THE GRAVITATIONAL VOICE

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NEWS FROM THE WORLD
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News from EGO and VIRGO

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The content of this newsletter does not necessarily represent the opinion of the management.

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EDITORIAL

h 32 is the last 2016 issue of our newsletter and gives the opportunity to the h editorial team to wish all the best for our readers in the coming year 2017. To be more specific, we wish for a very happy year to you and your families, and we also wish that a handful of genuine gravitational wave events will be detected in Cascina.

After wishing a Merry Christmas and a Happy New Year, we open h 32 with a piece of poetry on gravitational waves.

C.Bradaschia
Chief Editor

Virgo in poetry

The following is a translation, from the original Italian, of a poem on gravitation waves written by Rosalba Esperiani who won the international literary competition " La Rocca - Città di San Miniato" XXIV Edizione.

Gravitational Waves

I heard the scream of the universe
remote, distant.

The voice of the soul,
sweet sound,
vibrant,
deep ripples in space-time,
I heard them.

Waves, a dance of waves,
to feel oneself cradled, as only a gentle mother knows how.

Shining stars and black holes
pure energy,
the same force as in us.

Us a part of everything, fragments of material, star dust.

Us without fear, without limits.

Us infinite expanding universe.

A rhythmic cosmic breath of peace and beauty.

G. Hemming

LIGO-Virgo Open Science

Today, the Internet allows the free circulation of large volumes of data.
Open-data archives [1] are now available in many sectors of activity, not only science.
Cities in more than 35 countries have published nearly 300 datasets of interest to the general public.

The city of Lecce in Italy is particularly active in this domain [2].
In 2004, the Science Ministers of all nations of the OECD signed a declaration [3] to "work towards the establishment of [open] access regimes for digital research data from public funding". World-wide initiatives [4] provide guidance and good practices, and promote the idea of open data in a wide range of areas such as agriculture.

There are clear benefits in opening-up data: transparency and accountability for open-data government initiatives; maximising impact and ensuring reproducibility for science. NASA has estimated that open-data archives double an observatory's output in terms of number of publications [5].

Under the recommendations of the NSF, LIGO started few years ago to release their scientific dataset through the LIGO Open Science Center LOSC [6].
With the first detections, the LOSC has received a lot of attention from the scientific community (with a few papers published using this data) and from teachers and students [7].

A few months ago, we started a working group on this topic.
The working group is in charge of defining a road-map that leads towards the sharing of Virgo data with the world.
This road-map [8] was recently approved by the Virgo Steering Committee.
In agreement with the LOSC team, the objective is now to collaborate on a joint open-science centre that will collect data from both LIGO and Virgo, and eventually other future GW observatories. Stay tuned!

[1]https://en.wikipedia.org/wiki/Open_data
[2]http://it-city.census.okfn.org/place/lecce
[3] http://tinyurl.com/j9k5lju
[4] https://www.rd-alliance.org
[5]http://www.adass2016.inaf.it/images/presentations/09_Rebull.pdf
[6] http://www.losc.caltech.edu
[7]Scipy 2016 -- http://tinyurl.com/grbjnwr
[8]https://tds.virgo-gw.eu/-ql/?c=11654

Eric Chassande-Mottin

A lot of prizes

The first detection of gravitational waves has been awarded with many prizes. This is a, hopefully complete, list of the prizes.

LIGO/Virgo
The Special Breakthrough Prize. The $3 million prize will be shared as follows: the three LIGO founders will share $1 million; and the 1012 contributing scientists, engineers, and staff will share $2 million.

https://breakthroughprize.org/-News/32

Virgo Project
Premio Columbus 2016 per la scienza del Rotary Club Firenze Est

http:// www.rotaryfirenzeest.it /premi/39-columbus/ 517 -xxxv-premio-columbus.html

Alain Brillet
Grand prix Ampere de l'Académie des Sciences

http://www.academie-sciences.fr/fr/Prix-en-mathematique-physique-mecanique-informatique - et-sciences-de-la-Terre - et-de-l-univers/prix-ampere -de-l-electricite-de-france.html

