ANNUAL REPORT 2017

INSTITUTO DE FÍSICA CORPUSCULAR

Centre of Excellence Severo Ochoa

IFIC INSTITUT DE FÍSICA CORPUSCULAR

EXCELENCIA SEVERO OCHOA

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

VNIVERSITAT DE VALÈNCIA

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PROF. JUAN JOSÉ HERNÁNDEZ REY
Director of IFIC

WELCOME

Welcome to IFIC's 2017 Annual Report. You will find in this report a summary of the wide range of activities carried out during 2017 in our institute. Even though it is not possible to summarise in a few lines all the results and achievements of our research groups during 2017, I would like to give you a few highlights.

IFIC groups work in three experiments at the Large Hadron Collider, ATLAS, LHCb and MoEDAL. As you can see in this report, there is a wide variety of topics on which our scientists investigate, among others, the Higgs boson, the top quark, the Wtb vertex, search for new physics in supersymmetry and in FCNC processes, monopoles, etc. In addition to their contribution to the smooth operation of the present detectors, IFIC's groups are also working in the upgrading of these detectors, in particular related to the TileCal (hadronic calorimeter) and ITk (inner tracker) of ATLAS and to the SciFi (scintillating fibre detector) of LHCb. These activities will require gradually more resources in the future (the LHCb upgrade, though, will have to be ready much earlier, for Run 3). The groups working on the future colliders (ILC, CLIC) are engaged in the in-depth study of the possibilities that these projects could provide, in particular related to the top quark.

It is also a feature of the groups working in astroparticle and neutrino physics to be looking forward to the future facilities. In this sense, the astroparticle physics group, while taking full advantage of the data provided by the ANTARES neutrino telescope, is devoting a great deal of effort to the KM3NeT project, which has been featured this year in the 2017-2026 European Strategy of APPEC. Likewise, the group working in long-baseline neutrino experiments is not only analysing the data provided by the T2K experiment in which they participate, but also contributing to the DUNE project, which will start running in the next decade. The NEXT project is making excellent progress and the data taken by the NEW experiment is paving the way to the NEXT-100 phase, which may be operating by as early as 2020.

The groups working in experimental nuclear physics have a large variety of research activities taking place in different facilities such as RIKEN in Japan, the IGISOL IV facility of the University of Jyväskylä in Finland and HYMNS in nTOF at CERN. Likewise, the AGATA group is strongly involved in the AGATA detector for the FAIR facility. It is worth mentioning the R+D+i project between IFIC and ENRESA to develop a gamma camera to help in the dismantling of nuclear power plants.

The activities of the Grid and E-Science group are too numerous to name here. Let us just mention that they are presently tackling the problems associated to the enormous increase in computing resources that the High Luminosity LHC (HL-LHC) will require. This was in fact one of the issues which were discussed during the ATLAS Computing & Software Week that took place in Valencia this year hosted by the Grid group.

The group in medical physics is making good progress in their Compton telescope for hadron therapy treatment monitoring: with a new version of their prototype, they have improved the imaging capabilities of this technique. Finally, let us mention that the RF Laboratory, which will be a future test bench for RF cavities, is progressing quite well.

The research done by IFIC's theoretical groups cover a wide range of aspects in particle physics phenomenology. A thorough comparison of the SM predictions to the data at our disposal is an integral part of the quest for New Physics. Flavour physics, both in the quark and the lepton sectors, is an extraordinary ground to look for new phenomena or develop possible extensions of the SM.

Several theoretical groups devote their research to the fascinating area of hadronic interactions and

QCD. The long list of studies in these areas includes the investigation of the flavour violating processes involving kaons; new relations for scattering amplitudes at one-loop level obtained from the interplay of colour-kinematics duality (CKD) and LTD; the nontrivial dynamics in the weak non-leptonic and semi-leptonic decays of several hadrons with charm and beauty, often leading to dynamically generated states and several other studies described in more detail in this report.

Among the research performed by the group working on gravitation, it is worth mentioning the study of the effect that curved spacetime has on the electric-magnetic symmetry: the net polarization of the quantum electromagnetic field is not conserved in curved spacetimes.

Our theorists also investigate the neutrino sector, making global fits to identify possible deviations from the present common wisdom and extracting the best possible values of the mixing parameters. The search for hints of sterile neutrinos makes part of their research. Likewise, using CMB and BAO data they are able to provide very competitive bounds for the sum of the masses of the three active neutrinos.

A total of 440 articles in indexed journals in 2017 have been authored or co-authored by IFIC's researchers, 92% of which were published first-quartile journals. Our scientists have made 350 contributions to national and international conferences, out of which 333 were talks (82 invited) and 17 posters. A total of 22 PhD theses and 17 Master final projects have been defended.

IFIC has a lively scientific program that in 2017 included 17 "Severo Ochoa Colloquia" by world-wide reputed experts and 94 seminars covering an ample scope of topics. Likewise, several national and international conferences held in Valencia and elsewhere were organised by our scientists

Eleven students were trained at IFIC in technical areas such as Electronic Engineering or Industrial Engineering during 2017, through a fruitful collaboration with ADEIT, the University–Business Foundation of the University of Valencia. Moreover, five young technicians under 25 have worked at IFIC in 2017 within the 'Garantia Juvenil' programme.

The Scientific Advisory Committee of IFIC met in July 2017. They gave a very positive report on the running of the institute and at the same time letting us know those areas in which we could improve. Likewise, the Monitoring Committee of the Severo Ochoa project gave a positive assessment in their midterm review report.

In 2017 the Agència Valenciana de la Innovació (AVI, Valencia Innovation Agency) decided to fund the setting up of an UCIE (Scientific Unit for Entrepreneurial Innovation) at IFIC. This is very good news for the institute, not only because it is a recognition of the effort that IFIC is doing since some time in innovation and transfer, but also because it allows to foresee a sound structuring of IFIC's activities on this area. An UV-AVI agreement was worked out during 2017 and finally signed in 2018 by the parties. We are exceedingly enthusiastic about the future prospects of IFIC's UCIE that will clearly boost our endeavours in innovation and transfer.

IFIC is making a special effort in communication and outreach. Our portfolio in these areas is very rich in activities. 28 schools visited IFIC from all over Comunitat Valenciana and we hosted more than 900 visitors in 2017. Two particle physics international masterclasses were organised in coordination with CERN, which gathered 147 students and 55 teachers from 56 different high schools. IFIC offered a 30-hour programme to improve the training of school teachers in particle physics and cosmology and to discuss how to translate that knowledge into the classrooms. In 2017 our web site was redesigned, offering news about IFIC or related subjects on almost a weekly basis. News related with IFIC were reported in different media and we participated in a plethora of outreach activities organised by IFIC or together with other institutions.

All in all, 2017 was a very rewarding year for IFIC and the work and effort put by our personnel bore clear fruit. I modestly think we should be proud of our achievements.

PROF. JUAN JOSÉ HERNÁNDEZ REY

BIENVENIDA

Bienvenidos a la Memoria Anual de 2017 del IFIC. En este documento encontrarán un resumen de la amplia variedad de actividades llevadas a cabo en nuestro instituto durante 2017. Aunque es imposible resumir en unas pocas líneas todos los resultados y logros de nuestros grupos de investigación, me gustaría darles algunos titulares.

Los grupos del IFIC participan en tres experimentos del Gran Colisionador de Hadrones: ATLAS, LHCb y MoEDAL. Como pueden ver en este informe, hay una amplia variedad de temas en los que investigan nuestro personal científico, entre otros el bosón de Higgs, el quark top, el vértice Wtb, búsquedas de nueva física en supersimetría y procesos FCNC, monopolos, etc. Además de su contribución al buen funcionamiento de los detectores actuales, los grupos del IFIC trabajan también en la mejora de los mismos, en concreto en el calorímetro hadrónico (TileCal) y en el detector de trazas interno (ITk) de ATLAS y en el detector de fibras centelleadoras (SciFi) de LHCb. Estas actividades requerirán cada vez más recursos en el futuro (aunque la mejora de LHCb tendrá que estar lista mucho antes, para el Run 3). Los grupos que trabajan en futuros aceleradores (ILC, CLIC) están involucrados en el estudio en profundidad de las posibilidades que estos proyectos pueden proporcionar, en concreto las relacionadas con el estudio del quark top.

Es también una característica de los grupos que trabajan en astropartículas y física de neutrinos mirar a los experimentos del futuro. En este sentido, mientras saca todo el partido de los datos proporcionados por el telescopio de neutrinos ANTARES, el grupo de física de astropartículas dedica un gran esfuerzo al proyecto KM3NeT, que fue incluido ese año en la Estrategia Europea de la APPEC. Asimismo, el grupo implicado en experimentos de haces de neutrinos no solo analiza los datos del experimento T2K en el que participan, sino que también contribuyen al proyecto DUNE, que comenzará a funcionar la próxima década. El proyecto NEXT está haciendo excelentes progresos, y los datos tomados por el experimento NEW facilitan la siguiente fase NEXT-100, que podría comenzar a funcionar en 2020.

Los grupos de física nuclear experimental desarrollan una gran variedad de actividades investigadoras que tienen lugar en instalaciones diversas como RIKEN en Japón, IGISOL IV en la Universidad de Jyväskylä (Finlandia) e HYMNS en nTOF (CERN). Igualmente, el grupo de AGATA está muy involucrado en el detector AGATA para el laboratorio FAIR. Cabe destacar también el proyecto de I+D+i entre el IFIC y ENRESA para desarrollar una cámara gamma que ayude en el proceso de desmantelamiento de centrales nucleares.

Las actividades del grupo de Grid y E-Ciencia son demasiado numerosas para resumirlas aquí. Mencionar que sus miembros abordan los problemas asociados al enorme incremento de los recursos de computación que requerirá el LHC de Alta Luminosidad (HL-LHC). Este fue de hecho uno de los temas que se discutieron en la ATLAS Computing & Software Week, que tuvo lugar en Valencia este año organizada por el grupo de Grid.

El grupo de física médica está realizando grandes progresos en su telescopio Compton para monitorización de terapia hadrónica: una nueva versión de su prototipo ha mejorado las capacidades de obtener imágenes con esta técnica. Finalmente, el Laboratorio RF, que será un futuro banco de pruebas para las cavidades RF, está avanzando muy bien.

La investigación realizada por los grupos teóricos del IFIC cubre un amplio abanico de aspectos en fenomenología de física de partículas. Una meticulosa comparación de las predicciones del Modelo Estándar con los datos disponibles es una parte integral de la búsqueda de Nueva Física. La Física de Sabor, tanto en el sector de quarks como de leptones, es un extraordinario terreno para buscar nuevos fenómenos o desarrollar posibles extensiones del Modelo Estándar.

Varios grupos teóricos dedican sus investigaciones a la fascinante área de interacciones hadrónicas y QCD. La larga lista de estudios en estos campos incluyen la investigación de procesos de violación de sabor que involucran a kaones; nuevas relaciones para amplitudes de la dispersión al nivel one-loop obtenidas a partir de la interacción entre la dualidad color-cinemática (CKD) y LTD; las dinámicas no triviales en las desintegraciones débiles no leptónicas y semi-leptónicas de varios hadrones con quarks charm y beauty, que producen a menudo estados generados dinámicamente; y otros estudios descritos en mayor detalle en esta memoria.

Entre las investigaciones realizadas por el grupo dedicado a la gravedad, cabe destacar el estudio del

efecto que el espacio-tiempo curvado tiene sobre la simetría electromagnética: la polarización del campo cuántico electromagnético no se conserva en espacio-tiempo curvos.

Nuestros teóricos también investigan el sector del neutrino, realizando ajustes globales para identificar posibles desviaciones del conocimiento actual del área y extrayendo los mejores valores posibles de los parámetros de mezcla. La búsqueda de indicios de neutrinos estériles forman parte de su trabajo. Asimismo, usando datos de CMB y BAO son capaces de proporcionar límites muy competitivos para la suma de las masas de los tres neutrinos activos.

En 2017 se publicó un total de 440 artículos en revistas indexadas cuyos autores o co-autores son personal investigador del IFIC, el 92% de los cuales se publicó en revistas del primer cuartil. Nuestros científicos realizaron 350 contribuciones en conferencias nacionales e internacionales, de las cuales 333 fueron charlas (82 invitadas) y 17 pósters. Este año se defendieron 22 tesis doctorales y 17 proyectos fin de máster.

El IFIC tiene un vibrante programa científico que en 2017 incluyó 17 "Coloquios Severo Ochoa" impartidos por reputados expertos internacionales y 94 seminarios que cubrieron un amplio rango de temas. Además, varias conferencias nacionales e internacionales celebradas en Valencia y otras ciudades fueron organizadas por nuestro personal científico.

Once estudiantes se formaron en el IFIC en áreas técnicas como Ingeniería Electrónica o Industrial durante 2017, gracias a una fructífera colaboración con ADEIT, la Fundación Universidad-Empresa de la Universitat de València. Además, cinco técnicos jóvenes menores de 25 años trabajaron en el IFIC durante 2017 dentro del Programa de Garantía Juvenil.

El Comité Científico Asesor del IFIC se reunió en julio de 2017, emitiendo un informe muy positivo del funcionamiento del instituto y a la vez comunicándonos aquellas áreas donde podemos mejorar. De igual forma, el Comité de Seguimiento del proyecto Severo Ochoa emitió una evaluación positiva en su informe de revisión de mitad de proyecto.

En 2017, la Agència Valenciana de la Innovació (AVI) decidió financiar la creación de una Unidad Científica de Innovación Empresarial (UCIE) en el IFIC. Esta es una muy buena noticia para el instituto , no solo porque supone un reconocimiento del esfuerzo que realiza el IFIC desde hace algún tiempo en innovación y transferencia, sino también porque permite prever una estructuración de las actividades del IFIC en este área. El acuerdo UV-AVI se gestó durante 2017 y finalmente se firmó en 2018 por ambas partes. Estamos muy entusiasmados con las perspectivas futuras de la UCIE del IFIC, que supondrá un claro empujón a nuestros esfuerzos en innovación y transferencia.

El IFIC realiza un esfuerzo especial en comunicación y divulgación. Nuestras actividades en estas áreas son muy variadas. 28 colegios e institutos de toda la Comunidad Valenciana visitaron el IFIC, y albergamos más de 900 visitantes en 2017. Se organizaron dos masterclasses internacionales en coordinación con el CERN, que reunieron a 147 alumnos y 55 profesores de 56 institutos. El IFIC ofreció un programa de formación de 30 horas para mejorar los conocimientos sobre física de partículas y cosmología de los profesores, así como para mostrar formas de trasladar ese conocimiento a las aulas. En 2017 se rediseñó nuestra página web, ofreciendo noticias sobre el IFIC o temas relacionados casi diariamente. Noticias relacionadas con el IFIC se publicaron en diversos medios de comunicación, y participamos en una gran cantidad de actividades de divulgación organizadas por el IFIC o junto a otras instituciones.

Con todo esto, 2017 fue un año muy gratificante para el IFIC, y el trabajo y el esfuerzo de nuestro personal dio sus frutos. Creo modestamente que debemos estar orgullosos de nuestros logros.

BENVINGUTS

Benvinguts a la Memòria Anual de 2017 de l'IFIC. En aquest document trobareu un resum de l'àmplia varietat d'activitats dutes a terme al nostre institut durant 2017. Encara que és impossible resumir en unes poques línies tots els resultats i èxits dels nostres grups d'investigació, m'agradaria donar-vos alguns titulars.

Els grups de l'IFIC participen en tres experiments del Gran Colisionador d'Hadrones: ATLES, LHCb i MoEDAL. Com podeu veure en aquest informe, hi ha una àmplia varietat de temes en què investiga el nostre personal científic, entre altres el bosón de Higgs, el quark top, el vèrtex Wtb, recerca de nova física en supersimetria i processos FCNC, monopols, etc. A més de la seua contribució al bon funcionament dels detectors actuals, els grups de l'IFIC treballen també en la millora dels mateixos, en concret en el calorímetre hadrònic (TileCal), en el detector de traces intern (ITk) d'ATLES i en el detector de fibres centelleadores (SciFi) de LHCb. Aquestes activitats requeriran cada vegada més recursos en el futur (encara que la millora de LHCb haurà d'estar llesta molt abans, per al Run 3). Els grups que treballen en futurs acceleradors (ILC, CLIC) estan involucrats en l'estudi en profunditat de les possibilitats que aquests projectes poden proporcionar, en concret les relacionades amb l'estudi del quark top.

És també una característica dels grups que treballen en astropartícules i física de neutrins mirar als experiments del futur. En aquest sentit, mentre es treu tot el partit de les dades proporcionades pel telescopi de neutrins ANTARES, el grup de física d'astropartícules dedica un gran esforç al projecte KM3NeT, que va ser inclòs eixe any en l'Estratègia Europea de l'APPEC. Així mateix, el grup implicat en experiments de feixos de neutrins no sols analitza les dades de l'experiment T2K en el que participen, sinó que també contribuïxen al projecte DUNE, que començarà a funcionar la pròxima dècada. El projecte NEXT està fent excel·lents progressos, i les dades preses per l'experiment NEW faciliten la següent fase NEXT-100, que podria començar a funcionar en 2020.

Els grups de física nuclear experimental duen a terme una gran varietat d'activitats investigadores que tenen lloc en instal·lacions diverses com RIKEN al Japó, IGISOL IV a la Universitat de Jyväskylä (Finlàndia) i HYMNS en nTOF (CERN) . Igualment, el grup d'AGATA està molt involucrat en el detector AGATA per al laboratori FAIR. Cal destacar també el projecte d'I+D+i entre l'IFIC i ENRESA per a desenvolupar una cambra gamma que ajude en el procés de desmantellament de centrals nuclears.

Les activitats del grup de Grid i E-Ciencia són massa nombroses per a resumir-les ací. Mencionar que els seus membres aborden els problemes associats a l'enorme increment dels recursos de computació que requerirà l'LHC d'Alta Lluminositat (HL-LHC) . Aquest va ser de fet un dels temes que es van discutir a l'ATLES Computing & Programari Week, que va tindre lloc a València enguany organitzada pel grup de Grid.

El grup de física médica està realitzant grans progressos en el seu telescopi Compton per a monitorització de teràpia hadrònica: una nova versió del seu prototip ha millorat les capacitats d'obtindre imatges amb aquesta tècnica. Finalment, el Laboratori RF, que serà un futur banc de proves per a les cavitats RF, està avançant molt bé.

La investigació realitzada pels grups teòrics de l'IFIC cobrix un ampli rang d'aspectes en fenomenologia de física de partícules. Una meticulosa comparació de les prediccions del Model Estàndard amb les dades disponibles és una part integral de la recerca de Nova Física. La Física de Sabor, tant en el sector de quarks com de leptons, és un extraordinari terreny per buscar nous fenòmens o desenvolupar possibles extensions del Model Estàndard.

Diversos grups teòrics dediquen les seues investigacions a la fascinant àrea d'interaccions hadròniques i QCD. La llarga llista d'estudis en aquests camps inclou la investigació de processos de violació de sabor que involucren a kaons; noves relacions per a amplituds de dispersió a nivell one-loop obtingudes a partir de la interacció entre la dualitat color-cinemàtica (CKD) i LTD; les dinàmiques no trivials en les desintegracions dèbils no leptòniques i semi-leptòniques de diversos hadrons amb quarks charm i beauty, que produïxen sovint estats generats dinàmicament; i altres estudis descrits en major detall en aquesta memòria.

Entre les investigacions realitzades pel grup dedicat a la gravetat, cal destacar l'estudi de l'efecte que l'espai-temps corbat té sobre la simetria electromagnètica: la polarització del camp quàntic electromagnètic no es conserva en espai-temps corbats.

Els nostres teòrics també investiguen el sector del neutrí, realitzant ajusts globals per tal d'identificar possibles desviacions del coneixement actual de l'àrea i extraient els millors valors possibles dels paràmetres de mescla. La recerca d'indicis de neutrins estèrils formen part del seu treball. Així mateix, usant dades de CMB i BAU són capaços de proporcionar límits molt competitius per a la suma de les masses dels tres neutrins actius.

En 2017 es va publicar un total de 440 articles en revistes indexades dels quals els autors o coautors són personal investigador de l'IFIC, el 92% d'aquests es van publicar en revistes del primer quartil. Els nostres científics van realitzar 350 contribucions en conferències nacionals i internacionals, de les quals 333 van ser presentacions orals (82 invitades) i 17 pòsters. Enguany es van defendre 22 tesis doctorals i 17 projectes fi de màster.

L'IFIC té un vibrant programa científic que en 2017 va incloure 17 "Coloquios Severo Ochoa" impartits per prestigiosos experts internacionals i 94 seminaris que van cobrir un ampli rang de temes. A més, diverses conferències nacionals i internacionals celebrades a València i altres ciutats van ser organitzades pel nostre personal científic.

Onze estudiants es van formar a l'IFIC en àrees tècniques com Enginyeria Electrònica o Industrial durant 2017, gràcies a una fructífera col·laboració amb ADEIT, la Fundació Universidat-Empresa de la Universitat de València. A més, cinc tècnics jóvens menors de 25 anys van treballar a l'IFIC durant 2017 dins del Programa de Garantia Juvenil.

El Comité Científic Assessor de l'IFIC es va reunir al juliol de 2017, emetent un informe molt positiu del funcionament de l'institut i al mateix temps comunicant-nos aquelles àrees on podem millorar. De la mateixa manera, el Comité de Seguiment del projecte Severo Ochoa va emetre una avaluació positiva en el seu informe de revisió de meitat de projecte.

En 2017, l'Agència Valenciana de la Innovació (AVI) va decidir finançar la creació d'una Unitat Científica d'Innovació Empresarial (UCIE) a l'IFIC. Aquesta és una molt bona notícia per a l'institut, no sols perquè suposa un reconeixement de l'esforç que realitza l'IFIC des de fa algun temps en innovació i transferència, sinó també perquè permet preveure una estructuració de les activitats de l'IFIC en aquesta àrea. L'acord UV-AVI es va gestar durant 2017 i finalment es va signar en 2018 per ambdues parts. Estem molt entusiasmats amb les perspectives futures de la UCIE de l'IFIC, que suposarà una clara espenta als nostres esforços en innovació i transferència.

L'IFIC realitza un esforç especial en comunicació i divulgació. Les nostres activitats en aquestes àrees són molt variades. 28 col·legis i instituts de tota la Comunitat Valenciana van visitar l'IFIC, i alberguem més de 900 visitants en 2017. Es van organitzar dos masterclasses internacionals en coordinació amb el CERN, que van reunir a 147 alumnes i 55 professors de 56 instituts. L'IFIC va oferir un programa de formació de 30 hores per millorar els coneixements sobre física de partícules i cosmologia dels professors, així com per mostrar formes de traslladar eixe coneixement a les aules. En 2017 es va re-dissenyar la nostra pàgina web, oferint notícies sobre l'IFIC o temes relacionats quasi diàriament. Notícies relacionades amb l'IFIC es van publicar en diversos mitjans de comunicació, i participem en una gran quantitat d'activitats de divulgació organitzades per l'IFIC o junt amb altres institucions.

Amb tot açò, 2017 va ser un any molt gratificant per a l'IFIC, i el treball i l'esforç del nostre personal va donar els seus fruits. Crec modestament que hem d'estar orgullosos dels nostres èxits.

1. STRUCTURE AND ORGANIZATION

ABOUT IFIC

The **Institute for Corpuscular Physics** (Institut de Física Corpuscular, IFIC) of Valencia is a joint research institute belonging to two institutions: the Spanish National Research Council (Consejo Superior de Investigaciones Científicas, CSIC) and the University of Valencia (Universitat de València – Estudi General, UVEG). The synergies between the two institutions make IFIC a reference centre, both in terms of personnel and infrastructures.

IFIC's origins date back to 1950, when Prof Joaquín Catalá formed a group in Valencia to study atomic nuclei and elementary particles using the nuclear emulsion technique, a research activity not previously developed in Spain. Hence, IFIC is one of the oldest Spanish institutes in Experimental Physics and the first studying particle and nuclear physics.

The mission of IFIC covers a wide range of subjects. In a broad sense, we study the fundamental interactions (gravitational, electroweak and strong) and the building blocks of matter, considering both the theoretical and experimental aspects. Our aim is to understand the nature of these interactions and their phenomenological consequences in the laboratories, to predict the behaviour in future experiments and, as a final goal, to search for a unified theory of all of them. In parallel, we wish to know which physical processes occur in the Universe, and how it has evolved from its initial conditions.

It is our aim to keep our level as an international reference centre in Particle, Astroparticle and Nuclear Physics both in the theory and experimental domains. Although IFIC is clearly oriented towards basic research, we are also committed to work on applications that may derive from our activities on fundamental physics, such as advanced instrumentation, distributed computing and medical physics. In addition, we want to maintain and improve IFIC's training capabilities at the PhD and postdoctoral level. Last but not least, we plan to strengthen our connection with society through our outreach activities.

IFIC is structured in two scientific divisions: experimental and theoretical physics. Both divisions present an excellent research record and impact at the international level. The balance between these two divisions, a situation that is not very common in Spain, is one of the main strengths of IFIC and the close collaboration among their members is extremely fruitful. In addition, the support and managing services provide the adequate administrative and technical help for our research.

In 2005 IFIC was officially classified by the Spanish Ministry of Education and Science as a Class A institute in the list of CSIC research centres.

In 2015, IFIC was awarded with the 'Severo Ochoa' accreditation as centreof excellence in recognition of its outstanding performance and scientific contributions at national and international level, its impact at industrial and social level, and the ability to attract scientific talent.

IFIC is an international reference centre in Particle, Astroparticle and Nuclear Physics, both in the theory and experimental domains

A bit of history

In the autumn of 1950 Prof Joaquín Catalá formed a group at Valencia to study atomic nuclei and elementary particles using the nuclear emulsion technique[1], after working with Prof Cecil F. Powell at Bristol. This technique had been successfully employed to detect particles in cosmic rays and fixed target experiments leading to the discovery of the pion in 1947 by Powell, who was awarded the Nobel Prize in Physics in 1950.

Prof Catalá's group first operated as a local division of the Instituto de Óptica Daza de Valdés belonging to CSIC and specialized in photo-nuclear studies. The group's research program is considered the birth of institutional research in experimental nuclear and particle physics in Spain.

One of Catalá's students, Fernando Senent, who became later professor and director of IFIC, was the author in 1954 of the first Spanish thesis in experimental particle and nuclear physics, whose title was: *Distribuciones angulares de los protones producidos en el bombardeo del carbono 12 por deuterones*.

Another of his students, Eugenio Villar, obtained his PhD in 1957 and was later the person leading the particle physics group in Santander, now known as Instituto de Física de Cantabria (IFCA).

It was at the beginning of 1960 when the Institute got its present name, Instituto de Física Corpuscular (IFIC). During many years, the Institute shared the building, offices and facilities with the department of Atomic, Molecular and Nuclear Physics (FAMN) of the University of Valencia, which has been the traditional link with the University. The first observation of the exotic nucleus ^{8}He was performed by IFIC researchers in 1971 through the reaction $^{8}\mathrm{He} \rightarrow {}^{4}\mathrm{He} + {}^{4}\mathrm{He} + 2e^{-}$.

The international impact of our research activities has naturally been influenced by the social and political Spanish situation. In the period 1950-1984 IFIC survived having modest, but heroic, contributions to the physics performed at the international scale. However, after Spain re-entered CERN in 1984 the scientific activity of IFIC was boosted in both quantitative and qualitative aspects at the national and international scales.

Around the year 1985 most of the researchers of the department of Theoretical Physics of the University of Valencia joined the Institute and configured its final structure which benefits from the knowledge of both fields: theory and experiment. This provides an excellent atmosphere for scientific cooperation, in particular in the phenomenological and experimental areas. During the last years, it is worth mentioning the participation of IFIC in experiments at CERN (Geneva-Switzerland), GSI (Darmstad-Germany), SLAC (Stanford-USA), FERMILAB (Chicago-USA), KEK (Japan) and others.

In 2015, IFIC was awarded with the 'Severo Ochoa' accreditation as Centreof Excellence in recognition of its outstanding performance and scientific contributions at national and international level, its impact at industrial and social level, and the ability to attract scientific talent.

After Spain re-entered CERN in 1984, the scientific activity of IFIC was boosted in both quantitative and qualitative aspects

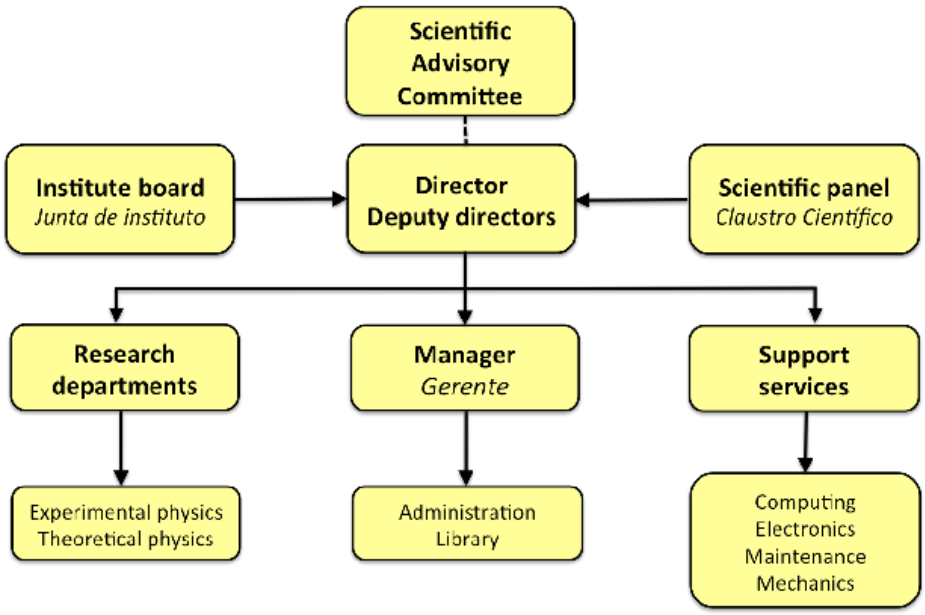
1 An excellent review article about the birth of experimental nuclear and particle physics in Spain, written by Agustín Ceba, Víctor Navarro y Jorge Velasco, was published in Revista Española de Física 25-2 (2011).

