SuperTRISTAN

A possibility of ring collider for Higgs factory

Higgs Factory Workshop

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K. Oide (KEK)

Inspired by A. Blondel and F. Zimmermann, "*A High Luminosity e+e- Collider in the LHC tunnel to study the Higgs Boson*", V2.1 - V2.7, arXiv:1112.2518v1 [hep-ex], 24 Dec 2011.

薬王院

Mt. Tsukuba

八郷植物センタ

12.3 km

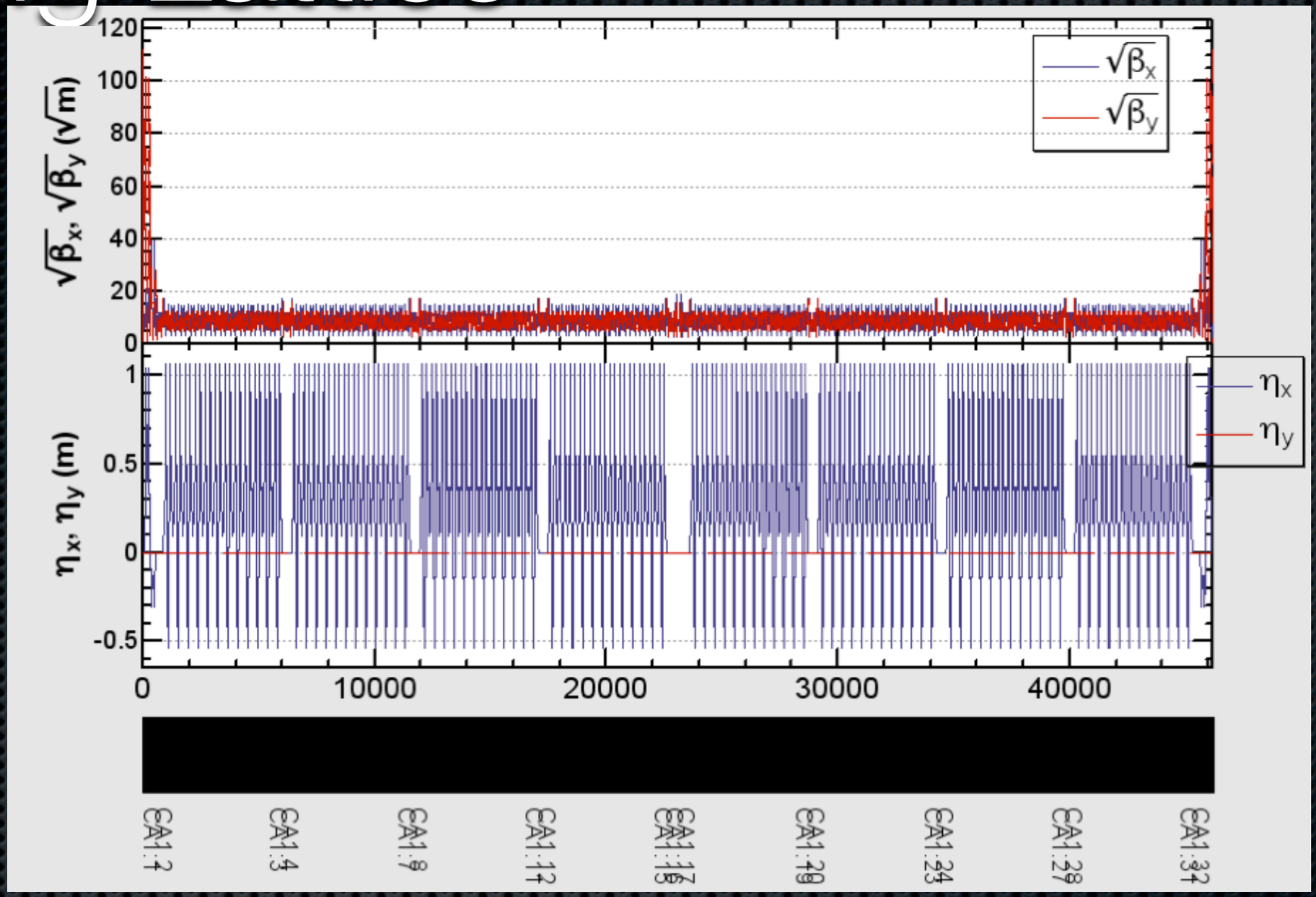
KEK

SuperTRISTAN 40

Parameters Example

	TRISTAN	KEKB	LEP2	LEP3	TLEP-t	SuperTRISTAN		
						40	80	
Beam Energy	32	8 / 3.5	105	120	175	120	175	GeV
Circumference	3	3	27	27	80	40	80	km
Beam Current / beam	7	1400 1700	4	7.2	5.4	6.5	4.2	mA
Bunches / beam	2	1600	4	4	12	8	22	
β* x / y	2000 / 40	1200 / 6	1500 / 65	200 / 1	200 / 2	200 / 1	200 / 1	mm
Emittances x / y		18 / 0.1	48 / 0.25	25 / 0.1	20 / 0.1	40 / 0.04	12 / 0.012	nm
Bunch length	10	6	3	3	1.5	1.2	1.2	mm
Beam-beam parameters x,y	0.02 0.025	0.05 0.09	0.025 0.065	0.09 0.08	0.05 0.05	0.032 0.083	0.035 0.089	
Beamstrahlung loss / spread / equil. spread				0.04 0.15	0.05 0.24	0.02 0.07 0.43	0.02 0.08 0.39	%
synch. tune	0.1	0.02				0.23	0.27	
mom. compact.	140	20	18.5	9.0	1.0	2.7	1.6	10^{-3}
Radiation loss / turn	300	4 / 2	2750	6900	9300	3450	8080	MV
RF Voltage	400	10 / 5	3640	9000	12000	8300	16000	MV
RF frequency	508	509	352	700	700	1300	1300	MHz
Total SR Power	4.2	5.6 / 3.4	22	100	100	45	68	MW
Luminosity / IP	0.04	21	0.13	9.4	6.5	10	10	/nb/s

