

Gravitational Waves and Virgo

A new window into the Universe

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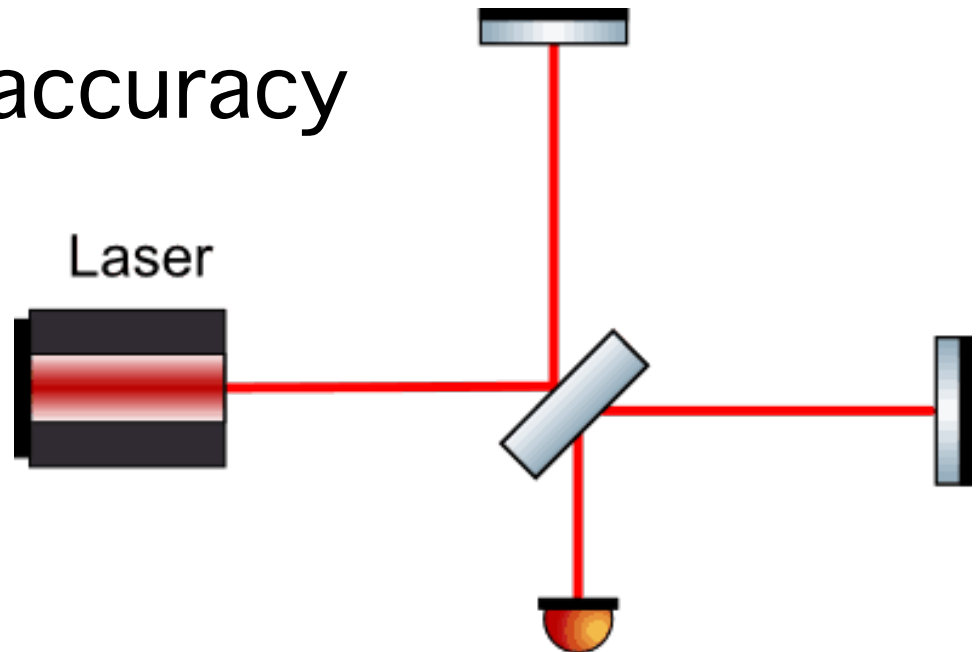


Gravitational waves

- Perturbations in space-time traveling at c
- GW amplitude $h = \Delta L/L < 10^{-21}$
- Gravitational analogue of electromagnetic waves
- Transverse waves
- Change distance between free falling particles

Interferometer

- Measures differential change of arm length
- Ideal for GW detection
- No directional accuracy



