BSM Measurements

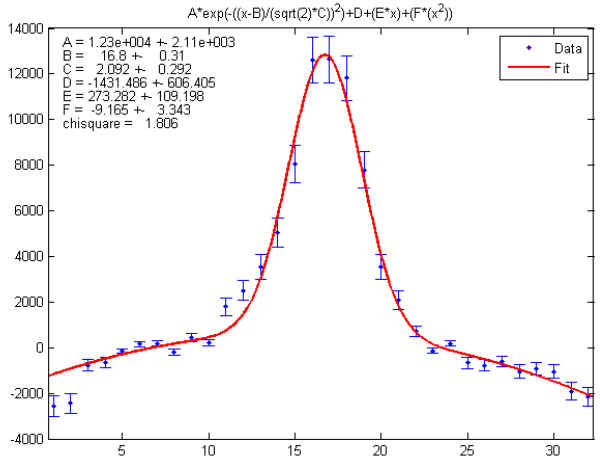
Experiment

During CESR-c operation, with 26 bunches in the machine (9x3, and empty bunch in train 1 bunch 3), the following beam size monitor measurements were taken for both electrons and positrons:

1) 2048 turns at the bottom of a fill (low current),
2) 2048 turns during fill (medium current),
3) 2048 turns at the top of a fill (high current).

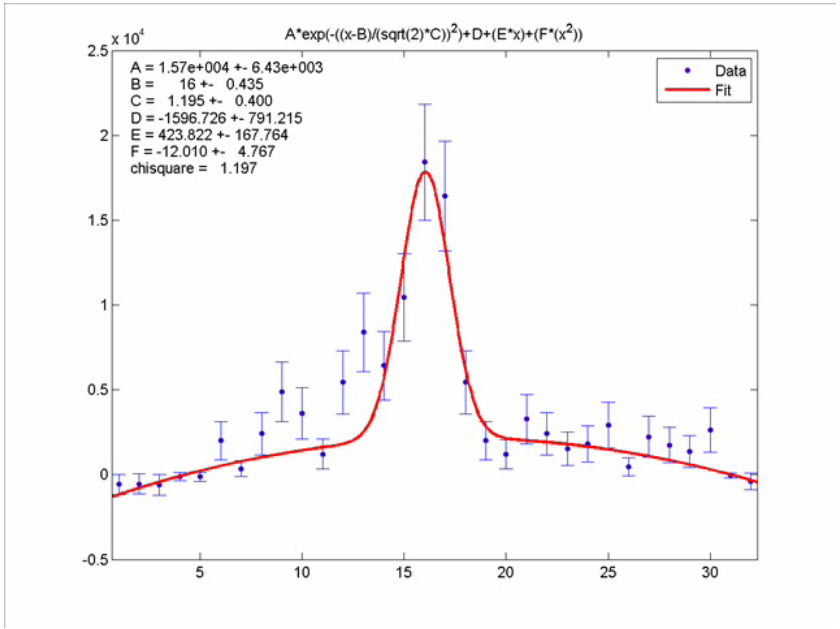
The above measurements were done during two consecutive fills.

A Gaussian distribution was fitted to the PMT array signal profile, which determined the beam position and size.

