Embry-Riddle Aeronautical University

- Proposal to join the LSC -

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Embry-Riddle Gravitational Wave Astrophysics Group
(ERGWAG)

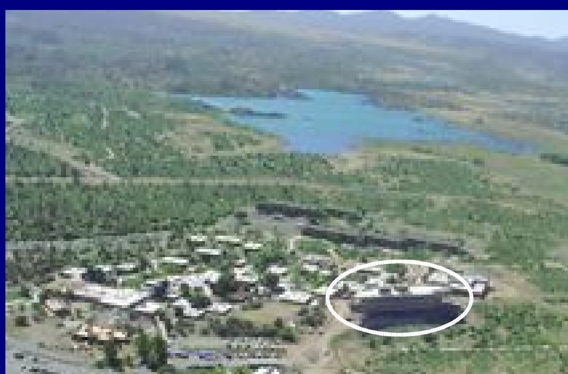
LIGO-G050450-00-Z

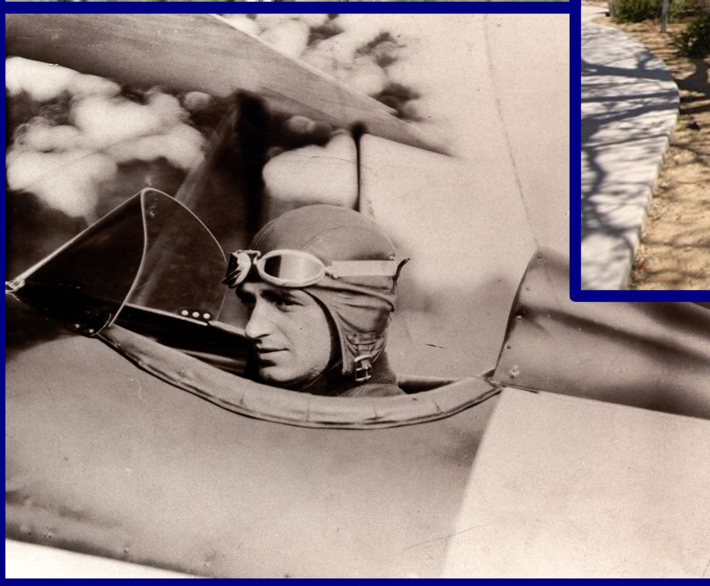
Who is ERGWAG?

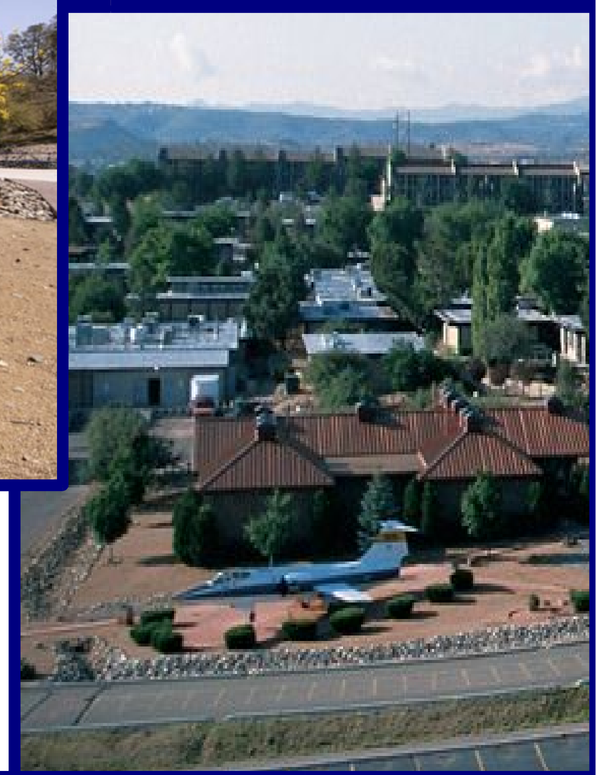
- Andri M. Gretarsson, *Asst. Prof. Physics. ERAU.*
  - Part of LSC since 1996
  - 1996-2002: Graduate student in Peter Saulson's laboratory
    - Suspension and thermal noise
    - AdLIGO coating thermal noise
    - Non-gaussian sources of mechanical noise
  - 2002-2005: Postdoc at LIGO Livingston Observatory
    - Commissioning
    - Nascent activity within Burst group (Glitch and ExtTrig)
- Up to 3 undergraduates
  - Most will be from ERAU's Space Physics program

