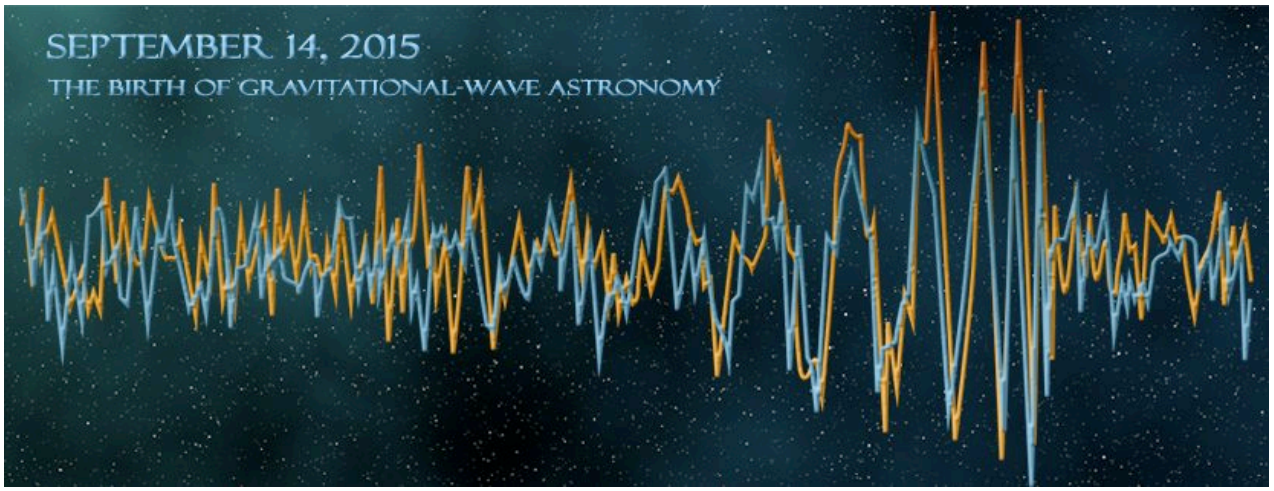
Observation of Gravitational Waves: A Team Effort (a personal view)

Gabriela González,
Louisiana State University

National Mentoring Community Conference
University of Houston, Texas, October 22 2016



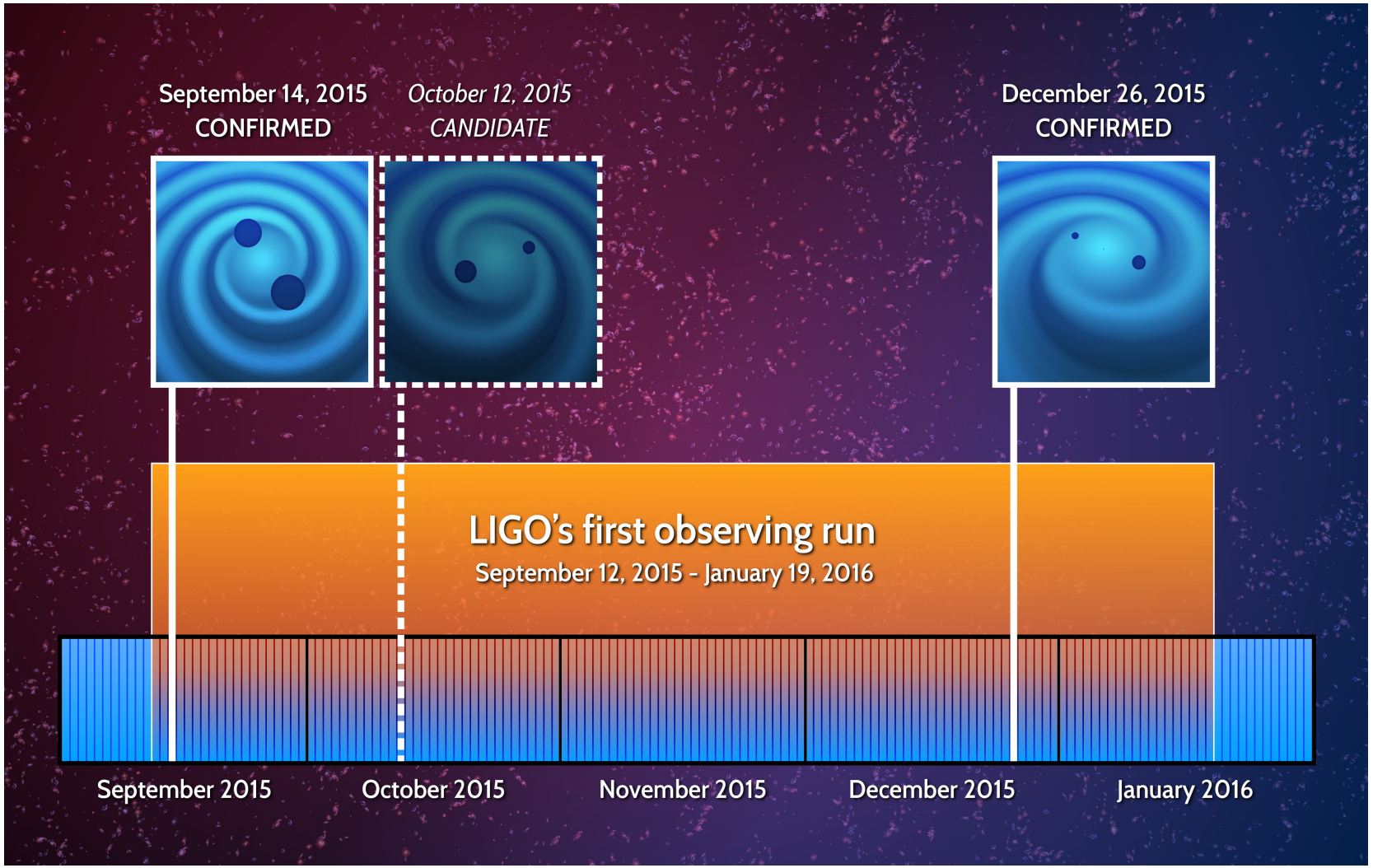
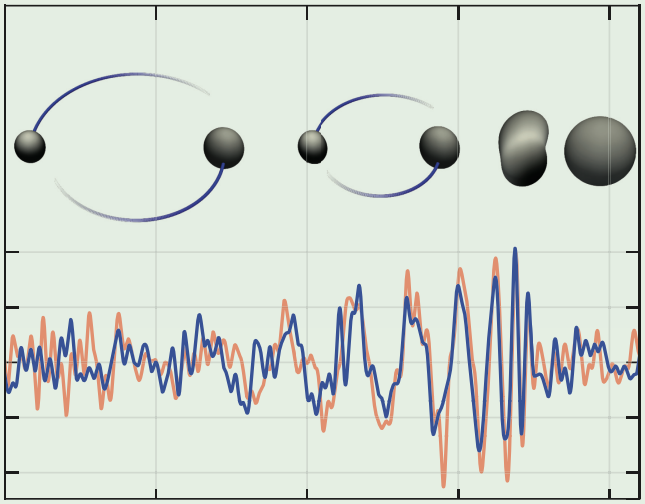


Image credit: LIGO

PRL 116, 061102 (2016) PHYSICAL REVIEW LETTERS week ending 12 FEBRUARY 2016

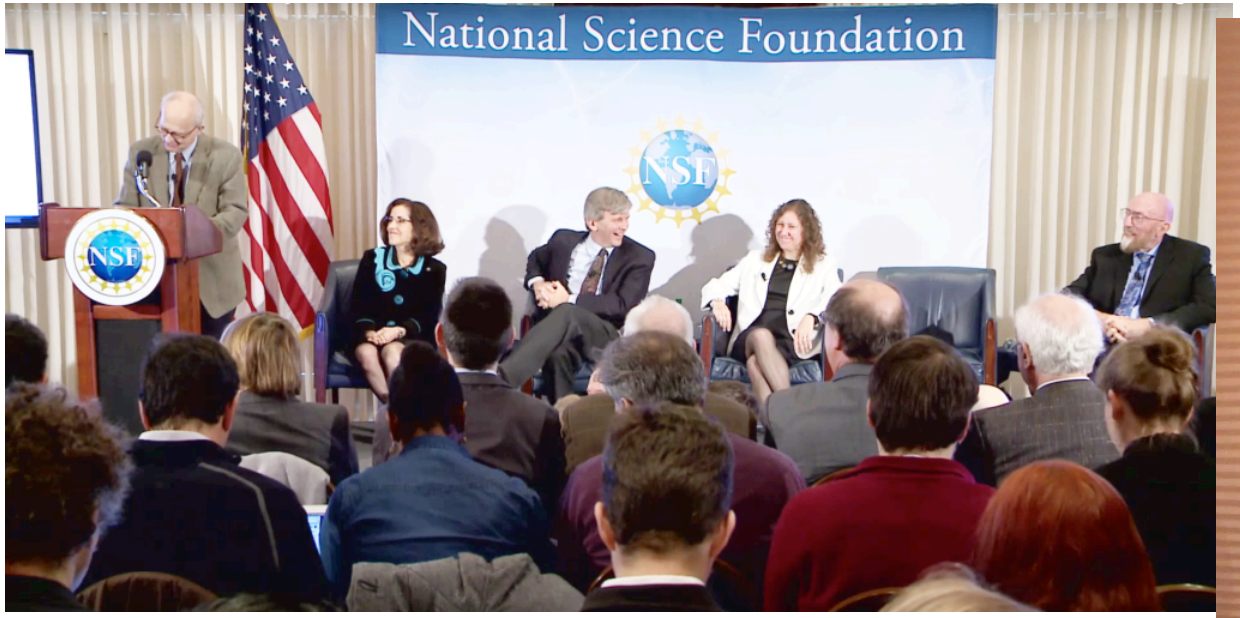
Observation of Gravitational Waves from a Binary Black Hole Merger

B. P. Abbott *et al.**
(LIGO Scientific Collaboration and Virgo Collaboration)
(Received 21 January 2016; published 11 February 2016)



Published by
American Physical Society
APS physics
Volume 116, Number 6

February 11: We did it!

