

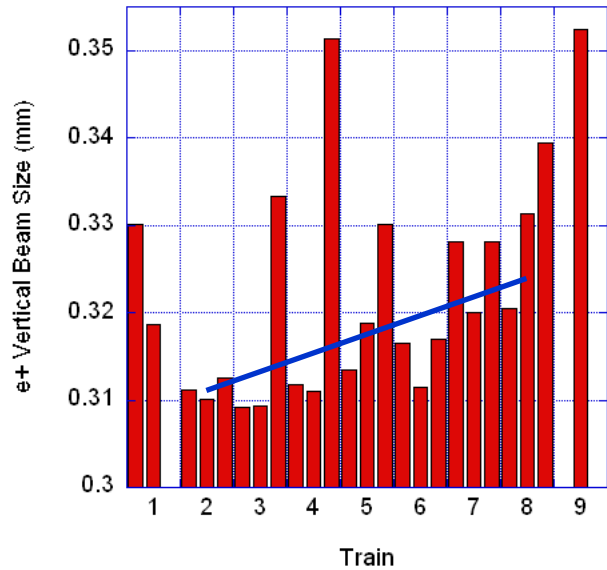
Parasitic CESR-c Colliding Beams PMT Measurements

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8/31/2006

Introduction:

- Single turn and average (100 turns) turn data was taken during CESR-c High Energy Physics collisions.
- Vertical profiles of e⁺/e⁻ bunches were measured using the photomultiplier tube (PMT) array when the PMT voltage was set at 550V.
- The bunch pattern during these measurements was 24 bunches in a 7x3 pattern (trains 2-8) with bunches 1 and 2 in train 1 and bunch 2 in train 9.

CESR-c colliding beams e+ 8x3 10K turn avg File: 451
 $I_{e-} = 1.954\text{mA}$, $I_{e+} = 1.624\text{mA}$

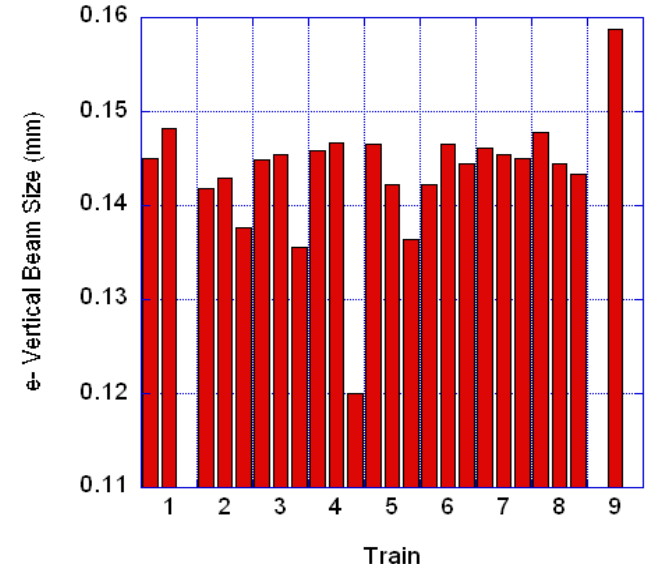


- The measurements shown here are 100 turn averages of the vertical position and beam size for 10K turns.

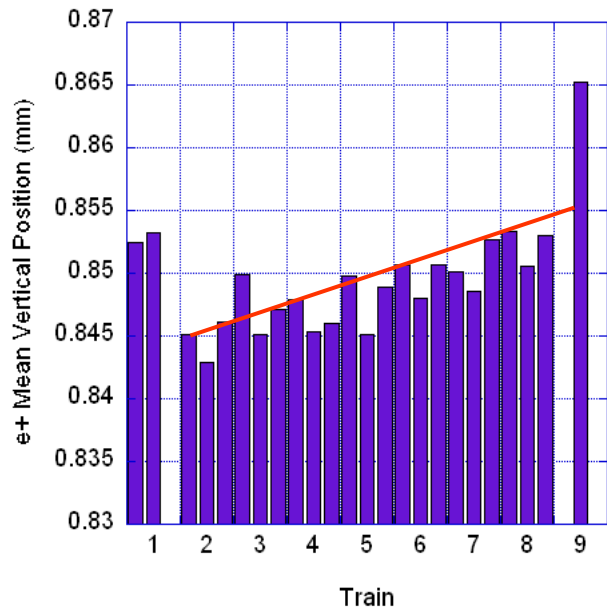
- The vertical position and beam size (σ_v) was measured for e+ and e-.

- Significant growth along the train is noted in the e+ beam size. There is also a shift in the vertical position along the train.

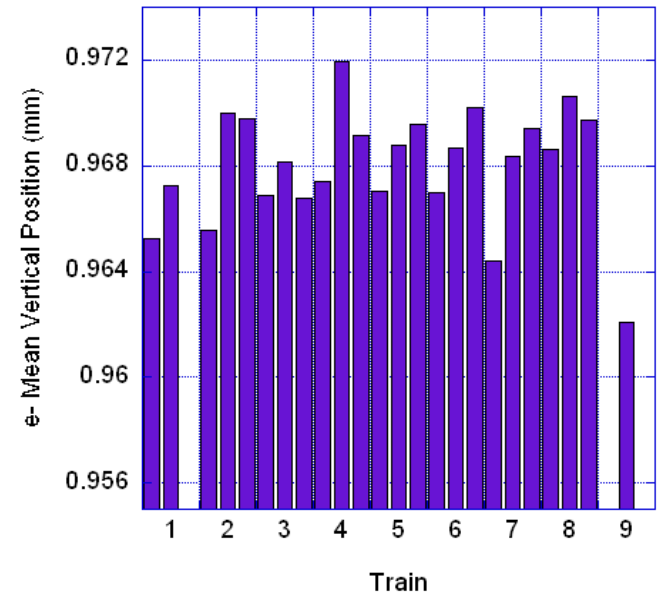
CESR-c colliding beams e- 8x3 10K turn avg File: 452
 $I_{e-} = 1.953\text{mA}$, $I_{e+} = 1.624\text{mA}$



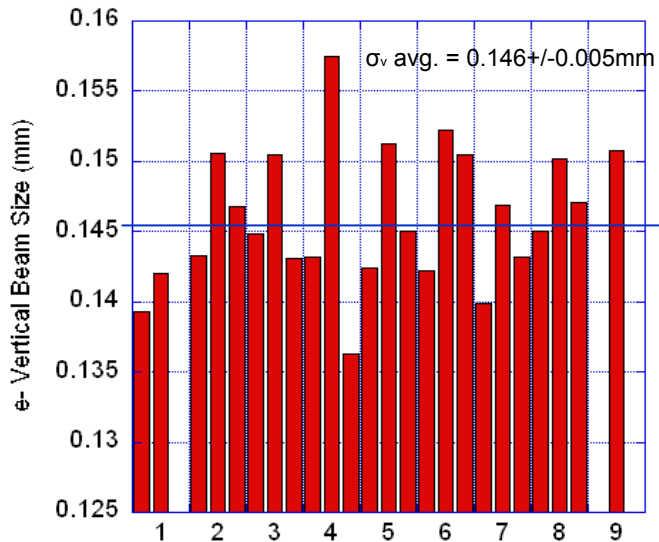
CESR-c colliding beams e+ 8x3 10K turn avg File: 451
 $I_{e-} = 1.954\text{mA}$, $I_{e+} = 1.624\text{mA}$



CESR-c colliding beams e- 8x3 10K turn avg File: 452
 $I_{e-} = 1.953\text{mA}$, $I_{e+} = 1.624\text{mA}$

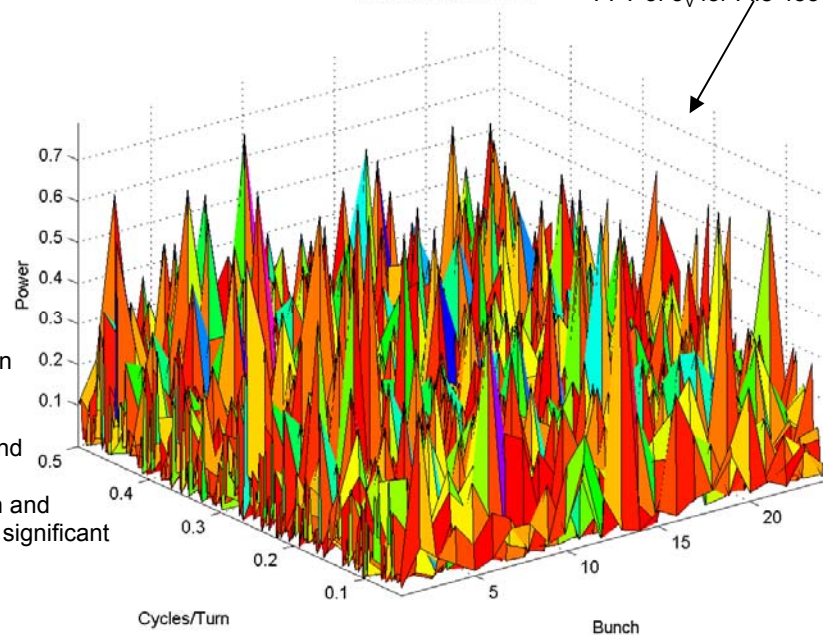


CESR-c colliding beams e- 8x3 500 turn-by-turn File: 453
le- =1.902mA, le+ =1.592mA

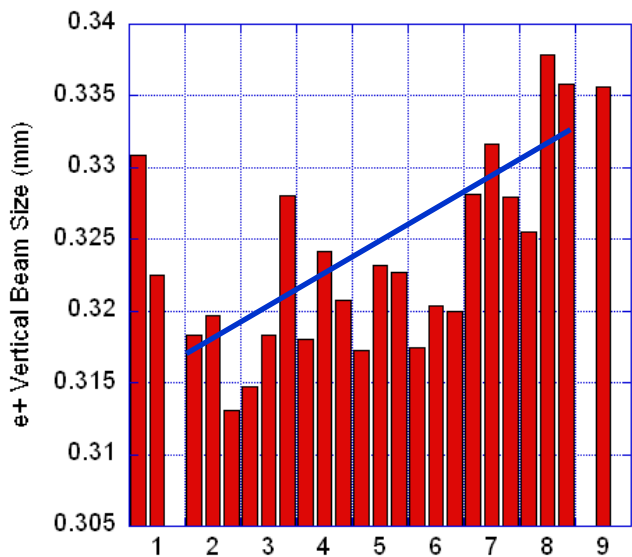


- e- single turn measurement for 500 turns
- The average vertical position and beam size for 500 turns
- No significant difference between 100 turn average and turn-by-turn results.
- The FFT of Vertical Position and Vertical Beam Size show no significant oscillation for File 453.

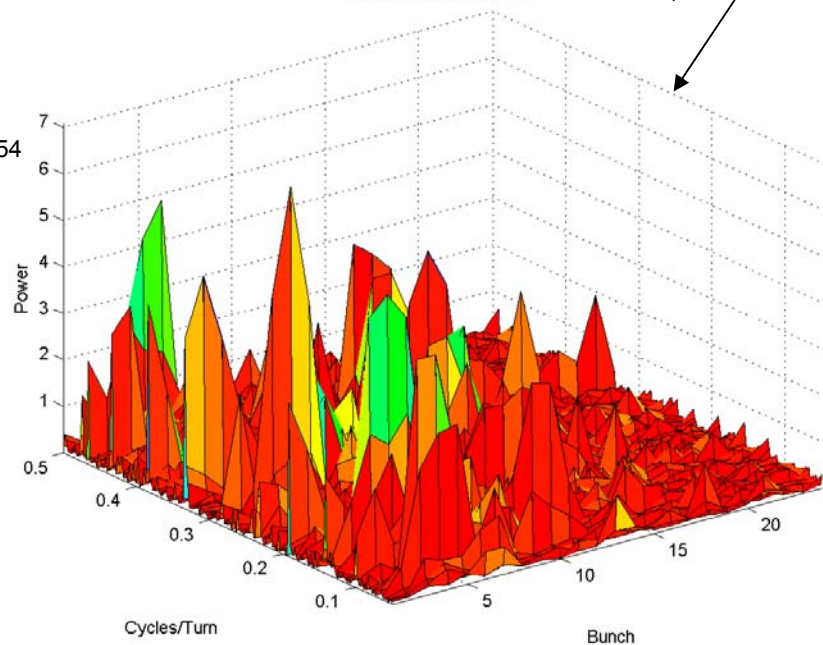
BSM23W453 results24 FFT of σ_v for File 453

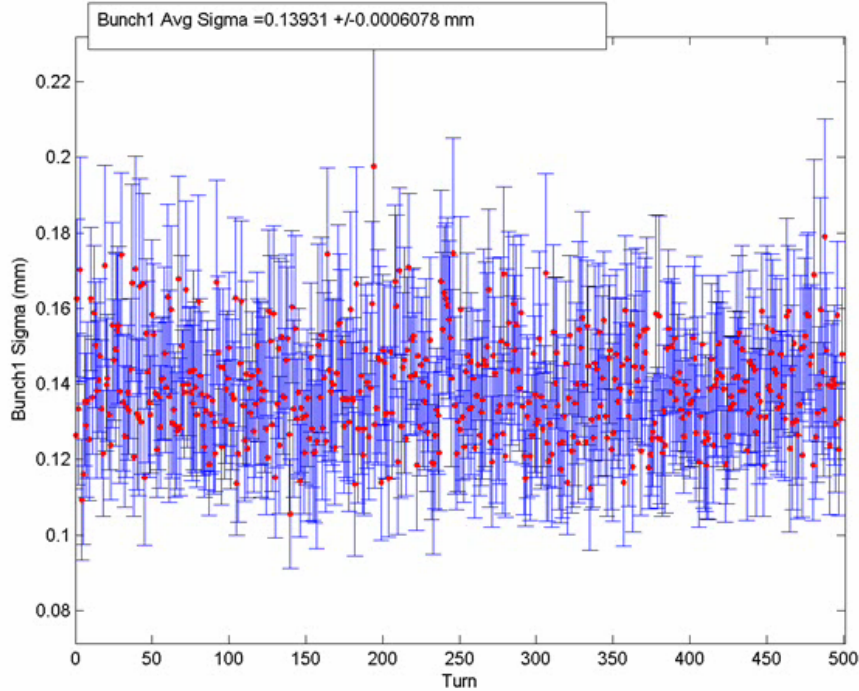


CESR-c colliding beams e+ 8x3 500 Turn-by-Turn File: 454
le- =1.902mA, le+ =1.592mA



