



# Tailored Bunch Operation

David Robin

based on work and input from

G. Portmann, B. Kinkaid, J. Kirz, S. Kwiatkowski, C. Steier, J. Julian, M. Hertlein, D. Plate, R. Low, K. Baptiste, W. Barry, C. Sun, C. Pappas, F. Sannibale, and W. Wan



# Strength of Storage Rings

An attractive feature of storage rings

**Ability to simultaneously serve many users  
with various requirements.**

- Different photon energies
- Different polarization
- Narrow and broadband pulses
- ...



# Limitation

However there are some several classes of users where it is difficult (or even impossible) to simultaneously serve them.

One example –

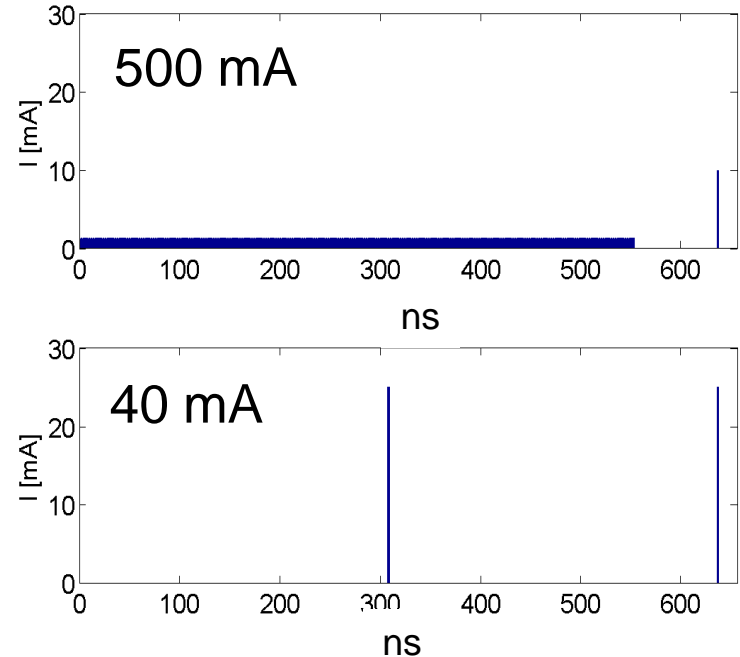
- High brightness and flux users
  - filling many bunches
- Dynamics/time of flight users
  - few bunches spaced far apart

This is especially true for rings with small circumferences



# ALS – Two separate fill patterns

- Presently at the ALS we need 2 fill patterns – one for each set of users



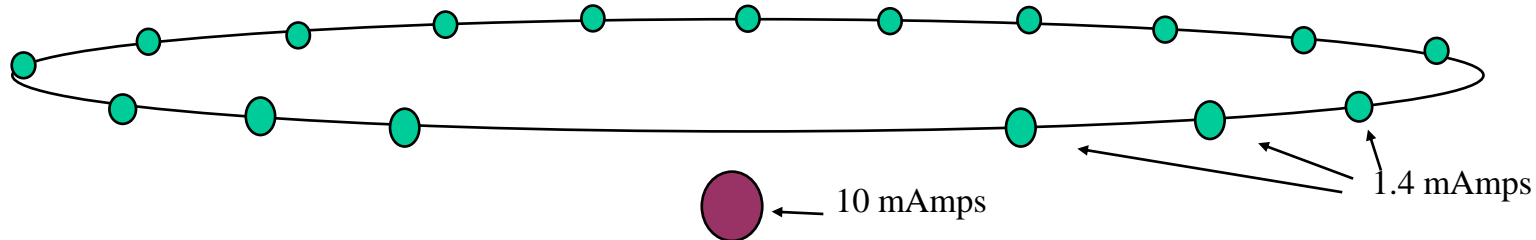
Multibunch and 2-bunch fill patterns

**The ability to simultaneously serve the high flux and dynamics users would expand the capabilities of a light sources**

# Tailored Bunch Operation

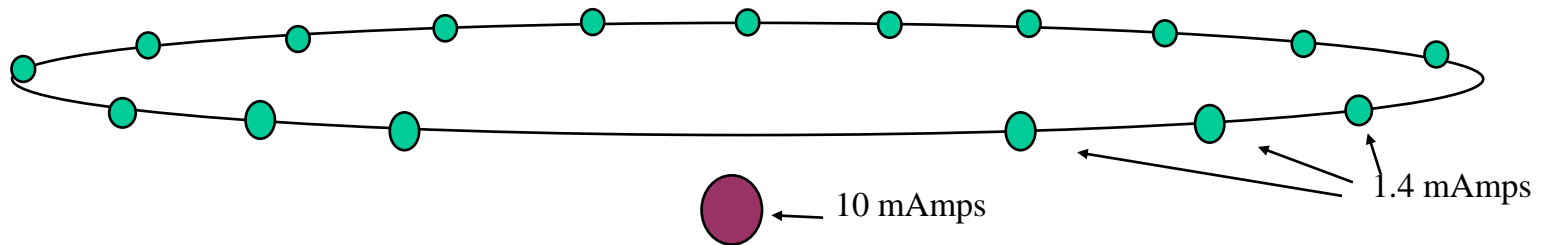
Changing the properties of individual bunches

- Orbit
- Beamsizes
- Energy
- ...



