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Comparing H and V MI BPMs Using the Upgraded System

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Abstract

This note presents a first look at data from a vertical MI BPM, taken using the upgraded MI BPM system. This data is compared with data from a horizontal MI BPM taken with the same upgraded system.

Contents

1 Introduction

The data presented in this note are from the horizontal MI BPM 412 and the vertical MI BPM 413. Both flash data and closed orbit data will be presented. Both types of data were taken using MI State 28, slip stacking only, which has a master reset of TCLK $29. In this state two batches are injected, with slip stacking, and then extracted to the antiproton production target.

Most of the data was taken at about 10:15 AM on December 22, 2005. The exception is the horizontal closed orbit data for the H BPM; that was taken on December 12, 2005 at about 4:15 PM. The reason for using old data is simply that I messed up taking the closed orbit data for the H BPM on the morning of the 22nd; fortunately I had some older data of the same state. I believe that the Echotek programming was the same for the two days. The horizontal and vertical flash data were taken about an hour apart.

The flash data were acquired by logging in to the front end and writing the data for state 28 to disk. Before writing the data, I temporarily disabled flash data taking to ensure that all data were for the same instance of the MI cycle.

The closed orbit data were acquired by watching a fast time plot of I:BEAM, triggered on $29, and writing the abort buffer to disk following an instance of state 28. The abort buffer holds about 8 seconds of data, taken at a rate of 500 Hz.

2 Flash Data

Figure 1 shows the sum signal, the position signal and the Fourier Transforms from both the H and V BPMs. The data shown is for the first of the two injections. Figure2 shows details of the Fourier transforms from the previous figure. The details show the low frequency region and the region near the betatron line.

The synchrotron frequency for the MI at injection energy is around 200 Hz. There is a some amplitude at that frequency in the position data for the horizontal BPM; the synchrotron line can be seen strongly in the Beams-doc-2060, figures 18 (upper two plots) and 20 (lower two plots). Presumably the injection shown in this figure was better tuned and the synchrotron line has a small amplitude.

Dave Capista tells me that, when slipping is on, the MI has two sets of cavities energized at frequencies separated by about 1200 Hz; a beat will be present at this frequency. The dominant line in the position data for the horizontal BPM has a line at about 1.4 kHz. This frequency is the sum of the beat frequency plus the synchrotron frequency. The line is absent in the data from the vertical BPM since both of the phenomena that contribute to this line, the beat frequency and the synchrotron motion, are felt only in the horizontal plane.

In Beams-doc-2060 it was demonstrated that the rate at which bunches slip out of the Echotek gate is also 1.4 kHz.

The line at 1.4 kHz does appear in the sum signal for both the horizontal and vertical BPMs. I don't yet know the explanation for this.

The Fourier transform of the sum signal has a second strong line at about 600 Hz; it is present in both the horizontal and vertical data. The line is also present in Beams-doc-2060, figures 17 (upper two plots) and 19 (lower two plots). This line is not caused by bunch length oscillations; if it were it would be at twice the synchrotron frequency, about 400 Hz and its frequency is clearly different from that. For now this line remains unexplained.

The lower right plot in Figure 2 shows the betatron tunes in the two planes. By eye I estimate that the tune split is about 1.5 ± 0.5 bins, or about 140 ± 45 Hz.

Figure 3 shows a summary of the data for flashes 2 and 3. Flash 2 measures the injection of the second bunch, while flash 3 measures the extraction. In the present timing card configuration, the house delays for injection from the booster are set relative to the AA marker and cannot be adjusted on a per injection basis. This data was taken the the delays set to capture batch 1 correctly. See beams-doc-2060 for details. In the future this will be fixed so that both injections can be captured correctly.