1. STRUCTURE AND ORGANIZATION

ORGANIZATION, SCIENTIFIC DEPARTMENTS AND SUPOPORT UNITS

GOVERNING BOARD

The Scientific Panel (Claustro Científico) is the discussion forum for scientific matters of the institute. Chaired by the director, the Panel consists of the CSIC scientific personnel and the UVEG researchers affiliated to IFIC. The Institute Board (Junta de Instituto) is the governing board of IFIC. It is composed by the Director, the Deputy Directors, the Heads of the two scientific departments and two representatives of the IFIC personnel. The Manager of IFIC acts as secretary of the Institute Board.



Members of the Scientific Advisory Committee:
Gustavo Branco (CFTP, IST, Univ. Lisbon), William Gelletly (Univ. Surrey), F. Halzen (Univ. Wisconsin), Cecilia Jarlskog (Univ. Lund), Peter Jenni (CERN, Albert-Ludwigs-Univ. Freiburg), Antonio Masiero (Univ. Padua), Tatsuya Nakada (EPFL Lausanne), Bing-Song Zou (IHEP Beijing)
Members of the Institute Board:
Director: Juan José Hernández Rey
Deputy Directors: María José Costa Mezquita, Juan Fuster Verdú (Innovation and Technology), Santiago Noguera Puchol
Manager: Ana Fandos Lario
Heads of the research departments: Carlos Lacasta Llácer (Experimental Physics), Juan M. Nieves Pamplona (Theoretical Physics)
Personnel representatives: Rosa Carrasco de Fez (non-doctoral members), Salvador Martí García (doctoral members)

The Institute is situated in the Burjassot-Paterna Campus of the University of Valencia, a few kilometres from the centre of Valencia. IFIC personnel are distributed at the Science Park of the UVEG in Paterna (PCUV) and at the University departments (Atomic, Molecular & Nuclear Physics and Theoretical Physics) in Burjassot, within walking distance of each other. At the PCUV, IFIC is one of the research institutes with offices in the main University building and owns the CSIC building where all the laboratories and infrastructures are located.

IFIC research buildings at the Science Park UVEG

Faculty of Physics (UVEG campus in Burjassot)

lider (LHC) at CERN, and participate in the preparation for the future Linear Collider (ILC and CLIC) under the framework of the Linear Collider Collaboration (LCC). The group of e-Science participates in the GRID for the LHC and in other activities of distributed computing.

In Astroparticle Physics the work is focused on the neutrino telescope ANTARES and its future extension KM3NeT, while the Neutrino Physics group is involved in the NEXT and T2K experiments.

In Nuclear Physics, we participate in the AGATA project, in the future accelerator Facility for Antiproton and Ion Research (FAIR), in the nTOF experiment at CERN and in the HADES experiment at Darmstadt GSI.

Finally, the group of Medical Physics carries out several activities mainly related to medical imaging and accelerator developments.

Accelerator-based Experimental High Energy Physics

This research line takes advantage of large particle accelerators to study the elementary components of matter. At present, this line is focused on two large projects: the LHC at CERN and the LCC.

IFIC members have participated in the construction of several systems of the ATLAS detector of the LHC, in the computing and data management related to the data supplied by this detector and in beam instrumentation for test facilities of the LCC.

In the past, the scientists of this research line participated in the DELPHI experiment at the LEP accelerator of CERN, the CDF experiment at the Tevatron in Fermilab and in the BaBar experiment at the PEP-II accelerator of SLAC. Recently, IFIC researches became members of the LHCb, MoEDAL and Belle II collaborations.

SCIENTIFIC DEPARTAMENTS

EXPERIMENTAL PHYSICS

Several groups of our institute participate in many of the most relevant experiments in Particle, Astroparticle and Nuclear Physics, as well as in the applications of these disciplines to other fields of Science and Technology. For instance, IFIC members are part of the international collaborations that manage the ATLAS, LHCb and MoEDAL detectors of the Large Hadron Col-

IFIC participated in the construction of several systems of ATLAS detector of the LHC, in the computing and data management

Astroparticle Physics

Astroparticle Physics studies the particles coming from the cosmos in order to investigate both their properties and the Universe. The group at IFIC participates in the neutrino telescopes ANTARES and KM3NeT. The former is installed at a depth of 2500 metres in the Mediterranean seabed in the coast near Toulon (France) and it has been in operation since 2008. The latter, KM3NeT, is also being deployed in the Mediterranean Sea with an effective detection volume of several cubic kilometres.

Neutrino Physics

This research line studies the intrinsic properties of the neutrino. The group studies the phenomenon of oscillations between neutrino families, measuring the parameters that define such oscillations. It also tries to elucidate the nature of the neutrino, namely whether the neutrino is a Majorana or a Dirac fermion. IFIC leads the NEXT experiment searching for neutrino-less double beta decay, whose detection would imply that neutrinos are Majorana particles. IFIC also participates in several accelerator-based oscillation experiments: the currently operating T2K experiment in Japan, and the next-generation DUNE experiment in the United States. In the past, scientists of this line participated in the SciBooNE, K2K, HARP and NOMAD experiments.

Nuclear Physics

After more than a century of their discovery, atomic nuclei still keep many secrets and there is a wide variety of phenomena not fully understood yet. IFIC researchers in this line work in a broad range of studies in nuclear physics and its applications, such as gamma spectroscopy, extreme nuclear states, nuclear waste incineration or stellar nuclear reactions. Likewise, they are involved in the AGATA project and in the construction of the detectors for the large European infrastructure FAIR. Some IFIC members have participated in the HADES experiment, designed to study di-electron emission in heavy ion reactions.

The Medical Physics group works on the development of instrumentation for medical imaging, image science and accelerator development

GRID and e-Science

In order to satisfy the computing needs of particle physics experiments such as those of the LHC, which are providing an enormous amount of data that must be recorded and analysed, a series of initiatives at CERN and the European Union have been carried out to set up a world network of computing nodes (GRID) communicating among themselves through a series of software protocols. IFIC participates in several of them with the aim of developing a model of distributed computing in Spain and in Europe. This type of development can also be interesting for the local industry and has a straightforward application to other research fields where distributed computing and communication are needed.

Medical Physics

The activities of the Medical Physics group are devoted to the biomedical applications of particle and nuclear physics. Its research includes the development of instrumentation for medical imaging, image science (image reconstruction and algorithmics, modelling of image formation and degradation phenomena, Monte-Carlo simulations, etc.), as well as accelerator developments. The group activities also cover developments in particle accelerating techniques, beam instrumentation, detector developments for dose monitoring and imaging for hadron therapy.

THEORETICAL PHYSICS

IFIC researchers cover a wide variety of topics in Theoretical Physics, such as the phenomenological aspects of the Standard Model (SM) and of theories beyond it, aspects of nuclear and many-body physics, or particle physics in astrophysics and cosmology. Both the formal aspects of Quantum Field Theory and the phenomenology of nature's fundamental interactions are investigated in the whole range of available energies both in present and future experiments. The research lines in Theoretical Physics are:

High-Energy Physics Phenomenology

The main goals of high-energy physics phenomenology are the study of the SM of the strong and electroweak interactions and the search for deviations from its predictions that could arise from new interactions expected in several of its extensions, such as supersymmetric models.

This strategy includes the precise determination of the SM parameters, couplings, masses and mix-

ing angles, as well as the phenomenological study of possible modifications from its predictions and of new signals arising from novel processes beyond the SM, with emphasis on the potential consequences for present and future high-energy experiments. Some aspects of Quantum Information are also developed.

High-energy Theoretical and Mathematical Physics: Gravity, Black Holes, and Supersymmetry

This line investigates quantum processes in intense gravitational fields and the appearance of new spatiotemporal symmetries. The combination of Quantum Field Theory with General Relativity is studied, as well as its application to black holes (Hawking radiation) and to Cosmology (primitive universe, inflation, etc.).

The classical and quantum aspects of the modification of einstenian gravity are also considered, as well as the use of supersymmetry and non-commutative geometries in the search for a quantum theory of gravity.

Nuclear Physics and Many-Body Theory

This line studies the interactions between hadrons and of these with the nuclear medium, using effective theories built from symmetries of Quantum Chromodynamics, perturbative and non-perturbative methods. Special emphasis is put on topics related to the scientific programme of PANDA and CBM of the European Laboratory FAIR and on the study of the neutrino-nucleus cross sections that are used in neutrino oscillation experiments (MiniBooNE, T2K, etc.). Some aspects of Non-linear Dynamics and Complex Systems are also treated.

Quantum Chromodynamics (QCD) and Strong Interactions

Here we study both the perturbative and non-perturbative aspects of the strong interaction, the fundamental force describing the interactions between quarks and gluons. Several approaches are used: lattice gauge theories, effective field theories, chiral perturbation theory or phenomenological lagrangians, such as that of the resonance chiral theory.

A variety of goals are pursued, for instance, the theoretical and phenomenological study of QCD in hadron colliders, the study of the hadronic phenomenology in the resonance region, such as in the hadron decays of the tau lepton or in the semileptonic decays of the D mesons and others.

Theoretical Astroparticle Physics and Cosmology

This line covers several interdisciplinary aspects of astroparticle physics and cosmology. Among others it is worth mentioning the basic properties of neutrinos and the future experiments in this field, the origin of neutrino mass and their mixing angles, neutrinos as messengers in astrophysics and cosmology, baryogenesis and leptogenesis, ultra high-energy cosmic rays and others. Although driven by phenomenology which is thriving on the neutrino front as well as cosmology, there is space for theoretical ideas on aspects such as inflation, dark matter or dark energy.

IFIC covers a wide range of topics in Theoretical Physics: phenomenology of SM and theories beyond it, nuclear, particle physics in astrophysics and cosmology

SUPPORT UNITS

Administration and Management

The Administration Service is located on the first floor of the main research building. A total of 17 people, belonging to CSIC and UVEG, manage the ordinary running of IFIC, as well as the budgets of many research grants. These funds are provided by different agencies at different levels (regional, national and European), each of them with its own special rules and particular conditions to manage.

At any time there are around 50 live research projects and grants, which implies to process a wide range of tasks as employment contracts, public calls, invoices, leaves of absence, etc. In addition, this Service deals with all sorts of matters in a community with staff belonging to two different institutions and with many nationalities.

Computing

This Unit provides a wide range of network and computing solutions for IFIC, giving support to users and projects. The service catalogue covers a wide spectrum, ranging from the installation and configuration of desktop and laptop computers to scientific computing, including the operation of computer farms with hundreds of multi-core CPUs. Our Computing Service is more than 20 years old and has pioneered the use and spread of new technologies, such as computer networks (FAENET), the web in the past and the GRID at present.

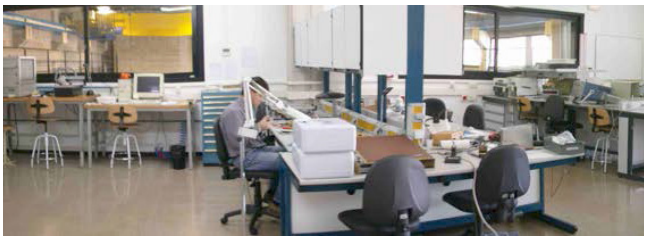
The computing centre houses several clusters with a total of 300 computer nodes (around 3000 cores) and 1.9 PB of disk storage, some of them using GRID technologies. More than 30 servers are constantly operating to provide email and web services, storage, resource management, user access, monitoring services, printing, databases, etc. The computing centre premises are located in a 150 m^2 hall with air conditioning (240 KW), technical floor and uninterruptible power supply (250 KVA).

Computer centre.

Electronics

This Unit provides service to any IFIC research project with demands on electronics. IFIC experiments develop particle sensors that generate electronic outputs that need to be recorded. The Unit staff and equipment support these activities with design, prototyping, manufacturing, testing and validation of electronic systems.

In addition, certain sensor technologies use microelectronics, as for instance silicon particle detectors. This Unit is in charge of providing chips and silicon structures testing, as well as chip-to-sensor assembly and also the connection of their microchannels. It also offers service and developments to external companies through contracts and agreements. This Unit makes use of two infrastructures: the general electronics laboratory (90 m^2, with PCB fabrication and component assembly equipment) and the clean room (80 m^2 in two areas, classes 10000 and 1000, ISO7 and ISO6, with X-ray inspection, flip-chip and wire-bonding machines) for support in microelectronics.



Electronics laboratory.

Library

IFIC's Library, part of CSIC's Library Network, is located on the first floor of the Research Building and has a collection of 3300 books both in topics of general interest and specific to our research. Its staff is responsible for managing the access to electronic journals and the book loans. The latter can be requested online, except for a selection of titles that are for on-site consultation only. IFIC members may request the purchase of books through an online application. The final decision is competence of the Library Commission.

This Service is also responsible for the inventory of theses and dissertations deposited in the library since 1954, as well as the registration of PhD theses and monographs in the general CSIC catalogue. Finally, the library staff collaborates actively in the preparation of IFIC's annual reports (CSIC and UVEG) and the tasks related to the inclusion of our scientific output in the institutional databases.

Library.

Mechanics

This Unit provides service to projects with mechanical needs, ranging from the conceptual design phase, calculation and simulation to the development of 3D models and drawings. In addition to manufacturing, we carry out measurements and tests on existing components and assemblies. We have a modest but versatile workshop that allows us to make and modify many of our prototypes in our own facilities, providing great flexibility in their development. We also have a dimensional inspection laboratory with contact and vision measuring machines.

This Service is also responsible for supervision of the design and management of the manufacturing of mechanical parts and assemblies in outside companies when they exceed our capacities.

IFIC workshop.

Maintenance

This Unit is an integrated service of maintenance management, occupational safety, radiation protection, environmental and quality management of the common facilities as well as the research laboratories of the Institute. Its tasks include the preventive and corrective maintenance of facilities and laboratories, the management and logistics of the Clean Room and the Laboratory of Radioactive Sources. This Unit is also in charge of safety issues at IFIC in collaboration with the corresponding Occupational Health and Safety Services of UVEG and CSIC, including our Radioactive Facility that depends on the Radiation Protection Service of UVEG, as well as the actions in environmental management (waste disposal and energy efficiency). Finally, this Service is responsible for the implementation of quality standards in the operation of shared facilities, such as the Clean Room, according to the guidelines of our parent institutions.

PERSONNEL

31 OCTOBER 2017

SCIENTIFIC STAFF (77)

Algora, Alejandro
Alvarez Ruso, Luis
Baremboim, Gabriela A.
Bordes Villagrasa, José Manuel
Botella Olcina, Francisco J.
Cabrera Urban, Susana
Campanario Pallas, Francisco
Cases Ruiz, Ramón
Castillo Giménez, M. Victoria
Cervera Villanueva, Anselmo
Costa Mezquita, Mª Jose
Díaz Medina, José
Domingo Pardo, César
Donini, Andrea
Fabbri, Alessandro
Fassi Imlahi, Farida
Fiorini, Luca
Furtado Valle, José Wagner
Fuster Verdú, Juan A.
Gadea Raga, Andres F.
García García, Carmen
García Navarro, Jose Enrique
Giménez Gómez, Vicente
Gómez Cadenas, Juan José
González de la Hoz, Santiago
González Marhuenda, Pedro
Hernández Gamazo, Pilar
Hernández Rey, Juan Jose
Higón Rodriguez, Emilio
Hirsch, Martin K.
Lacasta LLácer, Carlos
Lledó Barrena, Mª Antonia
Llosá LLácer, Gabriela
Martí García, Salvador
Martínez Vidal, Fernando
Mena Requejo, Olga
Mitsou, Vasiliki
Navarro Faus, Jesús
Navarro Salas, José
Nieves Pamplona, Juan Miguel
Noguera Puchol, Santiago
Novella Garijo, Pau
Olmo Alba, Gonzalo
Oset Báguena, Eulogio
Oyanguren Campos, Arantza
Palomares Ruiz, Sergio
Papavassiliou, Ioannis
Pastor Carpi, Sergio
Peñarrocha Gantes, José Antonio
Pérez Cañellas, Armando
Pich Zardoya, Antonio
Portoles Ibáñez, Jorge
Rius Dionis, Nuria
Rodrigo García, Germán
Ros Martínez, Eduardo
Rubio Barroso, Berta
Ruiz de Austri Bazán, Roberto
Salt Cairols, José
Sanchis Lozano, Miguel Angel
Santamaría Luna, Arcadi
Sorel, Michel
Taín Enríquez, José Luis
Tortola Baixauli, Mariam
Valls Ferrer, Juan Antonio
Velasco González, Jorge
Vento Torres, Vicente
Vicente Vacas, Manuel
Vidal Perona, Jorge
Vijande Asenjo, Javier
Vives García, Óscar
Vos, Marcel Andre
Yahlali, Nadia
Zornoza Gómez, Juande
Zuñiga Román, Juan

Emeriti

Bernabéu Alberola, José
de Azcárraga Feliu, José Adolfo
Ferrer Soria, Antonio

POSTDOCTORAL RESEARCHERS (47)

Albiol Colomer, Francisco Javier
Bailey, Adam
Barrio Toala, John
Boronat Arevalo, Marça
Caballero Ontanaya, Luis
Coleiro, Alexis
de Romeri, Valentina
Eberhardt, Otto
Escobar Ibañez, Carlos
Esperante Pereira, Daniel
Fernandez Menendez, Pablo
Ferrario, Paola
Fullana Torregrosa, Esteban
Garcia Garcia, Ignacio
Gariazzo, Stefano
Gozzini, Sara Rebecca
Henry, Louis
Izmaylov, Alexander
Jordan Martin, Mª Dolores
Krause, Claudius
Laing, Andrew
Lopez Ibañez, Mª Luisa
Lopez March, Neus
Lozano Bahilo, Jose Julio
Madaffari, Daniele
Mamuzic, Judita
Masud, Mehedi
Mavromatos, Nikolaos
Miñano Moya, Mercedes
Morais Dias, Jorgivan
Morales Lopez, Ana Isabel
Motohashi, Hayato
Neder, Thomas
Orrigo, Sonja
Pagura, Valeria Paula
Renner, Joshua
Rinaldi, Matteo
Ros Garcia, Ana
Rodriguez Chala, Mikael
Sakai, Shuntaro
Santra, Arka
Sousa da Fonseca, Renato
Srivastava, Rahul
Thakore, Tarak
Torres Bobadilla, William
Vicente Montesinos, Avelino
Yao, Deliang

PhD STUDENTS (68)

Adreine, Madeleine
Alcaide de Wandeleer, Julien
Anamiati, Gaetana
Aparisi Pozo, Javier Alberto
Barranco Navarro, Laura
Barrios Marti, Javier
Benlloch Rodriguez, Jose Mª
Caputo, Andrea
Castillo, Florencia
Centelles Chulia, Salvador
Cepedello Perez, Ricardo
Cerdà Alberich, Leonor
Collado Ruiz, Javier
Colomer Molla, Marta
Corbi Bellot, Alberto
Cornet Gomez, Fernando
Del Rio Vega, Adrian
Delhom Latorre, Adria
Driencourt-Mangin, Felix
Escudero Abenza, Miguel
Estrada Pastor, Oscar
Etxebeste Barrena, Ane Miren
Faubel Alama, Carlos
Felkai, Ryan
Fernandez de Salas, Pablo
Fernandez Soler, Pedro
Ferreiro de Aguiar, Antonio
Garcia Aparisi, Francisco
Garcia Folgado, Miguel
Garcia Martin, Luis Miguel
Gisbert Mullor, Hector
Gomis Lopez, Pablo
Gonzalvo Rodriguez, Galo
Illuminati, Giulia
Jimenez Peña, Javier
Jurado Gomez, Mª Luz
Khan Chowdhury, Nafis R.
Lotze, Moritz
Marquez Martin, Ivan
Martinez Roig, Marcos
Melis, Aurora
Menchon Perez, Cintia Cecilia
Miralles Aznar, Victor
Montaner Pizà, Ana
Muñoz Albaladejo, Enrique
Murgui Galvez, Clara
Palmeiro Pazos, Brais
Peñuelas Martinez, Ana
Pereira Pires Pavao, Rafael
Perello Rosello, Martin
Ramirez Rodriguez, Hector Ariel
Reig Lopez, Mario
Remon Alepuz, Clara
Renteria Olivo, Andres E.
Rodrigues Debastiani, Vinicius
Rodriguez Bosca, Sergi
Rodriguez Rodriguez, Daniel
Rodriguez Sanchez, Antonio
Sanchez Mayordomo, Carlos
Saul Sala, David Eduardo
Segarra Tamarit, Alejandro
Simon Estevez, Ander
Sobczyk, Joanna
Ternes, Christoph
Tolosa Delgado, Alvaro
Villanueva Domingo, Pablo
Vnuchenko, Anna
Witte, Samuel

ENGINEERS & TECHNICIANS (21)

Aliaga Varea, Ramon
Alvarez Puerta, Vicente
Blanch Gutierrez, Cesar
Botas, Alejandro
Calvo Diaz-Aldagalán, David
Carcel Garcia, Sara
Carrio Argos, Fernando
Carrion Burguete, Jose Vicente
Ladarescu Palivan, Ion
Lopez Macia, Pedro Felix
Martinez Perez, Alberto
Mazorra de Cos, Jose
Musti, Mafalda
Oliver Guillen, Jose Francisco
Platero Garcia, Adrian
Querol Segura, Marc
Real Mañez, Diego
Rodriguez Samaniego, Javier
Solaz Contell, Carles
Soldevila Serrano, Urmila
Torrent Collell, Jordi

ADMINISTRATION (17)

Aguilar Argilés, Teresa
Andreu Garcia, Mª Teresa
Boix Caballero, Pilar
Claramunt Pedrón, Luis Miguel
Fandos Lario, Ana María
Ferrer Lazaro, Jose Manuel
Fillol Ricart, Amparo
Garcia Gonzalez, Soledad
Gimeno Almela, Mª Jose
Gonzalez Romeu, Mª Teresa
Gracia Vidal, Mª Jose
Hernando Recuero, Mª Luisa
Montesinos Reig, Leonor
Pastor Clerigues, Elena
Pérez García, José
Serrano Perez, Carmen
Sifre García, Francisca

COMPUTING (7)

Alonso Gallardo, Miguel
Fernandez Casani, Alvaro
Garcia Montoro, Carlos
Martínez Saez, Carlos
Nadal Durà, Joaquin
Navajas Alba, Ximo

ELECTRONICS (7)

Bernabeu Verdú, José
Camara García, María Teresa
González González, Francisco
Lopez Redondo, Manuel
Marco, Ricardo
Nácher Arándiga, Jorge
Valero Biot, Jose Alberto

MECHANICS (6)

Civera Navarrete, José Vicente
Jordan Coronado, Jose Luis
Leon Lara, Pablo
Monserrate Sabroso, Jose Manuel
Perez Rabadan, Alberto
Villarejo Bermudez, Miguel Angel

MAINTENANCE (3)

Fuentes Castilla, Angel
Gallego Baviera, Fco. Javier
Carrasco de Fez, Rosa

OUTREACH (2)

Aparici Benages, Alberto
Garcia Cano, Isidoro

VISITORS (35)

290 Total personnel (October 2017)

192 Scientific personnel

27 Nationalities working at IFIC

60% Postdocs from abroad

27% PhD students from abroad

23% Women in scientific personnel

2. RESEARCH ACTIVITIES

EXPERIMENTAL PHYSICS

ACCELERATOR-BASED EXPERIMENTAL HIGH ENERGY PHYSICS

The activities of this research line comprise the participation in the LHC experiments ATLAS, LHCb and MoEDAL (physics analysis, detector operation and upgrade), plus the ones related with the future International Linear Collider (ILC) and the Compact Linear Collider (CLIC): physics goals, accelerator and detector technology.

LHC EXPERIMENTS

The exploitation of the 13 TeV proton-proton collisions at the LHC data received another boost during 2017, as its instantaneous luminosity reached 2.09×10^{34} $cm^{-2}s^{-1}$, more than twice its designed value.

ATLAS experiment

Our group is involved in all the aspects of running the experiment: detector operations, data preparation, computing, physics analysis, publication of results, conference presentations and organization, as well as playing a leading role through occupying managing posts within the collaboration.

ATLAS: operations

As the LHC luminosity increased, the demands on the ATLAS detectors performance was tightened. Our group, as responsible of the operation and maintenance of the Tile Calorimeter (TileCal) off-detector electronics, implemented an upgrade of its electronics during the first months of 2017. This represented the first upgrade of the TileCal back-end electronics since its installation in 2007. The processing power of the TileCal Read-Out Drivers (RODs) was doubled, as the number of Processing Units (PU) mounted on the board and the frequency of transmission from the RODs was increased by a factor two. These changes required, as well, updates of the electronics firmware and read-out software. Thanks to these improvements, the TileCal managed to cope with the consequences of the record level of luminosity of the LHC: exceptional high accept rate of the first level trigger of ATLAS, up to 100 kHz, with an unprecedented level of more than 60 simultaneous interactions per bunch crossing.

At the Inner Detector (ID) tracker operations front, the higher rate of data poured by LHC also represented an increased pressure over the detector alignment. An updated and accurate description of the detector geometry is needed within 24 hours after the data taking. With more data craming, the ID alignment model requested many changes to deal with its data base uploads (reduce the amount of payload while keeping the quality of the detector description), the monitoring (early detection of track parameter biases), discard the on-line beam spot as track constraint in the alignment and handshake with the off-line beam spot determination, etc. On top of that, the team was also responsible for the precise off-line alignment in order to prepare the 2017 data reprocessing campaign. The uses of resonance decays into $\mu+\mu-$ pairs as well as the E/p technique on electrons allows for a super-precise detector alignment. This is necessary for high precision measurements like the Z and W boson mass. Actually, during 2017, LHC had a special run where the pileup was much reduced and few collisions were produced per bunch crossing (low-μ run). The goal was to reduce the systematics in the electroweak boson masses. Our group was much involved in the calibration and analysis of these data. Finally, actions on the realignment of the 2015 and 2016 Heavy Ions data taking periods were conducted.

The use of resonant $\mu+\mu-$ decays allows the precise ATLAS tracker alignment necessary for high precision measurements, like the W and Z boson mass

Our group has also responsibilities in ATLAS tracking validation. Due to the LHC record luminosity, the tracking subdetectors (Pixels, SCT and TRT) had to adapt their reconstruction software in order to reduce the amount of data, of course, keeping the tracking performance high.

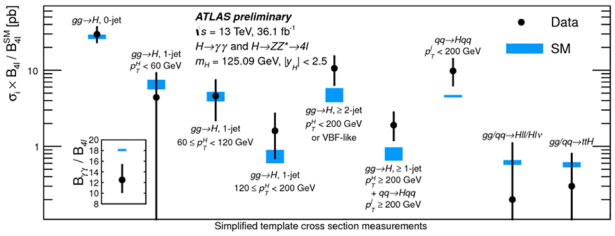
In what concerns our involvement in the ATLAS computing: the research topics include mainly the Spanish ATLAS Tier-2 goals of the Spanish HEP Program. During this year, the Tier-2 IFIC site has provided 23200 HS06 and 1800 TB of disk. The efficiency of the whole Tier-2 has been of about 97% (and in particular the IFIC part has got a very good performance). On top of that, the IFIC group has continued its role as centre of reference and advice in ATLAS computing. The ATLAS software and computing week was held at the IFIC premises with 125 attendees.

ATLAS: precision physics

The IFIC-ATLAS group contributed to many of the analysis of the proton-proton collisions data recorded by the experiment during LHC Run-1 (8 TeV) and Run-2 (13 TeV).

One of the main analysis lines focuses on the properties of Higgs boson measurements with 13 TeV data in the two photons final states, in particular its fiducial and differential cross-section and the measurements of the individual Higgs boson production modes.

The IFIC researchers have contributed to the first ATLAS measurements based on the Simplified Template Cross-Section (STXS). This is a new methodology to measure the Higgs boson cross-section which defines the phase spaces of interest balancing the precision of the theoretical uncertainties and the accuracy of the experimental measurements.



Best-fit results of STXS measurement regions.

Following a proposal of theoretician colleagues from IFIC-València and U. Granada, our group has led the ATLAS analysis sensitive to anomalous couplings in the Wtb vertex, in particular to its complex phases. This analysis is performed on t-channel single top quark produced events. Two publications in 2017 emanated from this effort. Both analyses used Run-1 (8 TeV) data, although two approaches were followed: either the measurements of asymmetries of one dimensional lepton angular distributions or the measurements of the triple-differential angular decay rate. These have led to the first measurements of the six W-boson polarisation observables and the most precise measurement of the top quark polarisation, as well as the strongest constraints on the complex parameters of the effective Lagrangian that describes the properties of the Wtb vertex. Within the current uncertainties, all measurements are in agreement with Standard Model predictions.

The group has also proposed the measurement of the four-dimensional top decay distribution, allowing to extract the top polarisation in three orthogonal directions and the five parameters determining the top decay distributions.

Also, within the context of single top quark physics, one of our members participates at the specialized group of theoretician and experimental experts who perform all the LHC or and Tevatron combinations from published results in the top-quark sector. This group also prepares and supervises all the material shown in publications and conferences.

The group is preparing the ATLAS measurement of the top quark pole mass on the 8 TeV ATLAS data, which aims for a very competitive precision of 1 GeV. In 2017 the group, moreover, published an interpretation in terms of the running MS mass of the previous measurement on 7 TeV collision data. This is currently the most precise measurement of the running mass of the top quark.