BSM23E454 results24 FFT of σ_v for File 454

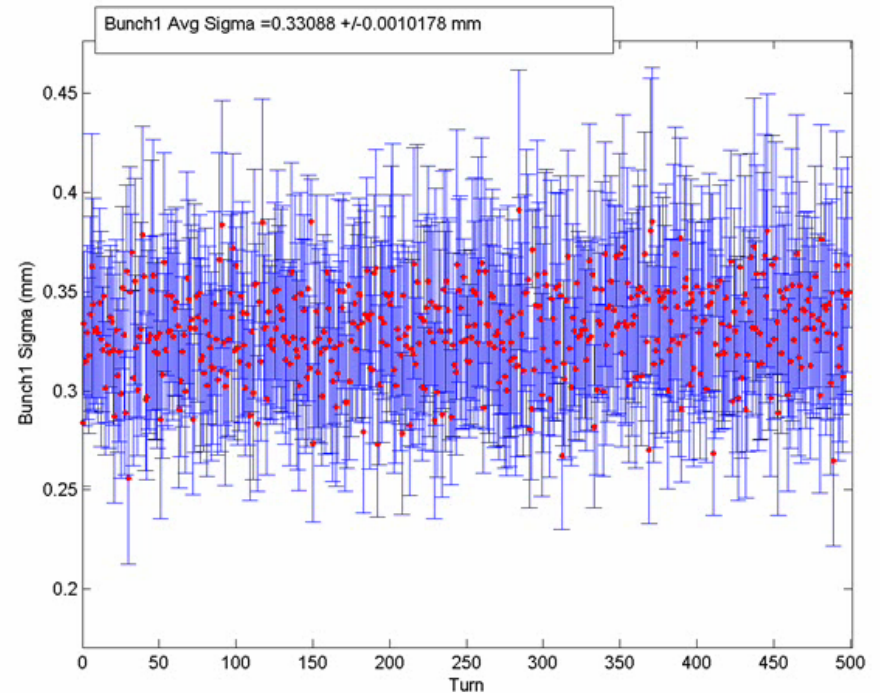




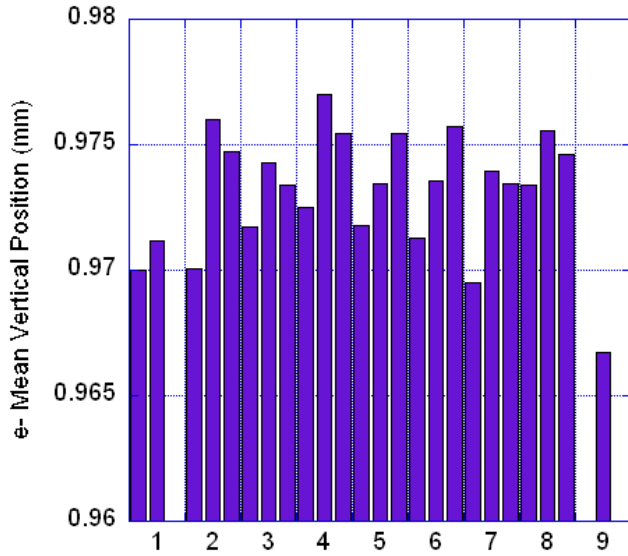
Video of turn-by-turn σ_v for 500 turns:

e- σ_v for 500 turns for all 24 bunches
(File 453)-movie

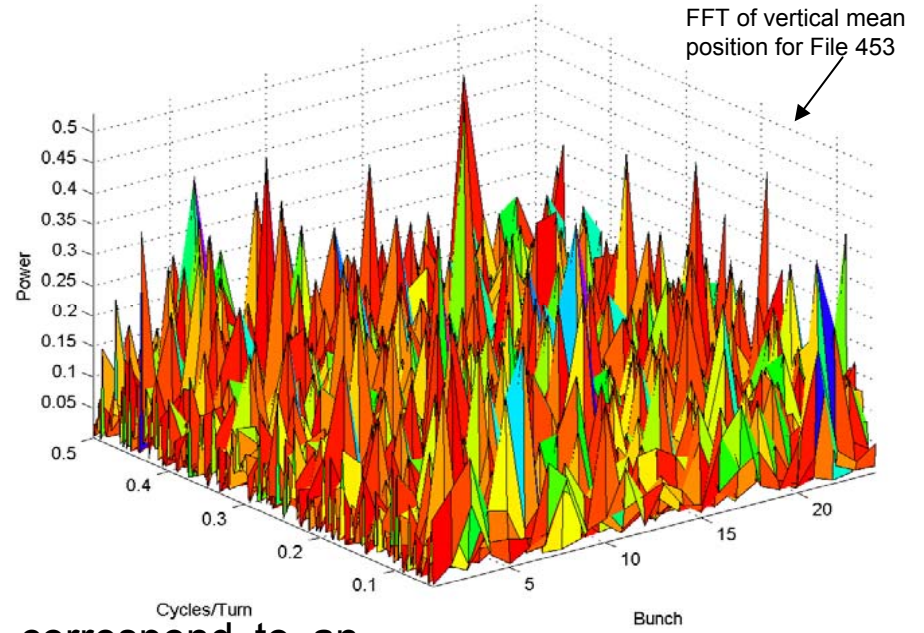
e+ single tune σ_v for 500 turns for all
24 bunches (File 454)-movie



CESR-c colliding beams e- 8x3 500 turn-by-turn File: 453
 $I_{e-} = 1.902\text{mA}$, $I_{e+} = 1.592\text{mA}$

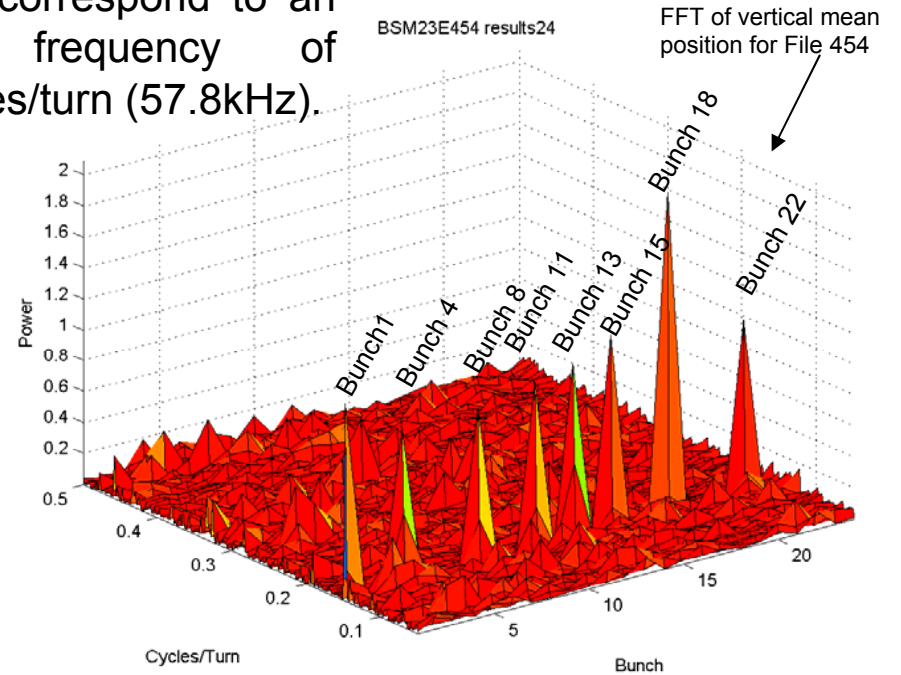


BSM23W453 results24

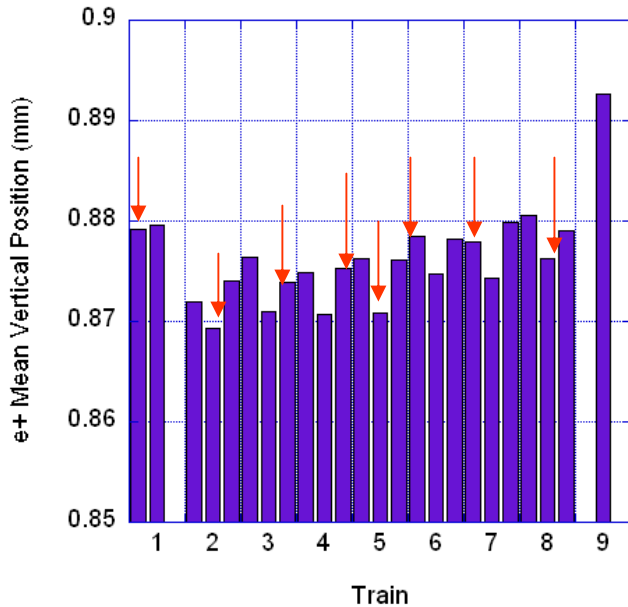


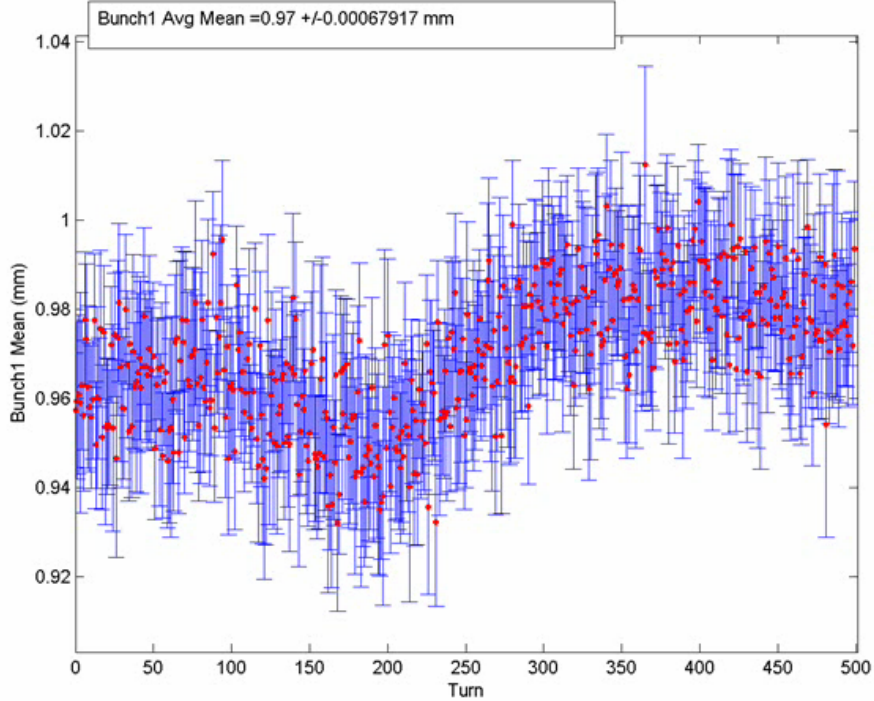
The peaks correspond to an oscillation frequency of 0.1480 cycles/turn (57.8kHz).

BSM23E454 results24



CESR-c colliding beams e+ 8x3 500 turn-by-turn File: 454
 $I_{e-} = 1.902\text{mA}$, $I_{e+} = 1.592\text{mA}$

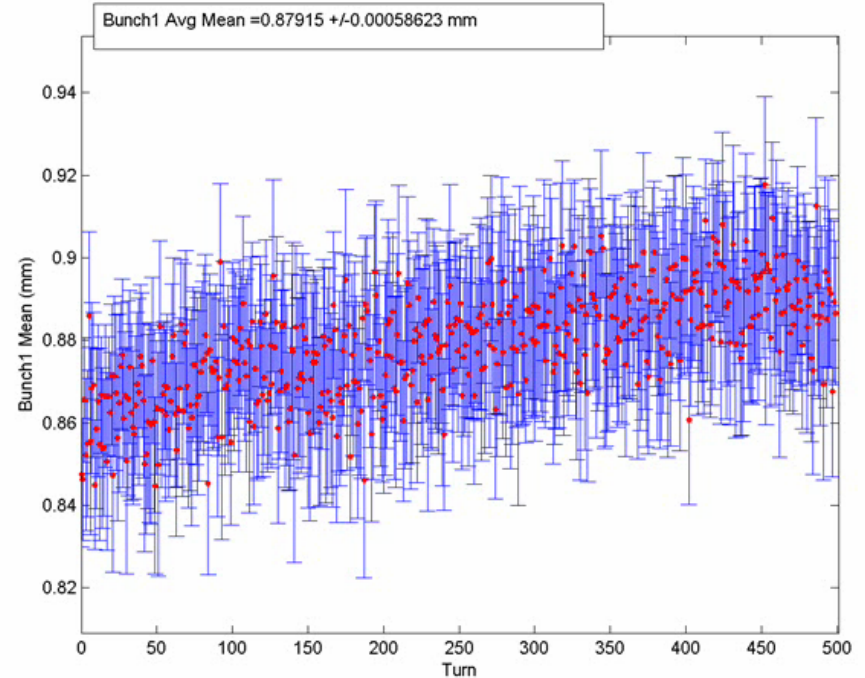




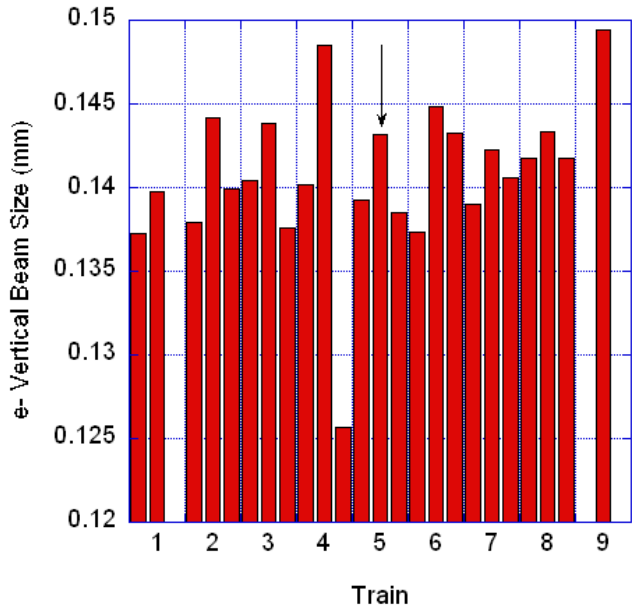
Video of mean vertical position for 500 turns:

e- mean vertical position for 500 turns for all 24 bunches (File 453)-movie
Low frequency oscillation is present.

e+ single turn mean vertical position for 500 turns for all 24 bunches (File 454)-movie.

