

# The LIGO Scientific Collaboration

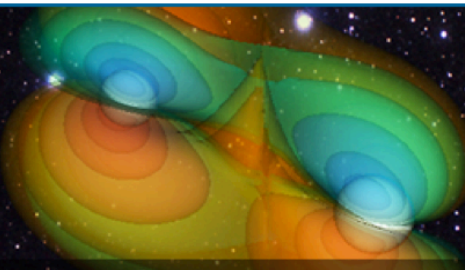


Gabriela González,  
Louisiana State University  
For the LIGO Scientific Collaboration





# www.ligo.org



## Gravitational Waves Detected 100 Years After Einstein's Prediction



**“LIGO Detection”**: The path to discovery. Watch a new documentary about LIGO

### NEWS

- Feb 11, 2016** [LIGO announces the detection of gravitational waves](#)
- Feb 8, 2016** [Media Advisory: Scientists to provide update on the search for gravitational waves](#)
- Jan 16, 2016** [LSC Statement on Harassment](#)
- Jan 12, 2016** [First Observing Run \(O1\) ends](#)
- Dec 23, 2015** [Planning for a bright tomorrow: prospects for gravitational-wave astronomy with Advanced LIGO and Advanced Virgo](#)
- Nov 24, 2015** [Stuck in the middle: an all-sky search for gravitational waves of intermediate duration](#)

### PRESS RELEASE

Feb 11, 2016  
[Gravitational Waves Detected 100 Years After Einstein's Prediction](#)  
[More at the LIGO Lab website](#)

### ABOUT LSC

LIGO Scientific Collaboration is a group of **more than 1000 scientists worldwide** who have joined together in the search for gravitational waves.

[Learn more now](#)

[Get involved!  
Find out how](#)



**“LIGO: A Passion for Understanding”**  
Watch a documentary about science and people of LIGO



**“LIGO: A Passion for Understanding”**  
Watch a documentary about science and people of LIGO



# LIGO detectors

Hanford, WA



Livingston, LA

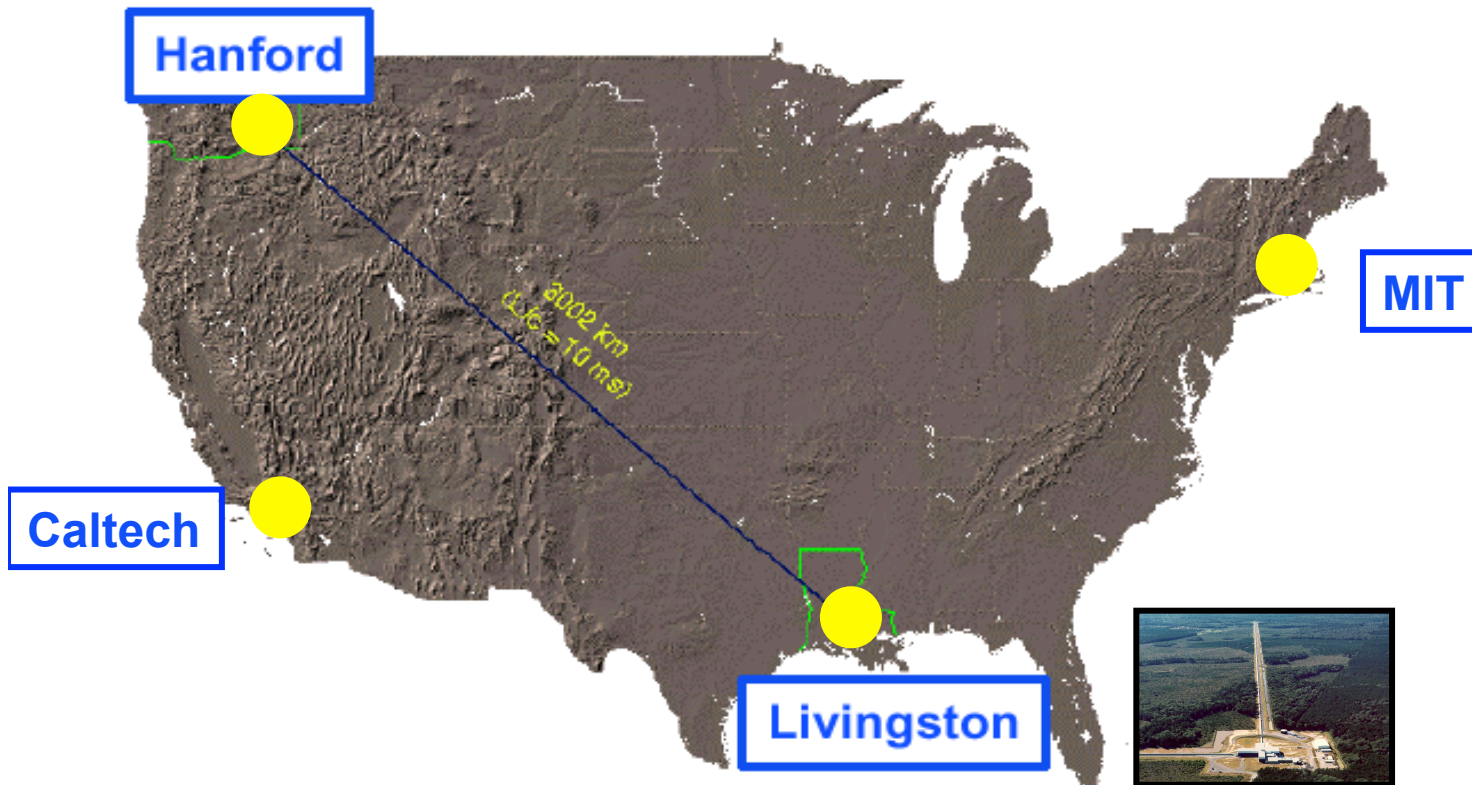
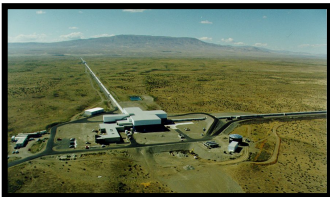


Advanced LIGO detectors:



# LIGO Laboratory

- Mission: Observe gravitational wave sources; operate the LIGO facilities; develop the instrument science and technology; scientific education and public outreach.
- NSF Major Research Facilities Construction LIGO grant in 1992 and in 2008; cooperative agreements since 1992, jointly managed by Caltech and MIT.
- ~200 scientists, engineer and staff; includes physicists working on instrument science and data analysis.