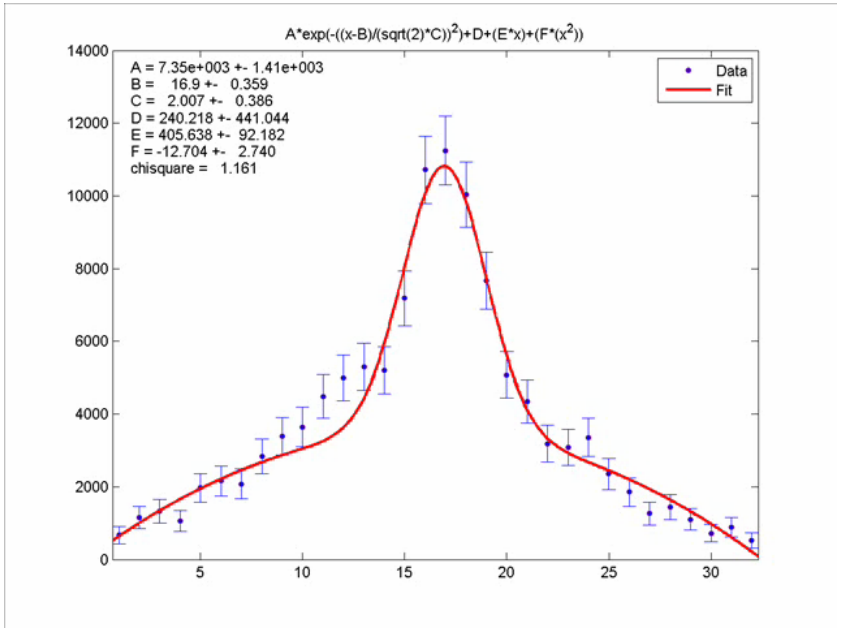


Comparison of e- and e+ Profiles

e-



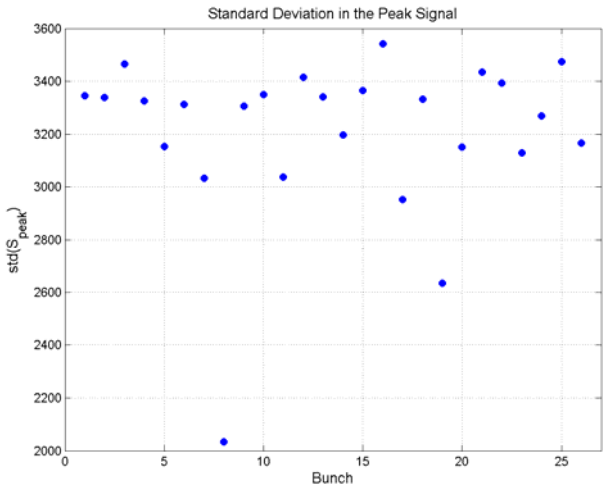
e+



The error bars are determined by $\sqrt{\frac{\sigma_{peak}^2}{S_{peak}}}S$, where S is the signal, S_{peak} is the average peak signal for a given bunch, and σ_{peak} is the standard deviation in the peak signal for a given bunch. The error to signal ratio is significantly higher for electrons, suggesting that there are intensity fluctuations in the electron data. The large error, along with a poor Gaussian profile, yields poor fits, giving inaccurate beam size and position values.

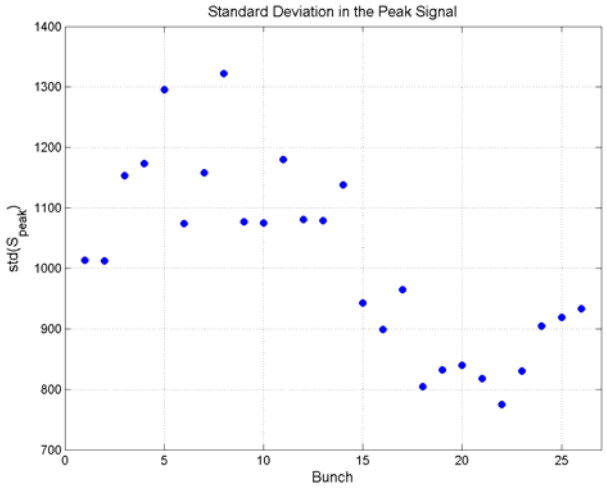
Statistics of Peak Signal: e- vs. e+

e-



$$\frac{\bar{\sigma}_{peak}}{\bar{S}_{peak}} \cong 0.19$$

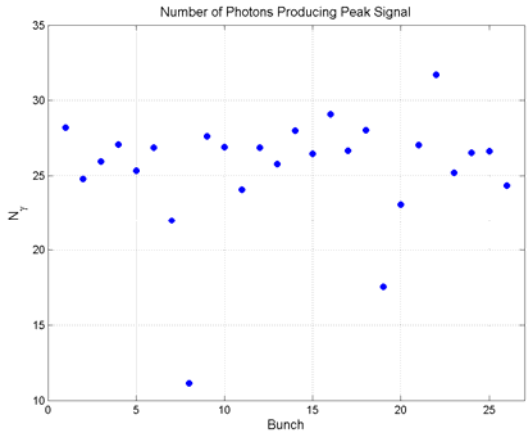
e+



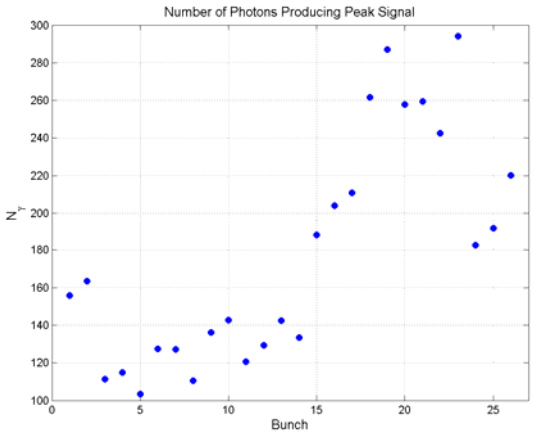
$$\frac{\bar{\sigma}_{peak}}{\bar{S}_{peak}} \cong 0.08$$

The standard deviation of the peak signal is significantly greater for electrons. Furthermore, the ratio of the average standard deviation (over all bunches) and the average signal (over all bunches) is greater. Evidently, the electron signal is fluctuating.

The number of photons incident on the channel of the peak signal is $N_\gamma = \left[\frac{S_{peak}}{\sigma_{peak}}\right]^2$. The following are plots (e- and e+) of N_γ for all bunches.

