

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -

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Summary of S5 Calibration Models and Uncertainties		
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	Magnitude Error (%)			Phase Error (deg)		
	40 Hz - 2 kHz	2 k - 4 kHz	4 k - 6 kHz	40 Hz - 2 kHz	2 k - 4 kHz	4 k - 6 kHz
L1	13.4	13.3	13.5	2.3	1.5	1.4
H1	10.2	15.4	24.4	4.3	4.6	5.6
H2	10.3	11.3	16.6	3.4	2.0	2.2

Table 1: Magnitude and phase error of V4 S5 calibration for three frequency bands.

1 Introduction

There are two versions of calibrations for the fifth science run of LIGO (S5). The latest one called version 4 or V4 calibration was reviewed for the frequency domain, but the time domain data (widely called “h of t” or $h(t)$) uses the version 3 or V3 calibration as of April 2010.

For some historical reasons, there was no document explicitly explaining the difference of V4 frequency domain, V3 frequency domain and V3 time domain calibration. This document is intended to be used as such a reference, which should be useful to give the readers some precautions that should be taken when using either of these calibrations.

2 Version 4 frequency domain calibration

Frequency domain Version 4 calibration was vetted by the calibration review committee. The error estimate is detailed in a paper by Jeff Kissel [1]. For readers’ convenience, Table 1 shows the magnitude and phase error of S5 V4 frequency domain calibration for three frequency bands. Readers in need of a more fine-grained error estimate should refer to the above mentioned paper [1] as well as calibration review web page [2].

Note that time domain data $h(t)$ is still using V3 calibration, not V4, as of April 2010. See the next section for the details of V3 calibration.

3 Version 3 time domain calibration

Version 3 calibration is in active use for the time domain data $h(t)$ as of April 2010. For frequency domain analysis, V3 is considered obsolete. Even though V3 was initially reviewed both for frequency domain [3] and time domain [4, 5], in light of a series of post S5 measurements we needed to update the uncertainty of V3 calibration.

As was explained in the usage policy of V3 frequency domain data announced in 2009 March LVC meeting [6], there are mainly three important precautions to use V3 frequency domain calibration:

- Looking at the difference between V3 and V4 frequency domain response function[7],
- Using the errors of V4.
- Taking care about the timing if looking at LIGO and VIRGO at the same time because of systematic timing offset mostly common to all LIGO interferometers in V3.¹

Figures 1, 2 and 3 show the V4/V3 frequency domain response function ratio. Data files used for this comparison are available at S5 frequency domain calibration review web page[7].

Since V3 time domain calibration has its own additional error in relation to V3 frequency domain[5], users should potentially add the time domain errors in quadrature to the frequency domain errors. This really depends on the nature of analysis (e.g. frequency of interest, epoch etc.).

Table 2 summarizes the error estimate of the V3 $h(t)$ (*after V4/V3 response function difference is taken into account*) using the worst systematic error of $h(t)$ over the entire S5 period for three frequency bands, which might be useful for people intending to start new analyses. As can be seen by comparison of Tables 1 and 2, the difference between V4 $h(f)$ and V3 $h(t)$ is mainly in the highest frequency band (except the aforementioned V4/V3 response function difference).

¹This is automatically taken care of when taking the V4/V3 response function difference into account.

