McNeese State University

Proposal to Join the LSC

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McNeese Gravitational Wave Astronomy Group
McGWAG

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LIGO-G070561-00-Z

McGWAG
about us

- Giovanni Santostasi, Ass. Professor Physics

- former member of the LSU ALLEGRO bar detector group (1997-2002)
- advisors: J. Frank: neutron star astrophysics and modeling
  W. Johnson: GW detection and data analysis
- visiting scientist at LLO (through Caltech sponsorship) since 2004
- supervisor: K. Riles: development and implementation of pulsar DMT-PulsarMon.

- Steve Stinnett, Ass. Professor Physics

(collaboration on Monte Carlo Simulation of GW NS Population in Galaxy)

-wants to join DetChar group

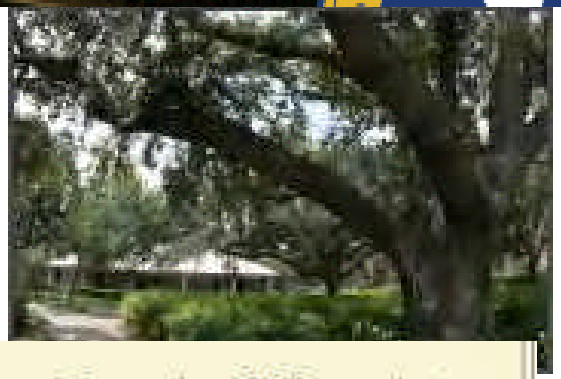
- 3 undergraduate students

- already familiar with different issues on GW data analysis and NS astrophysics, one of them spent this summer working at South Eastern LA University (LSC institution) on detector noise (kindly supported by research assistantship from S. Yoshida).

McNeese STATE UNIVERSITY
Excellence With A Personal Touch

- Master awarding State University (located in Lake Charles, LA) ~ 9k students
- Small but active Physics Department: 2 Physics Professors, (1 to be hired soon…apply!), 2 Geology Professors, 2 Instructors, 8 majors
- Strong Engineering Program, ongoing collaboration
- Experience in working with students in research: we have acquired NASA grants for aerospace student research, LIGO related work supported by Board of Regents.
- Strong support for research by administration, (Dean Mead paid for trip) and very supportive Research Services. We have received at least 3 internal grants to do LIGO work since 2004.
- Relatively close to LLO (2 ½ hours)
- Small cluster available for Monte Carlo simulations
- This summer McGWG has started a collaboration with Dr. Yoshida from South Eastern Louisiana University (we are in the same system).

McSU is part of the University of Louisiana System and it is located in South West-LA
2 hours from Houston (to the west) 2 ½ hours from Livingston (to the east).

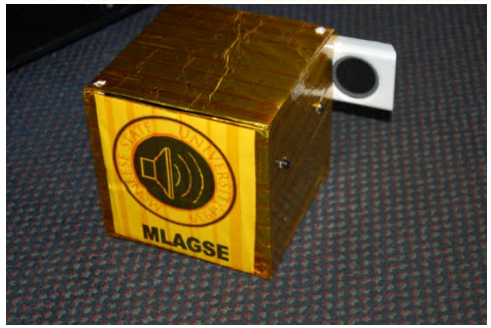


in·quire 1) To have a desire to discover new information; 2) To conduct an inquiry or investigation of.

AT McNEESE STATE UNIVERSITY'S

College of Science

I WILL EXPLORE MY DESIRES TO DISCOVER NEW AND EXCITING INFORMATION.
I WILL CONDUCT SCIENTIFIC INVESTIGATIONS. I WILL PERFORM EXPERIMENTS.
I WILL EXPAND MY KNOWLEDGE. I WILL INQUIRE.



Proposed Plan for Research

- Upgrade and maintenance of the DMT- PulsarMon
- Comprehensive analysis and monitoring of detector noise in terms of parameters relevant to CW detection. Particularly important is to characterize the detector output at the Crab's emission frequency. Study possible correlations of PulsarMon FOMs with environmental noise from different channels (seismic, audio, etc).
- If time permits, study of astrophysical characteristics of CW sources and galactic population modeling

PulsarMon

work already accomplished

Figures of Merit (FOM) in terms of parameters relevant to Pulsar Search

- Main FOM is the Integration Time (IT) for the Crab) to beat the Spin-Down limit at fine resolution **(new** !)
- Finer resolution spectrum. **Freq resolution 0.0167 Hz**
- Ellipticity for sample pulsars with antenna parameters **(tested and ready soon)**
- Slow but constant progress for the monitor.

