Machine Learning Gravitational Waveforms for Binary Neutron Star mergers

Jacopo Tissino

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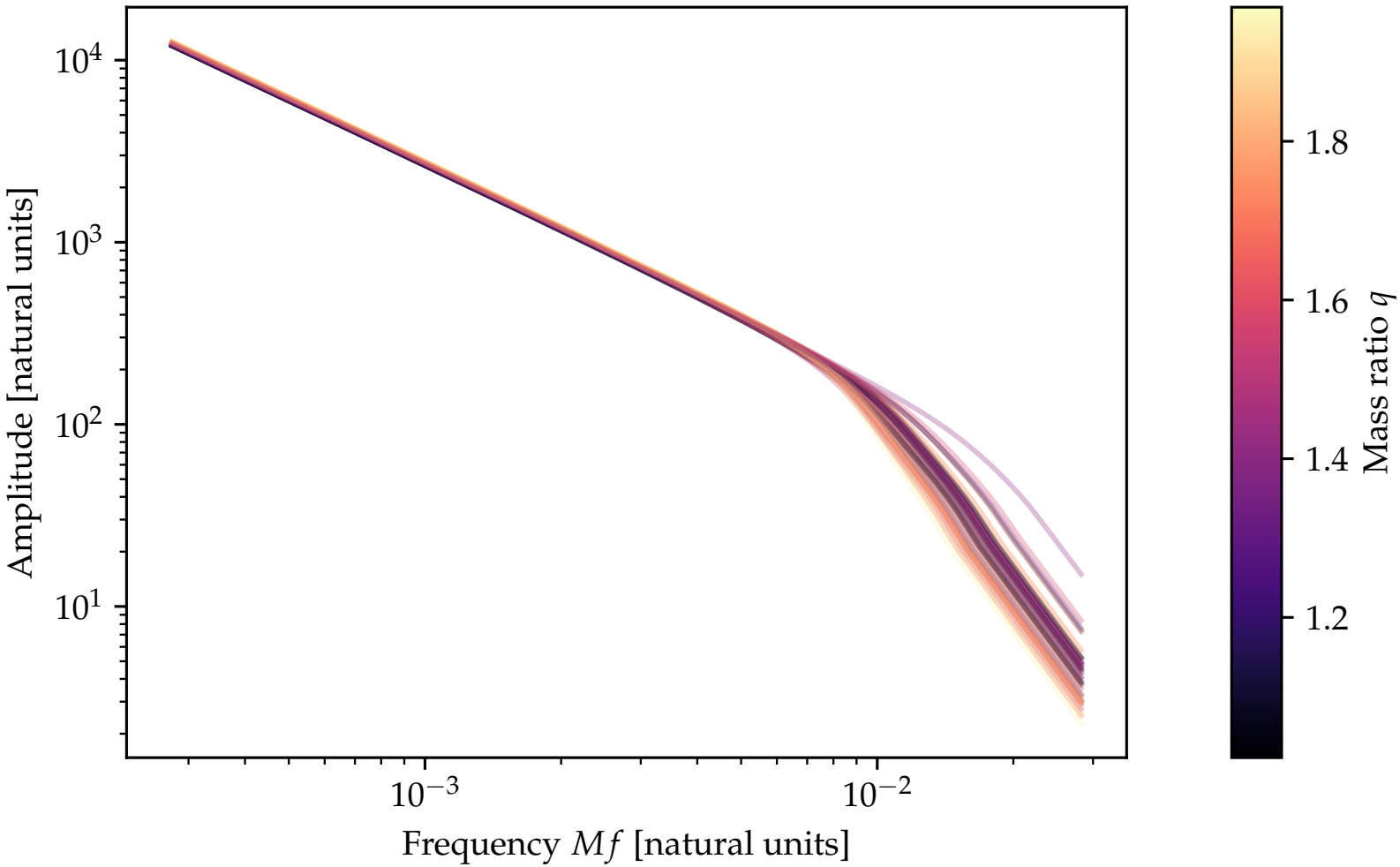
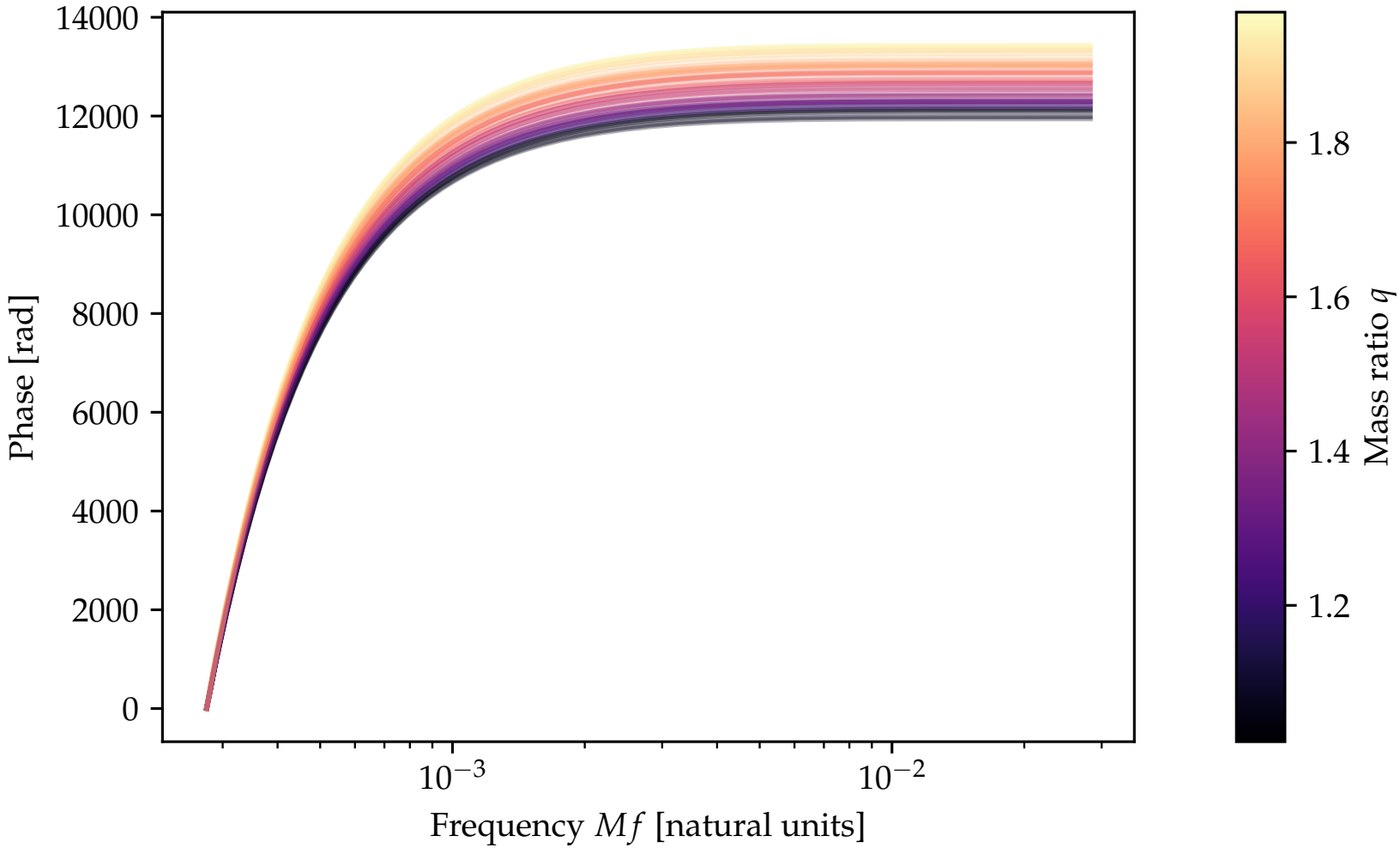
Amplitudes


10^4
10^3
10^2
10^1
Amplitude [natural units]
10^{-3}
10^{-2}
Frequency Mf [natural units]
1.8
1.6
1.4
1.2
Mass ratio q

