

e^-/e^+ Vertical Beam Dynamics with 6 and 12 Wigglers On

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9/6/2006

I. Introduction:

Goal: Examine e+/e- turn-by-turn vertical beam dynamics for 45 bunch train at CESR-c operating point.

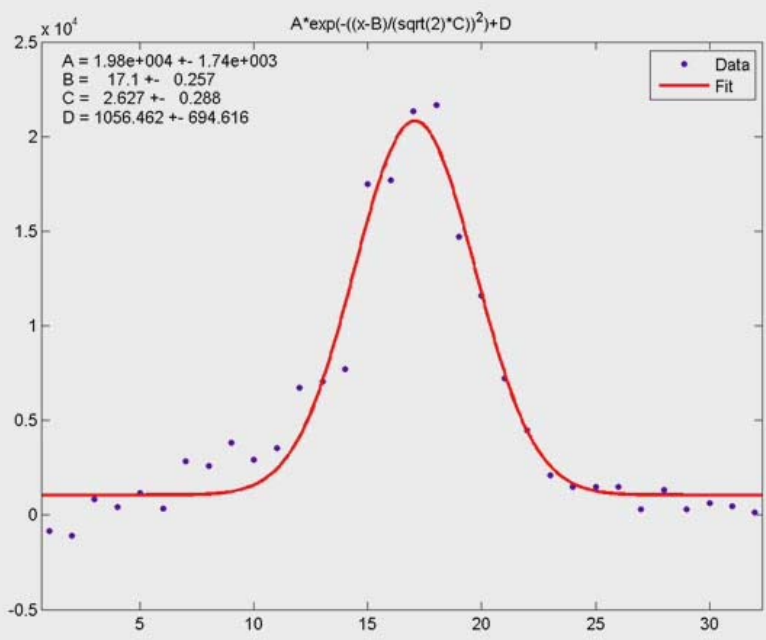
e+/e- vertical beam dynamics were measured in:

- 6 wiggler magnet configuration-14-15E/W on, 19E/W triplets are off
- 12 wiggler magnet configuration-14-15E/W and 19E/W triplets are on
- Vertical feedback was adjusted under certain current conditions.

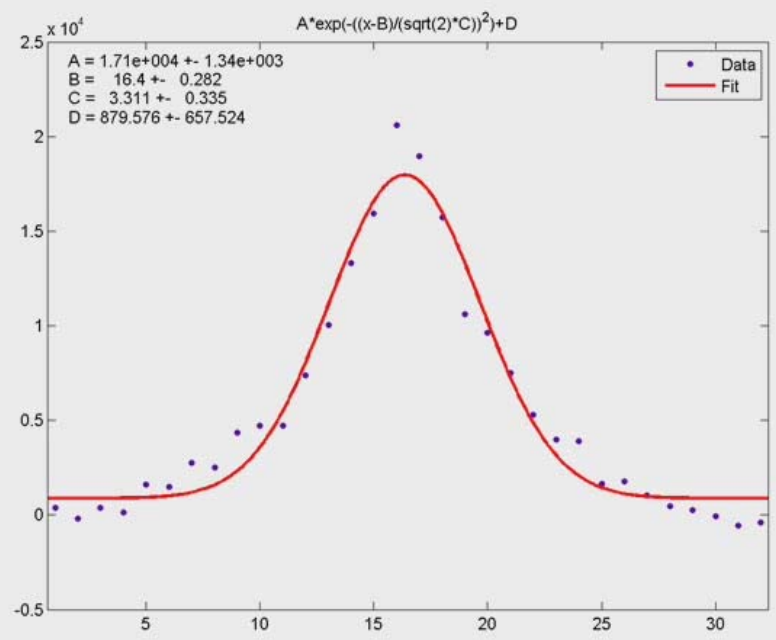
PMT calibration for the analysis is 10mm/pixel for both e- and e+. The calibration was measured to be 10.4mm/pixel for e+ and 8.6mm/pixel for e- on 9/18/2006.

e+/e- vertical distributions

e- 12 wigglers on I=1.25mA/bunch (movie)

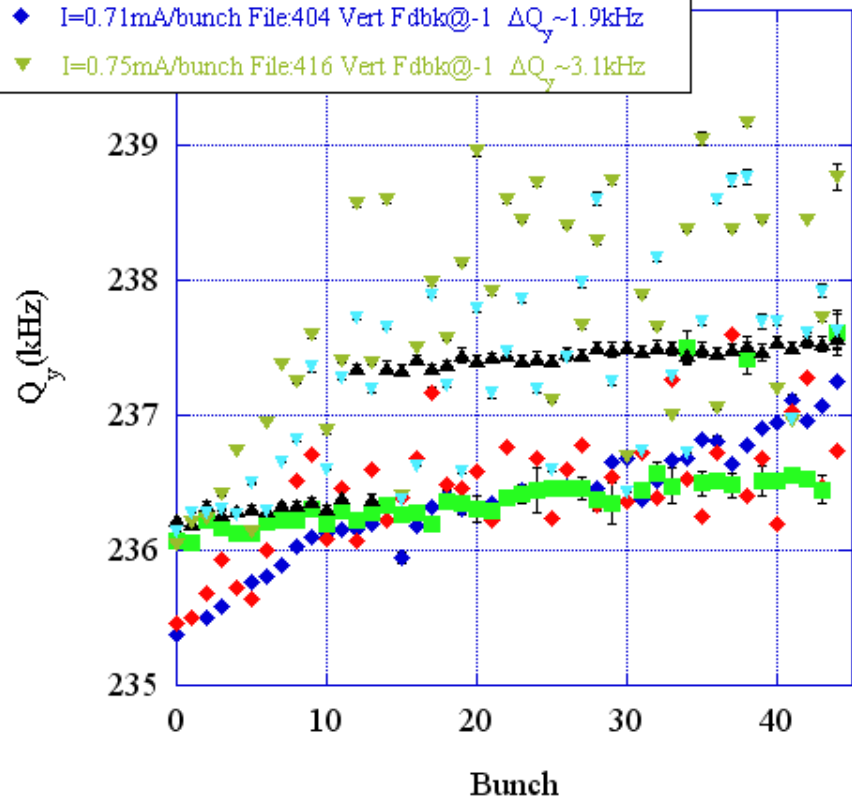


e+ 12 wigglers on I=0.84mA/bunch (movie)