3 Closed Orbit Data

Figure 4 shows the closed orbit data for a full cycle of state 28, for both horizontal and vertical BPMs. As expected, when the first batch starts to slip, the beam moves only in H, not in V. It was previously noted that the sum signal for the H BPM has a small step just before the main extraction; this was explained as a artifact of a bunch rotation. The effect is not present in the data for the vertical BPM; does this make sense?

Figure5 shows a detail of these plots focusing on the time when only batch 1 is in the MI. The position data suggests that the slipping starts 7 or 8 ticks of the 500 Hz clock after the injection; this corresponds to 14 or 16 ms, which is longer than the expected value of about 8 ms. Does this mean that the slipping takes 6 or 8 ms to accelerate to its full rate?

Now I will try to explain the slope in the sum signal while first batch is slipping. When the beam moves to a smaller radius, it its rotation frequency also changes. Since this frequency is away from the center frequency of the Echotek digital filter, the filter attenuates the signal a little. As the beam moves to an even smaller radius, the rotation frequency moves farther from the center frequency of the Echotek digital filter; and the signal is attenuated even more.

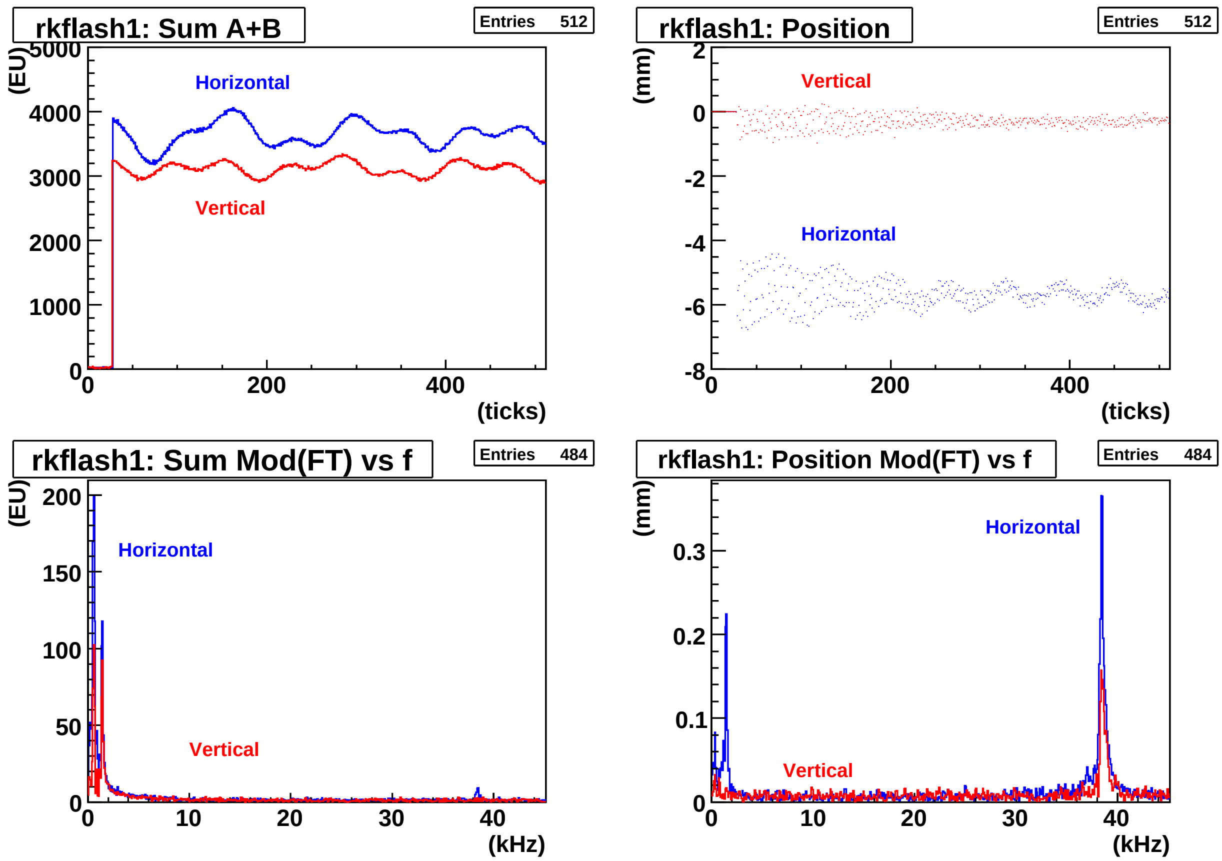

Figure 1: Flash turn by turn data from both BPMs for the first injection. The upper left plot show the sum signal; the upper right plot shows the position; the lower left plot shows the magnitude of the Fourier transform of the sum signal; the lower right plot shows the magnitude of the Fourier transform of the position. Details of the transforms are shown in the next figure.

