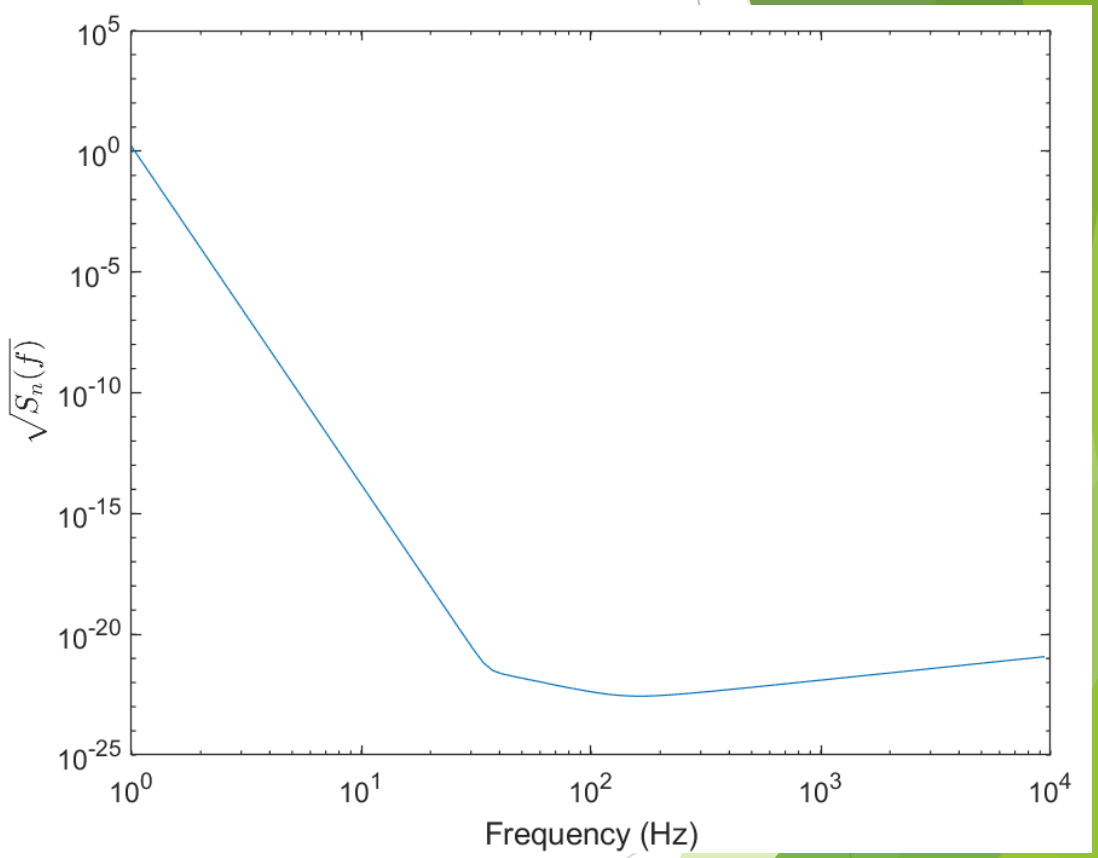
Simulating LIGO noise

Objective

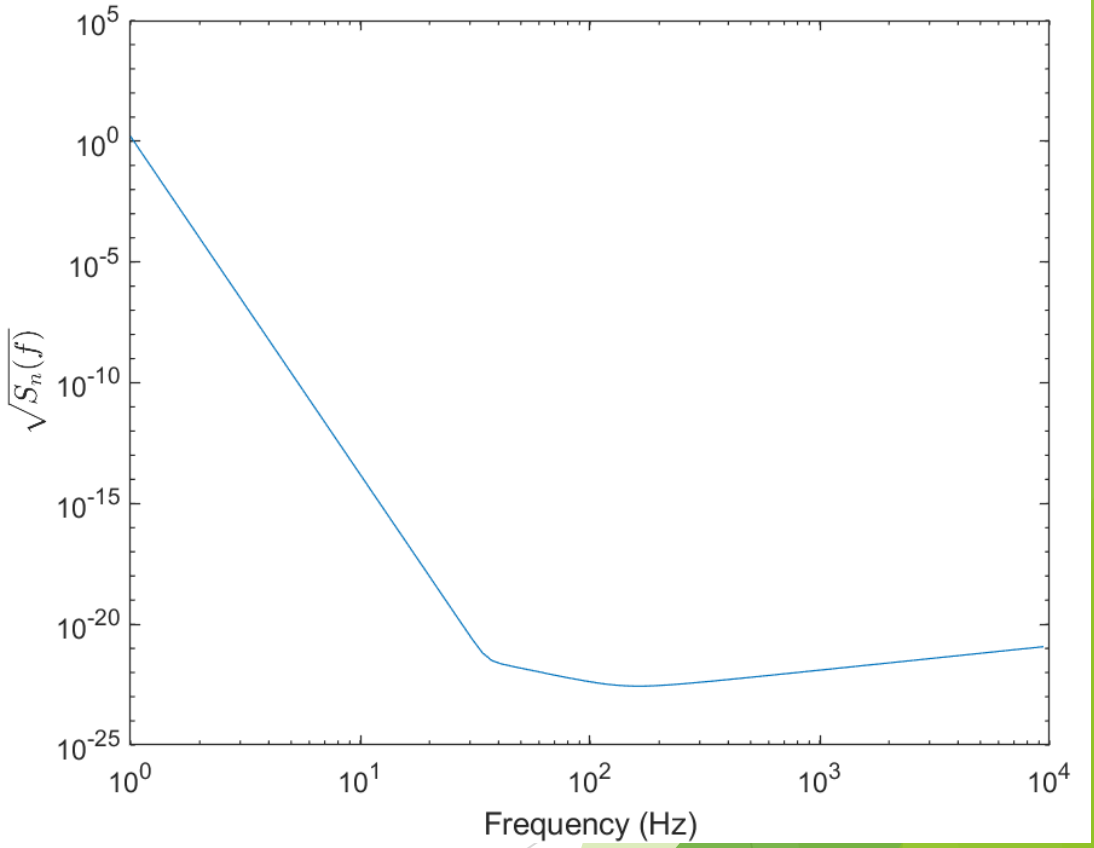
- Simulate the noise of an interferometric detector
- We will pick the sensitivity curve of the initial LIGO detector as an example for the target PSD
- The same steps can be used for any other design sensitivity curve (e.g., advanced LIGO, LISA etc)



Initial LIGO design sensitivity

- The PSD is provided in the file **NOISE/iLIGOSensitivity.txt**
- It is a plain text file which can be read into Matlab
- First column is Frequency f (Hz) and second column is $\sqrt{S_n(f)}$

```
>> y = load('iLIGOSensitivity.txt','-ascii');
>> whos y
  Name Size    Bytes  Class
  y    97x2    1552  double
>> loglog(y(:,1),y(:,2))
```



