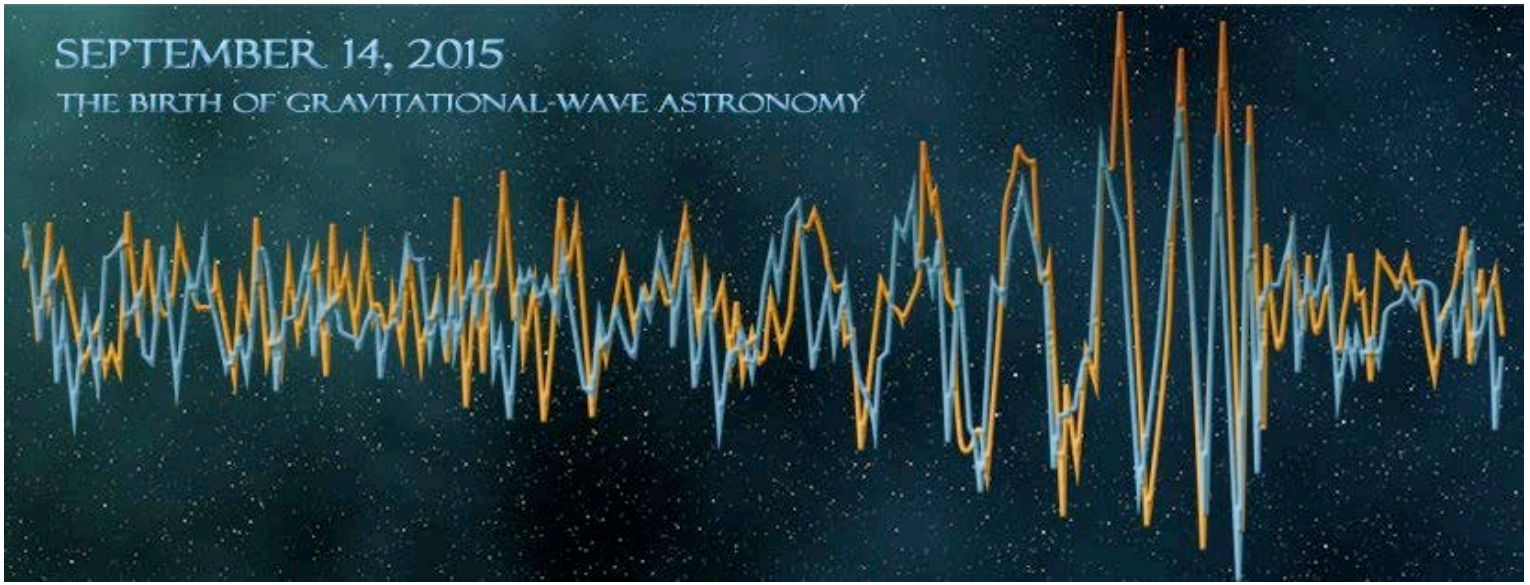
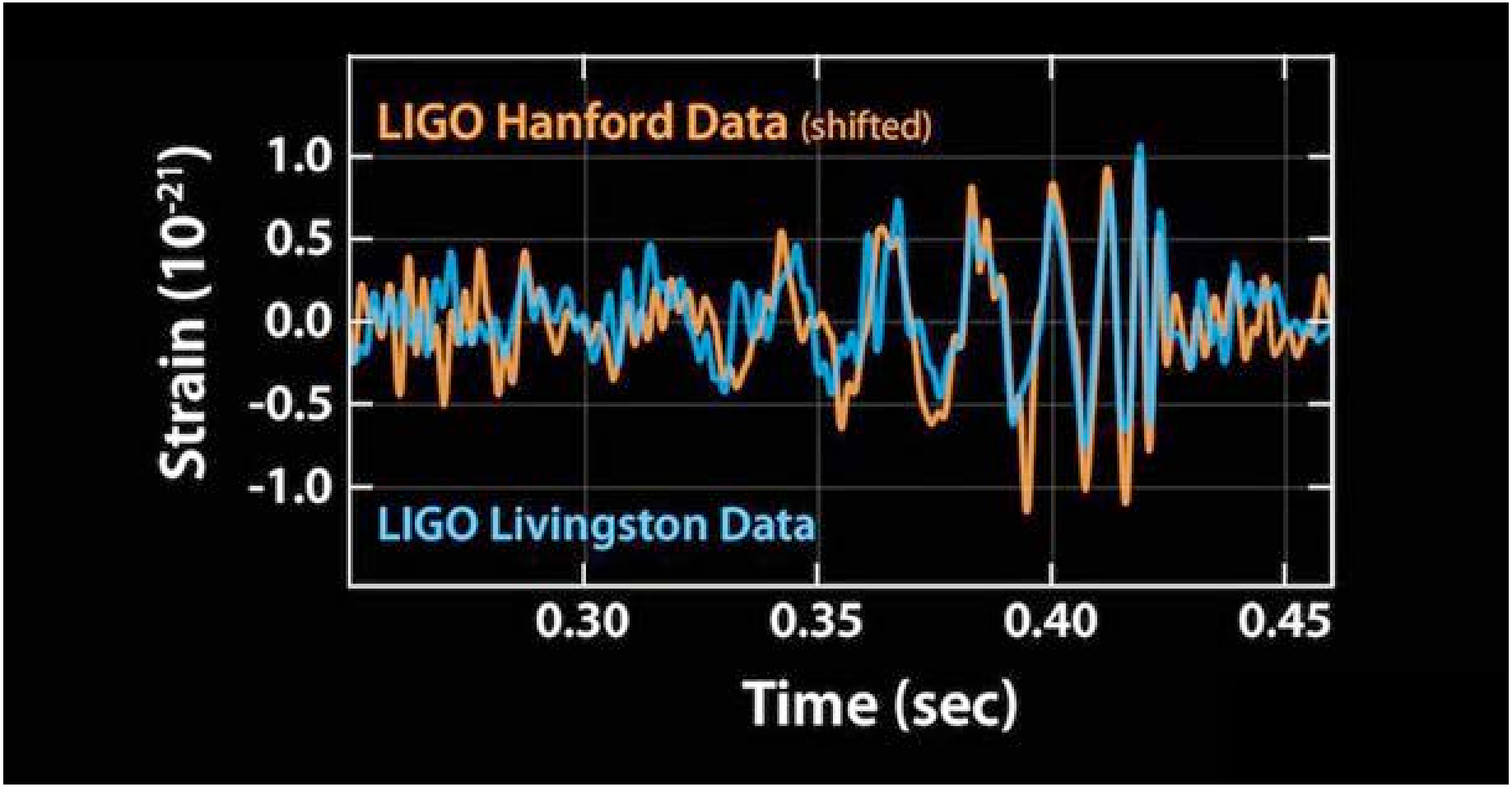
Science Done by a Global Community: The LIGO Scientific Collaboration

