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A Quick Look at MI BPM Data

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Abstract

This note presents the first closed orbit and turn by turn measurements that I made using the test MI BPM system in MI40. The bottom line is that the closed orbit measurements appear to be more or less working but there are several anomalies. I can explain one of the anomalies and it should be easy to fix. The others are under investigation. The picture for the turn by turn measurements is less clear.

1 Introduction

The data presented in this note were taken with the test system for the MIBPM upgrade that is installed at MI40. These measurements were taken between about 4:16 PM and 5:00 PM on Wednesday November 23, 2005. This is after the change to the code to add the scale factor of -20.2 in the position. It is also after the change that fixed the bug that limited the Echotek readout to 1200 points.

2 Closed Orbit Mode

I logged into ibpm40 and, at a randomly selected time, wrote the contents of buffer 11 to disk. This is the analog of the "fast abort buffer" in the Tevatron system: it contains the last 1024 closed orbit measurements, stored at 500 Hz. I believe that the system was configured to measure the signal at 53 MHz. I copied the disk file to my desktop and made the plots shown here.

Figure 1 shows the contents of this buffer. The upper plot shows the quantity $|A|+|B|$, known as the sum or intensity signal, plotted against the measurement number. The time covered by the horizontal axis is about 2 seconds. In this we can see the end of one MI state, followed by an empty period and then several injections. I don't yet understand why the sum signal drops just after 800 measurements; is it an extraction? I also don't know which MI state we are looking at.

The lower plot shows the measured position, in mm, plotted against measurement number. I don't know enough about the machine to know if the position information shows any diseases. Is the variation of a few mm believable?

I repeated the procedure to obtain a second data set. The results for that dataset are shown in Figure 2. This is similar to the first data set and I had to looked carefully to see that it is, in fact, different. It appears that the position resolution for this data set is a little better than for the first. The two data sets were taken 45 minutes apart so I suppose its possible that the machine changed somewhat during that time? The change in resolution between the two data sets might also mean that the system is not yet working correctly. For now we will proceed under the assumption that it is OK.

I chose to estimate the resolution using the data between the vertical blue lines in the middle plot in Figure 2. These data were projected onto the position axis and the results are shown as the bottom histogram. The RMS resolution is about 150 μm but it appears that the data are coarsely quantized.

To investigate the coarse quantization of the position measurement, Figure 3 shows the same data as the top two plots in Figure 2, but zoomed in to show the data between the two vertical blue lines. The sum plot is included for reference and the main discussion will focus on the position plot. In the position plot, there appears to be 3 main groups of values, with some smaller variation with each group. Note that measurements 644 through 647, have identical sum and position values. Table 2 shows the data from the buffer for these 4 points plus several of their neighbors. Inspection of the table shows that the quantization of the position is due to the granularity of the raw (I,Q) values. I can imagine several possible causes of this but I have no idea which might be the real reason: gain in the transition board that is too small, improper programming of the Echotek, or loss of precision when copying data in the front end. And there are probably explanations I have not thought of.

3 Turn by Turn Mode

To obtain turn by turn data, I logged into ibpm40, enabled turn by turn mode, wrote the turn by turn buffer to disk, and reset the system to closed orbit mode. There are 2048 points in the turn by turn buffer and I believe that the system was set up to measure the signal at 53 MHz. The turn by turn data was triggered by a clock event that is asserted once per second. This clock event is not timed in to any MI state so the trigger is essentially random. The first few times that I did this, the sum signal was only a few counts for all or most measurements; I presume that I triggered the measurement when there was no beam in the machine.

On the fifth try, I obtained the data shown in Figure 4. The top plot shows the sum signal for the 2048 turns in the buffer; most of the data is clustered near 230 counts but there are frequent outliers down to zero counts. There is a change in the behavior of the outliers after about 1650 measurements. The lower plot shows the measured position for the 2048 turns in this buffer. Again there is a main body of data plus many outliers. I have not yet had a chance to look for structure in the outliers in either plot. Nor have I had a chance to see if the big picture is repeatable.