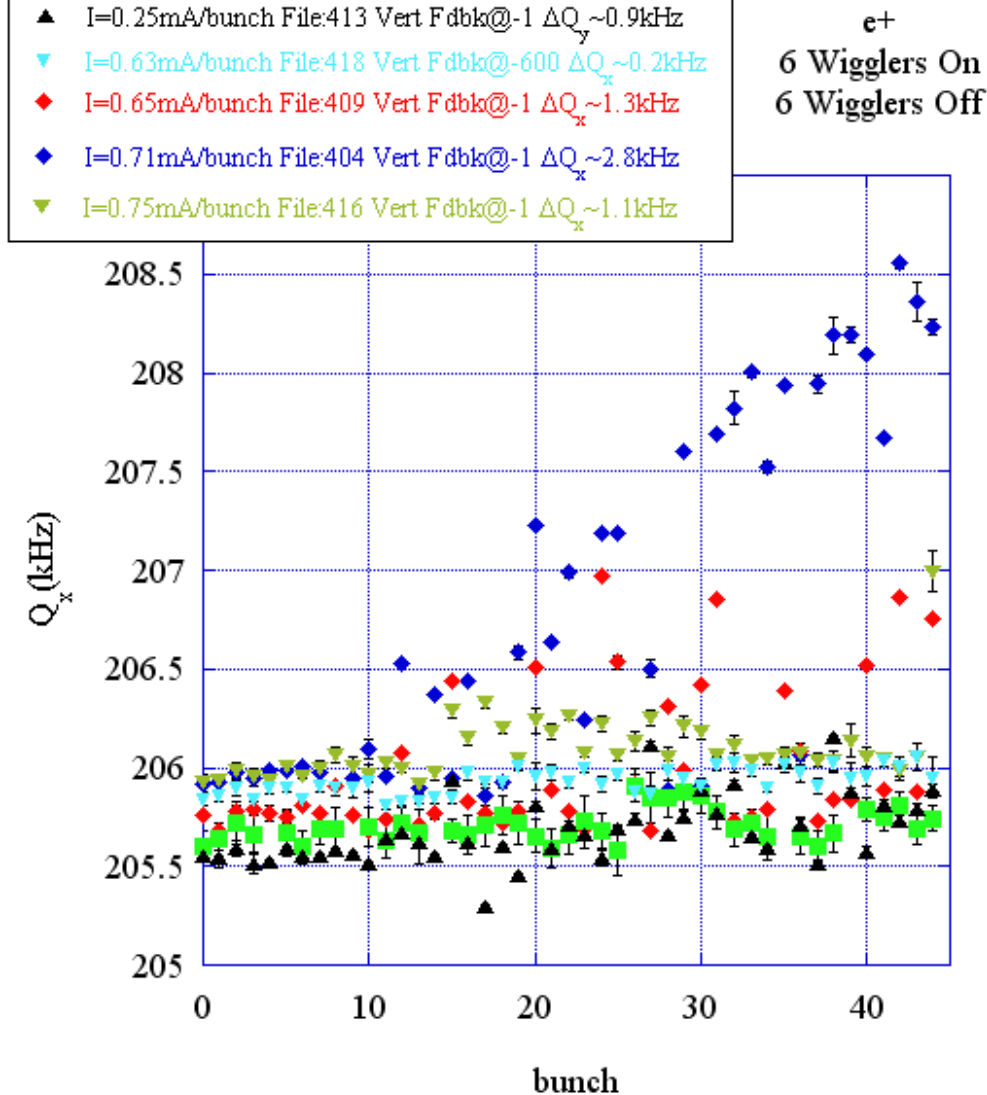
II. e+ 6 wigglers on/6 wigglers off

- I=0.25mA/bunch File:411 Vert Fdbk@-1 $\Delta Q_y \sim 1.6\text{kHz}$
- ▲ I=0.25mA/bunch File:413 Vert Fdbk@-1 $\Delta Q_y \sim 1.4\text{kHz}$
- ▼ I=0.63mA/bunch File:418 Vert Fdbk@-600 $\Delta Q_y \sim 2.6\text{kHz}$
- ◆ I=0.65mA/bunch File:409 Vert Fdbk@-1 $\Delta Q_y \sim 2.1\text{kHz}$
- ◆ I=0.71mA/bunch File:404 Vert Fdbk@-1 $\Delta Q_y \sim 1.9\text{kHz}$
- ▼ I=0.75mA/bunch File:416 Vert Fdbk@-1 $\Delta Q_y \sim 3.1\text{kHz}$



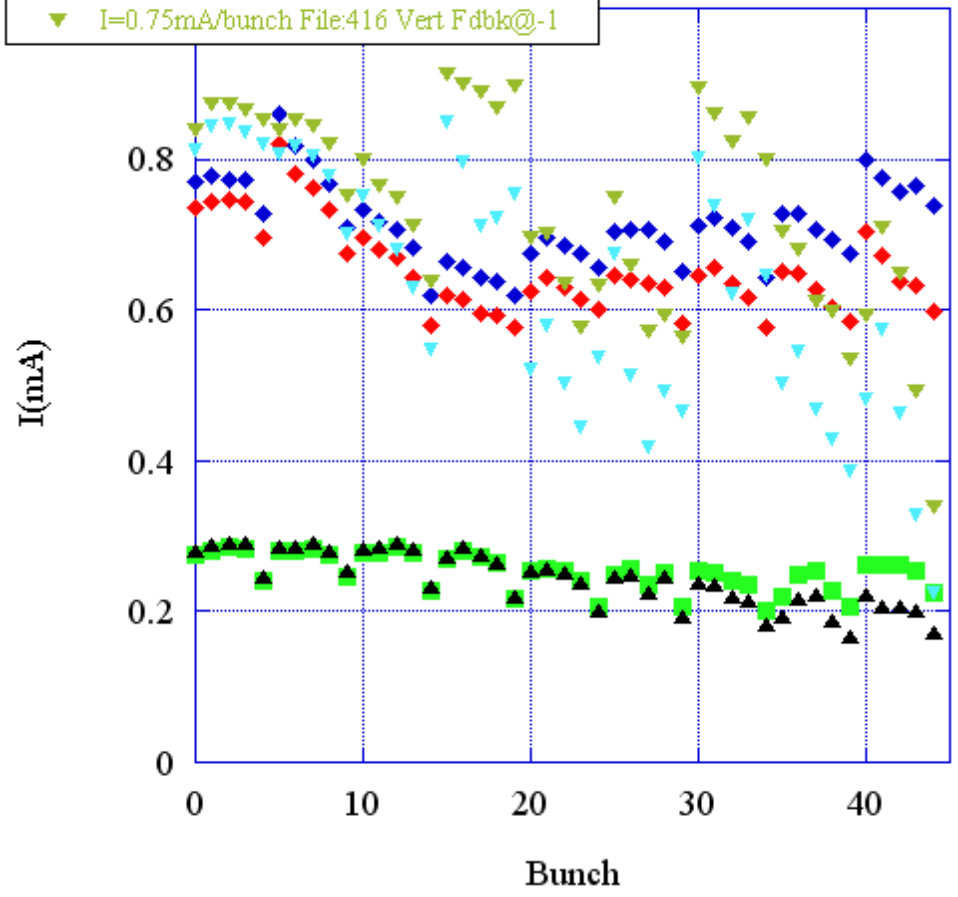
Significant tune shift, Q_y and Q_x , along the 45 bunch trains

- I=0.25mA/bunch File:411 Vert Fdbk@-1 $\Delta Q_x \sim 0.3\text{kHz}$
- ▲ I=0.25mA/bunch File:413 Vert Fdbk@-1 $\Delta Q_x \sim 0.9\text{kHz}$
- ▼ I=0.63mA/bunch File:418 Vert Fdbk@-600 $\Delta Q_x \sim 0.2\text{kHz}$
- ◆ I=0.65mA/bunch File:409 Vert Fdbk@-1 $\Delta Q_x \sim 1.3\text{kHz}$
- ◆ I=0.71mA/bunch File:404 Vert Fdbk@-1 $\Delta Q_x \sim 2.8\text{kHz}$
- ▼ I=0.75mA/bunch File:416 Vert Fdbk@-1 $\Delta Q_x \sim 1.1\text{kHz}$



- I=0.25mA/bunch File:411 Vert Fdbk@-1
- ▲ I=0.25mA/bunch File:413 Vert Fdbk@-1
- ▼ I=0.63mA/bunch File:418 Vert Fdbk@-600
- ◆ I=0.65mA/bunch File:409 Vert Fdbk@-1
- ◆ I=0.71mA/bunch File:404 Vert Fdbk@-1
- ▼ I=0.75mA/bunch File:416 Vert Fdbk@-1

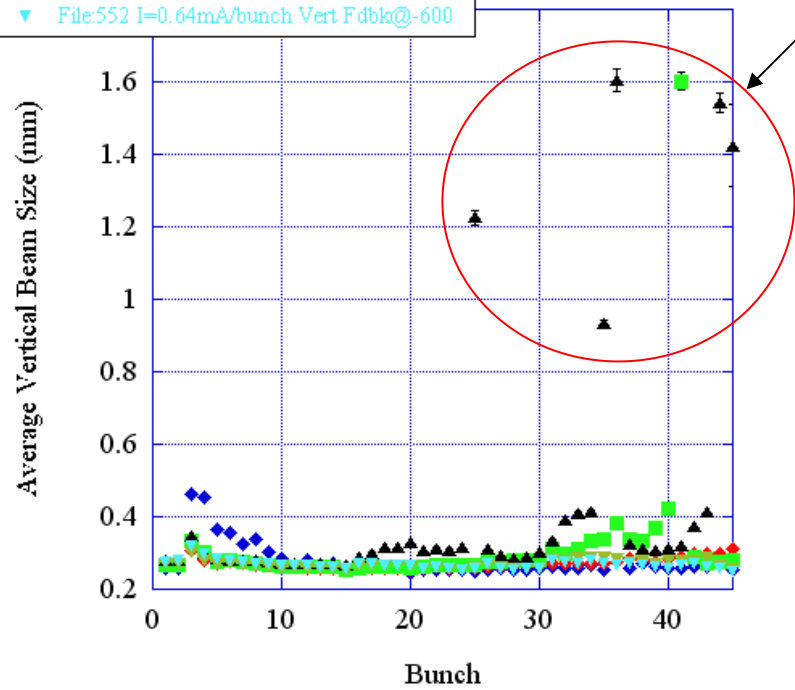
e+
6 Wigglers On
6 Wigglers Off



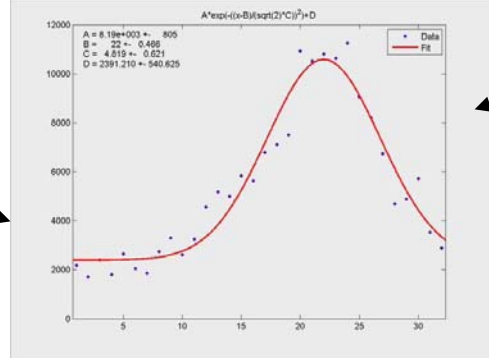
Bunch current is not uniform along the train at high current.

