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Update on Repeatability of the Duke X-ray Scanner with Type III module

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1. Introduction

Earlier we reported (DUKHEP03-04-15) on the repeatability measurement with the Duke X-ray scanner using a type II module (M2.15). This report describes the results from a similar study using a type III module (M3.14).

The data taking mode was similar to the type II. After about ½ of the straws were scanned, the module was rotated by 180 degrees and the rest of the straws were scanned. This was necessary because of the attenuation length of the x-ray beam. Previous study showed that we needed at least ~500 counts in the ADC distribution in order to obtain reasonable peak and sigma from fitting the distribution.

Because the transverse beam size is about 2 cm, not all sixteen straws belonging to one ASDBLR group can be covered with one x-ray position. In order to obtain enough counts in all straws, the data was taken at two x positions separated by 2 cm at one z position. Z-axis is defined along the straw tubes and x-axis is transverse to the straw tubes. This was good enough for type II modules, but we found that there were several straws with low counts in the type III module. In order to improve the uniformity in the number of counts, data was taken at three x positions separated by 3.5 cm in total. In order words, the two data sets used in this report were taken under slightly different conditions.

The number of measurements along the z-direction was 25 per ½ straw segment. Depending on the depth of straws, it took ~10 to 15 minutes to map 25 points of sixteen straws belonging to one ASDBLR group. Two complete sets of data were taken over a period of 1.5 weeks due to a holiday and an empty gas bottle.

2. Data Analysis

Figure 1 shows the average gain along the straw length from the two measurements. The variation in the front side (excluding the data point at 24 and 50) is about ~0.7% consistent with the earlier type II measurement. But the variation for the back side is higher (~1.5%). The back side variation is worse than the front side and the back side of

type II. One interesting difference compared to M2.15 is that the slope was positive rather than negative. It is not understood why the slope is opposite.

It seems that the two data points (24 and 50) may be too close to the mid wire-joint (data point at 24) and to the end plug (data point at 50). These two data points are excluded from the analysis. Figure 1 is used to make the slope correction and produce the rest of the plots.

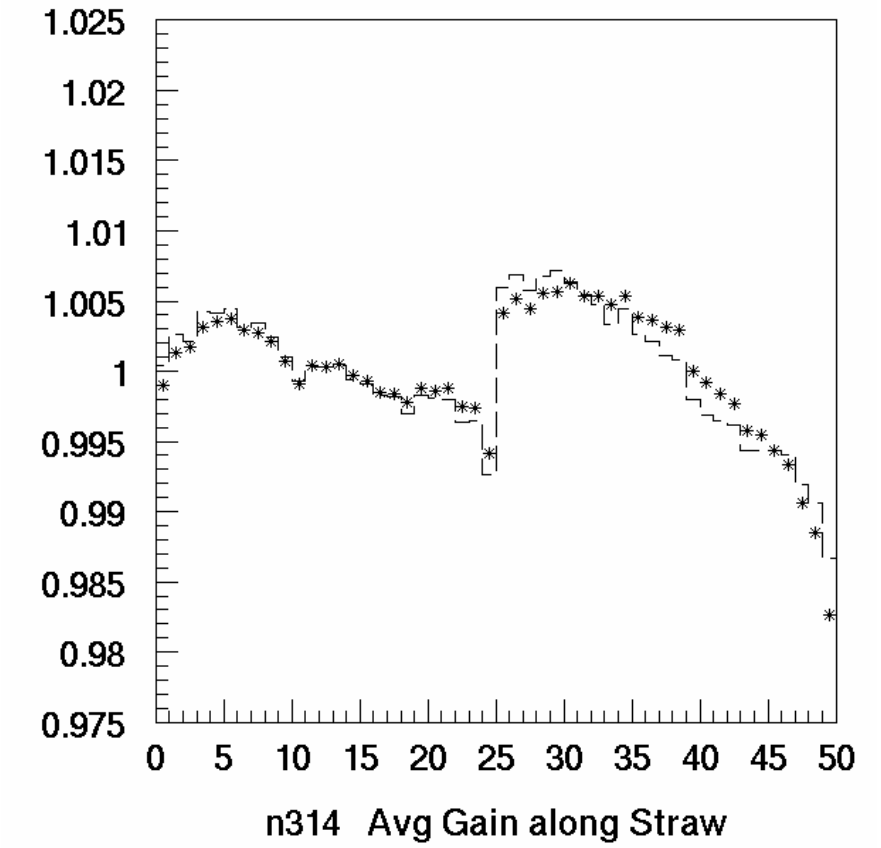


Figure 1. The average gain variation along the straw length. The points with * (dashed line) are from the first (second) measurement. The left (right) most side is the front (back) end. The first 25 points are from the front side and the last 25 points are from the back side.

Figure 2a and 2b show dG distributions from the first (dG_1) and second (dG_2) measurement respectively from the front side. Figure 2c and 2d show the same for the back side.

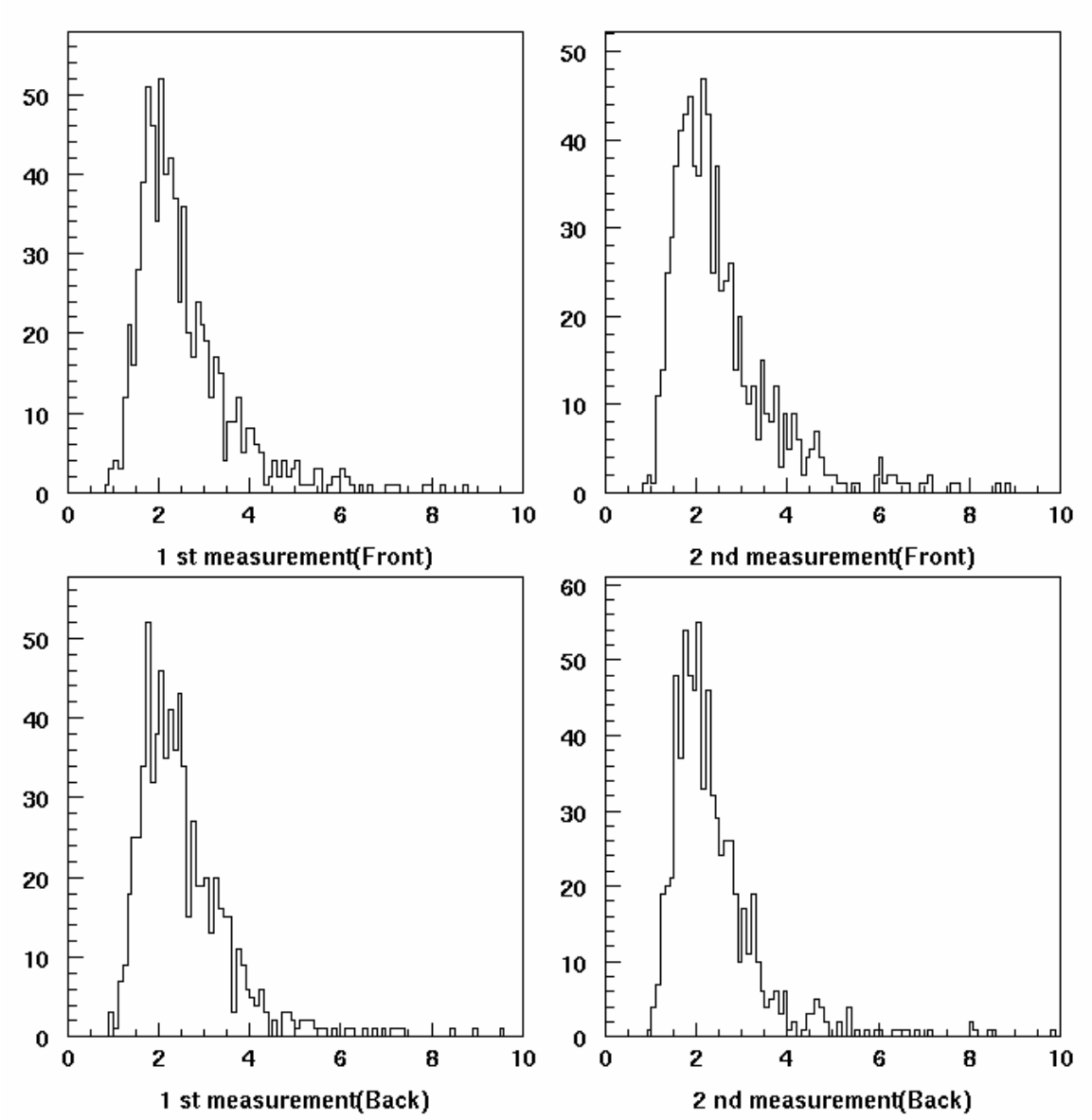


Figure 2. dG distributions. The x-axis is in percent. 2a):Upper left, Figure 2b):Upper right, Figure 2c): Lower right, Figure 2d):Lower right.

