

Study of Main Injector BLT



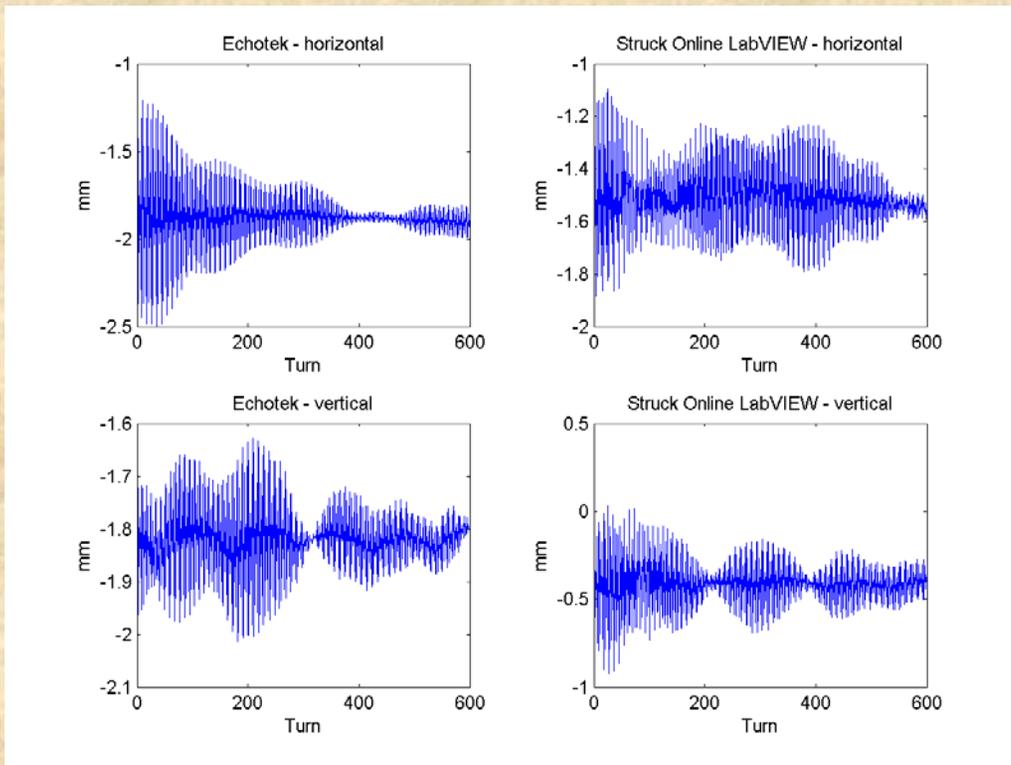
Beam Line Tuner (BLT)

- Measures the transverse oscillations of the beam injected into the Main Injector
- Currently used for closing 2.5MHz beam transfers

Issue

Positions

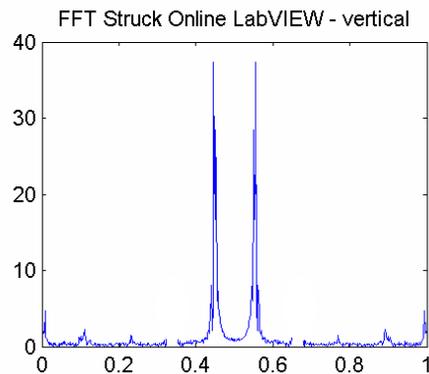
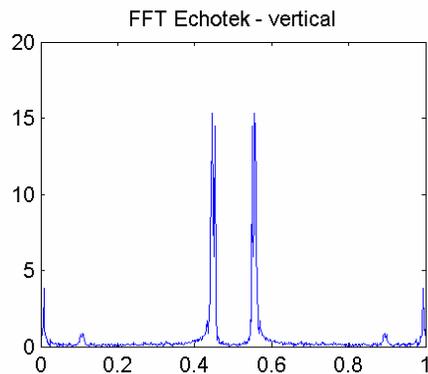
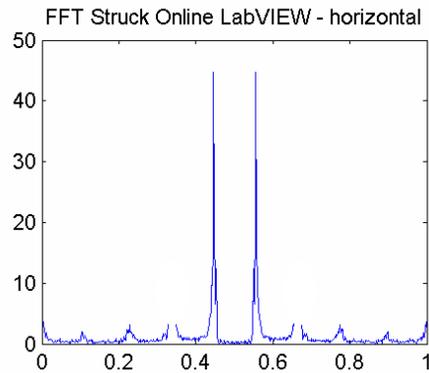
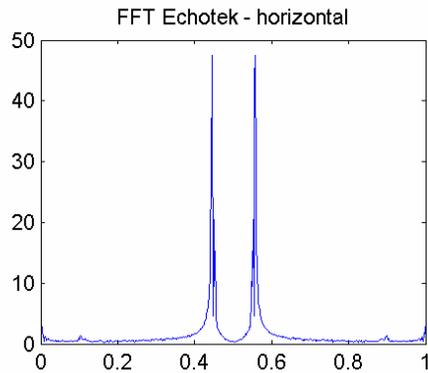
When the Echotek BPM (Beam Position Monitor) System was introduced, it should have measured the same positions as the as the Struck BLT System



But it didn't

Issue

FFT Plots

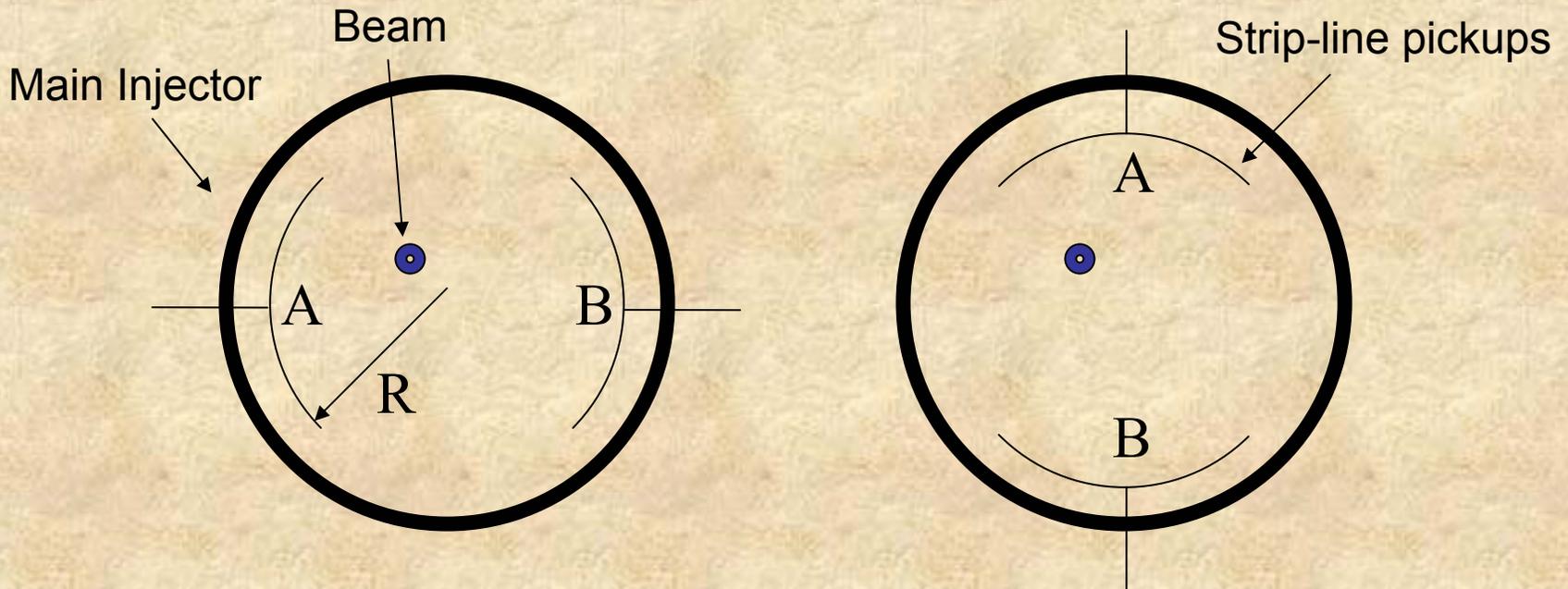


Not only are the positions remarkably different, but the FFT plots for the Struck BLT system have sidebands while the Echotek system doesn't.

