LIGO

S2 Bilinear Couplings Study

Vijay Chickarmane, Gabriela González
Louisiana State University

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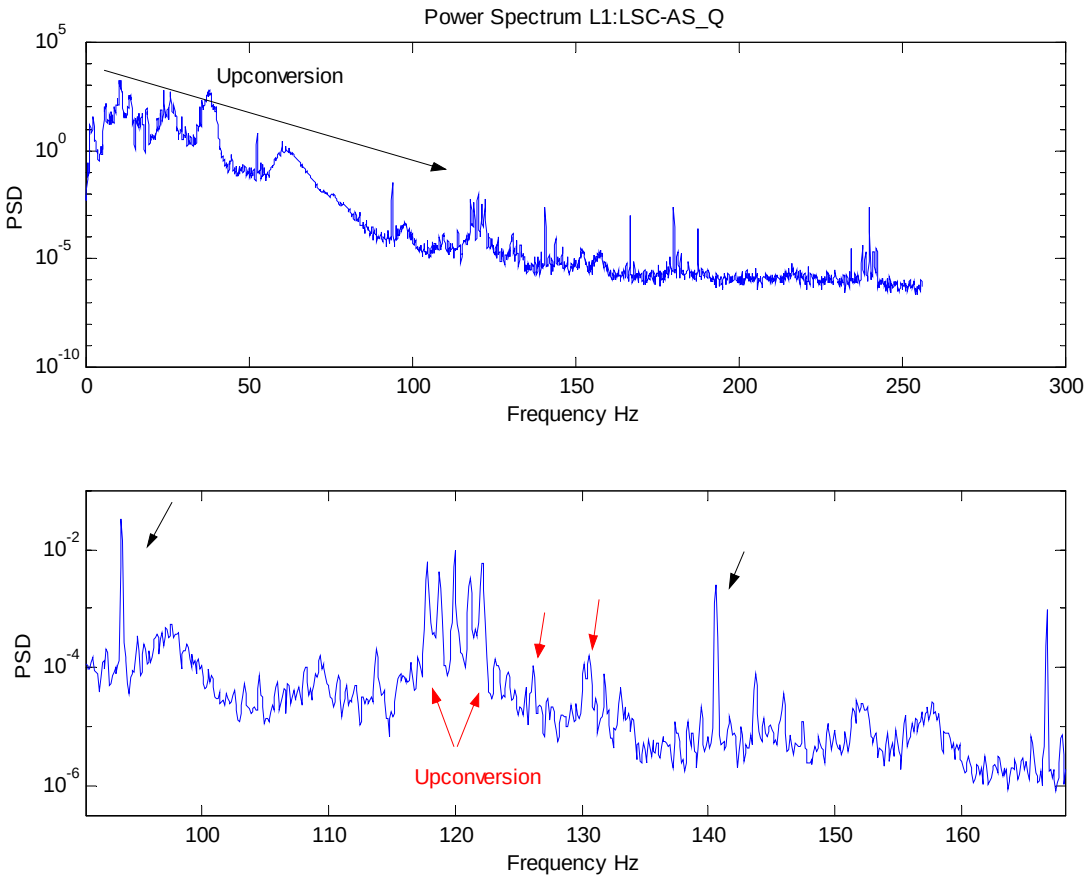
Bicoherence plane



Low frequencies get upconverted by line harmonics: 1.2Hz, 2.1Hz stack modes, vibrational modes of end test masses.

