



S5 Spectral Line Cataloguing

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for the Spectral Line Working Group



Why Look at Spectral Lines?

- Direct impact on GW searches
 - » Broad peaks cut into bandwidth (Pulsar)
 - » Narrow L1/H1 coherences (Pulsar)
 - » Broad H1/H2 coherences (Stochastic)
 - » Non-stationarity in line sources causes transients (Burst)
 - » They complicate data-conditioning filters (Burst)
- Indicate unwanted couplings into GW channel
 - » Specific sources typically are at particular frequencies
- Can be used to monitor interferometer elements
 - » Drumhead, body modes used to track test mass temperature

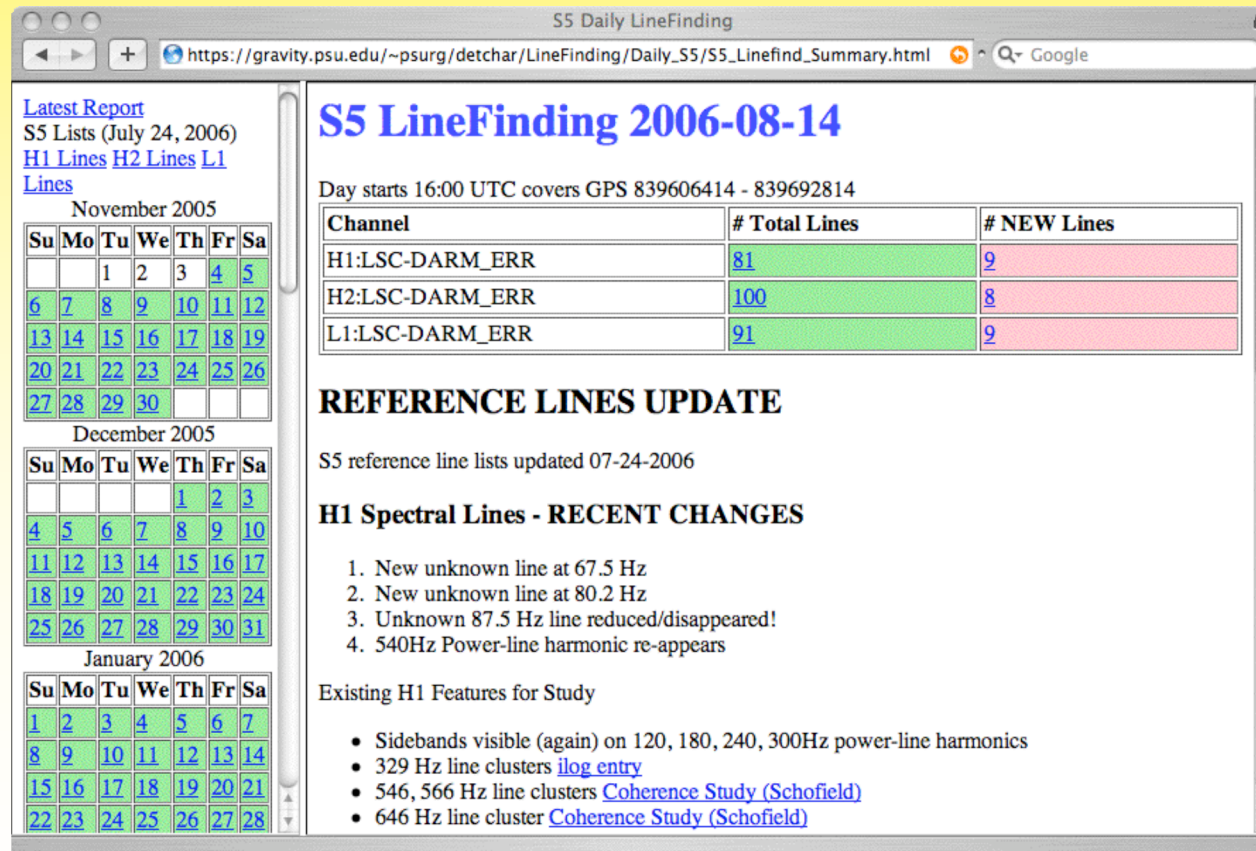


Spectral Line Measurement

- Control Room Investigations
 - » Fourier, Spectral Coherence Tools (Schofield)
 - » DMT Monitors - LineMon (Klimenko), SixtyHertzMon (Riles)
- Offline Studies
 - » Daily Spectral Line-Finding Summary (KT)
 - Can also do special runs on any other channels
 - » SFT-based Spectrograms (Dupuis)
 - » Environmental Coherence Catalogue (Carleton College)