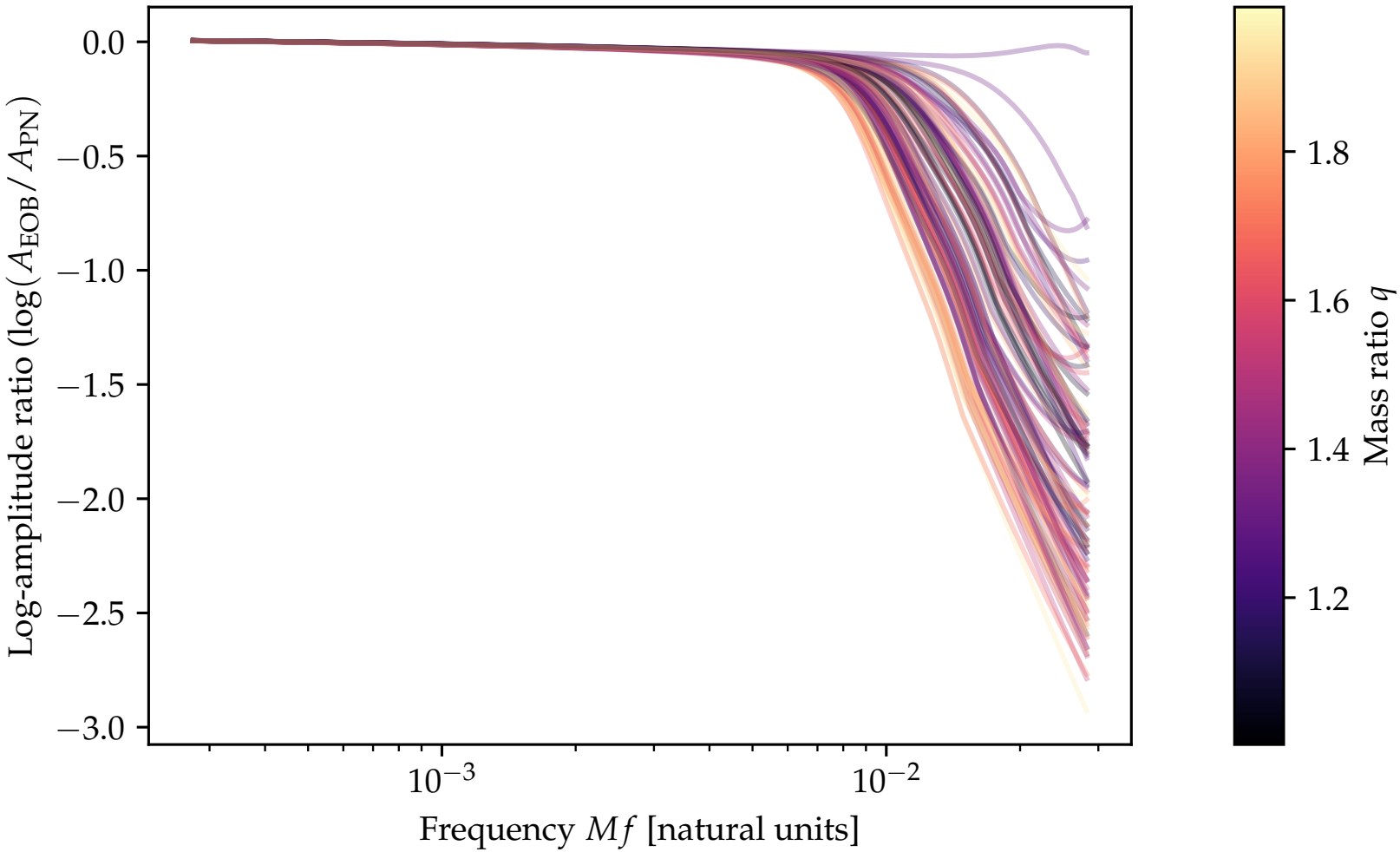
Phases


14000
12000
10000
8000
6000
4000
2000
0
Phase [rad]
10^{-3}
10^{-2}
Frequency Mf [natural units]
1.8
1.6
1.4
1.2
Mass ratio q

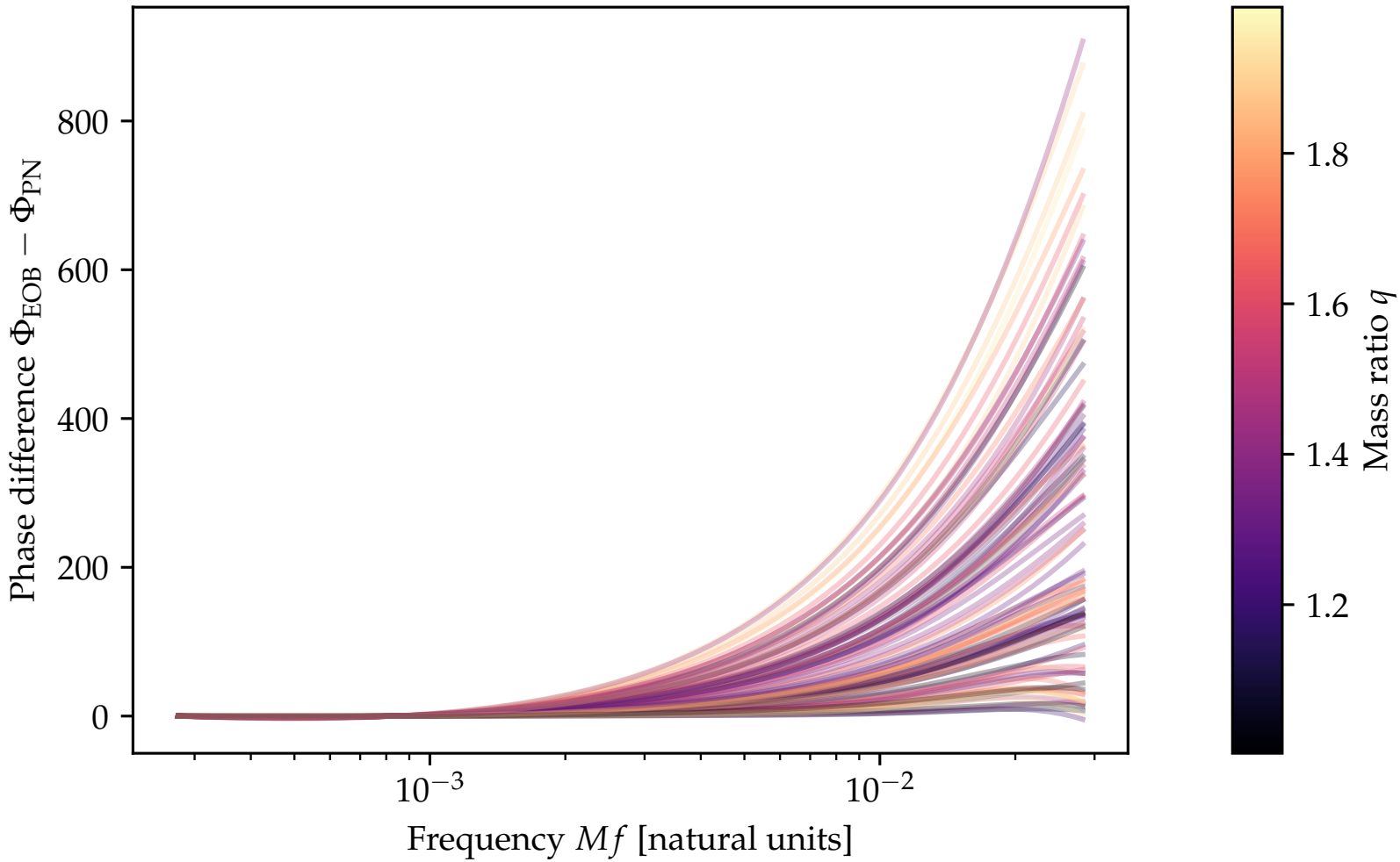
MLGW_BNS structure: training dataset generation

- Greedy adaptive downsampling fit;
- EOB waveform generation and downsampling;
- residuals from PN waveforms: $\Delta A = \log(A_{\mathrm{EOB}}/A_{\mathrm{PN}})$ and $\Delta\Phi = \Phi_{\mathrm{EOB}} - \Phi_{\mathrm{PN}}$;
- PCA on the combined, downsampled, rescaled residuals;
- a NN learns the map $\theta \to PC_i \lambda_i^{\alpha}$;
- the hyperparameters of the NN and α are optimized case-by-case.

