A Time-Frequency Gaussianity Monitor for the DMT

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Outline

- Motivation
- Measuring Gaussianity as a function of frequency
- Rayleigh Monitor & results from E5
- Summary & Discussion

Purpose

- Gravitational-wave detectors will soon open up a whole new area of astronomy and astrophysics.
- Gravitational-wave signals weak compared to noise.
- Noise arises from different sources:

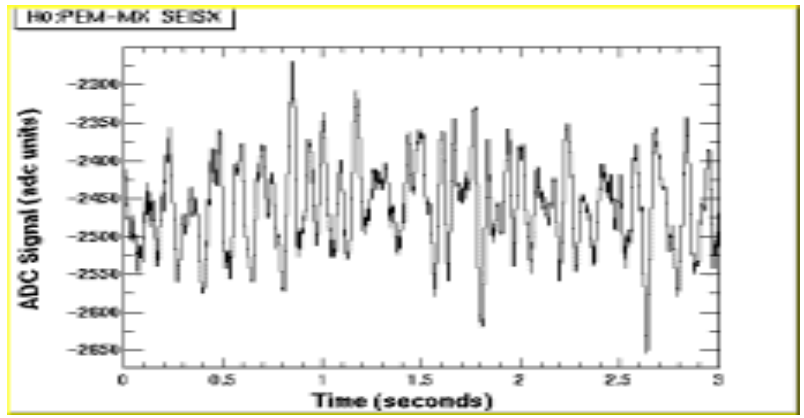
  Fundamental sources: Gaussian

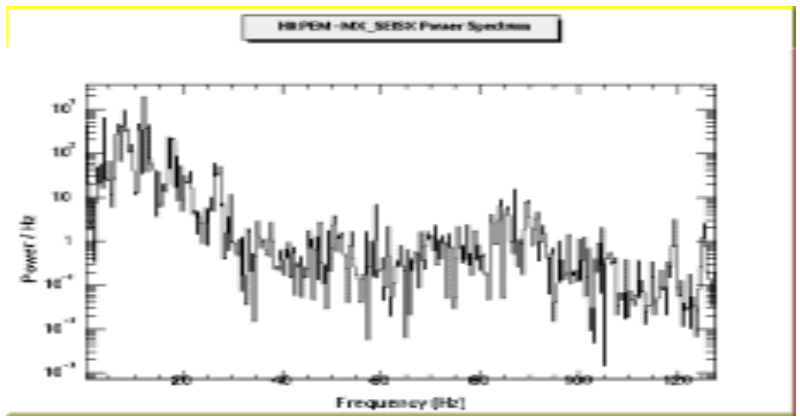
  Technical sources: non-Gaussian
- Characterising non-Gaussian noise may help to identify and remove underlying source.
- Must develop tools to characterise non-Gaussianity!

The present situation

- Operators & scientists have tools for studying time series, power spectrum, etc., of data.
- None of these alone give a full view of the data's characteristics.

eg: Gaussianity?





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Question: Do Gaussian random processes have distinguishing features in frequency space?

- Yes! The variability of the power spectrum.
- For Gaussian noise, the power spectrum at each frequency is exponentially distributed.
- Consequence:

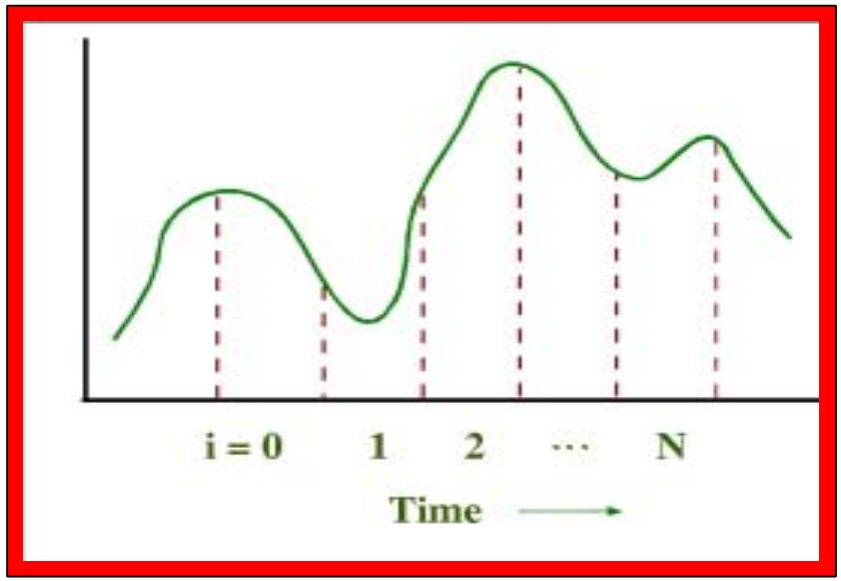
$$\hat{a}(f)\,\ddot{U}(f) = 1$$

- This ratio provides a measure of Gaussianity as a function of frequency.

