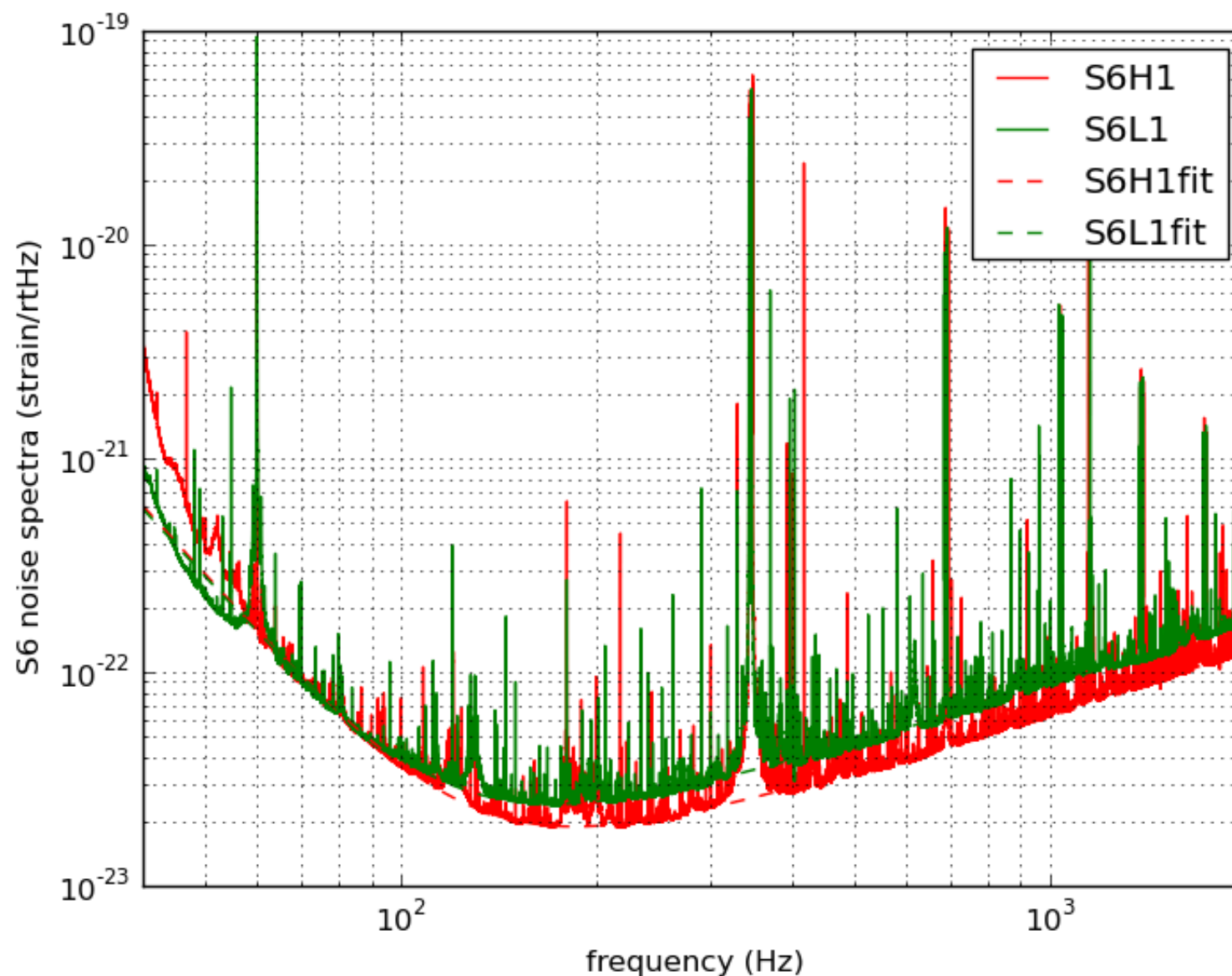


# LIGO Data

- <https://www.gw-openscience.org/tutorials/>
- Download: “file with data” will get you everything
- `simple_read_ligo.py` will read for you (once you have h5py installed and working)

# First, what should we see for noise?



# Matched Filter

- We want to search for a signal in data. We don't know where it will be. How do we find it?
- Best fit amplitude for 1-D template  $A$  is  $A^T N^{-1} d / A^T N^{-1} A$
- We can search many possible locations of template with matched filter, replacing top by correlation of  $A$  with  $N^{-1} d$  (or  $N^{-1} A$  with  $d$ ) if noise is stationary
- Alternatively, could take correlation of  $N^{-1/2} A$  with  $N^{-1/2} d$ . What would the noise in  $N^{-1/2} d$  look like?

