SLOTMODE timing after the Big Fix

A user's perspective by Marissa Kotze

1 My understanding of the past SLOTMODE timing issues

In 2008 it was reported that SLOTMODE data showed strange behaviour in the relative timing between successive data points of the lightcurves. Since the data points are also often referred to as frames, it is therefore considered equivalent to refer to timing differences between frames.

It was expected that the time values for successive data points, for the vast majority of data points, should differ only by the exposure time + the overhead for readout. Dropped frames etc may cause larger differences on occasion and data being saved every second may introduce an artificial 1 second periodicity (as pointed out to users in the SLOTMODE data reduction manual).

However, far more complex behaviour was apparent when considering the relative timing between successive data points. You may refer to the figures contained in the next section for an example.

Not only was the overhead much larger than expected (46 millisecond instead of just a few), there was also an additional variable error of up to 20 milliseconds introduced by unreliable PC timing as timing pulses were only received once per second. Together these introduced a far more complex pattern in the relative timing between successive data points.

Several users and SALT Astronomers inspected their SLOTMODE data, only to find that the problems affected all SLOTMODE data. After a meeting discussing the issue in detail, the impression was that the nature of the problem was well understood and that a combination of software fixes would address it.

The 46 millisecond overhead in the SLOTMODE data, should be dramatically reduced to ~ 2 millisecond with the software update. The additional error of up to 20 milliseconds should be eliminated by incorporating millisecond timing pulses.

Those software fixes ensued during, what was to become known as the Big Fix, wherein SALTICAM hardware issues were also being addressed. The Big Fix was implemented together with the S.A.C. and RSS fixes and the result of it can now be tested by considering real data.

There were also serious concerns about the accuracy of the absolute timing. Those will need to be addressed by specific laboratory tests and on-sky testing of sources with accurately timed events. It will not be discussed further here, but it remains a major concern, since Luis Belona pointed out in 2008 that the initial time stamp could be off by as much as 1 second.

2 Comparison of results BEFORE and AFTER the Big Fix

I present the timing results of two datasets, one before (11 August 2008) and one after (30 April 2011) the Big Fix. The improvement due to the implementation of the software fixes is immediately apparent when comparing the results. Consequently, a number of comparable visualizations are presented hereafter.

Firstly, by considering the plots of the timing differences between successive frames for the first 600 frames, the most important fix is shown clearly. The timing differences are now much closer to the exposure time. In fact, the majority of frames have timing differences $\sim$ exposure time + overhead (3 milliseconds), as expected. The 46 millisecond overhead that was previously present in the SLOTMODE data, has indeed been reduced to 3 milliseconds.

Secondly, by considering the plots of the timing differences between successive frames for the first 100 frames (zoomed in to show the more detailed behaviour) the other important fix is shown. The additional error, varying up to 20 milliseconds due to unreliable PC timing, has been eliminated.

Thirdly, by considering the histograms with 1 millisecond bin sizes, the spread of timing differences are clear. The vast majority of timing differences now occur at $\sim$ exposure time + 3 milliseconds overhead and are no longer distributed over such a wide variety of values as before.

Very importantly though, note that there are still features that are unexpected! I will discuss these in more detail where the relevant plots are presented.

2.1 Overall view of timing differences in the first 600 frames

The 46 millisecond overhead that was previously present in the SLOTMODE data, has been reduced to 3 milliseconds. The majority of the time differences between successive data points on the lightcurves are now (exposure time + 3 milliseconds). They are shown in red. The exposure time is indicated by a green line. Note that some points are now below the exposure time. I will discuss it in the next section.

