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A First Look at the Safe Mode Data

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Abstract

This note shows TeV BPM data taken using Safe Mode in the A3 house for the shot that went in at 10:48 PM on May 10, 2005. The data shows that Safe Mode worked well but that a few tweaks are still needed.

1 Introduction

For the HEP shot on May 10, the A3 house was configured to run in safe injection mode. In this mode the Echotek is triggered by injection, similar to normal injection mode, but a single trigger causes it to acquire 8192 measurements. There is only one bunch, or one booster batch, in the machine when this mode is running. These measurements cover, without any gaps, about 75 Tevatron rotation periods, ensuring that the Echotek will see the bunch even when the trigger module is not properly timed in with the bunch. These 8192 measurements are stored in the SafeInjection buffer, buffer 21 on the front end computer.

The front end computer processes the 8192 measurements to identify when the bunch passes the BPM on each turn. It then computes the beam position for each turn and stores it in the regular injection turn by turn buffer. In the case of this store, it was able to find 76 turns.

2 Raw Data from the SafeInjection Buffer

Figure 1 shows the proton sum and position data from the SafeInjection buffer for HA32. Note the regular pattern of spikes in the sum signal, indicating the presence of beam. The position data is at 999 when no beam is present and is at the measured position when the sum signal is above threshold.

Figure 2 is a detail of the data in Figure 1, showing the first three times that the bunch passes the pickup. From top to bottom the plots are the sum signal, the position, the magnitude of proton A and the magnitude of proton B. The sum and magnitude signals all look sensible but the position data has a shoulder on its trailing edge.

To help investigate the shoulder, Figure 3 shows the same data as Figure 2 but with an expanded vertical scale. From this figure, it appears that the

threshold to declare good position data in this buffer was probably around 10. Raising it to 50 or 100 will get rid of the shoulder.

Figure 4 shows an even finer detail of the proton sum and position signals for each of the first four turns. The position points are plotted only when the sum signal exceeds 50 counts. All of the position plots have a full vertical scale of 1.5 mm. Even with the threshold cut, the position data do have a few outliers, which are off from the main body of the data of a few hundred microns.

3 Processed data from the Injection Turn by Turn Buffer

Luciano tells me that the following algorithm is used to compute the information that goes into the injection turn by turn buffer. He uses a sliding window 10 bins wide to identify groups of points that correspond to the presence of a bunch. I think he said that he does not use an explicit threshold on the sum signal but that, instead, the algorithm looks for rising and falling derivatives in the sum signal. He then finds the point in the group that has the highest sum signal. The measurement for the high point is copied to the injection turn by turn buffer.

Figure 5 shows the sum signal from the injection turn by turn buffer for four BPMS in the A3 house. Luciano is investigating why the 6th point for VA33 has a low value, 67 counts. My guess is that this is a spurious extra point that can be fixed by a small threshold. The last point in the other three BPMs is zero because Luciano pads buffers to ensure that all buffers in a house have the same length.

Figure 6 shows the position data corresponding to the sum data from the previous figure. The sixth point for VA33 is set to 999 since this buffer requires that the sum signal exceed 100 in order to declare good data. The last point in each of the other BPMs is not meaningful. Is it stale memory?

I also computed the Fourier transforms of the sum and position data for one H BPM and one V BPM, HA32 and VA35. When I computed the transforms, I dropped the last point, leaving 75 good points. Figure 7 shows the Fourier transforms of the sum and position data for these two BPMs. In Figure 7, there are strong betatron oscillations present in the position data for both the H and V planes. You might even believe that the H and V tunes can be distinguished. There is evidence for synchrotron oscillations in the H plane but the resolution bandwidth is too large to be definitive; the 75 turns correspond to only about 1/8 of a synchrotron oscillation. As expected, there is no real evidence for synchrotron oscillations in the V plane but, again, the resolution bandwidth is too large to be definitive. The enhancement at low frequencies in the FT of the sum signal is probably the quadrupole oscillations.

For reference when looking at Figure 7, Figures 8 through 11 show time series and Fourier transforms for data from the A1 house for the same shot as the A3 data. At that time, the A1 house was configured in normal turn by turn

mode. In particular, Figure 11 shows the Fourier transforms of the first 75 non-empty turns of the A1 data. This can be compared directly to Figure 7. The dominant features are similar but I am not sure what quantitative comparisons are meaningful. For example synchrotron oscillations is much stronger in HA11 than in HA32. Figures 9 and 10 show the Fourier transforms of the A1 data using all 8192 points. This shows that injection was fairly typical and we are not trying to make sense of oddball data.

4 Conclusion

Safe mode appears to be working well. A few more tweaks are needed to the algorithm that fills the injection turn by turn buffer from the SafeInjection buffer.

