

**LASER INTERFEROMETER GRAVITATIONAL WAVE
OBSERVATORY**

- LIGO -

**CALIFORNIA INSTITUTE OF TECHNOLOGY
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Technical Note	LIGO-T030070-00-D	03/10/2003
Summary of LSC timing performance during the first Scientific Run (S1)		
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Introduction

During the first science run (S1), we measured the offset¹ of the DAQ time stamp relatively to the GPS second tic at the three observatories. In this document we provide the time evolution of these offsets for the three LSC systems.

Among the three, the H1 timing was the most stable. L1 follows it closely, showing only one small jump ($\sim 1\mu\text{s}$) in the middle of the run. Unfortunately the H2 timing was very irregular. There were large number of jumps and cases of huge delays ($\sim 5\text{ms}$!).

There are small gaps in the timing data due to two major reasons. The first is related to the signal used to measure the timing offset. We had to rely on a temporary channel (generally referred to as a “test point”) to measure and track the timing offset. Unfortunately it was not easy for everyone to keep the testpoints alive and we had periods when the testpoints were missing. We lack timing data for these times. The DMT machines also had to be rebooted from time to time leading to short missing segments.

The following pages speak for themselves.

For each interferometer, we report²

- the minute trend for the entire S1 duration
- the distribution (histogram) of the timing measurements for each significant time segment
- a Gaussian fit and its parameters for the core of each histogram
- a table summarizing the nominally valid offsets (from the fit) for each distinct time interval

Summary of results^{3 4}:

- **LIGO Livingston 4K LSC timing for the S1 run:**
 - Nominal offset : $-120.5 \pm 1 \mu\text{s}$
- **LIGO Hanford 4K LSC timing for the S1 run:**
 - Nominal offset : $-95 \pm 1 \mu\text{s}$
- **LIGO Hanford 2K LSC timing for the S1 run:**
 - Nominal offset : Impossible to determine. Please evaluate individual segments

¹ The quoted values are the measurements of the offset of the DAQ time stamp relatively to the GPS second tic. The timestamp of the data refers to the ADC input without any input filters.

² In particular, we do not measure the arrival time of a GW wave, the DAC output or the time of the calibration excitations on the test masses. The first has to take into account the delay in the electronics at the AS port as well as the analog filtering, the second has to take into account the delay in the digital system sending data to the end station DSCs, and the third has to add the analog output filtering as well as the characteristics of the current drive and the pendulum transfer function.

³ The + *sign* in front of the offset means that the DAQ time stamp second mark is *after* the GPS second tic.

⁴ Please note that the quoted errors are statistical in nature and the systematic errors are not included.

LIGO Livingston 4K interferometer LSC timing

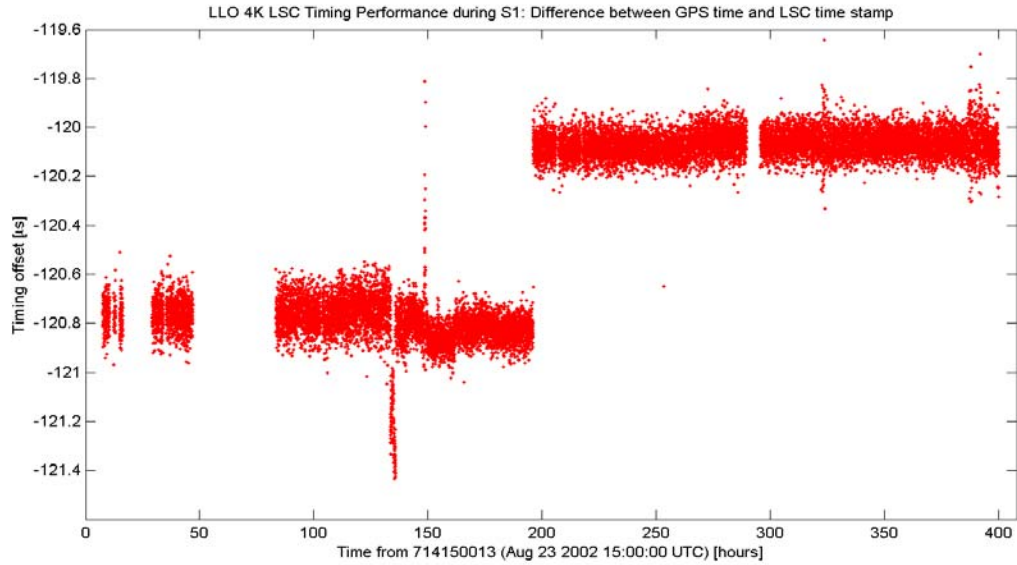


Figure 1 L4K LSC time offset during S1

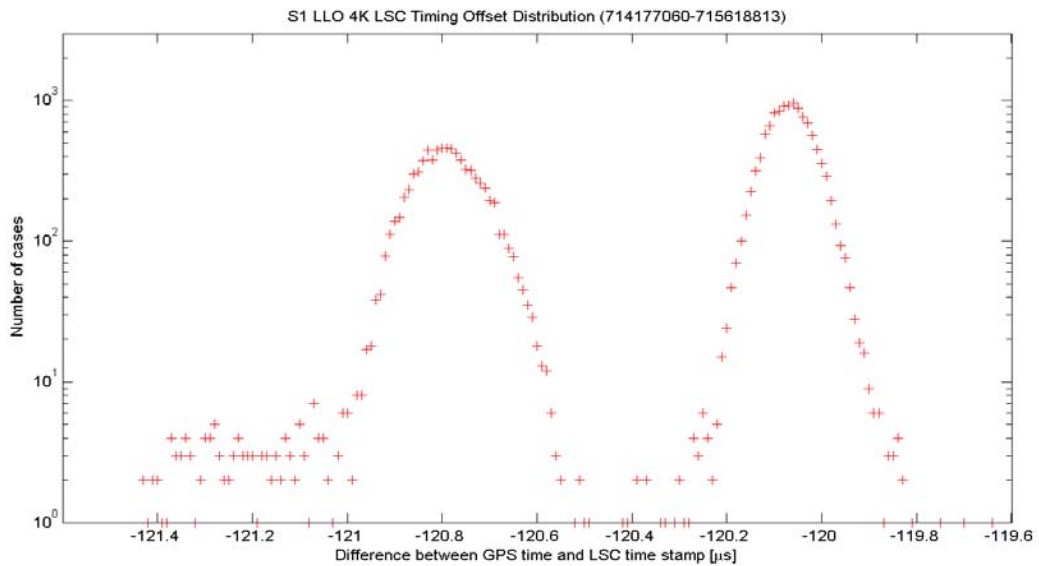


Figure 2 LIGO Livingston 4K interferometer LSC timing histogram

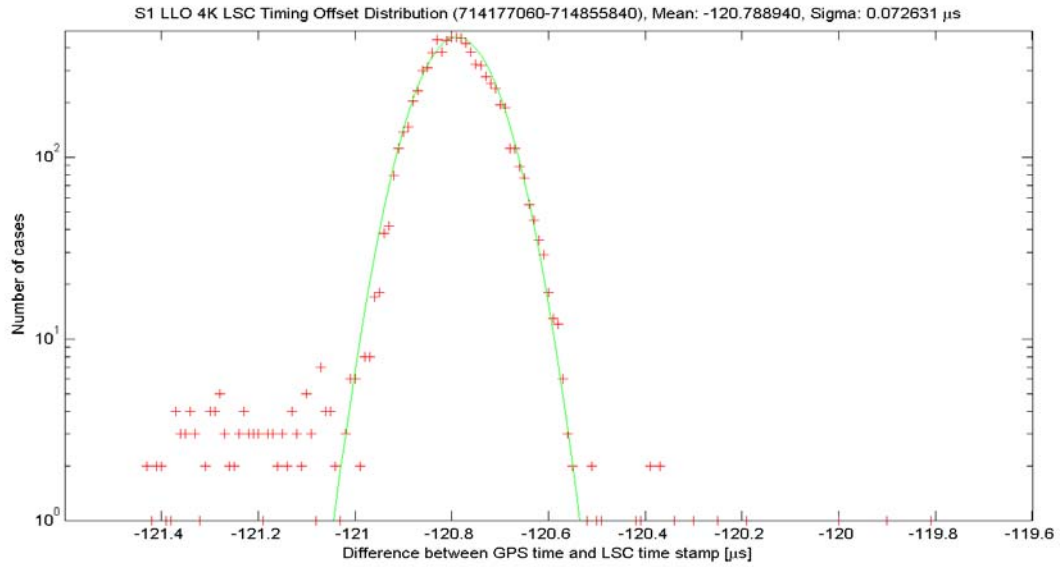


Figure 3 LIGO Livingston 4K interferometer LSC timing between 714177080 and 714855840

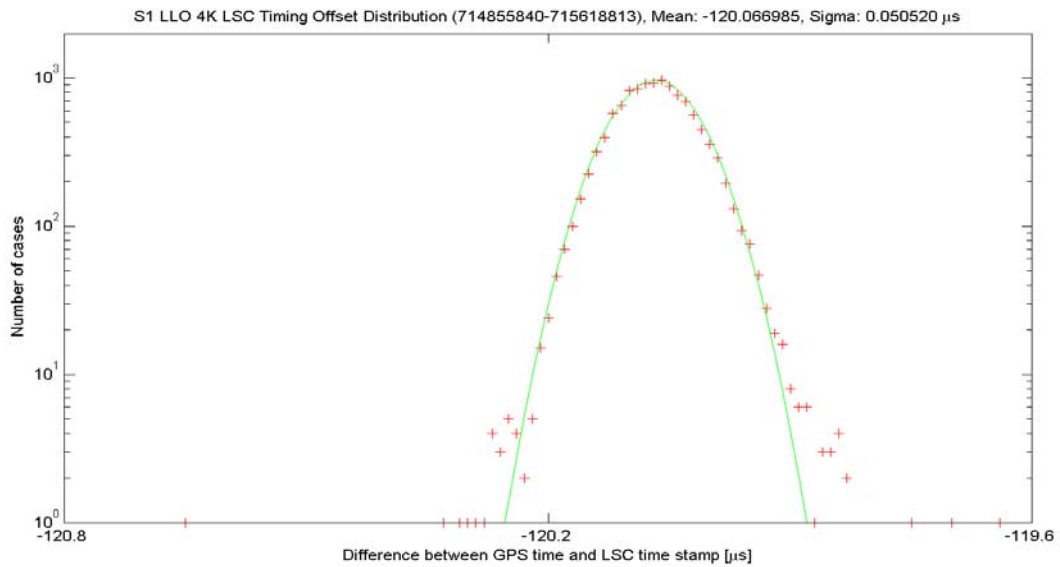


Figure 4 LIGO Livingston 4K interferometer LSC timing between 714855841 and 715618813

Nominally, the LLO 4K LSC timing offset was:

-121 μ s between 714177080 and 714855840

-120 μ s between 714855841 and 715618813

These values should be accurate for $\pm 1 \mu$ s.

