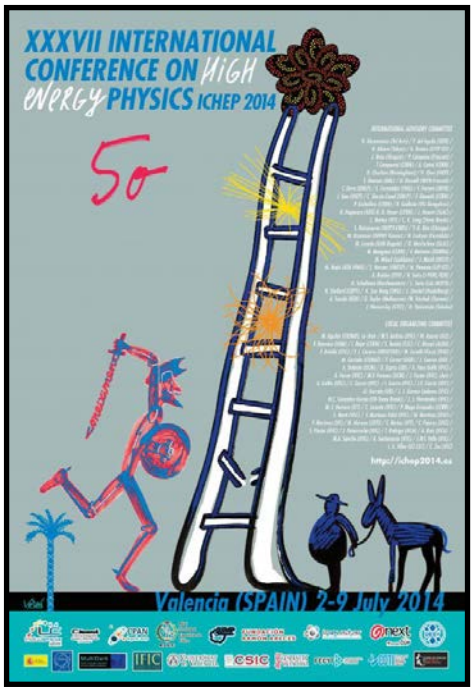

INSTITUT DE FÍSICA CORPUSCULAR

ANNUAL REPORT 2014

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CSIC
Consejo Superior de Investigaciones Científicas

Universitat de València

CONTENTS

BIENVENIDA – BENVINGUDA – WELCOME

Prof. Juan José Hernández Rey
Director IFIC

Es para mí un placer daros la bienvenida a esta Memoria Anual 2014 de nuestro instituto. Aunque me incorporé al cargo de director del IFIC en la segunda mitad de 2015, mi predecesor, el profesor Francisco Botella, me ha propuesto dirigirme a vosotros en esta introducción. Lo hago gustoso, agradeciéndole su generosidad.

Creo que recojo el sentir de todo el IFIC al decir que el profesor Botella, "Quico", ha sido un director extraordinario, con una aguda visión y una enorme competencia en la gestión de nuestro instituto y con una admirable capacidad de trabajo y de decisión. La etapa que la ha tocado lidiar, en especial los últimos años, ha sido una de las más duras y difíciles del IFIC debido a las estrecheces económicas que ha sufrido nuestro país y que se han hecho notar especialmente en el ámbito de la investigación. Quico ha sabido conducir al instituto por aguas procelosas y ha logrado que saliese fortalecido de una dura y complicada travesía en la que aún estamos parcialmente inmersos. No menos admirable ha sido su destreza para dirigir con sabiduría y mucha mano izquierda esta institución, entendiendo y apoyando de forma decidida las lícitas ambiciones de nuestros siempre competitivos grupos de investigación. Quiero expresar en nombre de todo el instituto nuestro más profundo agradecimiento a Quico por su labor.

En cuanto a mí, como nuevo director, sólo quiero manifestar el orgullo y el honor que siento al dirigir un instituto tan extraordinario y con tanta historia como es el IFIC. Haré todo lo que esté en mi mano para seguir manteniendo su probada excelencia.

Antes de pasar a resumir los hitos alcanzados en 2014, no me resisto a mencionar algo, que aún habiendo tenido lugar en 2015, es de rigor recoger aquí: la obtención por parte del IFIC de la acreditación como Centro de Excelencia Severo Ochoa. Esta prestigiosa acreditación del

És per a mi un plaer donar-vos la benvinguda a aquesta Memòria Anual 2014 del nostre institut. El meu predecessor en el càrrec, el professor Francisco Botella, m'ha proposat dirigir-me a vosaltres en aquesta introducció, inclús havent-me incorporat al càrrec tan sols a partir de la segona meitat de 2015. Ho faig gustós, agraint-li la seua generositat.

Crec que recull el sentir de tot l'IFIC al dir que el professor Botella, "Quico", ha estat un director extraordinari, amb una aguda visió i competència en la gestió del nostre institut i amb una admirable capacitat de treball i de decisió. L'etapa que li ha tocat lidiar, en especial els últims anys, ha estat una de les més dures i difícils de l'IFIC a causa de les estretors econòmiques que ha patit el nostre país i que s'han fet notar especialment en l'àmbit de la investigació. Quico ha sabut conduir a l'institut per aigües procel·loses i ha aconseguit que eixís enfortit d'una dura i complicada travessia en la qual encara estem parcialment immersos. No menys admirable ha estat la seua destresa per a dirigir amb saviesa i molta mà esquerra aquesta institució, entenent i recolzant de forma decidida les lícites ambicions dels nostres sempre competitius grups d'investigació. Vull expressar en nom de tot l'institut el nostre més profund agraïment a Quico per la seua tasca.

Pel que fa a mi, com a nou director, només vull manifestar l'orgull i l'honor que sent al dirigir un institut tan extraordinari i amb tanta història com l'IFIC. Faré tot el que estiga en la meua mà per continuar mantenint la seua provada excel·lència.

Abans de passar a resumir les fites aconseguides en 2014, no em resistisc a mencionar quelcom, que encara havent tingut lloc en 2015, és de rigor

Subprograma de Fortalecimiento Institucional de la Secretaría de Estado de Investigación, Desarrollo e Innovación del Ministerio de Economía y Competitividad es un reconocimiento a nuestra trayectoria científica y un fuerte acicate para seguir perseverando en la investigación de frontera, y para mantener e incrementar el impacto y la visibilidad que el instituto tiene a nivel mundial.

Y hablando de visibilidad y entrando en materia sobre el año que nos ocupa, el IFIC fue el foco de atención mundial de la Física de Partículas en julio de 2014, al ser el organizador de la *International Conference on High Energy Physics*, la conferencia más importante de la especialidad. Su trigesimoséptima edición, que contó con casi un millar de participantes, tuvo lugar en Valencia. Una interesante conferencia, llena de importantes resultados, y cuya organización fue sencillamente impecable. Las felicitaciones y las expresiones de admiración por la ejecutoria han llegado al IFIC incluso meses después de su finalización. Aunque es bien cierto que la realización de un evento de semejante envergadura es un logro de una larga lista de personas, no es menos cierto que este éxito incontestable es deudor de una persona en especial, el presidente del Comité Organizador Local, el Prof. Juan Fuster. La imagen de eficacia, profesionalidad y, a un tiempo, de cercanía de los físicos valencianos que la organización de la ICHEP 2014 ha dejado en la comunidad mundial es deudora del incansable trabajo del Prof. Fuster. Vaya a él nuestro agradecimiento.

Durante 2014, continuaron los trabajos de mejora del LHC. A pesar de su parada técnica, la actividad de los grupos que trabajan en los experimentos no ha disminuido un ápice, pues los análisis de los datos del *Run I* han seguido manteniendo muy ocupados a los físicos. En el experimento ATLAS, los investigadores del IFIC tienen una notable presencia en temas como el estudio del bosón de Higgs, del quark top y la búsqueda de Supersimetría. No menos activo ha estado el grupo que trabaja en el experimento LHCb. Precisamente en el capítulo de la Física del Sabor es de destacar la participación de físicos del IFIC

recollir ací: l'obtenció per part de l'IFIC de l'acreditació com a Centre d'Excel·lència Severo Ochoa. Esta prestigiosa acreditació del Subprograma d'Enfortiment Institucional de la Secretaria d'Estat d'Investigació, Desenrotllament i Innovació del Ministeri d'Economia i Competitivitat és un reconeixement a la nostra trajectòria científica i un fort estímul per a continuar perseverant en la investigació de frontera, i per mantenir i incrementar l'impacte i la visibilitat que l'institut té a nivell mundial.

I parlant de visibilitat i entrant en matèria sobre l'any que ens ocupa, l'IFIC va ser el focus d'atenció mundial de la Física de Partícules al juliol de 2014, al ser l'organitzador de la *International Conference on High Energy Physics*, la conferència més important de l'especialitat. La seua trenta-setena edició, que va comptar amb gairebé un miler de participants, va tindre lloc a València. Una interessant conferència, plena d'importants resultats, i l'organització de la qual va ser senzillament impecable. Les felicitacions i les expressions d'admiració per l'executòria han arribat a l'IFIC inclús mesos després de la seua finalització. Encara que és ben cert que la realització d'un esdeveniment de semblant envergadura és un èxit d'una llarga llista de persones, no és menys cert que aquest èxit incontestable és deutor d'una persona en especial, el president del Comité Organitzador Local, el Prof. Juan Fuster. La imatge d'eficàcia, professionalitat i, al mateix temps, de proximitat dels físics valencians que l'organització de la ICHEP 2014 ha deixat en la comunitat mundial és deutora de l'incansable treball del Prof. Fuster. Vaja a ell el nostre agraïment.

Durant 2014, van continuar els treballs de millora de l'LHC. Malgrat la seua parada tècnica, l'activitat dels grups que treballen en els experiments no ha disminuït gens, perquè les anàlisis de les dades del *Run I* han continuat mantenint als físics molt ocupats. En l'experiment ATLAS, els investigadors de l'IFIC tenen una notable presència en temes com l'estudi del bosó de Higgs, del quark top i la cerca de Supersimetria. No menys actiu ha estat el grup que treballa en l'experiment LHCb.

en la redacción del libro *"The Physics of the B factories"*, publicado en 2014 y que recoge todos los resultados de una década de investigación con los detectores *BaBar* en el colisionador PEP-II y de *Belle* en el KEKB. Por otro lado, los grupos están ya muy involucrados en el diseño y la construcción de los nuevos detectores para la fase de Alta Luminosidad del LHC (HL-LHC). Aunque esta nueva fase se espera que tenga lugar a mediados de la próxima década, los grupos tienen ya una agenda muy apretada para poder cumplir los plazos que se han propuesto. No menos exigente es la agenda de trabajo del grupo que trabaja en el ILC, el colisionador linear electrón-positrón que bien puede ser el próximo gran acelerador global. El IFIC sigue además con interés y participa en las discusiones sobre los posibles nuevos aceleradores del siglo XXI, como son el FCC, el CLIC, etc.

Los estudios experimentales sobre los neutrinos avanzan a buen ritmo. El experimento NEXT, después de una positiva etapa de demostración, ha entrado de lleno en la construcción de un detector de 10 kg, NEW, que será próximamente instalado en el Laboratorio Subterráneo de Canfranc. El experimento T2K ha suministrado valiosos resultados en cuanto a las oscilaciones de neutrinos, siendo los investigadores del IFIC especialmente activos en el estudio conjunto de los neutrinos muónicos y electrónicos.

Los telescopios de neutrinos viven un periodo de euforia después de la detección de las primeras señales de neutrinos cósmicos por IceCube. Antares, aun siendo mucho más pequeño, ha podido poner restricciones a la procedencia de dicha señal, estudios en los que los investigadores del IFIC han tenido un papel destacado, como también lo han tenido en la búsqueda indirecta de materia oscura con este tipo de detectores. Por otro lado, el gran telescopio de neutrinos en el mar mediterráneo, KM3NeT, está ya en plena Fase I de su construcción.

En un experimento liderado por investigadoras del IFIC se ha observado un modo de desintegración exótico tras la desintegración beta del ^{56}Zn, un núcleo con tercera componente de

Precisament en el capítol de la Física del Sabor cal destacar la participació de físics de l'IFIC en la redacció del llibre "*The Physics of the B factories*", publicat en 2014 i que recull tots els resultats d'una dècada d'investigació amb els detectors *BaBar* en el col·lisionador PEP-II i de *Belle* en el KEKB. D'altra banda, els grups estan ja molt involucrats en el disseny i la construcció dels nous detectors per a la fase d'Alta Lluminositat de l'LHC (HL-LHC). Encara que aquesta nova fase de l'LHC s'espera que tinga lloc a mitjans de la pròxima dècada, els grups tenen ja una agenda molt ajustada per poder complir els terminis que s'han proposat. No menys exigent és l'agenda de treball del grup que treballa en l'ILC, el col·lisionador electró-positró que bé pot ser el pròxim gran accelerador global. L'IFIC segueix a més amb interès i participa en les discussions sobre els possibles nous acceleradors del segle XXI, el FCC, el CLIC, etc.

Els estudis experimentals sobre els neutrins avancen a bon ritme. L'experiment NEXT, després d'una positiva etapa de demostració, ha entrat de ple en la construcció d'un detector de 10 kg, NEW, que serà instal·lat al Laboratori Subterrani de Canfranc. L'experiment T2K ha subministrat valuosos resultats pel que fa a les oscil·lacions de neutrins, sent els investigadors de l'IFIC especialment actius en l'estudi conjunt dels neutrins muònics i electrònics.

Els telescopis de neutrins viuen un període d'eufòria després de la detecció dels primers senyals de neutrins còsmics per IceCube. Antares, inclús sent molt més xicotet, ha pogut posar restriccions a la procedència d'aquest senyal, estudis en què els investigadors de l'IFIC han tingut un paper destacat, com també ho han tingut en la cerca indirecta de matèria fosca amb aquest tipus de detectors. D'altra banda, el gran telescopi de neutrins a la Mar Mediterrània, KM3NeT, està ja en plena Fase I de la seua construcció.

En un experiment liderat per investigadores de l'IFIC s'ha observat una manera de desintegració exòtica després de la desintegració beta del ^{56}Zn, un nucli amb tercera component d'isospín T_z=-2,

isospín T_z=–2, muy alejado del valle de la estabilidad; este modo de desexcitación sólo había sido observado, y muy recientemente, en el núcleo mucho más ligero ^{32}Ar. Por otro lado, la construcción del detector AGATA, en el que tenemos importantes responsabilidades sigue a buen ritmo.

Las contribuciones en Física Teórica son demasiado numerosas como para poder mencionarlas todas en esta bienvenida. Nuestros grupos investigan en temas tan variados como la fenomenología de física de partículas tanto dentro del Modelo Estándar como más allá de él, lo que incluye física de neutrinos, del sabor, del Higgs, así como QCD e interacciones fuertes, física de astropartículas y cosmología, información cuántica, física nuclear y de muchos cuerpos, gravitación, agujeros negros y física matemática. Animo al lector de esta memoria a que examine con detenimiento las interesantes y variadas contribuciones de nuestros grupos teóricos.

No quiero dejar de mencionar el progreso realizado en otras áreas, como el GRID y la e-Ciencia, o la de las aplicaciones médicas de la física nuclear y de partículas donde nuestro instituto trabaja de forma intensiva y cuyas contribuciones en 2014 se recogen en esta memoria.

Para acabar, quisiera agradecer a todo el instituto la dedicación, entusiasmo y empeño que ponen en su tarea investigadora. El haber sido nombrado Centro de Excelencia Severo Ochoa redundará aún más, si cabe, en nuestro profundo compromiso con la investigación de vanguardia y de calidad.

molt allunyat de la vall d'estabilitat; este mode de desexcitació només havia estat observat, i molt recentment, en el nucli molt més lleuger ^{32}Ar. D'altra banda, la construcció del detector AGATA, en el que tenim importants responsabilitats segueix a bon ritme.

Les contribucions en Física Teòrica són massa nombroses com per poder mencionar-les totes en aquesta benvinguda. Els nostres grups investiguen en temes tan variats com la fenomenologia de física de partícules tant dins com més enllà del Model Estàndard, la qual cosa inclou física de neutrins, del sabor, de l'Higgs, així com QCD i interaccions fortes, física d'astropartícules i cosmologia, informació quàntica, física nuclear i de molts cossos, gravitació, forats negres i física matemàtica. Anime el lector d'aquesta memòria a què examine amb deteniment les interessants i variades contribucions dels nostres grups teòrics.

No vull deixar de mencionar el progrés realitzat en altres àrees, com el GRID i l'e-Ciencia, o la de les aplicacions mèdiques de la física nuclear i de partícules on el nostre institut també treballa intensament i les contribucions del qual en 2014 aquesta memòria recull.

Per acabar, voldria agrair a tot l'institut la dedicació, entusiasme i interès que posen en la seua tasca investigadora. El fet d'haver estat nomenat Centre d'Excel·lència Severo Ochoa redundarà encara més si és possible en el nostre profund compromís amb la investigació d'avantguarda i de qualitat.

It is for me a pleasure to welcome you to the 2014 Annual Report of our institute. Although I took over as director only the second half of 2015, my predecessor, Prof. Francisco Botella, proposed me to write this welcome address. I do it gladly, and grateful for his generosity.

