LIGO AND VIRGO – ANOTHER SUCCESS FOR GLOBAL R&E COLLABORATION

The recent exciting announcements from the teams from LIGO (with two interferometers in the states of Louisiana and Washington) and Virgo (with the Italian interferometer in Cascina connected to the Italian R&E network GARR) of the first observations of a "Kilonova" (the merging of two neutron stars generating both gravitational waves and a range of electromagnetic waves) on 17 August 2017 demonstrates the power and value of international collaborations.

We live in an era of big science. For the past two decades, collaborations involving hundreds of scientists have been commonplace and there are even some involving thousands. These big projects have achieved great things that wouldn't have been possible without the ability of large groups to communicate and share data, from decoding the human genome to revealing the Higgs boson. Even by these standards, however, what happened on 17 August and the days that followed was special.

The LIGO and Virgo projects comprise more than 1,500 scientists, all of whom are working towards a single goal: to capture signs of gravitational waves and decode their meaning. The data gathering happens at massive observatories in the USA and Italy, but the analysis is done in countries all over the world. This distribution and analysis of Terabytes of data can only take place through the work done by GÉANT and dozens of NRENs building high performance research and education networks to allow huge volumes of data to be rapidly and securely shared around the world.

For the first time, gravitational waves, gamma-ray busts and light have been observed simultaneously from the same source. The European Southern Observatory (ESO) working in collaboration with scientists around the world, were able to pick up the infrared and optical signals from a gravitational wave and gamma source in the southern sky, within minutes of the announcement.

As a result, data from the ESO and their partner telescopes was passed back from Chile to the ESO science data archive at Garching in Germany. This data was transmitted through the R&E infrastructure of REUNA, RedCLARA, GÉANT and DFN. Not only have ESO been utilising the NREN networks to enhance the science that they do but they have also utilised the eduGAIN trust and identity infrastructure to inter-federate their logins, thereby allowing researchers to collaborate seamlessly across institutions. ESO currently have a 1 Gbps connection to DFN and have

Words
Interview by Maddalena Vario

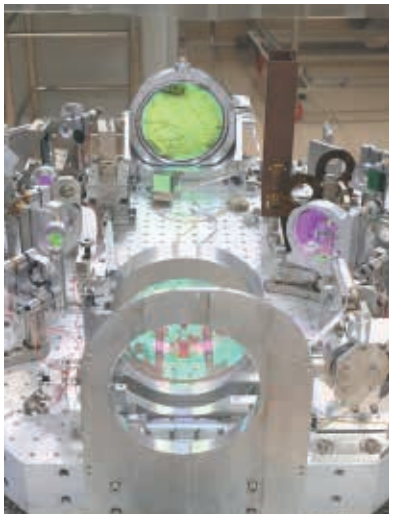
Picture
Above: Virgo detector

been actively participating in eduGAIN to enable the federation of single-sign-on identities for researchers and staff.

Across the whole period, some 3,500 scientists and astronomers, many of whom have never worked together at such a scale, had to all of a sudden figure out how to access and share data. The growth of Authentication, Authorisation and Identification (AAI) technologies and the expansion of interfederation between organisations and identity federations using eduGAIN has allowed these rapid collaborations to take place by allowing researchers to use their existing institutional identities to access data on remote systems and securely share results.

"LIGO and Virgo have been preparing to participate in multi-messenger observations, such as those from the kilonova event, for years - before we had even detected gravitational waves. The coordination between LIGO and Virgo scientists and astronomers from over 90 other observatories was facilitated through the use of federated identities, made possible by SAML identity providers at universities and research institutes around the world, by national identity federations and by eduGAIN. The foresight of these technologies and organizations really lowers the bar to creating ad-hoc research collaborations and it was crucial to the type of interdisciplinary effort that went into the kilonova announcement and papers. We hope that this is the first of many groundbreaking discoveries that these technologies will enable in gravitational wave astronomy!"

Warren Anderson, Identity and Access Management Lead for LIGO



What is a Kilonova?

The drama of a neutron-star merger is due to the fact that it involves one of the most extreme objects in the universe. Neutron stars are some of the smallest, densest stars we know. They do not have much more mass than our Sun, but all of it is compressed into a ball no bigger than the width of a mid-sized city (about 15 km, or 9 miles). That's a lot of compression. A teaspoon of neutron star would weigh 10 billion kg (or 22 billion lbs)—about the same as 1 million very large elephants. The merging of two of these stars has sufficient energy to literally shake the entire universe.

The event didn't just emit gravitational waves. It put out electromagnetic radiation in every spectrum: X-rays, gamma rays, ultraviolet, visible, and radio waves and this combination of gravitational waves and electromagnetic energy is what makes these events so exciting as it gives us multiple "views" of the same event.

Virgo and GARR – working together to support advanced research

Antonella Bozzi, Head of the IT Department at EGO (the European Gravitational Observatory, consortium founded by the National Institute for Nuclear Physics and the National Center for Scientific Research to build and manage the site of the Virgo interferometer), explained how this important international collaboration works and the role that the Italian research network plays in the data exchange between the involved sites.

When it comes to data analysis, LIGO and Virgo are a unique collaboration that shares analysis algorithms, software development, data management, analysis and computing resources. It is physics that requires a global approach because in order to locate the source of gravitational waves and to analyse their signal, it is crucial to have at least 3 detectors at a certain distance from each other.

Also, in order to reduce the rate of false alarms, it is crucial to work in multiple coincidence. For this reason, Virgo puts together the computing centres of CNAF in Bologna, CCIN2P3 in Lyon, Nikhef in Amsterdam and other resources in Poland. Thus, the computing and storage facility is shared through the GRID infrastructure, functioning on top of GÉANT and the European NRENs, which is available to both LIGO and Virgo researchers. CNAF and CCIN2P3 also act as final repositories of our raw data. Analysis is therefore a global activity, which means that there is a continuous transfer of data between Virgo and LIGO and vice versa.

We use heavily both the network and the computing centres. For example, not only do we have data going from Cascina to USA and from USA to Cascina in real time, but also from Cascina to the Italian and French computing centres, with a latency of a few seconds, where offline analysis is done. From this point of view, a reliable, secure and fast network is a key asset for our collaboration. Thanks to the high performance research and education networks we can share large amount of data in real time and with high levels of security all over the world.

In 2004, we joined the community of the Italian research network, GARR, and this led to a complete change in our network. We are very happy of this collaboration and we currently use an access fibre provided by the University of Pisa (which has a collaboration agreement with GARR) that allows us to first enter GARR network and, from here, to reach the GÉANT pan-European network and the international research networks.

To find out more about the advanced networking and AAI technologies that helped make these collaborations possible visit **www.geant.org**, **www.edugain.org** and **www.garr.it/en/**

For more information about the ground-breaking research visit **www.ligo.org/** and **www.virgo-gw.eu/**

Credit: Simone Schiavon