# Status of non-linear dynamics correction studies

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MEIC Accelerator R&D Meetingeting*(12 Feb., 2015), SLAC USA*

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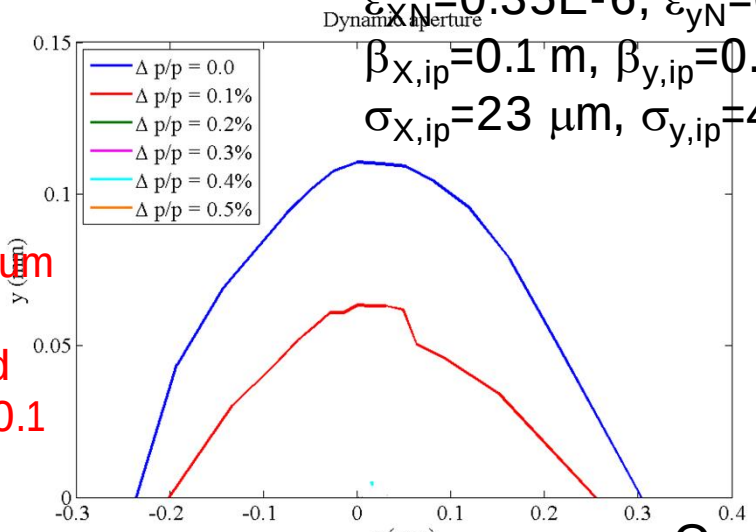
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

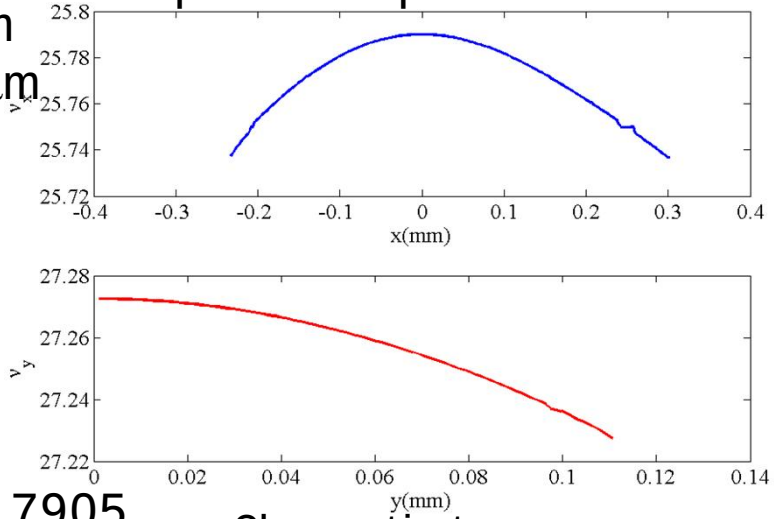
# Beam dynamics properties before optimization Original lattice

$\varepsilon_{xN}$=0.35E-6, $\varepsilon_{yN}$=0.07E-6
$\beta_{X,ip}$=0.1 m, $\beta_{y,ip}$=0.02 m
$\sigma_{X,ip}$=23 μm, $\sigma_{y,ip}$=4.6 μm