Gabriela González,
Louisiana State University

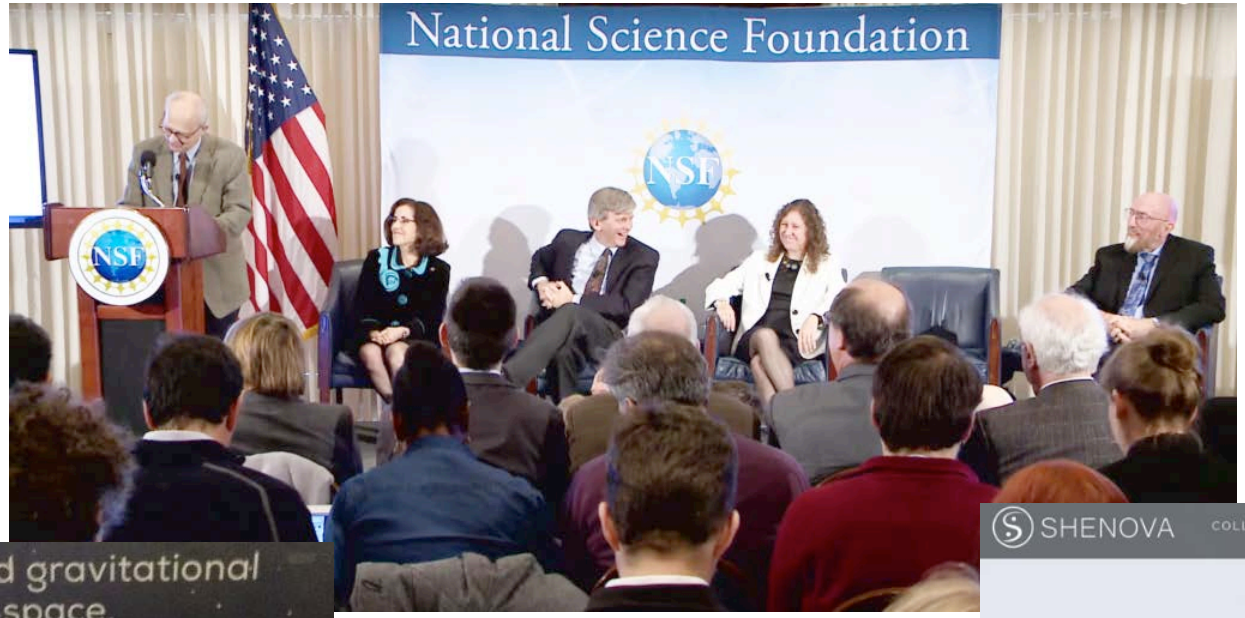


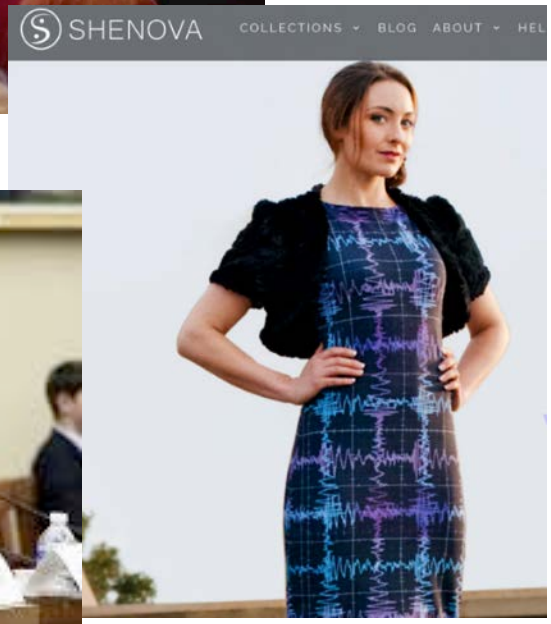
LIGO-G1700798

On Sept 14 2015…



February 11: We did it!

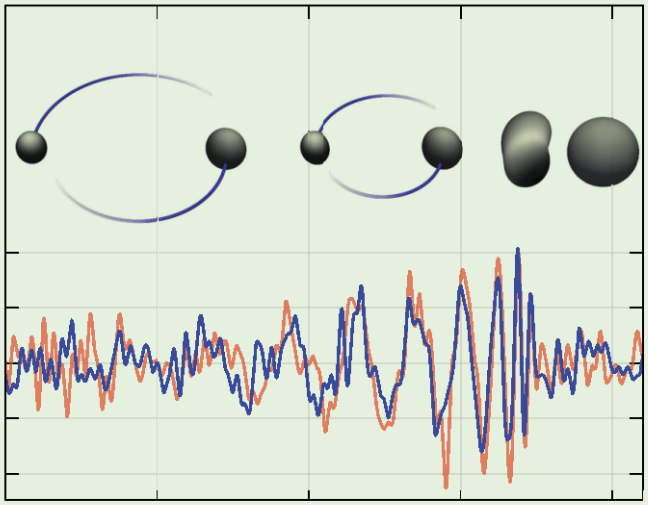




PRL 116, 061102 (2016) PHYSICAL REVIEW LETTERS week ending 12 FEBRUARY 2016

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)



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American Physical Society™
APS physics
Volume 116, Number 6

LIGO detectors

Hanford, WA

Livingston, LA

Advanced LIGO detectors:

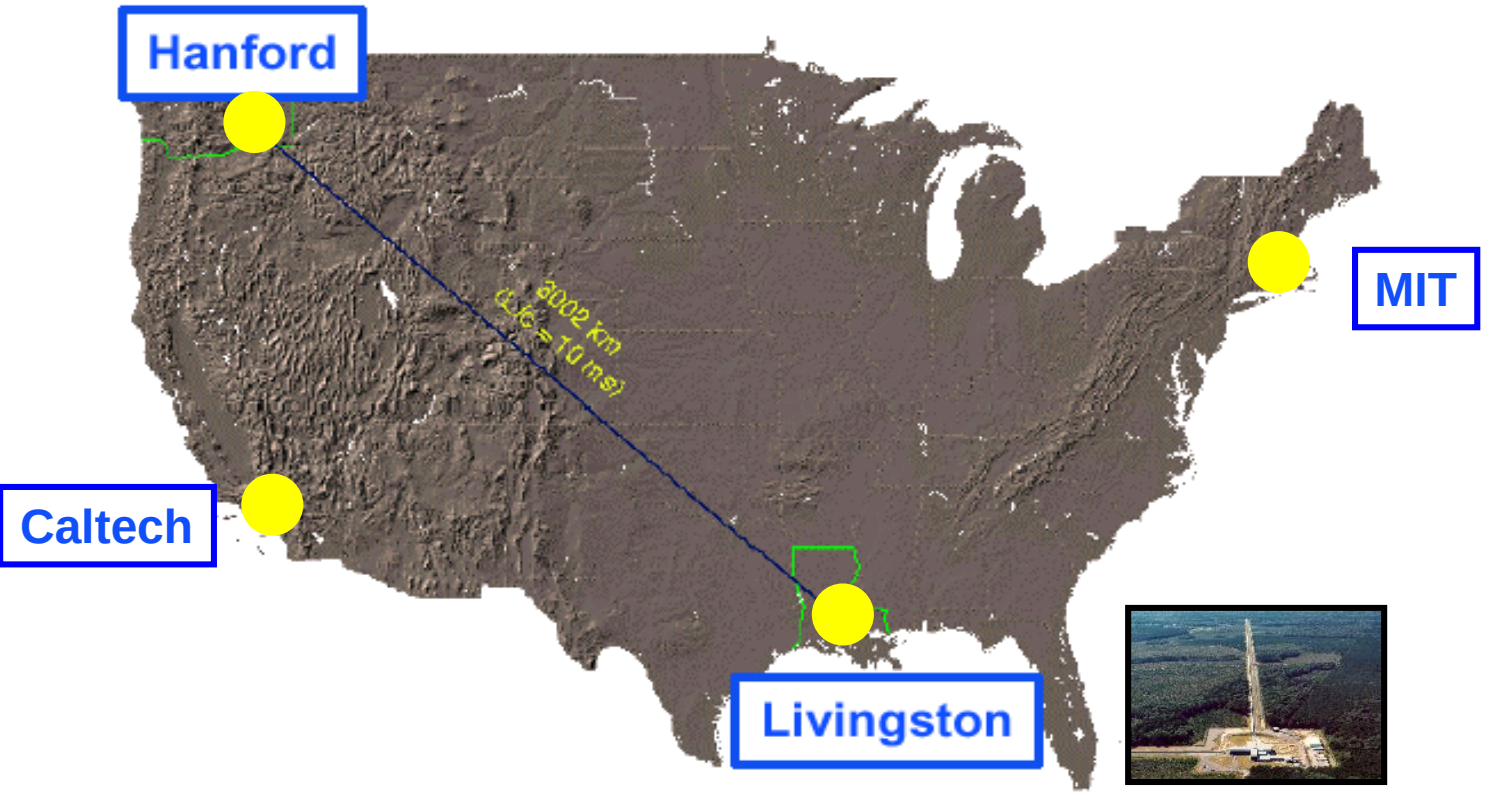
MAX-PLANCK-GESELLSCHAFT

Science & Technology Facilities Council

Australian Government
Australian Research Council

LIGO Laboratory

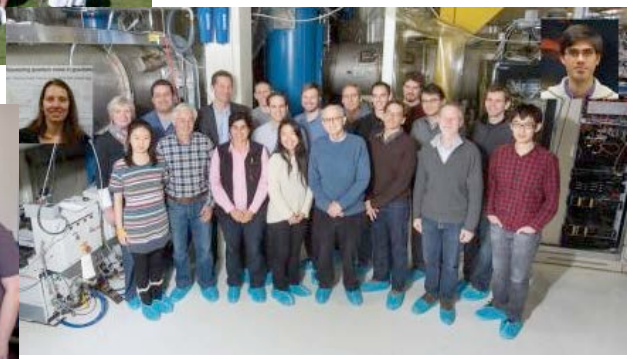
- Mission: Observe gravitational wave sources; operate the LIGO facilities; develop the instrument science and technology; scientific education and public outreach.
- NSF Major Research Facilities Construction LIGO grant in 1992 and in 2008; cooperative agreements since 1992, jointly managed by Caltech and MIT.
- ~170 scientists, engineer and staff; includes physicists working on instrument science and data analysis.