- ◆ File:545 I=0.25mA/bunch Vert Fdbk@-1
- ◆ File:539 I=0.70mA/bunch Vert Fdbk@-1000
- File:542 I=0.60mA/bunch Vert Fdbk@-1
- ▲ File:548 I=0.75mA/bunch Vert Fdbk@-1
- ▼ File:550 I=0.70mA/bunch Vert Fdbk@-1255
- ▼ File:552 I=0.64mA/bunch Vert Fdbk@-600

e+
6 Wigglers Off, 6 Wigglers On
Single Turn Beam Size



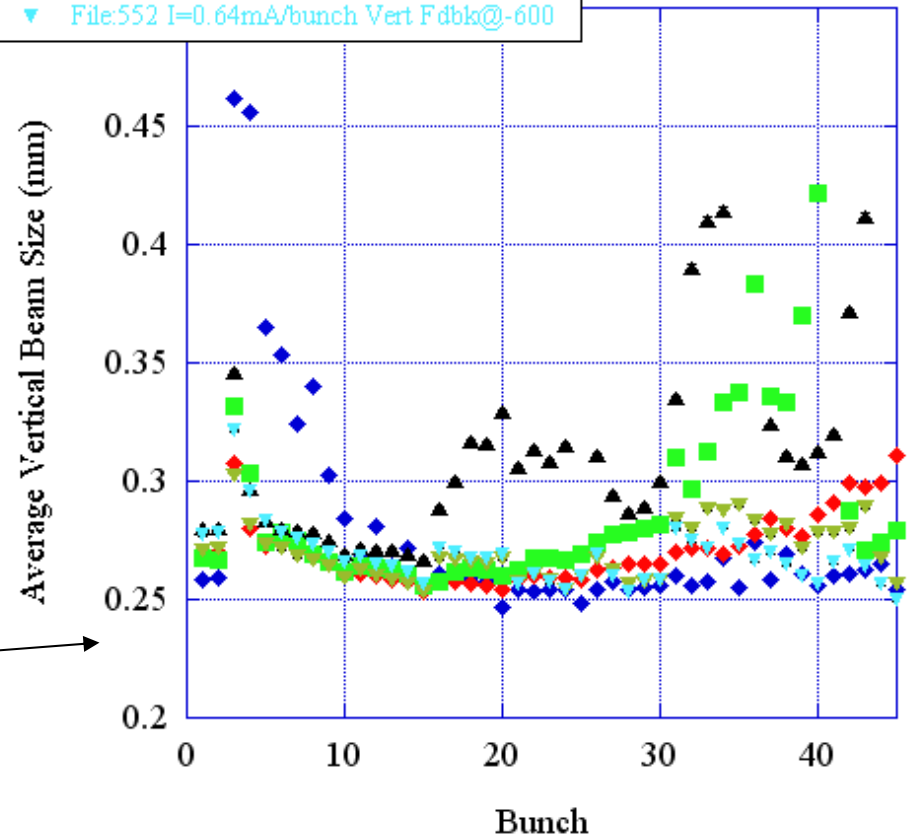
Unstable outliers



File 548 bunch 34
Movie

- ◆ File:545 I=0.25mA/bunch Vert Fdbk@-1
- ◆ File:539 I=0.70mA/bunch Vert Fdbk@-1000
- File:542 I=0.60mA/bunch Vert Fdbk@-1
- ▲ File:548 I=0.75mA/bunch Vert Fdbk@-1
- ▼ File:550 I=0.70mA/bunch Vert Fdbk@-1255
- ▼ File:552 I=0.64mA/bunch Vert Fdbk@-600

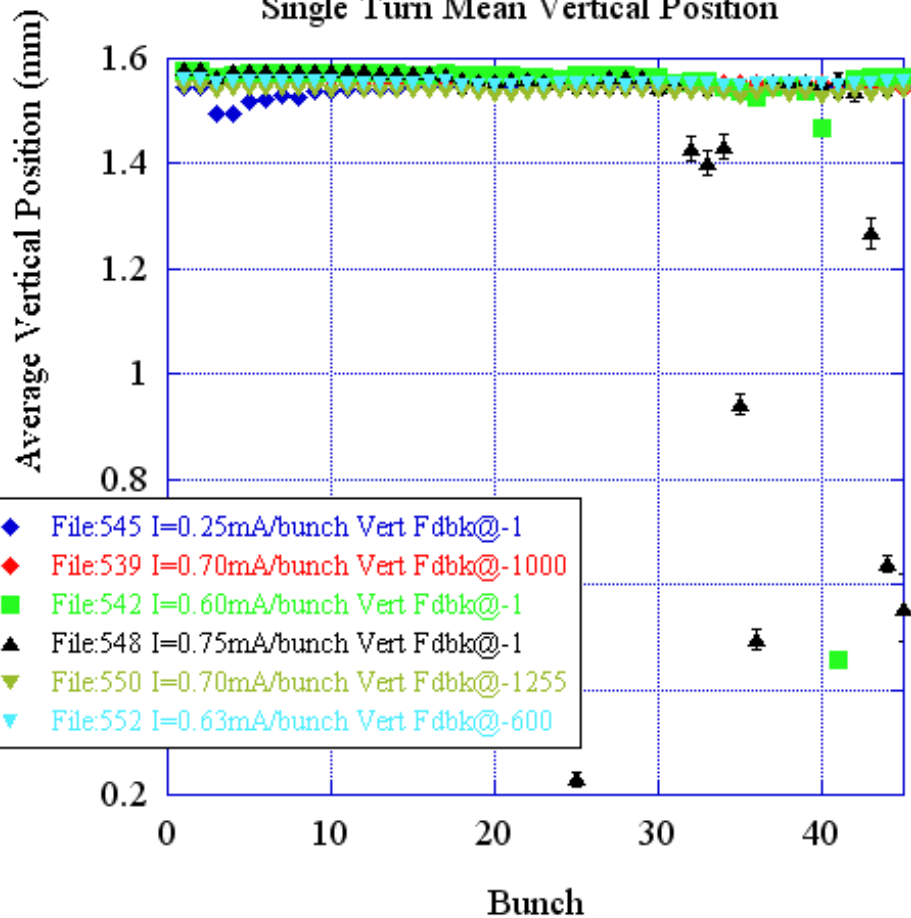
e+
6 Wigglers Off, 6 Wigglers On
Single Turn Beam Size



Detailed view

e+

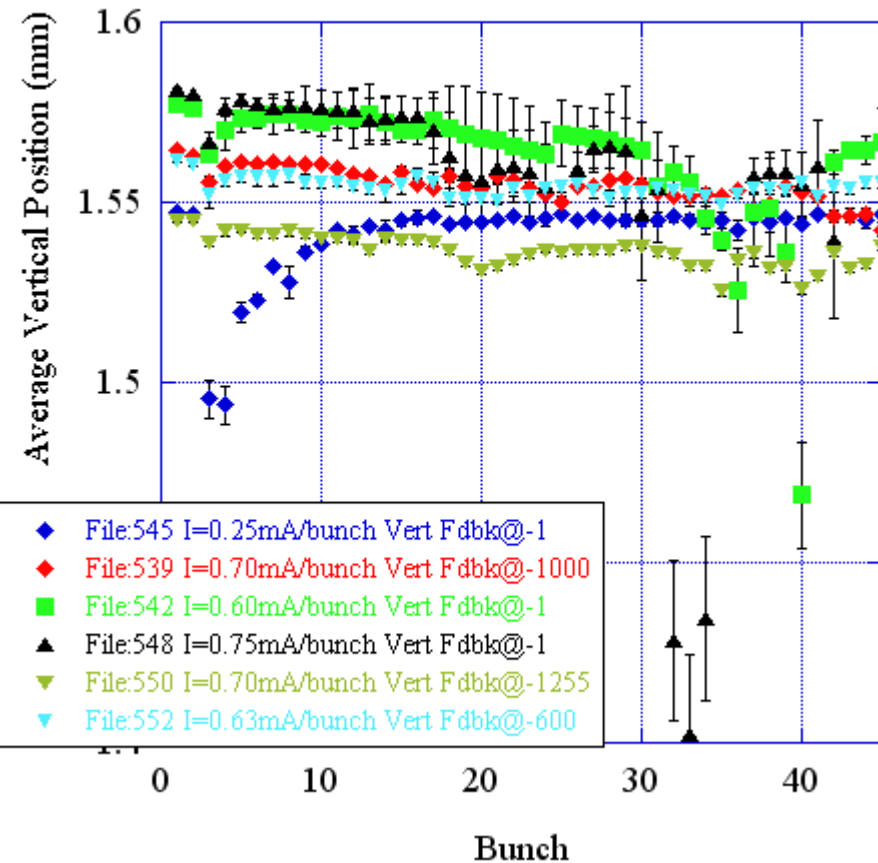
6 Wigglers Off, 6 Wigglers On Single Turn Mean Vertical Position



