Celebrating 10 years of CGWA

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The next frontier of gravitational physics and astronomy

We're here to honor a group of pioneers, the Center for Gravitational Wave Astronomy.

They are engaged in a quest at the forefront of physics and astronomy.

With their help, that quest is about to succeed.

What is it all about?

Einstein and relativity

In 1905, Einstein discovered an essential law of the universe:

No information can be transmitted faster than the speed of light, 186,000 mile/sec

Simple, but it revolutionized physics.

General Relativity: Einstein's account of gravity

In 1915, Einstein reformed our understanding of gravity for the first time since Isaac Newton (1686).

Gravity isn't a force that acts in space and time, but instead is built into the actual structure of space and time.

Space and time are *curved*; nothing can avoid feeling that curved structure. That makes gravity *universal*.

Gravitational waves

Gravity needs to obey the principle of relativity (no signals faster than light).

What about gravity from rapidly moving stars? Their gravitational effects at large distances can't change instantaneously. (Or else, would violate relativity.)

Gravitational changes "ripple out" from a moving/changing object. Those ripples, moving at the speed of light, are *gravitational waves*.

Gravitational waves would be a new way to scan the skies

To make gravitational waves, you need something that dramatically changes the distribution of matter.

Binary stars are a good example. The more massive the stars, the better. The faster they move, the better.

Binaries made of neutron stars are very good.

Binaries made of black holes are best.

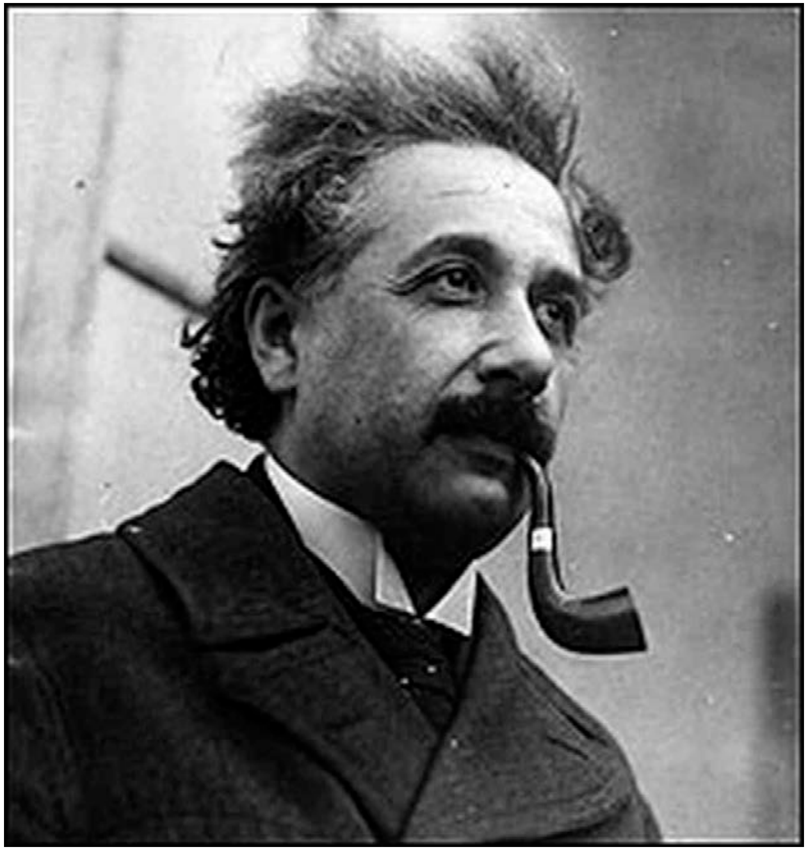
In gravitational wave signals, we'd see these things in ways no ordinary telescope can rival.

