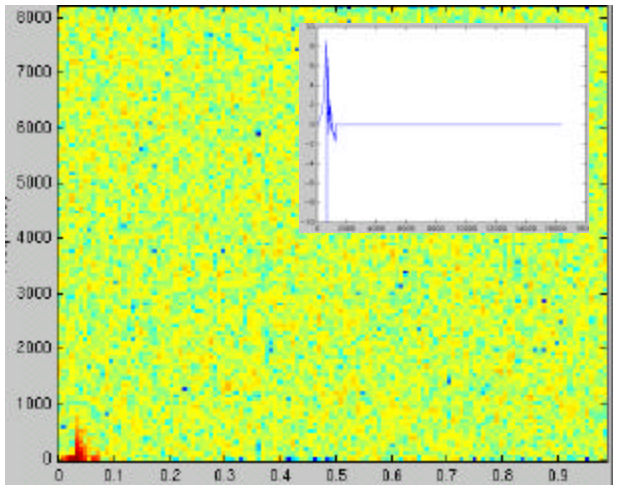
Progress on Burst Simulation

Alan Weinstein, Caltech, 3/20/02

- t-f character of burst waveforms
- Burst waveforms
- Calibration
- E7 data
- LDAS jobs
- Results from TFClusters
- More work to be done

t-f character of burst waveforms (relevant for astrophysics-based analysis)



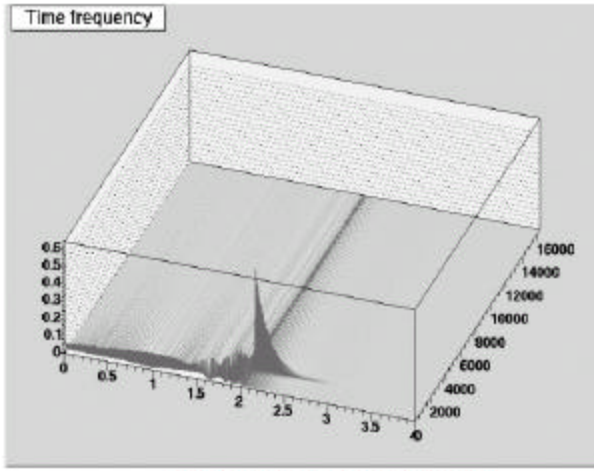
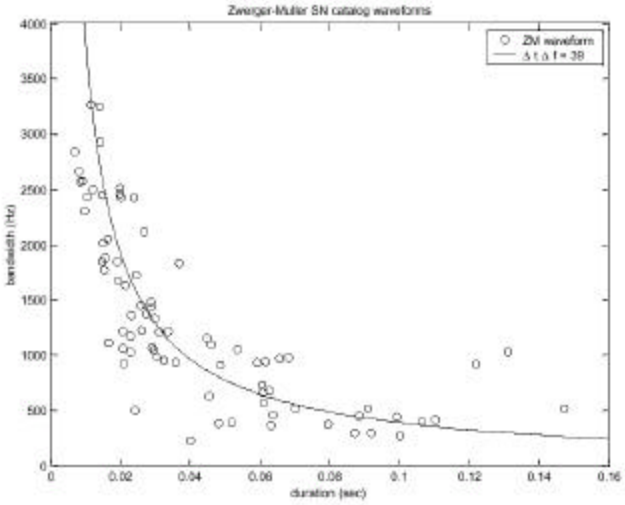


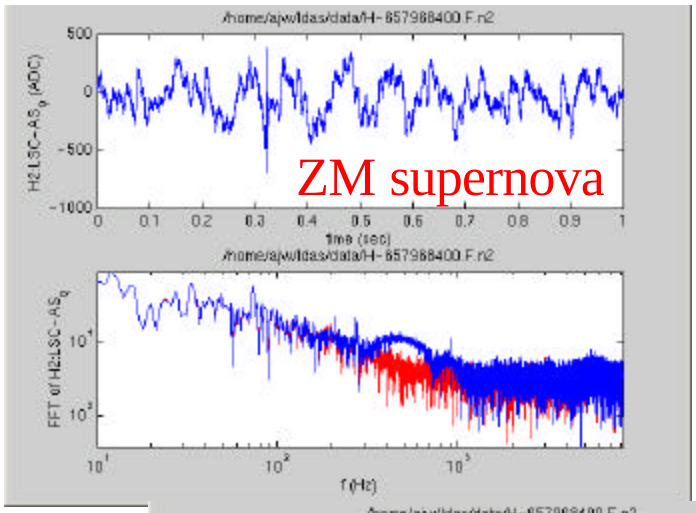
Fig. 3 Spectrogram of a composite signal

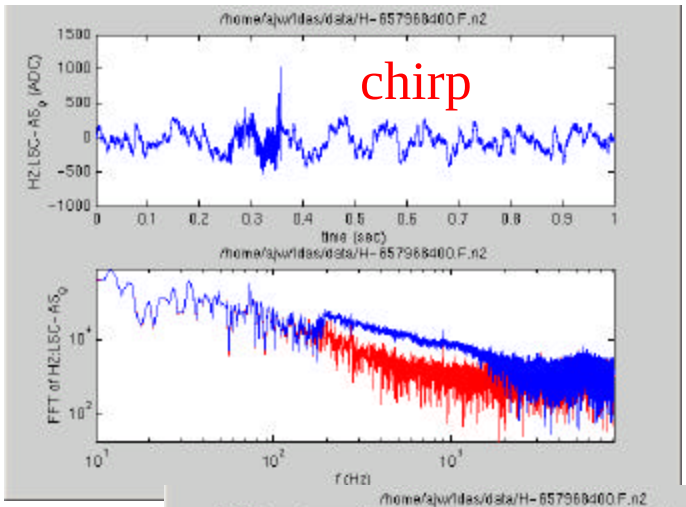


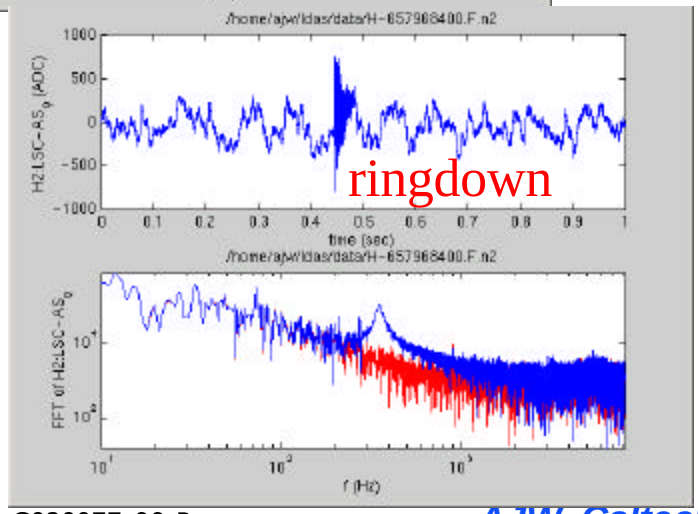
Generic statements about the sensitivity of our searches to poorly-modeled sources can straightforwardly be made from the t-f "morphology"…

