Gravitational Wave Bursts: Characterization of Transients in LIGO Interferometer Data

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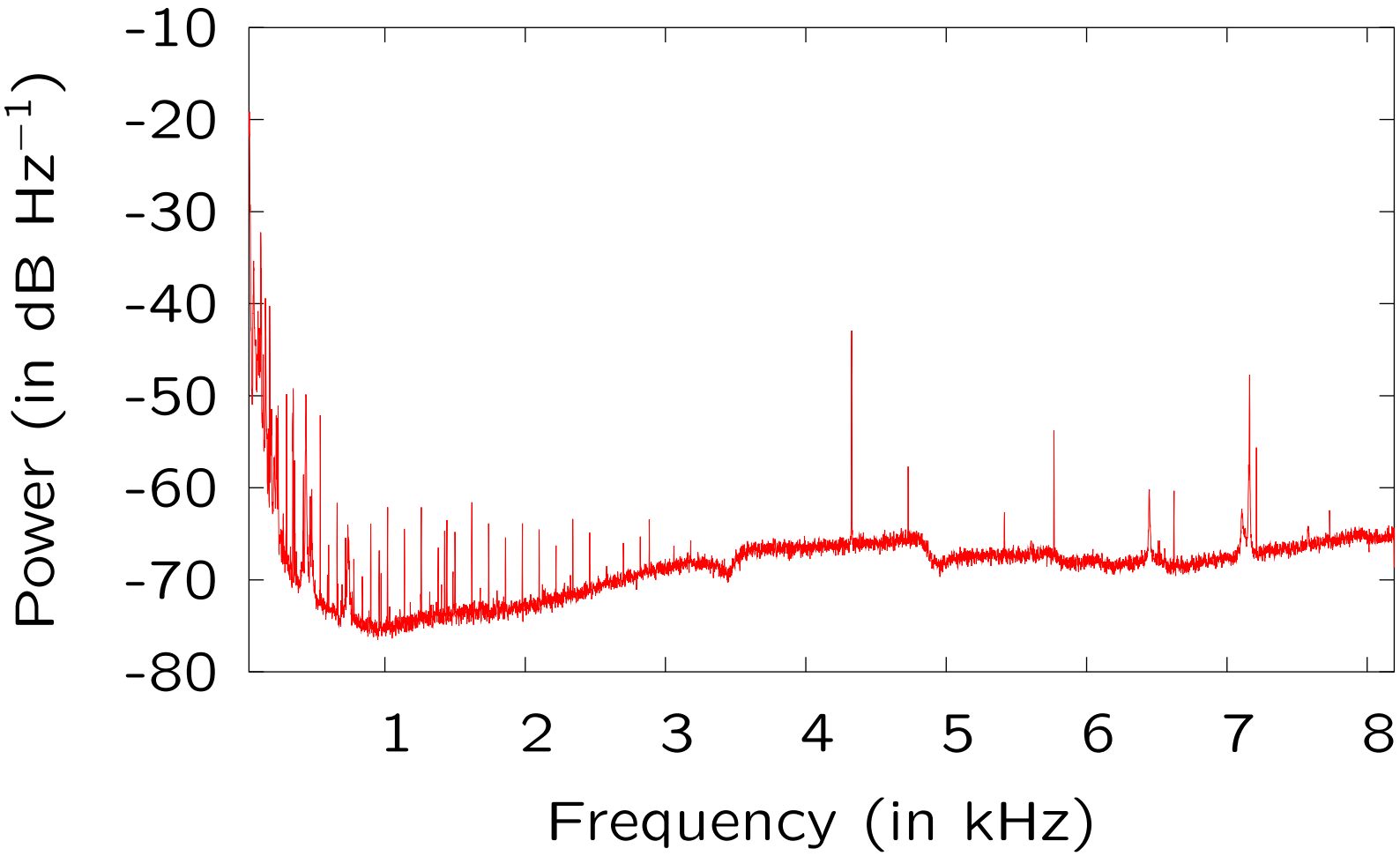
The Spectrum of LIGO Interferometer Output



Probability Distributions & Likelihood Ratios

- The probability distribution function (pdf) f:

$$\mathbb{P}(a < X \leq b) = \int_a^b f(x \,|\, \boldsymbol{\theta})\, dx \tag{1}$$