Off momentum particle survived only to 0.1 %

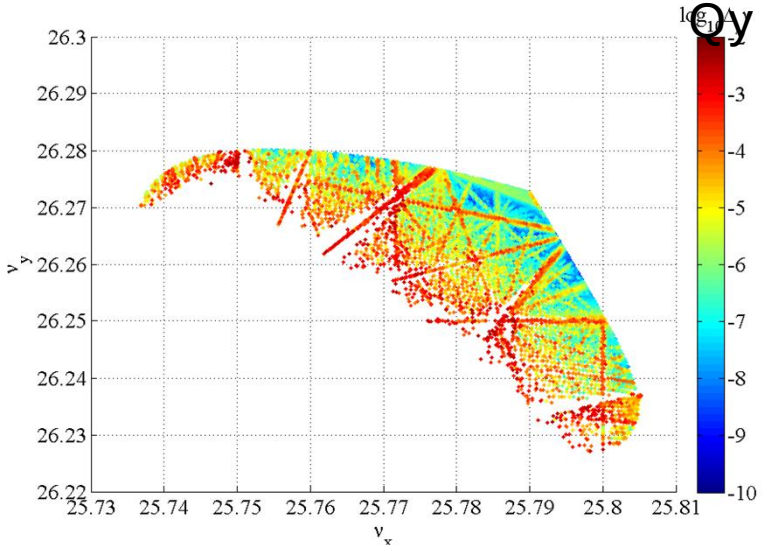



Amplitude dependent tune

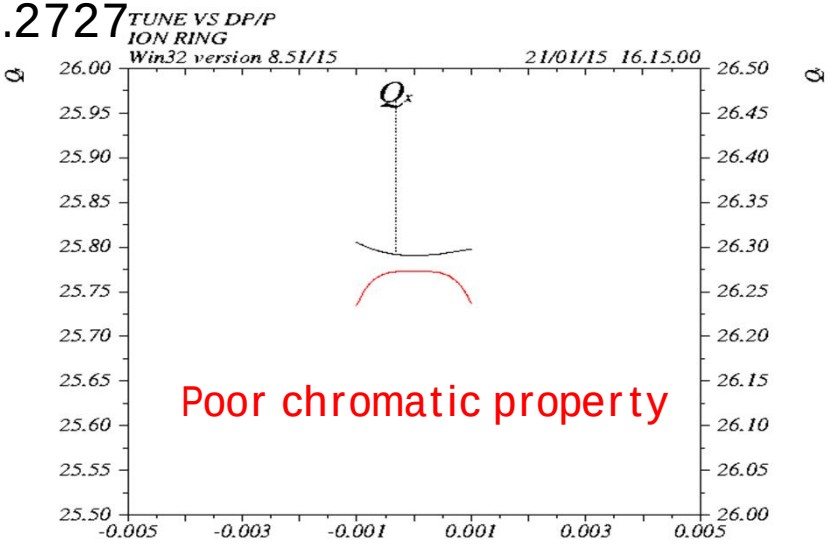



Tune footprint

Qx = 25.7905
Qy = 26.2727




Chromatic tune



# Beam dynamics properties before optimization
# Modified lattice with -I CCB and 60° arcs

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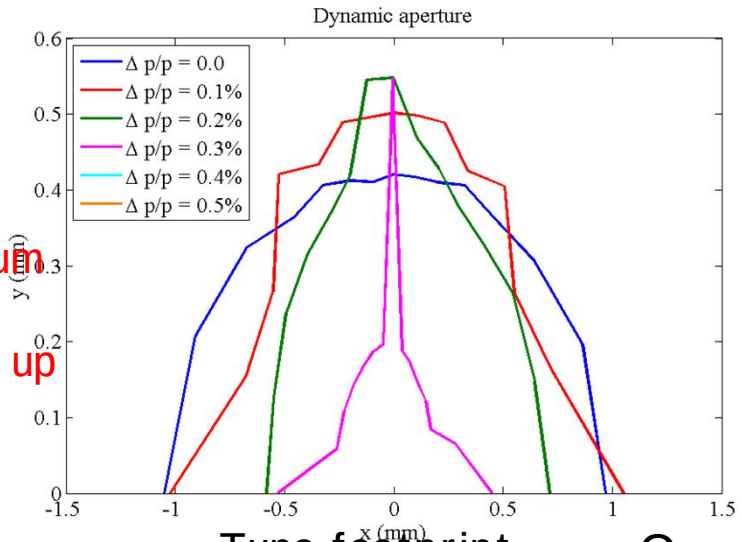
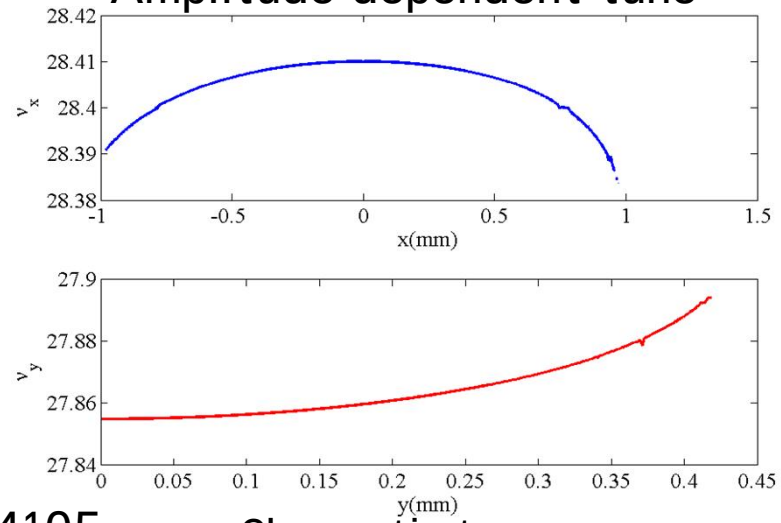
Off momentum particle survived up to 0.3 %