Procedure

- Divide data up into N segments "i" of fixed length; compute power spectrum of each.
- Monitor the ``Rayleigh statistic"

  R = â(f)½Ü(f) R <<
  1 1 coherent R >> 1
  1 incoherent

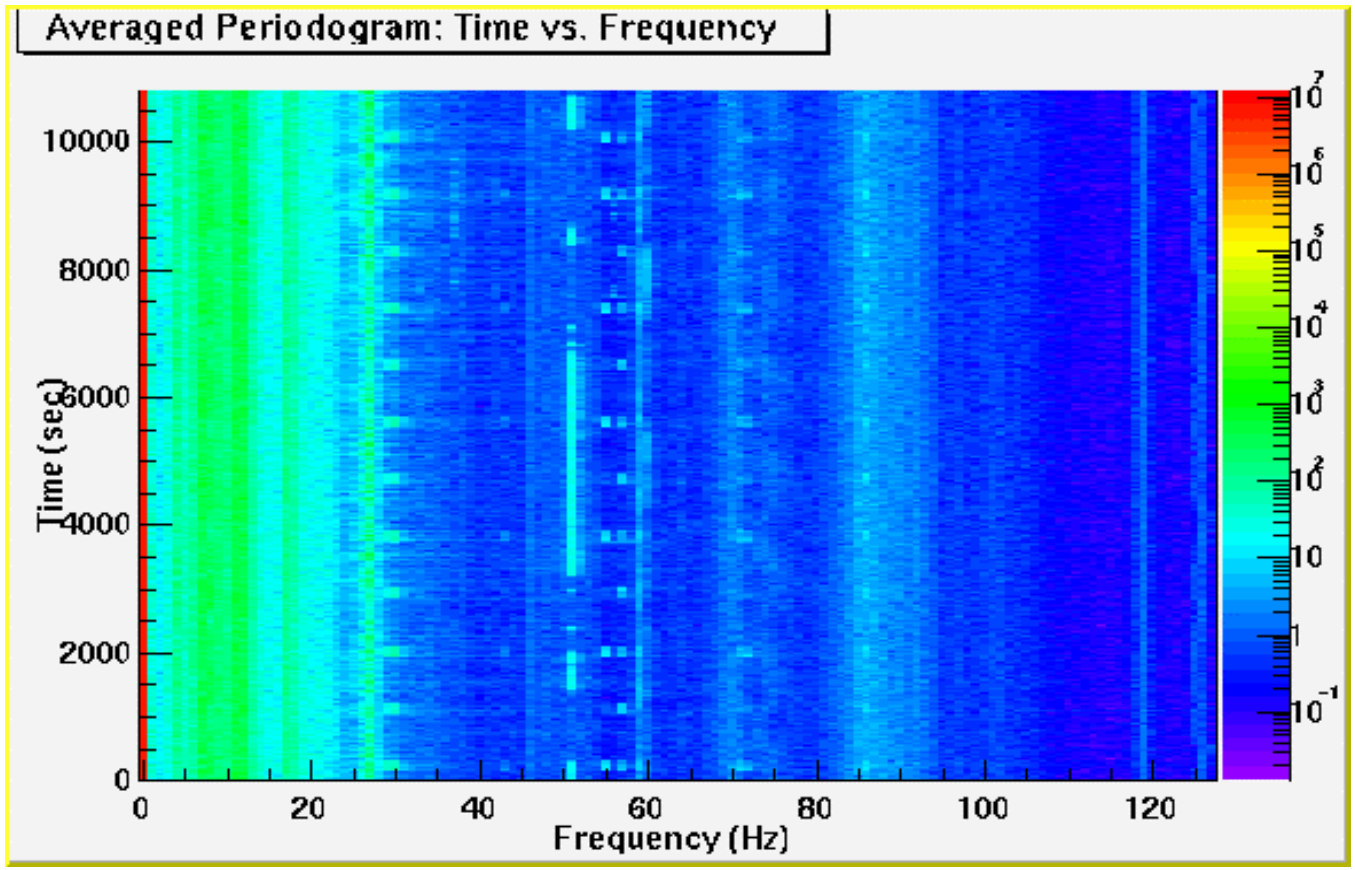


Rayleigh Monitor: Current Status

- Available as stand-alone data monitor for the DMT.
