

# LIGO – Livingston, LA

MIT Alumni Tour – March 2013

Led by Rai Weiss

Photos by Rick Dower

# First a little history

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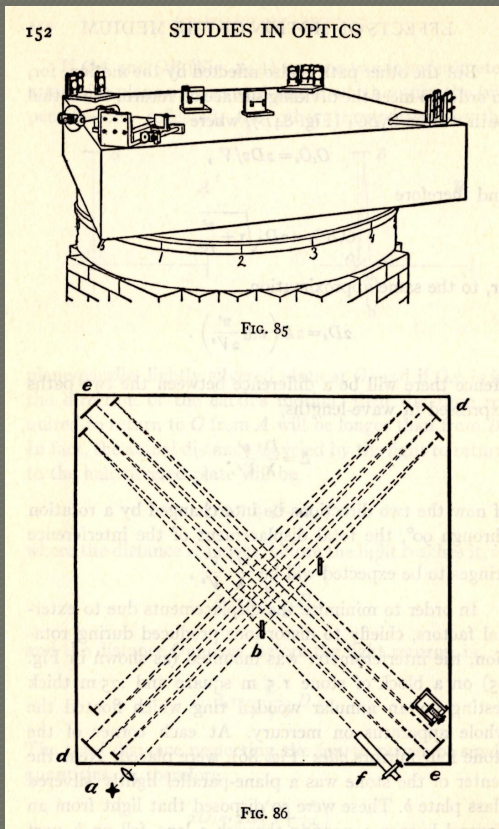
- Albert Michelson (1852-1931)
- First American to receive Nobel Prize (Physics 1907)
- Developed interferometer to detect Earth's motion through ether

# Michelson-Morley Experiment

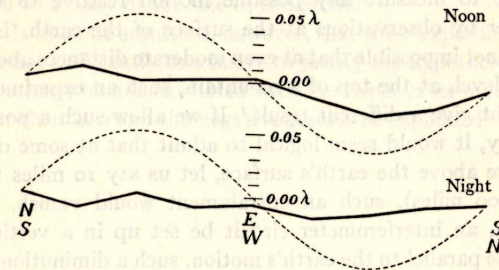
## 1887-1888

STONE BLOCK  
1.5 M X 1.5 M X 0.25 M

NO DISCERNABLE  
FRINGE SHIFT



By keeping up a fairly uniform and continuous rotation, observing the position of the central fringe at intervals of one-sixteenth of a revolution, the readings were found to give fairly consistent results, the mean of which



is represented by Figure 87, in which the dotted curve represents one-eighth of the theoretical displacement.