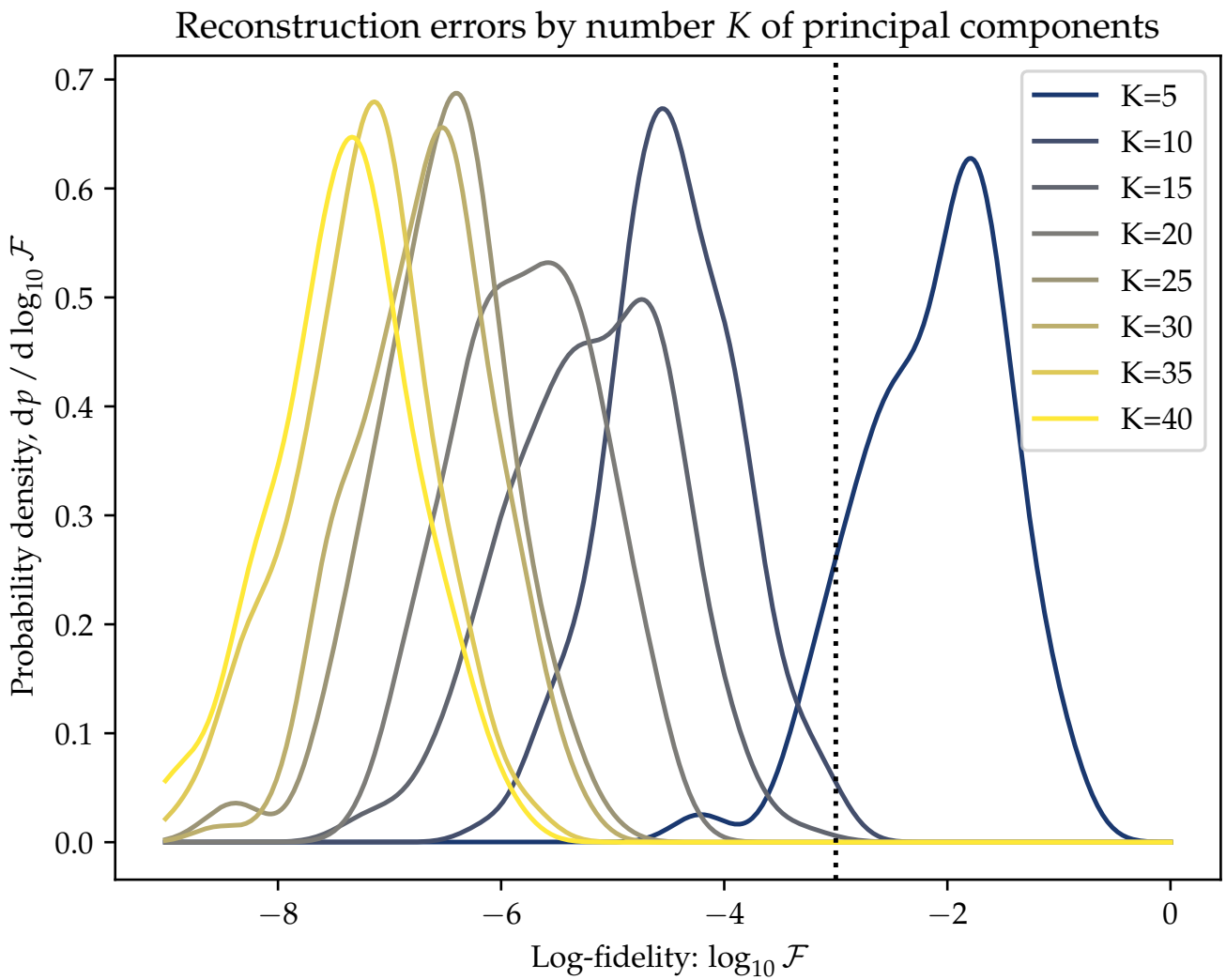
Residuals: amplitude



Residuals: phase

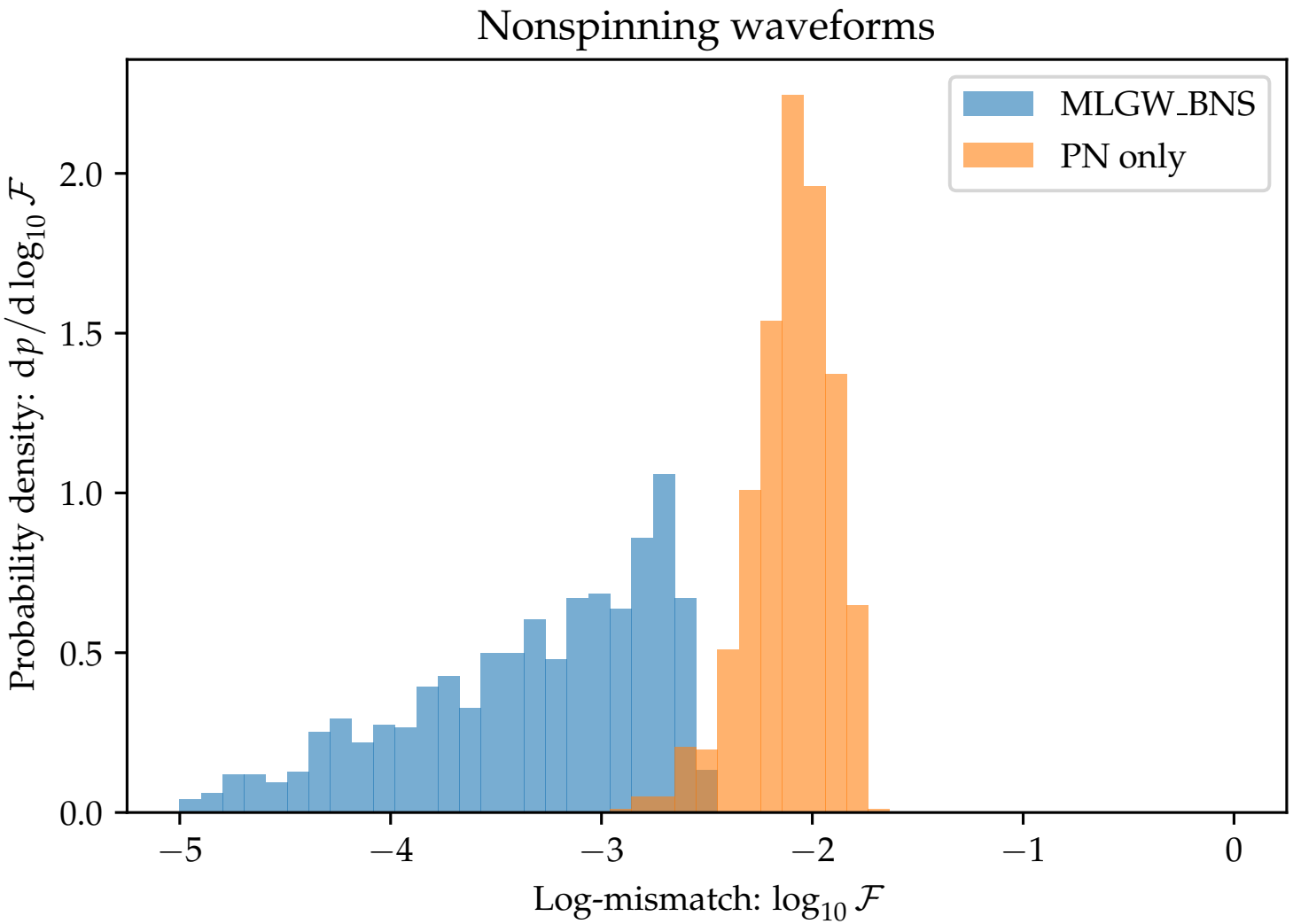


PCA mismatches

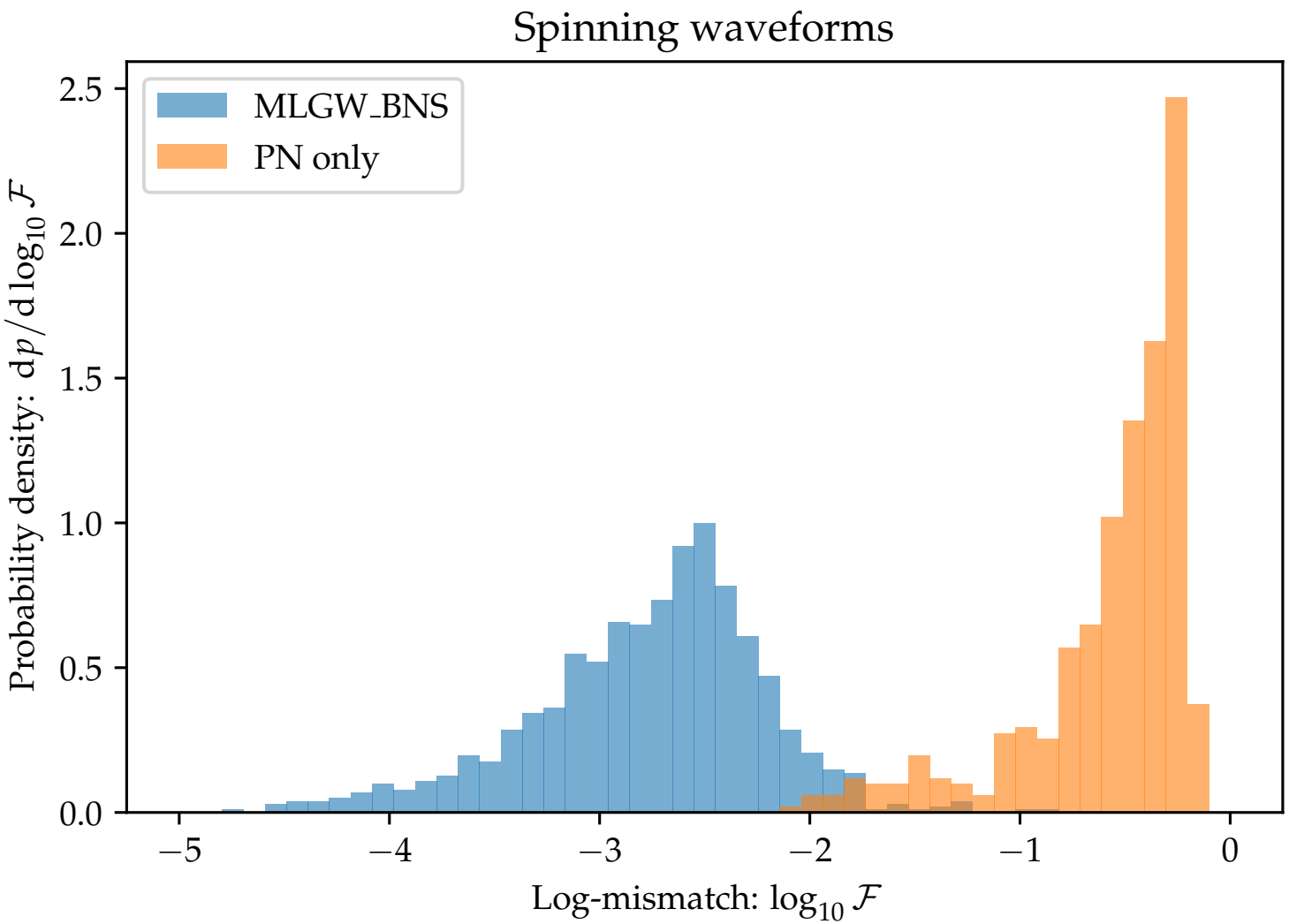


