Laser and Fiber Status in Pre-Repair Timing Calibrations

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1 Intro

Xu recently took a short set of laser calibration data for the pond PMTs and some of the outriggers (calib files available at UMD in /data/links/calib/laser/200308/ for pond data and /data/links/calib/laser/outrigger/200308/ for outrigger data.) Some changes have been made to the laser system since the last calibration run taken in September 2002. This includes a different laser, repairs to the pulse delay generator, and other modifications of the hardware setup. Running the calibration software on this data set provides a thorough check that the hardware and software are working as expected and allows any necessary changes to be made before the PMT repair. Additionally, it is helpful to know the health of the laser balls before opening the pond for the PMT repair in case they need any repair work. Recall that last year there were 8 with broken attachments to the PVC frame.

Last year after the repair two different sets of laser data were taken. The first was taken with 2000 shots at each filter wheel position (every 10 deg) at 20 Hz. The second was taken with 500 shots at every other filter position (every 20 deg) at 10 Hz to improve the amplitude stability of the laser for the PE calibration. Because amplitude stability is irrelevant for the slewing calibration, the 2000 shot version of the laser data was used for the 400 series timing calibrations. An additional test of the recent data set is the effect of less shots (1000 per wheel position) on the slewing analysis.

This memo includes the results of a nearly complete timing calibration lacking only fine tuning of fitting cuts and human intervention in the case of bad slewing fits. In summary, the timing stability looks good and I can not detect any laser ball dislocations in the data. There a few laser balls that although not worse than they have been could use some attention to improve their light levels to a level useful in the timing and PE calibrations.

2 Pond Status

2.1 Fibers

The nhit plots for each laser ball show the total hits for PMTs in the AS layer. The laser was set to fire 16000 times per fiber. These plots give an indication of a the laser ball's light level in the pond. The majority of the laser balls have several nearby tubes seeing $> 75\%$ of the shots. Laser balls with nearby tubes seeing $< 75\%$ and $> 50\%$ of the shots are classified as useful but weak. Those with $< 50\%$ are almost impossible to use in the timing calibration and can be considered out of commission. Even if a weak laser ball can be used for slewing curves for a couple nearby PMTs, it tends to fail the timing pedestal fitting and the fits cannot be used.

This last set includes only balls 15 and 30. Ball 15 registers no hits at all which has been its normal state since the 1999 calibrations. The connector in the laser shack was repaired last year. It appeared to be working briefly last September, but it seems to be back to no light now. Ball 30 has typically been weak in several previous data sets.

Laser balls in the $< 75\%$ club are 12, 17, 20, 25, and 28. Ball 17 had a bad time during the last repair and is still entangled with PMT 219. Currently balls 20 and 28 are not hitting enough tubes to register timing pedestal corrections and could really use some attention. All the weak fibers could benefit from a check of the fiber connector in the laser shack and, if that fails to improve things, a look at the laser ball end in the pond.

2.2 Timing Stability

A check of the stability of low threshold leading edges (lo start) over time for each of the laser balls shows none of the timing jumps seen in previous data sets. These jumps were typically 8-9 counts (4-4.5 ns). In some slewing curves this caused a noticeable doubling in tstart that confused the fitting. In the last data set used for timing calibrations (Sept. 2002 post-repair) 4 laser balls required a tstart correction before their slewing curves could be analyzed and 2 others had to have chunks of data excluded to get decent fits. In other words, this is a big improvement and makes life much easier for the timing calibrator.

2.3 Slewing

Raw slewing curve data (Figures 4-5) is shown for the PMT getting the most hits from each laser ball. The weaker laser balls can be picked out here, too, by noting the slewing curves that do not extend far in TOT. A preliminary run of slewing fits shows that the general light level is not quite as bright in the pond as in the previous data set. In the September 2002 post-repair data 169 PMTs have a maximum Hi TOT (highest Hi TOT bin getting a tstart fit) greater than 650 counts. For the recent calibration run only 47 PMTs pass the 650 count Hi TOT mark. See Figure 9 for the distributions. The minimum TOT distributions also differ, but this may be due to cuts in the fitter that were tuned to last year's higher density data set and still need to be adjusted to the new data. The cuts have little effect on the high end of the slewing curve.

2.4 Laser Ball Positions

A preliminary run of timing pedestals shows no detectable changes in laser ball positions. Typically, if a laser ball is far out of place, the timing pedestal fit fails due to using the wrong location to calculate the distance between PMTs and the laser ball. A separate test of location assuming the positions of neighboring laser balls are known indicates that none of the laser balls are dislocated beyond measurement errors, typically on the order of 10-20 cm. Nothing further can be determined without taking a direct look.

3 Outrigger Status

The data for the outriggers were taken for all filter wheel positions (every 10 deg) with 500 shots fired per position at 20 Hz. The difficulty in using this data set to determine outrigger status is that some portion of the outrigger fibers were disconnected during the data taking (mostly inner plus outer under the lightning system, A0, see Michael's logbook entry about outrigger fiber feeds.) This accounts for around 32 inner outriggers being absent, but only 10 show up in the data. A more complete data set is currently being taken along with the pedestal data. That data should be more useful in taking a real census.

However, 83 of the outer outriggers do see the laser. Something can be said about the brightness of the laser in these outriggers and the effect of longer cables on the slewing curve. Dispersion stretches the pulse and extends the slewing curve to much higher TOT values than pond or inner outrigger PMTs (Figure 17). The shapes are still very similar suggesting that the current fitting function may be suitable for hi slewing. However, the current method for choosing to apply hi or lo slewing corrections to data will not work well for these PMTs and the current placeholder fits they have been given in the current calibration are not at all suitable. Lo slewing in the outer outriggers is still under study.

	Inner Outriggers	Outer Outriggers
No data at all		822,833,835,902
No laser data	753-770,773,777-779, 781-804,809-818	859,861,862,867,868,876, 881,882,887,888,894,903
Dim data	771	820,825,828,838,839,851,854,855, 860,864,873,897,906,917,925,927

Table 1: Problem outrigger channels in the August, 2003, laser data set. Outriggers with no data recorded no hits for the duration of the data set. Outriggers with no laser data recorded no laser hits. Dim outriggers had laser hits, but no hits above 600 Hi TOT. The typical outer outrigger had data extending above 800 Hi TOT.

The outriggers receiving light show up in Figure 10 and Figures 12 and 13. The time plots of the outrigger data give an idea of the brightness of the laser in each outrigger. The outriggers with lower peak rates will have shorter slewing curves.

The hi and lo slewing for the inner outriggers (Figures 14 and 15) and a portion of the outer outriggers (Figure 16) are shown also to demonstrate how bright in TOT the laser is in many of the outer outriggers. Only one plot is shown for the outer outriggers to keep things brief. These TOT levels are typical of those that are not shown. If the outer outriggers see the laser, they tend see it at a very large TOT with the exceptions listed in Table 1.

