

Engaging **diverse audiences** worldwide
to the **quest for gravitational waves**

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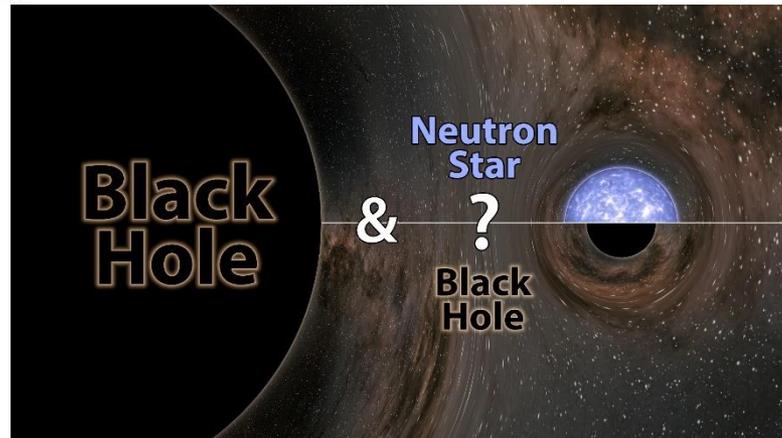
Laboratoire de Physique des Deux Infinis Irène Joliot-Curie
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European Gravitational Observatory (Consortium, CNRS & INFN)

On behalf of the **Virgo Collaboration** and the **LIGO Scientific Collaboration**
VIR-0686A-20 DCC G2001214



ICHEP – July 29, 2020



Outline

- **Detecting gravitational waves** with the **global LIGO-Virgo network** of **interferometric detectors**
- **Outreach & communication** about **scientific results** – and the **people** who make them
 - **Public alerts**
 - **Scientific announcements**
 - **LIGO-Virgo members**
- **Reaching out diverse audiences**
 - **Social media**
 - **Visits**: onsite and virtual
 - **Science festivals**
 - **Art & Science**
 - **Visually impaired people**
- **IGRAV**
- **Outlook**



LIGO/Virgo/CDS/T.Boch/G.Greco. Background image: A. Mellinger.

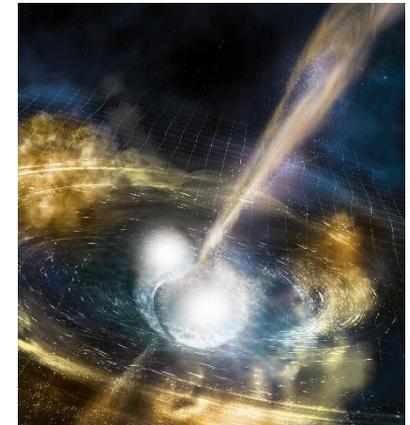
LIGO and Virgo: detecting gravitational waves

- **Two collaborations, three detectors** – KAGRA addition to the network in progress
 - **Joint searches for gravitational waves (GWs)**



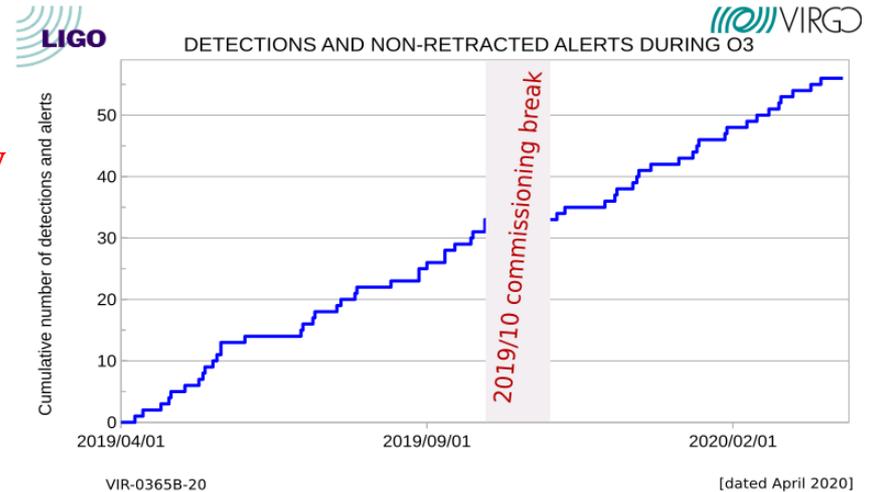
→ Giant Michelson interferometers with Fabry-Perot cavities in the kilometeric arms, recycling mirrors and suspended – ‘free-falling’ – optics and benches

- Alternating **observing runs** (O_n , $n = 1, 2, 3$) & shutdowns (**upgrades, commissioning**)
 - **O1**: 2015/09 → 2016/01
 - ◆ **GW150914**
 - **O2**: 2016/11 → 2017/08
 - ◆ **GW170814, GW170817, GWTC-1**
 - **O3**: 2019/04 → 2020/03 (early stop due to pandemic)
 - ◆ **56 non-retracted public alerts**
 - ◆ **First detections**: GW190412, GW190425. GW190814