Background

Strip-line pickups

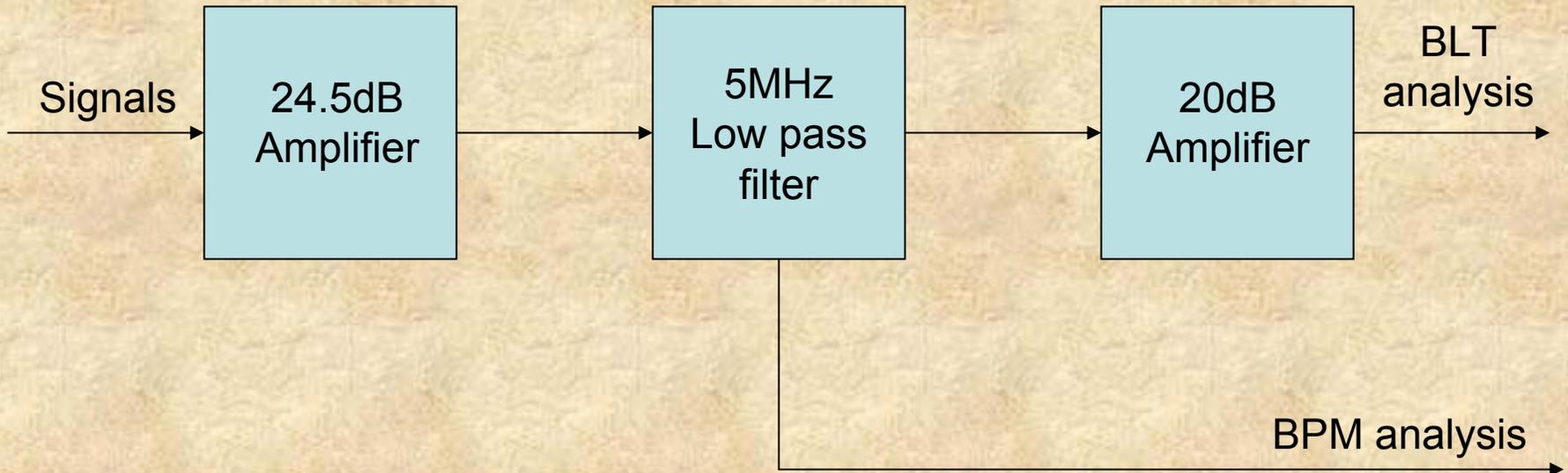
- The position of the beam is determined by measuring the signals induced by the beam on strip-line pickups.



- The signals from one of the plates are called "A" and are called "B" on the other plate.

Background

Signals' Path



Background

BLT

vs.

BPM

-digitized with a
12-bit digitizer

-digitized with a
14-bit digitizer

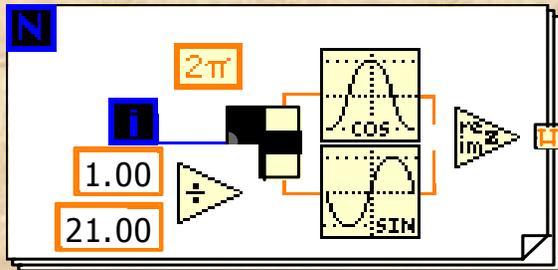
-digitized at MI Injection RF
(approximately 53MHz)

-digitized at 80MHz

105 samples ($2\mu\text{s}$ worth) are taken ea. turn for 600 turns to obtain
the signals from the 4 antiproton bunches.

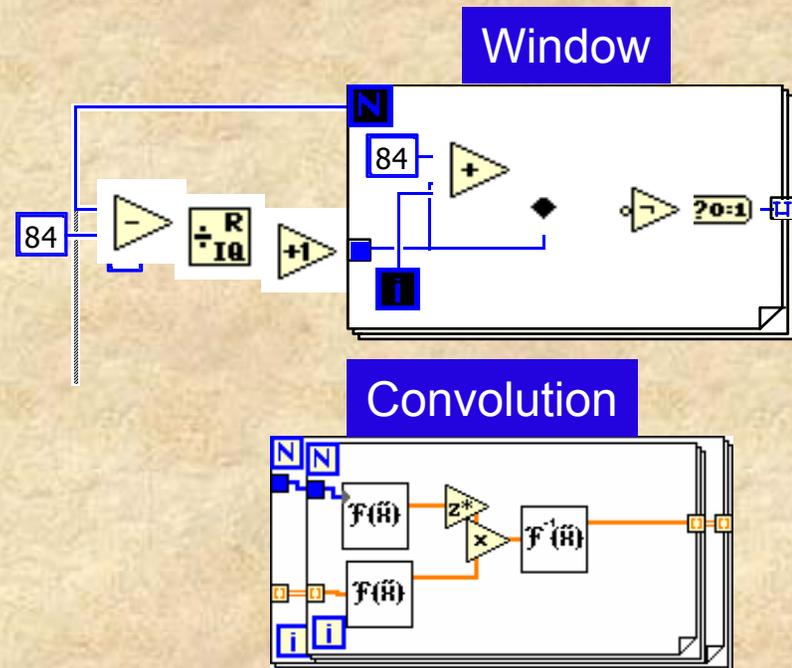
Background

Online Analysis



The digitized data is down converted at 2.5MHz by multiplying the data by $e^{-i2\pi N/21}$ where N is the sample index number minus 1

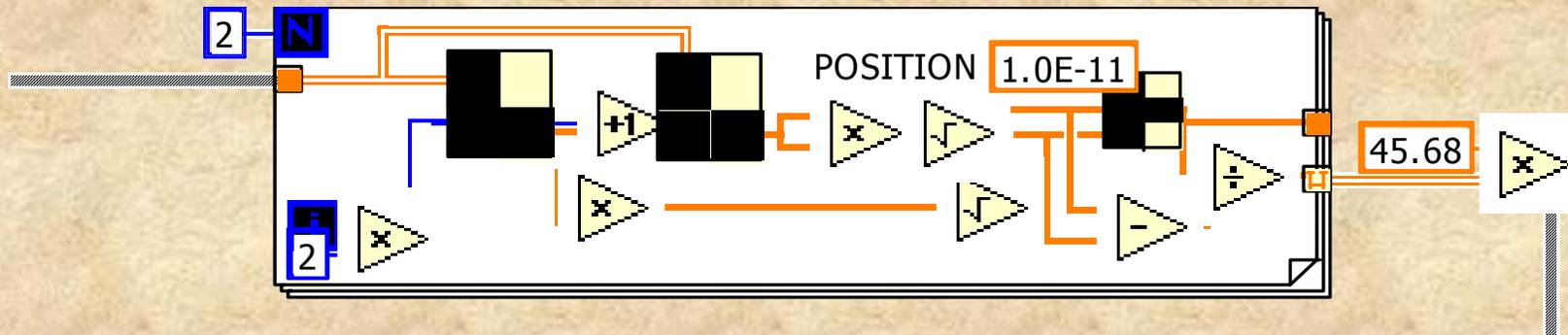
The down converted data are then convolved with a rectangular window designed to cover the four antiproton bunches (105 samples long with 11 zeros, 84 ones, and 10 zeros).



