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# Status and Plans for the LIGO-TAMA Joint Data Analysis

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# Joint Working Group

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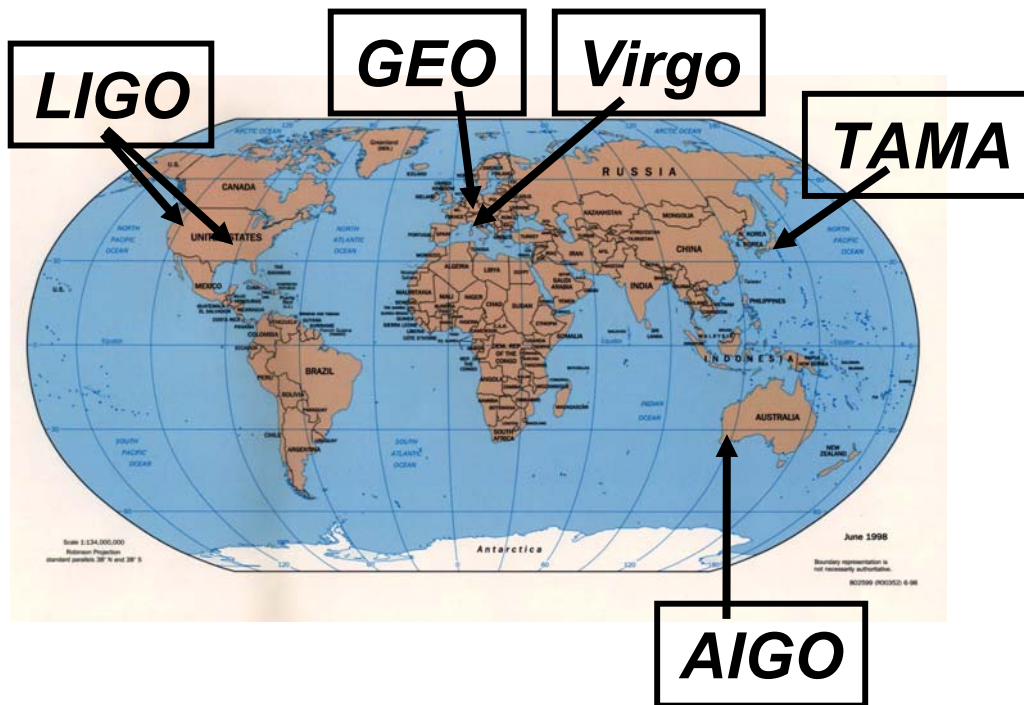
# Outline

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- Multi-detector searches
- LIGO-TAMA analysis: goals and plans
- Challenges of LIGO-TAMA analysis
- Current Status and Outlook

