Robust Detection of Noise Floor Drifts in Interferometric Data

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Motivation :

- Interferometric data has three components : Lines, transients, noise floor.
- Study of a change in any one of these without elimination of the other two will cause interference.
- Lines dominate.
- Presence of transients change the central tendency.
- "SLOW" nonstationarity of noise floor interesting in the analysis of several astrophysical searches, e.g. Externally triggered search.

Methods :

- Running Median.

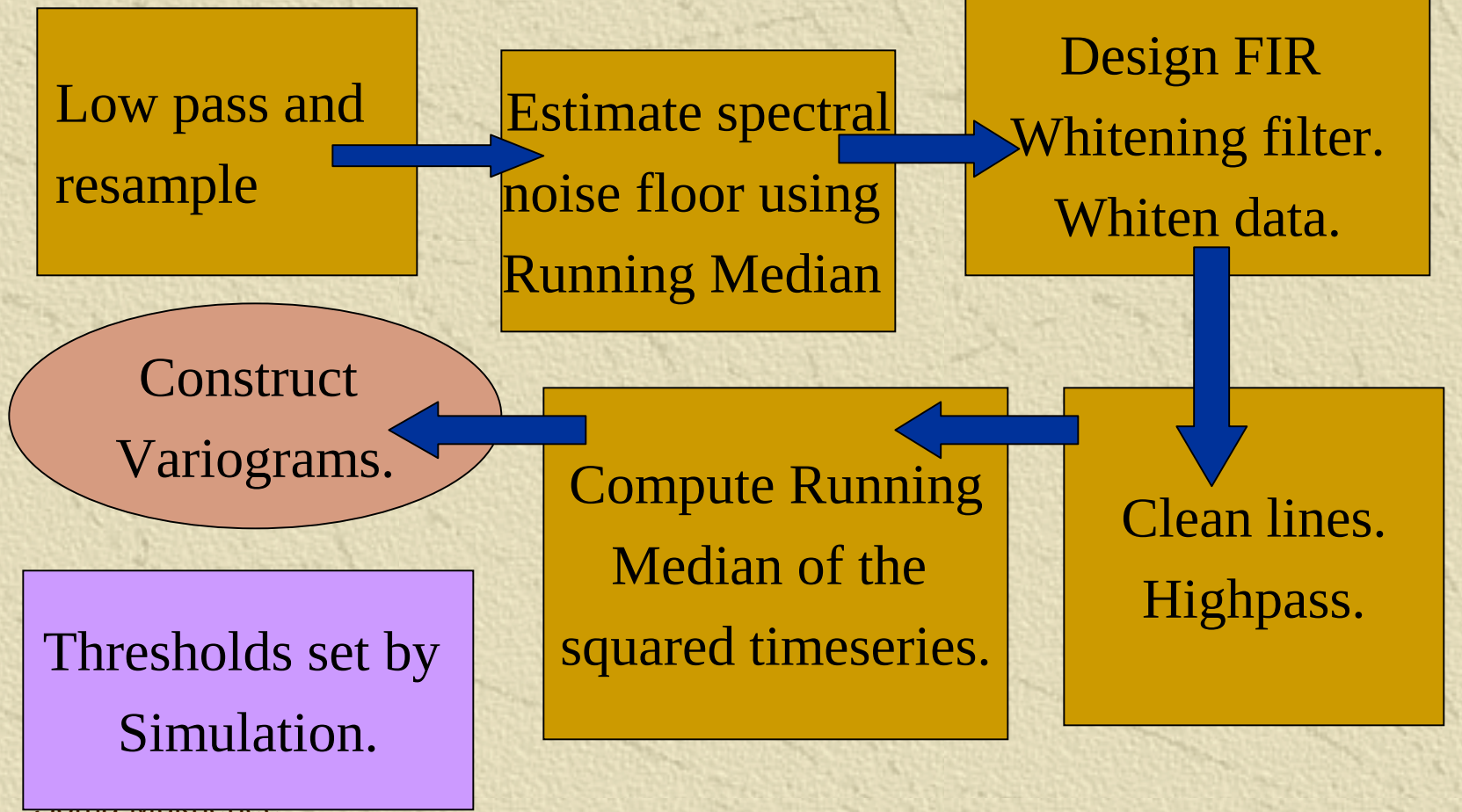
- Computation of :

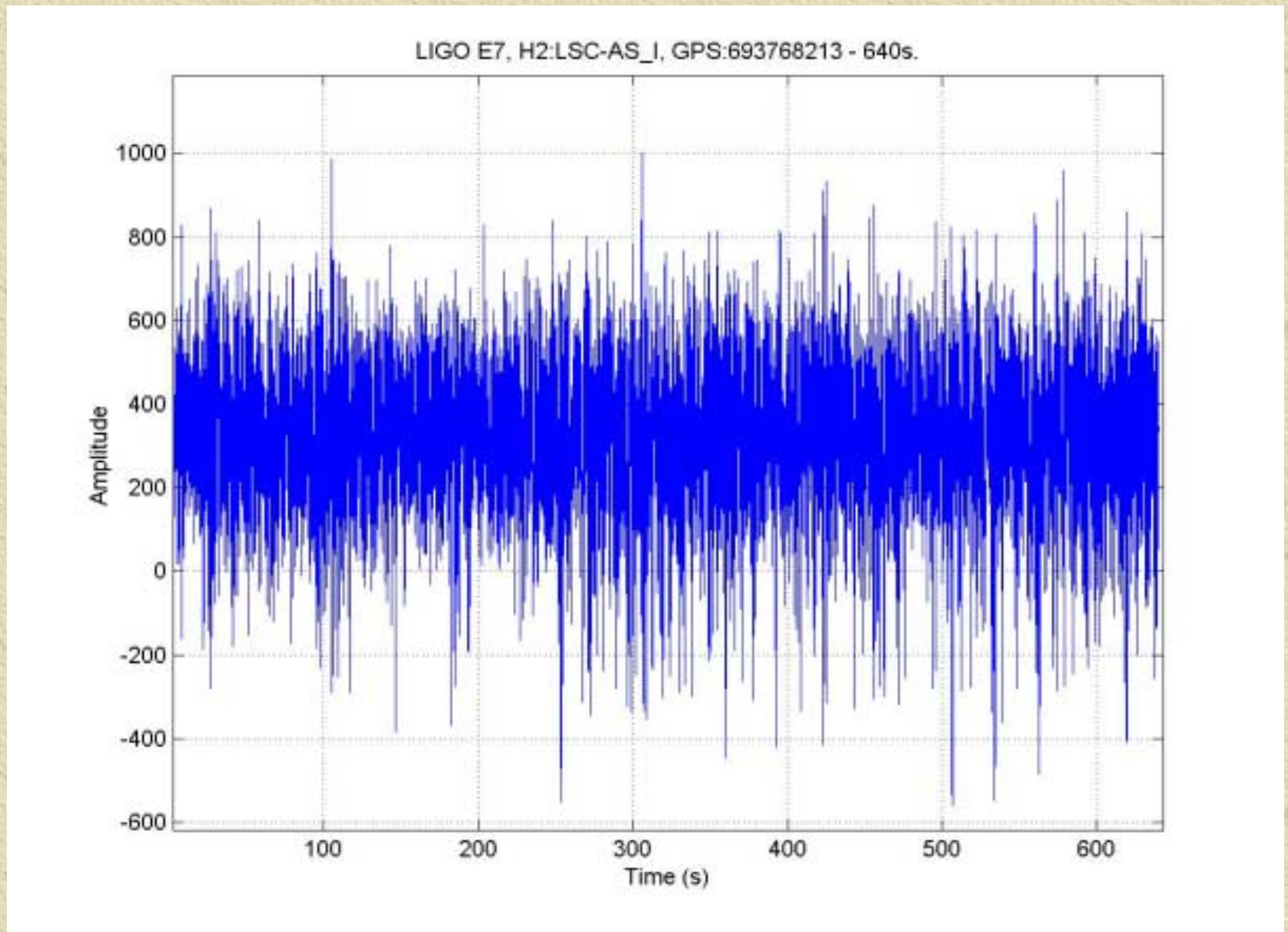
$$G(m)=V(Z_{t+m} - Z_t)/V(Z_{t+1} - Z_t)$$