- Used in E5 (on- and offline).
- Input: Reads channel list, number and length of data segments to average from file.
- Output: Snapshot of Rayleigh, PSD to dmtviewer. Accumulated Rayleigh and PSD data to file for 2D plotting by external ROOT macro (offline).

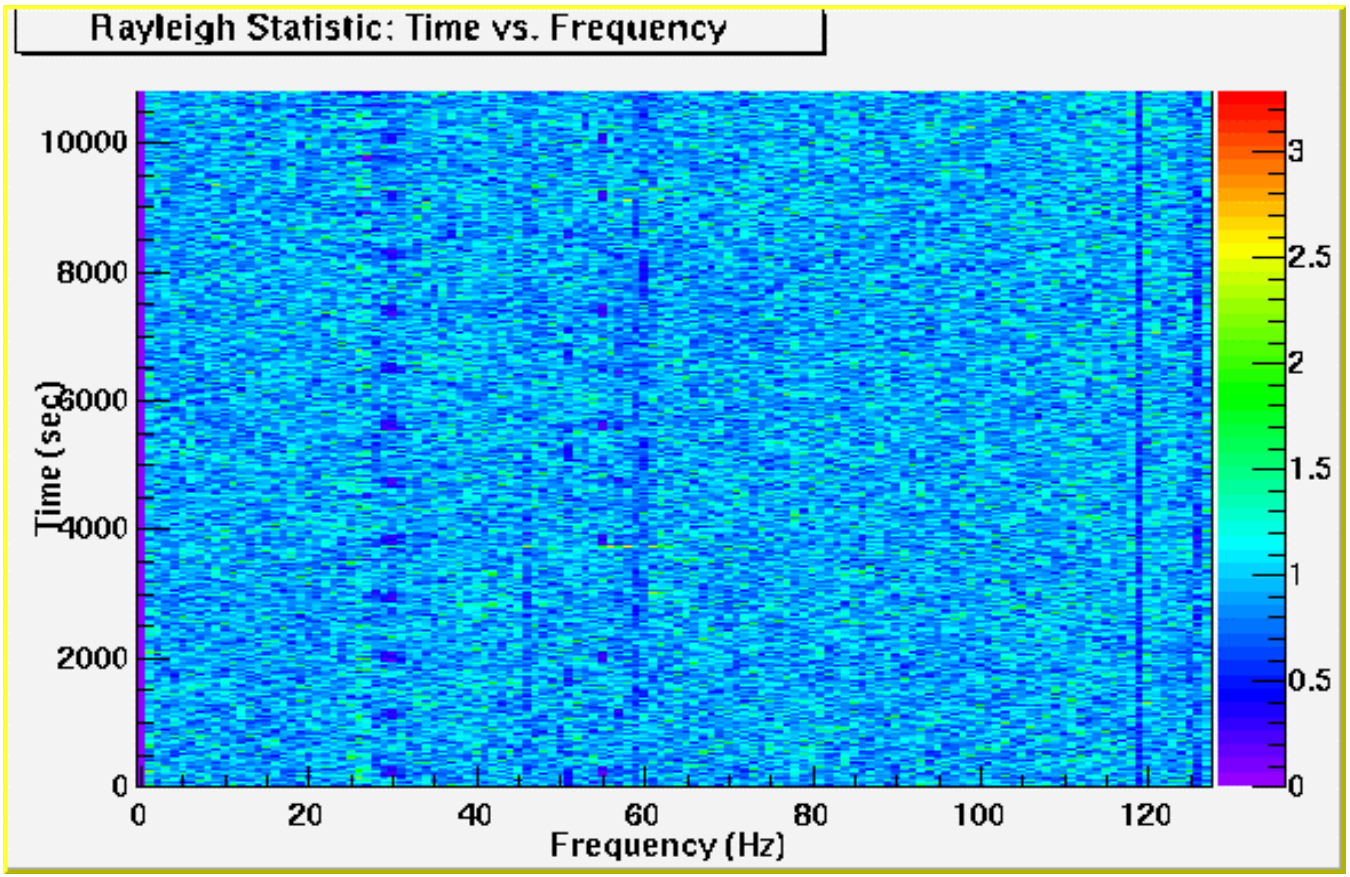
eg: H0:PEM-MX_SEISX

(GPS start time = 680950783)



