

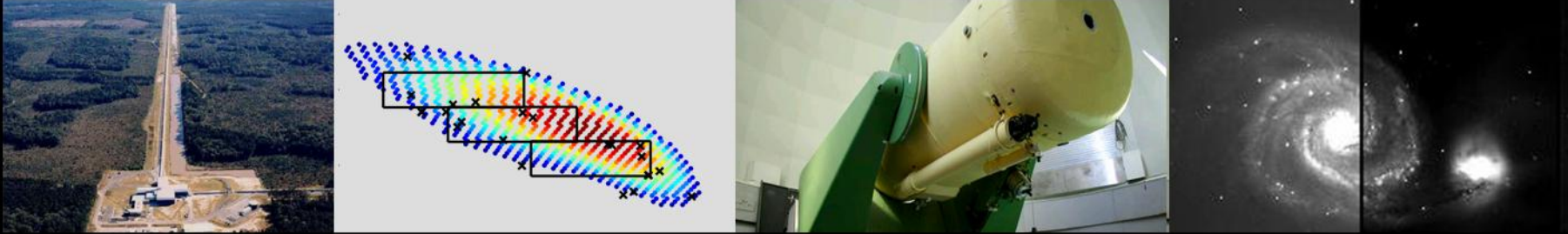
# LOOC UP

Seeking the EM counterparts to  
gravitational wave signal candidates

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for the LIGO Scientific Collaboration and the Virgo Collaboration  
together with the TAROT, QUEST and Pi of the Sky teams



LIGO DCC: G0900951-v4



- Data from 3-site LIGO/Virgo Network
- Real time GW data analysis
- GW data guides EM observation
- Transient search

