IGFAE
Instituto Galego de Física de Altas Enerxías

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

XUNTA DE GALICIA

# Annual Report 2020

June 2021

EXCELENCIA MARÍA DE MAEZTU

Instituto Galego de Física de Altas Enerxías (IGFAE)

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# Index

# Executive summary

This report reflects the development of the IGFAE project during 2020.

The extraordinary situation resulting from the Covid-19 crisis had a strong impact on the centre's activities in 2020, making it difficult and sometimes impossible to carry out what was initially planned. In this context, the IGFAE was forced to reorient its planning on several occasions. Practically no aspect of the IGFAE was free from these changes, but due to their impact, it is worth mentioning the significant changes in the recruitment of staff, especially foreigners –75% of the postdocs recruited are foreigners. These recruitments suffered delays of several months in most cases and, in some cases, were frustrated by the impossibility of incorporation after the resolution of the corresponding competitive call, due to administrative problems that made it impossible to sign the contract. (It is worth highlighting here the willingness of the administrative units of the USC that allowed modifications to the procedures that made electronic signatures, etc., possible in a short time).

Another item with a considerable budget that was significantly affected was dissemination and diffusion, for which a significant number of face-to-face activities were planned but could not be carried out. In this unstable and uncertain context, we consider that the IGFAE's progress in its first year as a Galician Research Centre is more than satisfactory. We managed to start practically all the initiatives that were initially proposed and ensured that this situation did not significantly affect our scientific activity, talent recruitment, etc. It should also be borne in mind that all the experimental collaborations in which the IGFAE participates also had more or less significant delays and that the IGFAE managed to fulfil all the commitments it had made. During the months of confinement, the IGFAE also supported the activities coordinated by the USC and participated in the development of a low-cost compact respirator in collaboration with CERN.

**In the area of talent,** one of the IGFAE's strategic axes is to attract postdocs, especially R3 or R2 in their transition to R3 (levels corresponding to the European Framework for Research Careers). To this end, the IGFAE has set up its own instrument, the Global Talent programme, for which 280 expressions of interest were received from researchers from all over the world. This programme enabled the recruitment of one Global Talent researcher and of two others who were successful in the Xunta de Galicia's Distinguished Researchers programme. Two Ramón y Cajal researchers and two La Caixa Junior Leaders researchers were also

recruited. All these programmes are accompanied by additional funding for research projects. The recruitment of seven junior staff in a single year is an unprecedented milestone in our institute. In addition, a call for expression of interest in pursuing a PhD at the IGFAE was also launched and received 67 applications, with four candidates selected. This is the first time we have launched this programme, which we expect to be even more successful in future editions. We also initiated actions aimed at monitoring and transversal training in international postdocs and predocs programmes as well as increasing our success rate in MSCA calls. It should be noted that the Gender Action Plan was also drawn up.

**Regarding the management of the centre and funding,** a key objective is the renewal of the María de Maeztu accreditation in 2020 –the application was finally submitted on 10/2/2021– for which the management team worked throughout the year with an external consultant. Significant improvements were made to the centre's management tools and monitoring and competitive surveillance systems, as well as coordination with the university's services.

**The scientific agenda achieved its objectives,** with important advances in the LHCb upgrade and the exploration of new opportunities in DUNE or CODEX-B, as well as the start-up of R3B, the performance of experiments in SPIRAL-II and ISOLDE or the development of detectors with medical and industrial applications, where the laser-induced plasma acceleration line is also noteworthy. There were essential contributions to the experimental analyses at LHCb, Auger, and LIGO. This last line of gravitational wave detection, opened only two years ago, is consolidating as a fundamental part of the institute's scientific agenda. On the theoretical side, the launch of the ERC Advanced Grant represents a significant increase in activity in the QCD programme. This programme also includes a research line on neutron stars and their detection by gravitational waves. The theoretical group will be strengthened by the new additions, especially the addition of experts in non-hadronic phenomenology, **which responds to one of the recommendations of the evaluation we received.**

**The planned RRI actions** suffered significant delays due to COVID-19, as the implementation of the "Labs" and the planned activities required a presence that was not possible throughout the year. Nevertheless, the institute made the effort to maintain these lines, reinventing some of the ideas in non-face-to-face activities, some of them with considerable success, such as the dialogues between art and

science "Transfronteirizas" or "Universo Peregrino: Ciencia Galega para o Mundo" (Pilgrim Universe: Galician Science for the World). During this year, several activities related to technology transfer and industry, a historically complicated area for a particle physics institute, were initiated.

**The Scientific Advisory Board conducted an in-depth evaluation** of the institute and all its researchers, as befits the operating model embodied in the institute's governance. From this evaluation, the committee's opinion on the functioning and progress of the IGFAE is very positive.

Finally, it should be noted that, despite several months of delay, again due to the pandemic situation in which we find ourselves, **the competition for the design of the IGFAE's new headquarters was launched.** The team of architects that won the competition has been working on the project for the last few months, with numerous interactions with the IGFAE management. This information was also shared with the other members of the institute who provided many proposals and comments. As a result, the basic project of the new IGFAE headquarters will be delivered in November and the drafting of the execution project in the following months. Below is a detailed report of the activities carried out during the year.

Santiago de Compostela – June 2021 – Carlos A. Salgado – IGFAE Director

## Personnel

During 2020, a total of 153 people were affiliated to the IGFAE at some point: 30 women (20%) and 123 men (80%). The distribution of the 145 scientific and technical staff by strategic area is as follows:

| Strategic Research Area | People |
|---|---|
| SA1. The Standard Model to the Limits | 81 |
| SA2. Cosmic particles and Fundamental Physics | 36 |
| SA3. Nuclear Physics from the Lab to improve people´s health | 28 |

In an extremely complicated year due to the situation generated by the pandemic caused by COVID-19, with funds from public calls for research projects, strengthening of research structures and public and private calls for human resources, contracts were signed with a start date in 2020 with 66 people from 16 countries. The management of the signature and the incorporation of international researchers (new to the system from Algeria, China, Mexico, Pakistan, and Russia) was an effort by all parties involved and an example of the institute's capacity to attract them. Of the 66, 22 (5 women) were postdoctoral researchers.

Concerning early stages of the scientific career, 4 predoctoral researcher contracts were signed with funding from the Xunta de Galicia's predoctoral funding programme, plus 3 from the doctoral training programme and 1 industrial doctorate, both programmes of the State Training Sub-programme of the State Plan for Scientific and Technical Research and Innovation 2017-2020.

The common structures were reinforced both for added-value research management (3 contracts) and for workshops, laboratories, and advanced computing infrastructure (3 contracts). 24 additional people started or completed their scientific training contributing to the development of programmed research tasks.

In addition, 6 research initiation contracts lasting about 8 months enabled 6 master's students to gain in-depth knowledge of the workings of a research centre by integrating into its dynamics: Clara Landesa, Xoán Mayo, Julio Novoa, Juan Santos, José Daniel Viqueira and Miguel Fernández Gómez will now be able to decide with better information and experience how to orientate their research careers.

It is important to highlight here the incorporation of *junior staff* in 2020, i.e. R3 researchers in the European Framework for Research Careers categorization, one of the IGFAE's strategic commitments in recent years to ensure an adequate renewal of the staff, increase international competitiveness, open up new lines of research and guarantee a constant flow of new ideas. A total of seven new contracts were secured:

- 1 Global Talent (Pier Paolo Giardino (SA1) mentioned in the list above). This is the IGFAE's own main recruitment programme.
- 2 Ramón y Cajal (joining in 2021): Yassid Ayyad (SA3), Lorenzo Cazón (SA2). The incorporation of these two researchers led to a change in the USC's strategy in which recruitment (which includes stabilization at the end of the R&C grant) is linked to co-responsibility on the part of the centre and not only for teaching reasons.
- 2 Distinguished Researchers in the recent call of the Consellería de Educación de la Xunta de Galicia: Bin Wu (SA1) and Tyler Corbett (SA1). The incorporation of these researchers is planned for 2021.
- 2 la Caixa Junior Leader (Incoming) researchers: Juan Calderón Bustillo (SA2) and Aarón Alejo Alonso (SA3).

It should be noted that both the Global Talent call and the call for Distinguished Researchers of the Consellería de Educación followed the advice of the evaluation committee of the present call for Research Centres, which indicated the need to recruit R3 theoreticians, particularly in non-hadronic phenomenology. All three researchers are theoreticians and two of them work in non-hadronic phenomenology, thus opening a new theoretical activity in the IGFAE.

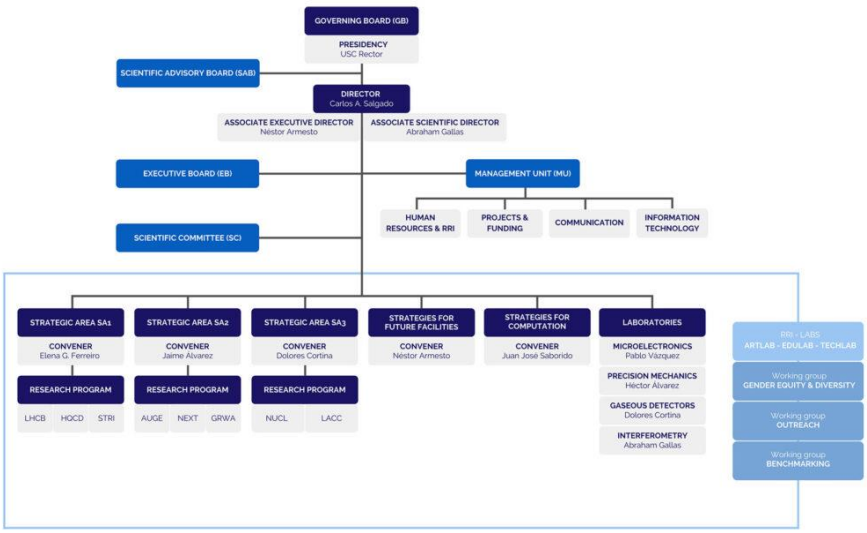
To increase our success rate in MSCA calls, an internal call for expressions of interest was published for applications to the Marie Skłodowska-Curie Individual Fellowship calls. Trend 2000 Ltd. provided a training day on the call and advised applicants and their mentors on how to improve the quality of the proposals. 5 applications were submitted, 1 of them in the career restart panel.

Also in the Marie Skłodowska-Curie programme, an application was submitted for an Initial Training Network with entities from Germany, Spain, Italy, United Kingdom and Czech Republic.

During this year, special mention must be made of the gender and, in general, diversity aspects. The Gender Working Group has continued its activities initiated last year and, in this framework, the IGFAE has drawn up a Diversity Plan which is currently being studied and approved by the Scientific Committee of the research centre. It will subsequently be sent for study and ratification, if appropriate, to the Institute's Governing Board.

# Management and financing

During this year, the Gender & Diversity, Outreach, Benchmarking working groups and Labs have been formally incorporated into the organizational chart. Despite having few human resources, we are currently generating interesting initiatives in these areas, as detailed on page 43 of this document.




## Accreditation "Unit of Excellence - María de Maeztu".

A priority objective was to renew the María de Maeztu accreditation in 2020. Throughout the year, the Direction, Executive Board, and Management Unit worked with an external consultant to define the strategic lines for the proposal, It has been the opportunity to update the institute's SWOT. The proposal was submitted in February of this year and the resolution is expected in November of this year.

## IGNITE+ Program.

Along with the programs for talent recruitment and structural strengthening of experimental laboratories, another pillar of IGFAE's scientific strengthening strategy is the IGNITE program.

The IGNITE* program serves to support emerging initiatives, identifying new scientific opportunities, especially for young researchers. During the current year, a project in the gravitational wave program (SA2_GRWA) led by Thomas Dent was funded.

Dr. Ilia Musco was contracted from late June 2020 to December 2020 to work on theoretical developments on the formation of primordial black holes (formed in the radiation-dominated epoch, one of the initial phases of the expansion of the Universe) that, depending on their size, could be detected by existing observatories such as LIGO or VIRGO, or future ones such as LISA.

Their work already resulted in the preprint The Threshold for Primordial Black Hole Formation: a Simple Analytic Prescription, by Ilia Musco, Valerio De Luca, Gabriele Franciolini and Antonio Riotto, e-Print: 2011.03014 [astro-ph.CO].

It is expected to support new initiatives under this program in the following project annuities.

## Competitive monitoring

Among the developments carried out this year, work has been done on the reformulation of the IGFAE database to improve the centre's results monitoring system, including information items related to IGFAE's technological offer, demonstrators, and prototypes. The diagnosis and technical support of a specialized technology company has been provided and the plan is to close the first phase in November of this year and evaluate the next steps.

The institute's activity monitoring system needed an in-depth update to meet the increasingly competitive challenges we face and to monitor it efficiently. Integration with the benchmarking process will be essential to achieve a useful competitive monitoring system.

## New projects in 2020

During 2020, 12 new externally funded projects have been launched: 4 funded by the State Research Agency in competitive calls, 2 funded by the Xunta de Galicia also in competitive calls, 5 service contracts and 1 privately funded talent attraction call. Annex 1 includes the data for each of the projects.
In 2020, the total amount of funds raised was 2.223.280€. Activities with an award date during 2020 are included - projects associated with the two Ramón y Cajal grants, the Distinguished Researchers of the Department of Education and the ongoing La Caixa Junior Leader contracts are not included here.
In addition, during the 2020 call, 4 grants have been awarded to the predoctoral stage of the Xunta de Galicia: 150.000€ in modality A, 137.384 € in modality B.

# Research Activity: Strategic Areas (SA)

## SA1 – THE STANDARD MODEL TO THE LIMITS

Our Institute works actively in the study of the Standard Model (SM) of particle physics, the best physics theory we currently have for explaining the microscopic reality. Our research plays a fundamental role in this broad field, which includes the search for new physics beyond the Standard Model (SM) using the LHCb experiment (SA1_LHCb), the study of the Quantum Chromodynamic (QCD) matter at extreme conditions (SA1_HQCD) and the investigations on string theory from both formal and applied points of view (SA1_STRI).

### SA1_LHCB: Beyond the Standard Model with LHCb

The LHCb experiment completed very successfully its data taking in 2018 and the installation period of the Upgrade phase-I has started in 2019. Flavour-physics measurements will be performed with much higher precision than was possible with the previous detector, and across a wider range of observables. The flexibility inherent in the new trigger scheme will also allow the experiment to further diversify its physics programme into important areas beyond flavour.

Researchers from the IGFAE are involved in the upgrade of the LHCb vertex sub-detector (VELO, Vertex Locator), and the high-level trigger (HLT). Concerning the VELO, considerable progress has been made. All the ancillary systems for this sub-detector are installed in the cavern, have been already commissioned, or are being commissioned at the time of the writing of this report. The production of the detector modules has started (see Figure 1).

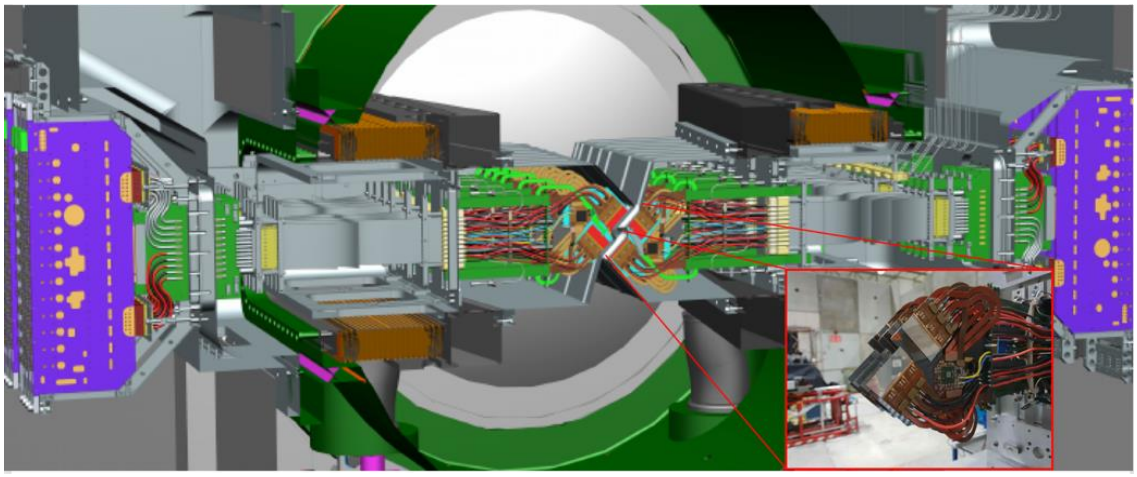


*Figure 1. Artistic view of the VELO sub-detector, detail of the detector modules.*

For the vertex sub-detector (VELO) the researchers at the IGFAE completed a first version of the readout firmware, the FPGA clustering algorithms, and the Time and Fast Control system (TFC) for the back-end electronics. In addition, 320 High-speed data links were assembled and certified, along with 190 High Voltage cables produced and tested, and the assembly of the Optical Power Boards and the Feedthroughs (see Figure 2).

*Figure 2. Assembly of Optical Power Boards, production of High Voltage cables, High-Speed data links*

One of the main characteristics of the LHCb upgrade is the full software trigger. The possibility of an HLT based on GPUs instead of CPUs can significantly improve the farm's computing power per euro at any of the LHCb upgrade phases. IGFAE contributes to the development of VELO clusterization algorithms, muon

identification algorithms, and track matching algorithms using GPU´s. The efforts in the trigger for strangeness decays for the LHCb upgrade progressed smoothly. A fully GPU-based implementation of the first level trigger for the upgrade of the LHCb detector, has been completed and published *Allen: A high level trigger on GPUs for LHCb, Computing and Software for Big Science* 4, 7 (2020). Allen is the first complete high-throughput GPU trigger proposed for a HEP experiment.

Since 2018, the reconstruction and trigger tasks of LHCb are organized in a subdetector-like working group called Real Time Analysis (RTA). IGFAE became part of the Spanish commitment to RTA.

The year 2020 has been highly successful for the LHCb physics output, with 30 papers published in high impact journals (Nature Physics, Physical Review Letters, Journal of High Energy Physics, etc.) More than 536 scientific publications already published. According to the SCOPUS database, more than 95% of the articles have been published in "first decil" category journals.

The main physics analysis research lines at IGFAE are: measurement of observables sensitive to lepton universality violation in b-hadron decays, measurement of CP-violating observables in B decays, the study of rare decays of mesons with b and s quarks, dark matter searches, and measurement of observables in proton-lead collisions.

The publications below were entirely made or have significant contribution by IGFAE members at LHCb during 2020:

**CP violating observables in B decays:**

- *Amplitude analysis of the* $B^+ \to \pi^+\pi^+\pi^-$ *decay*, arXiv:1909.05212, **Phys. Rev. D 101 (2020) 012006.**
- *Observation of several sources of CP violation in* $B^+ \to \pi^+\pi^+\pi^-$ *decays,* **Phys. Rev. Lett. 124 (2020) 031801**.

**Rare decays:**

- *Strong constraints on the* $K^0_S \to \mu^+\mu^-$ *branching fraction,* arXiv:2002.08229.

**Dark matter searches:**

- *Search for* $A' \to \mu^+\mu^-$ *decays,* **Phys. Rev. Lett. 124,** 041801.

**Proton-Lead collisions**:

- Nuclear Modification Factor of Charged Primary Particle Spectra in pPb/Pbp/pp Collisions at 5 TeV. **In preparation.**

In addition, the following **PhD these** was brilliantly defended by IGFAE-LHCb students:

- Search for $K^0_s$ $\mu$+ $\mu$- and trigger developments at LHCb **Miguel Ramos Pernas**, 24/7/2020

New research initiatives are being started by Dr. Cid Vidal, for instance the experiment Codex-b. This is a proposed new experiment to be located in the LHCb cavern, providing sensitivity to long-lived particles (LLPs) that cannot be reconstructed by standard LHC detectors. This initiative has received one of the IGFAE IGNITE projects.