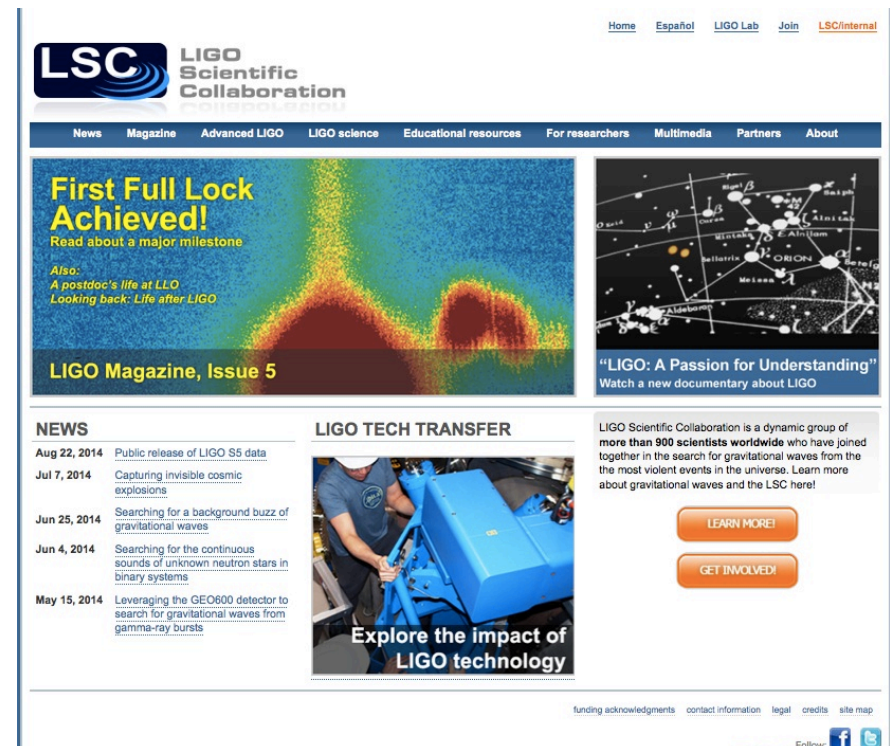


# LIGO Scientific Collaboration



# LIGO and LSC

- The LSC and the LIGO Laboratory together make up “LIGO”.
- LSC Mission: The LIGO Scientific Collaboration (LSC) is a **self-governing collaboration** seeking to detect gravitational waves, use them to explore the fundamental physics of gravity, and develop gravitational wave observations as a tool of astronomical discovery.
- LSC Responsibilities:
  - data analysis strategy, goals, and timeline, and carry out the data analysis program;
  - identify priorities for research and development, and carry out the R&D program;
  - carry out a public outreach, and provide educational opportunities for young people;
  - disseminate the results of the data analysis program and the R&D program;
  - participate in the scientific operations of the LIGO detectors;
  - perform internal evaluation of progress in data analysis and R&D.



The screenshot shows the LIGO Scientific Collaboration website. At the top right, there are navigation links: Home, Español, LIGO Lab, Join, and LSC/internal. The main header features the LSC logo and the text "LIGO Scientific Collaboration". Below this is a dark blue navigation bar with links for News, Magazine, Advanced LIGO, LIGO science, Educational resources, For researchers, Multimedia, Partners, and About.

The main content area is divided into several sections:

- First Full Lock Achieved!**: A large banner with a colorful gravitational wave detection plot. Text includes "Read about a major milestone", "Also: A postdoc's life at LLO", "Looking back: Life after LIGO", and "LIGO Magazine, Issue 5".
- LIGO Magazine, Issue 5**: A smaller banner with a star map background and the text "LIGO: A Passion for Understanding" and "Watch a new documentary about LIGO".
- NEWS**: A list of recent news items:
  - Aug 22, 2014: Public release of LIGO S5 data
  - Jul 7, 2014: Capturing invisible cosmic explosions
  - Jun 25, 2014: Searching for a background buzz of gravitational waves
  - Jun 4, 2014: Searching for the continuous sounds of unknown neutron stars in binary systems
  - May 15, 2014: Leveraging the GEO600 detector to search for gravitational waves from gamma-ray bursts
- LIGO TECH TRANSFER**: A section featuring a photo of a person working on a blue LIGO component, with the text "Explore the impact of LIGO technology".
- Call to Action**: Two orange buttons labeled "LEARN MORE!" and "GET INVOLVED!".

At the bottom of the page, there are links for "funding acknowledgments", "contact information", "legal", "credits", and "site map". Social media icons for Facebook and Twitter are also present.

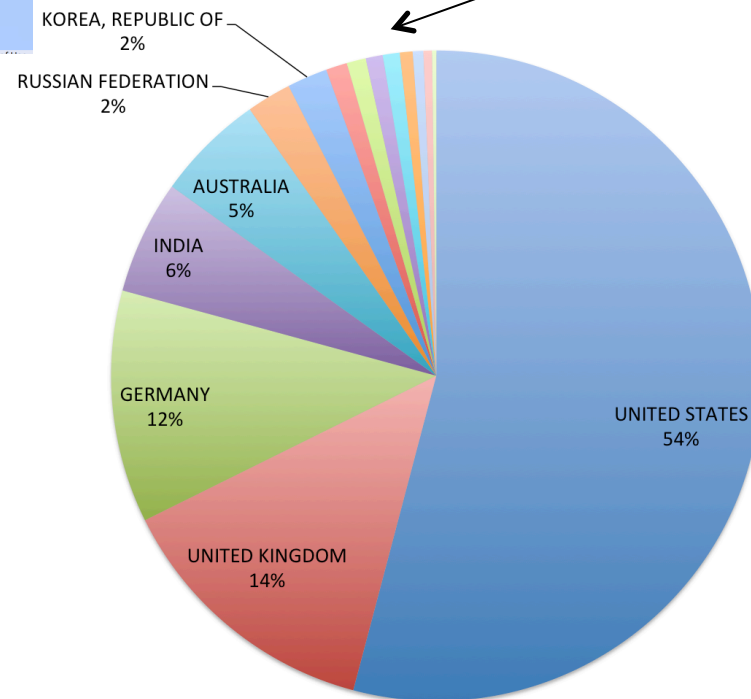
www.ligo.org



# LIGO Scientific Collaboration



LSC membership (945 members, 15 countries)



