LIGO

The LIGO Scientific Collaboration

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NSB Site Visit

LIGO Livingston Observatory

4 February 2004

LIGO

Outline

- What is the LIGO Scientific Collaboration?
- The LSC in LIGO operations
- The LSC in data analysis
- The LSC's role in advanced R&D

What is the LSC?

The LSC is the group of scientists that sets the scientific program of LIGO and carries it out.

It has 501 members. They come from the LIGO Lab and from 35 other institutions (including 19 single-investigator groups.)

76 members are postdocs, 96 are grad students. More than 20 are undergrads.

Most are from the U.S., but we have GEO members from the U.K. and Germany, and from Australia, India, Japan, Russia and Spain.

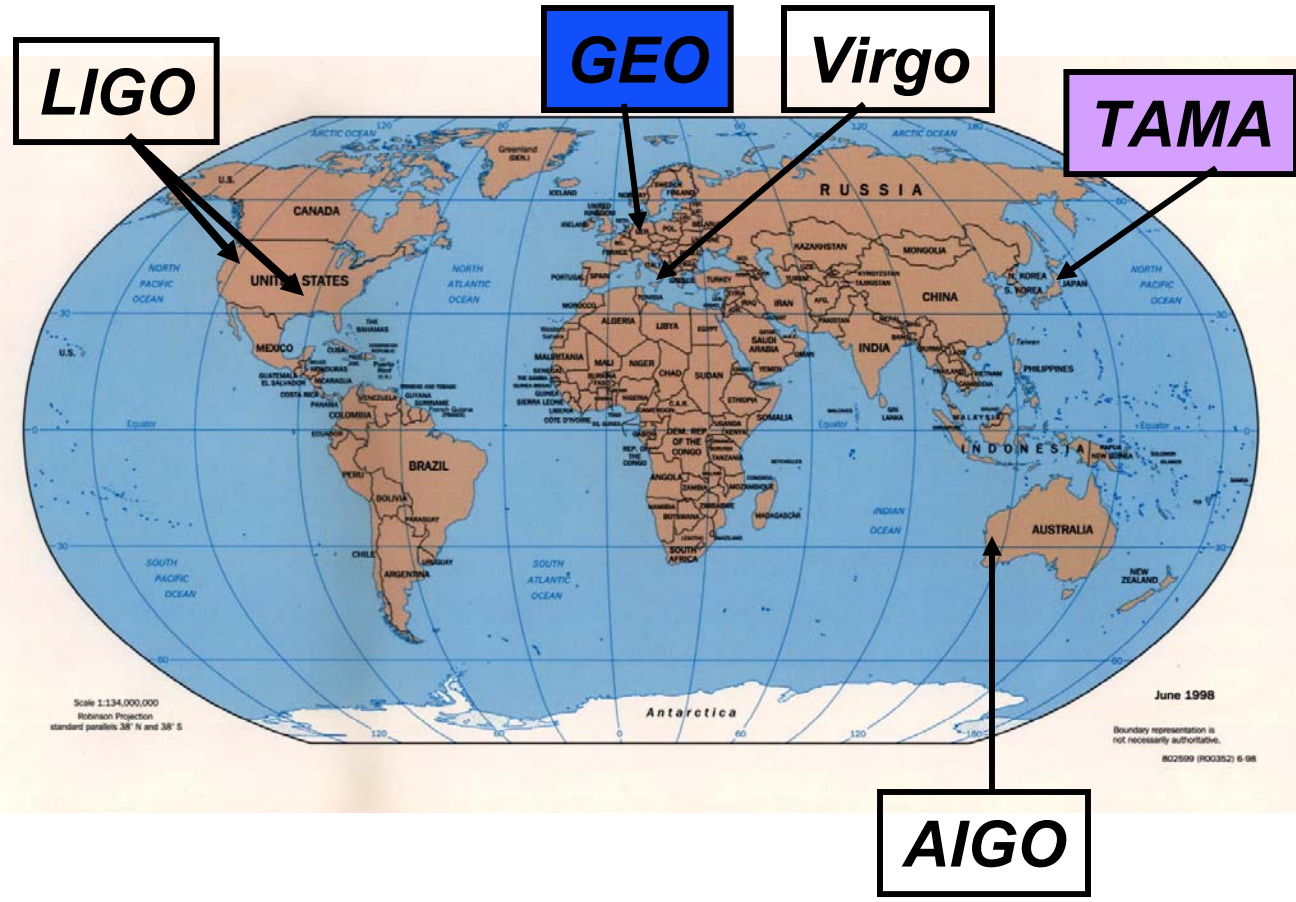
LIGO Anchors an International Network of Interferometers

Rare events require *coincident* detections.

LIGO's three interferometers were designed to emphasize obtaining good coincidences.

This makes LIGO the anchor of the worldwide network of interferometers

GEO and LIGO have a special link: all GEO members are also members of the LSC. Joint data analysis is routine.



