Outreach and Communication

Friday June 11, 2021

https://indico.in2p3.fr/event/20212/timetable

Livia Conti (INFN Padova) livia.conti@pd.infn.it
Virgo Outreach Coordinator

Nicolas Arnaud (IJCLab & EGO) nicolas.arnaud@ijclab.in2p3.fr
Former Virgo Outreach Coordinator, French representative to IPPOG

VIRGO

Outline

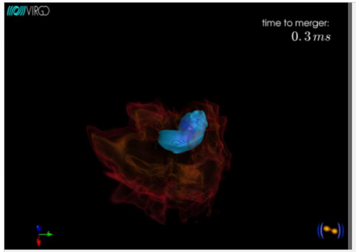
- Outreach, communication and education
- Addressing Diversity, Inclusion and Equity (DIE)
  - Remote audiences
  - Disabilities
  - Language barrier
  - Science summaries
- Visiting EGO-Virgo
  - In person and remote
- Art & Science
  - Production of images/animations
  - Artistic performances
  - Exhibitions
- Scientists producing outreach contents
  - Exhibits and posters
  - Graphic material
  - Social media

Outreach, communication and education

An attempt to define outreach and communication

- Communication
  - Report status, present results, describe strategy, etc.
  - Adapt means and contents to the target audience(s)
    - Stakeholders, medias, colleagues, general public
  - Different types
    - Internal / External
    - Corporate / Business
    - Media-based or not
    - Crisis or emergency
- Outreach
  - Reach out to target audiences
    - Public engagement
  - Add context, provide explanations
  - Create specific, supporting resources
    - Links with education

https://www.virgo-gw.eu/#news



GW190425: the merger of a compact binary with total mass of about 3.4 Msun

Change article language:

On April the 25th, 2019, the network of gravitational-wave (GW) detectors formed by the European Advanced Virgo, in Italy, and the two Advanced LIGO, in the US, detected a signal, named GW190425. This is the second observation of a gravitational-wave signal consistent with the merger of a binary-neutron-star system after GW170817. GW190425 was detected at 08:18:05 UTC; about 40 minutes later the LIGO Scientific Collaboration and the Virgo Collaboration sent an alert to trigger follow-up telescope observations.

The source of GW190425 is estimated to be at a distance of 500 million light years from the Earth. It is localized in the sky within an area about 300 times broader than was the case for the BNS observed by LIGO and Virgo in 2017, the famous GW170817, which gave birth to multi-messenger astrophysics. However, unlike GW170817, no counterpart (electromagnetic signals, neutrinos or charged particles) has been found to date.

There are a few explanations for the origin of GW190425. The most likely is the merger of a BNS system. Alternatively, it might have been produced by the merger of a system with a black hole (BH) as one or both components, even if light BHs in the mass-range consistent with GW190425 have not been observed. Yet, on the basis solely of GW data, these exotic scenarios cannot be ruled out. The estimated total mass of the compact binary is 3.4 times the mass of the Sun. Under the hypothesis that GW190425 originated from the merger of a BNS system, the latter would have been considerably different to all known BNS in our galaxy, the total mass range of which is between 2.5 and 2.9 times the mass of the Sun. This indicates that the NS system that originated GW190425 may have formed differently than known galactic BNSs.

"After the surprise of the initial results", says Alessandro Nagar of the Istituto Nazionale di Fisica Nucleare (INFN) of Turin, Italy, "we have finally reached a reliable understanding of this event. Although predicted theoretically, heavy binary systems like those that might have originated GW190425 may be invisible through electromagnetic observations."

"While we did not observe the object formed by the coalescence, our computer simulations based on general relativity predict that the probability that a BH is formed promptly after the merger is high, about 96%", says Sebastiano Bernuzzi of the University of Jena, Germany.

Image: A binary neutron star system just before merger: the two stars are deformed by tidal forces and are about to fuse together. The image is produced by a numerical simulation in General Relativity (animation) and shows the mass density volume rendering at nuclear densities in blue and lower density material in red. The snapshot refers to the central volume of approximately 45 km in diameter.

Image credit: CoRe / Jena FSU

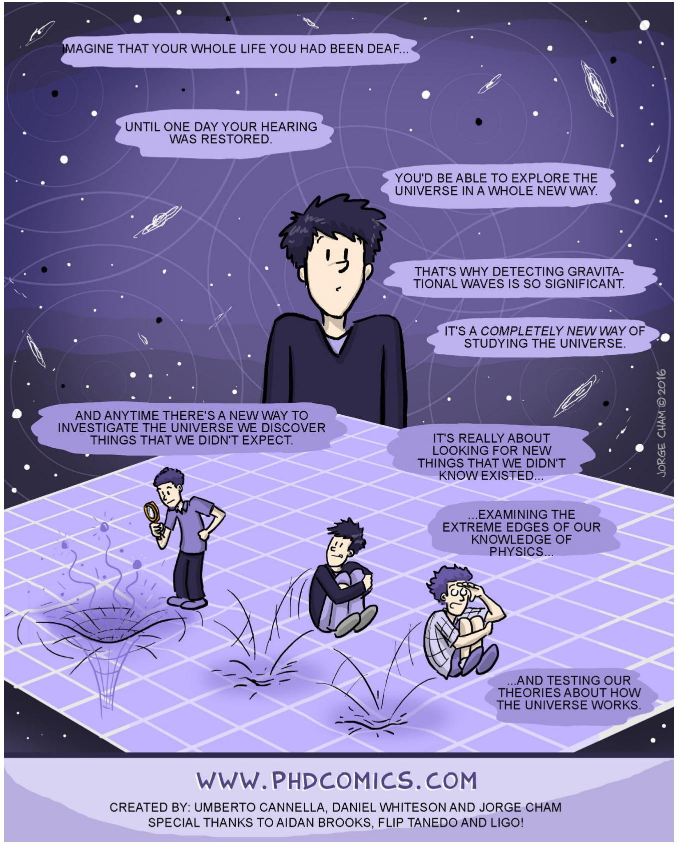
Press release - Communiqué de presse - Notas de prensa - Materiały dla prasy

Outreach vs. Communication?

- Two different specialities
  - Not to conflate
  - Not to mix
- Both require experts
  - Communication professionals
  - Scientists eager to share their research, education experts to connect science with curricula

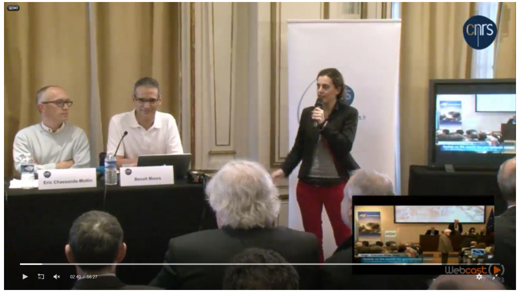
→ No improvisation

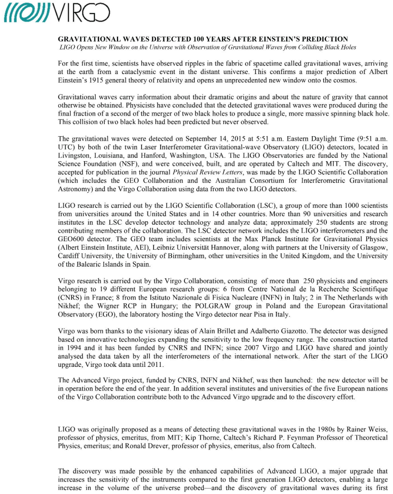
- Definitely not to oppose
  - Complementary
  - Doing only one or the other is not enough
- On equal footing
  - None better than the other
  - Fulfill different needs and expectations



Outreach and Communication!

- Two sides of a successful plan to convey results, or pass on information





VIRGO

GRAVITATIONAL WAVES DETECTED 100 YEARS AFTER EINSTEIN'S PREDICTION

LIGO Opens New Window on the Universe with Observation of Gravitational Waves from Colliding Black Holes

For the first time, scientists have observed ripples in the fabric of spacetime called gravitational waves, arriving at the earth from a cataclysmic event in the distant universe. This confirms a major prediction of Albert Einstein's 1915 general theory of relativity and opens an unprecedented new window onto the cosmos.

Gravitational waves carry information about their dramatic origins and about the nature of gravity that cannot otherwise be obtained. Physicists have concluded that the detected gravitational waves were produced during the final fraction of a second of the merger of two black holes to produce a single, more massive spinning black hole. This collision of two black holes had been predicted but never observed.

