CNRS
Centre National de la Recherche Scientifique

INFN
Insituto Nazionale Di Fisica Nucleara

h(t) reconstruction for VSR4.

B. Mours, L. Rolland

VIR-0704A-11

November 25, 2011

Abstract

The h(t) reconstruction for VSR4 (June 3rd to September 5th 2011) is described in this note. The used parameters and different checks of the h(t) validity are shown. No reprocessing of the data was performed since the quality of the online reconstruction is good enough: the systematic errors on the online h(t) channel are estimated in the last section.

Table of Contents

1 Introduction

The calibration parameters did not change between the Virgo Science Run 3 (VSR3) and the start VSR4 (note [1]). However, the interferometer configuration has changed three times during the run:

- on from July 1st 2011, the calibration lines around 356 Hz were moved down by 5 Hz to 351 Hz,
- starting from July 5th 2011, the end mirror actuation were used mainly in LowNoise2 mode instead of LowNoise1 mode,
- on from July 26th 2011, the actuation of the marionettes was modified.

During VSR4, the h(t) production was done online using a code with the same methods as for the VSR3 reprocessing. Only the configuration file was updated following the ITF configurations.
As a consequence, the methods use in hrec are not described in this note but can be found in [2] and [3].
Some details about the different configurations of hrec during the run are first given. The checks of the reconstruction (precision of the reconstructed h(t), absence of noise, …) are then studied. Finally, the validy range and the systematic errors of the online h(t) (HrecOnline) are estimated.

Weekly measurements have been done to check h(t). The weekly results are plotted in Appendix, section Erreur : source de la référence non trouvée.

2 Processing details

2.1 Processed datasets

The online h(t) (HrecOnline) processing ran all over VSR4 with two versions of the code:

- Hrec/v2r19 from May 24th to July 5th 2011(17h UTC): same as the version v2r18 used for VSR3 reprocessing, except for a bug about Hrec_Veto_Data_Quality that was fixed.
- Hrec/v2r21 from July 5th 2011 (17h UTC) up to the end of VSR4: modified in order to deal with switches between LN1 and LN2 modes of the end mirror actuation.

Four different configurations were used during the run. The files are given in appendix (section 6).

- Up to July 1st 2011 (7h05 UTC): file 1 (see Appendix section 6.1)
- From July 1st to July 5th 2011 (17h UTC): file 2, with calibration lines frequency reduced by 5 Hz (see Appendix section 6.2)
- From July 5th to July 26th 2011 (?? UTC): file 3, with the actuation parametrization in LN1 and LN2 of the end mirrors.
- From July 26th 2011: file 4, with new marionette actuation parametrization (see Appendix section 6.3).

The fine tuning of the timing applied to the calibration parameters during VSR3 has been kept for VSR4. It consists in adding 3 µs delay to the dark fringe sensing and removing 3 µs delay to the mirror and marionette actuation responses. See section 2.4 of note [3] for details.

The calibration configuration was not correct during one day, from July 19th morning (during the maintenance) to July 20th around 9h30 UTC: the marionette hardware was changed for tests and preliminary measurements, but the calibration not yet updated (see logbook entry 29929). This dataset cannot be used for analysis below few ~50 Hz.

2.2 Data Quality flags

The h(t) quality is evaluated for each 10 seconds frames. The conditions to get a good quality are:

- The interferometer is locked in step 12
- All needed channels are available for the current, previous and following 10 seconds frames. This is needed by the frequency domain filtering.
- The SNR of the NE, WE, BS calibration lines is above 3.
- The individual finesse extracted from the phase of each calibration lines (NE, WE and BS) is in the 40-60 range.
- The channel (V1:Pr_power50) for the power line subtraction is available

The results of these tests are recorded as the following 1Hz ADC channels:

- “Hrec_Flag_quality” for the overall quality (1 means OK)
- “Hrec_Flag_Frame” if the previous/following frames are present (1 means OK)
- “Hrec_Flag_Channel” if all channels are available (1 means OK)
- “Hrec_Flag_SNR” if the SNR test is OK (1 means OK)
- “Hrec_Flag_Finesse” if the finesse test is OK (1 means OK)
- “Hrec_Flag_LineRmvl” if the power monitoring channel is present (1 means OK)

3

Most of the time (except for transition period), the Hrec frames were written only when the h(t) channel was properly reconstructed (Hrec_Flag_quality =1)

2.3 Produced channels

The hrec processing produced 3 h(t) channels named V1:h_4096Hz, V1:h_16384Hz and V1:h_20000Hz corresponding to the three frequencies of their names.

In addition to this fast channels, and the data quality channels described in the previous section, the following 0.1Hz channels are available:

- V1:Hrec_OgPR: the optical gain measured with the 92.5Hz PR calibration line
- V1:Hrec_OgBS: the optical gain measured with the 357Hz BS calibration line
- V1:Hrec_OgWE: the optical gain measured with the 356.5Hz WE calibration line
- V1:Hrec_OgNE: the optical gain measured with the 356Hz NE calibration line
- V1:Hrec_OgCAVITIES: the average of the NE and WE optical gains
- V1:Hrec_finesse channel: the finesse measured with the calibration lines
- V1:Horizon_BHBH_Average: the averaged horizon (or range) for 10+10 solar mass black holes
- V1:Horizon_NSNS_Average: the averaged horizon (or range) for 1.4+1.4 solar mass neutron stars

The "V1:Horizon*", channels contains the horizon computed out of the 20 kHz h(t) channel for binary neutron stars and 10+10 solar mass binary black holes. The h(t) spectrum is computed on two-second long FFTs with Hanning windows and a 50% overlap, averaged with an exponential decay over 15 FFTs, starting from 10 Hz. The optimal horizon is dived by 2.26 to get the quoted averaged horizon.

3

3 Reconstruction checks for online h(t)

3.1 Checking the h(t) correctness using injections with out-of-loop actuators

A simple way to check that a signal is correctly reconstructed is to inject some noise in actuator not used by the control system. The typical case is to use the left and right coils of the WE mirror which, by the way, are used for the hardware injections. The injected signal could be translated to injected displacement using the actuators calibration. Then, the transfer function between this injected displacement and the reconstructed h(t) signal is a estimation of the correctness of the reconstruction process.

These measurements have been performed during the calibration period which took place almost every week. These weekly results have been averaged to reduce the statistical errors and are presented in Figure 3.1. As we can see, the modulus of transfer function is flat with a variation of not more than ± 2% around 1, except for frequencies at the power lines for which a larger dispersion is observed. The phase is also within ± 30mrad around zero below 1 kHz, except again for the power line frequencies. Above 1 kHz, the phase difference could be modelled as a 8 µs delay.

The stability of such measurements has been checked: Figures 3.2 and 3.3 show this ratio measured at two different frequencies as function of time.

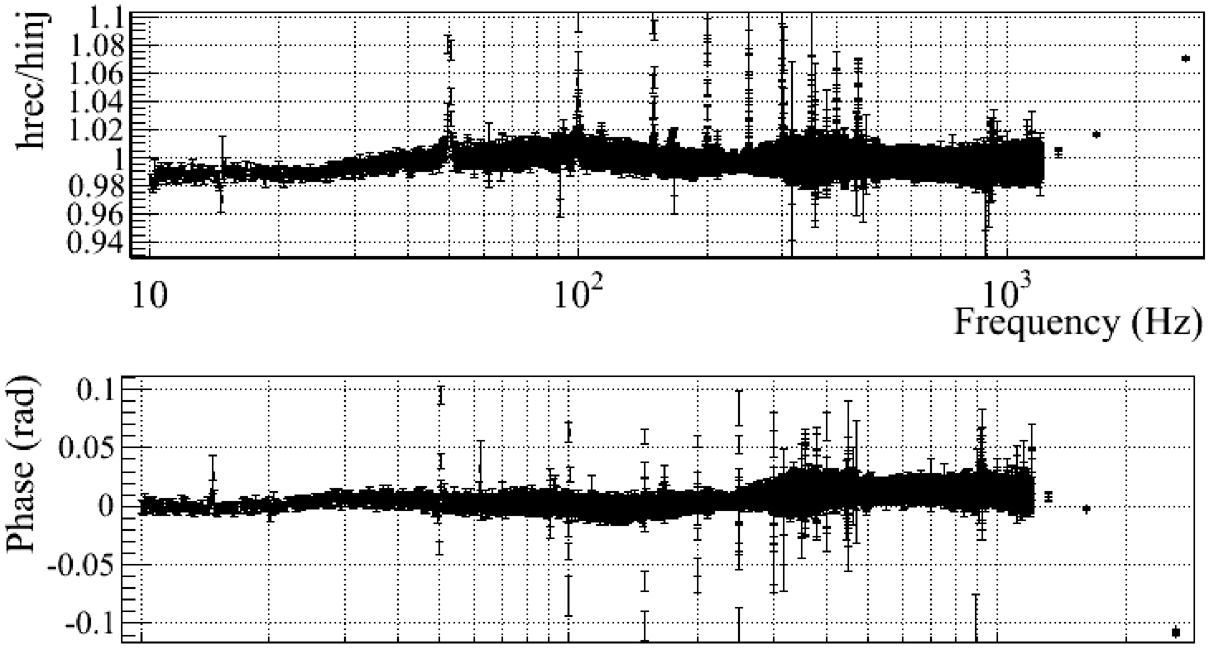


Figure 3.1 - Transfer function between the h(t) signal produced by out of loop coils (WE injections) and the reconstructed h(t) with HrecOnline. The error bars display only the statistical errors. The black points have coherence above 95% and could be perturbed by the presence of lines like the 50Hz harmonics. The weakly measurements have been averaged over VSR4 to produce this curve.

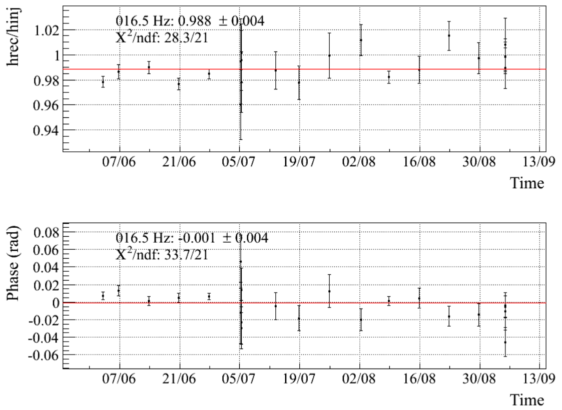


Figure 3.3: evolution, during VSR4, of the transfer function between the injected h(t) and the reconstructed h(t) at 17 Hz.

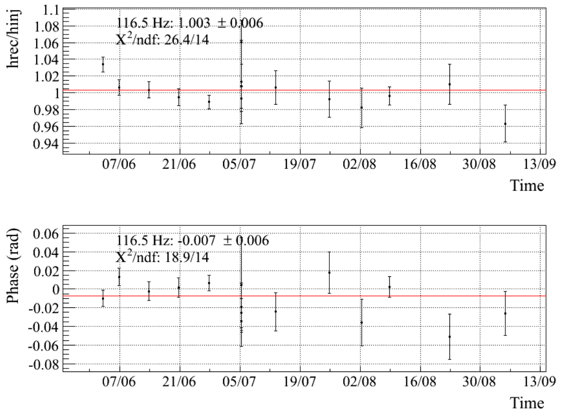


Figure 3.2: evolution, during VSR4, of the transfer function between the injected h(t) and the reconstructed h(t) at 117 Hz.

3.2 Check of the noise level in h(t) (HrecOnline)

The reconstruction process could reconstruct with the right transfer function the h(t) signal, but could also add extra noise if the controls signals are not properly cancelled out. If the online cancellation of the control signal is not optimal, the h(t) reconstruction could remove some of this control noise, in addition to the calibration lines subtraction. This is a more difficult check to perform since we do not expect the h(t) signal to be just the dark fringe signal on which only a transfer function is applied. Nevertheless, since during VSR2, various techniques of noise cancellation have been applied by the global control team (“α, β, γ techniques”), we can assume in first approximation that the dark fringe is a clean signal for differential arm length sensing.

3.2.1 h(t) spectrum versus the sensitivity computed in the frequency domain

In this first simple test, we compare the h(t) spectrum and the sensitivity computed in the frequency domain, i.e., the spectrum of Pr_B1_ACp on which the transfer function has been applied. Figure 3.5 shows these two curves overlapped. Figure 3.4 presents their ratio as well as its fluctuation

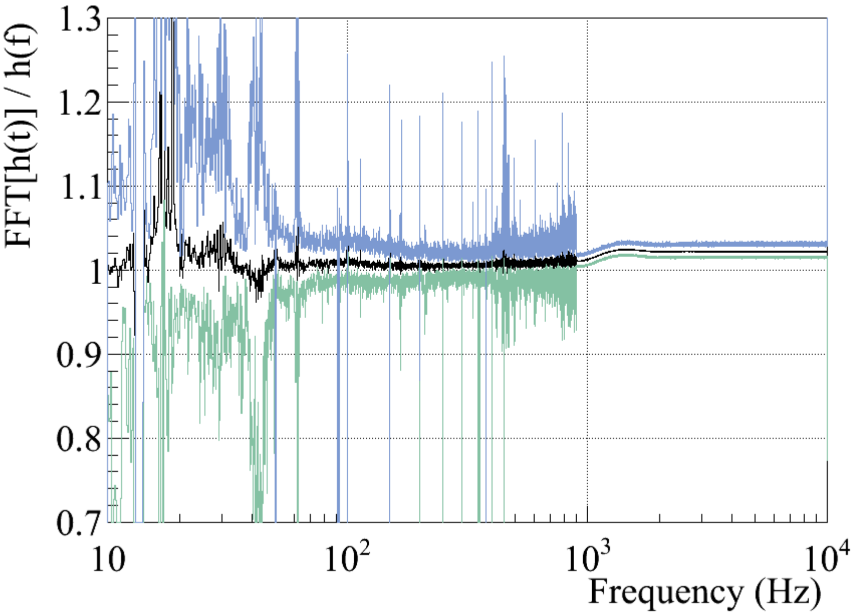


Figure 3.4 – Ratio between h(t) spectrum from HrecOnline and h(f). The black curve is the mean value over the weekly calibration periods. The blue/green curves are the maximum/minimum of this ratio to indicate the typical fluctuations.

during the run. Vertical lines indicate the power lines and calibration lines which are subtracted by the reconstruction process.