Einstein's prediction left many doubts …

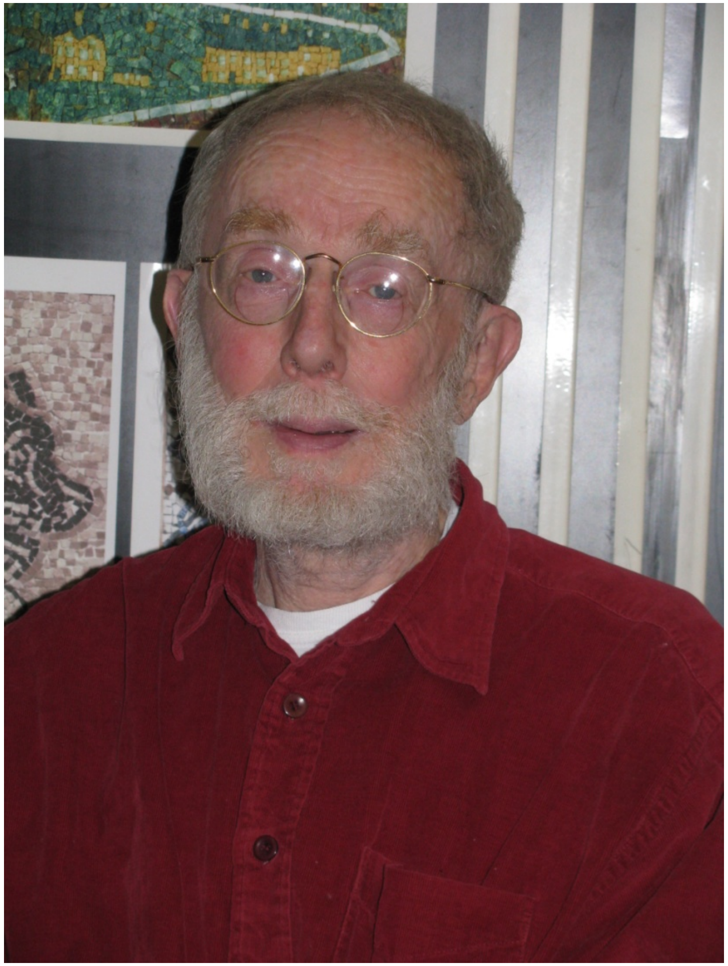
… even for Einstein.

The math was so hard, Einstein was never sure that this prediction was correct.

The resolution of this question came in 1957, shortly after Einstein's death.



Felix Pirani solved the problem of the reality of gravitational waves

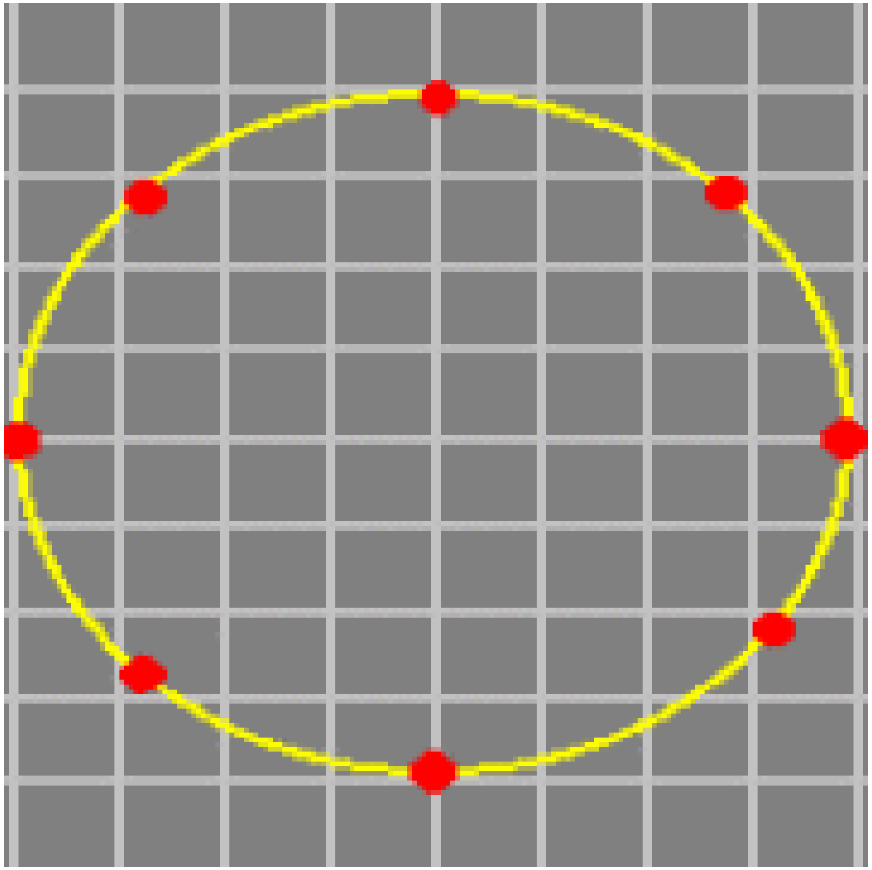


Felix Pirani was a young assistant professor in 1957.