The gravitational waves were detected on September 14, 2015 at 5:51 a.m. Eastern Daylight Time (9:51 a.m. UTC) by both of the twin Laser Interferometer Gravitational-wave Observatory (LIGO) detectors, located in Livingston, Louisiana, and Hanford, Washington, USA. The LIGO Observatories are funded by the National Science Foundation (NSF), and were conceived, built, and are operated by Caltech and MIT. The discovery, accepted for publication in the journal *Physical Review Letters*, was made by the LIGO Scientific Collaboration (which includes the GEO Collaboration and the Australian Consortium for Interferometric Gravitational Astronomy) and the Virgo Collaboration using data from the two LIGO detectors.

LIGO research is carried out by the LIGO Scientific Collaboration (LSC), a group of more than 1000 scientists from universities around the United States and in 14 other countries. More than 90 universities and research institutes in the LSC develop detector technology and analyze data; approximately 250 students are strong contributing members of the collaboration. The LSC detector network includes the LIGO interferometers and the GEO600 detector. The GEO team includes scientists at the Max Planck Institute for Gravitational Physics (Albert Einstein Institute, AEI), Leibniz Universität Hannover, along with partners at the University of Glasgow, Cardiff University, the University of Birmingham, other universities in the United Kingdom, and the University of the Balearic Islands in Spain.

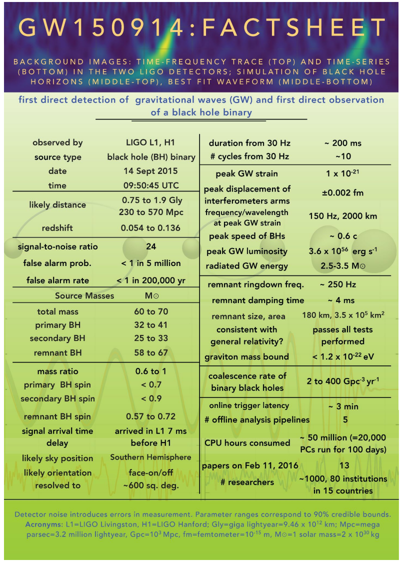
Virgo research is carried out by the Virgo Collaboration, consisting of more than 250 physicists and engineers belonging to 19 different European research groups: 6 from Centre National de la Recherche Scientifique (CNRS) in France; 8 from the Istituto Nazionale di Fisica Nucleare (INFN) in Italy; 2 in The Netherlands with Nikhef; the Wigner RCP in Hungary; the POLGRAW group in Poland and the European Gravitational Observatory (EGO), the laboratory hosting the Virgo detector near Pisa in Italy.

Virgo was born thanks to the visionary ideas of Alain Brillet and Adalberto Giazotto. The detector was designed based on innovative technologies expanding the sensitivity to the low frequency range. The construction started in 1994 and it has been funded by CNRS and INFN; since 2007 Virgo and LIGO have shared and jointly analysed the data taken by all the interferometers of the international network. After the start of the LIGO upgrade, Virgo took data until 2011.

The Advanced Virgo project, funded by CNRS, INFN and Nikhef, was then launched: the new detector will be in operation before the end of the year. In addition several institutes and universities of the five European nations of the Virgo Collaboration contribute both to the Advanced Virgo upgrade and to the discovery effort.

LIGO was originally proposed as a means of detecting these gravitational waves in the 1980s by Rainer Weiss, professor of physics, emeritus, from MIT; Kip Thorne, Caltech's Richard P. Feynman Professor of Theoretical Physics, emeritus; and Ronald Drever, professor of physics, emeritus, also from Caltech.

The discovery was made possible by the enhanced capabilities of Advanced LIGO, a major upgrade that increases the sensitivity of the instruments compared to the first generation LIGO detectors, enabling a large increase in the volume of the universe probed—and the discovery of gravitational waves during its first



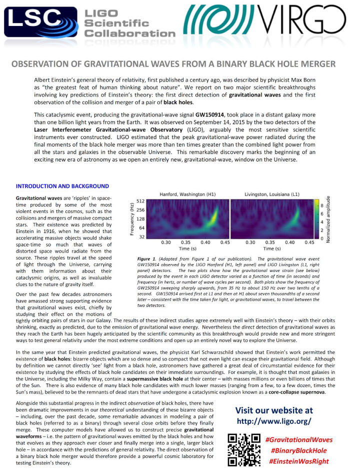
GW150914:FACTSHEET

BACKGROUND IMAGES: TIME-FREQUENCY TRACE (TOP) AND TIME-SERIES (BOTTOM) IN THE TWO LIGO DETECTORS; SIMULATION OF BLACK HOLE HORIZONS (MIDDLE-TOP), BEST FIT WAVEFORM (MIDDLE-BOTTOM)

first direct detection of gravitational waves (GW) and first direct observation of a black hole binary

observed by	LIGO L1, H1	duration from 30 Hz	~ 200 ms
source type	black hole (BH) binary	# cycles from 30 Hz	~10
date	14 Sept 2015	peak GW strain	1×10^{-21}
time	09:50:45 UTC	peak displacement of interferometers arms	±0.002 fm
likely distance	0.75 to 1.9 Gly 230 to 570 Mpc	frequency/wavelength at peak GW strain	150 Hz, 2000 km
redshift	0.054 to 0.136	peak speed of BHs	~ 0.6 c
signal-to-noise ratio	24	peak GW luminosity	3.6×10^{56} erg s^{-1}
false alarm prob.	< 1 in 5 million	radiated GW energy	2.5-3.5 M⊙
false alarm rate	< 1 in 200,000 yr	remnant ringdown freq.	~ 250 Hz
Source Masses	M⊙	remnant damping time	~ 4 ms
total mass	60 to 70	remnant size, area	180 km, 3.5×10^5 km^2
primary BH	32 to 41	consistent with general relativity?	passes all tests performed
secondary BH	25 to 33		
remnant BH	58 to 67	graviton mass bound	$< 1.2 \times 10^{-22}$ eV
mass ratio	0.6 to 1	coalescence rate of binary black holes	2 to 400 $Gpc^{-3} yr^{-1}$
primary BH spin	< 0.7		
secondary BH spin	< 0.9	online trigger latency	~ 3 min
remnant BH spin	0.57 to 0.72	# offline analysis pipelines	5
signal arrival time delay	arrived in L1 7 ms before H1	CPU hours consumed	~ 50 million (=20,000 PCs run for 100 days)
likely sky position	Southern Hemisphere	papers on Feb 11, 2016	13
likely orientation resolved to	face-on/off ~600 sq. deg.	# researchers	~1000, 80 institutions in 15 countries

Detector noise introduces errors in measurement. Parameter ranges correspond to 90% credible bounds.
Acronyms: L1=LIGO Livingston, H1=LIGO Hanford; Gly=giga lightyear=9.46×10^{12} km; Mpc=mega parsec=3.2 million lightyear, Gpc=10^3 Mpc, fm=femtometer=10^{-15} m, M⊙=1 solar mass=2×10^{30} kg



LSC LIGO Scientific Collaboration VIRGO

OBSERVATION OF GRAVITATIONAL WAVES FROM A BINARY BLACK HOLE MERGER

Albert Einstein's general theory of relativity, first published a century ago, was described by physicist Max Born as "the greatest feat of human thinking about nature". We report on two major scientific breakthroughs involving key predictions of Einstein's theory: the first direct detection of **gravitational waves** and the first observation of the collision and merger of a pair of **black holes**.

This cataclysmic event, producing the gravitational-wave signal **GW150914**, took place in a distant galaxy more than one billion light years from the Earth. It was observed on September 14, 2015 by the two detectors of the **Laser Interferometer Gravitational-wave Observatory** (LIGO), arguably the most sensitive scientific instruments ever constructed. LIGO estimated that the peak gravitational-wave power radiated during the final moments of the black hole merger was more than ten times greater than the combined light power from all the stars and galaxies in the observable Universe. This remarkable discovery marks the beginning of an exciting new era of astronomy as we open an entirely new, gravitational-wave, window on the Universe.