3.2.2 Coherence between h(t) and the auxiliary degrees of freedom

It is possible to look for the presence of residual control noise in the h(t) signal, as an indication of the remaining noise in the h(t) channel. Figure 3.6 (bottom) presents the sum of the coherence between h(t) and the three main auxiliary degrees of freedom (*Gc_Michelson, Gc_Recycling, Gc_Common*) in red as well as for Pr_B1_ACp in black. Beside the power lines, the coherence is pretty low indicating that the remaining control noise is small. The behaviour of h(t) and Pr_B1_ACp is about the same.
The appendix II presents the same plots computed during the weekly calibration periods.

3.2.3 Coherence between h(t) and the Pr_B1_ACp signal

Another way to check for extra noise in h(t) is to look at the coherence between h(t) and Pr_B1_ACp. Figure 3.6 (top) presents such a coherence for HrecOnline. A coherence below 1 indicates that either extra noise is still present in h(t) or noise has been subtracted in h(t) like for the power lines or calibration lines around 15 Hz. There is a very good coherence above 20 Hz. Below 20 Hz, the two signals do not give exactly the same answer, but this is the frequency band where there is still some residual control noise in both signals.

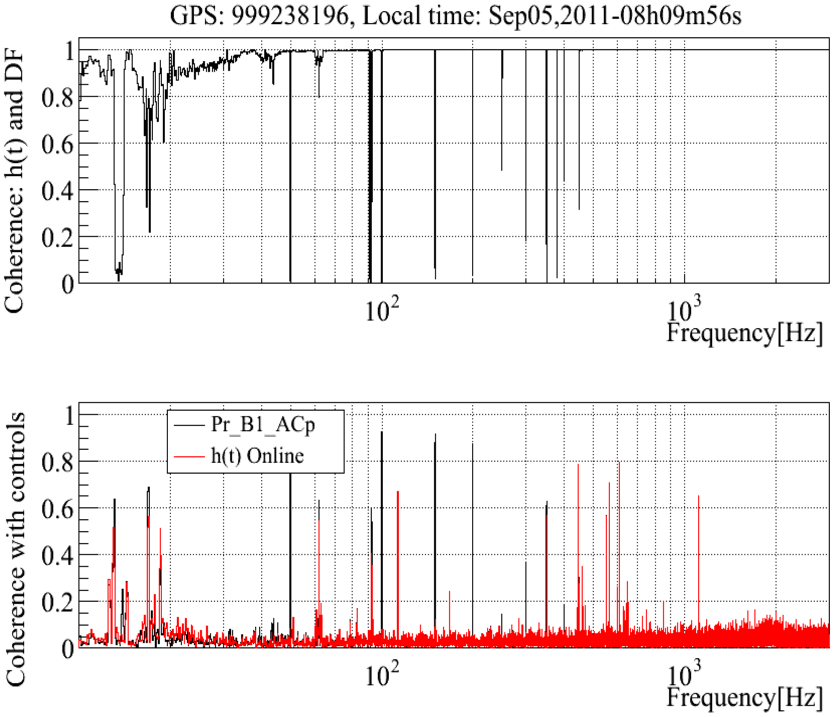


Figure 3.6 – Top: coherence between h(t) (HrecOnline) and the Pr_B1_ACp signal. Bottom: coherence between the sum of the control signals and h(t) (red) or Pr_B1_ACp (black).

Again, the appendix II presents this coherence for all the weekly calibration measurements.

3.3 Check of the sign of h(t) with the photon calibrator

As for previous Virgo science runs, the definition of the sign of h(t) has been agreed between LIGO and Virgo: h(t) = (Lx-Ly)/L. For Virgo, Lx is the length of the north arm and Ly the length of the west arm. L is of course their average length, L = 3 km for Virgo.
The method to check the sign of h(t) using the photon calibrator (PCal) is based on the fact that an optical power is always positive and therefore, by simply looking at the time series of the photon

calibrator power on which a sine wave is injected and at the h(t) signal we can validated the sign of h(t).
The photon calibrator is installed on the north input tower, pushing the mirror from the input of the cavity (i.e. from north to south). Therefore when the PCal power increases, we expect to increase the north (i.e. x) arm and therefore increase h(t). However, since we are injecting a sine wave well above the pendulum resonance, we expected that the response of the mirror be in opposition of phase compared to the injected signal. In other word, given the above definition of h(t), we expect that the observed h(t) signal should be in opposition of phase compared to the PCal power signal.

The sign of HrecOnline h(t) has been checked with this direct method in the frequency domain (the large amplitude of a mirror excitation around 8 Hz prevents the direct check in the time domain). The data shown Figure 3.7 confirm that the phase between the reconstructed h(t) and the power of the PCal laser is -π, as expected. Such measurements were performed every week during VSR4, starting from July 19th 2011.

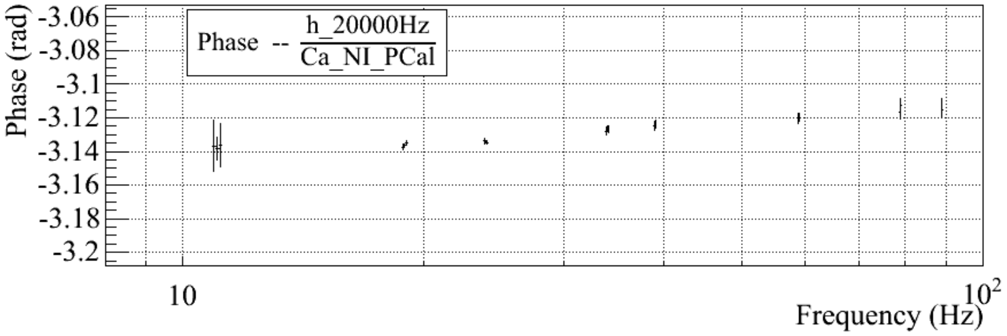


Figure 3.7: Phase of the reconstructed channel h_20000Hz as function of the power of the PCal laser (monitored by channel Ca_NI_PCal, with positive sensing sign). Few lines have been injected through the Pcal. Data with coherence higher than 99% are shown. Data from July 19th 2011.

3.4 Inspiral horizon from HrecOnline

The distribution of the horizon in the ScienceMode segments computed from HrecOnline is given in Figure 3.8. Its average is 9.9 Mpc.

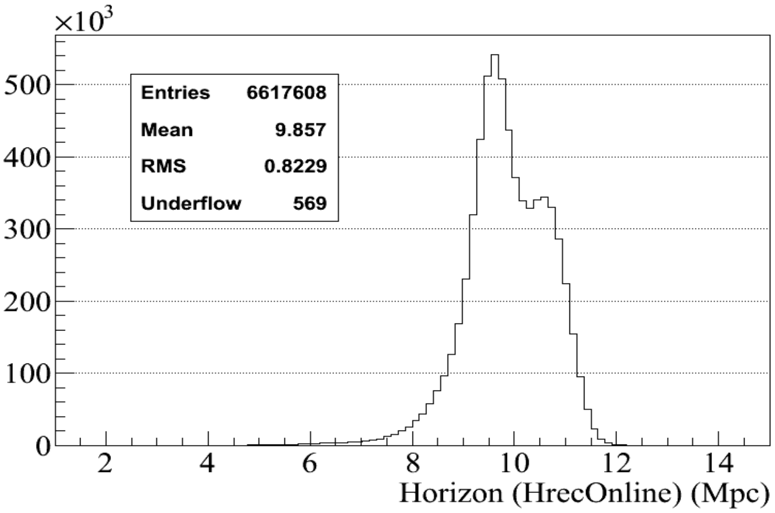


Figure 3.8 – Distribution of the NS-NS horizon computed online from hrec during VSR4.

4 Systematic errors

4.1 Computing the systematic errors for HrecOnline

The h(t) channel is obtained by a complex process of combining different channels. The direct propagation of the model/parameters uncertainties is difficult. Therefore a more global approach is used, based on the check of the recovery of the injections made with the out-of-loop coils (see section 3.1). The observed dispersion of the points on Figure 3.1 is therefore the starting point, on which we are adding the systematic error of the actuator model taken from the actuator calibration note (see page 22 of [1]).

However, this approach works only below 1 kHz where the actuator model is well known. But above this frequency, the control signals contribute to less than 1% to h(t). Therefore, in this frequency band, the systematic error is coming only from the sensing model (see again page 22 of [1]), the uncertainty on the optical gain, and the uncertainty on the optical model (the simple cavity model) which is small since we are well above the cavity pole. The Figure 4.1 shows the typical statistical fluctuations on the finesse measurement: 0.25 for a finesse of about 149 (a relative error of 0.2%).

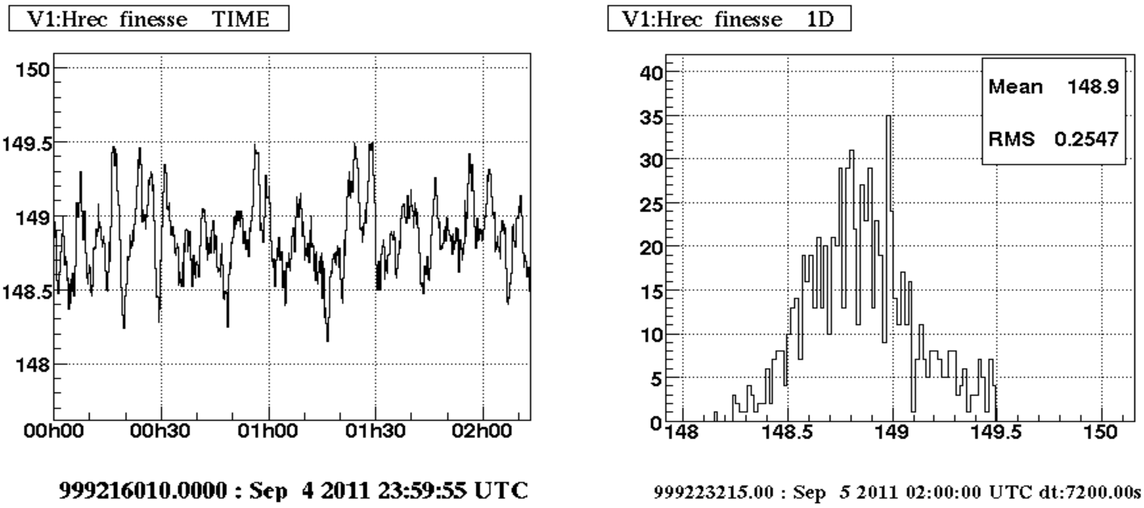


Figure 4.1 – Typical statistical fluctuation of the finesse measurement from hrec.

4.2 Amplitude error for HrecOnline

Below 1 kHz, the amplitude ratio on Figure 3.1 is within 2%. The systematic error of the actuation model is 5%. Therefore the systematic error on the h(t) amplitude is 2+5=7% below 1 kHz.

Above 1 kHz the systematic error is coming from:

- The optical gain, which is known to better than 1+5= 6%.The 1% is given by the SNR of the calibration line amplitude which is larger than 100 and the 5% by the actuator absolute calibration.
- The electronic response which in the 1-10 kHz band is flat within better than 1% since we are far away from any analog filtering (the first analog filter, for the ADC analog anti-aliasing filter is at 150 kHz).

- The uncertainty due the optical model is given by the fluctuation of the cavity finesse, typically 0.2% (see Figure 4.1) which translates to the same amount on the amplitude error above the cavity pole. Therefore we use a conservative 0.5% error for the model uncertainty.

Adding up all together we get for the h(t) amplitude systematic error is 6+1+0.5=7.5% above 1 kHz, slightly higher than below 1 kHz.

4.3 Absolute phase or timing for HrecOnline

Again, Figure 3.1 indicates that we get the correct phase within 30 mrad below 1 kHz. The systematic error of the model is 20 mrad and therefore the phase error on h(t) is 30+20=50 mrad below 1 kHz.

Above 1 kHz, the sensing systematic error is 4µs. Since we added 4 µs (well, 3.9µs) as systematic offset when doing the reconstruction, the overall systematic timing error is 4+4=8 µs above 1 kHz. The model uncertainty could be neglected since at 1 kHz, the 0.2% change of the finesse induce less than 0.15 µs timing change.

Since 8 µs translates to 50 mrad at 1 kHz, the phase/timing error is 50 mrad below 1 kHz and 8 µs above.

3

5 Summary: validity range and errors

h(t) has been produced online during VSR4 and its configuration was updated to follow the changes in the interferometer configuration that impact calibration.