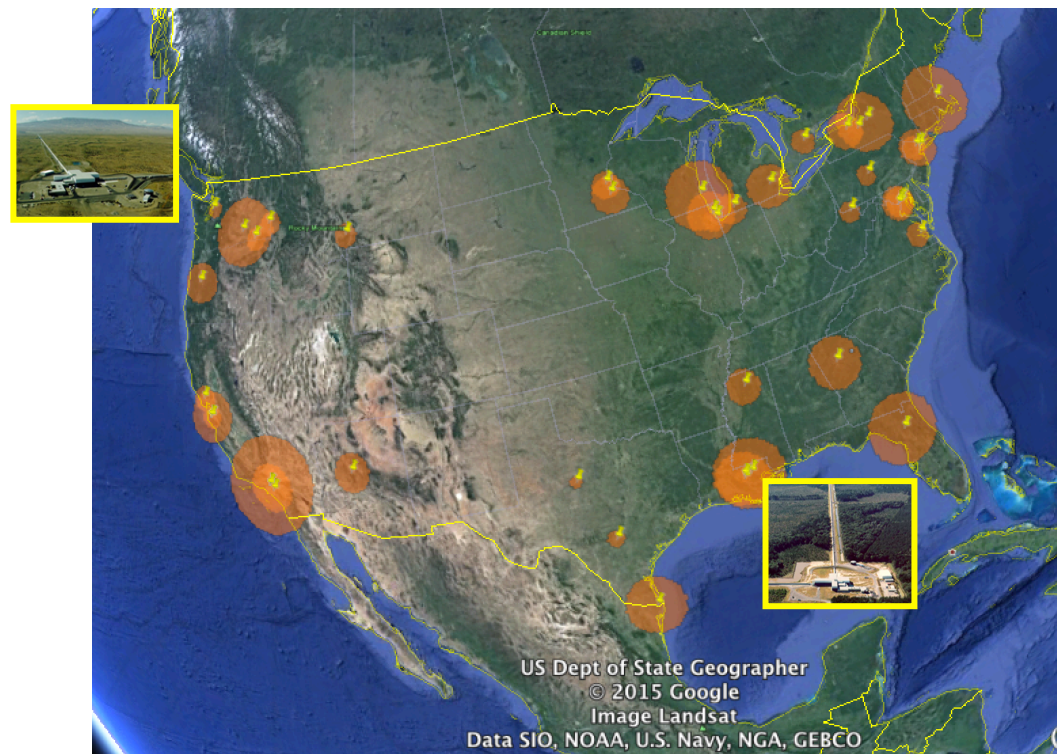
ITALY  
HUNGARY  
BRAZIL  
SPAIN  
CHINA  
TAIWAN  
CANADA  
BELGIUM



[www.ligo.org](http://www.ligo.org)

# LSC-USA

- Large institutional diversity: large and small departments, graduate and undergraduate institutions, several serving large under-represented groups.
- Most US groups are supported by NSF with competitive, single investigator NSF grants. LIGO Laboratory (~30% of LSC) is supported by CA NSF grant to Caltech and MIT.
- Many LSC “graduates” now working in STEM industries (Intel, Synaptics, Google, SpaceX, Apple, Facebook,...), national facilities (Lincoln Labs, NASA, ...) and academia.





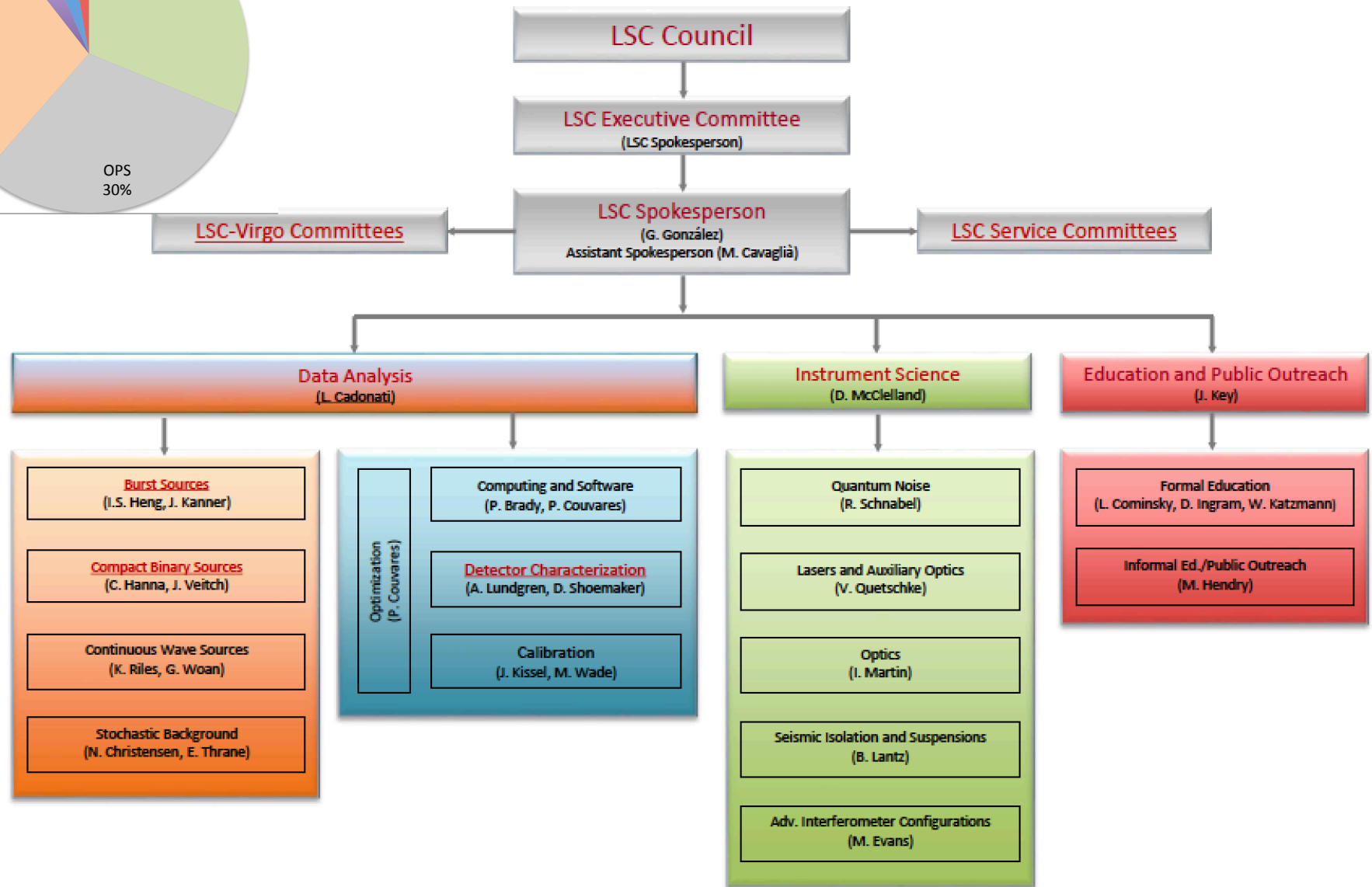
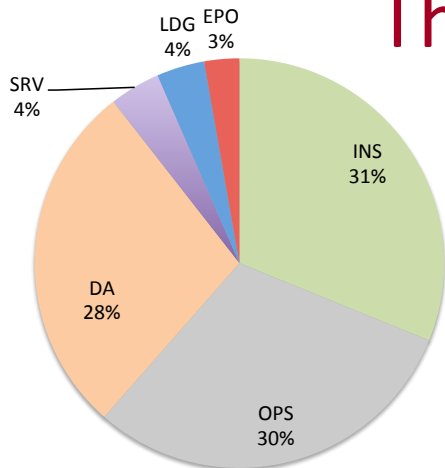


