Simulations for FCC-ee beam self-polarization

Content:

- Solenoid effect in SLIM

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Solenoids in SLIM

- Problem introducing more solenoids encompassed by defining all them at the beginning of the file....
- Solenoids + anti-solenoids on the lhs/rhs of both IPs each with B_{sol}=2 T (independent upon energy) and x'= -0.015 rad, x=0 at the IP

45 GeV:

x_{rms}=14.9 μm

y_{rms}=0.9 μm

$|\delta\hat{n}_0|_{rms}$=0.010 mrad

P_{lin}=88%

80 GeV:

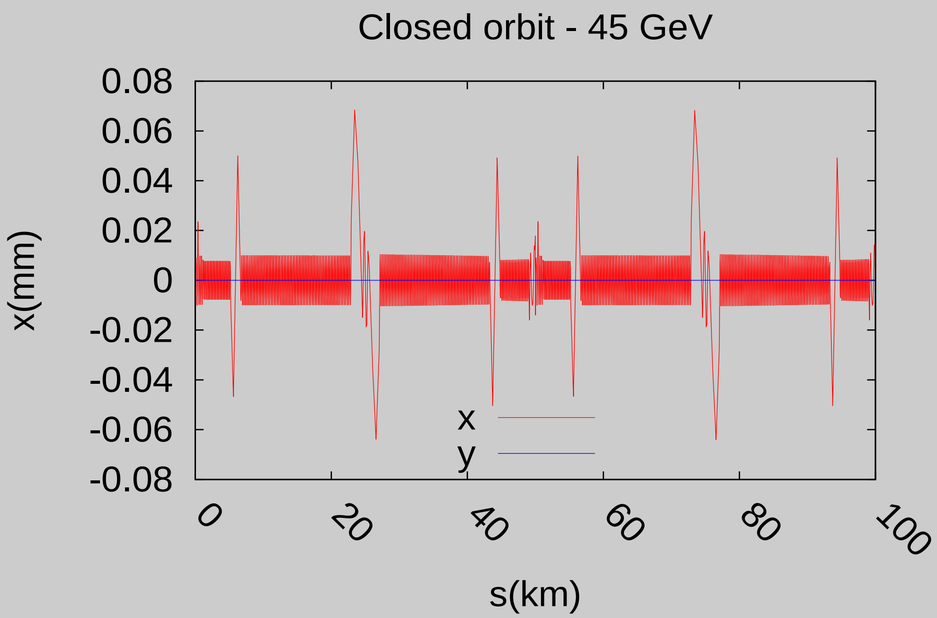
x_{rms}=4.7 μm

y_{rms}=0.5 μm

$|\delta\hat{n}_0|_{rms}$=0.001 mrad

P_{lin}=88%

Closed orbit at 45 GeV



Solenoids in SITROS

SITROS does not allow tilted solenoids. We can create an anti-symmetric beam bump across the IP. Due to SLIM results it is not a priority.

Effects of vertical emittance correction on polarization

Horizontal equilibrium emittance

$$\epsilon_x = C_q \gamma^2 \frac{\mathcal{I}_5}{J_x I_2} \quad \mathcal{I}_5 \equiv \oint ds \, \frac{\beta_x D_x'^2 + 2\alpha_x D_x D_x' + \gamma_x D_x^2}{|\rho|^3}$$

In a “flat” designed machine, vertical emittance originates from

- cone of photon emission which sets the lower limit for ϵ_y: very small, especially for large rings
- magnet misalignments
  - vertical displacement of quadrupoles
  - roll of horizontal bending magnets
  - roll of quadrupoles regions
  - vertical misalignment of sextupoles

A number of corrections have been considered by S. Aumon and S. Sinyatkin (see eeFact2016). Sandra used the Oide-san optics I am using for polarization simulations, but with tapering for dealing with the horizontal orbit in presence of synchrotron radiation. She considered following corrections

- Orbit/Dispersion correction
- Use of 1 skew quad every 6 FODO cells where $D_x \neq 0$ for correcting the linear coupling resonance driving terms

The parameters she considered are

- δ^Q_{rms}=20-30 μm
- δ^Q_{rms}=50 μrad

As I do not have Sandra files, I am trying of reproducing her corrections to assess impact on polarization.

To-do-list

- Add skew quadrupoles
- Introduce tapering
- Implement "dispersion free steering"
- Implement coupling correction

In addition: couple BPMs offsets to the close-by quadrupole.

Adding skew quads

Skew quads added as multipoles (ℓ=0) into MADX model each 7th FODO cells (as Sandra) next to either a QD3 or a QDG1. Total of 147 skew quads added[a]

Betatron coupling

I follow the treatment developed for Tevatron and that I used in ATF DR simulations (Dynamic Aperture Workshop, Bloomington 2010, unpublished) which I believe is what also Sandra is using. The codes used for ATF DR must be yet adapted to FCC.

- The value of the complex coupling functions $\boldsymbol{w}_{\pm}$ due to random quadrupole roll errors may be measured at BPMs with Turn-by-Turn capabilities.
- The spurious vertical dispersion is measured at the BPMs.
- The effect of each skew quadrupole on $\boldsymbol{w}_{\pm}$ and vertical dispersion is calibrated by using MADX: 147$\times$1586 ptc-tracking files + 147$\times$1586 dispersion matrix elements.
- The strenghts of the skew quadrupoles needed for correcting the “measured” $\boldsymbol{w}_{\pm}$ and $\boldsymbol{D_y}$ are computed by a SVD.

[a] Sandra has 272