The online h(t) HrecOnline version has been produced for VSR4, from 991170015 (UTC: June 3 2011, 21:00) to 999262815 (UTC: Sept 5 2011, 13h UTC). The h(t) channel is valid from 10 Hz up to the Nyquist frequency of the channel used, i.e. up to 2048, 8192 or 10000 Hz. In this validity range, the systematic error on the h(t) amplitude is 7.5%. The systematic error on the h(t) phase/absolute timing is the same as for VSR3, with a slight increase of the timing error (see Figure 5.1):

- 10 Hz - 500 Hz: (40+50 f) mrad, with f in kHz
- 500 Hz - 1 kHz: (10+110 f) mrad, with f in kHz
- 1 kHz - 2.4 kHz: 120 mrad
- 2.4 kHz - 10 kHz: 8 µs.

One period must be analysed with care: from July 19th morning (during the maintenance) to July 20th around 9h30 UTC, h(t) is valid only from ~50 Hz to 10 kHz.

Such errors being enough for analysis purposes, no h(t) reprocessing has been done after VSR4.

Hrec was running with such a configuration since September 10th 2010 and up to the end of Virgo+ in November 2011. The h(t) validity range and errors are probably the same during all this period, but no extensive calibration data are available for validating this guess.

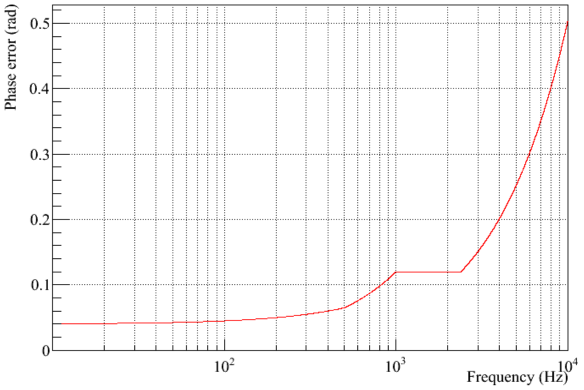


Figure 5.1: Frequency-dependent error on the phase of online h(t) during VSR4.

Bibliography

[1] L. Rolland, VIR-0703A-11 (2011) VSR4 calibration - Stability from VSR3 to VSR4
[2] B. Mours and L. Rolland, VIR-0340A-10 (2010) h(t) reconstruction for VSR2
[3] B. Mours, L. Rolland, VIR-0056A-11 (2011) h(t) reconstruction for VSR3

[3]

6 Appendix I – configuration files of hrec used online during VSR4

6.1 File 1: up tp July 1st 2011

```
CFG_PRIO 3              # Main priority; 0 means no change (nice(0))
CFG_NOFILESAVE
CFG_NODBSAVE            # No commit into Db
CFG_PWD /virgoLog/Hrec   # Current logfile path <path>/<cmName>
CFG_RFLAG eloff          # Report flags: el{on,off}, stdout{on,off}, log{on,off}

DEBUG 3

FDIN_SHM   FbmQc
FDIN_TAG   "*"

FDOUT_SHM 5000000 50

FDOUT_STAT 1
FDOUT_COMPRESSION    9
FDOUT_CHPREFIX2 "V1:"

FRAME_LENGTH_OUT 1
FRAME_LENGTH  10

MIN_FR_QUALITY 0

PROCESSING_TAG HrecOnline
MIN_LOCK_STATE 12

#-------------------------------------------------------
FINESSE 150. 357. 356. 356.5  0. 100. 200. # for the permanent lines
#------------------------------------------------------

#-------Channels used for the reconstruction-----------------
#  The parameters are from VIR-0610A-10 + add 3us on the sensing and 3us on the actuation
#---The first channel must be the dark fring---
#          name           Gain       delay    debug   OpticalGainName
CHANNEL   V1:Pr_B1_ACp    1.  +62.7e-6    0    CAVITIES  0. NONE

CHANNEL   V1:Sc_WE_zCorr   19.885e-6   +272.1e-6    0 WE  0. NONE
 ADD_DAC
 ADD_POLE    0.6   1000

CHANNEL   V1:Sc_NE_zCorr   22.48e-6   +268.2e-6    0  NE 0. NONE
 ADD_DAC
 ADD_POLE    0.6  1000

CHANNEL   V1:Sc_BS_zCorr   -89.628e-6  +222.5e-6    0 BS  0.  NONE
 ADD_POLE  3183.3  0
 ADD_DAC
 ADD_POLE  .6   1000

CHANNEL   V1:Sc_PR_zCorr   -14.26e-6  +459.9e-6    0 PR 0. NONE
 ADD_POLE  77.7  0
 ADD_ZERO  91.9  0
 ADD_POLE    0.6   1000
# next line is for the PR optical response 1/(2Pi*7.67) = 0.02075
#ADD_FILTER_2 0. 0.02075 0. 0. 0.02075 1.
#ADD_POLE 512.   0.
#ADD_ZERO 500.   0.
# this last zero is to remove to cavity pole which is already included

CHANNEL   V1:Sc_WE_zM  3.859e-6  +1456.7e-6    0 WE 0.  NONE
 ADD_POLE    15.528    0.
 ADD_ZERO    192.03     0.681
 ADD_POLE     0.6   1000.
 ADD_POLE     0.6   1000.
 ADD_POLE  1000.       0.7

CHANNEL   V1:Sc_NE_zM  4.074e-6  +520.3e-6    0 NE 0. NONE
 ADD_POLE     15.159    0.
 ADD_ZERO    406.0      0.
 ADD_POLE      0.6   1000.
 ADD_POLE      0.6   1000.
 ADD_POLE  1000.        0.7

SAVE_FFT V1:Pr_B1_ACp   0. 2000. 400
SAVE_FFT V1:Sc_WE_zCorr 0. 2000. 400
SAVE_FFT V1:Sc_NE_zCorr 0. 2000. 400
SAVE_FFT V1:Sc_BS_zCorr 0. 2000. 400
SAVE_FFT V1:Sc_PR_zCorr 0. 2000. 400
SAVE_FFT V1:Sc_NE_zM    0. 2000. 400
SAVE_FFT V1:Sc_WE_zM    0. 2000. 400
```

3

```
SAVE_FFT V1:h_Watt      0. 2000. 400

#--------- this is to compute the optical gains with the usual permanent lines ---
GET_OGAIN 4 4 V1:Sc_NE_zCorr   91.  0. V1:Sc_WE_zCorr   91.5  0. V1:Sc_BS_zCorr  92.  0. V1:Sc_PR_zCorr 92.5. 0.
GET_OGAIN 4 4 V1:Sc_NE_zCorr  356.  3. V1:Sc_WE_zCorr  356.5  3. V1:Sc_BS_zCorr 357.  3. V1:Sc_PR_zCorr 357.5 0.

#----------- name   coef1     channel       coef2    channel2
DEFINE_OGAIN  NE      1. V1:Sc_NE_zCorr_356    0. V1:Sc_NE_zCorr_91  # this is for the standard conditions
DEFINE_OGAIN  WE      1. V1:Sc_WE_zCorr_356.5  0. V1:Sc_WE_zCorr_91.5
DEFINE_OGAIN  BS      1. V1:Sc_BS_zCorr_357    0. V1:Sc_BS_zCorr_92
DEFINE_OGAIN  PR      1. V1:Sc_PR_zCorr_357.5  0. V1:Sc_PR_zCorr_92.5
DEFINE_OGAIN CAVITIES 0.5 NE                  0.5 WE

#-------- define the frequencies produced
#H_FREQUENCY  4000 V1:h_4000Hz_NEW
H_FREQUENCY  4096 V1:h_4096Hz_With50Hz
H_FREQUENCY 16384 V1:h_16384Hz_With50Hz
H_FREQUENCY 20000 V1:h_20kHz_With50Hz

#------ Power line removal
#--------------input------------output-----------monitor--------freq----tFreq---tCoupl.-nHarmonic
#LINE_REMOVAL V1:h_4000Hz_NEW   V1:h_4000Hz   V1:Em_IPSDET03_tmp    50.     1.      2.     18
LINE_REMOVAL V1:h_4096Hz_With50Hz   V1:h_4096Hz   V1:Em_IPSDET03_tmp    50.     1.      2.     9
LINE_REMOVAL V1:h_16384Hz_With50Hz  V1:h_16384Hz  V1:Em_IPSDET03_tmp    50.     1.      2.     9
LINE_REMOVAL V1:h_20kHz_With50Hz    V1:h_20000Hz  V1:Em_IPSDET03_tmp    50.     1.      2.     9

#--------------------------
HORIZON_CHANNEL V1:h_20000Hz

#-----------------------------------------------vetos cat 2
HRVETO_MINMAX ScienceMode          2 Qc_Moni  Mode           1 1        2. 2
HRVETO_MINMAX d2_ACq_Saturation     2 NULL    Pr_B1_d2_ACq   -990000 990000 2. 2. # +- 9.5 Volts
HRVETO_MINMAX d3_ACq_Saturation     2 NULL    Pr_B1_d3_ACq   -990000 990000 2. 2. # +- 9.5 Volts
HRVETO_MINMAX d4_ACq_Saturation     2 NULL    Pr_B1_d4_ACq   -990000 990000 2. 2. # +- 9.5 Volts
HRVETO_MINMAX d5_ACq_Saturation     2 NULL    Pr_B1_d5_ACq   -990000 990000 2. 2. # +- 9.5 Volts
HRVETO_MINMAX Sc_NE_CoilU_Saturation 2 NULL    Sc_NE_RM_CoilU  -9.9 9.9     2. 2.
HRVETO_MINMAX Sc_NE_CoilD_Saturation 2 NULL    Sc_NE_RM_CoilD  -9.9 9.9     2. 2.
HRVETO_MINMAX Sc_WE_CoilU_Saturation 2 NULL    Sc_WE_RM_CoilU  -9.9 9.9     2. 2.
HRVETO_MINMAX Sc_WE_CoilD_Saturation 2 NULL    Sc_WE_RM_CoilD  -9.9 9.9     2. 2.
HRVETO_MINMAX SSFS_Saturation       2 NULL    Sc_IB_SSFS_Corr -9.9 9.9     2. 2.
HRVETO_MINMAX Locked               2 Alp_Main LOCK_STEP_STATUS 12 12       10. 300.

#-----------------------------------------------vetos cat 1
HRVETO_MINMAX Locked               1 Alp_Main LOCK_STEP_STATUS 12 12       10. 10.

#HRVETO_MINMAX DSP-NE              1 LDMoni  deltaT_Gc_NE_z_Sc_NE_zGc  -1 1 10. 10.
#HRVETO_MINMAX DSP-WE               1 LDMoni  deltaT_Gc_WE_z_Sc_WE_zGc  -1 1 10. 10.
#HRVETO_MINMAX HrecQuality          1 Hrec     quality          1 1        5. 5.

#FIX_DSP_GLITCHES Sc_NE_zCorr Gc_NE_z Sc_NE_zGc
#FIX_DSP_GLITCHES Sc_WE_zCorr Gc_WE_z Sc_WE_zGc
```

6.2 File 2: from July 1st to July 5th 2011

This configuration file is mainy the same as previous one, except that the calibration lines around 356 Hz have been moved down to around 351 Hz. Only the lines that changed are shown below:

```
----
   FINESSE 150. 357. 356. 356.5  0. 100. 200. # for the permanent lines

→ FINESSE 150. 352. 351. 351.5  0. 100. 200. # for the permanent lines
----
   GET_OGAIN 4 4 V1:Sc_NE_zCorr  356.  3. V1:Sc_WE_zCorr  356.5  3. V1:Sc_BS_zCorr 357.  3. V1:Sc_PR_zCorr 357.5 0.

→ GET_OGAIN 4 4 V1:Sc_NE_zCorr  351.  3. V1:Sc_WE_zCorr  351.5  3. V1:Sc_BS_zCorr 352.  3. V1:Sc_PR_zCorr 352.5 0.
----
   DEFINE_OGAIN  NE     1. V1:Sc_NE_zCorr_356    0. V1:Sc_NE_zCorr_91  # this is for the standard conditions
   DEFINE_OGAIN  WE      1. V1:Sc_WE_zCorr_356.5  0. V1:Sc_WE_zCorr_91.5
   DEFINE_OGAIN  BS     1. V1:Sc_BS_zCorr_357    0. V1:Sc_BS_zCorr_92
   DEFINE_OGAIN  PR     1. V1:Sc_PR_zCorr_357.5  0. V1:Sc_PR_zCorr_92.5

→ DEFINE_OGAIN  NE     1. V1:Sc_NE_zCorr_351    0. V1:Sc_NE_zCorr_91  # this is for the standard conditions
   DEFINE_OGAIN  WE      1. V1:Sc_WE_zCorr_351.5  0. V1:Sc_WE_zCorr_91.5
   DEFINE_OGAIN  BS     1. V1:Sc_BS_zCorr_352    0. V1:Sc_BS_zCorr_92
   DEFINE_OGAIN  PR     1. V1:Sc_PR_zCorr_352.5  0. V1:Sc_PR_zCorr_92.5
----
```

6.3 File 4: from July 21st 2011 to November 2011

This configuration file contains

3

- the new key (ADD_LOW_NOISE_2) used to define the calibration of the end mirrors in LN2 mode used from July 5th 2011
- and the marionette actuation parametrization used from July 21st 2011.