Tailoring them to the needs of specific experiments

# Quasi single bunch Operation



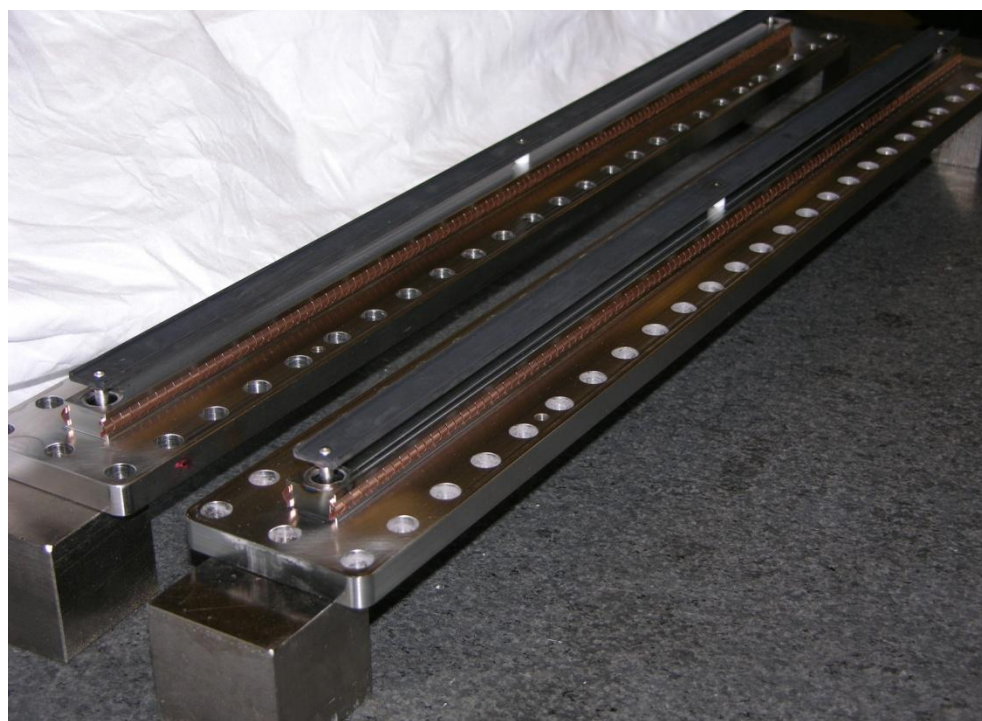
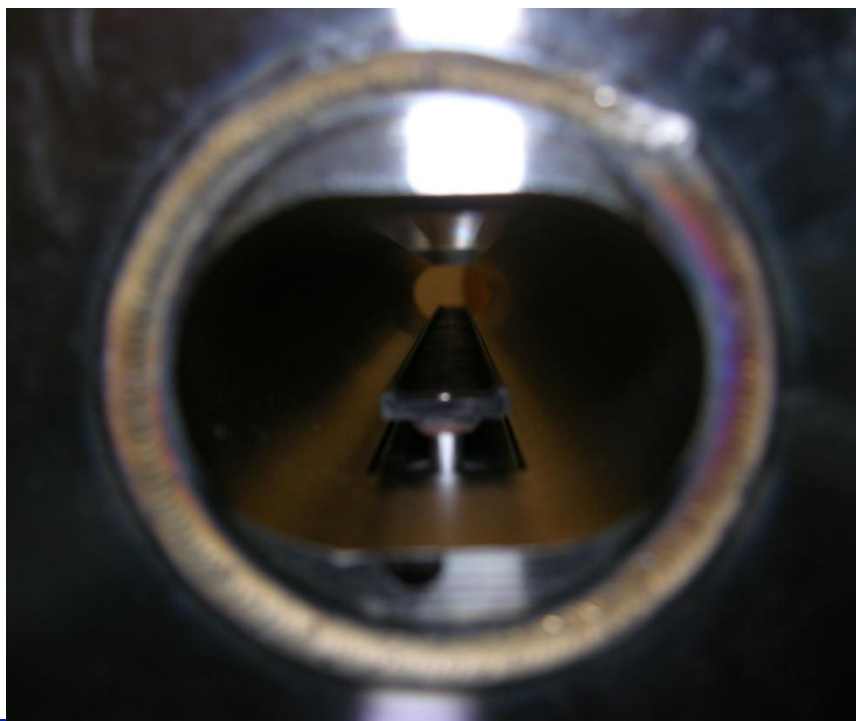
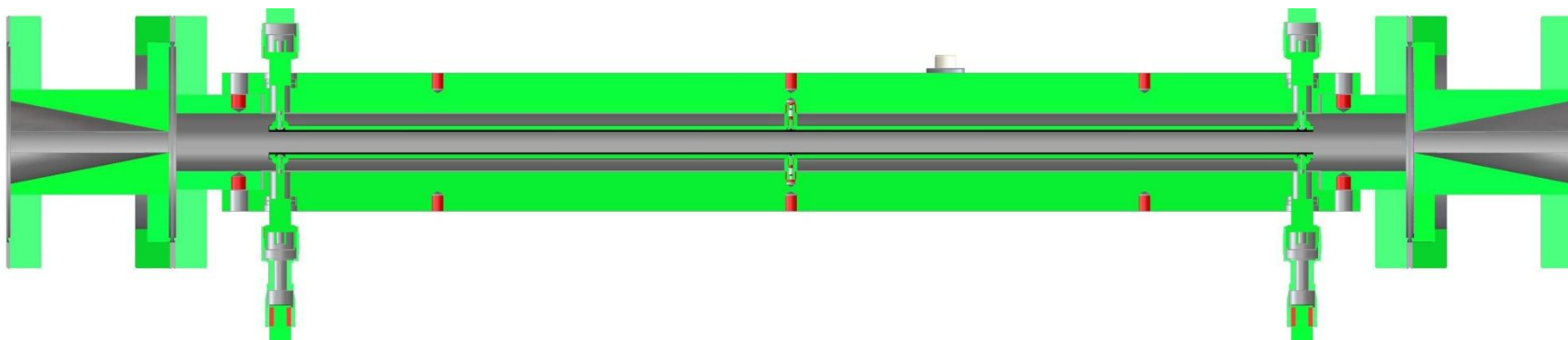
- Change the orbit of one bunch in the storage ring
- Requires short pulse / high repetition rate kickers

Idea originated in early 1980s at NSLS ("VUV Wobbler" by L. Blumberg.in 1980)  
but has been rediscovered and modified

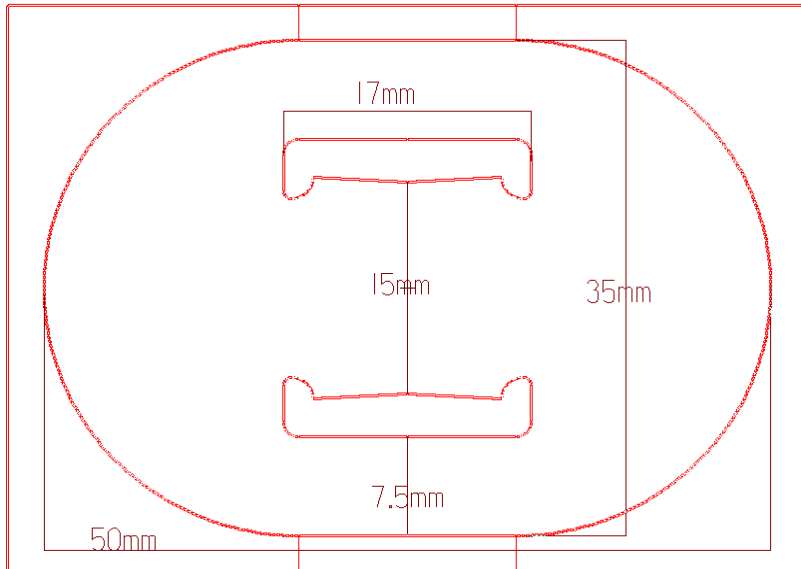
G. Portmann, S. Kwiatkowski, J. Julian, M. Hertlein, D. Plate, R. Low, K. Baptiste, W. Barry, D. Robin, *Creating a*

*Pseudo Single Bunch at the ALS First Results,2008 Beam Instrumentation Workshop, Tahoe City, CA USA*

