
First Results for Stochastic Gravitational Wave Searches Using LIGO Data

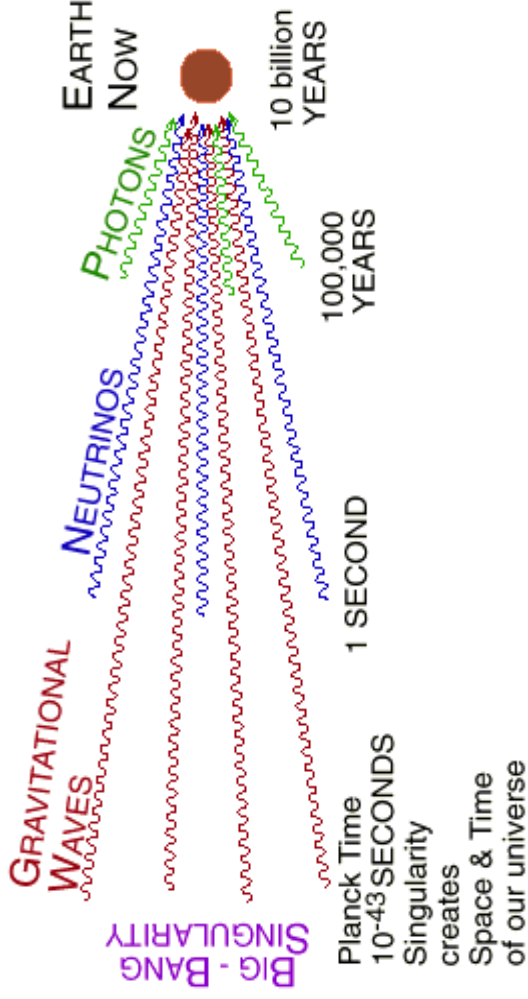
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April 6, 2003

Sources of Stochastic Gws

- Random GW signal produced by a large number of weak, independent, unresolved GW sources
- Detect by cross-correlating the output of two GW detectors
- Strength specified by the ratio of energy density in GWs to the total energy density needed to close universe



$$\int d(\ln f) \Omega_{\text{GW}}(f) = \frac{\rho_{\text{GW}}}{\rho_{\text{critical}}}$$