Figure 3a and 3b show two dimensional plots of dG.vs.rms from the two measurements. Figure 3c and 3d show the same for the back side. Unlike M2.15, it seems that M3.14 does not have wires with diameter problem.

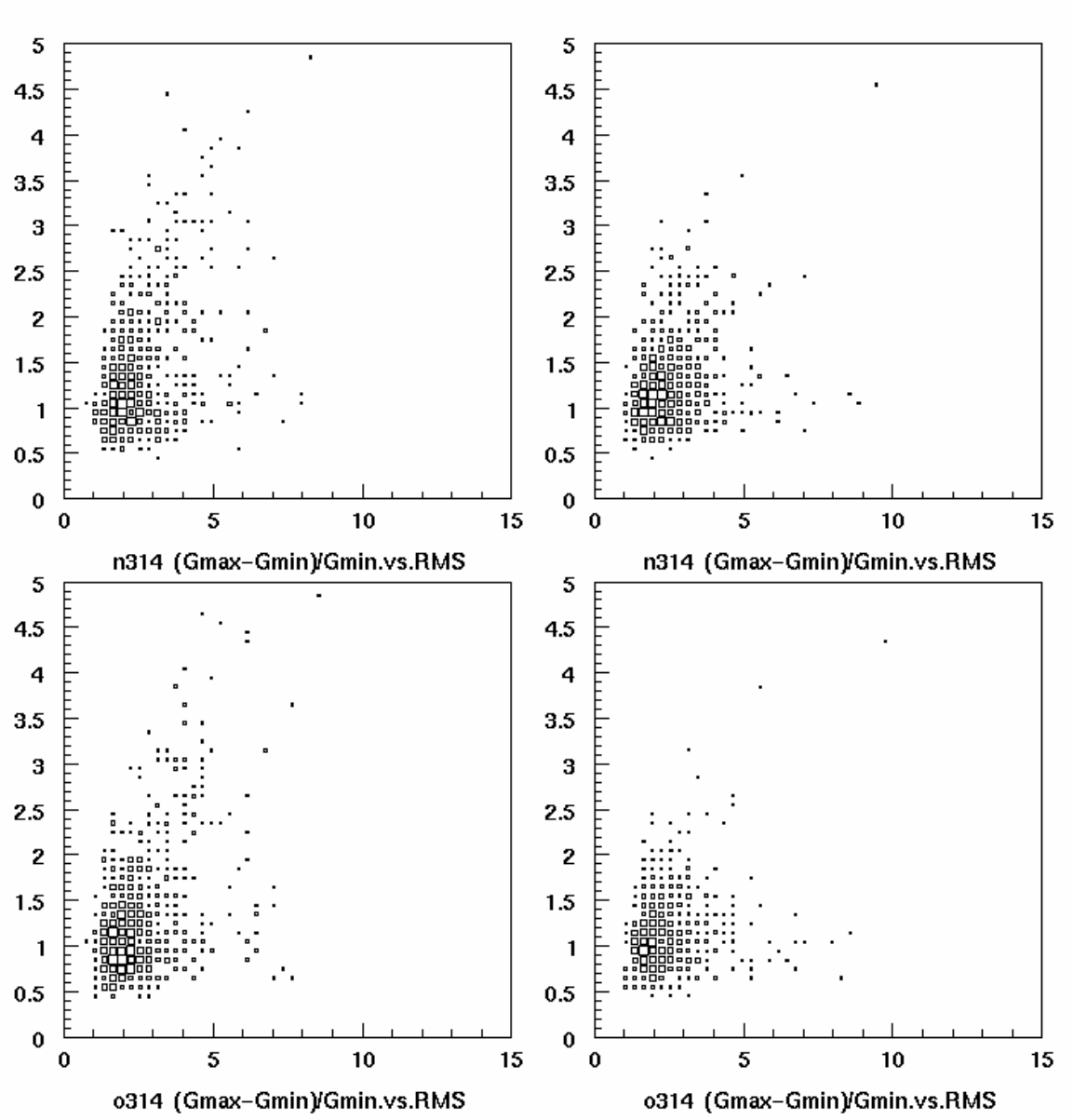


Figure 3. dG.vs.rms. 3a):1st measurement of the front side, upper left, Figure 3b):2nd measurement of the front side, upper right, Figure 3c): 1st measurement of the back side, lower left, Figure 3d):2nd measurement of the back side, lower right. The x-axis is in percent, and y-axis is rms of the width distribution in ADC count.

Figure 4a and 4b show the dG_1-dG_2 of the same straws for the front side and back side respectability. The difference distribution is fitted with a Gaussian function and sigma of ~0.5% for the front side and ~0.6% for the back side are obtained. This could be interpreted as the repeatability of the scanner. The value is also consistent with the previous sigma obtained from M2.15.

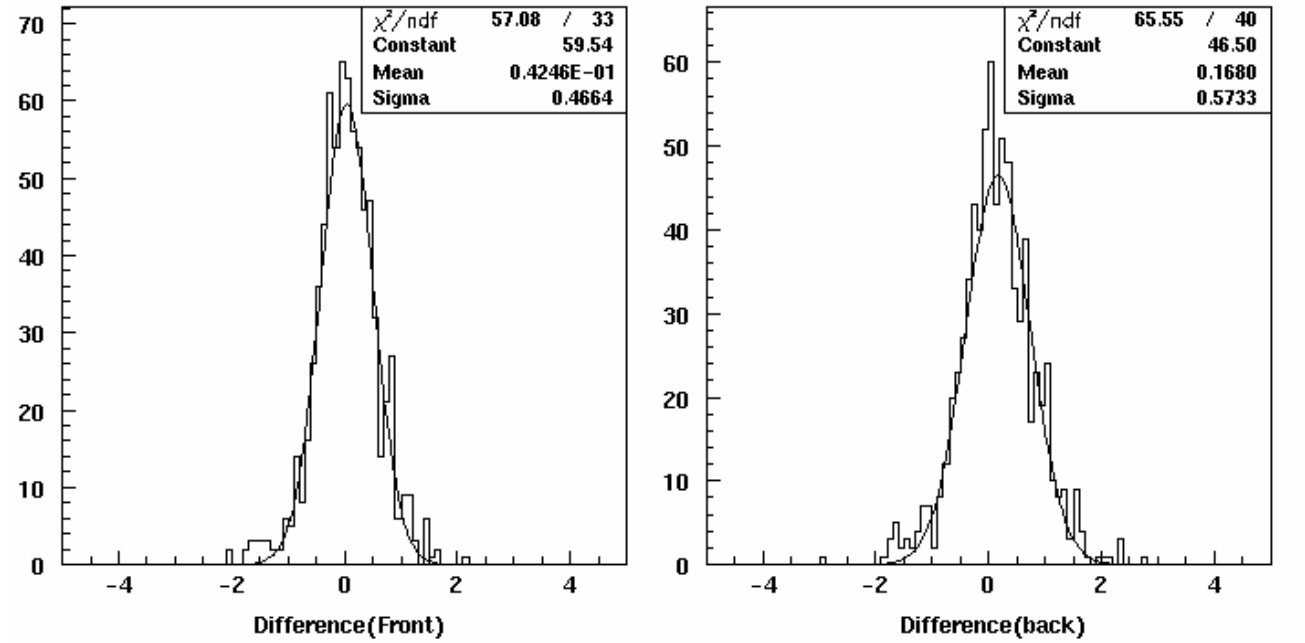


Figure 4. dG_1-dG_2 distribution in percent. The sigma for the back side (0.57%) is slightly worse than the front side (0.47%). These plots could be interpreted as the repeatability of the scanner.

Figure 5a shows a two dimensional plot of dG_1.vs.dG_2 of the front side and Figure 5b shows the same for the back side. There exists a good correlation between the two measurements. The two points (toward the top) in the right plot are due to the low number of counts at some positions such that fitting is not reliable.