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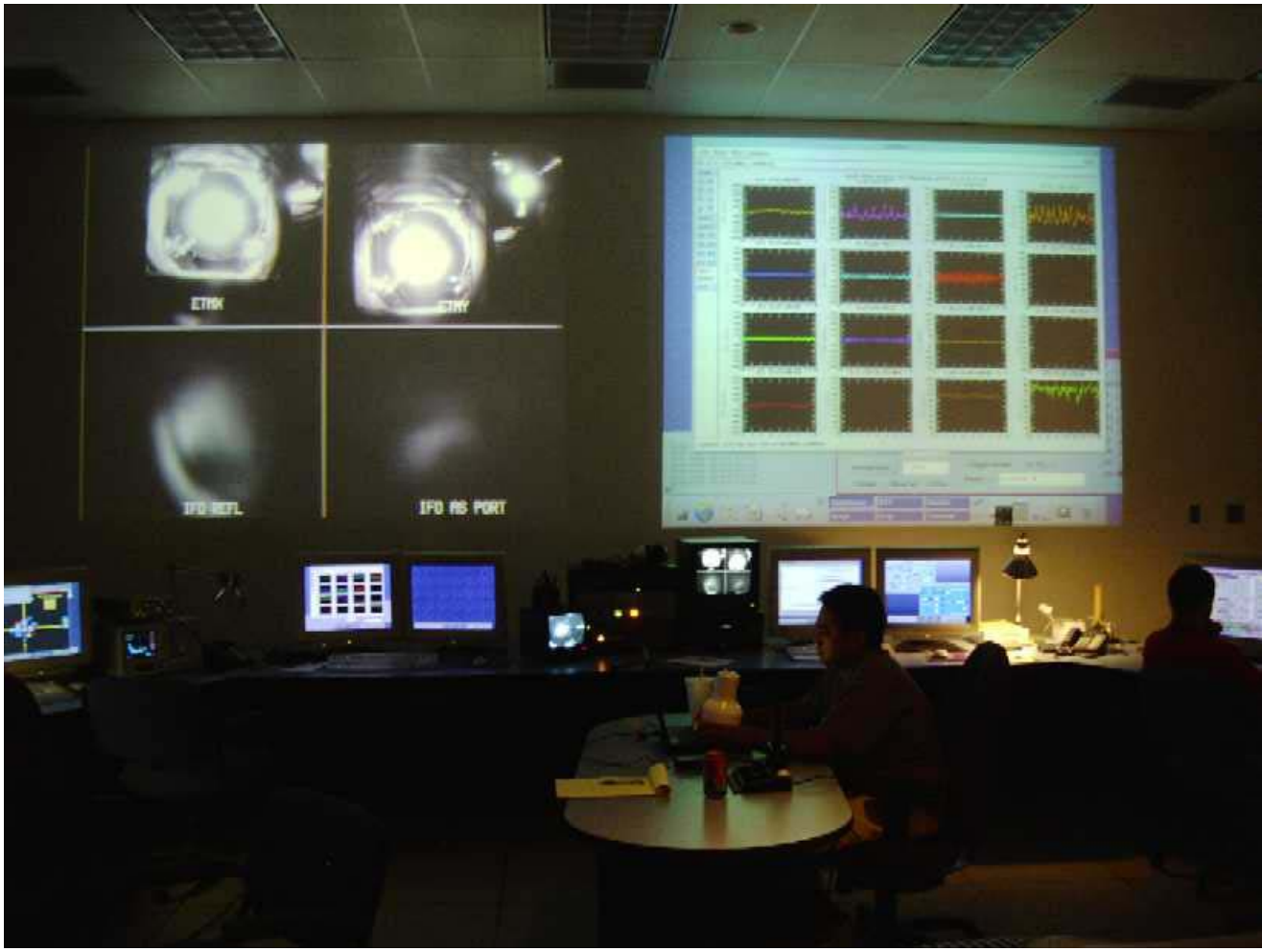
Organization of the LIGO Scientific Collaboration

- Governance:
  - » LSC Council, representative of all member groups, meets twice/yr.
  - » Executive Committee meets monthly by telecon
  - » Spokesperson
    - – Rai Weiss (MIT), 1997 – 2003
    - – Peter Saulson (Syracuse), 2003 – 2005
- Technical Working Groups:
  - » Carry out advanced R&D aimed at improving performance of subsystems or entire interferometer system.
  - » 2 of 6 chairs are from GEO.
- Data Analysis Groups:
  - » One for each of four major signal classes
  - » Two co-chairs, one experimentalist and one theorist

The LSC in LIGO Operations

Scientists examine interferometer performance during a data run.

