Search for Gravitational Wave Bursts from Supernovae with Matched Filtering Technique

James E. Brau, Masahiro Ito
University of Oregon

Daniel Sigg,
LIGO Hanford

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Proposal

Using the matched filtering technique and currently available gravitational burst event waveforms such as Newtionian (Zwerger-Müller) and Relativistic core collapse waveforms (DFM)[1,2,3], We plan to search for the gravitational wave burst event from supernovae and look for the upper limit.

1. Waveform Templates

Zwerger-Müller and DFM waveforms are currently available waveforms for the gravitational wave burst caused by massive star collapse. With these simulated waveforms, a set of waveform templates has to be built to cover the sensitive frequency band of laser interferometers as much as possible.

2. Matched Filtering Search Code

The inspiral group is using a matched filtering code for their search, so one possibility is to modify their code and run it on LDAS. Otherwise, a new code needs to be prepared. A trigger of the search code should include the event time window, signal to noise ratio and type of the waveform.

3. Search Pipeline

The data processing pipeline [Figure 1] will be started with running the search code on the gravitational wave channel of the most sensitive interferometer.

We can set the event threshold from the distance to the possible burst sources and sensitivity of the interferometers. Another option is finding the threshold based on statistical distribution of the event amplitude by running the search code on playground data. Next, the search code is run on other less sensitive interferometers with a wider time window around the time window of triggers from the previous step considering the time delay between interferometers. If a possible coincident event is found, the arrival time and event amplitudes are tested to confirm the consistency of the event. It is envisioned to apply a consistency check to make sure that a template has fired on the correct event type. After the consistency test, the time window is narrowed down to the resolution provided by the event and the time difference between different detectors.

4. Veto

The standard vetoing procedure [4] of the burst group, such as epoch veto and coincidental glitches to the gravitational wave channel in auxiliary IFO and environmental channels detected by DMT monitors, will also be applied to the event candidates to eliminate events of terrestrial origin at the end of the pipeline.

5. Sensitivity and Background Event

Background event rate will be obtained by a time shift analysis and the result will be fed back to choose the event threshold.

The probability of the detection of the supernovae event will be estimated by the Monte Carlo simulation of supernovae events from random locations in various amplitudes. In a further step, the antenna pattern and sensitivity of the LIGO interferometers and location of clusters can be taken into account for setting up the simulation.

Reference

1. Zwerger, T. and Müller, E., “Dynamics and gravitational wave signature of axisymmetric rotational core collapse”, Astron. Astrophys., 320, 209-227 (1997)

2. Dimmelmeier, H., Font, J.A., and Müller, E., "Relativistic simulations of rotational core collapse. II. Collapse dynamics and gravitational radiation", Astron. Astrophys., 393, 523-542 (2002); astro-ph/0204289.

3. Simulated gravitational wave signal data is available at the URL http://www.mpa-garching.mpg.de/Hydro/hydro.html

4. Burst Group, “Burst Group Report on the Search for Gravitational Wave Bursts of Unknown Origin, Using S1 Data from the Three LIGO Interferometers”, (2002); T020187-02-Z

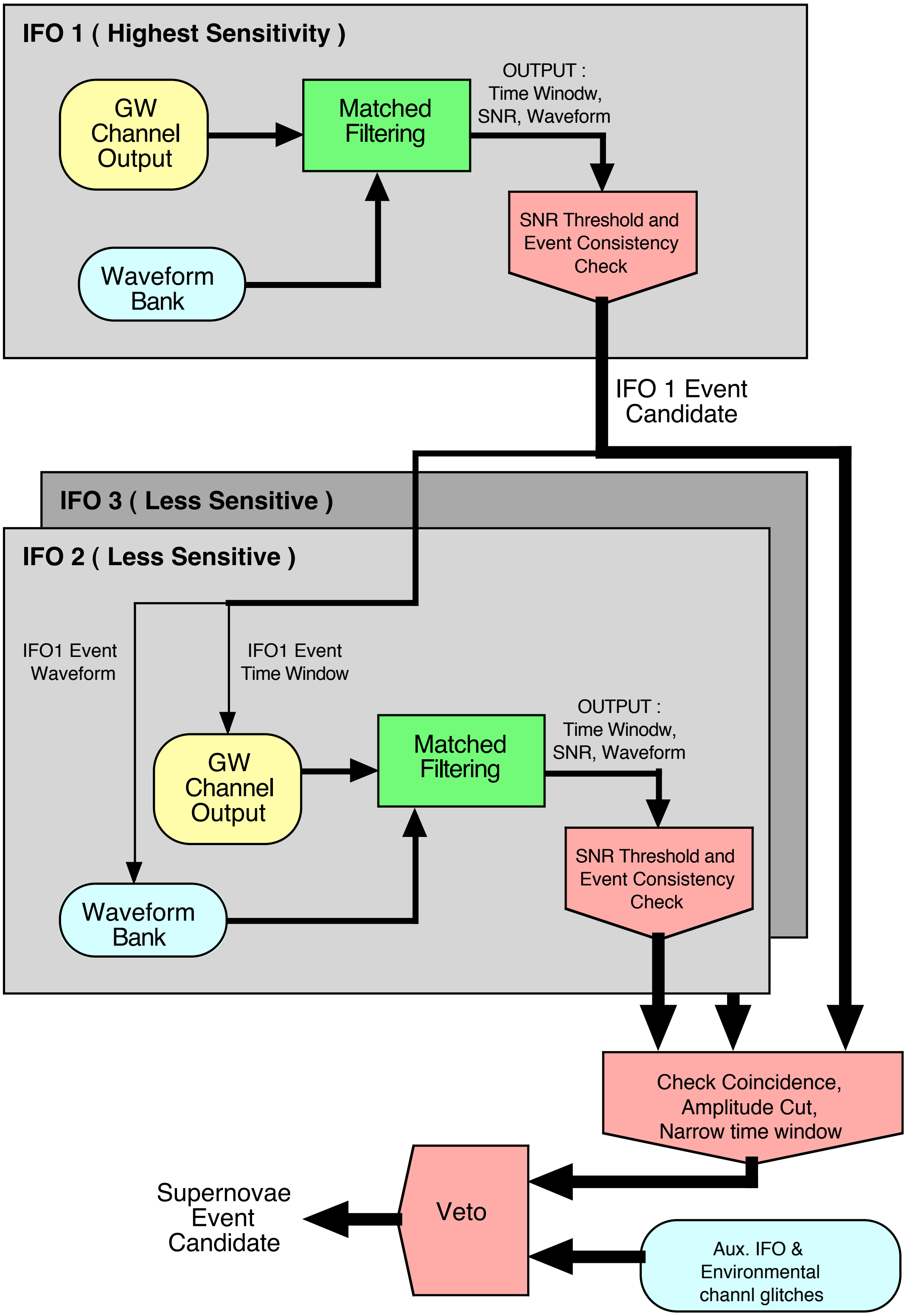
IFO 1 (Highest Sensitivity)
GW Channel Output
Matched Filtering
OUTPUT : Time Winodw, SNR, Waveform
Waveform Bank
SNR Threshold and Event Consistency Check
IFO 1 Event Candidate
IFO 3 (Less Sensitive)
IFO 2 (Less Sensitive)
IFO1 Event Waveform
IFO1 Event Time Window
GW Channel Output
Matched Filtering
OUTPUT : Time Winodw, SNR, Waveform
SNR Threshold and Event Consistency Check
Waveform Bank
Check Coincidence, Amplitude Cut, Narrow time window
Supernovae Event Candidate
Veto
Aux. IFO & Environmental channl glitches

Figure 1