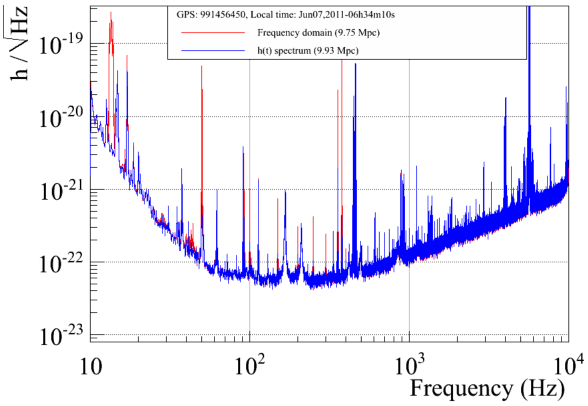
```
CFG_PRIO 3             # Main priority; 0 means no change (nice(0))
CFG_NOFILESAVE
CFG_NODBSAVE           # No commit into Db
CFG_PWD /virgoLog/Hrec   # Current logfile path <path>/<cmName>
CFG_RFLAG eloff          # Report flags: el{on,off}, stdout{on,off}, log{on,off}

DEBUG 3

FDIN_SHM   FbmQc
FDIN_TAG   "*"

FDOUT_SHM 5000000 50

FDOUT_STAT 1
FDOUT_COMPRESSION     9
FDOUT_CHPREFIX2 "V1:"

FRAME_LENGTH_OUT 1
FRAME_LENGTH  10

MIN_FR_QUALITY 0

PROCESSING_TAG HrecOnline
MIN_LOCK_STATE 12

#-------------------------------------------------------
FINESSE 150. 352. 351. 351.5  0. 100. 200. # for the permanent lines
#------------------------------------------------------

#-------Channels used for the reconstruction-----------------
#  The parameters are from VIR-0610A-10 + add 3us on the sensing and 3us on the actuation
#---The first channel must be the dark fring---
#         name          Gain      delay    debug    OpticalGainName
CHANNEL   V1:Pr_B1_ACp    1.  +62.7e-6    0    CAVITIES  0. NONE

CHANNEL   V1:Sc_WE_zCorr   19.885e-6   +272.1e-6    0 WE  0. NONE
 ADD_DAC
 ADD_POLE    0.6   1000
 ADD_LOW_NOISE_2  18.656e-6  249.5e-6 Sc_WE_Gain_LockSW -1

CHANNEL   V1:Sc_NE_zCorr   22.48e-6   +268.2e-6    0  NE 0. NONE
 ADD_DAC
 ADD_POLE    0.6  1000
 ADD_LOW_NOISE_2  20.847e-6   +262.5e-6 Sc_NE_Gain_LockSW -1

CHANNEL   V1:Sc_BS_zCorr   -89.628e-6  +222.5e-6    0 BS  0.  NONE
 ADD_POLE  3183.3  0
 ADD_DAC
 ADD_POLE  .6   1000

CHANNEL   V1:Sc_PR_zCorr   -14.26e-6  +459.9e-6    0 PR 0. NONE
 ADD_POLE  77.7  0
 ADD_ZERO  91.9  0
 ADD_POLE    0.6   1000
# next line is for the PR optical response 1/(2Pi*7.67) = 0.02075
#ADD_FILTER_2 0. 0.02075 0. 0. 0.02075 1.
#ADD_POLE 512.   0.
#ADD_ZERO 500.   0.
# this last zero is to remove to cavity pole which is already included


CHANNEL   V1:Sc_WE_zM  3.729e-6  +1809.41e-6    0 WE 0.  NONE
 ADD_POLE    85.1292    0.
 ADD_ZERO   167.594     0.9353
 ADD_POLE    10.513     0.
 ADD_ZERO    43.790     0.
 ADD_POLE     0.6    1000.
 ADD_POLE     0.6    1000.
 ADD_POLE  1000.       0.7

CHANNEL   V1:Sc_NE_zM  3.988e-6  +701.2e-6    0 NE 0. NONE
 ADD_POLE     54.940    0.
 ADD_ZERO    373.964    0.
 ADD_POLE     10.550    0.
 ADD_ZERO     37.734    0.
 ADD_POLE      0.6   1000.
 ADD_POLE      0.6   1000.
 ADD_POLE  1000.       0.7
```

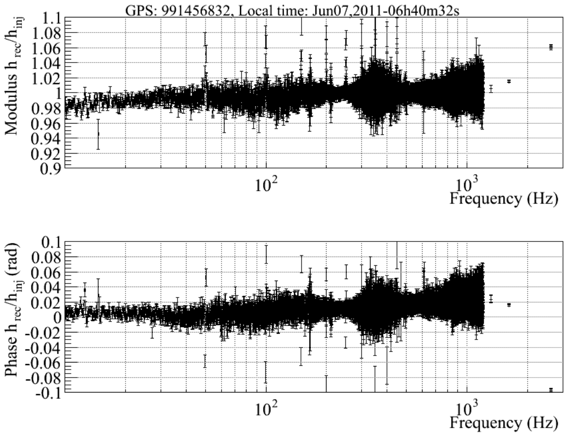
3

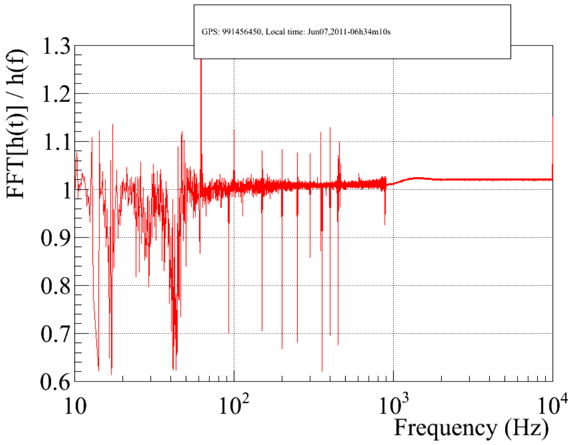
```
SAVE_FFT V1:Pr_B1_ACp   0. 2000. 400
SAVE_FFT V1:Sc_WE_zCorr 0. 2000. 400
SAVE_FFT V1:Sc_NE_zCorr 0. 2000. 400
SAVE_FFT V1:Sc_BS_zCorr 0. 2000. 400
SAVE_FFT V1:Sc_PR_zCorr 0. 2000. 400
SAVE_FFT V1:Sc_NE_zM    0. 2000. 400
SAVE_FFT V1:Sc_WE_zM    0. 2000. 400
SAVE_FFT V1:h_Watt      0. 2000. 400

#--------- this is to compute the optical gains with the usual permanent lines ---
GET_OGAIN 4 4 V1:Sc_NE_zCorr   91.  0. V1:Sc_WE_zCorr   91.5  0. V1:Sc_BS_zCorr  92.  0. V1:Sc_PR_zCorr 92.5. 0.
GET_OGAIN 4 4 V1:Sc_NE_zCorr  351.  3. V1:Sc_WE_zCorr  351.5  3. V1:Sc_BS_zCorr 352.  3. V1:Sc_PR_zCorr 352.5 0.

#----------- name   coef1     channel        coef2    channel2
DEFINE_OGAIN  NE      1. V1:Sc_NE_zCorr_351    0. V1:Sc_NE_zCorr_91  # this is for the standard conditions
DEFINE_OGAIN  WE      1. V1:Sc_WE_zCorr_351.5  0. V1:Sc_WE_zCorr_91.5
DEFINE_OGAIN  BS      1. V1:Sc_BS_zCorr_352    0. V1:Sc_BS_zCorr_92
DEFINE_OGAIN  PR      1. V1:Sc_PR_zCorr_352.5  0. V1:Sc_PR_zCorr_92.5
DEFINE_OGAIN CAVITIES 0.5 NE                   0.5 WE

#-------- define the frequencies produced
#H_FREQUENCY  4000 V1:h_4000Hz_NEW
H_FREQUENCY  4096 V1:h_4096Hz_With50Hz
H_FREQUENCY 16384 V1:h_16384Hz_With50Hz
H_FREQUENCY 20000 V1:h_20kHz_With50Hz

#------ Power line removal
#--------------input------------output-----------monitor--------freq----tFreq---tCoupl.-nHarmonic
#LINE_REMOVAL V1:h_4000Hz_NEW   V1:h_4000Hz   V1:Em_IPSDET03_tmp     50.      1.      2.     18
LINE_REMOVAL V1:h_4096Hz_With50Hz   V1:h_4096Hz   V1:Em_IPSDET03_tmp    50.      1.      2.     9
LINE_REMOVAL V1:h_16384Hz_With50Hz  V1:h_16384Hz  V1:Em_IPSDET03_tmp    50.      1.      2.     9
LINE_REMOVAL V1:h_20kHz_With50Hz    V1:h_20000Hz  V1:Em_IPSDET03_tmp    50.      1.      2.     9

#--------------------------
HORIZON_CHANNEL V1:h_20000Hz

#------------------------------------------------vetos cat 2
HRVETO_MINMAX ScienceMode           2 Qc_Moni  Mode            1 1        2. 2
HRVETO_MINMAX d2_ACq_Saturation      2 NULL     Pr_B1_d2_ACq    -990000 990000 2. 2. # +- 9.5 Volts
HRVETO_MINMAX d3_ACq_Saturation      2 NULL     Pr_B1_d3_ACq    -990000 990000 2. 2. # +- 9.5 Volts
HRVETO_MINMAX d4_ACq_Saturation      2 NULL     Pr_B1_d4_ACq    -990000 990000 2. 2. # +- 9.5 Volts
HRVETO_MINMAX d5_ACq_Saturation      2 NULL     Pr_B1_d5_ACq    -990000 990000 2. 2. # +- 9.5 Volts
HRVETO_MINMAX Sc_NE_CoilU_Saturation 2 NULL     Sc_NE_RM_CoilU  -9.9 9.9     2. 2.
HRVETO_MINMAX Sc_NE_CoilD_Saturation 2 NULL     Sc_NE_RM_CoilD  -9.9 9.9     2. 2.
HRVETO_MINMAX Sc_WE_CoilU_Saturation 2 NULL     Sc_WE_RM_CoilU  -9.9 9.9     2. 2.
HRVETO_MINMAX Sc_WE_CoilD_Saturation 2 NULL     Sc_WE_RM_CoilD  -9.9 9.9     2. 2.
HRVETO_MINMAX SSFS_Saturation        2 NULL     Sc_IB_SSFS_Corr -9.9 9.9     2. 2.
HRVETO_MINMAX Locked                2 Alp_Main LOCK_STEP_STATUS 12 13       10. 300.

#------------------------------------------------vetos cat 1
HRVETO_MINMAX Locked                1 Alp_Main LOCK_STEP_STATUS 12 13       10. 10.

#HRVETO_MINMAX DSP-NE               1 LDMoni  deltaT_Gc_NE_z_Sc_NE_zGc  -1 1 10. 10.
#HRVETO_MINMAX DSP-WE               1 LDMoni  deltaT_Gc_WE_z_Sc_WE_zGc  -1 1 10. 10.
#HRVETO_MINMAX HrecQuality          1 Hrec     quality         1 1        5. 5.

#FIX_DSP_GLITCHES Sc_NE_zCorr Gc_NE_z Sc_NE_zGc
#FIX_DSP_GLITCHES Sc_WE_zCorr Gc_WE_z Sc_WE_zGc
```

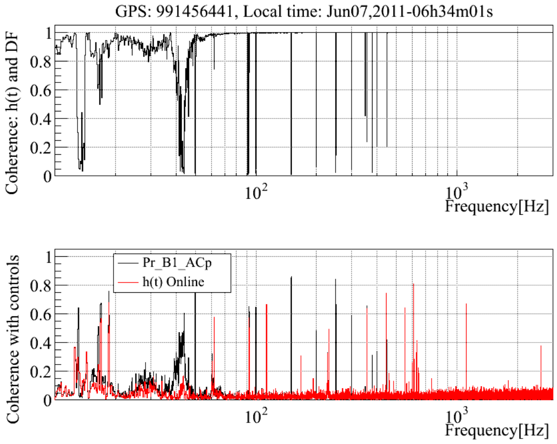
7 Appendix II – Weekly calibration checks of HrecOnline

The following figures present the results of the checks made during the weekly calibration periods.

