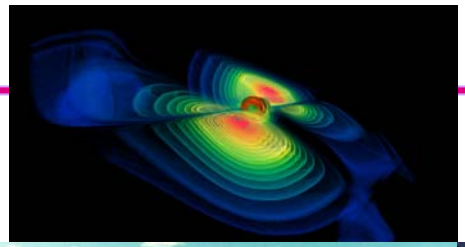
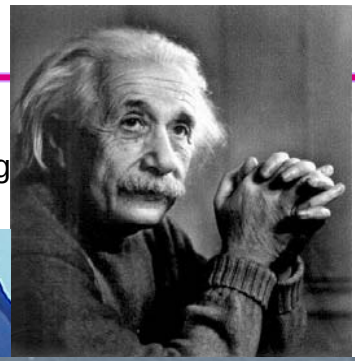
Broader Impacts of LIGO in Education



"Colliding Black Holes"

Credit:
National Center for Supercomputing Applications (NCSA)



Fred Raab,
LIGO Hanford Observatory

“Brought to you by the National Science Foundation, America’s investment in the future…”

- LIGO is on the forefront of international science
  - » detection of 1st traveling space warps from black holes and other exotic objects will be a signature event in science, comparable to the invention of the telescope, the microscope, or the dawn of flight
- LIGO aims to be on the forefront of education
  - » this science is so exciting, it must be shared with the public
  - » started with our local communities in the Northwest and in the Gulf states, where observatories are located
  - » regional, national and international coverage have grown over time

The LIGO Scientific Collaboration is an educational engine

- We will be developing a comprehensive guide to educational activities across LIGO
- We know the following:
  - » many of the hundreds of LSC members are at a young stage in their careers
  - » 28 thesis students are actively working analyzing LIGO data
  - » 30 REU/SURF students per year at Caltech/LHO/LLO alone
  - » hundreds of K-12 teachers and students utilize LIGO for professional development, school visits, etc.
  - » LIGO hosts many thousands of public visitors from all walks of life

LIGO Thesis Prize Entries (PhD within 2 years)

- R. Adhikari, *Sensitivity and Noise Analysis of 4 km Laser Interferometric Gravitational Wave Antennae*, (Weiss/Fritschel, MIT) currently at Caltech, winner
- D. A. Brown, *Searching for Gravitational Radiation from Black Hole Machos in the Galactic Halo*“, (Brady, UWM); currently at Caltech
- W. E. Butler, *Investigation of radiation pressure effect in a frequency-detuned interferometer and development of the readout scheme for a gravitational-wave detector*, (Melissinos, Rochester)
- R. J. Dupuis, *Bayesian searches for gravitational waves from pulsars*, (Woan, Glasgow); currently at Caltech
- C. Hardham, *Quiet Hydraulic Actuators for Advanced LIGO*, (DeBra, Stanford)
- W. Hua, *Low Frequency Vibration Isolation and Alignment System for Advanced LIGO*, (DeBra, Stanford)

Student dissertations currently underway

- Lindy Blackburn (MIT)
  - » Real-time searches for GWBs with multiresolution methods
- Josh Dalrymple (Syracuse)
  - » Study of coupling of PEM channels into interferometer output
- Masahiro Ito (Oregon)
  - » Study supernova GW detection using matched filtering with model-based waveforms
- Peter Kalmus (Columbia)
  - » TBD (currently working on SGR1806)
- Jared Markowitz (MIT)
  - » TBD (currently working on network analyses)
- Ajith Parameswara (AEI)
  - » TBD

Student dissertations currently underway

- Peter Raffai (Columbia), Diploma Thesis
  - » GRB search based on the Maurice van Putten model
- Rauha Rahkola (Oregon)
  - » Develop an externally-triggered search for bursts in the form of pulse-trains using cross-correlation methods
- Saikat Ray-Majumder (UWM)
  - » Use excess power algorithm to search for merger signals following inspiral event candidates
- Jamie Rollins (Columbia)
  - » TBD (currently working on optical supernovae/neutrino prompt look)
- Amber Stuver (Penn State)
  - » Carry out a comparative study of the performance of various burst ETGs on simulated signals of different types

