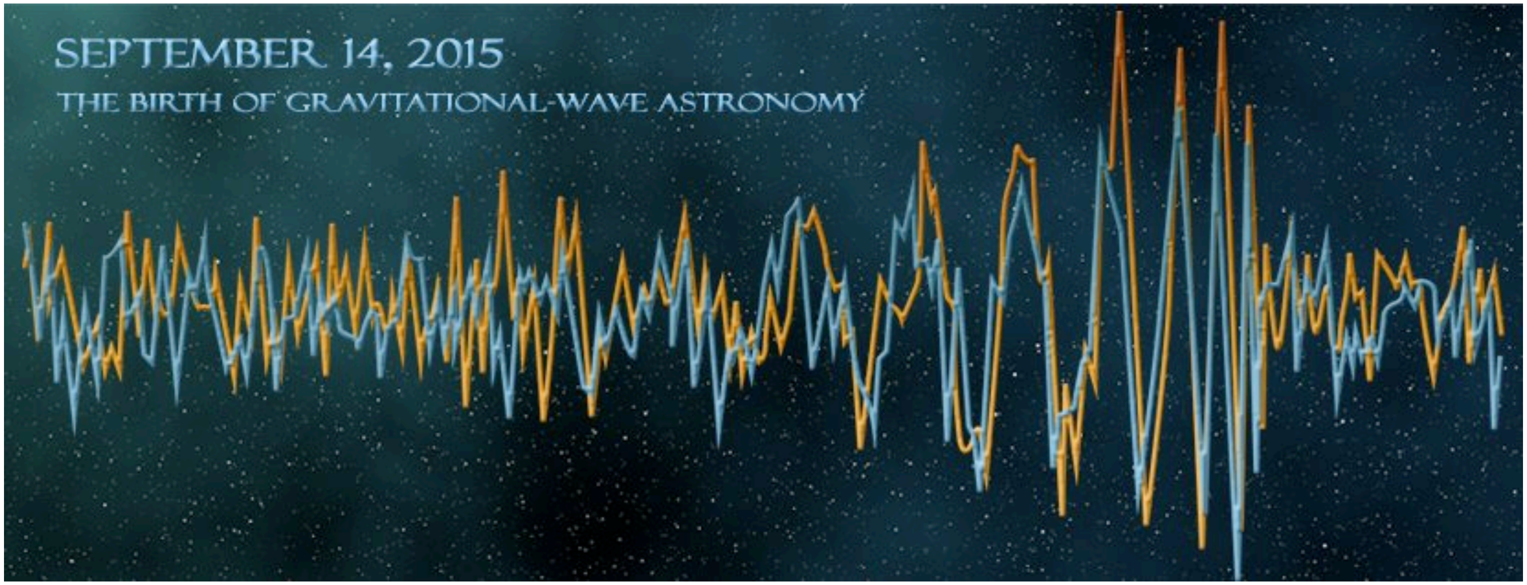
Observation of gravitational waves from a binary black hole system

Gabriela González
Louisiana State University

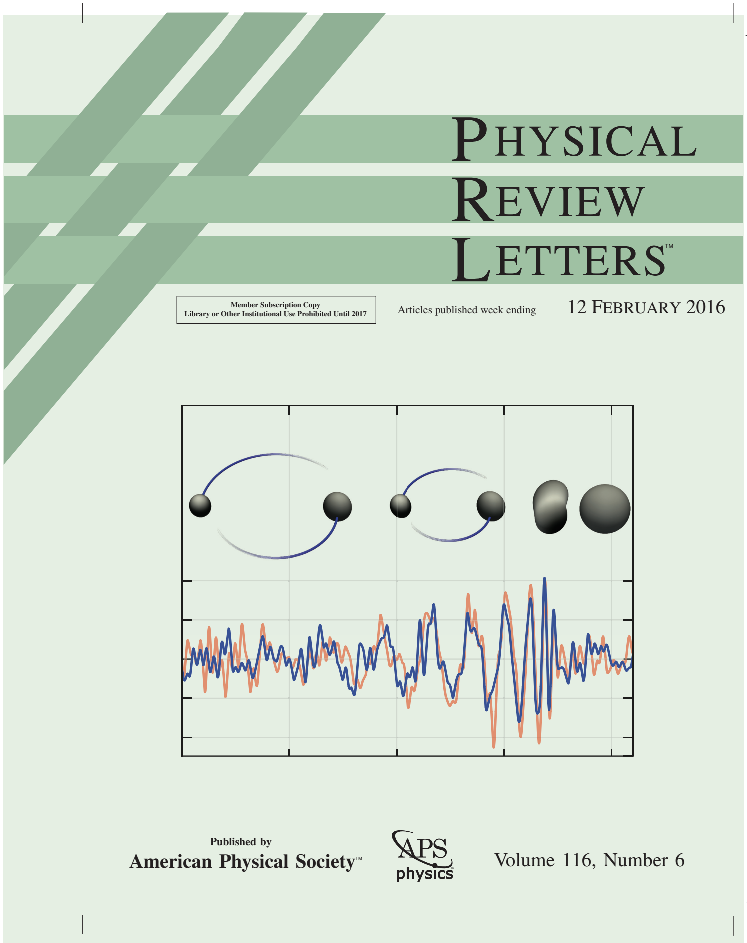
For the LIGO Scientific Collaboration and the Virgo Collaboration

CIFAR meeting, Whistler, BC, Canada
March 31, 2016



LIGO-G1600793

Recent celebrated news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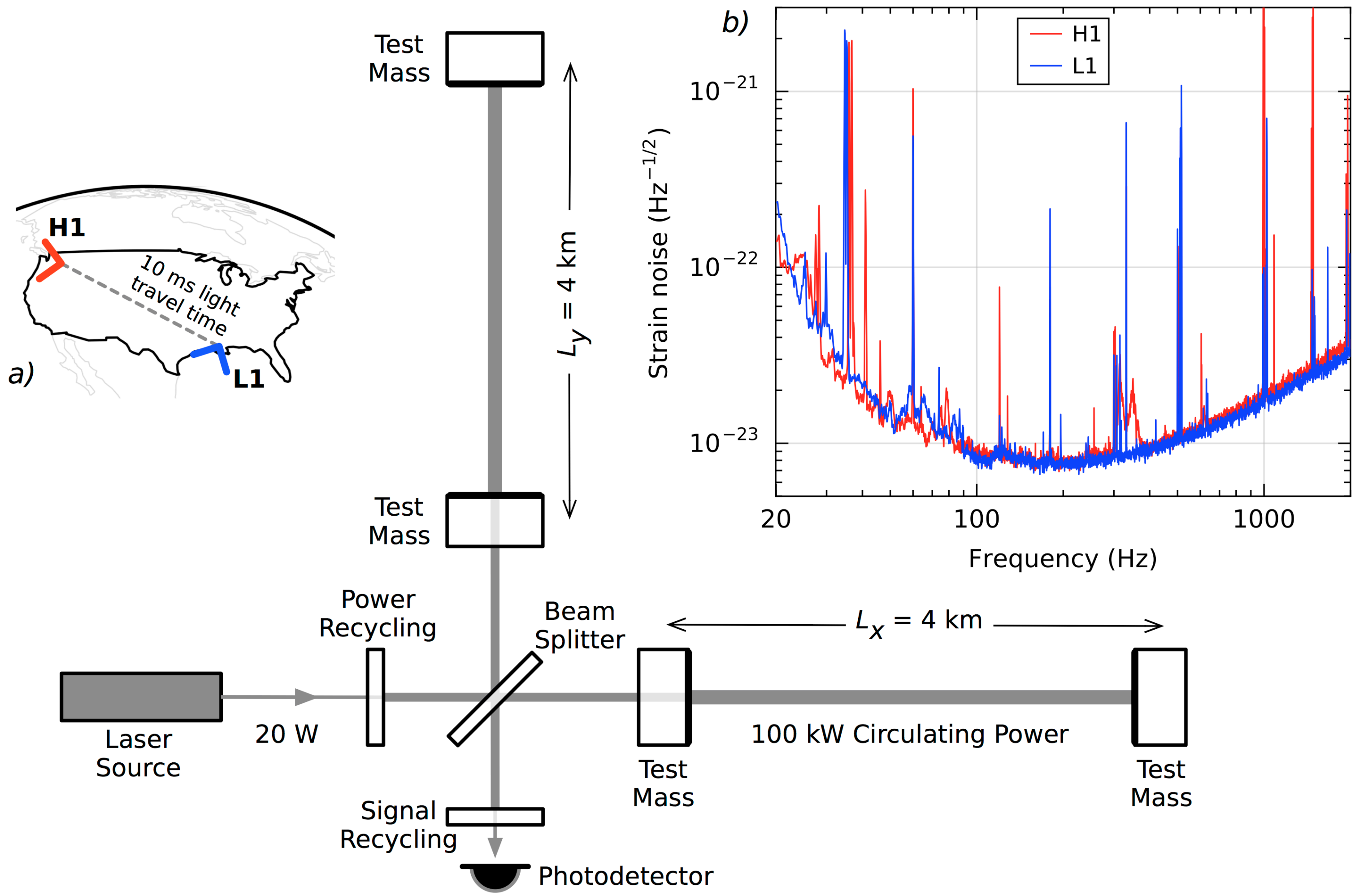
APS physics