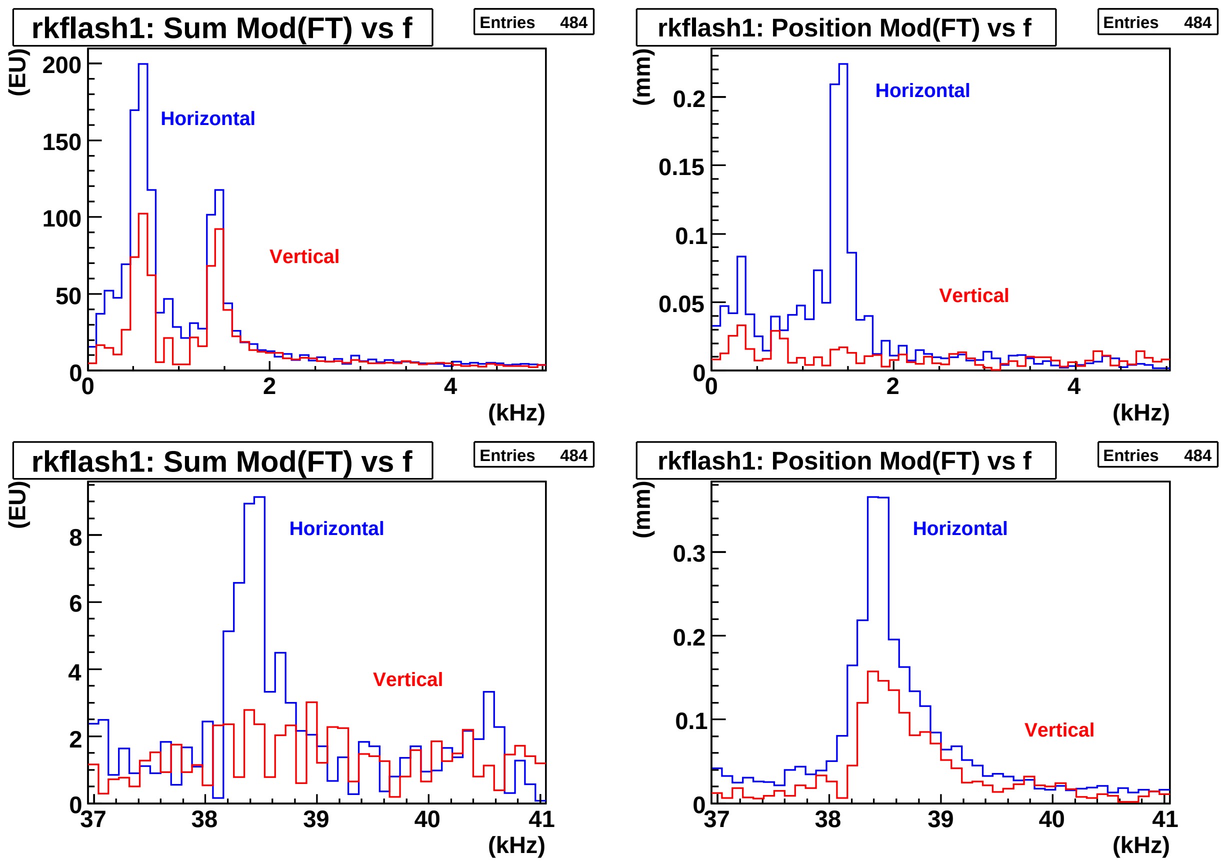

Figure 2: Details of the lower plots in Figure 1. The left plots show details of the Fourier transform of the sum signal while the right plots show the same detail for the position. Synchrotron motion is absent in the position data form the Vertical BPM. Each bin is about 92 Hz wide and on this scale it is hard to resolve the horizontal/vertical betatron tune split.