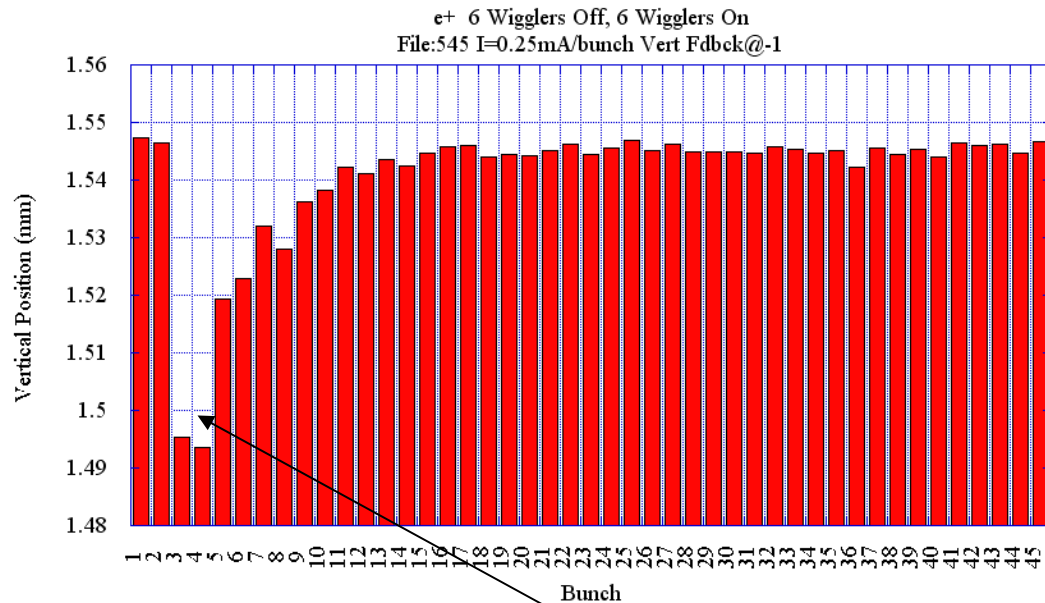
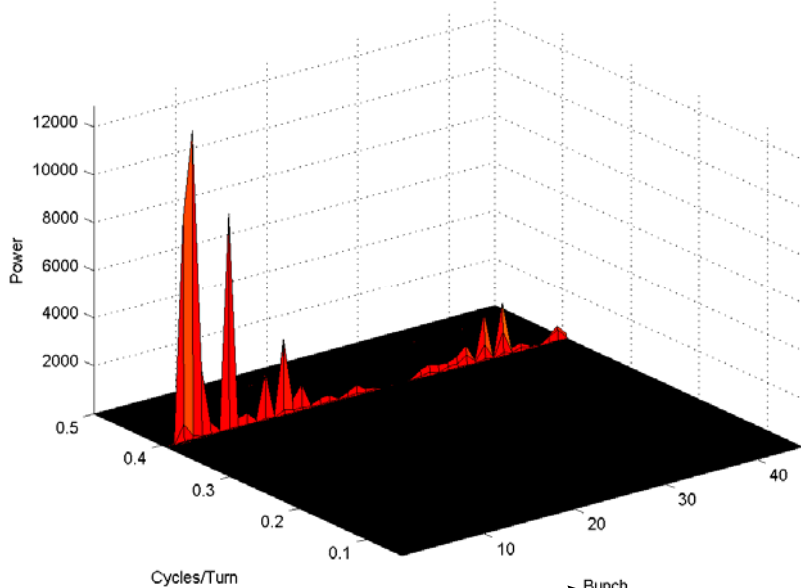
Detailed view

e+

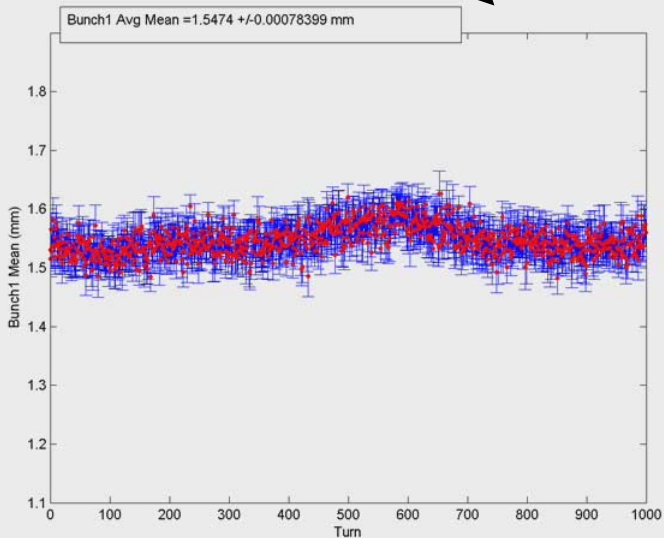
6 Wigglers Off, 6 Wigglers On Single Turn Mean Vertical Position



FFT Vertical position $I_{e^+}=0.25\text{mA/bunch}$
 File:545 e+ 6 wigglers on, 6 wigglers off
 Vert. Fdbck@-1