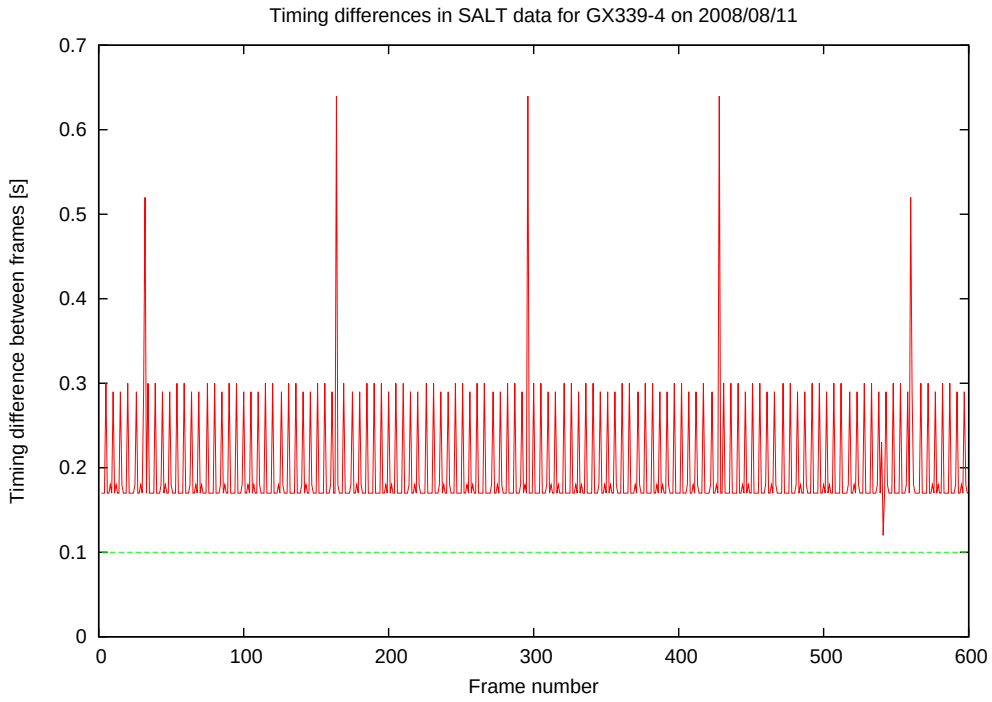

Figure 1: Timing behaviour BEFORE the Big Fix. Exposure time is shown by green dashed line.

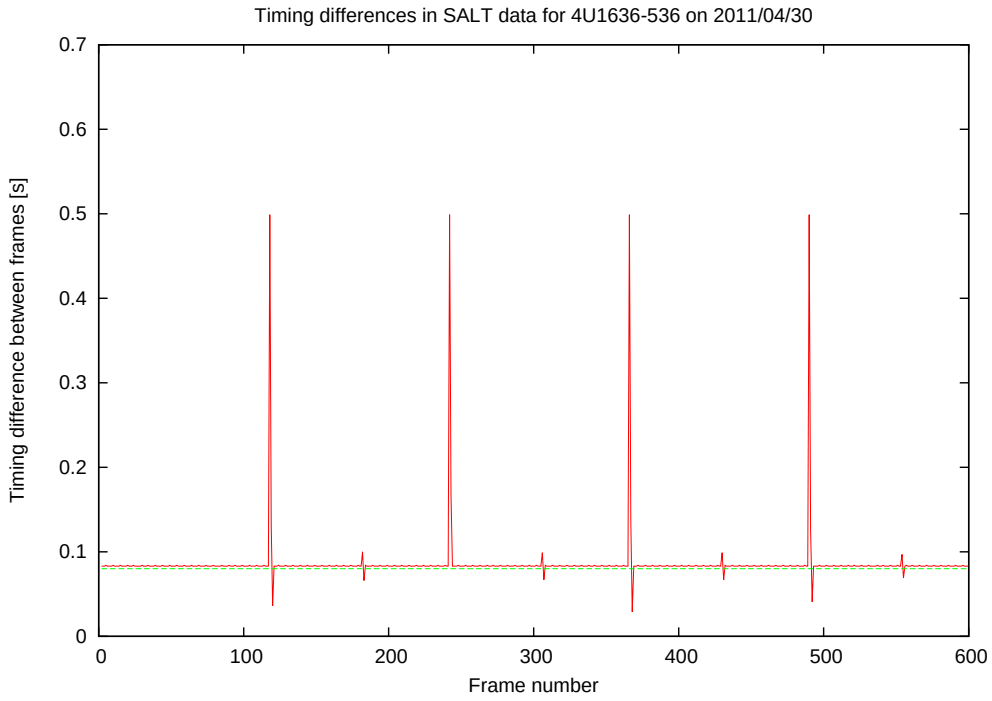

Figure 2: Timing behaviour AFTER the Big Fix. Exposure time is shown by green dashed line.

