

Time-Domain Behavior of the 40-Meter Interferometer

Fred Raab
January 15, 1996

A Report on Preliminary Studies and Future Plans for Work with Collaborators:

- Torrey Lyons
- Aaron Gillespie (now at NBS, Gaithersburg)
- Kent Blackburn
- Andy Kuhnert
- James Mason

Goal: Institute Regular Time-Domain Operation and Analysis.

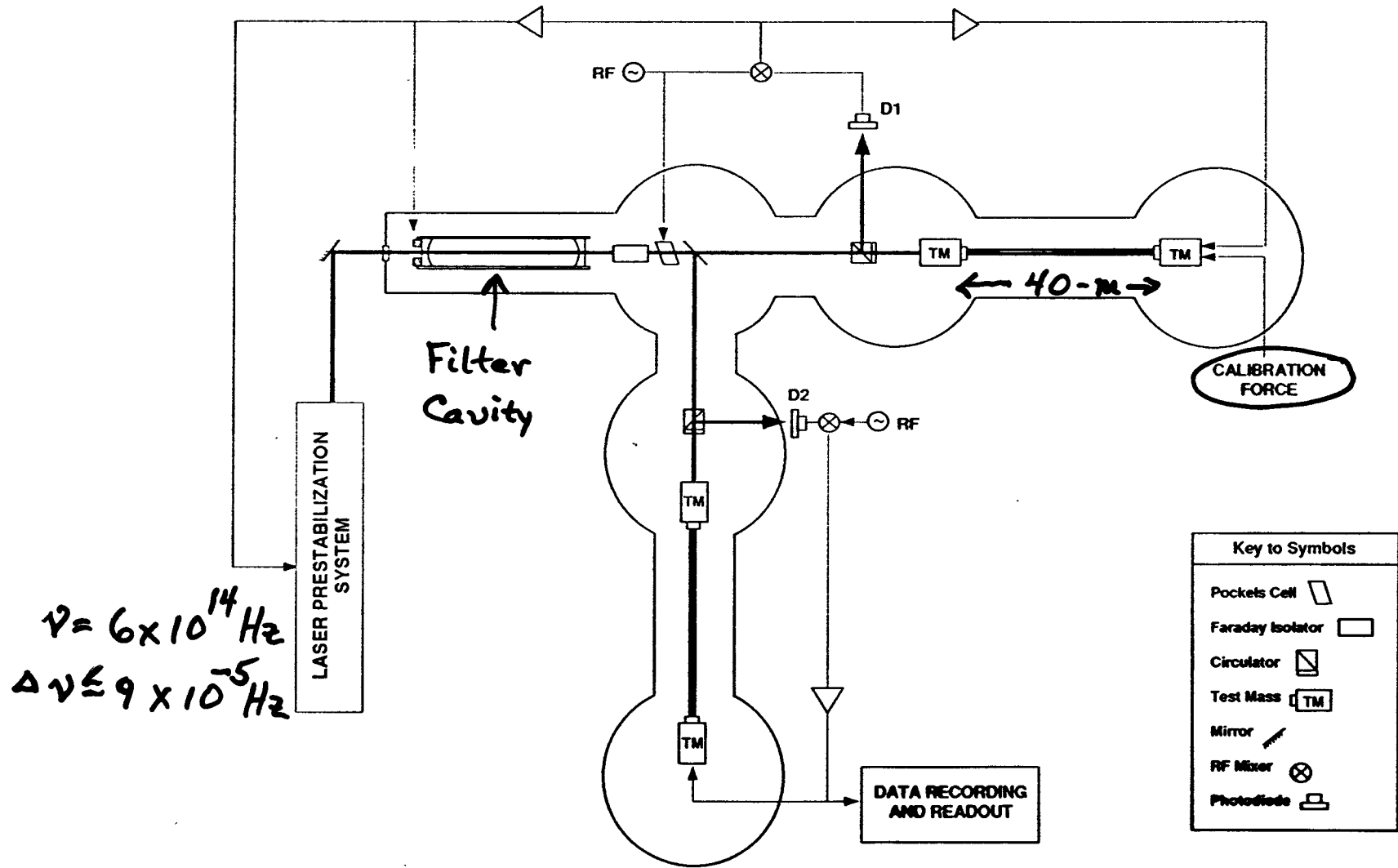
Non-Stationary Noise in a Laser Interferometer