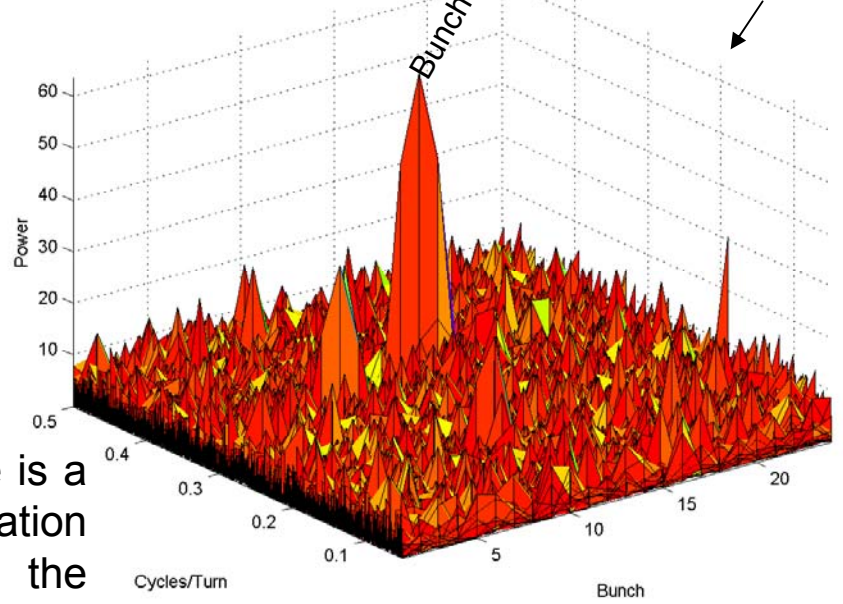


CESR-c colliding beams e- 8x3 10K turn-by-turn File: 455
 $I_{e-} = 1.863\text{mA}$, $I_{e+} = 1.565\text{mA}$

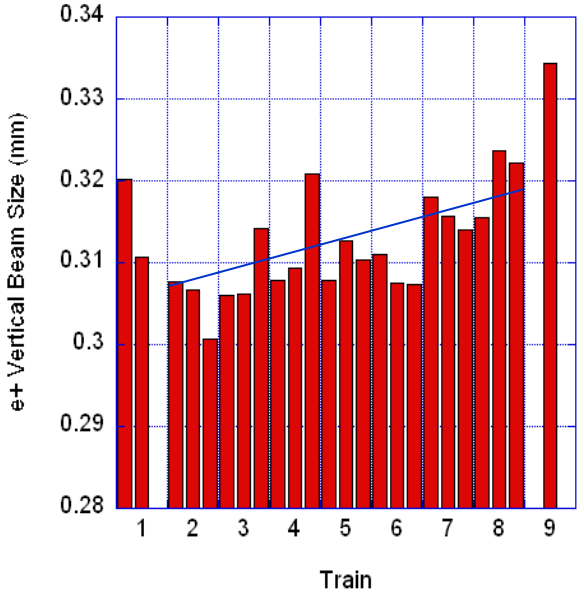


$I_{e-} > I_{e+}$. There is a strong oscillation frequency for the higher current e- bunches.

BSM23W455 results24
 FFT of σ_v for File 455

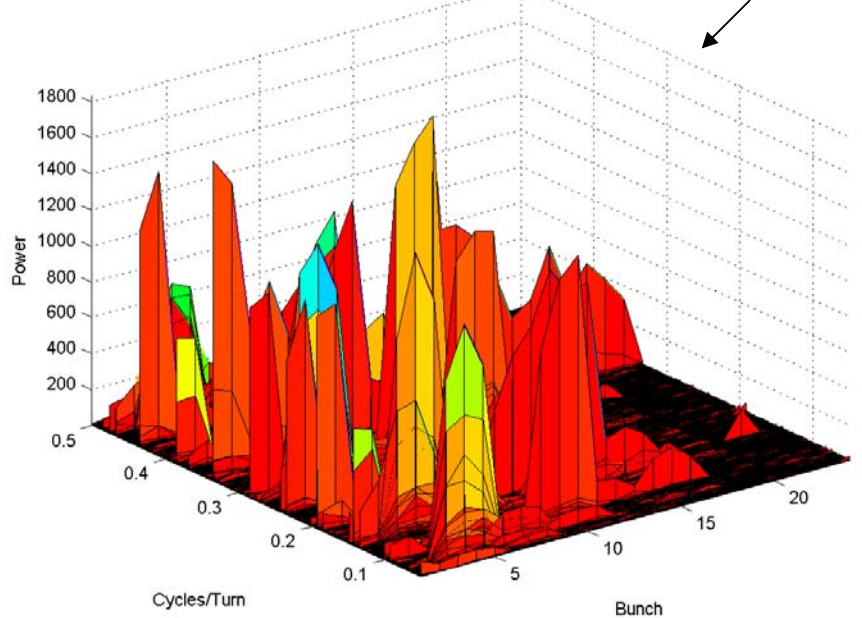


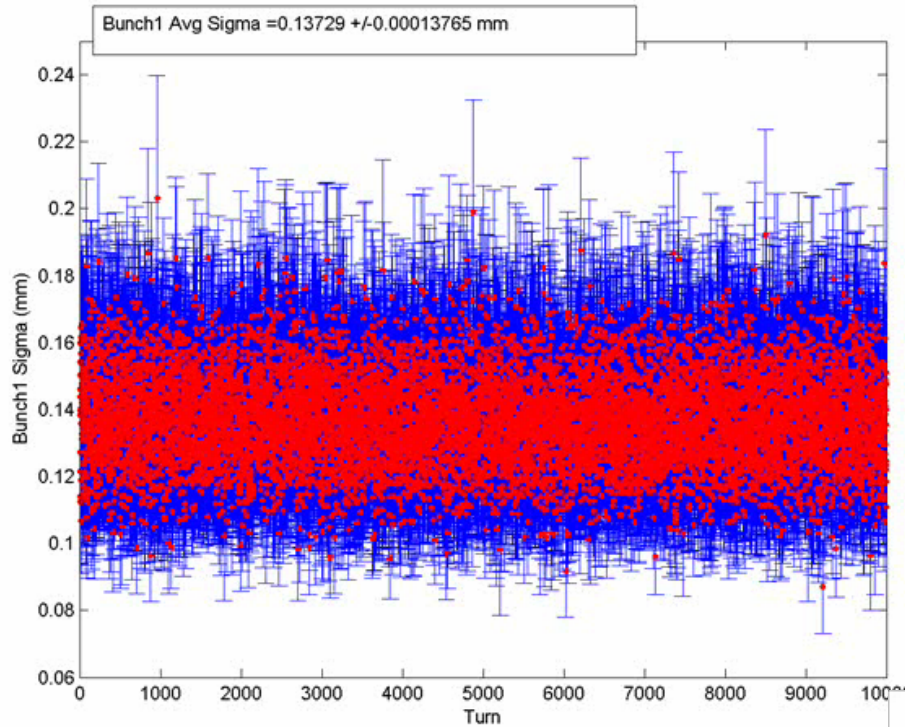
CESR-c colliding beams e+ 8x3 10K turn-by-turn File: 456
 $I_{e-} = 1.863\text{mA}$, $I_{e+} = 1.565\text{mA}$



10K turns of data.

BSM23E456 results24
 FFT of σ_v for File 456

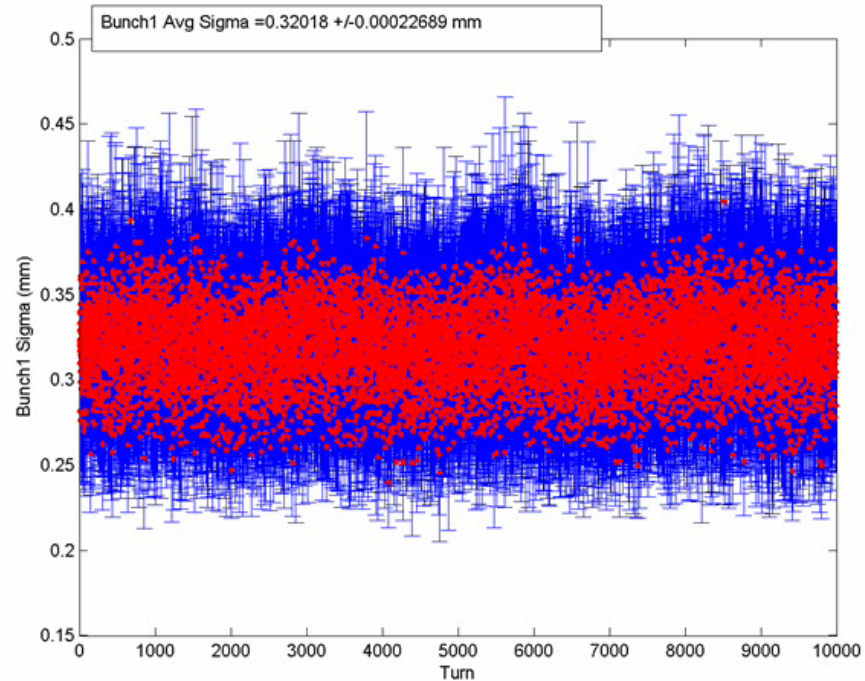




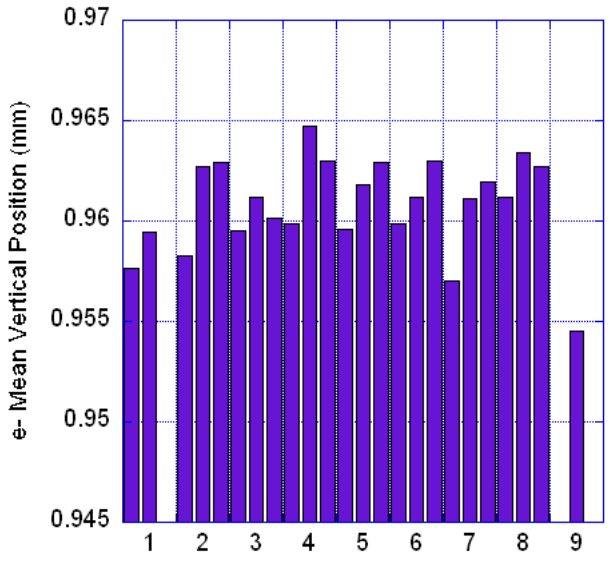
Video of turn-by-turn σ_v for 10K turns:

σ_v e- 10K turns for 24 bunches
(File 455)-movie

e+ σ_v 10K for 24 bunches (File 456)-movie

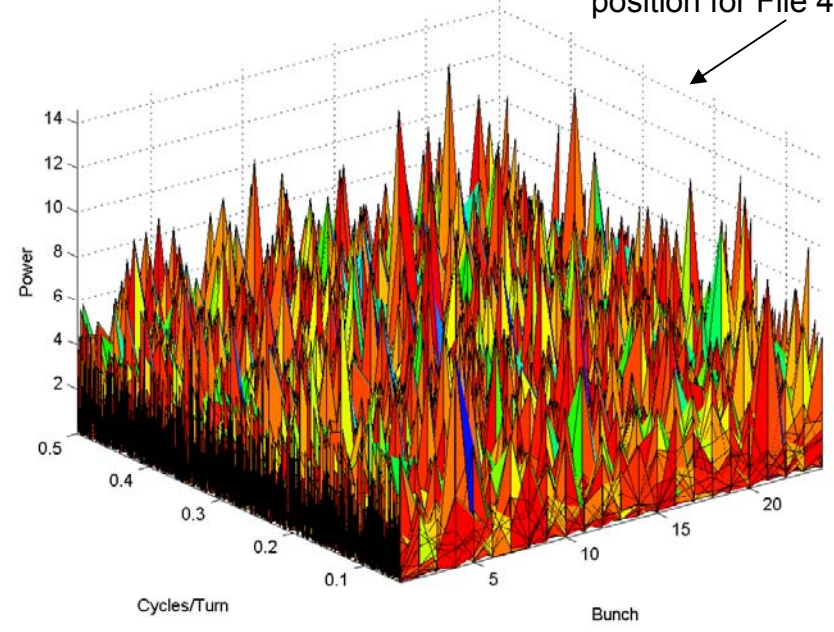


CESR-c colliding beams e- 8x3 10K turn-by-turn File: 455
 $I_{e-} = 1.863\text{mA}$, $I_{e+} = 1.565\text{mA}$

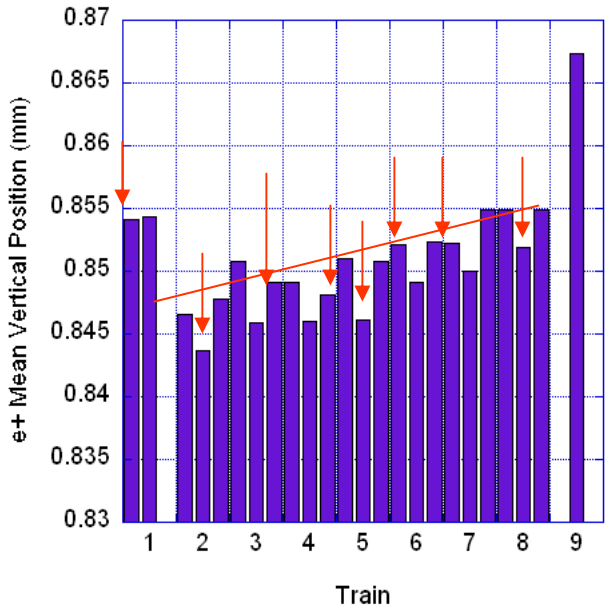


BSM23W455 results24

FFT of the mean vertical position for File 455



CESR-c colliding beams e+ 8x3 10K turn-by-turn File: 456
 $I_{e-} = 1.863\text{mA}$, $I_{e+} = 1.565\text{mA}$