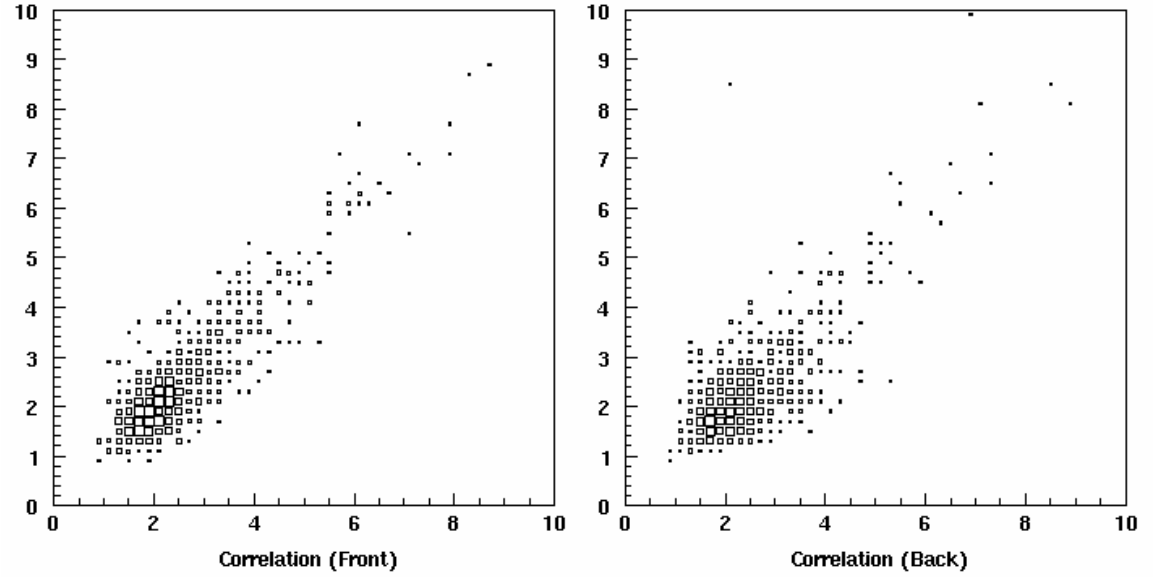


Figure 5. dG_1.vs.dG_2. Both axes are in percent. 5a (5b) is the left (right) plot.

The table below lists the straws with dG above 8%. The two measurements from the front side match quite well. But there are only two matches in the back side. The non matching straws (531, 548, 555, 783) a investigated and all of them have problems *not* related to the alignment as shown in the figures in Section 4. These straws would have been easily removed from the wirelist after looking at the figures. We are investigating the reasons for the fluctuation which result in the mismatch. We should note that the fluctuation only showed up in the second measurement. These straws have dG value larger than 10% and do not appear in the Figures 2 through 5 above.

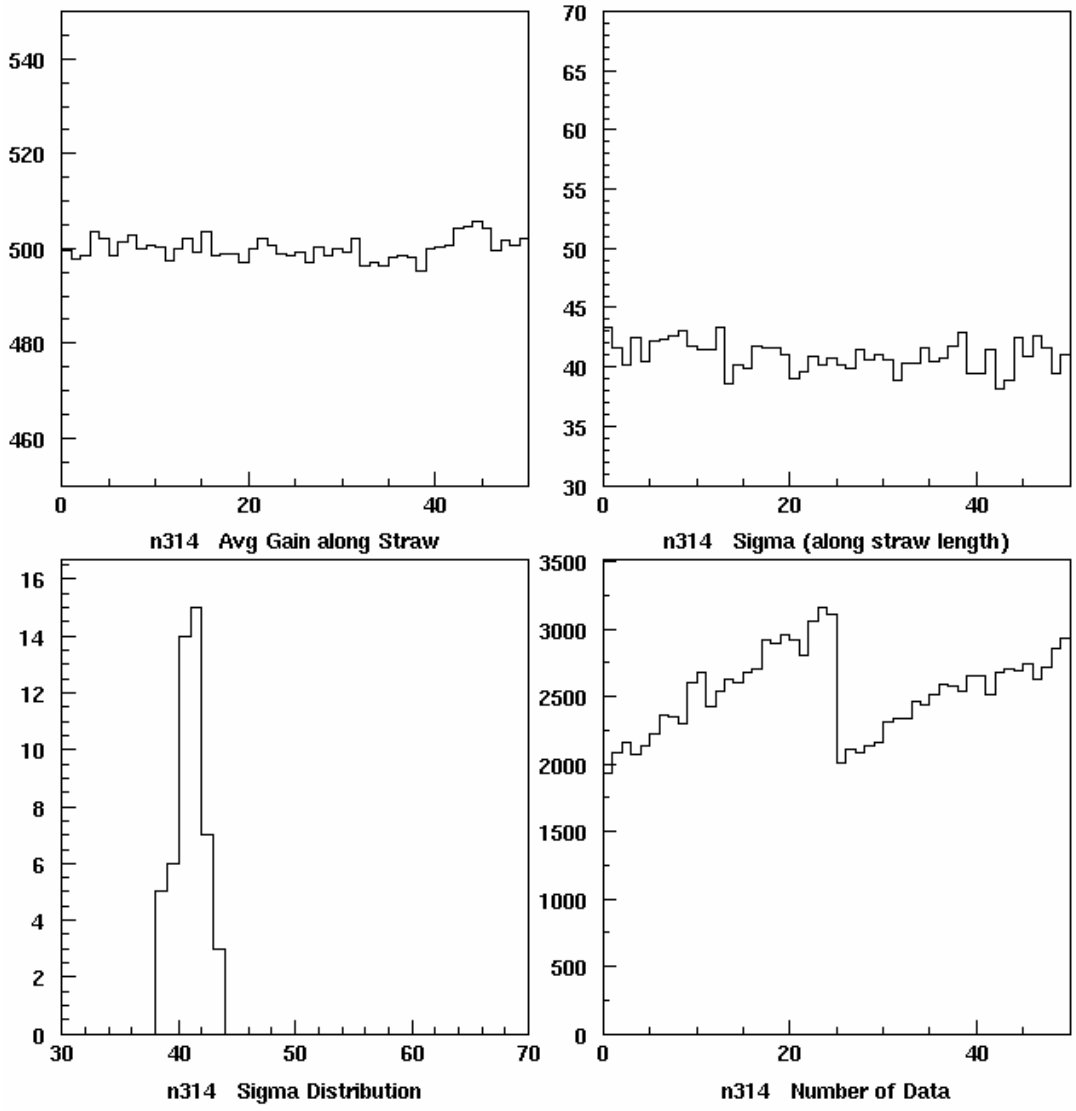
	1st measurement (Front)	2nd measurement (Front)		1st (Back)	2nd (Back)
Above 8%	**1, 2, 24**	**1, 2, 24**		**756, 782**	531, 548, 555, **756, 782,** 783

3. Conclusion

In summary, the repeatability of the Duke X-ray scanner from a type III module is quite consistent with the previous study using M2.15, and it is about 0.5%. There are several straws with unknown fluctuation. However, these straws can be easily identified for not having alignment problems and removed from the wirelist. They should not pose problems in producing the correct wirelist.

4. Detail plots of the mismatched straws in Table 1.

There are three pages of plots for each mismatched straws.



Straw #531. From the first measurement.

