Noise and Pulse Characteristics of the December 1993 Monster Buffer Data LSU-HEPA-4-94 Research Memo

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April 20, 1994

Abstract

One megabyte "snapshots" of raw data taken by the first string of the DU-MAND array in December, 1993 have been analyzed to check both the consistancy and the performance of the equipment. Each megabyte file collected encompasses an average of 0.17 seconds of data which is about 135,000 OM hits. The actual length of each file depends on the noise at the time the file was created. A total of 613 useable files were collected at roughly 15 second intervals.

First, the summed noise rate was plotted in 384 microsecond intervals for each file. Most of these plots were flat with a noise level of approximately 850 kHz. However, 23 files show either a complete or partial pulse with an approximate FWHM of 0.08 seconds. Inspection of the noise rates for individual OMs with in these files reveal that these pulse events were, with three exceptions, only recorded by one OM. At present, it is not clear if these pulses are biological or electronic in origin.

Second, both the pulse width and the time difference between pulses were histogramed for all the data. In the first case, the JOMs show a clear three peak structure that may be caused by ringing in the circuitry. The second case shows an exponential decrease, as expected, with a 125 nanosecond "valley" possibly due to OM deadtime. Each JOM also shows one or more Q pulse peaks approximately 200 nanoseconds after the noise peak.