Volume 116, Number 6

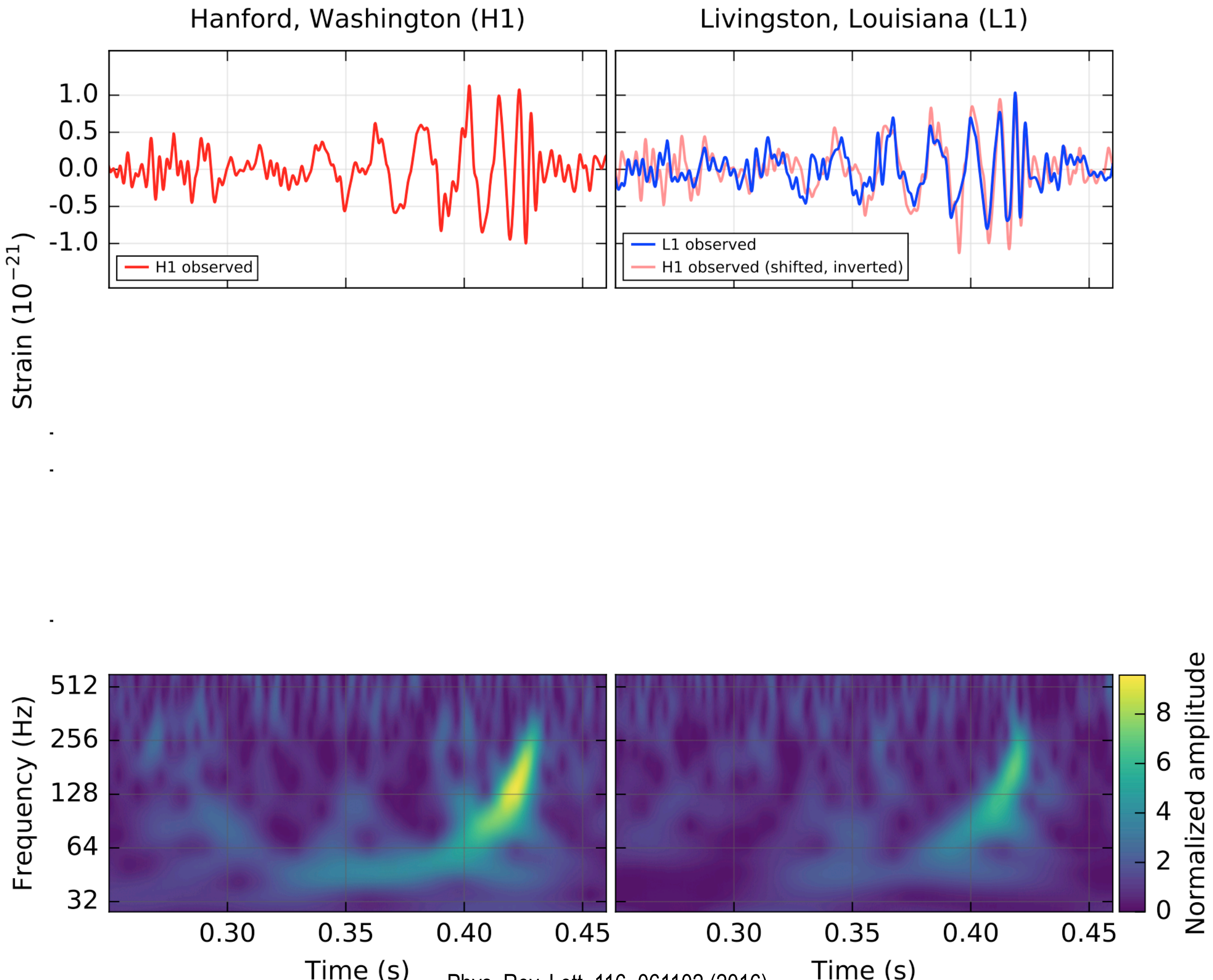
Phys. Rev. Lett. 116, 061102 (2016)

The LIGO detectors



Phys. Rev. Lett. 116, 061102 (2016)

The detection



Phys. Rev. Lett. 116, 061102 (2016)

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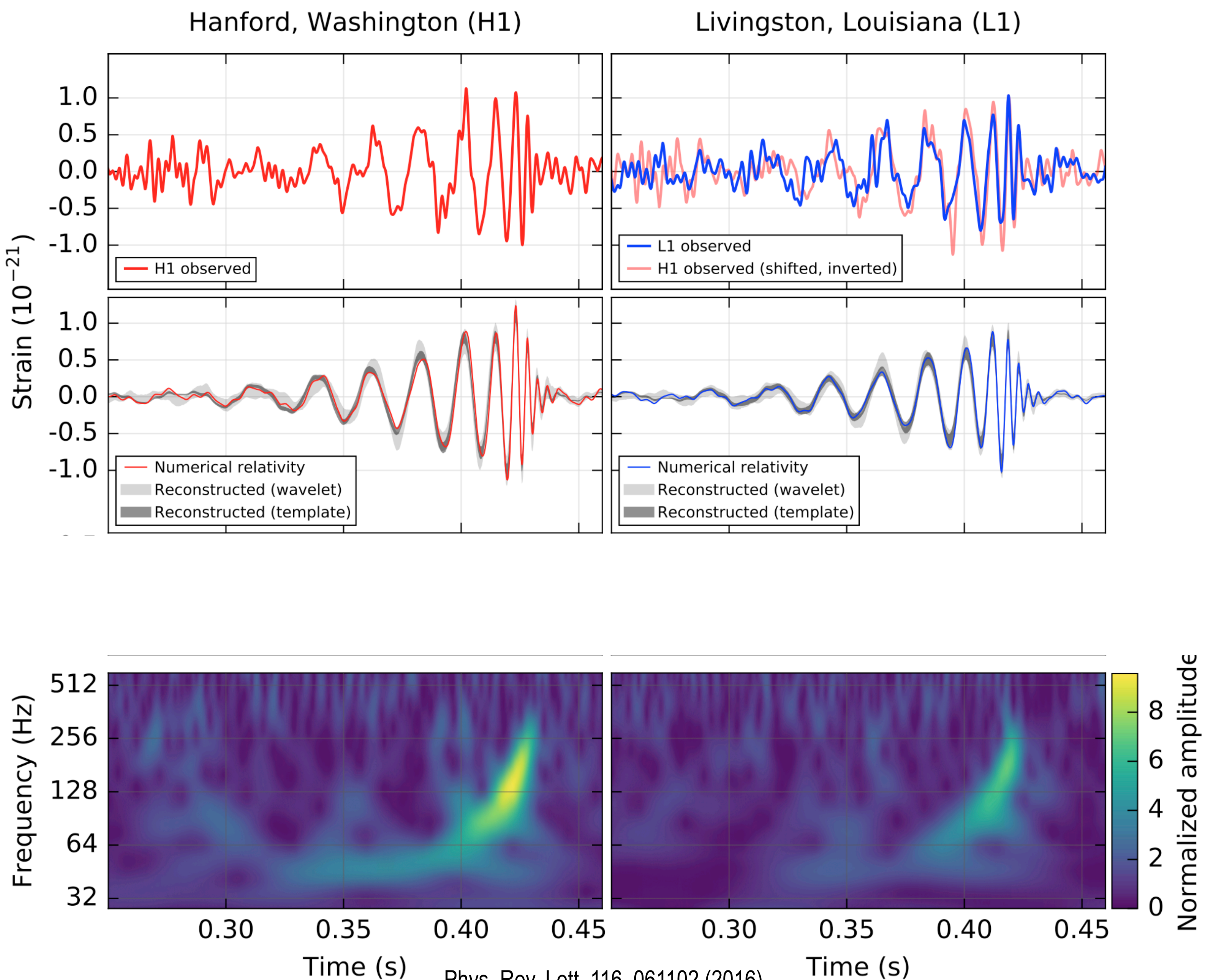