Hyperparameter optimization

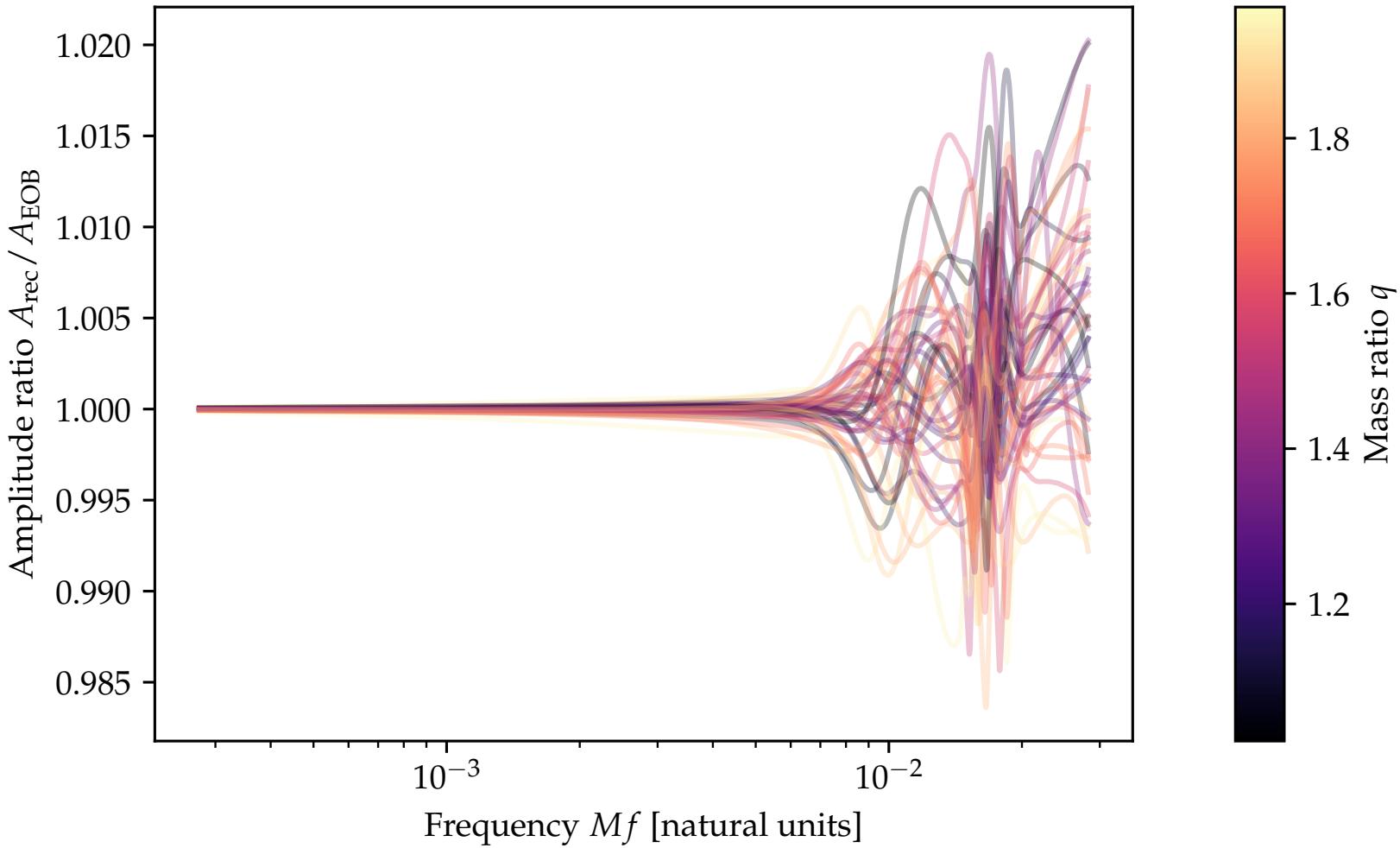
Fidelity: nonspinning case



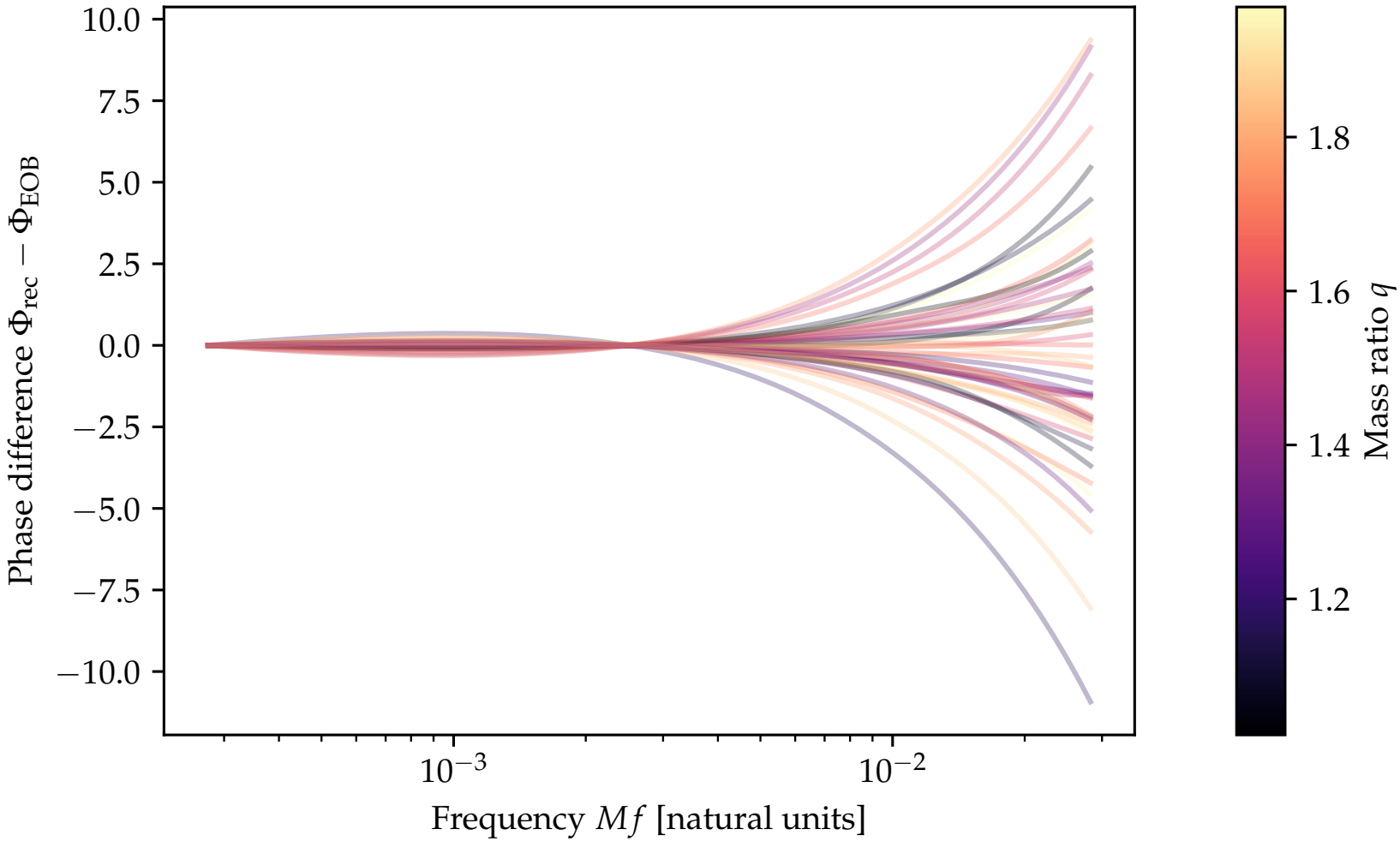
Fidelity: spinning case



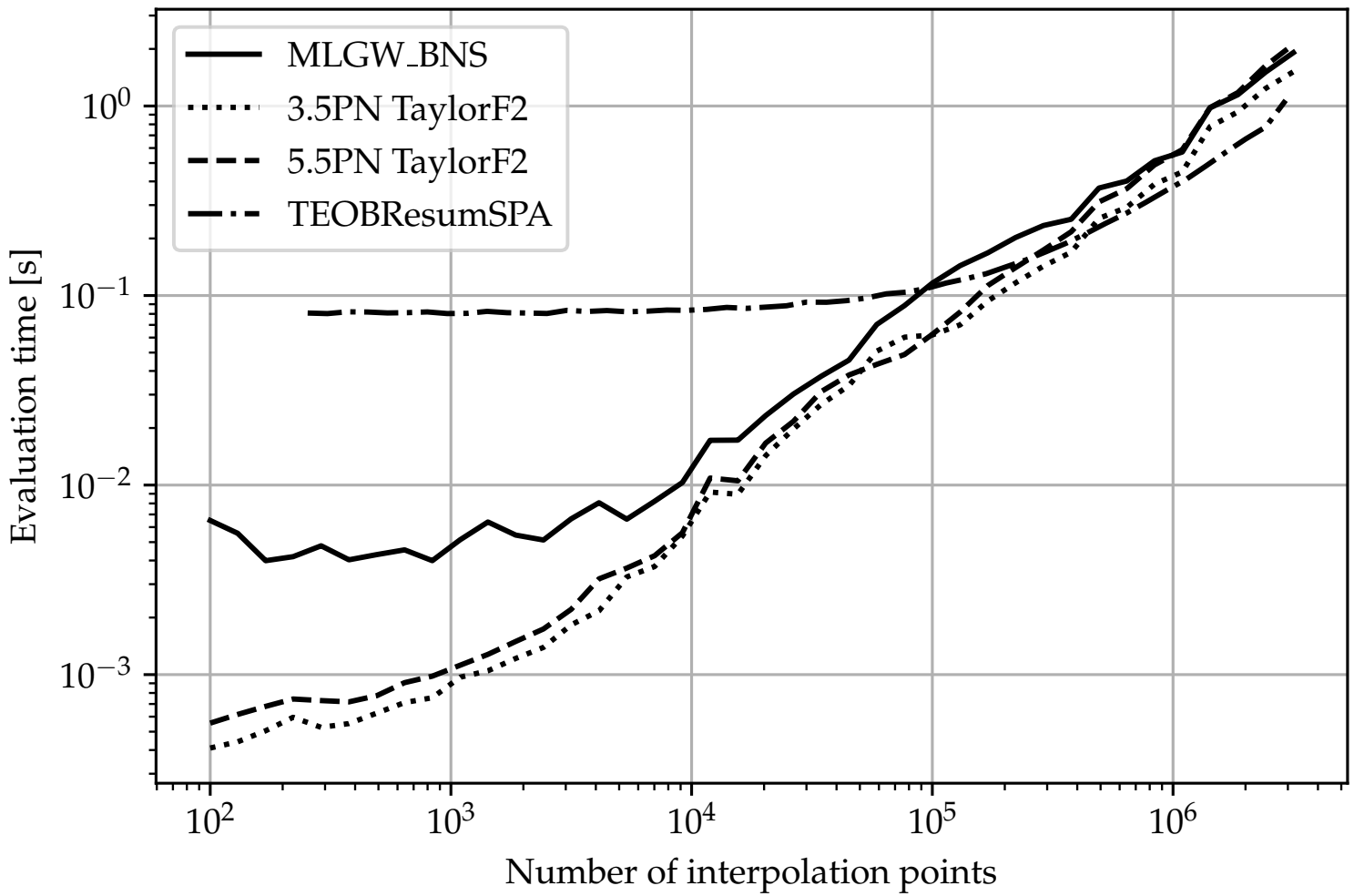
