

e⁺/e⁻ Vertical Beam Dynamics during CHESS Operation-Part II

- I. Introduction
- II. e⁺ turn-by-turn vertical dynamics
- III. e⁻ turn-by-turn vertical dynamics
- IV. Summary

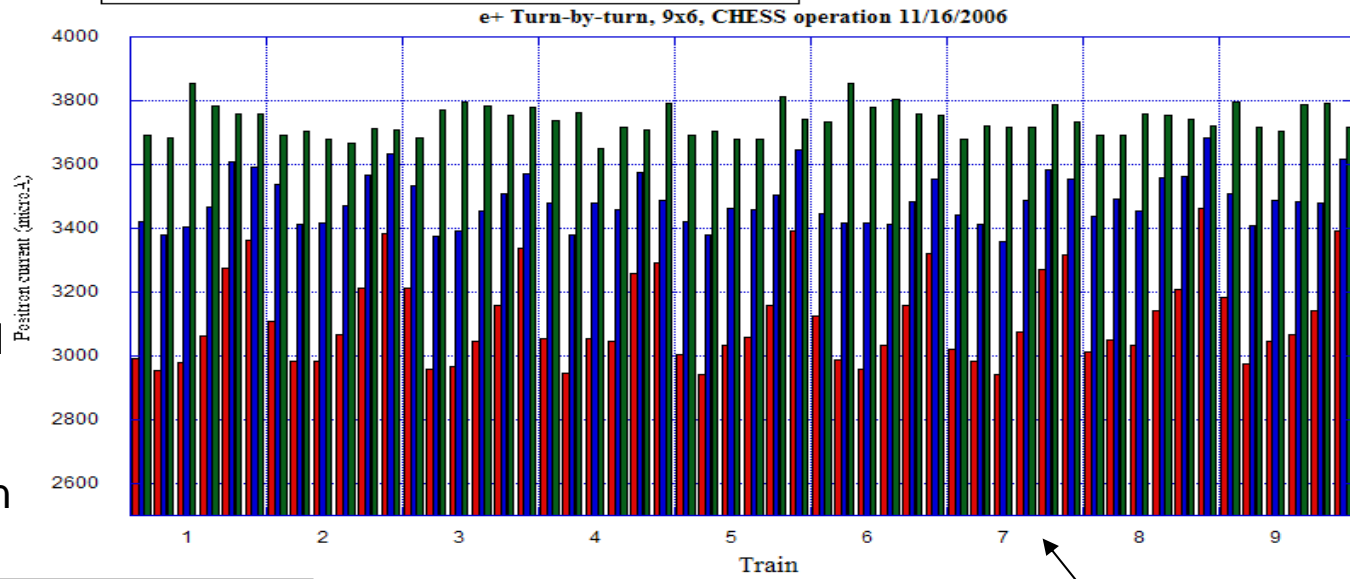
I. Introduction

e+/e- CHES
9x6 Pattern
Single bunch currents

Turn-by-turn vertical beam distribution measurements made at the top, middle, and bottom of a CHES fill.

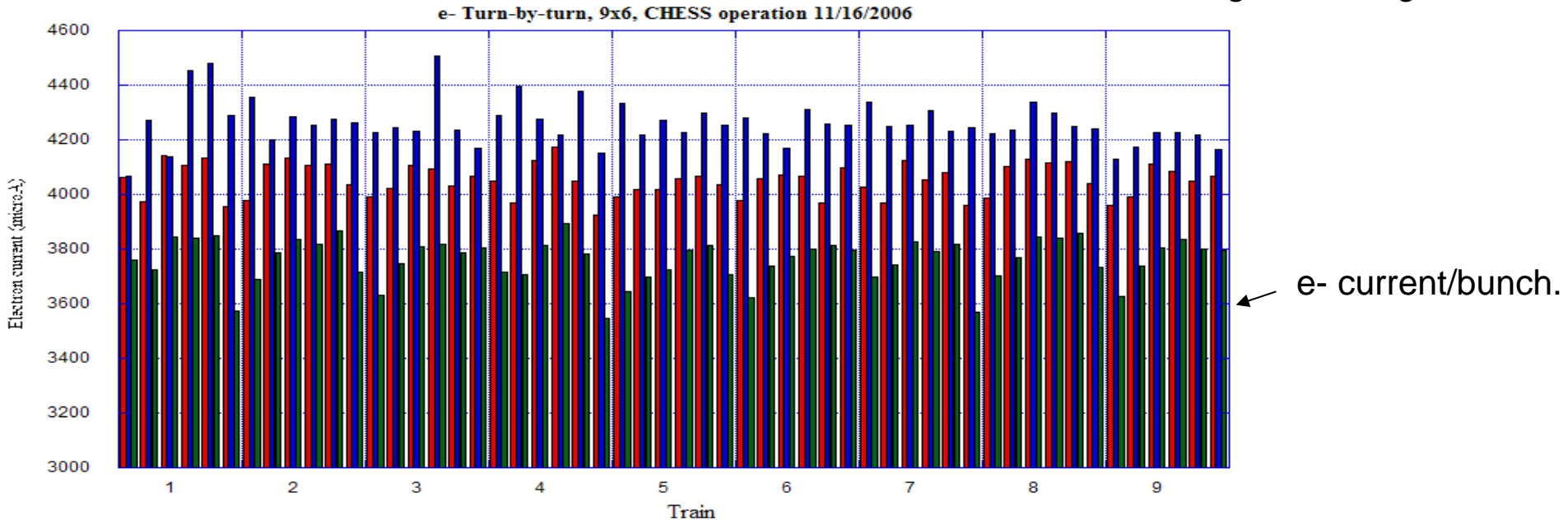
Similar analysis was done on 11/2/06.

■ File:921 $I_{e^-} = 203.08\text{mA}$ (3.8mA/bunch), $I_{e^+} = 168.18\text{mA}$ (3.1mA/bunch)
■ File:920 $I_{e^-} = 218.86\text{mA}$ (4.1 mA/bunch), $I_{e^+} = 188.22\text{mA}$ (3.5 mA/bunch)
■ File:924 $I_{e^-} = 230.09\text{mA}$ (4.3 mA/bunch), $I_{e^+} = 201.84\text{mA}$ (3.7 mA/bunch)



e+ current/bunch
Lifetime grows along the train.

■ File:921 $I_{e^-} = 203.08\text{mA}$ (3.8mA/bunch), $I_{e^+} = 168.18\text{mA}$ (3.1mA/bunch)
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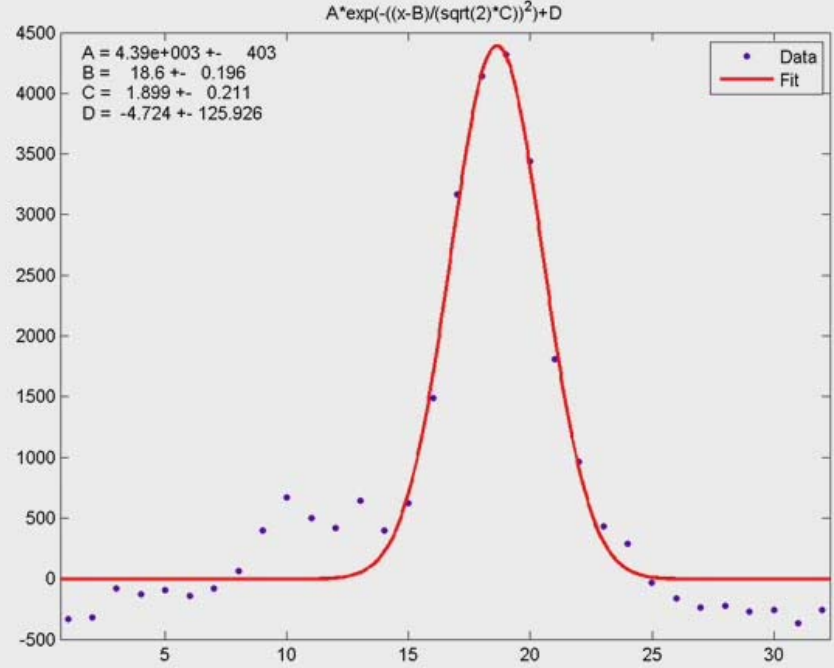


e- current/bunch.

