NASA EM Followup of LIGO-Virgo Candidate Events
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Abstract
We present a strategy for a follow-up of LIGO-Virgo candidate events using offline survey data from several NASA high-energy photon instruments aboard RXTE, Swift, and Fermi. Time and sky-location information provided by the GW trigger allows for a targeted search for prompt and afterglow EM signals. In doing so, we expect to be sensitive to signals which are too weak to be publicly reported as astrophysical EM events.

EM detectors:
<table>
<thead>
<tr>
<th>Mission</th>
<th>Instrument</th>
<th>Energy</th>
<th>FOV °</th>
<th>Δθ Transit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RXTE</td>
<td>ASM</td>
<td>1–10 keV</td>
<td>3%</td>
<td>&lt;1° 1.5 hr</td>
</tr>
<tr>
<td>SWIFT</td>
<td>BAT</td>
<td>20–150 keV</td>
<td>15%</td>
<td>&lt;1° n/a</td>
</tr>
<tr>
<td>FERMI</td>
<td>GBM</td>
<td>20 keV–40 MeV</td>
<td>65%</td>
<td>&gt;5° 3 hr</td>
</tr>
<tr>
<td>FERMI</td>
<td>LAT</td>
<td>20 MeV–300 GeV</td>
<td>20%</td>
<td>1–5° 3 hr</td>
</tr>
</tbody>
</table>

* FOV: fraction of sky observed, Δθ: source localization resolution, Transit time required for full-sky coverage

LIGO-Virgo GW network:
<table>
<thead>
<tr>
<th>Instruments</th>
<th>Frequency</th>
<th>Optimal NS/NS–NS/BH Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1L1V1</td>
<td>50–6000 Hz</td>
<td>~30–70 Mpc</td>
</tr>
</tbody>
</table>

Searches
Promt search
Search for prompt signal in GBM detectors (14% 60s) above level of GW event. Timescales and energy ranges are similar to those observed on board to target GBM’s. Use GW source localization to aid in combining GBM detector data in background rejection. Tune for a 0.01% coincident probability per GW event.

Afterglow search
Search for prompt signal in BAT high-time resolution (400 ms) data in background rejection. Tune for a 0.01% coincident probability per GW event.

FERMI Gamma-ray Burst Monitor 2 (GBM)

GBM offline data includes count rates (0.256 s bins, 8 energy channels) of the 12 NaI (8 keV–1 MeV) and 2 BGO (200 keV–40 MeV) detectors.

The NaI detectors are semi-directional (~cos θ response) and can be used for source localization and consistency checks. The GW location can be used as a basis for a coherent sum of the 12 data streams, increasing the overall response of the network compared to a single-detector approach.

RXTE All Sky Monitor 3 (ASM)

The ASM aboard RXTE provides a 90 s 1–10 keV (3 sub-bands) snapshot of an area in the sky as often as every 90 minutes. Localization of ~0.1° is achieved by use of three cameras each equipped with a shaded mask.

The analysis method of fitting the amplitudes of a small number of point sources in the FOV to the marked data is generally used to produce sensitive light curves for searches of interest (e.g., META wavemake use of the same technique to scan the 1500 sky-scan of the GW trigger in the few days following the event to search for X-ray afterglow signals. The fitted source is divided into 57 0.1° x 0.1° pixels, and is fit to the data along with a catalog of known active sources. The sensitivity of the 0.1° pipelines is about 20 MeV (4x10^3 electrons), and can be improved by averaging measurements to the duration of an expected source. This method of analyzing a limited region of the sky is more sensitive than the standard untriggered offline search for ASM transients which uses FFT deconvolution to create a image from the marked data.

SWIFT Burst Alert Telescope 4 (BAT)

- BAT lightcurve data contains total flux counts at 64 ms resolution in various energy bands.
- For un-triggered (low threshold) events, imaging is only available offline for 3 minutes timescales.
- Usability depends on level of non-Gaussian transients.

FERMI Large Area Telescope 5 (LAT)

- LAT complete individual photon data available for offline analysis.
- Each photon characterized by time, sky location and energy. Single photon resolved at 1° (10 MeV) to 0.1° (10 GeV). Cluster of photons improves source location estimate.
- Likelihood statistic used by LAT team to identify significant clusters of photons.


https://ntrs.nasa.gov/search.jsp?R=20110008162 2019-07-01T02:44:20+00:00Z