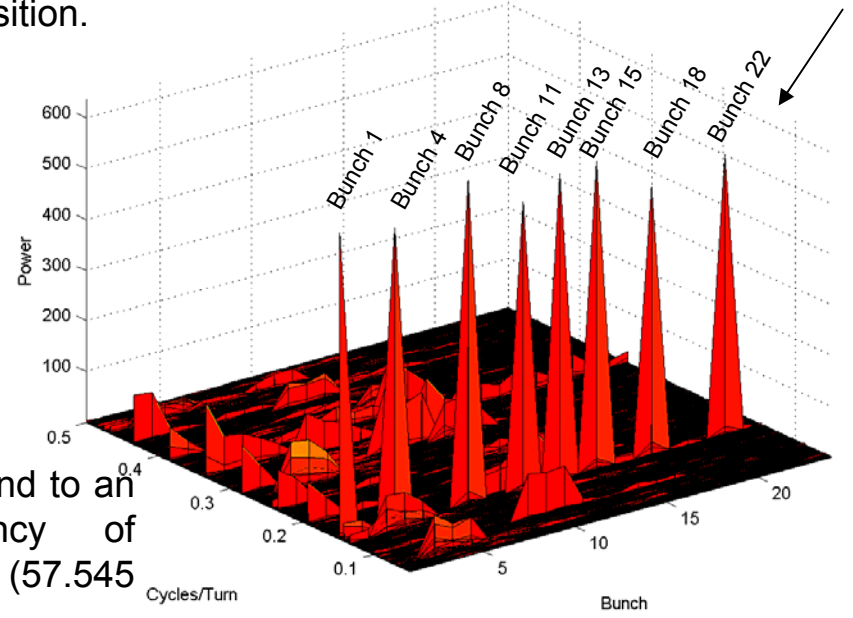
Shift in the vertical position.

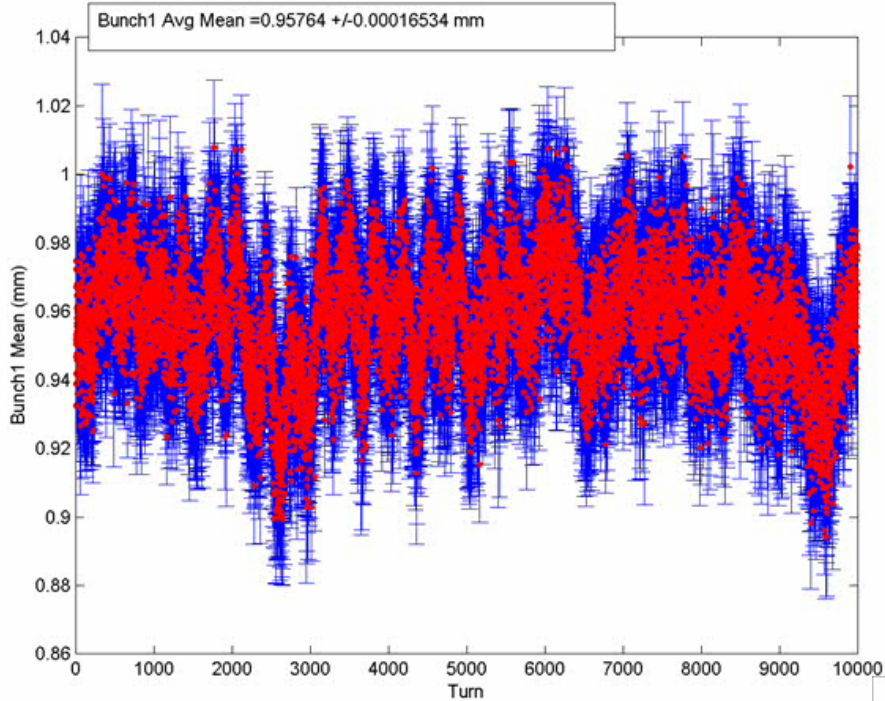
10K turns of data.

The peaks correspond to an oscillation frequency of 0.1474 cycles/turn (57.545 kHz)

BSM23E456 results24

FFT of the mean vertical position for File 456

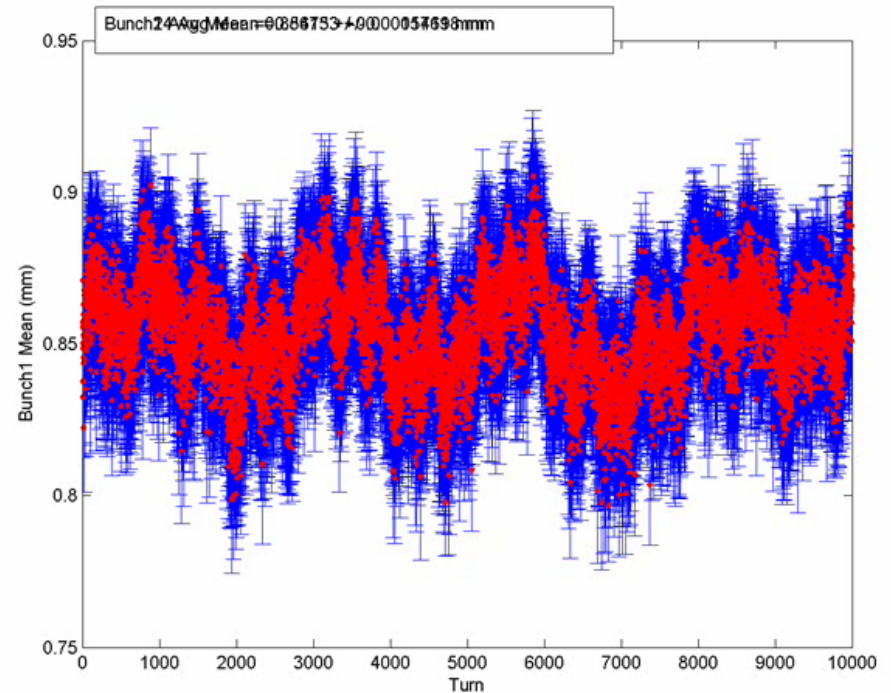




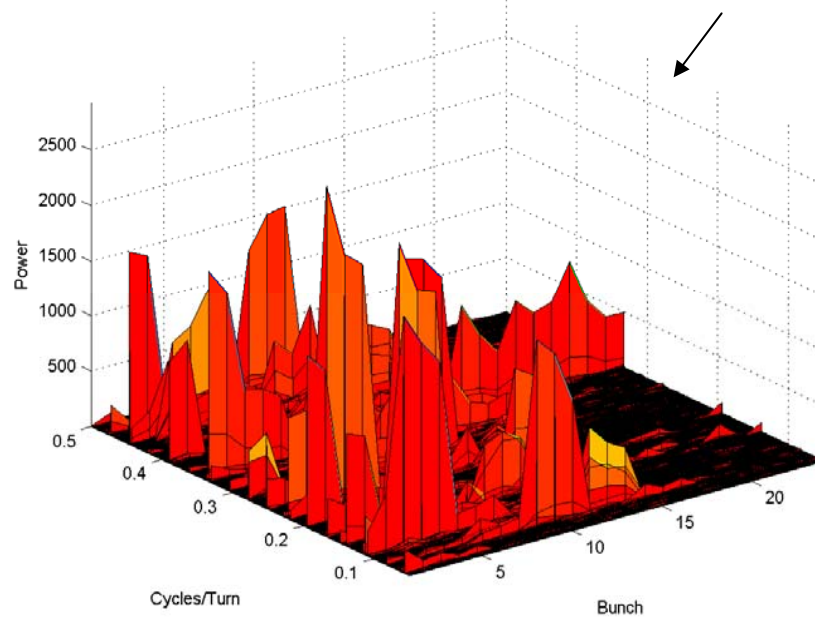
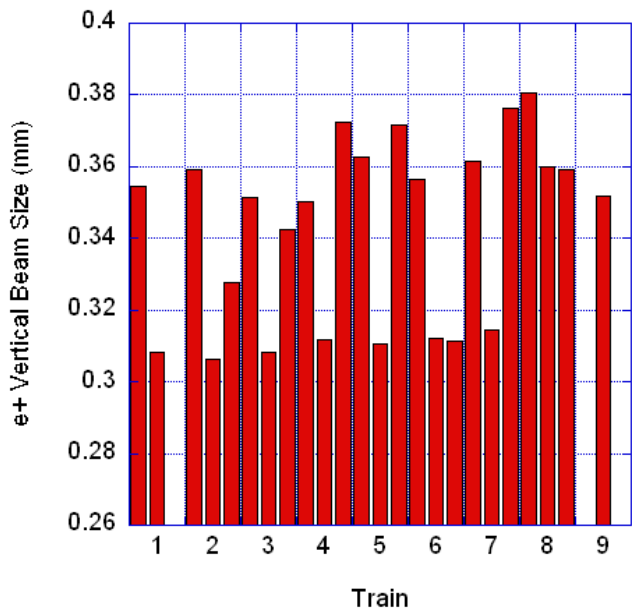
Video of Mean Vertical Position for 10K turns:

e- vertical position 10K turns for 24 bunches (File 455)-movie
 Low frequency oscillation ~1.1kHz

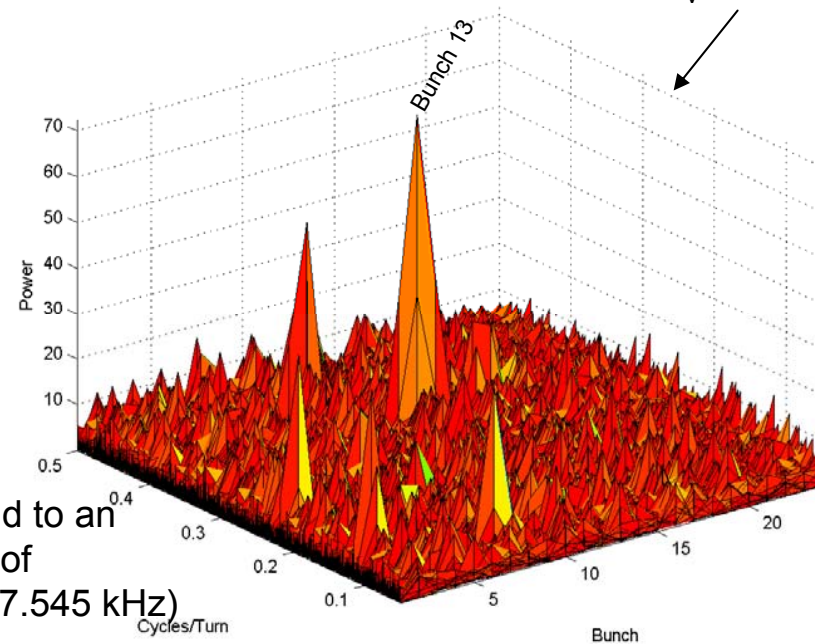
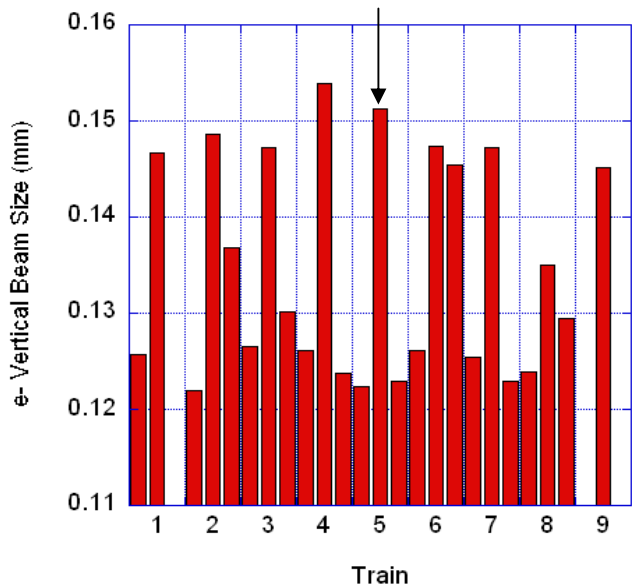
e+ vertical position 10K for 24 bunches (File 456)-movie
 Low frequency oscillation ~.16kHz



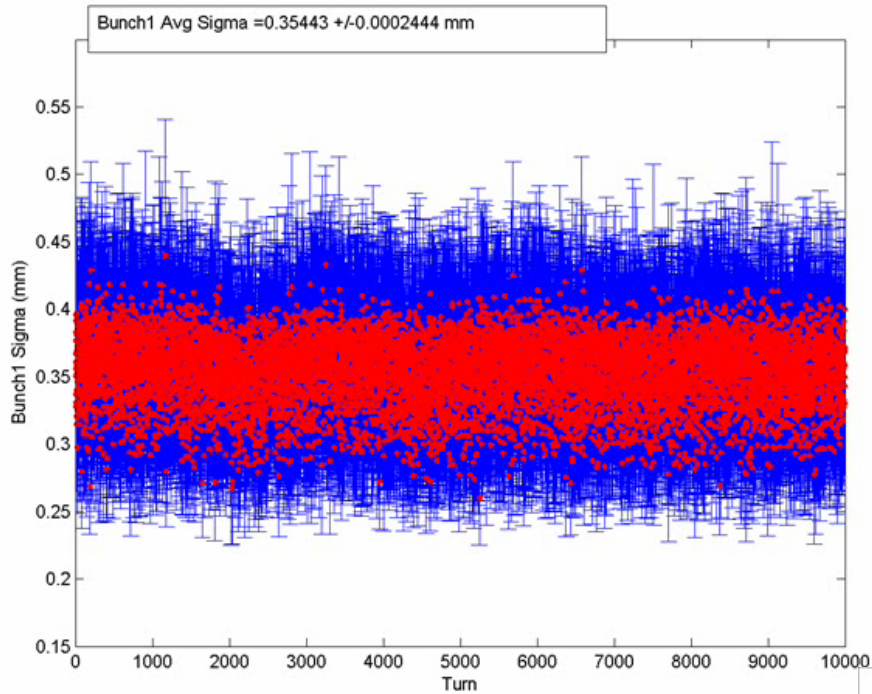
CESR-c colliding beams e+ 8x3 10K turn-by-turn File: 460
le- =1.862mA, le+ =1.614mA



