New Working Point for Polarized Protons

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The goal

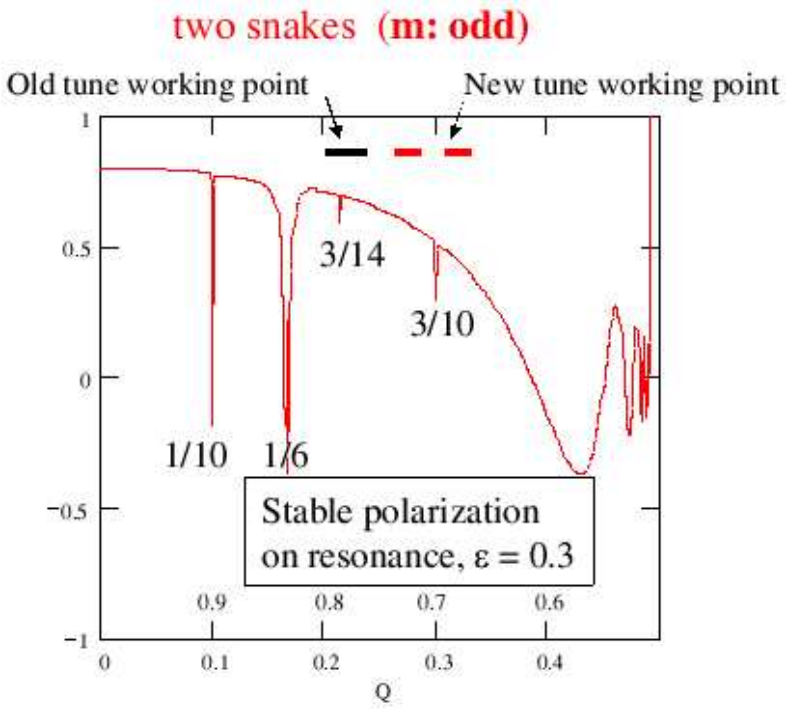
- Double the luminosity (to $40 \cdot 10^{30}\,\mathrm{cm}^{-2}\mathrm{sec}^{-1}$)

- Preserve (or even improve) polarization (65 percent)

Increased beam-beam tuneshift requires new working point with larger spacing between non-linear resonances

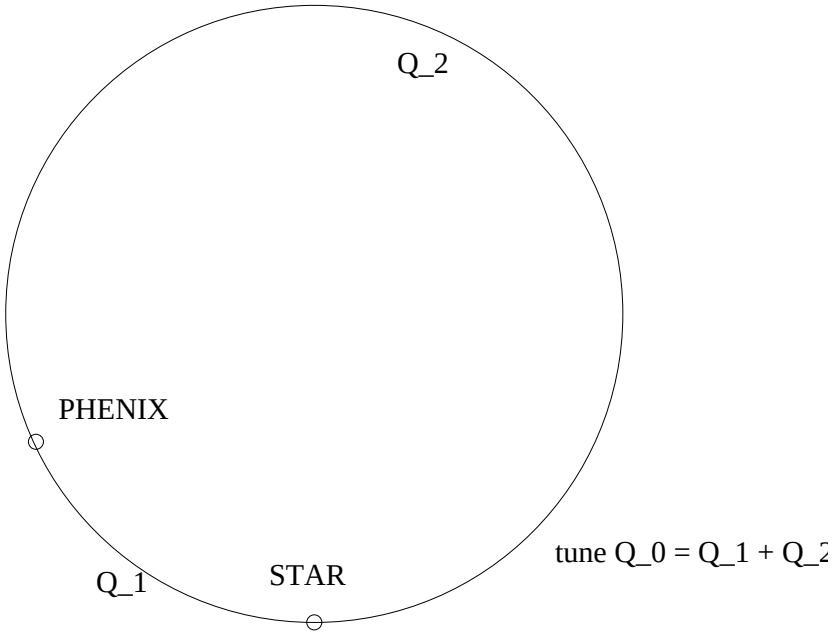
Choosing a new working point

Snake resonances (T. Roser, Retreat 2006):