Concerning **scientific management,** the IGFAE researchers were very active during 2020. Dr. Cid Vidal has been involved in the management of different working groups beyond LHCb. In particular, he is currently one of the coordinators of the WG of the DM LHC. Dr. Jeremy Dalseno is the convener of the BnoC working group at LHCb, dedicated to the study of B-meson decays to final particles with no net content in charm flavour.

For the instrumentation part of the scientific project, Dr. Lemos Cid, is the VELO DAQ and firmware coordinator, and Prof. Gallas Torreira holds the position of the collaboration chair of the VELO project.
In regards the **organization of scientific conferences,** during 2020 we were working on the organization of the 2020 edition of the Conference on Flavour Physics and CP Violation (FPCP 2020), that was held online due to the COVID-19 restrictions. https://igfae.usc.es/igfae/fpcp2020/
Finally, the group was engaged with great dedication to **science dissemination tasks** during 2020, both giving talks and conferences in secondary and high school institutes and organizing specific events at the IGFAE´s premises, mostly online.

**SA1_HQCD: Hot and dense QCD in the LHC era and beyond**

The study of the QCD matter at high temperatures and densities constitutes the main interest of the QCD phenomenology group at IGFAE. Under these extreme conditions, all hadronic matter is in a universal form, generically known as the Quark Gluon Plasma (QGP), which is also the state of the universe right after the Big Bang.

The main goal of our research work is the characterisation of this new form of matter. To do so, we have continued our activities on different lines, which include heavy-ion collisions, high-energy QCD and the description of strongly interacting matter in effective models like Skyrme.

Some highlights during 2020 are the following:

Concerning the use of **hard probes as jet quenching and quarkonia** for characterising the QGP, they have been studied in:

- The nature of X(3872) from high-multiplicity pp collisions, e-Print: 2006.15044
- Mapping collinear in-medium parton splittings, Eur.Phys.J.C 80 (2020) 1, 11
- Jet quenching as a probe of the initial stages in heavy-ion collisions, Phys. Lett. B 803 (2020) 135318
- Medium-induced cascade in expanding media, JHEP 07 (2020) 150

Central in this point is the proposed use of jet quenching to study the initial stages of a heavy ion collisions, which is the main topic of the ERC Advanced Grant "Yoctosecond Imaging of QCD collectivity using jet observables (YoctoLHC)" granted to Carlos Salgado.

We have also pursued the study of the **initial states** of the collision in the Color Glass Condensate effective theory for high energy QCD, in

- Particle correlations from the initial state, Eur.Phys.J.A 56 (2020) 8, 215

Our group is also heavily involved in the elaboration of physics cases for future experiments. In particular, during 2020 the group has been involved in the study of the physics opportunities with fixed target experiments at the LHC, AFTER@LHC (Phys.Rept. 911 (2021) 1-83) and at the LHeC (e-Print: 2007.14491).

Néstor Armesto is member of the board of the LHeC and Elena G. Ferreiro is institutional board member from European institutions of the Electron Ion Collider.

Finally, the applications of the effective **Skyrme model** and its soliton solutions are developed in:

- Incompressible topological solitons, Phys.Rev.D 102 (2020) 10, 105007
- BPS Skyrme neutron stars in generalized gravity, JCAP 08 (2020) 041
- The Dielectric Skyrme model, Phys.Lett.B 807 (2020) 135560

- Adding crust to BPS Skyrme neutron stars, Phys.Rev.D 102 (2020) 2, 023019
- Inflationary twin models, Phys.Rev.D 101 (2020) 6, 063514

As mentioned above, the members of this group have important roles in different activities, as the nomination of Elena Ferreiro as chair of the Governing Board of the Strong2020 consortium, where Carlos Salgado is member of the Executive Board and Nestor Armesto being leader of one of the Working Packages, or the ERC Advanced Grant "Yoctosecond Imaging of QCD collectivity using jet observables (YoctoLHC)" awarded in 2019 to Carlos Salgado.

**SA1_STRI: String theory and related fields**

Last but not least, the IGFAE theory group has performed research in more formal areas of particle physics, with a strong interest in String Theory, String Theory gives a fruitful framework to explore interesting problems in high-energy physics; most notably, putting together General Relativity and Quantum Mechanics in a consistent manner. One of its most robust ideas is the AdS/CFT correspondence, a holographic duality relating Quantum Field Theory with gravity in higher dimensions. It became by now a powerful tool to describe strongly coupled phenomena ranging from quantum field theories to lower dimensional condensed matter problems. A key aspect of this duality is the appearance of integrable structures. Furthermore, albeit less explored, the AdS/CFT correspondence can be used to understand space-time as an emergent concept and, in particular, to shed some light into a central problem in physics: how to go from General Relativity to Quantum Gravity. Our group is focused on these issues along three lines of research:

**Holographic tools for strongly coupled quantum systems:** The group has a wide experience in the uses of the AdS/CFT correspondence to tackle strongly coupled quantum systems. We have also used holographic tools to deal with time dependent processes in strongly coupled systems, which are mapped to dynamical gravitational problems demanding numerical simulation.

**Integrability in String Theory and the AdS/CFT correspondence:** The group is well recognised for its contributions in the application of integrability to the study of the AdS/CFT correspondence. Integrability was found in both sides of the AdS/CFT correspondence and provided new tools to investigate non-perturbatively the

conjectured duality. The success of the methods provided by integrability in the AdS/CFT correspondence motivated substantial activity in exploring deformations of string sigma-models that preserve integrability, and in the development of new strategies to obtain exact results in those cases.

**From General Relativity to Quantum Gravity:** This line of research is younger than the other two and currently explores consistence conditions on local Lorentz invariant gravity Lagrangians.

Some of the related publications are:

- Towards geometric inflation: the cubic case, Phys.Lett.B 802 (2020) 135272.
- Geometric Inflation, Phys.Lett.B 802 (2020) 135242.
- Holographic Floquet states in low dimensions, JHEP 10 (2020) 013.
- Holographic spontaneous anisotropy, JHEP 04 (2020) 062.

## SA2_COSMIC PARTICLES AND FUNDAMENTAL PHYSICS

Several discoveries over the past half century have placed neutrinos, the most abundant particles in the Universe, at the forefront of several investigations on fundamental questions about their nature and role in the evolution of the Universe. In 2020, IGFAE has actively participated in two experiments devoted to these studies: NEXT (Spain) and DUNE (USA).

**Participation in the NEXT neutrino experiment:**

NEXT is an international collaboration whose members are mostly from Spain and USA, and whose primary objective is the construction of the NEXT-100 detector at the Canfranc Underground Laboratory (LSC) in Spain. The primary aim of this detector is the search for the hypothetical and very rare neutrino-less double decay of the nucleus of Xenon 136. If this decay is realized in Nature, the neutrino would be its own antiparticle, a discovery with profound consequences in Particle Physics and Cosmology.

The IGFAE-NEXT group participates in the data taking, software development and data analysis of the NEXT-White detector at LSC. This is the initial phase of the NEXT-100 detector. IGFAE-NEXT group also participates in the data taking and data

analysis of a smaller prototype, DEMO++, installed at Instituto de Fisica Corpuscular (IFIC) in Valencia, Spain.

In 2020 the group led by Prof. J.A. Hernando (also a member of the Steering Committee of NEXT) has reinforced its participation in the software of the NEXT experiments. M. Kekic, a postdoctoral fellow of the group, is the software technical director leading, along with G. Diaz, PhD student funded by a Xunta de Galicia grant and J.A. Hernando, the development of algorithms for sensor simulation of the NEXT-100 detector, crucial for the validation of its design. On the other hand, J. Renner, junior fellow at IGFAE, has been responsible for the validation of the calibration of the NEXT-White detector, estimating its energy scale and resolution, one of the fundamental parameters of the experiment. J. Renner and G. Diaz also participated in the planning, data taking and data analysis of the DEMO++ detector as a test bench for different alternative track detectors. These studies are crucial to define the many elements of the NEXT-100 detector. Finally, M. Kekic and J. Renner have been the main authors of the paper Journal of High Energy Physics 189 (2021) on the use of neural networks to significantly improve the capabilities of the experiment to identify the expected signal. This study is based on calibration data of the NEXT-White detector. Recently the IGFAE-NEXT group with J. Renner as responsible, also participated together with other Spanish groups in defining a possible participation of Spain in the neutrino experiment Hyper-Kamiokande (HK) under construction in Japan.

**Participation in the DUNE neutrino experiment:**

The Deep Underground Neutrino Experiment (DUNE) is an international experiment for the study of neutrino science (neutrino oscillations and astrophysical neutrinos from core-collapse supernovae) and proton decay studies.

DUNE will consist of two neutrino detectors (Argon Time-Projection-Chambers or Ar-TPC) placed in the world's most intense neutrino beam. One detector will record particle interactions near the source of the beam, at the Fermi National Accelerator Laboratory in Batavia, Illinois, USA. A second, much larger, detector will be installed at the Sanford Underground Research Laboratory in Lead, South Dakota 1,300 kilometers downstream of the source and at more than a kilometer underground.

The Long-Baseline Neutrino Facility at Fermilab will provide the neutrino beamline and the infrastructure that will support the DUNE detectors.

IGFAE became a member of the DUNE collaboration in July 2020. Soon after joining DUNE, a new working group DUNE-TUNE coordinated by IGFAE member D. González was officially created. Its main focus is the optimization of the high-pressure Ar-TPC of the DUNE near detector (DUNE-ND). In particular the participation of IGFAE is on the experimental characterization of optical properties of scintillation in Argon mixtures in small setups. The main goal is the design of a gas mixture and optical system that would allow to simultaneously obtain high scintillation yields while keeping the operability/stability of the multiwire proportional chambers of the DUNE-ND. Despite the activities of this project are related to the study of the scintillation in Argon mixtures, there is a considerable momentum of Xenon-based studies that are synergic to DUNE activities. An experimental setup dedicated to optical studies in Xenon had been developed already at the beginning of 2019 at IGFAE, and commissioning performed in June that year, with a measurement campaign that lasted over 2 weeks. A new measurement campaign in Xenon has just started and extended until the end of 2020, with the aim to commission the optical system towards the envisioned Argon measurements, early 2021.

A directly related experimental effort has been the spectroscopic and temporal characterization of the scintillation in pure Argon, in the range 1-16 bar, as a function of electric field and for various primary particles (beta, alpha). This represents the most comprehensive study to date targeting specifically the possibility of using spectroscopic information for particle identification, and it is an excellent start for the future activities foreseen in the context of DUNE, where the scintillation of Ar-based mixtures will be studied.

There has also been a lot of progress on the modelling of the scintillation of various gas mixtures through the new simulation code Pyboltz, co-developed between Univ. of Texas at Austin (USA) and IGFAE [Computer Physics Communications 254, 107357 (2020)].

The Conceptual Design Report of the DUNE near detector has been released in March 2021, and efforts towards the Technical Design Report will follow, for a time

span of up to 1.5 years. Of relevance to this: one LOI was submitted to SNOWMASS on this specific R&D program and another one on the H-program (the latter is a larger consortium, consisting of about 20 experimentalists and theoreticians).

**Multi-Messenger Astronomy** is an activity in the framework of Astronomy that is receiving a great deal of attention internationally, and in which a great deal of effort and resources are being invested. This type of Astronomy consists in the observation and study of the Universe using different types of particles (neutrinos, photons and cosmic rays) and radiation (electromagnetic and gravitational). IGFAE is contributing actively to the development of Multi-Messenger Astronomy through its participation in the Pierre Auger cosmic-ray Observatory (Argentina) and the Gravitational Wave detector LIGO (USA).

**Participation in the Pierre Auger cosmic-ray Observatory.**

The Pierre Auger Observatory located in Malargüe, Mendoza (Argentina) is the world's largest ground-based air-shower array for the detection of Ultra-High-Energy (UHE) Cosmic Rays (CR) and UHE neutrinos with energies more than 1 EeV ($10^{18}$ eV). The Astroparticle Physics group at IGFAE has been involved in the Observatory since its early years leading the Spanish participation.

Multi-Messenger Astronomy activities were carried out by the Auger IGFAE group. The follow-up in UHE neutrinos of the active galaxy TXS 0506+056 with the surface detector stations of the Observatory was done in 2020, a result that appeared in The Astrophysical Journal, 902, 105 (2020). This was the direct responsibility of IGFAE members, where E. Zas acts as responsible for the Multi-messenger task in Auger and J. Alvarez as the corresponding responsible for the Neutral Particles Task that carried out this search. This is the first source ever detected simultaneously with neutrinos of lower energies than those searched with Auger by the IceCube observatory and in gamma-rays by several satellite and ground-based detectors. No UHE neutrinos were identified with Auger from the direction of the source in different periods of time and upper limits to the neutrino flux were placed. Also, in 2020 IGFAE has exploited Auger data to search for UHE neutrinos in coincidence with the Gravitational Wave (GW) candidate events detected in run O3 of LIGO and Virgo GW detectors (see Gravitational Wave Astronomy below). The results of these

investigations demonstrate that the Pierre Auger Observatory is a key detector in the Multi-Messenger Astronomy activities at UHE.

In 2020, IGFAE contributed to the measurement of the energy spectrum of the UHECR published in a series of two papers in Phys. Rev. Lett. 125, 121106 (2020) and Phys. Rev. D 102, 062005 (2020). Analyzing 215,000 events collected by the Pierre Auger Observatory above 2.5 x $10^{18}$ eV, a new feature of the UHECR energy spectrum has been identified, namely, a steepening of the curve around 13 x $10^{18}$ eV which is found to be independent of the direction from which particles arrive. The energy spectrum contains information on the unknown origin of the UHECR. In particular, this smoothing could be a natural consequence of the energy-dependent mass composition of UHECR, changing from light to heavy as other measurements performed with Auger seem to indicate. The observations exclude the hypothesis that the highest-energy cosmic-rays come from a small number of nearby sources, and those protons dominate in the astroparticle beam. These results had a great international impact in the Astroparticle Physics community.

**Developments in radiodetection for future neutrino experiments**

In 2020 the Astroparticle Physics group at IGFAE also participated in the development of large-exposure neutrino detectors exploiting the so-called radio technique consisting in the observation of electromagnetic waves at radio frequencies (MHz – GHz) from the neutrino-induced showers in the atmosphere or in a dense transparent medium such as Antarctic ice.

In 2020 the IGFAE Astroparticle Physics group contributed to the conceptual development of the Beamforming Elevated Array for Cosmic Neutrinos (BEACON), a planned array of antennas on a mountain at 2-3 km above sea level aiming at the detection of UHE tau neutrinos emerging from the Earth. This effort led to the publication of the journal paper Journal of Cosmology and Astroparticle Physics 11 (2020). A prototype beamformer array of four 30-80 MHz antennas has been deployed at the White Mountain Research Station in Bishop, California, USA.

IGFAE also participated in the conceptual development of the Particle Universe Extreme Observatory (PUEO) a long-duration balloon experiment designed to have world-leading sensitivity to UHE neutrinos above $10^{18}$ eV. PUEO benefits from the

experience of the successful Antarctic Impulsive Transient Antenna (ANITA) program, with a design that improves the sensitivity of ANITA by more than an order of magnitude at energies below $3 \times 10^{19}$ eV. PUEO will either make the first significant detection of or set the best limits on UHE neutrino fluxes. A whitepaper on PUEO with participation of the IGFAE-Auger group was recently submitted (arXiv:2010.02892).

Of relevance to PUEO has been the development of a phenomenological model to predict the emission in radio waves in neutrino-induced showers in ice, published by IGFAE members in Physical Review D 101, 083005 (2020).

**Participation en the analysis of data of the Gravitational Wave experiment LIGO.**
The IGFAE Gravitational Wave (GW) Astronomy group led by T. Dent is a member of the LIGO Collaboration. The group has developed and currently maintains one of the data analysis pipelines that is applied to the search for Gravitational Wave events using the two interferometric detectors of LIGO in USA and the one in Virgo in Italy. In 2020 the group continued its activities in the search for GW signals from the merger of compact binary systems such as Binary Black Holes (BBH) and Binary Neutron Stars (BNS), as well as on the study of the properties and formation mechanisms of these systems, and on the followup of these sources in UHE neutrinos in collaboration with the Auger Astroparticle Physics group. Also in 2020 a new La Caixa junior fellow and member of LIGO Juan Calderon joined IGFAE reinforcing the activities of the IGFAE-GW group.

In 2020 the IGFAE-GW group has analyzed the data taken during the so-called run O3 of LIGO and Virgo, the most sensitive run so far with a ~60% improvement in comparison with previous periods of data taking. During the O3 run that ended in March 2020, the GW detectors operated during ~75% of the time without interruption. The IGFAE-GW group had a leading role in the optimization of the PyCBC pipeline using signals from the three interferometers, as reflected in the publication The Astrophysical Journal 891, 123 (2020).

After several months of thorough analysis, the LIGO Scientific and the Virgo Collaborations released in 2020 an updated catalog of GW detections (arXiv:2010.14527), containing 39 new signals from Binary Black Hole or Binary Neutron Star systems detected between April 1 and Oct 1, 2019 corresponding to the first 6 months of the O3 run, which more than triples the number of confirmed

detections. The new set includes some of the most interesting systems seen so far. Studying the mass and spin distribution of these sources, a better understand of the formation of these black holes either as the result of stellar deaths or previous collisions is being achieved. It has been inferred that the distribution of black hole masses does not follow a simple power-law distribution and find that some merging black holes have spins which are misaligned with their orbital angular momentum (arXiv:2010.14533). The updated catalog was also used to put Einstein's theory of gravity to the test in more and better ways than before. This was done by comparing the data against predictions from the theory and constraining possible deviations obtaining the tightest constraints so far on the properties of gravity in the strong, highly-dynamical regime of black hole mergers (arXiv:2010.14529).

The high throughput computing cluster funded by Xunta de Galicia to be used by the IGFAE-GW group has been installed in 2020 at the Centro de Supercomputación de Galicia (CESGA). The cluster will be used for production of final O3 observational results and subsequently for prototyping and testing of upgraded analyses for the upcoming O4 and future runs reaching the Advanced network design sensitivity, with up to hundreds of GW signals per year detected.

**Developments for the Virgo Gravitational Wave experiment.**

Concerning the activities of instrumentation of the Gravitational Wave experiment Virgo in Italy, a study has been done to acquire the necessary equipment for the future Gravitational Wave laboratory at IGFAE, namely, a stable and high-precision laser for the characterization of the Virgo interferometer. The laser has still not been purchased because IGFAE lacks for the moment of a suitable space for its installation.

## SA3_ NUCLEAR PHYSICS FROM THE LAB TO IMPROVE PEOPLE´S HEALTH

The activity carried out at the IGFAE in the area of nuclear physics covers a very broad spectrum, ranging from fundamental research in large international facilities to the development of social applications in the field of natural radioactivity and medical physics. These activities are articulated around three axes: the study of the structure and dynamics of nuclear systems and their astrophysical and cosmological implications, the operation of the Laser Laboratory for Particle Applications and

Acceleration (L2A2) and the activity carried out around the Radiation Analysis Laboratory (LAR).

Like the rest of society, our activity in this period of pandemic has had to adapt. We summarise the main lines of our scientific activity:

- We have participated as invited speakers in 2 international conferences and workshops.

- We have contributed to 27 SCI publications.

- We are organising two major international events. One of them, International Conference on Direct Reactions with Exotic Beams (DREB) was scheduled from 29 June to 3 July 2020 (indico.cern.ch/event/812362/) with an expected attendance of 150 people, was cancelled and postponed to June 2022. On the other hand, we are organising the European Nuclear Physics Conference originally planned for June 2021 and finally postponed to September 2022. The organisation of this event has been entrusted to us by the Nuclear Physics Panel of the European Physical Society EPS with an expected attendance of 300 people.

