The Standard Model to the Limits

The Standard Model (SM) is our best construction of the microscopic reality at the most fundamental level. The level of performance with experiment is extremely high.

Our Institute has played a fundamental role in this broad field of research, that includes the search for new physics beyond the Standard Model (SM) using the LHCb experiment (RP1), the study of the Quantum Chromodynamic (QCD) matter at extreme conditions (RP2) and the investigations on string theory, both from a formal and applied point of view (RP3).

The LHCb experiment is designed to perform searches for new physics beyond the Standard Model using the enormous flux of beauty and charmed hadrons produced at the LHC. The main 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 to vector mesons, study of rare decays of mesons with b and s quarks and measurement of observables in proton-lead collisions. Important results belonging to these working lines, with crucial input from IGFAE members, have been published during 2017.

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 material. 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 2017 concern the use of top quarks for characterising the QGP and the study of high gluon densities. Moreover, our group has also been involved in the elaboration of physics case for future experiments.

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. During 2017 the group has been especially interested in Holography, that is, the duality between Quantum Field Theory (QFT) and gravity, and in AdS/CFT correspondence. This correspondence provides powerful computing tools for different scenarios, including Quark Gluon Plasma or Condensed Matter systems.
Beyond the SM searches with LHCb

The LHCb experiment is designed to perform high-precision measurements of CP-violation and search for New Physics beyond the Standard Model (SM) using the enormous flux of beauty and charmed hadrons produced at the LHC. The LHCb detector is a single-arm spectrometer with excellent tracking and particle identification capabilities. During Run 1 and Run 2, it has acquired 10 fb⁻¹ of data, surpassing the initial predictions.

The IGFAE is a founder member of the LHCb experiment. The institute was involved in the construction and installation of the Silicon Tracker together with the EPFL at Lausanne, the University of Zürich and the University of Heidelberg. The Silicon Tracker consists of two separate silicon micro-strip detectors; the Inner Tracker and the Tracker Turicensis. In total, it has 270,000 electronic channels. The IGFAE was responsible for 50% of the construction of the Inner Tracker and for the Experiment Control System for both sub-detectors. The coordination of the Silicon Tracker subsystem has been leaded by IGFAE members for several years.

Results obtained from already collected data are limited by statistics in the search for new phenomena. To overcome this an upgraded detector, with a readout at 40 MHz and a more flexible software-based trigger, will allow an increase in data rate and in the trigger efficiencies, especially in decays to hadronic final states. In addition, it will be possible to change triggers to explore different physics as LHC discoveries point us to the most interesting channels. The IGFAE is involved in two subsystems: the LHCb vertex detector (VELO) and the High-Level Trigger (HLT) system. The installation of the upgraded detector will start next year 2019.

An ambitious R&D program on silicon sensors for the VELO was carried out by the IGFAE. The upgraded VELO must be lightweight, radiation hard, vacuum compatible, and must drive data to the data acquisition system at speeds of up to 1.6 Tbits/s. These challenges are met with a new design based on hybrid pixel detectors, to be positioned within 5.1 mm of the LHC colliding beams. The sensors have 55x55 μm² square pixels and are read out by a new ASIC (VeloPix). The hottest ASIC must cope with integrated hit rates of up to 800 MHz and produce an output data rate of over 15 Gbits/s, adding up to 1.6 Tbits/s of data for the ~41 Mpixels of the whole upgraded VELO. The sensor guard ring design has been improved to cope with the high irradiation levels, which are highly non-uniform and reach 8x10¹⁵ 1 MeV neq cm⁻² at the innermost region. The material budget is optimised with the use of evaporative CO₂ coolant circulating in microchannels within a thin silicon substrate.
The first version of the VeloPix ASIC was thoroughly tested over the second half of 2016 and the first half of 2017 by IGFAE researchers. Several Heavy-Ion Irradiation campaigns showed an unexpected SEL (Single Event Latch-up) sensitivity in the pixel matrix as well as SET (Single Event Transient) in the SLVS receivers. A second version of the ASIC was submitted in 2017. The ASICs underwent again SEU and SEL tests up to a total fluence of 10 million ions cm\(^{-2}\). Throughout the test no current increase was observed, indicating that the SEL problem had been solved, there were no upsets on the SLVS reset receiver, and a test pulse run showed no SEU in the FIFO. Hence the design is considered to have fully addressed all the issues seen.

The electrical readout chain has been fully assembled for a half detector module. This includes the OPB (Opto Power Board), vacuum feedthrough, data tapes, low voltage cables, control and VeloPix hybrids and sensor triples. A mechanical demonstrator for a full range with 6 mounted modules has also been successfully assembled. The testing is performed fully in the context of the LHCb readout chain with the MiniDAQ2, which is already able to successfully control the OPB and VeloPixes. The firmware for the MiniDAQ2 system has been mainly developed at IGFAE.

One of the main characteristics of the LHCb upgrade is the full software trigger. Different technologies can be used for the HLT farm. The possibility of an HLT based on GPU instead of CPU can significantly improve the farm's computing power per euro at any of the LHCb upgrade phases. For this reason, we considered to join that effort. IGFAE contributes to the development of VELO clusterization algorithms, muon identification algorithms and track matching algorithms using GPU's.

The 2017 LHCb scientific production amounts to 80 papers published in high impact journals (Nature Physics, Physical Review Letters, Journal of High Energy Physics, etc.). 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 to vector mesons, study of rare decays of mesons with b and s quarks and measurement of observables in proton-lead collisions. Important results with crucial input from IGFAE members have been published outside the 2017 time-span in these working lines. Out of the bulk of LHCb results published in 2017 the following ones contain relevant contributions from IGFAE members.

"Tests of lepton universality with \(B_0 \rightarrow K^*\ell\ell\) decays, JHEP08(2017)055", which reports measurements of the ratio of the branching fractions of the \(B_0 \rightarrow K^*\mu^+\mu^-\) and \(B_0 \rightarrow K^*e^+e^-\) decays, called R(K*). This ratio is accurately predicted by the SM assuming that the
Electroweak couplings of leptons to gauge bosons are independent of their flavour. This key feature of the SM is known as “lepton universality”. The measurements of R(K*) performed by LHCb in different regions of the dilepton invariant mass squared are compatible with the SM expectations at the level of 2.1 to 2.5 standard deviations. Further analyses with more data are needed to clarify whether or not the SM correctly predicts the value of R(K*).

“Measurement of the Bs→μ+μ- branching fraction and effective lifetime and search for B0→μ+μ- decays, PRL 118, 191801 (2017)”. Within the SM, the Bs→μ+μ- and B0→μ+μ- decays are very rare because they occur only through loop diagrams and are helicity-suppressed. Their time-integrated branching fractions are predicted in the SM with small uncertainty thus being sensitive probes for physics beyond the SM. In this paper an excess of Bs→μ+μ- decays is reported with a significance of 7.8 standard deviations, representing the first observation of this decay in a single experiment. An upper limit is also determined for the Bd→μ+μ- branching fraction. All results are in agreement with the SM expectations.

“Improved limit on the branching fraction of the rare decay Ks→μ+μ-, Eur. Phys. J. C 77:678”. This decay proceeds exclusively through a flavour-changing neutral current transition, which cannot occur at tree level in the SM. Due to this suppression the decay is sensitive to possible contributions from dynamics beyond the SM. The observed yield is consistent with the background-only hypothesis and yields a limit on the branching fraction of $0.8 \times 10^{-9}$.

“Measurements of forward $t\bar{t}$, $W+b\bar{b}$ and $W+c\bar{c}$ production in pp collisions at $\sqrt{s}=8$ TeV”, PLB 767 (2017) 110-120. The production of $t\bar{t}$ pairs from proton-proton collisions in the forward region is of considerable interest, since it may be sensitive beyond the SM physics. Furthermore, forward $t\bar{t}$ events can be used to constrain the gluon parton distribution function at large momentum fraction. This paper reports measurements of production cross-sections in pp collisions at 8 TeV corresponding to an integrated luminosity of 2 fb$^{-1}$.

Hot and dense QCD in the LHC era and beyond

The main interest of the QCD phenomenology group is the application of perturbative QCD techniques to conditions of high temperature and/or large densities. Under these conditions, all hadronic matter is in a universal form, generically known as the Quark Gluon Plasma, which is also the state of the whole Universe some microseconds after the Big Bang. This material is created in laboratory by colliding two heavy nuclei at high energies (LHC energies are the highest at present). Characterizing this material is the main objective of our work. Do to so, we have continued our activities on the different lines: heavy-ion collisions and the Quark Gluon Plasma, high-energy QCD and the description of strongly interacting matter in effective models like Skyrme. Some highlights during 2017 are the following:

- In order to analyse the time structure of the Quark Gluon Plasma, the use of top quarks has been proposed in Phys. Rev. Lett. 120 (2018) no.23, 232301. In fact, the top production and its semileptonic decay offer different time scales: top decay, W decay and formation of a quark-antiquark pair in singlet colour state, whose pass through the plasma, with the associated energy loss processes, leaves an imprint in the reconstructed W mass. This observable has a promising future in the HL/HE-LHC and at the FCC-hh.

- We have also contributed to the predictions for cold nuclear matter effects in proton-lead collisions at 8.16 TeV for different observables, published in Nucl.Phys. A972 (2018) 18-85.

- The study of high gluon densities are also relevant in the partonic wave function of protons and nuclei at high energies, where a mechanism of saturation can also appear. In the past year, the group has released a new set of nuclear parton distribution functions, the so-called EPPS16, published in Eur. Phys. J. C77 (2017) no.3, 163, that, for the first time, include data from pPb collisions at the LHC. This analysis is the most updated existing one and the basis for future inclusions of new sets of data from the LHC.

- On the other hand, the study of correlations between partons in the initial state of hadronic collisions has been extended from gluons (employed to describe the ridge phenomenon observed in pp, pPb and PbPb collisions at the LHC) to quarks in Phys. Rev. D95 (2017) no.3, 034025. For gluons, it was proven before that the ridge is related with the existence of Bose enhancement in the wave function of the projectile and target. For quarks, Pauli blocking appears that suggests the existence of anticorrelations as a possible signature.
In other order of things, we have also contributed to the elaboration of two physics cases:

- The one for heavy-ion-physics studies using the multi-TeV lead LHC beams in the fixed-target mode, AFTER@LHC, published in Few Body Syst. 58 (2017) no.5, 148. We detailed the possible contributions of AFTER@LHC to heavy-ion physics with a specific emphasis on quarkonia and presented performance simulations for a selection of observables. These showed that $\Upsilon(nS)$, $J/\psi$ and $\Upsilon(2S)$ production in heavy-ion collisions can be studied in new energy and rapidity domains with the LHCb and ALICE detectors. We also discussed the relevance to analyse the Drell-Yan pair production in asymmetric nucleus-nucleus collisions to study the factorisation of the nuclear modification of partonic densities and of further quarkonia to restore their status of golden probes of the quark-gluon plasma formation.

- Also, in the CERN Yellow Report (2017) no.3, 635-692, the physics case for nuclear collisions at the proposed Future Circular Collider at CERN, that would deliver pp, pPb and PbPb collisions at centre-of-mass energies of 100, 63 and 39 TeV/nucleon respectively, is presented. The group participated prominently in the small-x and hard probes working groups, and in the editorial work.

During 2017, part of the group belonged to the ALICE collaboration, participating on the internal committees and authorising the collaboration papers.

Besides, the group continued working on: (i) on string models as phenomenological models for QCD in the soft domain, both on the description of strangeness production in the quark-gluon string models and of azimuthal asymmetries in particle production in the string percolation model; and (ii) in the research line on topological solitons, Skyrmions and their applications to Nuclear Physics and Astrophysics, in 2017 the main activities dealt with the mathematical problems of such models, like the existence of BPS submodels in the Skyrme model, the concept and bounds on the volume of solitons, and solitons in external magnetic fields.