Fulvio Ricci
Premio Roma URBS UNIVERSALIS

http://www.premioroma.it/Albo_Oro_2016.html

Fulvio Ricci
Medaglia della Sapienza

http://www.uniroma1.it/archivio-notizie/la-sapienza-premia-fulvio-ricci

Adalberto Giazotto
Premio Tomassoni

http://en.uniroma1.it/archivionotizie/sapienza- presents- award-adalberto-giazotto

Adalberto Giazotto
Medaglia Matteucci - Accademia Nazionale delle Scienze detta dei XL

http://www.accademiaxl.it/medaglia-matteucci/

Adalberto Giazotto
Paul Harris Fellowship

https://www.rotary.org/myrotary/it/history-paul-harris-fellow-recognition

Adalberto Giazotto
2016 Medal of the Schola Physica Romana

www.fondazionesapienza.uniroma1.it

Adalberto Giazotto, Guido Pizzella
Amaldi Medal - Sigrav

http://public.virgo-gw.eu/adalberto-giazotto-guido-pizzella-share-amaldi-medal/

Barry Barish, Adalberto Giazotto
Fermi Prize SIF

http://en.sif.it/activities/fermi_award

Federico Ferrini,Adalberto Giazotto
Premio Brunelleschi - Comune di Vicopisano

http://www.viconet.it/comune/BrunelleschiEinstein

Giovanni Losurdo
Premio Galileo Galilei dei Rotary Club Italiani

http://www.rotarypisa.it/index.php/2016/10/01/oggi-a-pisa-il-55-premio-galilei/giovanni-losurdo-di-virgo/

Andrzej Krolak
Polish Pearl in the category Science by Polish Market journal

http://www.polskieradio.pl/42/273/Artykul/1686219,XIV-Gala-Perel-Polskiej-Gospodarki-znamy-zwyciezcow

Polgraw-Virgo group
Copernicus Medal from Polish Academy of Sciences to all authors from Polgraw in the Discovery Paper

http://www.fnp.org.pl/en/oferta/the-polish-german-scientific-award-copernicus/

Polgraw-Virgo group
W. Rubinowicz Science Prize from Polish Physical Society to all authors from Polgraw
in the Discovery Paper

Ronald W.P. Drever (Caltech), Kip S. Thorne (Caltech), and Rainer Weiss (MIT)
Kavli Prize in Astrophysics

http://www.kavliprize.org/prizes-and-laureates/prizes/2016-kavli-prize-astrophysics

Ronald W.P. Drever (Caltech); Kip S. Thorne (Caltech); and Rainer Weiss (MIT)
2016 Shaw Prize in Astronomy

http://www.shawprize.org/en/-shaw.php?tmp=5&twoid=79&threeid=253&fourid=463

Ronald W.P. Drever (Caltech); Kip S. Thorne (Caltech); and Rainer Weiss (MIT)
2016 Gruber Prize in Cosmology

http://gruber.yale.edu/cosmology/press/2016-gruber-cosmology-prize-press-release

C.Bradaschia

Exhibitions

The year 2016, boosted by the exceptional discovery of gravitational waves, saw many exhibitions and conferences dedicated to LIGO and Virgo.

Immagini del mondo fluttuante (Images of the floating world):

from Hokusai to gravitational waves

16 ottobre-27 novembre 2016 - I.T.I. Marzotto (Valdagno – Vicenza)

This was an intriguing exhibition, spanning poetry and physics. The title comes from the ancient Japanese poetry style ukiyo-e (浮世絵 IPA: [u.ki.jo.e] which translates as "image[s] of the floating world").
It was composed of three sections, involving the concept of waves:
The floating world – images and poetries from XVII century Japan
The nature of waves – waves of different kinds, from the point of view of mathematics and physics
Gravitational waves – Einstein 1916 versus LIGO/Virgo 2016

Stelle oltre il buio (Stars beyond the dark)

On November 13, 2016 at the Osservatorio Polifunzionale, Barberino Val d'Elsa, the amateur astronomer association of Cascina (ACA) organised a very special event: astronomy for blind people.
In spite of an intrinsic contradiction, one could say, it was very successful.
The availability of touchable telescopes and of models of the solar system, the moon, the earth and even of the Virgo interferometer, was the key to the success, together with many amateurs eager to talk about their science.