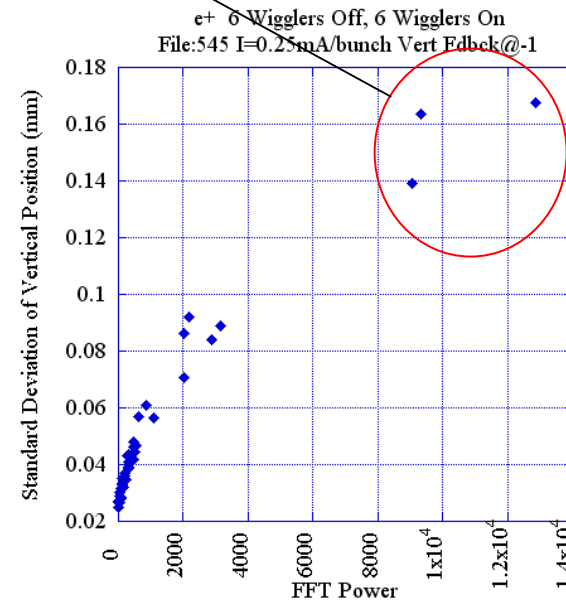


Vertical position movie

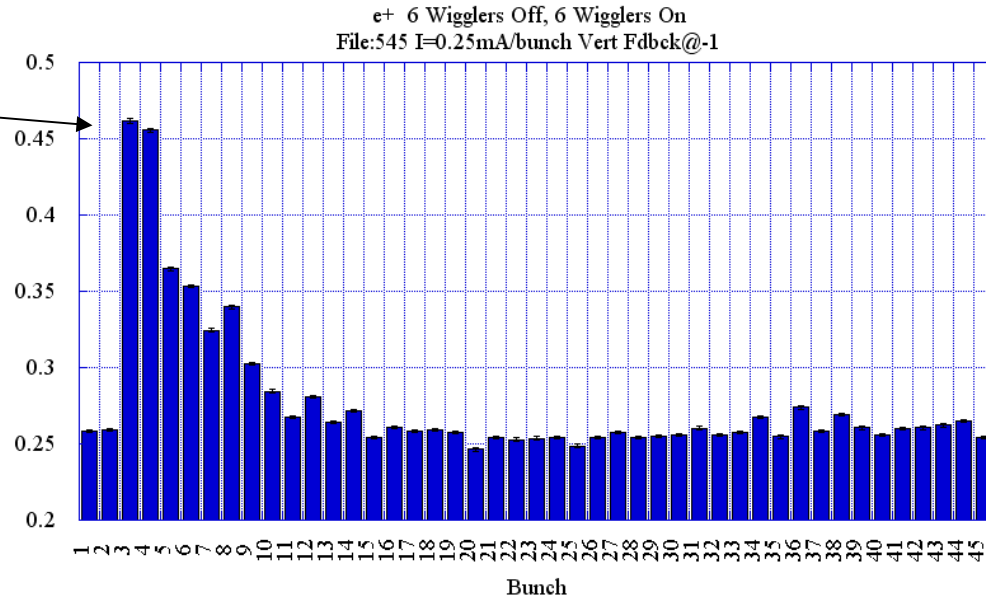
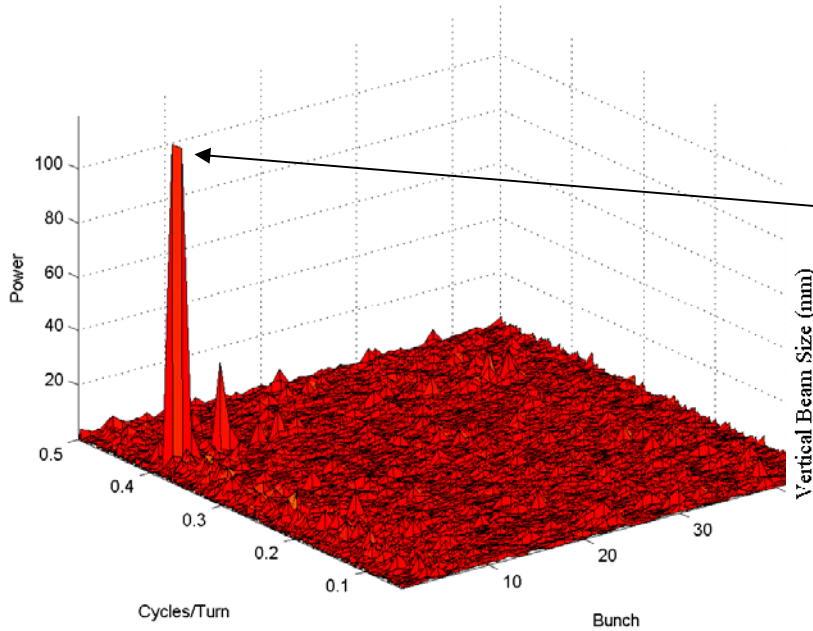


- The vertical position oscillation frequency, $f_{\text{osc}}=235.8\text{kHz}$, is determined from the FFT of the vertical position.

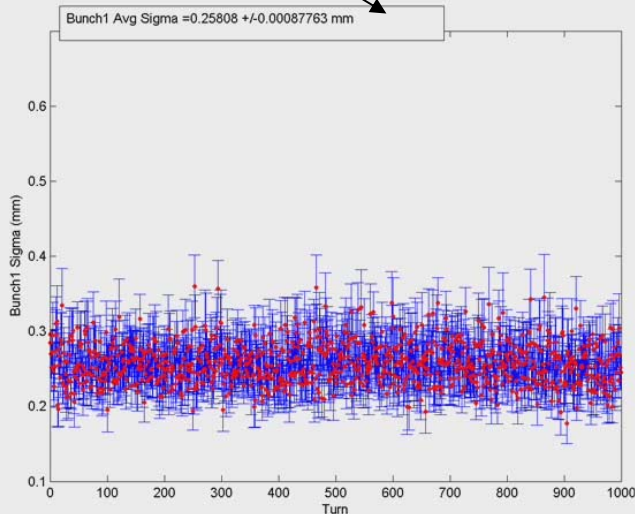
- There is a correlation between standard deviation of the vertical position (vertical position oscillation amplitude) and FFT power of mean position.



FFT $\sigma_v I_{e^+}=0.25\text{mA/bunch}$
 File:545 e+ 6 wigglers on, 6 wigglers off
 Vert. Fdbck@-1



σ_v movie

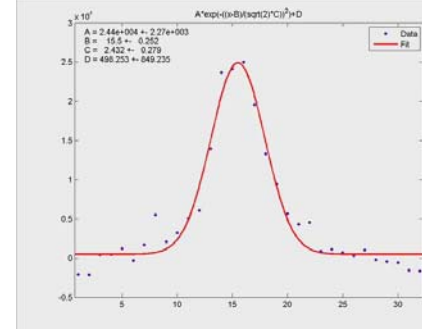


- A dramatic jump in vertical beam size occurs at bunch 3 and slowly decays by bunch 11. This jump correlates with a peak in the FFT spectrum at $f=235.8\text{kHz}$.

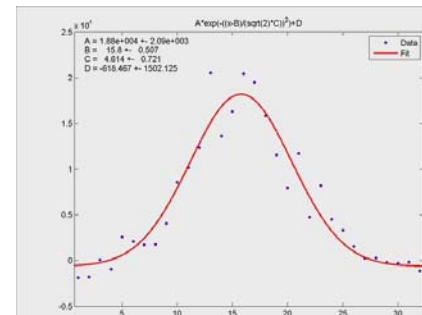
- From bunch 11-45, there are only small fluctuations in σ_v .

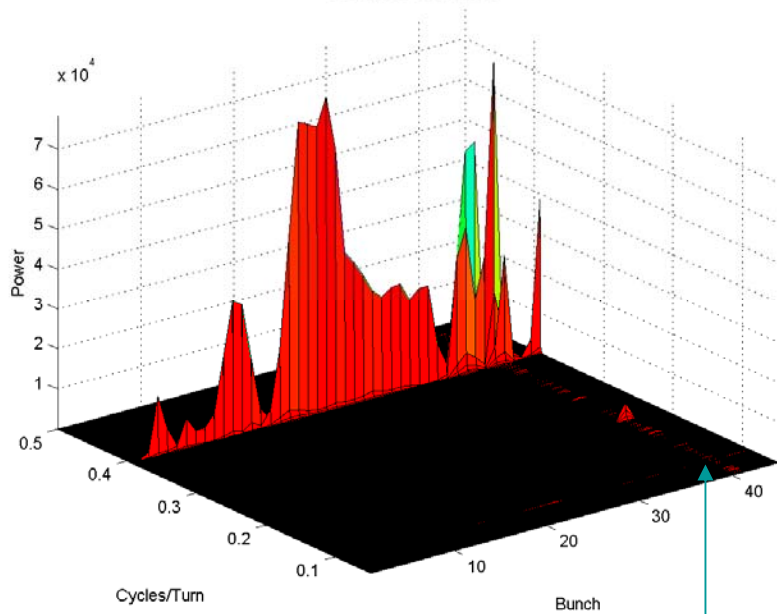
- The standard deviation of σ_v (σ_v oscillation amplitude) is fairly constant along the train.