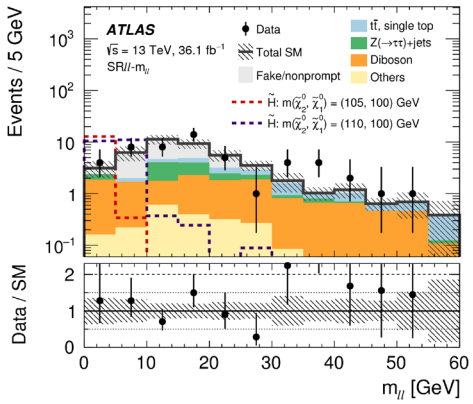
Theory	$m_t(m_t)$ (GeV)		M_t^{pole} (GeV)
$\mathcal{R}\,(m_t(m_t))$	$165.9^{+2.4}_{-2.0}$	$\rightarrow$	$173.5^{+2.5}_{-2.1}$
$\mathcal{R}\,(M_t^{\text{pole}})$	$165.8^{+2.2}_{-2.0}$	$\leftarrow$	$173.7^{+2.3}_{-2.1}$

Summary of the pole mass and running mass extracted from tt+jet events, and the values obtained from a conversion between both schemes, showing excellent consistency between the results in both schemes.

ATLAS: new physics searches

One of our main contributions has been to the final results of the searches for lepton flavour violating decays of the Higgs boson of the ATLAS experiment with the LHC Run 1 data, as well as the search for new heavy particles decaying to Higgs boson pairs.

In what concerns the searches for supersymmetric (SUSY) particles, the group has pioneered the ATLAS R-parity violating (RPV) SUSY searches. Our main analysis considers the channel with two strongly-produced electron or muons and large missing transverse momentum. Our collaboration with several theoretical physicists for the interpretation of the results has to be highlighted. In addition, in 2017 we searched for light higgsinos characterised by compressed spectra, a well-motivated scenario by naturalness arguments and an experimentally challenging final state. The results offer sensitivity beyond LEP limits. Furthermore, the fully hadronic channel, in which we are also involved, provides the strongest sensitivity for many supersymmetric scenarios.



Dilepton invariant mass distribution in searches for light higgsinos. Leptons of transverse momentum as low as 5 GeV are utilised.

Concerning direct searches for new physics in the top sector, the two analyses which are being pursued at IFIC with first Run-2 data are the search for dark matter candidates produced in association with single top quarks and the search for singly produced vector-like top quarks. Both analyses consist on a search for invisible particles produced in association with single-top quarks.

We would like to mention also our developments of novel techniques for the selection and reconstruction of highly boosted top quarks. In 2017 ATLAS published the first exhaustive in-situ calibration of the response to large-R jets and jet substructure, and a complete characterization of the performance of constituent-level pile-up subtraction methods, efforts that are led by our group.

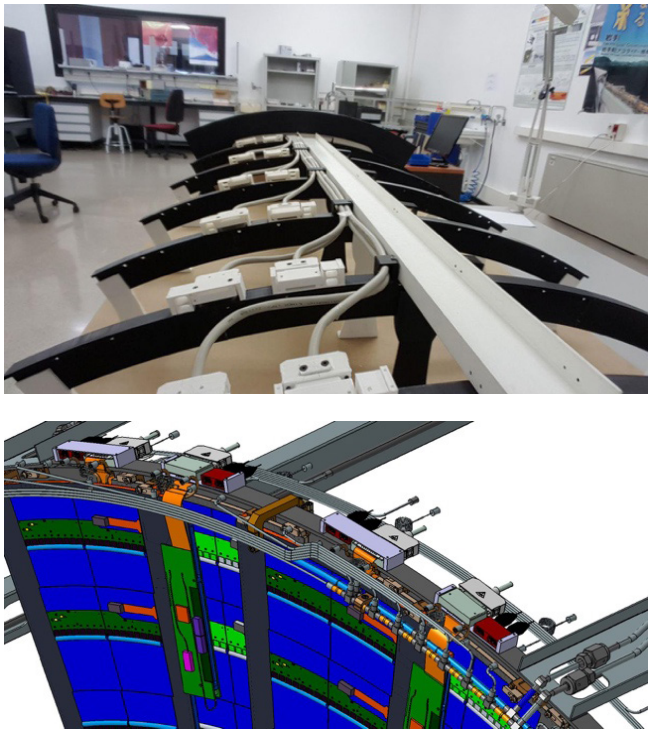
Sensitivity in the challenging phase-space of compressed spectra achieved in SUSY searches

ATLAS: upgrade

The upgrade of the LHC towards its High-Luminosity phase (HL-LHC) is planned to start collecting data in 2026. It will be operational for more than ten years, during which time ATLAS aims to accumulate a total data set of 4000 fb^{-1}.

The IFIC group is responsible of the Upgrade of the TileCal off-detector electronics. The TilePreProcessor (TilePPR) will be the core of TileCal off-detector electronics. The first prototype has been fully designed and built by our group with the purpose of standing full digitization of the calorimeter trigger data and transmission at 40 MHz rate with an accept trigger rate above 1 MHz. The TilePPR demonstrator prototypes have been used successfully during two test-beam tests at CERN in June and September 2017.

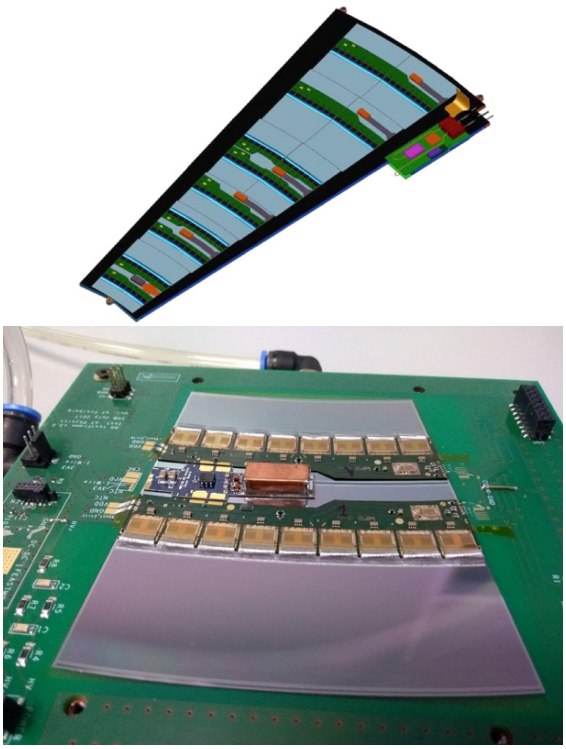
The ATLAS collaboration will replace the central tracking system for the HL-LHC. The ITk will be an all silicon detector formed by an inner pixel system surrounded by the strip sub-detector. The Technical Design Report (TDR) where the collaboration describes the design of the subsystem was approved during 2017. IFIC participated in the chapters for the sensors, the global support structure and the services (power and cooling). The current design of the ITk-Strips detector has 4 cylinders in the barrel and two 1.5 m long endcap cylinders at each side. Each of the cylinders houses 6 wheels that will be made of 32 petals. The petals are carbon fibre sandwiches that combine the mechanical support with all the required services.



Mock-up of the service tray built in Valencia and current design of the connections from services to petals.

IFIC plays a very important role in the design and construction of the endcap region and is responsible of the design of the endcap sensors, the petals and has participated in the design and simulation with finite elements of the global structure. The services that bring the power and control signals to the petals are also our responsibility. A mock-up of an octant of the endcap cylinder has been built. It contains the service trace and models the connectors and patch panel at the rear of the cylinder to study and determine the routing of the services and their connection to the petals.

Our group is taking care of the industrialization of the petal cores. A number of them have been already fabricated and have been characterized in our thermo-mechanical laboratory. Our group has started to prepare the laboratory for the production of the main parts of the system. Actually, the assembly of the readout electronics and the sensors in the module as well as the positioning of those modules onto the petal will happen in our laboratories.



A 3D CAD model of a fully populated petal on the left. Right: module with the electronics and power board glued on top of the sensor.

The knowledge of the damage threshold is the base for the evaluation of the risk of damages to the experiments in case of fast beam losses. In 2017, an experiment designed to provide a realistic estimate of the damage threshold for the ATLAS pixel and strip sensors and electronics was performed at the HiRadMat facility at the CERN Super Proton Synchrotron.

LHCb experiment

Since the start of the LHC Run 2, the experiment has integrated about 3.8 fb-1 of data, of which 1.8 fb-1 were recorded during 2017. Our group has contributed to the operation of the electromagnetic calorimeter and data quality.

During 2017, LHCb continued completing and extending physics analyses using both: Run 1 (3 fb^{-1}) and Run 2 (1.7 fb^{-1} from 2016 harvest). The so-called B flavour anomalies, first evidenced in 2014 and 2015, have continued to receive special attention. New measurements of lepton flavour universality, e.g. in $B^0 \to K^{*0} \ell^+ \ell^-$ decays, mediated by flavour-changing neutral currents (FCNC), and the charged-current (tree level) $B^0 \to D^{*+} \tau\text{-}\upsilon$ decay, with the tau decaying into hadronic final states, has shown 2.5σ discrepancies with respect to SM predictions, along the line of previous measurements in other decay modes.

In this context, our group has a big involvement in the study of FCNC process sensitive physics beyond the SM through the detection of an anomalous photon polarization (right-handed for a beauty quark). The experimentally challenging time-dependent analysis of the $B^0_s \to \phi\gamma$ radiative decay, an important milestone of the experiment, was published. Other related analyses are progressing well, including the study of time-dependent CP violation in B0s$\to \phi\gamma$ decays and angular distributions of b-baryon radiative decays.

Motivated by the potential and largely unexplored territory of heavy baryons, the group started during 2017 to get involved in a wide program of measurements using both LHC proton-proton and internal proton-gas SMOG (System for Measuring Overlap with Gas) data. These analyses aim at measuring hyperon polarizations, effective parity-violating decay asymmetry parameters, dynamical structure and polarised production in charm (and ultimately beauty) baryons.

The LHCb IFIC's group has been a main actor in the study of FCNC process sensitive physics beyond the SM through the detection of an anomalous photon polarization

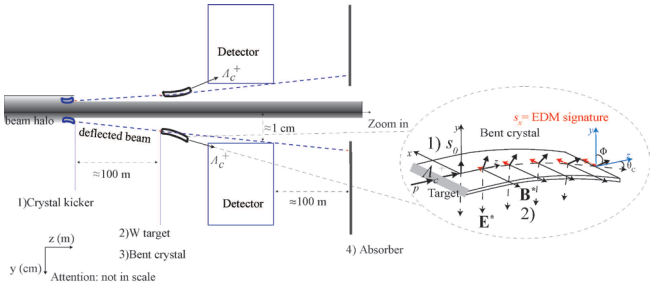
LHCb: upgrade

An upgraded LHCb detector will be installed and commissioned for the LHC Run 3. This upgrade will employ a 40 MHz readout with a flexible software-based trigger, which will provide significantly increased efficiency in hadronic final states, and allow the experiment to function effectively at the higher luminosity of $2x10^{33}$ $cm^{-2}s^{-1}$. The readout electronics will be completely replaced as well as some subsystems. Among these, the current tracker downstream the LHCb dipole magnet will be substituted by a Scintillating Fibre (SciFi) system. The upgraded detector will also offer the experiment to trigger on new signatures, such as long-lived particles and fixed-target topologies, opening new physics opportunities.

The SciFi detector has required the design of a high-performance front-end electronics capable to readout the SiPMs devices coupled to the 2.5m fibres with a good noise suppression. During the past years the IFIC's group has contributed to the design and testing of the front-end chip, which has developed into a 64-channel ASIC called PACIFIC, based on TSMC 130nm technology. During 2017 the final prototype (PACIFICr5), has been designed and fully characterized, allowing to successfully pass the Production Readiness Review (PRR). This effort has been backed by two test beam campaigns. A few key improvements were included in the production version of the chip, including an optimised sampling mechanism and additional radiation protection schemes for the digital block. In parallel, effort was invested in producing a compact test setup for both the ASICs and PCBs where the chips will be mounted, which allows to study the electronics under realistic conditions.

LHCb: fixed-target physics at LHCb upgrade

During 2017 the LHCb Collaboration started to explore new ideas to extend its physics program with the upgrade detector through a fixed target program. This would be in fact a natural extension of its current SMOG device. The IFIC group has been playing a major role in the proposal that aims at accessing magnetic and electric dipole moments of heavy fermions, such as charm baryons, and ultimately beauty baryons and tau leptons. The proposal would require the installation upstream the detector of a tungsten target, where the heavy fermions would be produced from impinging protons extracted from the LHC halo, paired to a silicon (or germanium) bent crystal, where the intense electromagnetic field between crystal atomic planes would induce spin precession while steering the fermions within the detector acceptance. The experimental setup aims at an installation during an EYETS after LS2. The proposal is also under discussion in the context of the CERN's Physics Beyond Colliders (PBC) study group.



Conceptual layout of the fixed-target setup shown in side view with down- and up-bending crystals. The zoom in shows the spin precession in the down-bending crystal for channeled Λ_c^+ baryons.

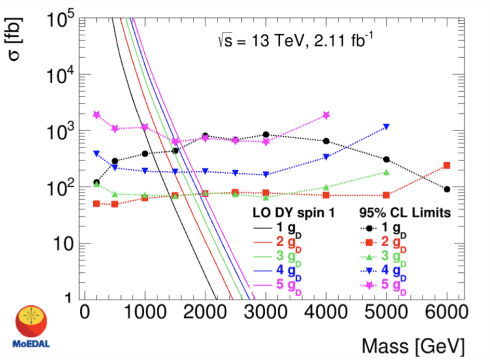
MoEDAL experiment

The IFIC-València team is the only Spanish participation in MoEDAL. This experiment is designed to search for manifestations of new physics through highly-ionising particles (HIPs) produced at the LHC. One of its motivations is to pursue the quest for magnetic monopoles, yet the experiment is also sensitive to any massive, stable or long-lived, slow-moving particles with single or multiple electric charges. MoEDAL uses a passive detector sitting next to LHCb, featuring aluminium monopole trapping detector volumes (MMTs), plastic NTDs (Nuclear Track Detectors) and TimePix detectors.

Our group is involved in the simulation of the detector, and also in the development and testing of key theoretical scenarios, such as the monopole production via photon fusion and SUSY models. It is important to highlight that our group plays a leading role in the MoEDAL management by holding the Chair of the Collaboration Board.

The 2017 MoEDAL physics results were based on MMTs exposed at an energy of 13 TeV. The MMTs were analysed by a superconducting quantum interference device looking for magnetic monopoles, showing no evidence yet for monopoles. The results allowed MoEDAL to place mass limits for spin-1 charges for the first time at the LHC. The world-best limits for monopoles of high magnetic charges, up to 5gD, and for masses up to 6 TeV were set.

Spin-1 magnetic monopoles have been constrained for the first time experimentally



Upper limits on production cross section for spin-0 magnetic monopoles and for different magnetic charges.

FUTURE COLLIDERS

Our group is also involved in the prospective studies for the feasibility of future colliders. We have contributed to the physics potential studies of linear collider projects as ILC (International Linear Collider, to be hosted in Japan) and CLIC (Compact Linear Collider, led by CERN). Our studies focused on precision measurements of the top quark and its electro-weak couplings. Our group has developed a new method to measure the top quark mass in radiative events.

The R&D effort in next-generation active pixel detectors had as main goal a contribution to the construction of the Belle II vertex detector in DEPFET technology, that is also an important candidate for the linear collider experiments and the development of pixel sensors with integrated micro-cooling channels.

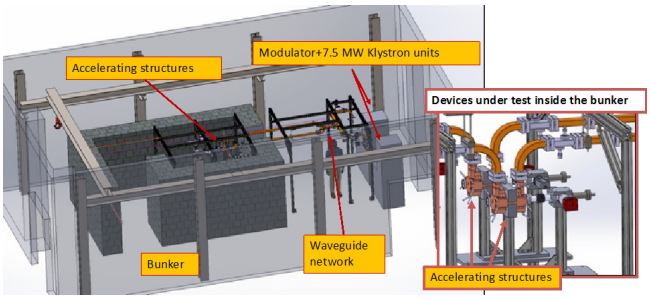
The R&D effort in next generation active pixel detectors contributed to the Belle II vertex detector, DEPFET

ACCELERATOR PHYSICS

IFIC-València is involved in the research studies of High-Gradient (HG) Radio-Frequency (RF) technologies for the CLIC collider, as well as in the construction of an RF facility at IFIC to conduct R&D studies.

Our group is engaged in the construction, commissioning and operation of the Xbox facilities at CERN. These are klystron-based X-band test stands dedicated to the testing and development of high-gradient accelerating cavities and high-power RF components. One of the test-stands that has been built is located at CTF3, operates in S-band and is being used to test a prototype accelerating cavity for a medical proton linac. The cavity was designed and built using technology developed by the CLIC collaboration and the special feature of this design is to produce gradient of more than 50 MV/m in low-β accelerating cavities (v/c=0.38).

An S-band High-Gradient RF facility is under construction at IFIC premises. The purpose of the facility is to perform investigations of HG phenomena and to develop normal-conducting RF technology, with special aim in hadron-therapy. The layout of the facility is derived from the scheme of the Xbox3 test facility at CERN and uses medium peak-power and high repetition rate klystrons, whose RF output is combined to drive two testing slots to the required power. The design and construction of the various components of the system started is progressing well.



3D of the high-power RF network of the IFIC HG RF facility and integration.

The IFIC group participates in the development of High-Gradient technology for compact accelerators

Selected Publications

ATLAS Collaboration (Aaboud, M. et al.), *Probing the Wtb vertex structure in t-channel single-top-quark production and decay in pp collisions at √s=8 TeV with the ATLAS detector*, https://doi.org/10.1007/JHEP04(2017)124 and *The fully differential top decay distribution*, Eur. Phys. J. C (2017) 77:200

ATLAS Collaboration (Aad, G et al.), *Search for lepton-flavour-violating decays of the Higgs and Z bosons with the ATLAS detector*, Eur. Phys. J. C (2017) 77: 70. https://doi.org/10.1140/epjc/s10052-017-4624-0

ATLAS Collaboration (Aad, G et al.), *Evidence for the H → bbar decay with the ATLAS detector*, JHEP 12 (2017) 024. 10.1007/JHEP12(2017)024

ATLAS Collaboration (Aaboud, M. et al.), *Search for electroweak production of supersymmetric states in scenarios with compressed mass spectra at √s = 13 TeV with the ATLAS detector*, Phys. Rev. D 97, 052010 (2018), 35pp, DOI: 10.1103/PhysRevD.97.052010 [arXiv:1712.08119].

L. M. Garcia Martin, L. Henry, F. Martinez Vidal, A. Oyanguren, C. Remon Alepuz, P. Ruiz Valls, J. Ruiz Vidal, C. Sanchez Mayordomo et al. [LHCb Collaboration], Test of lepton universality with $B^0 \to K^{*0} \ell^+ \ell^-$ decays, JHEP 1708 (2017) 055

MoEDAL Collaboration (Acharya, B. et al), *Search for magnetic monopoles with the MoEDAL forward trapping detector in 13 TeV proton-proton collisions at the LHC*, Phys. Rev. Lett. 118, 061801 (2017), 6pp, DOI: 10.1103/PhysRevLett.118.061801 [arXiv:1611.06817].

Selected Conference Talks

Damián Álvarez, *Search for neutral and charged BSM Higgs Bosons with the ATLAS detector*, The XXIII International Workshop High Energy Physics and Quantum Field Theory (QFTHEP 17), Yaroslavl, June 2017, Plenary Talk.

L. Fiorini, *Yukawa Couplings of the Higgs boson at LHC*, Spanish Flavour Network, Benasque, 22-26 May 2017. Talk.

J. Mamuzic, *SUSY searches at ATLAS*, Corfu2017, September 2017, Corfu, Greece

F. Martínez Vidal, *Recent LHCb results on hints for New Physics*, Plenary talk, PASCOS 2017-International Symposium on Particles, Strings and Cosmology, Madrid (Spain). June 2017.

V.A. Mitsou, *Searches for magnetic monopoles and beyond with MoEDAL at the LHC*, EXA2017, Vienna, Austria.

D. Esperante, *High-gradient RF activities in Valencia*, International Workshop on Future Linear Colliders (LCWS2017), October 2017, Strasbourg, France.

EXPERIMENTAL ASTROPARTICLE PHYSICS

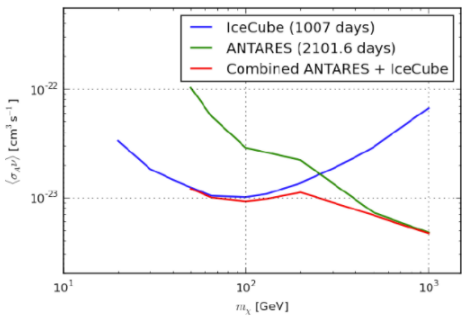
The year 2017 has brought important advances in the field of neutrino astronomy. For the first time, a simultaneous detection of high energy neutrinos and electromagnetic counterparts has been announced by IceCube and other experiments (Fermi, Agile, MAGIC…). Concerning the projects in the Mediterranean, progress continues in two parallel sides: many new results of ANTARES have been published, showing the maturity of the project, and KM3NeT continues gaining high momentum in terms of detector construction, funding and community support. The ANTARES/KM3NeT group of IFIC has actively participated in these achievements.

ANTARES

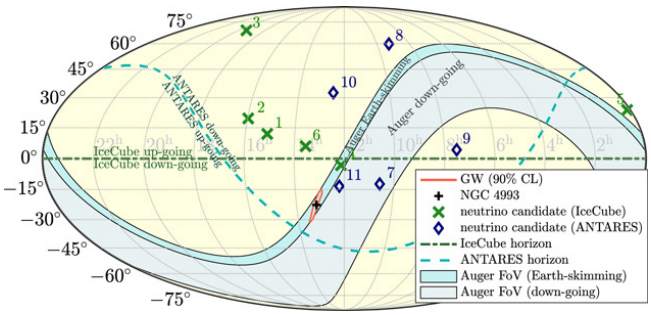
The ANTARES detector has continued taking data and producing new scientific results. As a matter of fact, the number of publications by ANTARES in 2017 has reached a maximum, more than doubling the score of the previous year and showing that mature experiments produce particularly rich harvests in their final years.

The contributions of our group to this harvest are various, including the search for point sources, dark matter and transient events. We have published the newest results of the search for neutrino point sources including for the first time cascade events. In water, these events can be reconstructed with an angular resolution good enough to help to look for point sources (contrary to what happens in ice, where they cannot be reconstructed in a useful way for these analyses).

The results of the search for dark matter, both for the Sun and the Galactic Centre, have been published this year, showing, for instance, the best limits worldwide in WIMP annihilation cross section for masses above 30 TeV. The main author of these analyses, Christoph Tönnis has successfully defended his doctoral thesis in 2017 and moved to IceCube to continue working on dark matter. An interesting novelty this year is the first combined analysis of dark matter searches using ANTARES and IceCube data.



Among the analyses on transient sources, one of the hottest topics has been the search for correlation with gravitational waves, following the alerts sent by LIGO. The IFIC group has also led this analysis and the publication of the corresponding papers. Another particularly interesting event has been the alert sent by IceCube of a high energy neutrino event, for which an electromagnetic counterpart has been detected by several experiments (gamma rays, radio, optical). Our group is analysing the data corresponding to this event.



Localizations of the events observed within 500 s around the gravitational wave GW170817 by ANTARES, IceCube and Auger.

The IFIC group in ANTARES leads the analyses on transient sources and its correlation with gravitational waves

KM3NeT

The KM3NeT Collaboration has continued the construction of the detector and the analysis of the data collected with the first lines. The first line of the ORCA part of KM3NeT (located in France) has been deployed and has provided its first data.

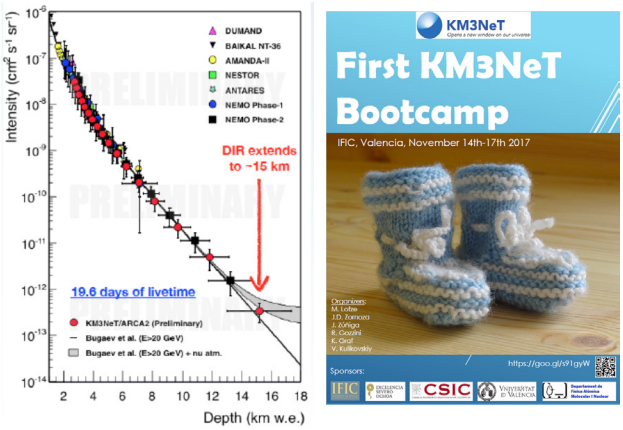
One of the highlights of the year has been the "strong endorsement" of the project by the Astroparticle Physics European Consortium (APPEC), who has included KM3NeT as priority in its strategy for the period 2017-2026 (reminder: KM3NeT was also included in 2016 in the ESFRI Roadmap).

During this year our group has firmly started a new front in physics analyses, which is considered as a strategic opportunity: the determination of the neutrino mass ordering with ORCA. This has been made possible thanks to the joining of a new postdoc with the H2020-InfraDev project with which our group was awarded last year. Within this European

project an ERIC is being set up for the KM3NeT infrastructure

The IFIC group has also organized the First KM3NeT Bootcamp, for new (and not so new) members in the Collaboration. This bootcamp covered analysis tools, simulations, data access, efficient programming, etc. More than 50 people attended this workshop, where experts of the Collaboration gave hands-on training.

Moreover, we have continued our tasks of design/tests of the main electronics elements of the detector (CLBs and PBs). Our lab at IFIC is the electronics upkeep node of KM3NeT.



Left: Intensity of muon flux as a function of depth measured by one of the deployed ARCA lines. Right: Poster of the First KM3NeT Bootcamp, organized at IFIC.

Selected Publications

ANTARES Collaboration (A. Albert et al.), *Results from the search for dark matter in the Milky Way with 9 years of data of the ANTARES neutrino telescope*, Phys. Let. B 769 (2017) 249, [arXiv:1612.04595]

ANTARES Collaboration (A. Albert et al.), *Search for Dark Matter Annihilation in the Earth using the ANTARES Neutrino Telescope*, Physics of the Dark Universe 16 (2017) 41–48, [arXiv:1612.06792]

ANTARES Collaboration (A. Albert et al.), *Search for High-energy Neutrinos from Gravitational Wave Event GW151226 and Candidate LVT151012 with ANTARES and IceCube*, Phys. Rev. D 96 (2017) 022005, [arXiv:1703.06298]

ANTARES Collaboration (A. Albert et al.), *First all-flavour neutrino pointlike source search with the ANTARES neutrino telescope*, Phys. Rev. D 96, 082001 (2017), [arxiv:1706.01857]

LIGO, ANTARES and other Collaborations (B. P. Abbott et al., A. Albert et al.), *Multi-messenger Observations of a Binary Neutron Star Merger*, ,ApJL 848 L12 (2017), [arXiv:1710.05833]

Selected Conference Talks

J.D. Zornoza, *Recent results from neutrino telescopes + ANTARES/KM3NeT*, CPAN Days, October 2017, Santander, Spain

G. Illuminati, J. Barrios, *All-flavour Neutrino Point-like Source Search with the ANTARES Neutrino Telescope*, ICRC2017, July 2017, Busan, South Korea

D. Real, D. Calvo, S. Colonges, *Reliability studies for KM3NeT electronics: The FIDES method*, ICRC2017, July 2017, Busan, South Korea

A. Coleiro, *Multi-messenger astronomy*, summer school on gravitational waves for cosmology and astrophysics, June 2017, Benasque, Spain.

A. Coleiro, *Multi-messenger astronomy with the ANTARES neutrino telescope*, Les Rencontres de Moriond 2017 (Very High Energy Phenomena in the Universe), March 2017, La Thuile, Italy

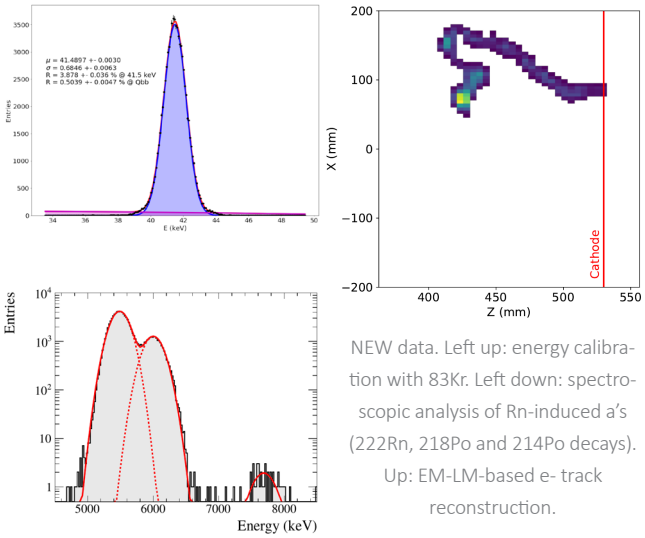
EXPERIMENTAL NEUTRINO PHYSICS

During 2017, the experimental Neutrino Physics group has continued with its activities on the NEXT, T2K and DUNE/ProtoDUNE experiments, in the quest for an answer to the major open questions in the physics of massive neutrinos.

NEXT

The NEXT experiment searches for the ββ0ν decay with a gaseous xenon TPC, an approach combining excellent energy resolution, powerful signal-background discrimination, and scalability. After demonstrating the feasibility of the technology, the first physics phase of NEXT, the NEW detector, is undergoing at LSC. During 2017, a second data taking period has comprised a calibration campaign with various calibration sources (^{83}Kr, ^{137}Cs, ^{228}Th) and a physics run meant to measure the radon induced backgrounds for the bb searches. The calibration data have allowed to achieve energy resolutions which extrapolate well below 1% FWHM at the ^{136}Xe Qbb (2.458 MeV), after characterizing the electron lifetime and the geometrical effects.

In addition, the electron drift properties in high pressure Xe have been measured. The physics data samples have been used to estimate the internal Rn activity and to evaluate the level of Rn-induced backgrounds, which are proven to be non-dominant in the ββ2ν (NEW) and ββ0ν (NEXT-100) searches. Beyond the analysis of the NEW data, a ML-EM tracking reconstruction algorithm and DNN-based background rejection techniques have been developed and published.