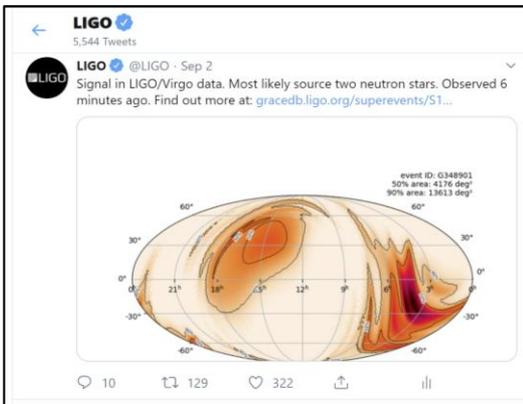


Public alerts

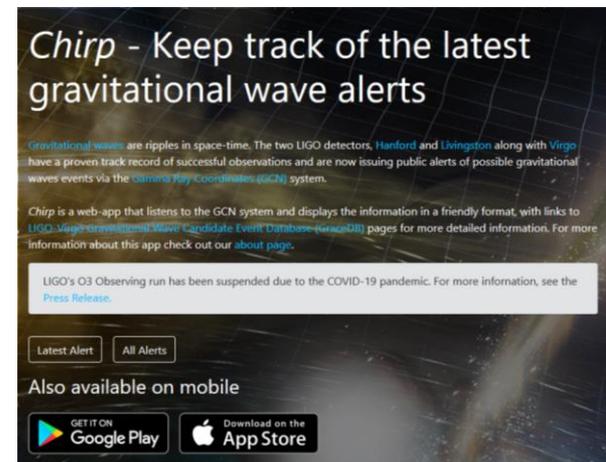
- Twofold goal: **detecting** GWs and **helping to locate the source in the sky**
 - Low-latency info including a **skymap**
 - ◆ Few tens of minutes at most
 - 56 such alerts during O3
- **Multi-stage alert process**
 - LIGO-Virgo internal
 - To astronomers through NASA's **GCN** network
 - To the general public
 - ◆ Automated tweets



- ◆ **Chirp app**: <http://chirp.sr.bham.ac.uk>



including public-relevant info about initial source classification



→ Usually blog posts after a few hours

Scientific announcements

- **Fully joint / coordinated processes between LIGO and Virgo – and soon KAGRA**
 - Makes the whole process more complex
 - ◆ Timezones, different teams / audiences / ways of communicating
- **Quite successful internally so far; excellent media engagement**

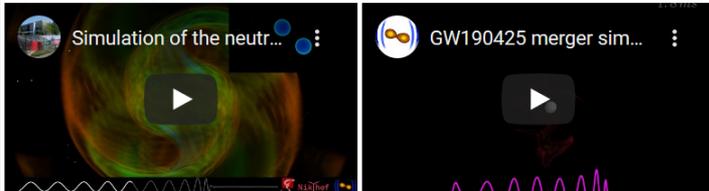
GW190425

On January 6, 2020, the LIGO Scientific Collaboration and the Virgo Collaboration announced the discovery of a second binary neutron star merger, labeled GW190425. This is the first confirmed gravitational-wave detection based on data from a single observatory. No electromagnetic counterpart was found. This system is notable for having a total mass that exceeds that of known galactic neutron star binaries.

PUBLICATIONS & DOCUMENTS

- **Publication:** *GW190425: Observation of a compact binary coalescence with total mass $\sim 3.4 M_{\text{sun}}$* (submitted for publication). [[arXiv link](#)] [[pdf download from LIGO DCC](#)] [[DCC page](#)]
- [LSC Press Release](#).
- [Also available in these languages: Blackfoot, Chinese, German, Hebrew, Hungarian, Japanese, Spanish](#)
- [Virgo Collaboration news item on GW190425](#)
- [Science summary webpage](#) [[pdf flyer](#)].
- [Data release for GW190425](#) (Gravitational Wave Open Science Center/GWOSC).
- [GW190425 fact sheet](#). Translations available [here](#).
- See the [main ligo.org detection page](#) for further resources.

SELECTED IMAGES & VIDEO



Simulation of the binary neutron star coalescence GW190425
This movie shows a numerical simulation representing the binary neutron star coalescence and merger which resulted in the detected gravitational-wave event GW190425. The two neutron stars shown here have properties consistent with the detection made by the Advanced LIGO/Virgo detectors. Still images can be downloaded from [this link](#).
[Credit: Numerical Relativity Simulation: T. Dietrich (Nikhef), Wolfgang Tichy (Florida Atlantic University) and the CoRe-collaboration Scientific Visualization: T. Dietrich (Nikhef), S. Ossokine, and A. Buonanno (Max Planck Institute for Gravitational Physics)]

Additional numerical simulation of GW190425
This video shows the numerical relativity simulation of a binary neutron star system compatible with the source of the GW190425 signal, detected by the LIGO-Virgo global network of gravitational-wave detectors on April 25th, 2019. It is made of two parts, both showing the last orbits of the neutron stars, then their collision, followed by the prompt collapse of the remnant into a black hole. The first part focuses on the dynamics of the neutron star matter in the strong field central region; the highest mass-density (blue) are above nuclear densities, the white surfaces appearing later approximate the black hole horizon. The second part, a zoom out of the same simulation, shows the propagation of the emitted gravitational waves on the orbital plane and far from the source.
[Credit: CoRe collaboration [www.computational-relativity.org](#) / Jena FSU]

GW190412: The merger of two black holes with unequal masses

Change article language: [EN](#) [FR](#) [IT](#) [ES](#) [DE](#) [RU](#)

The third LIGO-Virgo observing period (O3) is offering new insights into the late inspiral and merger phase of binary black hole (BBH) systems. The first gravitational wave event GW150914, detected back in 2015, originated from a binary black hole merger, and since then this class of events has become the most prominent. This allows us to advance in the characterization of the population of astrophysical BBHs. However, the systems observed so far were formed by black holes of nearly equal masses. This balance was broken by the observation of the merger of a very special BBH on the 12th of April, 2019 at 05:30:44 UTC, just a couple of weeks after the start of O3, on the 1st of April.