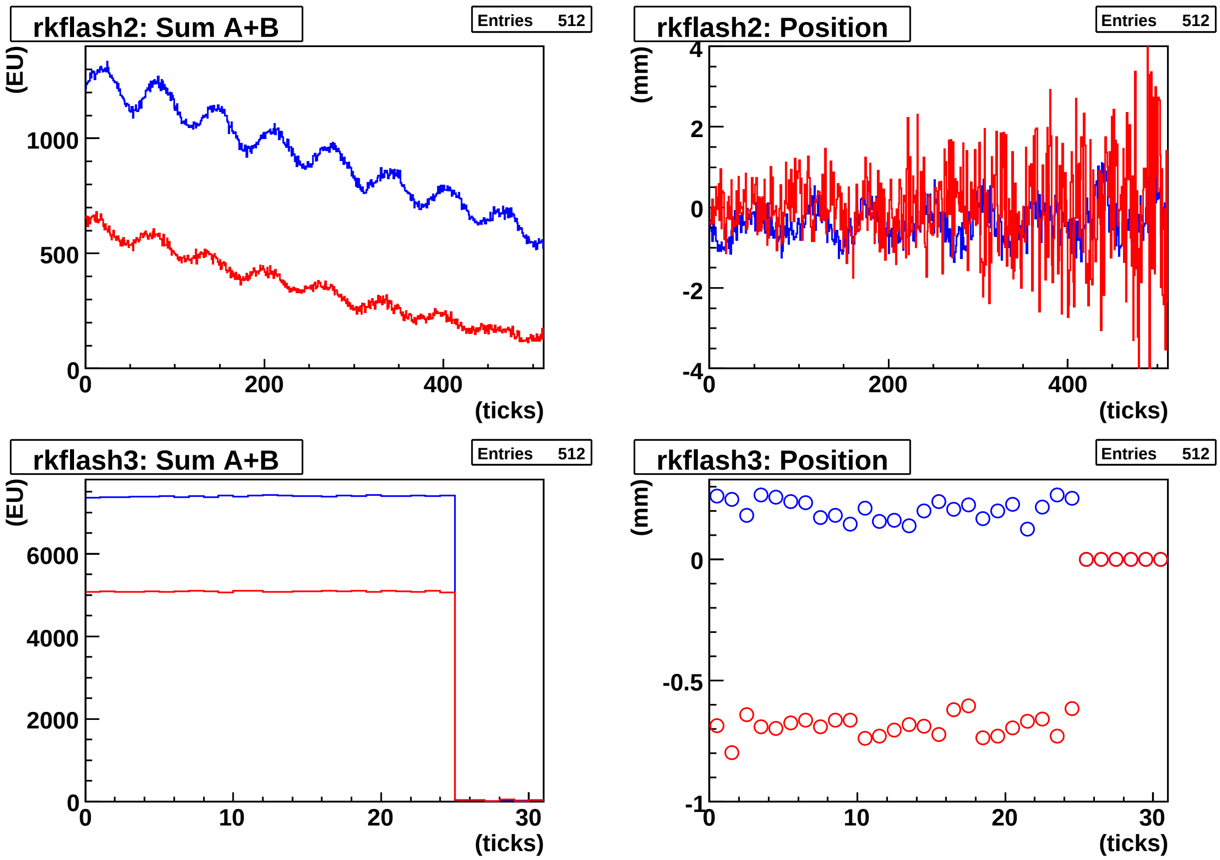

Figure 3: Sum and position information for flashes 2 and 3; flash 2 is the second injection and flash 3 is the extraction. The upper two plots are for flash 2 and the lower for flash 3. In this data the position is reported as 0 when the sum signal is below threshold.

