Transients Identification in Engineering Data

Julien Sylvestre
MIT

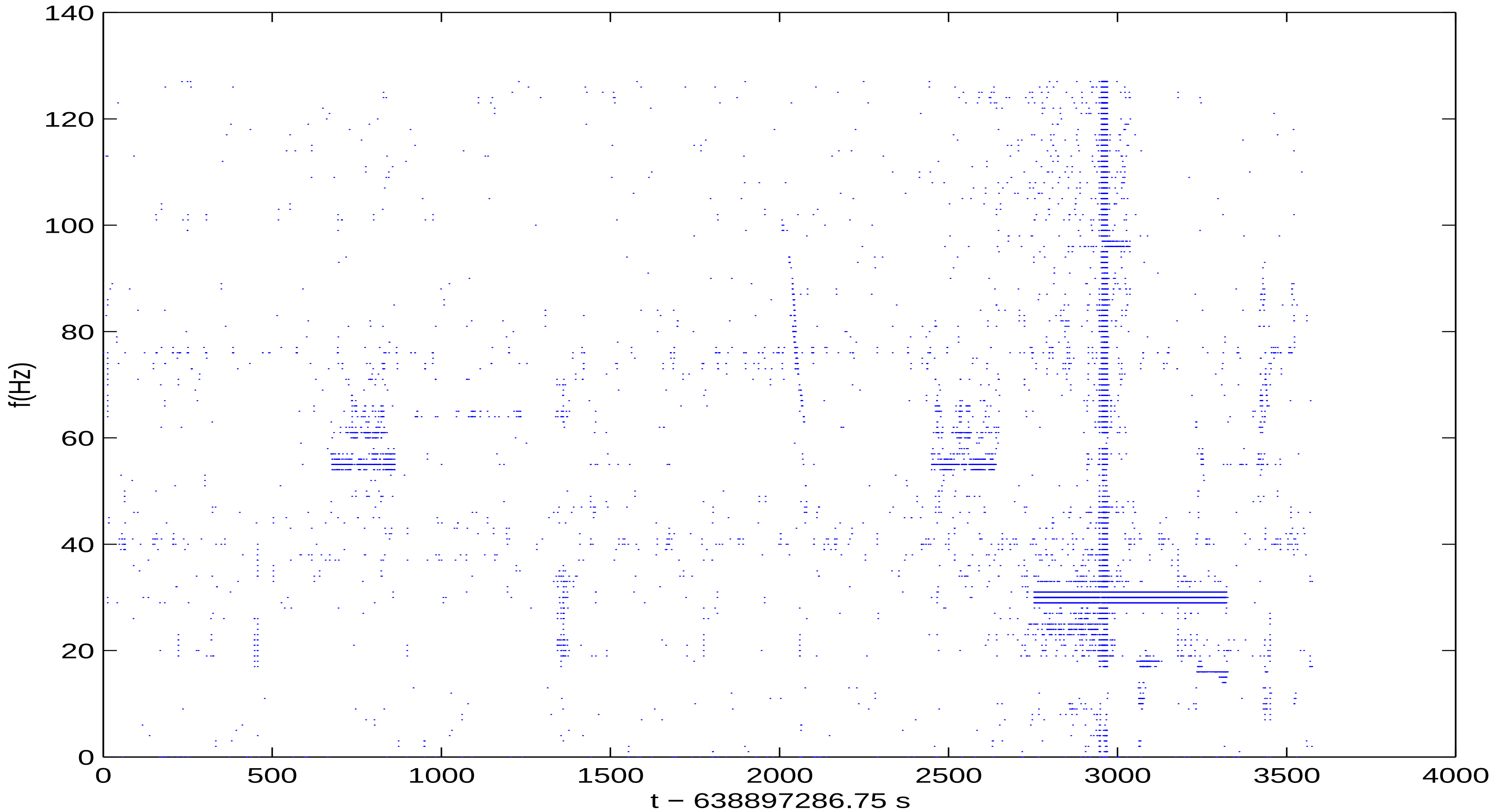
LSC Meeting, August 16, 2000.

