Interpretation of S5 H1H2 Results

Nelson Christensen and Eric Thrane
for the Stochastic Group

June 6, 2013

H1H2 Snapshot

- https://dcc.ligo.org/LIGO-P1000112
- Astrophysical limit set on Ω_3 in 460-1000 Hz band improves on previous best by a factor of 350x.
  - We may never reach comparable sensitivity with aLIGO-aVirgo detectors.
- No limit set in 80-160 Hz band.

Ground rules

- The group has developed a framework for deciding when a stochastic result should have astrophysical implications.
  - Basic idea: distinguish between plausible scenarios that could invalidate stated limits and implausible conspiracy theories.
  - If plausible scenarios exist, do not set limit.
  - If not, limit just GW signal.

Decision criteria

1. We have accounted for all known noise sources through either direct subtraction, vetoing, and/or proper estimate of systematic errors.
2. Having accounted for known noise sources, we do not observe evidence of residual noise that is inconsistent with our signal and noise models.

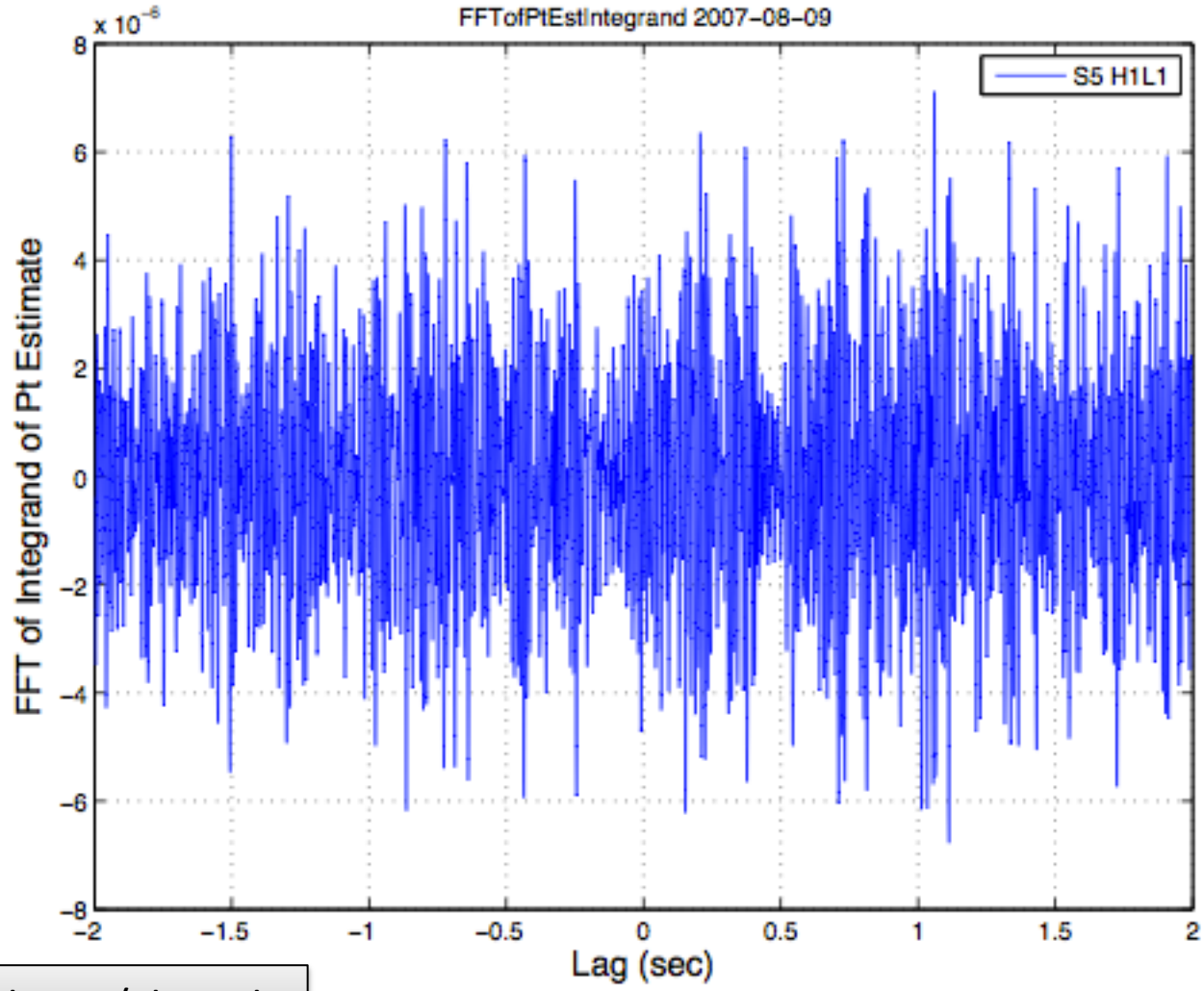
- To the best of our knowledge, there is no plausible mechanism which could produce persistent correlated noise comparable in magnitude and spectral shape to the GW signal we are trying to measure.

