

Data analysis with Bayesian Inference

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- Gravitational wave data analysis involves the identification of signal in data dominated by noise
 - must have robust estimate of background (non-gaussian) noise
 - many years of experience with this
- Our focus is to use Bayesian inference to fold in all info we have about potential signals
 - world leaders in search for GWs from neutron stars
- Model selection allows us to distinguish signals from transient noise
 - or distinguish between different kinds of signals

- For two competing models, M_1 and M_2 , we calculate odds ratio

$$O_{12} = \frac{P(M_1|D, I)}{P(M_2|D, I)}$$

- If O_{12} is greater than 1, then the data looks more like model 1 and vice versa for O_{12} less than 1
- Can also include multiple noise models so that

$$O_{123} = \frac{P(M_1|D, I)}{P(M_2|D, I) + P(M_3|D, I) + \dots}$$

- Model 3 can be spurious environmental noise

- Using Bayes' theorem, the odds ratio can be expanded to be

$$O_{12} = \frac{P(M_1|D, I)}{P(M_2|D, I)} = \underbrace{\frac{P(M_1|I)}{P(M_2|I)}}_{\text{Prior odds}} \times \underbrace{\frac{P(D|M_1, I)}{P(D|M_2, I)}}_{\text{Bayes factor}}$$

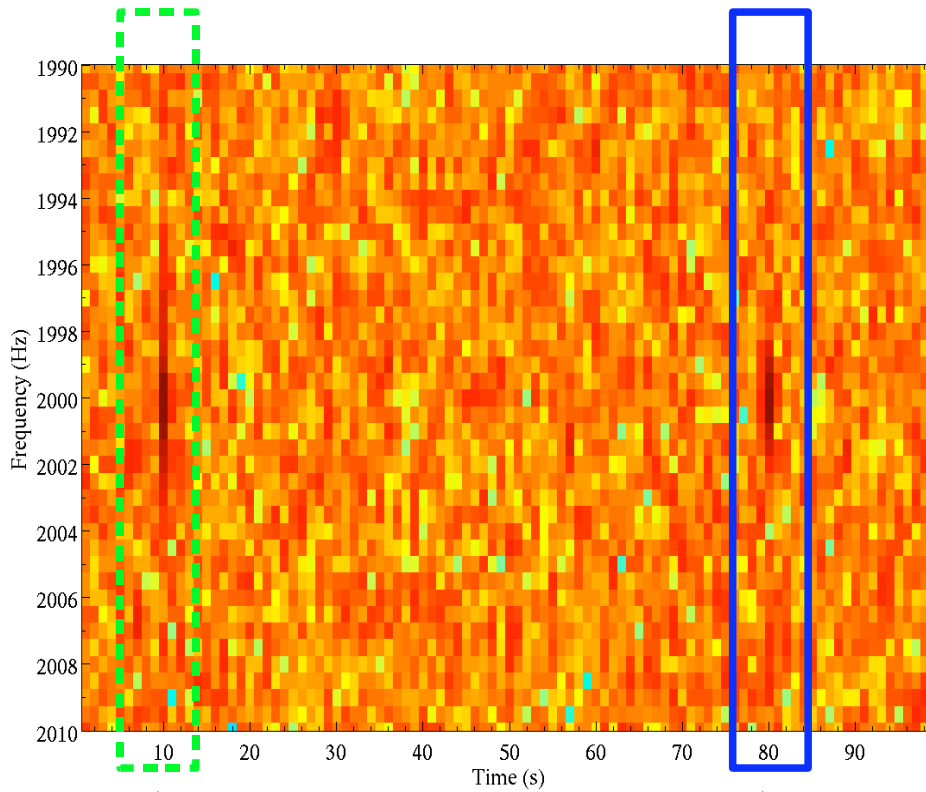
- The Bayes factor is a ratio of the evidences (likelihood marginalised over all parameters, θ)

