Crab Optics & Dynamics

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- Lattice Update
- Tracking with Transverse Wake
- Dynamic Aperture Survey
- Side Effect to Operation

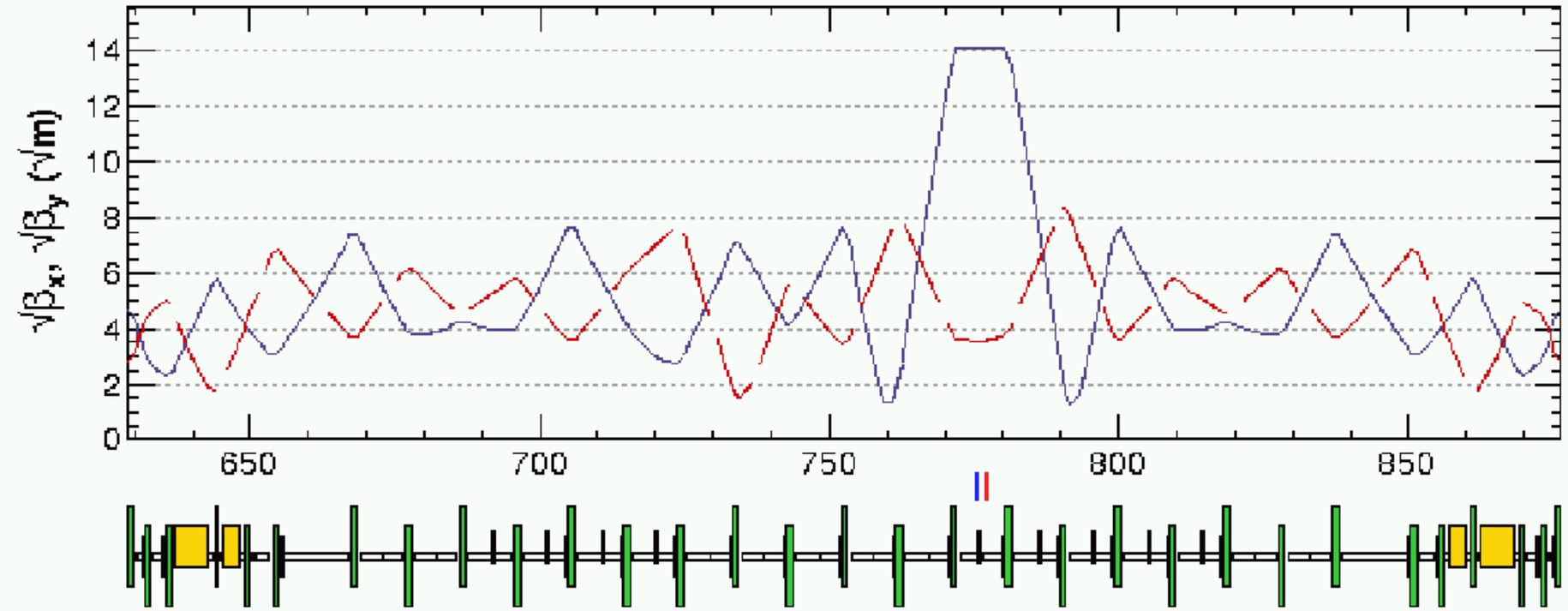
Crab Lattice Update from MAC2004

- Crab Cavity Position Changes Required from Cryostat & Vacuum Component Detail Design
  - HER 968.9mm toward down stream
  - LER 1365.8mm toward down stream