I think I gather IFIC's feelings when I say that Prof. Botella, "Quico", has been an outstanding director, with a sharp vision and a high competence in managing our institute and with an enormous capacity for hard work and decision making. The period of time he had dealt with, in particular recent years, has been one of the toughest and more complicated of IFIC's lifetime due to the economic straits our country has gone through, which have been especially noticeable in research. He has sailed our institute through troubled waters and has succeeded in getting it through a harsh and difficult passage in which we are still engaged. Equally admirable has been his skill to wisely lead and deftly manage this institute, understanding and staunchly supporting the legitimate ambition of our competitive research teams. I want to express on behalf of the institute our deepest gratitude to Quico for the wonderful job he has done.

As for me as new director, I just want to express the pride and honour I feel to run such an outstanding institute with such a long and accomplished history as IFIC. I will do my best to maintain and increase its proven excellence.

Prior to summarizing the milestones reached in 2014, I cannot help mentioning something that, although it took place in 2015, is compulsory to include here: the bestowal to IFIC of the Severo Ochoa Centre of Excellence Award. This prestigious award of the Secretary of State of Research, Development and Innovation is a recognition of our scientific trajectory and a strong incentive to persevere in frontier research and to keep and increase the impact and visibility that our institute has worldwide.

Talking about visibility and moving on to the substance of the year in question, IFIC was the focus of worldwide attention in Particle Physics in July 2014 as organizer of the *International Conference on High Energy Physics*, the most important conference of our field. Its 37^{th} edition – which gathered almost one thousand participants – took place in Valencia. An interesting conference, full of important results, whose organization was simply impeccable. The congratulations and expression of admiration for its faultless execution kept coming to IFIC months after its ending. Even though it is true that the realization of an event of such magnitude is an accomplishment of a long list of people, it is also true that this undeniable success owes a lot to one person in particular – the president of the Local Organizing Committee, Prof. Juan Fuster. The image of efficiency, professionalism and, at the same time, of nearness of the Valencian physicists that the organization of the ICHEP 2014 has left in the worldwide community is indebted to the tireless work of Prof. Fuster. Our sincere gratitude goes to him.

The upgrade of the LHC to higher energy continued during 2014. Despite this technical stop, the activity of the groups that work in the LHC's experiments did not yield an inch, since the analysis of the data taken in *Run I* have kept the physicists exceedingly occupied. In the ATLAS experiment, IFIC's scientists have a significant presence in topics such as the study of the Higgs boson, the top quark and the search for Supersymmetry. Not less active has been the group that works in the LHCb experiment. As a matter of fact, regarding Flavour Physics it is worth mentioning the contribution of IFIC's

physicists in the writing of the book *"The Physics of the B factories",* published in 2014, which gathers the results of a decade of research with the *BaBar* and *Belle* detectors in the PEP-II and KEKB colliders. On the other hand, the groups are highly involved in the design and construction of the new detectors for the High Luminosity phase of the LHC (HL-LHC). Although this new phase is expected to be commissioned by the middle of the next decade, the groups already have an extremely tight agenda to meet the deadlines they have set themselves. Not less demanding is the agenda of the group that is working on the ILC, the linear electron-positron collider that could well be the next large global accelerator. In addition, IFIC follows with interest and participates in the discussion about the new possible accelerators of the 21st century –the FCC, CLIC, etc.

The experimental studies about neutrinos progress at a good pace. The NEXT experiment, after a positive demonstration period, has fully entered the construction of a 10 kg detector, NEW, which will be installed in the Canfranc Underground Laboratory. The T2K experiment has provided valuable results about neutrino oscillations, being IFIC scientists especially active in the joint study of electronic and muonic neutrinos.

Neutrino telescopes live a time of excitement after the detection of the first signals of cosmic neutrinos by IceCube. Antares, even though much smaller, has been able to set constraints on the origin of that signal, studies in which IFIC's researchers have played a paramount role, as they have played as well in the indirect search for dark matter with this type of detectors. On the other hand, the large neutrino telescope in the Mediterranean Sea, KM3NeT, has now fully entered phase I of its construction.

In an experiment led by IFIC researchers, an exotic decay mode has been observed after the β decay of ^{56}Zn, a T_z=−2 nucleus, far away from the valley of stability; this de-excitation mode had only been observed, and very recently, in the much lighter nuclide ^{32}Ar. On another subject, the construction of the AGATA detector, on which IFIC has important responsibilities, moves forward at a good pace.

The contributions in Theoretical Physics are too numerous to be mentioned in this welcome address. Our groups investigate in such varied topics as particle physics phenomenology in the Standard Model and beyond, including collider, flavour, Higgs and neutrino physics, QCD and strong interactions, astroparticle physics and cosmology, quantum Information, nuclear and any-Body physics, gravitation and mathematical physics. I encourage the reader to peruse the interesting and varied contributions of our theoretical research teams.

I do not want to leave out the progress made in other areas, such as GRID and e-Science, or medical applications of nuclear and particle physics where our institute also intensively works and whose contributions in 2014 are collected in this report.

Finally, let me thank all the members of the institute for their dedication, enthusiasm and determination in fulfilling their research tasks. The awarding of the Severo Ochoa Centre of Excellence mention will further redound to our deep commitment with frontier and quality research.

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 center, both providing 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 open to support 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 best category Class A institute in the list of CSIC research centres.

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 been closely related to the 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 decades, it is worth mentioning the participation of IFIC in experiments at CERN (Geneva-Switzerland), GSI (Darmstad-Germany), Stanford (California-USA), FERMILAB (Chicago-USA), etc.

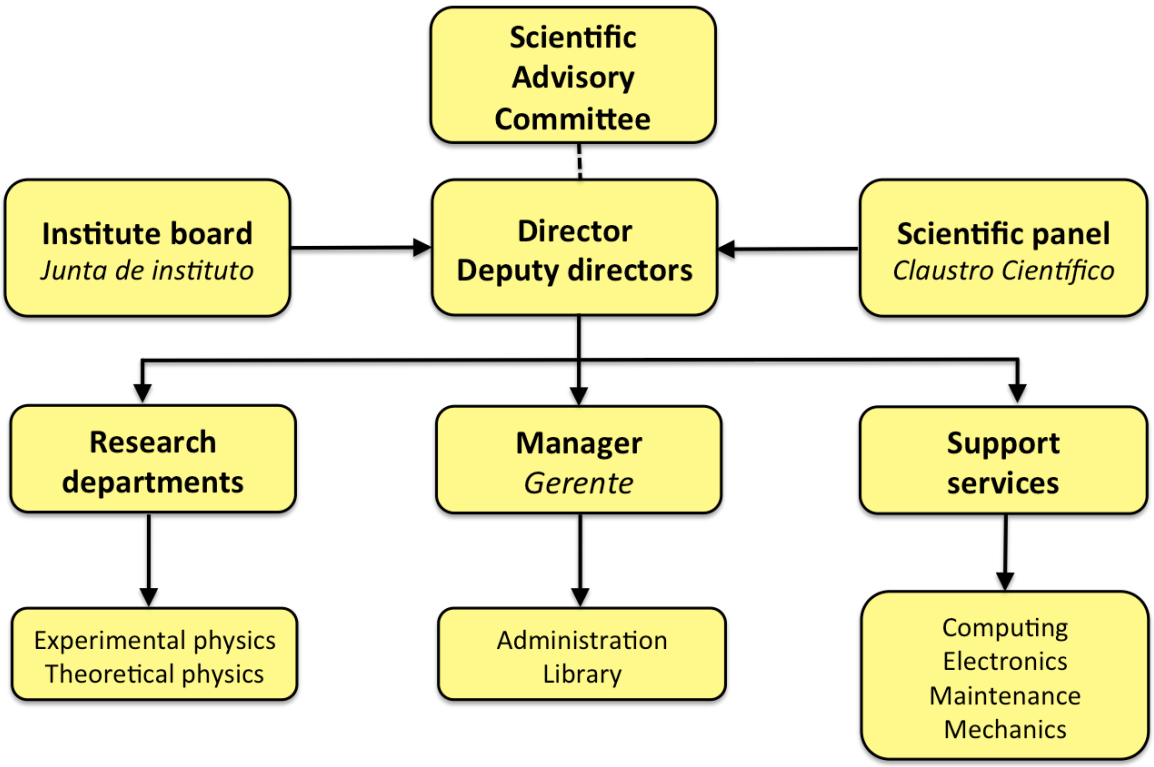
[1] An excellent review article about the birth of experimental nuclear and particle physics in Spain, written by Agustín Ceba, Víctor Navarro and Jorge Velasco, was published in *Revista Española de Física* 25-2 (2011).

ORGANIZATION, SCIENTIFIC DEPARTMENTS AND SUPPORT 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.

IFIC organization chart



Members of the Scientific Advisory Committee (31 Dec 2014): Guido Altarelli (CERN), William Gelletly (Univ. Surrey), F. Gianotti (CERN), F. Halzen (Univ. Wisconsin), Cecilia Jarlskog (Lund Univ.), Antonio Masiero (Univ. Padua), Tatsuya Nakada (EPF Lausanne), Bing-Song Zou (IHEP Beijing)

Heads of the support services: F. Javier Sánchez Martínez (Computing), J. Bernabeu Verdú (Electronics), Rosa Carrasco de Fez (Maintenance), J. Vicente Civera Navarrete (Mechanics)

Members of the Institute Board (31 Dec 2014)

Director: Francisco J. Botella Olcina

Deputy directors: Juan José Hernández Rey, Sergio Pastor Carpi

Manager: Ana Fandos Lario

Heads of the research departments: Berta Rubio Barroso (Experimental Physics), Juan M. Nieves Pamplona (Theoretical Physics)

Personnel representatives: José Bernabéu Verdú (non-doctoral members), Salvador Martí García (doctoral members)

The Institute is situated in the **Burjassot-Paterna Campus** of the University of Valencia, a few km from the centre of Valencia. IFIC personnel are distributed at the Scientific 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 buildings at the Scientific Park

Faculty of Physics (UVEG campus in Burjassot)

SCIENTIFIC DEPARTMENTS

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 and LHCb detectors of the Large Hadron Collider (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) and in the nTOF experiment at CERN. Finally, the group of Medical Physics carries out several activities mainly related to medical imaging and accelerator developments.

The research lines in Experimental Physics are:

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 and physics analyses as well as 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, some IFIC researchers became members of the LHCb and Belle II collaborations.

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, will also be deployed in the Mediterranean Sea with an effective detection volume of several cubic kilometres.

Neutrino Physics

This research line studies the intrinsic properties of neutrinos, in particular the phenomenon of flavour neutrino oscillations through the measurement of the mixing parameters. It also tries to elucidate the nature of the neutrino, i.e. if it is a Majorana or a Dirac fermion. IFIC participates in several projects, such as the long-baseline T2K experiment in Japan or SciBooNE in the United States. In addition, the IFIC group is leading the NEXT experiment which will look for neutrinoless double beta decays, a rare nuclear process whose detection would imply that neutrinos are Majorana particles. In the past, the scientists of this line participated in the experiments K2K (Japan) and NOMAD (CERN).

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.

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 analyzed, 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 mixing 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.

SUPPORT UNITS

Administration and Management

The Administration Service is located on the first floor of the main building. A total of 14 people, belonging to CSIC and UVEG, manage the ordinary performance 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.

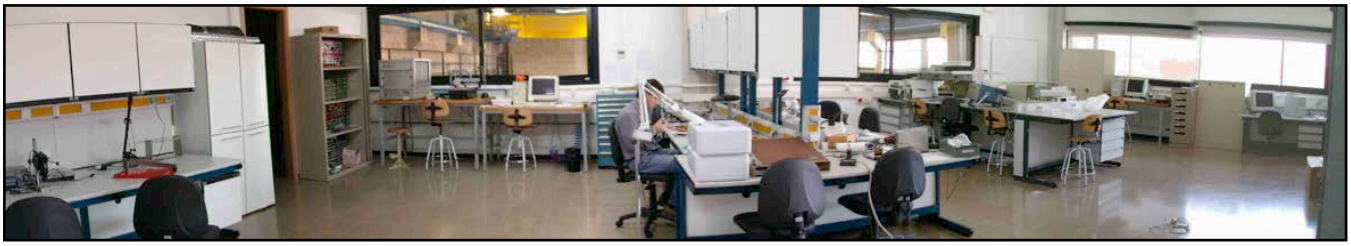
At any time there are around 50 research projects and grants, which implies to process a wide range of tasks as employment contracts, public calls, invoices, leaves of absence, etc. In addition, this Service deals with all sorts of matters in a community with staff belonging to two different institutions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


Computing centre

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 200 computer nodes (around 2000 cores) and 1.2 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).



Electronics laboratory

Electronics

This Unit provides service to any IFIC research project with demands in electronics. IFIC experiments develop particle detectors that generate as output electronic signals that have to be recorded. The staff and equipment of the Electronics Service is ready to support design, prototypes, manufacturing, testing and validation of electronic systems. In addition, certain detector technologies use microelectronics, as for instance silicon particle detectors. This Unit provides support in testing chips and silicon structures, as well as the connection of their microchannels. It also offers service and developments to external companies through contracts and agreements.

This Service Unit makes use of two infrastructures: the general electronics lab (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.

IFIC library

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.

IFIC workshop

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 visual measurement 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.

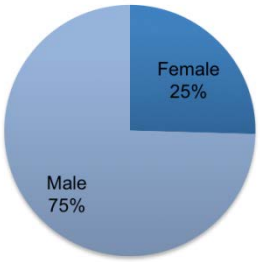
Maintenance

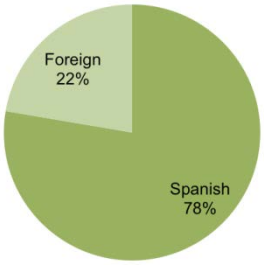
This Unit is an integrated service of maintenance management, occupational safety, radiation protection, environmental and quality management of the shared facilities as well as the research laboratories of the Institute. Its tasks include the preventive and corrective maintenance of facilities and laboratories, 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 DEC 2014)

IFIC employees

TOTAL	MALE	FEMALE	SPANISH	FOREIGN
224	167	57	174	50

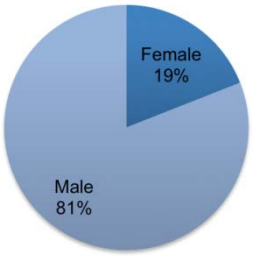


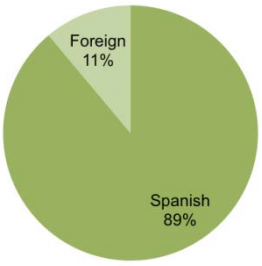


Foreign employees come from 24 different countries: Europe (29), America (12), Asia (7), Africa (2)

Scientific departments

Permanent staff (civil servants)





CATEDRÁTICOS – FULL PROFESSORS (UVEG)

de Azcárraga Feliu, José A. (emer.)

Bernabeu Alberola, José

Bordes Villagrasa, José Manuel

Botella Olcina, Francisco J.