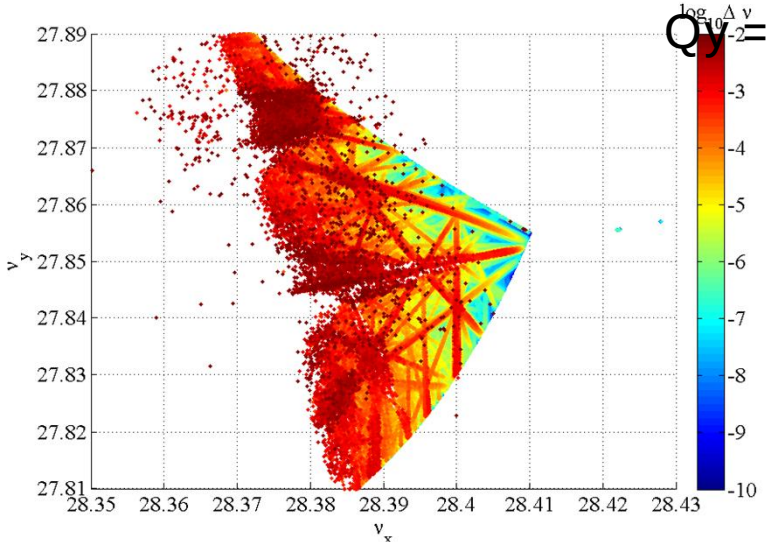



Amplitude dependent tune

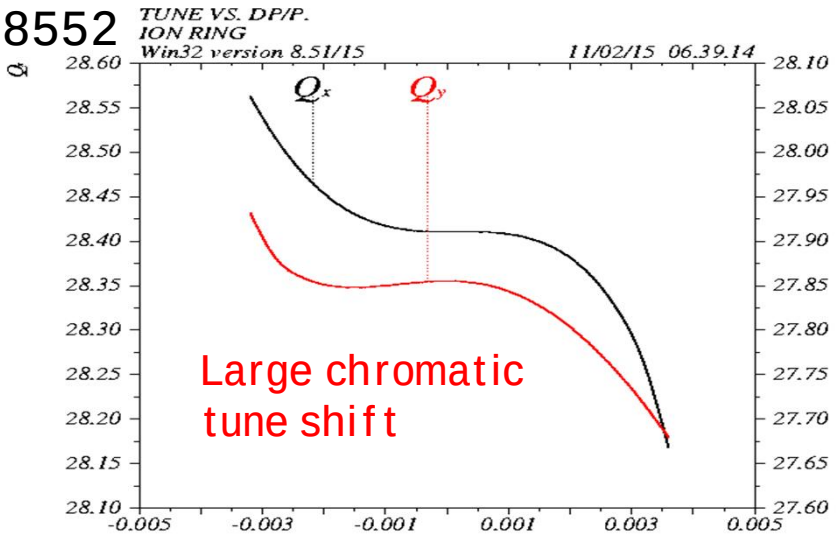



Tune footprint

Qx = 28.4105,
Qy = 27.8552



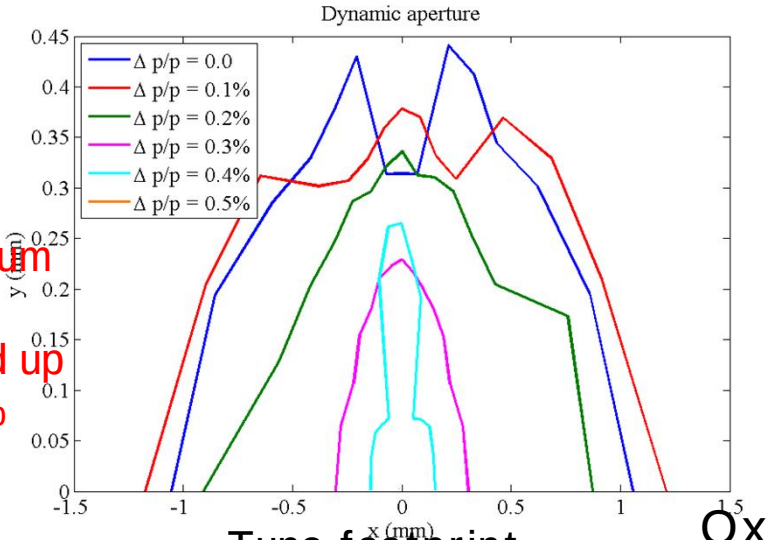

Chromatic tune



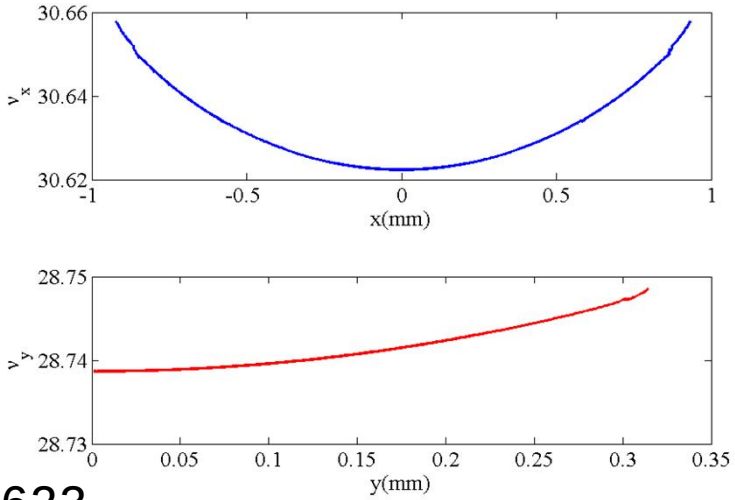
# Beam dynamics properties before optimization
# Modified lattice with -I CCB and 90° arcs

