"Effects of Insertion Devices on Beam Dynamics at Diamond"

European Synchrotron Light Source Workshop
25th - 27th November 2009

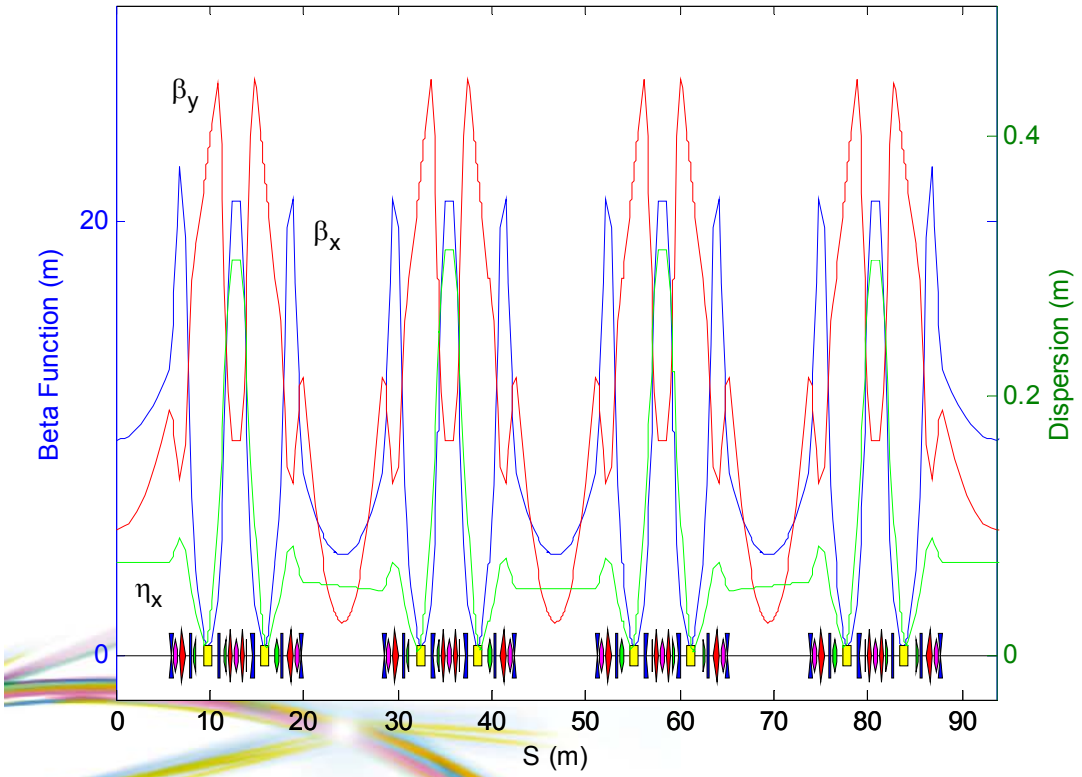
Ian Martin

Talk Outline

1) Introduction and Summary of IDs
2) Injection Efficiency and Lifetime
3) Dynamic Aperture Measurements
4) Wiggler Optics Correction
5) Summary

diamond

1) Introduction and Summary of IDs



Lattice	DBA
Structure	24 cell
Symmetry	6
Straights	18 × 5m / 6 × 8m
Energy	3 GeV
Length	561.6 m
Lifetime	>20h (target >10h)
Current	250mA (300mA)
Emittance	2.7nm.rad
En. Spread	9.6×10^{-4}

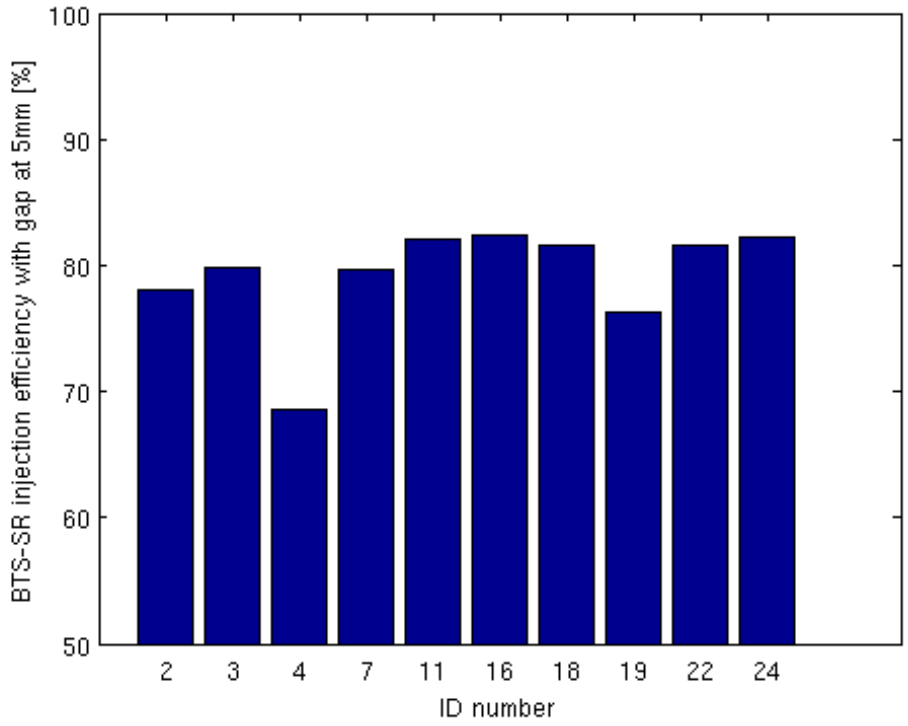
1) Introduction and Summary of IDs

ID	Type	# Periods	Period (mm)	Peak Field (T)	Min Gap (mm)	Cant (mrad)	Comment
I02	In-vac	85	23	0.92	5	+0.25	
I03	In-vac	94	21	0.86	5	+0.25	
I04	In-vac	85	23	0.92	5	+0.25	
I04.1	Ex-vac	21	30.8	0.45	16	-0.75	Typ. fixed gap
I06	APPLE II	2×33	64	0.96 / 0.72	16	-	Phase shifter installed
I07	In-vac	94	21	0.86	5	+1.5	
I11	In-vac	89	22	0.89	5.5	+1.5	
I12	SC Wiggler	24	48	4.2	-	-	Limited to 4T
I15	SC Wiggler	25	60	3.5	-	-	
I16	In-vac	73	27	0.79	7	-	
I18	In-vac	73	27	1.0	5	-	
I19	In-vac	94	21	0.64	7	+1.5	
I20	NC Wiggler	25	80	2	10	+0.8	Not yet installed
J20	NC Wiggler	9	83	1.3	15	-2.9	Installed in I20 slot
I22	In-vac	79	25	0.97	5	-	
I24	In-vac	94	21	0.86	5	+1.5	