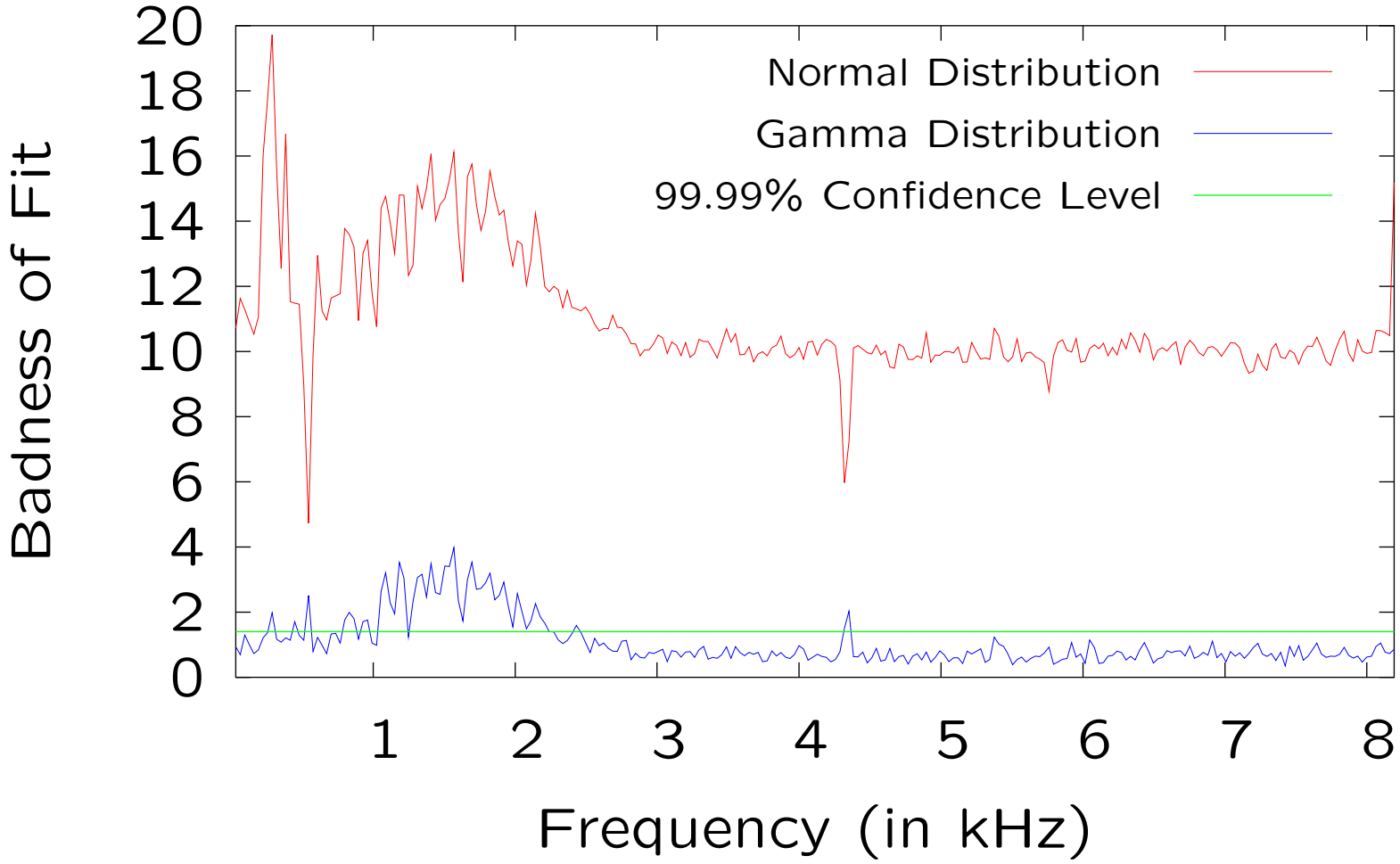
- The hypotheses:

  H_0: Data $\boldsymbol{x}$ comes from a pdf $f_0(\boldsymbol{x} \,|\, \boldsymbol{\theta}_0)$, for some $\boldsymbol{\theta}_0$.
  H_1: Data $\boldsymbol{x}$ comes from a pdf $f_1(\boldsymbol{x} \,|\, \boldsymbol{\theta}_1)$, for some $\boldsymbol{\theta}_1$.

