SSRL

ACCELERATOR DIRECTORATE

SPEAR3 Photon Beamline Stability from Ground Motion and Injection Transients

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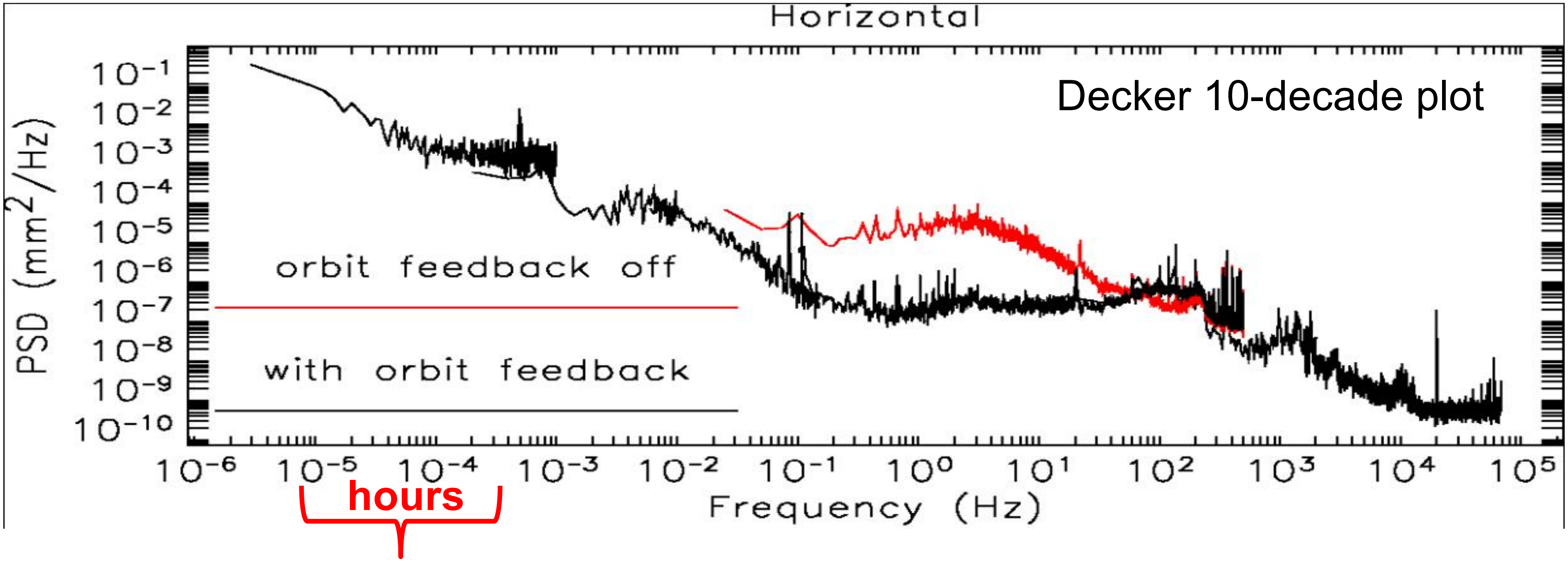
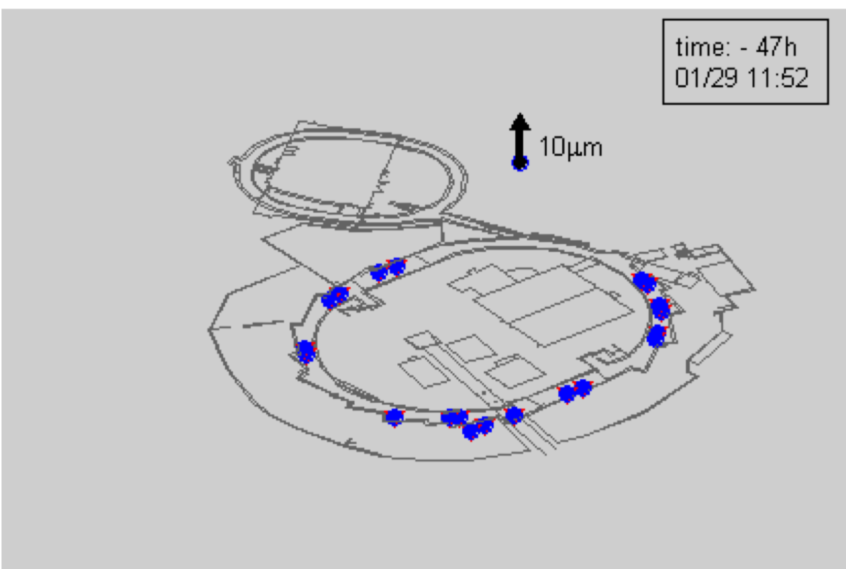
BES Light Sources Beam Stability Workshop