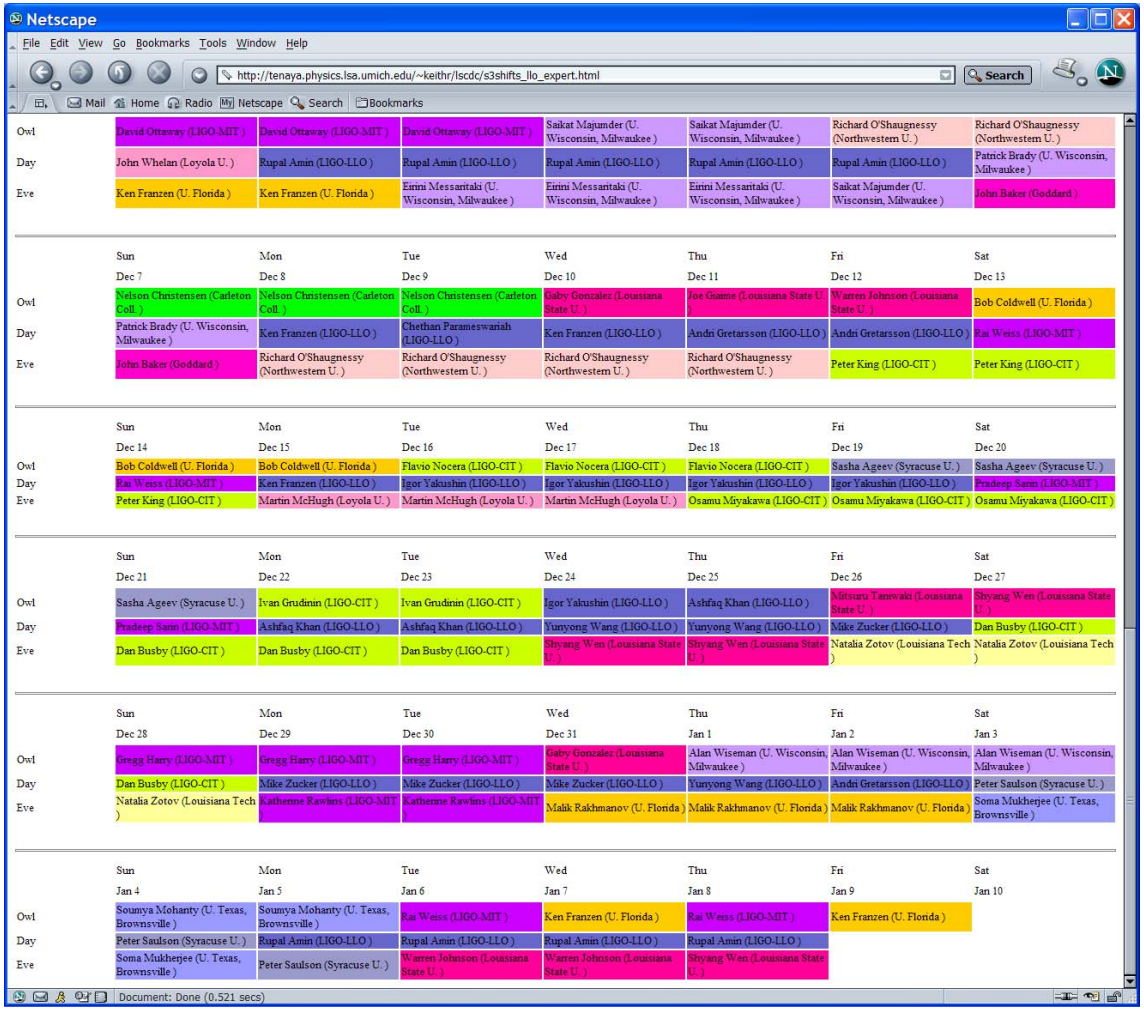


Scientific Monitoring Shifts

Part of the SciMon shift schedule during the S3 run, that just ended 9 Jan 2004.