- The infrastructures acquired with MICIN 2018 funding have been installed in the Radiation Analysis Laboratory, and the necessary technical studies have been carried out for the tendering of the purchases with MICIN 2018 funding necessary for the duplication of accelerator lines in L2A2. We have also purchased from the Xunta de Galicia's call for Centres, the necessary material for the adaptation of a laboratory for activities related to optical CPTs.

- We currently have 11 students preparing their PhD theses, 4 of whom joined this year (2 in SA3_NUCL and 2 in SA3_LACC). We also highlight the incorporation of two postdoctoral researchers in SA3_LACC, one of them in a highly competitive call ("la Caixa" Junior Leader).

The following are some of the main milestones achieved in the different research programmes.

**SA3_NUCL: The structure of the nuclear many-body systems and its astrophysical and cosmological implication**

In this research programme we develop experimental activities in international facilities and collaborations.

Experiments at high-energy facilities. Contribution to the R3B/FAIR experiment.

Following IGFAE's scientific strategy and agenda, we developed a scientific programme at the world's largest nuclear physics facility FAIR (https://fair-center.eu/), particularly at the R3B experiment. The IGFAE's commitment to this experiment is very strong. Dolores Cortina is currently spokesperson of this experiment, and we are among the groups with the largest investment (human capital and instrumentation) in it, funded through competitive projects of MICIN 2018 and Xunta de Galicia, as well as IGFAE's own funds through the calls María de Maeztu and the call for Centres of Xunta de Galicia. Our contribution to the development of advanced instrumentation mainly includes the design and construction of the CALIFA calorimeter. We also participated in the design of the Si-tracker that will surround the R3B target and in the development of a TPC adapted to this experiment.

- In 2020 we participated in FAIR-Phase 0 experiments. After the installation of the equipment at the end of 2019 we participated in the Commissioning S444 and in the S467 experiment Single-particle structure of neutron-rich Ca isotopes: shell evolution along Z=20.

- The next scheduled step (March 2020) was the determination of fission barriers and study of the dynamics of this process using QFS-type reactions. This measure, led by our team, had to be cancelled due to the pandemic. Fortunately, the closure of FAIR was not complete, and we were able to continue the activity: i.e. irradiation of detectors with light (p) and heavy (Au) beams, optimizing their response (delta electron signal in the tracker, calibration of the tracker and CALIFA with high energy protons, performance test with cosmic radiation (MIP)).

- We also participated in the design and construction together with the University of Vigo of a new vacuum chamber to house these detectors and an LH2 target.

- A few months ago, the collaboration identified a technical risk associated with CEPA, a sector of CALIFA that covers the very low polar angle area. IGFAE proposed a solution to mitigate this risk and after its validation, we have been involved in the preparation of eight new LH2 targets.

- We participated in the preparation of eight new experimental proposals that were presented to the Program Advisory Committee of the FAIR facility for the 2021/22 period. Five of them have been programmed with high priority. Our team is leading two of these proposals.

Summary of scientific production 2020: 12 publications, attendance at 2 conferences with invited presentations and 3 doctoral theses in progress (2 FPIs started in 2020 and one expected to be completed in 2021).

Development of new photon detection technologies applied to medical imaging.

At the beginning of the year, a new line of research was launched to transfer the knowledge acquired in the development of detectors to the design and construction of medical imaging devices, in particular PET (Positron Emission Tomography) and SPECT (Single Photon Emission Computed Tomography) devices, financed by the IGNITE call (IGFAE MdM).

- The design of the proposed detector is protected by a National Patent and Trademark Office Utility Model with reference ES1247974 (novel PET and SPECT medical imaging device based on GAGG/CsI scintillators in phoswich configuration and read with APDs).

- The feasibility of the device has been corroborated in a full simulation including a PET event generator, and image reconstruction using the Filtered Back Projection (FBP) reconstruction method.

- The system is designed and under construction in our laboratories, the detection units characterised and validated.

- Measurements with this assembly and validation of the image reconstruction methods will begin shortly.

Summary of scientific production 2020: Obtaining a utility model, start of a new doctoral thesis in 2020.

Stable and radioactive beam experiments in low energy facilities

The work carried out continues the lines of research in low energy facilities of previous years focused on the study of the structure of exotic nuclei at the limits of nuclear stability with an important use of new active target technologies. Activities related to the fission process are also continuing: the VAMOS/GANIL campaign and participation in n_TOF/CERN, nuclear data evaluation tasks at the IAEA. This is complemented by the development of a new detector based on optical readout for nuclear experiments.

- An experiment to study layer effects at the proton binding boundary with the ACTAR TPC detector has been proposed and accepted by the TRIUMF Scientific Committee (Canada).

- A paper led by IGFAE has been published in Phys. Lett. B on the structure of 17C showing the independent particle character of its bound states and the halo nature of the first 1/2+ state.

- We coordinate the ASTRANUCAP cooperation project (France-Spain), to study nuclear structure and astrophysics.

- New collaboration with the University of Huelva to test high-purity silicon detectors.

- The design and assembly of the optical TPC for structure and fission studies (n_TOF and others) is completed.

- The MAYA/ACTAR TPC collaboration has submitted two papers to Nature; one led by IGFAE.

- New results on the fission of U239 have been published in Phys. Rev. C, and submitted a Letter of Intent to develop a thorium beam at GANIL for fission studies, with the support of the GANIL Scientific Committee.

- "Letter of Intent" to extend our fission campaign to LNL facilities (Legnaro, Italy) in collaboration with AGATA accepted.

- IGFAE members have been invited to participate in the Scientific Committee for the design of the new beam injector of the high intensity line at Spiral2, being the only non-French institute present.

Summary of scientific production 2020: Publication of 12 articles and 4 theses in progress.

**SA3_LACC: Operation of the Laser Laboratory for Particle Acceleration and Applications**

The scientific programme led by the IGFAE in the Laser Laboratory for Acceleration and Applications (L2A2) aims to develop technologies related to the acceleration of particles by laser and their use in medical applications. We are working on two initiatives:

LaseX: use of R-X sources generated by laser interaction and their application in medical imaging techniques.

- The Retos Colaboración 2019 project coordinated by the company Sedecal S.L. has been awarded to develop a high-resolution mammograph based on a laser-generated microfocus source.

- A PhD thesis related to this project has been started.

LaserPET: production of radioisotopes for PET imaging by laser interaction.

- A plasma mirror has been built for the international ELI-ALPS facility (validated in 2021).

- A Retos Investigación 2018 project has been launched to study the potential of ultrashort laser-generated particle pulses in flash radiotherapy (with the participation of the CSIC-UPValencia I3M and the IDICHUS USC).

- A collaborative project with the University of Seville and the National Accelerator Centre (CAN) to investigate the generation of neutrons by laser interaction has been transferred to the CLPU (Salamanca) due to the impossibility of carrying out experiments at the L2A2.

- A new beamline for particle acceleration has been designed for the L2A2 (tender financed by infrastructures 2018).

- A new doctoral thesis (FPI) and Postdoctoral contract (funded by this call) has been started.

- Recruitment of a researcher in the prestigious "la Caixa" Junior Leadership call who joined the IGFAE in December 2020.

In spite of the difficulties of access and mobility this year

we have had 3 final degree students, 1 final master's degree student and 1 student on external placements.

- We have had visitors from the Universidad Autónoma de México: Jesús Delgado, Universidad Politécnica de Valencia: Michael Seimetz, Universidad de Salamanca: Camilo Ruiz and, Universidad Politécnica de Milán: Luccio Crincolli.

Summary of scientific production 2020: Publication of 3 articles and 4 theses in progress.

Natural radioactivity: applications to society

From the Radiation Analysis Laboratory, based on our experience in fundamental research, we implement techniques to quantify natural radiation, which will lead to an improvement in our quality of life.

- Our main line of action focuses on the detection of Rn, which has a particular impact in Galicia. We are authors of an action protocol, transferred to a spin-off of the USC to design and guide actions to mitigate high concentrations of this gas indoors. Throughout this year and with combined funding from this call and the Vice-rectorate for Quality of the USC, we have begun a process of accreditation according to ISO 17025 of this protocol.

- We have installed and put into operation the material acquired for equipment in the 2018 infrastructure call to expand our capacity to determine radioactive parameters in organic samples and develop multidisciplinary projects.

- The last phase of the Retos Colaboración 2017 project, consisting of field tests, has been carried out. This project, developed in collaboration with the CNM in Barcelona, has enabled the design and construction of a sensor (prototype) for continuous monitoring of Rn indoors based on Si detectors (currently in the preparation phase).

## Scientific Production

During this year 2020, 148 articles have been published, the details of which are shown in Annex 1 of this report. 95 are in the first decile (64%) and 129 in the first quartile (87%). The average CiteScore per article was 9.09. The distribution of articles by research program:

| Research Área | Research Program | Nº Pub. | 1st Decile |
|---|---|---|---|
| SA1 The Standard Model to the Limits | SA1_HQCD | 20 | 13 |
| | SA1_LHCB | 50 | 42 |
| | SA1_STRI | 13 | 12 |
| SA2 Cosmic Particles and Fundamental Physics | SA2_AUGE | 14 | 6 |
| | SA2_GRWA | 15 | 8 |
| | SA2_NEXT | 7 | 2 |
| SA3 Nuclear Physics from the Lab to Improve People´s Health | SA3_LACC | 3 | 1 |
| | SA3_NUCL | 26 | 11 |

## Publications of the year

We list a series of outstanding publications of this year 2020, IGFAE researchers have played a key role in all of them.

**Observation of Several Sources of CP Violation in B+ → π + π + π − Decays**

R. Aaij et al. (LHCb Collaboration). Phys. Rev. Lett. 124 (2020) 031801

Observations are reported of different sources of CP violation from an amplitude analysis of B+ → π+π+π− decays, based on a data sample corresponding to an integrated luminosity of 3 fb−1 of pp collisions recorded with the LHCb detector. A large CP asymmetry is observed in the decay amplitude involving the tensor f2(1270) resonance, and in addition significant CP violation is found in the π+π− S wave at low invariant mass. The presence of CP violation related to interference between the π+π−S wave and the P wave B+ → ρ0(770)π+ amplitude is also established; this causes large local asymmetries but cancels when integrated over the phase space of the decay. The results provide both qualitative and quantitative new insights into CP - violation effects in hadronic B decays.

DOI: 10.1103/PhysRevLett.124.03180

**Jet quenching as a probe of the initial stages in heavy-ion collisions**

Carlota Andres, Néstor Armesto, Harri Niemi, Risto Paatelainen, Carlos A. Salgado

Phys. Lett.B 803 (2020) 135318

Jet quenching provides a very flexible variety of observables which are sensitive to different energy- and time-scales of the strongly interacting matter created in heavy-ion collisions. Exploiting this versatility would make jet quenching an excellent chronometer of the yoctosecond structure of the evolution process. Here we show, for the first time, that a combination of jet quenching observables is sensitive to the initial stages of heavy-ion collisions, when the approach to local thermal equilibrium is expected to happen. Specifically, we find that in order to reproduce at the same time the inclusive particle production suppression, RAA, and the high-pT azimuthal asymmetries, v2, energy loss must be strongly suppressed for the first ~ 0.6 fm. This exploratory analysis shows the potential of jet observables, possibly more sophisticated than the ones studied here, to constrain the dynamics of the initial stages of the evolution.

DOI: 10.1016/j.physletb.2020.135318

**Search for A0 → μ + μ − Decays**

R. Aaij et al.* (LHCb Collaboration). Phys. Rev. Lett. 124, 041801(2020)

Searches are performed for both promptlike and long-lived dark photons, A0, produced in proton-proton collisions at a center-of-mass energy of 13 TeV. These searches look for A0 → μ+μ− decays using a data sample corresponding to an integrated luminosity of 5.5 fb−1 collected with the LHCb detector. Neither search finds evidence for a signal, and 90% confidence-level exclusion limits are placed on the γ−A0 kinetic mixing strength. The promptlike A0 search explores the mass region from near the dimuon threshold up to 70 GeV and places the most stringent constraints to date on dark photons with 214 < mA0 ≲ 740 MeV and 10.6 < mA0 ≲ 30 GeV. The search for long-lived A0 → μ+μ− decays places world-leading constraints on low-mass dark photons with lifetimes O(1) ps.

DOI: 10.1103/PhysRevLett.124.041801

**Features of the Energy Spectrum of Cosmic Rays above 2.5 × 1018 eV Using the Pierre Auger Observatory**

Alvarez-Muñiz, J., Choi, K., Parente, G., Pedreira, F., Torralba Elipe, G., Zas, E. Aab A. et al. Phys. Rev. Lett. 125, 121106 (2020)

We report a measurement of the energy spectrum of cosmic rays above 2.5 × 1018 eV based on 215 030 events. New results are presented: at about 1.3 × 1019 eV, the spectral index changes from 2.51 +- 0.03(stat) +- 0.05(syst) to 3.05 +- 0.05(stat) +- 0.10(syst), evolving to 5.1 +- 0.3(stat) +- 0.1(syst) beyond 5 × 10^19 eV, while no significant dependence of spectral features on the declination is seen in the accessible range. These features of the spectrum can be reproduced in models with energy-dependent mass composition. The energy density in cosmic rays above 5×10^18 eV is 5.66 +- 0.03(stat) +- 1.40(syst) × 10^53 erg Mpc−3.

DOI: 10.1103/PhysRevLett.125.121106

**First Direct Measurement of 22Mg(α;p)25Al and Implications for X-Ray Burst Model-Observation Comparisons**

J. S. Randhawa, Y. Ayyad, W. Mittig, Z. Meisel, T. Ahn, S. Aguilar, H. Alvarez-Pol, et al. Phys. Rev. Lett. 125 (2020) 20, 202701

Type-I x-ray bursts can reveal the properties of an accreting neutron star system when compared with astrophysics model calculations. However, model results are

sensitive to a handful of uncertain nuclear reaction rates, such as 22Mg(α; p). We report the first direct measurement of 22Mg(α; p), performed with the Active Target Time Projection Chamber. The corresponding astrophysical reaction rate is orders of magnitude larger than determined from a previous indirect measurement in a broad temperature range. Our new measurement suggests a less-compact neutron star in the source GS1826-24.
DOI: 10.1103/PhysRevLett.125.202701

**Allen: A High-Level Trigger on GPUs for LHCb**

R. Aaij, J. Albrecht, M. Belous, P. Billoir, T. Boettcher, A. Brea Rodríguez et al.
Comput. Softw. Big Sci. 4 (2020) 1, 7
Abstract We describe a fully GPU-based implementation of the first level trigger for the upgrade of the LHCb detector, due to start data taking in 2021. We demonstrate that our implementation, named Allen, can process the 40 Tbit/s data rate of the upgraded LHCb detector and perform a wide variety of pattern recognition tasks. These include finding the trajectories of charged particles, finding proton–proton collision points, identifying particles as hadrons or muons, and finding the displaced decay vertices of long-lived particles. We further demonstrate that Allen can be implemented in around 500 scientific or consumer GPU cards, that it is not I/O bound, and can be operated at the full LHC collision rate of 30 MHz. Allen is the first complete high-throughput GPU trigger proposed for a HEP experiment.
DOI: 10.1007/s41781-020-00039-7

**GW190521: A Binary Black Hole Merger with a Total Mass of 150 M⊙**

R. Abbott et al. (LIGO Scientific Collaboration and Virgo Collaboration). Phys. Rev. Lett. 125 (2020) 10, 101102
On May 21, 2019 at 03:02:29 UTC Advanced LIGO and Advanced Virgo observed a short duration gravitational-wave signal, GW190521, with a three-detector network signal-to-noise ratio of 14.7, and an estimated false-alarm rate of 1 in 4900 yr using a search sensitive to generic transients. If GW190521 is from a quasicircular binary inspiral, then the detected signal is consistent with the merger of two black holes with masses of 85+21 −14 M⊙ and 66+17 −18 M⊙ (90% credible intervals). We infer that the primary black hole mass lies within the gap produced by (pulsational) pair-instability supernova processes, with only a 0.32% probability of being below 65 M⊙. We calculate the mass of the remnant to be 142+28 −16 M⊙, which can be

considered an intermediate mass black hole (IMBH). The luminosity distance of the source is 5.3+2.4 −2.6 Gpc, corresponding to a redshift of 0.82+0.28 −0.34 . The inferred rate of mergers similar to GW190521 is 0.13+0.30 −0.11 Gpc−3 yr−1.
DOI: 10.1103/PhysRevLett.125.101102

**GW190814: Gravitational Waves from the Coalescence of a 23 Solar Mass Black Hole with a 2.6 Solar Mass Compact Object**

LIGO Scientific and Virgo Collaborations, R. Abbott et al. *Astrophys.J.Lett.* 896 (2020) 2, L44

We report the observation of a compact binary coalescence involving a 22.2–24.3 M⊙ black hole and a compact object with a mass of 2.50–2.67 M⊙ (all measurements quoted at the 90% credible level). The gravitational-wave signal, GW190814, was observed during LIGO's and Virgo's third observing run on 2019 August 14 at 21:10:39 UTC and has a signal-to-noise ratio of 25 in the three-detector network. The source was localized to 18.5 deg2 at a distance of 241-45+41 Mpc; no electromagnetic counterpart has been confirmed to date. The source has the most unequal mass ratio yet measured with gravitational waves, 0.112-0.009+0.008}, and its secondary component is either the lightest black hole or the heaviest neutron star ever discovered in a double compact-object system. The dimensionless spin of the primary black hole is tightly constrained to ≤0.07. Tests of general relativity reveal no measurable deviations from the theory, and its prediction of higher-multipole emission is confirmed at high confidence. We estimate a merger rate density of 1–23 Gpc−3 yr−1 for the new class of binary coalescence sources that GW190814 represents. Astrophysical models predict that binaries with mass ratios similar to this event can form through several channels but are unlikely to have formed in globular clusters. However, the combination of mass ratio, component masses, and the inferred merger rate for this event challenges all current models of the formation and mass distribution of compact-object binaries.
DOI: 10.3847/2041-8213/ab960f

**Post-merger chirps from binary black holes as probes of the final black-hole horizon**

Juan Calderon Bustillo, Christopher Evans, James A. Clark, Grace Kim, Pablo Laguna and Deirdre Shoemaker. Communications Physics volume 3, Article number: 176 (2020)

The merger of a binary black hole gives birth to a highly distorted final black hole. The gravitational radiation emitted as this black hole relaxes presents us with the unique opportunity to probe extreme gravity and its connection with the dynamics of the black hole horizon. Using numerical relativity simulations, we demonstrate a connection between a concrete observable feature in the gravitational waves and geometrical features on the dynamical apparent horizon of the final black hole. Specifically, we show how the line-of-sight passage of a "cusp"-like defect on the horizon of the final black hole correlates with "chirp"-like frequency peaks in the post-merger gravitational-waves. These post-merger chirps should be observed and analyzed as the sensitivity of LIGO and Virgo increase and as future generation detectors, such as LISA and the Einstein Telescope, become operational.
DOI: https://doi.org/10.1038/s42005-020-00446-7

**Physics opportunities with the Advanced Gamma Tracking Array: AGATA**
AGATA Collaboration, W. Korten et al. *Eur. Phys. J. A* 56 (2020) 5, 137
New physics opportunities are opening up by the Advanced Gamma Tracking Array, AGATA, as it evolves to the full 4π instrument. AGATA is a high-resolution γ-ray spectrometer, solely built from highly segmented high-purity Ge detectors, capable of measuring γ rays from a few tens of keV to beyond 10 MeV, with unprecedented efficiency, excellent position resolution for individual γ-ray interactions, and very high count-rate capability. As a travelling detector AGATA will be employed at all major current and near-future European research facilities delivering stable and radioactive ion beams.
DOI: 10.1140/epja/s10050-020-00132-w

## Laboratories

The strategic line of strengthening the experimental activity at instrumental level, efforts have been made in the acquisition of laboratory instruments, mainly with the calls for infrastructure of the Ministry of Science and reinforced with the incorporation of funds from the Xunta de Galicia. This is a process that is planned on a multiannual basis and for which the expansion of laboratory space planned at the new IGFAE headquarters will be essential. We consider this to be an essential line of financing, from a structural point of view, which provides baseline funding for competitive projects.