Available FOMs

The complete list of FOMs is :

- **Time Series:** IT for Crab, Ellipticity at 500 Hz, 1kpc distance **(available)**

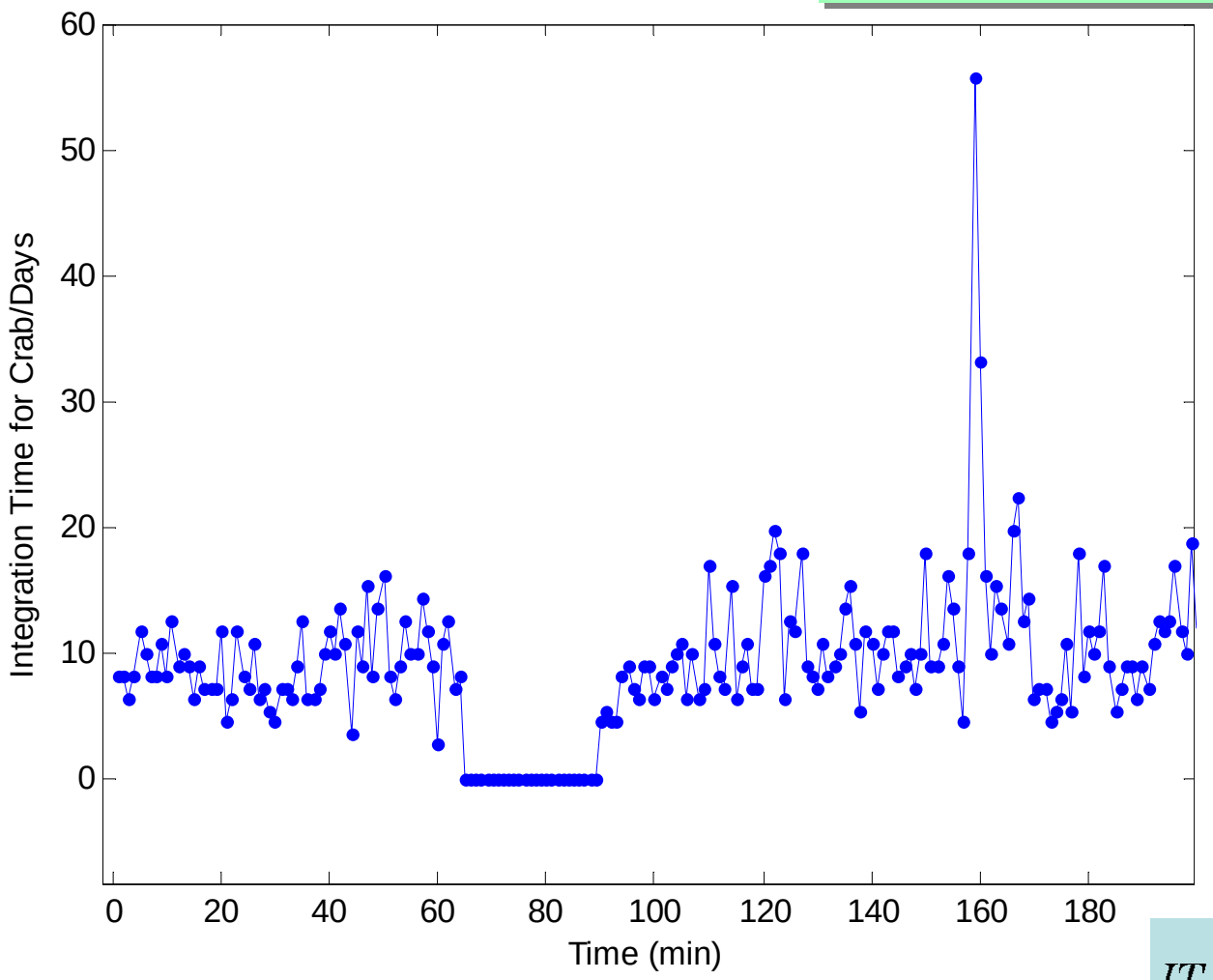
- **Power Spectra**:
  1) Noise Spectrum normalized to I year IT (available),
  2) Ellipticity for test pulsar 1 kpc vs. frequency **(available)**

- **Scatter Plots:** hEC for known pulsars, IT for known pulsars,
- Ellipticity for known pulsars vs. frequency (code to calculate values **available.** But Visualization problem for scatter points using DMT viewer not worked out yet).