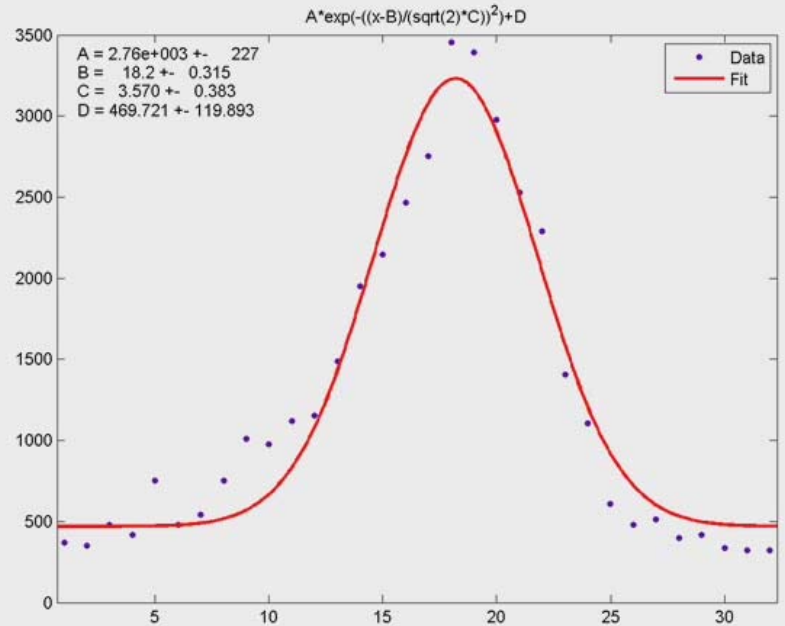
II. e+ turn-by-turn measurements

e+ single bunch vertical bunch distributions from the PMT array.

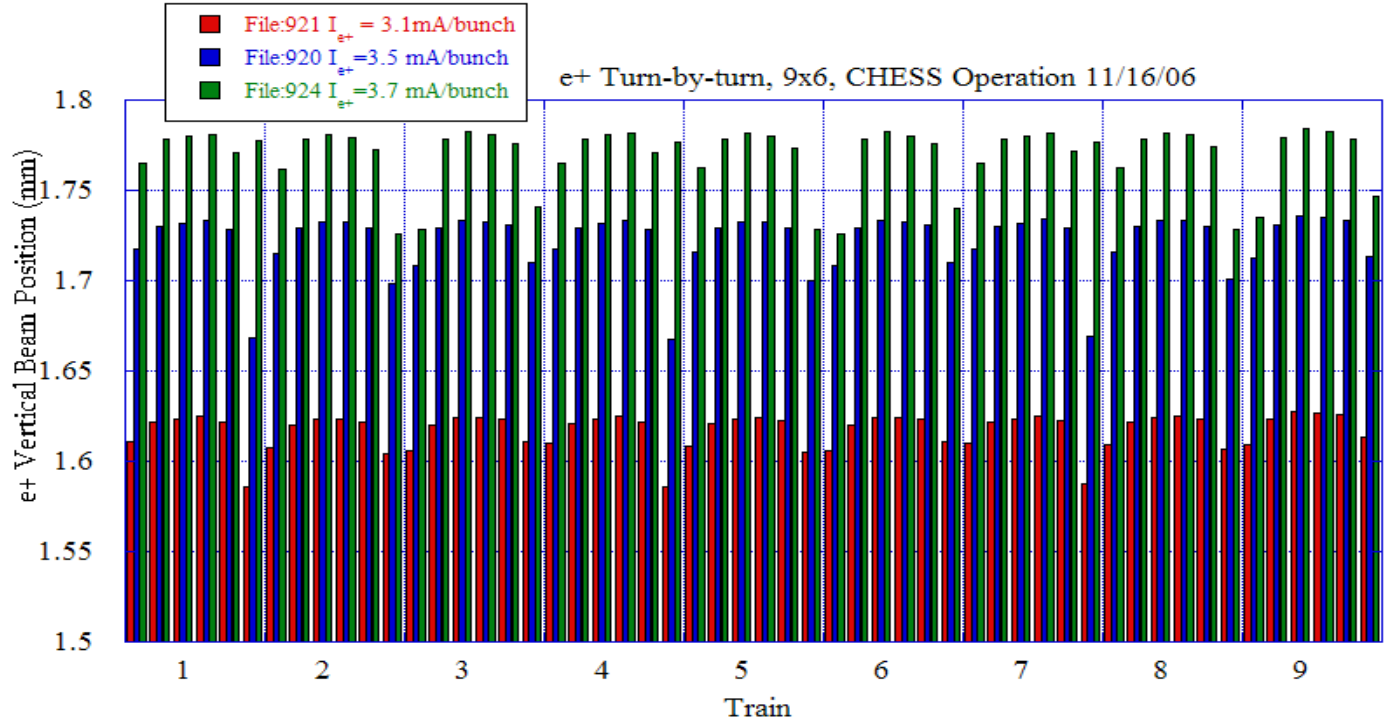
- 9,000 turns of all 54 e+/e- bunches.
- High I File:924 $I_{e+}=3.7\text{mA/bunch}$
- Note difference in σ_v



e+ Bunch 1 Train 1
1st ten turns (movie)



e+ Bunch 6 Train 2
1st ten turns (movie)



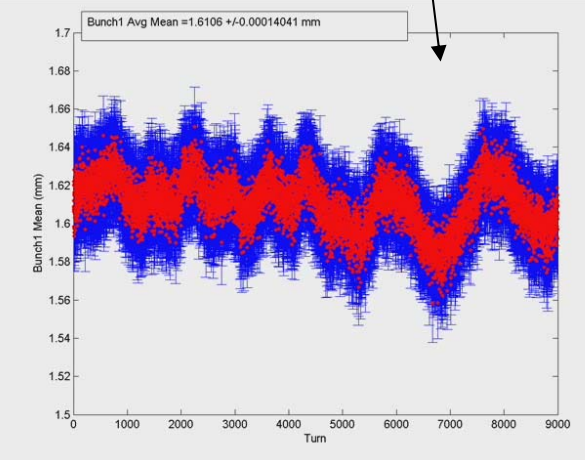
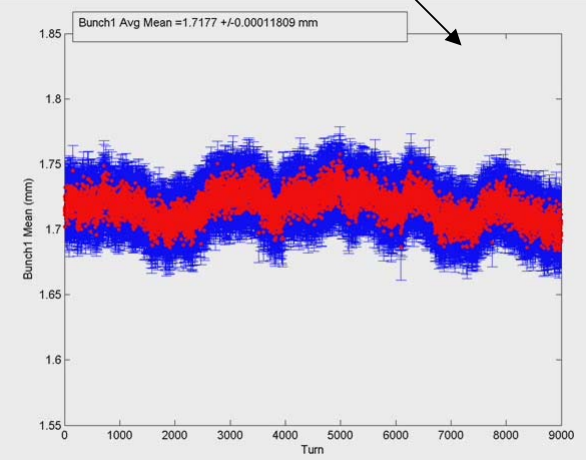
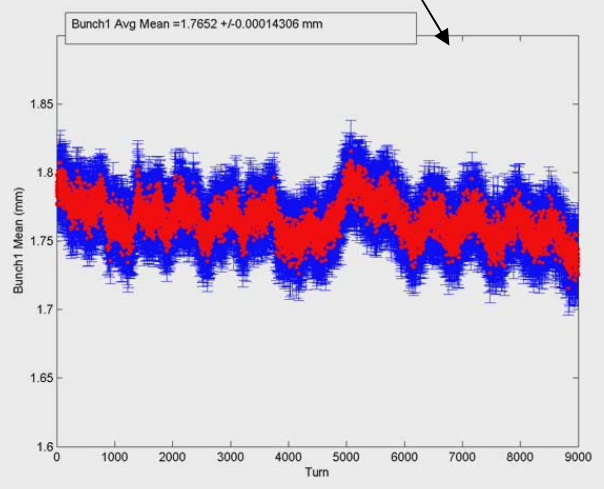
e+ Vertical Position

- Mean vertical position for 9,000 turns for 54 bunches.
- Low frequency vertical oscillation is denoted for all 54 bunches.