Ring Lattice



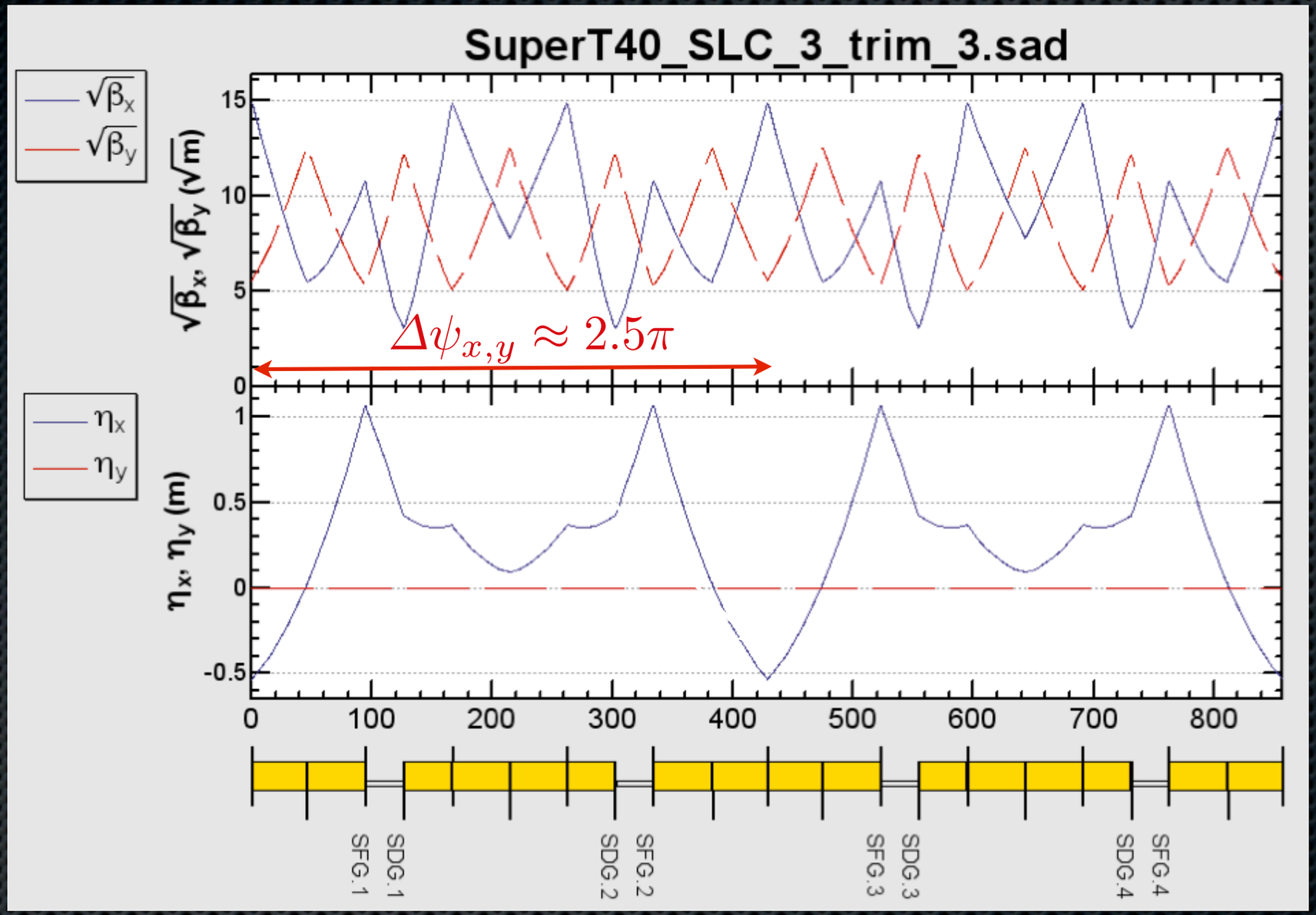
- 1 IP for the time being.
- 8 arc segments, 16 RF sections.
- 88 cells, $\nu_{x,y} = (146, 129)$.

- Should not be much more difficult than LEP2, except for **smaller IP β**'s (1500/50 vs 200/1 mm) and **shorter bunch length** (16 vs 1.2 mm).

Unit Cell

- Small momentum compaction is in favor:
  - lower rf voltage
  - shorter bunch length
  - smaller synchrotron tune
  - better dynamic aperture / beam-beam effects
- A good solution is a “2.5π cell”:
  - missing bend to allow negative dispersion region
  - naturally accomotates -I sextupole pairs

“2.5π” Unit Cell

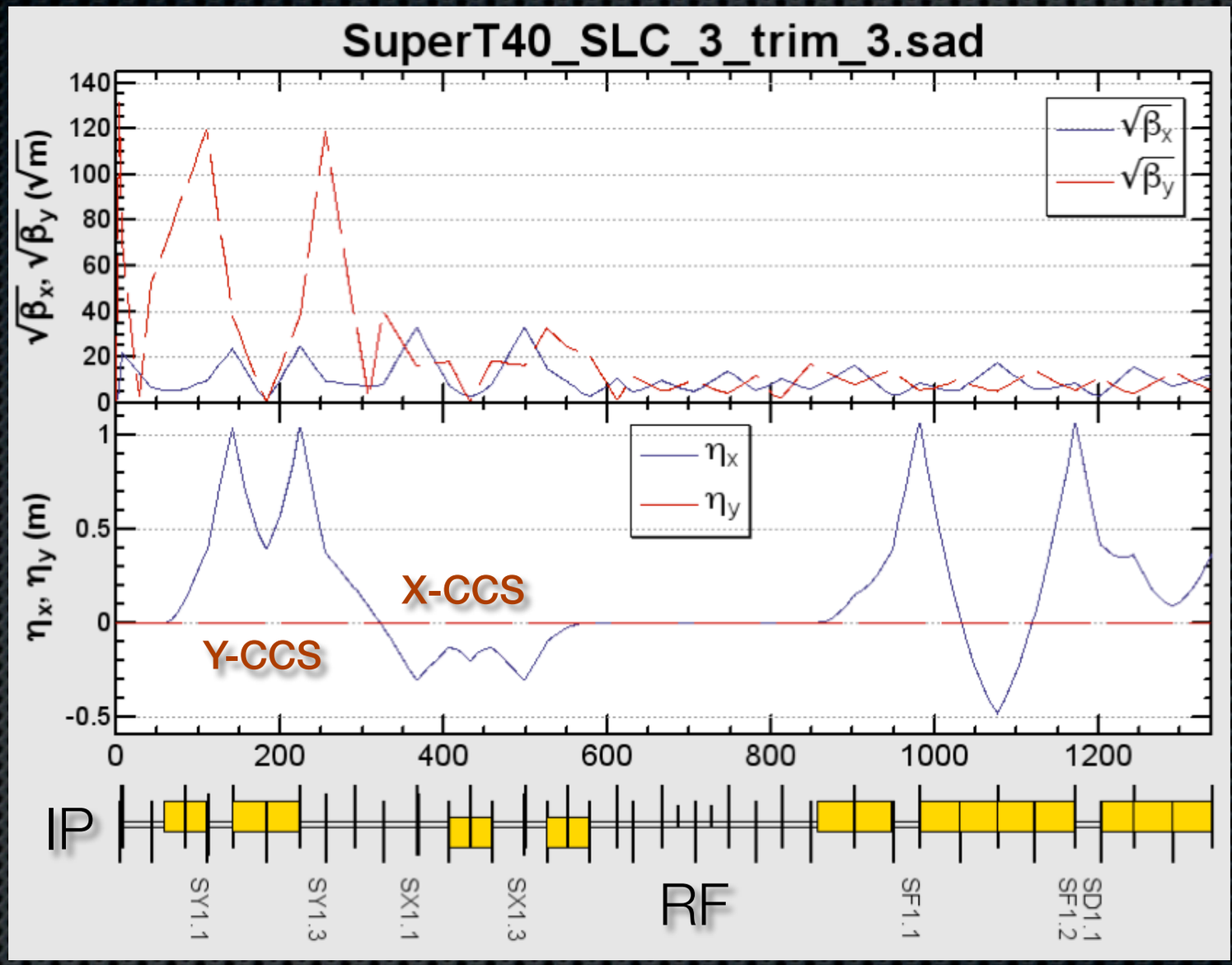


-I’ -I’ -I’

Sexupole pairs:
188 independent pairs for SuperTRISTAN 40.

IR Optics

"Semi-local" chromaticity correction scheme verified at FFTB / KEKB.