# LIGO Scientific Collaboration

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- Some LSC Principles:
  - Open: “No individual or group will be denied membership on any basis except scientific merit and the willingness to participate and contribute as described in this Charter.”
  - Member agreements (MOUs) describe scientific, not financial, commitments.
  - Democratic: Spokesperson and working group leaders elected (w/2 yr terms).
  - Formal LSC/LIGO Lab interaction: “LIGO directorate” consists of the LSC spokesperson, and the Executive and Deputy Directors of the LIGO Laboratory. The LIGO Directorate will be ex officio members of all planning and evaluative bodies of the LSC. (On the ground, there are no differences between LIGO Lab LSC members and other group members, other than funding.)
- Some history:
  - Created in 1997, already international (Germany, UK, Australia, Russia).
  - Initially ~25 groups, 200 people, Rai Weiss spokesperson 1997-2003
  - Peter Saulson elected spokesperson 2003-2007, David Reitze 2007-2011, GG 2011-2017.

# The LIGO Scientific Collaboration





# Education and Public Outreach



Multimedia

## LIGO AMA on Reddit

- On 2/13, reddit.com/r/science hosted us in an "Ask Us Anything" event [[link](#)]
- A team of 20 answered over 60 questions from internet users. The thread turned out to be very popular:
  - Pageviews: **21,046**
  - Pageviews from unique IPs: **18,378**
  - Average time spent on page: **3:08**
  - Comments: **557**
  - Frontpage of Reddit: **yes!**
- [OutreachFAQ wiki page](#) has now been seeded with the questions and answers from the AMA, help it keep growing!

Social media



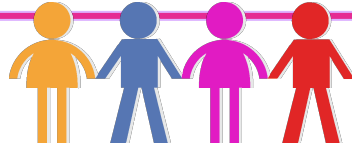
Science teachers' education




Science fairs, exhibits,  
Science Education Center

# Other important LSC activities

## • Diversity



- LSC has a “Diversity Committee. Some initiatives:
  - LSC Diversity statement; anti-harassment policy, LSC “best practices”
  - LSC “Ombudsperson” (former NSF program officer!)
  - LIGO summer undergraduate fellowships sponsored by NSBP and NSHP
  - “Family grants” to attend LSC meetings
  - Set up a booth and organize sessions in scientific meetings of women and minorities



Corey Gray

Corey Gray has served as an operations specialist at LIGO Hanford since 1998. A graduate of Humboldt State University with a B.S. in physics and mathematics, Corey enjoys participating in public outreach activities that connect with students and adults of all ages. He is a member of the Siksika Nation.

LIGO goes to  
SACNAS

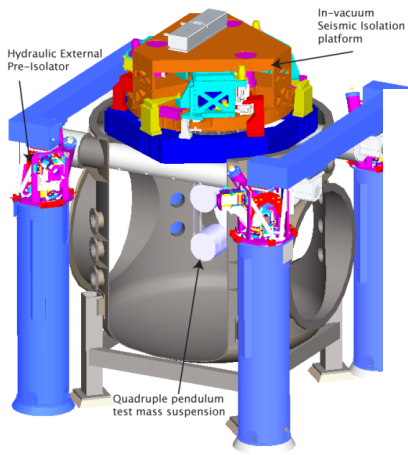
## • Academic mentoring

- The LSC has an “Academic Advisory Committee” to care about mentoring of young members. Some recent activities:
  - Student and postdoc events and useful tutorials.
  - “Industry panels” with colleagues working now in industry.
  - Mentoring program: a platform for members of the LSC to form and maintain mentoring relationships.

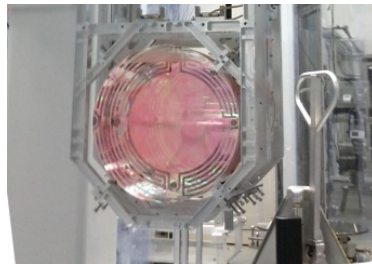
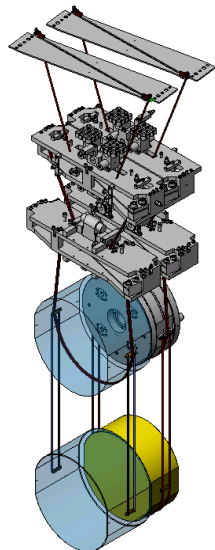
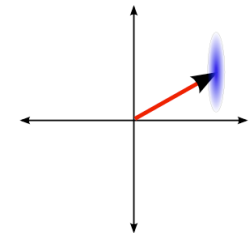
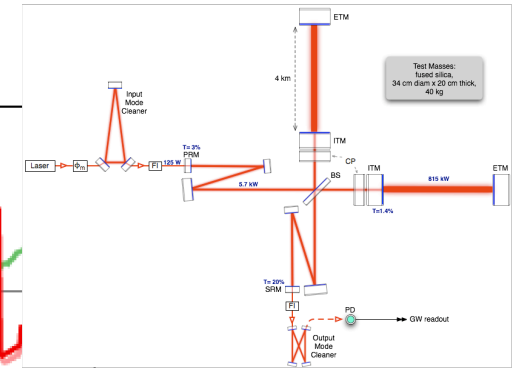
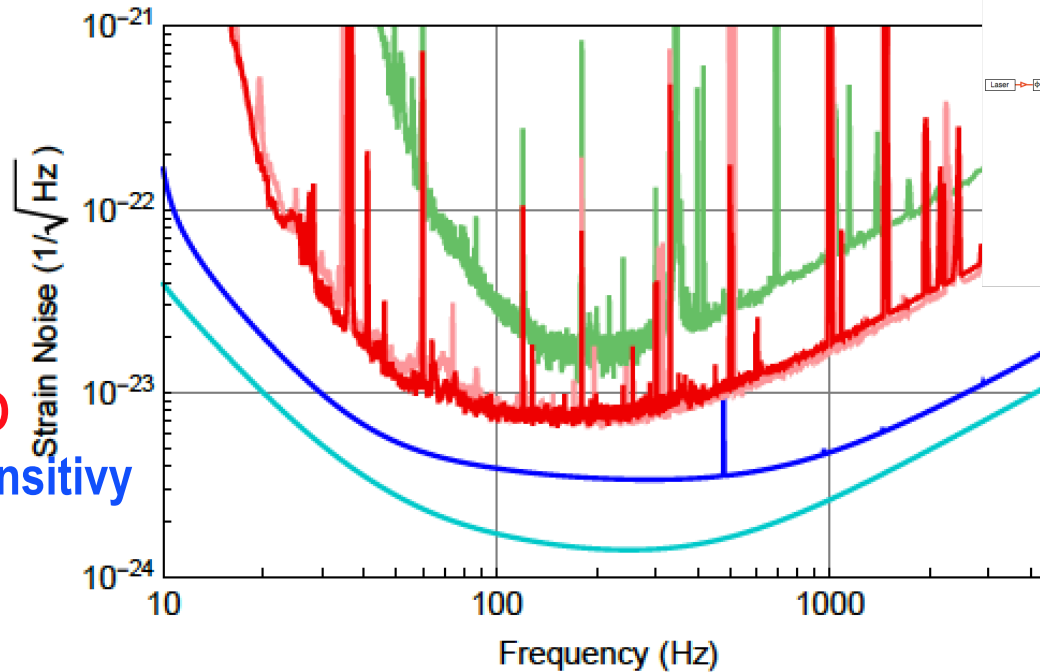