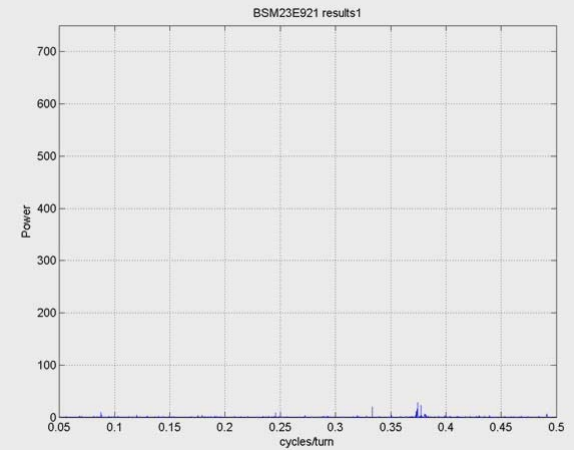
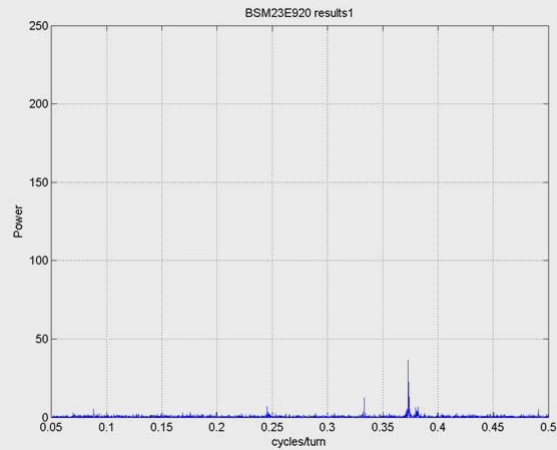
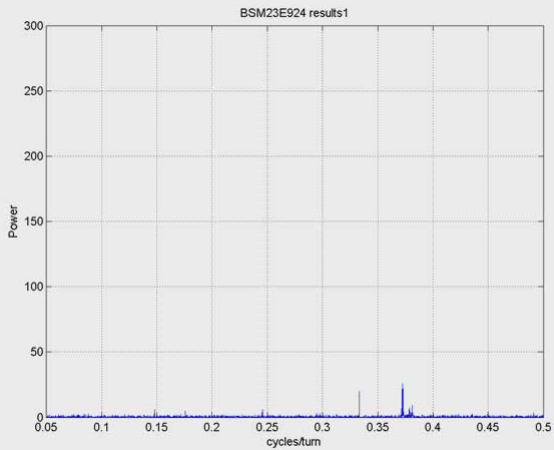
High I File:924
 $I_{e^+} = 3.7$ mA/bunch (movie)

Medium I File:920
 $I_{e^+} = 3.5$ mA/bunch (movie)

Low I File:921
 $I_{e^+} = 3.1$ mA/bunch (movie)



e+ vertical position oscillation-FFT of vertical position for 9,000 turns

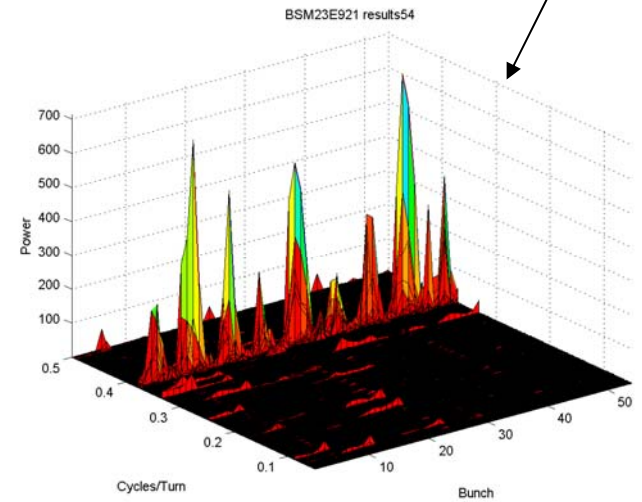
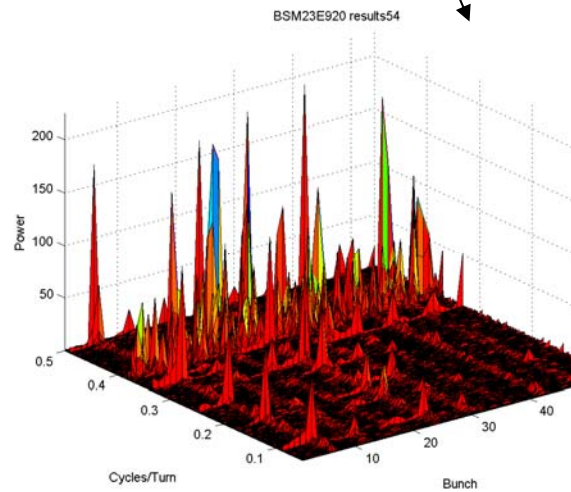
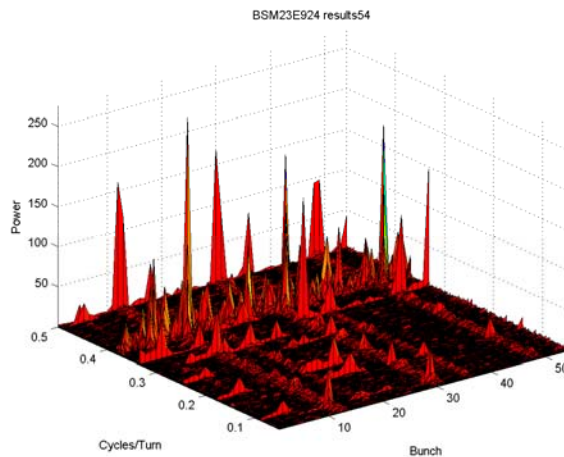


- FFT of the vertical position.
- The vertical position oscillation frequency is denoted in the FFT spectrum.

High I File:924
 $I_{e^+}=3.7\text{mA/bunch}$ (movie)

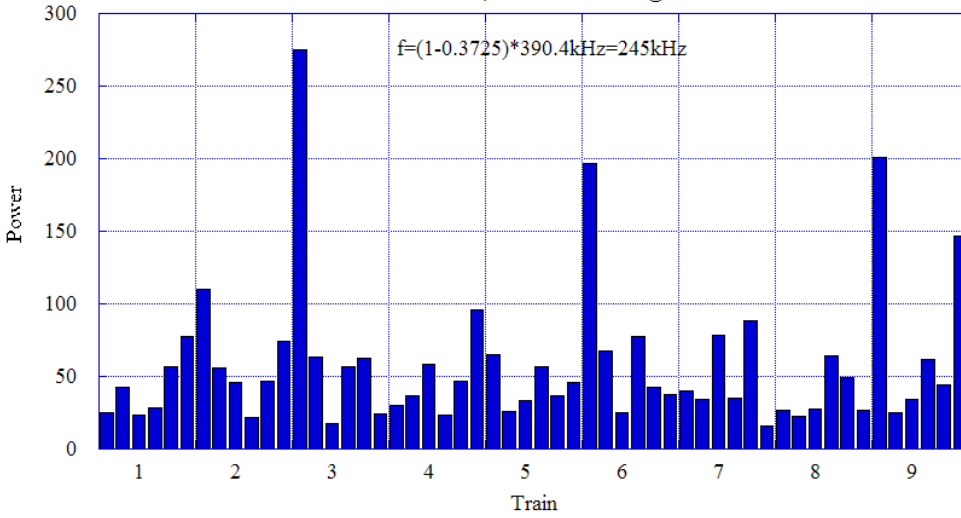
Medium I File:920
 $I_{e^+}=3.5\text{mA/bunch}$ (movie)

Low I File:921
 $I_{e^+}=3.1\text{mA/bunch}$ (movie)

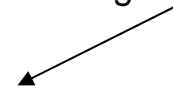


e+ high frequency vertical motion-FFT Power

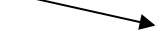
FFT of e+ Vertical Position, CHESS bunches @~245kHz File:924



