Optics for I13 Beamline and Its Recent Status

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Summary

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  - Virtual h-focussing
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- Optics for I13 beamline
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  - Effects of optics on ring dynamics
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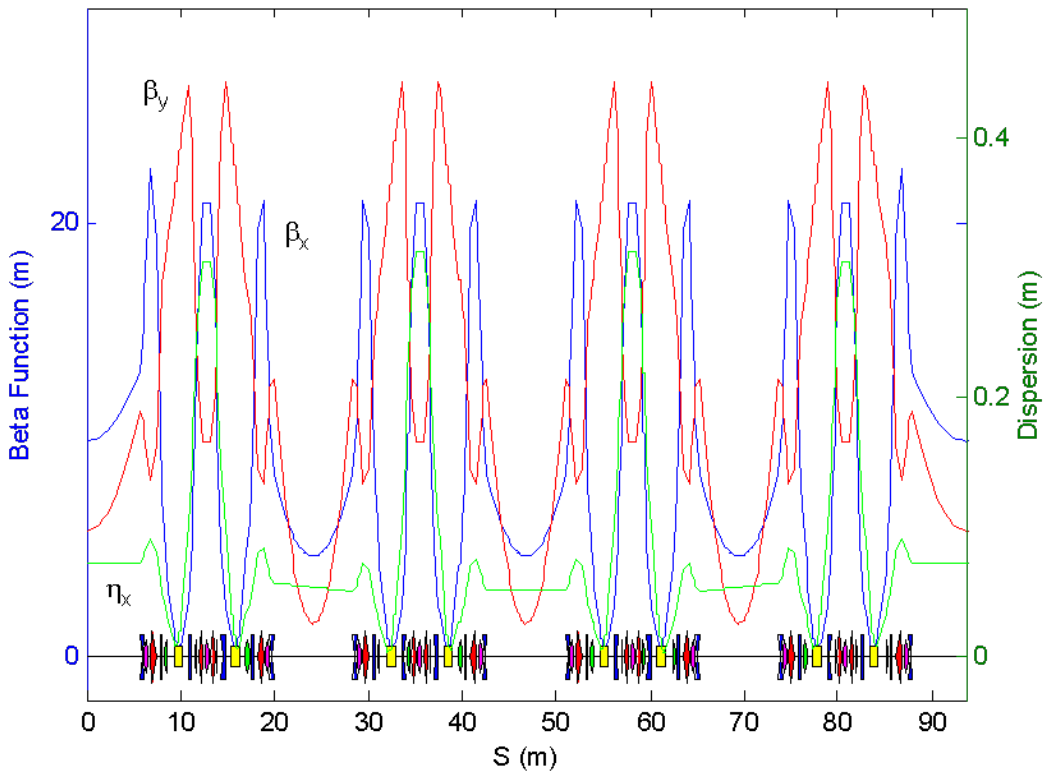
- Recent status
  - Implementation
  - Commissioning , user run and first light in coherence branch of beamline.
  - Conclusions and future outlook.

Introduction(1)



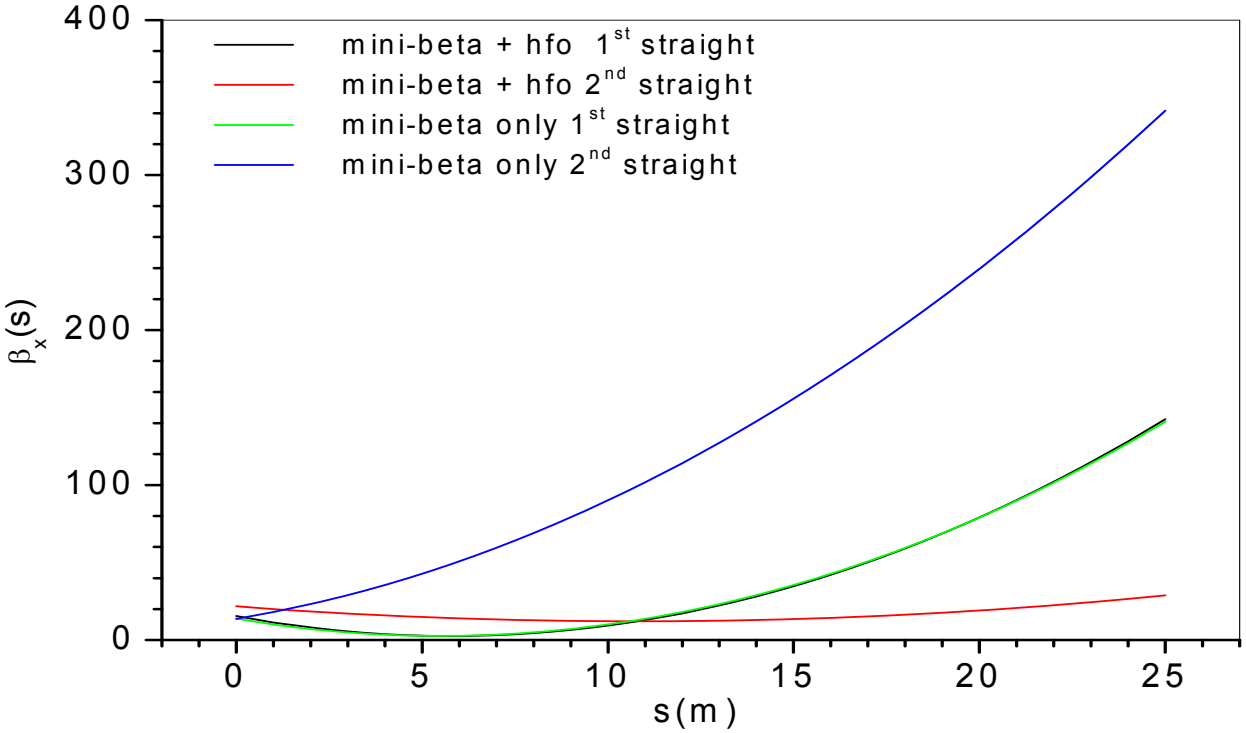
Lattice	DBA
Structure	24 cell
Symmetry	6
Straights	18 × 5m / 6 × 8m
Energy	3 GeV
Length	561.6 m
Lifetime	>20h (target>10h)
Current	200mA (300mA)
Emittance	2.7nm.rad
En. Spread	9.6×10^{-4}
Tunes(Qx,Qy)	*(27.22, 12.36)*