The astronomy was complemented by a section devoted to art, named "Impressioni Tattili" (Tactile Impressions) consisting of touchable paintings by Leopoldo Terreni.
The exceptional guest was Andrea Bocelli, who encouraged the organisers to continue and increase this beautiful initiative.

Viaggio nel Cosmo: un percorso alla scoperta delle profondità del cielo

Voyage in the Cosmos: a trail to the discovery of the depths of the sky

December 3, 2016 – February 19, 2017 – Hermann Geiger Cultural Foundation, Cecina

The Hermann Geiger Cultural Foundation opened its doors to "Voyage in the Cosmos", an exhibition that was conceived as a trail through time and space.
Its goal is to represent the different points of view on the close relation between human beings and the Sky standing above them.
Since the dawn of their history, humans have seen the sky as a compass, a clock, a calendar, a source of creation, a home of gods, a mysterious and fantastic space, a ground for scientific exploration.
The exhibition runs through the history of observation and exploration of the cosmos, from primeval instruments to the Moon landing and, more recently, the discovery of gravitational waves.
It remembers what people seek and see in the starry archway, from the primordial myths to science fiction.
Are these worlds as distant as they appear to be?

The Virgo instruments, at the end of the journey, balance with "De la Terre à la Lune" by Jules Verne and the precursory science-fiction film by Georges Méliès "Le voyage dans la Lune".

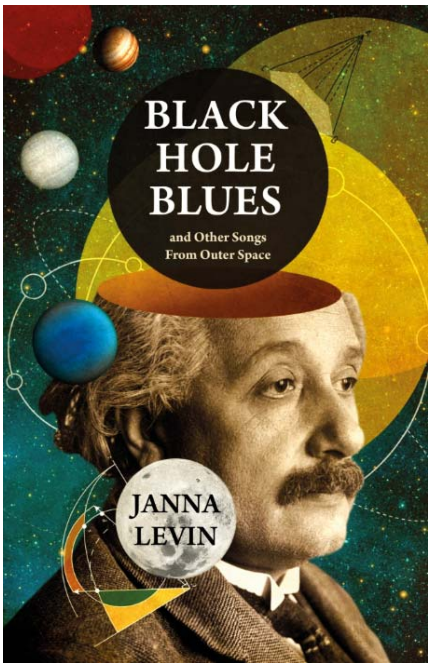
C.Bradaschia

Books

As everybody knows, after the first detection, the press coverage of our field increased to reach extraordinary levels: almost every week we have articles in newspapers and magazines of every kind. It is therefore not surprising that a book on the history of gravitational wave detection has been recently published: Janna Levin's 'Black Hole Blues and Other Songs from Outer Space'.

The book has been released by the Knopf editor in the US in April 2016 and has now been translated into Italian and Portuguese. The author Janna Levin is a theoretical physicist teaching at the Barnard College, a private college for women in New York city, affiliated with the Columbia University.

It is essentially a well written history of LIGO and their founders Rainer Weiss, Kip Thorne and Ron Drever. A myriad of fascinating anecdotes are described in the first chapters: Rainer's passion for music that lead him to drop out of college for the love of a piano player but also to imagine an instrument that could record the sounds of space-time; his pioneering work with a 1.5 m interferometer that could be operated only at night after the last train of the nearby subway had left; the Russian physicist Vladimir Braginsky's frequent visits to Thorne at Caltech, in the middle of cold war, that were closely monitored by both the KGB and the FBI; the genius of Ron Drever who, while still being a student at Glasgow University, designed a simple experiment using several used car batteries to test the equivalence principle, one of the basic concepts of general relativity.



The book describes also the tensions between the LIGO founding fathers and the difficulties they encountered with experiment approval and construction. For example, the relationship between the first LIGO director Rochus Vogt and Drever became so difficult that Ron was fired from Caltech in 1992.
He was fully reintegrated in the scientific collaboration only when Barry Barish became the new director.

Two chapters are dedicated to the controversial figure of Joseph Weber, the father of resonant bar detectors.
While he was an extraordinary gifted experimentalist and did pioneering work on the MASER working principles, his unverified claim of detection was a sort of original sin of the gravitational wave community.
Three chapters are dedicated to Hanford and Livingston observatories and to the 40 m prototype at Caltech: here several familiar people like Rana Adhikari and Jamie Rollings are interviewed.