Castillo Giménez, M. Victoria

Díaz Medina, José

Ferrer Soria, Antonio

Giménez Gómez, Vicent

González Marhuenda, Pedro

Hernández Gamazo, Pilar

Higón Rodriguez, Emilio

Navarro Salas, José

Noguera Puchol, Santiago

Oset Báguena, Eulogio

Peñarrocha Gantes, José Antonio

Pérez Cañellas, Armando

Pich Zardoya, Antonio

Ros Pallarés, José

Sanchis Lozano, Miguel Ángel

Santamaria Luna, Arcadi

Vento Torres, Vicente

Vidal Perona, Jorge

PROFESORES DE INVESTIGACIÓN – RESEARCH PROFESSORS (CSIC)

Furtado Valle, José W.
Fuster Verdú, Juan A.
García García, Carmen
Gómez Cadenas, Juan José
Hernández Rey, Juan José
Navarro Faus, Jesús
Rubio Barroso, Berta
Salt Cairols, José
Velasco González, Jorge (Brussels CSIC Coordinator)

INVESTIGADORES CIENTÍFICOS – RESEARCH SCIENTISTS (CSIC)

Donini, Andrea
Gadea Raga, Andrés
Hirsch, Martin K.
Lacasta Llácer, Carlos
Martí García, Salvador
Nieves Pamplona, Juan M.
Rodrigo García, Germán
Ros Martínez, Eduardo
Taín Enríquez, José Luis

PROFESORES TITULARES – LECTURER (UVEG)

Baremboim, Gabriela A.
Cases Ruiz, Ramón
González de la Hoz, Santiago
Lledó Barrena, M. Antonia
Martínez Vidal, Fernando
Papavassiliou, Ioannis
Rius Dionis, Nuria
Vicente Vacas, Manuel
Vijande Asensio, Javier
Vives Garcia, Oscar
Zúñiga Román, Juan

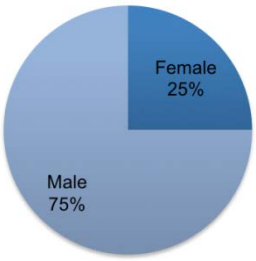
CIENTÍFICOS TITULARES – TENURED SCIENTISTS (CSIC)

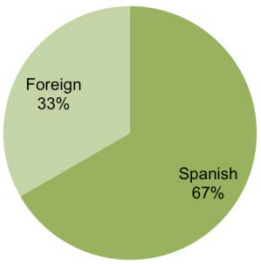
Algora, Alejandro
Cabrera Urbán, Susana
Cervera Villanueva, Anselmo
Costa Mezquita, María José
Faus Golfe, M. Ángeles
Mena Requejo, Olga
Pastor Carpi, Sergio
Peña Garay, Carlos
Portolés Ibáñez, Jorge
Valls Ferrer, Juan Antonio
Vos, Marcel

DOCTOR VINCULADO - ASSOCIATE

Fabbri, Alessandro

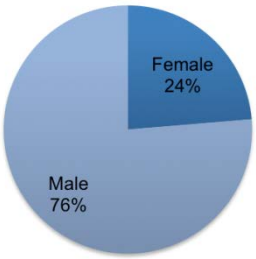
RAMÓN Y CAJAL RESEARCHERS

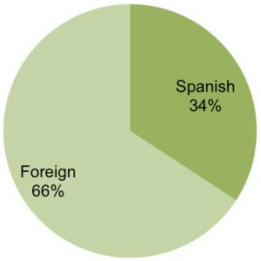




Álvarez Ruso, Luis (CSIC)
García Navarro, J. Enrique (CSIC)
Palomares Ruiz, Sergio (CSIC)
Della Morte, Michele (CSIC)
Llosá Llácer, Gabriela (CSIC)
Ruiz de Austri Bazán, Roberto (CSIC)
Domingo Pardo, César (CSIC)
Mitsou, Vasiliki (CSIC)
Sorel, Michel (CSIC)
Fiorini, Luca (UVEG)
Oyanguren Campos, Arantza (UVEG)
Zornoza Gómez, Juan de Dios (UVEG)

POSTDOCTORAL RESEARCHERS





Abbas, Gauhar
Albaladejo Serrano, Miguel
Albiol Colomer, Francisco Javier
Bou Cabo, Manuel
Campanario Pallás, Francisco
Deak, Michal
Esperante Pereira, Daniel
Fernández García, Avelina
Ferrario, Paola
Ganioglu, Ela
González Canales, Félix
Hernández Pinto, Roger
Kaci, Mohammed
King, Matthew
Laing, Andrew
Lineros Rodríguez, Roberto A.
Liubarsky, Igor
López March, Neus
Maiezza, Alessio
Monrabal Capilla, Francesc
Oliver Guillén, Josep F.
Olmo Alba, Gonzalo
Orrigo, Sonja E.A.
Pallis, Constantinos
Park, Jae Hyeon
Park, Wan Il
Racker, Jean Jacques

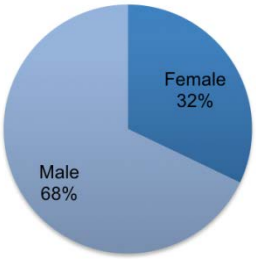
Renner, Joshua Edward | Rojas Pacheco, Alma D. | Sborlini, Germán

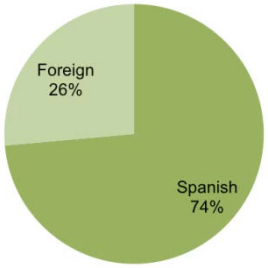
Sousa da Fonseca, Renato | Tarifeño, Ariel | Torró Pastor, Emma

Tórtola Baixauli, M. Amparo | Uchino, Toshitaka | Vicente Montesinos, Avelino

Yahlali Haddou, Nadia

PhD STUDENTS





Aceti, Francesca | Aliaga Varea, Ramón | Barranco Navarro, Laura

Barrio Toala, John | Barrios Martí, Javier | Belver Aguilar, Carolina

Bonilla Díaz, César M. | Boronat Arévalo, Marçà J. | Bosch Serrano, Cristian

Buchta, Sebastian | Cerdá Alberich, Leonor | De Carvalho Amaral García, Jose M.

Del Río Vega, Adrián | Egea Canet, Xavier | Etxebeste Barrena, Ane Miren

Fernández Martínez, Patricia | Fernández Soler, Pedro | Fuentes Martín, Javier

Fuster Martínez, Nuria | Galindo Muñoz, Natalia | García García, Ignacio

Gomis López, Pablo | González Pinochet, Marcela Paz | Guadilla Gómez, Víctor

Hidalgo Duque, Carlos | Hiller Blin, Astrid Nathalie | Ilisie, Victor

Irles Quiles, Adrián | Jiménez Peña, Javier | Kekic, Marija

Lami, Andrea | López Ibáñez, M. Luisa | Martí Martínez, J. Manuel

Martín-Albo Simón, Justo | Melini, Davide | Montaner Pizà, Ana

Nebot Guinot, Miquel | Papoulias, Dimitrios | Pedraza López, Sebastián

Pérez Pérez, Javier | Pérez Vidal, Rosa M. | Rodríguez Rodríguez, Daniel

Romero Adam, Elena | Ruiz Valls, Pablo | Sánchez Martínez, Victoria

Santos Blasco, Joaquín | Saul Sala, David Eduardo | Serra Díaz-Cano, Luis

Simón Estévez, Ander

Soldevila Serrano, Urmila

Tönnis, Christoph

Wang, En

Zahiri Abyaneh, Mehran

ENGINEERS & TECHNICIANS

Agramunt Ros, Jorge

Álvarez Piqueras, Damián

Álvarez Puerta, Vicente

Blanch Gutiérrez, César

Calvo Díaz-Aldagalán, David

Carcel García, Sara

Carrió Argos, Fernando

Carrión Burguete, J. Vicente

Corbí Bellot, Alberto

Lacort Pellicer, Víctor

Lorca Galindo, David

Martínez Pérez, Alberto

Mateo Jiménez, Fernando

Mazorra de Cos, José

Pérez García, Alberto

Pina Ballesteros, José M.

Platero García, Adrián

Querol Segura, Marc

Real Máñez, Diego

Rodríguez Samaniego, Javier

Solaz Contell, Carles

Villarejo Bermúdez, M. Ángel

Administration and management

Aguilar Argilés, Teresa

Almodóvar Gallardo, Guadalupe

Andreu García, M. Teresa (IFIMED)

Boix Caballero, Pilar

Claramunt Pedrón, Luis M.

Fandos Lario, Ana M. (Manager)

Fillol Ricart, Amparo

Gracia Vidal, M. José (CPAN)

Hernando Recuero, M. Luisa (CPAN)

Llorens Sebastià, Amparo (LHC Phenonet)

Pastor Clérigues, Elena (IVICFA)

Pérez García, José (CUP)

Pous Cuñat, Elena M. (Library)

Sifre García, Francisca

Outreach and technology transfer

García Cano, Isidoro (CPAN)

Aparici Benages, Alberto

Computing

De la Cruz Garrido, Jose Luis

García Montoro, Carlos (CPAN)

Fernández Casani, Álvaro

Lacruz Lacruz, Amparo

Martínez Sáez, Carlos

Nadal Durà, Joaquín

Sánchez Martínez, F. Javier

Electronics

Bernabeu Verdú, José
Cámara García, Teresa
González González, Francisco
López Redondo, Manuel
Marco Hernández, Ricardo
Nácher Arándiga, Jorge
Valero Biot, J. Alberto

Maintenance

Carrasco de Fez, Rosa
Fuentes Castilla, Ángel

Mechanics

Barjola Agulleiro, Agustín
Civera Navarrete, J. Vicente San
Monserrate Sabroso, J. Manuel
Santoyo Muñoz, David

2. RESEARCH ACTIVITIES

EXPERIMENTAL PHYSICS

Accelerator-based experimental High Energy Physics

The year 2014 was the final year of the LS1 (long shutdown 1) phase of the Large Hadron Collider (LHC). Yet, the activities of the LHC continued in a feverish manner. The 7 and 8 TeV data analyses continued or were completed, while preparations for the detector upgrade boosted their activities.

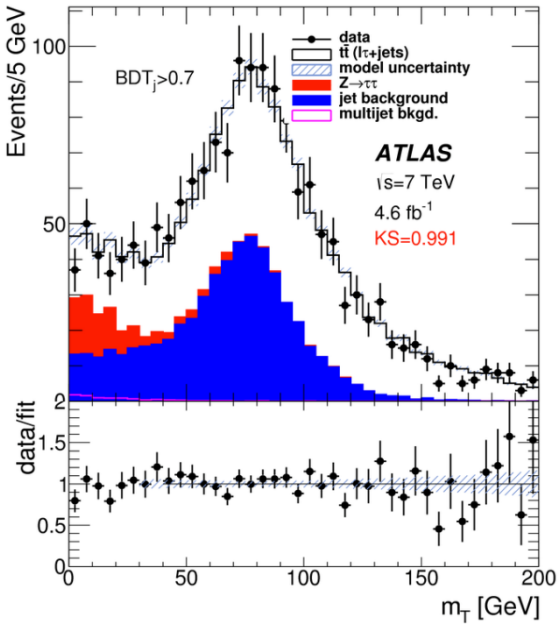
IFIC joined the LHCb collaboration during 2013. This experiment aims for detecting subtle quantum effects in which virtual particles created from the vacuum can influence the way heavy-quark hadrons behave. A study led by the IFIC researchers is the detection of any possible anomalous photon polarization in the FCNC b $\rightarrow$s γ transitions. After proving experimentally the non-zero photon polarization in these transitions through the analysis of $B^+ \rightarrow K^+\pi^-\pi^+\gamma$ decays (result compatible with the SM, but new physics scenarios may change the polarization), the emphasis has turned into the experimentally challenging $B^0_s \rightarrow \phi\gamma$ decay. IFIC members were chapter writers and editors of "The Physics of the B factories" book, published during 2014. It describes a decade long effort by about 1000 physicists and engineers from around the globe participating in the BaBar at PEP-II collider and Belle at KEKB collider, in their quest for the precise determination of broken symmetry between particles and anti-particles.

On the other hand, the effort on the design and characterization of the FE electronics chip for the new scintillating fibre (SciFi) tracker of the upgraded LHCb detector has been boosted. The SciFi is designed to provide standalone pattern recognition with high efficiency and resolution in the bending plane of the dipole magnet. The FE electronics has to procure full read-out of the SiPMs devices coupled to the fibres every 25 ns. During 2014, the TDR of the system was concluded, as well as the design and characterization of the first prototype, obtaining functionalities and responses according to design specifications.

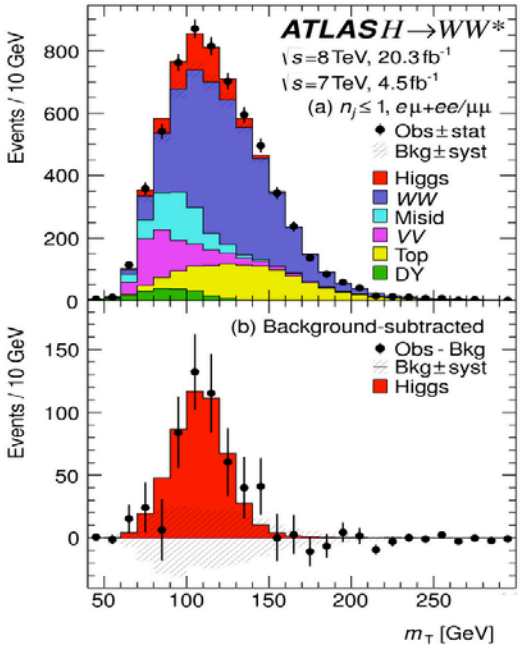
In what concerns the ATLAS detector front, the activities during the LS1 were still demanding as the group was responsible of coordinating the Monte Carlo production for Run 2 physics analyses, the operation and maintenance work of the ATLAS TileCal as well as leading the group studying the signal reconstruction performance of the TileCal under the new pile-up conditions expected for the Run 2 of the LHC. In parallel, the study of the $J/\Psi \rightarrow \mu^+\mu^-$ events allowed to define the strategy of the Inner Detector alignment to be used in the calibration loop for Run 2.

The analysis of the data collected by ATLAS during the Run 1 lead to many publications, with the special emphasis in the study of the Higgs boson decays to WW and then to two leptons in the final state, as well as $H \rightarrow \gamma\gamma$ and $H \rightarrow \tau^+\tau^-$ decays, in order to study the Higgs coupling to both, bosons and fermions. On the other hand, there were many contributions to the SM physics, specially to top quark

physics, as for instance the top-antitop cross section measurement (in the lepton+tau channel), the top quark mass, measurements in single top quark produced events and top quark pair charge asymmetry in the boosted regime, where searches for resonances decaying to top quarks were also performed.



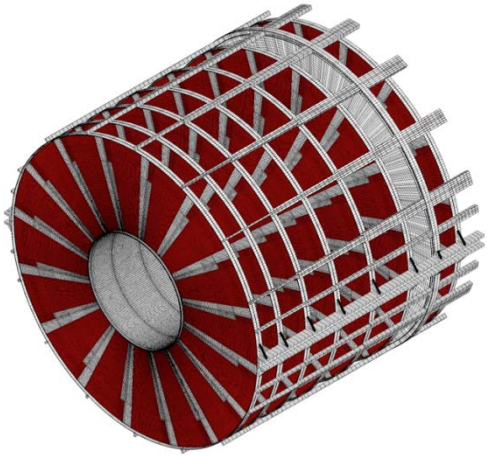
Transverse mass of the decaying tau plus jets.



Transverse mass of the Higgs candidate in WW analysis.

It must be added that the contribution of the group to the top quark physics covers a wide range of topics comprising: the physics analysis, the combined performance studies plus the coordination of the "Top LHC working group". This effort has led to the publication of the first joint results between ATLAS and CMS and with the Tevatron experiments. Another set of analysis with great involvement of the IFIC members in ATLAS is the search for super-symmetric (SUSY) particles. The group has pioneered the R-parity violating SUSY searches, as well as collaborated with several theoretical physics (specially IFIC & IFT). Fruits of these collaborations are the proposal to search for new SUSY signatures at LHC experiments and to strengthen the interpretation of experimental results.

The efforts towards the ATLAS detector upgrade with the perspective of the High Luminosity LHC (HL-LHC) are focussed in two parts: first the design of the data acquisition system of the TileCal and second the Inner Tracker (ITk) upgrade. In what concerns the first activity, the Optical Link Card was designed and produced. Their tests show it is able to operate with the bandwidth needed for the HL-LHC. In what concerns the ITk part, IFIC is in charge of the design of the support structure for the petals (basic unit of the tracker, equipped with microstrip silicon sensors and all associated electronics). The disks are built from 8 petals and are supported by carbon fibre planes.



Finite Element Analysis of the ITk end cap.

The mechanical structure has been optimized by means of a detailed Finite Element Analysis to ensure that the overall

deformation of the sensors plane is smaller than 2 µm. IFIC has also designed the service ducts or modules that bring the cooling pipes, power and trigger and control lines to the petals.

The ITk-strips collaboration is structured in work packages where IFIC has key roles as responsible of some of them: “Local Support, Electronics and Infrastructure”, “Sensors” and “Integration”.

The international particle physics community has concluded that there is a scientific case for an energy-frontier electron positron collider. The ILC is the most mature proposal. For the case of the Higgs boson and the top quark, the ILC will reach an unprecedented level of precision. As a part of the ILC detector development, IFIC follows the developments of the DEPFET technology for the pixels. This technology is well suited for most of the proposed future e^+e^- colliders. IFIC is member of the DEPFET collaboration. This collaboration of nearly 100 scientists of close to twenty European and Asian institutes develops an innovative pixel detector that integrates the amplification stage in the sensor and has developed a process that reduces the sensor thickness to a few tens of microns. In addition, IFIC leads within the DEPFET collaboration the design of a DEPFET-based vertex detector for the ILC, including the petals for the forward disks of the vertex detector end-cap.

Concerning the accelerators, the GAP-IFIC group has been participating actively in the study of collimation systems for Future Linear Colliders: ILC and CLIC, and Circular Colliders: LHC and its upgrade HL-LHC in the framework of Hi-Lumi EU Project.