1) Introduction and Summary of IDs

ID	ΔQ_x	ΔQ_y	$\Delta\xi_x$	$\Delta\xi_y$	$\Delta\chi$ (%)	$\Delta\varepsilon_x$ (nm.rad)	$\Delta\sigma_E$ (%)
I02	+0.0007	+0.0007	+0.20	+0.03	-0.09	-0.01	0.0
I03	+0.0002	+0.0011	-0.08	-0.35	0.0	0.0	-0.01
I04	+0.0003	+0.0011	-0.11	-0.06	+0.02	-0.02	0.0
I04.1	-0.0008	+0.0003	-0.06	-0.02	-0.02	+0.01	0.0
I06-01	+0.0001	+0.0015	+0.02	+0.02	0.0	-0.03	-0.01
I07	+0.0004	+0.0008	+0.02	+0.15	-0.01	-0.01	0.0
I11	+0.0008	+0.0007	+0.02	+0.05	+0.01	-0.03	0.0
I12	+0.0016	+0.0111	0.0	+0.13	+0.14	+0.05	+0.08
I15	+0.0005	+0.0109	+0.05	+0.18	+0.12	-0.02	+0.07
I16	+0.0003	+0.0009	-0.07	+0.07	0.0	-0.02	0.0
I18	-0.0001	+0.0014	-0.07	+0.05	-0.01	-0.03	-0.01
I19	-0.0006	+0.0013	-0.12	+0.06	0.0	-0.01	-0.01
I20	-	-	-	-	-	-	-
J20	-	-	-	-	-	-	-
I22	+0.0013	+0.0007	+0.04	+0.01	0.0	-0.03	0.0
I24	-0.0004	+0.0014	-0.02	+0.05	-0.01	-0.01	0.0

2) Injection Efficiency and Lifetime



IV IDs affect inj. eff. by ~few %

Exact effect depends on other IDs

I04 worst culprit:

- 10% reduction in efficiency at 5mm

Closing I11 improves efficiency!

SCWs require tune correction

Courtesy C. Christou

2) Injection Efficiency and Lifetime

In-vacuum IDs found to have minimal impact on beam lifetime

Change in lifetime generally < 0.5h for individual IDs at 5mm gap

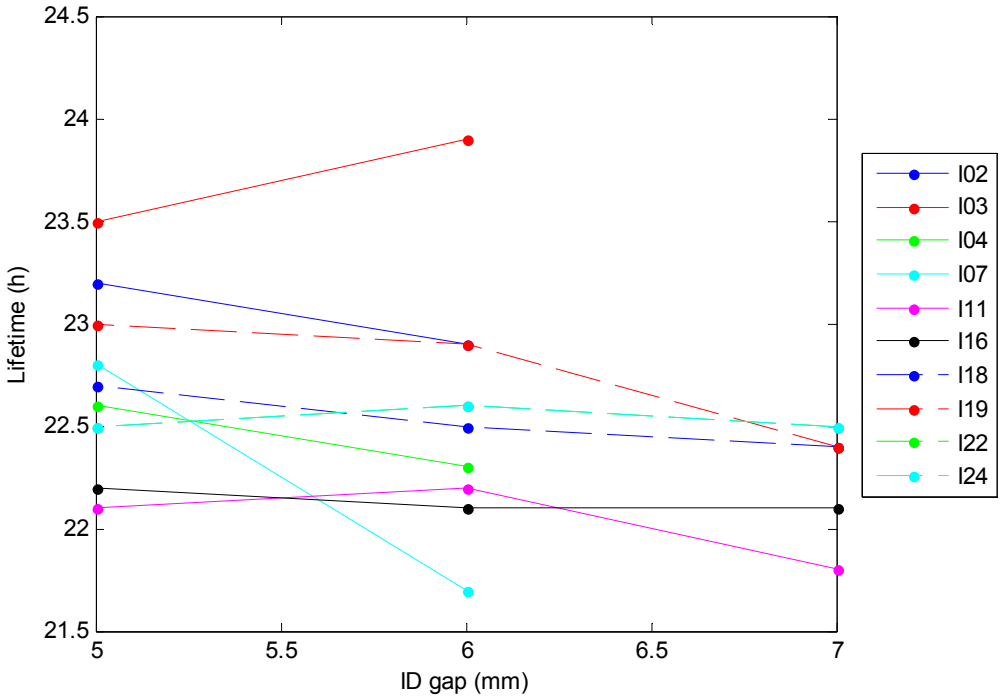
For nominal operating conditions of 1% coupling, V_{RF} = 2.8MV, 250mA, ¾ fill:

All IDs Open: 23.2h

All IDs Closed: 20.2h

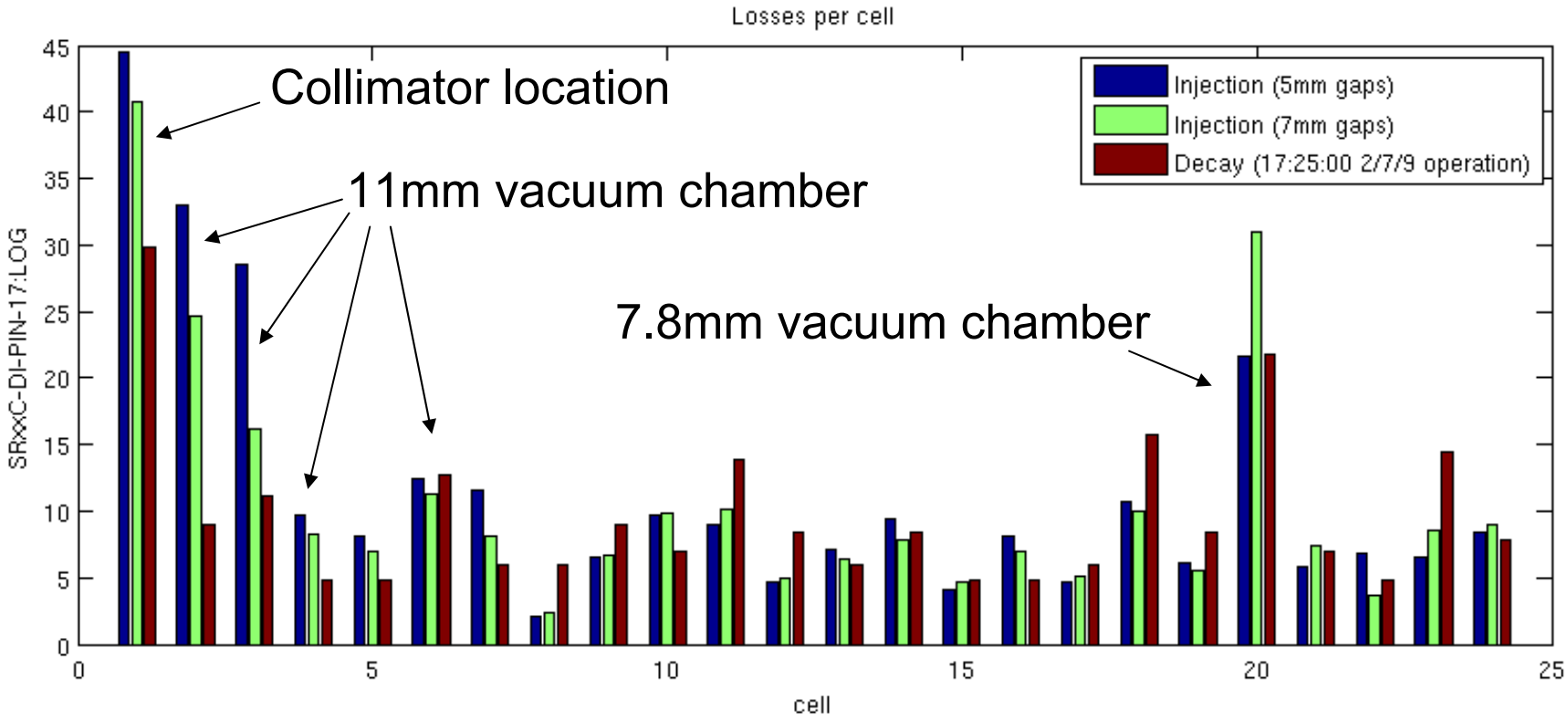
(Measurements subject to large errors due to beam polarisation, reinjection, natural oscillations, measurement error,…)

SCWs affect lifetime by 5-10% (reduction of RF acceptance and change in machine optics)



Courtesy R. Fielder

2) Injection Efficiency and Lifetime

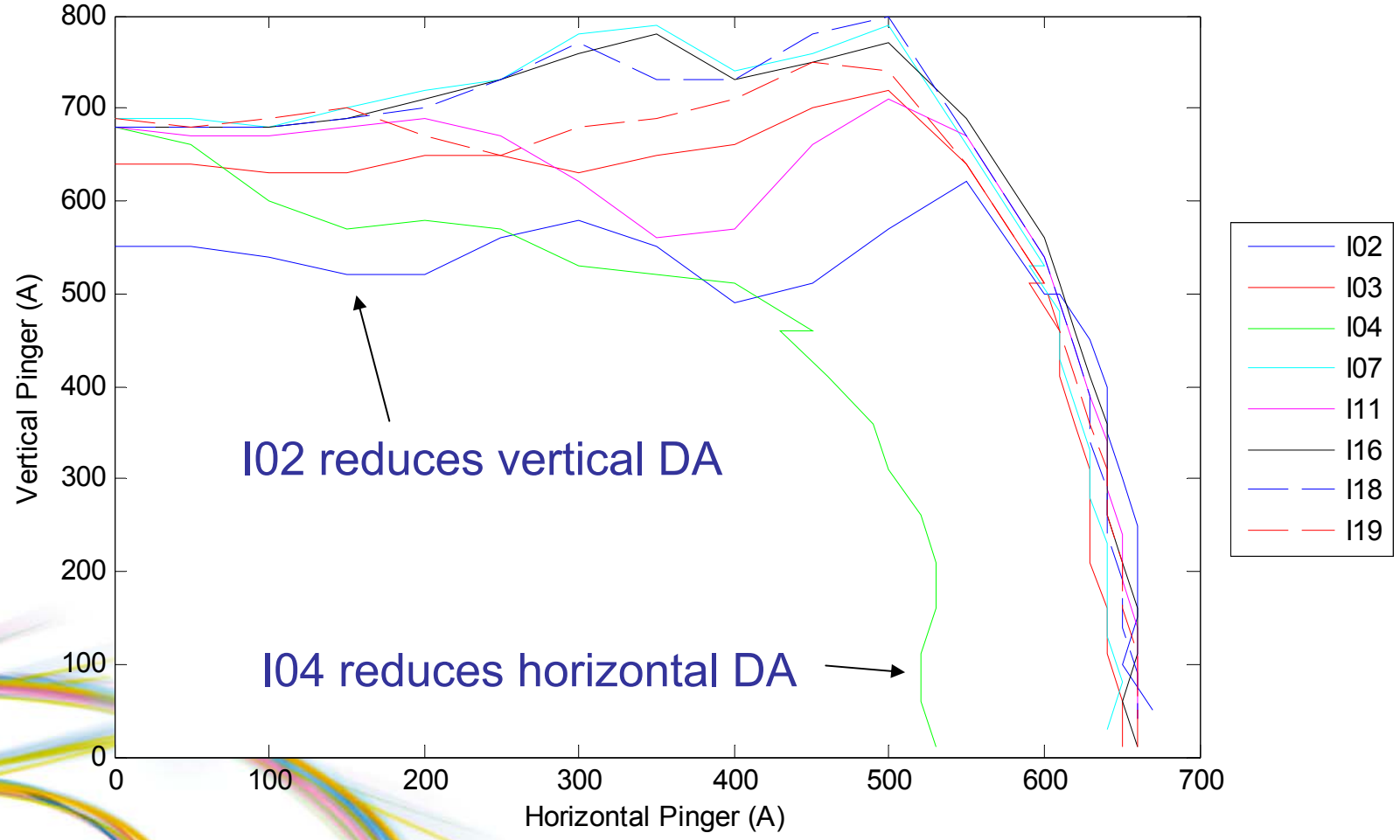


Loss distribution during injection and stored beam

(note log scale)