LIGO Scientific Collaboration

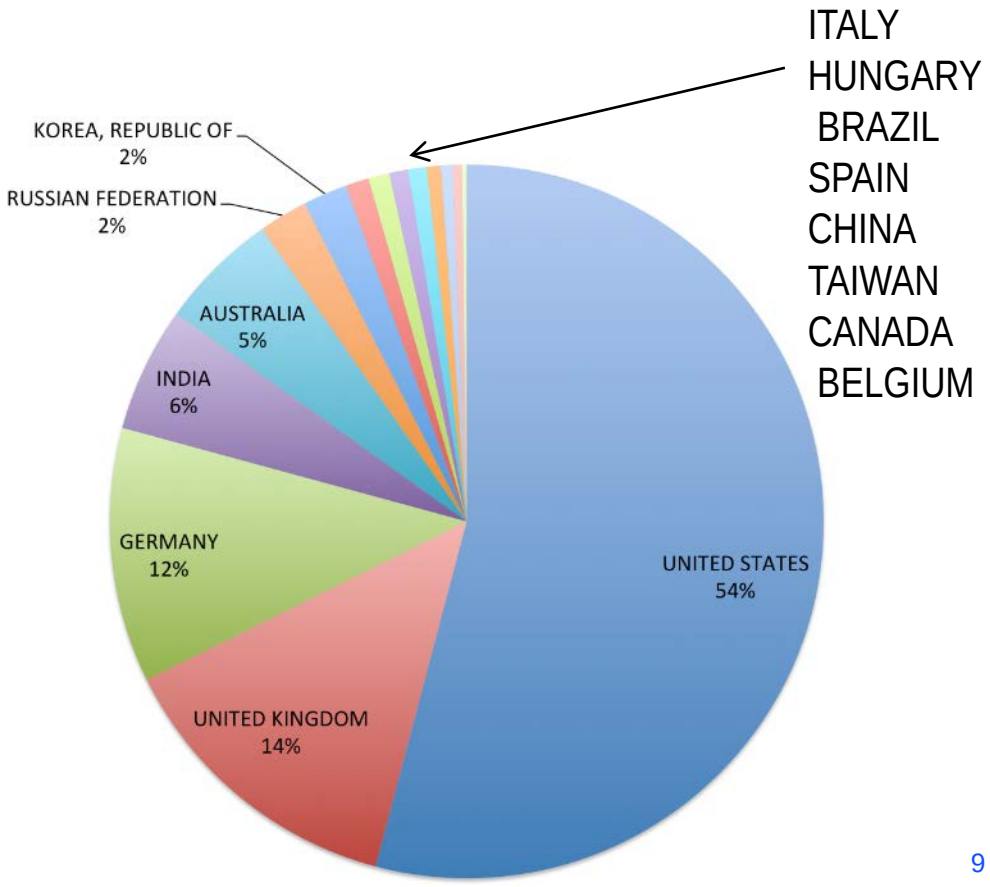

LIGO


THE NATIONAL
PRESS CLUB



LIGO Scientific Collaboration

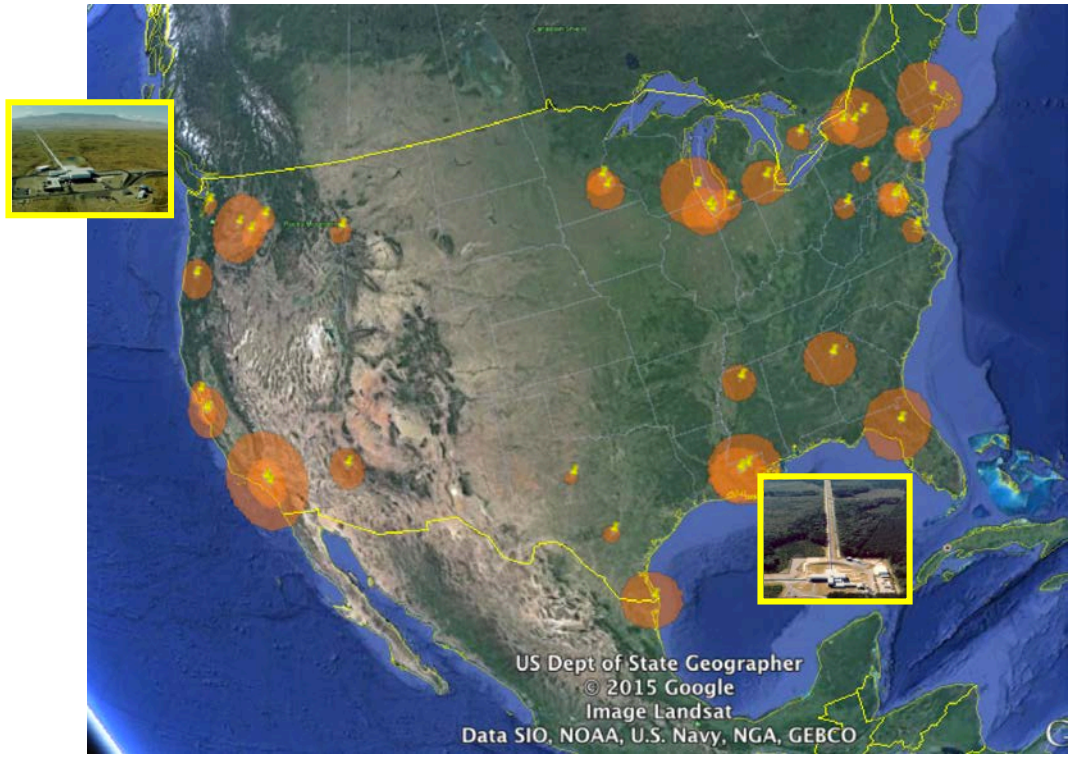
~1,200 members, >90 institutions, 15 countries.



www.ligo.org

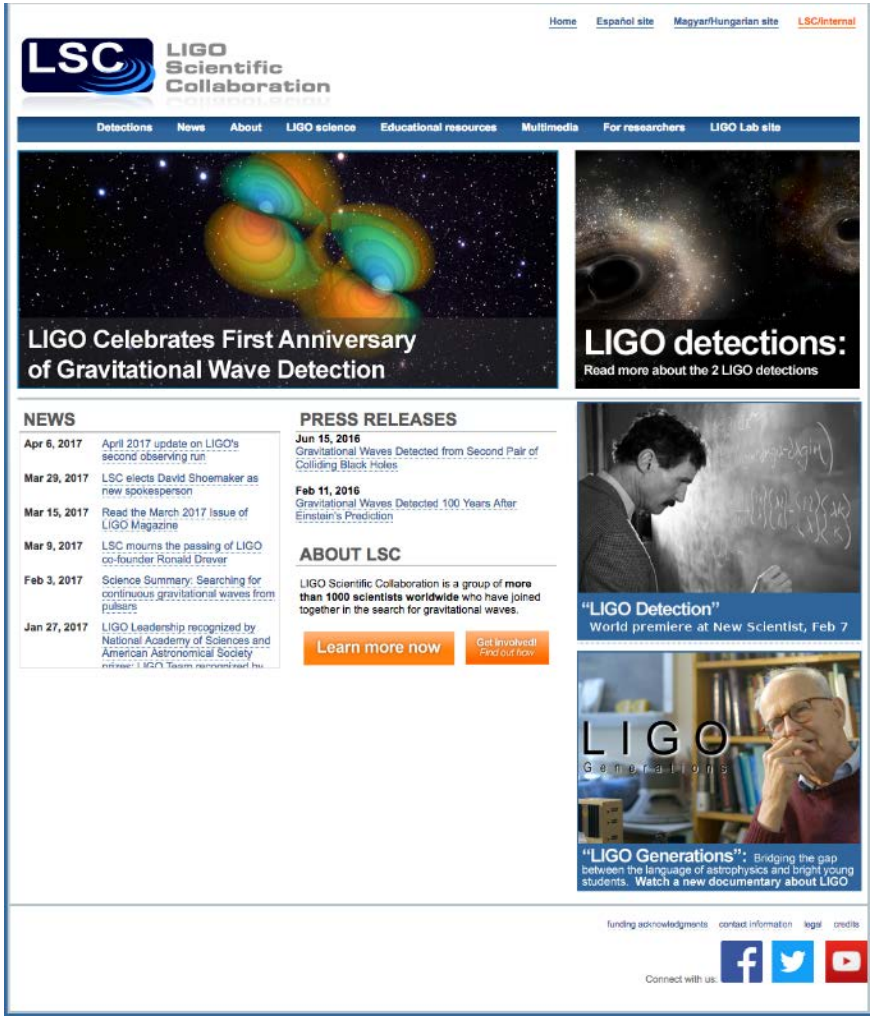
LSC-USA

- 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 a cooperative agreement from NSF with 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 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.



