



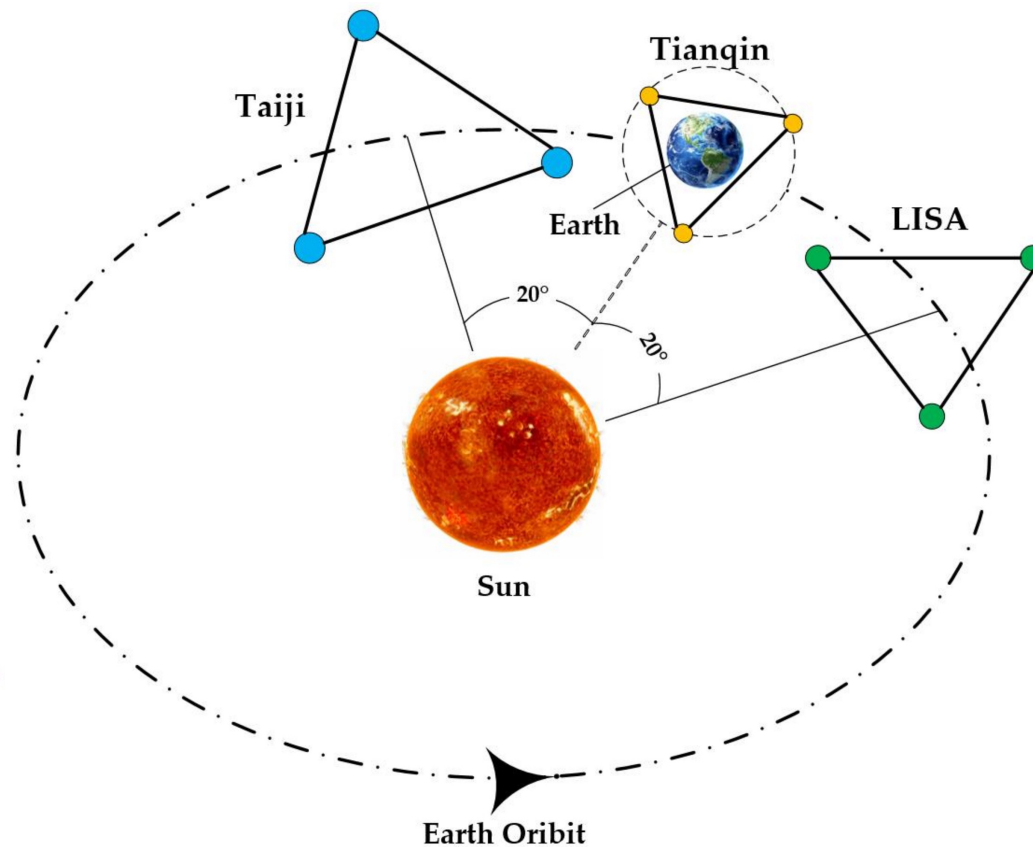
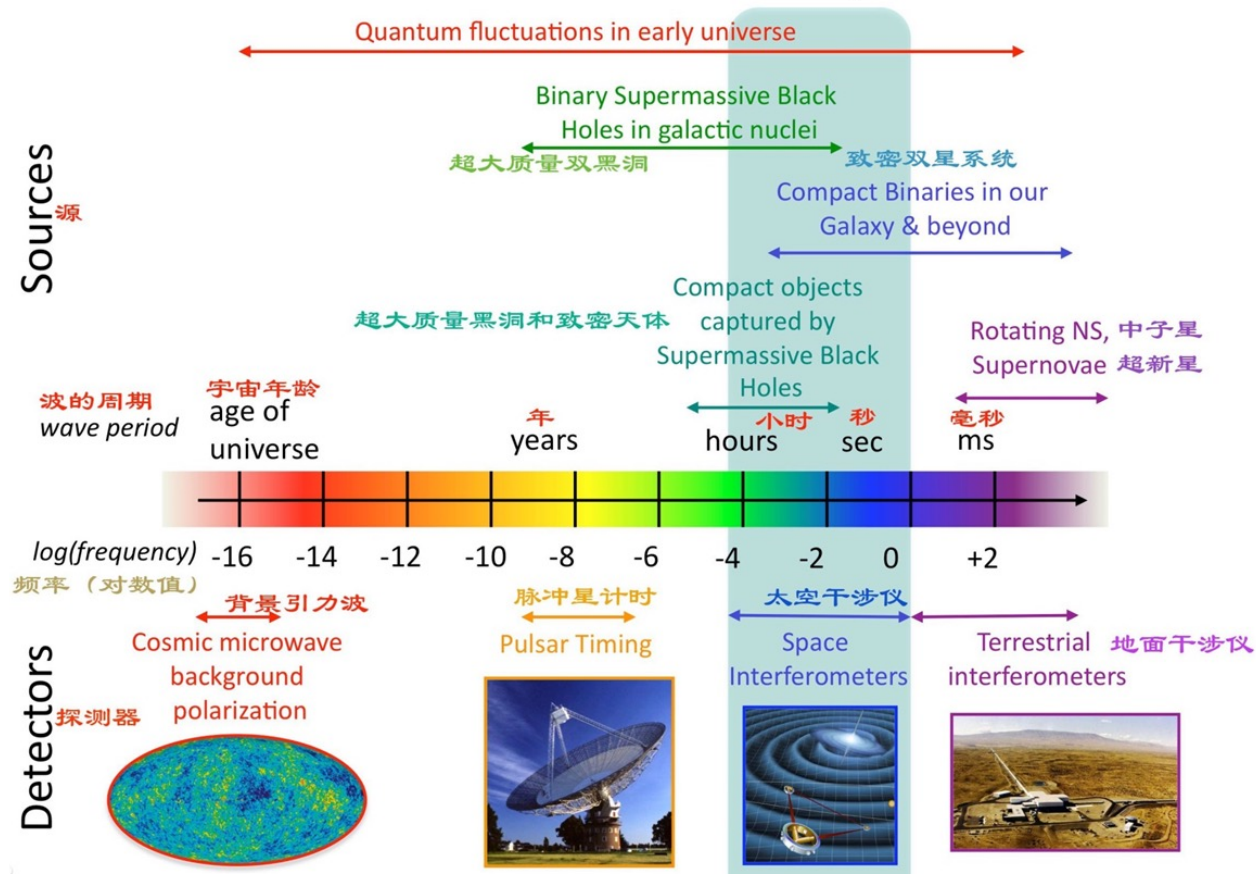
空间引力波数据处理新进展

