Optics Issues

Hiroshi Sugimoto
for Optics Group

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Optics Design Issues Except for IR

Machine Parameters

- Change LER vertical tune from 44.57 to 44.57

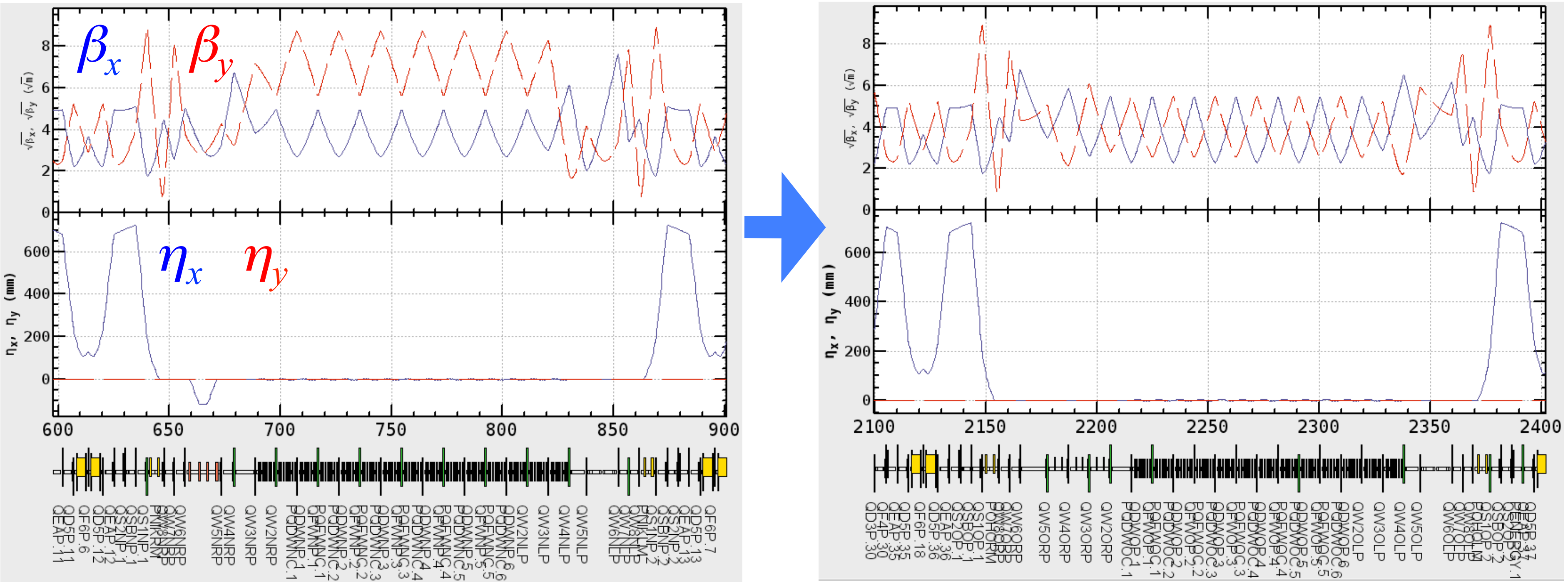
	LER	HER
Energy (GeV)	4.0	7.00729
Current (A)	3.6	2.6
#of bunches	2500	2500
β_x^* (mm)	32	25
β_y^* (mm)	0.27	0.30
ε_x^* (nm)	3.2	4.6
ε_y^* (pm)	8.64	11.5
σ_z^* (mm)	6	5
ν_x , ν_y	44.53 , 46.57	45.53 , 43.57
ν_s	-0.0247	-0.0280
ξ_y	0.0881	0.0807
Luminosity (10^{34} cm^{-2} s^{-1})	8×10^{35}	

LER Optics Changes - Wiggler Section -

- Vertical beta is suppressed to mitigate the beam-gas scattering effects.
- Integer part is increased by 2 while keeping the fractional part.

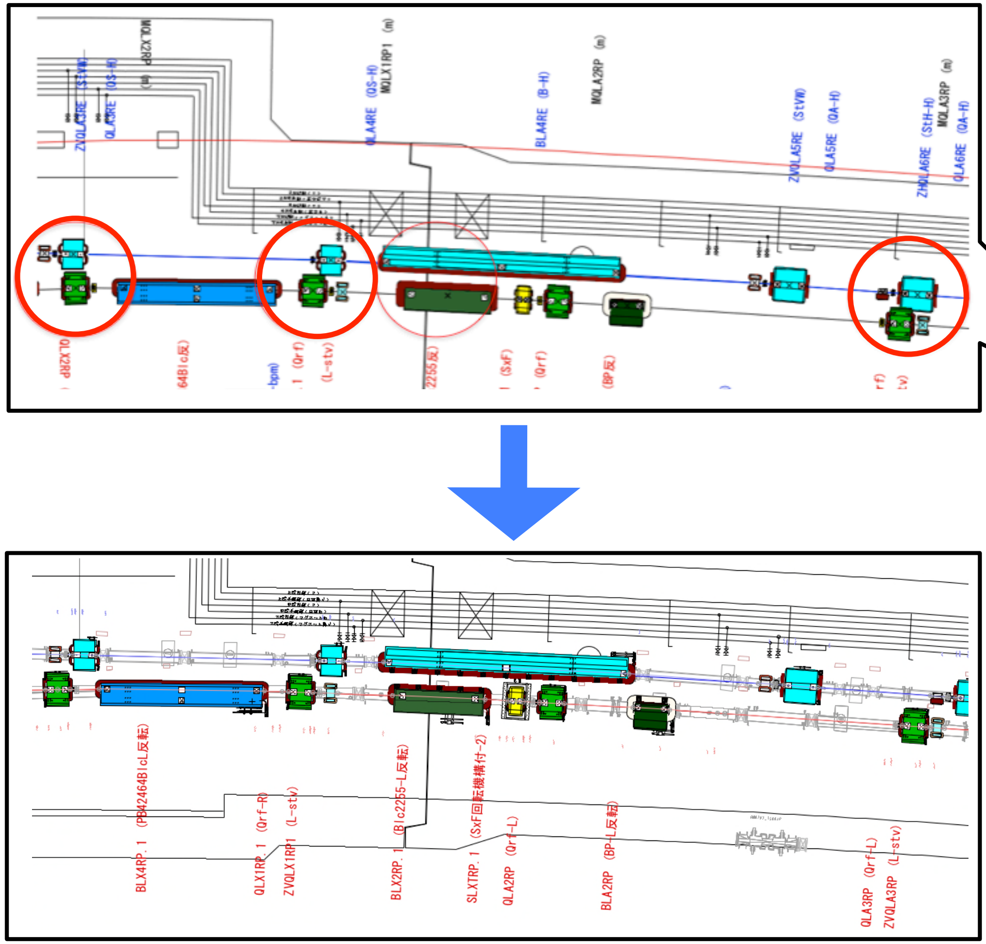
$$\left(\nu_x, \nu_y\right) = \left(44.53,\ 44.57\right) \quad \Rightarrow \quad \left(44.53,\ \underline{46.57}\right)$$

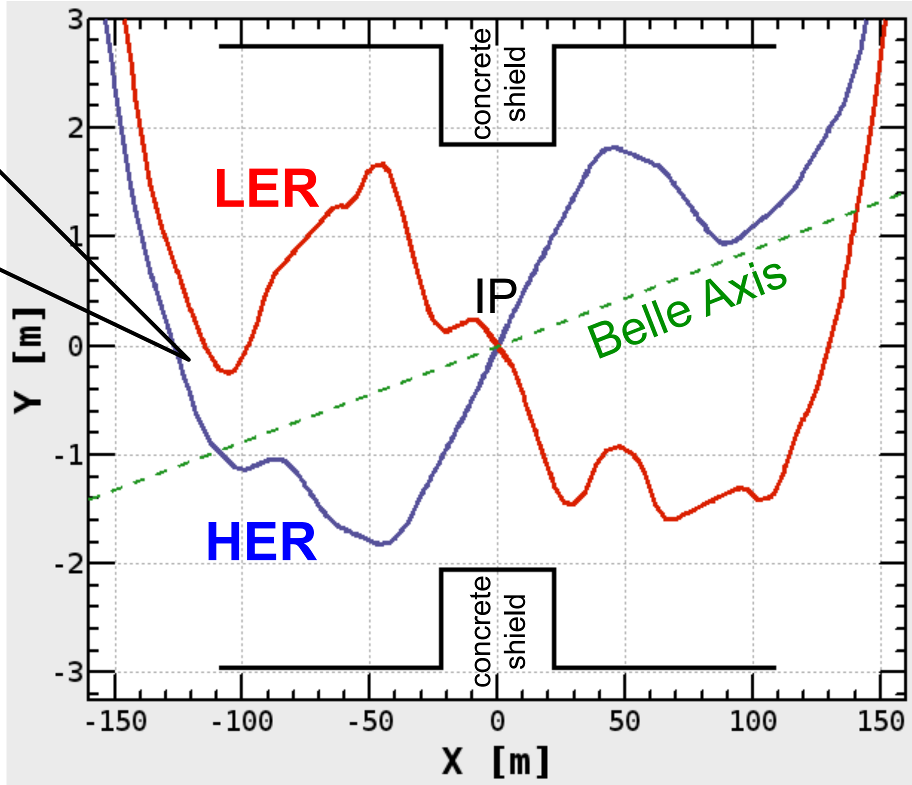
Old **New**



Tsukuba Straight Line is Finalized

- Interference problem between LER&HER has been resolved while keeping optics, orbit length and IP geometry.