**Microelectronics Lab.**

In addition to the upgrade of the LHCb experiment after 2020 (Upgrade Phase I), the IGFAE researchers are carrying out the necessary R&D for a second upgrade that will occur at the shutdown of the LHC accelerator around 2030. To perform this second upgrade (Upgrade Phase II) it is necessary to develop a new detection technology using silicon pixel sensors highly resistant to radiation, and incorporating very precise temporal and spatial information of the passage of the particles produced in the interaction (4D vertexing).

To this end, collaborations have been initiated with Nikhef (LHCb), IFCA (Santander, CMS), CNM (Barcelona), and CERN (LHCb, DT). A new sensor has been designed and is currently in production at the CNM. For this it has been necessary to acquire the silicon wafers, design the photolithographic masks and carry out the production in the integrated clean room of micro and nanotechnologies of the ICTS of the IMB-CNM-CSIC, also expendable materials have been acquired for the verification of the sensors once their production has been completed.

European funding has recently been obtained to carry out part of the necessary developments (AIDAinnova Grant Agreement 101004761 pending signature at the time of writing this report).

**L2A2 and LDD L**

The data in brackets indicate the laboratory where the work is carried out and then a reference of the project that "validates" the interest of the developments made in the framework of the laboratory:

- CALIFA/R3B calorimeter construction (LDD - Associated to a National Plan 2018 project).

- Construction of a PET based on CsI/GAGG scintillators in Phoswich mode (LDD IGNITE project).

- Installation and maintenance of a HpGe (LAR - Call for proposals of the National Infrastructure Plan).

- Development of a Si detector for radon concentration determination (LAR - RETOS Project).

- Generation of R-X images generated by plasma-matter interaction (L2A2 - RETOS Project).

- Generation of isotopes for PET use from proton acceleration by plasma-matter interaction (L2A2 - LaserPet. National Plan Project).

**TRASGO Lab**

Tragaldabas is a high-resolution cosmic ray detector of the Trasgo family located, active and taking data since 2015. Among its lines of work are, the study of the atmosphere, solar activity, and the search for new signatures to identify high energy primary cosmic rays.

**FICA Lab**

During this year it has been dedicated to the construction of an Optical Time Projection Camera. This project is part of the program dedicated to the study of the structure and dynamics of exotic nuclei with active targets. It belongs to the project in the area of Nuclear Physics and aims to understand the strong interaction of its fundamental components. Active targets are particularly useful in low energy experiments with low intensity radioactive beams.

# Industrial and Social Engagement Strategy

## Valorization and transfer

Once the application (U20203030667) was filed on 04/17/2020, the Ministry of Energy, Tourism and Digital Agenda granted the title of UTILITY MODEL on September 1, 2020 to an invention carried out by Dr. Pablo Cabanelas, referring to a device based on the response to radiation by combination of scintillation materials,

more specifically it refers to a phoswhich scintillator device with application in PET and SPECT imaging..

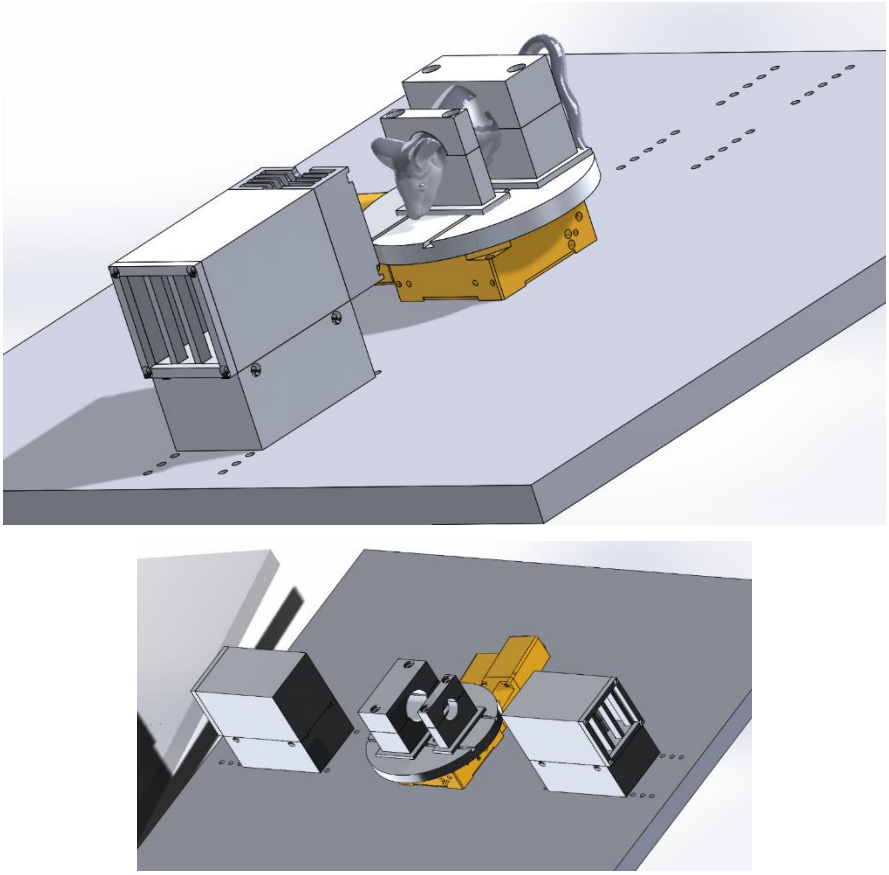


*Imagen 1. Montaje-SPECT y PET.*

During the first period of pandemic confinement in March of this year the IGFAE laboratories have been working on the construction of a PROTOTYPE respirator called HEV in coordination with CERN, the working group created CERN against COVID-19 was established at the end of March to identify and support these initiatives. This prototype has been developed in coordination with medical professionals. The design of the HEV is that of a high quality model at a lower cost and with application to the majority of COVID-19 patients, so that higher end models would be released for more intensive cases. The design is modular so that parts are easily interchangeable. For more information: HEV Collaboration

### R&D and technological services contracts

The service of measuring radon and other radioactive parameters in environmental samples for private companies such as Quirón Prevención S.L., Innovaciones Tecnológicas Radón, Biotécnicas Aplicadas S.l: etc. is being carried out.

There is a confidentiality agreement in place "possible commercial action and subsequent technical study consisting of the analysis of the regulations applicable to potential commercial and industrial activities of senra" and the Medical Applications of Laser Accelerators project.

Within the framework of laboratory improvement and to provide certain services from the Radiation Analysis Laboratory (LAR), the UNE-EN/ISO/IEC 17025:2017 certification is being carried out. In Spain, the Nuclear Safety Council (CSN) advises that the determination of radon concentration should be carried out by laboratories accredited according to the UNE-EN ISO/IEC 17025:2017 standard, which accredits both the administrative and technical quality management of testing and calibration laboratories.

### Other relationships

During this year, contacts have been made with other relevant agents of social sectors to establish possible collaborations for 2021. Among the agents contacted:

- Abanca is one of the possible entities interested in the insertion of IGFAE master's degree students.
- KimGlobal, ESA broker for Spain, member of the network Fusion for Energy Broker. IGFAE collaborator in tech transfer.

## Training

During this year, the IGFAE has offered 6 Master's scholarships for students of the **master's degree** in Physics of the USC, for an amount of 5,000 euros each, for the academic year 2020/2021. The institute's training offer also includes:

- Academic Training Program (Academic Training Program).

- International Postdoctoral Training Program

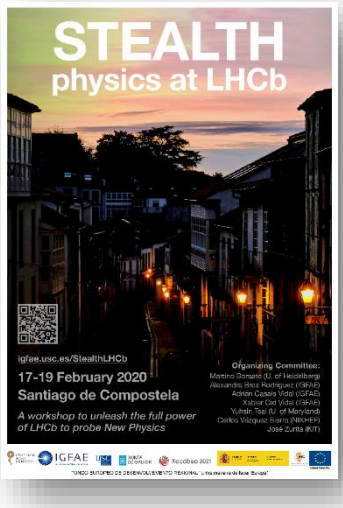
- International Doctoral Program and Professional Development Plan (International PHD Program). For the first time, an international call for PhD students launched

through the Academic Jobs Online platform, a reference in Particle Physics, and a total of 63 applications were received, with four international students joining the PhD program in this way.

As mentioned above, specific support was provided to IGFAE candidates preparing ITN and MSCA IF proposals.

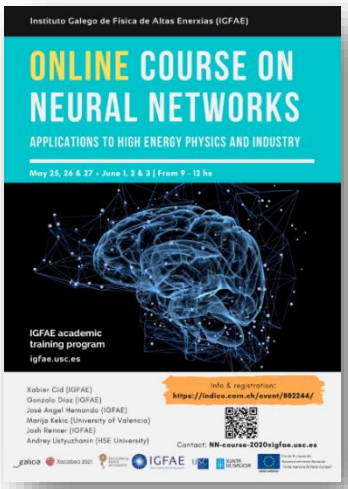
## Workshops, courses and conferences organised by the IGFAE

**STEALTH physics at LHCb: unleashing the full power of LHCb to probe new physics**



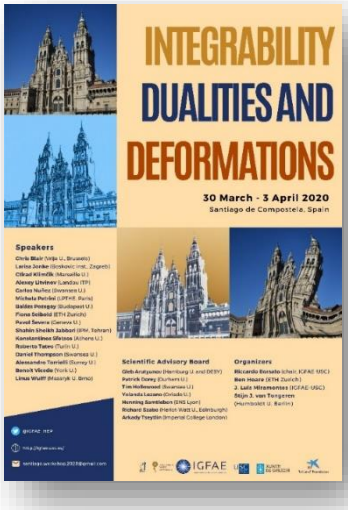

Stealth physics at LHCb was a workshop organised by the IGFAE in Santiago de Compostela from 17 to 19 February at the USC Centre for Advanced Studies. Although stealth physics is very recent, the leadership of the IGFAE in this area within the LHCb has motivated the organisation of this workshop with the aim of encouraging discussion and promoting the study of stealth physics, both from a theoretical and experimental point of view.

**Online course 'Neural Networks: applications to high-energy physics and industry'**




On the mornings of 25, 26 and 27 May and 1, 2 and 3 June, the IGFAE organised the course 'Neural Networks: applications to high-energy physics and industry', in virtual format due to the coronavirus, which allowed the participation of more than 60 people from different parts of the Peninsula. The course introduced machine learning techniques used in particle physics research and whose applications extend far beyond academic research. The sessions were recorded and are available on the IGFAE YouTube channel.

**Conference on Integrability, dualities and deformations**




The conference "Integrability, dualities and beyond," organised by researcher Riccardo Borsato had to be cancelled a fortnight before it was due to take place, but is now scheduled to take place in August 2021. The aim of this workshop is to bring together experts in the fields of deformations of integrable models; sheet dualities and extended field theories; non-commutative and non-associative QFT; quantum integrable systems in gauge/gravity duality.

**RD51 Collaboration Meeting and the topical workshop on 'New Horizons in TPCs'**

The week of 5-9 October saw the annual meeting of the CERN RD51 collaboration, a meeting organised by the IGFAE, which this year quadrupled its attendance, with 271 registrants. The programme included 40 technical talks and a further 34 (in review format) took place in the parallel workshop New Horizons in TPCs, organised by Paul Colas (Saclay-IRFU) and Diego González-Díaz (IGFAE). The organising committee of the collaboration meeting was formed by other IGFAE researchers: José Benlliure, Dolores Cortina, Abraham Gallas, Juan Antonio Garzón Heydt, Ángela Saa-Hernández, Pablo Amedo and Marcos Seco.

**Conference 'Direct Reactions with exotic beams – DREB2020'**

Due to the COVID-19 crisis, DREB2020 was to be held in July 2020 and has been postponed to 2022. The planned programme was as follows:

- Nuclear astrophysics
- Spectroscopy of exotic nuclei, drip line and unbound nuclei.
- Nuclear force. Short-range correlations
- Advances in direct reaction theory
- New instrumentation for direct reaction studies
- Ab-initio methods for structure and reactions.
- Clustering phenomena probed by nuclear reactions

**Conference: Iberian Strings 2020**


Iberian Strings 2020 was the 7th annual meeting of the Spanish and Portuguese string theory community, which was held between 15 and 17 January at the Hospedería San Martín Pinario in Santiago de Compostela. Recent developments in the field of supergravity, strings, branes and gauge theories were discussed.

**Congreso: Conference on flavour physics and CP violation (FPCP) 2020**


FPCP 2020 fue una conferencia organizada por el IGFAE en formato online celebrada entre el 8 y el 12 de junio donde se discutieron los temas más relevantes desde el punto de vista experimentos como teórico en el campo de la física del sabor.

**Forward Physics and Diffraction at the LHC**

Forward Physics and Diffraction at the LHC was a workshop organised by the IGFAE on 13-15 May and cancelled also by the coronavirus. This meeting is part of the series of workshops of the LHC Physics Centre, the LHC Working Group on Advanced Physics and Diffraction in which current and future theoretical and experimental results on these topics are discussed. It is planned to be held in fall 2021 if the COVID situation allows.

**9th International Conference on Acoustic And Radio Eev Neutrino Detection Activities Arena 2020**


ARENA 2020 is a conference organised by the IGFAE and scheduled for 26-29 May in Santiago de Compostela. It was also cancelled due to the pandemic and is scheduled to take place next year. It will bring together experts in the use of acoustic and radio techniques for the detection of high-energy cosmic ultra-rays and neutrinos. ARENA 2020 is the main biannual event for scientists to develop and consolidate techniques for the detection of ultra-high energy particles.

# Responsible Research and Innovation (RRI)

Within the framework of the center's Responsible Research, progress has been made in two ways: in the specific training of the center's personnel in calls focused on "Science with and for Society" and the increase in contacts with other international agents for the presentation of proposals, such as attendance at Brokerage Events in Brussels, etc...

On the other hand, progress has been made in the programming of the IGFAE Labs through the activities detailed on page X of this report.

Another milestone in this area during this year was the incorporation into the European Network GENERA (Gender Equality Network in the European Research Area). Under the activity of this network, the IGFAE has just been presented as a participating member in a COST action (BIRDIE Project) in which good practices in diversity and inclusion in large international scientific collaborations were identified. Although the proposal was not approved, the network is still working on a second and improved proposal for this year.

# Dissemination and promotion of scientific culture

## ArtLAB

**Cylce "Transfronteirizas, conversas de arte e ciencia"**

"Transfronteirizas, conversas de arte e ciencia" is a series of virtual dialogues broadcast on Youtube in which cultural figures are invited to explore the intersections between art and science with our research staff, seeking an interdisciplinary approach. This initiative, created in May 2020, is part of the ArtLAB programme, which aims to build bridges and encourage participation between society and the research community through different artistic expressions.




**Long lived particles: a new way to decipher the universe**

Production of an outreach video on a project by IGFAE researcher Xabier Cid Vidal, currently under development. The project consists of the design, construction, and installation of a detector, called Codex-b, in the cavern of the LHCb experiment at CERN when it starts its third period of operation (Run 3) in 2021. Its aim is to measure long-lived particles that currently elude existing detectors. The video explains through animations and interviews with the researcher himself what particle physics is, how it is studied with accelerators and what the discovery of new particles entails. The video is intended to introduce the project to the public and research staff. Video available at: https://youtu.be/V4Y7H_H2lKM


**"O soño musical dos Mapas Celestes"**

On the occasion of the year Xacobeo 2021, the IGFAE, through the researcher José Edelstein, with the Xunta de Galicia, the Universidade de Santiago de Compostela and possibly some other co-financing institution, such as the Concello de Santiago, to be confirmed, is working on the organisation of a performance/scenic musical exhibition with Irene Dubrovsky (visual artist), Uxía (singer), Germán Díaz (musician)

and Celtia Figueiras (actress). The researcher José Edelstein is in charge of writing the texts and the script. The topic brings together the history of the Camino de Santiago as a communicating thread of everything that was happening in Europe and that reached Santiago through the pilgrims, with their stories, literature, music and scientific knowledge. This route is also associated with the Milky Way and, in this sense, is linked to the exploration of our place in the cosmos. Since the second part of 2020 we have been working on the organisation of this event, which will be held in the Colexio de Fonseca's Salón Artesonado in the second week of September 2021.

## EduLAB

The following activities were carried out in 2020 within the framework of the Edulab space:

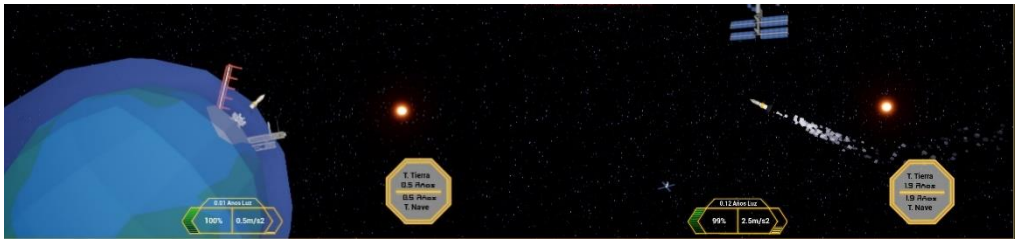
**Construction of a portable fog chamber**

Fog chambers were one of the first particle detectors developed at the beginning of the 20th century, and it was thanks to them that elementary particles such as the positron (1932) or the muon (1936) were discovered. Today, they are a tool of unquestionable educational value for the dissemination and understanding of particle physics, as they allow us to observe with our own eyes the traces of the subatomic particles that pass through the chamber.

The aim of this project has been to build a small fog chamber from scratch using thermoelectric plates for cooling. This will make it more transportable and easier to maintain than conventional dry ice cooling designs.

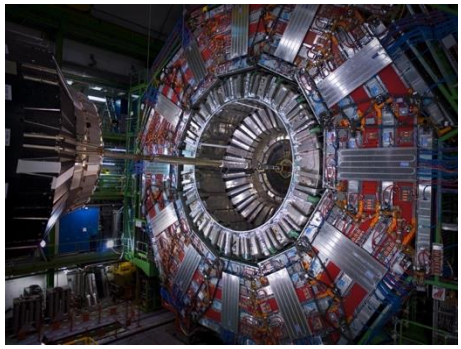
**Design and construction of relativistic video game 'Space Time Navigator'**

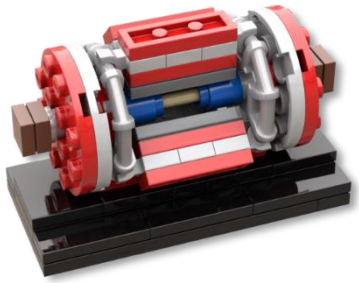
The **Space Time Navigator** video game is a console game about piloting a spacecraft that can reach speeds comparable to the speed of light. The journey is set between Earth and Proxima B, the closest known extrasolar planet. In particular, the player must consider not only the position of the spacecraft in space, but also the different time evolution in the clocks on board or on the Earth base. In this way, the aim of the mission can be not only to reach the planet Proxima B and return, but also to try to do so while generating a specific generation gap. The aim is to acquire, while playing, an intuition about the rules governing movement in space-time.