November 1, 2018

SLAC NATIONAL ACCELERATOR LABORATORY

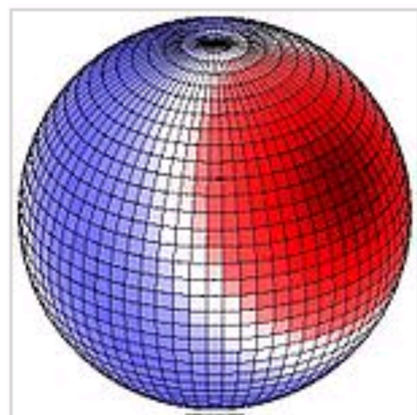


- Beam position monitor electronics
- Accelerator tunnel floor stability



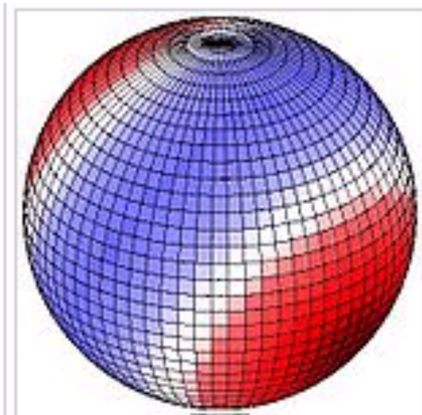
Hydrostatic Leveling System, G. Gassner

Earth tides: 20"+ motion

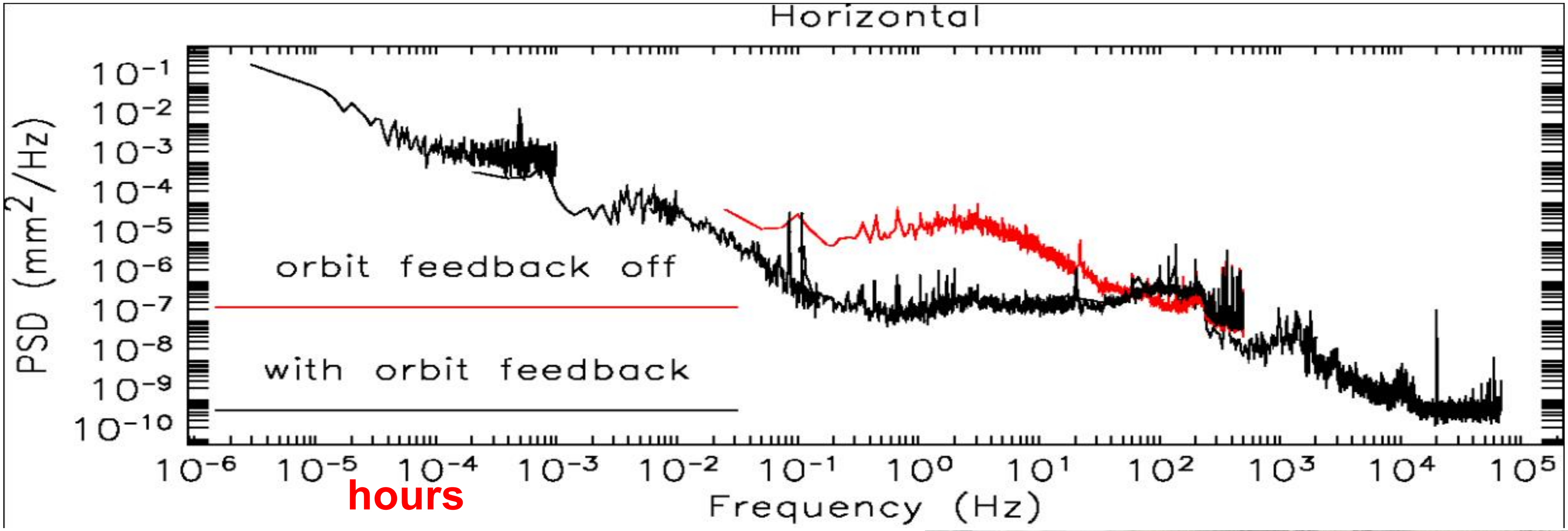


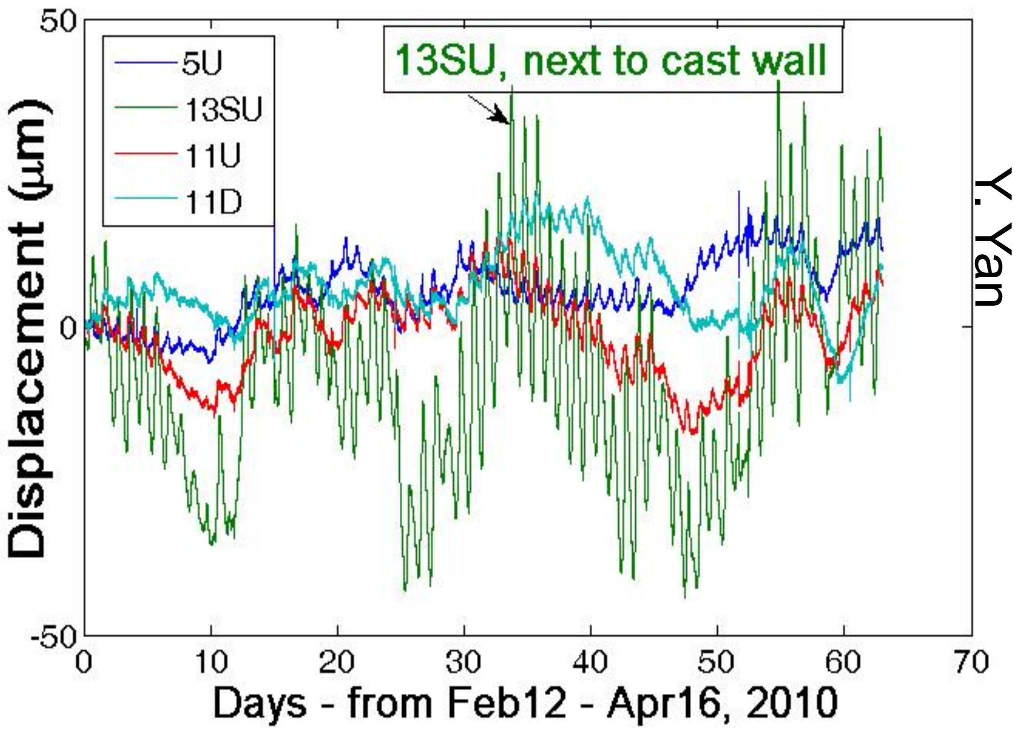
A. Lunar tidal forcing: this depicts the Moon directly over 30° N (or 30° S) viewed from above the Northern Hemisphere.

wikipedia



B. This view shows same forcing from 180° from view A. Viewed from above the Northern Hemisphere. Red up, blue down.


Horizontal
PSD (mm^2/Hz)
orbit feedback off
with orbit feedback
hours
Frequency (Hz)


5U
13SU
11U
11D
13SU, next to cast wall
Displacement (μm)
Days - from Feb12 - Apr16, 2010
Y. Yan

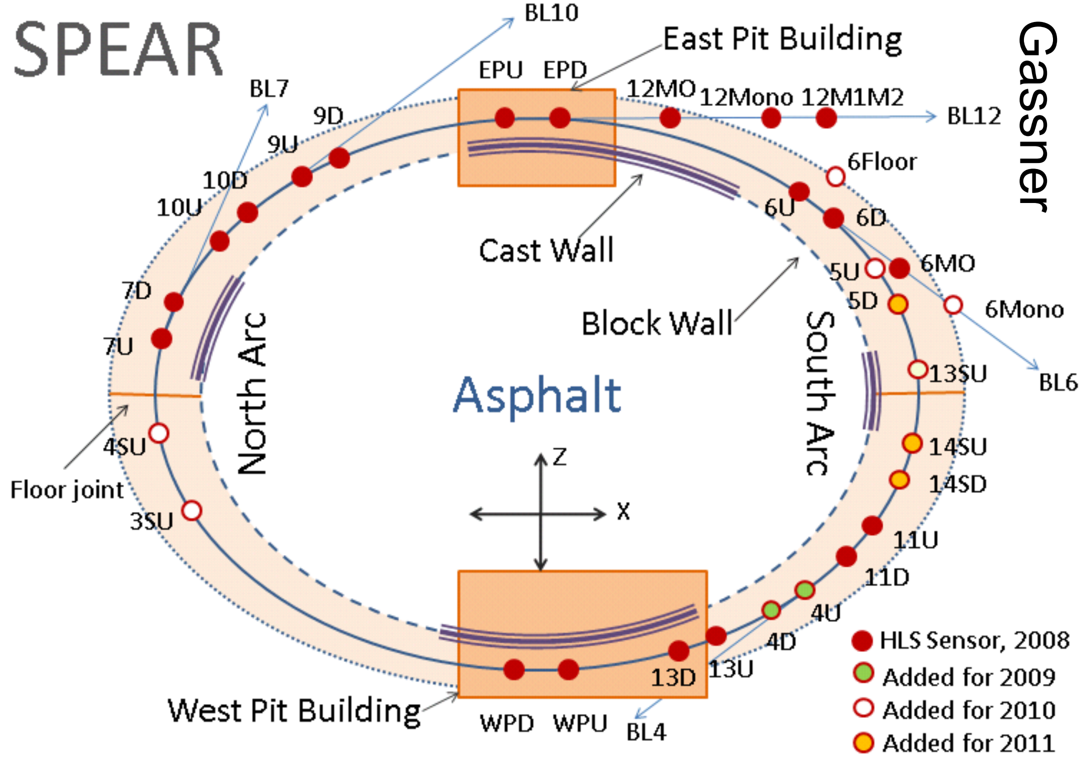

Spear Control Room
Stanford Synchrotron Radiation Lightsource
Stanford Synchrotron Radiation Lab(SSRL)

Hydrostatic Leveling System

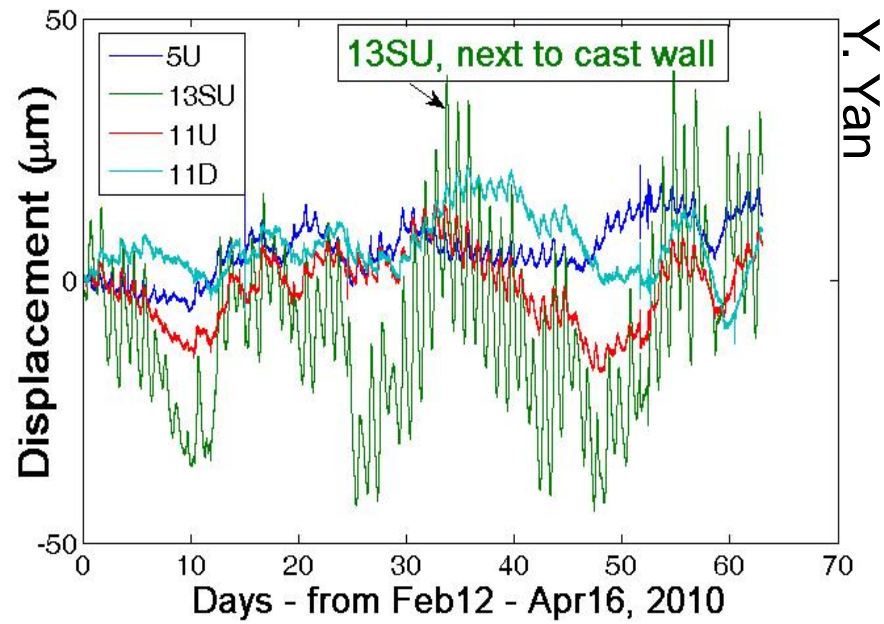
31 sensors

Measure water level in ½ filled PVC pipe

Measure ~40 micron daily floor motion = 5x e- beam size.



