Engaging diverse audiences worldwide to the quest for gravitational waves

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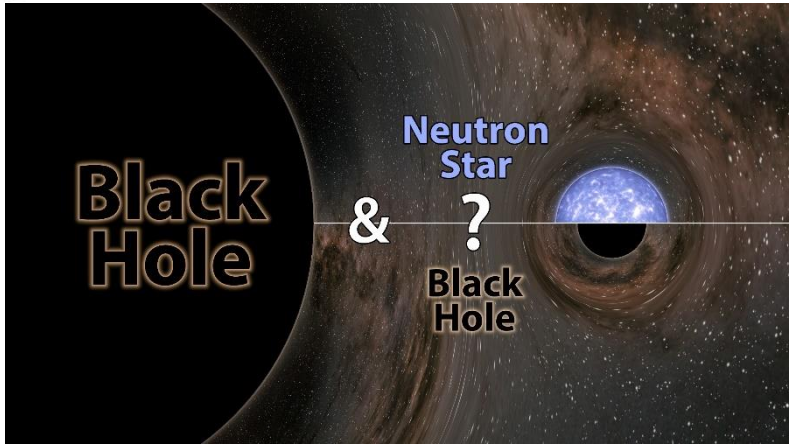
On behalf of the Virgo Collaboration and the LIGO Scientific Collaboration

VIR-0686A-20 DCC G2001214

LIGO Scientific Collaboration

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

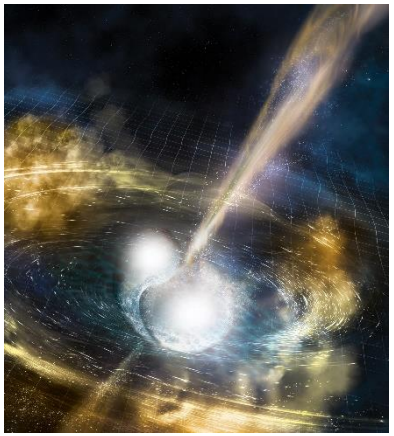
O3 alerts Christmas tree: December 2019

LIGO and Virgo: detecting gravitational waves

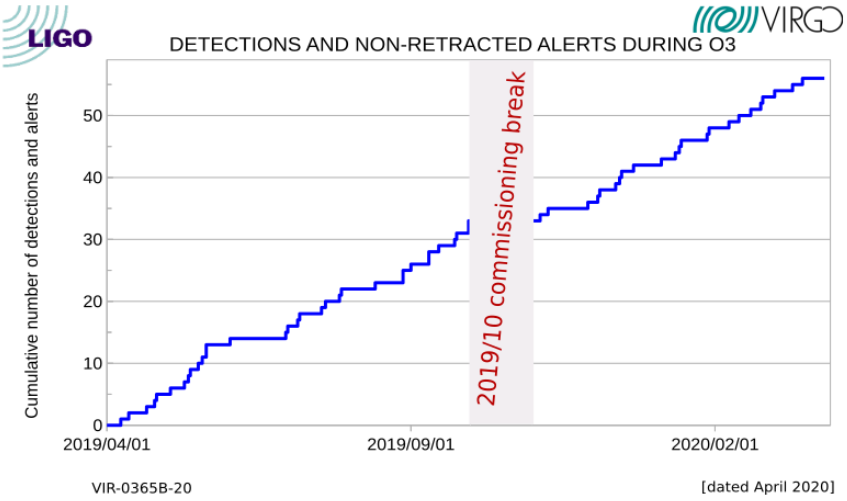
- Two collaborations, three detectors – KAGRA addition to the network in progress
  - Joint searches for gravitational waves (GWs)

→ Giant Michelson interferometers with Fabry-Perot cavities in the kilometric 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

