SuperKEKB Ring Optics

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Contents

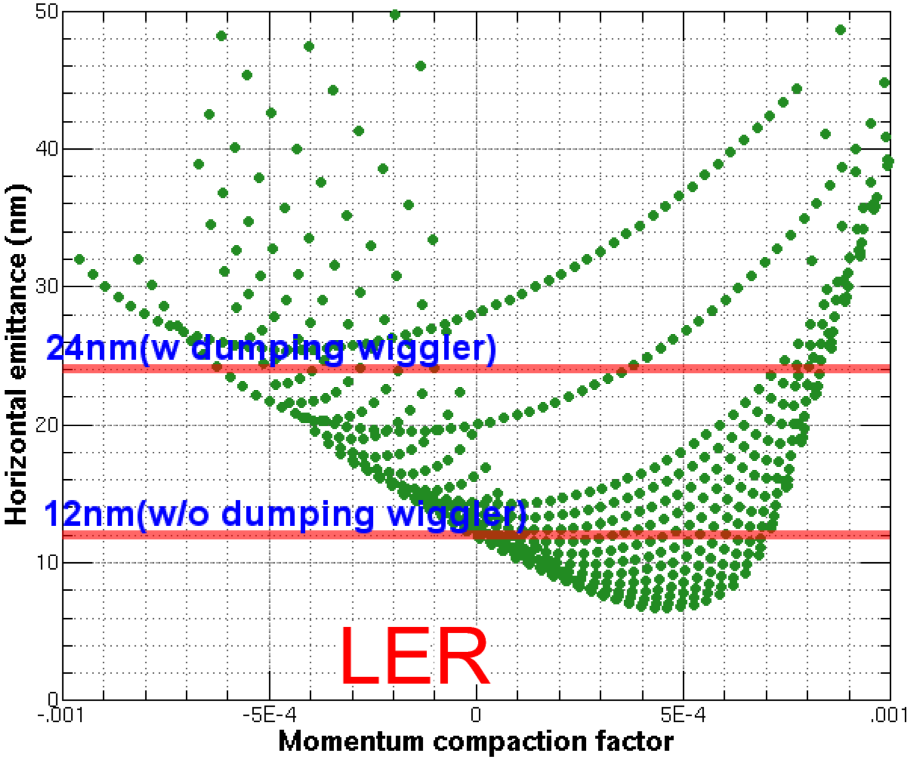
- Lower Emittance Arc Cell
- New Coupling/Dispersion Corrector
- Travel Focus(Travel Waist)