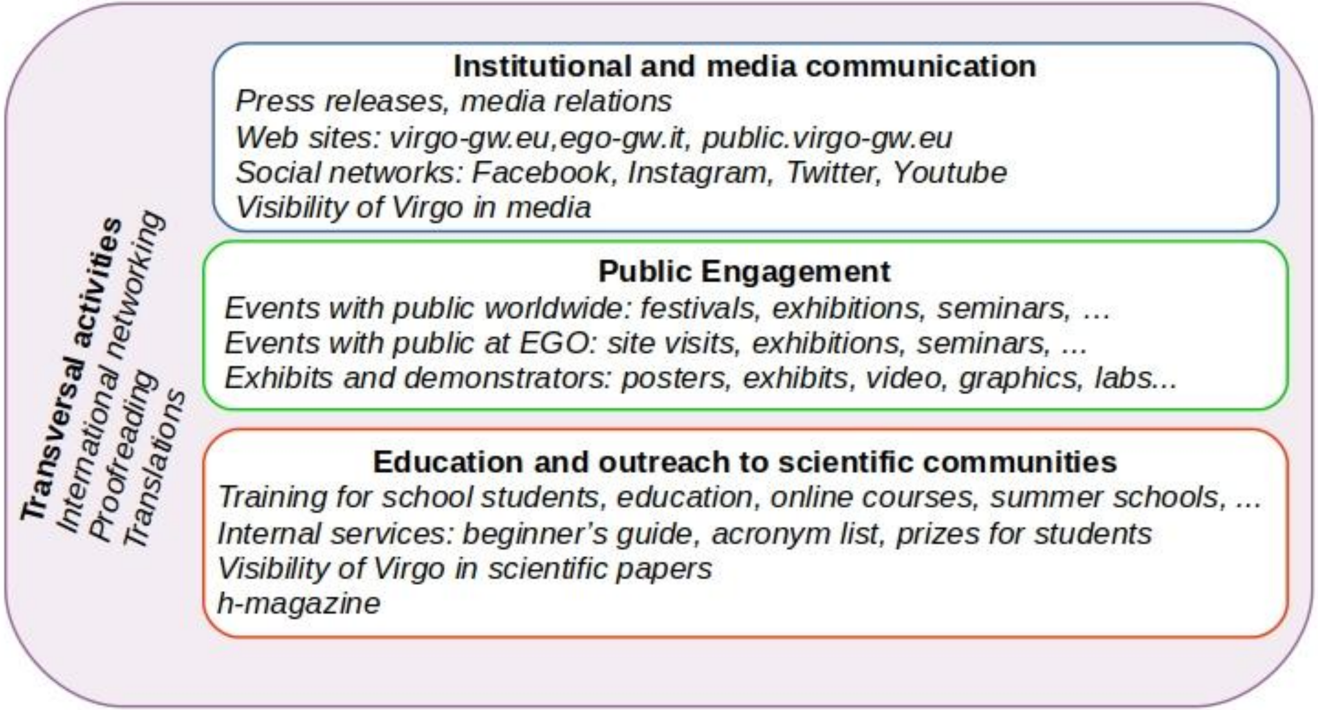
INTRODUCTION AND BACKGROUND

Visit our website at http://www.ligo.org/

#GravitationalWaves #BinaryBlackHole #EinsteinWasRight

Communication + Outreach → Education

- New structure of the Virgo outreach group
    - 3 main pillars



Why is this important? To whom does this matter?

- Communication and outreach should target all audiences
  - General public
    - Curious
      - Minimal knowledge of science required nowadays
        - Technologies more and more present
        - Many worldwide issues (and potential solutions) involve science
        - “Alternative facts” flooding social networks and spreading quickly
    - Taxpayers
    - Voters
  - Students
    - Tomorrow’s scientists
    - Attractiveness deficit of STEM studies in many (all?) countries
    - Higher education and high-school but also younger (undecided) students
  - Teachers
    - “Multiplicative factors”

Why is this important? To whom does this matter?

- Public relation for science
  - To ensure adequate funding for research
  - To get more young people to choose scientific career and one close to your science
  - To strengthen the professional reputation of your science
  - To ensure our society values science
  - To help people use science to make better personal decisions

    → To ensure policy makers use scientific evidence in their decisions

- Nota Bene: studies do not support the claim that increasing science literacy will lead to greater support for science

Why is this important? To whom does this matter?

- It is important for... yourself
  - A rewarding experience in terms of human interactions
    - Public lecture, Q&A with students, lab visit, etc.
      → Definitely worth the preparation effort!
  - A source of self-motivation
    - You can help promoting the science you are interested in
  - A sense of giving back to society, fulfilling a scientist’s duty
    - Most of us are funded by public taxes
      → Need to explain what we are doing and how
  - Outreach and dissemination activities are becoming standard part of a scientist’s CV
    - Although not always valued
      → At least initially: keep trying and involve the whole chain of command

Addressing Diversity, Inclusion and Equity (DIE)

Not only the quantity matters

- Need to increase both quantity AND quality of scientific outreach, taking into accounts needs of the global society:
    - Diversity, Inclusion and Equity (DIE)
- If no special care is taken, efforts of science communicators tend to reach out to specific (e.g., affluent, college-educated, non-disabled) audiences.
- Even with increasing interest in science and public engagement with science, historically marginalized and minoritized individuals and communities are ignored and undervalued in these efforts.

Reaching out far away

bringing science towards people living in remote/disadvantaged areas

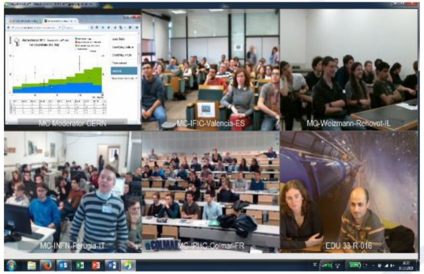
Amanar is a project (now closed) organised by GalileoMobile and the Canary Association of Friendship with the Sahrawi People (ACAPS), in collaboration with the Instituto de Astrofísica de Canarias (IAC) t**o inspire children and teachers from the Sahrawi refugee camps near Tindouf, Algeria, and the Canary Islands, Spain, using Astronomy**.

Interferometer kit from Nikhef (The Netherlands)

The Amanar project: “Our aim is to promote quality science education and support the youth and the teachers from the refugee camps, enhancing both their resilience and engagement in the community through skill development and self-empowerment activities.

On the long term, we aim at raising awareness on the harsh conditions of the Sahrawi refugees and foster a sense of global citizen through Astronomy for the Sahrawi community, that has been in refugee situation for more than 40 years.”

Masterclasses to new countries /areas



- International Masterclasses “Hands on particle physics”
  IMC: https://www.physicsmasterclasses.org

International Masterclasses

- 60 countries
- > 220 research labs
- > 10^4 Students
- Videoconferences at CERN, Fermilab, KEK, GSI, TRIUMF
- Organized by IPPOG, http://ippog.org/

Impact of the COVID-19 pandemic

- all videoconferences suspended by March 18
- only ~ 25 % of Masterclasses completed

Our response:

1) **BAMC** (Big Analysis of Muons in CMS)
   Simplified analysis, online support, teachers involved
   ~700 students participated, Apr and May; ~35K events analyzed

2) **Masterclass@home**
   Masterclass delivered online to groups of individual students, lectures+analysis spread over two afternoons

3) **IMC Summer VCs**
   arranged end of June, offered to all IMC institutes, very low turnout

2

Bilow + Cecire, ICHEP 2020 10

- https://indico.cern.ch/event/868940/contributions/3814087/attachments/2080598/3498844/2020_07_ichep_current_status_of_imc_v4.pdf

Masterclasses to new countries / areas

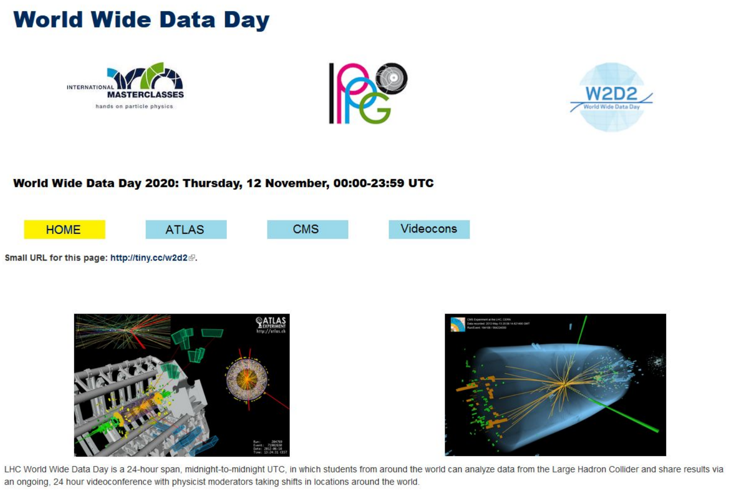
- Angola
- Armenia
- Baltic states
- Brazil
- Germany
- Hong Kong
- India
- Mexico
- Mozambique
- Poland
- Taiwan
- UAE
- Ukraine
- USA
- Vietnam
- Zambia