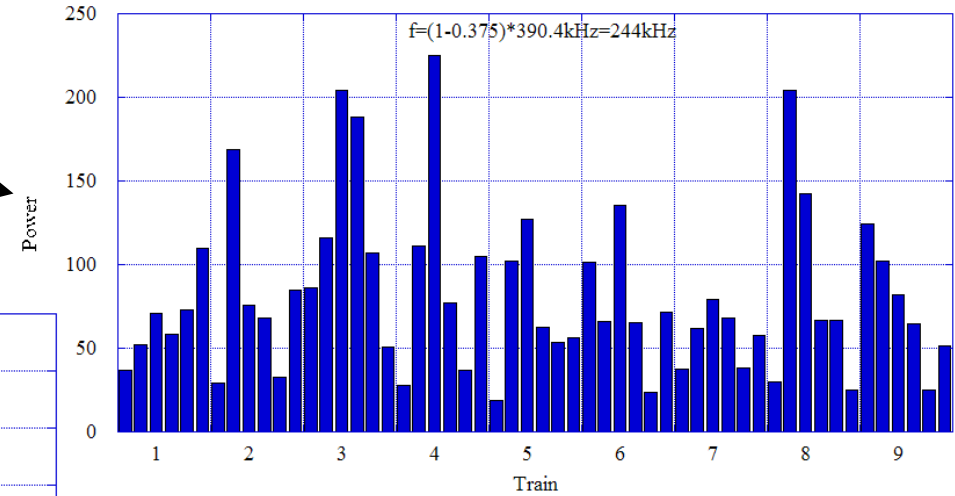
High I File:924 $I_{e^+}=3.7\text{mA/bunch}$



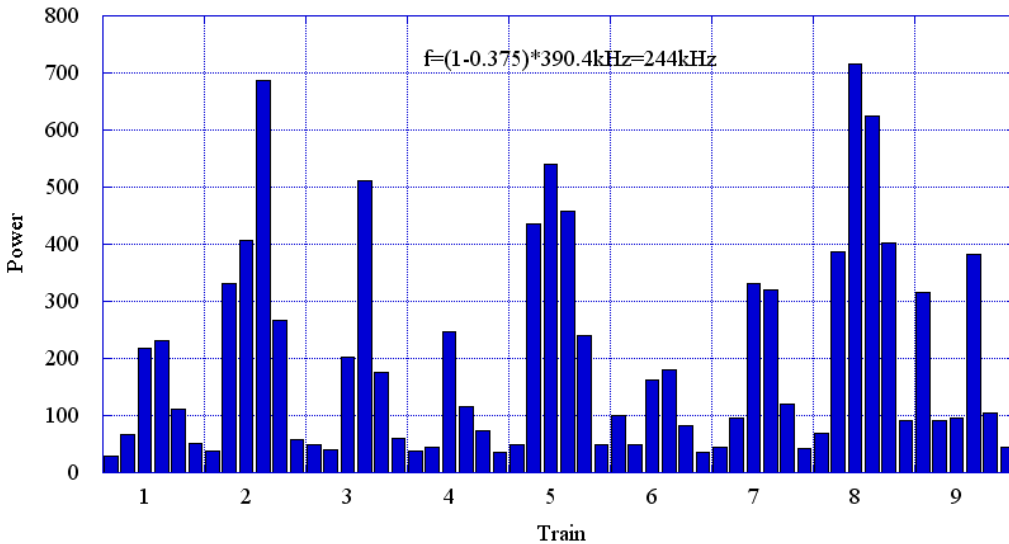
Medium I File:920 $I_{e^+}=3.5\text{mA/bunch}$



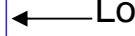
FFT of e+ Vertical Position, CHESS bunches @~244kHz File:920



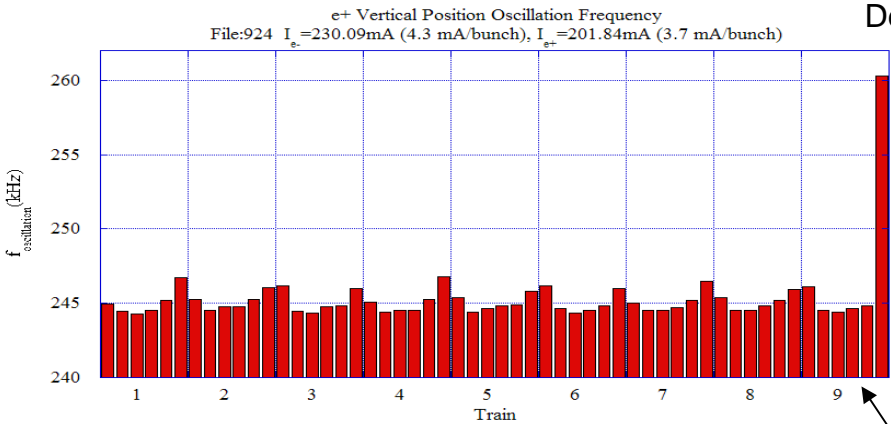
FFT of e+ Vertical Position, CHESS bunches @~244kHz File:921



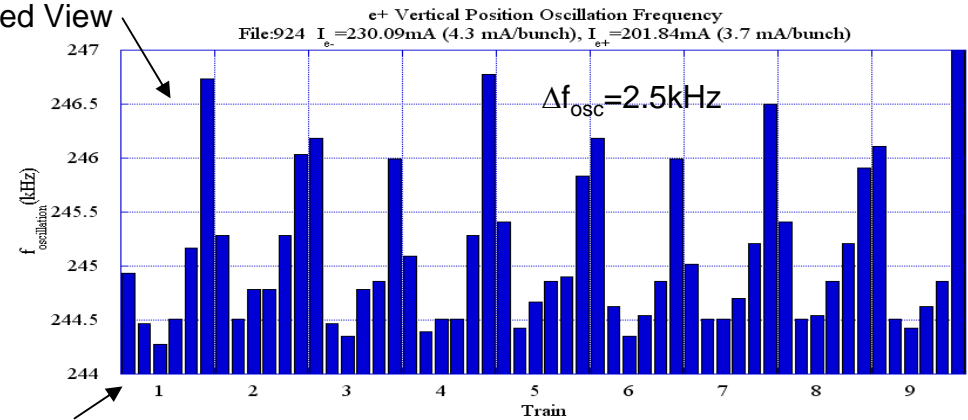
Low I File:921 $I_{e^+}=3.1\text{mA/bunch}$



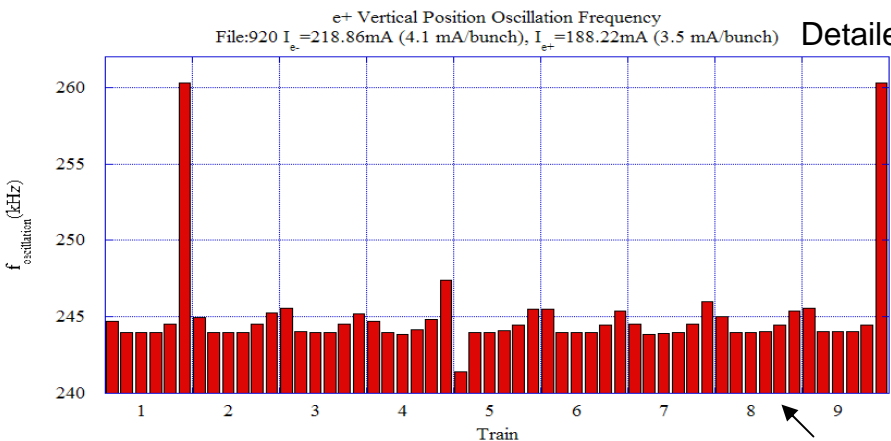
e+ high frequency vertical motion-FFT Frequency of Oscillation



