S5 Spectral Line Cataloguing

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for the Spectral Line Working Group

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Why Look at Spectral Lines?

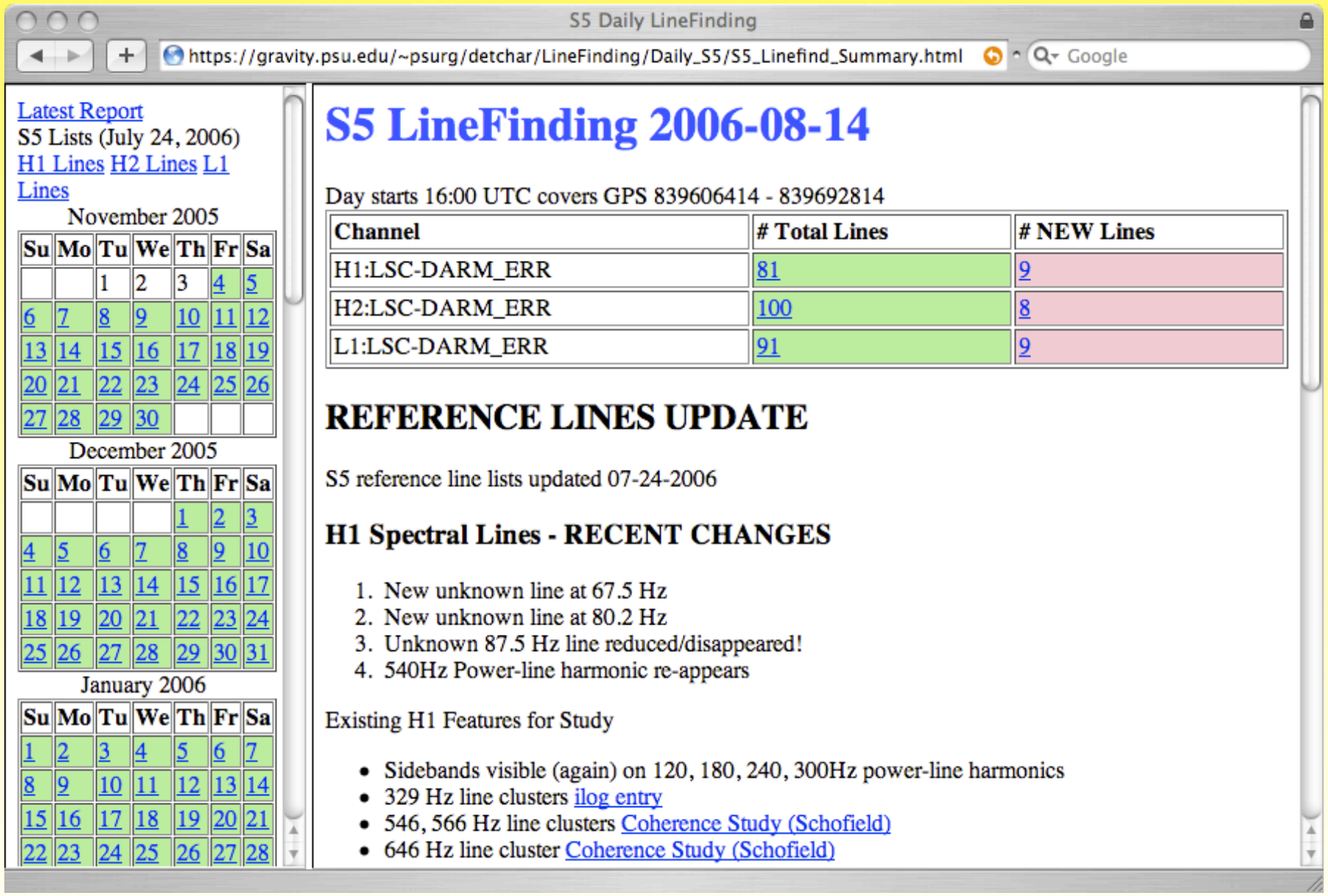
- Direct impact on GW searches
  - Broad peaks cut into bandwidth (Pulsar)
  - Narrow L1/H1 coherences (Pulsar)
  - Broad H1/H2 coherences (Stochastic)
  - Non-stationarity in line sources causes transients (Burst)
  - Broad, drifting lines (Burst)
- Indicate unwanted couplings into GW channel
  - Specific 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)
  - 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 H1/L1 Spectral Lines