Off 4S Operation

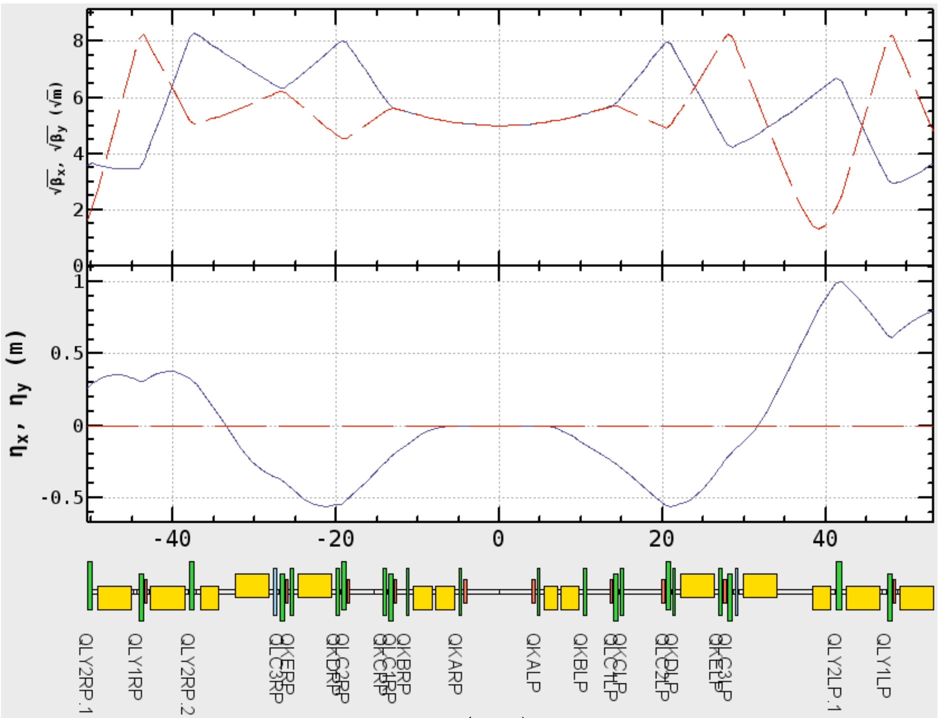
- Capability of off-4S operation is confirmed considering limitation of magnet field strength.
- Optics and hardware design is carried so that keep the capability.

	E_{CM} (GeV)	$\Delta E/E_{CM}(4S)$	LER (GeV)	HER (GeV)
1S	9.46030	-10.58 %	3.577	6.266
2S	10.02326	-5.25 %	3.790	6.638
3S	10.35520	-2.12 %	3.915	6.852
4S	10.57940	-	4.000	7.007
5S	10.87600	+2.80 %	4.112	7.204
6S	11.01900	+4.16 %	4.166	7.298

Phase 1 - Linear Optics -

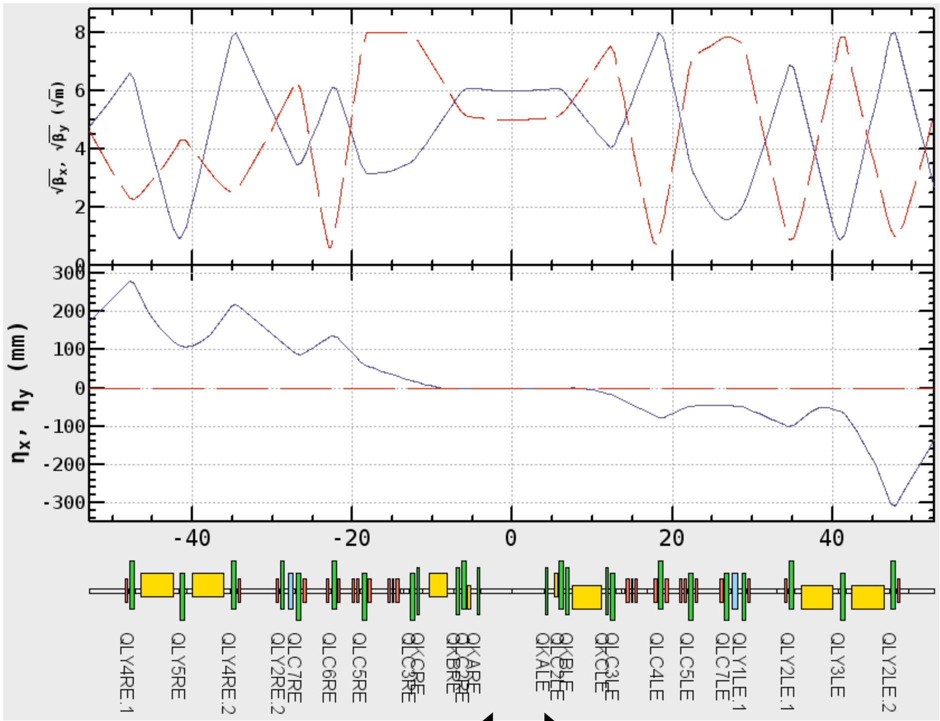
- Optics W/O QCS and solenoid has been designed
- QCS and solenoid is replaced by drift space.
- Machine tuning except for IR is expected to be done in this phase.

LER



Drift

HER



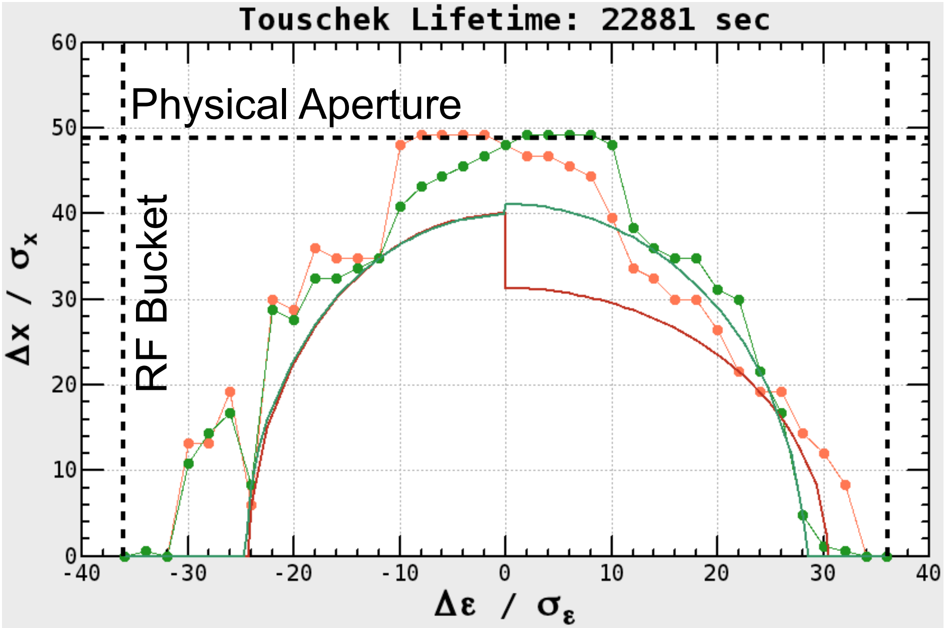
Drift

Phase 1 - Dynamic Aperture -

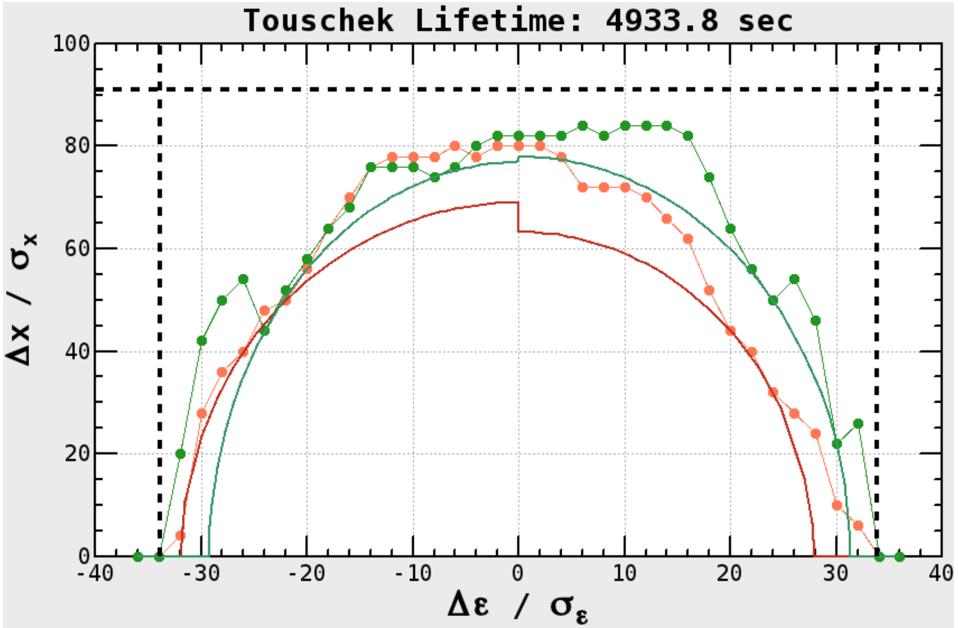
- DA example assuming,
  - Design bunch current.
  - 2% emittance ratio.
- Beam loss estimation is ongoing from view point of radiation protection.