LIGO and Virgo

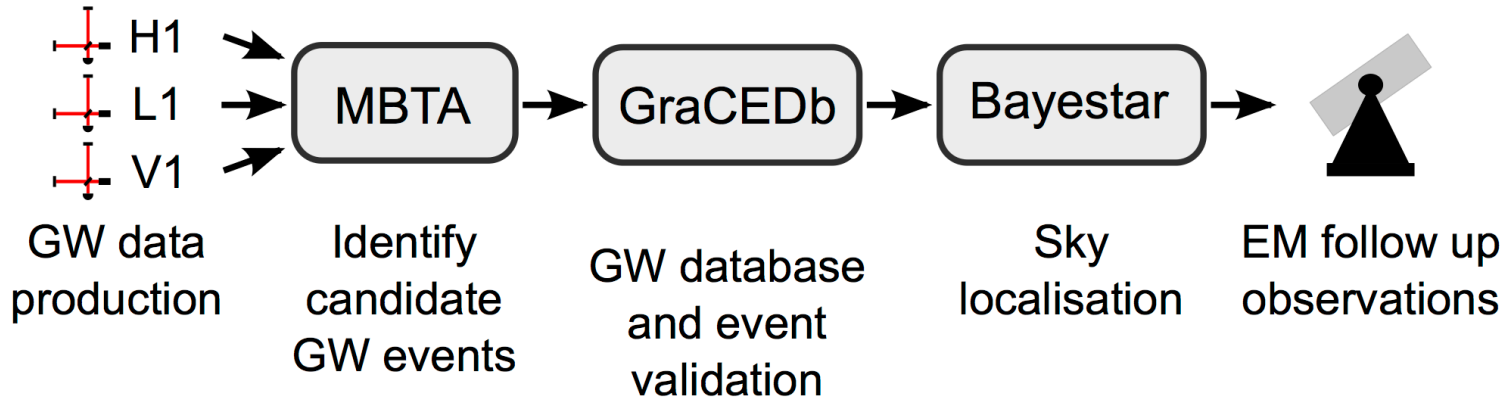


Advanced Virgo status

- Construction and Installation - complete
- Commissioning towards first lock – ongoing
- Noise hunting and calibration

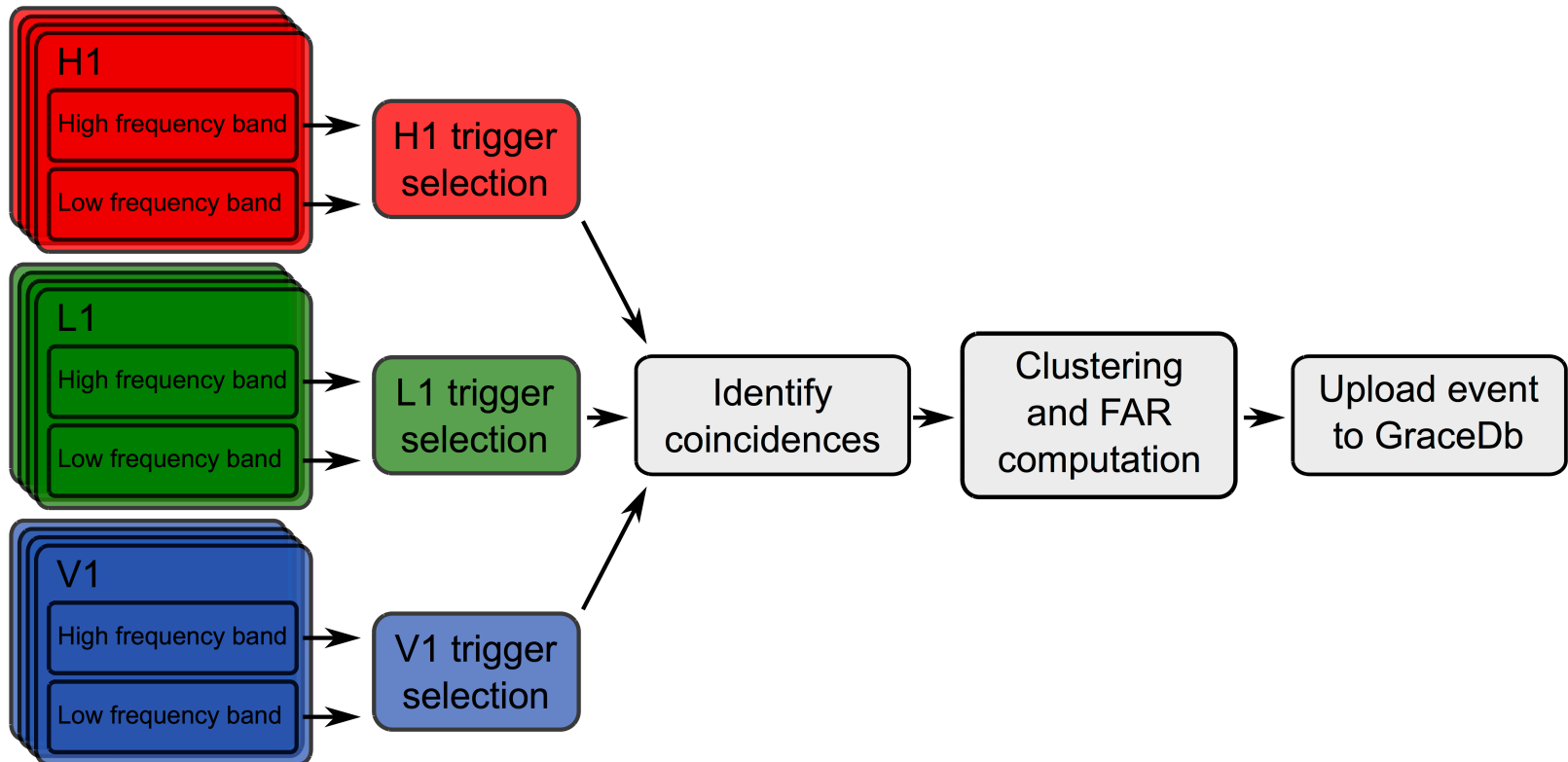
- Goal: Join O2B with sensitivity sufficient to contribute to the network