**LEGO project**

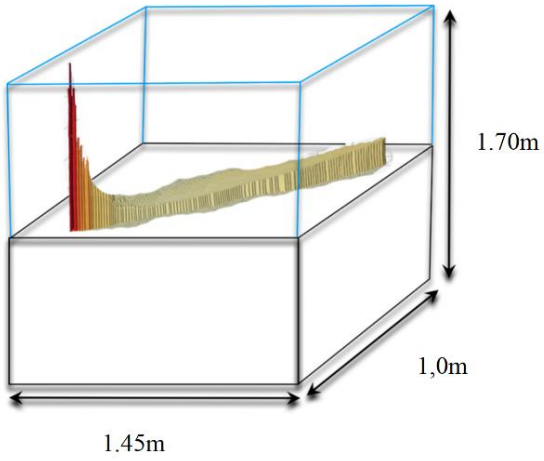
The IGFAE wanted to disseminate the advances in nuclear and particle physics through some of the detectors that are currently used in experiments and the design of a chart of nuclei in three dimensions. For this purpose, it was proposed to build a scale model of these detectors with LEGO blocks.





Through the dynamics of the activity, explaining its assembly and with complementary talks, the mechanisms that the real detectors use are detailed. A computer design was made of LEGO blocks, which would help to explain some of the fundamentals and specific advances in nuclear physics and the discoveries of new nuclei. Some of these discoveries, specifically discovered by IGFAE researchers.

This project has been in the pipeline before 2020, but always very limited in funding. After more than a year of work, the parts and the first versions of the designs are done, including assembly instructions, for a complete experience. It was planned to present these assemblies at the IGFAE open days, which was cancelled due to Covid19.



In the short-medium term, this activity could be linked to didactic units explaining the structure of the subject, acting as a bridge between the IGFAE and the students. In addition, the nuclei chart with more than 40,000 LEGO blocks will be a permanent exhibition at the institute, as a display case has been designed to display it.

The pictures show the CMS detector at CERN, involved in the discovery of the Higgs, in a real photo and the scale model with LEGO pieces, and the computer design of the LEGO blocks of the nuclei chart.

## Outreach Working Group

**International Masterclass 'Hands on Particle Physics'**


Once again, this year, the IGFAE organized the International Masterclass 'Hands on Particle Physics', in collaboration with the European Physical Society, CERN (European Organization for Nuclear Research) and Fermilab (Fermi National Laboratory) for students in their final academic year of high school. The event consists of a series of lectures on current particle physics, a computer-based training carried out in groups whose results are discussed by videoconference with other European centres that are simultaneously organising an identical masterclass, in which more than 13,000 students from 52 countries take part every year. Scheduled for 12 March and with 76 students registered, it was cancelled the day before as a precautionary measure due to the coronavirus.

**Cycle "Universo Peregrino: ciencia galega cara o mundo"**

"Universo peregrino: ciencia galega cara o mundo" is a series of online outreach talks organised by the IGFAE for the international Galician-speaking community. Emerging during confinement when pilgrims could not come to Santiago, the Xacobean city is the one that rebuilds the bridges and undertakes the pilgrimage to the world, bringing the physics that is done in Galicia to Galician around the world. Every

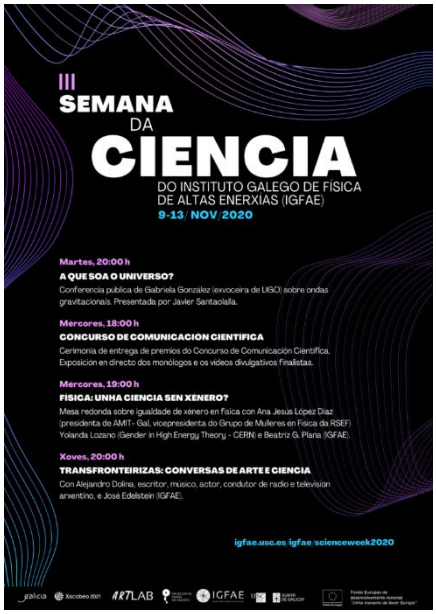
Thursday in May and June, IGFAE research staff gave a talk (8 in total) on different physics topics that could be followed online and are now available on the Youtube channel. The cycle is scheduled to continue in 2021 and Galician researchers from other research centres are expected to join in.



### 3rd Science Week

From 10 to 13 November IGFAE organized its 3rd Science Week with a program of activities for all audiences and a renewed, completely online format, which was streamed on the IGFAE YouTube channel. Program:

- November 10: Public lecture "What does the Universe sound like?" by Gabriela González, former LIGO spokesperson, presented by physicist, popularizer and youtuber Javier Santaolalla.
- November 11 | Award giving ceremony of the Scientific Communication Contest (IGFAE C3). In this edition, the contest had 3 categories: outreach articles, scientific monologues, and outreach videos. Round table "Physics: a science without gender?" *(See Gender Working Group section)*
- November 12: 'Transfronteirizas, conversas de arte e Ciencia' with Alejandro Dolina and José Edelstein *(See ArtLAB section)*

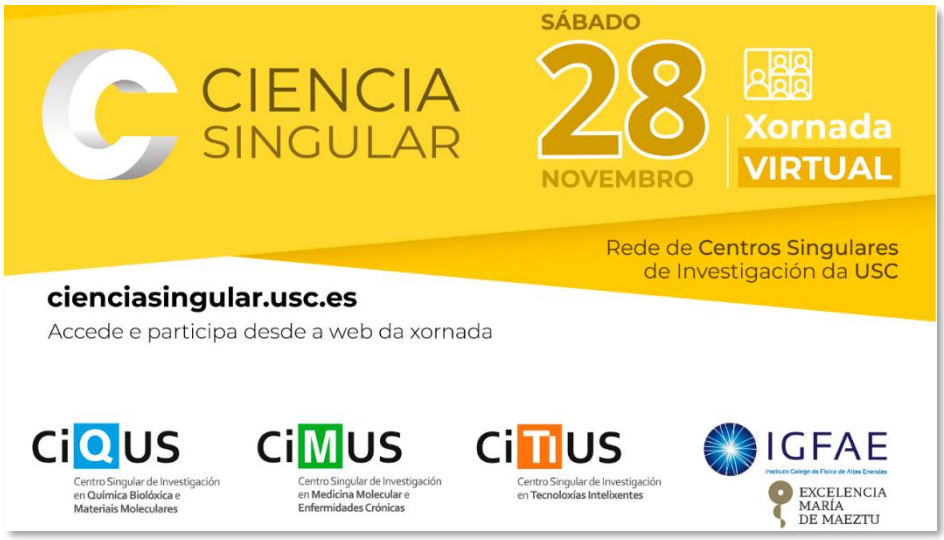


**'Ciencia Singular' Open Days**

The Network of Singular Research Centres (RCSI) of the University of Santiago de Compostela (USC) hold on Saturday 28th November a dissemination day aimed at showing society the work of excellence carried out by the four centres of the network (CiQUS, CiMUS, CiTIUS and IGFAE). The IGFAE organized 4 virtual talks, the release of a corporate video and an online trivial, available in the Youtube channel.

Programme:

- Alejandro Vilar: "A gravidade (cuántica) nun holograma"
- Cristina Cabo: "Del corazón de la materia al interior de las estrellas"
- Juan Calderón: "Cómo oír agujeros negros con ondas gravitacionales"
- Alessandra Gioventù: "Descubriendo el Universo de las partículas"
- Instituto Galego de Física de Altas Enerxías (IGFAE), Centro Singular de Investigación de Galicia
- Kahoot: ¿Cuánto sabes del IGFAE?




## Gender Working Group

One of its main objectives is to make a diagnosis of the situation of women researchers, mainly, and the initiatives carried out in favour of gender equity. Soon after the group developed the ***IGFAE's 1st Equity and Diversity plan***, which is currently about to be officially approved.

In addition, IGFAE joined the network GENERA (Gender Equality Network in Physics in the European Research Area). Due to this we participated in a COST proposal, BIRDIE. In addition, regular meetings to discuss issues such as the impact of COVID

on family reconciliation or possible measures to support female leadership in science took place.

**Particle Physics Masterclass "Women's and Girls' Science Day**

On 11 February, International Day of Women and Girls in Science, the IGFAE organised the second edition of the Particle Physics Masterclass aimed exclusively at female students. 40 girls from all over Galicia experienced the day-to-day life of a female researcher in particle physics and, on the other hand, participated in talks and debates aimed at raising awareness of the role of women scientists and encouraging STEM vocations. This initiative is the result of IGFAE's collaboration with the International Particle Physics Outreach Group and CERN and arose from the need to promote the participation of girls and women in science and to assume the commitment to put an end to the gender imbalance in this discipline.

**Round table: Physics: a science without gender?**


On 11 November, within the framework of the 3rd Science Week, it took place the virtual round table *Physics: a science without gender?*, where three experts on gender equality discuss some data and initiatives that are being carried out to achieve gender balance in Physics: Ana Jesús López Díaz (president of AMIT-Gal, vice president of the Group of Women in Physics of RSEF), Yolanda Lozano (Gender in High Energy Theory – CERN) and Beatriz G. Plana (IGFAE).

## Benchmarking Working Group

The group's work throughout the year has been very focused on María de Maeztu call. During 2020 the working group and its members have been formalized, A working group was set up with IGFAE personnel and an external consultant company, Knowledge Innovation Market

The results demonstrated that IGFAE is well positioned across all key metrics except technology transfer, and furthermore several interesting practices were identified which IGFAE plans to adopt.

# Annex 1. New funding

**Ref. 2020-SG043-1**

Service for measuring radon and other radioactive parameters in environmental simples.

| PI | Funder | |
|---|---|---|
| Cortina Gil, María Dolores | Fabián Marcelo Calandria López | |
| **Start date** | **End date** | **Funding** |
| 1/1/2016 | 12/31/2020 | 328,9€ |

**Ref. PID2019-105544GB-I00**

Astronomía de Multimensajeros y el Observatorio Pierre Auger

| PI | Funder | |
|---|---|---|
| Zas Arregui, Enrique | Axencia Estatal de Investigación (AEI) | |
| **Start date** | **End date** | **Funding** |
| 6/1/2020 | 5/31/2023 | 251.680€ |

**Ref. PID2019-109173GB-I00**

LHCb Data Exploitation.

| PI | Funder | |
|---|---|---|
| Martinez Santos, Diego | Axencia Estatal de Investigación (AEI) | |
| **Start date** | **End date** | **Funding** |
| 6/1/2020 | 5/31/2023 | 405.350€ |

**Ref. PID2019-110378GB-I00**

Estudiando la Universalidad Leptónica de Sabor y la Estructura Nuclear con el experimento LHCb mejorado

| PI | Funder | |
|---|---|---|
| Gallas Torreira, A.A. | Axencia Estatal de Investigación (AEI) | |
| **Start date** | **End date** | **Funding** |
| 6/1/2020 | 5/31/2023 | 869.627€ |

**Ref. 2020-AD029**

Convenio de colaboración para completar las ayudas al personal investigador principal de los programas del Consejo Europeo de Investigación

| PI | Funder | |
|---|---|---|
| Salgado López. C. | Xunta de Galicia | |
| **Start date** | **End date** | **Funding** |
| 1/1/2019 | 12/31/2024 | 400.000€ |

**Ref. 2020-HO001**

Postdoctoral Junior Leader Fellowships

| PI | Funder | |
|---|---|---|
| Salgado López. C. | Fundación Bancaria la Caixa | |
| **Start date** | **End date** | **Funding** |
| 9/1/2020 | 10/5/2023 | 303.300€ |

**Ref. ED431F 2020/13**

Estudio de la Universalidad de Sabor Leptónico en LHCb

| PI | Funder | |
|---|---|---|
| Romero Vidal, A. | Xunta de Galicia | |
| **Start date** | **End date** | **Funding** |
| **1/1/2020** | 11/30/2024 | 115.000€ |

**Ref. ED431F 2020/10**

Análisis de datos y High Level Trigger de LHCb

| PI | Funder | |
|---|---|---|
| Martinez Santos, D. | Xunta de Galicia | |
| **Start date** | **End date** | **Funding** |
| **1/1/2020** | 11/30/2023 | 200.000€ |

**Ref. 2020-CL042**

Micro soldering service from circuit-to-circuit board

| PI | Funder | |
|---|---|---|
| Gallas Torreira, Abraham | CETAG | |
| **Start date** | **End date** | **Funding** |
| 10/27/2020 | 11/03/2021 | 300€ |

**Ref. 2020-SG043-2**

Service for measuring radon and other radioactive parameters in environmental simples.

| PI | Funder | |
|---|---|---|
| Cortina Gil, María Dolores | Innovaciones Tecnológicas Radón S.L. | |
| **Start date** | **End date** | **Funding** |
| 01/01/2020 | 12/31/2020 | 1.804 € |

**Ref. 2020-SG043-3**

Service for measuring radon and other radioactive parameters in environmental simples.

| PI | Funder | |
|---|---|---|
| Cortina Gil, María Dolores | Marta Regueiro Abel | |
| **Start date** | **End date** | **Funding** |
| 01/01/2020 | 12/31/2020 | 65,29 € |

**Ref. 2020-SG043-4**

| PI | Funder | |
|---|---|---|
| Cortina Gil, María Dolores | Isabelle Sophie Leschier Gardet | |
| **Start date** | **End date** | **Funding** |
| 01/01/2020 | 12/31/2020 | 1.804 € |

# Annex 2: Scientific publications 2020

**Title** Next-generation experiments with the Active Target Time Projection Chamber (AT-TPC)

Ayyad Y. et al. Autores IGFAE Álvarez-Pol, H.

Referencia Nucl Instrum Methods Phys Res Sect A 954(2020)161341

Programa de Investigación SA3_NUCL

DOI 10.1016/j.nima.2018.10.019

**Title** Deep diffused Avalanche photodiodes for charged particles timing.

Centis Vignali M. et al. Autores IGFAE Otero Ugobono, S.

Referencia Nucl Instrum Methods Phys Res Sect A 958(2020)162405

Programa de Investigación SA1_LHCB

DOI 10.1016/j.nima.2019.162405

**Title** The Giant Radio Array for Neutrino Detection (GRAND): Science and design

Álvarez-Muñiz J. et al. Autores IGFAE Álvarez-Muñiz, J., Carvalho, W.

Referencia SCI. CHINA Phys. Mech. Astron. 63(2020)219501

Programa de Investigación SA2_AUGE

DOI 10.1007/s11433-018-9385-7

**Title** Deep diffused APDs for charged particle timing applications: Performance after neutron irradiation.

Centis Vignali M., Gallinaro M., Harrop B., Lu C., McClish M., Moll M., Newcomer F.M., Otero Ugobono S., White S. Autores IGFAE Otero Ugobono, S.

Referencia Nucl Instrum Methods Phys Res Sect A 949(2020)162930

Programa de Investigación SA1_LHCB

DOI 10.1016/j.nima.2019.162930

**Title** Search for the doubly charmed baryon Ξcc+

Aaij R. et al. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia SCI. CHINA Phys. Mech. Astron. 63(2020)221062

Programa de Investigación SA1_LHCB

DOI 10.1007/s11433-019-1471-8

**Title** Mapping collinear in-medium parton splittings

Domínguez F., Milhano J.G., Salgado C.A., Tywoniuk K., Vila V.. Autores IGFAE Domínguez, F., Salgado, C.A., Vila, V.

Referencia Eur. Phys. J. C 80(2020)11

Programa de Investigación SA1_HQCD

DOI 10.1140/epjc/s10052-019-7563-0

**Title** Gapless and gapped holographic phonons

Amoretti A., Areán D., Goutéraux B., Musso D.. Autores IGFAE Musso, D.

Referencia J. High Energy Phys. 2020(2020)58

Programa de Investigación SA1_HQCD

DOI 10.1007/JHEP01(2020)058

**Title** Strangeness production in the new version of the Liège intranuclear cascade model

Hirtz J., David J.-C., Boudard A., Cugnon J., Leray S., Leya I., Rodríguez-Sánchez J.L., Schnabel G.. Autores IGFAE Rodríguez-Sánchez, J.L.

Referencia Phys. Rev. C 101(2020)14608

Programa de Investigación SA3_NUCL

DOI 10.1103/PhysRevC.101.014608

**Title** Updated measurement of decay-time-dependent CP asymmetries in D0 →k+K- A nd D0 →π+π-decays

Aaij R. et al.. Autores IGFAE Adeva, B., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia Phy. Rev. D 101(2020)12005

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevD.101.012005

**Title** Dynamics of phase separation from holography

Attems M., Bea Y., Casalderrey-Solana J., Mateos D., Zilhão M.. Autores IGFAE Attems, M.

Referencia J. High Energy Phys. 2020(2020)106

Programa de Investigación SA1_HQCD

DOI 10.1007/JHEP01(2020)106

**Title** Unrecognized Sources of Uncertainties (USU) in Experimental Nuclear Data

Capote R. et al.. Autores IGFAE Duran, I.

Referencia Nucl. Data Sheets 163(2020)

Programa de Investigación SA3_NUCL

DOI 10.1016/j.nds.2019.12.004

**Title** Observation of Several Sources of CP Violation in B+ →π+π+π- Decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Dosil Suárez, A., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Lucio Martinez, M., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia Phys Rev Lett 124(2020)31801

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevLett.124.031801

**Title** Fragmentation of Single-Particle Strength around the Doubly Magic Nucleus Sn 132 and the Position of the 0f5/2 Proton-Hole State in In 131

Vaquero V. et al.. Autores IGFAE Rodríguez-Sánchez, J.L.

Referencia Phys Rev Lett 124(2020)22501

Programa de Investigación SA3_NUCL

DOI 10.1103/PhysRevLett.124.022501

**Title** Amplitude analysis of the B+ →π+π+π- decay

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Dosil Suárez, A., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Lucio Martinez, M., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia Phy. Rev. D 101(2020)12006

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevD.101.012006

**Title** Geometric inflation

Arciniega G., Bueno P., Cano P.A., Edelstein J.D., Hennigar R.A., Jaime L.G.. Autores IGFAE Arciniega, G., Edelstein, J.D.

Referencia Phys Lett Sect B Nucl Elem Part High-Energy Phys 802(2020)135242

Programa de Investigación SA1_STRI

DOI 10.1016/j.physletb.2020.135242**Title** Towards geometric inflation: The cubic case

Arciniega G., Edelstein J.D., Jaime L.G.. Autores IGFAE Arciniega, G., Edelstein, J.D.

Referencia Phys Lett Sect B Nucl Elem Part High-Energy Phys 802(2020)135272

Programa de Investigación SA1_STRI

DOI 10.1016/j.physletb.2020.135272

**Title** NuRadioMC: simulating the radio emission of neutrinos from interaction to detector

Glaser C. et al.. Autores IGFAE Alvarez-Muñiz, J.

Referencia Eur. Phys. J. C 80(2020)77

Programa de Investigación SA2_AUGE

DOI 10.1140/epjc/s10052-020-7612-8

**Title** Elliptic and triangular flows in dAu collisions at 200 GeV in the fusing color string model

Braun M.A., Pajares C.. Autores IGFAE Pajares, C.

Referencia Eur. Phys. J. A 56(2020)41

Programa de Investigación SA1_HQCD

DOI 10.1140/epja/s10050-020-00054-7

**Title** Search for A →μ+μ-Decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia Phys Rev Lett 124(2020)41801

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevLett.124.041801

**Title** Precision measurement of the Ξcc++ mass

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia J. High Energy Phys. 2020(2020)49

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP02(2020)049

**Title** Jet quenching as a probe of the initial stages in heavy-ion collisions

Andres C., Armesto N., Niemi H., Paatelainen R., Salgado C.A.. Autores IGFAE Armesto, N., Salgado, C.A.