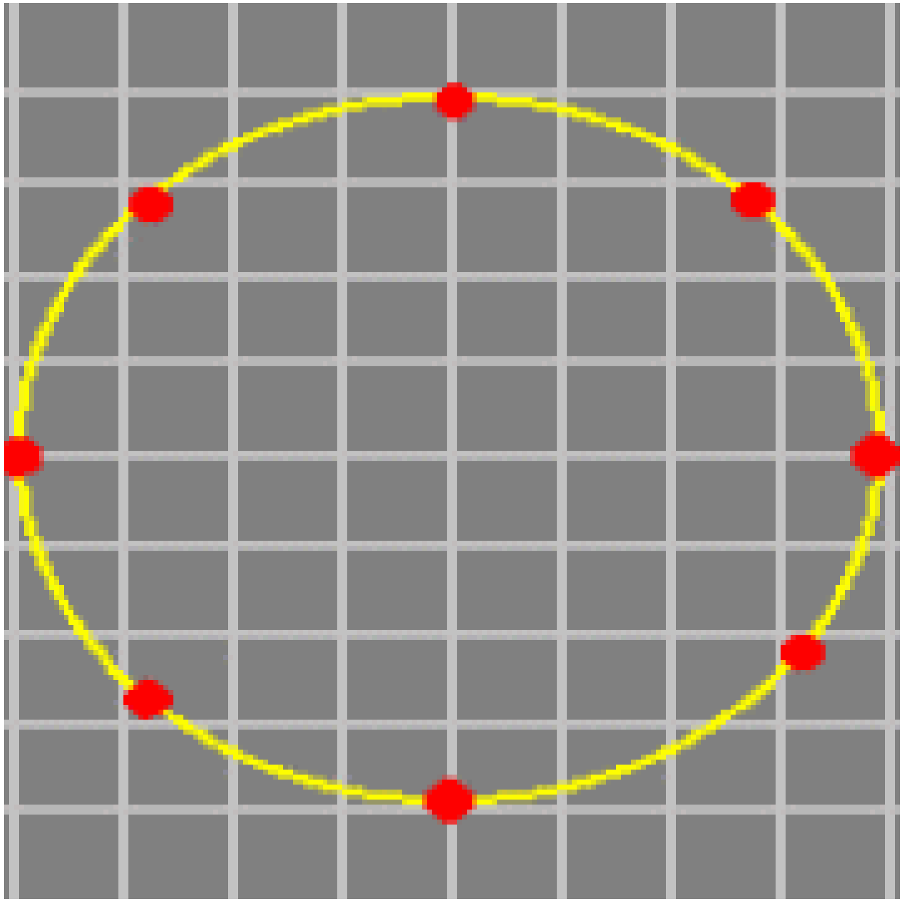
He published two papers in that year that resolved Einstein's confusion, and prompted the construction of the first gravitational wave detectors.

Photo by Josh Goldberg

Pirani's set of neighboring freely-falling test masses



They respond in a measurable way to a gravitational wave



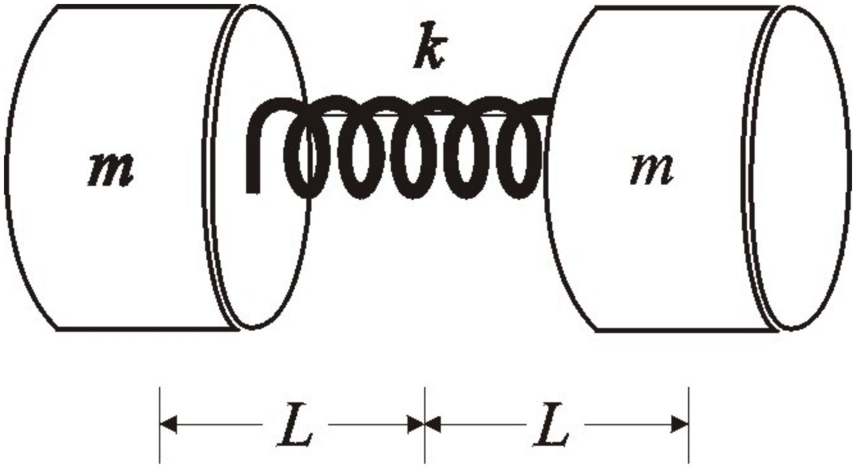
Joseph Weber: first to search for grav waves

Joseph Weber, co-inventor of the maser, learned of Pirani's insight at the Chapel Hill Conference in 1957.