Near-integer tunes best for polarization

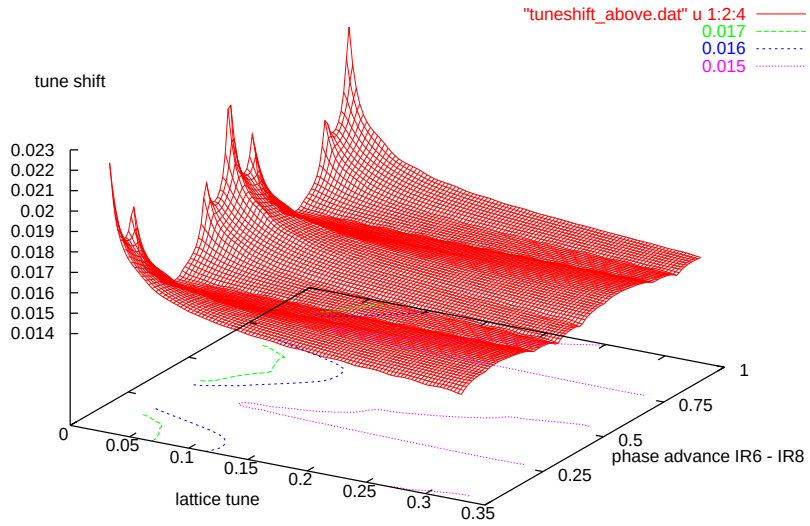
Above or below the integer?

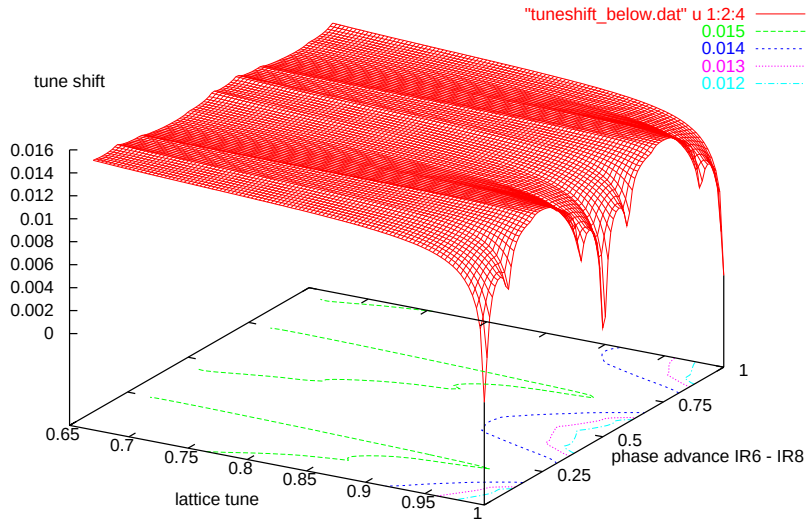


Resulting tune and β^* with beam-beam parameter ξ per IP ($\mu = 2\pi Q$):

$$\begin{aligned}
\cos\mu &= \cos\mu_0 - 4\pi\xi\sin\mu_0 + 8\pi^2\xi^2\sin\mu_1(\sin\mu_0\cos\mu_1 - \cos\mu_0\sin\mu_1) \\
\beta^* &= \beta_0^* \cdot (\cos\mu_1\sin(\mu_0-\mu_1) + \sin\mu_1\cdot(-4\pi\xi\sin(\mu_0-\mu_1) + \cos(\mu_0-\mu_1))) \\
&\quad / \sin\mu
\end{aligned}$$

Resulting tune shift for $\xi = -0.0075$ per IP:

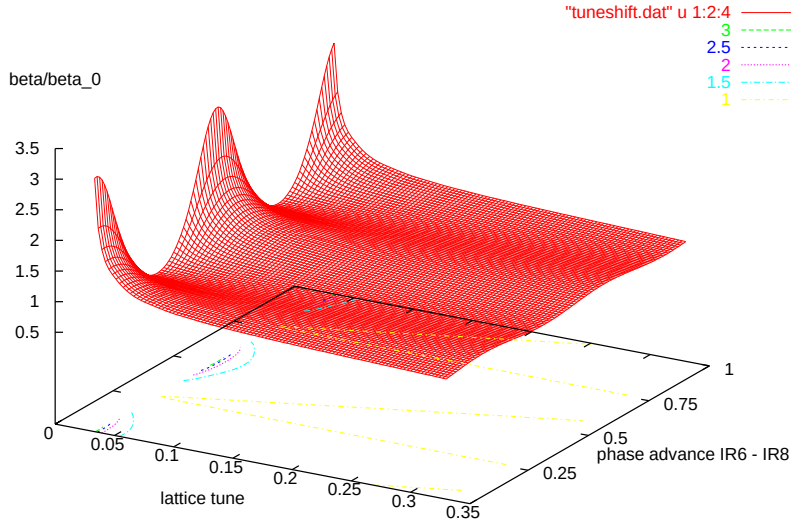


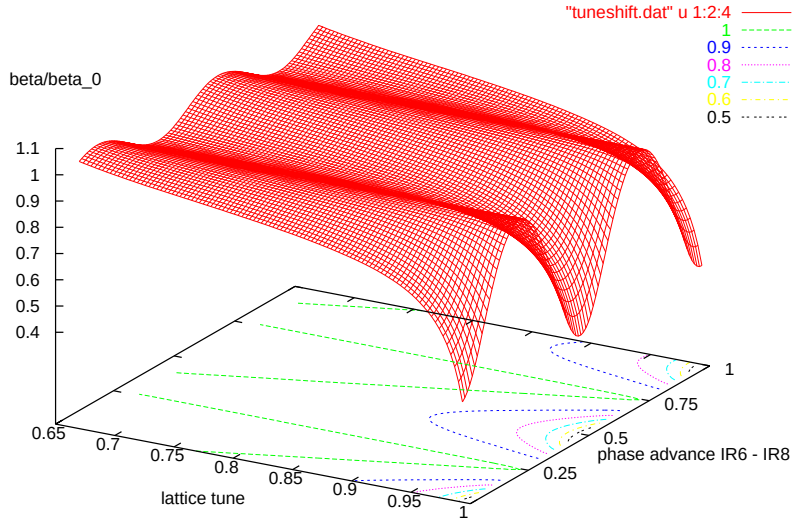


Below the integer, the resulting tuneshift is smaller than the total beam-beam parameter for $\mu_1 = k \cdot \pi$ between IPs

Less tune shift means less tune spread (smaller footprint)!

Dynamic β^* for $\xi = -0.0075$ per IP:





Below the integer, the beam-beam force reduces the lattice β^* for $\mu_1 = k \cdot \pi$ between IPs

(New lattice has $\mu_1 = .2 \cdot 2\pi = 0.4 \cdot \pi$)