4 Conclusions

The main goals of this memo were to highlight weak laser balls, to find any problems caused by changes to the calibration setup, and to get some plots circulated for future reference. Major results are the absence of timing instabilities and the successful run of the timing calibration software on data taken with the current calibration hardware setup. Taking 1000 shots per filter wheel seems sufficient for pond slewing, but the data could be brighter in TOT to improve the Hi slewing fits. The outrigger slewing data suggests some changes to fitting and applying slewing corrections will be necessary.

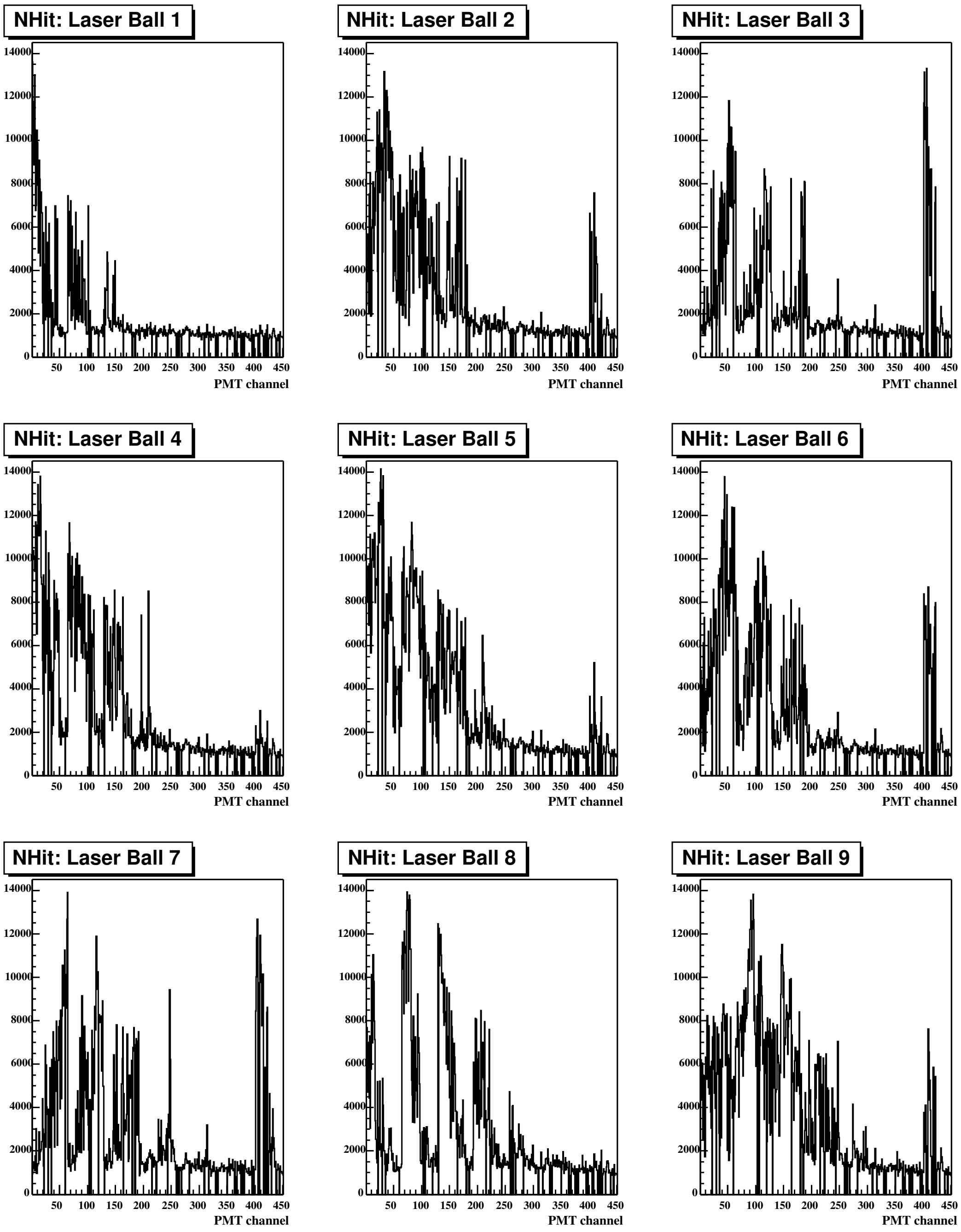

Figure 1: NHit distribution for laser balls 1-9 for 16000 laser shots.