Gassner



Y. Yan

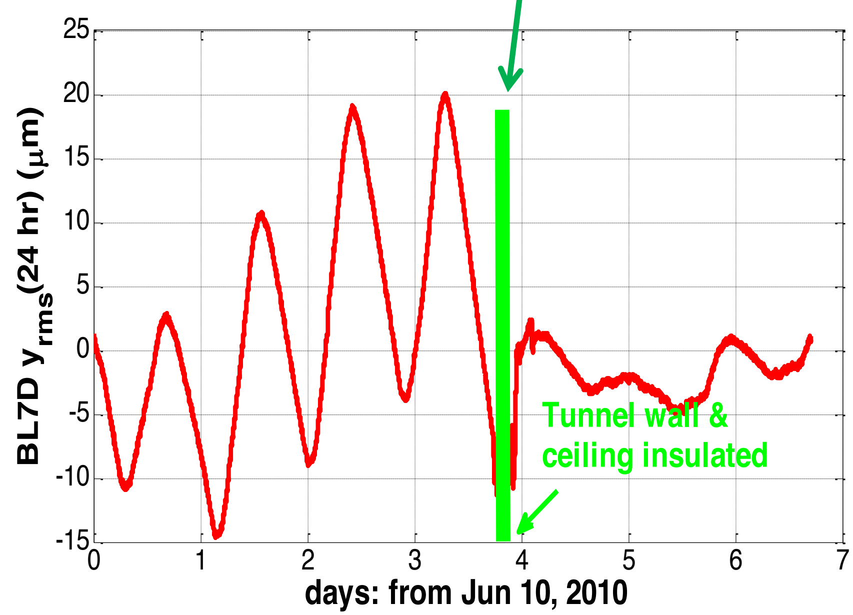
What's driving tunnel floor?

Experiments

- White paint
- Mylar
- Insulation

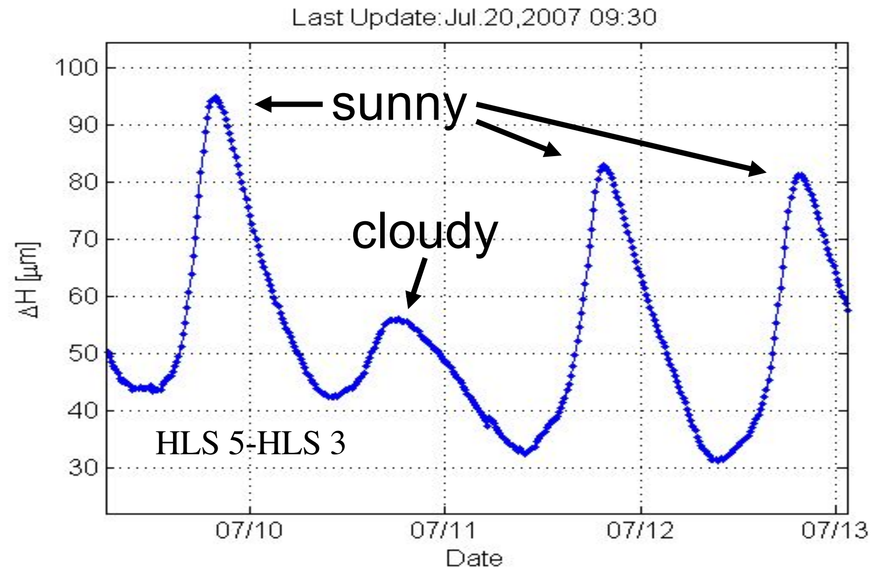
LCLS undulator tunnel is stable

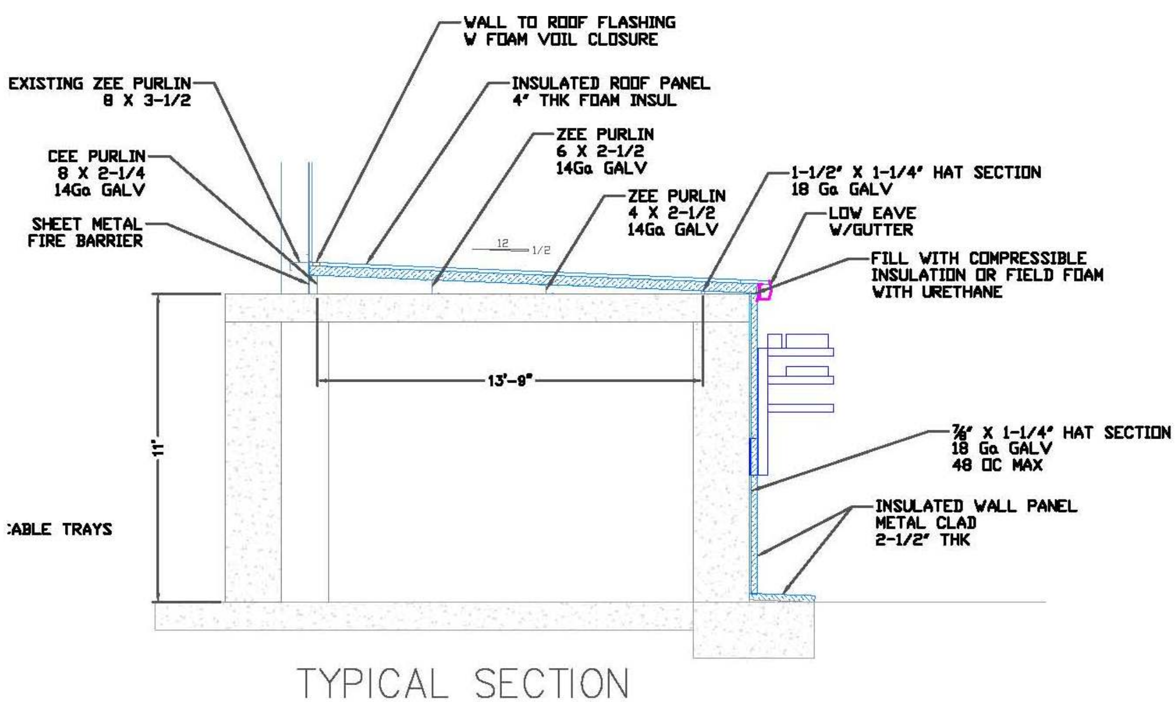
PEP-X (under ground) should also be stable



Diagnosed SPEAR3 tunnel floor motion

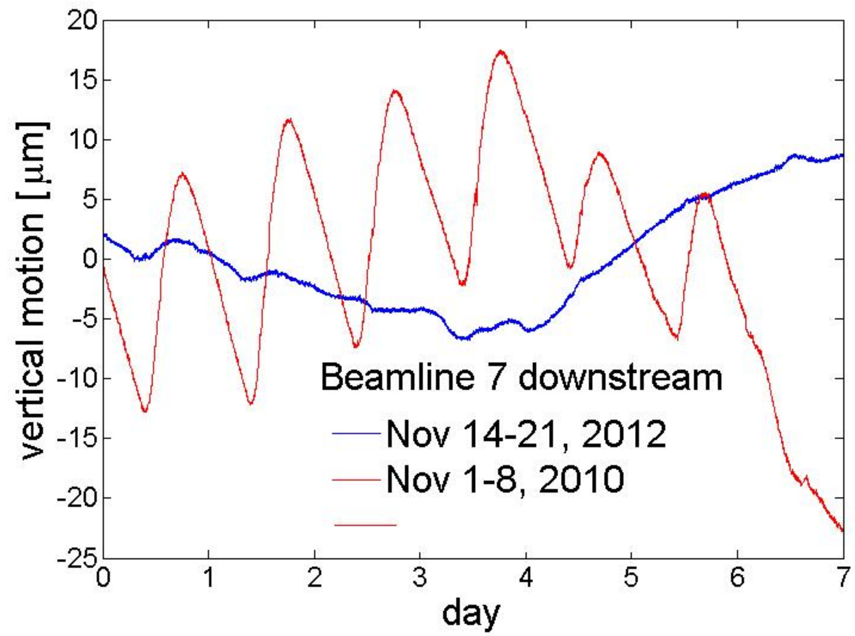
- SPEAR3 tunnel floor moving 10's of microns, diurnal motion
- Priority identified by 2011 review