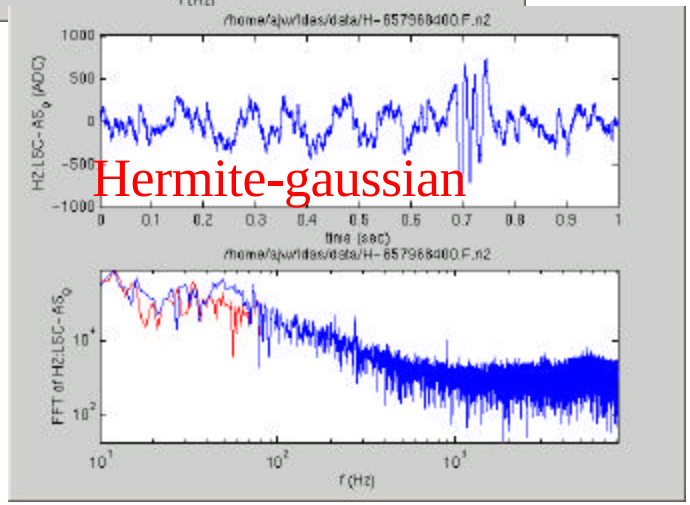
- longish-duration, small bandwidth (chirps, ringdowns)
- short duration, large bandwidth (merger)
- In-between (ZM waveforms)
- Of course, depends on t-f resolution, which must be optimized

Waveforms buried in E2 noise, including calibration/TF

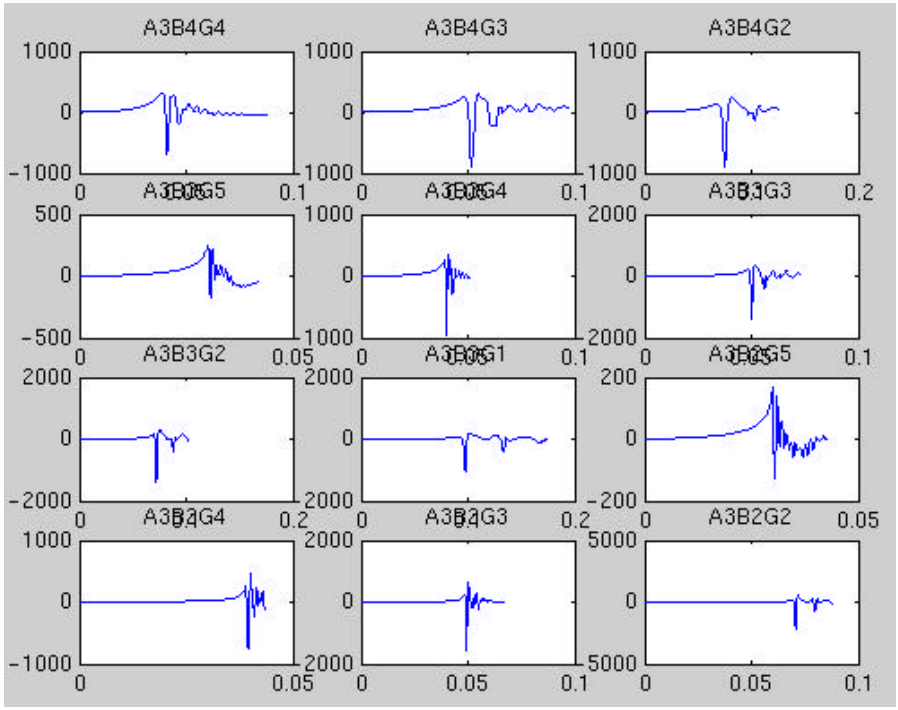


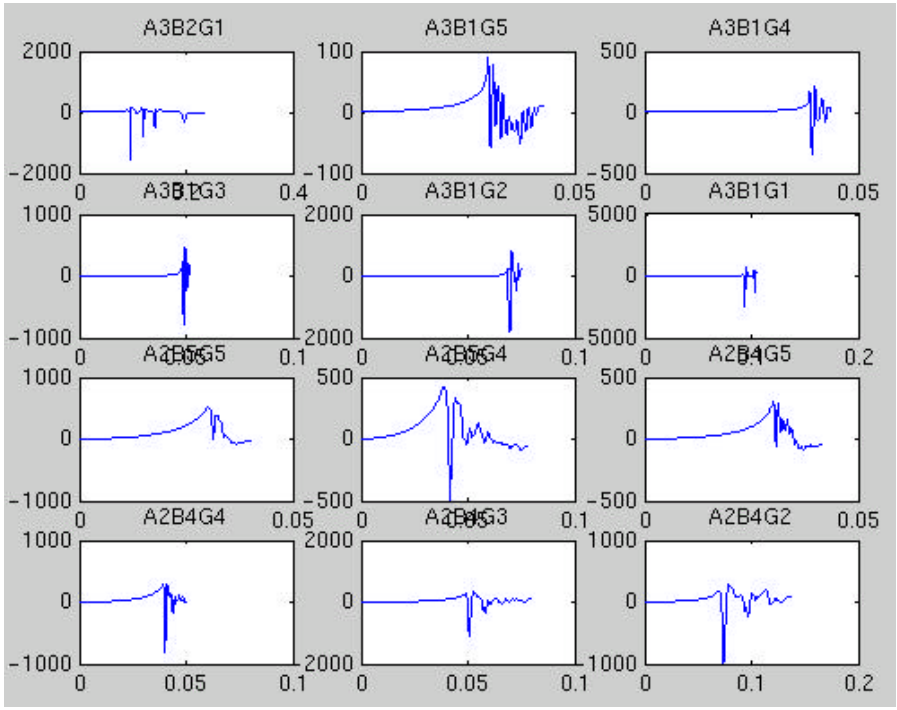






Z-M waveforms (un-normalized)