Amplitude reconstruction residuals



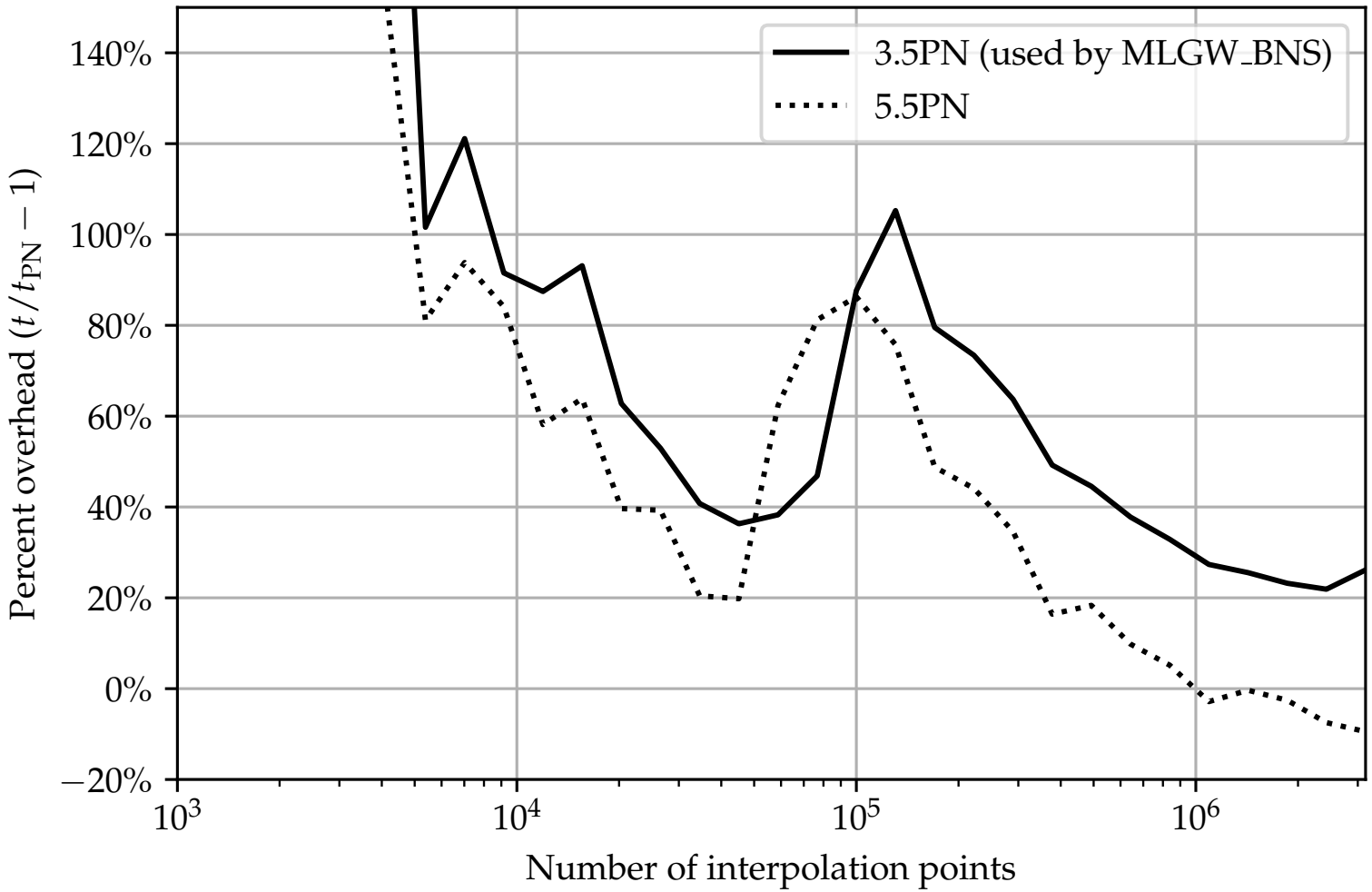
Phase reconstruction residuals



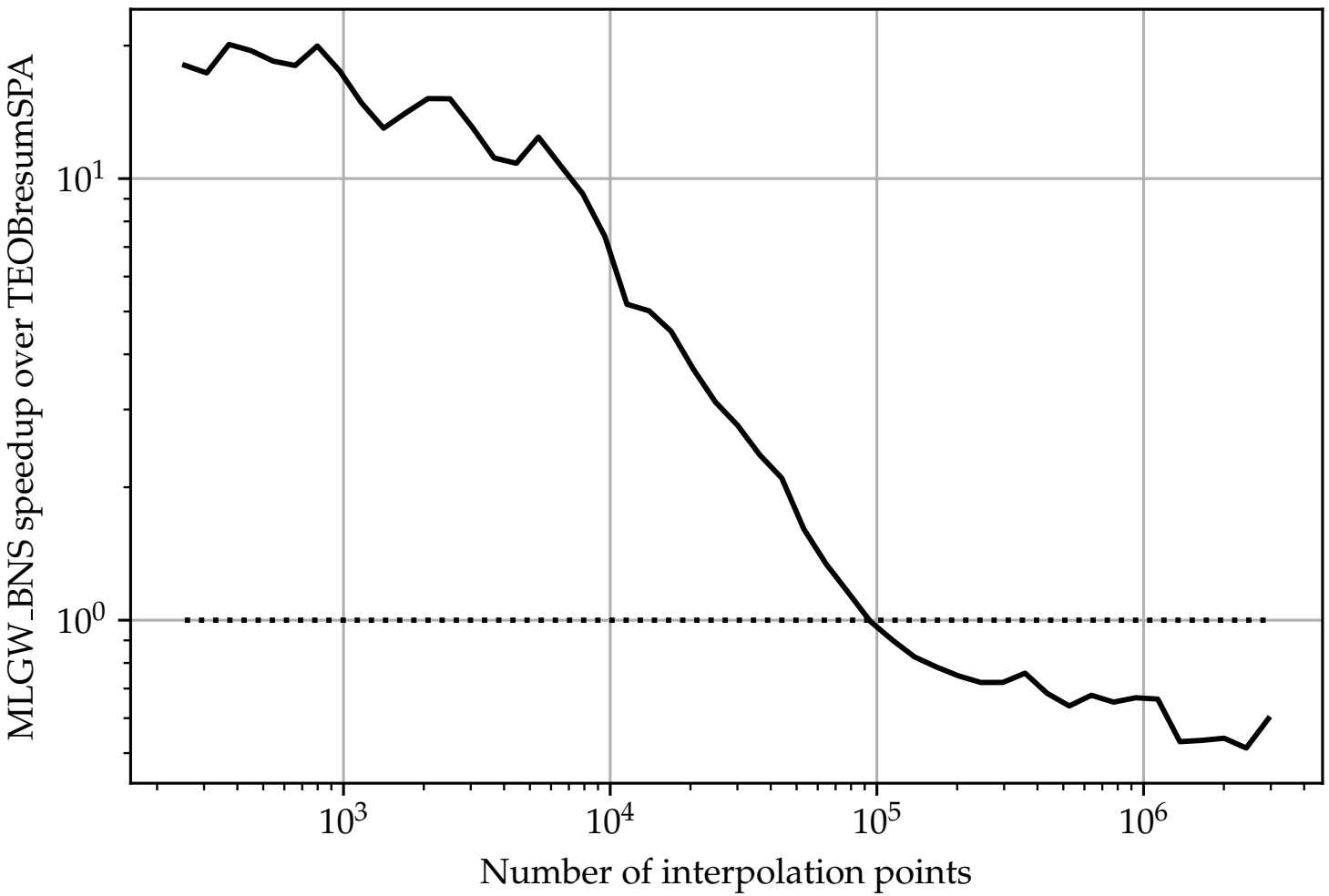
Evaluation time: $f_0 = 20\,\mathrm{Hz}$