- New South Wales

- IMC builds on collaboration and new masterclasses
  → Strategy for expansion
  - Geographically: see sample list of countries on the right
    - Language, local mentors, diversity
  - Thematically: astronomy, astroparticles, etc.
  - [Still opportunistically]
- High impact from covid-19
  - Contacts preserved, interest remains strong

→ New tools / frameworks

- Less complex -- web event displays
  - Big Analysis of Muons (ATLAS/CMS)
- Direct-to-student virtual masterclasses
- World Wide Data Day: https://quarknet.org/content/world-wide-data-day



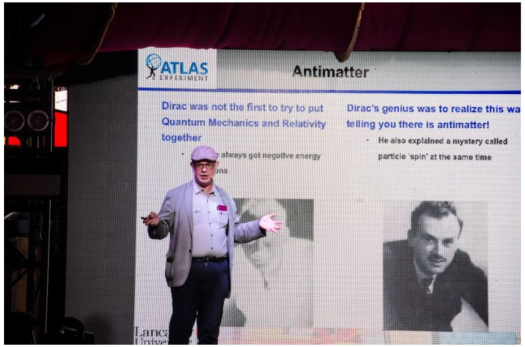
Reaching out to different public

- <u>Example:</u> music festivals!
  - Reaching out to other audiences
    - that don’t expect to see science
    - that you wouldn’t have imagined connecting to
    - and that are nevertheless quite interested, when a ‘cool’ opportunity shows up

Magical science at Pohoda festival, Slovakia
Jul 11-13, 2019

The largest art/music festival in Slovakia – limited capacity of 30 000 visitors

Norbert Werner, Beating hearts of galaxies



Roger Jones (Lancaster U), Antimatter

Programme details

- Friday Jul 12, 9:00 – 13:30
  - Simple experiments
  - Why and how we wake up
  - Cloud chamber workshop
  - What have CERN and the LHC ever done for you
  - What is space made of?
  - The physics of beer workshop

M. Mojzis, Neural networks which paint like Picasso

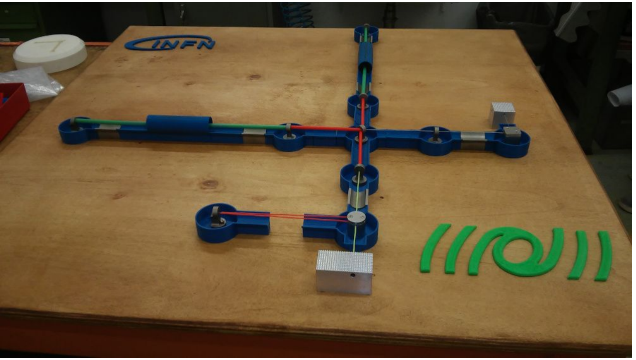
- Saturday Jul 13, 9:00 -13:30
  - Cloud chamber workshop
  - What‘s the matter with antimatter?
  - Beating hearts of galaxies
  - Mad science (simple experiments)
  - Neural networks which paint like Picasso
  - Smells, pheromones and passion

B. Sitar, What have CERN and the LHC ever done for you

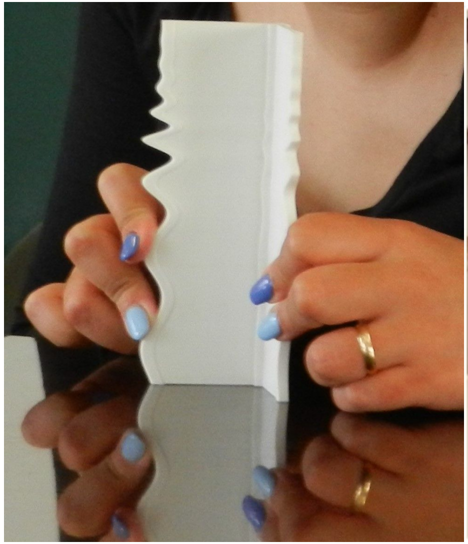
Improving access to science for Visually Impaired People

- Lots of effort worldwide to make science accessible to VIP
  - Development of tactile exhibits and experiences

Tactile panel
of Advanced Virgo in O3



Tactile rendering of the effect of GW passage on interferometer vs time

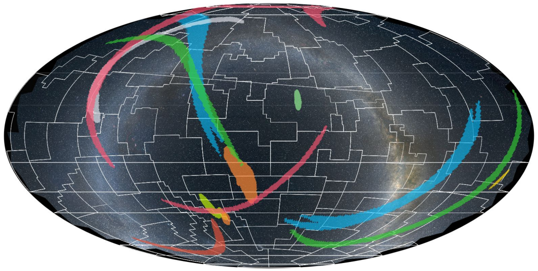


3D printable model shared in:
https://www.thingiverse.com/thing:4755899

Improving access to science for Visually Impaired People

lots of effort worldwide to make science accessible to VIP:

- sonification of astronomical signals



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.
Work in progress

Sonification :

- offers new ways for scientists to study data, by employing the highly developed sense of hearing as an adjunct to data visualization
- provides blind and VIP with a new level of data access and analysis

Interesting interview to Wanda Diaz Merced:
https://www.nature.com/articles/d41586-019-03938-x

- sound of GW signals: https://www.gw-openscience.org/audiogwtc1/

Fighting stereotypes

- Scientists are neither crazy nor magicians

Who are these scientists?

Good question! I have often tried to ask children this question, and the answers were usually that scientists are crazy, absent-minded, messy, very bad (or perhaps very good), and often dangerous. They also know everything, but do not think about the consequences of what they do; they want to destroy the world (or perhaps to save it). Then, I tried to ask those children what sort of people they imagined scientists to be. And it turned out that they imagined them as being male, and always wearing white coats. Then, there was usually a description of tinkering test tubes and glassware, of mixing colored and perhaps smelly steaming liquids. Or they imagined them building complicated machinery, full of small lights and switches—so complex that no-one even understands how it can hold itself together without falling apart, much less how it works. It often ends up blowing everything up, destroying machinery, glassware, and scientist.

But this is absolutely not true!

Let's start from the coat. In movies and cartoons, scientists always wear a coat to distinguish themselves from the others, so that we recognize them. But in reality, only some scientists, chemists or biologists, for example, put on a white coat, and only when they have to do things where they might get dirty. Then, the world is also full of female scientists, who are as brave as their male colleagues, if not braver. Anyway, no scientist, man or woman, with or without coat, would want to blow up just for the sake of an experiment. Indeed, in general, scientists are very careful to avoid this. And do you know why? Because they are normal people. They have a mom and a dad, they are often married and have children. They go to the grocery store, and also to the doctor's, when they are sick. When they can, they go to the cinema, and also on vacation to the beach or to the mountains. They sometimes build complicated machinery, this is true (things such as telescopes, or even worse, particle accelerators), but they have good knowledge of it. They know how it works and know every piece of it. And they do all this only because they want to understand how things in the world work.

6

https://www.lnf.infn.it/edu/kids/da-qui-al-big-bang.php

https://ippog-static.web.cern.ch/ippog-static/resources/2015/da-qui-al-big-bang.html

- Scientists are not necessarily white senior males

Removing (English) language barrier

Select Language ▼

Not the solution...

LSC LIGO Scientific Collaboration VIRGO

News | Detections | Our science explained | Multimedia | Educational resources | For researchers | About the LSC | LIGO Lab | Observing Plans

Intro to LIGO & Gravitational Waves | Science Summaries | Popular Articles | Frequently Asked Questions | Magazine | Advanced LIGO

GW190521: THE MOST MASSIVE BLACK HOLE COLLISION OBSERVED TO DATE

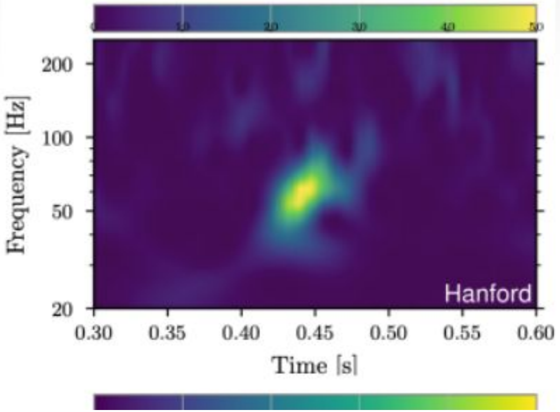
Dated 02 September 2020. Read this summary in PDF format (in English) and in other languages: Blackfoot | Chinese (traditional) | Dutch | French | Galician | German | Greek | Hindi | Hungarian | Italian | Japanese | Korean | Marathi | Polish | Spanish .

