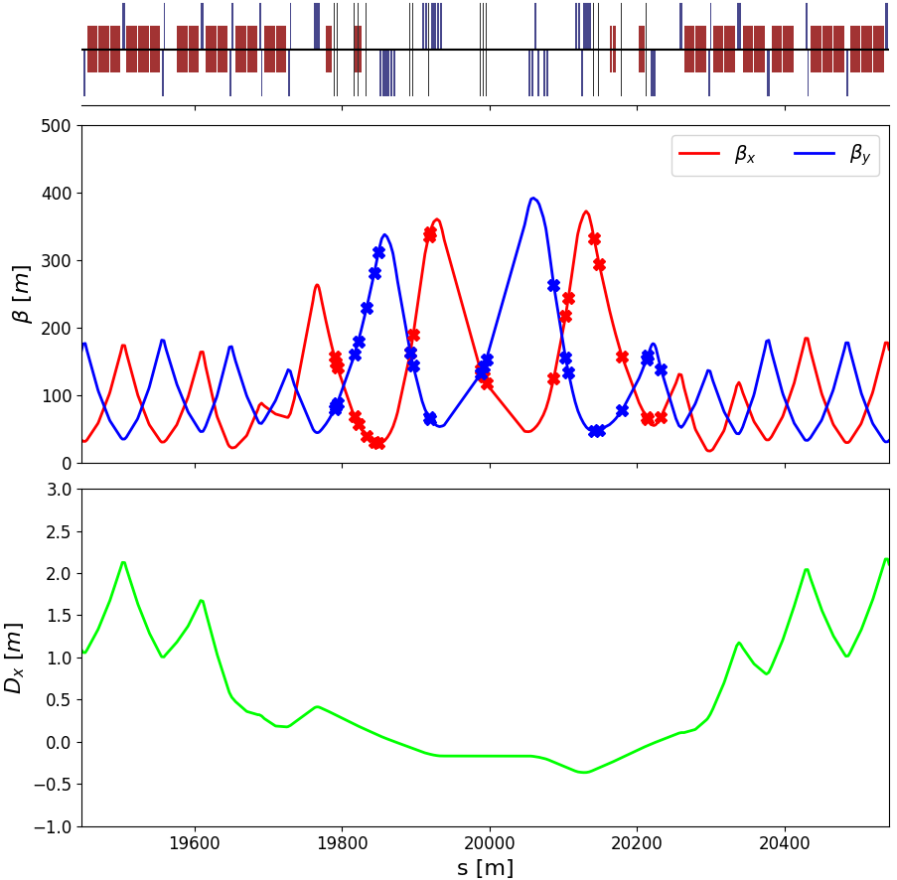
Location and constraints on FCC-ee collimation insertion

- In FCC-ee, implement a LEP like system
  - One straight section where aperture limiting collimators are placed
    - Collimation in arcs is unfavorable due to optics changes between operation modes
- In 2IP layout, 1.4 km long sections before and after each experiment
- Looking into clockwise beam, place collimation in PF
  - Collimation before the experiment likely improves background
  - Potential to install second system in PL



Layout considerations and requirements

- Starting guess is scaled layout from the LHC β-collimation section (IP7)
  - Based on longer FODO cells, layout adjusted for control on phase (ref.)
  - Multistage hierarchy, using hor., ver., and skew primary collimators for betatron collimation
  - Placement of secondary based on phase advance considerations, and numerical optimization based on amplitude of escaping particles (ref.)



Constraints on FCC-ee collimation insertion

- Polarimeter currently located on the inside beam in PF
  - Last dipole of dispersion suppressor used to separate photons and scattered electrons from beam
  - Constraint from length of drift space for separation

- First collimation layout integrates drift for polarimeter
  - Impact on performance to be assessed