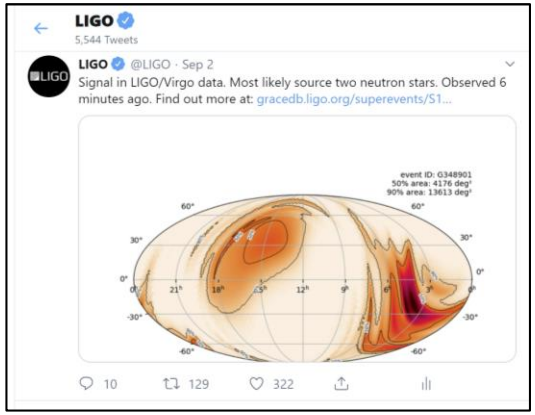


Public alerts

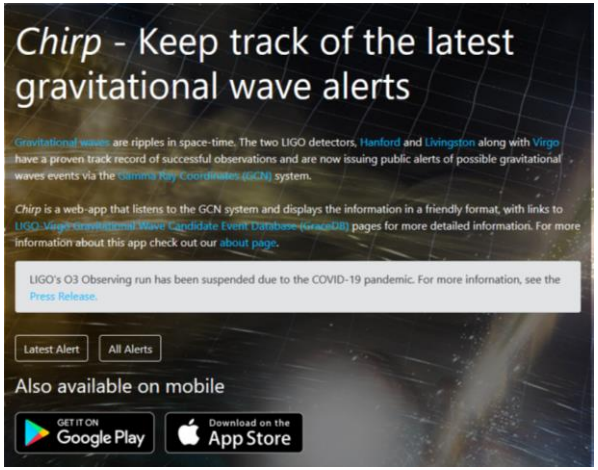


- Twofold goal: detecting GWs and helping to locate the source in the sky
  - → Low-latency info including a skymap
    - Few tens of minutes at most
  - 56 such alerts during O3

- 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 ~3.4 Msun* (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.

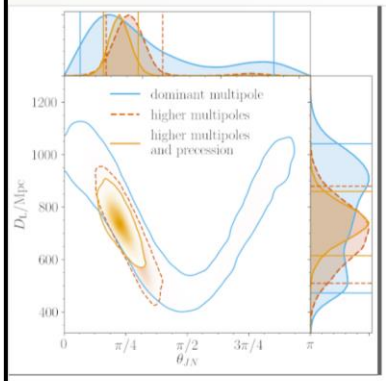
SELECTED IMAGES & VIDEO

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]

LIGO news

Posted: 23/06/2020



GW190412: The merger of two black holes with unequal masses

Change article language:

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 GW191412 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