The book ends with the first detection and the days of excite ment that followed.
A suggestive description of GW150914 signal path through the universe during the ages of human history is given.

Let's come now to the negative side of the book for us: while the complete detection paper author list is included as a sort of appendix, Virgo is cited only a couple of times without mentioning any of the people of our experiment that deeply contributed to our field.
This lack of recognition is of course disappointing but can also be a source of motivation for writing a book dedicated to the history of gravitational wave detectors in Europe.
In conclusion this is a book that everybody in the field would certainly enjoy and should read because several lessons can be learned from the past.
As Cicero said "history is life's teacher".

V.Boschi

GWs on Mickey mouse

Topolino is an Italian digest-sized comic series featuring Disney comics. In Italy the small magazine is extremely famous and is read by virtually all children younger than 18.
On October 25th - issue, a comic strip was dedicated to gravitational waves: the very imaginative title was 'Mickey Mouse and the transformational waves'.
The spaceship driven by Mickey Mouse and Horace Horsecollar passes nearby a black hole and is invested by gravitational waves.
A brief but very well done simple scientific introduction followed the strip.

V.Boschi

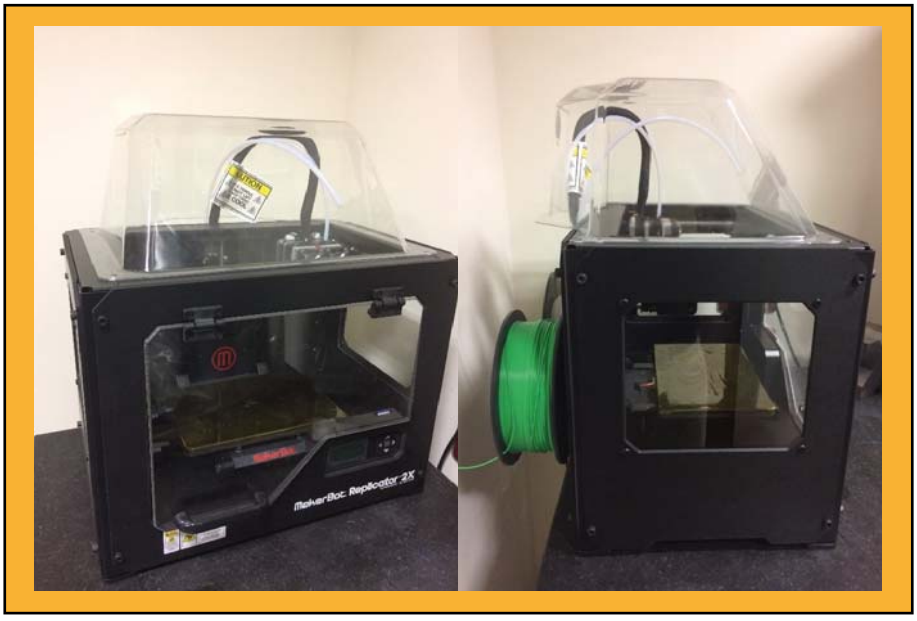


Fig 1 and 2: *Our 3D printer (49 L X 52 W X 53,1 H cm) with the plastic filaments used to create the objects (green and white coils)*

3-D Printer

Each device, machine or facility at EGO corresponds to a specific need.

In a few cases it is not possible to estimate the immediate return on investment, but this is not the case for the brand new 3D printer purchased by EGO a few months ago (Fig 1&2), and the return on investment is a double one: in both technical and economical terms!