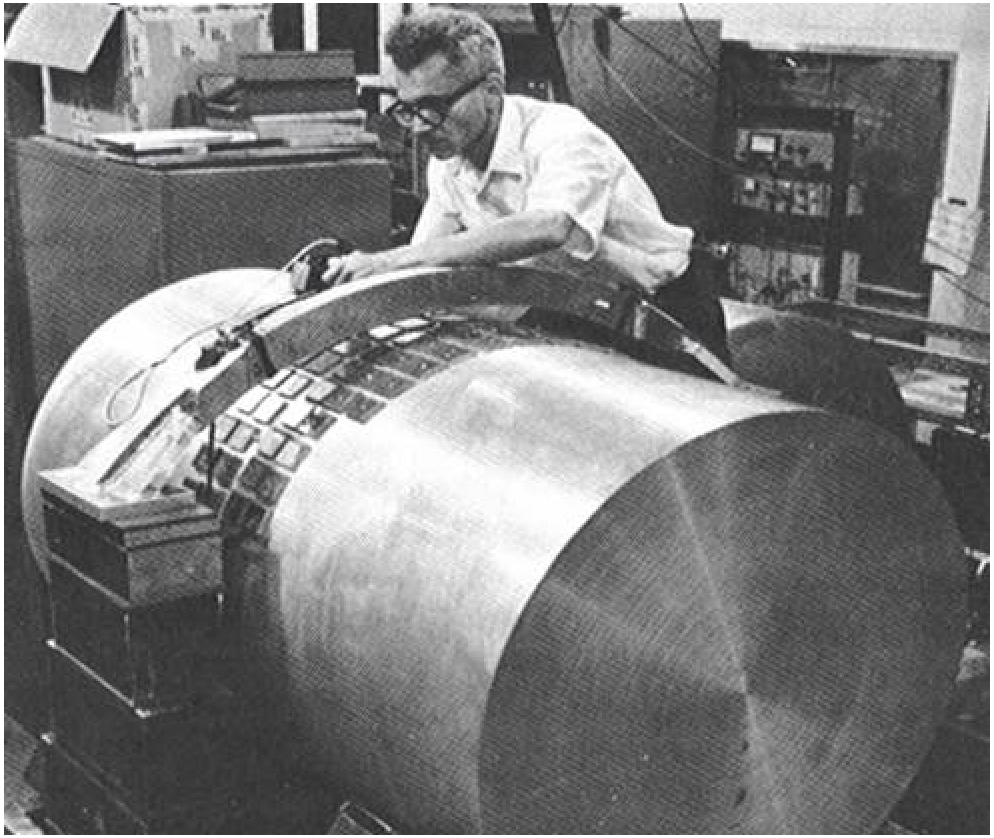
He immediately started designing actual detectors of gravitational waves.

Weber's "bar"

A massive (aluminum) cylinder. Vibrating in its gravest longitudinal mode, its two ends are like two test masses connected by a spring.