Phys. Rev. Lett. 116, 061102 (2016)

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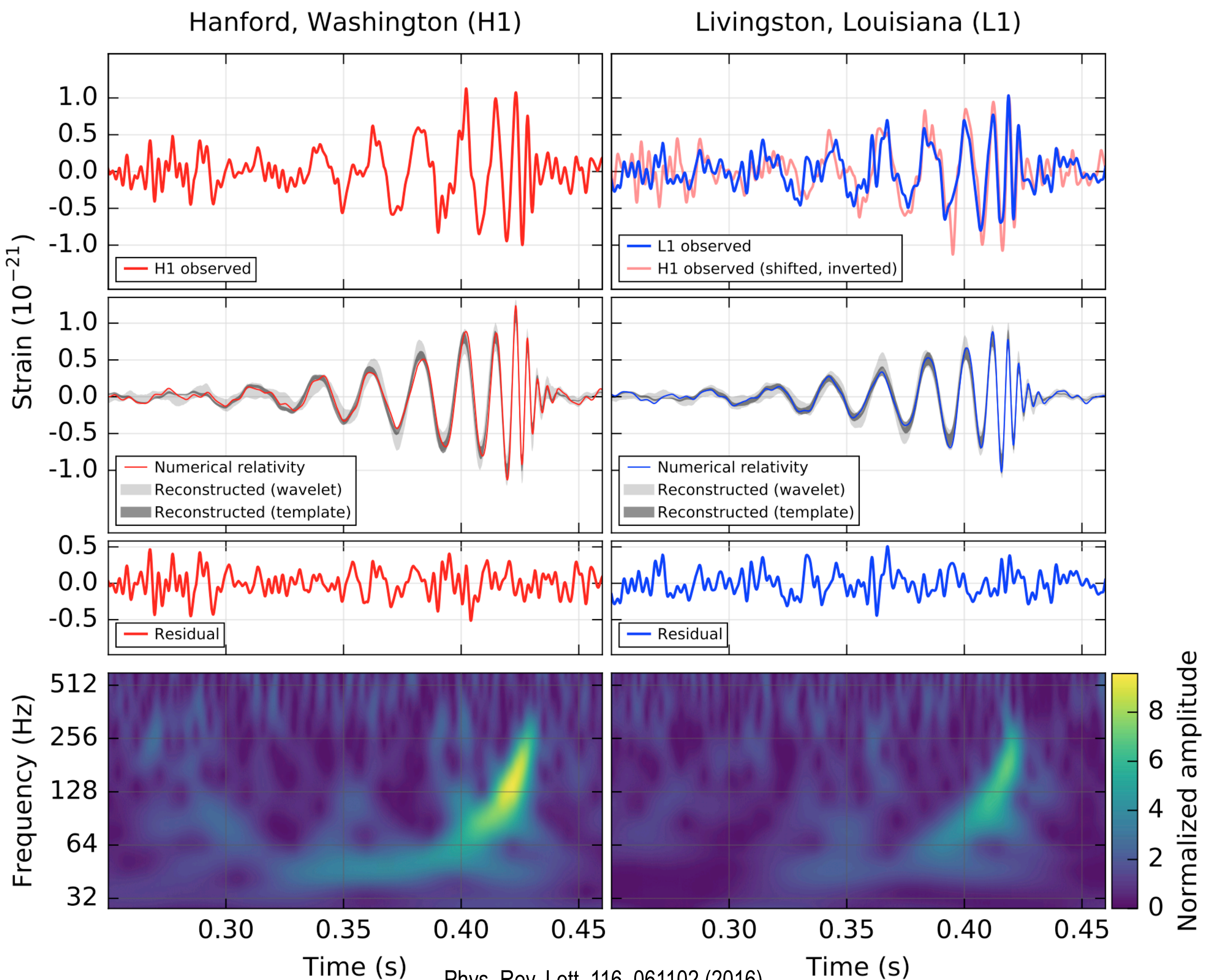
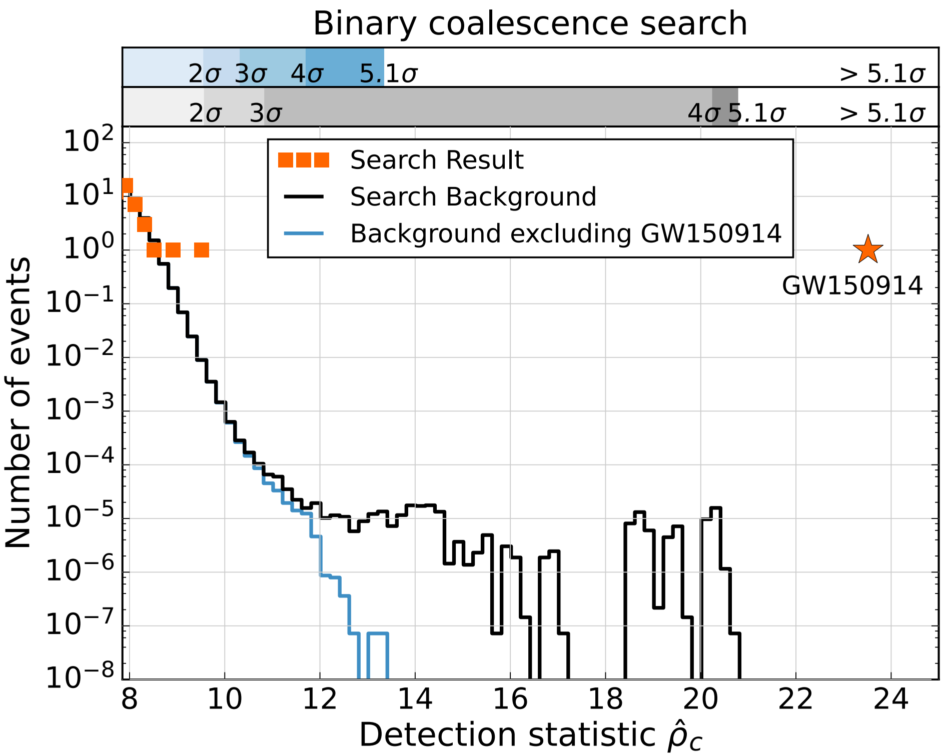
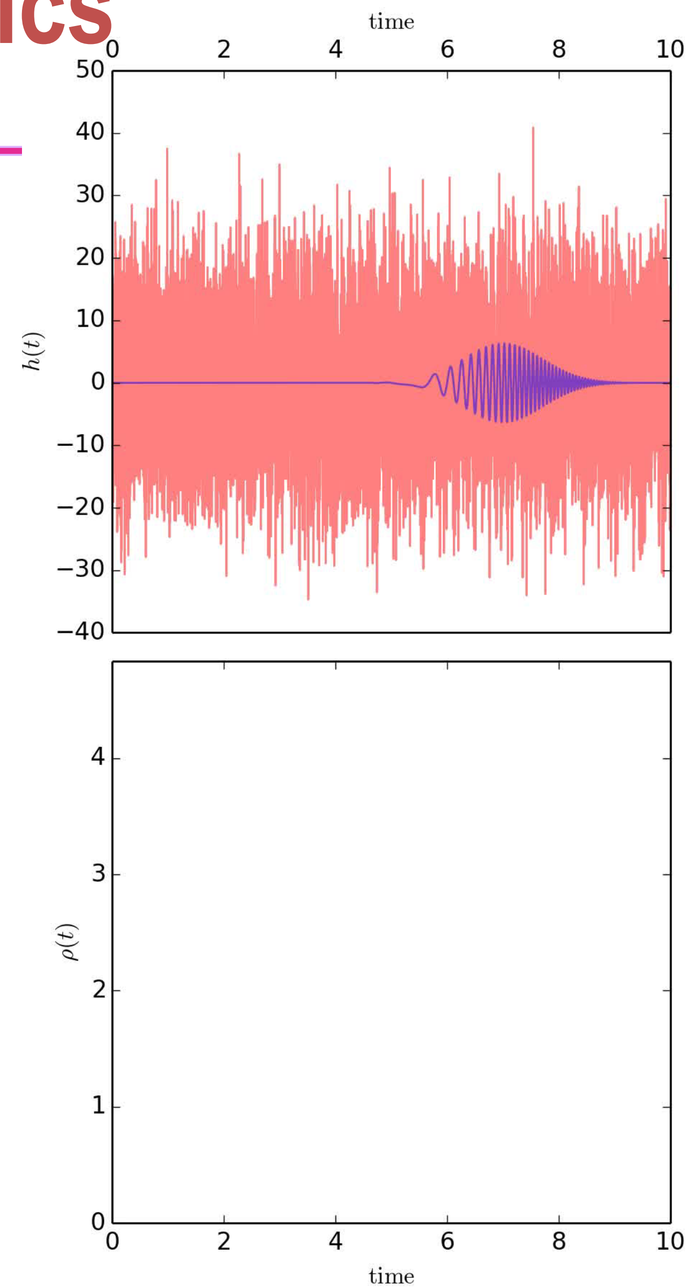