Student dissertations currently underway

- Tiffany Summerscales (Penn State)
  - » Develop analysis to detect supernova GW and extract information from the signal about supernova physics
- Charlie Torres (UT Brownsville)
  - » Develop “track search” method for detecting long-duration unmodeled signals
- Lisa Goggin (Caltech)
  - » BH Ringdown search
- Chad Hanna
  - » PBH & instrumental veto studies
- Gareth Jones
  - » Spinning binary black holes
- Craig Robinson
  - » BBH – physical waveform follow-up step

Student dissertations currently underway

- Andy Rodriguez
  - » PBH & signal based veto studies
- Matt Pitkin, University of Glasgow
  - » TDS search for GWs from known, isolated and binary NS
- John Veitch, University of Glasgow
  - » MCMC method, search for GWs from SN1987A
- Chris Messenger, University of Birmingham
  - » Fstat binary search for GWs from ScoX-1
- Vladimir Dergachev, University of Michigan
  - » Powerflux incoherent method, all-sky broadband search
- Joe Betzweizer, MIT
  - » Stackslide search for GWs from NS candidates such as Chandra X-ray point sources

Student dissertations currently underway

- N. Fotopolous (MIT, Master's student)
  - » H1-H2 (> 300 Hz)
- S. Ballmer (MIT)
  - » 'Radiometer' search for excess GW flux
- S. Mitra (IUUCA)
  - » All-sky map of SGWB
- S. Giampanis, T. Fricke (Rochester)
  - » H1-H2 search at 37.5 kHz
- New PhD student (Birmingham)
  - » SGWBs with aribtrary WGW(f)

Major Education & Outreach Efforts within LIGO

LIGO Hanford Observatory

LIGO Science Education Center

LIGO Livingston Observatory

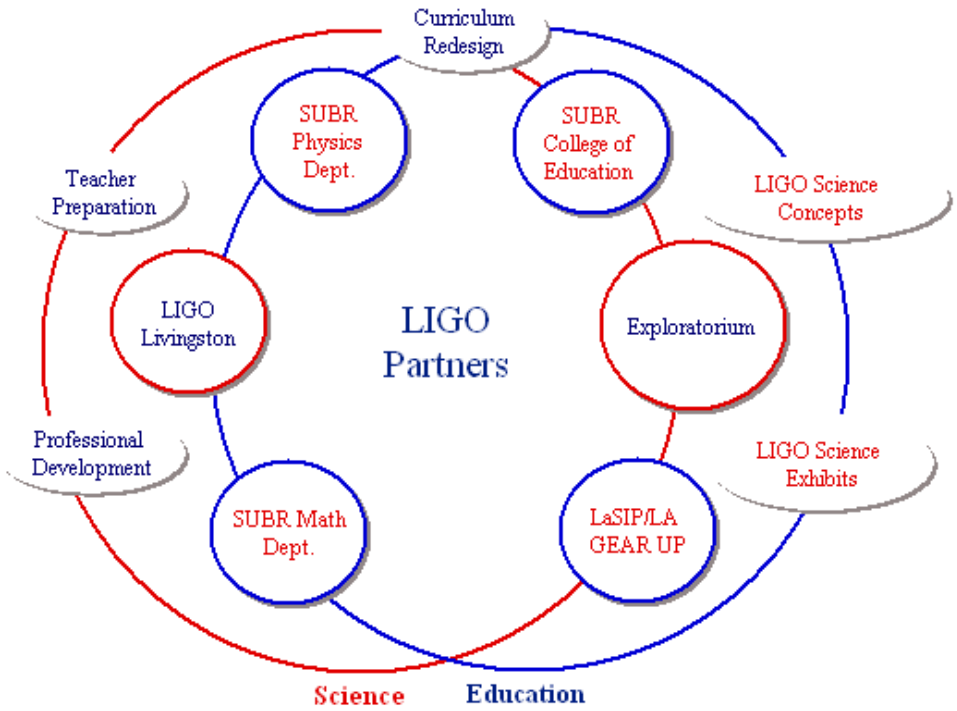
Center for Gravitational Wave Physics (PSU)

Center for Gravitational Wave Astronomy (UTB)

Top priority activities recommended by Local Educator Networks at LHO, LLO

- Bring public out to “touch and see” science in the making
- Help our schools with teacher training, internships and school tours
- Help us integrate science research into science teaching
- Help the public to value the richness of science