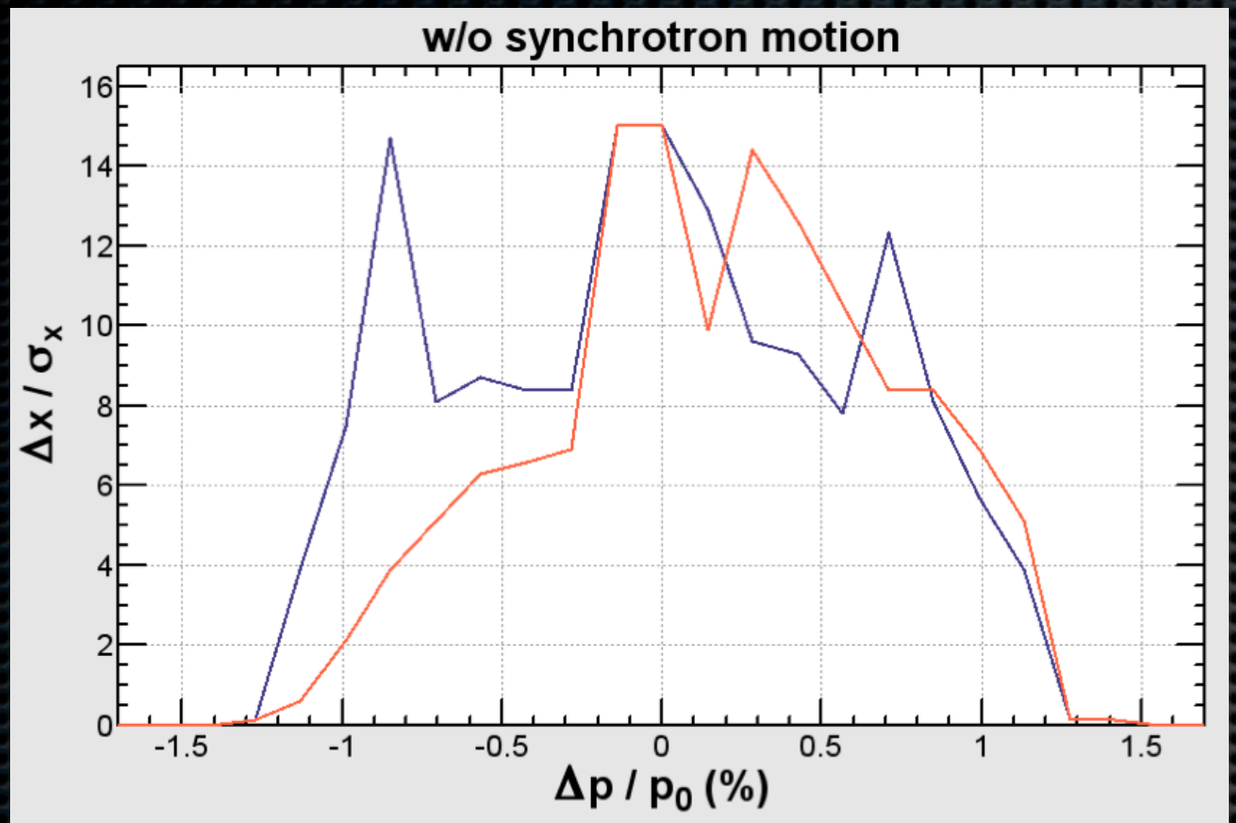
ARC

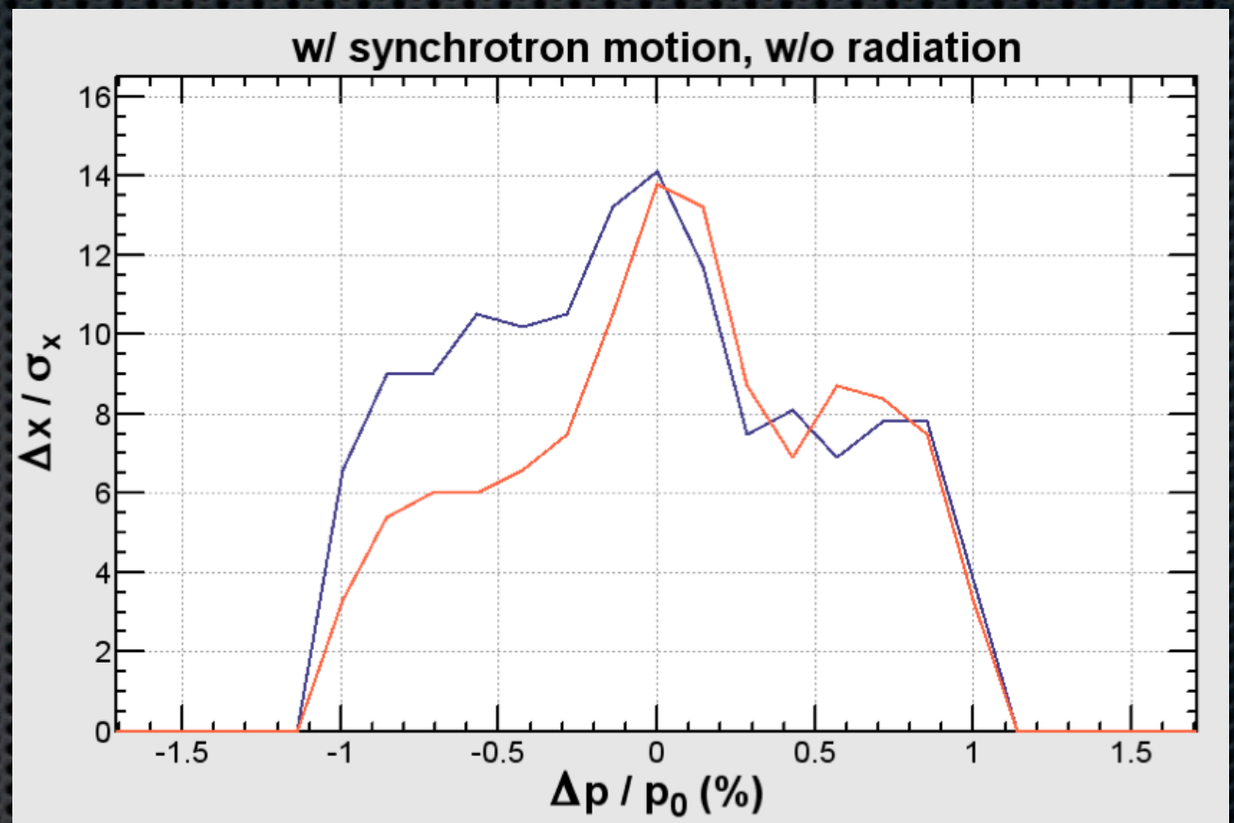
-I' -I'