Phys. Rev. Lett. 116, 061102 (2016)

The statistics





LIGO-G1600793

Phys. Rev. Lett. 116, 061102 (2016)

Even if we don't look for inspirals, we find it…

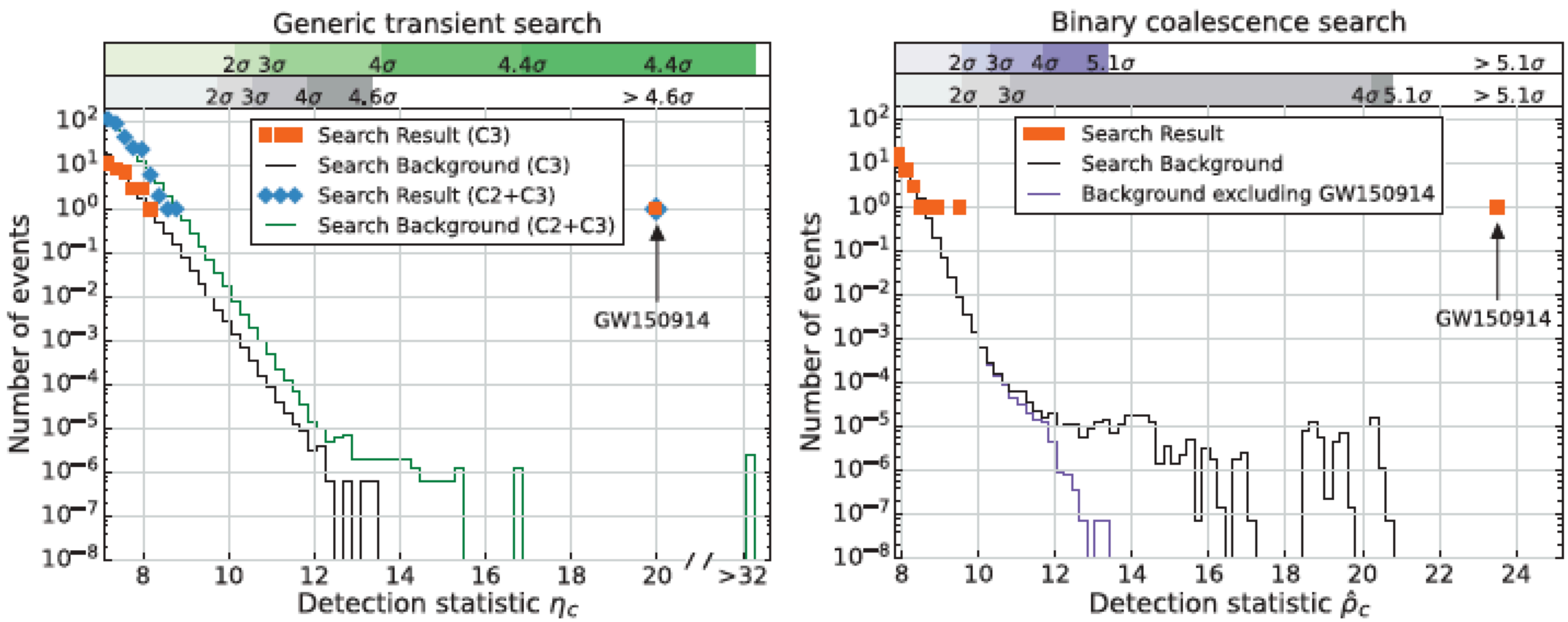
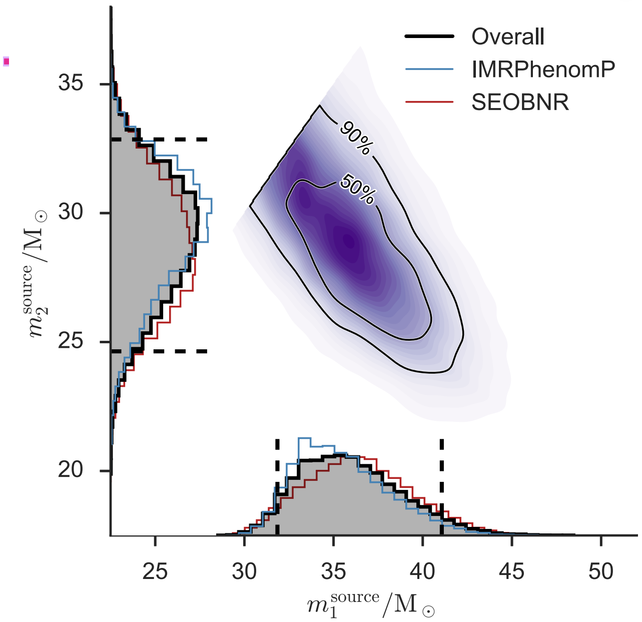
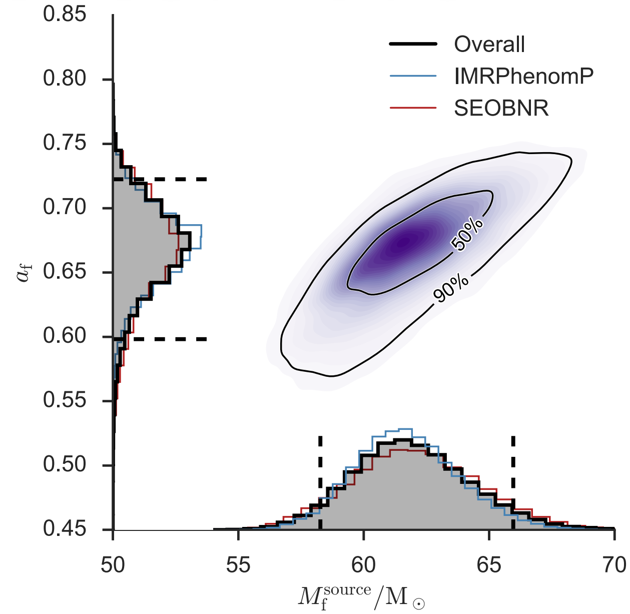