LIGO Science Education Center in Livingston, LA



- Southern University will integrate LIGO Science Education Center into its pre-service and in-service teacher training program
- Exploratorium -- nation's premier designer of exhibit-based science teaching -- supplies exhibits and teacher training
- LaSIP/LaGEAR-UP will ensure state-wide visitation by schools, with emphasis on teachers and schools with greatest needs

LSEC Exhibits in Play

Center for Gravitational Wave Astronomy

- University of Texas, Brownsville
- Students >90% Hispanic Origin
- Operates GRID summer school for senior and early graduate student training
- Summer academy for high school students →

CGWA GRID Summer School at South Padre Island

2004

36 students from 19 universities including 4 international students from Brazil, Canada, Mexico and Russia.
Diverse backgrounds.
4 Minority Serving Institutions.
12 students belonging to minority groups.
10 women.

2005

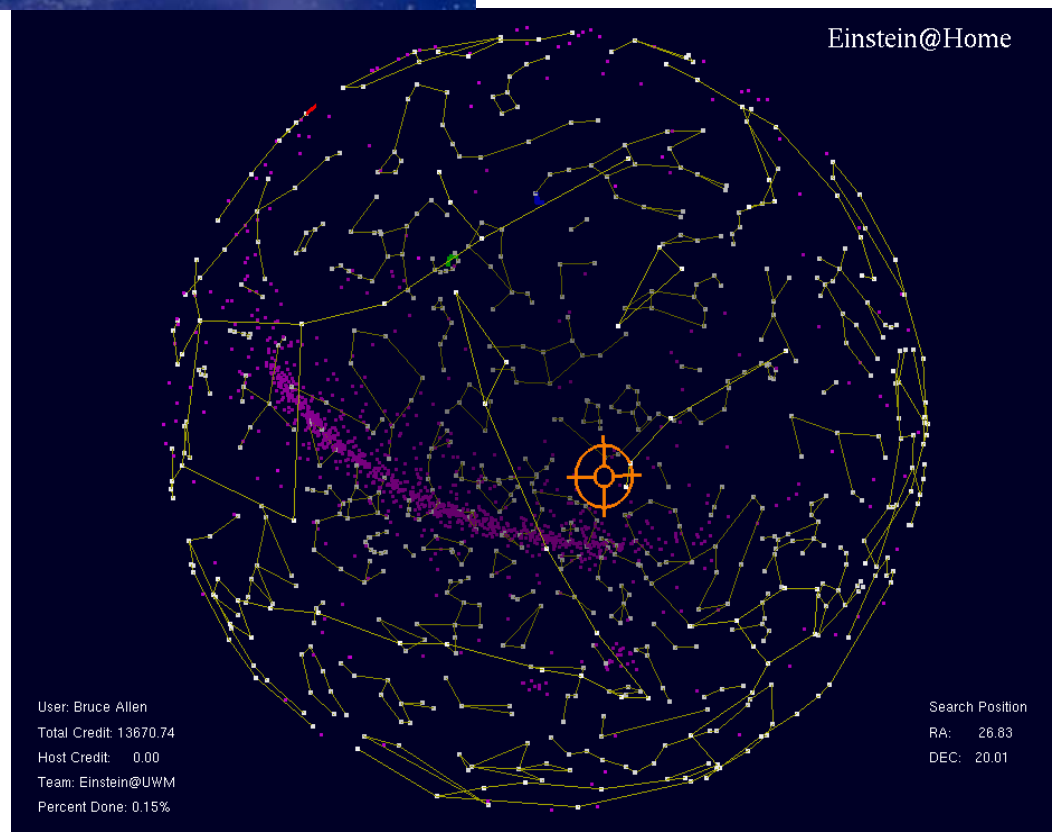
42 students from 23 universities including 6 international students from Argentina, Brazil and India.
4 Minority Serving Institutions.
16 students belonging to minority groups.
10 women.
Increased participation from UTB.