# Multiple-Detector Searches

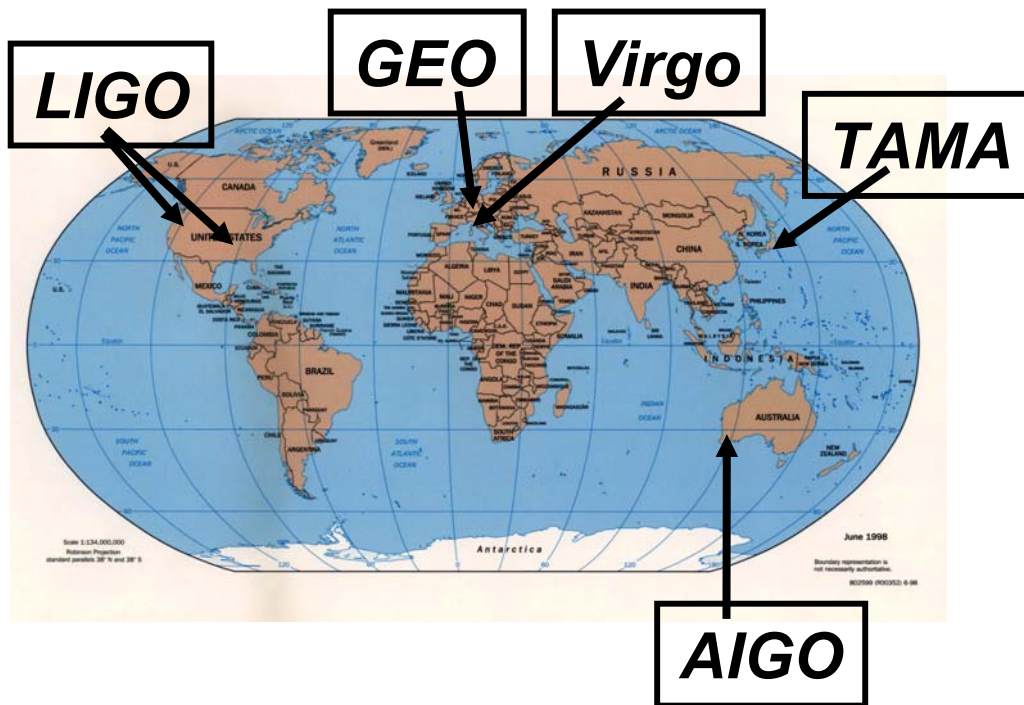
- Most confident detection and maximum exploitation of gravitational waves will require cooperative analyses by the various observatories:



- » Decreased background.
- » Better statistics on signal parameters.
- » Better frequency coverage.
- » Better sky coverage.
- » Better sky location, polarization information.
- » Independent hardware, software, and algorithms minimize chances of error.

# Multiple-Detector Searches

- Unfortunately, these benefits don't come without hard work. Physical and technical challenges abound.

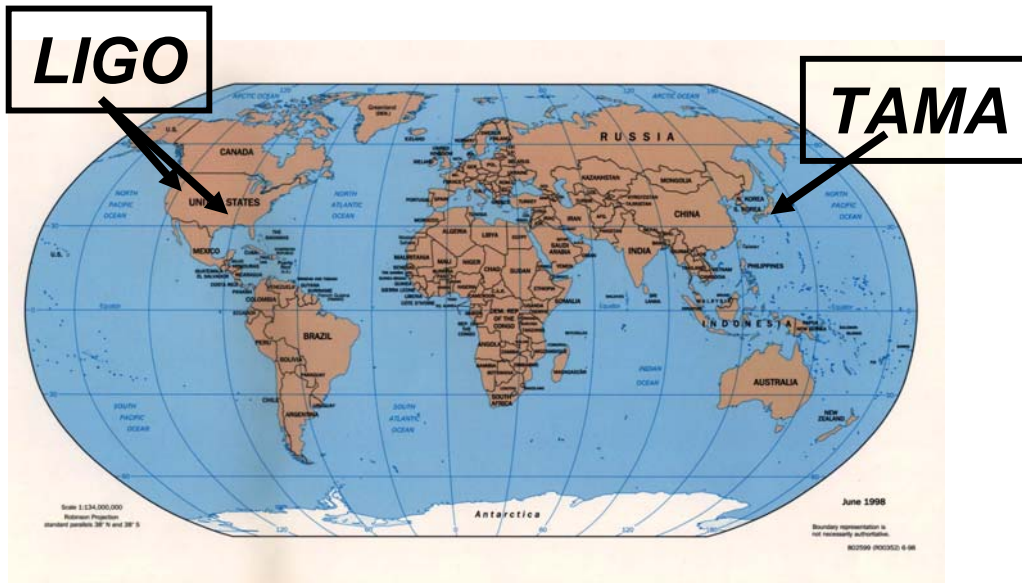


Detectors see:

- » ... different frequency bands.
- » ... different parts of the sky.
- » ... different polarization combinations.
- » Different search algorithms, file formats, sampling frequencies, etc.