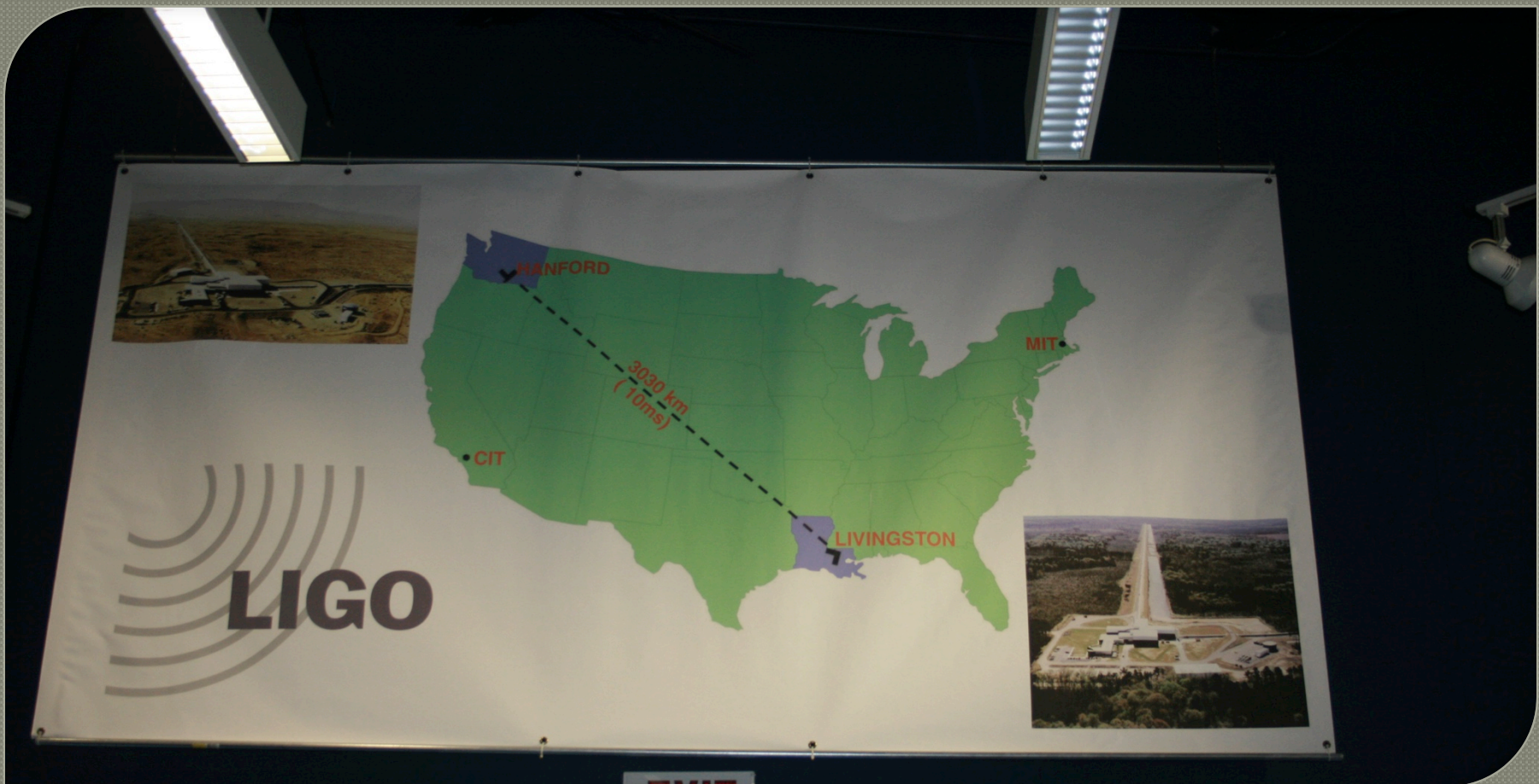
It must be concluded that the experiment shows no evidence of a displacement greater than 0.01 of a fringe. Considering the motion of the earth in its orbit only, this displacement should be  $\frac{2D}{\lambda} \frac{v^2}{V^2}$ . The distance  $D$  was about 11 m, or  $2 \times 10^7$  waves of yellow light. With  $\frac{v}{V} = \frac{1}{10,000}$ , this gives an expected displacement of 0.4 fringe. The actual value is certainly less than one-twentieth of this amount and probably less than one-fortieth.

“But then how can the  
negative results be  
explained?”

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A. Michelson, *Studies in Optics*,  
University of Chicago Press, 1927, p.155.

Michelson used an interferometer to measure the size of stars.  
Interferometers were subsequently adapted to do precision  
measurement of many kinds and control precision machines.