EMBRY-RIDDLE AERONAUTICAL UNIVERSITY

- 4-year undergraduate institution specializing in science related to aerospace (~30 degree programs).
- Two residential campuses:
  Daytona Beach, FL, Prescott, AZ.
- Prescott campus physics department has 8 full-time faculty of which 7 are active experimentalists:
  - 1 GW-detection, 2 Observational Astronomy,
    1 Remote Sensing, 2 High Energy,
    1 Electron Spectroscopy, 1 Pedagogy.
- Approx. 1700 students on Prescott campus of which approx. 80 are Space Physics majors.
- Faculty and Dean place great emphasis on participation of undergraduates in research.







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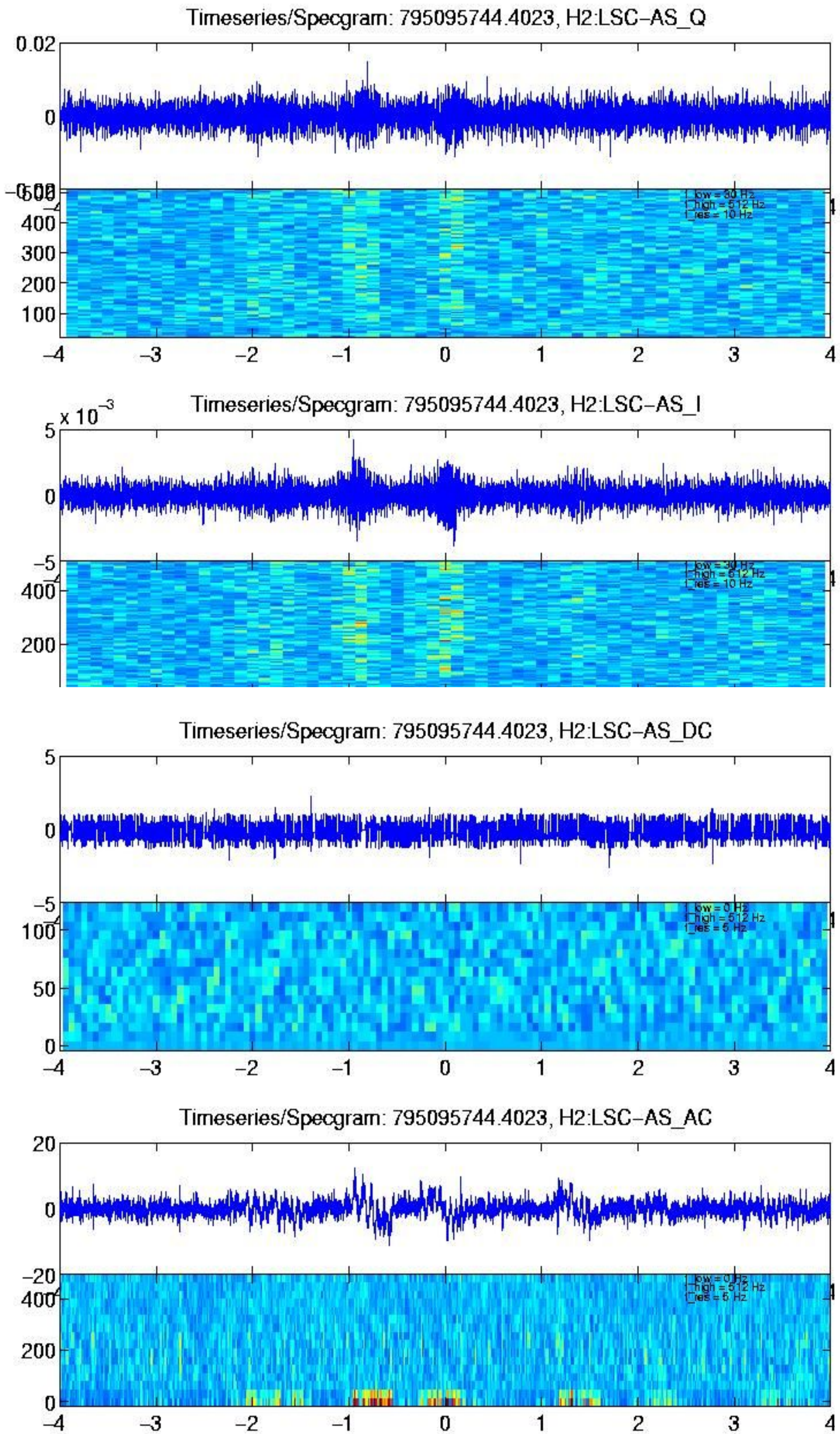
Proposed Area of Research