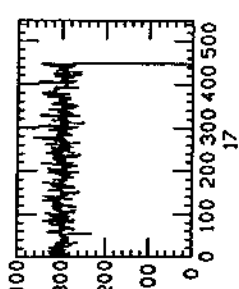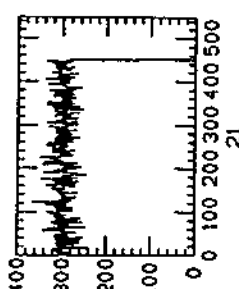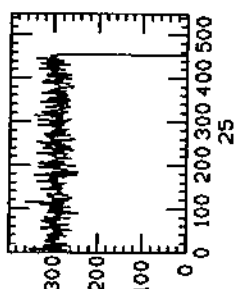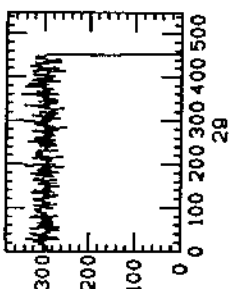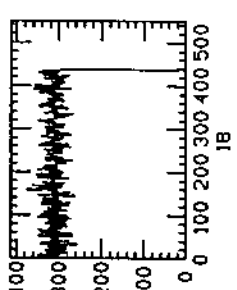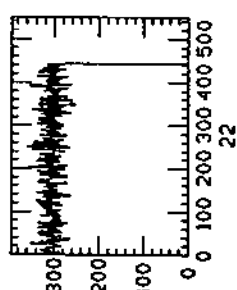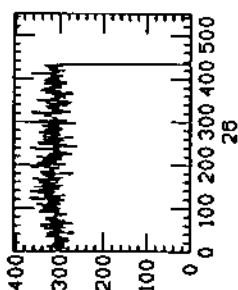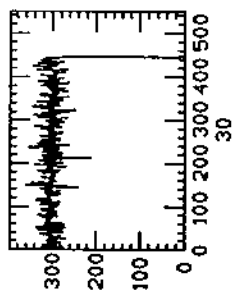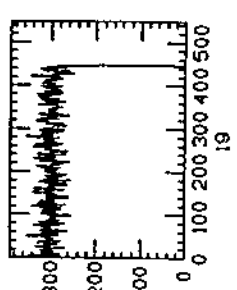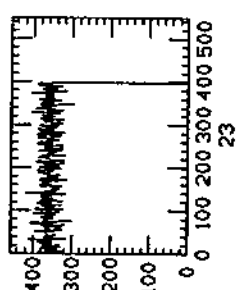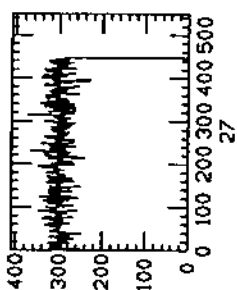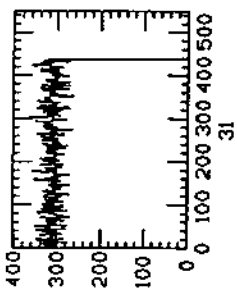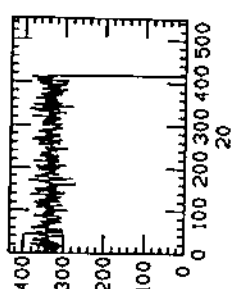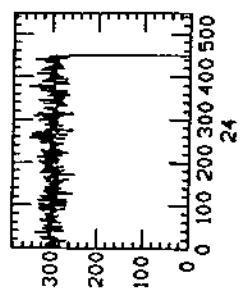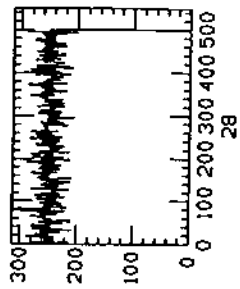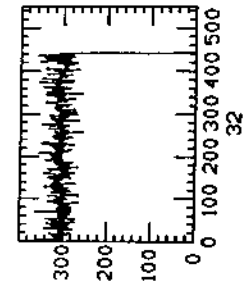
Figure 1
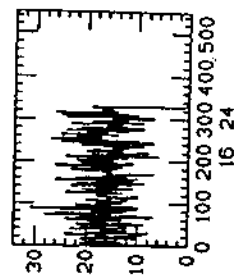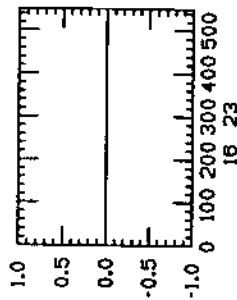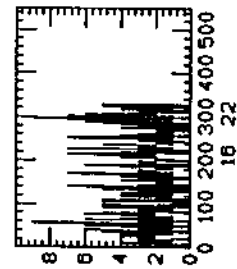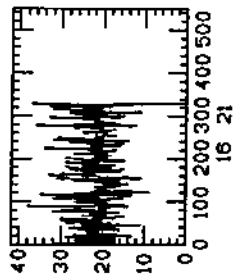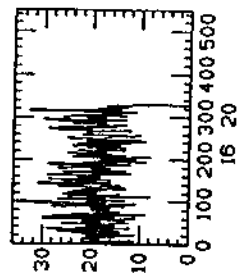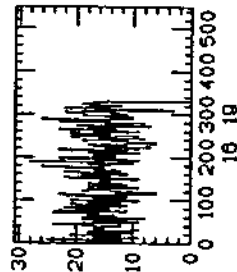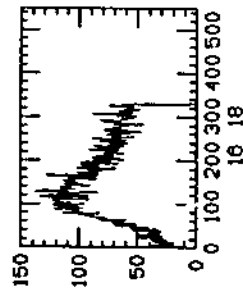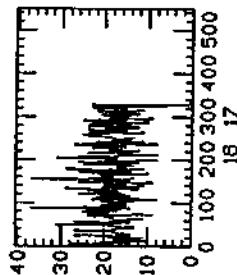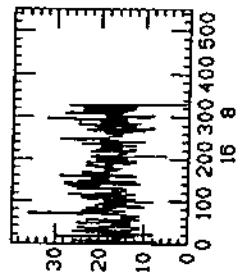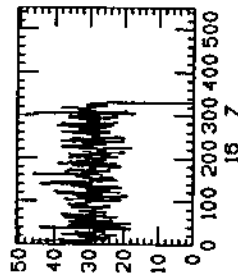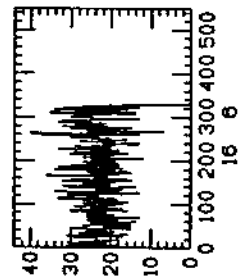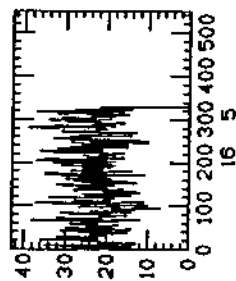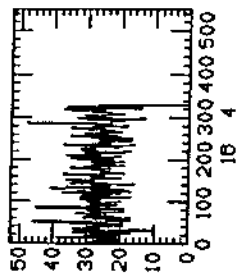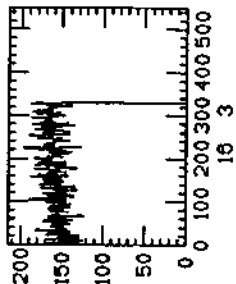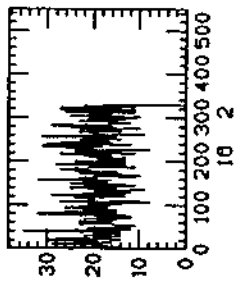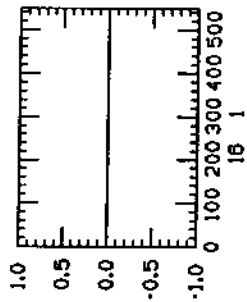
Figure 2