$\Delta\psi_y = \pi$

$\Delta\psi_x = 2\pi$

Dynamic Aperture



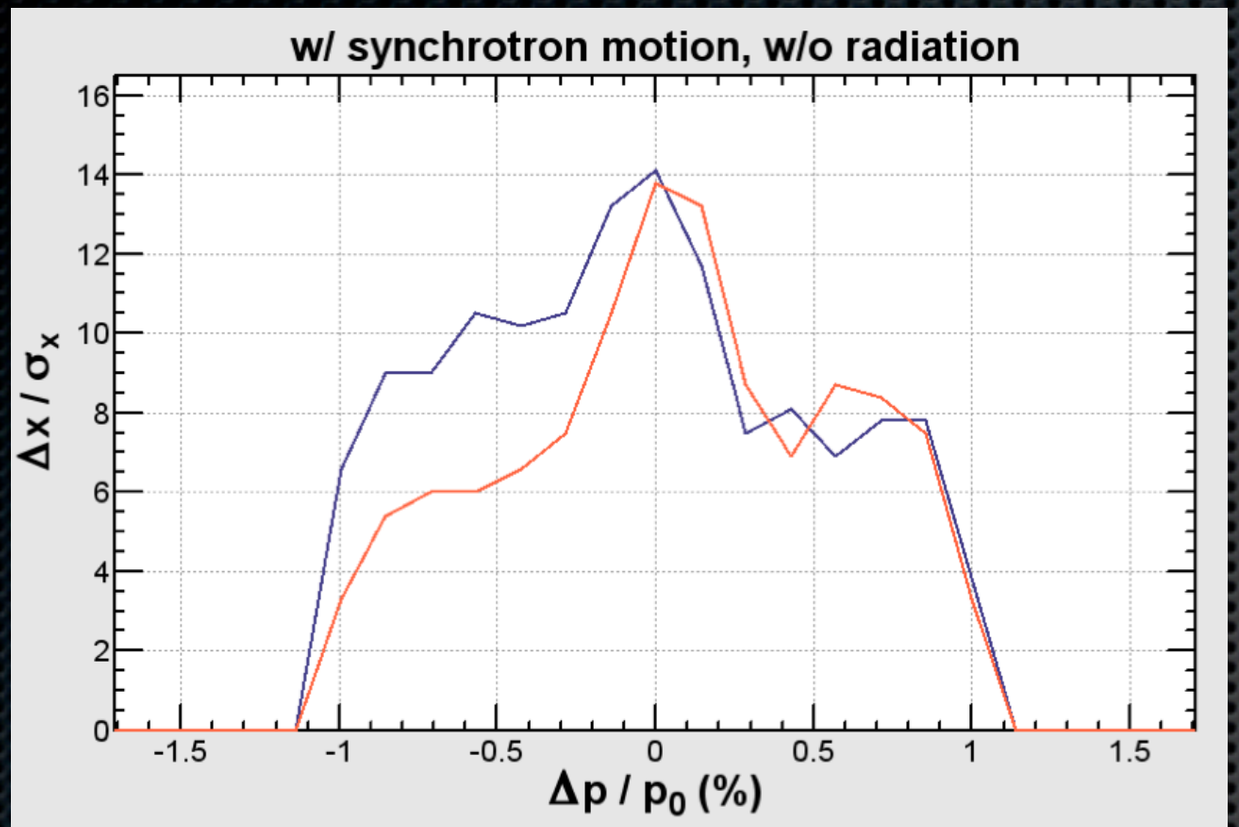


No synch. motion

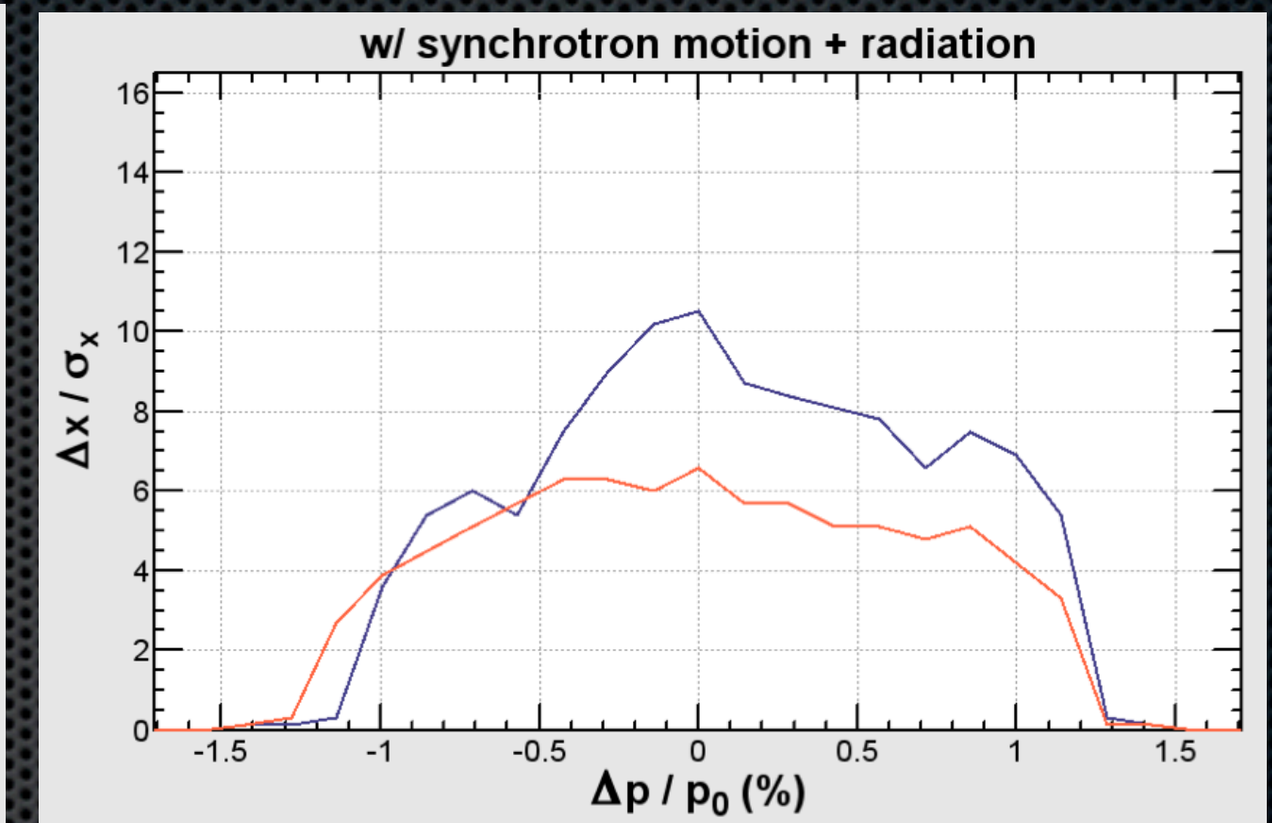
Synch. motion

- Difference is seen in the dynamic aperture between on/off of synchrotron motion.
- Smaller synchtron tune may reduce the difference.

