

Incorporating Stepping-Stone Sampling into BayesWave

Seth Moriarty

Mentors: Katerina Chatziioannou and Sophie Hourihane


DCC: G2201234-v1



BayesWave



bayeswave 

Project ID: 2102 

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 **1,123** Commits  **35** Branches  **24** Tags  **5.4 MB** Files  **408.9 MB** Storage  **12** Releases

master  bayeswave

Find file

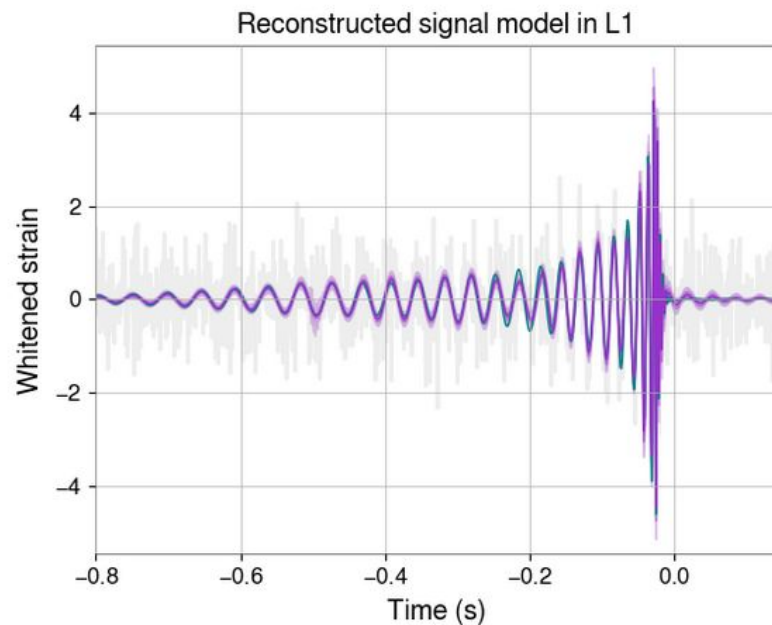
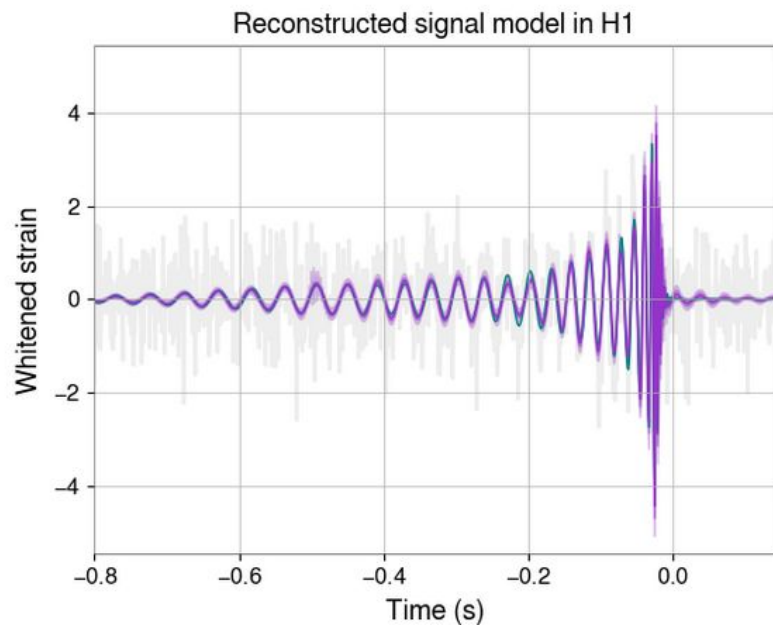
Clone 