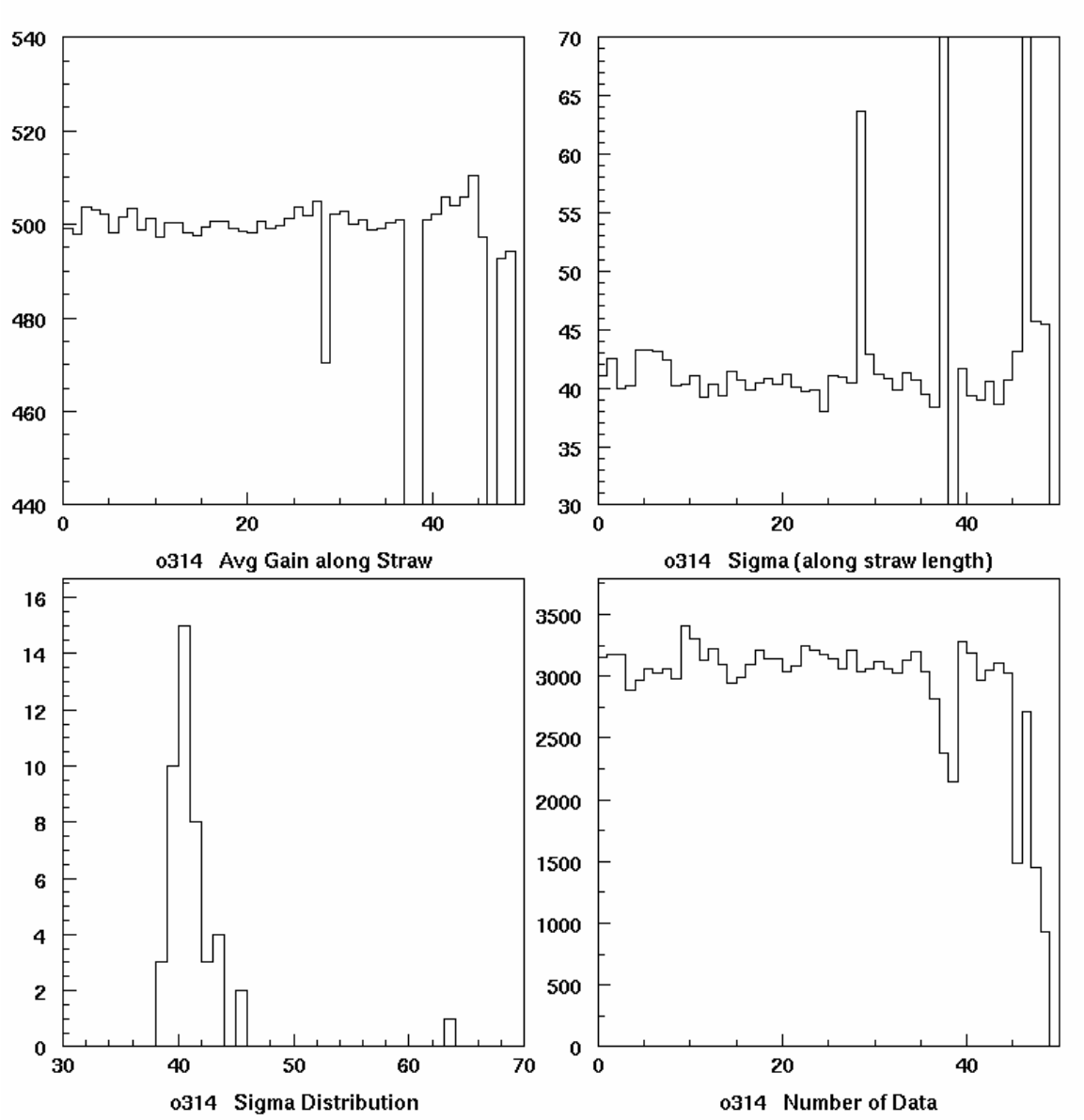
There are four plots. First (last) 25 measurements are from the front (back) side.

Upper left: The gain along the straw length.

Upper right: Width of ADC distributions along the straw length.

Lower left: Width distribution.

Lower right: Number of entries in ADC distributions.



