Polarized Protons Run Plan

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The goal for Run-7 and beyond

- Achieved $\mathcal{L}_{\text{store, avg}} = 20 \cdot 10^{30}\,\text{cm}^{-2}\text{sec}^{-1}$ in Run-6

- $\mathcal{L}_{\text{store, avg}} = 40 \cdot 10^{30}\,\text{cm}^{-2}\text{sec}^{-1}$ in Run-7,
  $\mathcal{L}_{\text{store, avg}} = 60 \cdot 10^{30}\,\text{cm}^{-2}\text{sec}^{-1}$ in Run-8

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

How can we get there?

Luminosity formula:

$$\mathcal{L} = \frac{N^2 f_c}{4\pi\epsilon\beta^*}$$

Collision frequency f_c is already maximized (111 bunches). Remaining "free" parameters are bunch intensity N, emittance ϵ, and β^*.

What are the limitations on these?

Beam-beam formula:

$$\xi = \frac{r_0 N \beta^*}{4\pi\gamma\sigma^2} = \frac{r_0 N}{4\pi\gamma\epsilon}$$

Beam-beam is independent of β^*.

$\Rightarrow$ squeeze β^* as much as possible.

Limitations on β^* :

- magnet strength and triplet aperture
- hourglass effect (need shorter bunches)

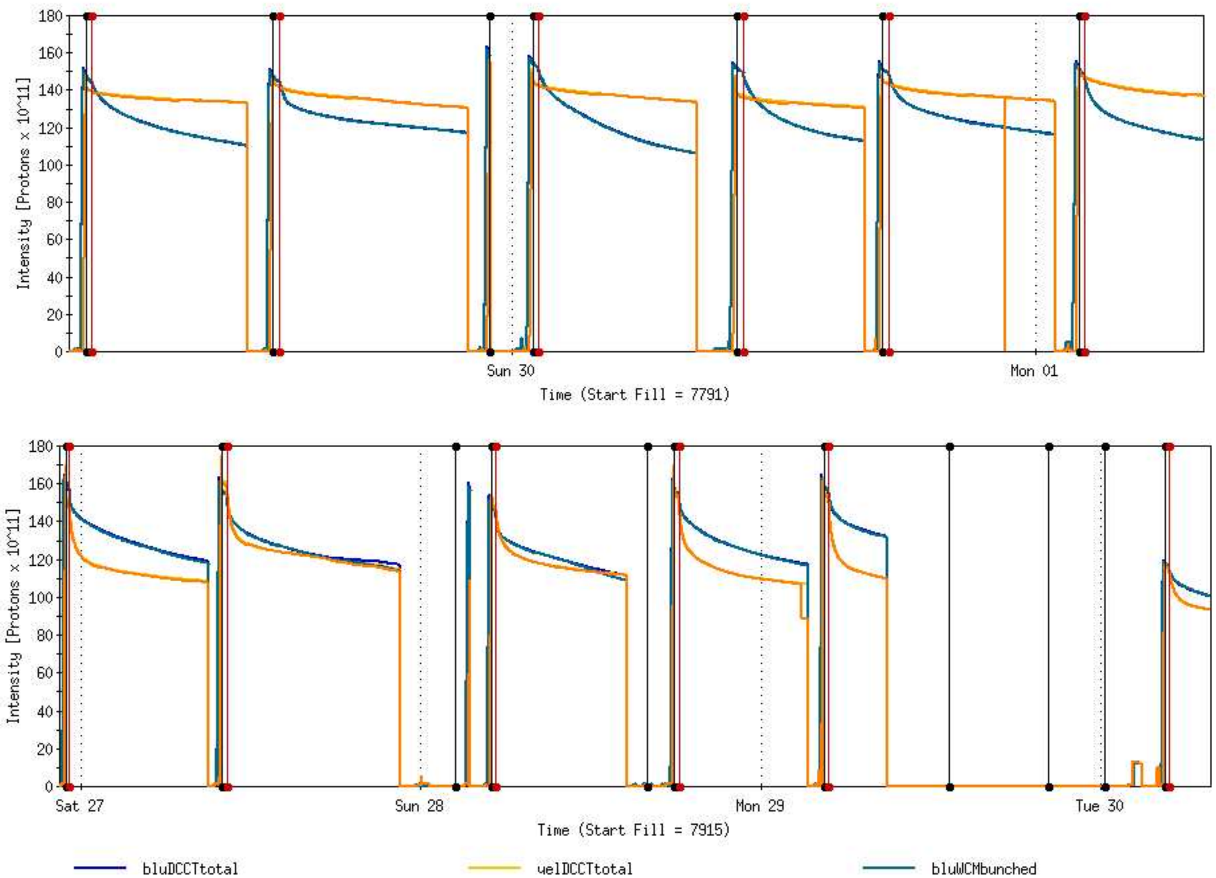
Main luminosity improvement has to come from higher intensity ($N = 2 \cdot 10^{11}$/bunch). Fortunately, AGS polarization seems largely intensity-independent.

