Effects on Scaler and Trigger Rates from Physical Interactions with the Cover

Linda Kelley and Don Coyne
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Between February 16th and February 23rd, while Don was on shift, he performed various tests to attempt to determine the cause of an increase in the air shower layer low threshold scaler rate and the overall trigger rate on cold nights and mornings. This note details the effect of some direct interactions with the cover on the scaler rate for individual tubes in the pond. Other tests performed at this time ruled out possible equipment problems as a source of the trigger rate increases. For a more complete description of these tests, please look in the online logbook during this time period.

February 19: Cover Agitation

On February 19th, Don attempted to break up any hypothesized ice which may have formed under the cover by running globally on the cover for approximately ½ hour. As was noted in the logbook after this test, the results were interesting. Figure 1 shows the gated trigger rate on February 19th. The two lines indicate the times that the "run" began and ended, at 13:25UT and 14:00 UT. In both the scaler and triggered data, a rate increase is seen beginning at about 13:30 UT and reaching a maximum near about 14:00UT.

There was some speculation that this bump was due to light leaks aggravated by the agitation of the cover. It is interesting to note that this rate bump is seen in the low threshold for nearly every tube in the pond, both in the air shower layer and in the muon layer, and it is not present in the high threshold data. Examples of this rate bump in the muon layer are presented in Figure 2. The upper plot is tube 725 in the Northwest corner of the pond, and the lower plot is tube 626 which is near the center of the pond. It is not larger in tubes near known light leaks. In Figure 3 the upper plot of tube 443 is near a large light leak, while the lower plot, tube 214 is in a dark part of the pond away from known light leaks. Tube 214 sees at least as large a rate bump as is seen by tube 443. In addition, since this small bump is seen clearly in the trigger rate, it is unlikely that aggravated light leaks are the cause. This bump is even seen to some extent by tubes which do not see the longer overnight rate increase in the air shower layer. This is seen in Figure 4 which compares tube 52 near the Southwest corner, which does not typically see the longer rate increase seen on cold nights, with tube 299 which routinely sees this increase when the temperature is below freezing. The small bump beginning at 13:30UT is seen to some extent in both tubes. It is not clear whether this bump is related to ice formation, or another cold weather phenomena, or whether this bump in coincidence with cover agitation would be seen even if the the outside temperature were above freezing. It could be, for example, the breaking up of an ice layer changing the reflective properties at the cover surface, followed by additional freezing of water near the cover. Since it is seen in both layers of the pond, it is also possible that it has some other cause unrelated to ice formation.

February 23: Cover Heating

The test on February 23rd involved pouring 5 gallons of ~110°F water and then 5 gallons of ~80°F water on the cover above and around tube 450. Prior to this test, the tube was surveyed in relative to the edge of the pond using Peter's survey numbers. The measurements, and the marking of the location using a large rock, caused quite some agitation of the cover locally, occurring between 11:52 and 12:05 UT. Tube 450 is located in the Northwest corner of the pond. The water was poured in approximately a 3m x 3m square centered near tube 450's position, and it puddled at this location because of the weight of the rock. The conformation of the water is as follows: The depth at the rock was about 5cm, falling to 0.2cm by 50cm radially from the rock. Beyond that, over the 3m x 3m square it was $\leq$ 0.1cm deep, and zero outside that square. The total amount of water added to the pond is very small. Assuming that the cover is not completely stiff, and the the rock displaced water in the pond, the increase in overburden caused by the added water is very small. There might be some effect in that this depth of water is removed from the Cherenkov−active volume; though this is to small by approximately a factor of 30 to account for the deficit described below.

The upper plot in Figure 5 is the scaler rate for tube 450 for the entire day, and the lower plot expands the region near 12:40 UT when hot water was first applied. The solid line on both plots is at 12:40UT, and the dashed lines represent the start of the period of agitation during the survey. Notice that for this tube, there also appears to be an increase in scaler rate coincident with agitation of the cover. The tubes adjacent to 450 also see a small rate increase beginning at approximately 11:50UT when the agitation first occurred, but this increase is not seen in the remainder of the pond. A significant increase in the trigger rate is not seen. However, Figure 5 does show a remarkable drop in scaler rate, >600Hz, immediately following the application of the water.

In the upper plot in Figure 5, the rise in the scaler rate around 6:00UT is the start of a typical scaler rate increase seen primarily in the air shower layer on cold nights. In the absence of light leaks, pressure changes, or other such factors, this would plateau (as seen between about 7:30 and 12:00 UT) then begin to decrease after sunrise, assuming that the temperature remained below freezing during this time. Tube 450 is near a substantial light leak and the rate increase seen after about 17:30UT and continuing until about 22:00 UT (3pm local time) is most likely associated with this leak.

Figure 6 shows tube 450 on February 19th when the overnight low temperature was also below 32F, but it was not quite as cold as February 23rd. The rate rise due to the nearby light leak is also seen in these rates and displays some similar characteristics to the features seen on February 23rd. Neither the increase beginning at 11:50UT nor the deficit beginning at 12:40UT are seen. Thus, in Figure 5, the rate drop beginning shortly after 12:40 and lasting until approximately 13:20 is clearly associated with the cover heating. Since this drop is on top of a rate increase, this appears by eye to be a very small deficit. The deficit, from 15 minutes after the warm water was poured on the cover to the time when this water was observed to be half frozen at 13:13UT, represents 25−40% of the total 6:00UT rate increase. Figure 5 can be compared to a similar tube not subject to heating: tube 385 plotted in Figure 7 on the same relative scale as Figure 5. This tube is in the Northeast corner of the pond. Tube 385 is obviously not effected by any light leaks. It does not see a rate increase coincident with the cover agitation above tube 450, and it does not see anything unusual at 12:40UT, as expected.