Center for Gravitational Wave Physics

- Pennsylvania State University
- Co-sponsored and collaborated with MacDonald Observatory to create five ***Star Date*** radio programs on Gravity to commemorate World Year of Physics and reach a broad audience of English- and Spanish-speaking listeners
- Collaborated with WPSX-TV/Penn State Public Broadcasting on the creation of a What's In The News (WITN) television episode titled ***Grasping for Gravity***
- Horizons/Frontiers programs to help involve scientists in local community educational activities and in regional/national outreach

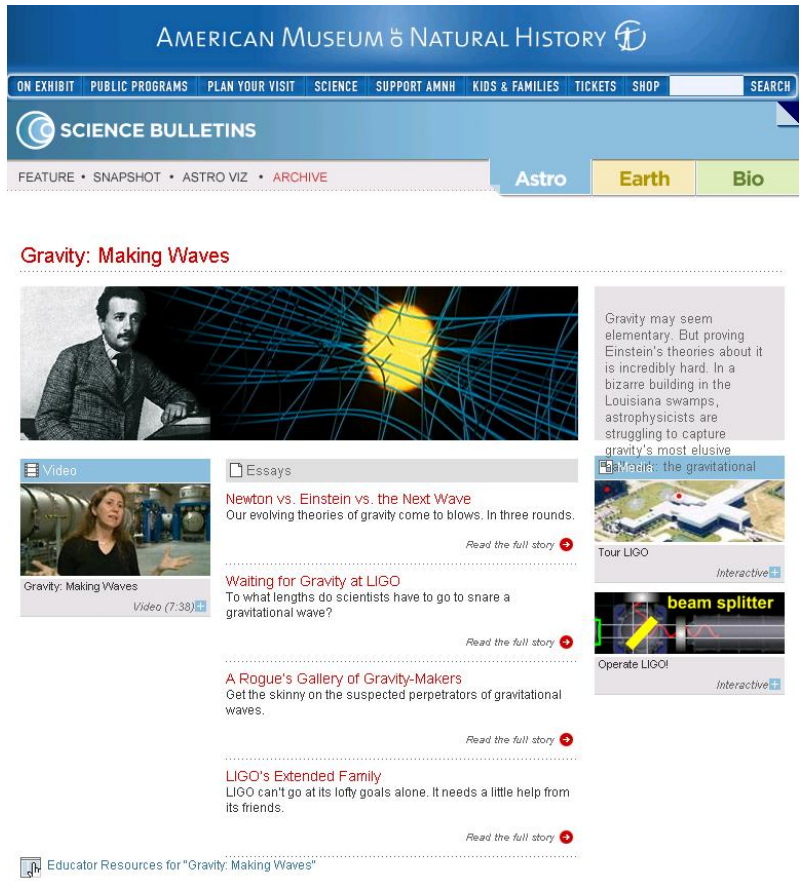
LIGO

- "Screensaver" search for undiscovered neutron stars and strange quark stars
- Uses 40,000 host computers with capacity ~20 Tflops, 24x7
- First-pass analysis for LIGO/GEO600 data