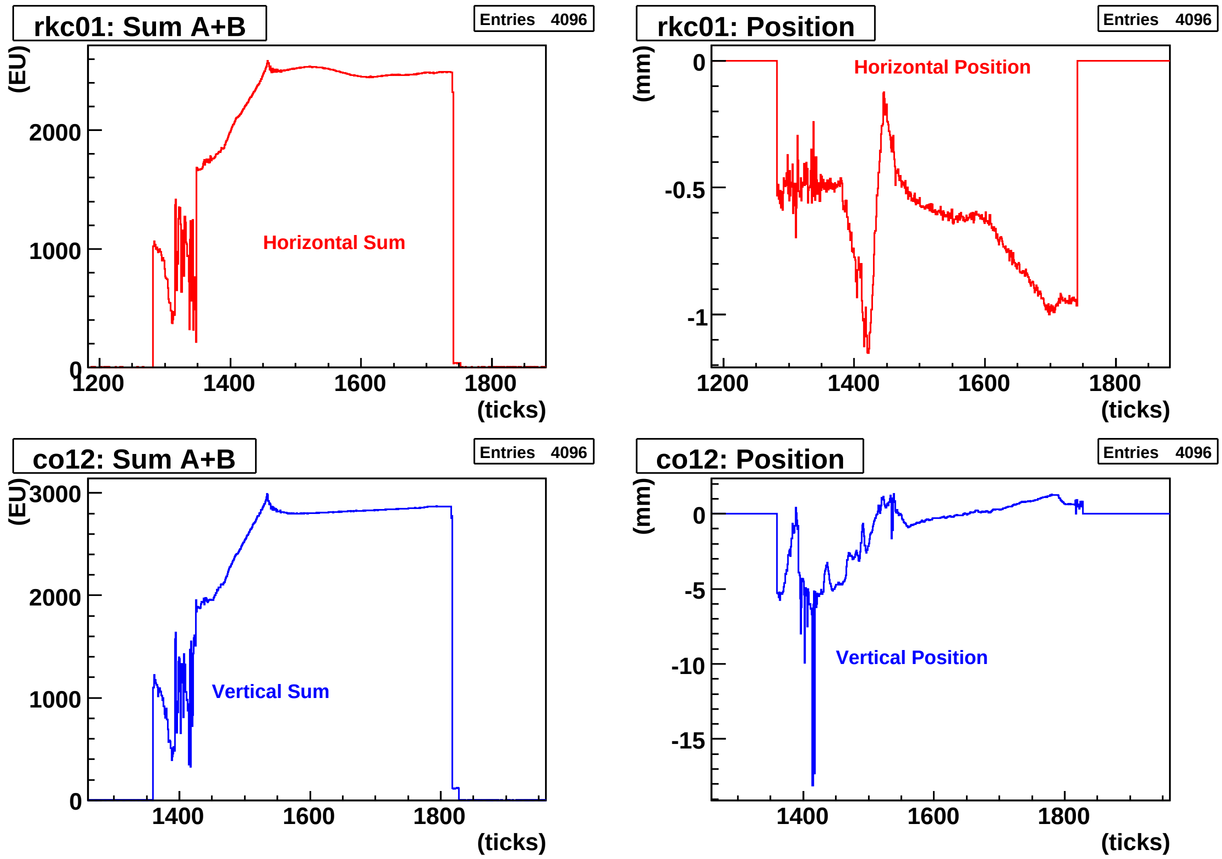

Figure 4: Closed orbit data for the slip stacking state. The left plots show the sum signal while the right plots show the position. The upper plots show the vertical BPM while the lower plots show the horizontal BPM. Note that the vertical position is stable when the first batch is moved to the orbit with a smaller radius. Note the large scale difference for the position data for the two BPMs.