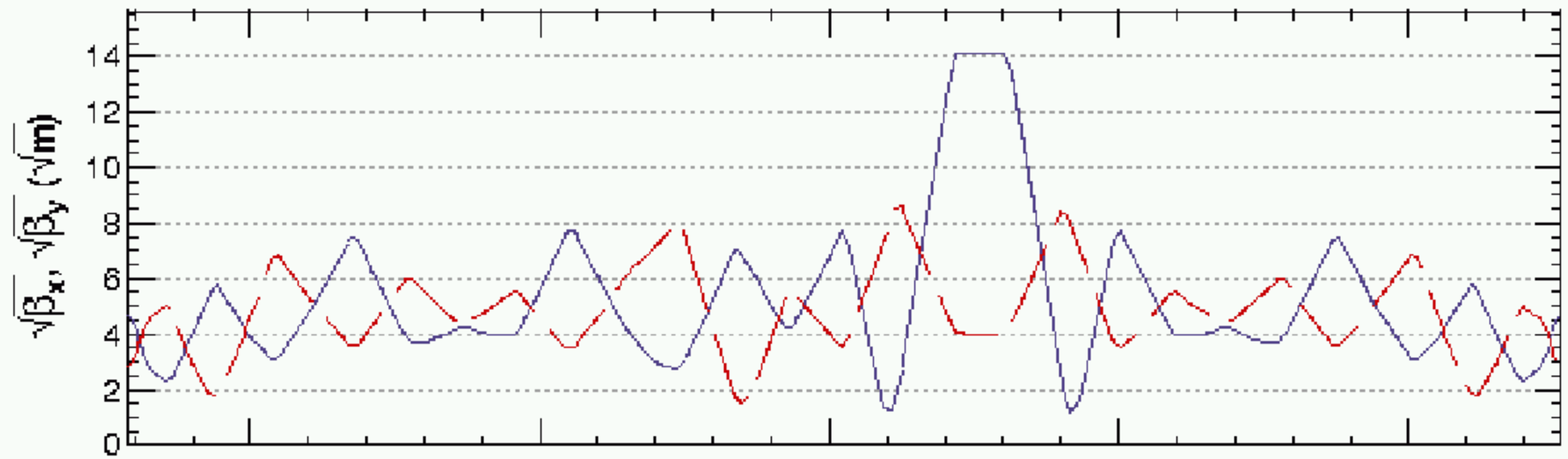
- Side Effect of Cavity Position Changes
  - HER
    - Minor Betatron Phase Tuning(F-F β Bump)
  - LER
    - β Function Rematching ($\alpha \neq 0$)
    - Increase β max of NIKKO Section (74/89m→102/85m)

