Implementation and Study of Noise floor Monitor

DetChar meeting

2014/11/25

Motivation

- Generate clean data finder
  - required low-latency
    - monitor stationarity
      - stable noise floor level
      - non - high rate glitch
  - To reduce the effect on short-term glitch, algorithm is generated by concept of running median
- With LIGO paper, we tried to implement it

Implessmentation of Noise Floor Monitor

- Reference papers
- Median based noise floor tracker(MNFT): robust estimation of noise floor drifts in LIGO S1 data.
  - Soma Mukherjee, LIGO-T030019-00-Z, March 2003
- Development of a DMT monitor for tracking slow non-stationarities present in LIGO science data
  - S.Mukherjee, Journal of Physics:Conference Series 32(2006) 44-51
- Environmentally induced nonstationarity in LIGO science run data
  - Robert Stone and Soma Mukherjee, CQG 26(2009) 204021

Introduction and Background

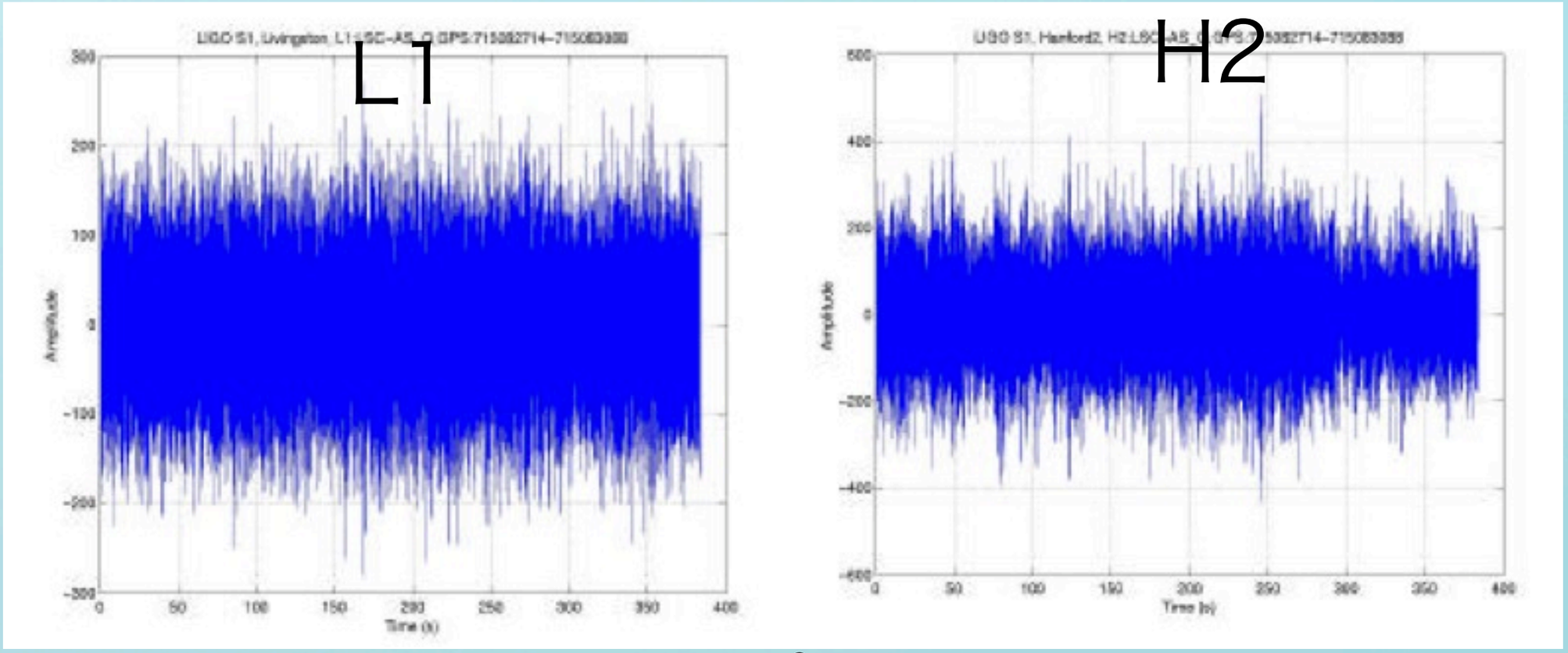
- Tracking temporal variation in the statistical properties of the noise floor in a time series
- power spectral density of time series after removing of narrowband technical noise features
    - high power line features in the time domain
- interested in slow variation of the noise floor
    - slow variations but not significantly affected by the transient
- MNFT (Median based Noise Floor Tracker)
    - Why Median average base?