The signal, named GW190412, was detected by the Advanced Virgo and the two Advanced LIGO detectors, and it was produced by a coalescing BBH system with unequal masses, one component being more than 3 times heavier than the other one. More in detail, the merged black holes had masses respectively about 30 and 8 times the mass of the Sun. The mass difference produces specific signal modulations that were predicted by theory, but have now been observed for the first time. In fact, the mass unbalance produces an unusually high intensity of gravitational radiation in the so-called "Higher Order Modes", which are detectable in GW190412 and provide yet another confirmation of the validity of Einstein's General Relativity. GW190412 also depends on other parameters of the binary system which cause modulations that enable us to constrain the inclination of the plane of the binary with respect to the line of sight and the distance of the source: two quantities that are otherwise highly correlated.

"The Virgo and LIGO detectors are becoming more and more sensitive, the rate of detections increases and we expect new and unusual events. GW190412 is unusual and interesting, because of the large mass difference between the two coalescing black holes. We are learning that systems of this kind exist and how rare they are. This will allow us to deduce how they formed, which is something that I find exciting", says Giancarlo Cella, researcher at Istituto Nazionale di Fisica Nucleare (INFN) and the Virgo Data Analysis Coordinator.

"The unequal masses of this source caused overtones of the main signal to be visible for the very first time. This provided us with an exciting new opportunity to test an important prediction of Einstein's theory about what happens when black holes of unequal size collide", says Anuradha Samajdar, postdoc fellow at the Dutch National Institute for Subatomic Physics (Nikhef), and member of the Virgo Collaboration.

Image: The distance inferred for the source of GW190412 versus the inclination angle of the binary's orbit with respect to the line of sight. In general the two quantities are highly correlated but the different masses of the BH in the binary allow us to partially disentangle them. The distance is most likely about 700 Mpc, that is 2.3 billions of light years.

Image credit: LIGO Scientific Collaboration/Virgo Collaboration

GW190412: Observation of a Binary-Black-Hole Coalescence with Asymmetric Masses

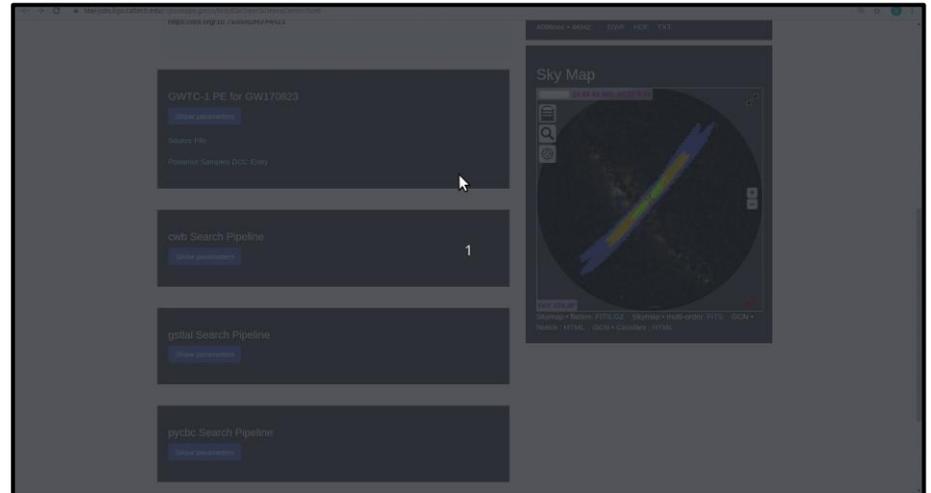
Science summaries - LIGO news

Binary Black Hole Merger animation

Posted: 20/04/2020

Scientific announcements

- Each significant publication goes along with **various companion products**
 - Press releases, collaboration website announcements
 - Social media posts: Twitter, Facebook, Instagram
 - Media resources
 - ◆ Animations of various kinds: numerical simulations, source localization, etc.
 - ◆ Graphics, pictures
 - Not always easy to find the right balance between scientific correctness and artistic interpretation



<https://www.virgo-gw.eu/video/gw190814.html>

Scientific announcements

- **Supporting material** targeting the general public, students, teachers
 - **Multilingual science summaries**
 - **Reaching out to people in their language leads to more engagement**
 - ◆ **Thanks to the many different languages spoken by LIGO-Virgo members**
 - **Factsheet**
 - **Infographics**

GW190412: THE FIRST OBSERVATION OF AN UNEQUAL-MASS BLACK HOLE MERGER

WHAT DID WE FIND?
On April 12, 2019, the LIGO Scientific Collaboration and Virgo Collaboration observed gravitational waves produced by the inspiral and merger of two black holes. This event, dubbed GW190412, was observed with all three detectors operating in the network: both LIGO detectors (one in Hanford, Washington and one in Livingston, Louisiana) as well as the Virgo detector (located in Caserta, Italy). GW190412 was detected near the beginning of Advanced LIGO and Virgo's third observing run, known as O3, which started on April 2nd 2019 and was suspended on March 27th 2020.

While the masses of the two black holes are consistent with those of previously observed black holes, GW190412 is unique in that it is the first black hole merger where the masses of the two black holes are definitively unequal—one black hole in the system is more than 3 times heavier than the other. This asymmetry in masses modifies the gravitational-wave signal in such a way that we can better measure other parameters, such as the distance and inclination of the system, the spin of the heavier black hole, and the amount that the system is precessing. In addition, the unequal masses of GW190412 enable us to verify a fundamental prediction of Albert Einstein's General relativity: that gravitational waves "ring" at more than one fundamental frequency, so-called higher multipole.