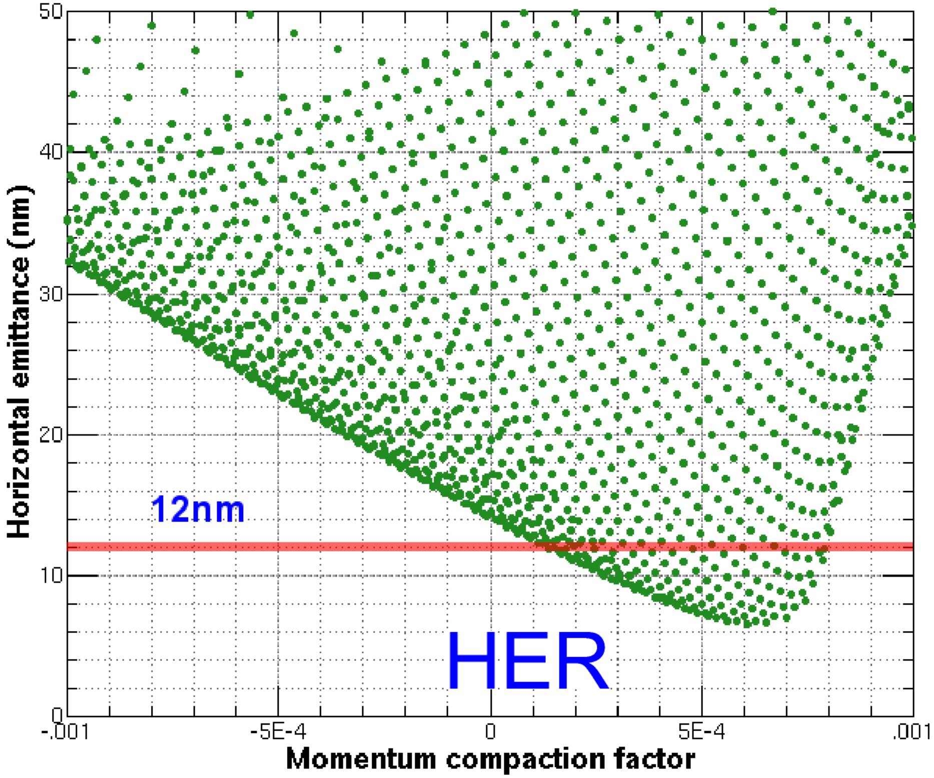
Major Issues

- Lower Horizontal Emittance than KEKB
  - Current KEKB emittance is 18/24nm(LER/HER) @ 2008/12
  - Nominal SuperKEKB design is 12nm @ 2008/07/25
- New Coupling/Dispersion Corrector
  - New coupling/dispersion corrector is required instead of vertical closed bump based corrector.
- Travel Focus(Travel Waist)
  - High current operation with short bunch is unstable due to CSR instability.
  - Method to cure luminosity degradation by longer bunch operation is required.
    - We are discussing possibility to introduce 'Travel Focus' into LER optics.

Variable Range of Arc Cell

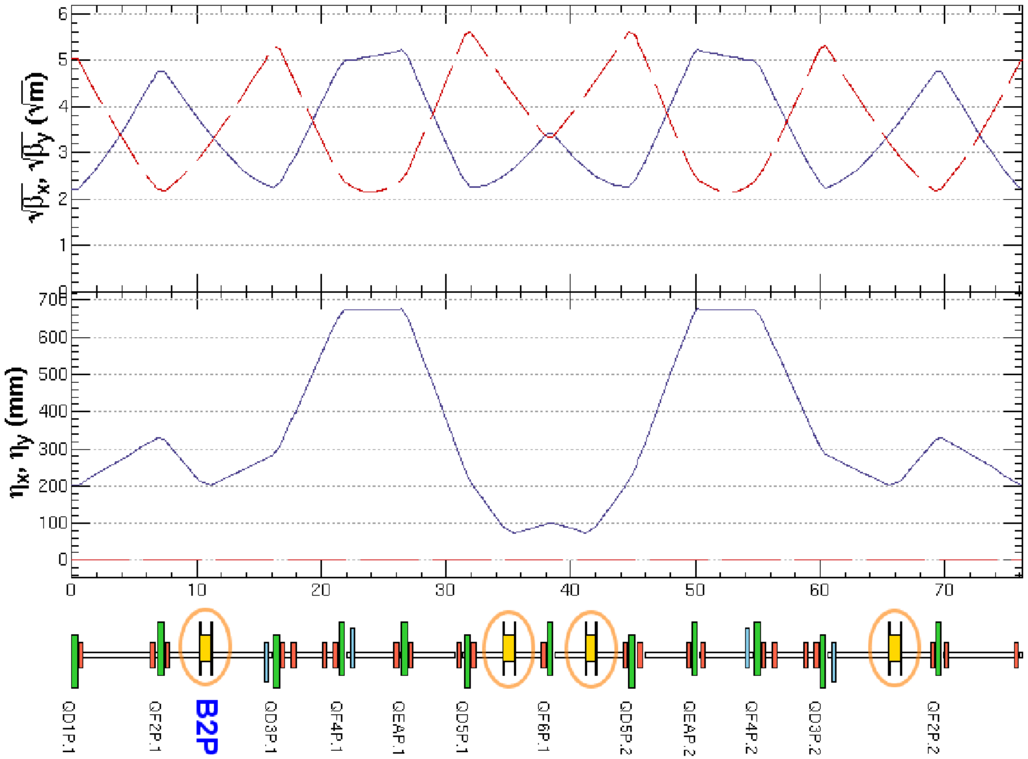
- 12nm can be achieved by current KEKB arc cell.
- Negative α_c can't be selected in 12nm emittance case.
- LER could be operated at negative α_c by using damping wiggler.
  - Ring emittance becomes one-half by using dumping wiggler.(LER)