CESR-c Colliding Beams e- 8x3 10K Turn-by-Turn File: 461
le- =1.862mA le+ =1.614mA



The peaks correspond to an oscillation frequency of 0.1474 cycles/turn (57.545 kHz)

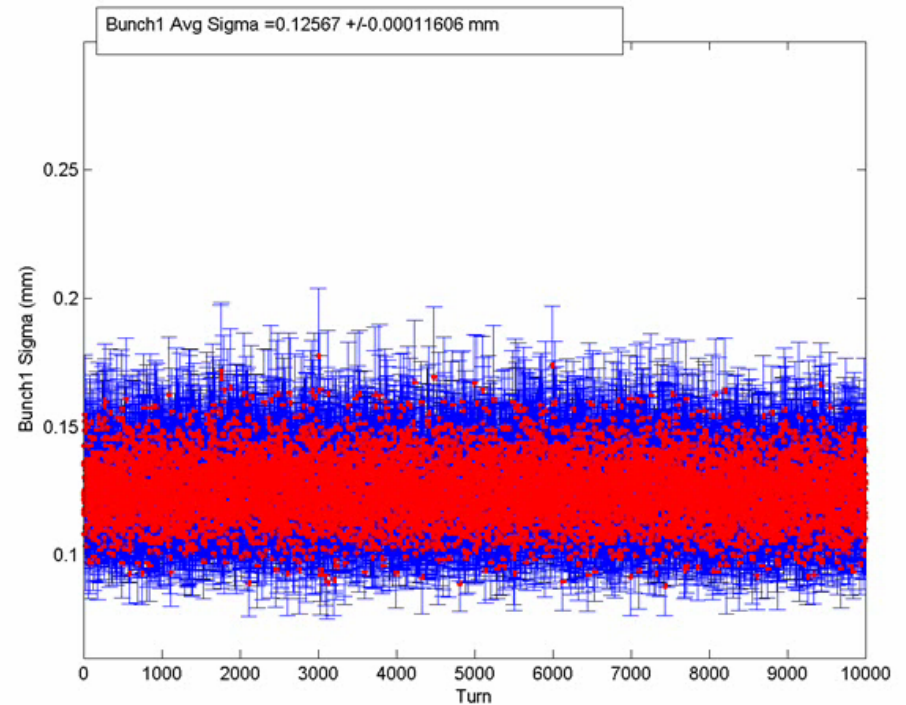


Video of σ_v for 10K turns:

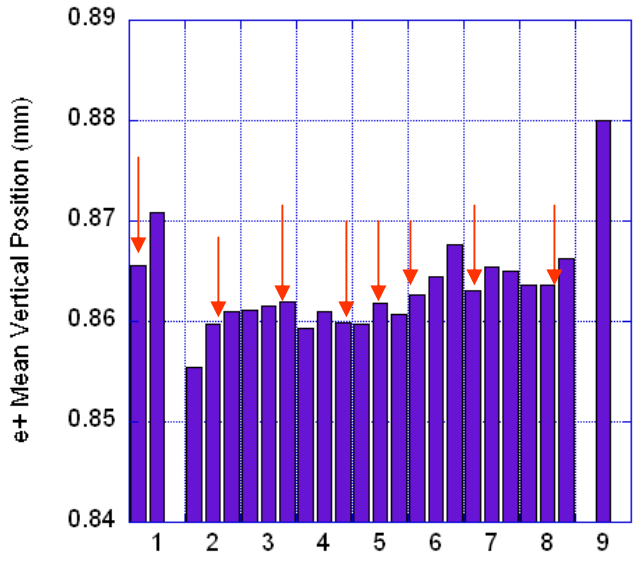
e+ σ_v 10K turns for 24 bunches
(File 460)-movie

e- σ_v turn-by-turn for 10K turns for
24 bunches (File 461)-movie

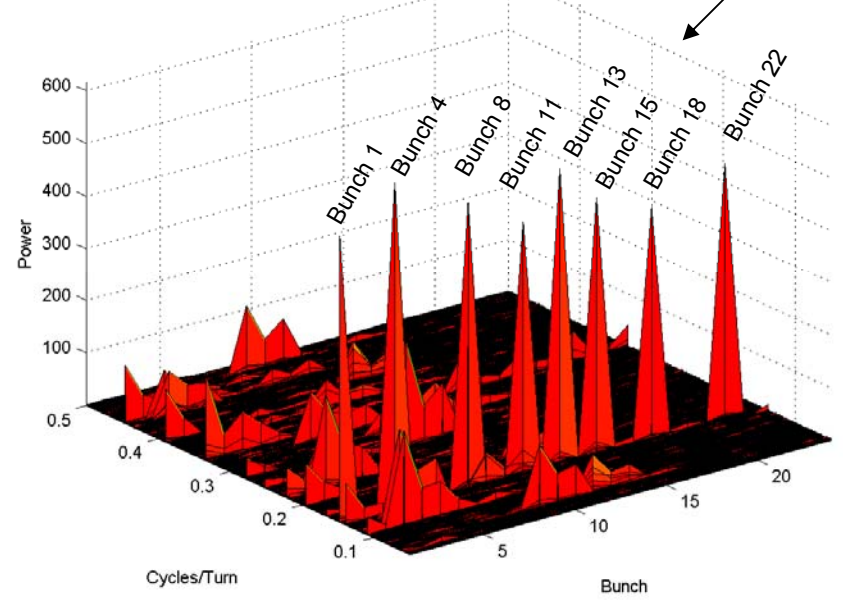
No low frequency oscillation is
present for e+ bunches.



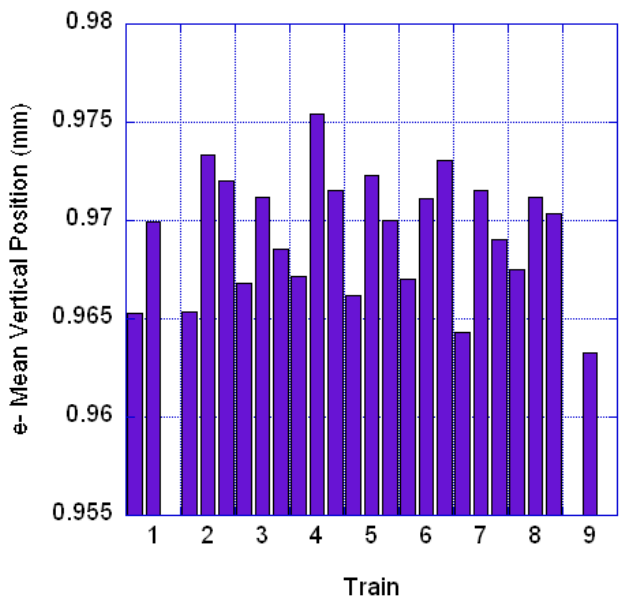
CESR-c colliding beams e+ 8x3 10K turn-by-turn File: 460
le- =1.862mA, le+=1.614mA



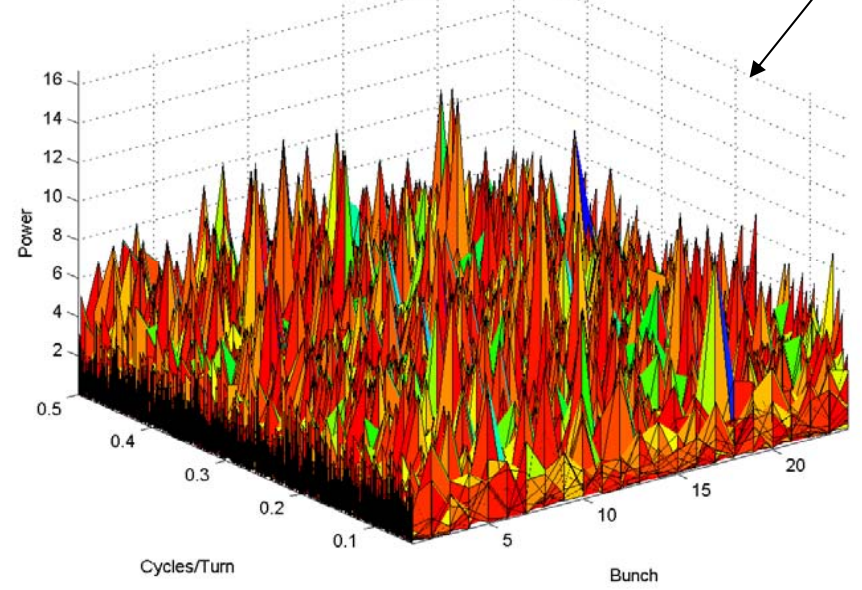
BSM23E460 results24 FFT of the mean vertical position for File 460

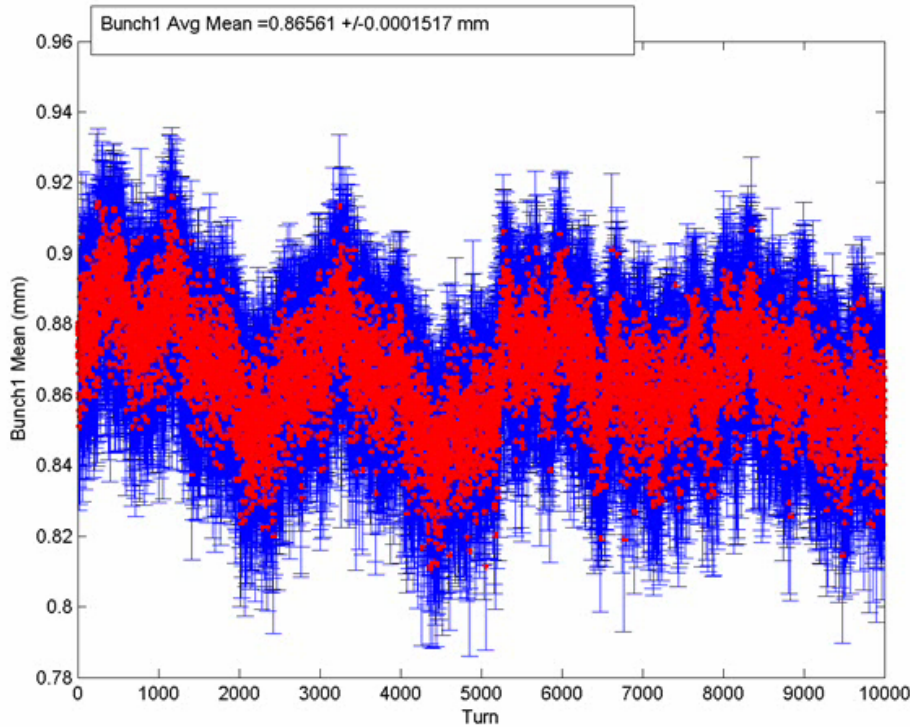


CESR-c Colliding Beams e- 8x3 10K Turn-by-Turn File: 461
le- =1.862mA le+=1.614mA



BSM23W461 results24 FFT of the mean vertical position for File 461

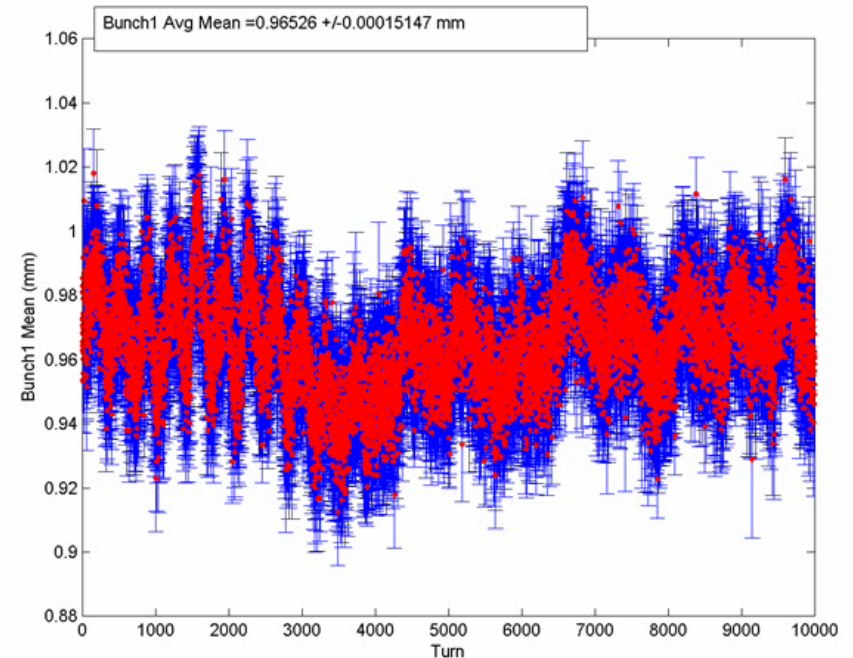




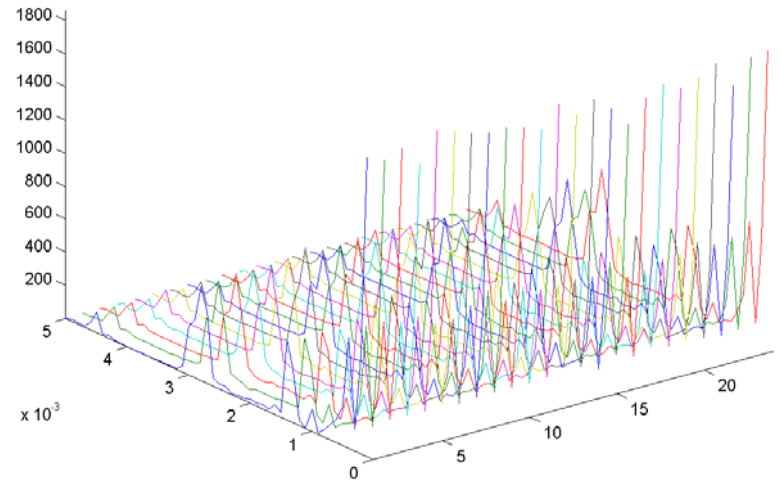
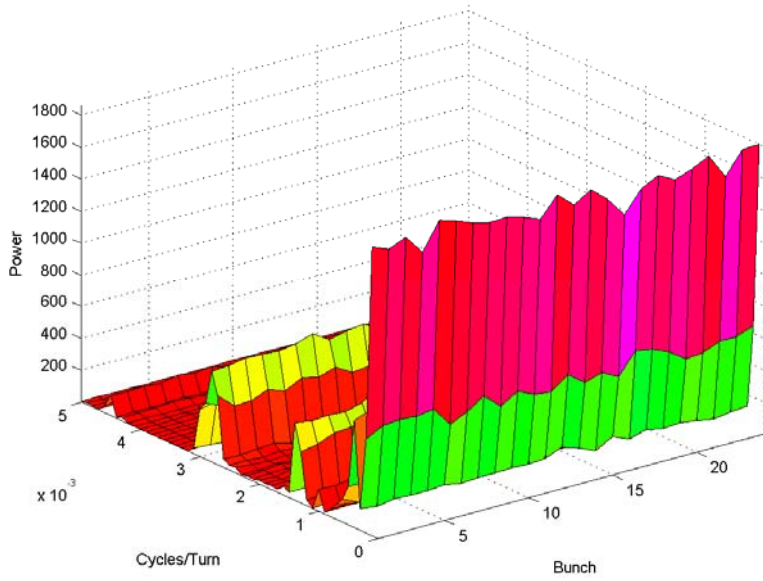
Video of Mean Vertical Position:

e+ vertical beam size for 10K turns for 24 bunches (File 460)-movie

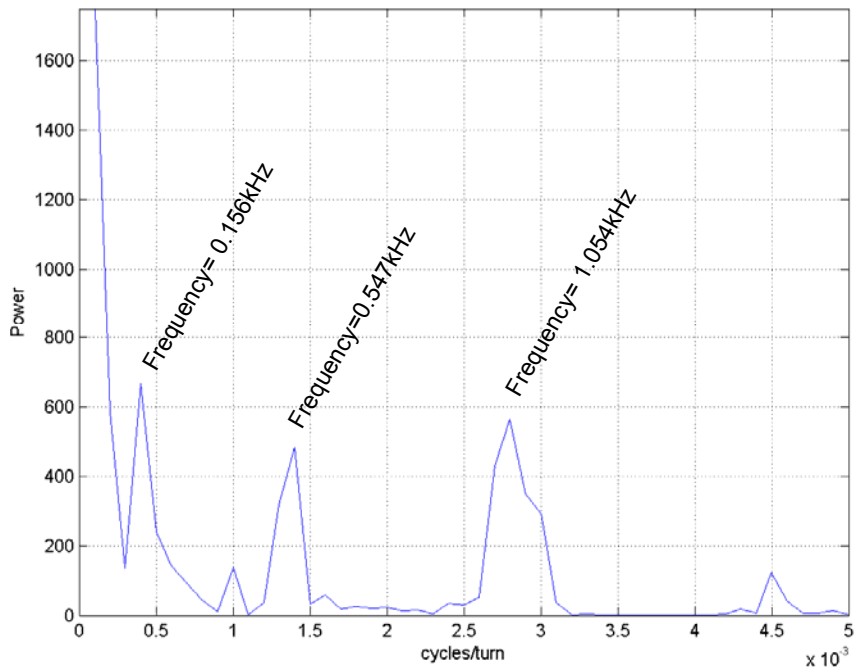
e- vertical position turn-by-turn for 10K turns for 24 bunches (File 461)-movie
 Low frequency oscillation from 0-3000 Turns = 0.0781kHz
 Low frequency oscillation from 4500-10000 Turns = 0.1562kHz



BSM23W461 results24



BSM23W461 results1

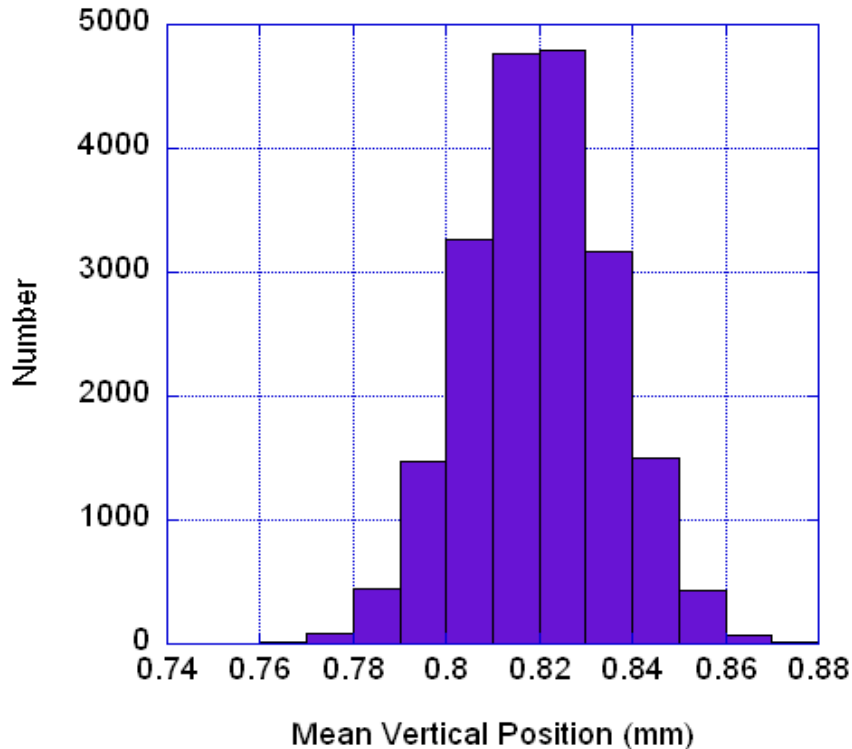


FFT of the mean vertical position was made between 0.0 and 0.005 to determine the low frequency oscillation.

Turn-by-turn e- Vertical Position and Vertical Beam Size, bunch 3 train 3, 20K turns.

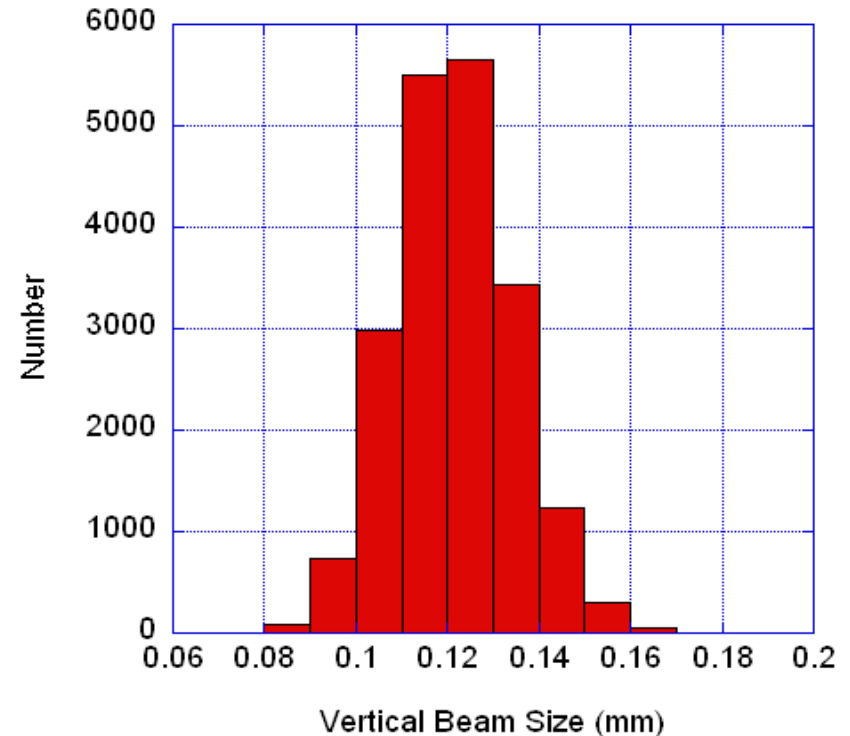
e- Train 3, Bunch 3
20K Turn-by-Turn
File: 458 I=1.67mA

e- Mean Vertical Position (mm)	
Mean	0.81995555
Std Deviation	0.015490757
Std Error	0.0001095362



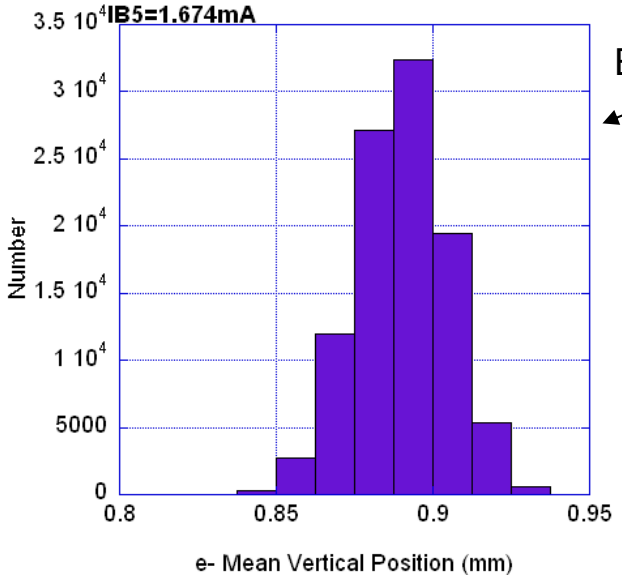
e- Train 3, Bunch 3
20K Turn-by-Turn
File: 458 I=1.67mA

e- Vertical Beam Size (mm)	
Mean	0.12151611
Std Deviation	0.012986761
Std Error	9.1830271e-05



e- Train 4, Bunch 3-5
100K Turn-by-Turn
File: 462 mean
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

e- Mean Vertical Position (mm)	
Mean	0.89021319
Std Deviation	0.014593173
Std Error	4.6147665e-05

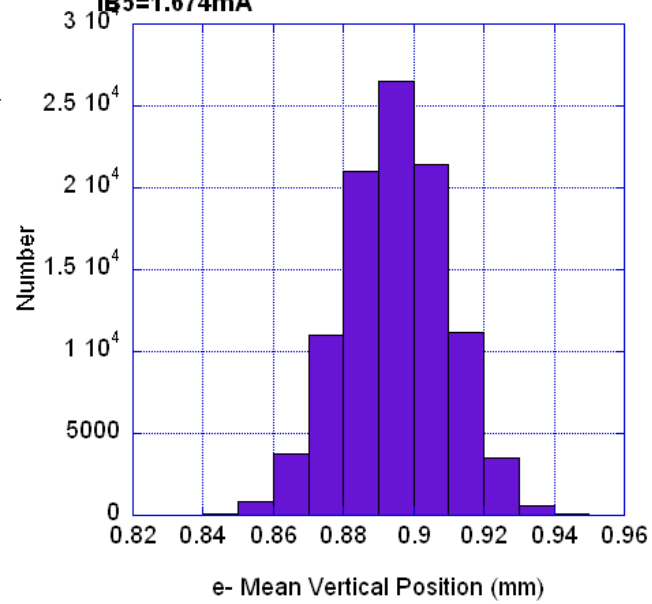


Bunch 3

e- Mean vertical position For train 4, bunches 3-5.

e- Train 4, Bunch 3-5
100K Turn-by-Turn
File: 462 mean 2
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

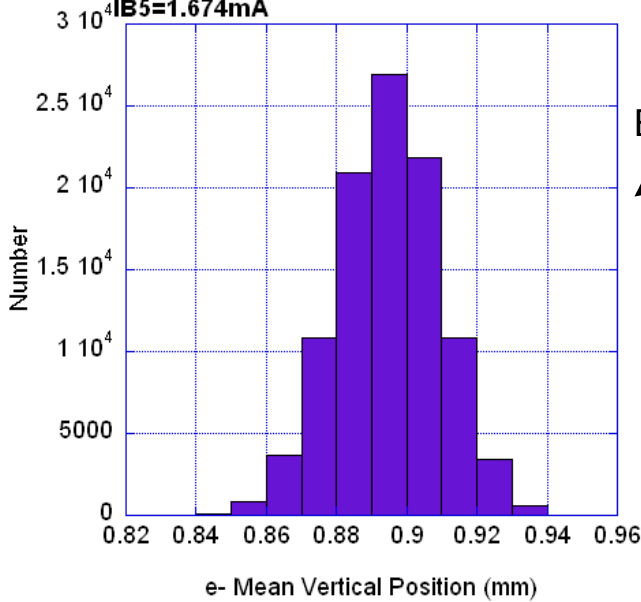
e- Mean Vertical Position (mm)	
Mean	0.89487405
Std Deviation	0.014538789
Std Error	4.5975688e-05



Bunch 4

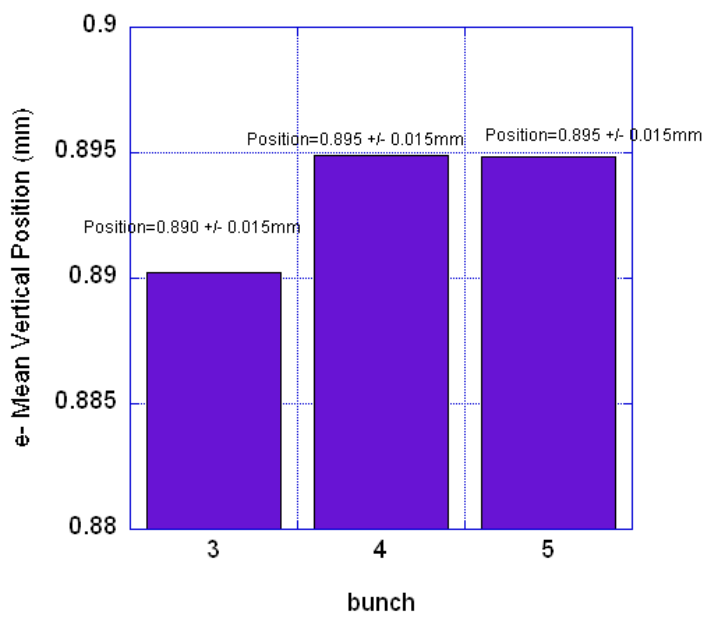
e- Train 4, Bunch 3-5
100K Turn-by-Turn
File: 462 mean 3
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

e- Mean Vertical Position (mm)	
Mean	0.8948614
Std Deviation	0.014670272
Std Error	4.6391473e-05