HER Lattice Update

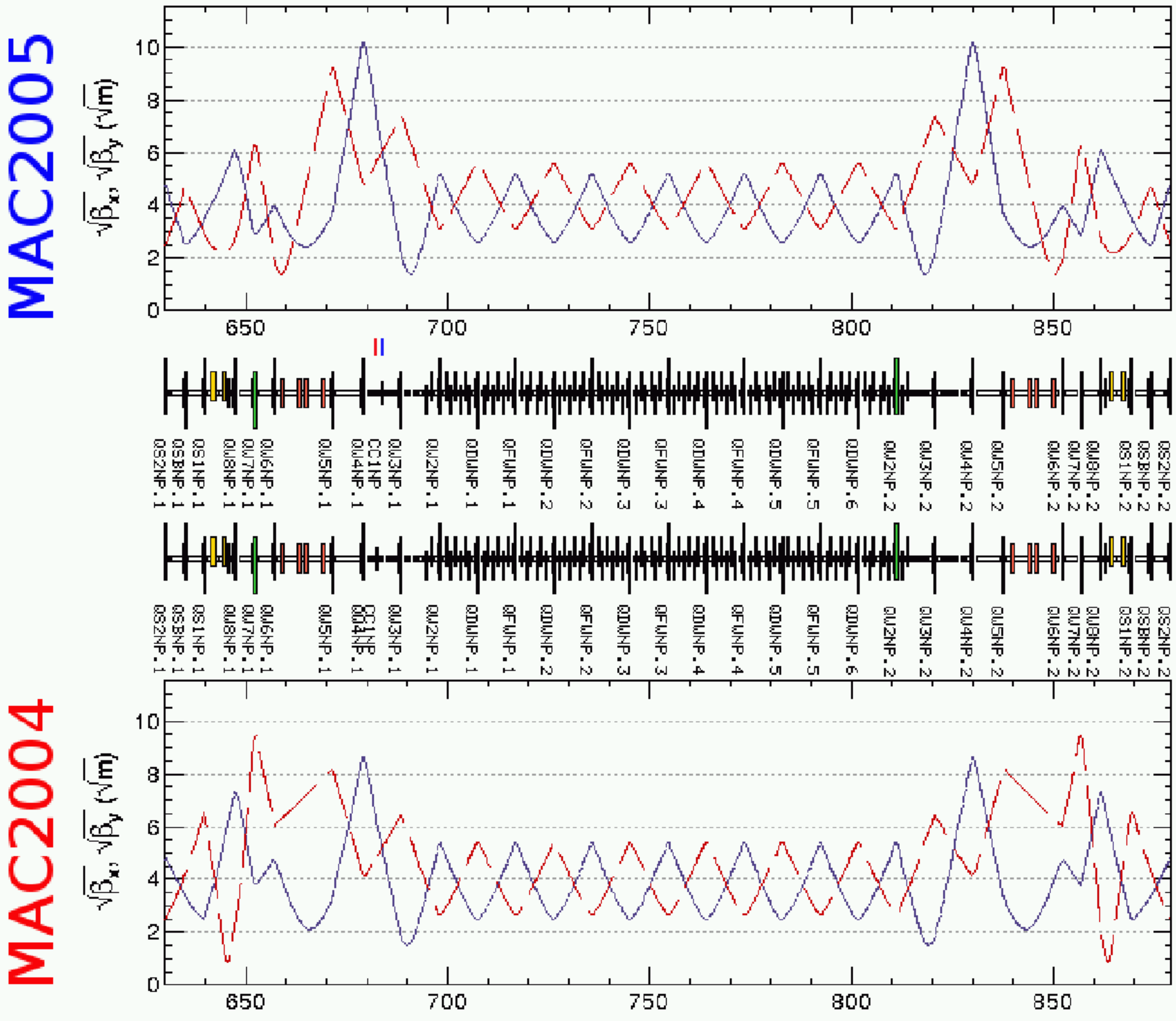
MAC2005



MAC2004