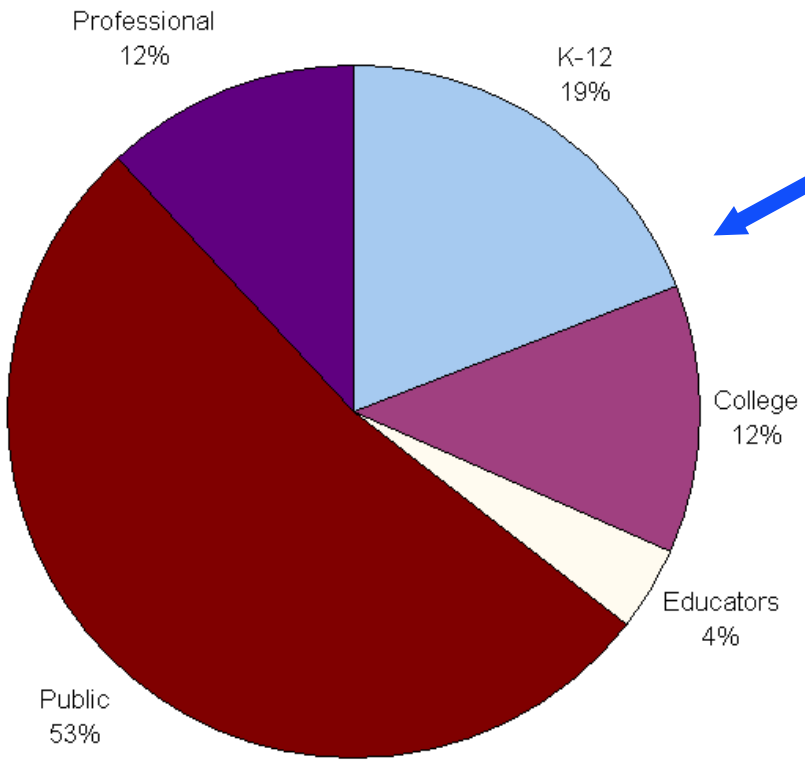


LIGO International Media Support

- AMNH bulletin →
- David Kestenbaum (NPR) received 2003 AAAS Science Journalism Award for best radio program, "Experiment Attempts to Detect Gravity Waves" (16 September 2002)
- Articles in *US News, Asahi Shimbun, The Bent, Air and Space*, dozens of national and international newspapers
- Work with BBC radio and TV, NOVA, Scientific American Frontiers, etc.
- *Einstein's Unfinished Symphony* by Marcia Bartusiak



LIGO Public Outreach Last Year



LIGO Hanford Observatory expects > 3000 visitors in 2005, for tours, star parties, workshops and other programs.

LIGO Livingston Observatory has comparable number of visitors, but more heavily weighted toward teacher workshops and school visits.

A special series of monthly events . . .

LIGO

Celebrate the International Year of Physics

with the

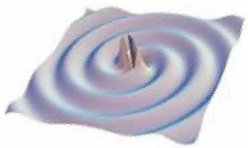
LIGO Hanford Observatory

World Year of PHYSICS 2005

Event	Date	Appetizer
Say Hello to Einstein@Home	Saturday, January 8	Enjoy an evening of Einstein and neutron stars. Learn how to search for gravitational waves on your own computer
Einstein@The Movies	Saturday, February 5	A showing and discussion of the film "Runaway Universe" in LIGO's auditorium
Einstein@The Movies	Saturday, March 5	"Death Star." View and discuss this fascinating glimpse into gamma ray bursts, perhaps the most violent events in the universe
National Astronomy Day	Saturday, April 16	Explore the wonders of the night sky. All ages and levels of experience are welcome
El Cielo en Mayo	Saturday, May 21	Un acontecimiento de la astronomía de la lengua Española para las familias
Shadows, Sticks, the Earth & You	Saturday, June 18	Welcome the Summer Solstice by measuring the size of the earth. We'll provide the sticks!
Einstein@The Movies	Saturday, July 16	"Time Travel." Join us for a viewing and discussion of this mind-bending aspect of Einstein's legacy
Watch the Space Rocks Roll	Friday, August 12	Take in the Perseid Meteor Shower from the darkness of the LIGO night sky
LIGO Public Lecture	Sunday, August 14	Learn how Einstein's ideas continue to influence the big questions in astrophysics
Einstein@The Movies	Saturday, Sept. 17	"The Elegant Universe, Part One." Einstein's work set in motion the quest for a theory of everything
Einstein@The Movies	Saturday, October 15	"The Elegant Universe, Part Two." What are strings, and are they part of everything?
Einstein@The Movies	Saturday, Nov. 19	"The Elegant Universe, Part Three." 3 dimensions, or 4, or 10? How many are there, and where are they hiding?
Here Comes the Sun	Saturday, Dec. 17	Winter Solstice means more daylight is on the way. Get ready - come and build a take-home Sundial!

Free Observatory Tours on the 2nd Saturday of every month

For times, driving directions and more information about World Year of Physics events, find LIGO Hanford on the Web at http://www.ligo-wa.caltech.edu or call 509-372-8300 ext 248



Free admission for all events

Interactive Exhibits at the Site

Summer Research

Professional development:
WSU-TC T&L 523, *The Nature of Science*

Using Virtual Computing to Integrate Research into High Schools

- LIGO is part of *Interactions in Understanding the Universe* through its Hanford Observatory
  - » Goal to support and strengthen the E&O activities of Grid-based scientific experiments that utilize federated resources at U.S. labs and universities
  - » Coalition of Fermilab, Adler Planetarium, Brookhaven, U. Chicago, U. Houston, LHC (ATLAS&CMS), LIGO, QuarkNet, MARIACHI, CHEPREO
  - » LIGO Hanford will utilize its experience embedding scientific research into high school science classrooms to pilot tools for delivery and analysis of LIGO Physics Environmental Monitoring data and its utilization by teachers