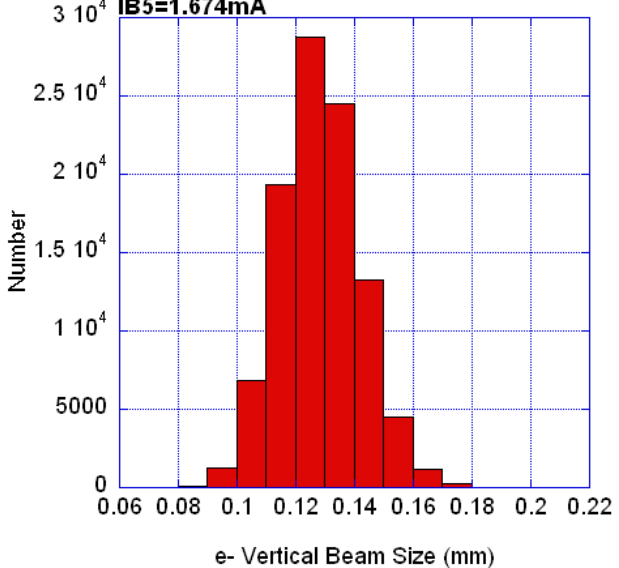
Bunch 5

e- Train 4, Bunch3-5 100K Turn-by-Turn File: 462
IB3=1.712mA IB4=1.681mA IB5=1.674mA



e- Train 4, Bunch 3-5
100K Turn-by-Turn
File: 462 sigma bunch 3
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

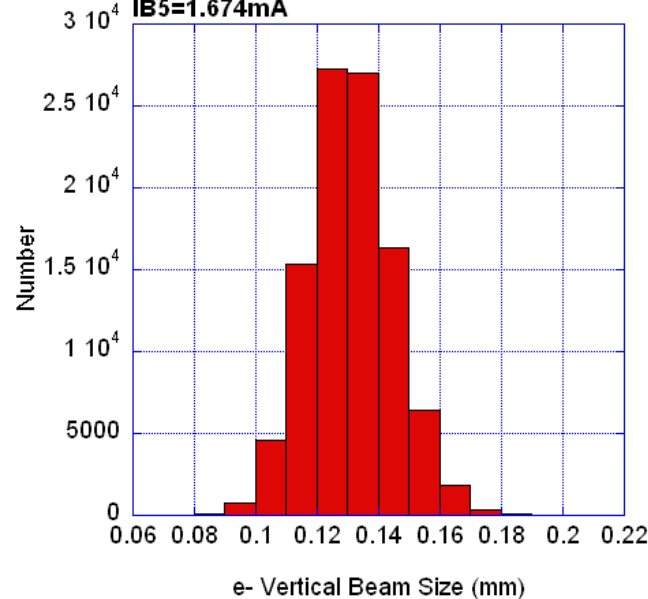
e- Vertical Beam Size (mm)	
Mean	0.12833605
Std Deviation	0.013617865
Std Error	4.3063471e-05



e- σ_v for train 4,
 bunches 3-5.

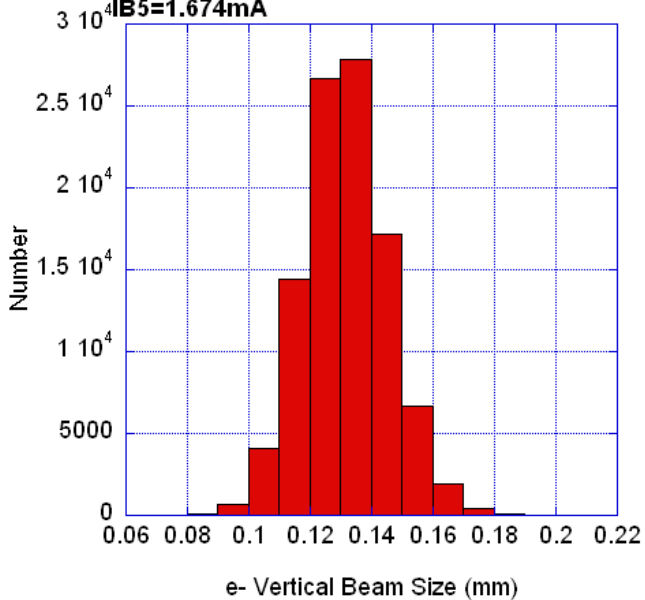
e- Train 4, Bunch 3-5
100K Turn-by-Turn
File: 462 sigma bunch 4
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

e- Vertical Beam Size (mm)	
Mean	0.13119181
Std Deviation	0.013670982
Std Error	4.3231441e-05

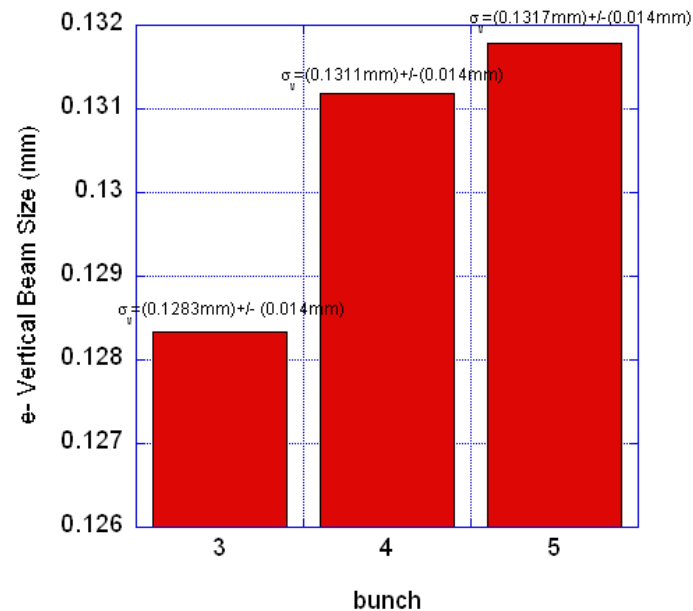


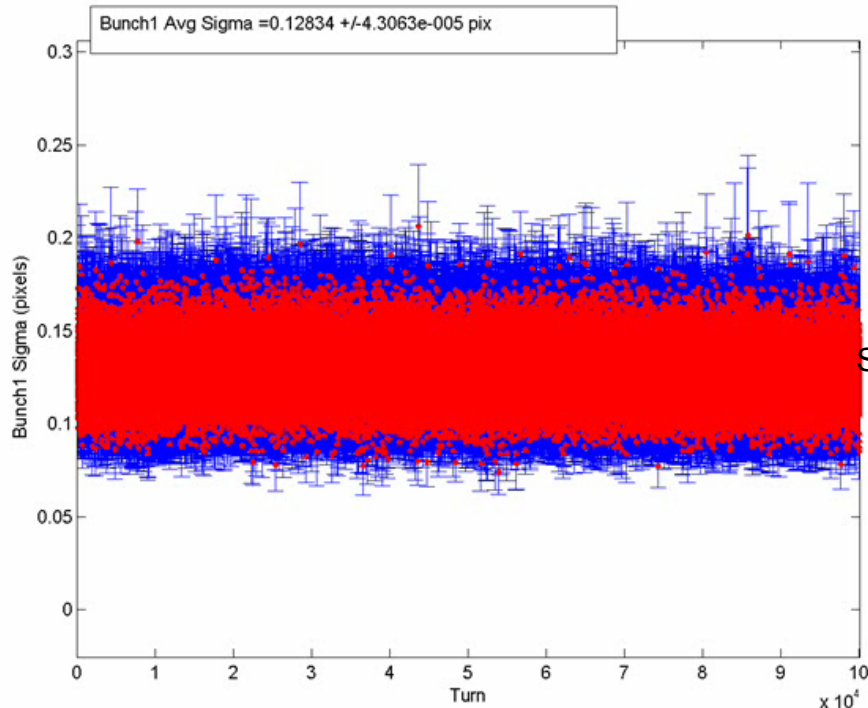
e- Train 4, Bunch 3-5
100K Turn-by-Turn
File: 462 sigma bunch 5
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

e- Vertical Beam Size (mm)	
Mean	0.13177784
Std Deviation	0.013576906
Std Error	4.2933948e-05



e- Train 4, Bunch3-5 100K Turn-by-Turn File: 462
IB3=1.712mA IB4=1.681mA IB5=1.674mA

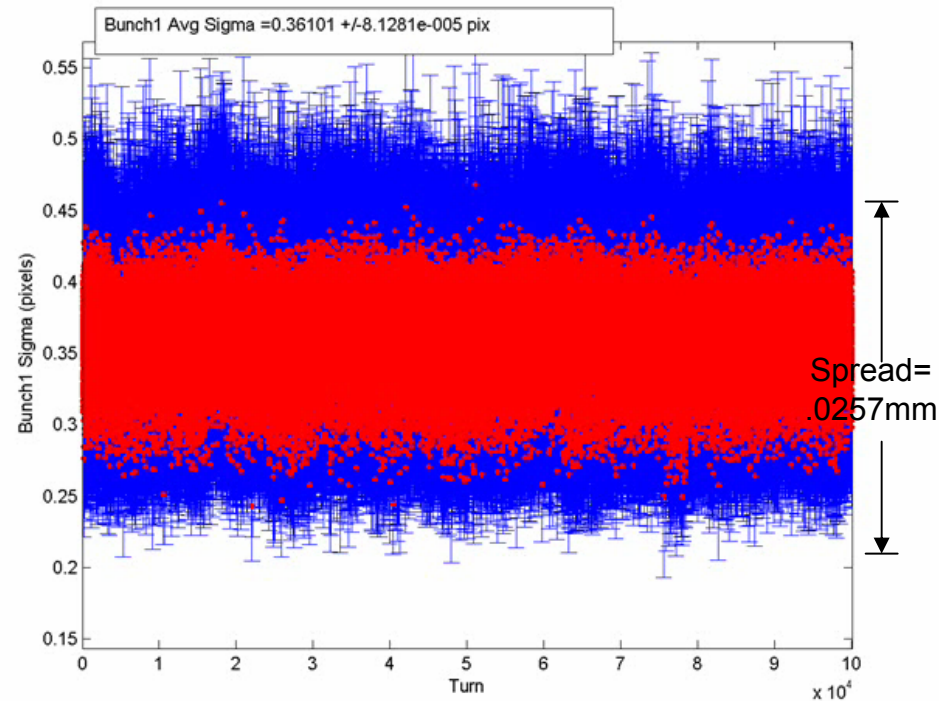




Video of σ_v for 100K turns:

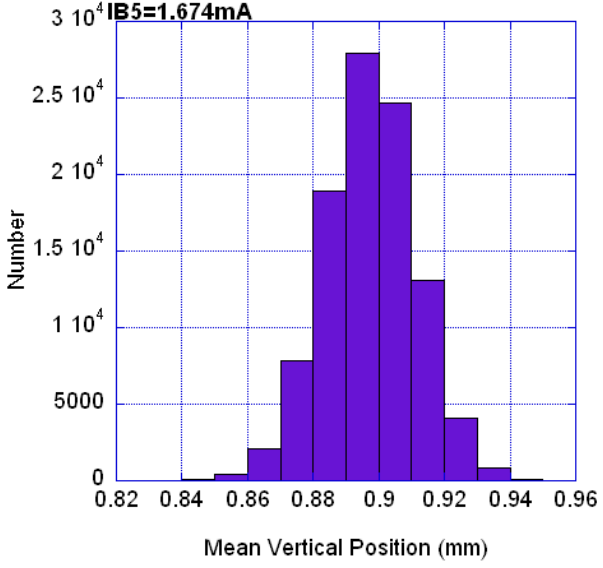
e- σ_v for 100K turns for 3 bunches
(File 462)- movie.

e+ σ_v for 100K turns
for all 24 bunches (File 463)-movie.



e+ Train 4, Bunch 3-5
100K Turn-by-Turn
File: 463 mean bunch 3
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

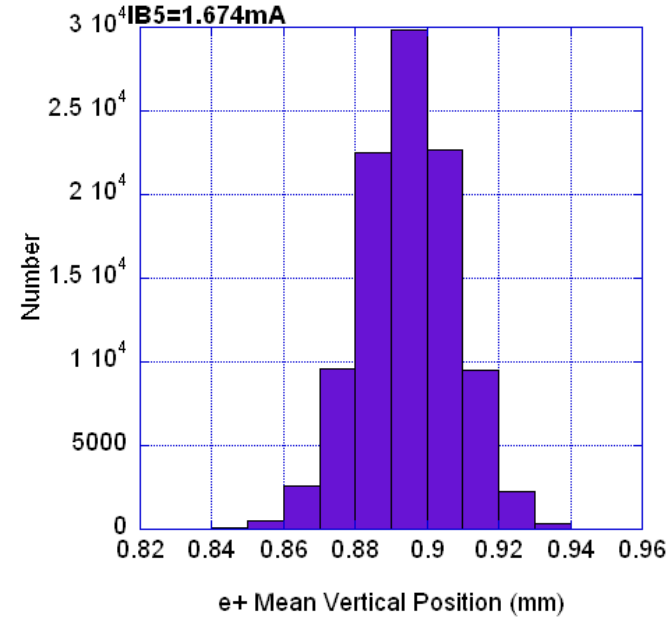
e+ Mean Vertical Position (mm)	
Mean	0.89739271
Std Deviation	0.013903975
Std Error	4.3968229e-05