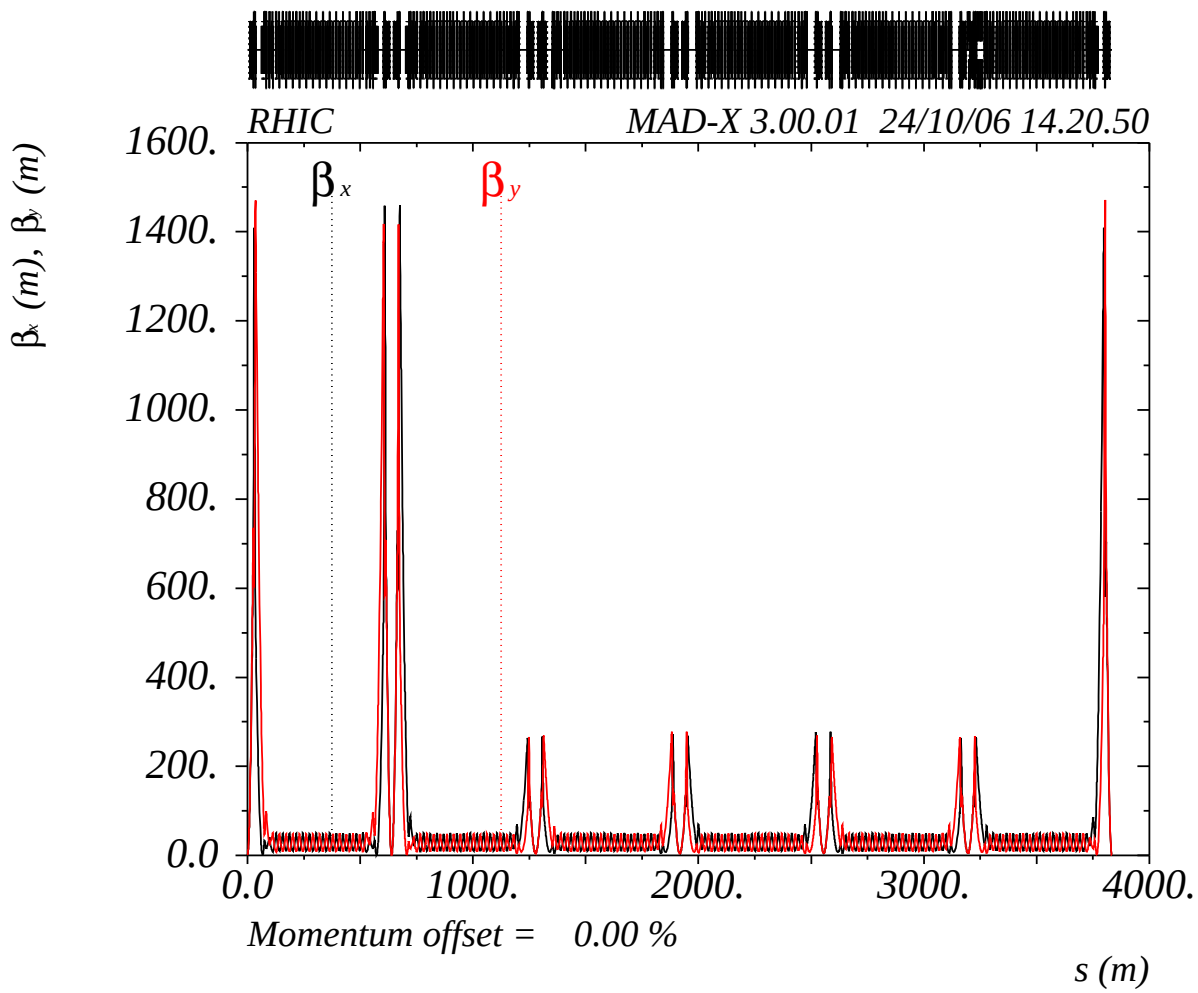
What integer tune?