- Results from Search Groups
 - » Narrow Lines seen in Pulsar Group analyses (Mendel, Riles)
 - » Broader Coherences seen in Stochastic Group analyses
 - PEM - DARM_ERR coherences (Mandic, Fotopoulos)

Daily Line-Finding Pipeline

- Running since November 2005
- Makes daily summaries of DARM_ERR spectral lines
- Reports on changes in lines prepared about every ~3 weeks



S5 Daily LineFinding

https://gravity.psu.edu/~psurg/detchar/LineFinding/Daily_S5/S5_Linefind_Summary.html

[Latest Report](#)
[S5 Lists \(July 24, 2006\)](#)
[H1 Lines](#) [H2 Lines](#) [L1 Lines](#)

S5 LineFinding 2006-08-14

Day starts 16:00 UTC covers GPS 839606414 - 839692814

Channel	# Total Lines	# NEW Lines
H1:LSC-DARM_ERR	81	9
H2:LSC-DARM_ERR	100	8
L1:LSC-DARM_ERR	91	9

REFERENCE LINES UPDATE

S5 reference line lists updated 07-24-2006

H1 Spectral Lines - RECENT CHANGES

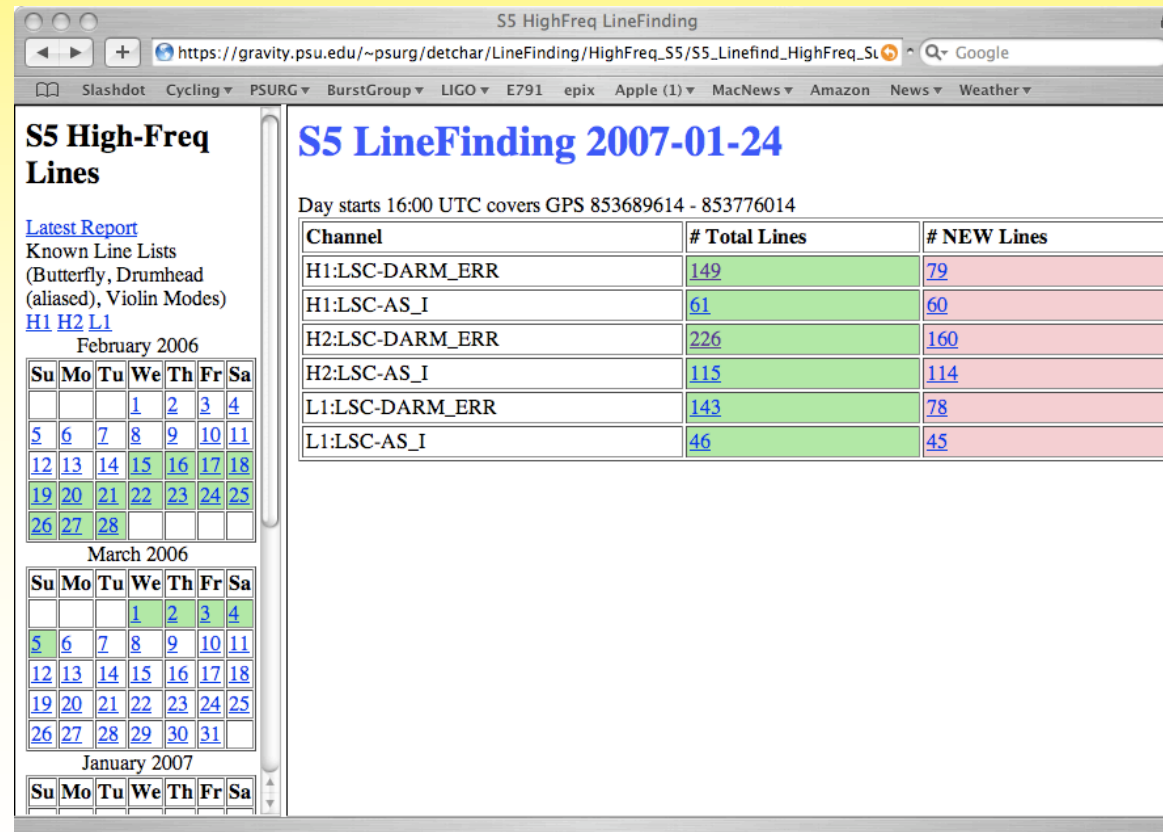
1. New unknown line at 67.5 Hz
2. New unknown line at 80.2 Hz
3. Unknown 87.5 Hz line reduced/disappeared!
4. 540Hz Power-line harmonic re-appears