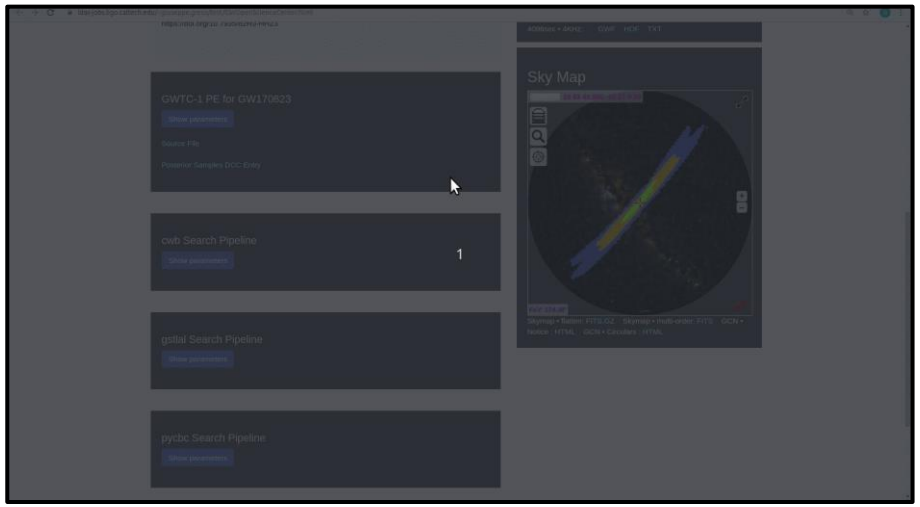
Binary Black Hole Merger animation

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

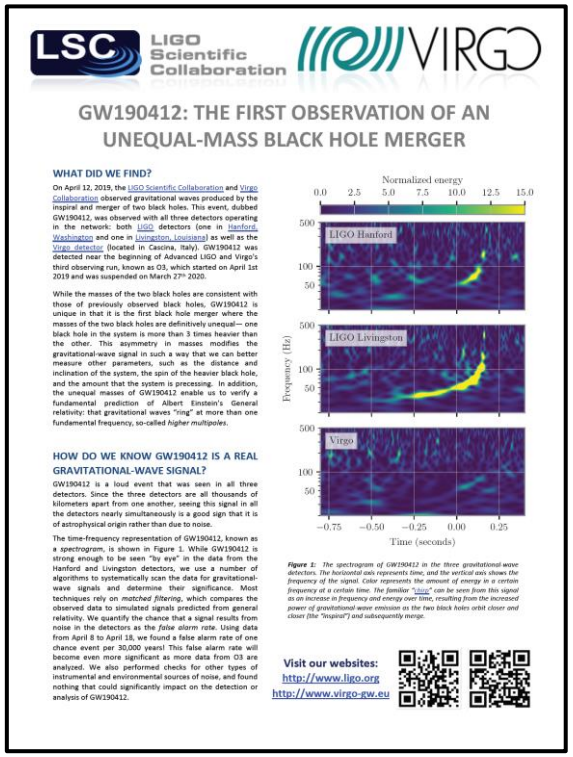
      → Not always easy to find the right balance between scientific correctness and artistical interpretation

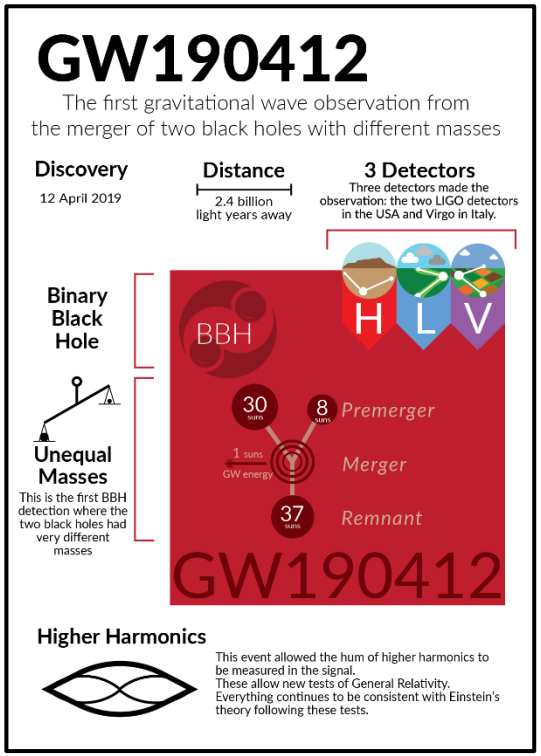


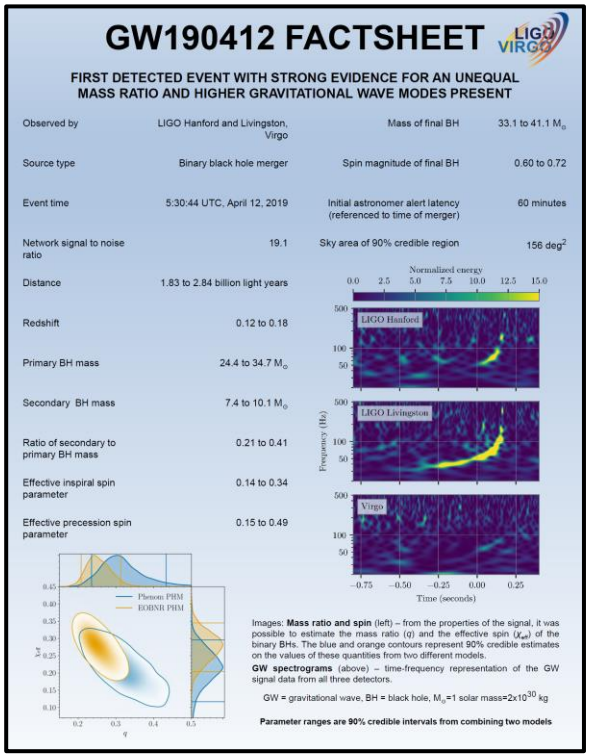
https://www.virgo-gw.eu/video/gw190814.html