Low-latency analysis

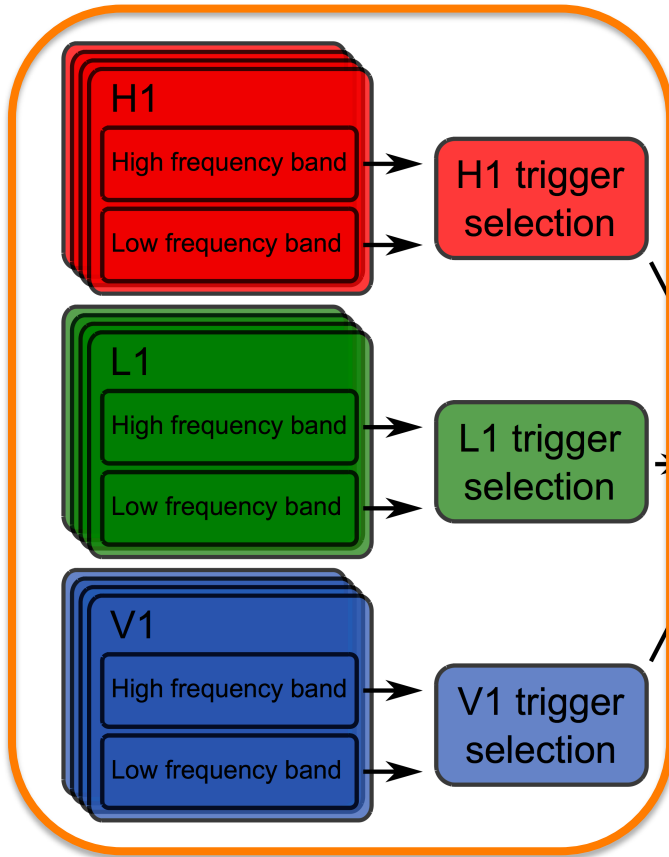


- Data production by detectors
- Pipelines identify candidate GW events
- Events submitted to GraCEDb, event validation
- Sky localisation
- Alerts for EM follow-up observations