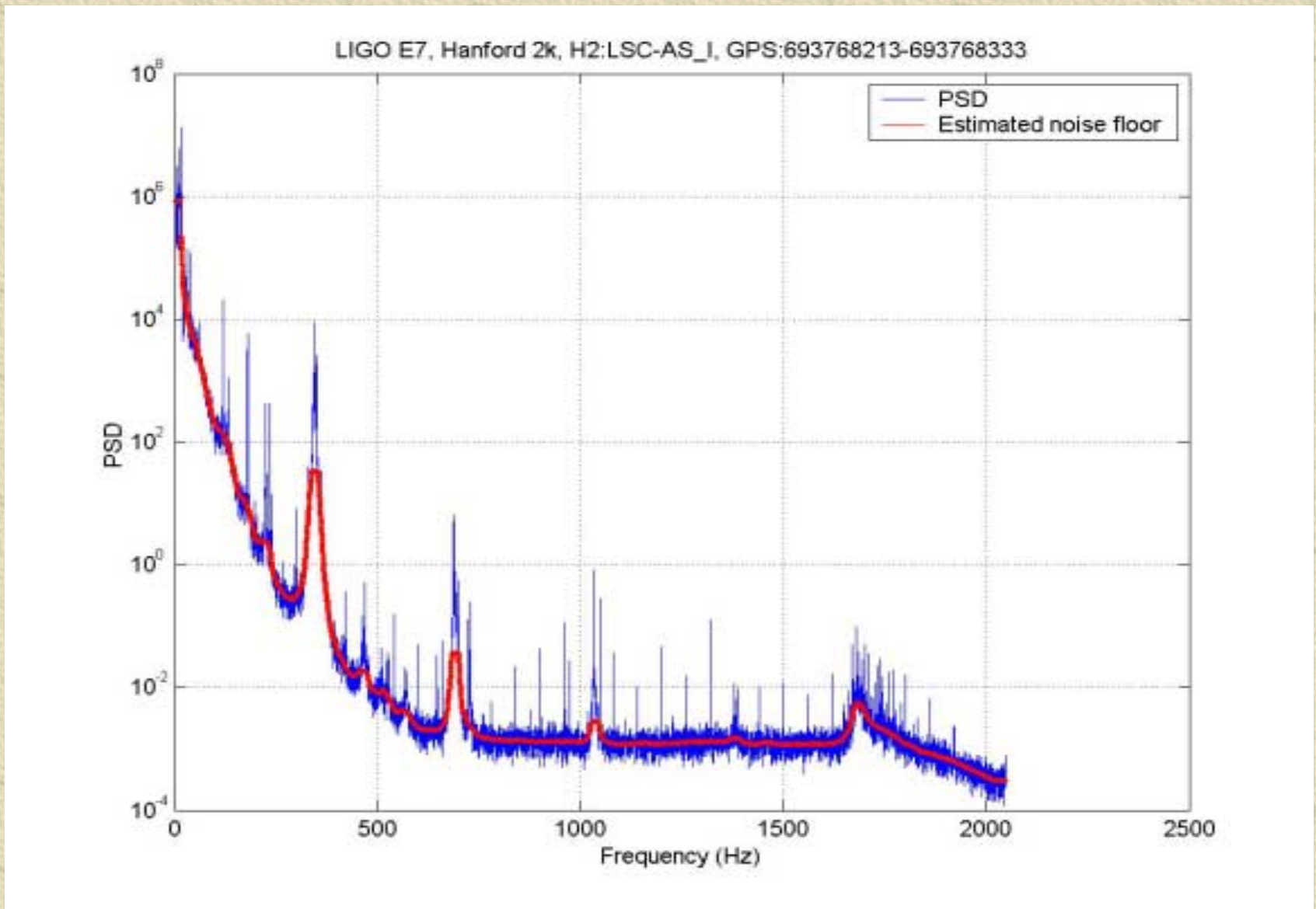
Z_t : t^{th} sample of a timeseries.

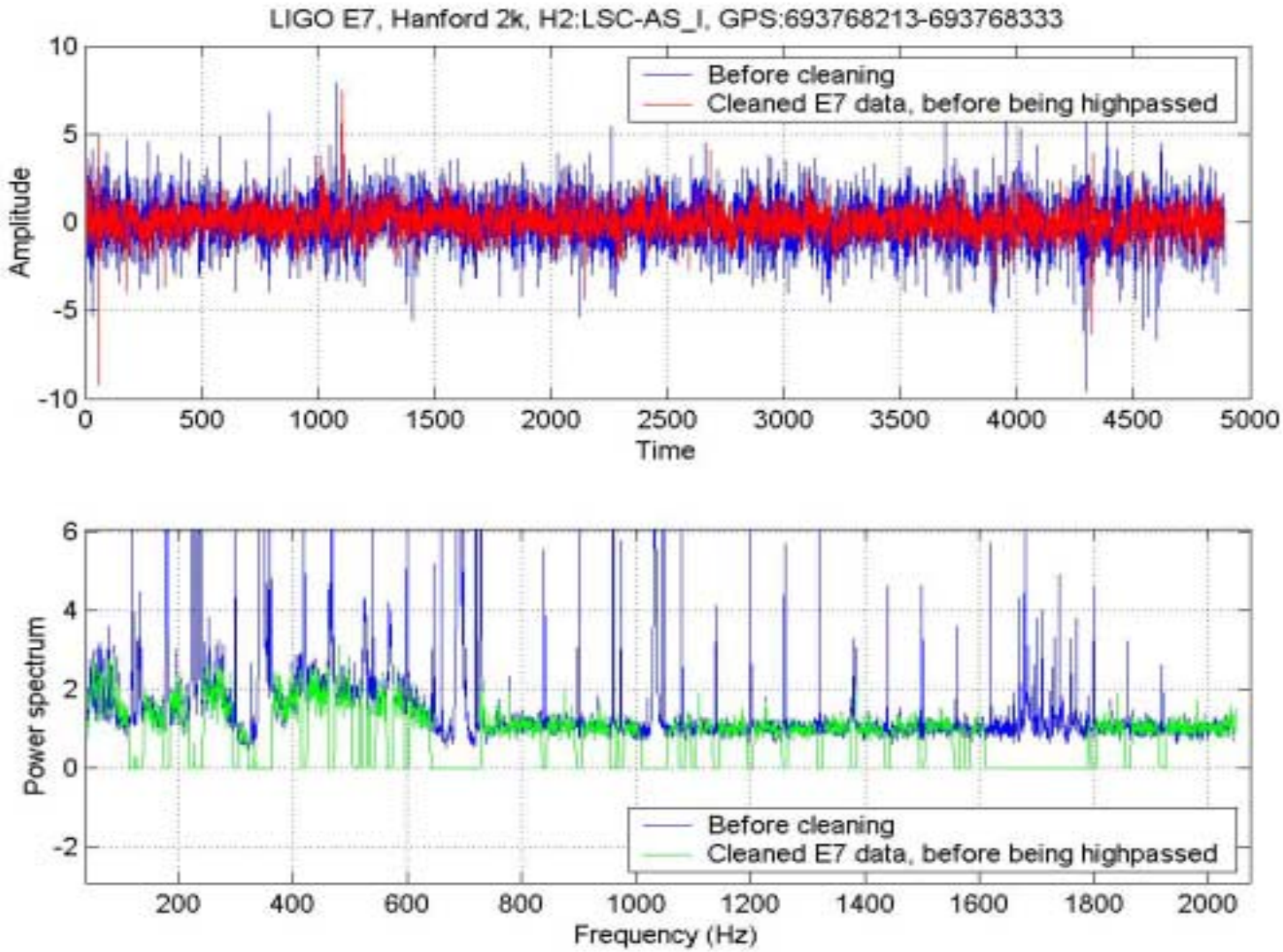
m: Lag.

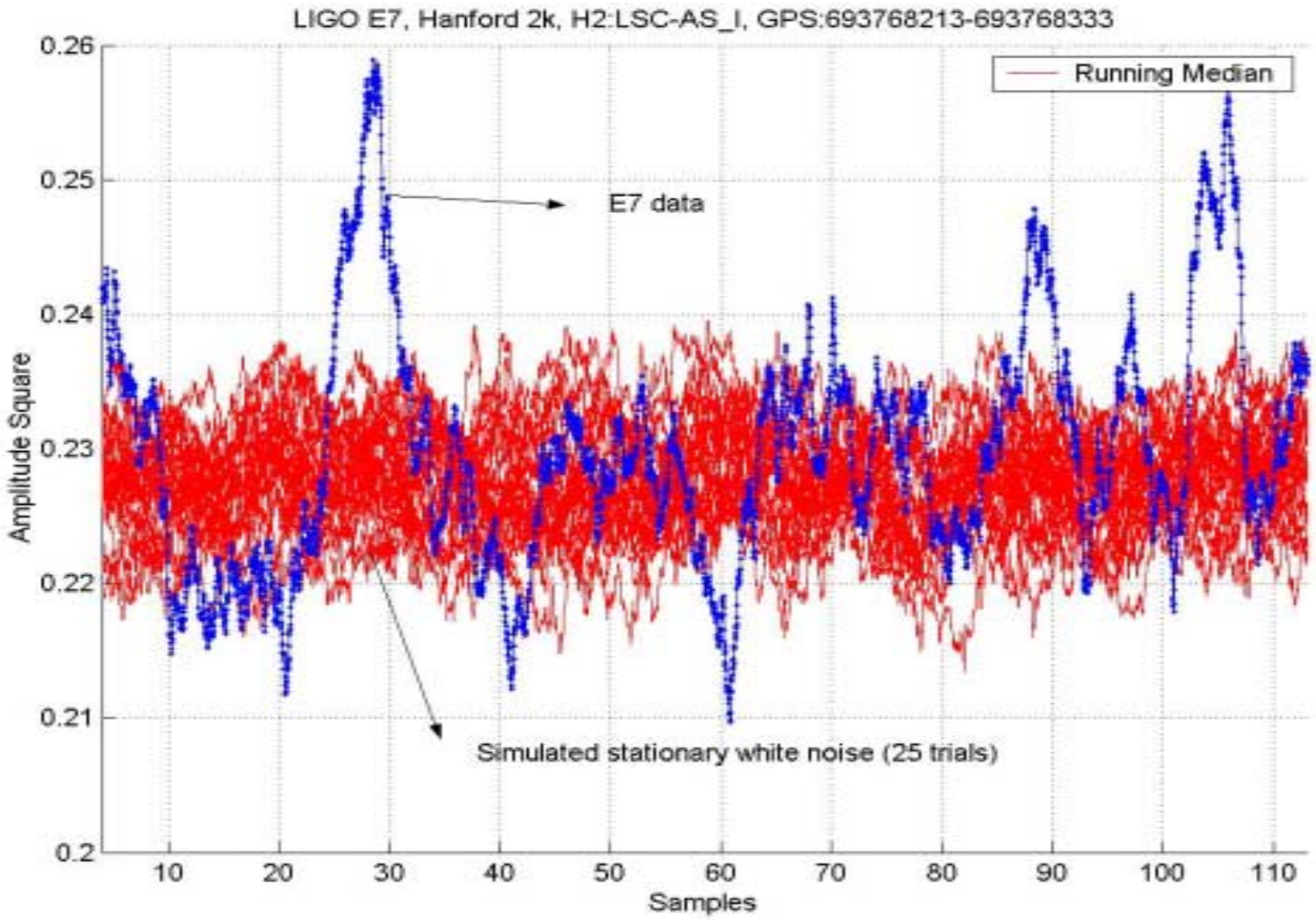
Sequence :