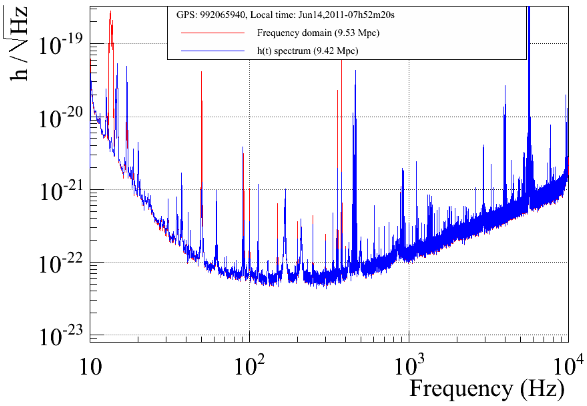


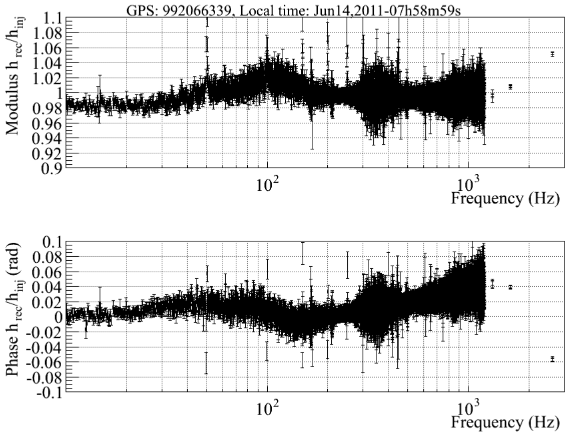


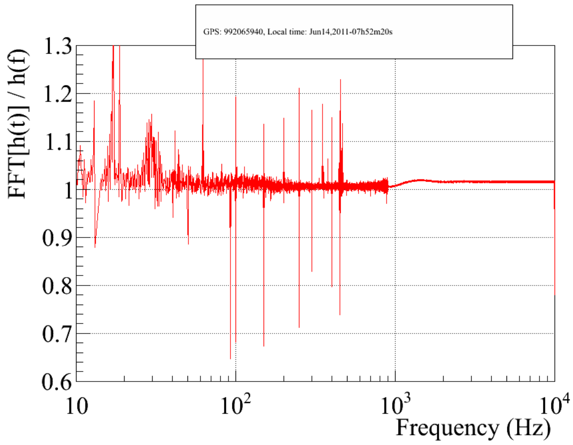


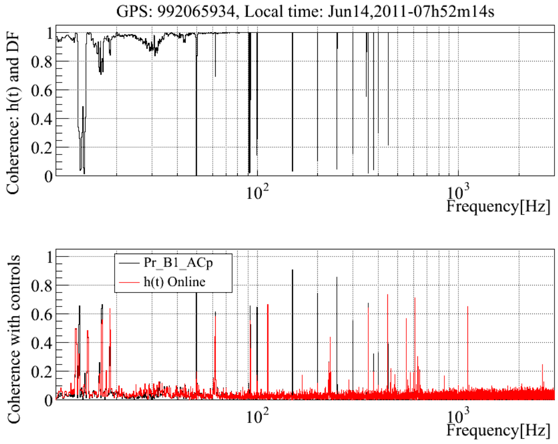


3

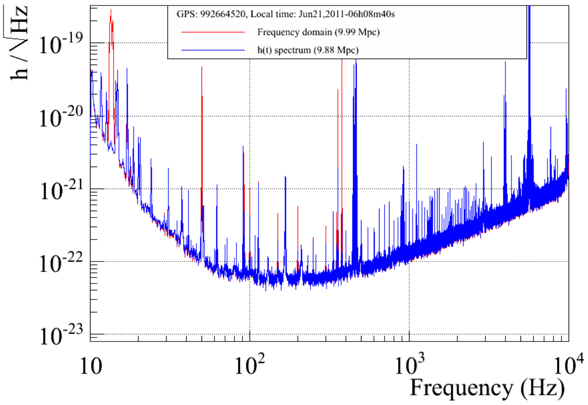

GPS: 992065940, Local time: Jun14,2011-07h52m20s
Frequency domain (9.53 Mpc)
h(t) spectrum (9.42 Mpc)
h / √Hz
10^-19
10^-20
10^-21
10^-22
10^-23
10
10^2
10^3
10^4
Frequency (Hz)

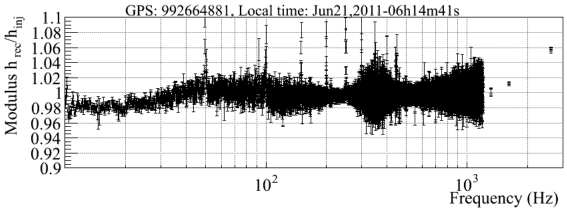

GPS: 992066339, Local time: Jun14,2011-07h58m59s
Modulus h_rec/h_inj
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h_rec/h_inj (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

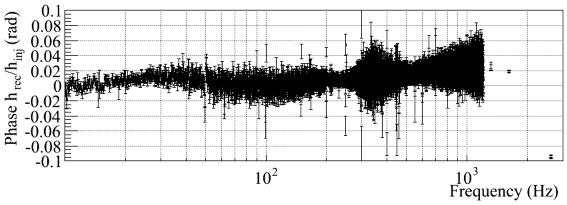

GPS: 992065940, Local time: Jun14,2011-07h52m20s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

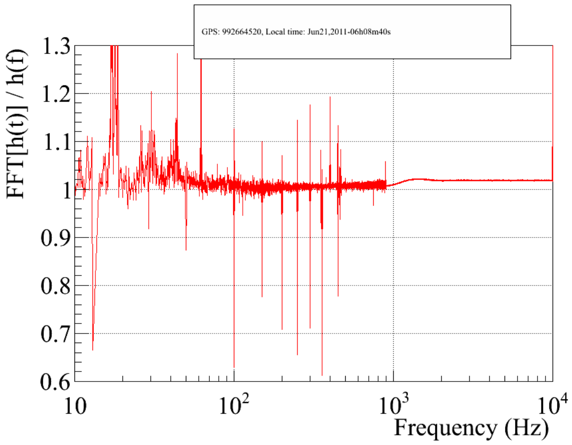

GPS: 992065934, Local time: Jun14,2011-07h52m14s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]
Coherence with controls
Pr_B1_ACp
h(t) Online
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

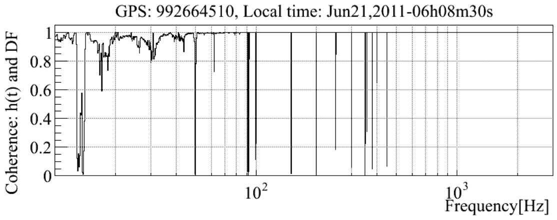
3

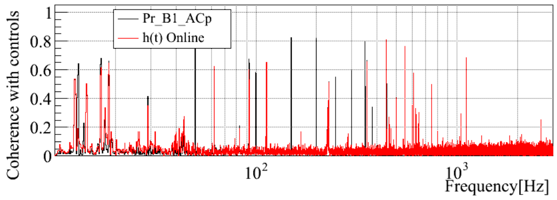

GPS: 992664520, Local time: Jun21,2011-06h08m40s
Frequency domain (9.99 Mpc)
h(t) spectrum (9.88 Mpc)
h / √Hz
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10
10^2
10^3
10^4
Frequency (Hz)


GPS: 992664881, Local time: Jun21,2011-06h14m41s
Modulus h_{rec}/h_{inj}
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)

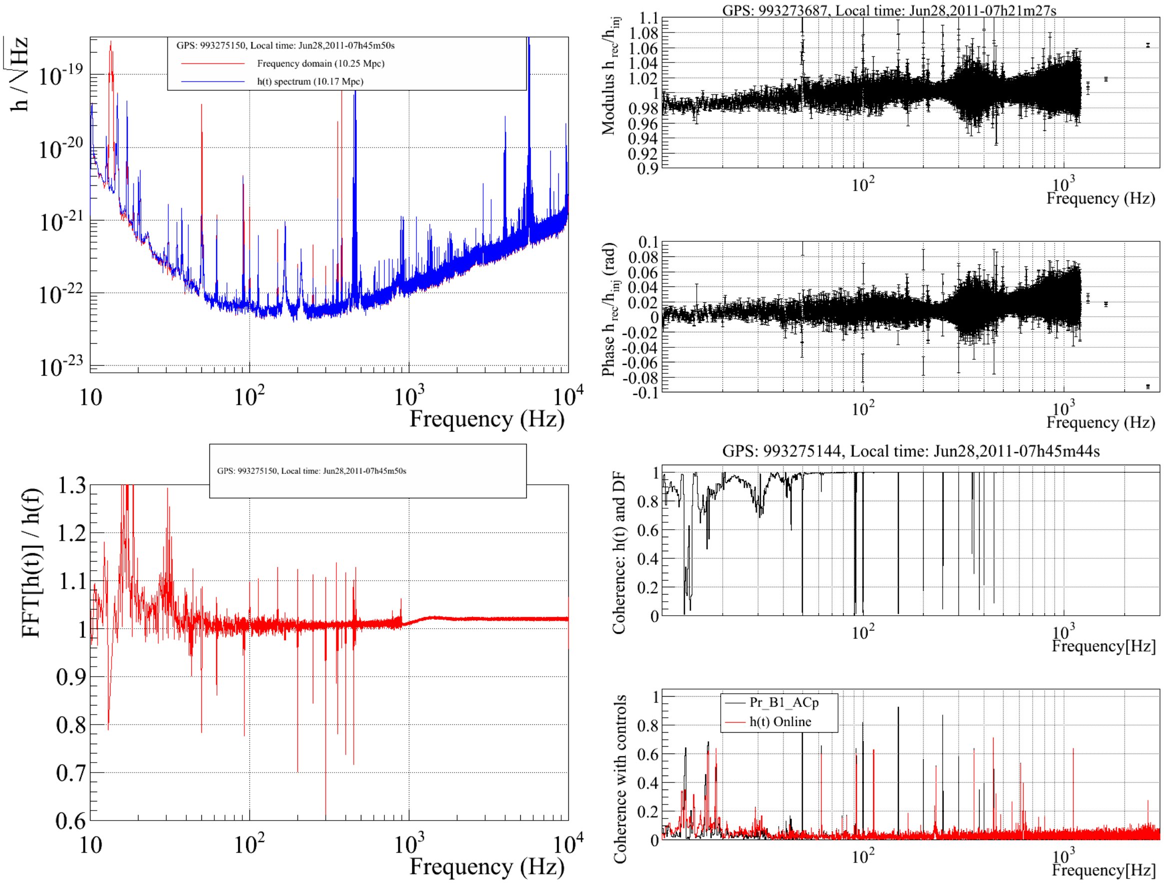

Phase h_{rec}/h_{inj} (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)


GPS: 992664520, Local time: Jun21,2011-06h08m40s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

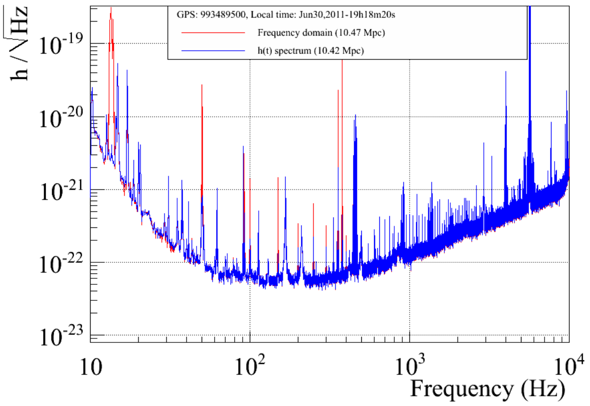

GPS: 992664510, Local time: Jun21,2011-06h08m30s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

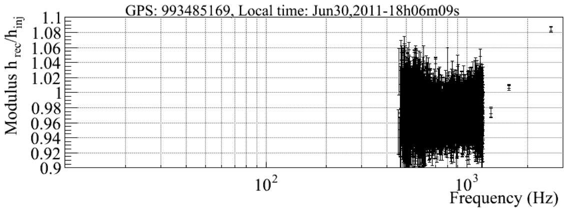

Pr_B1_ACp
h(t) Online
Coherence with controls
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

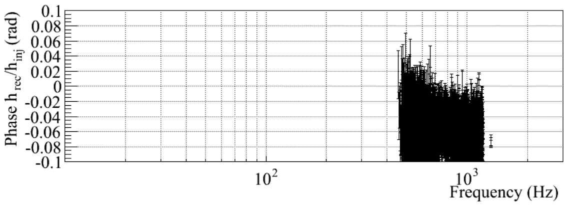
[3]

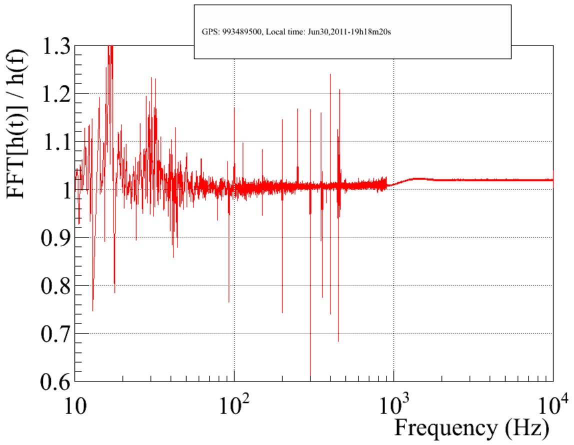

h / √Hz
10^-19
10^-20
10^-21
10^-22
10^-23
GPS: 993275150, Local time: Jun28,2011-07h45m50s
Frequency domain (10.25 Mpc)
h(t) spectrum (10.17 Mpc)
10
10^2
10^3
10^4
Frequency (Hz)
GPS: 993273687, Local time: Jun28,2011-07h21m27s
Modulus h_rec/h_inj
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h_rec/h_inj (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)
GPS: 993275150, Local time: Jun28,2011-07h45m50s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)
GPS: 993275144, Local time: Jun28,2011-07h45m44s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]
Coherence with controls
Pr_B1_ACp
h(t) Online
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

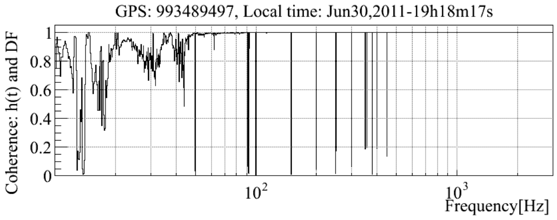
3

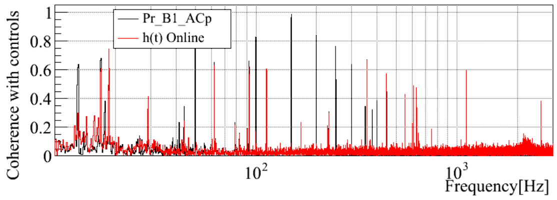

GPS: 993489500, Local time: Jun30,2011-19h18m20s
Frequency domain (10.47 Mpc)
h(t) spectrum (10.42 Mpc)
h / √Hz
10^-19
10^-20
10^-21
10^-22
10^-23
10
10^2
10^3
10^4
Frequency (Hz)