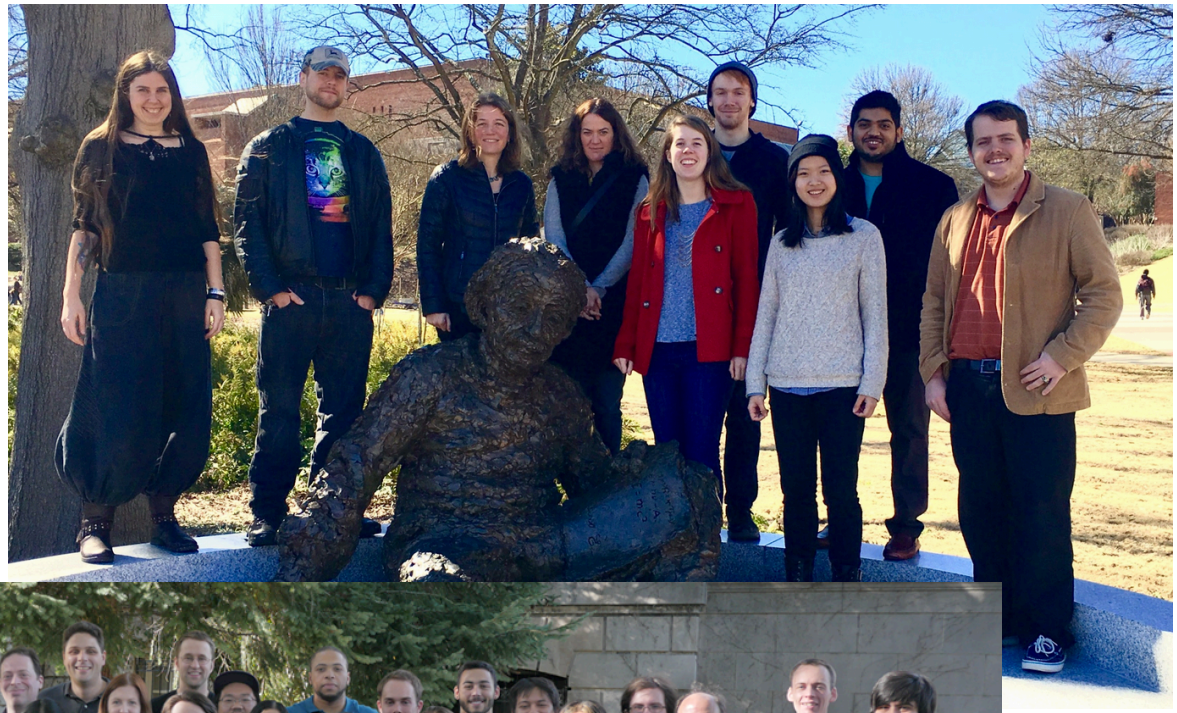


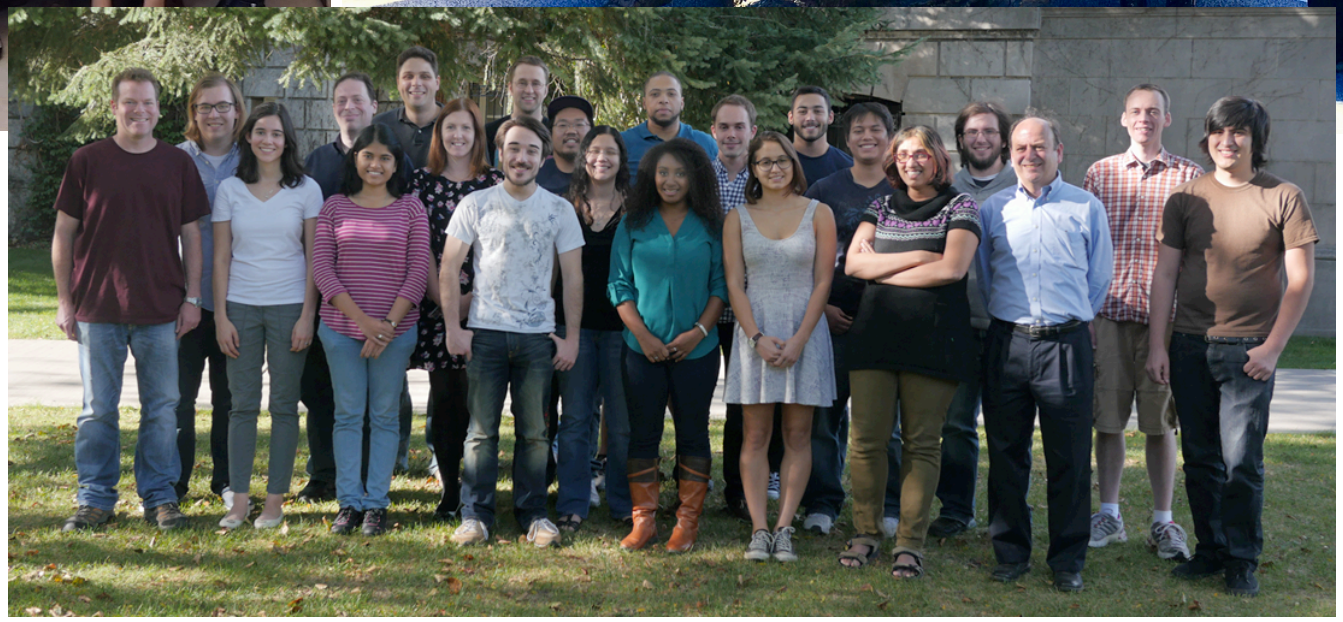
LIGO Scientific Collaboration

Founded in 1997
1000+ members
15 countries
www.ligo.org

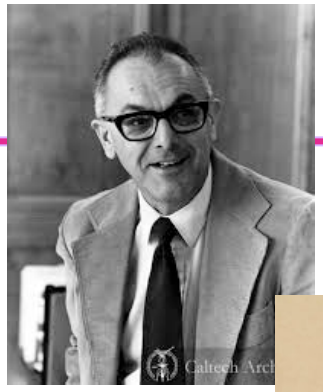
LIGO Scientific Collaboration

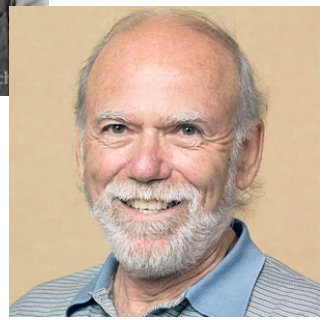
Each group has quite a few young people!





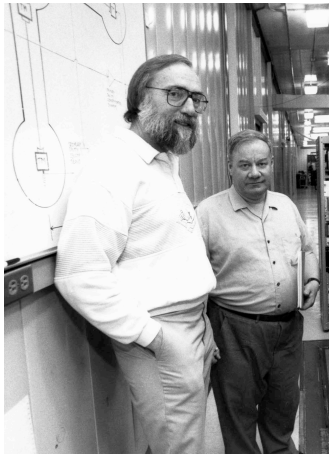
LIGO Laboratory



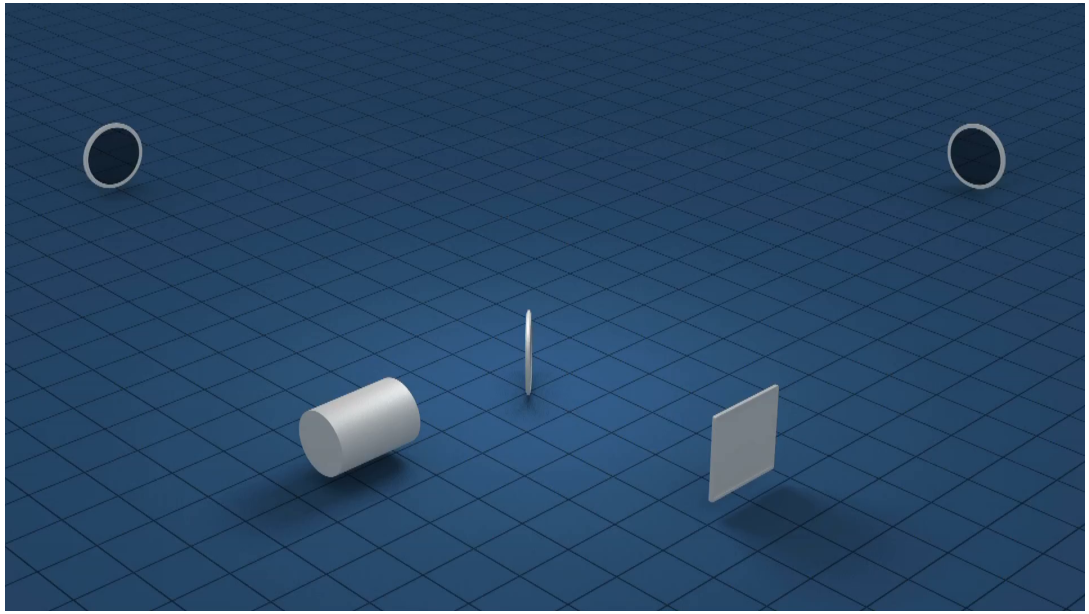


In the 70-80s: LIGO concept

Rai Weiss, MIT



Kip Thorne, Ron Drever, Caltech



Credit: LIGO/T. Pyle

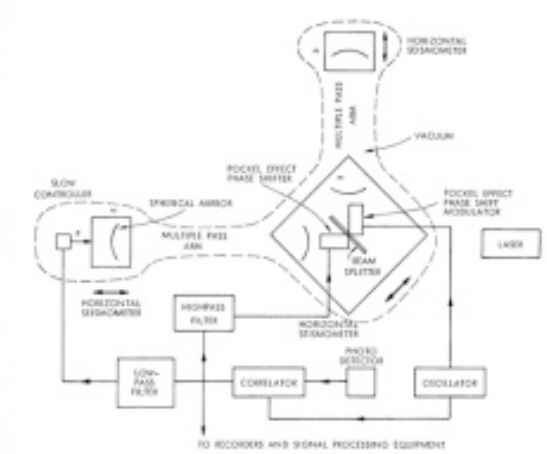
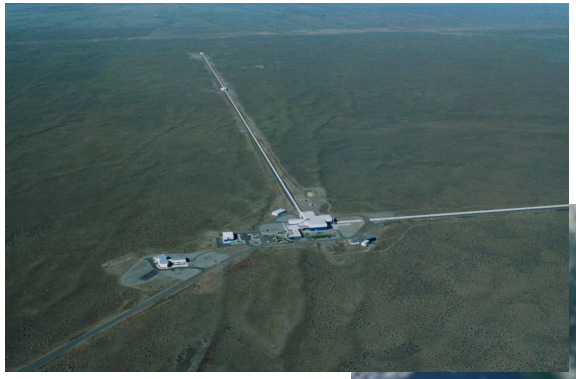


Fig. V-20. Proposed antenna.