# Power Spectrum Description

- Modes are uncorrelated in Fourier space
- $\text{SNR}^2/\text{mode}$  is set by  $(\text{template FT})^2/\text{noise PS}$
- Noise PS is just FT of correlation function

# Fourier Interpretation

- Noise model has same total variance independent of correlation length.
- Looking at FT, long length packs noise power into many long wavelengths. Template has more power on high-frequency scales (good SNR)
- Short length spreads out power over many many modes, dropping average noise power. Template well above noise on large scales (good SNR).
- Intermediate packs all its noise into same scales as template. Never have good SNR.

When your noise looks like your signal,  
you're going to have a bad day...

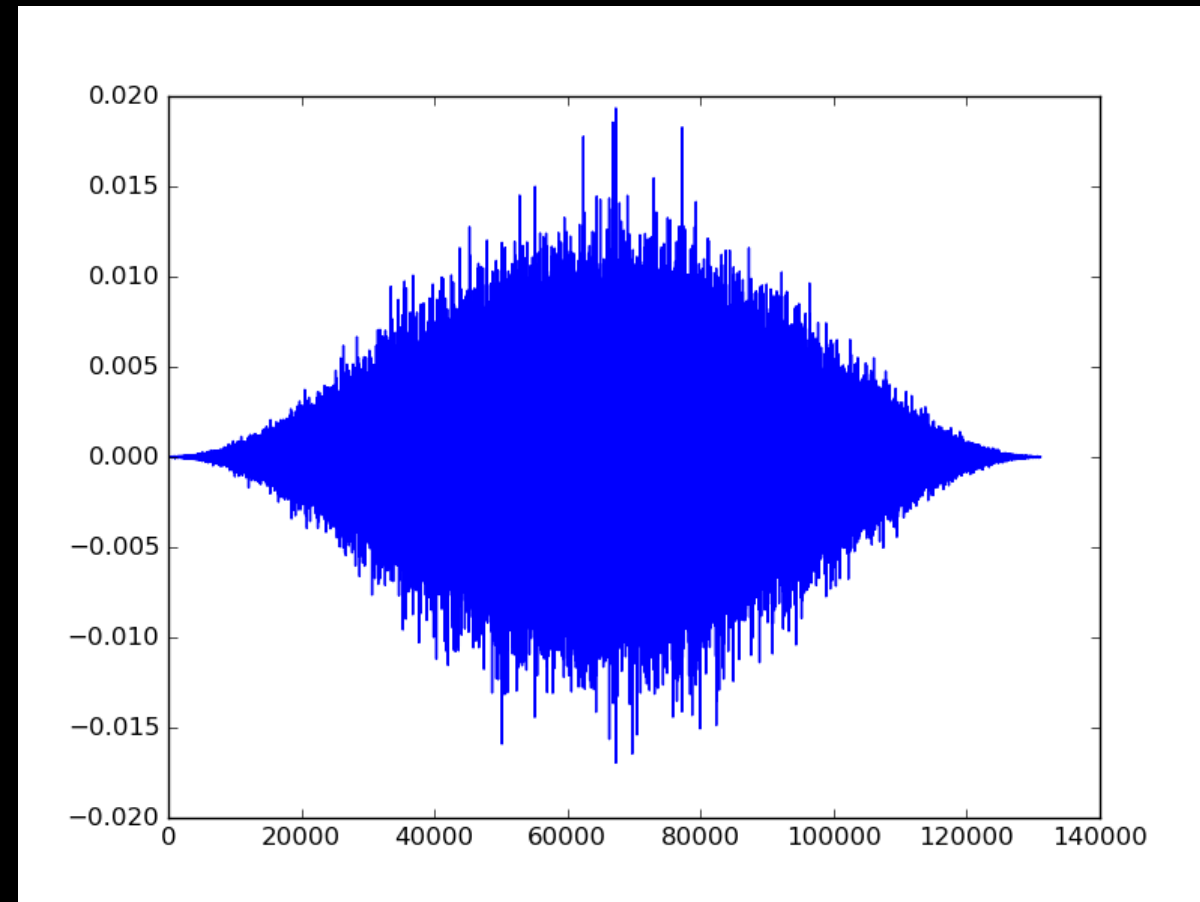
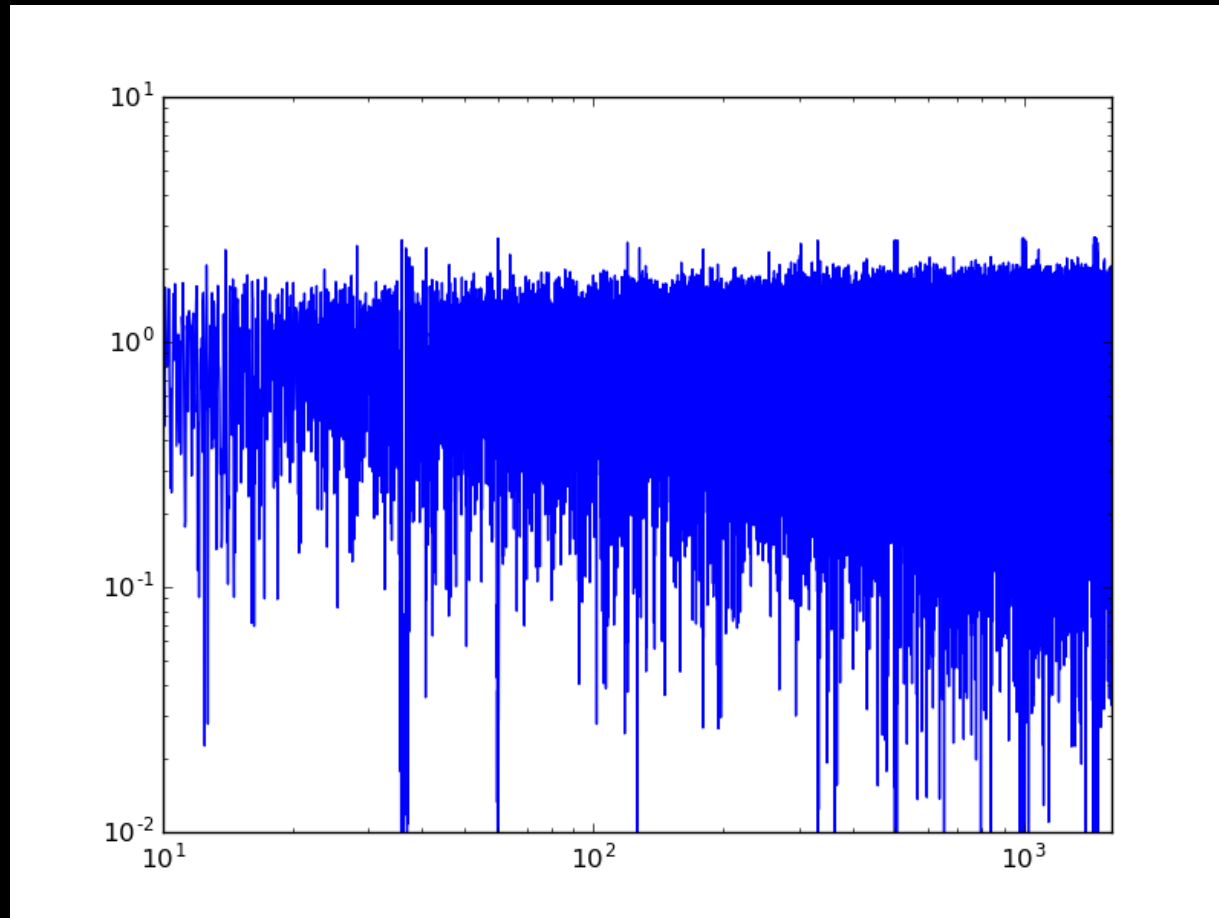
# How Should We Estimate Noise?