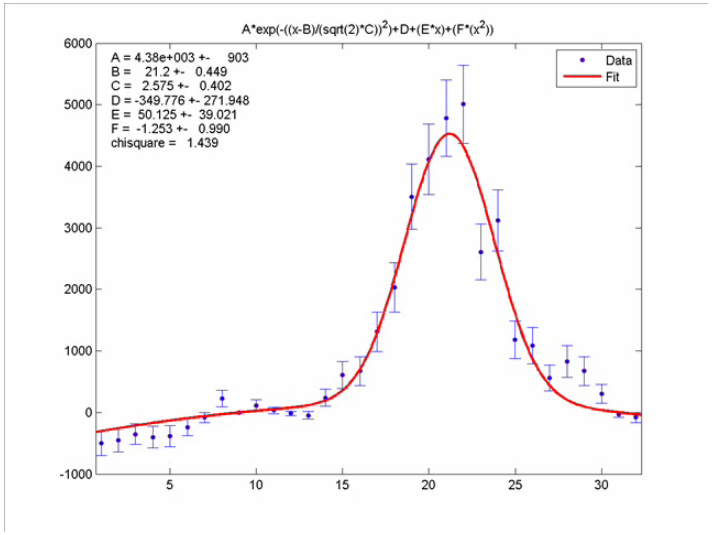


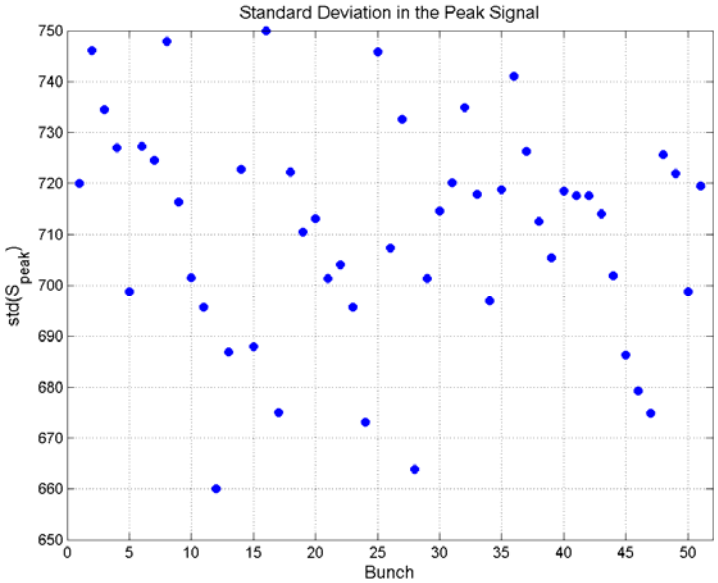
$$\bar{N}_\gamma \cong 25$$



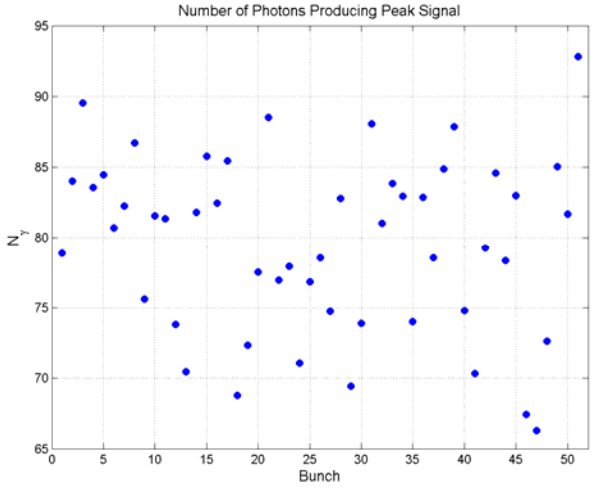
$$\bar{N}_\gamma \cong 178$$

Did the electron signal fluctuate in CHESS data?





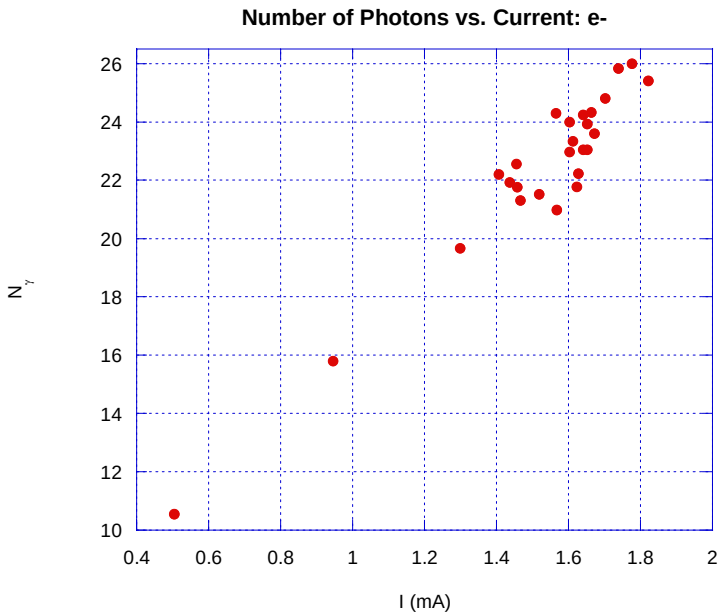
$$\frac{\bar{\sigma}_{peak}}{\bar{S}_{peak}} \cong 0.11$$