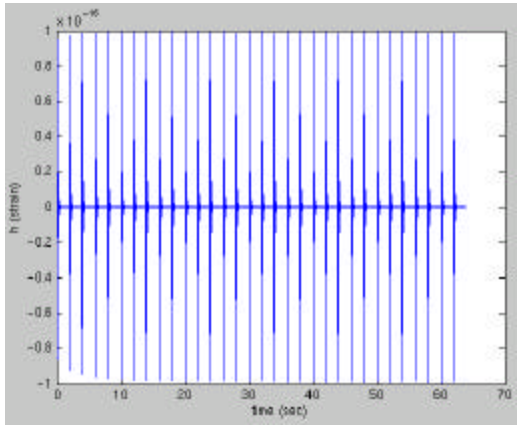


Burst waveforms

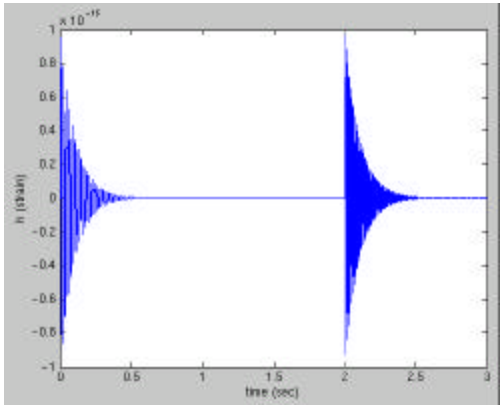
- Start with simple, easy to interpret waveforms: damped sinusoids have well-defined central frequency and bandwidth:
- $h(t) = h_{peak} \exp(-t/\tau) \sin(2\pi f_{cent} t)$, $BW = 1/\tau$
- Choose narrow bandwidth for now, $\tau = 0.1$ sec, BW = 10 Hz
- Scan over range of f_{cent}, h_{peak}
- Consider other bandwidths, other waveforms, later.
- Since we're analyzing lots of data (~512 secs) per job, inject multiple waveforms in one job, so that we don't have to run so many jobs…
- BUT, if these waveforms are BIG, and if the DSO calculates average power using the data itself, many injected waveforms could throw it off…
- For now, this is just a convenience…

Burst scan

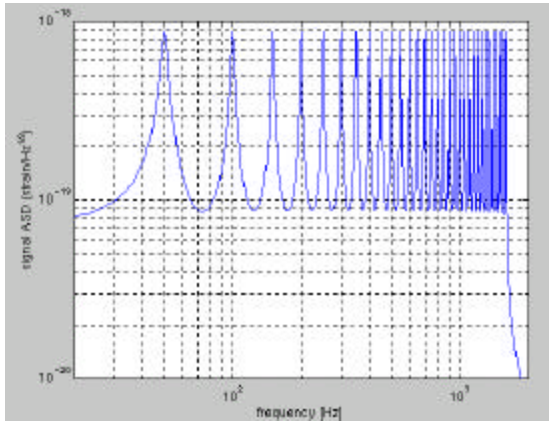
32 waveforms, each 2 sec long, Scanning from 50 to 1600 Hz in 50 Hz steps.



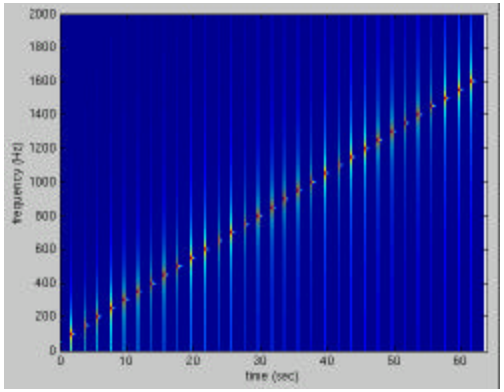
The first 2 waveforms, with f_{cent} = 50 and 100 Hz; τ=0.1 sec



ASD of this 64-sec stretch of simulated data.

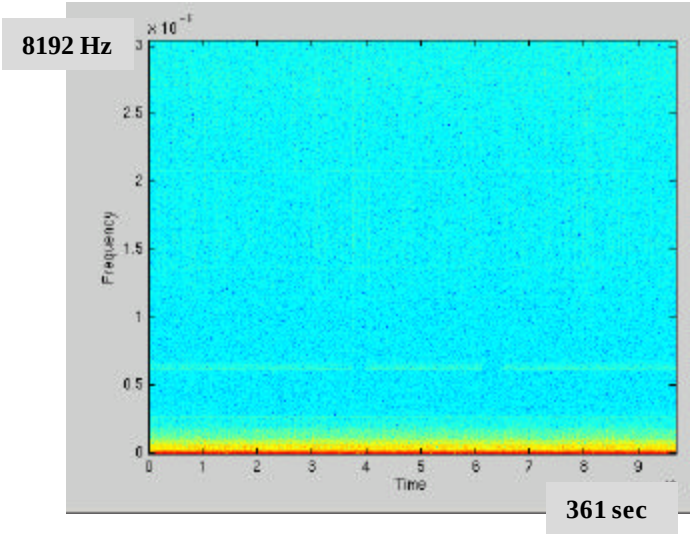


Spectrogram to illustrate the frequency scan



E7 data

- Want to run at MIT
- GUILD reports that at MIT, we have
  - » 693960000 693967184 H R gwf /export/E7/LHO/frames
  - » 693960000 693967184 L R gwf /export/E7/LLO/frames
- These are 2 hrs of data from 1/1/02, when all 3 IFOs are in lock.
- This is not playground data. We need playground data at MIT.
- In the meantime, I choose a 361-sec stretch, since TFCLUSTERS apparently likes to run on that much data (I need to learn how to change that, if possible): 693961586-693961946, H2:LSC-AS_Q . (This stretch has lots of noise bursts).