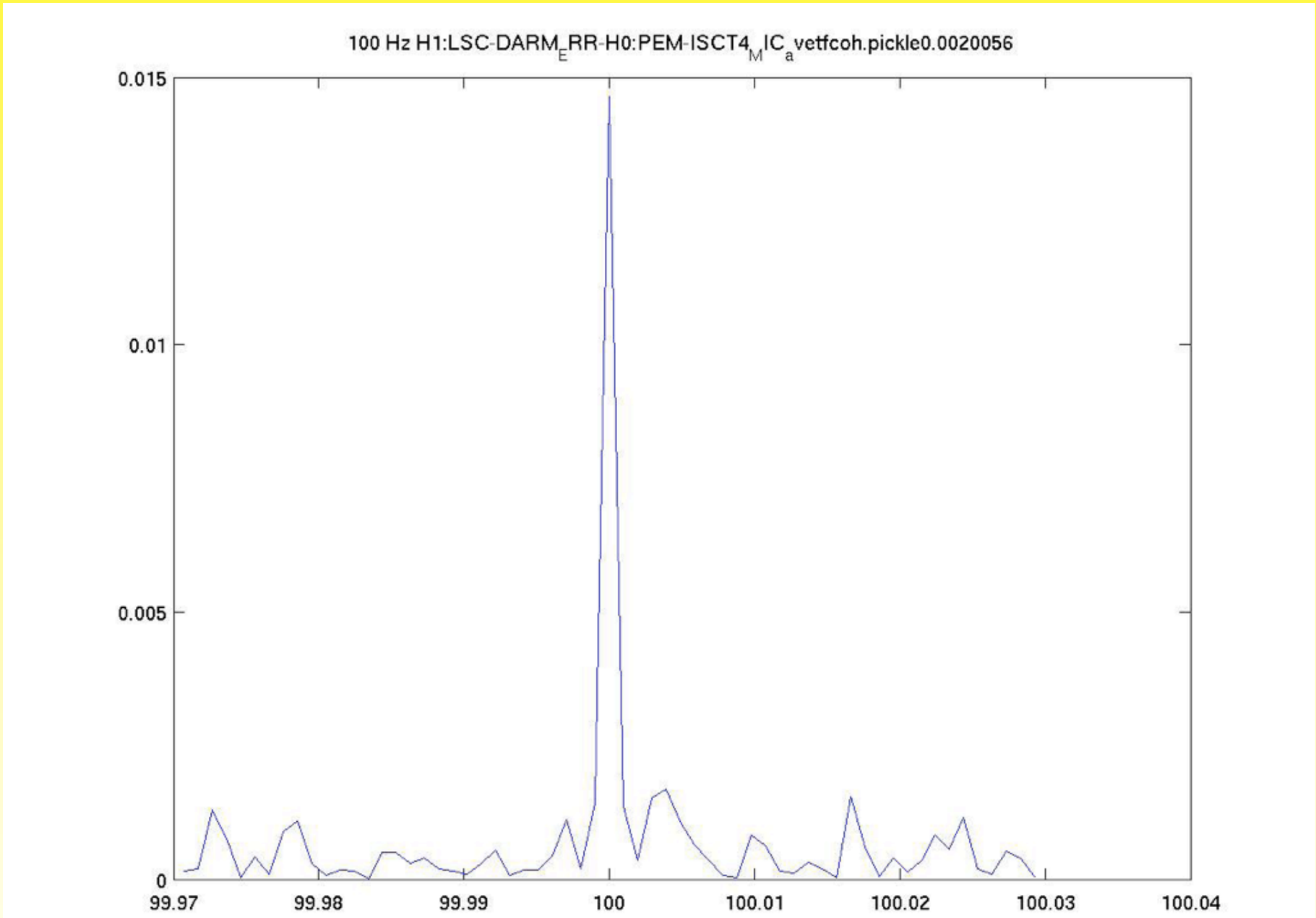
- Pulsar searches are particularly concerned with lines that are coherent between the 4K detectors (H1, L1)
- Short Fourier Transforms (SFTs) were searched with Fscan and spectrograms prepared (Mendell, Dupuis)
  - Required Δf of 2.2 x10-4 (generous Doppler window), SNR > 4
  - http://www.ligo.caltech.edu/~rejean/S5/spectrograms/
  - Very good at showing wandering lines
- Quasi-stationary lines coincident within 10 mHz between H1 and L1 reported from PowerFlux (Riles)
  - Strongest were harmonics of 16 Hz