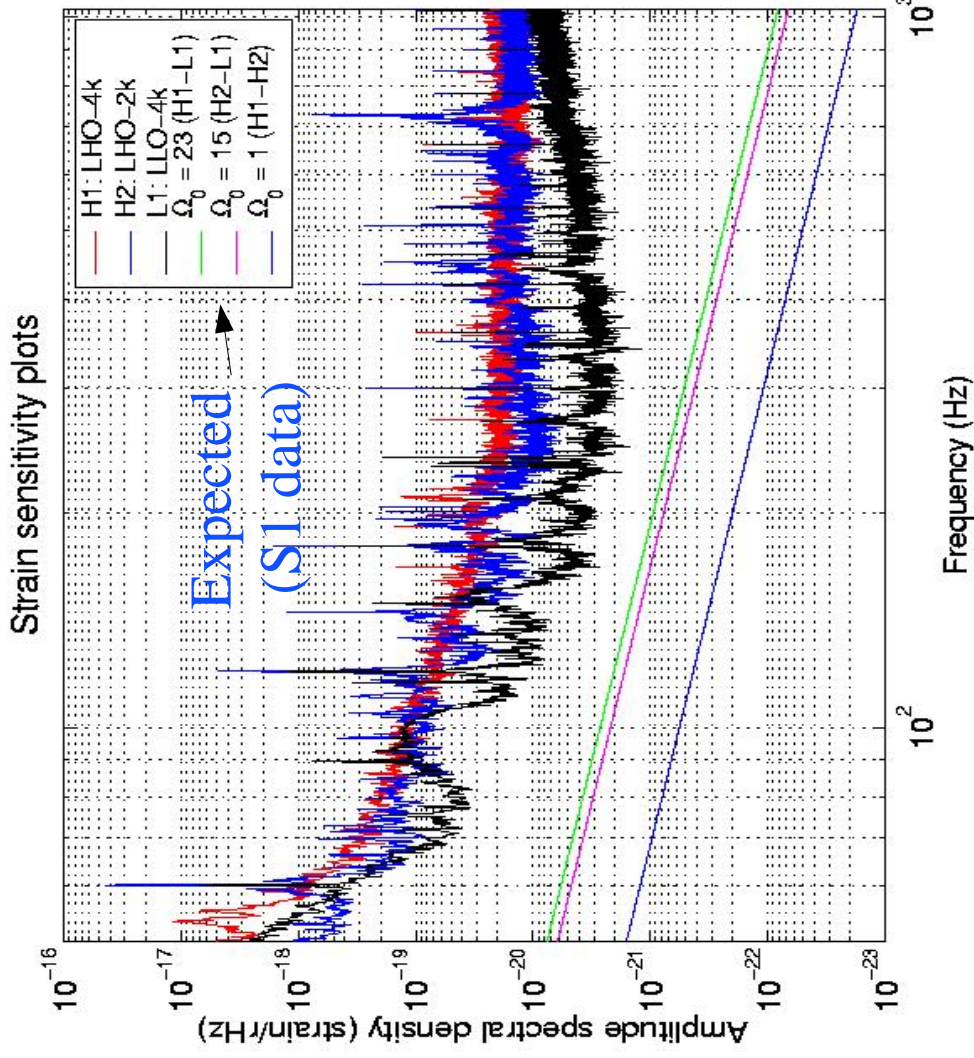
Upper Limits on Stochastic Gws

- Current best upper limits:
 - » From big-bang nucleosynthesis:

$$\int d(\ln f) \Omega_{GW}(f) < 1 \times 10^{-5}$$
 - » Garching-Glasgow interferometers:

$$\Omega_{GW}(f) < 3 \times 10^5$$
 - » EXPLORER-NAUTILUS cryogenic bars:

$$\Omega_{GW}(907 \text{ Hz}) < 60$$
- Cross-correlation technique allows one to dig out the signal below individual noise floors



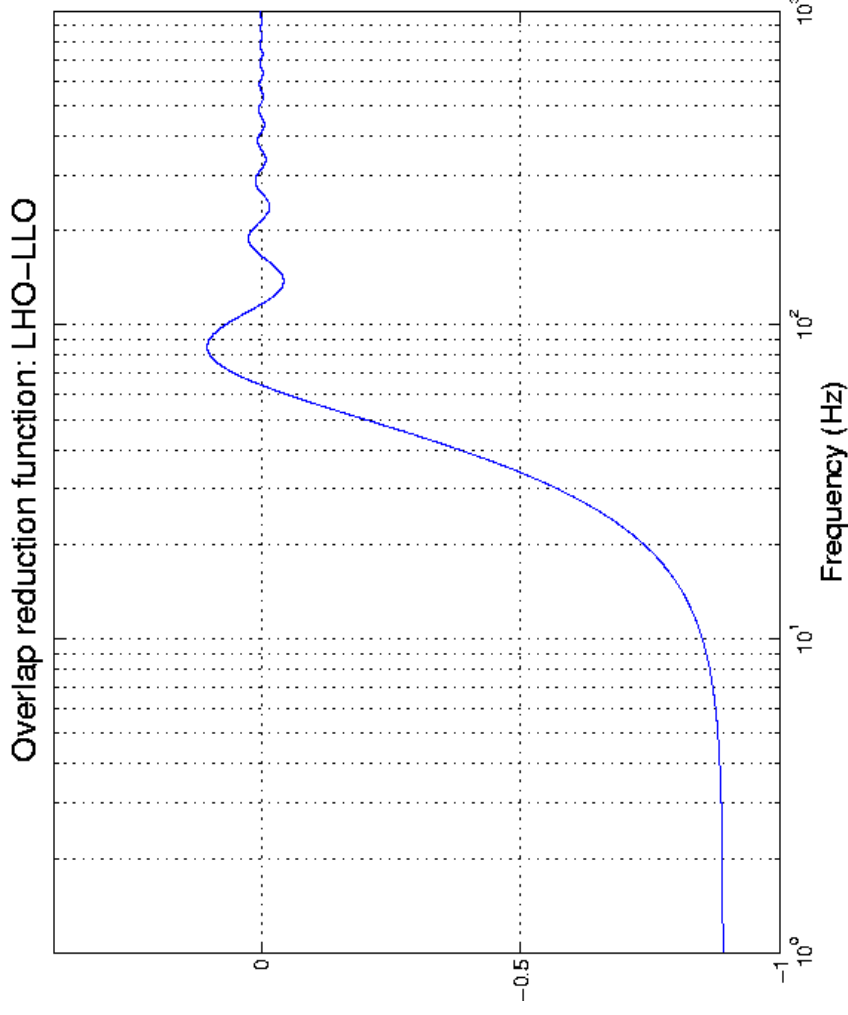
Detection Method

- Cross-correlation statistic:

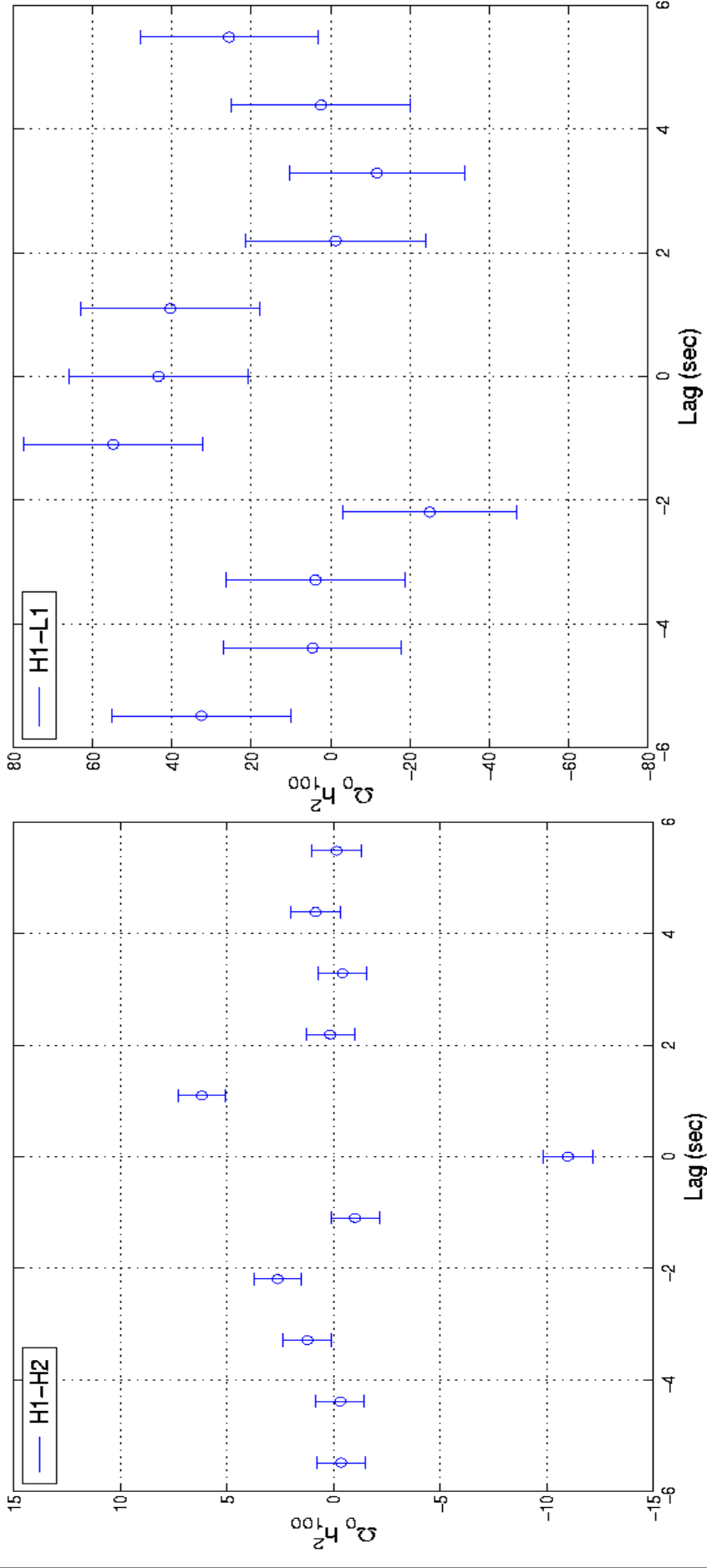
$$Y = T \int df h_1(f) Q(f) h_2(f)$$
- Optimal filter:

$$Q(f) = N \frac{\chi(f) \Omega_{GW}(f)}{f^3 P_1(f) P_2(f)}$$
- Normalization chosen so:

$$\langle Y \rangle = \Omega_0 T$$
- Overlap reduction function $\chi(\mathbf{f})$ encodes reduction in sensitivity due to separation and orientation of detectors



Time Shift Analyses -- S1 Data



Upper Limits and Confidence Intervals

I/O pair	90% CL interval	90% CL UL	Freq range	Obs time
H1-H2	-11 +/- 1.9	----	[40 Hz, 300 Hz]	107 hrs
H1-L1	+43 +/- 37	72.4	[40 Hz, 314 Hz]	62.3 hrs
H2-L1	0.36 +/- 22	In progress	[40 Hz, 314 Hz]	61.0 hrs

Expected Upper Limits for S1 data: 1 (H1-H2), 23 (H1-L1), 15 (H2-L1)

- Cross-correlation statistic technique applied to S1 data to set an UL on strength of stochastic GWs
- Evidence of cross-correlated instrumental noise for H1-H2 measurement (**currently under investigation**)
- Presence of line features in H2-L1 cross-correlation spectrum (**also currently under investigation**)
- Future runs expected to yield more interesting ULs:
 - » S2 (2 months, 10x better sensitivity): $\Omega_0 < 1 \times 10^{-2}$
 - » Four months at design sensitivity: $\Omega_0 < 5 \times 10^{-6}$