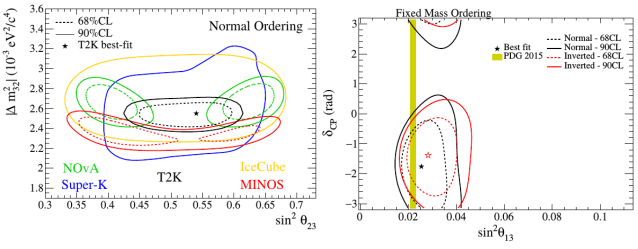


NEW data. Left up: energy calibration with 83Kr. Left down: spectroscopic analysis of Rn-induced a's (222Rn, 218Po and 214Po decays). Up: EM-LM-based e- track reconstruction.

T2K

The T2K long baseline neutrino oscillation experiment, in Japan, published in the past the most precise limit so far on the δ_{CP} value resulting from its discovery of the appearance of electron neutrinos in a muon neutrino beam. In 2017, new oscillation results have been released. Taking into account all the available data samples, a global oscillation analysis is performed, producing a simultaneous measurement of the oscillation parameters $|\Delta m_{32}^2|$, $\sin^2\theta_{23}$, $\sin^2\theta_{13}$ and δ_{CP}, and the neutrino mass ordering.

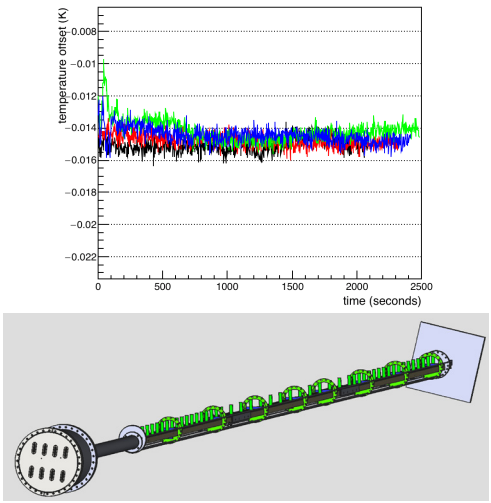
When combined with reactor measurements, the hypothesis of CP conservation ($\delta_{CP} = 0$ or π) is excluded at 90% confidence level. The IFIC group has continued contributing to the oscillation analyses in several ways. IFIC members are co-conveners of various T2K working groups in the ND280 near detector (software, "new physics", muon neutrino input to oscillation analyses, etc). Beyond those coordination activities, the IFIC group is heavily involved in several software, calibration and analysis activities in ND280, being the main focus the measurement of the unoscillated anti-neutrino flux.



T2K oscillation results in 2017. Left: two-dimensional ($|\Delta m|$,$\sin^2\theta_{23}$) contours. Right: two-dimensional (d_{cp},$\sin^2\theta_{13}$) contours, superimposed to the reactor-based θ_{13} value.

DUNE

DUNE is a next-generation neutrino facility, with a very rich scientific program, including neutrino oscillations, nucleon decay searches and astroparticle physics. It plans to start data taking in 2026. After joining the collaboration in 2016, the IFIC group has been actively involved in the ProtoDUNE-SP prototype (CERN) in 2017. In particular, it coordinates the Cryogenics Instrumentation and Slow Control working groups. The IFIC group is building and calibrating a system to provide the 3D temperature map over the entire cryostat with a precision better than 0.005 K. The group has been also very active in preparing the physics program for the DUNE project, co-coordinating the Nucleon Decay Physics working group and contributing to the software and sensitivity studies.



ProtoDUNE-SP instrumentation. Up: temperature offset between two sensors in liquid Ar. Down: 3D model for the 9 m long temperature sensor array (green rectangles).

IFIC built a system to provide the 3D temperature map over the entire cryostat of ProtoDUNE-SP with high precision

Selected publications

T2K Collaboration (Abe, K t al), *Combined Analysis of Neutrino and Antineutrino Oscillations at T2K*, Phys. Rev. Lett 118, no.15, 151801 - 9 pp, DOI: 10.1103/PhysRevLett.118.151801 [arXiv:1701.00432].

T2K Collaboration (Abe, K t al), *Measurement of neutrino and antineutrino oscillations by the T2K experiment including a new additional sample of ve*, Phys. Rev. D96, no.9, 092006 – 49 pp, DOI: 10.1103/PhysRevD.96.092006 [arXiv:1707.01048]

NEXT Collaboration (Simón, A. et al), *Application and performance of an ML-EM algorithm in NEXT*, JINST 12, no. 08, P08009 – 21pp, DOI: 10.1088/1748-0221/12/08/P08009 [arXiv:1705.10270].

NEXT Collaboration (Renner, J. et al), *Background rejection in NEXT using deep neural networks*, JINST 12 (2017) no.01, T01004 – 21 pp, DOI: 10.1088/1748-0221/12/01/T01004 [arXiv:1609.06202].

Selected Conference Talks

M. Sorel, *Status of DUNE*, NUFACT 2017, September 2017, Uppsala, Sweden.

A. Simón, *The NEXT experiment for bb0n decay searches*, TAUP 2017, July 2017, Sudbury, Canada.

A. Izmaylov, *T2K neutrino experiment: results and future perspectives*, XVII Neutrino Telescopes, Venezia, Italy.

P. Novella, *NEXT: searching for the bb0n decay at the LSC*, PANIC 2017, September 2017, Beijing, China

NUCLEAR PHYSICS

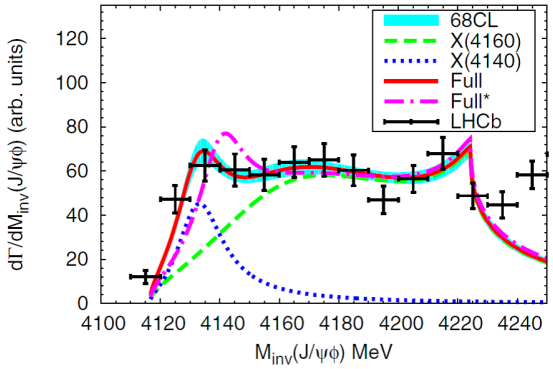
The experimental Nuclear Physics activity at IFIC is carried out by two groups, the Gamma and Neutron Spectroscopy group and the AGATA group.

The research of the **Gamma and Neutron Spectroscopy Group** covers aspects of nuclear structure, astrophysics and applications.

Some of the most important results of the group this year are related to the study of beta decays that can have impact in more fundamental applications. These results are based on experiments performed at state of the art installations to produce the exotic nuclei of interest. For example, the publication by A. I. Morales et al. in *Physical Review C* (PRC 95, 064327 (2017)) presents the results of the study of the beta decay of two isomers in ^{70}Br produced in the in-flight fragmentation of ^{78}Kr at RIKEN, Japan. Apart from the new nuclear structure results, from this experiment it was possible to determine with a better precision the $T_{1/2}$ of the decay of the 0+ isomer and estimate for the very first time the super-allowed 0+ → 0+ branching fraction of ^{70}Br. These results are the first steps to include this decay among the cases used for testing the CVC hypothesis and calculating the Vud matrix element of the Cabibbo-Kobayashi-Maskawa (CKM) matrix. We also confirmed the need to perform a new measurement of the atomic mass of ^{70}Br. As a consequence a proposal for measuring it at the ISOLTRAP (CERN) Penning trap was also presented.

Another example is the study of the beta decay of ^{100}Tc by V. Guadilla et al. (PRC 96, 014319 (2017)) using the total absorption spectrometer DTAS developed by the group for the DESPEC experiment at FAIR. This decay experiment was performed at the IGISOL IV facility of the Univ. of Jyväskylä, Finland using isotopically purified beams provided by the JYFL Penning-trap. This single decay is considered of relevance to fix parameters used in theoretical calculations of the A=100 double beta decay system. With this measurement we confirmed the results previously obtained using the high-resolution spectroscopy. These results are also relevant for a second order correction of the antineutrino flux produced in reactors which is associated with the beta decay of nuclei produced in the neutron capture of long live fission products.

An important part of work of the group is devoted to the development of instrumentation. The group plays a key role in the BRIKEN collaboration, which has constructed the largest beta delayed neutron detector based in He3 counters and installed it at RIKEN. An article by A. Tarifeño-Saldivia et al.(JINST 12 P04006 (2017) presents details of the design of this detector. The Gamma and Neutron Spectroscoy Group has developed the data acquisition used in the experiment and presently coordinates the BRIKEN collaboration.



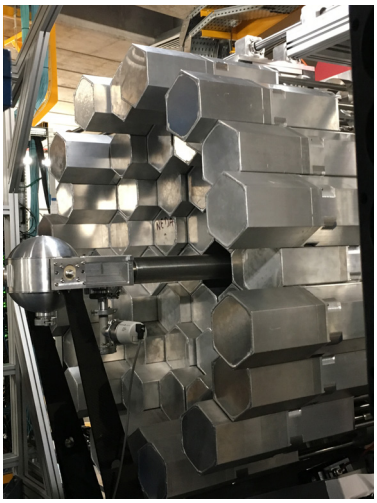
In the framework of the ERC-Consolidator project HYMNS (High sensitivitY Measurements of key stellar Nucleo-Synthesis reactions) in 2017 several neutron-capture measurements were successfully carried out at CERN n_TOF. This allowed validating technically a prototype of i-TED, Total-Energy Detector with gamma-ray imaging capability. The group is working on the development of an i-TED demonstrator to carry out proof-of-concept measurements during 2018.

In the R+D+i project between IFIC and ENRESA, the GUALI-I (Gamma Unit Advanced Location Imager) was completed in 2017. GUALI-I consists of a portable gamma-camera with large field-of-view and capability to identify, locate and quantify gamma-ray emitting radioisotopes. This apparatus is helping in the decommissioning of the José Cabrera nuclear power plant in Zorita, Guadalajara.

The year 2017 has been of particular interest for the IFIC AGATA group. In addition to the contribution to AGATA, the group worked in the last 8 years in the

The Gamma and Neutron Spectroscoy Group developed the data acquisition used in BRIKEN and coordinates the collaboration

development of ancillary instrumentation for AGATA, in particular in the Neutron Detector Array NEDA. The IFIC contribution to this detector ranges from electronics to detector production and mechanics. During 2017 NEDA was installed at GANIL and put on operation, coupled to AGATA, as preparation to the experimental campaign to be done in 2018.



The NEDA Array Coupled to AGATA at GANIL.

Additionally the AGATA group of IFIC has participated to the AGATA experimental campaign performed in 2017 in GANIL. In this year the AGATA setup has included, as complementary instrumentation, several detector, as FATIMA, a detector array for fast timing developed by a collaboration led by the Universidad Complutense de Madrid. The campaign included as well the experiment E693, with A. Jungclaus, a member of the AGATA-Spain collaboration, as Spokesperson.

The Gamma and Neutron Spectroscopy group has published/coauthored 22 articles in 2017 including 3 *Physical Review Letters*. The AGATA group has published/coauthored 15 articles including one in *Physics Letter B* and another in *Physical Review Letters.* One PhD student of the AGATA group has presented his thesis obtaining the qualification of excellence

The AGATA group of IFIC participated to the experimental campaing in GANIL, with A. Jungclaus as Spoksperson of the experiment E693

Selected publications

A. I. Morales et al., *Simultaneous investigation of the T = 1(Jπ = 0+) and T = 0(Jπ = 9+) beta decays in 70Br*, Phys. Rev. C 95, 064327 (2017)

V. Guadilla et al., *Experimental study of 100Tc beta decay with total absorption gamma-ray spectroscopy*, Phys. Rev. C 96, 014319 (2017)

S. Rice et al., *Total absorption spectroscopy study of the β decay of 86Br and 91Rb*, Phys. Rev. C 96, 014320 (2017)

A. Tarifeño-Saldivia et al., *Conceptual design of a hybrid neutron-gamma detector for study of beta-delayed neutrons at the RIB facility of RIKEN*, JINST 12 P04006 (2017)

J. Dudouet et al., *96Kr Low-Z Boundary of the Island of Deformation at N=60*, Phys. Rev. Lett. 118, 162501 (2017)

L. Kucuk et al., *Half-life determination of Tz = −1 and Tz = −1/2 proton-rich nuclei and the beta decay of 58Zn*, Eur. Phys. J. A 53, 134 (2017)

B. Rubio et al., *Beta decay studies with total absorption spectroscopy and the Lucrecia spectrometer at ISOLDE*, J. Phys. G: Nucl. Part. Phys. 44, 084004, (2017)

Selected Conference Talks

J.L. Tain, *The BRIKEN project: Extensive measurements of beta-delayed neutron emitters for the astrophysical r process*, XXXV Mazurian Lakes Conference on Physics, Piaski, POLAND

A. Algora, *Experimental study of the beta decay of fission fragments*, Solvay Workshop on "Beyond the Standard Model with Neutrinos and Nuclear Physics", Brussels, Belgium

B. Rubio, *Discussion on EURISOL Distributed Facility*, Colloque GANIL 2017, Amboise, France

A. Tolosa-Delgado, *Commissioning of the BRIKEN beta-delayed neutron detector for the study of exotic neutron-rich nuclei*, 8th Nuclear Physics in Astrophysics International Conference, Catania, Italy

A. Gadea, *Status of the AGATA Project*, NUSPIN 2017, Darmstadt, Germany

GRID & E-SCIENCE

The research topics of this research line include mainly the Spanish ATLAS Tier-2 goals. It also includes several generic activities devoted to the application of Distributed Computing and to improve the performance of the physics analysis work:

− delivery of the committed resources for 2017 (in April). 2017 has been the first year funded by the project FPA2016-75141-C2-1-R of the Spanish HEP Program. During this year, the Tier-2 IFIC site has provided 21150 HS06 and 1950 TB of disk. The efficiency of the whole Tier-2 has been of about 98% (and in particular the IFIC part has got a very good performance).

− On 19th and 20th January took place the First IFIC Scientific Days and our group presented a talk about the 'GRID Tier-2 of the ATLAS Experiment' (see at https://indico.ific.uv.es/event/2874/).

− Organization of the Computing & Software Week at Valencia. With the horizon set in the flood of data that will provide the Large Hadron Collider (LHC) of CERN in the coming years, more than a hundred experts from around the world gathered at the ATLAS Software & Computing Week, an event organized by the IFIC, from June 12 to 16. This meeting has been held very rarely outside CERN and the fact that it takes place in Valencia on this occasion shows us the weight that the IFIC has in the distributed computing network (GRID) of ATLAS.

Poster announcing the Software & Computing Workshop held in Valencia.

On the verge of finishing the second cycle of operation of the LHC, Run 2 (2015-2018), the teams that manage the GRID are prepared for the avalanche of data of the next cycle (2021-2023), where the CERN accelerator will operate through end to the maximum of its benefits both in energy and light. This has been one of the main topics that the 125 attendees of ATLAS Software & Computing Week will discuss, attended by participants from the 130 research centers participating in ATLAS from around the world.

In addition, the GRID begins to prepare to face something new, the so-called High Luminosity LHC (HL-LHC), which from 2026 will increase by 10 the luminosity of the accelerator (measure of the number of collisions). This is another of the key issues of the meeting in Valencia, the planning of GRID resources to address the HL-LHC. The organizers of the congress estimate in almost 50% more the necessary computing resources from 2025.

− We have progressed in the main objectives of the project:

a) Taking into account the need of computing power in the near future our group has started the exploration of conventional ATLAS production and analysis pipelines and workflows on opportunistic resources, mainly HPC infrastructures (MareNostrum, Lusitania, etc). The ATLAS Event Service is a new computing framework to exploit these resources. In particular, in the commissioning of the new framework by developing several analysis tools to compare the performance of event service with respect to the standard framework. At the end of 2017 it started developing the monitoring tools for the computing shooters in order to facilitate a prompt identification of problems.

b) On the other hand, since the users wish to perform their interactive data analysis in the cloud, the SWAN platform (https://swan.web.cern.ch/) is being adapted to the IFIC environment. Currently the IFIC implementation is in a "proof-of-concept" stage so that the service works properly but the full platform setup is still underway

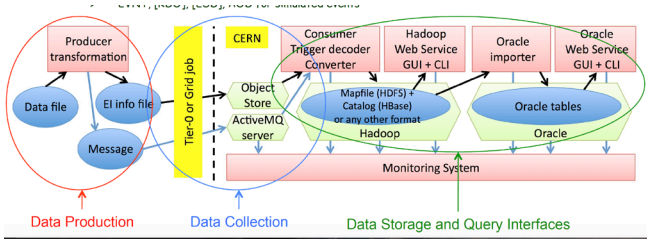
GRID begins to prepare to face something new, the so-called High Luminosity LHC, which will increase by 10 the luminosity of the accelerator

c) Monitoring of Frontier servers: The so called Frontier servers handle the enormous amounts of queries done by ATLAS jobs to access Conditions data in a parallel and distributed way; thus, optimizing the performance of the Oracle databases. The Frontier servers are composed by Tomcat servers and Squid servers. In order to understand the characteristics of the queries which cause occasional overloads on the frontier servers, a full monitoring system based on the ELK stack (Elasticsearch, Logstash and Kibana) has been established. The whole system treats the information coming from the Frontier servers (about 7M of queries with peaks of more than 12M each day) in real time.

d) Application methods for Physics Analysis in ATLAS: This new activity reinforces the link between the Computing experts and the ATLAS end-user community at IFIC. Our starting objective is Extraction of the top pair resonance signal from the SM process background using Multidimensional Analysis and Machine Learning techniques.

The Event Index Project and Event WhiteBoard

The Event Index Project (EI) has avanced and has been improved in different areas. During 2017 the IFIC team designed and put in production the Distributed Data Collection System based on the ObjectStore, collecting 1 billion indexed events/day on the grid since September 2017. The central Hadoop backend currently contains 63 billion entries for 2016 and 2017 real data and MC. The present EI scheme can be found in the figure.



Present schema of the Event Index project.

The IFIC developers recently added a new feature that allows to get trigger counts and overlapping in human time scale, processing millions of events in 2 minutes.

Our team is participating in the future evolution of Event Index, the so-called Event White Board (EWB) which includes capabilities to create logical collection of events for building Virtual Datasets:

− Created either explicitly (giving a collection of Event Ids) of implicitly (selection based on some other collection or event attributes).

− Labelling individual events by a process or a user with attributes (key:value)

On top of that, the IFIC group has continued its role as centre of reference and advice in ATLAS computing. This year the CSIC Cooperation Agreement I-COOP+ (COOPB20247) has started ('Launching a platform of GRID Computing in Morocco to meet the new challenges of Physics Research'). The activities have been the teaching of a training course on GRID Computing for the four moroccan PhD students of the University of Rabat (https://indico.cern.ch/event/606256/).The lectures have been given by members of our group. Moreover, the students have progressed in their thesis objectives (Physics in ATLAS experiment, Astroparticle and Medical Physics).

IFIC team designed and put in production the Distributed Data Collection System, collecting 1 Billion indexed events/day on the Grid

Selected publications

A. Pacheco Pagés, F.H. Barreiro Megino, D. Cameron, F. Fassi, A. Filipcic, A. Di Girolamo, S. Gonzalez de la Hoz, I. Glushkov, T. Maeno, R. Walker, W. Yang on behalf of the ATLAS Collaboration, *How to keep the Grid full and working with ATLAS production and physics jobs?*, Proceedings of the International Conference on Computing in High Energy and Nuclear Physics (CHEP16). Journal of Physics: Conference Series 898 (2017) 052001.

A. Fernández Casaní, D. Barberis, A. Favareto, C. García Montoro, S. González de la Hoz, J. Hřivnáč, F. Prokoshin, J. Salt, J. Sánchez, R. Többicke, R. Yuan, on behalf of the ATLAS Collaboration, *ATLAS EventIndex general dataflow and monitoring infrastructure*, Proceedings of the International Conference on Computing in High Energy and Nuclear Physics (CHEP16), 10-14 October 2016. San Francisco (USA). Journal of Physics: Conference Series 898 (2017) 062010, ATL-COMSOFT-2016-121.

C. Adam, D. Barberis, S. Crépé-Renaudin, K. De, F. Fassi, A. Stradling, M. Svatos, A. Vartapetian and H. Wolters on behalf of the ATLAS Collaboration, *Computing shifts to monitor ATLAS distributed computing infrastructure and operations,* Proceedings of the International Conference on Computing in High Energy and Nuclear Physics (CHEP16) Journal of Physics: J. Phys.: Conf. Ser. 898 (2017) 092004, ATL-SOFT-PROC-2017-004.

Selected conference talks

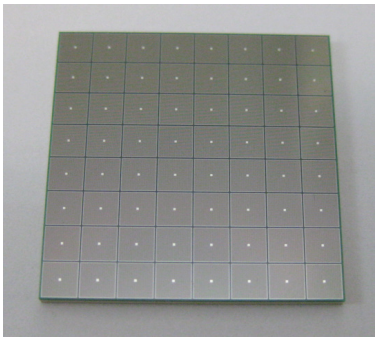
S. González de la Hoz, Building on the Event Index, 55th ATLAS Software and Computing week, Valencia (Spain), 12-16 June 2017.
E. Fullana Torregrosa, *How to monitor ES tasks?*, 56th ATLAS Software and Computing week and Technical Meeting, CERN, 18-22 September 2017.

J. Lozano-Bahilo, *Frontier Analytics and Alerts*, ADCand 56th Software&Computing Week 14th November 2017.

E. Fullana Torregrosa, *Event Service and Event Streaming Service*, 57th ATLAS Software and Computing week and Technical Meeting, CERN, 11-15 December 2017.

MEDICAL APPLICATION OF NUCLEAR AND PARTICLE PHYSICS

The IRIS medical physics group works on the development of a Compton telescope for hadron therapy treatment monitoring. In hadron therapy, protons or carbon ions are employed to administer the radiation dose to the patients. Given that the ions are stopped within the patient, secondary particles are employed to monitor the treatment, as opposed to the case of traditional gamma therapy. In order to monitor the treatment administration, PET techniques are employed which leave room for significant improvements. The group works on the development of a three-layer Compton telescope for treatment monitoring based on LaBr crystals and silicon photomultipliers (SiPMs) as photodetectors. A first version of the device was developed within the European project ENVISION and it has been tested in laboratory tests and in accelerator facilities, assessing the viability of this technique with satisfactory results.



SiPM array employed in the construction of the new detectors, with 64 channels.

The group is now working on the performance improvement of the system, both on the instrumentation side and on the image reconstruction codes. New detectors have been assembled employing last-generation silicon photomultiplier arrays with 64 pixel elements. This has led to an improved energy resolution with respect to the previous version. Energy resolution is a critical parameter in Compton cameras, as it can be deduced from theory and it has been shown in previous studies by the group. On the image reconstruction side, the group has extended the codes with the inclusion of a detailed model able to correct by sensitivity variations in the field of view. This extension allows imaging regions which are outside the telescope footprint. In addition, the image reconstruction codes start to include events made of three interactions in different planes. Despite these events are less abundant, they convey more information than conventional, two-interaction ones.

As a result, the prototype has significantly improved its performance. It has been possible to image an array of 37 point-like Na-22 sources separated 10 mm from one another, which could not be imaged with the previous version of the prototype. In addition, the first tests in accelerator facilities have been carried out at CNA, Sevilla. With the new system, it has been possible to image the interaction region of a 18 MeV proton beam on a graphite target producing 4.4 MeV gamma rays, in two different positions separated by 5 mm.

The IRIS group also continues to set up the new laboratories of IFIMED. The pre-clinical PET/CT laboratory has completed all the main aspects necessary to pass the start up inspection to be done in 2018 by the Consejo de Seguridad Nuclear.

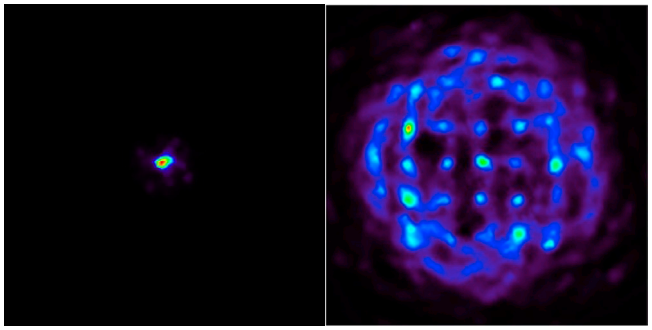


Image of an array of 37 point-like sources separated 10 mm from one another. Without sensitivity compensation (left) and with it (right).

Regarding medical diagnose and personalised medicine, a major goal to prevent breast cancer is to expand the medical imaging to a larger population which cannot be covered by specialised and experienced radiologists. In this context, IFIC participated in the first international contest on Digital Mammography to build a model to help reduce the recall rate for breast cancer screening, using Machine Learning techniques to train the algorithms in a competitive effort. The team was one of the top performers in the world and later participated in a collaborative phase to improve the algorithms.

Also in terms of personalised medicine, diseases such as scoliosis require the use of X-ray devices to validate treatments related with location and orientation of vertebras. The required regulations reduce the exposition of the patient to take full advantage of modern treatments where a close follow-up provides information to physicians to continue or invalidate a treatment. IFIC has a patent that allows 3D reconstruction from planar radiography which provides far less radiation than conventional TACs and allows patients to be placed in vertical position. Several 3D machine learning reconstruction algorithms will be incorporated in order to provide a CAD system to the physician. This patent is being developed and licensed under an R&D contract with IST Medical, and is currently the phase of getting permissions to be used with real patients.

Selected publications

E. Muñoz, J. Barrio, A. Etxebeste, P. Garcia Ortega, C. Lacasta, J.F. Oliver, C. Solaz and G. Llosa, *Performance evaluation of MACACO: a multilayer Compton camera*, Phys. Med. Biol., 62 (2017) 7321.

J. Barrio, A. Etxebeste, L. Granado, E. Muñoz, J.F. Oliver, A. Ros, J. Roser, C. Solaz and G. Llosa, *Performance improvement tests of MACACO: a Compton telescope based on continuous crystals and SiPMs*, Nucl. Inst. Meth. A. ISSN: 0031-9155. DOI:10.1016/j.nima.2017.10.033

R. Becker, A. Buck, C. Casella, G. Dissertori, J. Fischer, A. Howard, M. Ito, P. Khateri, W. Lustermann, J.F. Oliver, U. Röser, G. Warnock, B. Weber, *The SAFIR Experiment: Concept, status and perspectives*, Nucl. Instr. Meth. A 845, (2017) 648-651 ISSN: 0168-9002. DOI: 10.1016/j.nima.2016.05.037

Selected conference talks

J. Barrio, A. Etxebeste, L. Granado, C. Lacasta, E. Muñoz, J.F. Oliver, A. Ros, J. Roser, C. Solaz and G. Llosá, *Improving MACACO, a Compton Telescope for Treatment Monitoring in Hadron Therapy*, 2017 IEEE Nuclear Science Symposium and Medical Imaging Conference (IEEE NSS MIC). Atlanta (USA), 21-28 October 2017.

G. Llosá, J. Barrio, A. Etxebeste, L. Granado, C. Lacasta, E. Muñoz, J. F. Oliver, A. Ros, J. Roser, C. Solaz, *Mejoras en la respuesta de MACACO, un telescopio Compton para monitorización en terapia hadrónica*, IX CPAN Days. Santander (Spain), 23-25 October 2017.

G. Llosá, J. Barrio, A. Etxebeste, P.G. Ortega, C. Lacasta, E. Muñoz, J. F. Oliver, C. Solaz, *Final tests with MACACO: a Compton telescope for hadron therapy treatment monitoring*, 8th International Conference on New Developments in Photodetection: NDIP 2017. Tours (France), 3-7 July 2017.

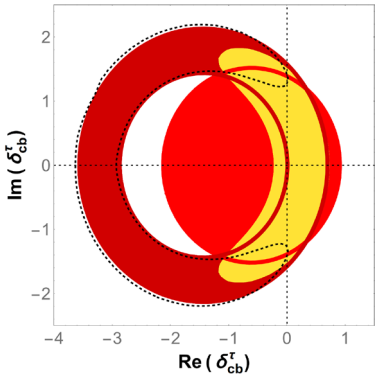
G. Llosá, J. Barrio, A. Etxebeste, L. Granado, C. Lacasta, E. Muñoz, J. F. Oliver, A. Ros, C. Solaz, *From MACACO to MACACO II: a Compton telescope for treatment monitoring in hadron therapy*, V MEDAMI workshop. Orosei (Sardinia, Italy) 30 May- 4 June 2017.

G. Llosá, Compton telescope for hadron therapy treatment monitoring, Invited talk at World Cancer Congress. Barcelona (Spain) 19-21 May 2017.

THEORETICAL PHYSICS

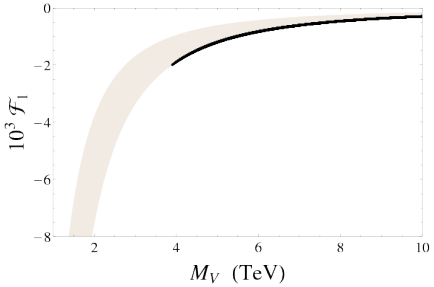
HIGH-ENERGY PHYSICS PHENOMENOLOGY

The BaBar, Belle and LHCb collaborations have recently found substantial discrepancies between their measurements of the R(D) and R(D*) ratios and the Standard Model predicted values. In order to explore an explanation in terms of scalar contributions, researchers from IFIC have performed a comprehensive analysis, including these observables as well as angular distributions and the measured t polarization asymmetry. The complementarity between the b → c and b → u sectors has also been investigated.



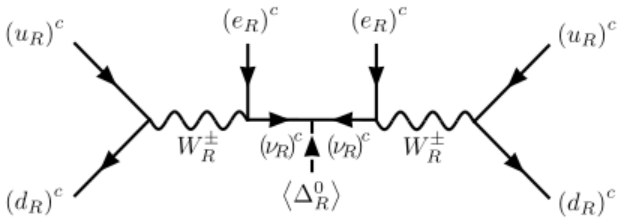
Results of a model-independent fit to b → c observables. The coloured areas correspond to 95% CL regions, whereas the dashed line indicates the 68% CL region.