何吉波（中国科学院大学）

2026年7月16日

Introduction

The Gravitational Wave Spectrum

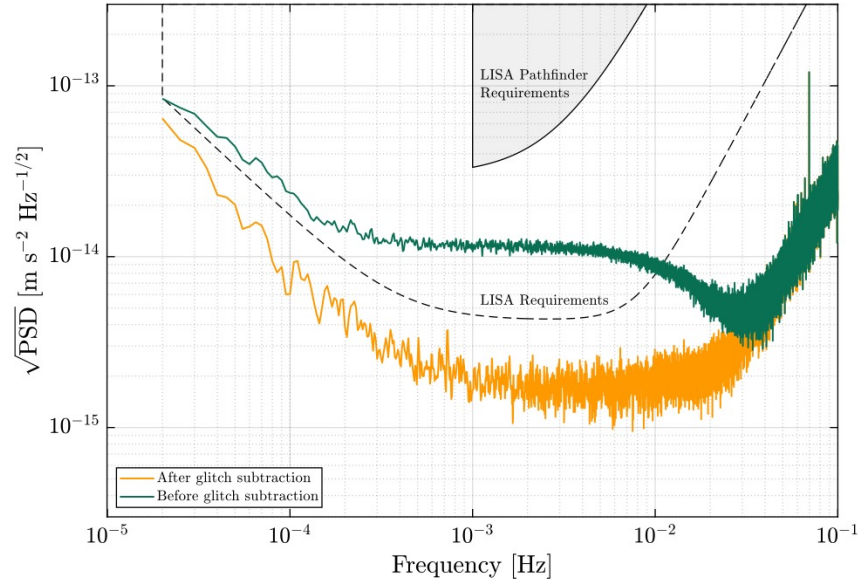
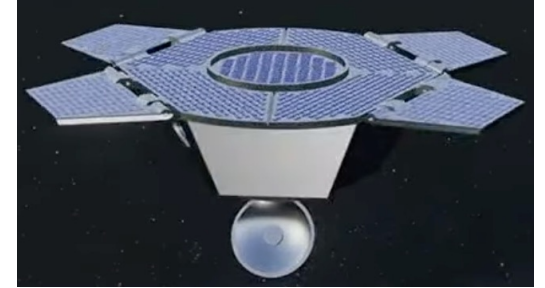


[S. Wang et al., Sensors 2023, 23(19), 8087]

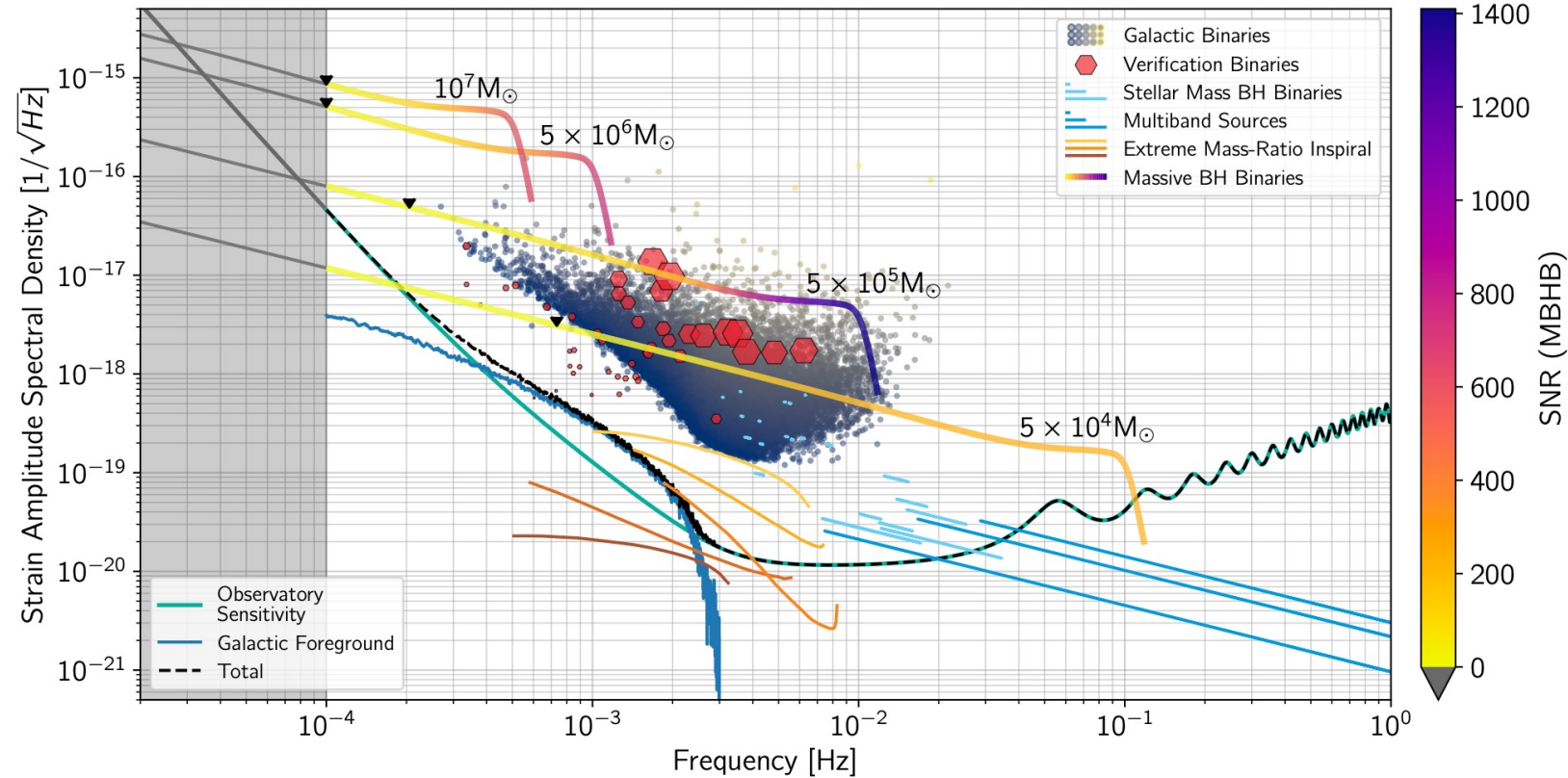
Challenges in data analysis

- Multi-sources
- Gap
- Glitch...

[LISA, arXiv:2402.07571]



