Gravitational wave informed pointing of short-gamma-ray bursts observations

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Overview: Our multimessenger astronomy study uses early-warning gravitational wave (GW) signals from binary neutron star (BNS) mergers to refine source localization and viewing angles, improving short gamma-ray burst (sGRB) detectability with NASA's *Swift* telescope and enhancing electromagnetic (EM) follow-up.

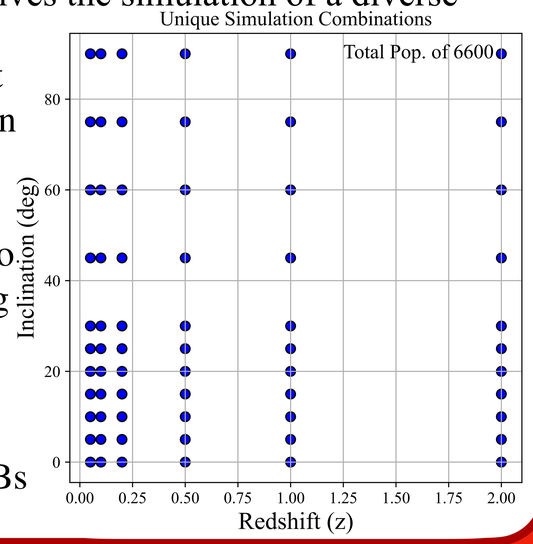
Introduction: The detection of GW170817 by LIGO/Virgo and the coincident short-GRB by Fermi-GBM confirmed that neutron star mergers produce sGRBs, launching the era of MMA for GWs.

- Next-generation (XG) GW observatories, like Cosmic Explorer, will be able to detect BNS mergers up to redshift ~2, with events occurring nearly every minute.
- However, space-based gamma-ray observatories, such as Swift, face challenges in rapid follow-up due to communication and repositioning delays.

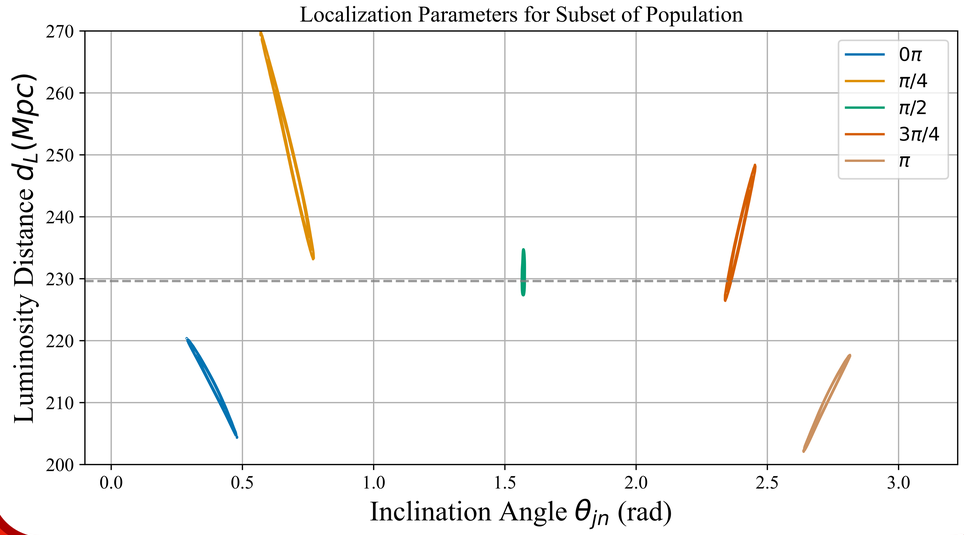
We aim to construct a probabilistic framework capable of accurately deducing the orientation and location of BNS systems from noisy EM-GW simulated data. This will enhance the feasibility of prompt sGRB detection and early afterglow observations across multiple wavelengths.

Methods: This project involves the simulation of a diverse

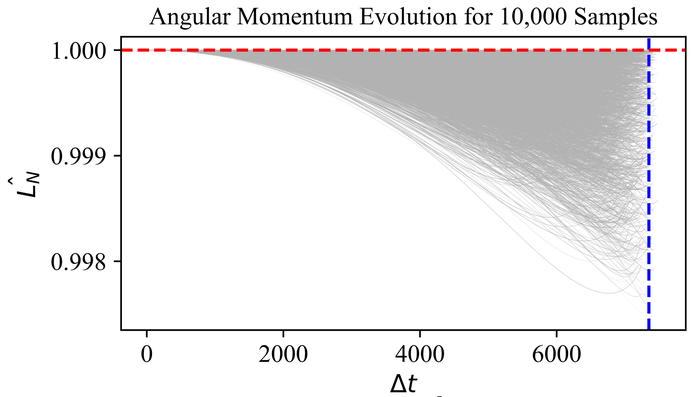
- Population of BNS signals detected via GWs by current and XG observatories, run on NASA high-performance computing clusters.
- Covers redshifts from 0.05 to 2, representing the observing capabilities of XG-GW detectors.
- Tests viewing angles to determine the range of sGRBs observable from Earth.



Preliminary Results: While the main simulations are ongoing, a subset of the population was used to implement the early-warning signal likelihood calculation into *bilby*, a user-friendly Bayesian inference library for GW analysis. By performing parameter estimation, we constrain key source localization variables for varied inclination angles and luminosity distances, as shown below:



Preliminary Results cont.: If the sGRB is directed towards Earth during the early-warning portion of the GW signal, it will remain pointed at Earth once merger occurs.



Max. angular momentum, $\hat{L}_N$ evolution from start of GW signal to merger:

$$\theta = \tan^{-1}\frac{0.0025}{7350} \approx 1.95 \times 10^{-5}\ ^{\circ}$$

Conclusion: By leveraging early-warning GW signals to refine BNS merger localization, this research enhances NASA's endeavors in high-energy and time-domain astrophysics. Our probabilistic framework will improve targeted MMA follow-up searches, strengthening the synergy between XG-GW observatories and EM facilities for rapid sGRB detection and characterization.

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