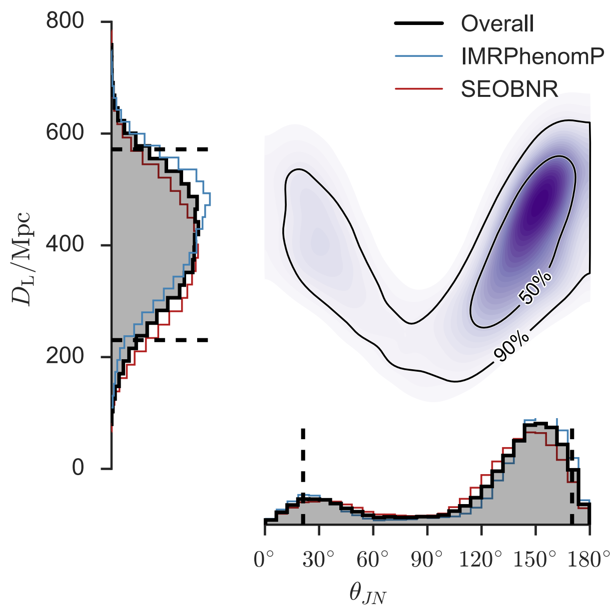
FIG. 4. Search results from the generic transient search (left) and the binary coalescence search (right). These histograms show the number of candidate events (orange markers) and the mean number of background events (black lines) in the search class where GW150914 was found as a function of the search detection statistic and with a bin width of 0.2. The scales on the top give the significance of an event in Gaussian standard deviations based on the corresponding noise background. The significance of GW150914 is greater than 5.1σ and 4.6σ for the binary coalescence and the generic transient searches, respectively. *Left:* Along with the primary search (C3) we also show the results (blue markers) and background (green curve) for an alternative search that treats events independently of their frequency evolution (C2 + C3). The classes C2 and C3 are defined in the text. *Right:* The tail in the black-line background of the binary coalescence search is due to random coincidences of GW150914 in one detector with noise in the other detector. (This type of event is practically absent in the generic transient search background because they do not pass the time-frequency consistency requirements used in that search.) The purple curve is the background excluding those coincidences, which is used to assess the significance of the second strongest event.

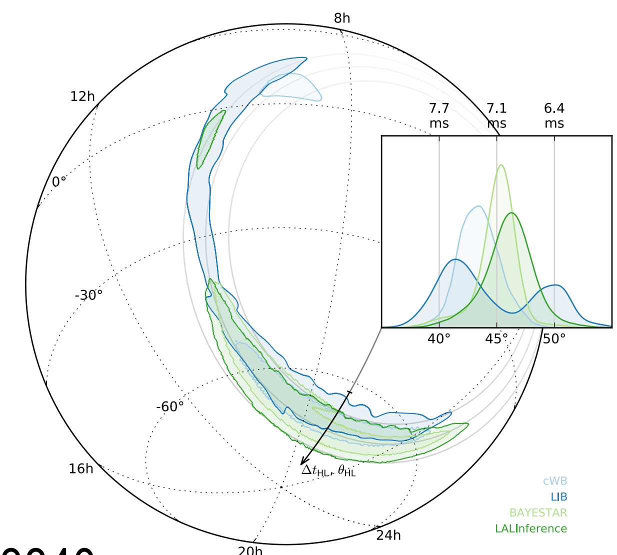
Phys. Rev. Lett. 116, 061102 (2016)

Parameter estimation

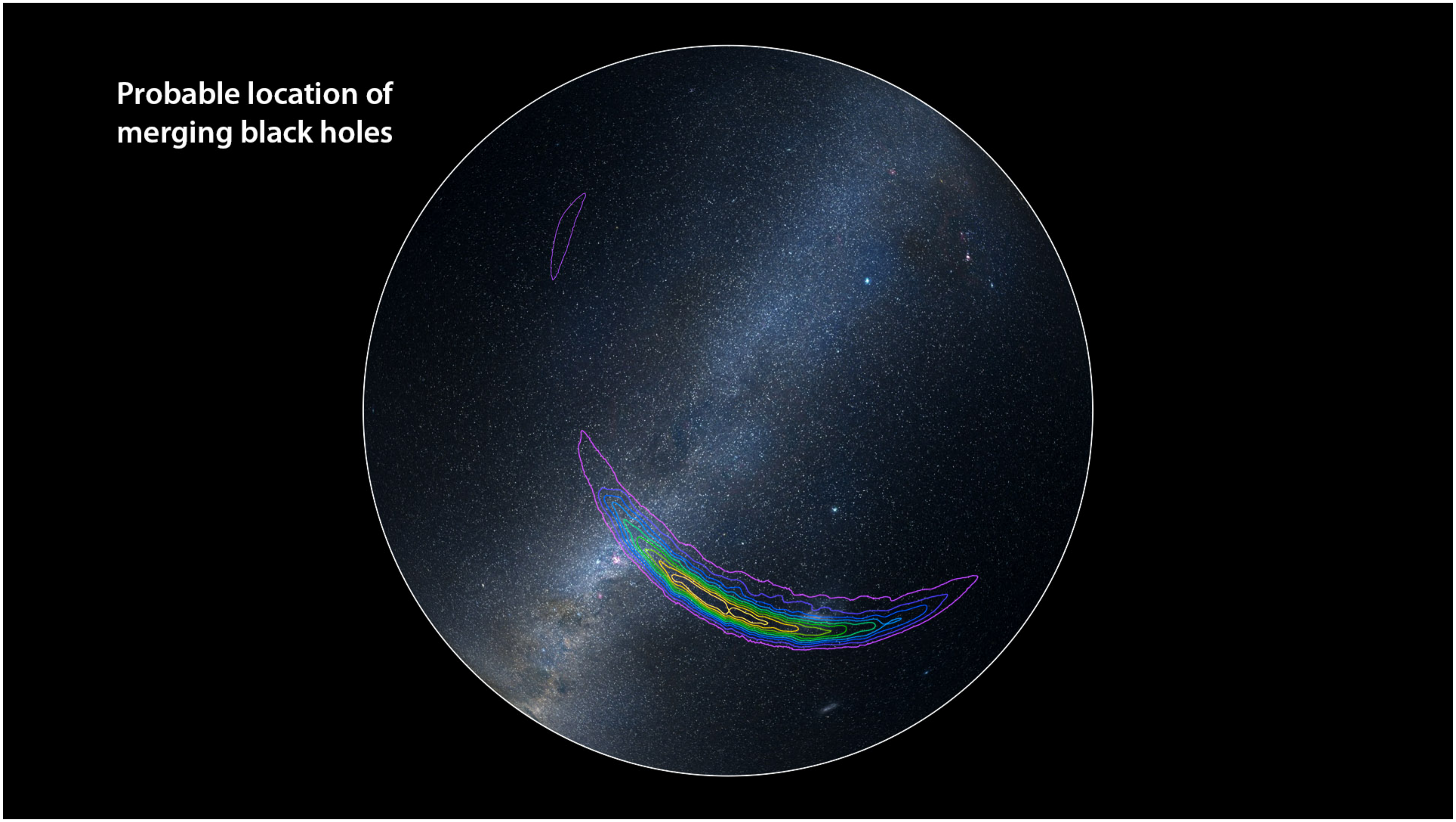








arXiv:1602.03840


Probable location of
merging black holes

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

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

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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