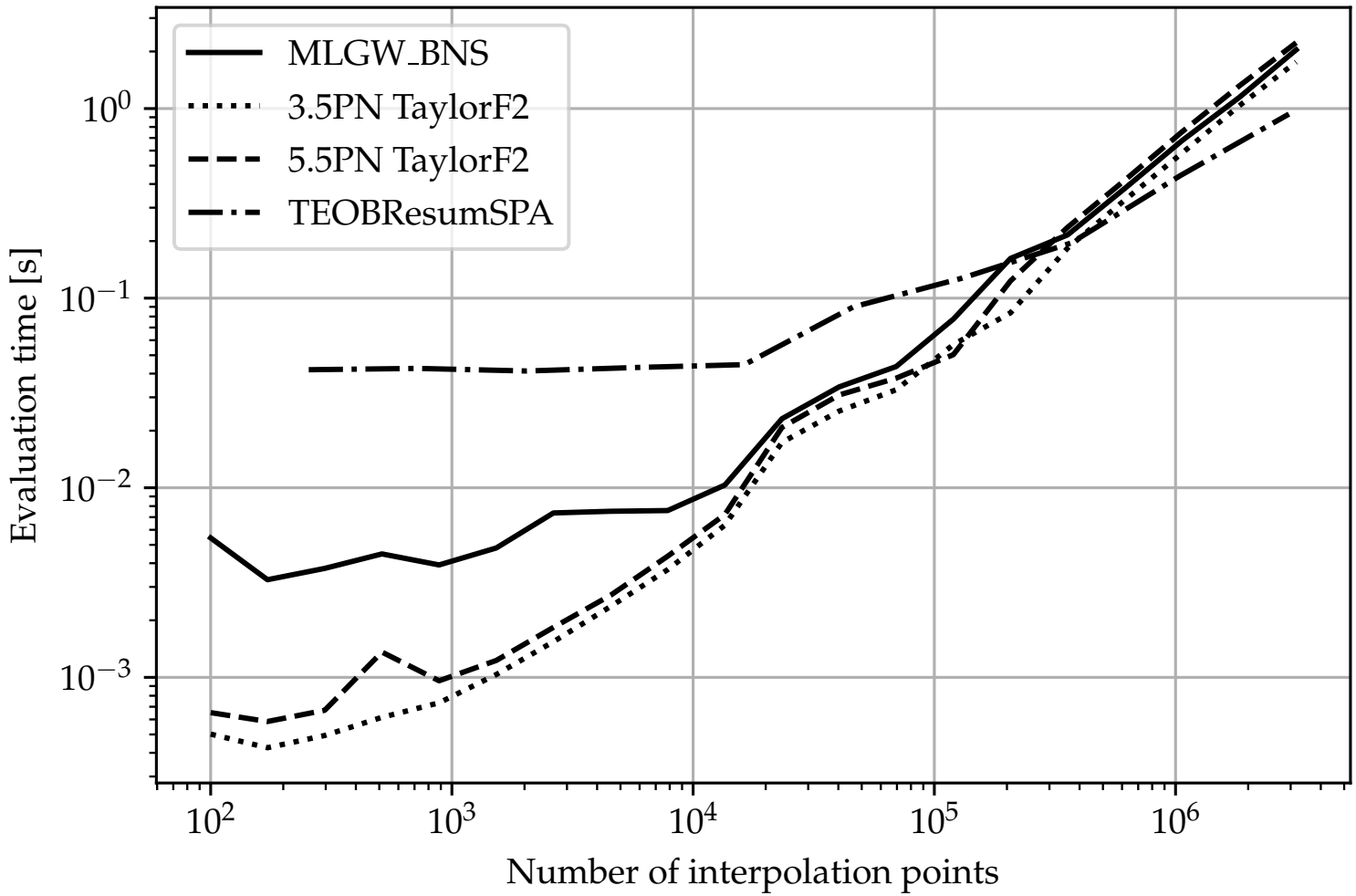
Evaluation time: $f_0 = 20\,\mathrm{Hz}$



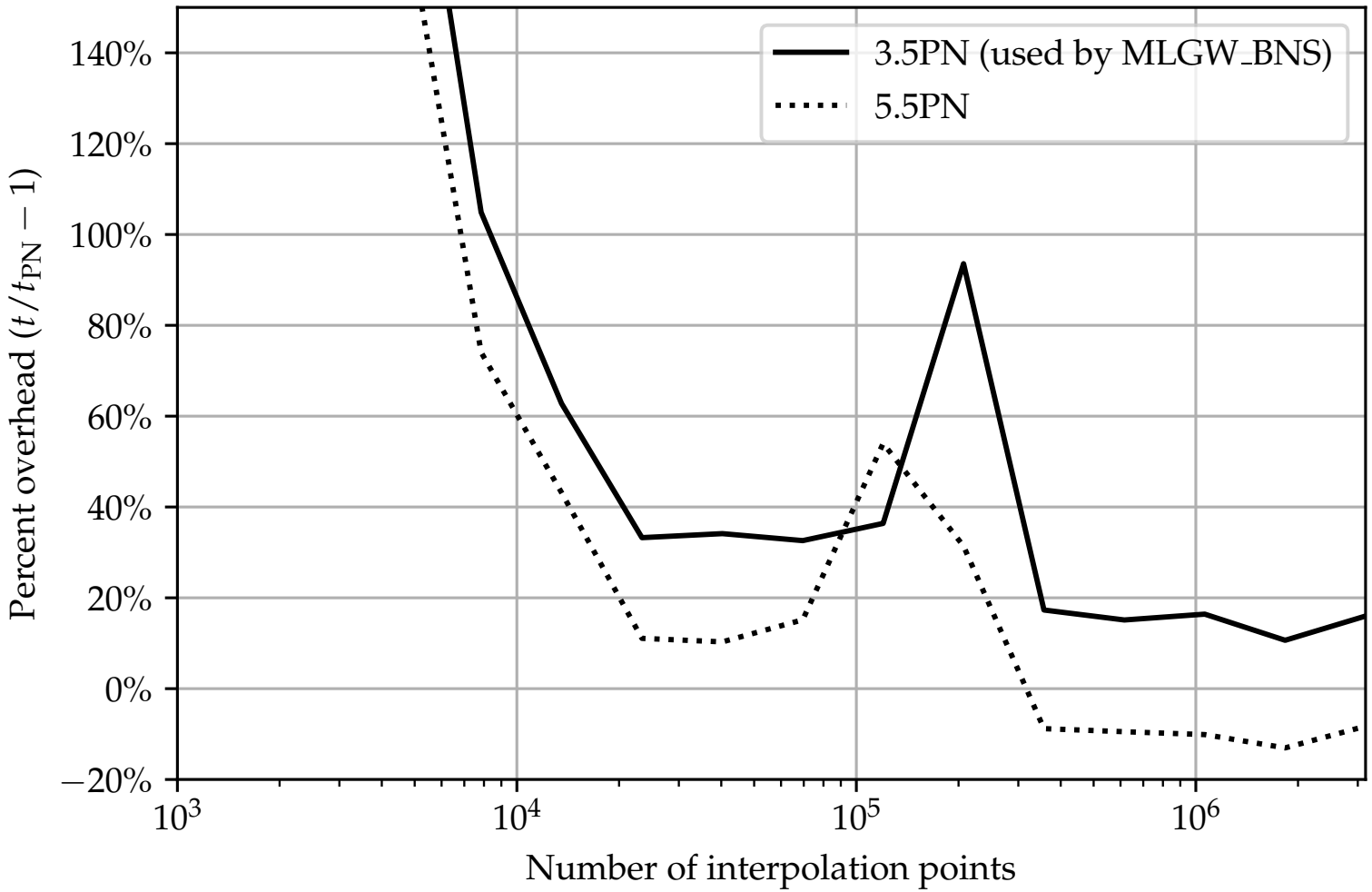
Evaluation time: $f_0 = 20\,\mathrm{Hz}$