LIGO location map  
and aerial photos



# LIGO

Livingston  
Observatory

*A Collaboration of*

California Institute  
of Technology

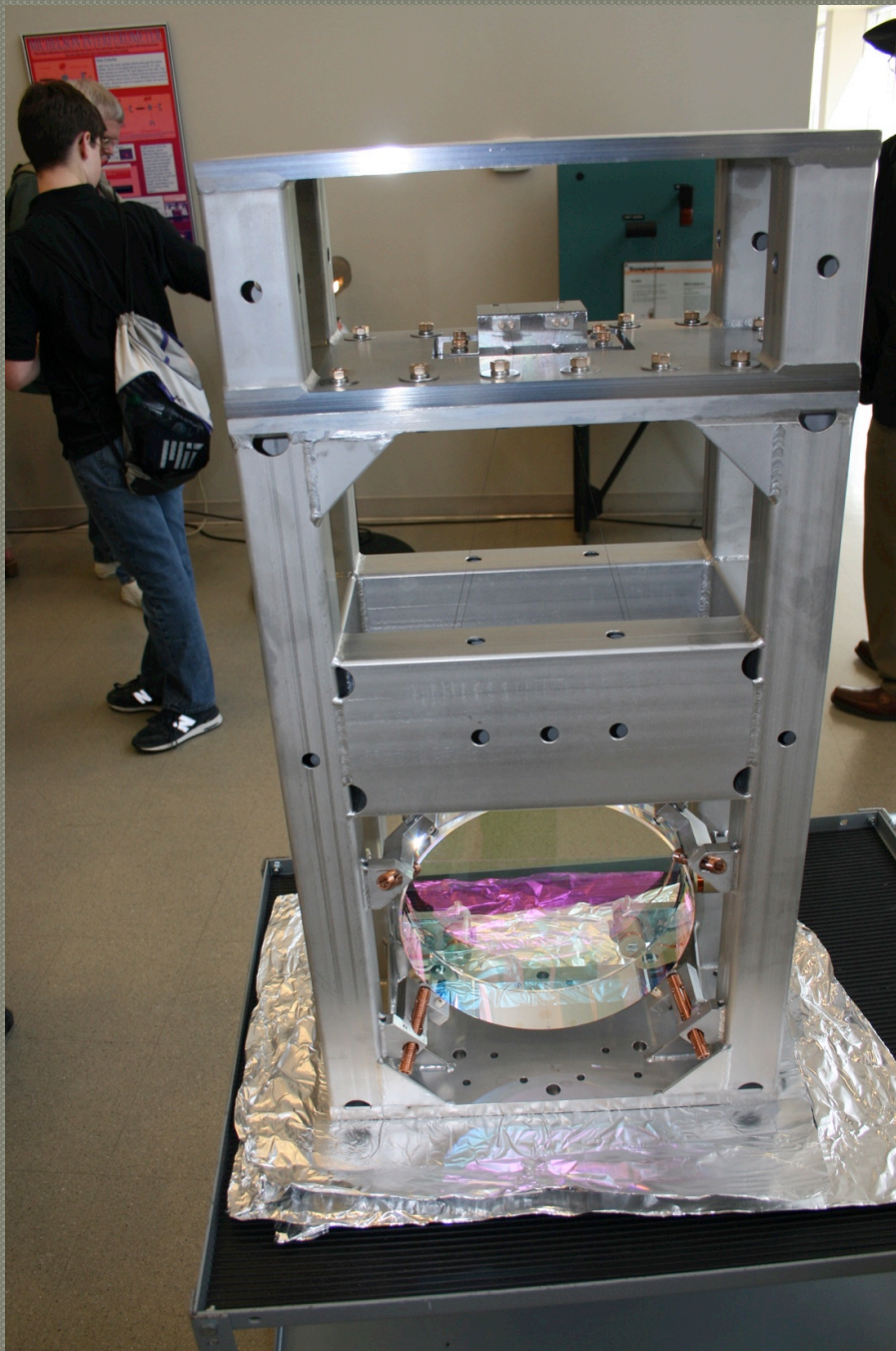