Stepping-Stone branch by Meg Millhouse

Injected 150914 waveform, reconstructed with BayesWave

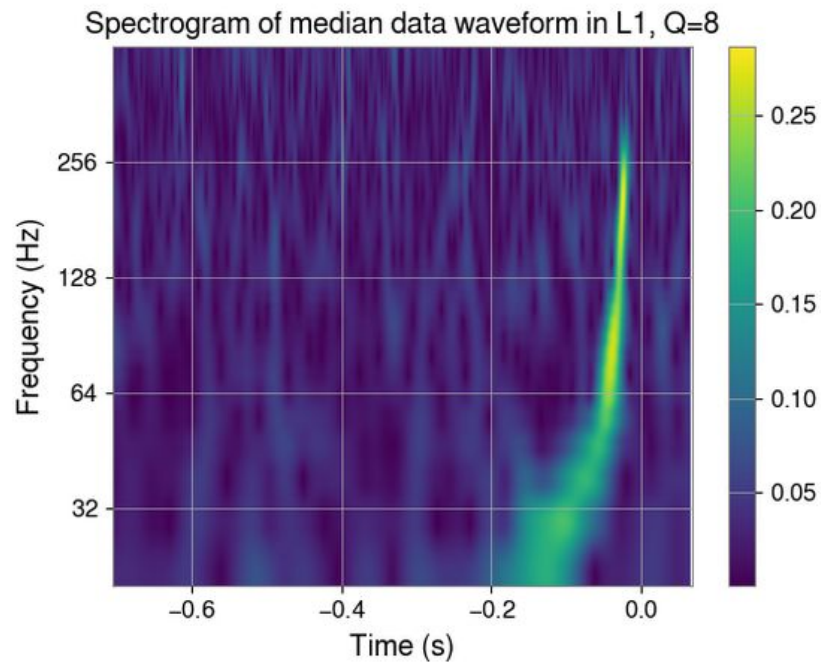
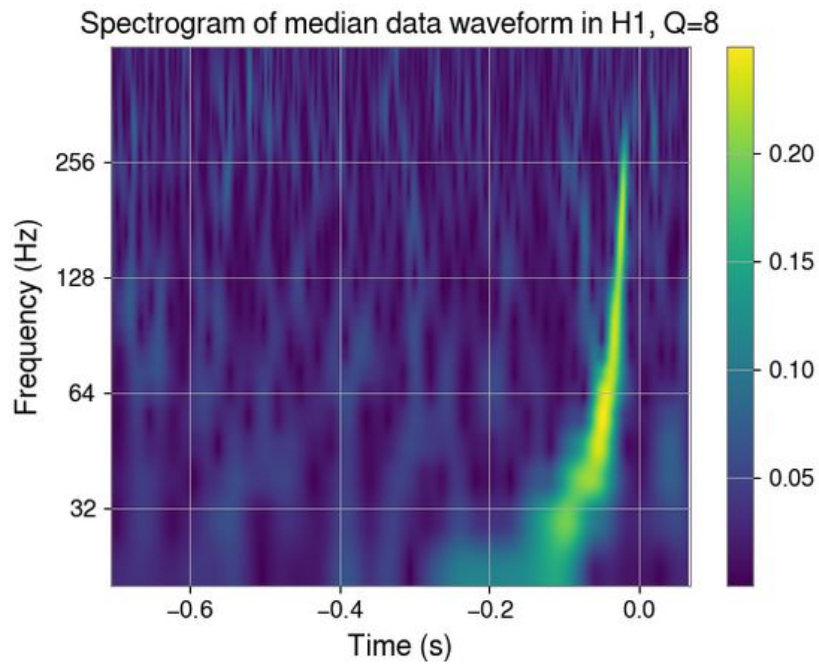
signal model

Time Domain Waveforms



Spectrogram reconstruction

Spectrogram of Data



Bayes' Theorem

$$\text{Posterior } p_i(\theta) = \frac{\text{Likelihood } \mathcal{L}(D|\theta, M_i) \text{ Prior } \pi(\theta|M_i)}{z_i}$$