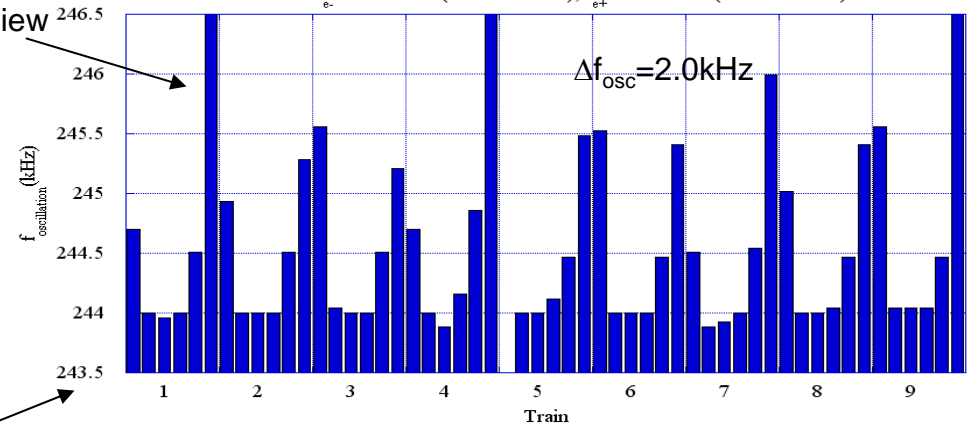
Detailed View



High I File:924 $I_{e^+}=3.7\text{mA/bunch}$

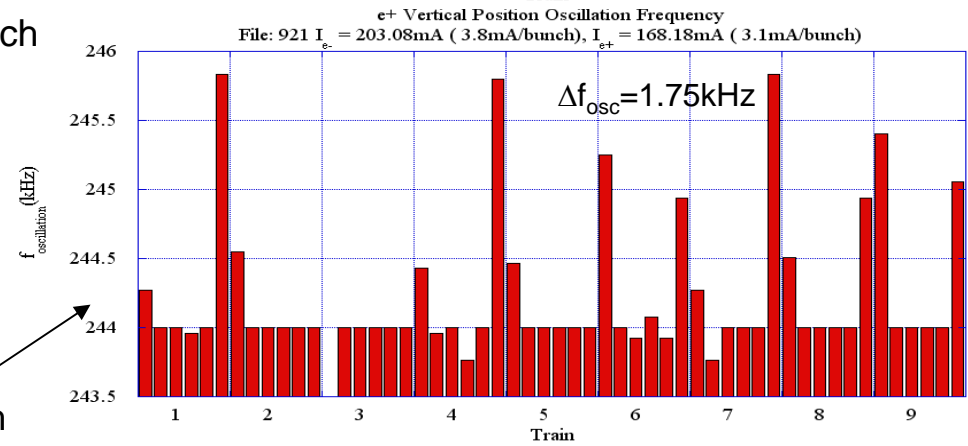


Detailed View



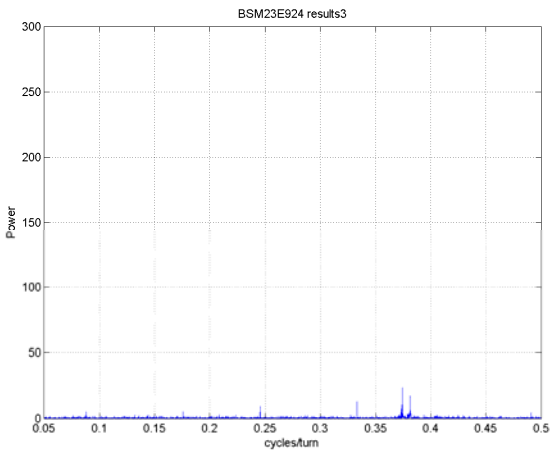
Medium I File:920 $I_{e^+}=3.5\text{mA/bunch}$

- Oscillation frequency shift, Δf_{OSC} , along the trains is current dependent.
- Large frequency jump is occasionally noted.

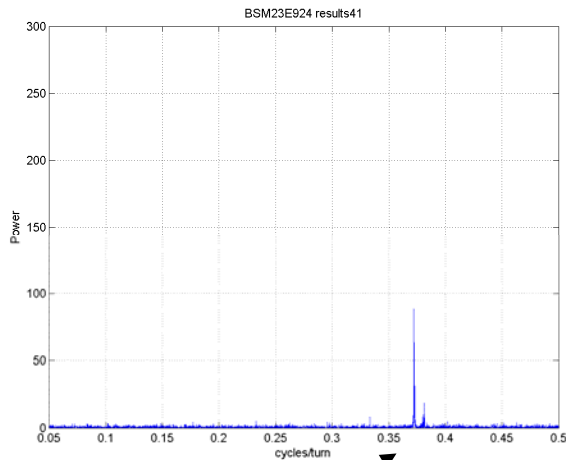


Low I File:921 $I_{e^+}=3.1\text{mA/bunch}$

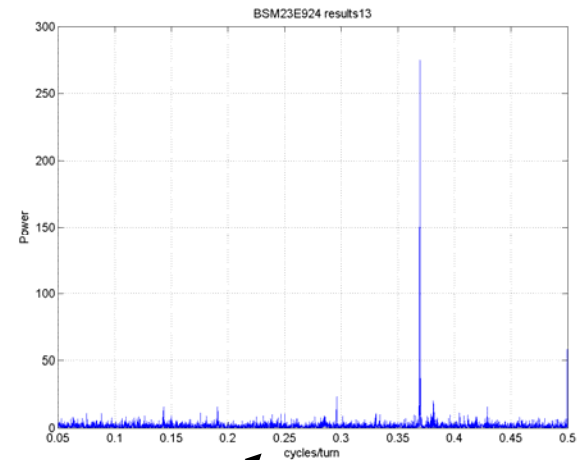
e+ FFT power dependence on vertical position oscillation amplitude—High I



Bunch 3
Peak Power=23@244.3kHz
 $y_{avg}=1.78\text{mm}$
Std=0.013mm



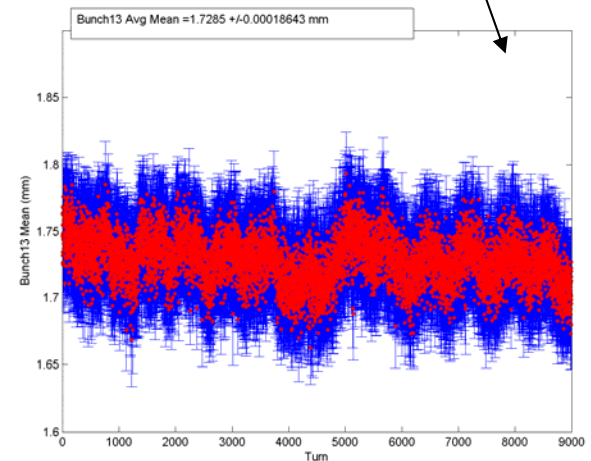
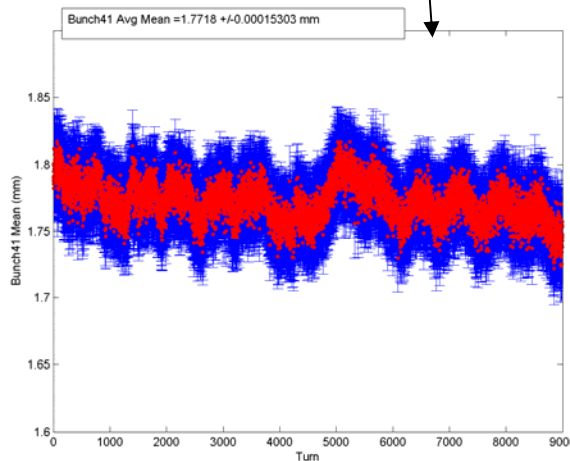
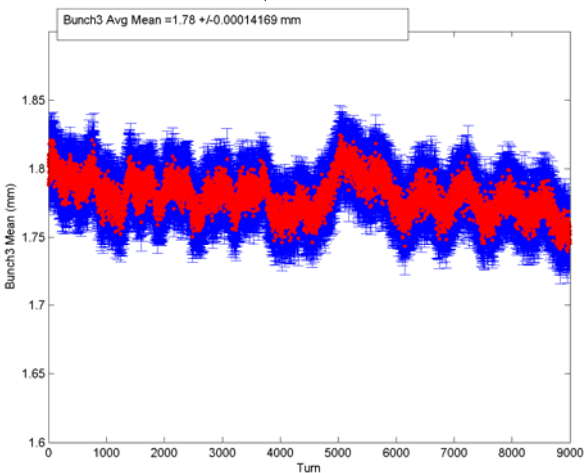
Bunch 41
Peak Power=88@245.2kHz
 $y_{avg}=1.77\text{mm}$
Std=0.015mm



