Low-latency search for gravitational-wave transients with electromagnetic follow-up

Joshua Smith, Syracuse University
for the LIGO Scientific Collaboration and the Virgo Collaboration

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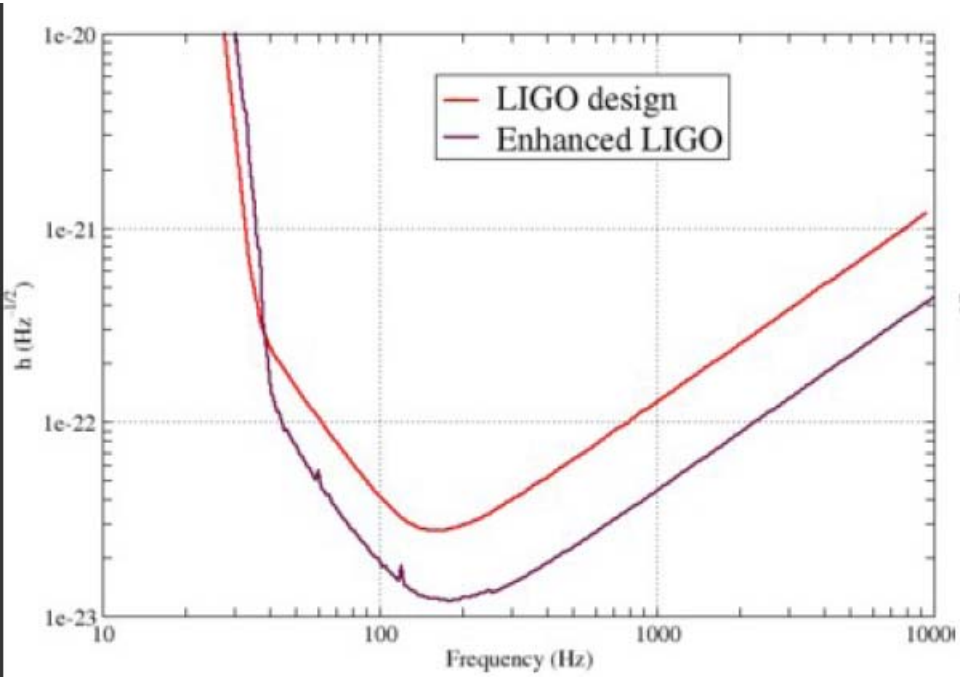
The LIGO/Virgo Burst Search

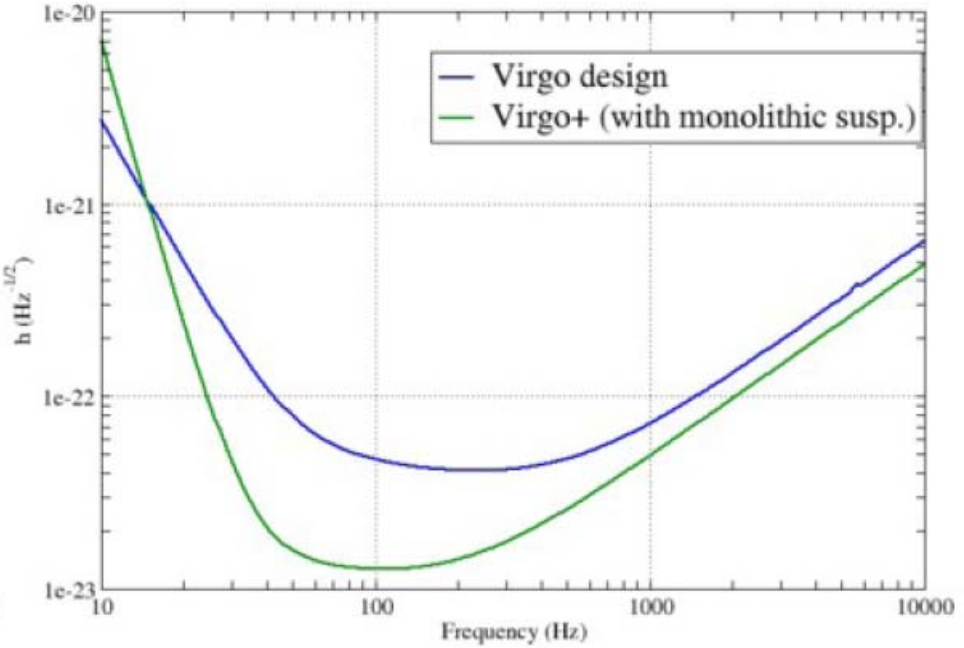
- Burst searches cast a wide net
  - Short <1s transients
  - Including un-modeled / poorly modeled signals
- Search for excess power in time-frequency that is coincident/coherent/consistent between detectors
- Several S5/VSR1 results presented at APS
  - SGRs, Peter Kalmus (earlier session B11)
  - GRBs (estimates only), Isabel Leonor (2:42PM session C5)
  - All-sky low-f search, Michele Zanolin (2:54PM session C5)
  - All-sky high-f search, Brennan Hughey (3:06PM session C5)

