# FCC-ee booster: preliminary design study

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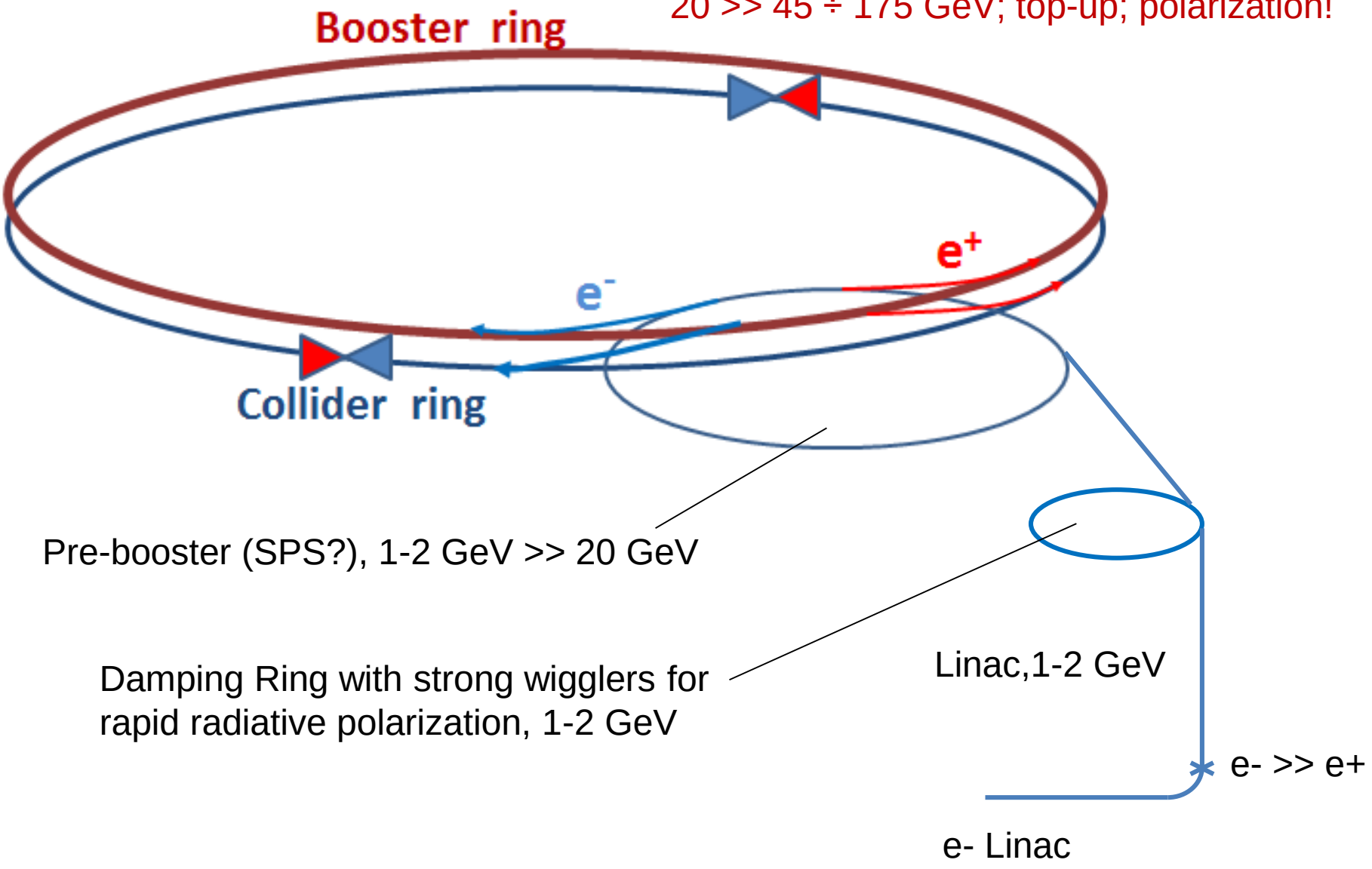
# FCC-ee complex possible scheme