SLAC

Off momentum particle survived up to 0.4 %

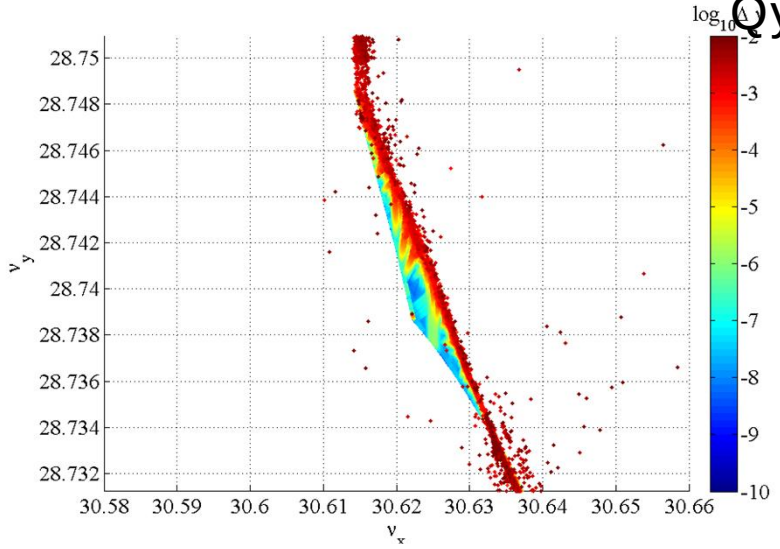



Amplitude dependent tune

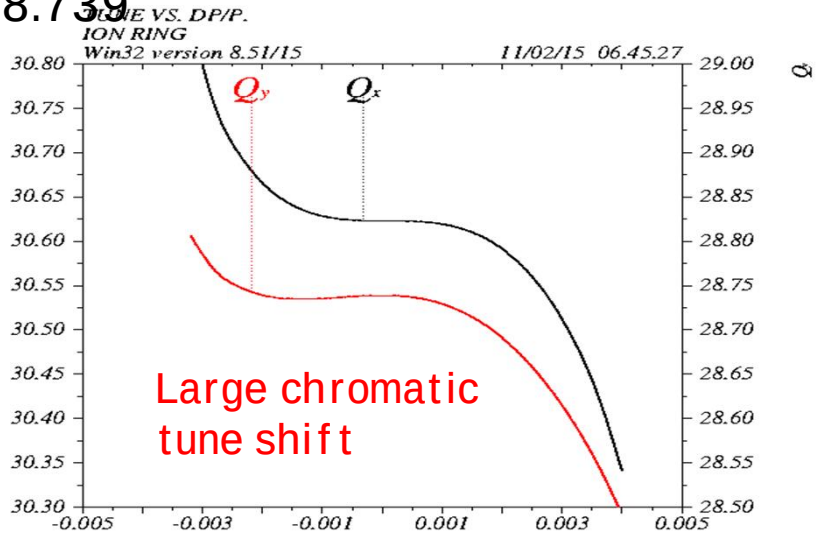



Qx = 30.623,
Qy = 28.739

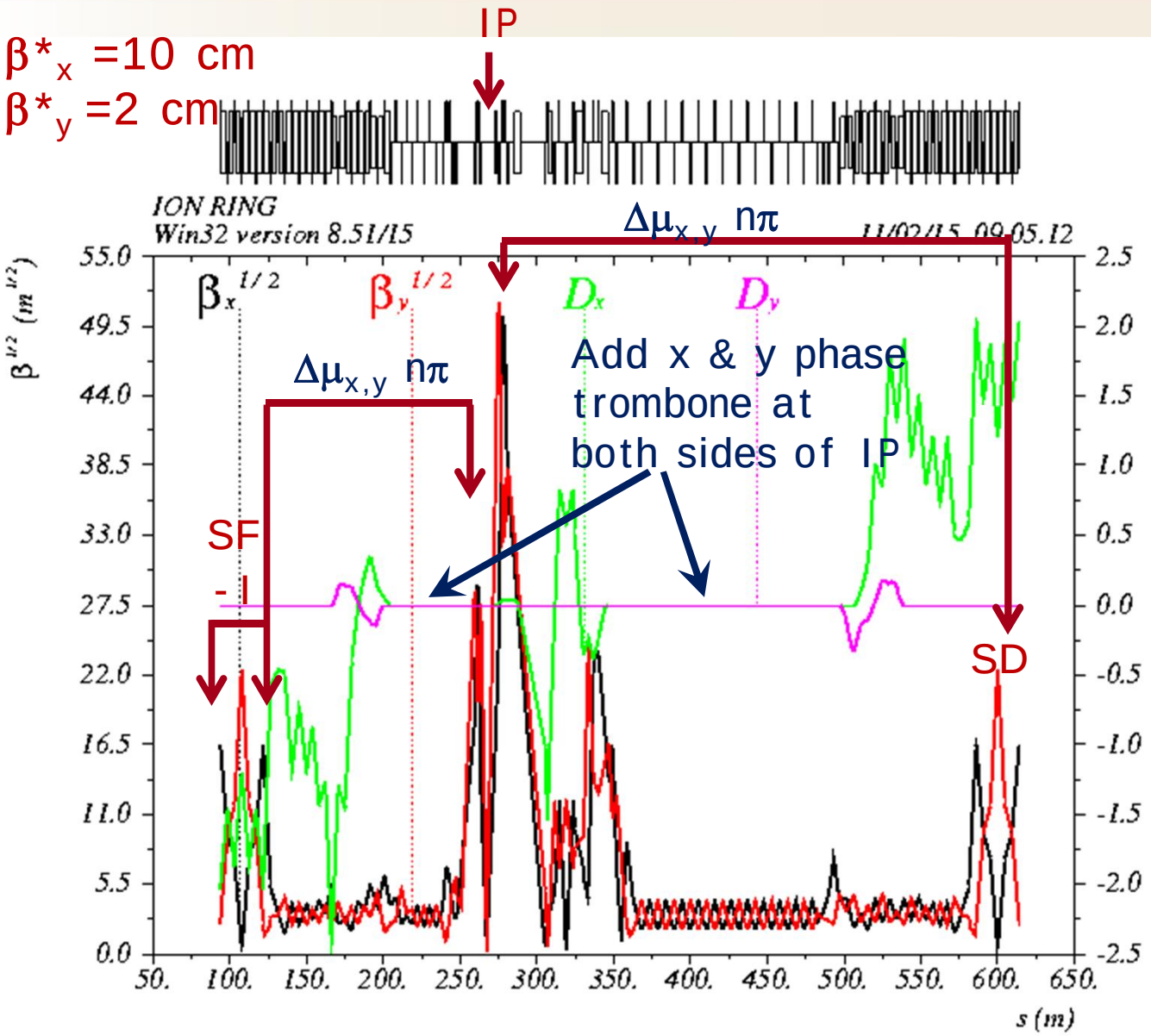
Tune footprint




Chromatic tune



# Phase trombone of original lattice




Add x & y phase trombone at both sides of IP to make the IP sextupoles have –I phase to final doublet

$d\mu_{X\_S\text{-}Q\,U}$ =2.0141
$d\mu_{y\_S\text{-}Q\,U}$ = 3.2843
$d\mu_{X\_S\text{-}Q\,d}$ = 6.1026
$d\mu_{y\_S\text{-}Q\,d}$ = 5.4109
Qx = 25.7905,
Qy = 26.2727

KSF = 25.065
KSD =-26.888
KSFIPU = 5.591
KSDIPU = 6.282
KSFIPD = 4.983
KSDIPD =-5.202

ξx/ξy = 0/0,
$W_{x,IP}$ /$W_{y,IP}$ = 0/0

# Original lattice + phase trombone makes nπ phase advance

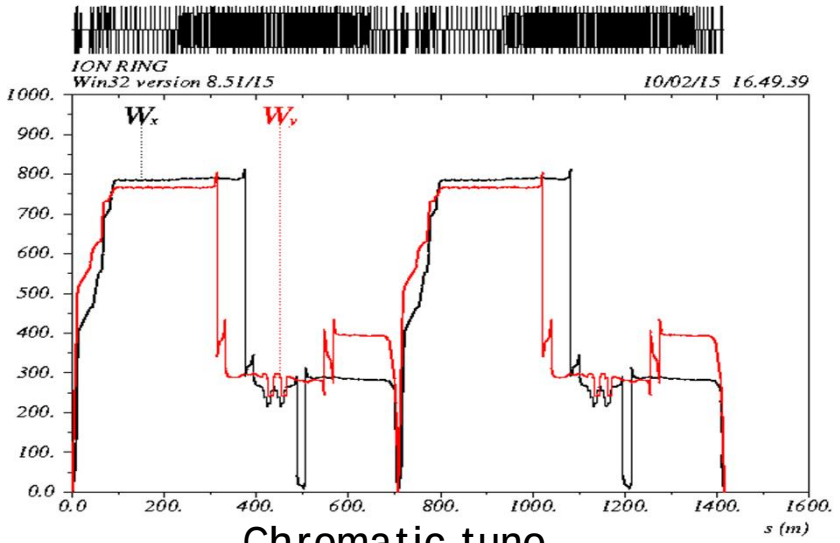
Phase Trombone

$\Delta\mu_{x\_U}$ = -0.0141
$\Delta\mu_{y\_U}$ = 0.2157
$\Delta\mu_{x\_d}$ = 0.3974
$\Delta\mu_{y\_d}$ = 0.0891