String theory and relation with other fields

The IGFAE theory group performs research in more formal areas of particle physics, with a strong interest in String Theory, both from a formal and applied point of view. During the last years the group has been especially interested in Holography, that is, the duality between Quantum Field Theory and Gravity which relates the strong coupling limit of the QFT side to the weak-coupling limit in the Gravity side. This correspondence provides powerful computing tools for different scenarios, including Quark Gluon Plasma or Condensed Matter.
systems. In the last couple of years the group has also developed an intense activity in numerically solving the Gravity problem for metrics of interest in AdS/CFT correspondence. The work developed by group is summarized in the next paragraphs. We can distinguish three driving lines of our research:

**Gauge-Gravity duality and Holography**

AdS/CFT duality is a computational tool with which one can study Quantum Field Theory in the non-perturbative strong coupling regime. This is a central part of our studies and we have focused on the following aspects:

- **Out of equilibrium dynamics.** Its gravity dual involves time dependent evolution in numerical relativity. An efficient code has been set up to deal with them and we have performed numerical studies of periodically driven systems at strong coupling, in a toy model involving a scalar in global AdS (Floquet system). We have proven that the system has a stability regions where quantum coherence is preserved. Also we proved that a holographic version of time-crystals can be obtained as Floquet condensates by means of a suitable quench.

- **Translation symmetry breaking and the dynamical emergence of phonons.** We have addressed the topic with both quantum field theory and holographic methods. The study of the simplest dynamical translation-breaking model in field theory has allowed to prove general statements like the presence of higher-derivative terms and the necessity of breaking relativistic invariance explicitly. Also the demonstration that holography is able to capture the bad metal phenomenology and describe quantitatively the presence of a gapped soft collective mode in the conductivity and the existence of sub-harmonic response in strongly-coupled driven systems.

- **Construction of string dual geometries for defects in N=4 super Yang-Mills in (2+1) dimensions (defect theories) with flavor in the Veneziano limit.** These defects are generated by D5-branes, which act as sources in the equations of supergravity. When the flavors are massless the solution we found is analytic and displays an anisotropic Lifshitz-like invariance.

- **Non-relativistic anyons.** We modeled holographically a strongly coupled non-relativistic anyonic fluid characterized by its dynamical and hyperscaling violation exponents. We focused in the analysis of the collective excitations of dense matter in the presence of an external magnetic field. In particular we obtained the dispersion relation of the holographic zero sound, as well as the diffusion constant, the conductivities and the susceptibility.
Consistent generalizations of General Relativity

Motivated from generic expectations for a consistent theory of quantum gravity, a long standing problem is related to the consistence conditions for higher-curvature corrections to General Relativity. In this sense the following items have been scrutinized:

- Causality issues raised by these terms in three dimensions and their relation to the sign problem of the Newton constant.
- Consistence of T-duality and black hole thermodynamics in the case of the BTZ black hole.

Generalization of the AdS5xS5 duality

The work during 2017 was a continuation of the investigation on the, so called, lambda-deformation of the superstring theory in AdS5xS5 proposed by our group in 2015. This is an integrable theory that was originally proposed as a possible Lagrangian formulation of the deformation of the S-matrix of the superstring theory obtained by replacing its group of symmetries with a quantum group. Subsequently, several authors (including R. Borsato, now in our group) verified that it specifies a consistent solution of the supergravity equations. The main part of the work developed in 2017 was the construction of exact classic solutions of the deformed theory similar to the giant magnons of Hofman-Maldacena and Chen-Dorey-Okamura in the theory of superstrings in AdS5xS5, and the comparison of some of its properties (spectrum, dispersion matrix, etc.) with those of the deformed S-matrix. The objective was to support the proposed relationship between the lambda-deformation and the quantum group deformed S-matrix. One of the main difficulties is that the Lagrangian action of the lambda-deformation does not have global symmetries which, in particular, makes it difficult to identify the conserved quantities that correspond to energy and momentum. An important result of our work is a proposal to define the energy and momentum and the verification that they satisfy the same dispersion relations as the energy and momentum of the fundamental excitations that define the S-matrix.

Some of the above results are summarized in the following articles:


Cosmic Particles and Fundamental Physics

Astroparticle physics is a rapidly evolving field of research at the intersection of astronomy, particle physics and cosmology, observing the Universe with the advanced instrumentation of particle physics, while connecting the Big Bang model of the origin and evolution of the Universe to the Standard Model of particle physics. Astroparticle physics aims to gain insight into long-standing enigmas at the heart of our understanding of the Universe such as: What can we learn about the most extreme events in our universe by combining all messengers at our disposal namely high-energy cosmic rays, gamma-rays, neutrinos and gravitational waves? What is the nature of Dark Matter and Dark Energy? What are the intricate properties of neutrinos and what can they tell us about Fundamental Physics? IGFAE is tackling these fundamental questions in Physics with two research programmes.

Extremely energetic cosmic rays and neutrinos – Large exposure experiments

Detection of Ultra-High-Energy Cosmic Rays (UHECR) and neutrinos demands observatories spreading over areas of thousands of km² and operating for long periods of time. With this idea in mind the Pierre Auger Observatory was conceived in 1999. Auger is the world’s largest and most sensitive ground-based air-shower array for the detection of UHECR and UHE neutrinos. IGFAE is a member of the Pierre Auger Observatory since 2001. Located near the town of Malargüe in the Mendoza province in Argentina, the Pierre Auger Observatory is
contributing to deciphering some of the long-standing and most important questions in Astroparticle Physics, such as what are the sources of the UHECR at energies above $10^{18}$ eV, what is their nature and what are the mechanisms responsible for the acceleration of the observed particles to energies a million times larger than those of the protons accelerated at the LHC. Auger has observed a suppression in the energy spectrum of UHECR but it is not clear if it is due to particles being limited in energy because of interactions with the cosmic microwave background, or due to cosmic sources running out of steam to accelerate particles. The Auger collaboration will install additional particle detectors ('AugerPrime') to those existing to discriminate between the electron and muon content of the shower to help determine the mass of the primary cosmic-ray, a key observable to decipher among the two scenarios. This upgrade will also deepen the understanding of hadronic showers and interactions at center-of-mass energies above those accessible at the LHC.

In 2017 the Astroparticle Physics group at IGFAE has continued its successful participation in the Pierre Auger Observatory. The activities of the group are mainly focused in the analysis of data related to the measurement of the energy spectrum of UHECR, their composition, the determination of their arrival directions and distribution in the sky, the search for UHE neutrinos, and the study of UHECR properties using the radio-technique. Remarkably, the group contributed directly to two of the most important discoveries in the field of Astroparticle Physics in 2017, that were awarded with the “Physics World Breakthrough of the Year” for the top ten discoveries of 2017.

By studying the distribution of the arrival directions of more than 30000 cosmic rays, the Auger Collaboration discovered a dipolar anisotropy, significant at 5.2 standard deviations, in a direction where the distribution of galaxies is relatively high. It was found that the rate of arrival of cosmic rays is ~ 6% greater from one half of the sky than from the opposite one, with the excess lying 120 degrees away from the Galactic center. This provides observational evidence that cosmic rays with energies about a million times greater than that of the protons accelerated in the Large Hadron Collider come from much further away than from our own Galaxy, clearly indicating an extragalactic origin for the particles (Observation of a large-scale anisotropy in the arrival directions of cosmic rays above 8 x $10^{18}$ eV. Pierre Auger Collaboration, Science 357, 1266–1270 (2017)). The Astroparticle Physics group at IGFAE contributed directly to this discovery by analyzing inclined showers induced by ultra-high energy cosmic rays that arrive at Earth at large angles with respect to the vertical to the ground and that allowed to extend the field of view of the Auger Observatory towards the Northern hemisphere. This key piece of Auger analysis activities were coordinated by IGFAE member I. Valiño.
The Astroparticle Physics group at IGFAE also contributed directly to the follow-up of the source of the Gravitational Wave event GW170817 discovered by the LIGO and Virgo Collaborations and traced back to a binary neutron-star (BNS) system in the outskirts of the galaxy NGC 4993 at approximately 40 Mpc distance from the Earth. The same collision was also seen 1.7 s later in gamma-rays as a result of a short duration (< 2 s) gamma-ray burst (GRB) and, subsequently, across the electromagnetic spectrum, with radio, optical, and X-ray detections by a plethora of observatories across the globe (Multi-messenger Observations of a Binary Neutron Star Merger. Astrophysical Journal Letters 848, no.2, L12, 2017). The event marks the beginning of a new era in Astronomy and Astrophysics since it is the first source of GW seen also in electromagnetic radiation. In a joint and unprecedented effort by the neutrino observatories ANTARES and IceCube, the Pierre Auger cosmic-ray and neutrino observatory along with LIGO and Virgo GW detectors, scientists have searched for neutrino emission from this merger. Remarkably, at the moment of the merger the source was in an almost ideal position in the sky for neutrino detection with the surface detector array of the Pierre Auger Observatory (see Figure). No candidate neutrino events were found in directional coincidence with the position of the source within +/- 500 s of the onset of the BNS merger, nor in the subsequent 14 days. The non-detection allowed us to put limits on neutrino production in BNS for the first time (Search for High-energy Neutrinos from Binary Neutron Star Merger GW170817 with ANTARES, IceCube, and the Pierre Auger Observatory. ANTARES, IceCube, Auger, LIGO & Virgo Collabs., Astrophysical Journal Letters 850, no. 2, L35, 2017). The members of IGFAE, E. Zas and J. Alvarez-Muñiz in charge of the Multi-Messenger and Neutral Particle analysis activities in the Pierre Auger Collaboration respectively, carried out and coordinated this work.

Figure: Localizations and sensitive sky areas at the time of the GW170817 event in equatorial coordinates: 90% credible-level localization of GW170817 (red contour), direction of the galaxy NGC 4993 (black plus symbol), ANTARES´s horizon separating down-going (north of horizon) and up-going (south of horizon) neutrino directions (dashed blue line), and Auger’s fields of view for Earth-skimming (darker blue) and down-going (lighter blue) directions. IceCube’s up-going and down-going directions are on the northern and southern hemispheres, respectively.

**Dark Matter and the nature of neutrinos**

Despite all previous efforts, some of the fundamental properties of the neutrinos remain unknown. Notably, these include neutrino mass and whether the neutrino is its own anti-particle or not (in other words, whether it is a Majorana-type particle or a Dirac-type particle).
These are crucial questions whose answer has revolutionary implications in Particle Physics and Cosmology. These issues can be explored by studying the beta decay of selected isotopes.

IGFAE is a member of the NEXT experiment, an international collaboration to search for the hypothetical neutrino-less double beta decay in $^{136}$Xe, a process only allowed if neutrinos are Majorana-type particles. Its observation would also demonstrate the violation of lepton number. For this purpose, the NEXT collaboration is currently operating a medium-sized detector, NEXT-White, at the Underground Laboratory of Canfranc (LSC) in the Spanish Pyrenees, and plans to build starting in 2020 a large 100 kg Xenon detector, NEXT-100. This project is financed by ERC, national and regional funds. NEXT activities at IGFAE have been funded by MINECO.

The NEXT group at IGFAE has been deeply involved in the operation of the NEXT-White detector, being responsible for its daily calibration with Kr decays (The NEXT Collaboration, G. Martinez-Lema et al., Calibration of the NEXT-White detector using $^{83}$mKr decays, JINST 13 (2018) P10014 & G. Martinez Lema, Ph.D thesis to be presented in Dec. 2018). J.A. Hernando a member of the NEXT group at IGFAE is responsible for the calibration, reconstruction and coordination of the physics analysis. Also the NEXT group has taken a fundamental role in the development of the NEXT software with J.A. Hernando being the software and analysis project manager of the experiment (The NEXT experimental analysis and data flow at PyHEP 2018 Workshop (Bulgaria)).