Referencia Phys Lett Sect B Nucl Elem Part High-Energy Phys 803(2020)135318

Programa de Investigación SA1_HQCD

DOI 10.1016/j.physletb.2020.135318**Title** Measurement of ψ(2 S) production cross-sections in proton-proton collisions at √s=7 and 13TeV

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Garcia, O.B., Chobanova, V., Vidal, X.C., Dalseno, J., Suárez, A.D., Prieto, A.F., Torreira, A.G., Plana, B.G., Martinez, M.L., Santos, D.M., Casasus, M.P., Prisciandaro, J., Prouve, C., Pernas, M.R., Vidal, A.R., Silva, J.J.S., Sedes, B.S., Rios, C.S.

Referencia Eur. Phys. J. C 80(2020)185

Programa de Investigación SA1_LHCB

DOI 10.1140/epjc/s10052-020-7638-y

**Title** First Observation of Excited ωb- States

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia Phys Rev Lett 124(2020)82002

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevLett.124.082002

**Title** Measurement of the ηc(1 S) production cross-section in p p collisions at √s=13TeV

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Garcia, O.B., Rodriguez, A.B., Vidal, A.C., Chobanova, V., Vidal, X.C., Dalseno, J., Suárez, A.D., Prieto, A.F., Torreira, A.G., Plana, B.G., Gioventù, A., Castro, J.L., Santos, D.M., Casasus, M.P., Prouve, C., Pernas, M.R., Lamas, M.R., Vidal, A.R., Silva, J.J.S., Sedes, B.S., Rios, C.S.

Referencia Eur. Phys. J. C 80(2020)191

Programa de Investigación SA1_LHCB

DOI 10.1140/epjc/s10052-020-7733-0

**Title** Model comparison from LIGO-Virgo data on GW170817's binary components and consequences for the merger remnant

Abbott B.P. et al.. Autores IGFAE Dent, T.

Referencia Classical Quantum Gravity 37(2020)45006

Programa de Investigación SA2_GRWA

DOI 10.1088/1361-6382/ab5f7c

**Title** A guide to LIGO-Virgo detector noise and extraction of transient gravitational-wave signals

Abbott B.P. et al.. Autores IGFAE Dent, T.

Referencia Classical Quantum Gravity 37(2020)55002

Programa de Investigación SA2_GRWA

DOI 10.1088/1361-6382/ab685e

**Title** Observation of a new baryon state in the Λb0π+π− mass spectrum

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia J. High Energy Phys. 2020(2020)136

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP06(2020)136

**Title** Performance recovery of long CsI(Tl) scintillator crystals with APD-based readout

Cabanelas P. et al.. Autores IGFAE Cabanelas, P., González, D., Alvarez-Pol, H., Boillos, J.M., Cortina, D., Feijoo, M., Galiana, E., Pietras, B., Rodríguez-Sánchez, J.L.

Referencia Nucl Instrum Methods Phys Res Sect A 965(2020)163845

Programa de Investigación SA3_NUCL

DOI 10.1016/j.nima.2020.163845

**Title** Two-loop conformal invariance for Yang-Baxter deformed strings

Borsato R., Wulff L.. Autores IGFAE Borsato, R.

Referencia J. High Energy Phys. 2020(2020)126

Programa de Investigación SA1_STRI

DOI 10.1007/JHEP03(2020)126**Title** Site-bond percolation solution to preventing the propagation of Phytophthora zoospores on plantations

Ramírez J.E., Pajares C., Martínez M.I., Rodríguez Fernández R., Molina-Gayosso E., Lozada-Lechuga J., Fernández Téllez A.. Autores IGFAE Ramírez, J.E., Pajares, C., Rodríguez Fernández, R.

Referencia Phys. Rev. E 101(2020)32301

Programa de Investigación SA1_HQCD

DOI 10.1103/PhysRevE.101.032301**Title** Scission configuration of U 239 from yields and kinetic information of fission fragments

Ramos D. et al.. Autores IGFAE Caamaño, M., Alvarez-Pol, H., Fernández-Domínguez, B., Galiana-Baldó, E.

Referencia Phys. Rev. C 101(2020)34609

Programa de Investigación SA3_NUCL

DOI 10.1103/PhysRevC.101.034609

**Title** Isospin Amplitudes in Λb0 →J/ψ Λ (ς0) and Ξb0 →J/ψ Ξ0 (Λ) Decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia Phys Rev Lett 124(2020)111802

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevLett.124.111802**Title** Dipole picture and the nonrelativistic expansion

Escobedo M.Á., Lappi T.. Autores IGFAE Escobedo, M.Á.

Referencia Phy. Rev. D 101(2020)34030

Programa de Investigación SA1_HQCD

DOI 10.1103/PhysRevD.101.034030

**Title** Measurement of CP violation in B 0 → D ∗± D ∓ decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia J. High Energy Phys. 2020(2020)147

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP03(2020)147

**Title** Measurement of the 154Gd(n,γ) cross section and its astrophysical implications

Mazzone A. et al.. Autores IGFAE Caamaño, M., Durán, I., Fernández-Domínguez, B.

Referencia Phys Lett Sect B Nucl Elem Part High-Energy Phys 804(2020)135405

Programa de Investigación SA3_NUCL

DOI 10.1016/j.physletb.2020.135405**Title** Observation of the semileptonic decay B+⟶ pp¯ μ+νμ

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Vidal, X.C., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventú, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia J. High Energy Phys. 2020(2020)146

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP03(2020)146

**Title** Low-diffusion Xe-He gas mixtures for rare-event detection: electroluminescence yield

Fernandes A.F.M. et al.. Autores IGFAE González-Díaz, D., Díaz, G., Hernando Morata, J.A., Martínez-Lema, G.

Referencia J. High Energy Phys. 2020(2020)34

Programa de Investigación SA2_NEXT

DOI 10.1007/JHEP04(2020)034

**Title** Holographic spontaneous anisotropy

Hoyos C., Jokela N., Penín J.M., Ramallo A.V.. Autores IGFAE Penín, J.M., Ramallo, A.V.

Referencia J. High Energy Phys. 2020(2020)62

Programa de Investigación SA1_STRI

DOI 10.1007/JHEP04(2020)062

**Title** A compact fission detector for fission-tagging neutron capture experiments with radioactive fissile isotopes

Bacak M. et al.. Autores IGFAE Caamaño, M., Durán, I., Fernández-Domínguez, B., Leal-Cidoncha, E.

Referencia Nucl Instrum Methods Phys Res Sect A 969(2020)163981

Programa de Investigación SA3_NUCL

DOI 10.1016/j.nima.2020.163981

**Title** Inflationary twin models

Adam C., Varela D.. Autores IGFAE Adam, C., Varela, D.

Referencia Phy. Rev. D 101(2020)63514

Programa de Investigación SA1_HQCD

DOI 10.1103/PhysRevD.101.063514

**Title** Measurement of fs /fu Variation with Proton-Proton Collision Energy and B - Meson Kinematics

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Dosil Suárez, A., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Lucio Martinez, M., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia Phys Rev Lett 124(2020)122002

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevLett.124.122002

**Title** A 3-Year Sample of Almost 1,600 Elves Recorded Above South America by the Pierre Auger Cosmic-Ray Observatory

Aab A. et al.. Autores IGFAE Alvarez-Muñiz, J., López Casado, A., Parente, G., Pedreira, F., Torralba Elipe, G., Zas, E.

Referencia Earth Space Sci. 7(2020)e2019EA000582

Programa de Investigación SA2_AUGE

DOI 10.1029/2019EA000582

**Title** Phase I Upgrade of the Readout System of the Vertex Detector at the LHCb Experiment

Fernandez Prieto A. et al.. Autores IGFAE Fernandez Prieto, A., Regueiro, P.V., Cid, E.L., Garcia, O.B., Torreira, A.G., Plana, B.G.

Referencia IEEE Trans Nucl Sci 67(2020)8976212

Programa de Investigación SA1_LHCB

DOI 10.1109/TNS.2020.2970534

**Title** 2-OGC: Open Gravitational-wave Catalog of Binary Mergers from Analysis of Public Advanced LIGO and Virgo Data

Nitz A.H., Dent T., Davies G.S., Kumar S., Capano C.D., Harry I., Mozzon S., Nuttall L., Lundgren A., Tápai M.. Autores IGFAE Dent, T., Davies, G.S.

Referencia Astrophys. J. 891(2020)123

Programa de Investigación SA2_GRWA

DOI 10.3847/1538-4357/ab733f

**Title** Classical spectral curve of the AdS5 × S 5 lambda superstring

Hollowood T.J., Miramontes J.L., Price D.. Autores IGFAE Miramontes, J.L.

Referencia J. High Energy Phys. 2020(2020)10

Programa de Investigación SA1_STRI

DOI 10.1007/JHEP05(2020)010**Title** Cosmic-Ray Anisotropies in Right Ascension Measured by the Pierre Auger Observatory

Aab A. et al.. Autores IGFAE Alvarez-Muñiz, J., Casado, A.L., Parente, G., Pedreira, F., Elipe, G.T., Zas, E.

Referencia Astrophys. J. 891(2020)142

Programa de Investigación SA2_AUGE

DOI 10.3847/1538-4357/ab7236

**Title** A QCD analysis of LHCb D-meson data in p+Pb collisions

Eskola K.J., Helenius I., Paakkinen P., Paukkunen H.. Autores IGFAE Paakkinen, P.

Referencia J. High Energy Phys. 2020(2020)37

Programa de Investigación SA1_HQCD

DOI 10.1007/JHEP05(2020)037

**Title** GW190425: Observation of a Compact Binary Coalescence with Total Mass ~ 3.4 M o

Abbott B.P. et al.. Autores IGFAE Dent, T.

Referencia Astrophys. J. Lett. 892(2020)L3

Programa de Investigación SA2_GRWA

DOI 10.3847/2041-8213/ab75f5

**Title** Test of lepton universality with Λb0→pK− ℓ+ ℓ− decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia J. High Energy Phys. 2020(2020)40

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP05(2020)040

**Title** Measurement of |Vcb | with Bs0 → Ds (∗)- μ+νμ decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia Phy. Rev. D 101(2020)72004

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevD.101.072004

**Title** Optically targeted search for gravitational waves emitted by core-collapse supernovae during the first and second observing runs of advanced LIGO and advanced Virgo

Abbott B.P. et al.. Autores IGFAE Dent, T.

Referencia Phy. Rev. D 101(2020)84002

Programa de Investigación SA2_GRWA

DOI 10.1103/PhysRevD.101.084002

**Title** Askaryan radiation from neutrino-induced showers in ice

Alvarez-Muñiz J., Hansen P.M., Romero-Wolf A., Zas E.. Autores IGFAE Alvarez-Muñiz, J., Zas, E.

Referencia Phy. Rev. D 101(2020)83005

Programa de Investigación SA2_AUGE

DOI 10.1103/PhysRevD.101.083005**Title** Measurement of Ξ cc ++ production in pp collisions at √s = 13 TeV

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia Chin. Phys. C 44(2020)22001

Programa de Investigación SA1_LHCB

DOI 10.1088/1674-1137/44/2/022001

**Title** Electron transport in gaseous detectors with a Python-based Monte Carlo simulation code

Al Atoum B., Biagi S.F., González-Díaz D., Jones B.J.P., McDonald A.D.. Autores IGFAE González-Díaz, D.

Referencia Comput Phys Commun 254(2020)107357

Programa de Investigación SA2_NEXT

DOI 10.1016/j.cpc.2020.107357

**Title** A joint fermi-gbm and ligo/virgo analysis of compact binary mergers from the first and second gravitational-wave observing runs

Ligo Scientific Collaboration And The Virgo Collaboration T. et al.. Autores IGFAE Davies, G.S., Dent, T.

Referencia Astrophys. J. 893(2020)100

Programa de Investigación SA2_GRWA

DOI 10.3847/1538-4357/ab7d3e**Title** Novel tools and observables for jet physics in heavy-ion collisions

Andrews H.A. et al.. Autores IGFAE Dominguez, F., Vila, V.

Referencia J. Phys. G Nucl. Part. Phys. 47(2020)65102

Programa de Investigación SA1_HQCD

DOI 10.1088/1361-6471/ab7cbc

**Title** Improved stability of a compact vacuum-free laser-plasma X-ray source

Martin L., Benlliure J., Cortina-Gil D., Penas J., Ruiz C.. Autores IGFAE Martin, L., Benlliure, J., Cortina-Gil, D., Penas, J.

Referencia High Power Laser Sci. Eng. 8(2020)e18

Programa de Investigación SA3_LACC

DOI 10.1017/hpl.2020.15

**Title** Radio frequency and DC high voltage breakdown of high pressure helium, argon, and xenon

Woodruff K. et al.. Autores IGFAE Díaz, G., González-Díaz, D., Hernando Morata, J.A., Martínez-Lema, G.

Referencia J. Instrum. 15(2020)P04022

Programa de Investigación SA2_NEXT

DOI 10.1088/1748-0221/15/04/P04022

**Title** Physics opportunities with the Advanced Gamma Tracking Array: AGATA

Korten W. et al.. Autores IGFAE Fernandez-Dominguez, B.

Referencia Eur. Phys. J. A 56(2020)137

Programa de Investigación SA3_NUCL

DOI 10.1140/epja/s10050-020-00132-w

**Title** Mitigation of backgrounds from cosmogenic 137Xe in xenon gas experiments using 3He neutron capture

Rogers L. et al.. Autores IGFAE Díaz, G., González-Díaz, D., Morata, J.A.H., Kekic, M., Martínez-Lema, G., Renner, J.

Referencia J. Phys. G Nucl. Part. Phys. 47(2020)75001

Programa de Investigación SA2_NEXT

DOI 10.1088/1361-6471/ab8915

**Title** Identical pion intensity interferometry at √sNN=2.4GeV : HADES collaboration

Adamczewski-Musch J. et al.. Autores IGFAE Garzón, J.A.

Referencia Eur. Phys. J. A 56(2020)140

Programa de Investigación SA3_NUCL

DOI 10.1140/epja/s10050-020-00116-w

**Title** Tl concentration and its variation in a CsI(Tl) crystal for the CALIFA detector

Knyazev A. et al.. Autores IGFAE Alvarez-Pol, H., Benlliure, J., Cabanelas, P., Cortina-Gil, D., Feijoo, M., Gonzalez, D., Rodriguez-Sanchez, J.L.

Referencia Nucl Instrum Methods Phys Res Sect A 975(2020)164197

Programa de Investigación SA3_NUCL

DOI 10.1016/j.nima.2020.164197

**Title** Evidence for a New Compact Symmetric Fission Mode in Light Thorium Isotopes

Chatillon A. et al.. Autores IGFAE Alvarez-Pol, H., Ayyad, Y., Benlliure, J., Caamañõ, M., Cortina-Gil, D., Fernández-Domínguez, B., Paradela, C., Rodríguez-Sánchez, J.L., Vargas, J.

Referencia Phys Rev Lett 124(2020)202502

Programa de Investigación SA3_NUCL

DOI 10.1103/PhysRevLett.124.202502

**Title** Search for the Rare Decays Bs0 →e+e- And B0 →e+e

Zucchelli S. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia Phys Rev Lett 124(2020)211802

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevLett.124.211802

**Title** Kink-antikink scattering in the ϕ4 model without static intersoliton forces

Adam C., Oles K., Romanczukiewicz T., Wereszczynski A.. Autores IGFAE Adam, C.

Referencia Phy. Rev. D 101(2020)105021

Programa de Investigación SA1_HQCD

DOI 10.1103/PhysRevD.101.105021

**Title** Measurement of CP observables in B ± → DK ± and B ± → Dπ ± with D → KS0K±π∓ decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia J. High Energy Phys. 2020(2020)58

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP06(2020)058

**Title** Independent Goldstone modes for translations and shift symmetry from a real modulated scalar

Musso D., Naegels D.. Autores IGFAE Musso, D.

Referencia Phy. Rev. D 101(2020)45016

Programa de Investigación SA1_STRI

DOI 10.1103/PhysRevD.101.045016

**Title** Search for the lepton flavour violating decay B + → K + μ − τ + using Bs2∗0 decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia J. High Energy Phys. 2020(2020)129

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP06(2020)129

**Title** Observation of New Ξc0 Baryons Decaying to Λc+ K-

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Parkinson, C.J., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia Phys Rev Lett 124(2020)222001

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevLett.124.222001

**Title** PADC nuclear track detector for ion spectroscopy in laser-plasma acceleration

Seimetz M., Peñas J., Llerena J.J., Benlliure J., García López J., Millán-Callado M.A., Benlloch J.M.. Autores IGFAE Peñas, J., Llerena, J.J., Benlliure, J.

Referencia Phys. Med. 76(2020)

Programa de Investigación SA3_LACC

DOI 10.1016/j.ejmp.2020.06.005**Title** Study of Δ excitations in medium-mass nuclei with peripheral heavy ion charge-exchange reactions

Rodríguez-Sánchez J.L. et al.. Autores IGFAE Rodríguez-Sánchez, J.L., Benlliure, J., Vargas, J., Alvarez-Pol, H., Ayyad, Y., Beceiro-Novo, S., Caamaño, M., Cortina-Gil, D., Díaz Fernández, P., Paradela, C., Pérez-Loureiro, D.

Referencia Phys Lett Sect B Nucl Elem Part High-Energy Phys 807(2020)135565

Programa de Investigación SA3_NUCL

DOI 10.1016/j.physletb.2020.135565

**Title** Measurement of the Λb0 → J/ψΛ angular distribution and the Λb0 polarisation in pp collisions

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Parkinson, C.J., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia J. High Energy Phys. 2020(2020)110

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP06(2020)110

**Title** The dielectric Skyrme model

Adam C., Oles K., Wereszczynski A.. Autores IGFAE Adam, C.

Referencia Phys Lett Sect B Nucl Elem Part High-Energy Phys 807(2020)135560

Programa de Investigación SA1_HQCD

DOI 10.1016/j.physletb.2020.135560

**Title** Medium-induced gluon radiation with full resummation of multiple scatterings for realistic parton-medium interactions

Andres C., Apolinário L., Dominguez F.. Autores IGFAE Dominguez, F.

Referencia J. High Energy Phys. 2020(2020)114

Programa de Investigación SA1_HQCD

DOI 10.1007/JHEP07(2020)114

**Title** Measurement of CP -Averaged Observables in the B0 →k∗0μ+μ- Decay

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia Phys Rev Lett 125(2020)11802

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevLett.125.011802**Title** Precision measurement of the Bc+ meson mass

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Santamarina Rios, C.

Referencia J. High Energy Phys. 2020(2020)123

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP07(2020)123

**Title** Phase transitions of neutral planar hairy AdS black holes

Anabalon A., Astefanesei D., Choque D., Edelstein J.D.. Autores IGFAE Edelstein, J.D.

Referencia J. High Energy Phys. 2020(2020)129

Programa de Investigación SA1_STRI

DOI 10.1007/JHEP07(2020)129

**Title** Medium-induced cascade in expanding media

Adhya S.P., Salgado C.A., Spousta M., Tywoniuk K.. Autores IGFAE Salgado, C.A.

Referencia J. High Energy Phys. 2020(2020)150

Programa de Investigación SA1_HQCD

DOI 10.1007/JHEP07(2020)150

**Title** Extending the PyCBC search for gravitational waves from compact binary mergers to a global network

Davies G.S., Dent T., Tápai M., Harry I., McIsaac C., Nitz A.H.. Autores IGFAE Davies, G.S., Dent, T.

Referencia Phy. Rev. D 102(2020)22004

Programa de Investigación SA2_GRWA

DOI 10.1103/PhysRevD.102.022004

**Title** Adding crust to BPS Skyrme neutron stars

Adam C., Sanchez-Guillen J., Vazquez R., Wereszczynski A.. Autores IGFAE Adam, C., Sanchez-Guillen, J., Vazquez, R.