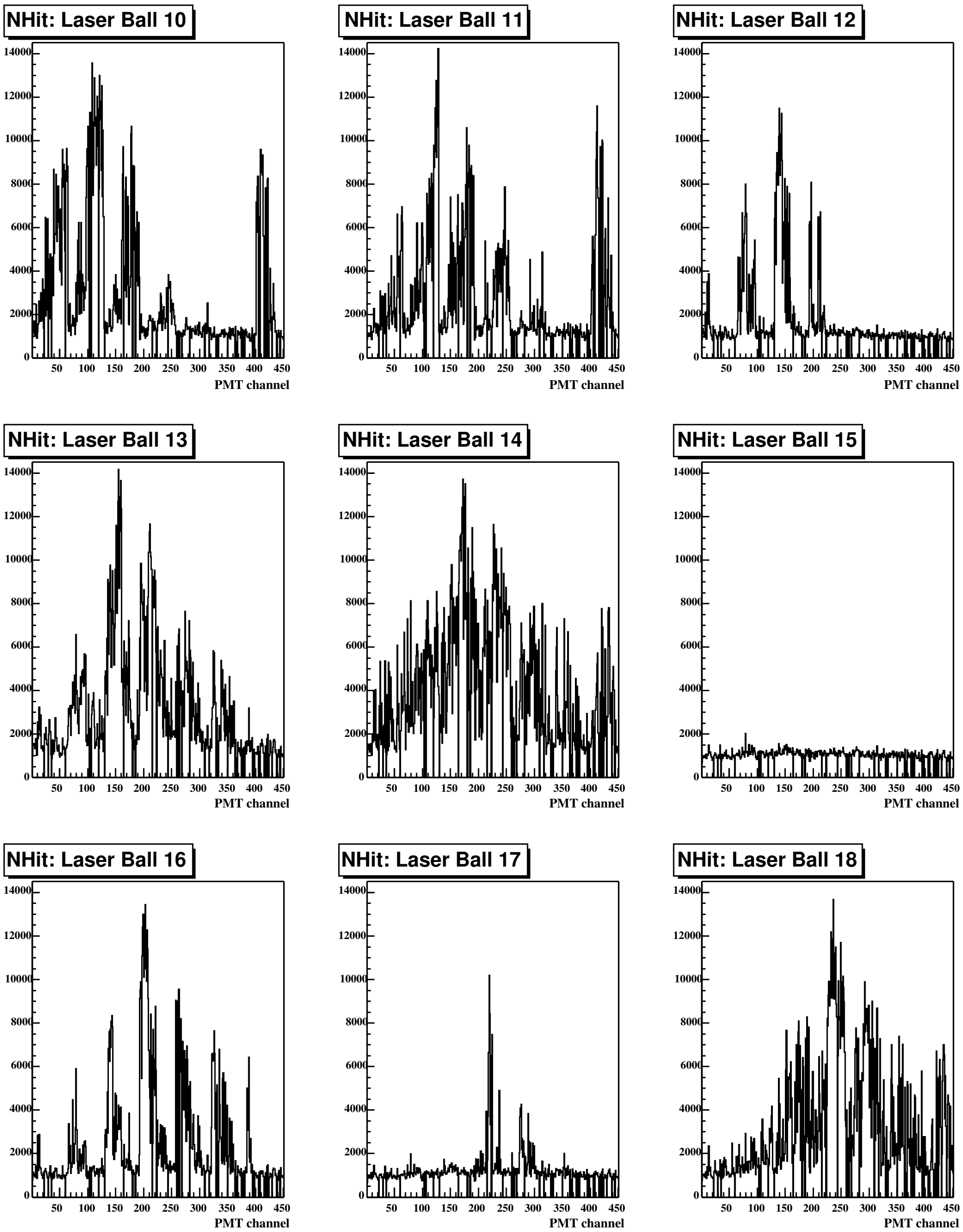

Figure 2: NHit distribution for laser balls 10-18 for 16000 laser shots.

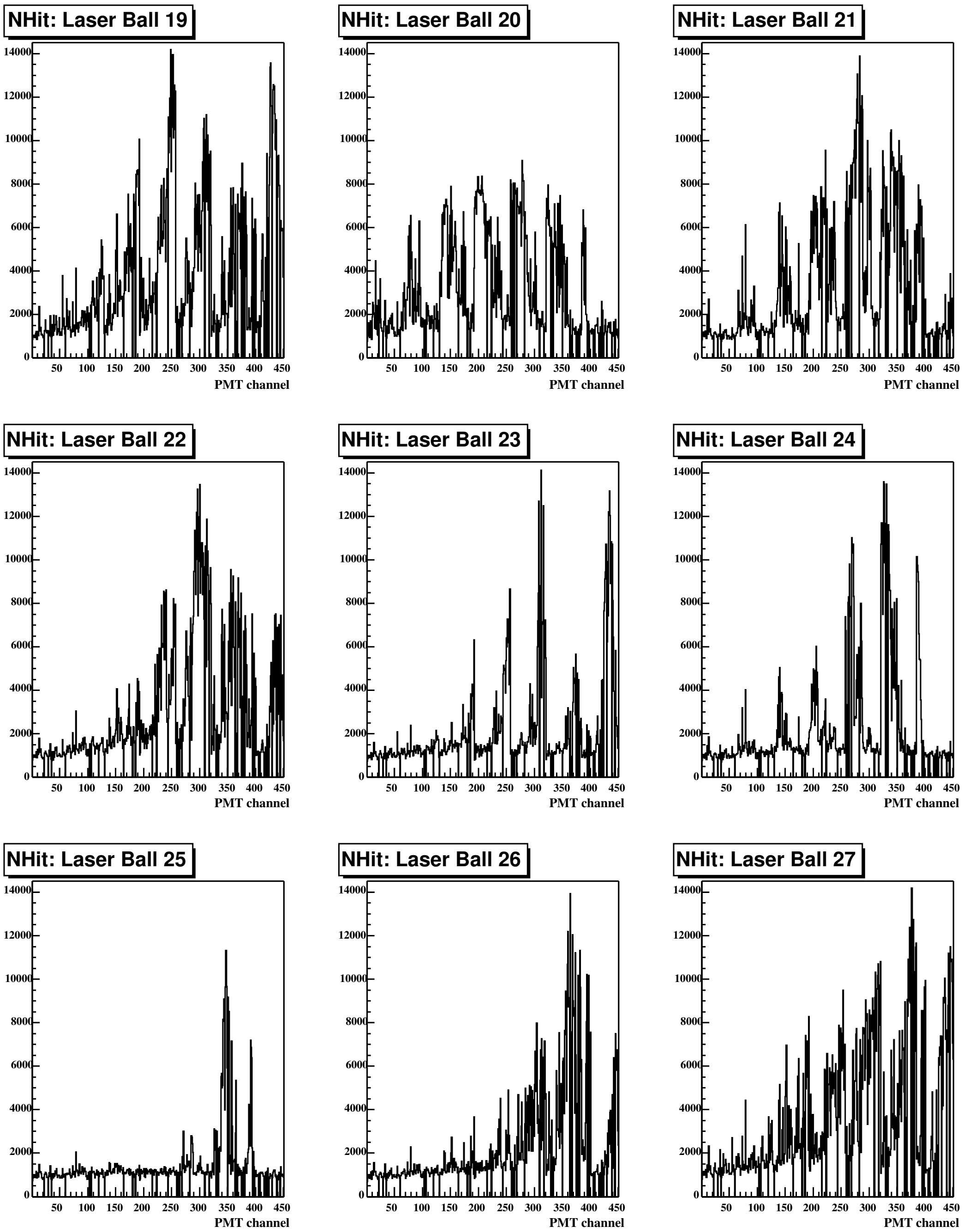

Figure 3: NHit distribution for laser balls 19-27 for 16000 laser shots.

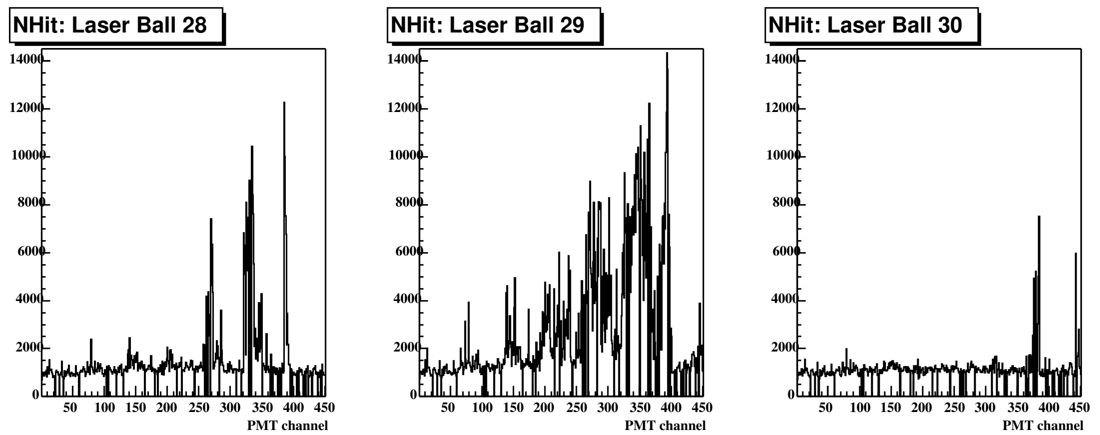

Figure 4: NHit distribution for laser balls 28-30 for 16000 laser shots.