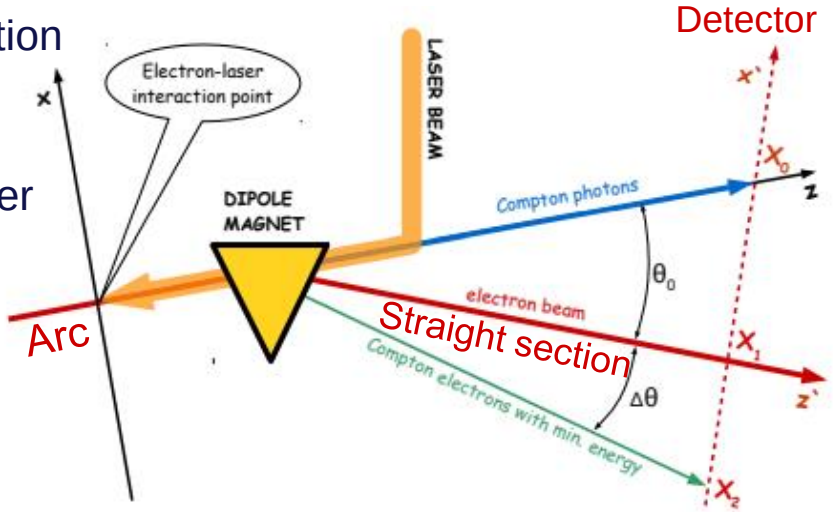
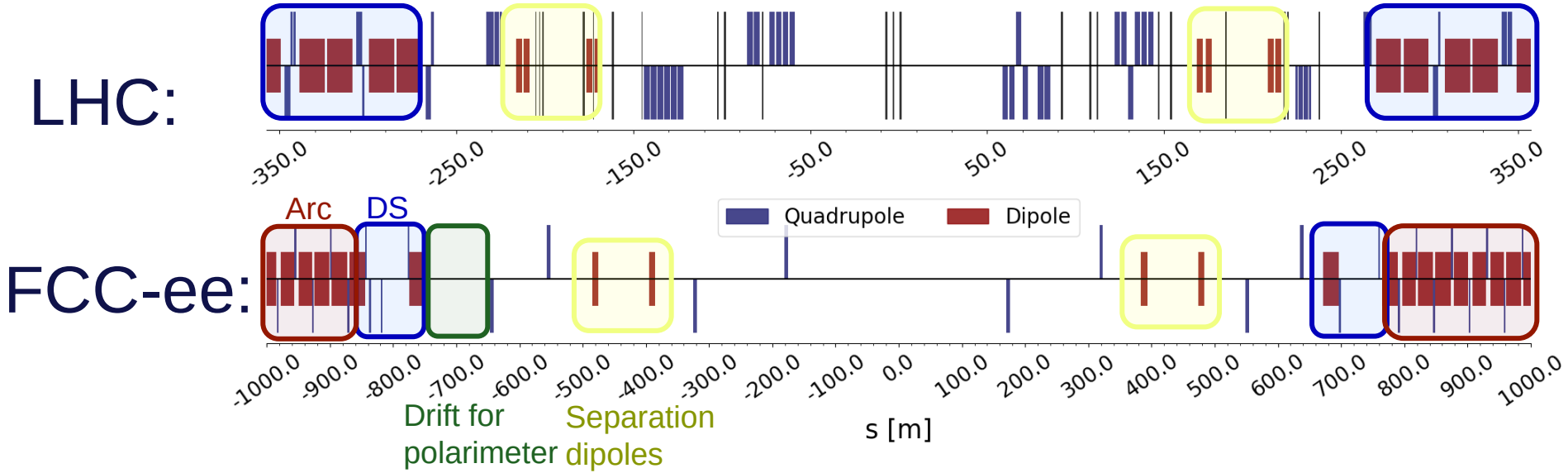


Figure 25. Regular layout of ICS experiments realization.