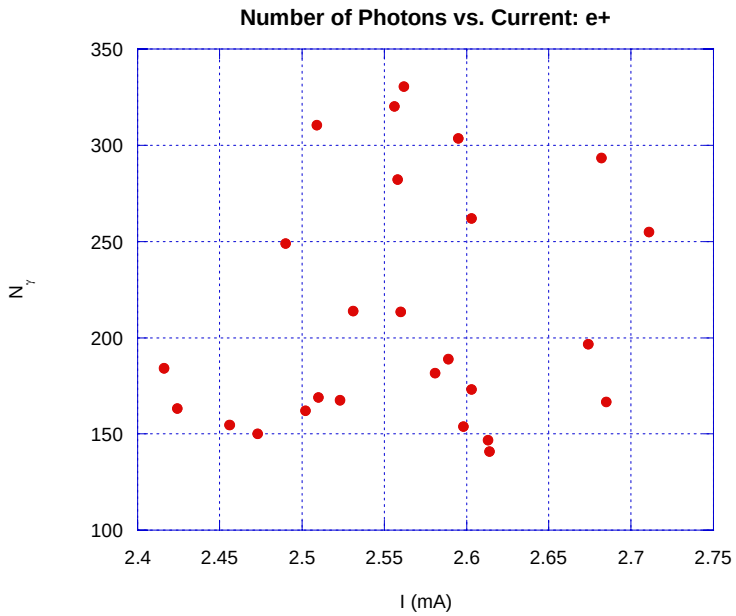


$$\bar{N}_{\gamma} \cong 80$$

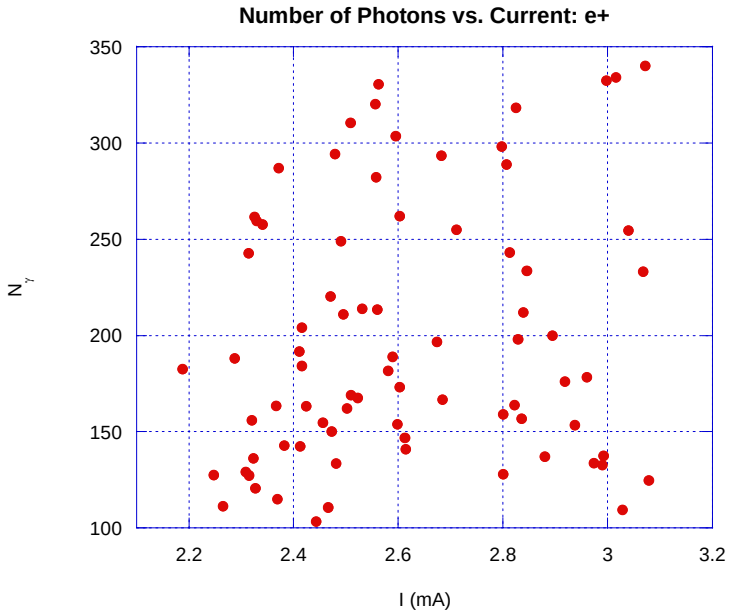
i) The profile appears to be more Gaussian, as the reflection to the left of the mean is less prominent.
ii) The ratio of the average standard deviation to the average signal is lower for the low current CHESS data than for the low current CESR-c data, implying less fluctuation.
iii) The number of photons producing the peak signal is greater for all bunches, which is expected, since current is higher in CHESS.

Relationship between Current and Number of Photons



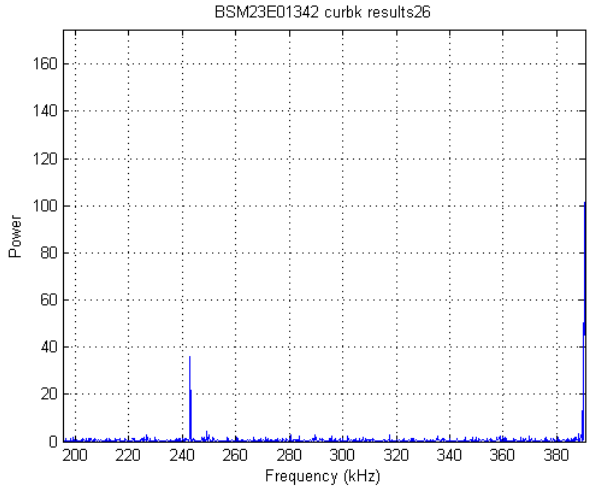


i) The relationship between number of photons producing the peak signal and current is strongly linear for electrons.
ii) There does not appear to be a linear relationship between current and number of photons for positrons. However, the current range is smaller. Looking over a larger current range (right), the relationship is still weak.