- Windowing key to avoiding FFT ringing
- smooths out spectral features
- Noise large per mode in FT, so we have to average
- What are your thoughts on averaging?

# Smoothing PS

- Take  $|FT|^2$ , which is an estimate
- Smooth by convolving with an extended function.
- Thoughts on the function?

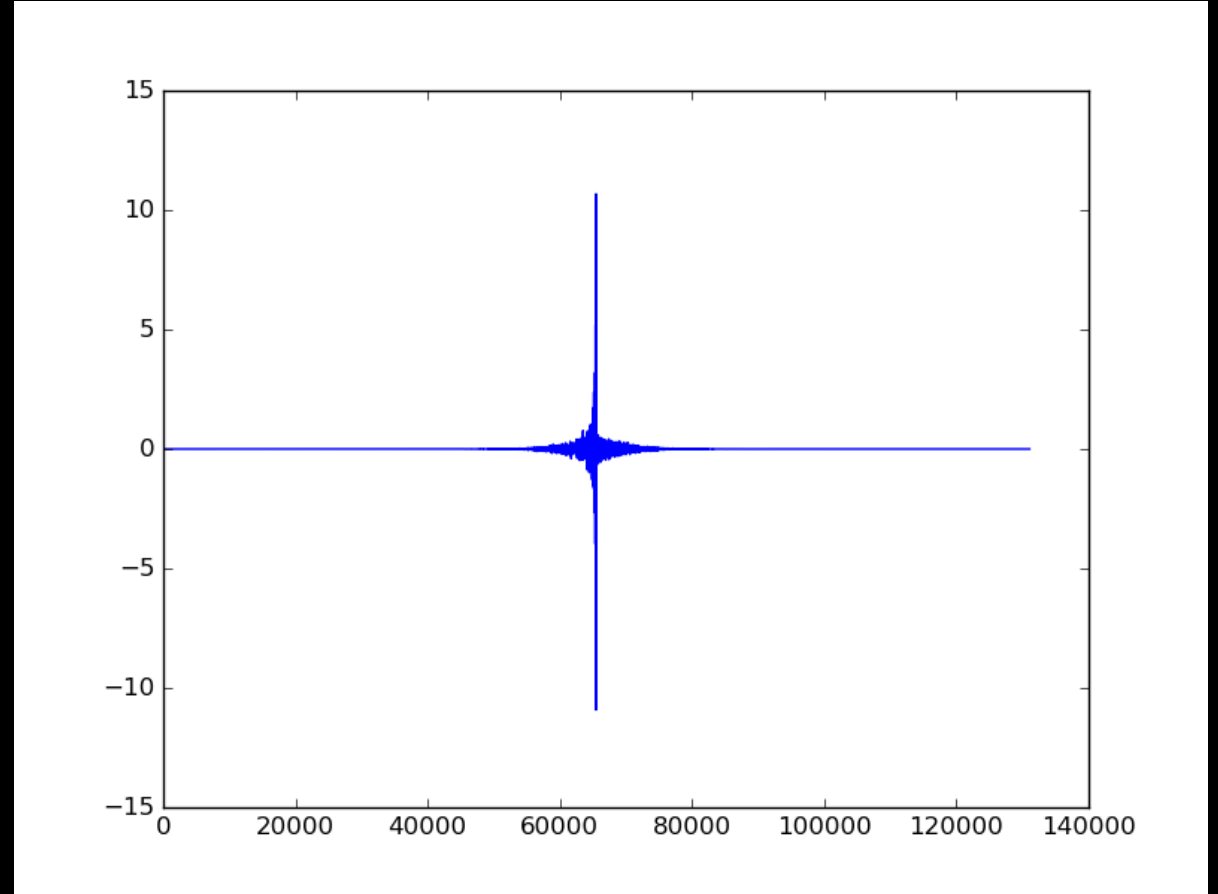
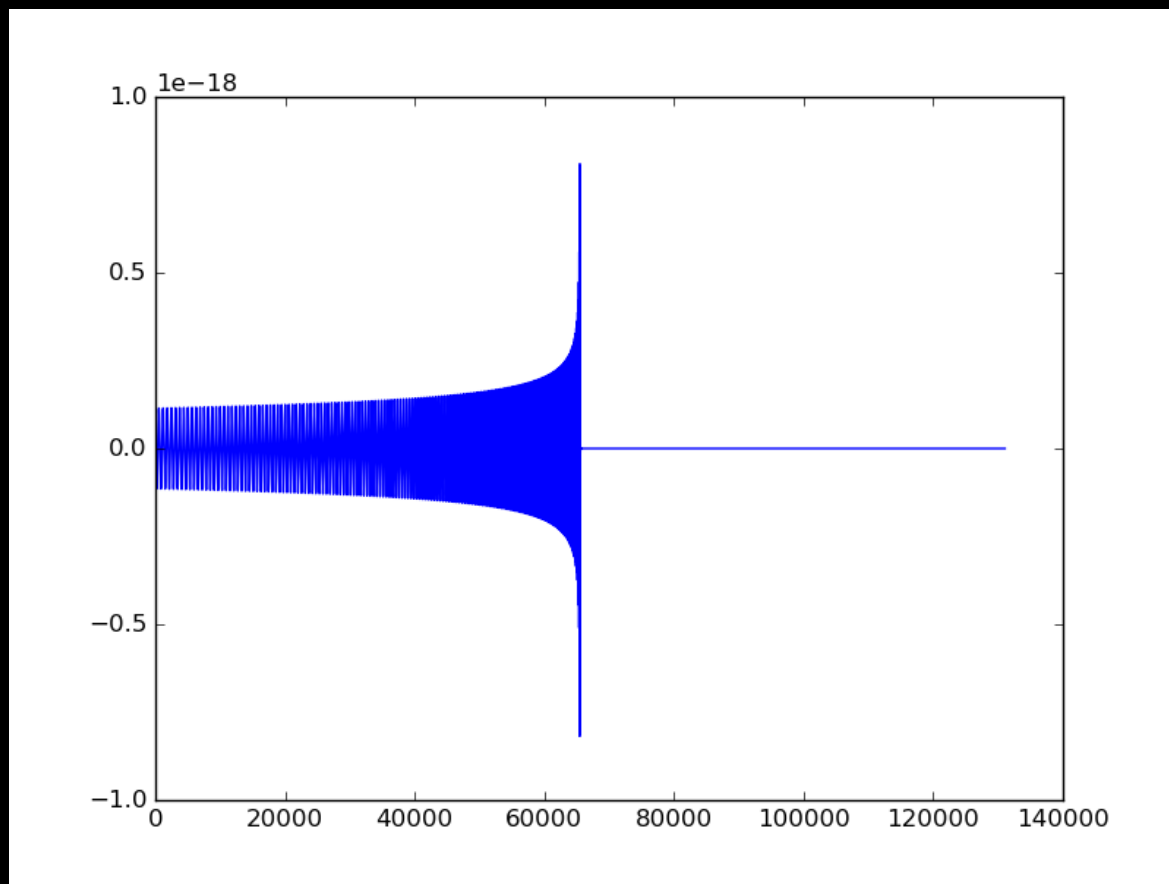
# Pre-Whitened Data from Smoothed PS



Left: Whitened FT of data. Looks not crazy. What are little nubbins sticking up?  
Right: whitened data. Window shape is pretty obvious.