HOW DO WE KNOW GW190412 IS A REAL GRAVITATIONAL-WAVE SIGNAL?
GW190412 is a loud event that was seen in all three detectors. Since the three detectors are all thousands of kilometers apart from one another, seeing this signal in all the detectors nearly simultaneously is a good sign that it is of astrophysical origin rather than due to noise.

The time-frequency representation of GW190412, known as a spectrogram, is shown in Figure 1. While GW190412 is strong enough to be seen "by eye" in the data from the Hanford and Livingston detectors, we use a number of algorithms to systematically scan the data for gravitational-wave signals and determine their significance. Most techniques rely on matched filtering, which compares the observed data to simulated signals predicted from general relativity. We quantify the chance that a signal results from noise in the detectors as the false alarm rate. Using data from April 8 to April 13, we found a false alarm rate of 0.3 per chance event per 30,000 years! This false alarm rate will become even more significant as more data from O3 are analyzed. We also performed checks for other types of instrumental and environmental sources of noise, and found nothing that could significantly impact on the detection or analyses of GW190412.

Visit our websites:
<http://www.ligo.org>
<http://www.virgo-gw.eu>

GW190412

The first gravitational wave observation from the merger of two black holes with different masses

Discovery
12 April 2019

Distance
2.4 billion light years away

3 Detectors
Three detectors made the observation: the two LIGO detectors in the USA and Virgo in Italy.

Binary Black Hole

Unequal Masses
This is the first BBH detection where the two black holes had very different masses

Higher Harmonics

Figure 1: The spectrogram of GW190412 in the three gravitational wave detectors. The horizontal axis represents time, and the vertical axis shows the frequency of the signal. Color represents the amount of energy in a certain frequency at a certain time. The familiar "chirp" can be seen from the signal as it increases in frequency and energy over time, resulting from the increased power of gravitational wave emission as the two black holes orbit closer and closer (the "inspiral") and subsequently merge.

GW190412 FACTSHEET

FIRST DETECTED EVENT WITH STRONG EVIDENCE FOR AN UNEQUAL MASS RATIO AND HIGHER GRAVITATIONAL WAVE MODES PRESENT

Observed by	LIGO Hanford and Livingston, Virgo	Mass of final BH	33.1 to 41.1 M_{\odot}
Source type	Binary black hole merger	Spin magnitude of final BH	0.60 to 0.72
Event time	5:30:44 UTC, April 12, 2019	Initial astronomer alert latency (referenced to time of merger)	60 minutes
Network signal to noise ratio	19.1	Sky area of 90% credible region	156 deg ²
Distance	1.83 to 2.84 billion light years		
Redshift	0.12 to 0.18		
Primary BH mass	24.4 to 34.7 M_{\odot}		
Secondary BH mass	7.4 to 10.1 M_{\odot}		
Ratio of secondary to primary BH mass	0.21 to 0.41		
Effective inspiral spin parameter	0.14 to 0.34		
Effective precession spin parameter	0.15 to 0.49		

Images: Mass ratio and spin (left) – from the properties of the signal, it was possible to estimate the mass ratio (q) and the effective spin (χ_{eff}) of the binary BHs. The blue and orange contours represent 90% credible estimates on the values of these quantities from two different models.

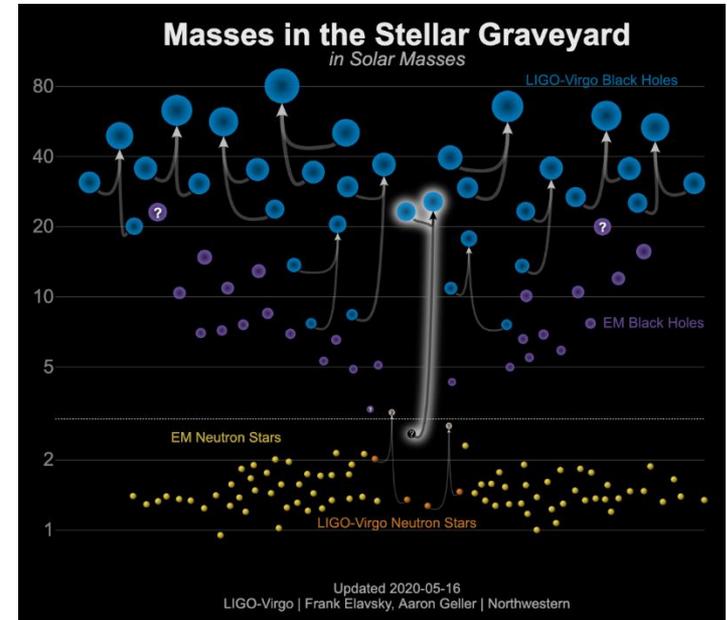
GW spectrograms (above) – time-frequency representation of the GW signal data from all three detectors.

GW = gravitational wave, BH = black hole, M_{\odot} = 1 solar mass = 2×10^{30} kg