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

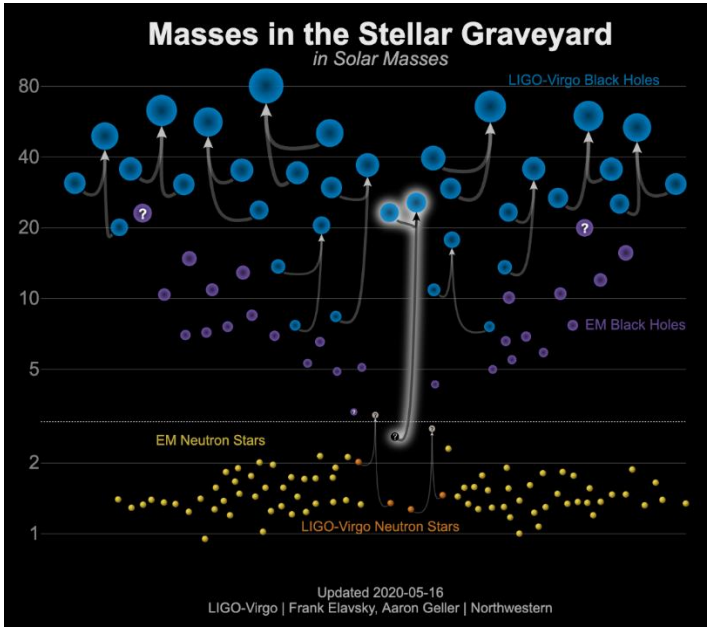




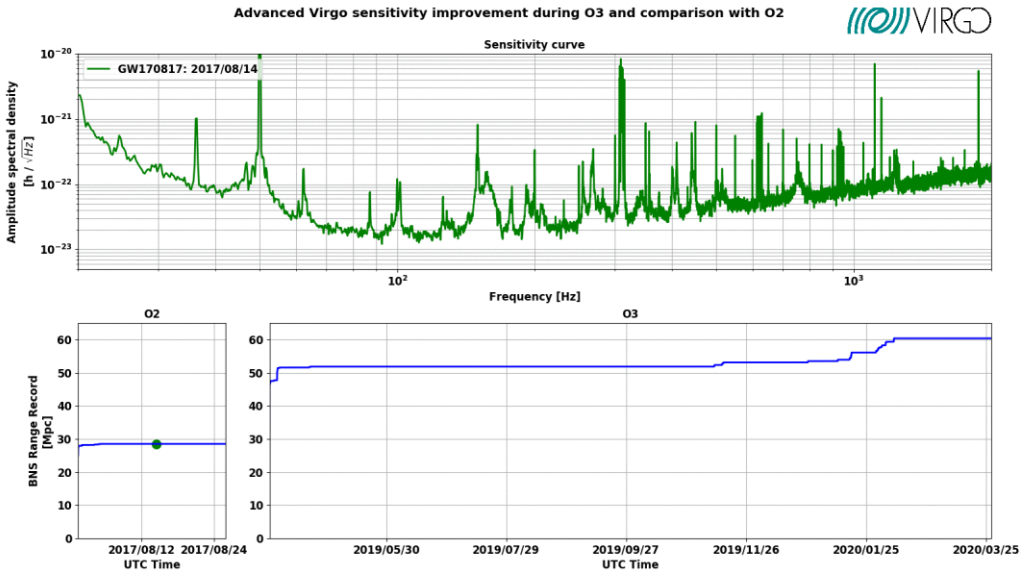


Outreach plots and animations

- 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

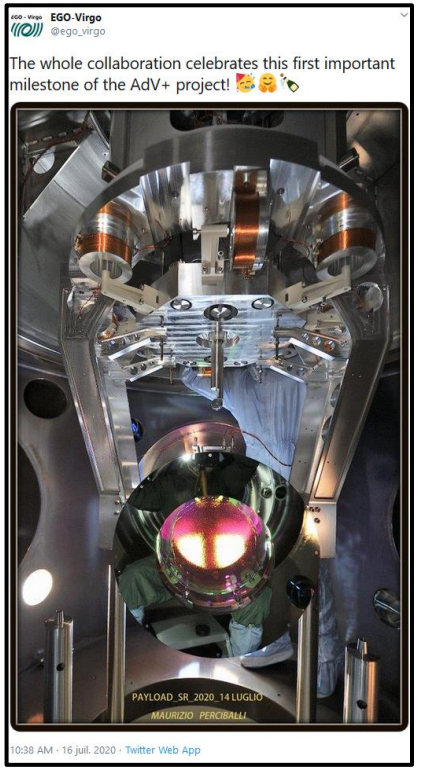


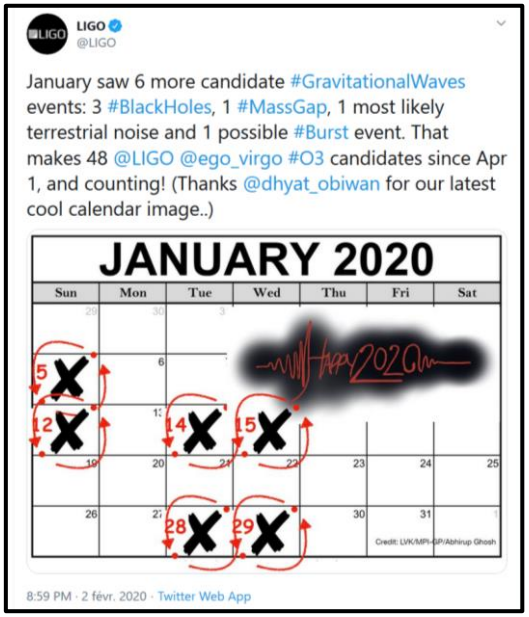
Focusing on LIGO-Virgo members

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

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





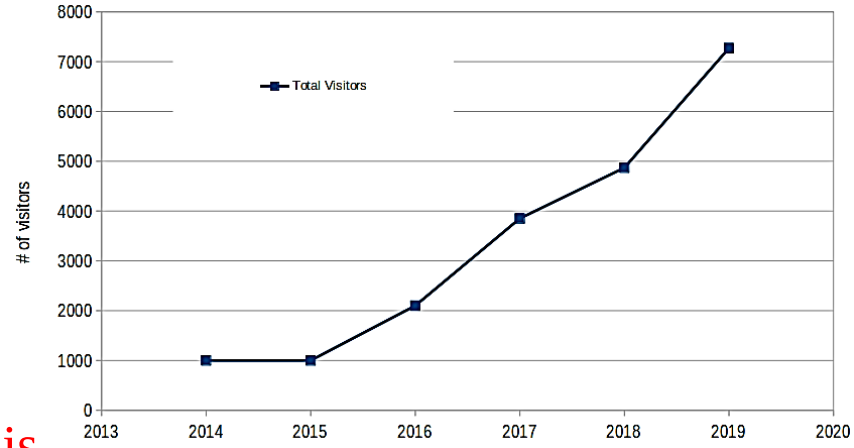