The NEXT group is also very active in the analysis to estimate the energy scale and energy resolution, and in the use of Neural Networks to efficiently reject background contamination (The NEXT Collaboration, J. Renner et al., Initial results on energy resolution of the NEXT-White detector, JINST 13 (2018) no.10, P10020 & NEXT Collaboration, A. Simón et al., Electron drift properties in high pressure gaseous xenon, JINST 13 (2018) no.07, P07013. The NEXT Collaboration, J. Renner et al., Background rejection in NEXT using deep neural networks, JINST 12 (2017) no.01, T01004).

Since his incorporation to IGFAE in 2017 as a Ramón y Cajal fellow, D. González a NEXT member, has built a gas-detector laboratory to test small-gas TPC prototypes with optical readout for the development of a new Electro-Luminiscence technique. He has been the proponent of two mayor NEXT R+D programs to improve the electro-luminescence readout, and to improve tracking resolution using different gas mixtures (The NEXT Collaboration, R. Felkai et al., Helium-Xenon mixtures to improve the topological signature in high pressure gas xenon TPCs, Nucl. Instrum. Meth. A905 (2018) 82–90 & NEXT Collaboration, C.A.O. Henriques et al., Secondary scintillation yield of xenon with sub-percent levels of CO₂
additive for rare-event detection, Phys. Lett. B773 (2017) 663-671. In July 2018 a specialized thematic workshop of optical TPCs “Scintillation meets gaseous detectors” was held at IGFAE.

The future plans involve commissioning and operating NEXT-100 the 100-kg Xenon detector at LSC. A request for funding for the years 2019-2021 was submitted to the Spanish Agency of Research in collaboration with other Spanish institutions in NEXT (DIPC, IFIC and UPV).

**Nuclear Physics from the Lab to Improve People’s Health**

Nuclear Physics is a mature discipline that concentrates on the understanding of the structure of atomic nuclei and forces at play in the nuclear medium. Impressive progress has been achieved in this field, but there are still some not answered key questions related to how the chemical elements were created during the evolution of the universe, how is the energy generated in the stars, what are the limits of existence of nuclei, how are complex nuclei built from their basic constituents, or even what are the fundamental properties of the interactions at play in atomic nuclei.

The scientific strategy of the nuclear physics area at IGFAE covers a broad spectrum of experimental activities ranging from fundamental research and aiming to dilucidate the answer of the above mention topics, up to development of societal applications, namely in the field of human health. The implementation of this strategy is based on two research programs: the structure of the nuclear many-body systems and its astrophysical and cosmological implication and the commissioning and exploitation of the Laser Laboratory for Accelerator and Applications. Following this structure, we will present the scientific highlights of the activity performed in 2017.

Education and training of new researcher is a fundamental piece of our activity. Four PhD students have been working with us in 2017 in the different research programs. One of them, E. Leal got the doctoral degree in March 2017. Our students have attended different specialised international schools complementing their education and profited from long research stays in different international laboratories.

One of our Postdocs, J.L. Rodríguez Sánchez was awarded this year with the Prize to the best PhD work in Nuclear Physics 2016/17 (Grupo especializado de Física Nuclear de la RSEF).
The structure of the nuclear many-body systems and its astrophysical and cosmological implications

The approach we follow to unravel the fundamental properties of matter is the study of the many body structure and dynamics of nuclei. Present studies work in the knowledge frontier and continuously look for higher precision experiments linked to the existing and in-construction worldwide radioactive ion beam facilities.

The detection of gravitational waves from a neutron-star merger by the LIGO–VIRGO collaboration, followed by the observation of electromagnetic radiation by numerous telescopes, boosted experimental and theoretical physics in many domains. Nuclear physics was not an exception.

Contribution to FAIR/R3B experiment. Reaction studies induced by exotic projectiles at relativistic energies

The interpretation of neutron-star merger data and the expected new observations demand high precision nuclear data, in particular of heavy neutron-rich nuclei to reproduce the observations. This breakthrough puts focus on the Facility for Antiproton and Ion Research (FAIR), that will offer unique physics opportunities to determine the properties of heavy neutron-rich nuclei of relevance to r-process of nucleosynthesis. The R3B experiment will be a perfect laboratory to conduct advanced research projects combining these intense heavy neutron-rich beams and new generation nuclear physics equipment. Both will allow the study of nuclear matter in similar conditions to those met in neutron stars.

IGFAE develops an outstanding experimental program based on reactions induced by exotic projectiles at relativistic energies and contribute to the R&D program related to the R3B experiment at FAIR (https://fair-center.eu/). We are deeply engaged with the completion and exploitation of this versatile set up to perform experiments with Relativistic Heavy Ions in inverse kinematics.

Since May 2017, D. Cortina Gil, is the spokesperson of the R3B experiment (https://fair-center.eu/for-users/experiments/nustar/experiments/r3b.html). IGFAE has also an outstanding contribution to the data sorting of previous experimental campaigns and H. Álvarez Pol leads the R3B simulation software development (R3BRoot).

Along 2017 IGFAE has participated on the R3B cave refurbishment necessary to develop the experimental program in FAIR Phase 0. R3B cave needs to house the newly constructed detectors (i.e: GLAD, NeuLAND and CALIFA).
CALIFA construction and implementation

Since 2008 IGFAE led the design and construction of CALIFA, a dedicated gamma and proton calorimeter that will surround the R3B target. Up to 192 detection units, covering the angular region between 45-90 deg in polar angle have been built and tested in our laboratories along 2017 (from quality control to final performance of the detection units). Those tests were extended to commissioning under realistic conditions with the irradiation at Krakow proton cyclotron facility (160 MeV p beam), inducing 16O(p,2p) reactions in direct kinematics, that allowed to evaluate the efficiency and detector response.

Definition of R3B/ Phase 0 experimental program

In May 2017 FAIR management opened a call to evaluate the experimental proposals that would be performed during FAIR Phase 0 (2019-2021). IGFAE participated in the elaboration of five experimental proposals that were approved by the FAIR PAC (October 2017), covering topics that go from structure of exotic nuclear species, study of reactions of astrophysical interest to the comprehension of nuclear reaction mechanisms or constraining the nuclear equation of state.

One of them, led by J. Benlliure Anaya, proposes to investigate the potential-energy surface and the dynamics of fission over a broad range in fissility and excitation energy, taking advantage of relativistic radioactive beams and the advanced SOFIA@R3B setup, using (p,2pf) and Coulomb excitation to investigate fission of unstable nuclei in inverse kinematics. This combination will give, for the first time, access to the complete characterization of the fissioning system and the fission fragments. This worldwide unique next-generation fission experiment will provide the most comprehensive data collection on fission barriers, fission yields, and neutrons and gamma rays emitted in coincidence.

Studies of the structure and dynamics of the nucleus at beam energies around the Coulomb barrier studied using active targets. Commissioning of ACTAR-TPC

IGFAE develops experimental activities in the low energy regime around the Coulomb barrier. This activity makes use of different facilities and focus on the use of active targets.

In November 2017, the detector ACTAR TPC funded by the European Research Council via an ERC/Starting Grant was fully commissioned at GANIL (http://www.ganil-spiral2.eu). The technical challenge to connect 16,384 electronic channels on a surface of 25x25 cm2 was tried out with the prototype and was fully operational. The full 128 x 128 pad detector was tested at GANIL using a SPIRAL1 beam of 18O at 3.2 AMeV in 100 mbar of iC4H10. Two experiments (p,p) and (p,a) were carried out to build the excitation functions of the well-
known nuclei $^{19}\text{F}$ and $^{21}\text{Na}$. The measured resolutions for the (p,p) and (p,a) channels provided very good results. The commissioning was performed by members of the collaboration that involved researchers from GANIL, USC, K.U. Leuven, CENBG and IPNO-Orsay. The detector is now ready to use for physics experiments. Currently, four experiments are approved at GANIL with ACTAR TPC, among them one led by B. Fernández-Dominguez to study the spectroscopy of the unbound proton-rich nucleus $^{33}\text{K}$ which is expected to run in 2019. In addition, the program with active targets that is being conducted by researchers at the IGFAE is now expanding with a new experiment approved at the RCNP(Japan) to study the spectroscopy of $^{18}\text{C}$ using the American active target AT TPC.

**Fission campaign at VAMOS/GANIL**

The ongoing campaign at VAMOS/GANIL continued in 2017 with the realization of the experiment E753 (Spokesperson: M. Caamaño) by an international team of institutions from Spain, France, Sweden, and Portugal, and partially funded by ERC/ENSAR2. The aim of this experiment is the study of the role of shell effects in high-energy fission and quasi-fission reactions, including the measurement of prompt gammas with the AGATA detector. This is the first time that fragment isotopic identification, and thus structure information, is obtained for quasi-fission reactions. The data analysis is being carried out in collaboration with IPN Orsay and the INFN-Laboratory of Legnaro/University of Padova (Italy), where a PhD student is being co-supervised by M. Caamaño at the USC.

In parallel, data from previous experiments on the campaign continue to be analysed and communicated. Among them, we can mention the invited presentation at the Nuclear Chemistry Gordon Conference (New London, USA); and the publication “Energy balance and deformation at scission in $^{240}\text{Pu}$ fission” M. Caamaño and F. Farget, PLB 770, 72 (2017), where for the first time, experimental data is used to extract the balance between fission fragments of deformation and intrinsic energy.

On the instrumental side the development and construction of a new detector, based on the “Time Projection Chamber” technique with optical read out. The aim is to measure and record complete tracks of fission fragments from fixed targets in direct kinematics.

**Participation in CERN-n_TOF collaboration**

IGFAE researchers contribute to the facility maintenance, the data taking and its technical and scientific analysis. We shared authorship in 20 SCI peer reviewed articles. Esther Leal-Cidoncha defended her PhD thesis directed by I. Durán and C. Paradela by March 2017

Among the societal applications identified in 2017 we highlight:
Participation in data evaluation

I. Durán is IAEA consultant, his work leaded to the publication of Evaluation of the Neutron data Standards, Nuclear data Sheets 148(2018)143-188, with Allan Carlson and 19 al., putting the USC affiliation among the most outstanding nuclear institutions at world level, as NIST(USA), IAEA(International), EC-JRC-Geel (EU), Rosatom (Russia), JIAEA (Japan), CIAE (China) or ANU (Australia).

Creation of a Spin-off company for the indoor radon detection and mitigation.

IGFAE hosts a dedicated laboratory for the detection and study of environmental radioactivity (LAR). LAR speciality is the development of new detection systems and protocols to determine the presence of indoor radon and its mitigation. In November 2017, a substantial part of the associated technology and knowledge was transfer to the newly created spin-off INTERA S.L. (participated by USC and the IGFAE founding partners J. Benlliure, D. Cortina and JJ Llerena).

Commissioning and exploitation of the Laser Laboratory for Accelerator and Applications

The Laser Laboratory for Acceleration and Applications (L2A2) aims at developing new technologies and applications related to laser-plasma accelerators. This scientific infrastructure, promoted by IGFAE researchers (J. Benlliure Anaya), was built between 2013 and 2016. During that period the IGFAE team took the responsibility of coordinating the project, and in particular, the global design of the infrastructure, a 700 m² facility including a clean room hosting a 50 TW laser system, a radio-protected experimental area, a laboratory with mechanical, electronic and optic workshops, and the operation rooms of the laser and the experiments.

The research program lead by IGFAE at L2A2 focused on medical applications of laser-accelerated particles. At present this program concentrates in two initiatives: new laser-driven X-ray sources and their application in imaging (LaseX), and laser-driven production of radio-isotopes for PET imaging (LaserPET)

LaseX: A new laser-driven X-ray sources and their application in imaging

Low-energy laser pulses produced at L2A2 (1 mJ, 25 fs, 1kHz), efficiently focused (~ 10 m²) on different target materials, generate a plasma where electrons are accelerated up to some tens of kiloelectronvolts. The interaction of these electrons with the same target material
generates X-rays within the same range of energies. The advantage of these new X-ray sources, with respect to conventional ones, is the micrometric size of the focus. Under such conditions one can produce X-ray images with much better quality and lower doses. Moreover, one can also produce images not only based on the simple absorption technique, but also taking advantage of the phase of the produced X-rays, the so-called "phase-contrast imaging". This technology provides an additional sensitivity to the density of the exposed object, which is particularly interesting for biological samples.