LIGO Hanford 4K interferometer LSC timing

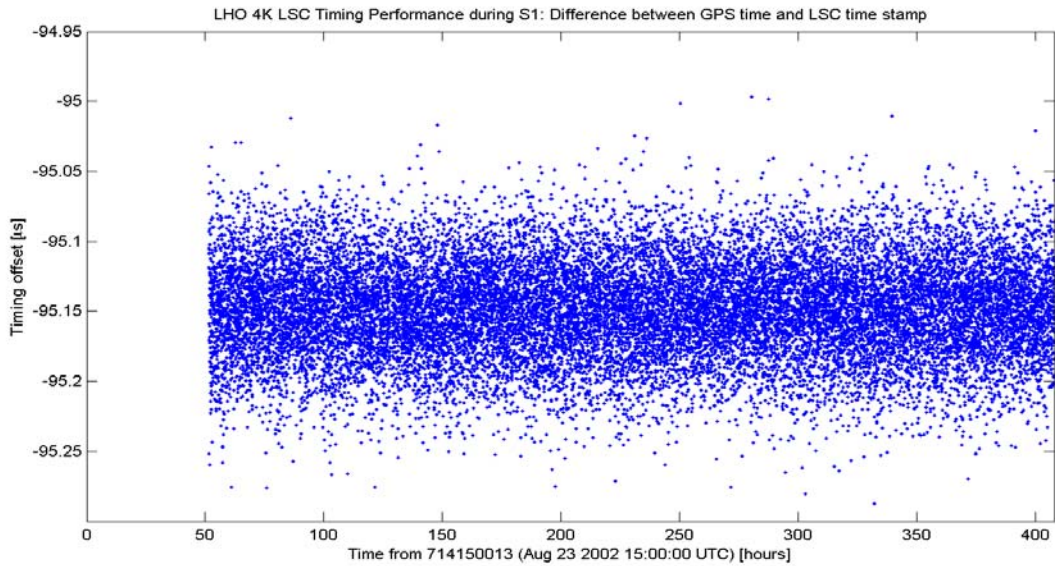


Figure 5 LIGO Hanford 4K interferometer LSC timing

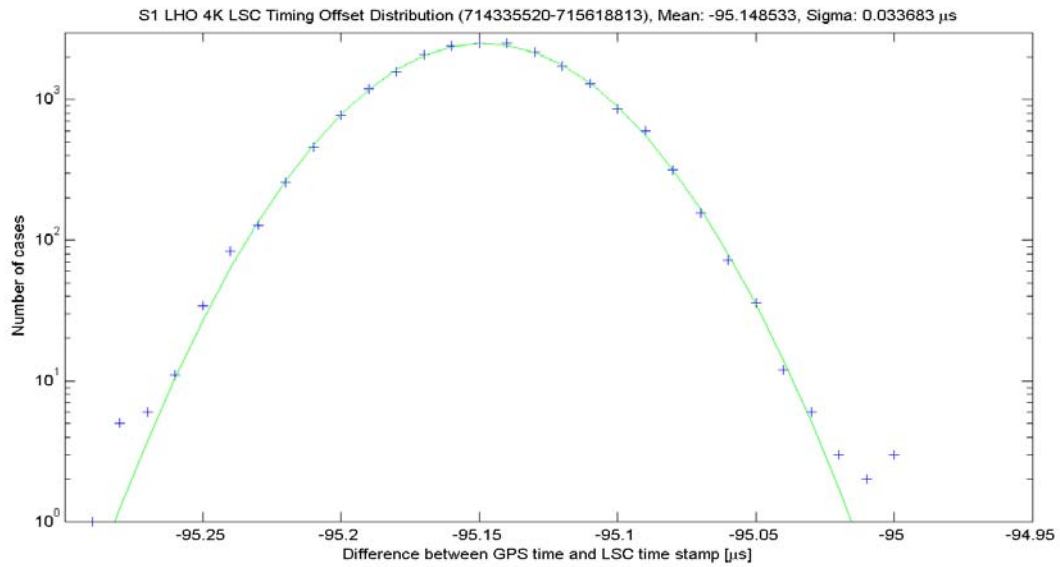


Figure 6 LIGO Hanford 4K interferometer LSC timing histogram

Nominally, the LHO 4K LSC timing offset was :

-95 μs between 714335520 and 715618813

This value should be more accurate than $\pm 1 \mu\text{s}$.

LIGO Hanford 2K interferometer LSC timing

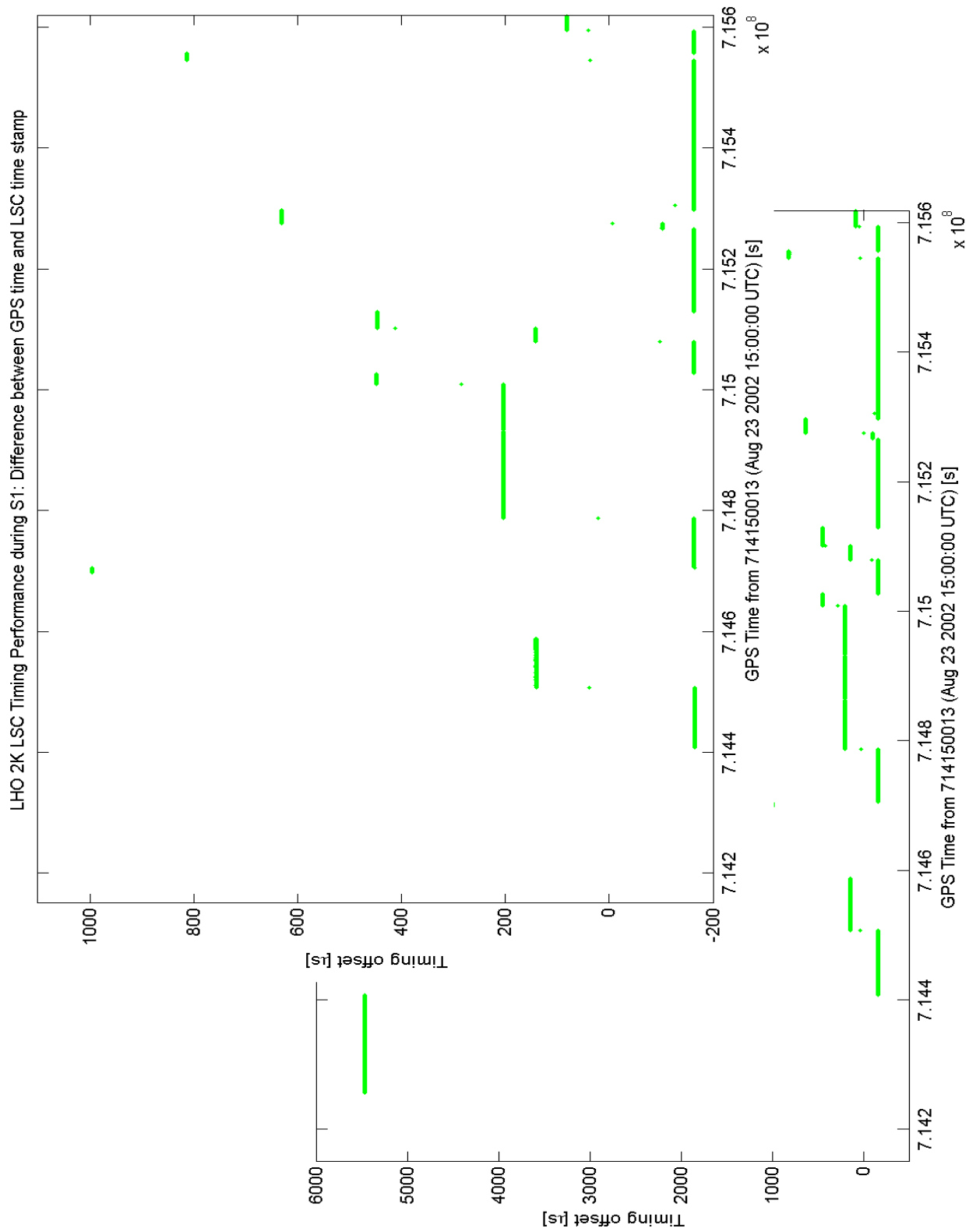
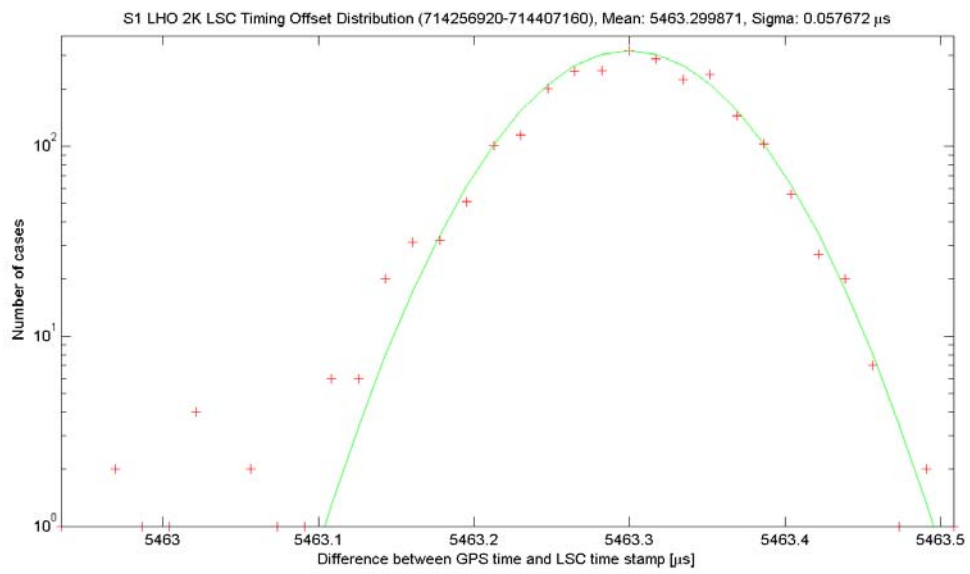
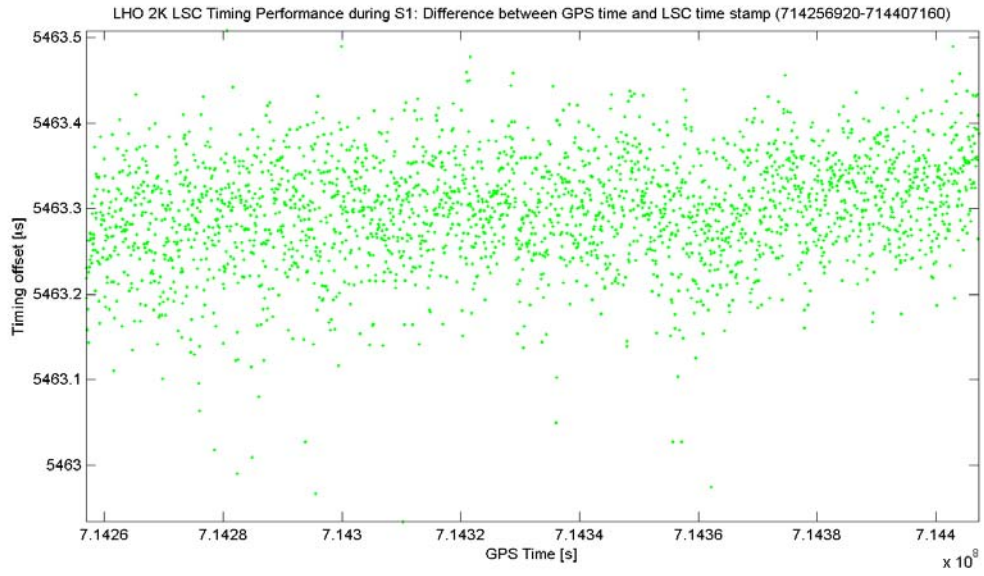
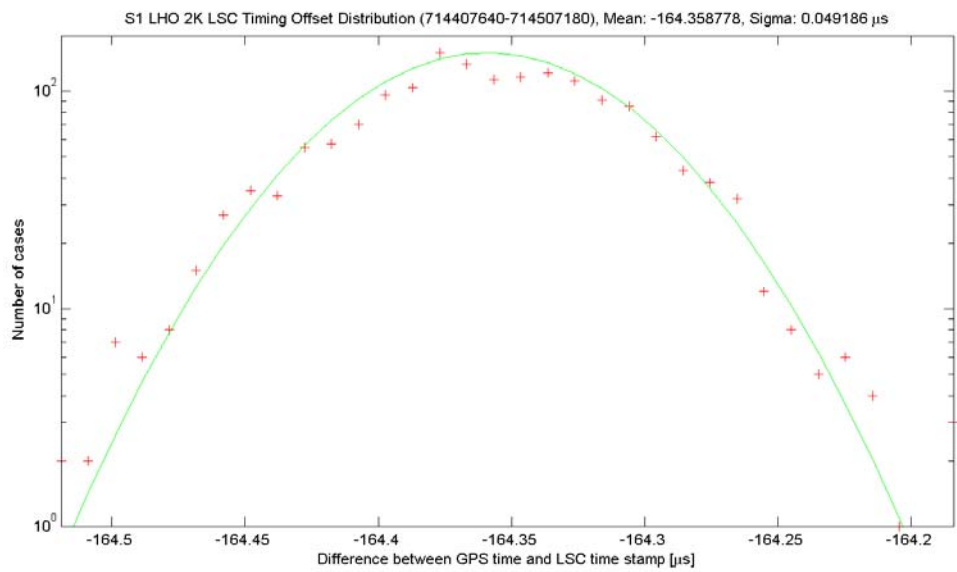
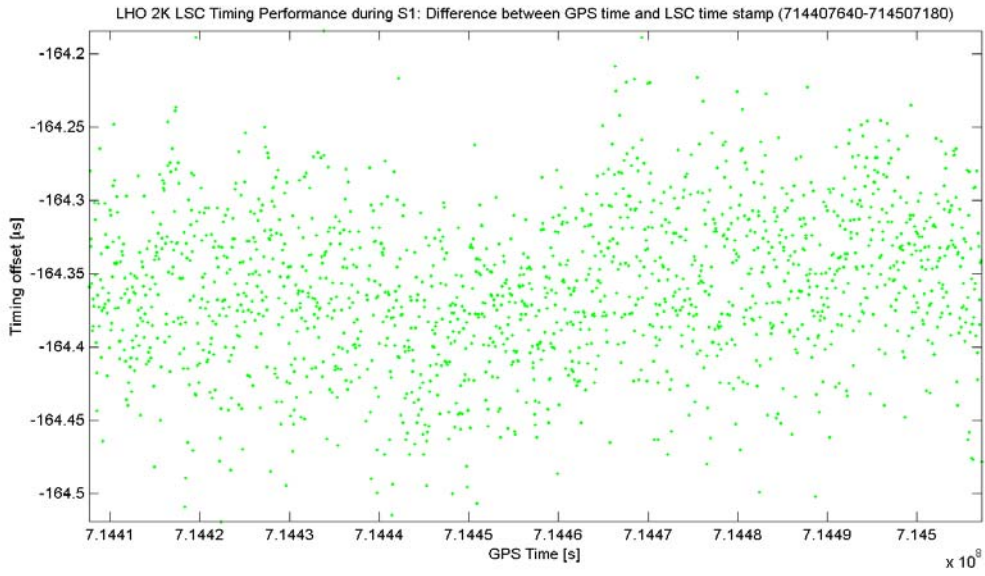