Analysis flow

(1) bandpass and resample given timeseries
　16,384->4,096Hz in LIGO
　Main purpose is to reduce calculation time(this method use running median many times)
(2) Construct FIR filter that whitens the noise floor
　1second block size, construct with running median
(3) remove lines using notch filter
　Skip this time(For the future, we'd like to use MBLT, Asano-san)
　But, some problem ->see following page
(4) track variation in second moment using Running median
　check variance of time domain
(5) obtain significance levels from Monte Carlo simulations
　I'd like to finish until this meeting, but couldn't ... sorry

(1)lowpass and resample

- To reduce sampling rate and to restrict the analysis to the frequency band of interest.
  - time series x(k), k is the sample index
- 16,384Hz -> 4096Hz for GPS 715082714-715083088



(1) implementation

Sample frame file

L-L1_RDS_C03_L2-877264406-128.gwf

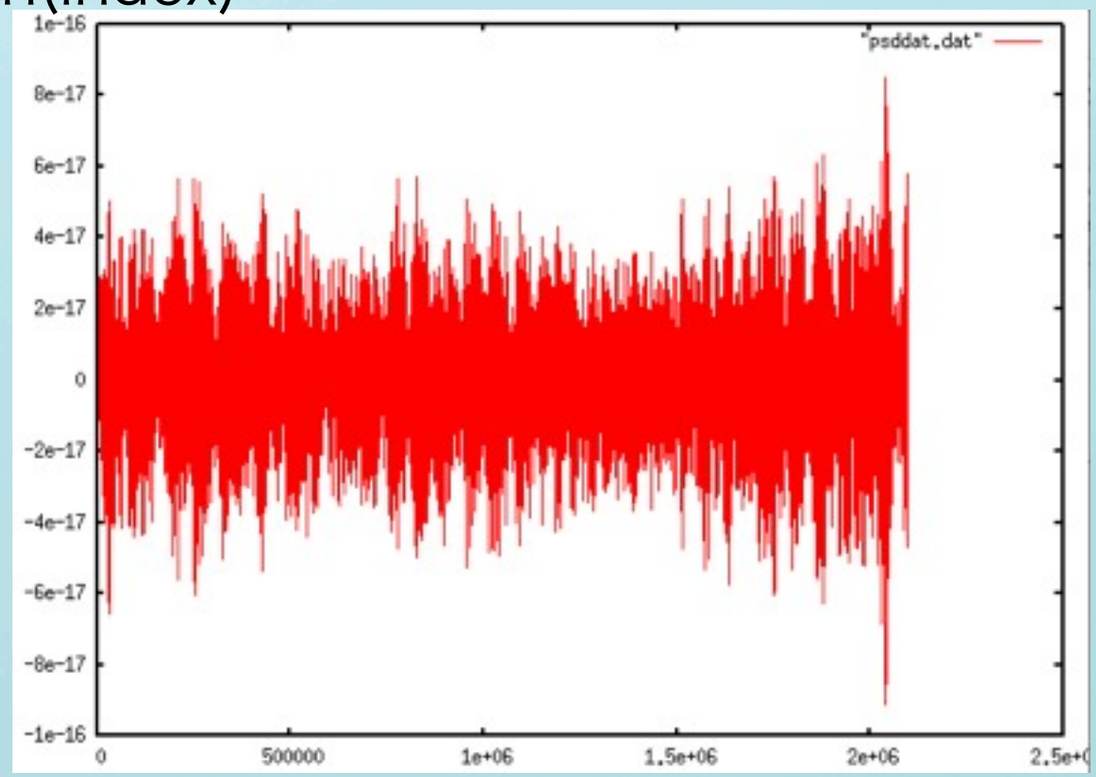
Oct 24, 2007 12:14:52(UTC)

resampling 16,384Hz to 4,096Hz

(use HasKAL function(IIR low pass filter + resampling))

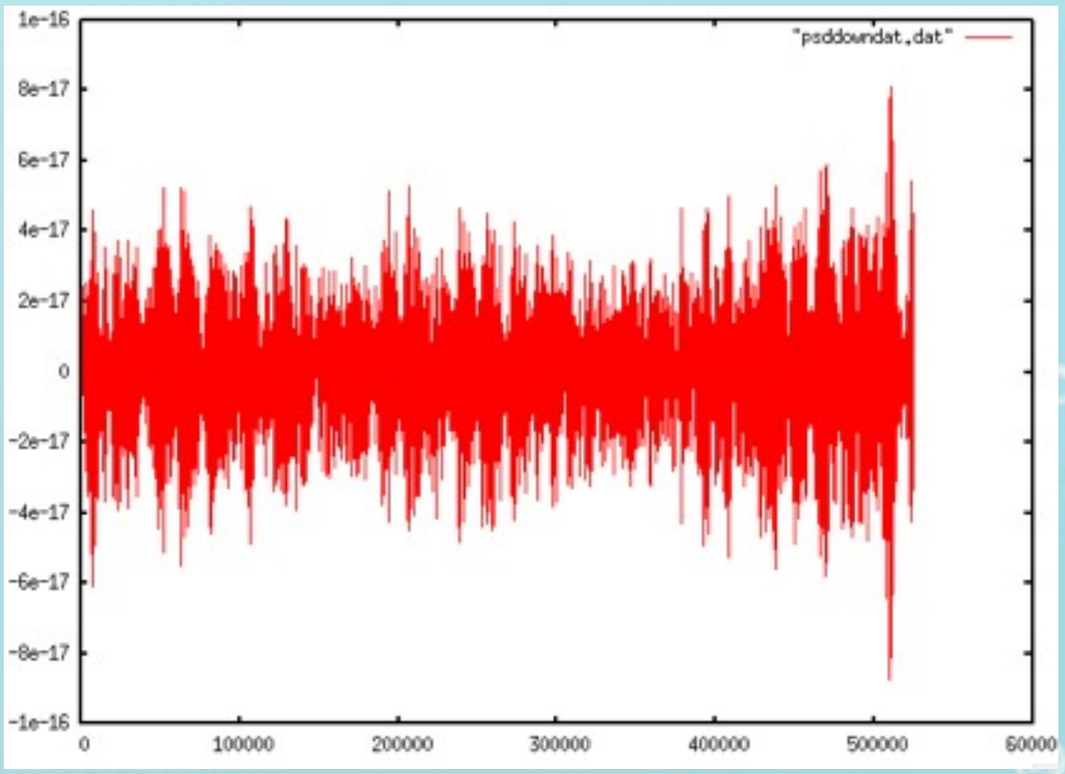
resampled time domain data is defined as s(index)