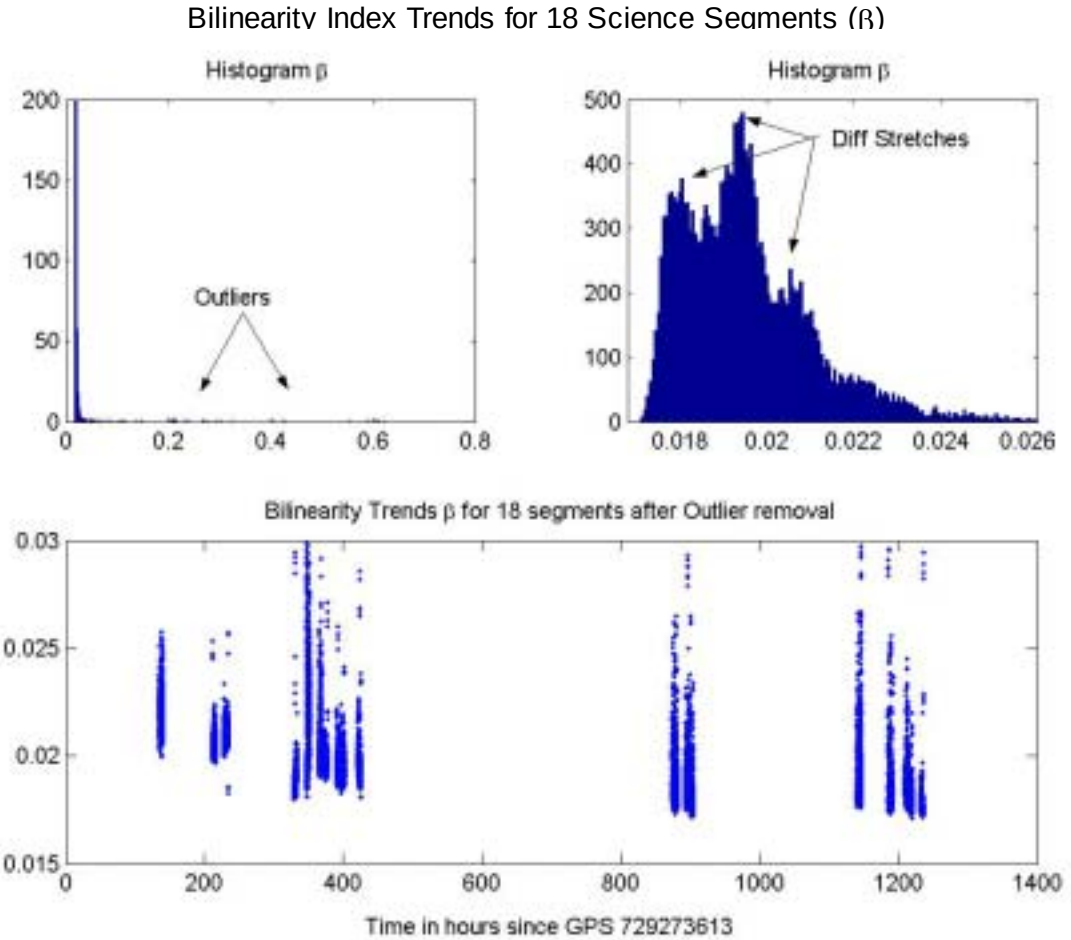
A: Low freqs upconverted by 60, 120Hz.

B: Features due to coherence between 60, 120 & 180, and the upconverted peaks.

C: Due to Optical lever servo oscillations.(harmonics of 46.9Hz)