Environmental Coherence

- Work done by Carleton College (Nelson Christensen, et.al.)
- Monthly analysis of coherence between GW channel and selected environmental channels
  - 1024 s periods, 2000 averages per month
  - Identify significant peaks
    - http://virgo.physics.carleton.edu/Hans/coherence/peaks
- Targeted searches to follow up specific lines from the S5 pulsar searches, line-finder “Top Ten” Lists
  - They note when line appear/disappear, 30Hz band around line
  - http://virgo.physics.carleton.edu/Hans/coherence/peaks/Top_Ten/index.html
- Open offer to scan other line lists!

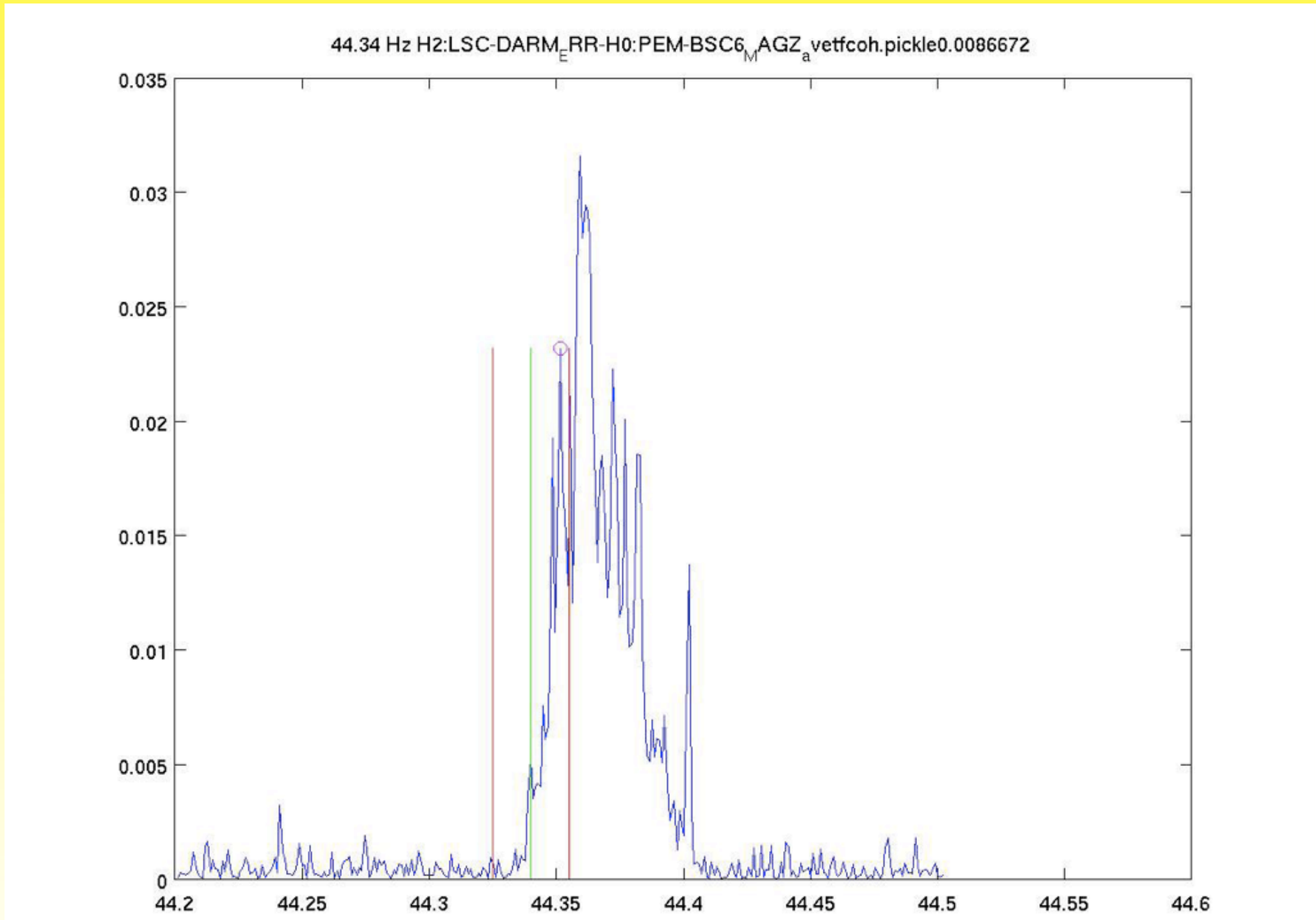
Pulsar Line Coherence

- H1 - 100 Hz - Coherence with microphones



Top Ten List Coherence

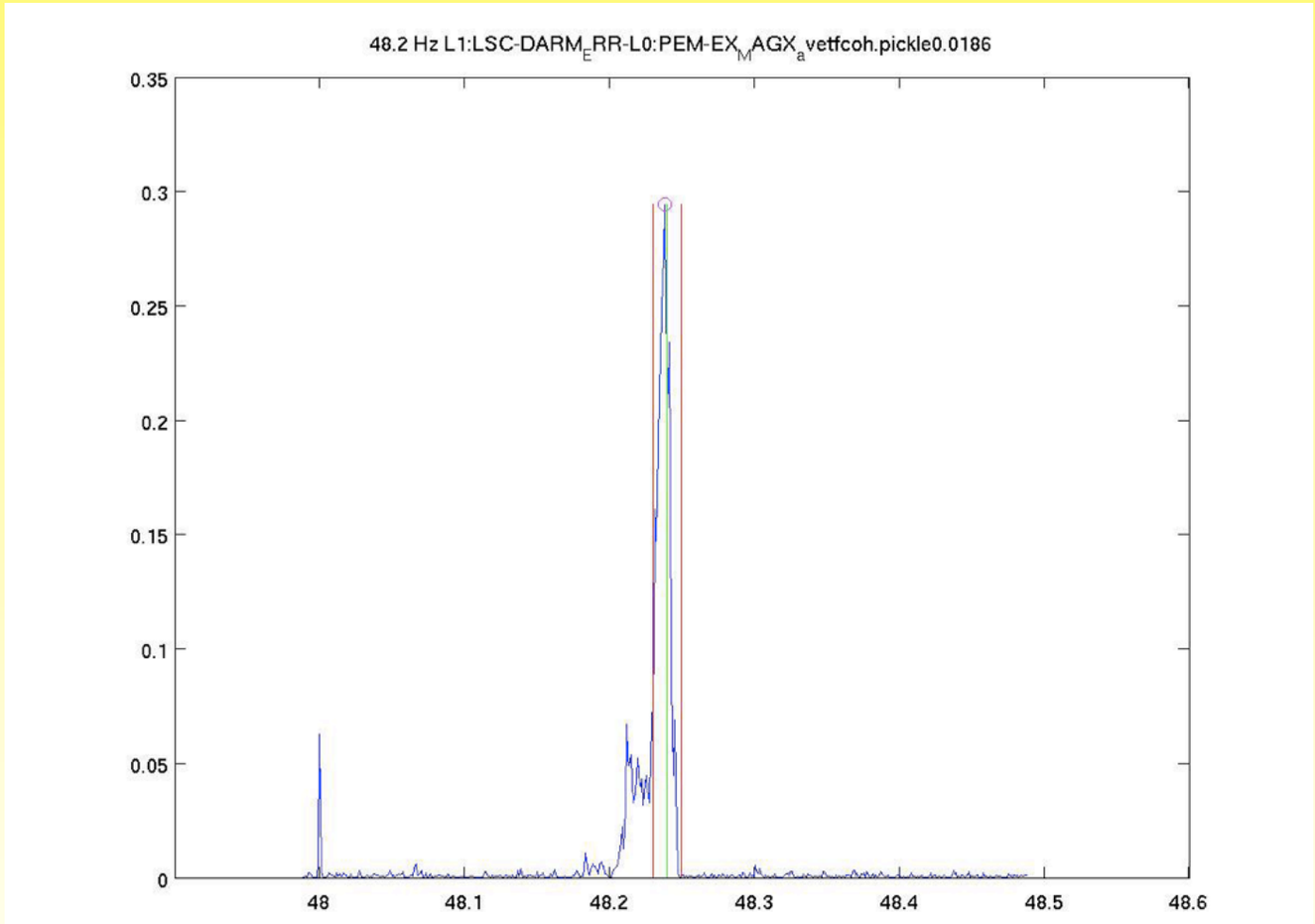
- H2 44.34 Hz line - Coherence with BSC6_MAG_(X,Y,Z)