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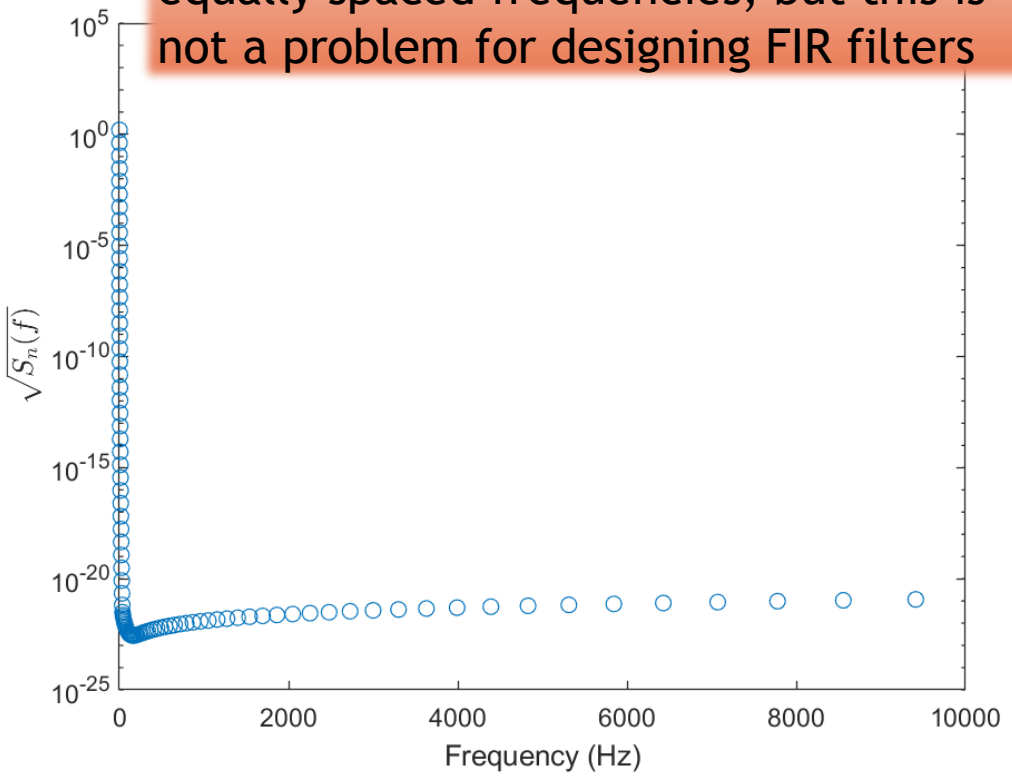
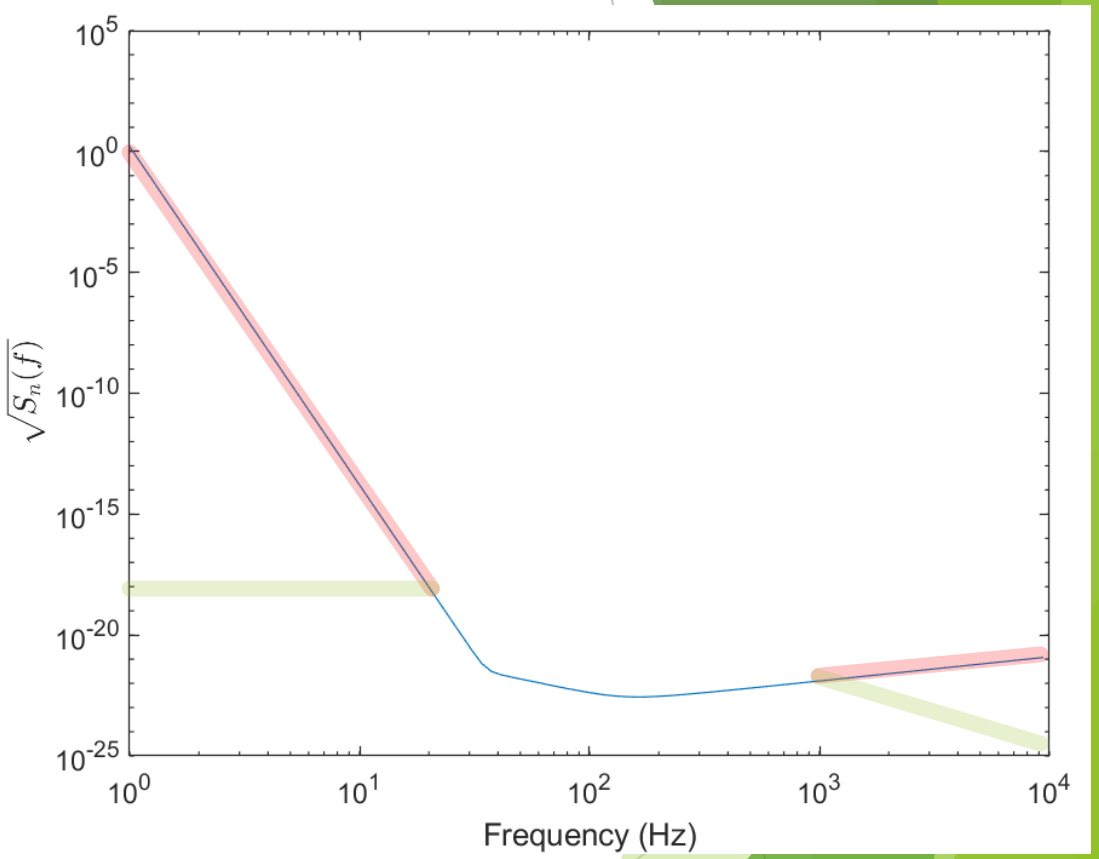
Design sensitivity is not specified at equally spaced frequencies, but this is not a problem for designing FIR filters



Modifications

- In any data analysis method, the low and high frequency parts will be filtered out ⇒ the PSD of the simulated noise need not match the design PSD in those parts
- The order of an FIR filter that can reproduce the steeply rising seismic part in its transfer function will be very high ⇒ Making the PSD goes smoothly to zero or just be a constant in these parts will help Matlab in designing better filters



Modifications

- For $f \leq 50$ Hz: $S_n(f) \rightarrow S_n(f = 50)$
- For $f \geq 700$ Hz: $S_n(f) \rightarrow S_n(f = 700)$
  - 700 Hz is where the inspiral phase of a binary of double neutron star will terminate
  - No point in keeping noise above this frequency in the data
- Remember that you need normalized frequencies of 0 and 1 for input to FIR1
  - Add $f = 0, S_n(f = 0)$ and $\frac{f_s}{2}, S_n\left(f = \frac{f_s}{2}\right)$ to the list if these are missing
- Task: Use the supplied codes (**NOISE/colGaussNoiseDemo.m, statgaussnoisegen.m**) to produce a simulated LIGO noise realization and estimate the PSD

Example of simulated LIGO noise PSD

- Note that the LIGO design sensitivity plots are logarithmic in frequency while the plot here is on a linear scale
  - Also, different truncation and sampling frequencies were used here
- The “bumpiness” in the PSD near the minimum is an artifact of the approximation inherent in filter design
  - You should try to minimize such artifacts by choosing the design parameters appropriately.