Along 2017 the IGFAE team designed and built a laser driven X-ray source that was installed at the radio-protected area of the L2A2. The main elements of this source are:

- Laser-beam transport and focalization system. This system not only guides and focuses the laser pulses into the plasma target, but also generates a probe beam to characterize the plasma generated at the target.
- Plasma-target. A motorized assembly for the positioning of the target at the laser focus, typically a 100x100x1 mm³ copper plate, and the refreshment of the target material shot-by-shot at 1 kHz.
- X-ray detection system based on a CdTe detector for the spectral characterization of the source and TLD dosimeters for the dose measurement.
- On-line control system to remotely control the target assembly movement, the operation of the sensors and the data acquisition system.

An experimental campaign was also performed with the first low-energy laser beam delivered by L2A2. This campaign allowed for the characterization the X-ray source and first imaging applications based on the standard absorption technique. The results were presented at the Targ3 workshop “Targetry for High Repetition Rate Laser-Driven Sources” (Salamanca, June 2017) and a dedicated paper will be submitted soon.

**LaserPET: A laser-driven production of radio-isotopes for PET imaging**

This project was the core of the funding proposal for the construction of the L2A2. The aim of the project is to develop the technology required for the competitive production of radioisotopes used in positron-emission tomography (PET) by using laser-particle accelerators. The main argument is that present technologies for the production of PET isotopes are based on a centralized production and distribution scheme because of the rather large cost of the infrastructure required. Compact laser-accelerators could become the enabling technology for the on-demand production of PET radioisotopes, opening the
possibility of using short-lived isotopes, such as $^{11}$C, $^{13}$N or $^{15}$O, of special interest for the diagnostic of neurodegenerative and cardiovascular diseases.

The first milestone of this project is the design and construction of a laser-driven proton source delivering protons at energies above 10 MeV in a continuous operation mode at 10 Hz. For this purpose the L2A2 laser system is equipped with a high-energy laser line (1 J, 30 fs, 10 Hz). Focusing these laser pulses in few squared microns one can produce energy densities around $5 \times 10^{19}$ W/cm$^2$, sufficient for the acceleration of protons at the above mentioned energies.

The main activities carried out by the IGFAE team along 2017 are:

- Validation of the radiation shielding and the radiation security system installed at L2A2.
- Installation of the vacuum chamber hosting the experiment.
- Installation of the vacuum line between the laser compressor and the experimental chamber.
- Design and installation of the laser pulses transport and focusing system.
- Design and installation of a proton detection system based on passive CR39 sensors.

These activities were part of the IGFAE’s contribution to the “Retos/Colaboración” research grant in collaboration with the company PLA.S.L., and the I3M and CNM research institutes from CSIC. Moreover, the ELI-ALPS facility granted a contract to IGFAE for the construction of a high repetition rate plasma mirror. All these activities were reported in several workshops and invited seminars.
Christoph Adam, Scientific staff
Bernardo Adeva Andany, Scientific staff
Pedro Augusto Agostini Infante, Students
Jaime Álvarez Muñiz, Scientific staff
Héctor Álvarez Pol, Scientific staff
Carlota Andrés Casas, Students
Nestor Armesto Pérez, Scientific staff
Maximilian Attems, Postdocs
José Fernando Benlliure Anaya, Scientific staff
Óscar Boente García, Students
Juan Manuel Boillos Betete, Students
Martino Borsato, Postdocs
Manuel Caamaño Fresco, Scientific staff
Pablo Cabanelas Eiras, Postdocs
Veronika Chobanova, Postdocs
Xabier Cid Vidal, Postdocs, Scientific staff
Dolores Cortina Gil, Scientific staff
José Javier Cuenca García, Students
Jorge Da Cunha López, Administrative and Technical staff
José Luis Del Olmo Claudio, Students
Javier Diaz Cortés, Students
Fabio Alejandro Domínguez González, Postdocs
Álvaro Dosil Suárez, Students, Postdocs
Ignacio Durán Escribano, Scientific staff
José Daniel Edelstein Glaubach, Scientific staff
Anxo Fariña Biasi, Students
Manuel Feijoo Rodriguez, Students
Beatriz Fernández Domínguez, Scientific staff
Miguel Angel Fernández Morales, Students
Antonio Fernández Prieto, Students
Yanis Fontenla Barba, Students
Elisabet Galiana Baldó, Students
Abraham Antonio Gallas Torreira, Scientific staff
Damían García Castro, Students
Xabier García Feal, Students
Julián García Pardiñas, Students
Beatriz García Plana, Students
Juan Antonio Garzón Heydt, Scientific staff
David González Caamaño, Administrative and Technical staff
Diego González Díaz, Scientific staff
Elena González Ferreiro, Scientific staff
José Angel Hernando Morata, Scientific staff
Esther Leal Cidoncha, Students
Edgar Lemos Cid, Students, Postdocs
Juan José LLerena Cristobo, Administrative and Technical staff
Aida López Casado, Students
Miriam Lucio Martínez, Students
Lucía Martín Blanco, Students
Gonzalo Martínez Lema, Students
Diego Martínez Santos, Scientific staff
Javier Mas Solé, Scientific staff
Carlos Miguel Merino Gayoso, Scientific staff
José Luis Miramontes Antas, Scientific staff
Alexis Moscoso Rial, Students
Daniele Musso, Postdocs
Vanessa Nimo Fernández, Administrative and Technical staff
Sofía Otero Ugobono, Students
Carlos Pajares Vales, Scientific staff
Brais Palmeiro Pazos, Students
Gonzalo Parente Bermúdez, Scientific staff
Antonio Pazos Álvarez, Administrative and Technical staff
Francisco Pedreira Giralda, Students
José Manuel Penín Ascariz, Students
Eliseo Pérez Trigo, Administrative and Technical staff
Máximo Tomás Pló Casasús, Scientific staff
Jessica Prisciandaro, Postdocs
Miguel Ramos Pernas, Students
Manoel Anxo Rodriguez Moldes, Students
José Luis Rodríguez Sánchez, Postdocs
Antonio Romero Vidal, Postdocs
Juan José Saborido Silva, Scientific staff
Carlos Alberto Salgado López, Scientific staff
José Manuel Sánchez de Santos, Scientific staff
José Joaquín Sánchez Guillén, Scientific staff
Brais Sanmartín Sedes, Students
Cibrán Santamarina Ríos, Scientific staff
Marcos Antonio Seco Miguélez, Administrative and Technical staff
Alexandre Serantes Rubianes, Students, Postdocs
Jesús Aníbal Sierra García, Students
Guillermo Torralba Elipe, Students, Visitors and Collaborators
Inés Valiño Rielo, Postdocs
Ana Belén Vázquez Fidalgo, Administrative and Technical staff
Ricardo Antonio Vázquez López, Scientific staff
Alfonso Vázquez Ramallo, Scientific staff
Pablo Vázquez Regueiro, Scientific staff
Carlos Vázquez Sierra, Postdocs
Maria Vieites Díaz, Students
Víctor Vila Pérez, Students
Alejandro Vilar López, Students
Douglas Evan Wertepny, Postdocs
Enrique Zas Arregui, Scientific staff
Annual Report 2017

Scientific production

IGFAE Executive Board
14 December 2018
Inferences on mass composition and tests of hadronic interactions from 0.3 to 100 EeV using the water-Cherenkov detectors of the Pierre Auger Observatory

Aab, A. et al. [Auger collaboration]

Phys. Rev. D, 96, 122003
RL4, RL2, RL1
DOI: 10.1103/PhysRevD.96.122003

Spectral calibration of the fluorescence telescopes of the Pierre Auger Observatory

Aab, A. et al. [Auger collaboration]

Astropart. Phys., 95, 44
RL4, RL2, RL1
DOI: 10.1016/j.astropartphys.2017.09.001

Observation of a large-scale anisotropy in the arrival directions of cosmic rays above $8 \times 10^{18}$ eV

Aab, A. et al. [Auger collaboration]

Science, 357, 1266
RL4, RL2, RL1
DOI: 10.1126/science.aan4338

Multi-resolution anisotropy studies of ultrahigh-energy cosmic rays detected at the Pierre Auger Observatory

Aab, A. et al. [Auger collaboration]

J. Cosmol. Astropart. Phys., 6, 026
RL4, RL2, RL1
Annual Report 2017. Scientific production

Combined fit of spectrum and composition data as measured by the Pierre Auger Observatory
Aab, A. et al. [Auger collaboration]
J. Cosmol. Astropart. Phys., 4, 038
RL4, RL2, RL1
DOI: 10.1088/1475-7516/2017/04/038

A Targeted Search for Point Sources of EeV Photons with the Pierre Auger Observatory
Aab, A. et al. [Auger collaboration]
RL4, RL2, RL1
DOI: 10.3847/2041-8213/aa61a5

Muon counting using silicon photomultipliers in the AMIGA detector of the Pierre Auger observatory
Aab, A. et al. [Auger collaboration]
J. Instrum., 12, P03002
RL4, RL2, RL1
DOI: 10.1088/1748-0221/12/03/P03002

Search for photons with energies above 1018 eV using the hybrid detector of the Pierre Auger Observatory
Aab, A. et al. [Auger collaboration]
First Observation of the Rare Purely Baryonic Decay $B_0 \rightarrow p \bar{p}$

Aaij, R. et al. [LHCb collaboration]


RC1

DOI: 10.1103/PhysRevLett.119.232001

Measurement of the shape of the $\Lambda_0b \rightarrow \Lambda c \mu^-\mu^+$ differential decay rate

Aaij, R. et al. [LHCb collaboration]


Phys. Rev. D, 96, 112005

RC1

DOI: 10.1103/PhysRevD.96.112005

Updated search for long-lived particles decaying to jet pairs

Aaij, R. et al. [LHCb collaboration]


RC1

DOI: 10.1140/epjc/s10052-017-5178-x
Measurement of the $B^\pm$ production cross-section in pp collisions at $\sqrt{s}=7$ and 13 TeV
Aaij,R. et al. [LHCb collaboration]
JHEP, 12, 26
RL1
DOI: 10.1007/JHEP12(2017)026

Measurement of the $Y(nS)$ polarizations in pp collisions at $\sqrt{s}=7$ and 8 TeV
Aaij,R. et al. [LHCb collaboration]
JHEP, 12, 110
RL1
DOI: 10.1007/JHEP12(2017)110

Bose-Einstein correlations of same-sign charged pions in the forward region in pp collisions at $\sqrt{s}=7$ TeV
Aaij,R. et al. [LHCb collaboration]
JHEP, 12, 25
RL1
DOI: 10.1007/JHEP12(2017)025

$\chi c_1$ and $\chi c_2$ Resonance Parameters with the Decays $\chi c_{1,2} \rightarrow j/\psi \mu^+\mu^-$
Aaij,R. et al. [LHCb collaboration]
Annual Report 2017. Scientific production


*Phys. Rev. Lett.*, 119, 221801

RL1

DOI: 10.1103/PhysRevLett.119.221801

**Search for Baryon-Number Violating Ξb0 Oscillations**

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. Lett.*, 119, 181807

RL1

DOI: 10.1103/PhysRevLett.119.181807

**Updated branching fraction measurements of B (s) 0 → K S 0 h + h ' − decays**

Aaij, R. et al. [LHCb collaboration]


*JHEP*, 11, 27

RL1

DOI: 10.1007/JHEP11(2017)027

**Measurement of CP violation in B 0 → J/ψK S 0 and B 0 → ψ(2S)K S 0 decays**

Aaij, R. et al. [LHCb collaboration]

Annual Report 2017. Scientific production

JHEP, 11, 170
RL1
DOI: 10.1007/JHEP11(2017)170

Measurement of CP observables in $B ^ \pm \rightarrow DK ^ \ast \pm$ decays using two- and four-body $D$ final states
Aaij, R. et al. [LHCb collaboration]
JHEP, 11, 156
RL1
DOI: 10.1007/JHEP11(2017)156