Furthermore, the group is involved in Optics Design and Beam Instrumentation studies for the Beam Delivery System of Future Linear Colliders: ILC and CLIC, and their associated Test Facilities: ATF2 and CTF3. More specifically in the measure of the beam size and emittance by means of a multi-OTR system, the control of the beam halo by movable collimators, the beam position monitoring and injection-extraction devices (Kickers) in close collaboration with the Ciemat and an industrial partner.

Selected publications

ATLAS Collaboration (Aad, G. et al), *Measurement of Higgs boson production in the diphoton decay channel in pp collisions at center-of-mass energies of 7 and 8 TeV with the ATLAS detector*, , Phys. Rev. D 90, 112015 - 44pp, DOI: 10.1103/PhysRevD.90.112005 [arXiv:1409.5542]

ATLAS, CDF, CMS and D0 Collaborations, *First combination of Tevatron and LHC measurements of the top-quark mass,* [arXiv:1403.4427]

LHCb Collaboration (Aaij, R. et al), *Observation of Photon Polarization in the $b \to s\gamma$ Transition*, Phys. Rev. Lett. 112, 161801 - 8pp, DOI: 10.1103/PhysRevLett.112.161801 [arXiv:1402.6852]

Bevan, A.J. et al; Martínez-Vidal, F., *The Physics of the B Factories*, Eur. Phys. J. C 74, 3026 - 916pp, DOI: 10.1140/epjc/s10052-014-3026-9 [arXiv:1406.6311]

ATF2 Collaboration (White, G.R. et al); Blanch, C.; Faus-Golfe, A.; Resta-López, J., *Experimental Validation of a Novel Compact Focusing Scheme for Future Energy-Frontier Linear Lepton Colliders,* Phys. Rev. Lett. 112, 034802 - 6pp, DOI: 10.1103/PhysRevLett.112.034802

Belver-Aguilar, C.; Faus-Golfe, A.; Toral, F.; Barnes, M.J., *Stripline design for the extraction kicker of Compact Linear Collider damping rings*, Phys. Rev. Spec. Top.-Accel. Beams 17, 071003 - 14pp, DOI: 10.1103/PhysRevSTAB.17.071003

Selected conference talks

M. Boronat, *DEPFET pixel detectors for future electron-positron experiments*, 37th International Conference on High Energy Physics (ICHEP 2014), July 2014, Valencia, Spain.

M.J. Costa, *Experimental systematic uncertainties (and object reconstruction) on top physics*, TOP2014: 7th International Workshop on Top-Quark Physics, September 2014, Cannes, France.

C. García, *ATLAS upgrade physics*, Mitchell Workshop on Collider and Dark Matter Physics, May 2014, Dallas, U.S.A.

I. García, A new jet reconstruction algorithm for e+e- colliders, 37th International Conference on High Energy Physics (ICHEP 2014), July 2014, Valencia, Spain.

A. Faus, *Accelerator Research Assessment in Spain*, 1st EuCAN meeting, September 2014, Germany.

A. Oyanguren, Experimental study of time dependent CP asymmetry in Bs – y, June 2014, France.

Main research grants (National Plan)

CONTRIBUTIONS TO THE ATLAS EXPERIMENT AT THE LARGE HADRON COLLIDER (ref. FPA2012-39055-C02-01)
CONTRIBUTIONS TO THE HADRONIC TILE CALORIMETER OF THE ATLAS DETECTOR (ref. FPA2012-32843)
DEVELOPMENT OF NEW DETECTORS FOR FUTURE COLLIDERS IN PARTICLE PHYSICS (ref. FPA2013-48387-C6-5-P)
PARTICIPACIÓN EN EL DESARROLLO DE NUEVAS TECNOLOGÍAS EN ACELERADORES PARA LOS FUTUROS COLISIONADORES EN FÍSICA DE PARTÍCULAS (ref. FPA2013-47883-C2-1-P)

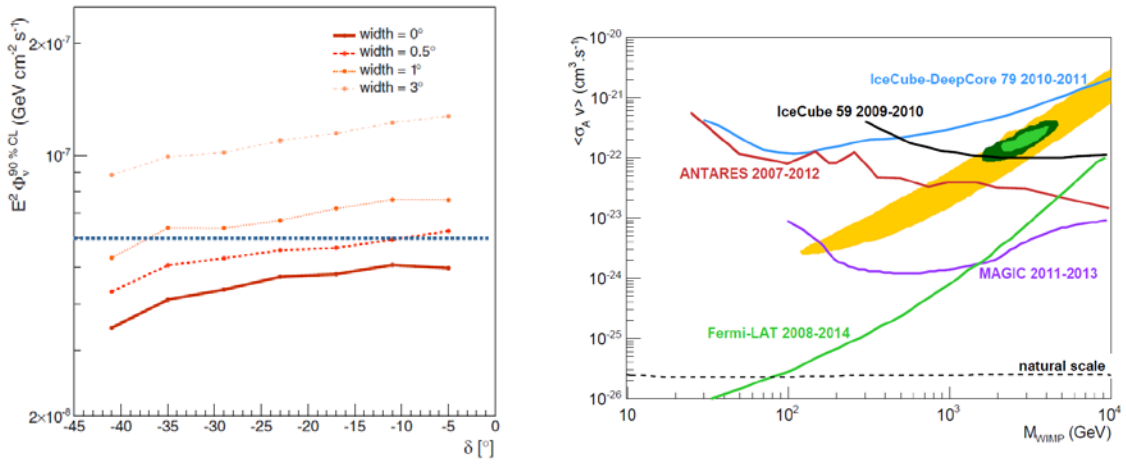
Experimental astroparticle physics

ANTARES:

The year 2014 has been very fruitful for ANTARES from the physics point of view. The recent discovery by IceCube of a cosmic neutrino flux has spurred a strong interest in the field and has highlighted the advantages of doing neutrino astronomy from the Mediterranean Sea. The analysis of point sources led by our group has put constraints on some of the possible interpretations of the IceCube cosmic neutrino signal. In addition, our group had also a paramount role in the indirect search for dark matter. The absence of a signal has yielded the best limits provided by a neutrino telescope on WIMP self-annihilation in the Galactic Centre. Another contribution worth mentioning is the use of gravitational lensing to better constrain neutrino fluxes coming from quasars.

KM3NeT:

During 2014, several important steps have been taken by the KM3NeT collaboration. The definition of Phase 2.0 strategy, namely a sparse detector for neutrino astronomy, ARCA, and a dense detector for neutrino mass hierarchy measurement, ORCA, has been fixed. The main contribution of our team to KM3NeT, hardware-wise, lies in the design of the Control Logic Board and in the time calibration system. Members of the IFIC group coordinate the Electronics and Time Calibration Working Groups.



Left: 90% C.L. flux upper limits for different source widths as a function of declination. The blue horizontal line corresponds to the flux prediction given by González-García et al. 2013. Right: 90% C.L. upper limit on the WIMP velocity averaged self-annihilation cross-section as a function of the WIMP mass for the channel WIMP WIMP → τ τ.

Selected publications:

ANTARES Collaboration (Adrián-Martínez, S. et al.), *Searches for Point-like and extended neutrino sources close to the Galactic Centre using the ANTARES neutrino Telescope,* Astrophys. J. Lett. 786, L5 - 5pp, DOI: 10.1088/2041-8205/786/1/L5 [arXiv:1402.6182]

ANTARES Collaboration (Adrián-Martínez, S. et al.), *Constraining the neutrino emission of gravitationally lensed Flat-Spectrum Radio Quasars with ANTARES data*, J. Cosmol. Astropart. Phys. 11, 017 - 12pp, DOI: 10.1088/1475-

7516/2014/11/017 [arXiv:1407.8525]

KM3NeT Collaboration (Adrián-Martínez, S. et al);, *Deep sea tests of a prototype of the KM3NeT digital optical module,* Eur. Phys. J. C 74, 3056 - 8pp, DOI: 10.1140/epjc/s10052-014-3056-3 [arXiv:1405.0839]

D. Calvo and D. Real, *High resolution time to digital converter for the KM3NeT neutrino telescope*, J. Instrum. 10, C01015 - 73pp, DOI: 10.1088/1748-0221/10/01/C01015

Selected conference talks

Ch. Tönnis, *The indirect search for dark matter with the ANTARES neutrino telescope*, Dark Side of the Universe DSU 2014, Cape Town, South Africa, November 2014.

J. Barrios-Martí, *Search of point-like sources using the ANTARES neutrino telescope*, European Cosmic Ray Conference 2014, Kiel, Germany, September 2014.

A. Sánchez-Losa, *Multi-Messenger analyses with the ANTARES High Energy Neutrino Telescope*, Astroparticle Physics: a joint TeVPA/IDM conference (TeV Particle Astrophysics and Identification of Dark Matter), Amsterdam, The Netherlands, June 2014.

Ch. Tönnis, *The indirect search for dark matter with the ANTARES neutrino telescope*, Astroparticle Physics: a joint TeVPA/IDM conference (TeV Particle Astrophysics and Identification of Dark Matter), Amsterdam, The Netherlands, June 2014.

J.J. Hernández-Rey, *ANTARES Highlights*, *Invited Plenary Speaker,* Neutrino 2014 – XXVI International Conference on Neutrino Physics and Astrophysics , Boston, U.S.A., June 2014.

J.D. Zornoza, *Overview of ANTARES results on Dark Matter Searches*, 49th Rencontres de Moriond, Cosmology, La Thuile, Italy, March 2014.

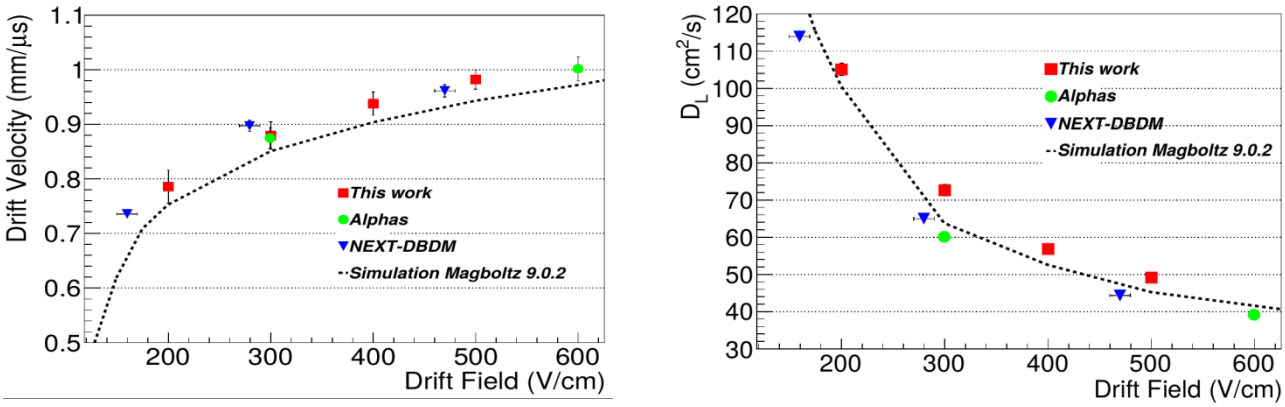
Main research grants (National Plan):

PARTICIPATION OF IFIC IN THE ANTARES AND KM3NET NEUTRINO TELESCOPES (ref. FPA2012-37528-C02-01)

Experimental neutrino physics

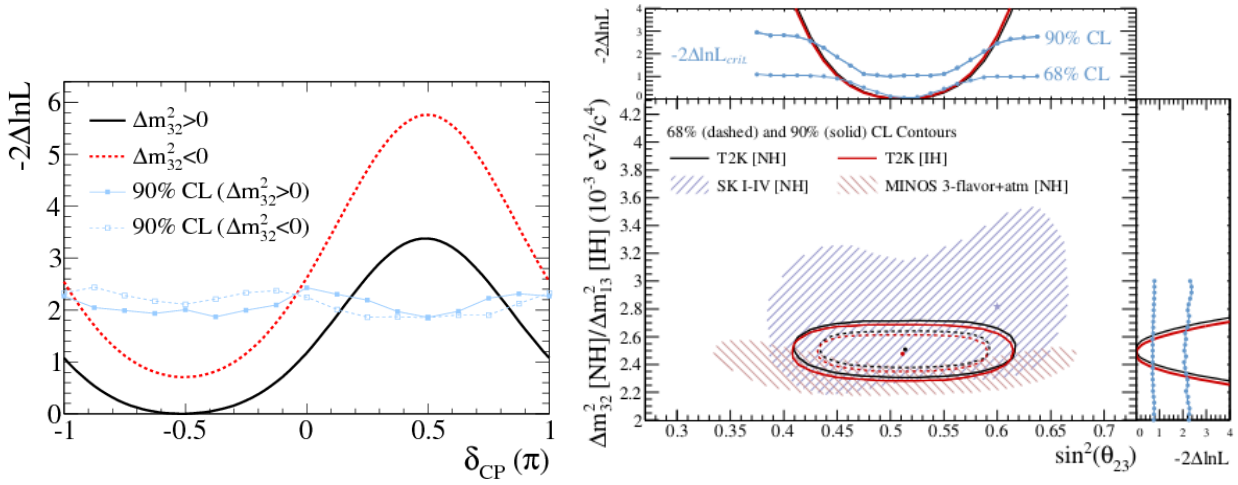
The experimental neutrino physics group at IFIC is deeply involved in the international collaborations NEXT and T2K. Both experiments explore the nature of neutrinos from two complementary sides: the search of the neutrino-less double beta decay with a gas-xenon TPC (NEXT), and the measurement of oscillations with an accelerator-based neutrino beam (T2K). While NEXT aims at demonstrating the Majorana nature of neutrino masses, T2K is probing the flavor mixing and the leptonic CP violation. During 2014, the group has made major contributions to these two fields.

This has been the last year of operation of the NEXT-DEMO prototype. After proving the feasibility of sub-percent energy measurements with the electroluminiscence (EL) technology, further work has been carried out to characterize the performance of the detector and the response of the photosensors. In particular, a novel analysis technique based on the abundance of xenon K-shell X-ray emission has been developed and published. This analysis has provided the measurements of the drift-electron properties, the effects of the EL production region, and the position dependent energy corrections (thus improving the energy resolution). After the successful NEXT-DEMO campaign, the NEXT experiment has entered a new phase whose main goal is the installation and operation of a 10-Kg detector in the Canfranc Underground Laboratory (LSC): NEXT-NEW. The installation of this detector in the LSC has begun in 2014.



Drift velocity (left) and longitudinal diffusion coefficient (right) as a function of drift field, for xenon gas at 10 bar.

T2K has published in 2014 the most precise limit so far on the δ_{CP} value and again the most precise measurement of the atmospheric oscillation parameters θ_{23} and Δm^2_{23} in Phys. Rev. Lett.. At the same time, the near detector complex (ND280), a state-of-the-art composed detector, provides an excellent opportunity to perform a wide variety of the neutrino interaction studies (3 publications in 2014). During 2014, T2K started data taking in antineutrino mode and has recently released the world's best measurement on anti-ν_μ disappearance. Our group has contributed in 2014 to several aspects of the experiment. Apart from our involvement in the ND280 input to the publish oscillation analyses mentioned previously, specially relevant is our participation in the joint ν_μ -ν_e oscillation analysis (PhD thesis defended in December 2014 and recently published Phys. Rev. D 91) and in the measurement of the ν_μCC cross section with no pions in the final state, which will be published shortly.



Left: δ_{CP} allowed region in "Observation of Electron Neutrino Appearance in a Muon Neutrino Beam", Right: Precise Measurement of the Neutrino Mixing Parameter ϑ_{23} from Muon Neutrino Disappearance in an Off-Axis Beam

Selected publications

NEXT Collaboration (Lorca, D. et al), *Characterisation of NEXT-DEMO using xenon K-alpha X-rays*, J. Instrum. 9, P10007 - 20pp, DOI: 10.1088/1748-0221/9/10/P10007 [arXiv:1407.3966]

T2K Collaboration (Abe, K. et al), *Observation of Electron Neutrino Appearance in a Muon Neutrino Beam*, Phys. Rev. Lett. 112, 061802 - 8pp, DOI: 10.1103/PhysRevLett.112.061802 [arXiv:1311.4750]

T2K Collaboration (Abe, K. et al), *Precise Measurement of the Neutrino Mixing Parameter ϑ_{23} from Muon Neutrino Disappearance in an Off-Axis Beam*, Phys. Rev. Lett. 112, 181801 - 8pp, DOI: 10.1103/PhysRevLett.112.181801 [arXiv:1403.1532]

Selected conference talks

L. Escudero*, Initial probe of delta_CP by T2K with muon neutrino disappearance and electron neutrino appearance*, 37th International Conference on High Energy Physics (ICHEP 2014), Valencia (Spain), July 2014.

