E-lens Related Beam Dynamics Studies

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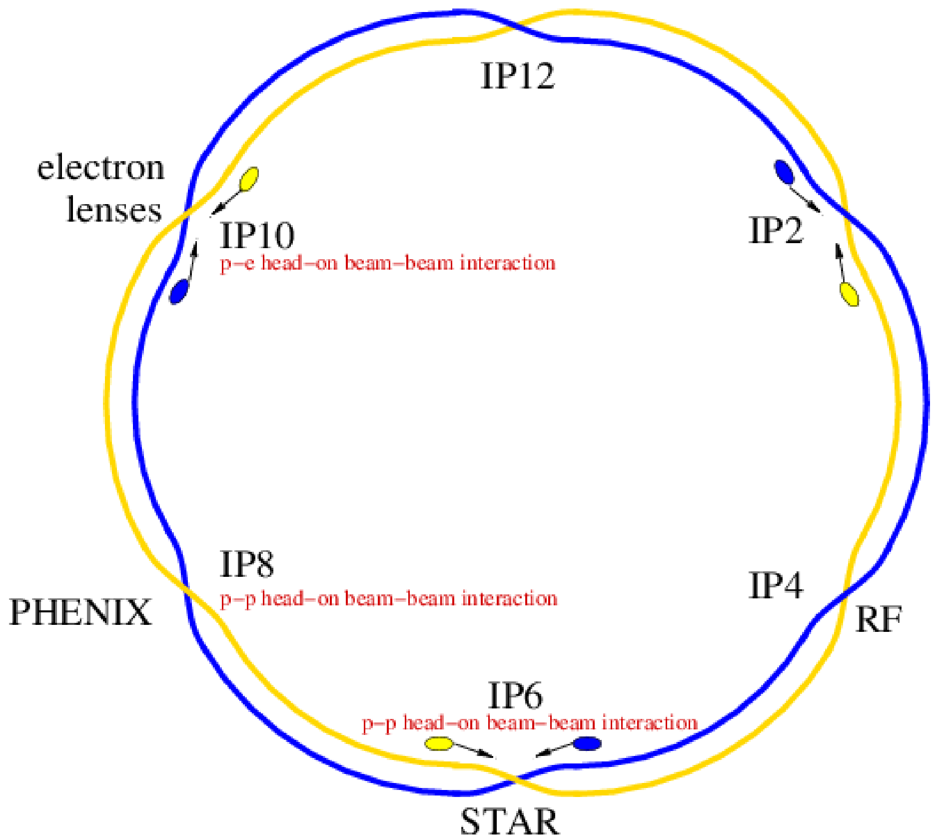
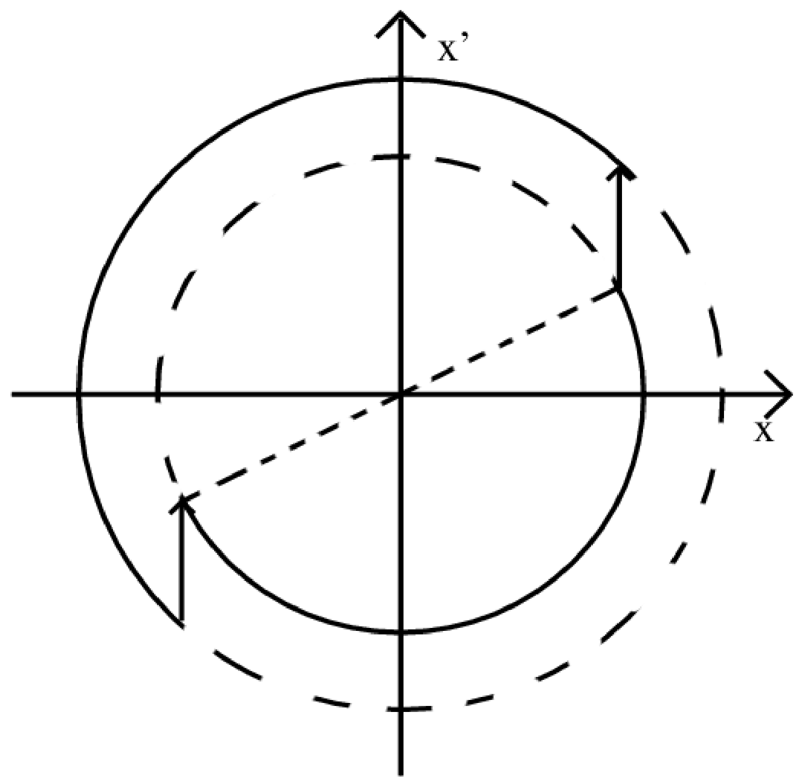
RHIC beam-beam compensation scheme