- Most source detectability arguments are based on smooth stationary gaussian noise spectra with $\Delta f \approx f$; is this reasonable?
- Excess (non-gaussian) noise must be vetoed through environmental monitoring and coincidence techniques.
- Coincidence strategies often assume uniform rates for non-gaussian events (i.e. stationary). For LIGO:

$$R_{TRIPLE} \approx \tau_{12}\tau_{13}R_1R_2R_3$$

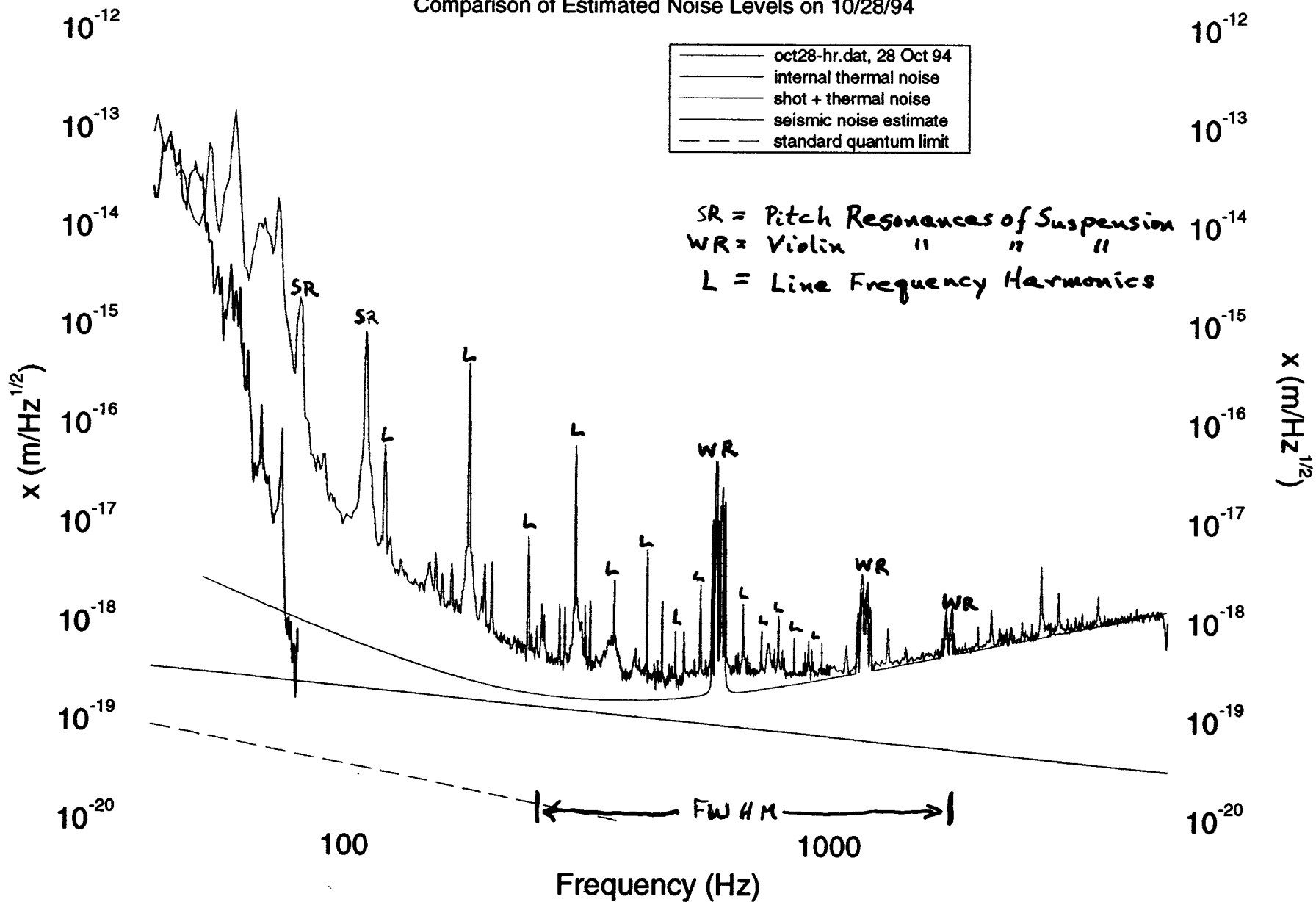
where τ_{ij} refer to coincidence window widths and R_k refer to the post-veto singles rates for interferometers 1, 2 and 3.