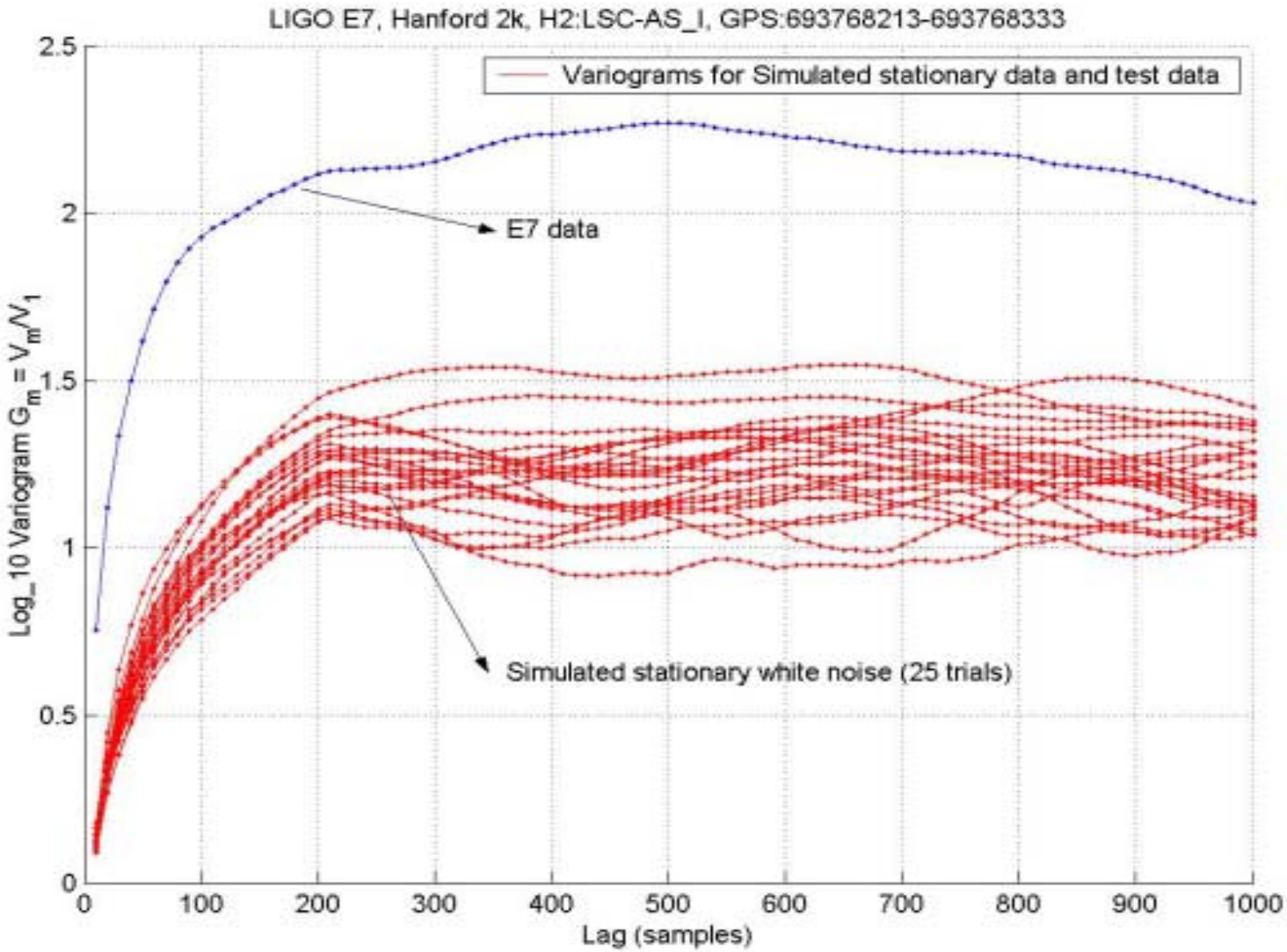

Low pass and resample
Estimate spectral noise floor using Running Median
Design FIR Whitening filter. Whiten data.
Clean lines. Highpass.
Compute Running Median of the squared timeseries.
Construct Variograms.
Thresholds set by Simulation.

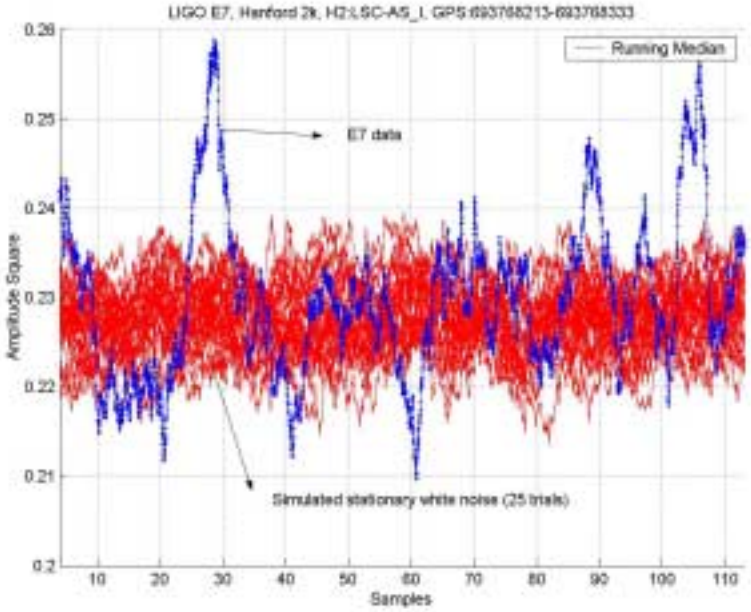

LIGO E7, H2:LSC-AS_I, GPS:693768213 - 640s.
Amplitude
1000
800
600
400
200
0
-200
-400
-600
100
200
300
400
500
600
Time (s)

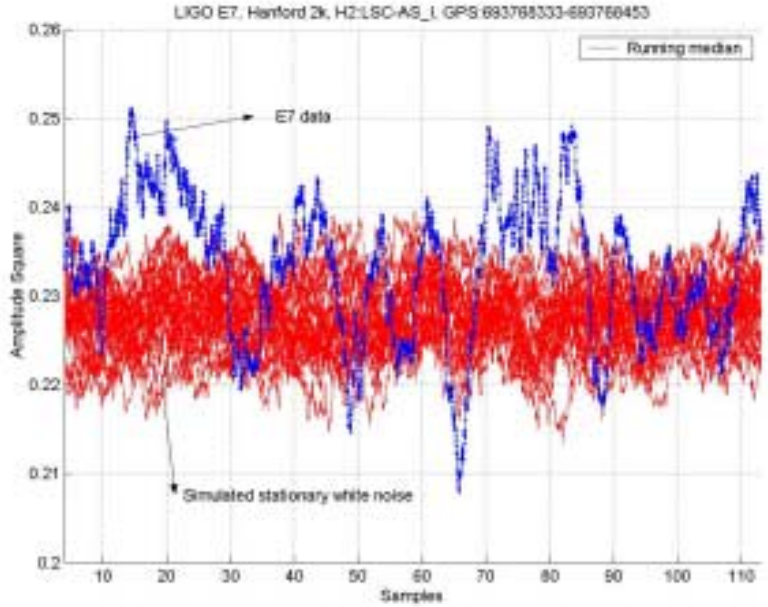

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768213-693768333
PSD
Estimated noise floor
PSD
Frequency (Hz)
10^{8}
10^{6}
10^{4}
10^{2}
10^{0}
10^{-2}
10^{-4}
0
500
1000
1500
2000
2500

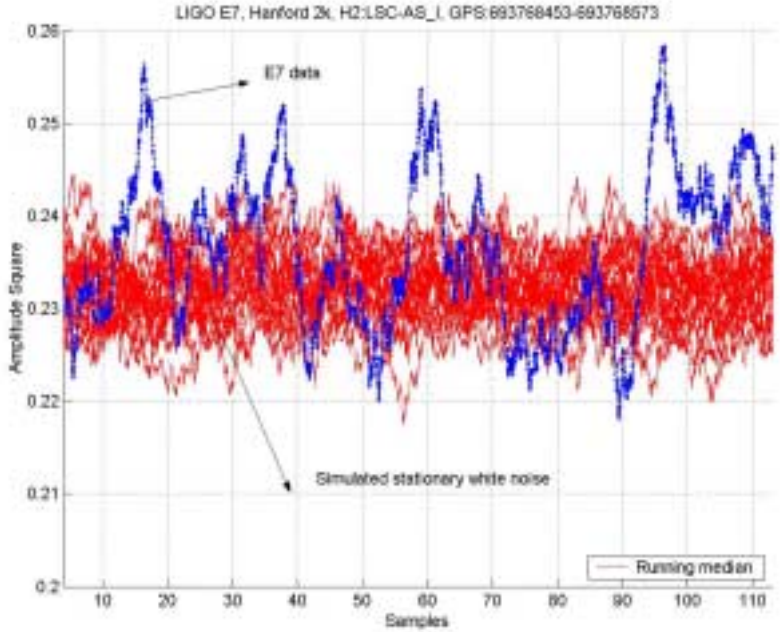

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768213-693768333
Before cleaning
Cleaned E7 data, before being highpassed
Amplitude
Time
Power spectrum
Frequency (Hz)

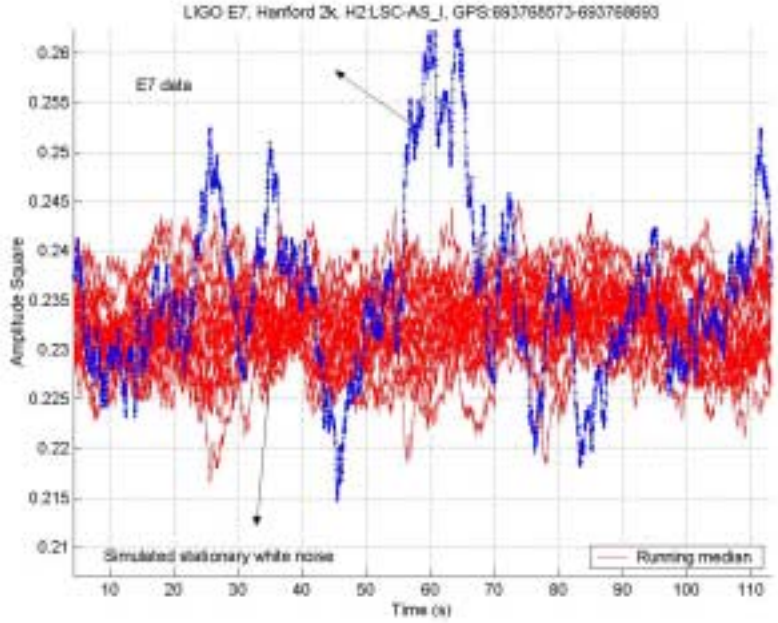

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768213-693768333
Running Median
E7 data
Simulated stationary white noise (25 trials)
Amplitude Square
Samples
0.26
0.25
0.24
0.23
0.22
0.21
0.2
10
20
30
40
50
60
70
80
90
100
110