# Experimental Kicker – Installed in Spring 2007 shutdown



# Transmission Line Kicker



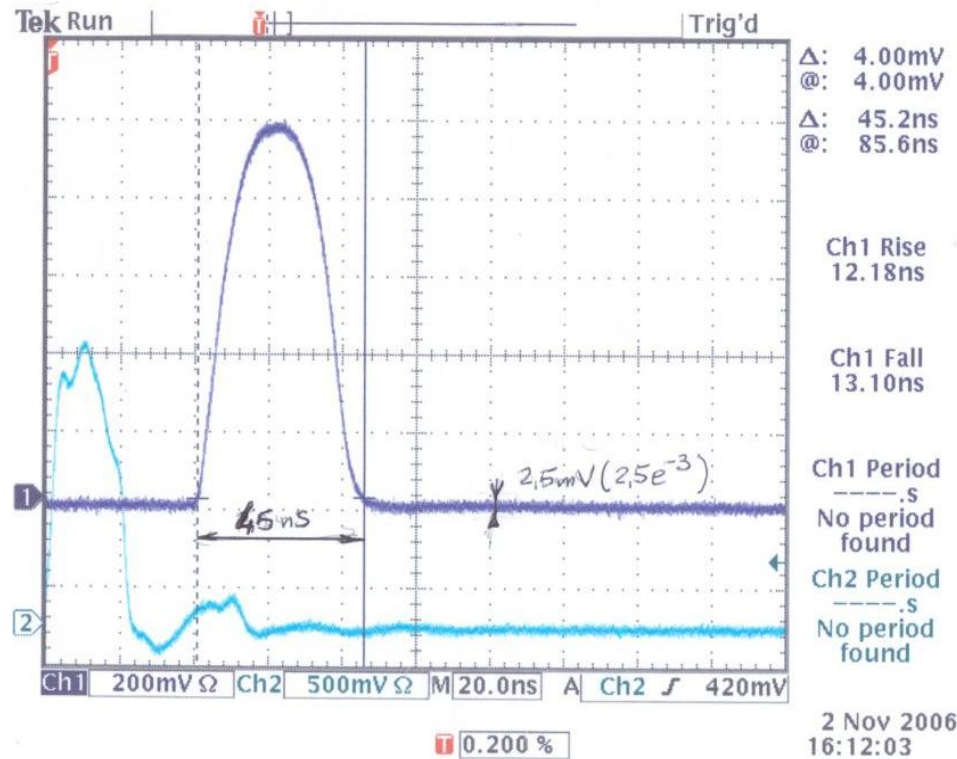
Length: .6 meters  
 Deflection Angle: 80 uradians

### Concerns:

- Dynamic aperture
- Impedance
- Shot-to-shot repeatability
- Pulser electronics is a research effort

### Pulser Electronics

1 kVolt / Electrode @ 1.5 MHz  
 1 kWatt Average Power  
 10 kWatt Peak Power

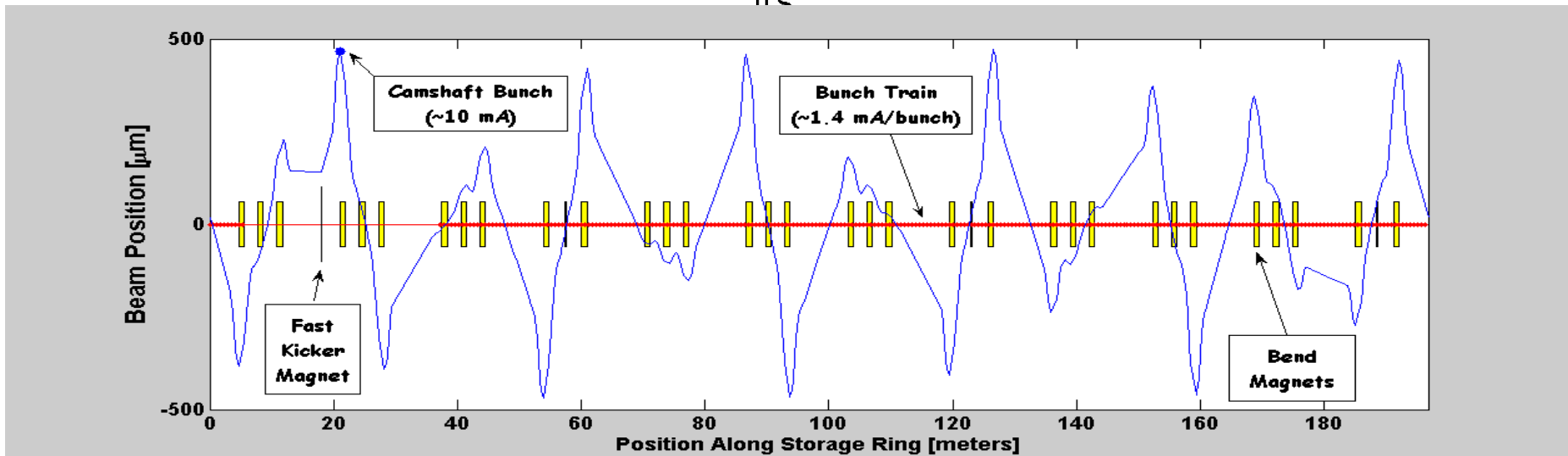
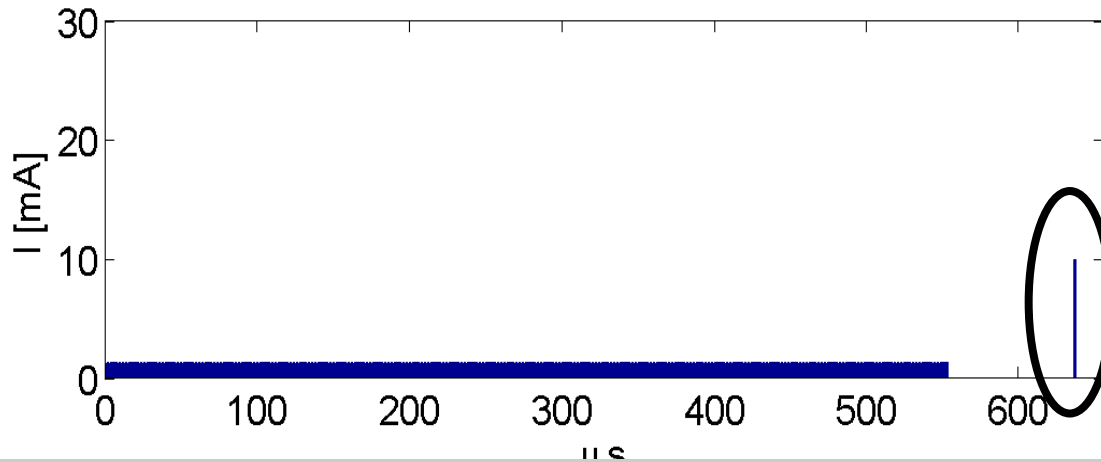


Ion clearing gap is presently 104 nsec.  
 (But it's a bit of a moving target)