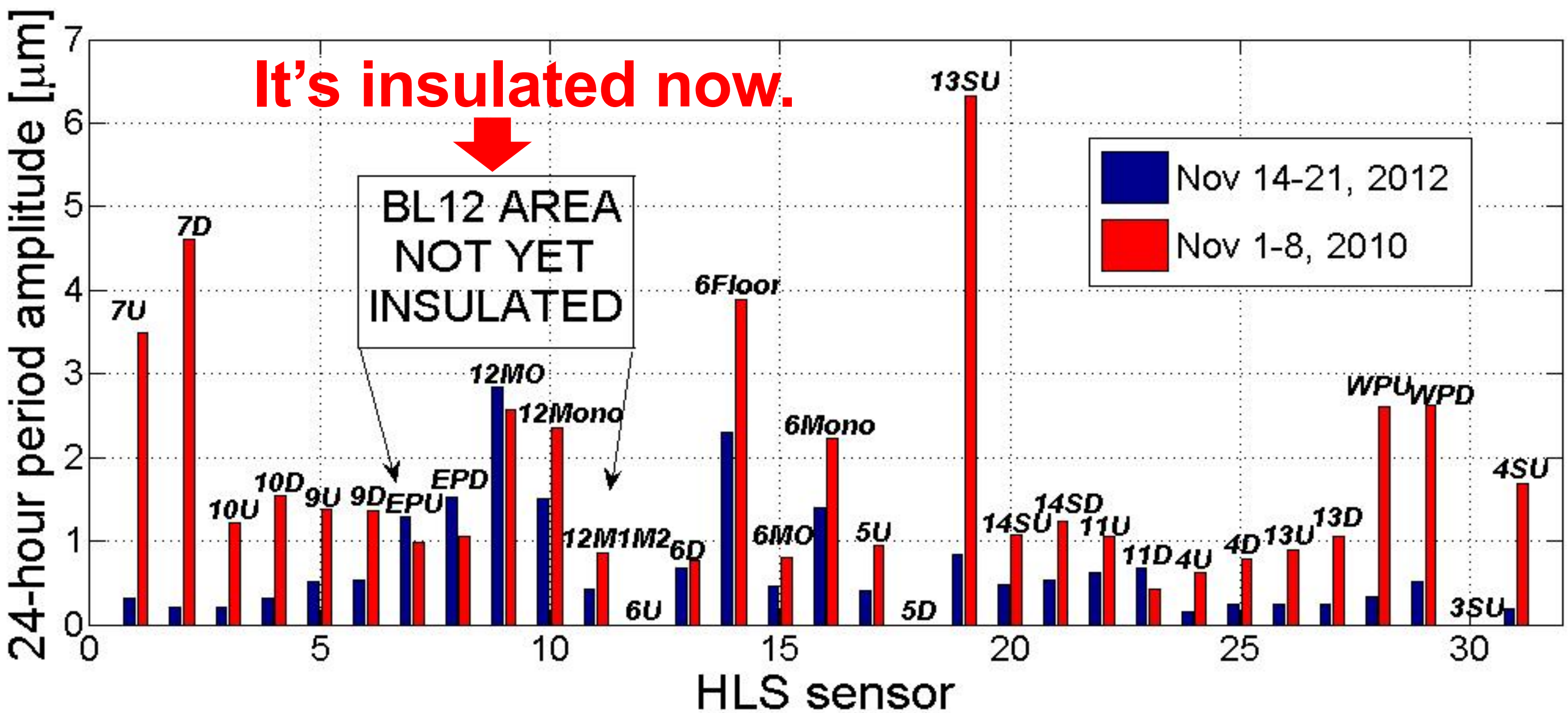




Mitigated SPEAR3 Tunnel Floor Motion

- DOE AIP funding
- Tunnel insulation installed 2012
- Up to x10 motion reduction

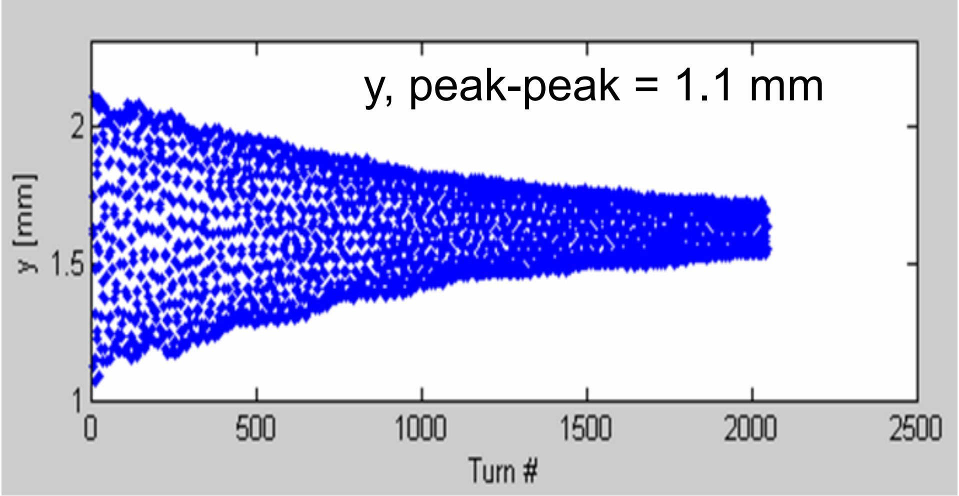




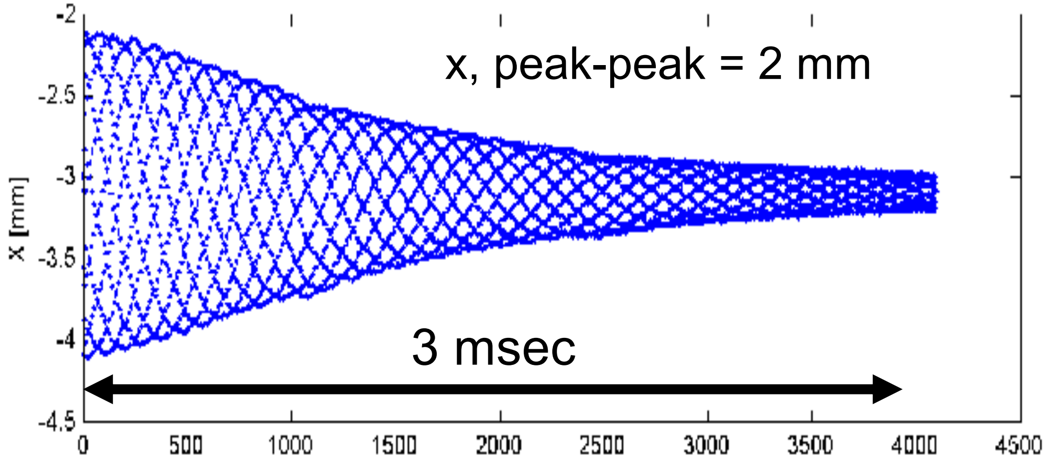
Top-off stored beam perturbation

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

Measured turn-by-turn oscillations of beam

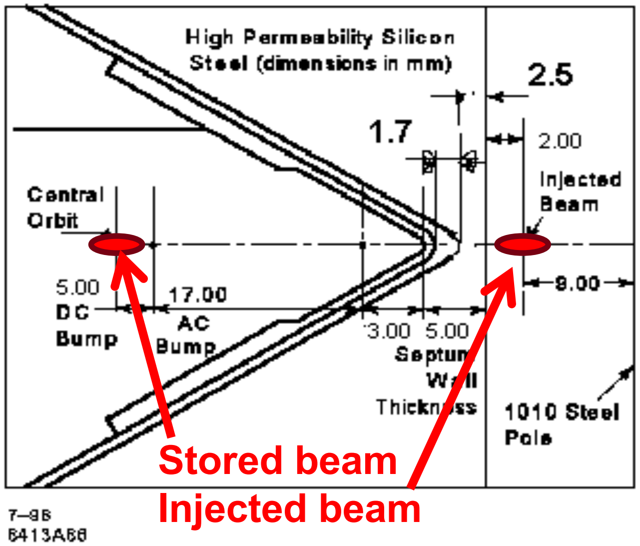


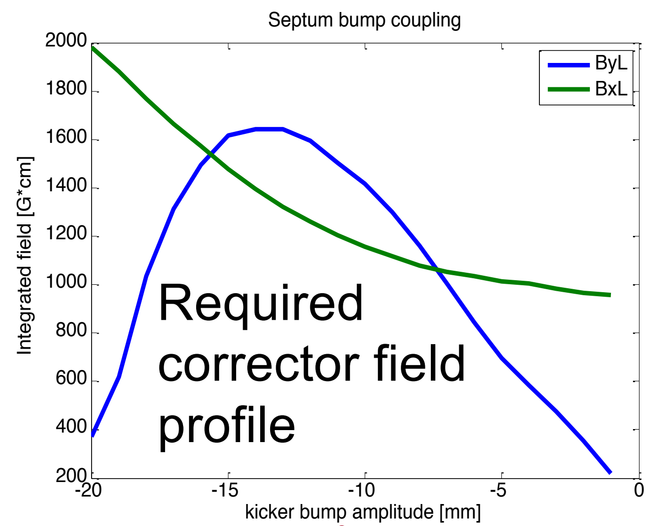
(Oscillations at β_x = 3.5 m, β_y = 12.5 m)