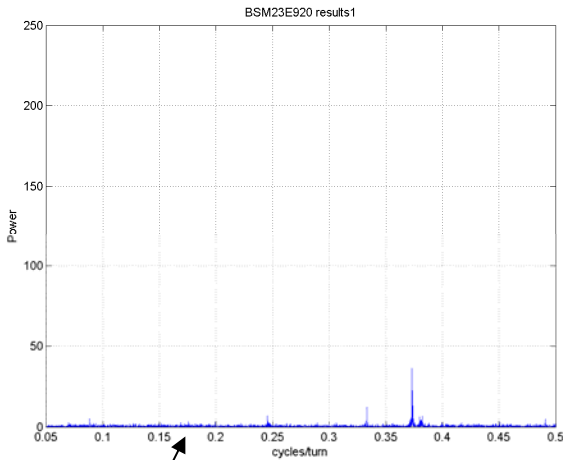
Bunch 13
Peak Power=275@246.2kHz
 $y_{avg}=1.73\text{mm}$
Std=0.018mm

Noisy FFT spectrum background

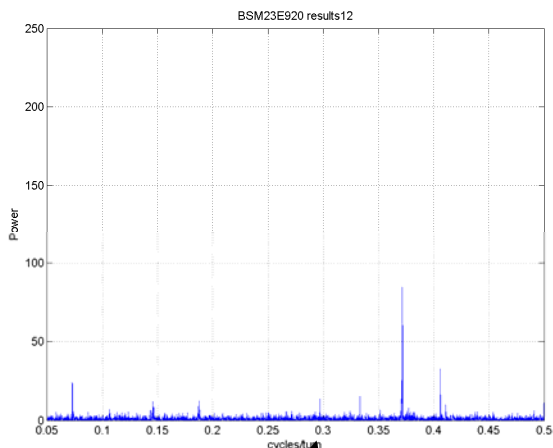
File:924 $I_{e+}=3.7\text{mA/bunch}$
•Noisy FFT spectrum correlates to increased vertical position oscillation amplitude.



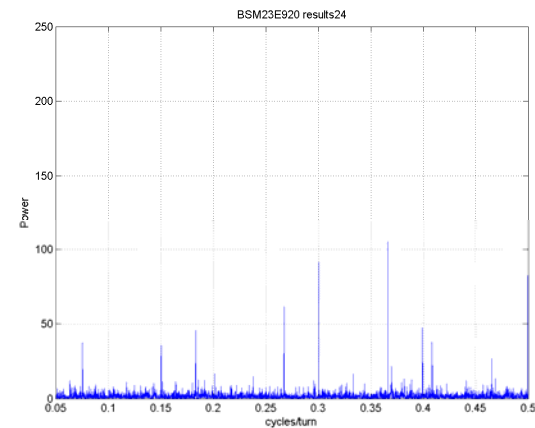
e+ FFT power dependence on vertical position oscillation amplitude—Medium I



Bunch 1
Peak Power=37@244.7kHz
 $y_{avg}=1.718\text{mm}$
Std=0.011mm

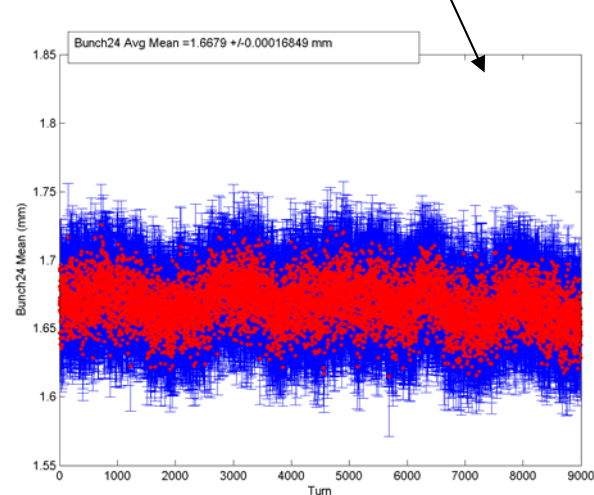
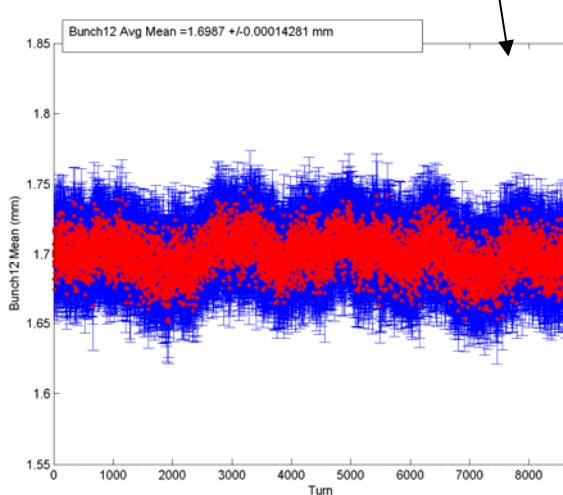
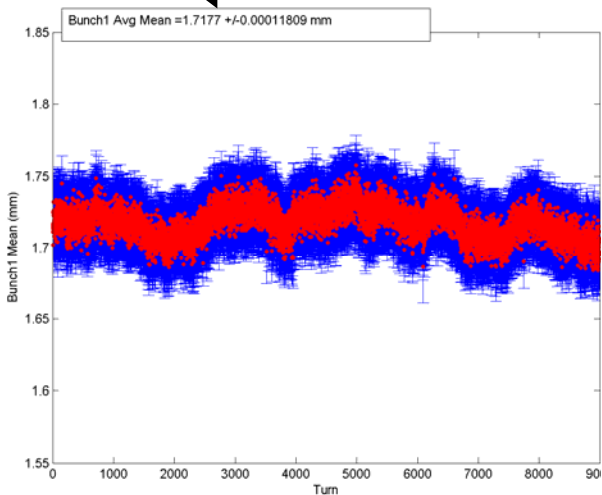


Bunch 12
Peak Power=85@245.6kHz
 $y_{avg}=1.700\text{mm}$
Std=0.014mm



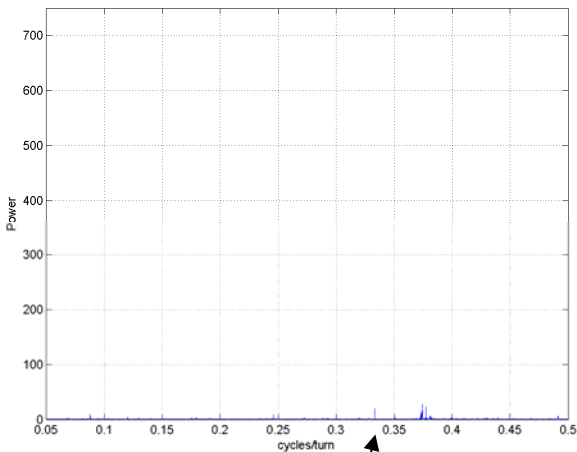
Bunch 24
Peak Power=165@195.2kHz
 $y_{avg}=1.668\text{mm}$
Std=0.016mm
Many peaks and noise in FFT spectrum.