# LIGO Detector Technology

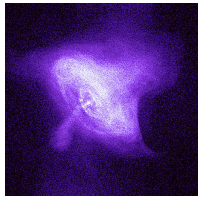


2010 LIGO  
 2015 aLIGO  
 aLIGO design sensitivity  
 aLIGO+

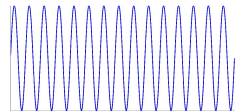
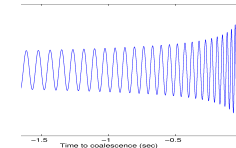
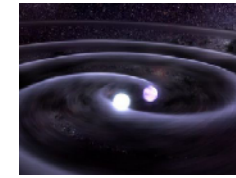
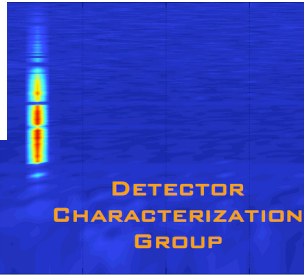
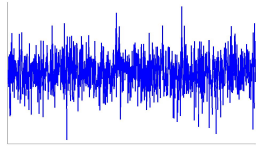


Five instrumental working groups – white paper LIGO-T1500290 ([dcc.ligo.org](http://dcc.ligo.org)) about R&D for future detectors with improved sensitivities

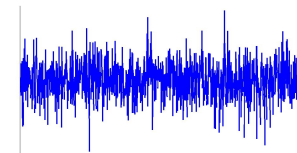
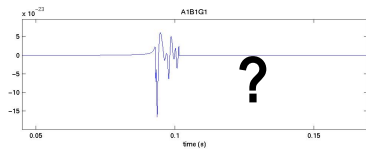
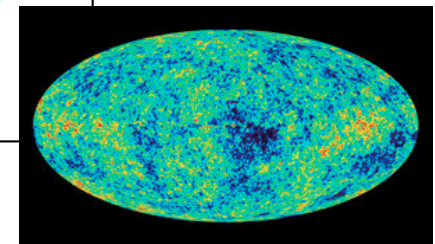
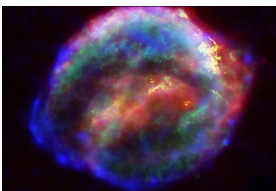
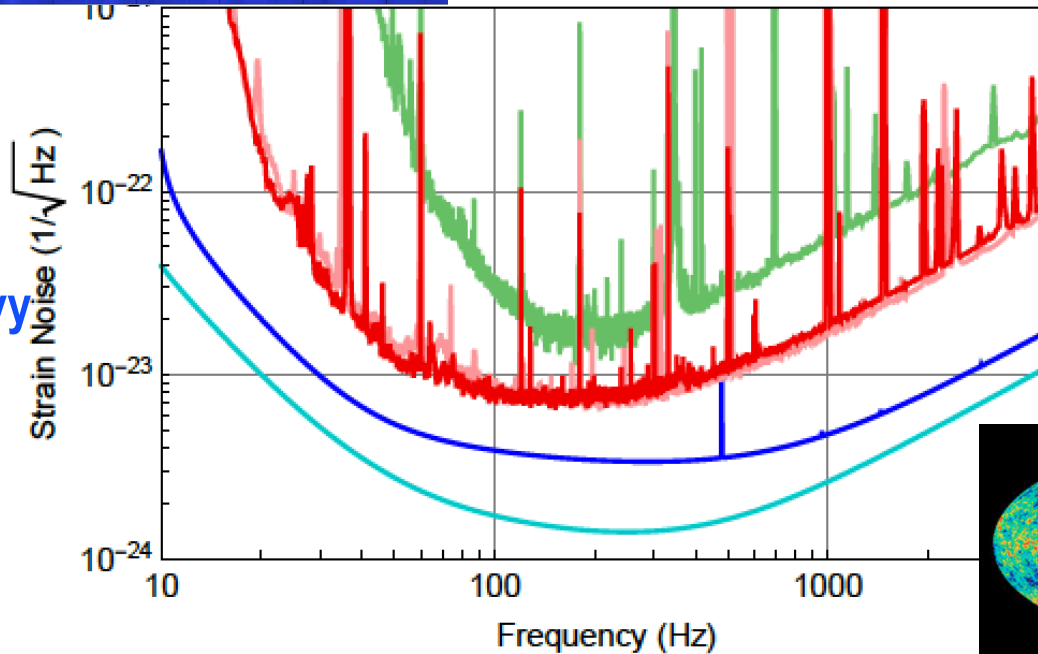
# LIGO Data Analysis



Crab pulsar (NASA, Chandra Observatory)



2010 LIGO  
 2015 aLIGO  
 aLIGO design sensitivity  
 aLIGO+



NASA, WMAP

Four analysis working groups (plus detector characterization, software and computing)  
 white paper LIGO-LIGO-T1500055 ([dcc.ligo.org](http://dcc.ligo.org))  
 about search plans for Adv LIGO and Virgo detections

