# Transients Identification in Engineering Data

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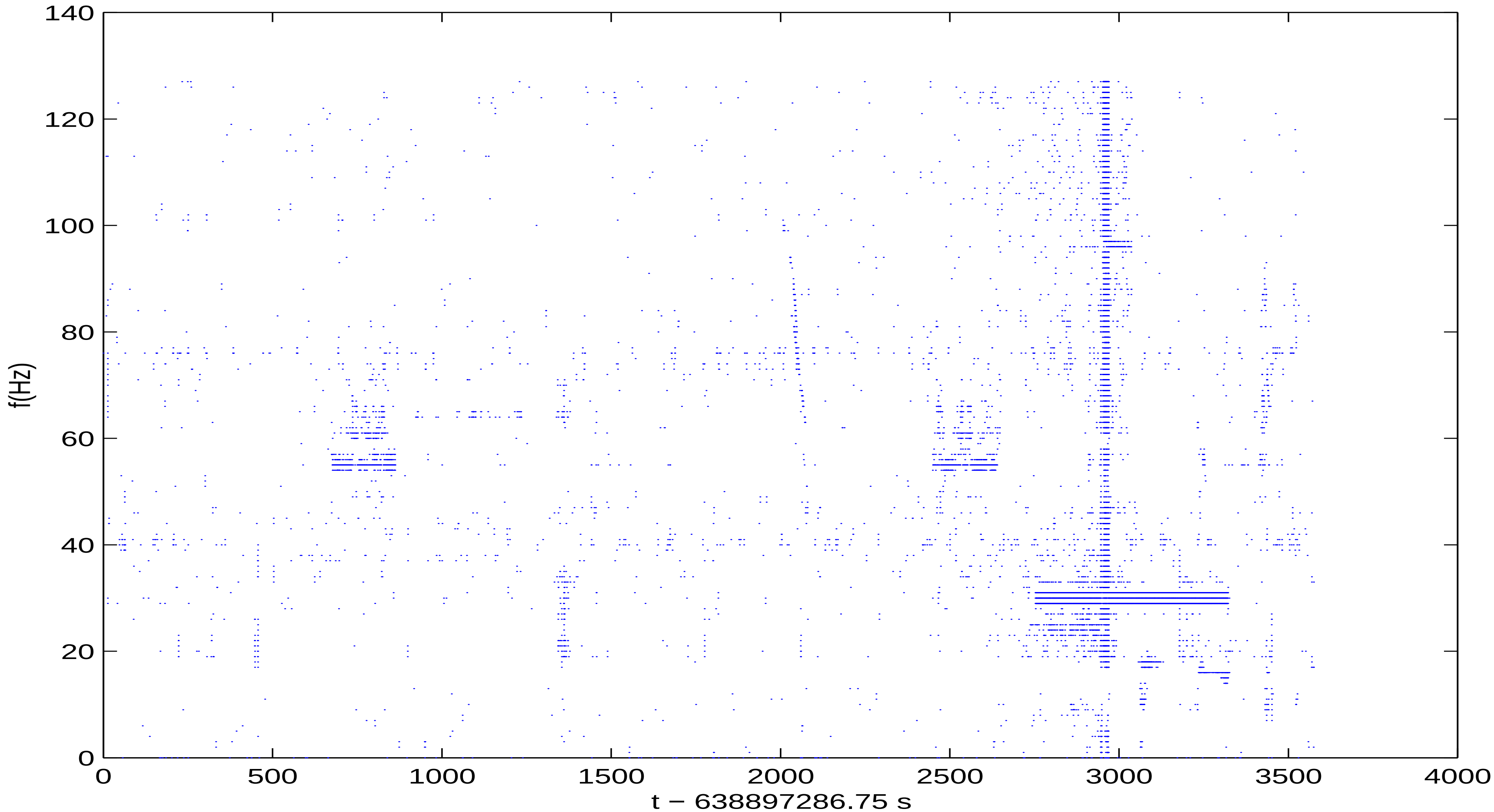
# Power Detector:
# high-contrast t-f representation