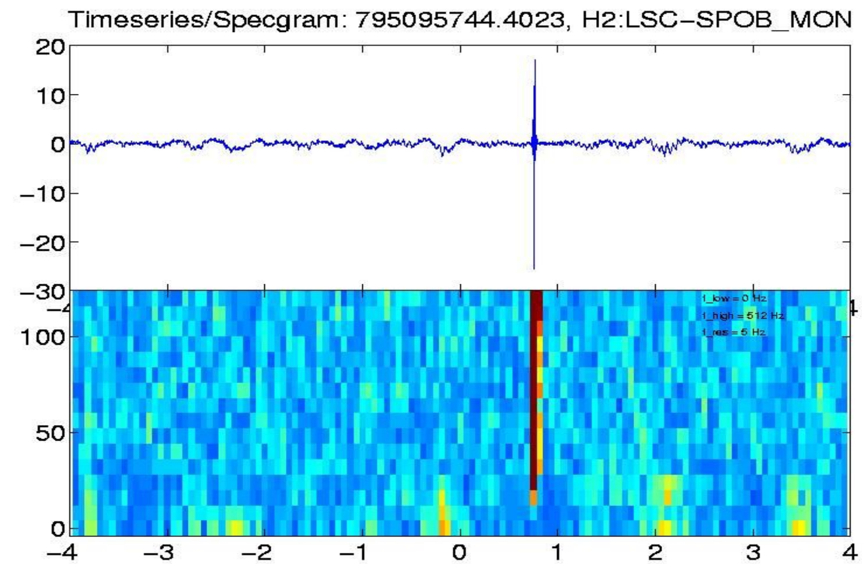
a) Characterization of instrumental artifacts (glitches) in LIGO within the context of the Burst Analysis Group.

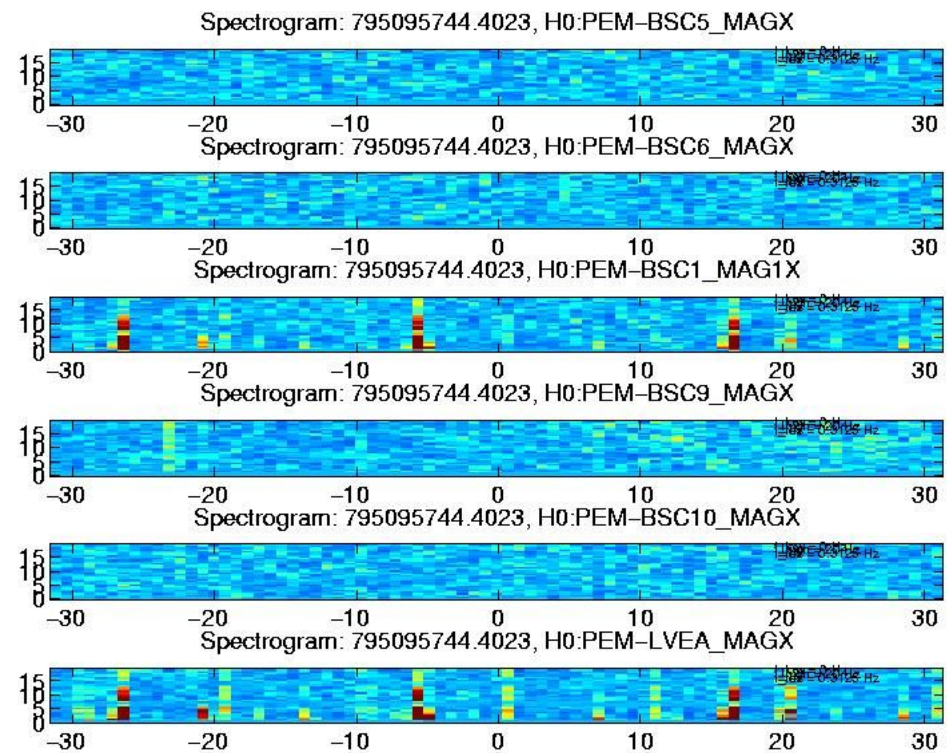
b) Experimental work towards the development of large composite test masses for future gravitational wave detectors.