h(index)



index

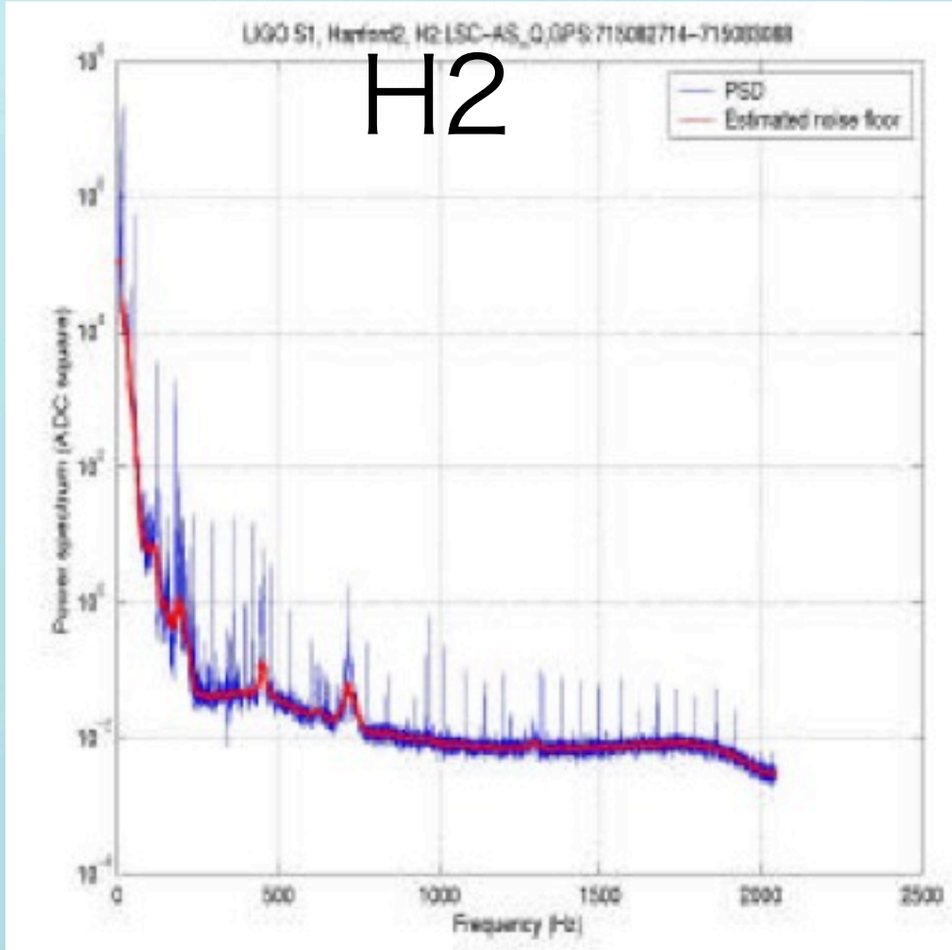
s(index)