In the 90's…

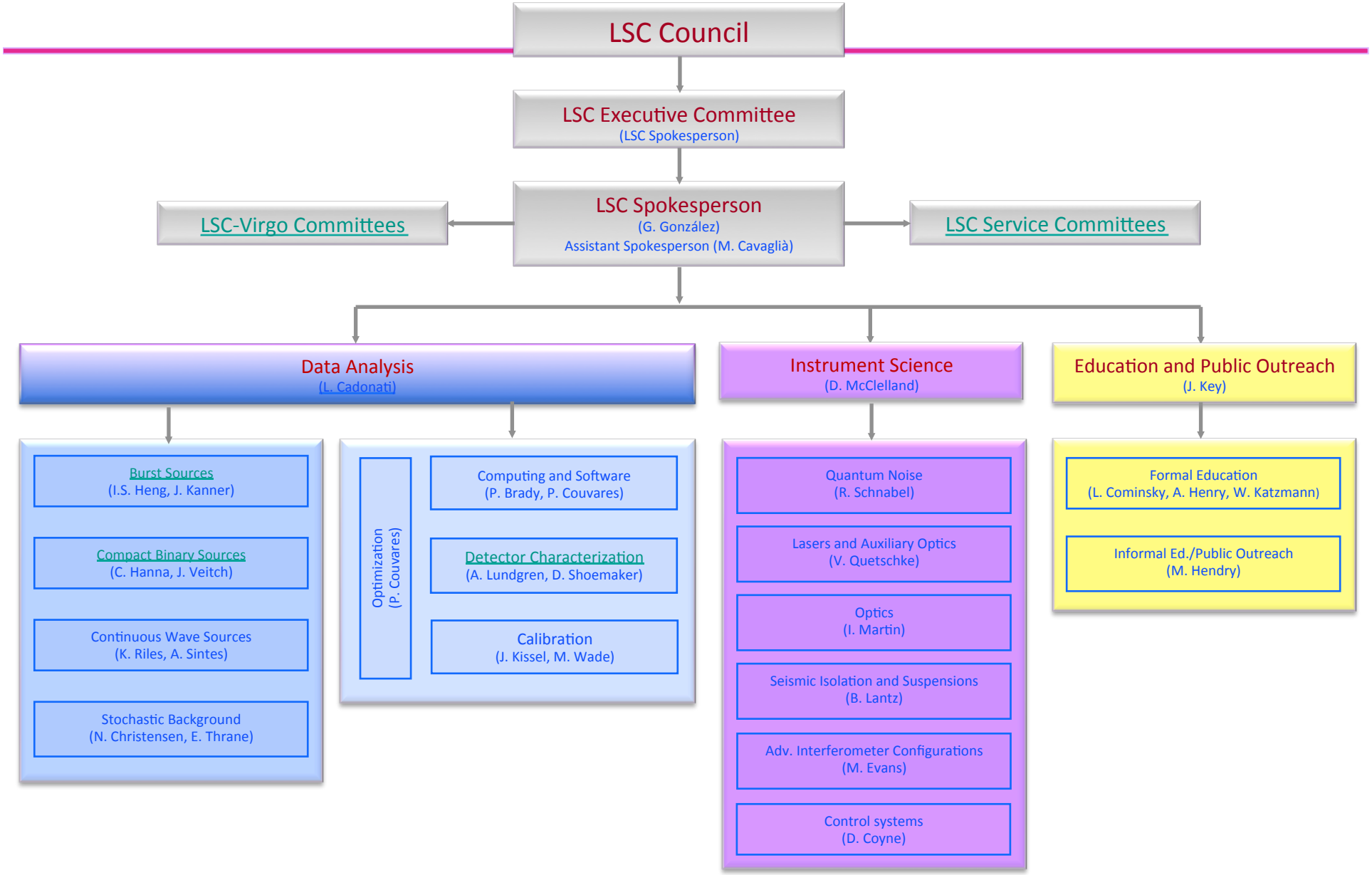
"Initial" LIGO detectors



Hanford, WA

Livingston, LA

The LIGO Scientific Collaboration



Mentor and mentees in all scientific groups, developing technology and analyzing data

Students in the media

Physics students are a part of LIGO gravitational-wave discovery

Gravitational wave contributors Undergraduate students Melissa Guidry (left) and Eve Chase are part of the international collaborative that reported observation of gravitational waves, as was Hunter Rew

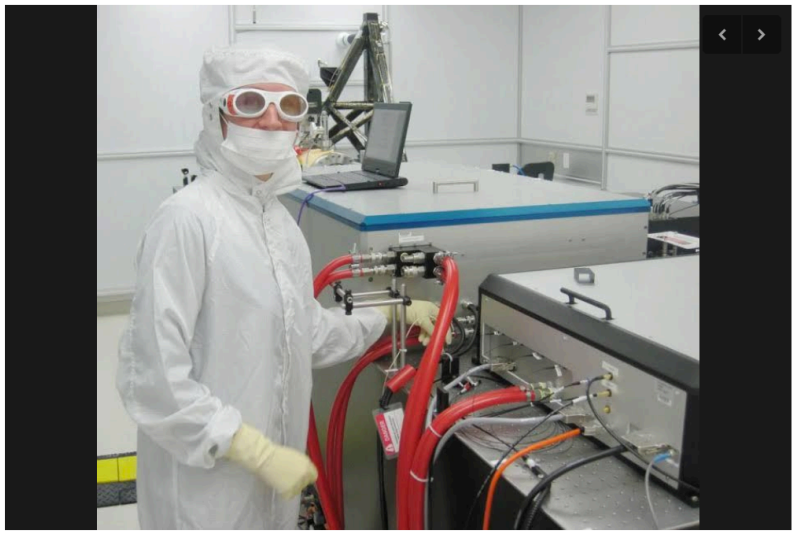
Carleton Professor, Students Research Gravitational Waves with LIGO

Associate Professor of Physics Nelson Christensen has spent the last 20 years chasing waves. Now, his search may be nearing an end.

Rosalyn Claret '04 • Sep. 16, 2003

LSU students, alumni involved in LIGO reflect on discovery

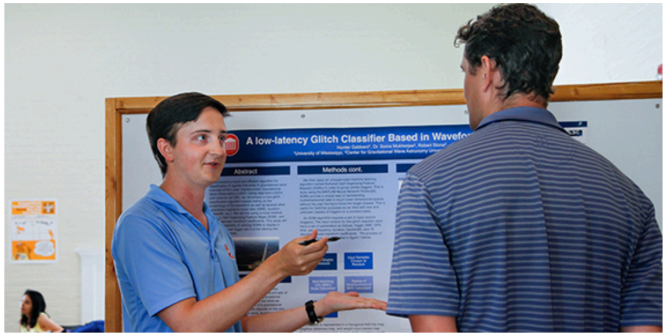
Caitlin Burkes Feb 29, 2016 (0)



Courtesy of Terra Hardwick

LSU graduate student Terra Hardwick has worked on the LIGO project for the past four years.

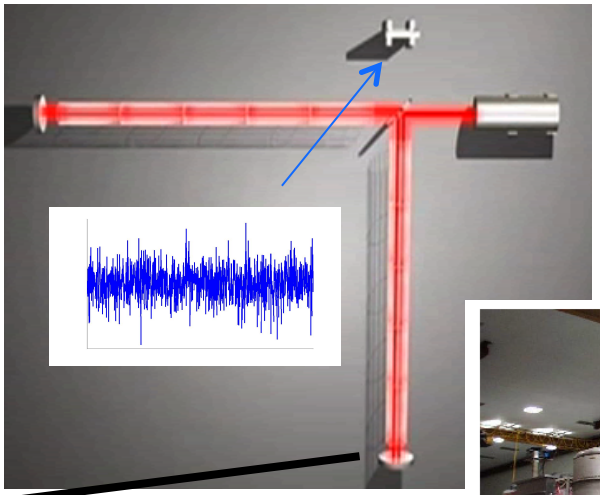
Undergraduates in physics complete research experience

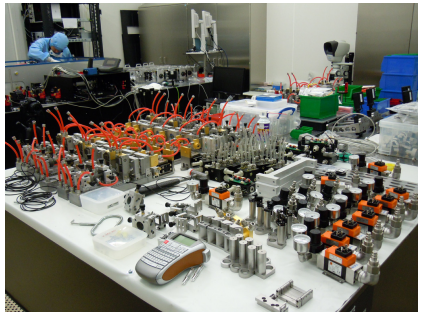


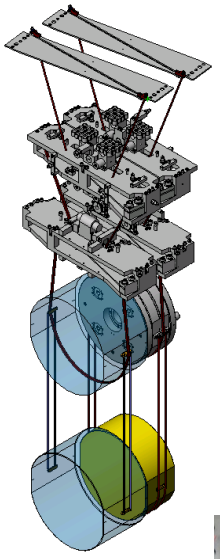
Hunter Gabbard, a physics major at the University of Mississippi, recently presented a project on gravitational waves during the Research Experiences for Undergrad Students and Research Experiences in Physics Program for Teachers, hosted on the UTRGV Brownsville Campus.

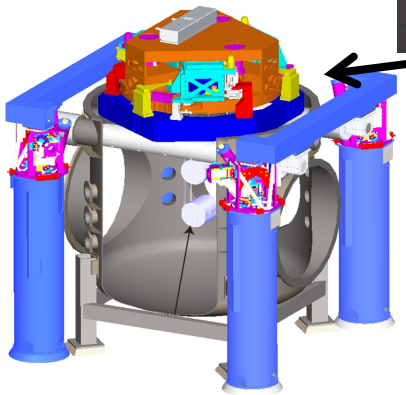
BROWNSVILLE, TEXAS – AUGUST 18, 2015 – For the fourth year, the University of Texas at Brownsville's Center for Gravitational Wave Astronomy and the Department of Physics and Astronomy is hosting a program titled Research Experiences for Undergraduates and Research Experiences for Teachers in Physics.