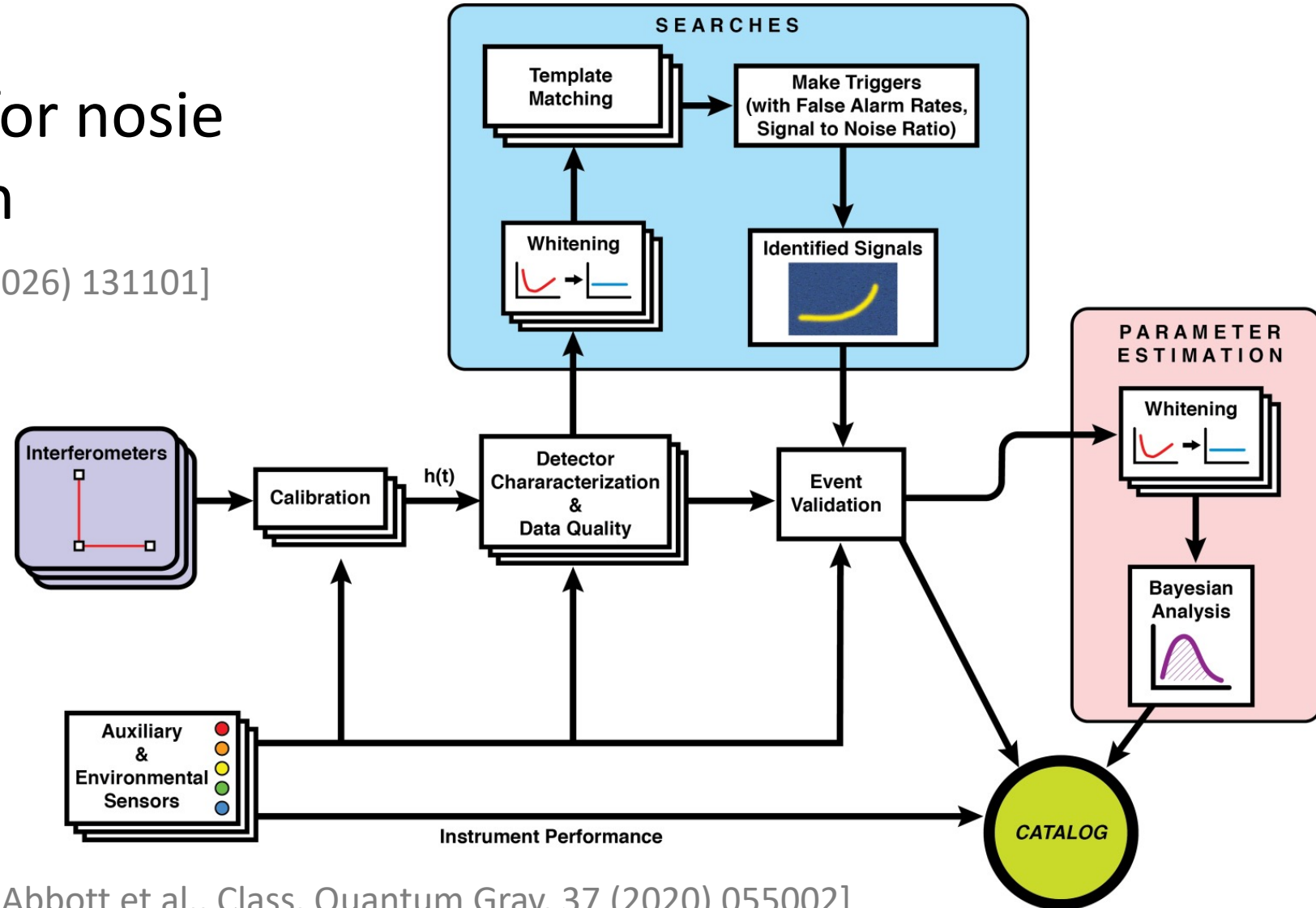
[Q. Baghi et al., PRD 105 (2022) 042002]



Detector characterization

- Important for noise suppression

[Acta Phys. Sin. 75 (2026) 131101]

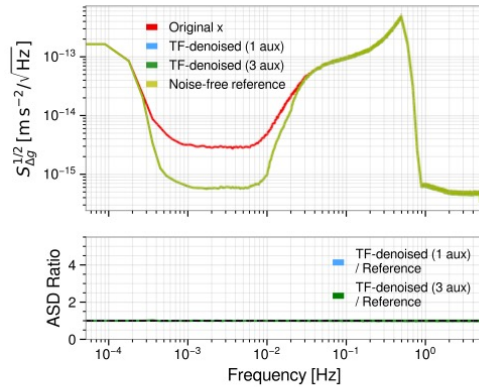


[B P Abbott et al., Class. Quantum Grav. 37 (2020) 055002]

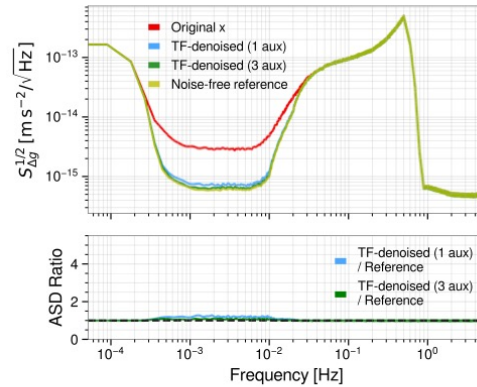
Auxiliary-channel-assisted noise removal

[arXiv:2607.05236]

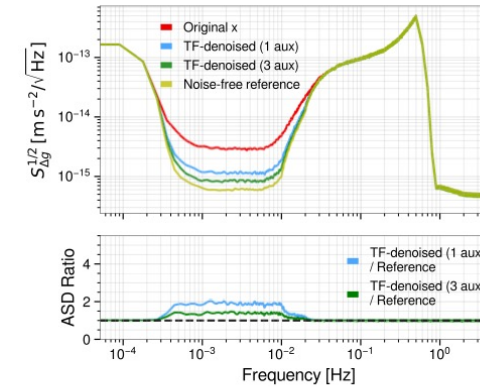
- Requirements on noise level in Auxiliary-channel studied