Site visits: for real and virtual

- 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

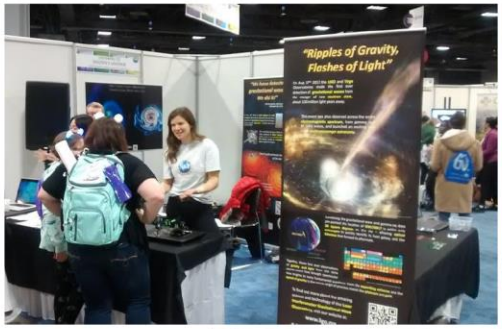
- Astronomical observation evenings
  - Including talks about GW & Virgo + site tours

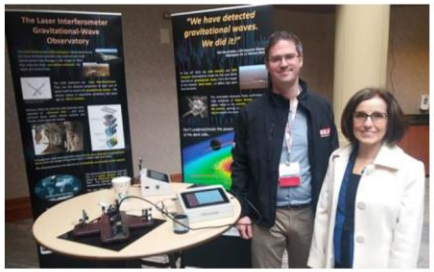
Site visits: for real and virtual

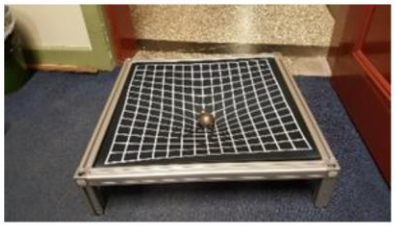
- Pre-existing plans to setup a regular offer of virtual visits
  - Conference + connection with scientists onsite / standalone: spherical pictures