Bilinearity Index trends

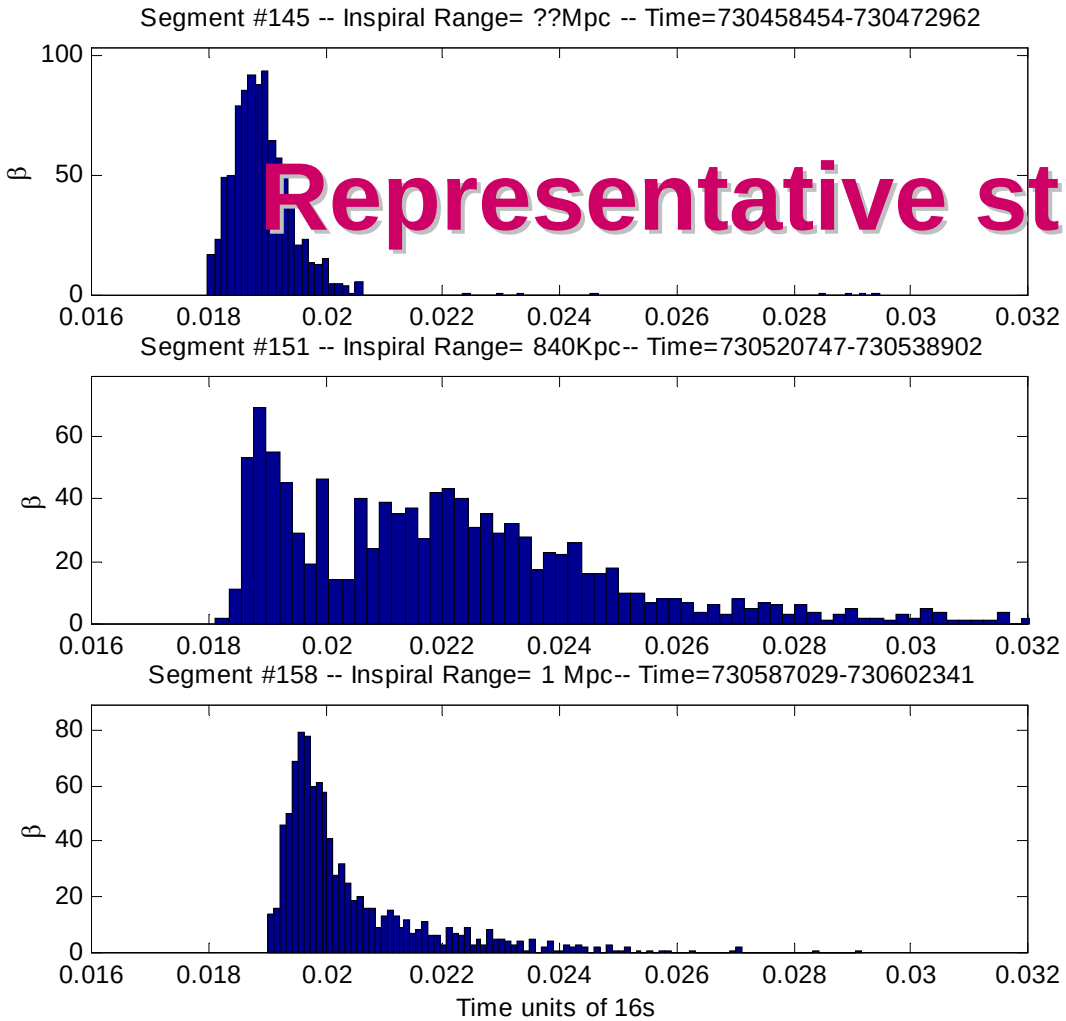
Integrated bilinearity computed every 16s over 64sec with 0.5 Hz resolution in the f1-f2 plane

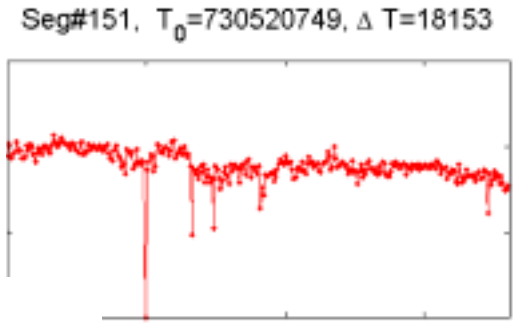


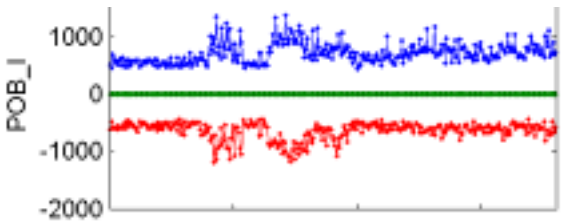
$$\beta = \frac{\sum_{L} b^2(k,l)}{L}$$

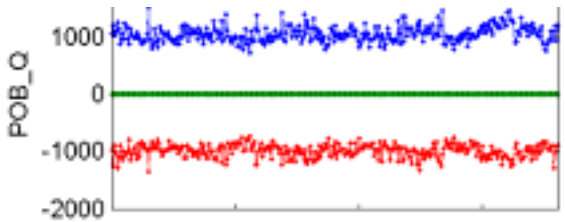
Large outliers are due to glitches which spread energy over several frequencies!