But: higher intensity (or smaller emittance) increases beam-beam tuneshift.

Large tuneshift parameters make working point search very delicate. Working points in the two rings need to be different to avoid coherent beam-beam effects.

FY06 pp-run was already largely beam-beam limited.

Run-6 intensities before and after working point swap



$Q_x = 2/3$ limits lifetime and luminosity performance

What can (and needs to) be done?

- Provide more tune space by compensating $Q_x = 2/3$ resonance: 20 percent

- Correct nonlinear chromaticity (smaller tune footprint): 40 percent

- Eliminate 10 Hz beam-beam modulation: 10 percent

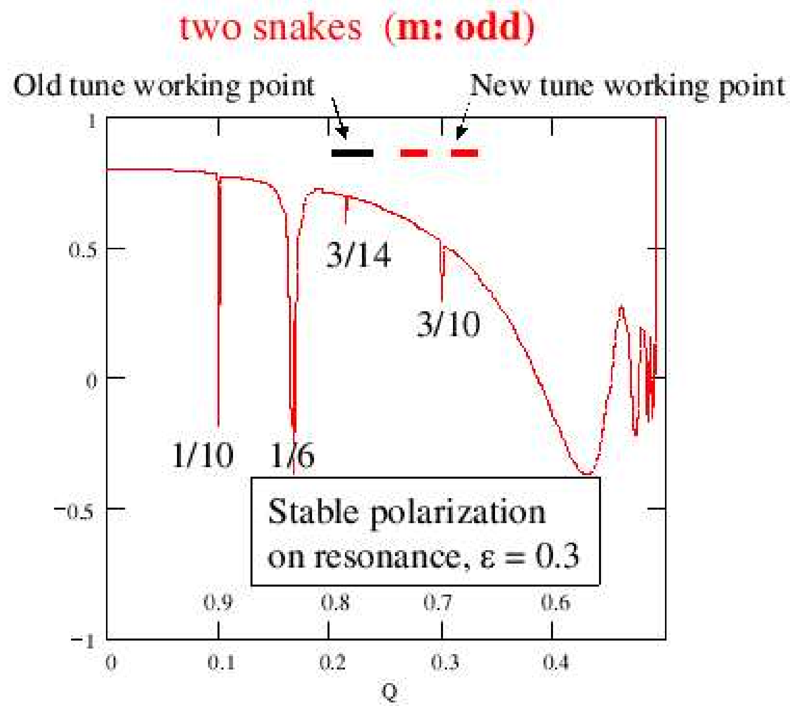
- β^* reduction: 10 percent

Total: 205 percent luminosity increase

How can we get even more?