From arxiv:1909.12245

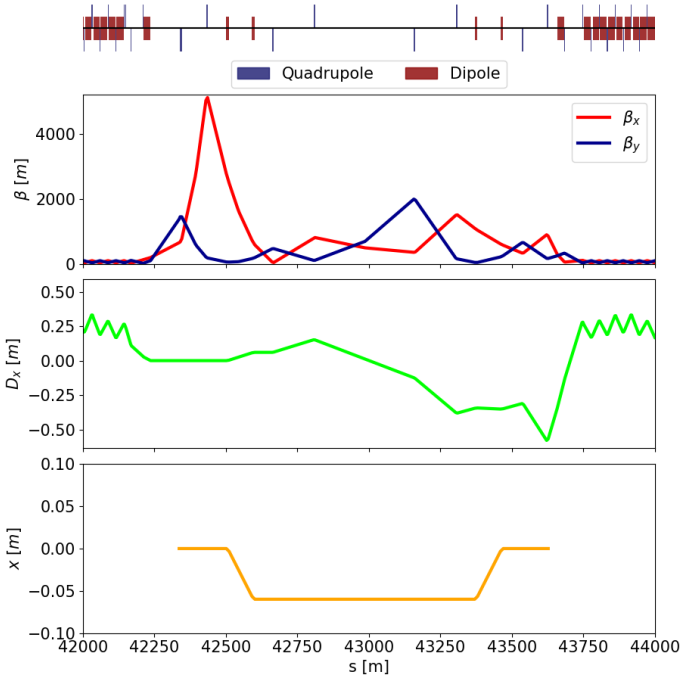
Layout considerations and requirements

- Starting guess is scaled layout from the LHC β-collimation section (IP7)
  - Drift space of 100m left between last dipole and first IR quadrupole for pol. detectors
  - No dispersion in the polarimeter drift, separation dipoles after to create some dispersion at collimators

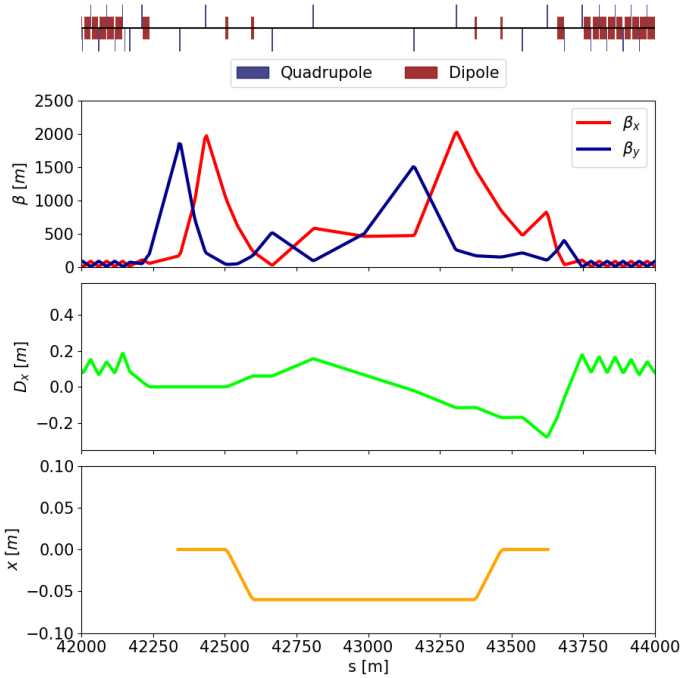


Optics

- First integration into Z- and $t\bar{t}$-lattice
  - Of particular interest since operation modes with the highest stored beam energy (Z with 20 MJ) and highest beam energy ($t\bar{t}$ with 182.5 GeV)



Z-lattice (45.6 GeV)

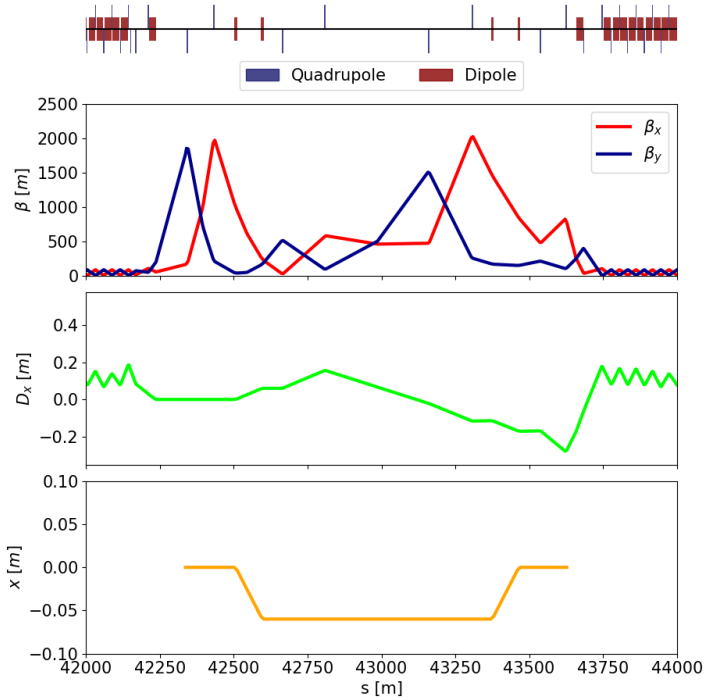


$t\bar{t}$-lattice (182.5 GeV)