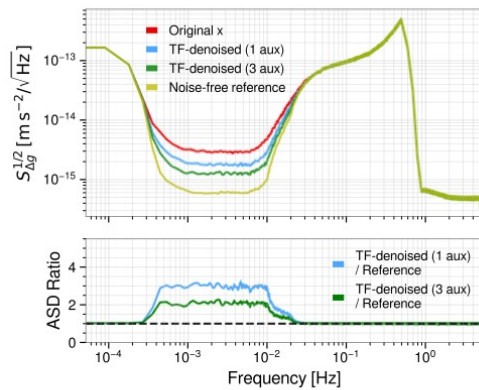
(a) $\delta = 0.01$



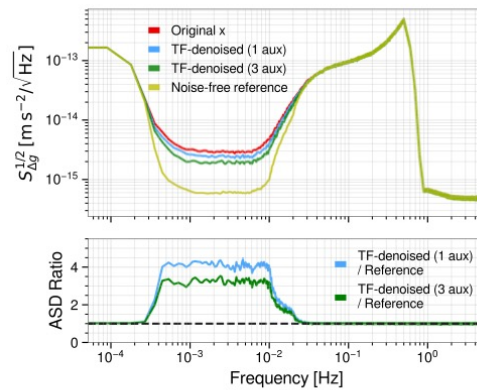
(b) $\delta = 0.2$



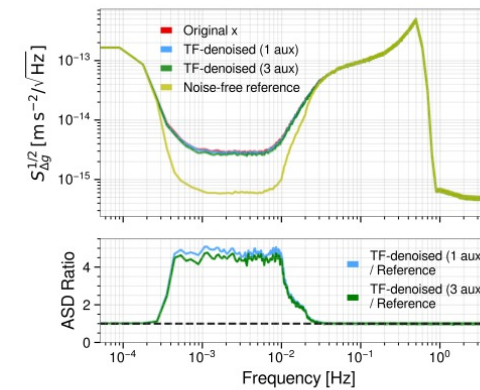
(c) $\delta = 0.5$



(d) $\delta = 1.0$



(e) $\delta = 2.0$

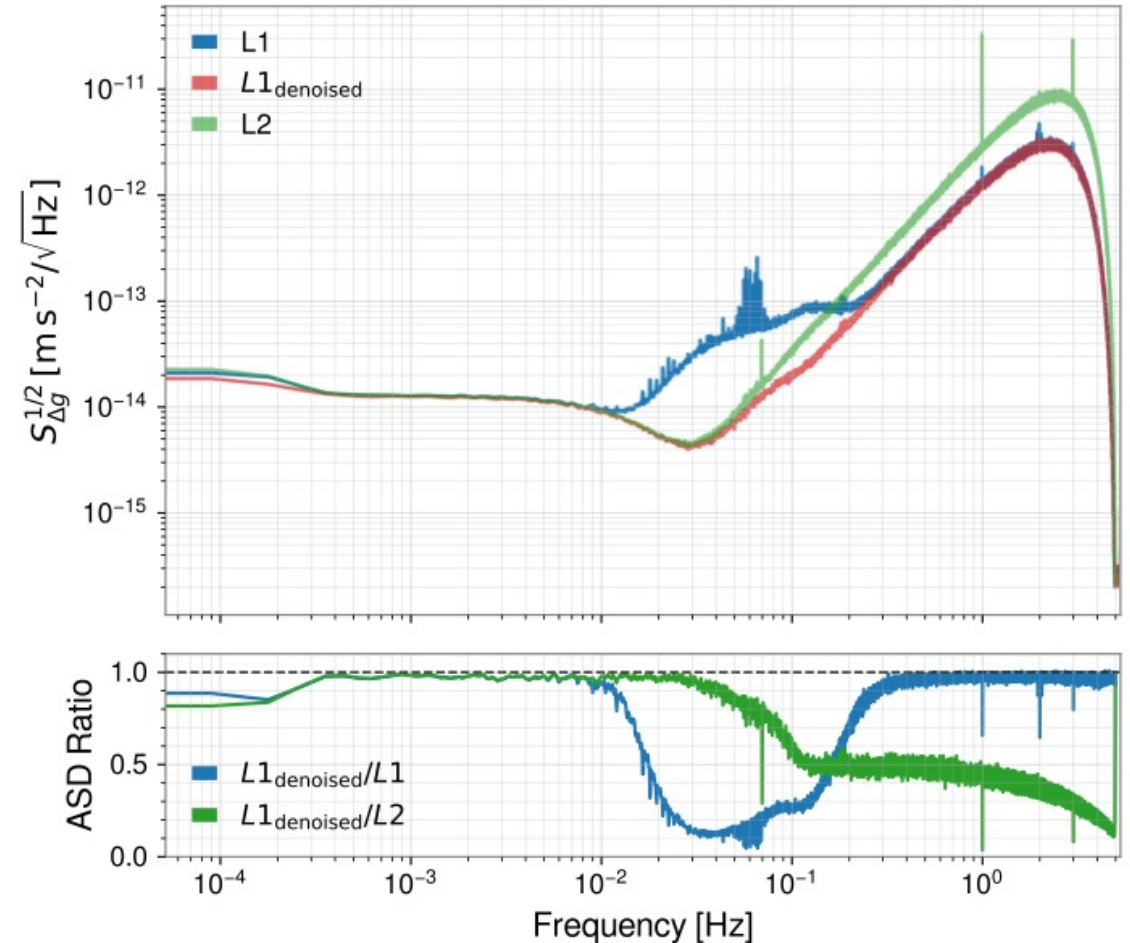
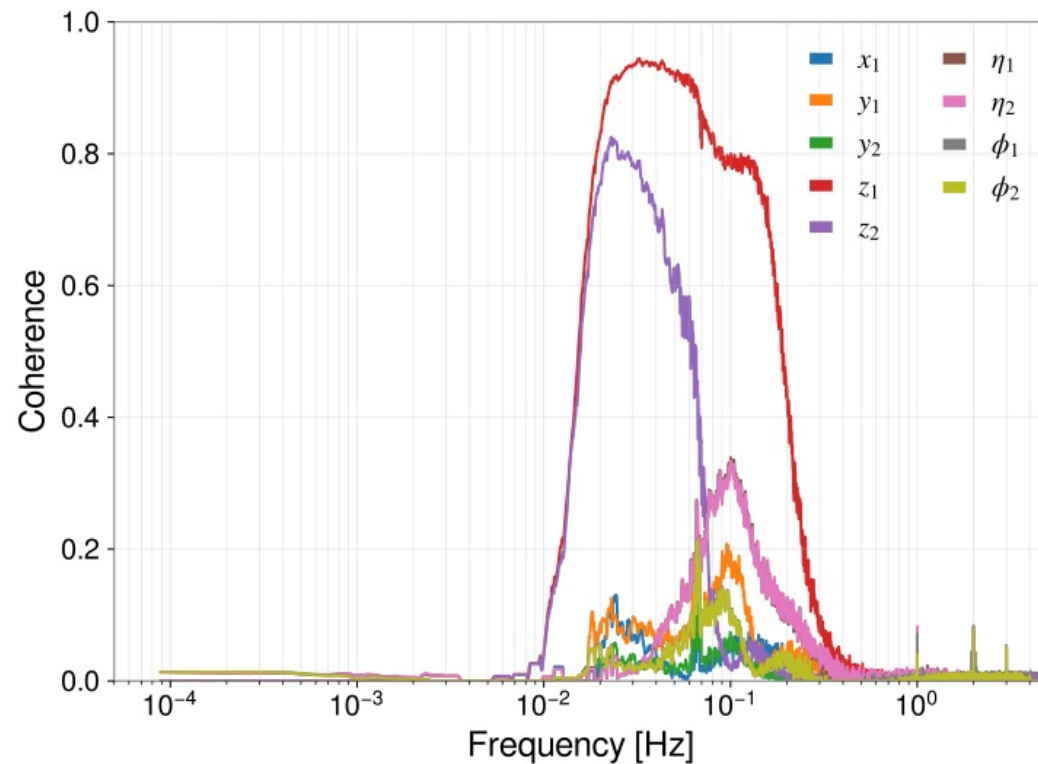


(f) $\delta = 5.0$

Auxiliary-channel-assisted noise removal

[arXiv:2607.05236]