Features of I13 Beamline(2)

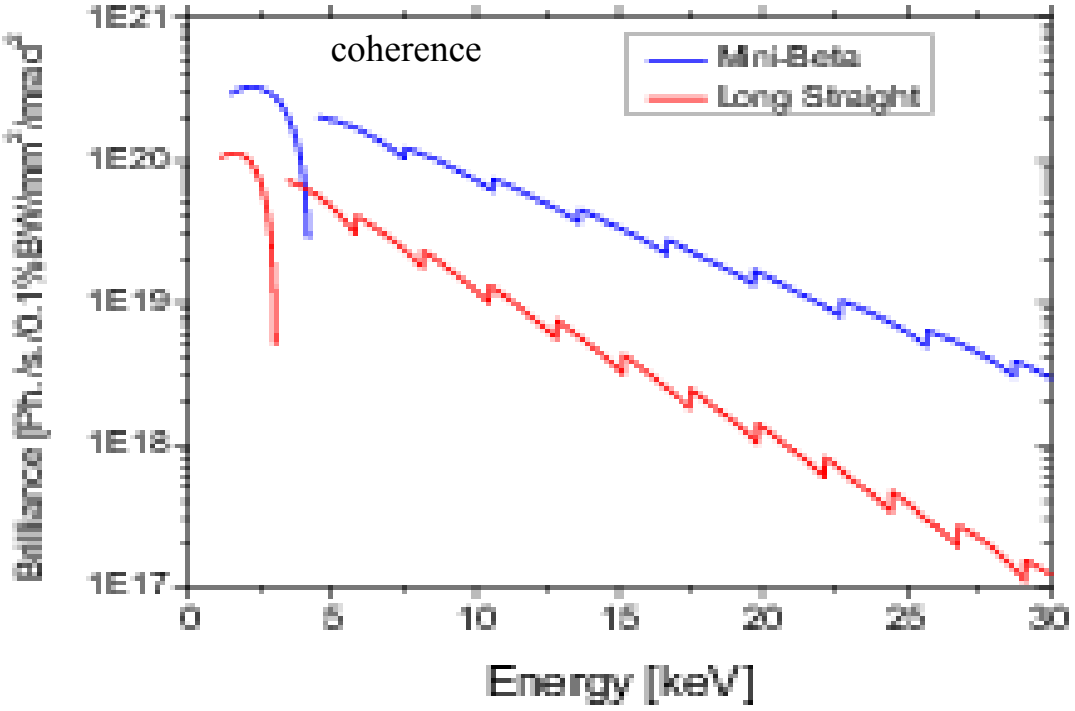
- Two independent branches for Coherence and Imaging applications.
- Coherence : 6-20 KeV, Imaging : 8-30 KeV
- Two in-vac. Undulators : two mini $-\beta_y$ (SLS)
- Coherence: virtual h-focussing → large β_x *and* $\alpha_x \sim 1$ (APS, ESRF)
- Coherence: high brilliance → large number of periods (N) or longer length (L) of undulator
- Imaging: in-vac. undulator with gap of 5mm
- Location: long insertion straight

Virtual h-focussing (4)

Comparison of virtual β_x for 'two mini- β_y+hfo' and 'two mini- β_y' optics



Advantages to I13 Beamline (5)



Virtual h-focussing allows to have fully coherent beam without loosing unnecessarily flux for coherence related experiments.

Figure: A comparison of a 3m long U20 cryo-cooled undulator (blue) in a mini-beta section and a comparable undulator in a long straight (U28).

Thanks to C. Rau, I13 beamline

Solution to I13 Optics(1)

- MAD Optics Code
- π-trick with small deviation (ΔQ_x=0.06, ΔQ_y=0.5)

  ---- to preserve symmetry of ring sextupoles for Δp/p=0
- $\alpha_x \leq 1.3$ at middle of 1st mini β_Y to contain the size of mirror
- Doublet at the middle ----- to maximize drift spaces
- Existing quad Q1D is retained and one more focussing quad is added on either side
- Designs of extra quads are chosen from existing quads of ring.

  ---- to avoid design efforts.

Solution to I13 Optics(2)