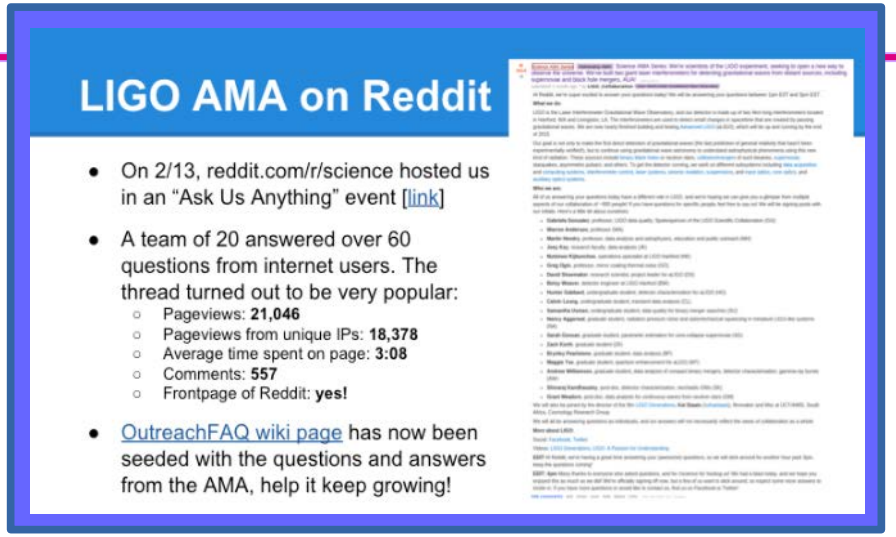
www.ligo.org

LIGO Scientific Collaboration

- 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 (MIT) initial spokesperson 1997-2003
  - Peter Saulson (Syracuse University) elected spokesperson 2003-2007, David Reitze (University of Florida) 2007-2011, GG (Louisiana State University) 2011-2017
  - Current spokesperson is David Shoemaker (MIT), with Deputy spokesperson Laura Cadonati (Georgia Tech).

Education and Public Outreach

Multimedia

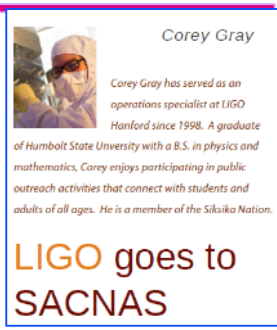


Social media

Science teachers' education

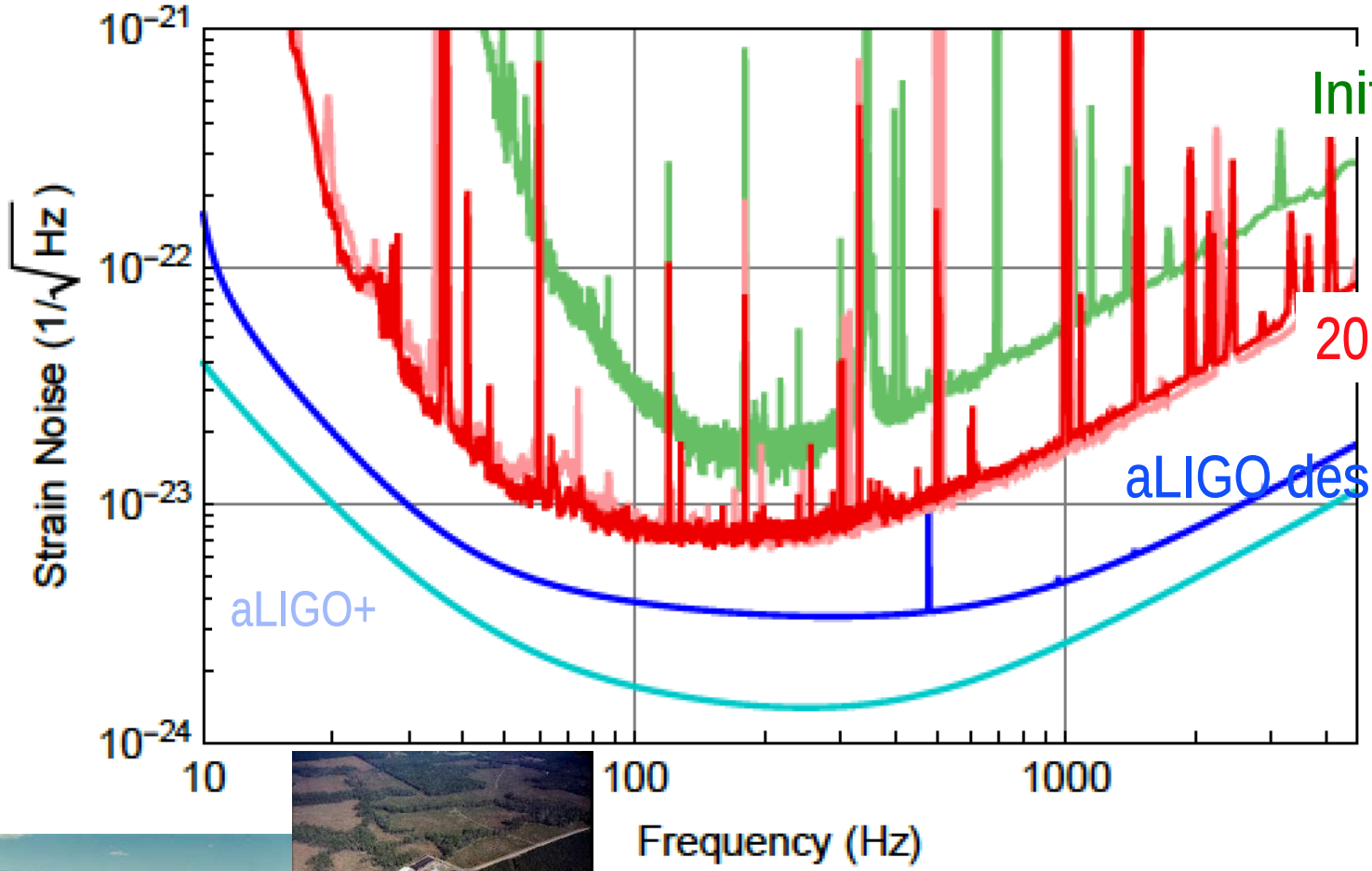
Science fairs, exhibits,
Science Education Center