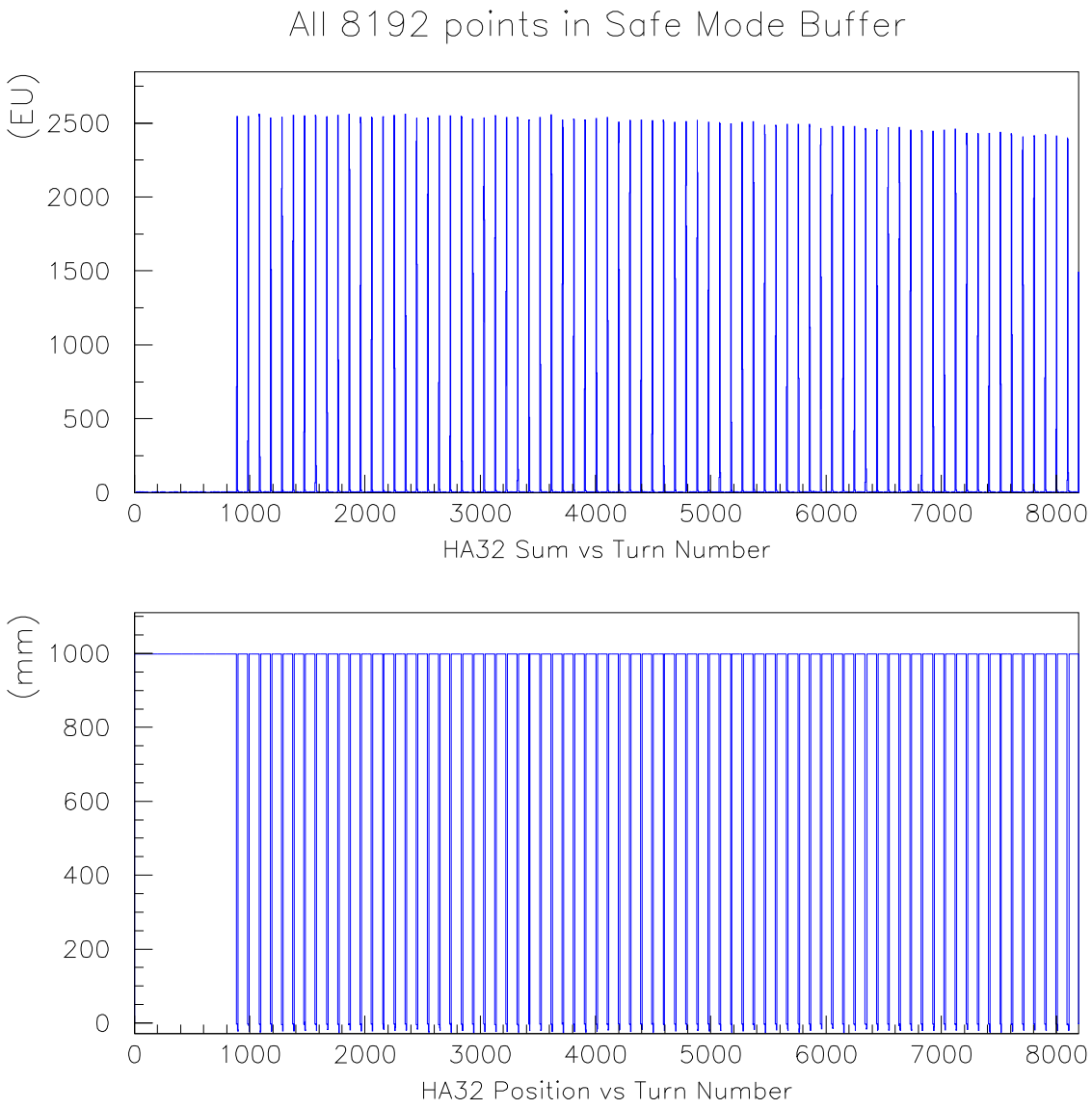

Figure 1: The proton sum and position data for all 8192 measurements in the SafeInjection buffer.

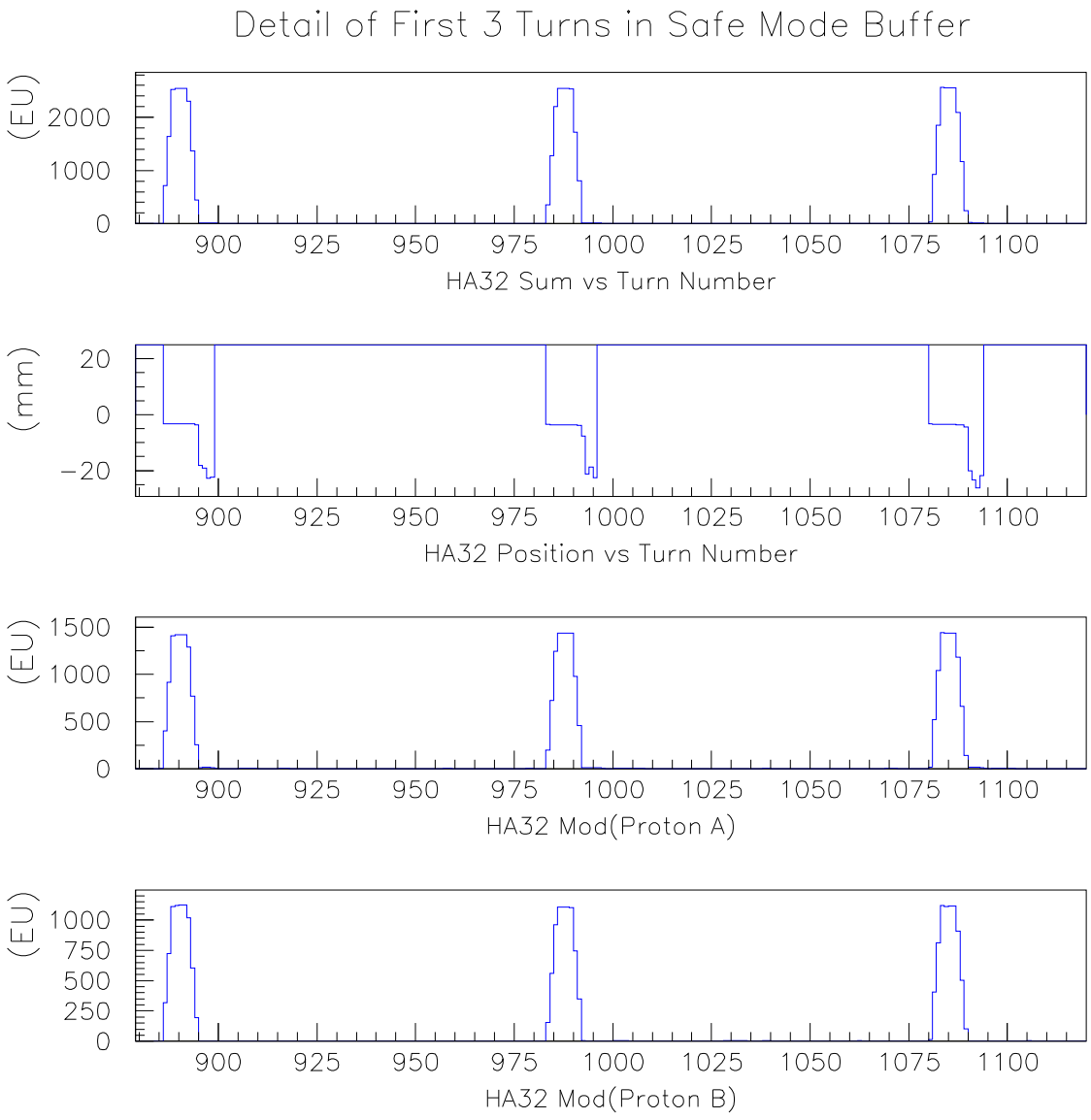

Figure 2: Detail of the data from Figure 1. The data shown here correspond to the first three turns. Note the shoulder on the position data.