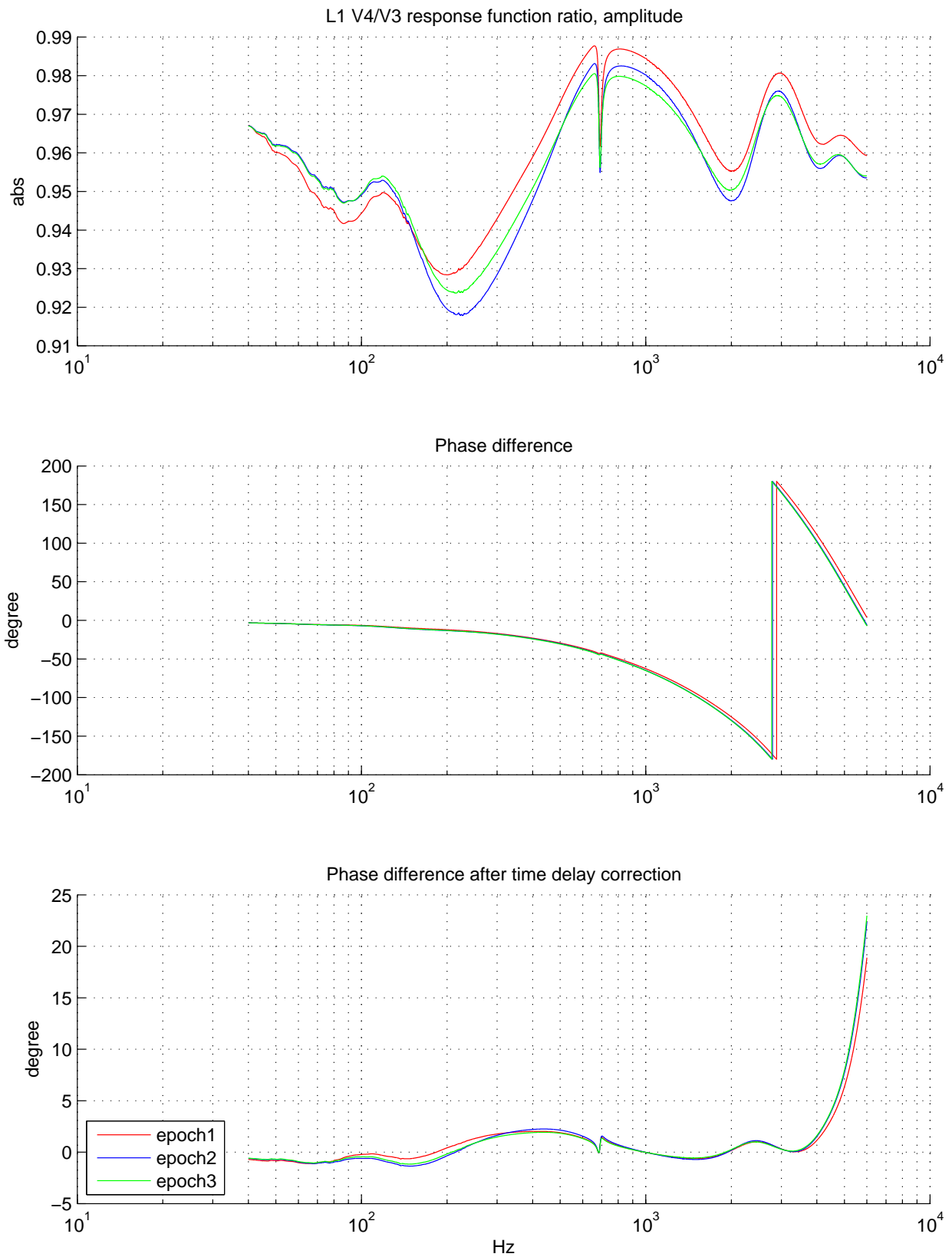


Figure 1: L1 V4/V3 response function ratio for S5. Top, middle and bottom plot represents the amplitude ratio, phase difference, and the phase difference after removing the systematic time advancement of V3 (174, 180 and 181 us for the first, second and third epoch).