Effect of Arc Radiation



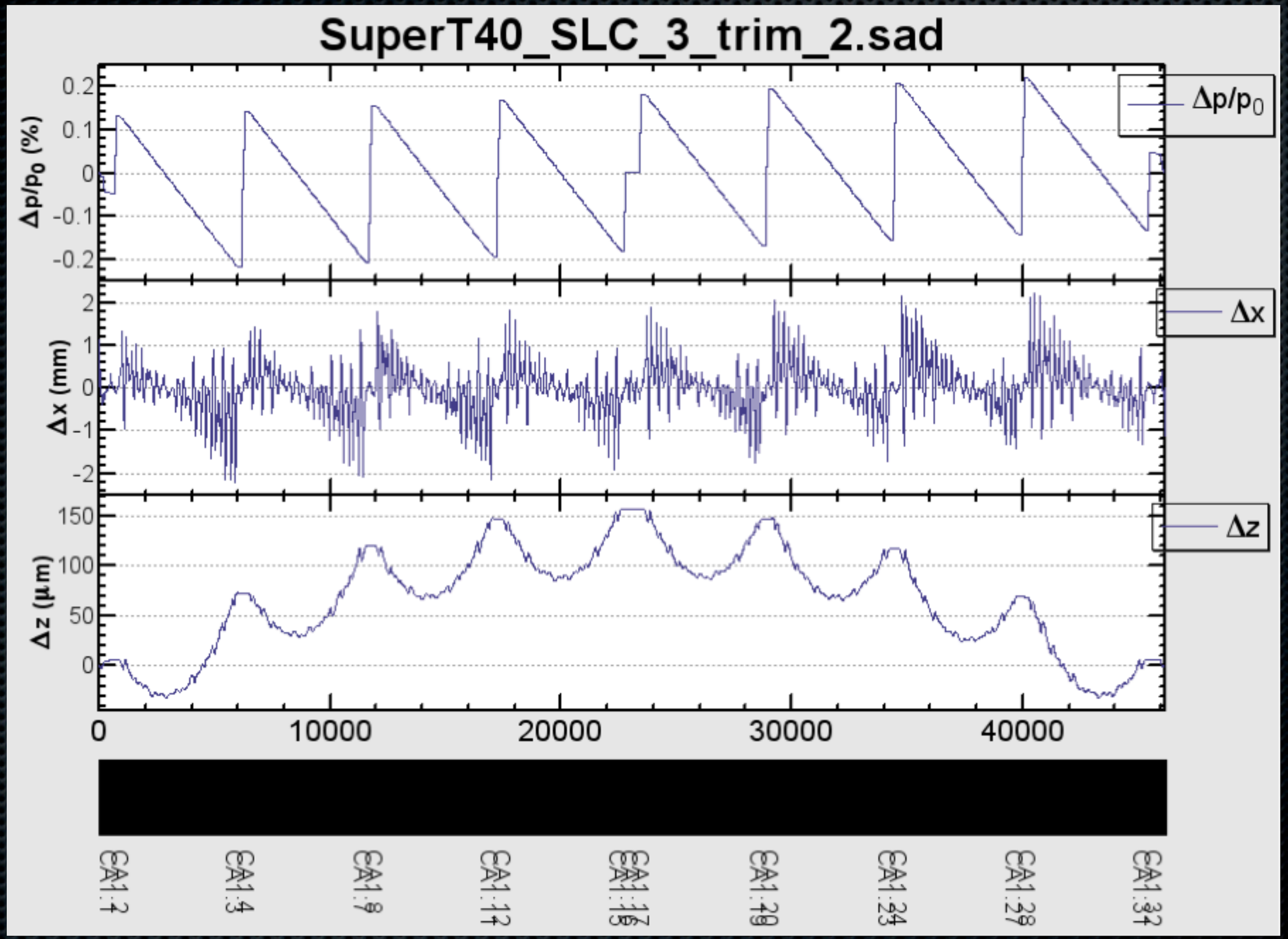
Synch. motion
No radiation



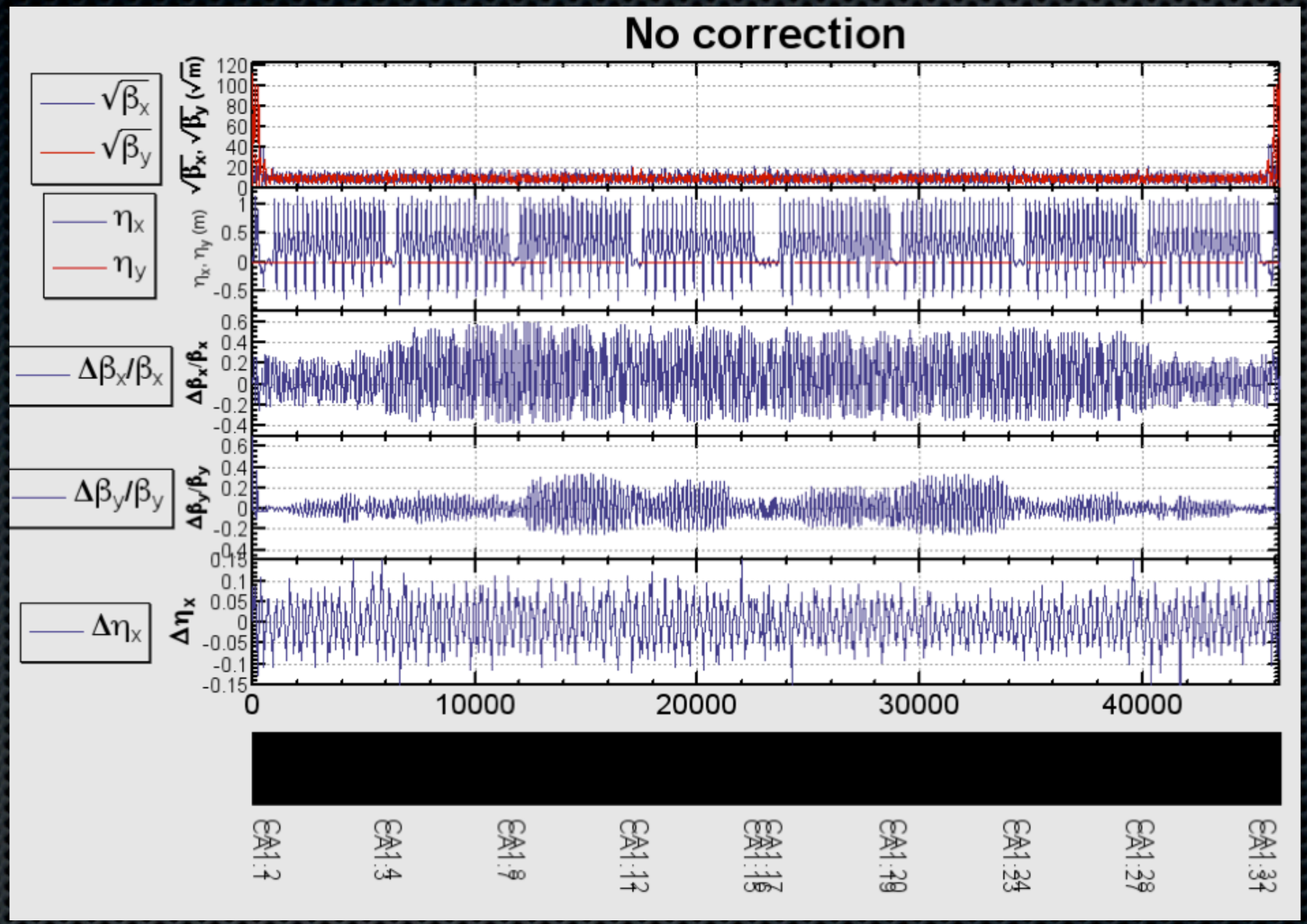
Synch. motion
+ Radiation

- Synchrotron radiation somewhat increases the momentum acceptance, but reduces the transverse aperture.