LIGO-G000294-00-D

Power Detector: high-contrast t-f representation

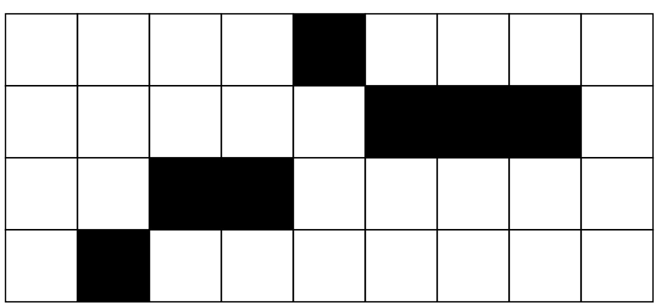
- Built using spectrogram with adaptative threshold
- Robust to non-gaussian noise (steady part), colored noise, strong transients
- Fast
- Bias statistics in a known way depending on choice of reso-lutions
- Real time code available under the DMT

Power Detector: an example from E1 data



Power Detector: clusters identification

- Test output: binary map, black pixel probability p for gaussian noise
- Connected clusters: results from Percolation Theory
- Disconnected clusters: new results for 2-points correlations
- Complete knowledge of false alarm rates and probability of detection



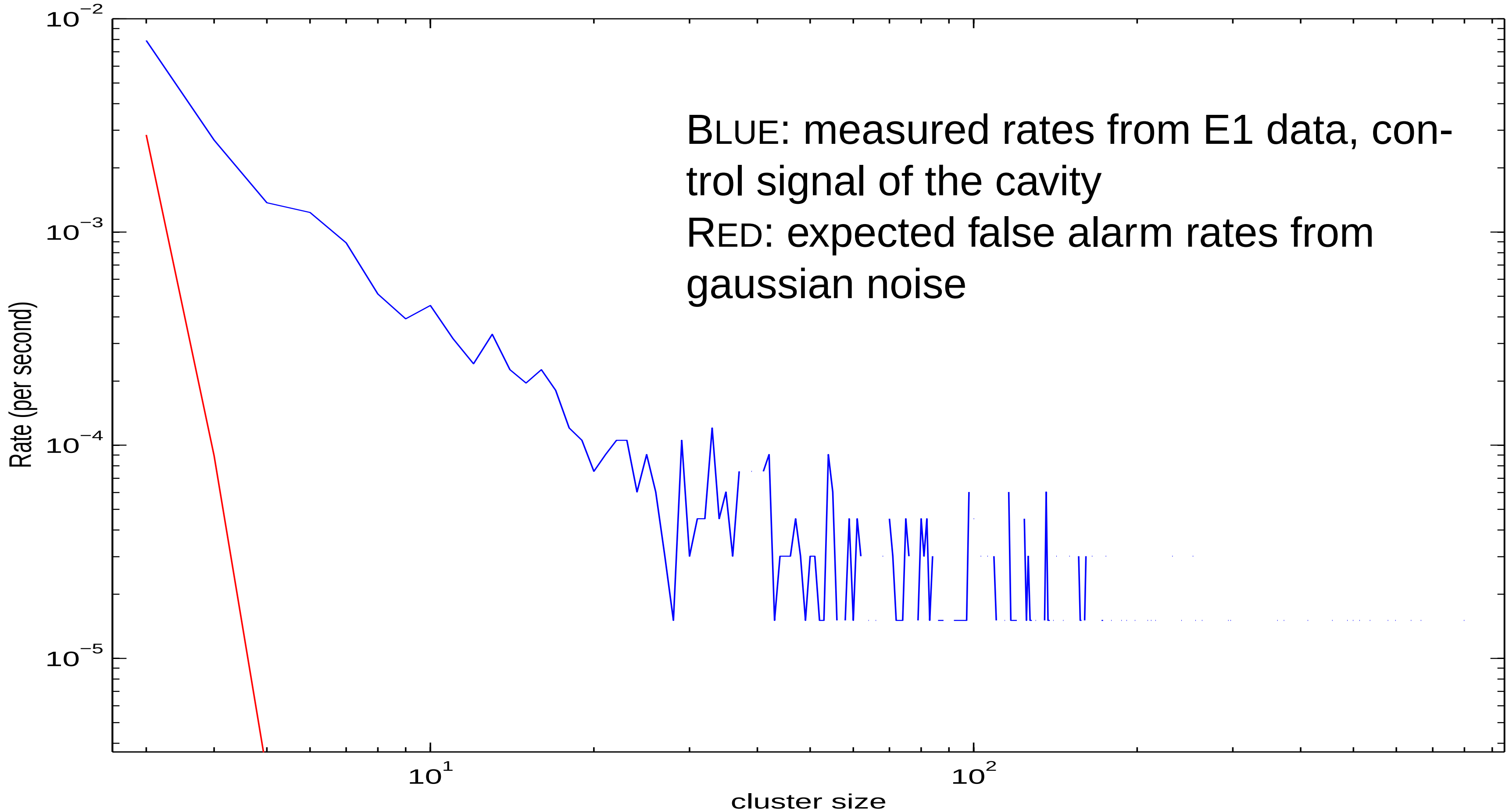
False alarm probability:

$$p^7(1-p)^{18}$$

Probability of detection:

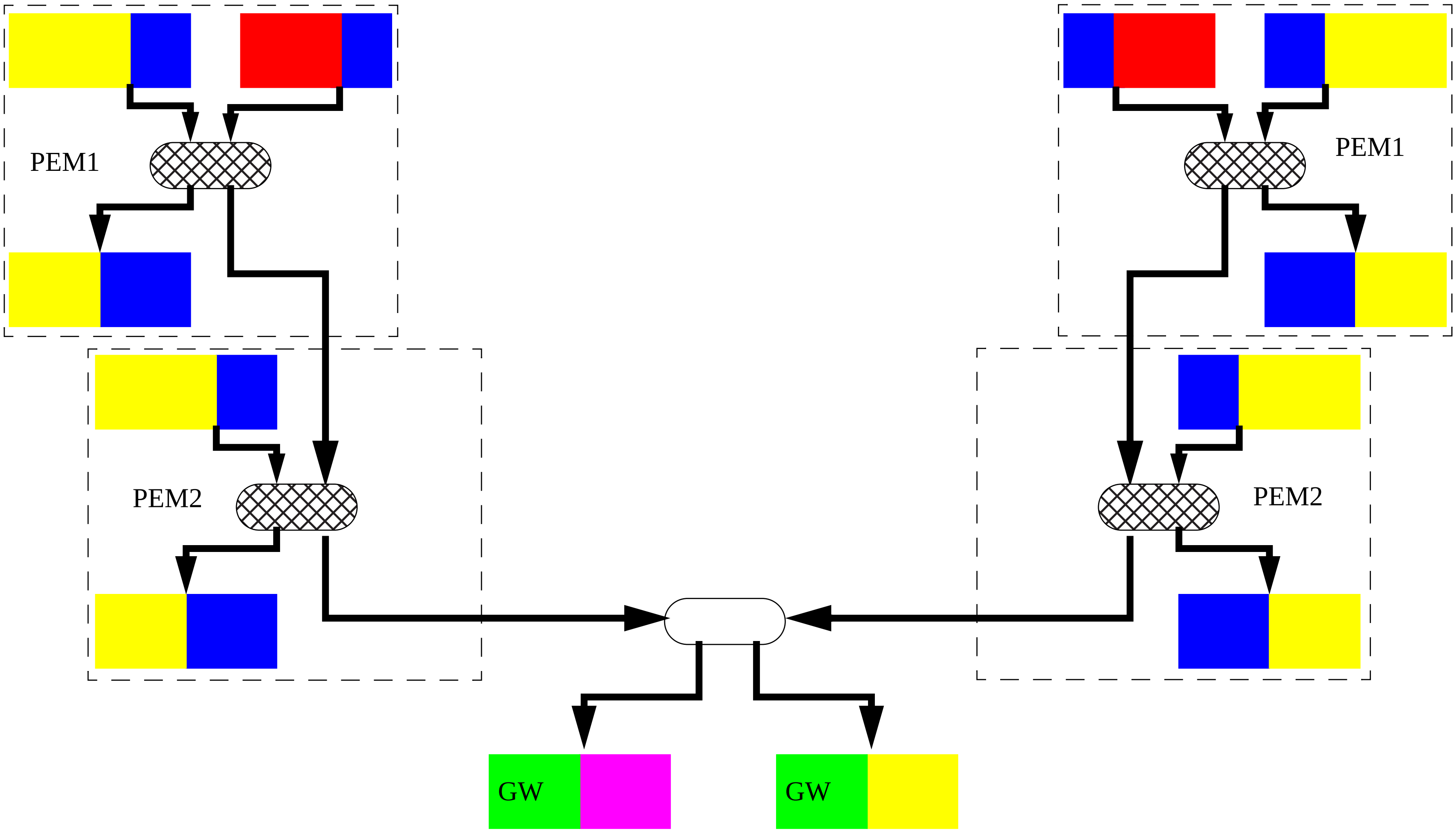
$$\sum (\#\text{ configs})\ \bar{p}^{\#\text{ holes}}(1-\bar{p})^{7-\#\text{ holes}}$$