LER Lattice Update

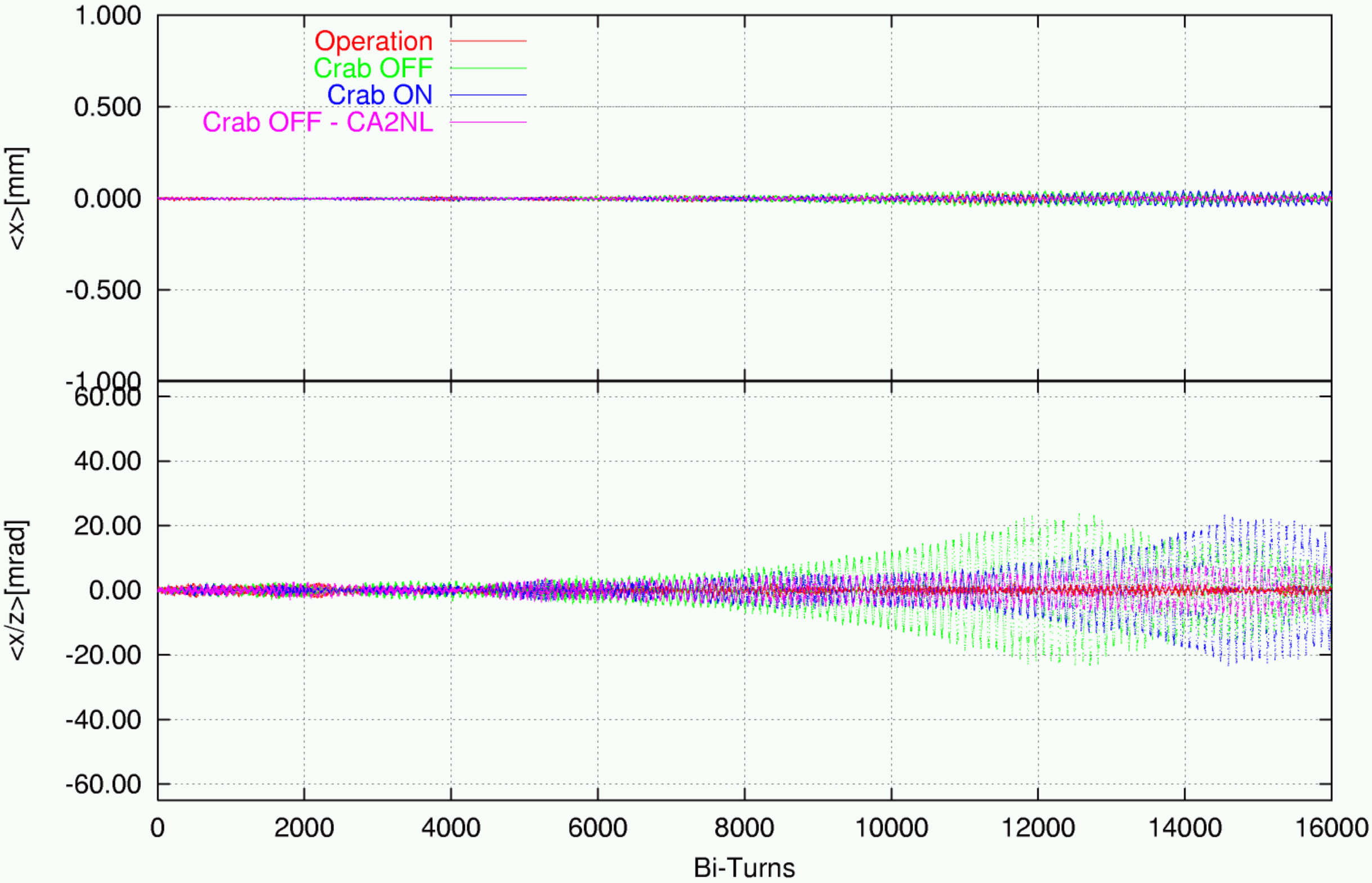


Tracking with Transverse Wake(1/2)