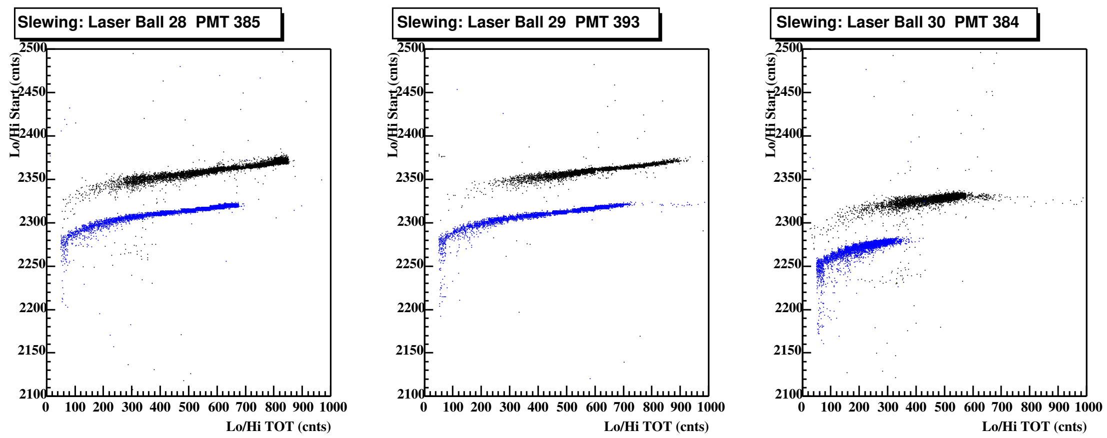

Figure 5: Slewing for brightest PMT for laser balls 28-30. Lo slewing is black; Hi slewing is blue.

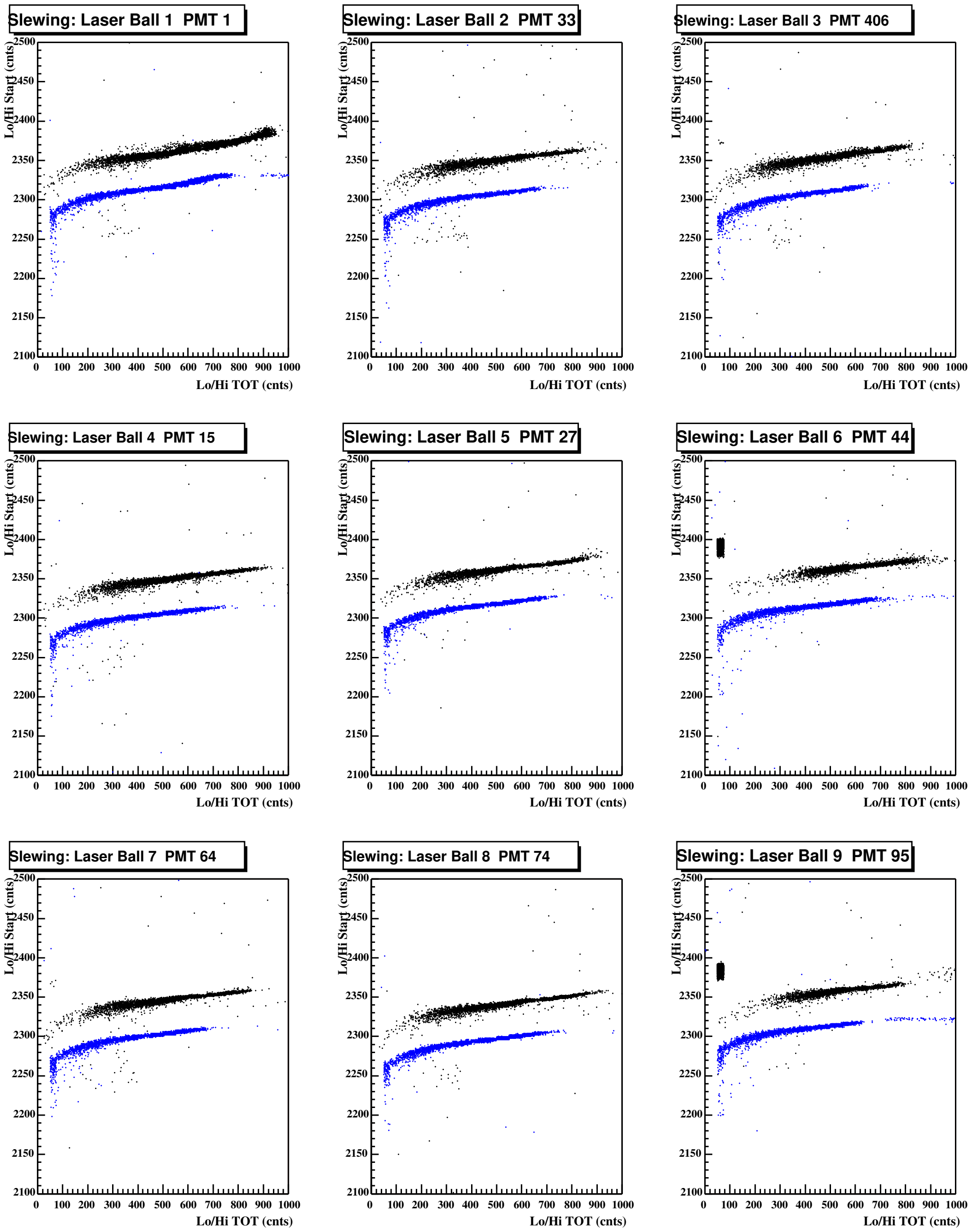

Figure 6: Slewing for brightest PMT for laser balls 1-9. Lo slewing is black; Hi slewing is blue.