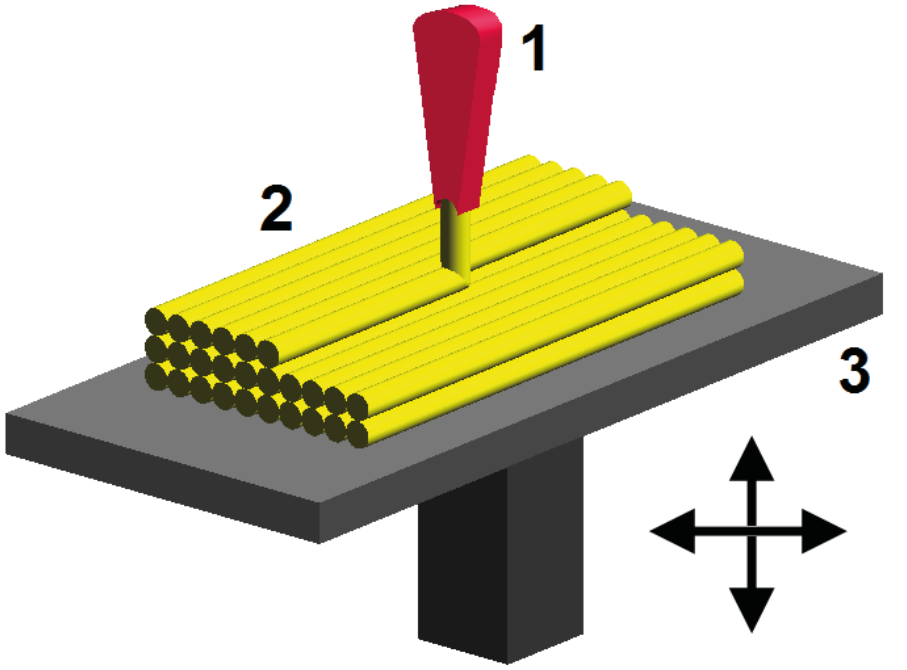
But first of all, let me describe how it works:

It all starts with making a virtual design of the object you want to create. This virtual design is for instance a CAD (Computer Aided Design) file. You then have to prepare a 3D model that is readable by the printer, before it is ready to be 3D printed: this is what they call slicing.

Slicing is dividing a 3D model into hundreds or thousands of horizontal layers and needs to be done with a software (MakerBot Desktop Software in our case).

Sometimes a 3D model can be sliced from within a 3D modeling software application.
It is also possible that you are forced to use a certain slicing tool for a certain 3D printer.

When the 3D model is sliced, you are ready to feed it to your 3D printer.
This can be done via USB, SD or wifi; it really depends on what brand and type of 3D Printer you have.
When a file is uploaded to a 3D printer, the object is ready to be 3D printed layer by layer. The 3D printer reads every slice (2D



Fused deposition modelling: 1 – nozzle ejecting molten material, 2 – deposited material (modeled part), 3 – controlled movable table

Fig.3: Fusion deposition modelling (https://en.wikipedia.org/wiki/3D_printing)

image) and creates a three-dimensional object.

Here are the technical specifications for our 3D printer:

• Print Technology: FDM (Fused Deposition Modeling)
• Build Volume: 24.6 L x 15.2 W x 15.5 H cm
• Layer Resolution: from 100 to 300 microns
• Filament Diameter: 1.75 mm
• Compatible Filaments: ABS, PLA
• Nozzle Diameter: 0.4 mm
• XY Positioning Precision: 11 microns
• Z Positioning Precision: 2.5 microns
• Print File Type: Stl, Obj, Thing, Makerbot

About the process and technology used for this specific 3D printer:

Not all 3D printers use the same technology. There are several ways to print and all those available are additive, differing mainly in the way layers are built to create the final object.

Our printer uses the fused-deposition-modeling technology(FDM). It is an additive manufacturing technology commonly used for modeling, prototyping, and production applications.

In our case, a plastic filament is unwound from a coil and supplies material to an extrusion nozzle, which can turn the flow on and off.
There is typically a worm-drive that pushes the filament into the nozzle at a controlled rate, the nozzle is heated to melt the material.
The thermoplastics are heated past their glass transition temperature and are then deposited by an extrusion head (Fig 3)

About the material:

We use a "common" thermoplastic polymer: Acrylonitrile Butadiene Styrene (ABS), the alternative (PLA material) being weaker with respect to ABS, with a lower melting point.
Indeed, the most important mechanical properties of ABS are impact resistance and toughness.

ABS has a glass-transition zone (the temperature at which the plastic starts to soften) of 105º C, and this matters because if you aim to print something for a hot-drink coaster you don't want it to start getting soft and collapsing!