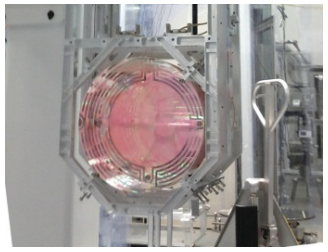
2008+: Building Advanced LIGO



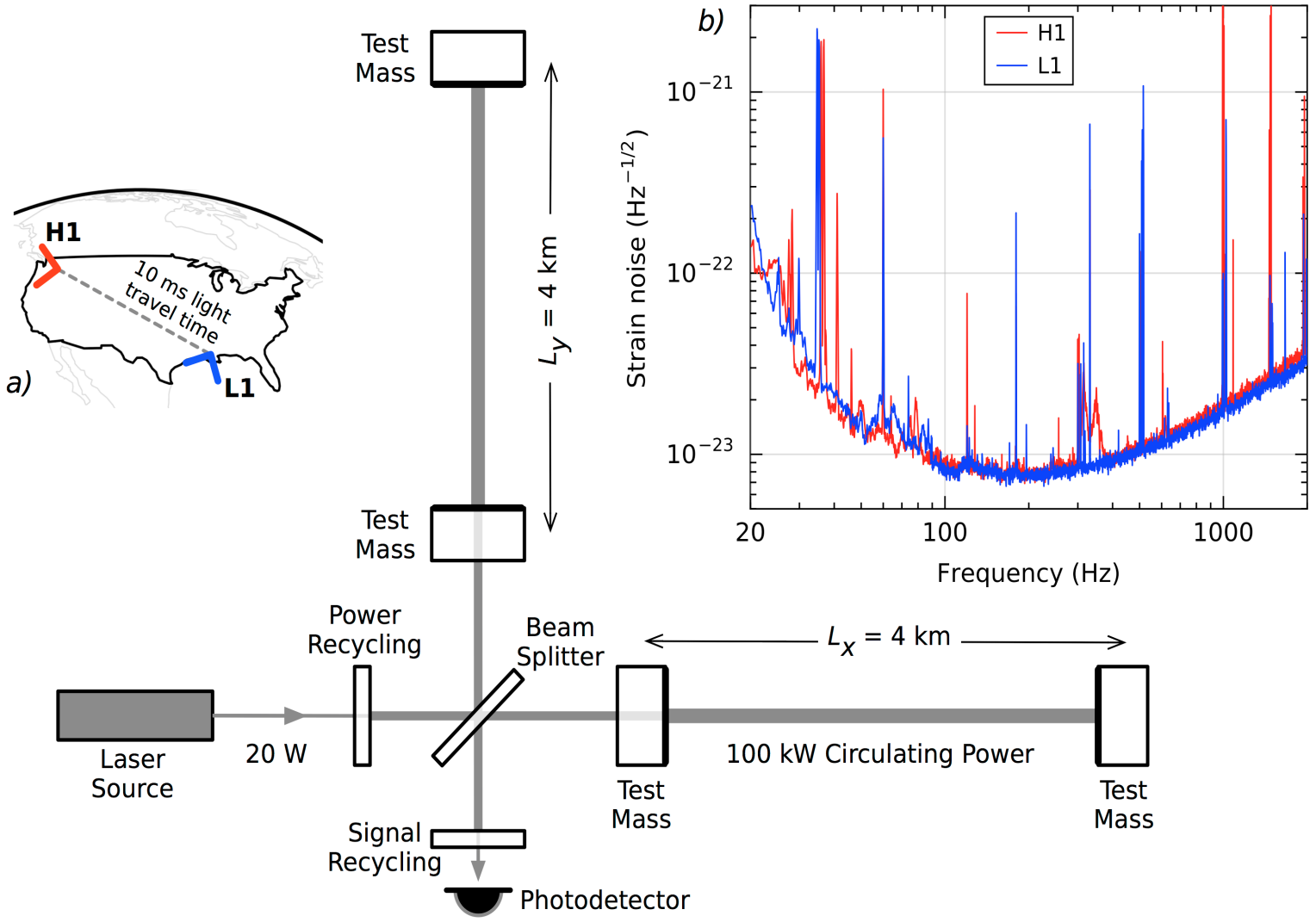


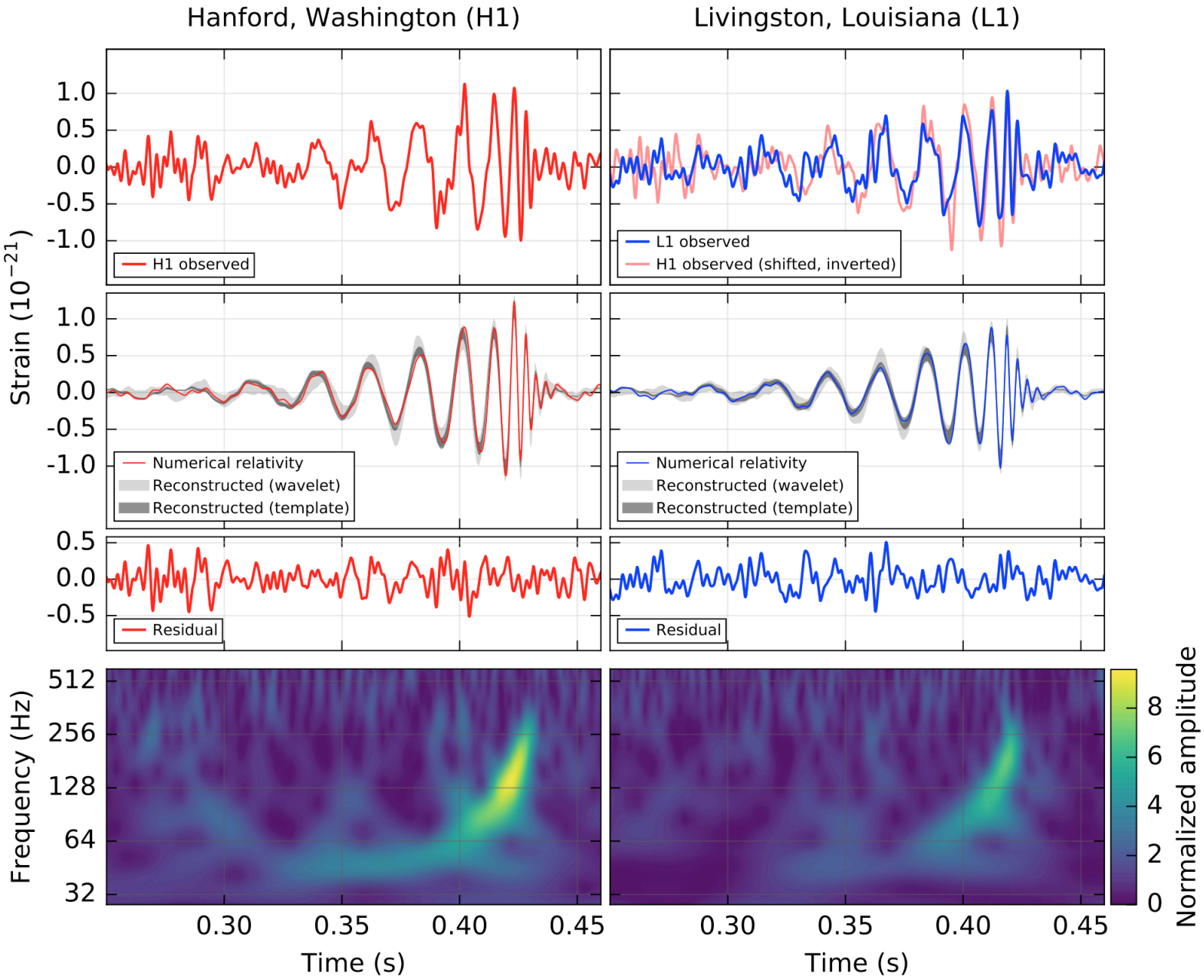




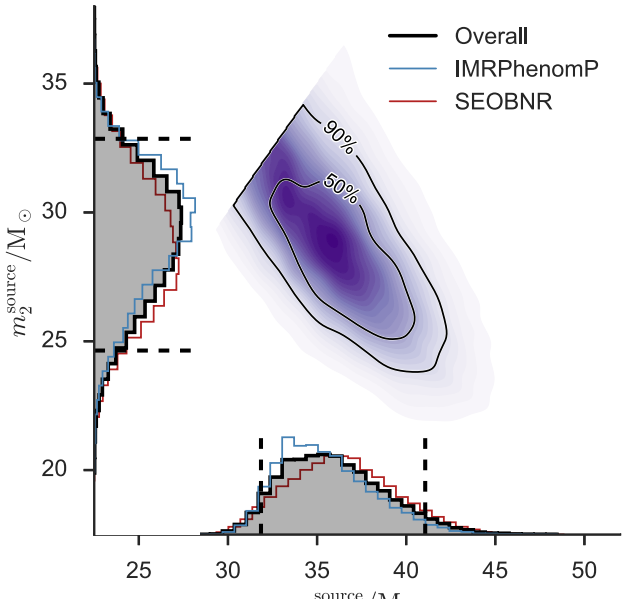


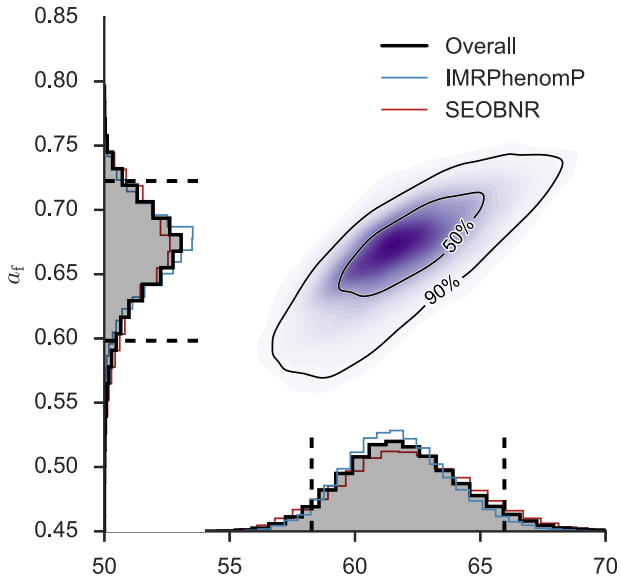
Advanced LIGO detectors September 2015

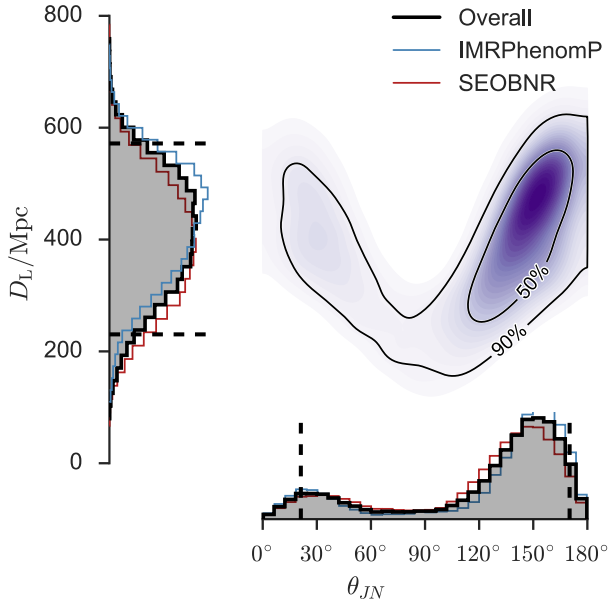


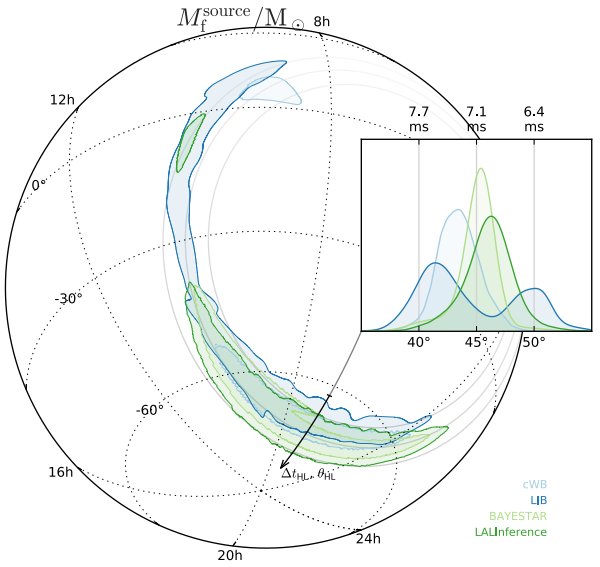

Hanford, Washington (H1)
Livingston, Louisiana (L1)
Strain (10^{-21})
H1 observed
L1 observed
H1 observed (shifted, inverted)
Numerical relativity
Reconstructed (wavelet)
Reconstructed (template)
Residual
Frequency (Hz)
512
256
128
64
32
0.30
0.35
0.40
0.45
Time (s)
Normalized amplitude
0
2
4
6
8