Other important LSC activities

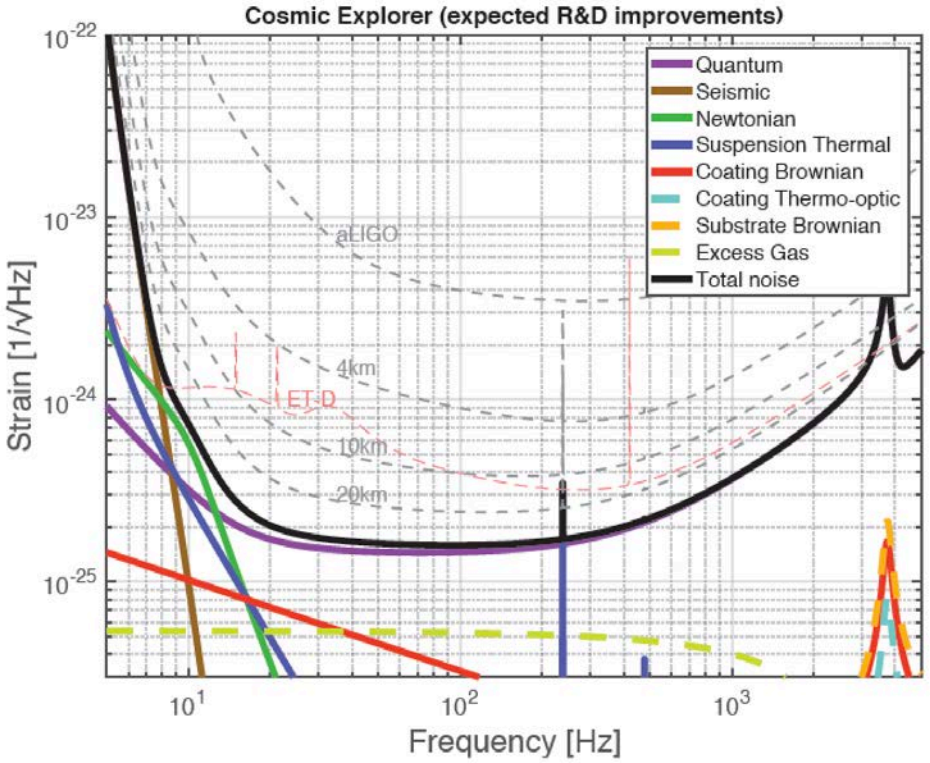


- Diversity
  - LSC has a Diversity Committee. Some initiatives:
    - LSC Diversity statement; anti-harassment policy, LSC “best practices”
    - LSC “Ombudsperson” (former NSF program officer!)
    - LIGO summer undergraduate fellowships sponsored by NSBP and NSHP
    - “Family grants” to attend LSC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

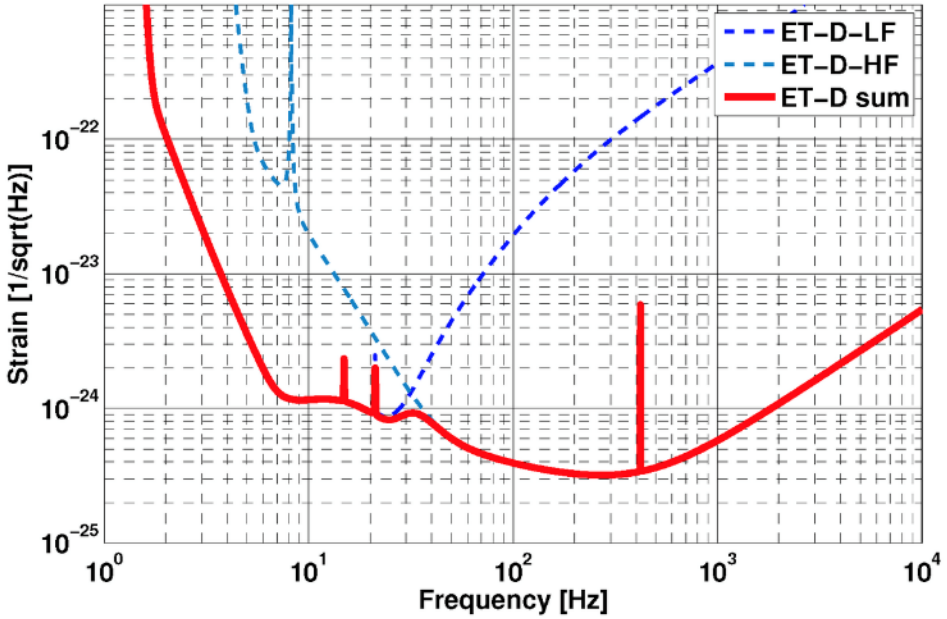


The future: 3rd generation detectors

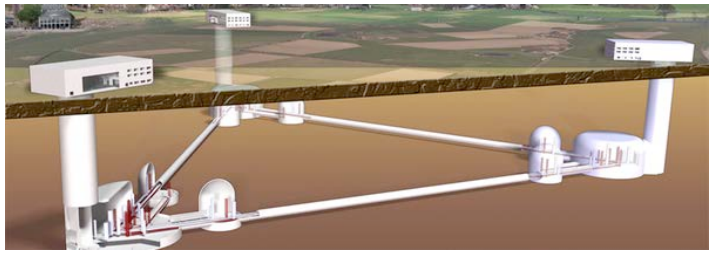


arXiv:1607.08697

Einstein Telescope

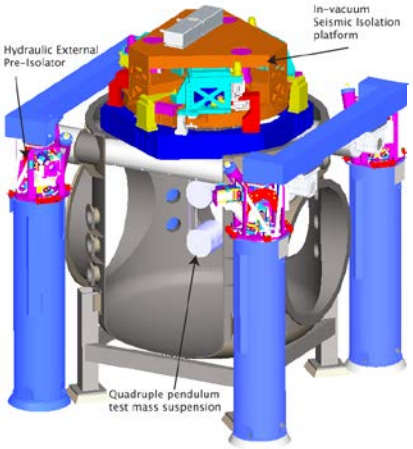


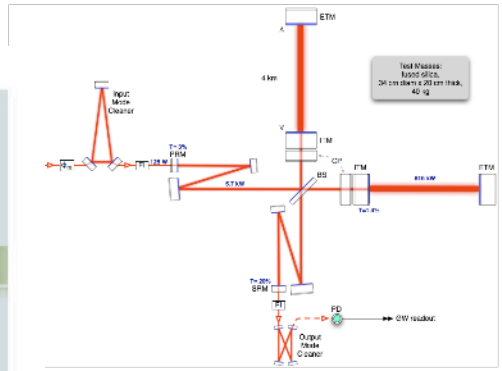
S.Hild et al., Classical and Quantum Gravity, 28 094013, 2011

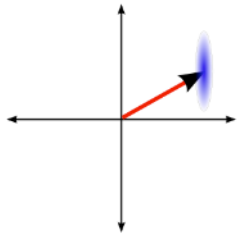


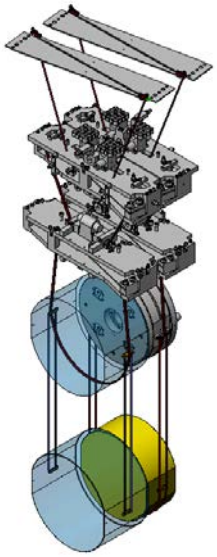
http://www.et-gw.eu/

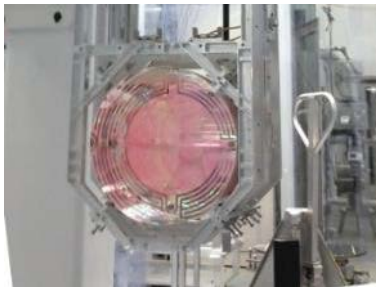
LIGO Detector Technology





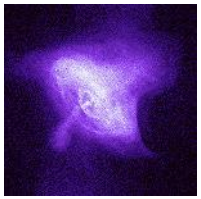




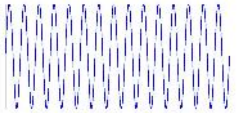


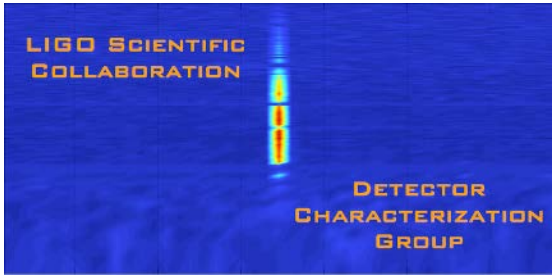
Five instrumental working groups – white paper LIGO-T1600119 (dcc.ligo.org) about R&D for future detectors with improved sensitivities

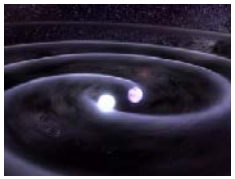
LIGO Data Analysis

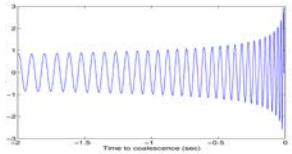


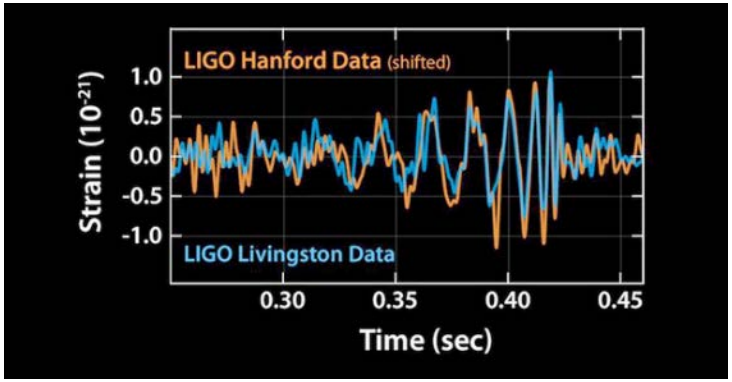
Crab pulsar (NASA, Chandra Observatory)