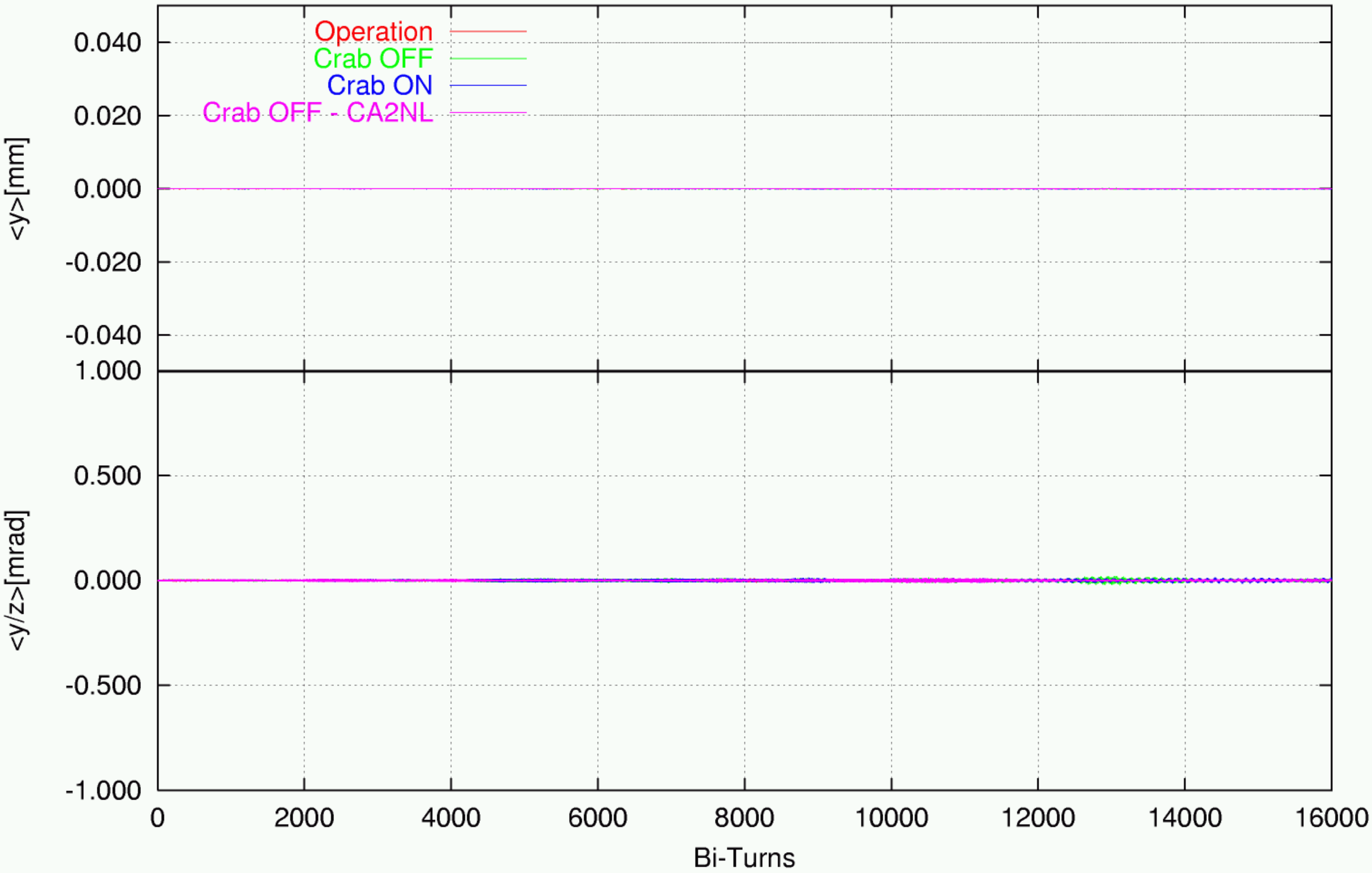
Simulation Condition

- Optics: HER Crab Optics
- # of Super Particles: 10^3
- Particles / Bunch: 3.3 × 10^10
- # of Turns: 32000(8 damping time)
- Transverse Wake
  - Model: Short Range Linear Wake
  - Distribution: Distributed on Acceleration Cavity
  - Potential: 10^16 V/Cm (total)

HER Optics[Op/Cr20040127c02x05] $(\xi_x,\xi_y)=(0.2,0.5)$ by tracking - 1/3
N_p=1000 with Distributed Linear Wake Potential 10^{16} V/C·m



HER Optics[Op/Cr20040127c02x05] $(\xi_x,\xi_y)=(0.2,0.5)$ by tracking - 2/3
N_p=1000 with Distributed Linear Wake Potential 10^{16} V/C·m



HER Optics[Op/Cr20040127c02x05] $(\xi_x,\xi_y)=(0.2,0.5)$ by tracking - 3/3
N_p=1000 with Distributed Linear Wake Potential 10^{16} V/C·m

Operation
Crab OFF
Crab ON
Crab OFF - CA2NL

Ex[m·rad]
1.0e-07
1.0e-08

Ey[m·rad]
1.0e-11
1.0e-12

0
2000
4000
6000
8000
10000
12000
14000
16000

Bi-Turns

Tracking with Transverse Wake(2/2)

- Horizontal Head-Tail instability seems to be generated by CA2NL(acceleration cavity nearest with crab cavity)
  - βx of CA2NL: 15.5(operation) → 59.1m(crab)

- Transverse wake potential of CA2NL
  - 2.78 × 10^14V/Cm(used in tracking)
  - 4.73 × 10^12V/Cm(estimated by computer code)

- Head-Tail instability WOULD not occur if strong wake source did not exist in β bump region

Dynamic Aperture Survey(1/2)

Background

- Synchro-Beta Resonance is Observed on HER
  - 3rd order resonance: $2\nu_x + \nu_s$ = Int.
  - Observed as Beam Life Shortening & Beam Loss in Machine
  - Observed as Dynamic Aperture Shrinkage in Model
  - Resonance Strength depends on Chromaticity Correction
  - Determine Lower Limit of HER ν_x in Physics Run(.510)