Existing H1 Features for Study

- Sidebands visible (again) on 120, 180, 240, 300Hz power-line harmonics
- 329 Hz line clusters [ilog entry](#)
- 546, 566 Hz line clusters [Coherence Study \(Schofield\)](#)
- 646 Hz line cluster [Coherence Study \(Schofield\)](#)

High-Frequency Line Search

- Extended to 8192Hz for Butterfly, Drumhead modes
- Supplanted by monitor of high-rate GW channel to track internal modes (to measure test mass temperature)



S5 High-Freq Lines

[Latest Report](#)
Known Line Lists
(Butterfly, Drumhead (aliased), Violin Modes)
[H1](#) [H2](#) [L1](#)

February 2006

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

March 2006

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

January 2007

Su	Mo	Tu	We	Th	Fr	Sa

S5 LineFinding 2007-01-24

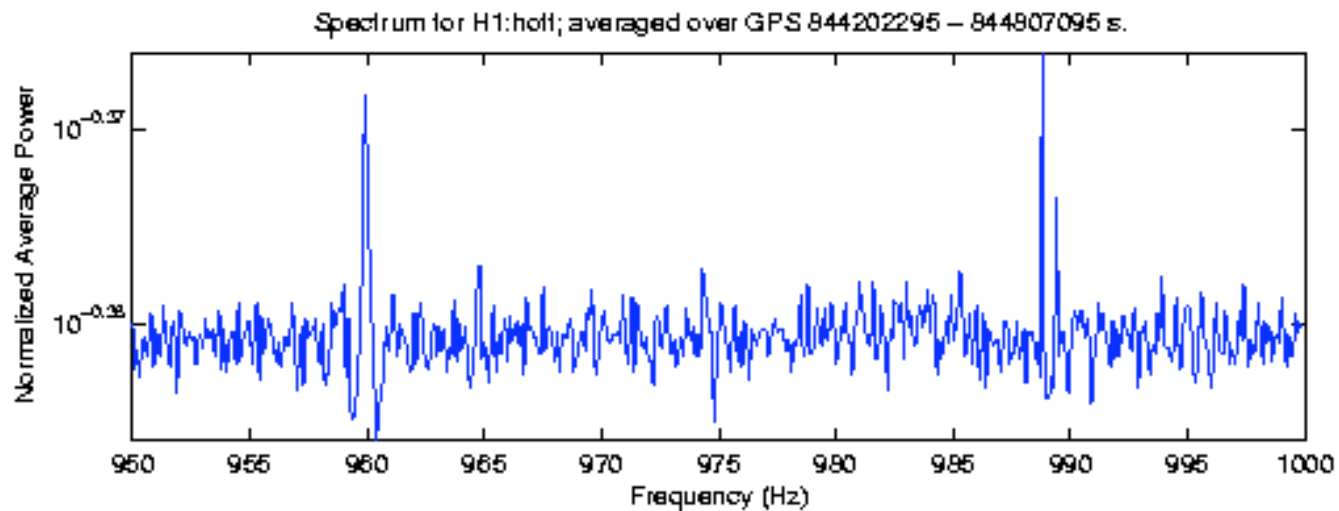
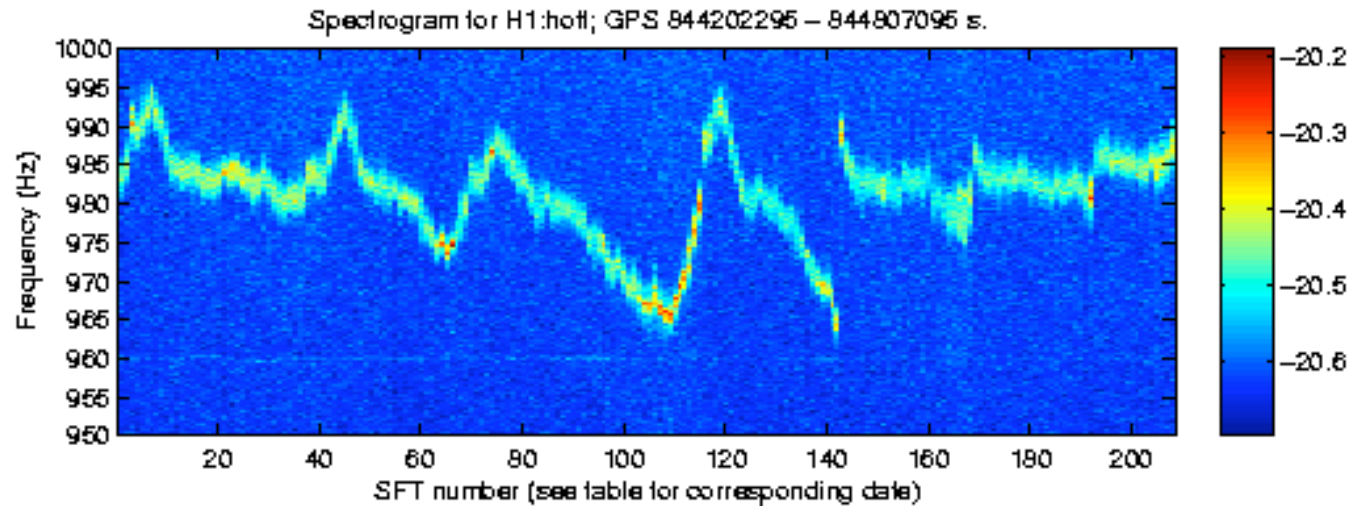
Day starts 16:00 UTC covers GPS 853689614 - 853776014

Channel	# Total Lines	# NEW Lines
H1:LSC-DARM_ERR	149	79
H1:LSC-AS_I	61	60
H2:LSC-DARM_ERR	226	160
H2:LSC-AS_I	115	114
L1:LSC-DARM_ERR	143	78
L1:LSC-AS_I	46	45