MBTA Overview



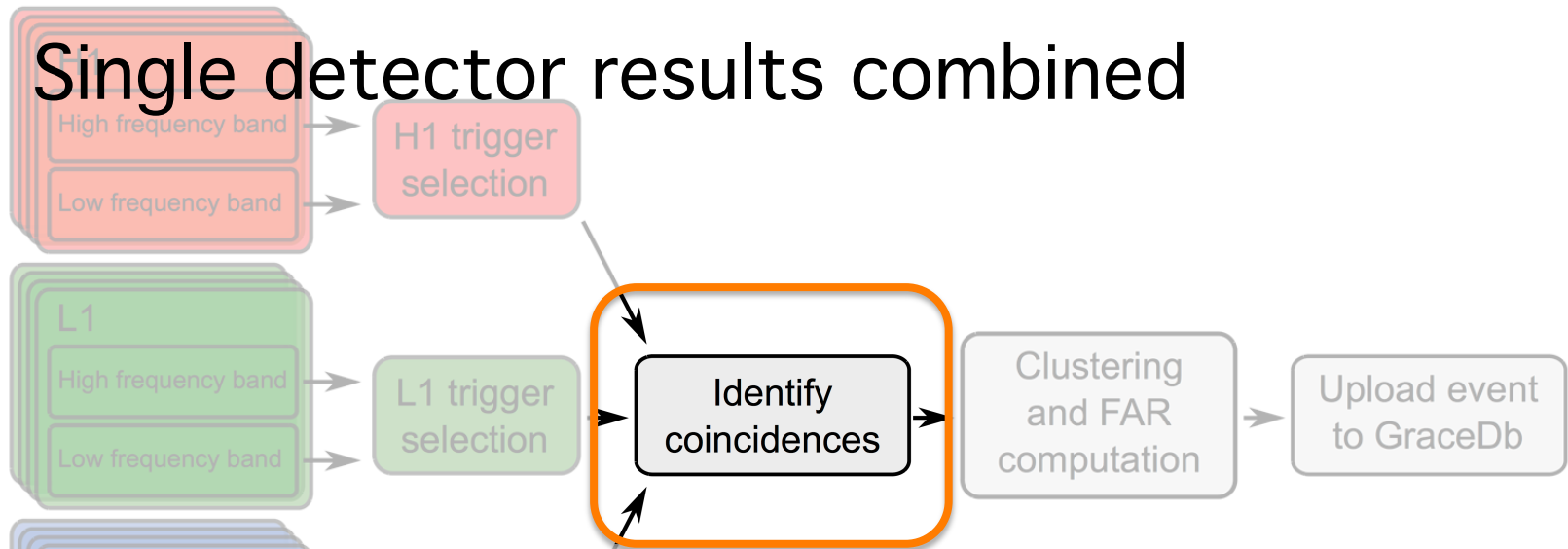
Filtering



- Coincident analysis
- Match filtering is split across two frequency bands to reduce computational cost
- We are not searching for BNS, NSBH, and BBH $M_{\text{tot}} < 100M_{\odot}$