The Data

The first string of the DUMAND array was deployed on December 14th, 1993. Due to a leak in the pressure housing of the string controller, no useable data was collected after 1:50am December 15th, 1993. There was no trigger processor available at the time, so the data was taken by filling a "Monster Buffer" with raw data. The buffer held 1,024,000 bytes of data which was written to disk after the buffer filled up. The format of the data consisted of information from two channels contained in a 5 byte word. Each channel could either be an OM transition or general housekeeping data. For each OM hit, there were two transitions. An up transition represented the start of a pulse and a down transition represented the end of a pulse. The length of a pulse, therefore, is the time difference between an up and a down transition on a single OM. More detailed information about this process has been covered elsewhere (see Svoboda, LSU-HEPA-3-94).

All in all, there were 613 useable data files generated by the Monster Buffer between 7:25pm HST December 14th, 1993 and 1:50am HST December 15th, 1993. The first 571 files were collected before 10:07pm HST December 14th and files 572 through 613 were collected after 1:38am HST December 15th. Since the Monster Buffer held exactly 204800 five byte data words, the time to fill the buffer was not constant but depended on the noise rate at the time it was filled. On average, the buffer filled up in 0.17 seconds. Once the buffer was full, the contents were written to disk in a single, numbered file. For this reason, the buffer was filled approximately every 15 seconds. The total data sample represents approximately 104.2 seconds of hits collected over 2.9 hours.

Noise Rates

It is expected that random background noise should be fairly constant. Thus a histogram of the hit rate versus time should be flat. There are two different ways to generate this type of histogram. The first is to average the hit rate in each file for each OM and then plot the averages versus file number or time since the files are sequential. This first analysis has been done by R. Svoboda (LSU-HEPA-3-94) and it reveals sharp spikes with long tails that cover several different files. The length of these noise excursions therefore can vary from 10 to 200 seconds. It is likely these excursions are caused by bioluminescence.

The second is to plot the hit rate versus time within each file. In this

report, given the large number of files, the summed hit rate from all working OMs was plotted at 384 microsecond intervals. For the most part, this rate was flat as expected. In general, the hit rate for these flat plots falls around 850 kHz. Figure 1 shows the hit rate versus time for files 17 through 32 as a typical example of the curves generated. In 20 files, the noise rate is over 2.6 MHz and these most likely correspond to the spikes observed by R. Svoboda. Fortunately these files with high hit rates represent only 3 percent of the data and, as will be discussed later, they are usually associated with a single OM. This means that normally only one OM need be removed from the trigger when searching for particle events in files with high noise rates.