Study of $b \ b ^ \prime$ correlations in high energy proton-proton collisions
Aaij, R. et al. [LHCb collaboration]
JHEP, 11, 30
RL1
DOI: 10.1007/JHEP11(2017)030

Observation of $D^0$ Meson Decays to $\pi^+\pi^-\mu^+\mu^-$ and $K^+K^-\mu^+\mu^-$ Final States
Aaij, R. et al. [LHCb collaboration]
RL1
DOI: 10.1103/PhysRevLett.119.181805
**Improved limit on the branching fraction of the rare decay $K^0 \rightarrow \mu^+ \mu^-$**

Aaij, R. et al. [LHCb collaboration]


**Study of prompt $D^0$ meson production in $pPb$ collisions at $\sqrt{s_{NN}}=5$ TeV**

Aaij, R. et al. [LHCb collaboration]


*JHEP*, 10, 90

**Observation of the Doubly Charmed Baryon $\Xi_{cc}^+$**

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. Lett.*, 119, 112001

**Measurement of $B_s^0$ and $D_s^-$ Meson Lifetimes**

Aaij, R. et al. [LHCb collaboration]

IGFAE authors: Santos, D.M.; Gallas, A.; Romero Vidal, A.; Vidal, X.C.; Vazquez Regueiro, P.; Adeva, B.; Saborido, J.; Borsato, M.; Santamarina Rios, C.; Chobanova,
Study of charmonium production in $b$ -hadron decays and first evidence for the decay $B_{s0}$

Aaij, R. et al. [LHCb collaboration]


Test of lepton universality with $B^0 \rightarrow K^{*0} \ell^+ \ell^-$ decays

Aaij, R. et al. [LHCb collaboration]


*JHEP*, 8, 55
**Resonances and CP violation in Bs and B\(^-\)s\(0\to J/\psi K^+ K^-\) decays in the mass region above the \(\varphi(1020)\)**

Aaij, R. et al. [LHCb collaboration]


*JHEP*, 8, 37

**First Observation of a Baryonic Bs\(0\) Decay**

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. Lett.*, 119, 041802

**Observation of the B\(^+\to d^*-K^+\pi^+\) decay**

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. D*, 96, 011101
Observation of the decay $B_s \rightarrow \eta c \phi$ and evidence for $B_s \rightarrow \eta c \pi^+ \pi^-$
Aaij, R. et al. [LHCb collaboration]

*JHEP*, 7, 21

RL1
DOI: 10.1007/JHEP07(2017)021

Measurement of the CP Violation Parameter $A_\Gamma$ in $D_0 \rightarrow K^+K^-$ and $D_0 \rightarrow \pi^+\pi^-$ Decays
Aaij, R. et al. [LHCb collaboration]

*Phys. Rev. Lett.*, 118, 261803

RL1
DOI: 10.1103/PhysRevLett.118.261803

Search for the Decays $B_{s0} \rightarrow \tau^+\tau^-$ and $B_0 \rightarrow \tau^+\tau^-$
Aaij, R. et al. [LHCb collaboration]

*Phys. Rev. Lett.*, 118, 251802

RL1
DOI: 10.1103/PhysRevLett.118.251802

Measurements of prompt charm production cross-sections in pp collisions at $\sqrt{s}=5$ TeV
Aaij, R. et al. [LHCb collaboration]

**Observation of the decay $\Lambda b^0 \rightarrow pK^-\mu^+\mu^-$ and a search for CP violation**

Aaij, R. et al. [LHCb collaboration]


*JHEP*, 6, 147

**RL1, RL5**

DOI: 10.1007/JHEP06(2017)147

**Measurement of the $J/\psi$ pair production cross-section in pp collisions at $\sqrt{s}$=13 TeV**

Aaij, R. et al. [LHCb collaboration]


*JHEP*, 6, 047

**RL1**

DOI: 10.1007/JHEP06(2017)047

**Measurement of the $B_s^0 \rightarrow \mu^+\mu^-$ Branching Fraction and Effective Lifetime and Search for $B^0 \rightarrow \mu^+\mu^-$ Decays**

Aaij, R. et al. [LHCb collaboration]

IGFAE authors: Santos, D.M.; Gallas, A.; Romero Vidal, A.; Vidal, X.C.; Vazquez Regueiro, P.; Adeva, B.; Saborido, J.; Borsato, M.; Santamarina Rios, C.; Chobanova,
Study of $J/\psi$ Production in Jets
Aaij, R. et al. [LHCb collaboration]
*Phys. Rev. Lett.*, 118, 191801
RL1
DOI: 10.1103/PhysRevLett.118.191801

Observation of Five New Narrow $\Omega_{c0}$ States Decaying to $\Xi_{c+}$ $K^-$
Aaij, R. et al. [LHCb collaboration]
*Phys. Rev. Lett.*, 118, 192001
RL1
DOI: 10.1103/PhysRevLett.118.192001

Study of the D $0$ $p$ amplitude in $\Lambda b$ $0 \rightarrow D$ $0$ $p$ $\pi^-$ decays
Aaij, R. et al. [LHCb collaboration]
*JHEP*, 5, 30
RL1
DOI: 10.1007/JHEP05(2017)030

Search for the $B_s^0 \rightarrow \eta'\phi$ decay
Aaij, R. et al. [LHCb collaboration]
*JHEP*, 5, 158

**RL1**
DOI: 10.1007/JHEP05(2017)158

Measurement of matter–antimatter differences in beauty baryon decays
Aaij, R. et al. [LHCb collaboration]
*Nat. Phys.*, 13, 391

**RL1, RL5**
DOI: 10.1038/nphys4021

Search for massive long-lived particles decaying semileptonically in the LHCb detector
Aaij, R. et al. [LHCb collaboration]

**RL1**
DOI: 10.1140/epjc/s10052-017-4744-6

Observation of the suppressed decay $\Lambda b \rightarrow p\pi - \mu + \mu -$
Aaij, R. et al. [LHCb collaboration]
*JHEP*, 4, 29

**Search for long-lived scalar particles in $B^+ \rightarrow k^+ \chi (\mu^+\mu^-)$ decays**
Aaij, R. et al. [LHCb collaboration]
*Phys. Rev. D*, 95, 071101

**New algorithms for identifying the flavour of B0mesons using pions and protons**
Aaij, R. et al. [LHCb collaboration]

**Evidence for the two-body charmless baryonic decay $B^+ \rightarrow p\Lambda^-$**
Aaij, R. et al. [LHCb collaboration]
IGFAE authors: Santos, D.M.; Gallas, A.; Romero Vidal, A.; Vidal, X.C.; Vazquez Regueiro, P.; Adeva, B.; Saborido, J.; Borsato, M.; Santamarina Rios, C.; Chobanova,
Observation of $Bc^+ \rightarrow d^0 K^+$ Decays
Aaij, R. et al. [LHCb collaboration]
*JHEP*, 4, 162
RL1
DOI: 10.1007/JHEP04(2017)162

Measurements of charm mixing and CP violation using $D^0 \rightarrow K^\mp \pi^\pm$ decays
Aaij, R. et al. [LHCb collaboration]
*Phys. Rev. Lett.*, 118, 111803
RL1
DOI: 10.1103/PhysRevLett.118.111803

Measurement of the ratio of branching fractions and difference in CP asymmetries of the decays $B^+ \rightarrow J/\psi \pi^+$ and $B^+ \rightarrow J/\psi K^+$
Aaij, R. et al. [LHCb collaboration]
*JHEP*, 3, 36
Measurement of the $B_±$ production asymmetry and the CP asymmetry in $B_±\rightarrow J/ψK_±$ decays  
Aaij, R. et al. [LHCb collaboration]  
Phys. Rev. D, 95, 052005  

Measurement of the phase difference between short- and long-distance amplitudes in the $B^+\rightarrow K^+μ^+μ^-$ decay  
Aaij, R. et al. [LHCb collaboration]  

Search for decays of neutral beauty mesons into four muons  
Aaij, R. et al. [LHCb collaboration]  
JHEP, 3, 1  

DOI: 10.1007/JHEP03(2017)001
**Observation of **$B_{c}^{+} \rightarrow J/ψ D^{(*)} K^{(*)}$** decays**

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. D*, 95, 032005

**RL1**

DOI: 10.1103/PhysRevD.95.032005

**Observation of the Annihilation Decay Mode $B_{0} \rightarrow k^{+} k^{-}$**

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. Lett.*, 118, 081801

**RL1, RL5**

DOI: 10.1103/PhysRevLett.118.081801

**Observation of the Decay $Ξ_{b}^{-} \rightarrow p K^{-} K^{-}$**

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. Lett.*, 118, 071801

**RL1**

DOI: 10.1103/PhysRevLett.118.071801

**Measurement of the $b$-Quark Production Cross Section in 7 and 13 TeV pp Collisions**

Aaij, R. et al. [LHCb collaboration]

*Phys. Rev. Lett.*, 118, 052002

**RL1, RL5**

DOI: 10.1103/PhysRevLett.118.052002

**Observation of** $B \rightarrow J/\psi \ 3 \pi \ +2 \pi \ - \ and \ B \rightarrow \psi (2 \ S) \ \pi \ +\pi \ +\pi \ - \ decays**

Aaij, R. et al. [LHCb collaboration]


**RL1, RL5**

DOI: 10.1140/epjc/s10052-017-4610-6

**Amplitude analysis of** $B^+ \rightarrow j/\psi \phi \ K^+$ decays

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. D*, 95, 012002

**RL1, RL5**

DOI: 10.1103/PhysRevD.95.012002

**Observation of** $J/\psi \phi$ **Structures Consistent with Exotic States** **from Amplitude Analysis of** $B^+ \rightarrow j/\psi \phi \ K^+$ decays

Aaij, R. et al. [LHCb collaboration]

IGFAE authors: Santos, D.M.; Gallas, A.; Romero Vidal, A.; Vidal, X.C.; Vazquez Regueiro, P.; Adeva, B.; Hernando Morata, J.A.; Saborido, J.; Borsato, M.; Santamarina
Rios, C.; Chobanova, V.; Plo, M.; Ramos Pernas, M.; Vieites Diaz, M.; Lucio Martinez, M.; Garcia Pardinas, M.