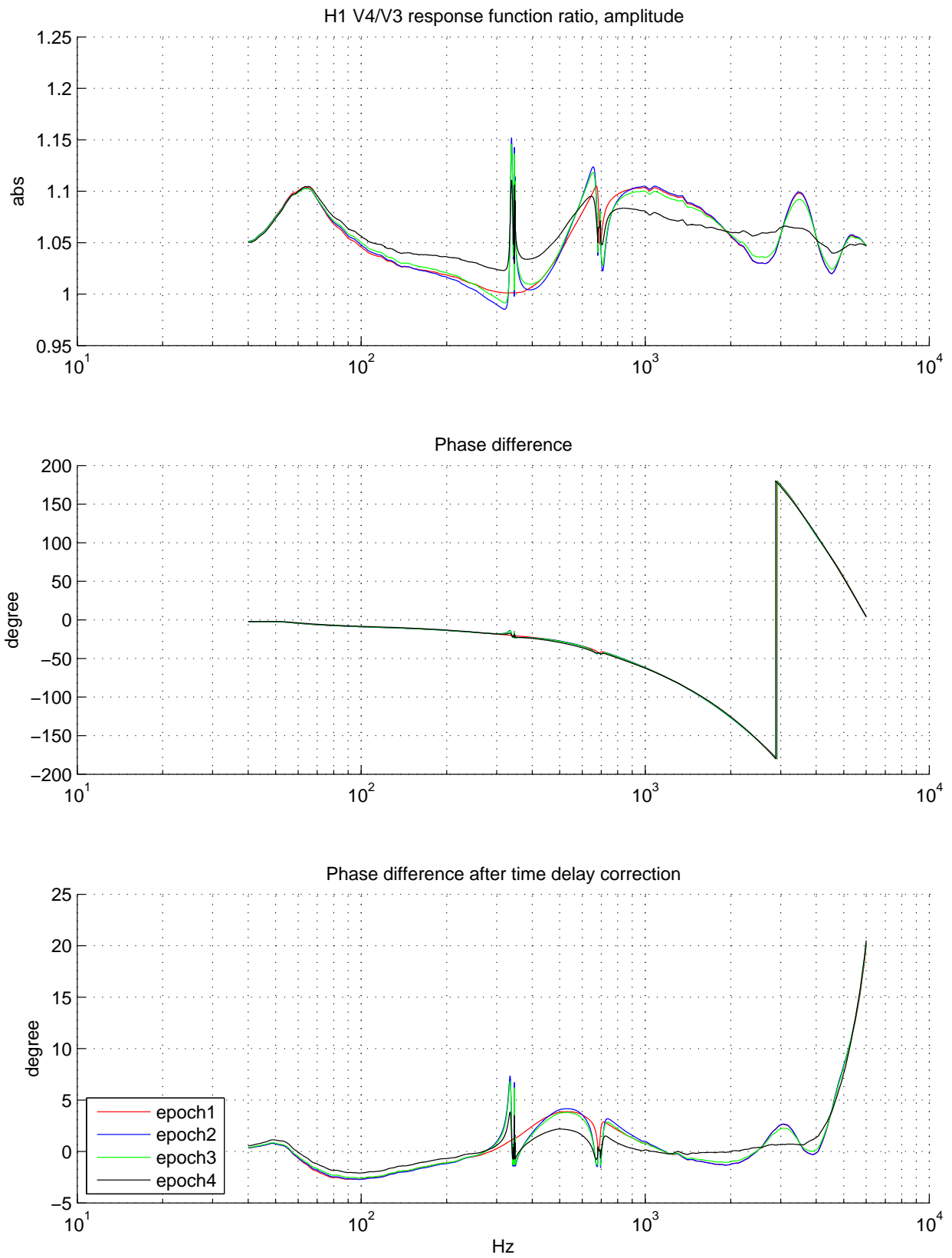


Figure 2: H1 V4/V3 response function ratio for S5. In the bottom plot, systematic time advancement of 174 μ s in V3 was removed from all of the four epochs.