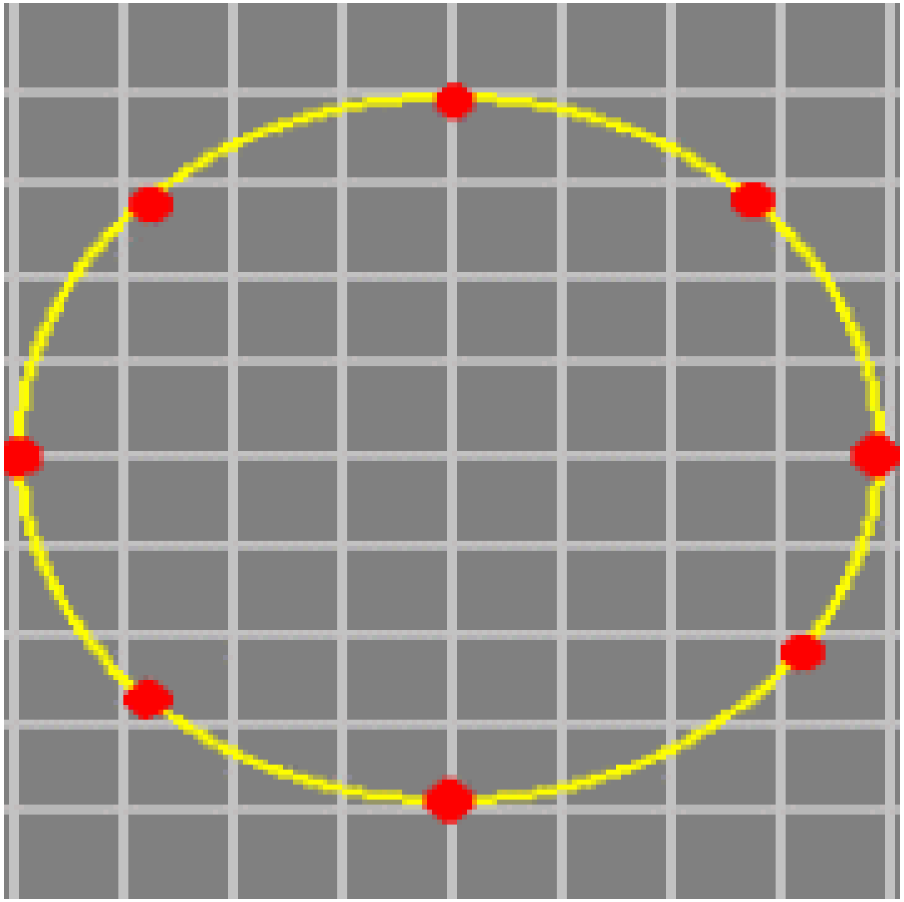
Weber's bar, in real life



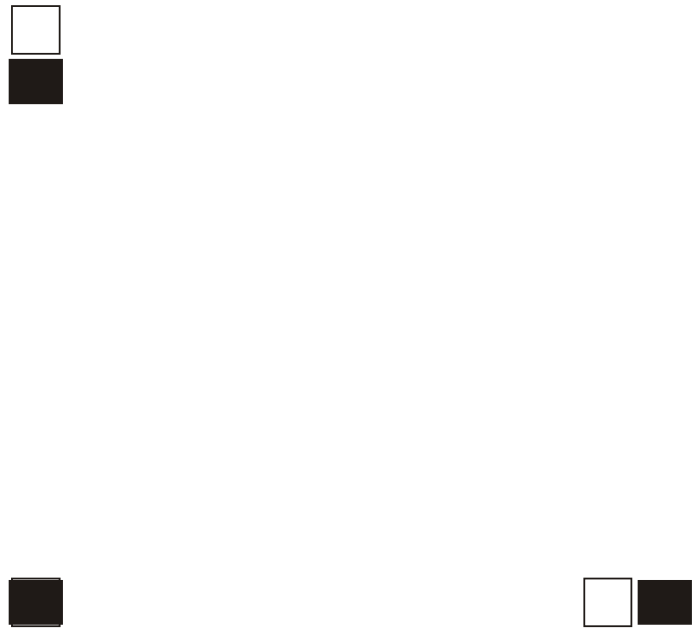
Rainer Weiss, inventor of GW interferometers

Rai Weiss participated in the early development of lasers. When he heard of Weber's efforts to detect gravitational waves, Weiss studied Pirani's papers and saw how to do better.

They respond in a measurable way to a gravitational wave



An alternative detection strategy



Masses don’t need to be the ends of a single object. They can be miles apart, for a bigger signal.

Rai Weiss envisions LIGO in 1972

(V. GRAVITATION RESEARCH)