See Section VII of the paper draft.

S5 LHO-LLO

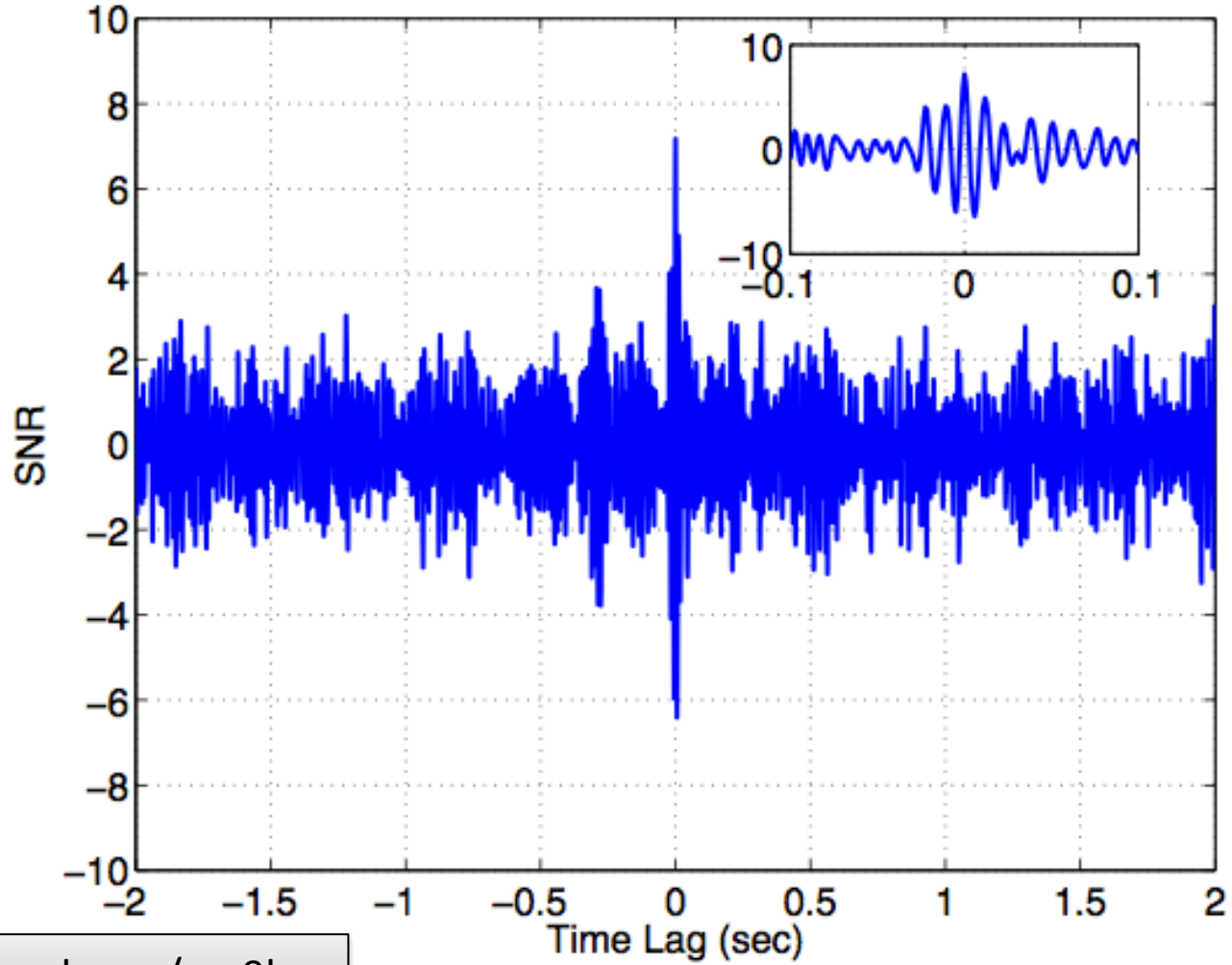
1. Known noise sources ✓
   - We perform coherence and time-shift analyses to test if the data appear well-behaved.
   - We notch instrumental lines, eliminate glitchy segments, etc..
2. Residual noise ✓
   - Diagnostic plots such as IFFT(Y) vs. lag are consistent with signal + well-behaved noise.
3. Broadband correlation ✓
   - Only plausible candidate—Schumann resonances—are too small to matter according to order-of-magnitude calculations; more on this below.