Nota Bene: The printing with ABS is at 210-240º C with a heated bed at 100º C.

One of the first implementations at EGO:

The EGO Vacuum group was facing a problem with a metallic condensed-water picker also (internally) known as a drain-water collector (Fig. 4) used in two Virgo small cryotraps present in the Central Building (geometrical and thermal issues), so they decided to test both the 3D printer and the plastic water collector on one cryotrap:

So our EGO mechanical designer modeled the collector in such a way as to allow an easy 3D print (four quarters in total) (Fig.5)

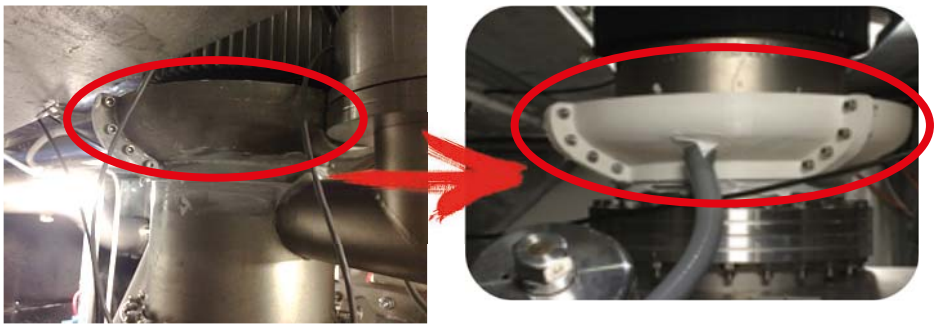


Fig. 4: the former condensed water picker (metallic) and its 3D printed version

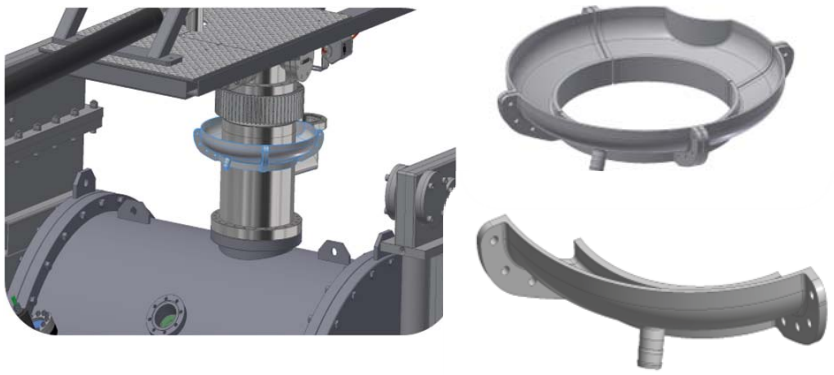


Fig. 5: CAD model of the drain collector and its environment

Fig. 6: Exportation into a format readable by the 3D printer and production

Then it imported the CAD model into a format readable by the 3D printer (Fig.6)

Et voilà!: the piece is being constructed (Fig.6) and in a few hours it will be ready for installation as shown in Fig. 4.

Tangible benefits

We have already saved, with only one piece, €500 (the cost of the metallic version with respect to the 3D printed equivalent.
The process took 23 hours in total and the cost of the material used on this piece was about €25 (half a coil used) (1 coil = 1kg, corresponding to €50 max).

You might rightly retort that I have not taken into account the initial cost of the machine: … only €2000 for this 3D printer.
I leave you to make your own calculations …

The applications are so various: here below a 3D representation of our interferometer… and a special thanks to Alessio for having brought such an important machine tool to EGO!

But the real return on investment for Virgo is that we can create pieces with complex geometry by ourselves, which is simply exciting, isn't it?!