WHAT DID WE OBSERVE?

On May 21, 2019, the Advanced LIGO and Advanced Virgo detectors observed a gravitational-wave signal from the merger of an extraordinary pair of black holes. The signal, named GW190521, was shorter in duration, and peaked at lower frequency, than any other binary black hole merger observed to date.

The time interval that the signal from a binary black hole merger spends in the sensitivity band of Advanced Virgo and Advanced LIGO is inversely proportional to the total mass of the binary system. In the case of GW190521 this time interval was only about 0.1 seconds, much shorter than for e.g. GW150914 — the first

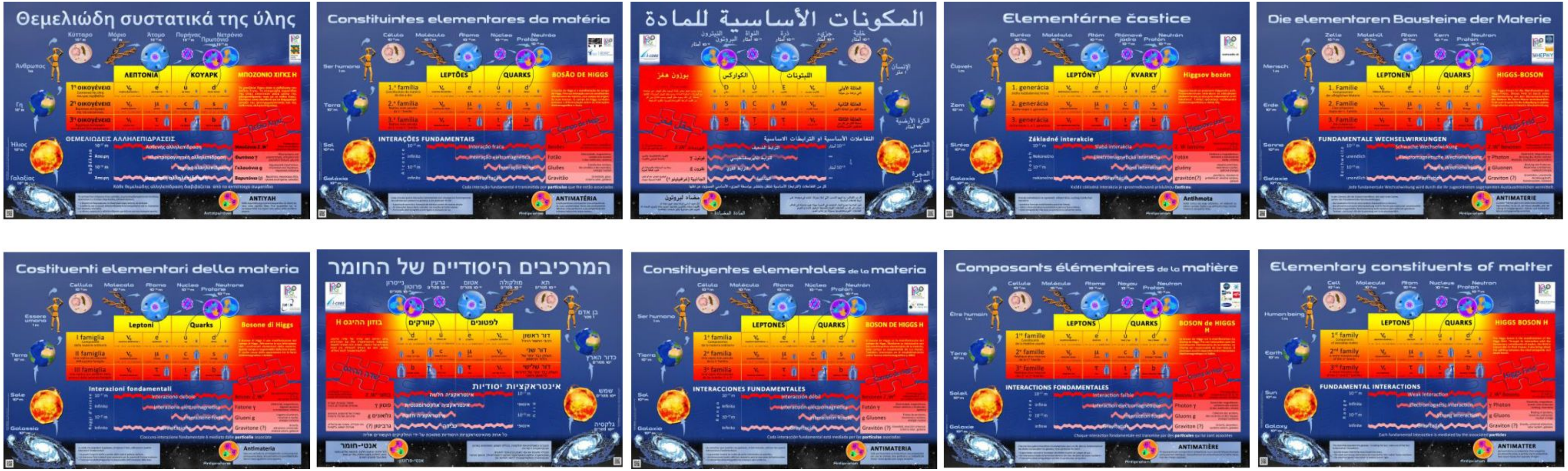
FIGURES



Translation is an integral part of outreach and communication

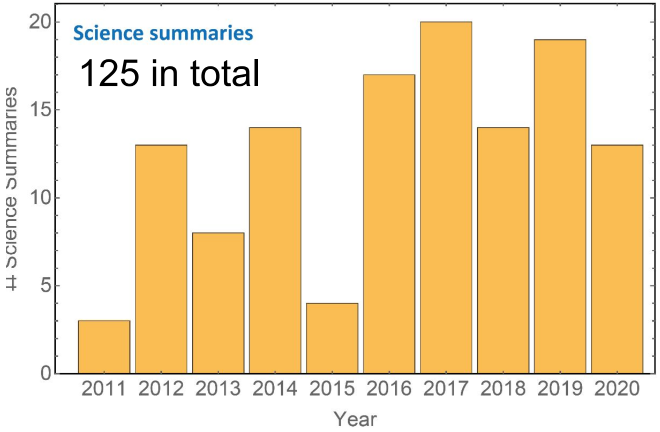
- Example: poster about “Elementary constituents of matter”

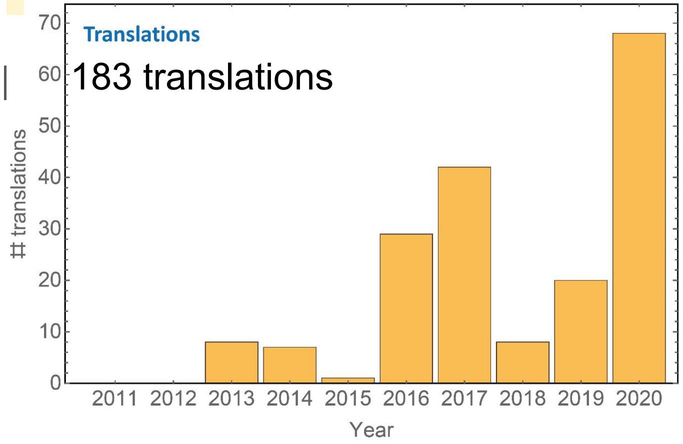
  → *Which one is the original?*



LIGO-Virgo science summaries

- Short scientific accounts of scientific articles authored by LIGO-Virgo
  - 1-4 pages: longer than associated press release, with more scientific information
  - Target audience: the general public
  - External references (mostly from Wikipedia) + glossary defining the main keywords / concepts
  - Master version written in English; then translated in as many languages as possible
- Some stats (from https://tds.virgo-gw.eu/ql/?c=16027)

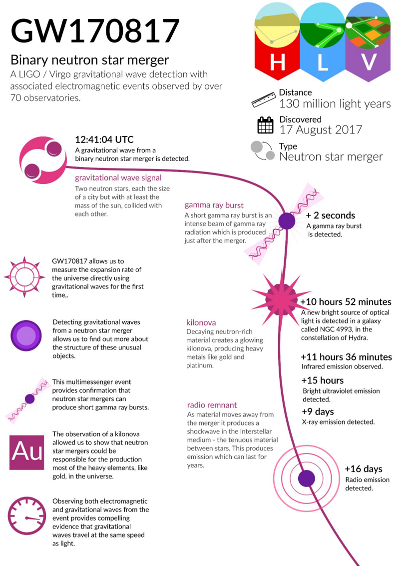




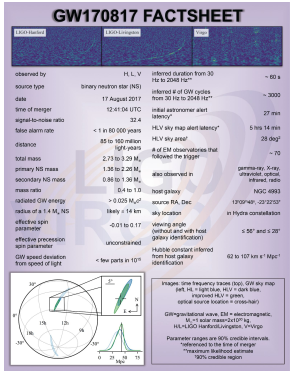
[it]: Italian (Italiano)	(19)
[ja]: Japanese (Nihongo)	(9)
[ko]: Korean (Hanguk-eo)	(4)
[mr]: Marathi	(3)
[ne]: Nepali	(1)
[nl]: Dutch (Nederlands)	(3)
[pl]: Polish (Polszczyzna)	(1)
[pt]: Portuguese (Português)	(6)
[ru]: Russian (Rússkiy)	(1)
[zh]: Chinese (Hànyǔ);	(6)
sometimes two versions are available:	
[zh-Hans] (simplified characters)	(0)
[zh-Hant] (traditional characters)	(5)
[bla]: Blackfoot (Siksiká)	(3)
[bn]: Bengali (Bangla)	(2)
[de]: German (Deutsch)	(51)
[el]: Greek (Ellinika)	(3)
[es]: Spanish (Español)	(39)
[fr]: French (Français)	(20)
[gl]: Galician (Galego)	(1)
[he]: Hebrew (Ivrit)	(1)
[hi]: Hindi	(2)
[hu]: Hungarian (Magyar)	(1)

84% in "Virgo languages"