S5 LHO-LLO IFFT



http://tinyurl.com/ak7w4ly

S5 LHO-LLO injected signal IFFT

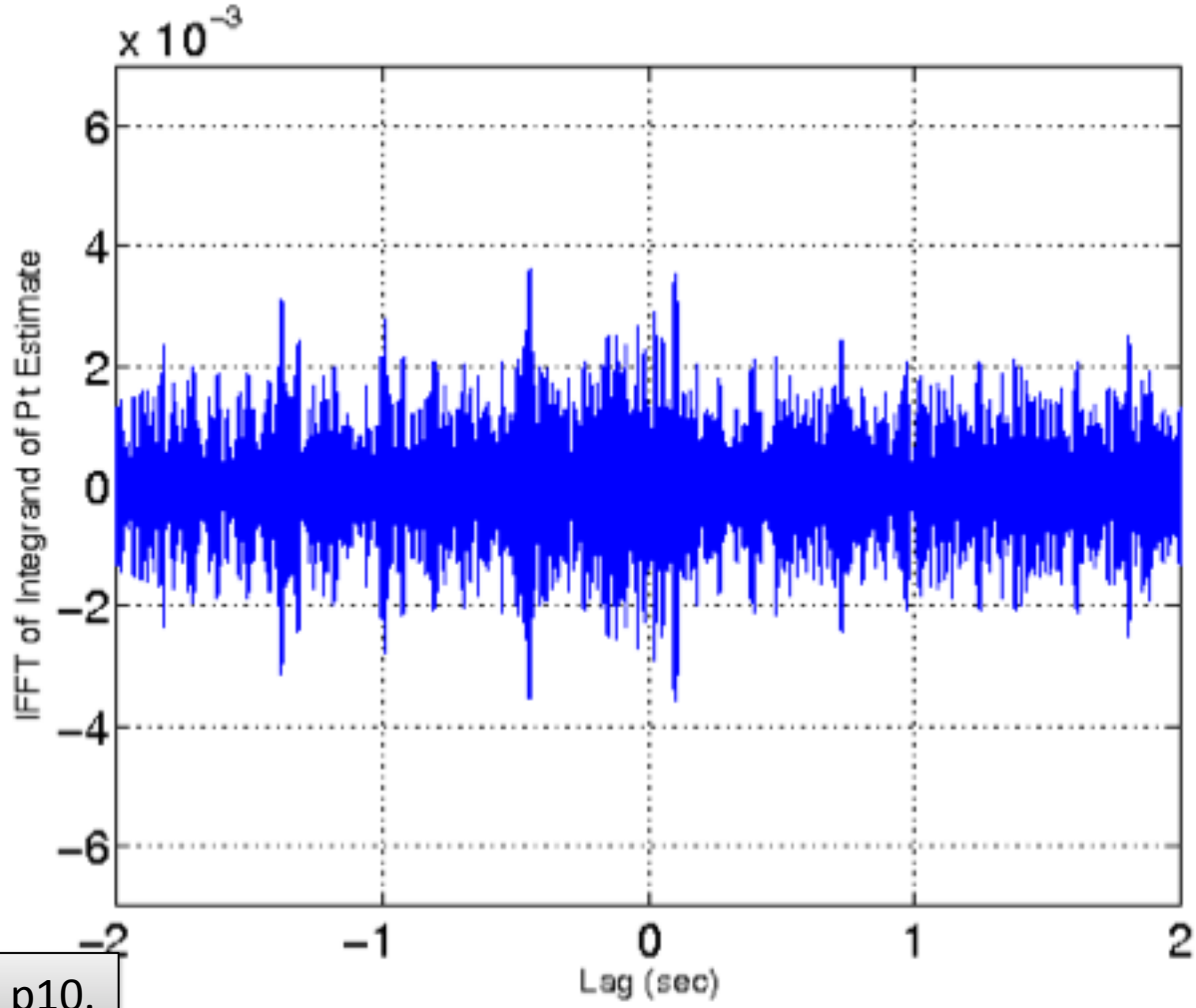


http://tinyurl.com/aar9lpp

S5 H1H2 high-frequency

1. Known noise sources ✓
   - In addition to usual procedures, PEM analysis used to notch instrumental artifacts, etc..
2. Residual noise ✓
   - Diagnostic plots consistent with well-behaved noise + signal.
3. Broadband correlation ✓
   - Report from R. Schofield: *We think that the H1-H2 investigation adequately addressed known potential sources of systematic error, and we have no evidence that the H1-H2 experiment is uniquely susceptible to unknown systematics.*