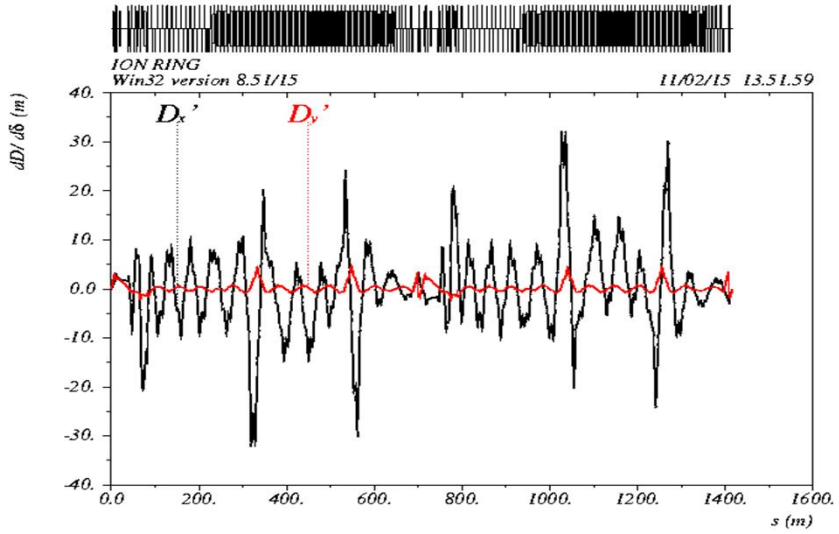
Qx = 26.557,
Qy = 26.882

KSF = 5.418
KSD =-13.029
KSFIPU = 1.194
KSDIPU = -1.219
KSFIPD = 2.579
KSDIPD = -4.746

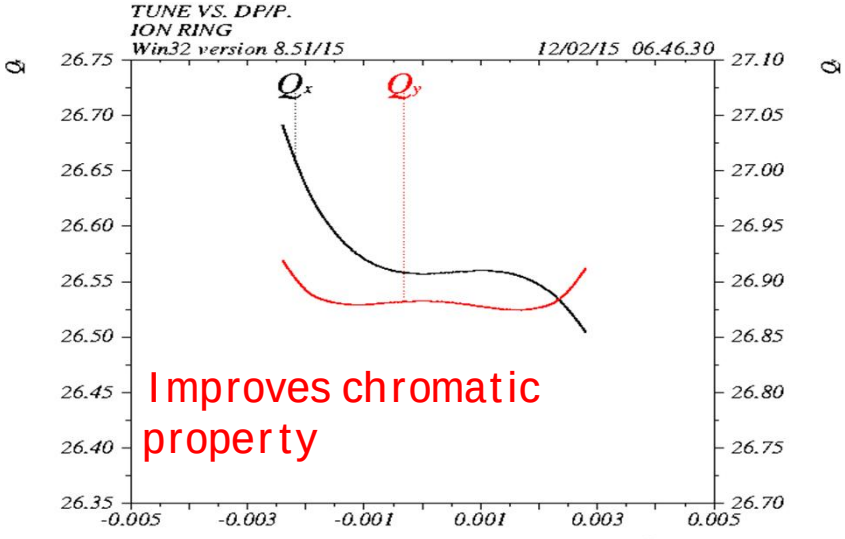
W function



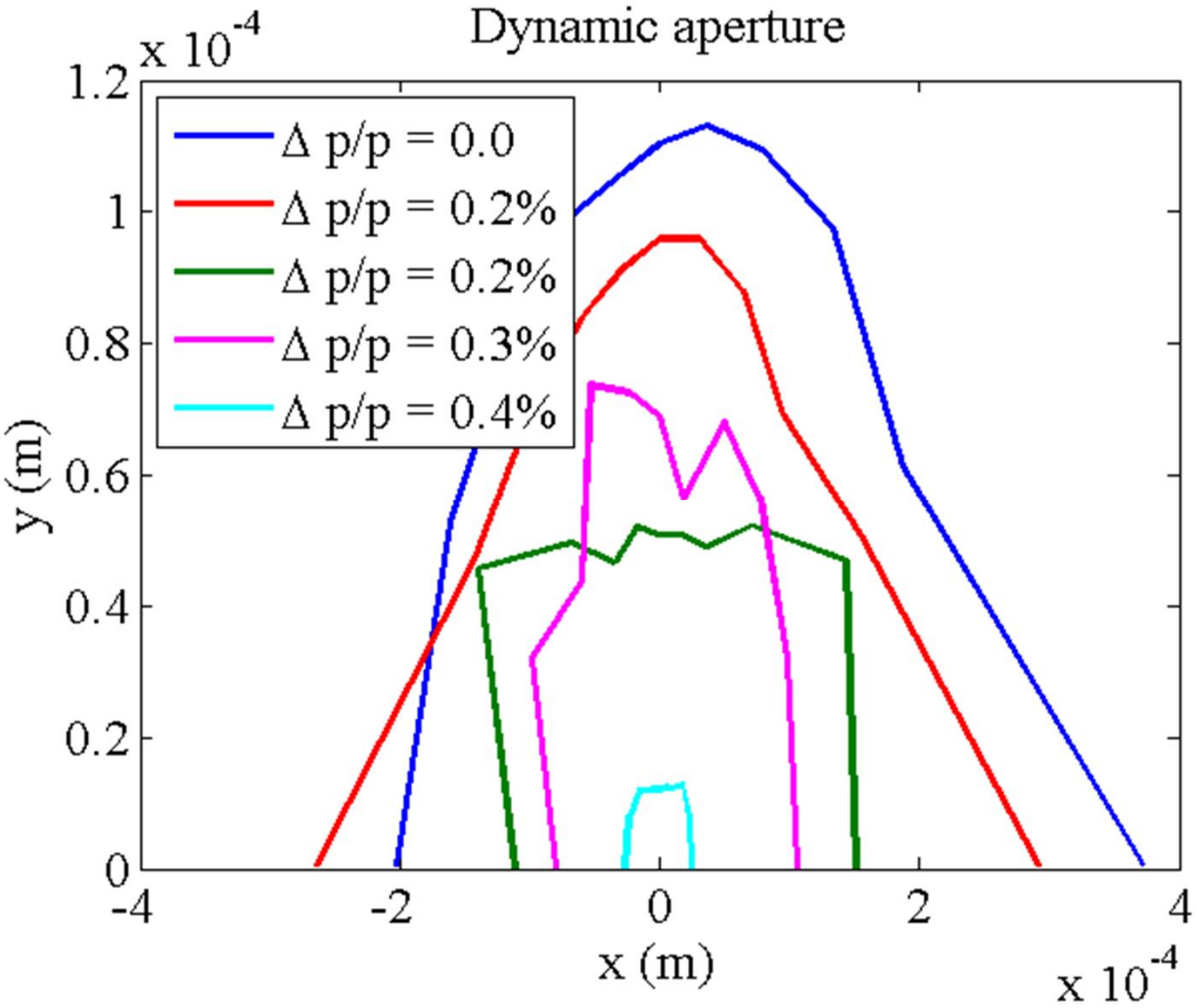

Second order dispersion




Chromatic tune



# Original lattice + phase trombone nπ




MAD8 Lie4 dynamic aperture tracking

# Original lattice + fine tune phase trombone

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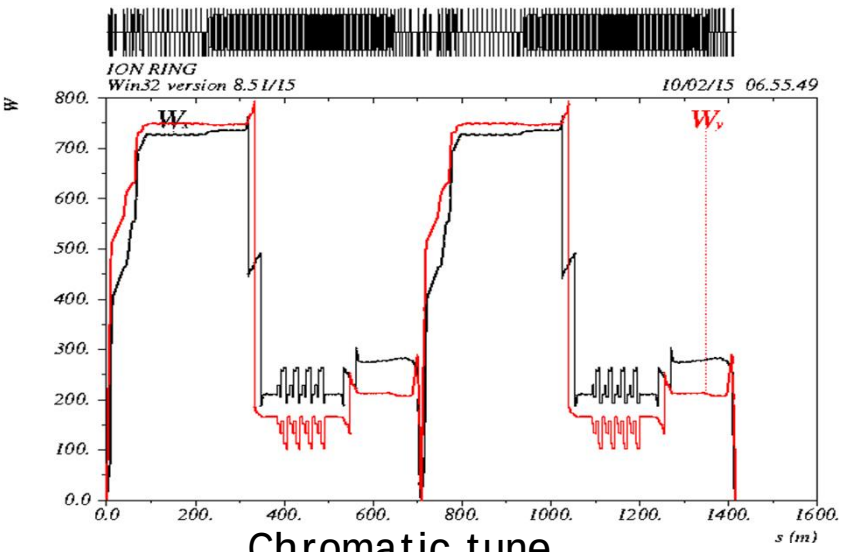
Phase Trombone

