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OzGrav

ARC Centre of Excellence for Gravitational Wave Discovery

Gravitational-wave burst detection efficiency of the BayesWave pipeline with Multi-detector networks

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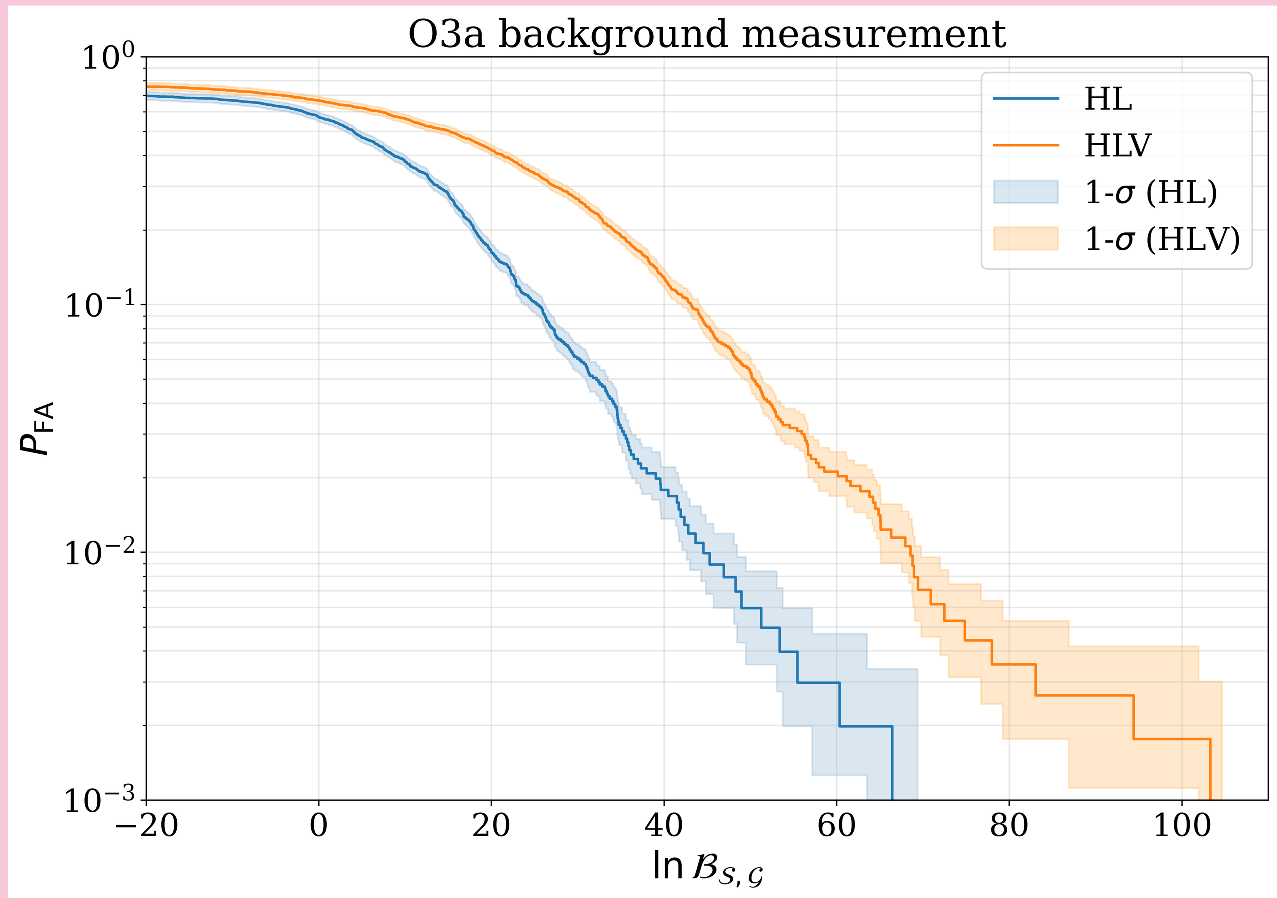
INTRODUCTION

Detection confidence of the source-agnostic gravitational-wave (GW) burst search pipeline *BayesWave* [1] is quantified by the log signal-versus-glitch Bayes factor, $\ln \mathcal{B}_{\mathcal{S},\mathcal{G}}$. A recent study [2] shows that $\ln \mathcal{B}_{\mathcal{S},\mathcal{G}}$ increases with the number of detectors. However, as the detector network expands, non-Gaussian detector noise events (glitches) become more frequent. Glitches can mimic or mask burst signals resulting in false alarm detections, consequently reducing detection significance. This work presents an empirical study on the impact of increased false alarm probability on the overall performance of *BayesWave* with expanded detector networks, comparing between the Hanford-Livingston (HL, two-detector) and Hanford-Livingston-Virgo (HLV, three-detector) networks.