c) Be available to perform short notice laboratory tabletop measurement tasks for LIGO.

Glitches



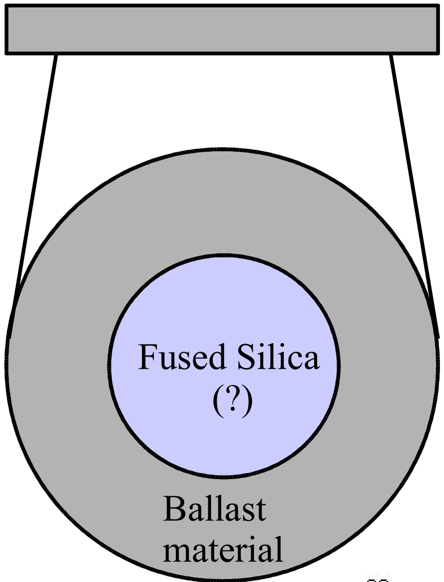




Spectrograms by K. Rawlins

Proposed Burst work

- Work within the Burst group to identify and track down sources of glitches.
- Develop a set of glitch-classification tools.
  - To the extent possible, describe common characteristics of glitches whose source is known.
  - Develop channel-specific filters that trigger on known glitch types (dust, contrast changes...)
  - Analyze the propagation of glitches between the auxiliary ports in a statistical manner.
  - See if these methods can be used to establish what is normal instrument behavior and what is "abnormal" glitchiness -- ideally in real-time.



Composite test masses:

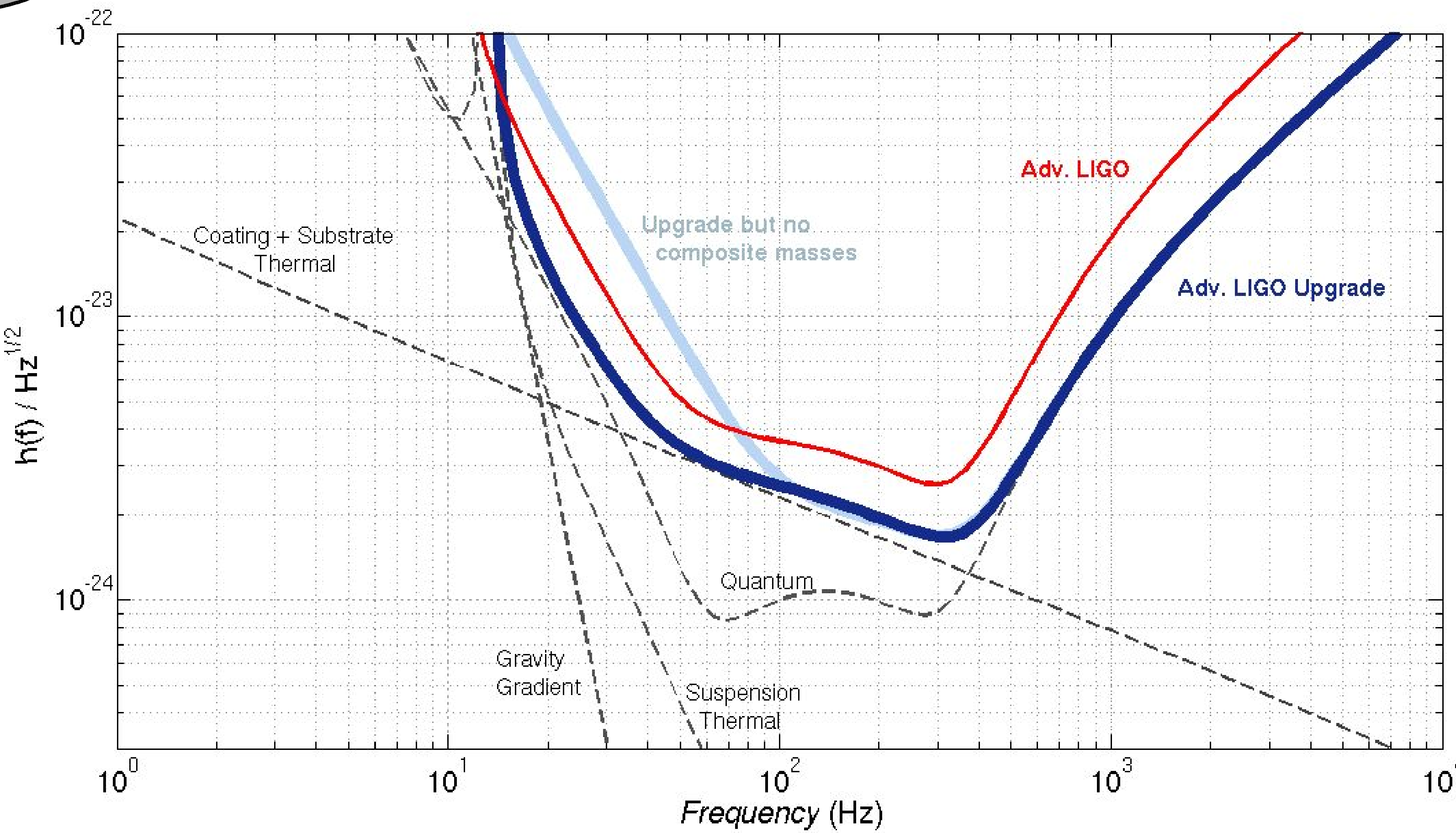
3^{rd} generation interferometer / Adv. LIGO Upgrade

Upgrade:

$\phi_{coating\_high\_n}$: 2×10^{-4} → 0.5×10^{-4}

P_{laser} : 125 W → 500 W

m_{test_mass} : 40 kg → composite 160 kg



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Noise curves generated with Bench 3.0

Challenges and Rewards

- Rewards
  - Complementary with squeezing – noise improvement by a factor of *slightly more than two* from each technology leads to a factor of *one hundred* in detection rate.
  - Ballast can be heated to help reduce thermal lensing.
  - If significant coating improvements are realized in time for Adv. LIGO, existing Adv. LIGO test masses could conceivably be embedded "as-is" in the ballast material.
- Challenges
  - Thermal noise from the ballast and ballast/optic interface must be kept below the coating and bulk thermal noise.
  - Effect of mismatched materials properties needs to be studied (thermal expansion, elastic properties)
  - Unforeseen issues (creak noise...)

Prioritized project list for Sep. '05 - Aug '06

- If nothing else:
  - Participate fully in burst group. Begin classification of glitch features.
  - Set up vacuum system in laboratory and investigate Q of wires clamped in the Initial LIGO manner.
  - Measure the vibration frequencies of an Initial LIGO test mass cage (RM cage on loan from LLO, to be shipped.)
  - Spend several weeks during summer at LLO, possibly with an undergraduate or two, to study propagation of intentionally injected transients.
- With successful undergraduate(s) do one or two of the following:
  - Apply statistical methods to investigate transient propagation in long data sets.
  - Finite element modeling of energy distribution in a clamp-wire interface & comparison with clamped wire loss measurements.
  - Finite element models of composite test mass
- Longer term:
  - Model, build and test scale-model composite test masses.
  - Build real-time glitch classification/tracking tool.

How to deal with ballast and interface thermal noise

- Extending Levin-type calculations into the optic bulk shows that even for large spot sizes, the effect of interface loss and ballast material intrinsic loss may be manageable

Relative contribution of loss centers to the interferometer thermal noise