J.J. Gómez-Cadenas*, Status of the NEXT experiment*, 37th International Conference on High Energy Physics (ICHEP 2014), Valencia (Spain), July 2014.

Main research grants (National Plan)

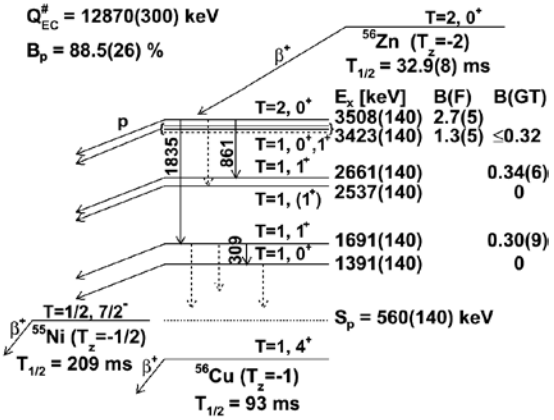
PARTICIPATION IN THE T2K EXPERIMENT (ref. FPA2011-29823-C02-01)
CONSTRUCTION OF THE NEXT EXPERIMENT AT THE LSC (ref. FIS2012-37947-C04-01)
THE NEXT PROJECT: ENERGY AND TRAJECTORY MEASUREMENTS (ref. FIS2012-37947-C04-03)

Experimental nuclear physics

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

One important field of research of the Gamma and Neutron Spectroscopy Group at IFIC is to understand how exotic nuclei decay. In 2014 the most relevant result in this context was the investigation of the beta decay of the ^{56}Zn nucleus (S.E.A Orrigo *et al*., PRL 112, 222501 (2014)). This study showed the first experimental observation of a very exotic decay mode at the proton drip-line in the fp-shell, the beta-delayed gamma-proton decay.

In proton-rich nuclei the beta-delayed proton decay is expected to dominate for states populated in the daughter nucleus well above the proton separation energy S_p. We have found, instead, that the decay of ^{56}Zn proceeds by both beta-delayed proton emission and beta-delayed gamma de-excitation. We observe competition between these two decay modes in states of the daughter ^{56}Cu nucleus lying well above S_p. Moreover we observe beta-delayed gamma rays that populate levels in ^{56}Cu, which are proton-unbound and thereafter decay by proton emission (see the figure).



Thus we have observed the exotic beta-delayed gamma-proton emission for the first time in the fp-shell, and from three different levels of ^{56}Cu. This decay will be significant in heavier proton-rich nuclei. This observation is very important because it does affect the conventional way to determine the Gamow-Teller strength near the proton drip line and shows that the use of gamma detectors in this kind of studies is necessary. In addition, evidence for fragmentation of the Fermi strength due to a strong isospin-mixing has been found, which is important for the mass evaluation. This study was performed at GANIL (France) in the framework of an international collaboration, led by the IFIC group.

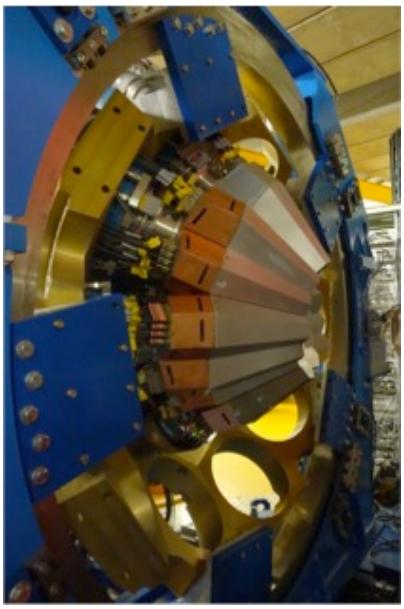
Other important results of the group in 2014 are related to the use of detectors that the Spanish groups are developing for FAIR. In February 2014 the segmented total absorption spectrometer DTAS developed by the IFIC group was used for the first time in measurements at the IGISOL IV facility in Jyväskylä. The performed measurements aim to study beta decays of relevance for the prediction of the neutrino spectrum from reactors. Also at this facility the newest version of the BELEN neutron counter developed by UPC and IFIC with 48 ^{3}He tubes was used for the first time in experiments. The goals of the measurements were reactor technology and nuclear astrophysics. A highlight of this experiment was the observation for the first time of the rare phenomenon of beta-delayed two-neutron emission in a nucleus beyond mass A=100 (to be confirmed by the off-line analysis).

During 2014 the construction of the new high intensity experimental area EAR2 of nTOF at CERN was completed and the group was involved in the commissioning. The collaboration will exploit this installation to make measurements on unstable targets of astrophysical interest.

The AGATA group of IFIC devotes its activity mainly to the construction, deployment and experimental activity on Nuclear Spectroscopy with the Advanced Gamma Tracking Array, as well as its complementary instrumentation, as NEDA (NEutron Detector Array) and the highly segmented light-charged particle Si detector array TRACE.

AGATA is a large scale European instrument for high resolution gamma spectroscopy based on position sensitive Ge semiconductor detectors. Despite the fact that AGATA is still in the early phases of construction (only about 15% of the array detectors are available), AGATA is already having experimental activity in some of the most relevant laboratories for Nuclear Structure studies in Europe.

During 2014 the group has participated in the experimental activity as well as in technological developments. Regarding the experimental activity, the AGATA group has actively participated in the last experiments of the AGATA-PRESPEC campaign at the GSI Fragment Separator (FRS). This campaign is not only providing unique Nuclear Structure data from exotic nuclei, produced by relativistic fragmentation or Fission, but it is as well the first preparatory campaign for the NUSTAR-HISPEC installation at FAIR.



AGATA implementation with 24 crystals at GANIL.

Following the end of the AGATA-PRESPEC campaign in April 2014, our group has contributed as well to the installation first and to the commissioning latter, of AGATA-VAMOS setup at GANIL in Caen, France. During the first year of operation, one of the six measurements to be performed corresponds to a proposal led by IFIC.

The group is also actively working in instrumentation developments. In particular, in 2014 the group has completed the development of the Front-End Electronics Control Card for the AGATA sampling Digitizers and has contributed to its integration and mechanics, in collaboration with the ETSE of the University of Valencia (UVEG) and the Mechanical Design and Construction Services of IFIC.

Regarding the construction of instrumentation for complementary detectors of AGATA, in 2014 the group has started the production of 9 NEDA neutron detector modules and has completed the production of all the sampling ADC mezzanines for the first phase of NEDA. This work has been done in collaboration with the AGATA group of ETSE, University of Valencia (UVEG).

The last 2014 instrumental activity to mention concerns the conceptual design of the TRACE Front-End electronics and in particular the development of an analogue buffer, in ASIC technology, for the highly segmented TRACE detector telescope. This last activity is being done in collaboration with the I3M, CSIC- Politecnical University of Valencia.

From 22nd to 26th of September the FAIR-NUSTAR week was organized at IFIC. This is an important point in the NUSTAR calendar where the community can check progress towards the ultimate goal of carrying out experiments at FAIR. The meeting is held in countries where the nuclear structure community has a significant involvement in NUSTAR/FAIR. In the meeting one complete session was devoted to the R&D and construction of instrumentation being carried out by Spanish groups including an important contribution from the Gamma and Neutron Spectroscopy and AGATA groups at IFIC.

Concerning the scientific achievements, both groups has more than 45 publications in 2014, including 7 Physical Review Letters and 2 Physics letters B.

Selected publications:

Grodner, E. et al, *Hindered Gamow-Teller Decay to the Odd-Odd N = Z Ga-62: Absence of Proton-Neutron T=0 Condensate in A=62*, Phys. Rev. Lett. 113, 092501 - 5pp, DOI: 10.1103/PhysRevLett.113.092501

AGATA Collaboration (Crespi, F.C.L. et al), *Isospin Character of Low-Lying Pygmy Dipole States in Pb-208 via Inelastic Scattering of O-17 Ions*, Phys. Rev. Lett. 113, 012501 - 5pp, DOI: 10.1103/PhysRevLett.113.012501

Taprogge, J. et al, *1p(3/2) Proton-Hole State in Sn-132 and the Shell Structure Along N=82*, Phys. Rev. Lett. 112, 132501 - 6pp, DOI: 10.1103/PhysRevLett.112.132501

Marchi, T. et al, *Quadrupole Transition Strength in the Ni-74 Nucleus and Core Polarization Effects in the Neutron-Rich Ni Isotopes*, Phys. Rev. Lett. 113, 182501 - 5pp, DOI: 10.1103/PhysRevLett.113.182501

AGATA Collaboration (Pellegri, L. et al), *Pygmy dipole resonance in Sn-124 populated by inelastic scattering of O-17,* Phys. Lett. B 738, 519-523, DOI: 10.1016/j.physletb.2014.08.029

Morales, A.I.; Algora, A.; Molina, F.; Rubio, B., *Half-Life Systematics across the N=126 Shell Closure: Role of First-Forbidden Transitions in the beta Decay of Heavy Neutron-Rich Nuclei*, Phys. Rev. Lett. 113, 022702 - 5pp, DOI: 10.1103/PhysRevLett.113.022702

Orrigo, S.E.A. et al, *Observation of the beta-Delayed gamma-Proton Decay of Zn-56 and its Impact on the Gamow-Teller Strength Evaluation*, Phys. Rev. Lett. 112, 222501 - 5pp, DOI: 10.1103/PhysRevLett.112.222501 [arXiv:1401.7685]

Caballero-Folch, R. et al, *beta-decay and beta-delayed Neutron Emission Measurements at GSI-FRS Beyond N=126, for r-process Nucleosynthesis*, Nucl. Data Sheets 120, 81-83, DOI: 10.1016/j.nds.2014.07.012

n_TOF Collaboration (Zugec, P. et al), *Measurement of the C-12(n, p)B-12 cross section at n_TOF at CERN by in-beam activation analysis*, Phys. Rev. C 90, 021601 - 5pp, DOI: 10.1103/PhysRevC.90.021601 [arXiv:1408.6652]

Algora, A. et al, *Total Absorption Study of Beta Decays Relevant for Nuclear Applications and Nuclear Structure*, Nucl. Data Sheets 120, 12-15, DOI: 10.1016/j.nds.2014.06.129

Selected conference talks

Gadea, A., *Status of the AGATA Project*, 14th AGATA week, Madrid (Spain), 2014.

Gadea, A., *HISPEC – Spain*, NUSTAR Week 2014, Valencia (Spain), 2014.

Gadea, A, *AGATA: Status and Future Plans*, ECOS-EURISOL Joint Town Meeting, Orsay (France), 2014.

A.Gadea, *Status of AGATA and the AGATA setup at the SPES ISOL Radioactive Ion beam facility*, SPES 2014 Second International Workshop, Legnaro-Padova (Italy), 2014.

B. Rubio, *Beta Decay and Charge Exchange Reactions, invited talk to the Isolde Workshop*, ISOLDE (CERN), 50th Aniversary Edtion 2014.

C. Domingo, *BELEN & The BRIKEN Project*, invited talk to the NUSTAR Week, Valencia, Spain, 2014.

A. Algora, *Total Absorption Measurements for Applications (and Nuclear Structure)*, invited talk to Notre Dame-Europe Symposium in Nuclear Science and Society, 2014 , London, UK.

J. L. Tain, *Total Absorption Gamma-ray Spectroscopy measurements for basic and applied b-decay studies*, Fifteenth International Symposium on Capture Gamma-Ray Spectroscopy and Related Topics (CGS15), Dresden, Germany, 2014.

S.E.A. Orrigo, *First observation of b-delayed g-proton decay in the fp-shell in ^{56}Zn*, Zakopane Conference on Nuclear Physics, Extremes of the Nuclear Landscape, Zakopane (Poland) 2014.

Main research grants (National Plan):

NUCLEAR STRUCTURE, APPLICATIONS AND ASTROPHYSICS: THE PATH TO FAIR (ref: FPA2011- 24553)
HIGH-RESOLUTION GAMMA-RAY SPECTROSCOPY TOWARDS AGATA (ref. FPA2011-29854-C04)

Grid and e-Science

The research topics of this research line include mainly the Spanish ATLAS Tier-2 goals. Moreover, there are several generic activities devoted to the application of Distributed Computing to other scientific and technological fields (the so-called e-Science).
The main contribution of this year has been the delivery in April of the committed resources for 2014. The IFIC Tier2 site has provided 10,300 HS06 and 1,400 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 availability. We have progressed in the main objectives of the proyect: for instance, the FAX implementation, which is an approach for having a system of federated data, the work performed in DAST (Distributed Analysis Support Team), the national Tier-2 support and the interface with the end-users via the Tier-3 infrastructure.

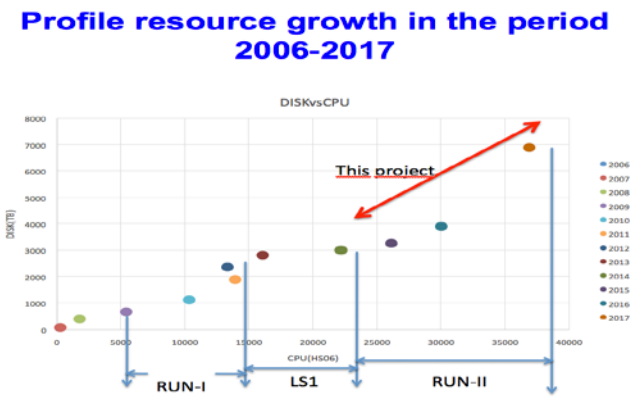


Figure A: Evolution of the growth of the computing resources in the Spanish ATLAS Tier-2 in period 2006-2017. It can be seen the contribution of 2014 and the trend for the future years.

The new R&D activity started in 2013, the Event Index Project, has continued with a lot of activiy made by our group. During this year, the group has pursued the development and deployment of a catalogue of events with a large amount of data, the so-called ATLAS Event Index (EI). This EI is the successor of the TAGDB, the old catalogue. The main objective was to reach a better performance using the new NoSQL technologies. In particular, IFIC is responsible of the Data Collection part of the project. At the end of the year the EI prototype was almost ready to be deployed.

Several people of the research line are doing Physics Analysis in the Exotics group in ATLAS. This activity has the benefit of ensuring the link between the GRID Computing people and the ATLAS end-users community. Moreover, several sites that participate in ATLAS have contacted the IFIC team to be helped in the installation and deployment of GRID features in their centers. In November, a team of argelian computing technicians of the CERIST center in Argel came to IFIC to follow a training course of management and administration of an ATLAS Tier-2 Infrastructure.

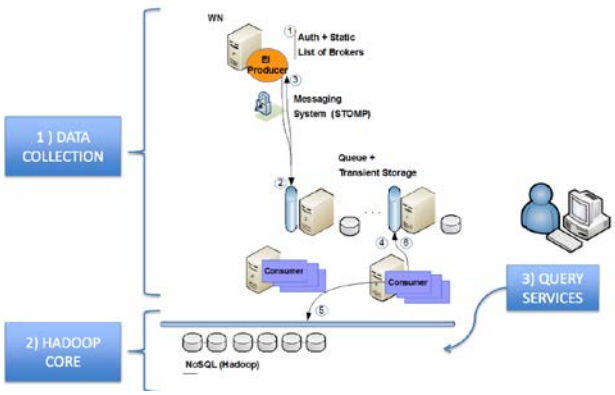


Figure B: Prototype Overview of the Event Index Project. IFIC group is involved in 'Data Collection' part

On top of that, the group has participated in several activities related to the extension of GRID computing. They were shown at different meetings and workshops, addressing mainly the resolution of problems arising from the management and access to large amounts of data. This progress can be applied to others scientific fields (Bioinformatics, Earth Observation, Social Sciences, etc).

Selected publications

D. Barberis, J. Cranshaw, A. Favareto, A. Fernández, E. Gallas. S. González de la Hoz, J. Hrivnac, D. Malon, M. Novak, F. Prokoshin, J. Salt, J. Sánchez, R. Yuan, P. Briongos, *ATLAS Event Index prototype for cataloguing large amounts of data*, EGI Community Forum 14, Helsinki Finland. Book of Abstracts 2014 ISBN: 978 90 816927 2 4.

Selected conference talks

Santiago González del la Hoz on behalf of ATLAS and CMS collaboration, *Exotics Searches with ATLAS and CMS,* XX Cracow Epiphany Conference on the Physics at the LHC, Cracow (Poland), January 2014.