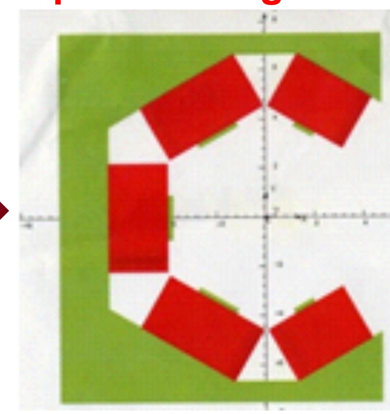
Stored beam kick vs. bump amplitude

Septum x-section

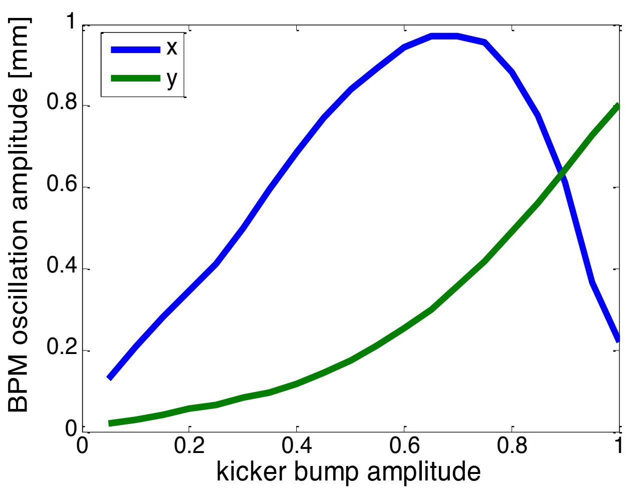




5-pole magnet, cancels septum leakage fields



Measurements



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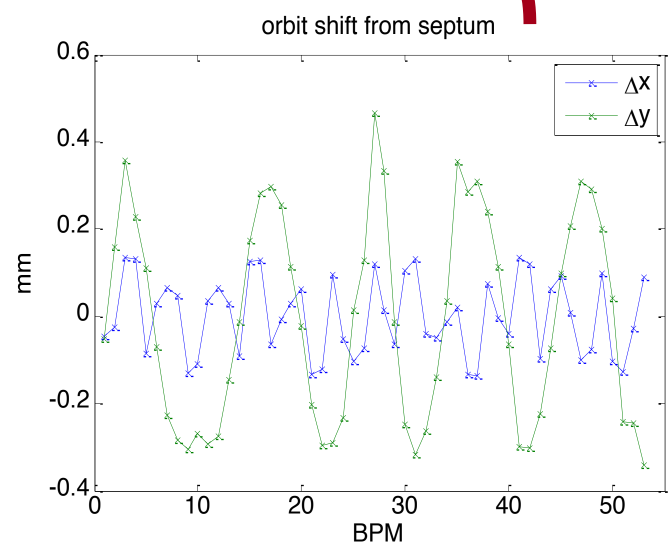
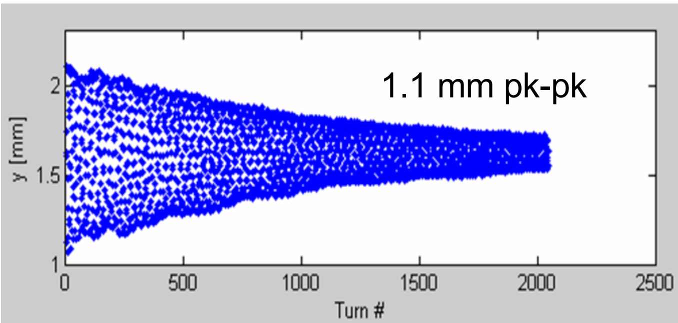


SPEAR 3 Top-Off Injection Transient

- Vertical transient from septum magnet leakage field corrected:



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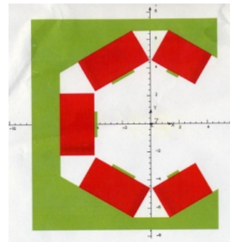
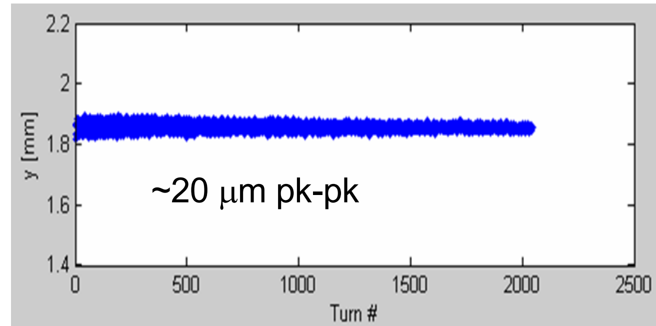
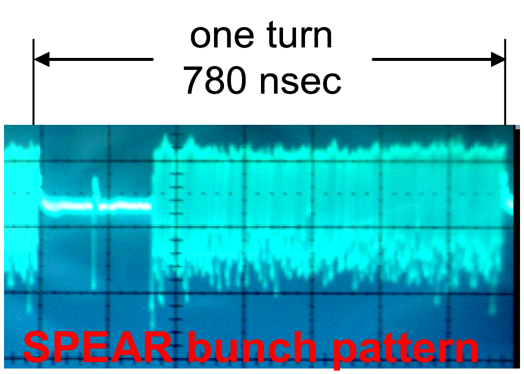