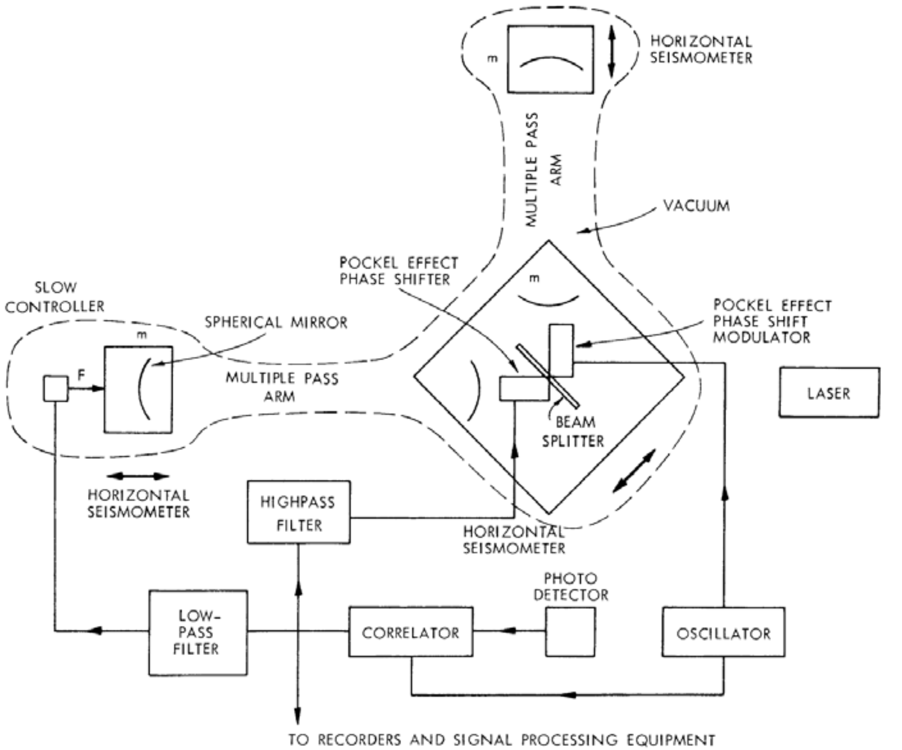
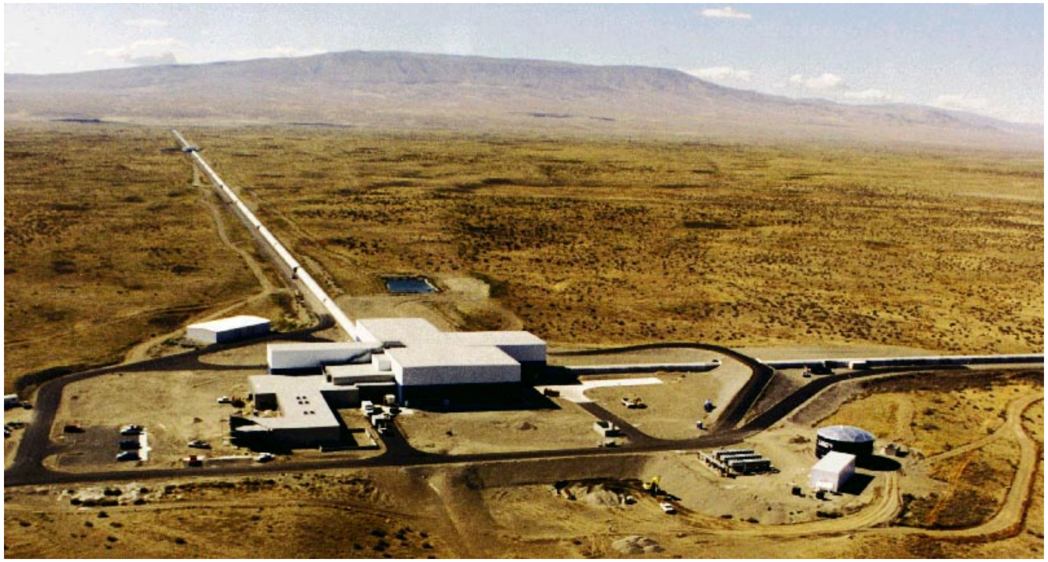


Fig. V-20. Proposed antenna.

Proposed in 1972, ready to go to work in 1999

The facilities of the Laser Interferometer Gravitational Wave Observatory (LIGO) at Hanford, WA and Livingston, LA. Each holds an interferometer with arms 4 km long.



The LIGO team

LIGO was built by a team of physicists and engineers at Caltech and MIT.

But it needed to serve the broader community of physicists and astronomers.

To bring together all who could contribute, the LIGO Scientific Collaboration was formed in 1997.

Formation of the LIGO Scientific Collaboration

The LSC held its inaugural meeting in Aug 1997 at LSU.

Rai Weiss was the first Spokesperson. The original membership consisted of 12 research groups.

Over the years, the LSC's membership grew. We needed more help on:

- Interferometer technology
- Data analysis
- Scientific interpretation of our searches.

Center for Gravitational Wave Astronomy, born in 2003

From Left to right: Joseph D. Romano, Manuela Campanelli, Mario C. Diaz, Carlos O. Lousto and Warren G. Anderson collaborated on the award winning grant proposal to NASA.

From its birth, the CGWA has aimed to contribute across many aspects of the field.

The original team included experts in General Relativity and in gravitational wave data analysis.

Today, the CGWA plays a key role in all parts of the field.

First observations, and next steps

CGWA members played a key role in LIGO's search for gravitational wave signals, carried out from 2005 through 2011.

So far, we haven't seen them.

As Gabriela Gonzalez is about to describe, we're about to start a new search. We are confident that this time we'll succeed.

Again, CGWA members will be central to those efforts.

Thank you, CGWA!