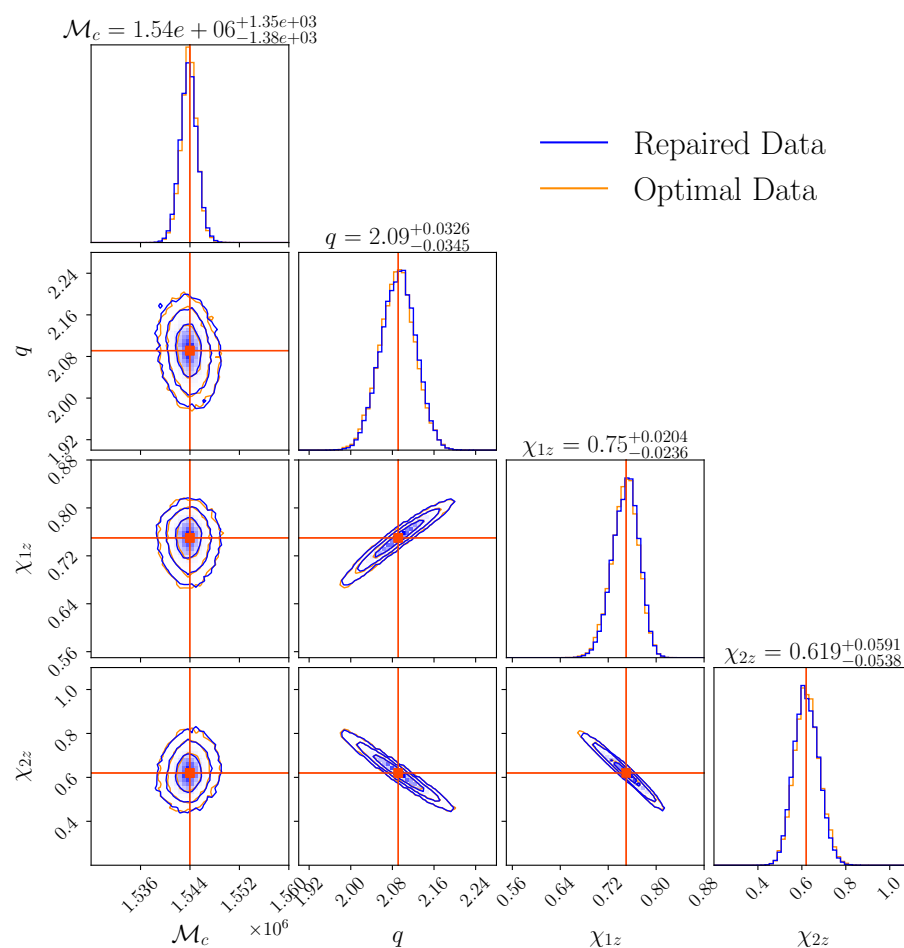
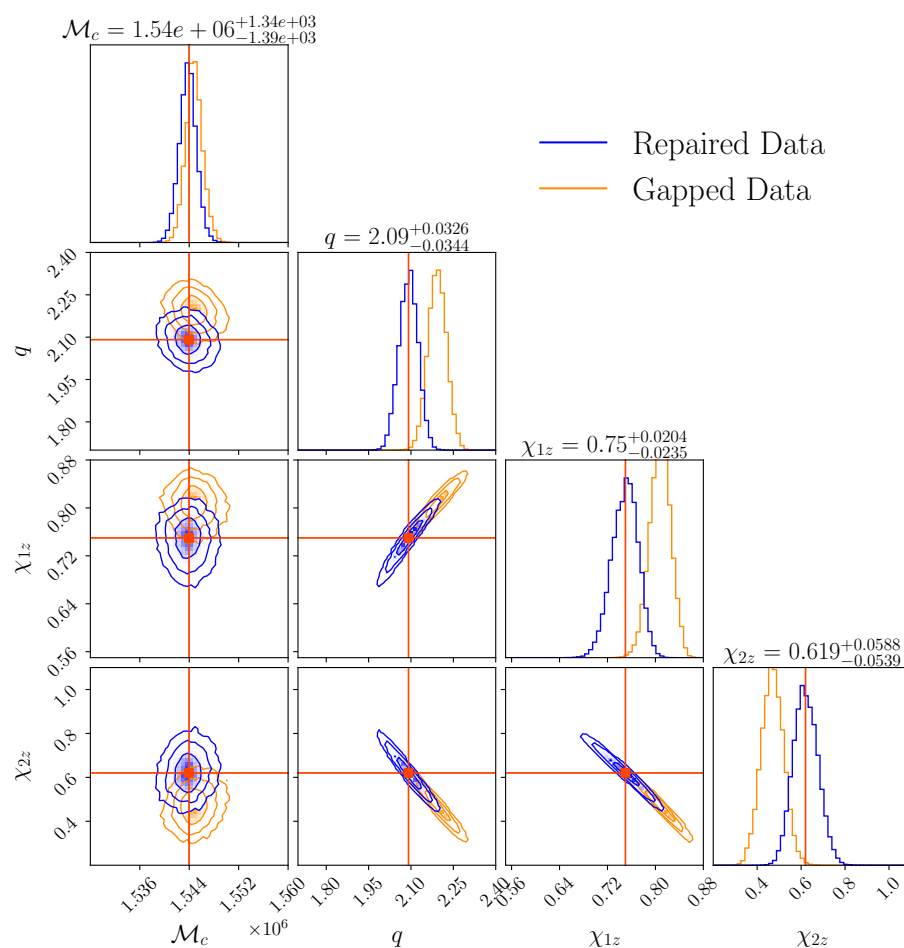
- Good performance in LPF data



Data gap

[arXiv:2507.02458]