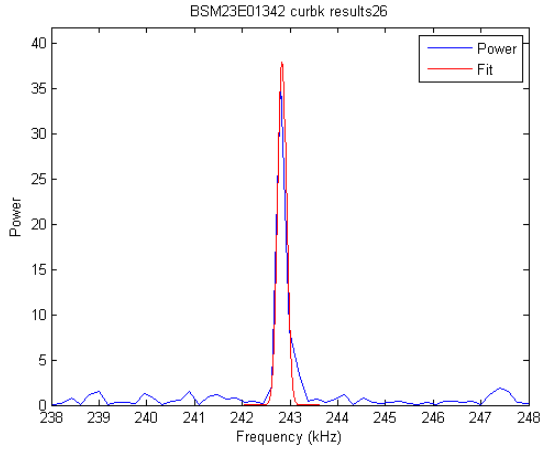


Determining Vertical Tune with BSM data

The vertical beam position of a given bunch on a given turn is defined as the mean of the Gaussian fit. A fast Fourier transform (FFT) is applied to the position data, with which a frequency spectrum (shown below) is determined.



To determine the tune, the peak power is identified, and a parabola is fitted to the log of this data point and the log of the two on either side (as shown below).

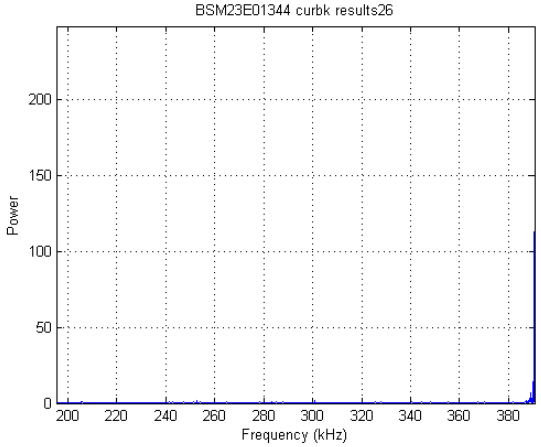


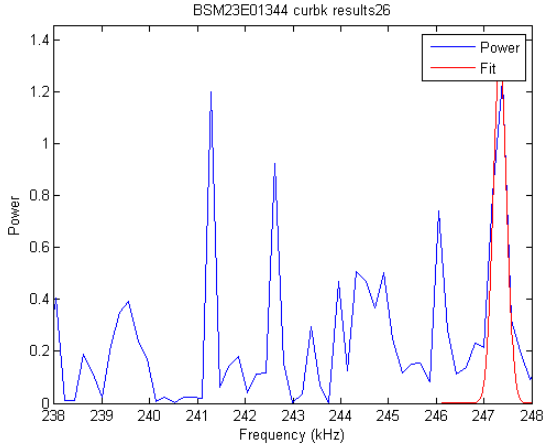
Finally, the interpolated vertical tune is defined as the frequency at which the parabola reaches a maximum.

Weak Tune Signal in Frequency Domain

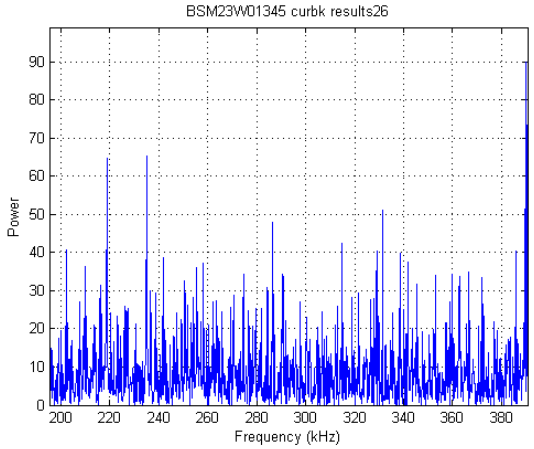
We did not observe a significant (high signal to noise ratio) power peak near the expected tune in the frequency spectrum for the majority of the data taken. To maximize the signal in future experiments, the beam should be pinged at low amplitude. The following is a plot of a typical frequency spectrum. The tune is expected to be ~242 kHz for positrons and ~235 kHz for electrons.