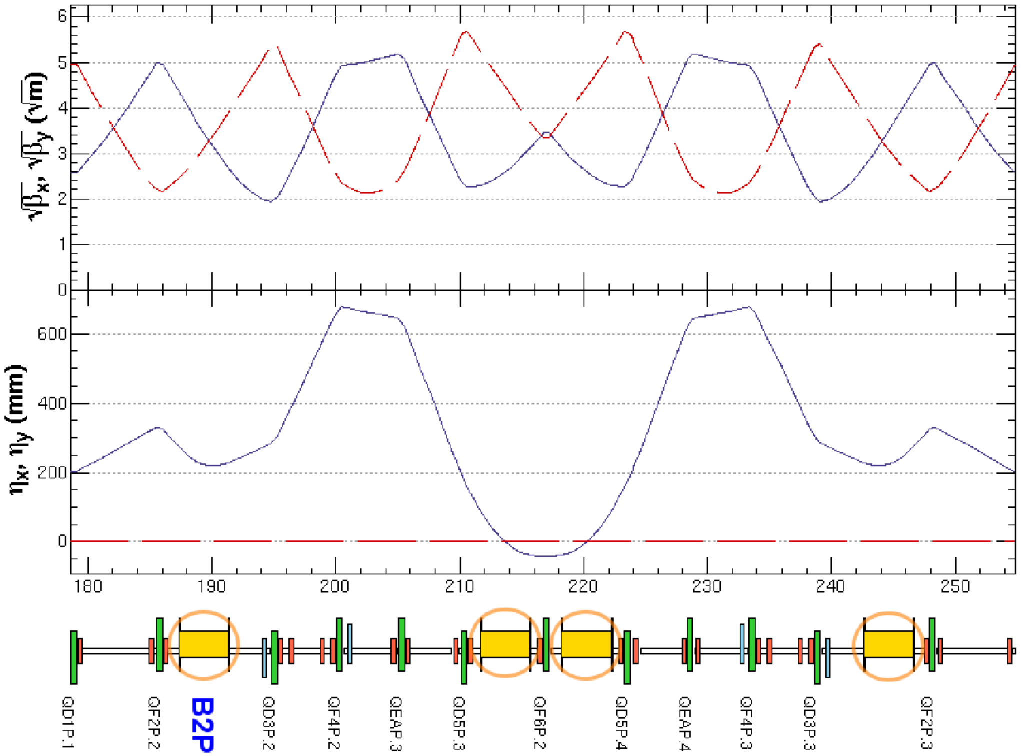
LER Low Emittance Option

- Replace B2P bending magnet with longer one.
- 1.1nm would be possible by using damping wiggler.
- Emittance from local chromaticity corrector is about 5nm.
  - Modification of local chromaticity corrector is required for low emittance optics.



Current B2P(L_{eff}=.89m)

ε_x~6.8nm, α_c~4.15×10^{-4}

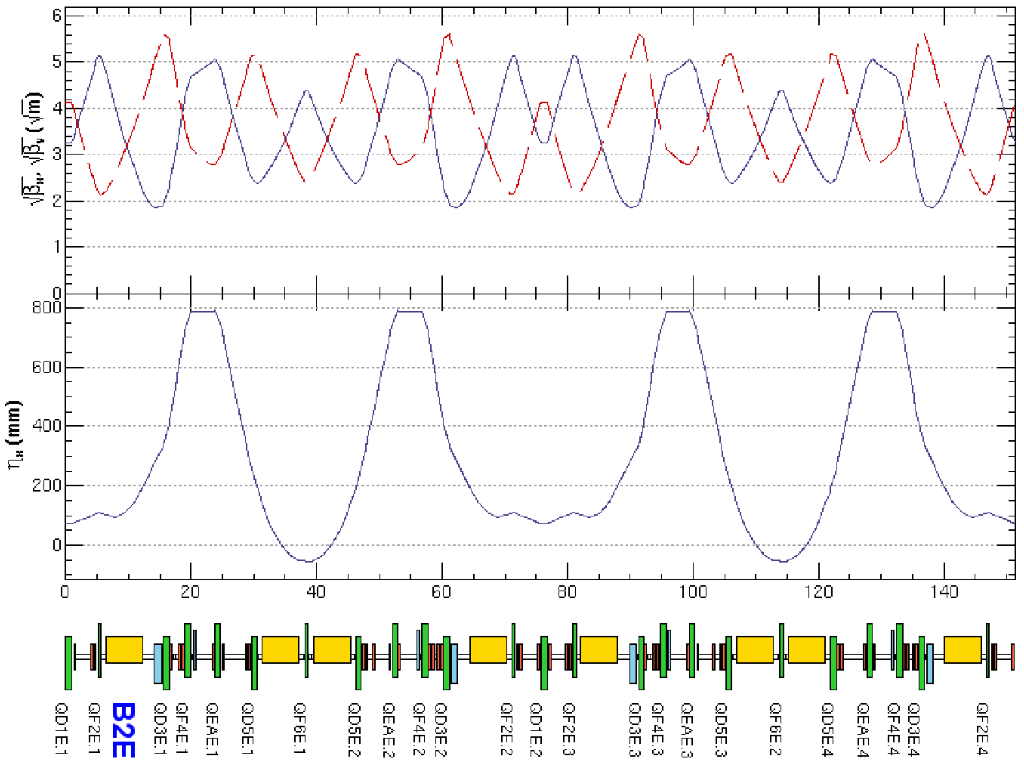


Longer B2P(L_{eff}=4.0m)