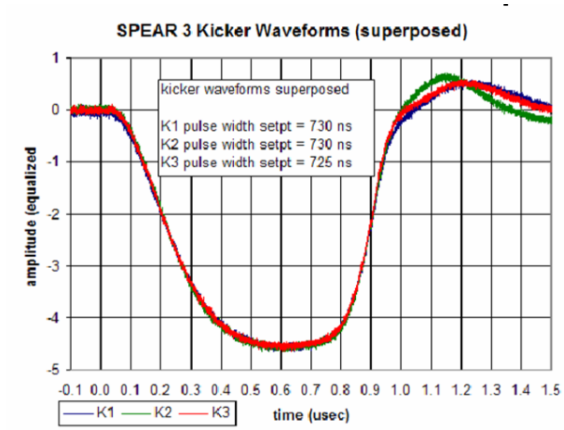
CORB9V + 2 skew quads

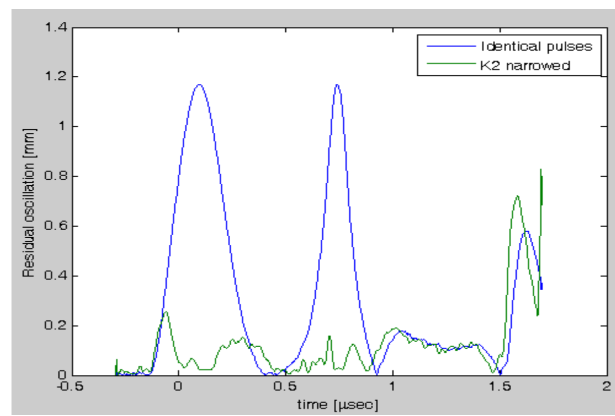
=



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

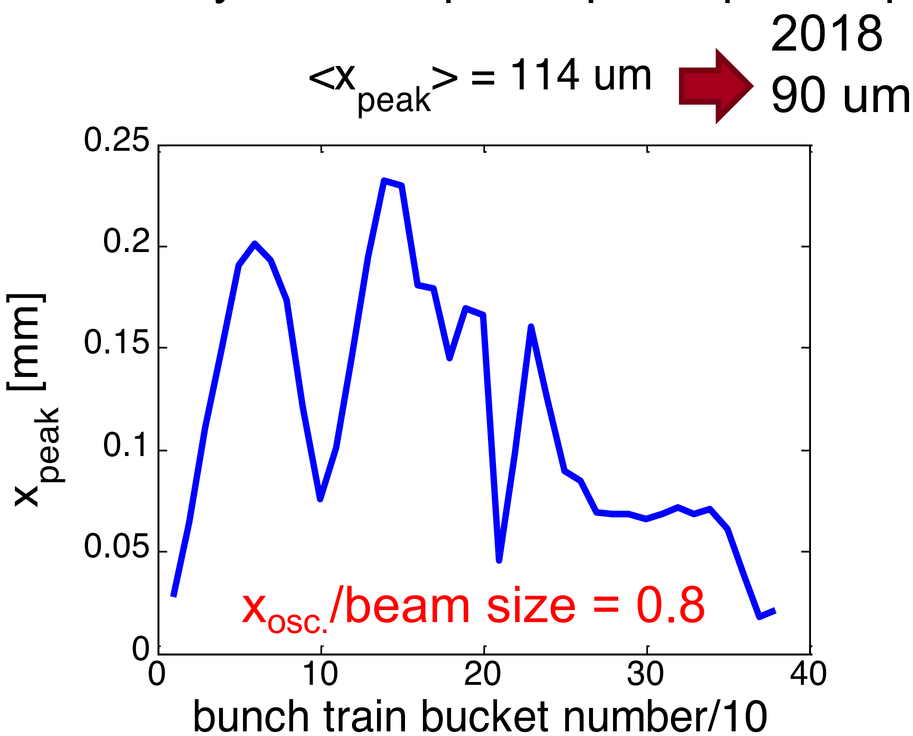


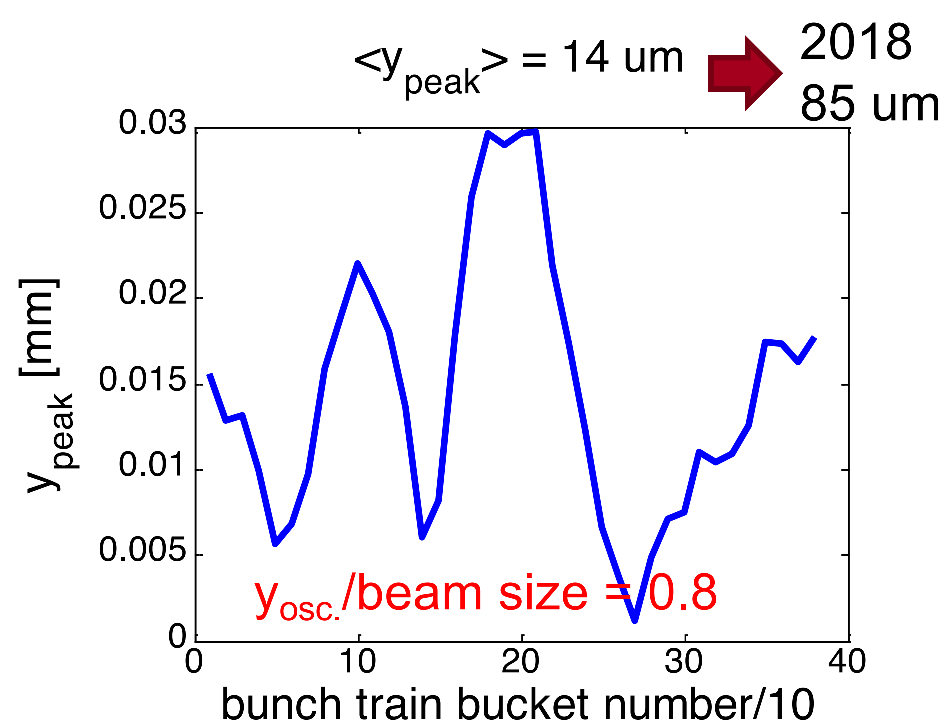




Beam-based injection bump matching

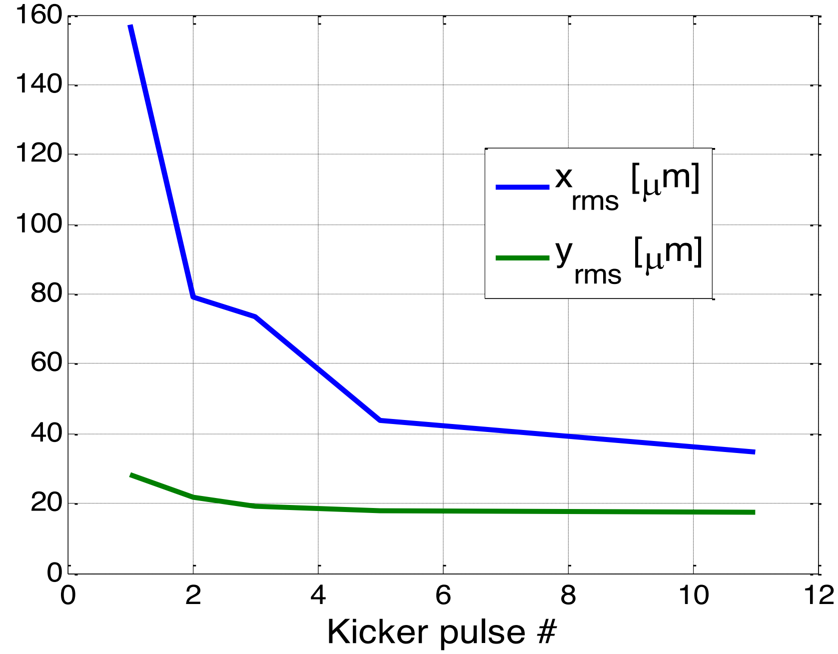
- Measure horizontal and vertical oscillations of stored beam as a function of bunch number kicked.
- Vary 2 kicker strengths, kicker timing, and kicker pulse widths to minimize x.
- Vary 2 skew quadrupoles plus septum 5-pole corrector to minimize y.