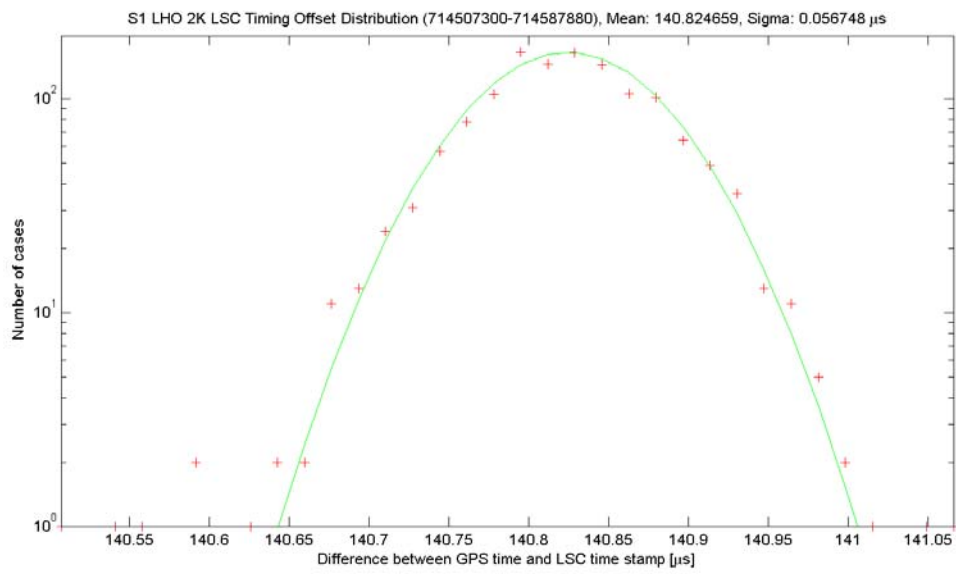
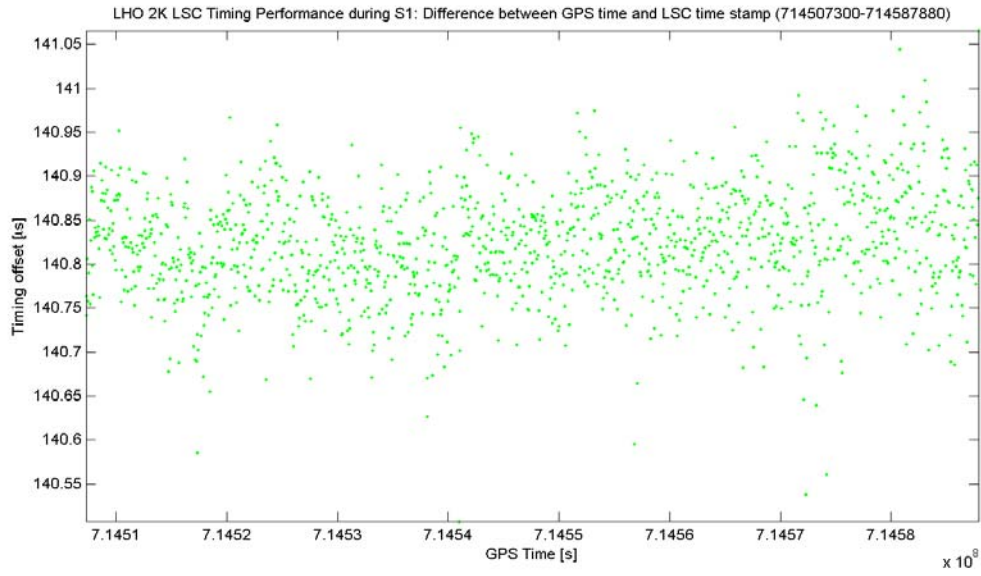
Figure 7 LIGO Hanford 2K interferometer LSC timing

Table 1 Major H2 timing segments, their duration and the measured offset for each

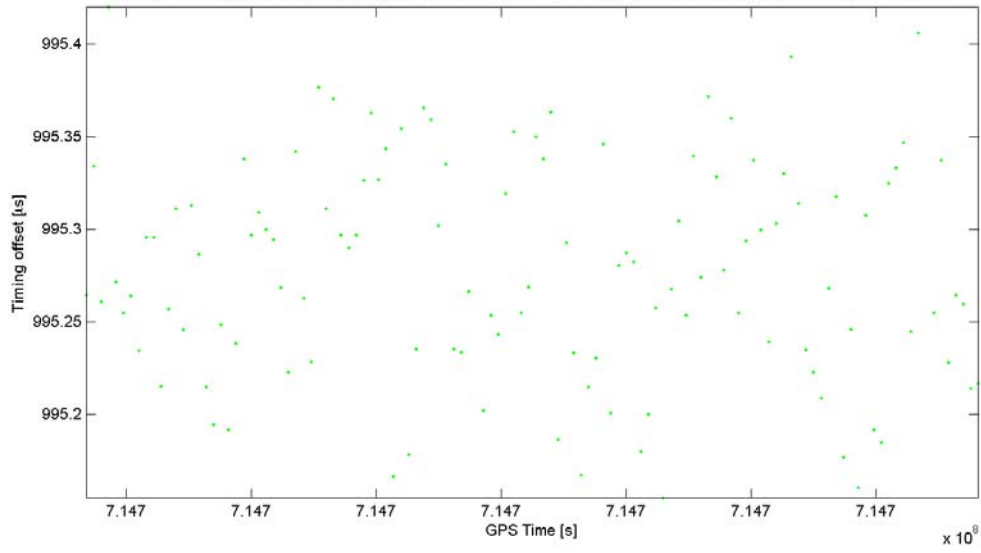
Start time	Stop Time	Offset	Duration
GPS [s]	GPS [s]	[μ s]	[s]
714256920	714407160	5463	150240
714407640	714507180	-164	99540
714507300	714587880	141	80580
714697680	714704820	995	7140
714705000	714786780	-162	81780
714786900	715008660	204	221760
715008780	715026480	448	17700
715026780	715079460	-163	52680
715079580	715101120	142	21540
715101240	715129260	447	28020
715129500	715165740	-162	36240
715166640	715265820	-163	99180
715266180	715274580	-102	8400
715274700	715296960	630	22260
715297440	715298280	-163	840
715299420	715305660	-163	6240
715306920	715545120	-163	238200
715545240	715556400	814	11160
715556640	715594020	-163	37380
715594140	715618800	81	24660