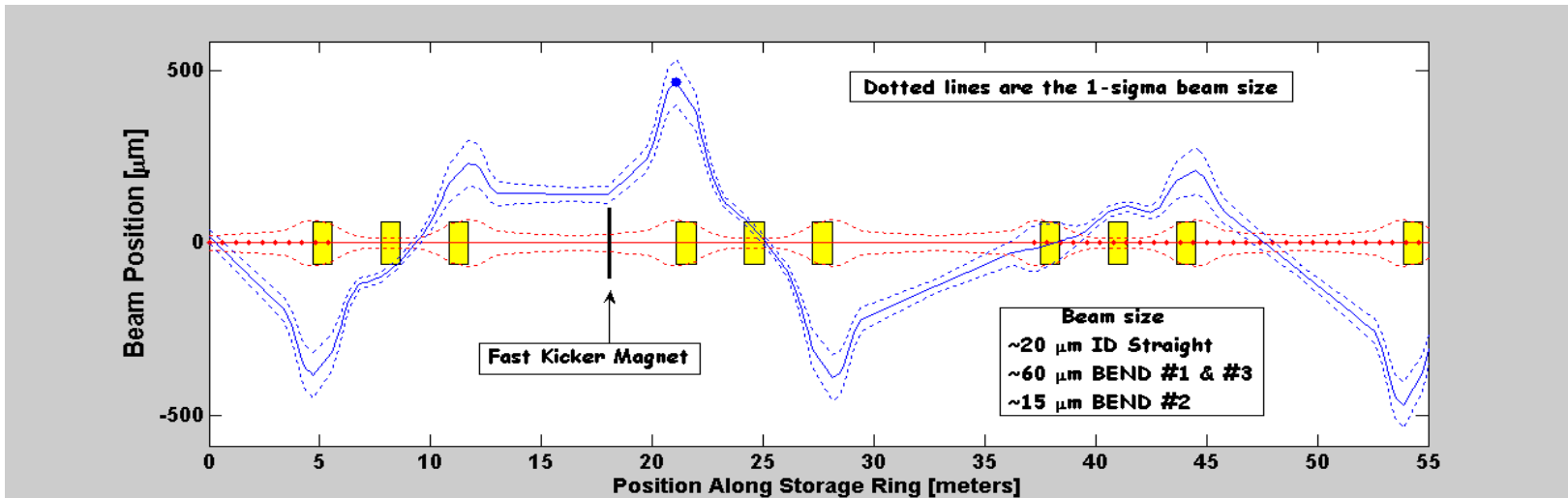
# Single Kicker – Closed orbit distortion

- Kicking one bunch each turn





# Displacement can be several sigma at certain beamlines



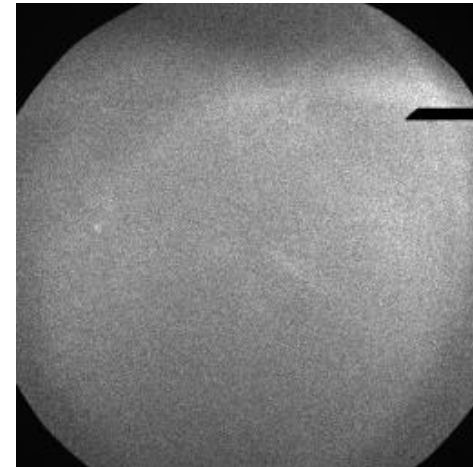
First results:

- XMCD contrast at Fe  $L_3$  edge (707eV)
- Sample: Ferromagnetic GdFe alloy film
- Off-orbit single bunch can be distinguished by offsetting the X-ray optic

Kicker ON



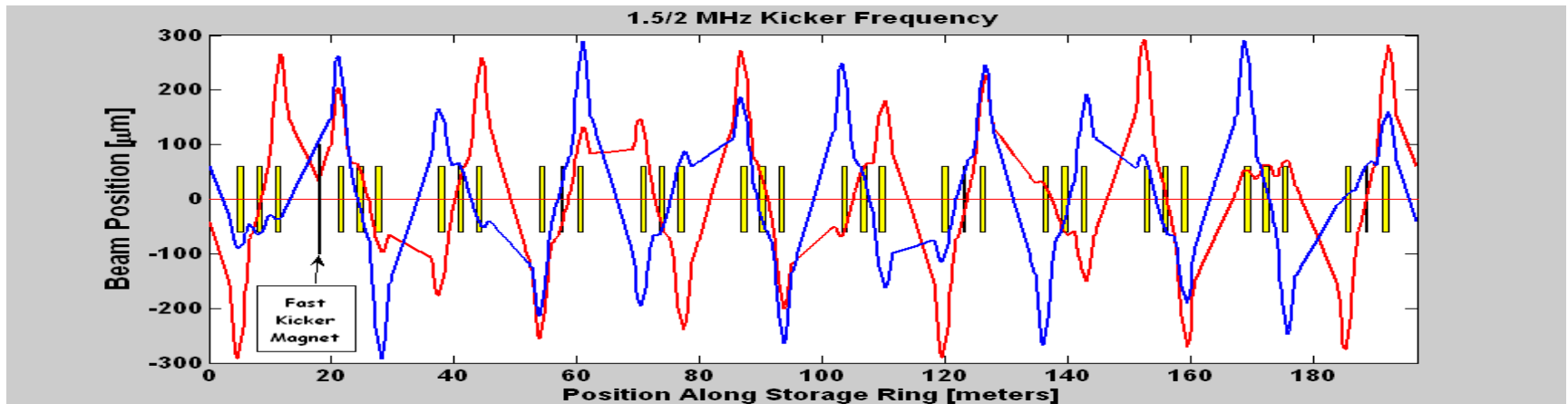
Kicker OFF



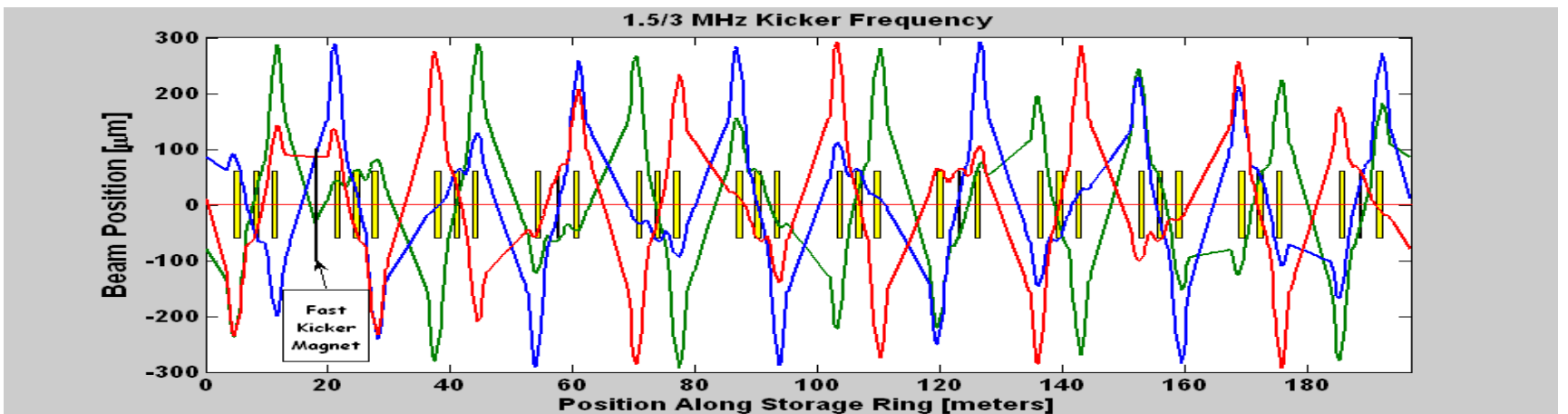
- Looks promising but more studies are needed

