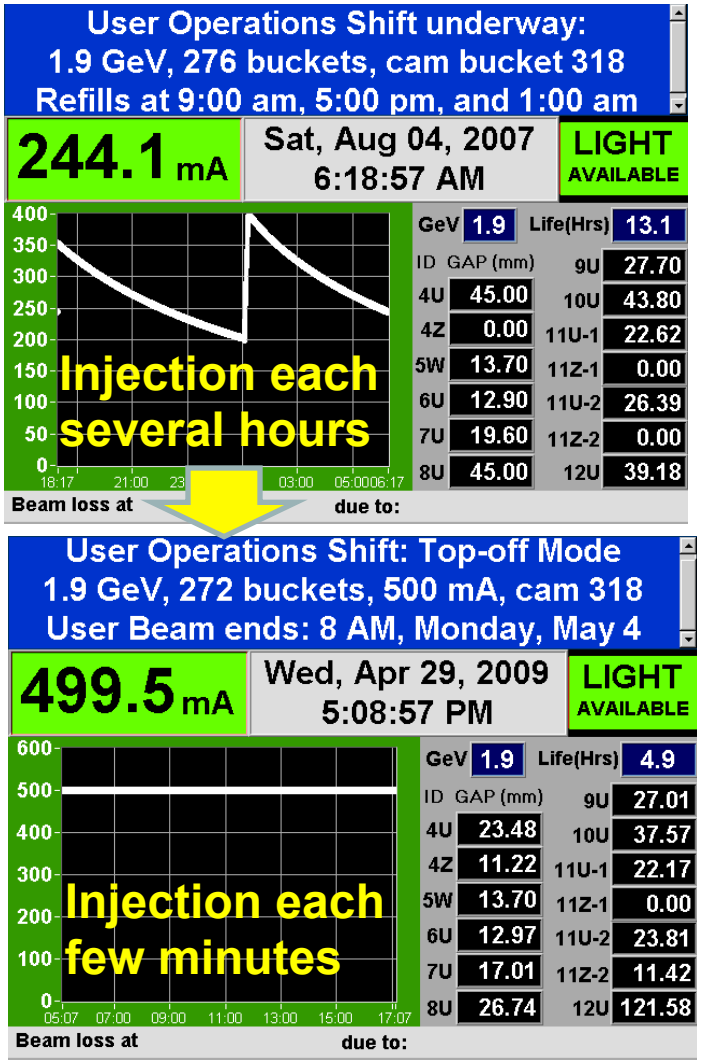
Motivation for Top-off at ALS

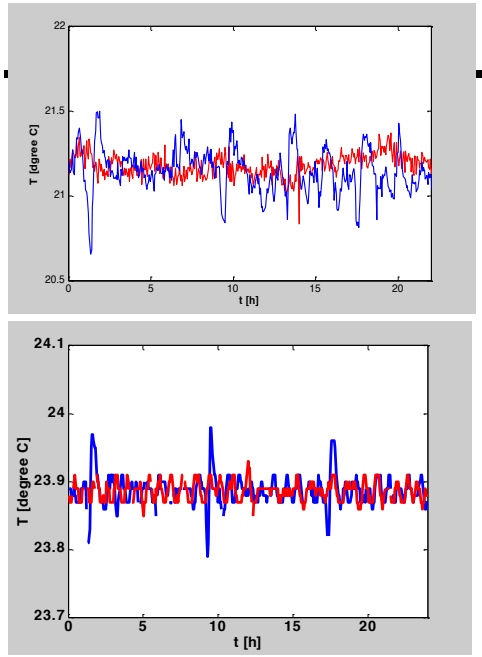
- ***Top-off == Quasi-Continuous Injection: Opens the door to large increases in brightness and improvements in beam stability***

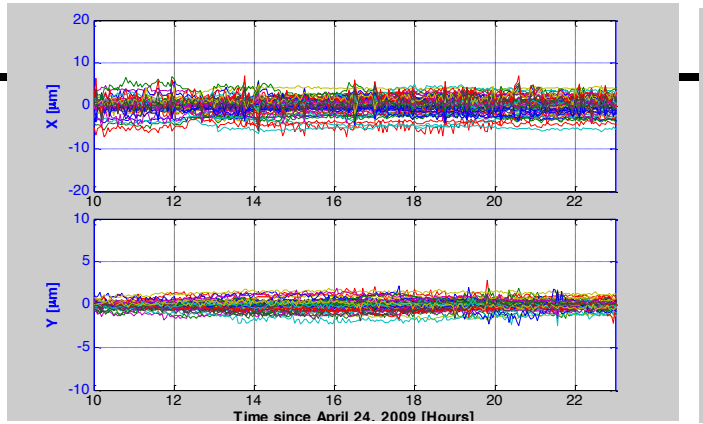
- **Top-off mode was used initially at CESR, later at APS, SLS, SPRING-8 and an increasing number of other light sources**