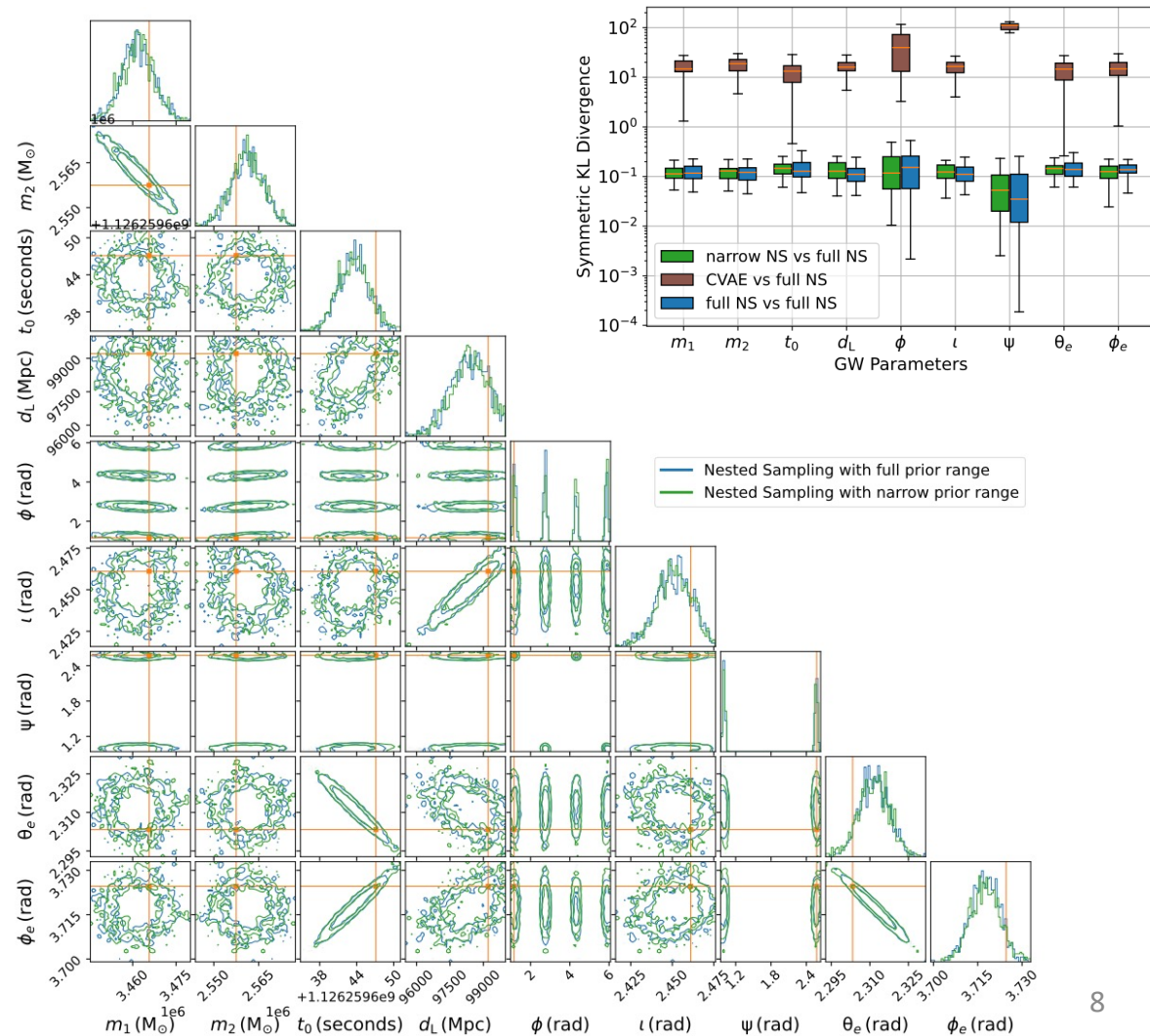
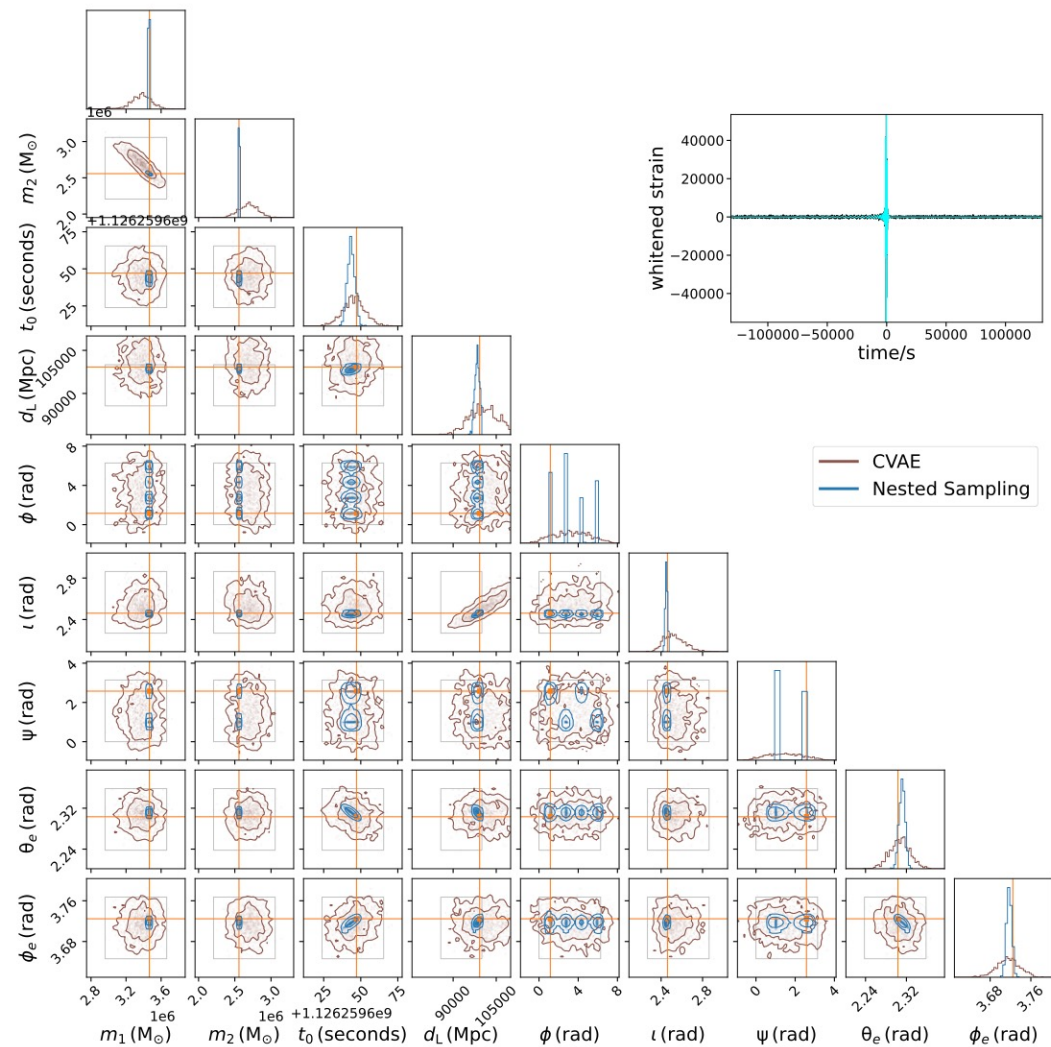
- Effects mitigated using a Kalman smoother



Accelerating Bayesian sampling w/ AI

- Sampling time reduced by a factor of ~ 6

[PRD 111 (2025) 103053]



Interpretability of AI (CNN)

[Mach. Learn.: Sci. Technol. 6 (2025) 035045]