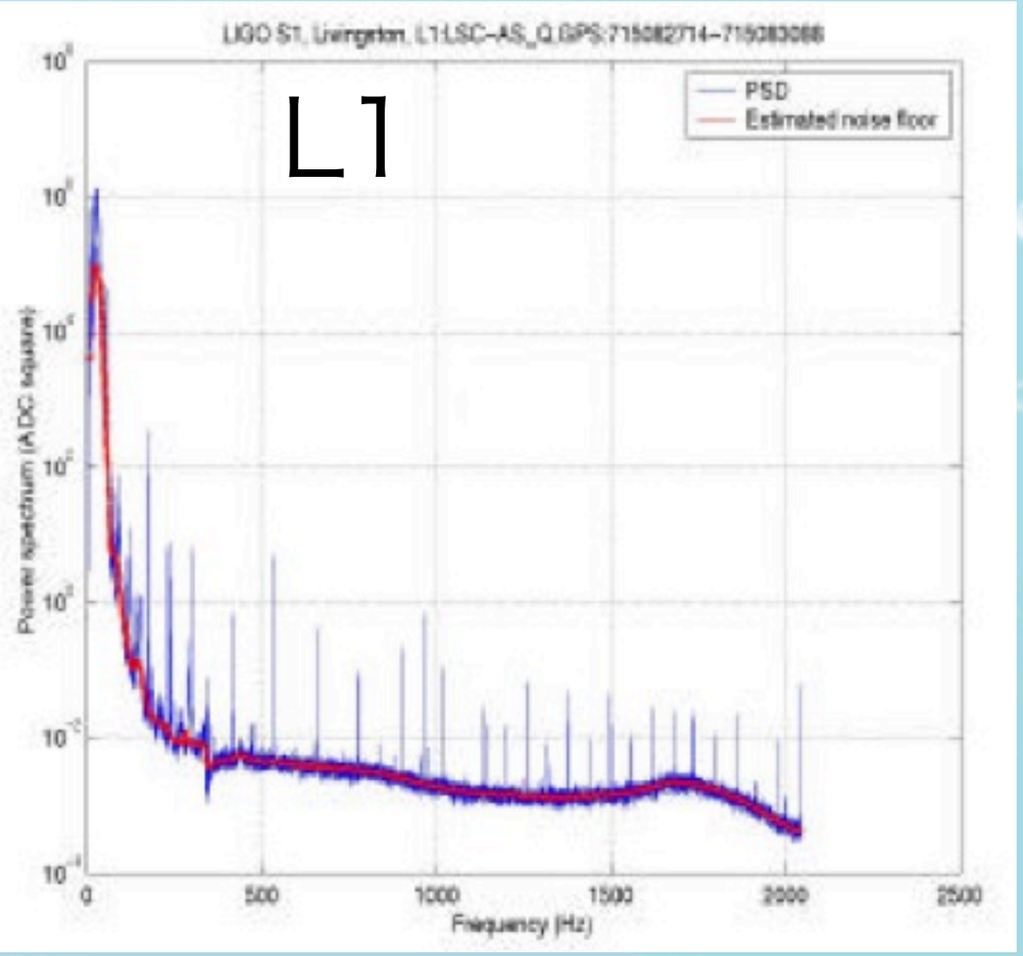


index

(2) Whiting the data

- A quiet stretch(no large transient) is identified and PSD computed
- Construct an FIR filter that whitens the noise floor w(k)(frequency domain)
- running median is used on the PSD to obtain an estimate of the noise floor(definition of the noise floor)
- Apply linear prediction filter to obtain whitened time domain c(t)