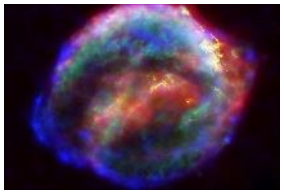


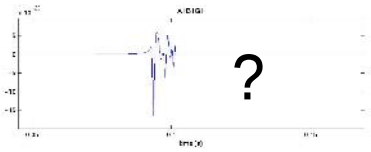


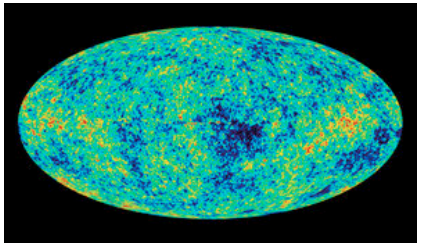












NASA, WMAP

Four analysis working groups (plus calibration, detector characterization, software and computing)
white paper LIGO-T1600115 (dcc.ligo.org)
about search plans for Adv LIGO and Virgo detections

Detections in O1

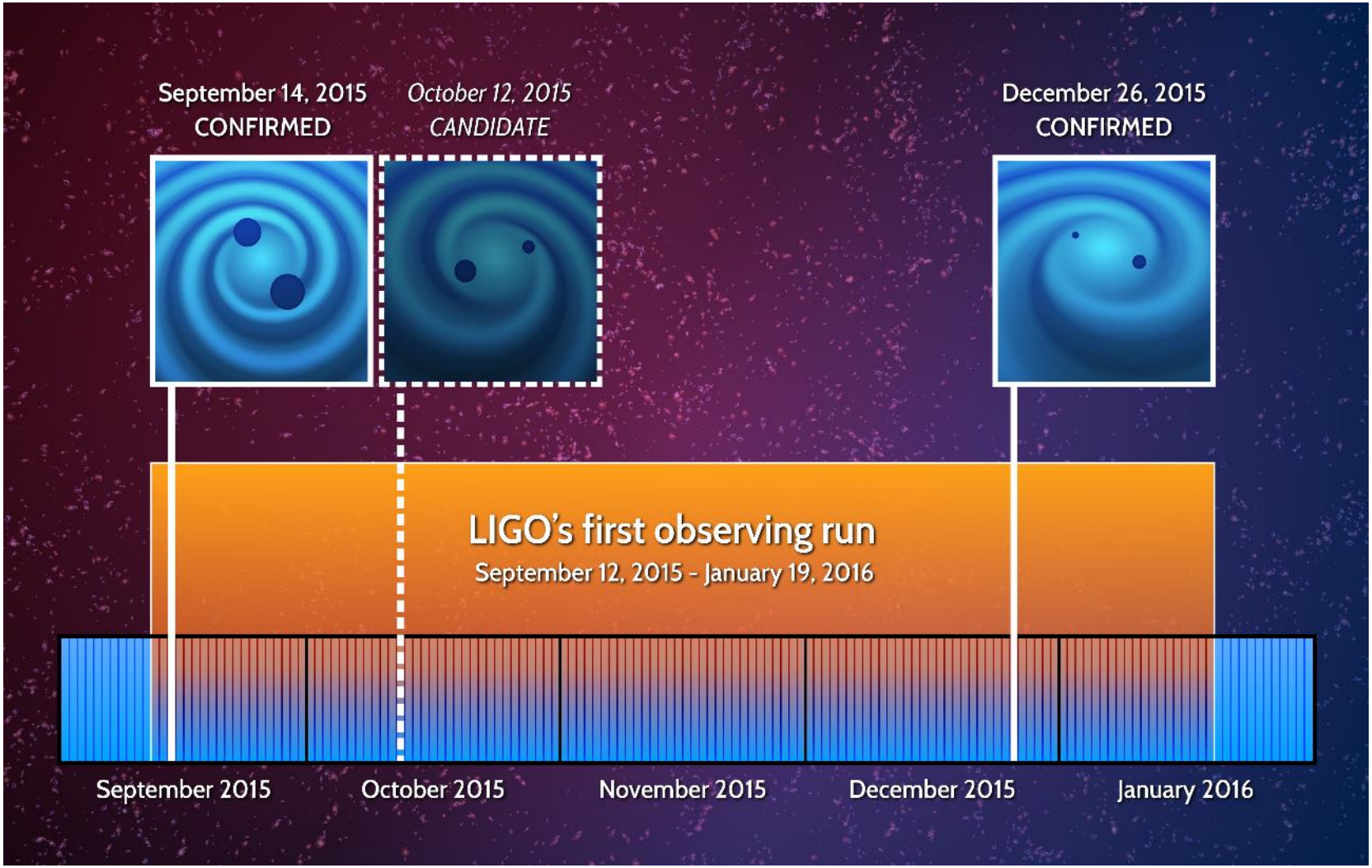
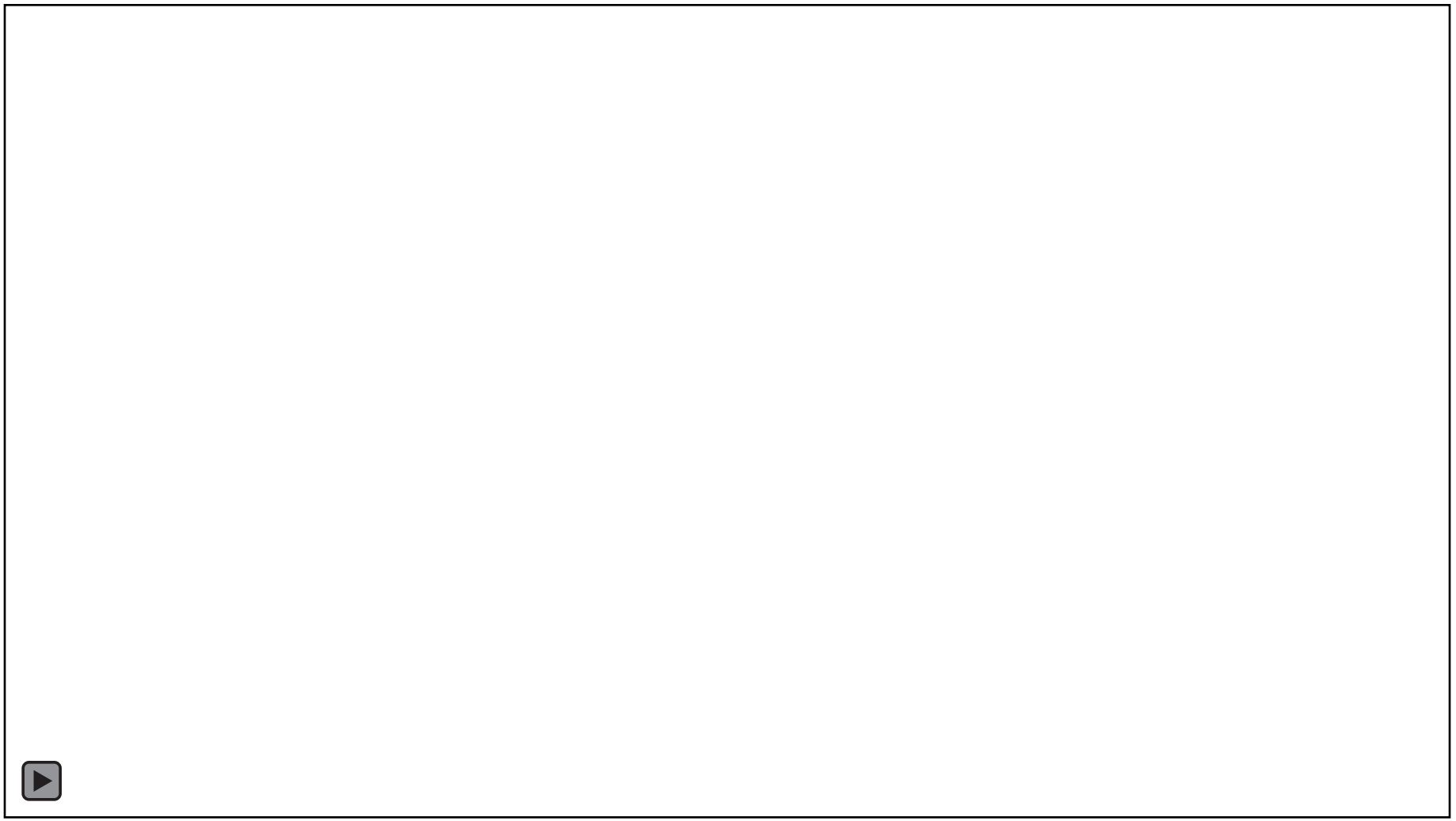
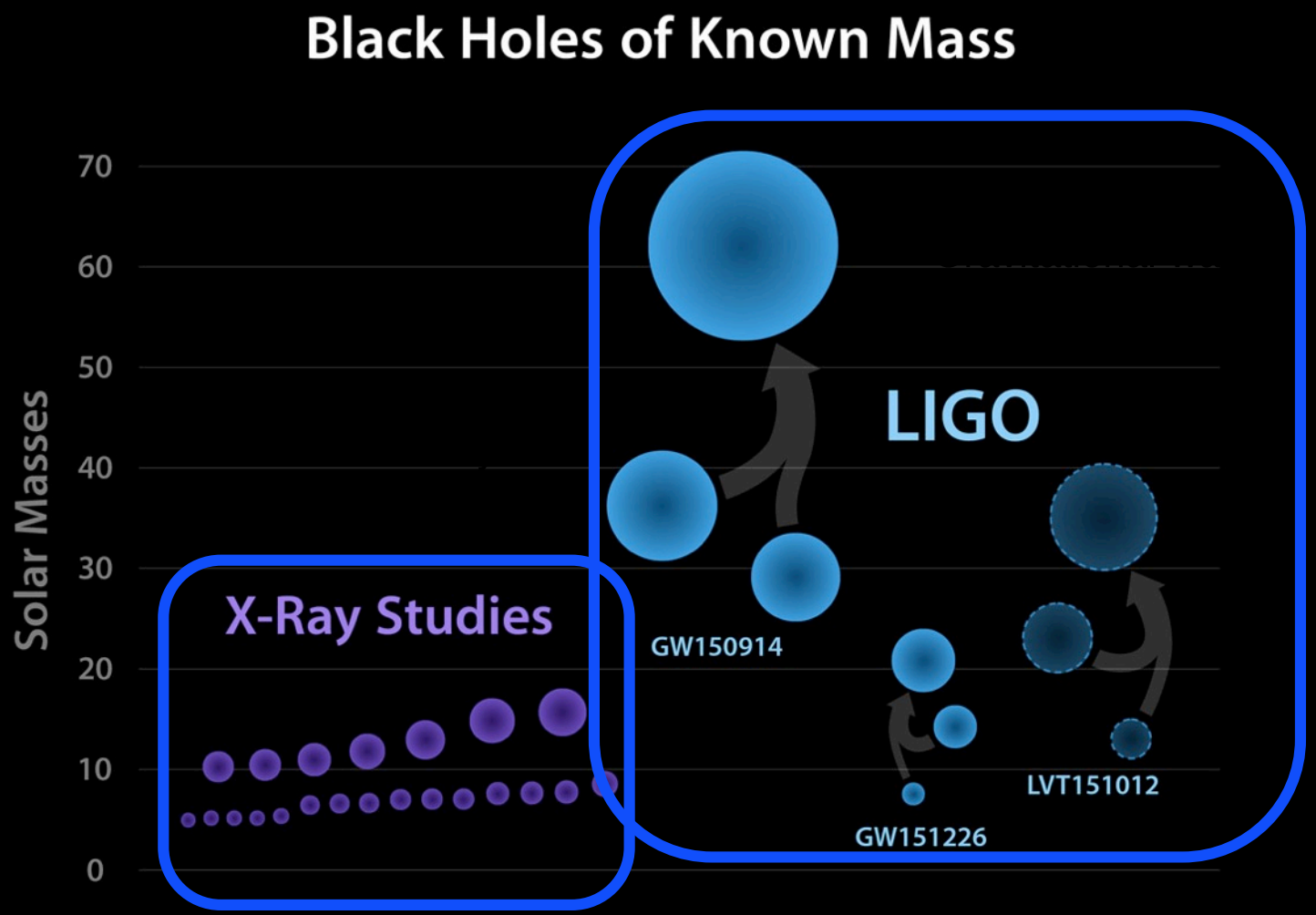