A decrease in the scaler rate is also seen in the nearest neighboring tubes (449, 448, and 444) in Figure 8. In the two tubes directly adjacent to 450, a decrease of 20−30% relative to the rate increase at 6:00UT is observed. The diagonal neighbor, tube 444, shows corresponding decrease of 15% relative to its increase at this time. In the next nearest neighbors (447, 443, 400 and 384 in Figure 9) the rate decrease is insignificant. Photons scattered off the cover reaching these next nearest neighbors from the patch above tube 450 are at angles greater than 70^{o}. This represents a small portion of these large angle photons, so even before taking the baffle into account no significant effect is expected.

To summarize, several interesting effects are seen in the individual scaler rates during the tests performed on February 19 and 23. In both tests, there appears to be an increase in the scaler rate corresponding to the start of agitation of the cover. When agitation took place over the entire cover, an increase in the trigger rate was also seen. More tests would be needed to confirm this correlation and to isolate a mechanism which would produce this effect. What is clear is that heating the cover does successfully decrease the scaler rate for the tube directly beneath the heated patch, as well as the nearest neighboring tubes. This implies that increased reflectivity of the cover related to freezing is a likely cause of the large rate increase seen on very cold nights.

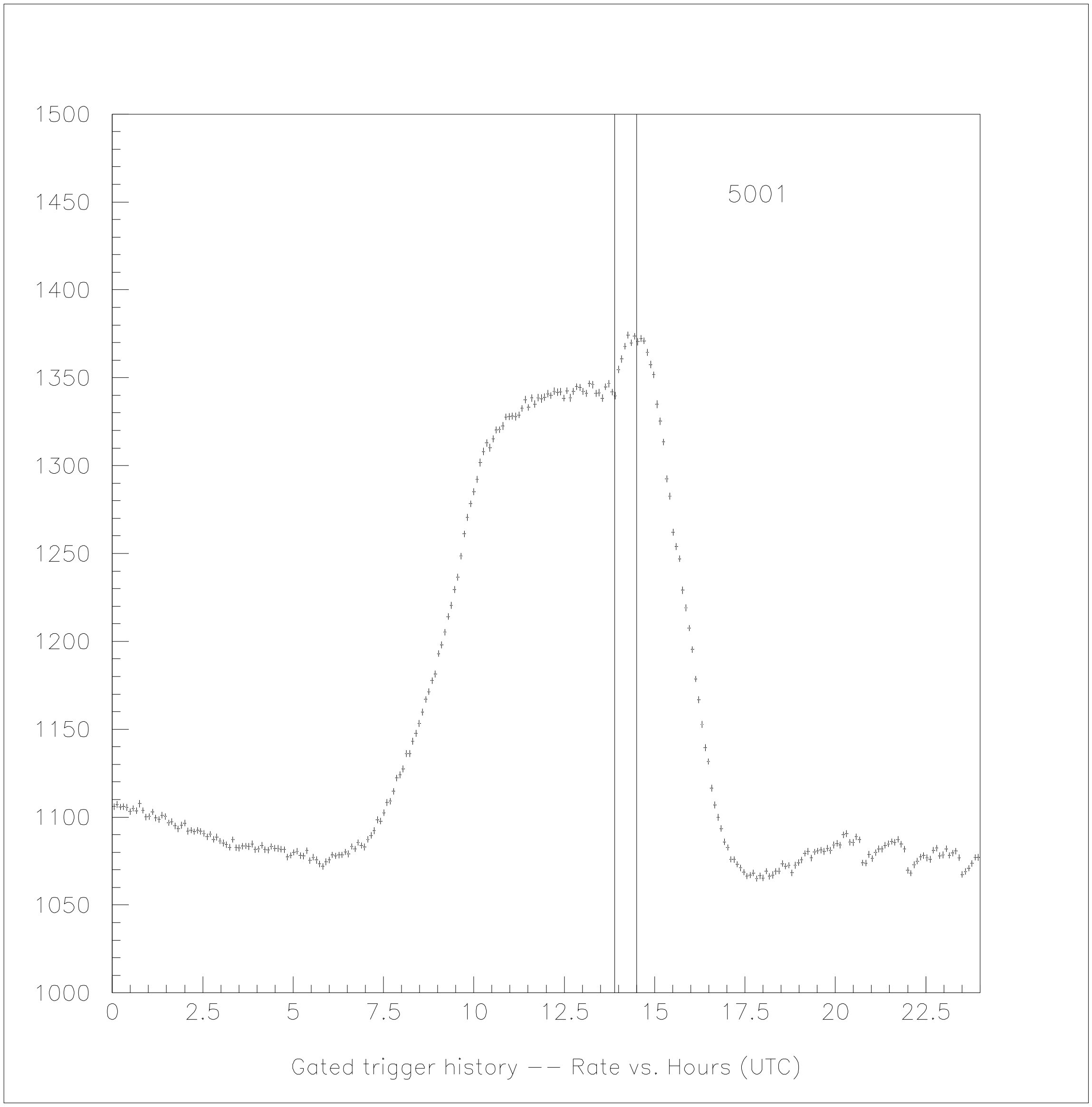

Figure 1: The gated trigger rate in hertz vs the time in UTC hours on February 19th. The solid lines represent the time interval when cover agitation was taking place.