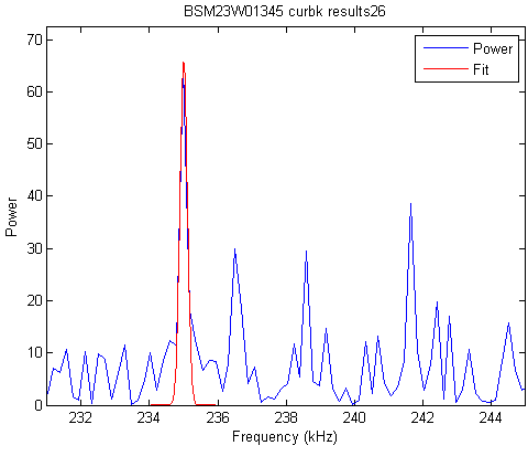
e+





e-



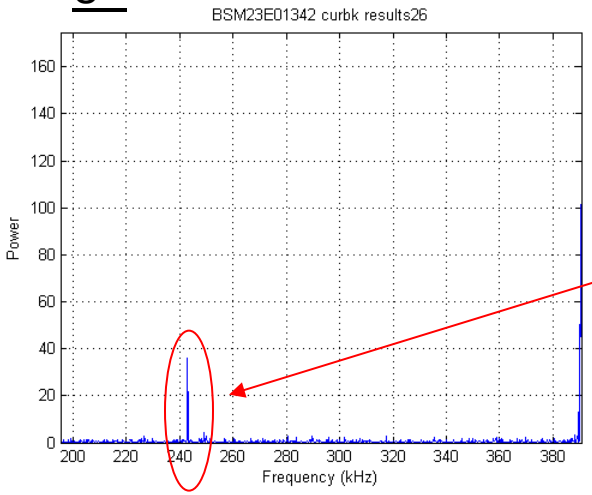


i) A low frequency oscillation dominates in the e+ and e- spectrums (in the plots to the left it appears as a high frequency peak).
ii) Near the expected tune, there is not a peak with a high signal to noise ratio.

Tune Measurement during CESR-c Fill

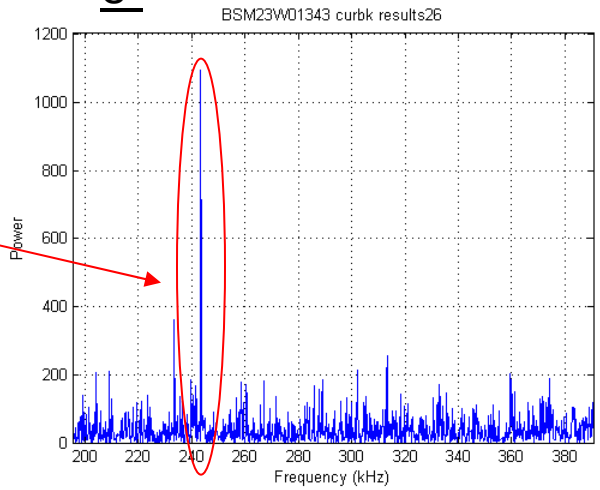
During the fill, the beam was bumped enough to produce a significant signal.

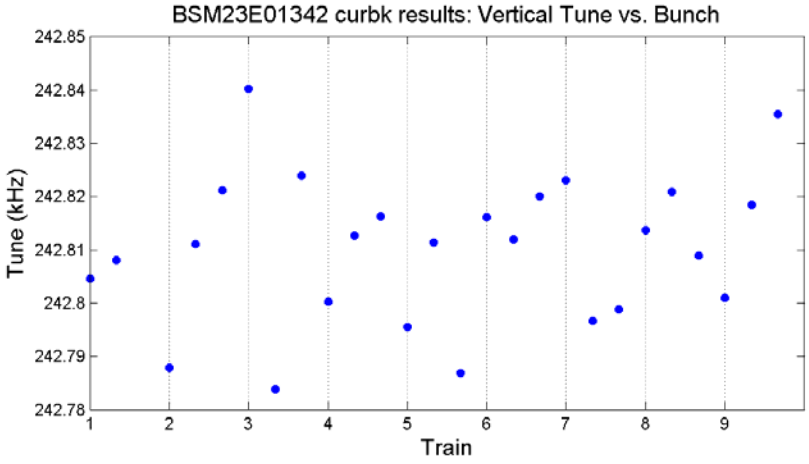
e+

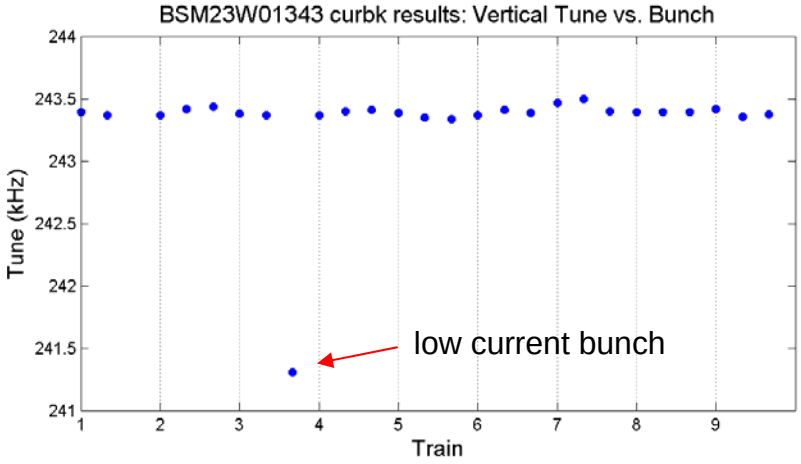


power peaks correspond to vertical tune.