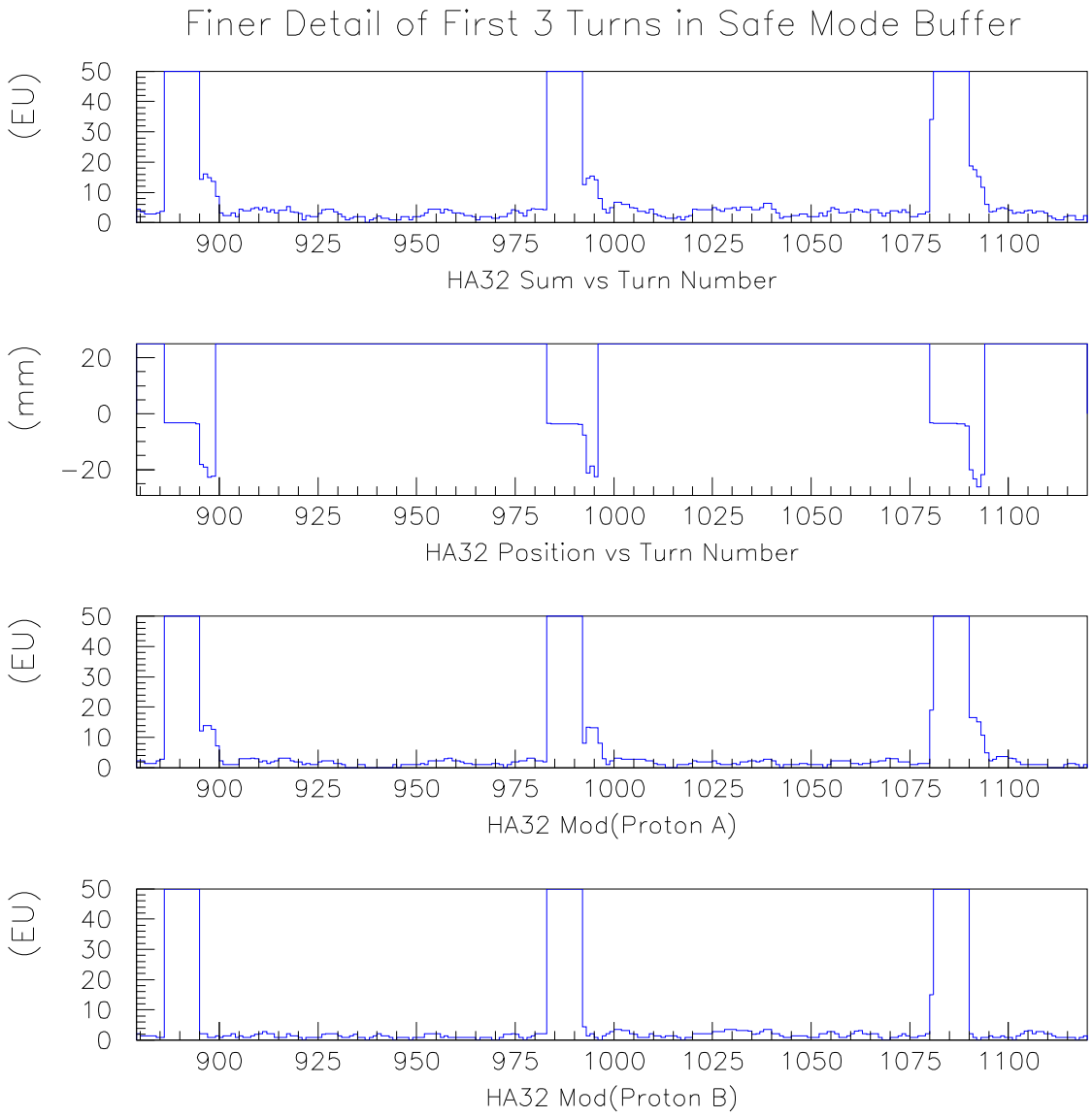

Figure 3: Same plots as Figure 2 but with an expanded vertical scale. The source of the shoulder in the position data is clear and can be fixed by setting a threshold on the sum signal.