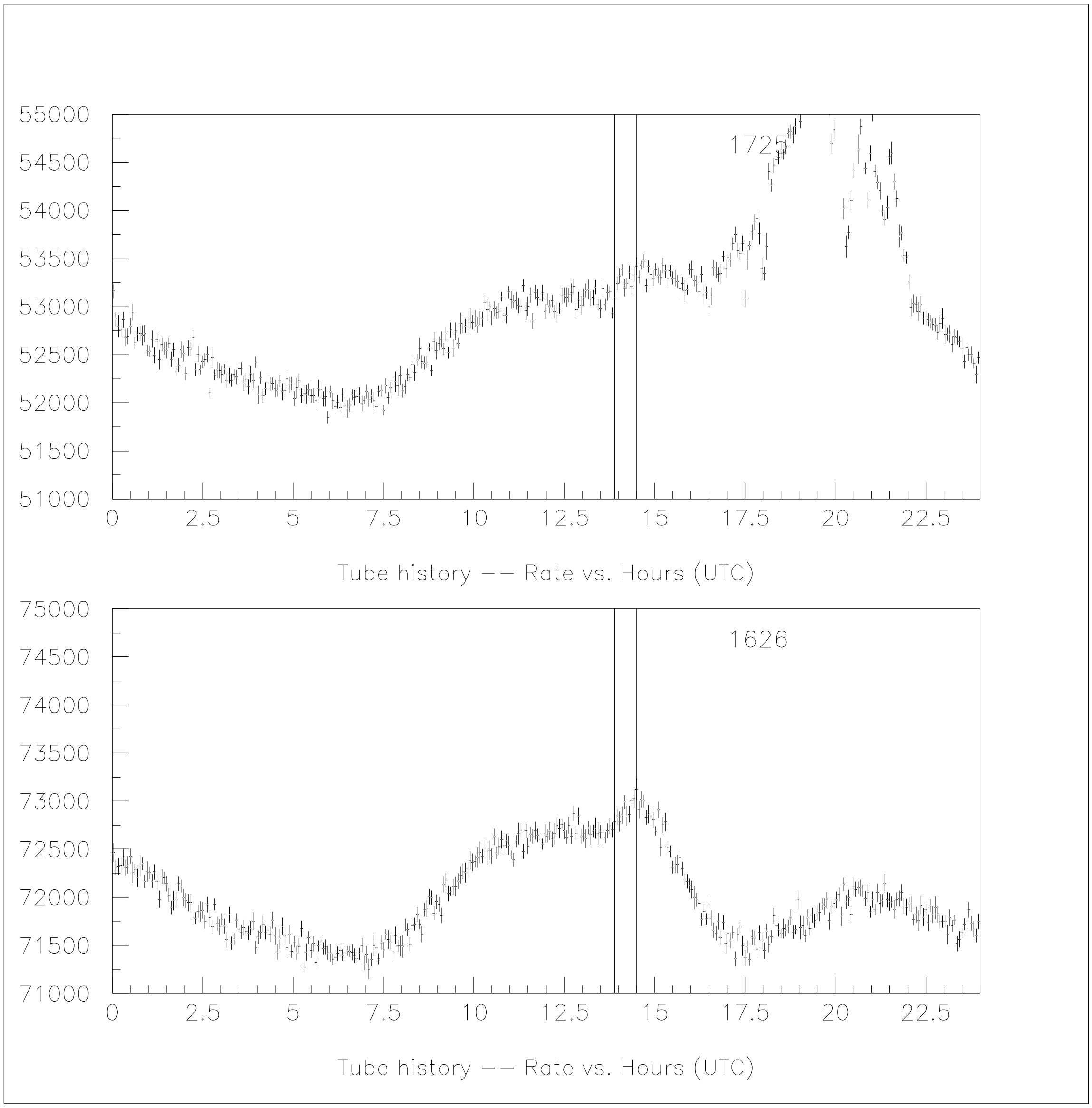

Figure 2: Individual scaler rates for tube 725 and tube 626 on February 19th.