LIGO-Virgo science summaries

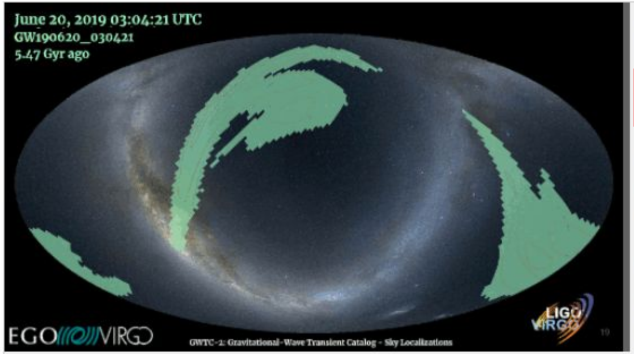


- Prepared by the PWT in various formats
  - pdf, html, flyer
  - Mandatory for LIGO/NSF
  - Not required (so far) on the Virgo side
- Difficulties
  - Not all science summaries are equally “popular”
    - Number of translations varies a lot: 0-O(10)
    - Good translation does take time:
      - Wording: try translating “strain” or“squeezing” in your favourite language
      - Turns of phrase: English much more concise than, say, French
    - Voluntary basis: translations usually done by scientists on spare time
  - Style and level of complexity not uniform among original authors
    - Mitigations: 1 → 2 main authors when possible + reviewers
    - Attempts to pool resources
      - Same language in different countries: single translation effort
- Complementary to other resources
  - Factsheet, infographics



Translation is an integral part of outreach and communication

- Virgo press release and news
  - Drafted, proofread and published in English
  - Translated into (all) “Virgo languages”



Over 100 black holes detected by Virgo and LIGO in the first run of 2019

Change article language:

The classification and definitive analysis of the 39 events detected by Virgo and LIGO in the third observation period (which ran from April to October 2019) was published today on the ArXiv online archive. Most of these are black hole mergers, the characteristics of which, however, question some established astrophysical models and open up new scenarios. A likely merger of neutron stars and two probable 'mixed' neutron star-black hole systems were also detected in the same period.

It took a year of work and complex analysis by the researchers of the Virgo and LIGO scientific collaborations to complete the study of all of the gravitational-wave signals that were recorded by the Virgo interferometer, installed at the European Gravitational Observatory, in Italy, and the two LIGO detectors, in the US, during the data-taking period - called '03a' - which ran from the 1st of April to the 1st of October, 2019. Events included: 36 mergers of black holes; a likely merger of a binary system of neutron stars; and two systems that were most likely composed of a black hole and a neutron star. Among these, four “exceptional events” have, during the last year, already been published, but the catalogue released today provides, for the first time, a complete picture of the extraordinarily large number of recorded gravitational-wave signals and their sources. It represents a wealth of observations and data on the physics of black holes, barely imaginable until only a few years ago.

Some thoughts about DIE in science comm

Universal Design for learning is a set of principles that allow teachers with a structure to develop instructions to meet the diverse needs of all learners. (Wikipedia)

exhibits, techniques, approaches that are developed in particular to suit people with special needs have indeed much wider application: they can be used to increase the understanding and appreciation of science by anyone

However some special needs require tools which cannot be easily standardized but are better tailored to the specific needs of a person.

Common barriers preventing DIE in science comm:

- existing organizational structures in research and the academy
- inherent, unconscious, and implicit biases
- lack of funding
- lack of understanding, knowledge, training, or resources for doing inclusive science communication

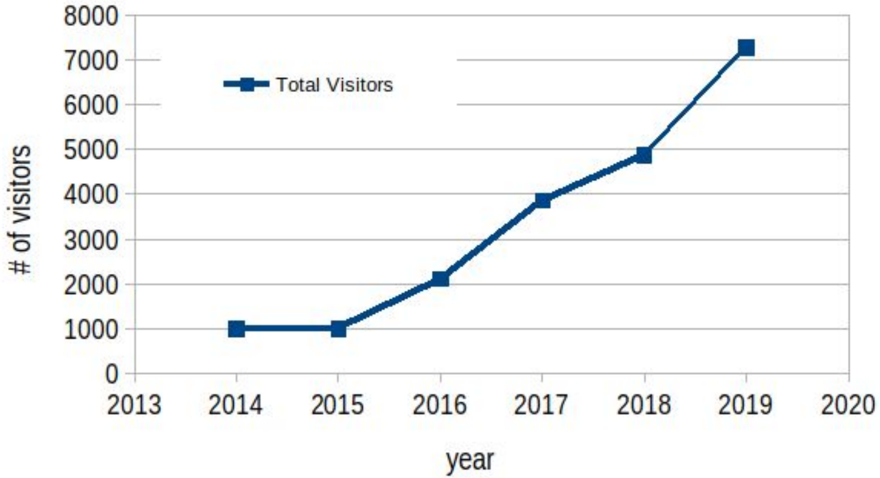
Visiting EGO-Virgo

Site visits

- A lot of visitors at each site
  - General audience, teachers and students
  - Boost after first detection announcements
    - Steady upward trend since then
      - 7× more in 5 years at EGO: 200/week in 2019

        → Stressing the system a lot:

        voluntary basis for visit management + guides



- In February 2020, the calendar of visits was almost fully booked for the whole year

- Due to the pandemic, the program of (in person) visits at EGO and Virgo was stopped at the beginning of 2020

Site visits

- Pandemic
  - Abrupt stop of all visits on-site
  - Development of a regular offer for virtual visits
    - Based on pre-existing plans/reflections, boosted by covid-19
    - Short conference + virtual tour live + Q&A
    - → Still ramping up
    - Several languages

- Longer term plans
  - Reopen in-person site visits
  - Continue the offer of live remote visits
  - Complement with virtual tour based on immersive spherical photos

Virtual tour to Virgo based on immersive spherical photos

(under development)

(courtesy of G. Ciani, Virgo Collaboration)

- Can be used
  - in standalone by a visitor
  - a Virgo scientist can use it to tour a group of people around
- Opportunity to visits access-restricted areas
- Visitors can stroll and poke around.
- Interactivity is the key
- Technical requirements can be very basic: the tour must be experienced with a variety of devices, including augmented reality goggles.

In-person vs remote/virtual visits

- Both the live visits and the virtual tours target (high) school students and the general public

- Remote visits provide access to Virgo to international and wider audiences
  - People do not need to travel to Pisa to visit Virgo
  - Limited the amount of information that can be passed on
    - Not too concrete
    - Keep people’s attention / focused on the visit
    - Q&A session more difficult?

- In-person visits offer *the real experience*
  - Very impacting from an emotional viewpoint
  - Fundamental to make a long-standing effect
  - Limited number of visits and of visitors per visit

→ Complementary: should pursuit both ideally
→ We still have to assess the impact and outcomes of the visits

Art & Science

Art & Science

A new prolific trend in science communication:

scientist's viewpoint: use the universal language of art to convey a scientific message and engage people with science

- Make science more appealing
- An entry point to talk about science
- Artists have interesting point of views

Target: general public

Larger audiences

GW190521

Image credit: Raúl Rubio / Virgo Valencia Group / The Virgo Collaboration

- Image developed by Raul Rubio in collaboration with Virgo-LIGO
  - Selected as Astronomy Picture Of the Day : https://apod.nasa.gov/apod/ap200908.html
- News item available in 7 languages

GW190814

GW190814 - the merger of a 23-solar-mass black-hole and an enigmatic lighter object

Change article language:

Another unprecedented discovery has just been unveiled by LIGO-Virgo scientists. Data from the third observation period (O3) of the Advanced LIGO and Advanced Virgo detectors reveal that, at 21:10 (UTC) on the 14^{th} of August, 2019, the three instruments in the network detected a gravitational-wave signal, called GW190814. The signal originated from the merger of an enigmatic couple: a binary system composed of a black hole, 23 times heavier than our sun, and a much lighter object, about 2.6 times the mass of the Sun. The merger resulted in a final black hole about 25 times the mass of the sun.

It is this lighter object that makes GW190814 so special. It may just be either the lightest black hole or the heaviest neutron star ever discovered in a binary system. Another peculiar feature of GW190814 is the mass ratio of the objects in the binary system. The factor 9 ratio is even more extreme than was the case with the first detected merger of a binary with unequal masses, GW190412.