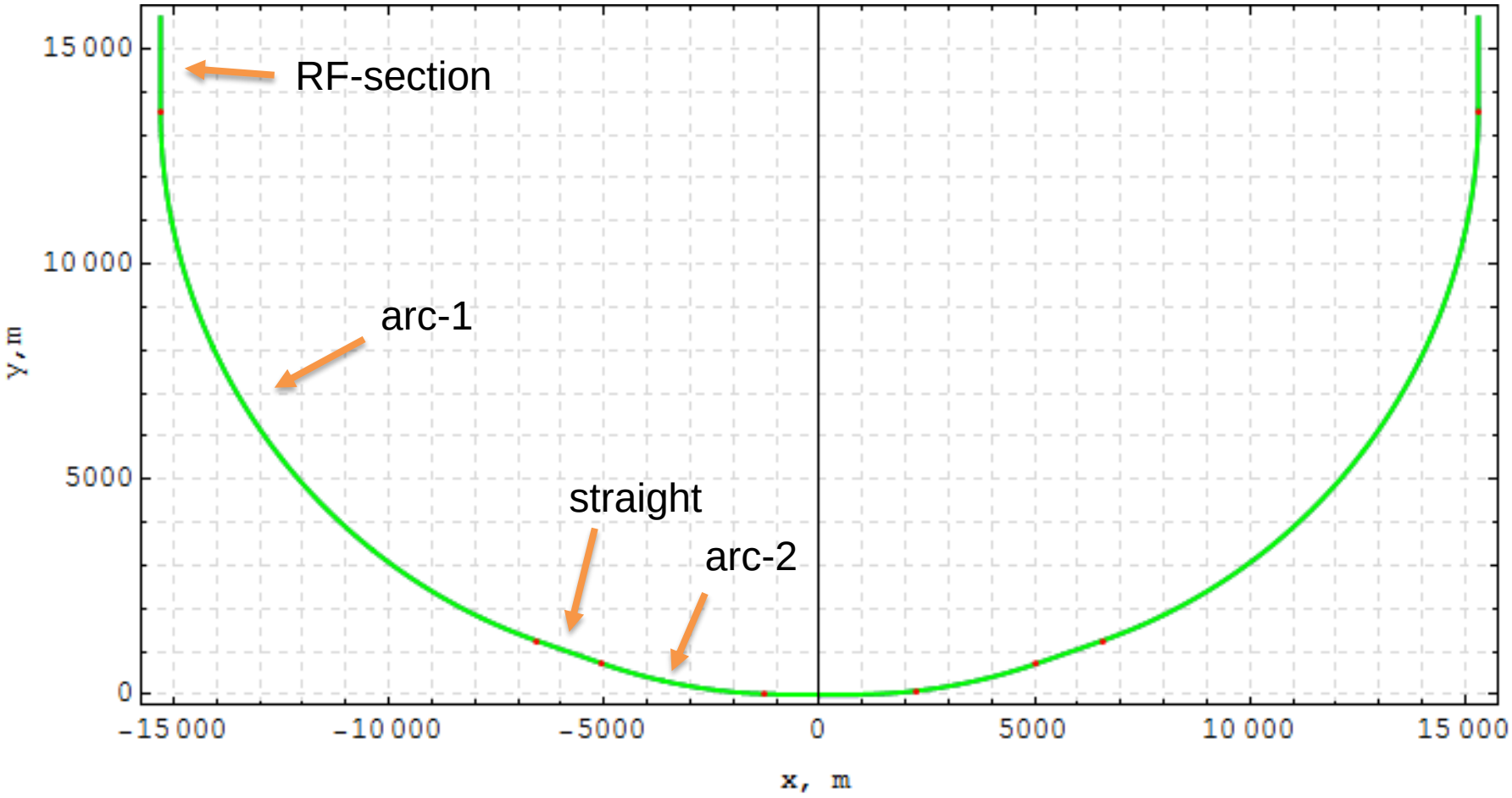
20 >> 45 ÷ 175 GeV; top-up; polarization!



# Geometry

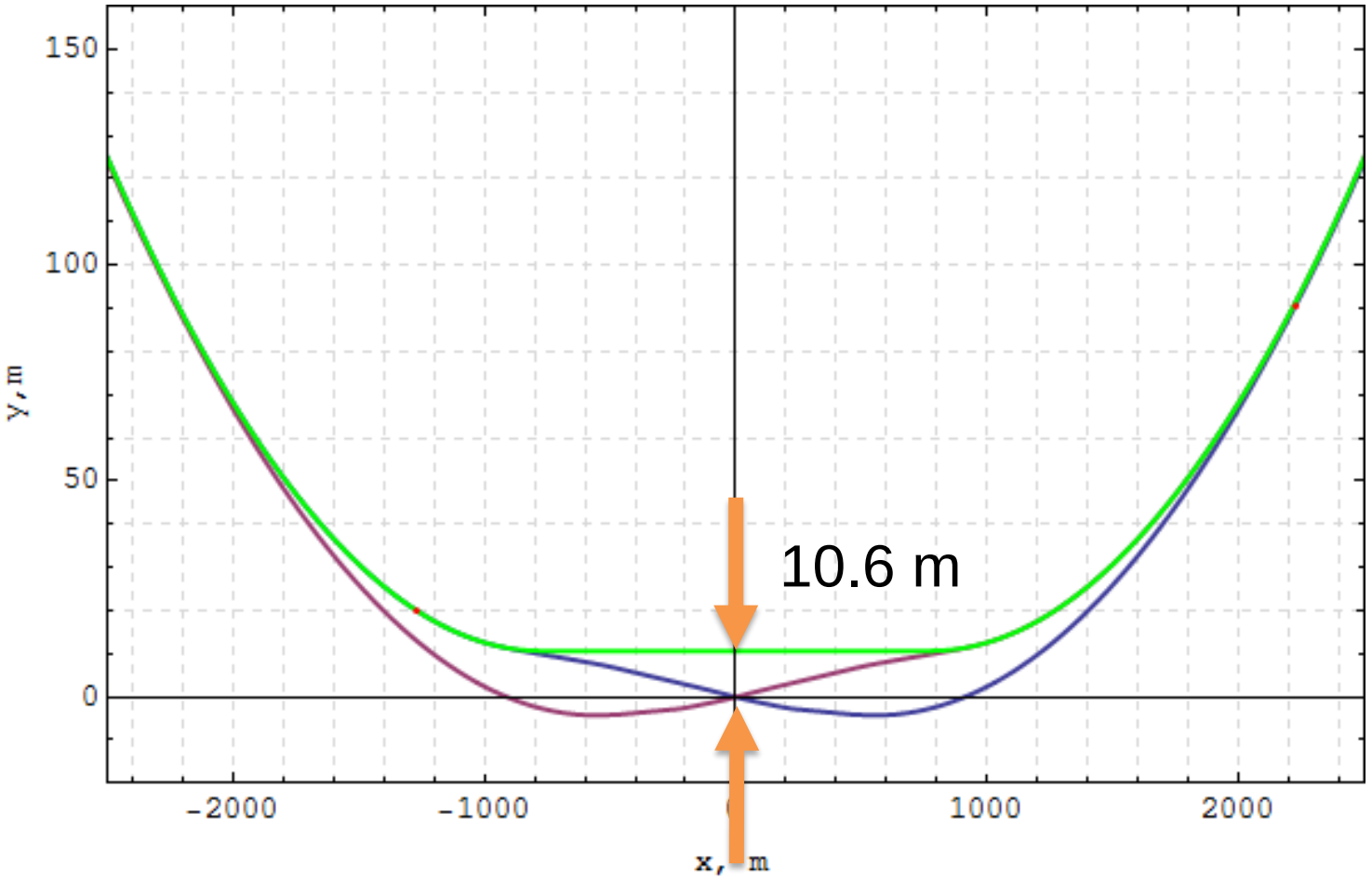
Booster vs collider: same circumference, same tunnel, same emittance.