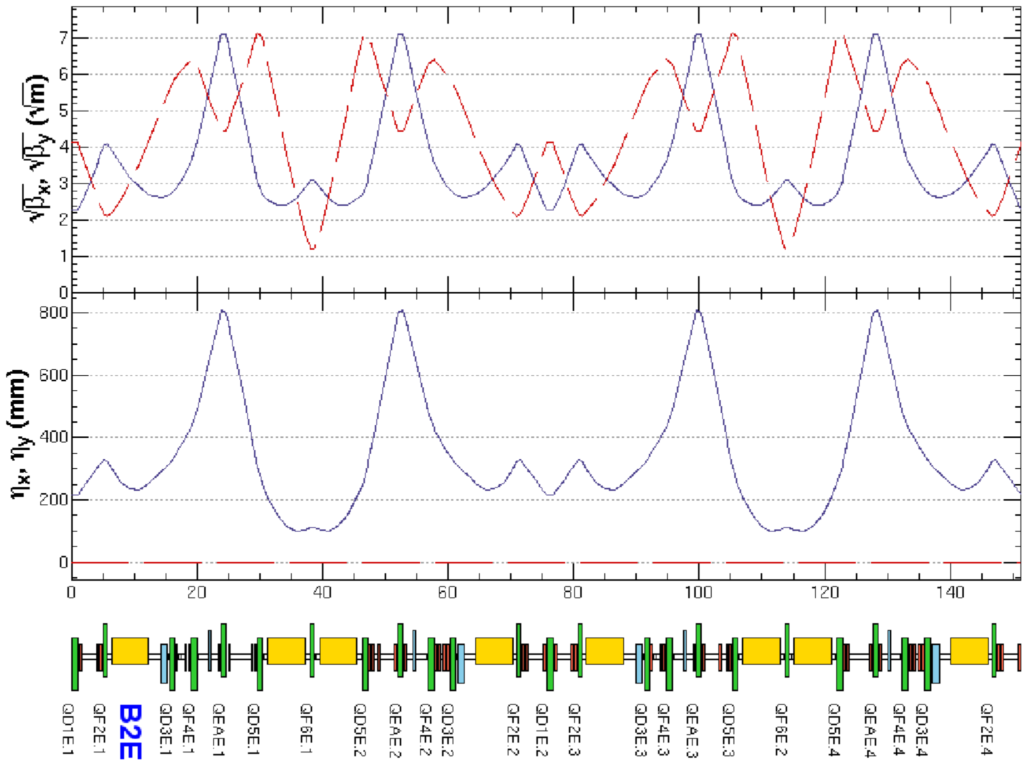
ε_x~2.2nm, α_c~3.52×10^{-4}

HER Arc Cell

- No available space for extending B2E bending magnet.



$\varepsilon_x \sim 11.0$nm



$\varepsilon_x \sim 6.08$nm

New Coupling/Dispersion Corrector[1]

- Coupling/Dispersion Corrector of KEKB
  - Normal/Skew Q field from horizontal/vertical displacement at sextupole magnets are used for coupling/dispersion corrector.
  - It is used not only for global correction but also for IP knob.
  - Corrector strength depends on sextupole strength related to optics and chromaticity correction.
  - Chromaticity of IP coupling/dispersion is not controlled.
    - These chromaticity is pointed out as source of luminosity degradation from beam-beam simulation.