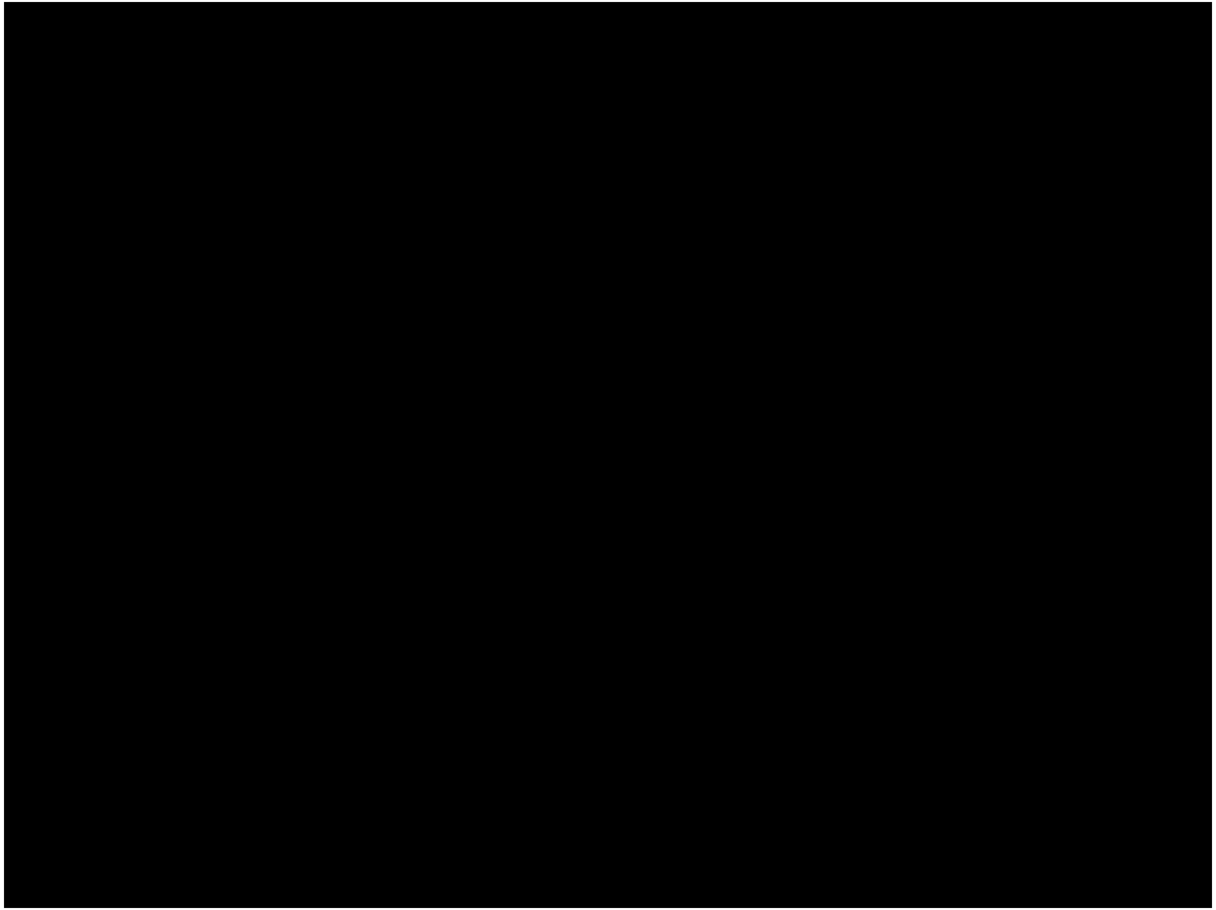
An artist's impression of the mysterious cosmic object, which weighs about 2.6 solar masses and lies 780 million light-years away — or did, until a black hole consumed it. Alex Andrix/Virgo/EGO

By Dennis Overbye

Published June 24, 2020 Updated June 25, 2020

- Image/Animation credit: Alex Andrix
    - Developed in collaboration with Virgo-LIGO
    - Available at: https://vimeo.com/413180380
- News item available in 6 languages
- Good resonance out of the LIGO-Virgo community

GW190814 artistic interpretation by Alex Andrix



Dance & choreography

High conservatory of dance of Valencia (Spain), performance based on GWs, 100th anniversary of the 1919 eclipse

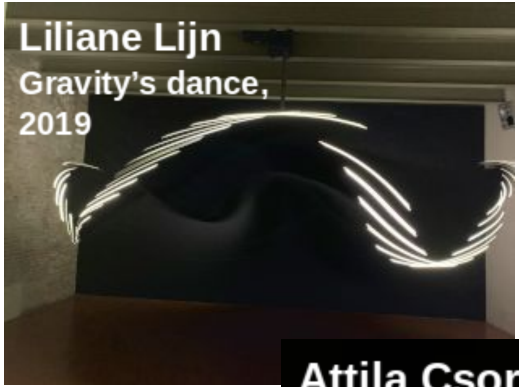
Surfing Einstein - On the track of Gravitational Waves

Choreographer and dancer: Meritxell Campos Olivé

https://vimeo.com/290147565

"Surfing Einstein is a two legs project: it is a dance pièce inspired by the gravitational waves' hunters, the physicists, and a documentary, whose central narrative is based on their charisma and feelings."

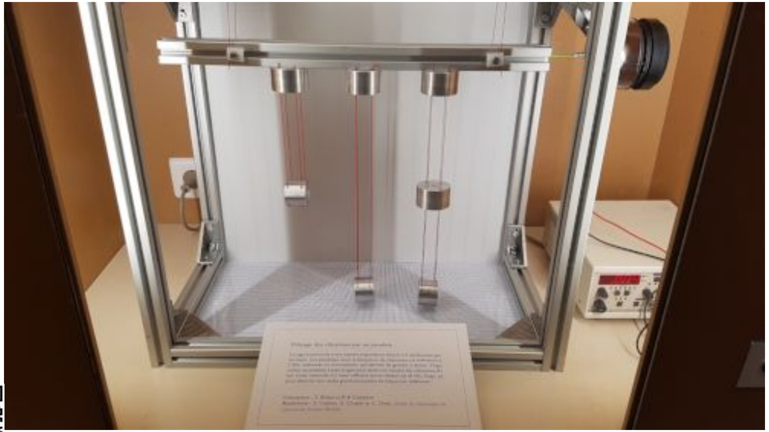
Art&Science Exhibition

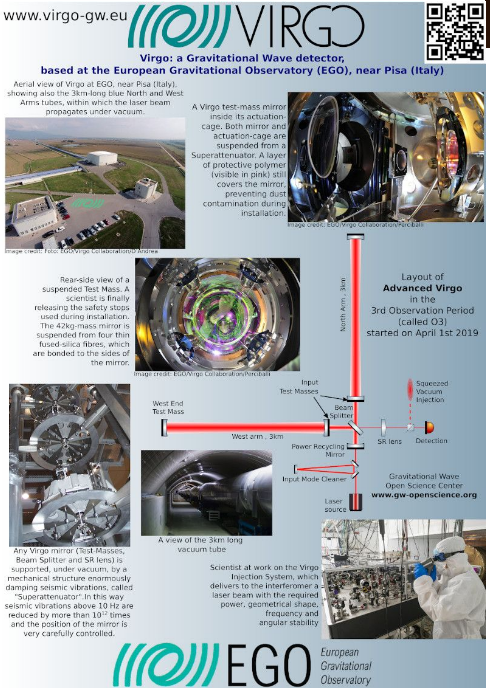


"The aim of the project is to initiate an exploration, through a **cross-reflection between artists and scientists**, of the field that began with the discovery of gravitational waves, urgently questioning again the nature and texture of space-time and matter, the notions of origin and horizon, the role of representation, information and transformational activity, artistic or scientific, the questions of individuality " (S.Katsanevas)