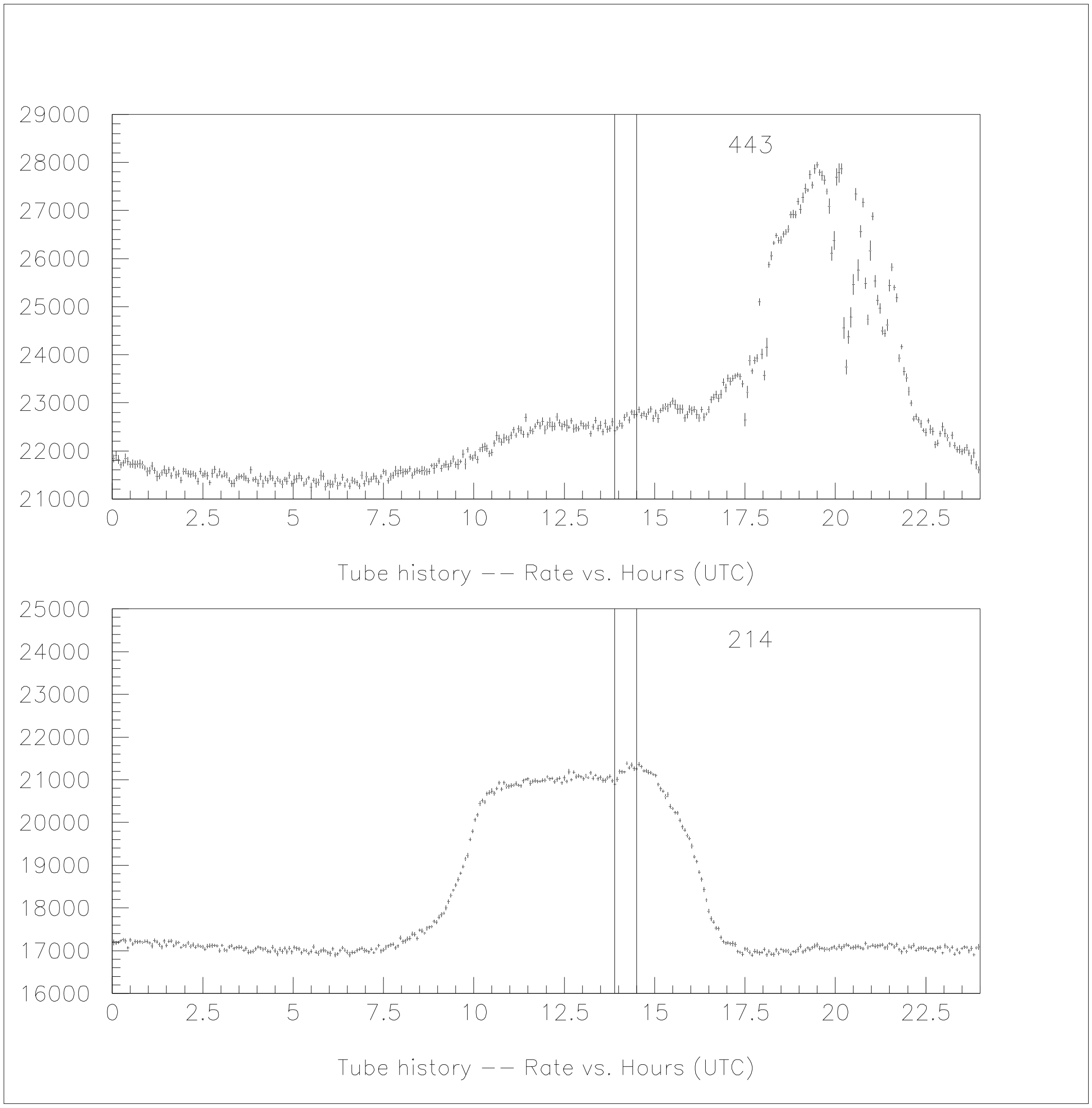

Figure 3: Individual scaler rates for tube 443 which is near a light leak and for tube 214 which is not near a light leak.