Massachusetts Institute  
of Technology

*Operated for*

*National Science Foundation*



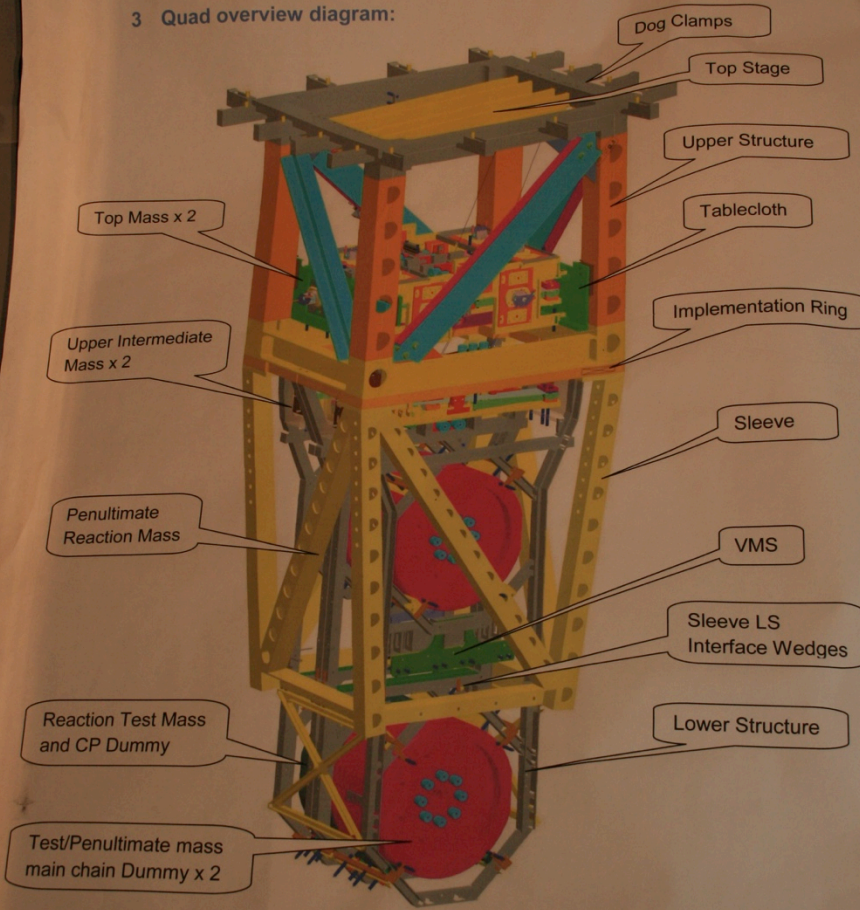
**Visitors Center  
and other buildings**