A. Fernández et al., *The Event Index: Full Chain deployment and first operation*, 37th International Conference on High Energy Physics (ICHEP 2014), Valencia (Spain), July 2014.

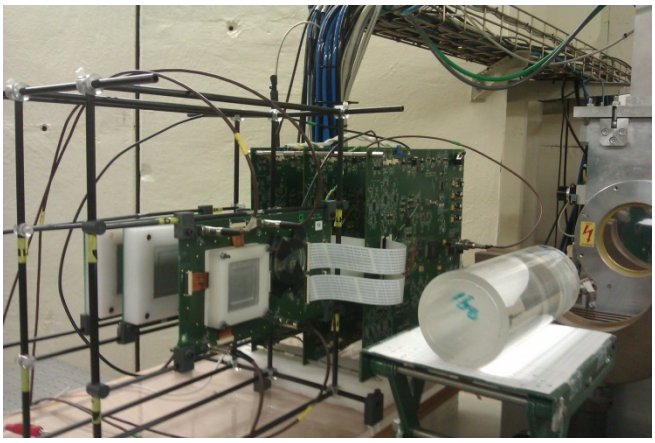
J. Salt, A. Pacheco, J. Del Peso, F. Fassi, A. Fernández, V. Lacort, M. Kaci, S. González de la Hoz, J. Sánchez, E. Oliver, M. Villaplana, V. Sánchez and A. Montiel . *New challenges of the Spanish ATLAS Tier-2 to address the RUN 2 period of LHC*, 8th Iberian GRID Infrastructures Conference IBERGRID 2014, 8-10 September, 2014; Aveiro (Portugal). Published in conference proceedings ISBN: 978-84-9048-246-9.

Main research grants (National Plan)

TIER-2 DISTRIBUIDO ESPAÑOL PARA EL EXPERIMENTO ATLAS (LHC) FASE 2 (ref. FPA2010 -21919-C03-01)

TIER-2 DISTRIBUIDO ESPAÑOL PARA EL EXPERIMENTO ATLAS (LHC) FASE 3 (ref. FPA2013 -47424-C3-1-R)

Medical application of nuclear and particle physics



The activities of the IFIC medical physics group of IFIC in 2014 have focused on the development of PET detectors and monitoring systems for hadron therapy. In addition, the group is in charge of the activities related with the future imaging and hadron therapy center IFIMED.

In hadron therapy protons or carbon ions are employed to administer the radiation dose to the patients. In order to monitor the treatment administration, PET techniques are employed which leave room for significant improvements. Within the European project ENVISION, finished in July 2014, the group participates in the development of improved PET devices and of Compton Cameras for treatment monitoring.

The group has developed a three-layer Compton telescope based on LaBr3 crystals and silicon photomultipliers as photodetectors for treatment monitoring. The main achievements during 2014 include the first tests of the device in a proton beam. They are:

- Optimization of the device performance with three detector layers.
- Optimization of the image reconstruction algorithms.
- Image reconstruction of sources in the laboratory.
- Test of the prototype in a proton beam at KVI Groningen.
- Successful reconstruction of the Bragg peak at different target positions.

Related to the development of a small animal PET systems, the group is using continuous crystals and SiPMs to replace pixellated crystals in order to improve spatial resolution and efficiency. In 2014 the group has focused on:

- Tests with liquid sources and phantoms in collaboration with the Klinikum rechts der Isar, Munchen.
- Improvement of the simulations and algorithms for position determination in continuous crystals.
- Adapt image reconstruction algorithms for using position determination.

The IFIC Accelerator Physics group is also involved in various activities centred in cyclinacs for hadrontherary applications and high-gradient RF structures studies. This work has been started under the framework of the EU project PARTNER and the ENLIGHT EU platform. We focused our studies in design of the cyclinacs for carbon therapy in collaboration with TERA and in the experimental study of the high-gradient RF structures in collaboration with the CLIC RF group at CERN. The latter has been the seed for the new HG-RF lab, being constructed with FEDER funds in the “Parque Tecnológico” of the UVEG.

Selected publications:

Brzeziński, K.; Oliver, J.F.; Gillam, J.; Rafecas, M., *Study of a high-resolution PET system using a Silicon detector probe*, Phys. Med. Biol. 59, 6117-6140, DOI: 10.1088/0031-9155/59/20/6117

Gillam, J.E.; Solevi, P.; Oliver, J.F.; Casella, C.; Heller, M.; Joram, C.; Rafecas, M., *Sensitivity recovery for the AX-PET prototype using inter-crystal scattering events*, Phys. Med. Biol. 59, 4065-4083, DOI: 10.1088/0031-9155/59/15/4065

Selected conference talks:

G. Llosá, *Aplicaciones en medicina de la física de partículas*, Invited talk at 37th International Conference on High Energy Physics (ICHEP 2014), Valencia (Spain), July 2014.

G. Llosá, *Recent developments in photodetectors for medical applications*, Invited review talk at NDIP 2014. Tours (France) 30 Jun- 4 Jul 2014.

G. Llosá, J. Barrio, J. Cabello, A. Etxebeste, C. Lacasta, J.F. Oliver, M. Rafecas, C. Solaz, V. Stankova, *Development of a high resolution animal PET with continuous crystals and SiPMs*, Invited talk at the II PET Symposium. Krakow (Poland) 21-24 September 2014.

J.F.Oliver on behalf of ENVISION members, *European ENVISION project for improving timing resolution in PET systems*., Invited talk at the II PET Symposium. Krakow (Poland) 21-24 September 2014.

J.F.Oliver and M. Rafecas, *Estimation of accidental coincidences in PET*, Invited talk at the II PET Symposium. Krakow (Poland) 21-24 September 2014.

G. Llosá, J. Cabello, J. E. Gillam, C. Lacasta, J. F. Oliver, M. Rafecas, C. Solaz, P. Solevi, V. Stankova, I. Torres-Espallardo, M. Trovato, *Compton telescope for dose monitoring in hadron therapy*, Invited talk at the VI CPAN days. Sevilla (Spain) 20-22 October 2014.

G. Llosá, *Developments for PET and Hadron Therapy Applications*, Invited talk at IVICFA Medical Physics workshop. Valencia (Spain) 31st October 2014.

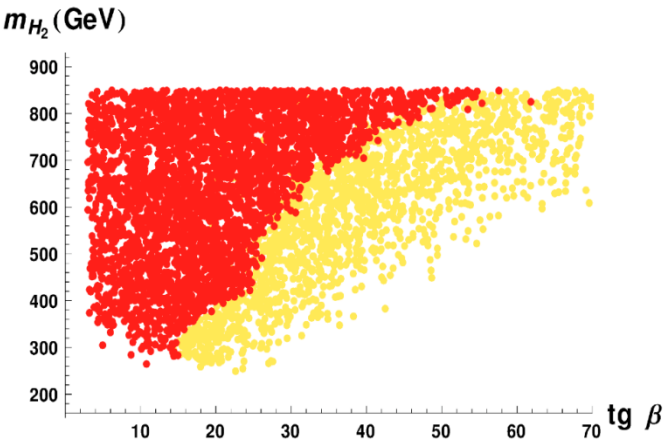
Main research grants (National Plan):

IMAGE QUALITY AND QUANTIFICATION IN POSITRON EMISSION TOMOGRAPHY (ref. FPA2010-14891).

High-energy physics phenomenology

Some selected results published in 2014 are:

- The results from Higgs searches in the $\gamma\gamma$ and $\tau\tau$ decay channels at LHC and indirect bounds as $\mathrm{BR}(B \to X_s\gamma)$ have been used to constrain a generic minimal supersymmetric standard model (MSSM) Higgs sector. It has been show that the $\tau\tau$ channel is the best and most accurate tool in the hunt for new Higgs states beyond the Standard Model. Present experimental results rule out additional neutral Higgs bosons in a generic MSSM below 300 GeV, while values of $\tan\beta$ above 30 are only possible for Higgs masses above 600 GeV.



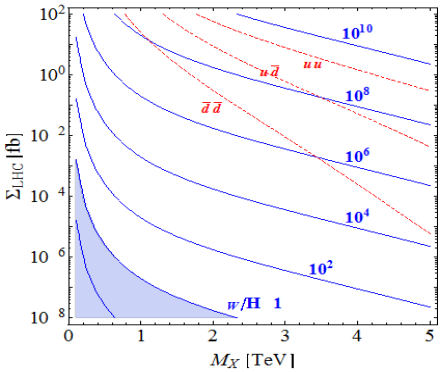
Allowed Higgs masses in the plane (tanβ, M_{H2}) taking into account the diphoton signal strength, ττ bounds and BR(B→ X_s γ). Yellow (light grey) points satisfy the present ATLAS bounds at 95% C.L., whereas red (dark grey) points fulfill the recent CMS constraints at 95% C.L

- The proposal of an alternative T-Violation asymmetry at meson factories which allows its opening to any pair of decay channels has been made. Instead of searching for the pair of decay channels associated to the *T*-reverse meson transition, an asymmetry tagging the initial states of the reference and the *T*-reverse meson transitions can be built. This observable filters the appropriate final states by means of two measurable survival probabilities.

- A new radiative mechanism for neutrino mass generation based on the $SU(3)_c \otimes SU(3)_L \otimes U(1)_X$ electroweak gauge group was proposed. In this model, light Majorana masses arise from neutral gauge boson exchanges at the one-loop level and isosinglet neutrinos that may be produced at the LHC through the extended gauge boson portals. The model also contains new quarks at the TeV scale which can provide a plethora of accessible collider phenomena.

- Complete NLO radiative corrections to $\mu^+\mu^-\gamma$ production have been calculated and implemented in the Monte Carlo event generator PHOKHARA9.0. The novel features include the contribution of pentagon diagrams in the virtual corrections as well as the two-photon final state emission contributions. It is found that the numerical influence is not larger than 0.1% at KLOE and 0.3% at BaBar energies and then the approximations in earlier versions of PHOKHARA are excluded as origin of the experimental discrepancy observed.

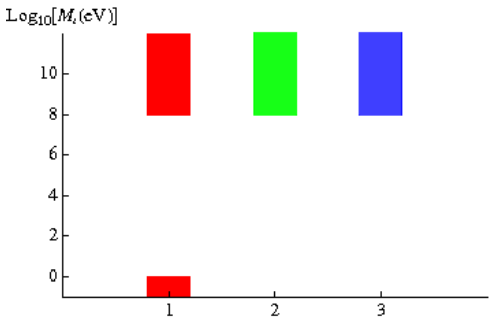
- Leptogenesis (LG) is one of the most-studied ideas for the generation of the baryon asymmetry of the universe. It has been demonstrated that observation of lepton number violating processes at the LHC would result in the falsification of high-scale LG models, independent on the details of the LG realization.



Contours of the washout rate of the lepton number as a function of the resonant mass observed and LHC cross section. The large washout factors would guarantee that any pre-existing lepton number would be erased before the electro-weak phase.

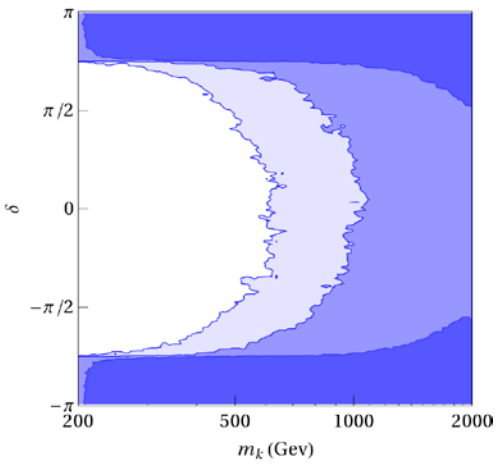
- The "μ from ν" supersymmetric standard model (μνSSM) can accommodate the newly discovered Higgs-like scalar boson with a mass around 125 GeV. This model provides a solution to the μ-problem and simultaneously reproduces correct neutrino physics by the simple use of right-handed neutrino superfields. These new superfields together with the introduced R-parity violation can produce novel and characteristic signatures of the μνSSM at the LHC. We explore the signatures produced through two-body Higgs decays into the new states, provided that these states lie below in the mass spectrum. For example, a pair produced light neutralinos depending on the associated decay length can give rise to displaced multi-leptons/taus/jets/photons with small/moderate missing transverse energy. In the same spirit, a Higgs-like scalar decaying to a pair of scalars/pseudoscalars can produce final states with prompt multi-leptons/taus/jets/photons.

- We evaluate the contribution to N_{eff} of the extra sterile states in low-scale type I seesaw models (with three extra sterile states). We explore the full parameter space and find that at least two of the heavy states always reach thermalization in the early Universe, while the third one might not thermalize provided the lightest neutrino mass is below $O(10^{-3}$ eV). Constraints from cosmology therefore severely restrict the spectra of heavy states in the range 1 eV–100 MeV. The implications for neutrinoless double beta decay are also discussed.



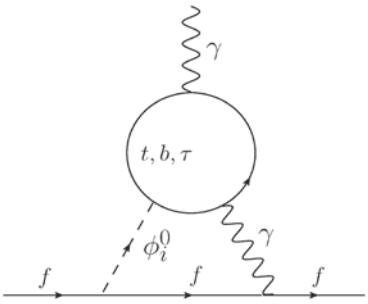
Allowed spectra of the heavy states M_i for $m_1 \geq m_{th\,1}$.

- We update previous analyses of the Zee–Babu model in the light of new data, e.g. the mixing angle θ_{13}, the rare decay $\mu \to e\gamma$ and the LHC results. We also analyze the possibility of accommodating the deviations in $\Gamma(H \to \gamma\gamma)$ hinted by the LHC experiments, and the stability of the scalar potential. We find that neutrino oscillation data and low energy constraints are still compatible with masses of the extra charged scalars accessible to LHC. Moreover, if any of them is discovered, the model can be falsified by combining the information on the singly and doubly charged scalar decay modes with neutrino data. Conversely, if the neutrino spectrum is found to be inverted and the CP phase δ is quite different from π, the masses of the charged scalars will be well outside the LHC reach.



δ vs m_k in IH.

- Electric dipole moments are extremely sensitive probes for additional sources of CP violation in new physics models. Specifically, they have been argued in the past to exclude new CP-violating phases in two-Higgs-doublet models. Since recently models including such phases have been discussed widely. We revisit the available constraints in the presence of mechanisms which are typically invoked to evade flavour-changing neutral currents. To that aim, we start by assessing the necessary calculations on the hadronic, nuclear and atomic/molecular level, deriving expressions with conservative error estimates. Their phenomenological analysis in the context of two-Higgs-doublet models yields strong constraints, in some cases weakened by a cancellation mechanism among contributions from neutral scalars. While the corresponding parameter combinations do not yet have to be unnaturally small, the constraints are likely to preclude large effects in other CP-violating observables. Nevertheless, the generically expected contributions to electric dipole moments in this class of models lie within the projected sensitivity of the next-generation experiments.



Example of a Barr-Zee diagram, contributing to all EDMs.

Selected publications:

Barenboim, G.; Bosch, C.; López-Ibáñez, M.L.; Vives, O., *Improved tau-lepton tools for Higgs boson hunting*, Phys. Rev. D 90, 015003 - 14pp, DOI: 10.1103/PhysRevD.90.015003 [arXiv:1311.7321]

Bernabeu, J.; Botella, F.J.; Nebot, M., *Novel T-Violation observable open to any pair of decay channels at meson factories*, Phys. Lett. B 728, 95-98, DOI: 10.1016/j.physletb.2013.11.031 [arXiv:1309.0439]

Boucenna, M.S.; Morisi, S.; Valle, J.W.F., *Radiative neutrino mass in 3-3-1 scheme*, Phys. Rev. D 90, 013005 - 5pp, DOI:

10.1103/PhysRevD.90.013005 [arXiv:1405.2332]

Campanario, F.; Czyz, H.; Gluza, J.; Gunia, M.; Riemann, T.; Rodrigo, G.; Yundin, V., *Complete QED NLO contributions to the reaction $e^+e^- \to \mu^+\mu^-\gamma$ and their implementation in the event generator PHOKHARA*, J. High Energy Phys. 2, 114 - 27pp, DOI: 10.1007/JHEP02(2014)114 [arXiv:1312.3610]

Deppisch, F.F.; Harz, J.; Hirsch, M., *Falsifying High-Scale Leptogenesis at the LHC*, Phys. Rev. Lett. 112, 221601 - 5pp, DOI: 10.1103/PhysRevLett.112.221601 [arXiv:1312.4447]

Ghosh, P.; López-Fogliani, D.E.; Mitsou, V.A.; Muñoz, C.; Ruiz de Austri, R., *Probing the $\mu\nu$SSM with light scalars, pseudo-scalars and neutralinos from the decay of a SM-like Higgs boson at the LHC*, J. High Energy Phys. 11, 102 - 57pp, DOI: 10.1007/JHEP11(2014)102 [arXiv:1410.2070]

Hernández, P.; Kekic, M.; López-Pavón, J., *N_{eff} in low-scale seesaw models versus the lightest neutrino mass*, Phys. Rev. D 90, 065033 - 12pp, DOI: 10.1103/PhysRevD.90.065033 [arXiv:1406.2961]

Herrero-García, J.; Nebot, M.; Rius, N.; Santamaria, A., *The Zee-Babu model revisited in the light of new data*, Nucl. Phys. B 885, 542-570, DOI: 10.1016/j.nuclphysb.2014.06.001 [arXiv:1402.4491]

Jung, M.; Pich, A., *Electric dipole moments in two-Higgs-doublet models*, J. High Energy Phys. 4, 076 - 42pp, DOI: 10.1007/JHEP04(2014)076 [arXiv:1308.6283]

Selected conference talks

Hernández, P., *On Massive Gauge Theories Beyond Perturbation Theory*, MASS 2014 Conference, Odense (Denmark), May 2014.