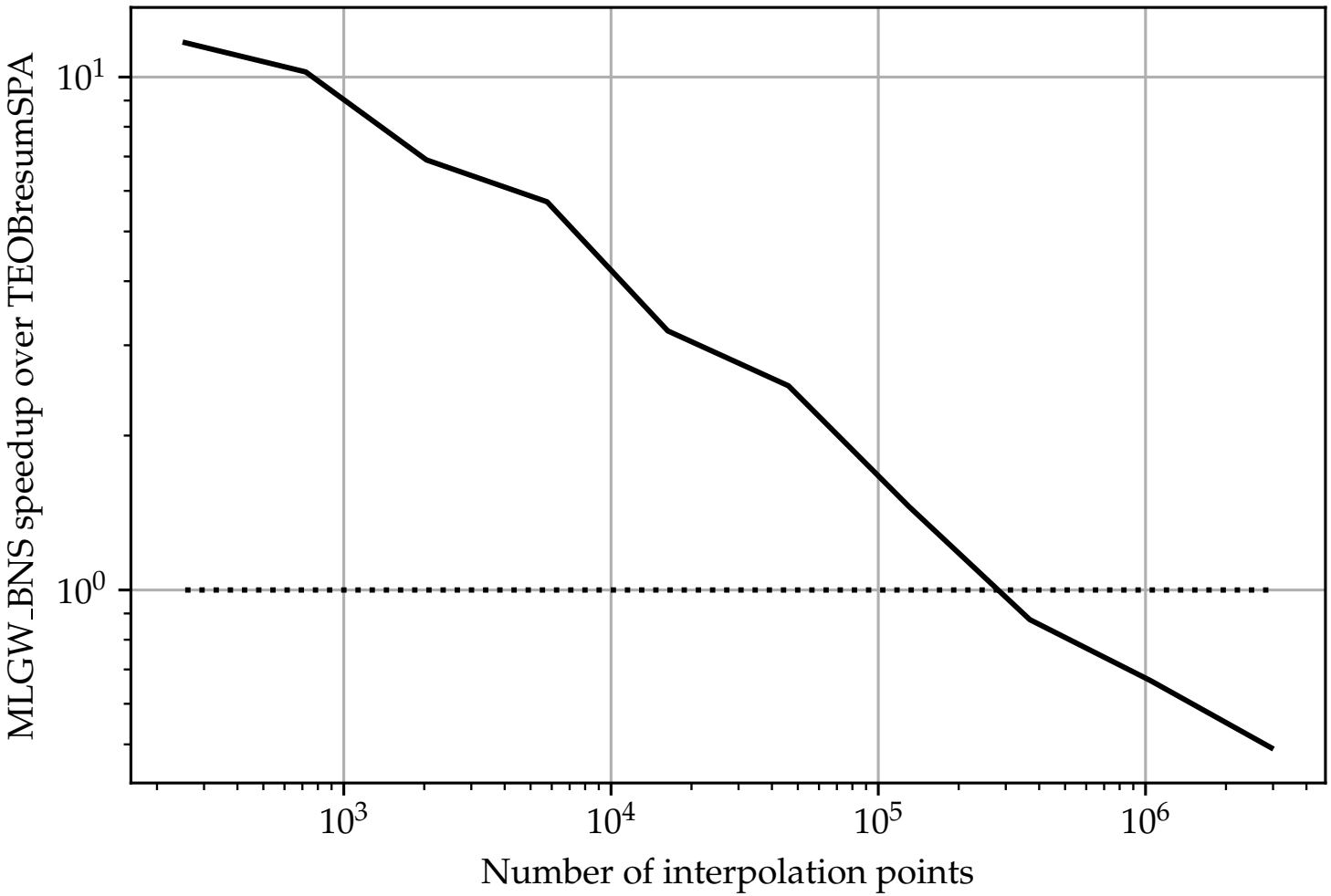
Evaluation time: $f_0 = 10\,\mathrm{Hz}$



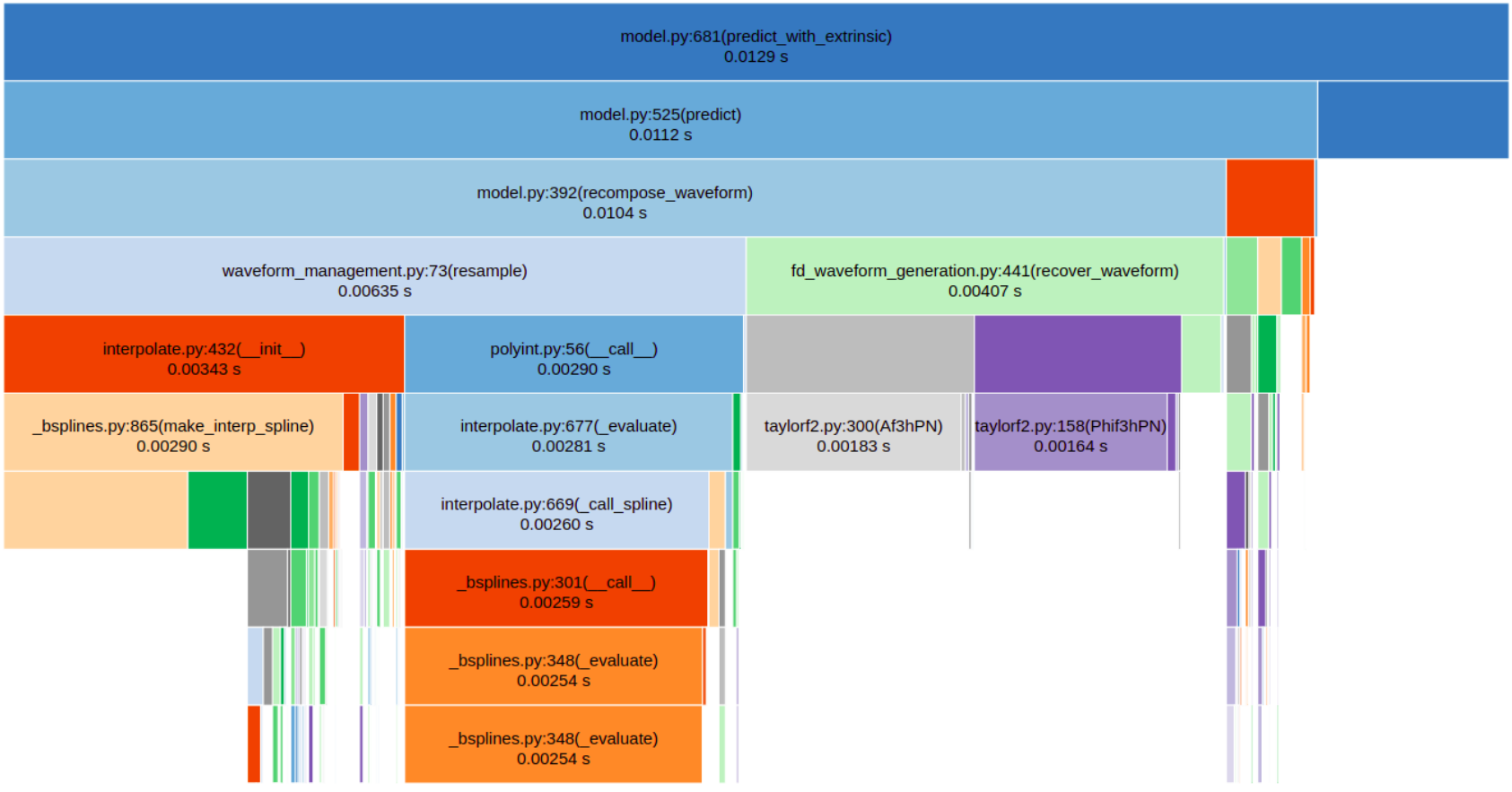
Evaluation time: $f_0 = 10\,\mathrm{Hz}$



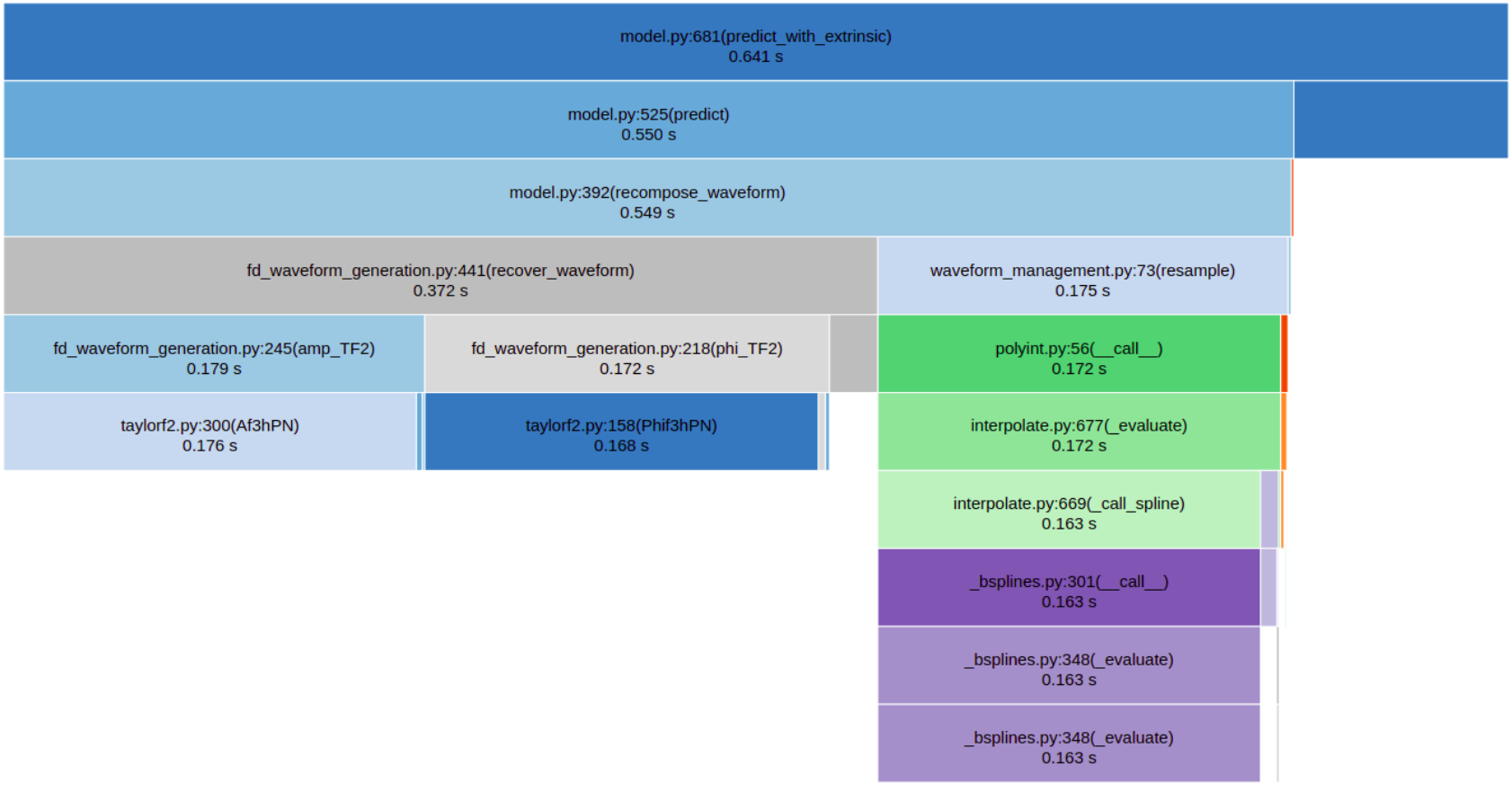
Evaluation time: $f_0 = 10\,\mathrm{Hz}$