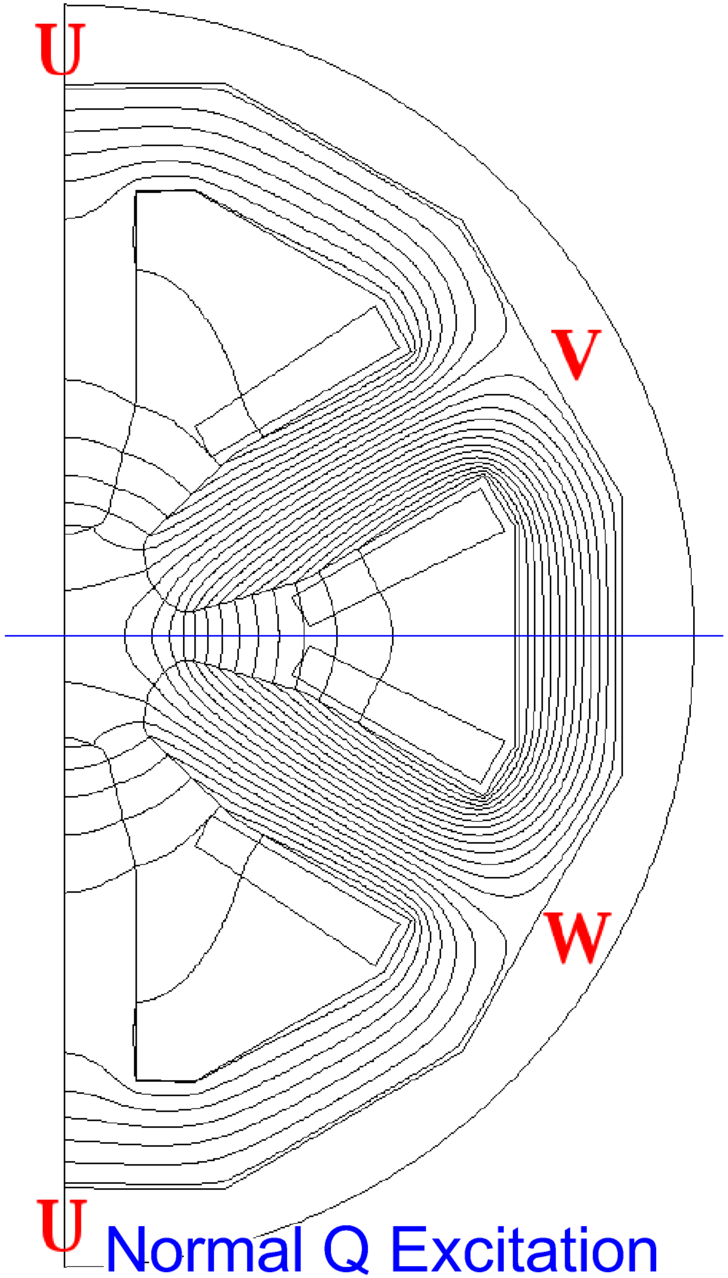
- Vertical Bump Height Limitation at SuperKEKB
  - Vertical local bump height for coupling/dispersion correction is limited by SR light direction at high currect operation with antechamber.

New corrector without vertical bump is required.

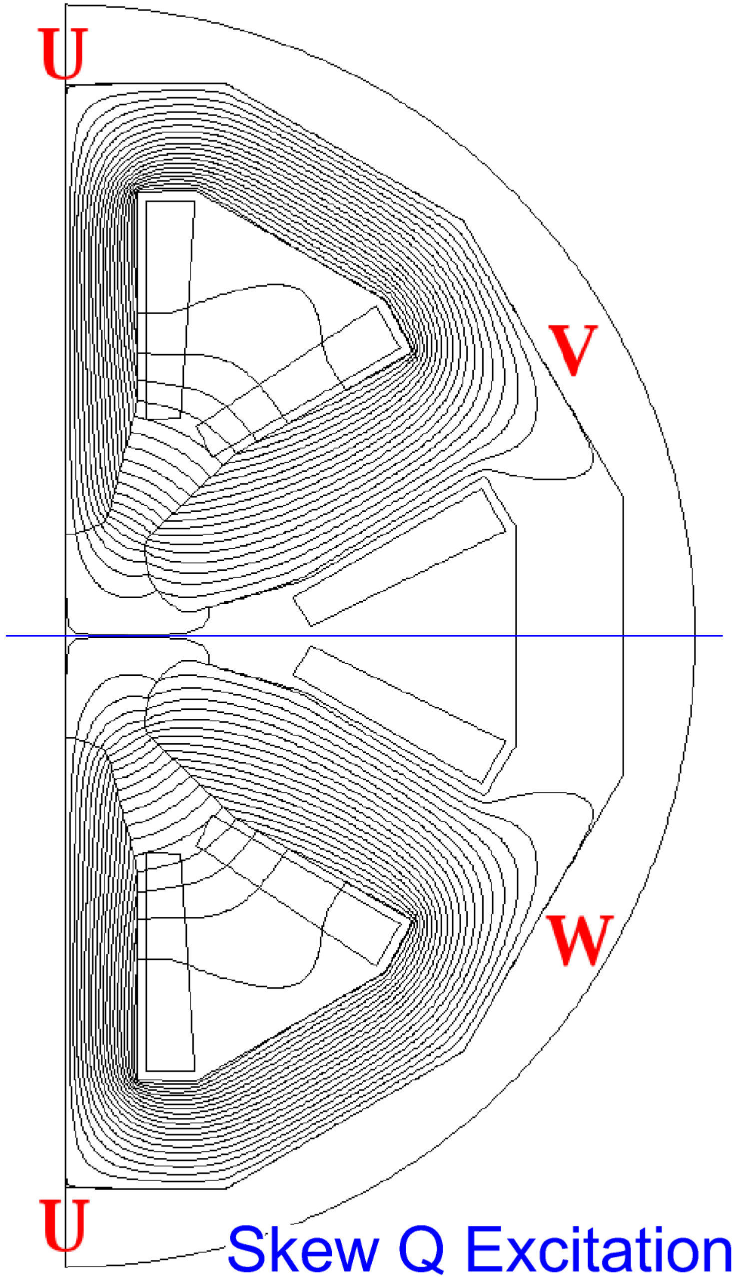
New Coupling/Dispersion Corrector[2]

- Normal/Skew Q Excitation of Sextupole
  - Auxiliary winding is already included into KEKB magnets.
    - Under testing at HER sextupole (SD7TRE.1)
  - Install new power supplies for skew quadrupole excitation.
    - Horizontal bump for normal quadrupole field could be used for SuperKEKB.
    - Individual skew quadrupole magnet may be necessary for IP coupling/dispersion knob.
- Skew Sextupole for Coupling Chromaticity
  - Installing 4 family for LER and 10 family for HER as a trial.
    - It would be imported into SuperKEKB design, if this trial succeeded.