*Seek significant GW + EM transient coincidence  
Data December 18 to January 8*

# Scientific Motivation

## Gravitational Wave Signal

- Bulk motion dynamics
- Luminosity distance
- Progenitor mass

+

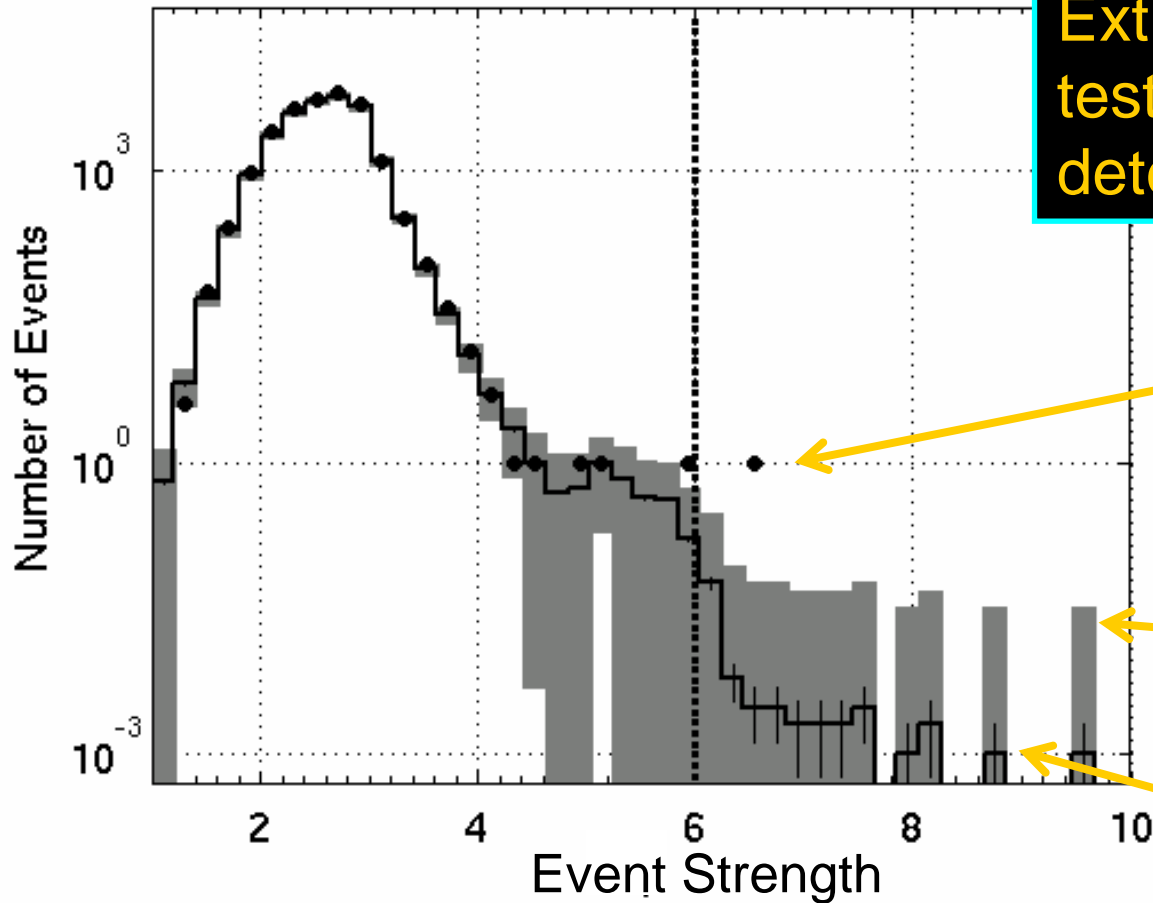
## Light curve and spectrum

- Host galaxy
- Gas environment
- Red shift distance

Multi-messenger  
astro-physics!!

***Enhanced picture of progenitor physics***  
***Map compact object hosts***  
***Probe cosmology (Adv.)***

# Observational Motivation



Extra coincidence test could improve detection confidence.

Simulated "marginal" foreground event

Fluctuations in background rate

Average Background Rate

Example with S5/VSR1 cWB data: arXiv:1002.1036v1

# Real Time Data Analysis



Lag time

Calibrate and transfer data from 3 detector sites

Identify significant 3-site events

Evaluate background

Apply data quality criteria

Reconstruct the sky position

Send alert to human monitors



5 - 10 Minutes

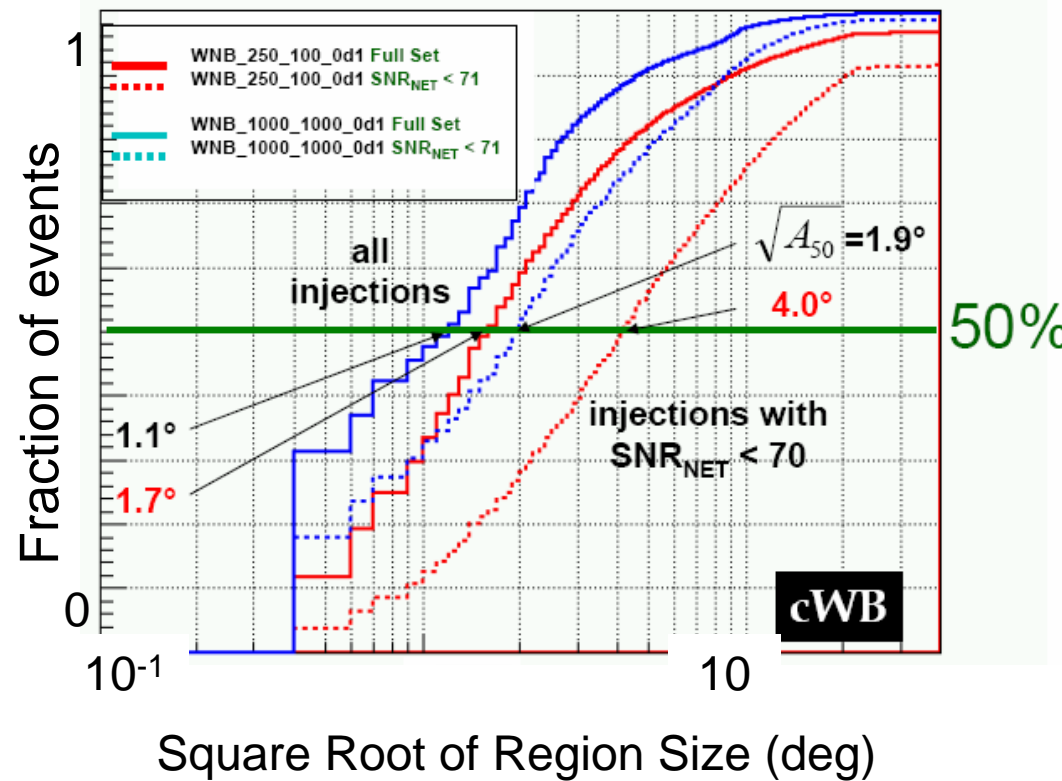
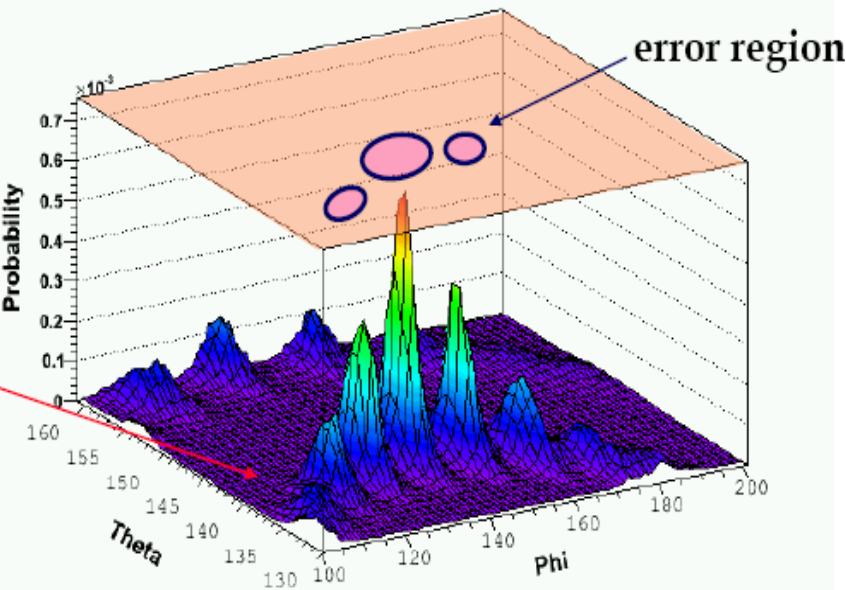
30 - 45 Minutes