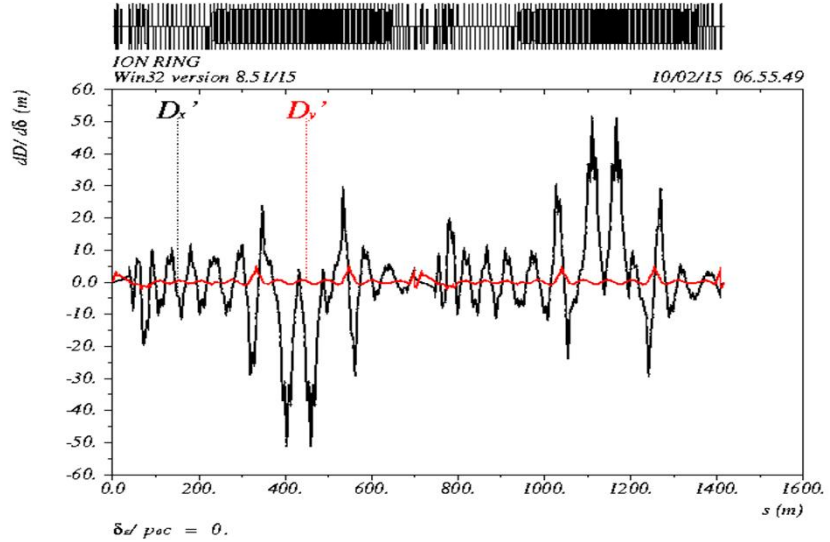
$\Delta\mu_{X\_U}$ = -0.0141 -0.008
$\Delta\mu_{y\_U}$ = 0.2157 -0.008
$\Delta\mu_{X\_d}$ = 0.3974-0.008
$\Delta\mu_{y\_d}$ = 0.0891-0.008
Qx = 26.509,
Qy = 26.850