→ Funakoshi-san's talk

HER Touscheck Life ~6.3 hours

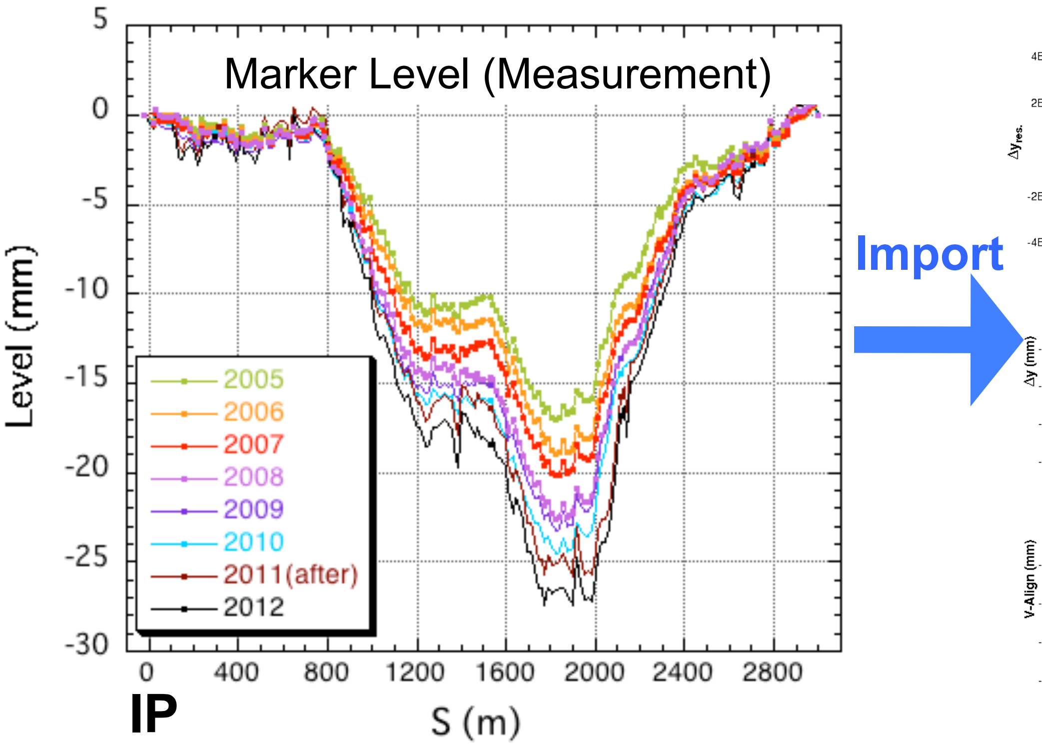


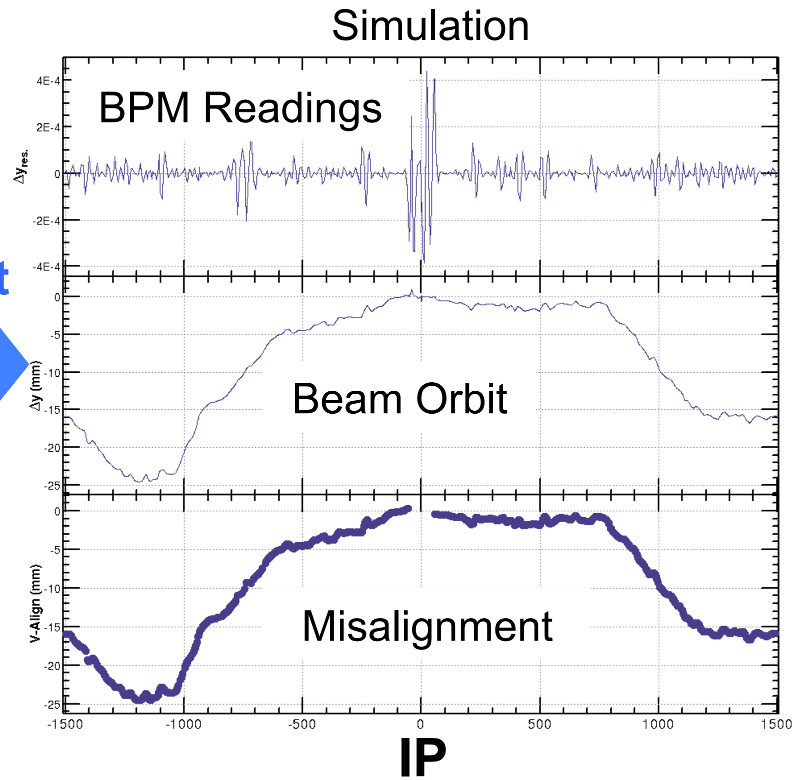
LER Touscheck Life ~1.4 hours



Simulation of Tunnel Subsidence

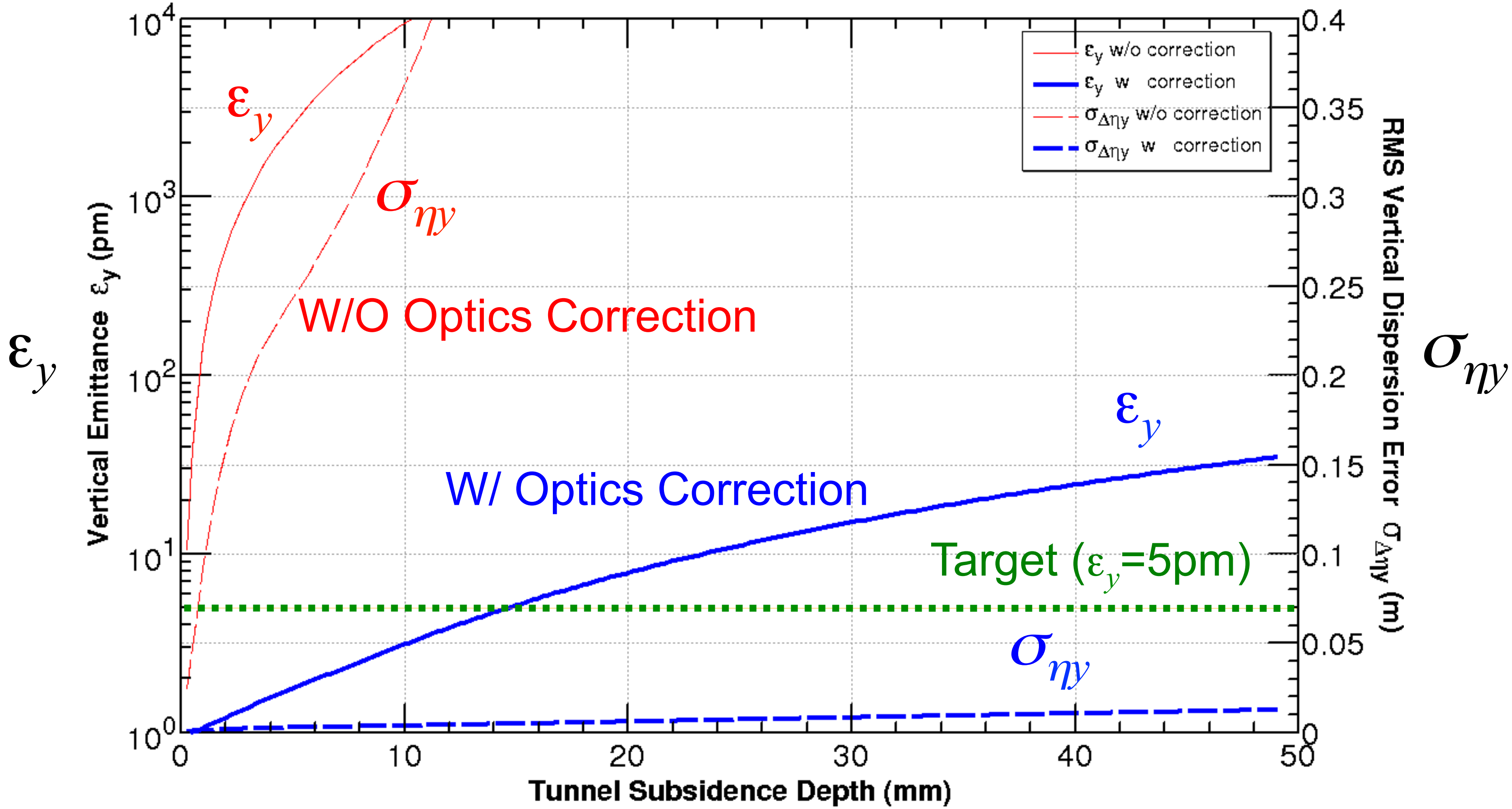
- The subsidence effect is investigated with numerical simulation.
- Put the subsidence to design lattice as a vertical misalignment of each magnet.





- Change amplitude of misalignment, and evaluate vertical emittance.

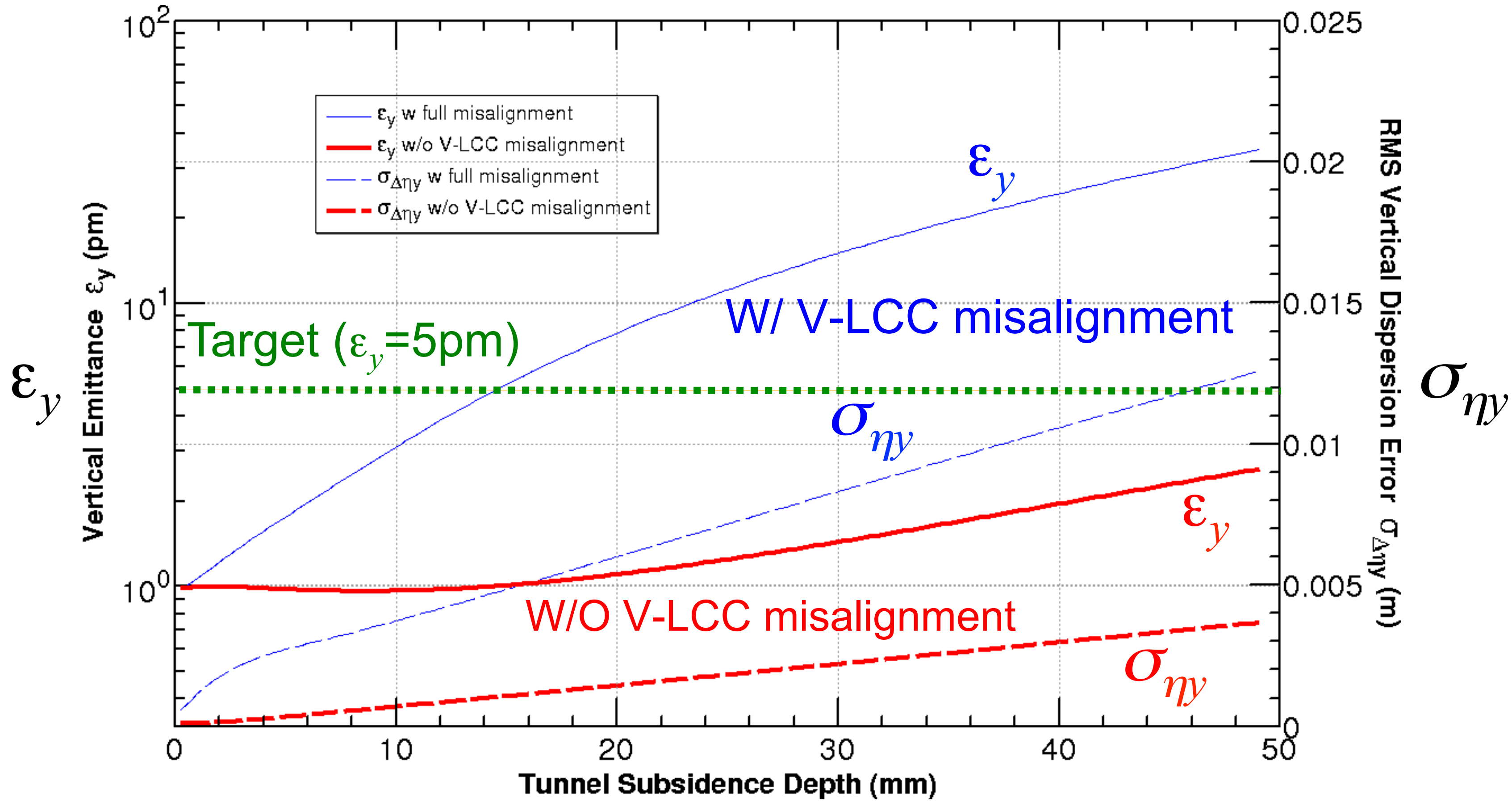
Simulation of Tunnel Subsidence (cont'd)