# Multiple-Detector Searches

- This talk: Examine some of these challenges for a bursts analysis of LIGO and TAMA data.



# LIGO-TAMA Joint Analyses

- MOU for joint analysis of TAMA DT8 / LIGO S2 data (February-April 2003) signed at GWDAAW 7.
- Search for GW transients:
  - » GRB-triggered search for unmodelled bursts (Marka)
    - First analyse GRB 030329, then other GRBs from S2/DT8.
  - » Inspirals (under discussion)
  - » **Untriggered search for unmodelled bursts (this talk)**

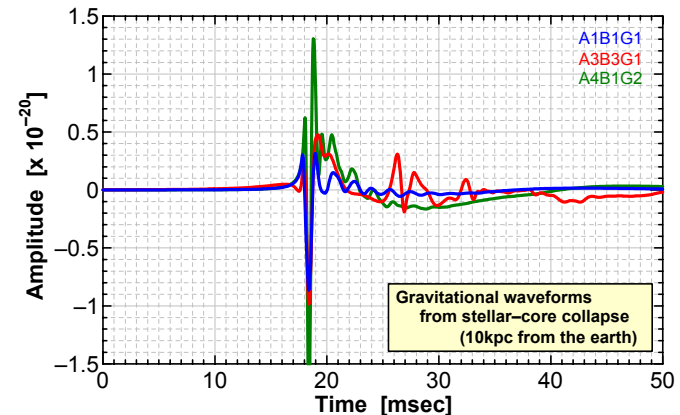
# Untriggered Bursts Analysis

## Targets:

- » “Eyes wide open” search – minimal assumptions about GW signal (no templates!).
- » GWBs of duration 1-100ms, frequency 300-3000Hz.
- » Maintain sensitivity to astrophysical waveforms (eg, supernovae).

## Goals:

- » Detections (?)
- » Upper limit on number of detected GWBs.
- » Upper limit on rate-vs-strength for selected signal and population models.