Courtesy C. Christou

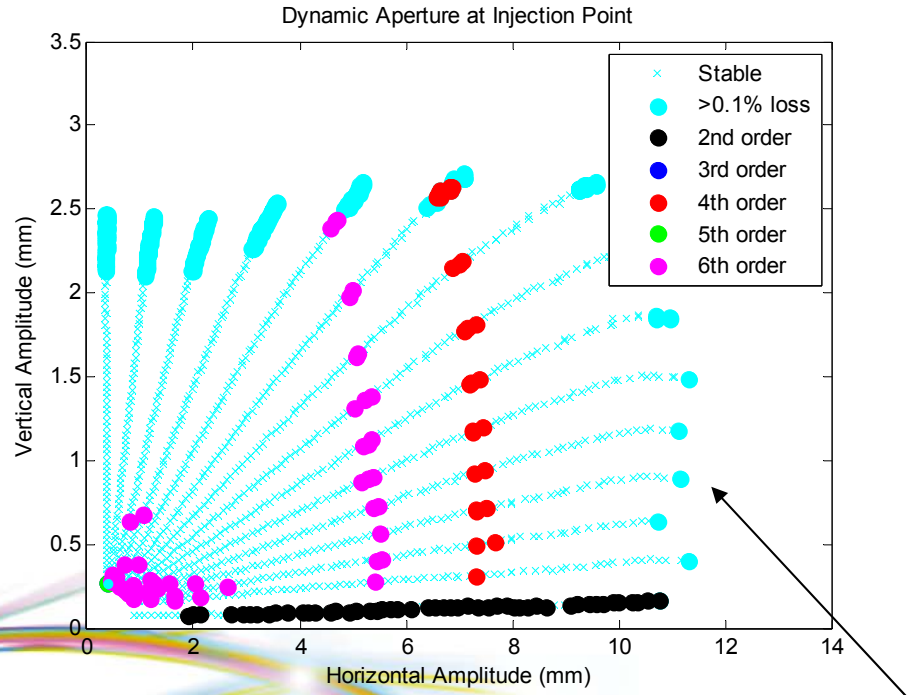
3) Dynamic Aperture Measurements

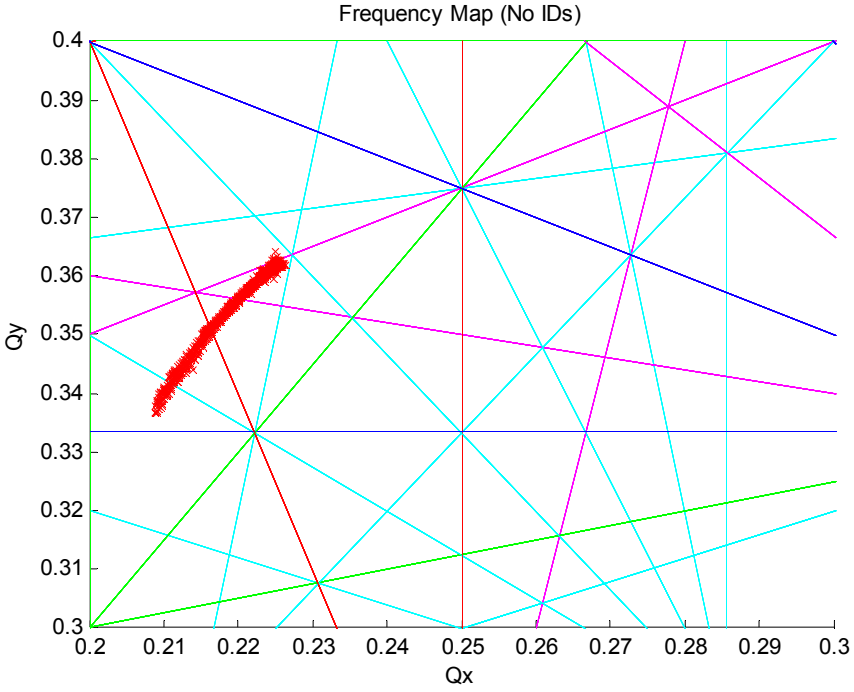


Courtesy R. Fielder

3) Dynamic Aperture Measurements

Bare Lattice

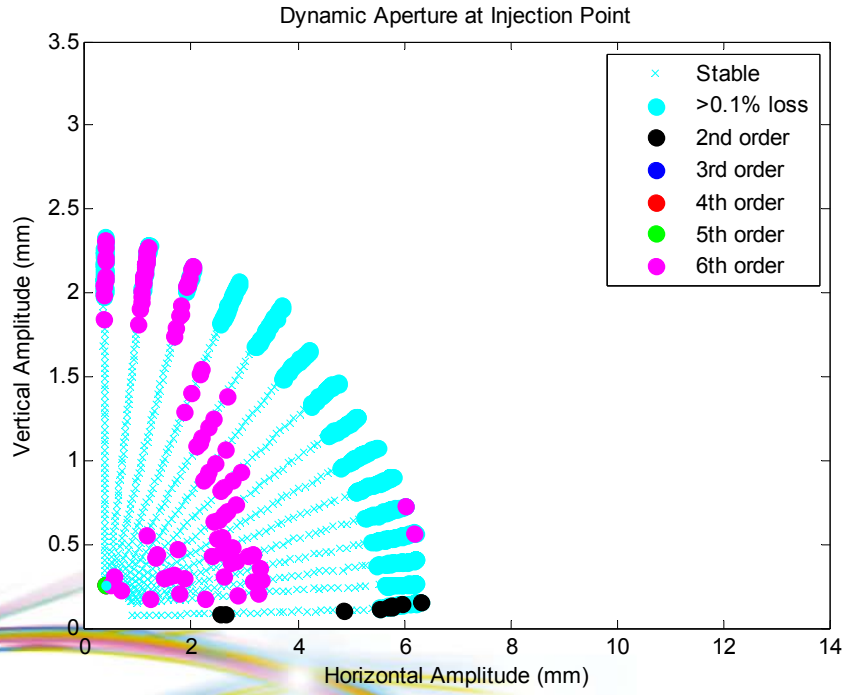


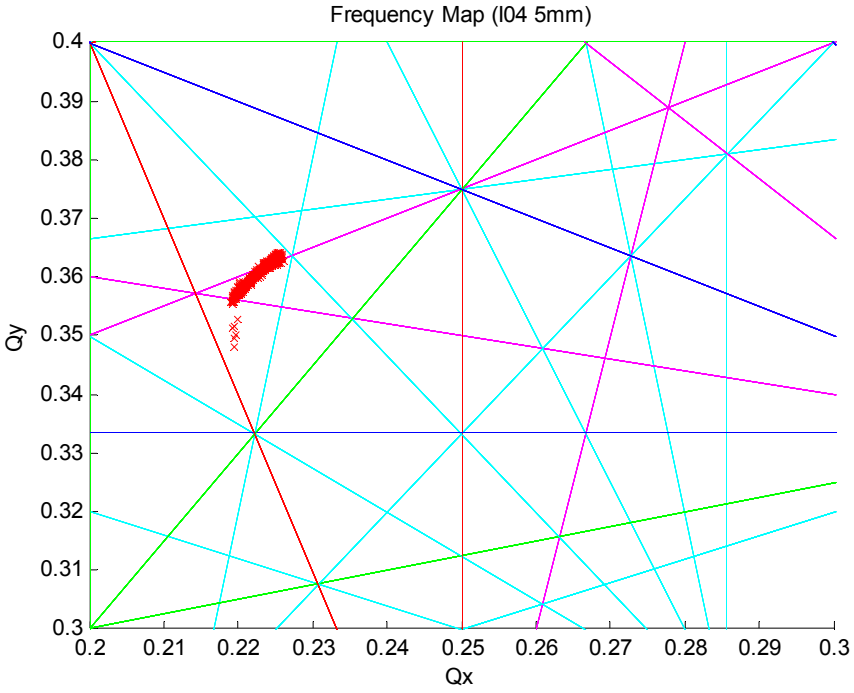