Hirsch, M., *Theoretical Implications of Neutrinoless Double-Beta Decay*, XXVI International Conference on Neutrino Physics and Astrophysics, Boston (USA), June 2014.

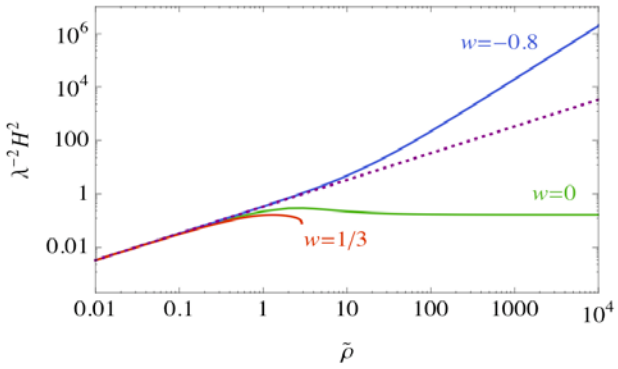
Rodrigo, G., *Forward-backward and charge asymmetries at Tevatron and the LHC*, 8th International Workshop on the CKM Unitarity Triangle, Vienna (Austria), September 2014.

Ruiz de Austri, R., *Global Fits of Supersymmetry,* Astroparticle Physics: A joint TeVPA/IDM conference, Amsterdam (Netherlands), 2014.

Main research grants (National Plan):

ASTROPARTICLE AND HIGH ENERGY PHYSICS (ref. FPA2011-22975)
FUNDAMENTAL INTERACTIONS AND THEIR EXPERIMENTAL IMPLICATIONS (ref. FPA2011-23596)
PARTICLE PHYSICS PHENOMENOLOGY AT THE LHC AND FLAVOUR FACTORIES (ref. FPA2011-23778)
PERTURBATIVE AND NON-PERTURBATIVE STUDIES OF THE STANDARD MODEL AND ITS EXTENSIONS (ref. FPA2011-23897)
FLAVOUR AND ORIGIN OF MATTER (ref. FPA2011-29678-C02-01)

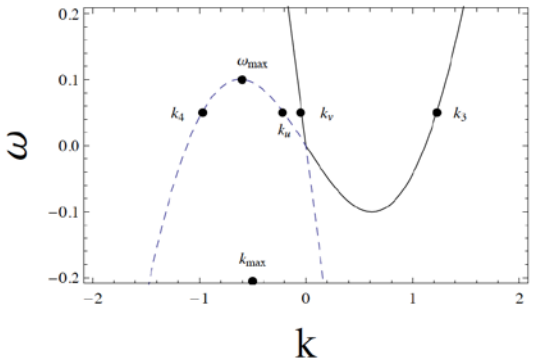
Mathematical and theoretical high energy physics. Gravity, Black Holes, and Supersymmetry



Hubble function in GR (dotted curve) and in a Born-Infeld like extension of GR (red, green, and blue curves). The w=0 case shows a period of inflation supported by dust particles.

The fundamental research topic of this line is the interphase of gravitation and quantum theory. At energy scales well below the Planck energy, quantum field theory in curved spacetime has a striking success. It predicts particle creation in the very early universe (gravitational waves, primordial inhomogeneities) and black hole radiance. At lengths or energies approaching the Planck scale the absence of a well-understood theory urges a worldwide effort to construct a viable quantum theory for the gravitational field. The complexity of the problem requires a multidisciplinary approach, incorporating a wide range of viewpoints, running from sophisticated mathematics to ambitious experiments. A deeper understanding of our basic theories is required, as well as an improvement of the leading approaches for a proper quantum gravity theory. Our research line follows this strategy in an intertwining way. The main lines and results in 2014 were:

- Analysis of the low frequency features of the analog Hawking radiation in 1D acoustic black holes in Bose-Einstein condensates through the analytical calculation of the (low frequency) gray-body factor.
- Perturbation analysis of certain classes of spherically symmetric black holes in massive (bi)-gravity, derivation of the first rotating black hole solution.
- Considering metric-affine (Palatini) extensions of Einstein's gravity, we have shown that spacetime may have a foam-like microstructure with wormholes generated by fluctuations of the quantum vacuum. This involves the spontaneous creation/annihilation of entangled particle-antiparticle pairs, existing in a maximally entangled state connected by a non-traversable wormhole, which gives further support to the recent ER=EPR claim.



Bogoliubov dispersion relation for a one-dimensional Bose liquid flowing at constant velocity in the supersonic region.

- The ultraviolet sector of gravitation is generalized via a Born-Infeld action using lessons from massive gravity. The theory contains all of the elementary symmetric polynomials constructed with the inverse space-time metric and the Ricci tensor, may avoid the big bang singularity, and predicts inflationary epochs supported by dust.
- We have pointed out that the duality symmetry of free electromagnetism does not hold in the quantum theory if an arbitrary classical gravitational background is present. The symmetry breaks in the process of renormalization, as also happens with conformal invariance.
- We have provided an exact expression for the renormalized stress-energy tensor of a spin-1/2 field in a spatially flat Friedmann-Lemaitre-Robertson-Walker universe.

Selected publications:

de Azcárraga, J.A.; Izquierdo, J.M., *Minimal D=4 supergravity from the superMaxwell algebra*, Nucl. Phys. B 885, 34-45, DOI: 10.1016/j.nuclphysb.2014.05.007 [arXiv:1403.4128]

Agulló, I.; Landete, A.; Navarro-Salas, J., *Electric-magnetic duality and renormalization in curved spacetimes*, Phys. Rev. D 90, 124067 - 7pp, DOI: 10.1103/PhysRevD.90.124067 [arXiv:1409.6406]

del Río, A.; Navarro-Salas, J., *Spacetime correlators of perturbations in slow-roll de Sitter inflation*, Phys. Rev. D 89, 084037 - 7pp, DOI: 10.1103/PhysRevD.89.084037 [arXiv:1401.6912]

Babichev, E.; Fabbri, A., *A class of charged black hole solutions in massive (bi)gravity*, J. High Energy Phys. 7, 016 - 10pp, DOI: 10.1007/JHEP07(2014)016 [arXiv:1405.0581]

Anderson, P.R.; Balbinot, R.; Fabbri, A.; Parentani, R., *Gray-body factor and infrared divergences in 1D BEC acoustic black holes*, Phys. Rev. D 90, 104044 - 6pp, DOI: 10.1103/PhysRevD.90.104044 [arXiv:1404.3224]

Beltrán Jiménez, J.; Heisenberg, L.; Olmo, G.J., *Infrared lessons for ultraviolet gravity: the case of massive gravity and Born-Infeld*, J. Cosmol. Astropart. Phys. 11, 004 - 26pp, DOI: 10.1088/1475-7516/2014/11/004 [arXiv:1409.0233]

Lobo, F.S.N.; Olmo, G.J.; Rubiera-García, D., *Microscopic wormholes and the geometry of entanglement*, Eur. Phys. J. C 74, 2924 - 5pp, DOI: 10.1140/epjc/s10052-014-2924-1 [arXiv:1402.5099]

Selected conference talks

Fabbri, A., *The analog of the Hawking effect in BECs*, Plenary talk at Spanish Relativity Meeting ERE2014, Valencia, September 2014.

Fabbri, A., *An alternative scenario for critical scalar field collapse in AdS_3*, 37th International Conference on High Energy Physics (ICHEP 2014), Valencia (Spain), July 2014.

Fabbri, A., *Analog of Black Hole Evaporation in Bose-Einstein condensates*, (Coloquium) Wake Forest Univ. (USA), August 2014.

Olmo, G.J., *Minimal extensions of Einstein's theory of gravity*, Plenary talk at XXXII Encontro de físicos do Norte e Nordeste. João Pessoa (Brazil), November 2014.

Olmo, G.J., *Crystal clear lessons for cosmology from the microcosmos*, (Coloquium) UNAM (México), April 2014.

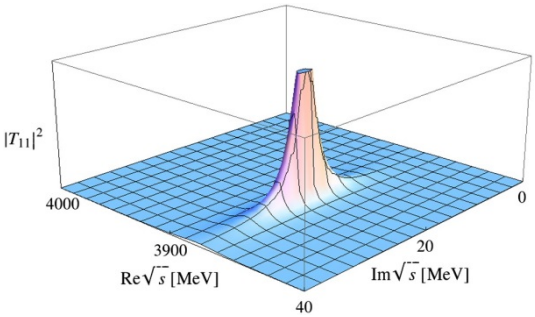
Main research grants (National Plan):

QUANTUM BLACK HOLES, SUPERGRAVITY AND COSMOLOGY (ref. FIS2011-29813-C02-02)

Nuclear and many-body theory

Effective field theories (EFT) provide one of the most efficient and predictive tools to describe hadron dynamics at low energies, unraveling the properties of strong interacting systems. Chiral symmetry and heavy quark spin-flavor symmetry, for systems with (hidden) charm or beauty provide the guiding principles to build the effective interactions. The validity range and predictive power of perturbative calculations has been significantly increased by imposing unitarity in coupled channels. Within this framework, known as chiral unitary theory (c*UT*), many mesonic and baryonic resonances emerge as as dynamically generated states.

Experiments like BES, CLEO, BELLE, LHCb have brought to light a new hadron spectroscopy by discovering many exotic states that cannot be easily accommodated into the constituent quark model picture. The $D^{(*)}\overline{D}^{(*)}$ system in isospin I=0 has been extensively studied because of the X(3872) discovered at BELLE. It has also attracted the attention of lattice QCD (lQCD) practitioners. At IFIC, a significant effort has been put into understanding this state. It has been recently shown that the $X(3872) \to D\overline{D}^0\pi^0$ decay is particularly sensitive to the long-distance structure of the X(3872) and the strength of the $D\overline{D}$ s-wave interaction. We have also established the strategy for a determination of the X(3872) binding energy in lQCD. We have calculated the precision in the energy of lQCD states, depending on the box size and the number of available levels, required to obtain the desired accuracy in the binding energy. The interaction in the I=1 channel is weaker than in I=0. For this reason, the discovery of the I=1 $Z_c(3900)$ state by BESIII came as a surprise. We have obtained this resonance as a dynamically generated state that, within our framework, is an isospin partner of the X(3872). We suggest that it also corresponds to the $Z_c(3894)$ and $Z_c(3886)$ reported by Belle and CLEO, respectively.



Amplitude squared in the second Riemann sheet for $D\overline{D}^* \to D\overline{D}^*$ in the $I^G(J^{PC}) = 1^+(1^{+-})$ sector.

The command of c*UT* by IFIC specialists in hadron physics has led to important progress in our understanding of B and D meson weak decays. Recent LHCb data has unexpectedly revealed that the decay $\bar{B}_s^0 \to J/\psi\,\pi^+\pi^-$ shows a large signal for the excitation of the scalar $f_0(980)$ resonance but no trace of $f_0(500)$, also known as σ meson. Conversely, $\bar{B}^0 \to J/\psi\,\pi^+\pi^-$ has a prominent signal of $f_0(500)$ but only a tiny fraction of $f_0(980)$ excitation is present. This puzzle has received a quantitative explanation by selecting the dominant weak decay mechanism at the quark level followed by the hadronization of $q\bar{q}$ pairs into two mesons. The later then interact in coupled channels to produce the $f_0(500)$ and $f_0(980)$ resonances with different intensities according to the specific decay. The results

$$\frac{\mathcal{B}[\bar{B}^0 \to J/\psi\, f_0(980),\, f_0(980) \to \pi^+\pi^-]}{\mathcal{B}[\bar{B}^0 \to J/\psi\, f_0(500),\, f_0(500) \to \pi^+\pi^-]} = 0.033 \pm 0.007,$$

$$\frac{\Gamma(B^0 \to J/\psi\, f_0(500))}{\Gamma(B_s^0 \to J/\psi\, f_0(980))} \simeq (4.5 \pm 1.0) \times 10^{-2}$$

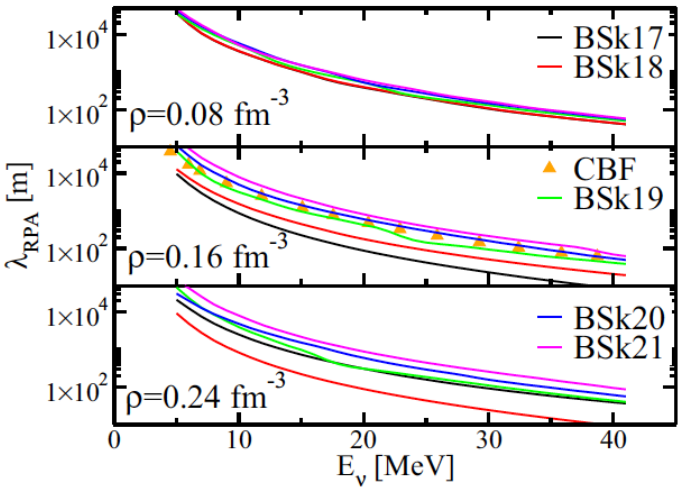
are in quantitative agreement with the experiment.

In the recent past, there has been important progress in the systematic description of baryons using Chiral Perturbation Theory and the Extended on Mass Shell renormalization scheme, which solves the power counting problem of the theory with baryons without altering its relativistic and analytic structure. In 2014 new results about the axial properties of lightest baryon octet have been reported. In spite of playing an important role in low-energy hyperon and nuclear phenomenology, the axial structure of baryons is not well understood. We have studied the axial charges and the g_1/f_1 ratios measured in the semileptonic hyperon decays up to $O(p^3)$ and including contributions from the lightest decuplet explicitly. We have clarified the role of different low-energy constants and found a good convergence of the chiral expansion.

Recent years have witnessed an intense experimental and theoretical activity aimed at a better understanding of neutrino interactions with nucleons and nuclei. Although this activity has been stimulated mostly by the needs of neutrino oscillation experiments in their quest for a precise determination of neutrino properties, the study of neutrino interactions with matter is relevant for hadronic and nuclear physics. In 2014, IFIC researchers have published a review describing the recent progress and open questions in neutrino interactions with nucleons and nuclei that has had a very positive impact on the community. We have also modeled photon emission in neutral current interactions at intermediate energies, taking into account the relevant hadronic degrees of freedom and nuclear effects: Fermi motion, Pauli blocking and in-medium [source of irreducible background in electron-neutrino appearance experiments with Cherenkov detectors such as MiniBooNE and T2K.

The formalism of linear response theory for a Skyrme functional including spin-orbit and tensor terms has been generalized to the case of infinite nuclear matter with arbitrary isospin asymmetry. Spin-isospin strength functions have been analyzed varying the conditions of density, momentum transfer, asymmetry, and temperature. The presence of instabilities, including the spinodal one, has been studied by means of the static susceptibility.

As a direct astrophysical application of this formalism, the neutrino mean-free path (NMFP) in neutron matter has been calculated at different densities and temperatures. Although such calculations can be considered still schematic since they do not take into account properly the stellar medium, a variety of trends and behaviors of the different functionals can be clearly observed. In particular, the vector part of the residual interaction plays a major role in the NMFP, while it is quite difficult to constrain by looking at properties of finite nuclei. The predictions from the Brussels-Montreal-Skyrme (BSk) functionals reproduce the main features of ab-initio calculations such as CBF. This is a remarkable advantage in terms of computational time, and suggests that calculations based on Skyrme functionals could be implemented in astrophysical codes that require the calculations of NMFP.