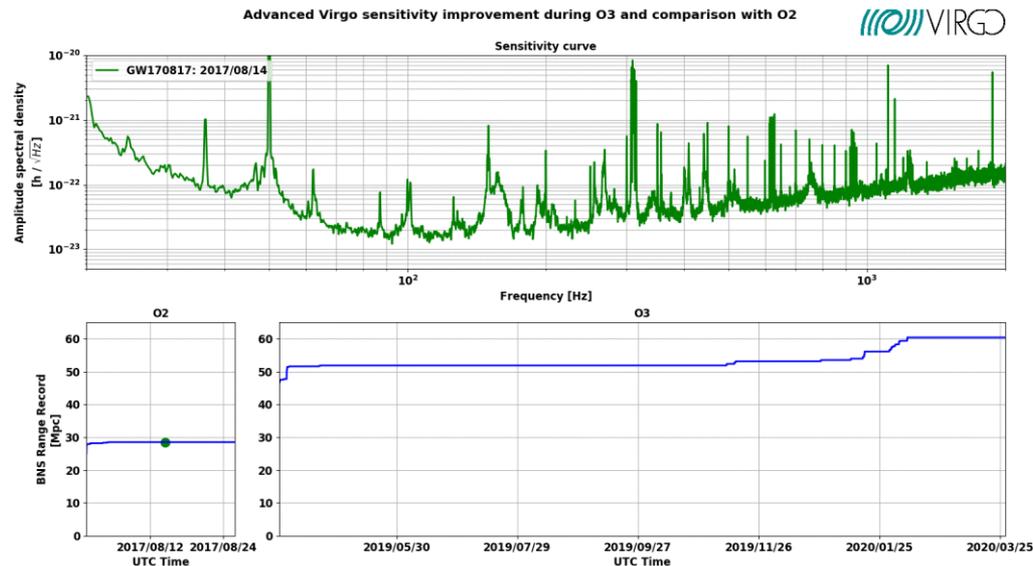
Parameter ranges are 90% credible intervals from combining two models

Outreach plots and animations

- LIGO-Virgo « **Masses in the Stellar Graveyard** »



- 2017-2020 evolution of the Virgo sensitivity
 - The smaller the noise curve or the larger the detection range, the better



Focusing on LIGO-Virgo members

- A great example: **Humans of LIGO**
 - Website: <https://humansofligo.blogspot.com>

About LIGO

The Laser Interferometer Gravitational-Wave Observatory (LIGO) is a large-scale scientific experiment designed to detect gravitational waves as predicted by Einstein's General Theory of Relativity. The twin LIGO observatories made the first-ever direct detection of Gravitational Waves coming from a collision of two Black Holes in 2015, a feat that was awarded the Nobel prize in Physics in 2017.



Humans of LIGO, a short timeline:

- AUGUST 2018**
 - The First Humans**
 - The project kicked off in August 2018 with the first Humans sharing their stories via written responses or phone interviews.
 - OCTOBER 2018**
 - Thirsty the Raven**
 - Ravens, pecking on ice forming on the cooling systems at LIGO Hanford caused noise that showed up in the Gravitational Wave channel! These thirsty birds got a well-deserved and much-loved guest appearance on the blog on Halloween.
 - MARCH 2019**
 - LGBT STEM Day**
 - The blog celebrated LGBTQ+ representation within the collaboration and continues to be a platform for their expression.
 - AUGUST 2019**
 - 30 Humans ...**
 - One year since its inception, the blog has created profiled over 30 humans and shared them across LIGO's social media handles.
- ... and counting!

Humans of



Editors:
Zohyr Doctor, University of Oregon
Sumeet Kulkarni, University of Mississippi (ComSciCon presenter)
Phil Landry, California State University, Fullerton
Denyz Melchor, California State University, Fullerton
Sudarshan Ghonghe, Georgia Tech



Check out the blog here!

Humans of LIGO

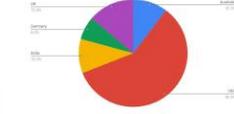
The LIGO Scientific Collaboration exhibits incredible diversity among its members, with people coming from all backgrounds and at various stages of their careers. Since August 2018, the Humans of LIGO project has brought individuals from the collaboration to the forefront and given them a chance to tell their story. It has showcased different aspects of their personalities: from their thoughts and experiences to their hobbies and interests. Not only is it a platform for highlighting LIGO researchers, but it also offers the public a glimpse into their daily lives and life journeys.

Stats at a glance...

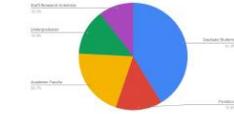
Pageviews by Countries



Place of Work



Positions



18+ Countries

100+ Institutions

1300+ Faces

1 Collaboration

"I would have gotten away with it if it hadn't been for those meddling scientists and their extensive environmental monitors!" -Thirsty the Raven

"That sun-baked summer, surrounded by scientists who sincerely believed that we could someday detect the motion of space itself, changed how I saw life in science." -Grant Meadors

"I've been into space since elementary school, where I had the privilege of being able to attend a NASA Explorer School!" -Oli Patane

"My mother Sharon Yellowjoy translated our GW150914 press release into an Indigenous language (Blackfoot). I am SOO proud of that." -Corey Gray

"Dungeons and Dragons is one of the merriest things I've done. I've been playing it since I was about 10. It's one of the things in my life I've been doing longer than working at LIGO!" -Jax Sanders

"One time, at a public outreach event, a little kid turned and said, with a smile, 'Did I just make a gravitational wave event?'" -Ann MacMillan

"I watched part of the GW150914 press conference while being recorded and the biggest smile appeared on my face when I saw the plot I made show up in the press conference." -Amber Lenon

"My main project at the moment is my podcast SciCurious where I highlight LGBTQ people in STEM and talk about their science." -Dryley Healdstone

"In June 2016, a few months after the first gravitational wave detection was announced, I flew with a Dutch TV crew to Pisa to shoot an episode for AlibiKius, a Dutch children's TV show." -Joris van Heijningen

"I feel like the thing I'm actually more interested in now is the human drama - and comedy - of science. How scientists behave, how chaotic it is, people squabbling and fighting and making mistakes and not having a clue what they're doing. And yet it works!" -Mark Hamann

"I somehow managed to merge drawing with science (well, at least the human side of it). I'mie comes out of things that happen around me." -Nutsinee Kijbunchoo