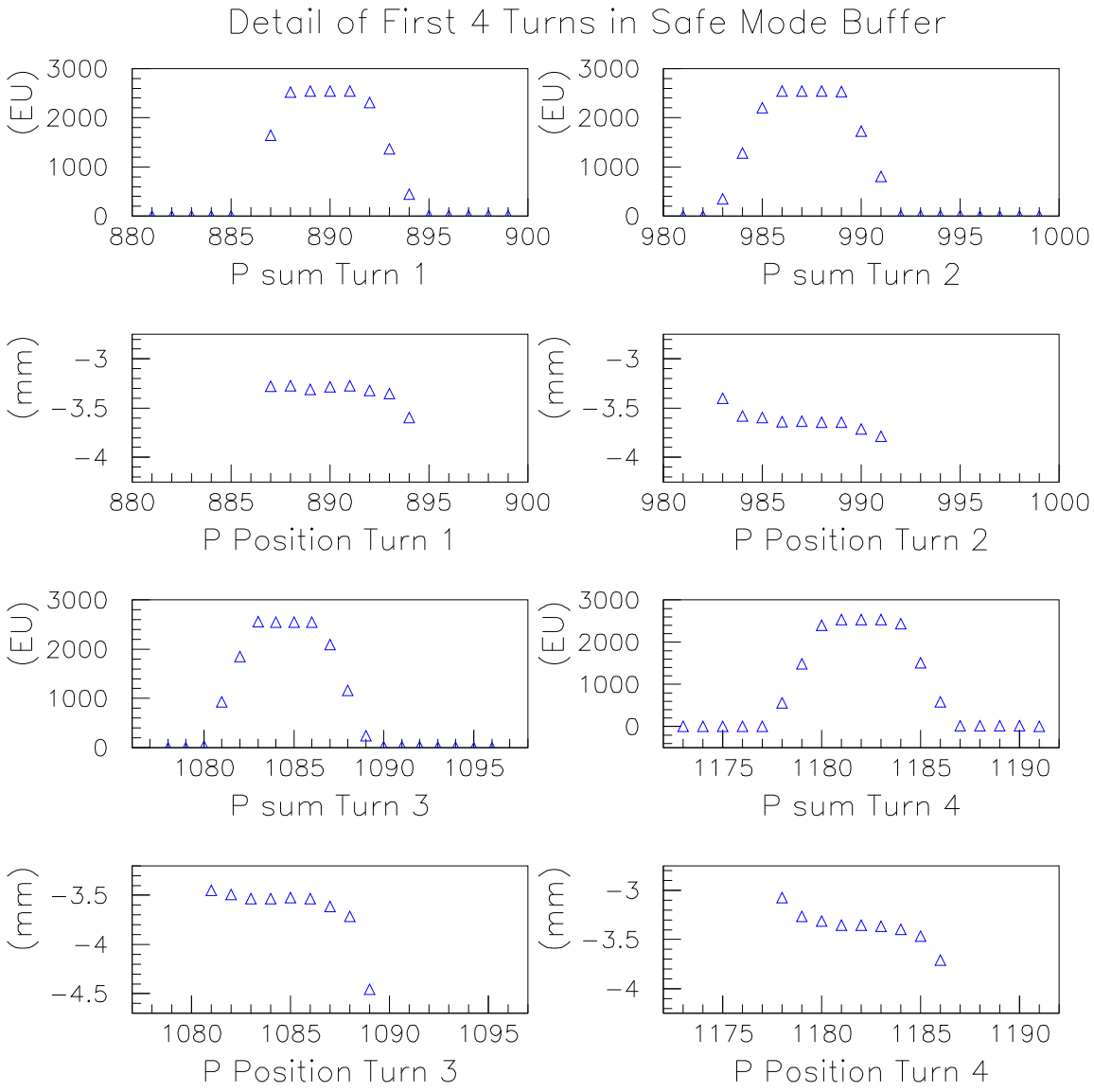

Figure 4: Finer detail of the proton sum and position data for the first 4 bunches. The position data is plotted only when the sum signal is above 50 counts.

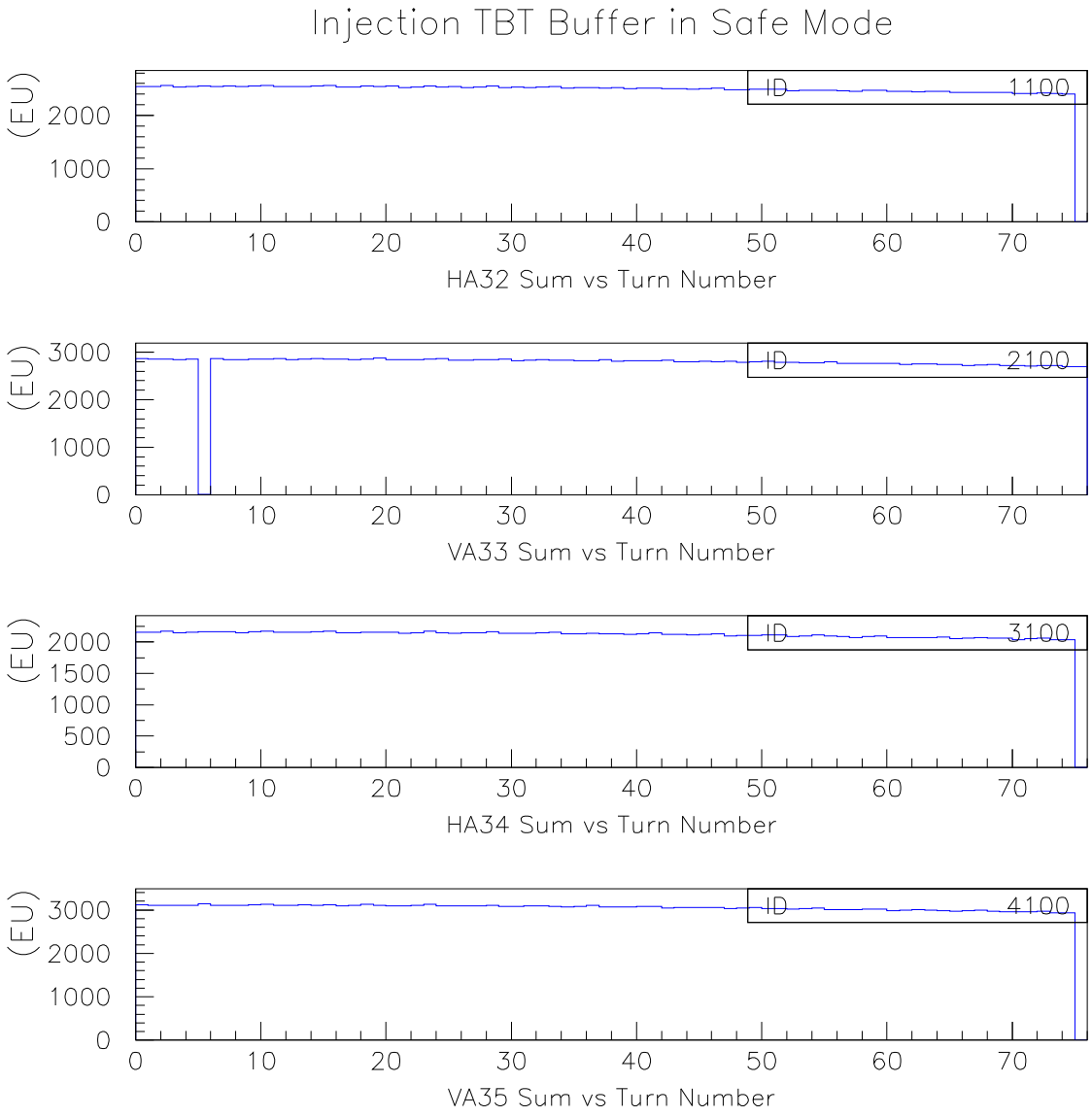

Figure 5: Sum signals from the injection TBT buffer. These data were derived from the raw data as described in the text. The sixth point for VA33 appears to be a spurious extra point. The last point in the other three buffers is zero padding to make all buffers the same length.