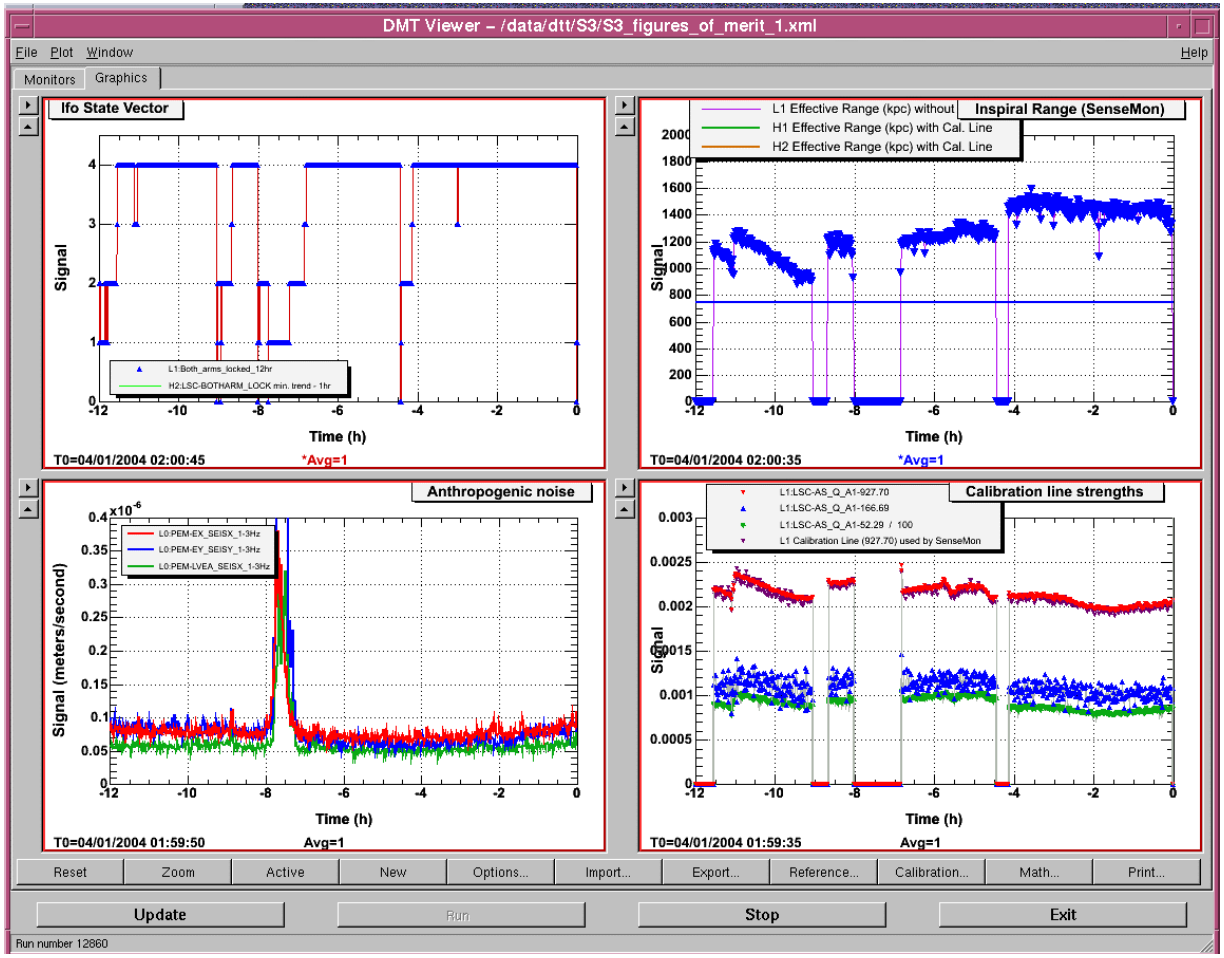
Participation in shifts is a responsibility of all groups with authors on LIGO observational results papers.

GEO members take shifts at GEO600, but we have LIGO SciMons from Australia and India.