Evidence/marginal likelihood

$$z_i = p(D|M_i)$$

Computing Bayes Factors Using Thermodynamic Integration

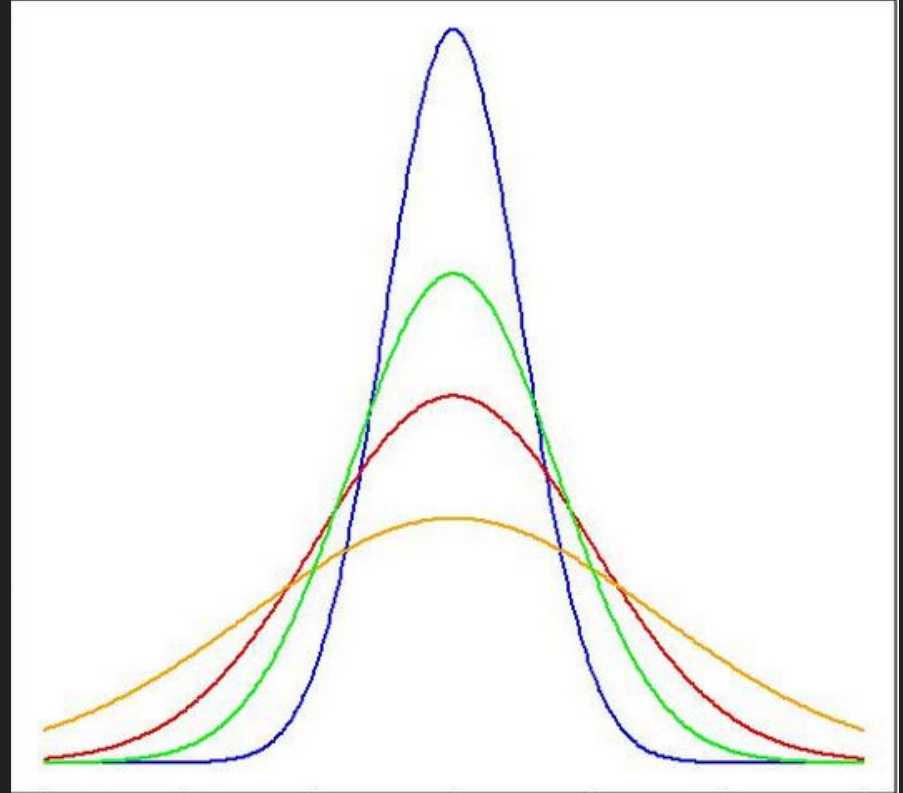
NICOLAS LARTILLOT¹ AND HERVÉ PHILIPPE²

Comparing Models using Bayes' Factors

$$\mu = \ln\left(\frac{z_1}{z_0}\right) = \ln(z_1) - \ln(z_0) = \int_0^1 \frac{\partial \ln(z_\beta)}{\partial \beta} d\beta$$

Temperature/sampling

$$\beta = \frac{1}{\text{temperature}}$$

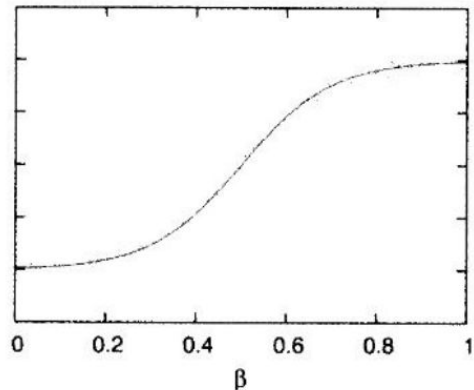
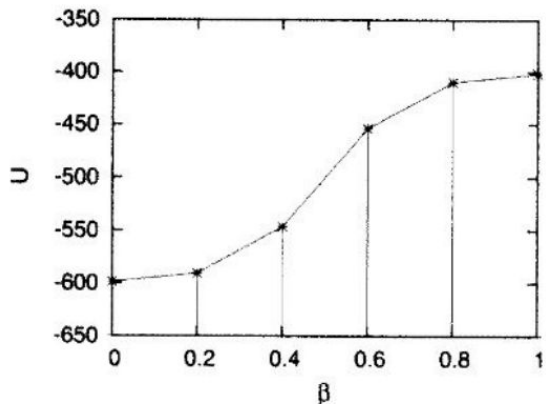


$$\int_0^1 \frac{\partial \ln(z_\beta)}{\partial \beta} d\beta$$

Thermodynamic Integration

Stepping-Stone

$$z = \frac{z_1}{z_0} = \prod_{k=1}^{K-1} \frac{z_{\beta_k}}{z_{\beta_{k-1}}}$$



Run Information:

Gaussian noise with injected 150914 waveform

Number of Chains - Number of temperatures at which samples are taken

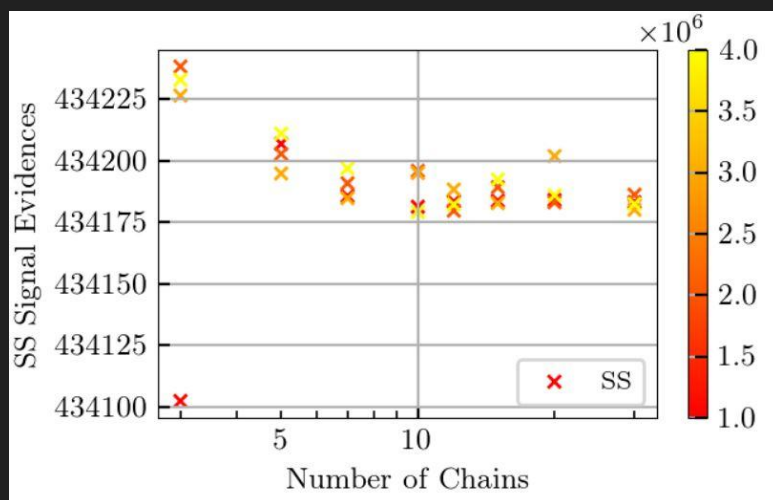
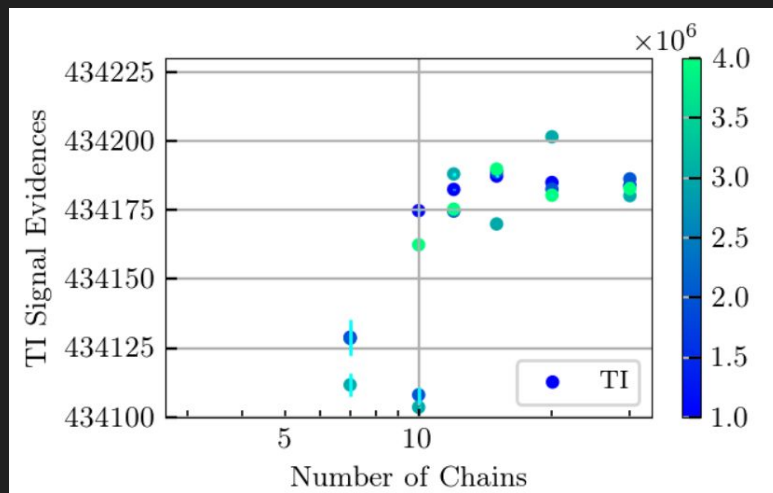
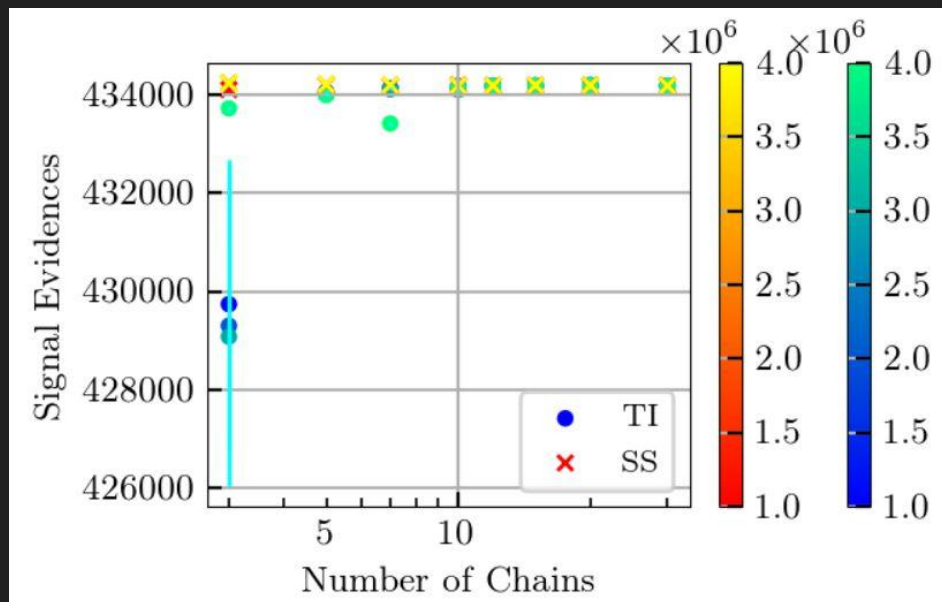
Number of iterations - Number of moves in parameter space a sampling chain can make