Background

Online Analysis

The maximum values of these convolutions are the A and B values for the horizontal and vertical beam positions.



$$\text{Position (mm)} = 45.68 * (A-B)/(A+B)$$

Note: The correct conversion factor is 35.09, but the online analysis uses 45.68

Analysis

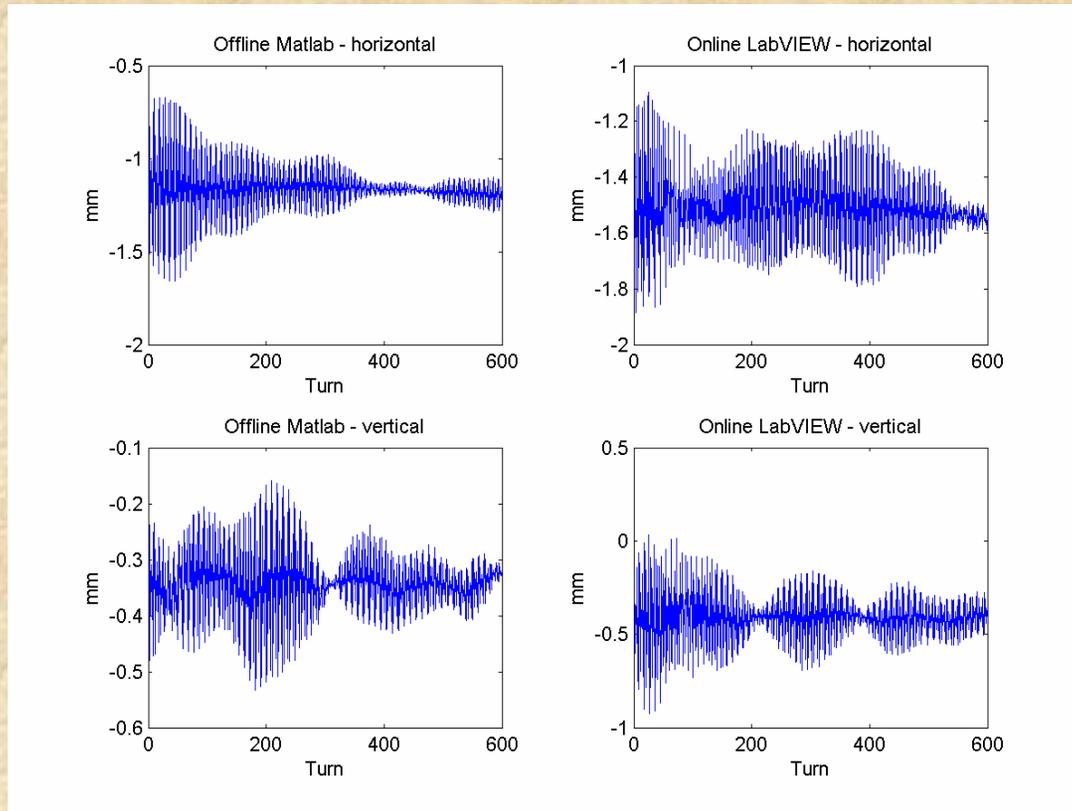
1) Make sure that the Echotek BPM system and Struck BLT system were looking at the same turns.

2) Write an offline program in Matlab that calculated the position using the signals given by the Struck BLT.

Analysis

Offline vs. Online

The offline Matlab analysis didn't match the online analysis

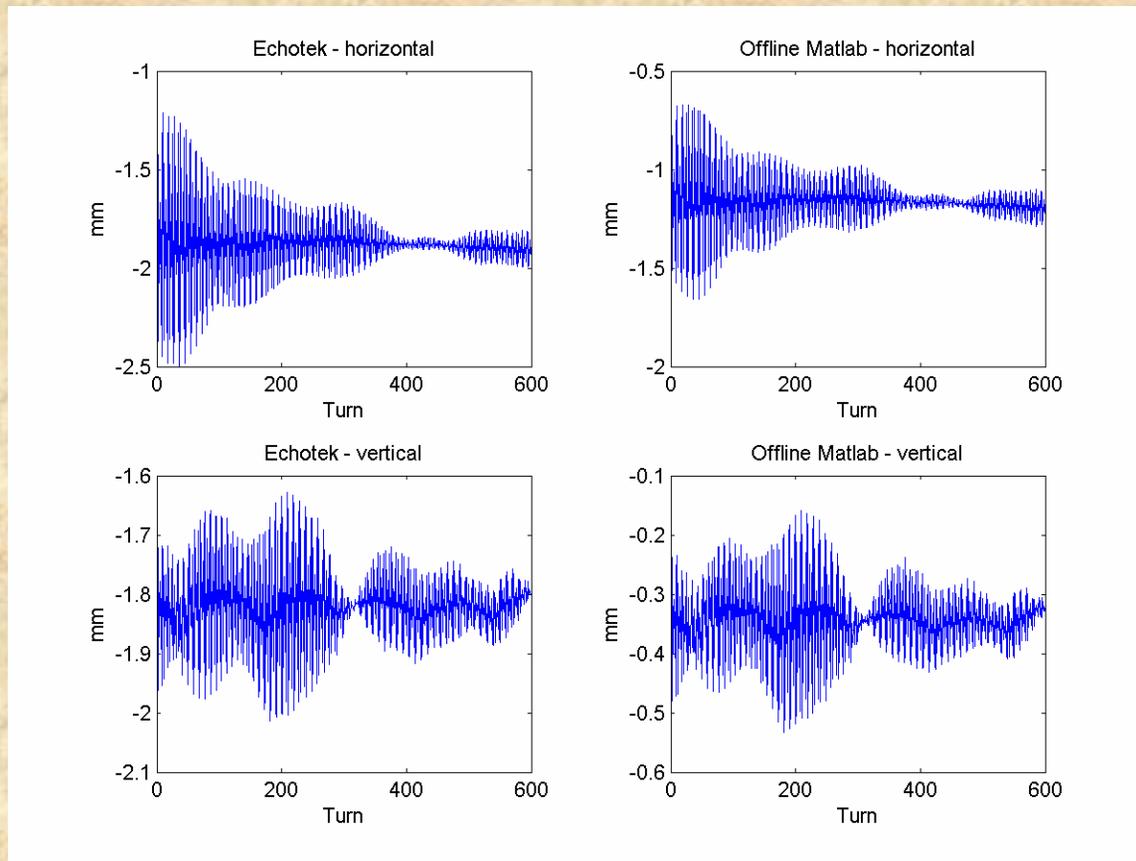


However...