Bunch 2
 movie

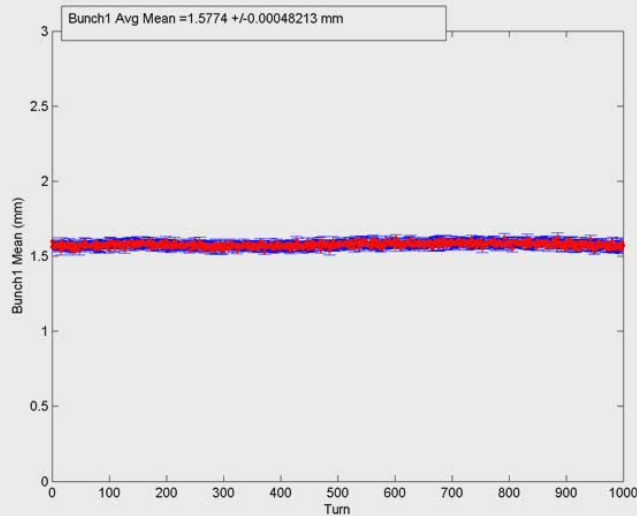


Bunch 3
 movie

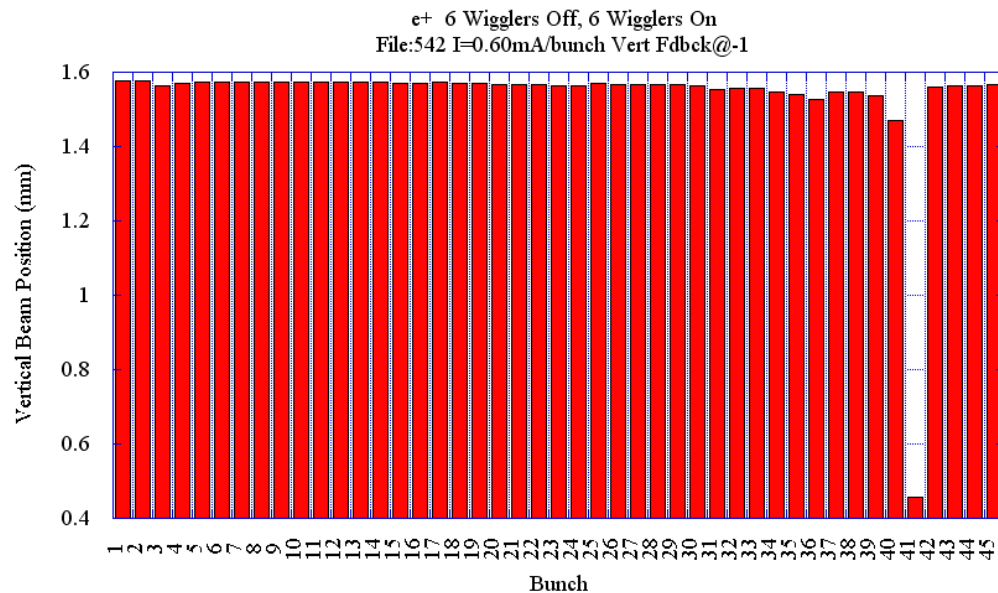




Vertical position movie

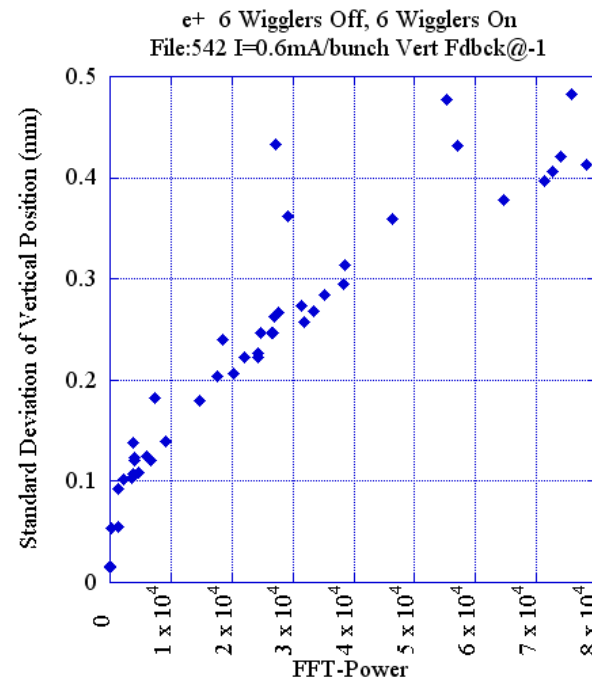


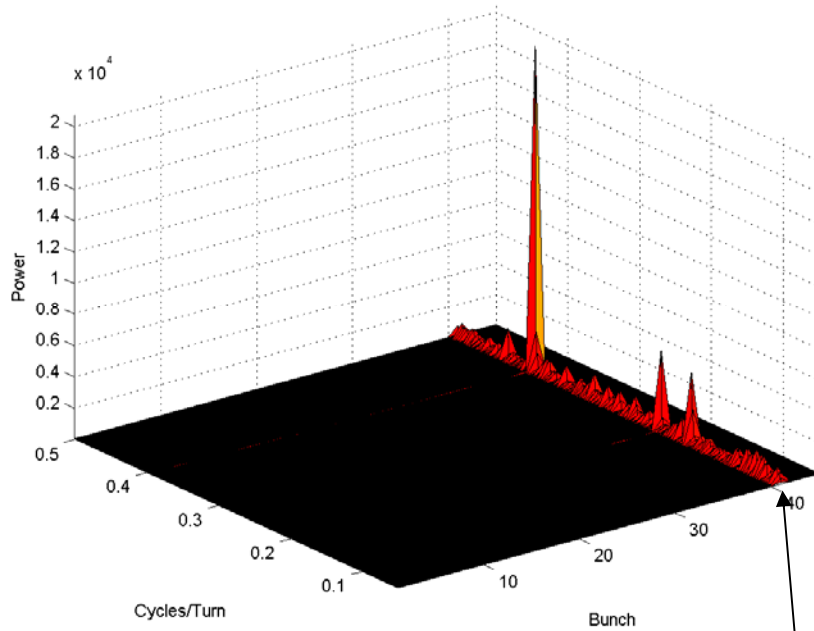
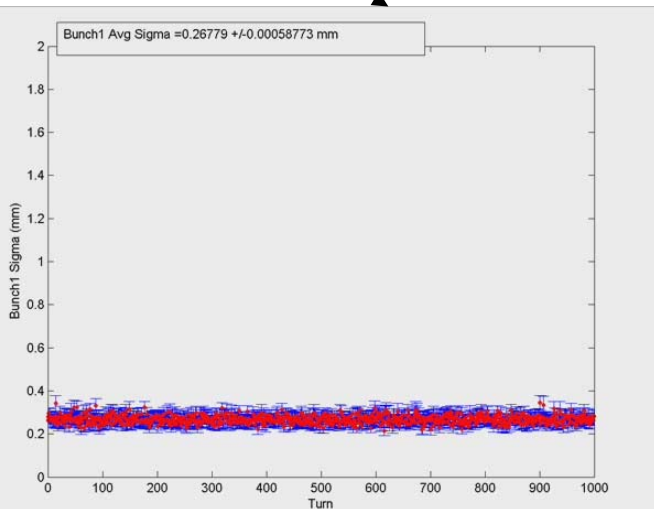
FFT Vertical position $I_{e^+}=0.6\text{mA/bunch}$
 File:542 e+ 6 wigglers on, 6 wigglers off
 Vert. Fdbck@-1



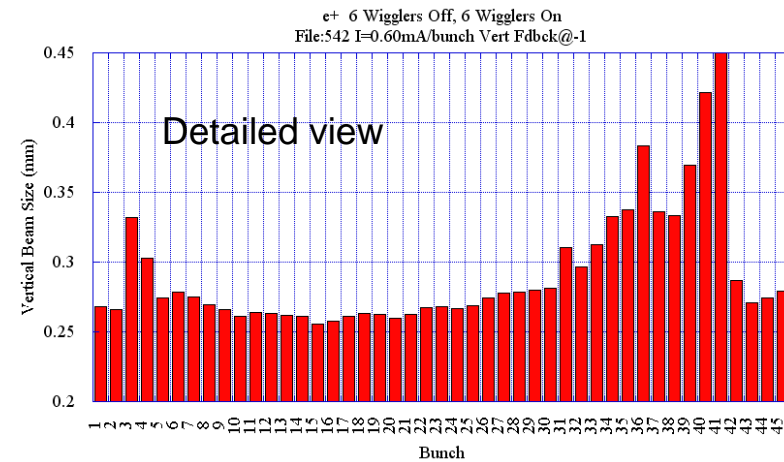
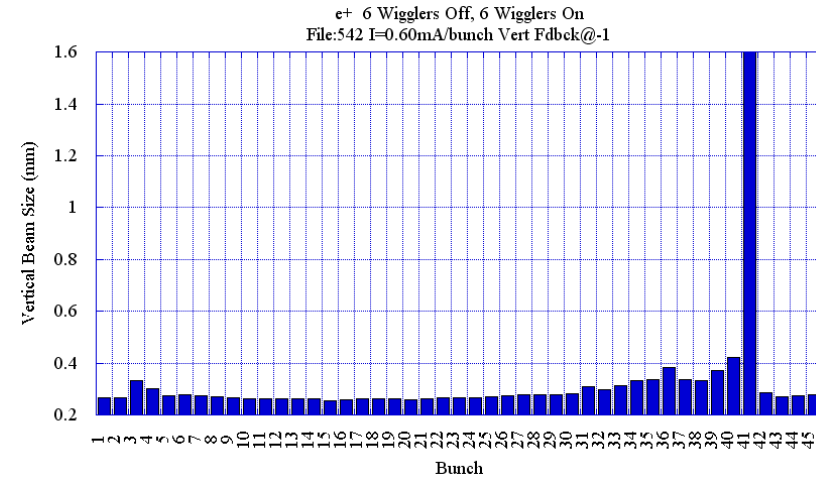
• The vertical position oscillation frequency is $f_{\text{osc}}=235.8\text{kHz}$. The vertical position oscillation amplitude increased with bunch current and correlates with FFT power.

• Bunch 41 has a broad frequency spectrum.