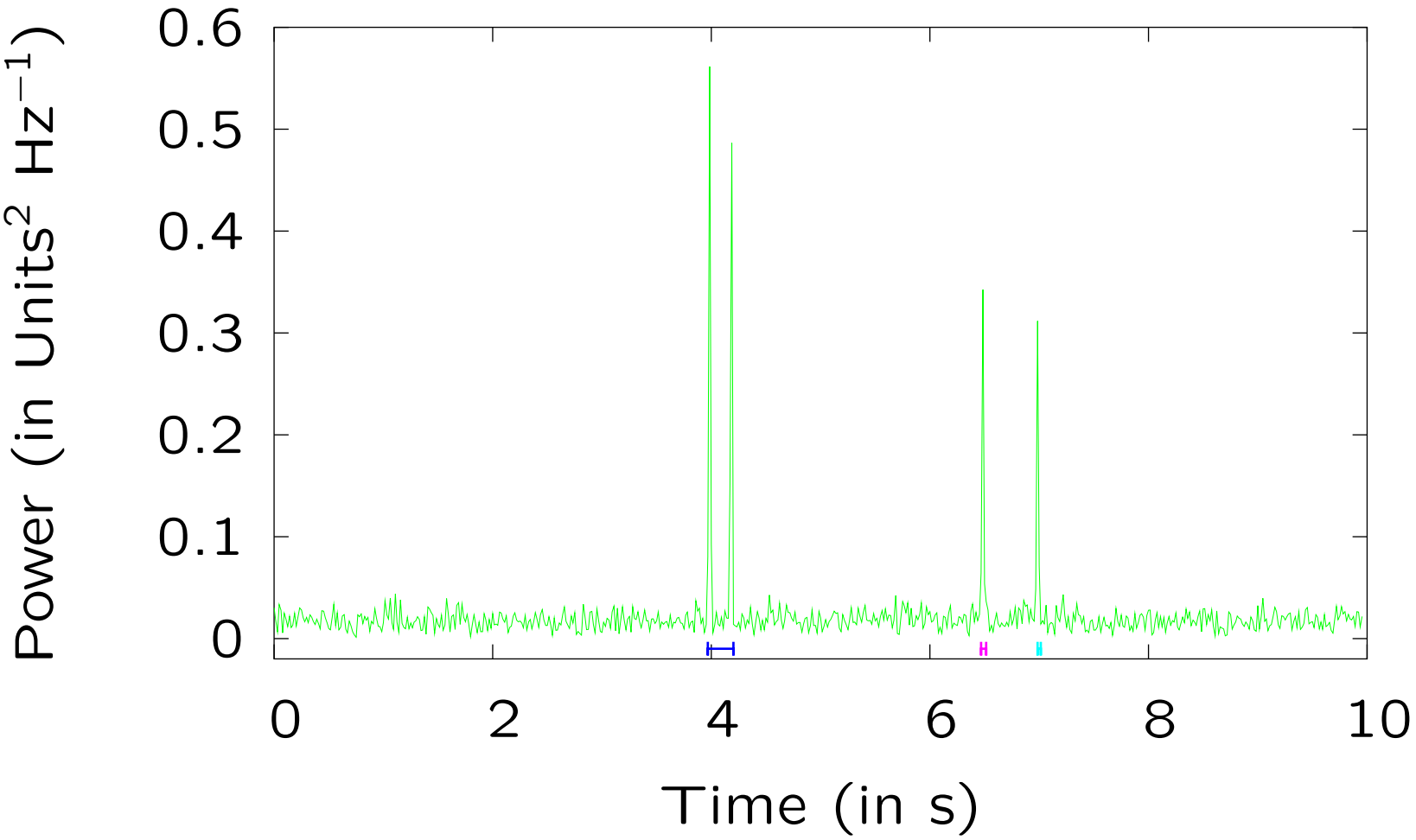
- The log profile likelihood ratio statistic:

$$2 \log \left(\frac{\sup_{\boldsymbol{\theta}_1} \left\{ f_1(\boldsymbol{x} \,|\, \boldsymbol{\theta}_1) \right\}}{\sup_{\boldsymbol{\theta}_0} \left\{ f_0(\boldsymbol{x} \,|\, \boldsymbol{\theta}_0) \right\}} \right) \tag{2}$$