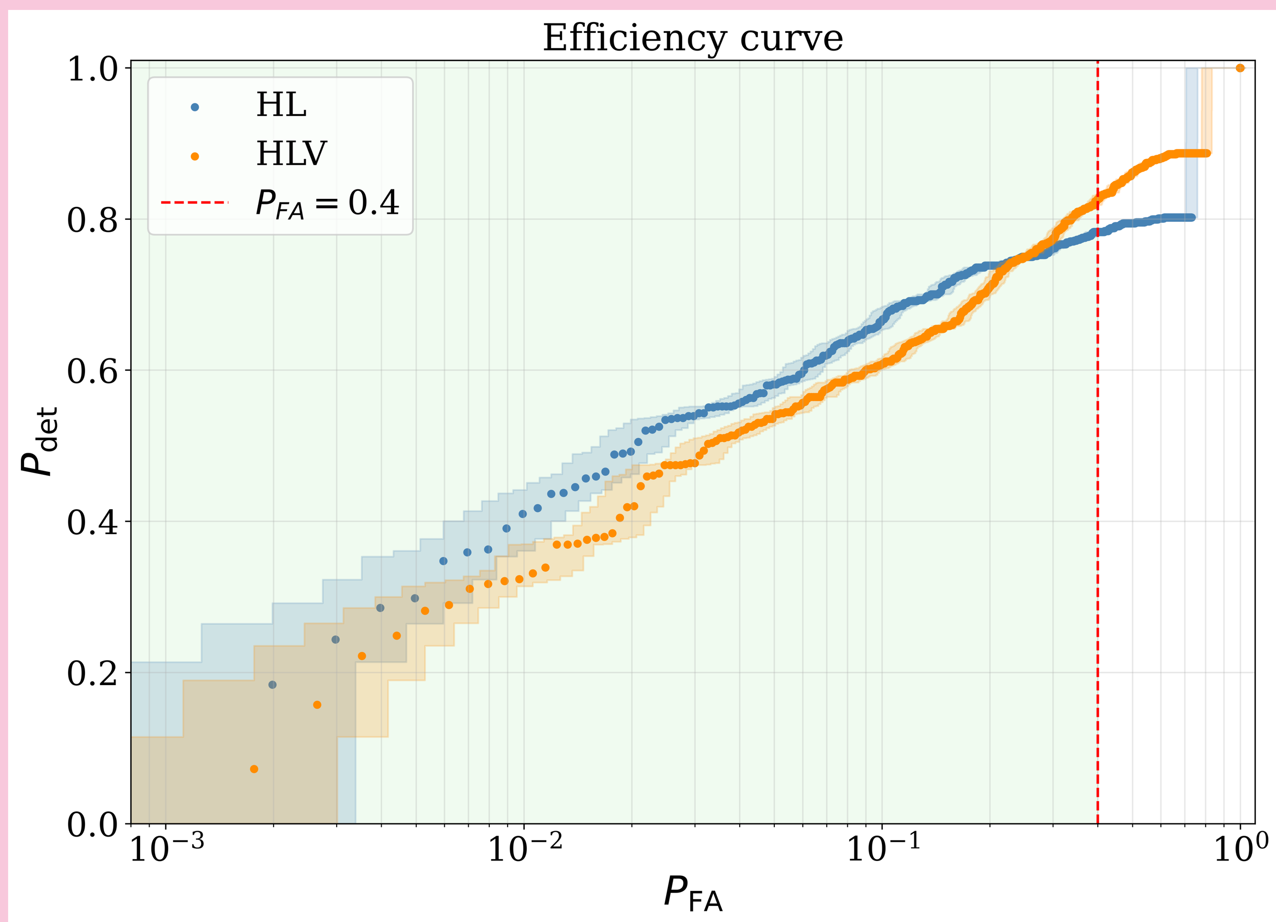
NOISE BACKGROUND

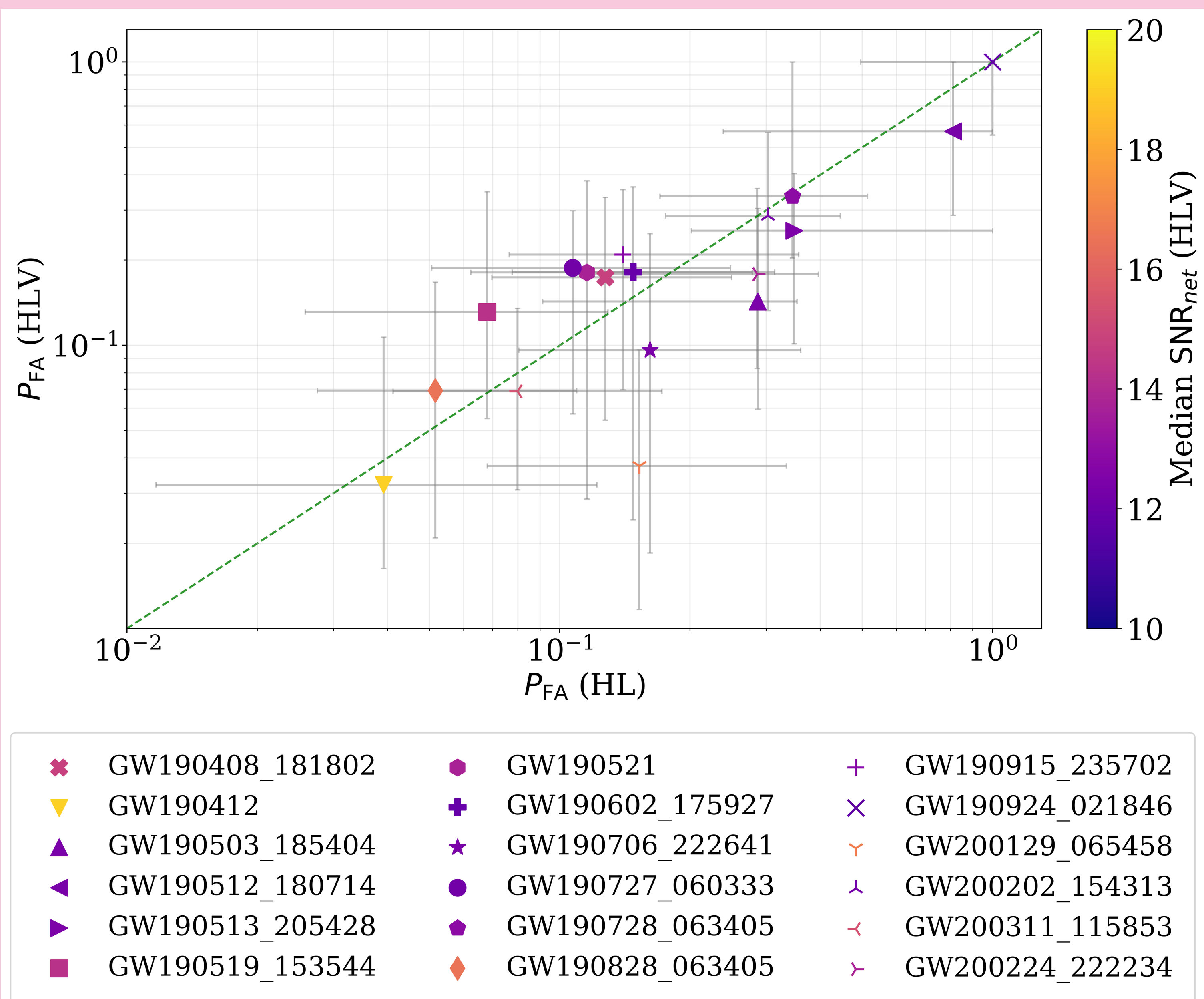
False alarm probability (P_{FA}) is the probability that an event detected with some $\ln \mathcal{B}_{\mathcal{S},\mathcal{G}}$ is a false alarm. P_{FA} is used to quantify *BayesWave's* detection significance, where low P_{FA} indicates high astrophysical significance. P_{FA} is measured using non-astrophysical background events, down-selected from coherentWave Burst (cWB)'s trigger list for first half of Advanced LIGO-Virgo's Third Observing Run (O3a) [3, 5]. Assuming the detector noise background can be modelled as a Poisson process, the shaded regions show the 1-σ Poisson uncertainty regions. The background measurements show that P_{FA} is higher for HLV than for HL at all $\ln \mathcal{B}_{\mathcal{S},\mathcal{G}}$ because the occurrence of background triggers increases with the number of detectors. As a result, events detected by the HLV network need to attain a higher $\ln \mathcal{B}_{\mathcal{S},\mathcal{G}}$ to achieve the same significance as the HL network.



EFFICIENCY CURVES

Detection efficiency (P_{det}) of *BayesWave* is measured as the probability of detecting an astrophysical event at a given significance. We combine $\ln \mathcal{B}_{\mathcal{S},\mathcal{G}}$ of simulated binary black hole (BBH) signals with the background measurements to construct **efficiency curves**, which plots P_{det} against P_{FA}. By comparing the efficiency curves within the astrophysical relevant regime ($P_{\mathrm{FA}} \leq 0.4$), we find that BW's overall detection efficiency is similar for both HL and HLV.





SIGNIFICANCE OF O3 GW CANDIDATES

As a consistency check, we analyse a set of O3-like compact binary coalescence (CBC) signals i.e. off-source waveforms with parameters sampled from the match-filter posteriors of O3 GW detection events [4, 5]. We use the background measurements above to quantify the significance of 18 GW events, each with their own set of off-source waveforms. The figure to the left compares the median P_{FA} between HL and HLV off-source waveforms. Events with higher network signal-to-noise ratios are detected with lower P_{FA}, but all 18 events lie close to the diagonal line where P_{FA} (HL) = P_{FA}(HLV). This observation suggests that *BayesWave* recovers events with similar significance from both HL and HLV.

CONCLUSION

The results from two independent analyses show that there are no major differences between *BayesWave's* overall performance with the HL and HLV networks. This is because the increased false alarm probability (P_{FA}) in larger detector networks offsets the advantage of increased $\ln \mathcal{B}_{\mathcal{S},\mathcal{G}}$. Our findings are consistent with previous studies [6, 7].

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