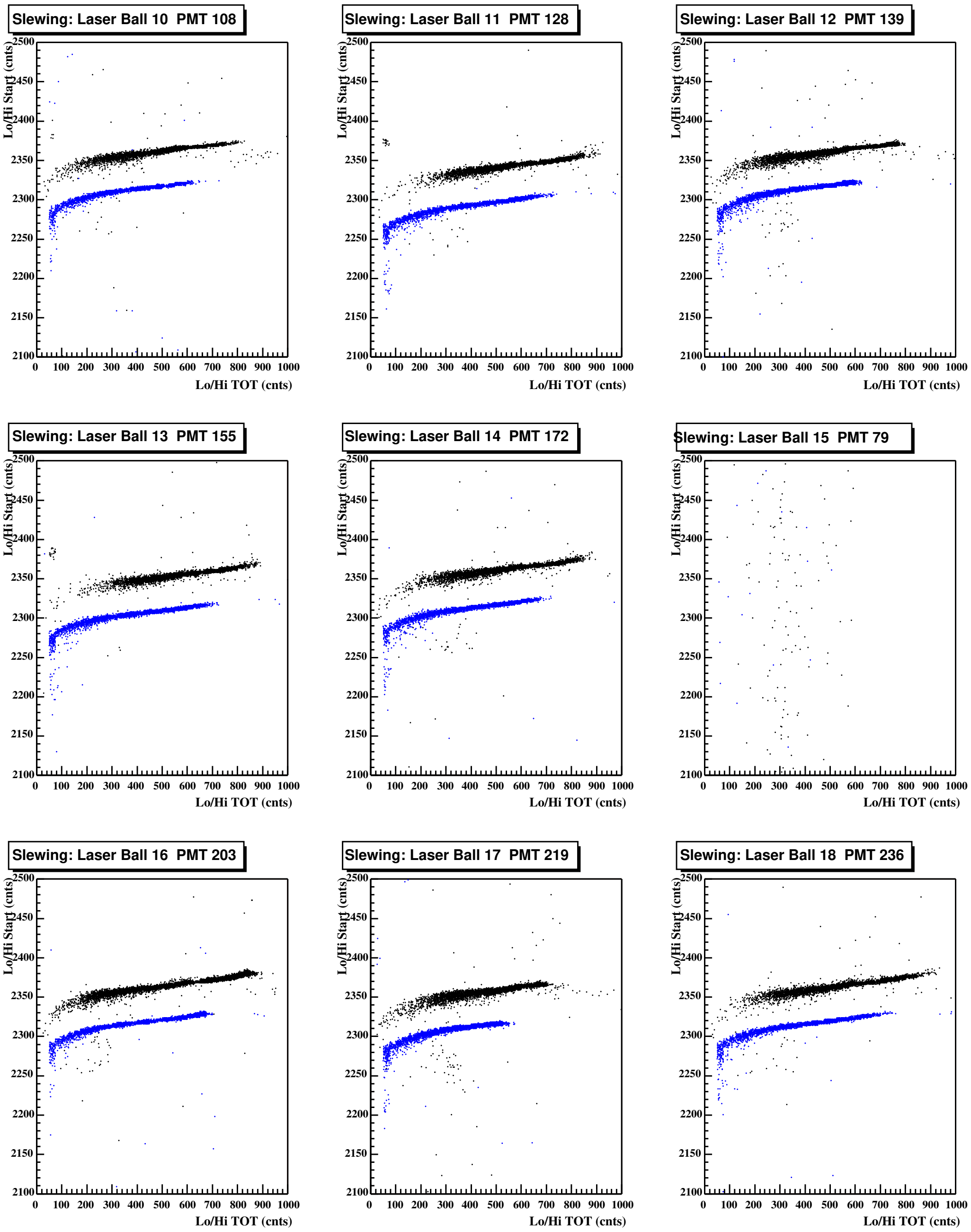

Figure 7: Slewing for brightest PMT for laser balls 10-18. Lo slewing is black; Hi slewing is blue.

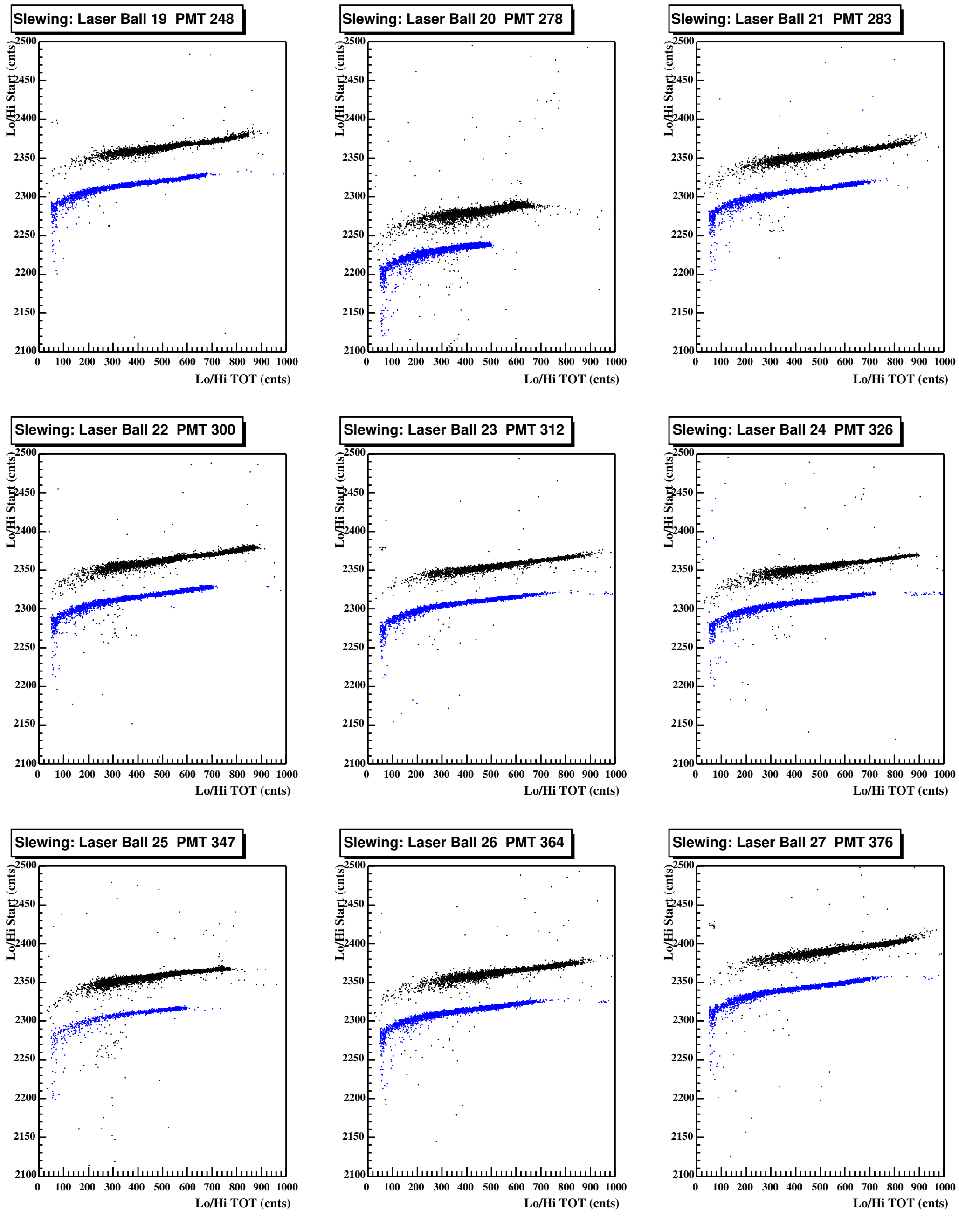

Figure 8: Slewing for brightest PMT for laser balls 19-27. Lo slewing is black; Hi slewing is blue.