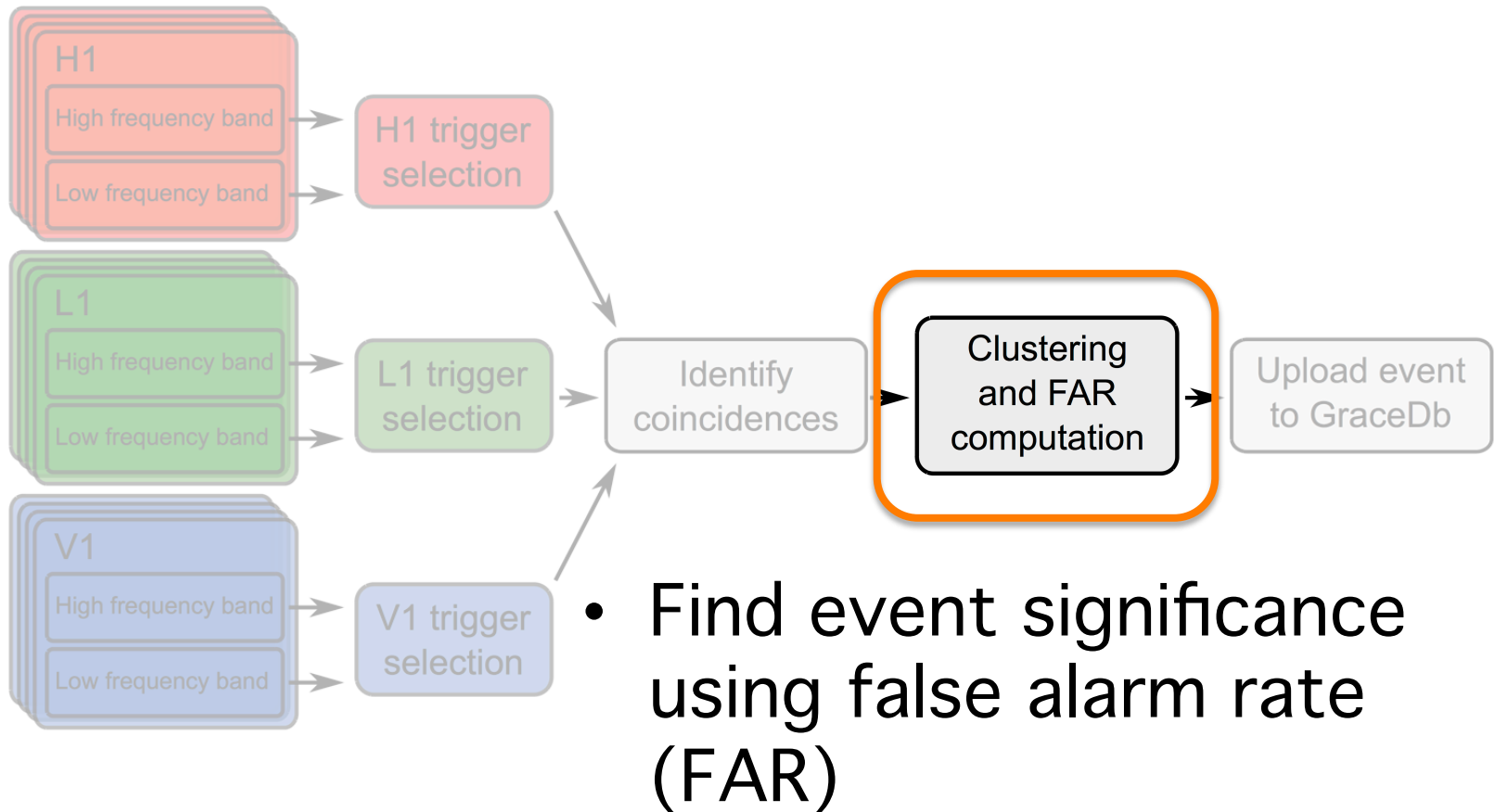
Identify coincidences

- Single detector results combined

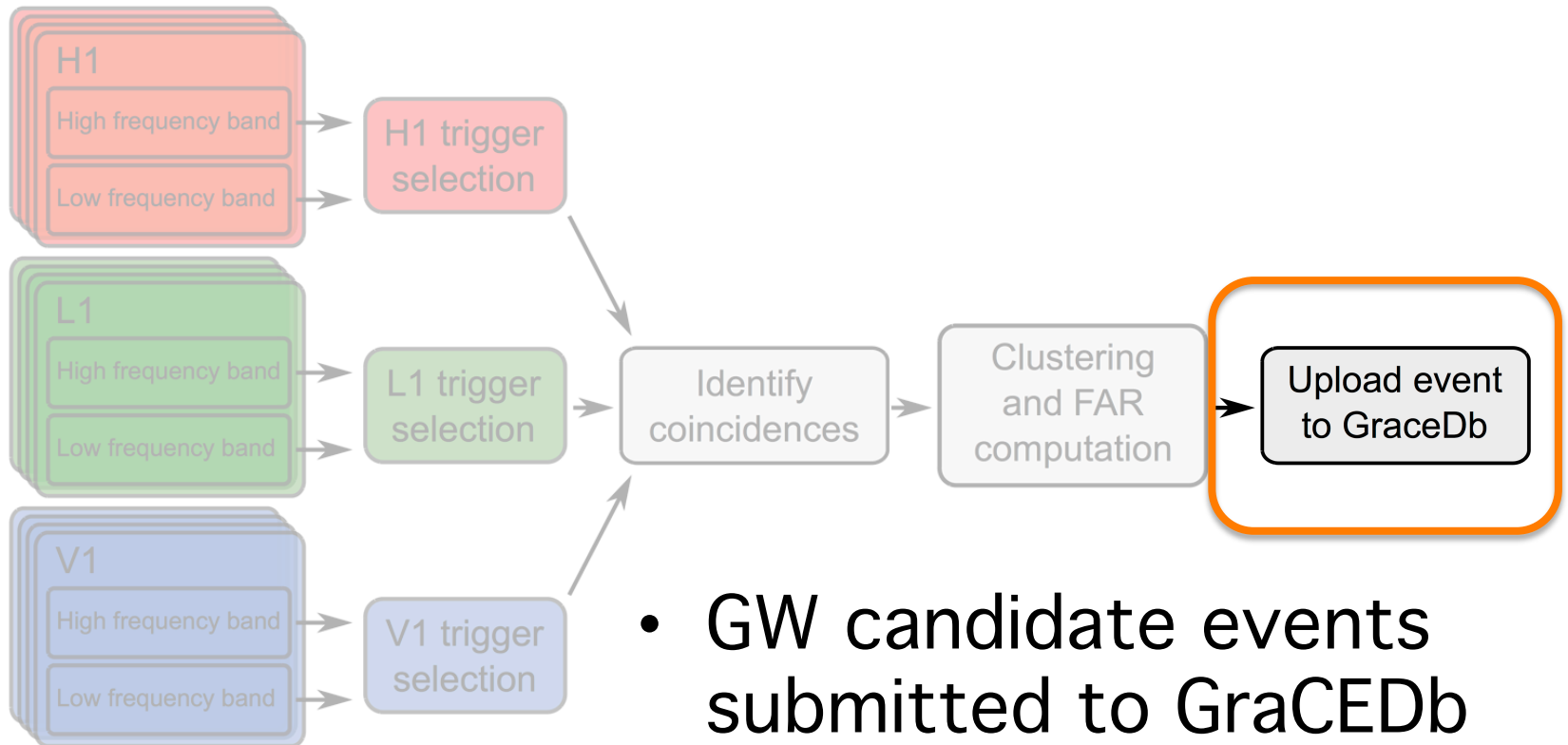


- Coincidence events identified:
 - Timing coincidence between detectors
 - Source parameter consistency between detectors

Event significance

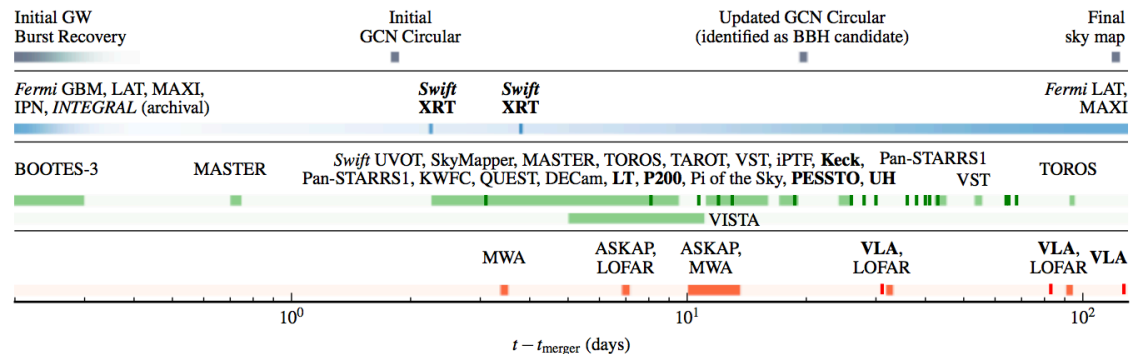
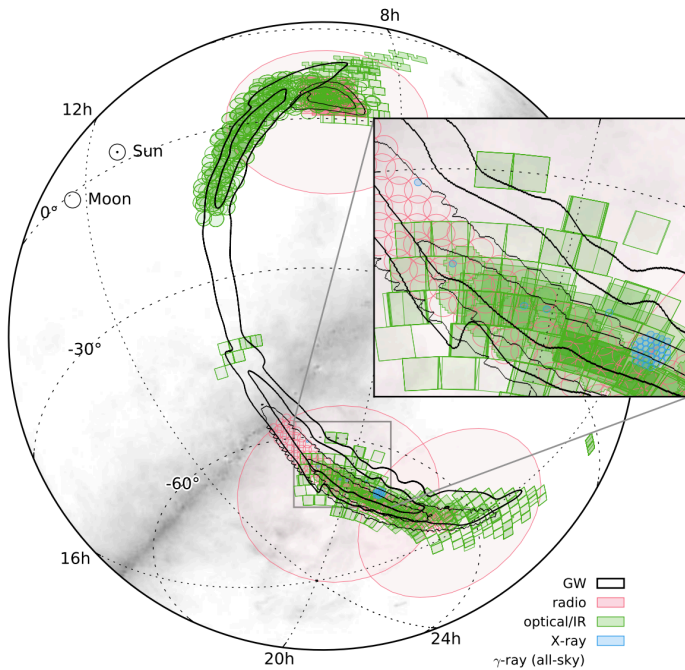