Measurement Number	Position (mm)	Sum (EU)	A (EU)	B (EU)
640	1.40601	80.3165	[-42,9]	[-36,10]
641	1.22792	80.6101	[-42,8]	[-37,8]
642	1.25719	78.6514	[-41,8]	[-36,8]
643	0.98339	80.0551	[-41,9]	[-37,9]
644	1.22848	79.5650	[-41,10]	[-36,10]
645	1.22848	79.5650	[-41,10]	[-36,10]
646	1.22848	79.5650	[-41,10]	[-36,10]
647	1.22848	79.5650	[-41,10]	[-36,10]
648	0.93750	78.3631	[-40,9]	[-36,10]
649	1.24346	79.0841	[-41,9]	[-36,9]
650	1.19468	78.8811	[-41,8]	[-36,9]
651	1.42835	79.8631	[-42,8]	[-36,9]

Table 1: The raw data for a few of the points shown in Figure 3. For reference, the 12 points listed here are centered on the 4 identical measurements between measurements 644 and 647. For the quantities A and B, both the I and Q values are given. The units of A, B and the sum signal are Echotek Units (EU).

I considered the idea that I had triggered the measurement when some RF gymnastics, such as coalescing, were being performed. I can't exclude this but my guess is that this is not the case; I guess that RF gymnastics would show a slower variation than is seen here. My gut tells me that this a timing problem but I can't prove it.

A final comment for the turn by turn measurement shown here. The last 11 points all have the same value of A=[-8531,-16657] and B=[-8531,-16657]. This is far off scale and I presume that this indicates some problem with the system.

4 Summary

I have shown the results of my first attempts to look at beam with the test MI BPM system. Some things look good but there are a number of anomalies. One anomaly is that raw IQ values coarsely quantized, which should be fixed. I can't yet explain the other anomalies. I will look into them but I welcome any ideas that others have.