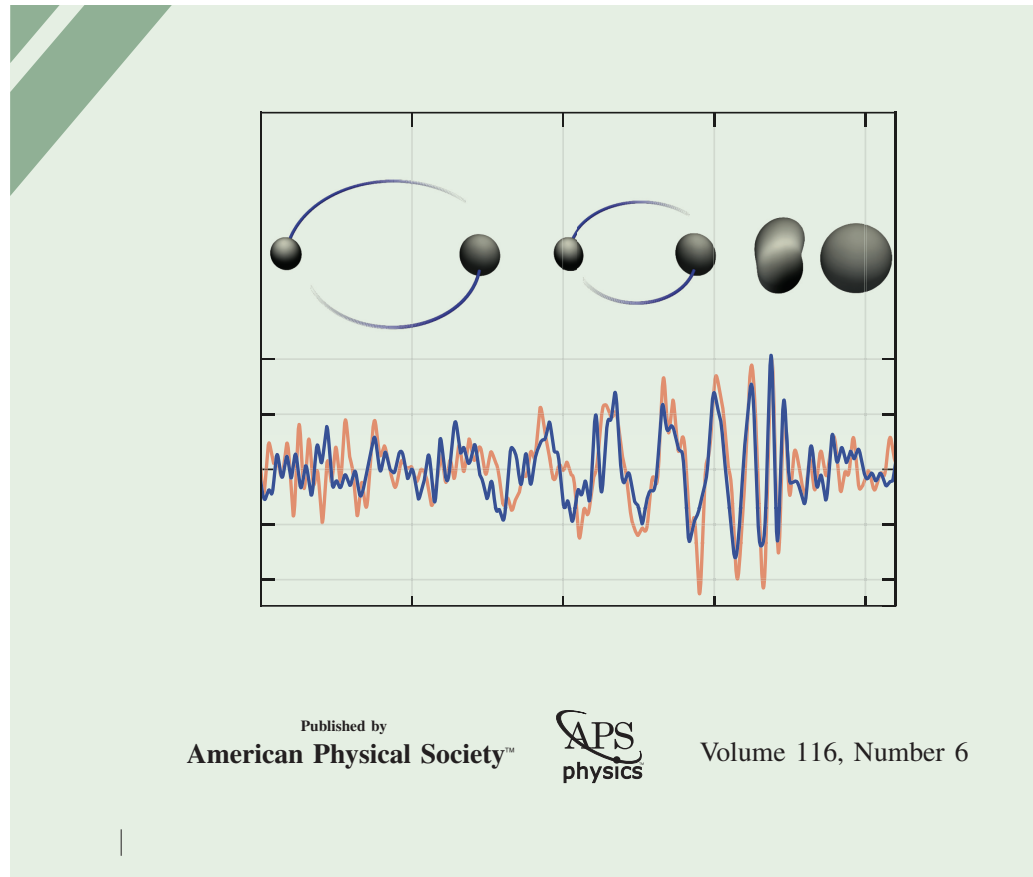


# Observation of Gravitational Waves from a Binary Black Hole Merger

B. P. Abbott *et al.*\*

(LIGO Scientific Collaboration and Virgo Collaboration)

(Received 21 January 2016; published 11 February 2016)