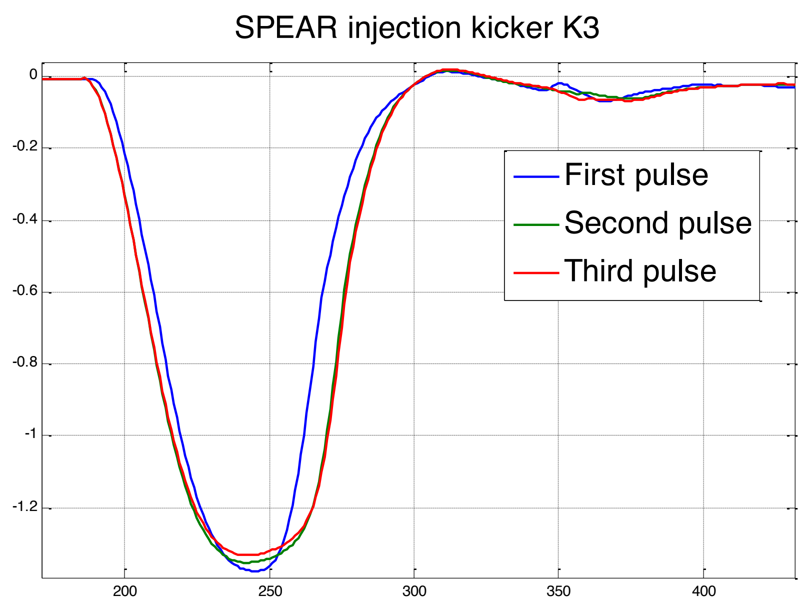


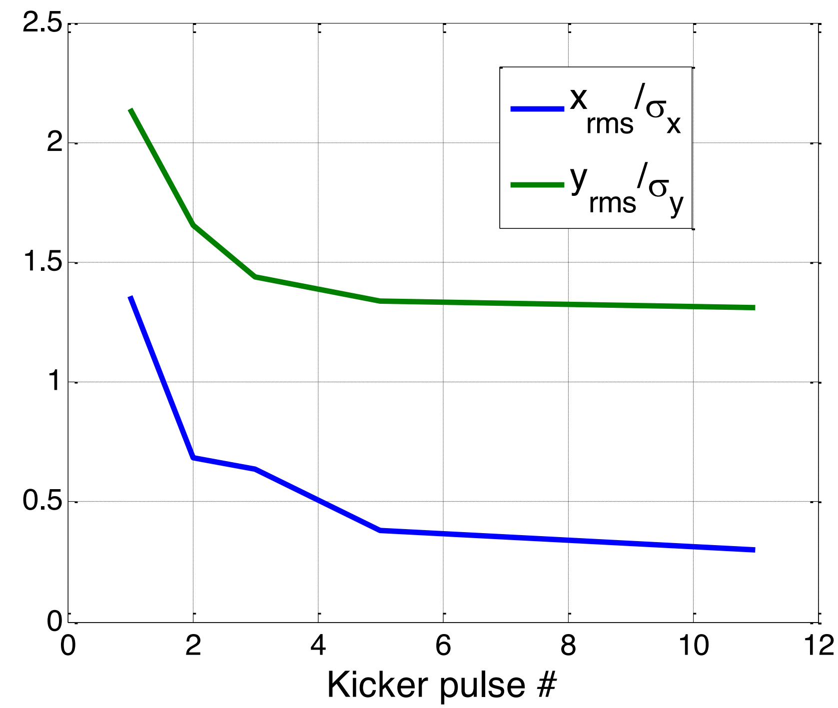


SPEAR injection kickers, first kicks

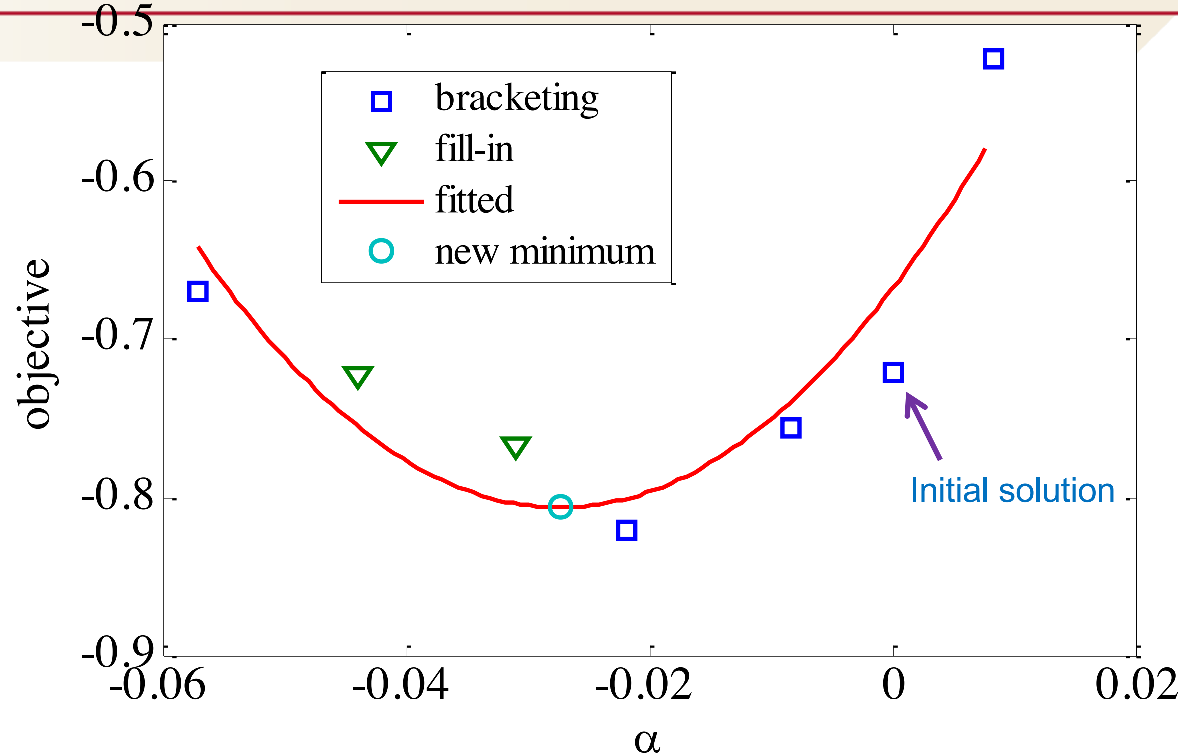
- Initial pulses narrower
- Increases stored beam kick
- Improvements under way







The robust line optimizer



Step 1: bracketing the minimum with noise considered.
Step 2: Fill in empty space in the bracket with solutions and perform quadratic fitting. Remove any outlier and fit again. Find the minimum from the fitted curve.

Global sampling within the bracket helps reducing the noise effect.

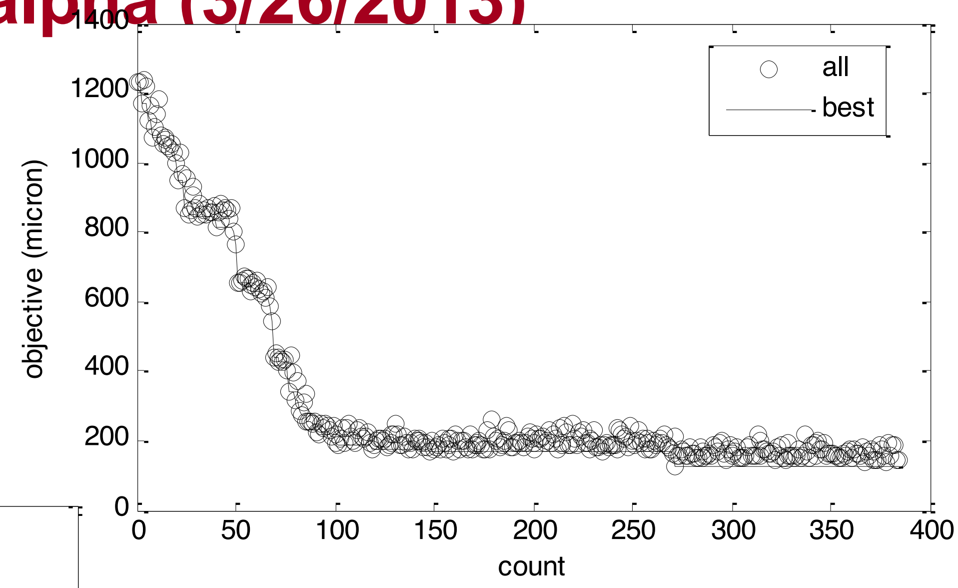
RCDS is Powell's conjugate method* + the new robust line optimizer.

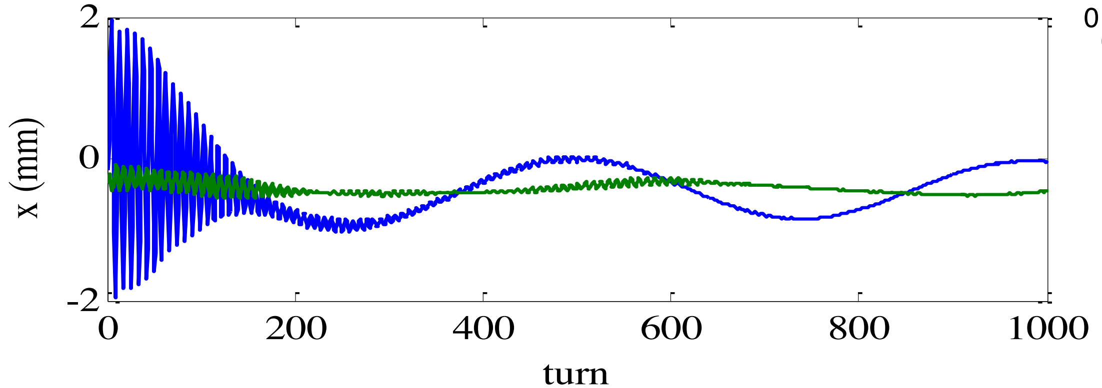
*however, since the online run time is usually short, it is important to provide good an initial conjugate direction set which may be calculated with a model.

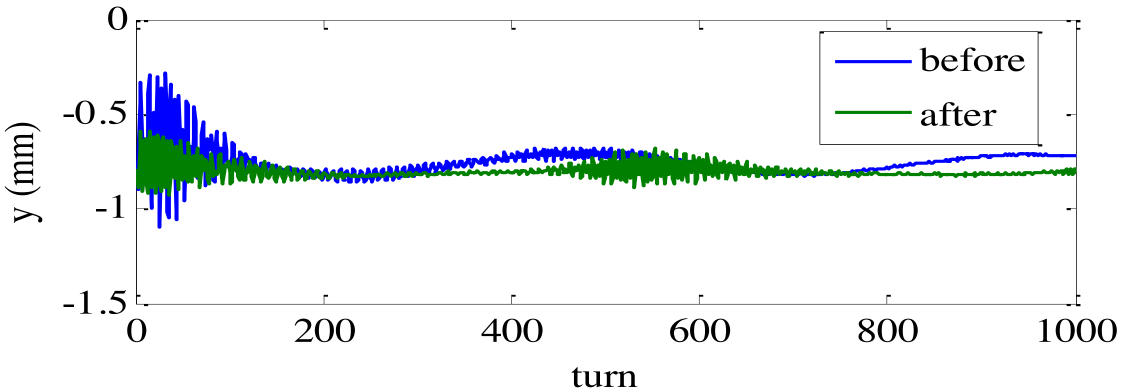
Kicker bump match for low-alpha (3/26/2013)

Use RCDS code.