Representative stretches





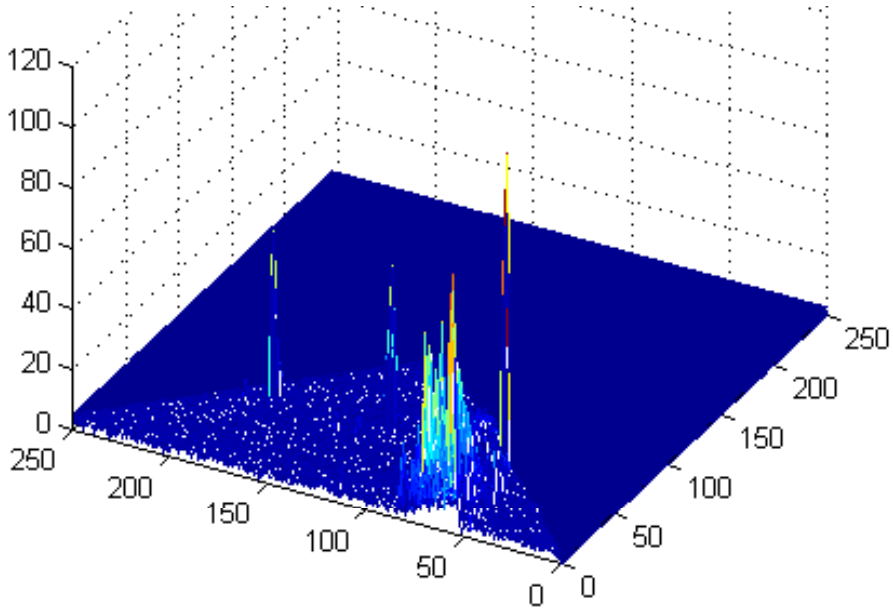




Bilinearity "Glitch" Histograms

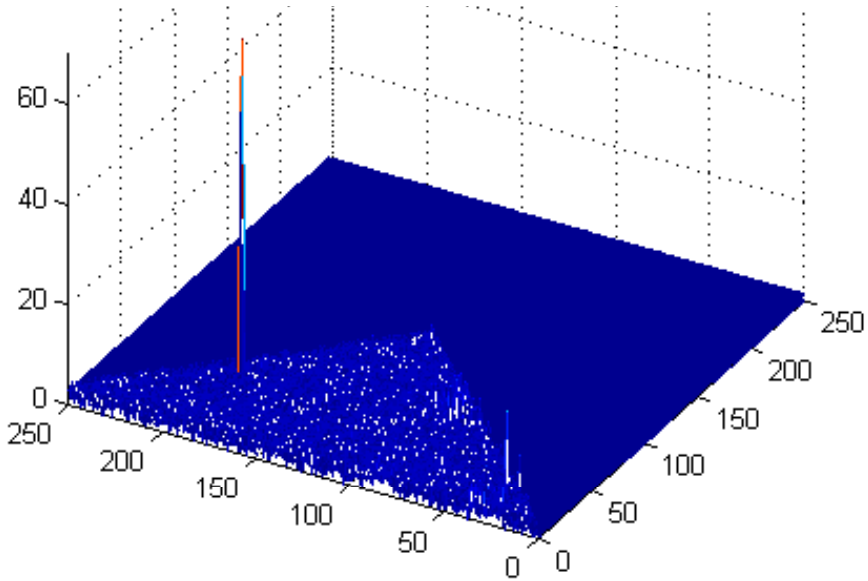
Segment #158 -- Inspiral Range= 1 Mpc-- Time=730587029-730602341

Low freqs around
60Hz and harmonics (60-60, 60-120)