e-



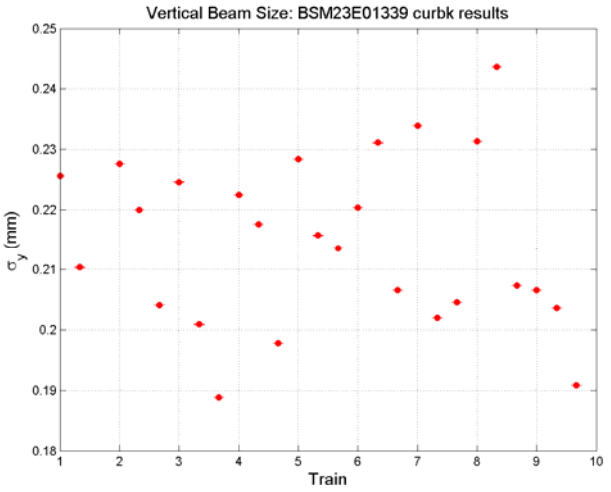


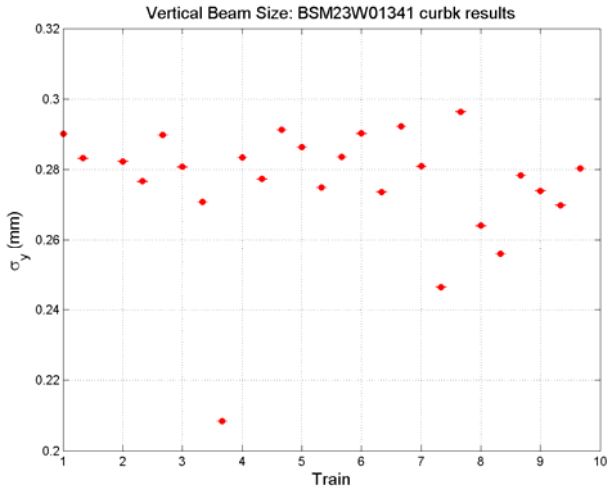


Vertical Beam Size Measurements

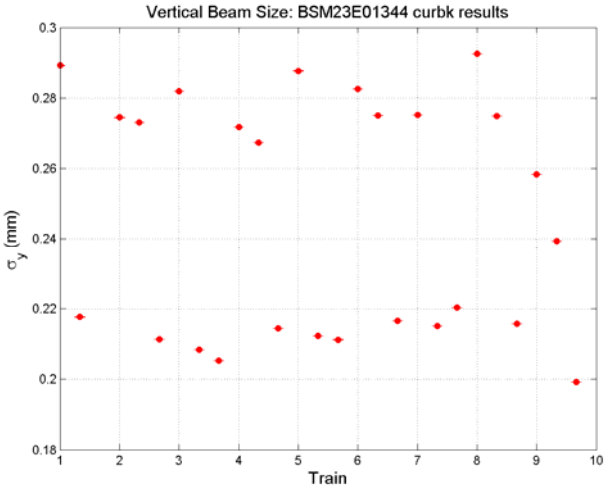
e+ e-

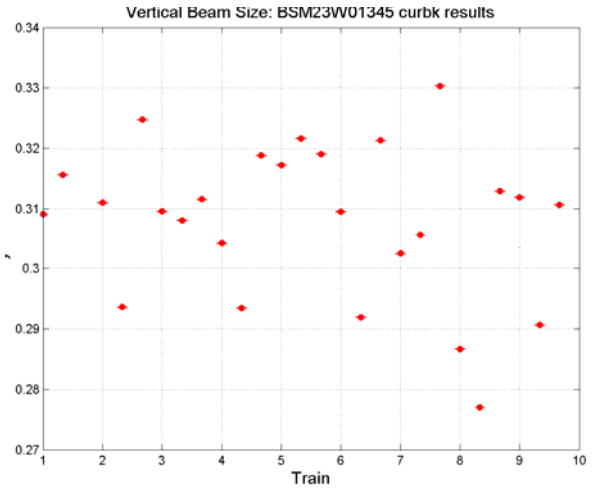
low I





high I

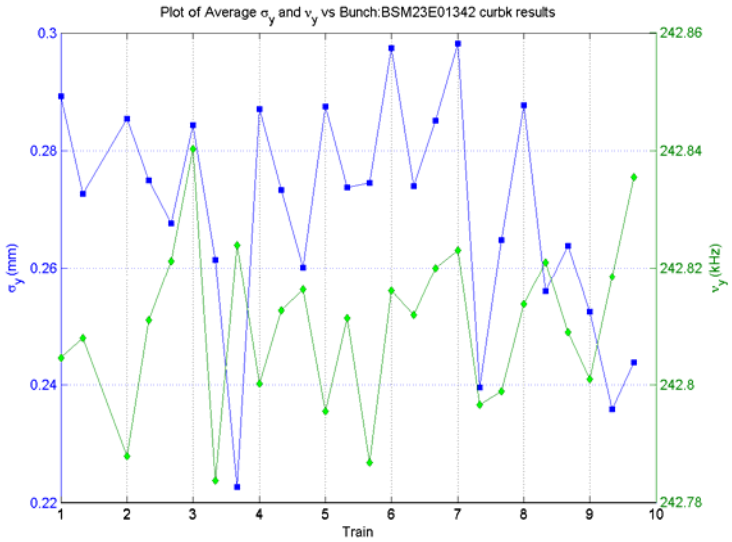




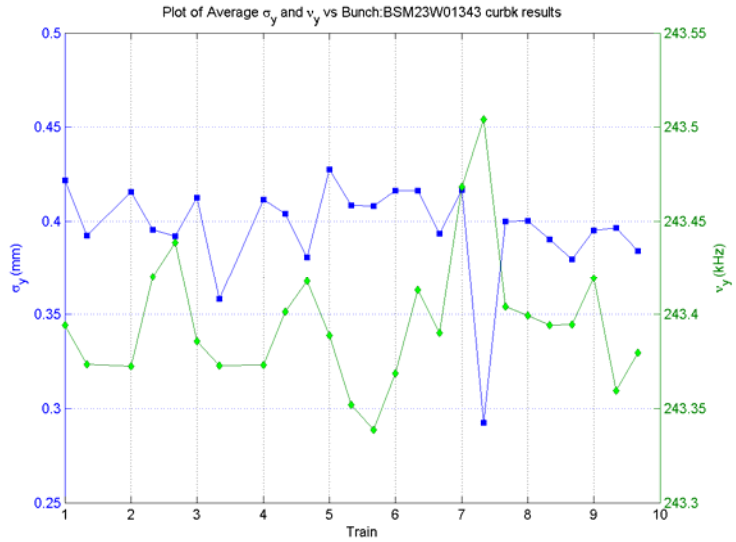
i) Positron beam size decreases over the train.
ii) Electron beam size decreases, but increases for the last bunch in the train.
iii) (i) and (ii) are consistent with CHESS beam size measurements. These results were attributed to a tune shift due to electron cloud. Unfortunately, we do not have accurate tune measurements for these data.