Mean vertical Position
for e+ Train 4,
bunches 3-5

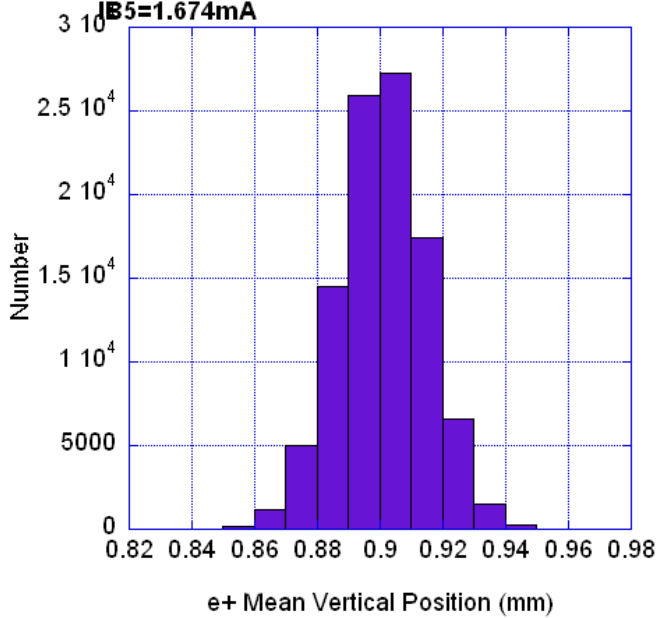
e+ Train 4, Bunch 3-5
100K Turn-by-Turn
File: 463 mean bunch 4
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

e+ Mean Vertical Position (mm)	
Mean	0.89480208
Std Deviation	0.013204173
Std Error	4.1755263e-05

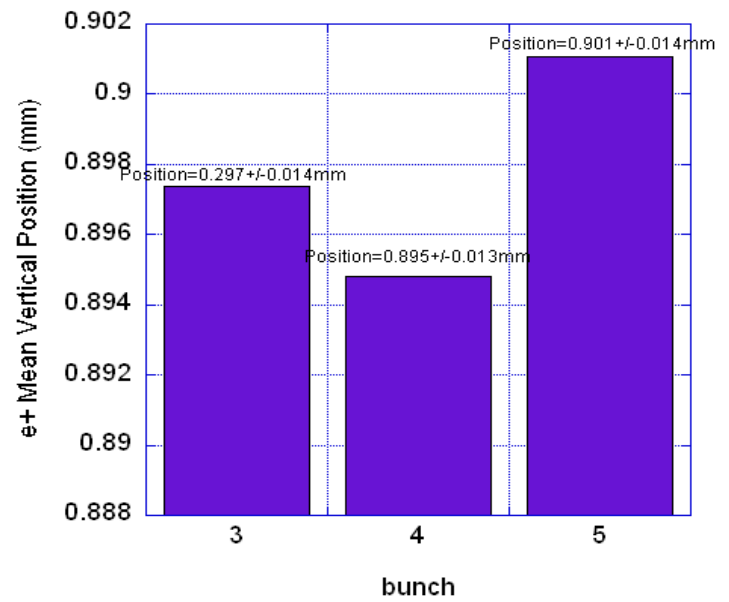


e+ Train 4, Bunch 3-5
100K Turn-by-Turn
File: 463 mean bunch 5
IB3= 1.712mA, IB4=1.681mA,
IB5=1.674mA

e+ Mean Vertical Position (mm)	
Mean	0.90106153
Std Deviation	0.013864307
Std Error	4.384279e-05

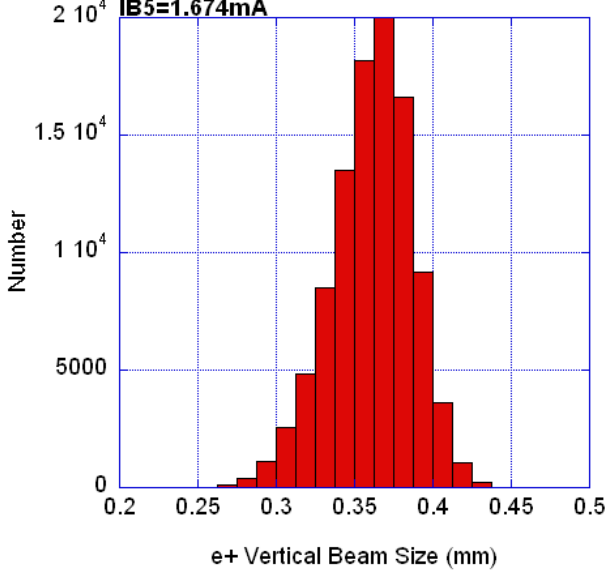


e+ Train 4, Bunch3-5 100K Turn-by-Turn File:463
IB3= 1.712mA IB4=1.681mA IB5=1.674mA



e+ Train 4, Bunch 3-5
100K Turn-by-Turn
File: 463 sigma bunch 3
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

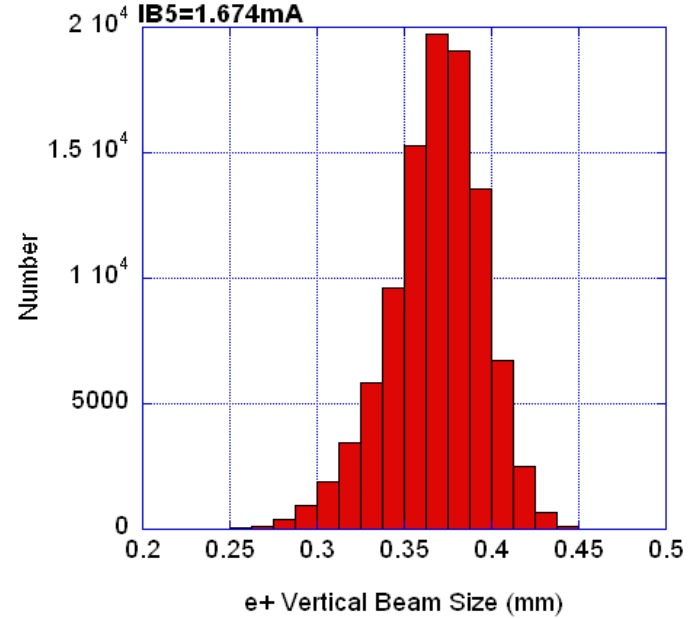
e+ Vertical Beam Size (mm)	
Mean	0.36100808
Std Deviation	0.025703261
Std Error	8.1280847e-05



$e+ \sigma_v$ for train 4,
 bunches 3-5.

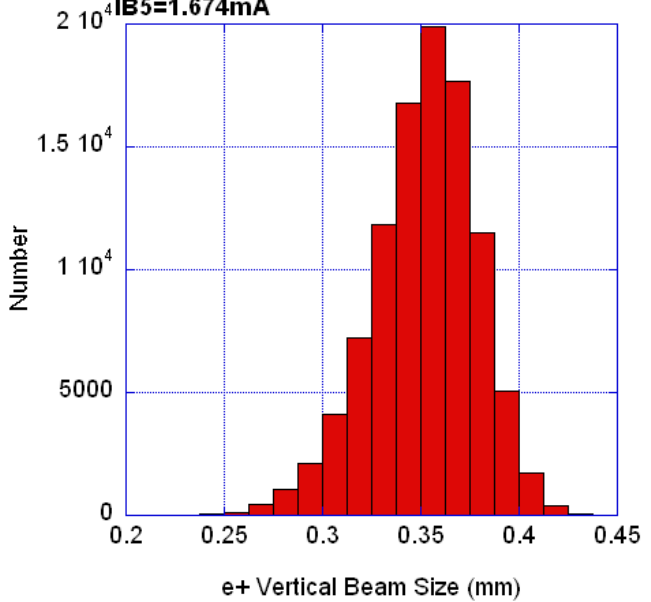
e+ Train 4, Bunch 3-5
100K Turn-by-Turn
File: 463 sigma bunch 4
IB3=1.712mA, IB4=1.681mA,
IB5=1.674mA

e+ Vertical Beam Size (mm)	
Mean	0.36816397
Std Deviation	0.026884603
Std Error	8.5016579e-05

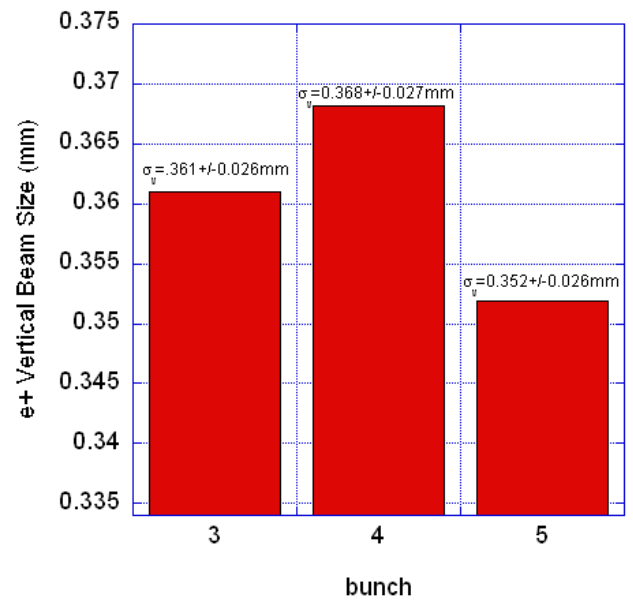


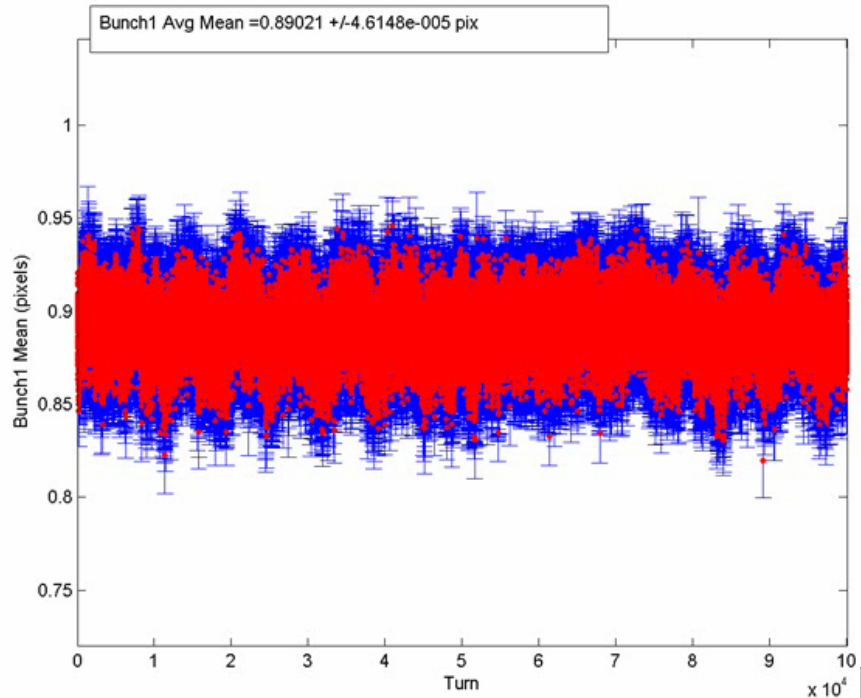
e+ Train 4, Bunch 3-5
100K Turn-by-Turn
File: 463 sigma bunch 5
IB3= 1.712mA, IB4=1.681mA,
IB5=1.674mA

e+ Vertical Beam Size (mm)	
Mean	0.35190183
Std Deviation	0.026464513
Std Error	8.368814e-05



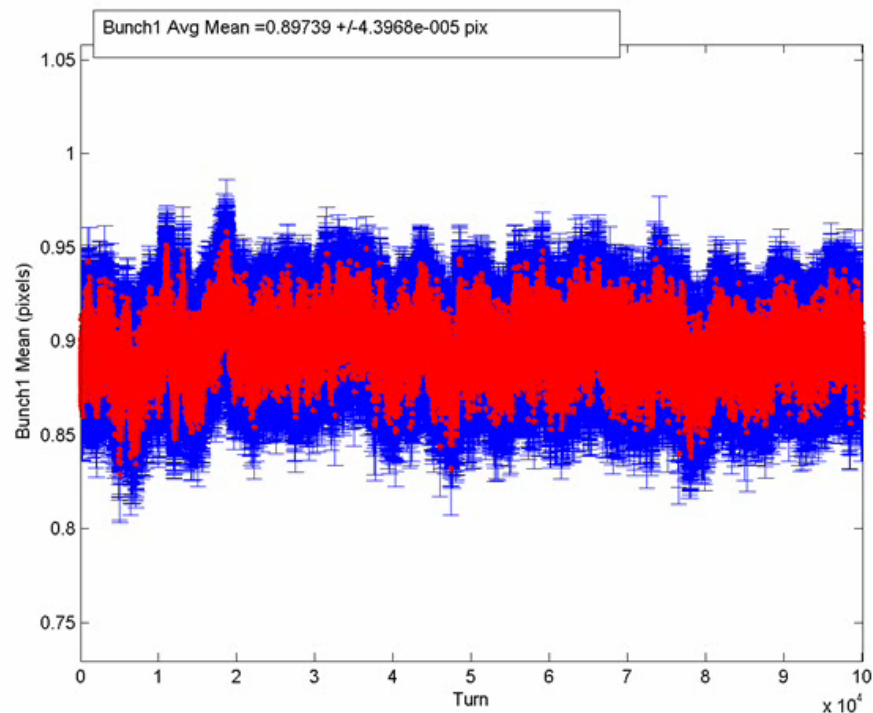
e+ Train 4, Bunch3-5 100K Turn-by-Turn File: 463
IB3= 1.712mA IB4=1.681mA IB5=1.674mA





Video of mean Vertical Position:

e- vertical position for 100K turns for 3 bunches (File 462)-movie.



e+ vertical position for 100K turns for 3 bunches (File 463)-movie.

Conclusions:

- The positron beams showed significant growth along and within the trains while electron beams remained fairly flat.
- A changing low frequency vertical oscillation is evident for both the e^+/e^- bunches.