# Analysis Procedure

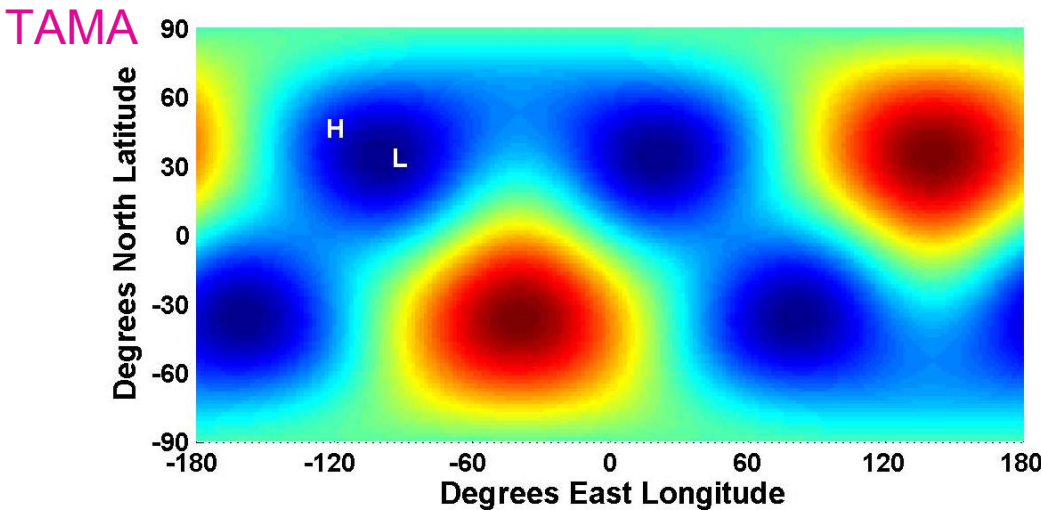
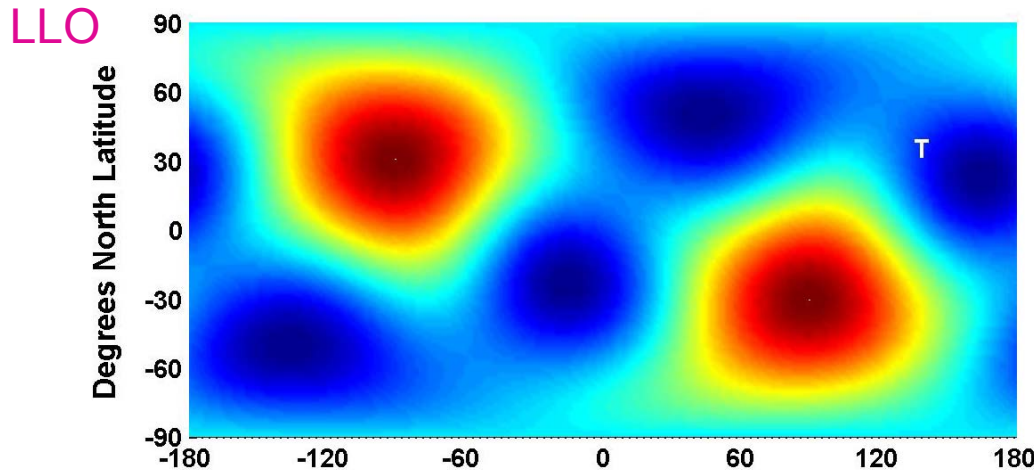
- **Single-IFO Event Generation:**
  - » ETGs: Excess Power, TFClusters, BlockNormal for LIGO, Excess Power for TAMA (talks by Brady/Ray Majumder, Sylvestre, McNabb, Ando)
  - » Tune for maximum efficiencies at fixed false rate in each IFO.
  - » Veto on data quality and “glitches” in auxiliary channels.
- **Efficiencies:**
  - » Measure for ad-hoc and astrophysical waveforms using Monte Carlo with coordinated signal injections.
- **4 x Coincidence & Coherence:**
  - » Temporal coincidence in all 4 IFOs.
  - » Coherent r-statistic test (talk by Cadonati).
  - » Frequency, amplitude comparisons (unlikely for LIGO-TAMA).
- **Background Estimation:**
  - » Use time shifts.
- **Statistics:**
  - » Upper limits – number of detected events, rate versus strength.
  - » Detections -- requires criteria for establishing confidence!

# Challenges for LIGO-TAMA

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- Strongly non-aligned detectors
- Different noise curves
- Different ETGs