Thus, the ring is cloned of Katsunobu Oide's version collider "inner" quarter-ring, except the IR. Two-fold & mirror-symmetry.



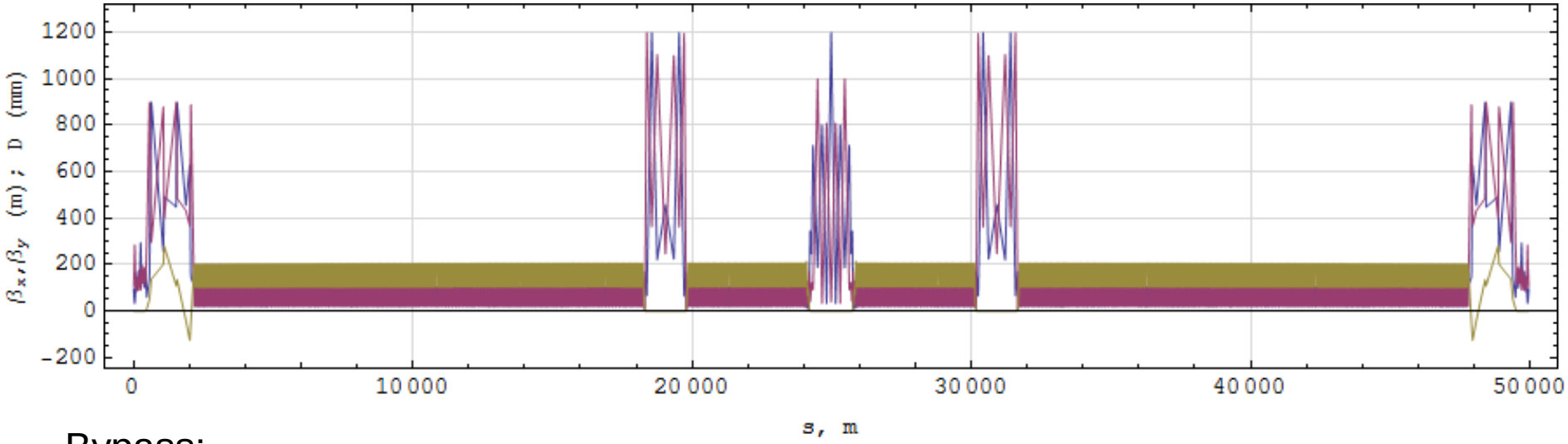
# Geometry (2)

Inner arc & bypass was chosen by chance.
Probable problems with MeV SR photons showering the detector (?)