Injecting bursts

- The burst signals are absolutely normalized by h_{peak}. Need to put it into same units as H2:LSC-AS_Q (volts) by using response function, obtained from calibration.
- The burst signals are passed through a linear filter implementing the E7 H2 calibration transfer function, then saved to a frame file and ftp'ed to
  - » http://www-ldas.mit.edu/ldas_outgoing/jobs/ldasmdc_data/burst-stochastic/burstscan_e7h2.F
- Add signals to the data in LDAS DatacondAPI; can scale magnitude of signals as desired, at run-time.

```
-framequery { { R H {} $times Adc($channel) }
              { F H /ldas_outgoing/jobs/ldasmdc_data/burst -stochastic/burstscan_e7h2.F {} Adc(0) } }
-aliases { x = _ch0; s = _ch1; }
-algorithms { zx = slice(x,0,5914624,1);
              zy = slice(s,0,5914624,1);
              zm = mul(zy,1.e0);
              zs = add(zx,zm);
              zz = tseries(zs, 16384.0, $stime, 0);
              pz = psd(zz,16384);
              intermediate(,pzs.ilwd,pz,psd of ch0);
              z = resample(zz,1,8);
              m = mean(z);
              y = sub(z,m);
              q = linfilt(b,y);
              r = slice(q,2047,737280,1); }
```

E7 calibration

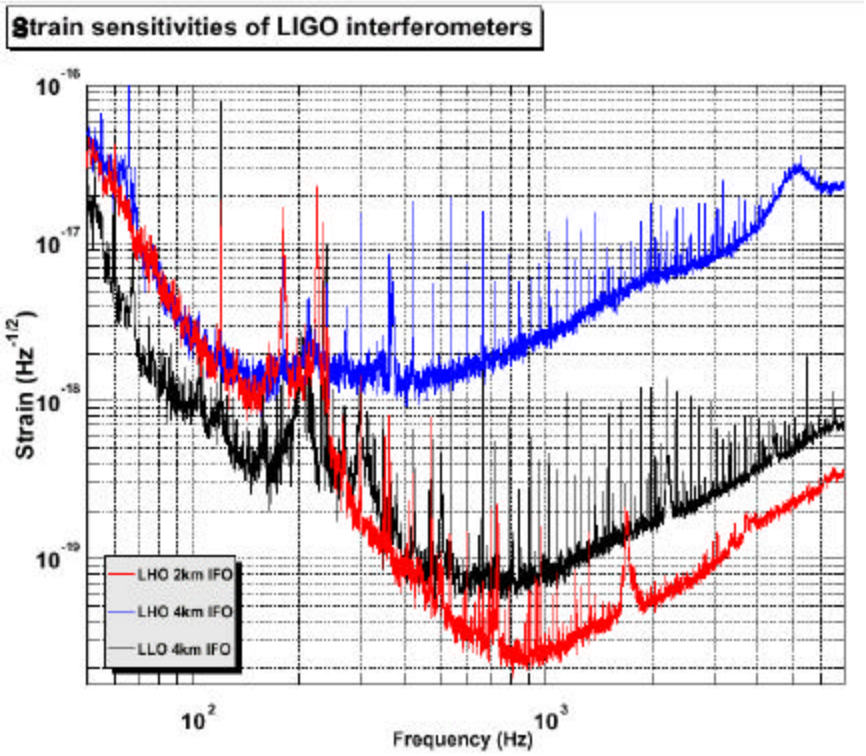
http://blue.ligo-wa.caltech.edu/engrun/Calib_Home/

Summary of the calibration parameters

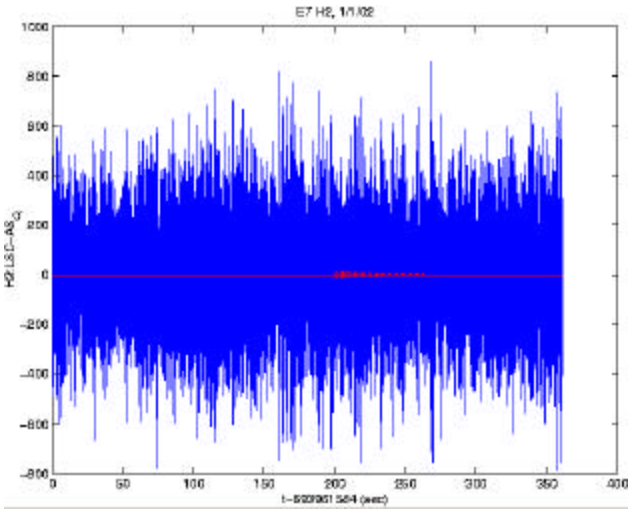
Run	Gain	Poles (Hz)	Zeros	Channel to use
E2 (LHO 2k)	6.8e-8	0.74, 0.74, 0, 0	50.35, 50.35, 12.1, 12.1, 186	H2:LSC-AS_Q
E3 (LLO one arm)	4.9e-6	0.74, 0.74, 0.1, 0.1, 1000	7.38, 7.38, 7.38, 313, 313, 313	L1:LSC-AS_I
E4 (LLO two arms)	1.69e-9	0.74, 0.74, 0, 0	16.82, 0.391, 0.391, 232.6, 232.6	L1:LSC-AS_Q
E7 LHO 2k fully recycled	1.89e-8	0.74, 0.74, 0, 0	119.5, 33.04, 33.04, 33.04, 33.04	H2:LSC-AS_Q
E7 LHO 4k recombined	6.00e-8	0.74, 0.74, 0, 0	20.28, 20.28, 20.28, 20.28, 20.28	H1:LSC-AS_Q

Except for the double pole at 0.74 Hz (mirror pendulum) the poles and zero are the result of a transfer function fit.

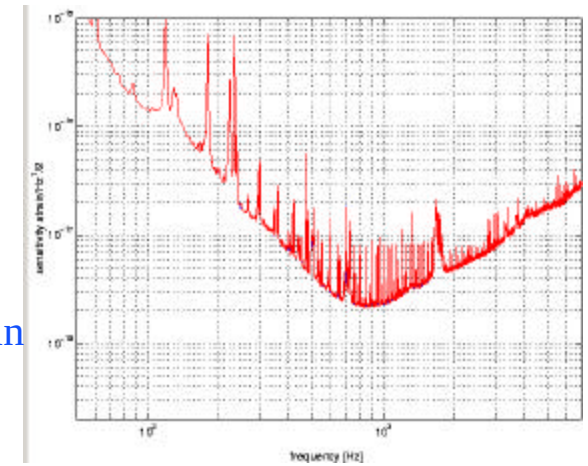
No calibration info from LLO has been posted here yet.