Normal/Skew Q by using Sextupole



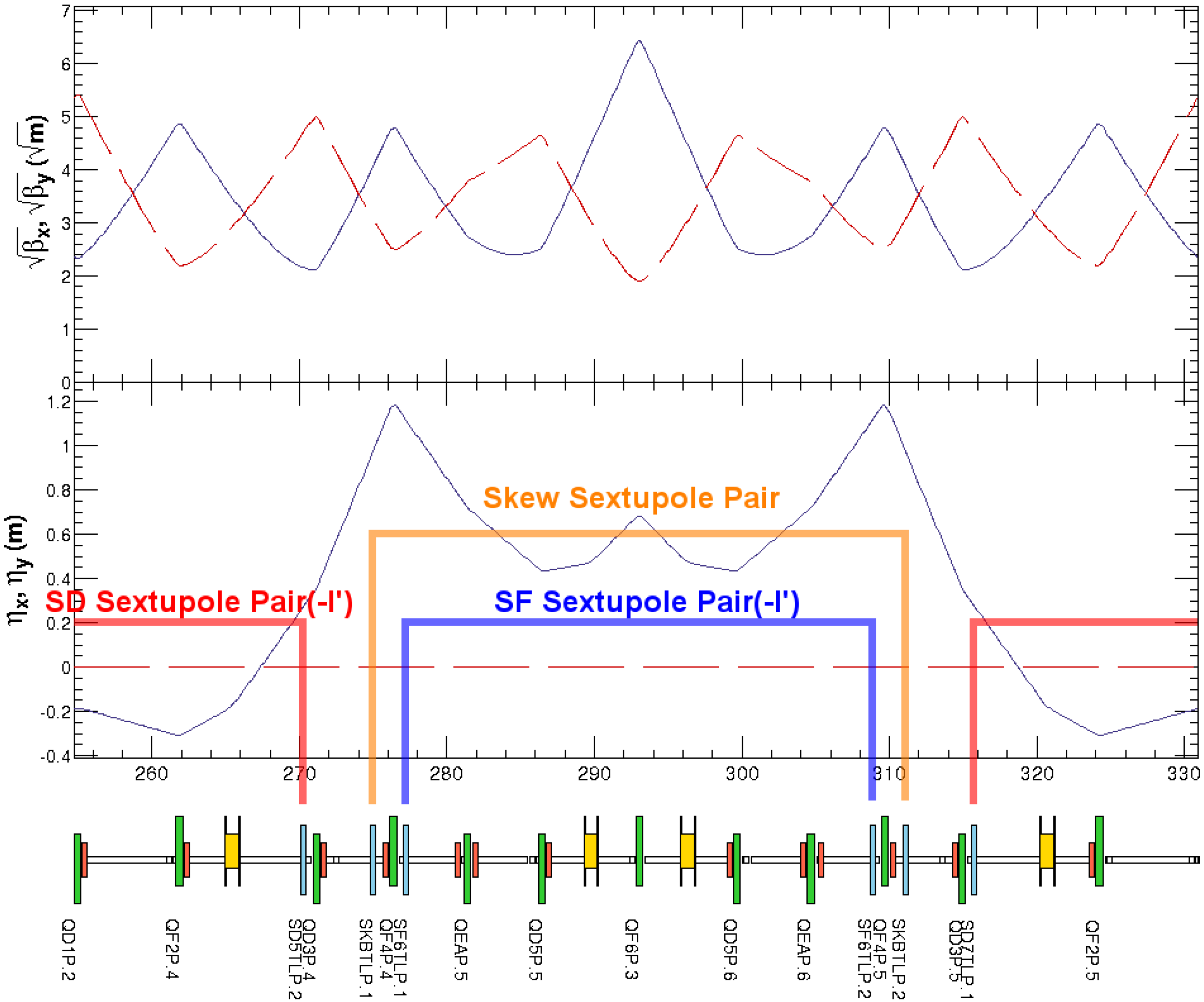
Normal Q Excitation
$I_U = 0, I_V = -I_W$