- Vertical emittance exceeds the target values, 5pm, after 7 years when 2mm/year is assumed.

Simulation of Tunnel Subsidence (cont'd)

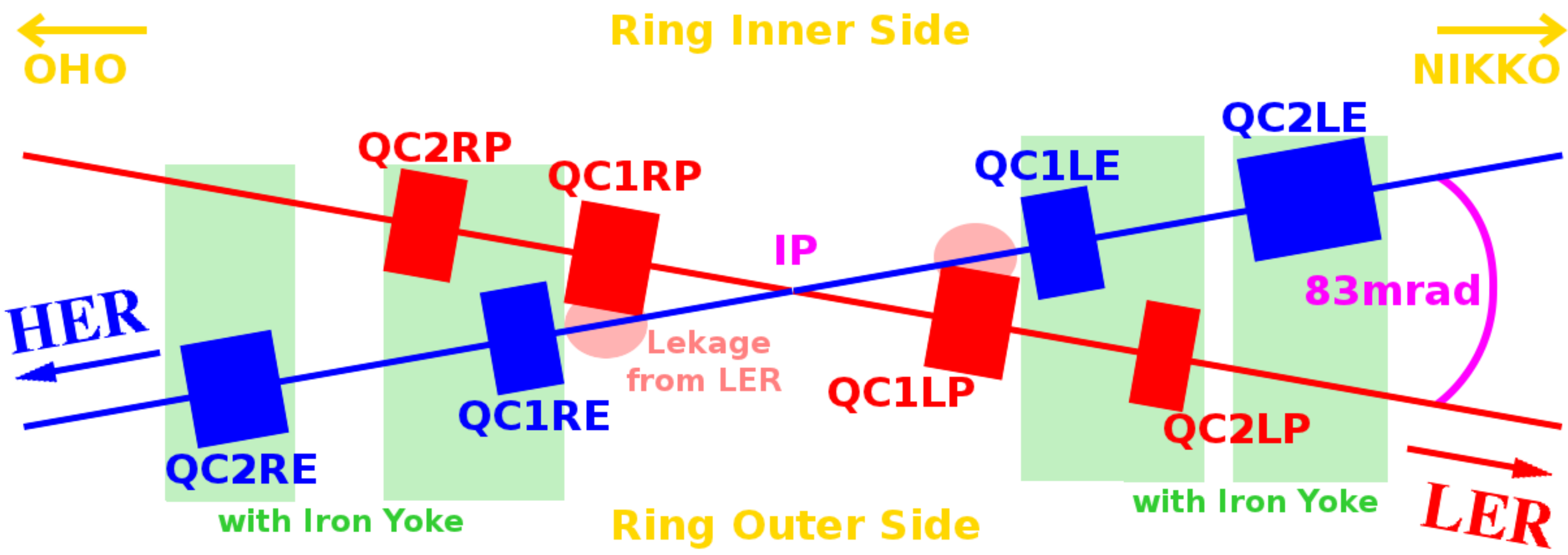
- What is the most dominant source of emittance dilution?



- V-LCC misalignment has very critical impact on emittance.
- Need special care for orbit control or/and alignment in this region.

IR Optics Design

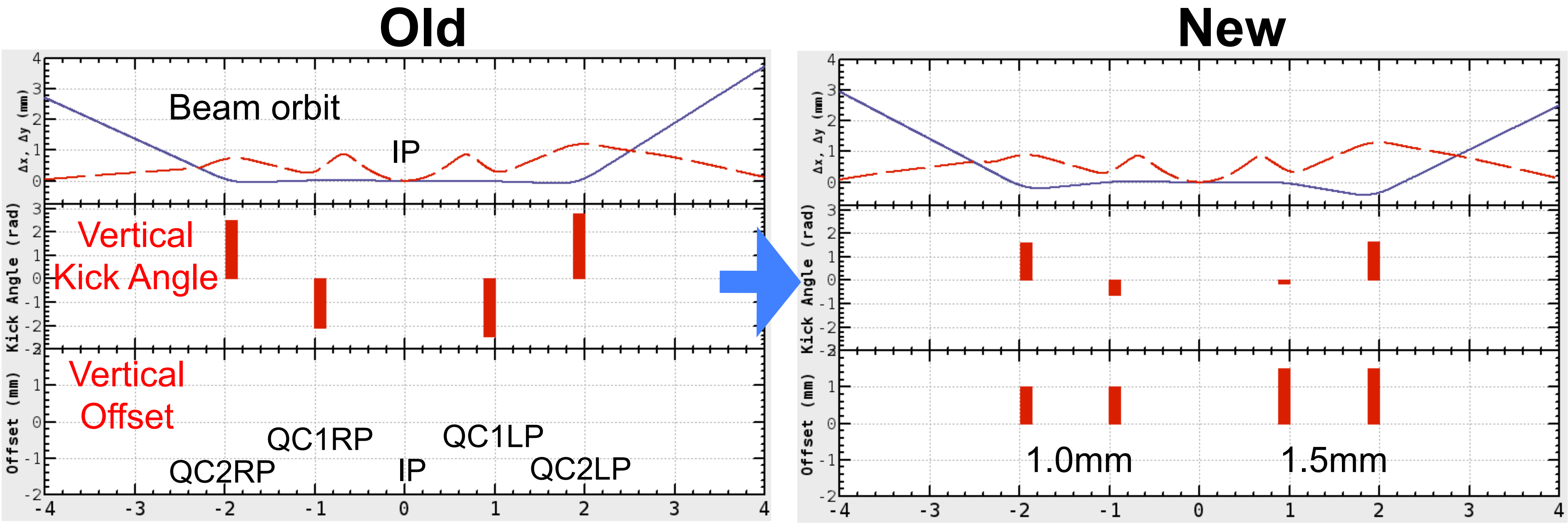
IR Design



- All quadrupoles except for QC1P have iron yoke for preventing field leakage to the another beam line
- Canceller coils are installed for HER beam line to suppress leakage filed from LER QC1 magnet.
- All magnets have super-conducting corrector coils.
  - Normal&Skew Dipole, Skew Quad, Octupole

IR Design Upgrade

- LER QCs now have vertical offset to reduce dipole corrector strength.



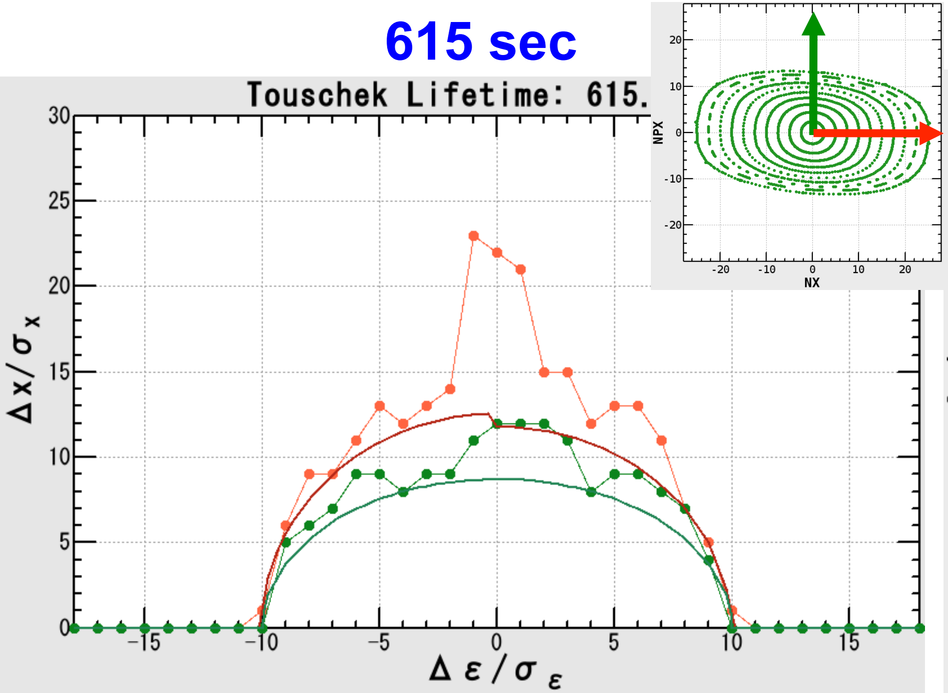
Vertical Kick Angle

Magnet	QC1LP (mrad)	QC2LP (mrad)	QC1RP (mrad)	QC2RP (mrad)
Old	2.472	2.746	-2.082	2.491
New	**-0.149**	**1.651**	**-0.644**	**1.602**