Scientists producing outreach contents

Exhibits
& posters



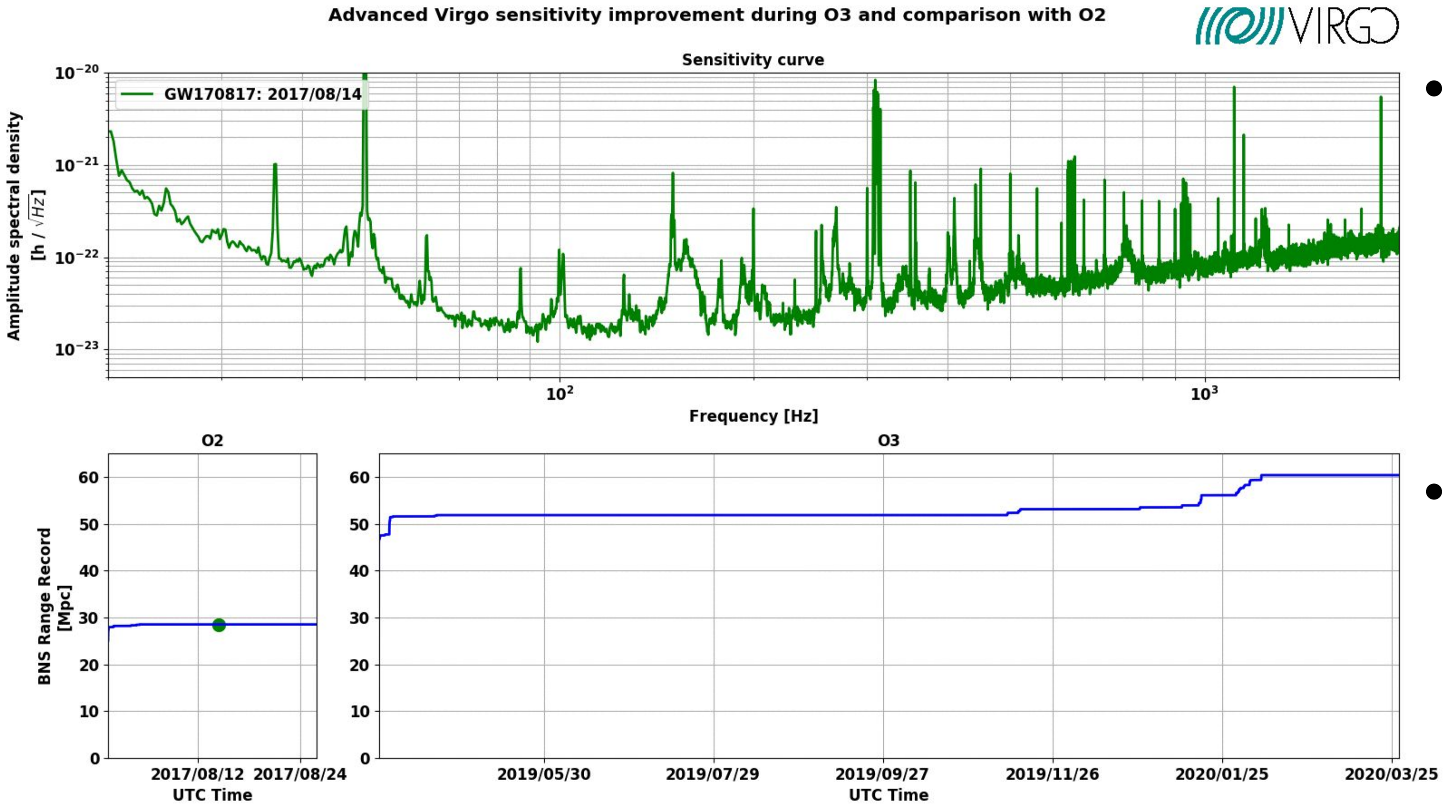


Production of time lapse videos:
[Virgo playlist on YouTube]

Ready-to-print
multilingual poster
of Advanced Virgo in O3

English : VIR-0645A-19
Italian : VIR-0745A-19
French : VIR-0836A-19
Polish : VIR-0834A-19
Spanish : VIR-0835A-19

Production of outreach plots and animations by scientists

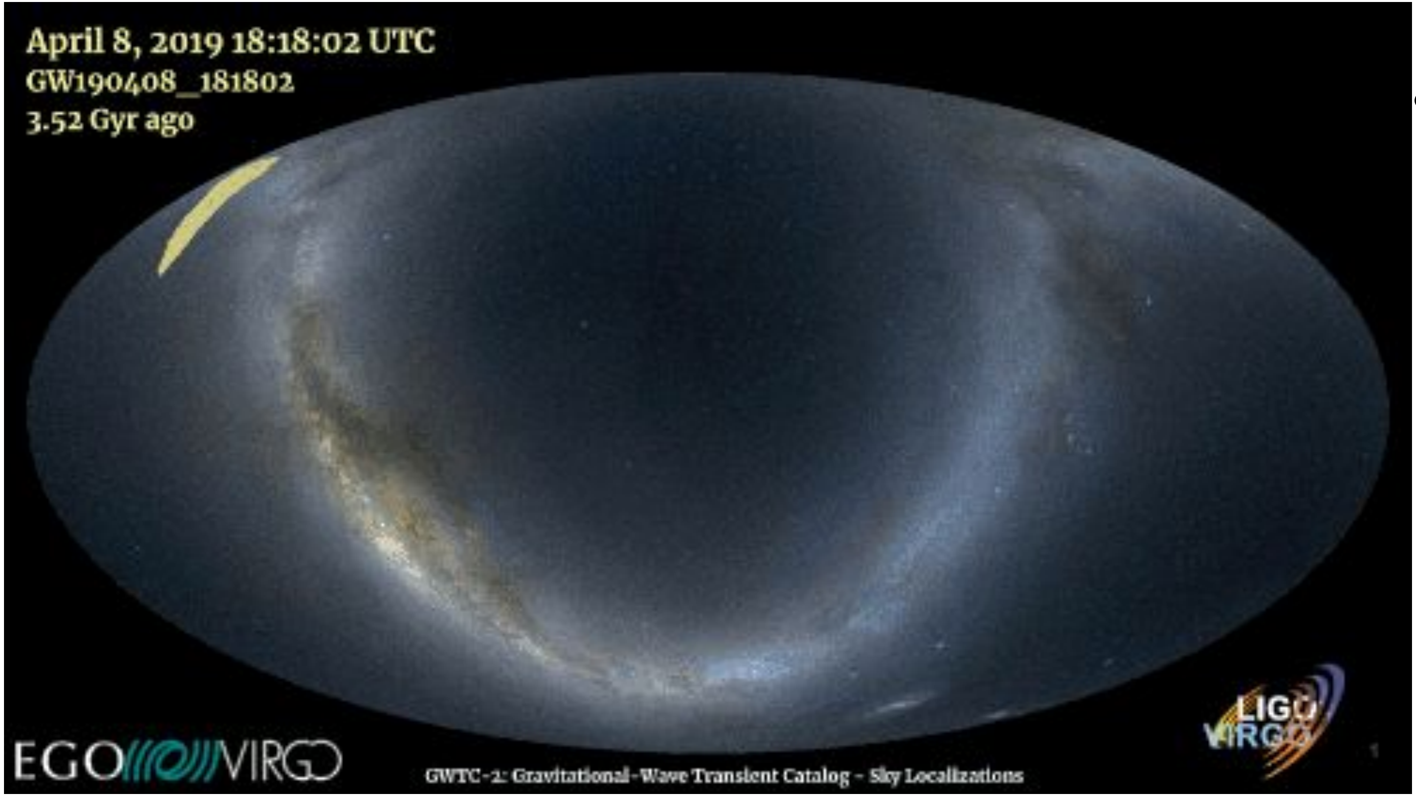


- GW detector sensitivity
    - Amplitude spectral density vs.
    - Frequency

- Average distance up to which a binary neutron star merger can be observed
    - Goes up as sensitivity goes down

https://www.virgo-gw.eu/status.html

Production of outreach plots and animations by scientists



- Source localization skymap
    - Area in which the GW source is likely to be located

→The smaller, the higher the probability a telescope could find an counterpart [if existing]

Engaging people in the social media

Web sites used for searching more in depth knowledge and for institutional communication.

Live engagement kept with social media.

LIGO, Virgo, KAGRA are active in the social media with frequent updates:

- Facebook
- Instagram
- Twitter
- Youtube

In some cases, social media accounts are shared, eg LIGO-Virgo jointly on Instagram

Attention to produce different content targeting different audience (both age and location/language) in the various social media.
Ideal to have professionals in parallel with scientist for managing the accounts.

Resources and references

- https://www.virgo-gw.eu https://www.ligo.org
  https://www.ligo.caltech.edu
- IGrav
  - *The mission of IGrav (the **International Gravity Outreach Group)** is to engage people throughout the world in exploring the exciting field of gravitation, and in particular gravitational-wave and multi-messenger astrophysics. IGrav will accomplish this mission through the creation, sharing and dissemination of a variety of educational and outreach materials.*
    https://www.igrav.org [In construction]
- https://ippog.org
  https://ippog-static.web.cern.ch/ippog-static/resources.html [Upgraded websites online soon]
- https://in2p3.cnrs.fr/fr/mediation-scientifique-et-communication
  https://home.infn.it/it/comunicazione