There are 23 files out of 613 which do not have a flat hit rate versus time curve. Instead, they show a complete or partial "bump". For these particular cases, plots were generated for individual OM hit rates rather than the summed hit rates. Again, the hit rate was plotted at 384 microsecond intervals. In all but three of the 23 exceptional files, a single OM was responsible for the bump or pulse. Figure 2 shows the curves for file 16. This pulse is typical of others observed. There is a quick, though not sharp, rise time and a long tail. The FWHM of the pulse is about 0.08 seconds. The hit rate jumps from the nominal value of 65 kHz to a peak around 313 kHz. Table 1 show how often these pulses occured for each functioning OM. It should be noted that OM 18 recorded a pulse in 11 of the 23 files. The exact cause of this is still not certain. If the pulses are caused by localized bioluminescence, then something must have been very interested in OM 18.

Working OMs	Pulses recorded
2	2
3	1
4	3
5	1
6	0
7	1
8	0
17	2
18	11
19	1
20	1
21	3
24	0

There were three files in which two OMs recorded a pulse. These files are shown in Figures 3, 4 and 5. Figure 3 shows file 168. Here adjacent OMs 20
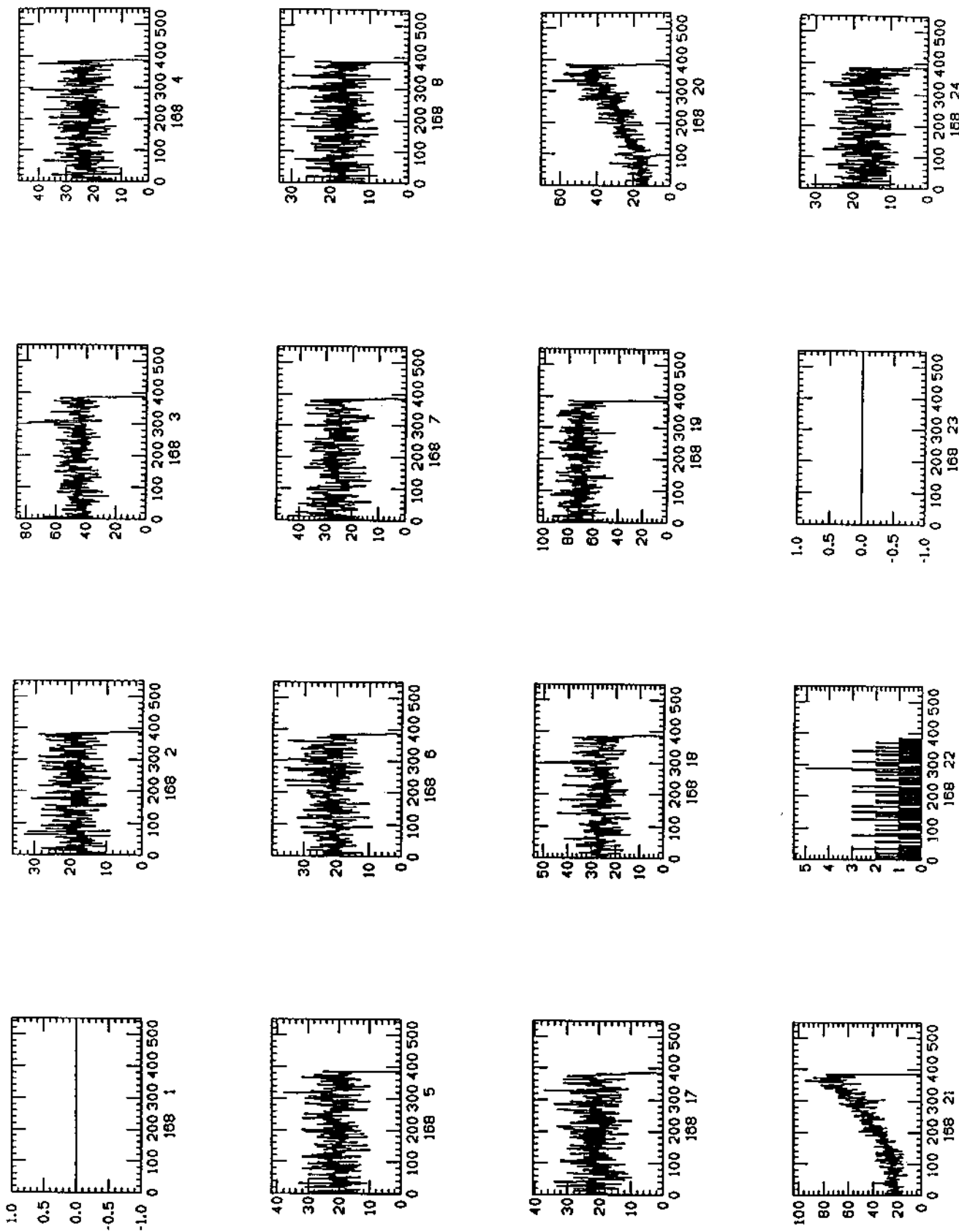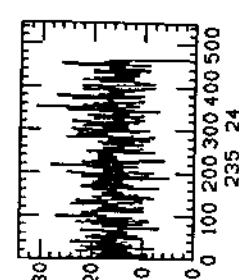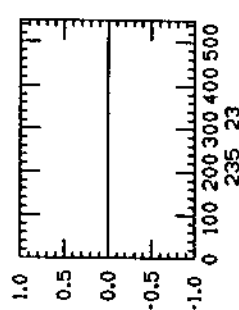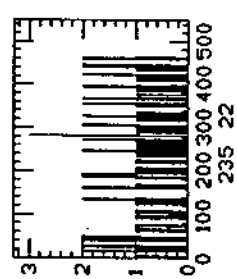
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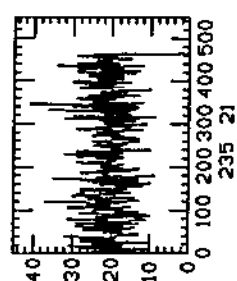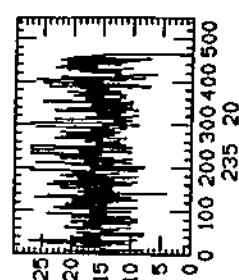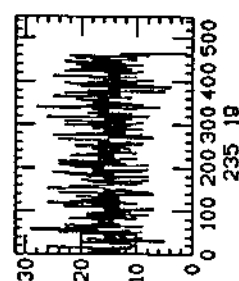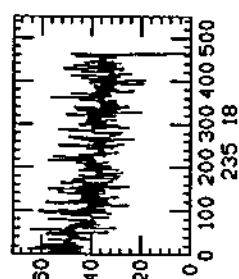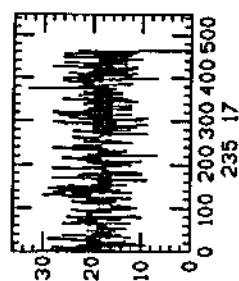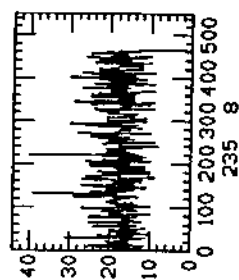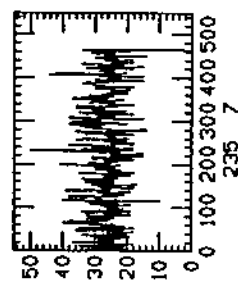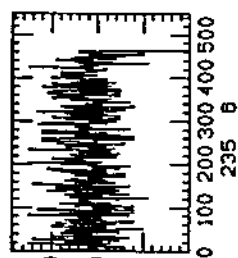