Assignment 6
Phys 512 Computational Physics

Hans Hopkins 260919593

Q1:
a)
Window function:
I chose the Tucky Window because it's flat in the middle and relatively simple. `en.wikipedia.org/wiki/Window_function#Tukey_window`
It is defined by (for some $0 < \alpha < 1$):

$$\text{Tukey Window}(n) = \begin{cases} \frac{1}{2}\left(1 - \cos\left(\frac{2\pi n}{\alpha N}\right)\right) & 0 \leq n < \frac{\alpha N}{2} \\ 1 & \frac{\alpha N}{2} \leq n \leq N - \frac{\alpha N}{2} \\ \frac{1}{2}\left(1 - \cos\left(\frac{2\pi(N-n)}{\alpha N}\right)\right) & N - \frac{\alpha N}{2} < n < N \end{cases}$$

I'm going to pick $\alpha = 0.5$ because why not. We want a flat window like this because the information we want to keep is in the center of the data. If we curve too much in the middle, it might reduce the magnitude of the hit.

For the smoothing/dealing with lines, our goal is to reduce the big spikes. Usually when you want to reduce a spike by smoothing, we take a median of the surrounding points, which discards the spike completely. The question is whether this method will discard way too much information at the small level. I guess I'll just commit to it and see what happens.

To be more specific, I'm taking the median of 10 points around each point in the nft. It looks like this is pretty good for reducing spikes. Plotting the unsmoothed and smooth looks like:

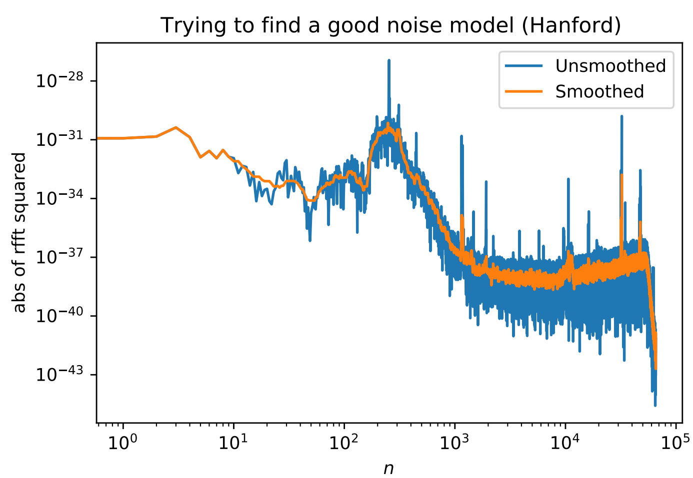

Figure 1: There's a visible difference pretty much everywhere between the smoothed and unsmoothed, which is concerning. Hopefully there's not too much information being lost here. On the bright side, those spikes are completely gone or a lot smaller.

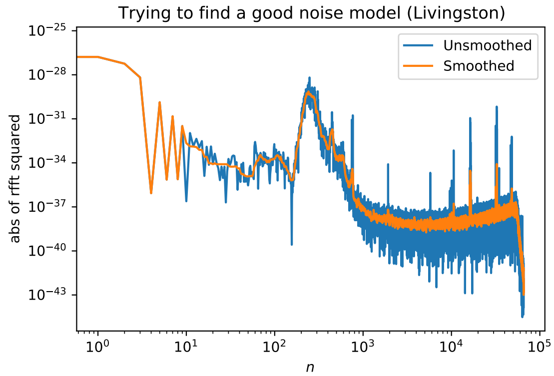

Figure 2: Here's the Livingston one. It's pretty similar.

b) Here are the plots I get:

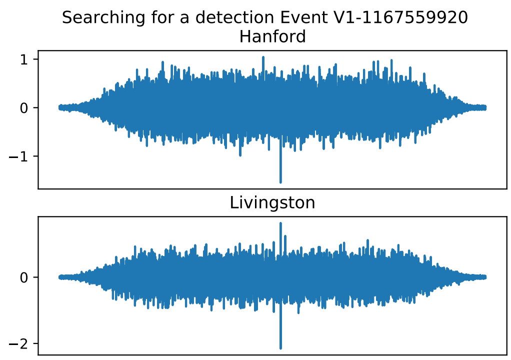

Figure 3: I think there's a detection here. There's a big spike downward for Hanford and spikes visible for Livingston