S5 H1-H2 460-1000 Hz IFFT

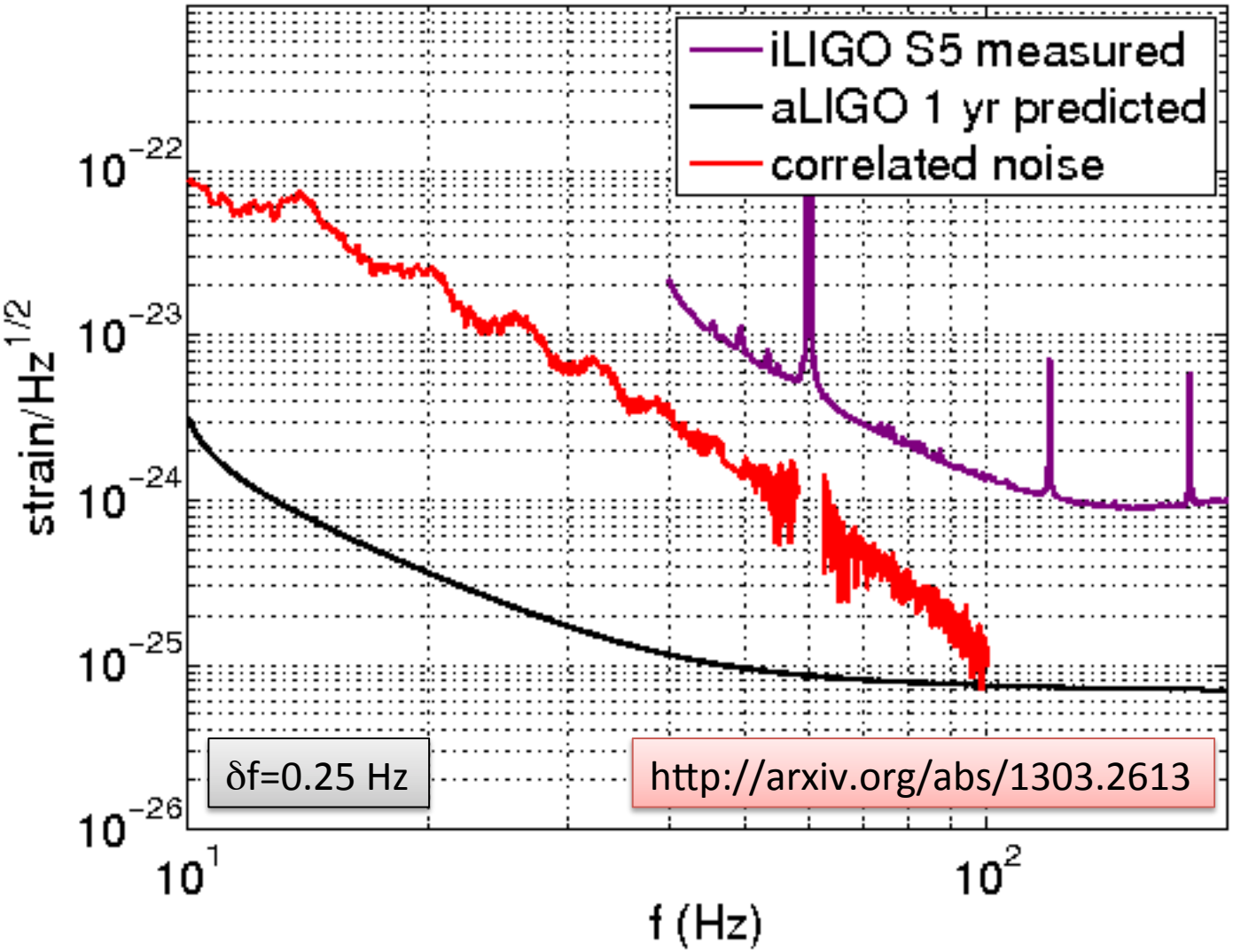


See Fig 5 on p10.

View of the stochastic group

- Use decision criteria to decide on whether or not to set limits.
- We argue that they are met for S5 H1H2 high-f results.
- No asymmetry in the way we treat co-located and separated detectors.
- Our decisions now may affect results in the advanced detector era…