GPS: 993485169, Local time: Jun30,2011-18h06m09s
Modulus h_rec/h_inj
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)

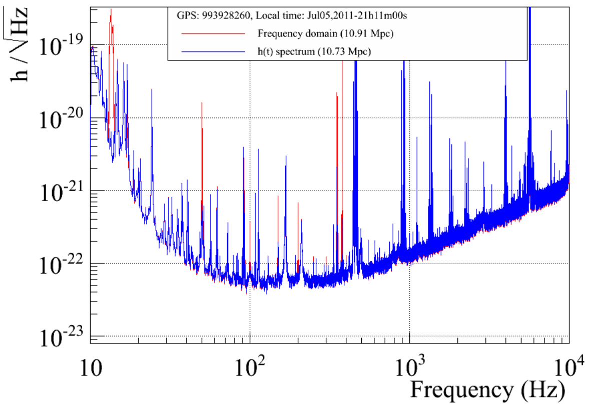

Phase h_rec/h_inj (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

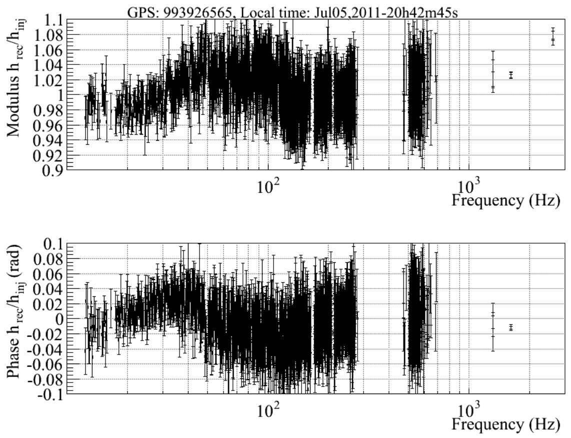

GPS: 993489500, Local time: Jun30,2011-19h18m20s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

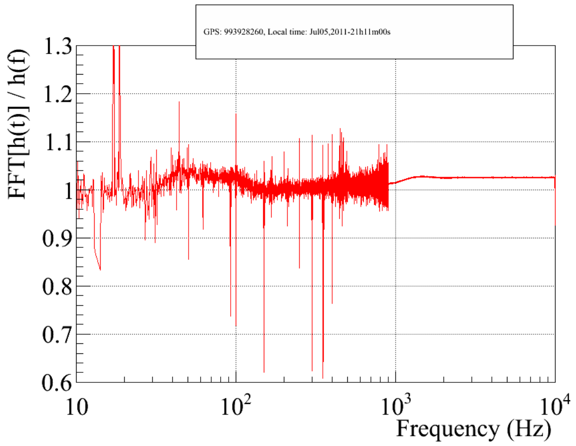

GPS: 993489497, Local time: Jun30,2011-19h18m17s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

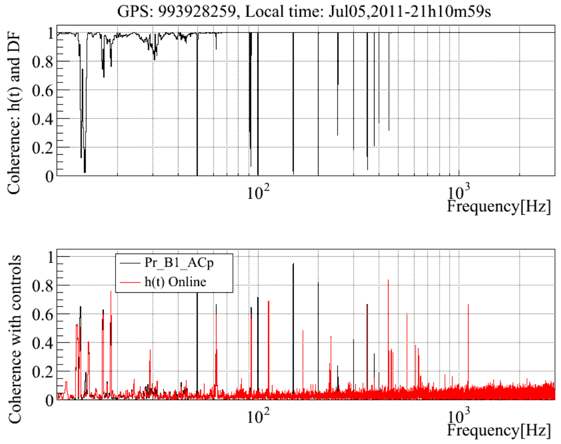

Pr_B1_ACp
h(t) Online
Coherence with controls
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

3

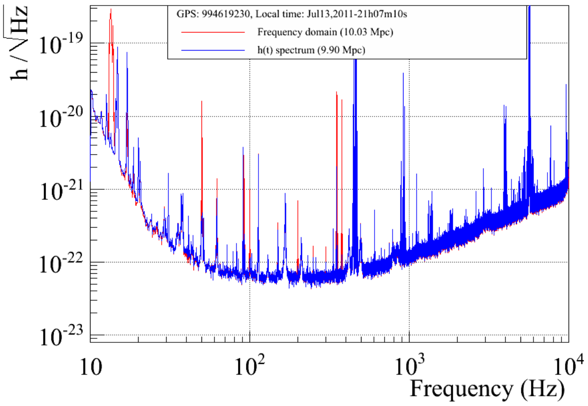

GPS: 993928260, Local time: Jul05,2011-21h11m00s
Frequency domain (10.91 Mpc)
h(t) spectrum (10.73 Mpc)
$h / \sqrt{Hz}$
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10
10^2
10^3
10^4
Frequency (Hz)

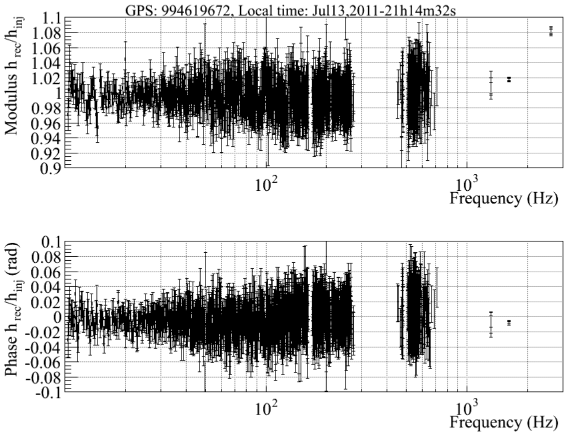

GPS: 993926565, Local time: Jul05,2011-20h42m45s
Modulus h_{rec}/h_{inj}
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h_{rec}/h_{inj} (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

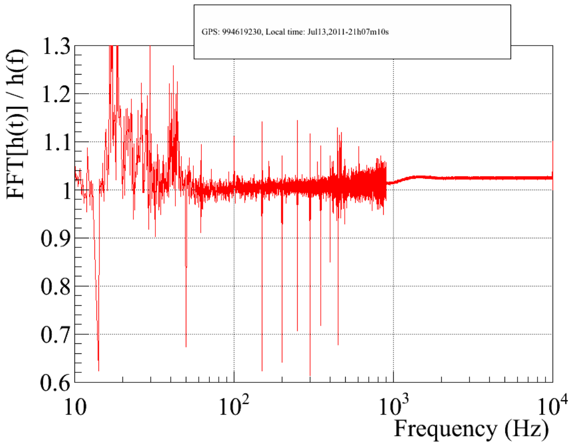

GPS: 993928260, Local time: Jul05,2011-21h11m00s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

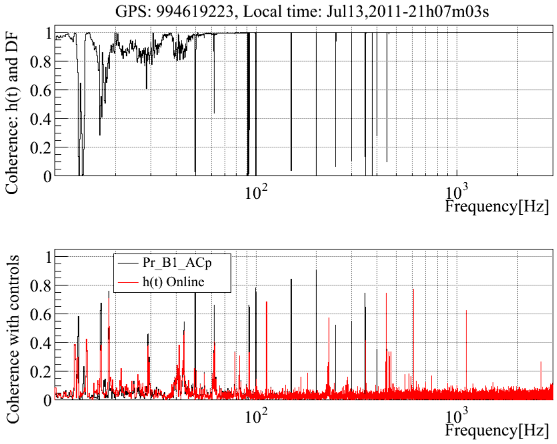

GPS: 993928259, Local time: Jul05,2011-21h10m59s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]
Coherence with controls
Pr_B1_ACp
h(t) Online
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

3

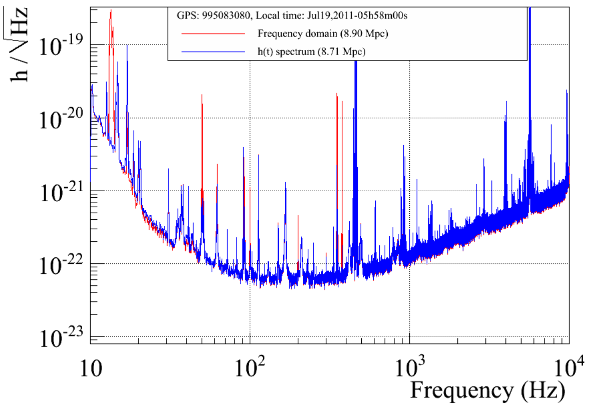

GPS: 994619230, Local time: Jul13,2011-21h07m10s
Frequency domain (10.03 Mpc)
h(t) spectrum (9.90 Mpc)
h / √Hz
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10
10^2
10^3
10^4
Frequency (Hz)

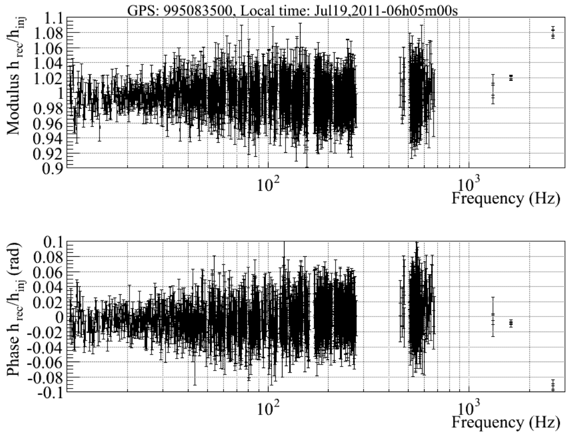

GPS: 994619672, Local time: Jul13,2011-21h14m32s
Modulus h_{rec}/h_{inj}
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h_{rec}/h_{inj} (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

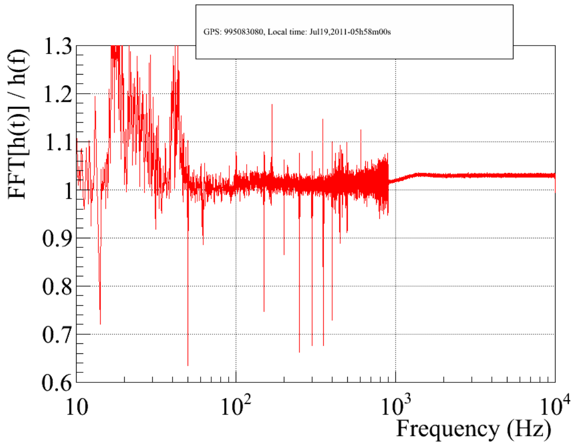

GPS: 994619230, Local time: Jul13,2011-21h07m10s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

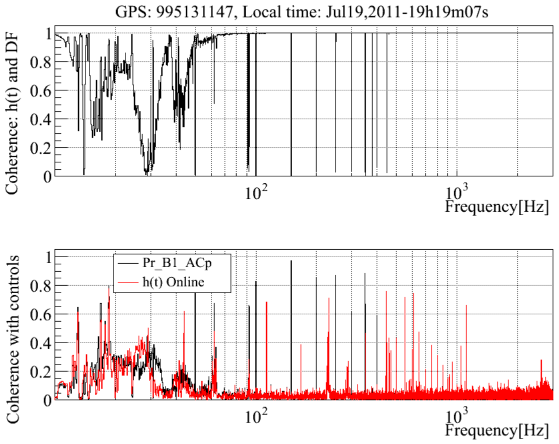

GPS: 994619223, Local time: Jul13,2011-21h07m03s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]
Pr_B1_ACp
h(t) Online
Coherence with controls
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

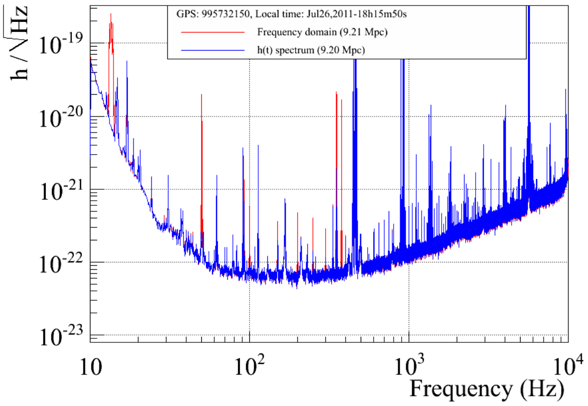
3

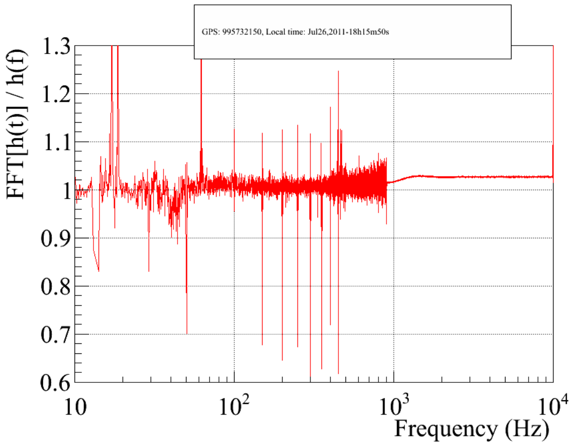

GPS: 995083080, Local time: Jul19,2011-05h58m00s
Frequency domain (8.90 Mpc)
h(t) spectrum (8.71 Mpc)
h / √Hz
10^-19
10^-20
10^-21
10^-22
10^-23
10
10^2
10^3
10^4
Frequency (Hz)