Image credit: LIGO

Gravity's music

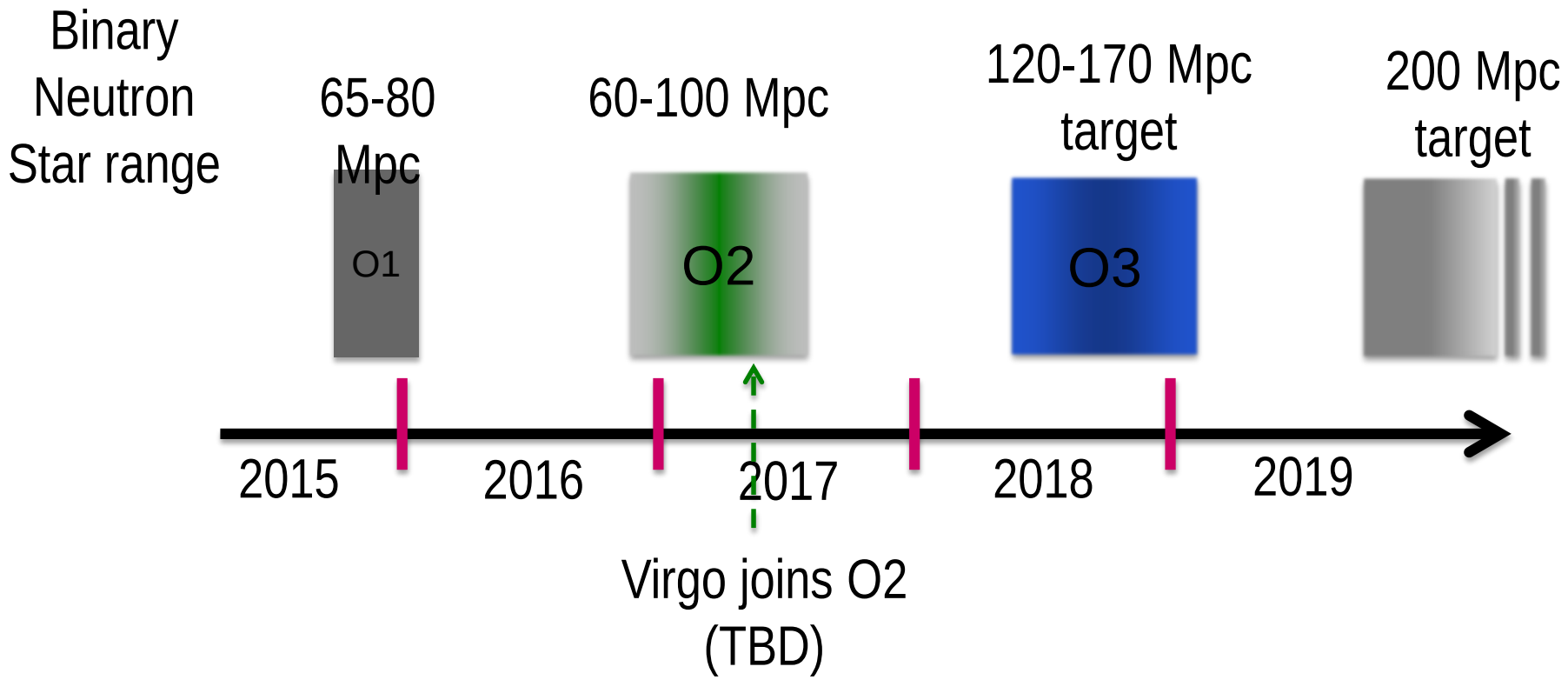


The Black Hole Mass Menagerie

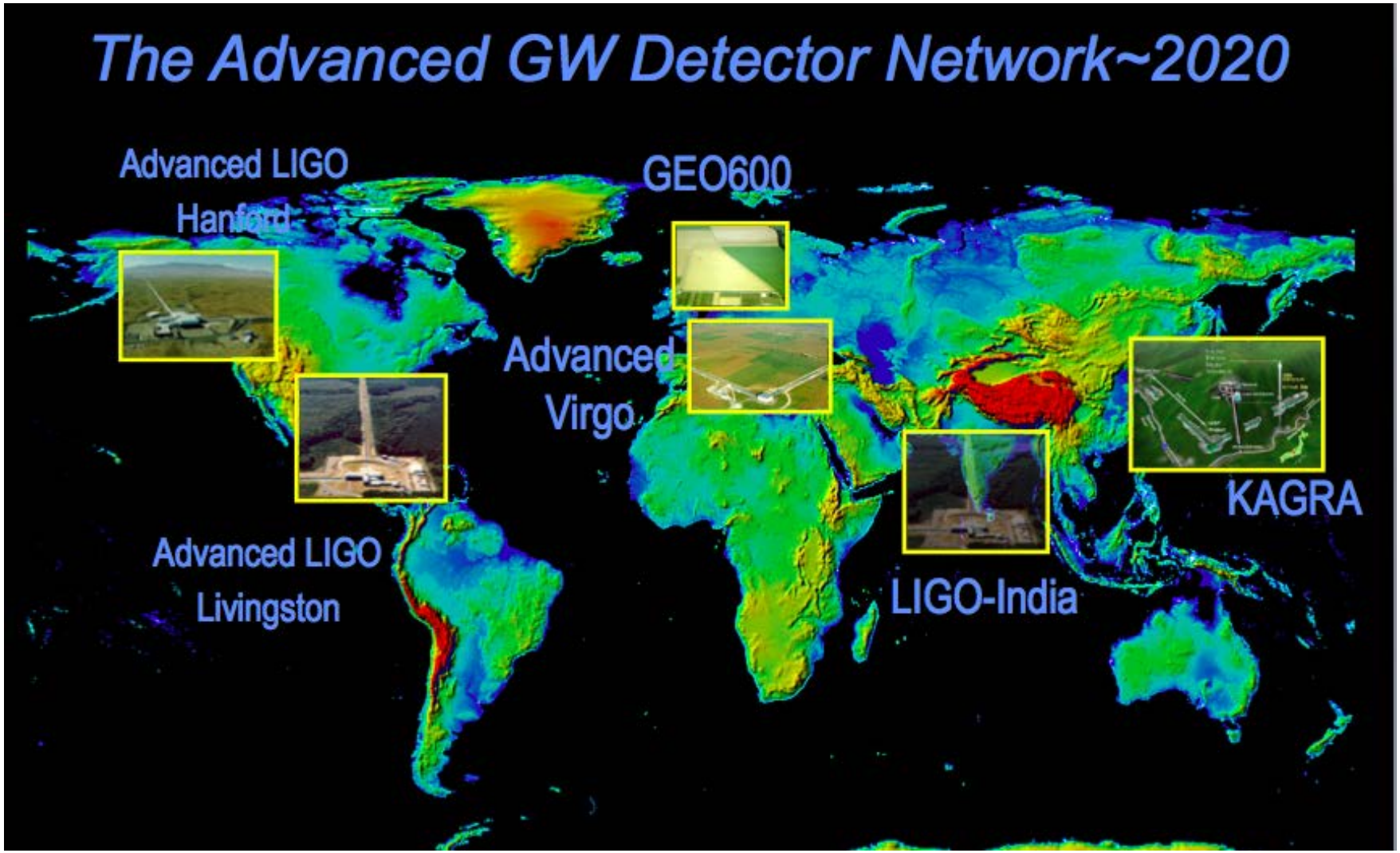


Plausible Observing Run Timeline

(plans still under development within the LIGO and Virgo Collaborations)



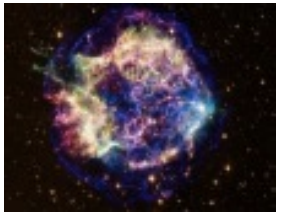
LIGO leads but it's not alone: gravitational wave network



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
- We have more than 60 agreements 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, LIGO-M1200055
- We have made initial LIGO data public (losc.ligo.org), and will make Advanced LIGO data public after curated and a proprietary period.



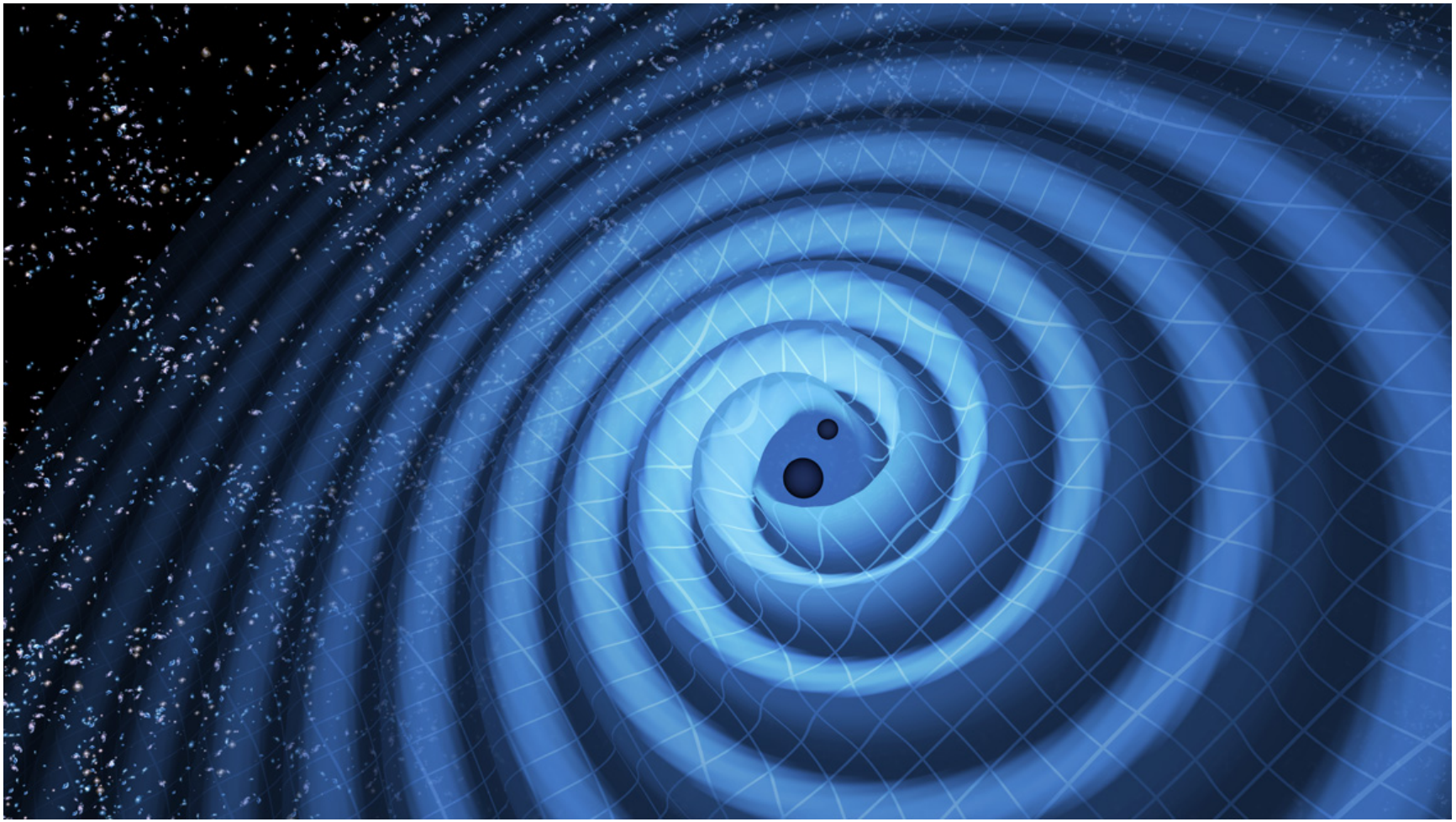
Conclusions

- Although atypical, the LSC model with an open and international collaboration created around a “LIGO Laboratory” has been very successful.

- Large size has already many challenges. More challenges lie ahead: collaboration model is evolving 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, as well innovative methods for analysis and research on new technologies.

Gravitational waves astronomy: this is just the begnning!



www.ligo.org