Analysis

Echotek vs. Offline

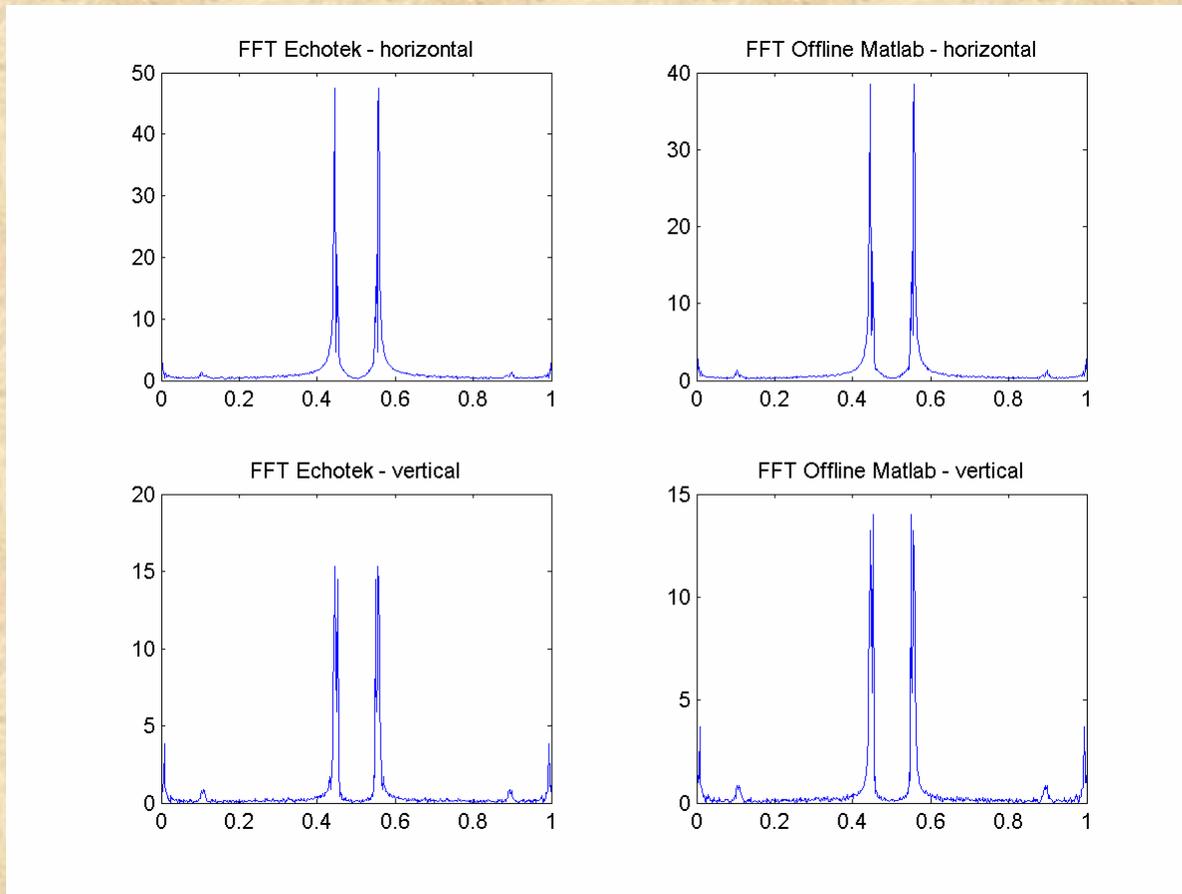
The Echotek analysis and the offline Matlab analysis looked very similar.



Analysis

FFT Echotek vs. Offline

The spurious sidebands that once appeared in the online analysis do not appear in the offline analysis



Analysis

3) Find the difference between the offline Matlab analysis and the online analysis.

Analysis

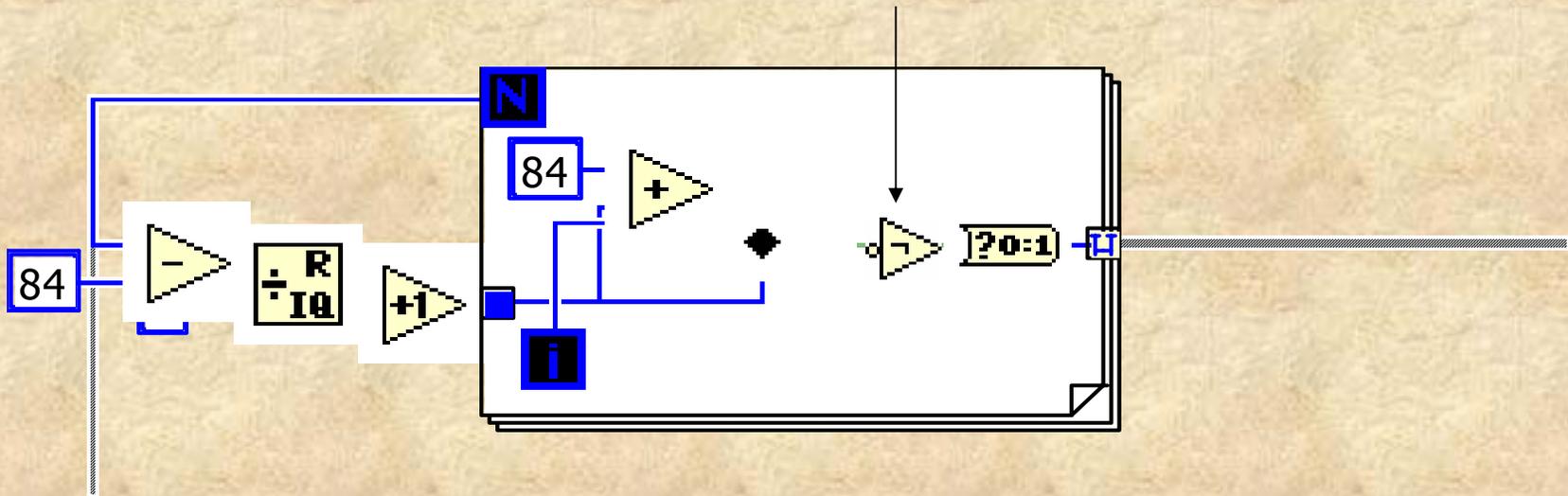
What is the difference?
The Window



Analysis

Window Explanation

There's an unintended "not" statement in the code for the window.



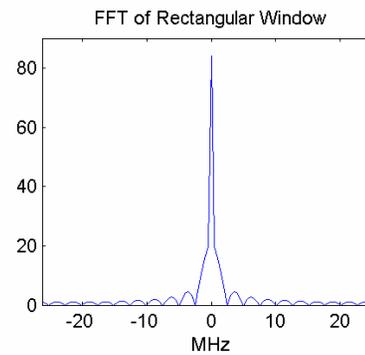
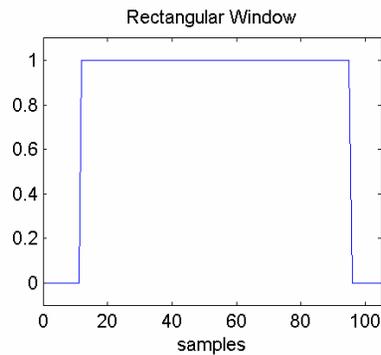
When this "not" statement was removed, it read the same results as the offline Matlab analysis.