KSF = 13.497
KSD =-18.878
KSFIPU = 0.501
KSDIPU =-0.747
KSFIPD = 1.904
KSDIPD =-4.895

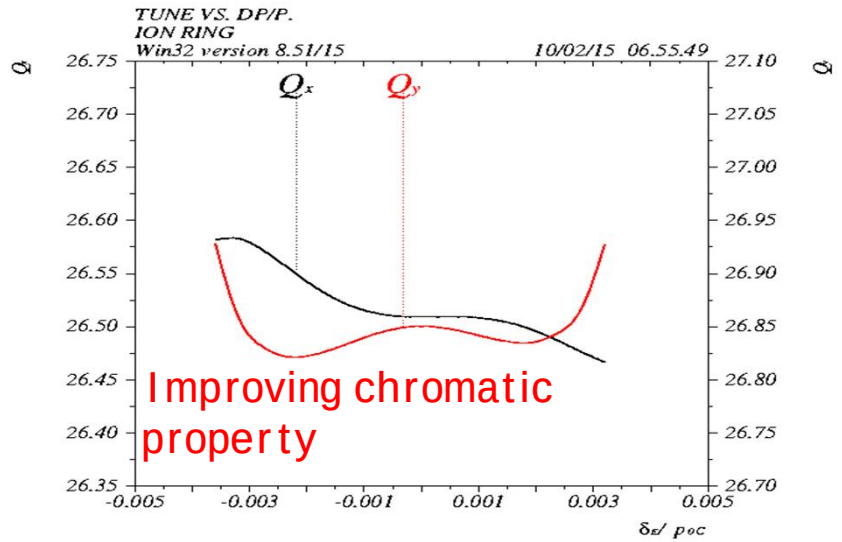
W function




Second order dispersion

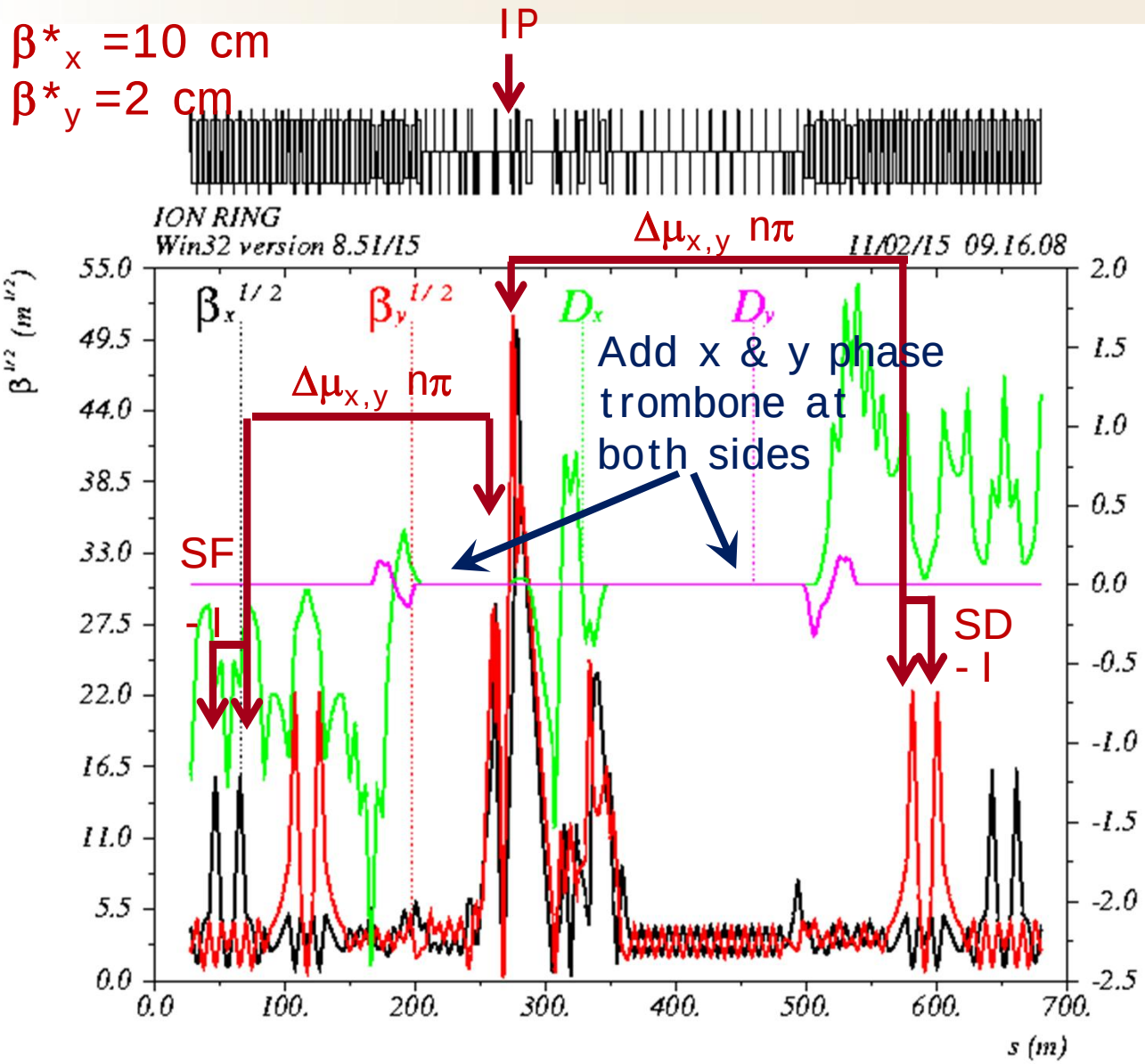



Chromatic tune




Improving chromatic property

# Phase trombone of Modified lattice with -I CCB and 60° arcs




Add x & y phase trombone at both sides of IP to fine adjust phase of the IP sextupoles and the final doublet

$d\mu_{X\_S\text{-}Q\,U} = 3.5$
$d\mu_{y\_S\text{-}Q\,U} = 2.5$
$d\mu_{X\_S\text{-}Q\,d} = 7.5$
$d\mu_{y\_S\text{-}Q\,d} = 5.0$

Qx = 28.4105,
Qy = 27.8552

KSF = 15.007
KSD =-19.187
KSFIPU = 3.166
KSDIPU = -5.527
KSFIPD = 8.297
KSDIPD =-10.747

$\xi x/\xi y = 0/0$,
$W_{x,IP} / W_{y,IP} = 0/0$

# Beam dynamics properties of modified lattice with -I CCB and 60° arcs

SLAC

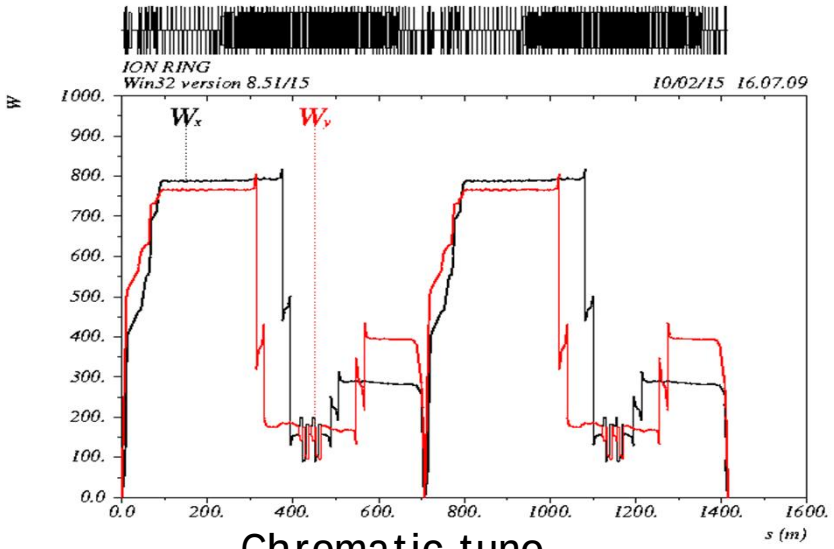
Phase Trombone

$\Delta\mu_{x\_U}$ := -0.001
$\Delta\mu_{y\_U}$ := -0.011
$\Delta\mu_{x\_d}$ := 0.004
$\Delta\mu_{y\_d}$ := -0.01