# Antenna Patterns

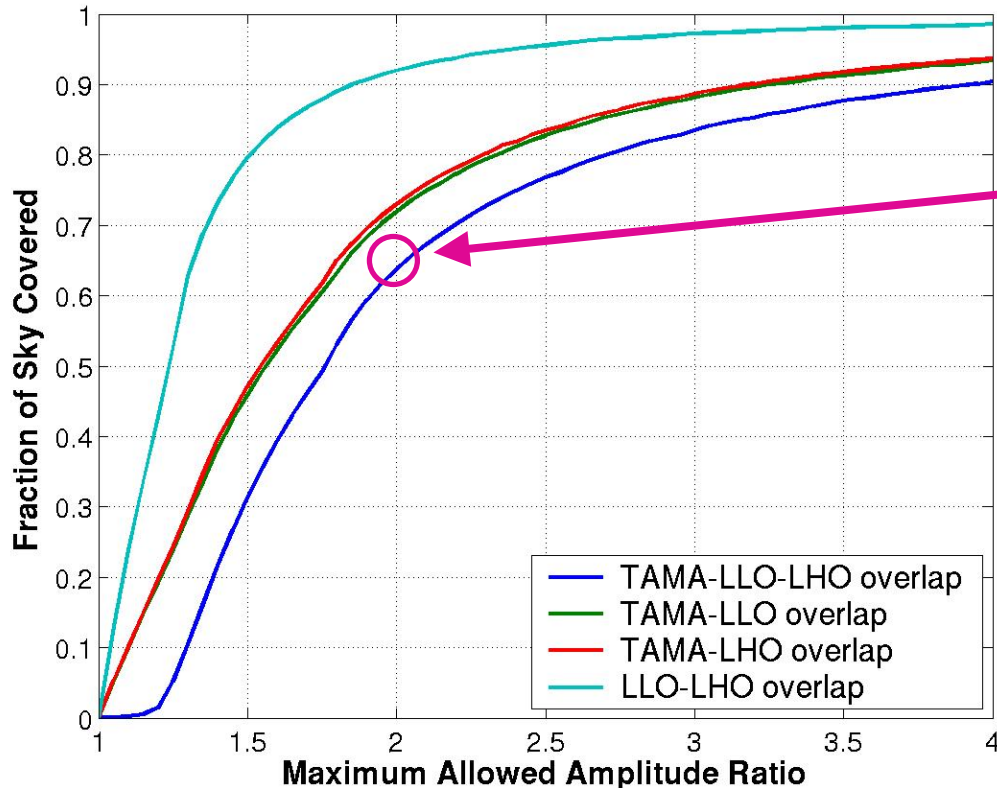


LIGO and TAMA look with best sensitivity at different parts of the sky:

- » Lower efficiency for coincident detection → limited by **minimum** of antenna responses.
- » Position- and polarization-dependent response makes amplitude comparisons difficult.
- » Polarization dependence could weaken r-statistic test.
- » **Requires extensive coordinated Monte Carlo simulations with various polarizations.**

(This plot: Equal power in uncorrelated polarizations)

# Cumulative Overlap on Sky



## LLO-LHO-TAMA:

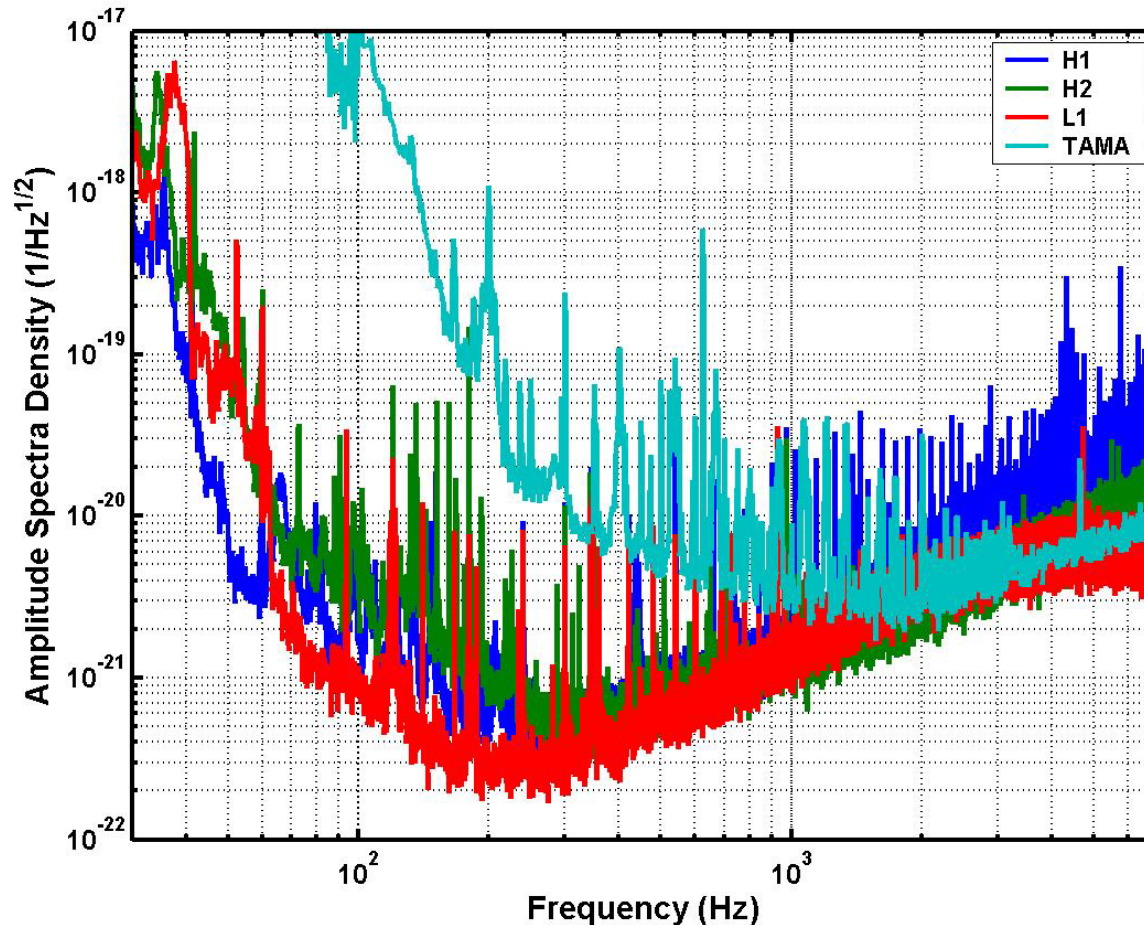
- » Strain response same within factor of 2 for  $\sim 2/3$  of sky.
- » Could limit efficiencies.