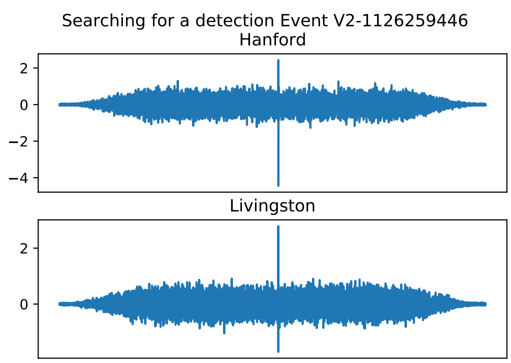

Figure 4: This is the nicest detection. You can easily see spikes for both.

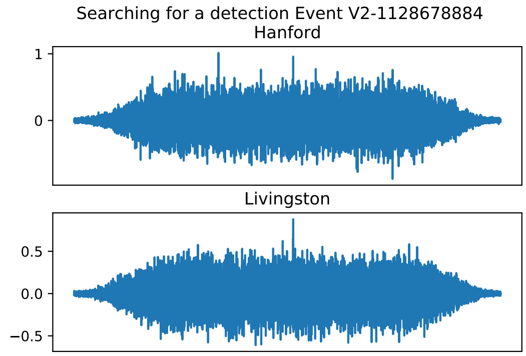

Figure 5: This one is a little more sketchy. Hanford has a few spikes that are the same height as the one in the middle.

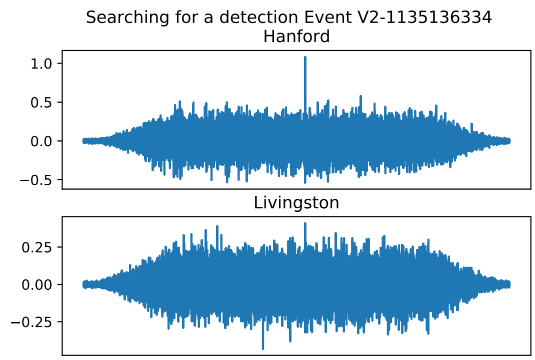

Figure 6: This one's also sketchy, but the spike for Hanford is pretty high.

c)

Disclaimer: I have no clue what the combined events means. I just added the the signals and the noises and divided them to find that. I hope that's right.

The SNRs:

Event	Hanford	Livingston	Combined
V1-1167559920	9.5	11.6	10.6
V2-1126259446	21.4	17.8	19.8
V2-1128678884	7.81	8.48	8.11
V2-1135136334	12.2	7.54	10.4

Wow the second one is pretty good. Even the third, which is the worst, is more than 5σ.

For the analytic noise, I'll use

$$\sigma_{\text{analytic}} = \sqrt{\frac{\sum (\text{template})^2}{\sum \text{Noise}}}$$

I just kind of took this from the Slack.
The SNRs I get are not even close to the same.
Anyway the comparison table is this:

Event	Analytic	From Scatter
V1-1167559920 Hanford	409	9.5
V1-1167559920 Livingston	14657	11.6
V2-1126259446 Hanford	2212	21.4
V2-1126259446 Livingston	10798	17.8
V2-1128678884 Hanford	962	7.81
V2-1128678884 Livingston	6888	8.48
V2-1135136334 Hansford	1862	12.2
V2-1135136334 Livingston	7481	7.54

They don't agree at all, and the reason is probably that the noise model isn't very good. In particular, it wildly oscillates even after smoothing, so summing it up probably won't give a very useful quantity.

I'm going to leave it here for tonight. Hopefully we'll get an extension and I can upload the complete version later. I started the bonus but didn't complete it.