GraCEDb/ Sky Localisation



EM follow up

- GW150914
- Footprints of EM observations
- Observation timeline

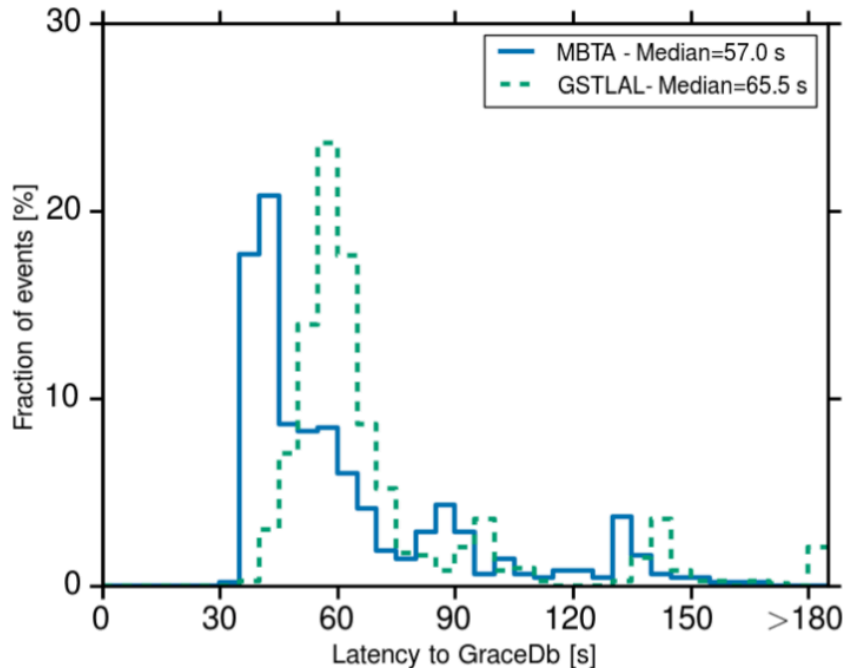


Validation of MBTA localisation

- Before O1, this procedure was tested with MBTA
- Using simulated signals and simulated O1/O2 noise
- Sky localisation performance agrees across low-latency pipelines within a few percent