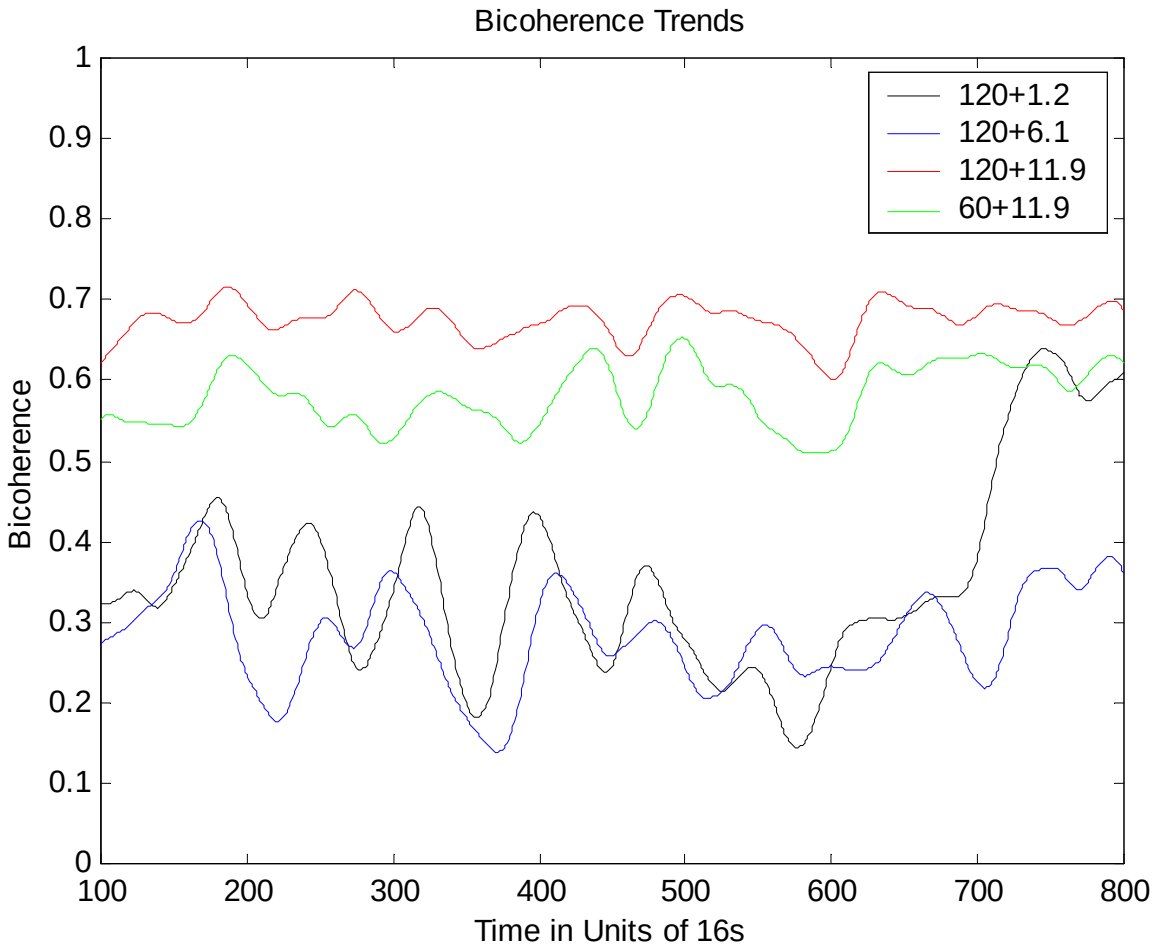
Segment #562 -- Inspiral Range= 960Kpc-- Time=733709427-733724388

Coupling between calibration line
and Optical lever ETMY



Analyze the f1-f2 plane for times with large variations in bilinearity trend.

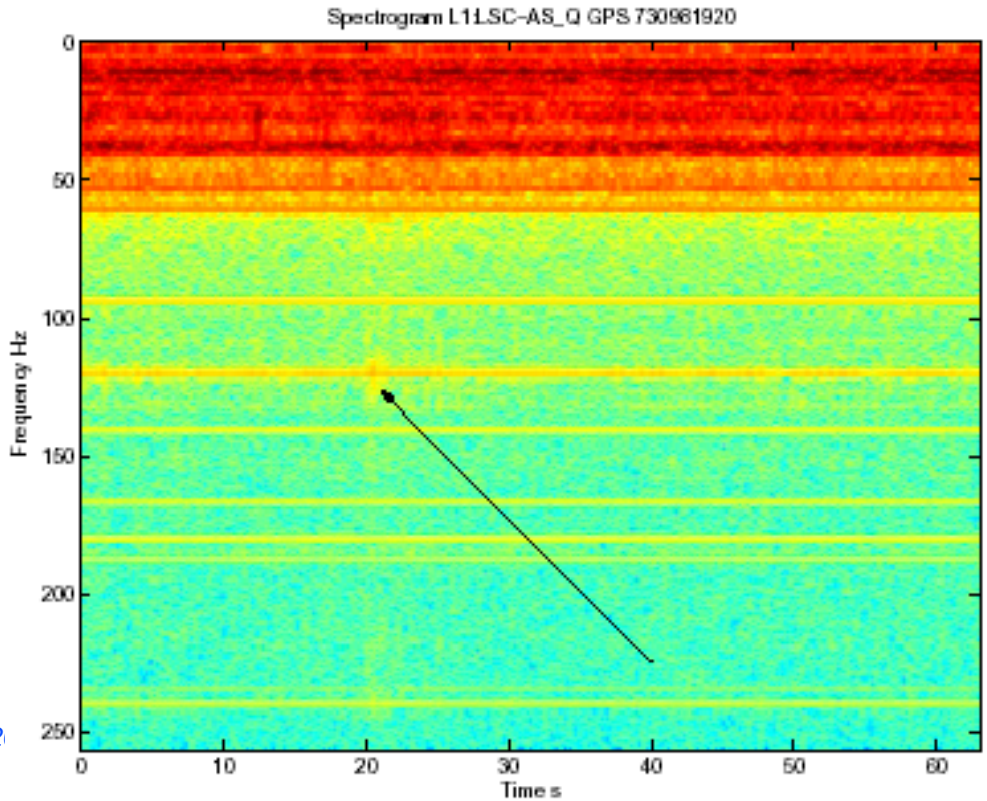
Bicoherence Trends



Bicoherence computed for 3hrs stretch for several low freqs. Data window of 64s → slide over by 16s.