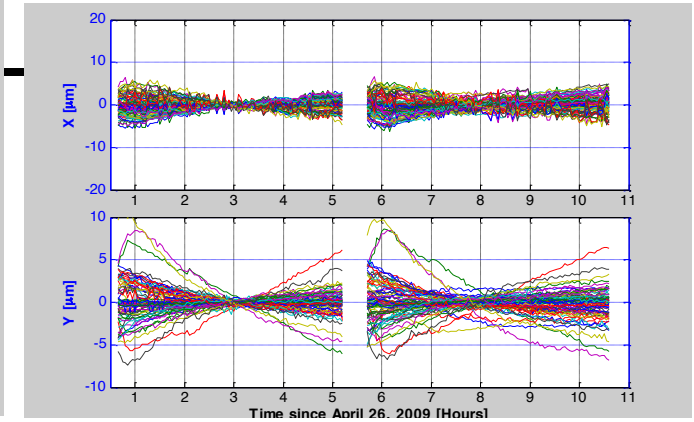
- **BENEFITS**
  - **Higher average current**
  - **Improved stability**
  - **Lifetime less important**
    - **can reduce vertical beam size**



Stability Improvement







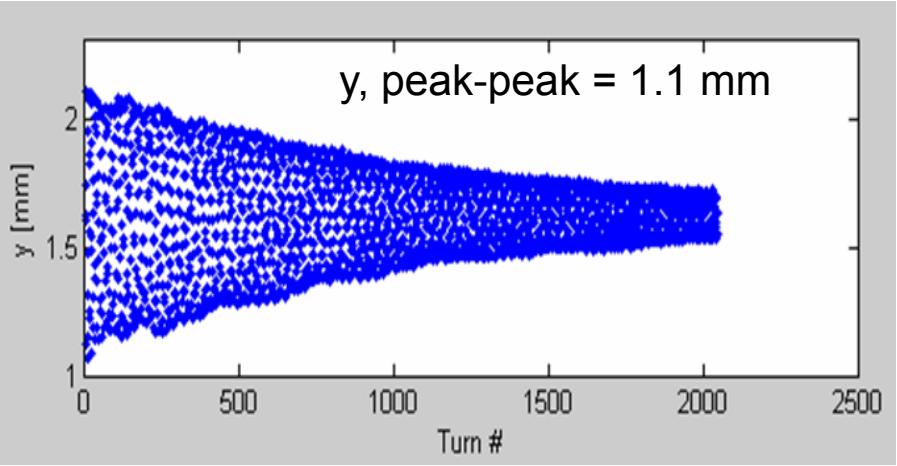
Left: Water (top) and air (bottom) temperature stability with (red) and without (blue) top-off (refills happened every 8 hours). Middle: Mid term orbit stability (12 h) with top-off; right: Without top-off.

- Significant improvement in temperature stability (water, air) as well as elimination of (fake) current dependence of BPM readings
- Improved long term orbit stability
- Many beamlines see improved stability of their optics and some experimenters see big advantage in not having to normalize data
- ALS provides gating signal, but most users do not use it

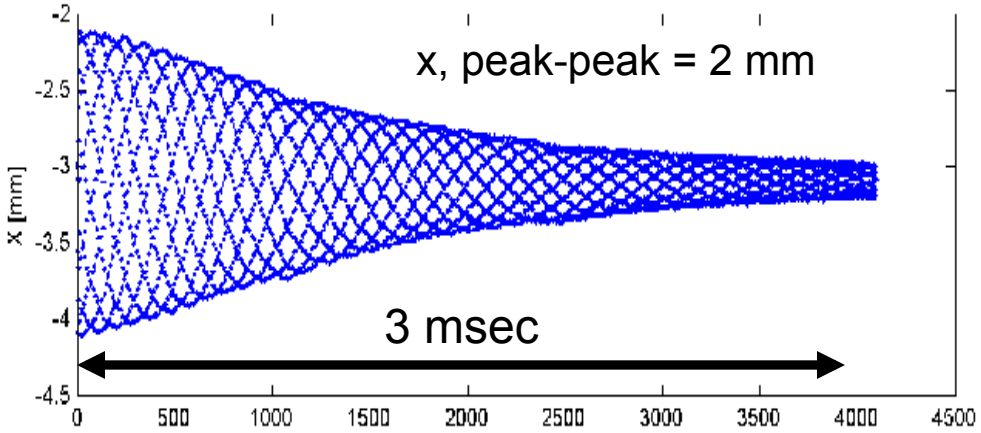
Top-off stored beam perturbation

Measured turn-by-turn oscillations of beam

- peak-to-peak/FWHM:
  - **horizontal = 6**
  - **vertical = 100**
  - **IDs FWHM$_{x,y}$ = (1.0,0.022) mm**
- damping time: 5 msec
- repetition period
  - **now: 100 msec**
  - **top-off: 10 minutes**