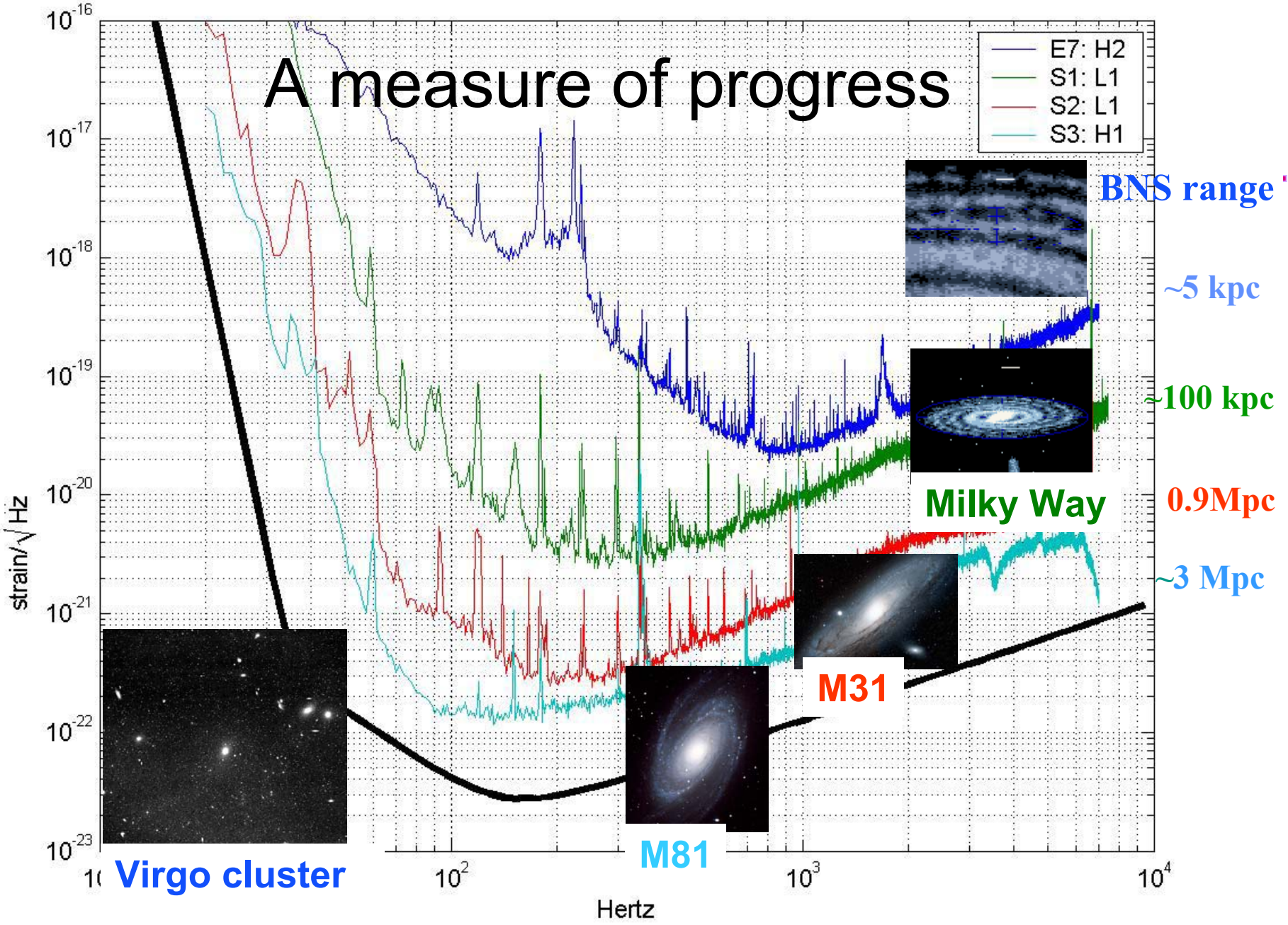


On-line Figures of Merit

Figure of Merit displays, shown on the walls of the Control Rooms, were developed by LSC members participating in the Detector Characterization Working Group.



A measure of progress



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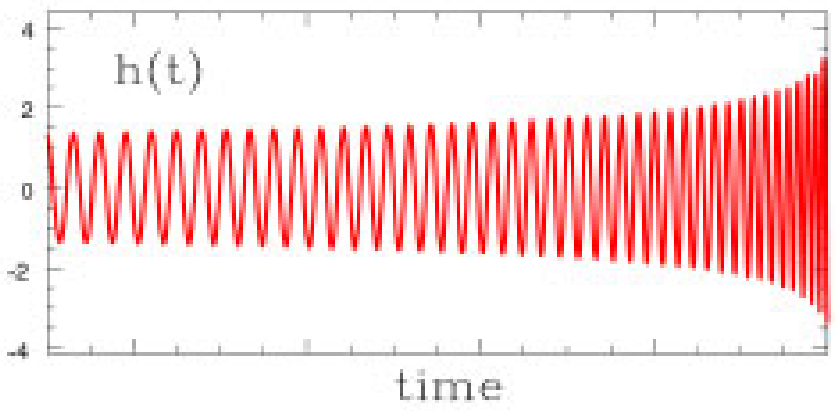
The LSC in Data Analysis

- Leadership of data analysis is distributed across the LSC. (GEO members in red.)
  - » Inspiral Group: Gonzalez (LSU) and Brady (UWM)
  - » Burst Group: Whitcomb (LIGO-Caltech) and Katsavounidis (LIGO-MIT)
  - » Stochastic Group: Fritschel (LIGO-MIT) and Romano (Cardiff)
  - » Pulsar Group: Landry (LIGO-Hanford) and Papa (AEI)
- Four papers from S1 Science Run are submitted to PRD (two already accepted.)
- S1 paved the way on methodology. Subsequent runs will push down our upper limits, or better yet, might detect signals.
- Six Ph.D. theses expected from the S2 run.