*Phys. Rev. Lett.*, 118, 022003

**RL1, RL5**

DOI: 10.1103/PhysRevLett.118.022003

**Observation of the decay Bs0 → φπ⁺π⁻ and evidence for B0 → φπ⁺π⁻**

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. D*, 95, 012006

**RL1, RL5**

DOI: 10.1103/PhysRevD.95.012006

**First Experimental Study of Photon Polarization in Radiative Bs0 Decays**

Aaij, R. et al. [LHCb collaboration]


*Phys. Rev. D*, 96, 051103

**RL1**
Measurement of $B_0$, $B_s$, $B^+$ and $A_b$ production asymmetries in 7 and 8 TeV proton–proton collisions
Aaij, R. et al. [LHCb collaboration]
Phys. Lett. B, 774, 139
RL1
DOI: 10.1016/j.physletb.2017.09.023

Prompt and nonprompt $J/\psi$ production and nuclear modification in pPb collisions at $s_{NN}=8.16$ TeV
Aaij, R. et al. [LHCb collaboration]
Phys. Lett. B, 774, 159
RL1
DOI: 10.1016/j.physletb.2017.09.058

Observation of $\eta_c(2S)\rightarrow pp^*$ and search for $X(3872)\rightarrow pp^*$ decays
Aaij, R. et al. [LHCb collaboration]
Phys. Lett. B, 769, 305
RL1, RL5
DOI: 10.1016/j.physletb.2017.03.046
Search for CP violation in the phase space of $D^0 \to \pi^+\pi^-\pi^+\pi^-$ decays

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Phys. Lett. B, 769, 345

RL1, RL5

DOI: 10.1016/j.physletb.2017.03.062

Measurement of forward $t\bar{t}$, $W^+b\bar{b}i\frac{1}{2}$ and $W^+c\bar{c}i\frac{1}{2}$ production in pp collisions at $s=8$ TeV

Aaij, R. et al. [LHCb collaboration]


Phys. Lett. B, 767, 110

RL1, RL5

DOI: 10.1016/j.physletb.2017.01.044

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Aaij, R. et al. [LHCb collaboration]


Phys. Lett. B, 767, 177

RL1, RL5

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Search for the suppressed decays $B^+ \to K^+K^+\pi^-$ and $B^+ \to \pi^+\pi^+K^-$

Aaij, R. et al. [LHCb collaboration]


**RL1, RL5**
DOI: 10.1016/j.physletb.2016.11.053

**Search for the CP-violating strong decays \( \eta \rightarrow \pi^+\pi^- \) and \( \eta'(958) \rightarrow \pi^+\pi^- \)**
Aaij, R. et al. [LHCb collaboration]


**RL1, RL5**
DOI: 10.1016/j.physletb.2016.11.032

**Observation of the \( \Xi_b \rightarrow J/\psi K^- \) decay**
Aaij, R. et al. [LHCb collaboration]


Phys. Lett. B, 772, 265

**RL1**
DOI: 10.1016/j.physletb.2017.06.045

**Measurement of CP asymmetries in \( D^\pm \rightarrow \eta'\pi^\pm \) and \( D_{s^\pm} \rightarrow \eta'\pi^\pm \) decays**
Aaij, R. et al. [LHCb collaboration]

Heavy-flavor production and medium properties in high-energy nuclear collisions -- What next?
Aarts, G. et al.
IGFAE authors: Ferreiro, E.G.

Multi-messenger observations of a binary neutron star merger
Abbott, B.P. et al. [Auger collaboration]

Kaon femtoscopy in Pb-Pb collisions at s NN = 2.76 TeV
Acharya, S. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
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J/ψ Elliptic Flow in Pb-Pb Collisions at s NN = 5.02 TeV
Acharya, S. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
Charged-particle multiplicity distributions over a wide pseudorapidity range in proton-proton collisions at $\sqrt{s}= 0.9, 7, \text{ and } 8 \text{ TeV}$
Acharya, S. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
RL2
DOI: 10.1140/epjc/s10052-017-5412-6

Measurement of deuteron spectra and elliptic flow in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76 \text{ TeV}$ at the LHC
Acharya, S. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
RL2
DOI: 10.1140/epjc/s10052-017-5222-x

Searches for transverse momentum dependent flow vector fluctuations in Pb-Pb and p-Pb collisions at the LHC
Acharya, S. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
_JHEP_, 9, 32
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Measurement of D-meson production at mid-rapidity in pp collisions at $\sqrt{s}=7 \text{ TeV}$
Acharya, S. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
RL2
DOI: 10.1140/epjc/s10052-017-5090-4

Energy dependence of forward-rapidity $J/\psi$ and $\psi(2S)$ production in pp collisions at the LHC
Acharya, S. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.  
**RL2**  
DOI: 10.1140/epjc/s10052-017-4940-4

**Production of π0 and η mesons up to high transverse momentum in pp collisions at 2.76 TeV**  
Acharya, S. et al. [Alice collaboration]  
IGFAE authors: Ferreiro, E.G.  
**RL2**  
DOI: 10.1140/epjc/s10052-017-4890-x

**Measuring KS 0K± interactions using Pb–Pb collisions at sNN=2.76 TeV**  
Acharya, S. et al. [Alice collaboration]  
IGFAE authors: Ferreiro, E.G.  
*Phys. Lett. B, 774, 64*  
**RL2**  
DOI: 10.1016/j.physletb.2017.09.009

**Linear and non-linear flow mode in Pb–Pb collisions at sNN=2.76 TeV**  
Acharya, S. et al. [Alice collaboration]  
IGFAE authors: Ferreiro, E.G.  
*Phys. Lett. B, 773, 68*  
**RL2**  
DOI: 10.1016/j.physletb.2017.07.060

**Production of muons from heavy-flavour hadron decays in p–Pb collisions at sNN=5.02 TeV**  
Acharya, S. et al. [Alice collaboration]  
IGFAE authors: Ferreiro, E.G.  
*Phys. Lett. B, 770, 459*  
**RL2**  
DOI: 10.1016/j.physletb.2017.03.049
BPS submodels of the Skyrme model
Adam C., Sanchez-Guillen J., Wereszczynski A.
IGFAE authors: Adam, C.; Sanchez-Guillen, J.
*Phys. Lett. B*, 769, 362

**RL2**
DOI: 10.1016/j.physletb.2017.04.003

Volume of a vortex and the Bradlow bound
Adam C., Speight J.M., Wereszczynski A.
IGFAE authors: Adam, C.
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**RL2**
DOI: 10.1103/PhysRevD.95.116007

Gauged BPS baby Skyrmions with quantized magnetic flux
Adam C., Wereszczynski A.
IGFAE authors: Adam, C.
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DOI: 10.1103/PhysRevD.95.116006

Evolution of the longitudinal and azimuthal structure of the near-side jet peak in Pb-Pb collisions at sNN =2.76 TeV
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
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**RL2**
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Anomalous Evolution of the Near-Side Jet Peak Shape in Pb-Pb Collisions at sNN =2.76 TeV
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
*Phys. Rev. Lett.*, 119, 102301
Insight into particle production mechanisms via angular correlations of identified particles in pp collisions at $\sqrt{s}=7$ TeV
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.

Measurement of electrons from beauty-hadron decays in p-Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV and Pb-Pb collisions at $\sqrt{s_{NN}}=2.76$ TeV
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
JHEP, 7, 52

$K^*(892)0$ and $\phi(1020)$ meson production at high transverse momentum in pp and Pb-Pb collisions at $s_{NN}=2.76$ TeV
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
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Enhanced production of multi-strange hadrons in high-multiplicity proton-proton collisions
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
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Addendum to: Centrality dependence of high-pT D-meson suppression in Pb-Pb collisions at $\sqrt{s_{NN}}=2.76$ TeV
Adam, J. et al. [Alice collaboration]
IGFAE authors: Armesto, N.; Ferreiro, E.G.; Salgado, C.A.; Pajares, C.
JHEP, 6, 032
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Flow Dominance and Factorization of Transverse Momentum Correlations in Pb-Pb Collisions at the LHC
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
RL2
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Measurement of azimuthal correlations of D mesons with charged particles in pp collisions at $\sqrt{s}=7$ TeV and p–Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
RL2
DOI: 10.1140/epjc/s10052-017-4779-8

W and Z boson production in p-Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
JHEP, 2, 77
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DOI: 10.1007/JHEP02(2017)077

Determination of the event collision time with the ALICE detector at the LHC
Adam, J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
Charged-particle multiplicities in proton–proton collisions at √s=0.9 to 8 TeV
Adam,J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.

Centrality dependence of the pseudorapidity density distribution for charged particles in Pb–Pb collisions at sNN=5.02 TeV
Adam,J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.

Measurement of the production of high-pT electrons from heavy-flavour hadron decays in Pb–Pb collisions at sNN=2.76 TeV
Adam,J. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
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ϕ-Meson production at forward rapidity in p–Pb collisions at sNN=5.02 TeV and in pp collisions at s=2.76 TeV
Adam,J. et al. [Alice collaboration]
IGFAE authors: Armesto, N.; Ferreiro, E.G.; Salgado, C.A.; Pajares, C.
Phys. Lett. B, 768, 203
**J/ψ suppression at forward rapidity in Pb–Pb collisions at sNN=5.02\text{GeV}**
Adam.J. et al.  [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
*Phys. Lett. B*, 766, 212
RL2
DOI: 10.1016/j.physletb.2016.12.064

**A facility for pion-induced nuclear reaction studies with HADES**
Adamczewski-Musch.J. et al.  [HADES collaboration]
IGFAE authors: Garzon, J.A.
RL6
DOI: 10.1140/epja/i2017-12365-7

**Analysis of the exclusive final state npe+e- in the quasi-free np reaction**
Adamczewski-Musch.J. et al.  [HADES collaboration]
IGFAE authors: Garzon, J.A.
RL6
DOI: 10.1140/epja/i2017-12341-3

**Δ°(1232) Dalitz decay in proton-proton collisions at T=1.25 GeV measured with HADES at GSI**
Adamczewski-Musch.J. et al.  [HADES collaboration]
IGFAE authors: Garzon, J.A.
*Phys. Rev. C*, 95, 065205
RL6
DOI: 10.1103/PhysRevC.95.065205

**Inclusive Λ production in proton-proton collisions at 3.5 GeV**
Adamczewski-Musch.J. et al.  [HADES collaboration]
IGFAE authors: Garzon, J.A.
*Phys. Rev. C*, 95, 015207
RL6
Azimuthally Differential Pion Femtoscopy in Pb-Pb Collisions at sNN = 2.76 TeV
Adamová, D. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
RL2
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Production of $\Sigma(1385)$± and $\Xi(1530)$ 0 in p–Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV
Adamová, D. et al. [Alice collaboration]
IGFAE authors: Ferreiro, E.G.
RL2
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Measurement of the $\pi k$ atom lifetime and the $\pi k$ scattering length
Afanasyev, L. et al. [DIRAC collaboration]
IGFAE authors: Romero Vidal, A.; Adeva, B.; Saborido, J.; Plo, M.
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Search for High-energy Neutrinos from Binary Neutron Star Merger GW170817 with ANTARES, IceCube, and the Pierre Auger Observatory
Albert, A. et al. [Antares, Auger, IceCube, Ligo and Virgo collaboration]
RL4, RL2, RL1
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Quark correlations in the color glass condensate: Pauli blocking and the ridge
Altinoluk T., Armesto N., Beuf G., Kovner A., Lublinsky M.
IGFAE authors: Armesto, N.
A holographic perspective on phonons and pseudo-phonons
Amoretti A., Areán D., Argurio R., Musso D., Zayas L.A.P.
IGFAE authors: Musso, D
_JHEP_, 5, 51

DOI: 10.1007/JHEP05(2017)051

Extracting $q^*$ from single inclusive data at RHIC and at the LHC for different centralities: a new puzzle?
Andrés C., Armesto N., Luzum M., Salgado C.A., Zurita P.
IGFAE authors: Armesto, N.; Salgado, C.A.

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Extracting $q^*$ in event-by-event hydrodynamics and the centrality/energy puzzle
Andres C., Armesto N., Niemi H., Paatelainen R., Salgado C.A., Zurita P.
IGFAE authors: Paatelainen, R.; Armesto, N.; Salgado, C.A.
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Energy loss as the origin of a universal scaling law of the elliptic flow
Andrés C., Braun M., Pajares C.
IGFAE authors: Pajares, C.

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Factorization of in-medium parton branching beyond the eikonal approximation
Apolinário L., Armesto N., Milhano J.G., Salgado C.A.  
IGFAE authors: Armesto, N.; Salgado, C.A.  