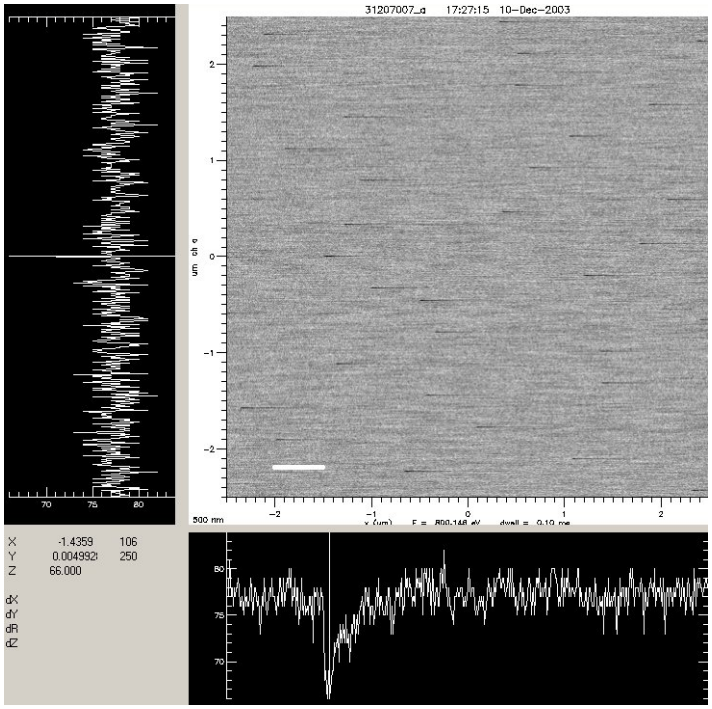


(Oscillations at β_x = 3.5 m, β_y = 12.5 m)



Example of injection transient effect: STXM

Recorded image



15 %

Horizontal scale is 60 ms

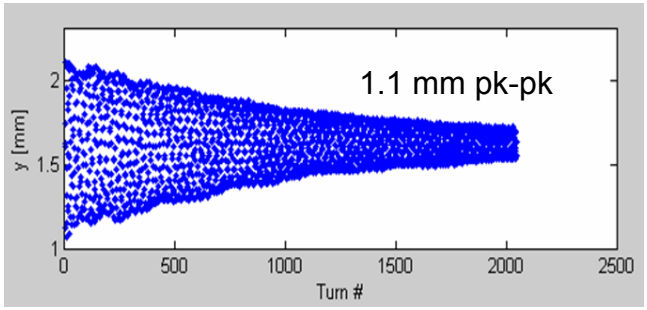
Tolek Tyliszczak

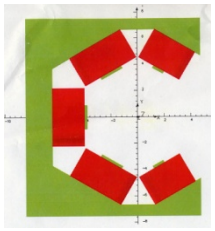
Second "Injection" test
7 Dec 2003 STXM 11.0.2
septum magnet turned off

- Significant effect observed at STXM (Scanning Transmission X-ray Microscope)
- Very sensitive due to combination of high resolution zone-plate and pin hole.
- Gating can be implemented relatively easily – Gating signal is provided and is used at STXMs

SPEAR 3 Top-Off Injection Transient

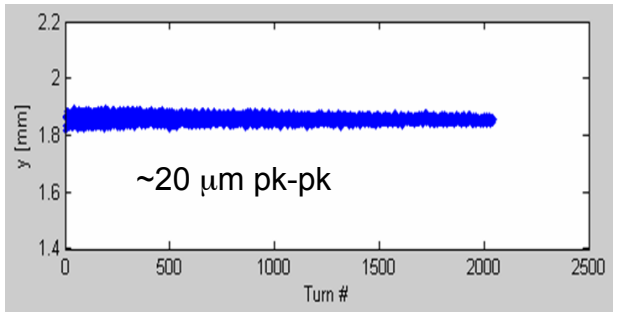
- Vertical transient from septum magnet leakage field corrected:



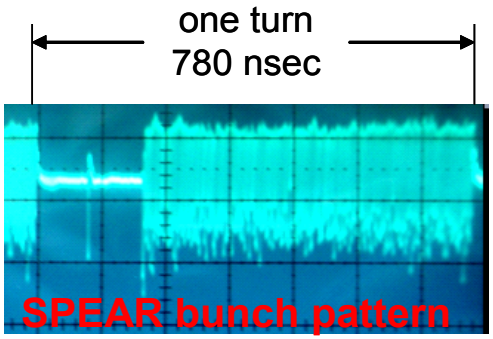


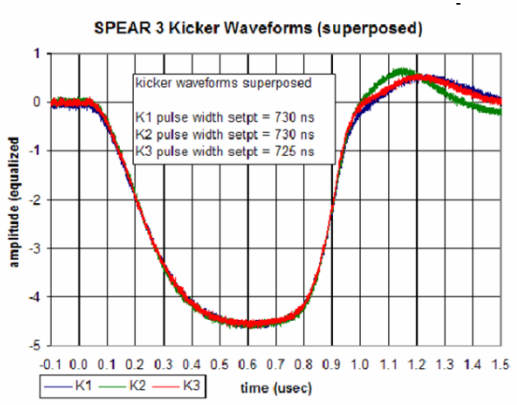
CORB9V + 2 skew quads

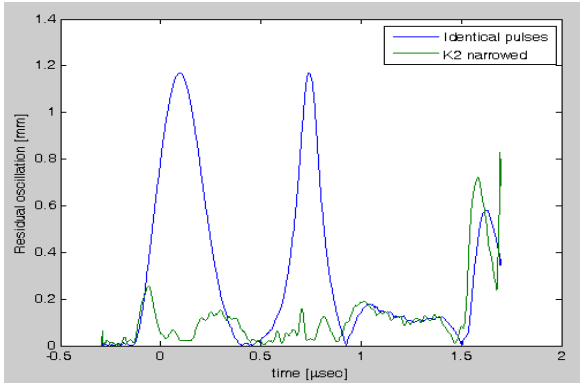
=



- Horizontal transient from injection kicker bump through sextupoles reduced by adjusting middle kicker pulse width:

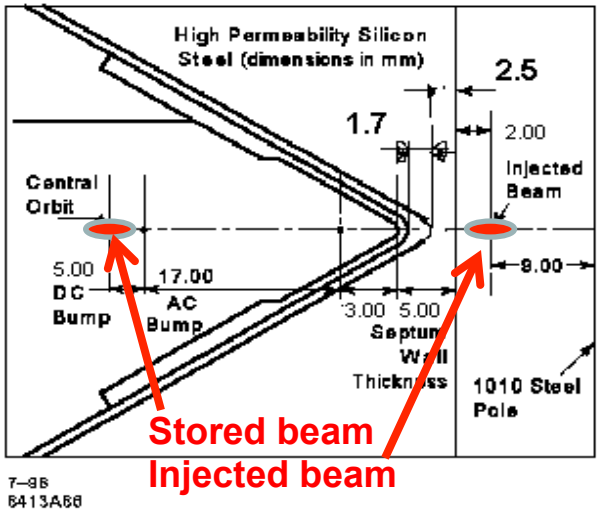


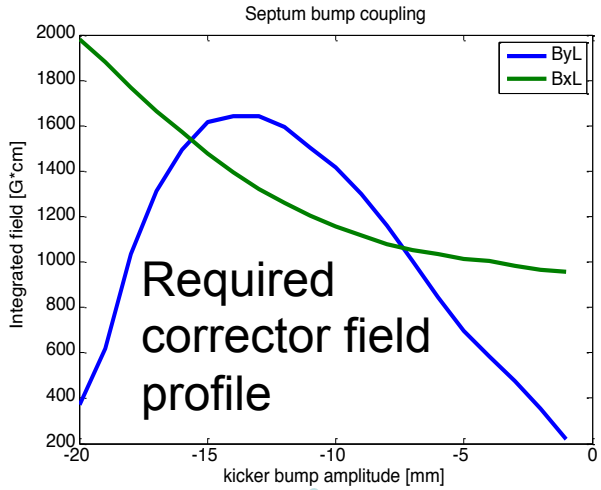




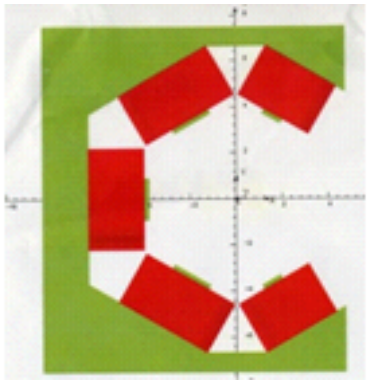
Stored beam kick vs. bump amplitude

Septum x-section

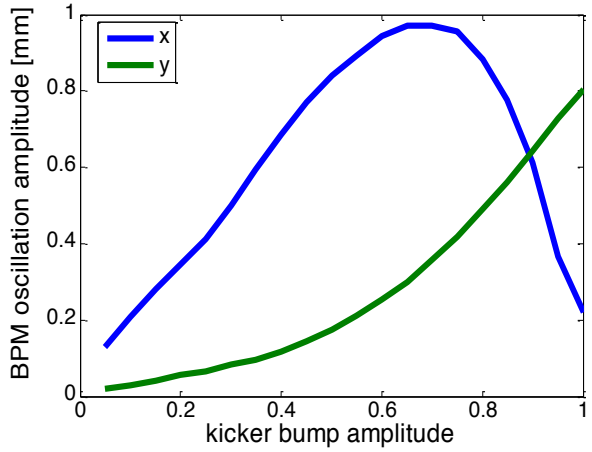




5-pole magnet, cancels septum leakage fields



Measurements



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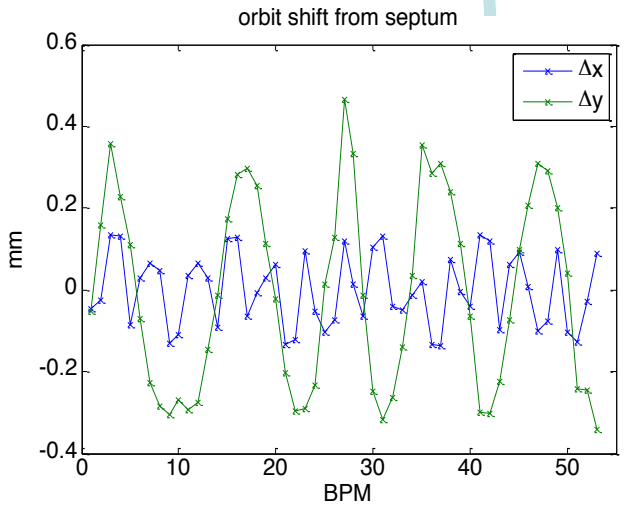
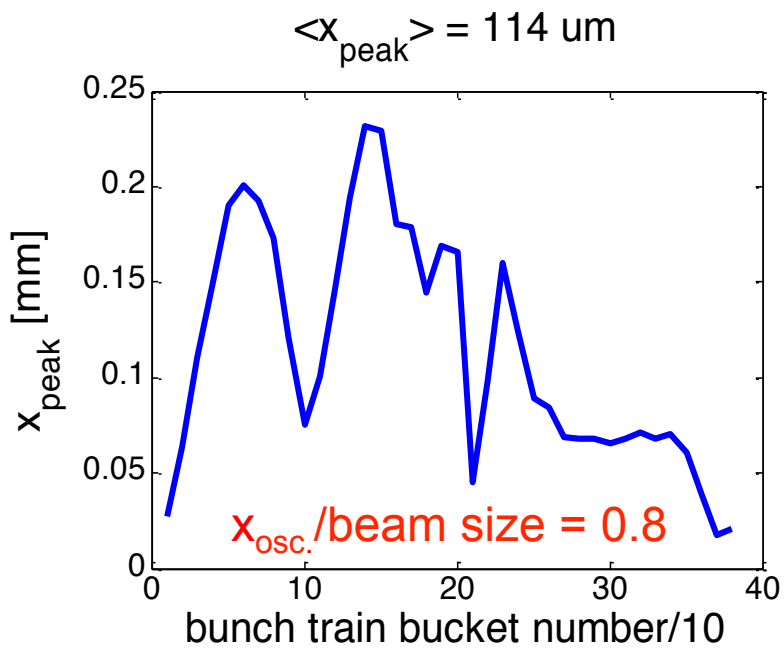