Nonlinear beam-beam kick at IP8 is compensated by opposite kick at IP10

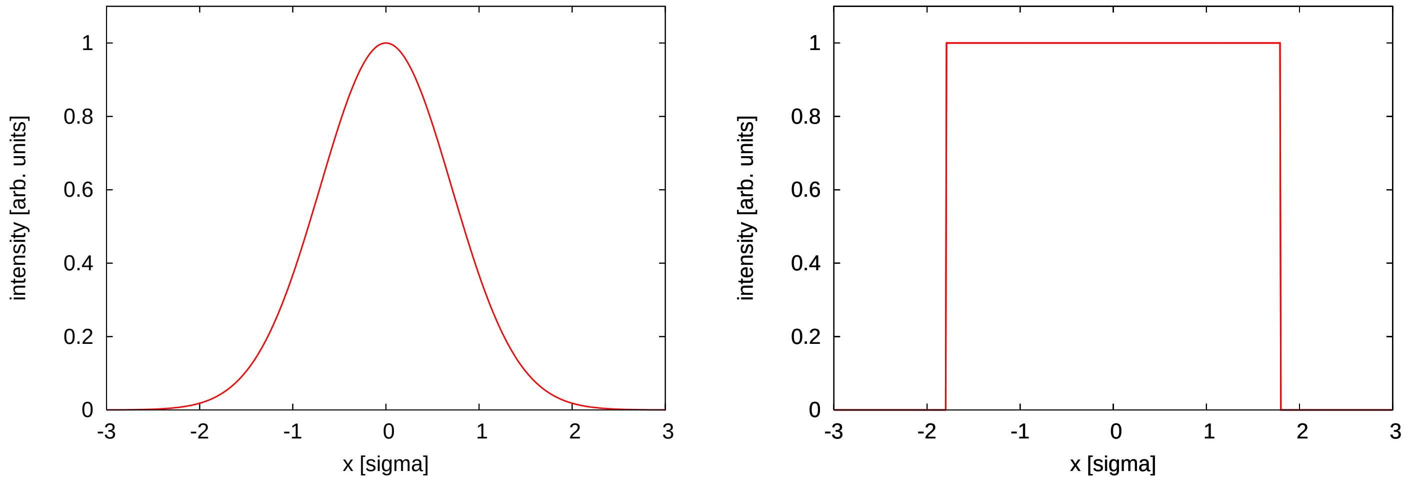
Requirements

- Betatron phase advance of $k \cdot \pi$ between IPs 8 and 10



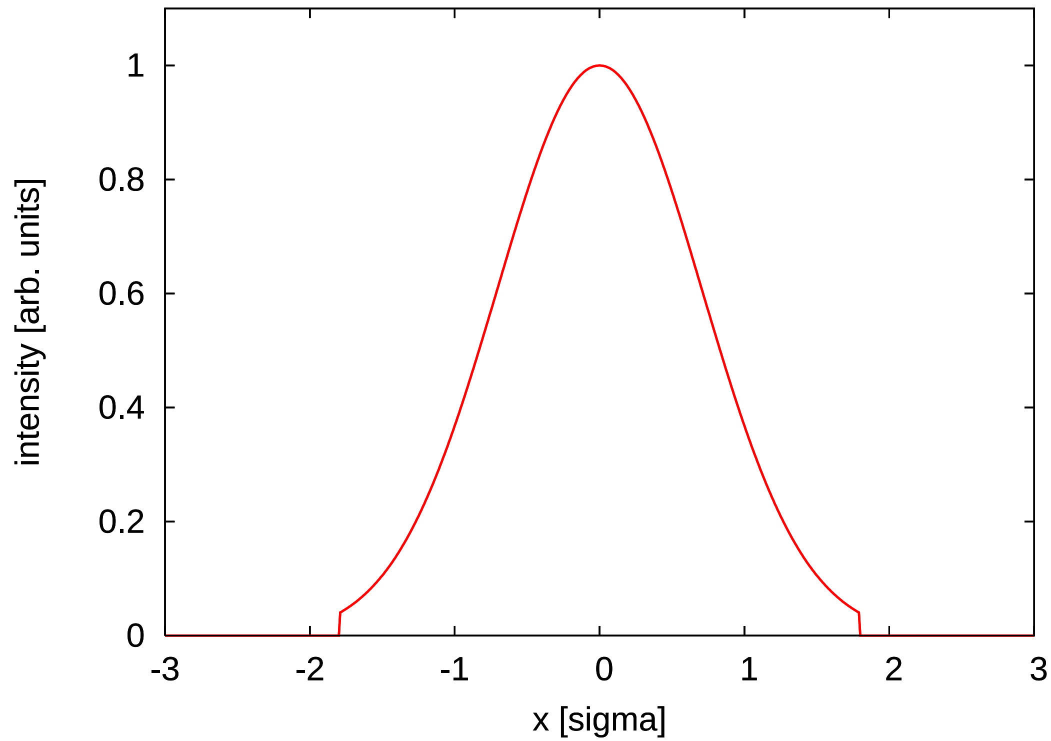
Requirements (cont.)

- Gaussian electron beam profile



Gaussian profile would be ideal, rectangular profile disastrous

Electron lens profile has a sharp cut-off at 2.8σ due to limited cathode size:



Sharp edges are generally dangerous, but intensity in the tails is very low

(Cut-off shown at 1.8σ for illustrative purposes)

Requirements (cont.)

- Electron lens solenoid straightness

Consider solenoid to be composed of many thin slices:

- Random, uncorrelated Gaussian misalignment of those slices ("spatial white noise") just broadens the rms width of the electron beam, while keeping the profile Gaussian

- In reality, long wavelengths will dominate, resulting in profile distortion. For very large misalignment amplitudes, a double hump structure appears.