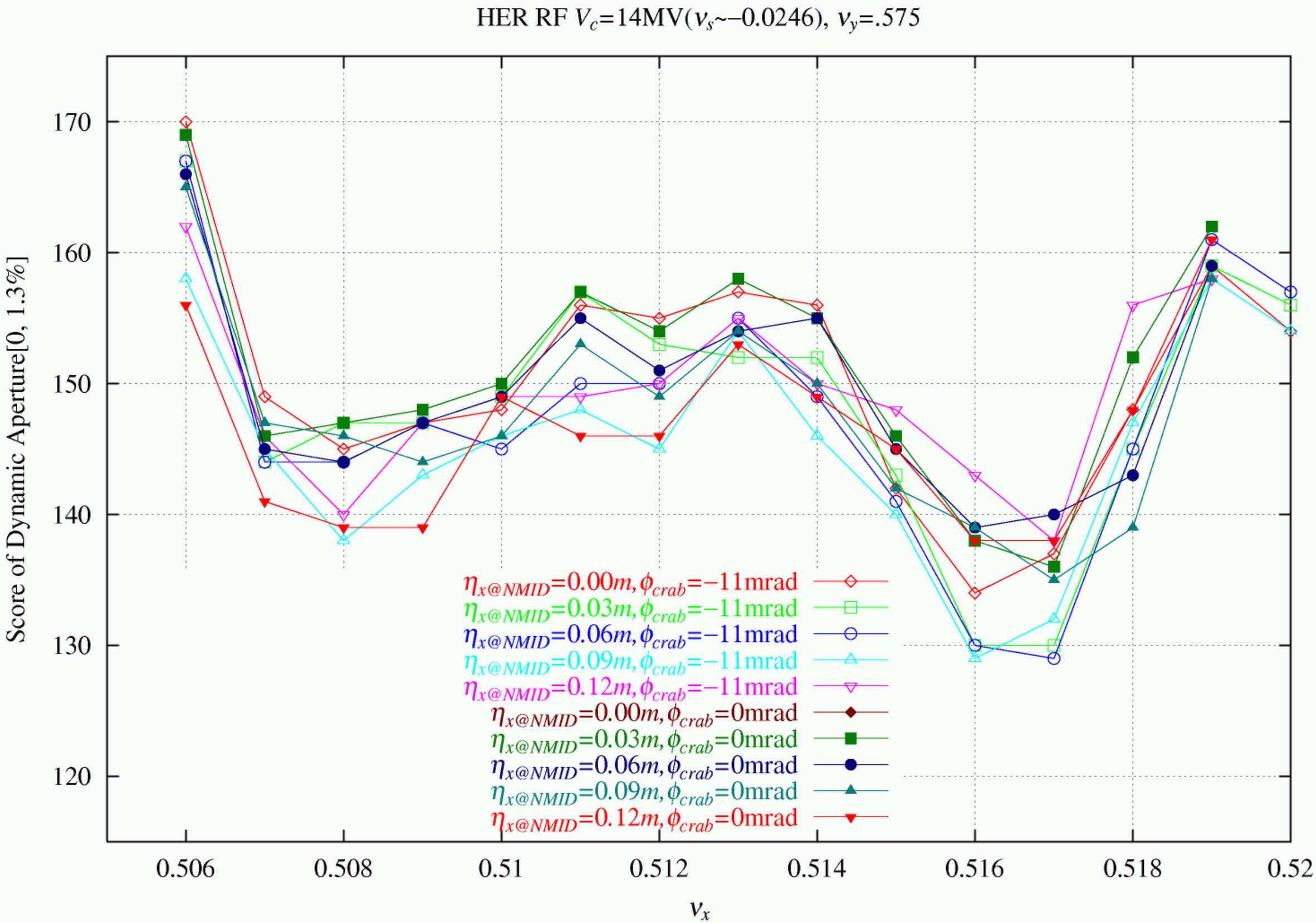
Question

- Do Crab Optics have such Resonance?
- Do η_x at Crab Cavity make Resonance?