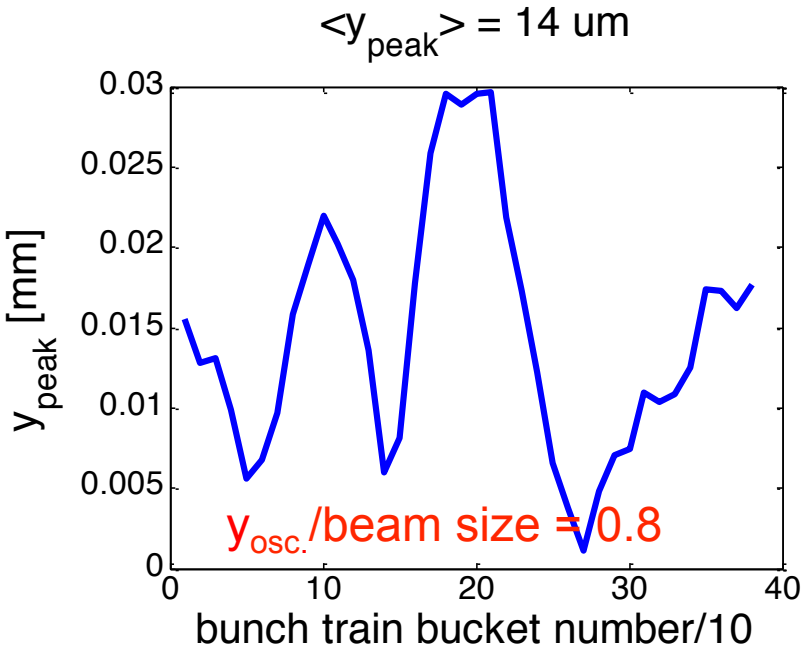


Beam-based injection bump matching

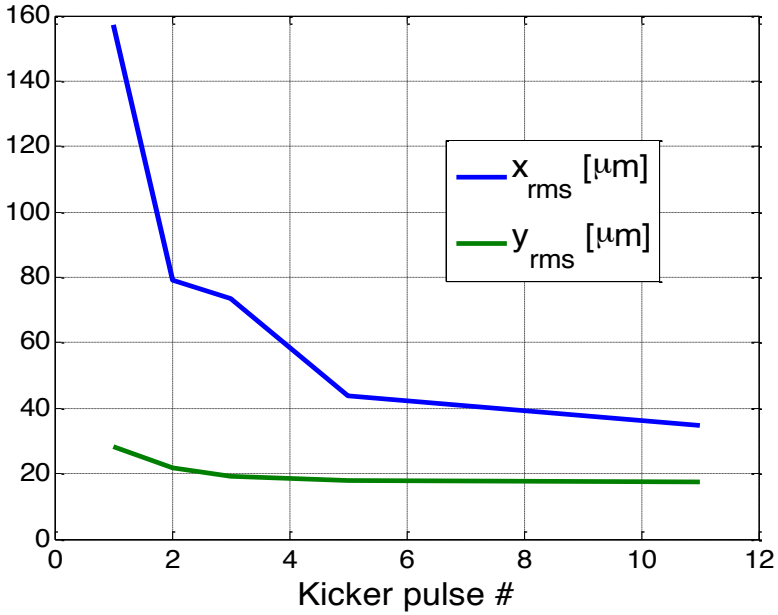
- Measure horizontal and vertical oscillations of stored beam as a function of bunch number kicked.
- Vary 2 kicker strengths, kicker timing, and kicker pulse widths to minimize x.
- Vary 2 skew quadrupoles plus septum 5-pole corrector to minimize y.
- Measure response matrix, and invert (SVD!), for correction