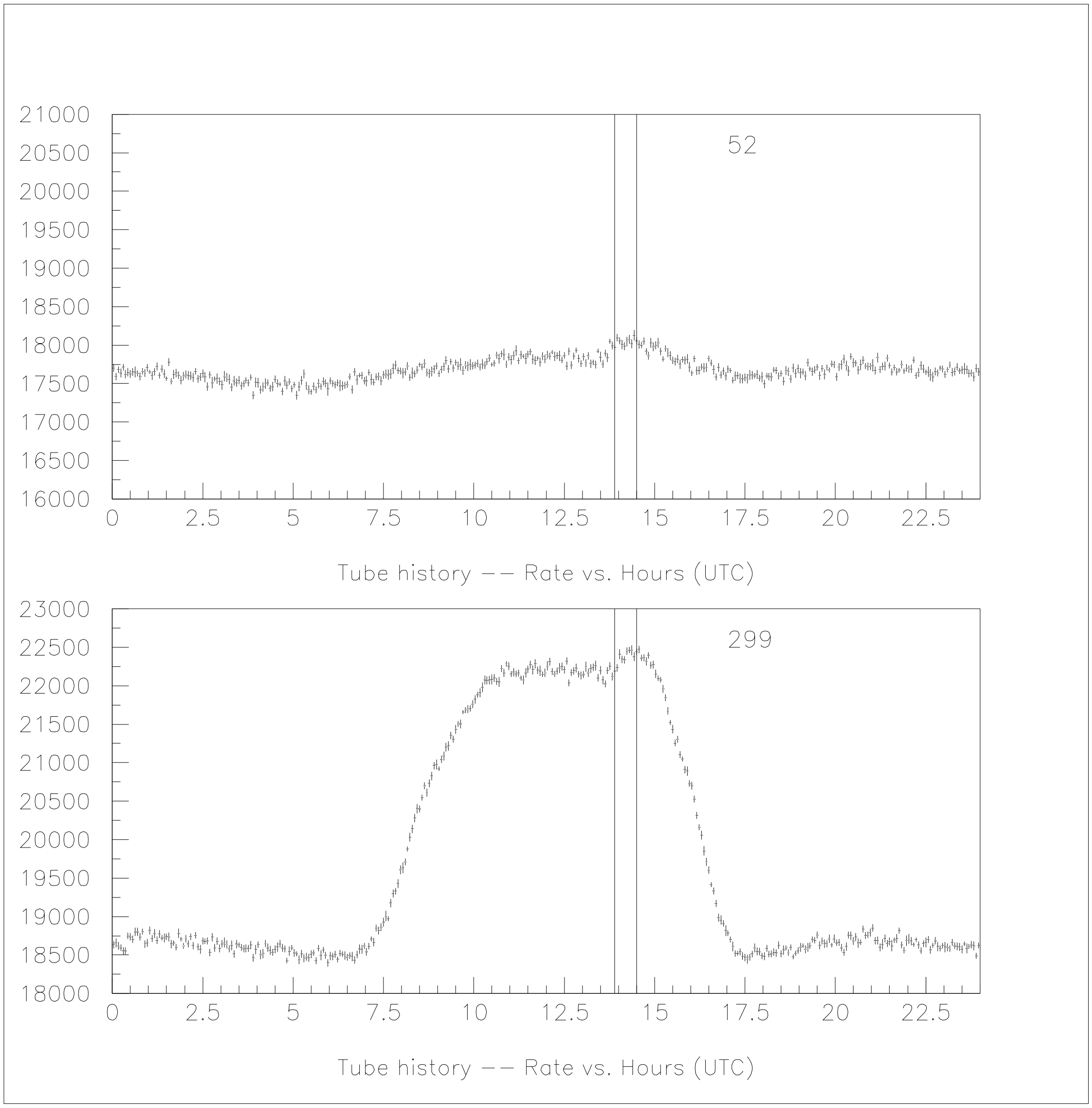

Figure 4: Individual scaler rates for tube 52, which typically does not see the large overnight temperature increase, and for tube 299, where this increase is present.

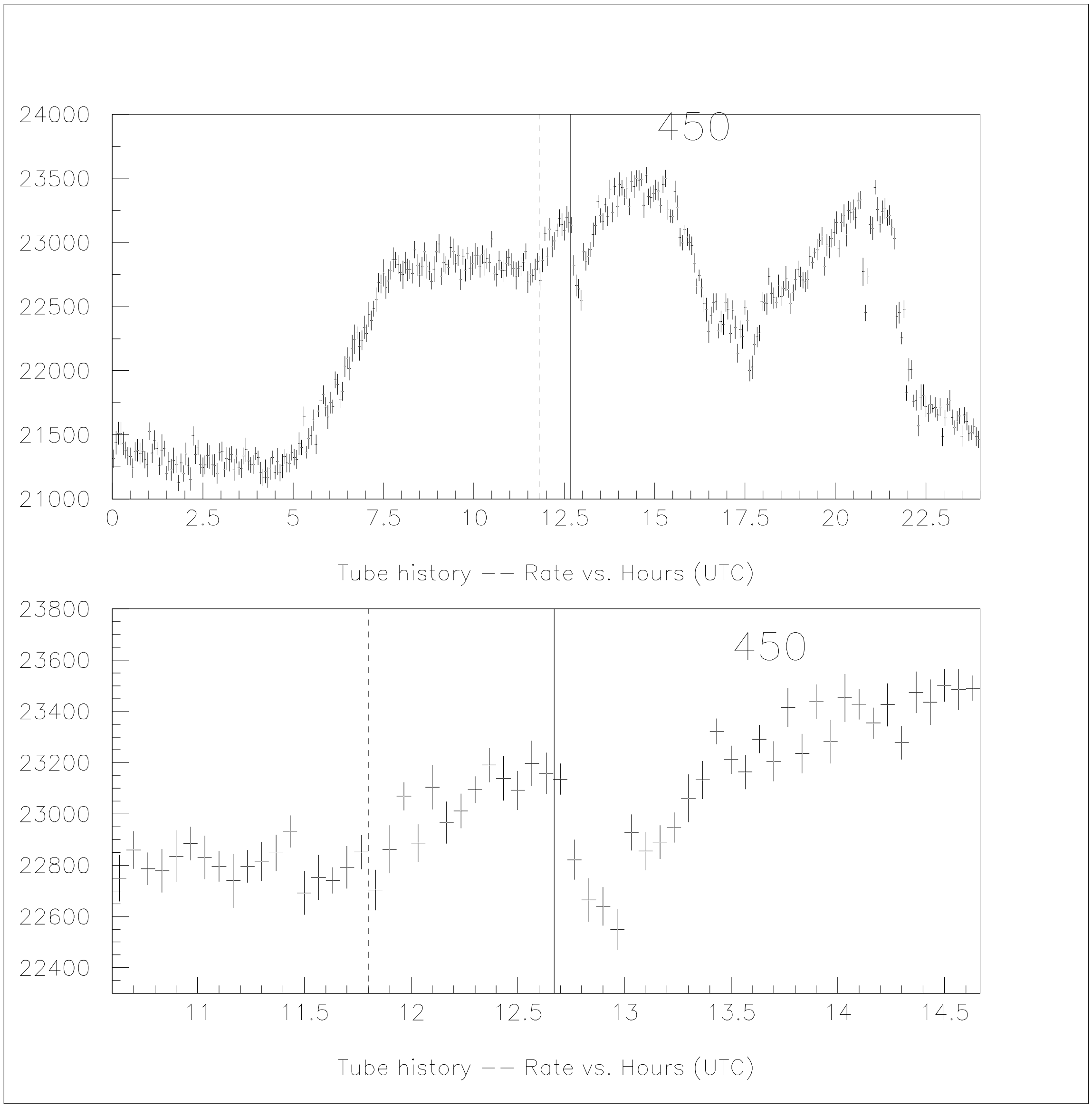

Figure 5: Scaler rates for tube 450 on February 23rd, for the entire day and for a region around 12:40UT. The solid line is when hot water was first applied at 12:40UT and the dashed line is when local cover agitation began at 11:50UT.