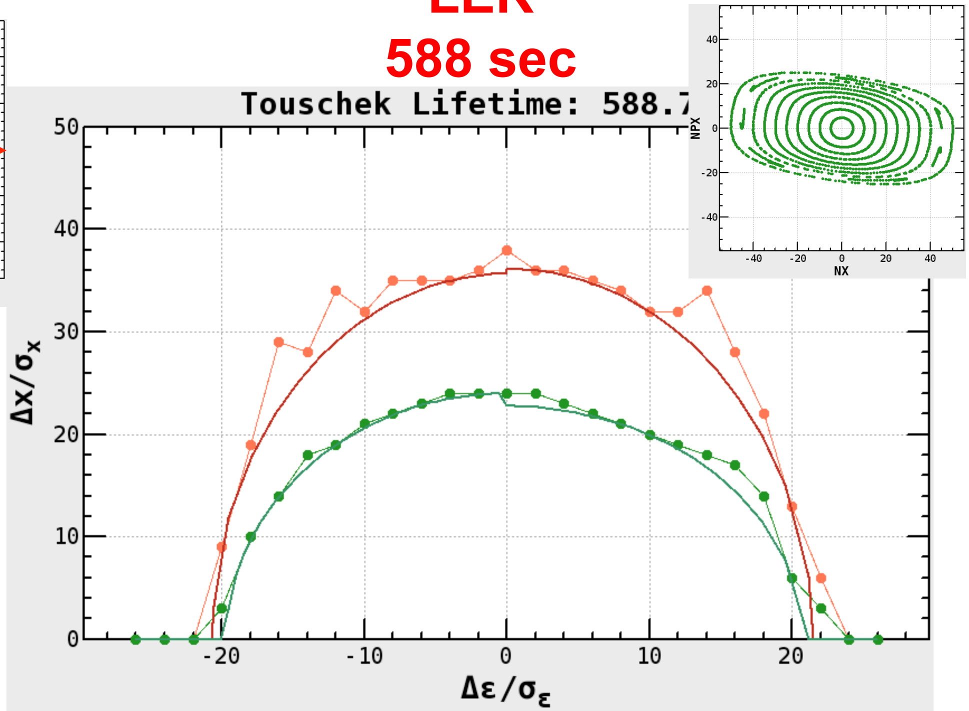
Dynamic Aperture & Touschek Lifetime

- Touschek lifetime is optimized with Down-hill simplex method.
- Available knobs are 54 sextupole families and 4 octupole magnets.
- Lifetime of both beams is almost reached the target value, 600 sec.

HER
615 sec



LER
588 sec



Error Field from QCS

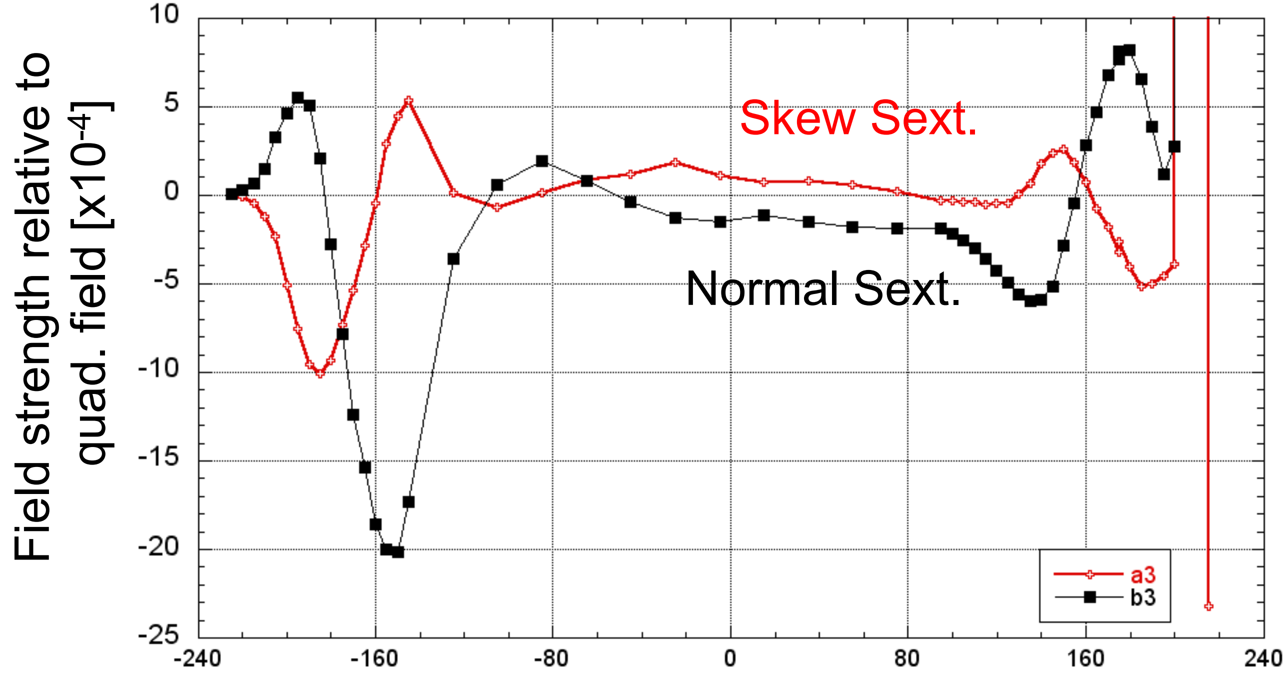
Field Measurements of QCS Prototype

- Unexpected normal&skew sextupole have been observed.

→ Ohuchi -san's talk

- Their magnetic field strength is ~0.1% of quadrupole field.

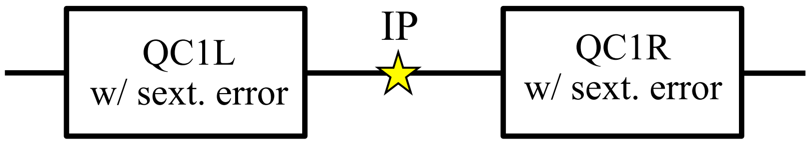
Field profile along QC1P

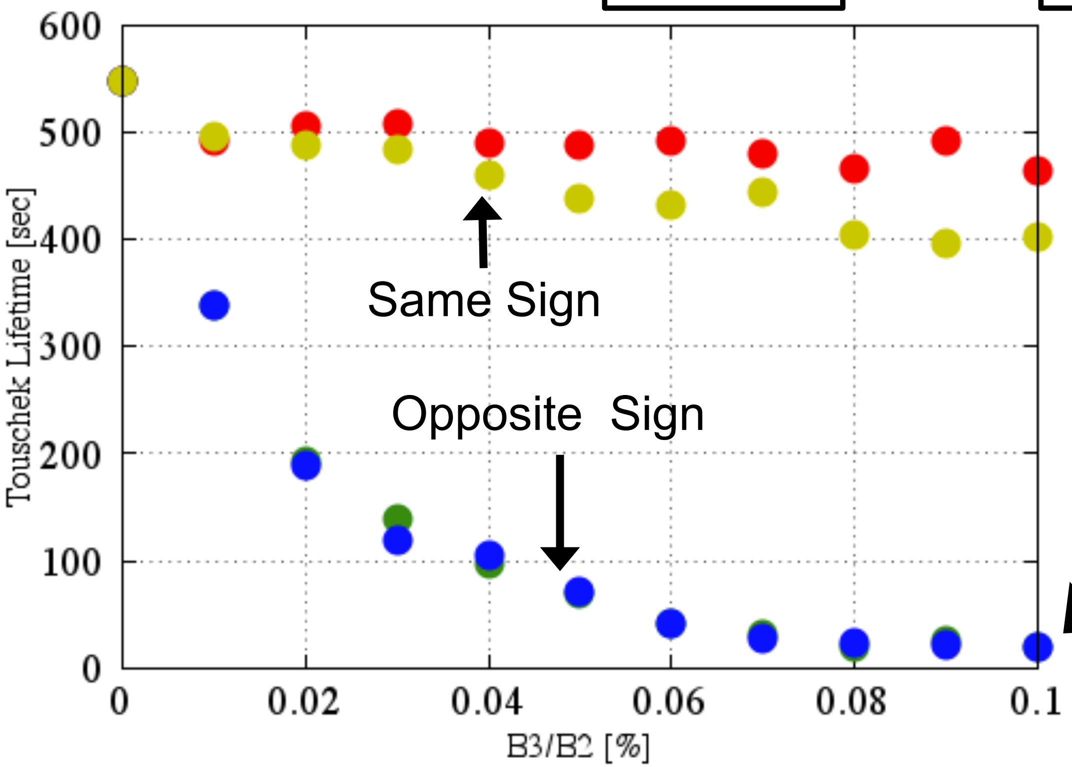


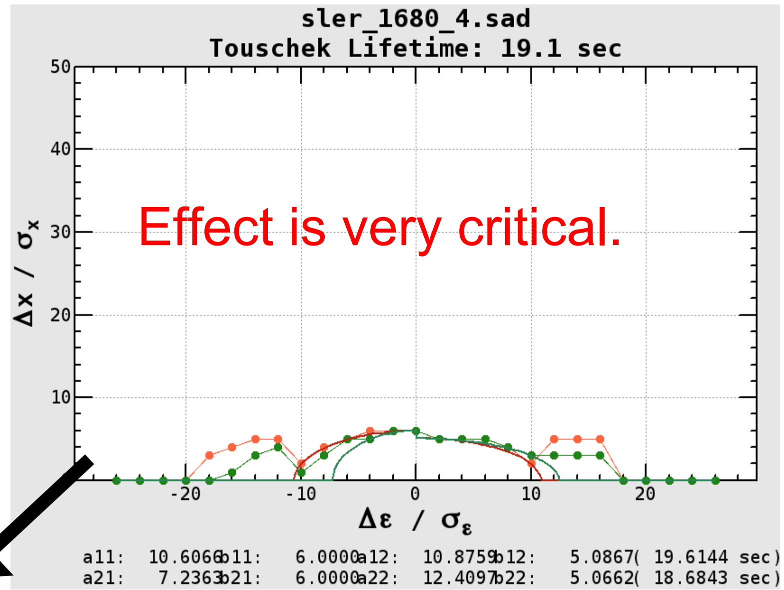
- Impact on dynamic aperture has been investigated.