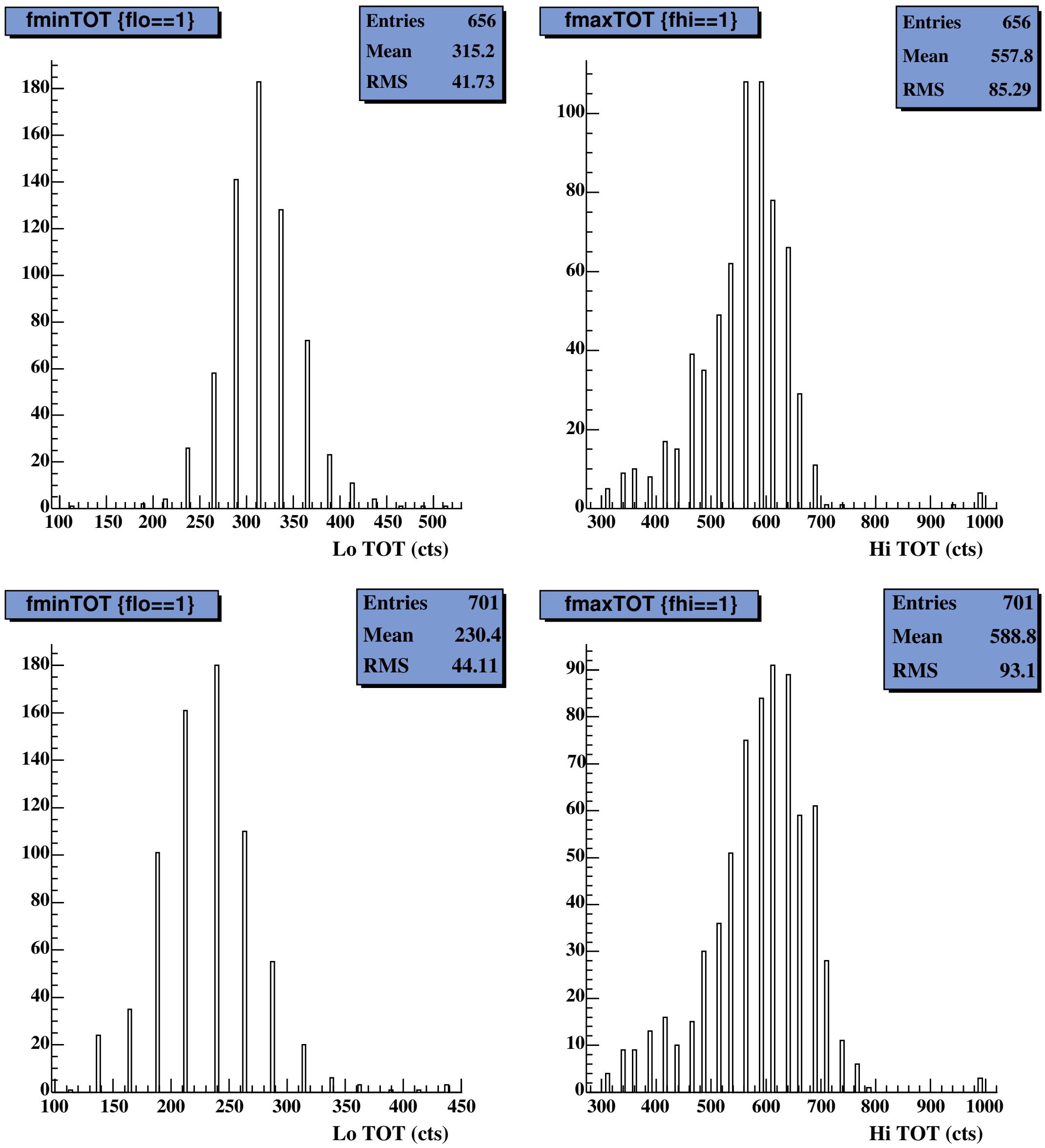

Figure 9: Minimum lo TOT and maximum hi TOT value distributions for pond PMTs in the recent data (upper) and in September 2002 post-repair data (lower). The recent data has more dead tubes but is in general not as bright as last year's data. The minimum TOT values are also different but this will probably disappear when the fitting cuts are tuned properly to the recent data.

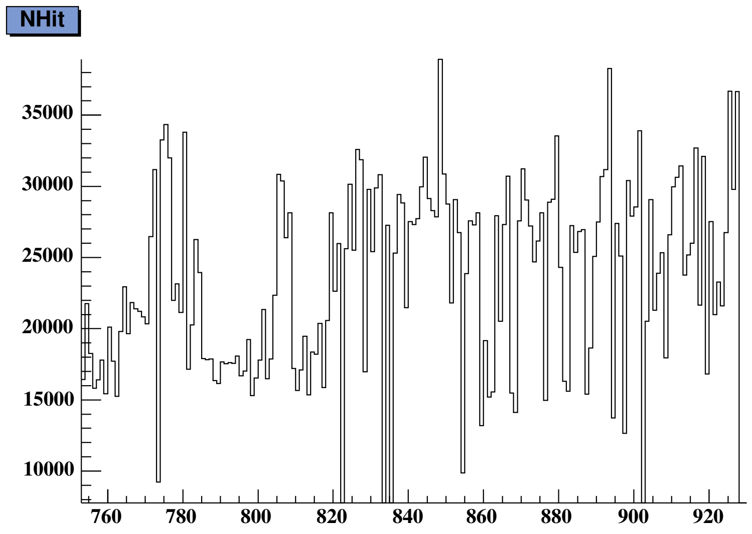

Figure 10: The nhit distribution for outriggers over the entire duration of the outrigger laser calibration (about 6 hours). The PMTs receiving laser hits show an increase over the non-laser background.

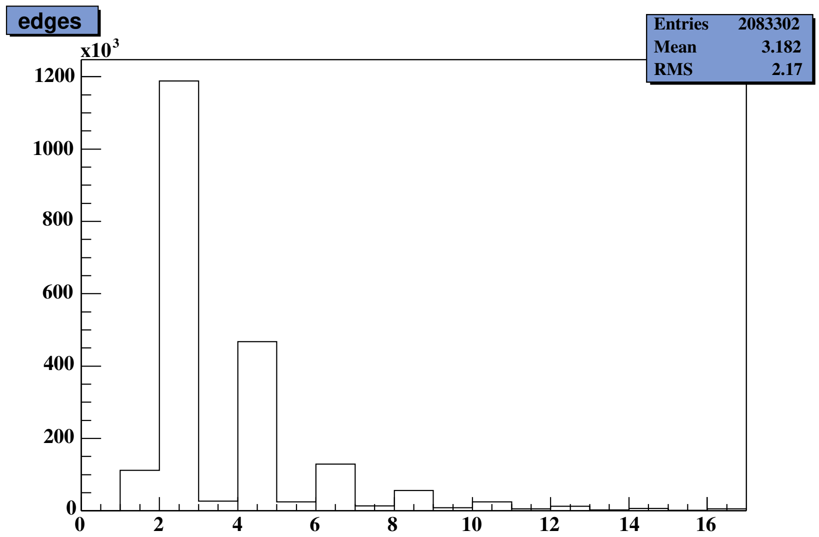

Figure 11: Outrigger edge distribution from laser data looks similar to triggered data.