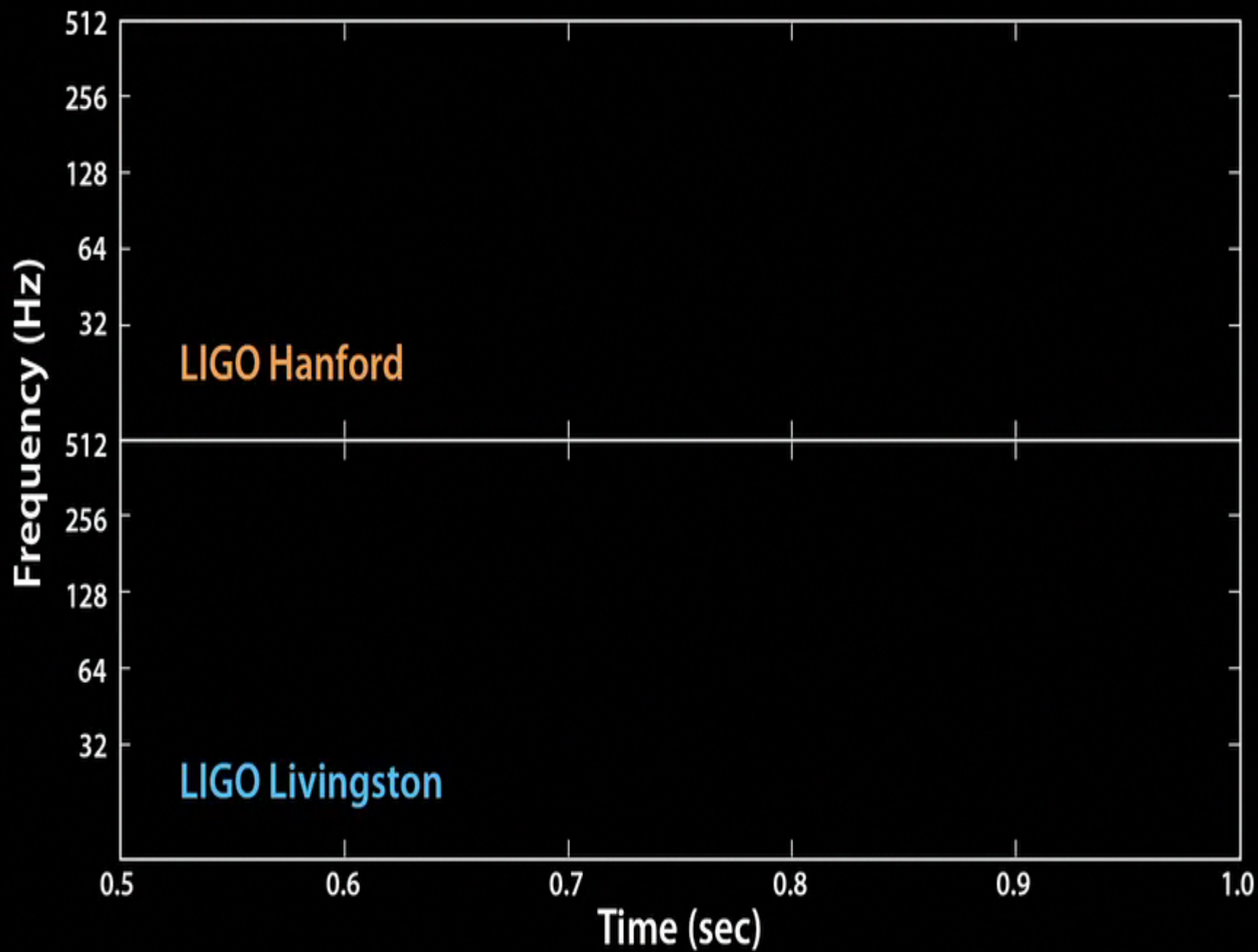


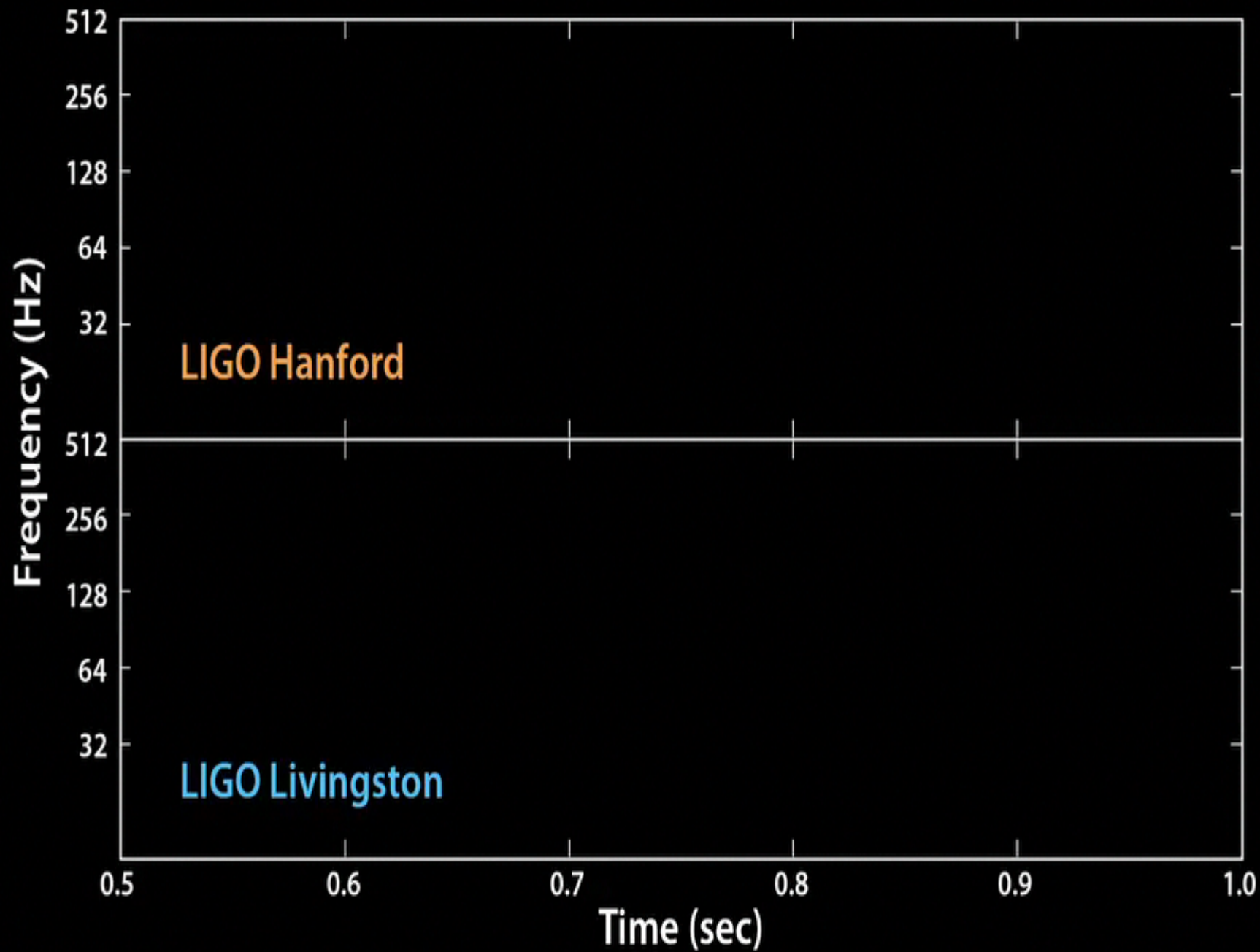
Published by  
American Physical Society™