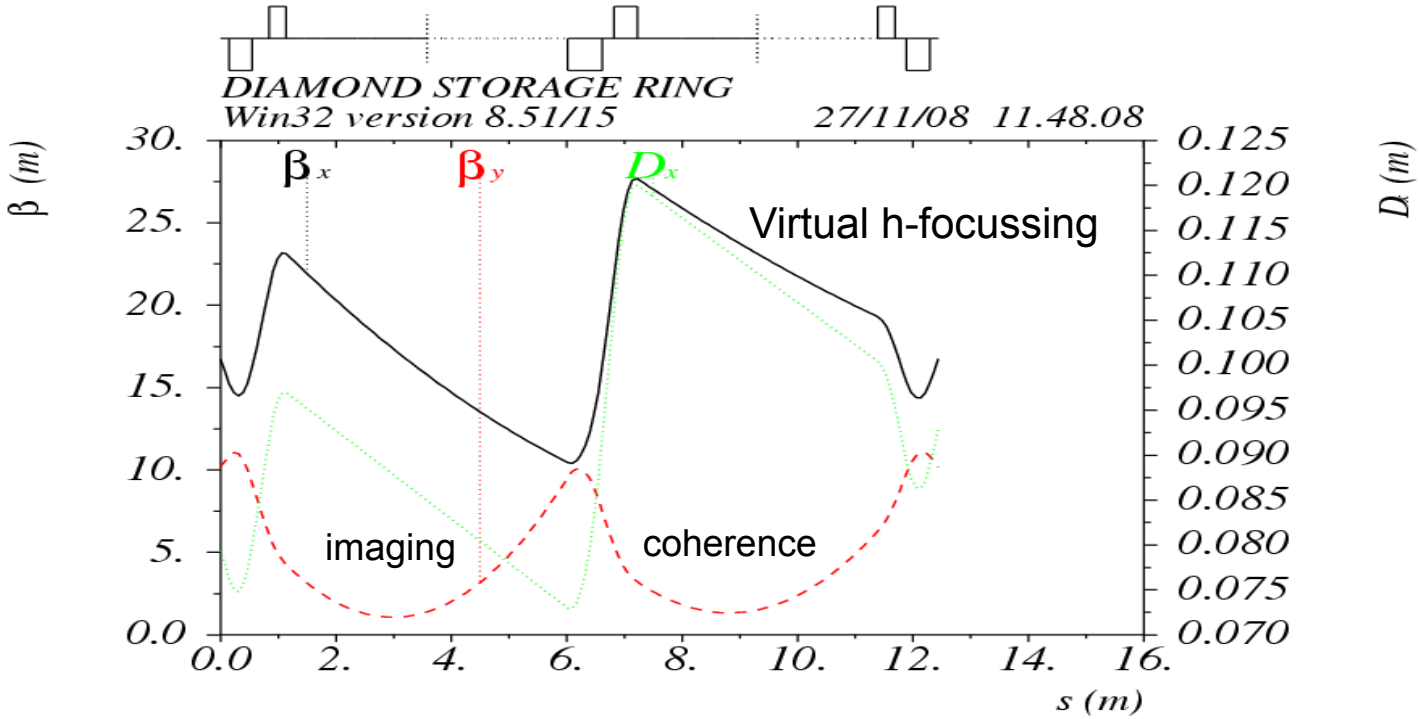


Figure: β-functions of final optics for I13 beamline

Solution to I13 Optics (3)

- New WP (Q_x, Q_y) =(27.22,12.86)
- Emittance = unchanged
- Upstream undulator (Imaging): L=2m, Gap=5mm
- Downstream Undulator (coherence): L=2.8m, gap=6mm

Effects of I13 Optics on Ring Dynamics (1)

- Instabilities (Resistive Wall): Q_y above half integer
- DA and FMA
- Injection Efficiency
- Touschek Lifetime
- Orbit Errors

Instabilities: Q_y above half integer ---- Resistive Wall

---- TMBF will be used (No 3rd harmonic cavity in Diamond)

Effects of I13 Optics: Dynamic Aperture (Δp/p=0) (2)

on-momentum DA for zero chromaticities

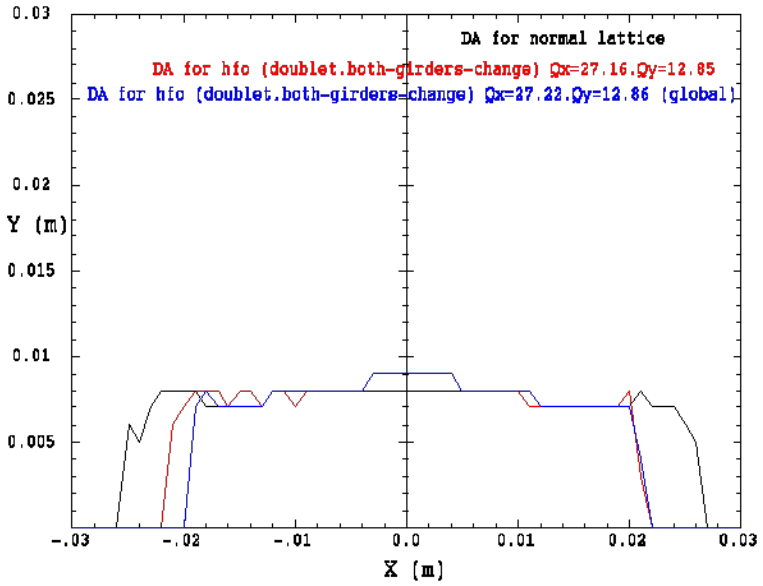
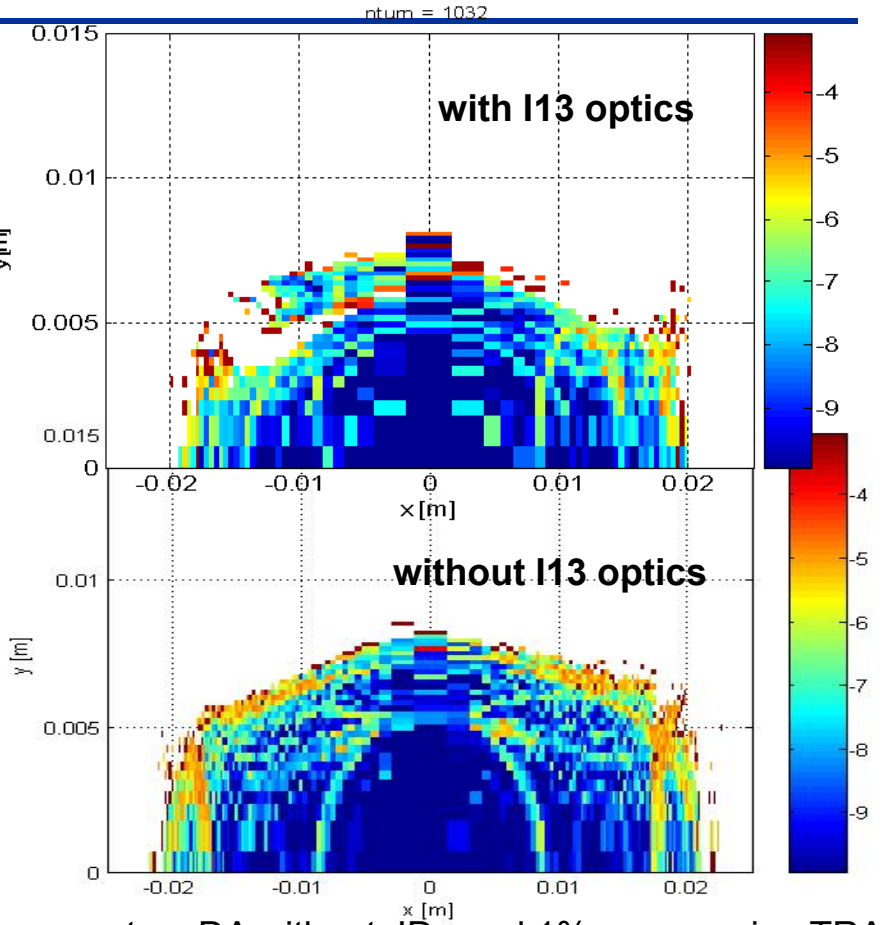