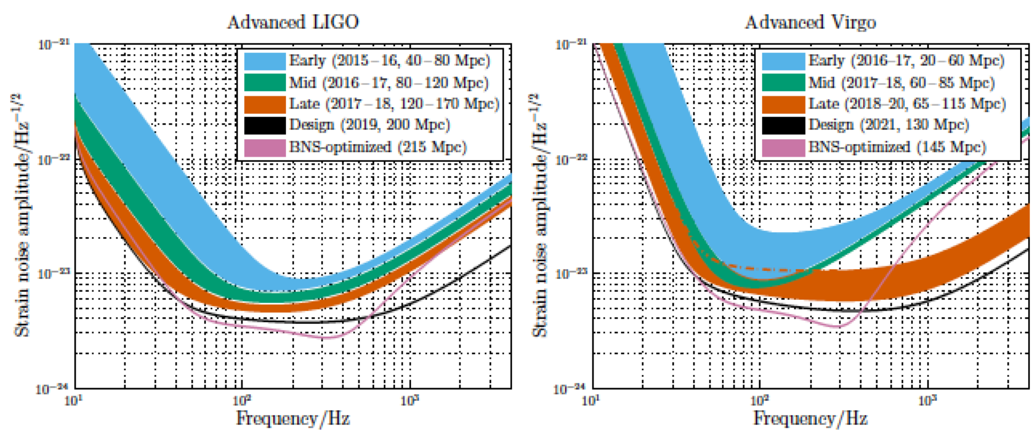

Figure 1: aLIGO (*left*) and AdV (*right*) target strain sensitivity as a function of frequency. The binary neutron-star (BNS) range, the average distance to which these signals could be detected, is given in megaparsec. Current notions of the progression of sensitivity are given for early, mid and late 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.

More references: papers.ligo.org

Detection Papers

Discovery Paper

"Observation of Gravitational Waves from a Binary Black Hole Merger"
Published in *PRL* **116**, 061102 (2016).

Related papers

"Observing gravitational-wave transient GW150914 with minimal assumptions"

"GW150914: First results from the search for binary black hole coalescence with Advanced LIGO4"

"Properties of the binary black hole merger GW150914"

"The Rate of Binary Black Hole Mergers Inferred from Advanced LIGO Observations Surrounding GW150914"

"Astrophysical Implications of the Binary Black-Hole Merger GW150914"

"Tests of general relativity with GW150914"

"GW150914: Implications for the stochastic gravitational-wave background from binary black holes"

"Calibration of the Advanced LIGO detectors for the discovery of the binary black-hole merger GW150914"

"Characterization of transient noise in Advanced LIGO relevant to gravitational wave signal GW150914"

"High-energy Neutrino follow-up search of Gravitational Wave Event GW150914 with IceCube and ANTARES"

"GW150914: The Advanced LIGO Detectors in the Era of First Discoveries"

"Localization and broadband follow-up of the gravitational-wave transient GW150914"

GW150914 Data Release

Data release at LIGO Open Science Center (LOSC) website.

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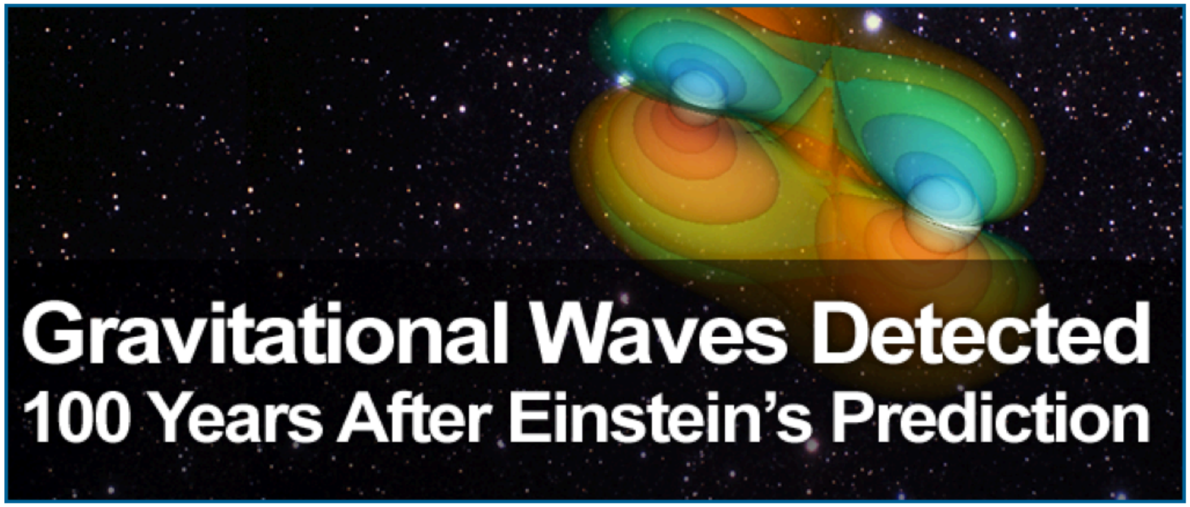

NEWS

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 Magazine

▼ ISSUE 8, MARCH 2016

(PDF, 16 MB)