Evaluate information and send observing request



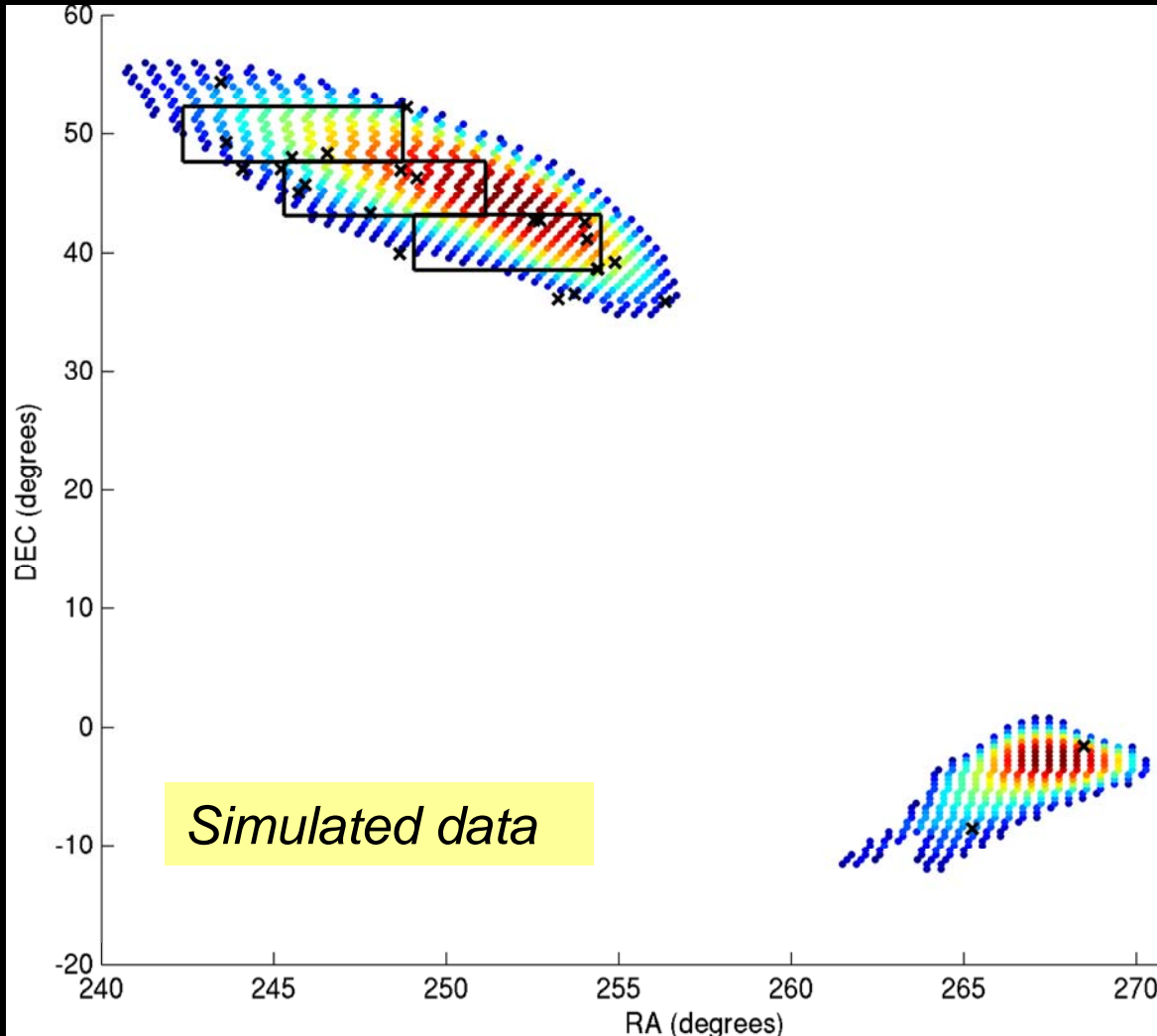
# Position reconstruction of burst sources