Figure :Comparison of On-momentum DA without (black)/with I13 optics with (blue)/without (red)adjustment tunes globally using BETA



On-momentum DA without IDs and 1% coup. using TRACY II

Effects of I13 Optics: Injection Efficiency (3)

Injection efficiency: TRACY II

All kick maps + all multipolar errors+ engineering apertures

Injection efficiency

case	new sextupoles $\xi_{x/y}$=1.5/.7	Old sextupoles $\xi_{x/y}$=.0/0	normal lattice
no tunes corr.	76%	85%	83% ($\xi_{x,y}$=.0,0)
tunes corr.	97%	91%	99% ($\xi_{x,y}$=1.5,.7)

Effects of I13 Optics: Touschek Lifetime (4)

Touschek lifetime calculated using TRACY II in presence of real engineering apertures for (bunch length σ_l = 2.8mm; 500mA; 2/3 fill, V=3.3MV)

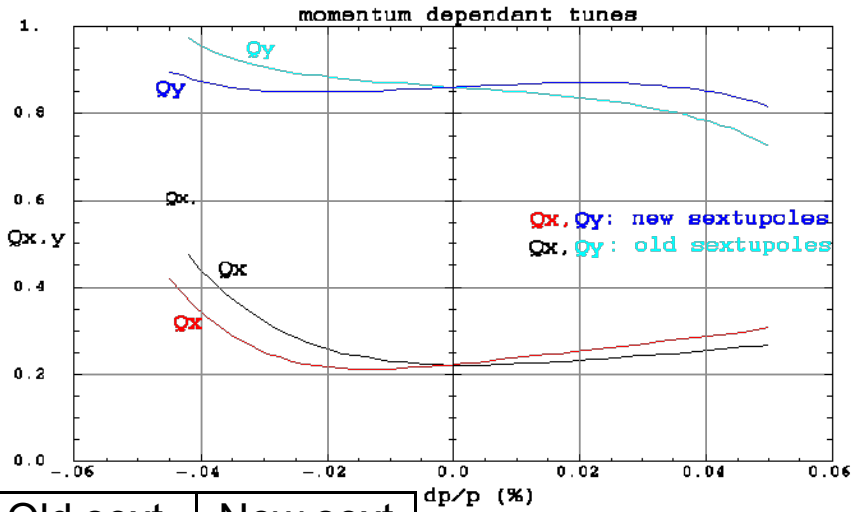
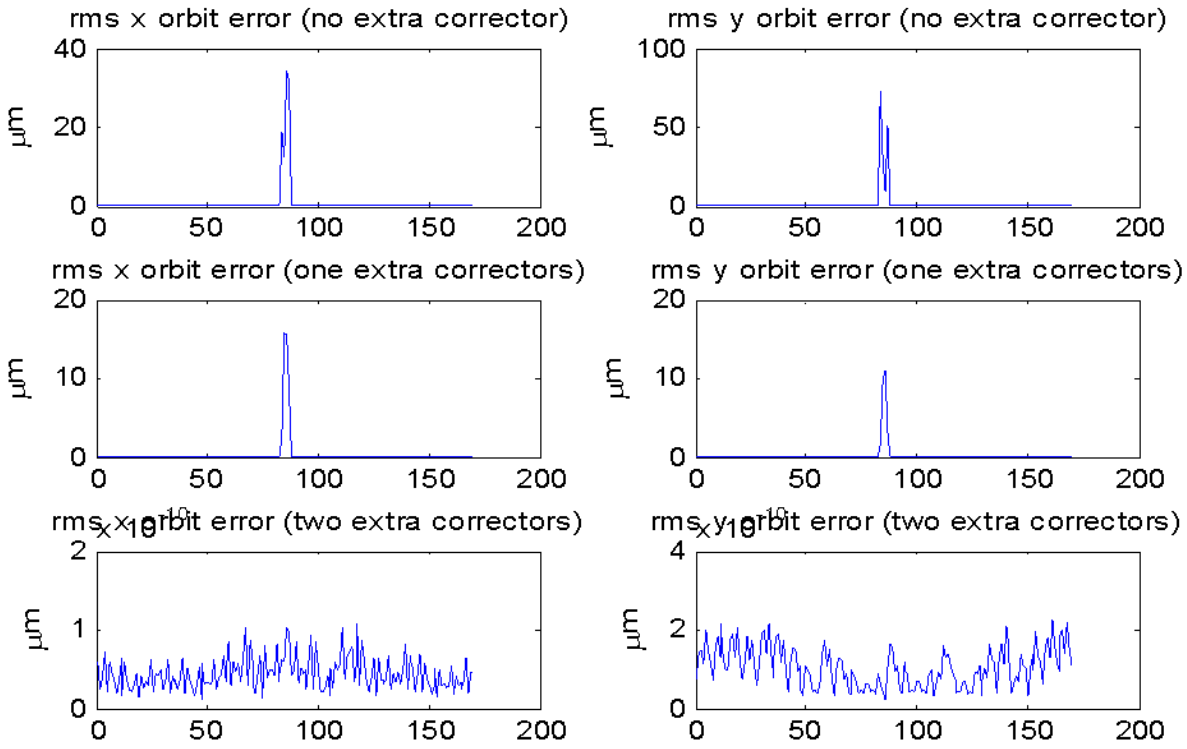