Mark II 40-Meter Interferometer



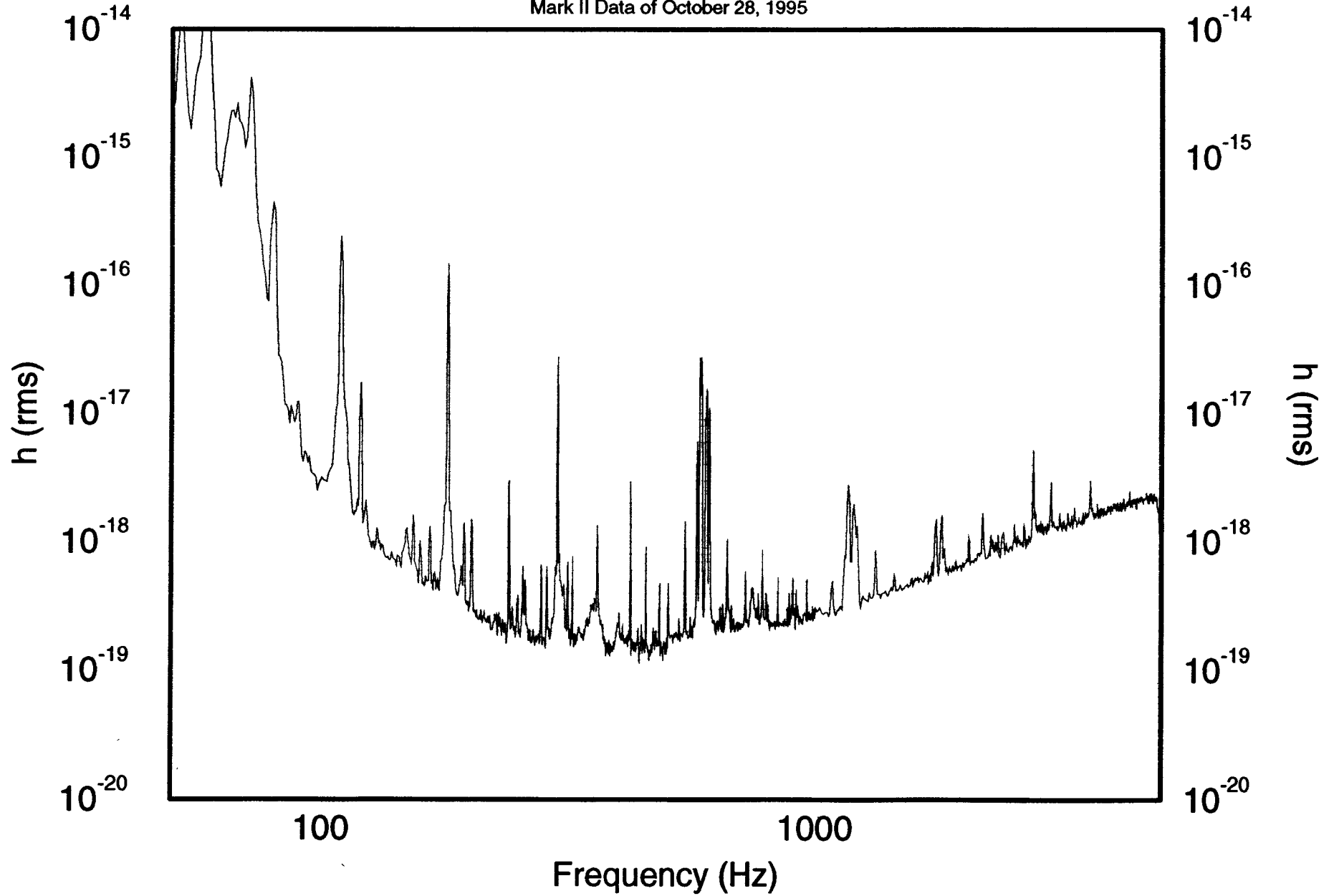
40 m Displacement Sensitivity

Comparison of Estimated Noise Levels on 10/28/94



RMS Strain Sensitivity of 40-Meter Interferometer

Mark II Data of October 28, 1995



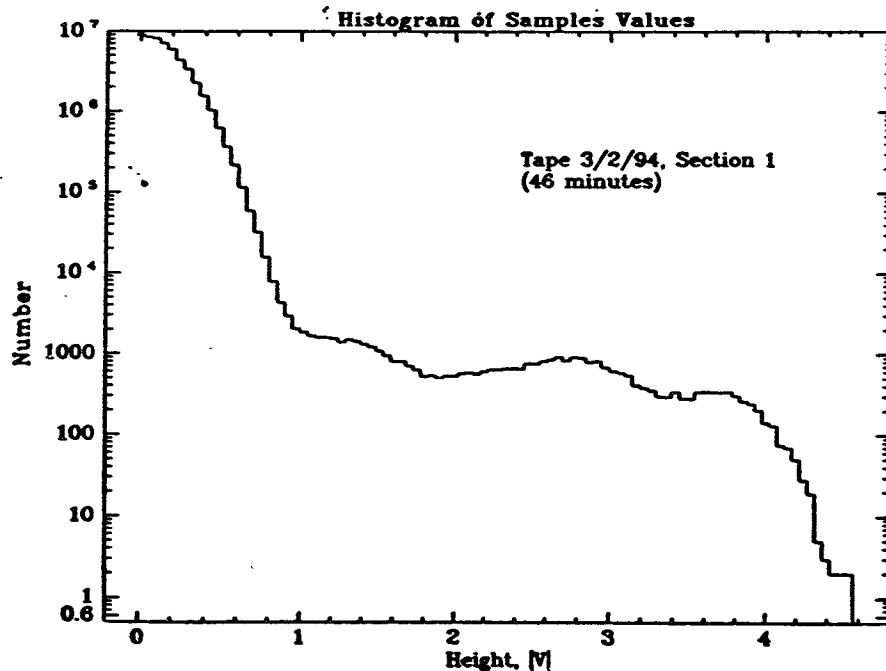
How Can Experimental Data From a Noisy Interferometer Be Characterized?

- Sample histograms from a wide-band channel are not very informative (at least not to us).