GW150914

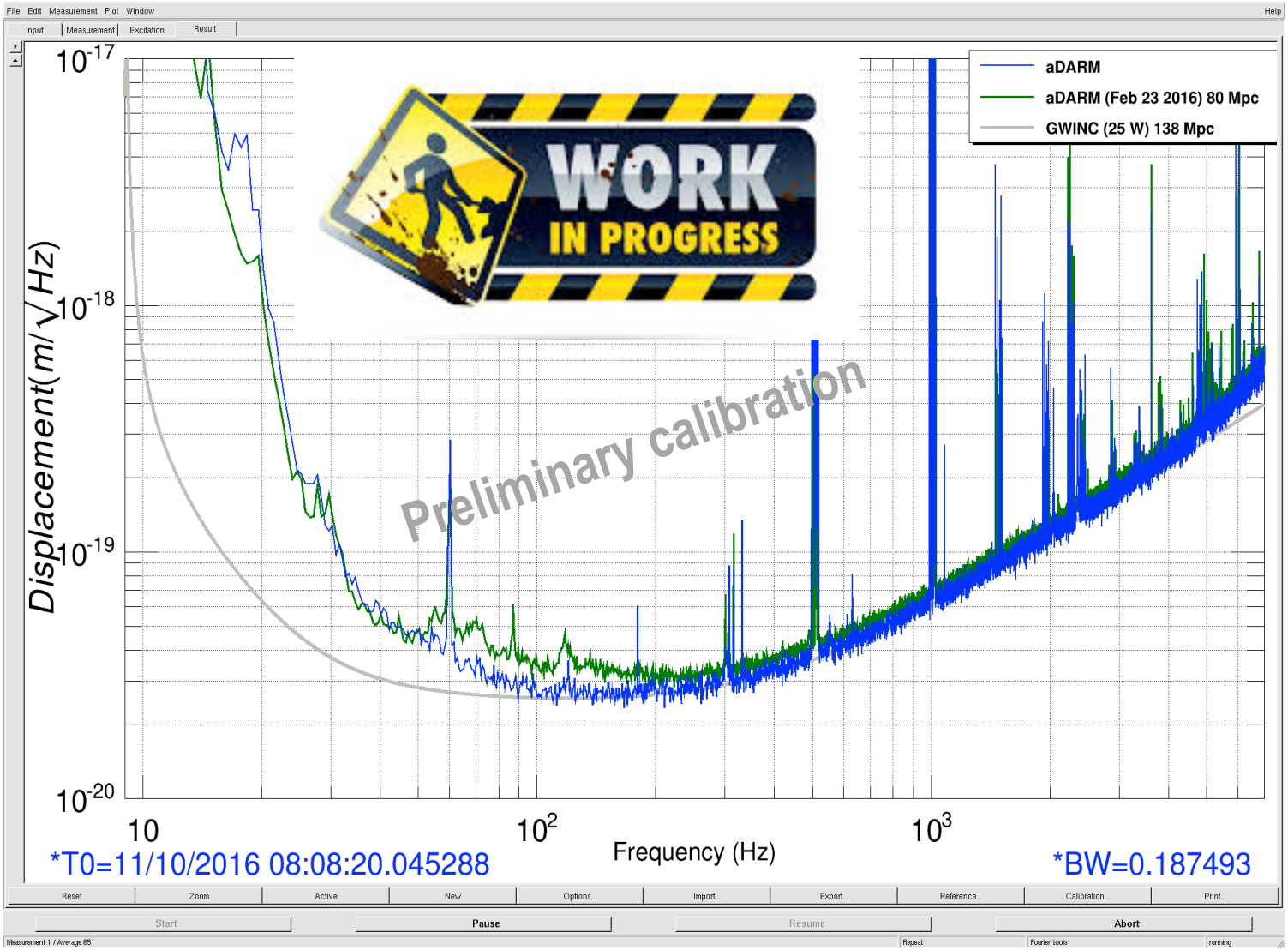

Overall
IMRPhenomP
SEOBNR
90%
50%
35
30
25
20
25
30
35
40
45
50

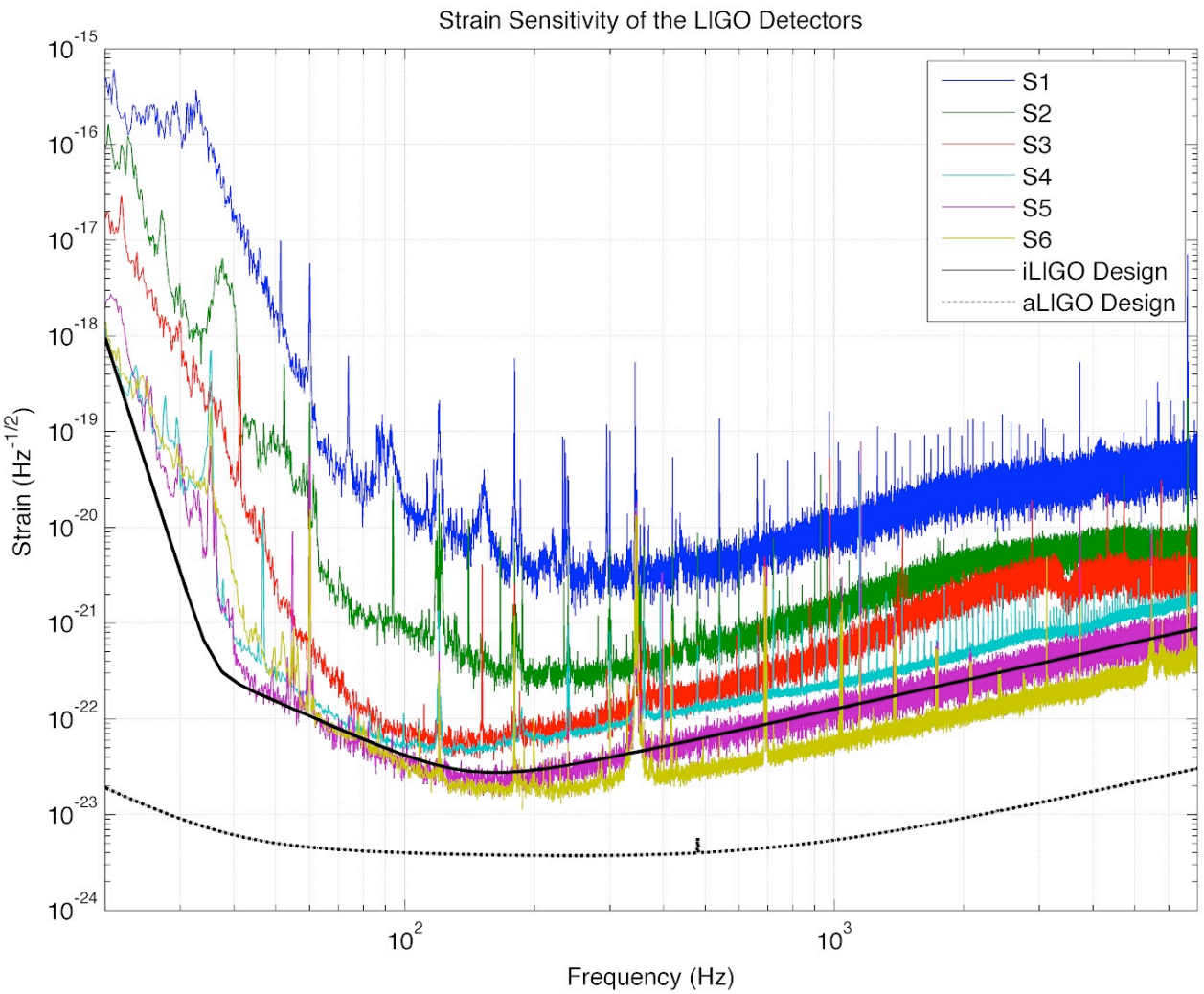

Overall
IMRPhenomP
SEOBNR
50%
90%
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
50
55
60
65
70


Overall
IMRPhenomP
SEOBNR
50%
90%
800
600
400
200
0
0°
30°
60°
90°
120°
150°
180°

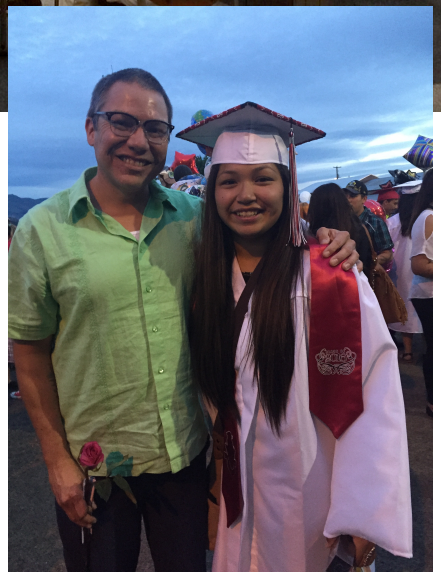

12h
0°
-30°
-60°
16h
20h
24h
7.7 ms
7.1 ms
6.4 ms
40°
45°
50°
cWB
LIB
BAYESTAR
LALInference