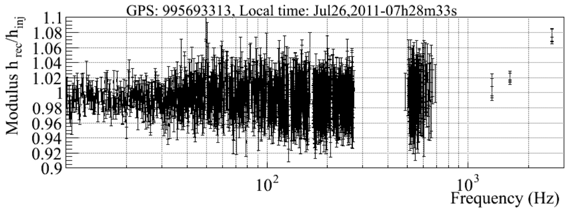

GPS: 995083500, Local time: Jul19,2011-06h05m00s
Modulus h_rec/h_inj
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h_rec/h_inj (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

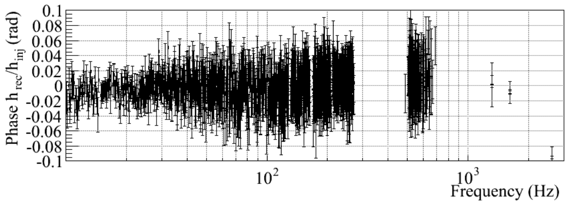

GPS: 995083080, Local time: Jul19,2011-05h58m00s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

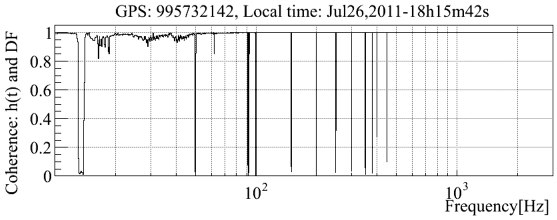

GPS: 995131147, Local time: Jul19,2011-19h19m07s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]
Coherence with controls
Pr_B1_ACp
h(t) Online
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

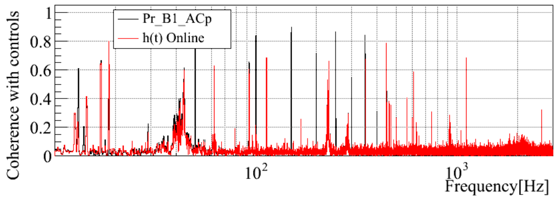

GPS: 995732150, Local time: Jul26,2011-18h15m50s
Frequency domain (9.21 Mpc)
h(t) spectrum (9.20 Mpc)
h / √Hz
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10
10^{2}
10^{3}
10^{4}
Frequency (Hz)

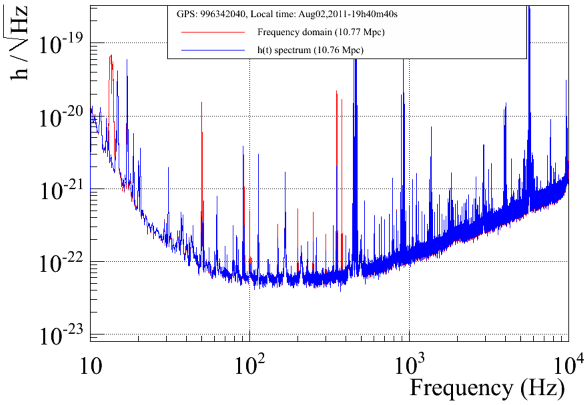

GPS: 995732150, Local time: Jul26,2011-18h15m50s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^{2}
10^{3}
10^{4}
Frequency (Hz)

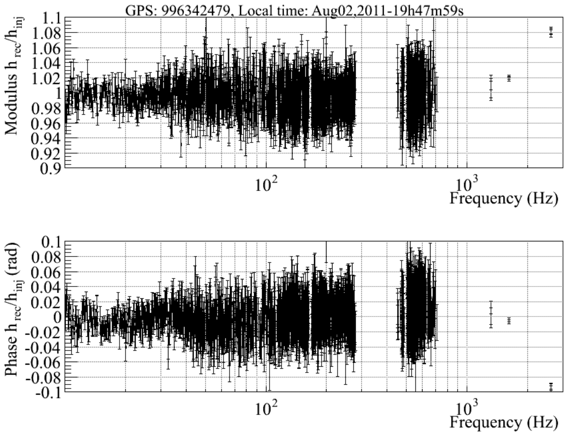

GPS: 995693313, Local time: Jul26,2011-07h28m33s
Modulus h_{rec}/h_{inj}
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^{2}
10^{3}
Frequency (Hz)

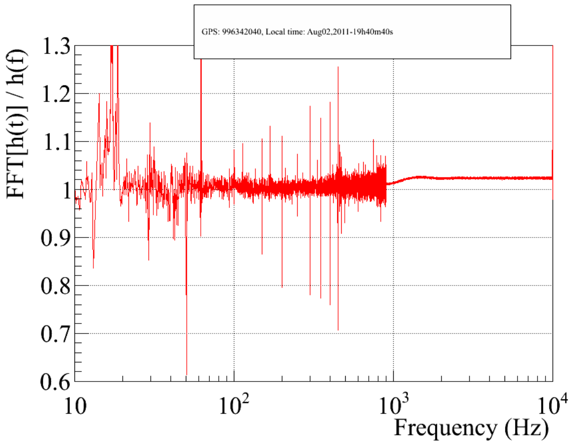

Phase h_{rec}/h_{inj} (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^{2}
10^{3}
Frequency (Hz)

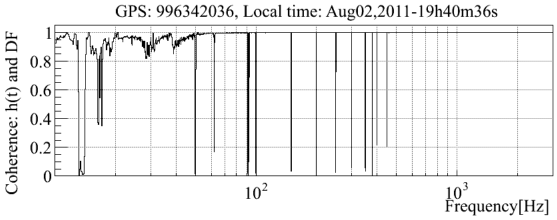

GPS: 995732142, Local time: Jul26,2011-18h15m42s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^{2}
10^{3}
Frequency[Hz]

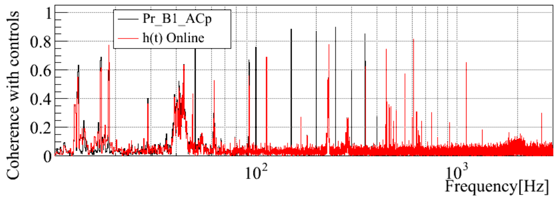

Pr_B1_ACp
h(t) Online
Coherence with controls
1
0.8
0.6
0.4
0.2
0
10^{2}
10^{3}
Frequency[Hz]


GPS: 996342040, Local time: Aug02,2011-19h40m40s
Frequency domain (10.77 Mpc)
h(t) spectrum (10.76 Mpc)
h / √Hz
10^-19
10^-20
10^-21
10^-22
10^-23
10
10^2
10^3
10^4
Frequency (Hz)

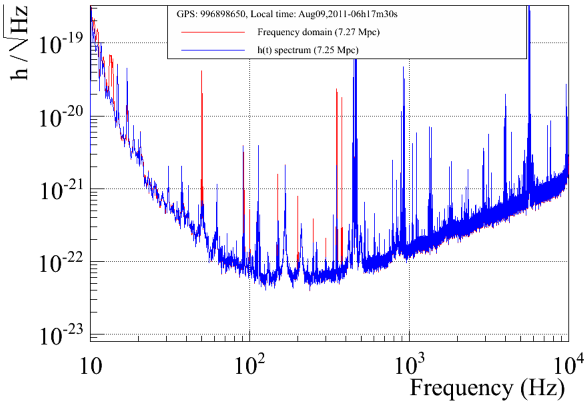

GPS: 996342479, Local time: Aug02,2011-19h47m59s
Modulus h rec/h inj
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h rec/h inj (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

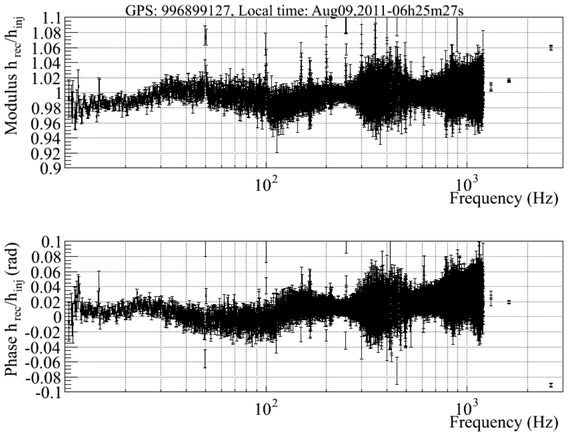

GPS: 996342040, Local time: Aug02,2011-19h40m40s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

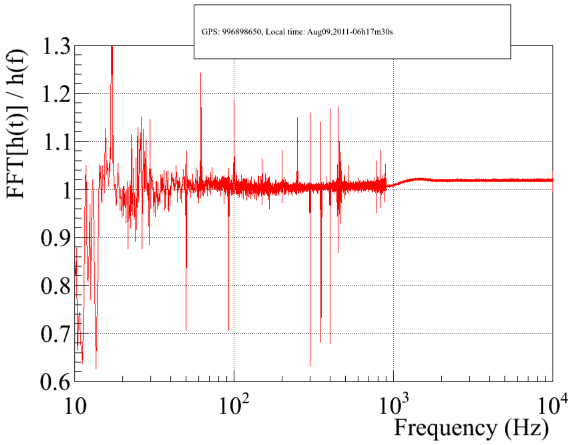

GPS: 996342036, Local time: Aug02,2011-19h40m36s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

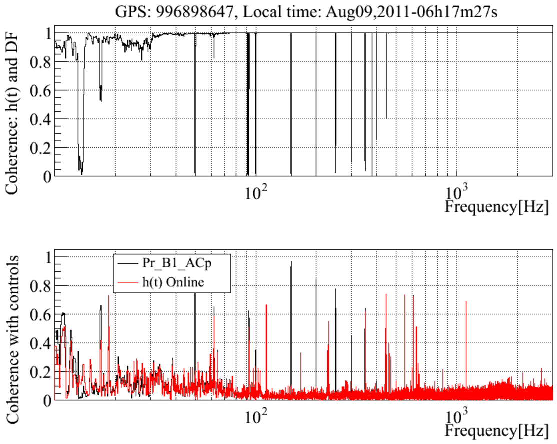

Pr_B1_ACp
h(t) Online
Coherence with controls
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

3

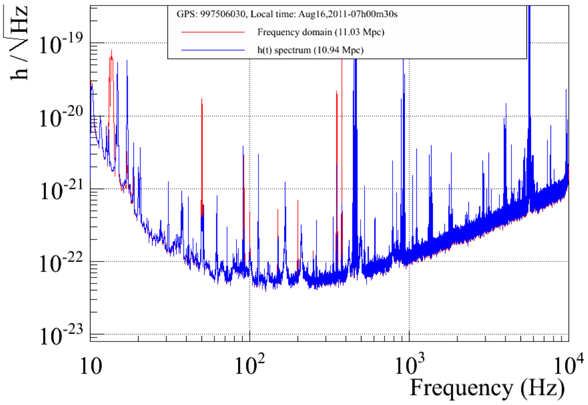

GPS: 996898650, Local time: Aug09,2011-06h17m30s
Frequency domain (7.27 Mpc)
h(t) spectrum (7.25 Mpc)
$h / \sqrt{Hz}$
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10
10^2
10^3
10^4
Frequency (Hz)

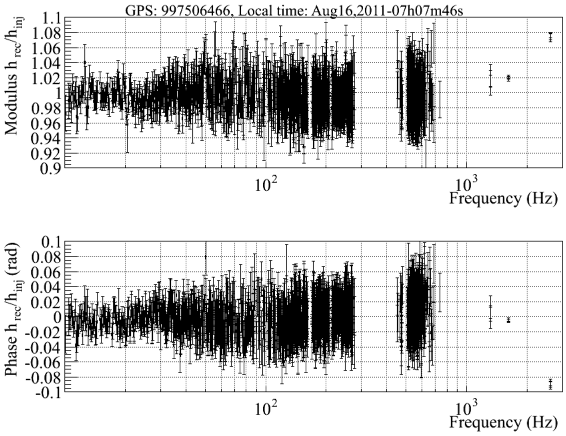

GPS: 996899127, Local time: Aug09,2011-06h25m27s
Modulus h_{rec}/h_{inj}
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h_{rec}/h_{inj} (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

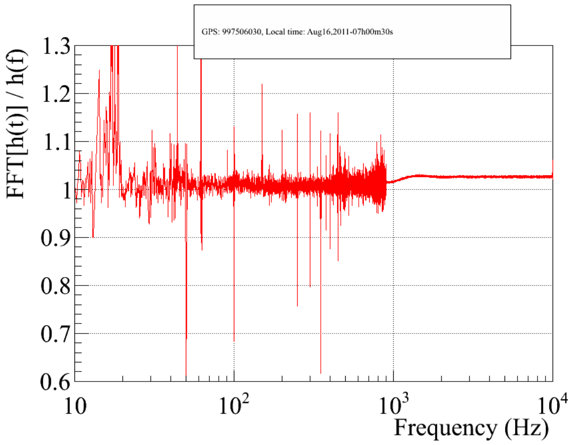

GPS: 996898650, Local time: Aug09,2011-06h17m30s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