- Correlating data with templates: great for finding the expected, but surprises could get away!
- Machine artifacts need identification and characterization, but may not trigger sharply even in extensive template sets.
- Some tool kit for identifying “events” and characterizing is needed.

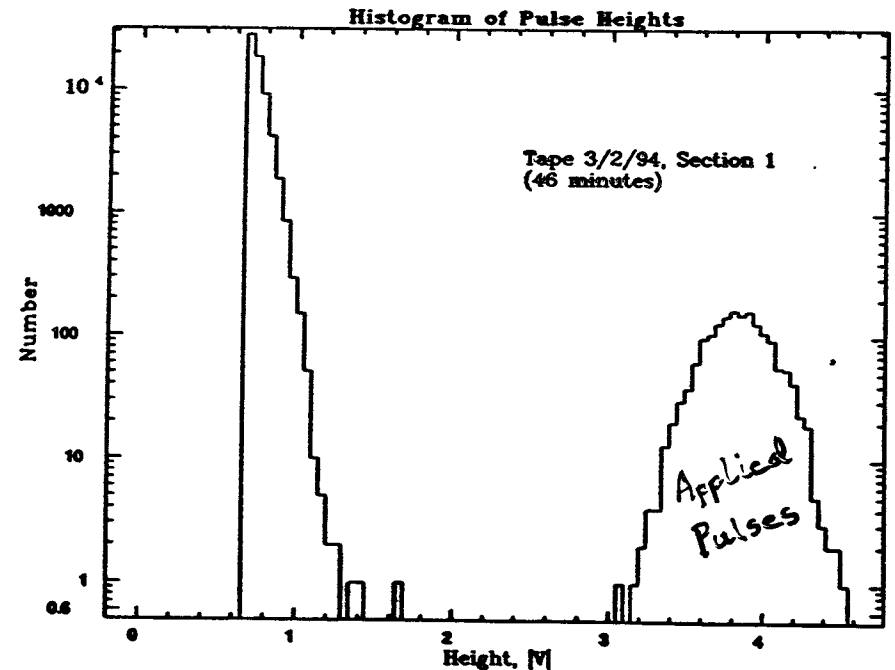
Utility of a Simple Event Finder Algorithm