Straw #531. From the second measurement

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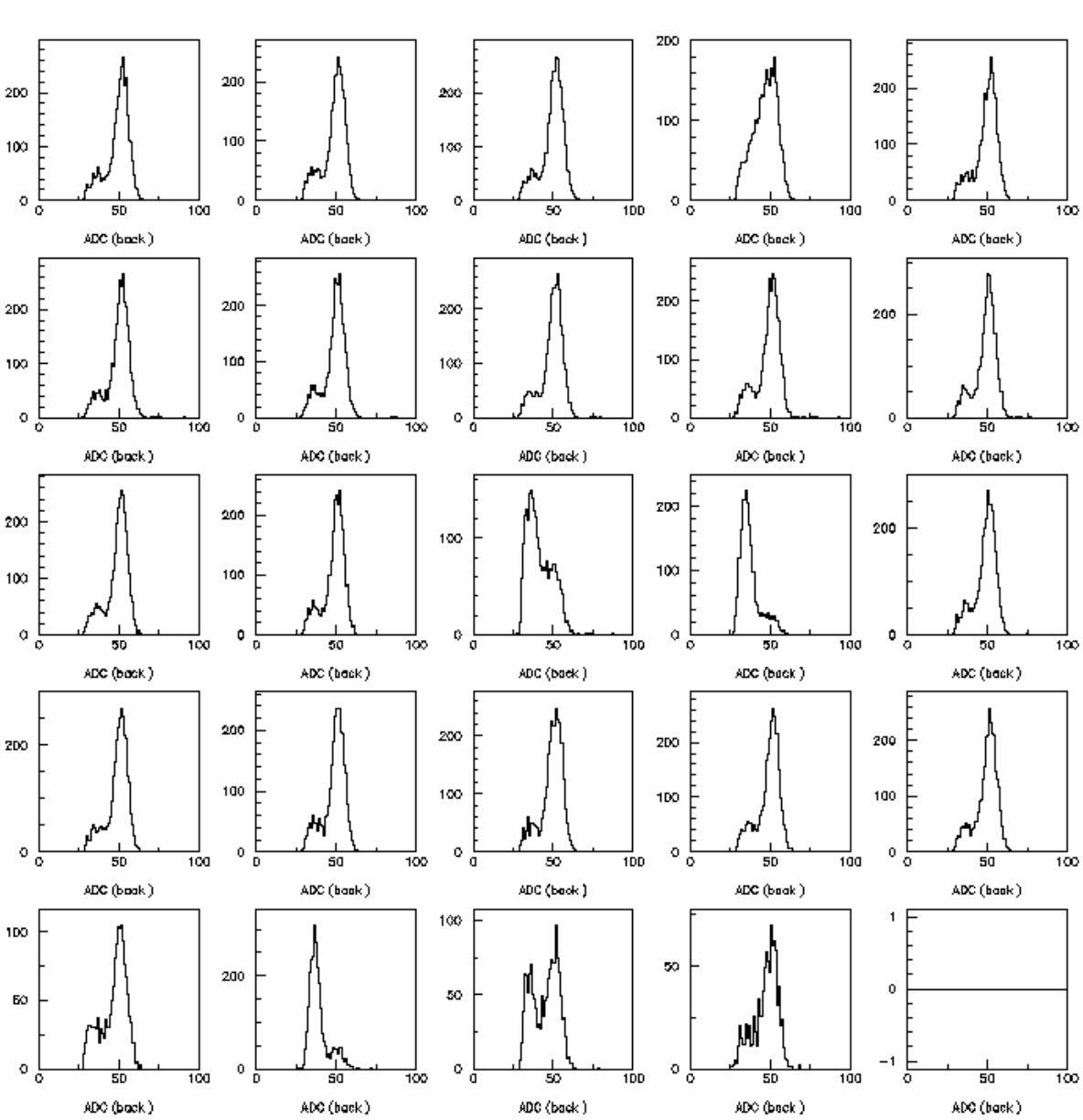
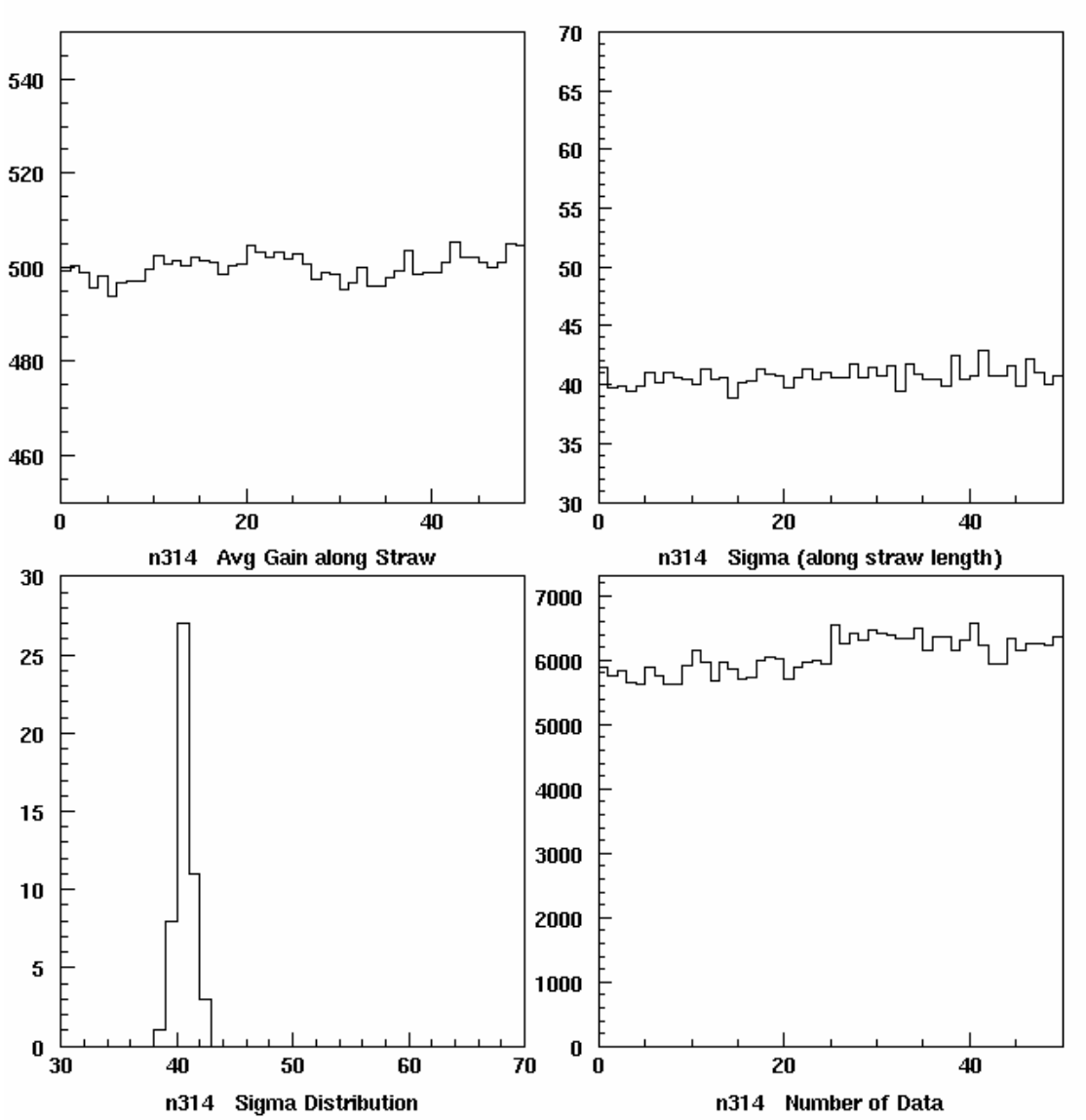
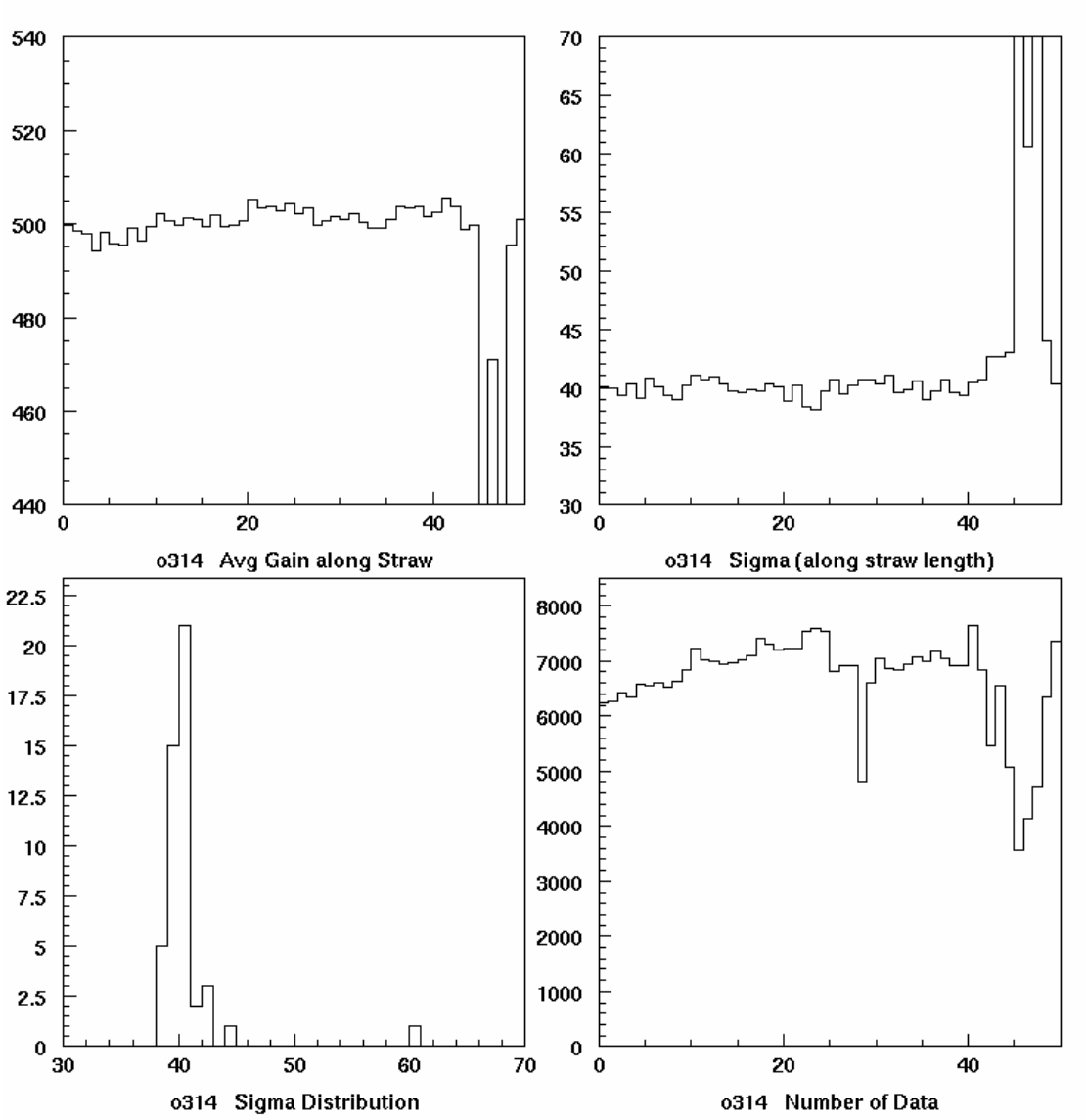


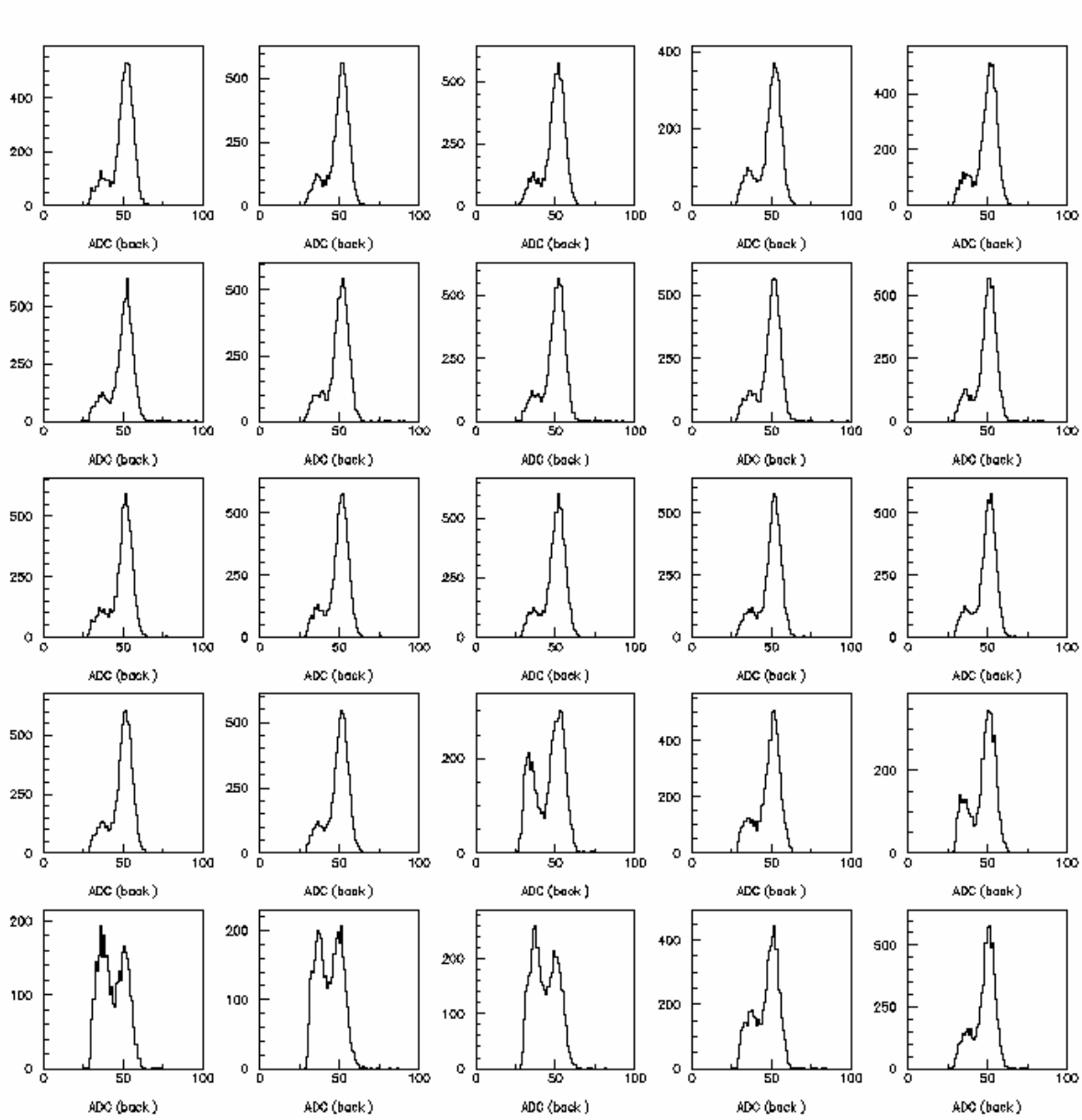
Straw # 531. Twenty-five ADC distributions corresponding to the 25 back side measurements from the second data set.