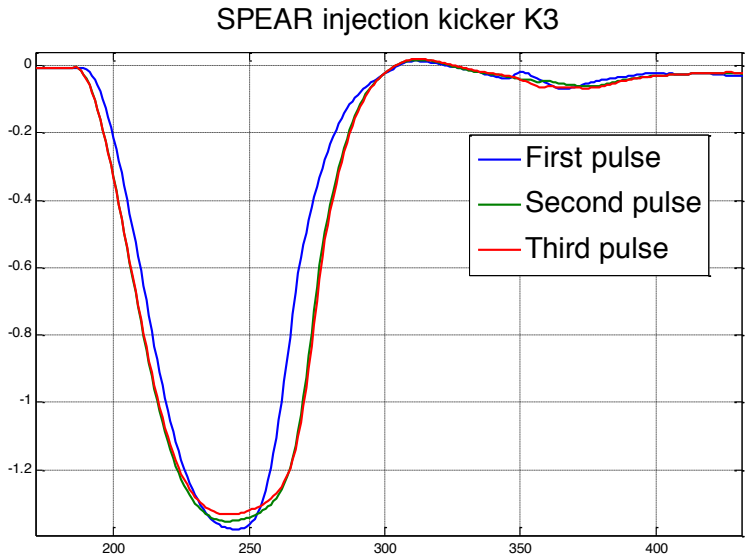


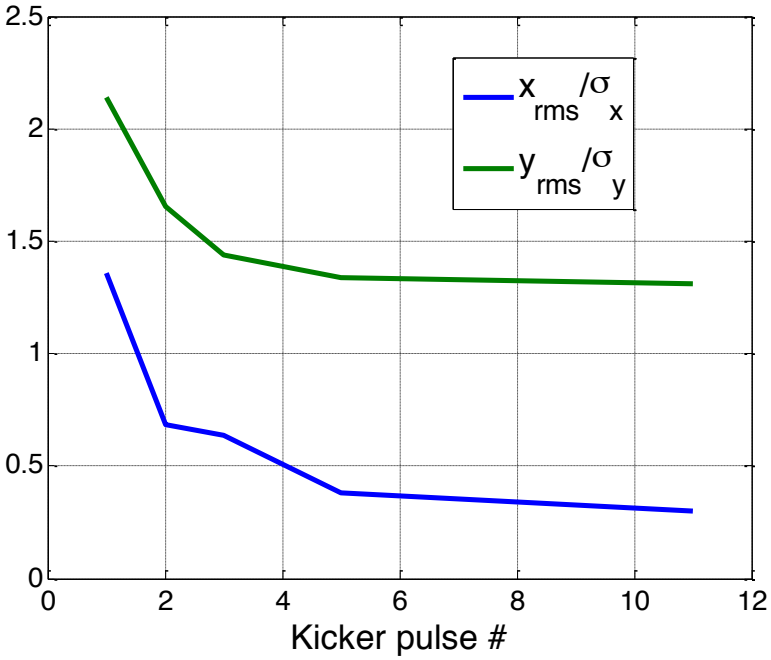


SPEAR injection kickers, first kicks

- Initial pulses narrower
- Increases stored beam kick
- Improvements under way



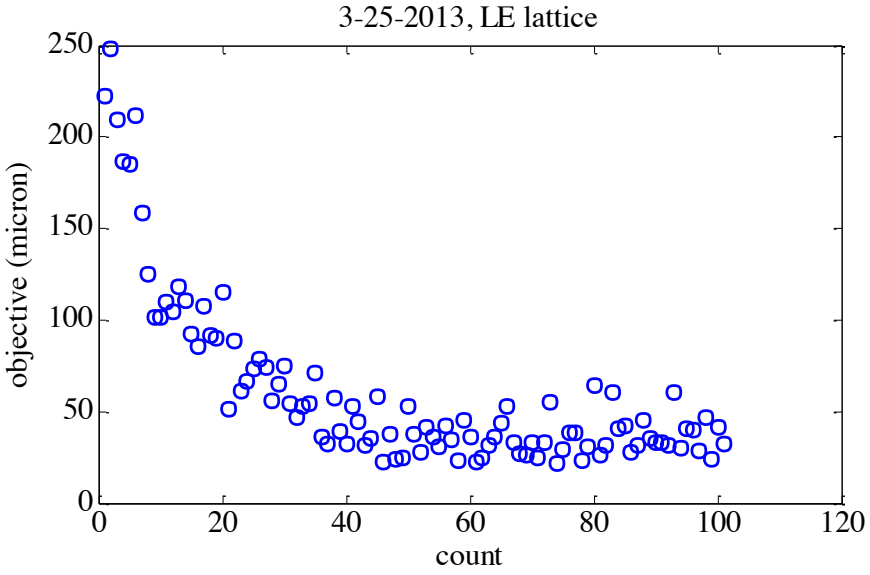


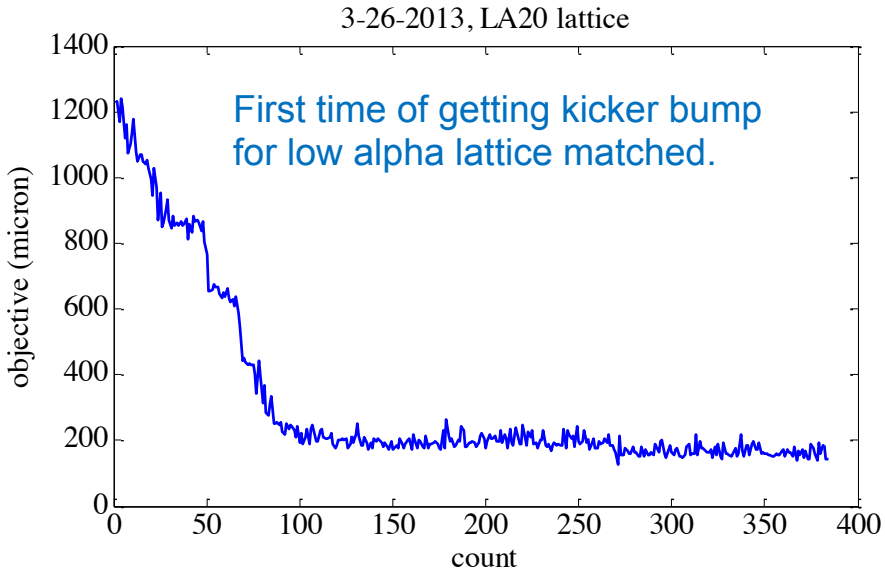


Kicker bump matching, RCDS optimization

Parameters: Adjusting pulse amplitude, pulse width and timing delay of K1 and K3 (with K2 fixed) and two skew quads for vertical plane, 8 parameters total.

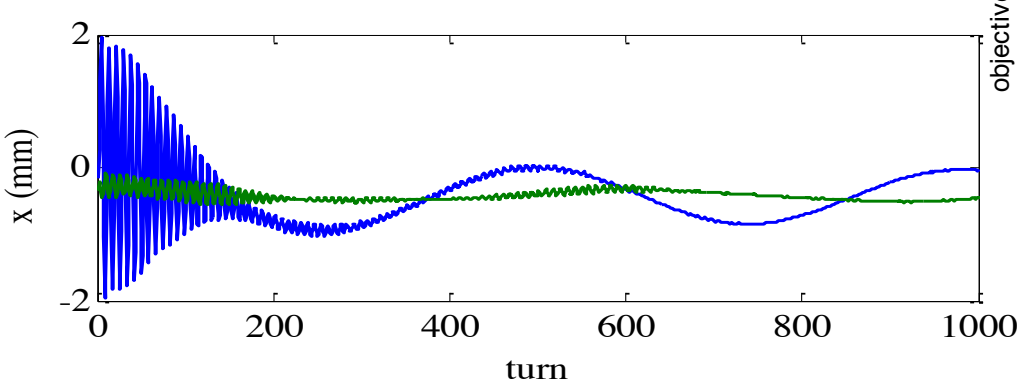
Objective: sum of rms(x) and rms(y) of turn-by-turn orbit (for 30~300 turns).

