PHYS 512 - Problem Set 6 Solutions

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1 Question a

The noise model devised by convolving the data for each event with a Gaussian and then apply a window function that is flat near the center (tukey) in order to avoid tapering the data where the signal is not small using the Welch method. Doing so, we get the following plots for the four events detected.

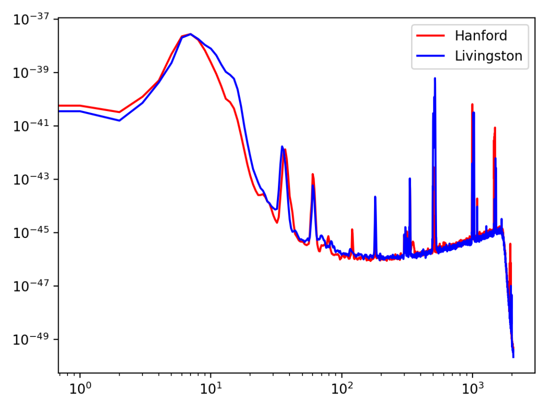

Figure 1: Noise model for event 1.

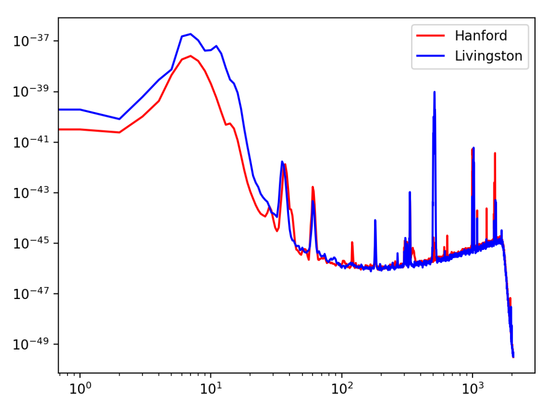

Figure 2: Noise model for event 2.

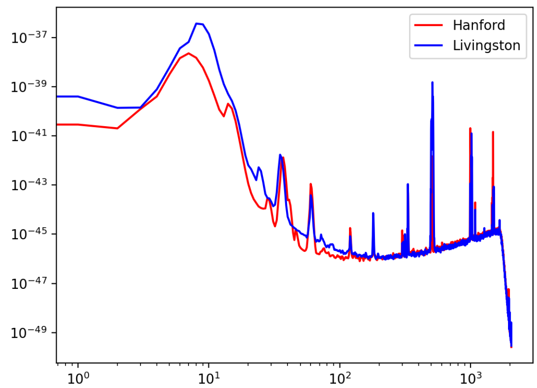

Figure 3: Noise model for event 3.

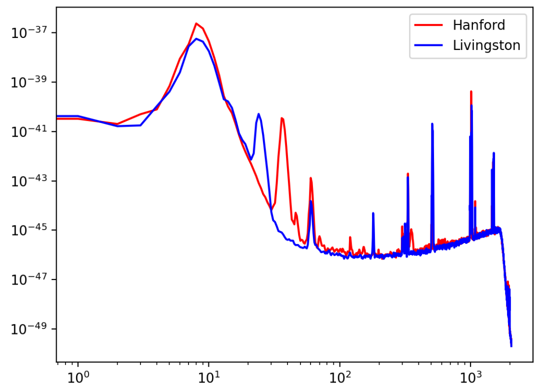

Figure 4: Noise model for event 4.

2 Question b

Using the noise model, we can use a match filter to look for signals like the ones shown below:

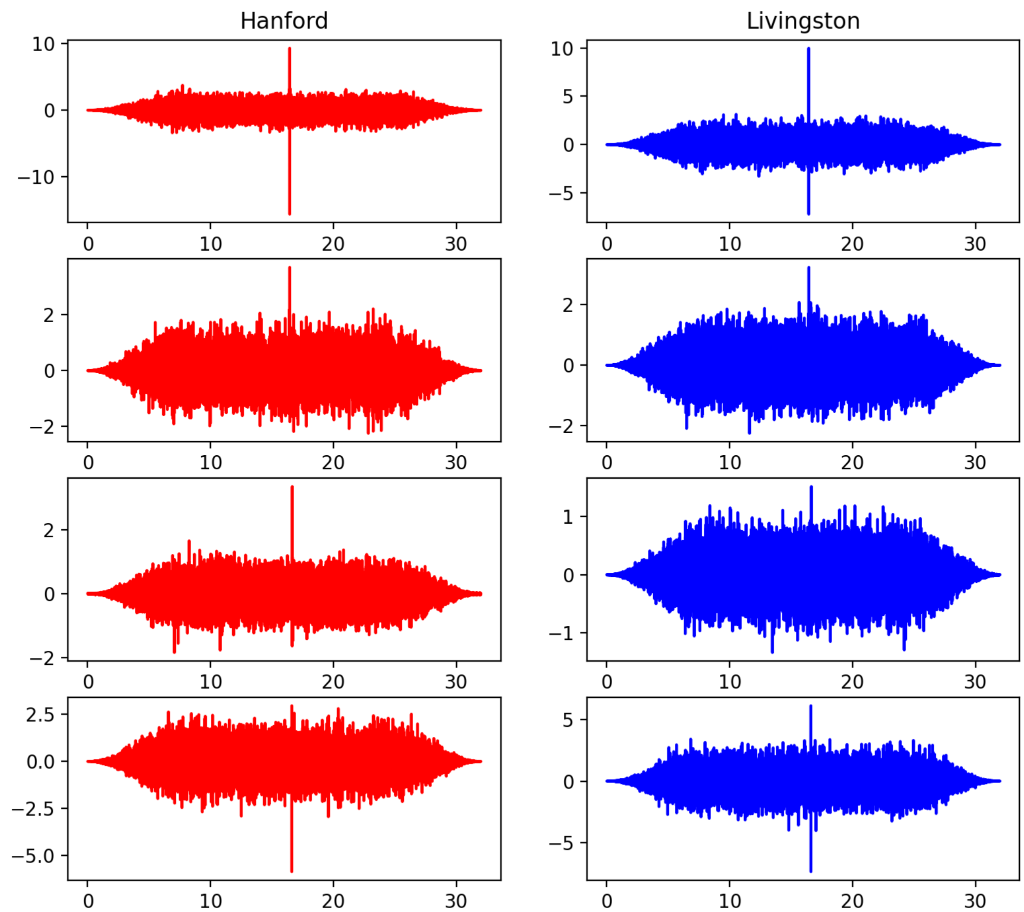

Figure 5: Match filters for the different events using the Hanford (left, red) and Livingston data (right, blue).

3 Question c and d

Noise for each event estimated by taking the standard deviation of the match filter data. The signal to noise ratio is the ratio between the magnitude of the signal to the estimated noise we calculated. The magnitude of the noise can be taken as the average of points that is neither tapering off nor containing the spike. These values are calculated for each event and is shown below in the tables.

Match Filters		
Hanford	Livingston	Combined
17.544147773295553	12.249754123427577	21.397513808283012
6.608395956806091	6.089687969889861	8.986389524862162
8.84709386792706	5.073077506813771	10.198391309321906
8.42996438703722	7.923740933505006	11.569354776651057

Analytic		
Hanford	Livingston	Combined
18.0557933446932	17.847438558149673	25.387846233841792
6.721405899968976	6.785330580651311	9.55081192155199
8.887437429470186	8.489267850228194	12.290411412791096
8.378989375305938	7.258532682812402	11.085745787223592

We observe that the values obtained using the two methods are very similar. The largest deviation observed is a difference for the first event in Livingston which increased by a factor of 1.45.

4 Question e

We can sum up the values are different frequencies and look for when the sum is more than half. This was found to occur at at the following frequencies for each data set:

Event	Hanford	Livingston
1	136.3125	138.78125
2	129.46875	135.8125
3	149.625	176.1875
4	141.1875	121.125

Table 1: The frequency from each event where half the weight comes from above that frequency and half below.

5 Question f

We want to estimate the time of arrival. This can be done by observing the difference between the horizontal shift (location of peak) between the two detectors. This would be the difference in time between when the signal was detected. The average time for all four events is $t \approx 0.00238037109375s$. Then to estimate the uncertainty in the position, we recall that distance is equal to velocity times time. So we can calculate the uncertainty in position is $\approx 714111.328125m \approx 714km$.