Sawtooth Orbit



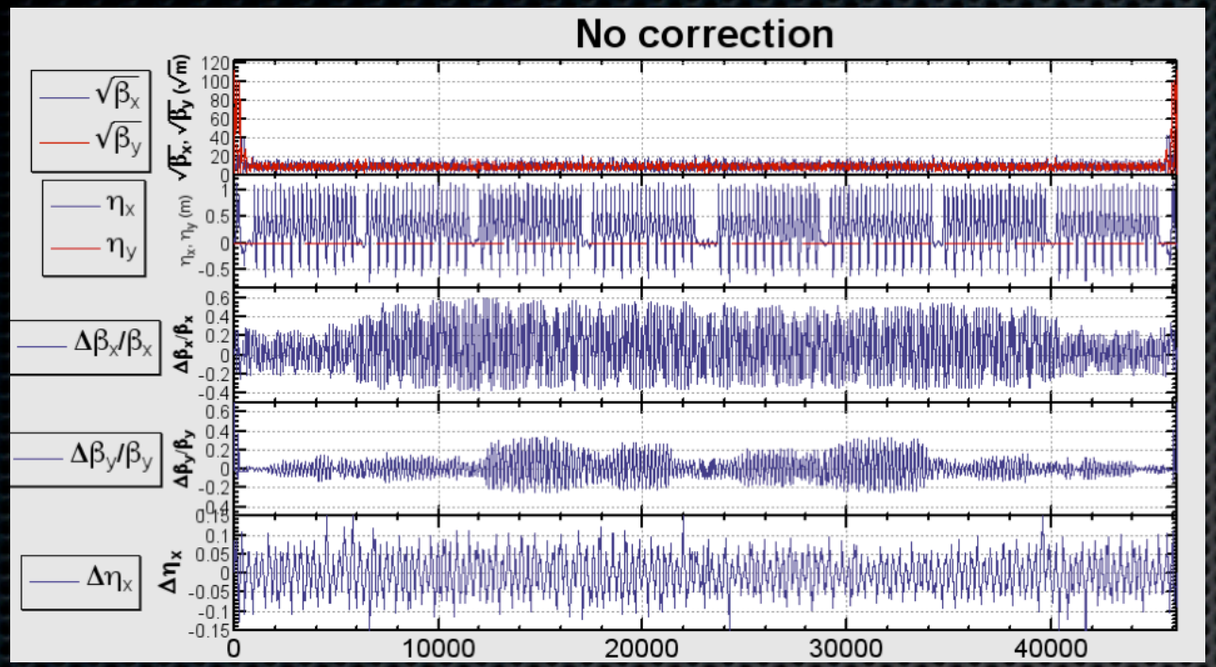
Optics Disturbance by Sawtooth

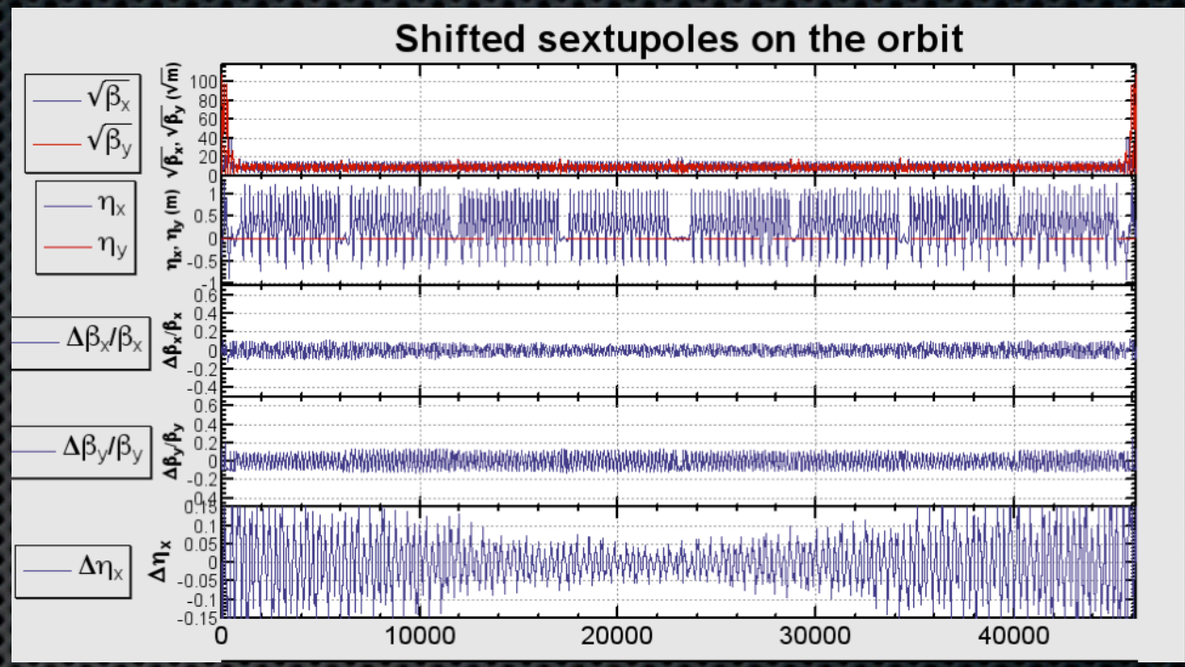


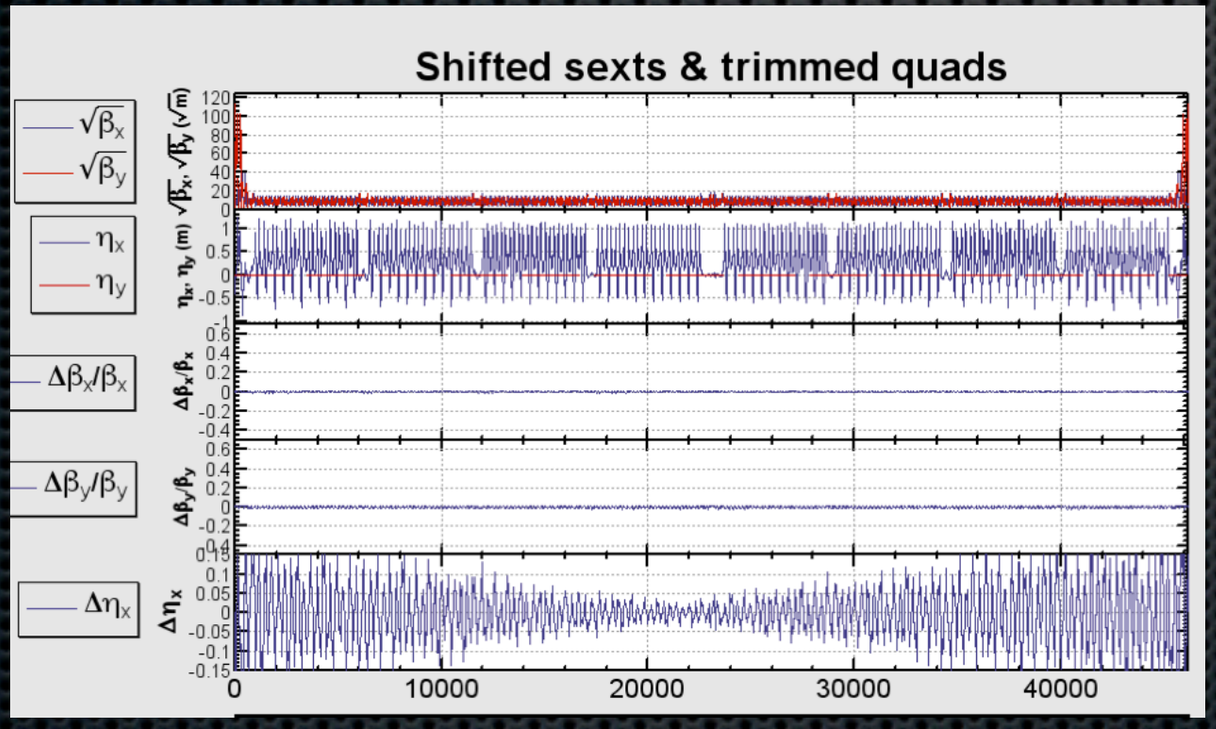
$\Delta\beta_x/\beta_x \sim 70\%, \qquad \Delta\beta_y/\beta_y \sim 30\%$