2.2 Zoomed-in view of smaller timing differences in the first 100 frames

The additional error, varying up to 20 milliseconds due to unreliable PC timing, has been eliminated. Most of the time differences between successive data points on the lightcurves are now (exposure time + 3 milliseconds). Note however that there are also number of points at (exposure time + 4 milliseconds).

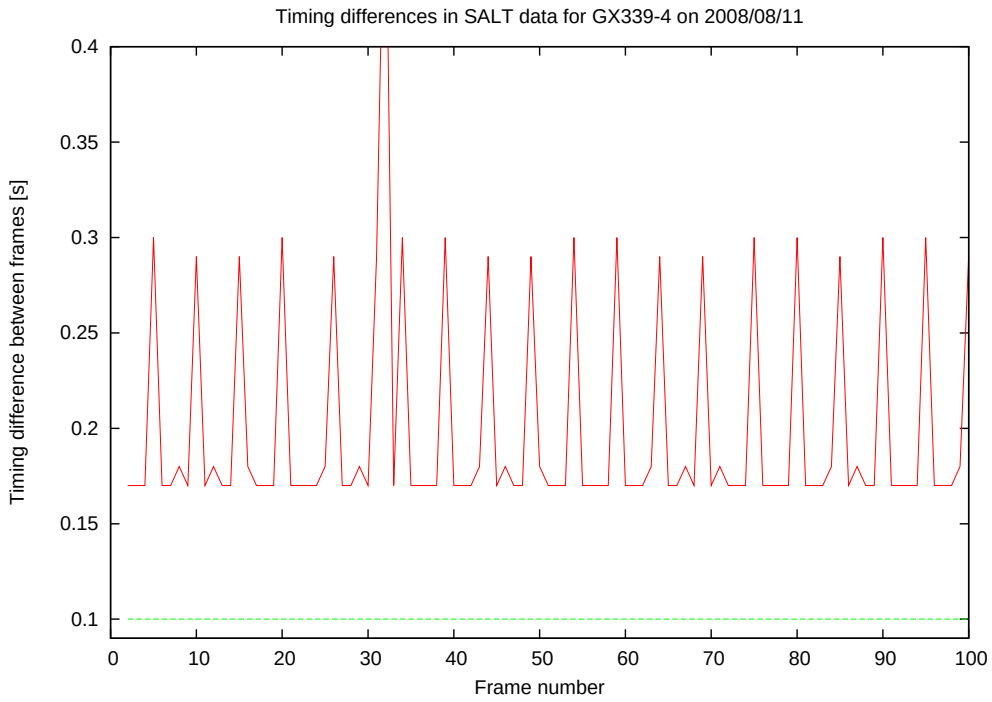

Figure 3: Timing behaviour BEFORE the Big Fix. Exposure time is shown by green dashed line.