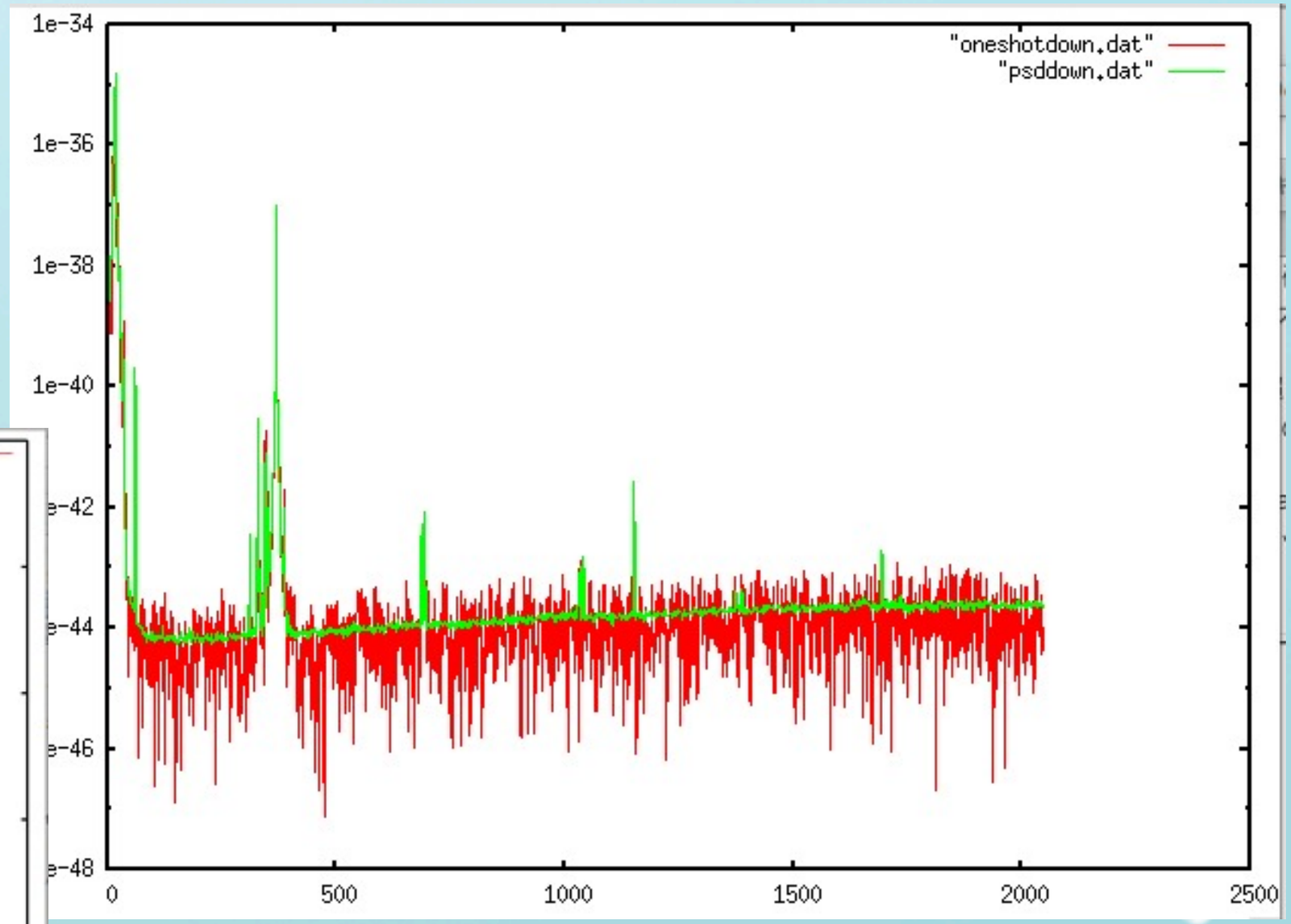
(2) Implementation

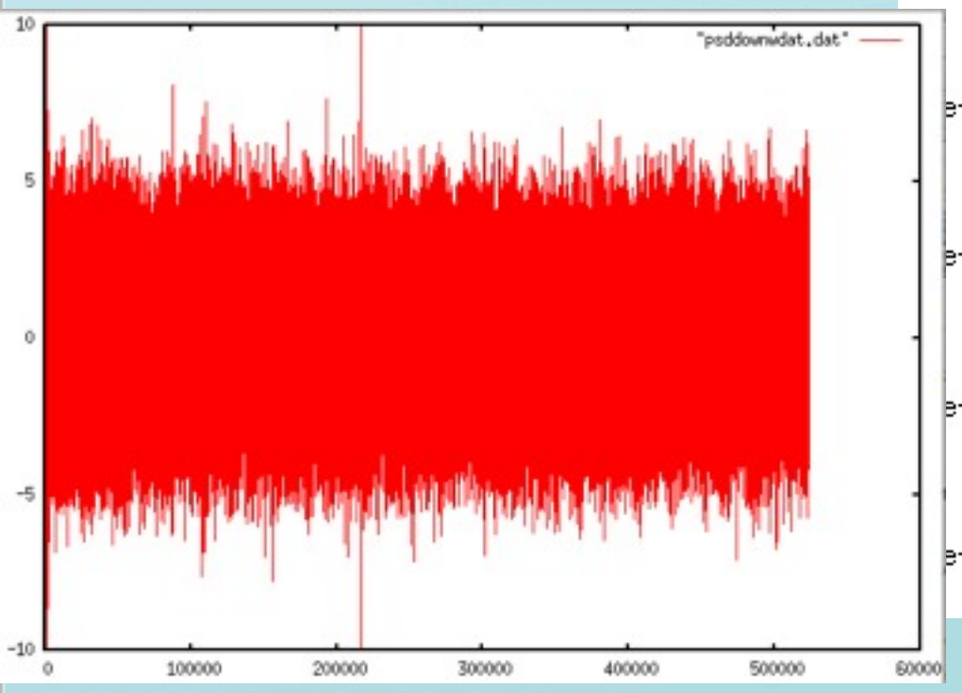
Red : Oneshot of power spectrum density(PSD), 1second

Green : Running average of this frame file

1second block size, Short Fourier Transform with Hann window function

validation1 : 1second block size





(3) Line removal

- Remove lines using a notch filter
  - cleaned time series c(k)
- A high order FIR notch filter is constructed using Matlab with notches positioned at the central frequencies
- Trade off between the order of the notch filter and prevention of false slow non-stationarity due to strong high rate transient