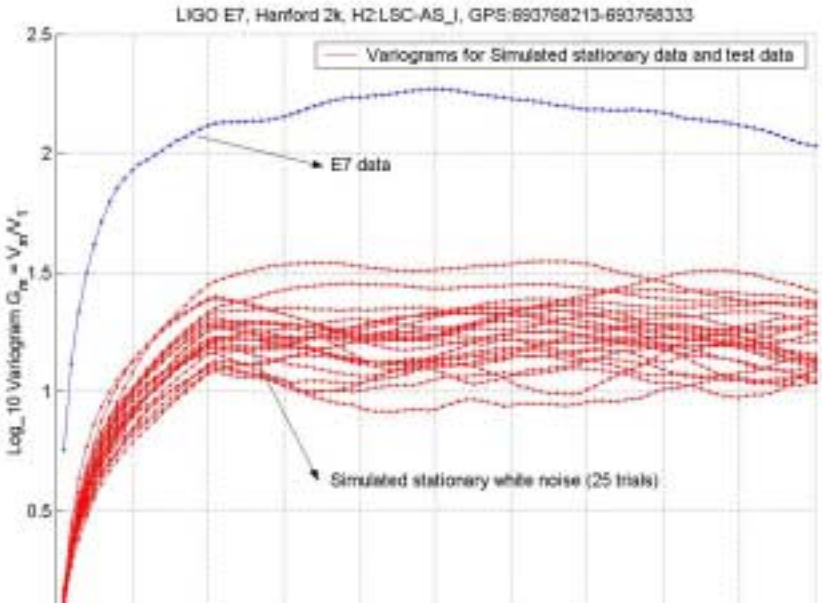

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768213-693768333
Variograms for Simulated stationary data and test data
E7 data
Simulated stationary white noise (25 trials)
Log_10 Variogram $G_m = V_m/V_1$
Lag (samples)
0
0.5
1
1.5
2
2.5
0
100
200
300
400
500
600
700
800
900
1000

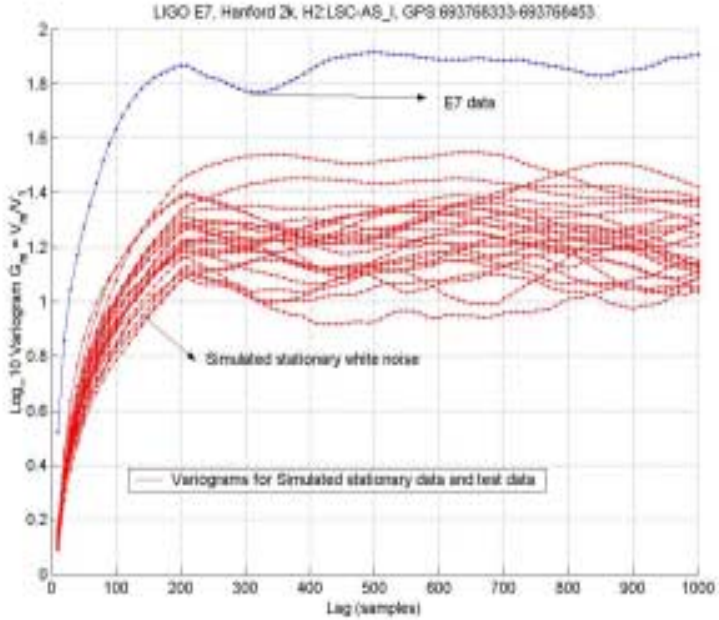

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768213-693768333
Running Median
E7 data
Simulated stationary white noise (25 trials)
Amplitude Square
Samples

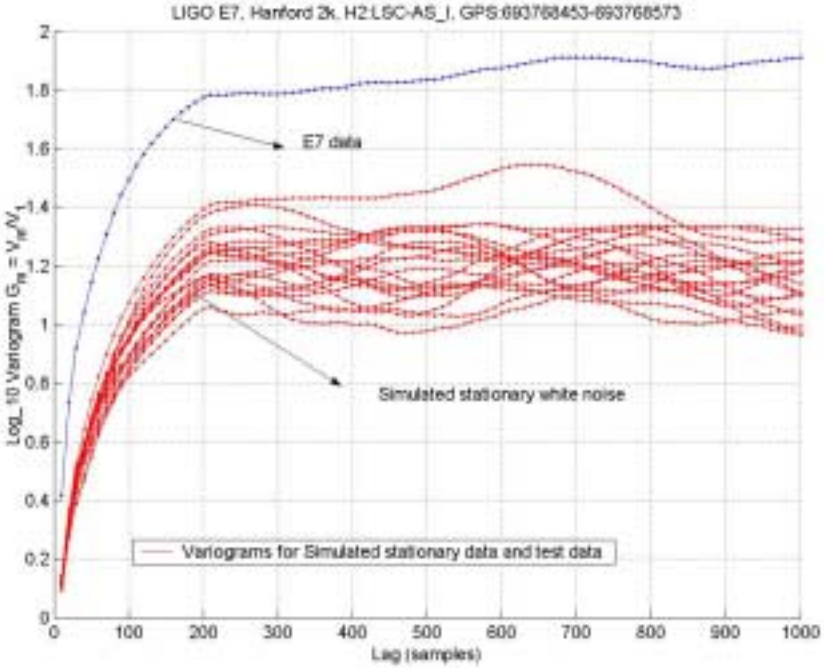

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768333-693768453
Running median
E7 data
Simulated stationary white noise
Amplitude Square
Samples

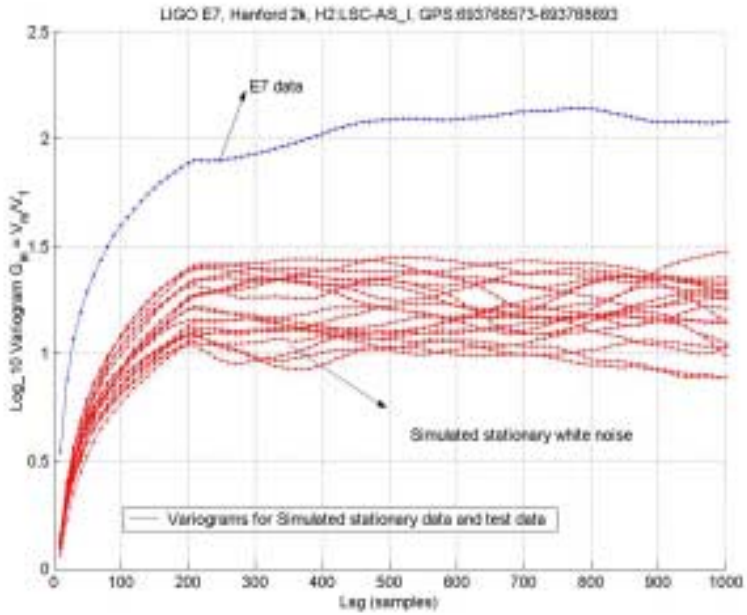

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768453-693768573
E7 data
Simulated stationary white noise
Running median
Amplitude Square
Samples

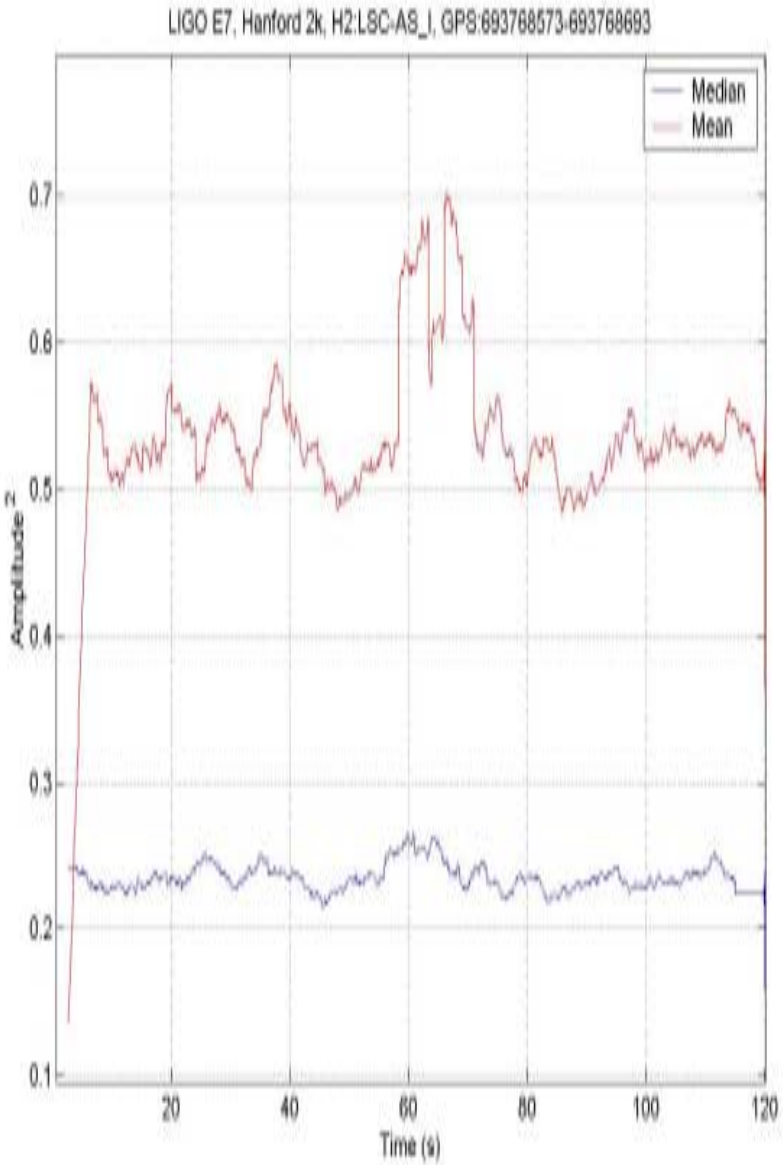

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768573-693768693
E7 data
Simulated stationary white noise
Running median
Amplitude Square
Time (s)