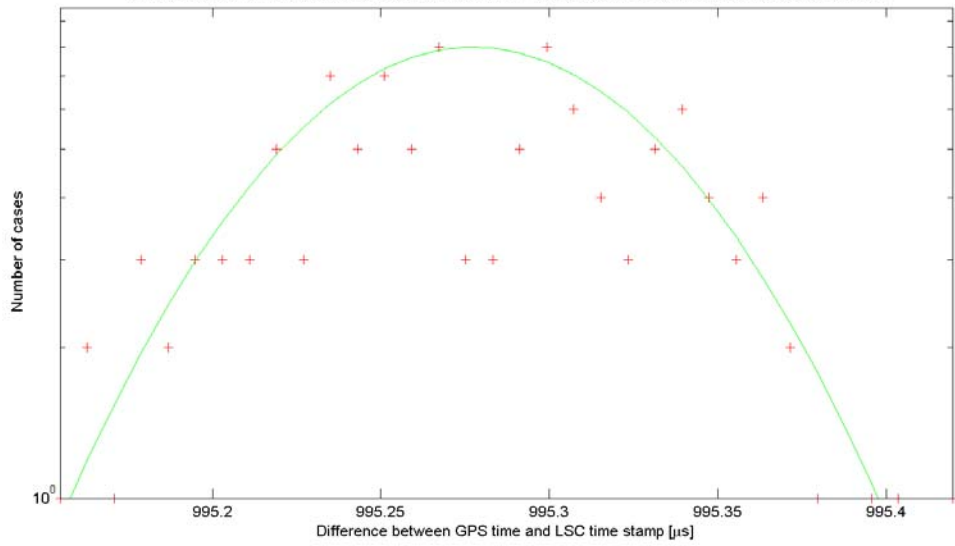




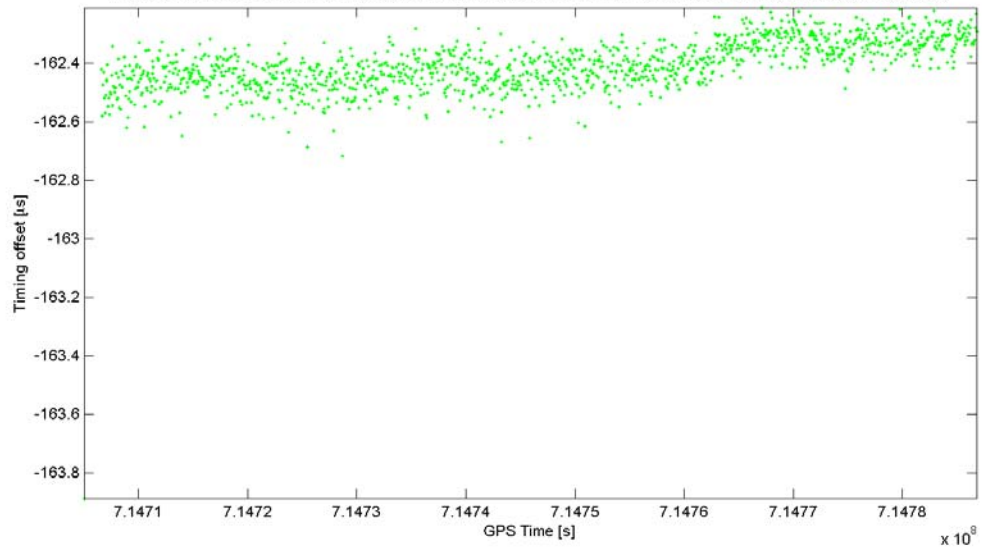
LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (714697680-714704820)



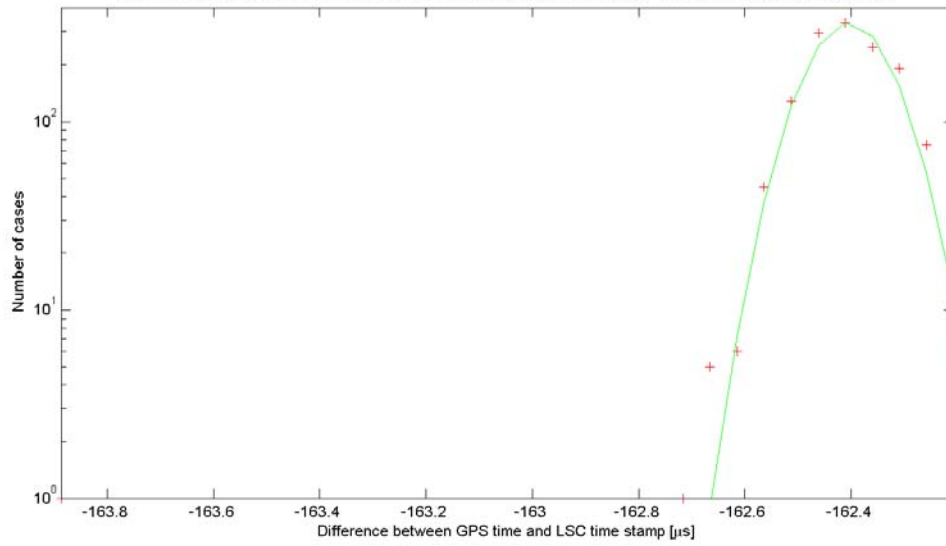
S1 LHO 2K LSC Timing Offset Distribution (714697680-714704820), Mean: 995.277630, Sigma: 0.058852 μ s

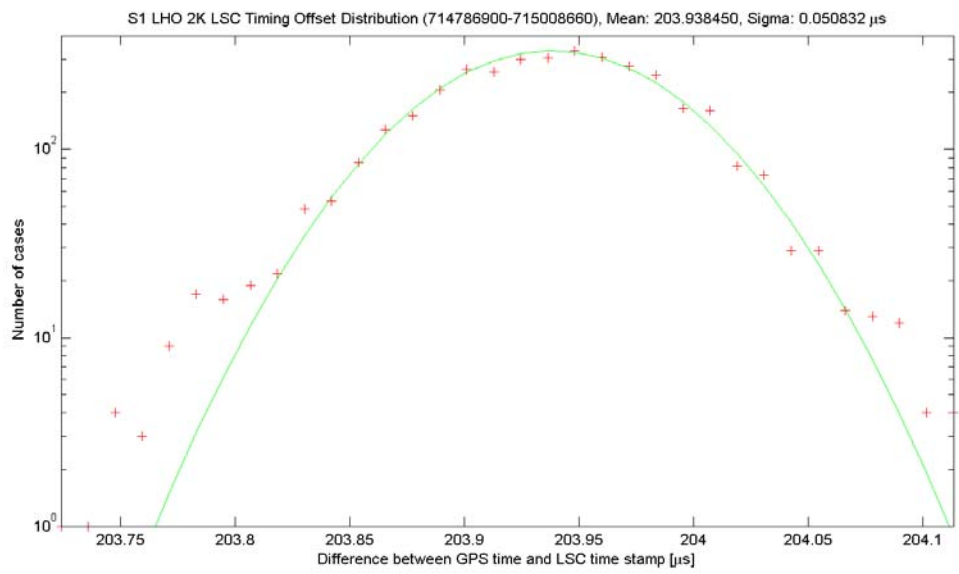
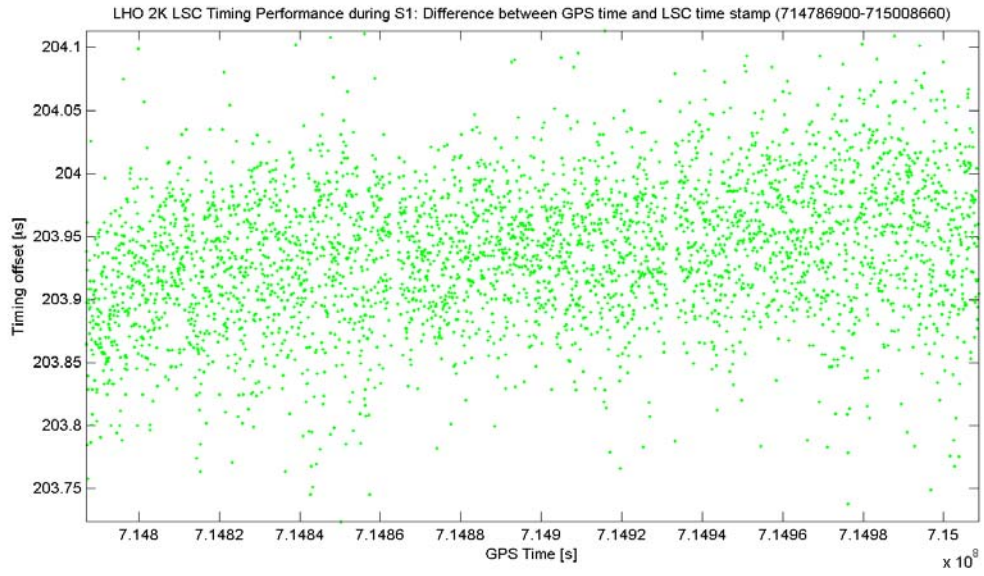


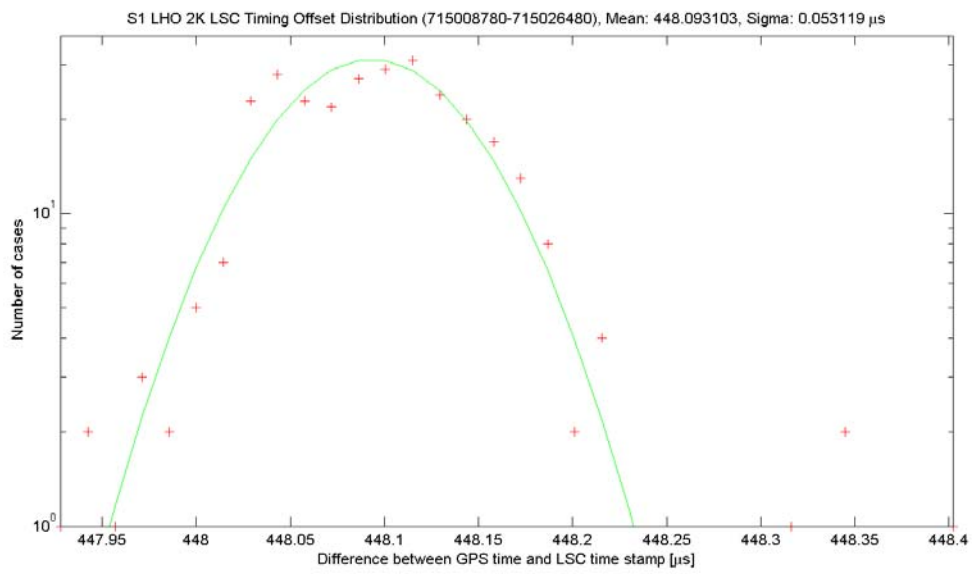
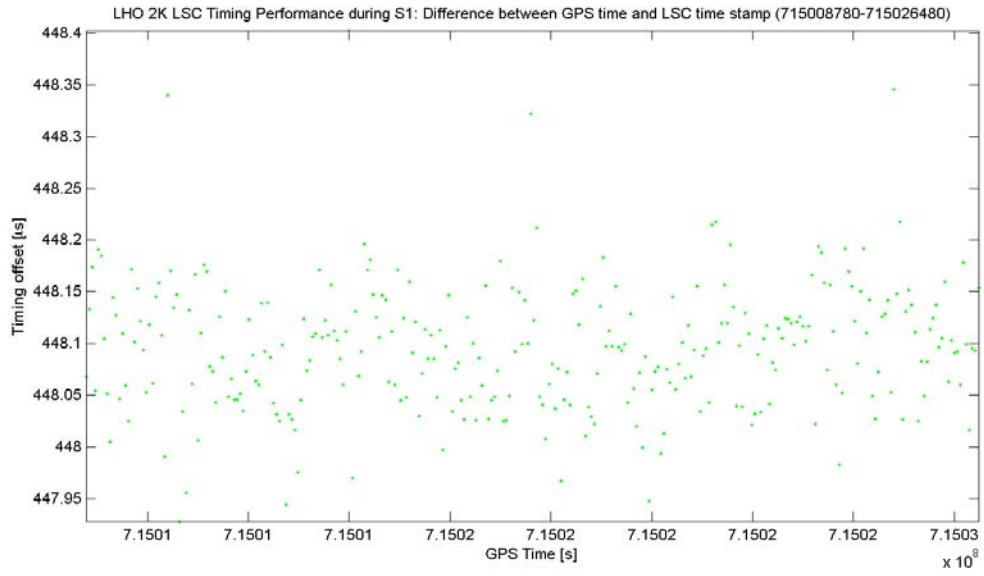
LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (714705000-714786780)