- Threshold for event turn-on, variable dead time filter

Sample Histogram

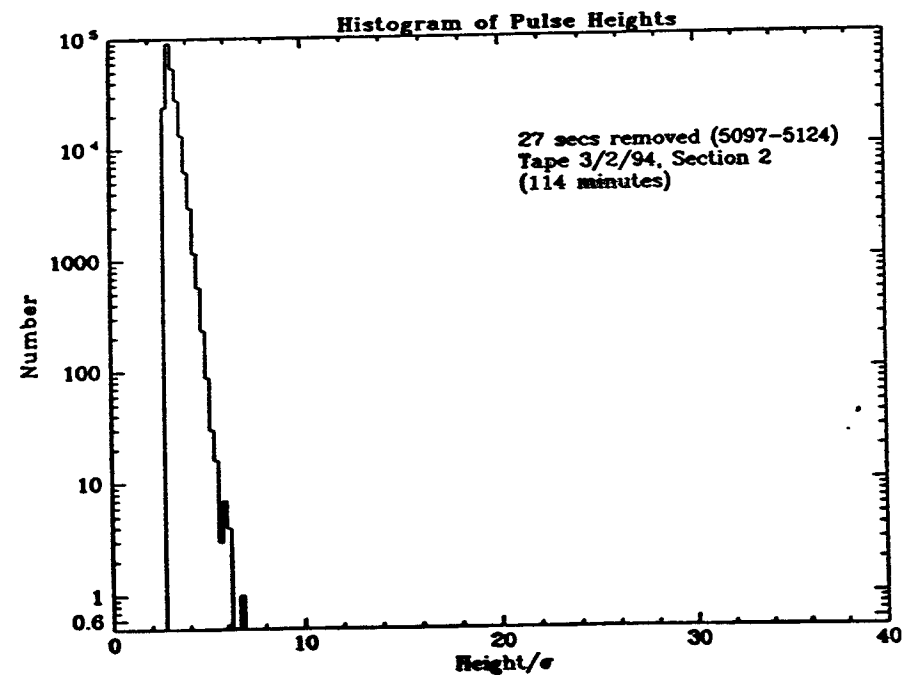
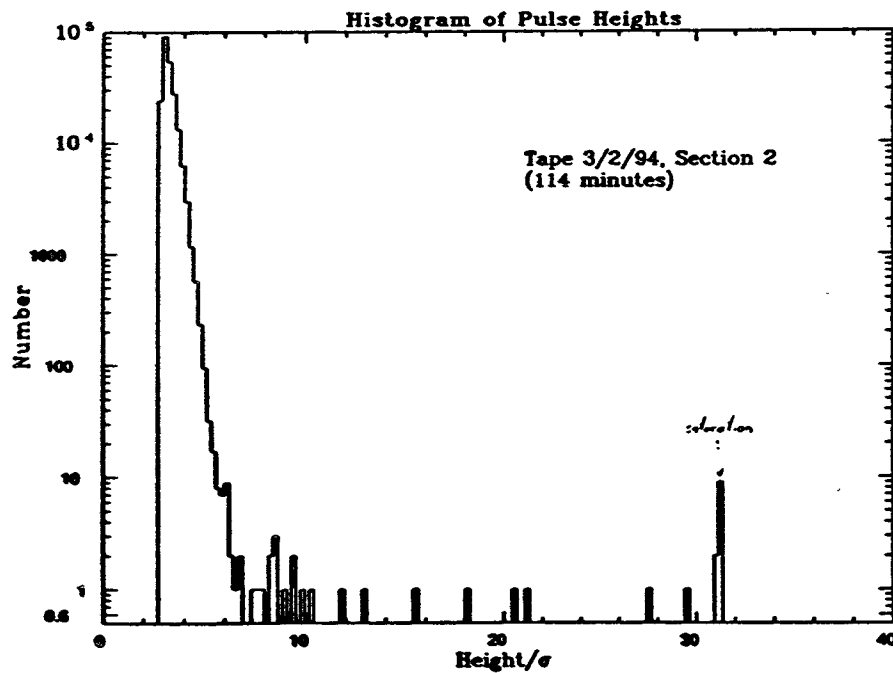