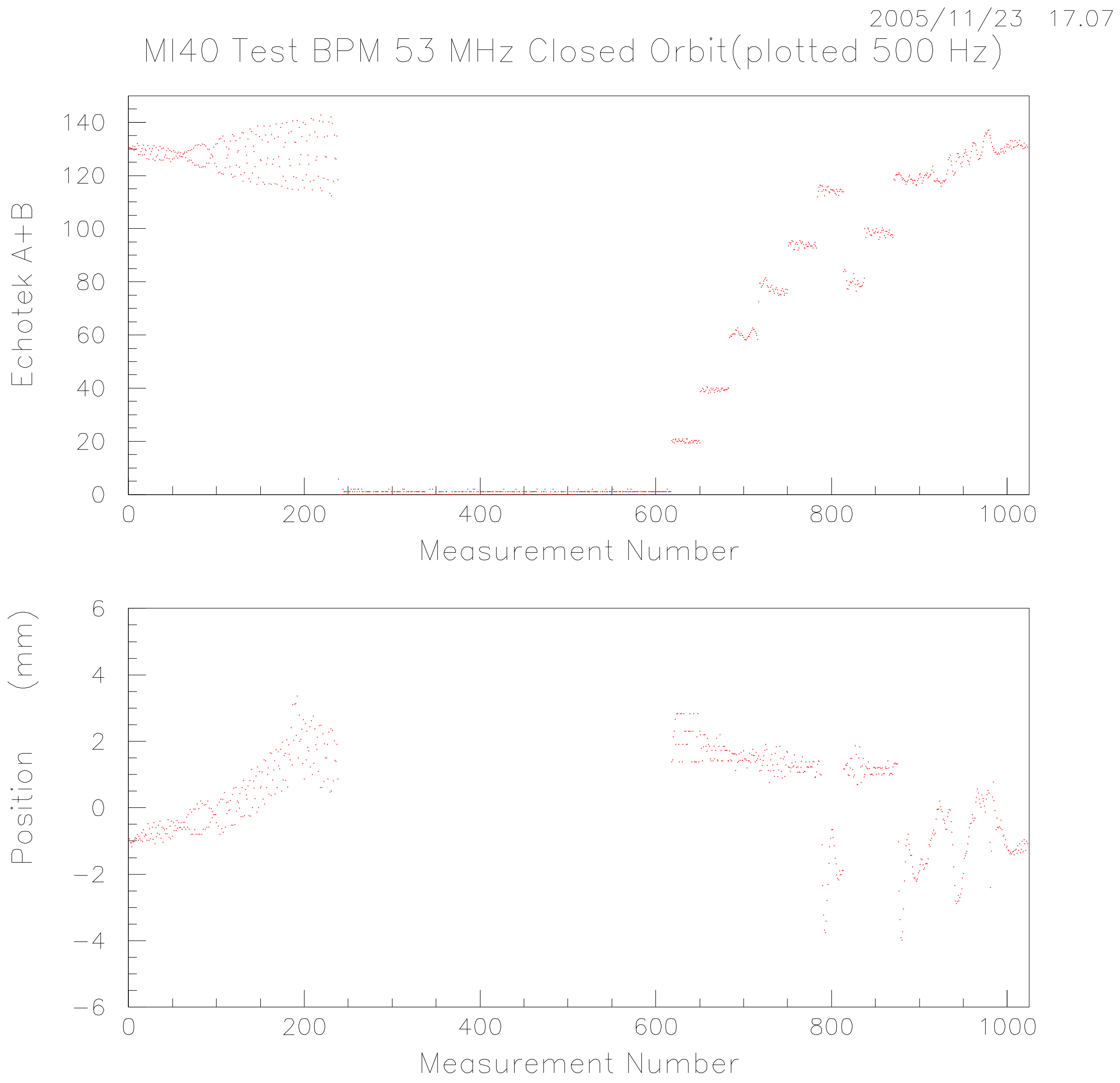

Figure 1: These plots show 1024 consecutive closed orbit measurements taken with the MI BPM test equipment in MI40. The points were recorded at 500 Hz, which means that the horizontal axis covers about 2 seconds. The start time was not synchronized with any timing signal. The upper plot shows the sum signal ($|A| + |B|$) plotted against measurement number. The lower plot shows the position, in mm, plotted against measurement number.