Results from S1: Upper Limits on Neutron Star Binary Inspirals

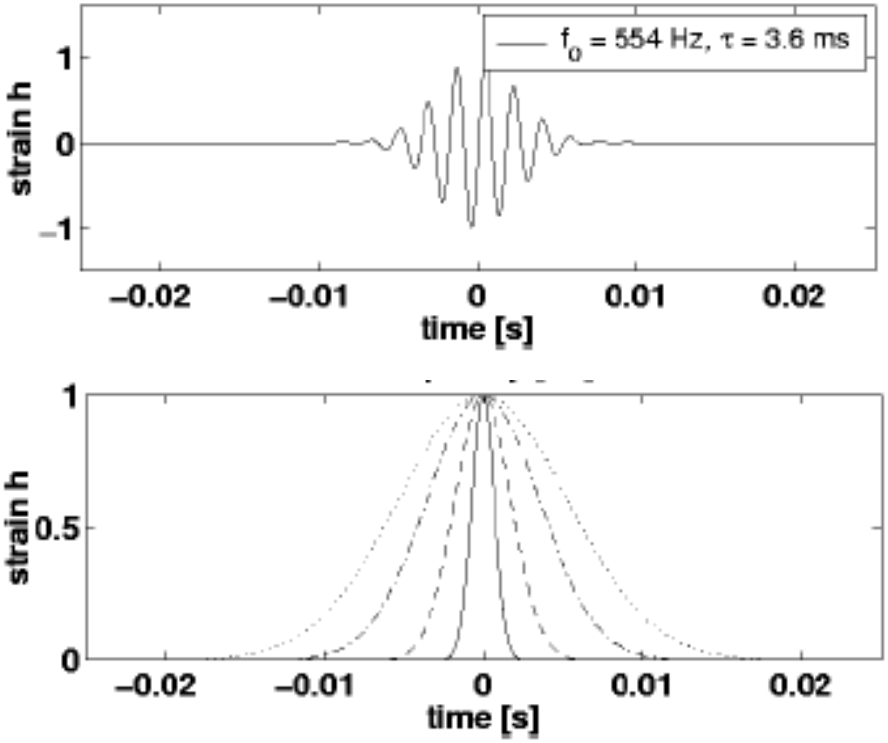


We carried out a *matched-filter* search for chirp waveforms associated with neutron star binaries between 1 and 3 solar masses.

S1 upper limit: fewer than 170/yr per Milky Way

Subsequent runs have pushed far beyond our galaxy. Stronger limits coming soon.

Results from S1: Upper Limits on Burst Signals

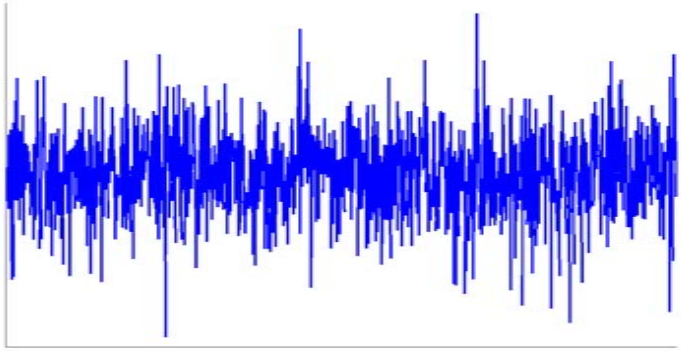


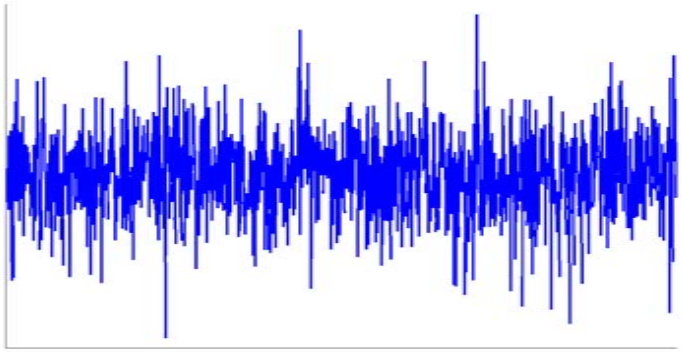
We performed a *robust* search for *coincident* transient waveforms of any shape, with durations between 4 and 100 ms and frequencies between 150 and 3000 Hz.

S1 upper limit: fewer than 1.6/day with strains large enough to see.
(root sum square strain > 10^{-18} /√Hz.)

S2 analysis also being carried out in collaboration with TAMA (Japan.)
Future runs will use a global network including not only GEO but also Virgo, and perhaps some bars.

Results from S1:
Upper Limits on a Stochastic Background





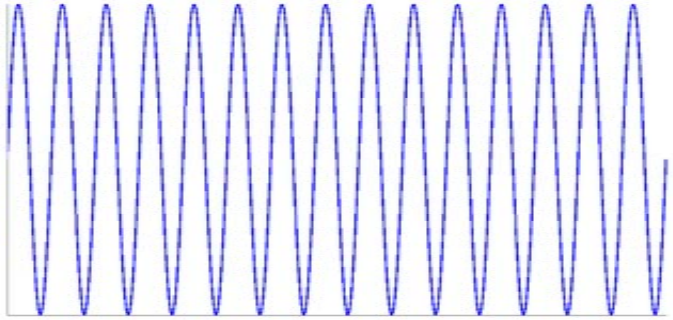
We searched for correlated noise in the three LIGO interferometers.

(Internal noises wouldn't be correlated. All external noises should be shielded or incoherent, except a gravitational background.)

S1 upper limit is the best yet made by direct observation.

(This limit improves rapidly as noise drops. For S2, should be ~1000 times better.)

Preliminary S2 result from Pulsar Search



We examined LIGO/GEO data for nearly pure sinusoids, but with the amplitude- and phase-modulation that would come from the earth's rotation and motion.

During S2, we set upper limits on the radiation from 28 known pulsars.

For the Crab pulsar, the limit is within a factor of ~35 of what is allowed by other measurements. This gap should be bridged in the data from the S3 run.

This search has an especially strong contribution from GEO.

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LSC R&D toward Advanced LIGO

- Beyond the LIGO Lab, 19 other LSC groups carry out R&D aimed at the proposed Advanced LIGO.
- The concept and basic design of Advanced LIGO came out of the first few years of LSC work.
- This work has a strong international flavor.
  GEO contributions are key, but also very important contributions from ACIGA (Australia), as well as NOAJ-TAMA (Japan) and IAP-Nizhny Novgorod (Russia.)
- A few highlights follow.

