

Burst Group: Overview

The goal of this group is to develop an analysis that searches for, or sets limits on the character of, unanticipated or unmodeled burst sources of gravitational radiation. The first step in that process is to define the search and develop a plan for its execution. That includes learning about those resources that are available to us, as well as those we need to develop. The definition of the search and the plan for carrying it out will form the basis for our formal analysis proposal to the LSC. Once the analysis is defined we will begin the actual work of putting the analysis together.

At the first meeting (a teleconference) we will discuss the goals of the search and one plan for how we might carry it out. A date will be set for comments and additions, following which a draft proposal and draft task list will be circulated

At the second meeting (a teleconference) we will discuss the draft proposal and task list. Following this meeting a date will be set for written comments, which will be incorporated into a final draft of the proposal and an amended task list and work plan. These will, in turn, be circulated. Final comments on the draft proposal will be solicited, via e-mail, and the proposal will be submitted to the LSC Spokesperson.

At the third meeting, which will take place at the GWDAW, we will discuss the work plan and people will have the opportunity to volunteer for tasks. At the same time we will set a regular schedule for future teleconferences to monitor progress toward our goals.

Meeting 1: Agenda

- 1) Overview
 - a) GWDAW (LSU), 14-16 December 2000
 - b) Aspen Workshop, 4-10 February 2001
 - c) LSC Meeting (LLO), 14-17 March 2001
 - d) Engineering Data Run (LHO/LLO), late spring/summer 2001
- 2) Search Goals
- 3) Analysis Proposal Components
- 4) Analysis Plan (see below for notes and discussion)
 - a) Producing "Level 3" data set: e.g., regressions, calibrations, vetos, etc.
 - b) Statistical Characterization: e.g., (non)Gaussianity, stationarity, inter-detector cross-correlations, etc.
 - c) Burst search
 - d) Post-search interpretation
 - e) Resources: DMT, LDAS, etc.
- 5) Action Items
 - a) Date for other comments, additions
 - b) Date for draft proposal
 - c) Date for next meeting
- 6) Other business:
 - a) Burst group meeting coincident with GWDAW
 - b) Burst group meeting at Aspen?

Draft plan for doing a search for bursts

The analysis will begin with a data set consisting of

- A time series “ $h(t)$ ” from each of two interferometers, with known instrumental or environmental artifacts removed or at least noted.
- Transfer functions and calibrations that relate each h to the projection of the gravitational wave on the detector (i.e., h may be – is, in fact, preferred to be – whitened). We assume that t is with respect to the moment when the wavefront is incident on the beamsplitter.
- A set of other time series that serve as diagnostic channels. A generic “quality channel”, indicating which intervals of t give valid or invalid data, may be derived from such information.

The search for bursts will involve two parallel tracks of work:

- A search for candidate signals by study of the $h(t)$ series, both in isolation and in concert (i.e., through the search for coincident events as well as through the analysis of the cross-correlation of the two h)
- A search for reasons not to believe candidate signals. Some of these reasons will come from study of each $h(t)$ series, some from coincidence analysis, and some from study of the diagnostic channels.

Events that survive the first set of cuts will be examined more carefully: i.e., there will be a broader search for instrumental causes for excursions.

The outcome of the search will be four lists, which may be empty:

- A list of events, not coincident in the two detectors, together with their discovered instrumental or environmental origin;
- A list of events, coincident in the two detectors, together with their discovered instrumental or environmental origin;
- A list of events, not coincident in the two detectors, for which no discovered instrumental or environmental explanation has been found.
- A list of events, coincident in the two detectors, for which no discovered instrumental or environmental explanation has been found.

The first two lists are useful for improving the detector performance. The final two lists, empty or no, will be interpreted:

- Events not coincident in the two detectors will be considered from the perspective of signal amplitude: is the amplitude for a burst of this character such that there is a reasonable probability that there might have been a coincident signal in the other detector that was missed by the analysis?
- The list of events coincident, but with no identifiable instrumental or environmental origin, will also be interpreted:
 - If empty, the lack of events will be interpreted in terms of
 - an upper limit on the rate density of a hypothetical gravitational wave standard candle; and
 - an upper limit on source strength in different wavebands.
 - If non-empty,
 - The events will be correlated with other events of astronomical origin (e.g., gamma-ray bursts, etc.);
 - The events will be correlated with other on-air detectors of comparable or better sensitivity and reliability in the relevant bandwidth;

- The events will be interpreted in terms of “cherished beliefs”: expectations based on broad and accepted principles of astrophysics. The final disposition of these events will depend on how they relate to these preconceptions and further analysis.

Diagnostics

Diagnostics on each interferometer will include

- servo loop signals
- PEM channels
- suspension signals (?)

(This list plus $h(t)$ constitutes a reduced (light-weight?) data set.)

Analysis

- Characterization of the data
 - Statistical properties: stationarity, (non)Gaussianity,
 - Search for anomalies in the diagnostic channels and their cross-correlations (identifying epochs of detector misbehavior, which may later be correlated with candidate “signals”) to provide global “quality” channel.
- Search for candidate signals by study of the $h(t)$ series
- Search for reasons not to believe candidate signals

There are several different ways of analyzing the data stream to identify events. We will term all these methods “filters”. Each filter will involve one or more thresholds. (Filters, in this context, should not be construed to necessarily mean “templates”: a filter may be as simple as searching for greater than expected power in a sub-band over some time interval. Perhaps pipeline is a better term.)

- The setting of filter thresholds and their interpretation requires Monte Carlo studies of their false alarm and detection efficiency, based upon the statistical characterization of the data.
- Efficiency will be measured relative to a set of hypothetical “standard candles”

Checks of the coincidence statistics will include

- Study of the cross-correlation between $h(t)$ time series with large t . This is used to determine the statistics of chance coincidences, and thus to set reasonable event thresholds.
- Study of cross-correlation between PEM signals at the two sites. This is used to look for non-gravitational sources of spurious coincidences.

Candidate burst signals are events that are

- coincident in the two interferometers,
- with amplitude that makes a coincidence very unlikely (tolerance?)
- not coincident with disturbances in PEM signals or other diagnostic channels that offer a plausible alternative explanation for excursions in the $h(t)$ channel (what degree of plausibility?)

Any events that survive this set of cuts on a first pass need to be examined more carefully, especially in terms of a broader search for instrumental causes for excursions.

Task List

Generic tasks, necessary for all searches:

- Record calibrated gravitational wave data.
- Generate list of obvious anomalies, unlocked intervals, etc.

Tasks necessary to generate list of burst candidates:

- Develop and implement statistical tests of filtered time series (stationarity, Gaussianity, etc.)
- Develop and implement analysis filters (production and quick-look versions?).
- Determine threshold-setting criterion.
- Develop and implement coincidence identification techniques, including cross-correlation and event list comparison procedures

Tasks necessary to find ways to reject burst candidates:

- Generate list of most-wanted diagnostic channels.
- Establish tests of diagnostic channels (in addition to application of search templates.)
- Gather knowledge of transfer functions between diagnostic channels and $h(t)$.

Tasks necessary to characterize results of search:

- Monte Carlo model of search
- Establish best method for reporting results

Tasks necessary to link results with other data

- Determine procedure for comparison with other gravitational wave data
- Determine procedure for comparison with other astrophysical data.

Proposal Outline

- A. Character of proposed activity
- B. Scientific and technical rationale
- C. Technical approach
- D. Deliverables (software, reduced data sets or databases, detector or data characterizations, publications, documentation)
- E. Required resources (computer time, software, data, travel and site support, LSC and Lab FTEs)
- F. Work plan (schedule with milestones, management plan)