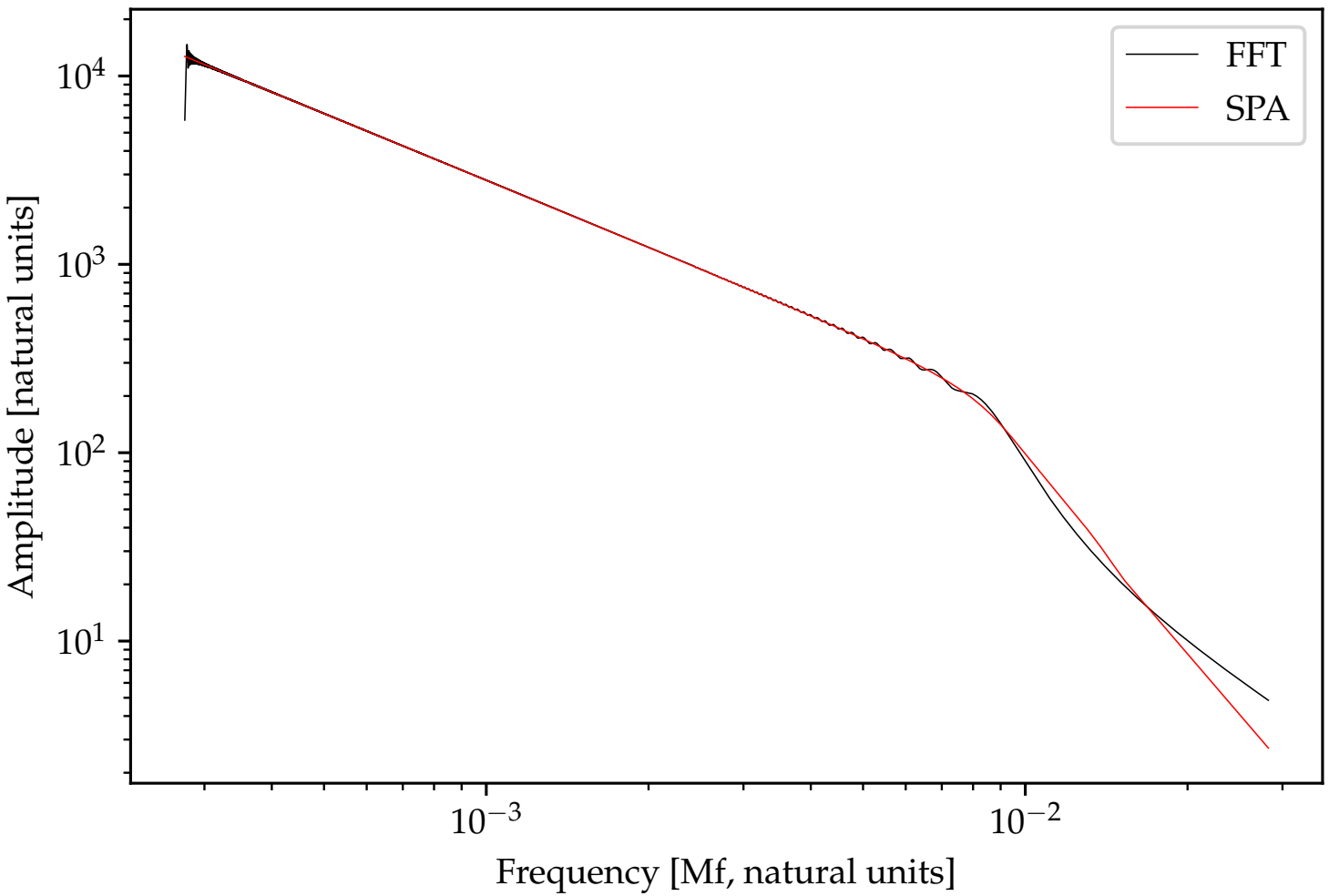
Profiling the evaluation: 10^4 interpolation points



Profiling the evaluation: 10^6 interpolation points



Fourier transform issues



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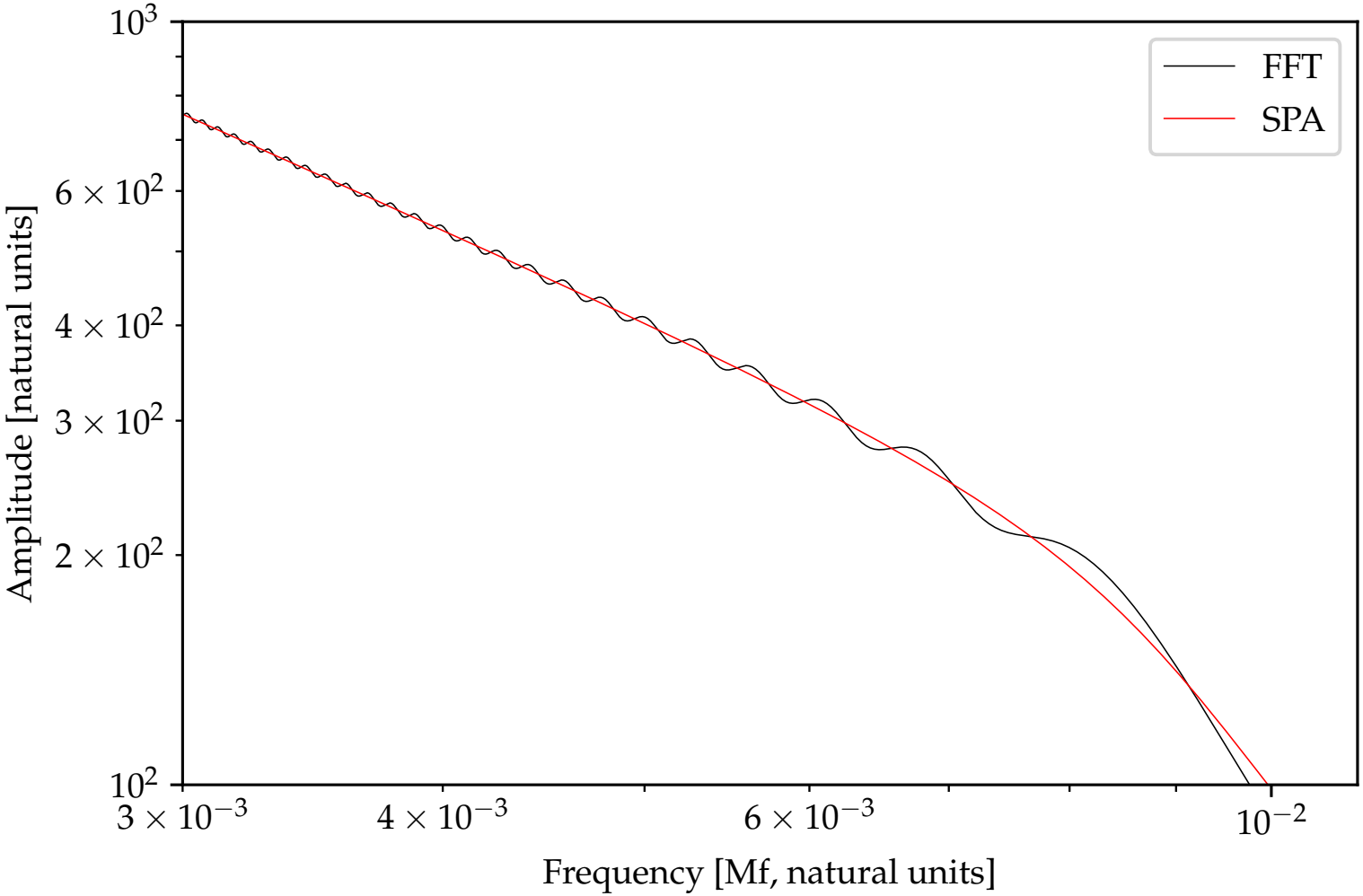

Fourier transform issues