iv) Beam size results are similar for other data sets.

Relationship between Tune and Beam Size

e+



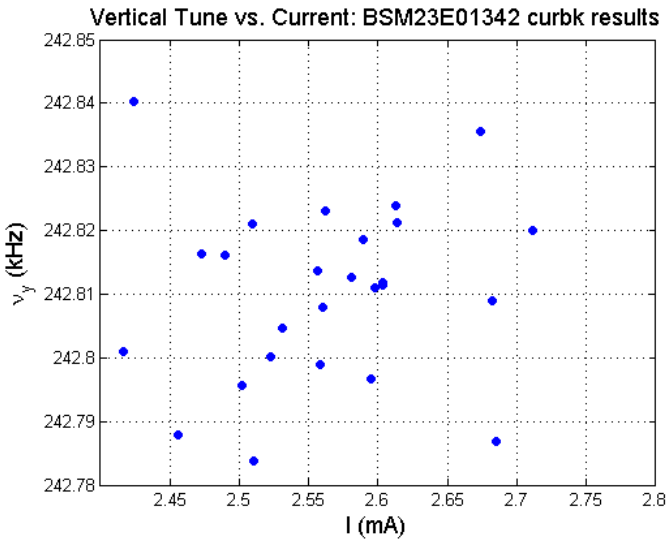
e-



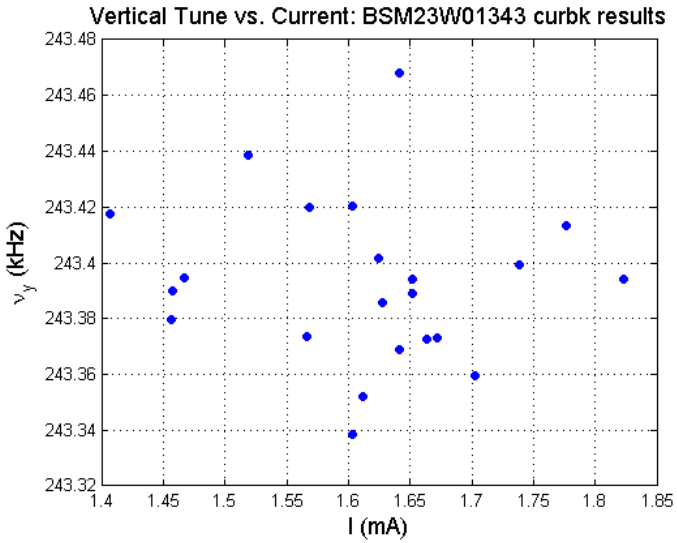
i) For positrons, there is not an obvious relationship between bunch size and tune.
ii) For electrons, high tune weakly corresponds to low bunch size.

Vertical Tune vs. Current

e+



e-



i) There is not an obvious relationship between tune and current in this current range. In future experiments, measure tune over larger current spread if possible.

ii) Expect beam-beam interaction to be stronger in horizontal plane. Measure vertical tune as a function of current in future experiment.