Figure: Momentum-dependant tunes for zero/nonzero chromaticities

Touschek lifetime

case	Old sext.	New sext
No kick maps+no errors	10h	14h
All kick maps+no errors+1% coup.	11h	14.0
All kick maps+errors+tunes corr.	10h	12h
All kick maps+no errors+tunes corr.	11h	14h
Normal lattice--- kick maps+errors+tunes corr.	11h	13h

Effects of I13 Optics : Orbit Errors (5)



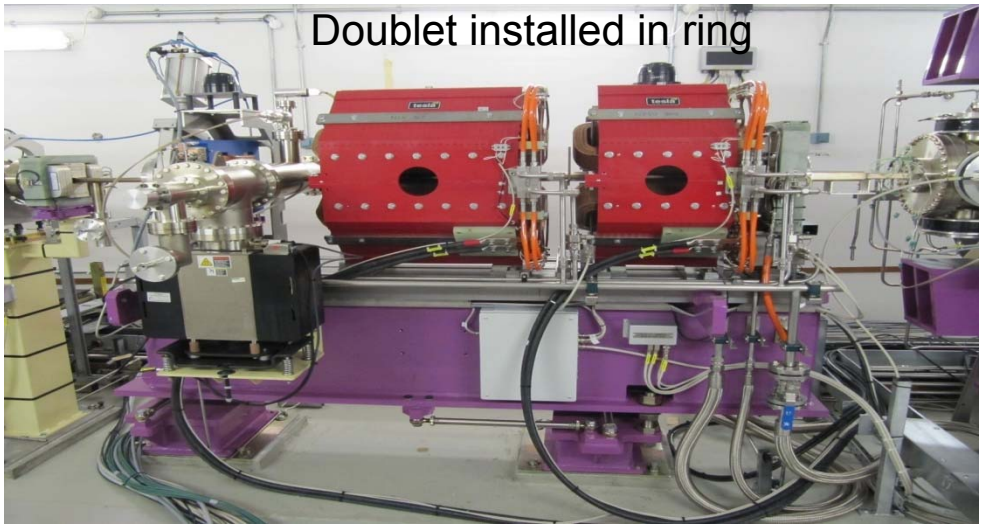
- Needed two extra h/v correctors.
- Located before and after doublet.

Figure: comparison of rms orbit errors : a) no extra correctors, b) one extra h/v corrector, c) two extra h/v correctors.

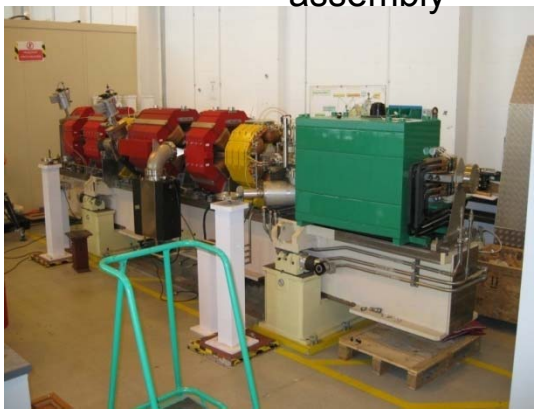
Recent Status: Implementation(1)

- Redesign of girders G1,G3 and one extra middle girder for doublet as well as redesign vacuum vessel.
- Four extra Quadrupoles
- Modification of existing Q1D quad power supply to reach .k=0.7m^{-2} to 2.2 m^{-2} and its cooling.

Middle girder with doublet under assembly



Doublet installed in ring



Girder G1 assembled

Recent Status: Commissioning (2)

- Optics established with WP = (27.22,12.86).
- Injection efficiency > 75% (IDs open).
- Instability: strong

with in-vac IDs open

---- 180mA, 2/3 fill ---- $\xi_{x/y}$ =1.7/1.9 (normal operational values)
---- 200mA, 2/3 fill ---- $\xi_{x/y}$ =1.7/2.1+TMBF
---- 200mA, full fill ---- $\xi_{x/y}$ =1.7/3.5
---- 200mA, full fill ---- $\xi_{x/y}$ =1.7/2.8+TMBF
---- 200mA all in-vac IDs closed 7mm for $\xi_{x/y}$ =1.7/4.0 for both fills

It has not been possible to close all in-vac ID to 5mm at 200mA with either fill pattern even with help of TMBF.