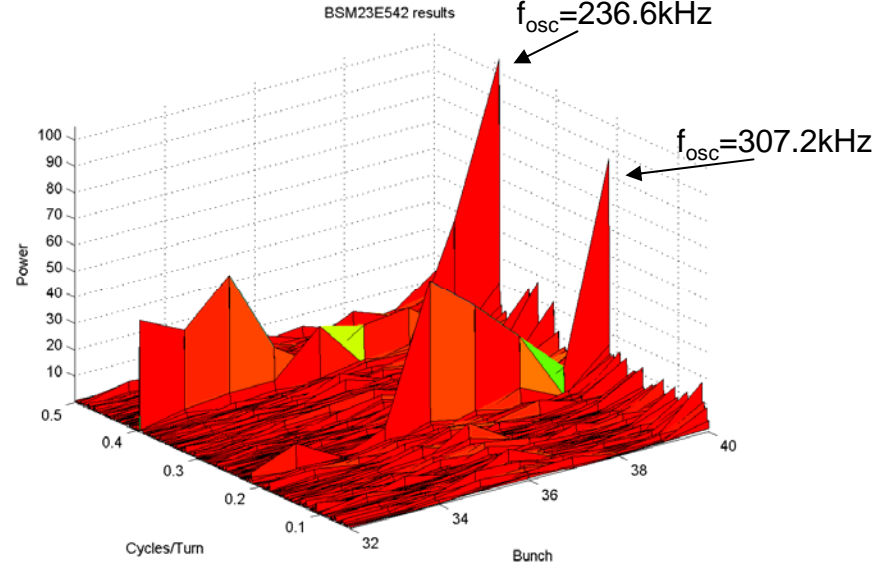


 σ_v movie

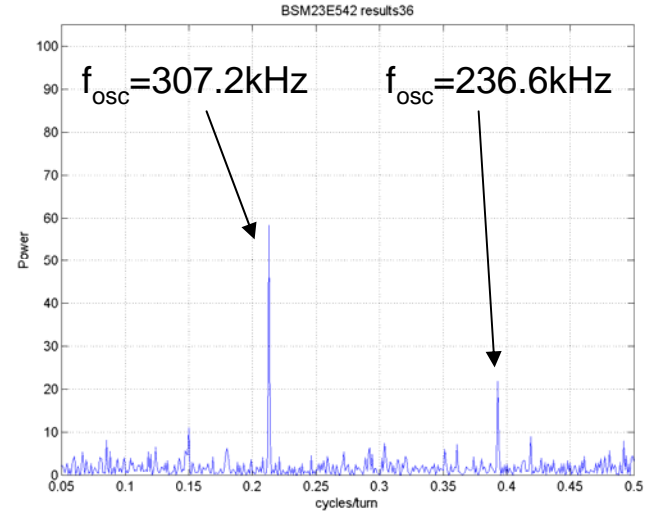
FFT σ_v $I_{e+}=0.6\text{mA/bunch}$
 File:542 e+ 6 wigglers on, 6 wigglers off
 Vert. Fdbck@-1



- From the FFT of σ_v , a broad frequency spectrum is detected for bunch 41. Bunch 41 has a large vertical position and σ_v oscillation amplitude.
- A 45% decrease in σ_v for bunch 3 (compared to $I=0.25\text{mA/bunch}$).
- σ_v growth along the 45 bunch trains starts at bunch 23.

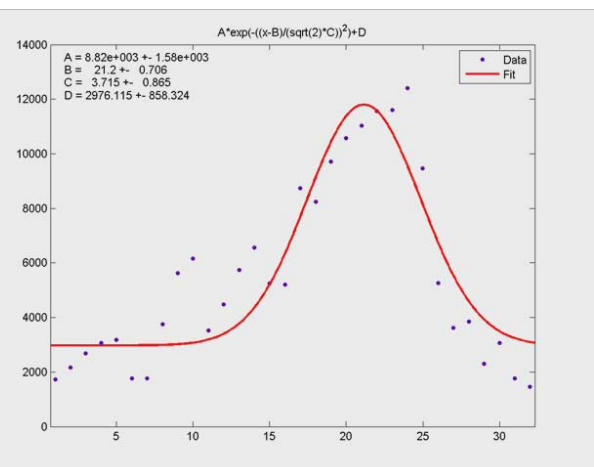


Bunch 36

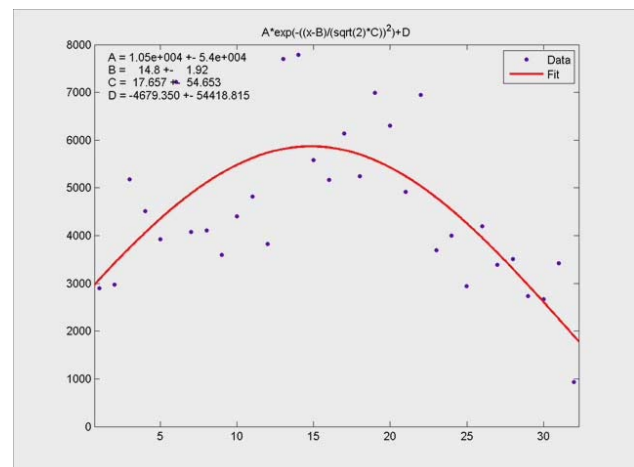


At the onset of the beam blow-up at bunch 41, two peaks in the FFT spectrum is observed at $f_{osc} = 236.6\text{kHz}$ (cycles/turn=0.396) and $f_{osc} = 307.2\text{kHz}$ (cycles/turn=0.213).

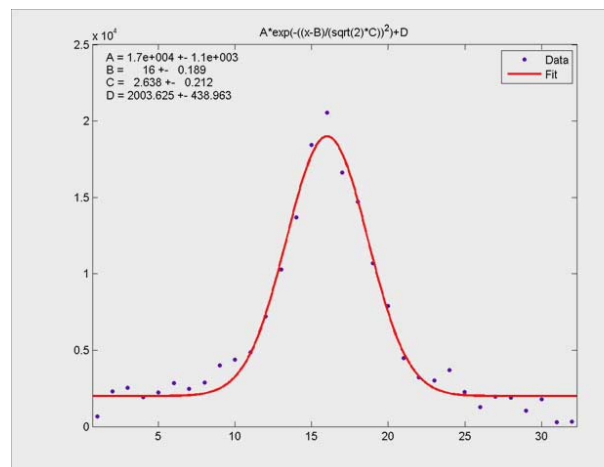
Bunch 36-movie



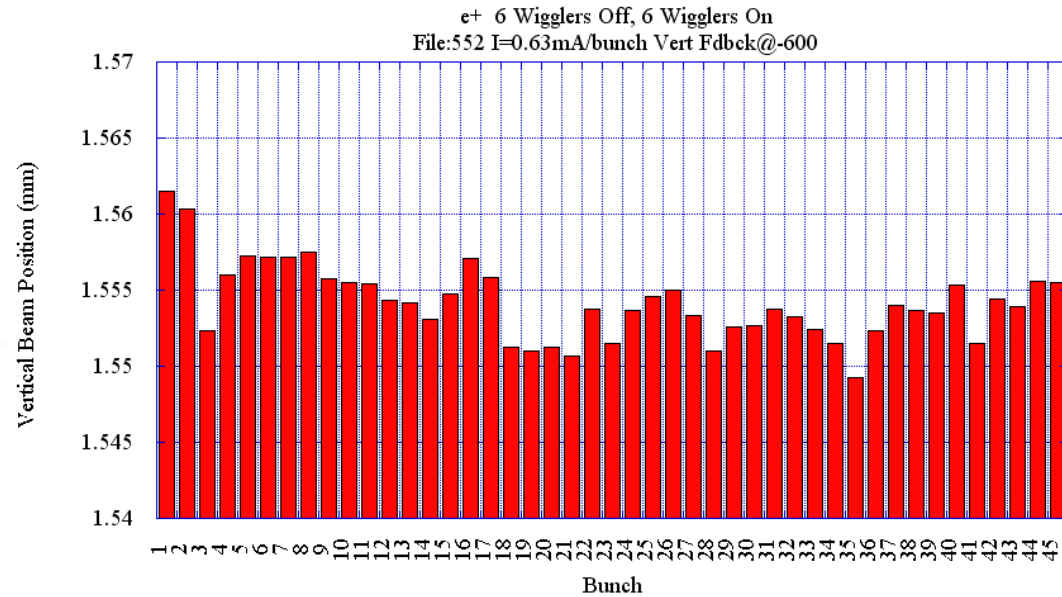
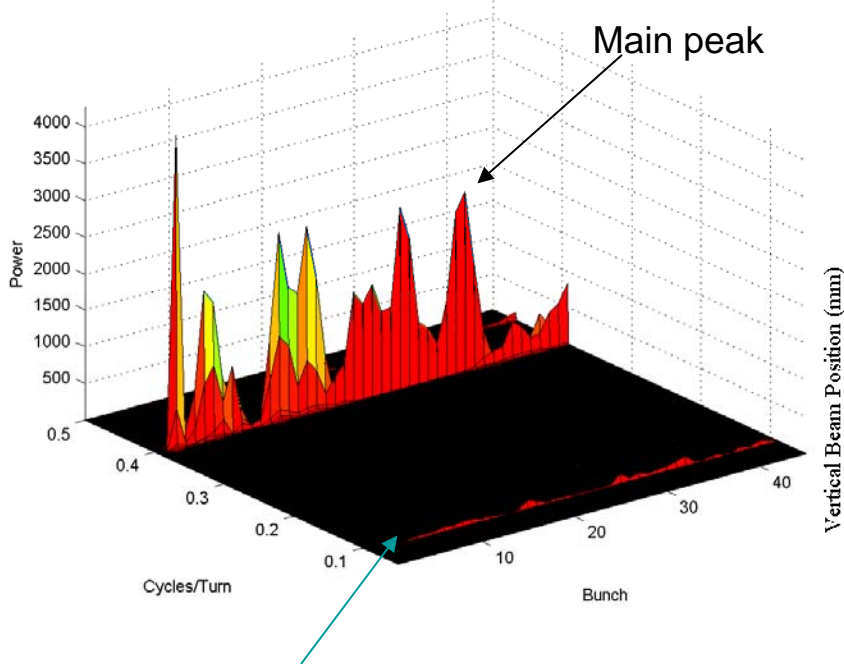
Bunch 41-movie