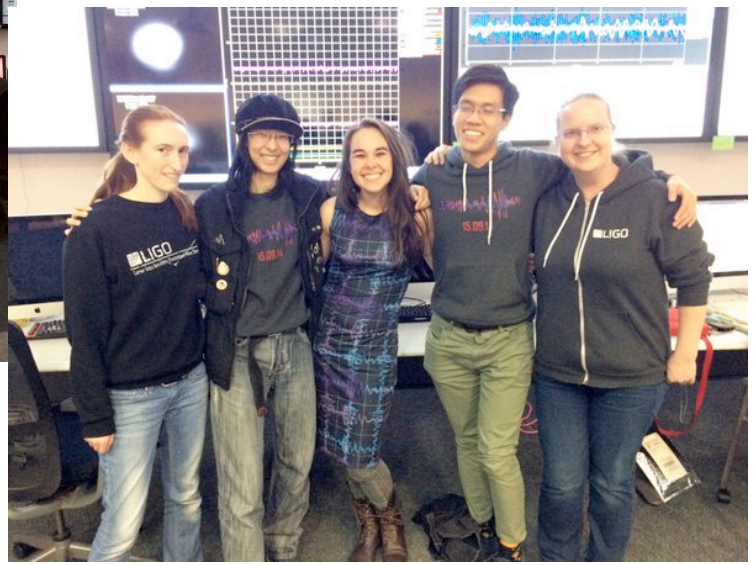
Latest news from LLO




Strain Sensitivity of the LIGO Detectors
S1
S2
S3
S4
S5
S6
iLIGO Design
aLIGO Design
Strain (Hz^-1/2)
Frequency (Hz)
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10^-21
10^-22
10^-23
10^-24
10^2
10^3

LIGO control rooms





Living Rev. Relativity, **19**, (2016), 1
DOI 10.1007/lrr-2016-1

LIVING REVIEWS in relativity

Prospects for Observing and Localizing Gravitational-Wave Transients with Advanced LIGO and Advanced Virgo

Abbott, B. P. et al.
The LIGO Scientific Collaboration and the Virgo Collaboration
(The full author list and affiliations are given at the end of paper.)
email: lsc-spokesperson@ligo.org, virgo-spokesperson@ego-gw.it

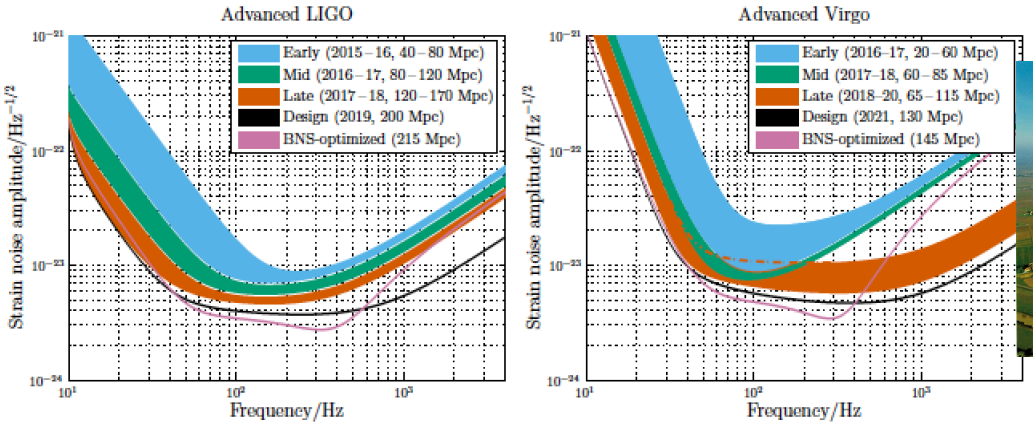


Figure 1: aLIGO (*left*) and AdV (*right*) target strain sensitivity as a function of frequency. The binary neutron-star (BNS) range, the average distance to which these signals could be detected, is given in megaparsec. Current notions of the progression of sensitivity are given for early, mid and late commissioning phases, as well as the final design sensitivity target and the BNS-optimized sensitivity. While both dates and sensitivity curves are subject to change, the overall progression represents our best current estimates.

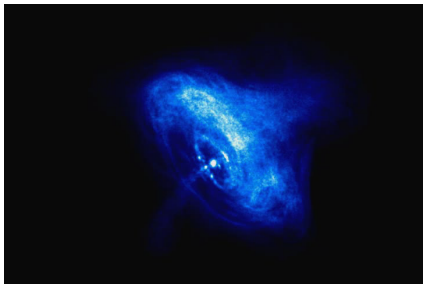
2015 – 2016 (O1) A four-month run (beginning 18 September 2015 and ending 12 January 2016) with the two-detector H1L1 network at early aLIGO sensitivity (40 – 80 Mpc BNS range).

2016 – 2017 (O2) A six-month run with H1L1 at 80 – 120 Mpc and V1 at 20 – 60 Mpc.

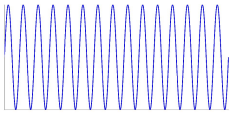
2017 – 2018 (O3) A nine-month run with H1L1 at 120 – 170 Mpc and V1 at 60 – 85 Mpc.

2019+ Three-detector network with H1L1 at full sensitivity of 200 Mpc and V1 at 65 – 115 Mpc.

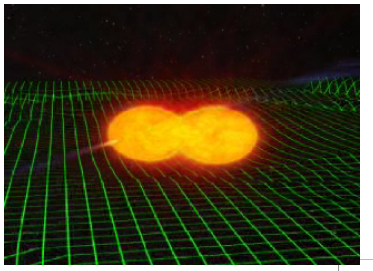
Sources of gravitational waves: not just black holes!



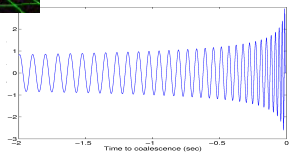
Crab pulsar (NASA, Chandra Observatory)



Periodic, continuous waves



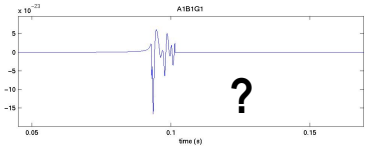
Credit: John Rowe



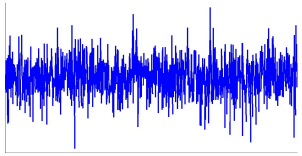
Binary systems with neutron stars, and/or black holes

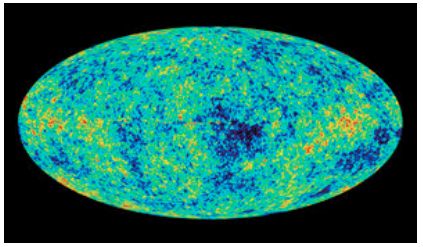
Short transients from supernova explosions or other sources

W49B composite;
X-ray: NASA/CXC/MIT/L.Lopez et al.;
Infrared: Palomar; Radio: NSF/NRAO/VLA



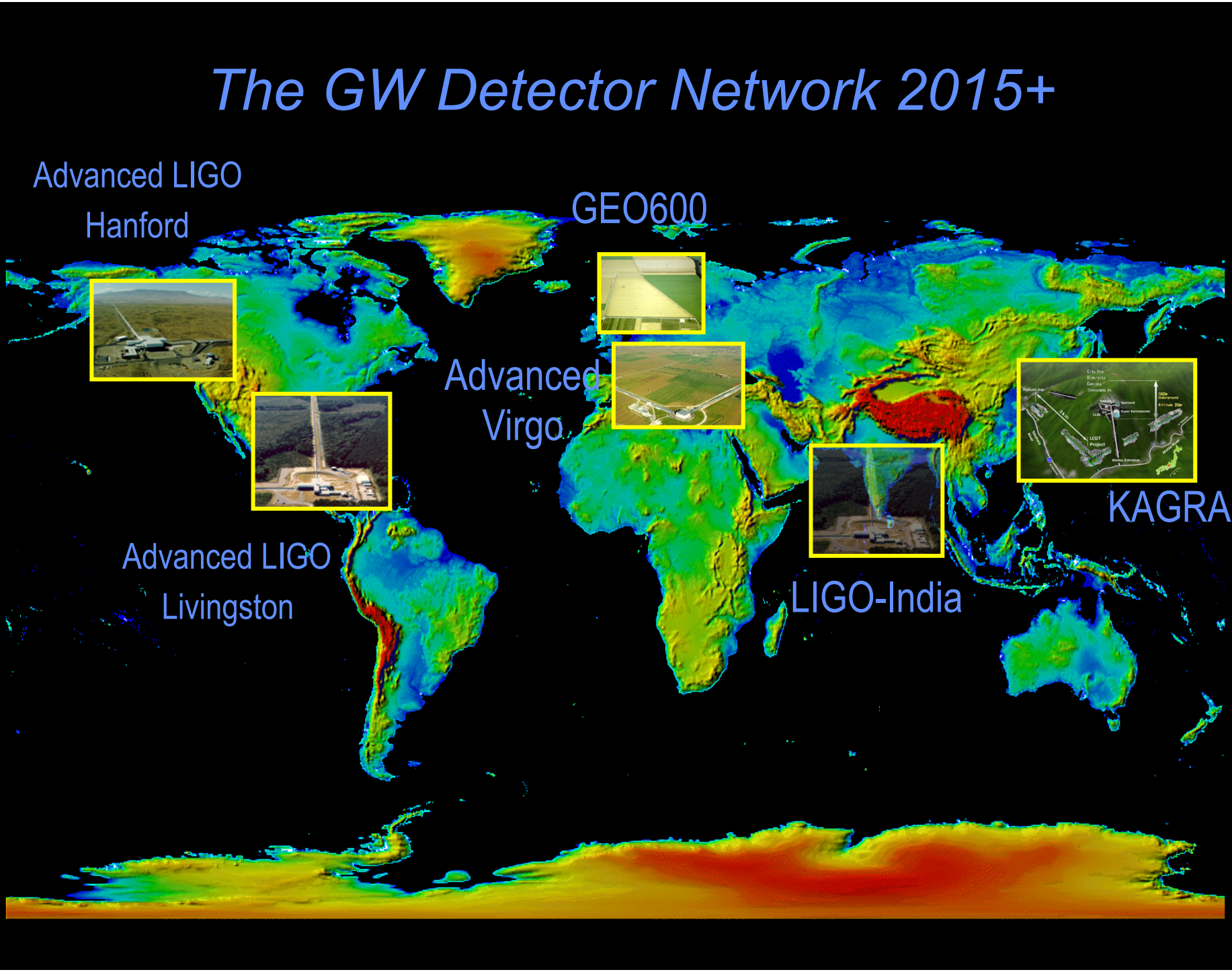
Stochastic background from many unresolved sources, or from the beginning of the Universe