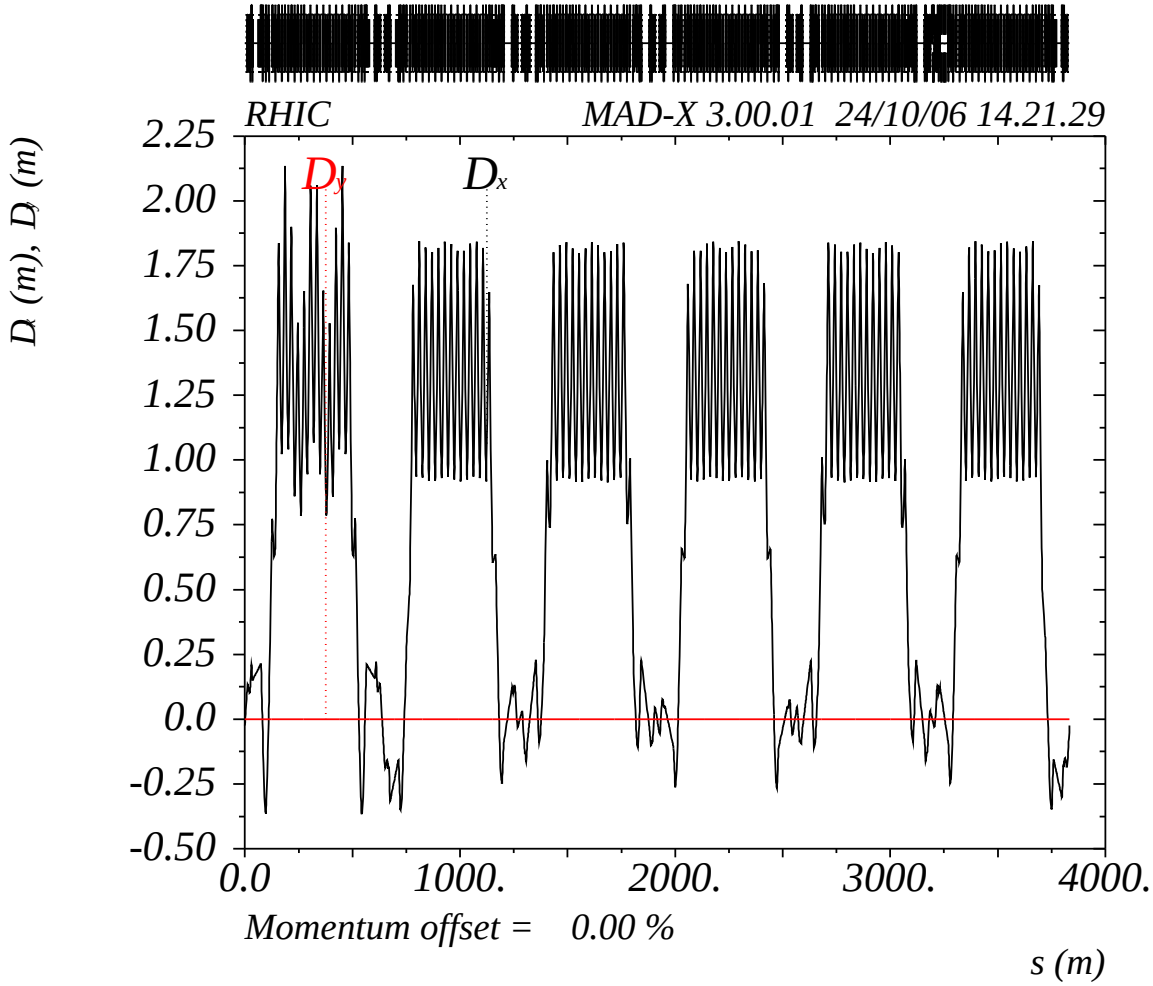
- Raising the tune from the present .68 to .92 increases γ_t

- An increased γ_t leads to bucket matching difficulties at injection

Tunes should be lowered to reach new working point (27.92/28.93)

New lattice


RHIC
MAD-X 3.00.01 24/10/06 14.20.50
βx (m), βy (m)
βx
βy
1600.
1400.
1200.
1000.
800.
600.
400.
200.
0.0
0.0
1000.
2000.
3000.
4000.
Momentum offset = 0.00 %
s (m)



20 percent dispersion beat between IRs 6 and 8

Orbit correction

$$\Delta x = \frac{\sqrt{\beta_{\mathrm{BPM}}}}{2\sin \pi Q} \oint \delta(s) \sqrt{\beta(s)} \cos(|\psi(s) - \psi_{\mathrm{BPM}}| - \pi Q)$$

$\Rightarrow$ factor $2-3$ larger closed orbit distortions at near-integer tunes

(This is also the case for 10 Hz oscillation amplitudes)

Nonlinear dynamics

Near the integer, the spacing between resonance lines is largest.

However, the integer resonance includes ALL nonlinear resonances: 2/2, 3/3, 4/4, 5/5,...

Dynamic aperture needs to be determined by tracking

Tracking studies

- Tracking studies are being performed to compare dynamic aperture at current and proposed working points

- Initial results seemed to indicate that the dynamic aperture is comparable, while the proposed new working point provides a larger range of "good" dynamic aperture in tune space

- However, multipole errors in D0 and DX magnets were not treated correctly during these studies (at both working points); this is being worked on

$\Rightarrow$ Work in progress

Conclusion

- A new, near-integer working point has been selected to accomodate increased beam-beam tuneshift
- Orbit control will be a major challenge at this new working point
- Tracking studies to determine dynamic aperture are in progress