Referencia Phy. Rev. D 102(2020)23019

Programa de Investigación SA1_HQCD

DOI 10.1103/PhysRevD.102.023019

**Title** Search for magnetically-induced signatures in the arrival directions of ultra-high-energy cosmic rays measured at the Pierre Auger Observatory

Maris I.C. et al.. Autores IGFAE Alvarez-Muñiz, J., Choi, K., Parente, G., Pedreira, F., Elipe, G.T., Zas, E.

Referencia J. Cosmol. Astroparticle Phys. 2020(2020)17

Programa de Investigación SA2_AUGE

DOI 10.1088/1475-7516/2020/06/017

**Title** Investigation of the Pu 240 (n,f) reaction at the n_TOF/EAR2 facility in the 9 meV-6 MeV range

Stamatopoulos A. et al.. Autores IGFAE Caamaño, M., Durán, I., Fernández-Domínguez, B., Leal-Cidoncha, E., Paradela, C., Robles, M.

Referencia Phys. Rev. C 102(2020)14616

Programa de Investigación SA3_NUCL

DOI 10.1103/PhysRevC.102.014616

**Title** Direct measurement of the muonic content of extensive air showers between 2× 1017 and 2×1018 eV at the Pierre Auger Observatory

Aab A. et al.. Autores IGFAE Alvarez-Muñiz, J., López Casado, A., Parente, G., Pedreira, F., Torralba Elipe, G., Zas, E.

Referencia Eur. Phys. J. C 80(2020)751

Programa de Investigación SA2_AUGE

DOI 10.1140/epjc/s10052-020-8055-y

**Title** Particle correlations from the initial state

Altinoluk T., Armesto N.. Autores IGFAE Armesto, N.

Referencia Eur. Phys. J. A 56(2020)215

Programa de Investigación SA1_HQCD

DOI 10.1140/epja/s10050-020-00225-6

**Title** Study of the ψ 2(3823) and χ c1(3872) states in B+ → (J/ψπ + π −)K+ decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Baladron Rodriguez, P., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Parkinson, C.J., Plo Casasus, M., Prouve, C., Ramos Pernas, M.

Referencia J. High Energy Phys. 2020(2020)123

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP08(2020)123**Title** TRASGOS: Towards a New Standard for the Regular Measurement of Cosmic Rays

Garzón J.A.. Autores IGFAE Garzón, J.A.

Referencia Phys. At. Nucl. 83(2020)

Programa de Investigación SA3_NUCL

DOI 10.1134/S1063778820030084

**Title** GW190814: Gravitational Waves from the Coalescence of a 23 Solar Mass Black Hole with a 2.6 Solar Mass Compact Object

Abbott R. et al.. Autores IGFAE Davies, G.S., Dent, T.

Referencia Astrophys. J. Lett. 896(2020)L44

Programa de Investigación SA2_GRWA

DOI 10.3847/2041-8213/ab960f

**Title** BPS Skyrme neutron stars in generalized gravity

Adam C., Huidobro M., Vazquez R., Wereszczynski A.. Autores IGFAE Adam, C., Huidobro, M., Vazquez, R.

Referencia J. Cosmol. Astroparticle Phys. 2020(2020)41

Programa de Investigación SA1_HQCD

DOI 10.1088/1475-7516/2020/08/041

**Title** GW190412: Observation of a binary-black-hole coalescence with asymmetric masses

Abbott R. et al.. Autores IGFAE Davies, G.S., Dent, T.

Referencia Phy. Rev. D 102(2020)43015

Programa de Investigación SA2_GRWA

DOI 10.1103/PhysRevD.102.043015

**Title** Probing the Z = 6 spin-orbit shell gap with (p,2p) quasi-free scattering reactions

Syndikus I. et al.. Autores IGFAE Alvarez-Pol, H., Beceiro-Novo, S., Benlliure, J., Boillos, J.M., Caamaño, M., Cortina-Gil, D., Díaz Fernández, P.

Referencia Phys Lett Sect B Nucl Elem Part High-Energy Phys 809(2020)135748

Programa de Investigación SA3_NUCL

DOI 10.1016/j.physletb.2020.135748

**Title** A Search for Gravitational Waves from Binary Mergers with a Single Observatory

Nitz A.H., Dent T., Davies G.S., Harry I.. Autores IGFAE Dent, T., Davies, G.S.

Referencia Astrophys. J. 897(2020)169

Programa de Investigación SA2_GRWA

DOI 10.3847/1538-4357/ab96c7

**Title** GW190521: A Binary Black Hole Merger with a Total Mass of 150 $M_{\odot}$

Abbott R. et al.. Autores IGFAE Davies, G.S., Dent, T.

Referencia Phys. Rev. Lett. 125(2020)

Programa de Investigación SA2_GRWA

DOI 10.1103/PhysRevLett.125.101102

**Title** Atmospheric Temperature Effect in Secondary Cosmic Rays Observed With a 2 m2 Ground-Based tRPC Detector

Riádigos I., García-Castro D., González-Díaz D., Pérez-Muñuzuri V.. Autores IGFAE Riádigos, I., García-Castro, D., González-Díaz, D., Pérez-Muñuzuri, V.

Referencia Earth Space Sci. 7(2020)e2020EA001131

Programa de Investigación SA2_NEXT

DOI 10.1029/2020EA001131

**Title** Prospects for observing and localizing gravitational-wave transients with Advanced LIGO, Advanced Virgo and KAGRA

Abbott B.P. et al.. Autores IGFAE Dent, T.

Referencia Living Rev. Relativ. 23(2020)3

Programa de Investigación SA2_GRWA

DOI 10.1007/s41114-020-00026-9

**Title** Searching for long-lived particles beyond the Standard Model at the Large Hadron Collider

Alimena J. et al.. Autores IGFAE Vidal, X.C.

Referencia J. Phys. G Nucl. Part. Phys. 47(2020)90501

Programa de Investigación SA1_LHCB

DOI 10.1088/1361-6471/ab4574**Title** The first α′-correction to homogeneous Yang-Baxter deformations using O(d, d)

Borsato R., López A.V., Wulff L.. Autores IGFAE Borsato, R., López, A.V.

Referencia J. High Energy Phys. 2020(2020)103

Programa de Investigación SA1_STRI

DOI 10.1007/JHEP07(2020)103

**Title** Holographic Floquet states in low dimensions

Garbayo A., Mas J., Ramallo A.V.. Autores IGFAE Garbayo, A., Mas, J., Ramallo, A.V.

Referencia J. High Energy Phys. 2020(2020)13

Programa de Investigación SA1_STRI

DOI 10.1007/JHEP10(2020)013

**Title** Two-pion production in the second resonance region in π-p collisions with the High-Acceptance Di-Electron Spectrometer (HADES)

Adamczewski-Musch J. et al.. Autores IGFAE Garzón, J.A.

Referencia Phys. Rev. C 102(2020)24001

Programa de Investigación SA3_NUCL

DOI 10.1103/PhysRevC.102.024001

**Title** Charged-pion production in Au+ Au collisions at √sNN=2.4GeV : HADES Collaboration

Adamczewski-Musch J. et al.. Autores IGFAE Garzón, J.A.

Referencia Eur. Phys. J. A 56(2020)259

Programa de Investigación SA3_NUCL

DOI 10.1140/epja/s10050-020-00237-2

**Title** Features of the energy spectrum of cosmic rays above 2.5×1018 eV using the pierre auger observatory

Aab A. et al.. Autores IGFAE Alvarez-Muñiz, J., Choi, K., Parente, G., Pedreira, F., Torralba Elipe, G., Zas, E.

Referencia Phys Rev Lett 125(2020)121106

Programa de Investigación SA2_AUGE

DOI 10.1103/PhysRevLett.125.121106

**Title** Studies on the response of a water-Cherenkov detector of the Pierre Auger Observatory to atmospheric muons using an RPC hodoscope

Aab A. et al.. Autores IGFAE Alvarez-Muñiz, J., Choi, K., Parente, G., Pedreira, F., Elipe, G.T., Zas, E.

Referencia J. Instrum. 15(2020)P09002

Programa de Investigación SA2_AUGE

DOI 10.1088/1748-0221/15/09/P09002

**Title** Search for CP violation and observation of P violation in Λb0 →pπ-π+π- decays

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia Phy. Rev. D 102(2020)51101

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevD.102.051101

**Title** First observation of the decay B0 →d0 D ¯ K+ 0 π- FIRST OBSERVATION of the DECAY B0 →d0 D ¯ K+ 0 π- AAIJ R. et al.

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Baladron Rodriguez, P., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Parkinson, C.J., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J.

Referencia Phy. Rev. D 102(2020)51102

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevD.102.051102

**Title** Measurement of the branching fraction of the decay Bs0 → K S0 K S0

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Plo Casasus, M., Prouve, C., Ramos Pernas, M., Romero Lamas, M., Romero Vidal, A., Saborido Silva, J.J., Sanmartin Sedes, B., Santamarina Rios, C.

Referencia Phy. Rev. D 102(2020)12011

Programa de Investigación SA1_LHCB

DOI 10.1103/PhysRevD.102.012011

**Title** Electromagnetic pulse generation in laser-proton acceleration from conductive and dielectric targets

Seimetz M. et al.. Autores IGFAE Benlliure, J.

Referencia Plasma Phys Controlled Fusion 62(2020)abb2e5

Programa de Investigación SA3_NUCL

DOI 10.1088/1361-6587/abb2e5

**Title** Adiabatic lapse rate of nonideal gases: The role of molecular interactions and vibrations

Díaz B., Ramírez J.E.. Autores IGFAE Ramírez, J.E.

Referencia Phys. Rev. E 102(2020)42107

Programa de Investigación SA1_HQCD

DOI 10.1103/PhysRevE.102.042107

**Title** Proton-number fluctuations in sNN =2.4 GeV Au + Au collisions studied with the High-Acceptance DiElectron Spectrometer (HADES) PROTON-NUMBER FLUCTUATIONS in sNN =2.4 GeV Au + Au ... J. ADAMCZEWSKI-MUSCH et al.

Adamczewski-Musch J. et al.. Autores IGFAE Garzón, J.A.

Referencia Phys. Rev. C 102(2020)24914

Programa de Investigación SA3_NUCL

DOI 10.1103/PhysRevC.102.024914**Title** Neutron Capture on the s-Process Branching Point Tm 171 via Time-of-Flight and Activation

Guerrero C. et al.. Autores IGFAE Caamañõ, M., Durán, I., Fernández-Domínguez, B., Leal-Cidoncha, E.

Referencia Phys Rev Lett 125(2020)142701

Programa de Investigación SA3_NUCL

DOI 10.1103/PhysRevLett.125.142701

**Title** Searches for low-mass dimuon resonances

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Baladron Rodriguez, P., Boente Garcia, O., Brea Rodriguez, A., Casais Vidal, A., Chobanova, V., Cid Vidal, X., Dalseno, J., Fernandez Prieto, A., Gallas Torreira, A., Garcia Plana, B., Gioventù, A., Lomba Castro, J., Martinez Santos, D., Parkinson, C.J., Plo Casasus, M., Prouve, C., Ramos Pernas, M.

Referencia J. High Energy Phys. 2020(2020)156

Programa de Investigación SA1_LHCB

DOI 10.1007/JHEP10(2020)156**Title** Search for CP violation in Ξc+→pK-π+ decays using model-independent techniques

Aaij R. et al.. Autores IGFAE Adeva, B., Alves, A.A., Garcia, O.B., Rodriguez, A.B., Vidal, A.C., Chobanova, V., Vidal, X.C., Dalseno, J., Suárez, A.D., Prieto, A.F., Torreira, A.G., Plana, B.G., Gioventù, A., Castro, J.L., Santos, D.M., Casasus, M.P., Prouve, C., Pernas, M.R., Lamas, M.R., Vidal, A.R., Silva, J.J.S., Sedes, B.S., Rios, C.S.

Referencia Eur. Phys. J. C 80(2020)986

Programa de Investigación SA1_LHCB

DOI 10.1140/epjc/s10052-020-8365-0**Title** Properties and Astrophysical Implications of the 150 M o˙Binary Black Hole Merger GW190521

Abbott R. et al.. Autores IGFAE Davies, G.S., Dent, T.

Referencia Astrophys. J. Lett. 900(2020)L13

Programa de Investigación SA2_GRWA

DOI 10.3847/2041-8213/aba493

**Title** Gravitational-wave Constraints on the Equatorial Ellipticity of Millisecond Pulsars

Abbott R. et al.. Autores IGFAE Davies, G.S., Dent, T.

Referencia Astrophys. J. Lett. 902(2020)L21

Programa de Investigación SA2_GRWA

DOI 10.3847/2041-8213/abb655

**Title** Dynamic normalization for compact binary coalescence searches in non-stationary noise

Mozzon S., Nuttall L.K., Lundgren A., Dent T., Kumar S., Nitz A.H.. Autores IGFAE Dent, T.

Referencia Classical Quantum Gravity 37(2020)215014

Programa de Investigación SA2_GRWA

DOI 10.1088/1361-6382/abac6c

**Title** A Search for Ultra-high-energy Neutrinos from TXS 0506+056 Using the Pierre Auger Observatory

Aab A. et al.. Autores IGFAE Alvarez-Muñiz, J., Choi, K., Parente, G., Pedreira, F., Zas, E.

Referencia Astrophys. J. 902(2020)105

Programa de Investigación SA2_AUGE

DOI 10.3847/1538-4357/abb476

**Title** Reconstruction of events recorded with the surface detector of the Pierre Auger Observatory

Aab A. et al.. Autores IGFAE Alvarez-Muñiz, J., Choi, K., Parente, G., Pedreira, F., Elipe, G.T., Zas, E.

Referencia J. Instrum. 15(2020)P10021

Programa de Investigación SA2_AUGE

DOI 10.1088/1748-0221/15/10/P10021

**Title** Gapped dilatons in scale invariant superfluids

Argurio R., Hoyos C., Musso D., Naegels D.. Autores IGFAE Musso, D.

Referencia Phy. Rev. D 102(2020)76011

Programa de Investigación SA1_STRI

DOI 10.1103/PhysRevD.102.076011

**Title** Measurement of the α ratio and (n,γ) cross section of U 235 from 0.2 to 200 eV at n_TOF MEASUREMENT of the α RATIO and ... J. BALIBREA-CORREA et al.

Balibrea-Correa J. et al.. Autores IGFAE Durán, I., Leal-Cidoncha, E., Paradela, C., Robles, M., Tarrío, D.

Referencia Phys. Rev. C 102(2020)44615

Programa de Investigación SA3_NUCL

DOI 10.1103/PhysRevC.102.044615

# Annex 2. Press clipping

| Date | Media | Headline | Type |
|---|---|---|---|
| 05/01/2020 | La Voz de Galicia | «O día a día da investigación pode ser moi estimulante e, sobre todo, divertido» | Press/Digital |
| 06/01/2020 | El Mundo | Segunda detección de la fusión cósmica en la que se produce oro | Press/Digital |
| 07/01/2020 | Galicia Digital | Nova detección de ondas gravitacionais nun proxecto con participación galega | Digital |
| 07/01/2020 | Galicia Press | El Instituto de Física de Altas Enerxías participa en una nueva detección de ondas gravitacionales | Digital |
| 07/01/2020 | Agencia SINC | Un detector LIGO capta otra colisión de estrellas de neutrones | Digital |
| 07/01/2020 | La Opinión de A Coruña | Científicos gallegos participan en la detección de nuevas ondas gravitacionales | Press/Digital |
| 07/01/2020 | Galicia Confidencial | Galicia, presente na detección das ondas gravitacionais | Digital |
| 07/01/2020 | La Voz de Galicia | Un equipo gallego participa en la detección de la mayor colisión estelar del universo | Press/Digital |
| 07/01/2020 | Galicia Diario | Galicia, presente en una nueva detección de ondas gravitacionales | Digital |
| 07/01/2020 | GCiencia | Galicia, presente na detección da segunda colisión de estrelas de neutróns | Digital |
| 07/01/2020 | El Espectador | Detectan nuevas ondas gravitacionales producto de una colisión de estrellas de neutrones | Digital |
| 08/01/2020 | Faro de Vigo | Científicos gallegos participan en la detección de nuevas ondas gravitacionales | Press/Digital |
| 08/01/2020 | El Correo Gallego | Nueva detección de ondas gravitacionales de una colisión de estrellas de neutrones | Press/Digital |
| 08/01/2020 | El Cultural | Un detector LIGO capta la mayor colisión de dos estrellas de neutrones | Digital |
| 14/01/2020 | La Ventana (SER) | La Ventana (14/01/2020 - Tramo de 16:00 a 17:00) | Radio |
| 17/01/2020 | Compostela 24h | O IGFAE celebrará unha masterclass polo Día Interacional da Muller e a Nena na Ciencia | Digital |
| 28/01/2020 | GCiencia | As científicas de Galicia entre as máis citadas de España | Press/Digital |
| 29/01/2020 | La Voz de Galicia | Pulpo á feira en el fin del mundo: «Este plato gallego está buenísimo» | Press/Digital |
| 29/01/2020 | Las mañanas (RNE) | Día 20 \| De la Antártida a la galaxia | Radio |
| 03/02/2020 | Nós diario | Un detector galego de raios cósmicos na Antártida | Press/Digital |

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| 03/02/2020 | GCiencia | Galicia leva á Antártida un detector de raios cósmicos | Press/Digital |
| 03/02/2020 | El Correo Gallego | Investigadores de la USC instalan un detector de rayos cósmicos en la Antártida | Press/Digital |
| 03/02/2020 | Faro de Vigo | Instalan un detector de raios cósmicos galego na Antártida | Press/Digital |
| 03/02/2020 | Xornal de Lugo | Un detector de raios cósmicos galego na Antártida | Digital |
| 03/02/2020 | Galicia é | Investigadores da USC instalan un detector de raios cósmicos na Antártida | Digital |
| 03/02/2020 | Diario de Pontevedra | Investigadores da USC instalan un detector de raios cósmicos na Antártida | Press/Digital |
| 03/02/2020 | El progreso | Investigadores da USC instalan un detector de raios cósmicos na Antártida | Digital |
| 03/02/2020 | Galicia Confidencial | Investigadores galegos instalan un detector de raios cósmicos na Antártida | Digital |
| 03/02/2020 | Galicia Press | Investigadores de la USC instalan un detector de rayos cósmicos en la base científica 'Juan Carlos I' de la Antártida | Digital |
| 04/02/2020 | A tarde (Radio Galega) | "Estudando os raios cósmicos podemos prever se chega unha tormenta magnética" | Radio |
| 04/02/2020 | COPE Santiago | Investigadores de la USC instalan un detector de rayos cósmicos en la Antártida | Radio |
| 04/02/2020 | La Voz de Galicia | Los centros singulares de la USC captan el 60 % de ayudas de la Xunta | Press/Digital |
| 04/02/2020 | El Correo Gallego | La USC capta de la Xunta 10,8 millones para sus investigadores | Press/Digital |
| 04/02/2020 | Agencia SINC | Nuevo detector de rayos cósmicos en la Antártida | Digital |
| 05/02/2020 | Econoticias.com | Tecnología verde para el detector de rayos cósmicos en la Antártida | Digital |
| 05/02/2020 | Madri+d | Nuevo detector de rayos cósmicos en la Antártida | Digital |
| 05/02/2020 | NCYT | Nuevo detector de rayos cósmicos en la Antártida | Digital |
| 10/02/2020 | Abc Galicia | Galicia lleva un detector de rayos cósmicos a la Antártida | Digital |
| 12/02/2020 | Galiciapress | La USC conmemora este martes el Día de la Mujer y de la Niña en la Ciencia con mesas redondas 'masterclass' o teatro | Digital |
| 12/02/2020 | El Correo Gallego | Un día dedicado a poner el foco en la presencia de las científicas | Press/Digital |
| 23/02/2020 | El Correo Gallego | Un físico de la USC, en el top 50 del ranquin de investigadores del CSIC | Press/Digital |
| 23/02/2020 | El Correo Gallego | Cibrán Santamarina Ríos: "de pequeno regaláronme unha maquiniña para facer contas" | Press/Digital |
| 05/03/2020 | Physics | Synopsis: Stopping the Spreading of Plant Disease | Digital |