File 920 $I_{e+}=3.5\text{mA/bunch}$
• Increase of vertical position oscillation amplitude noted in FFT spectrum



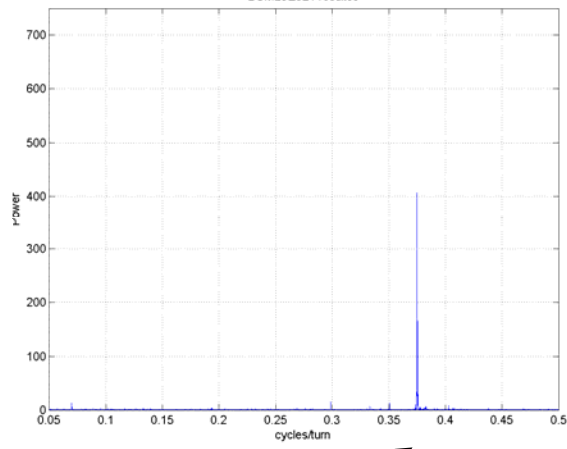
e+ FFT power dependence on vertical position oscillation amplitude—Low I

BSM23E921 results1



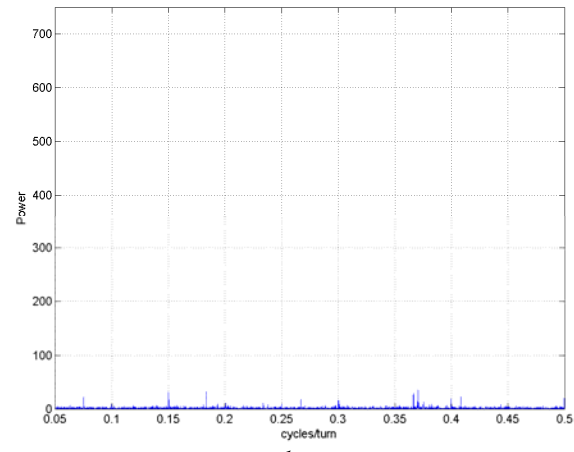
Bunch 1
Peak Power=28@244.3kHz
 $y_{avg}=1.611\text{mm}$
Std=0.013mm

BSM23E921 results9



Bunch 9
Peak Power=407@244.0kHz
 $y_{avg}=1.623\text{mm}$
Std=0.014mm

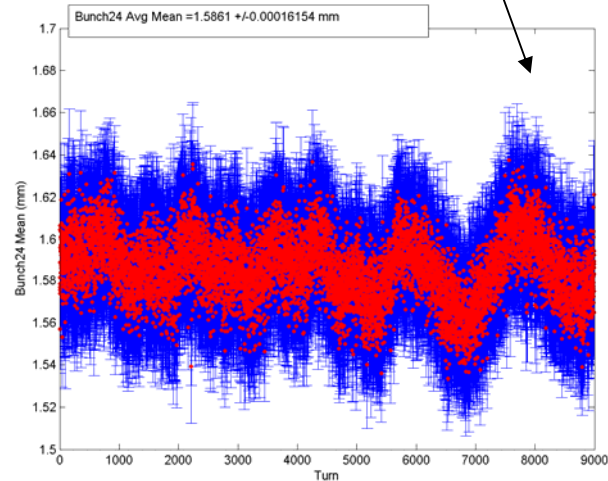
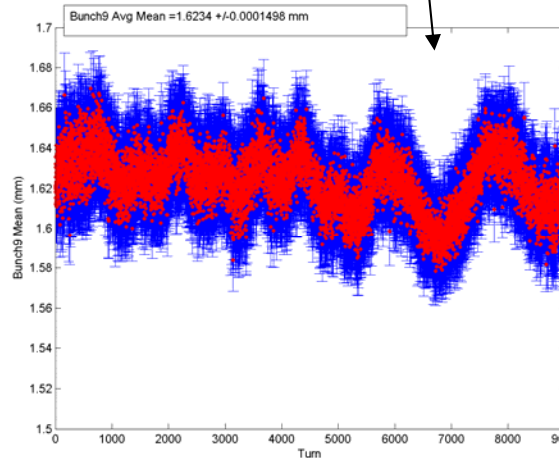
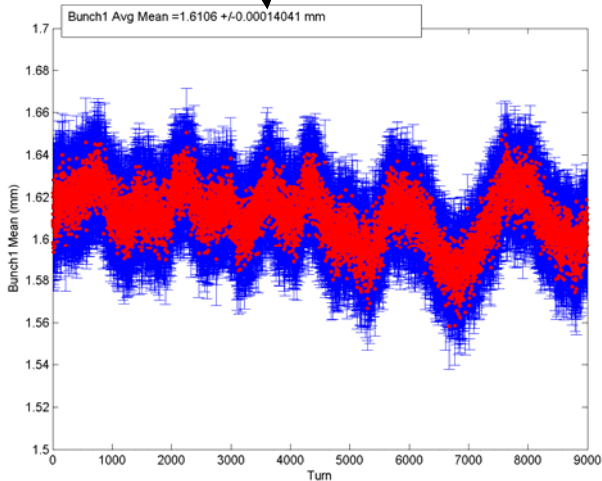
BSM23E921 results24

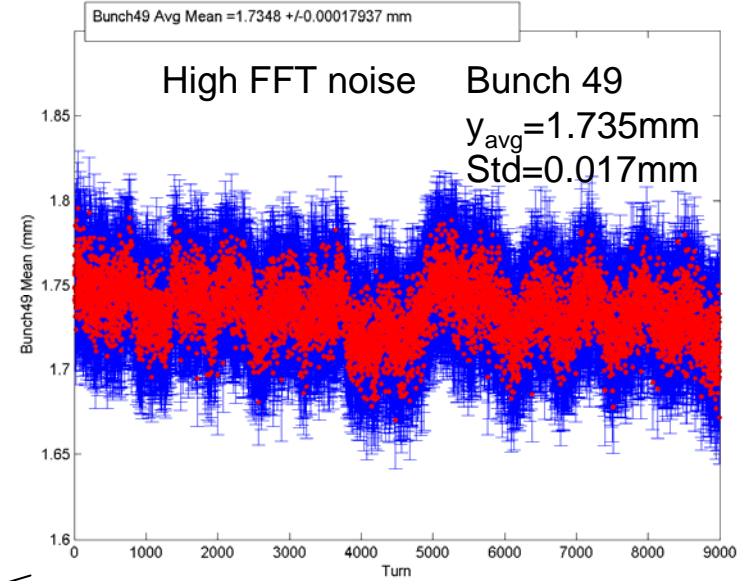
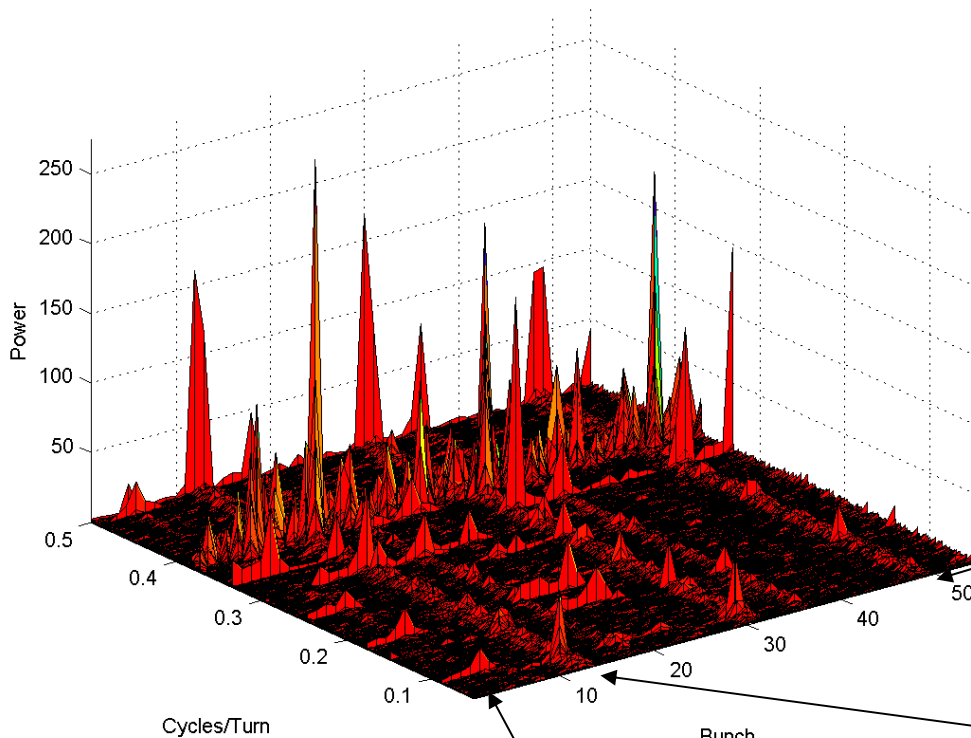