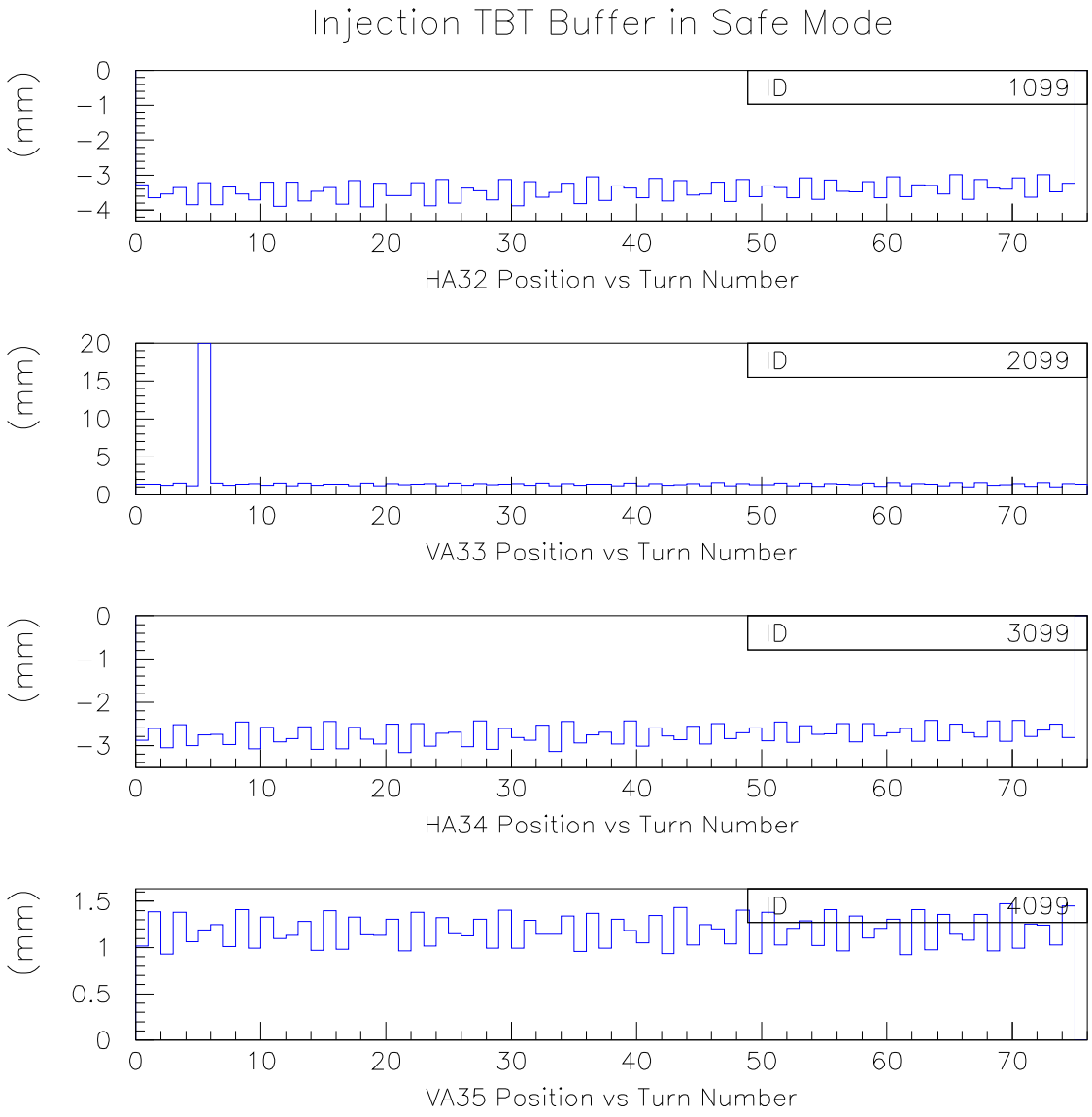

Figure 6: Position signals in the injection TBT buffer, corresponding to the sum signals from the previous figure. The off-scale sixth point for VA33 is probably a spurious extra point. The last point in each of the other three BPMS is not meaningful — it is probably stale memory.