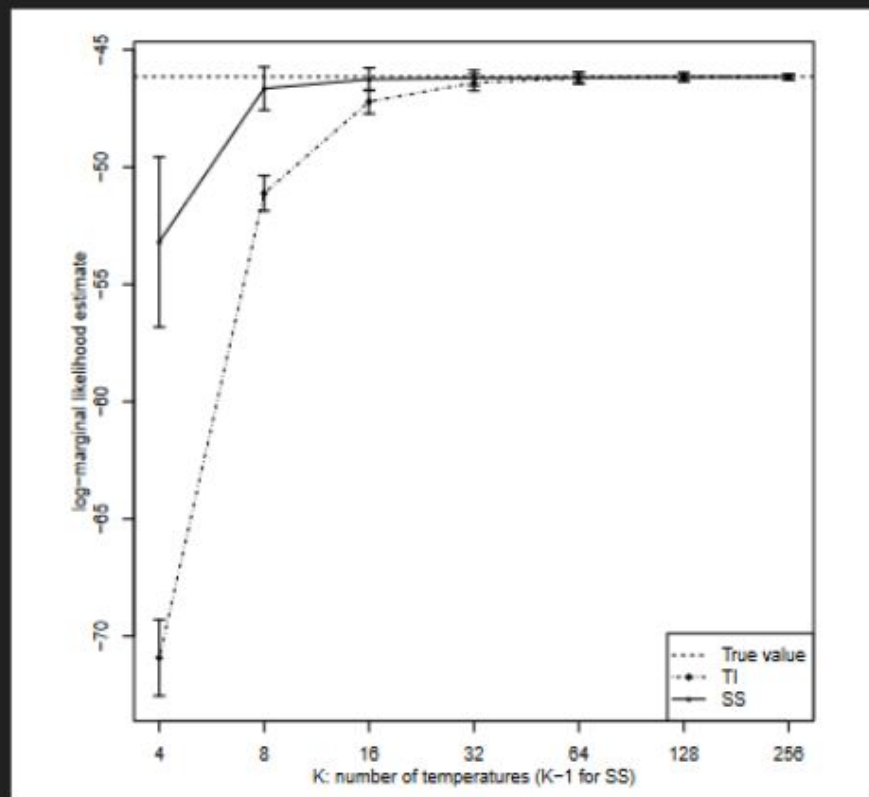
BayesLine on/off - BayesLine estimates PSD more accurately when turned on

Noise realization - Different seeds determine different realizations of random noise

Signal Evidences:

Varying number of chains and number of iterations. No BayesLine

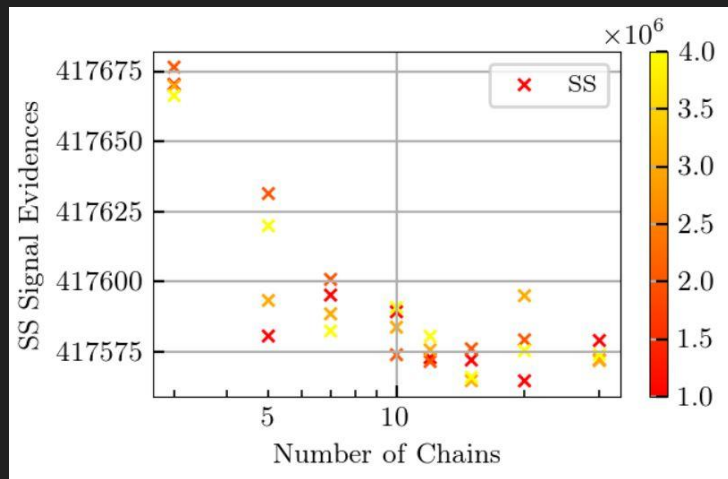
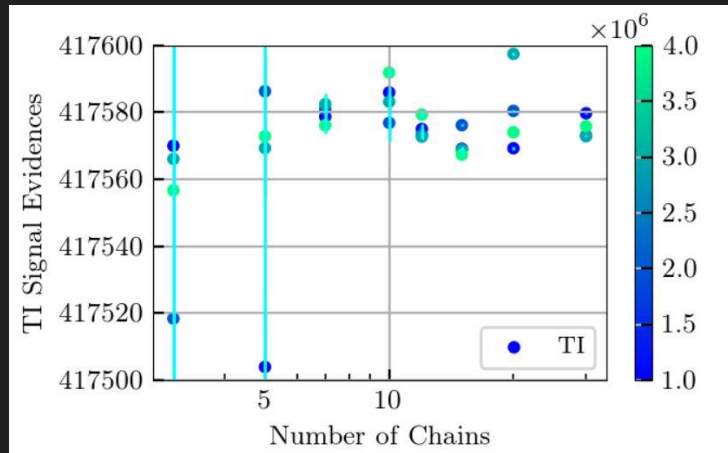
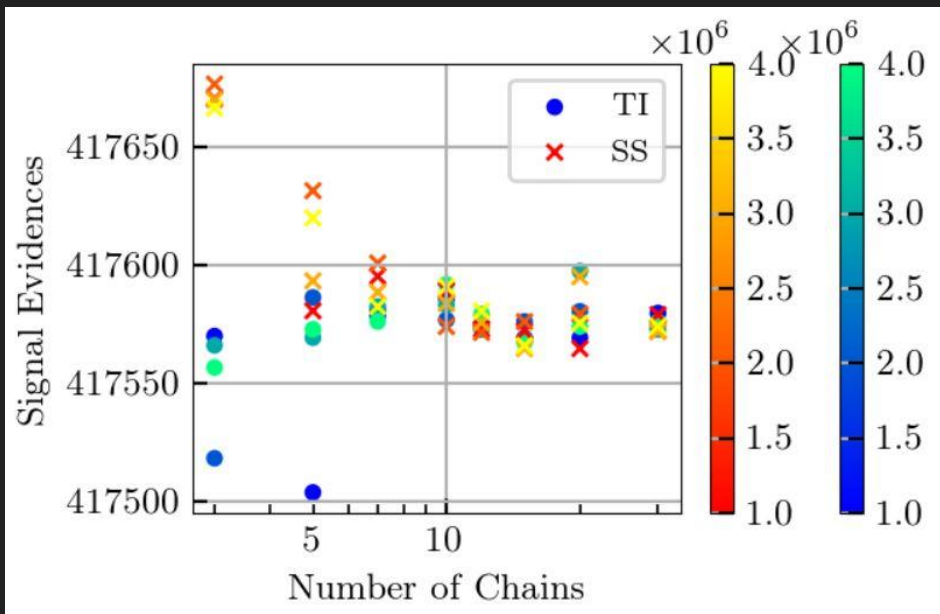




The stepping-stone sampling algorithm for calculating the evidence of gravitational wave models