While the open questions in the Standard Model call for new dynamics, the LHC searches push the scale where this New Physics could exist well above the TeV scale. This motivates a treatment based on effective field theory. Researchers from IFIC have participated in an analysis that adopts a non-linear realization of electroweak symmetry breaking, finding possible effects that would reveal the presence of new states at high energies.



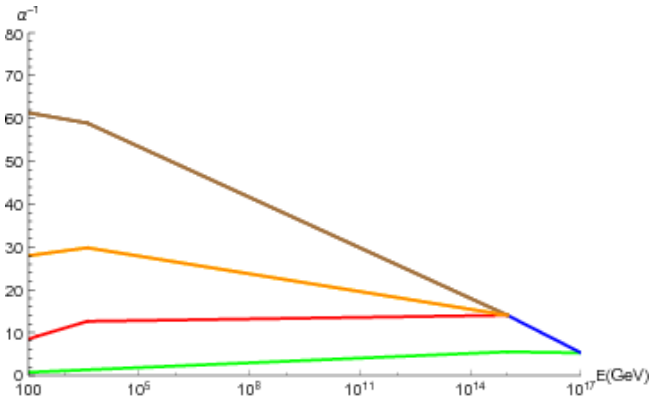
Determination of the O(p^4) low-energy coupling F_1 as a function of the mass of a heavy vector resonance.

The observation of neutrinoless double beta decay would clearly imply that neutrinos are Majorana fermions. A group of researchers from IFIC have investigated the possible contributions to this process by gauge vectors. Even though the list of gauge vectors and groups that may contribute is very long, the number of phenomenologically viable cases turns out to be very low.



Neutrinoless double beta decay diagram in a left-right symmetric model.

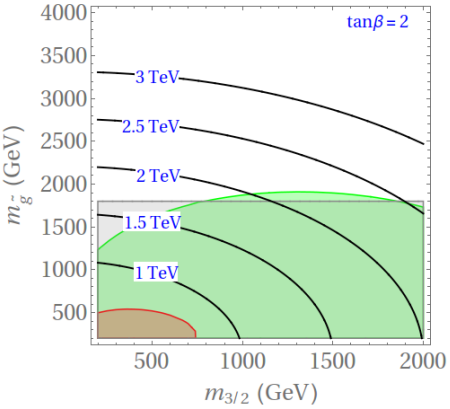
Comprehensive gauge and family unification using spinors has many attractive features, but it has been challenged to explain chirality. Researchers from IFIC have found a way out by combining an orbifold construction with more traditional ideas. The resulting model can be tested in accelerator and astronomical searches.



Running of the gauge couplings below the SO(10) scale. The SM couplings are shown in brown, orange and red, whereas the SO(5) coupling is shown in green.

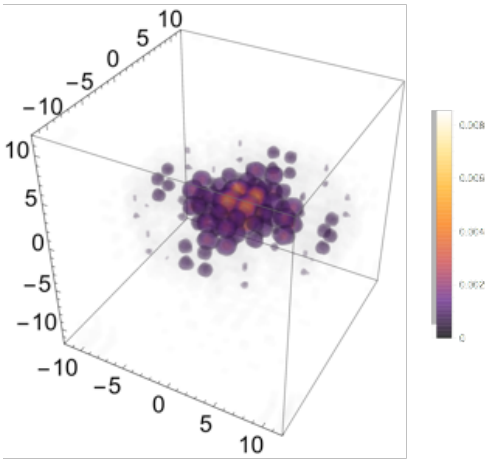
The pattern of low-energy couplings could reveal the presence of New Physics at high energies

The Froggatt-Nielsen mechanism constitutes a very compelling explanation of the observed fermion mass hierarchies. A team of researchers from IFIC have considered flavoured supersymmetric scenarios and shown that, even starting with completely flavour blind soft terms at high scales, the low-energy sfermion mass matrices and trilinear terms can be strongly non-universal. This provides a new tool for tackling the flavour puzzle.



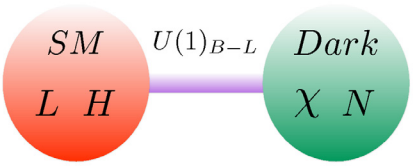
DmK (red) and eK (green) exclusion regions for a model based on an SU(3) flavour symmetry. The grey region is excluded by direct gluino searches at the LHC.

The properties of a two- and three-dimensional quantum walk inspired by the idea of the brane-world model of Rubakov and Shaposhnikov have been analyzed. Researchers from IFIC have translated this model into an alternate quantum walk with a coin that depends on the external field, and a dependence which mimics a domain wall solution. As in the original model, fermions (the walker), become localized in one of the dimensions, not from the action of a random noise on the lattice (as in Anderson localization), but from a regular dependence in space.



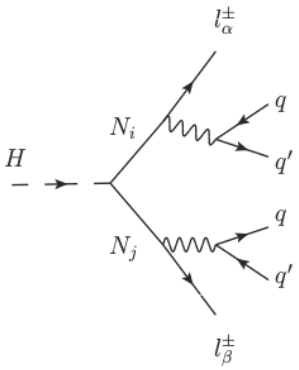
Density plots in 3D at time j = 20 with Gaussian initial wave packe, centered around (0; 0). The parameters of the potential are λ = 90, h = 4 and m=11.

Researchers from IFIC have explored the possibility of a common origin for sterile neutrinos and dark matter in a setup that extends the Standard Model with a new dark sector charged under a global $U(1)_{B-L}$ symmetry. The resulting scenario has a very rich phenomenology, with an interesting interplay between dark matter annihilation to dark scalars and heavy neutrinos, as well as collider probes via the coupling to the Higgs boson. Indirect detection signatures have also been studied.



The global U(1)_B-L symmetry serves as a portal that couples the Standard Model particles to a new dark sector.

A minimal extension of the Standard Model with just two right-handed neutrinos can explain the measured neutrino masses and mixings and account for the matter-antimatter asymmetry of the Universe. A group of researchers from IFIC have studied the phenomenology of this model extended with a set of additional effective operators, finding that one of the operators gives a new production mechanism for the heavy neutrinos at the LHC via Higgs boson decays.



A Higgs boson can decay to two heavy neutrinos leading to displaced vertices at the LHC.

Sterile neutrinos and dark matter could have a common origin

Selected publications

A. Celis, M. Jung, X-Q. Li, A. Pich, *Scalar contributions to b → c(u) t n transitions*, Phys. Lett. B 771, 168-179 (2017) – 12 pp, DOI: 10.1016/j.physletb.2017.05.037 [arXiv:1612.07757].

A. Pich, I. Rosell, J. Santos, J. J. Sanz-Cillero, *Fingerprints of heavy scales in electroweak effective Lagrangians*, JHEP 1704, 012 (2017) – 57 pp, DOI: 10.1007/JHEP04(2017)012 [arXiv:1609.06659].

R. M. Fonseca, M. Hirsch, *Gauge vectors and double beta decay*, Phys. Rev. D 95, no.3, 035033 (2017) – 14 pp, DOI: 10.1103/PhysRevD.95.035033 [arXiv:1612.04272].

M. Reig, J. W. F. Valle, C. A. Vaquera-Araujo, F. Wilczek, *A model of comprehensive unification*, Phys. Lett. B 774, 667-670 (2017) – 4 pp, DOI: 10.1016/j.physletb.2017.10.038 [arXiv:1706.03116].

D. Das, M.L. López-Ibáñez, M. Jay Pérez, O. Vives, *Effective theories of flavour and the nonuniversal MSSM*, Phys. Rev. D 95, no.3, 035001 (2017) – 16 pp, DOI: 10.1103/PhysRevD.95.035001 [arXiv:1607.06827].

I. Marquez-Martín, G. Di Molfetta and A. Pérez, *Fermion confinement via Quantum Walks in 2D+1 and 3D+1 spacetime*, Phys. Rev. A 95, no. 4, 042112 (2017) – 5 pp, DOI:10.1103/PhysRevA.95.042112 [arXiv:1612.08027].

M. Escudero, N. Rius, V. Sanz, *Sterile neutrino portal to Dark Matter I: The U(1)_(B–L) case*, JHEP 1702, 045 (2017) – 28 pp, DOI: 10.1007/JHEP02(2017)045 [arXiv:1606.01258].

A. Caputo, P. Hernández, J. Lopez-Pavón, J. Salvado, *The seesaw portal in testable models of neutrino masses*, JHEP 1706, 112 (2017) – 20 pp, DOI: 10.1007/JHEP06(2017)112 [arXiv:1704.08721].

Selected conference talks

O. Eberhardt, *Two-Higgs-doublet model fits with HEPfit*, EPS-HEP 2017: The European Physical Society Conference on High Energy Physics, July 2017, Venice, Italy.

I. Rosell, C. Krause, A. Pich, J. Santos and J.J. Sanz Cillero, *Tracks of resonances in electroweak effective Lagrangians*, EPS-HEP 2017: The European Physical Society Conference on High Energy Physics, July 2017, Venice, Italy.

V. de Romeri, *Impact of sterile neutrinos on cLFV processes*, WIN2017: 26th International Workshop on Weak Interactions and Neutrinos, June 2017, Irvine, USA.

A. Vicente, *DsixTools, the SM Effective Field Theory code, New physics at the junction of flavour and collider phenomenology*, April 2017, Portoroz, Slovenia.

M. Chala, *Collider signals of models with radiatively-induced neutrino masses*, Corfu 2017: Workshop on the Standard Model and Beyond, September 2017, Corfu, Greece.

G. Barenboim, *Bounds on CPT Violation*, DUNE Collaboration meeting, January 2017, CERN, Geneva, Switzerland.

A. Caputo, *Higgs Couplings in Extensions of Low-Scale See-Saw*, Higgs Couplings 2017, November 2017, Heidelberg, Germany.

P. Hernández, *Leptogenesis and CP violation,* NUFACT 2017: The 19th International Workshop on Neutrinos from Accelerators, September 2017, Uppsala, Sweden.

HIGH-ENERGY THEORETICAL AND MATHEMATICAL PHYSICS: GRAVITY, BLACK HOLES AND SUPERSYMMETRY

Members of the group have submitted a comprehensive review article on metric-affine theories of gravity to *Physics Reports*. The work thoroughly describes the main results in cosmology, astrophysics, and black hole physics derived in the context of Born-Infeld inspired modified theories of gravity, including and up-to-date presentation of the observational and experimental constraints on such theories. This work soon led to an improved reanalysis of the impact that deviations from the metricity condition could have on elementary particle interactions. This analysis allowed to improve the existing constraints by six orders of magnitude based on potential effects on electron-electron scattering.

It is well known that the source-free Maxwell equations are invariant under electric-magnetic duality rotations. However, it is less known that Maxwell's action also remains invariant. These transformations are therefore a symmetry of the theory in Noether's sense. The associated constant of motion is related to the difference of intensity between the right and left circularly polarized components. This conservation law holds even if the electromagnetic field interacts with an arbitrary classical gravitational field.

We have analyzed whether this symmetry is maintained when the electromagnetic field is quantized. The answer is affirmative in the absence of gravity, but we find that a non-trivial classical gravitational background can break the symmetry. As a consequence, the net polarization of the quantum electromagnetic field fails to be conserved in curved spacetimes. This is a quantum effect, and it can be understood as the generalization of the fermionic chiral anomaly to fields of spin one.

The backreaction problem for rotating black holes has been solved for the first time in 2+1 dimensions

In the context of quantum field theory in curved spacetimes, we solved for the first time the backreaction problem for rotating black holes and naked singularities in 2+1 dimensions. In particular, we showed that the quantum effects make the black hole event horizon and static limit surface grow, while its angular velocity is reduced. At the same time, the quantum effects act as 'cosmic censors' by producing a (small) horizon around naked singularities and a curvature singularity at the Cauchy horizon of the rotating black hole solutions. Reviews of these results appeared in divulgative journals: *APS Physics, New Scientist, International Business Times, AIP Inside Science*.

On the field of supersymmetry, a new approach to superfields was proposed, giving an interpretation of them in terms of (quantum) observables. Certain non-linear constraints on superfields are seen as superschemes that do not define a standard supermanifold. Also, the study of the (complex) quantum superconformal space, a projective superflag manifold, was completed by using the line superbundle associated to the projective embedding together with a quantum section on it.

IberiCos2017.

At the beginning of the year we were notified that our proposal to lead the "*Red Temática de Relatividad y Gravitación*" had been approved for funding, opening an excellent opportunity for our group to coordinate research and outreach activities within the Spanish community working on gravitation and relativity. A dedicated website, blog, and Facebook profiles are currently fully operative.

On March 14th, Antonio Sanchez Puente obtained his doctorate degree with a thesis entitled "*Black holes, geons, and singularities in metric-affine gravity*", supervised by Gonzalo J. Olmo. A few days later, two new students formally joined our group with brand new fellowships: A. Delhom and A. Ferreiro. They are working on quamtum effects in curved space-times and on the observational characterization of gravitational phenomena involving potential departures from Riemannian geometry, respectively.

From the 10th to the 12th of April we organized the XII Iberian Cosmology Meeting (IberiCos2017). This series of meetings is aimed at encouraging the interaction and collaboration between researchers working in Cosmology and related areas (Gravitation, Particle Physics, and Astronomy) in Portugal and Spain. The Lise Meitner Room of the Physics Faculty hosted the 43 talks imparted those days, with participation of people from different IFIC groups. A public lecture entitled "*Cosmología: la historia de nuestro universo*" was delivered on Friday 7*th* at the Colegio Mayor Rector Peset. The talk is available on YouTube.

In May our group received with joy the announcement from the Gravity Research Foundation of their Awards for Essays. The work by I. Agulló, A. del Río and J. Navarro-Salas entitled "*Gravity and handedness of photons*" received the First Award, becoming the first group of Spanish researchers to have ever received such an honour. For the details, and the historical series of the Awarded essays, see https://www.gravityresearchfoundation.org/.

To conclude the year, we organized the 1st Valencia Winter Workshop on Theoretical Physics (10-14 December). This meeting consisted on a series of talks and discussions aimed at summarizing the activities of our local group and close collaborators and to plan new research activities and funding opportunities.

I. Agulló, A. del Río and J. Navarro-Salas received the First Award of the Gravity Research Foundation Essay Competition on 2017

Selected publications

I. Agulló, A. del Rio, J. Navarro-Salas, *Gravity and handedness of photons*, Int. J. Mod. Phys. D26, no.12, 1742001 (2017) - 5pp, DOI: 10.1142/S0218271817420019 [arXiv:1705.07082]

M. Casals, A. Fabbri, C. Martínez, J. Zanelli., *Quantum Backreaction on Three-Dimensional Black Holes and Naked Singularities*, Phys. Rev. Lett. 118, no.13, 131102 (2017) - 6pp, DOI: 10.1103/PhysRevLett.118.131102 [arXiv:1608.05366]

I. Agulló, A. del Rio, J. Navarro-Salas, *Electromagnetic duality anomaly in curved spacetimes*, Phys. Rev. Lett. 118 (2017) no.11, 111301 (2017) – 5pp, DOI: 10.1103/PhysRevLett.118.111301 [arXiv:1607.08879]

J. Beltrán Jiménez, L. Heisenberg, G. J. Olmo, D. Rubiera-Garcia, *Born–Infeld inspired modifications of gravity*, Phys. Rept. 727, 1-129 (2018) – 129pp, DOI: 10.1016/j.physrep.2017.11.001 [arXiv:1704.03351]

A. Delhom-Latorre, G. J. Olmo, M. Ronco, *Observable traces of non-metricity: new constraints on metric-affine gravity*, Phys. Lett. B780 294-299 (2018) – 6pp, DOI:10.1016/j.physletb.2018.03.002 [arXiv:1709.04249]

Selected conference talks

María A. Lledó, *Superfields and superschemes*, Iberian Strings 2017, January 2017, Lisboa, Portugal.

A. del Río, *CMB bounds on the hidden universe*, XII Iberian Cosmology Meeting, April 2017, Valencia, Spain.

J. Navarro-Salas, *The many faces of gravitational particle creation*, VI Postgraduate Meeting On Theoretical Physics, December 2017, Valencia, Spain.

A. Delhom-Latorre, *Observable traces of non-metricity: accelerator constraints on metric-affine gravity*, COTB: VII Essential Cosmology for the Next Generation, December 2017, Punta Mita, Mexico.

A. Ferreiro, *Vacuum particle production: reheating, Schwinger effect and renormalization*, COTB: VII Essential Cosmology for the Next Generation, December 2017, Punta Mita, Mexico.

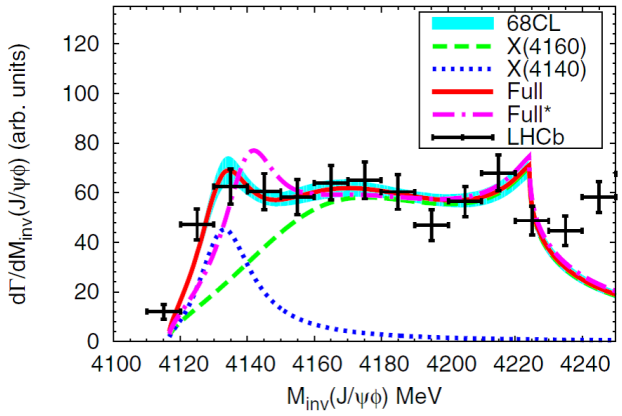
Responsibilities

Gonzalo J. Olmo is PI of the Red Temática de Relatividad y Gravitación (FIS2016-81770-REDT).

NUCLEAR PHYSICS AND MANY-BODY THEORY

With the help of effective field theory and many-body techniques, we have addressed a broad range of open problems in hadronic and nuclear physics regarding the properties of light and heavy hadrons in the vacuum and in the nuclear medium, dynamically-generated resonances and exotic states, the interactions of electrons and neutrinos with nuclei and nuclear-matter responses.

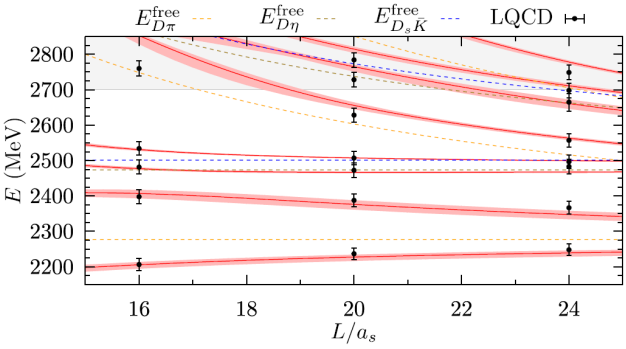
With the production of heavy mesons and baryons at Belle, BES and LHCb facilities, a vast phenomenology has become available. We have unraveled the nontrivial dynamics in the weak non-leptonic and semi-leptonic decays of several hadrons with charm and beauty, often leading to dynamically generated states. For example, the J/ψ ϕ invariant mass distribution from the decay $B^- \to K^-$ J/ψ ϕ, measured at LHCb, results from the interplay of two resonances with hidden charm and strangeness: the narrow *X*(4140) and *X*(4160). The latter is generated by the D_s^* D^−_s^* interaction, as experimentally revealed by the strong cusp at the D_s^* D^−_s^* threshold.



J/ψ ϕ mass distribution from the $B^- \to K^-$ J/ψ ϕ decay at LHCb.

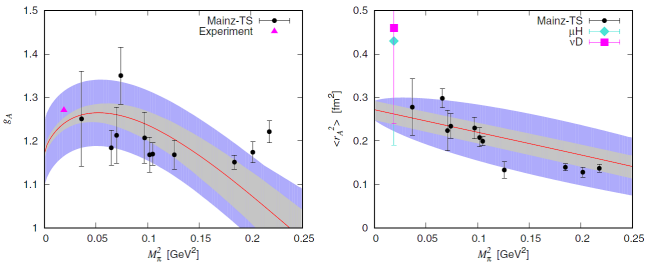
Triangle singularities have also become relevant characters in hadron dynamics and spectroscopy. We have proposed that resonance candidates such as the isoscalar $f_2(1810)$ and $f_1(1420)$ might not be genuine resonances but merely manifestations of such singularities. Furthermore, we have explained the abnormal isospin violations in D_s^+→(π^+ π^0 f_0 (980))/(a_0 (980)) and B^−_s^0→ J/ψ π^0 f_0 (980)/a_0 (980) decays in terms of the mass differences of intermediate-state kaons, enhanced by triangle singularities.

Lattice QCD (LQCD) provides another valuable source of information about hadronic structure. It has been shown using unitarized chiral perturbation theory that two poles contribute to the only known charmed non-strange scalar meson D_0^* (2400). The remarkable agreement of the energy levels at finite volume with the available LQCD results provides strong support to the prediction. A good understanding of the D_0^* (2400) properties is important because of its potential impact on the determination of $|V_{cd}|$.



Lattice-volume (L3) dependence of the D_0^* (2400) energy levels. Model predictions (red lines and bands) are compared to the LQCD results

Chiral perturbation theory for baryons (BChPT) has allowed a deeper insight into the nucleon properties. It was possible to establish a connection between the neutron electric-dipole moment and CP-violating two-pion decay of η and η' mesons, for which upper bounds orders of magnitude more stringent than those from available observations were obtained. A global analysis of the low-momentum transfer and light-quark mass dependence of recent LQCD determinations of the nucleon axial form factor has been also undertaken using BChPT up to next-to-leading order. The explicit inclusion of the (1232) intermediate states turn out to be critical for the description of LQCD data.



Pion-mass dependence of the nucleon axial coupling and radius from a BChPT analysis of lattice QCD results.

New developments in the description of nuclear properties across the nuclide chart with the Nuclear Energy Density Functional theory have been made. For the first time, it has been possible to go beyond the nonrelativistic zero-range Skyrme interaction by including physically motivated terms. Using the linear response formalism, we have been able to solve the long-standing problem of finite-size instabilities in effective functionals. The properties of the effective nucleon mass in nuclear matter have also been systematically investigated for general two-body interactions. Our study of the scaling properties of electromagnetic responses obtained with the ab-initio Green's function Monte Carlo approach and using spectral functions has unveiled the role of correlations in the distinctive asymmetric shape of the universal scaling function defined in terms of the nucleon-density response. Finally, various quasielastic processes have been described using a many-body framework with nucleon spectral functions and Random-Phase-Approximation (RPA) corrections. Of particular importance for current and future oscillation experiments are the ^{40}Ar cross sections obtained with different nuclear effects for neutrinos and antineutrinos.

For the first time, it has been possible to go beyond the Skyrme interaction by including physically motivated terms

Selected publications

M. Albaladejo, P. Fernandez-Soler, F. K. Guo, J. Nieves, *Two-pole structure of the D_0^* (2400)*, Phys. Lett. B 767, 465-469 (2017) – 5pp, DOI: 10.1016/j.physletb.2017.02.036, [arXiv:1610.06727].

T. Gutsche, As. N. Hiller Blin, S. Kovalenko, S. Kuleshov, V. E. Lyubovitskij, M. J. Vicente Vacas, and A. Zhevlakov, *CP-violating decays of the pseudoscalars η and η' and their connection to the electric dipole moment of the neutron*, Phys. Rev. D 95, 036022 (2017) – 9pp, DOI: 10.1103/PhysRevD.95.036022 [arXiv:1612.02276].

P. Becker, D. Davesne, J. Meyer, J. Navarro, A. Pastore, *Solution of Hartree-Fock-Bogoliubov equations and fitting procedure using the N2LO Skyrme pseudopotential in spherical symmetry*, Phys. Rev. C 96, 044330 (2017) – 17pp, DOI: 10.1103/PhysRevC.96.044330 [arXiv:1707.08622].

D. L. Yao, L. Alvarez-Ruso, M. J. Vicente Vacas, *Extraction of nucleon axial charge and radius from lattice QCD results using baryon chiral perturbation theory*, Phys. Rev. D 96, 116022 (2017) – 11pp, DOI: 10.1103/PhysRevD.96.116022 [arXiv:1708.08776].

E. Wang, J. J. Xie, L. S. Geng, E. Oset, *Analysis of the $B+\to J/\psi\phi K^+$ data at low $J/\psi\phi$ invariant masses and the X(4140) and X(4160) resonances*, Phys. Rev. D 97, 014017 (2018) – 6pp, DOI: 10.1103/PhysRevD.97.014017 [arXiv:1710.02061].

Selected conference talks

J. Nieves, *Theory of neutrino cross sections*, XVII International Workshop on Neutrino Telescopes, March 2017, Venice, Italy.

V. R. Debastiani, W. H. Liang, J. J. Xie, E. Oset, *Production of f_0 (500), f_0 (980) and a_0 (500), in the χ_c1→η π^+ π^- and η_c→η π^+ π^- decays*, Excited QCD, May 2017, Sintra, Portugal.

J. Navarro, *Density Functional Theory of Superfluid Helium-4 and Droplets*, CECAM School on Dopant Dynamics in Superfluid Helium-4 Nanodroplets, June 2017, Toulouse, France.

L. Alvarez-Ruso, *Present status of neutrino cross sections*, EPS-HEP 2017: European Physical Society Conference on High Energy Physics, July 2017, Venice, Italy.

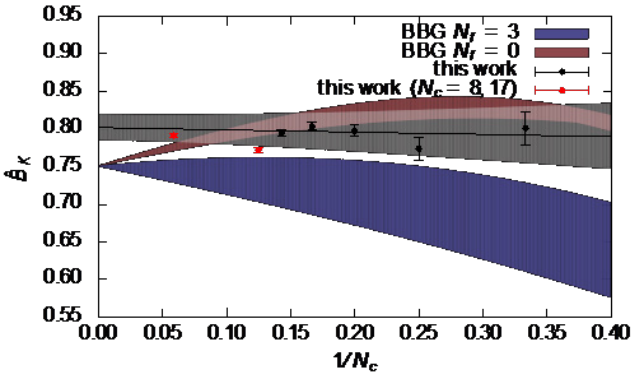
A. N. Hiller Blin, J. M. Alarcón, M. J. Vicente Vacas, C. Weiss, *Exploring hyperon structure with electromagnetic transverse densities*, NSTAR 2017: 11th International Workshop on the Physics of Excited Nucleons, August 2017, Columbia, USA.

QCD AND STRONG INTERACTIONS

This research line focuses on the studies of perturbative and non-perturbative aspects of the strong interactions. These interactions are investigated from a wide range of approaches: multi-loop perturbation theory, lattice gauge theories, effective field theories, chiral perturbation theory and phenomenological Lagrangians, including searches for new physics beyond the Standard Model. In particular, their study allows to deepen our understanding of the physics at the CERN Large Hadron Collider (LHC) and flavour factories.

An interesting problem is the study of the flavour violating processes involving kaons. There is still no satisfactory explanation of the $\Delta I = 1/2$ rule, nor a reliable prediction of ε'/ε. The large NC limit of QCD has been invoked in many phenomenological approaches to these problems. This seems counter-intuitive, since the NC $\to\infty$ limit of the $\Delta I = 1/2$ rule fails completely. Predictions, therefore, rely on significant sub-leading NC effects, which are very difficult to compute accurately.

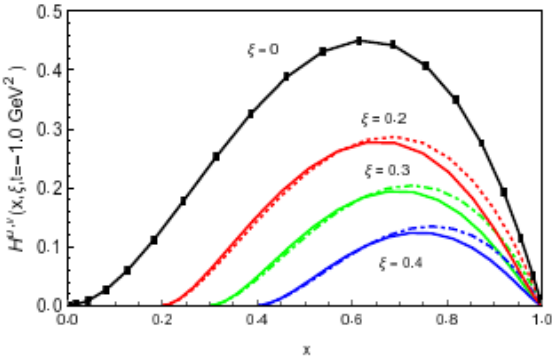
Additionally, the scattering of vector-vector from lattice was presented by using an extension of the Luscher formalism to include the interaction of particles with any spin. The derived formalism will be applied to scalar QED in the Higgs boson phase, where the U(1) gauge boson acquires mass.



Mixing B^_K=K-K¯ as a function of N_c.

Effects to tackle the puzzling flavour violating processes involving kaons in theory with large number of colours have been evaluated

The AdS/QCD softwall model has allowed to evaluate the generalised parton distributions (GPDs) of nucleons. The standard procedures, within this model, have been extended in order to include the dependence on the skewness, which states for the longitudinal momentum transfer fraction. As by product, the Compton form factors can be computed and directly compared with the experimental data.



Generalised parton distributions in the scenario where quark correlations are basically neglected.

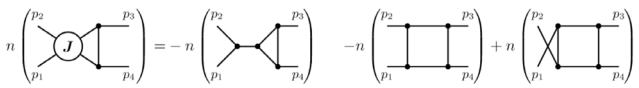
Equivalently, the AdS/CFT glueball spectrum has been revisited in the light of new phenomenological analyses of the scalar and tensor glueballs based on QCD lattice calculations with the aim of clarifying the controversy regarding the mass of the lightest glueball. The AdS7 geometry model used favours a low mass glueball of order one GeV.

Theoretical predictions for physical observables in perturbative Quantum Chromodynamics (pQCD) are obtained from scattering amplitudes. Their mathematical properties reveal hidden symmetries in quantum field theories. They are also the backbone for the physics at the LHC. In order to consider higher orders in the perturbative expansion, one needs to establish a well-defined scheme to treat internal virtual particles.

These particles, usually defined in a d-dimensional space-time in the traditional approach, can be treated directly in four-dimensions via the four-dimensional-formulation (FDF). Furthermore, for the calculation of these scattering amplitudes, alternative techniques have been developed, based on integrand reduction methods and the local cancelation of singularities. This cancellation is done by the proper use of the loop-tree duality (LTD) and the four-dimensional unsubtraction (FDU) scheme. A comprehensive comparison of all these methods has been published by members of IFIC.

Feynman diagrams contributing to $\gamma^* \to q\bar{q}$ at NLO within FDF.