- Interpretability important, e.g., for detector R&D

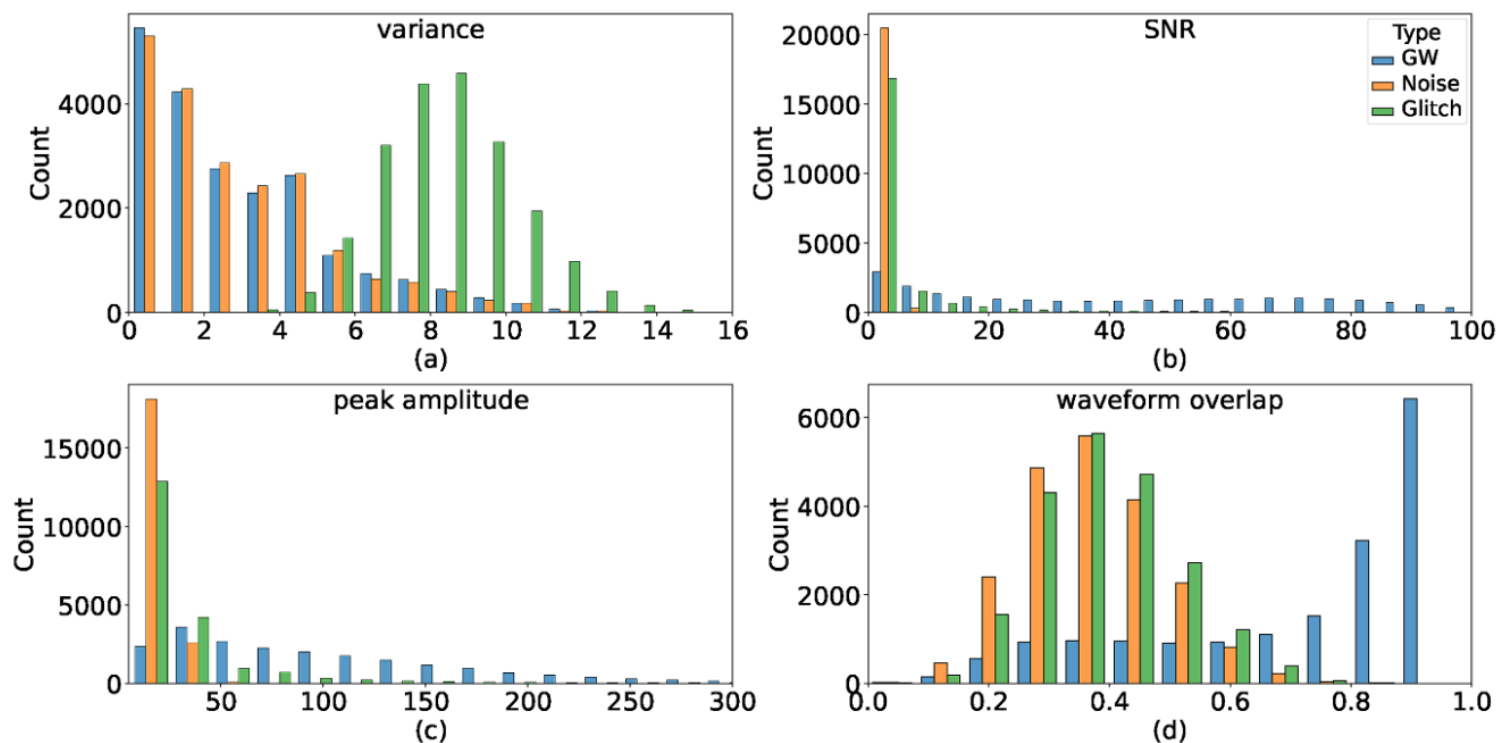
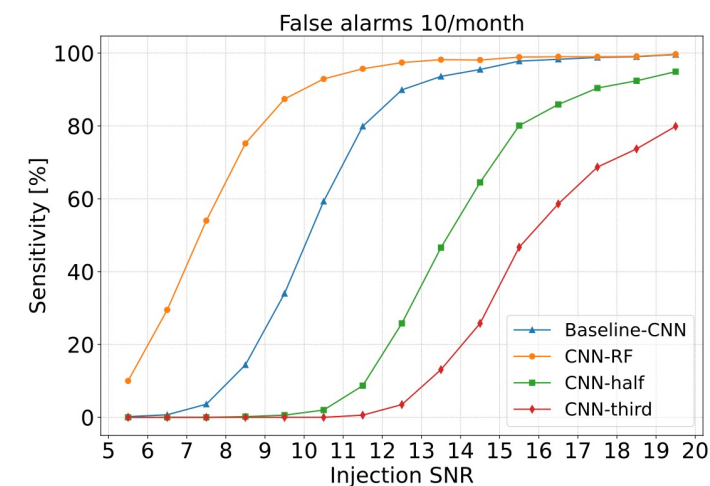


Table 2. Feature importance ranking from the RF classifier.

Rank	Feature	Feature importance
1	variance	0.3943
2	CNN probability	0.2583
3	SNR	0.1629
4	waveform overlap	0.1219
5	peak amplitude	0.0626

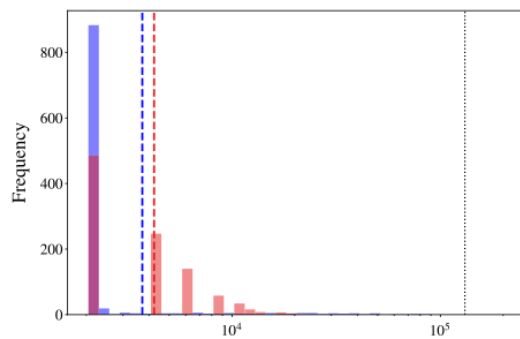


Grover-algorithm based GW search

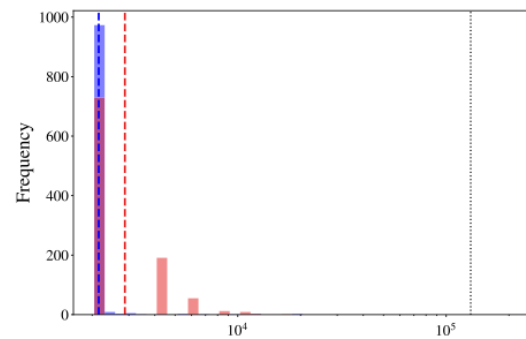
[PRD 112 (2026) 083004]

- Quantum matched filtering proposed by S. Gao et al. applied to MBHB, $\mathcal{O}(\sqrt{N})$. Some instability found, also for GW150914

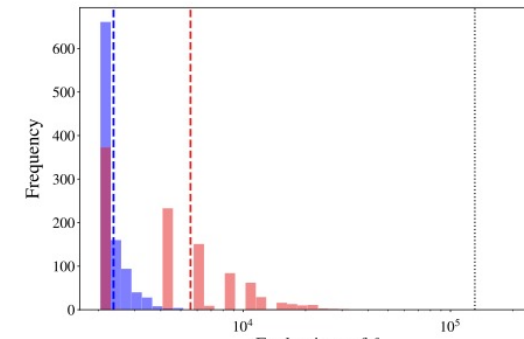
[S. Gao et al., PRR 4 (2022) 023006]