    → Higher priority now given the circumstances
  - Virgo virtual visits during the Genova Science Festival at the end of October
- EGO: purchase of cameras 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

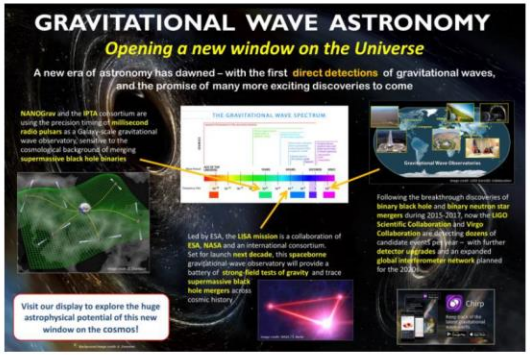
Science festivals

- Pictures from LIGO booths at conferences or public events





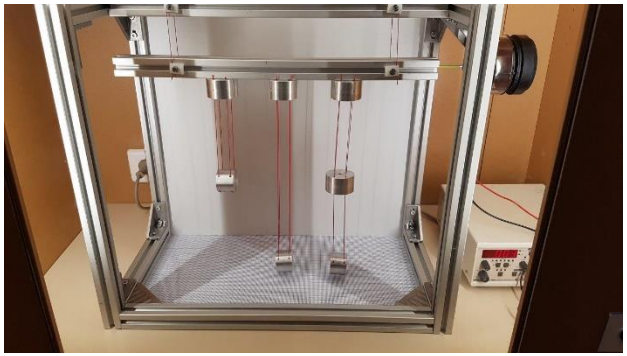


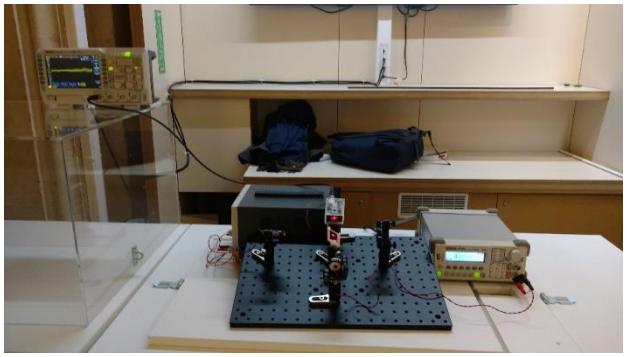


Virgo exhibitions

- 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 »