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| 07/03/2020 | El Correo Gallego | A la espera del Nobel de Física, continúa investigando en la USC | Press/Digital |
| 07/03/2020 | El Correo Gallego | Investigadores de la USC estudian anular un patógeno que ataca plantas y árboles | Press/Digital |
| 09/03/2020 | La Voz de Galicia | Científicos gallegos usan la física de partículas para proteger a las patatas | Press/Digital |
| 10/03/2020 | GCiencia | A USC e institutos galegos buscan mecenas para dous proxectos de ciencia cidadá | Digital |
| 11/03/2020 | Boísimo | Investigadores galegos frean o patóxeno que devora o aguacate | Digital |
| 11/03/2020 | La Voz de Galicia | Estudiantes gallegos piden apoyo ciudadano para lanzar un globo que mida los rayos cósmicos | Press/Digital |
| 14/03/2020 | Galiciapress | Coronavirus: Galicia participa no deseño dun respirador na Organización Europea para a Investigación Nuclear | Digital |
| 28/04/2020 | Faro de Vigo | Coronavirus en Galicia \| El CERN de Ginebra ficha a un investigador gallego para diseñar un respirador barato | Press/Digital |
| 04/05/2020 | Concello A Coruña | Universo Peregrino: ciencia galega cara o mundo | Digital |
| 13/05/2020 | GCiencia | O Instituto de Física de Altas Enerxías de Santiago impulsa un ciclo de arte e ciencia | Digital |
| 15/05/2020 | Cadena SER (Hoy por hoy Santiago) | Hoy por Hoy Santiago (15/05/2020) | Radio |
| 15/05/2020 | Compostela 24h | Rosa Montero abrirá este venres na USC o ciclo en liña 'Transfronteirizas, conversas de arte e ciencia' | Digital |
| 09/06/2020 | GCiencia | Firma galega para o novo superordenador do CERN | Digital |
| 09/06/2020 | Nós diario | Un superordenador con pegada galega para o CERN | Digital |
| 10/06/2020 | 21Noticias | Un superordenador para o CERN con firma galega | Digital |
| 18/06/2020 | 21Noticias | El escritor y periodista mexicano José Gordon, próximo invitado del ciclo "Transfronteirizas" | Digital |
| 23/06/2020 | Agencia SINC | LIGO y Virgo descubren un misterioso objeto fusionándose con un agujero negro | Digital |
| 23/06/2020 | El Mundo | La fusión cósmica más misteriosa: detectan ondas gravitacionales de un agujero negro chocando con un objeto desconocido | Press/Digital |
| 23/06/2020 | ABC | Logran un método para observar el «fondo de ondas gravitacionales» del Universo | Press/Digital |
| 23/06/2020 | La Voz de Galicia | La ciencia detecta un objeto cósmico misterioso de 800 millones de años | Press/Digital |
| 23/06/2020 | Noticias Canarias | Observatorios LIGO en Estados Unidos y Virgo en Europa descubren un misterioso objeto fusionándose con un agujero negro | Digital |
| 23/06/2020 | Bajo palabra | Descubren misterioso objeto fusionándose con un agujero negro | Digital |

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| 23/06/2020 | La Sexta | LIGO y Virgo descubren un misterioso objeto fusionándose con un agujero negro | Digital |
| 23/06/2020 | Ara Balears | Investigadors de la UIB descobreixen la fusió d'un forat negre amb un "objecte misteriós" | Digital |
| 23/06/2020 | El Correo Gallego | Científicos de la USC participan en el descubrimiento de un misterioso objeto fusionándose con un agujero negro | Press/Digital |
| 23/06/2020 | Galicia Confidencial | Detectan unha "misteriosa zona gris" fusionándose cun buraco negro | Digital |
| 23/06/2020 | GCiencia | O misterioso obxecto que se fusionou cun buraco negro hai 800 millóns de anos | Digital |
| 23/06/2020 | CERN | LHCb honours its Thesis and Early Career Awards Winners | Digital |
| 24/06/2020 | ABC | Detectan el choque entre un agujero negro y un misterioso objeto astrofísico | Press/Digital |
| 25/06/2020 | GCiencia | O galego Edgar Lemos, premiado polo CERN como investigador novo | Digital |
| 26/06/2020 | Ambientum | Un objeto misterioso se fusiona con un agujero negro | Digital |
| 01/07/2020 | GCiencia | Científicos galegos, no achado dun novo tipo de tetraquark no CERN | Digital |
| 21/07/2020 | El Correo Gallego | El profesor de la USC Carlos Salgado, nuevo miembro plenario del Comité europeo para futuros aceleradores del CERN | Press/Digital |
| 21/07/2020 | 21Noticias | Carlos Salgado, nuevo miembro plenario del Comité Europeo para Futuros Aceleradores del CERN | Digital |
| 21/07/2020 | GCiencia | Carlos Salgado, no grupo que definirá os futuros aceleradores do CERN | Digital |
| 21/07/2020 | Galiciapress | El profesor de la USC Carlos Salgado, nuevo miembro plenario del Comité europeo para futuros aceleradores del CERN | Digital |
| 21/07/2020 | Galicia Confidencial | O profesor da USC Carlos Salgado, novo membro plenario do Comité europeo para futuros aceleradores do CERN | Digital |
| 21/07/2020 | Efervesciencia (Radio Galega) | Un TRASGO na Antartida con Juan Antonio Garzón | Radio |
| 22/07/2020 | Compostela 24h | El profesor de la USC Carlos Salgado, nuevo miembro plenario del Comité europeo para futuros aceleradores del CERN | Digital |
| 02/09/2020 | El Cultural | Descubierto el agujero negro más masivo jamás observado | Digital |
| 02/09/2020 | Público | La fusión de dos agujeros negros en otro supermasivo desconcierta a la comunidad astrofísica | Digital |
| 02/09/2020 | El Periòdic | Un grupo internacional de especialistas, con participación de la Universitat de València, revelan nuevas e inesperadas poblaciones de agujeros negros | Digital |
| 02/09/2020 | La Voz de Galicia | Detectan el agujero negro más masivo observado a través de ondas gravitacionales | Press/Digital |
| 02/09/2020 | 20minutos | Un grupo internacional de especialistas, con participación de la UV, revela nuevas poblaciones de agujeros negros | Digital |

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| 02/09/2020 | El Mundo | La mayor fuente de ondas gravitacionales nunca vista muestra la formación de un nuevo tipo de agujero negro | Press/Digital |
| 02/09/2020 | 21Noticias | A colisión de buracos negros máis masiva xamáis observada | Digital |
| 02/09/2020 | Gciencia | Detectan a máis potente onda gravitacional, que desconcerta aos científicos | Digital |
| 02/09/2020 | Time24story | Scientists capture a huge gravitational wave that shouldn't exist and that they can't explain | Digital |
| 02/09/2020 | Agencia SINC | La fusión de dos agujeros negros en otro supermasivo desconcierta a la comunidad astrofísica | Digital |
| 02/09/2020 | Galicia Confidencial | Científicos galegos toman parte no descubrimento do maior buraco negro atopado ata a data | Digital |
| 02/09/2020 | Quobit | Científicos registran agujeros negros con onda gravitacional inusual | Digital |
| 02/09/2020 | Europapress Galicia | Especialistas internacionales revelan el agujero negro más masivo jamás detectado a través de ondas gravitacionales | Digital |
| 02/09/2020 | Huffington post | Los científicos captan una enorme onda gravitacional que no debería existir y que no pueden explicar | Digital |
| 02/09/2020 | Ara Balears | La UIB participa en la detecció d'un forat negre 142 vegades més gran que el sol | Digital |
| 02/09/2020 | La Voz de Asturias | Detectan el agujero negro más masivo observado a través de ondas gravitacionales | Digital |
| 02/09/2020 | GCiencia | As claves do achado, con participación galega, do "buraco negro imposible" | Digital |
| 02/09/2020 | La Opinión de A Coruña | Descubren la onda gravitacional más grande hasta la fecha | Press/Digital |
| 02/09/2020 | Xakata ciencia | Las ondas gravitacionales han vuelto a hacerlo: acabamos de detectar la colisión de agujeros negros más masiva jamás observada | Digital |
| 02/09/2020 | ABC | Detectan la mayor fusión de agujeros negros observada hasta ahora | Press/Digital |
| 02/09/2020 | BBC | La gigantesca colisión de dos agujeros negros que la ciencia no logra explicar | Digital |
| 02/09/2020 | EFE Futuro | Detectan una onda gravitacional gigante que abre más preguntas que respuestas | Digital |
| 02/09/2020 | La Sexta | Descubren la fuente de ondas gravitacionales más grande hasta la fecha | TV |
| 02/09/2020 | Diario de Avisos | España ayuda a descubrir el mayor agujero negro: 142 veces más grande que el Sol | Press/Digital |
| 02/09/2020 | Cadena SER | Descubierto el agujero negro más masivo con ondas gravitacionales | Radio |
| 02/09/2020 | Europapress | Un 'bang' señala la fuente de ondas gravitacionales más fuerte recibida | Digital |
| 02/09/2020 | Antena 3 | Detectada la mayor fusión de agujeros negros gracias a la masiva recepción de ondas gravitacionales | TV |

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| 02/09/2020 | RTVE | Detectan el agujero negro más grande jamás conocido: 142 veces la masa del Sol | TV |
| 02/09/2020 | Periodista digital | Los científicos captan una potente onda gravitacional jamás registrada y su origen es un misterio | Digital |
| 02/09/2020 | Next | Detectan la fuente de ondas gravitacionales más grande hasta la fecha | Digital |
| 03/09/2020 | Murciaplaza | Un equipo internacional descubre el agujero negro "más masivo" detectado con ondas gravitacionales | Digital |
| 03/09/2020 | 14ymedio | La fusión de dos agujeros negros desconcierta a la comunidad astrofísica | Digital |
| 03/09/2020 | Nobbot | Ondas gravitacionales: murmullos que llegan a la Tierra desde los confines del espacio-tiempo | Digital |
| 03/09/2020 | National Geographic | Descubren el agujero negro más masivo detectado con ondas gravitacionales | Digital |
| 03/09/2020 | Página12 | La fusión de dos agujeros negros en otro supermasivo desconcierta a la comunidad astrofísica | Digital |
| 03/09/2020 | Telecinco | Fusión inexplicable de dos agujeros negros: detectan una señal desconcertante en el espacio | TV |
| 03/09/2020 | La Crónica Hidalgo | Registran ondas gravitacionales inusuales creadas por fusión de dos agujeros negros | Press/Digital |
| 03/09/2020 | Crónica | Detectan ondas gravitacionales inusuales creadas por fusión de dos agujeros negros | Digital |
| 03/09/2020 | Valencia Plaza | Un equipo internacional descubre el agujero negro "más masivo" detectado con ondas gravitacionales | Digital |
| 03/09/2020 | La Sexta | Qué son las ondas gravitacionales y cómo se originan | TV |
| 03/09/2020 | El País | Los científicos captan una enorme onda gravitacional que no debería existir | Press/Digital |
| 04/09/2020 | Hoyydia.com | Supermasivo agujero negro | Digital |
| 04/09/2020 | Technology.org | International group reveals new and unexpected black hole populations | Digital |
| 15/09/2020 | 21Noticias | Arranca la III edición del Concurso de Comunicación Científica del IGFAE | Digital |
| 15/09/2020 | El Mundo | Alicia Sintes: "Este gran descubrimiento nos obliga a revisar la ley de la evolución estelar" | Press/Digital |
| 15/09/2020 | CORDIS | Cómo las tarjetas gráficas ayudan a capturar el fenómeno más insólito del universo | Digital |
| 17/09/2020 | Nós diario | Furados negros (non tan) supermasivos | Digital |
| 17/09/2020 | 21Noticias | Schrödinger en Santiago e outras anécdotas científicas co historiador Ricardo Gurriarán, próximo invitado do ciclo "Transfronteirizas, conversas de arte e ciencia" | Digital |
| 01/10/2020 | Galicia Press | Educación destina más de 2 millones de euros para cofinanciar material de investigación en las universidades | Digital |

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| 02/10/2020 | GCiencia | O IGFAE de Santiago lidera as medicións máis precisas de raios cósmicos ultraenerxéticos | Digital |
| 02/10/2020 | Gciencia | O accidente mortal do que se salvou Erwin Schrödinger no Pazo de Oca | Digital |
| 02/10/2020 | El Correo Gallego | La Xunta destina más de dos millones para cofinanciar la I+D+i de las tres universidades | Press/Digital |
| 02/10/2020 | El Ideal Gallego | Feijóo se prepara para definir las cuentas gallegas sin el respaldo de las del Estado | Digital |
| 05/10/2020 | Galicia Press | Las Medallas de Investigación 2020 reconocen la trayectoria de cinco científicos gallegos de la USC y UVigo | Digital |
| 05/10/2020 | Galicia Confidencial | As Medallas de Investigación 2020 recoñecen a traxectoria de cinco científicos galegos | Digital |
| 05/10/2020 | La Voz de Galicia | Santiago despunta en las Medallas de Investigación | Press/Digital |
| 05/10/2020 | La Región | Cinco científicos gallegos recibirán las Medallas de Investigación de la RAGC | Press/Digital |
| 06/10/2020 | Cultura Galega | A Academia Galega de Ciencias recoñece coas súas Medallas de Investigación cinco científicos da Uvigo e da USC | Digital |
| 06/10/2020 | El progreso | Un científico de Monforte, incluído no quinteto dos máis destacados de Galicia | Press/Digital |
| 06/10/2020 | Qué! | LAS MEDALLAS DE INVESTIGACIÓN 2020 RECONOCEN LA TRAYECTORIA DE CINCO CIENTÍFICOS | Digital |
| 06/10/2020 | El Correo Gallego | Medallas de Investigación 2020: recoñecemento á prestixiosa traxectoria de cinco científicos galegos | Press/Digital |
| 06/10/2020 | Faro de Vigo | La Real Academia Galega de Ciencias otorga medallas a Xosé Ramón Nóvoa y Jesús Simal | Press/Digital |
| 07/10/2020 | Pagina Jornal | Os cientistas encontram pistas para decifrar a forma dos buracos negros | Digital |
| 08/10/2020 | EurekAlert | The black hole always chirps twice: New clues deciphering the shape of black holes | Digital |
| 08/10/2020 | Galicia Confidencial | Os buracos negros emiten varios "chíos" cando se fusionan | Digital |
| 08/10/2020 | Nanova | Las ondas gravitacionales resultante de la fusión de dos agujeros negros podrían revelar la forma del objeto resultante. | Digital |
| 08/10/2020 | Nuevo Periódico | Los científicos encuentran pistas para descifrar la forma de los agujeros negros | Digital |
| 08/10/2020 | Yahoo | Los agujeros negros emiten chirridos al colisionar | Digital |
| 08/10/2020 | 20 minutos | Descubren los "chirridos" que emiten los agujeros negros al colisionar | Digital |
| 08/10/2020 | Cienciaplus | Las agujeros negros codifican su forma en pitidos cuando se fusionan | Digital |
| 08/10/2020 | La Voz de Gaicia | Descubren que los agujeros negros emiten «chirridos» al colisionar | Press/Digital |

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| 08/10/2020 | GCiencia | A fusión de buracos negros emite chíos de ondas gravitacionais como un faro | Digital |
| 08/10/2020 | El Correo Gallego | El resultado entre la fusión de dos agujeros negros emite impulsos de ondas semejantes a las de un faro | Press/Digital |
| 08/10/2020 | La Gradona | LAS ONDAS EN EL TEJIDO DEL ESPACIO Y EL TIEMPO OFRECEN NUEVAS PISTAS SOBRE LA FORMA DE LOS AGUJEROS NEGROS | Digital |
| 08/10/2020 | Ágora (Aragón radio) | El 'No Premio Nobel' del científico español Francis Mojica | Radio |
| 09/10/2020 | 21Noticias | O buraco negro sempre "pía" dúas veces: novas pistas permiten descifrar a forma destes obxectos cósmicos | Digital |
| 09/10/2020 | Notiulti | Los agujeros negros emiten señales como 'chirridos' cuando chocan entre sí | Digital |
| 09/10/2020 | Faro de Vigo | Los agujeros negros codifican su forma en pitidos cuando se fusionan | Press/Digital |
| 13/10/2020 | La Voz de Galicia | «Podríamos probar la teoría de la gravedad de Einstein como nunca» | Press/Digital |
| 13/10/2020 | Faro de Vigo | Un fármaco de esponja marina anticovid | Press/Digital |
| 20/10/2020 | 21Noticias | Física cuántica y astronomía con el músico Javier Ruibal en el próximo "Transfronteirizas. conversas de arte e ciencia" | Digital |
| 29/10/2020 | GCiencia | O IGFAE de Santiago participa nun novo catálogo que recolle 39 ondas gravitacionais | Digital |
| 29/10/2020 | Agencia SINC | Nuevo catálogo con decenas de nuevas ondas gravitacionales detectadas por Virgo y LIGO | Digital |
| 29/10/2020 | 20minutos | LIGO y Virgo anuncian nuevas detecciones de ondas gravitacionales | Digital |
| 03/11/2020 | 21Noticias | La Semana de la Ciencia del IGFAE se reinventa | Digital |
| 04/11/2020 | La Vanguardia | La Xunta anuncia la incorporación de 15 científicos de prestigio internacional a las universidades gallegas | Press/Digital |
| 04/11/2020 | El Correo Gallego | Las universidades gallegas incorporan a 15 científicos de prestigio internacional | Press/Digital |
| 04/11/2020 | Galicia Digital | A III Semana da Ciencia do IGFAE bota a andar o 10 de novembro | Digital |
| 05/11/2020 | Galicia Confidencial | A ciencia non é só cousa de homes | Digital |
| 05/11/2020 | La Voz de Galicia | La Semana da Ciencia inicia su tercera edición | Press/Digital |
| 09/11/2020 | 21Noticias | Gabriela González, Javier Santaolalla y las ondas gravitacionales inauguran mañana la III Semana de la Ciencia del IGFAE | Digital |
| 09/11/2020 | Cultura.gal | III Semana de la Ciencia del Instituto Gallego de Física de Altas Energías | Digital |
| 12/11/2020 | A tarde (Radio Galega) | A tarde do día 12/11/2020 | Radio |

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| 12/11/2020 | Nós diario | Ciencia e xénero | Press/Digital |
| 21/11/2020 | IES de Sar | Dous novos premios para o IES de SAR. | Digital |
| 25/11/2020 | TecnoXplora (La Sexta) | Nuevo catálogo con decenas de nuevas ondas gravitacionales detectadas por Virgo y LIGO | Digital |
| 27/11/2020 | Lindeiros | Ciencia singular sen moverse da casa coa USC | Digital |
| 27/11/2020 | Gciencia | Unha xornada de portas abertas 'virtual' nos centros singulares da USC | Digital |
| 27/11/2020 | Colegio Compañía de María | Ciencia Singular USC | Digital |
| 04/12/2020 | El Correo Gallego | La marca CIGUS identificará a los centros de investigación gallegos | Press/Digital |
| 04/12/2020 | La Voz de Galicia | Galicia reúne a sus centros de investigación punteros bajo la marca Cigus | Press/Digital |
| 04/12/2020 | 20 minutos | Los centros universitarios gallegos se agrupan bajo la marca CIGUS, que será la "Galicia Calidade de la investigación" | Digital |