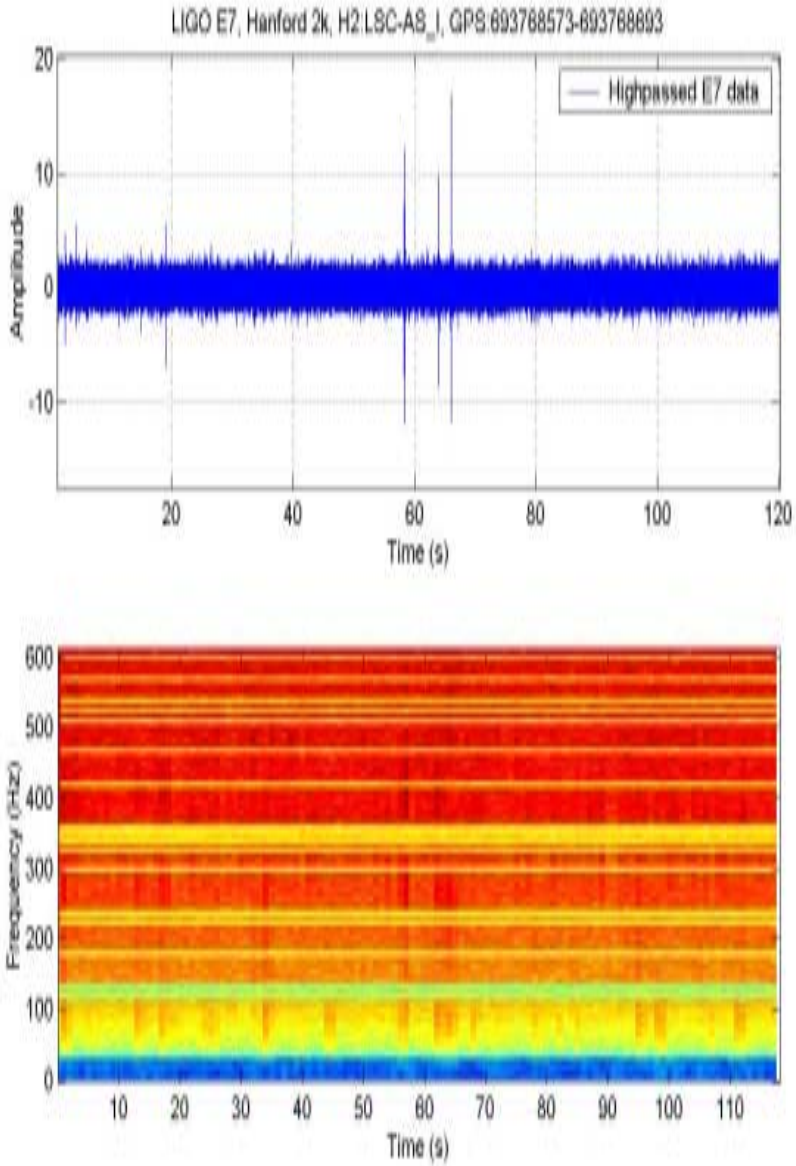

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768213-693768333
Variograms for Simulated stationary data and test data
E7 data
Simulated stationary white noise (25 trials)
Log_10 Variogram $G_{re} = V_{re}/V_1$

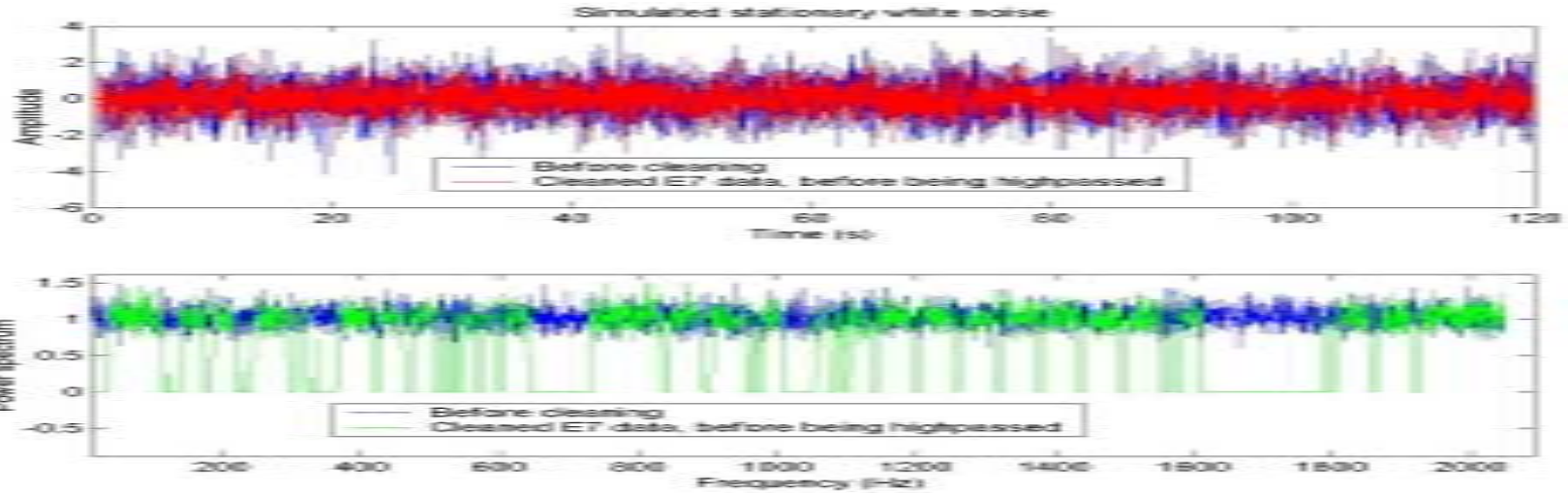

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768333-693768453
E7 data
Simulated stationary white noise
Variograms for Simulated stationary data and test data
Log_10 Variogram $G_{re} = V_{re}/V_1$
Lag (samples)

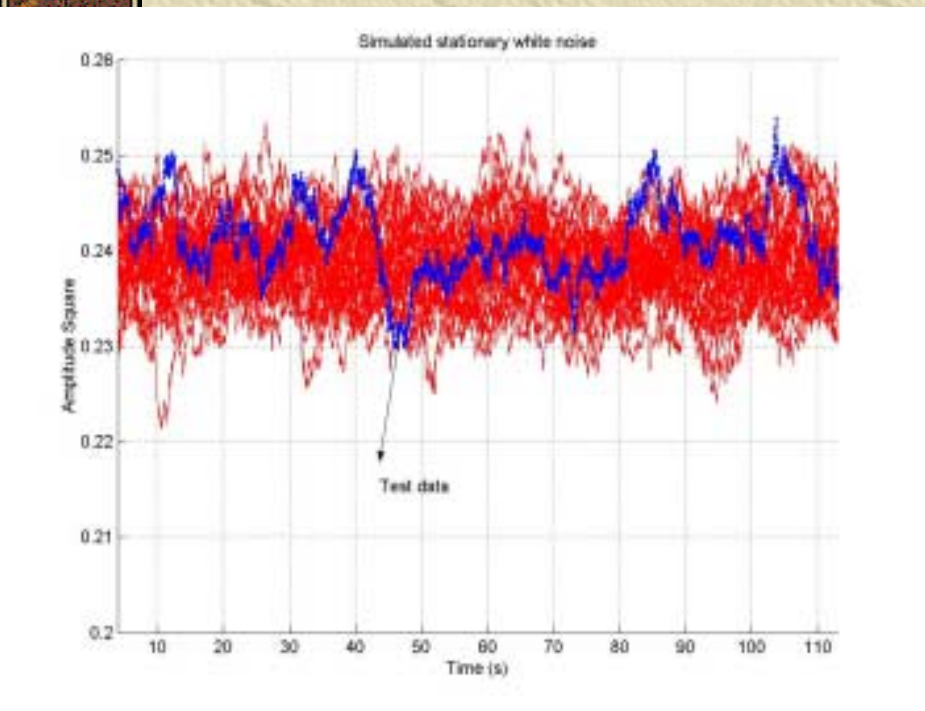

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768453-693768573
E7 data
Simulated stationary white noise
Variograms for Simulated stationary data and test data
Log_10 Variogram $G_{re} = V_{re}/V_1$
Lag (samples)

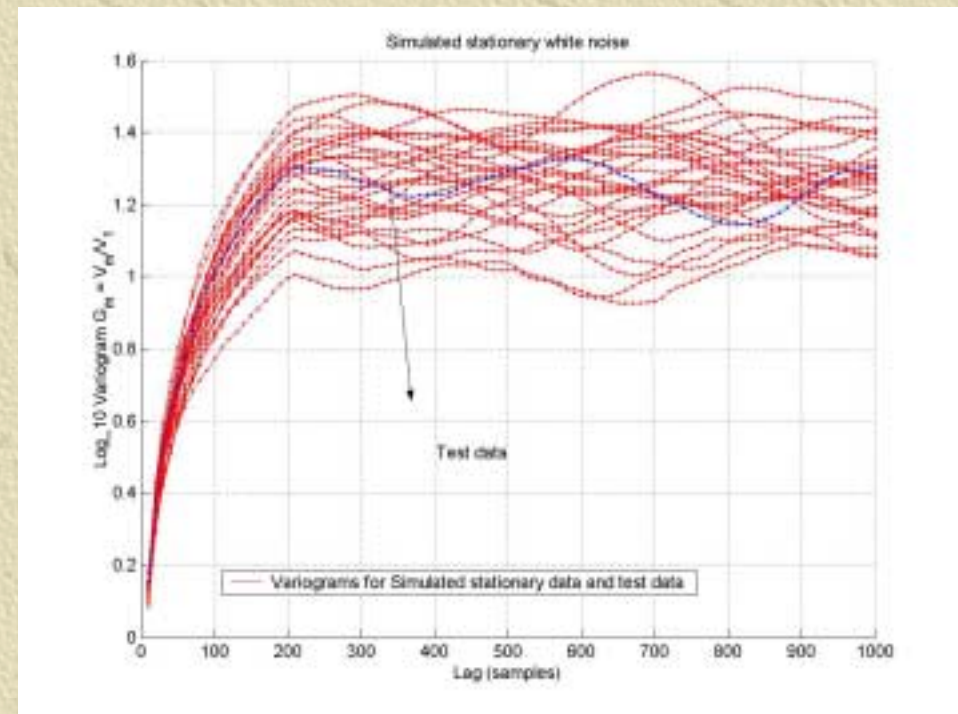

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768573-693768693
E7 data
Simulated stationary white noise
Variograms for Simulated stationary data and test data
Log_10 Variogram $G_{re} = V_{re}/V_1$
Lag (samples)

