Low latency search for CBCs using MBTA

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Gravitational wave detector network

- Exciting time as detectors are about to enter advanced detector era
Low latency plan

- For low latency analyses we are interested in sources which could also produce EM signals
- We provide time and sky localisation information to EM astronomers
- Multi-messenger detection will add extra information to GW triggers
- Could give accurate sky localisation, redshift, and the host galaxy
MBTA, a very low latency search pipeline

- Multi-band template analysis (MBTA)
- Run online, as soon as we receive calibrated data and basic data quality information
- Efficient implementation of matched filtering over a bank of templates
- Computing resources optimised by splitting correlation on two or more frequency bands, then combining
- Pipeline is focused on being low latency (of order one minute)
Single detector analysis

- For each detector the matched filtering is performed over two (or more) frequency bands to reduce latency
- The result of the bands is combined coherently
- We can also split the parameter space across multiple processes to improve latency
Cheep and fast

- Multi-band analysis reduces computational cost and analysis time
- We can use shorter templates in each band
- Requiring fewer templates to cover equivalent mass space of single band analysis
- Reduced sampling frequency needed for the low frequency band
- This makes the analysis cheep to run, one detector on one 16 core machine
Signal consistency checks

- Low latency data quality information is used to remove noise
- Multiple frequency bands are used to check consistency with chirp signal
Coincidence

- Merge triggers from multiple detectors
- Find coincidences:
  - Triggers must be found in all detectors with the same parameters
  - Timing is consistent with flight time between detectors and time measurement accuracy
- Trigger significance estimated by computing false alarm rate
Event follow up

- Candidate events are then sent to the Gravitational Wave Candidate Event Database (GraceDB)
- Sky localisation is performed by Bayestar using time, amplitude and phase of the trigger

Figure: Two detectors localisation example
MBTA triggers during the last LIGO Virgo run

- Focused on triple detector coincidences
- Extra data quality checks were performed on candidate events
- Alerts were sent to EM astronomers for follow up observations

Figure: Trigger from the last LIGO Virgo analysis

New features and the future

- Reduce minimum frequency from 50 hz to 30 hz while maintaining the same latency (challenging due to longer waveforms)
- Can now run using spinning templates
- Signal based consistency test
- Provide more information for localisation
- Running Mock Data Challenges to test and tune improvements to the analysis
- Validating results against other search pipelines
- Preparing for O1 at the end of 2015