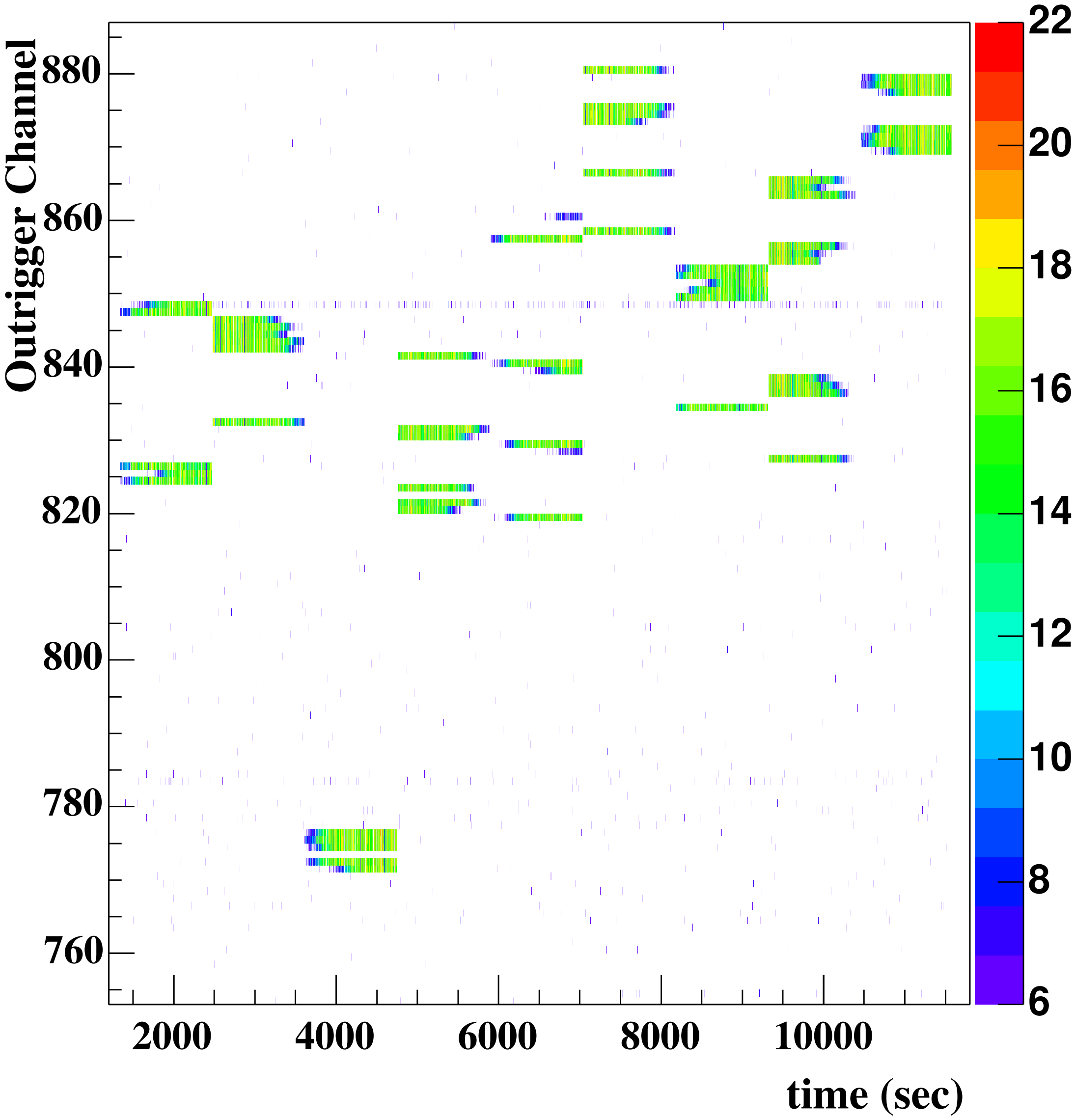

Figure 12: One plot summary: Shows which channel was hit when and at what rate. The groupings in time are the outriggers on the same switch. Z axis indicates hit rate in Hz. Outer outriggers start at 819. Outrigger number is channel number - 752.

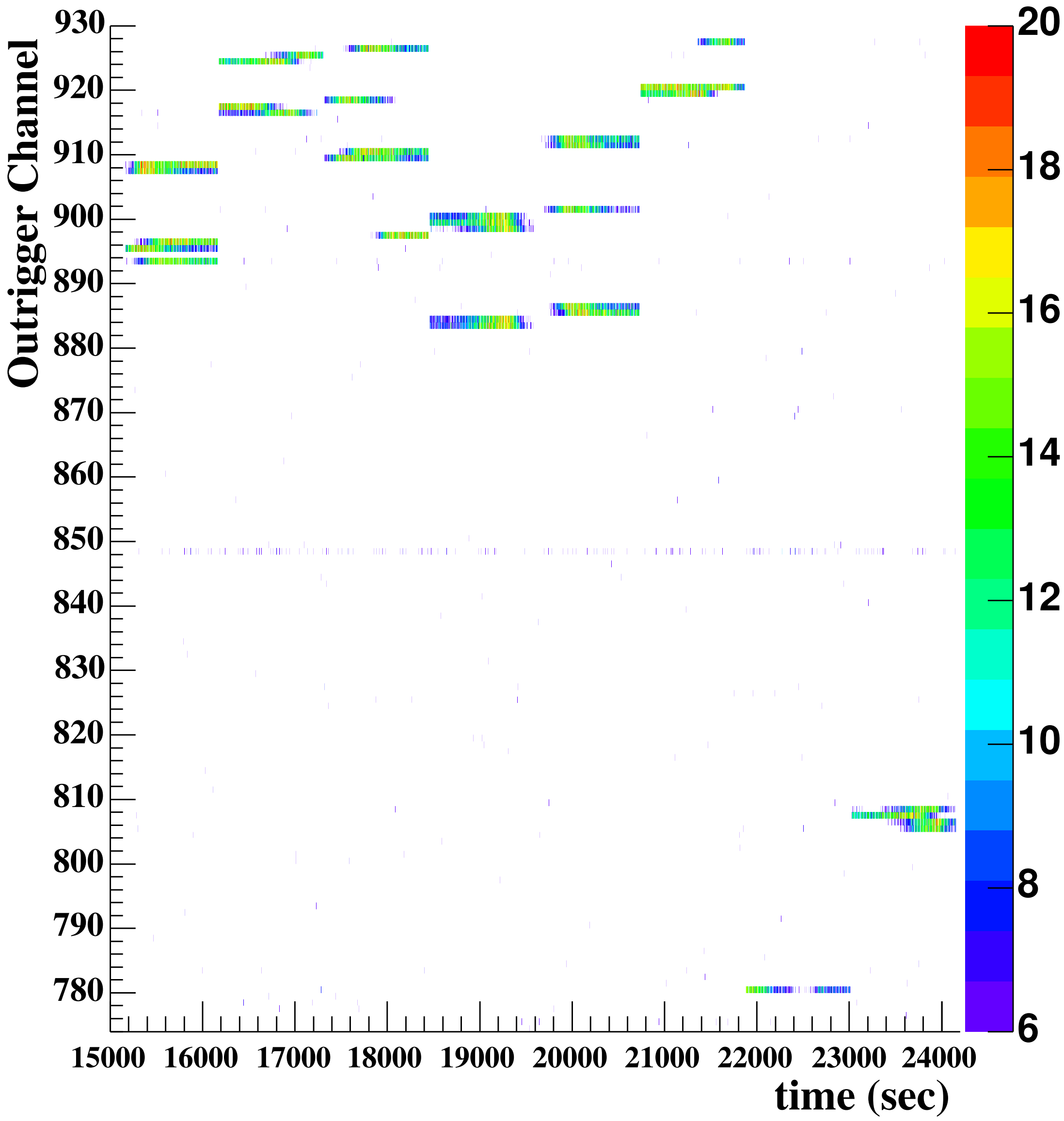

Figure 13: One plot summary, part 2: Shows which channel was hit when and at what rate. The groupings in time are the outriggers on the same switch. Z axis indicates rate of 2 and 4 edge hits in Hz.