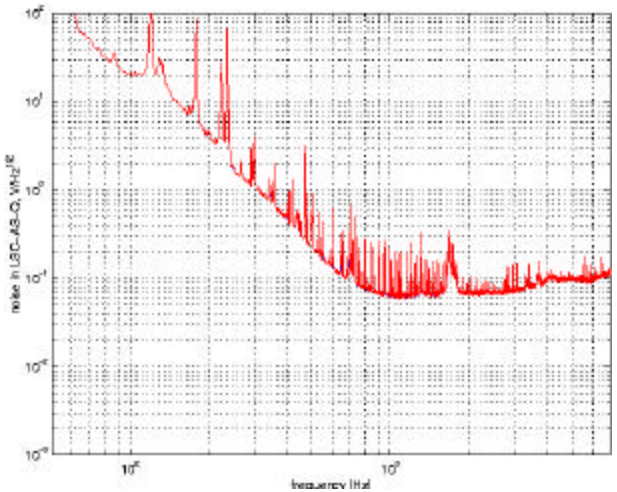
Add bursts to data



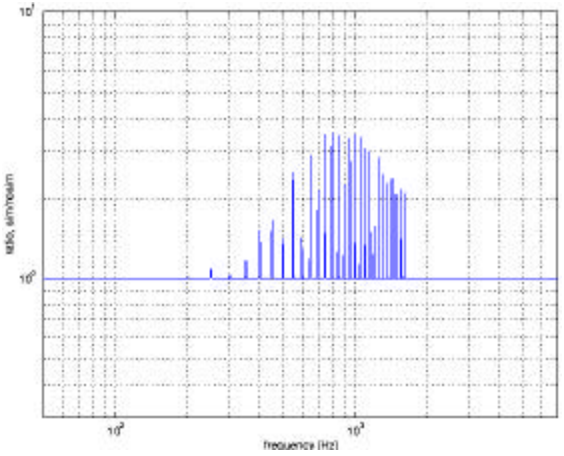
Time series



Calibrated strain
noise spectrum

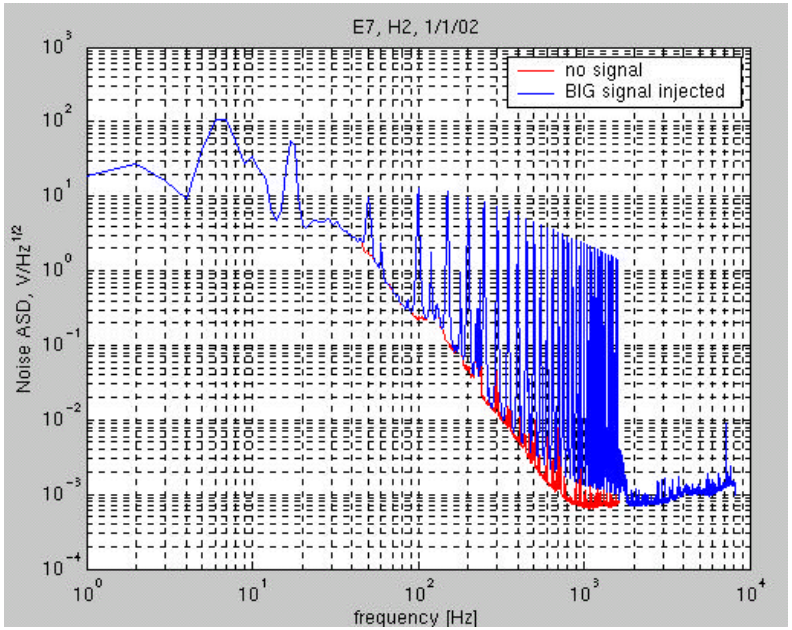


Noise spectrum

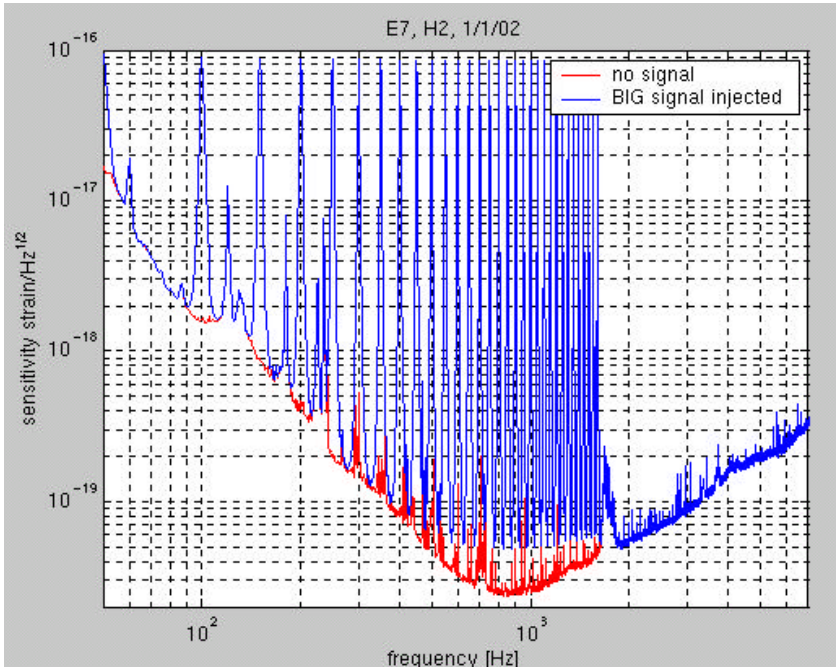


Ratio of noise spectra,
With/without injected signal

BIG Bursts added to E7 data (as a check)



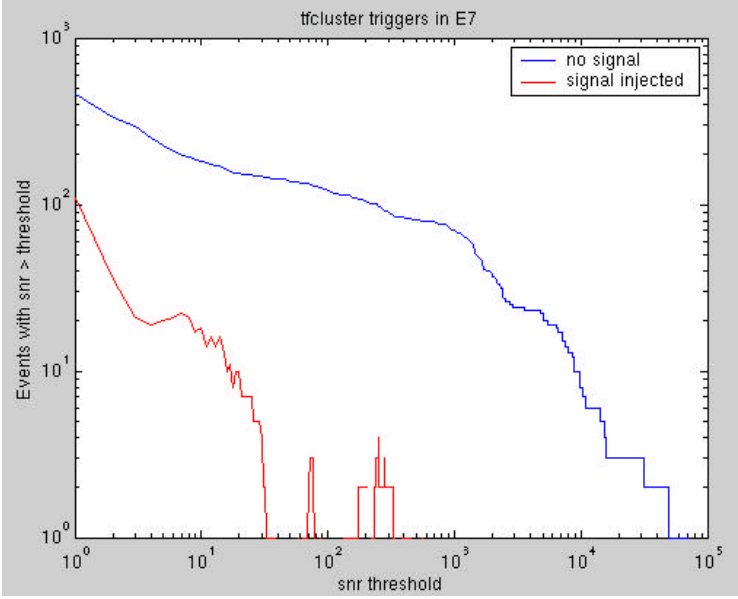
Noise ASD for 361 secs of H2:LSC-AS_Q (red), And with BIG bursts added during secs 201-264 (blue). Bursts are added, and PSDs obtained, using LDAS/DataCond (thanks to Philip Charlton for his help).