Adams, T. et al., 2016, *CQG*, 33, 175012

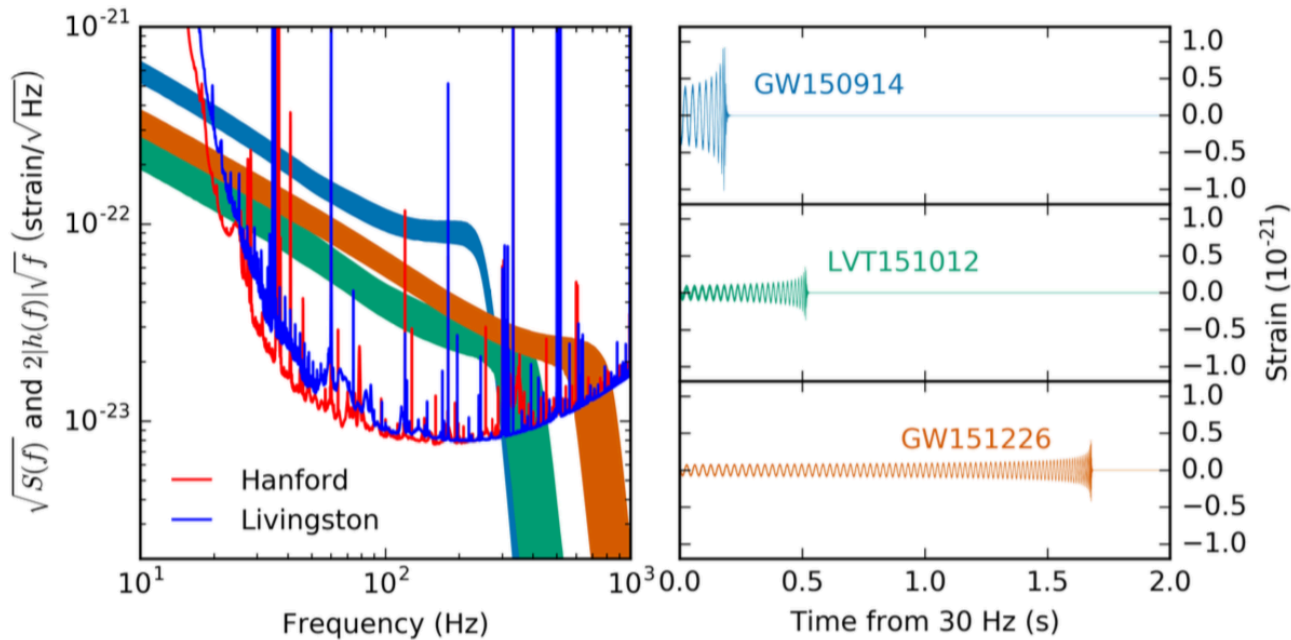
Low-latency analyses in O1



- MBTA 486 events
- 52.2 days available
 - MBTA: 96.6%
 - All pipelines: 99.5%
- GWs outside search space for MBTA

Abbott. B. et al., 2016, arXiv:1607.07456

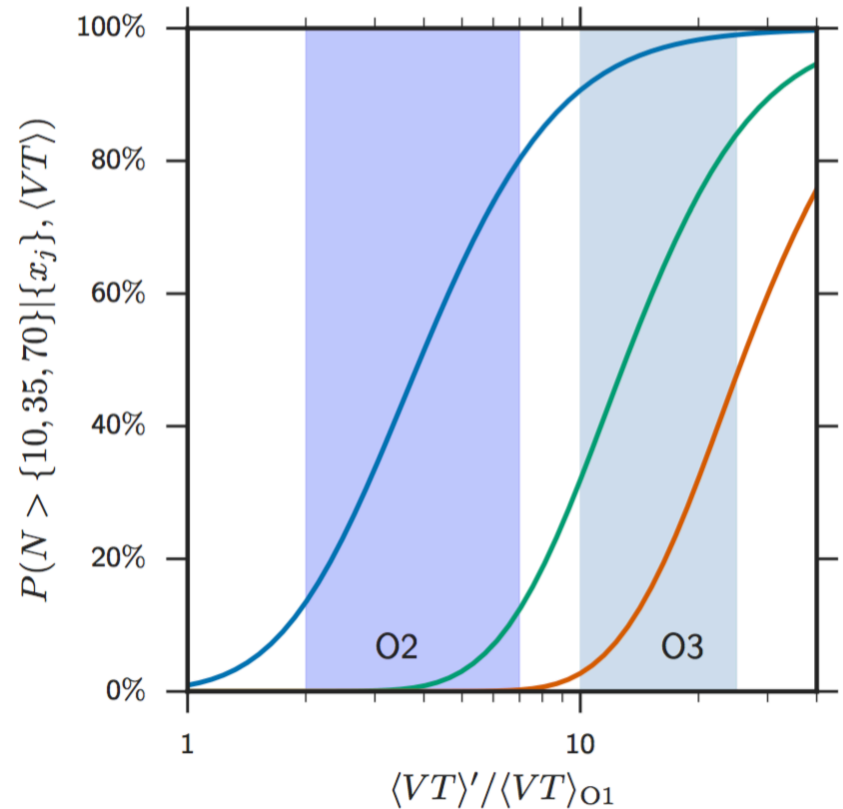
Detections



- GW150914, GW151226 – Confirmed BBH detections
- LVT151012 - 87% probability of being of astrophysical

The future

- O2A has begun
- MBTA running
- Virgo commissioning for O2B
- Prob of $N > 10, > 35, > 70$ BBH events against VT



The future

- Virgo will improve sky localisation for significant events