$$P(D|M, I) = \int_{\theta} P(\theta|M, I)P(D|\theta, M, I)d\theta$$

M_1 : simulated signal

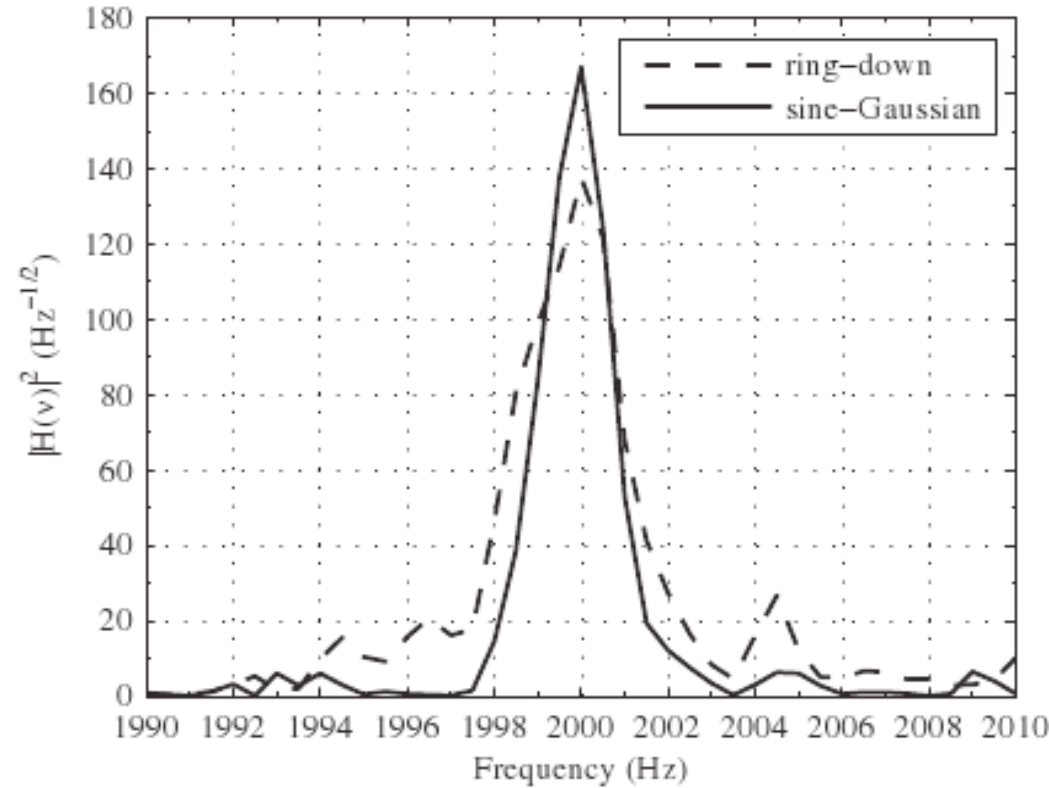
M_2 : simulated noise

M_3 : simulated transient noise



↑
signal

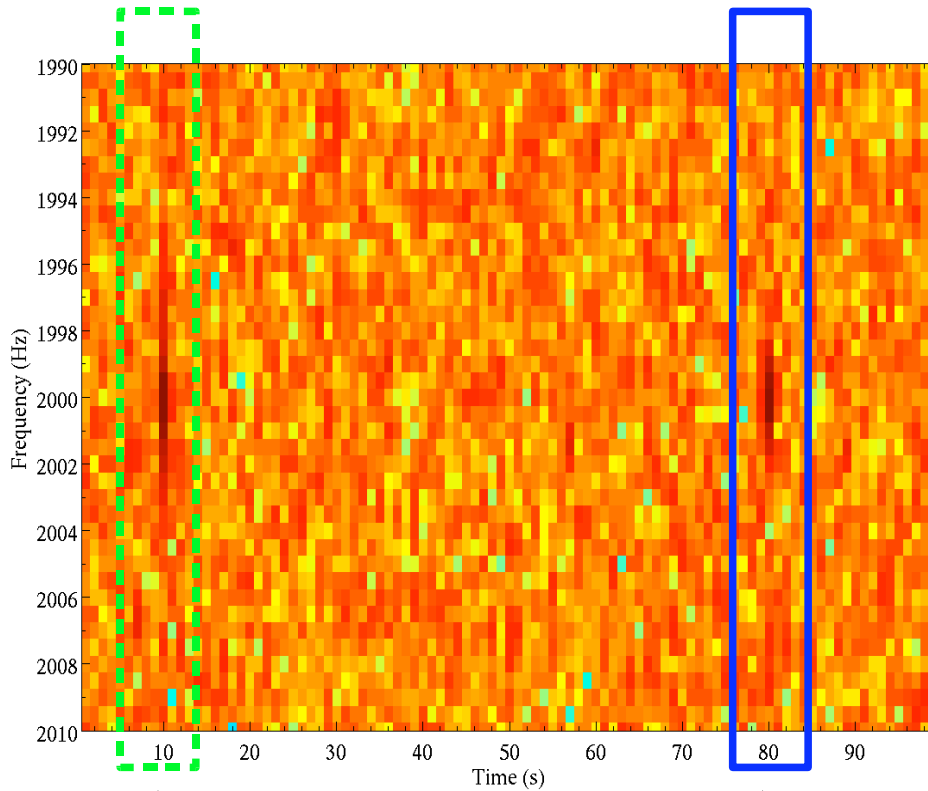
↑
signal-like
noise



M_1 : simulated signal

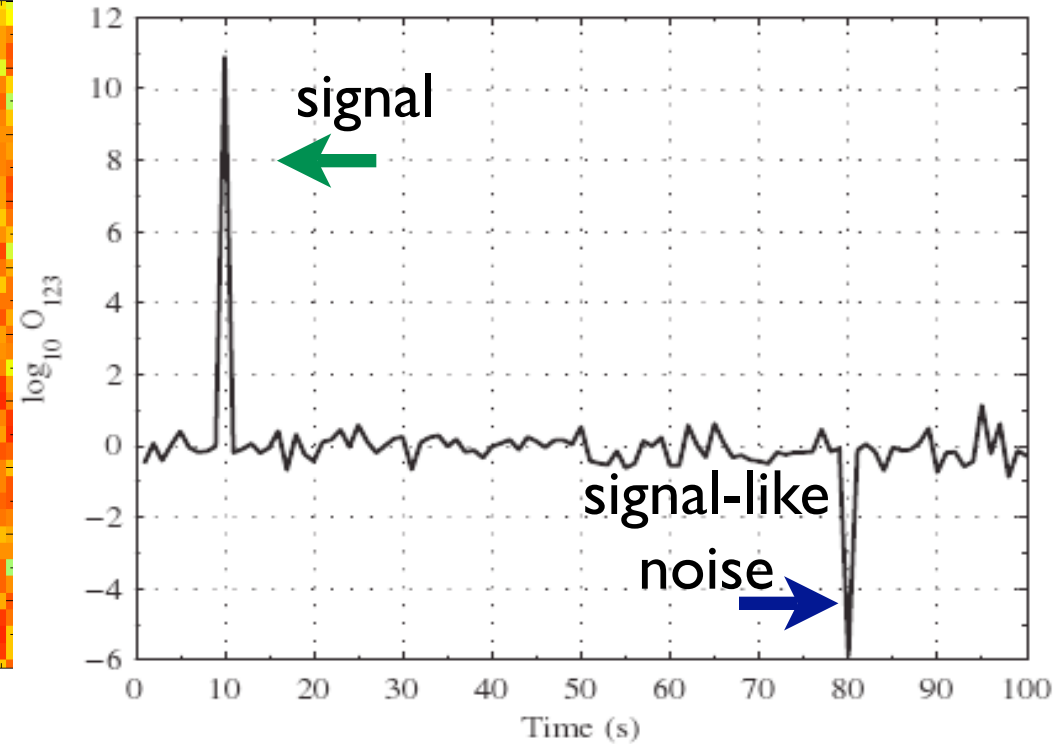
M_2 : simulated noise

M_3 : simulated transient noise



↑
signal

↑
signal-like
noise



- This approach is being applied to search for gravitational wave signals associated with excited neutron stars
- Investigating instrumental transients and use to distinguish signal from noise transients with model selection
- Compare the Bayesian approach with matched filtering



Other analyses at Glasgow

- Signal decomposition and classification
- Search for quasi-sinusoidal signal embedded in noise
- Markov chain Monte Carlo for parameter estimation

- We have the expertise and a lot of experience with signal detection and parameter estimation in noise dominated data
- World leaders in Bayesian analysis for gravitational wave data analysis
- Explore the use of our methods to applications outside of gravitational wave data analysis
 - CASE studentship? PIPS?