F-M.Richard

Fig.7 A plastic model of Advanced Virgo and Alessio Buggiani next to the 3D printer

GraWITon School

During the week 21-15 November EGO hosted the 6th GraWIToN school.
This was the conclusive school of the GraWIToN project.
The GraWIToN Early Stage Researchers (ESRs) underwent a long period of training in different aspects of Gravitational Wave and astrophysics research: Optics, Simulation, High Power Lasers and Data Analysis and many additional complementary skills.
The project started in the local Universities where the ESRs had to defend their PhD thesis and was augmented by schools on various aspects of GW research.
The last school was completely dedicated to ensure our ESRs good managerial skills.
M. Punturo, the project coordinator, selected the main teacher Luisella Lari of this school and the speakers for the 2 seminars: Antonio Giacomucci, working as Sustainability manager at ABB and Enrico Flamini, coordinatore scientifico dell'Agenzia Spaziale Italiana.
Luisella Lari gave a very deep insight into the whole project management path, from writing the proposal, to the start of the project, until the conclusive 'lesson learned', with all the management tools to be used to coordinate a scientific project in an efficient way.
She has a lot of expertises, having worked at CERN as an Applied Physisicts and Planning Engineer and now being Associate PM/Planning & Reporting, and Scientist at Fermilab.
A very good opportunity for our students, who are almost concluding their path towards a PhD title and maybe in the future will be project coordinators of big scientific enterprises!

Also in this school we invested a lot of effort in giving them science communication lectures.
We insisted on this aspect during the training period, since we are training very good scientists, but we want to make them aware of the importance to communicate to the general public what they are doing in their day by day life as researchers.
We relied on the professional skills of 2 fantastic teachers: Xenia Fosella and Daniele Molaro. Daniele gave the Monday introductory lectures inviting the ESRs to prepare brief scientific presentations on randomly selected scientific experiments.
On November 23rd the high school students from "Liceo Internazionale Pesenti" came on EGO site and worked in teams with ESRs to prepare outreach projects related to the ESRs research activities in the GraWIToN environment.
We all were impressed by how well they integrated into the teams, by the way in which our ESRs have improved their communication ability and on the results they produced since the starting of the project.
The Project Coordinator Michele Punturo said: "seeing people coming from all over the world, even from nations which are in conflict, such as Pakistan and India, working so friendly together represents our idea of peace in the world… "
I, as scientific coordinator of the project and the person mainly responsible for their training path, have to admit to be very proud of each of our ESRs, of their consolidated professional capacity, of their good attitude in interacting with young students and of the fantastic GraWIToN ESRs team they built.
A big thank you to our project assistant Erika Morucci: she made everything work perfectly for a successful school!

E.Cuoco

Interferometer progress

The interferometer is stepping forward

Advanced Virgo (AdV) has been steadily progressing from a construction/integration phase to the commissioning phase over last few months.
Many and demanding challenges were (and still are) ahead of us in reaching a satisfactory working point of the interferometer, a configuration allowing to significantly contribute to the newly-born GW-Astronomy. Many of these challenges were already expected by design: AdV is much more demanding in many aspects as compared with Virgo+. For instance the payloads of core optics had to cope with an increased complexity, the vacuum system had to encompass new and enlarged cryogenic links, new electronics have been deployed almost everywhere, Injection and Detection systems had to cope with the modified beam required by the interferometer in order to decrease the coating thermal noise, and this partial list is just to mention some of the expected technical challenges.

But of course there was no shortage of unexpected problems. For instance, at some point many of the "maraging" steel blades of the super-attenuators were found to be broken, and an extensive campaign of replacement had to be put in place by SAT subsystem. Furthermore PAY subsystem had to deal with unexpected silica fiber failures that prevented up to now the reliable operation of designed payloads. So a workaround with steel fibers had to be employed to suspend the core optics. Luckily, reassuring news is coming from the experts studying the fiber failures, so that we can hope to have silica-fiber suspended mirrors after O2 run.

The commissioning of the interferometer is progressing well, although the need to rush towards the main goal – joining LIGO in O2b observation run with a decent sensitivity – implied for some subsystems to delay a few leftovers to a further phase, and some time for pre-commissioning of some subsystems is still required to achieve optimal performance.
Meanwhile, the commissioning crew achieved remarkable progress in a few months, moving from the first lock of one arm cavity in May '16, to the current recombined configuration including: both arms locked with CARM and DARM degrees of freedom, alignment drift control, short Michelson in dark fringe. This configuration is now stable and reliable, and is a solid ground to move on towards full ITF lock.

None of these milestones were easy at all.
For instance, due to the more demanding cavity parameters in AdV with respect to Virgo, even the lock of one arm implied the development of a "guided lock" technique for the lock acquisition consisting in the online estimation of cavity resonance "speed" and related force to slow it down.