LER DA with Normal Sextupole Error Field

- Thin lens Sextupoles are inserted to QC1L and QC1R.
- There magnitudes are same, but signs are independent.
- Evaluate DA for 4 possible combinations of sign at each error field strength.

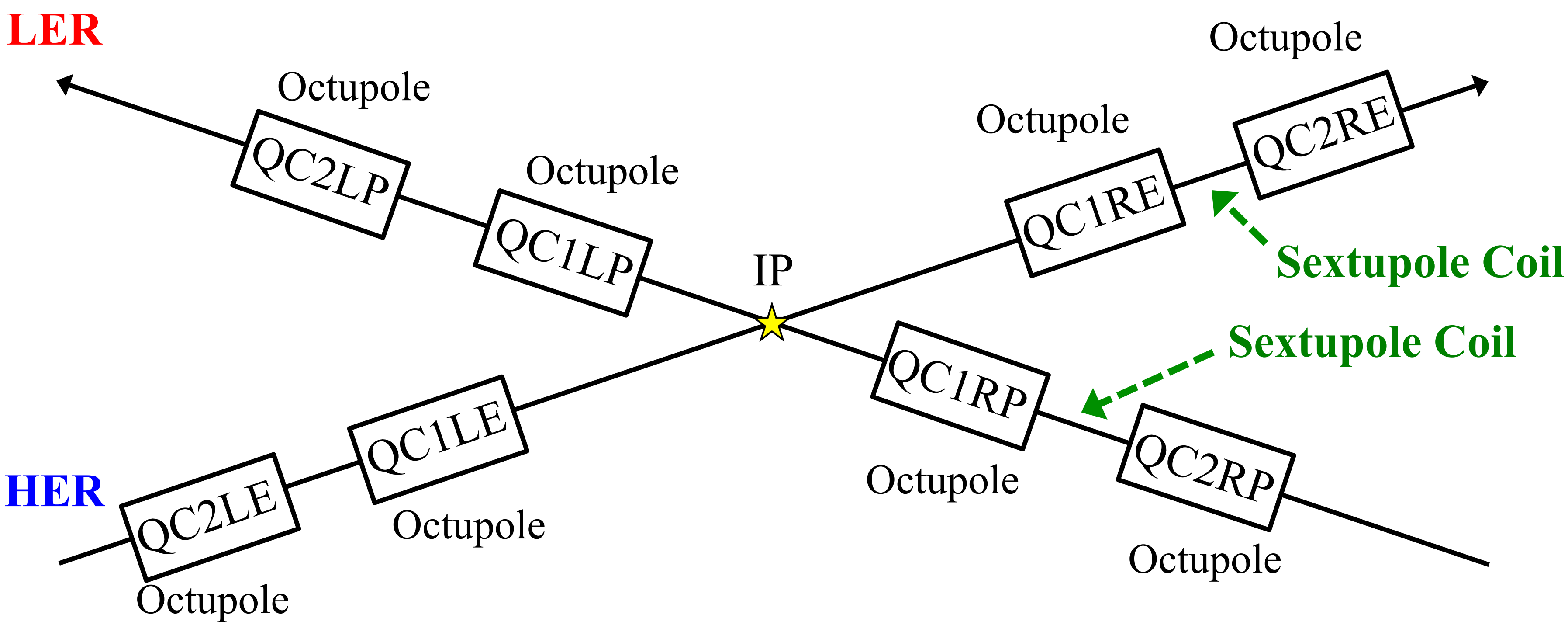






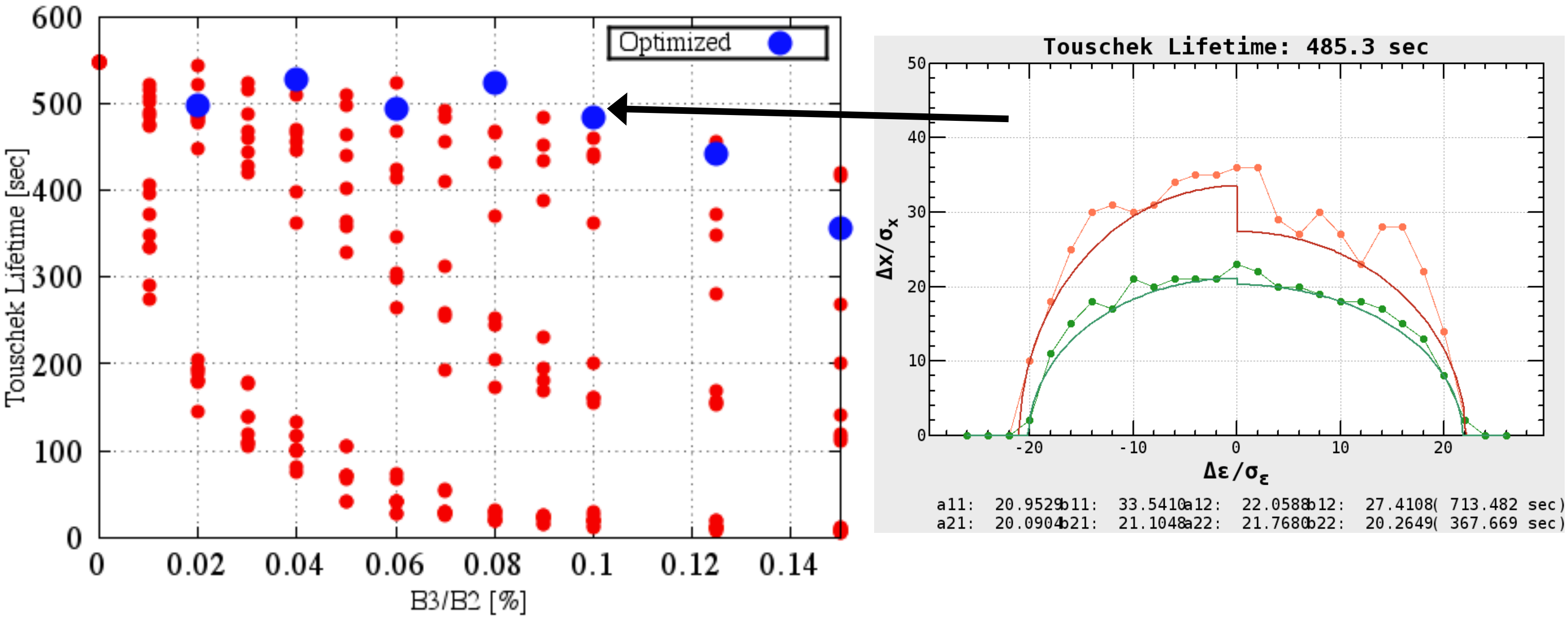
Sextupole Corrector Coil

- Only R-size design can be changed. (L-size is already fixed)
- No more space for installing the corrector to QCS itself.
- We are considering installation between QC1R and QC2R.



DA Improvement by Corrector Coil

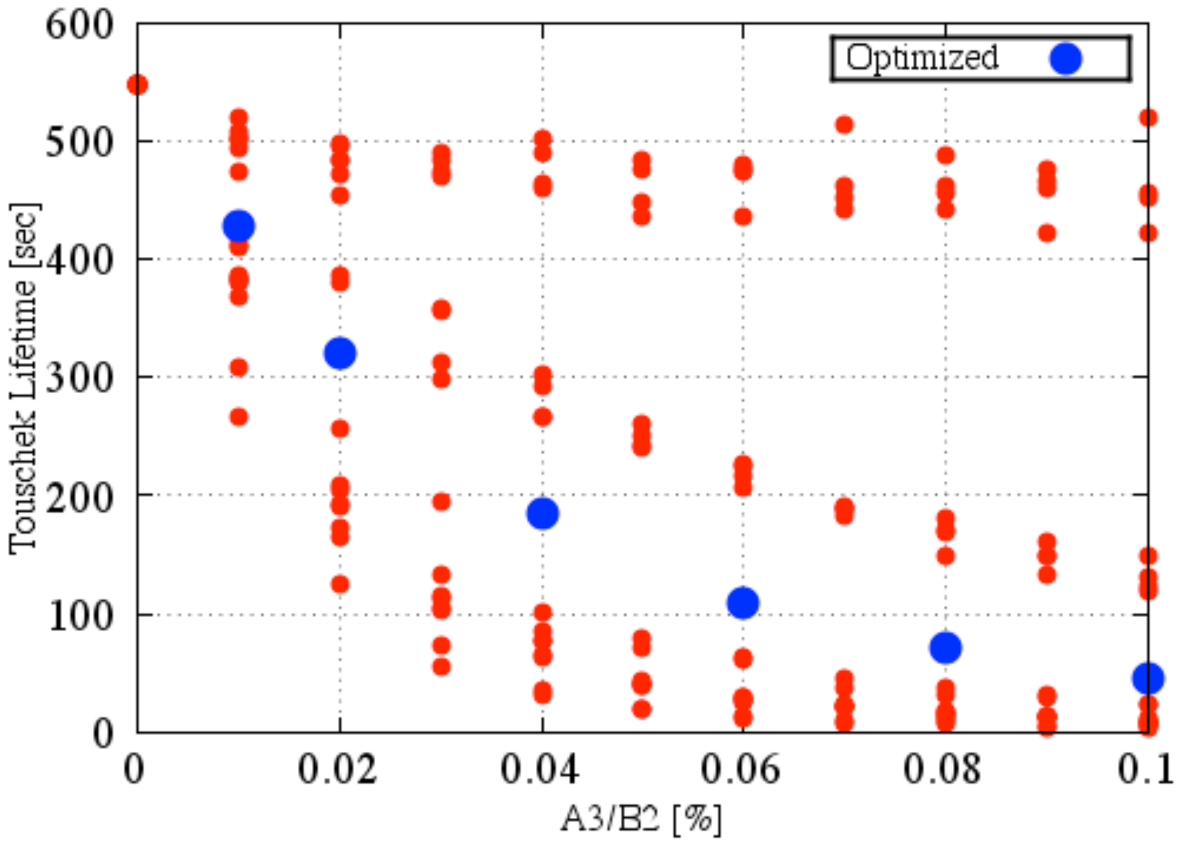
- Introduce sextupole error to ALL QCs.
- Check whether we can mitigate DA degradation by optimizing the corrector strength.