- Performance varies significantly with signal-to-noise ratio, morphology, sky position
- 20 - 100 deg<sup>2</sup> near threshold, 1-4 deg<sup>2</sup> for “loud” signals

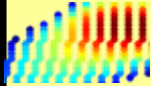



Position error areas hide the fact that they may be broken down to many disjoint patches

# Position Reconstruction



**x** **Known mass source**  
in local universe

 **Regions consistent with GW data**  
may be many disjoint regions

 **Chosen telescope pointing**  
based on mass distribution and GW data

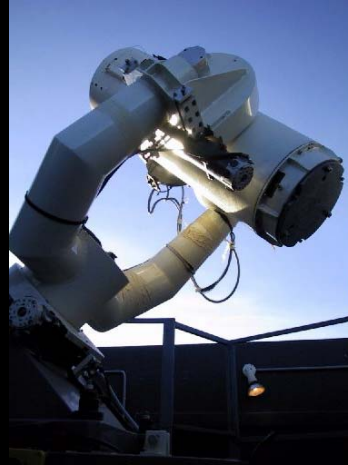


## QUEST camera on ESO Schmidt Telescope



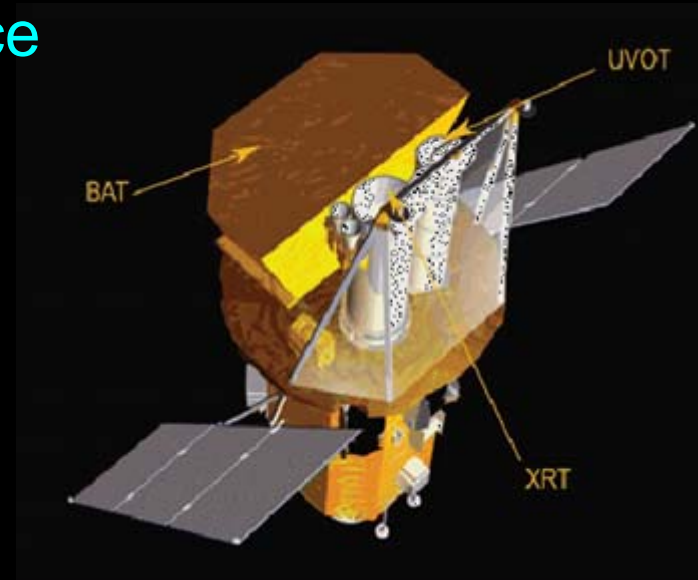
- 4.1 x 4.6 deg FOV
- Survey telescope for supernovas, etc.

## TAROT Chile & France



- 1.85 x 1.85 deg. FOV
- History of GRB follow-ups

## Swift Satellite



- UV/optical telescope: 0.4x0.4 sq. deg. FOV
- X-ray telescope: 0.3x0.3 sq. deg. FOV



# Run Statistics

- December 18 through January 8
- Observing requests sent in about 30 minutes
- Sent alerts to all telescopes in network (collected data with QUEST, TAROT, and Swift)
- Searching data for transients associated with candidate GW events (in progress)
- 1<sup>st</sup> attempt at systematic, EM follow-ups of GW event candidates

# Summary

- Seeking EM counterparts to GW events can increase search sensitivity and maximize physical knowledge for an event
- Completed “winter run”, hope to add additional telescopes to network for summer run
- The first LIGO/Virgo, EM follow-ups are paving the way for the advanced detector era, when detections are expected.

# Image Credits

- Computer clip art:  
[http://openclipart.org/people/kattekrab/kattekrab\\_computer\\_workstation.png](http://openclipart.org/people/kattekrab/kattekrab_computer_workstation.png)
- ESO Schmidt telescope image:  
[http://hepwww.physics.yale.edu/lasillaquest/ESO\\_telescope.html](http://hepwww.physics.yale.edu/lasillaquest/ESO_telescope.html)
- TAROT image from the TAROT collaboration
- Swift image from NASA