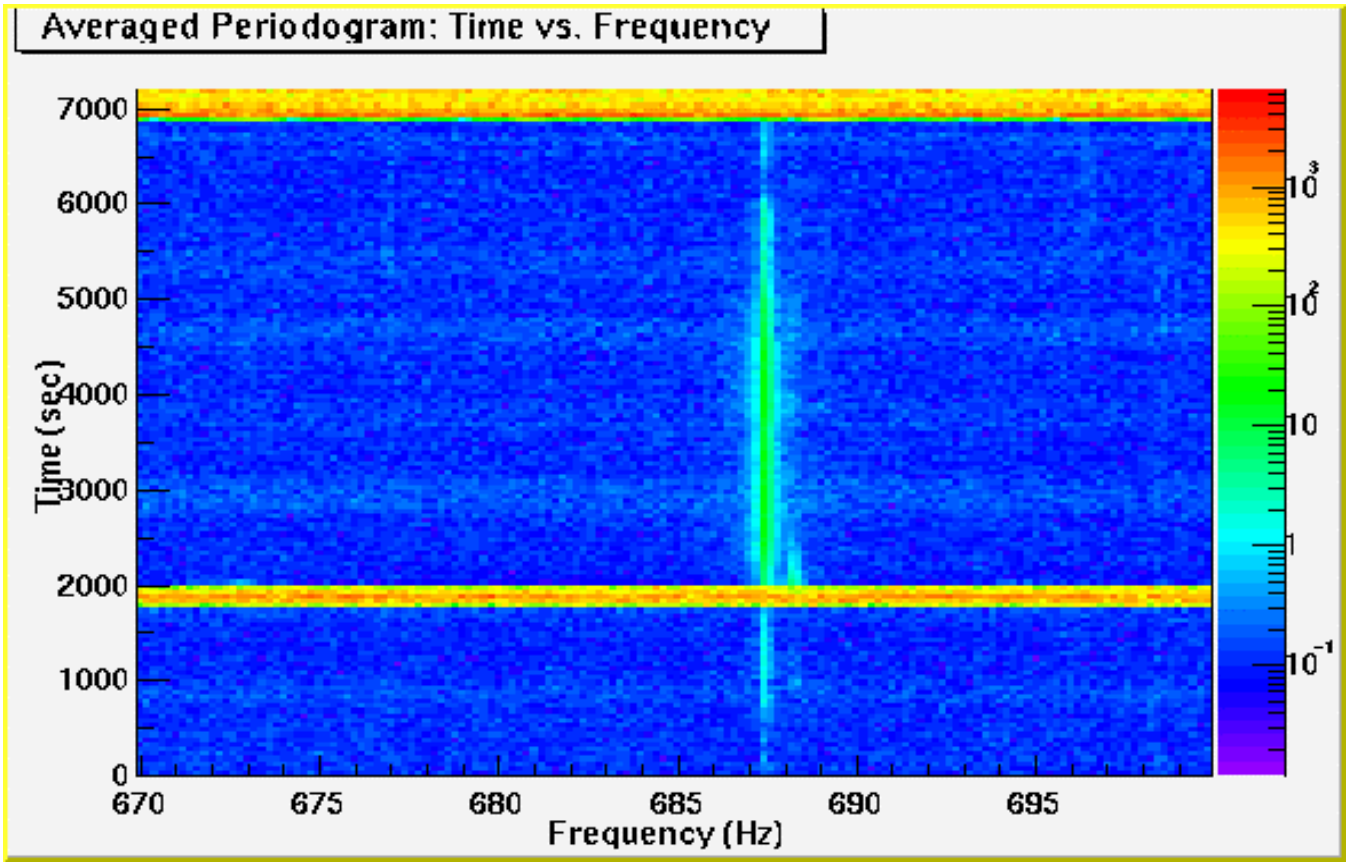
eg: H0:PEM-MX_SEISX

(GPS start time = 680950783)



eg: H2:LSC-DARM_CTRL

(GPS start time = 680954383)