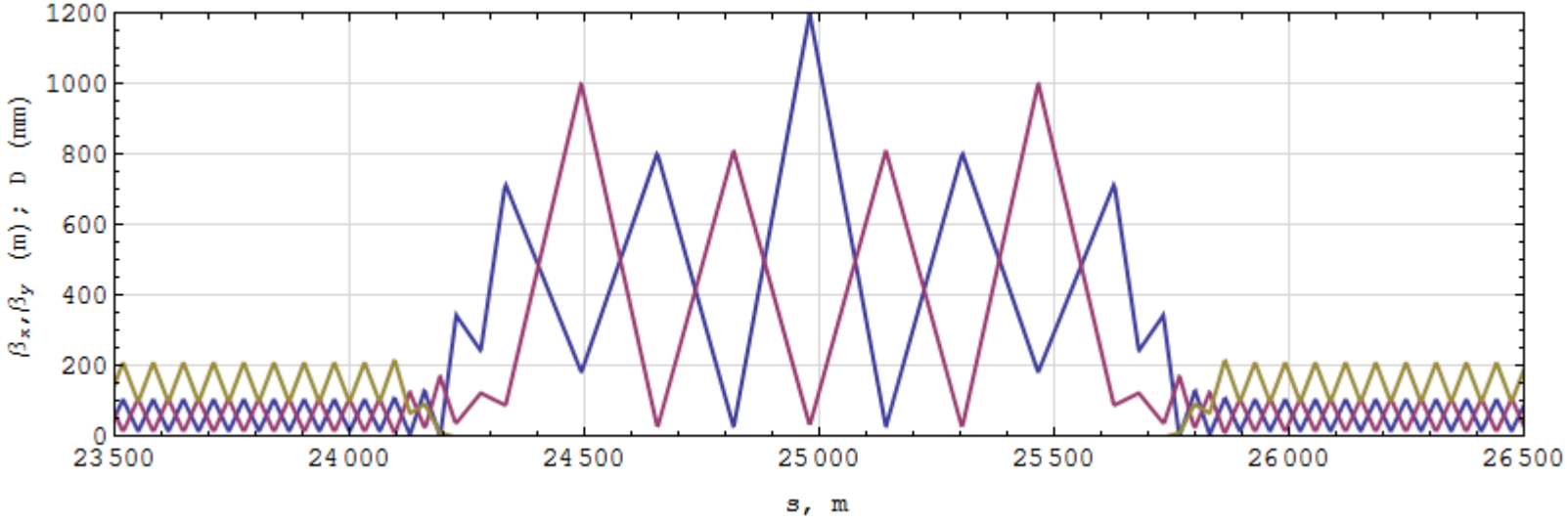


# Lattice functions

Half ring:




Bypass:



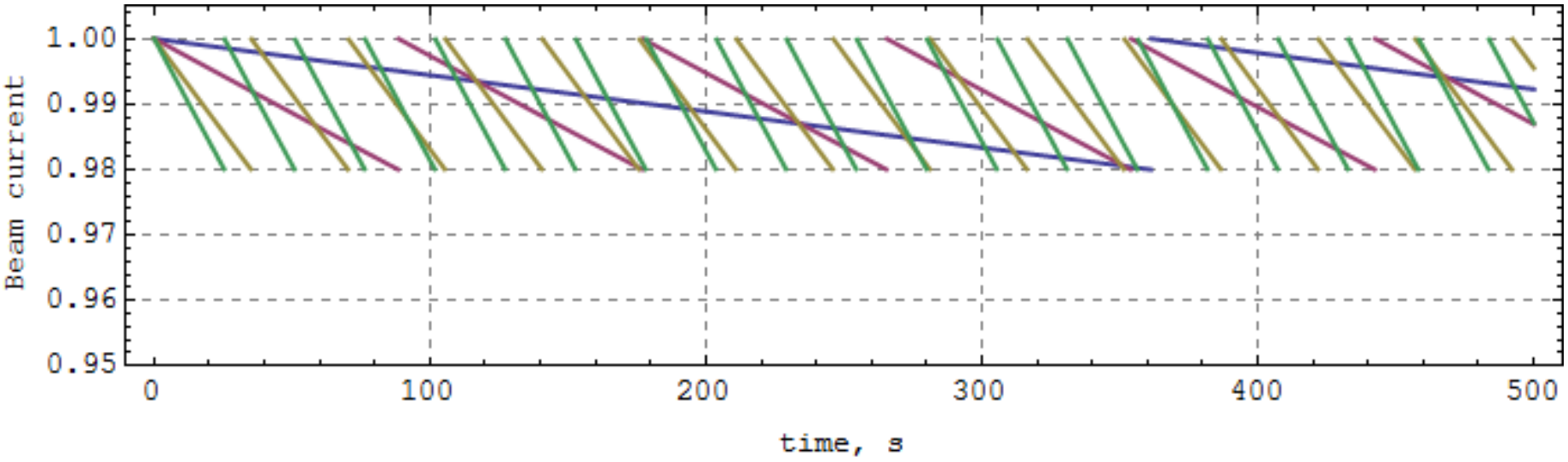
# Top-up injection

Collider bhabha scattering lifetime:

| E [GeV] | 45.5 | 80 | 120 | 175 |
|---|---|---|---|---|
| Lifetime [min] | 298 | 73 | 29 | 21 |
| Inj. Cycle [sec] | 361 | 88 | 35 | 25 |

<< Injection both e+ & e-

Beam current decay in the collider for the set of energies.