Accelerator studies at RHIC

1. Betatron phase shifter

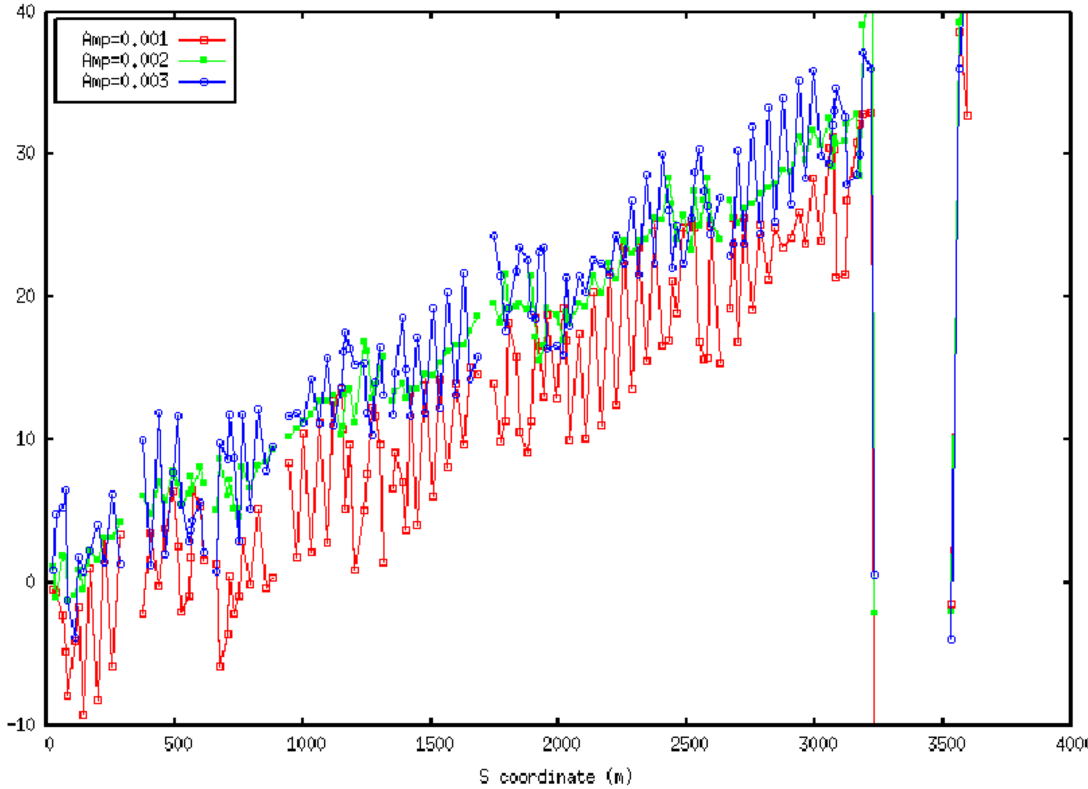
- Two shunt power supplies will be added to main quads in arc IP8 - 10, to allow control of betatron phase advance

- For successful operation, we have to be able to measure this phase advance with an accuracy of a few degrees

- Changed RHIC tune by $\Delta Q \approx 0.1$ (or 30 degrees), which changes phase advance per arc by 5 degrees

- Measured optics by AC dipole to verify the change in phase advance

Measured phase advance



AC dipole tune was off due to testing this during low energy run. Need to repeat to get better data.

2. Limit for lowering γ_t

   - Integer tunes need to be modified to minimize optics distortions by betatron phase shifter
   - Blue tunes: (27.69,29.68), Yellow: (29.69,30.68)
   - Increasing the horizontal integer tune in Yellow will inevitably raise γ_t
   - For good longitudinal matching, Yellow γ_t has to be lowered at injection, using γ_t quads and possibly lattice modifications
   - γ_t was lowered by 0.35 at injection during APEX on 2/23/2011, limited by power supply currents

   May need dedicated DC "γ_t" supplies to lower γ_t during proton injection, or use solution similar to ion "split transition" lattice