------ Efforts to suppress instabilities using TMBF are underway

Recent Status: Commissioning (3)

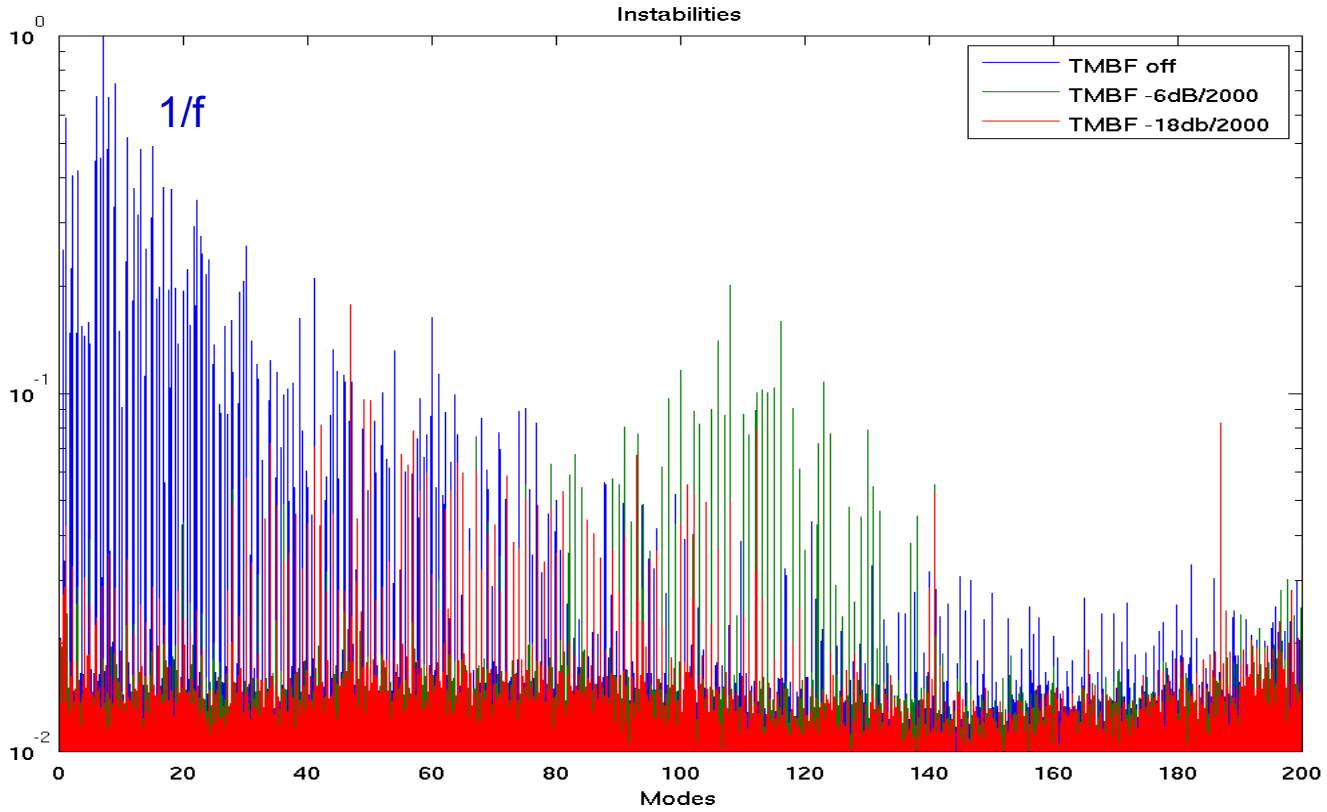


Figure: Evidence of RW instability when TMBF is turned off

Recent Status: Commissioning (4)

- Moved the **Q_y=12.86 to 13.09** to overcome instability

  New WP =(27.237,13.095)

- Ring optics re-optimized to keep β_y(1.6m) unchanged in all standard straights and twiss parameters of I13 straights using ELEGANT.

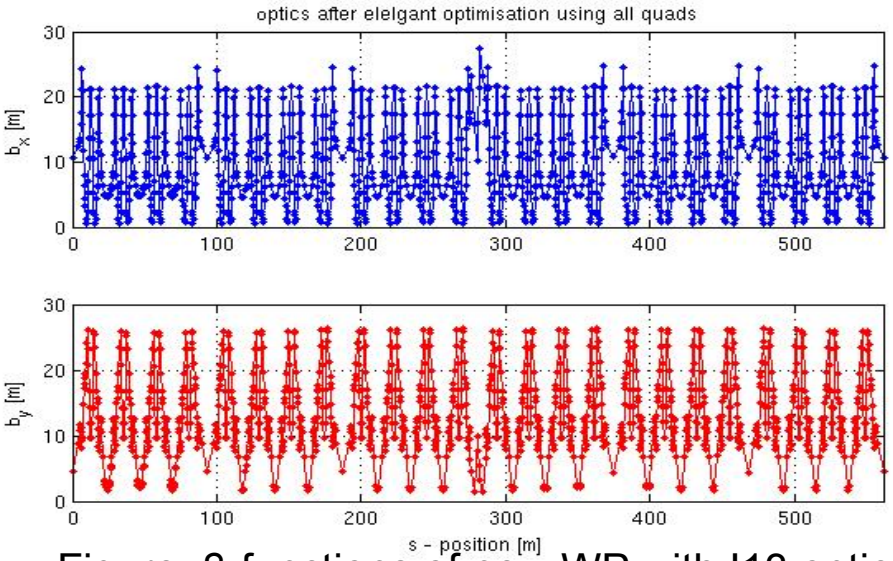


Figure: β-functions of new WP with I13 optics

- Emittance = 2.6nm.rad
- Injection Efficiency
  (all IDs close/open) >75%
- $\xi_{x/y}$ =2.1/1.7
- Lifetime >18h

Recent Status: Commissioning (5)