Note: $L \propto I^+ I^-$ : 2% I >> 4% L

# Parameters

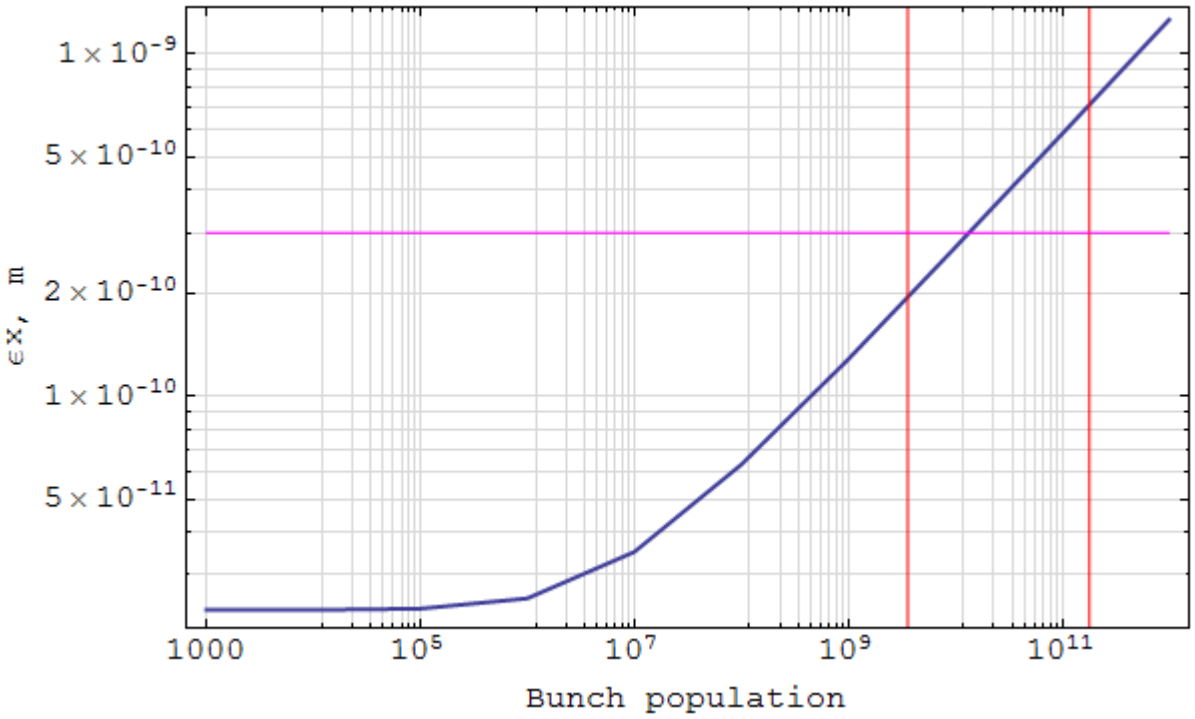
| Energy [GeV] | 20 | 45 | 80 | 120 | 175 |
|---|---|---|---|---|---|
| Cycle time [s] | 12 | | | | |
| Stacking | no | | | | |
| Circumference [m] | 99918.2 | | | | |
| Bending radius [m] | 11653.8 | | | | |
| FODO-cell length [m] | 64.245 | | | | |
| Betatron tunes per cell | 0.25 | | | | |
| Betatron tunes | 334.45 / 333.2 | | | | |
| Radiative emittance [nm] | 0.024 | 0.12 | 0.38 | 0.85 | 1.81 |
| Bending field [Gs] | 57 | 129 | 229 | 343 | 509 |
| Energy Loss / turn [MeV] | 1.21 | 31.1 | 310 | 1572 | 7109 |
| Transv. Damping time [s] | 11 | 0.965 | 0.172 | 0.051 | 0.017 |
| Transv. Damping time [turns] | 32974 | 2895 | 516 | 153 | 50 |
| Critical energy [MeV] | 0.0015 | 0.017 | 0.097 | 0.33 | 1.02 |

# Intrabeam scattering

Energy: 20 GeV
Total voltage: 141 MV
“Nominal” bunch length: 0.63 mm
Damping time: 11 s