- 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



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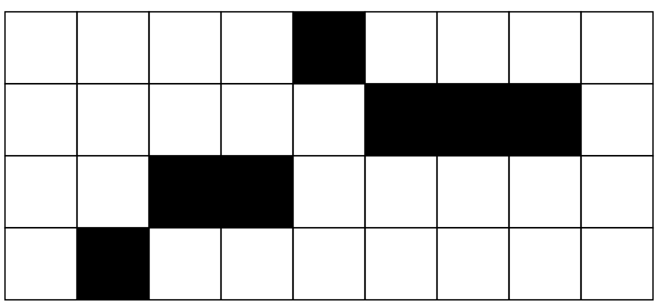
# Power Detector: clusters identification

- 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



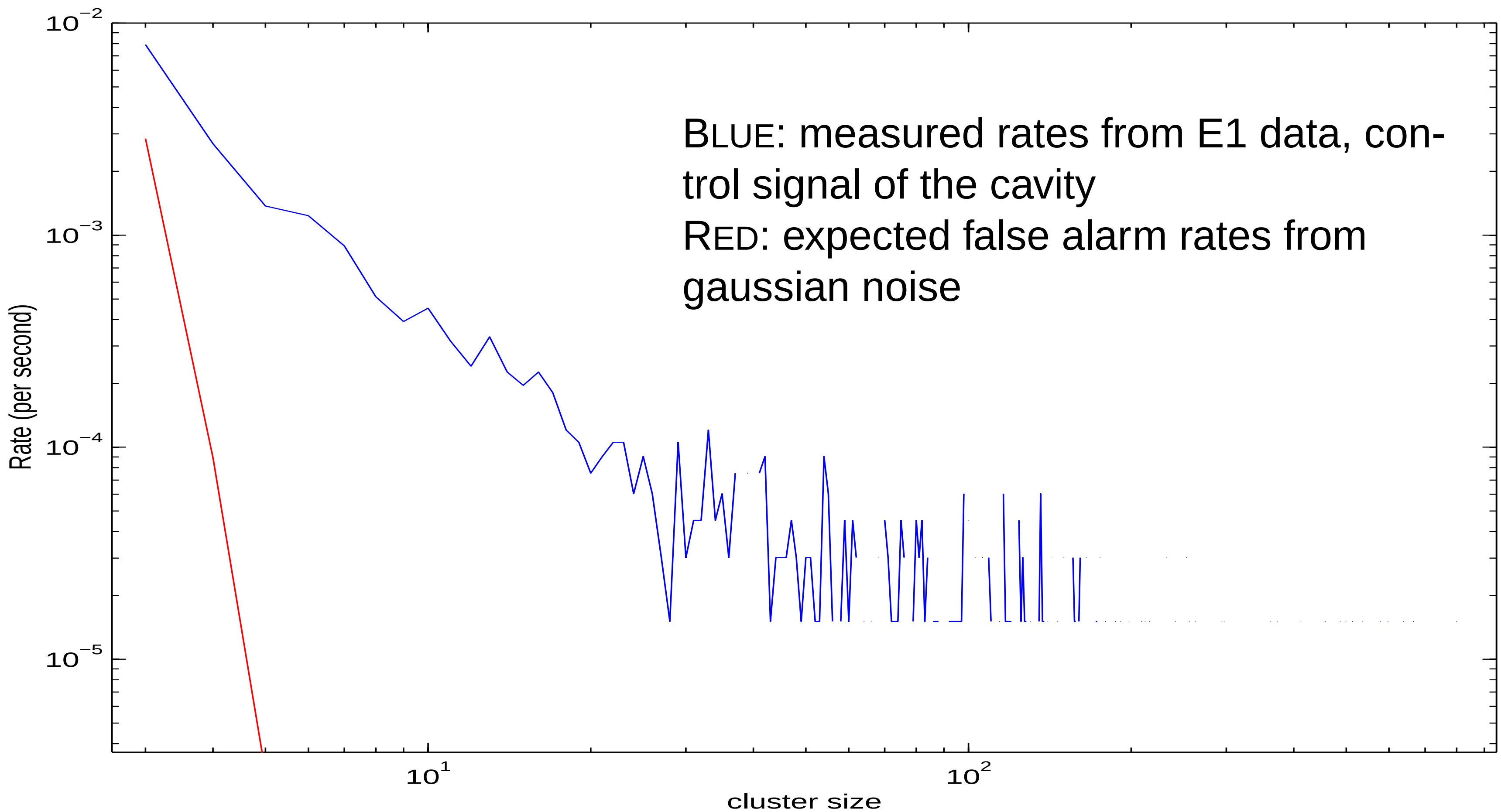
False alarm probability:

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

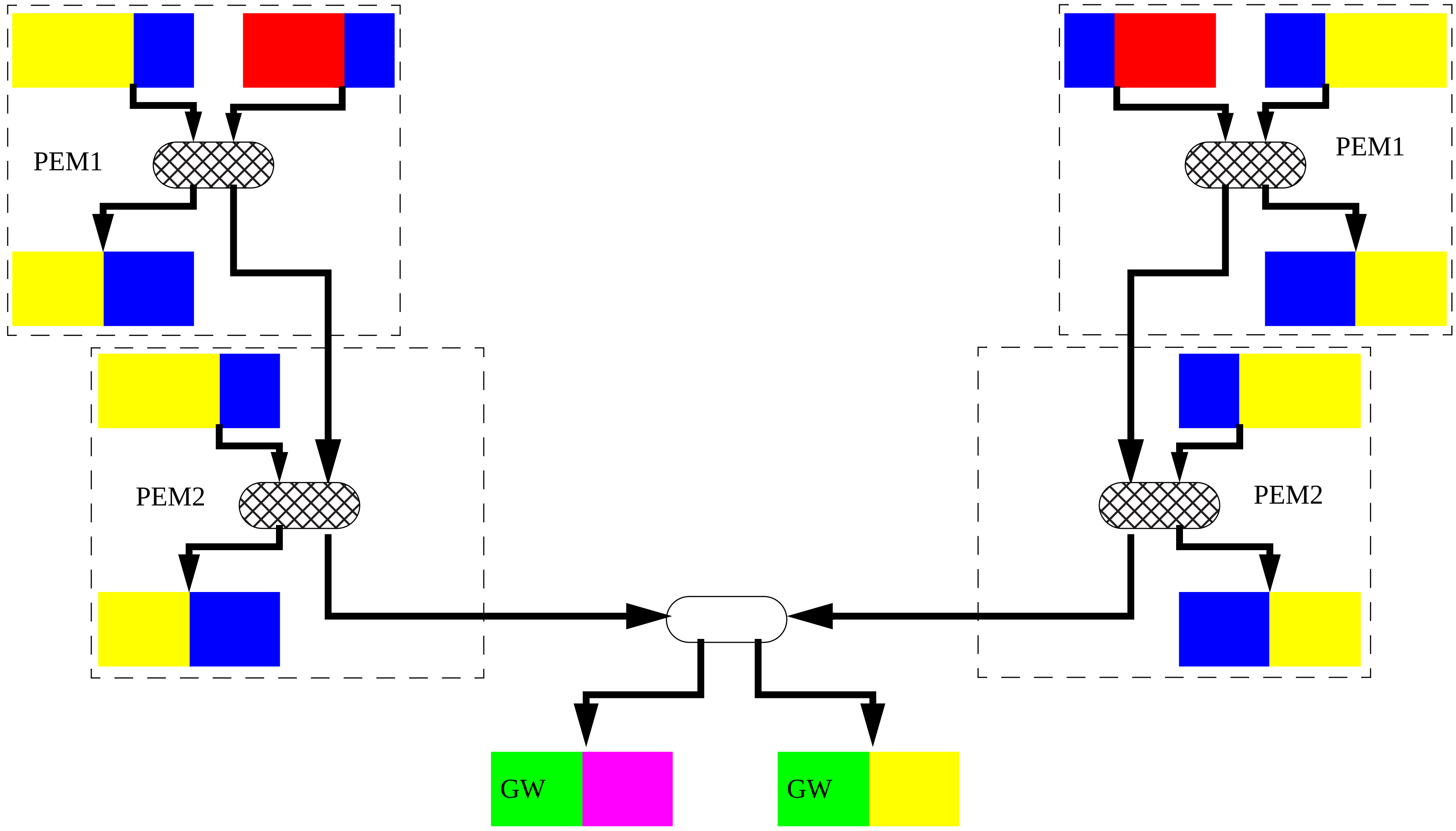
Probability of detection:

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

# Non-gaussian noise: an example from E1

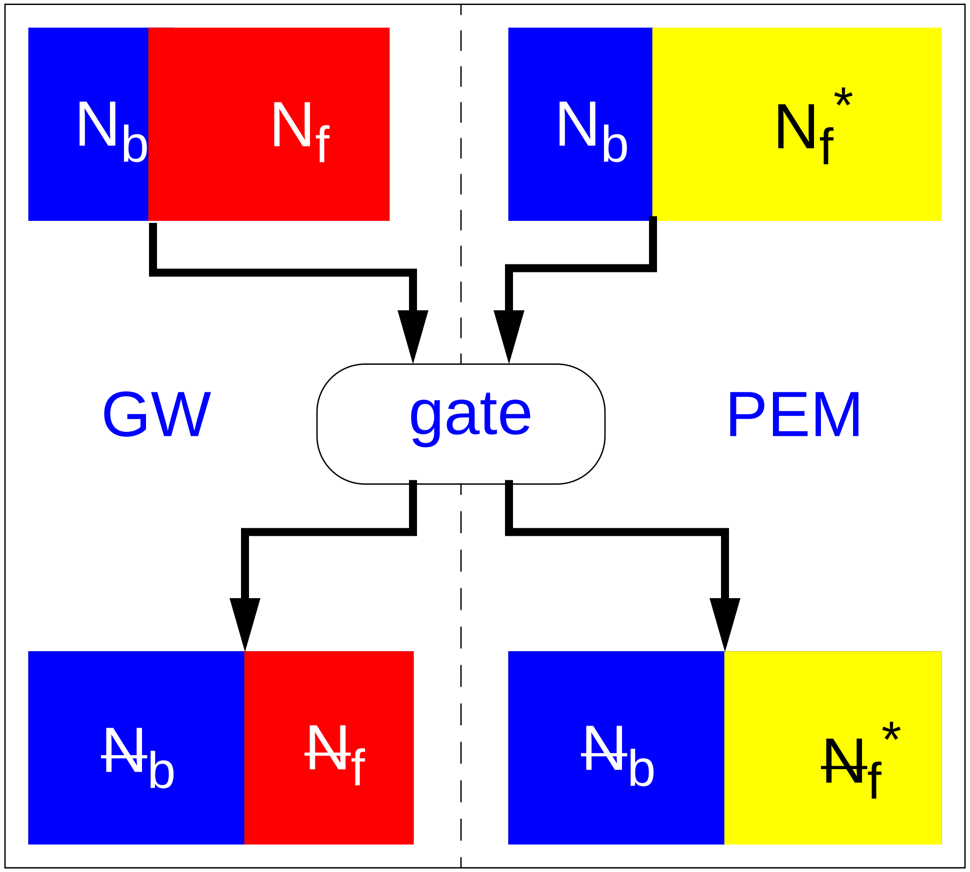


# General model for two detectors



# 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



# 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 $p(N \epsilon V) = \alpha$
- Projections give the confidence interval on GW foreground.

# Coincidence gate:
# an exercise with E1

## Single anti-coincidence with MX Seismometer

Measured rates:

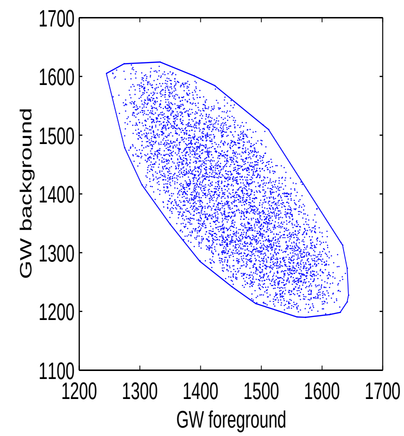
GW foreground: 2.16 $10^{-2}$ $s^{-1}$

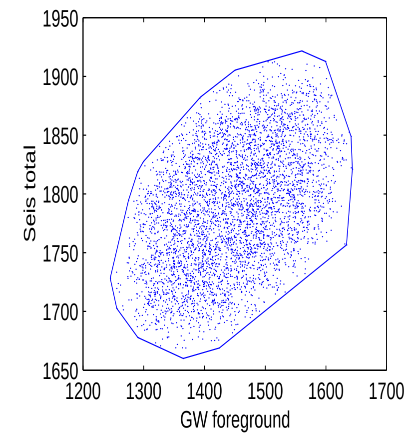
GW background: 2.12 $10^{-2}$ $s^{-1}$

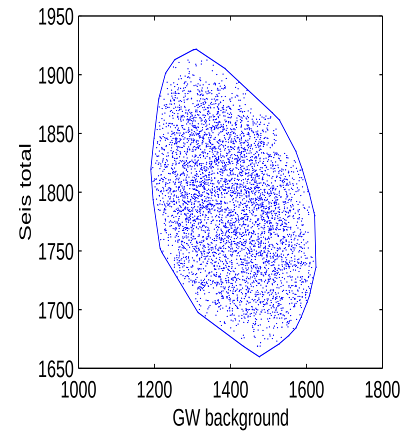
Seis foreground: 5.73 $10^{-3}$ $s^{-1}$

90% level confidence interval on GW fore-ground:

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



# Non-gaussian noise: identified classes

- Airplanes:

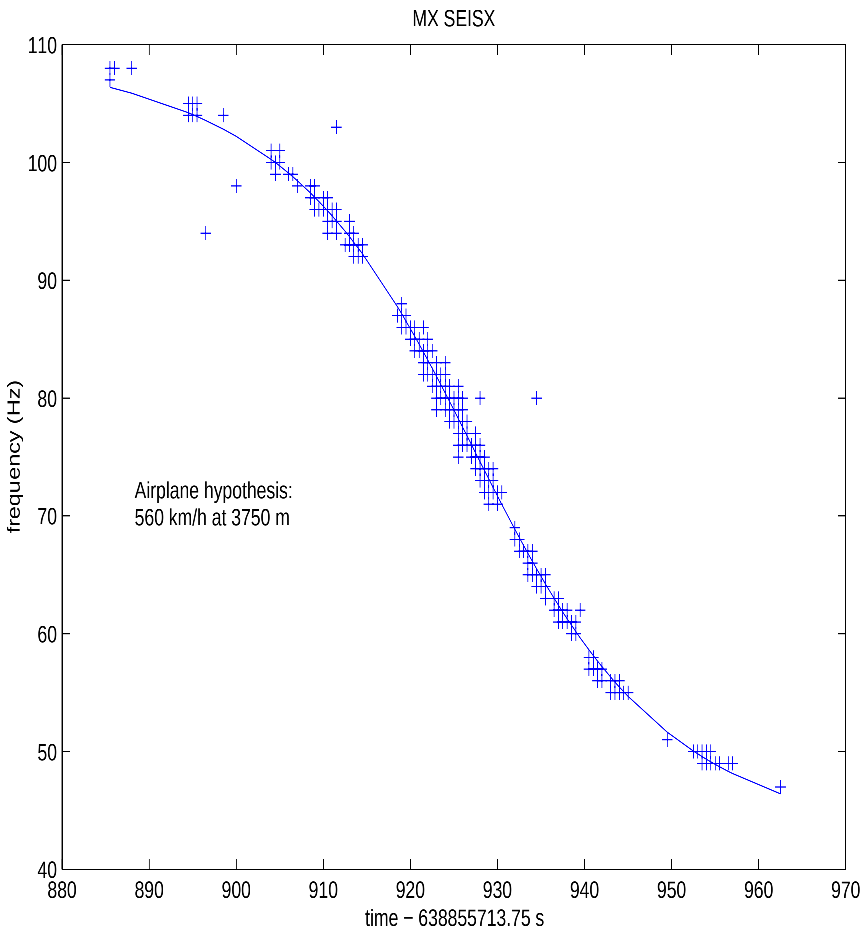
  ››found in cavity signals, seismometers, accelerometers, etc.

  ››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



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# 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