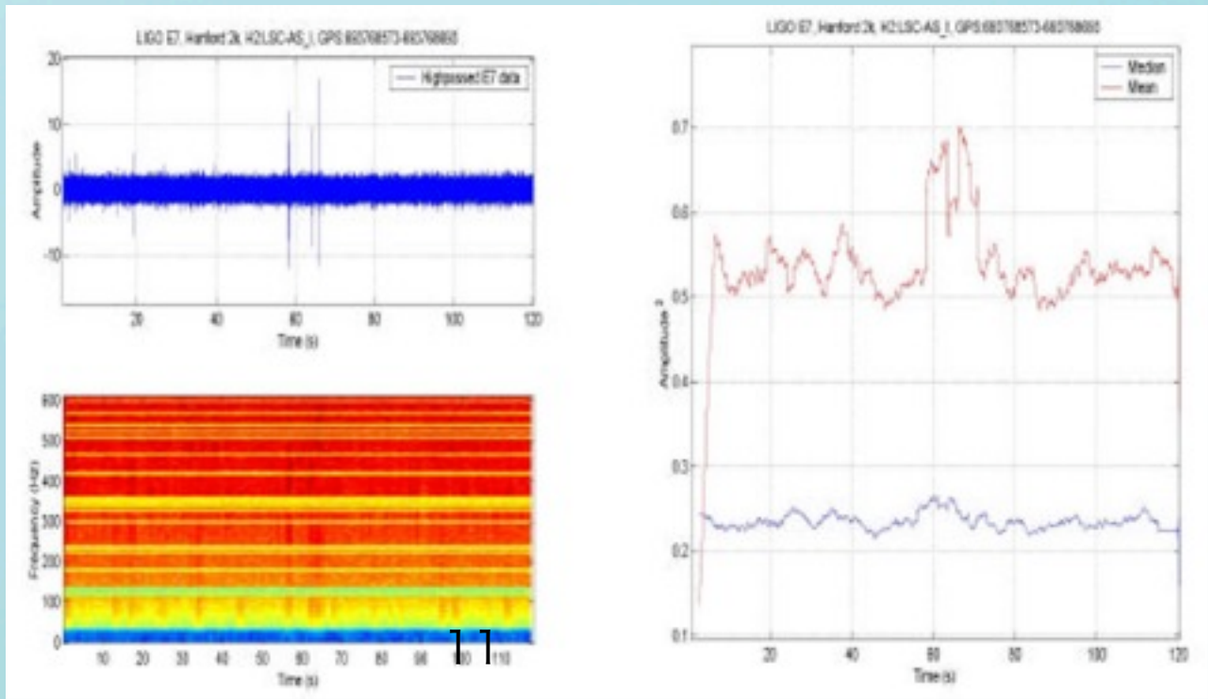
(4) Tracking Non-Stationarity

- Time variation of non-stationary noise floor is caused by
  - a change in the shape of the noise floor
  - and/or change in its overall level
- Track variation in the second moment of c(k) using a running median. $\Sigma(k)$ -> tracking variance of one block length
- Compare the running mean and median estimation

LIGO E7 H2:LSC-AS_Q median is much smoothing

Time series:
three strong
transient

spectrogram

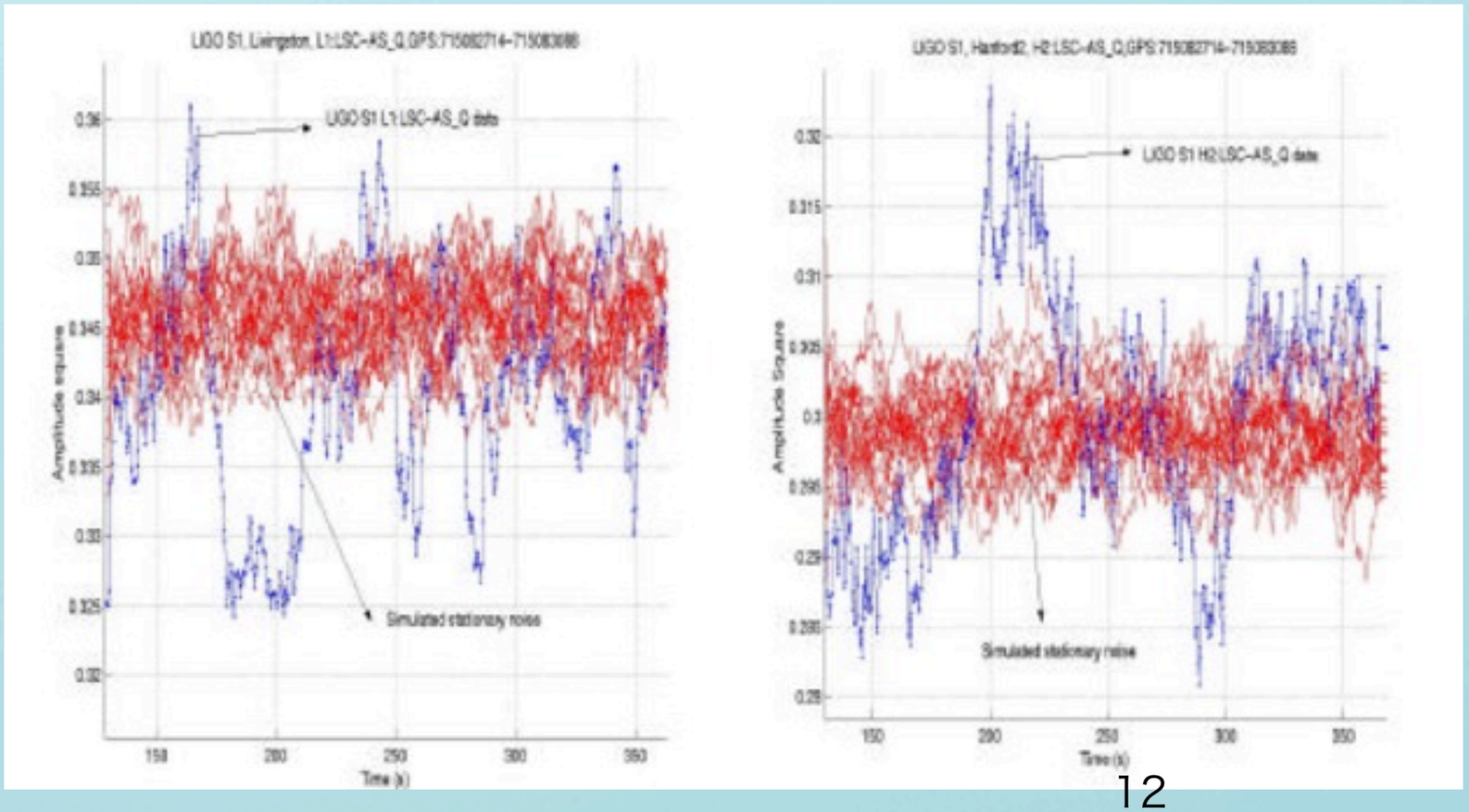


(5) Simulation

- Assume stationary and Gaussianity, generate time domain simulated data and calculate mean and variance
- Obtained significance level (ready programs)
- (continued...) How to take into account line features (or remove)