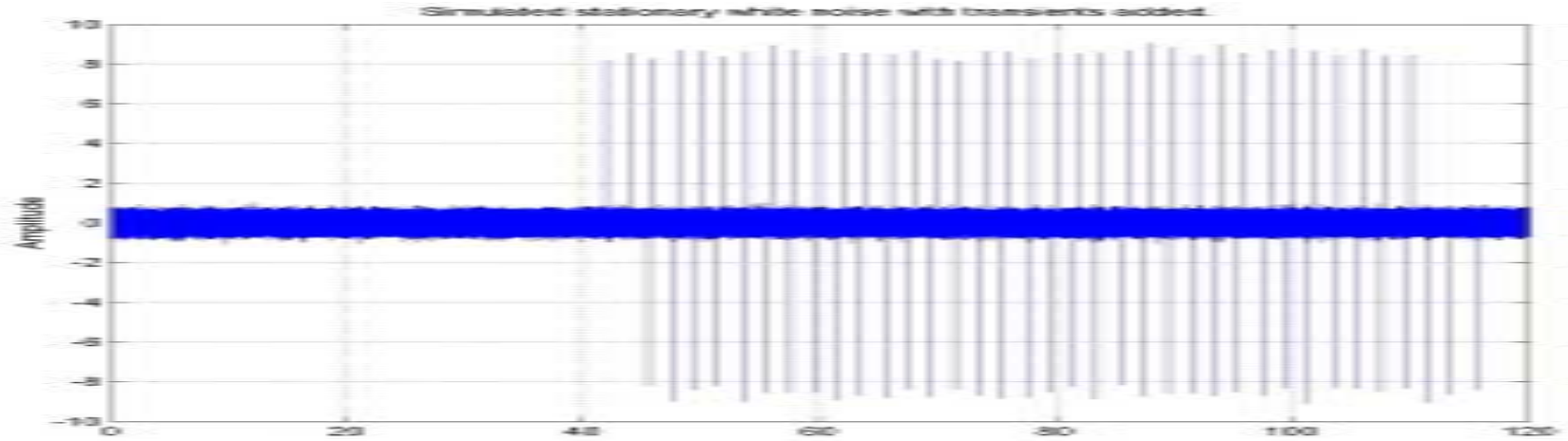

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768573-693768693
Median
Mean
Amplitude^2
Time (s)

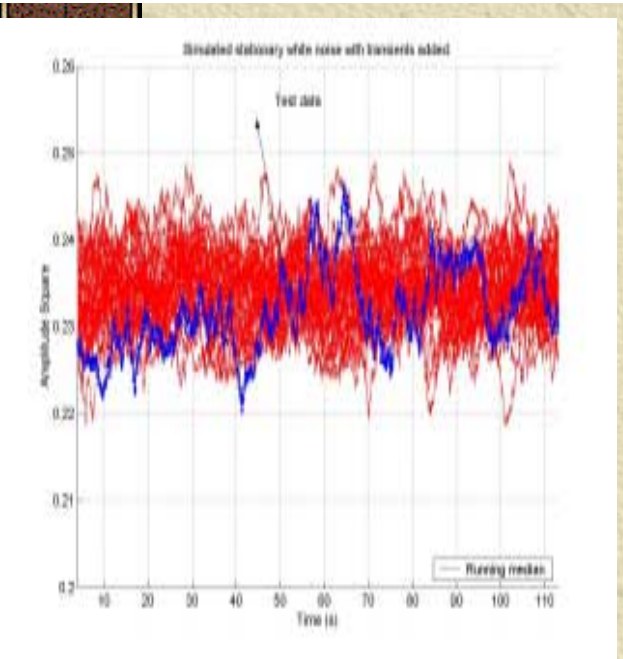

LIGO E7, Hanford 2k, H2:LSC-AS_I, GPS:693768573-693768693
Highpassed E7 data
Amplitude
Time (s)
Frequency (Hz)
Time (s)

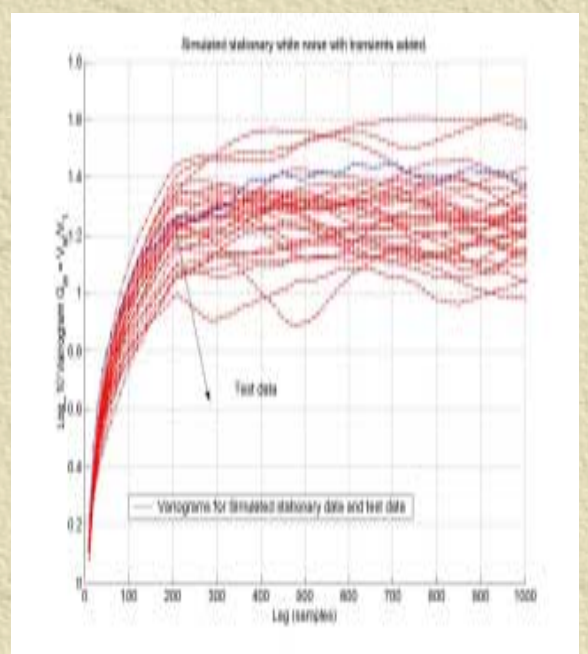

Simulated stationary white noise
Amplitude
Time (s)
Before cleaning
Cleaned E7 data, before being highpassed
Power spectrum
Frequency (Hz)
Before cleaning
Cleaned E7 data, before being highpassed

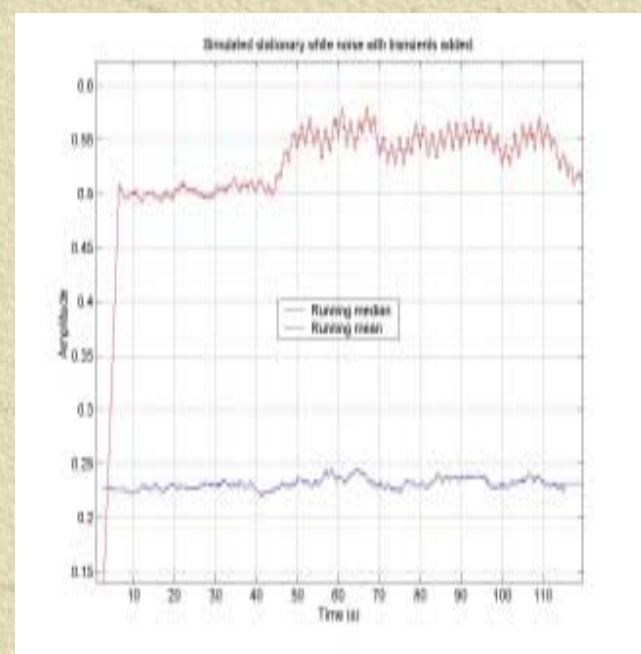

Simulated stationary white noise
Amplitude Square
Time (s)
Test data

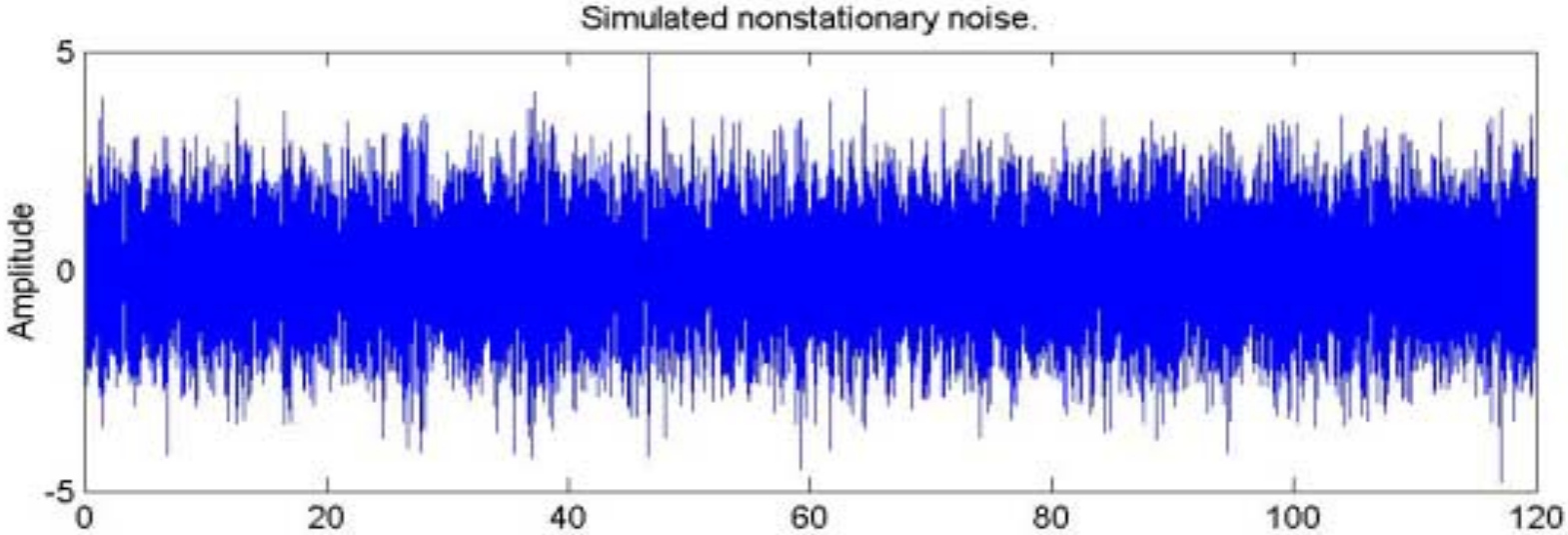

Simulated stationary white noise
Log_10 Variogram
Lag (samples)
Test data
Variograms for Simulated stationary data and test data