1% collider bunch intensity

100% collider bunch intensity

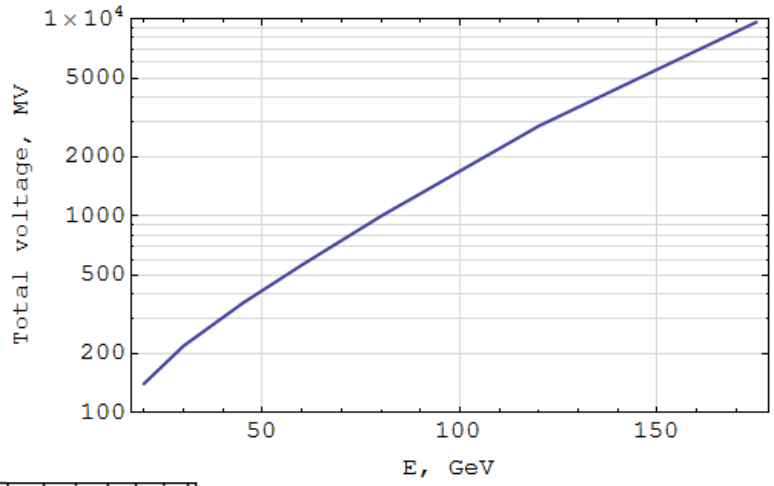


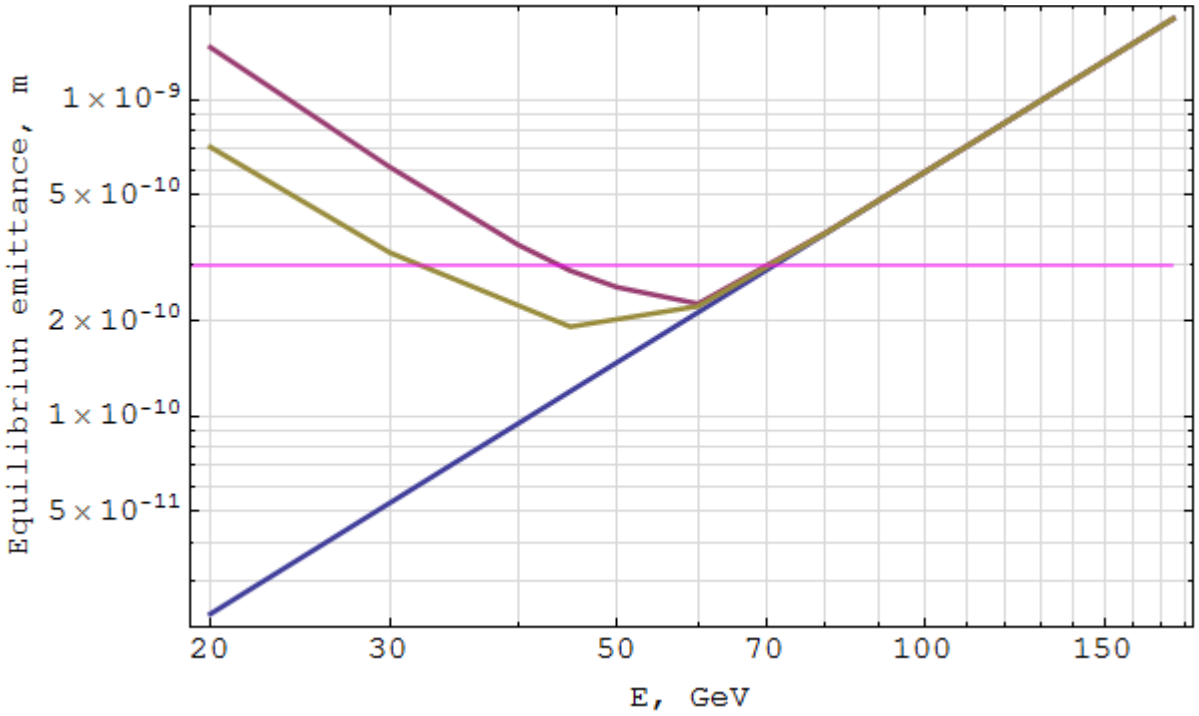

SPS lowest emittance:
0.3 nm @ 20 GeV

# IBS (2)

Voltage following energy with invariant bucket width ~0.06 (9.6 GV with 7.1 GeV energy loss @ 175 GeV).

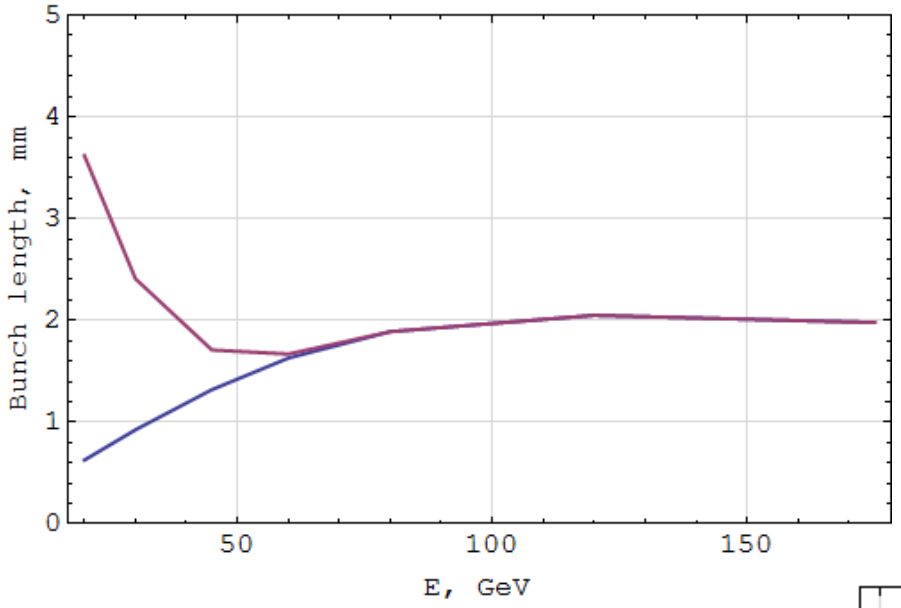
Emittance (equilibrium) growth due to IBS. $N_{bunch} = 1.8 \times 10^{11}$.



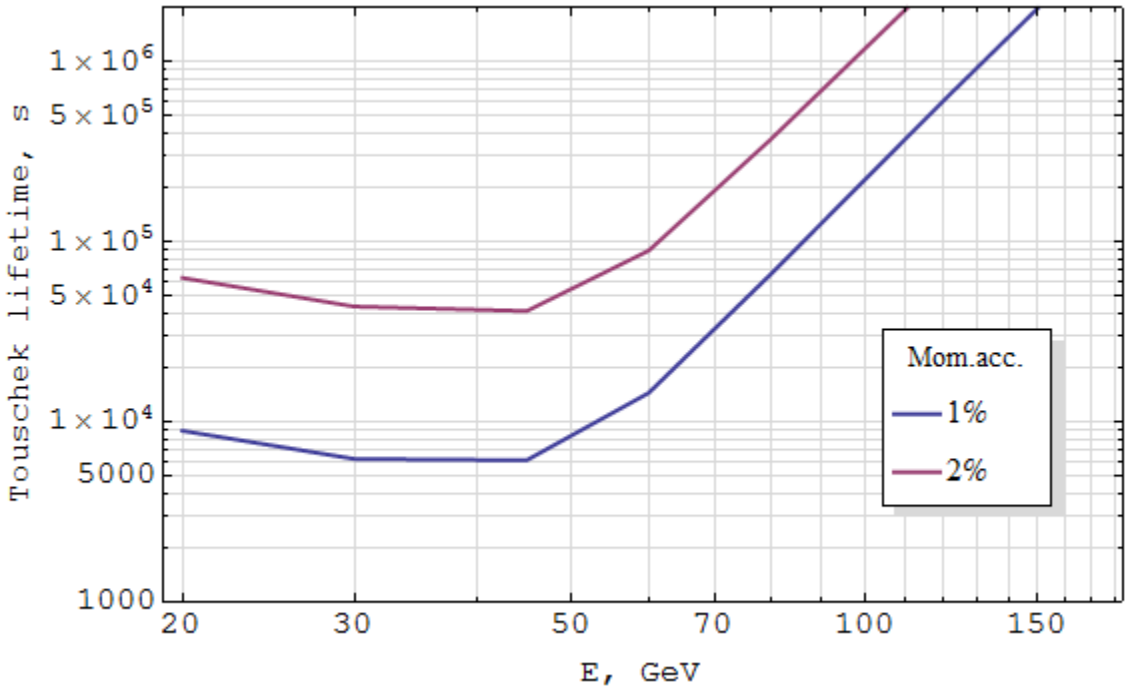




SPS lowest emittance:
0.3 nm @ 20 GeV

# IBS (3)




Same conditions:
voltage variation,
$N_{bunch} = 1.8 \times 10^{11}$.