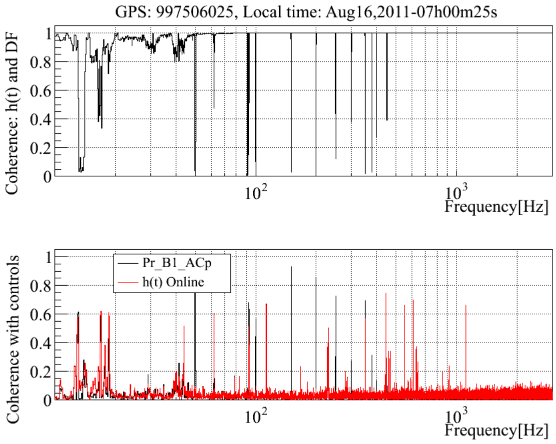

GPS: 996898647, Local time: Aug09,2011-06h17m27s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]
Coherence with controls
Pr_B1_ACp
h(t) Online
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

3

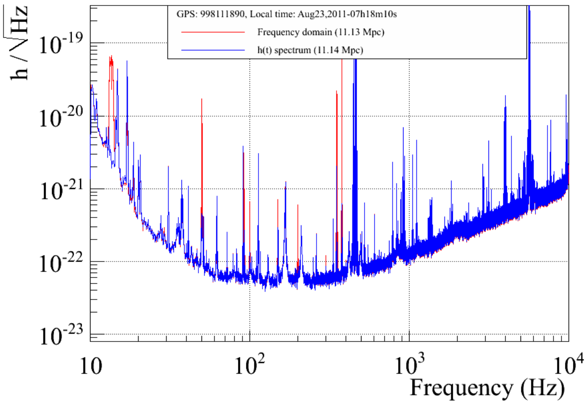

GPS: 997506030, Local time: Aug16,2011-07h00m30s
Frequency domain (11.03 Mpc)
h(t) spectrum (10.94 Mpc)
h / √Hz
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10
10^2
10^3
10^4
Frequency (Hz)

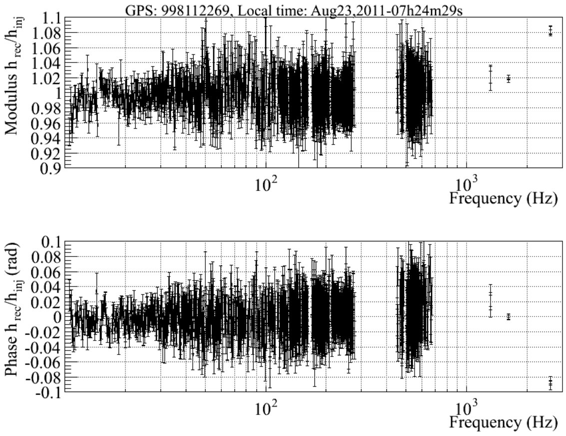

GPS: 997506466, Local time: Aug16,2011-07h07m46s
Modulus h_{rec}/h_{inj}
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h_{rec}/h_{inj} (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

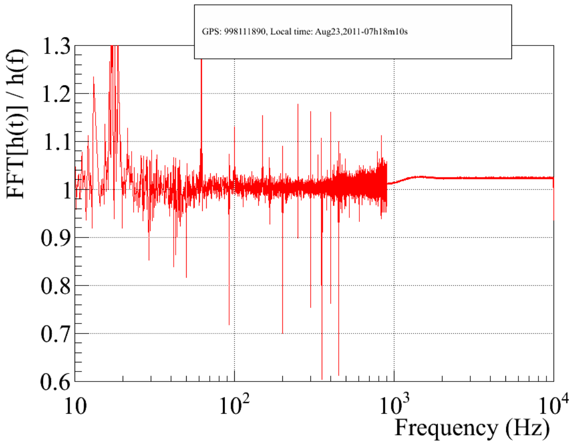

GPS: 997506030, Local time: Aug16,2011-07h00m30s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

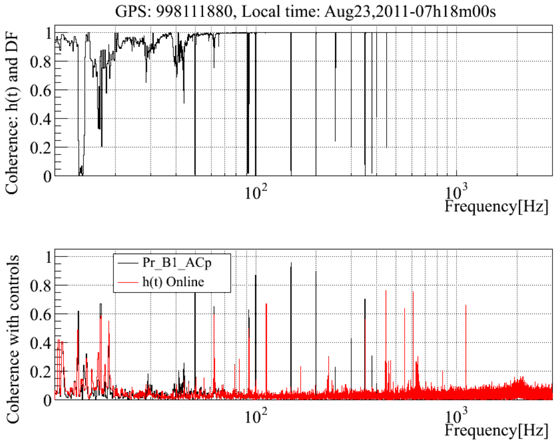

GPS: 997506025, Local time: Aug16,2011-07h00m25s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]
Pr_B1_ACp
h(t) Online
Coherence with controls
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

3

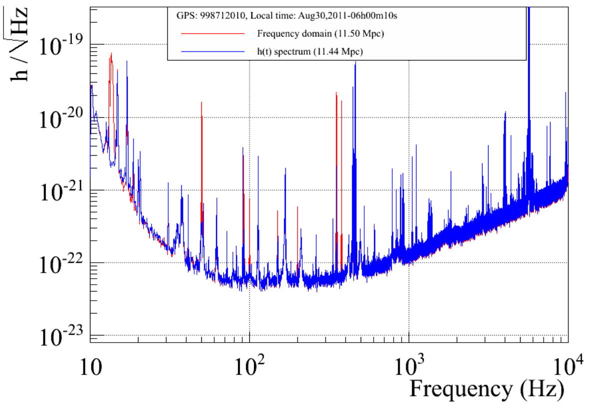

GPS: 998111890, Local time: Aug23,2011-07h18m10s
Frequency domain (11.13 Mpc)
h(t) spectrum (11.14 Mpc)
h / √Hz
10^-19
10^-20
10^-21
10^-22
10^-23
10
10^2
10^3
10^4
Frequency (Hz)

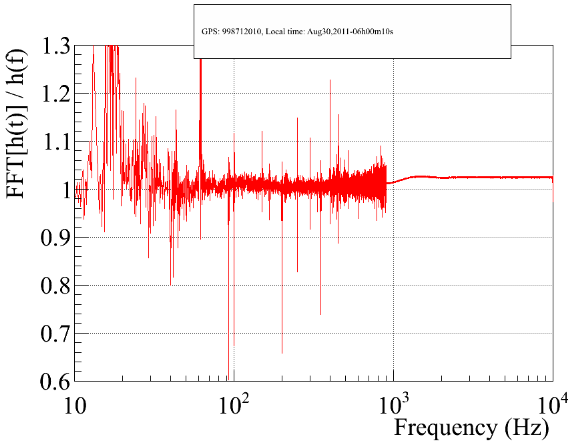

GPS: 998112269, Local time: Aug23,2011-07h24m29s
Modulus h_rec/h_inj
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h_rec/h_inj (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

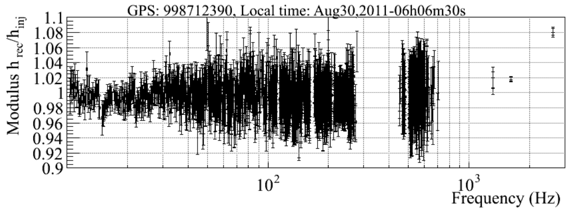

GPS: 998111890, Local time: Aug23,2011-07h18m10s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

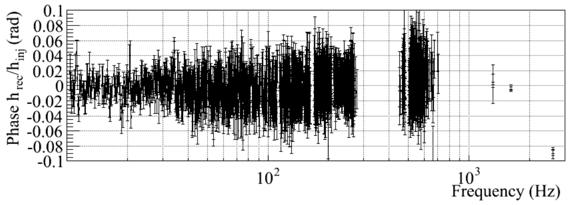

GPS: 998111880, Local time: Aug23,2011-07h18m00s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]
Pr_B1_ACp
h(t) Online
Coherence with controls
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

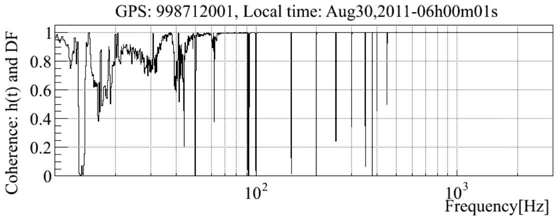
3

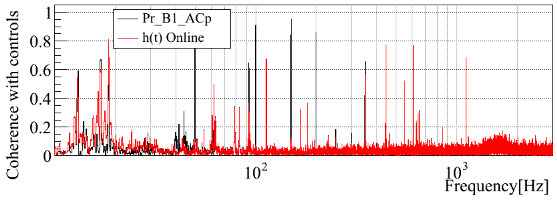

GPS: 998712010, Local time: Aug30,2011-06h00m10s
Frequency domain (11.50 Mpc)
h(t) spectrum (11.44 Mpc)
h / √Hz
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10
10^2
10^3
10^4
Frequency (Hz)


GPS: 998712010, Local time: Aug30,2011-06h00m10s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)

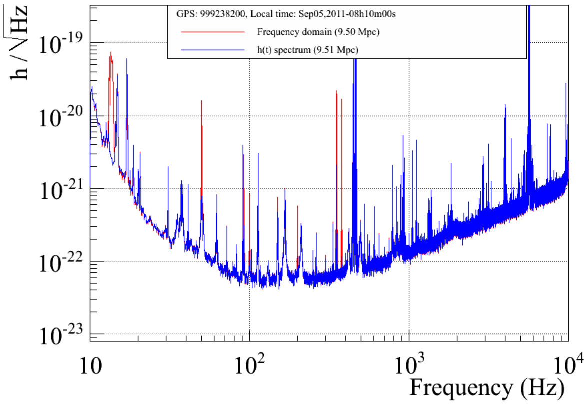

GPS: 998712390, Local time: Aug30,2011-06h06m30s
Modulus h_{rec}/h_{inj}
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)

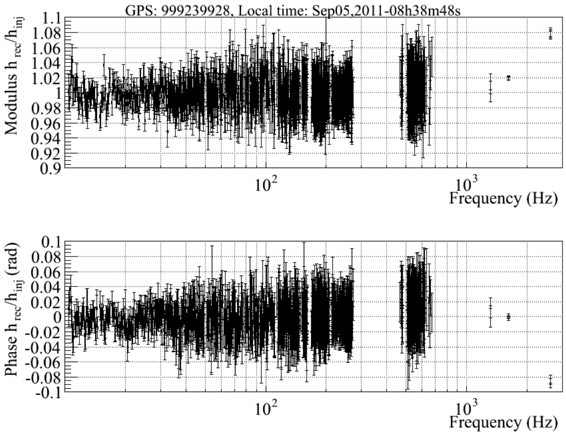

Phase h_{rec}/h_{inj} (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)

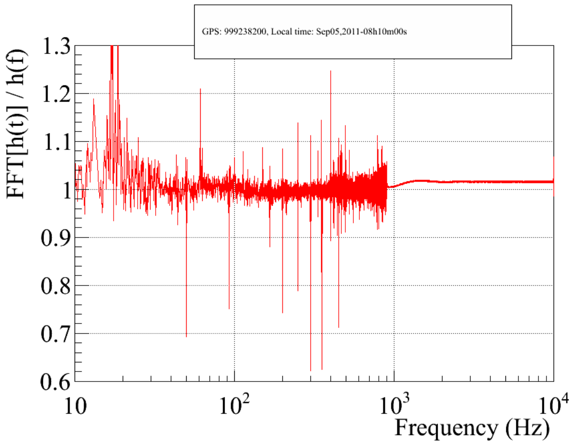

GPS: 998712001, Local time: Aug30,2011-06h00m01s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

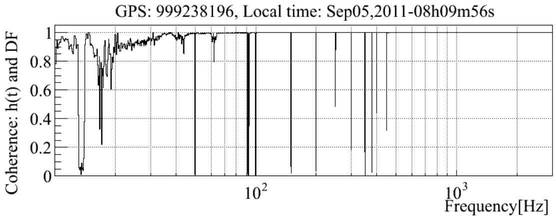

Pr_B1_ACp
h(t) Online
Coherence with controls
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]

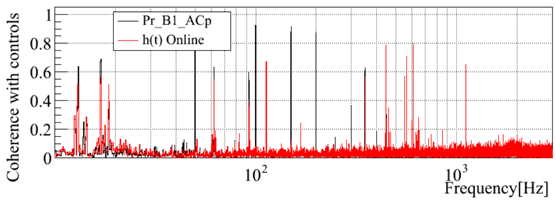
3


GPS: 999238200, Local time: Sep05,2011-08h10m00s
Frequency domain (9.50 Mpc)
h(t) spectrum (9.51 Mpc)
h / √Hz
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10
10^2
10^3
10^4
Frequency (Hz)


GPS: 999239928, Local time: Sep05,2011-08h38m48s
Modulus h_{rec}/h_{inj}
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
Frequency (Hz)
Phase h_{rec}/h_{inj} (rad)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10^2
10^3
Frequency (Hz)


GPS: 999238200, Local time: Sep05,2011-08h10m00s
FFT[h(t)] / h(f)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
10
10^2
10^3
10^4
Frequency (Hz)


GPS: 999238196, Local time: Sep05,2011-08h09m56s
Coherence: h(t) and DF
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]


Pr_B1_ACp
h(t) Online
Coherence with controls
1
0.8
0.6
0.4
0.2
0
10^2
10^3
Frequency[Hz]