Skew Q Excitation
$I_U = -I_V = -I_W$

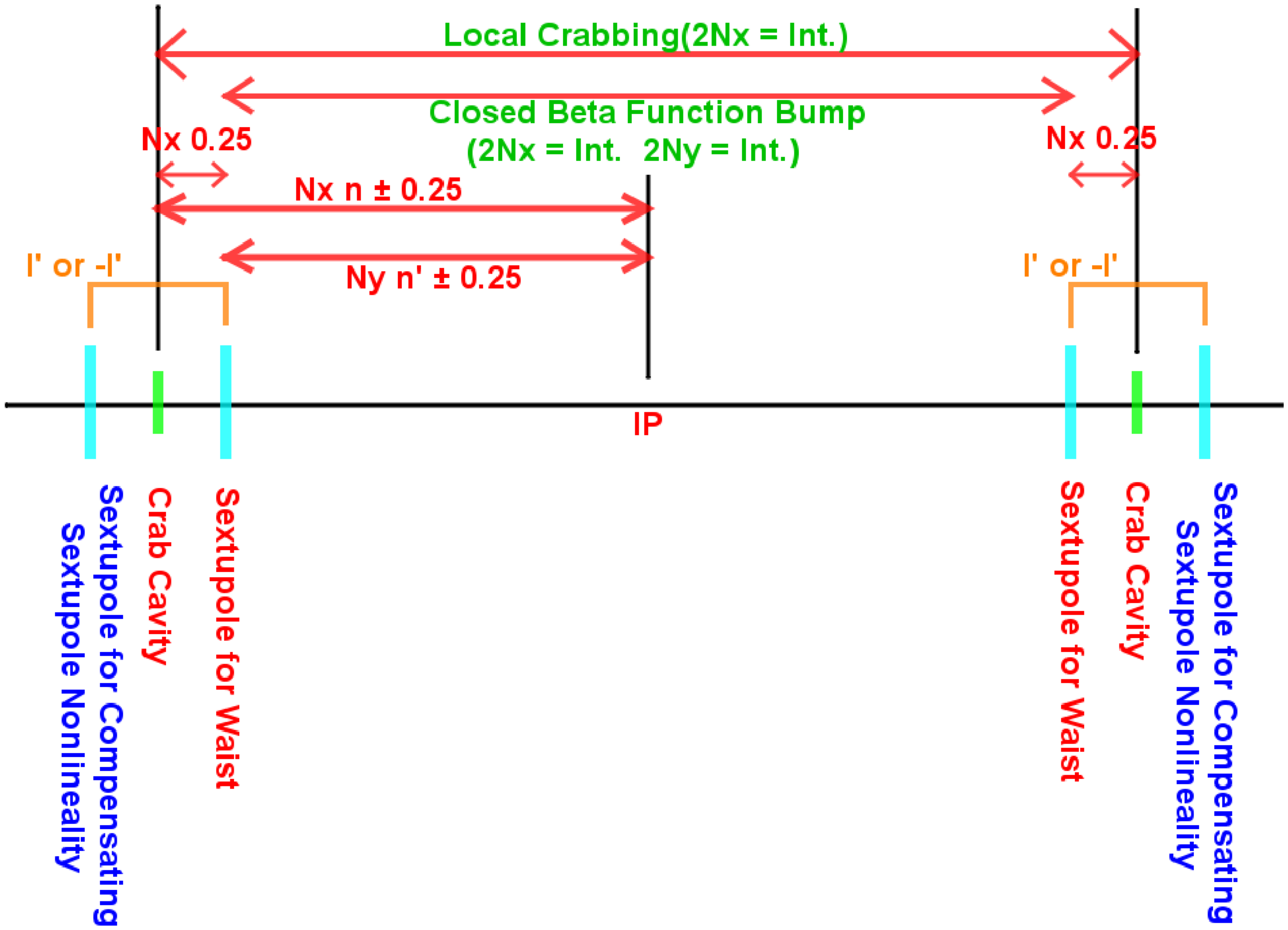
Skew Sextupole for KEKB

- Replace unused vertical steering magnet for QF4 with skew sextupole.