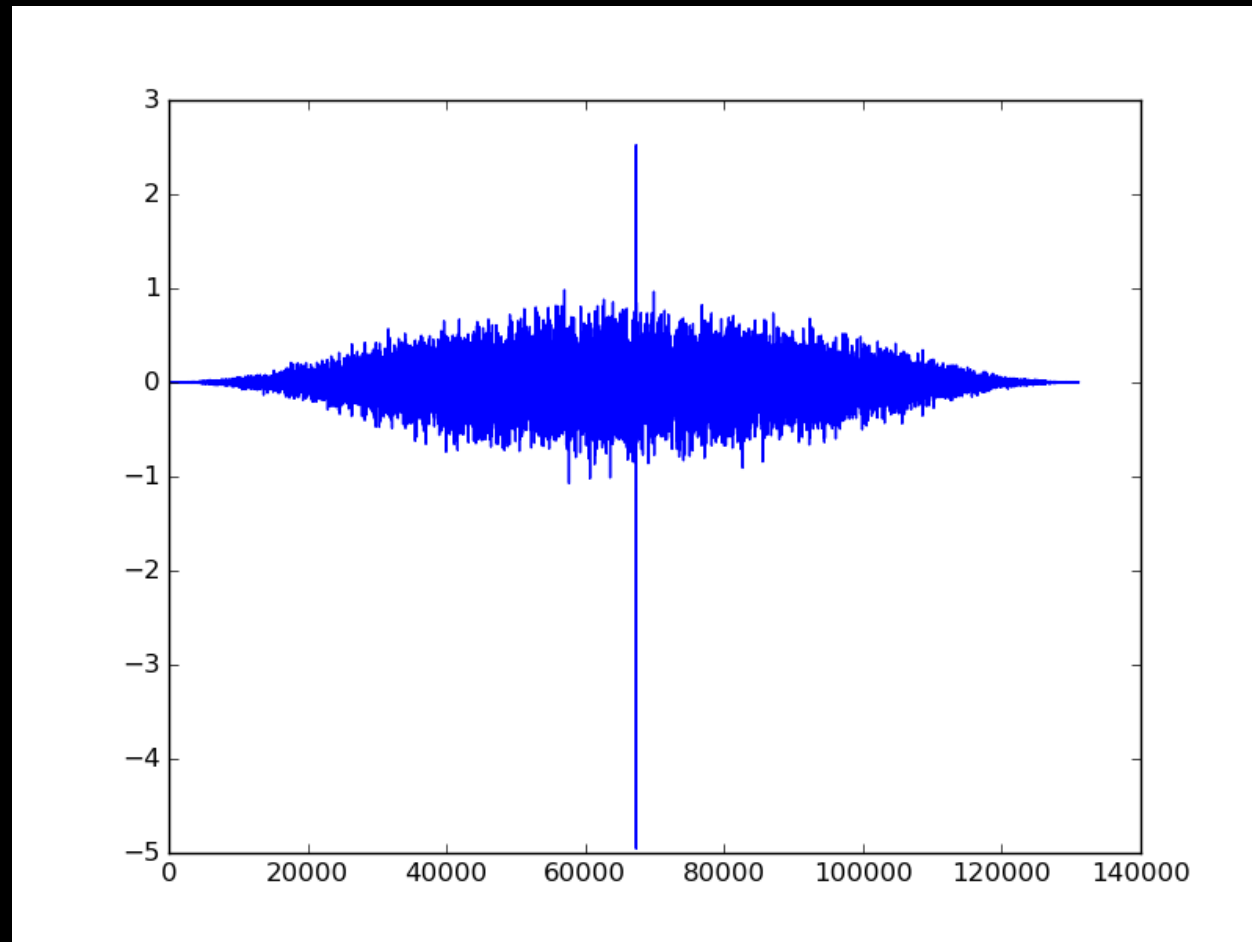


# Pre-whitened template



- For this event, template is not small at start of data. Will this be a problem?
- Can look at pre-whitened version of template to get an idea.

# Can Use for MF now



FFT Shift of matched filter output. We found a GW!

# Averaging PS

- Break PS up into small chunks so we have many
- Take the FT of each chunk
- Add the FT<sup>2</sup>s together.
- How do we apply this (short) PS to original data?
- Qualitatively, how do we relate this PS estimate to smoothed one?

# More Windowing

- Usual windows taper every sample.
- Reduces power in a way we probably aren't happy with
- How could we modify window to make this less of an issue?
- Let's try this on data...