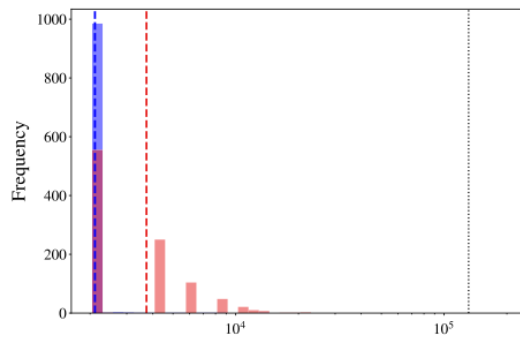
(a) $\rho_{\text{thr}} = 800$



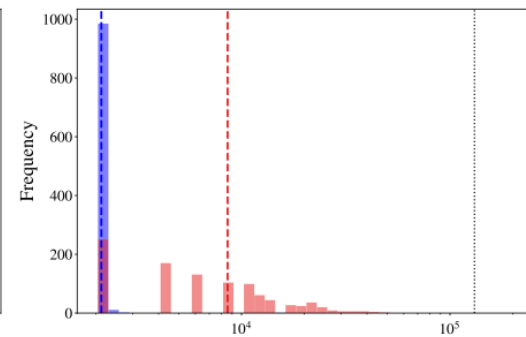
(b) $\rho_{\text{thr}} = 850$



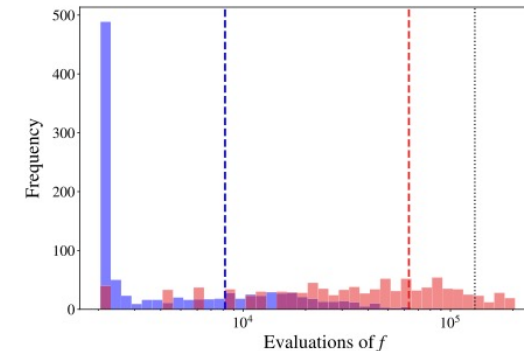
(a) $\rho_{\text{thr}} = 18$



(c) $\rho_{\text{thr}} = 860$



(d) $\rho_{\text{thr}} = 870$

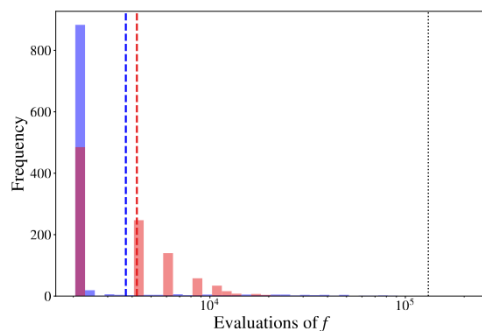


(b) $\rho_{\text{thr}} = 16$

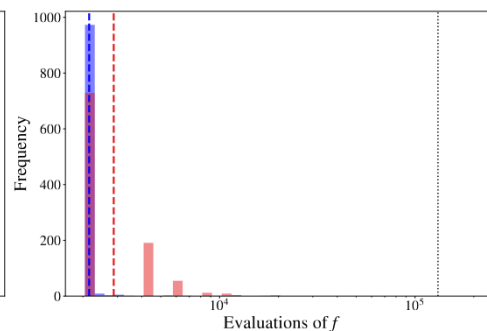
Long-algorithm (龙算法) based GW search

[arXiv:2603.17698]

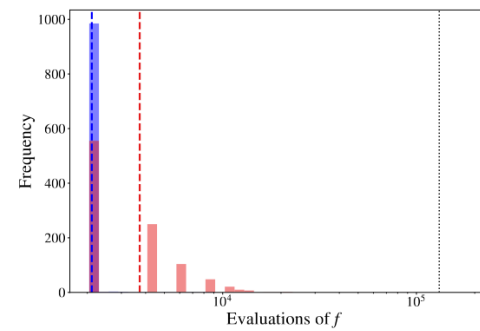
- Robustness improved significantly while preserving the quadratic speedup of quantum search



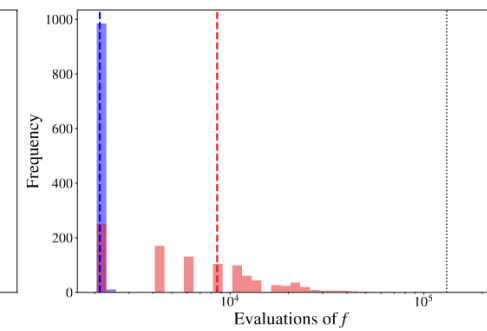
(a) Grover $\rho_{\text{thr}} = 800$



(b) Grover $\rho_{\text{thr}} = 850$



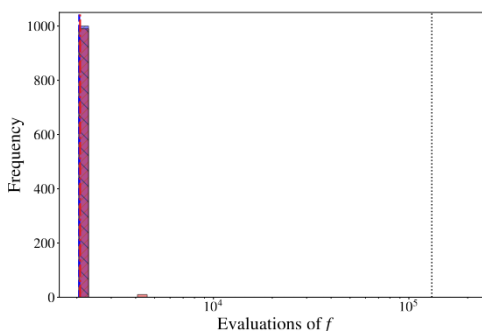
(e) Grover $\rho_{\text{thr}} = 860$



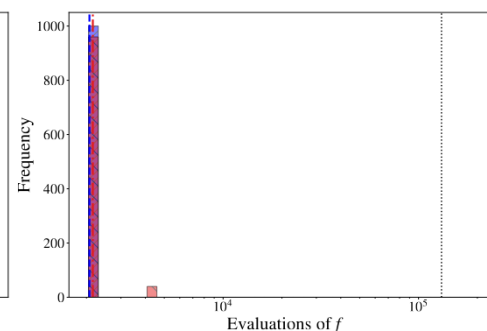
(f) Grover $\rho_{\text{thr}} = 870$



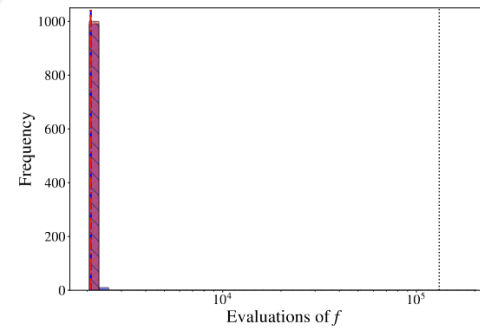
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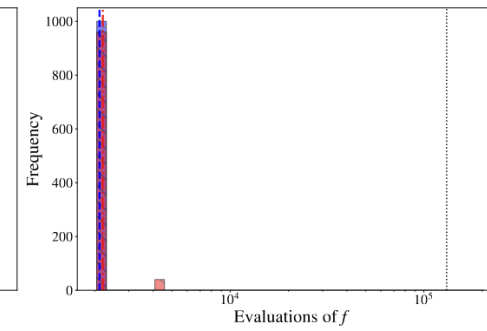
(c) Long $\rho_{\text{thr}} = 800$



(d) Long $\rho_{\text{thr}} = 850$



(g) Long $\rho_{\text{thr}} = 860$



(h) Long $\rho_{\text{thr}} = 870$

Summary

- Recent progress on GW data analysis
 - Detector characterization
 - Auxiliary-channel-assisted noise removal
 - Data gap effects mitigated w/ Kalman smoother
 - Accelerating Bayesian sampling w/ AI
 - Interpretability of AI
 - Quantum computing applied to GW search
- You are always welcome to join the efforts