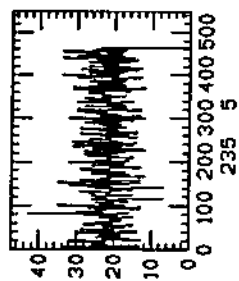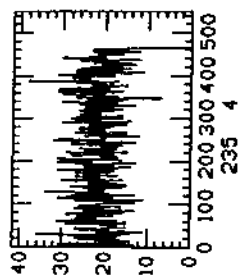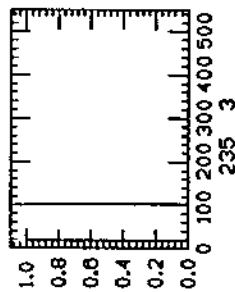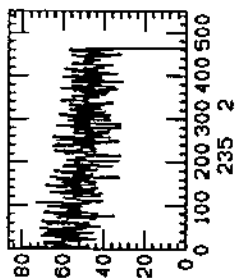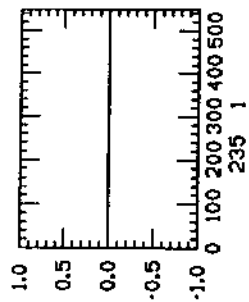
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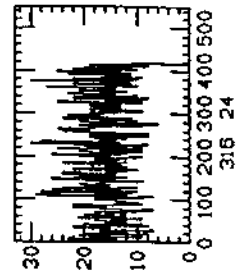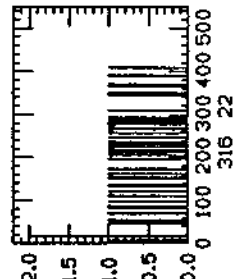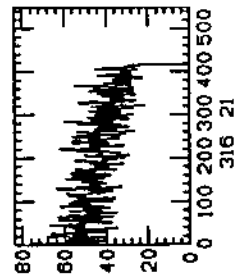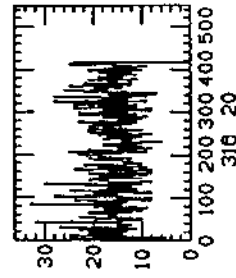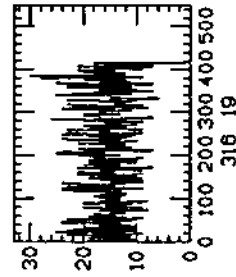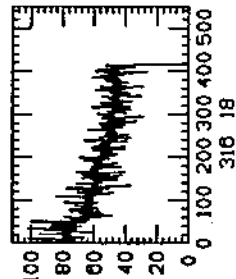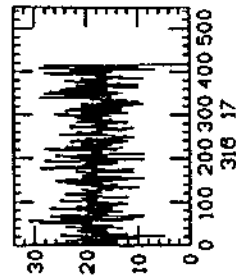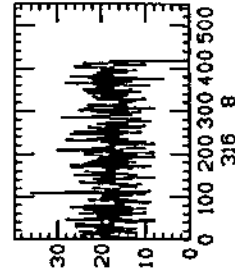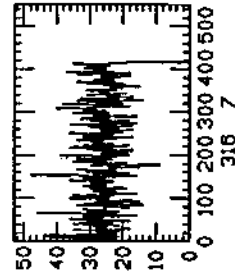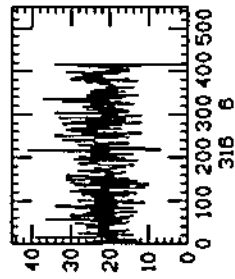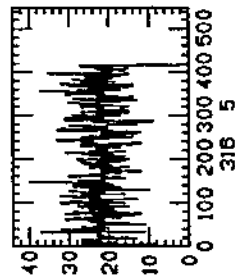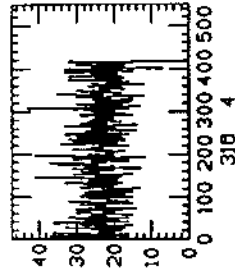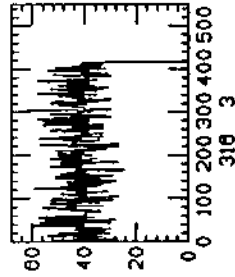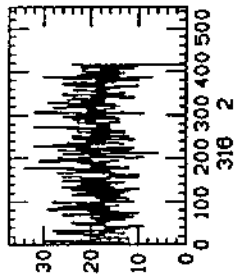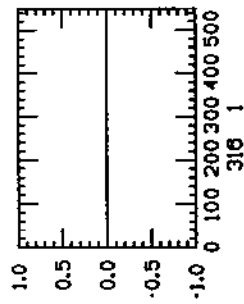
Figure 5