External Pre-isolator

Since before the LSC was formed, there was work on active seismic isolation for low frequencies.

Groups at Colorado, LSU, and Stanford led this effort.

Blue structures at right show parts prepared for installation at LLO this month, to deal with excess noise in the 1 – 3 Hz band.

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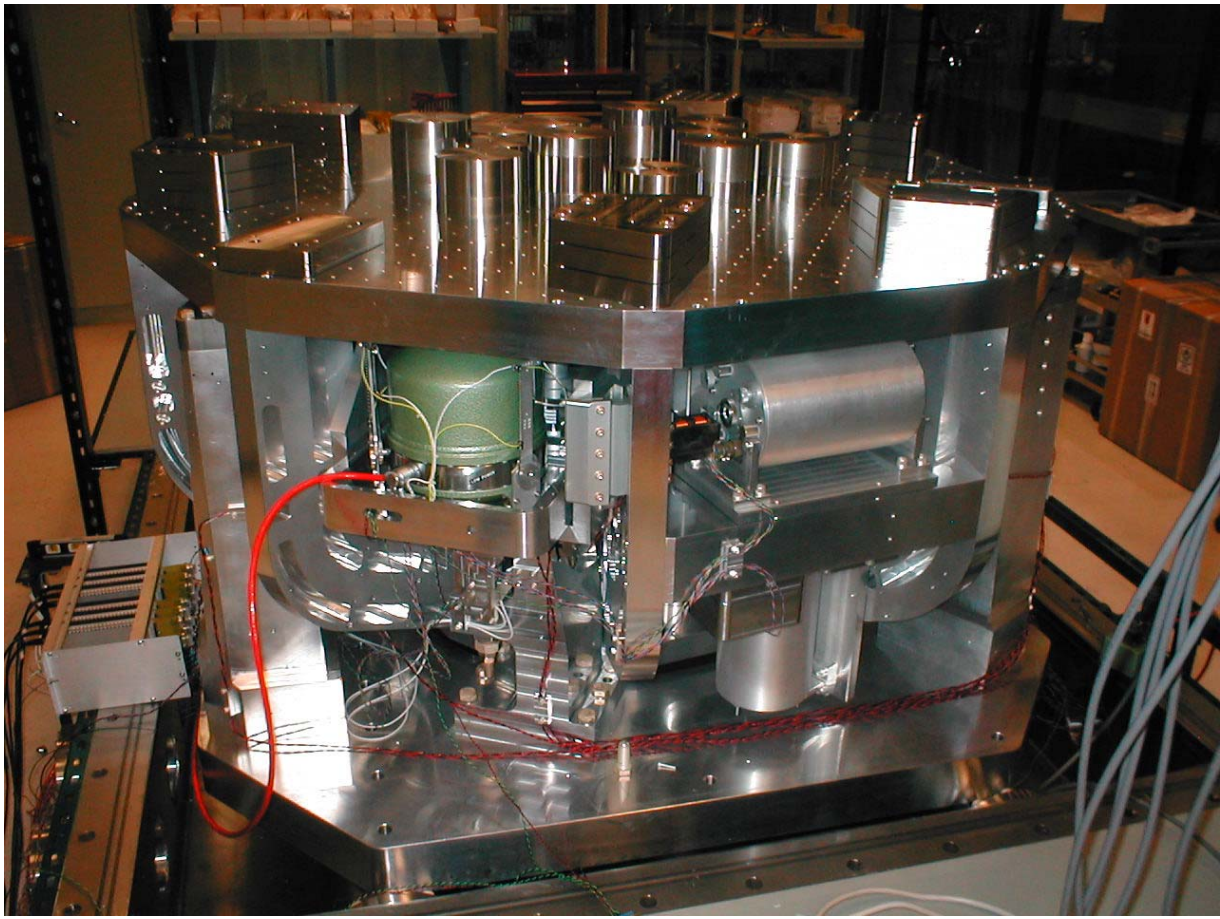
Two-stage active isolation platform

Low frequency noise will need to be attenuated further.

This structure at Stanford shows a prototype of in-vacuum low noise active seismic isolation.