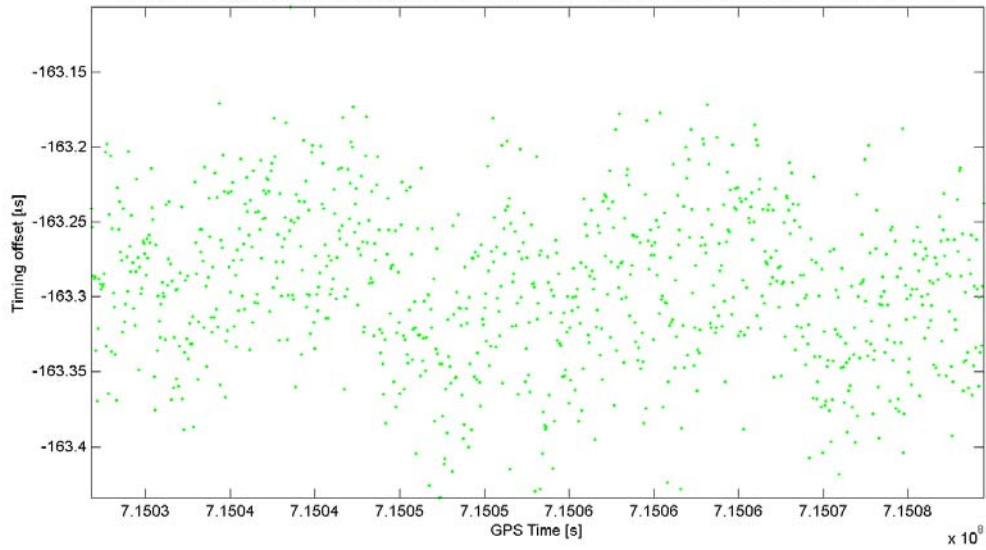
S1 LHO 2K LSC Timing Offset Distribution (714705000-714786780), Mean: -162.404275, Sigma: 0.075999 μ s



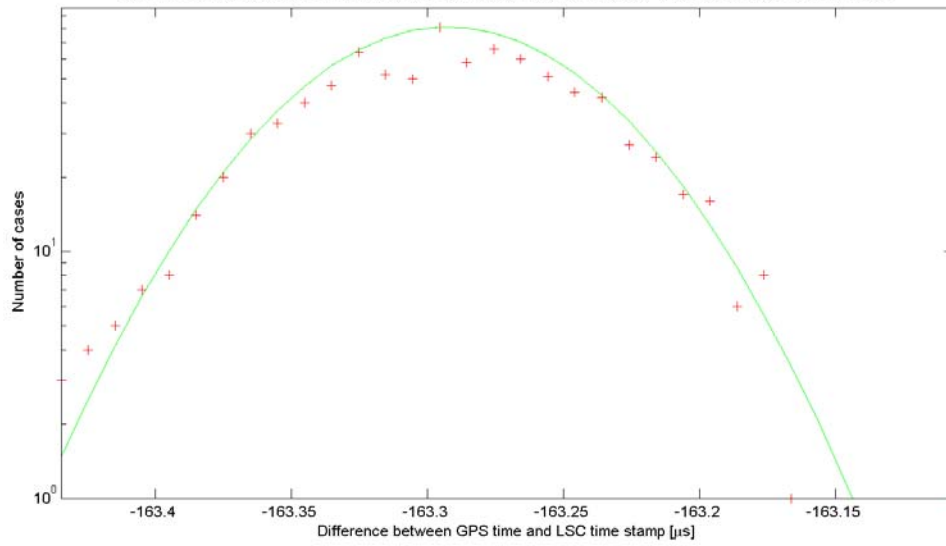


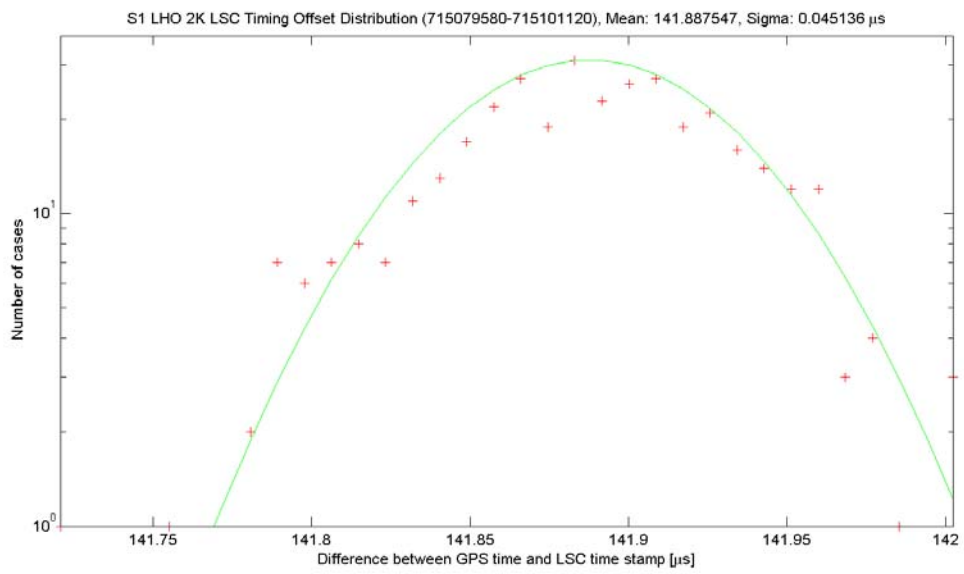
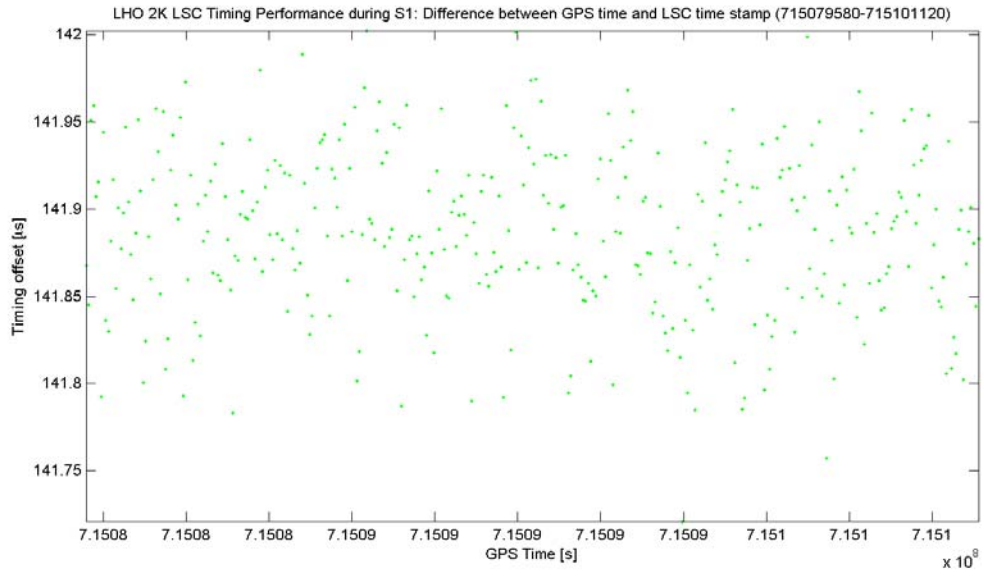


LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (715026780-715079460)

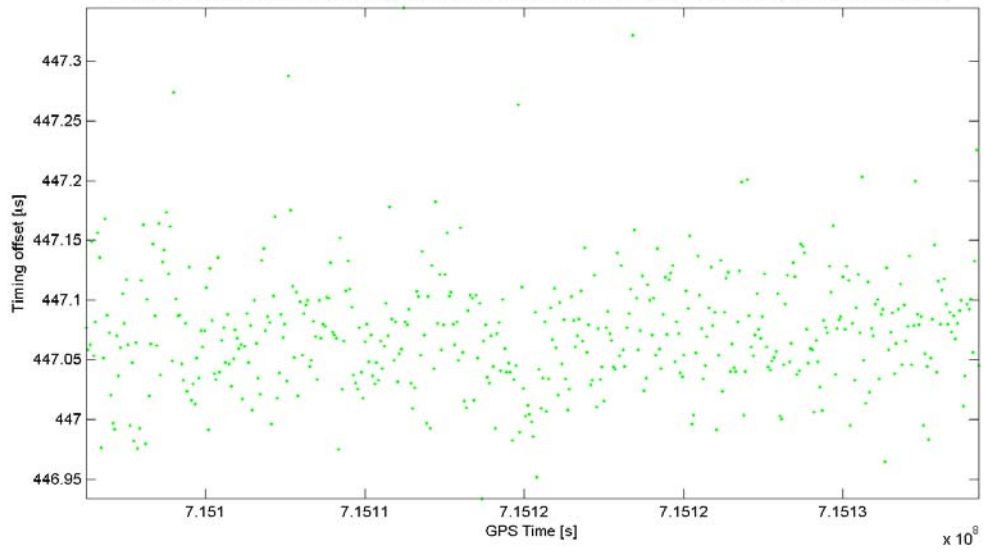


S1 LHO 2K LSC Timing Offset Distribution (715026780-715079460), Mean: -163.292500, Sigma: 0.050133 μ s

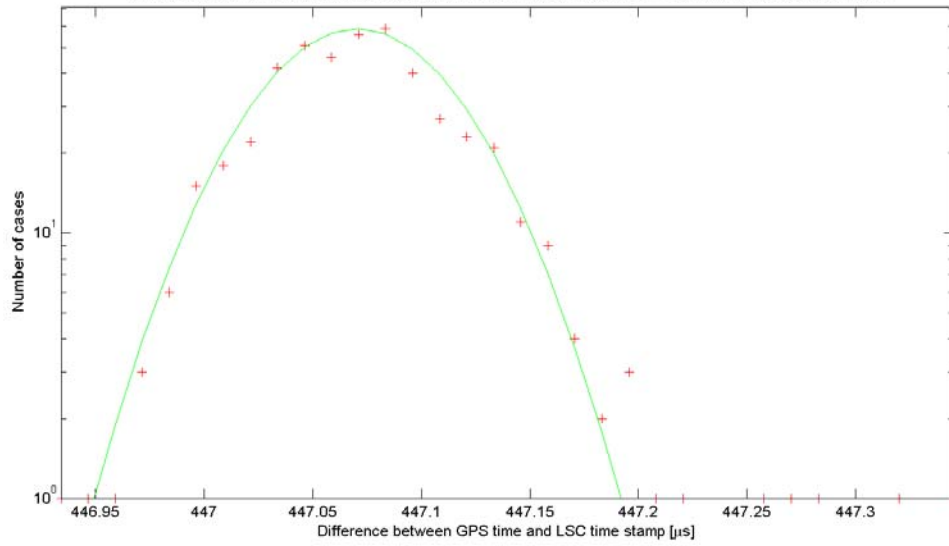




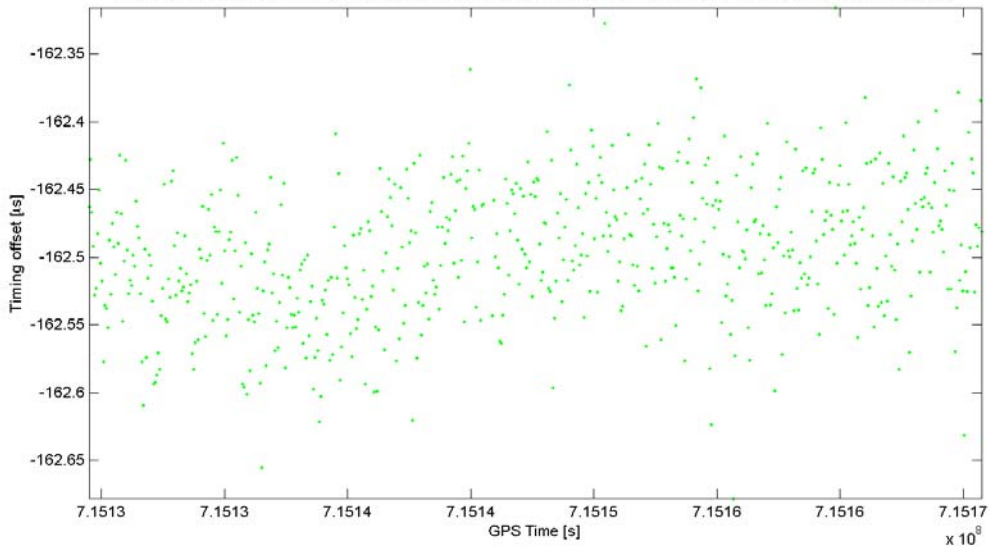
LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (715101240-715129260)