Correlated noise from global B fields



Extra slides

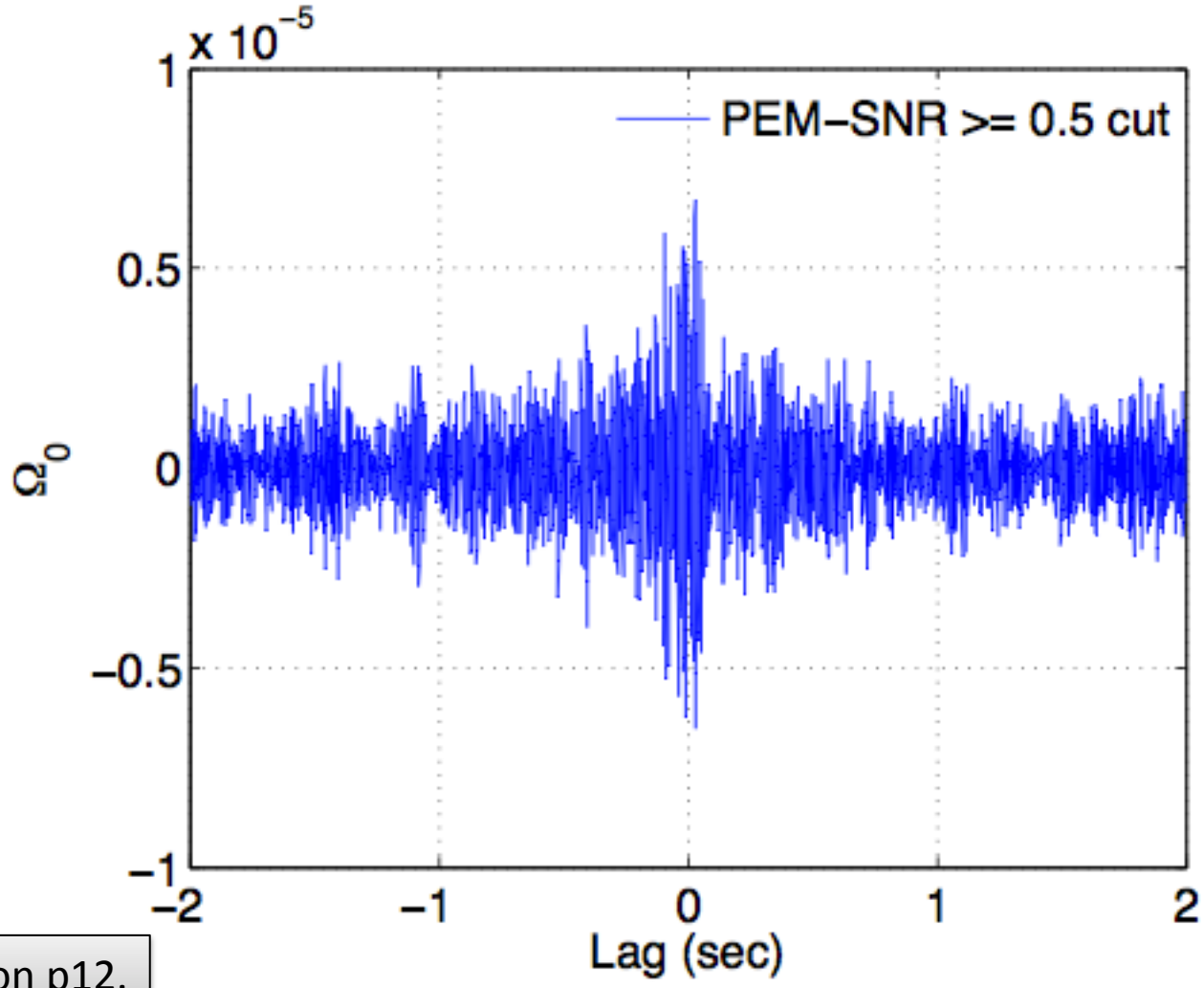
Report from R. Schofield: Summary

1. We know of no environmental influences that could produce correlated signals in H1 and H2 without being detected with much higher SNR by the PEM sensors.
2. We statistically tested for self-inflicted sources of correlations from control and data systems.
3. We argued that light leaking from H1 into H2 could not produce a correlation, and we tested for one anyway.
4. We searched extensively for scattering sites that might modulate both H1 and H2 light and ensured that the sites that we found were well covered by the PEM system.
5. To test our understanding of correlation mechanisms and to search for any mystery sources of correlations, we attempted to identify the sources of all excess coherence features in H1H2 between 80 and 400 Hz.

S5 H1H2 low-frequency

1. Known noise sources ✓
   - In addition to usual procedures, PEM analysis used to notch instrumental artifacts, etc..
2. Residual noise ?
   - Qualitatively, diagnostic plots consistent with expected correlated noise sources.
   - More work necessary to build quantitative model, but…
   - Expected Ω_0 improvement marginal anyway, so we are not pursuing this option.
3. Broadband correlation ✓
   - See report from R. Schofield.

S5 H1-H2 460-1000 Hz IFFT



See Fig 8 on p12.