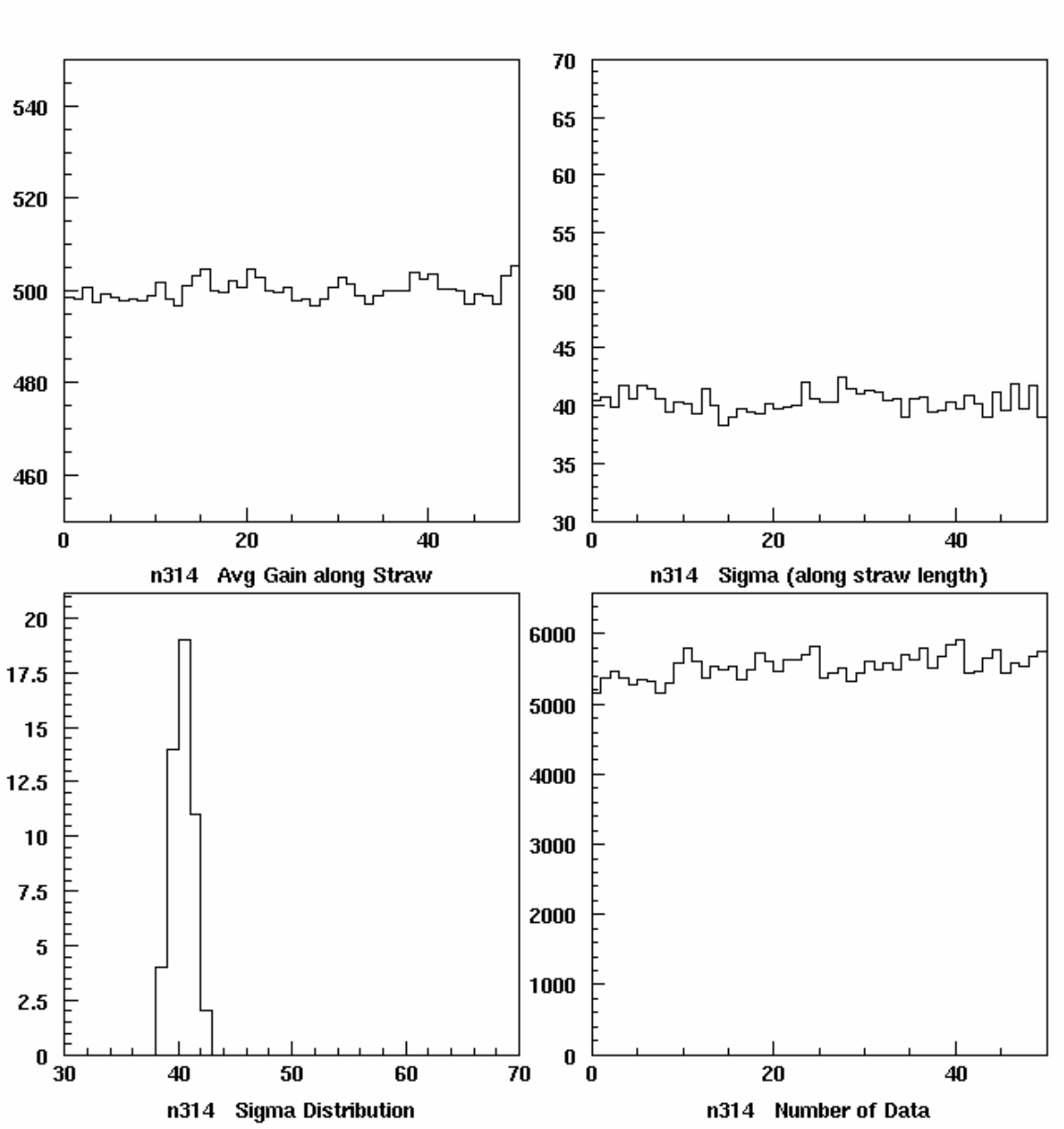
Straw #548. From the first measurement.



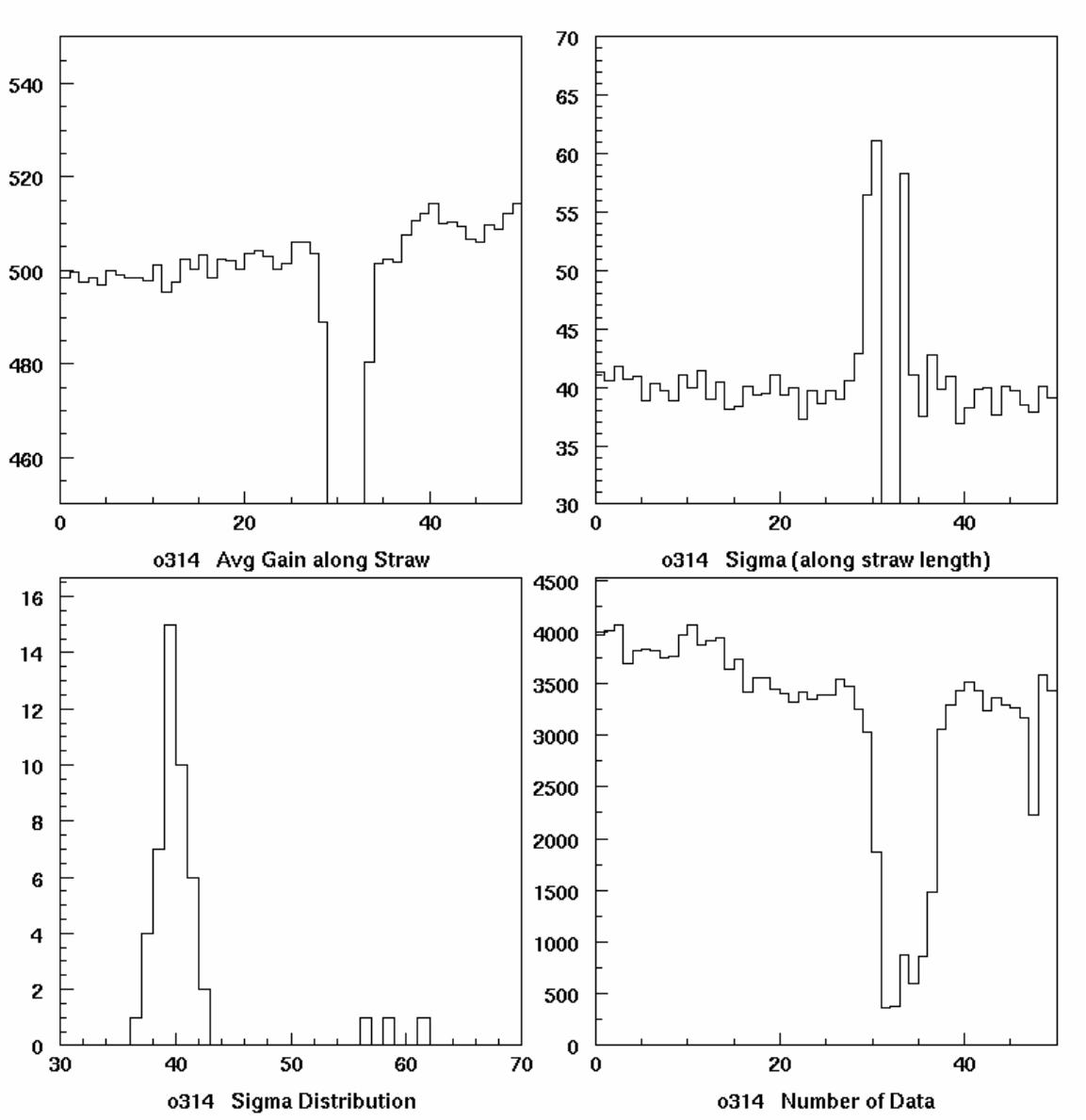
Straw #548. From the second measurement. See the next plot for the ADC distributions.