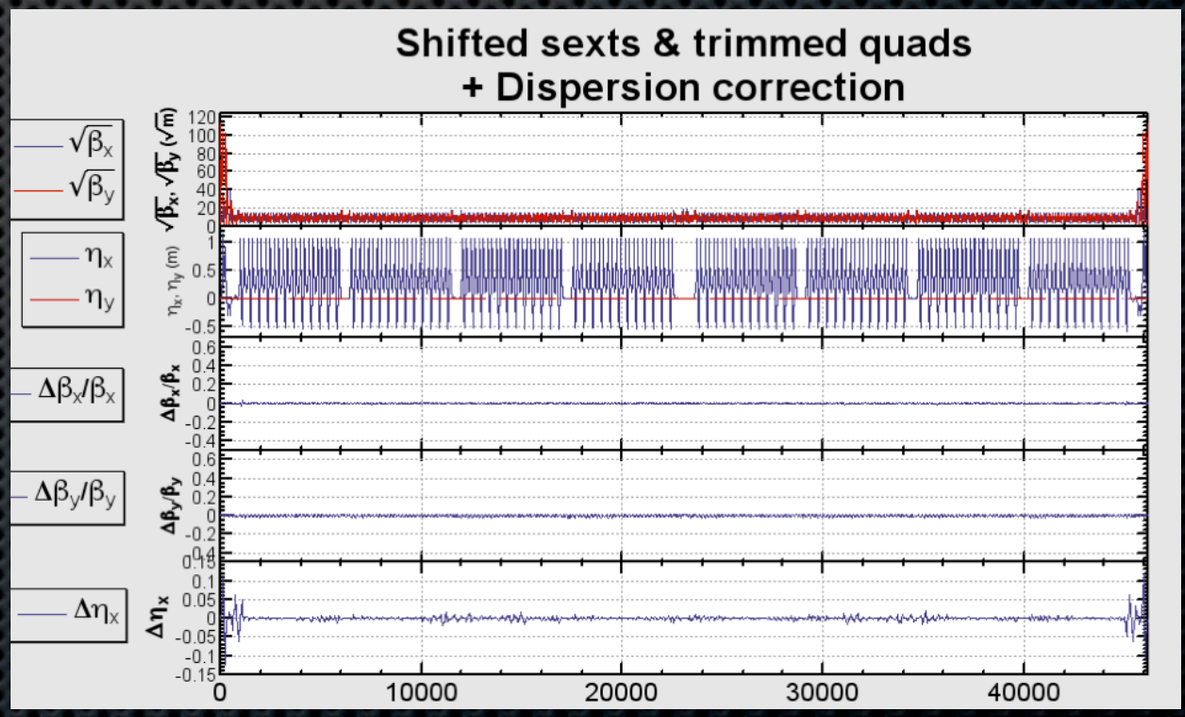
$\Delta\eta_x \sim 10\mathrm{mm}$

Optics Corrections



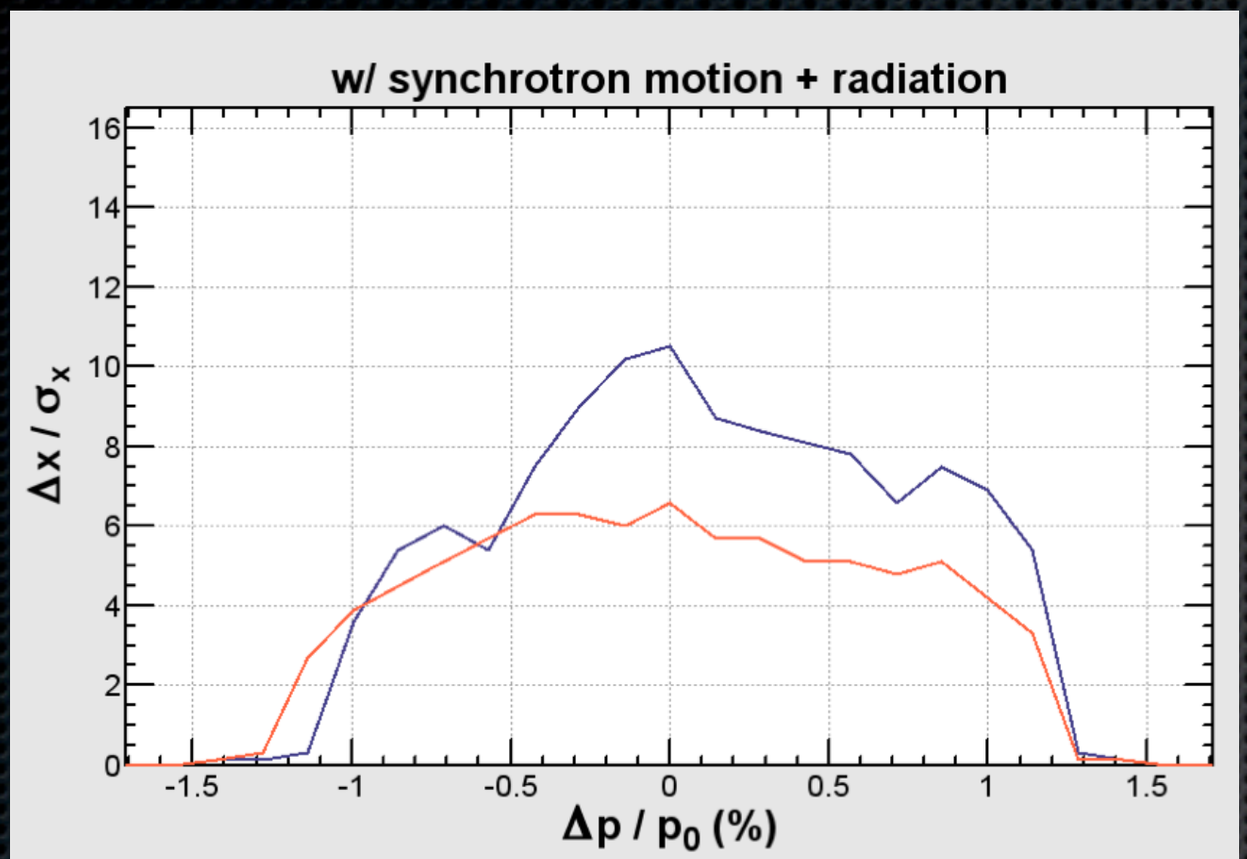




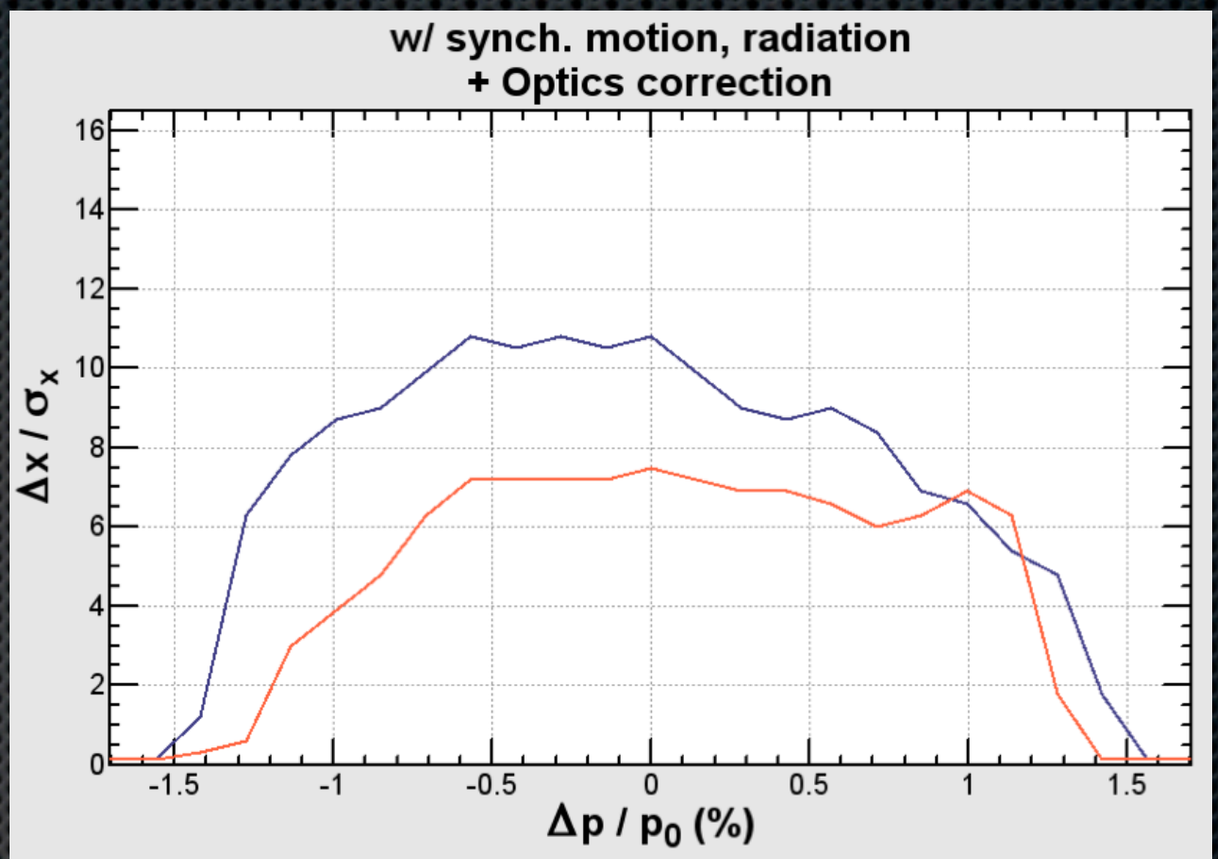


- By shifting quads horizontally and trimming quad strengths according to the sawtooth, the optics can be recovered.