# Single Kicker – different mode

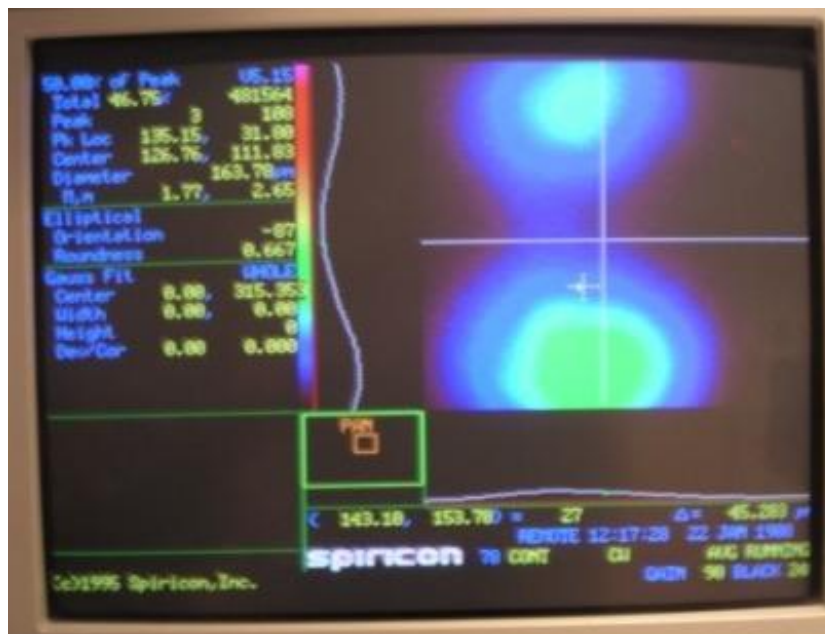
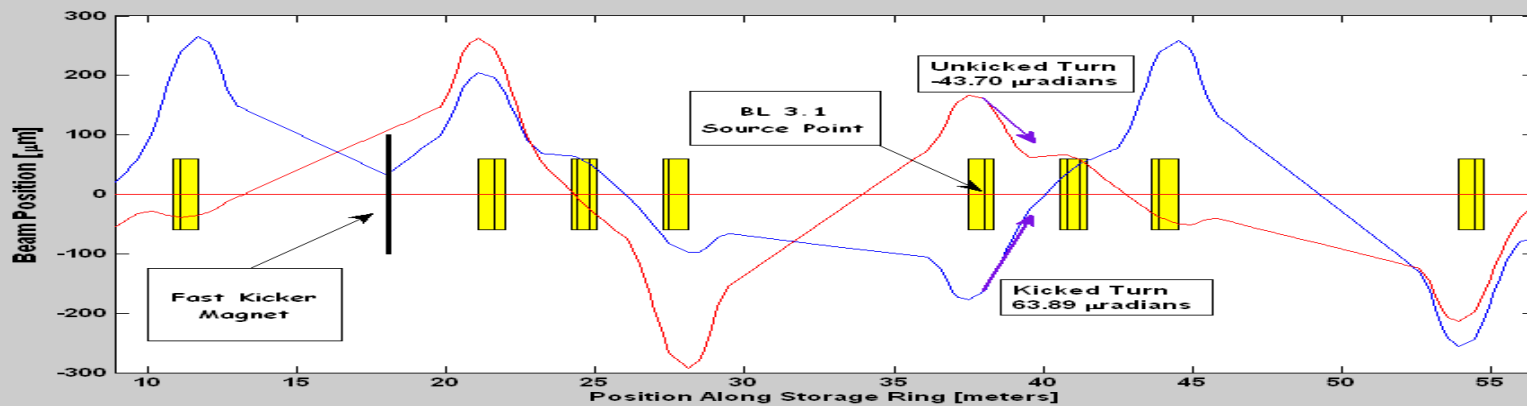
- Kicking every 2<sup>nd</sup> turn → 2 turn closed orbit



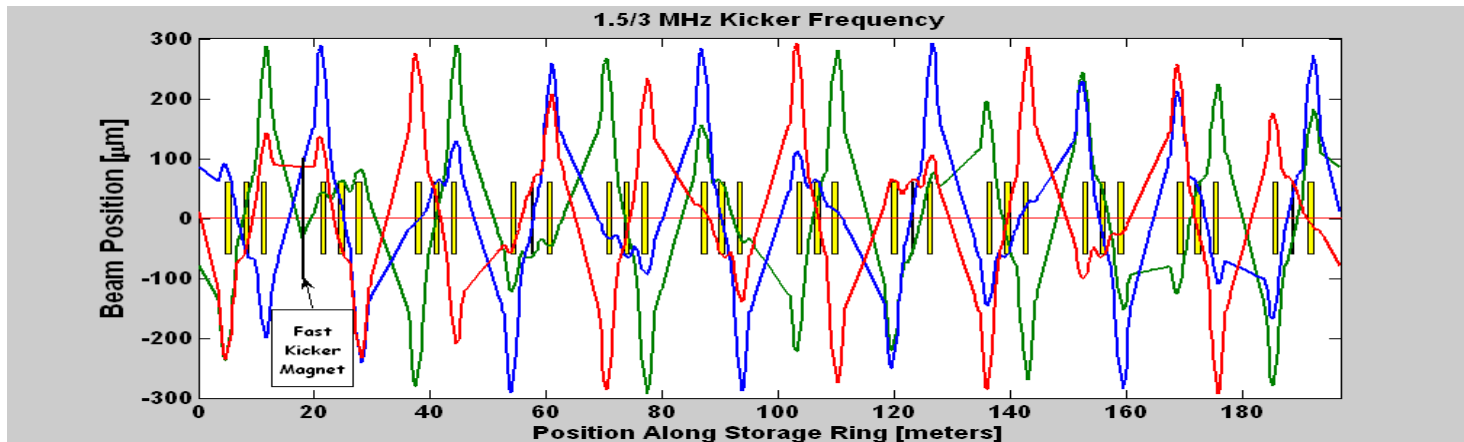
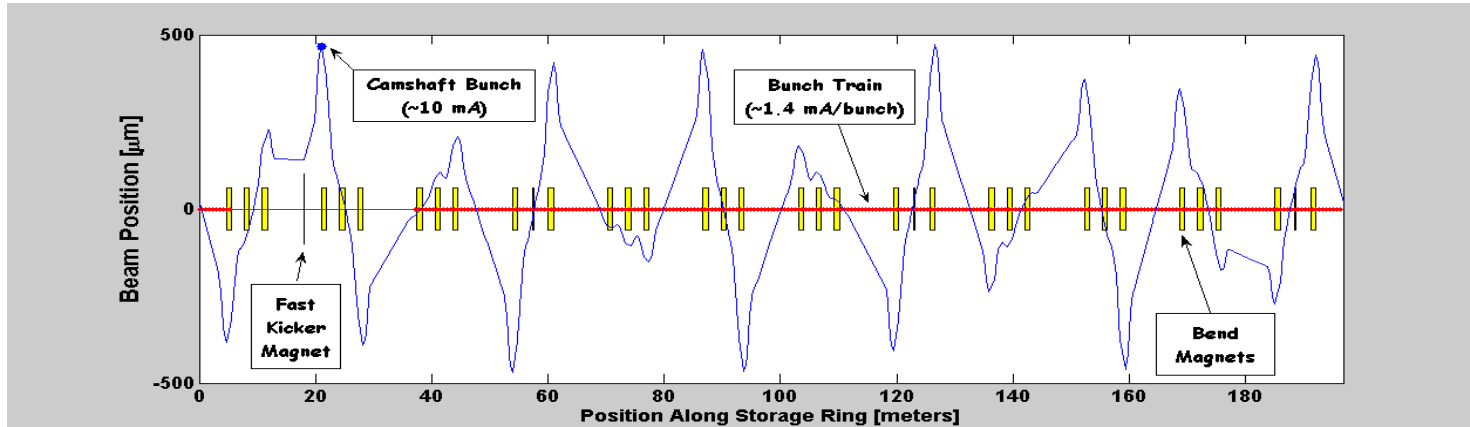
- Kicking every 3<sup>rd</sup> turn → 3 turn closed orbit