Bunch 42-movie



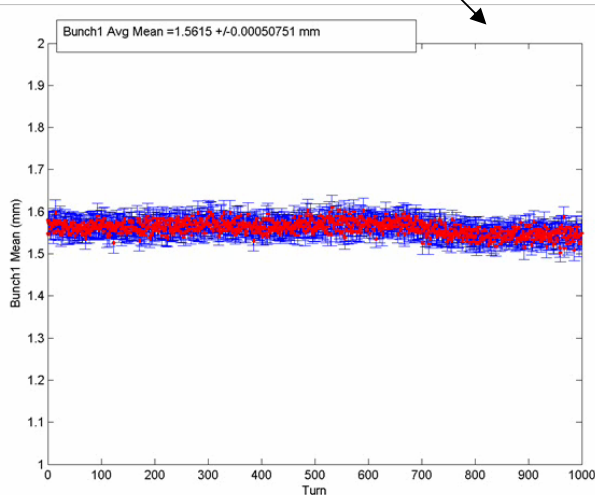
FFT Vertical position $I_{e^+}=0.63\text{mA/bunch}$
 File:552 e+ 6 wigglers on, 6 wigglers off
 Vert. Fdbck@-600



Secondary peak

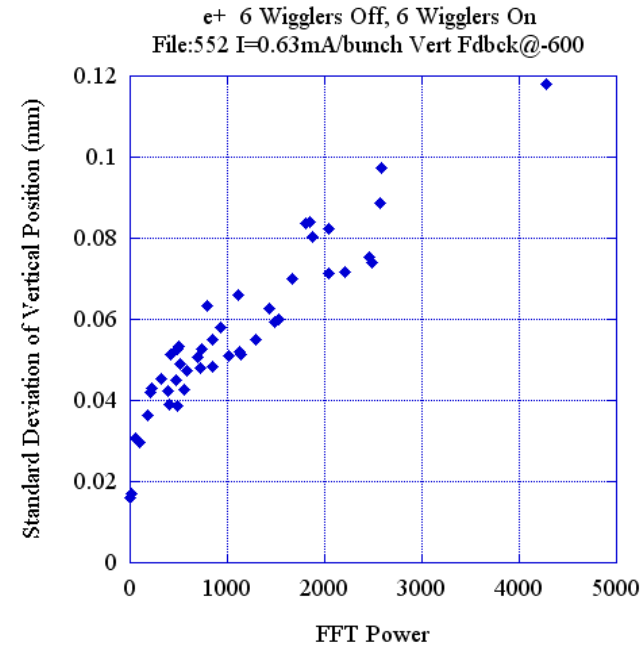
Turn on vertical feedback:

Vertical position movie

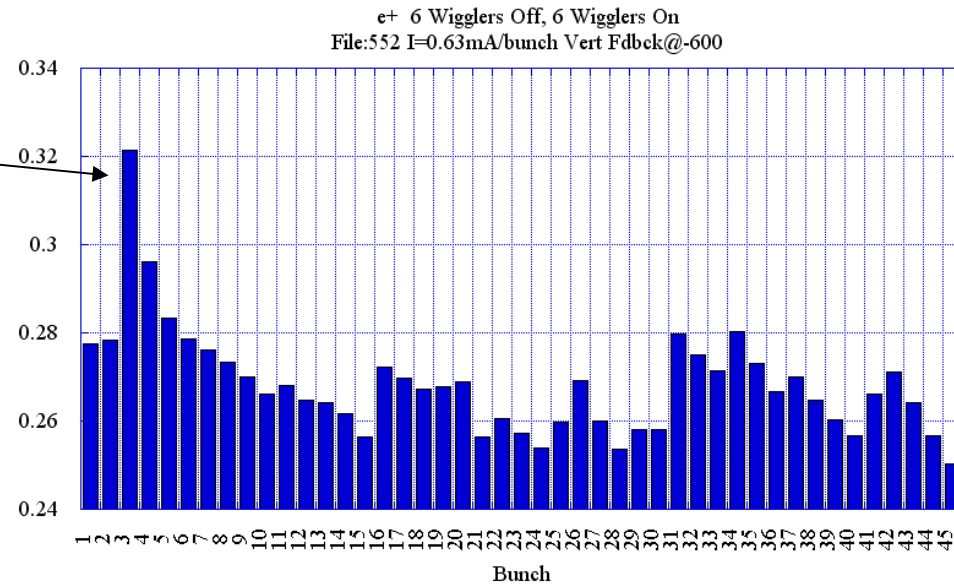
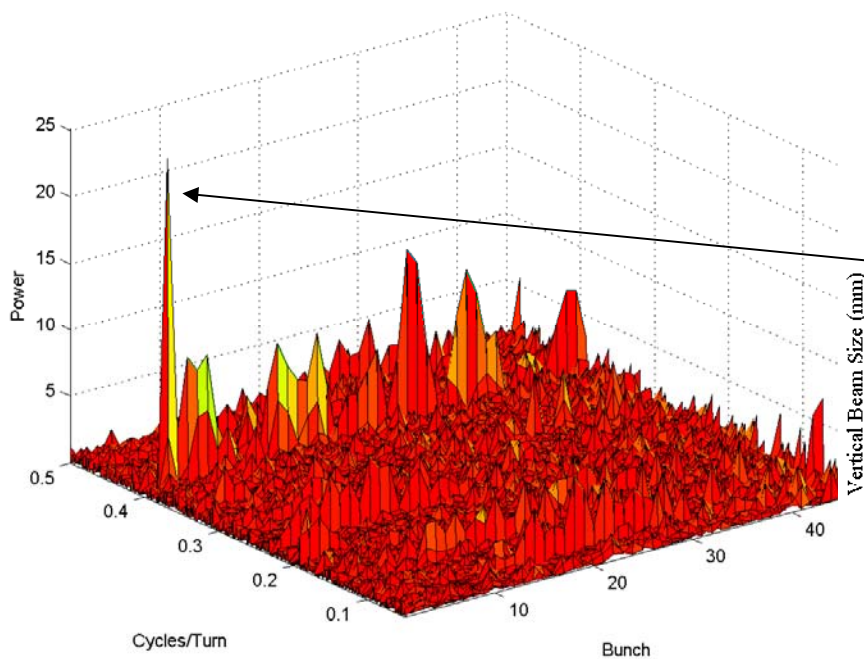


- Vertical feedback **reduces** the vertical position oscillation amplitude. The oscillation amplitude correlates with FFT power.

- The vertical position oscillation frequency has two peaks, at $f_{\text{osc}}=236.6\text{kHz}$ (0.396 cycles/turn), and $f_{\text{osc}}=354.9\text{kHz}$ (0.091 cycles/turn).



FFT $\sigma_v I_{e^+}=0.63\text{mA/bunch}$
 File:552 e+ 6 wigglers on, 6 wigglers off
 Vert. Fdbck@-600



- FFT spectrum peak ($@f_{osc}=236.6\text{kHz}$) correlates with maximum σ_v measured for bunch 3. Feedback reduces bunch 3 σ_v slightly.
- Vertical feedback eliminated the σ_v growth near the end of the train.

σ_v movie