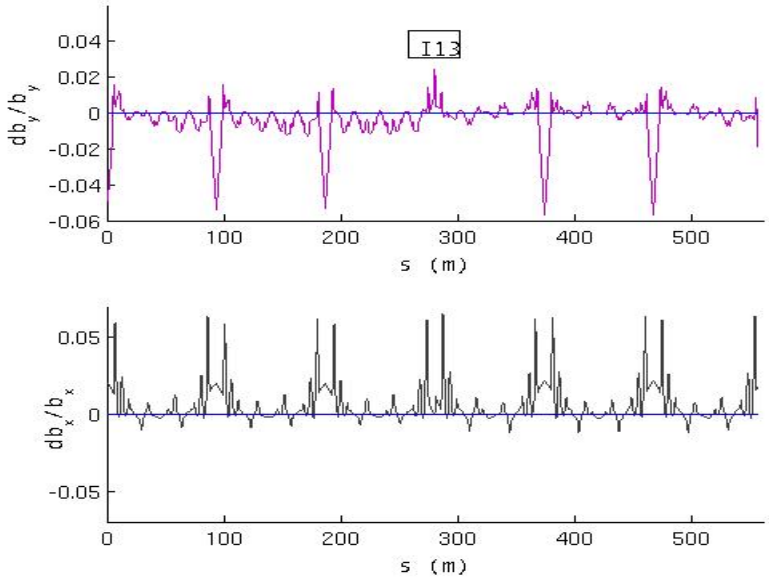


Figure: relative beta-beat with new I13 optics (27.237,13.095) w.r.t designed I13 optics (27.22,12.86) from model

Relative beta-beat with new I13 optics w.r.t designed I13 optics calculated from models

------ 6% in x, y

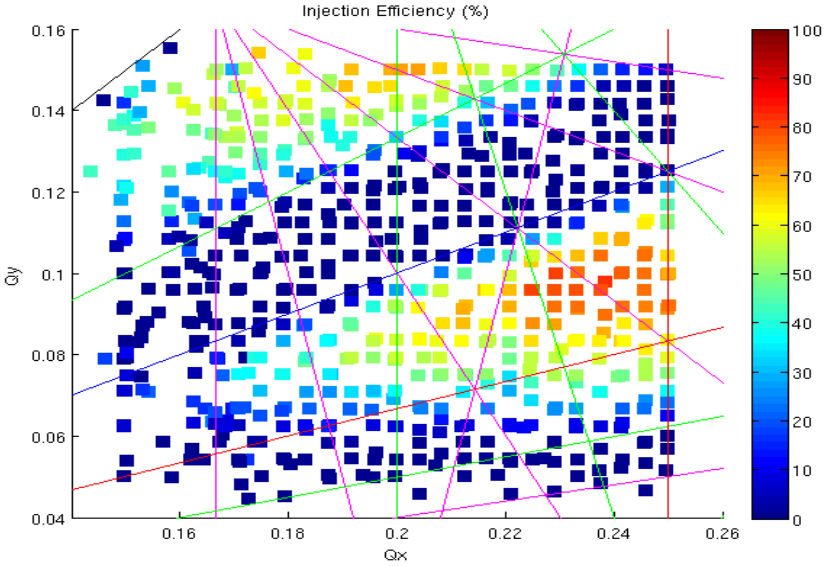


Figure: Injection efficiency vs. $Q_{x/y}$

Recent Status: User run with I13 Optics (4)