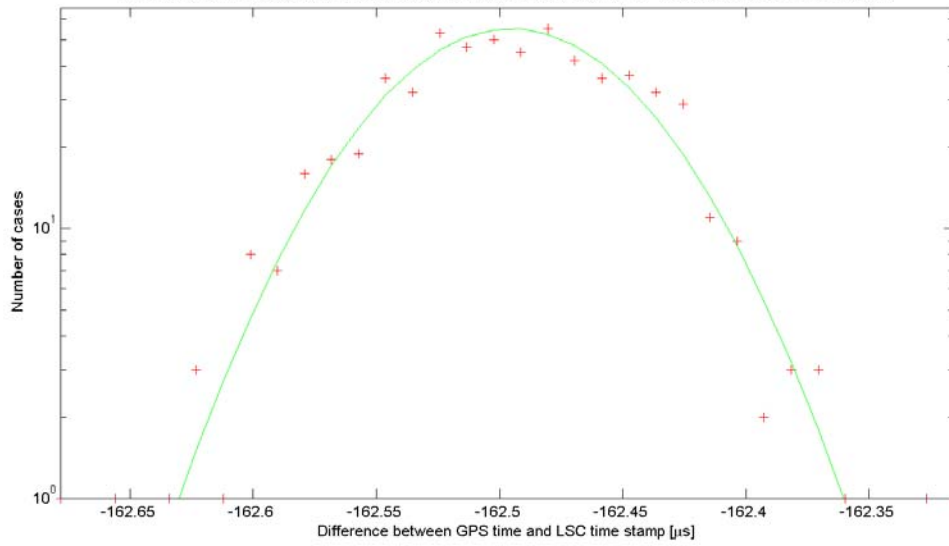
S1 LHO 2K LSC Timing Offset Distribution (715101240-715129260), Mean: 447.070509, Sigma: 0.042553 μ s

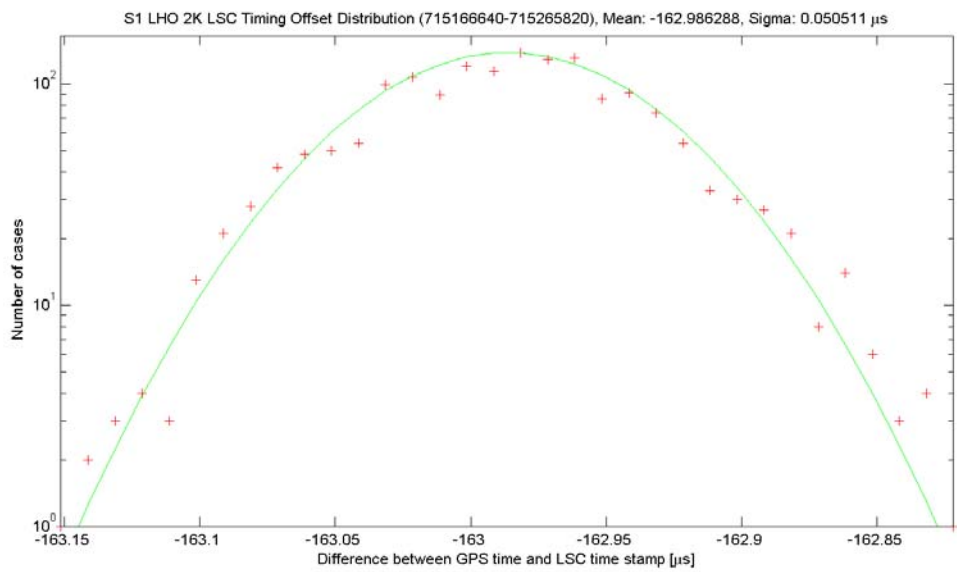
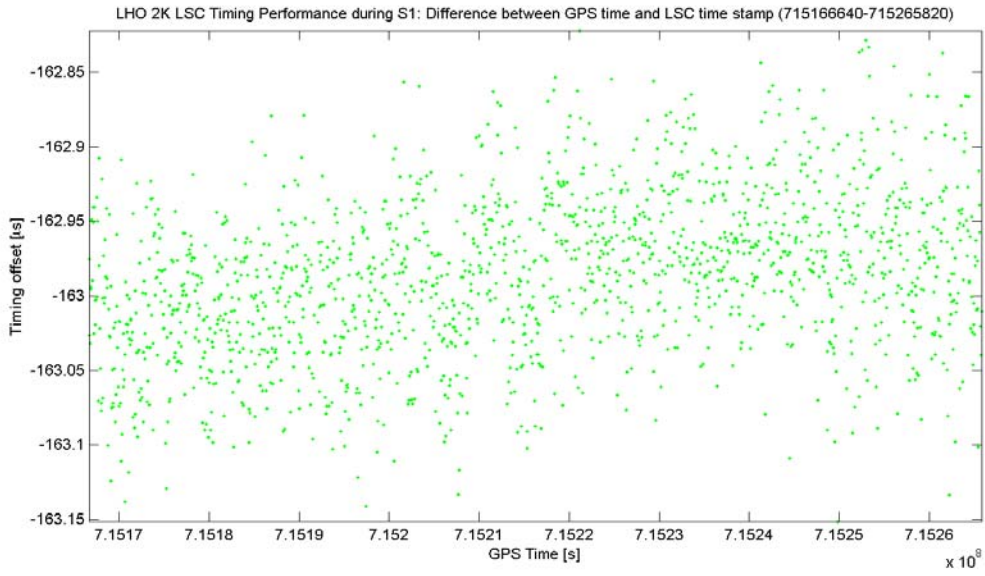


LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (715129500-715165740)

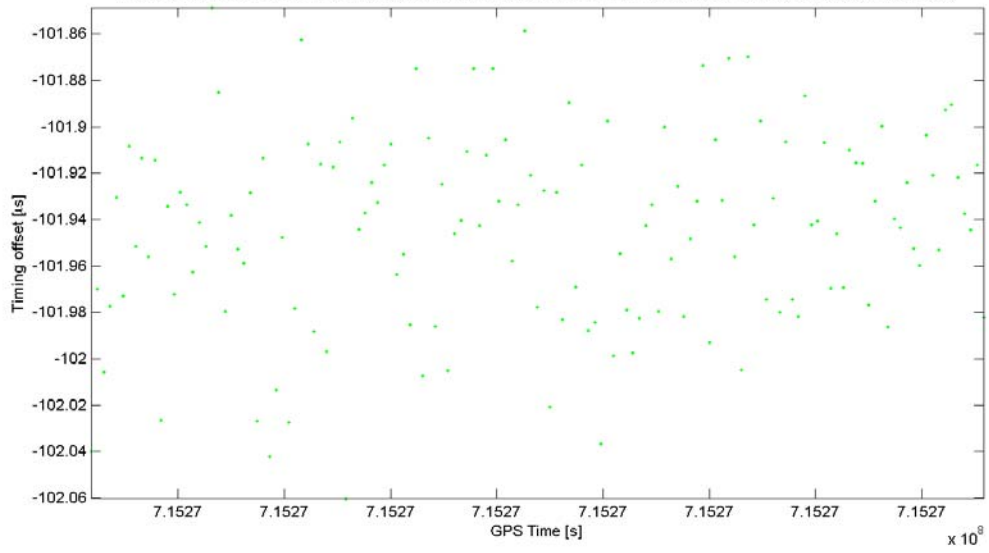


S1 LHO 2K LSC Timing Offset Distribution (715129500-715165740), Mean: -162.495281, Sigma: 0.047645 μ s

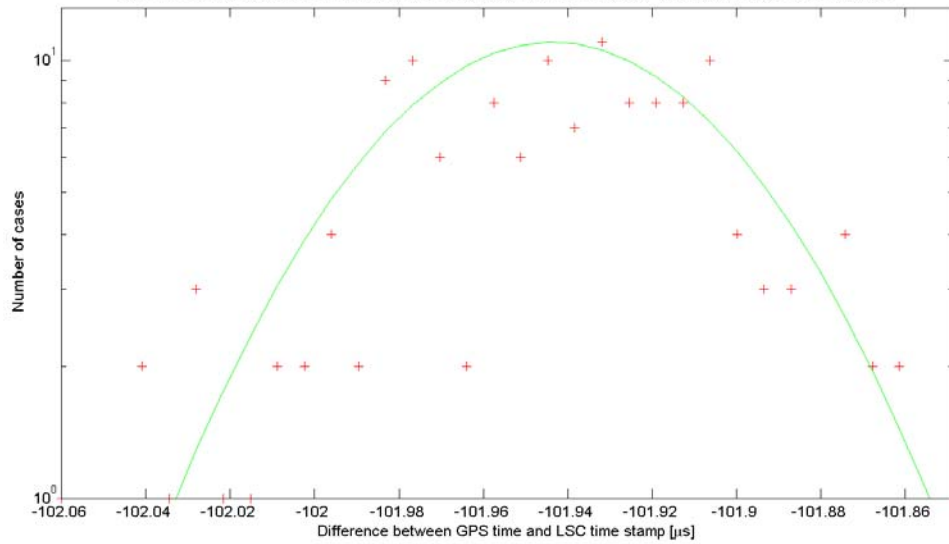




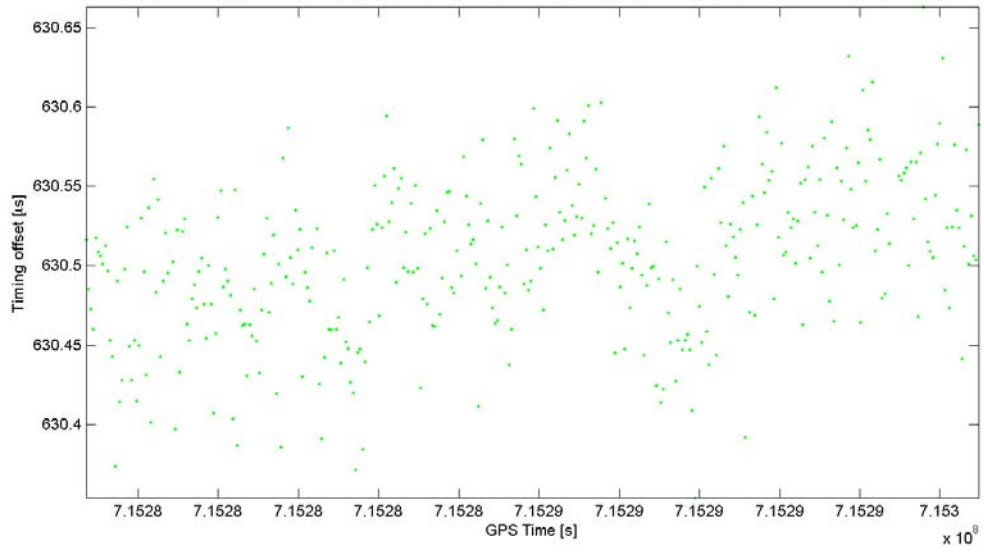
LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (715266180-715274580)