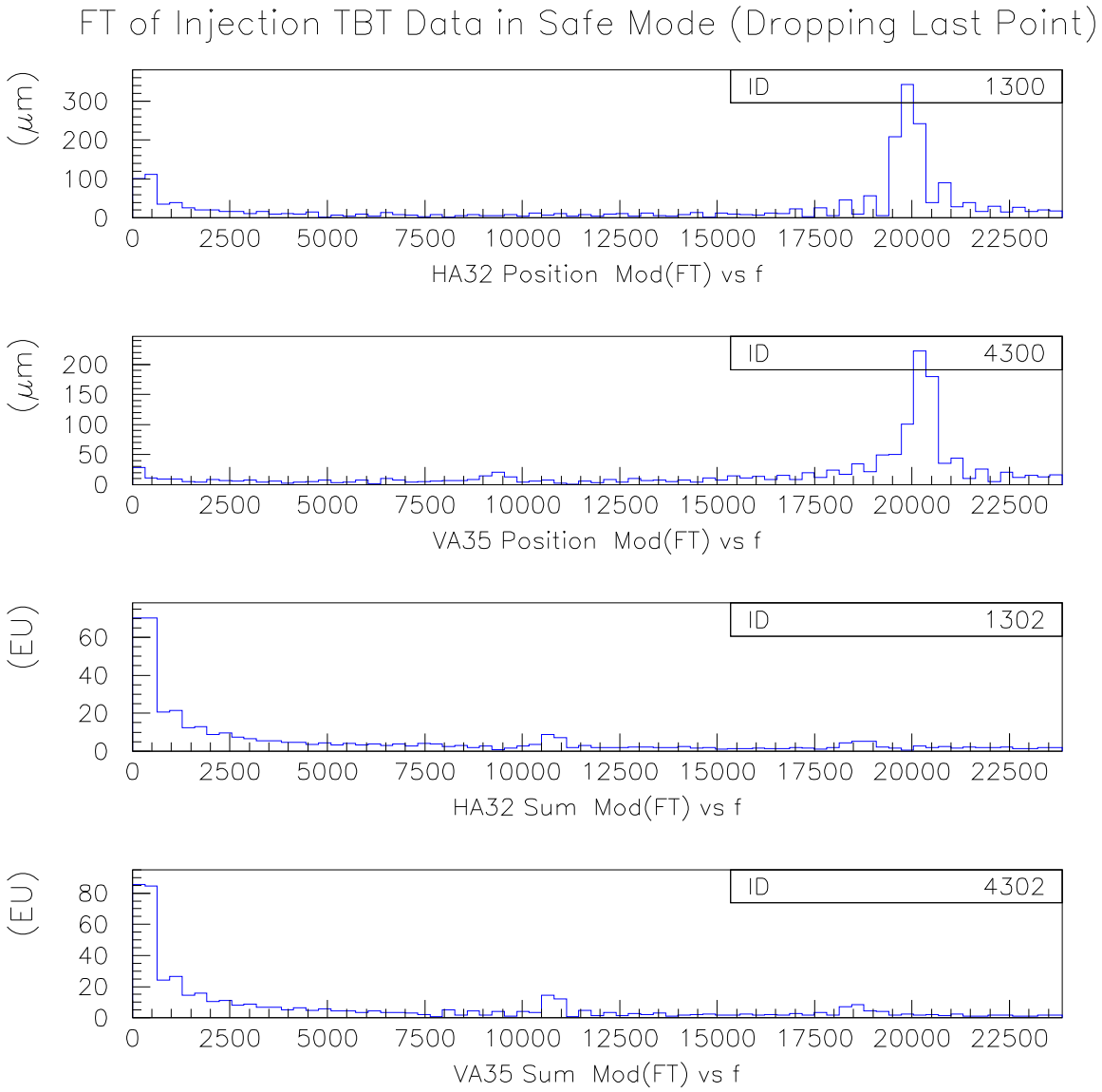

Figure 7: Fourier transforms of the sum and position data from the injection TBT buffers for HA32 and VA35. When computing the transforms, the last data point was dropped. For reference, figure 11 shows the same plots for the first 75 non-empty turns using data from HA11 and VA11. For this shot, HA11 and VA11 were configured in regular injection turn by turn mode.

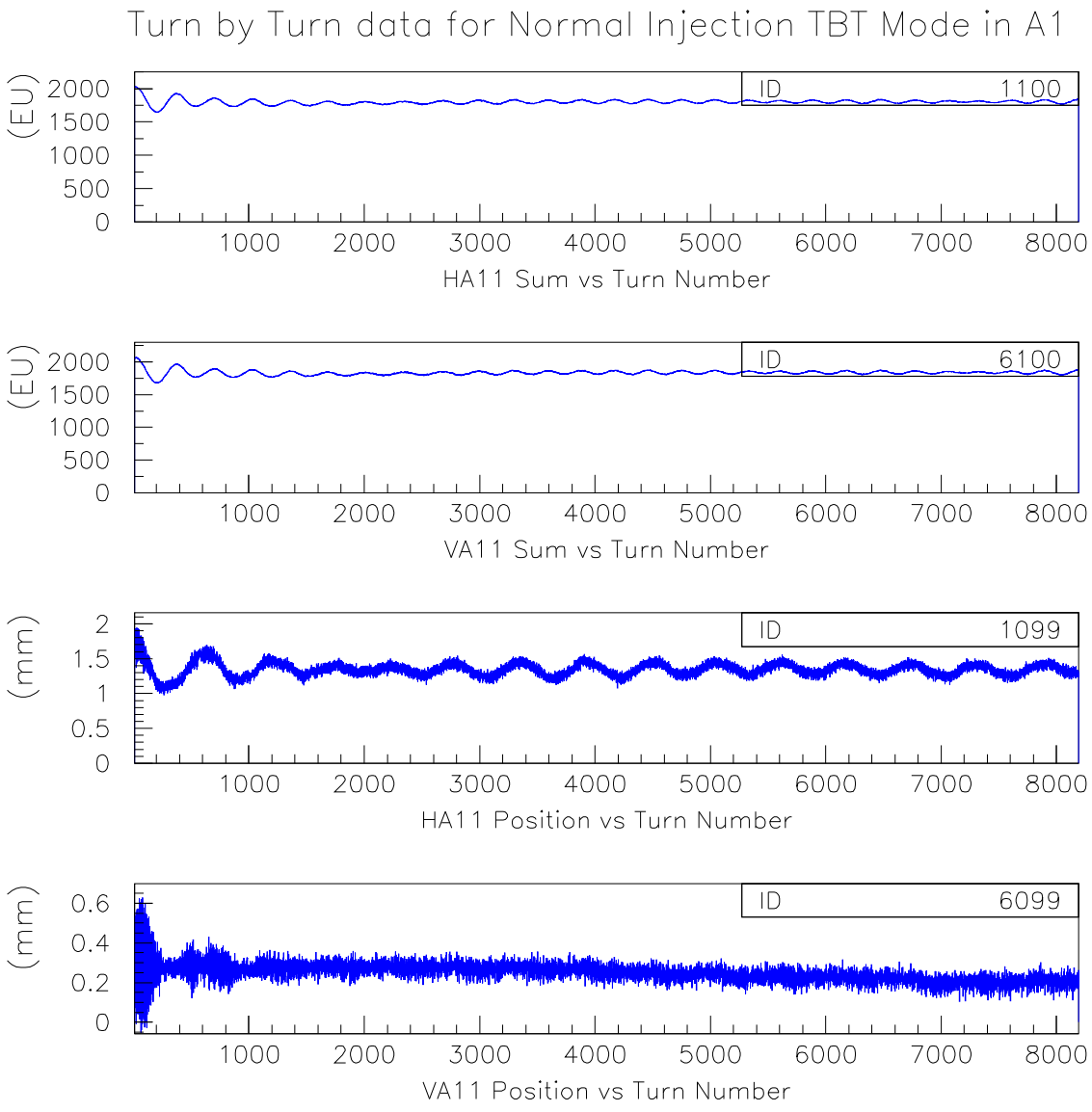

Figure 8: Normal injection turn by turn measurements at HA11 and VA11, for the same shot as the A3 data. These are provided for reference.