Analysis

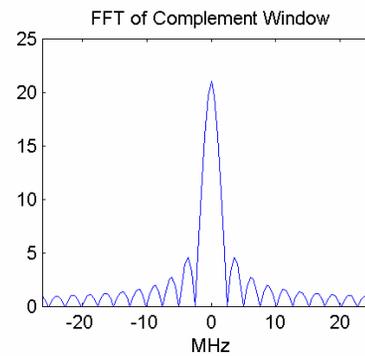
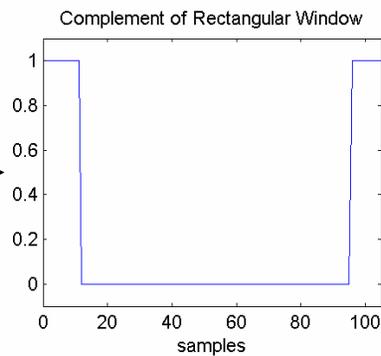
Window Explanation

What did having the “not” command do?

Without “not” →



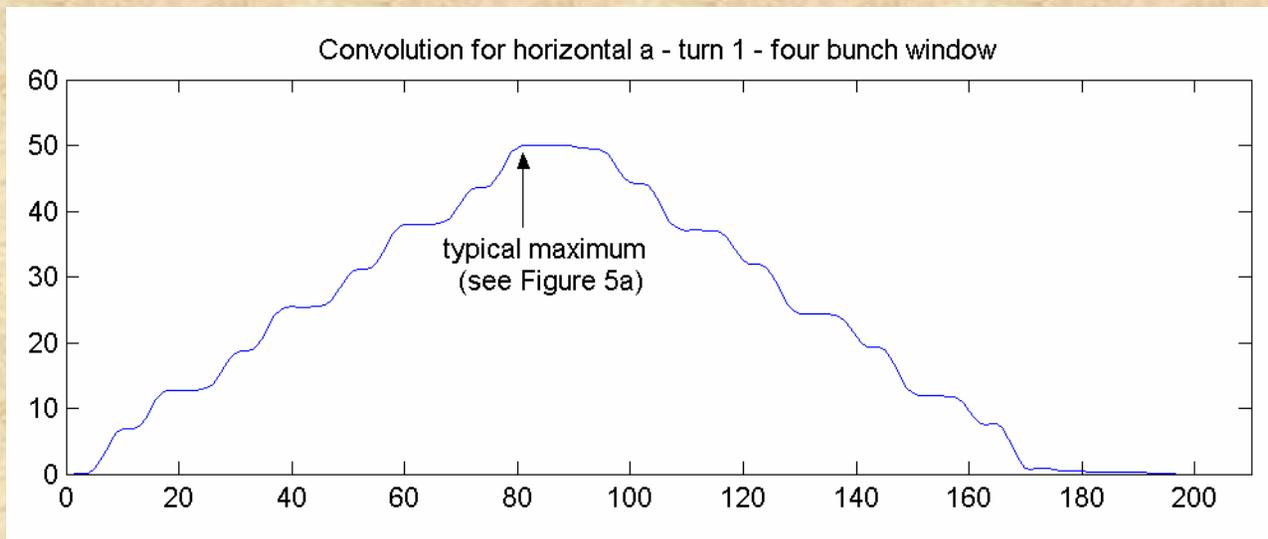
With “not” →

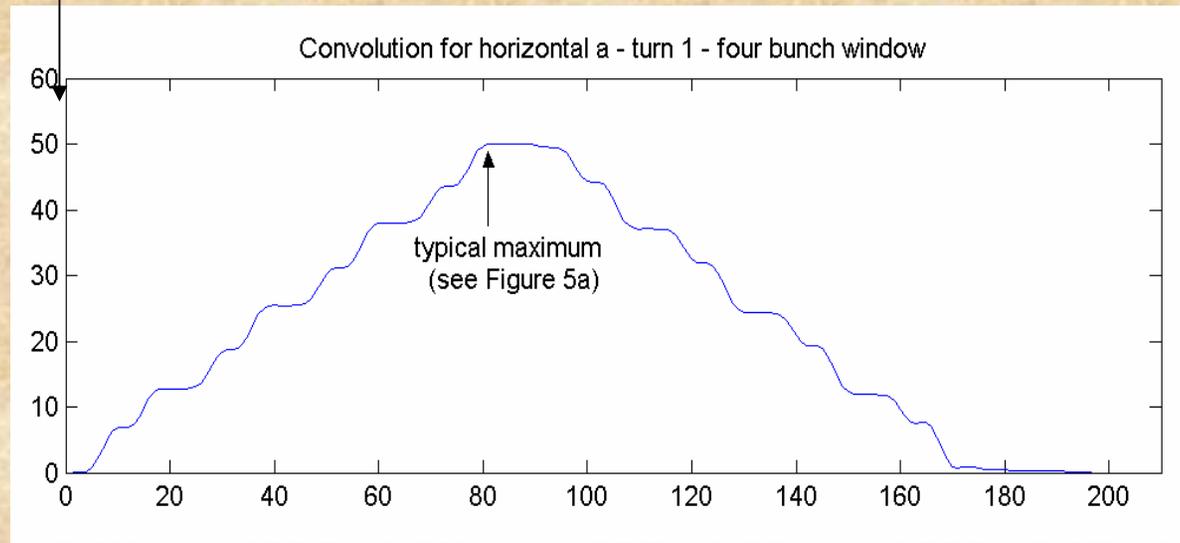
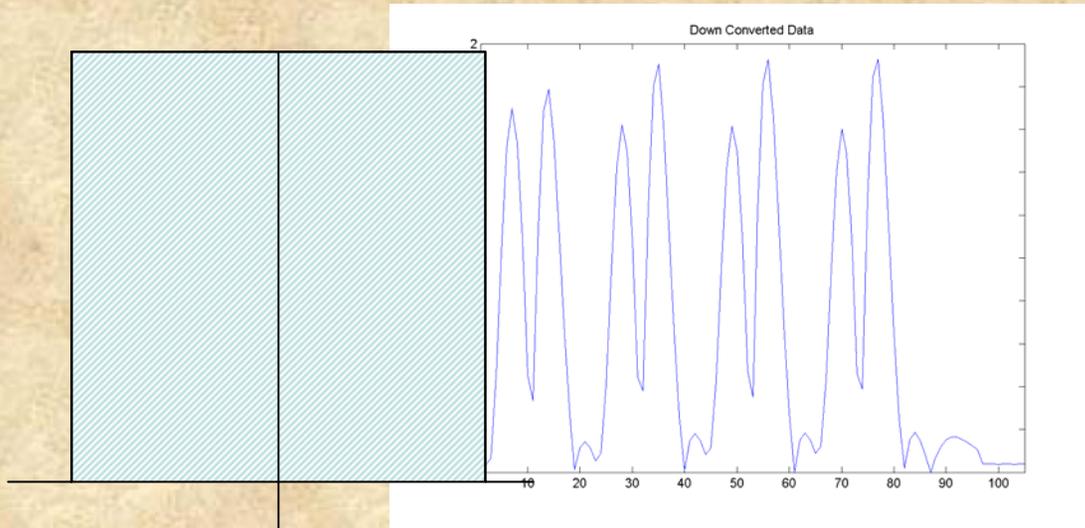


Analysis

Window Explanation

Convolution – Window scans across the graph and gives the integral of what lies beneath it.