Bunch 24
Peak Power=40@195.2kHz
 $y_{avg}=1.586\text{mm}$
Std=0.015mm

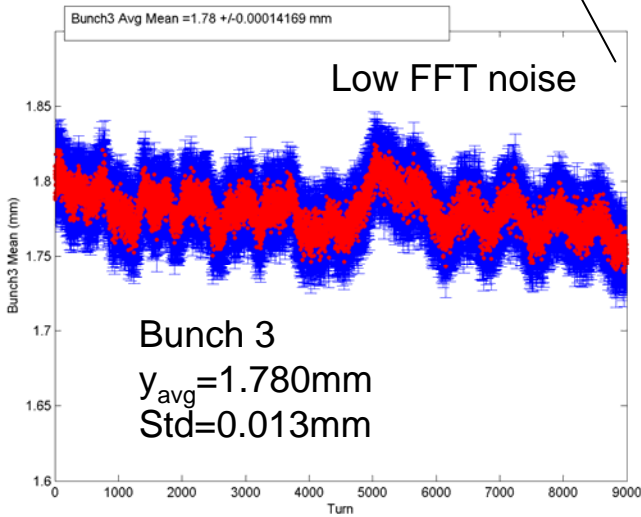
No real peak in FFT spectrum but noisy FFT spectrum background

File:921 $I_{e+}=3.1\text{mA/bunch}$
•Noisy FFT spectrum correlates to increased vertical position oscillation amplitude.



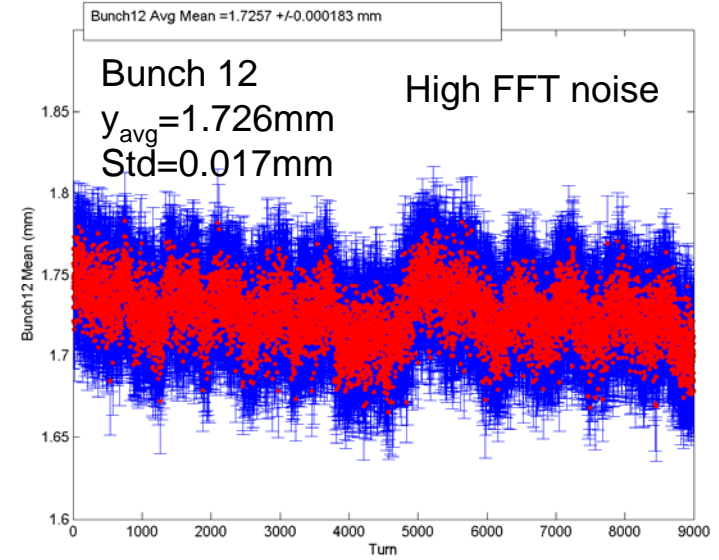


e+ high frequency vertical motion
High I File:924 $I_{e^+}=3.7\text{mA/bunch}$

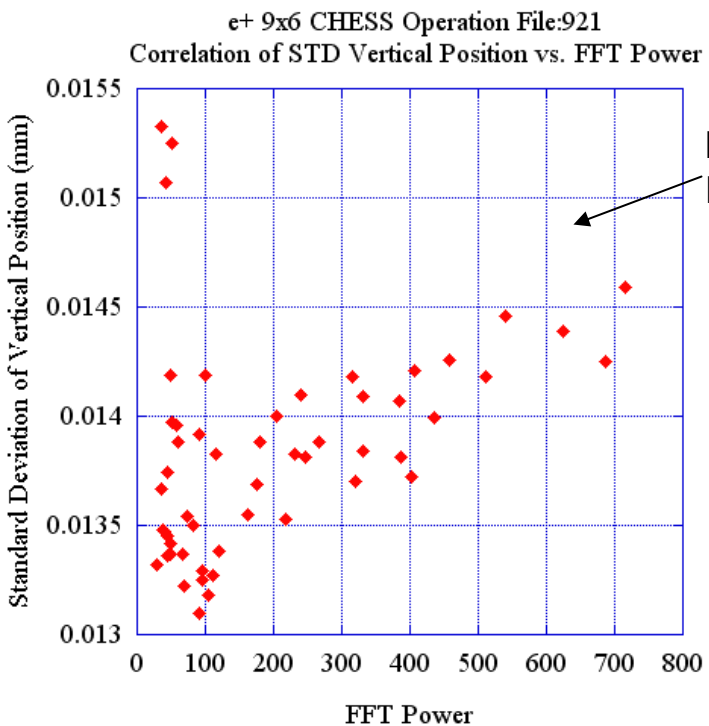
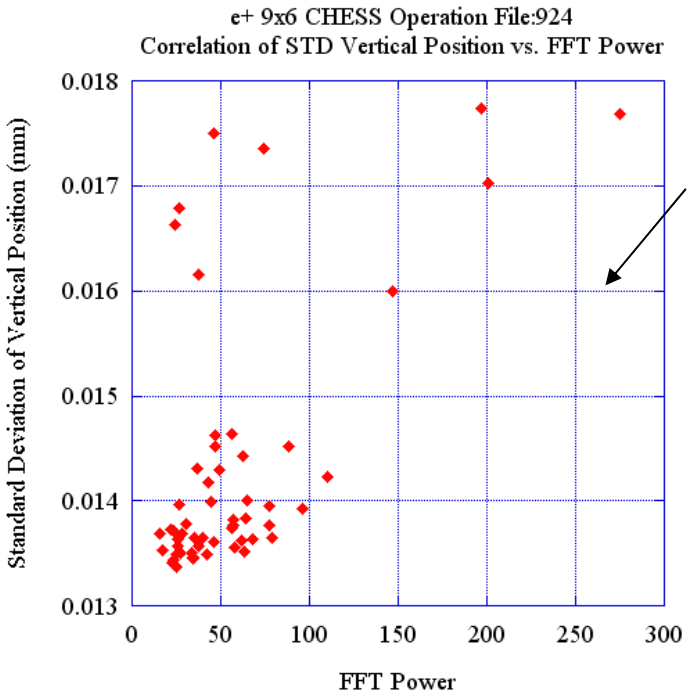


• Several bunches oscillate over a wide frequency spectrum-particularly bunches 12,31,49 (noisy FFT spectrum). The bunches have large oscillation amplitudes.

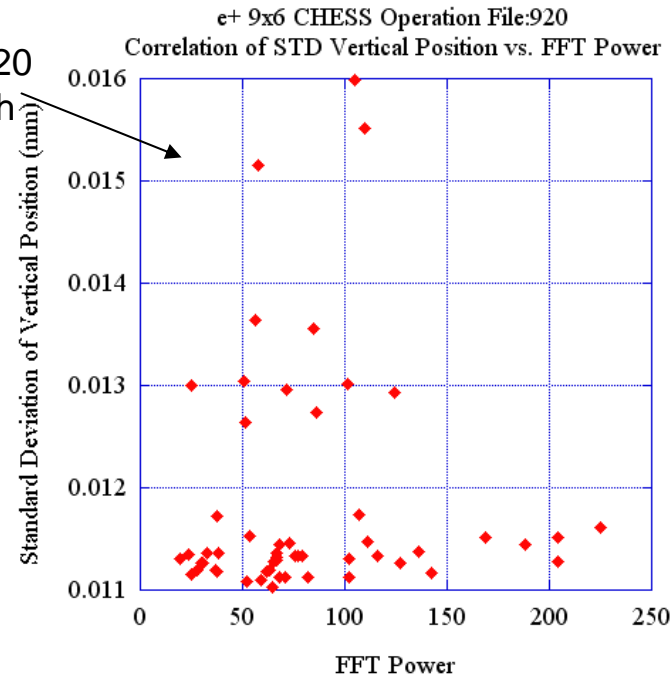
• The peak oscillation frequency of $f_{osc} = 195.2\text{kHz} = 1/2 * f_{rev}$ appears for the last bunch in a train. These bunches have a large oscillation amplitude that does not correlate with FFT noise.



e+ vertical position oscillation amplitude



Medium I File:920
 $I_{e^+}=3.5\text{mA/bunch}$



e+ vertical position oscillation amplitude (standard deviation of vertical position) does not correlate with FFT power. Instead, the amplitude increases with FFT noise.