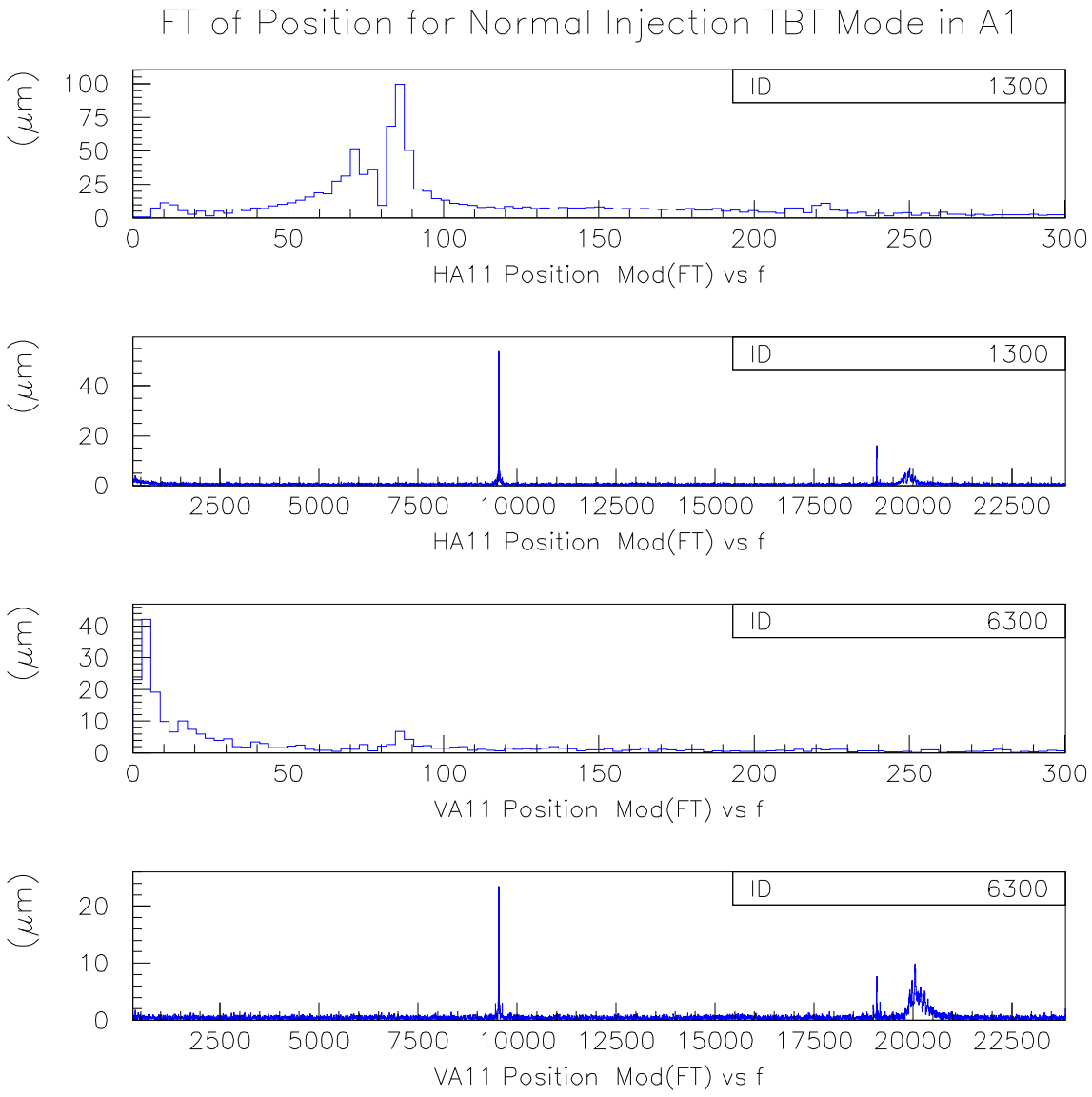

Figure 9: Fourier transforms of the position data from A1 that was shown in Figure 8. The top pair of plots show one transform: the upper plot from 0 to 300 Hz and the lower plot from 300 Hz up. Similarly, the bottom pair of plots show one transform.