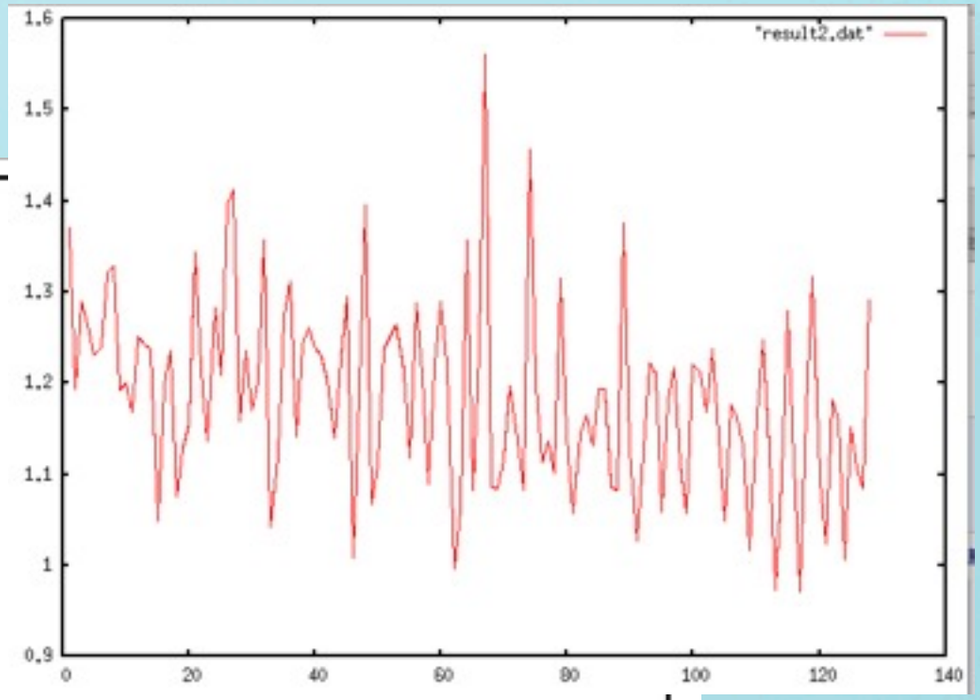
red : Expected fluctuation obtained by simulation