# Single Kicker – Every 2<sup>nd</sup> Turn

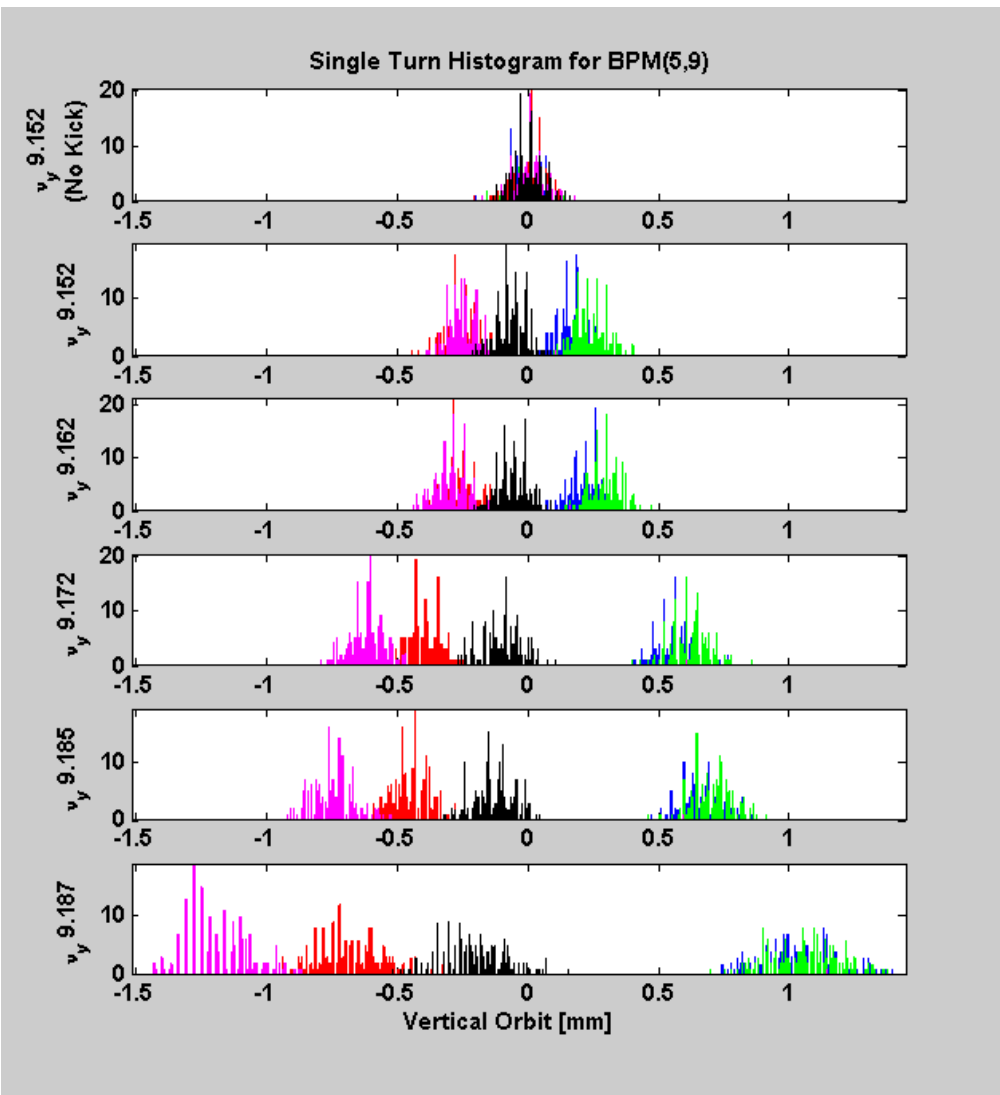


# Kicking every turn versus every 3<sup>rd</sup> turn



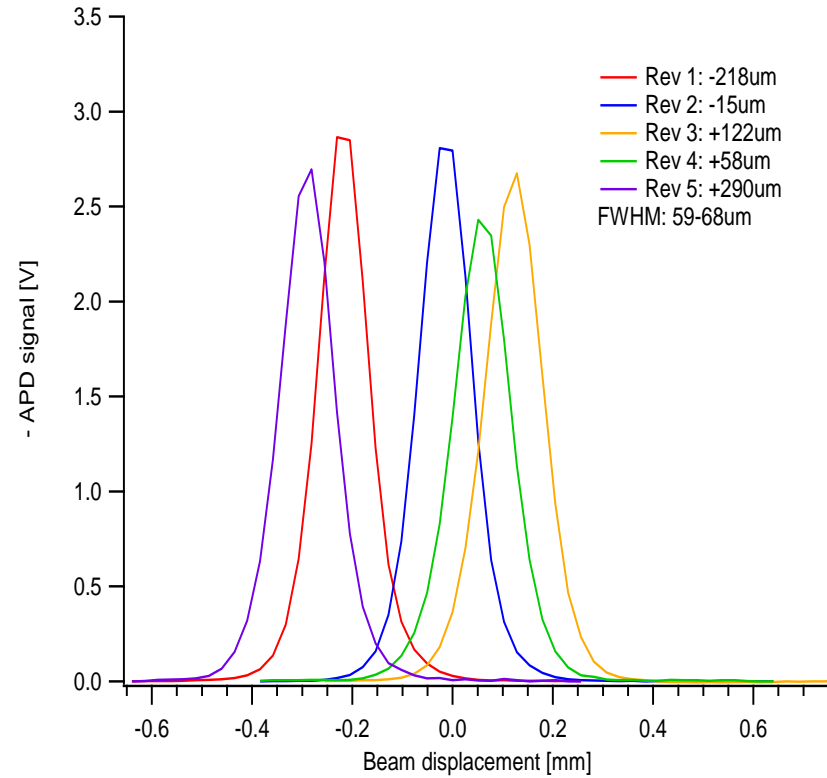
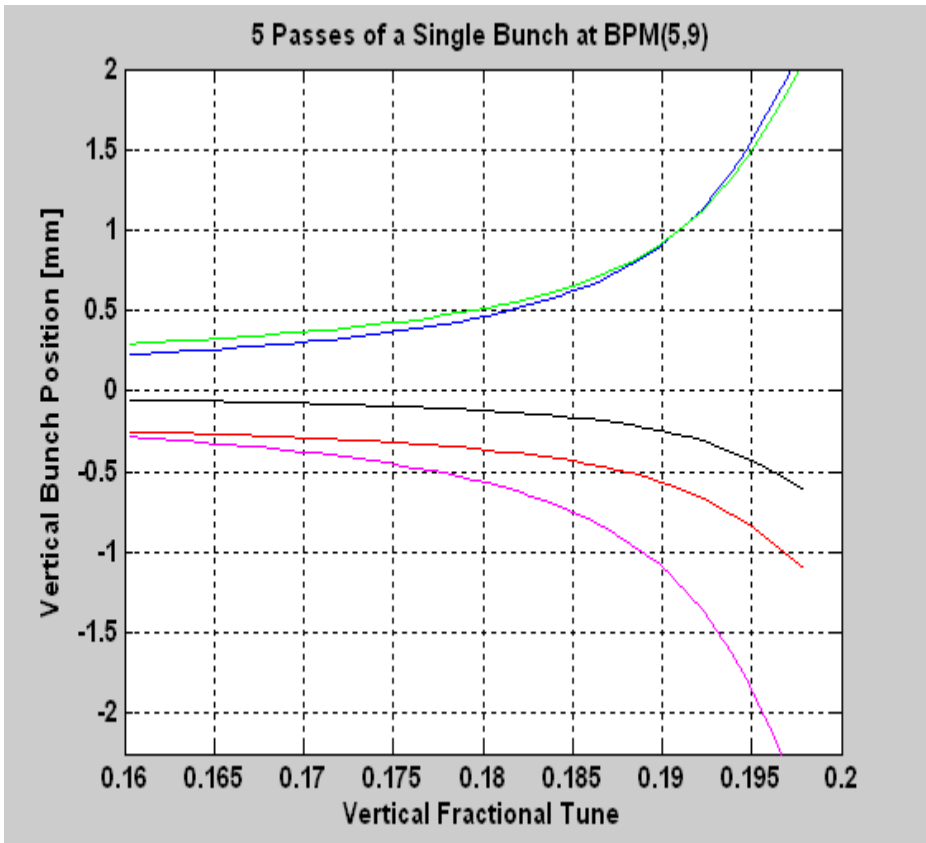
Possibility of finding an offset at each beamline

# Every 5<sup>th</sup> turn





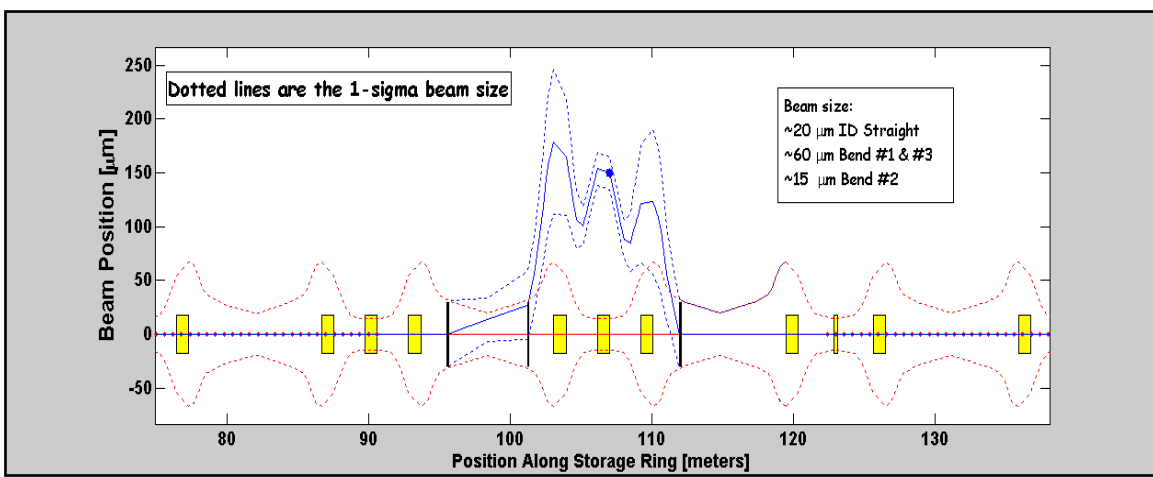
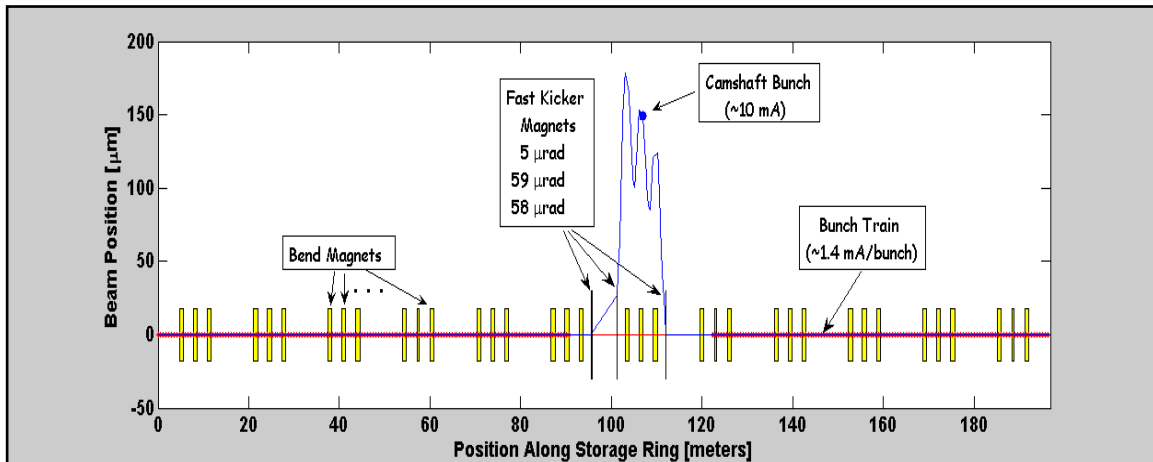
# Using the tune to amplify the amplitude







# Multiple kickers → Local single bunch





# Status of Quasi-single bunch

- Kicker is installed in the ring and being studied
- Preliminary results with a single turn operation looks promising for one user (more experiments need to be done)
- Need more data to understand the impact on other users who do not use the quasi-single bunch
- More study needs to be done on the every 3<sup>rd</sup> turn kick which might be useful for more beamlines (particular interest with femto slicing)