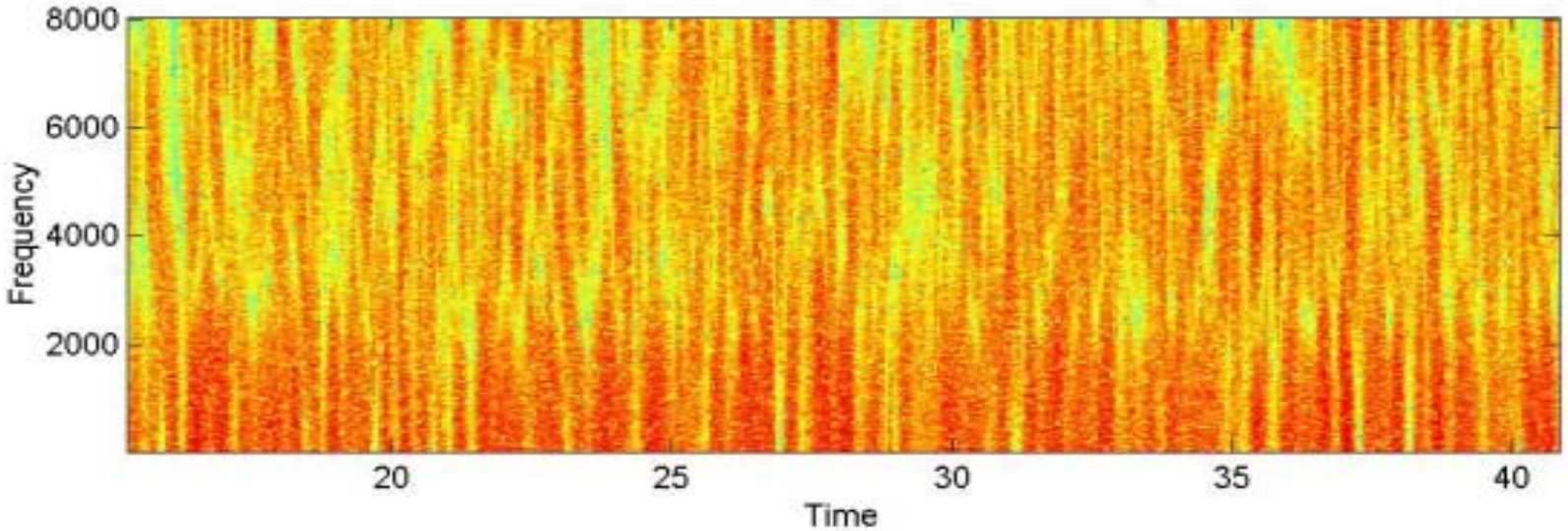

Simulated stationary white noise with transients added
Amplitude

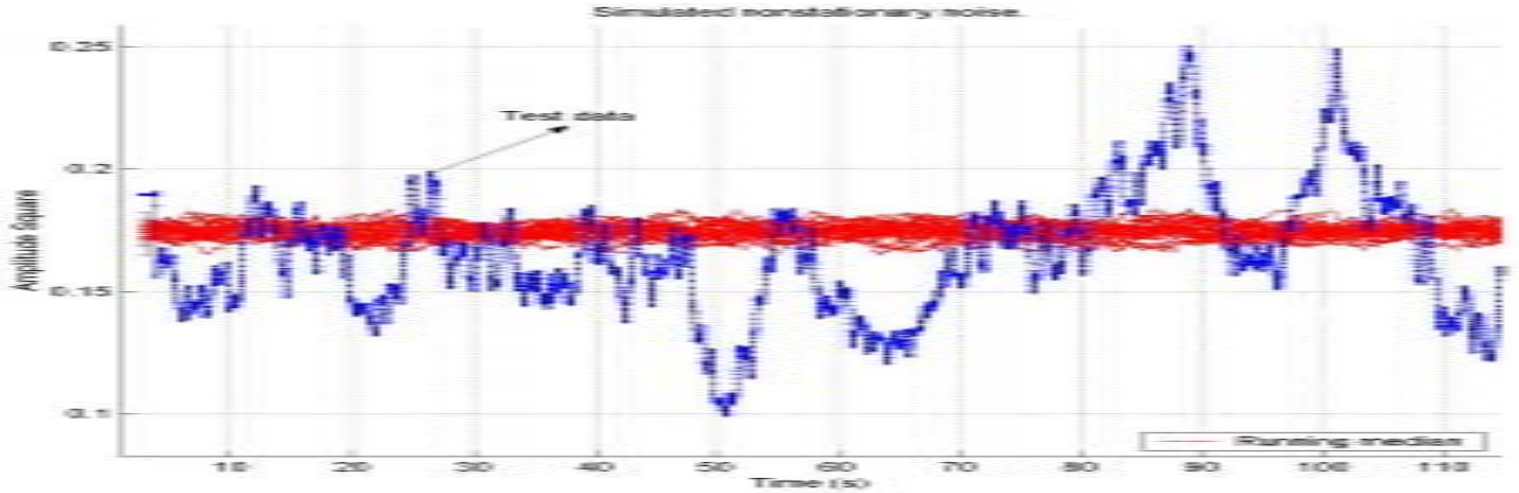

Simulated stationary white noise with transients added
Test data
Running median
Amplitude Square
Time (s)

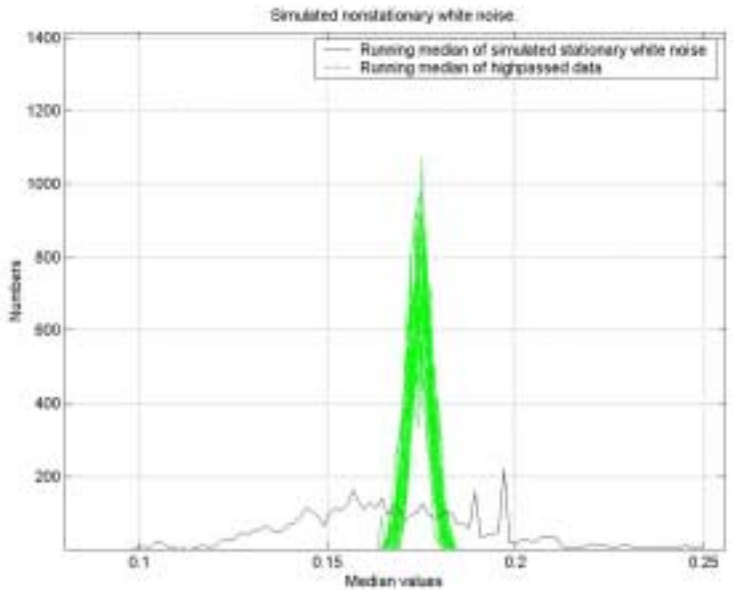

Simulated stationary white noise with transients added
Test data
Variograms for Simulated stationary data and test data
Lag (samples)

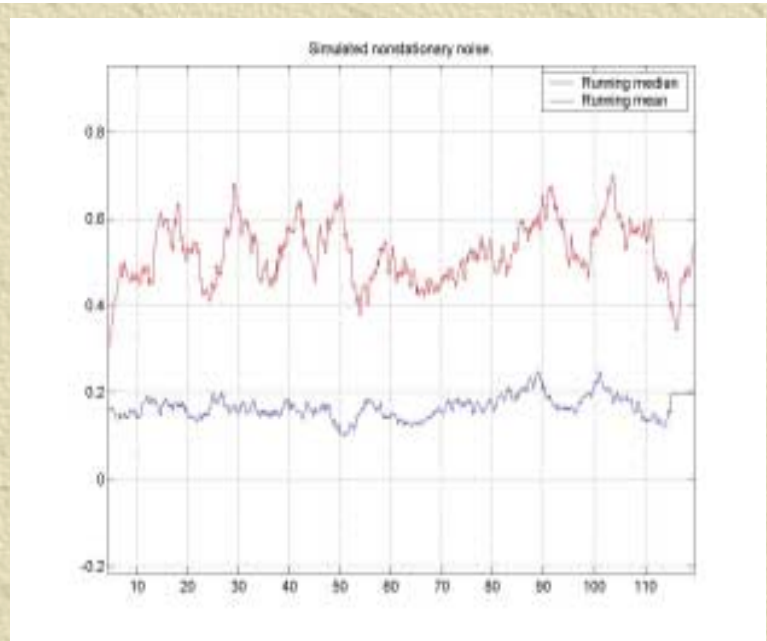

Simulated stationary white noise with transients added
Running median
Running mean
Amplitude
Time (s)