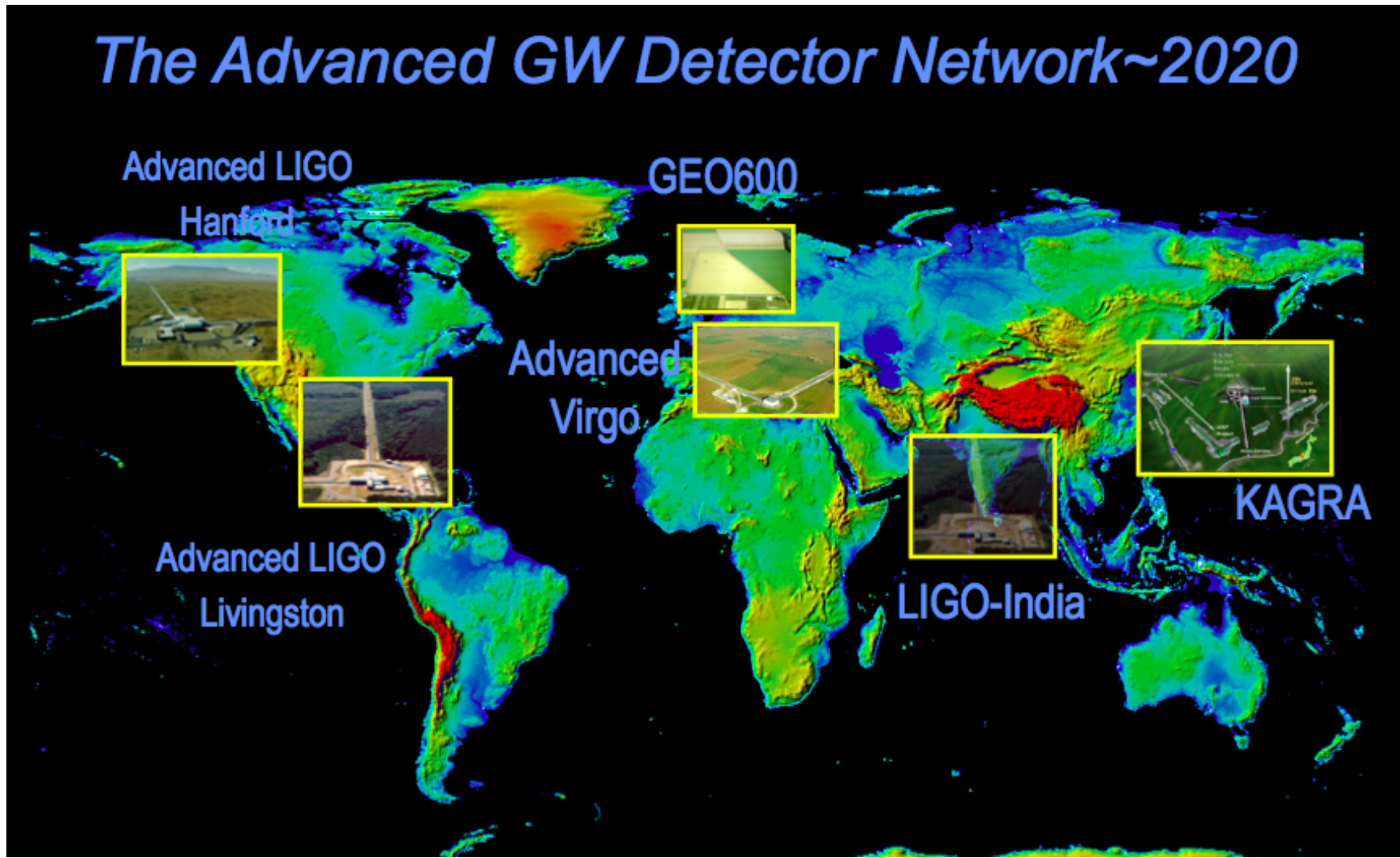
Volume 116, Number 6





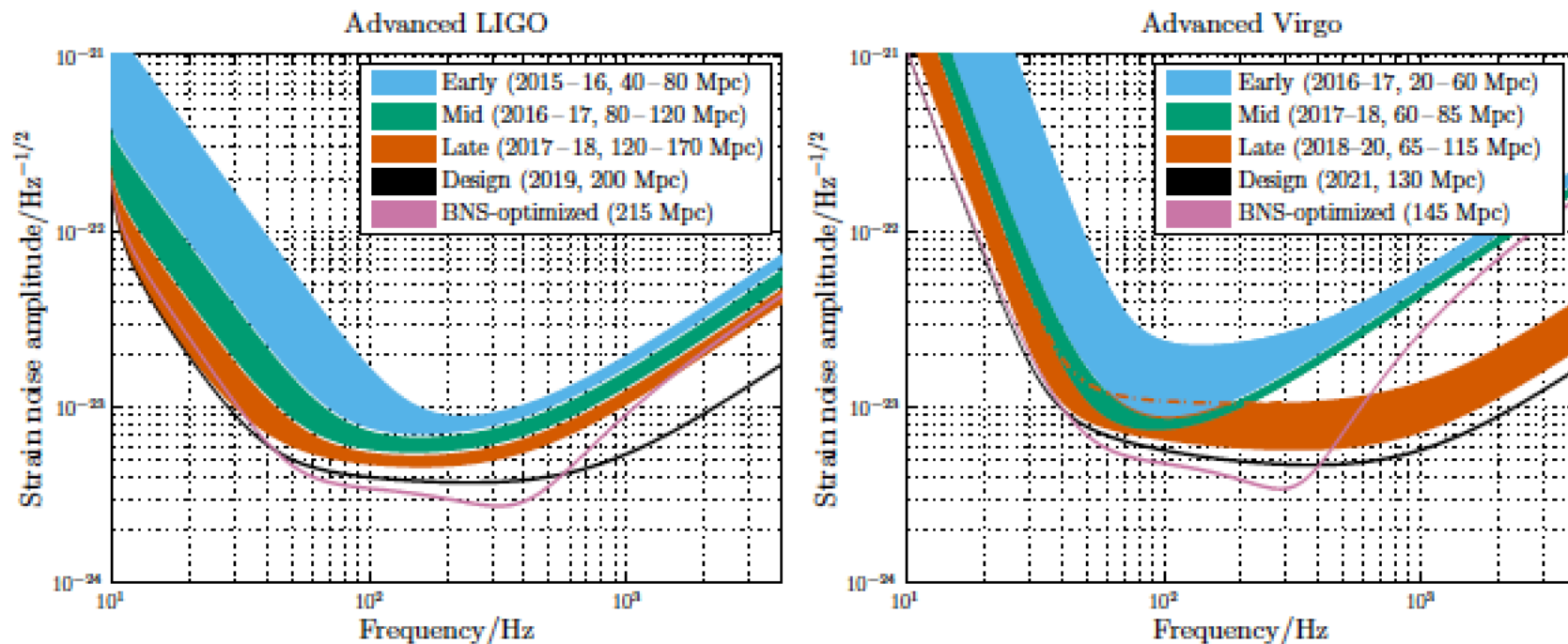


# LIGO leads but it's not alone: gravitational wave network





# Prospects: LIGO – Virgo network



**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.

*Living Rev. Relativity*, 19 (2016), 1, doi:10.1007/lrr-2016-1,  
 URL : <http://www.livingreviews.org/lrr-2016-1>.

# The near future

*Living Rev. Relativity*, 19 (2016), 1, doi:10.1007/lrr-2016-1,  
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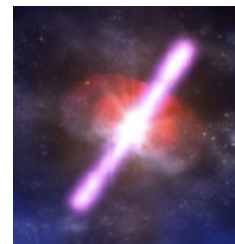
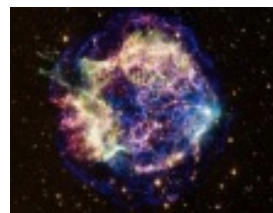
Epoch			2015 – 2016	2016 – 2017	2017 – 2018	2019+	2022+ (India)
Estimated run duration			4 months	6 months	9 months	(per year)	(per year)
Burst range/Mpc	LIGO		40 – 60	60 – 75	75 – 90	105	105
	Virgo		—	20 – 40	40 – 50	40 – 80	80
BNS range/Mpc	LIGO		40 – 80	80 – 120	120 – 170	200	200
	Virgo		—	20 – 60	60 – 85	65 – 115	130
Estimated BNS detections			0.0005 – 4	0.006 – 20	0.04 – 100	0.2 – 200	0.4 – 400
90% CR	% within	5 deg <sup>2</sup>	< 1	2	> 1 – 2	> 3 – 8	> 20
		20 deg <sup>2</sup>	< 1	14	> 10	> 8 – 30	> 50
		median/deg <sup>2</sup>	480	230	—	—	—
searched area	% within	5 deg <sup>2</sup>	6	20	—	—	—
		20 deg <sup>2</sup>	16	44	—	—	—
		median/deg <sup>2</sup>	88	29	—	—	—

# Multi-messenger astronomy: GW/EM observations



We will obtain rich astrophysics combining gravitational-wave and electromagnetic information.

- LSC and Virgo opened a call to sign agreements for the identification of EM counterparts to GW triggers in Advanced detectors starting in 2015: <http://www.ligo.org/scientists/GWEMAlerts.php>
- We received and approved more than 60 applications from 19 countries, with about 150 instruments covering the full spectrum, from radio to high-energy gamma-rays.
- Shortly after a few detections, LSC/Virgo will publicly release GW triggers for follow up: [dcc.ligo.org](http://dcc.ligo.org), LIGO-M1200055.





# LIGO open data

LIGO is committed to open data and prompt release of GW observations  
<https://losc.ligo.org/>

## Getting Started

Tutorials

Data & Catalogs

Timelines

My Sources

Software

GPS ↔ UTC

About LIGO

Student Projects

Acknowledgement

## Welcome to the LIGO Open Science Center

About LIGO

Get Started with LIGO data

Join the E-mail list for updates

### LIGO releases discovery data! **GW150914 Data Release**

For general information on LIGO, please visit [ligo.org](http://ligo.org).

If you have LSC credentials, you may go to the [development site](#).



# Conclusions

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- Although atypical, the LSC model with an open and international collaboration created around a “LIGO Laboratory” has worked well.
- Large size has already many challenges. More challenges lie ahead: collaboration model will evolve in the presence of detections and open data, funding for future detectors, ...
- The field will always need a large collaborative team working on operations, timely science analysis, and R&D ready for installation in new detectors, plus innovative methods for analysis and research on new technologies.