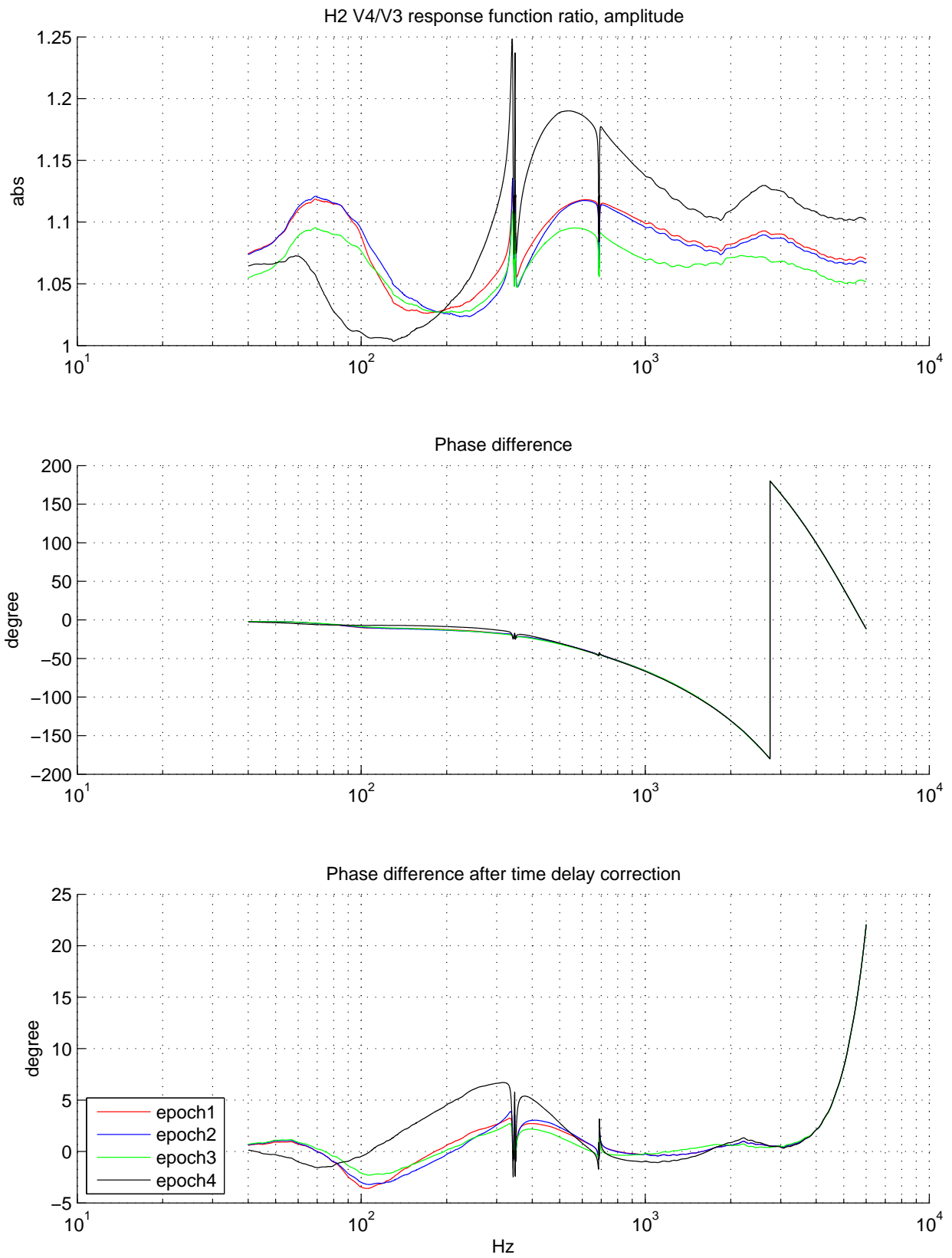


Figure 3: H2 V4/V3 response function ratio for S5. In the bottom plot, systematic time advancement of 182 μ s in V3 was removed from all of the four epochs.

	Magnitude Error (%)			Phase Error (deg)		
	40 Hz - 2 kHz	2 k - 4 kHz	4 k - 6 kHz	40 Hz - 2 kHz	2 k - 4 kHz	4 k - 6 kHz
L1	13.4	13.3	14.6	3.4	2.9	6.2
H1	10.2	15.4	25.0	5.6	5.8	7.7
H2	10.5	11.5	17.4	4.4	3.4	3.9

Table 2: Error estimate of the V3 $h(t)$ after V_4/V_3 response function difference is taken into account using the worst systematic error of $h(t)$ for all epochs during S5.

All the caveats explained in V3 time domain calibration review report[5] are still valid. It is strongly recommended that the readers refer to this document. Together with Kissel’s V4 frequency domain paper[1], the readers will be able to obtain a finer grained knowledge of V3 $h(t)$ calibration.

4 References

1. J. Kissel, LIGO-P0900120.
2. S5 V4 frequency domain calibration review:
<http://touro.ligo-la.caltech.edu/~irish/Work/Calibration/S5V4Review/S5V4Review.html>
3. S5 V3 frequency domain calibration review:
<http://touro.ligo-la.caltech.edu/~irish/Work/Calibration/S5V3Review/S5V3Review.html>
4. S5 V3 time domain calibration review:
<http://lhocds.ligo-wa.caltech.edu:8000/cdswiki/CalRev>
 Note that you need to log in to lhocds server using LVC password first, and then into wiki using FirstnameFamilyname as a username and the default elog password .
5. J. Betzwieser et. al, “S5 V3 $h(t)$ review and validation”, LIGO-T0800??? (2008).
6. The Calibration Committee, “S5/S6 Calibration Status”, LIGO-G0900225 (2008)
7. S5 V3 and V4 Response Functions:
<http://touro.ligo-la.caltech.edu/~irish/Work/Calibration/V3V4Response/>