- DA degradation is improved, but B3/B2 < 0.1% is preferable.

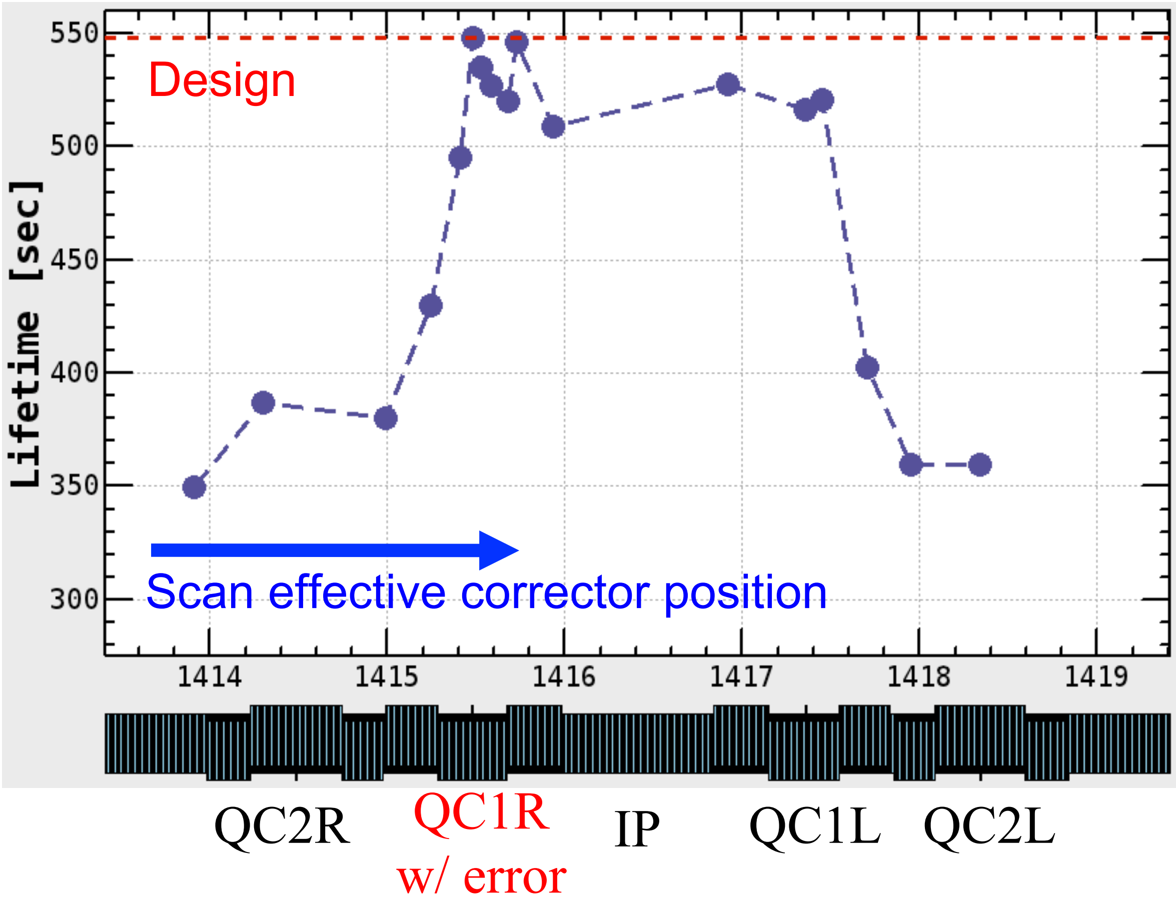
Skew Sextupole Error Field

- Analogous calculation for skew sextupole error field.
- Different feature compared to the normal sextupole case.
- DA Improvement is not enough level.



Lifetime and Corrector Coil Position

- DA survey with changing corrector position.
- Only QC1RP has skew sextupole error.

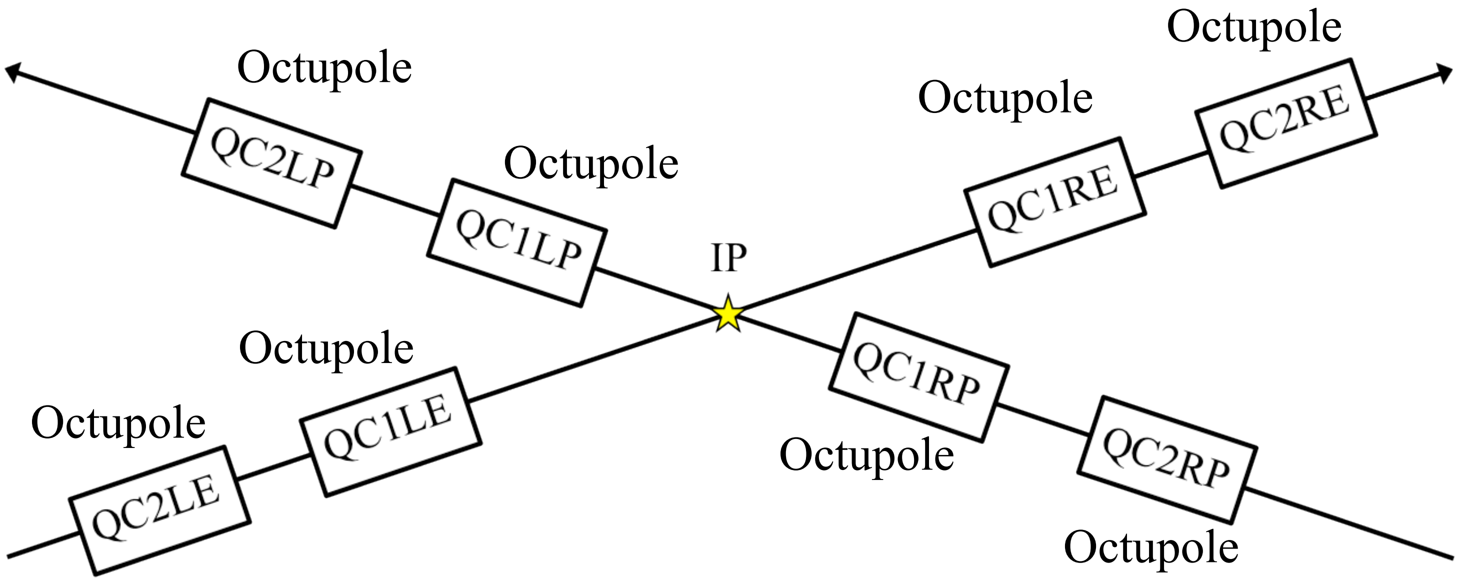


- Corrector coil must be installed between QC1L & QC1R

Design Change Strategy

Points to be considered.

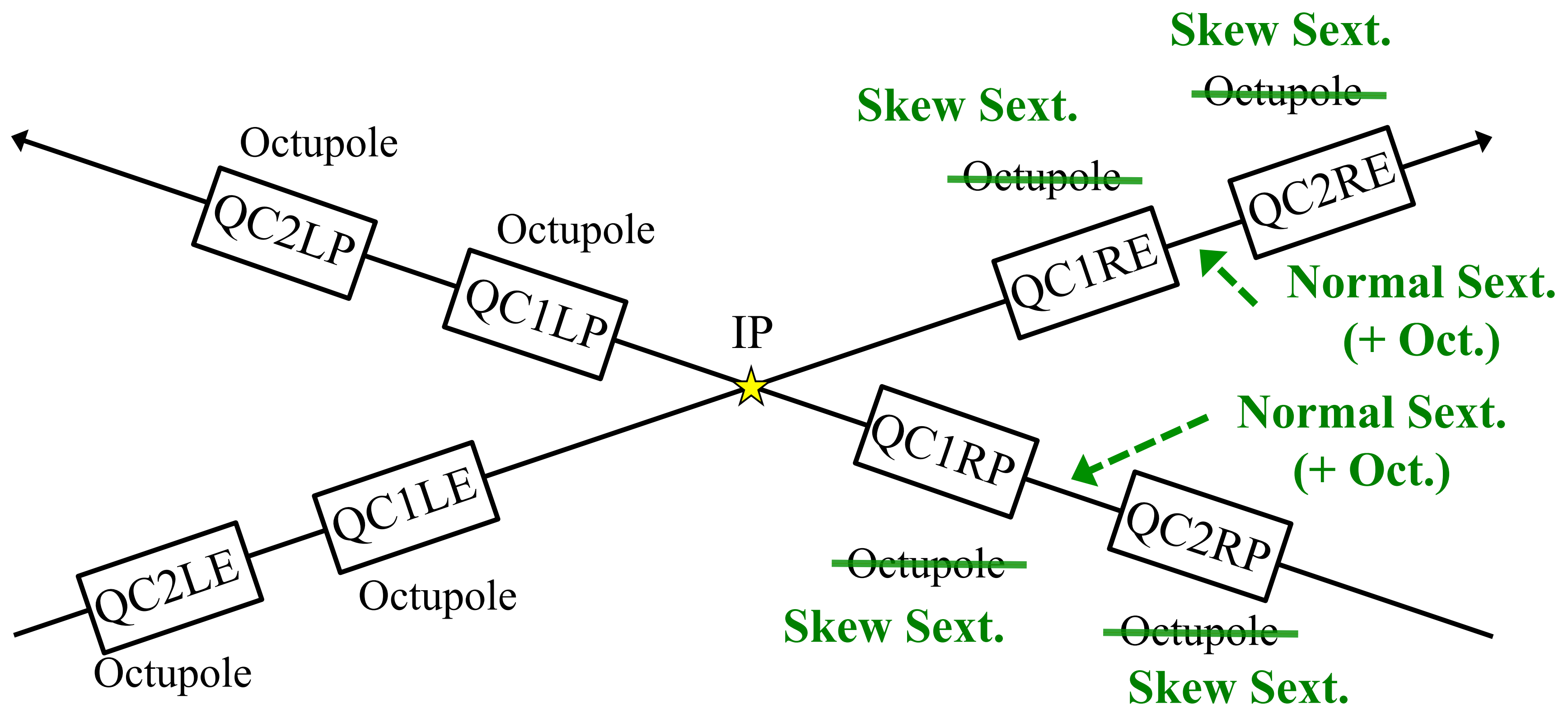
- Need 1 normal sextupole corrector.
- Need 2 skew sext. correctors.
- One of skew sext. must be installed to QC1R.
- Each QC can have only one corrector coil
- Possible to install additional coil between QC1R and QC2R.