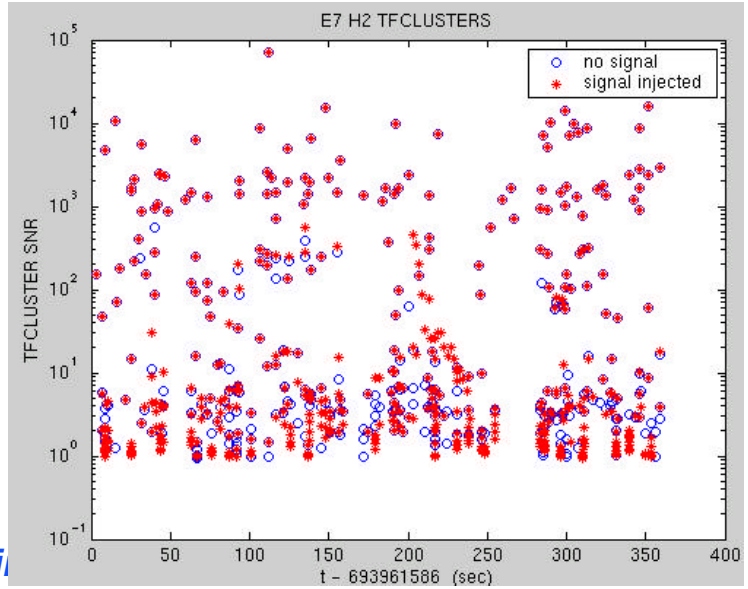
Strain sensitivity from 361 secs of H2:LSC-AS_Q (red), And with BIG bursts added (blue). Note that red curve is in good qualitative agreement with spectrum in Calib page, and bursts scan frequencies from 50-1600 Hz in 50 Hz steps, bandwidth = 10 Hz, and all with same peak strain.

DSO search

- Run with TFCLUSTERS, 361 seconds at a time.
- Run on 361 sec data segment from H2, no injected signals:
  - » 357 triggers into mit_test sngl_bursts table.
- Inject 32 bursts with $h_{peak} = 1 \times 10^{-16}$, scanning f_{cent} from 50 to 1600 Hz in 50 Hz steps, signals spaced 2 secs apart, starting at sec 200.
  - » 471 triggers into mit_test sngl_bursts table.



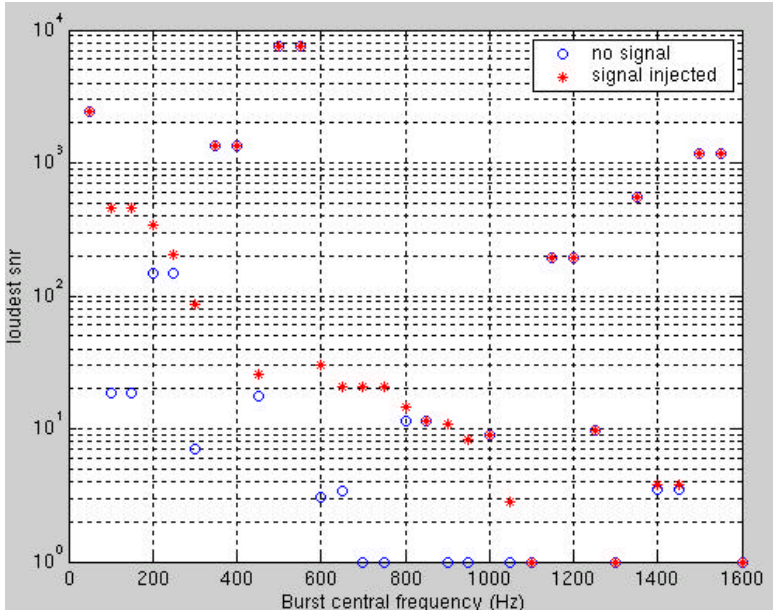
Most big SNR triggers are unchanged after injection of simulated bursts. Many of the first 16 bursts stand out over the fakes.

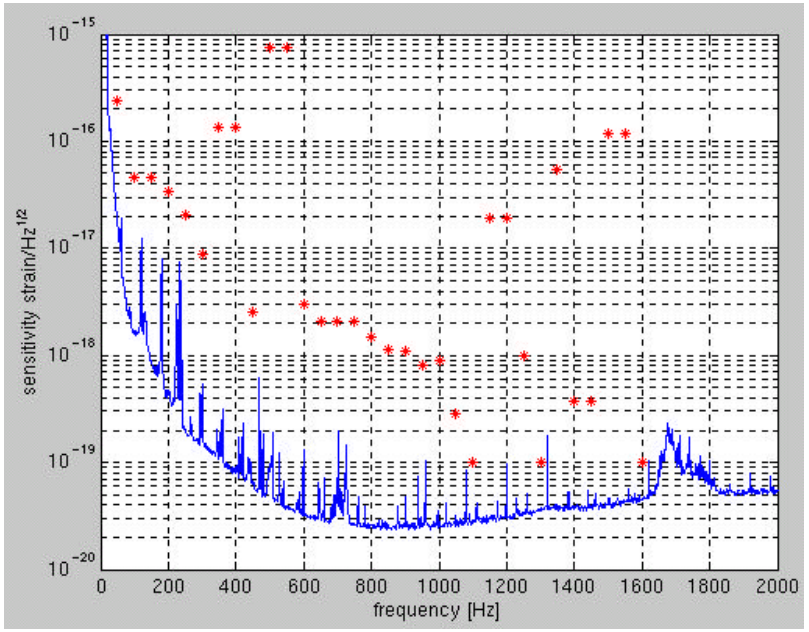


Efficiencies: Presenting the results

Find loudest trigger within 1 sec of injected burst. Plot SNR vs frequency of injected burst.