Inspired by the symmetry group of QCD, SU(N), new relations for scattering amplitudes at one-loop level have been provided. They are obtained from the interplay of colour-kinematics duality (CKD) and LTD. The former relies on the intrinsic relation between the colour structure constants and the kinematic numerators given by the Jacobi identities, and leads to remarkable simplifications in the evaluation of multi-loop Feynman diagrams to be considered for a given scattering process. These investigations can be useful in the derivation of gravity amplitudes through a double copy of the CKD amplitudes.



Jacobi integrand relations for 2→2 scattering processes

The interplay between gauge theories and gravity through the colour-kinematics duality has been analysed

Selected publications

D. Binosi, L. Chang, J. Papavassiliou, S. X. Qin and C. D. Roberts, *Natural constraints on the gluon-quark vertex*, Phys. Rev. D 95, no. 3, 031501 (2017) – 7pp, DOI: 10.1103/PhysRevD.95.031501 [arXiv:1609.02568]

M. Traini, M. Rinaldi, S. Scopetta and V. Vento, *The effective cross section for double parton scattering within a holographic AdS/QCD approach*, Phys. Lett. B 768, 270-273 (2017) – 4pp, DOI: 10.1016/j.physletb.2017.02.061 [arXiv:1609.07242]

M. Rinaldi, *GPDs at non-zero skewness in AdS/QCD model*, Phys. Lett. B 771, 563-567 (2017) – 5pp, DOI: 10.1016/j.physletb.2017.06.010 [arXiv:1703.00348]

C. Gnendiger (F. Driencourt-Mangin, G. Rodrigo, W. J. Torres Bobadilla), *To d, or not to d: recent developments and comparisons of regularization schemes*, Eur. Phys. J. C 77, no. 7, 471 (2017), DOI: 10.1140/epjc/s10052-017-5023-2 [arXiv:1705.01827]

J. Llanes Jurado, G. Rodrigo and W. J. Torres Bobadilla, *From Jacobi off-shell currents to integral relations*, JHEP 1712, 122 (2017) – 22pp, DOI: 10.1007/JHEP12(2017)122 [arXiv:1710.11010]

Selected conference talks

P. González, *Heavy meson potential from a modified Schwinger-Dyson coupling*, XVII international Conference on Hadron Spectroscopy and Structure, September 2017, Salamanca, Spain.

J. Vijande, *Breaking symmetry effects on heavy tetraquarks*, PANIC 2017: Particles and Nuclei International Conference 2017, September 2017, Beijing, China.

W. J. Torres Bobadilla, *Interplay of colour-kinematics duality and analytic calculation of multi-loop scattering amplitudes: one- and two-loops*, RADCOR 2017: 13th International Symposium on Radiative Corrections Applications of Quantum Field Theory to Phenomenology, September 2017, St. Gilgen, Austria.

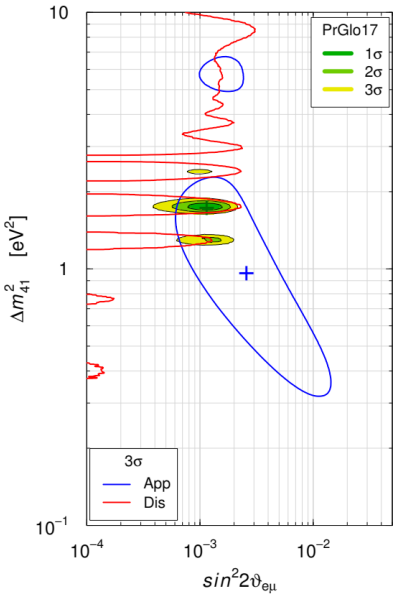
G.F.R. Sborlini, F. Driencourt-Mangin, R.J. Hernández-Pinto and G. Rodrigo, *Four-dimensional regularization of higher-order computations: FDU approach*, EPS-HEP 2017: European Physical Society Conference on High Energy Physics, July 2017, Venice, Italy.

G. Rodrigo, *Unsubtractions and asymptotic expansion for the Higgs boson interactions*, LOOPFEST XVI: Radiative Corrections for the LHC and Future Colliders, June 2017, Chicago, USA.

THEORETICAL ASTROPARTICLE PHYSICS AND COSMOLOGY

The research topics of this line include cosmic rays, neutrinos, dark matter, dark energy and inflationary theories, involving international collaborations that study high-energy cosmic rays (Pierre Auger Observatory), neutrino oscillations and CP violation searches (Deep Underground Neutrino Experiment, DUNE) and the role of dark matter and neutrinos or dark energy in the context of the future Square Kilometre Array (SKA) Telescope.

One of the studies investigated the so called Short-BaseLine (SBL) anomalies in the paradigm of neutrino oscillations. A number of experiments give a small indication of neutrino oscillations that cannot be explained by the three-neutrino mixing, but can be solved with the introduction of a new (sterile) neutrino with a mass around 1 eV. Performing a combined analysis of all SBL data, the fit is dominated by measurements at reactors, in particular by the indication provided by the electron antineutrino disappearance at the NEOS experiment, which uses the flux normalization obtained by Daya Bay to avoid the problems related to the theoretical reactor antineutrino spectrum. When all the bounds from appearance and disappearance experiments are included in the global pragmatic fit, one obtains a new squared mass difference Δm_41^2≃1.7eV^2 and mixing matrix elements |U_e4 |^2≃0.02,|U_μ4 |^2≃0.015.



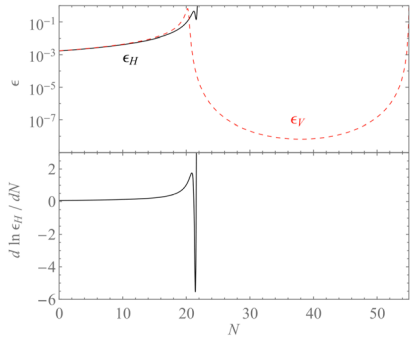
Allowed regions obtained in the 2017 global fit of Short-BaseLine neutrino oscillation data.

The impact of a fourth sterile neutrino has also been considered in the context of short-baseline coherent elastic neutrino-nucleus scattering experiments. It has been found that the COHERENT experiment as well as the low energy measurements planned at reactor facilities such as TEXONO may provide key information concerning the existence of light sterile neutrinos, complementing the charged current appearance and disappearance searches program. The performed analysis found that high-purity Germanium detectors with sub-keV thresholds offer optimal sensitivities on the sterile neutrino mixing parameters.

Researchers at IFIC have further improved our knowledge on the cosmological neutrino mass constraints, leading the field and producing results that have been extensively cited in the literature. A recent analysis shows that, in the most conservative scheme, combining Planck Cosmic Microwave Background (CMB) temperature anisotropies and Baryon Acoustic Oscillations (BAO) data, as well as the most recent constraint on the optical depth to reionization, the upper bound on the sum of the three active neutrino masses at 95% confidence level (C.L.) is 0.151 eV. Adding Planck high-multipole polarization data tightens this bound to 0.118 eV.

The most constraining bound on the sum of the three active neutrino masses is 0.093 eV, when adding to the former data combination a prior on the Hubble constant of 73.02 ± 1.79 km/s/Mpc and the latest measurements from the Planck Sunyaev-Zeldovich galaxy cluster catalogue. This most constraining and less conservative combination of data sets is able to disfavour the inverted ordering at 77% C.L., with an odds ratio for normal hierarchy versus the inverted one of 3.3:1. While these bounds are still unable to robustly disfavour the inverted neutrino mass ordering, they significantly reduce the volume of parameter space allowed within the inverted neutrino mass ordering. These results have also been quoted in the *Particle Data Group Neutrino Cosmology Review* of 2017.

With the detection of black hole mergers by LIGO and the continuing lack of direct detection of WIMPs, interest in primordial black holes (PBHs) as candidates for dark matter has received renewed attention. PBHs form from density fluctuations that are comparable to or exceed order unity at horizon crossing. Researchers at IFIC have found that for PBH to be the dark matter, in single-field inflation, the usual slow-roll approximation must be violated. Power spectrum predictions which rely on the inflaton remaining on the slow-roll attractor can therefore fail dramatically, leading to qualitatively incorrect conclusions. However, an optimized temporal evaluation of the Hubble slow-roll parameters to second order remains a good description.



Evolution of slow-roll parameters in the inflation model. Numerically calculated slow-roll parameter (black, solid) exhibits a significant difference from potential slow-roll parameter (red, dashed) which has been employed in the literature to evaluate PBH abundance.

The existence of flavour neutrino oscillations requires that these elusive particles possess nonzero masses, much smaller than those of other particles and with values at least of the order of 50 meV. IFIC researchers have considered the gravitational clustering of relic neutrinos with minimal masses, produced in the very early Universe, at the Earth neighbourhood. In our local region, the neutrino number density is enhanced with respect to its average cosmic value, and this over-density was found using the so-called N-one-body simulations, including an improved treatment of matter distribution in the Milky Way, both baryonic and dark matter. The results found could be interesting for future experiments aiming at detecting the relic neutrino background, such as the PTOLEMY project.

New conditions have been determined for primordial black holes to be valid candidates for dark matter

Selected publications

S. Gariazzo, C. Giunti, M. Laveder, Y. F. Li, *Updated Global 3+1 Analysis of Short-BaseLine Neutrino Oscillations*, JHEP 1706, 135, (2017) – 38pp, doi:10.1007/JHEP06(2017)135 [arXiv:1703.00860].

T.S. Kosmas, D.K. Papoulias, M. Tórtola, J.W.F. Valle, *Probing light sterile neutrino signatures at reactor and Spallation Neutron Source neutrino experiments*, Phys. Rev. D96, no.6, 063013 (2017) - 12pp, DOI: 10.1103/PhysRevD.96.063013 [arXiv:1703.00054].

S. Vagnozzi et al, *Unveiling ν secrets with cosmological data: neutrino masses and mass hierarchy*, Phys. Rev. D 96, no.12, 123503 (2017) - 26pp, DOI: 10.1103/PhysRevD.96.123503 [arXiv:1701.08172].

H. Motohashi, W. Hu, *Primordial Black Holes and Slow-Roll Violation*, Phys. Rev. D 96, 063503 (2017) - 9pp, DOI: 10.1103/PhysRevD.96.063503 [arXiv:1706.06784].

P.F. de Salas, S. Gariazzo, J. Lesgourgues, S. Pastor, *Calculation of the local density of relic neutrinos*, JCAP 1709, 034 (2017) - 24pp, DOI: 10.1088/1475-7516/2017/09/034 [arXiv:1706.09850].

Selected conference talks

P. Hernández, *Recent Progress in Neutrino Physics: a Theoretical Overview*, Les Rencontres de Physique de la Vallée d'Aoste, March 2017, La Thuile, Aosta Valley, Italy

M. Hirsch, *Overview: Prospects in neutrinoless double-beta decay and other lepton number violating searches*, Neutrinos: the quest for a new physics scale, March 2017, CERN, Switzerland

S. Palomares-Ruiz, *On the high-energy IceCube neutrinos,* Perspectives in Astroparticle physics from High Energy Neutrinos, September 2017, Napoli, Italy
N. Rius, Non-standard interactions with high-energy atmospheric neutrinos at IceCube, NUFACT17, September 2017, Uppsala, Sweden

J.W.F. Valle, *Neutrino pathways to dark matter*, International workshop on WIMP dark matter and beyond, September 2017, Shanghai Jiao Tong University

3. IFIC RESPONSABILITIES IN 2017

Alejandro Algora:
– Member of the Joint Evaluated Fission and Fusion File (JEFF) Coordination Group.
– Member of the Steering Committee of ISOLDE Decay Station (IDS, ISOLDE, CERN).
– International Expert of the International Atomic Energy Agency (IAEA), Vienna.
– Secretary of the Nuclear Physics Group of the Royal Spanish Society of Physics.

Luis Álvarez:
– Co-spokesperson of the Neutrino Scattering Theory Experiment Collaboration (NuSTEC).
– Member of the International Advisory Committee of the Neutrino Physics Centreat Fermilab.

Gabriela Barenboim:
– Coordinator of the CERN Theory neutrino Platform.

José Bernabéu:
– ATLAS Inner Tracker Strip Services Coordinator.
– ATLAS Inner Tracker Grounding and Shielding Deputy Coordinator.

José M. Bordés:
– Coordinator of Erasmus, Faculty of Physics.

José Adolfo de Azcárraga:
– President of the Royal Spanish Society of Physics.

Luca Fiorini:
– ATLAS Tau Working Group Convener.
– ATLAS Tile Calorimeter Speakers Committee Chair.

Juan Fuster:
– Spanish representative at ECFA.

Carlos Lacasta:
– Scientific Secretary of ECFA and Spanish representative in RECFA.
– ATLAS Inner Tracker Strips deputy project leader.

Gabriela Llosá:
– Secretary of the Medical Physics Group of the Royal Spanish Society of Physics.

Carmen García:
– Coordinator of the Physics and Technology Area of CSIC.

José Enrique García:
– Convener of Subgroup Generator Development & Tuning, ATLAS Collaboration.

Santiago González:
– Vice-President of the Theoretical and Particle Physics Area of the Royal Spanish Society of Physics.
– Responsible of Data Production in the Event Index Project, ATLAS Collaboration.

Pilar Hernández:
– External Review Committee CERN Theory Division.
– Associate Editor of *European Journal of Physics C*.
– Coordinator of the CERN Theory neutrino Platform.

Salvador Martí:
– ATLAS Inner Detector Alignment Convener.
– Member of the Collaboration Board of RD50 experiment.
– Member of the ATLAS Speakers Committee.

Vasiliki Mitsou:
– Member of MoEDAL Speakers Committee.
– Chairperson of the Collaboration Board of MoEDAL experiment.

Juan Nieves:
– Member of the Theory Advisory Group of the Panda Collaboration, FAIR.

Sergio Palomares:
– Editor of *Heliyon* and *Advances in High Energy Physics*.

Sergio Pastor:
– Member of the Director Scientific Committee of the International School on Astroparticle Physics European Doctorate School (ISAPP).

Armando Pérez:
– Member of the Academic Commission of Degree (CAT), Faculty of Physics.

Antonio Pich:
– Coordinator of Red Consolider CPAN *Centro Nacional de Física de Partículas, Astropartículas y Nuclear*.

Diego Real:
– Coordinator of Electronics Working Group KM3NeT.

– Member of the Technical Advisory Board of Baikal.

Nuria Rius:
– General Coordinator of the PhD Physics Program of the University of Valencia.

Germán Rodrigo:
– Chair of the COST Action CA16201 *Unraveling new physics at the LHC through the precision frontier*.

Berta Rubio:
– Member of the Scientific Committee of Canfranc Underground Laboratory.
– Member of the Scientific Committee of IPN Orsay.
– Member of the Scientific Committee of NSCL Michigan State University.
– Member of the Board of Representatives NUSTAR/FAIR.
– Scientific adviser to the Ministry at the Resource Review Board FAIR.
– Chair Users Executive Committee Eurisol.

Jose Salt:
– Treasurer of the Theoretical and Particle Physics Area of the Royal Spanish Society of Physics.
– Member of the LHC Experiments Resources Review Boards (RRB) at CERN.
– Representative of ATLAS-Spain Tier-2 Federation in the Collaboration Board of the Worldwide LHC Computing GRID.

Javier Sánchez
– Responsible of Data Collecting in the Event Index Project, ATLAS Collaboration.

Miguel Angel Sanchís:
– Vice-President of the Royal Spanish Society of Physics.
– Member of the Committee on Equality, Faculty of Physics, University of Valencia.

William José Torres:
– Member of the Management Committee of the COST Action CA16201 *Unraveling new physics at the LHC through the precision frontier*.

José Luis Taín:
– Spokesperson of the BRIKEN Collaboration.
– Co-spokesperson of NP1412-RIBF127R1 and RIBF1712-RIBF158 experiments at RIKEN.
– Member of the Panel of Experts on Control and Security of Nuclear Reactors, International Atomic Energy Agency (IAEA).

Mariam Tórtola:
– Secretary of the Management Board of ANIRC (Asociación Nacional de Investigadores Ramón y Cajal).
– Representative of non-permanent research staff (PDI), Board of Faculty of Physics.

Alberto Valero:
– ATLAS Tile Calorimeter Upgrade Coordinator.
– ATLAS Tile Calorimeter Signal Reconstruction group Coordinator.

José W. F. Valle:
– Member of the Director Scientific Committee of the International School on Astroparticle Physics European Doctorate School (ISAPP).
– Editor in Chief of *Frontiers*.
– Member of the Editorial Board of the Institute of Physics (NJP).

Jordi Vidal:
– Dean of the Faculty of Physics, University of Valencia.

Oscar Vives:
– Director of the Theoretical Physics Department of the University of Valencia.
– Member of the Research Commission of the University of Valencia.
– Member of the Board and the Academic Commission of Degree (CAT), Faculty of Physics.
– Coordinator of the *Entreiguals Erasmus,* Faculty of Physics.

Juan de Dios Zornoza:
– Coordinator of Dark Matter & Exotics Working Group in KM3NeT.
– Coordinator of the Time Calibration Group in KM3NeT.
– Member of Conference Committee in KM3NeT.
– Member of the Publication Committee in KM3NeT.

Juan Zúñiga:
– Member of ANTARES Publication Committee.
– Member of the Quality Assurance & Quality Control Group of KM3NeT

4. SCIENTIFIC OUTCOME 2017

440 Articles in indexed journals

91.8% In first quartile journals
(JCR-WoS or SJR-Scopus, 2017)

TOP 5 JOURNALS (BY IMPACT FACTOR, JCR-WOS) WITH IFIC AUTHORS

Nature Physics (IF 22.7): **2**

Physical Review Letters (IF 8.8): **31**

Astrophysical Journal Letters (IF 6.6): **2**

Physics of the Dark Universe (IF 6.5): **3**

Journal of High Energy Physics (IF 5.5): **71**

TOP 5 JOURNALS (BY NUMBER OF PAPERS) WITH IFIC AUTHORS

Physical Review D (IF 4.4): **92**

European Physical Journal C (IF 5.2): **72**

Journal of High Energy Physics (IF 5.5): **71**

Physics Letters B (IF 4.2): **47**

Physical Review Letters (IF 8.8): **31**

SEE FULL LIST OF ARTICLES ON PAGE 80

350 Presentations at national and international conferences

17 Severo Ochoa Colloquia

94 Seminars

5. TRAINING

TEACHING ACTIVITIES

The members of IFIC with positions at the University of Valencia are mainly involved in its Degree in Physics, although they also teach in Chemistry and Engineering. At the postgraduate level, IFIC participates in two of the Master's Degrees offered by the UVEG: Master in Advanced Physics and Master in Medical Physics. In the former, we are responsible for two of the four specialities: Theoretical Physics and Nuclear & Particle Physics. The Gamma Spectroscopy group participates in the inter-university Master in Nuclear Physics, where six Spanish universities, CIEMAT and CSIC are involved. Finally, a large number of PhD students carry out their research work in our institute, many of them from foreign countries.

In addition, IFIC researchers often teach at international schools for PhD students. Some of the series include the International Doctorate Network in Particle Physics, Astrophysics and Cosmology (IDPASC), the International School of AstroParticle Physics (ISAPP), the European School of High-Energy Physics or the *Taller de Altas Energías* (TAE).

22 PhD Theses

15 Experimental

7 Theoretical

17 Master's Final Projects

9 Experimental

8 Theoretical

PHD THESES

Experimental Physics

Breakdown studies for high gradient RF warm technology in: CLIC and hadron therapy linacs
Jorge Giner Navarro
Advisors: Ángeles Faus Golfe and Nuria Catalán Lasheras
10 February, University of Valencia
TESEO: 1361709

Silicon Strip Detectors for the ATLAS End-Cap Tracker at the HL-LHC
Urmila Soldevila Serrano
Advisor: Carlos Lacasta Llácer
13 March, University of Valencia
TESEO: 1376979

Supersymmetry searches in ATLAS at the LHC
Elena Romero Adam
Advisors: Vasiliki Mitsou y José Bernabéu Alberola
31 March, University of Valencia
TESEO: 1382085

Indirect search for dark matter in the Sun and the Galactic Centre with the ANTARES neutrino telescope
Christoph Tönnis
Advisors: Juan José Hernández Rey and Juan de Dios Zornoza Gómez
31 March, University of Valencia
TESEO: 1379154

Development of high resolution and efficiency detectors based on Silicon Photomultipliers (SiPMs) and continuous crystals for medical physics
John Barrio Toala
Advisors: Gabriela Llosá Llácer y Carlos Lacasta Llácer
19 June, University of Valencia
TESEO: 1452399

Beam Halo Collimation and Induced Wakefield Studies for Future Linear Colliders: The ATF2 case
Nuria Fuster Martínez
Advisor: Ángeles Faus Golfe
4 July, University of Valencia
TESEO: 1468671

Performance enhancement of a small animal Positron Emission Tomograph based on continuous crystals and silicon photomultipliers
Ane Miren Etxebeste Barrena
Advisors: José Bernabeu Alberola, José Francisco Oliver Guillén and Gabriela Llosá Llácer

14 July, University of Valencia
TESEO: 1474746

Development of the quality test protocol for the DEPFET pixel detectors and top-quark mass measurement at high energy e+e- colliders
Marçà Boronat Arevalo
Advisors: Juan Fuster Verdú and Carlos Lacasta Llácer
20 July, University of Valencia
TESEO: 1475964

Environment recognition applied to particle detectors
Alberto Corbi Bellot
Advisors: Francisco Albiol Colomer y Alberto Albiol Colomer
25 July, University of Valencia
TESEO: 1473708

Measurement of top quark and W boson polarisation observables with t-channel single-top-quark events in the ATLAS experiment
Sebastián Pedraza Lopez
Advisor: Susana Cabrera Urbán
26 July, University of Valencia
TESEO: 1463436

TAGS measurements for neutrino physics and applications
Víctor Guadilla Gómez
Advisors: Alejandro Algora and José Luis Taín.
13 September, University of Valencia
TESEO: 1510854

Event reconstruction in NEXT using a ML-EM algorithm
Ander Simón Estévez
Advisors: Juan José Gómez Cadenas and Francesc Monrabal Capilla
15 September, University of Valencia
TESEO: 1500174

Development of Readout Electronics for the ATLAS Tile Calorimeter at the HL-LHC
Fernando Carrió Argos
Advisor: Alberto Valero Biot
22 September, University of Valencia
TESEO: 1495902

Calibration and background model of the NEW detector at the LSC
Miquel Nebot Guinot
Advisors: Juan José Gómez Cadenas and Justo Martín-Albo Simón
27 September, University of Valencia
TESEO: 1524393

The Next Generation Nuclear Instruments: AGATA and NEDA, and Nuclear Structure Studies near N=Z line
Tayfun Hüyük
Advisor: Andrés Gadea Raga
29 September, University of Valencia
TESEO: 1518282

Theoretical Physics

Higgs and flavour phenomenology at the LHC era
María Luisa López Ibáñez
Advisor: Óscar M. Vives García
27 January, University of Valencia
TESEO: 1358514

Electromagnetic interactions of light hadrons in covariant chiral perturbation theory
Astrid Hiller Blin
Advisors: Manuel Vicente Vacas and Eulogio Oset Baguena
15 February, University of Valencia
TESEO: 1298364

Black Holes, Geons and Singularities in Metric-Affine Gravity
Antonio Sánchez Puente
Advisor: Gonzalo Olmo Alba
14 March, University of Valencia
TESEO: 1380519

The BSM hunting guide after Run I
Cristian Bosch Serrano
Advisor: Gabriela Barenboim
7 April, University of Valencia
TESEO: 1393578

New Physics adventures in the LHC age
Javier Fuentes Martín
Advisors: Antonio Pich Zardoya, Jorge Portolés Ibáñez and Pedro David Ruiz Femenía
20 July, University of Valencia
TESEO: 1477248

Electroweak breaking and neutrino mass
César Manuel Bonilla Díaz
Advisor: José W. F. Valle
12 September, University of Valencia
TESEO: 1502799

Some Aspects of Chiral Perturbation Theory and Neutrino Physics
Mehran Zahiri Abyaneh
Advisor: Antonio Pich Zardoya
21 September, University of Valencia
TESEO: 1504179

MASTER'S FINAL PROJECTS

Experimental Physics

Computing model and new physics effects in high energy top-quarks pairs at the ATLAS experiment
José Antonio Victoria Fernández
Advisors: José Francisco Salt Cariols and Santiago González de la Hoz

Prospects for discovery of single production of vector-like top quarks with the ATLAS detector at the LHC
Galo Golzalvo Rodríguez
Advisors: María José Costa Mezquita and José Enrique García Navarro

Monte Carlo studies of calibration sources for the NEXT-White detector
Carmen Romo Luque
Advisor: Paola Ferrario

Design of a beta detector telescope for the study of the decay of relevant fission products
Héctor García Cabrera
Advisor: Alejandro Algora

Diseño de un detector de aguas tritiadas basado en fibras centelleadoras leídas por fotomultiplicadores de silicio
Marcos Martínez Roig
Advisors: José Díaz Medina and Nadia Yahlali Haddou

Desarrollo del sistema de radiofrecuencia del Laboratorio de Alto Gradiente del IFIMED
Manuel Usó Izquierdo
Advisor: Daniel Esperante Pereira

Optimisation of selection criteria of t-channel single-top-quark events at $\sqrt{s}$ = 13 TeV for studies of anomalous couplings in the Wtb vertex
Pablo Martínez Agulló
Advisors: Susana Cabrera Urbán and Carlos Escobar Ibáñez

Spatial resolution determination of medical devices by using Bayesian estimators
Jorge Roser Martínez
Advisor: Josep F. Oliver Guillen

ATLAS Inner Detector alignment weak modes analysis
Marina Vergara Díaz
Advisor: Salvador Martí García

Theoretical Physics

The Schwinger Effect and the Cosmic Reheating
Robert Santacruz Zaragoza
Advisor: José Navarro Salas

Zeros of the $W_L Z_L \to W_L Z_L$ amplitude: vector resonances at the LHC
Madeleine Adrien
Advisor: Jorge Portolés Ibáñez

Neutron star oscillations beyond General Relativity
Conrado Badenas Mengod
Advisor: Gonzalo Olmo Alba

A scalar extension of the SM. The Higgs triplet model
Javier Castellano Ruiz
Advisor: Antonio Pich Zardoya

Color kinematics duality towards off-shell calculations
Jose Llanes Jurado
Advisors: Germán Rodrigo García and William J. Torres Bobadilla

Colour octet Higgs model
Víctor Miralles Aznar
Advisor: Antonio Pich Zardoya

Modelo de Gross-Neveu: rotura dinámica de simetría en teorías con libertad asintótica
Jose Manuel Morgado Chávez
Advisor: Joannis Papavassiliou

Neutrino masses in extended Gauge theories
Mario Reig López
Advisors: José Wagner Furtado Valle and María Amparo Tórtola Baixauli

TECHNICAL TRAINING

The members of IFIC have trained 11 students from technical areas such as Electronic Engineering or Industrial Engineering during 2017, through a fruitful colaboration with ADEIT, the University–Business Foundation of the University of Valencia. Moreover, 5 young technicians under 25 have worked at IFIC in 2017 within 'Garantia Juvenil' programme.

6. CONFERENCES, SEMINARS AND COLLOQUIA

CONFERENCES AND MEETINGS

IFIC researchers present their results in the main international conferences and workshops. A total of 350 contributions were presented in 2017: 333 talks (82 invited) and 17 posters. Here we highlight conferences and workshops organized by IFIC members in Valencia or elsewhere:

78th meeting of the International Committee for Future Accelerators (ICFA). 16-17 February. Valencia.

IberiCOS 2017. 10-12 April. Valencia.

Flavour Physics at LHC Run II. 21-27 May. Benasque.

ATLAS Software & Computing Week. 12-16 June, Valencia.
International Workshop on Breakdown Science and High Gradient Technology (HG2017). 13-16 June, Valencia.

35º Simposio Internacional en Lattice Field Theory (Lattice 2017). 18-24 June, Granada.

RIA Meeting: Physics opportunities with a new universe's view: the SKA radio telescope. 6-7 November, Valencia.

KM3NeT Bootcamp. 14-17 November, Valencia.

The Openning Session of the RIA Meeting at IFIC, with the Spanish Secretary for Science, President of CSIC, Principal of the University of Valencia and the director of IFIC.

IFIC COLLOQUIA

The colloquium series "Severo Ochoa" brings the world leading experts to Valencia to present a vision of their area of science. The programme envisages of the order of ten lectures per year. Lectures are primarily devoted to particle, astroparticle and nuclear physics, but also explore other areas of science. Colloquia are open to scientists of other research institutes and to personnel and students of the science faculties. The outreach department shares recordings of the lectures on the institute's YouTube channel.

Organisers: Germán Rodrigo, Mariam Tórtola and Marcel Vos.

Andreas Hoecker, *"Particle Physics at the Dawn of a New High-Energy Frontier"*. January, 18th.

Cristina Volpe, *"Neutrino Astrophysics"*. February, 1st.

Pushalatha Bhat, *"Fifty Years of Particle Physics and Discoveries at Fermilab"*. February, 15th.
Javier Santolalla, Santi García, "Big Van, divulgación científica sobre el escenario". March, 29th.

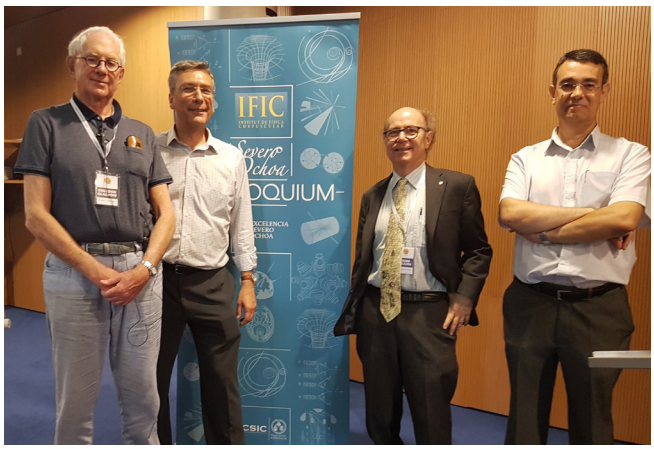
Alfredo Segura, *"The 2016 Nobel prize: Topological phases of matter and topological phase transitions"*. April, 11th.