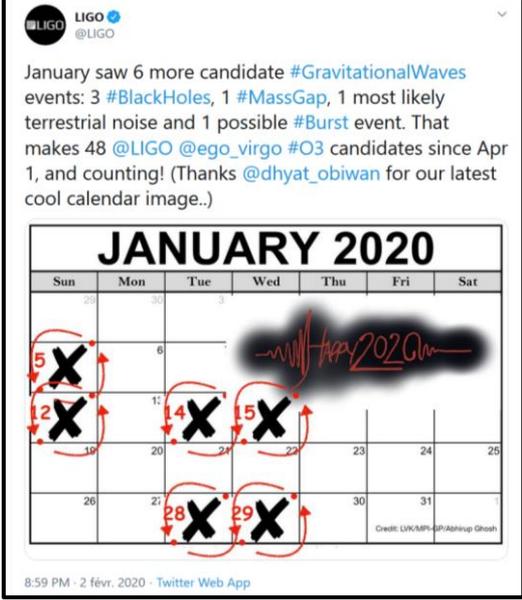
"I'm hispanic, female, first-generation American, first-generation to go to college. A lot of people at my school are basically where I'm starting, so I want to go do something for the people like me." -Denyz Melchor

"My dream as a kid, rather than winning the Nobel prize was to win the Winkler Award." -Barish

"I first joined my high school astronomy club because the planetarium seemed like a nice place to take a nap. Now, as a member of LIGO, I get to study Black Holes and Neutron Stars every day." -Eve Chase

Social media

- **Twitter** 
 - [@ligo](#): 103K followers
 - [@ego_virgo](#): 10K followers
- **Facebook** 
 - [@LigoScientificCollaboration](#): 30K followers
 - [@EGOVirgoCollaboration](#): ?? followers
- **Instagram** 
 - [@ligo_virgo](#): 8K followers
- **YouTube** 
 - [ligovirgo](#): 3K subscribers
 - [EGOtheVirgoCollaboration](#): 170 subscribers



January saw 6 more candidate #GravitationalWaves events: 3 #BlackHoles, 1 #MassGap, 1 most likely terrestrial noise and 1 possible #Burst event. That makes 48 @LIGO @ego_virgo #O3 candidates since Apr 1, and counting! (Thanks @dhyat_obiwan for our latest cool calendar image..)

JANUARY 2020						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
5 X	6	7	8	9	10	11
12 X	13	14 X	15 X	16	17	18
19	20	21	22	23	24	25
26	27	28 X	29 X	30	31	

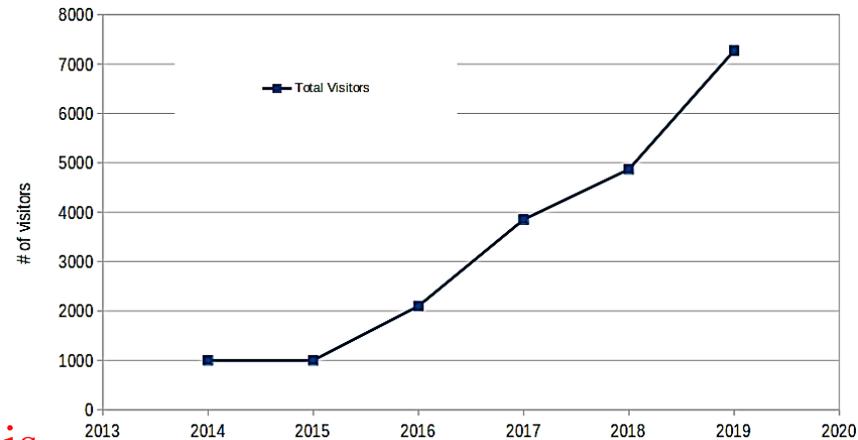
Credit: LVC/APS-@PAbhinav Ghosh

Site visits: for real and virtual

- **A lot of visitors to all three sites**
 - General audience, in particular students and teachers
- Boost due to the first detection announcements – 2016-2017
 - ◆ **Public interest proved consistent ever since**

- **Example of Virgo**

- **7 times more in 5 years!**
 - ~200 / week in 2019
 - ◆ Excluding holidays
- Actually beyond the capacity of reception at EGO!
 - ◆ Visit management + guides: **voluntary basis**



- **Plan to construct a science center at LIGO-Hanford**
 - Center already existing at LIGO-Livingston



→ Pre covid-19 pandemic times...

Events organized at EGO

- **Researchers Night**



- **Astronomical observation evenings**
 - Including talks about GW & Virgo + site tours



Site visits: for real and virtual

- Pre-existing plans to setup a **regular offer of virtual visits**
 - **Conference + connection with scientists onsite / standalone**: spherical pictures
→ **Higher priority now** given the circumstances
 - Virgo virtual visits during the Genova Science Festival at the end of October
- EGO: **purchase of cameras to record the ongoing upgrades** – « **Advanced Virgo Plus** »
 - **Time-lapse videos** to be produced
- LIGO-Virgo groups organizing **online conferences for their local audience**
 - Example: The Netherlands
 - ◆ Recording: <https://www.youtube.com/watch?v=gsf-2pTopCk&feature=youtu.be>