R-side Design Change Plan (Not Fixed Yet)

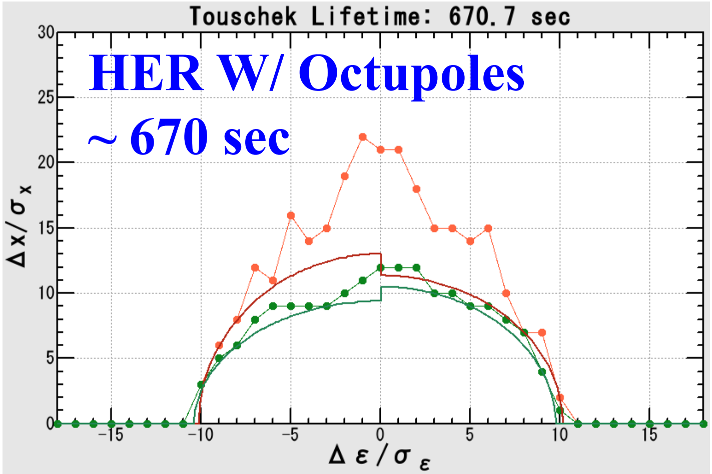
Possible Plan

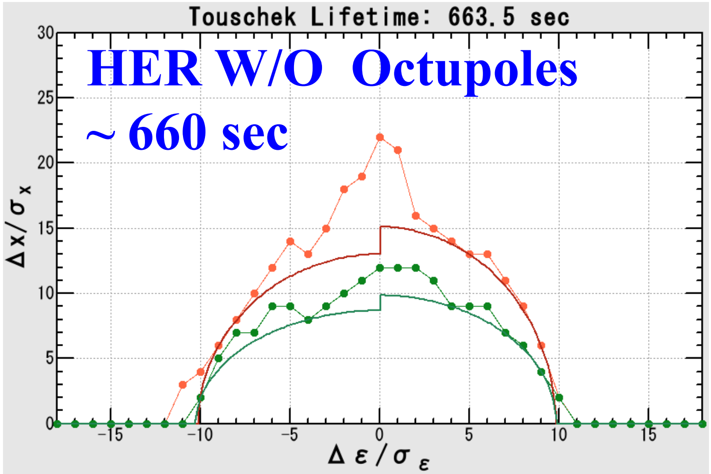
- Install normal Sext. coil (+octupole) to between QC1 and QC2.
- Install skew Sext. coil to both QC1 and QC2 instead of octupoles.

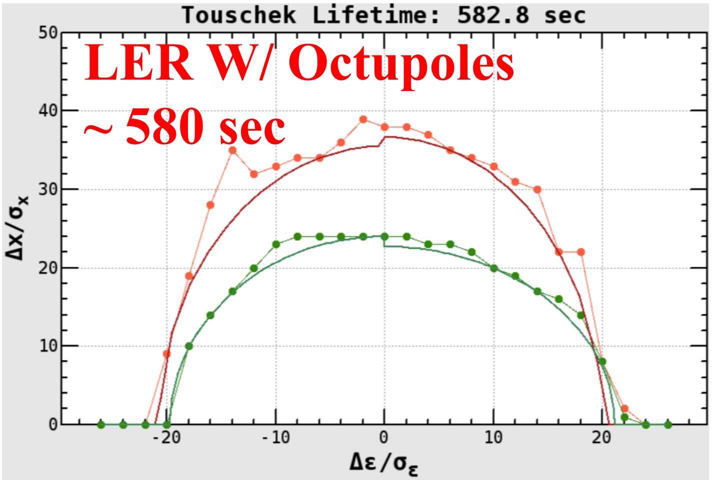


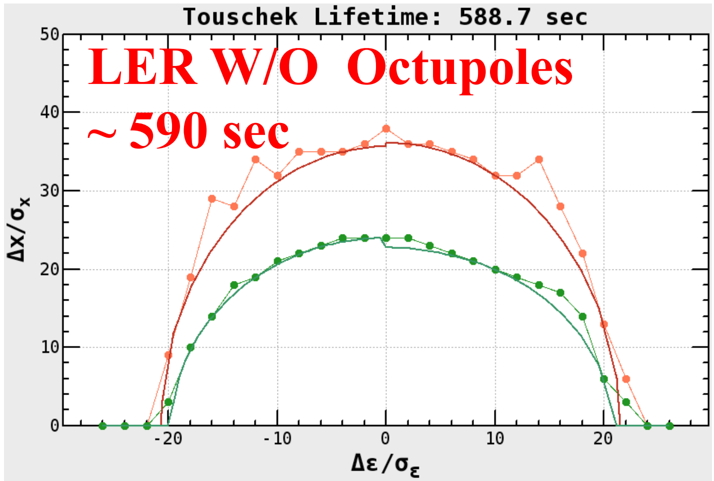
DA W/ and W/O R-side Octupoles

- Touschek lifetime estimated by DA seems OK.









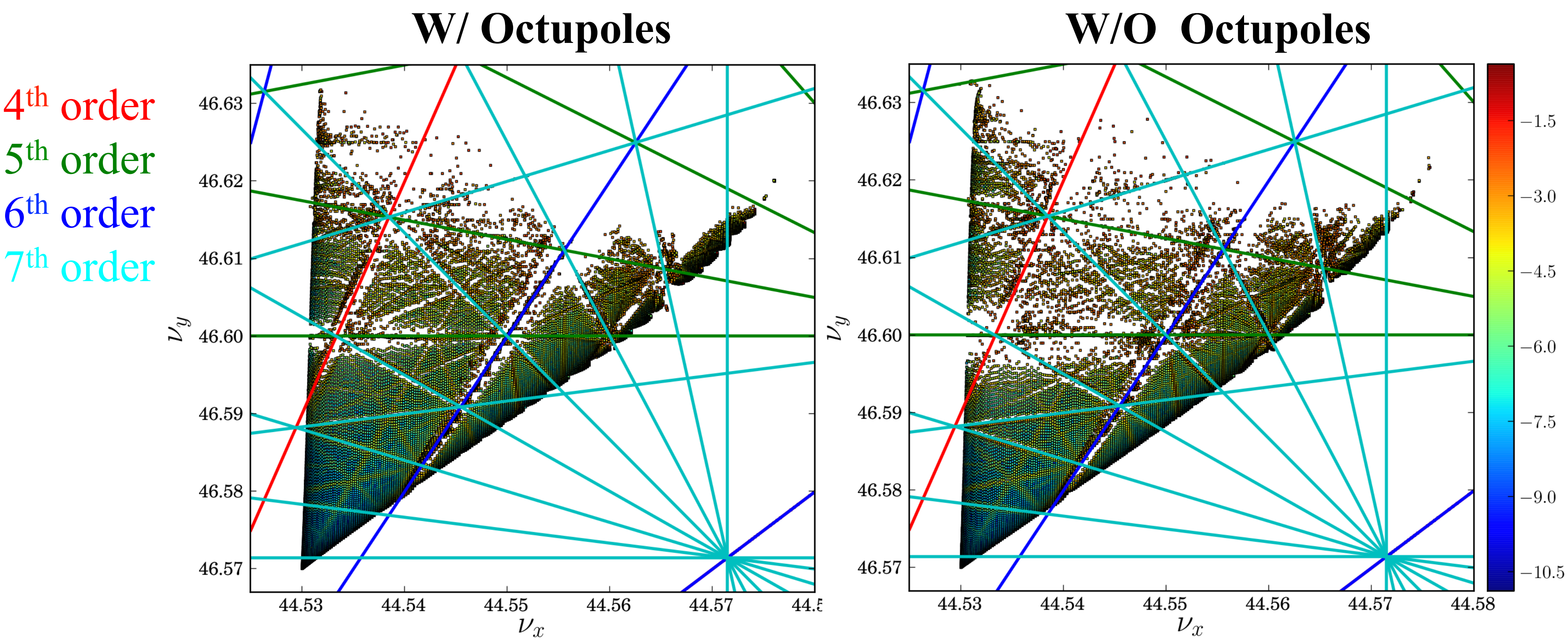
Side Effect of Removing Octupole from QC1

HER

- No remarkable effect is observed so far.

LER

- FMA indicates enhancement of some ronances.



Summary

1. Optics Design and Issues (Except for IR)
   - Almost completed.
   - Minor changes related to detailed hardware design is now continued.
   - Need special cares for orbit control or/and alignment in V-LCC region.

2. IR Design
   - Vertical offset is adopted to LER-QCS
     for saving dipole corrector strength.
   - Lifetime of both beams is almost reached the target value, 600 sec.

3. Error Field from QCS
   - Nomal&Skew sextuple error field has critical effects on DA.
   - Additional corrector coil is planned to install.

Thank you for listening!

Appendix

Appendix

Touschek-Lifetime History

- DA has been steadily improved by feedback cycle between Optics & Magnet group.