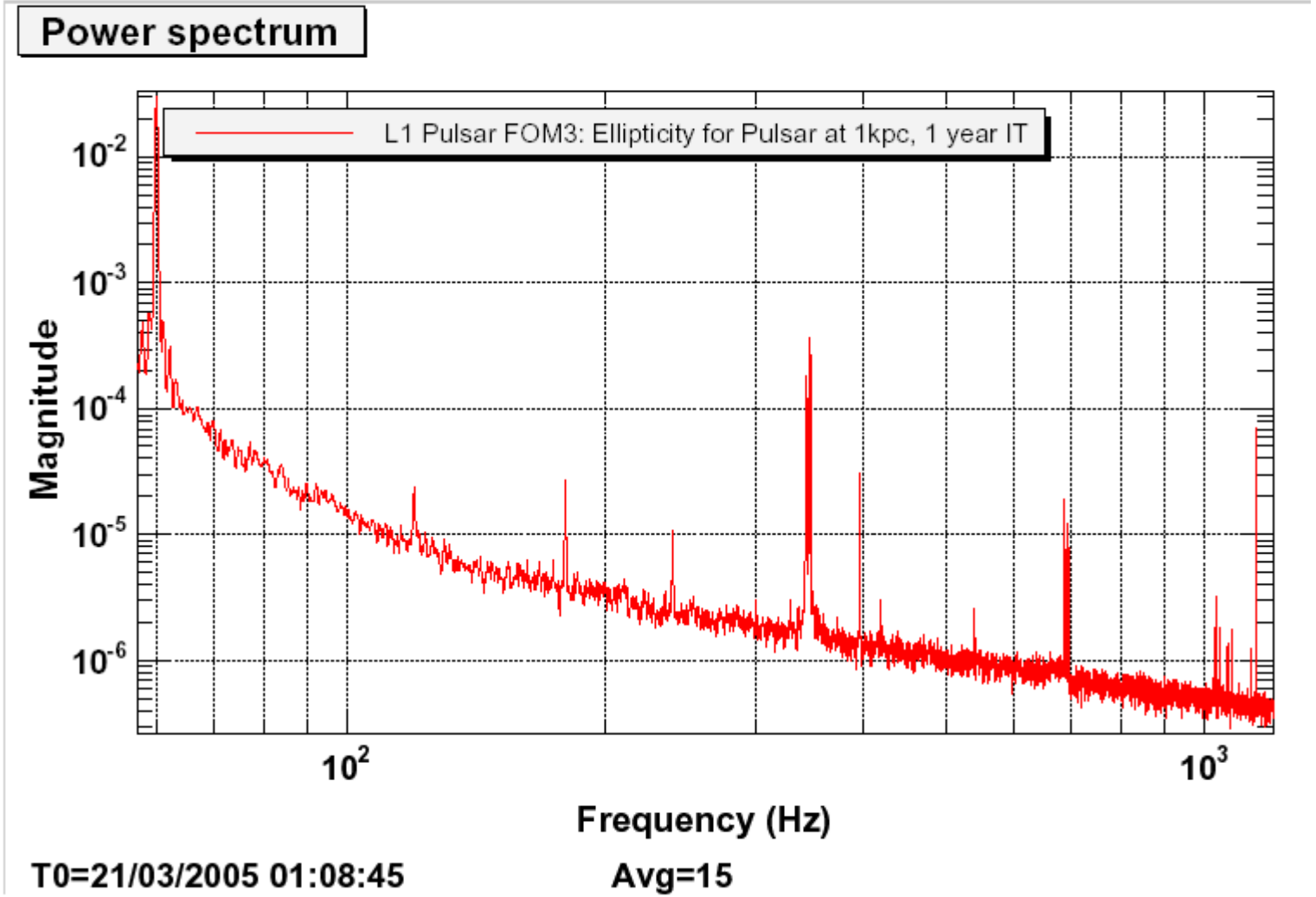
- **Power Spectrum**: Cumulative Spectrum over the current run period