Science festivals

- Pictures from **LIGO** booths at conferences or public events

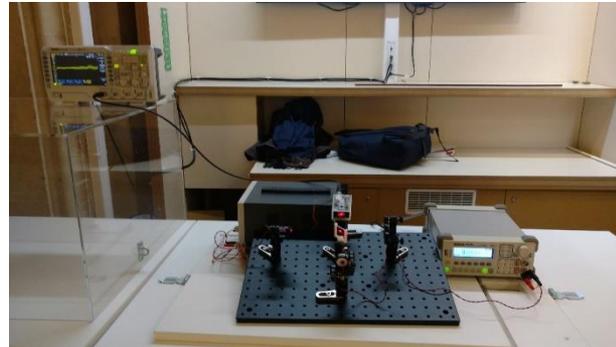
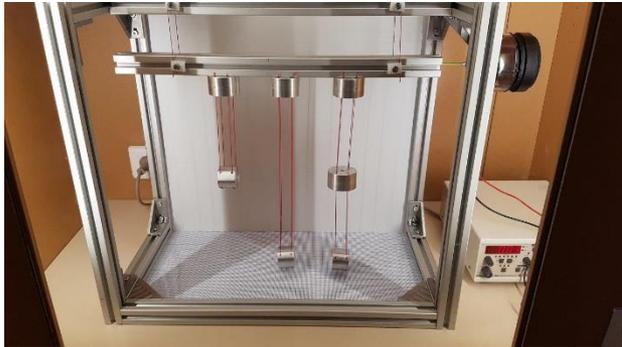


Virgo exhibitions

- [CosmoCaixa exhibition](#) in Barcelona
 - **Virgo payload**: mirror suspension



- Spring 2019: Virgo host of the « 1 researcher, 1 experiment » stand at the [Paris](#) science museum « [Palais de la Découverte](#) »



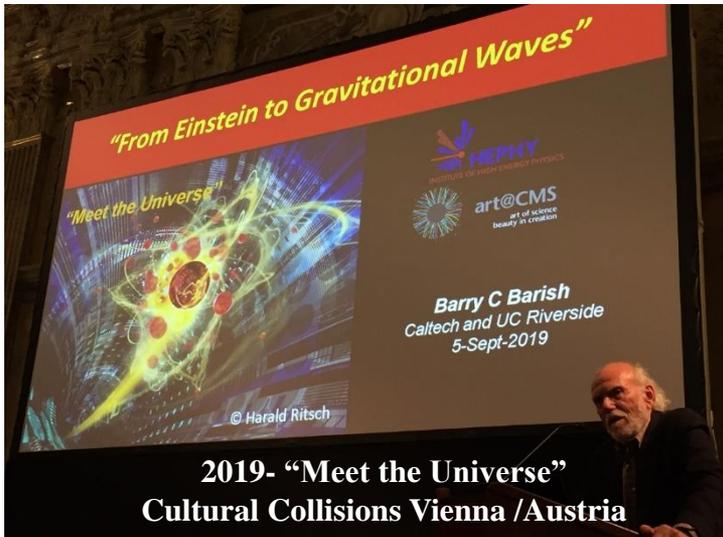
- Virgo exhibition at the 2020 Euroscience open forum ([ESOF](#)) in [Trieste](#)
 - Postponed to September
 - A major post-lockdown event in Italy



- [Parma Italian Capital of the Culture](#) in 2020: postponed to 2021

The Origin Network

- Website: <https://originnetwork.web.cern.ch>



The ORIGIN network

ORIGIN is a network founded in January 2018 by several high energy and astrophysics collaborations and research centres. Its purpose is to create and support events, exhibits and workshops where public engagement and education are enhanced by both art and science.

Stereotypes are still a challenge for many STEM fields, including physics and engineering. ORIGIN events aim to overcome these by creating an environment infused with a variety of perspectives, tools and skills. Scientists and artists join forces to demystify concepts and practises, engaging students and the general public to integrate them into everyday life.

The project initially grew around an exhibition called "Origin and Evolution of the Universe through Art and Science". We chose to keep and highlight the name ORIGIN because it is a theme that unites all people. Philosophers, artists, scientists, and human beings in general consider and address it. By creating events where the question of origins is looked at from diverse perspectives we aim to inspire awe, creativity and critical thinking.

After a two years long pilot period, the project will move in January 2020 to a new structure. This web site groups the R&D material and experience collected in 2018-2019.

Load a [social media album of 2018/2019 activities](#)

CERN insiders: please sign in at the top right corner (or [HERE](#)) to see more.

Contact: origin-coordination@cern.ch

SCIENTIFIC PARTNERS

[ALICE collaboration](#)

[ATLAS collaboration](#)

[CMS collaboration](#)

[IceCube collaboration](#)

[LHCb collaboration](#)

[LIGO collaboration](#)

[Muography collaboration](#)

[VIRGO collaboration](#)

ART-SCIENCE PARTNERS

[art@CMS](#)

[Fine-Art Muographer](#)

[Cuántico](#)