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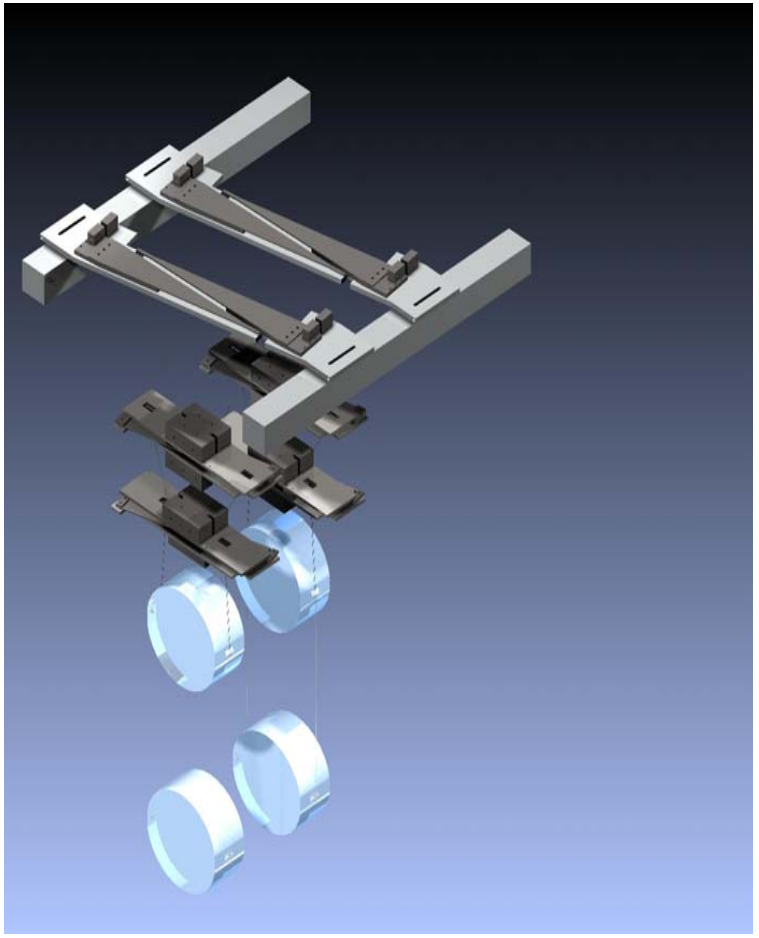
Advanced Suspensions

Better sensitivity will require substantially greater attenuation of seismic noise, and also much lower thermal noise (Brownian motion of mirrors.)

This schematic shows the test mass suspension design developed by GEO (Glasgow).



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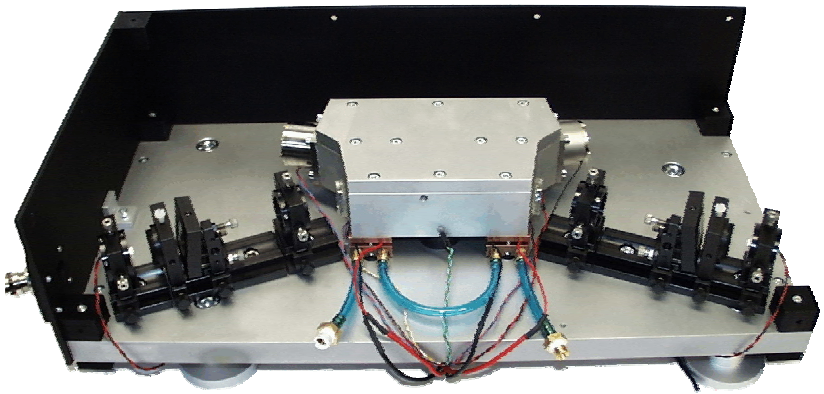
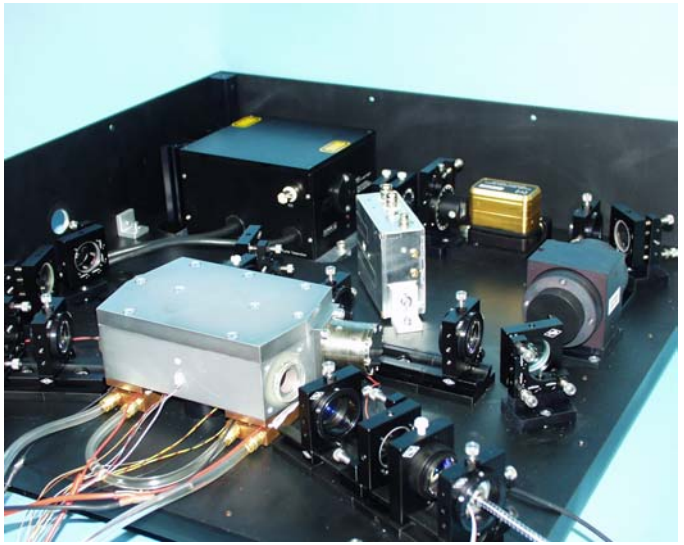
Prototype advanced suspension

An engineering prototype of one of the GEO suspensions, similar to the schematic on previous slide.

Designed in Glasgow, it is being tested at LIGO's full-scale test facility at MIT.

Laser Zentrum Hannover leads development of high power lasers





To reduce shot noise, one needs more powerful lasers. These solid-state lasers, developed for GEO and Virgo, are the foundation for new work that already has demonstrated ~ 100 W output.

LIGO

A thriving scientific collaboration

- The LSC is an open collaboration with a strong international character and a large population of students.
- Our first round of papers are all with the journals. A new round of papers from the S2 and S3 runs is being prepared now.
- Advanced R&D has found practical ways to push sensitivity by an order of magnitude beyond the present LIGO design, as embodied in the Advanced LIGO proposal.
- LSC research is full of the excitement of a growing discovery field of science.