Note: hard edge due to beam position interlock, not edge of dynamic aperture

3) Dynamic Aperture Measurements

I04 at 5mm

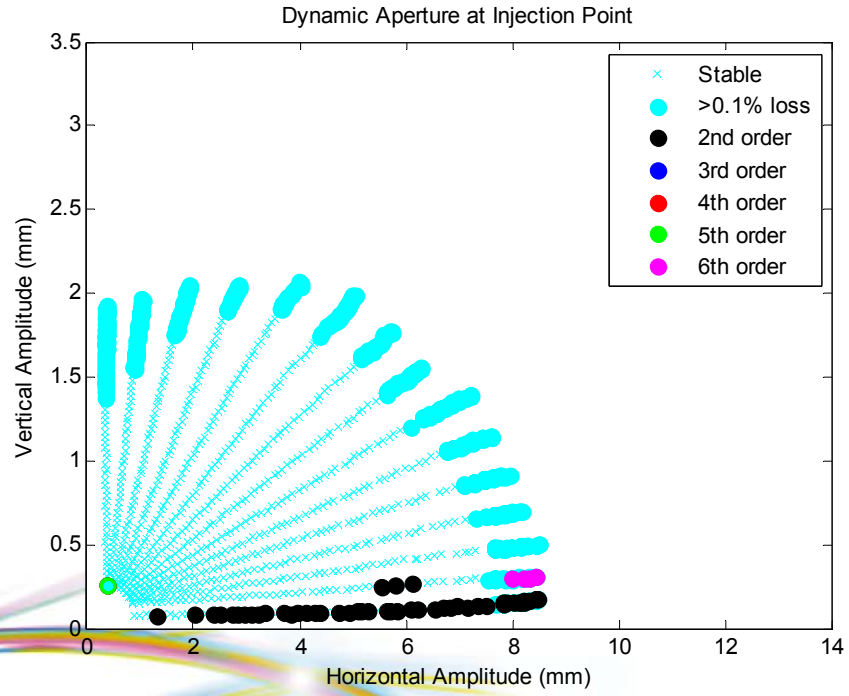


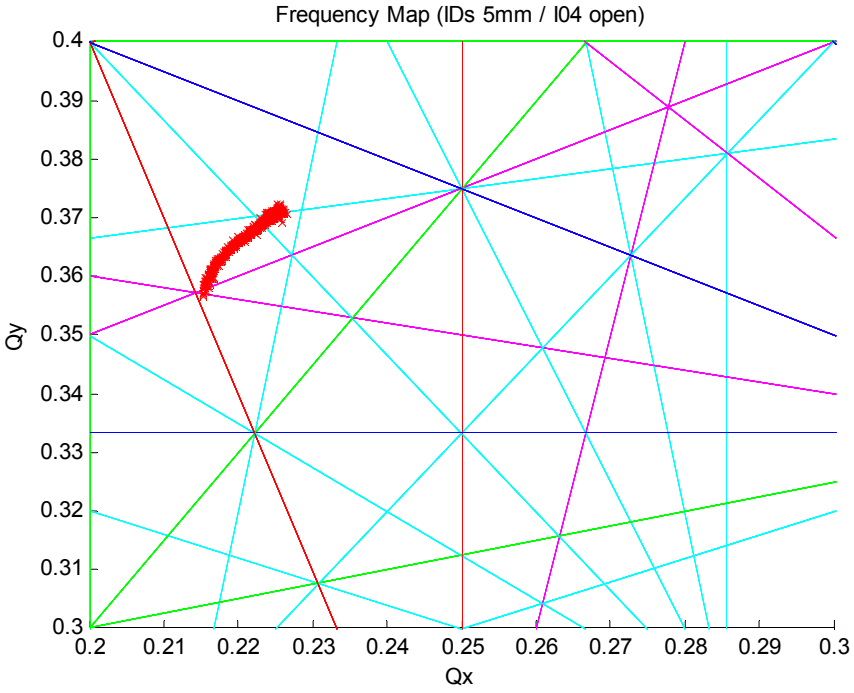


Reduction in horizontal dynamic aperture leads to 10% reduction in inj. efficiency