## Difficult to compensate for:

- » ETG timing resolution of order 10-100ms – no direction information.
- » No polarization information.

(This plot: Equal power in uncorrelated polarizations)

# Sample S2/DT8 Spectra



LIGO and TAMA look with best sensitivity at different frequencies:

- Tune for signals near minimum of envelope, [300-3000]Hz.
- Frequency, amplitude comparisons difficult.
- May weaken coherent test.
- Requires extensive coordinated Monte Carlo simulations (broad- and narrow-band).

# Simulations

- **Waveform catalogs:** Gaussians, sine-Gaussians, sine-cosine-Gaussians, supernovae (Zwerg et al, Dimmelmeier et al, ...)
  - » narrow and broad-band signals
  - » linear polarization and ~circular polarization
  - » ad-hoc and astrophysically motivated
- **Use:** Generate sets of simulated GWBs, including sky position and polarization, for coherent addition to data streams.
  - » Includes effects of time delay, antenna response, signal polarization.
  - » Determine coincidence windows and feasibility of amplitude and frequency comparisons.
  - » Determine detection efficiencies.

# Analysis Status

- Single-IFO Event Generation:
  - » Tune for maximum efficiencies at fixed false rate in each IFO (preliminary tuning done – Ando, Brady/Ray-Majumder, McNabb, Sylvestre).
  - » Veto on data quality and “glitches” in auxiliary channels (preliminary selections done).
- Efficiencies:
  - » Measure for ad-hoc and astrophysical waveforms using Monte Carlo with coordinated signal injections (underway).
- 4 x Coincidence & Coherence:
  - » Temporal coincidence and r-statistic (underway - Cadonati).
  - » Frequency, amplitude/energy comparisons (?).
- Background Estimation:
  - » Use time shifts.
- Statistics:
  - » Upper limits/Detection.

# Summary

- TAMA and LIGO are conducting joint analyses of the S2/DT8 data:
  - » GRB-triggered searches (GRB 030329 and others)
  - » Untriggered bursts search
  - » Possible joint inspiral analysis
- Challenges for untriggered bursts search:
  - » non-aligned IFOs
  - » different response functions
  - » different ETGs
  - » Response: Rely heavily on coordinated simulations and (hopefully) coherent test.
- Status:
  - » Currently tuning ETGs and coincidence procedure.
  - » Target date for completion: May.