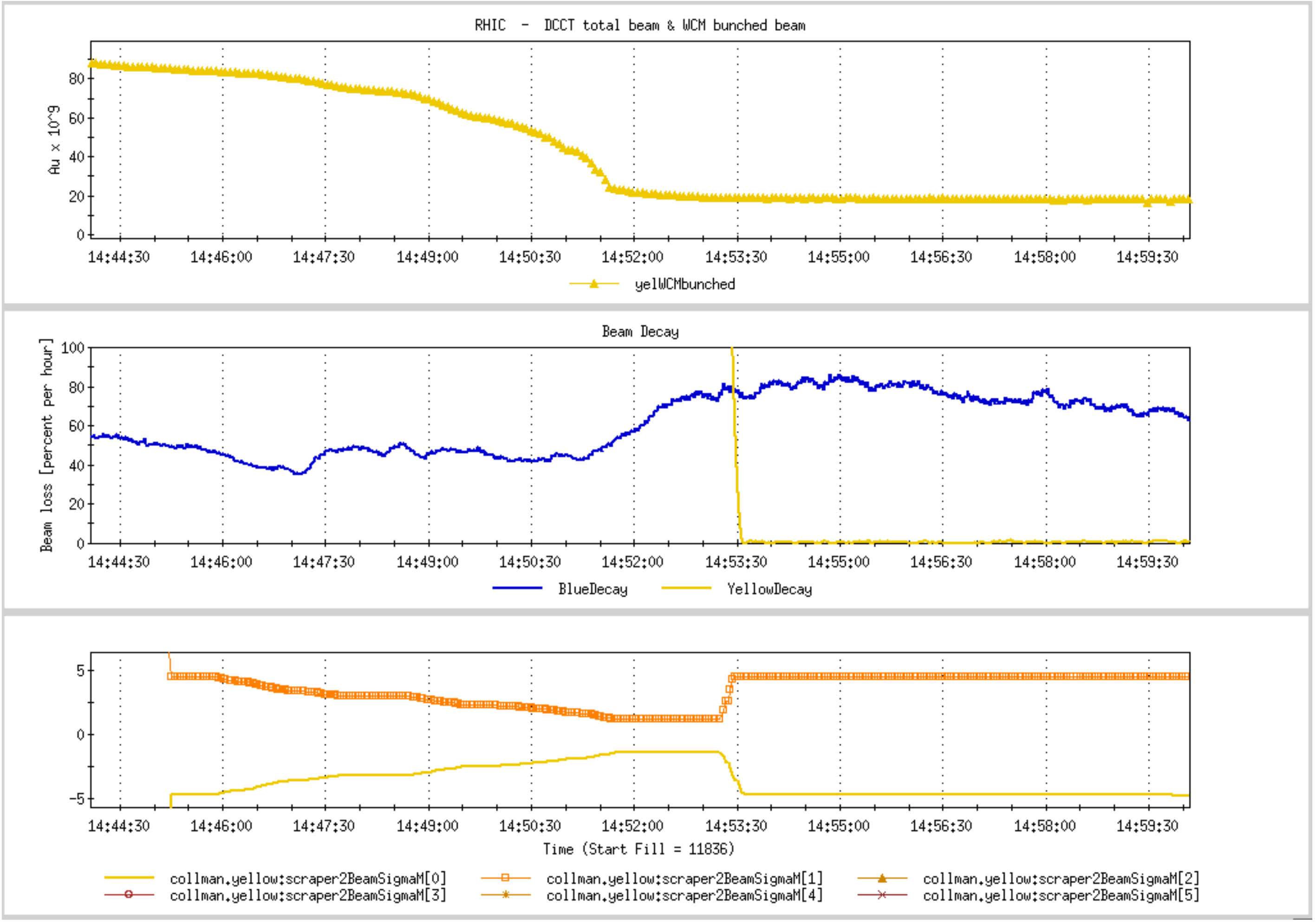
3. Effect of limited cathode size

- Established collisions at STAR with 111x111 at injection

- No luck finding collisions at PHENIX

- Re-injected, then started scraping in Yellow

Blue beam decay as function of Yellow collimator position



- Blue beam decay was still improving after injection when we started scraping in Yellow (lack of time)

- Blue beam decay stopped improving when Yellow collimators were inserted to 3σ

- Sharp increase in Blue beam decay with Yellow collimators at $\approx 1.7\sigma$, despite low Yellow bunch intensity

- Blue beam decay improved after retracting Yellow collimators, demonstrating that observed beam decay is not just due to blow-up via IBS

- Results were not reproducible during two subsequent attempts

Bottom line: Experiment should be repeated with protons at store, for better lifetime and larger beam-beam parameter (two IPs)

4. E-lens straightness requirement

- In the thin-lens approximation, a non-straight electron lens beam is equivalent to a “smoke ring” in phase space

- Generate “smoke rings” by single kicks of different amplitude to bunches in the “Blue” beam

- Observe lifetime and emittance evolution of corresponding bunches in the “Yellow” ring