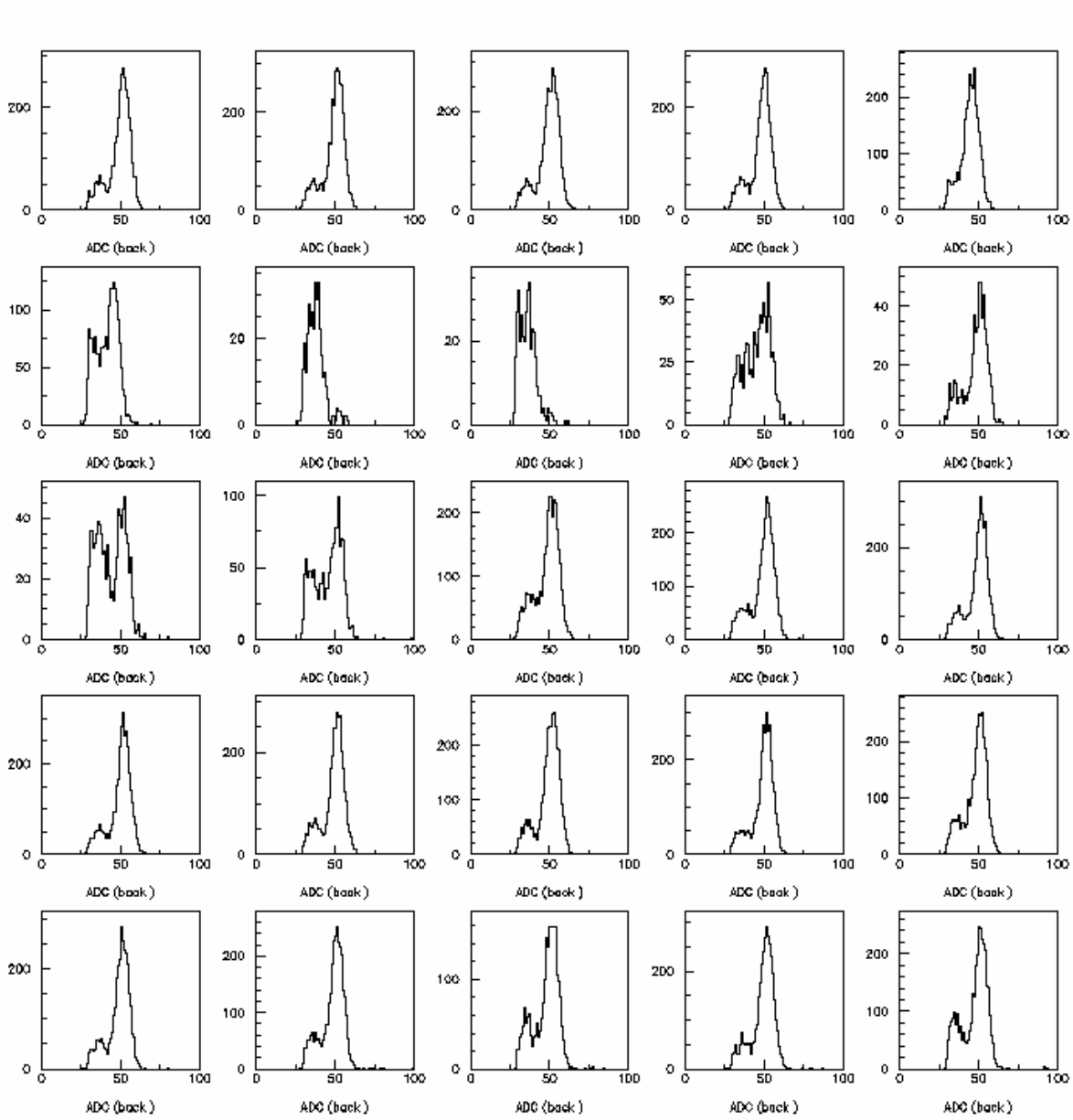
Straw #548. The 25 ADC distributions from the back side. There are plots with double peaks, and the reason is unknown.



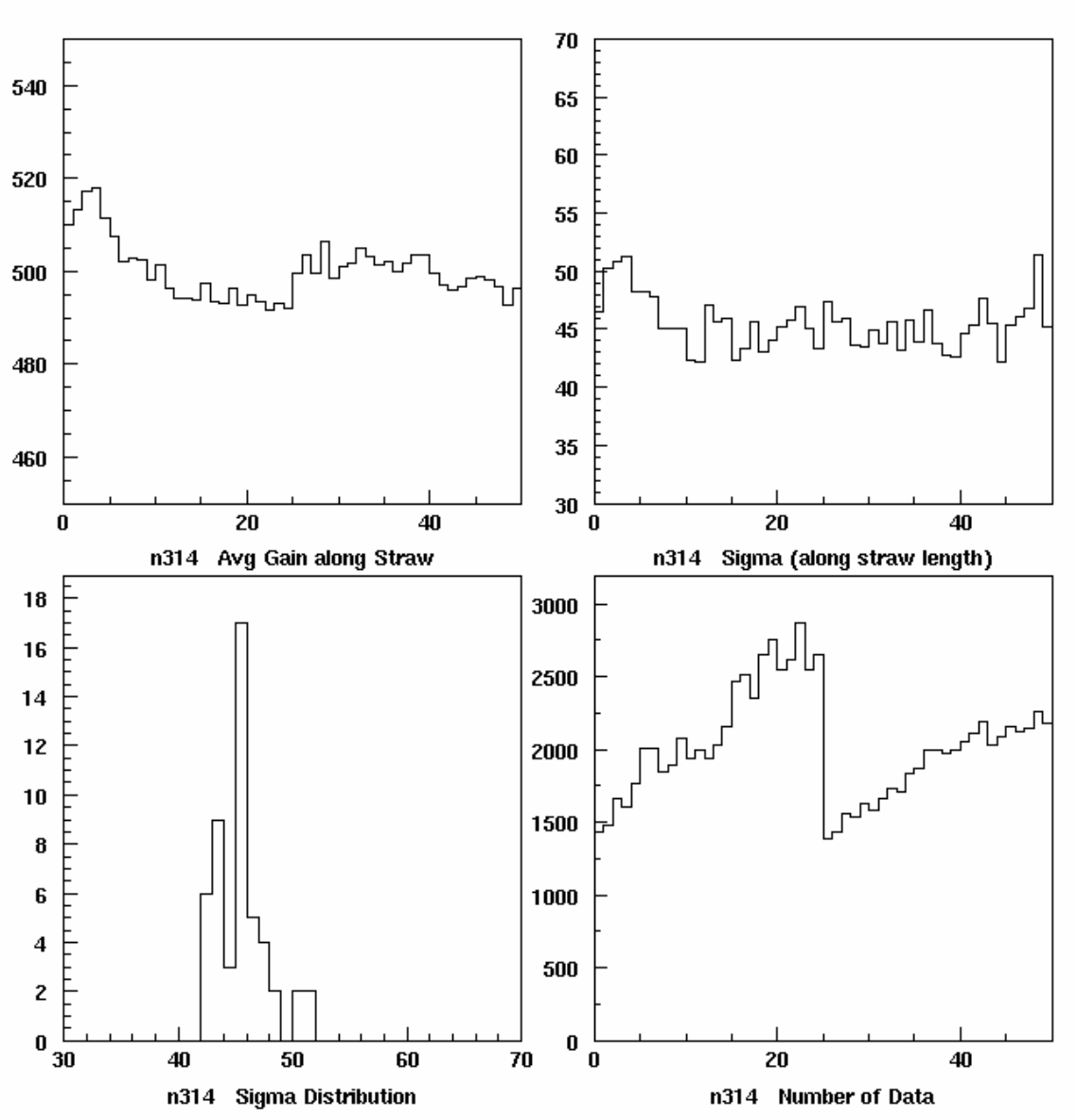
Straw #555. From the first measurement.