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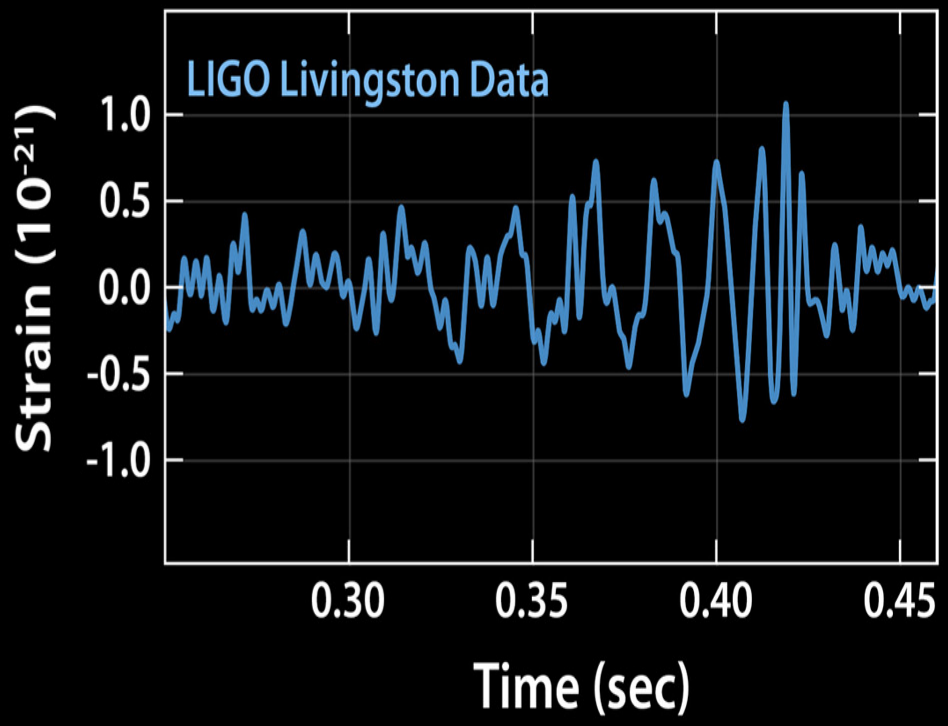
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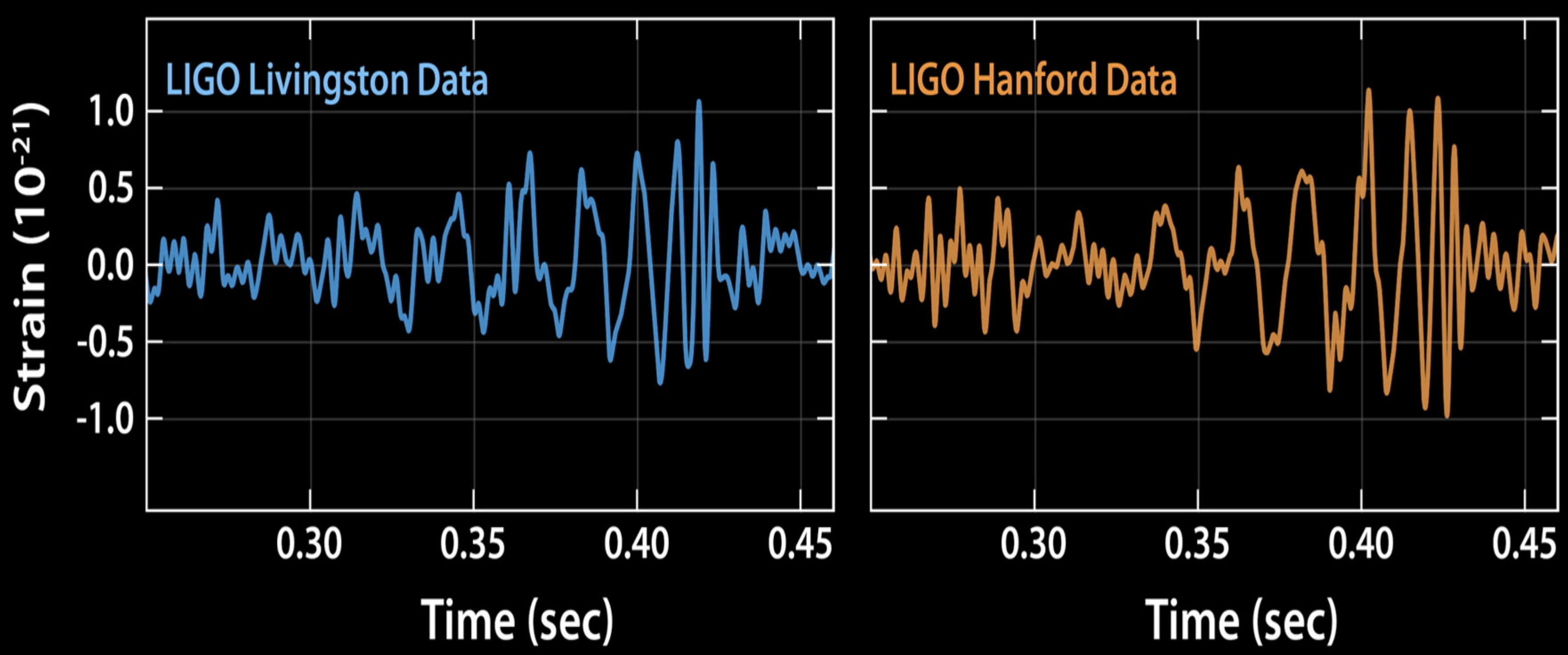
0.5
0.0
-0.5
-1.0
0.30
0.35
0.40
0.45
Time (sec)


LIGO Livingston Data
LIGO Hanford Data
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0.0
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-1.0
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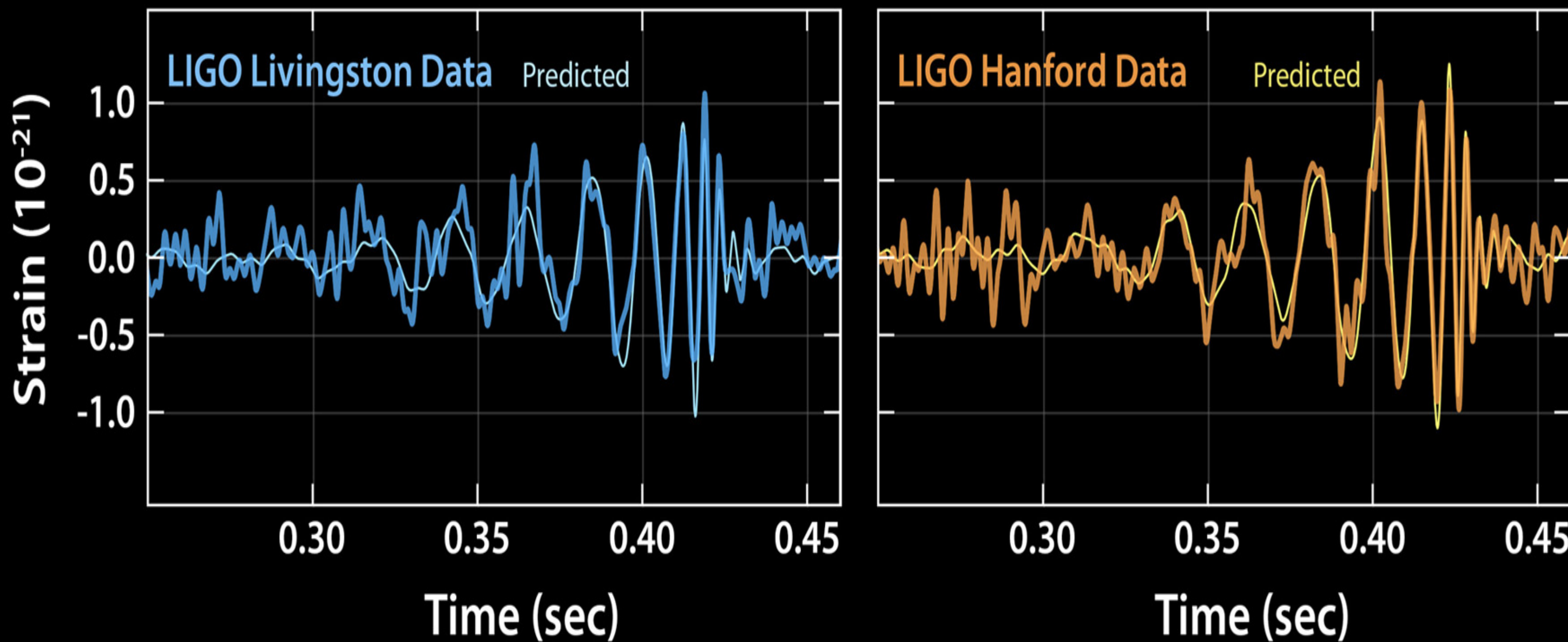
0.35
0.40
0.45
Time (sec)
0.30
0.35
0.40
0.45
Time (sec)