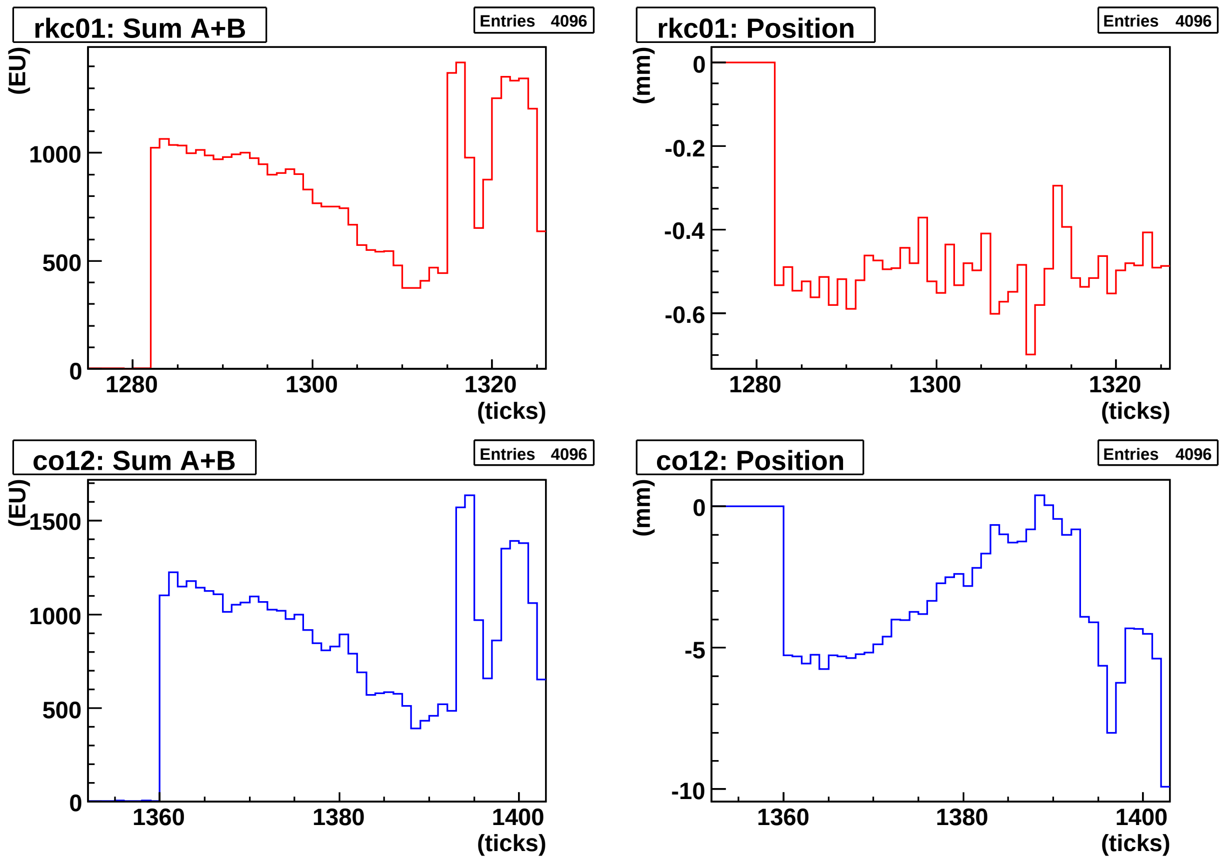

Figure 5: Detail of the previous figure, zoomed in to show the time between injection of the two batches.