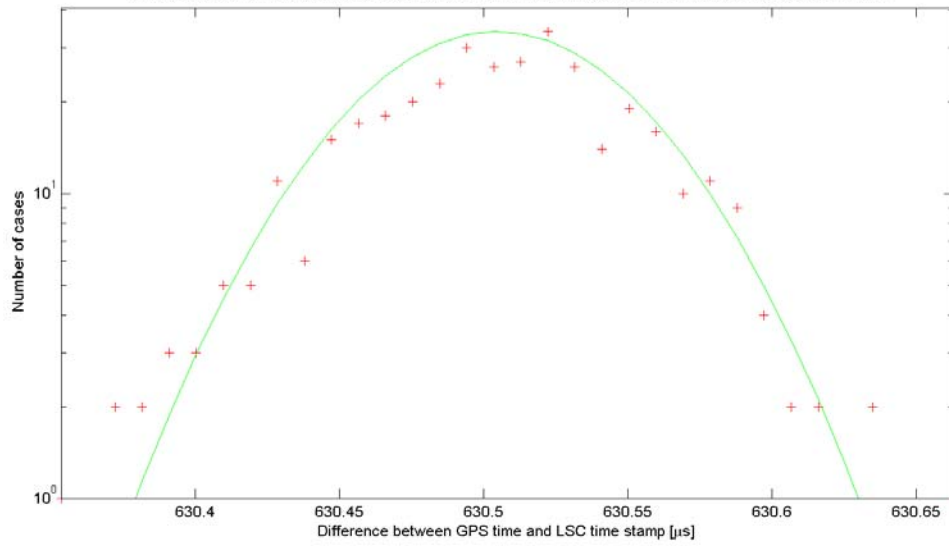
S1 LHO 2K LSC Timing Offset Distribution (715266180-715274580), Mean: -101.943581, Sigma: 0.040804 μ s

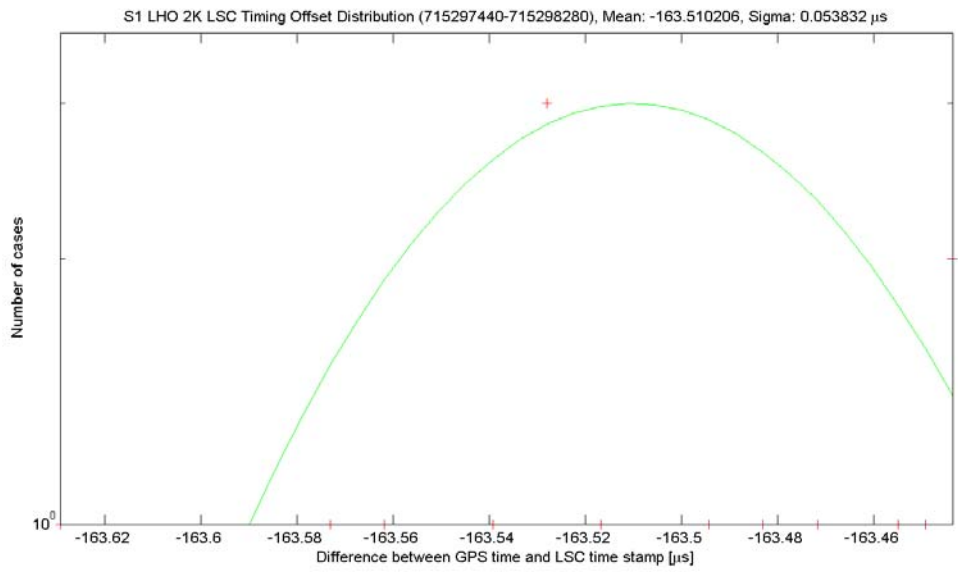
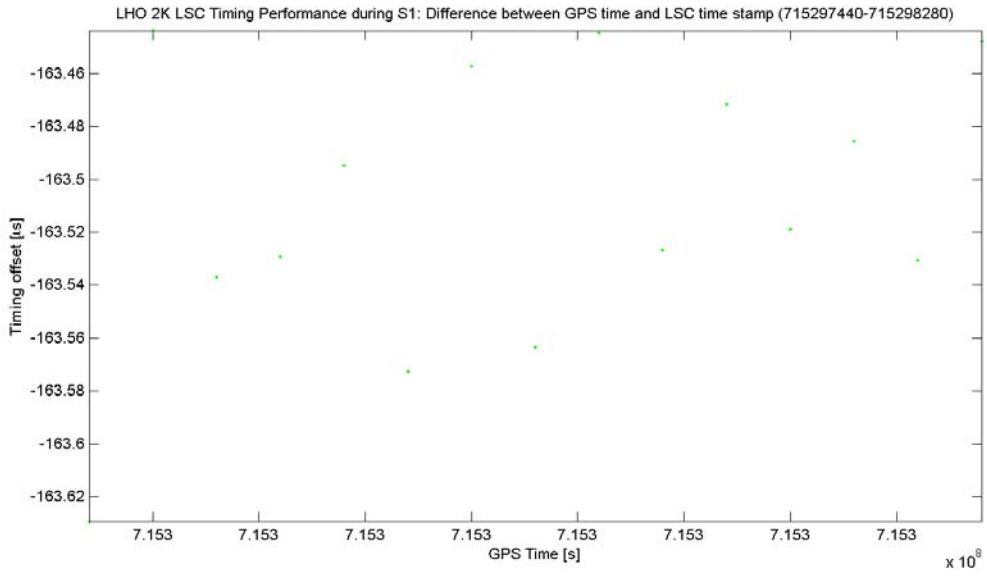


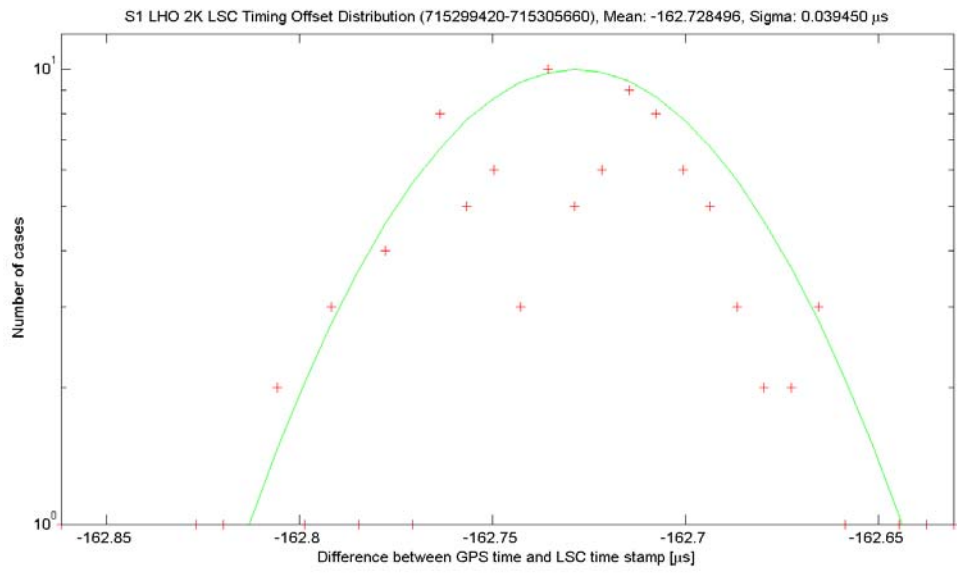
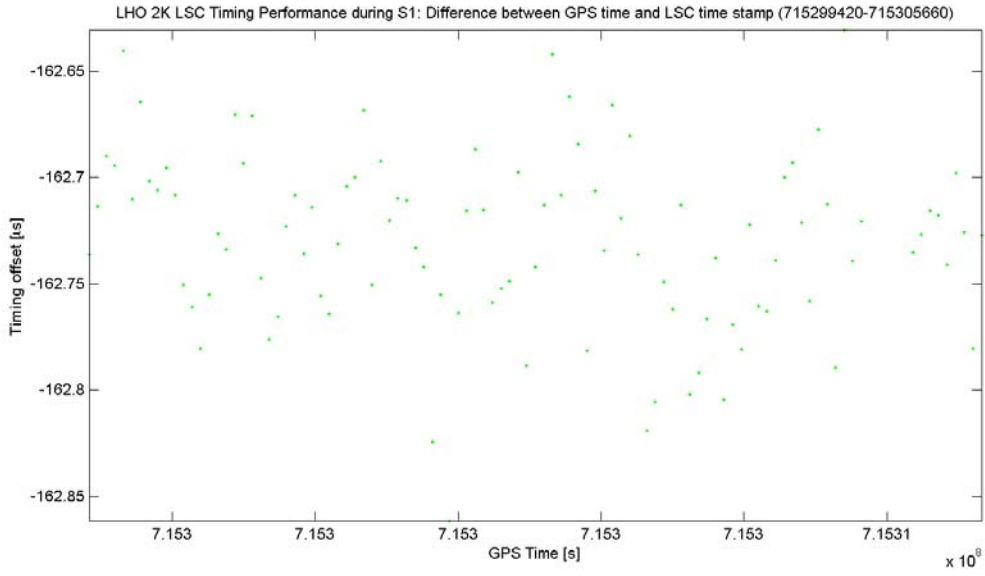
LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (715274700-715296960)



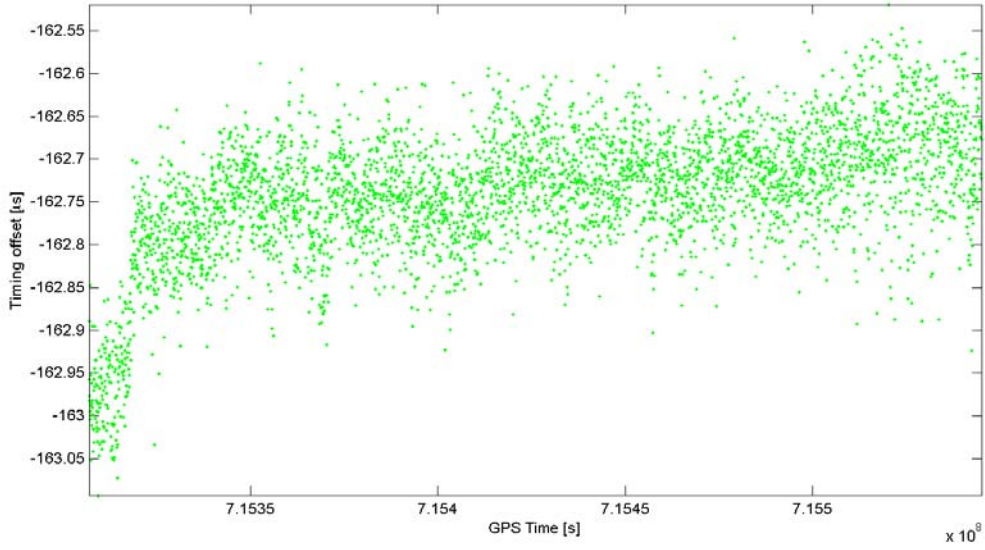
S1 LHO 2K LSC Timing Offset Distribution (715274700-715296960), Mean: 630.504606, Sigma: 0.047238 μ s