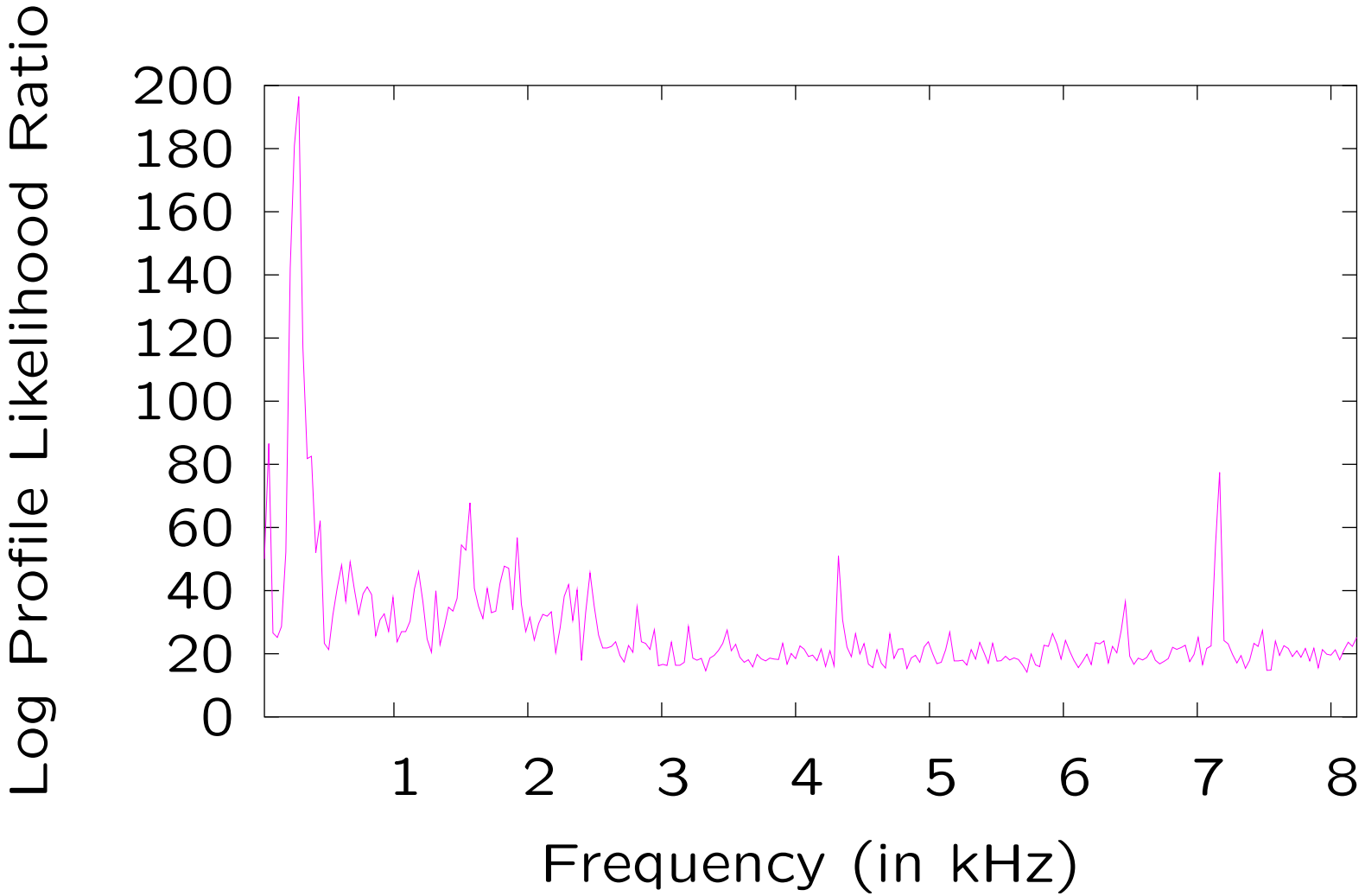
Goodness of Fit of Different Distributions