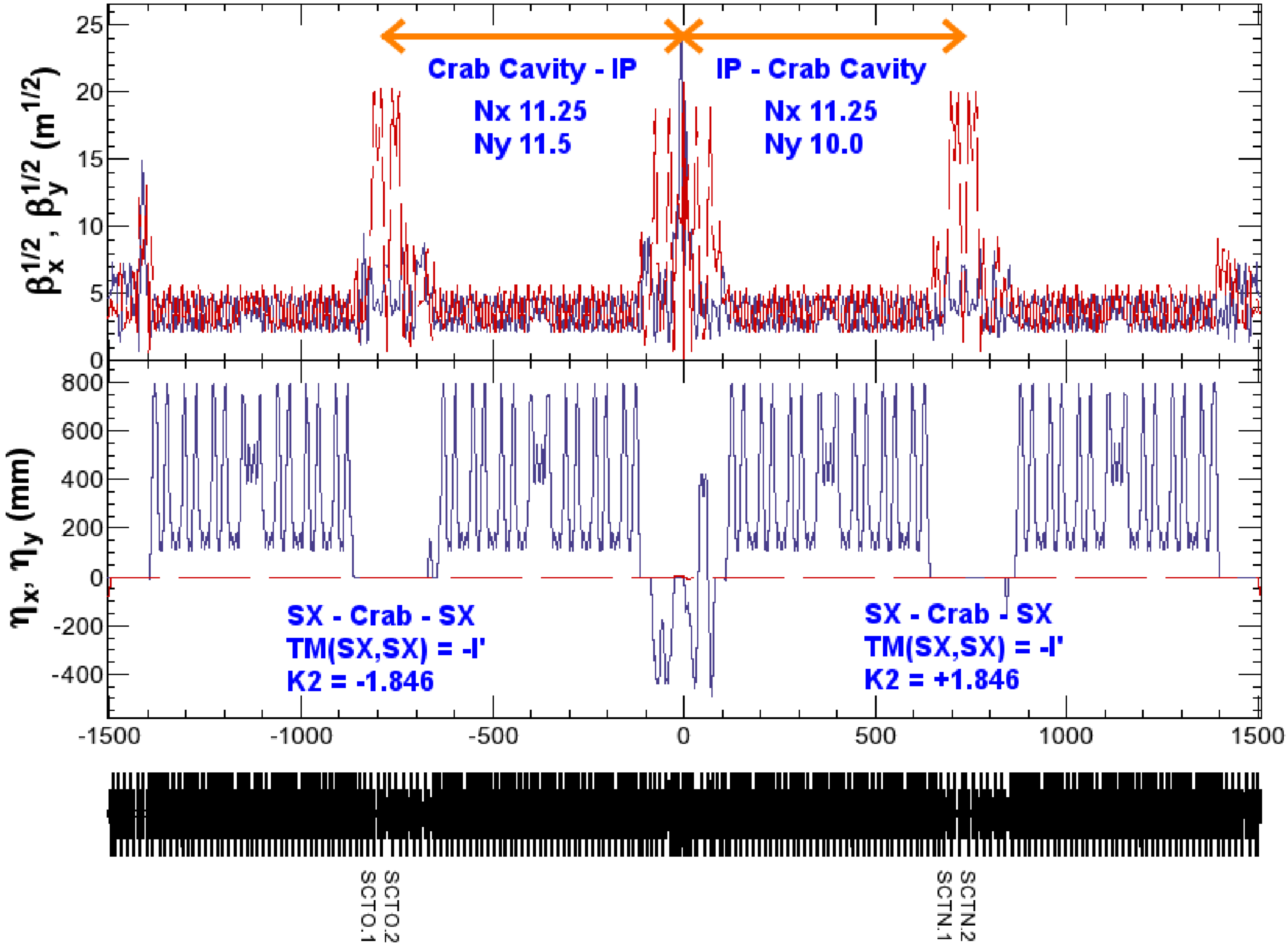


Travel Focus

Travel Focus = Crab Crossing + z-dependent Waist
Crab Crossing = z-dependent horizontal displacement
z-dependent Waist = z-dependent β function
= z-dependent horizontal displacement + Sextupole



LER Travel Focus Example[1]



- New cryogenic infrastructure is required for OHO.

LER Travel Focus Example[2]

- Install 2 set of 'SX-Crab-SX' unit into NIKKO
  - Required number of quadrupoles for 'SX-Crab-SX' unit
    - 2 for Crab Cavity βx, ϕx(IP-C.C.)
    - 1 for Sextupole ϕy(IP-SX)
    - 1 for ϕx between Sextupole and Crab Cavity
    - 4 for -I' cell condition($\Delta\phi$x = $\Delta\phi$y = π, βx, βy)
    - 1 for Sextupole βy
  - Required number of quadrupoles for Twiss/Tune matching
    - 4 for Twiss parameter matching(βx, βy, αx, αy)
    - 2 for betatron tune matching(νx, νy)
- Total 24 quadrupoles are required.
  - This is possible.
    - 25 quadrupoles in NIKKO, OHO.
    - 28/36 quadrupoles in FUJI/TSUKUBA.
  - Implement & Operation would be difficult.
    - Interference with HER magnets should be solved.
    - Tune must be controlled by quadrupoles between crab cavities.