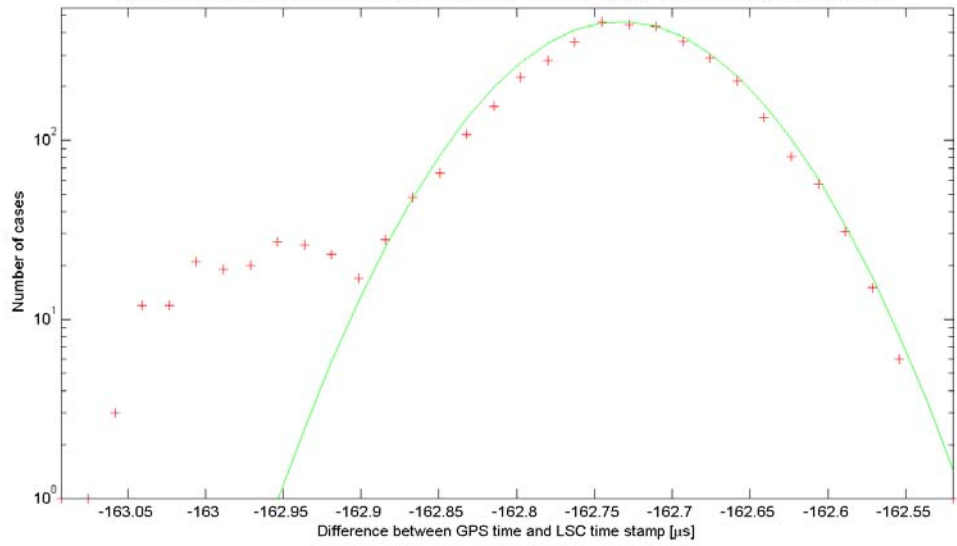




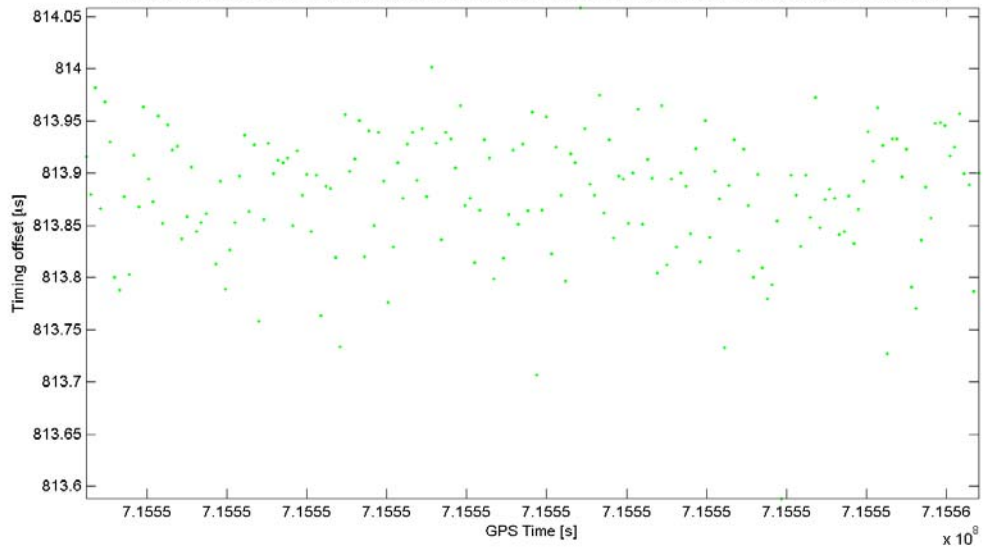
LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (715306920-715545120)



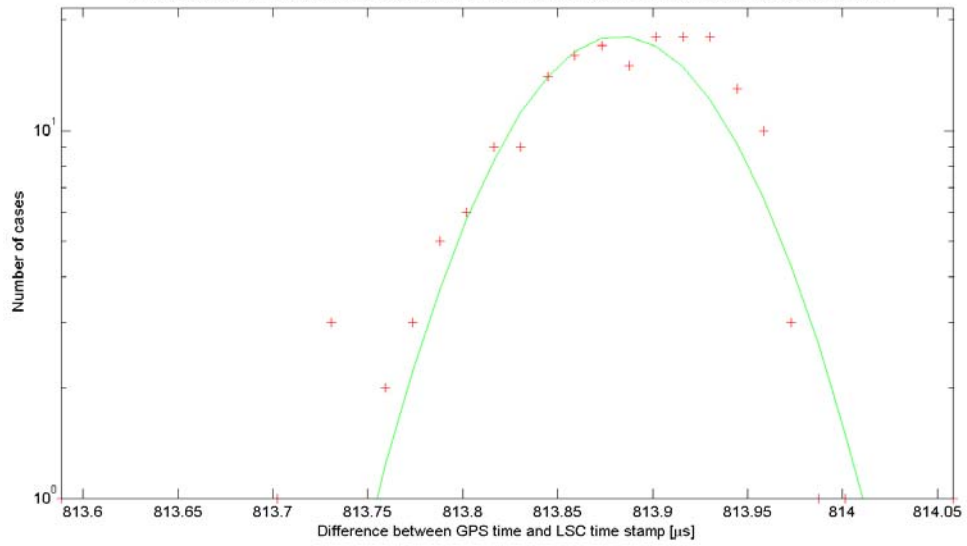
S1 LHO 2K LSC Timing Offset Distribution (715306920-715545120), Mean: -162.732823, Sigma: 0.062896 μ s

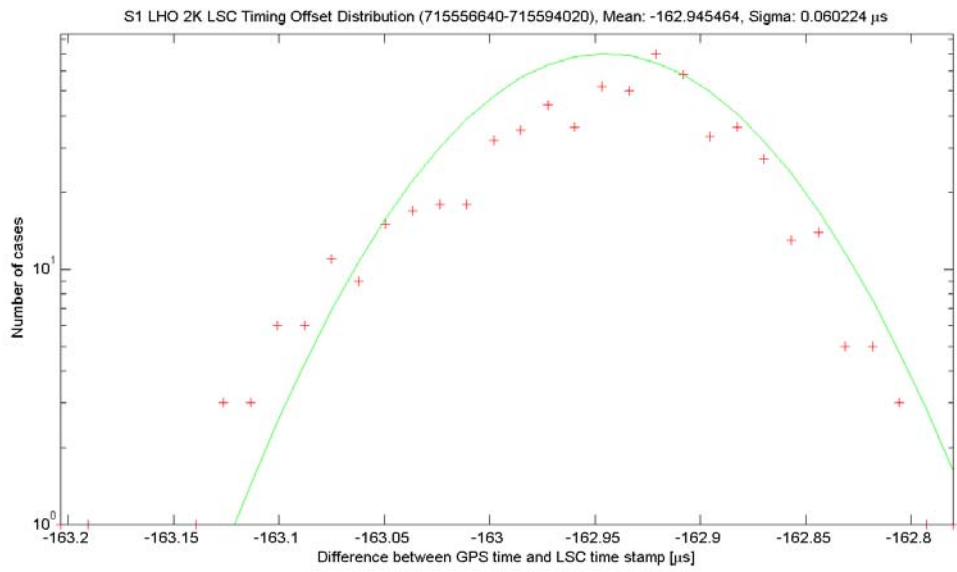
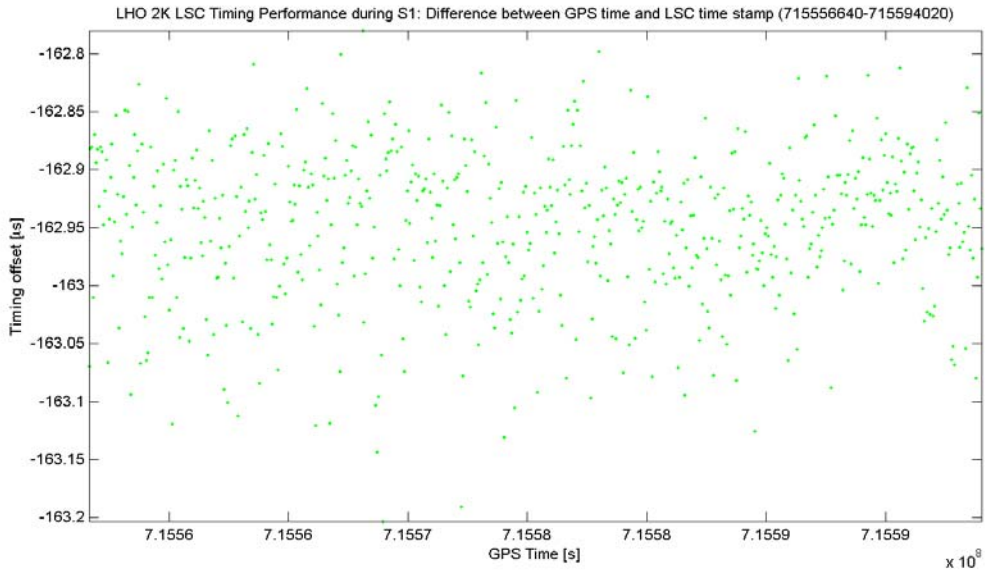


LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (715545240-715556400)

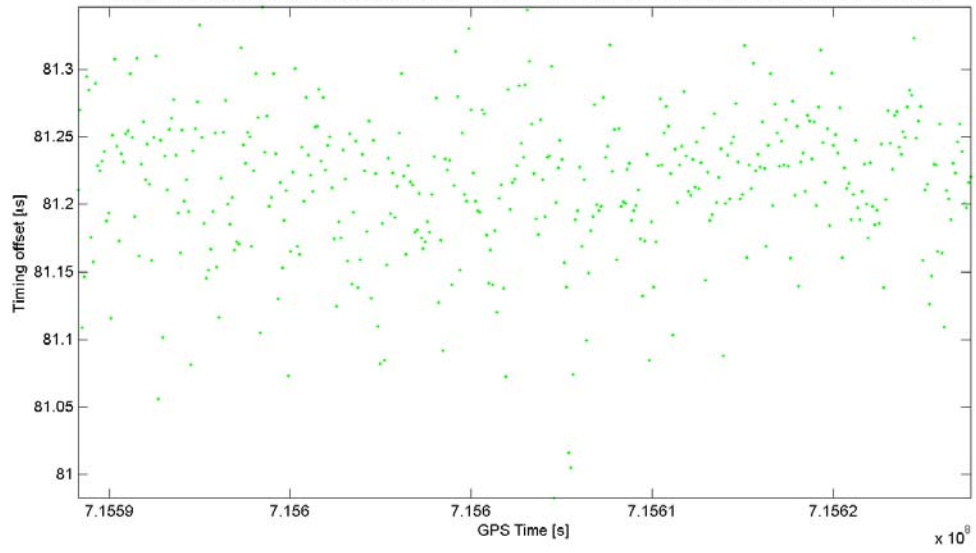


S1 LHO 2K LSC Timing Offset Distribution (715545240-715556400), Mean: 813.882693, Sigma: 0.053233 μ s





LHO 2K LSC Timing Performance during S1: Difference between GPS time and LSC time stamp (715594140-715618800)



S1 LHO 2K LSC Timing Offset Distribution (715594140-715618800), Mean: 81.217634, Sigma: 0.049001 μ s