L1 Optical Lever Lines

- Line-finder sees ~ 48Hz lines in L1 DARM_ERR
  - Associated with Optical Lever lasers (Waldman)
- Coherence seen with magnetometers confirms location
  - 48.2Hz - ETMX, 47.4Hz - ETMY

- May arise from currents in Peltier coolers for lasers



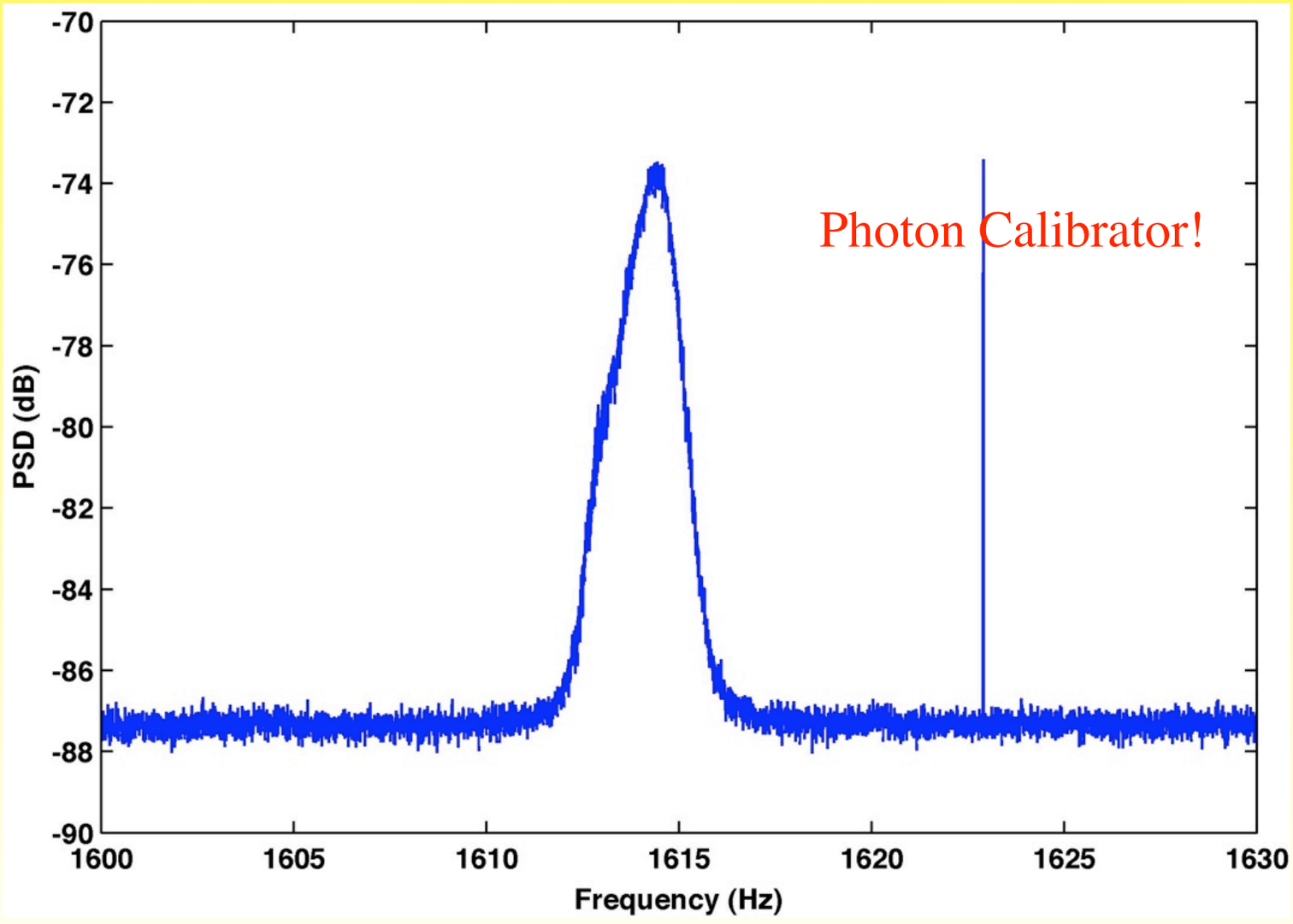
Progress on 546, 646Hz Lines

- 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 from H1 DARM_ERR seen in +-15V center supply ripple
  - This does not implicate power supply as source. May just be response to load from somewhere within racks
- Similar features in H2, L1 spectra since S2
- Often 2nd and 3rd harmonics are seen in DARM_ERR
- Definite nuisance for pulsar studies (Einstein@Home)