Crab parameters: fs=59.6 Hz Fdot= 3.86e-10 s^-2, distance 2kpc

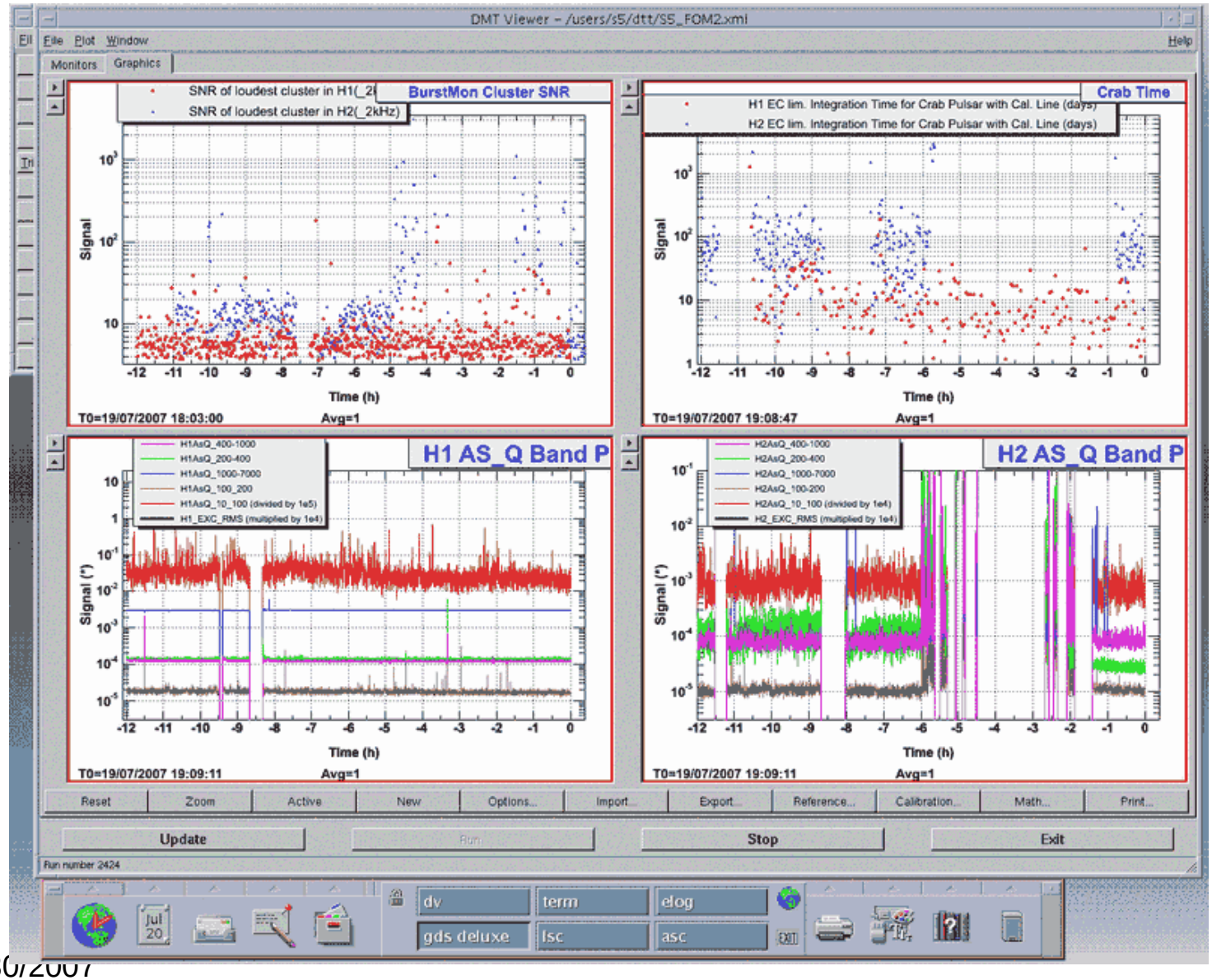
$$h_{EC} = \frac{5.7 \times 10^{-24}}{r/1kpc} \sqrt{\frac{f_s}{1kHz} \frac{\dot{P}}{10^{-13} s/s} \frac{I}{10^{45} gcm^2}}$$