NASA, WMAP

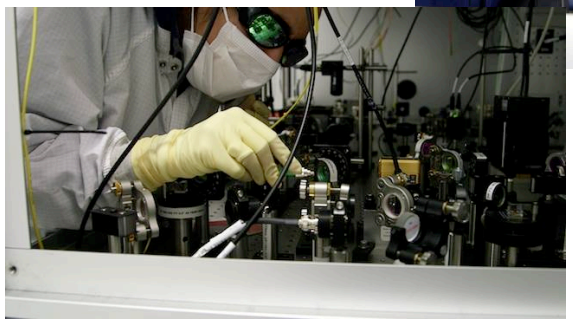
The GW Detector Network 2015+



People and LIGO

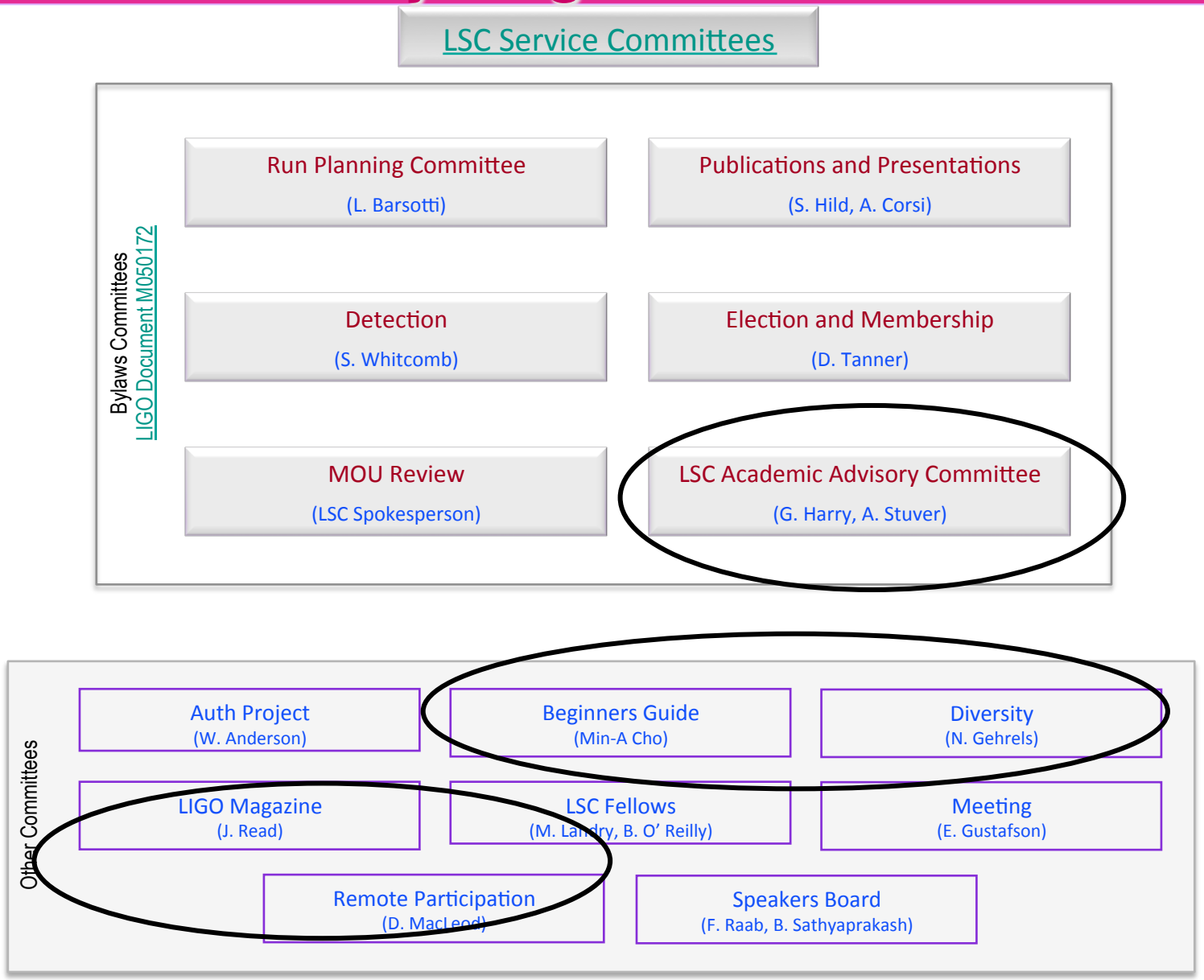
My mentors: Peter Saulson, Rai Weiss

"LIGO Generations"
http://www.kaistaats.com/film/ligo-generations/



"LIGO: A passion for understanding"
http://www.kaistaats.com/film/ligo-passion/

Lots of service activities – many with young scientists



Activities where input from young scientiss is essential

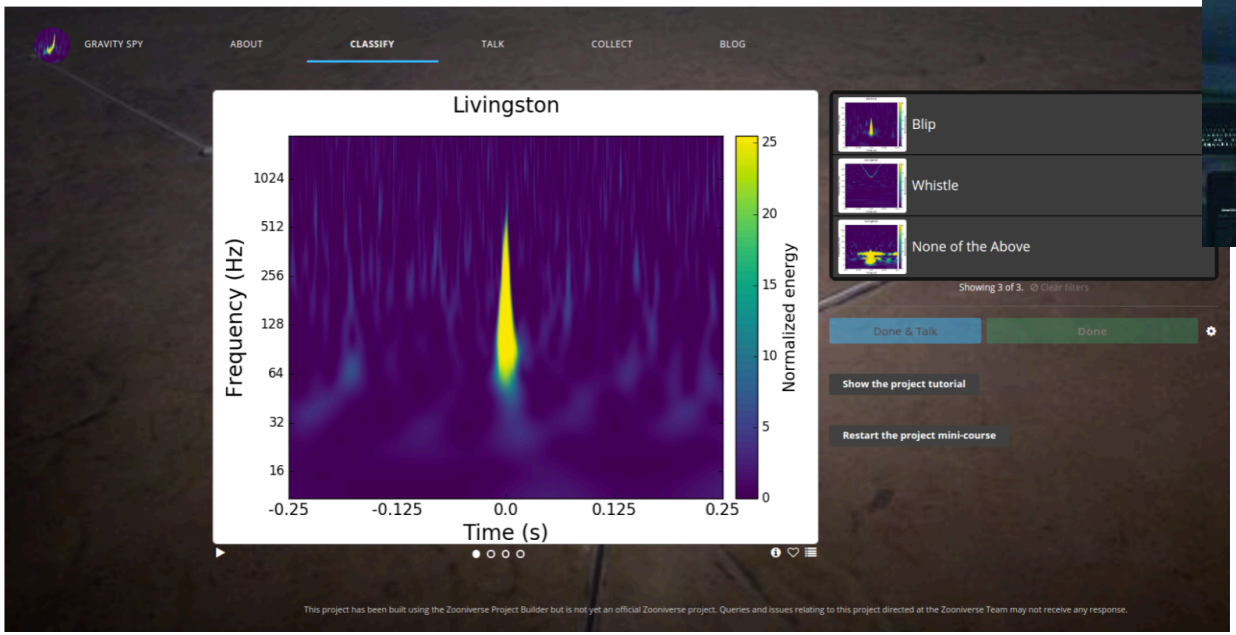
DAILY ZOONIVERSE

DAILY ZOONIVERSE

Something awesome from across the Zooniverse every weekday.

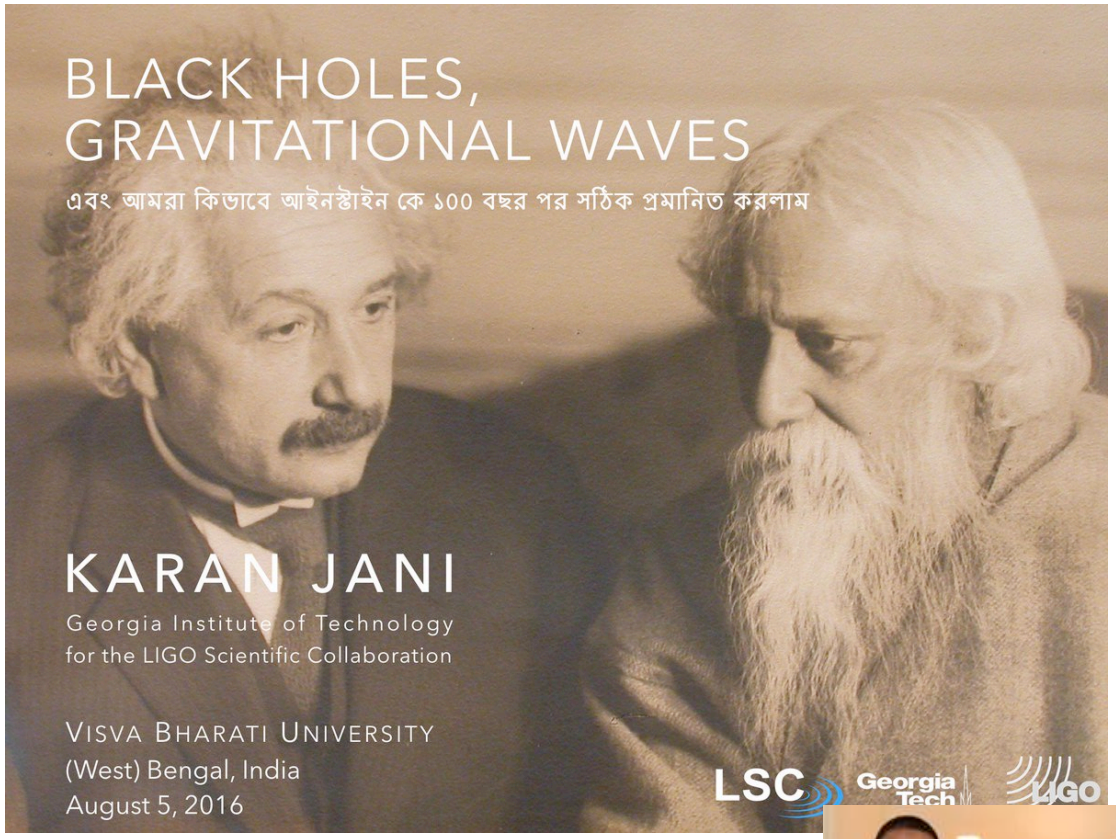
New Project – Gravity Spy!