and 21 recorded what appears to be the same pulse. The buffer was filled, and thus the file ended before the entire pulse was finished. The peak hit rate on OM 20 was 125 kHz and the peak hit rate on OM 21 was 208 kHz. Assuming an external source, it must have been closer to 21 than to 20. Figure 4 shows file 235 which recorded the tail end of a pulse in OMs 2 and 18. Given that none of the other OMs show this structure it is unlikely that the two are from the same external source. Likewise with figure 5 which shows file 316. Here OMs 18 and 21 both saw the tail of a pulse. Since OMs 19 and 20 did not record the pulse, it is again unlikely that OMs 18 and 21 saw the same thing.

These three cases cast doubt on the theory that the pulses are caused by bioluminescence. If the pulses originated from external biological sources, why were they only observed by one OM at a time. Even in the case of file 168, given the hit rates of both OM 20 and 21, it seems likely that OM 19 should have seen something as well (OM 22 too, but it was not working). Also, in the cases of files 235 and 316, it is unlikely that two non-adjacent OMs with seperations as high as 160 meters could have seen different yet identically shaped pulses.

Now that the string has been recovered and repaired it is possible to look at raw data taken outside the ocean. If these pulses are still present in the data, then it will be clear that they are relics of the electronics. Otherwise, biological light may be the best explaination but further testing will be necessary once the string is back in the ocean.

Pulsewidth Distribution

The goal of this report is to make sure the data that came from the string is both consistent with expectations and with calibration data collected before the deployment. One check of this is the distribution of pulsewidths from the JOMs. The calibration data shown in Figure 6 shows a distribution with multiple peaks for OMs 2, 4, 5 and 6. It is thought that these multiple peaks come from ringing in the JOM circuitry. The horizontal scale in this figure is in nanoseconds. Figure 7 shows the distributions of pulsewidths for each JOM summed over all 613 useable data files. Again, for each JOM, multiple peaks may be seen clearly. Here the horizontal scale is in clock ticks.

Each clock tick is 1.25 nanoseconds long. If this factor is applied to Figure 7, then the highest peaks for OMs 2, 4, 5 and 6 occur at 14, 13, 14 and 15 nanoseconds respectively. However, from Figure 6, these same peaks occur at

21, 21, 17 and 17 respectively. The difference may be attributed to two factors. First, the high voltage settings used during the collection of the data was about 10 percent lower than those used during the calibration. Second, there was some attenuation of the pulsewidths on the order of a few nanoseconds due to the length of the ~~shore~~ cable.

riser

Pulse Seperation Distribution

Figure 8 shows the distribution of times between the pulses for each of the working OMs. In the case of the JOMs, the curve is essentially exponential with minor variations. The exponential form comes from the random nature of the hits. Long time differences between pulses are less likely than short time differences. Each curve has a valley that comes just after the noise peak of the curve. The width of the valley varies for each JOM but is roughly about 125 nanoseconds. Some of the curves actually show a small peak within the valleys. These valleys are possibly due to JOM dead time but futher investigation is necessary.