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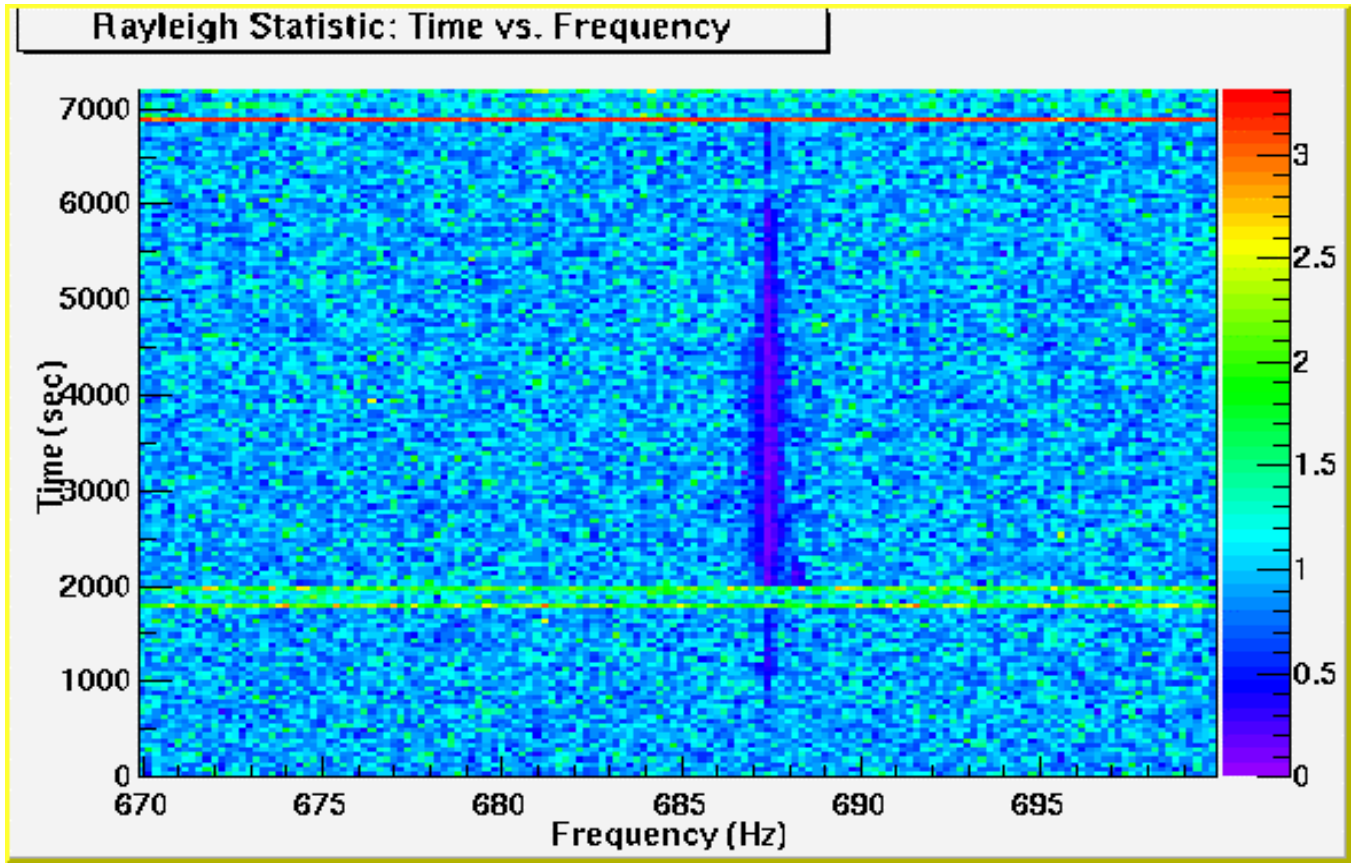
eg: H2:LSC-DARM_CTRL

(GPS start time = 680954383)



Summary

- Fine-tuning of gravitational-wave detectors requires understanding noise, particularly from non-Gaussian sources.
- Rayleigh statistic gives simple measure of coherence of noise compared to Gaussian as a function of frequency.
- Information may be useful in identifying and removing physical source of noise.
- Available for use as stand-alone monitor with graphical output to dmtviewer.