S5 H1/L1 Spectral Lines

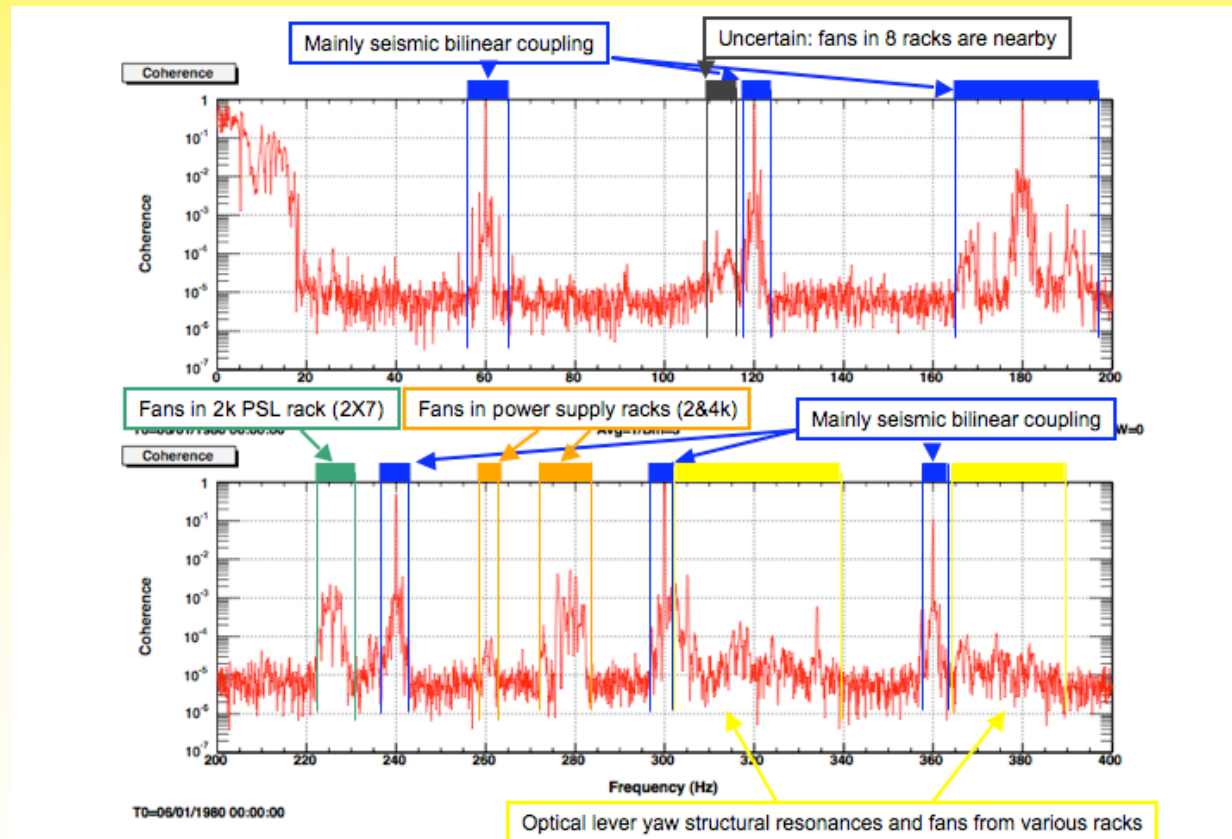
- Pulsar searches are particularly concerned with lines that are coherent between the 4K detectors (H1, L1)
- Short Fourier Transforms (SFTs) were searched with Fscan and spectrograms prepared (Mendell, Dupuis)
 - » Required Δf of 2.2×10^{-4} (generous Doppler window), $\text{SNR} > 4$
 - » Found 3-Hz sidebands on 60Hz, 16Hz harmonics
 - » Also coherences from violin modes, Duotone(?) near 1920Hz
- Quasi-stationary lines coincident within 10 mHz between H1 and L1 reported from PowerFlux (Riles)
 - » Strongest were harmonics of 16 Hz
- These were used to focus later studies (to address issues most of need by pulsar group)

S5 Coherence Spectrograms



S5 H1-H2 Coherences

- Prepared by Stochastic Group
- Robert Schofield attempted feature identification (Sept 06)





January 2007 Commissioning

- Power supply ripple monitor installed to search for line sources (Schofield)
 - » Fscan spectrograms prepared for ripple data (Mendel)
 - » Long-mysterious 546, 564, 566, 646, 648Hz lines seen in +/-15V center supply ripple!
- Mitigation attempt on 10Hz comb from IRIG-B
- 3-Hz sidebands of 60Hz tracked down to the Neslab PSL chiller (SCR pulsed heaters)
- 280Hz lines from power supply fans in 4K PSL
- Broad, wandering lines in spectrograms mitigated by improved cooling of H1 LSC racks