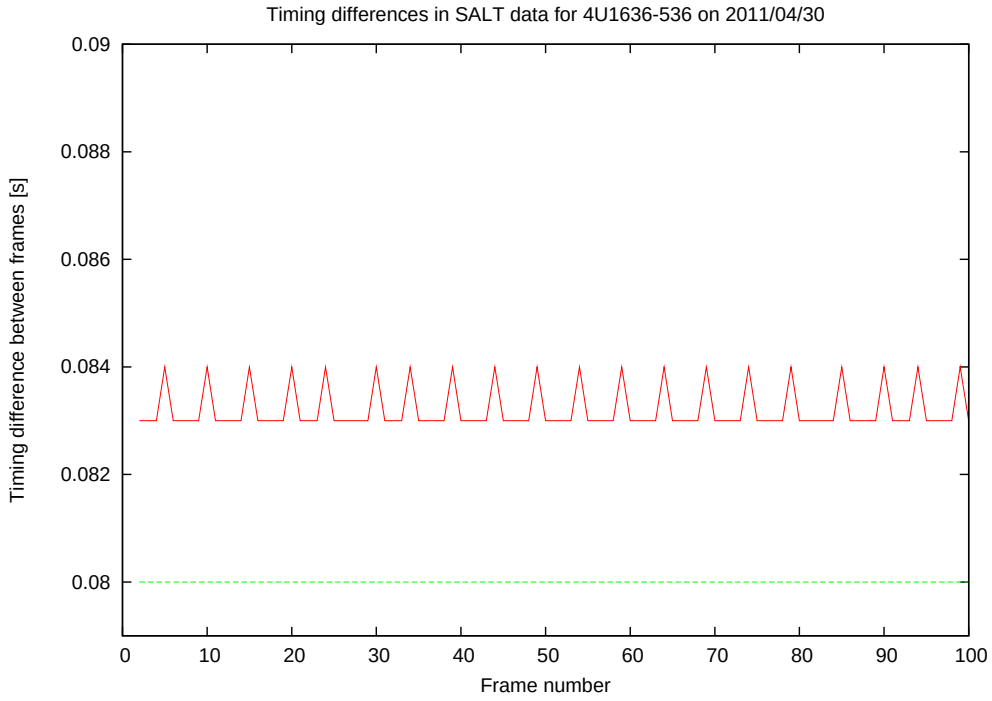

Figure 4: Timing behaviour AFTER the Big Fix. Exposure time is shown by green dashed line.

2.3 Histograms of the spread of timing differences

The vast majority of timing differences between successive data points on the lightcurves now occur at (exposure time + 3 milliseconds overhead). Note however that there are also number of points at (exposure time + 4 milliseconds). There are also some points below the exposure time.

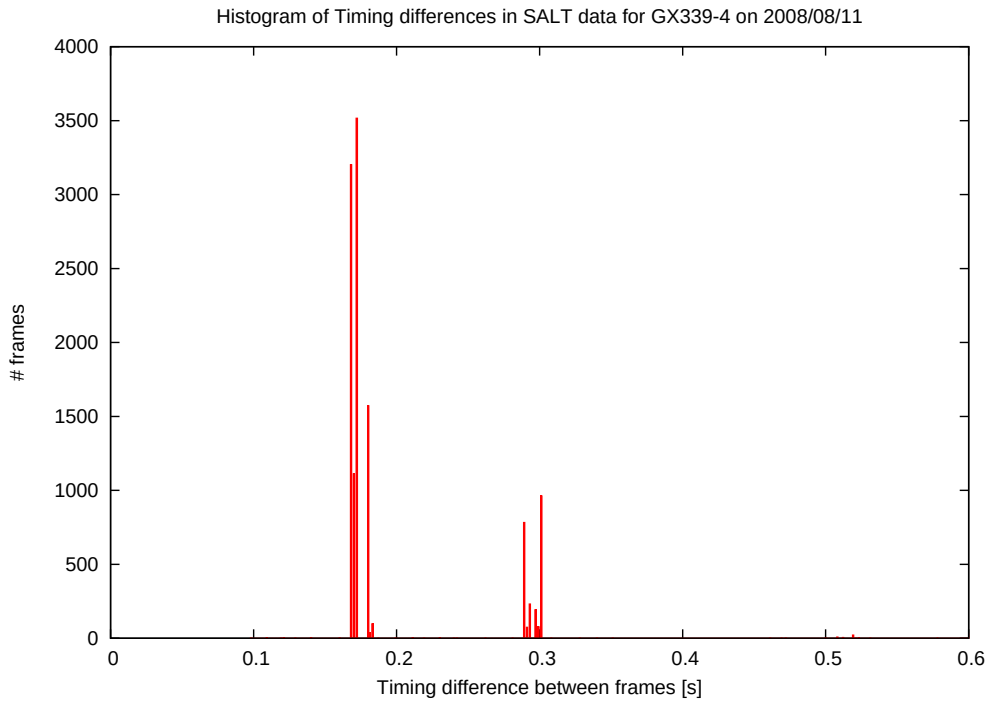

Figure 5: Timing behaviour BEFORE the Big Fix. Exposure time was 0.1 seconds.