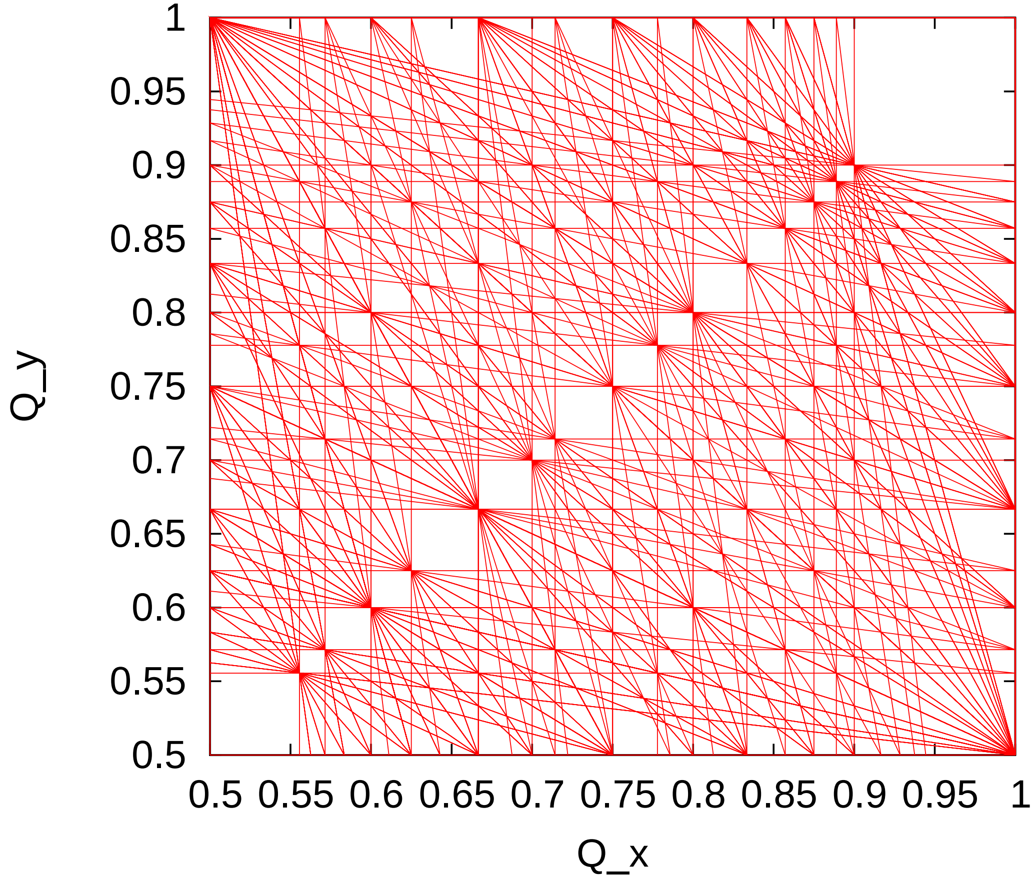
Choosing a new working point

Snake resonances:



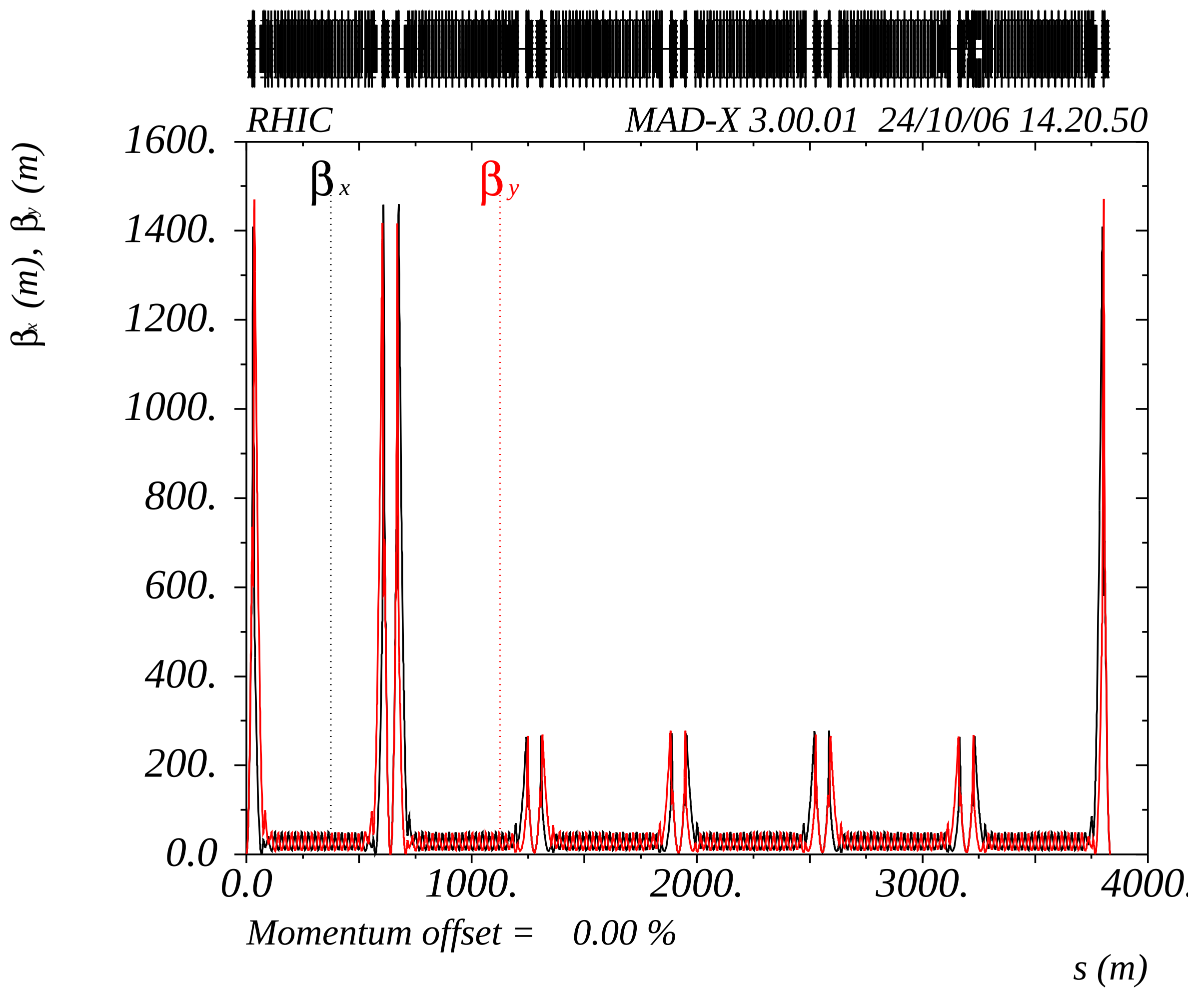
Near-integer tunes best for polarization

Nonlinear resonances, up to 10th order:

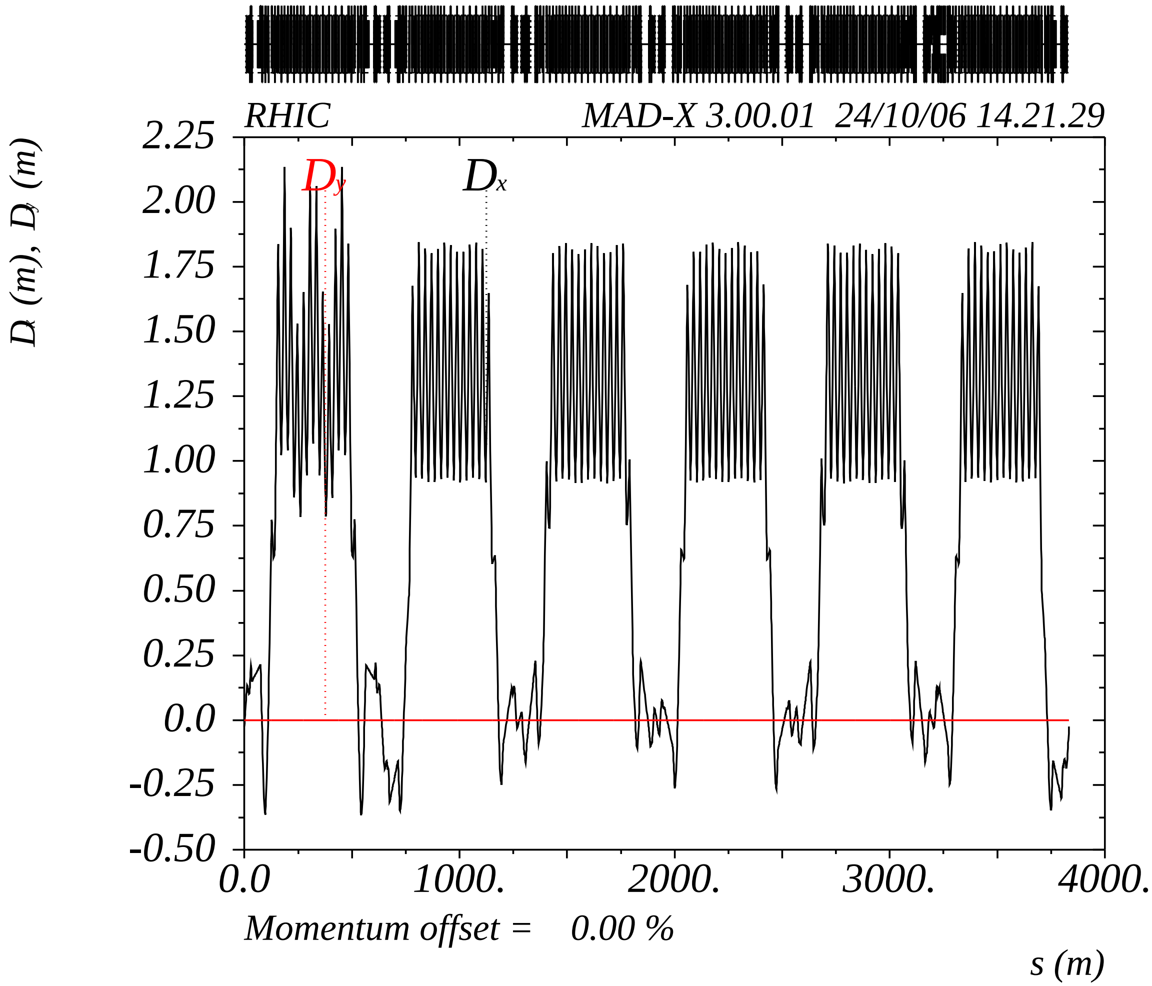


Near-integer working point provides largest tune space

New lattice



RHIC
MAD-X 3.00.01 24/10/06 14.20.50
β_x (m), β_y (m)
β_x
β_y
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

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

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

Note:
β-beat scales with $1/\sin(2\pi Q)$

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, with and without nonlinear chromaticity correction and 2/3 resonance compensation

- 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

Experimental studies

- If tracking results are promising, new working point should be tested during Au-Au run
- At injection, lower tunes from .22 to .08
- Correct orbit
- Measure β-beat with AC dipole

Summary

- Run-7 luminosity goal seems achievable with "minor" lattice changes (resonance compensation, nonlinear chromaticity correction)

- However, luminosities beyond $40 \cdot 10^{30}\,\mathrm{cm}^{-2}\mathrm{sec}^{-1}$ require major changes (new working point)

- Currently, tracking studies are in progress to determine feasibility of near-integer tunes, as well as nonlinear chromaticity correction and resonance compensation