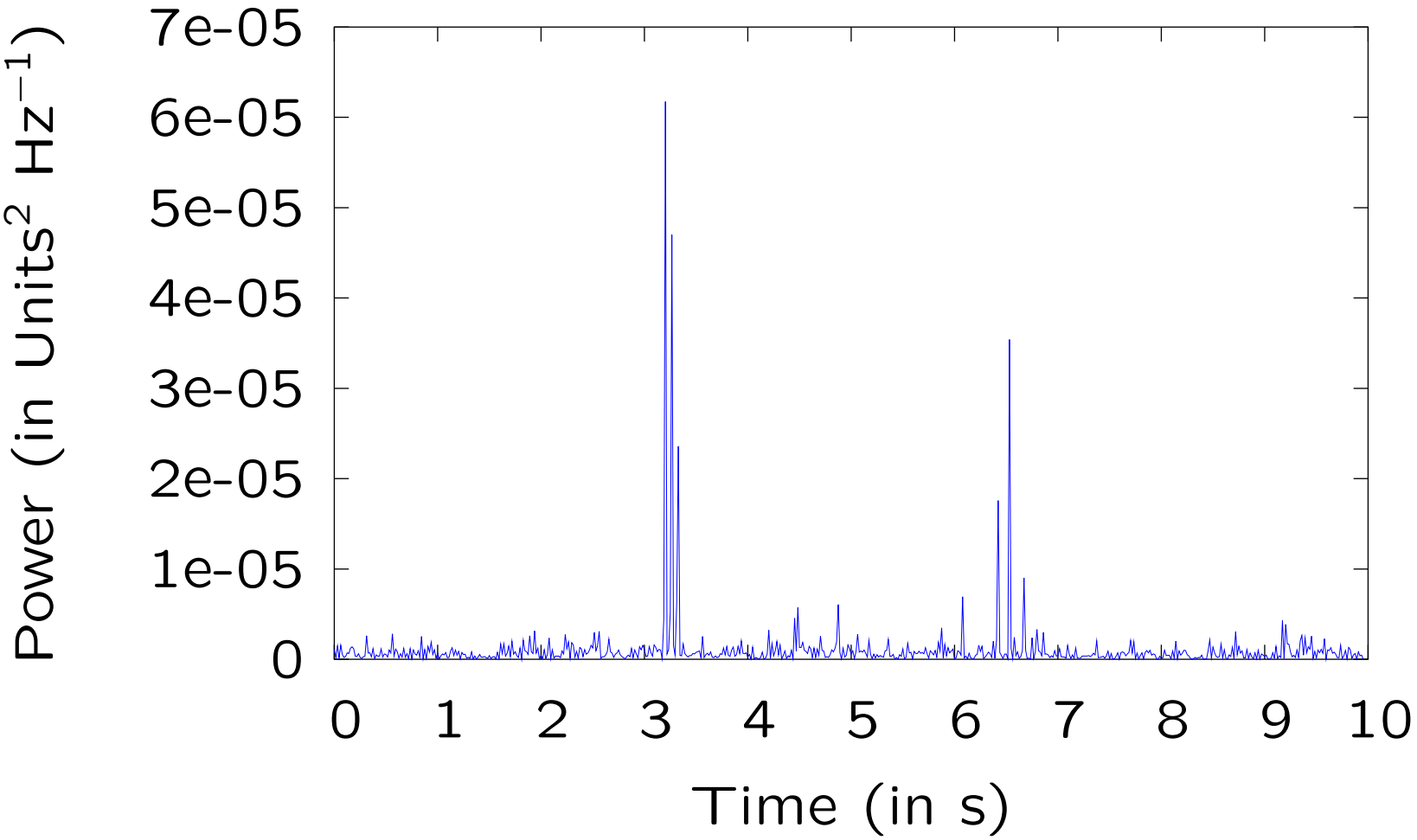
Iterative Search Method



Significance of the Signal Found



Power Evolution in the 272–304Hz Frequency Band



Results after Post-Processing

```
Transient 1:
    Start        : 3.17969
    End          : 3.36719
    Significance: 196.498
    Power        : 0.00265712
    Frequency composition:
        208 - 400: 1
```

```
Transient 2:
    Start        : 6.42969
    End          : 6.55469
    Significance: 81.7497
    Power        : 0.000221876
    Frequency composition:
        272 - 304: 1
```

```
Transient 3:
    Start        : 6.88281
    End          : 7.11719
    Significance: 86.5563
    Power        : 4.19208
    Frequency composition:
        48 - 80: 1
```

Conclusions

- The algorithm created can detect transients — it did so in the example presented. It can also indicate which frequency bands it believes the transients occurred in.

- It is susceptible to badness of fit and non-stationarity.

- General problems occurred in the 1–3kHz range, where there is the least power.

- Specific, isolated problems occurred at 4320Hz and 7168Hz. These frequencies correspond to dramatically higher power than the surrounding frequencies.