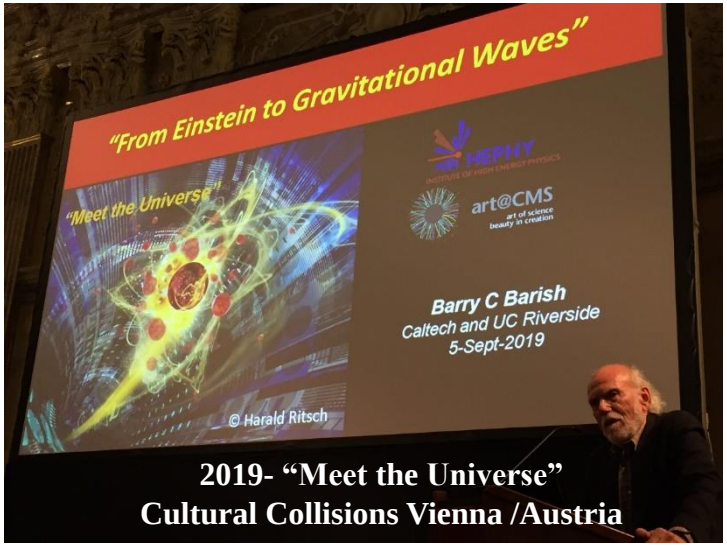


- Virgo exhibition at the 2020 Euroscience open forum (ESOF) in Trieste
  - Postponed to September
    → A major post-lockdown event in Italy

- Parma Italian Capital of the Culture in 2020: postponed to 2021

The Origin Network

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



2019- "Meet the Universe"
Cultural Collisions Vienna /Austria

Oman Science festival 2019

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
Muographix collaboration
VIRGO collaboration

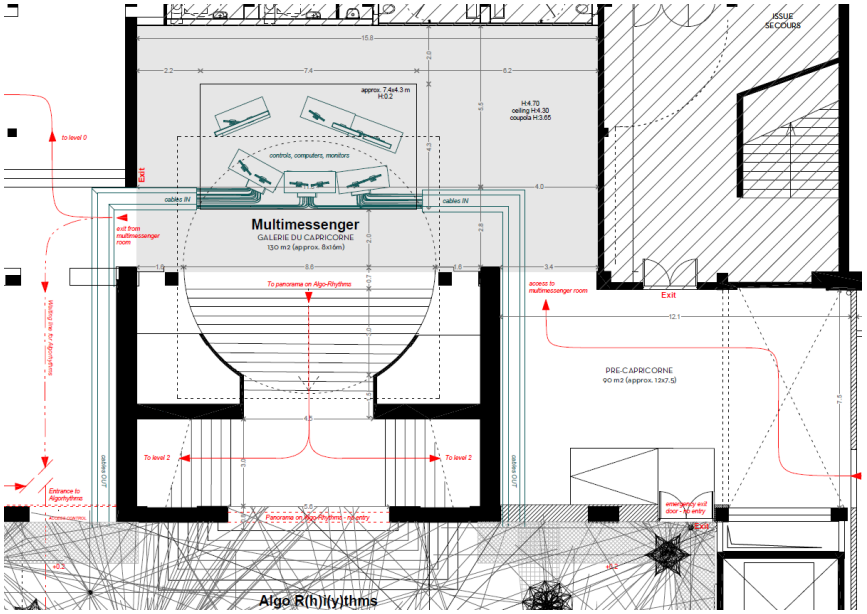
ART-SCIENCE PARTNERS

art@CMS
Fine-Art Muographer
Cuántico

Art & Science: multimessenger room

- Tomas Saraceno's exhibition at Palais de Tokyo in Paris
  - Famous modern art museum in Paris