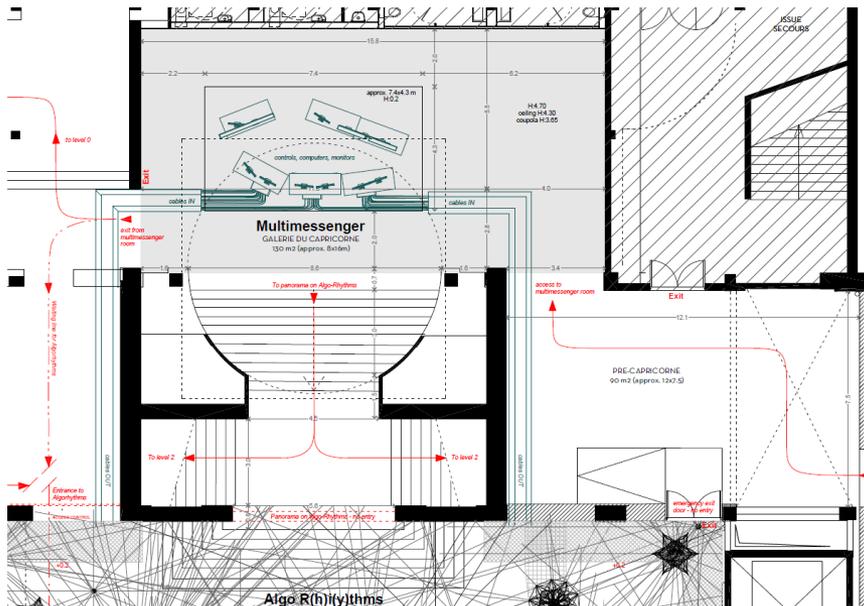


Oman Science festival 2019

Art & Science: multimessenger room

- **Tomas Saraceno's** exhibition at **Palais de Tokyo** in Paris
 - Famous modern **art** museum in Paris
- **Multimessenger room**
 - Gathering (live) data from **IceCube**, **Antares**, **KM3Net**, **Virgo**, **Auger**
→ **Images and sound**

Carte Blanche à Tomás	Exposition
Saraceno	Du 17/10/2018 au
ON AIR	06/01/2019
PALAIS DE TOKYO	À découvrir de midi à minuit, tous les jours sauf le mardi
	#TomásSaraceno



Reaching out to more audiences

- **Science dating on a rowing boat** in Lyon (France)
- For visually-impaired people
 - **3D detector model** and **GW « chirp »**
 - **Contacts with a blind artist**
- More innovative: **sonification projects**
 - Example: **GW localization in the sky**



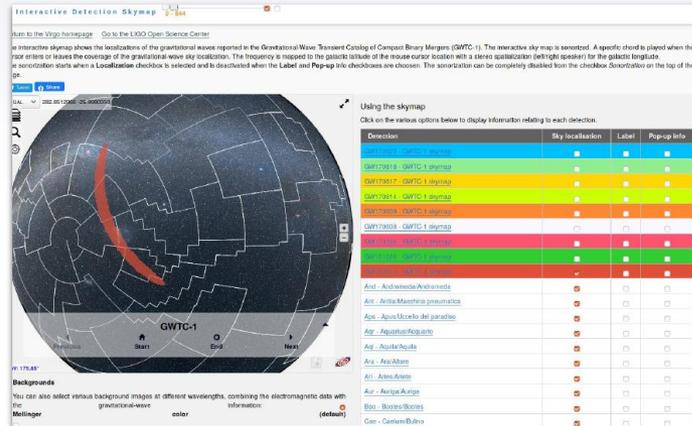
The frequency is mapped to the galactic latitude of the mouse cursor location with a stereo spatialization (left/right speaker) for the galactic longitude.

A specific chord is played when the cursor enters or leaves the coverage of the sky localization.

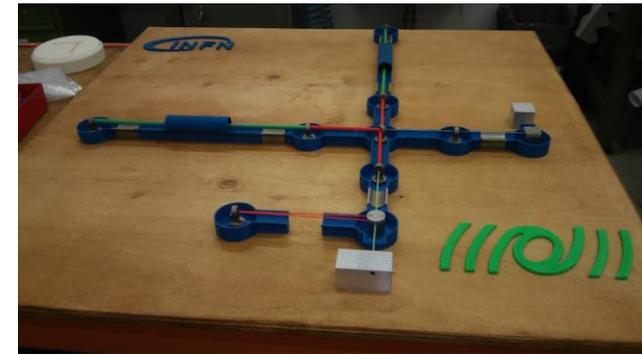
An audio file is added to explain the nature of each event and the main properties.

The constellations as well as the GW sky localizations are sonorized with a chord and a mp3 file description.

An automatic tour is added using the Aladin Lite Plugin developed by Tamara Civera.



Under tests in the Virgo/EGO outreach meeting



- **Virgo in jail**: project of conferences in prison in various countries at the same time
 - Postponed to 2021 due to the pandemic

IGRAV

- Building a **gravitational-wave outreach network**
 - All experiments / GW probes + theory groups
 - Outreach and communication experts, science educators
- **Model: the IPPOG Collaboration**
 - Joint LIGO-Virgo-IPPOG session at the 2018 Spring IPPOG meeting in Pisa
- Creation of **IGRAV: International Gravitational Wave Outreach Group**
 - Slow but real progress: no dedicated personpower + pandemic
- **Working groups**
 - Art and Science Collaborations
 - Communication
 - Formal Education & Evaluation
 - IGRAV Organizational Structure
 - Multi-Messenger Astronomy
 - Outreach to Under-Represented and Under-Served Groups
 - Science Festivals
- **Two meetings already**
 - 2019/07: Amaldi conference in Valencia 2020/07 (remote): **earlier this week!**



Outlook

- **Busy** – and **exciting** – **period** for **LIGO** and **Virgo** (and soon **KAGRA**)
 - **More GW signals detected as the detector sensitivities and duty cycles improve**→ Yet: less than five years since GW150914
- **Busy** – and **exciting** – **period** for the **outreach groups** as well
 - **Coping with the detection / announcement rates**
 - **Conveying excitement to the general public**
- **Many channels**
 - From the **most classic** to the **most modern / technological**
 - **Caring about all audiences**
 - ◆ **Multilingual resources**
 - ◆ **Developing specific tools to reach out a particular audience / workaround issues**
- **One of the main strengths of LIGO-Virgo is working together**
 - **Will to go beyond and to build a cross-experience outreach network: IGRAV**
- **Stay tuned for future announcements**
 - **Next run (O4) should start sometime in 2022 with « Advanced Plus » detectors**