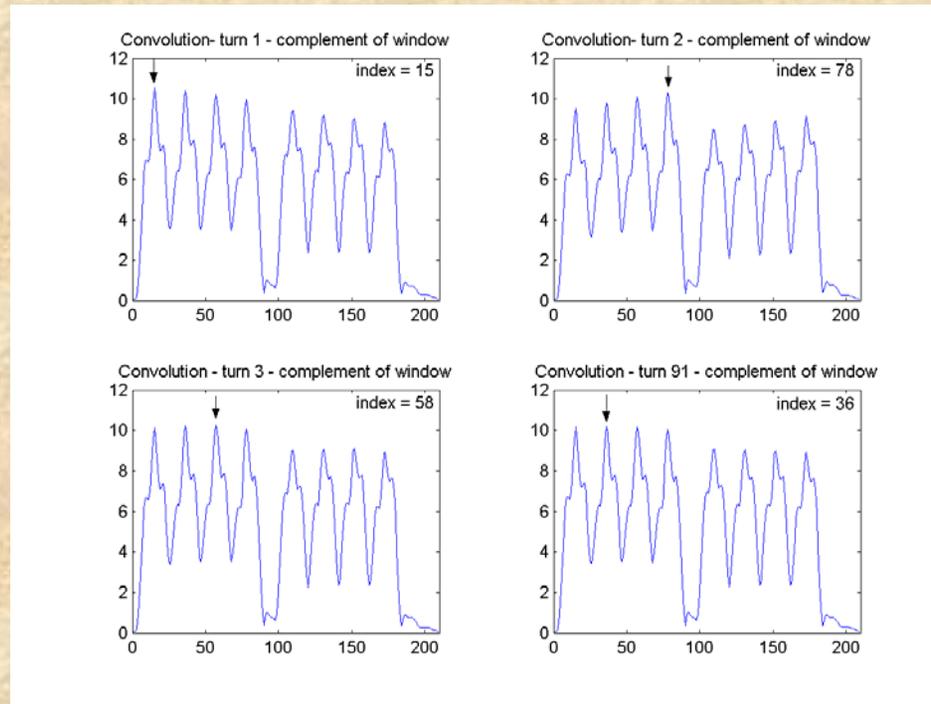




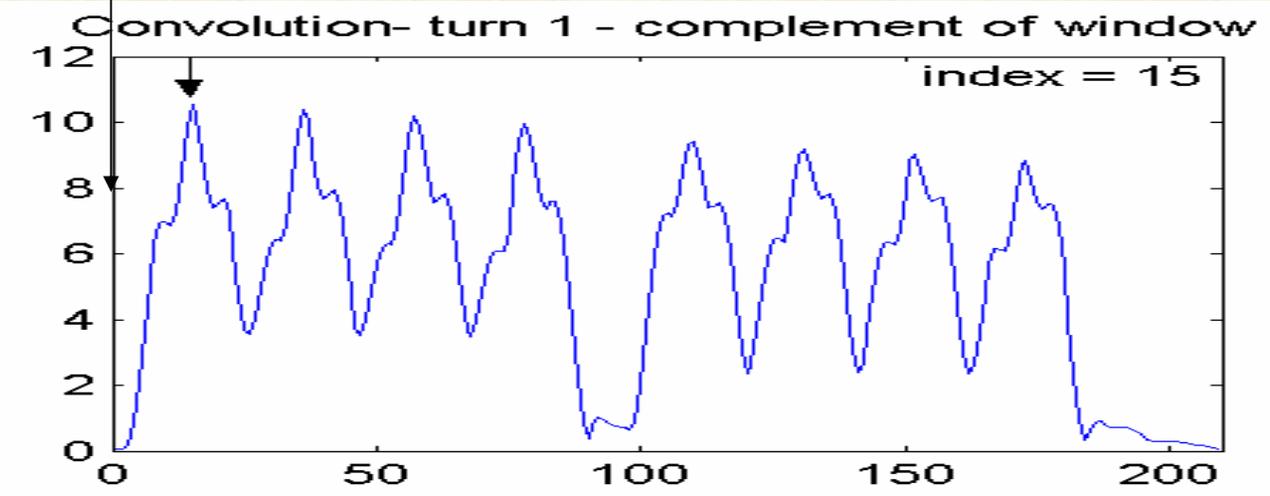
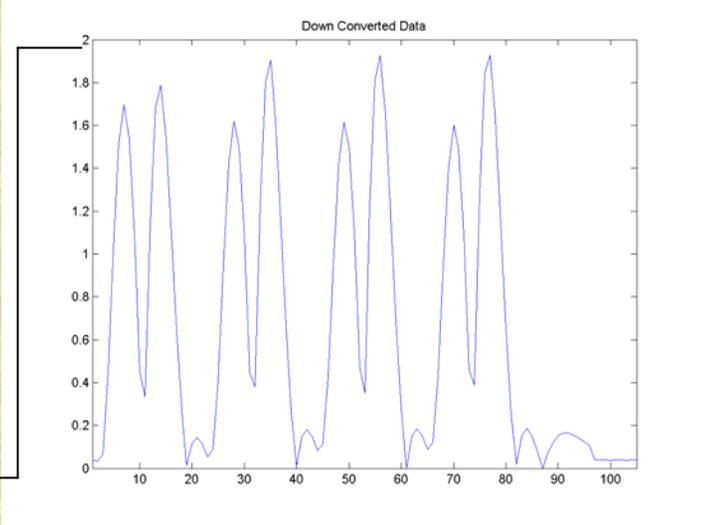
Analysis

Window Explanation

However, when the convolution is done using the complement of the window, the convolution has multiple peaks.