Event Histogram



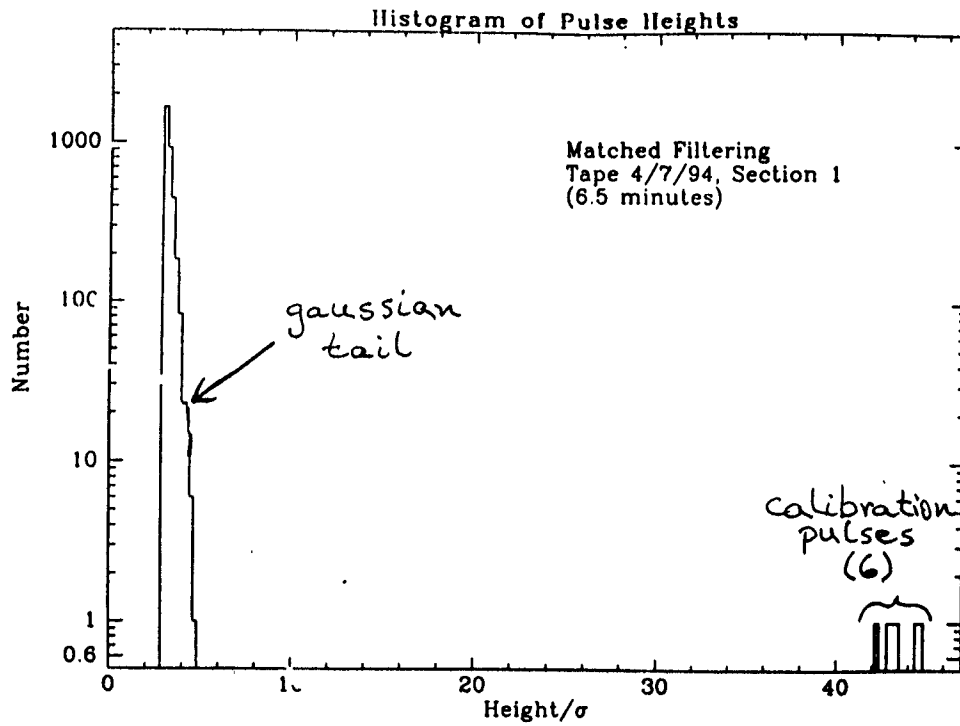
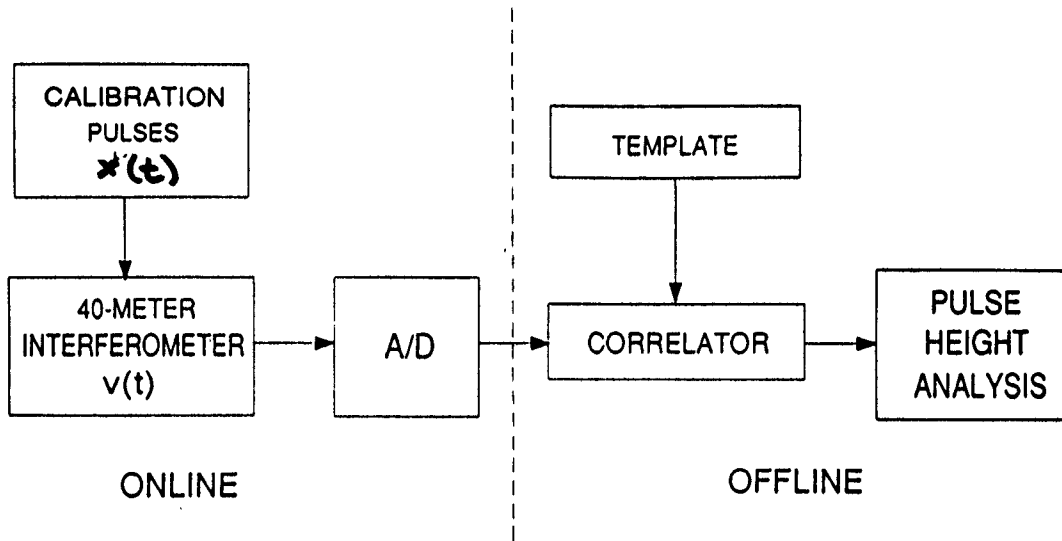
An Example of Non-Stationary Non-Gaussian Events