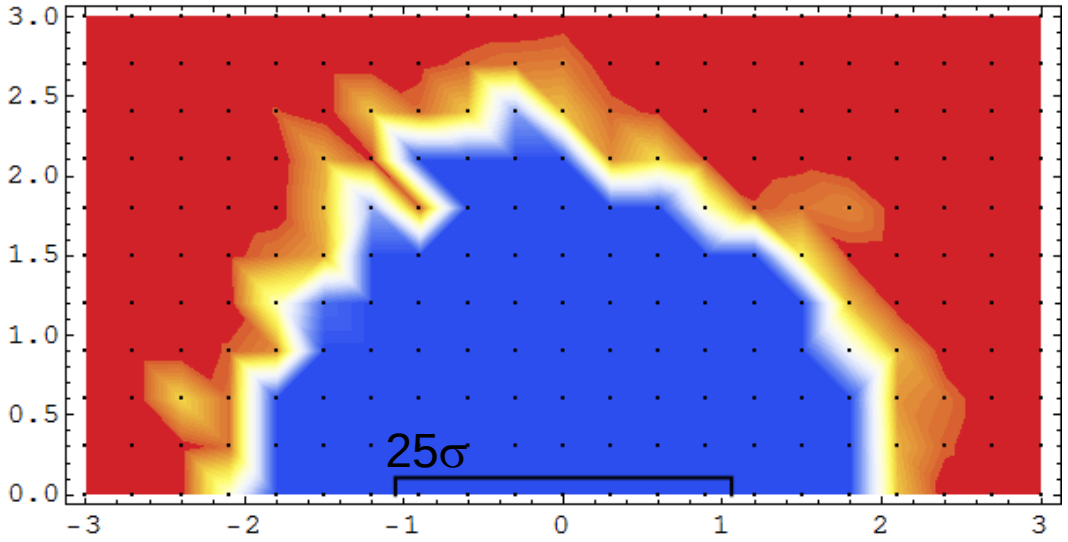
# Dynamic Aperture estimations

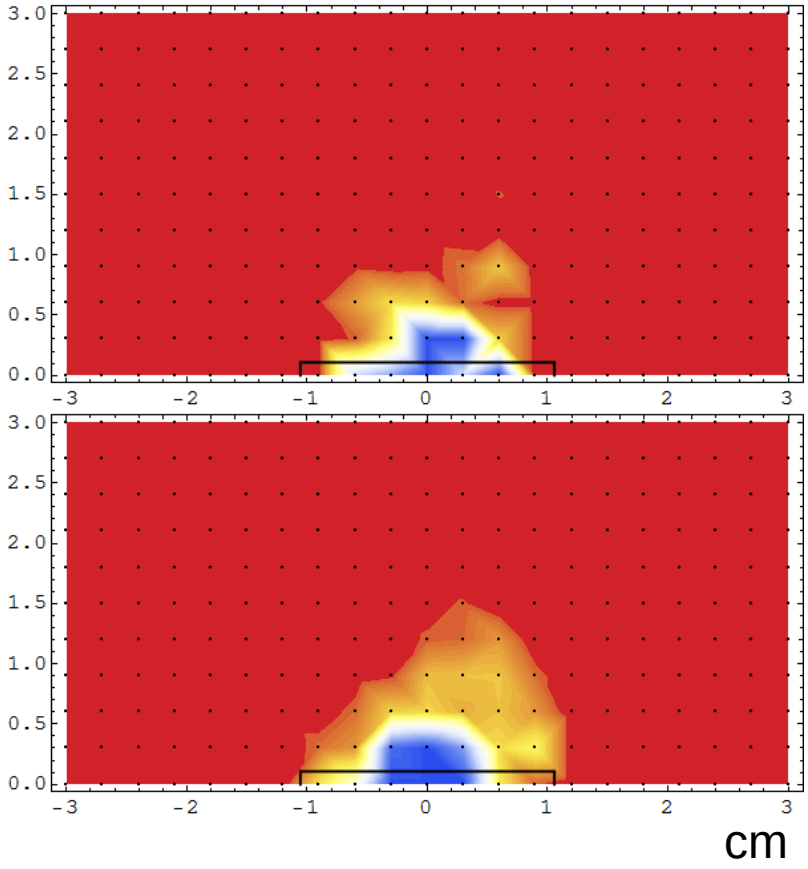
Primitive tune chromaticity correction: two non-interleaved families SF, SD