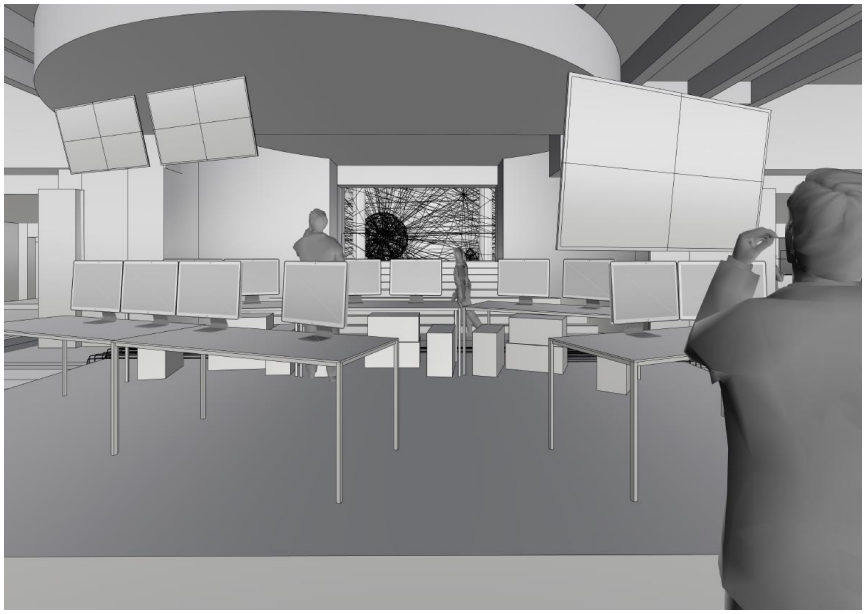
- Multimessenger room
  - Gathering (live) data from IceCube, Antares, KM3Net, Virgo, Auger
    → Images and sound



Carte Blanche à Tomás Saraceno
ON AIR

PALAIS DE TOKYO

Exposition
Du 17/10/2018 au 06/01/2019
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

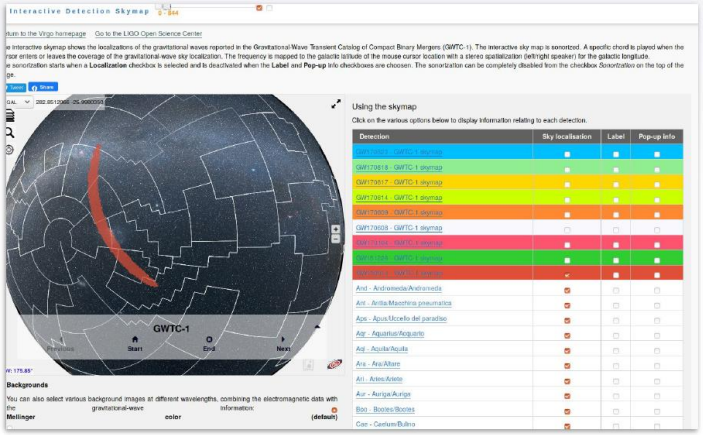
The frequency is mapped to the galactic latitude of the mouse cursor location with a stereo spatialization (left/right speaker) for the galactic longitude.

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

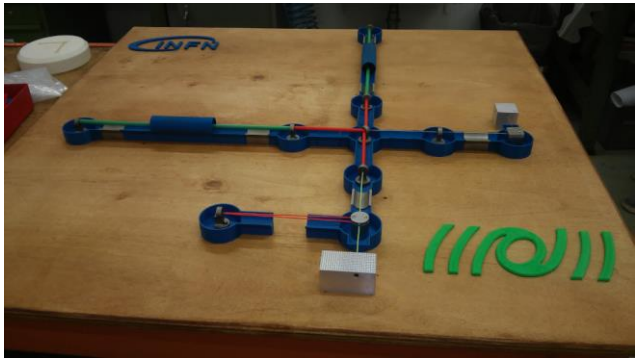
An audio file is added to explain the nature of each event and the main properties.

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