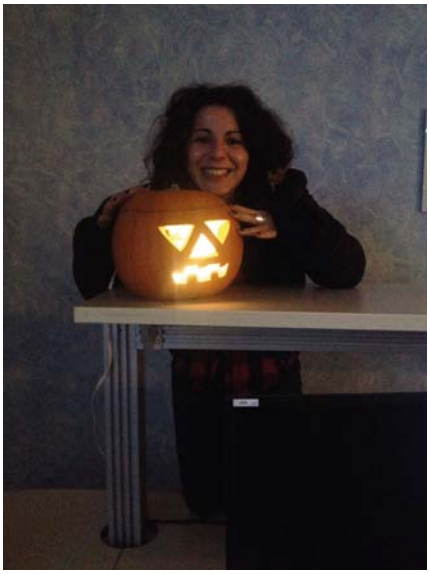
As of the writing of these few lines we are struggling with the addition of the Power Recycling Cavity lock to the current configuration.
A step that took more than one year in the past Virgo generation and that is now required to be achieved in a significantly shorter time with a significantly more demanding interferometer.

Nonetheless, if there is no shortage of problems and troubles in the commissioning, there is no shortage either of ingenious solutions, clever workarounds and imaginative fixings in the commissioners. Our engagement is firm and clear: Advanced Virgo will be there - no matter how - to meet aLIGO for O2b observing run and will contribute to the detection of GW signals.

(Of course, it would not hurt to have a little more time, but never mind…).

A.Chiummo

Magic to propitiate commissioning



Even magic has been tried to assist with commissioning progress.

Events

Below a brief report on the last outreach events

Gravity Day

To celebrate the first anniversary of the gravitational wave detection, we organised on site a "Gravity Day" with: site tours, and a spectacle in the evening followed by astronomical observations.
On the occasion, we presented a 3D model of the Advanced Virgo interferometer created by Alessio Buggiani in collaboration with Michele Bazzi, with the use of a 3D printer (see picture in the article about 3D printers).

During the spectacle Star Waves on Friday night

In the morning at the B. Ciari School, Cascina.
About one hundred children attended the activities!

This model has been produced to reach a blind or visually impaired public in the prospect of opening a sensory tour at Virgo. It is now available in the hall of the main building.

European Researchers' Night 2016 (SHARPER project)

EGO is partner of the SHARPER project that received European funding to organise the Researchers' Night initiative in Cascina in the years 2016 and 2017.
The content of the 2016 edition was shared between two locations; activities took place in a school at Cascina, and other activities at the EGO site for a larger audience.
The participation was pretty good: more than 300 people attended the event and enjoyed the activities organised.
A particular wink goes to Antonino Chiummo and Gabriel Pillant for their very funny interpretation of two crew members of the Einstein1 station in the spectacle "Star Waves" a production by Teatri della Resistenza in collaboration with our "ricerc-attori". New stars were born!

"Code Week"

For the 1st time EGO hosted at its site in Cascina on Monday 17th October, one of the three workshops Code Week 2016 organised by EURid, the non-profit organisation and registry manager of the .eu country code top-level domains.
A qualified team from EGO's I.T Department held a lecture for students from the Institute "Vincenzo Galilei" of Pisa. The lecture consisted of doing playful coding activities through a user-friendly programming language.
Taking advantage of the presence on-site of the students, the groups had the opportunity to take a tour of the Virgo interferometer before leaving the site.

More information on Code Week http://codeweek.eu/

"Stelle oltre il buio"

The astronomical observatory located in the Chianti area organised on the 13th of November, the inauguration of astronomical observations for visually impaired people and invited EGO to present the ITF model created for the Gravity Day. The Italian tenor, Andrea Bocelli, was special guest at this event and had the opportunity to learn about Virgo and GW through the touching of our 3D model.

In addition to these special events, site visits continue at full speed. We had more than 770 visitors over the last four months (September-December 2016) and regularly receive enthusiastic messages from people who visited the site.
Thank you so much to those who contributed to the outreach activities!

S.Perus

Kids listening to Gary's explanations!