LIGO Livingston Data
Predicted
LIGO Hanford Data
Predicted
Strain (10^{-21})
1.0
0.5
0.0
-0.5
-1.0
0.30
0.35
0.40
0.45
Time (sec)
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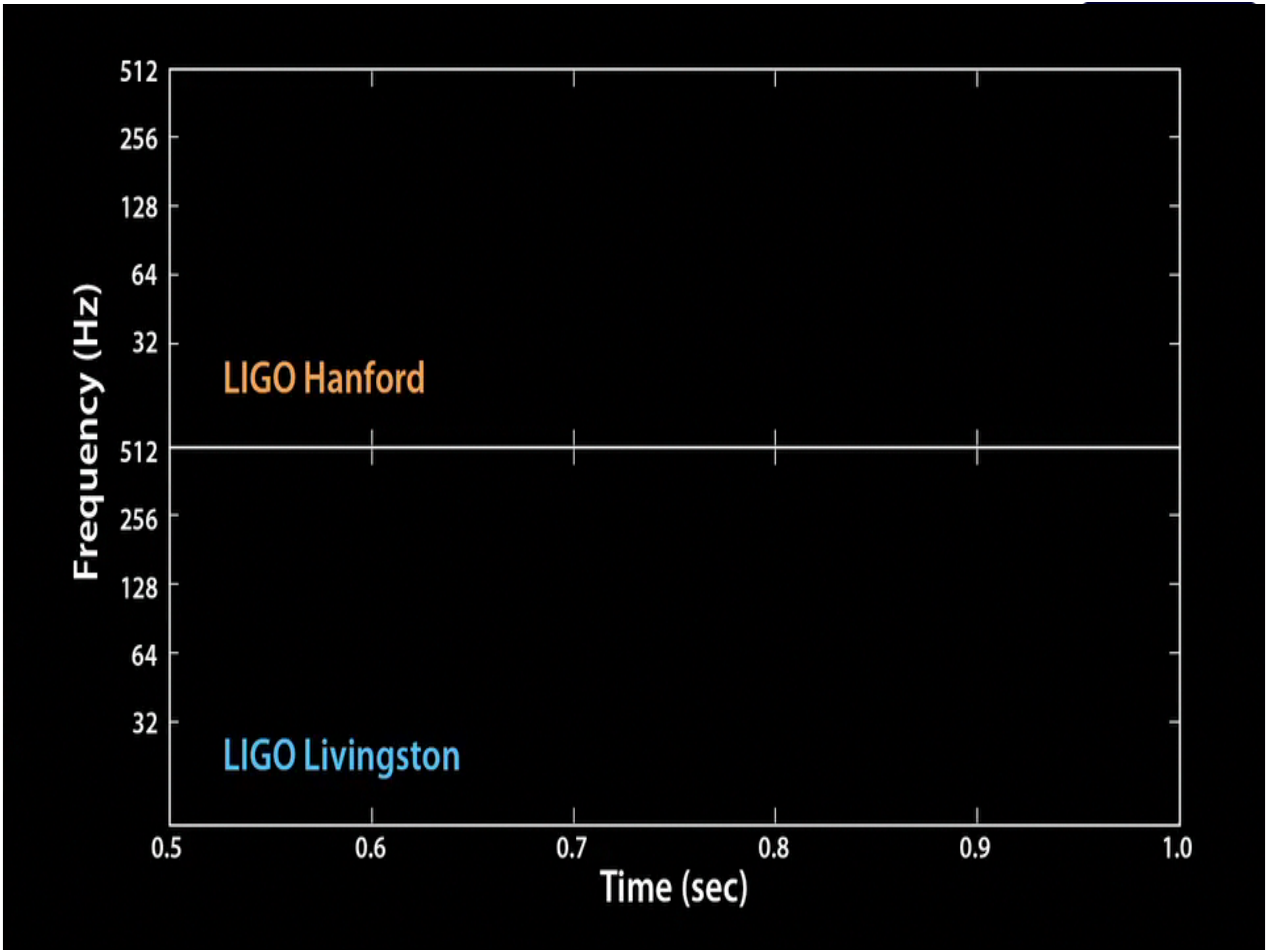
Time (sec)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32
LIGO Hanford
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LIGO Livingston
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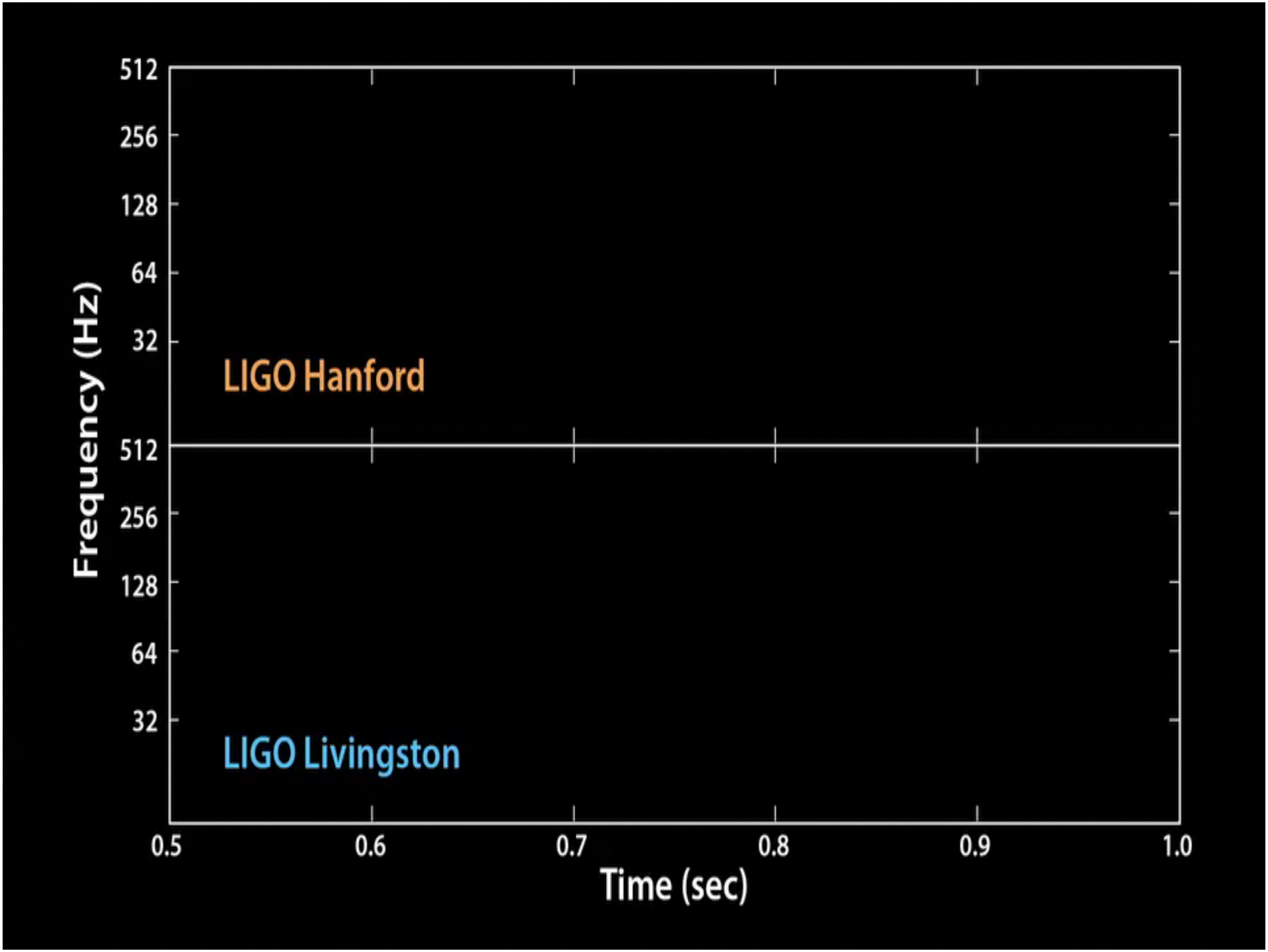

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512
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Time (sec)