Optimization of the IR in SuperKEKB LER

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Plan of collaboration between CEPC and SuperKEKB

• Start with a simplified SuperKEKB lattice (By H. Sugimoto, w/o solenoid)
  – Try to re-optimize the IR nonlinearity

• With a realistic SuperKEKB lattice
  – Try to find a better solution combine the beam-beam, space charge and nonlinearity in lattice (I hope but long-term study)
Aberration in IR

• Amplitude dependent
  – kinematic aberration due to ultra-low beta (not corrected intended)
  – fringe field of final doublet
  – finite length effect of vertical sextupoles in IR (maybe corrected globally by sextupole in ARC)
• Momentum dependent
  – high order chromaticities (corrected globally by sextupole in ARC)
• making effort to correct the high order aberration more locally in the IR.
Lattice of IRL

SLYTL.1  SLYTL.2

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**W function**

- W function along the beamline IRL ("INS")
- blue/red lines for x/y

Phase advance between center of QC1LP and SLYTLP.1: \(0.4999 \times 2\pi\)
QC2LP and SLYTLP.1: \(0.9679 \times 2\pi\)

\[
W = \sqrt{\left(\frac{d\beta}{\beta d\delta}\right)^2 + \left(\frac{d\alpha}{d\delta} - \alpha \frac{d\beta}{\beta d\delta}\right)^2}
\]

At PTSULM:
- \(W_x = 124.9\)
- \(W_y = 114.6\)

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Beta, tune vs. dp/p for only IRL

- The high order chromaticity of IR are not corrected locally
  - blue/red lines for x/y

**non-periodic solution from “IP.1” to “PTSULM” (with IRL only)**

**periodic solution at “PTSULM” (with ASC)**
Correction of high order chromaticity

• High order chromaticity due to the small chromaticity from 1\textsuperscript{st} waist of $\beta_y$, i.e. QLC1LP  
  *K. Oide, SLAC-PUB-4806

• Correct the high order chromaticity with an additional weak sextupole at 1\textsuperscript{st} waist of $\beta_y$  
  *R. Brinkmann, DESY M-90-14
  
  – Phase advance (Y direction) of QLC1LP change significantly from 0.338*2\text{Pi} to 0.506*2\text{Pi}
  – add sextupole after the QLC1LP
  – SLYTLP, SLXTLP reoptimized together

• The 2\textsuperscript{nd} order geometric nonlinearity from the additional sextupole is much smaller than other sextupoles
  
  – QLC1LP: $\beta_y*K2=0.28$ m\textsuperscript{-1}
  – SLYTLP: $\beta_y*K2=4847$ m\textsuperscript{-1}
  – ARC sextupoles: $\beta_y*K2=180$ m\textsuperscript{-1}
Correction result of first try

- The phase advance between FD and sextupole will be tuned as well to further optimization.

At PTSULM:
- $W_x = 104.5$
- $W_y = 27.1$
Correction result of first try

- The phase advance between FD and sextupole will be tuned as well to further optimization

non-periodic solution from “IP.1” to “PTSULM” (with IRL only)
Summary

• Try to correct the high order chromaticity of IR more locally
  – Preliminary result got
  – The phase advance between FD and sextupole will be tuned as well to further optimization
  – Further work is under going

• A question on SAD: What’s the difference between QUAD and MULT(K2=0)? (For example, changing QLC1LP from “QUAD” to “MULT” will change the W function. Similar experiences in CEPC.)