blue : S1 time variation of noise floor



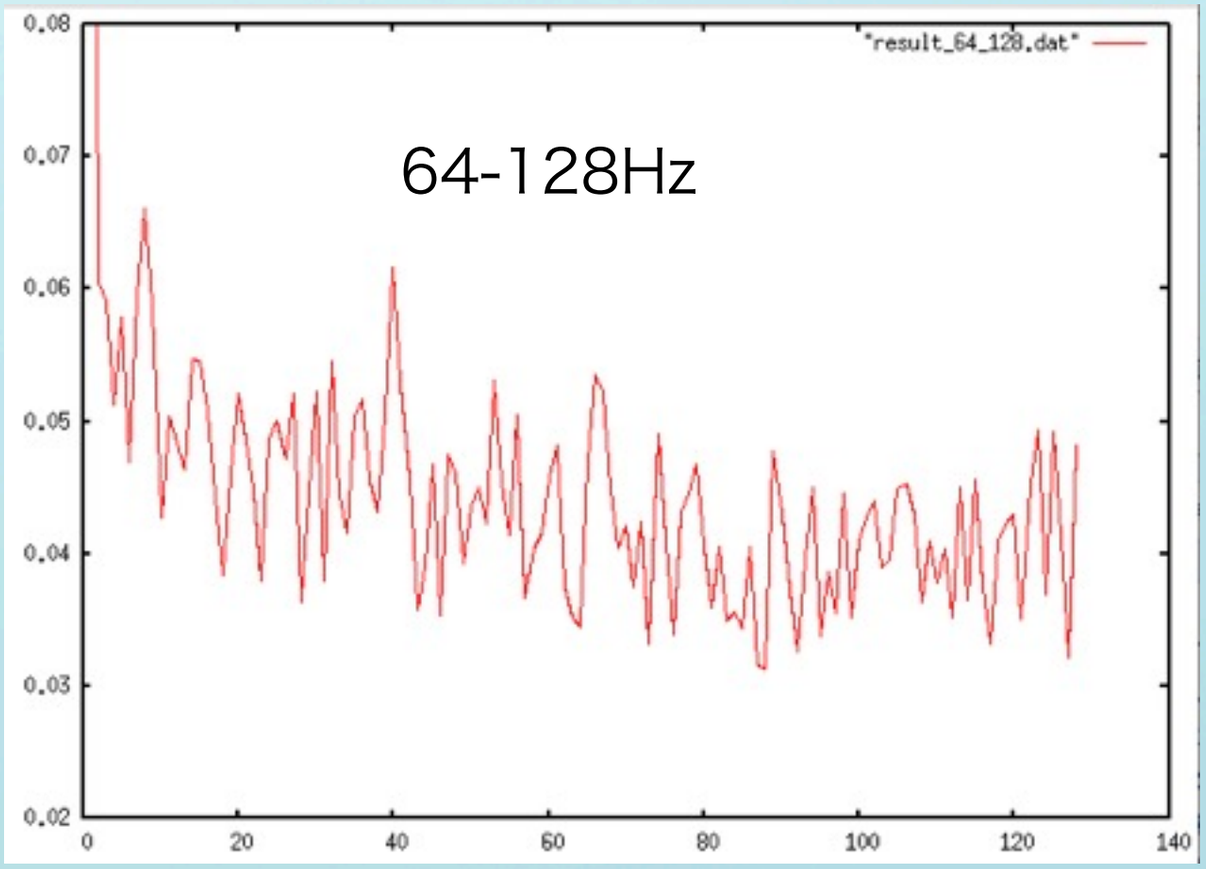
(4)Implementation

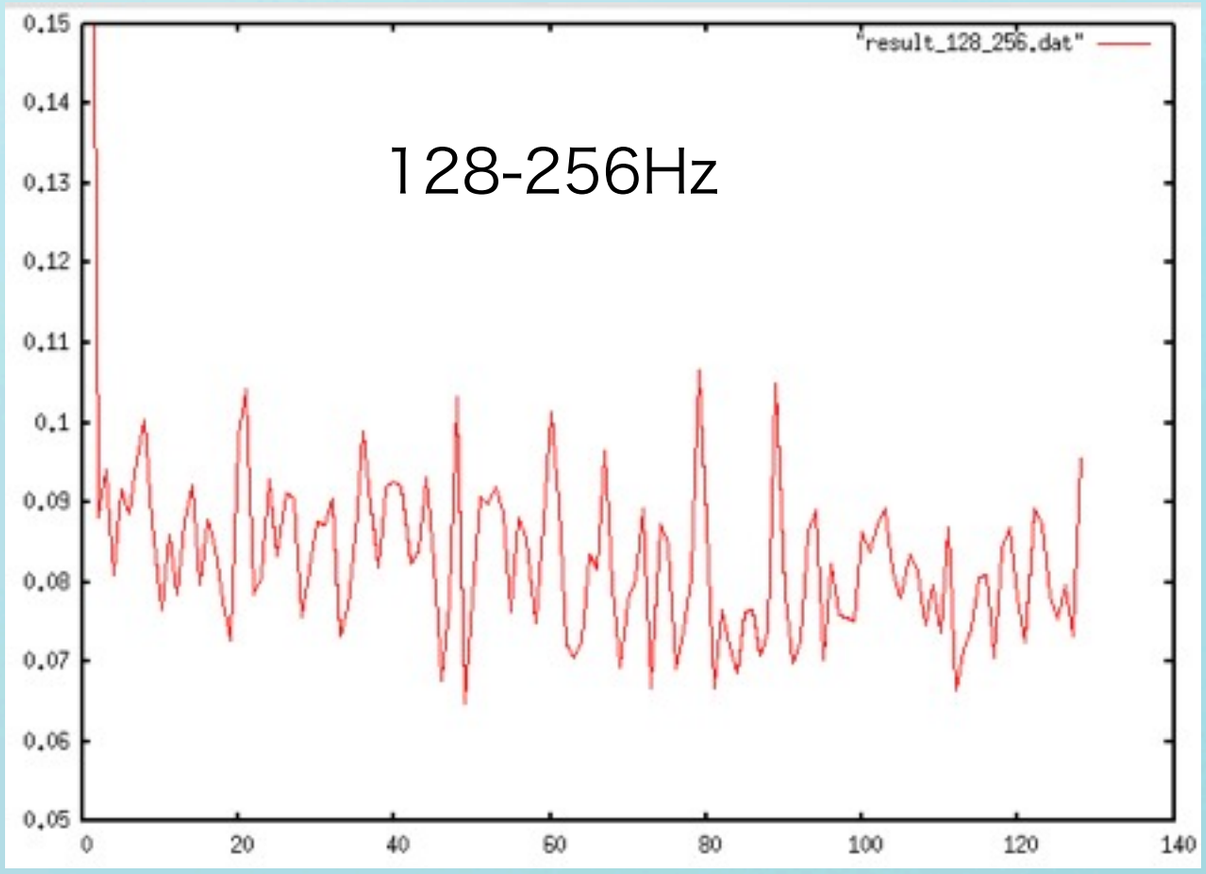
- There are bias in earlier time caused by resampling
  - there is no bias when not applying resampling
  - checking the code
- Take 45sec for 128sec data
- Obtained significance level by simulation
- (continued...)



(4)Implementation

- Apply bandpass filter, we can focus on specific frequencies
  - 64-128Hz, 128-256Hz





Summary and future plan

- Implementation noise floor monitor
  - Operation check by LIGO S5 data
    - not apply line removal algorithm
- Future plan
  - Apply to long data and check program stationarity
  - Include Line removal algorith