Eugenio Coronado Miralles, *"Molecular nanoscience: from functional molecules to molecular devices"*. May, 4th.

Juan Lerma, *"Exploring Neurons and Circuits to Understand our Brain"*. May, 18th.

Manjit Dosanjh, *"CERN and Hadron Therapy: common beginnings, or from physics to medical applications"*. May, 25th.

Sheldon Glashow, *"Fun with Fundamental Physics"*. Frank Wilczek, *"Augmenting reality"*. June, 5th.



Gianfranco Bertone, *"The quest for dark matter"*. June, 29th.

Eiichiro Komatsu, *"Critical Tests of Theory of the Early Universe using the Cosmic Microwave Background"*. September, 14th.

Carl M. Bender, *"Physics in the complex domain"*. October, 20th.

Georgi Dvali, *"Secret quantum life of black holes"*. November, 2nd.

Pavel Fileviez Pérez, *"New Physics and Unification of Forces"*. November, 16th.

Ignacio Cirac, *"Quantum simulations and tensor networks in condensed matter and high energy physics"*. November, 30th.

José Manuel López Nicolás, *"La divulgación como herramienta de investigación"*. December, 13th.

IFIC SEMINARS

Seminars are more specific research talks given by an invited speaker, usually connected to one of the IFIC research groups. Some of them are more informal talks followed by a discussion session, such as those within La Trobada or Student Seminars series. In 2017 we hosted a total of 94 seminars (some of them webinars). The complete list can be found at the IFIC's Indico webpage. Organiser: Andrea Donini

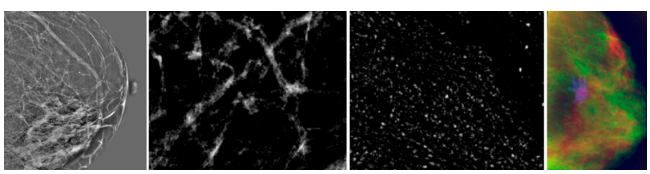
7. TECHNOLOGY TRANSFER

In 2017, IFIC and Agència Valenciana de la Innovació (AVI, Valencian Innovation Agency) initiated contacts exploring possibilities of collaboration to foster innovation and technology transfer related with IFIC's activities. The goal of such discussions were to shape a cooperation agreement between the two entities.

Among the innovation activities carried on at IFIC during 2017, are the following achievements:

Within the R+D+i project between IFIC and ENRESA, the GUALI-I (Gamma Unit Advanced Location Imager) was completed. GUALI-I consists of a portable gamma-camera with large eld-of-view and capability to identify, locate and quantify gamma-ray emitting radioisotopes. This apparatus is helping in the decommissioning of the José Cabrera nuclear power plant in Zorita, Guadalajara.

Regarding medical diagnose and personalised medicine, a major goal to prevent breast cancer is to expand the medical imaging to a larger population which cannot be covered by specialised and experienced radiologists. In this context, IFIC participated in the first international contest on Digital Mammography to build a model to help reduce the recall rate for breast cancer screening, using Machine Learning techniques to train the algorithms in a competitive effort. The team was one of the top performers in the world and later participated in a collaborative phase to improve the algorithms.



Also in terms of personalised medicine, diseases such as scoliosis require the use of X-ray devices to validate treatments related with location and orientation of vertebras. The required regulations reduce the exposition of the patient to take full advantage of modern treatments where a close follow-up provides information to physicians to continue or invalidate a treatment. IFIC has a patent that allows 3D reconstruction from planar radiography which provides far less radiation than conventional TACs and allows patients to be placed in vertical position. Several 3D machine learning reconstruction algorithms will be incorporated in order to provide a CAD system to the physician. This patent is being developed and licensed under an R&D contract with IST Medical, and is currently the phase of getting permissions to be used with real patients.

IFIC also works on the development of a Compton telescope for hadron therapy treatment monitoring, consisting in a three-layer Compton telescope based on LaBr crystals and silicon photomultipliers as photodetectors. A first version of the device was developed within the European project ENVISION and it has been tested in laboratory tests and accelerator facilities. Additional improvements of the system has also been studied using last-generation silicon photomultipliers arrays and new image reconstruction algorithms.

An S-band High-Gradient RF facility is under construction at IFIC in order to perform investigations of HG phenomena and to develop normal-conducting RF technology, with special aim in hadron-therapy. The layout of the facility is derived from the scheme of the Xbox3 test facility at CERN and uses medium peak-power and high repetition rate klystrons, whose RF output is combined to drive two testing slots to the required power. Design and construction of the various components of the system started and had positive progress.

IFIC and Valencian Innovation Agency (AVI) iniciated contacts to foster innovation and technology transfer related with IFIC's activities

7. OUTREACH

IFIC participates and organises many activities of science dissemination that would not be possible without an active involvement of the members of the Institute. These activities range from public talks outside our facilities to opening the doors of our laboratories, and are aimed both at the general public and the educational community. Two people at IFIC coordinate and conduct these activities: Isidoro García, who manages our web, as well as our relation with journalists and press offices of other institutions, and Alberto Aparici, who deals with activities and materials aimed at students and the general public.

OUTREACH MATERIALS

IFIC web site

In 2017 our site was re-designed with a more modern and diaphanous appearance. The slider was upgraded, as a means to keep visible the most important announcements and to highlight some of the research topics of the institute. Often the articles featured on the slider were aimed at a non-technical public, covering subjects such as the search for dark matter and the CPT symmetry.

We continued to report on the activities in the institute by means of the news section, which in 2017 included more than 50 pieces, and in the new design we added a new section, "Actualidad", which covers a broader spectrum of news, from the particle physics community to relevant events of CSIC and Universitat de València. This new section featured more than 20 stories along 2017.

Entre cientIFIC@s, the outreach blog of IFIC

Our outreach blog, Entre cientIFIC@s, is a platform where the members of IFIC can publish texts aimed at the general public. These texts can be about their research or about broader topics in physics or even the history of science. During 2017 we produced seven pieces, from neutrino telescopes to cosmology, and we hosted two invited contributions about gravitational waves by José Antonio Font, the head of the Valencia Virgo Group, entitled The Sound of Silence.

The blog has an editorial board that receives the candidate texts and revises them before publishing, to ensure mostly that the format is consistent and there is a good image-to-text ratio. This board is formed by Alberto Aparici, Avelino Vicente, Luis Álvarez, César Domingo, Roberto Ruiz de Austri and Juan de Dios Zornoza. Apart from them, in 2017 Sergio Palomares, Pablo Fernández and Mario Reig contributed with texts to the blog.

Books

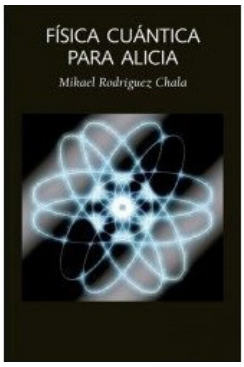
Four books were published by members of the institute during 2017:

> Sergio Pastor published *"La Nucleosíntesis"* within the series *Un paseo por el Cosmos* (RBA publishers).

> Jesús Navarro authored *"El principio de incertidumbre de Heisenberg"* for Natgeo Ciencias, a National Geographic series.

> Mikael Rodríguez released *"Física Cuántica para Alicia"* (Laetoli).

> Miguel Ángel Sanchis, also in *Un paseo por el Cosmos*, published *"Los límites del universo"* (RBA publishers).



Science communication Colloquia

As part of the programme of Severo Ochoa Colloquia we invited three well-known science communicators who offered two colloquia on the value of outreach and how it impacts society and the scientific career:

- Javier Santaolalla and Santiago García presented some of the new audiovisual formats that are being used, especially to reach the youngest sectors of the public: YouTube, podcasting, and even stage shows, are emergent languages and are the reference for the public under 20.

- José Manuel López Nicolás, professor at the University of Murcia and author of Scientia, one of the most successful science blogs in Spanish, talked about the synergies between research and outreach, which work of course in the sense that new research can produce new communication pieces, but also in the opposite direction.

In 2017 IFIC web site was re-designed, publishing around 70 updates with information on the activities of IFIC

OUTREACH ACTIVITIES

Guided tours for students

The institute offers guided tours to our facilities for groups of students interested in particle physics. These tours, usually spanning a whole morning, include a talk introducing some particle physics concepts and the research lines of IFIC, followed by a visit to our outreach material in the experimental building (cloud chamber, ATLAS Lego model, LHC photocall). After a break for coffee and food the tour continues with visits to two of our laboratories.

The available labs for the tours are ANTARES/Km-3NET, NEXT, ATLAS-Silicon, ATLAS-TileCal, Medical Imaging, GRID-Computing centre, Gamma Spectroscopy and Future Colliders. Alberto Aparici is the main responsible and coordinator for these visits, and usually he also plays the role of maître-de-cérémonie, but each laboratory provides one or two people who can share their expertise with the students during their visit to the labs. Thirty-three members of IFIC contributed to the tours throughout the year.

The total number of visiting schools in 2017 was twenty-eight, from towns all over our region, mainly from the province of Valencia, but also including Villena and Novelda from Alicante and Castellón de la Plana. Some visits were arranged together with the local delegation of CSIC in the Valencian Community, which sponsors the program Conciencia Sé to connect CSIC research centers and high schools.

The programme of joint visits with Observatori Astronòmic continued along 2017. By means of this collaboration the staff of Observatori brings some of their own guided tours to the experimental building of IFIC, and there they receive a short talk about particle physics and can see our outreach material. Eleven groups visited IFIC as part of this program, from towns all over the province of Valencia.

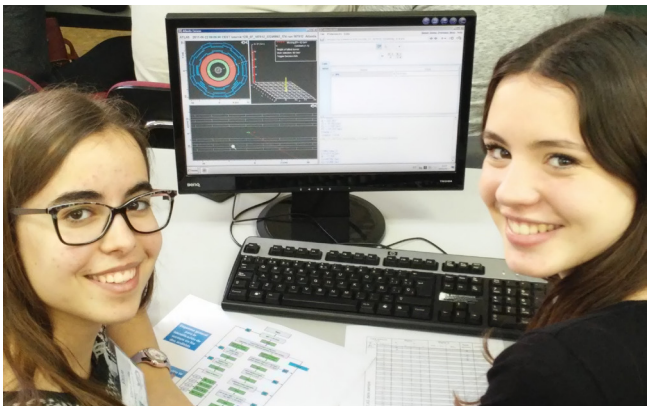
We were also pleased to host some special visits during this year. We received three groups of degree students of Universitat de València, two from the Degree in Physics and one from Electronics Engineering, and two groups studying an Associate Degree in Medical Physics, who came specifically to visit IFIMED. The ESTALMAT programme, devoted to promoting mathematical talent, visited the institute with a group of 60 students. In summer we also hosted the two groups of students within the VLC/Campus programme and one group of High School #1517 from Moscow, whose visits have already become a tradition. Besides these, we were also pleased to host two groups of senior people: the GeoGrans collective and a group from the senior programme of Florida Universitària. As we also mention below, we received in addition a group of high school teachers as part of our programme of particle physics outreach for teachers. Overall, in 2017 we hosted 900 visitors, getting over the figures of the previous year.

28 schools visited IFIC from all over Comunitat Valenciana. Overall, we hosted 900 visitors in 2017

International Masterclasses

Every year since 2005 CERN promotes the organisation of the Hands On Particle Physics International Masterclasses, a series of events that gather together high school students from all over the world to learn about particle physics by analysing real data from the experiments at CERN. IFIC participates since the very beginning, and in 2017 hosted two masterclasses: one using data of the ATLAS experiment, coordinated by Santiago González, and another with data of the LHCb experiment, led by Fernando Martínez.

The masterclasses are held at the facilities of IFIC and at the Faculty of Physics on the nearby Campus de Burjassot. The participating students, accompanied by their teachers, gather at the Campus and spend the rest of the day together. The schedule of a masterclass includes several talks introducing basic concepts of the Standard Model and of experimental particle physics, and then a practical exercise analysing real data from the LHC experiments. In the ATLAS masterclass the exercise aims at probing the quark structure of the proton and trying to identify possible Higgs boson decays. In the LHCb masterclass the aim is to measure the lifetime of the D^0 meson.



After the exercise the group prepares for lunch, and in the afternoon the obtained results are discussed and interpreted. The masterclass comes to an end with a videoconference where the students can share their results with other participants in different countries that have worked through the same exercise. One or two experts at CERN act as masters of ceremonies and discuss how the results change when more data are put together.

In 2017 we booked two classrooms for the exercise, which allowed to almost double the attendance: overall, 147 students and 55 teachers from 56 different high schools came to IFIC to feel like particle physicists for one day. Some of them travelled as much as four hours by train to attend their masterclass. Twenty-three members of IFIC were involved in the different tasks, from logistics to lecturing.

Particle Physics Programme for high school teachers

Starting in 2016, IFIC sponsors a programme aimed at the teaching community of Comunitat Valenciana. Teachers in Spain have the opportunity to attend courses to update their background, but the number of courses focused on Physics is scarce. Together with the Department of Science Teaching of Universitat de València and CEFIRE, the government body that regulates such courses, IFIC offered a 30-hour programme to improve the teachers' training in particle physics and cosmology and to discuss how to translate that knowledge into the classrooms. The call for applications was a success, more than doubling the available places. All 30 places were covered.

The course was held in the Faculty of Physics, which kindly provided a classroom for the course. It included two sessions devoted to teaching techniques specific to particle physics, and two introductory lectures to relativity and quantum physics. Then several sessions followed which focused on particular topics: nuclear physics, accelerator physics, imaging techniques for medicine and neutrino physics. A special session described homemade particle physics experiments that can be used in the classroom, and the programme ended with a visit to the laboratories of the institute. Nine members of IFIC were involved in the different sessions that comprise the programme.

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Comunitat Valenciana

INNOVACIÓN EN LAS AULAS

Formación del profesorado. El Cefire de Torrent y el Instituto de Física Corpuscular de Valencia ofrecen un curso de actualización científico didáctica en física de partículas al que por segundo año se presentan el doble de profesores de Secundaria que plazas hay.

El investigador del IFIC, José Enrique Navarro, explica cómo funciona una cámara de niebla casera.

Hambre de física de partículas

► Treinta docentes de ESO y Bachillerato se ponen al día en los últimos avances científicos en un curso impartido por investigadores del Instituto de Física Corpuscular de la Universitat de València y el CSIC

Rafel Montaner
VALENCIA

FOTOS DE DANIEL TORTAJADA

■ El bosón de Higgs, los grandes aceleradores de partículas, los agujeros negros, la física nuclear, los neutrinos, la mecánica cuántica y el gato de Schrödinger que puede estar a la vez vivo y muerto dentro de una misma caja... Nunca ha estado tan omnipresente en la sociedad la física de partículas, esa que en la que a través de altas energías se busca entre la materia subatómica con el objetivo de desentrañar los orígenes del Universo.

Sin embargo en los temarios de ESO y Bachillerato el reloj se paró hace 100 años con Einstein y su Teoría de la relatividad. Y eso, siendo optimista, pues hasta aquí sólo llegarán en el último trimestre del curso aquellos que elijan la optativa de Física en 2º de Bachillerato.

Poner freno a tamaño desatino es lo que ha llevado al Centro de Formación, Innovación y Recursos Educativos (Cefire) de Torrent y al Instituto de Física Corpuscular (IFIC) de Valencia, centro de investigación mixto del Consejo Superior de Investigaciones Científ-

por segundo año un curso de Actualización científico didáctica en física de partículas para enseñanza Secundaria. En ambas convocatorias se han presentado el doble de aspirantes de las 30 plazas que ofertan.

Actualización científica

«La actualización científica del profesorado es una de las necesi-

EXPERIMENTOS

Cámara de niebla casera y simulador de acelerador de partículas

► Entre los recursos didácticos que ofrece el curso al profesorado destacan una serie de experimentos sencillos de aplicar en el aula como por ejemplo una cámara de niebla casera para observar las trazas que dejan las partículas de la radioactividad natural de la atmósfera. Lo hacen con una pecera para tortugas, hielo seco y un alcohol que se evapora a 0ºC. En la nube que se forma se pueden observar las trazas de los núcleos de helio de las partículas alfa del radón o algunas de los miles de electrones que emite cada segundo el Carbono 14 de nuestro cuerpo. Otra propuesta es construir un simulador de acelerador circular con una ensaladera, una pelota con pintura metálica, dos bandas metálicas

presentes en la sociedad actual, por lo que el alumnado pide saber mucho más de lo que ve en el temario», cuenta Eva Camarero, asesora de Ámbito Científico del Cefire de Torrent y codirectora del curso.

El otro codirector es Alberto Aparici, doctor en Física Teórica y responsable de la divulgación científica en el IFIC. Destaca el valor del curso porque pone en contacto a investigadores en activo que están trabajando en los experimentos más importantes de la física moderna como el LHC, el gran acelerador de partículas del CERN de Ginebra, con los docentes encargados de enseñar a los jóvenes. «Explicar lo que estamos investigando ahora en física nos permite transmitir que la ciencia está viva», subraya.

Entre los 30 profesores que han participado en esta segunda edición del curso están Aitor Monserrate, que vive su primer año dando clase en el Instituto público de Educación Secundaria (IES) Nº 1 de Requena. «Los alumnos ven muchas noticias sobre los avances recientes de la física y están muy interesados en saber más», explica Aitor. Isabel Algaba, profesora del Colegio Palma de La Canyada (Paterna), relata que a sus estudiantes «lo que más les gusta es que les hable de física moderna, tienen una gran curiosi-

Expociència 2017

Every year, around the end of May, Parc Científic organises Expociència, an open door day in the context of which demonstrations are performed and science outreach activities are offered to the public. In 2017 more than 4,300 people attended the event, visited the facilities of Parc Científic and swarmed around more than 80 different stands whose activities ranged from robotics to food science. IFIC contributed with six activities, including a videoconference from the Louisiana University with the former member of IFIC Iván Agulló. Overall, 50 members of IFIC were involved in the organisation, logistics and execution of Expociència activities.

Activity	IFIC members involved
Telescopios de neutrinos: observando el universo desde las profundidades del mar	J. Zúñiga, J. Barrios, D. Real, A. Coleiro
Cocinando en el Ártico	J. Salvadó, M. Jay-Pérez, A. Rodríguez, A. Laing, M. Kekic, A. Botas, L. Rogers
ATLAS, un gigante para atrapar partículas	S. Cabrera, R. Ruiz de Austri, M. Alonso, L. Barranco, P. Fernández de Salas, L. Fiorini, P. Zuccarello, O. Estrada, S. Rodríguez, D. Álvarez, F. Castillo, W. Torres, C. Krause
¿Somos radiactivos?	A. Montaner, V. Guadilla, B. Rubio, P. Aguilera, P. Olleros, H. García
Buscando antimateria en LHCb	A. Oyanguren, C. Sánchez, C. Remón, L. Miguel García, J. Ruiz, J. Mazorra, M. Nebot, F. Cornet, L. Henry, M. Vergara
Videoconferencia con Louisiana	J. Navarro, A. Aparici

147 students from 56 schools participated at IFIC Masterclasses. 30 teachers attended to a training programme on particle physics

Experimenta

Every year the Faculty of Physics of Universitat de València organises the Experimenta Exhibition-Contest, an event aimed at high school students for which they develop a project in basic science or technology with the help of their teachers. The projects are exhibited in a public session where the students themselves explain the science within, and then they are evaluated by a jury and four winners are selected. IFIC was involved as part of the organising committee, several members of the institute served as jurors during the contest phase of the event, and several others helped in organisational tasks and logistics.

Pint of Science

Pint of Science is an international festival that aims at transforming pubs into public forums of science discussion. In Valencia it is sponsored by the Town Council by means of the InnDEA Foundation. The researcher of IFIC Miguel Ángel Sanchis was the physics coordinator of the Valencian node of the festival, and three members of the institute acted as speakers: Ana Montanter, Alberto Aparici and Miguel Ángel Sanchis.

Herbert Dreiner's Physics Show

The professor at the University of Bonn Herbert Dreiner is the creator of What's (the) Matter?, a show that aims to explain to the layman some concepts of fundamental physics, such as the atomic structure or the discovery of the Higgs boson, by means of a storyline and 28 different physics experiments. The show, that was started in 2001, came to Valencia for the first time thanks to the sponsorship of the member of IFIC Gabriela Barenboim and the Invisibles+ and Elusives networks. Two performances were scheduled at the Santiago Grisolía auditorium in the Príncipe Felipe Science Museum: one was aimed at high school students, and the other was open to anyone interested with free entrance. Both had all their seats sold out.

European Researchers' Night

September 29th was the chosen day to celebrate the European Researchers' Night, a Europe-wide event sponsored by the European Commission which aims to bring together researchers and citizens. Valencia joined the initiative for the first time, and it was decided that on this occasion the event would be devoted to women in science. Thirty female researchers participated by sharing their experiences and their scientific expertise, and four of them were members of IFIC: Carmen García, Berta Rubio, Susana Cabrera and María José Costa.

Dark Matter Day

IFIC joined the initiative of the Interactions Collaboration to promote public knowledge of the physics of dark matter and the many efforts devoted to elucidate its nature. For this aim, the institute participated in the production of the documentary *Phantom of the Universe*, which summarizes what we know about dark matter and is publicly available for projection in planetarium (fulldome) format.

IFIC sponsored the exhibition of the documentary in planetariums in Valencia, Granada and Castellón, together with a short talk by a member of the institute: in Valencia the speaker was Alberto Aparici; in Granada, Juan de Dios Zornoza; and in Castellón, Sergio Palomares. The three events were a success, with an overall attendance of more than 700 people.

IFIC participated for the first time in the European Researchers' Night and organized the first Dark Matter Day

Anniversary of Marie Skłodowska Curie

November 7th, 2017 marked the 150th birth anniversary of Marie Skłodowska Curie. IFIC and the Faculty of Physics celebrated the date with a conference offered by Berta Rubio, which reviewed the scientific achievements of Curie and posed one question: were there other women with outstanding achievements whose memory has not managed to diffuse into the history books? The conference was a huge success, with an attendance of more than 150 people, mostly students from the Physics and Chemistry faculties.

Outreach activities in the context of meetings and projects

The IFIC researcher Olga Mena serves as outreach coordinator for the Elusives ITN Project and the InvisiblesPlus RISE Project, wherein several outreach efforts are carried out, including comments on recent relevant advances and multimedia materials. She was also one of the organisers of the SKA meeting in Valencia, which included a public conference at the Príncipe Felipe Science Museum by Lourdes Verdes-Montenegro.

PUBLIC LECTURES

The members of IFIC offered 103 lectures along 2017 in different contexts. Some of them were aimed at high school students, and others were open to anyone interested; a few were part of courses within broader formative programmes. Some members of the institute served as organisers of conference series. In what follows we give details about all these activities.

CPAN Talks at High Schools

The Centro de Partículas, Astropartículas y Nuclear (CPAN) encourages its member institutions to offer outreach talks to local high schools and coordinates their organisation. In 2017 IFIC offered 37 such talks on three different topics: LHC physics, astroparticles and nuclear physics research. Overall, 20 members of IFIC participated in this activity.

Topic	Location	Speakers
LHC Physics	Valencia, Almussafes, Riba-roja, Carcaixent, Burjassot, Sagunt, Alzira, Castelló de la Plana, San Antonio de Benagéber, Llíria, Manises, Tavernes de la Valldigna, Almenara, Picanya, Foios, Els Pallaresos	L. Barranco, S. Cabrera, O. Estrada, C. García, J.E. García, J. Jiménez, S. Martí
Astroparticles	Valencia, La Vall d'Uixó, Vila-real, Villena, Petrer, La Pobla de Farnals, Massanassa, Alaquàs, Xirivella, Cocentaina, Pinoso, Alicante	S. Pastor, M. Tórtola, J. Zornoza
Nuclear Physics	Valencia, Burjassot, Quart de Poblet, Picassent, Manises, Alcàsser, Albal, Sagunt	B. Rubio, A. Morales, A. Montaner, J.L. Taín, A. Tolosa, A. Algora, S. Orrigo, J. Agramunt, E. Nácher, C. Domingo

Other talks at high schools

Alberto Aparici, *Mundos distantes*, SES Jaume I, Picassent.

Alberto Aparici, *Agujeros negros, mucho más que ciencia-ficción*, IES La Eliana; Colegio Sagrado Corazón de Jesús, Castellón; IES Isabel Perillán, Campo de Criptana.

Alberto Aparici, *La ciencia y la física*, Instituto 1517, Moscú.

Alberto Aparici, *El mundo de las partículas: el Modelo Estándar y más allá*, IES Massamagrell.

José Bernabeu, *Las dos fronteras de la Física: Partículas y Cosmología*, IES Lloixa, San Juan de Alicante.

Vicente Vento, *Premio Nobel del Física 2016: Transiciones de fase topológicas y fases topológicas de la materia,* IES Camp de Túria, Llíria.

Miguel Ángel Sanchis, *Del micro al macrocosmos, un viaje de ida y vuelta*, IES Marítim, Valencia.

Other public talks

During the year 2017 various members of IFIC gave a total of 30 public conferences covering a wide range of topics, from accelerator physics to quantum black holes. The talks were aimed both to official and casual gatherings.

Berta Rubio, *Somos polvo de estrellas*, Al voltant de la ciència (conference series, La Eliana).

Berta Rubio, *Marie Curie, una gran figura de la ciencia que ha pasado a la historia. ¿Hubo otras?*, Escuela oficial de idiomas (Valencia).

Vicente Vento, *Premio Nobel del Física 2016, Transiciones de fase topológicas y fases topológicas de la materia,* Octubre Centre de Cultura Contemporània (Valencia).

Mariam Tórtola, *Dones en ciència: passat, present i futur,* International Day of Women and Girls in Science (Xilxes); Associació Dones Clara Campoamor (La Vall d'Uixó).

Alberto Aparici, *La ciencia del futuro,* Senior programme of Universitat Jaume I (Sagunt).

Alberto Aparici, *Mundos distantes*, ASSTEC Bétera conference series; Science conference series of the Senior programme of Universitat de València (Valencia).

Alberto Aparici, A*gujeros negros, mucho más que ciencia-ficción*, Senior programme of Universitat Jaume I (Sagunt); Invited conference at Asociación Valenciana de Astronomía (Valencia); Invited conference of CEIC Alfons el Vell (Gandia).

Alberto Aparici, *La zona de penumbra del Sistema Solar*, 4th Meeting of Biomedical Research (Valencia).

Alberto Aparici, *Taller de astronomía*, Senior programme of Universitat Jaume I (Sagunt).

Alberto Aparici, *El mundo de las partículas: el Modelo Estándar y más allá*, Las charlas del GREL (conference series, Valencia); 1st Educational Meeting of Campo de Criptana; Escociencia 2017 (science week of San Lorenzo de El Escorial).

Alberto Aparici, *Relatividad y agujeros negros*, 3rd Meeting of Science Students of Universidad de Alicante (Alicante).

Alberto Aparici, *El origen de la fotosíntesis*, 1st ConBioPreVal (Meeting of predoctoral students in biomedicine, Valencia)

Alberto Aparici, *Round table on Outreach and the media*, 1st ConBioPreVal (Meeting of predoctoral students in biomedicine, Valencia)

Luis Álvarez, *Los neutrinos y sus interacciones con la materia*, Colloquium of the Physics Department of the University of Murcia.

Pedro González, *Estructura última de la materia*, Ciencia para todos (conference series, Albacete).

José Navarro, *El valor de la curiosidad*, Ceremony of the Fundación Cañada Blanch Awards (Borriana).

Avelino Vicente, *Problemas actuales en física de partículas*, 2017 SEMF Summer School (Valencia).

Avelino Vicente, *Viaje al corazón de la materia: ¿de qué estamos hechos?*, Una copa con la ciencia (conference series, Puerto de Sagunto).

Jordi Salvadó, *Universo invisible*, Birra y Ciencia (conference series, Valencia).

José Díaz, *Procedimientálisis en emergencias mediante espectroscopía y en laboratorio*, Workshop on environmental radiological surveillance during emergencies (IVASPE, Cheste).

Mikael Rodríguez, *Una nueva manera de ver las ondas electromagnéticas*, Ciencia en Acción 18 (educational science fair, Eibar). This contribution reached the final series of Ciencia en Acción 18.

Sergio Pastor, *Neutrinos: las partículas fantasma*, Ciencia de tomo y lomo (conference series, Madrid).

Jesús Navarro, *Trois femmes radioactives*, Journées Scientifiques de l'Emulation (conference series, Liège).

Outreach courses

The member of IFIC Alberto Aparici offered the course "De Einstein al bosón de Higgs" for the senior programmes of Universitat de València and Universitat Jaume I (Castellón de la Plana). In Valencia the course comprised 34 hours (17 lectures) and in Castellón 20 hours (10 lectures). The course reviewed some topics of 20th century physics, including relativity, quantum mechanics, particle physics and cosmology. Senior programmes in Comunitat Valenciana often lack science contents, and so this initiatives fill in a gap in the training of senior people, which is going to be of paramount importance in the 21st century.

As organisers

Several members of IFIC acted as organisers of public conferences and conference series. We list here the results of these initiatives:

- Olga Mena, as part of the organisation of the meeting of SKA in Valencia, promoted a public conference of Lourdes Verdes-Montenegro in the Príncipe Felipe Science Museum in Valencia. The title of the conference was *El Square Kilometer Array o qué tienen que ver Einstein, Jodie Foster y 300 ingenieros*, and was attended by over 200 people.

- Gonzalo Olmo and the Quantum Black Holes, Supergravity and Cosmology group hosted the 12th Iberian Cosmology Meeting, which included a public conference by Diego Rubiera-García at the Rector Peset residence, entitled *Cosmología: la Historia de nuestro Universo*.

- Alberto Aparici organised the conference series *Birra y Ciencia* at Olhöps Craft Beer House in Valencia. In 2017 the series comprised three talks, by Jordi Salvadó, Fernando Cervera and Ignacio Crespo.