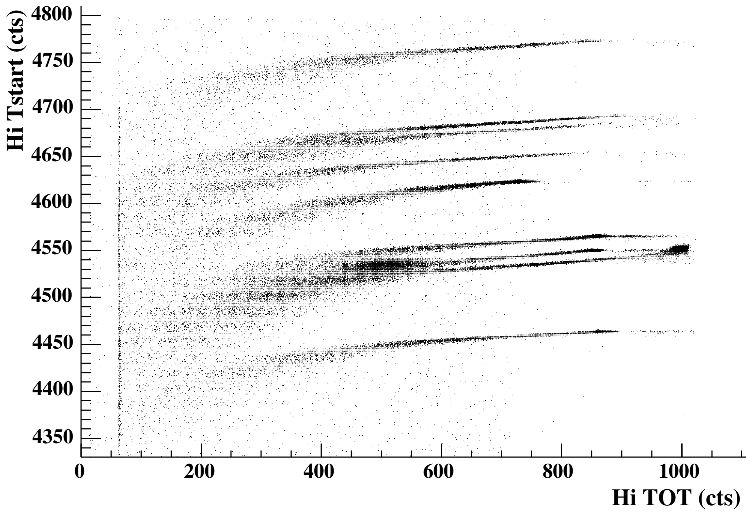

Figure 14: Hi slewing (hi start (cts) vs hi TOT (cts)) for inner outriggers, channels 753-818. Something like 32 inner outriggers were optically disconnected during this data set and are not expected to appear, but only 10 of the 66 appear.

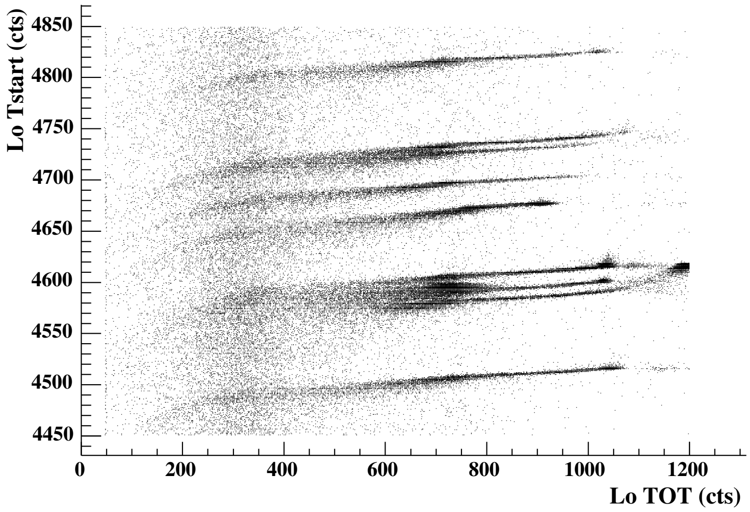

Figure 15: Lo slewing (lo start (cts) vs lo TOT (cts)) for inner outriggers, channels 753-818.

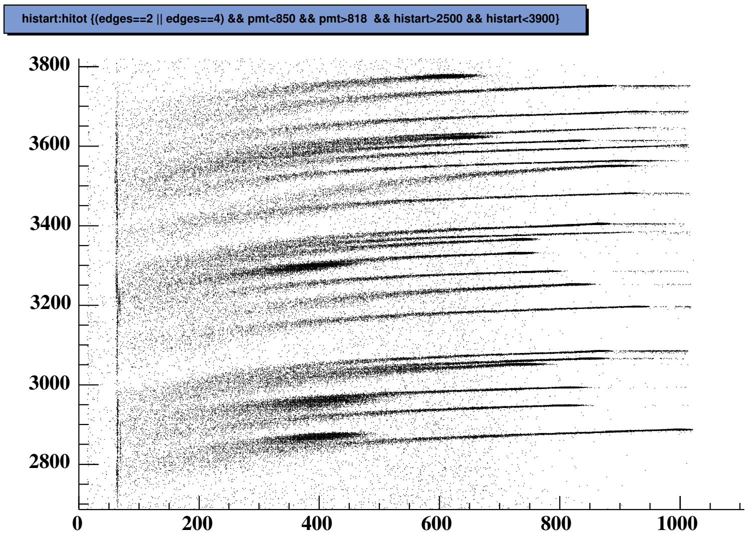

Figure 16: Hi slewing (hi start (cts) vs hi TOT (cts)) for outer outriggers, channels 819-849. Note that the slewing curves are very similar in shape with the exception of one slewing curve in the middle.

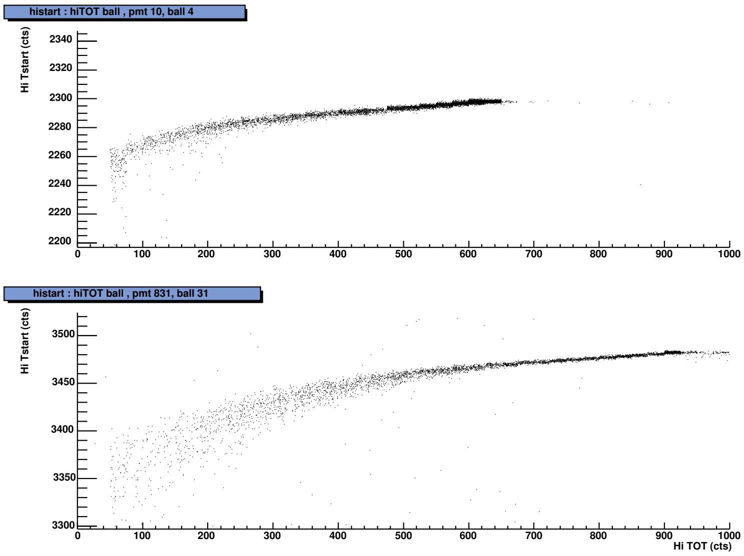

Figure 17: Hi slewing data for a pond PMT (top) and an outer outrigger (bottom). The outer outrigger slewing shows the effects of dispersion on the signal.