**Giant magnons of string theory in the lambda background**
Appadu C., Hollowood T.J., Miramontes J.L., Price D., Schmidtt D.M.  
IGFAE authors: Miramontes, J.L.  
*JHEP*, 7, 98

**Production of $\phi$ Mesons on Nuclear Targets in the Quark–Gluon String Model**
Arakelyan G.H., Merino C., Shabelski Y.M.  
IGFAE authors: Merino, C.  
*Phys. At. Nucl.*, 80, 1198

**Inelastic nuclear screening for different secondaries produced in p+Pb collisions at LHC energy**
Arakelyan G.H., Merino C., Shabelski Yu.M., Shuvaev A.  
IGFAE authors: Merino, C.  
*Phys. Rev. D*, 95, 074013

**Performance of resistive plate chambers under irradiation of 136Xe at relativistic energies**
Ayyad Y., Benlliure J., Casarejos E., Duran I., Paradela C.  
IGFAE authors: Benlliure, J.; Duran, I.  
DOI: 10.1016/j.nima.2017.06.014

**Likelihood analysis of the minimal AMSB model**
Bagnaschi, E. et al.
IGFAE authors: Santos, D.M.; Borsato, M.; Chobanova, V.; Lucio Martinez, M.
**RL1**
DOI: 10.1140/epjc/s10052-017-4810-0

**Likelihood analysis of supersymmetric SU(5) GUTs**
Bagnaschi, E. et al.
IGFAE authors: Santos, D.M.; Borsato, M.; Chobanova, V.; Lucio Martinez, M.
**RL1**
DOI: 10.1140/epjc/s10052-017-4639-6

**Spallation-induced fission reactions**
Benlliure, J., Rodriguez-Sánchez, J.L.
IGFAE authors: Benlliure, J.; Rodriguez-Sanchez, J.L.
**RL6, RL7**
DOI: 10.1140/epjp/i2017-11377-0

**Knockout and fragmentation reactions using a broad range of tin isotopes**
Bertulani, C.A. et al.
IGFAE authors: Benlliure, J.; Cortina-Gil, D.; Rodriguez-Sanchez, J.L.; Caamano, M.; Alvarez, H.; Díaz Cortés, J
*Phys. Rev. C*, 96, 034303
**RL6, RL7**
DOI: 10.1103/PhysRevC.96.034303

**Delayed collapses of Bose-Einstein condensates in relation to anti-de Sitter gravity**
Biasi, A.F., Mas, J., Paredes, A.
IGFAE authors: Mas, J.
Energy balance and deformation at scission in 240Pu fission
Caamaño M., Farget F.
IGFAE authors: Caamaño, M.
Phys. Lett. B, 770, 72

β-decay half-lives and β-delayed neutron emission probabilities for several isotopes of Au, Hg, Tl, Pb, and Bi, beyond N=126
Caballero-Folch, R. et al.
IGFAE authors: Benlliure, J.
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Adiabatic pumping solutions in global AdS
Carracedo P., Mas J., Musso D., Serantes A.
IGFAE authors: Mas, J.; Musso, D
JHEP, 5, 141

Probing jet decoherence in heavy ion collisions
Casalderrey-Solana J., Mehtar-Tani Y., Salgado C.A., Tywoniuk K.
IGFAE authors: Salgado, C.A.
Nucl. Phys. A, 967, 564

Radiopurity assessment of the energy readout for the NEXT double beta decay experiment
Cebrián, S. et al. [NEXT collaboration]
IGFAE authors: Hernando Morata, J.A.; Palmeiro Pazos, B.; Martinez-Lema, G.; Gonzalez, D.
*J. Instrum.*, 12, T08003

**RL6, RL5**
DOI: 10.1088/1748-0221/12/08/T08003

**Ground-state configuration of neutron-rich Al 35 via Coulomb breakup**
Chakraborty, S. et al.
IGFAE authors: Cortina-Gil, D.; Gonzalez, D.
*Phys. Rev. C*, 96, 034301

**RL6, RL7, RL5**
DOI: 10.1103/PhysRevC.96.034301

**Large hadronic power corrections or new physics in the rare decay B → K⁺·μ⁻·μ⁻?**
Chobanova, V.G., Hurth, T., Mahmoudi, F., Santos, D.M., Neshatpour, S.
IGFAE authors: Santos, D.M.
*JHEP*, 7, 25

**RL1**
DOI: 10.1007/JHEP07(2017)025

**D3–D5 theories with unquenched flavors**
Conde, E., Lin, H., Penín, J.M., Ramallo, A.V., Zoakos, D.
IGFAE authors: Ramallo, A.V.
*Nucl. Phys. B*, 914, 599

**RL3**
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**Physics with ions at the Future Circular Collider**
d’Enterria, D. et al.
IGFAE authors: Armesto, N.; Salgado, C.A.
*Nucl. Phys. A*, 967, 888

**RL2**
Causality in 3D massive gravity theories
Edelstein J.D., Giribet G., Gómez C., Kiliaris E., Leoni M., Tekin B.
IGFAE authors: Edelstein, J.D.
Phys. Rev. D, 95, 104016
RL3
DOI: 10.1103/PhysRevD.95.104016

EPPS16: nuclear parton distributions with LHC data
Eskola K.J., Paakkinen P., Paukkunen H., Salgado C.A.
IGFAE authors: Paukkunen, H.; Salgado, C.A.
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DOI: 10.1140/epjc/s10052-017-4725-9

First inverse-kinematics fission measurements in a gaseous active target
Farget, F. et al.
IGFAE authors: Alvarez, H.
Nucl. Phys. A, 958, 246
RL6
DOI: 10.1016/j.nuclphysa.2016.12.003

Development of a silicon bulk radiation damage model for Sentaurus TCAD
Folkestad, Å. et al. [LHCb collaboration]
IGFAE authors: Vieites Diaz, M.; Garcia Pardinas, J.
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DOI: 10.1016/j.nima.2017.08.042

High precision measurement of the Ne 19 β-decay half-life using real-time digital acquisition
Fontbonne, C. et al.
IGFAE authors: Ramos, D.
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**Spectroscopy of Fe 61 via the neutron transfer reaction H 2 (Fe 60,p) Fe * 61**
Giron,S. et al.
IGFAE authors: Fernandez-Dominguez, B.
*Phys. Rev. C*, 95, 035806

**Determination of the neutron-capture rate of C 17 for r-process nucleosynthesis**
Heine,M. et al.
IGFAE authors: Benlliure, J.; Cortina-Gil, D.; Caamano, M.; Alvarez, H.; Gonzalez, D.
*Phys. Rev. C*, 95, 014613

**Neutron-skin effect in direct-photon and charged-hadron production in Pb+Pb collisions at the LHC**
Helenius I., Paukkunen H., Eskola K.J.
IGFAE authors: Paukkunen, H.

**Secondary scintillation yield of xenon with sub-percent levels of CO2 additive for rare-event detection**
Henriques,C.A.O. et al. [NEXT collaboration]
IGFAE authors: Hernando Morata, J.A.; Palmeiro Pazos,B; Martinez-Lema, G.;
Gonzalez, D.
*Phys. Lett. B*, 773, 663

**Lepton nonuniversality in exclusive b →sℓℓ decays**
Hurth T., Mahmoudi F., Martinez Santos D., Neshatpour S.
IGFAE authors: Santos, D.M.
*Phys. Rev. D*, 96, 095034
**RL1**
DOI: 10.1103/PhysRevD.96.095034

*Non-relativistic anyons from holography*
Jokela N., Jõrveli õ, Ramallo A.V.
IGFAE authors: Ramallo, A.V.
*Nucl. Phys. B*, 916, 727
**RL3**
DOI: 10.1016/j.nuclphysb.2017.01.014

*The impact of the intruder orbitals on the structure of neutron-rich Ag isotopes*
Kim Y.H., Biswas S., Rejmund M., Navin A., Lemasson A., Bhattacharyya S., Caamaño M., Clément E., de France G., Jacquot B.
IGFAE authors: Caamaño, M.
*Phys. Lett. B*, 772, 403
**RL6**
DOI: 10.1016/j.physletb.2017.06.058

*The one loop gluon emission light cone wave function*
Lappi T., Paatelainen R.
IGFAE authors: Paatelainen, R.
*Ann. Phys.*, 379, 34
**RL2**
DOI: 10.1016/j.aop.2017.02.002

*Unveiling saturation effects from nuclear structure function measurements at the EIC*
Marquet C., Moldes M.R., Zurita P.
IGFAE authors: Rodríguez Moldes, M
*Phys. Lett. B*, 772, 607
**RL2**
Neutron spectroscopy of 26Mg states: Constraining the stellar neutron source 
$^{22}\text{Ne}(\alpha,n)^{25}\text{Mg}$
Massimi, C. et al. [n_TOF collaboration]
IGFAE authors: Duran, I.
Phys. Lett. B, 768, 1
RL6
DOI: 10.1016/j.physletb.2017.02.025

Neutron capture cross section measurement of U 238 at the CERN n-TOF facility in the energy region from 1 eV to 700 keV
Mingrone, F. et al. [n_TOF collaboration]
IGFAE authors: Duran, I.
Phys. Rev. C, 95, 034604
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Can transition radiation explain the ANITA event 3985267?
Motloch P., Alvarez-Muñiz J., Privitera P., Zas E.
IGFAE authors: Alvarez-Muniz, J.; Zas, E.
Phys. Rev. D, 95, 043004
RL4
DOI: 10.1103/PhysRevD.95.043004

Medium-induced gluon radiation in hard forward parton scattering in the saturation formalism
Munier S., Peigné S., Petreska E.
IGFAE authors: Petreska, E.
Phys. Rev. D, 95, 014014
RL2
DOI: 10.1103/PhysRevD.95.014014

Evolution of triaxial shapes at large isospin: Rh isotopes
Navin, A. et al.
IGFAE authors: Caamano, M.
*Phys. Lett. B*, 767, 480
**RL6**
DOI: 10.1016/j.physletb.2016.11.020

**Applicability of pion–nucleus Drell–Yan data in global analysis of nuclear parton distribution functions**

Paakkinen P., Eskola K.J., Paukkunen H.
IGFAE authors: Paukkunen, H.
*Phys. Lett. B*, 768, 7
**RL2**
DOI: 10.1016/j.physletb.2017.02.009

**Status of nuclear PDFs after the first LHC p–Pb run**

Paukkunen H.
IGFAE authors: Paukkunen, H.
*Nucl. Phys. A*, 967, 241
**RL2**
DOI: 10.1016/j.nuclphysa.2017.05.014

**Accurate isotopic fission yields of electromagnetically induced fission of U 238 measured in inverse kinematics at relativistic energies**

Pellereau, E. et al.
IGFAE authors: Benlliure, J.; Cortina-Gil, D.; Rodriguez-Sanchez, J.L.; Fernandez-Dominguez, B.; Caamano, M.; Alvarez, H.
*Phys. Rev. C*, 95, 054603
**RL6, RL7**
DOI: 10.1103/PhysRevC.95.054603

**Coulomb breakup of neutron-rich 29,30Na isotopes near the island of inversion**

Rahaman, A. et al.
IGFAE authors: Cortina-Gil, D.; Gonzalez, D.
*J. Phys. G*, 44, 045101
**RL6, RL7, RL5**
Background rejection in NEXT using deep neural networks
Renner,J. et al. [NEXT collaboration]
IGFAE authors: Hernando Morata, J.A.; Palmeiro Pazos,B
J. Instrum., 12, T01004
RL5
DOI: 10.1088/1748-0221/12/01/T01004

High-accuracy determination of the neutron flux in the new experimental area n_TOF-EAR2 at CERN
Sabate-Gilarte,M. et al. [n_TOF collaboration]
IGFAE authors: Duran, I.; Ferreiro, E.G.; Fernandez-Dominguez, B.; Caamano, M.
RL6, RL2
DOI: 10.1140/epja/i2017-12392-4

Application and performance of an ML-EM algorithm in NEXT
Simón,A. et al. [NEXT collaboration]
IGFAE authors: Hernando Morata, J.A.; Palmeiro Pazos,B; Martinez-Lema, G.; Gonzalez, D.
J. Instrum., 12, P08009
RL5,RL6
DOI: 10.1088/1748-0221/12/08/P08009

Isotopic production cross sections of residual nuclei in the spallation reaction Xe 136 (200A MeV) + p
Tassan-Got,L. et al.
IGFAE authors: Benlliure, J.; Rodriguez-Sanchez, J.L.; Fernandez-Dominguez, B.
Phys. Rev. C, 95, 044606
RL6, RL7
DOI: 10.1103/PhysRevC.95.044606
Heavy-Ion Physics at a Fixed-Target Experiment Using the LHC Proton and Lead Beams (AFTER@LHC): Feasibility Studies for Quarkonium and Drell–Yan Production
Trzeciak B., Da Silva C., Ferreiro E.G., Hadjidakis C., Kikola D., Lansberg J.P., Massacrier L., Seixas J., Uras A., Yang Z.
IGFAE authors: Ferreiro, E.G.
Few-Body Syst., 58, 148
RL2
DOI: 10.1007/s00601-017-1308-0