- Event histogram for this locked section is almost purely gaussian, except for a “minute” interval:



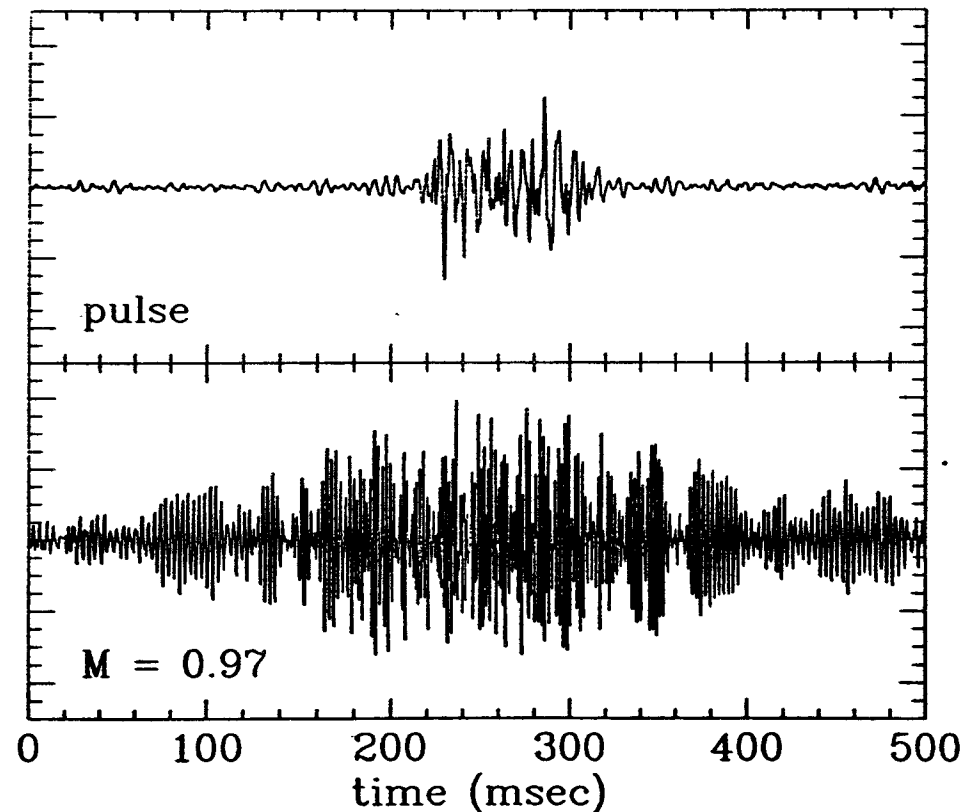
Pulse Sensitivity

(preliminary data)



An Example of a Non-Gaussian Event Feeding Through a Template

- Coalescing binary filter output is typical over large range of filters



Findings From Preliminary Look at 40-Meter IFO Time-Domain Data

- Observed non-gaussian events are non-stationary
- Events vary in character: clicks, “the scraper”, “the howler”, “the whistler”, etc.
- Causes which have been identified:
 - ›› higher-order transverse optical modes
 - ›› maladies in test-mass damping servos
 - ›› connector noise
 - ›› edge effects on photodiodes
- Promising news: event rates are sometimes very low!
- To keep rates always low will require comprehensive data on machine status

Future Plans

- Commence program of regular data runs with rapid analysis turn-around time:
 - ›› Increase running time with split between R&D and DATA shifts
 - ›› Limited manpower requires automated hardware and modest but efficient analysis
 - ›› Constant changes required by R&D/Detector programs means sensitivity will often be less than optimal
- Institute low-bandwidth, high-channel environmental/status monitoring system
 - ›› Use housekeeping statistics for cross-correlation studies of non-stationary noise
 - ›› Learn about drift and aging effects in machine operation