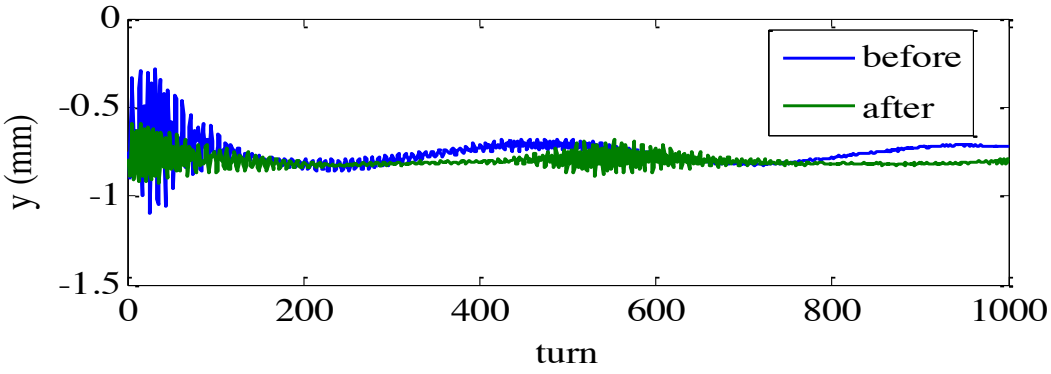


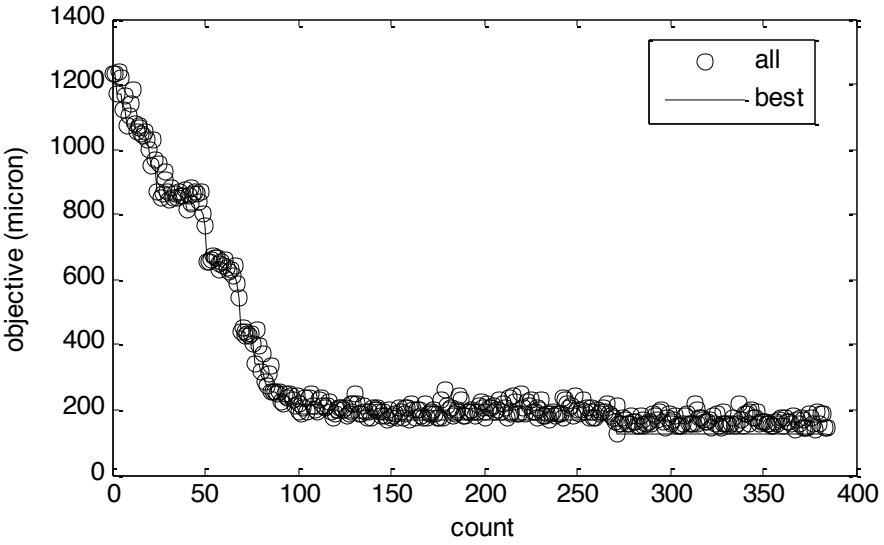


Kicker bump match for low-α

Use RCDS code.
Minimize rms orbit deviation for the first 30 turns with 8 parameters.



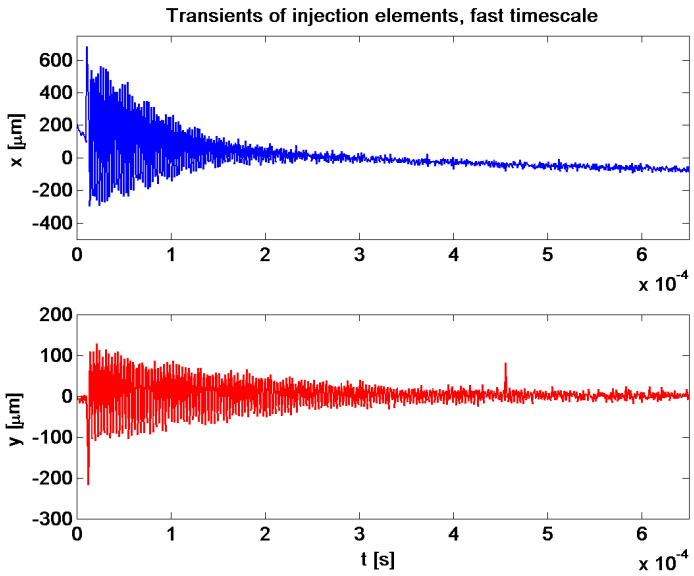




Response matrix technique had been unsuccessful at minimizing top-off transient in low-α, perhaps due to the lower beam stability in low-α. RCDS worked well.

ALS Top-Off Transients

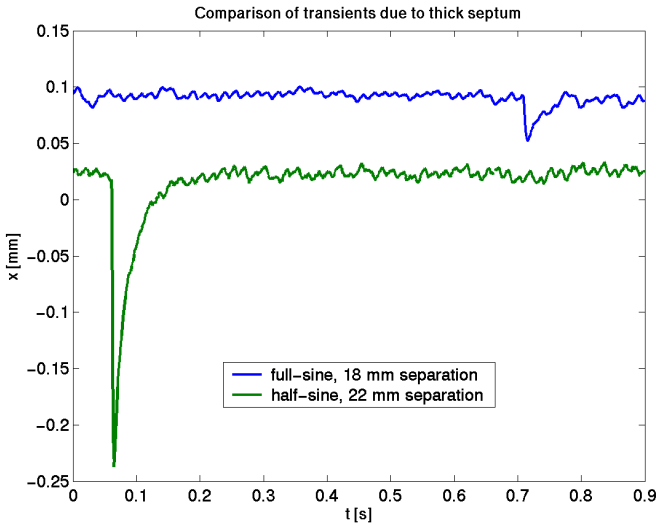
β-tron oscillations from injection kickers, ~msec



RMS Beam sizes are 300 by 8 microns

Transverse feedback system reduces the duration of the transients

Closed orbit distortion, ~0.1 second.



Delayed stray field using 'full sine' excitation reduced by factor of 10

- ALS provides gating signal, but most users do not use it