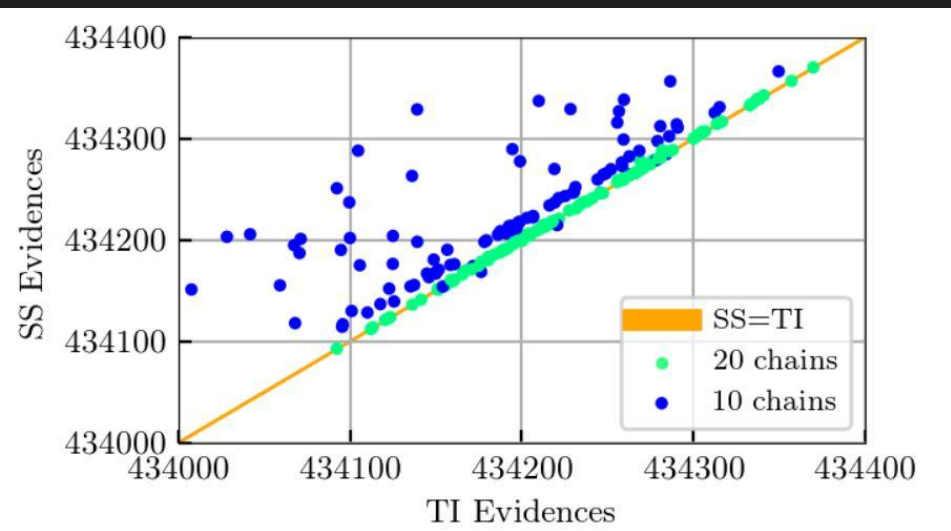
Patricio Maturana Russel¹, Renate Meyer¹, John Veitch² and Nelson Christensen^{3,4}

Signal Evidences (with BayesLine on)

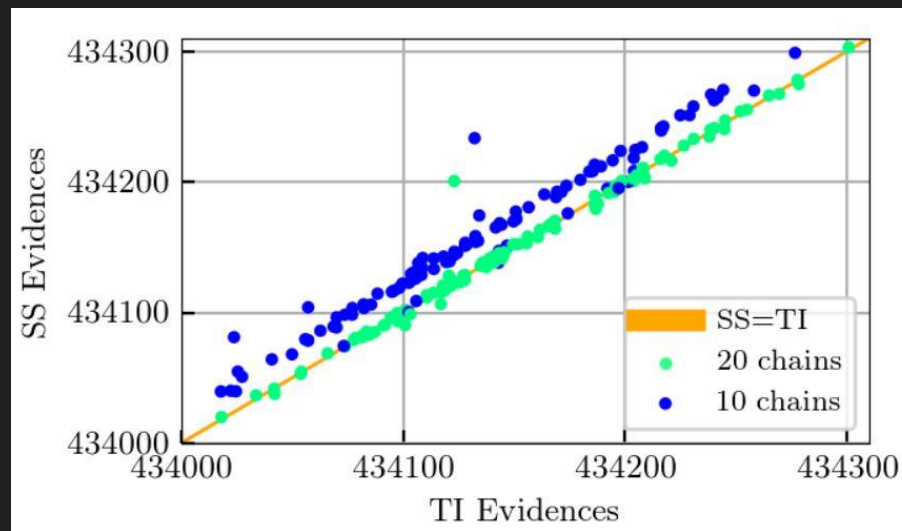


TI vs SS (without BayesLine)

Signal Model:

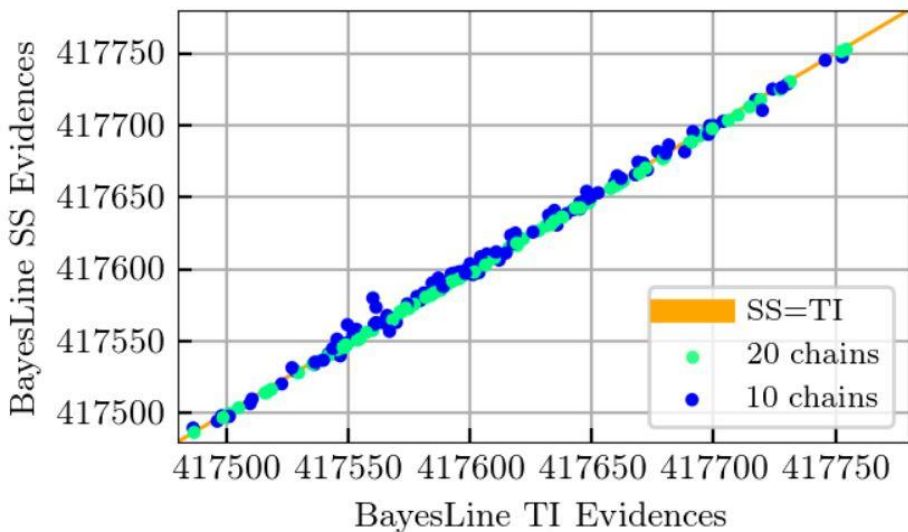


Glitch Model:

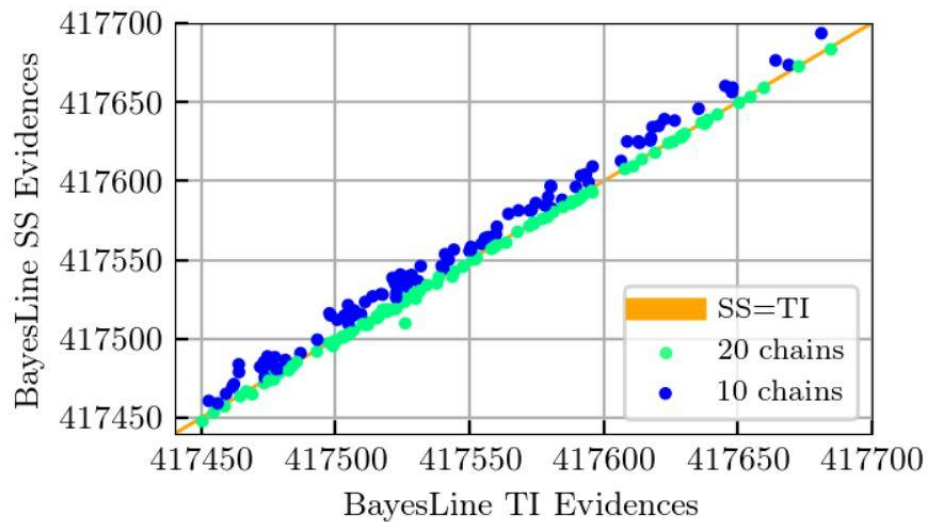


TI vs SS (with BayesLine)

Signal Model:



Glitch Model:



Conclusions

Stepping-Stone branch is running very well

When BayesLine is off, SS requires fewer chains than TI

When BayesLine is on, SS and TI produce very similar evidence estimates

Future goals/questions

Merge Stepping-Stone branch into main BayesWave

See how TI and SS compare for more complex runs

Incorporate SS standard deviation

Sources/Acknowledgements



Mentors: Sophie Hourihane and Katerina Chatziioannou

Thank you to Meg Millhouse

- [1] [LIGO- A Gravitational-Wave Interferometer](#).
- [2] N. J. Cornish, T. B. Littenberg, B. Bécsy, K. Chatziioannou, J. A. Clark, S. Ghonge, and M. Millhouse, BayesWave analysis pipeline in the era of gravitational wave observations, *Phys. Rev. D* **103**, 044006 (2021), [arXiv:2011.09494 \[gr-qc\]](#).
- [3] N. Lartillot and H. Phillipe, [Computing Bayes' Factors Using Thermodynamic Integration](#) (2006).
- [4] S. Carstens, [Introduction to Markov Chain Monte Carlo \(MCMC\) Sampling](#) (2020).
- [5] J. Annis, Thermodynamic Integration and Steppingstone Sampling Methods for Estimating Bayes Factors: A Tutorial, *Journal of mathematical psychology* **89** (2019).
- [6] J. S. Speagle, [A Conceptual Introduction to Markov Chain Monte Carlo Methods](#) (2020).
- [7] P. Maturana-Russel, R. Meyer, J. Veitch, and N. Christensen, Stepping-stone sampling algorithm for calculating the evidence of gravitational wave models, *Phys. Rev. D* **99**, 084006 (2019), [arXiv:1810.04488 \[physics.data-an\]](#).
- [8] W. Xie, P. Lewis, Y. Fan, L. Kuo, and M.-H. Chen, Improving Marginal Likelihood Estimation for Bayesian Phylogenetic Model Selection", url =.