Enhanced LIGO and Virgo+

LIGO S6



Virgo VSR2



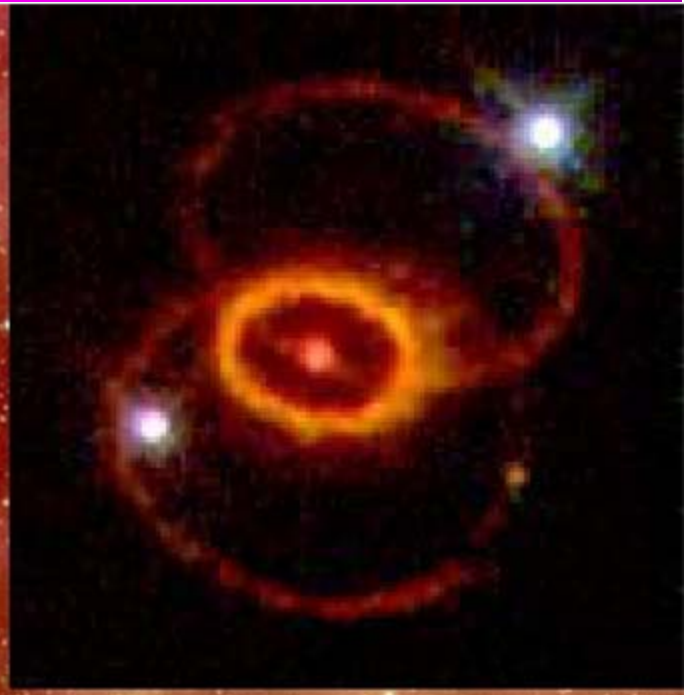
- Target NS/NS inspiral range 15-50 Mpc
- Three-site network Hanford, Livingston, Cascina
- Beginning summer 2009

S6/VSR2 Online Burst Search Goals

- Make LIGO/Virgo network an integral part of the astronomical community
  - Produce candidate events (most/all noise triggers) for follow up at other astronomical observatories
  - Increase speed that we can follow up triggers from other astronomical observatories
  - Lay the foundations of multi-messenger astronomy for the Advanced GW detector era
- Produce candidate GW events with low-latency
- Assist detector characterization efforts
- Reduce work/time needed for offline analysis

Science Motivators

- Many likely gravitational-wave sources also produce electromagnetic radiation and/or high energy particles
- EM relatively easy to detect
- Multi-messenger astronomy can increase our confidence in events, lead to deeper knowledge



SN1987A
ESA, NASA, Hubble Heritage

Science Motivators II

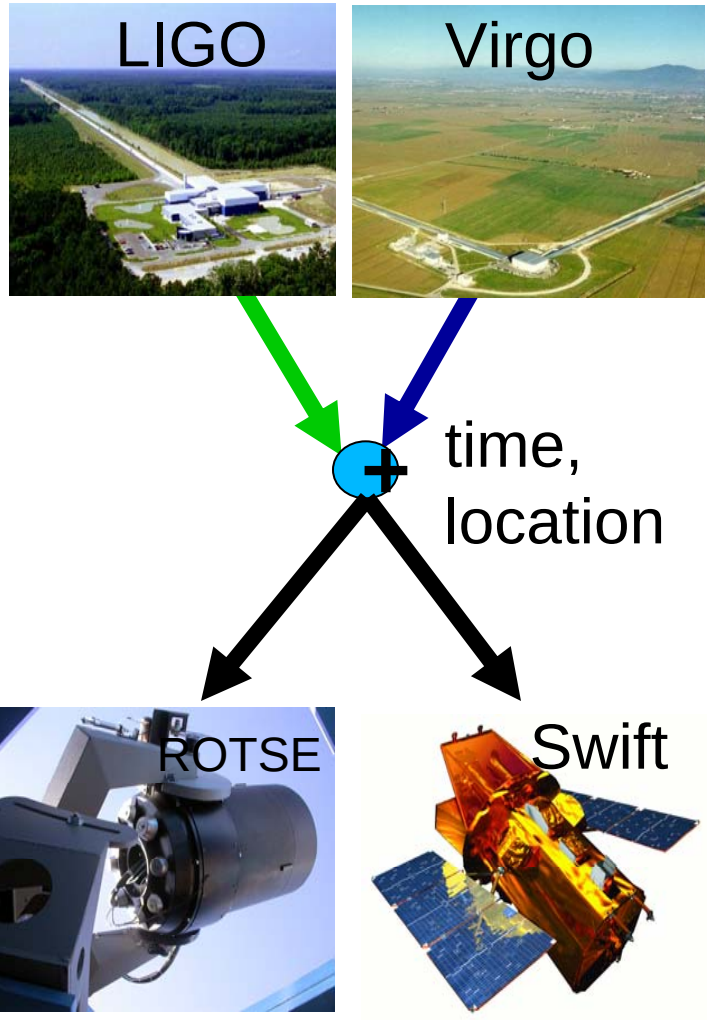
Gravitational waves may be accompanied by other signals:

- Binary inspirals
  - Short GRBs < 1s
  - Neutrinos < 1s
  - Broad EM afterglow
    - Hours to weeks
- SGR starquakes
  - Gamma rays
    - Repeating bursts

- Core-collapse supernovae
  - Neutrinos < 1s
  - Long GRBs < 1s (maybe longer)
  - Broad EM afterglow
    - Hours to weeks
- Other/unknown
  - ???
    - ???

Triggering follow-up observations

- EM observatories: attempt to observe afterglow
  - Wide-field optical telescopes: SkyMapper, ROTSE, TAROT, Quest, etc.
  - Radio: VLA, etc.
  - Xray/softGR: Swift, etc.
- Coordinated in LIGO/Virgo by Looc-up project
  - [Kanner et al. 2008, CQG 25.184034]

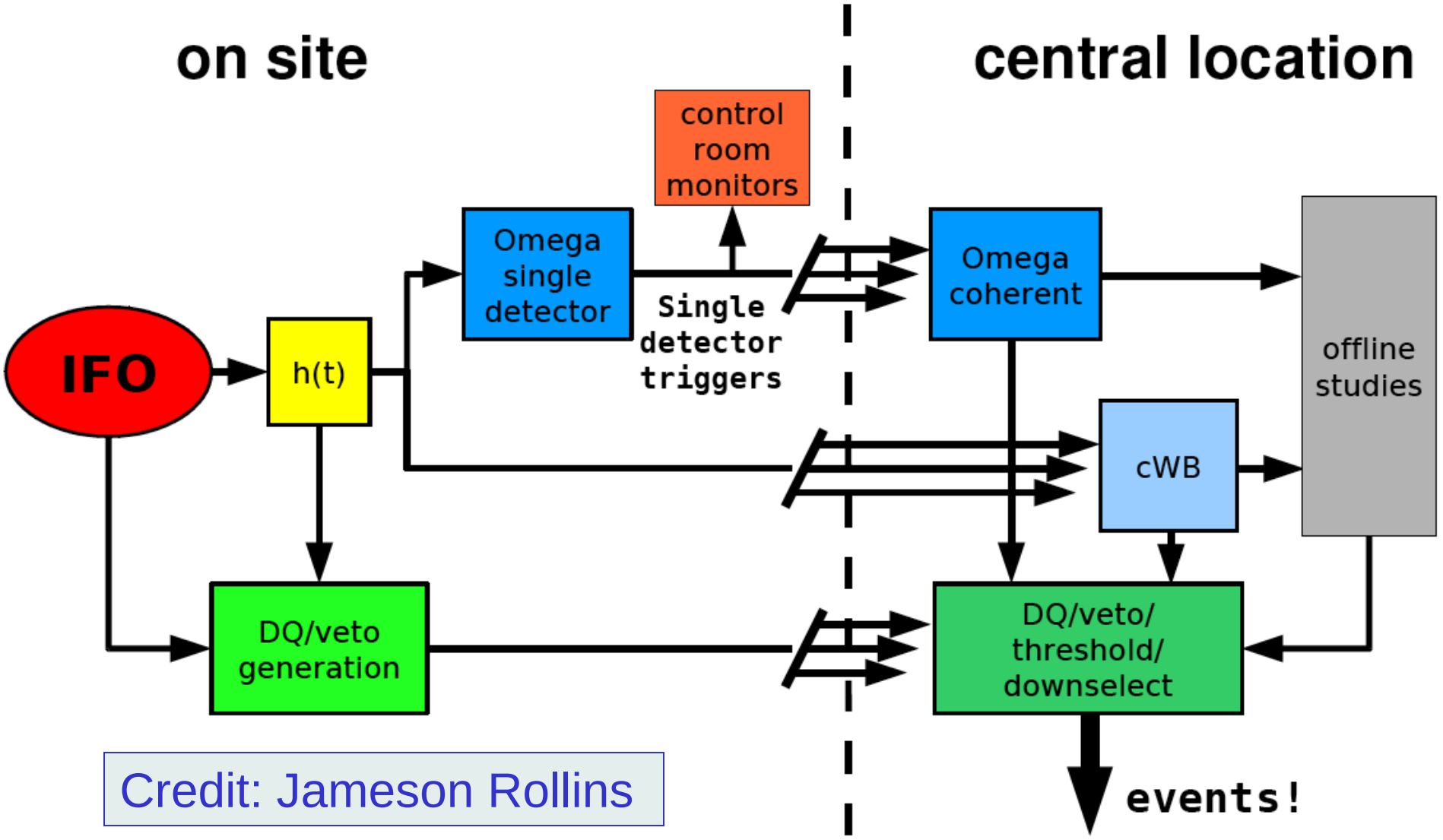


Credit: ROTSE Credit: NASA

The Online Burst Search

- Search Pipelines
  - Omega:
    - Sine-Gaussian wavelet time-frequency decomposition
    - Single detector triggers based on excess power statistic
    - Time/frequency coincidence with coherent network follow up
  - Coherent Wave Burst (cWB):