On-energy

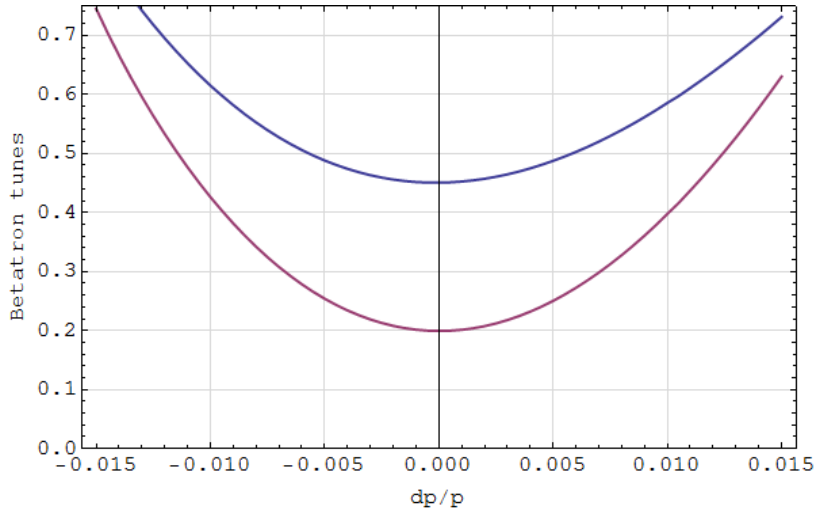
1000 turns (damping off)

Off-energy (±1%)



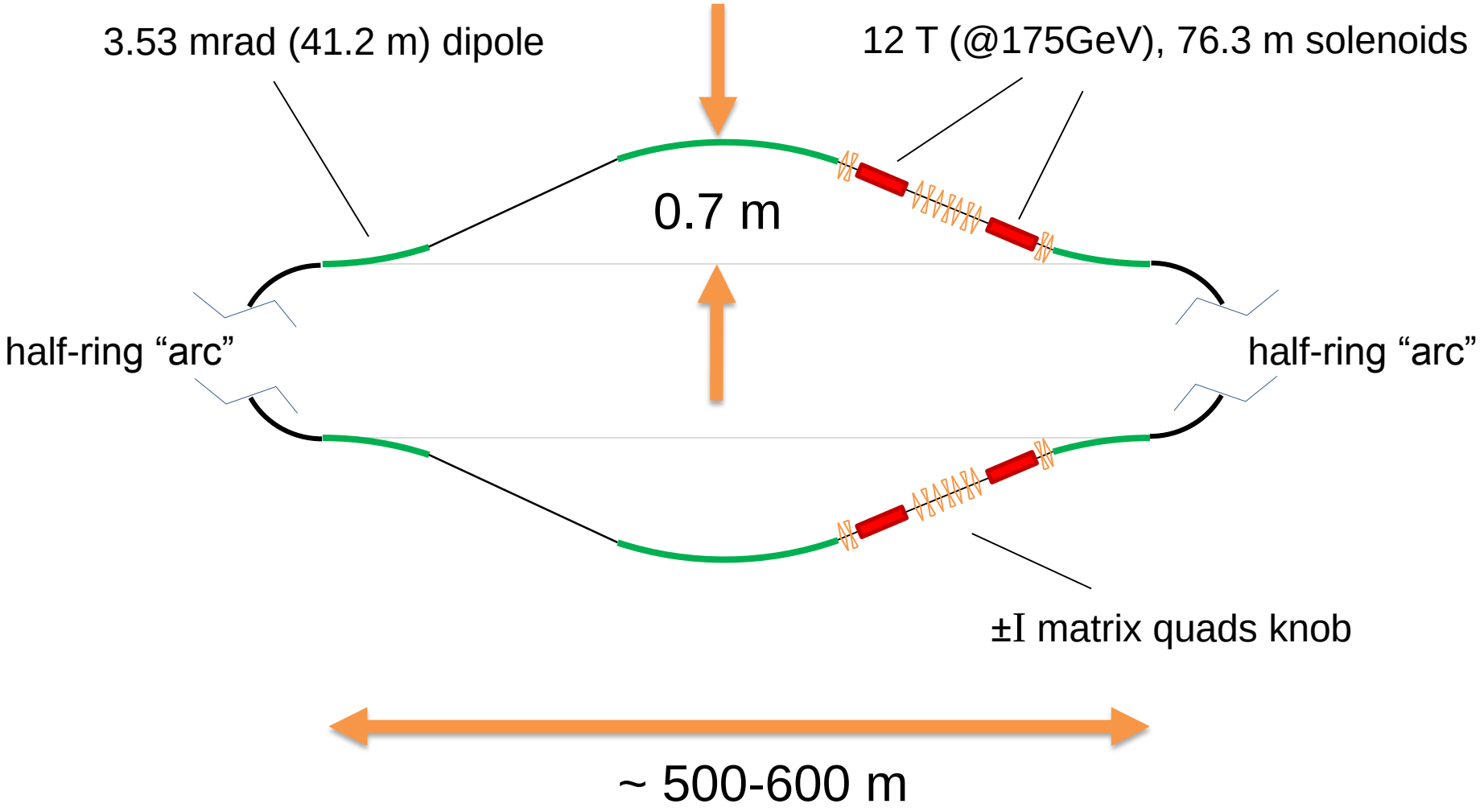
cm




Strong second-order tune chromaticity

# Siberian snakes

Polarization preservation during acceleration demands two Siberian snakes placed with proper azimuthal angle proportion (Ivan Koop).



# Plenty of work to be done!

- Lowest energy? Injection chain?
- Cycling, filling, intensities…
- Arrangement in the tunnel
- Injection to collider scheme
- 50 Gs dipoles – practical possibility (cycling, shielding, stability, quality)
- Polarization aspects & insertions
- Tapering?
- Linear optics (depending on energy?)
- Nonlinear optics
- etc