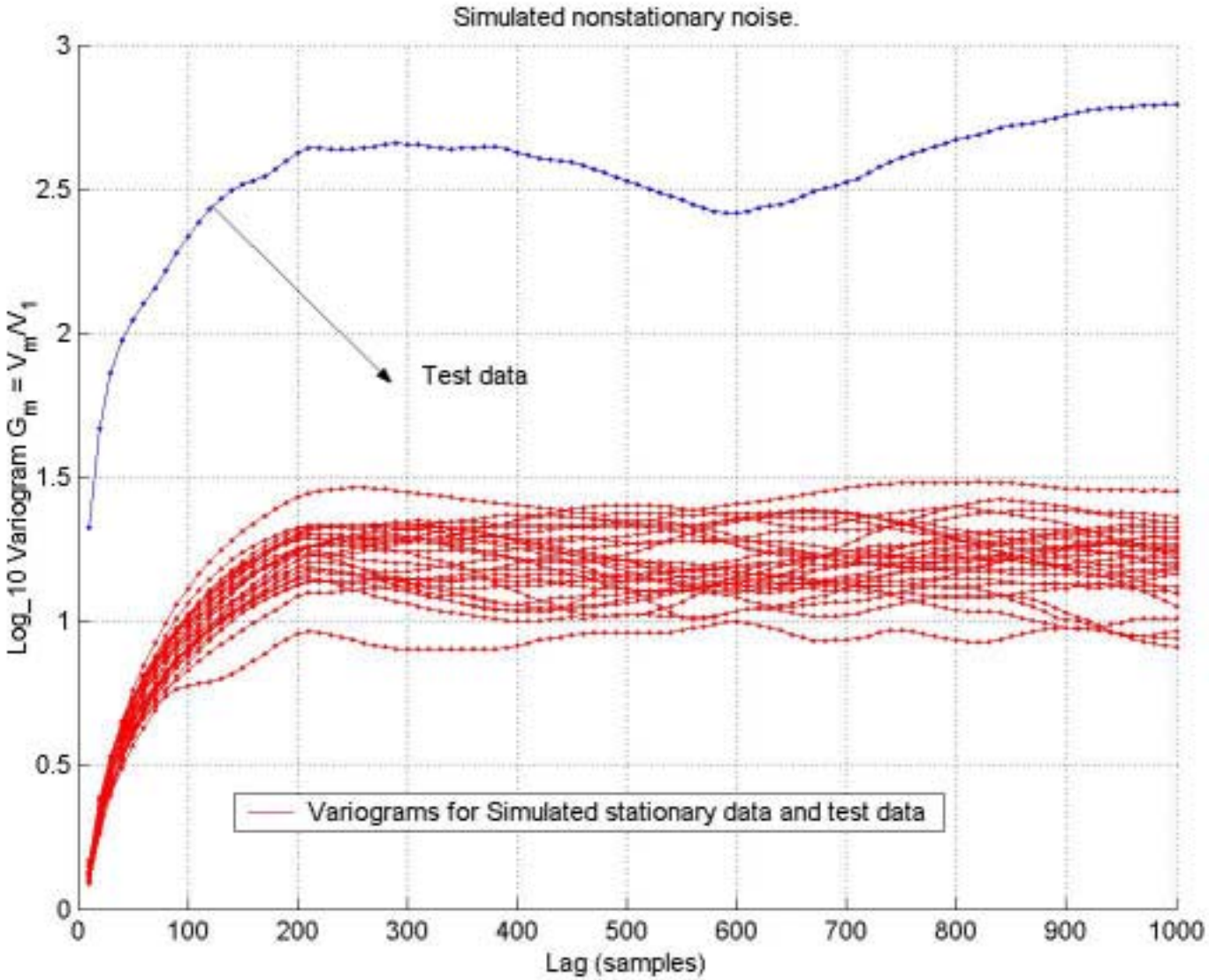

Simulated nonstationary noise.
Amplitude
5
0
-5
0
20
40
60
80
100
120

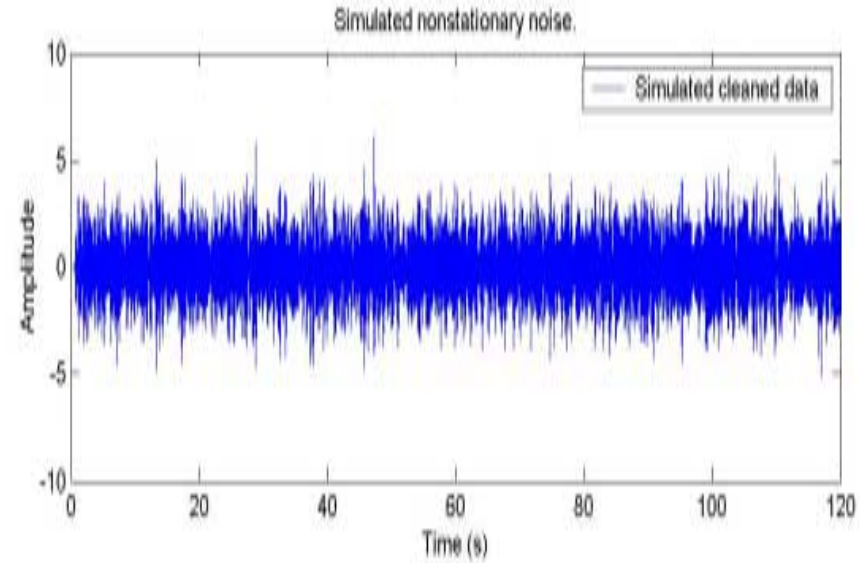

Frequency
8000
6000
4000
2000
20
25
30
35
40
Time

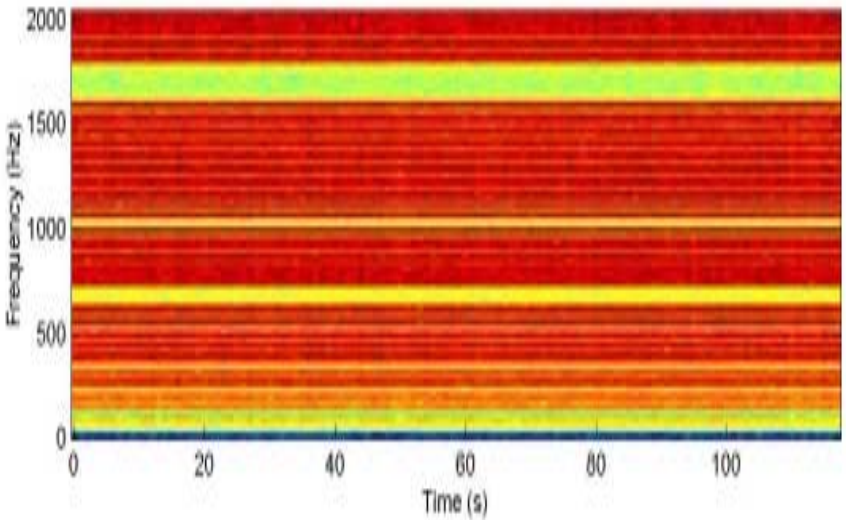

Simulated nonstationary noise
Test data
Amplitude Square
Time (S)
Running median

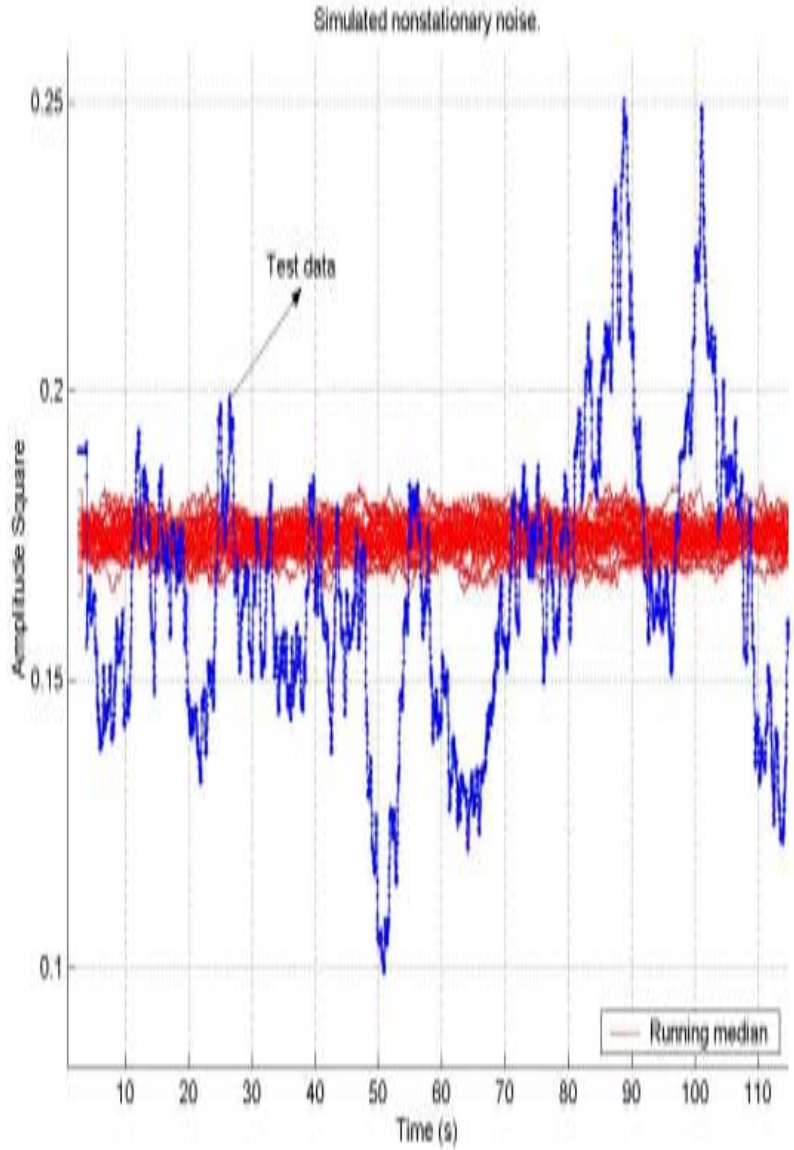

Simulated nonstationary white noise
Running median of simulated stationary white noise
Running median of highpassed data
Numbers
Median values


Simulated nonstationary noise
Running median
Running mean


Simulated nonstationary noise.
Log_10 Variogram $G_m = V_m/V_1$
Lag (samples)
Test data
Variograms for Simulated stationary data and test data
0
0.5
1
1.5
2
2.5
3
0
100
200
300
400
500
600
700
800
900
1000


Simulated nonstationary noise.
Simulated cleaned data
Amplitude
Time (s)


Frequency (Hz)
Time (s)


Simulated nonstationary noise.
Test data
Amplitude Square
Running median
Time (s)

Future :

- `To be run on full S1 data (LIGO/GEO).
- More quantification of the Running Median and variogram.
- To be tested on bandlimited data.
- Automation and incorporation in the DCR underway.