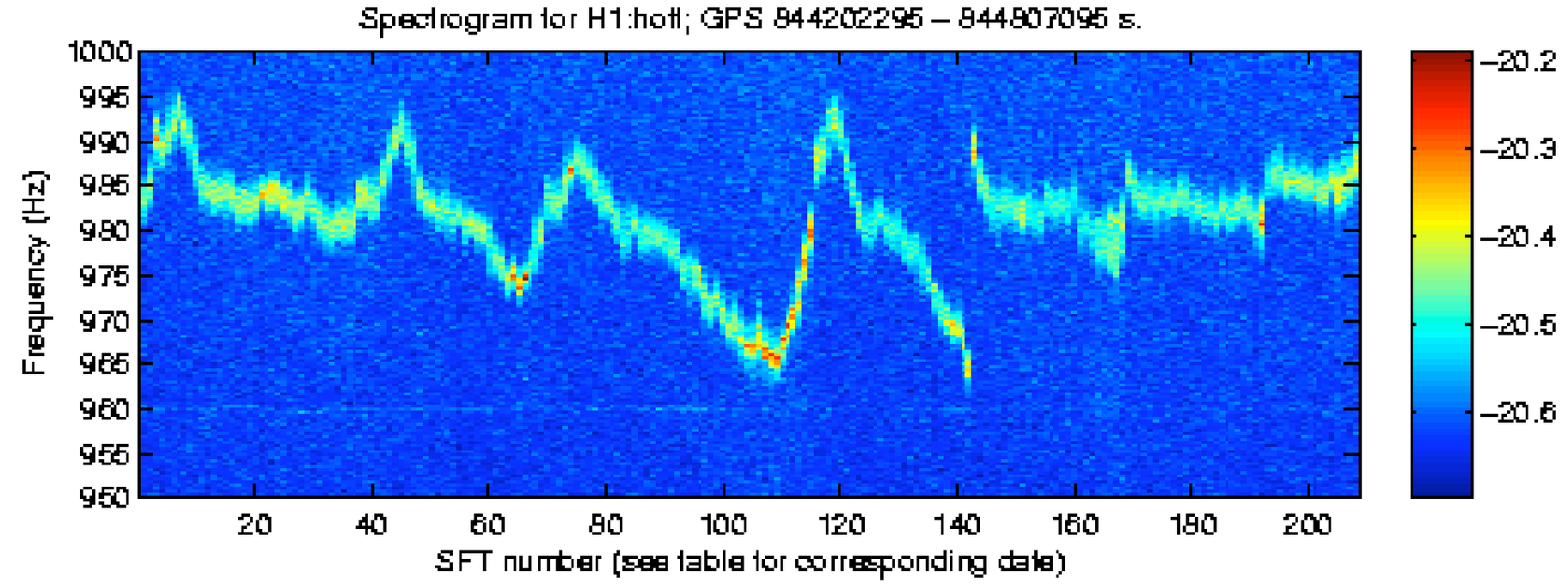
Broad, wandering Lines

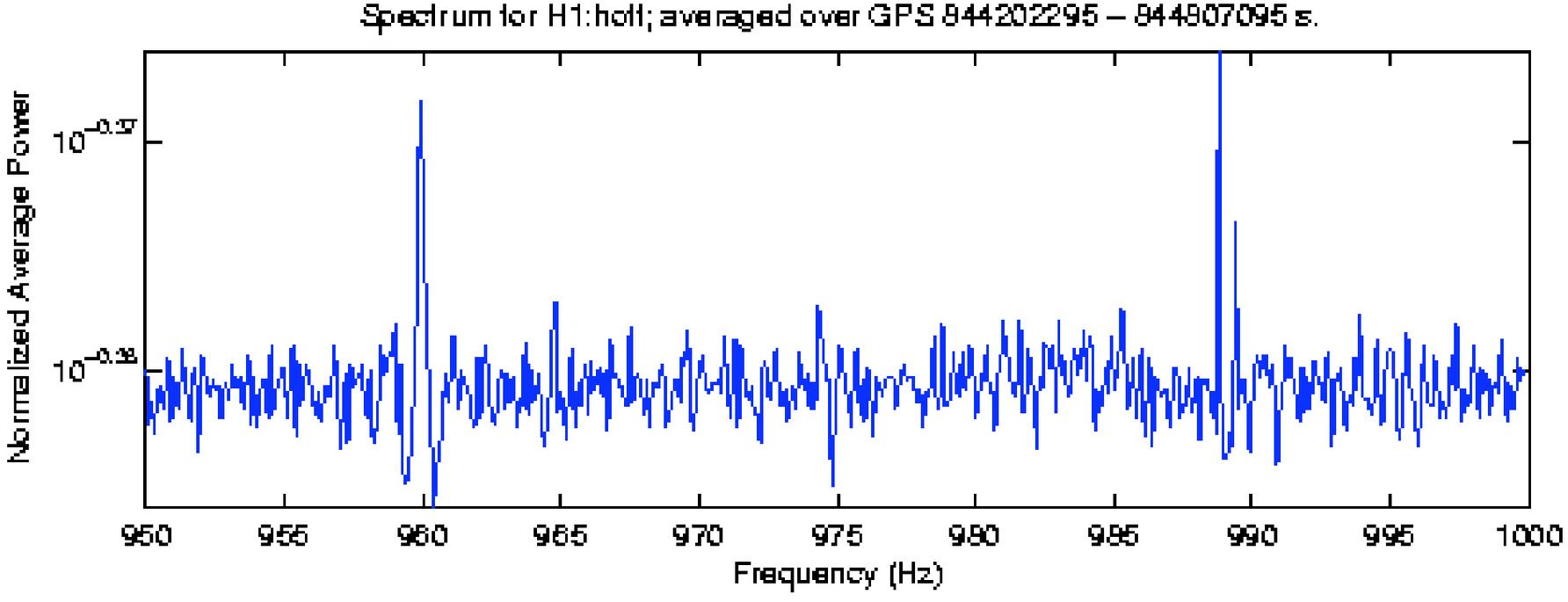
- Broad (< 1Hz) wandering between 1 and 2 KHz
  - H1 has ~1020, ~1090 Hz, H2 has ~1490, ~1615 Hz (July 2007)
- Seen in daily line-finder, spectrograms

PSD of H2 for 24 hour period (Line-finder)



S5 Spectrogram





The Future

- Near-Term Priorities
  - Source identification studies during S5 close-out
  - “Identified” Spectral Line Catalogue for pulsar analysis
  - PEM coherence tabulation for stochastic analysis
  - Work with Virgo on spectral line studies
- Longer-Term Possibilities
  - H2 line source identification and mitigation
  - Review of PEM sensor locations for S6
  - Development of rapid-followup tools for commissioning