- Jesús Navarro is one of the organisers of the conference series *Al voltant de la ciència* in La Eliana. During 2017 he organised three conferences: the speakers were Berta Rubio, Juli Peretó and Rafael García Molina.

- Avelino Vicente organises the conference series *Una copa con la ciencia* as part of Sapiencia, the science association of Sagunto. Four such talks took place during 2017: one by the same Avelino Vicente (listed above) and three more by Francesc Gascó, Isabel Cordero and Néstor Calvo.

IFIC IN THE MEDIA

In 2017 IFIC participated in the production of more than 150 pieces for several media, from newspapers to television. Some of them were produced directly by members of IFIC and others were the result of interviews or press releases issued by the outreach office of the institute.

Written articles

The institute produced 27 press releases during 2017. All of them were echoed on their web sites by Universitat de València and the branch of CSIC in Comunitat Valenciana. Some of them reached the media, either on physical paper or online.

Nuevo sistema para monitorizar en tiempo real la terapia con partículas pesadas contra el cáncer, Europa Press (26/01/2017)

Hambre de física de partículas, Levante EMV (06/02/2017)

Científicos buscan alternativas al LHC, que dejará de funcionar en 2035, ABC (16/02/2017)

China planea la mayor máquina del mundo para entender el universo, El País (24/02/2017)

IFIC colabora con la universidad Mohamed V de Rabat para lanzar una infraestructura de computación del LHC en Marruecos, El Economista (01/03/2017)

La ciència amb humor arriba millor, InfoUniversitat (05/04/2017)

Investigadores del IFIC lideran un estudio que mejora la búsqueda de nuevos bosones de Higgs, Valencia Plaza (29/04/2017)

La Gravity Research Foundation premia por primera vez un ensayo de científicos de una institución española, el IFIC, La Información (19/05/2017)


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Portada Mercados y Cotizaciones Empresas Economía Tecnología Vivienda Opinión Autonomías Servicios

IFIC colabora con la universidad Mohamed V de Rabat para lanzar una infraestructura de computación del LHC en Marruecos

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UNIVERSITAT DE VALÈNCIA Y CSIC

Investigadores de l'IFIC lideran un estudio que mejora la búsqueda de nuevos bosones de Higgs


CIENCIA | EM 38

Los 'Leonardos' del siglo XXI

La Fundación BBVA ha recibido más de 2.000 solicitudes para sus becas de 2017 ● La investigación de nueva farmacopea' y de la materia oscura figuran entre los 50 proyectos científicos y culturales seleccionados

enDetalle


CIENCIA

Mejoran la búsqueda de nuevos bosones de Higgs


El IFIC, en la élite de la investigación mundial para mejorar la detección del cáncer de mama

EUROPA PRESS 28.06.2017

- Un equipo de investigadores de la Universitat Politècnica de València y el Instituto de Física Corpuscular (IFIC), centro mixto de la Universitat de València y el Consejo Superior de Investigaciones Científicas (CSIC), ha sido seleccionado para la fase final del Digital Mammography DREAM Challenge (DM Challenge), un proyecto mundial impulsado por las principales instituciones de lucha contra el cáncer americanas, IBM y Amazon, cuyo objetivo final es mejorar la detección de cáncer de mama mediante la interpretación de la mamografía con técnicas de inteligencia artificial.

Nueva tecnología para crear aceleradores de partículas más compactos, en IFIC, Las Provincias (12/06/2017)

El IFIC, en la élite de la investigación mundial para mejorar la detección del cáncer de mama, 20 minutos (28/06/2017)

Una investigadora del IFIC recibe una beca de la Fundación BBVA para buscar nueva física en el LHC, Europa Press (07/07/2017)

El IFIC lidera un proyecto europeo para mejorar las teorías que buscan nueva física en el LHC, 20 minutos (14/07/2017)

El experimento DUNE para estudiar los neutrinos da su primer paso en EE.UU., eldiario.es (22/07/2017)

Los 'Leonardos' del siglo XXI, El Mundo (15/08/2017)

El IFIC desarrollará un sistema para medir el nivel de tritio en agua, Las Provincias (13/09/2017)

El proyecto de Paola Ferrario, seleccionado por el Consejo Europeo de Investigación, Las Provincias (25/09/2017)

El IFIC estrena un documental sobre el estudio de la materia oscura, ABC (26/10/2017)

España participará en la celebración de un Halloween científico, One Magazine (30/10/2017)

Científicos se reúnen en Valencia para debatir sobre el mayor radiotelescopio del mundo, Valencia Plaza (06/11/2017)

IFIC organiza campamento formación de investigadores en telescopio neutrinos, La Vanguardia (14/11/2017)

L'Oréal-Unesco For Women in Science destaca a cinco científicas españolas, La Razón (27/11/2017)

Investigador IFIC, premio Arquímedes por trabajo que rescata idea de Wilczek, ABC (27/11/2017)

El IFIC lidera un experimento en Japón para probar cómo se forman los elementos pesados en el Universo, Levante EMV (20/12/2017)

Researchers of IFIC also appeared in several other pieces in written media:

La antimateria: el reverso oculto de todo lo que nos rodea, EcoDiario (16/04/2017)

Un telescopio de neutrinos bajo el Mediterráneo para 'cazar' la materia oscura, El Confidencial (26/04/2017)

A conversation with José Bernabéu, Biofísica Magazine

Comunitat Valenciana

La «mili» de la física de neutrinos

▶ Cincuenta jóvenes físicos de 7 países se entrenan en el IFIC de València para investigar en el mayor telescopio submarino del mundo

A la caza de la materia oscura

MUJERES Y CIENCIA: DEL HIDRÓGENO AL UNIVERSO

La astroquímica o la biología centran cinco proyectos premiados con la idea de animar a las más jóvenes

EN PRIMERA PERSONA

«Quedan muchos retos por delante»

Prado Martín

Eva María Fernández

Mariam Tórtola

Mariona Coll

Maia Van-Vergniory

Articles authored by IFIC members

Gonzalo Olmo, *Radiación Hawking y agujeros negros acústicos*, La Física del GREL.

Gonzalo Olmo, *Entrevista a Iván Agulló*, La Física del GREL.

Juan Zúñiga, Juan de Dios Zornoza, Juan José Hernández, *A new way of looking at the sky: neutrino telescopes*, Mètode.

Juan de Dios Zornoza, *Telescopios submarinos de neutrinos: ANTARES y KM3NeT*, Entre cientIFIC@s

Alberto Aparici, *Adiós a la gran dama de la materia oscura*, Jot Down.

Alberto Aparici, *Muertes anunciadas: los finales que la ciencia prevé para nuestros vecindarios en el cosmos*, Jot Down.

Alberto Aparici, *Cuando las bacterias inventaron el mundo*, El Confidencial.

Alberto Aparici, *Los enigmáticos agujeros negros 'invisibles' que fascinan a los astrónomos*, El Confidencial.

Sergio Palomares, *Neutrinos cósmicos: una nueva ventana al Universo*, Entre cientIFIC@s

Juan José Gómez, *Carmen Vela y Marina Villegas: una conversación en el Museo de Ciencias Naturales*, Jot Down

Juan José Gómez, *Fabiola Gianotti: «Progress evolves smoothly based on the development and improvement of known technology»*, Jot Down

Avelino Vicente, *¿Cómo descubrimos nueva física en el LHC?*, Entre cientIFIC@s

Avelino Vicente, *Viaje al corazón de la materia: ¿de qué estamos hechos?*, Blog Sapiencia

Avelino Vicente, *La vida de un científico (I)*, Blog Sapiencia

Pablo Fernández, *El modelo cosmológico estándar*, Entre cientIFIC@s

Mario Reig, *Sobre la estructura del Modelo Estándar (I): Partículas y familias*, Entre cientIFIC@s

Radio pieces

Alberto Aparici, 45 issues of *La Brújula de la Ciencia*, Onda Cero

Alberto Aparici, *Primos de Fermat, números perfectos y polígonos construibles*, Especial Lotería de Navidad de Onda Cero

Alberto Aparici, *Collaborator in 20 issues*, Coffee Break: Señal y Ruido

Alberto Aparici, *Interstellar: análisis científico, filosófico y político (1)*, ¡Qué significa esta película?

Alberto Aparici, *Interstellar: análisis científico, filosófico y político (2)*, ¡Qué significa esta película?

Alberto Aparici, *Charlando acerca de Grafeno y física de partículas con Alberto Aparici*, La Buhardilla Geek

Alberto Aparici, *Conductor in the show La ciencia y sus evidencias*, Scenio podcast

Alberto Aparici, *Isaac Newton*, A ciencia cierta

Pedro González, *Estructura última de la Materia (I)*, Hablando con científicos

Pedro González, *Estructura última de la Materia (II)*, Hablando con científicos

Paola Ferrario, *Mujeres y ciencia*, A ciencia cierta

Antonio Sánchez, *Agujeros negros, ¿guarida de gusanos?*, El Café cuántico

Diego Rubiera-García, *Retos del espacio profundo*, El Café cuántico

Gonzalo Olmo, *Un asunto de gravedad*, El Café cuántico

Juan de Dios Zornoza, *Interview on the Dark Matter Day*, El Radioscopio

TV and audiovisual pieces

Juan de Dios Zornoza, *Descubren una nueva cámara vacía en la Gran Pirámide de Keops*, Antena 3

Alberto Aparici, *La NASA anuncia el hallazgo de siete exoplanetas en el sistema TRAPPIST-1*, Antena 3

Pedro González, *Naturaleza cuántica del electrón*, Didactic videos of the Laboratory of Quantum Physics

Pedro González, *Efecto fotoeléctrico*, Didactic videos of the Laboratory of Quantum Physics

Pedro González, *Experimento de Franck-Hertz*, Didactic videos of the Laboratory of Quantum Physics

Pedro González, *Espectro de Rayos X*, Didactic videos of the Laboratory of Quantum Physics

Pablo Fernández, *Two cosmologists answer your questions about the universe!*, Periscope of the TTK Institute RWTH (Aachen)

Apart from these pieces IFIC also produced the recordings of 14 Severo Ochoa Colloquia, available at the YouTube channel of the institute, and participated in the production of the documentary Phantom of the Universe, as explained above.

IFIC produced 27 press releases in 2017. More than 150 hits on media were obtained

8. YOUNG RESEARCHERS, GENDER AND DIVERSITY

In October 2017 it was created the Office for Early Career Researchers, Gender and Diversity (JIGD for its acronym in Spanish). The aim of this Office is to eliminate any harassment or discrimation that could happen in the Institute, ensuring equal opportunities for all members and promoting good relationship among them. This team is formed by Arantza Oyanguren and Juande Zornoza, with a mandate of two years.

The first action taken was the distribution of a questionnaire among members of the Insititute to assess the present situation concerning these issues. More than 50 people participated in this questionnaire. Among the most relevent results, it can be mentioned that the percentage of members who report to have felt some kind of discrimination at IFIC is about 6%, which underlines the importance of the existence of this office. Another conclusion is that 96% of respondants aswered "Yes" or "Maybe" when asked about their willingness to stay at IFIC.

Before the creation of this office, IFIC collaborated in the First Day Workshop on Female Researchers, organized by the ICMol and the Unit for Equality of the University of Valencia), where IFIC members participated in the talks and in the round table discussion.

In 2017 it was created the Office for Early Career Researchers, Gender and Diversity to ensuring equal opportunities for all IFIC 's members

9. FUNDING

In this section we include all research grants that were active during the whole or part of 2017, funded by European Union (EU), national (NP), regional (CCAA) or other agencies.

3.4 million in 37 new projects

obtained in 2017

14 Regional projects / 1.7 million

4 European projects / 1.1 million

3 National projects

The number of new national projects is low because most of them started in 2016.

24 million in 90 projects

underway in 2017

28 National projects / 12.8 millon

16 European projects / 7.5 million

19 Regional / 2 million

9 Technology / 0.9

NATIONAL PLAN PROJECTS

Funded by the Ministerio de Economía y Competitividad (MINECO) of the Spanish Government.

Experimental Physics

Tier-2 Distribuido español para el experimento ATLAS (LHC) Fase 3 y su papel en la gestion y procesamiento de grandes cantidades de datos
Ref. FPA2013-47424-C3-1-R
PI: Jose Salt Cairols
1,252,350 € (Jan 2014 – Jun 2017)

Red de Física en el LHC y actualización de sus experimentos
Ref. FPA2015-71967-REDT
PI: Carmen García García
35,000 € (Jan 2015 – Nov 2017)

Detectores para aplicaciones médicas
Ref. FPA2014-53599-R
PI: Gabriela Llosa Llácer
30,250 € (Jan 2015 – Dec 2017)

Estudios de desintegraciones beta y de reacciones para la estructura nuclear, astrofísica y aplicaciones
Ref. FPA2014-52823-C2-1-P
PI: Alejandro Algora
423,500 € (Jan 2015 – Dec 2017)

Estructura nuclear en núcleos exóticos: Experimentación, estudios teóricos y desarrollos instrumentales para AGATA
Ref. FPA2014-57196-C5-1-P
PI: Andres Gadea Raga
187,550 € (Jan 2015 – Dec 2017)

Espectrómetro portátil de xenon a alta presión para rayos gamma y neutrones
Ref. FPA2014-61149-JIN
PI: Nadia Yahlali
169,100 € (Jan 2015 – Dec 2017)

Desafios presentes y futuros del experimento LHCb del CERN (II)
Ref. FPA2015-68318-R
PI: Arantza Oyanguren
272,250 € (Jan 2016 – Dec 2017)

Detectores nobles para busquedas de violación de los numeros bariónico y leptónico
Ref. FPA2017-82081-ERC
PI: Michel Sorel
68,181€ (Jan 2017 – Nov 2018)

Construcción, operación e I+D+i para el experimento NEXT en el LSC
Ref. FIS2014-53371-C4-1-R
PI: Juan Jose Gomez Cadenas
895,400 € (Jan 2015 – Dec 2018)

Contribuciones al detector interno de trazas y al programa de física del experimento ATLAS en el LHC
Ref. FPA2015-65652-C4-1-R
PI: Carmen García García
1,833,150 € (Jan 2016 – Dec 2018)

Contribucion a la operación ATLAS y análisis de datos. Investigación y desarrollo (I+D) para futuros aceleradores y estudios de fisica
Ref. FPA2015-65652-C4-3-R
PI: Juan Fuster Verdú
290,400 € (Jan 2016 – Dec 2018)

Contribuciones al calorimetro hadronico Tilecal y al programa de física del experimento ALTAS
Ref. FPA2015-65652-C4-2-R
PI: Luca Fiorini
496,100 € (Jan 2016 – Dec 2018)

Participación del IFIC en ANTARES, Km3NET-ARCA/ORCA y PDG
Ref. FPA2015-65150-C3-1-P
PI: Juan de Dios Zornoza Gómez
301,895 € (Jan 2016 – Dec 2018)

Desarrollo de un nuevo tipo de aparato PET de alta sensibilidad basado en xenon líquido
Ref: FPA2016-78595-C3-1-R
PI: José Díaz Medina
60,500 € (Dec 2016 – Dec 2018)

Apoyo a Centros Excelencia Severo Ochoa
Ref. SEV-2014-0398
PI: Juan J. Hernandez Rey
4,000,000 € (Jul 2015 – Jun 2019)

Red Española de Física del Sabor
Ref. FPA2016-81784-REDt
PI: Arantza Oyanguren
20,000 € (Jan 2017 – Jun 2019)

Hacia un genuino TIER-2 federado español de ATLAS para afrontar el reto de la gestión y procesado del Big Data del LHC
Ref. FPA2016-75141-C2-1-R
PI: Santiago González de la Hoz
925,650 € (Dec 2016 – Dec 2019)

Física de Oscilaciones de neutrinos en el IFIC y la UAM
Ref: FPA2016-78417-C2-1-P

PI: Anselmo Cervera Villanueva
195,000 € (Dec 2016 – Dec 2019)

Theoretical Physics

Red nacional Temática de Astropartículas
Ref. FPA2015-68786-REDT
PI: Sergio Pastor Carpi
35,000 € (Dec 2015 – Nov 2018)

Teorías efectivas en física nuclear y de hadrones
Ref. FIS2014-51948-C2-1-P
PI: Juan M. Nieves Pamplona
159,720 € (Jan 2015 – Dec 2017)

Física de Partículas en el LHC y las factorías de sabor
Ref. FPA2014-53631-C2-1-P
PI: Antonio Pich Zardoya
231,110 € (Jan 2015 – Dec 2017)

Física Nuclear y de hadrones a energías intermedias
Ref. FIS2014-51948-C2-2-P
PI: Manuel Vicente Vacas
54,540 € (Jan 2015 – Dec 2017)

Partículas elementales: El Modelo Estándar y sus extensiones
Ref. FPA2014-54459-P
PI: Arcadi Santamaria Luna
349,690 € (Jan 2015 – Dec 2017)

Astropartículas y física de altas energías
Ref. FPA2014-58183-P
PI: Jose Furtado Valle
217,800 € (Jan 2015 – Dec 2017)

Sabor y Origen de la materia
Ref. FPA2014-57816-P
PI: Pilar Hernandez Gamazo
164,560 € (Jan 2015 – Dec 2017)

Gravitación y campos cuánticos
Ref. FIS2014-57387-C3-1-P
PI: Jose Navarro Salas
72,600 € (Jan 2015 – Dec 2017)

Red Española de Relatividad y gravitación
Ref. FIS2016-81770-REDT
PI: Gonzalo Olmo Alba
18,500 € (Jan 2017 – Jun 2019)

Física Hadrónica Interacciones fundamentales y física nuclear
Ref: FPA2016-77177-C2-1-P
PI: Pedro González Marhuenda
78,650 € (Dec 2016 – Dec 2019)

EUROPEAN PROJECTS

EUCARD-2
Ref. 312453
IFIC PI: Juan Fuster Verdú
20,000 € (May 2013 – Apr 2017)

Solving Challenges in Nuclear Data (CHANDA)
FP7-EURATOM-FISSION, Ref. 605203
IFIC PI: José Luis Taín Enríquez
76,000 € (Dec 2013 – Nov 2017)

Towards the NEXT generation of neutrinoless double beta experiments
ERC Advanced Grant, Ref. 284518
PI: Juan J. Gómez Cadenas
2,791,776 € (Feb 2014 – Jan 2019)

Advanced European Infrastructures for Detectors at Accelerators (AIDA)-2020
H2020. Ref. 654168
IFIC PI: Marcel A. Vos
93,396.22 € (May 2015 – Apr 2019)

Europe-Japan Accelerator Development Exchange Programme (E-JADE)
H2020-MSCA-RISE-2014 Ref. 645479
IFIC PI: Ángeles Faus Golfe
63,000 € (Jan 2015 – Dec 2019)

European Nuclear Science and Applications Research (ENSAR2)
H2020. Ref. 654002
IFIC PI: Andres Gadea Raga
159,625 € (Mar 2016 – Feb 2020)

Optimization of Medical Accelerators (OMA)
H2020. Ref. 675265
IFIC PI: Juan Fuster Verdú
247,872.96 € (Feb 2016 – Jan 2020)

INVISIBLESPLUS
Ref. 690575
IFIC PI: Pilar Hernández Gamazo
198,500 € (Feb 2016 – Jan 2020)

ELUSIVES
Ref. 674896
IFIC PI: Pilar Hernández Gamazo
454,402.92 € (Apr 2016 – Mar 2020)

TRITIUM
Ref. SOE1/P4/EO214
IFIC PI: Jose Diaz Medina
281,304.16 € (Jul 2016 – Jul 2019)

High-sensitivity Measurements of key stellar Nu-

cleo-synthesis reactions
ERC Consolidator Grant
Ref. 681740
PI: César Domingo Pardo
1,886,558 € (Jun 2016 – May 2021)

INVISIBLESPLUS
Ref. 690575
IFIC PI: Olga Mena Requejo
103,220 € (Feb 2016 – Jan 2020)

Developing new world-class research infrastructures Astroparticle and Oscillations Research with Cosmics in the Abyss (ARCA and ORCA)
Ref: 739560
IFIC PI: Juan de Dios Zornoza Gómez
251,250 € (Jan 2017 – Dec 2019)

Commissioning, first tests and upgrade of a high-power S-Band Radio Frequency (RF) sustem for +D of high-gradient normal- accelerating cavities in breakdown science and RF conditioning - HGRF
Ref. 750871
PI: Daniel Esperante
170,121.60 € (May 2017 – May 2019)

Molecule for low diffusion TPCs for rare event searches - MELODIC
Ref. 740055
PI: Neus López March
159,126 € (Sep 2017 – Sep 2019)

Unraveled new physics at the LHC through the precision frontier
Ref. CA16201
PI: Germán Rodrigo García
560,000 € (Oct 2017 – Sep 2021)

REGIONAL PROJECTS

Funded by the Conselleria d' Educació, Investigació, Cultura i Esport of the Generalitat Valenciana (Valencian Government).

Soporte para el desarrollo de componentes de software y hardware de la solicitud de patente P201231242
Ref. APOTI/2014/010
PI: German Rodrigo Garcia
6,000 € (Jan 2016 – Dec 2016)

Estudio de la interacción de hadrones a partir de la desintegración de hadrones pesados
Ref. APOTI/2016/A/028
PI: Juan M. Nieves Pamplona
4,500 € (Jan 2016 – Dec 2016)

Aplicación de teorías efectivas y modelos hadrónicos en simulaciones de transporte de colisiones de iones pesados
Ref. GV/2016/190
PI: Miguel Albaladejo Serrano
15,646 € (Jan 2016 – Dec 2016)

Física de neutrinos en el experimento DUNE
Ref. GV/2016/142
PI: Amparo Tortola Baixauli
13,200 € (Jan 2016 – Dec 2016)

Desarrollo de nuevas tecnologías basadas en el xenón
Ref. PROMETEO/2016/120
PI: Juan José Gómez Cadenas
300,375 € (Jan 2016 – Dec 2019)

Experiment ATLAS en el RUN 2 del LHC: alineament i upgrade del detector intern. Física del Quark Top
Ref. PROMETEOII/2014/016
PI: Salvador Martí Garcia
23,600 € (Jan 2017 – Dec 2017)

Desarrollos instrumentales para los detectores complementarios de AGATA: Actividad experimental para estudios de estructura nuclear con AGATA y sus detectores complementarios
Ref. PROMETEOII/2014/019
PI: Andres Gadea Raga
43,700 € (Jan 2017 – Dec 2017)

Aproximación teórico-experimental a la búsqueda de nueva física con sabores pesados
Ref. PROMETEOII/2014/049
PI: Francisco J. Botella Olcina
66,000 € (Jan 2017 – Dec 2017)

Sabor y origen de la materia
Ref. PROMETEOII/2014/050
PI: Nuria Rius Dionis
53,300 € (Jan 2017 – Dec 2017)

Estructura Quark de la materia
Ref. PROMETEOII/2014/066
PI: Santiago Noguera Puchol
45,700 € (Jan 2017 – Dec 2017)

Física Hadrónica y nuclear
Ref. PROMETEOII/2014/068
PI: Eulogio Oset Baguena
63,400 € (Jan 2017 – Dec 2017)

Astroparticulas y física de Altas Energías
Ref. PROMETEOII/2014/084
PI: Jose Furtado Valle
45,000 € (Jan 2017 – Dec 2017)

Telescopios de Neutrinos en el Mediterráneo
Ref. PROMETEOII/2014/079
PI: Juan J. Hernandez Rey
25,900 € (Jan 2017 – Dec 2017)

Estudios perturbativos y no perturbativos del modelo estandar y sus extensiones
Ref. PROMETEOII/2014/087
PI: Arcadi Santamaria Luna
26,300 € (Jan 2017 – Dec 2017)

Precise phenomenology in the LHC ERA
Ref. SEJI/2017/019
PI: Francisco Campanario Pallas
182,156.80 € (Jan 2017 – Dec 2019)

Aspectos Teóricos y observacionales de la estructura geométrica del Espacio Tiempo
Ref. SEJI/2017/042
PI: Gonzalo Olmo Alba
182,044.50 € (Jan 2017 – Dec 2019)

Aprendizaje profundo en análisis de detectores en física
Ref. SEJI/2017/011
PI: Joshua Edward Renner
207,568.40 € (Jan 2017 – Dec 2019)

Nuevas interacciones en la frontera de altas energías
Ref. PROMETEO/2017/053
PI: Antonio Pich Zardoya
392,000 € (Nov 2017 – Oct 2021)

De la física del LHC a las claves del universo primordial en la era de los datos
Ref. PROMETEO/2017/033
PI: Gabriela Barenboim Szuchman
381,625 (Nov 2017 – Oct 2021)

OTHER PROJECTS

Impulso estratégico a la transferencia en el IFIC
Ref. PIE201350E50
PI: Juan Jose Hernandez Rey
288,000 € (Feb 2013 – Jun 2017)

Planck 2016: Desde la escala Planck hasta la escala electro-débil
Ref. FPA2015-62983-CIN
PI: Martin K. Hirsch
10,000 € (Jan 2015 – Dec 2017)

Participacion en el proyecto ATLAS: Operación del detector, análisis de datos y actualización del detector para la fase de alta luminosidad
Ref. PIE 201650E004
PI: Carmen García García
96,100 € (Jan 2016 – Dec 2019)

Estudio de núcleos exóticos ricos en protones
Ref. COOPA20125
PI: Berta Rubio Barroso
17,850 € (Jan 2016 – Dec 2017)

Calibration Unit for KM3NeT Observatory
Ref. PICS 22015
PI: Juan J. Hernandez Rey
10,000 € (Jan 2016 – Dec 2018)

Búsquedas de nueva física y desarrollo de detectores en los experimentos ATLAS y MoEDAL del LHC
Ref. PIE 201650I002
PI: Vasiliky Mitsou
9,000 € (Jun 2016 – Jun 2017)

Robot de ensamblado de gran superficie
Ref. CSIC15-EE-3099
PI: Carlos Lacasta Llácer
98,475 € (Jan 2016 – Dec 2017)

Relies in the cosmos in the 21th century
Ref. 201650I035
PI: Olga Mena Requejo
5,000 € (Nov 2016 – Nov 2017)

Launch a platform of grid computing in Morocco to meet the new challenges of physics research
Ref. COOPB20247
PI: J. Salt Cairols
17,000 € (Jan 2013 – Dec 2016)

Particle Physics at the LHC in the crossroad
Ref. 2017 50 E021
PI: Germán Rodrigo García
113,871 € (Jan 2017 – Dec 2019)

Desarrollo y estudio de elementos de reconocimiento de entorno de detectores
Ref. 201750E024
PI: Francisco José Botella Olcina
39,476.47 € (Jan 2017 – Dec 2018)

Estancia Breve FPU2017 (Italia)
Pablo Fernandez de Salas
4,290 € (Jan 2017 – Dec 2017)

Estancia Breve FPU2017 (EE.UU.)
Adrián del Río Vega
5,160 € (Jan 2017 – Dec 2017)

Impulso a las nuevas fases de los experimentos del IFIC (ATLAS upgrade, Km3NeT Fase 2,0, NEXT 100, DUNE, IFIMED)
Ref. 2017050E070
PI: María José Costa Mezquita
130,200 € (Jan 2017 – Jun 2020)

Materia oscura y neutrinos: en busca de la "nueva física"
Ref. S2017C0003
PI: Valentina De Romeri
4,820 € (Jan 2017 – Dec 2017)

Descifrando la asimetría materia-antimateria del universo con oscilaciones de neutrinos
PI: María Amparo Tórtola Baixauli
15,000 € (Jan 2018 – Dec 2018)

Desarrollo de instrumentación avanzada para medidas de reacciones nucleares de interés astrofísico
Ref. 201750I026
PI: César Domingo Pardo
5,000 € (Dec 2017 – Nov 2018)

Participación en los experimentos DUNE y NEXT
Ref. 201750I093
PI: Michel Sorel
5,000 € (Dec 2017 – Nov 2018)

TECHNOLOGY TRANSFER

Contrato de licencia exclusiva de la patente 201231243 "Dispositivo y procedimiento de obtencion de imágenes desitometricas de objetos mediente combinacion de sistemas radiologicos"
Ref. 20132089
PI: German Rodrigo Garcia
6,171 € (May 2013 – Jul 2032)

Convenio entre el CSIC, IFIC y la Empresa Nacional de Residuos Radioactivos, S.A. (ENRESA) para el desarrollo de un dispositivo para la identificación, cuantificación y distribución espacial de isótopos emisores gamma
Ref. 20145181
PI: César Domingo Pardo
301,332.97 € (Jul 2014 – Jul 2017)

Development of accelerator science and technologies associated with the CLIC accelerating structures design
Ref. 20158278
PI: Juan Fuster Verdú
526,880 € (Jan 2015 – Mar 2018)

Ensamblado de 180 tarjetas electrónicas
Ref. 20174086
PI: José Bernabeu Verdú
16,988.40 € (May 2017 – Jul 2017)

Ensamblado de 320 tarjetas electrónicas
PI: Santiago Noguera Puchol
30,201.6 € (May 2017 – Jul 2017)

Inspección por rayos X de multiples tarjetas
Ref. 20174337
PI: Francisco González González
290.40 € (Jan 2017 – Dec 2017)

EPPCN Agreement
Ref. 20173504
PI: Antonio Pich Zardoya
4,571.22 € (Jan 2017 – Dec 2017)

Contrato de Apoyo tecnológico entre el CSIC e IST "FACIEM-3D"
Ref. 20177060
PI: Francisco Albiol Colomer
23,437.70 € (Jan 2017 – Dec 2019)

Contrato licencia exclusiva de software "predicciones para el sector eléctrico"
Ref. 20162171
PI: Francisco Albiol Colomer
4,994.19 € (Jan 2017 – Dec 2017)

ANNEX: PUBLICATIONS

EXPERIMENTAL PHYSICS

AGATA Collaboration

IFIC authors: Domingo-Pardo, C.; Gadea, A.; Perez-Vidal, R.M.; Civera, J.V.

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