Note that accidental coincidence of injected burst with noise burst obscures injected bursts at, eg, 350, 500, 550, 850, 1000 Hz.

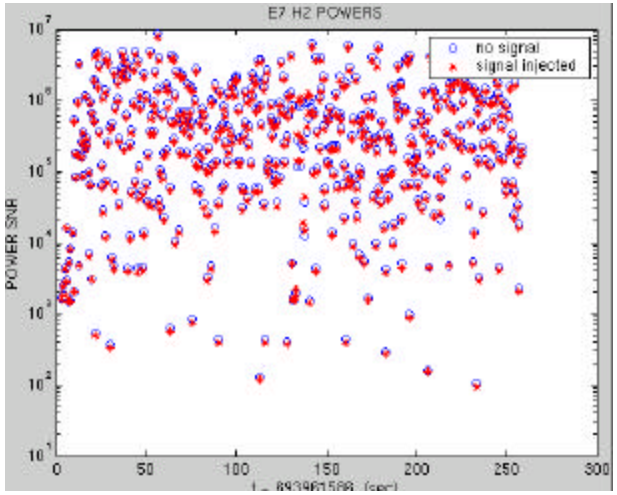


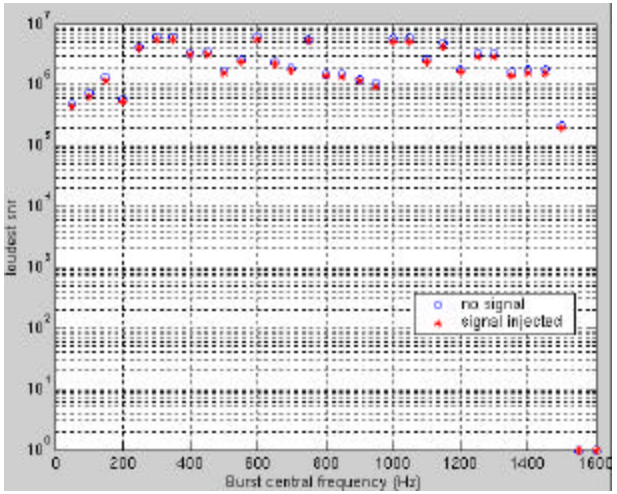


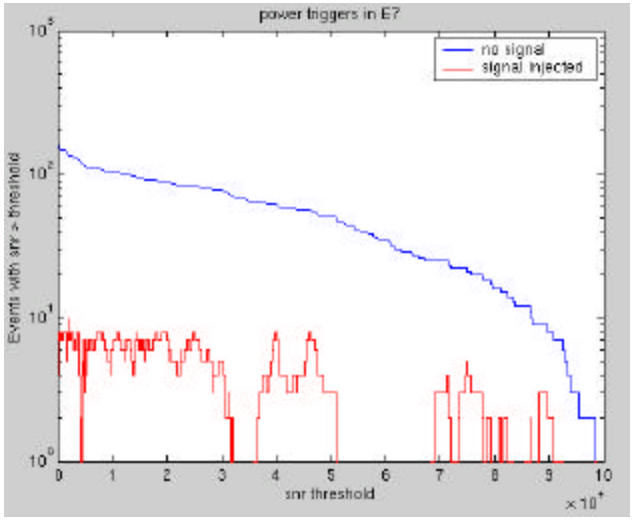
Compare SNR of triggers coincident with injected bursts, with measured noise spectrum. Arbitrary relative scale, for now – needs work! Anyway, it looks like with the burst amplitudes that were injected, we run out of efficiency above ~1100 Hz.

Power DSO

- Running on 260 sec stretches of playground E7 data
- With no signals injected, get 510 triggers (hard limit??)
- If I run with large signals, baseline power (calculated from the same data stretch that we are searching in!) gets trashed;
  - » ALL snrs go down for ALL triggers.
  - » Even in the windows where signals are injected.
- With smallish signals injected, still get 510 triggers, but they do seem to show up a bit.
- Still, with these huge numbers of large SNR bursts, how can we hope to see signals that *should* be seen given the mean power levels?