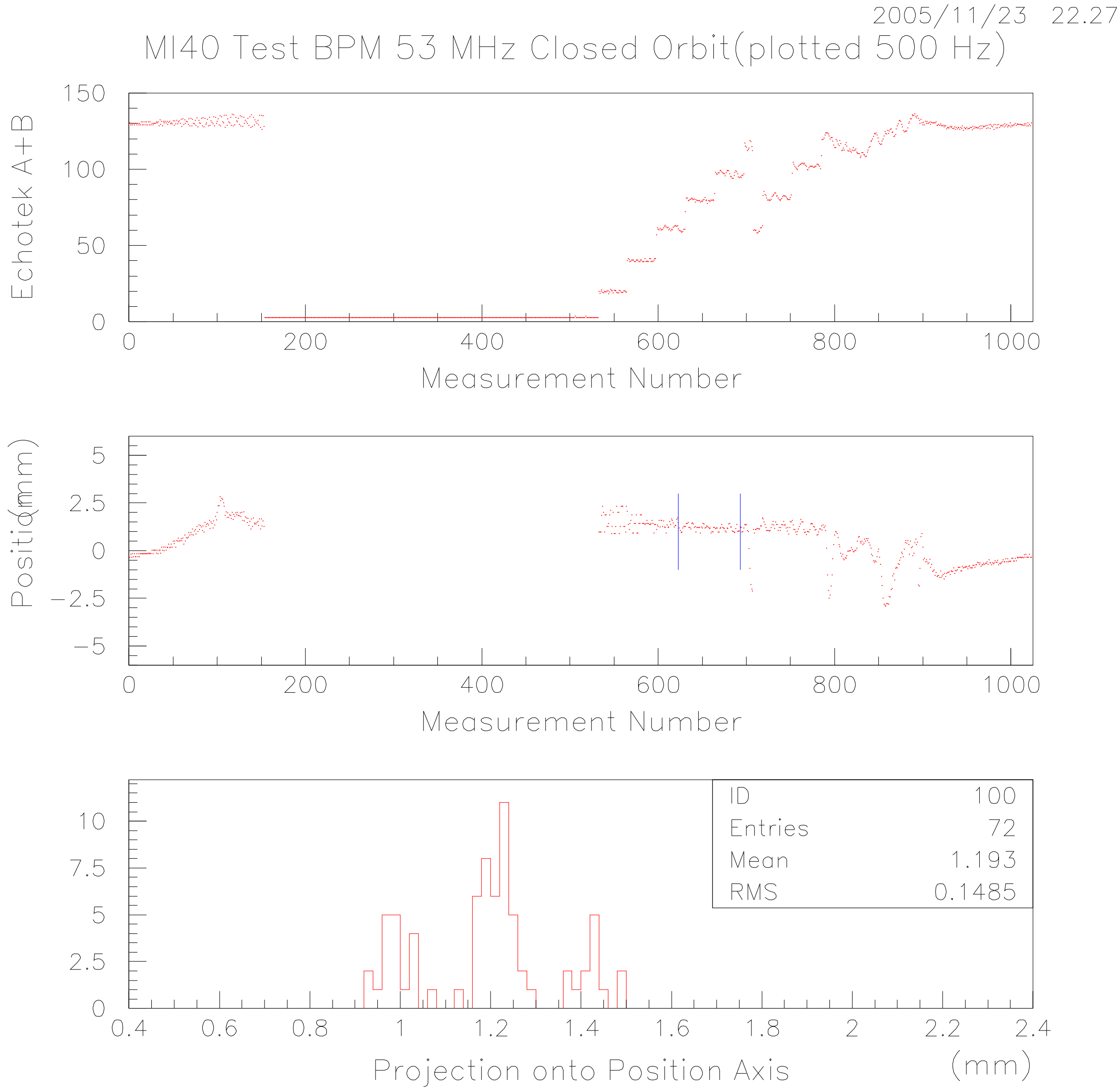

Figure 2: The upper two plots shows the same information as the previous plot but for a second data set. The vertical blue lines in the middle plot show the range of data selected to measure the position resolution. The bottom plot shows the projection of the data between the blue lines onto the position axis. The structure in this last plot will be investigated in the next figure.

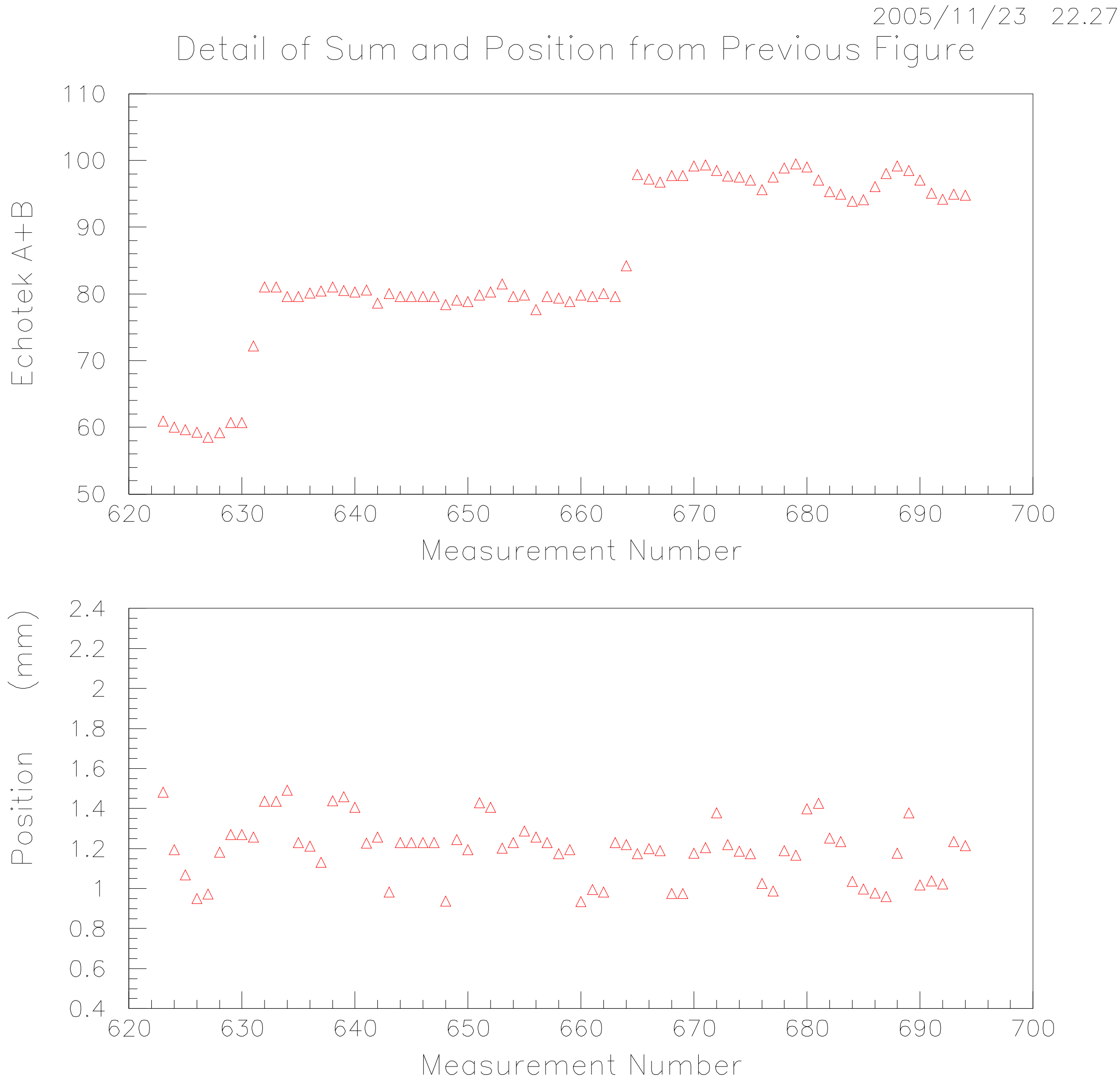

Figure 3: These two plots show details of the upper two plots in the previous figure. The period selected for detail is that used to measure the resolution (between the vertical blue lines). The position appears to be quantized and I interpret this as evidence that we are seeing the granularity of the Echotek.