    - Meyer Wavelet time-frequency decomposition
    - Coherent network triggers
    - Single coherent search statistic: coherent network amplitude
- Position reconstruction:
  - Omega (Bayesian), cWB (maximum likelihood)
  - **Network angular resolution of a few square degrees**
- Latency: Target 10 minutes by end of run
- Online DQ and Vetoes to increase quality of triggers sent

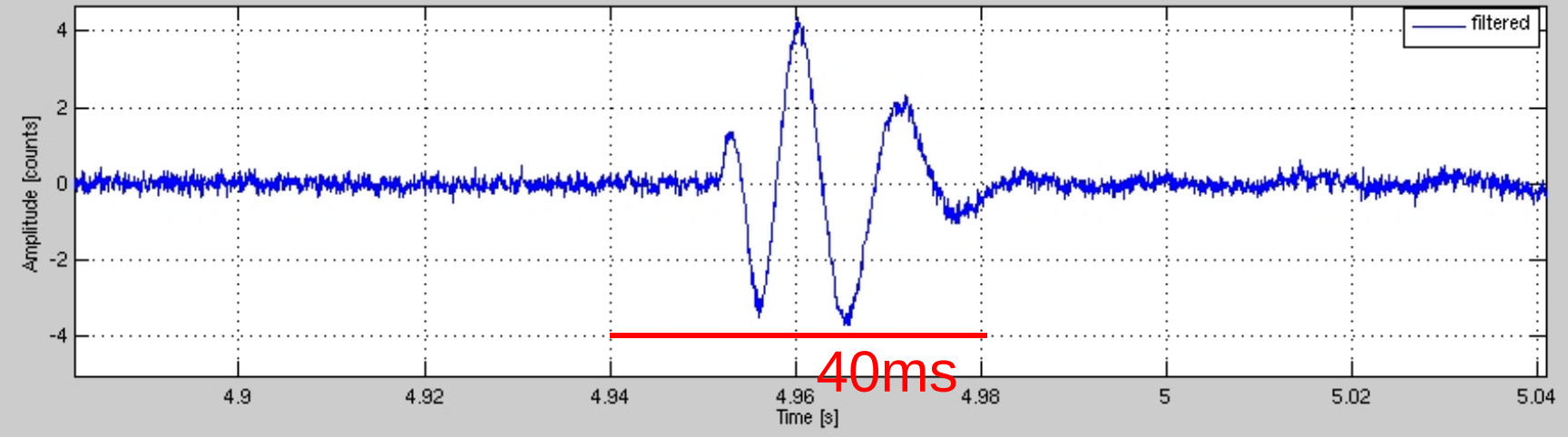
The Online Burst Search



Credit: Jameson Rollins

The End

Glitches



- Non-Gaussian transients (environmental or self-made) reduce significance of events
- **Can prevent us from detecting GWs!**

Reducing the influence of glitches

- Find and remove disturbances/coupling in the detector
- Identify times when the detector was malfunctioning, define data-quality flags to “clean” the data
- Identify event-by-event vetoes that, based on coupling measurements or statistics, flag short intervals (~100ms) as questionable data