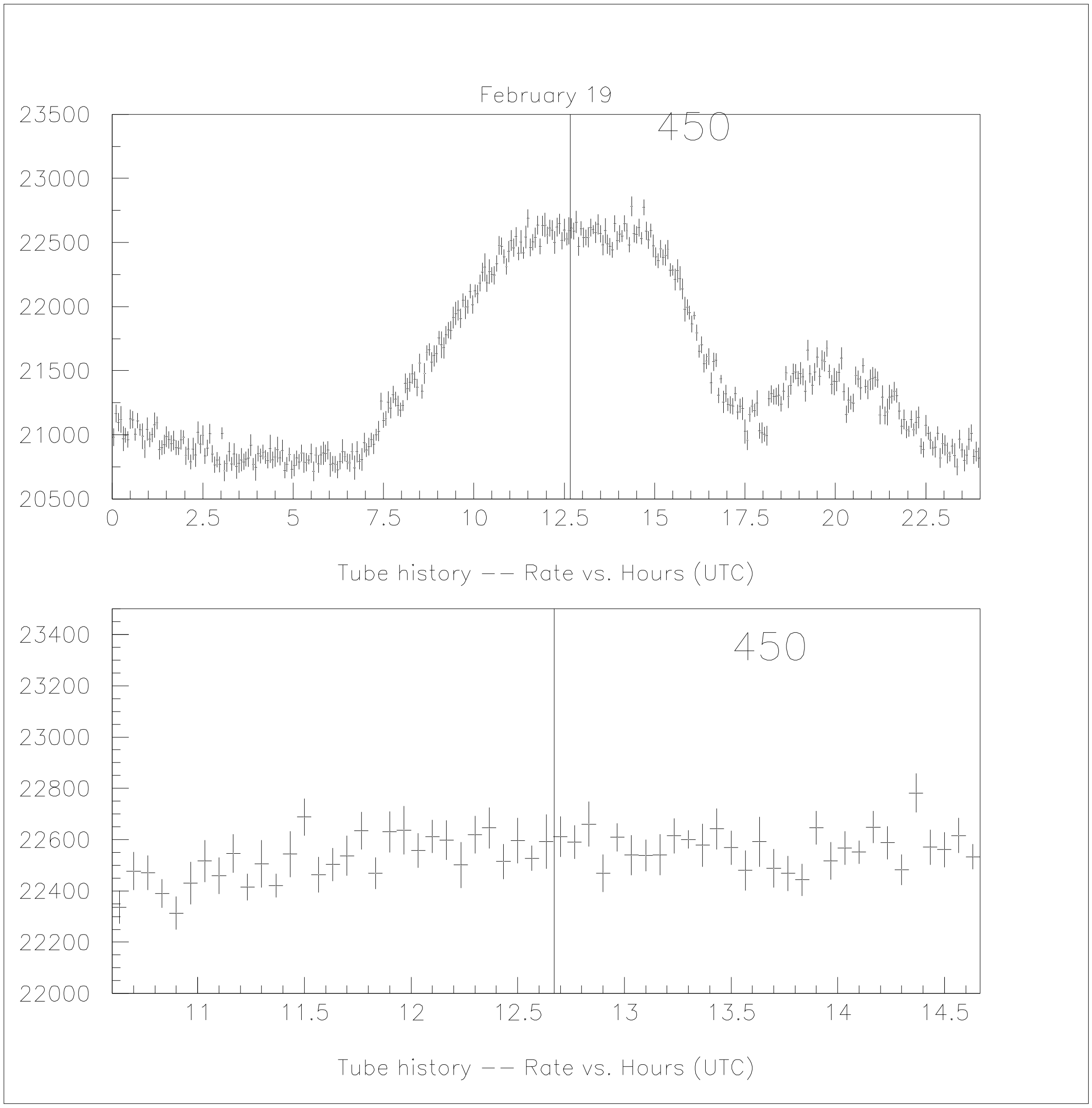

Figure 6: Scaler rates for tube 450 on February 19th.