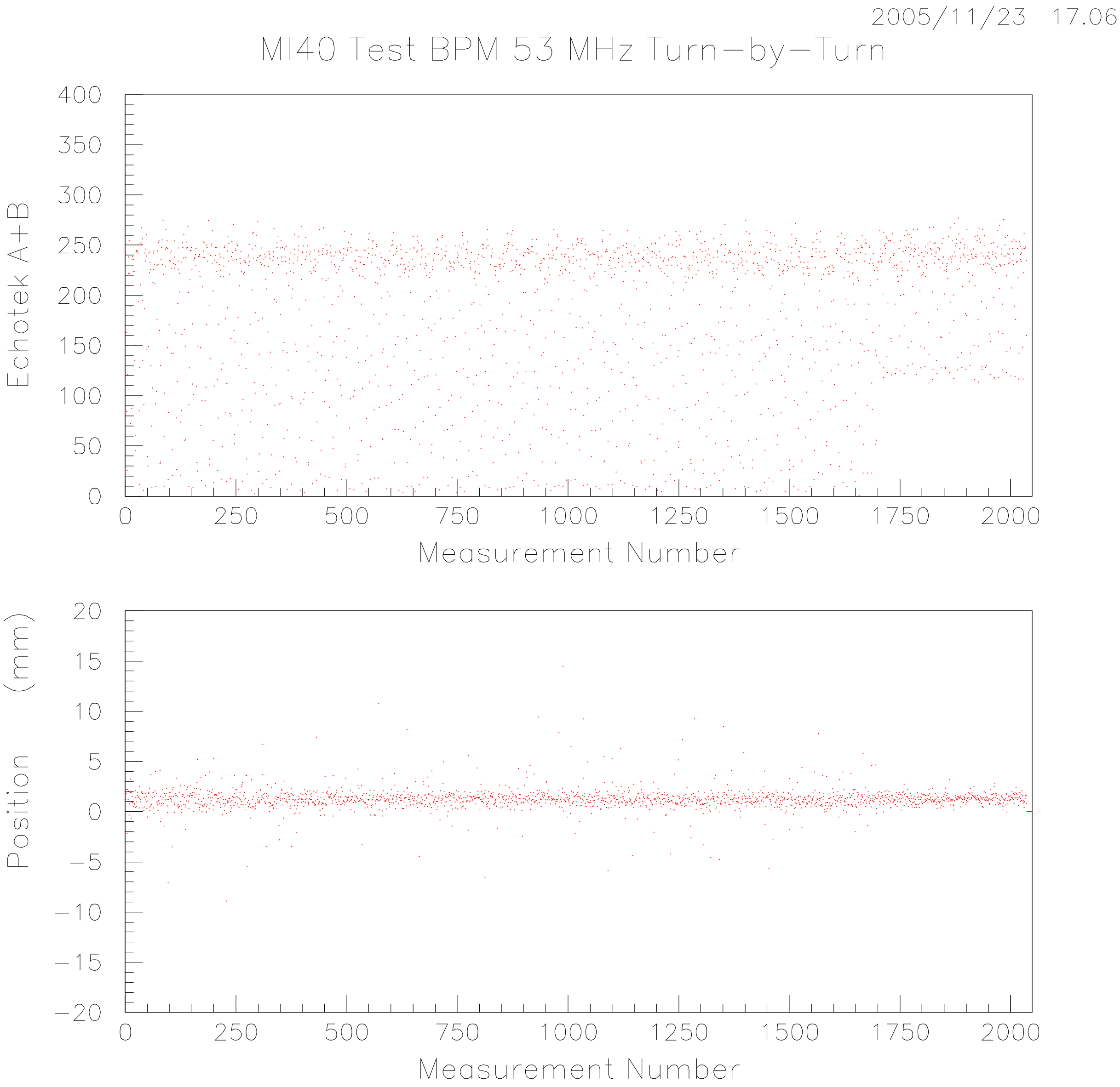

Figure 4: These plots show 2048 consecutive points from a hand triggered turn by turn measurement. The measurement was triggered by hand, without any reference to any timing signals. I believe, but can't really prove, that there was indeed beam in the machine for this measurement. There is clearly a big problem with the sum signal and there are significant outliers in the position signal. See the text for details.