$$IT = 11.4^2 \frac{Sn(f)}{h_{EC}^2}$$


Power spectrum
L1 Pulsar FOM3: Ellipticity for Pulsar at 1kpc, 1 year IT
Magnitude
10-2
10-3
10-4
10-5
10-6
10^2
10^3
Frequency (Hz)
T0=21/03/2005 01:08:45
Avg=15

PulsarMon Crab IT is one of the main FOMs in the controlling rooms at the sites !



PulsarMon
proposed Upgrade

1) Implementing upgrades to PulsarMon based on Fred Raab's speculation (see e-log entry on June 16th) that some of the large spread in Crab IT comes from sporadic disturbance seen in a seismometer channel.

   Fred suggests for PulsarMon to have a new option to look at a figure of merit like the Crab IT, but applied to PEM channels suspected to measure relevant disturbances, such as LVEA_SEIS_Z. If one were to look at a scatterplot of true Crab IT from DARM_ERR vs a pseudo-Crab IT from a PEM channel, one might see a strong correlation, which could aid in the offline search for the Crab.

   Therefore:

   Computing a Crab-IT-like quantity for many PEM channels at once and allowing the user to plot those alongside the true Crab IT would be very handy.

PulsarMon Upgrade (cont.)

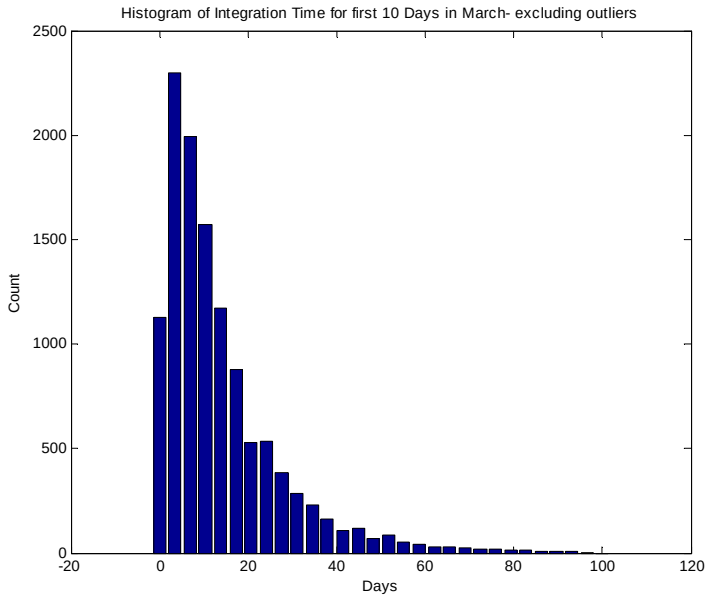
2) Given the current frequency resolution of PulsarMon gives +/-0.008 Hz variations in detected frequency and with potential contaminating lines wandering in and out of its band, knowing more precisely where to look for the Crab at any moment seems important (update frequency considering the spin-down and first order Doppler effects).

Adjust at regular time intervals looked for emission frequency taking in consideration spin-down and Doppler modulation of the Crab emission frequency during the course of the year (use a simple circular orbit model).

Noise Characterization
proposed analysis

- **Crab IT Noise characterization**: at the moment we see large variations non consistent with simple statistical fluctuations
- To get our higher freq. resolution we use a single 1 minute fft every minute. Then we use an exponential average to smooth the output. Is PDF a Chi Square with 2-Inf degrees of freedom for base-line noise (depending of decay constant of exponential averaging)? Test this prediction….
- Create a continuously updated histogram to compare with theoretical expectation.

Histogram Crab IT
Mean= 11.9 days,
StD = 8.6 days
over 300 minutes
Many outliers, not
used in this plot.