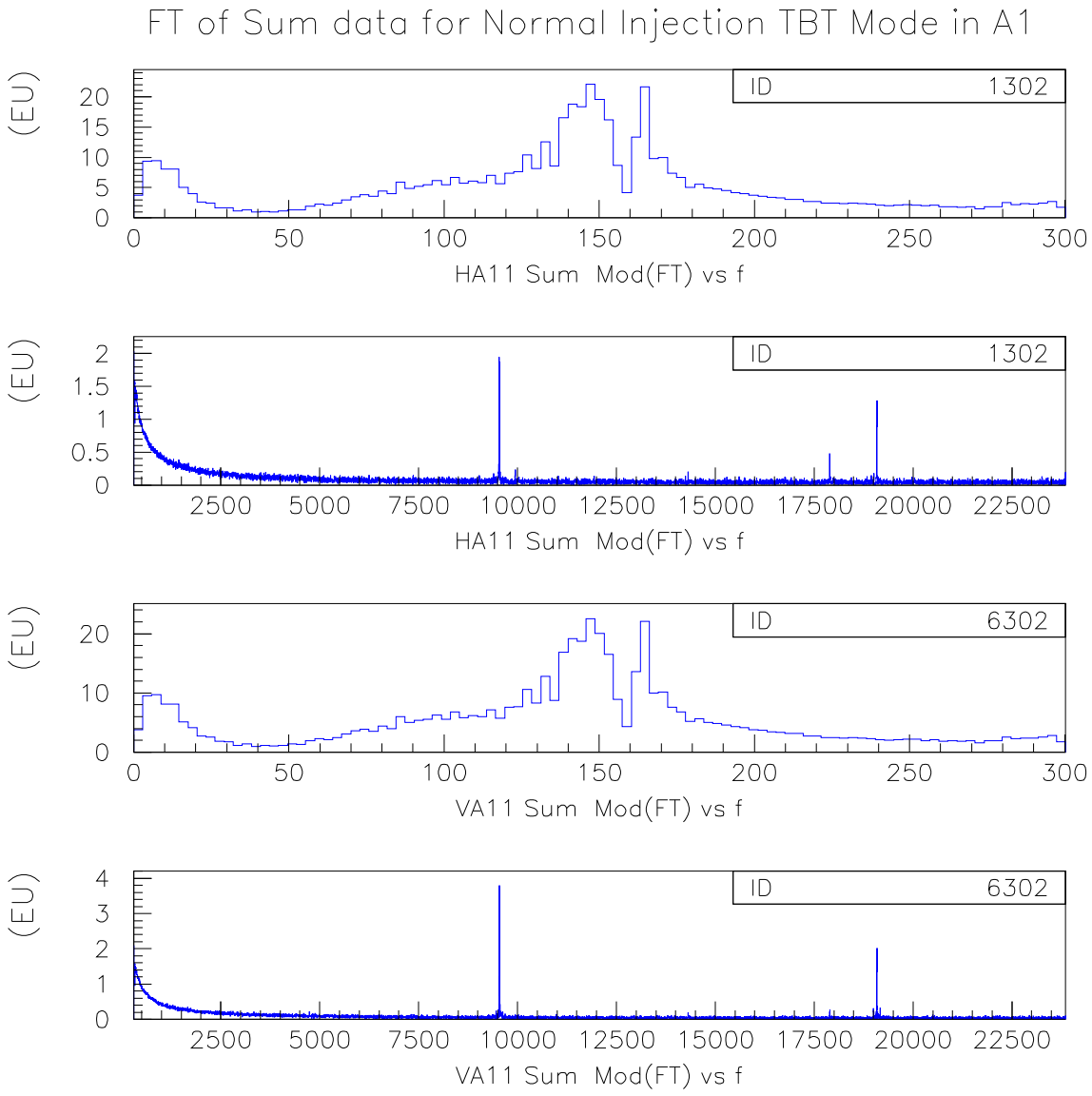

Figure 10: Fourier transforms of the sum data from A1 that was shown in Figure 8. The top pair of plots show one transform: the upper plot from 0 to 300 Hz and the lower plot from 300 Hz up. Similarly, the bottom pair of plots show one transform.

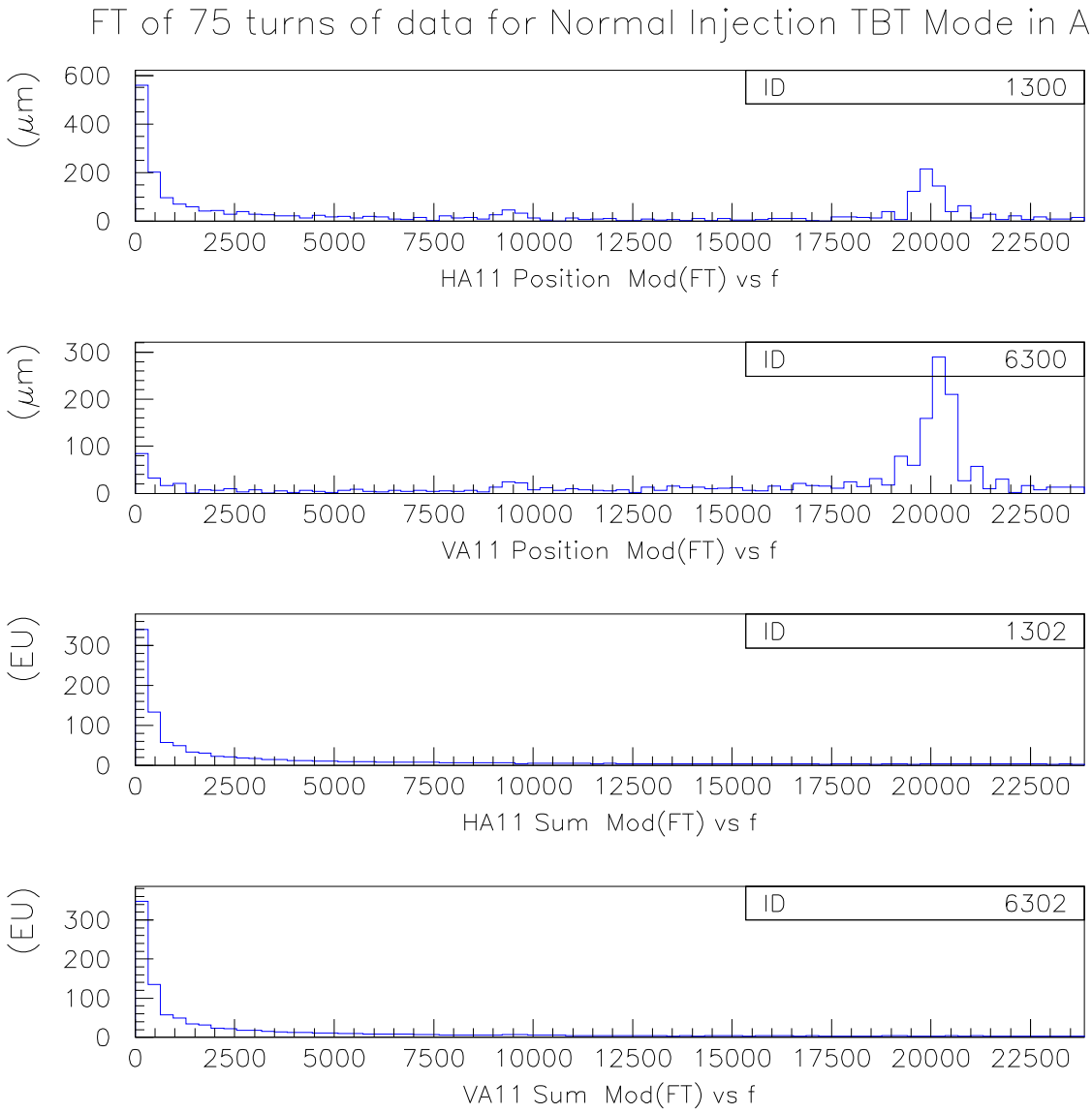

Figure 11: Fourier transforms of the first 75 turns of the sum and position data from A1. This figure can be compared to Figure 7. Figures 9 and Figures 10 show the same transforms but using all of the data. In those figures the important details are much better resolved.