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







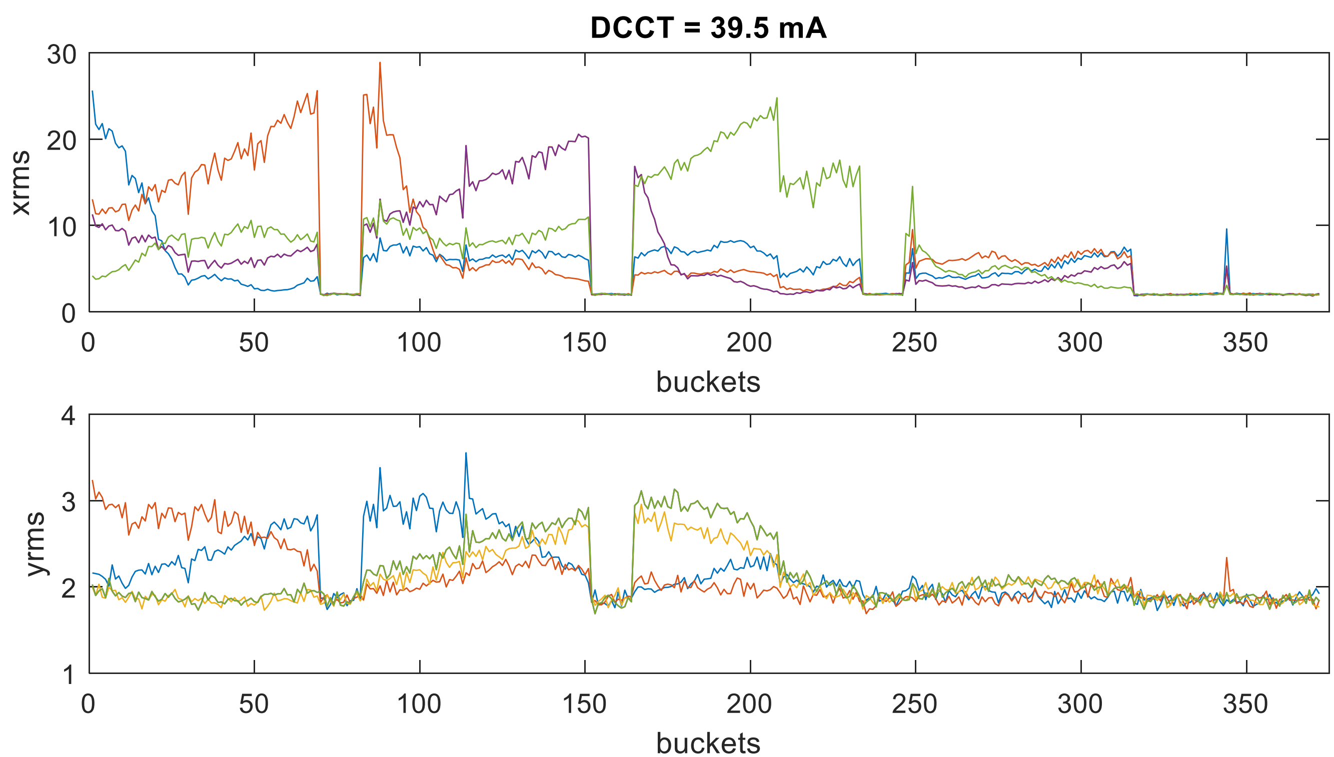
1.1842 1.4921 129.0226 144.2629 817.8182 700.1871 10.9197 6.5550

Kicker bump match automation, July, 2018

Use BxB feedback to measure oscillations in individual bunches. Calculate average oscillation amplitude (or rms) and use it as the objective function.

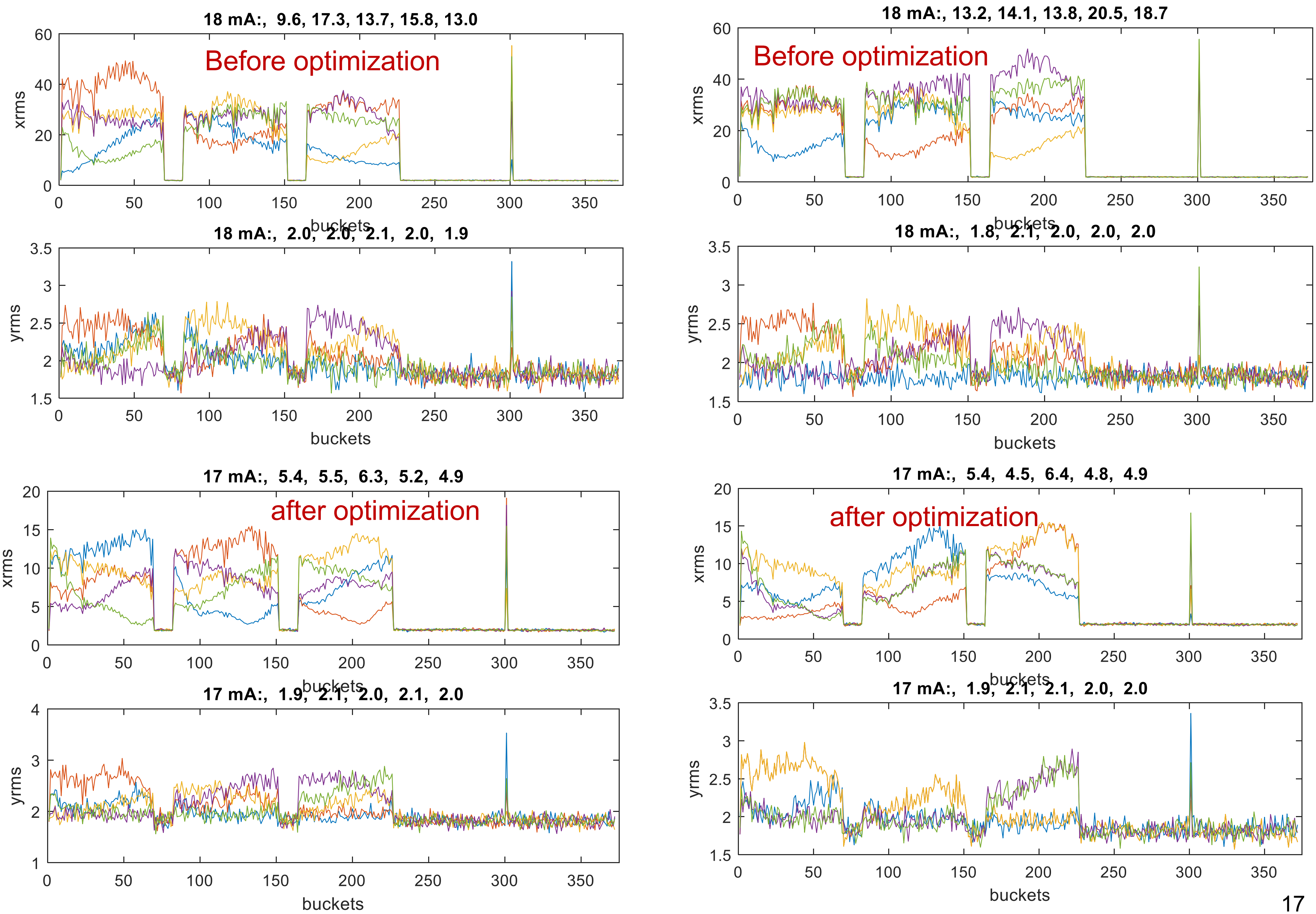
Kai had to adjust BRAM gain to trigger BxB data output when the kickers are fired (if signal is too low, no output update).

- Kicker timing sync'ed to bunch [1:75:372] (5 buckets).



5 traces correspond to 5 timing settings

Kicker bump matching using MBF detector



Longitudinal oscillations

- Electron bunch length is 20 psec rms
- Electron bunches vary in arrival time by 1 to 3 psec rms
  - Primary frequencies: 10 kHz, 60*n Hz
- Vary in energy by 0.5 to 1.5e-4 ($\Delta E/E$)