Optics

- Chosen operation mode also feature different arc optics (Z with arc phase 60°/60°, $t\bar{t}$ with 90°/90°)
  - Insertion optics different between working points
  - Partly constrained by dispersion suppressor design and polarimeter drift
  - Same design in PL

- Magnet strengths kept below arc magnets specifications
  - Dipole: 10m, B < 0.04 T
  - Quadrupole: 5.6m, G < 2 T/m



$t\bar{t}$-lattice (182.5 GeV)

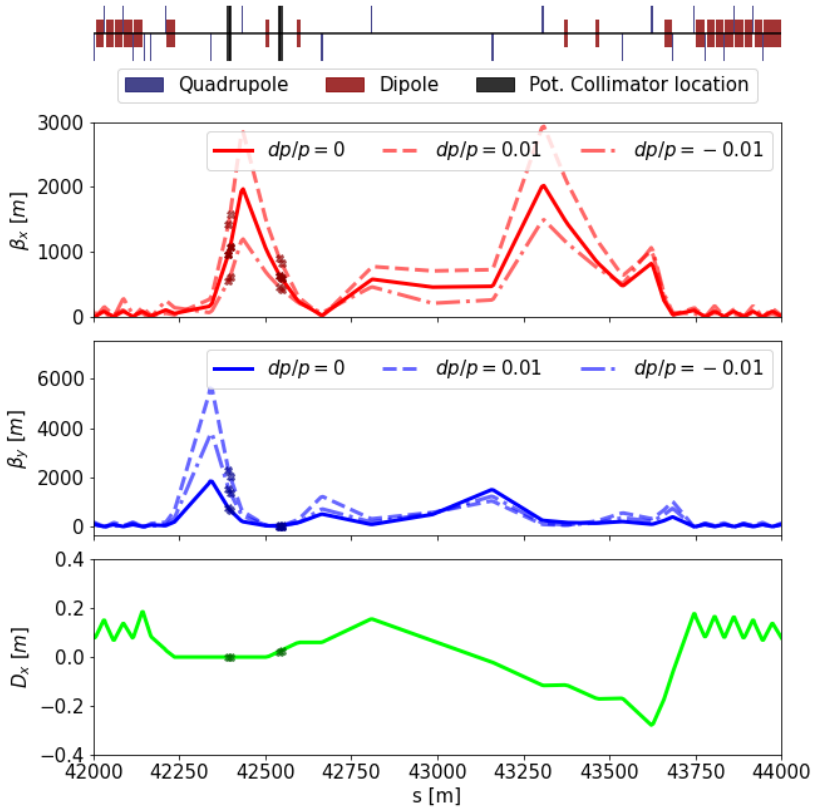
Collimator placement

- Two places for primary collimators considered
  1. As in LHC, place between separation dipoles
  2. Place in low disp. region and profit from larger β-function

- Placement of secondary collimators following **PRST AB1, 081001**
  - Choose phase advance between primary and secondary based on

$$\tan\mu = \frac{\sqrt{n_2^2 - n_1^2}}{n_1}$$

where $n_{1,2}$ opening in σ of primary/secondary collimator



$t\bar{t}$-lattice (182.5 GeV)

Conclusions

- Dedicate one straight section to betatron collimation in FCC-ee
  - LHC-type collimation section layout integrated
    - Constraints from combination with polarimeter considered
      - Optics different between working points

- Next steps for optics design include:
  - Integration in WW and ZH lattices
    - Refine based on input from first tracking studies
      - In 2IP layout, decide on role of insertion PL
        - Option to keep momentum and betatron system separate or combination of systems (combination required in 4IP case)

Thanks for your attention!