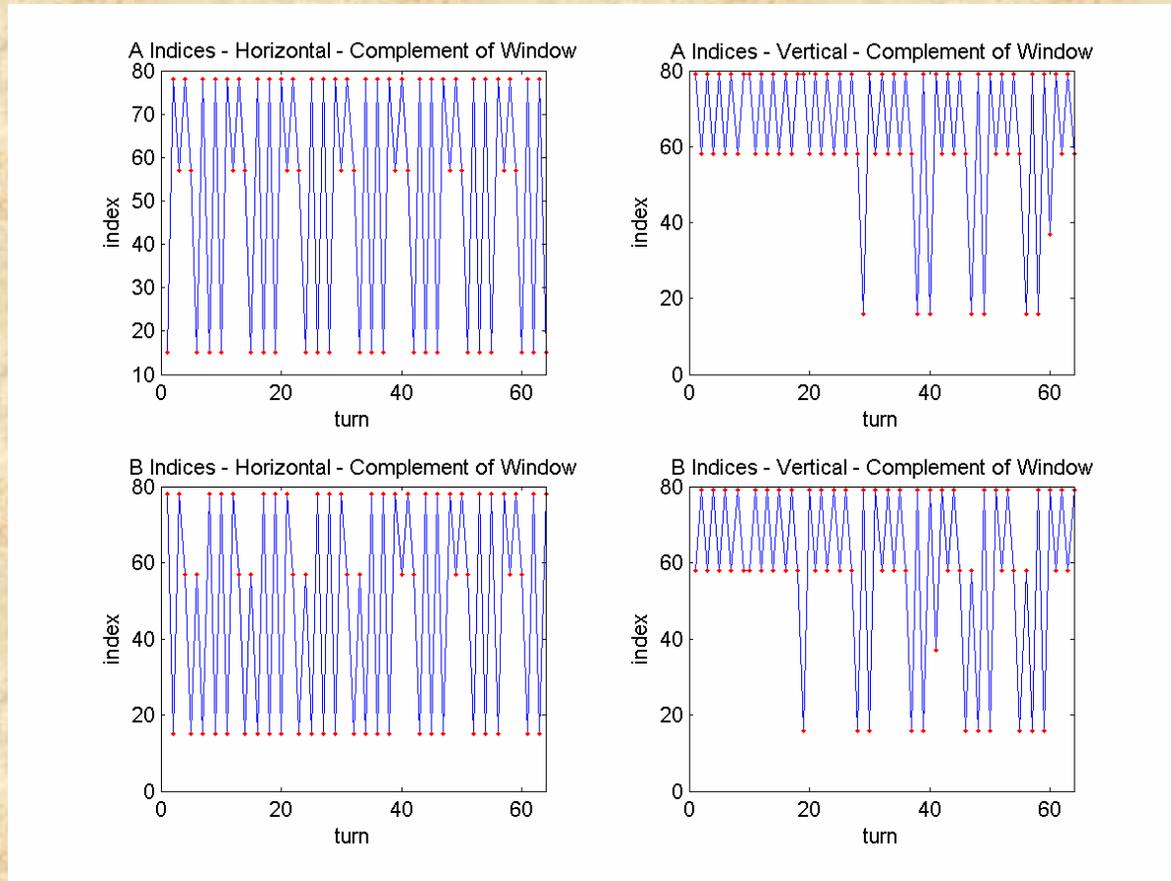


Why does this happen?



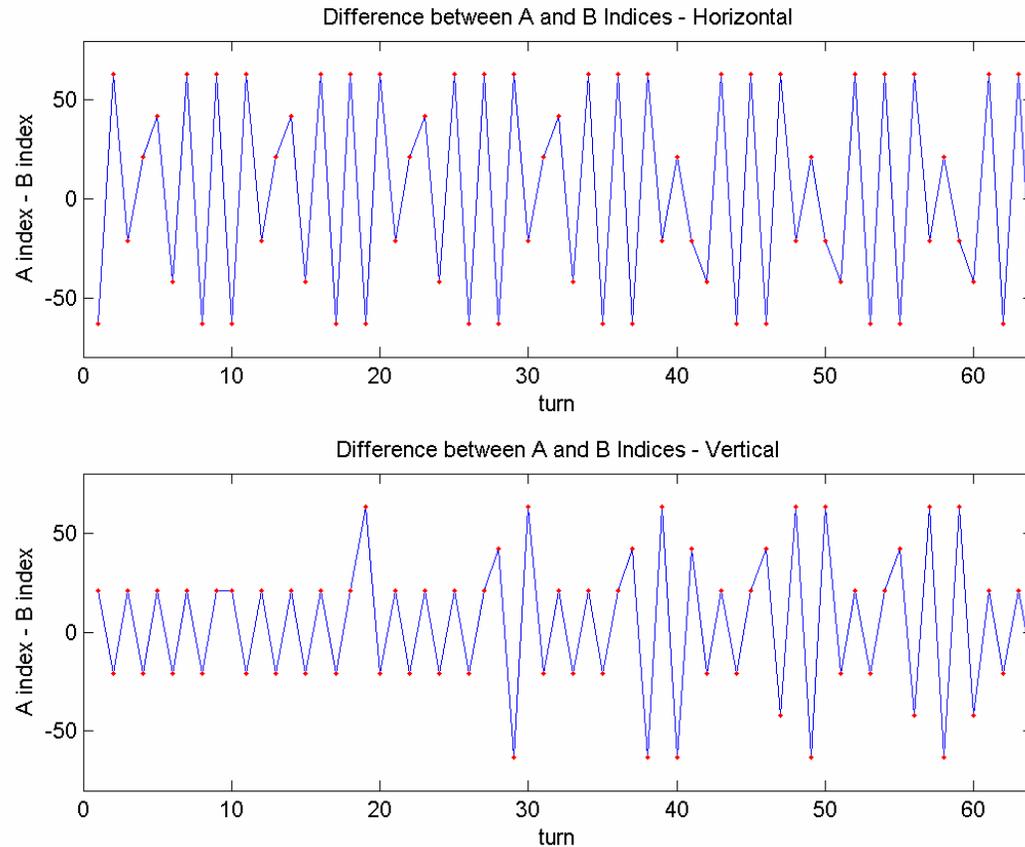
Analysis

The maximum of the convolution using the complement of the window can reside on different peaks, meaning that the position is determined using a different bunch every turn.



Analysis

Not only are different bunches used to measure the positions from turn to turn, but different bunches are used to calculate the A and B values for the given turn.



Keep in mind that the BLT **does** close.

Future

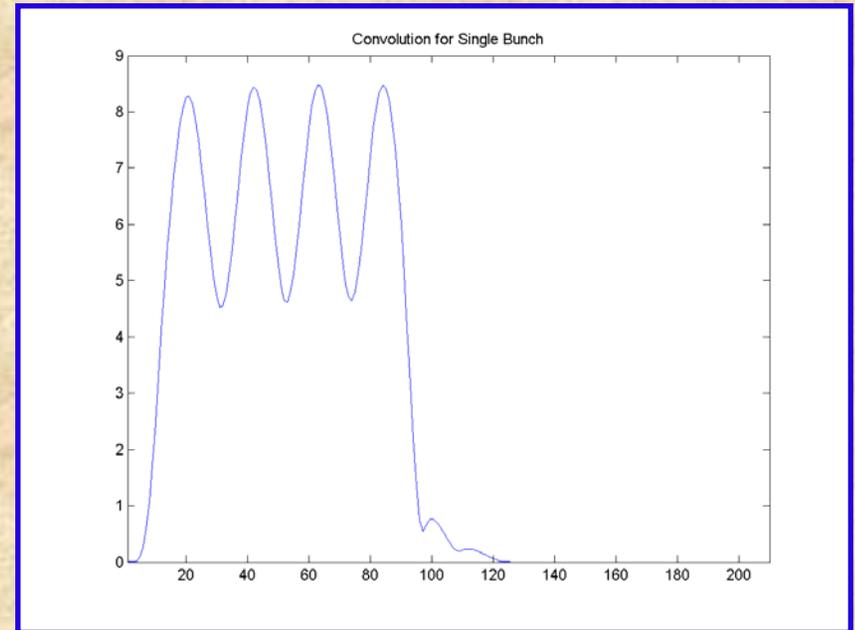
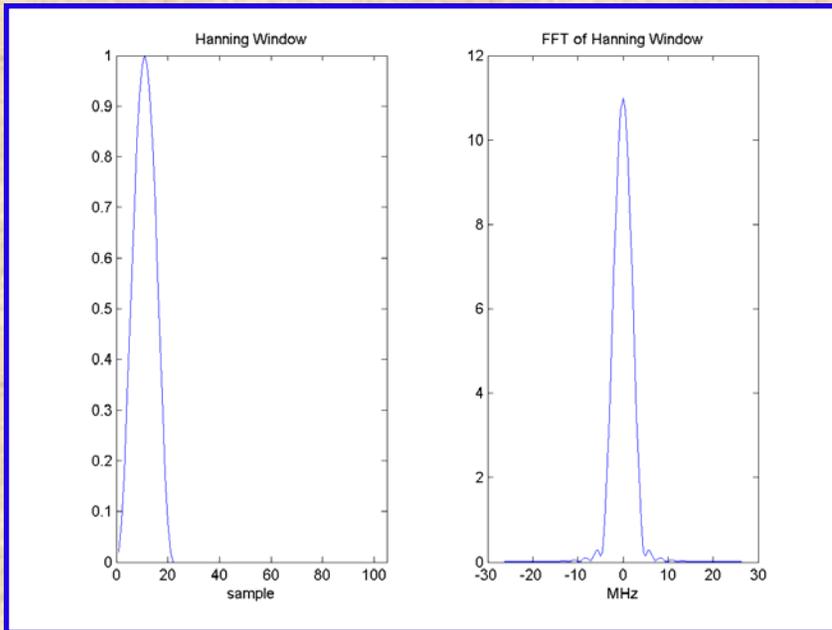
What technique should be used for closing?