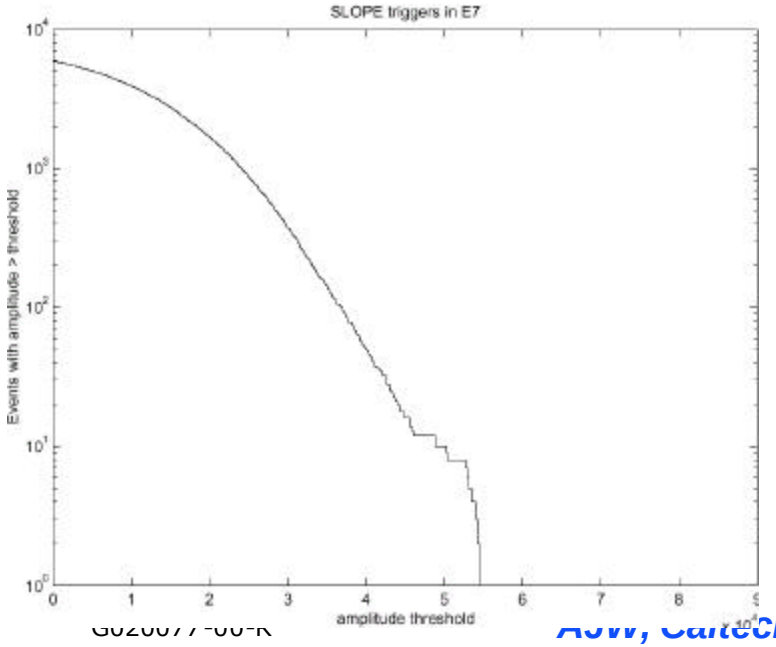


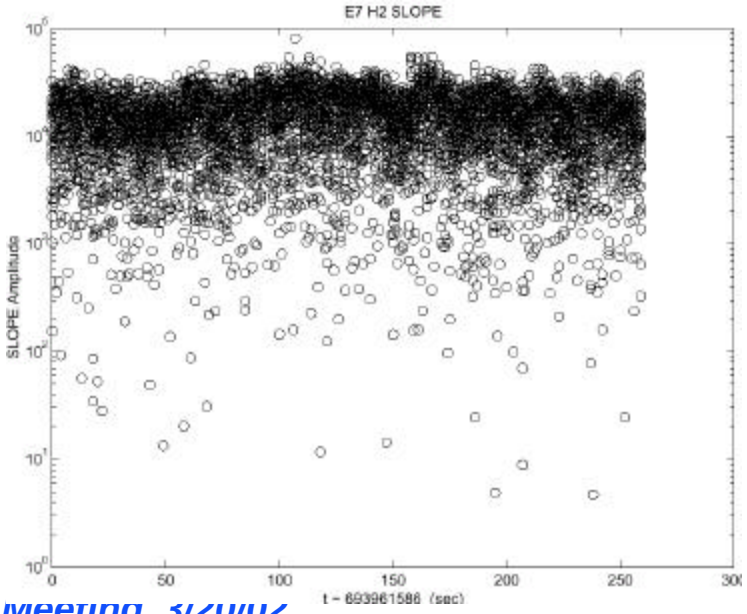




SLOPE DSO

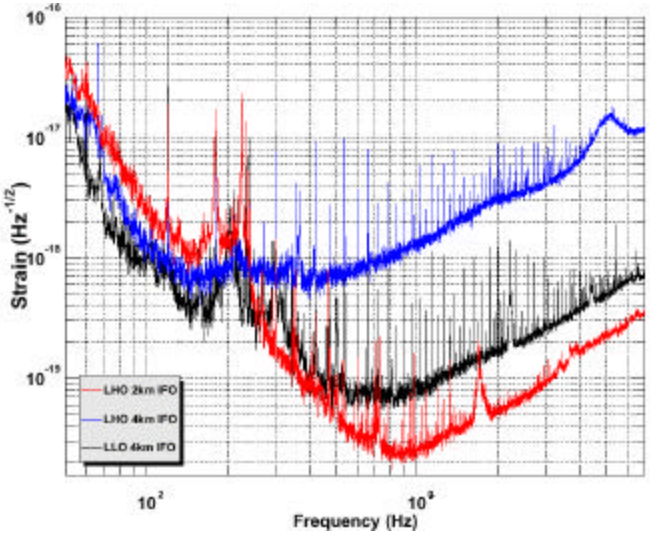
- Ran on 260 secs of E7 data from 1/1/02
- With no signals injected, get 5938 triggers
- With signals injected, get same (?) 5938 triggers
- At the moment, can't seem to run slope DSO anymore at MIT; get wrapperAPI errors that data are unavailable…

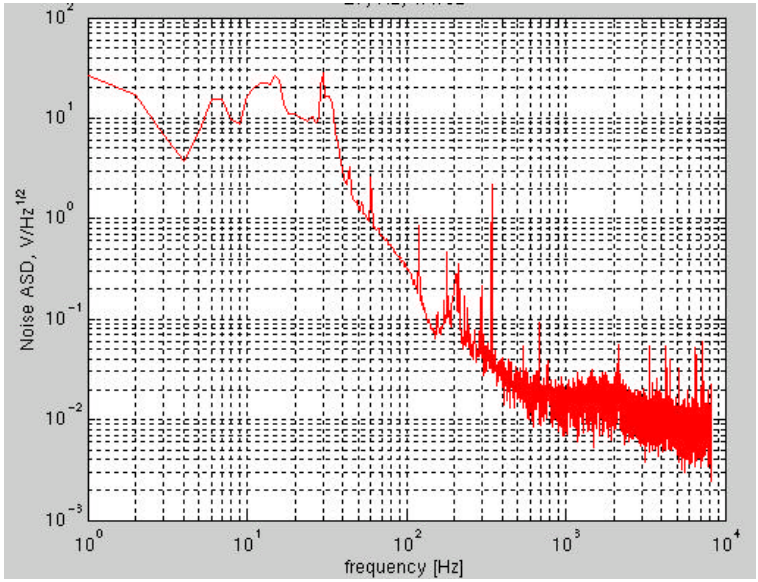


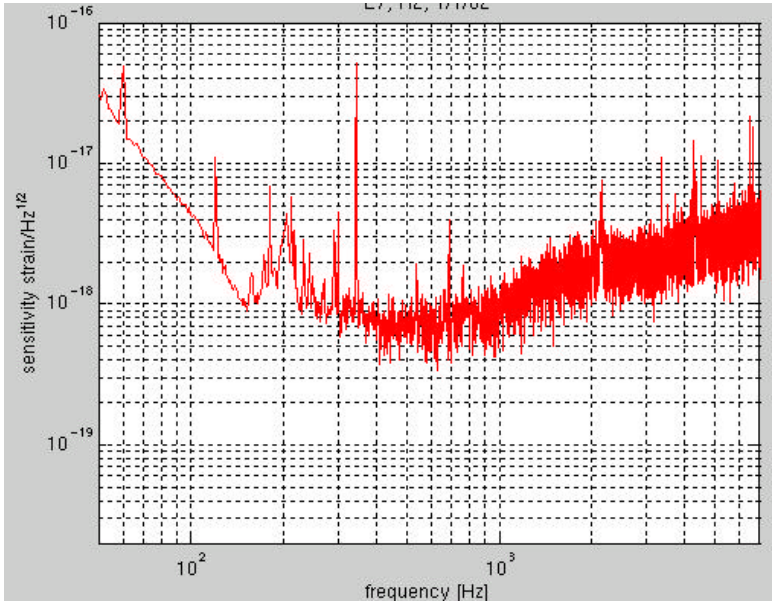


First look at L1

- 361 secs of L1:LSC-AS_Q (693961586-693961946) around 1/1/02.
- Hmm. Doesn't look a lot like expected…







AJW, Caltech, LSC Meeting, 3/20/02

More work

- Get the full playground data at MIT.
- Run on colored gaussian noise with same PSD as data.
- Get absolute scale right.
- Consider all three IFOs.
- Learn how to tune/optimize DSOs.
- Consider other bandwidths, waveforms.
- Learn how to use Event class in ROOT. (Currently use MATLAB).
- Enhance DatacondAPI capabilities to more easily modify the injected bursts on the fly.
- Automate LDAS submissions, Trigger processing (*rundso* script).
- Decide on best way to summarize results.