Posted on October 12, 2016 by The Zooniverse

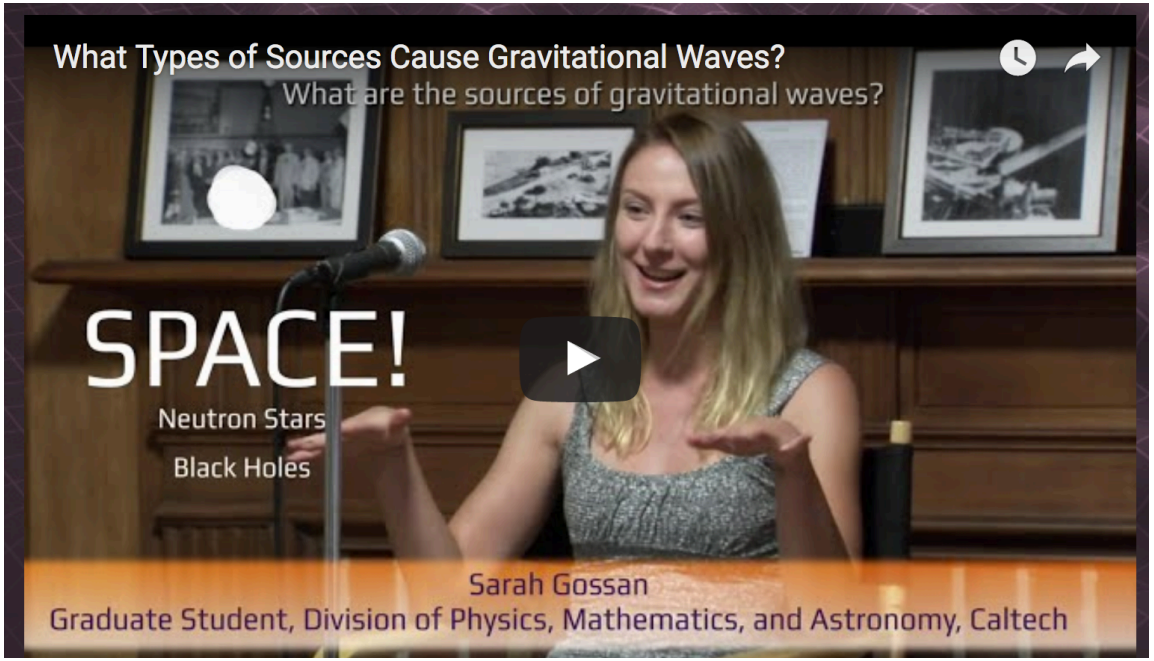


Friendly activities in LVC meetings

Activities where input from young scientiss is essential



Activities where input from young scientiss is essential



Social Media Impact of LIGO Detection

Activities where input from young scientiss is essential

LVC Allies | Mission | Allies | Get Involved | Resources

LVC Allies

Anti-harassment initiative for the LIGO Scientific Collaboration and the Virgo Collaboration

The LVC Allies team will be attending the next joint LSC-Virgo in Glasgow (UK), August 29 - September 2 2016. Come and talk to us if you want advice, a friendly ear, or to find out more about who we are.

The LVC Allies are a safe and confidential resource for all LVC members. Our goal is to foster an inclusive and harassment-free environment. If you experience harassment or bullying, the LVC Allies will provide you with a safe space to discuss your options and how you want to proceed. We are a judgement-free zone.

We are available at all times via email at lvcallies@gmail.com. Messages sent to this address are only seen by the Allies coordination team, and will never be shared without your consent; or write any one of us if preferred.

For more information on Allies in the wider astronomy community, please visit astronomyallies.com.

If you see this button, feel free to approach the person and ask about the Allies

Thanks!

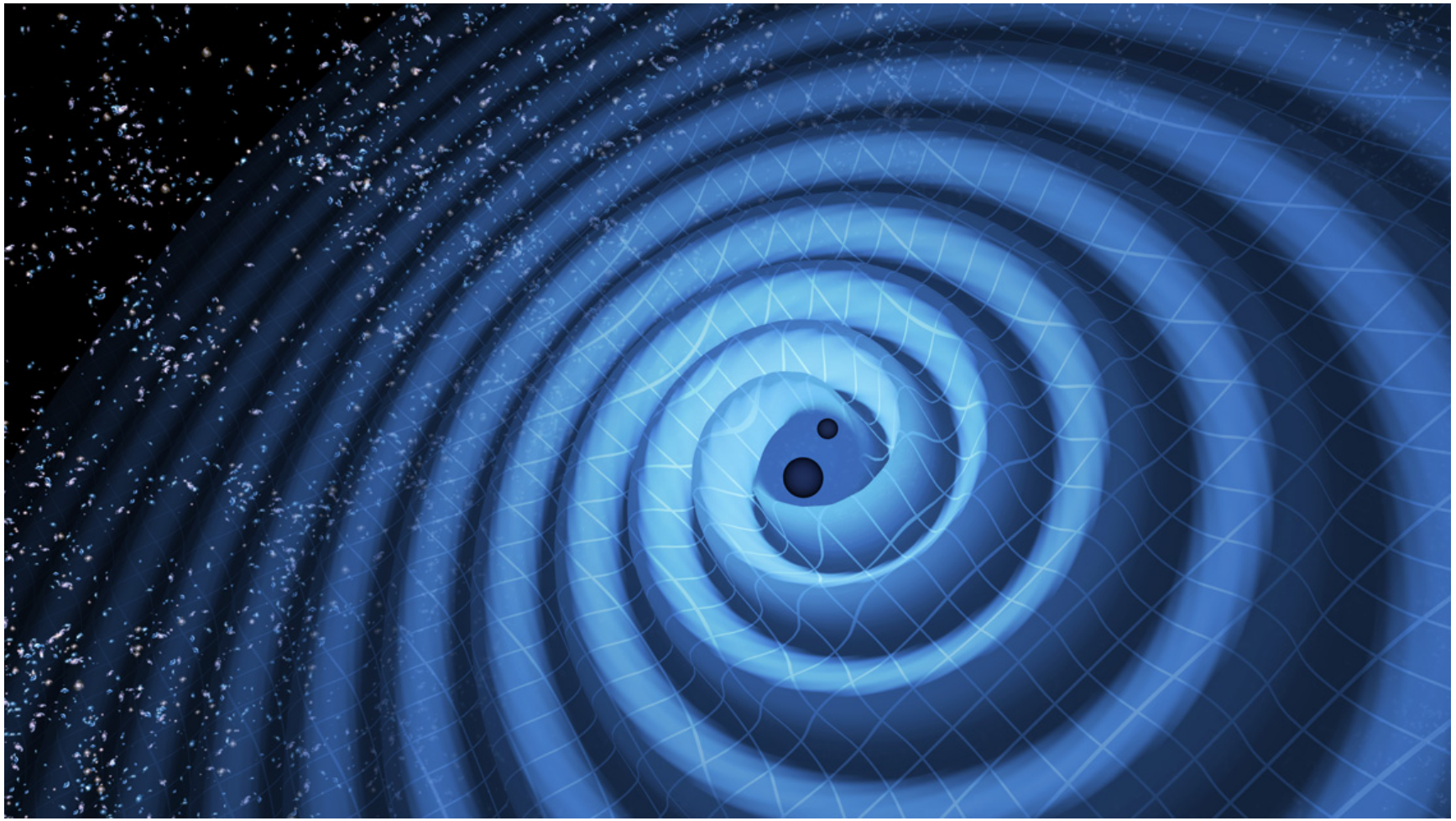
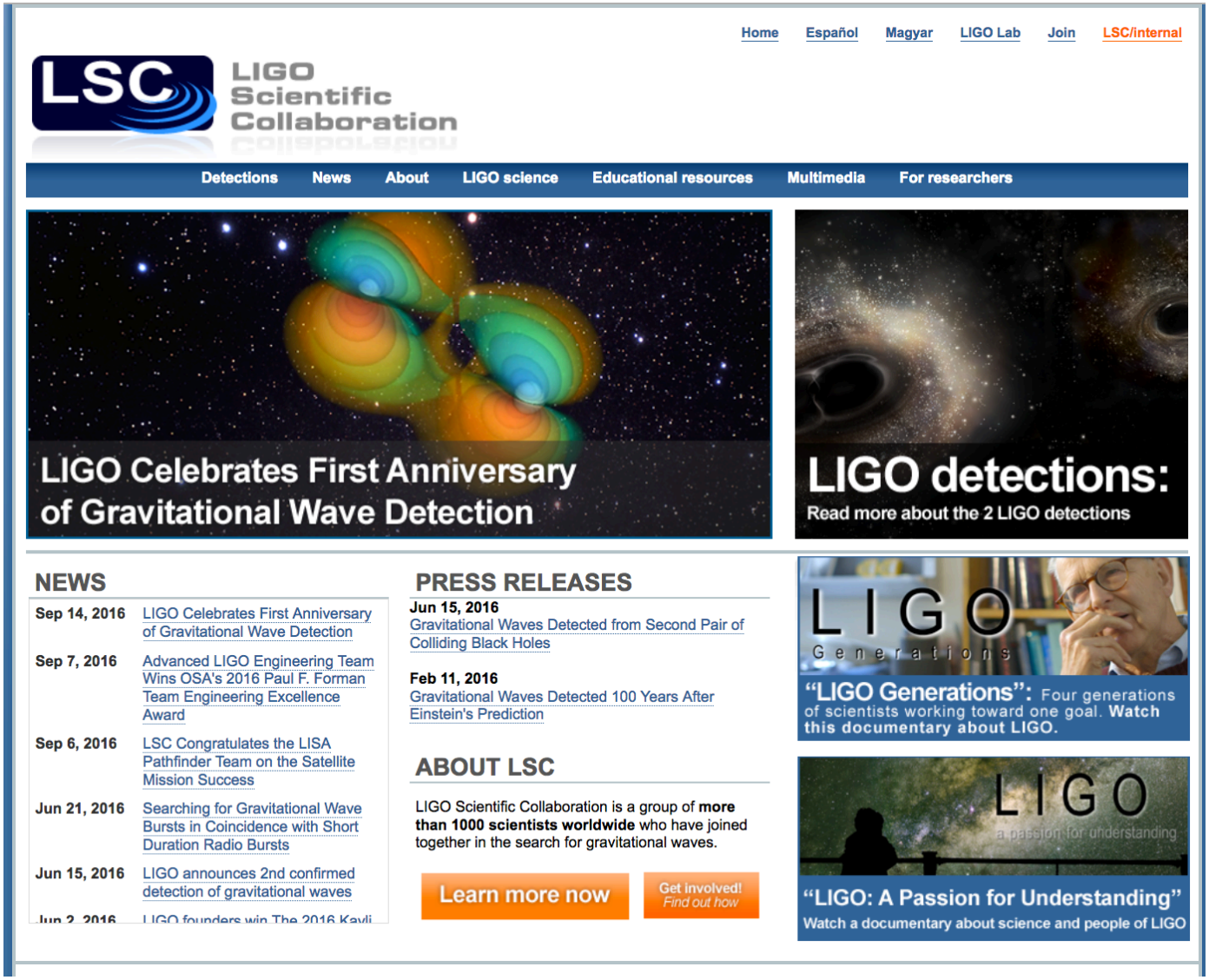


Image credit: LIGO/T. Pyle

www.ligo.org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