3) Dynamic Aperture Measurements

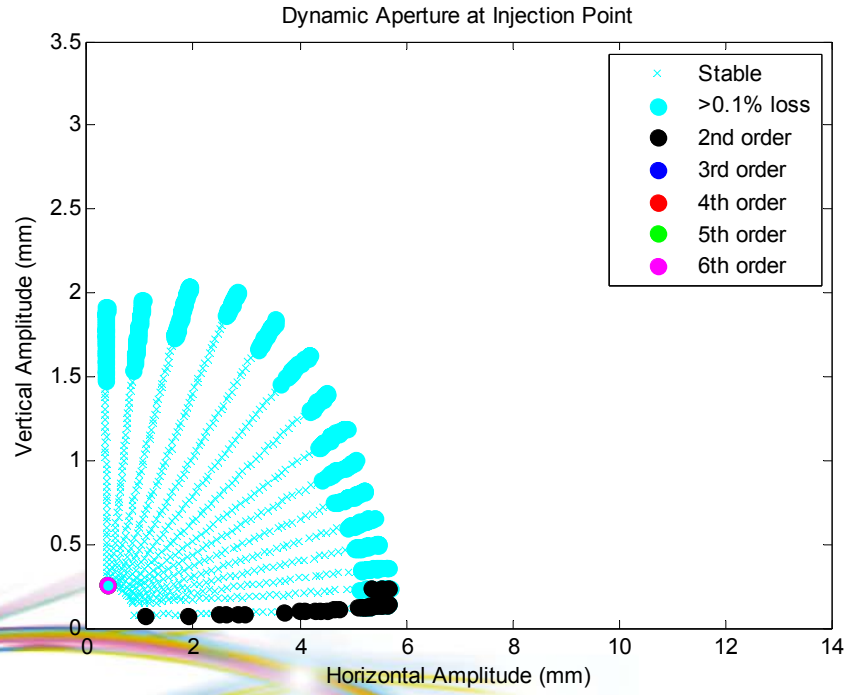
All In-Vacuum IDs 5mm
(I04 open)

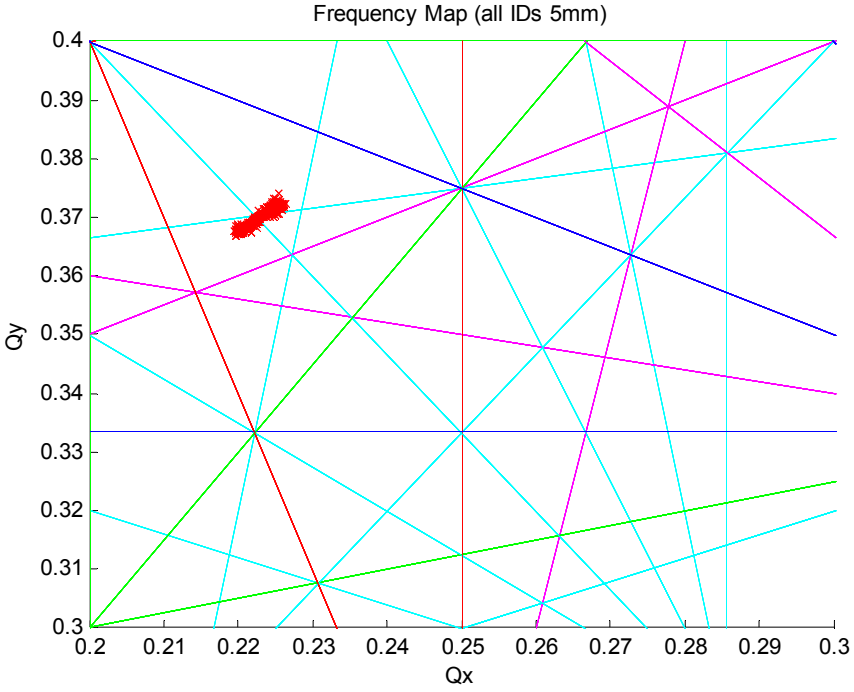




3) Dynamic Aperture Measurements

All In-Vacuum IDs 5mm





4) Wiggler Optics Correction

Diamond storage ring contains two superconducting wigglers (3.5T / 4.2T)

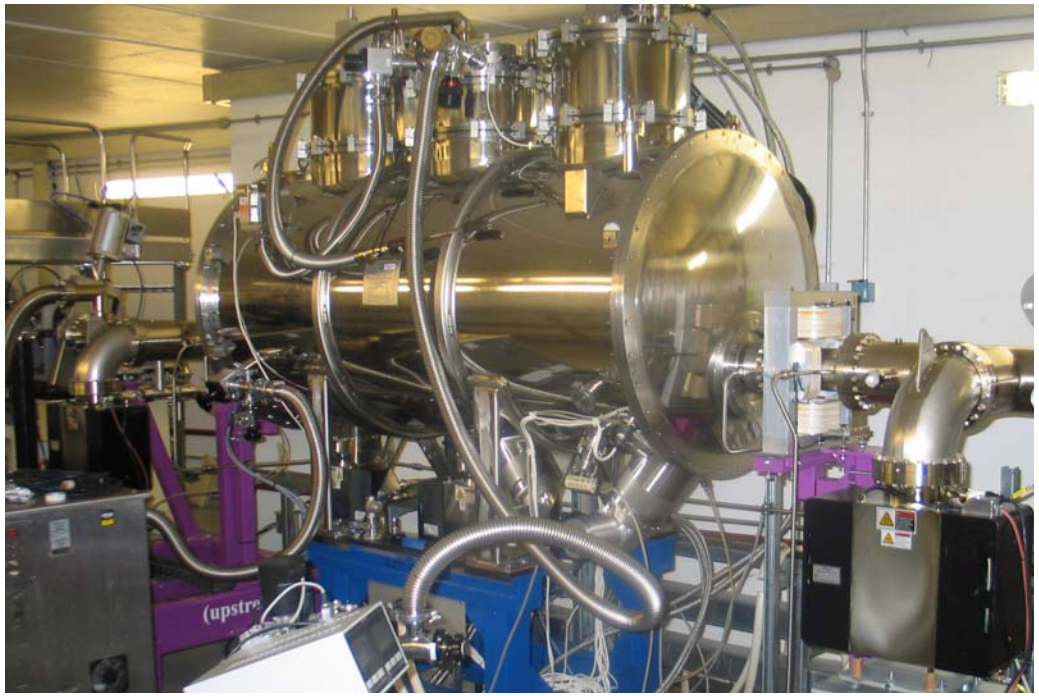
Both generate beta-beating of 10-15% in vertical plane

In process of generating feed forward tables for SR quadrupoles to correct optics

Investigated two methods:

1) Alpha-matching plus global tune correction

2) LOCO

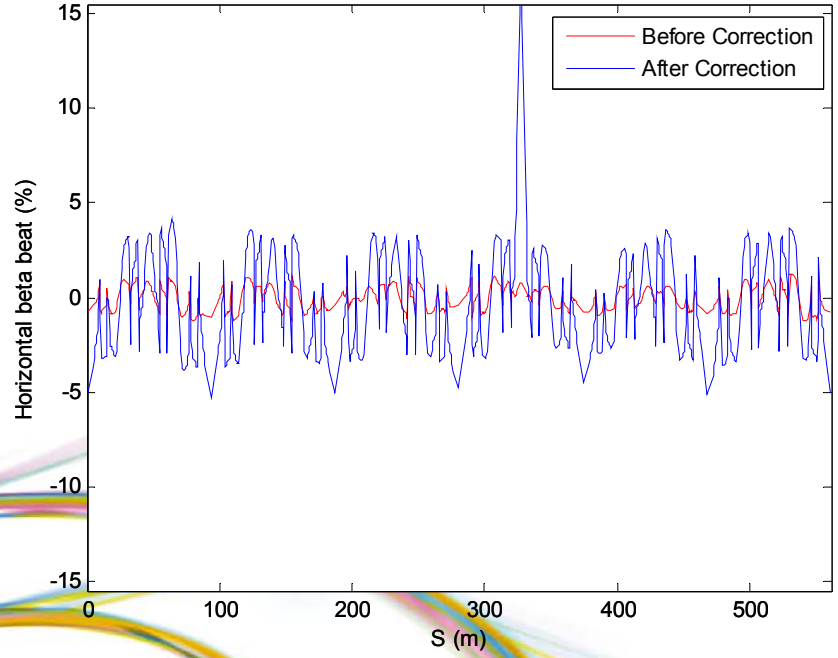


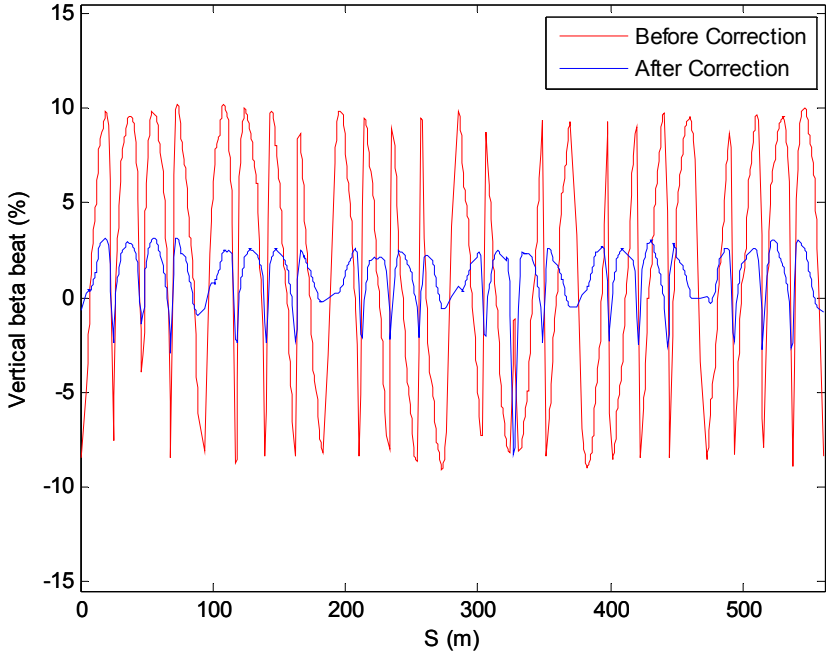
4) Wiggler Optics Correction

Correcting for I15 using alpha-matching plus global tune correction

I15 at 3.5T

Residual beta beat <5% in both planes





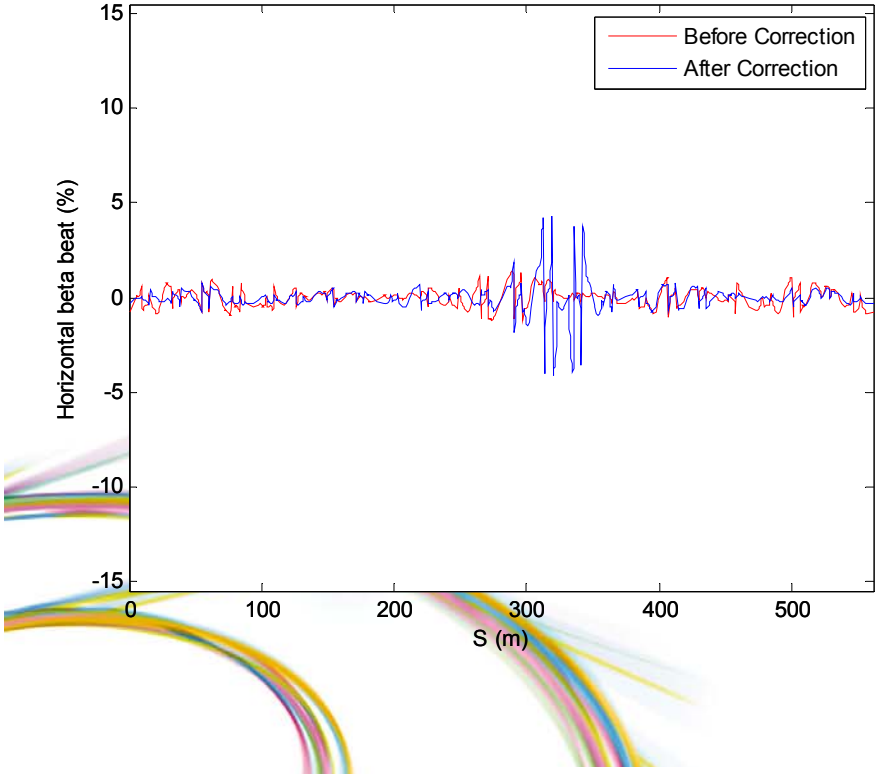
Courtesy B. Singh

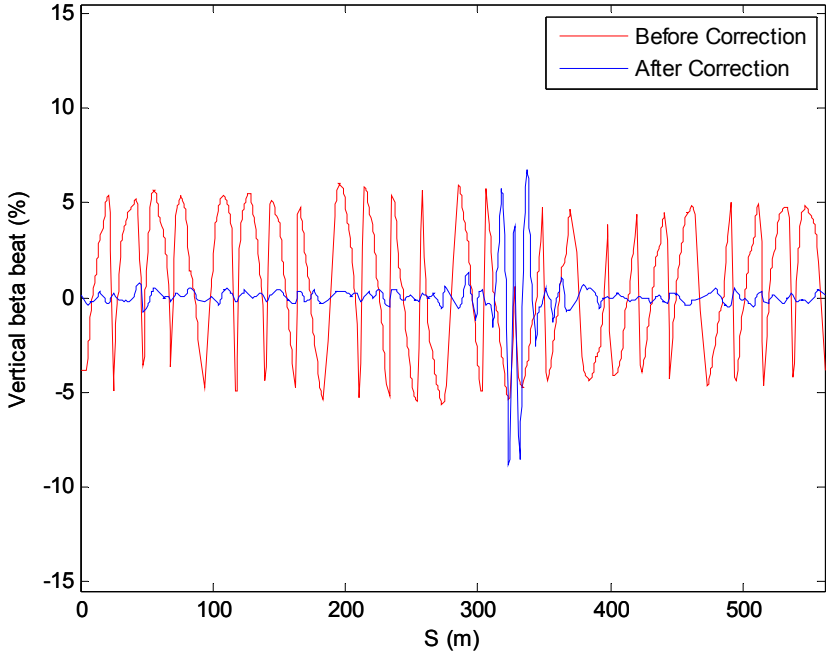
4) Wiggler Optics Correction

Correcting for I15 using LOCO

I15 at 2.5T

Residual beta beat <1% in both planes





Courtesy B. Singh

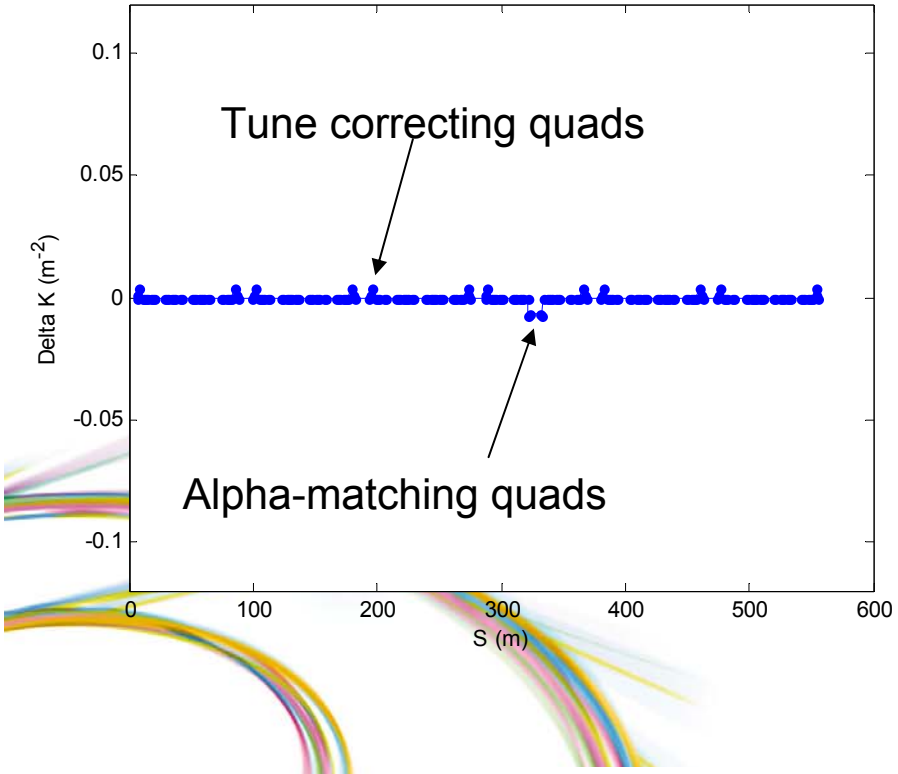
4) Wiggler Optics Correction

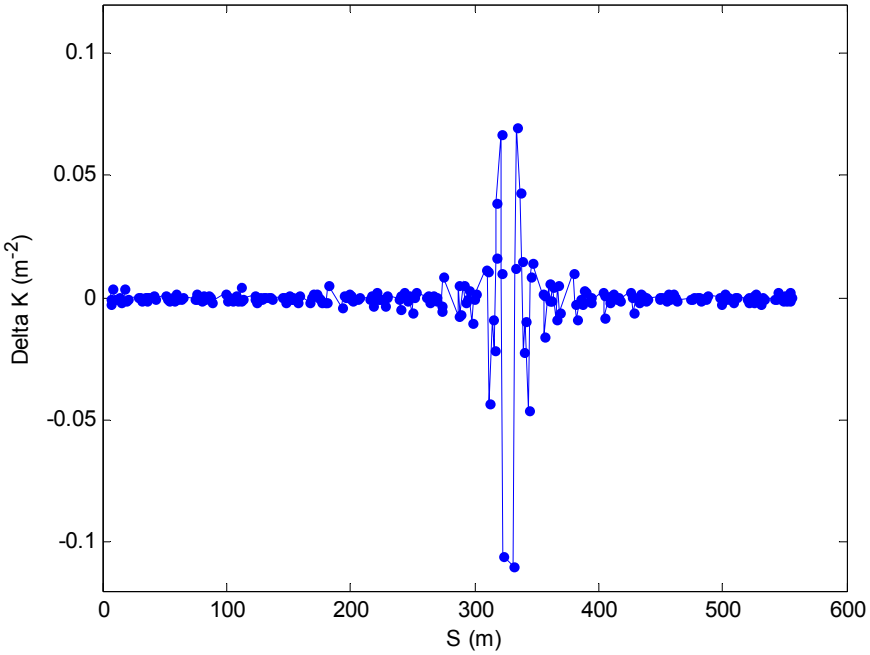
Alpha-matching:

- 28 Quadrupoles
- Max $\Delta K = -0.0071 m^{-2}$

LOCO:

- 240 Quadrupoles
- Max $\Delta K = -0.11 m^{-2}$





5) Summary

In-vacuum IDs

-Generally have minimal affect on lifetime and injection efficiency (3h reduction in lifetime for all IV at 5mm)

-Indications that I04 has strong skew octupole component. Reduces horizontal DA and lowers injection efficiency by ~10%

SC Wigglers

-Generate 10-15% beta beat, require quadrupole feedforward tables to correct

-No effect on injection (assuming tunes corrected to nominal)

-5-10% change in lifetime

Thanks:

B. Singh, R. Fielder , R. Bartolini, C. Christou, E. Longhi