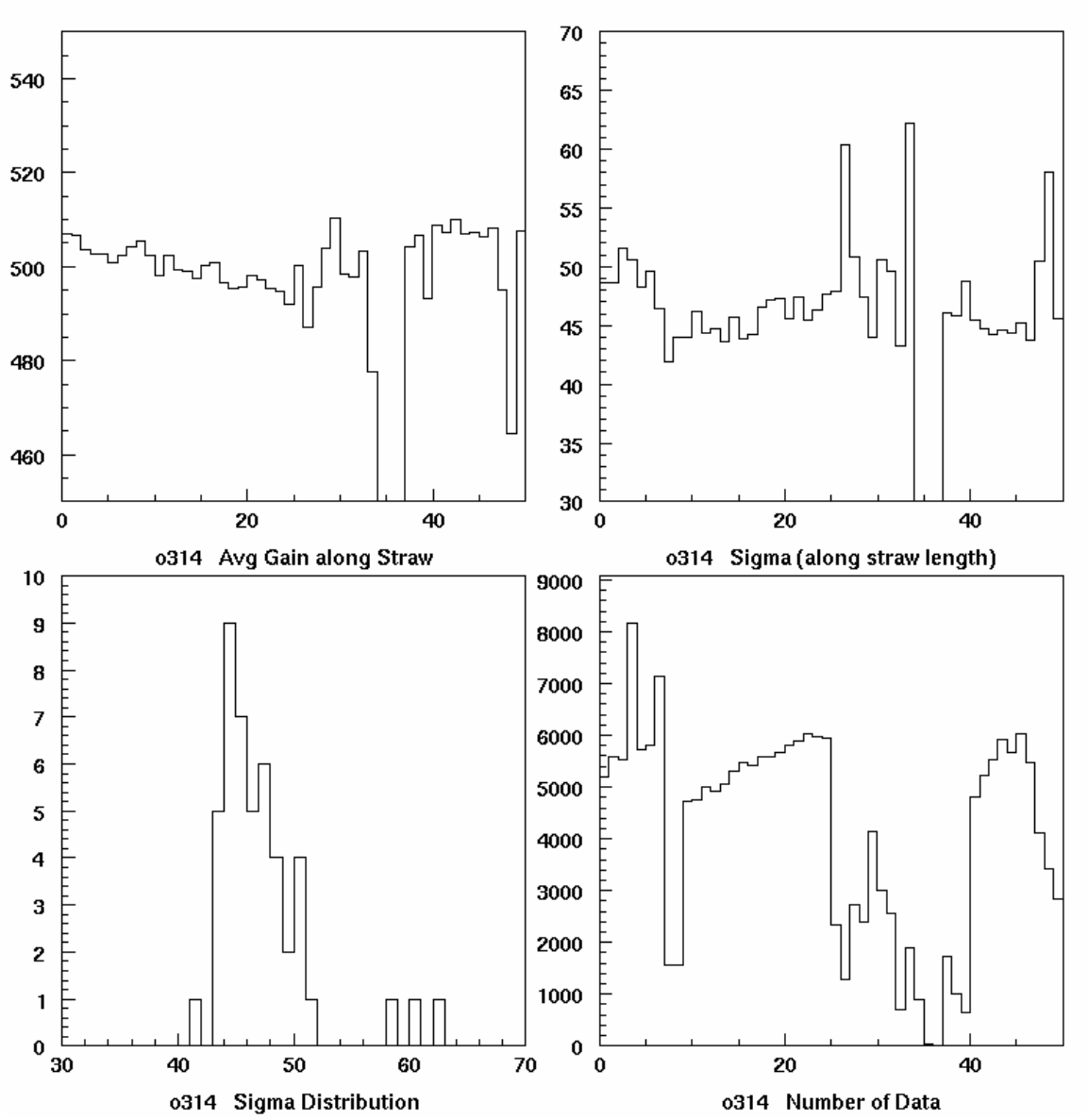
Strwa #555. From the second measurement.



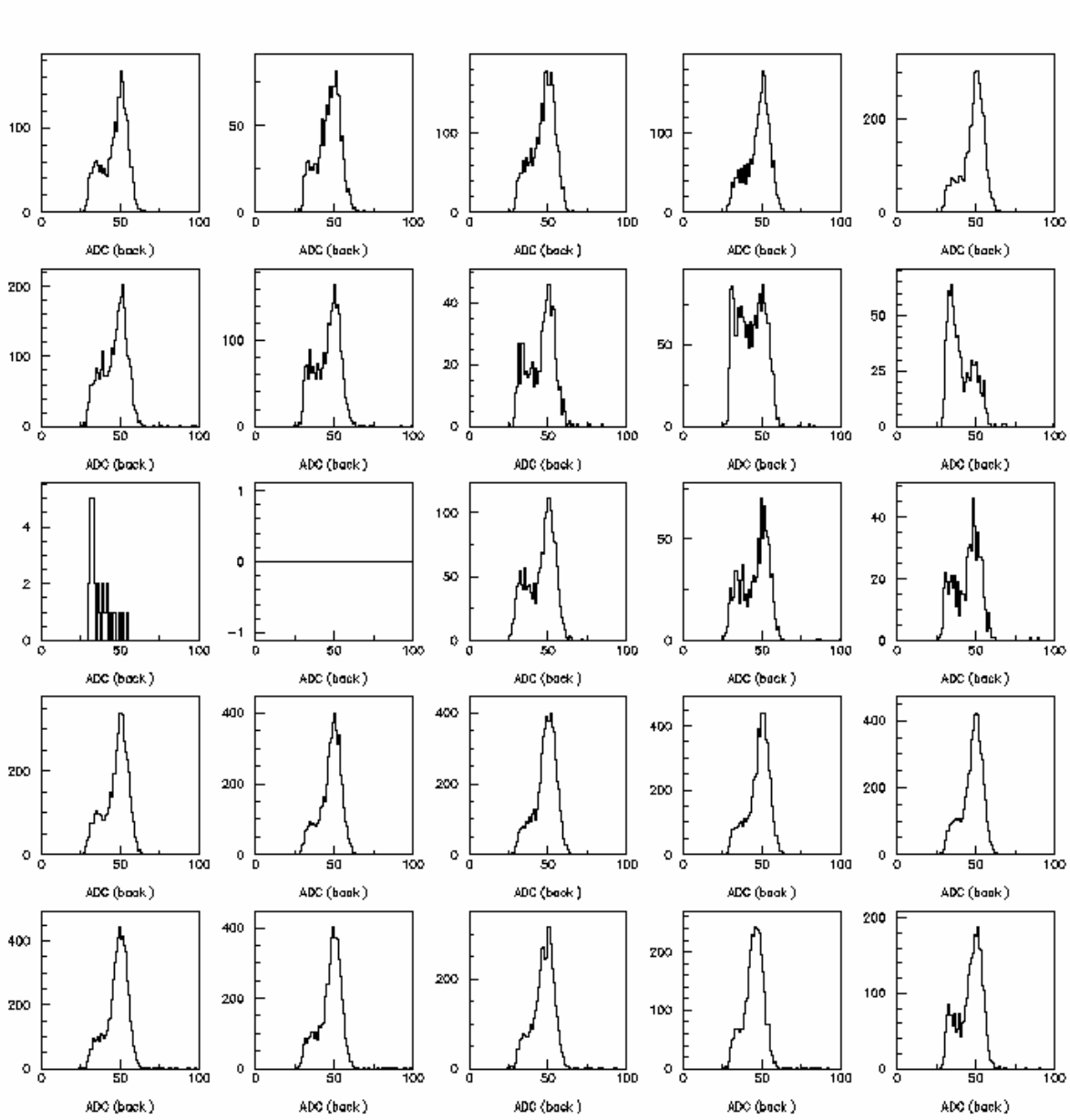
Straw #555. ADC plots from the second measurement.



Straw #783. From the first measurement.



Straw #783. From the second measurement.



Straw # 783. ADC plots from the second measurement.