Non-gaussian noise: an example from E1



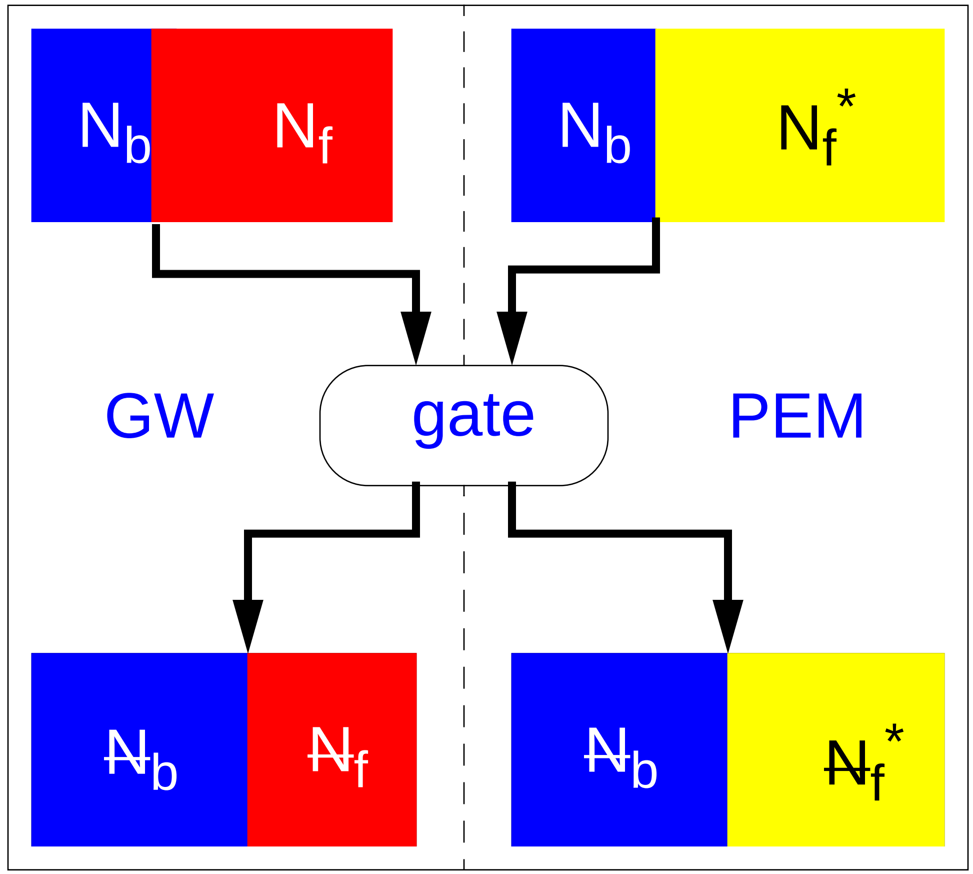
BLUE: measured rates from E1 data, control signal of the cavity
RED: expected false alarm rates from gaussian noise