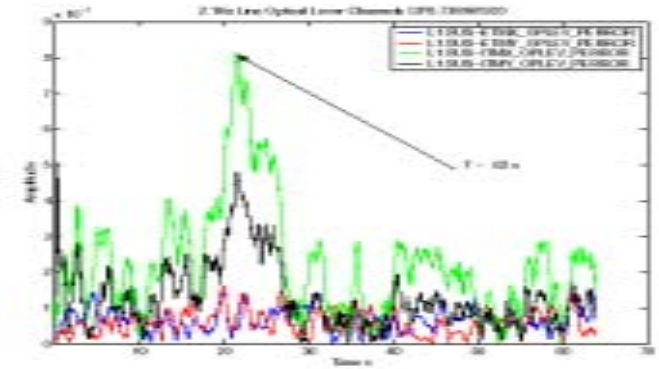
Bicoherence and inspiral triggers

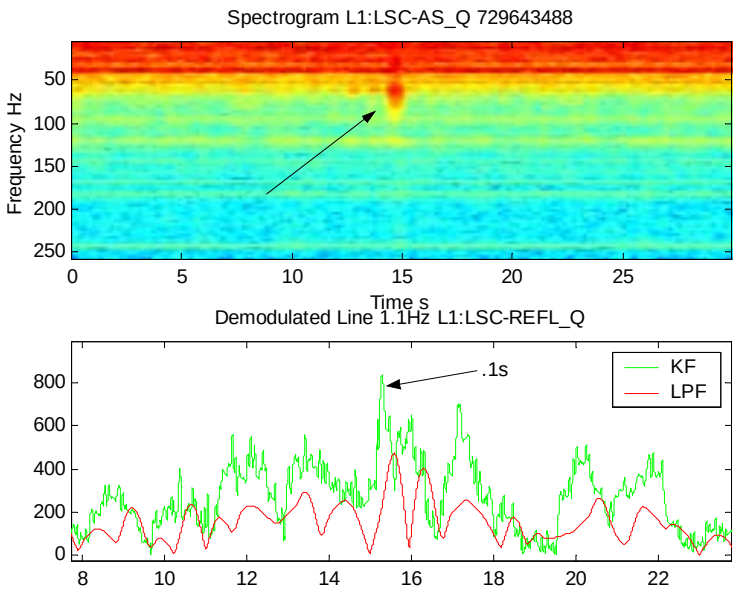
Compute Bic with trigger vs Bic without trigger, analyze difference
→ Which couplings glitched? → Which channels to look at ?
Bicoherence analysis of all S2 inspiral triggers with SNR > 10 analyzed, some examples. Results is a text file with the bi-freq glitches.



306	0.00	0.00
306	62.50	60.00
306	119.50	116.00
306	120.00	115.50
306	122.00	2.50
306	122.00	113.50
306	122.50	2.00
306	122.50	2.50
306	122.50	122.00
306	124.00	120.50
306	124.50	120.00
306	235.50	2.00
306	236.00	2.00
306	242.00	2.50
306	242.50	2.00

Looking for the source





Demodulate the upconverted frequencies in suspect auxiliary channels. Ex: Plot of the amplitude of the 2.1 Hz line for oplev channels. Look for significant excursion around trigger time.

Demodulation involves mixing at a certain freq + low pass filtering(LPF) LPF introduces phase delay, you can use other technique's to "track" the lines. Ex: Here we use a Kalman Filter to track the 2.1 Hz line. Slight improvement seen.

Summary & Conclusions

- Analyzed Bicoherence of S2 LLO data for science stretches > 4hrs.
- Computed Bilinearity Index trends, Bilinearity “Glitch” Histograms, Bicoherence Trends.
- Characterized typical glitches seen as Inspiral triggers, due to upconversion.
- Need to understand mechanisms of upconversion→ simulations of detector → experimentally inject signals in seismic channels ect.
- Veto trigger: Study of trend low frequency peaks ?