If the bunches are significantly different due to the imperfections in the kicker magnet, should we close on the average of all four bunches or close on one bunch?

Future

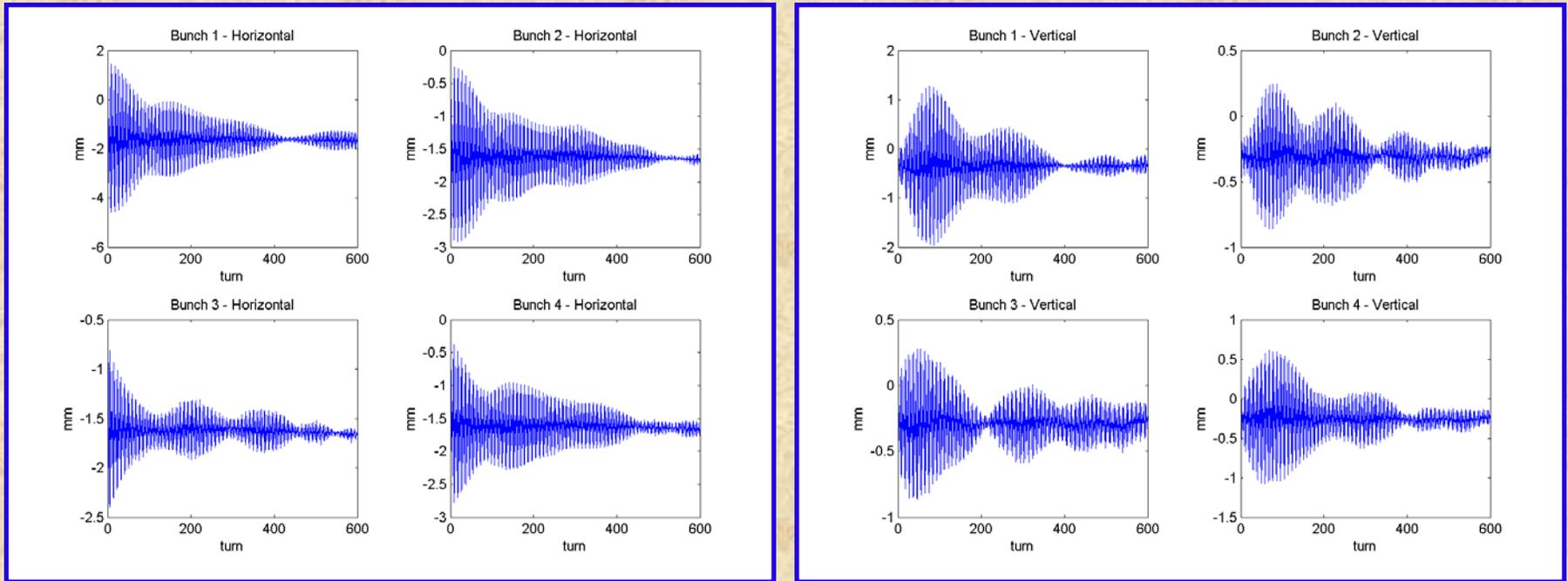
Hanning Window

We have found that by using a Hanning Window, single-bunch analysis is possible.



Future

Bunch-by-Bunch Analysis



Acknowledgements

-Stephen Pordes and Vic Scarpine

-Everyone who helped make this experience possible

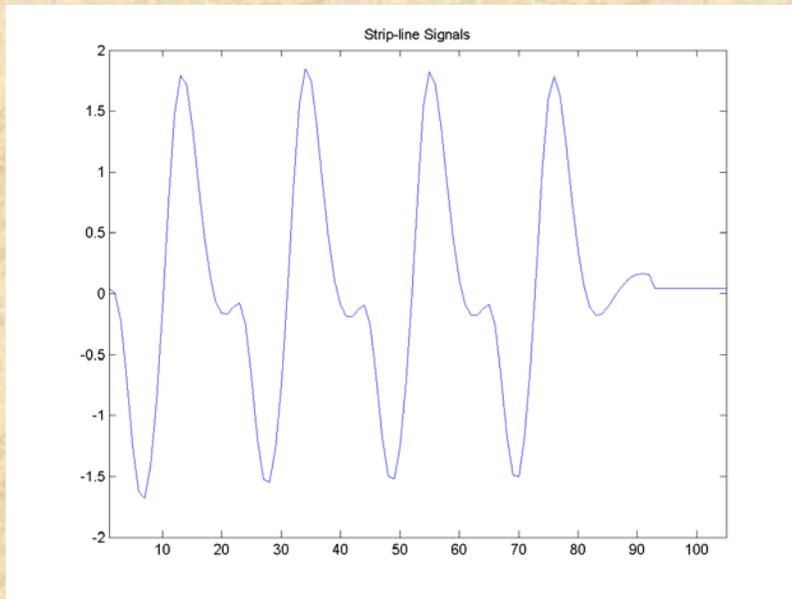
Analysis

Down Converted Data

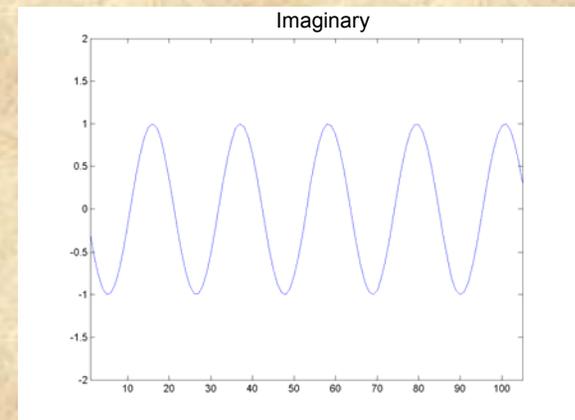
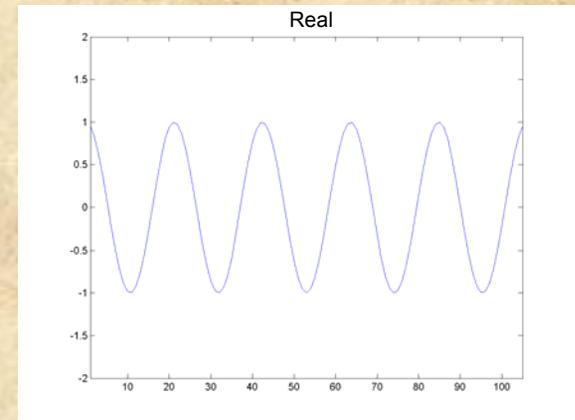
(Signals from Strip-lines)

x

$(e^{-i2\pi N/21})$



X



Analysis

Down Converted Data

=

Down Converted Data

==