General model for two detectors



The basic coincidence gate

- GW channel: N events, N_b are back-ground, N_f are foregnd.
- PEM channel: N^* events, $N_b^* = N_b$ are backgnd, N_f^* foregnd.
- Coincidence gate moves the partitions



LIGO-G950000-00-M

Coincidence gate: operational characteristics

- p(C|f) : probability of accidental coincidence
  - function of N_f^* and of “width” of coincidence window in simplest case
- p(C|b) : probability of detection of a coincidence
  - can compute probability of detection of any signal analytically
  - doing “ensemble averages” require additional knowledge
- Measurements of N_b , N_f and N^* enough if coincidence is on time only; more complex cases require other information from the three sets.

Coincidence gate: metric

- "mass" moments computed for each cluster
  - ›› X_0 = number of pixels
  - ›› X_1 = mean time, X_2 = mean frequency
  - ›› X_3 = t,t component of "inertia" tensor, X_4 = t,f component, X_5 = f,f
  - ›› etc.
- A coincidence is detected when two clusters are close enough:

$$g_{ij}\, dX_i\, dX_j < 1$$

Coincidence gate: confidence regions

- Three parameters estimated: background, foreground and total rate in PEM channel.
- Tri-dimensional confidence regions
- "Unified" classical approach (Feldman & Cousins, PRD 57, 7)
  - ››Classical construction
  - ››Ordering Principle
  - ››Give $p(N \in V) = \alpha$
- Projections give the confidence interval on GW foreground.

Coincidence gate: an exercise with E1

Single anti-coincidence with MX Seismometer

Measured rates:

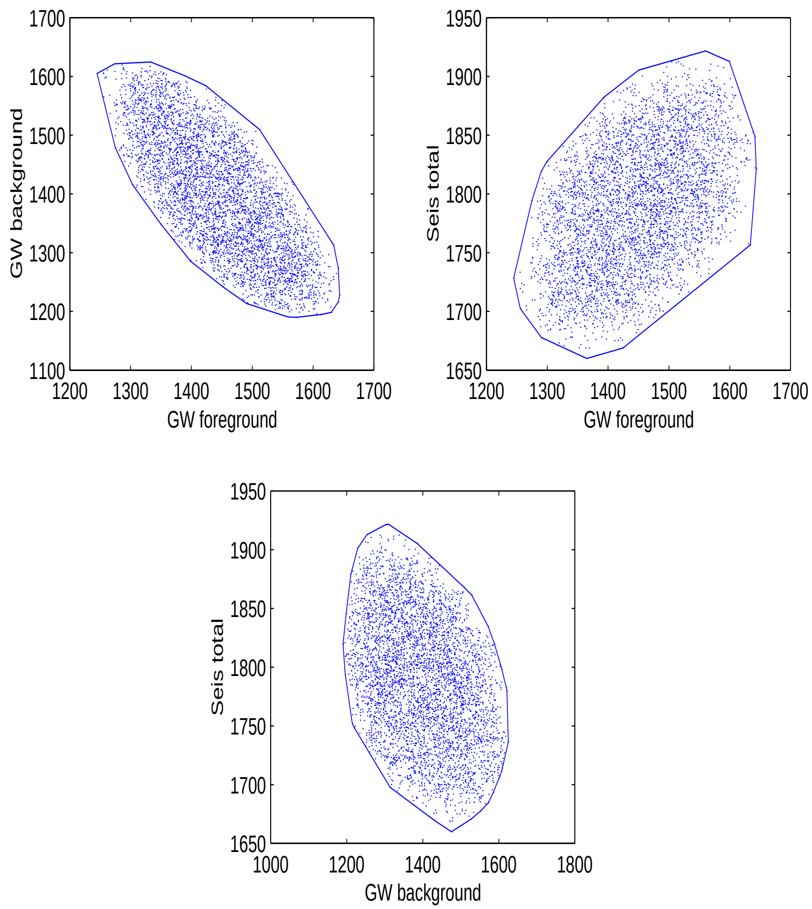
GW foreground: $2.16\ 10^{-2}\ s^{-1}$

GW background: $2.12\ 10^{-2}\ s^{-1}$

Seis foreground: $5.73\ 10^{-3}\ s^{-1}$

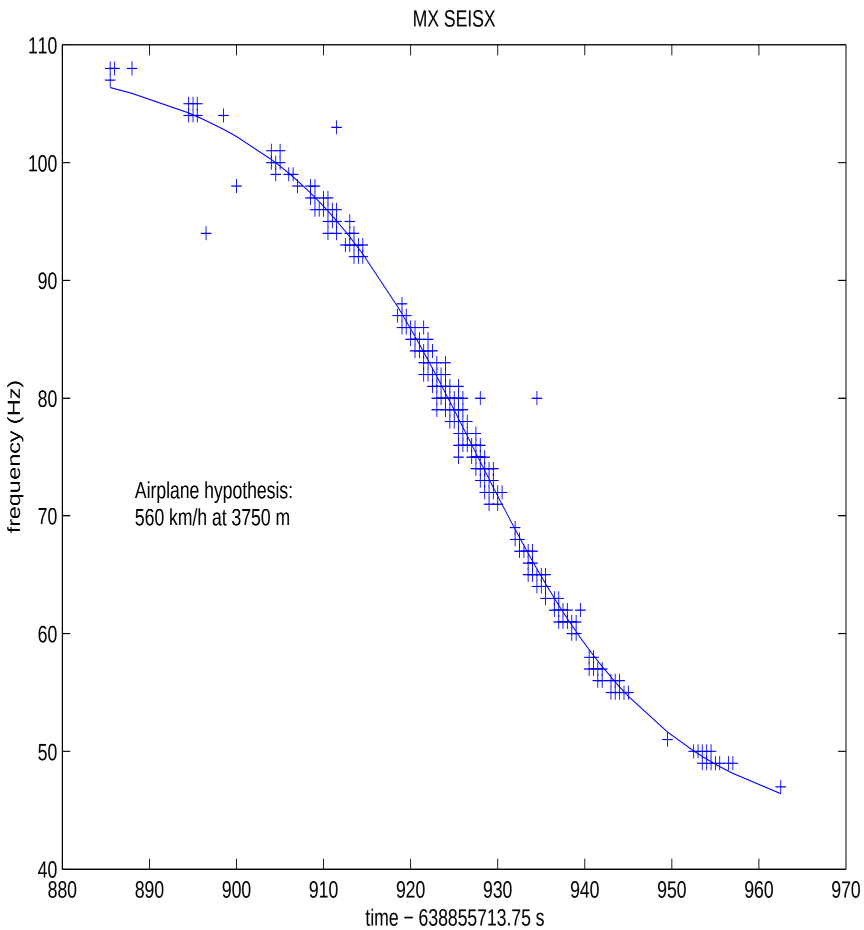
90% level confidence interval on GW foreground:

$$1.87\ 10^{-2}\ s^{-1} < F < 2.48\ 10^{-2}\ s^{-1}$$



Non-gaussian noise: identified classes

- Airplanes:
  - ››found in cavity signals, seismometers, accelerometers, etc.
  - ››delays between MX and LVEA are -15 s < ΔT < 15 s
  - ››excellent fit to Doppler shifted monochromatic source
  - ››events in E1 coincident with airplanes within 5.5km from LVEA, from FAA radar data
  - ››filter bank running at LHO



Non-gaussian noise: identified classes

- Narrow-band periodic bursts
  - ››duration ~100s
  - ››period ~15 minutes
- Resonance driven by impulse in seismic noise
  - ››decay time >100s
  - ›› frequency ~17Hz (roll mode of pendulum?)
- string of bursts
  - ››multiple, “symmetric” bursts