Generally, two Q pulse peaks are observed after the valleys. They are closely spaced together and the second is usually much larger than the first. The second larger peak comes about 215 nanoseconds which is expected for Q pulses.
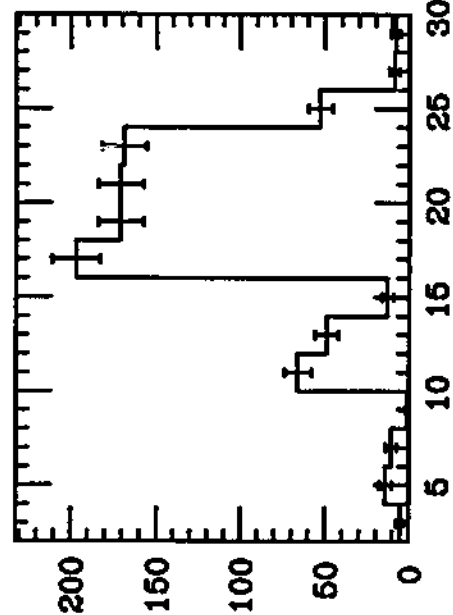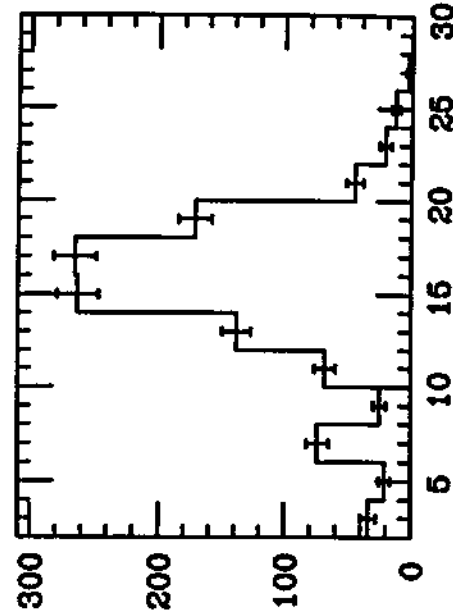
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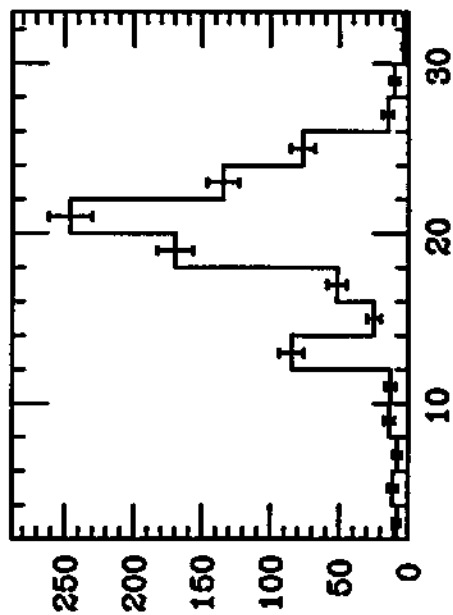
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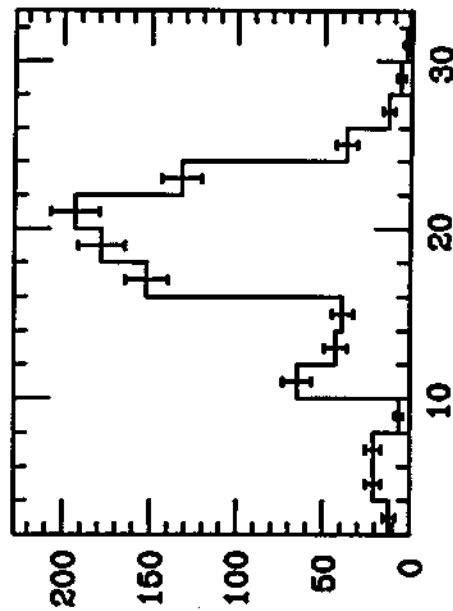
TOT dist. BA0151

TOT dist. BA0126

TOT width for run # 0, ns

OM 2

OM 4

OM 5

OM 6

Figure 6

80/08/93

Figure 7

Figure 8