Environmental Coherence

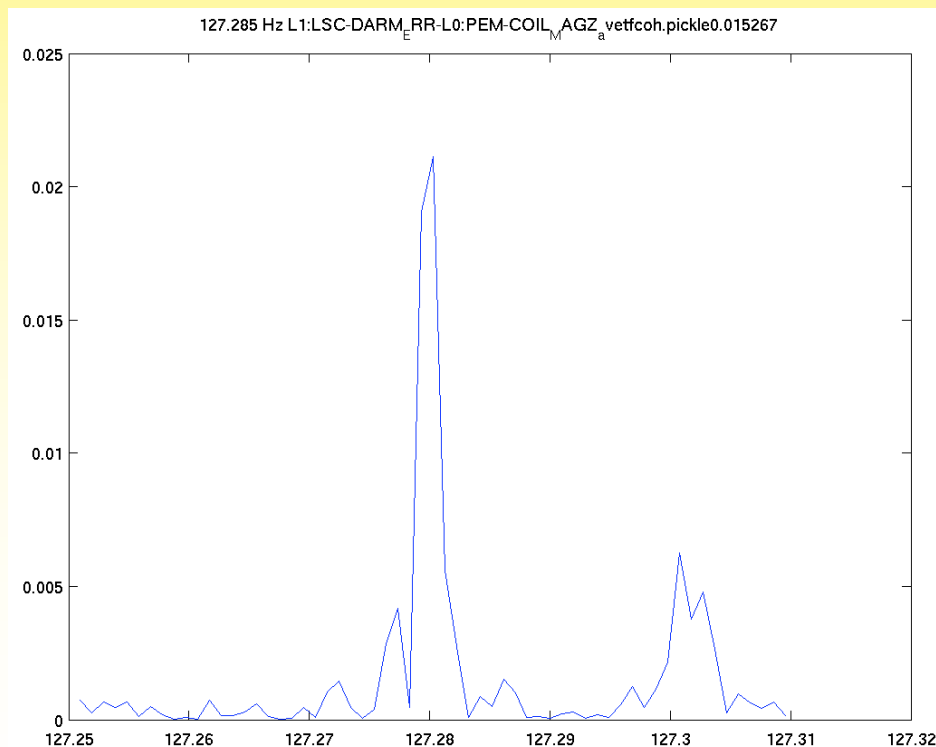


Catalogue

- Work done by Carleton College (Nelson Christensen, et.al.)
- Monthly analysis of coherence between GW channel and selected environmental channels
 - 1024 s periods, 0.977 mHz resolution
 - Peaks identified as exceeding cutoff level at 3 sigma
- Also “mining” the same results for specific lines from the S5 pulsar searches
- Results for August, September 2006 ready
 - » Web page:
<http://virgo.physics.carleton.edu/Hans/coherence/peaks/index.html>

Sample pulsar line coherences

- H1 - 66 Hz - Coherence with LVEA, BSC1 EM channels
- L1 - 90.475Hz - Coherence with BSC1 accelerometers
- L1 - 127.285Hz - Coherence with coil magnetometers





“Eternal” Spectral Line Mysteries



- 329 Hz Lines (all IFOs)
 - » Strong enough that 2nd, 3rd harmonics seen
 - » Speculation that they are Beam Splitter (BS) Violin Modes
- 335 Hz Lines (H1, etc.)
 - » Rung up very strongly when beam power raised prior to science mode
 - » Speculation that they are Recycling Mirror (RM) violin modes
- 646-648 Hz Lines (all IFOs)
 - » 2nd, 3rd Harmonics often seen
 - » Coherences in other interferometer channels (**+/-15V power supply ripple?**)
- 546,566 Hz Lines (H1 only)
 - » Again, 2nd, 3rd harmonics often seen
 - » Coherent with some WFS channels (**+/-15V power supply ripple?**)
- 2.60, 2.64 Hz combs (H2 only)
 - » Extend from 40-100 Hz
 - » Seen in ETMX, ETMY shadow sensors

Possible Future Work

- Improve follow-up on commissioning investigations
- Continue Environmental Coherence Catalog
- Help Pulsar, Stochastic Groups prepare final lists
- Perhaps plan commissioning work to mitigate 546, 646Hz lines apparently due to $\pm 15V$ power supplies
- Perhaps more commissioning investigations at Livingston
- Do we need more planning of our activities (or not?)
- Work on joint investigations with Virgo
- Suggestions from the floor...