Peter Saulson 20 April 2001

Thoughts on calibrating the burst upper limit effort:

Issues:
1) Efficiency for a particular waveform
2) What kind of statements can we make about unknown waveforms?

Item 1) can be done with appropriate (software) Monte Carlo, with some checks in hardware for verification.

a) Pick filter method to test.
b) Pick a trial waveform.
c) Pick a strength and stick to it for many trials and then adjust to map out efficiency. Or, do we want to do the astrophysical thing and pick a luminosity, then pick distances in next step, d)?
d) Pick a random time and a random (?) place on the sky. N.B.: Special places like GC or Virgo have special dec, but random hour angle.
e) Calculate projection of waveform onto each antenna. Straightforward with LIGO, almost as straightforward for GEO, we'll need help from ALLEGRO to make sure we do bar right. (N.B.: Need separate ALLEGRO track (from Siong?) of e) through j).)
f) Superpose with noise (calculated or pre-recorded.) Noise time series should have built-in lock losses, and other non-stationarities that we want to model. If we want to model gain variations, need to do that in step d).
g) Do c) through e) many times to prepare 3 time series with many signals to find.
h) Pass time series through DMT monitors that determine lock state, as well as any others that will be queried by LDAS pipeline.
i) Pass time series through LDAS pipeline (datacondAPI, filters.) This generates filter output versus time for each filter.
j) Create list of threshold crossings.

How will we have set thresholds? In Monte Carlo, can look at histogram of noise without (added) signals, and know what thresholds give what probabilities (except perhaps at the 1/10 per year level, but fortunately our singles rate can be much higher and still yield coincidences at 1/10 per year.) Even with pre-recorded data, we can use coincidence information to get some confidence that no signals are present.

k) Exercise "event logic" to establish time/filter best representing event in each time series.
l) Check for coincidence among detectors.

How do we set threshold for coincidences? Sam/Stefano/others had suggestion on joint probability. This also feeds back into how sharply we try to do event logic, that is to say we want to check whether we falsely dismiss a coincidence if we put it in the wrong time or filter bin in one detector.

We should construct histograms of coincident event size (however we end up defining it) to investigate probability at low thresholds. We guarantee no real coincidences by using non-physical delays to generate histogram that illustrates probability distribution of false coincidences. With many delays, can generate good statistics from limited duration of data. XX true?

m) Construct graphs of false dismissal versus event strength for interesting thresholds (in other words, efficiency.)
n) Construct graphs of false detection (fake rate) versus threshold.
o) Using time series without added signals and/or with time shifts, construct trial graph of rate vs. strength.

See Amaldi et al. Astron. Astrophys. **216**, 325 (1989). We probably want to cast the problem a bit differently than they did. Firstly, they pick a single threshold that shows some accidental coincidences, and ask what are the odds that this is drawn from the population of accidentals (as probed by the time-delay histogram.) I would think you'd want to pick a threshold with less than 1/10 per year probability of an accidental, then ask if you see a coincident signal.

Secondly, the model they test is a set of pulses all of a single strength. Why not a more astrophysically-motivated model, where events of a certain intrinsic strength are distributed homogeneously (or tracking galaxies) throughout the universe, giving a range of pulse strengths?

p) Repeat for other filters. Comparison based on which criteria? Efficiency of detection at fixed false alarm rate, but for which signal(s)?

Item 2) should be amenable to study through the choice of waveform in step b) above. An arbitrary waveform ought to be characterizable by its inner product with the various filters. Best filter is the one with the largest inner product (suitably normalized as largest SNR.) For any particular waveform suggested either prior to the experiment or after the fact, we can find the best one of our filters and the ratio of that filter's performance to that of a matched filter. I think that separate upper limits for each of a large bank of filters (e.g. various center frequencies and various durations), along with this prescription of comparing an arbitrary waveform to the best-matched of our filters, is the most general thing we can say about arbitrary waveforms.

We may want to run through a large catalog of possible waveforms to explore how far we are from performance equivalent to "matched". But since the space of possible waveforms has very high dimension, it doesn't seem possible to span the space or even to sample it well.

Two comments:

A. We need to draw a larger group into this, perhaps by scheduling a "Design Review".
B. This doesn't cover the analysis track of starting from, say, a list of supernova times and doing the test for excess power in LIGO ifos.