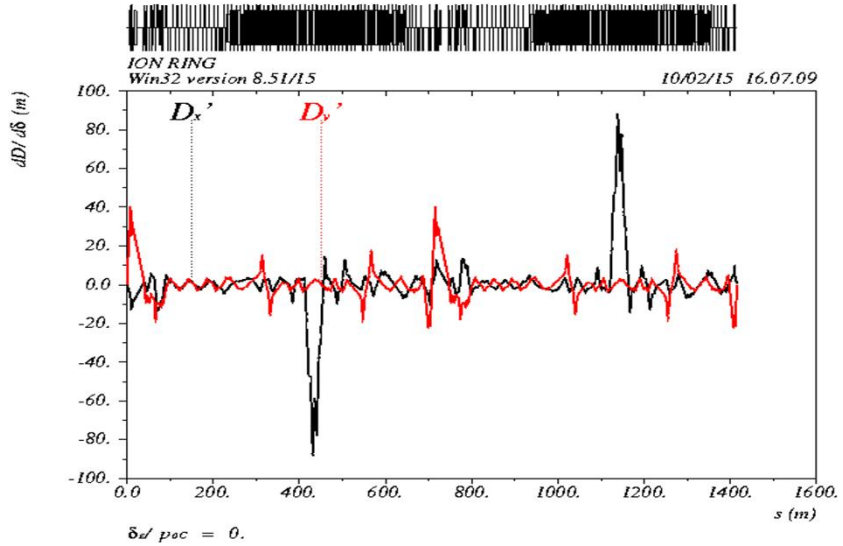
Qx = 28.417,
Qy = 27.813

KSF = 19.926
KSD = -25.841
KSFIPU = 2.534
KSDIPU = -4.590
KSFIPD = 7.763
KSDIPD = -10.841

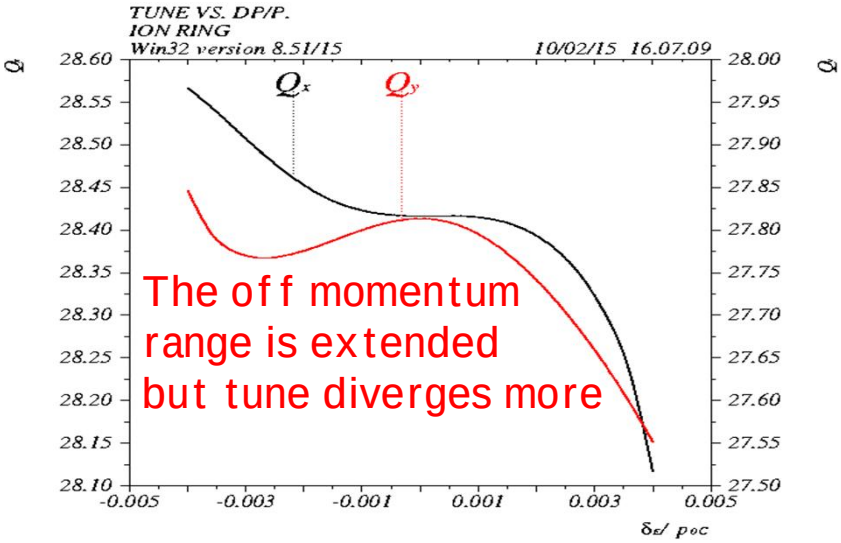
W function



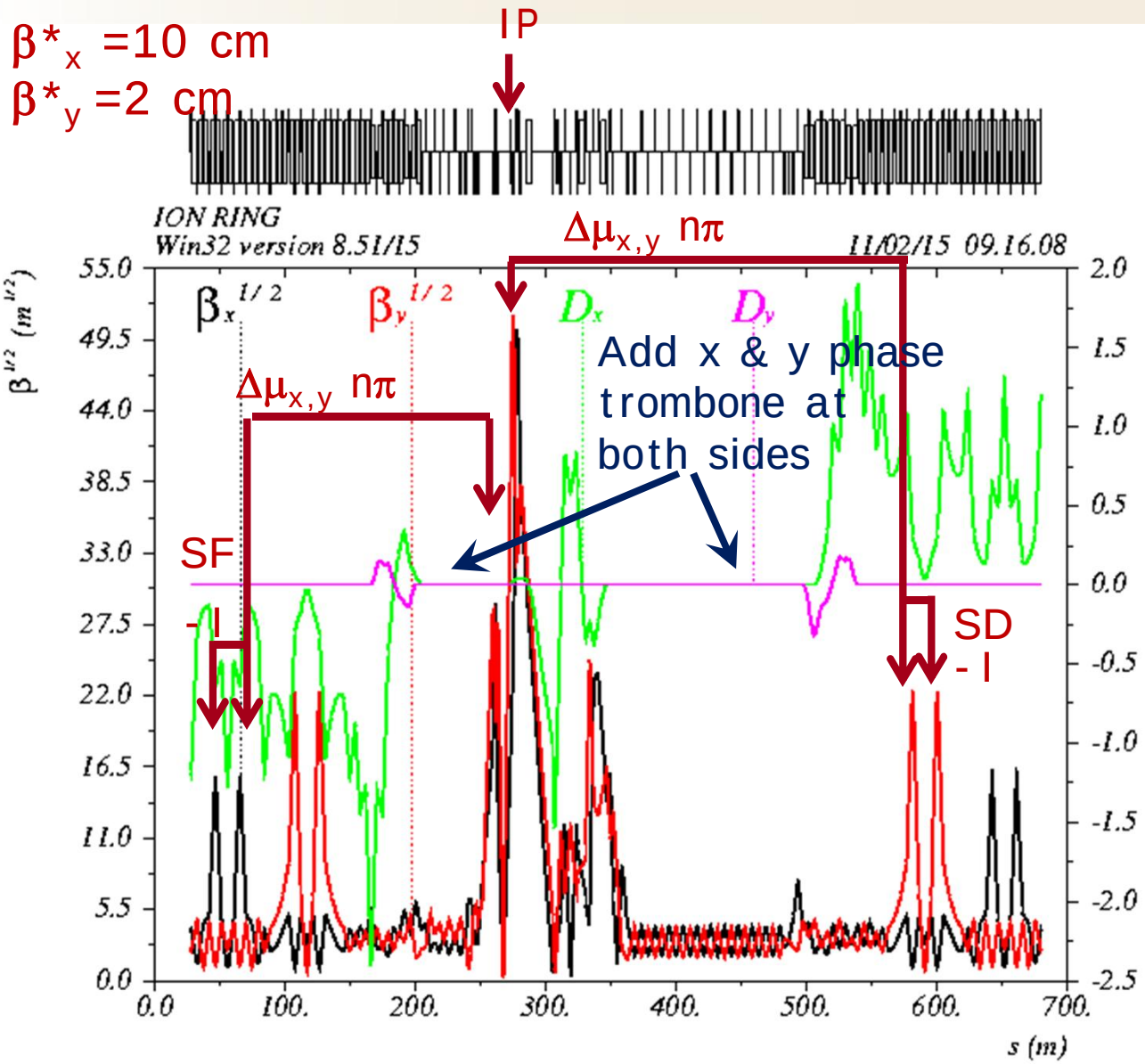

Second order dispersion




Chromatic tune



# Phase trombone of Modified lattice with -I CCB and 90° arcs

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$d\mu_{y\_S\text{-}Q\,U} = 2.5$
$d\mu_{X\_S\text{-}Q\,d} = 7.5$
$d\mu_{y\_S\text{-}Q\,d} = 5.5$

Qx = 30.623,
Qy = 28.739

KSF = 7.938
KSD =-25.042
KSFIPU = 4.273
KSDIPU = -5.601
KSFIPD = 9.548
KSDIPD =-10.222

$\xi x/\xi y = 0/0$,
$W_{x,IP}/W_{y,IP} = 0/0$

# Summary

- Phase trombones of the original lattice to make $n\pi$ phase advance between final doublets and sextupoles help to reduce the sextupole strengths and improve the chromatic properties of the lattice.
- A quick check with MAD8 dynamic aperture tracking agrees with the gain from chromatic tune correction.
- The fine tune of the phase trombone around $n\pi$ can help to further optimize the dynamic aperture, it's still under investigation.