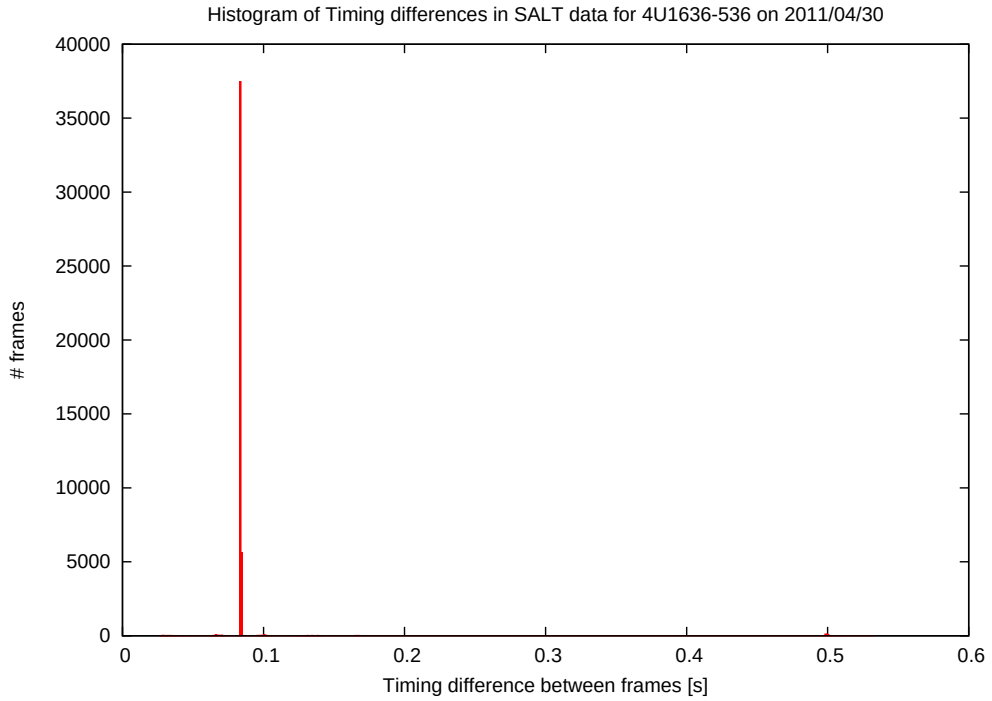

Figure 6: Timing behaviour AFTER the Big Fix. Exposure time was 0.08 seconds.

3 Discussion

The new data show a remarkable improvement to the state of affairs prior to the Big Fix. The overhead appears to have been reduced to 3 milliseconds. I mention the remaining deviations from the expected timing difference (exposure time + 3 milliseconds overhead) below.

3.1 Additional 1 millisecond

The vast majority of timing differences between successive data points on the lightcurves now occur at (exposure time + 3 milliseconds overhead), with a large number also occurring at (exposure time + 4 milliseconds overhead). Given millisecond accuracy, it is expected that the actual timing differences may vary to within a millisecond from the expected exposure time + overhead.

3.2 Values < exposure time

Hundreds of frames have a time difference between frames that are BELOW the exposure time (0.08 seconds)!

I note that they always seem to follow directly after a frame for which the time difference was higher than (exposure time + 3 milliseconds) + 1 milliseconds. See the spike below the green line that always seem to follow a spike above the green line in the figure below. This is true for the larger spikes also. This might just require a code fix in the data reduction software or at least an explanation.

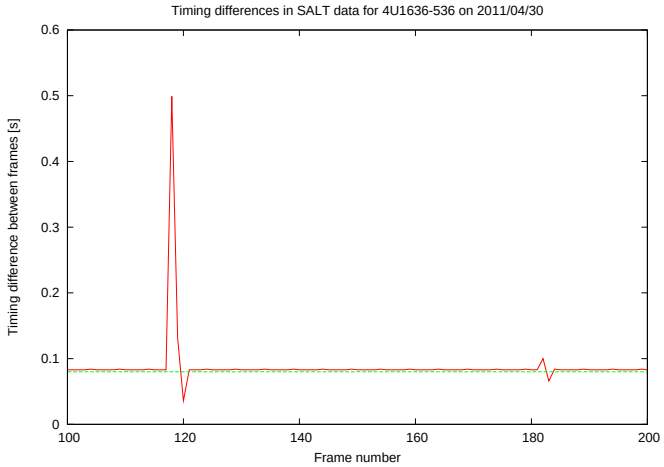

Figure 7: Timing behaviour AFTER the Big Fix. Exposure time was 0.08 seconds.