Successful user run with I13 optics and top-up before Nov. shut down

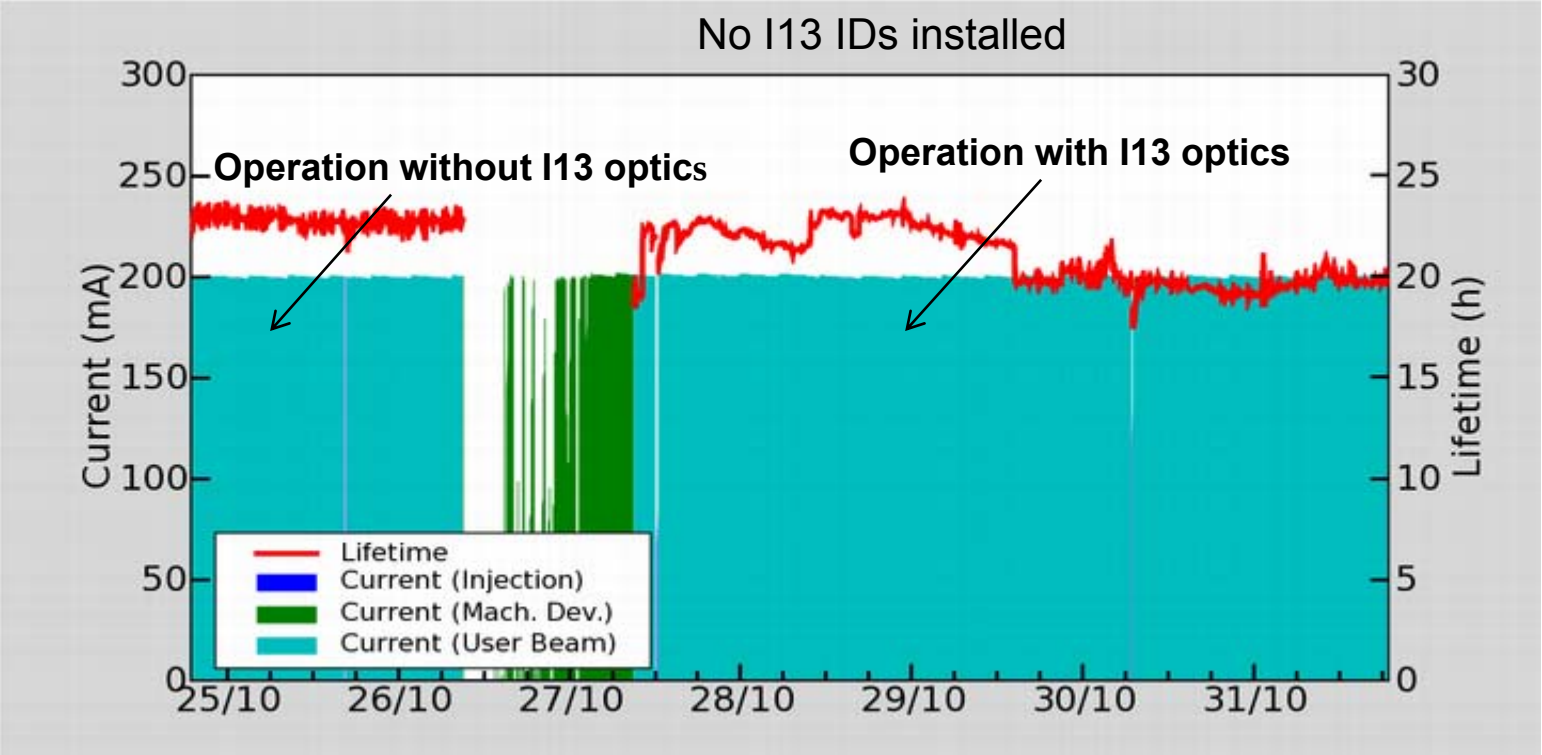
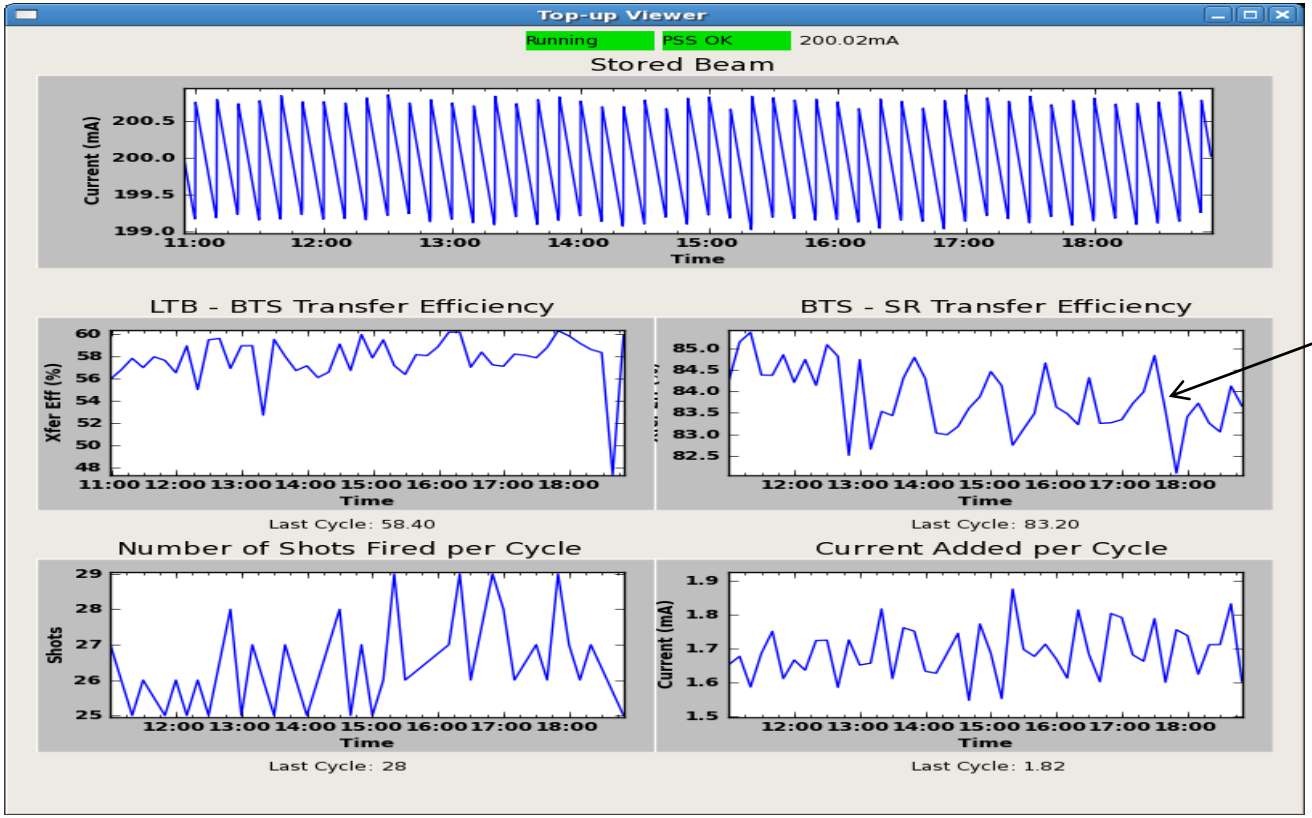


Figure: Machine status of user run

Recent Status: User run with I13 Optics (5)



Injection Efficiency >80%

Figure: Top-up Viewer of last shift with I13 optics before shut down

Recent Status: First Light in Coherence Branch of I13 Beamline

Expected on 24-11-2010

Undulator installed in ring for coherence branch of I13 beamline

Assembled I13 straight with downstream undulator (coherence)

Conclusions and Future Outlook

- Strong RW instability for operation above half integer (Q_y=12.86).
- Alternate optics devised to operate below half integer (Q_y=13.09).
- Successful user operation with alternate optics.
- Another long straight is under modification with similar optics for I09 beamline and new WP =(27.22, 13.36) allowing machine operation below half integer.
- Future operation will be at WP =(27.22, 13.36) when I09 quadrupoles (march,2011) will be installed.

Thanks

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Engineering group

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Operations group

I13 beamline

C. Rau, U. Wagner