Effective proton-neutron interaction near the drip line from unbound states in F
Vandebrouck,M. et al. [R3B collaboration]
IGFAE authors: Benlliure, J.; Cortina-Gil, D.; Caamano, M.; Alvarez, H.; Boillos Betete, J
Phys. Rev. C, 96, 054305
RL6, RL7
DOI: 10.1103/PhysRevC.96.054305

Measurement of the U 238 (n,γ) cross section up to 80 keV with the Total Absorption Calorimeter at the CERN n-TOF facility
Wright,T. et al. [n_TOF collaboration]
IGFAE authors: Duran, I.
Phys. Rev. C, 96, 064601
RL6
DOI: 10.1103/PhysRevC.96.064601
Annual Report 2017

New projects

IGFAE Executive Board
14 December 2018
**Apoyo a Unidades de Excelencia María de Maeztu**
Carlos Alberto Salgado López
7/1/2017 - 6/30/2021
MICINN
MDM-2016-0692
2,000,000 euros

**Consolidación e estruturación de unidades de investigación competitivas (Grupos de referencia competitiva)**
José Fernando Benlliure Anaya
1/1/2017 - 11/30/2020
CONSELLERÍA DE EDUCACIÓN E ORDENACIÓN UNIVERSITARIA
ED431C 2017/54
400,000 euros

**Consolidación e estruturación de unidades de investigación competitivas (Grupos de referencia competitiva)**
José Luis Miramontes Antas
1/1/2017 - 11/30/2020
CONSELDERÍA DE EDUCACIÓN E ORDENACIÓN UNIVERSITARIA
ED431C 2017/07
400,000 euros

**Consolidación e estruturación de unidades de investigación competitivas (Proxectos de persoal investigador con traxectoria excelente)**
Carlos Alberto Salgado López
1/1/2017 - 11/30/2020
CONSELLERÍA DE EDUCACIÓN E ORDENACIÓN UNIVERSITARIA
ED431F 2017/01
200,000 euros

**QCD a alta temperatura y densidad desde escalas pequeñas a grandes**
Elena González Ferreiro, Carlos Alberto Salgado López
Annual Report 2017. New projects

1/1/2018 - 12/31/2019
MINECO - Plan Estatal (2013-2016)
FPA2017-83814-P
145,200 euros

Análisis de las partículas más energéticas de la naturaleza: el observatorio Pierre Auger
Jaime Álvarez Muñiz, Enrique Zas Arregui
1/1/2018 - 12/31/2019
MINECO - Plan Estatal (2013-2016)
FPA2017-85114-P
145,200 euros

Búsqueda de nueva física con experimento mejorado LHCb del CERN
Abraham Antonio Gallas Torreira, Pablo Vázquez Regueiro
1/1/2018 - 12/31/2019
MINECO - Plan Estatal (2013-2016)
FPA2017-89204-C2-1-P
931,700 euros

Búsqueda de nueva física con experimento mejorado LHCb del CERN
Diego Martínez Santos, Veronika Chobanova
1/1/2018 - 12/31/2019
MINECO - Plan Estatal (2013-2016)
FPA2017-89204-C2-2-P
133,100 euros

Holografía, gravitación y teorías gauge
Javier Mas Solé, José Luis Miramontes Antas
1/1/2018 - 12/31/2019
MINECO - Plan Estatal (2013-2016)
FPA2017-84436-P
48,400 euros
Hot and dense QCD in the LHC era (Hot LHC)
Carlos Alberto Salgado López
1/1/2012 - 12/31/2017
European Commission - VII PM - Ideas
279579
1,379,376 euros

Solving Challenges in Nuclear Data (CHANDA)
José Fernando Benlliure Anaya
12/1/2013 - 11/30/2017
European Commission - VII PM - Capacidades
605203
97,000 euros

Collaboration for high-energy physics and astrophysics on the basis of unique scientific facility NEVOD
Juan Antonio Garzón Heydt
1/1/2014 - 12/31/2017
National Research Nuclear University MEPHI

Challenging the Standard Model using an extended Physics program in LHCb (BSMFLEET)
Diego Martínez Santos
1/4/2015 - 3/31/2020
European Commission - Horizon 2020
ERC-2014-STG-639068
1,499,855 euros
**Hard Probes of Hot and Dense QCD Matter (HppQCD)**

Carlos Alberto Salgado López  
1/7/2015 - 8/31/2017  
European Commission - Horizon 2020  
660952  
158,122 euros

**European Nuclear Science and Application Research 2 (ENSAR2)**

Héctor Álvarez Pol  
3/1/2016 - 2/29/2020  
European Commission - Horizon 2020  
654002  
105,500 euros

**Desafíos presentes y futuros del experimento LHCb del CERN. - RETOS 2014**

Abraham Antonio Gallas Torreira  
1/1/2015 - 12/31/2017  
MINECO - Plan Estatal (2013-2016)  
FPA2014-57896-C4-1-R  
885,720 euros

**Calibración y reconstrucción de NEXT. - RETOS 2014**

José Angel Hernando Morata  
1/1/2015 - 12/31/2018  
MINECO - Plan Estatal (2013-2016)  
FIS2014-53371-C4-2-R  
100,430 euros
Holografía e Integrabilidad en Teorías Cuánticas de Campos y Cuerdas. - EXCELENCIA 2014
Javier Mas Solé
1/1/2015 - 12/31/2018
MINECO - Plan Estatal (2013-2016)
FPA2014-52218-P
160,930 euros

Interacciones fundamentales en condiciones extremas. - EXCELENCIA 2014
Nestor Armesto Pérez, Carlos Alberto Salgado López
1/1/2015 - 12/31/2017
MINECO - Plan Estatal (2013-2016)
FPA2014-58293-C2-1-P
243,210 euros

Sistema de Tomografía Industrial de Muones y Radiografía Multivariable de rayos cósmicos para la Detección de Trafico Ilegal de Material Radioactivo Especial (MACROESCANER2015). Feder-Innterconecta 2015
Juan Antonio Garzón Heydt
2/1/2016 - 1/1/2018
Digafer, S.A.
154,880 euros

Agrupacións estratéxicas 2015 - AEFIS
Carlos Alberto Salgado López
9/8/2015 - 12/31/2017
Consellería de Cultura, Educación e Ordenación Universitaria
AGRUP2015/11
500,000 euros

**Búsqueda de nueva física en asimetrías con violación CP en LHCb - EXCELENCIA 2015**
Bernardo Adeva Andany
1/1/2016 - 12/31/2017
MINECO - Plan Estatal (2013-2016)
FPA2015-67133-P
37,500 euros

**Desafiando al Modelo Estandar con un nuevo programa de física en LHCb. - EXCELENCIA 2015**
Diego Martínez Santos
1/1/2016 - 12/31/2017
MINECO - Plan Estatal (2013-2016)
FPA2015-70479-P
45,375 euros

**Contribución al programa científico de investigación nuclear a baja energía de excitación en instalaciones europeas tipo TOF e ISOL 2016. - EXCELENCIA 2015**
Ignacio Durán Escribano
1/1/2016 - 12/31/2018
MINECO - Plan Estatal (2013-2016)
FPA2015-71690-P
130,438 euros
**Experimento R3B del día cero en el GSI y contribución a la construcción del Demostrador de CALIFA. - EXCELENCIA 2015**

Dolores Cortina Gil  
1/1/2016 - 12/31/2018  
MINECO - Plan Estatal (2013-2016)  
FPA2015-69640-C2-1-P  
242,000 euros

**Participación en el Observatorio Pierre Auger: AugerPrime. - RETOS 2015**

Enrique Zas Arregui  
1/1/2016 - 12/31/2017  
MINECO - Plan Estatal (2013-2016)  
FPA2015-70420-C2-1-R  
278,300 euros

**Proyecto para la investigación, desarrollo y validación de un sistema que, mediante el uso de blancos primarios y secundarios, genere radiofármacos por aceleración láser. - RETOS COLABORACIÓN 2015**

José Fernando Benlliure Anaya  
6/1/2015 - 12/31/2018  
MINECO - Plan Estatal (2013-2016)  
RTC-2015-3278-1  
218,042 euros

**Desenvolvemento de novas tecnoloxías para a prevención de radón (TECRA) Conecta Peme 2016**

Dolores Cortina Gil  
10/18/2016 - 3/17/2019  
ATI Sistemas SL  
72,981 euros
Desenvolvemento de novas tecnoloxías para a prevención de radón (TECRA)
Conecta Peme 2016
Dolores Cortina Gil
10/18/2016 - 6/17/2019
Padreiro SL
37,441 euros

Desenvolvemento de novas tecnoloxías para a prevención de radón (TECRA)
Conecta Peme 2016
José Fernando Benlliure Anaya
10/18/2016 - 6/17/2019
Galaicontrol SL
44,403 euros

Desenvolvemento de novas tecnoloxías para a prevención de radón (TECRA)
Conecta Peme 2016
José Fernando Benlliure Anaya
10/18/2016 - 6/17/2019
ARRAELA, S.L.
55,504 euros

Axuda complementaria aos contratos postdoutorais da modalidade B 2016
Antonio Romero Vidal
7/31/2016 - 7/30/2018
Consellería de Cultura, Educación e Ordenación Universitaria
POS-B/2016/009
20,000 euros
Axuda complementaria aos contratos postdoutorais da modalidade B 2016
Pablo Cabanelas Eiras
7/31/2016 - 7/30/2018
Consellería de Cultura, Educación e Ordenación Universitaria
POS-B/2016/015
20,000 euros

Búsqueda de nueva física en el detector LHCb del CERN siguiendo las aproximaciones directa e indirecta
Xabier Cid Vidal
1/1/2016 - 12/31/2017
Ministerio de Economía, industria y Competitividad
IJCI-2014-21751
6,000 euros

Desarrollo de un sistema de control automático de la concentración de radón en edificios. RETOS-COLABORACIÓN 2016
Dolores Cortina Gil
3/7/2016 - 12/31/2019
AEI - Agencia Estatal de Investigación
RTC-2016-5627-1
127,751 euros

Medida de rayos cósmicos con un detector tipo Trasgo en la base antártica española. EXCELENCIA 2016
Juan Antonio Garzón Heydt
12/30/2016 - 12/29/2019
AEI - Agencia Estatal de Investigación
CTM2016-77325-C2-2-P

35,090 euros
Bayesian analysis of the mass composition of Ultra-high Energy Cosmic Rays
Guillermo Torralba Elipe
11/2/2017
Director: Enrique Zas Arregui

On gravitational Phase Transitions, T-duality and Symmetry Breaking in AdS-CFT
Jesús Aníbal Sierra García
9/8/2017
Director: José Daniel Edelstein Glaubach

Holographic Thermalization in Finite-Size Systems
Alexandre Serantes Rubianes
5/30/2017
Director: Javier Mas Solé

Study of the decays B0(s) -> Kst Kstb and first observation of the Bs -> Phi Kstb decay at the LHCb experiment
Brais Sanmartín Sedes
12/18/2017
Director: Bernardo Adeva Andany, Cibrán Santamarina Ríos

Neutron-induced fission fragment angular distribution and cross section of uranium targets at CERN-n_TOF
Esther Leal Cidoncha
5/22/2017
Director: Ignacio Durán Escribano

Measurement of the inelastic pp cross-sections using the LHCb experiment and development of a new vertex detector
Álvaro Dosil Suárez
5/5/2017
Director: Abraham Antonio Gallas Torreira

Phenomenological studies of initial state effects and jet quenching in High-Energy Nuclear Collisions at LHC
Carlota Andrés Casas
10/25/2017
Director: Carlos Pajares Vales, Carlos Alberto Salgado López