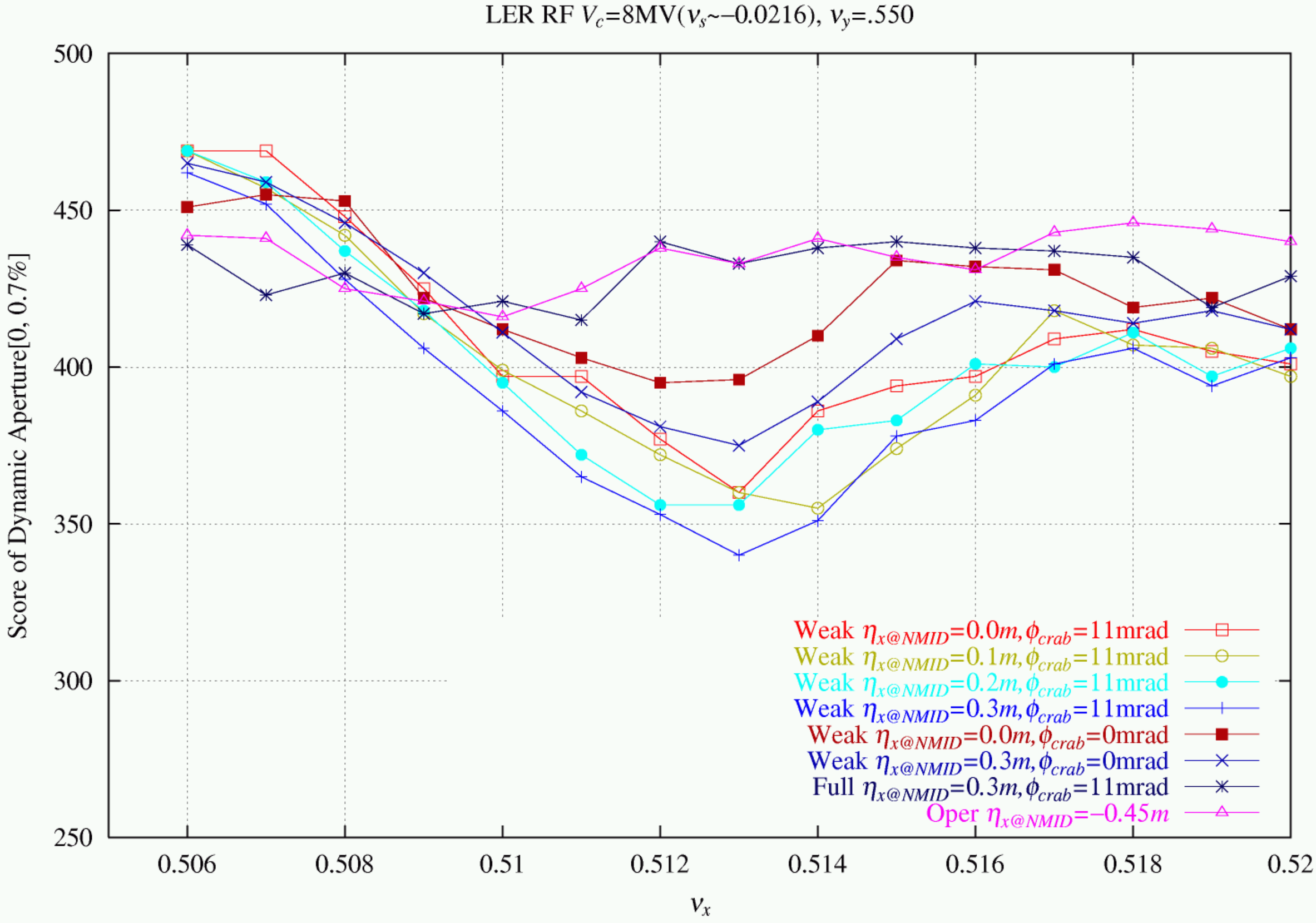
Survey

- ν_x dependence of Dynamic Aperture Cross-section

HER Dynamic Aperture



LER Dynamic Aperture



Dynamic Aperture Survey(2/2)

- Strong synchro-beta resonance is NOT found by dynamic aperture survey
- Dynamic aperture changes is small between Crab Cavity ON and OFF
- LER dynamic aperture shrinkage around $2\nu x + \nu s$ =Integer line is observed in the SL(sextupole for local correction) weak condition
  - Local chromaticity correction works fine in operation optics
- Dynamic aperture is not reduced by small ηx
  - Optics correction CAN correct ηx error into 5cm

Side Effects to Operation(1/3)

Source of Vertical Crossing Side Effect in Crab Optics

- Rotation Error of Crab Cavity
  - Generate Vertical Crabbing Kick
- IP Coupling Knob for Luminosity Tuning
  - Horizontal Crabbing Motion is prejected into Vertical Axis by R1 tilt knob

Side Effects to Operation(2/3)

Order Estimation: Cavity Rotation

Crab Optics Parameter	LER	HER
β x/ β y@crab cavity	40/35.9m	200/15.5m
ν x/ ν y@crab cavity	10.25/10.1393	10.75/10.2476
β x/ β y@IP	590/5.8mm	560/7.0mm
ν x/ ν y	45.506/43.540	43.512/40.590
Amplitude Factor Ratio $\left\|\frac{\sin\pi\nu_x}{\sin\pi\nu_y}\right\|\sqrt{\frac{\beta_y^*}{\beta_x^*}\frac{\beta_{y\ crab}}{\beta_{x\ crab}}}$	9.46 x 10^-2	3.23 x 10^-2
Phase Factor $\cos\left\|2\pi\nu_{y\ crab}-\pi\nu_y\right\|$	.681	.956
Vertical Crabbing (1% coupling)	7.08	3.40 μrad/1%

Side Effects to Operation(3/3)

Order Estimation: IP Knob

- Horizontal crabbing motion is projected to vertical axis via x-y coupling(R1 ≠ 0 case)
- R1 tile knob unit: 2.42/1.79mrad(LER/HER)
- Vertical crabbing: 36.6/19.7 μ rad/unit

Vertical Angle Feedback

- Vertical Crossing Angle is controlled by using beam-beam kick measurement via iBump feedback
- Typical value of V-Angle target in luminosity tuning
  100 μ rad(scan width) / 10 μ rad(setting resolution)
- Cavity rotation and R1 knob side effect WOULD be covered by V-Angle FB