Effect of Optics Correction



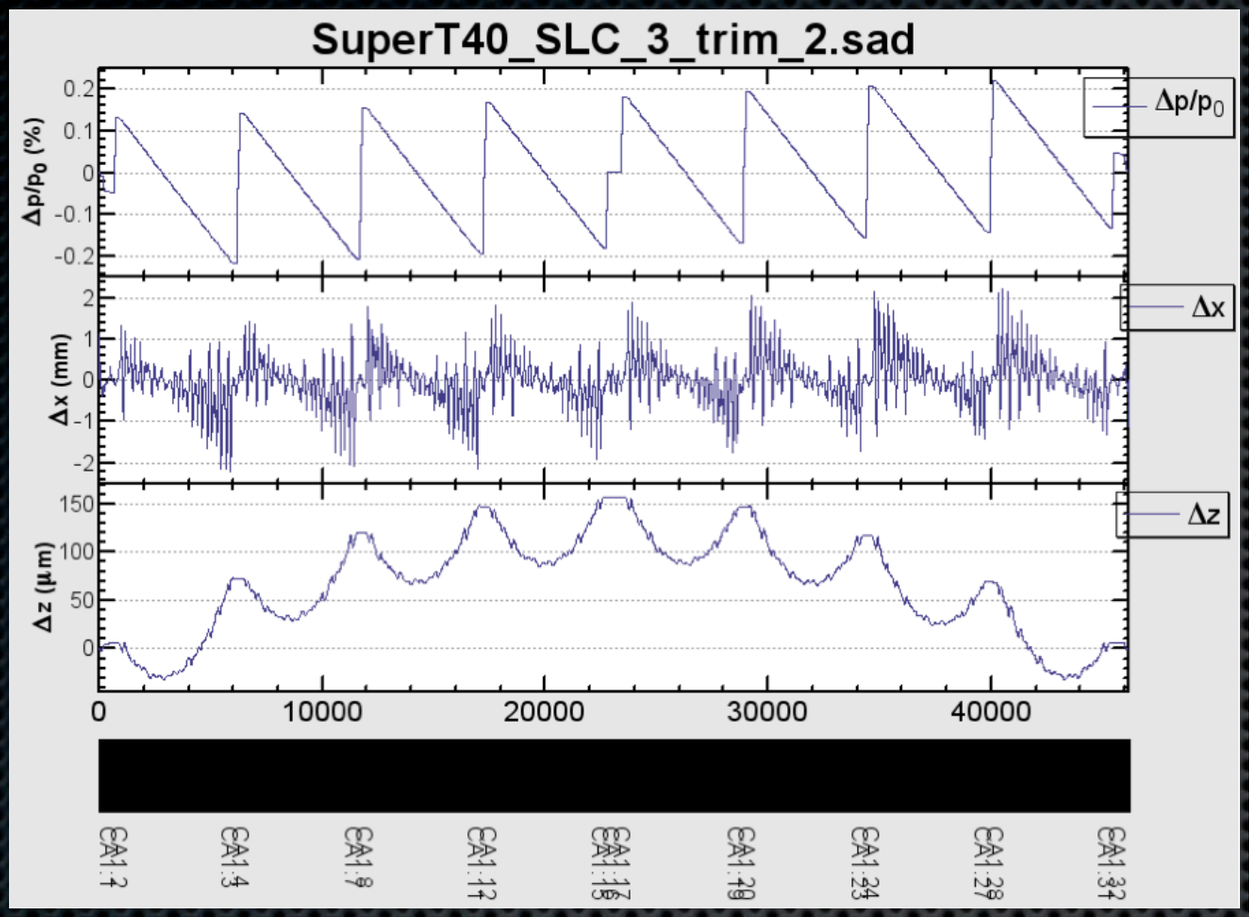
Synch. motion
+ Radiation



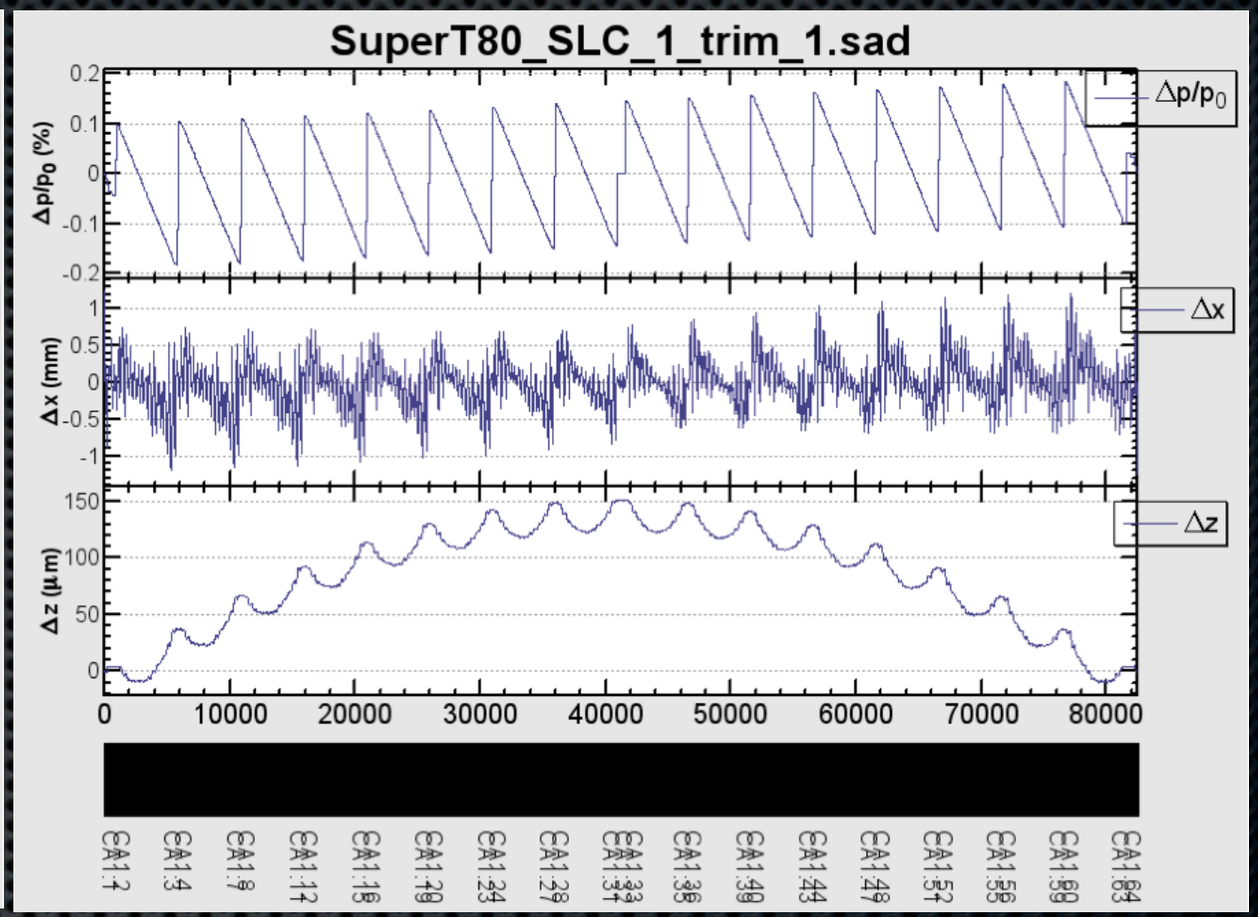
Synch. motion + Radiation
Corrected Sawtooth Optics

- The dynamic aperture is improved by the optics correction, even achieved a wider momentum acceptance than the no-radiation case.

Larger Version:
E_{CM} = 350 GeV, C = 80 km



240 GeV, 40 km



350 GeV, 80 km

- By dividing the arc into 16 segments, the amplitude of sawtooth becomes comparable to the 40 km version.
- A dynamic aperture similar to 40 km is expected (not yet confirmed).

Summary

- A very preliminary evaluation was made for the dynamic aperture of an e+e- ring Higgs factory.
- “Sawtooth orbit” due to the synchrotron radiation in the arc is taken into account.
- The dynamic aperture is more or less acceptable, if simple optics correction to the sawtooth effect is applied.
- Further studies are needed to include
  - IP solenoid
  - Spin rotator
  - Injection scheme
  - High energy version