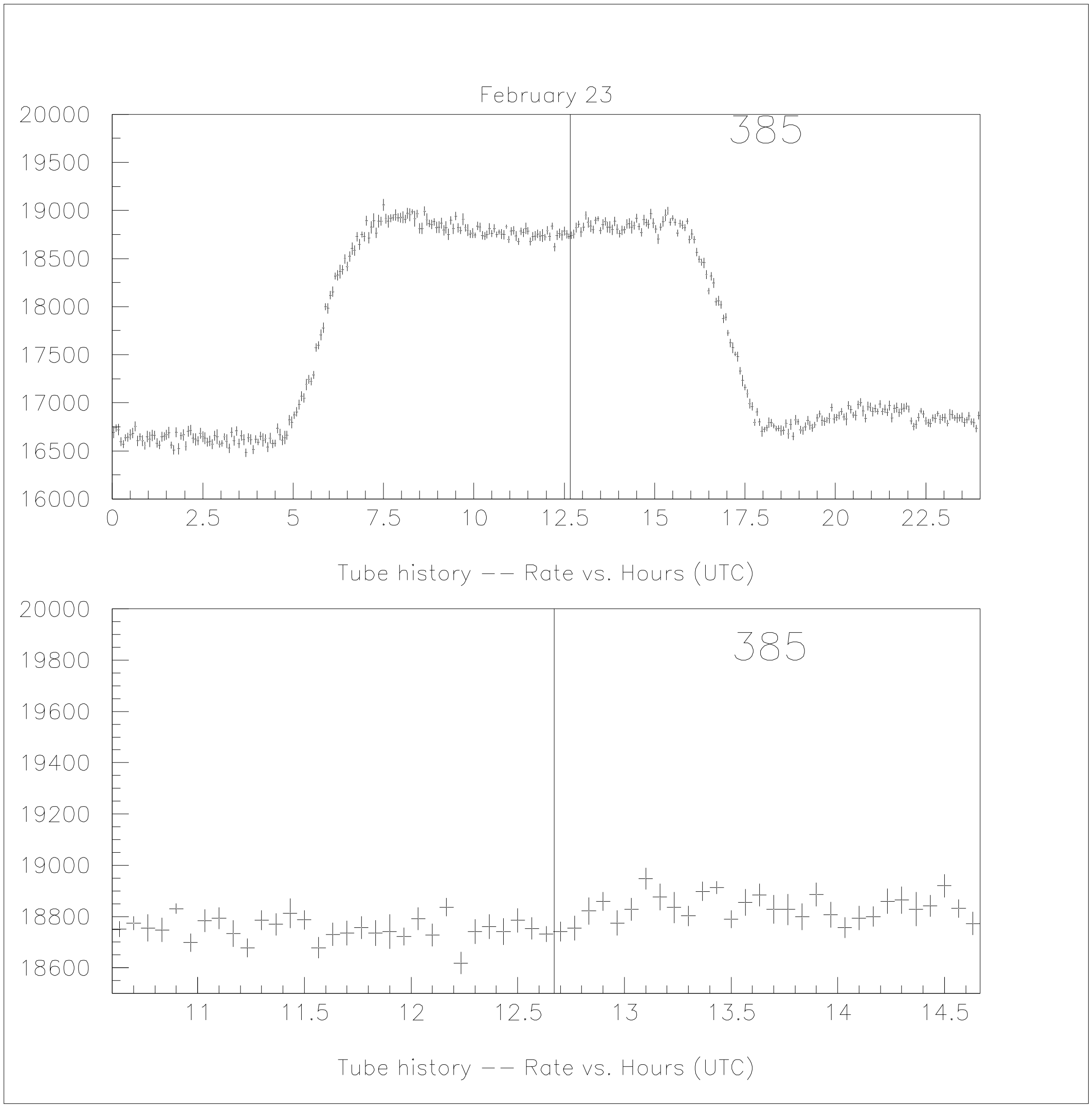

Figure 7: Scaler rates for tube 385 on February 23rd.