Environmental Noise Characterization

- Search for possible correlation between PulsarMon output and different environmental disturbances. Look at the Crab IT range and other critical frequencies.

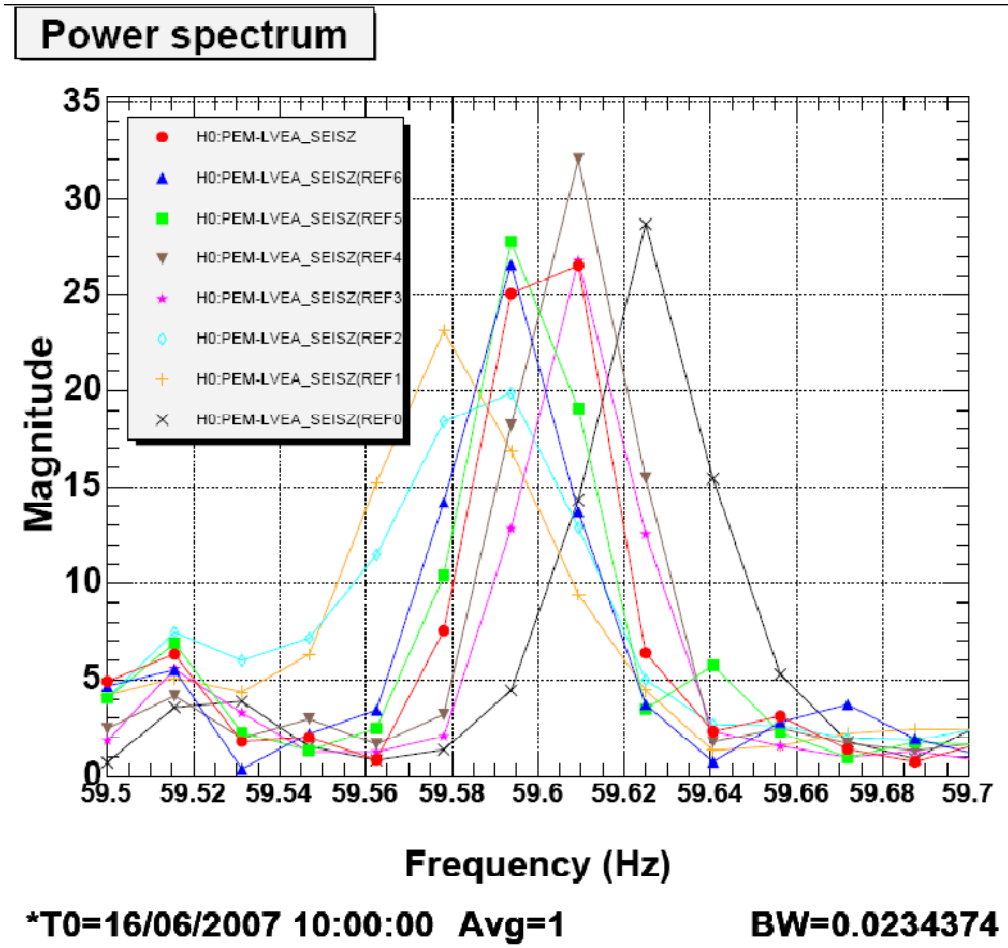
- In the Crab IT range a possible source of noise (cause of the large observed variations) could be the upcoversion of low frequency noise through modulation of the 60 Hz noise (that creates sidebands that can enter the relevant frequency band).

Qualitative Evidence:

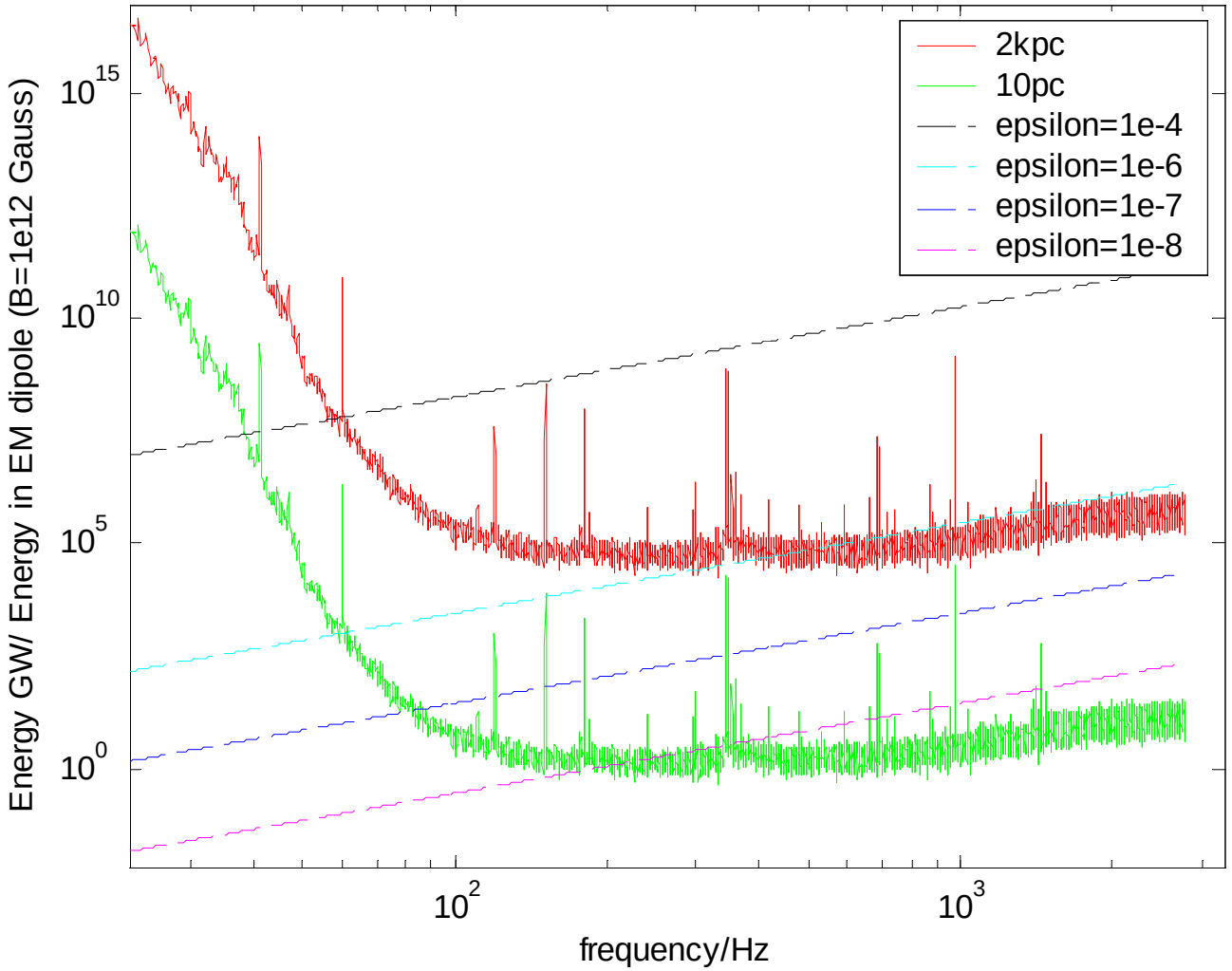
Single-shot FTs using 1 minute of data from each minute of seismic data around line near 59.6 Hz (H0:PEM-LVEA_SEISZ) taken by Fred Raab on June 16 2007.

Inference:

wandering lines crossing frequency range of Crab could make the noise jump.



Other possible work: New FOMs for PulsarMon
Other astrophysical interesting FOMs



Conclusion

- McNeese State University has expertise on an important monitoring tool for the LSC: PulsarMon, (beside some knowledge about NS astrophysics and Monte Carlo simulations).
- G. Santostasi, the main PI, has created and updated on regular basis PulsarMon starting in 2004. Students already working on LIGO related projects, McSU has in several occasions offered financial and logistic support to this work.
- PulsarMon has shown to be very useful but it needs different non-trivial improvements to increase its usefulness and efficiency.
- Further studies of the behavior of PulsarMon could help improve the detection of CW sources, especially for the Crab where non-statistical fluctuations seen by PulsarMon indicate noise that may be mitigated.
- McNeese has been supportive of the LIGO research effort and it is time for McNeese to be part of the LSC (if so pleases the audience)