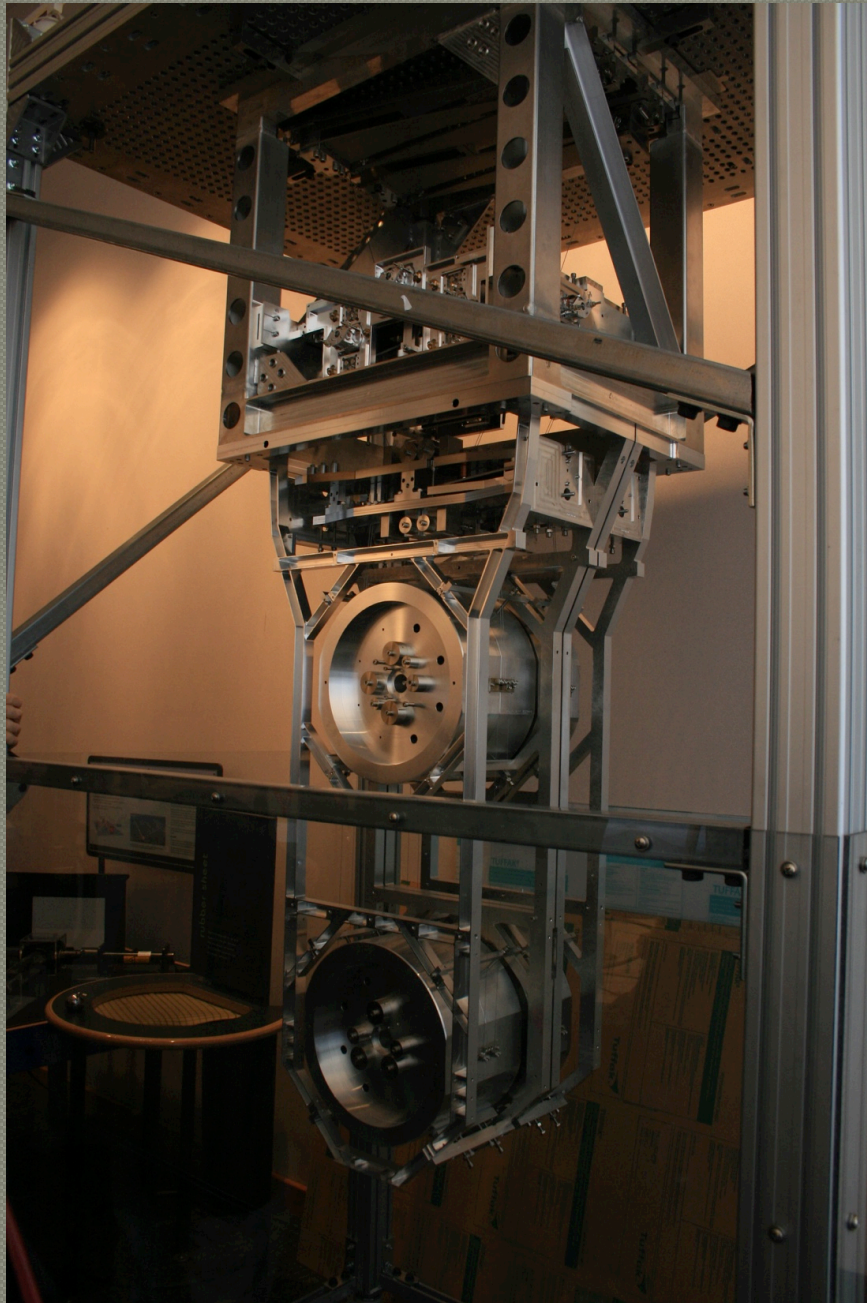
Original Mirror  
and Mount



3 Quad overview diagram:



# Advanced LIGO Mirror Mount Diagram



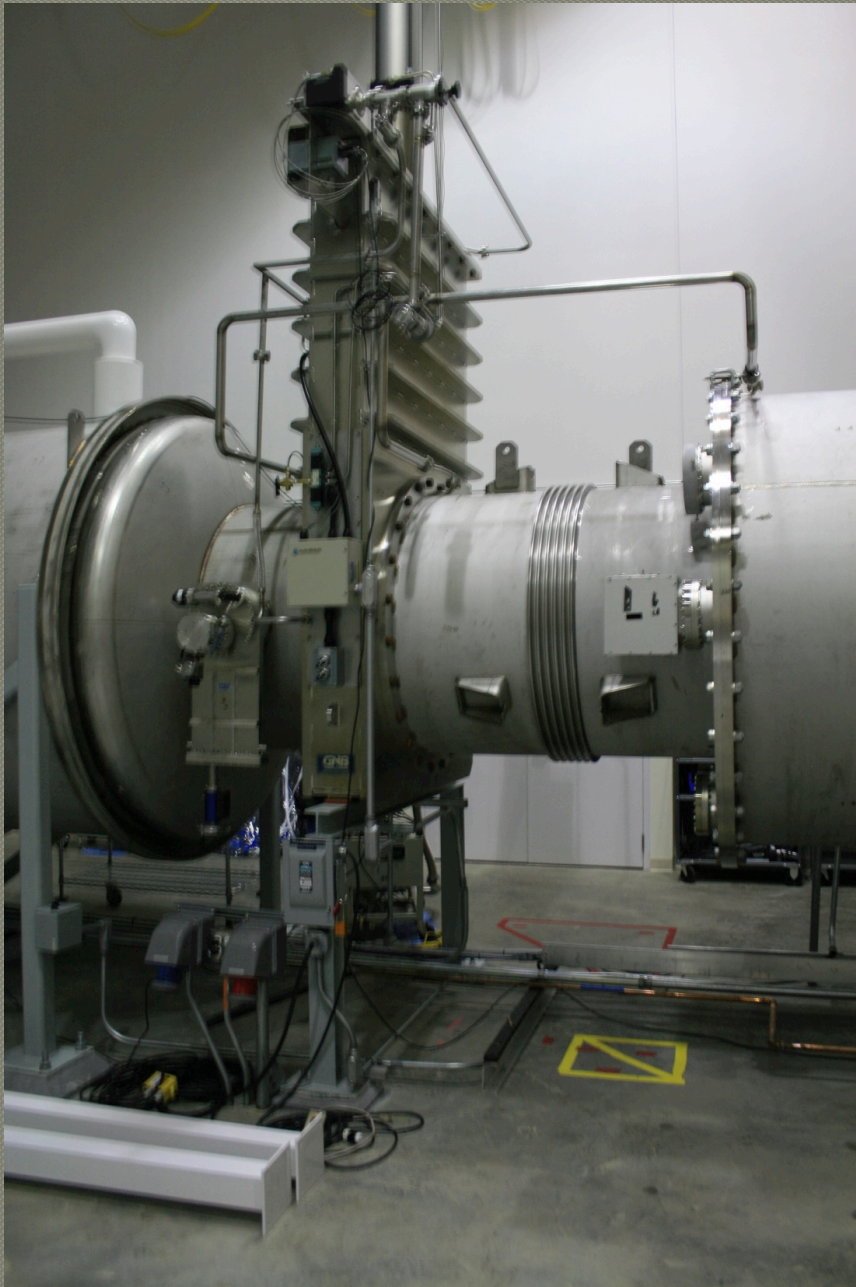
Advanced LIGO  
Mirror Mount



**LIGO Vacuum Chamber - Open**



Vacuum tube near  
building exit



Vacuum tube  
junction



Vacuum tube - continuous weld



**Interferometer Arm Intersection**



**Interferometer arm  
to far mirror**





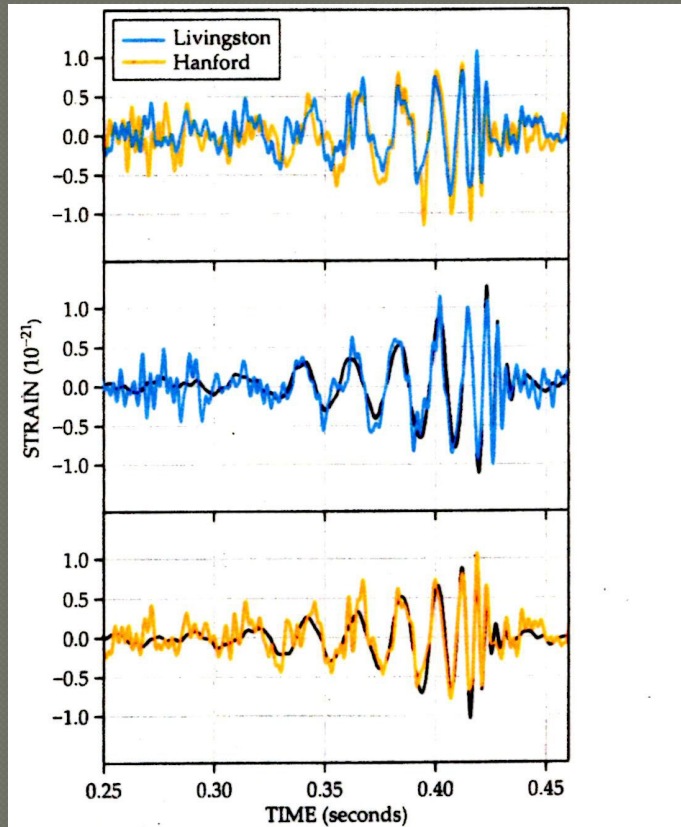
LIGO Control Room

# LIGO success

## 14 September 2015 05:51 CDT

FIGURE FROM *PHYSICS TODAY* APRIL 2016

CAPTION FROM *PHYSICS TODAY* APRIL 2016



**FIGURE 1. SIGNALS RECEIVED** by the Laser Interferometer Gravitational-Wave Observatory instruments in Livingston, Louisiana, and in Hanford, Washington, were the first direct detection of gravitational waves. At top, the Hanford signal has been shifted in time to correct for the arrival-time delay between the two detectors, and inverted to account for the Hanford detector's orientation relative to Livingston. The lower two panels show the observed data individually, along with best-fit calculations (black) generated from numerical relativity simulations. (Courtesy of Caltech/MIT/LIGO Laboratory.)



P. S. MIT Celebration 19 February 2016