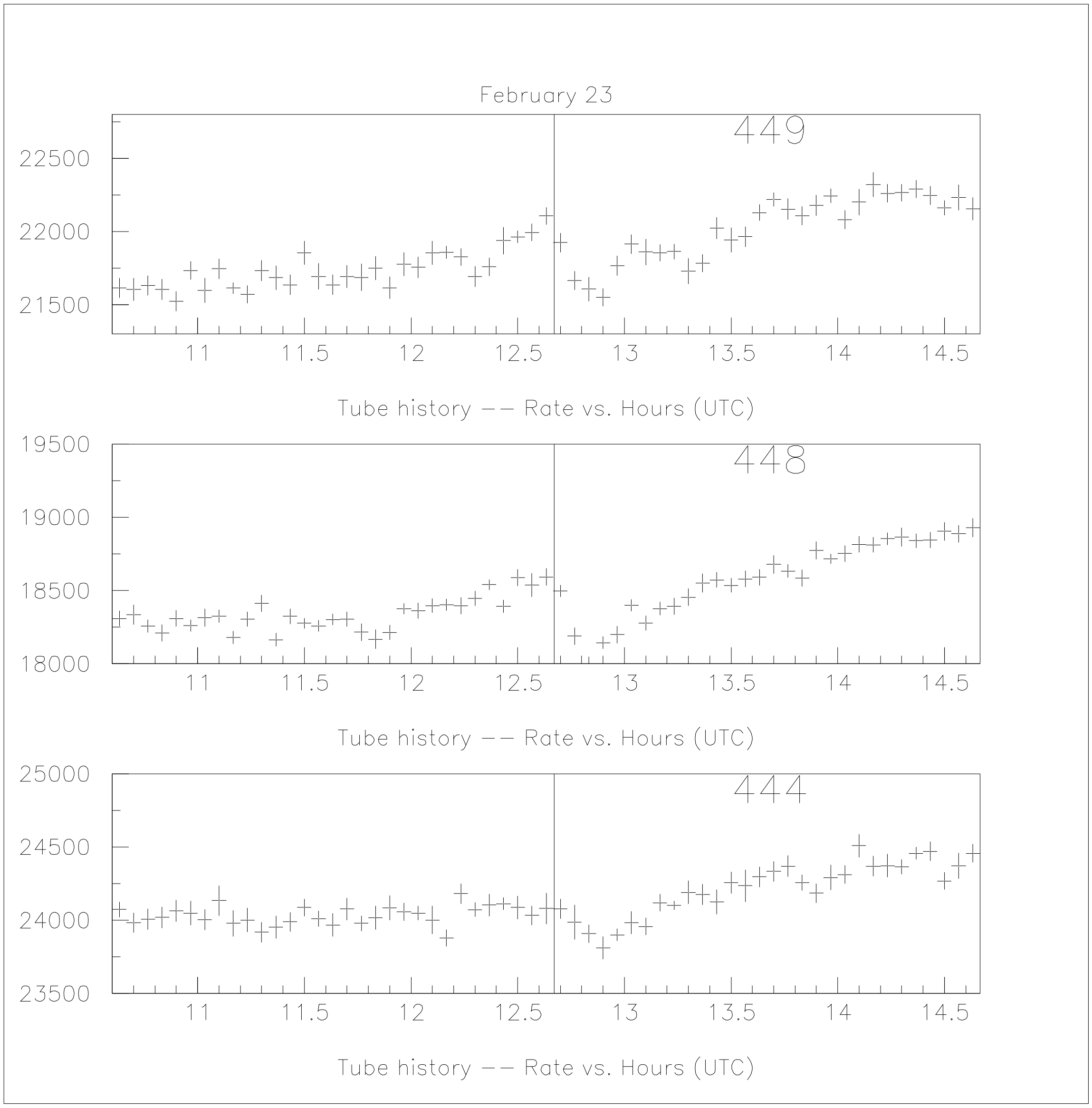

Figure 8: Scaler rates for tube 450's nearest neighbors.

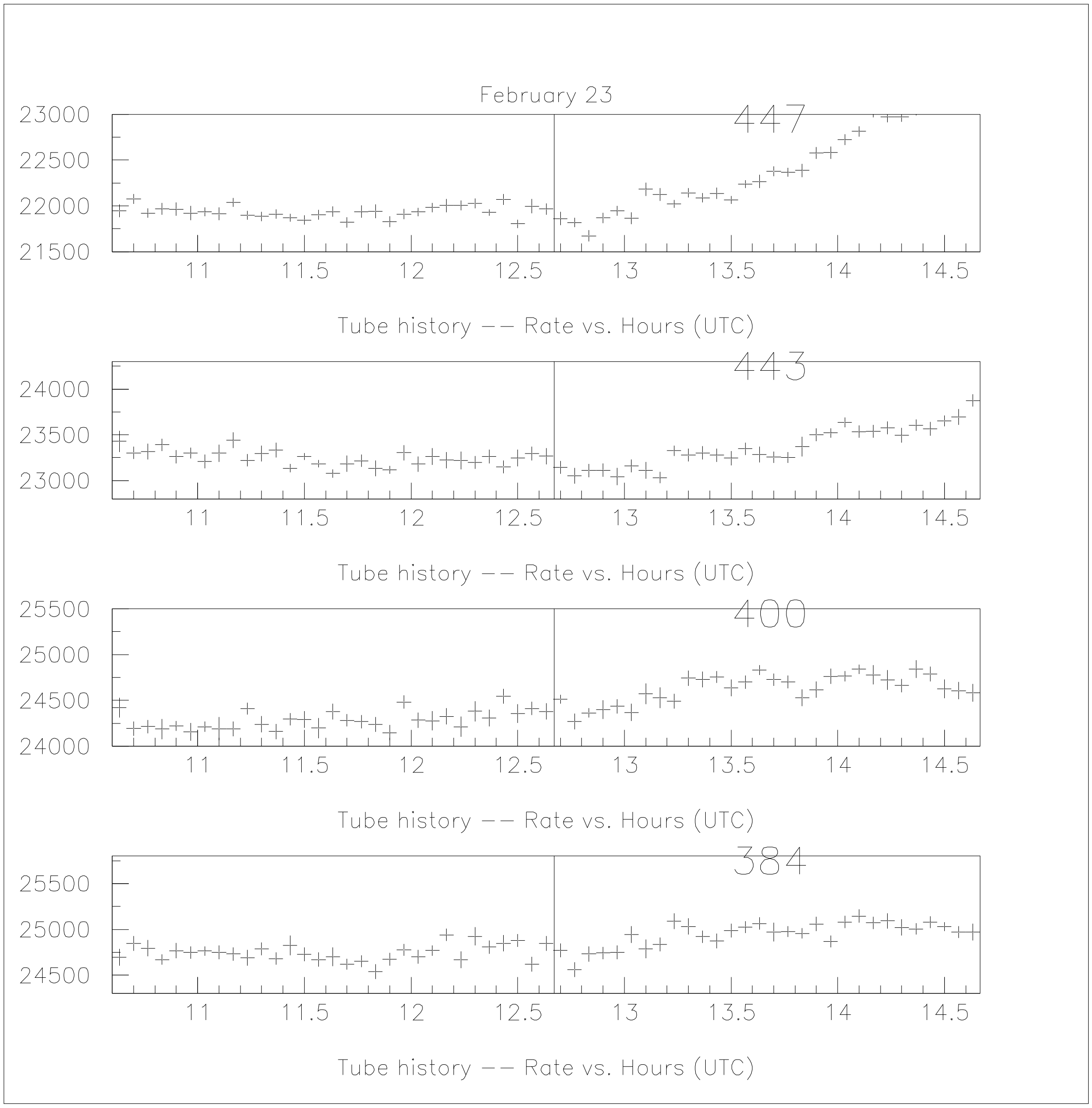

Figure 9: Scaler rates for tube 450's next nearest neighbors.