# Some other ideas

## Change the energy of the bunch

- 2 color
- Orbit separation via dispersion

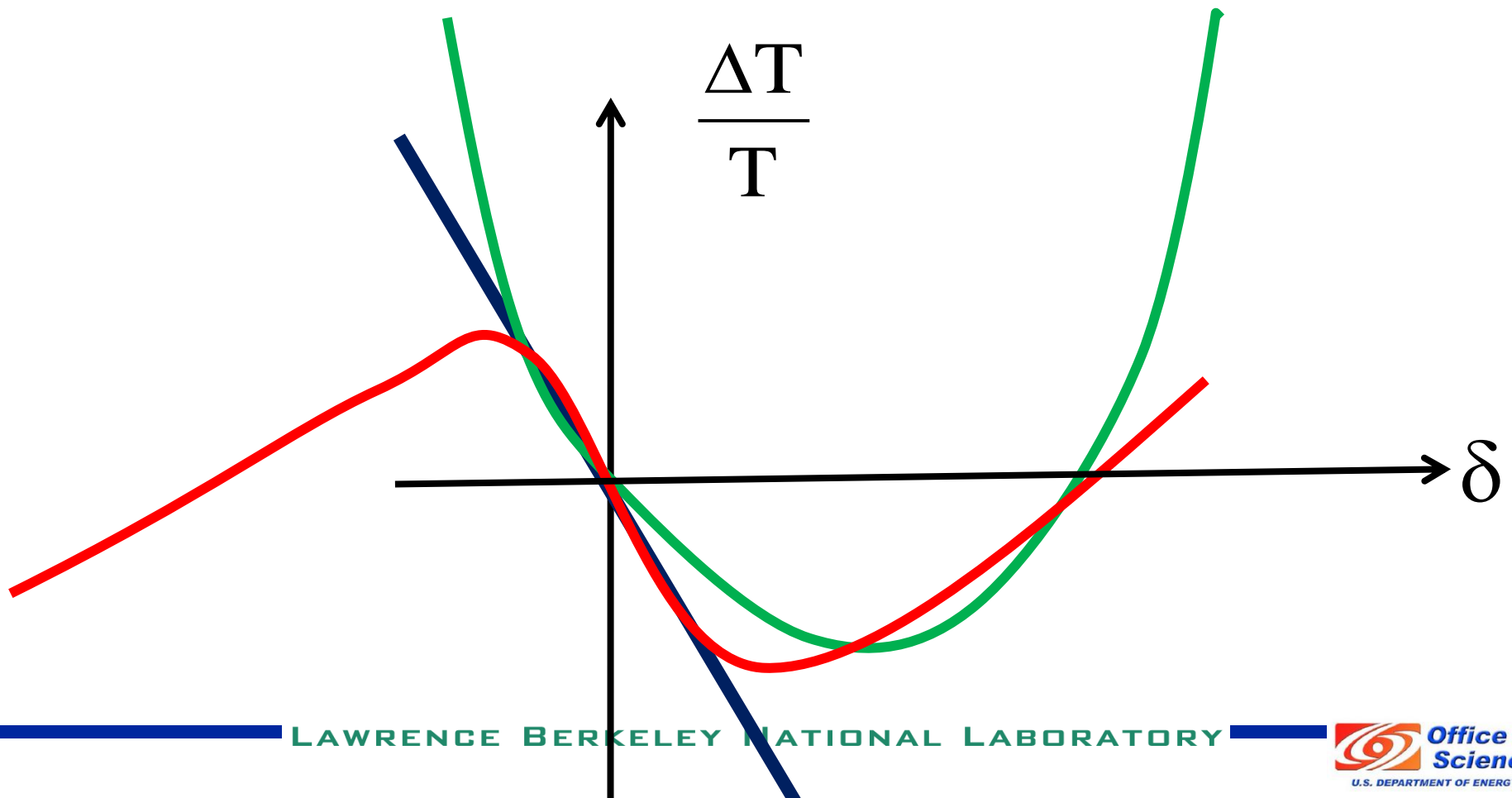
## Short pulses

- Combining low alpha with tailored bunches
- Combining single kick with bunch tilting (ala W. Guo)



# Longitudinal Equation

$$\frac{\Delta T}{T} = \alpha_1 \delta + \alpha_2 \delta^2 + \alpha_3 \delta^3 + \alpha_4 \delta^4 + \dots$$

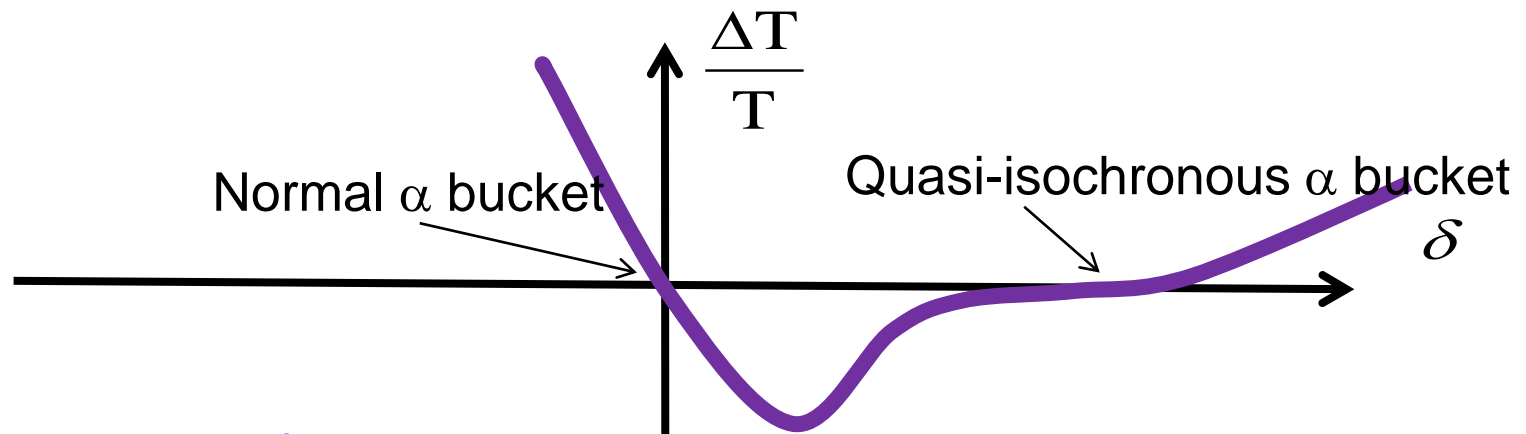


# One semi crazy idea

(D. Robin, et. al. EPAC 2008 pp. 2100-2102)

Bunches with different energies have been stored in the ring

(Murphy and Kramer, Phys. Rev. Lett. 84, 5516–5519 )



Can one shape the function to have zero crossings with different slopes?

→ Different energy bunches with different momentum compaction

Has been done at SOLIEL (factor of 2 difference in momentum compaction)



# Summary

- Tailored bunch operation has the potential to extend the flexibility of storage rings
  - Potential to avoid “special” operational modes with limited beam availability
- Studying the simplest incarnation of this mode – Quasi-single bunch
  - Enabled via fast high repetition rate kickers
- May be possible to do more exotic modes