NMFP at a density value of 0.16 neutrons per fm^3 and zero temperature for different BSk functionals. The triangles represent the result obtained using the CBF method.

Selected publications:

Guo, F.K.; Hidalgo-Duque, C.; Nieves, J.; Ozpineci, A.; Pavón Valderrama, M., *Detecting the long-distance structure of the X(3872)*, Eur. Phys. J. C 74, 2885 - 10pp, DOI: 10.1140/epjc/s10052-014-2885-4 [arXiv:1404.1776]

Garzón, E.J.; Molina, R.; Hosaka, A.; Oset, E., *Strategies for an accurate determination of the X(3872) energy from QCD lattice simulations*, Phys. Rev. D 89, 014504 - 9pp, DOI: 10.1103/PhysRevD.89.014504 [arXiv:1310.0972]

Aceti, F.; Bayar, M.; Oset, E.; Martínez Torres, A.; Khemchandani, K.P.; Dias, J.M.; Navarra, F.S.; Nielsen, M., *Prediction of an I=1 D(D)over-bar* state and relationship to the claimed $Z_c(3900)$, $Z_c(3885)$*, Phys. Rev. D 90, 016003 - 13pp, DOI: 10.1103/PhysRevD.90.016003 [arXiv:1401.8216]

Liang, W.H.; Oset, E., *B^0 and B_s^0 decays into $J/\Psi f_0(980)$ and $J/\Psi f_0(500)$ and the nature of the scalar resonances*, Phys. Lett. B 737, 70-74, DOI: 10.1016/j.physletb.2014.08.030 [arXiv:1406.7228]

Ledwig, T.; Martín Camalich, J.; Geng, L.S.; Vicente Vacas, M.J., *Octet-baryon axial-vector charges and SU(3)-breaking effects in the semileptonic hyperon decays*, Phys. Rev. D 90, 054502 - 16pp, DOI: 10.1103/PhysRevD.90.054502 [arXiv:1405.5456]

Álvarez-Ruso, L.; Hayato, Y.; Nieves, J., *Progress and open questions in the physics of neutrino cross sections at intermediate energies*, New J. Phys. 16, 075015 - 62pp, DOI: 10.1088/1367-2630/16/7/075015 [arXiv:1403.2673]

Wang, E.; Álvarez-Ruso, L.; Nieves, J., *Photon emission in neutral-current interactions at intermediate energies*, Phys. Rev. C 89, 015503 - 21pp, DOI: 10.1103/PhysRevC.89.015503 [arXiv:1311.2151]

Davesne, D.; Pastore, A.; Navarro, J., *Linear response theory in asymmetric nuclear matter for Skyrme functionals including spin-orbit and tensor terms*, Phys. Rev. C 89, 044302 - 14pp, DOI: 10.1103/PhysRevC.89.044302 [arXiv:1402.4284]

Pastore, A.; Martini, M.; Davesne, D.; Navarro, J.; Goriely, S.; Chamel, N., *Linear response theory and neutrino mean free path using Brussels-Montreal Skyrme functionals*, Phys. Rev. C 90, 025804 - 11pp, DOI: 10.1103/PhysRevC.90.025804 [arXiv:1408.2811]. Editor's suggestion.

Selected conference talks

D. Davesne, J. Meyer, A. Pastore and J. Navarro, *Partial wave decomposition of the N3LO equation of state*, XXI Nuclear Physics Workshop 'Marie and Pierre Curie'. Kazimierz Dolny (Poland), May 2014.

E. Oset et al., *Signature of an h_1 state from $J/\psi \to K^{*0}\bar{K}^{*0}$ and theoretical description of the $Z_c(3900)$ and $Z_c(4020)$ as $D\bar{D}^*$ and $D^*\bar{D}^*$ molecular states,* 13th Int. Workshop on Meson Production, Properties & Interaction, Krakow (Poland), May 2014.

L. Álvarez-Ruso, J. Nieves, E. Wang, *Photon Emission in NC interactions with nucleons and nuclei*, CETUP* 2014: Neutrino Interactions, Lead (USA), July 2014.

L. Álvarez-Ruso, *Electroweak interactions on the nucleon (lectures)*, NuSTEC Training in Neutrino Nucleus Scattering Physics, Fermilab, Batavia (USA) October 2014.

J. Nieves, *Approximate Methods for Nuclei: RPA, MEC, 2p2h… (pionic modes of excitation in nuclei) (lectures)*, NuSTEC Training in Neutrino Nucleus Scattering Physics, Fermilab, Batavia (USA) October 2014.

Feng-Kun Guo, C. Hidalgo-Duque, J.Nieves, A. Ozpineci and M. Pavón Valderrama, *Molecules,* International Workshop on Heavy Quarkonium 2014, CERN, Geneva (Switzerland), November 2014.

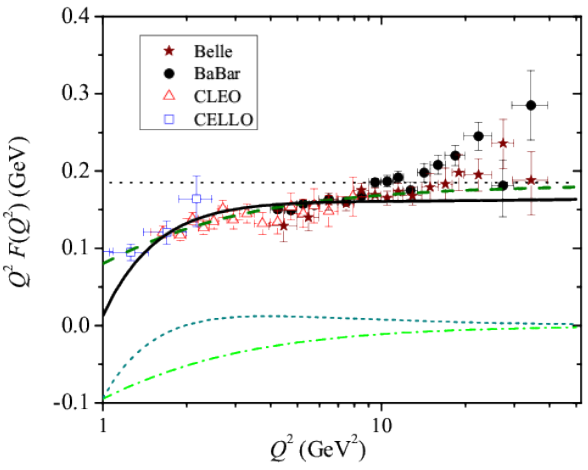
Main research grants (National Plan):

RESEARCH TOPICS IN THE STRUCTURE AND DYNAMICS OF ATOMIC, NUCLEAR AND ELECTRONIC SYSTEMS (ref. FIS2011-28617-C02-02)
NUCLEAR AND HADRON PHYSICS AT INTERMEDIATE ENERGIES (ref. FIS2011-28853-C02-01)

QCD and strong interactions

This research line is focused on fundamental perturbative and non-perturvative aspects of the strong interactions. The progress, current status, and open challenges of QCD-driven physics, in theory and in experiment has been highlighted in a comprehensive report with contribution from leading experts in the field. The strong interaction is intimately connected to a broad sweep of physical problems, in settings ranging from astrophysics and cosmology to strongly-coupled, complex systems in particle and condensed-matter physics, as well as to searches for physics beyond the Standard Model. This report also discussed how success in describing the strong interaction impacts other fields, and, in turn, how such subjects can impact studies of the strong interaction. In the course of this work, a perspective on the many research streams which flow into and out of QCD, as well as a vision for future developments has been offered.

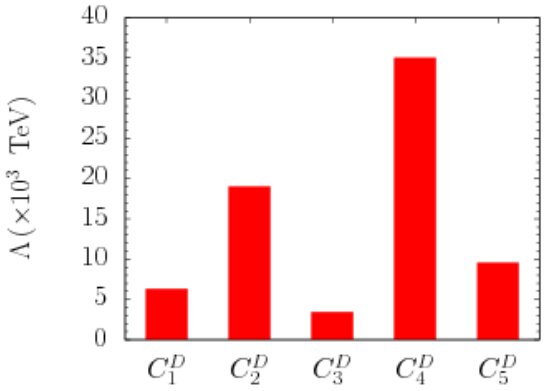
Using a model of screened potential, new bottomonium states 0 (J^{++}) have been predicted, which are not expected from conventional quark models. These new states would be equivalent to new states detected in charmonium (X (3872), X (4140), etc.)



The pion transition form factor.

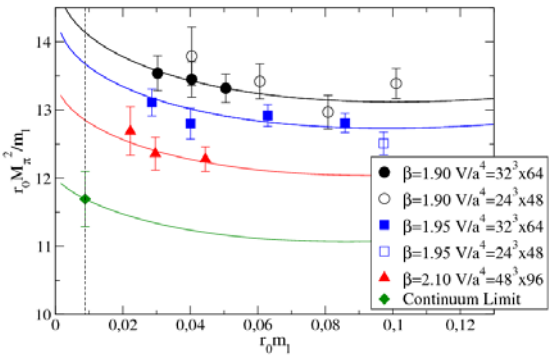
The pion distribution amplitude (πDA) has been studied in the context of a nonlocal chiral quark model. The corresponding Lagrangean reproduced the phenomenological values of the pion mass and decay constant, as well as the momentum dependence of the quark propagator obtained in lattice calculations. It was found that the obtained πDA has two symmetric maxima, which arise from the new contributions generated by the nonlocal character of the interactions. This πDA was applied to leading order and next-to-leading order calculations of the pion-photon transition form factor.

An explicit evaluation of the double parton distribution functions (dPDFs), within a relativistic Light-Front approach to constituent quark models, has been presented. dPDFs encode information on the correlations between two partons inside a target and represent the non-perturbative QCD ingredient for the description of double parton scattering in proton-proton collisions, a crucial issue in the search of new physics at the LHC. The present results show that the strong correlation effects are sizable at the experimental scale. At the low values of x, presently studied at the LHC, the correlations become less relevant, although they are still important for the spin-dependent contributions to unpolarized proton scattering.



Lower bonds on the new physics scale as obtained from the constraints on the imaginary part of the Wilson coefficient.

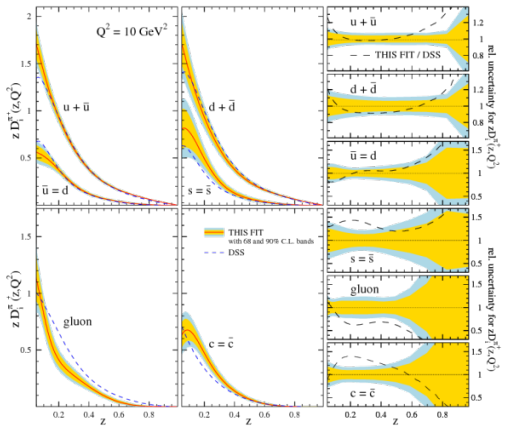
The first unquenched lattice QCD results for the bag parameters controlling the short distance contribution to meson oscillations in the Standard Model and beyond have been presented. We have used the gauge configurations produced by the European Twisted Mass collaboration with dynamical quarks, at four lattice spacings and light meson masses in the range 280–500 MeV. Renormalization was carried out non-perturbatively with the regularization-independent momentum subtraction method. The bag-parameter results have been used to constrain new physics effects in mixing, to put a lower bound to the generic new physics scale and to constrain off-diagonal squark mass terms for TeV scale supersymmetry.



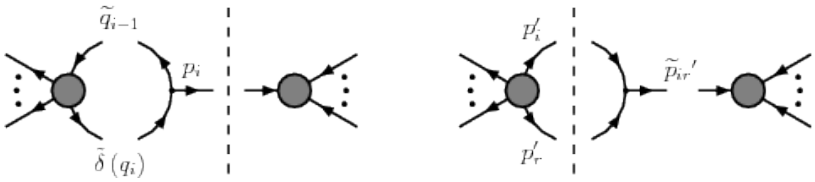
Chiral and continuum extrapolation based on the NLO ChPT fit.

A lattice QCD calculation of the up, down, strange and charm quark masses was performed using the gauge configurations produced by the European Twisted Mass Collaboration with N_f=2+1+1 dynamical quarks, which include in the sea, besides two light mass degenerate quarks, also the strange and charm quarks with masses close to their physical values. The simulations were based on a unitary setup for the two light quarks and on a mixed action approach for the strange and charm quarks. The analysis used data at three values of the lattice spacing and pion masses in the range 210–450 MeV, allowing for accurate continuum limit and controlled chiral extrapolation. The results for the quark masses in the MSbar scheme were: m_{ud}(2 GeV)=3.70(17)MeV, m_s(2GeV)=99.6(4.3)MeV and $m_c(m_c)$=1.348(46) GeV, and the quark mass ratios m_s/m_{ud}=26.66(32) and m_c/m_s=11.62(16). By studying the mass splitting between the neutral and charged kaons and using available lattice results for the electromagnetic contributions, we evaluate m_u/m_d=0.470(56), leading to m_u=2.36(24) MeV and m_d=5.03(26) MeV.

A new comprehensive global analysis of parton-to-pion fragmentation functions at next-to-leading-order accuracy in QCD has been presented, based on the latest experimental information on single-inclusive pion production in electron-positron annihilation, lepton-nucleon deep-inelastic scattering, and proton-proton collisions. The achieved, very satisfactory and simultaneous description of all data sets strongly supports the validity of the underlying theoretical framework based on pQCD and, in particular, the notion of factorization and universality for parton-to-pion fragmentation functions.



Fragmentation functions for positively charged pions along with uncertainty estimates at 68% and 90% C.L.



Factorization of the dual one-loop and tree-level squared amplitudes in the collinear limit.

The singular behaviour of loop integrals and scattering amplitudes in the framework of the loop-tree duality approach has been analyzed, then showing that there is a partial cancellation of singularities at the loop integrand level among the different components of the corresponding dual representation that can be interpreted in terms of causality. The remaining threshold and infrared singularities are restricted to a finite region of the loop momentum space, which is of the size of the external momenta and can be mapped to the phase-space of real corrections to cancel the soft and collinear divergences directly at the integrand level. This result represents a breakthough in perturbative calculations at higher orders to obtain high precision theoretical predictions of hard scattering processes at the LHC. In this context, also the splitting functions encoding the infrared singular behavior of scattering amplitudes in the triple collinear limit have been calculated at next-to-leading order (NLO).

Selected publications:

Brambilla, N. et al; Pich, A., *QCD and strongly coupled gauge theories: challenges and perspectives*, Eur. Phys. J. C 74, 2981 - 241pp, DOI: 10.1140/epjc/s10052-014-2981-5 [arXiv:1404.3723]

González, P., *Generalized screened potential model*, J. Phys. G 41, 095001 - 12pp, DOI: 10.1088/0954-3899/41/9/095001 [arXiv:1406.5025]

Gómez Dumm, D.; Noguera, S.; Scoccola, N.N.; Scopetta, S., *Pion distribution amplitude and the pion-photon transition form factor in a nonlocal chiral quark model*, Phys. Rev. D 89, 054031 - 14pp, DOI: 10.1103/PhysRevD.89.054031 [arXiv:1311.3595]

Rinaldi, M.; Scopetta, S.; Traini, M.; Vento, V., *Double parton correlations and constituent quark models: a light front approach to the valence sector*, J. High Energy Phys. 12, 028 - 23pp, DOI: 10.1007/JHEP12(2014)028 [arXiv:1409.1500]

Carrasco, N.; Ciuchini, M.; Dimopoulos, P.; Frezzotti, R.; Giménez, V.; Lubicz, V.; Rossi, G.C.; Sanfilippo, F.; Silvestrini, L.; Simula, S.; Tarantino, C., *D-0-(D)over-bar(0) mixing in the standard model and beyond from N-f=2 twisted mass QCD*, Phys. Rev. D 90, 014502 - 9pp, DOI: 10.1103/PhysRevD.90.014502 [arXiv:1403.7302]

Carrasco, N.; Deuzeman, A.; Dimopoulos, P.; Frezzotti, R.; Giménez, V.; Herdoiza, G.; Lami, P.; Lubicz, V.; Palao, D.; Picca, E.; Reker, S.; Riggio, L.; Rossi, G.C.; Sanfilippo, F.; Scorzato, L.; Simula, S.; Tarantino, C.; Urbach, C.; Wenger, U., *Up, down, strange and charm quark masses with N_f= 2+1+1 twisted mass lattice QCD*, Nucl. Phys. B 887, 19-68, DOI: 10.1016/j.nuclphysb.2014.07.025 [arXiv:1403.4504]

Buchta, S.; Chachamis, G.; Draggiotis, P.; Malamos, I.; Rodrigo, G., *On the singular behaviour of scattering amplitudes in quantum field theory*, J. High Energy Phys. 11, 014 - 13pp, DOI: 10.1007/JHEP11(2014)014 [arXiv:1405.7850]

Sborlini, G.F.R.; de Florian, D.; Rodrigo, G., *Triple collinear splitting functions at NLO for scattering processes with photons*, J. High Energy Phys. 10, 161 - 29pp, DOI: 10.1007/JHEP10(2014)161 [arXiv:1408.4821]

Selected conference talks

Pich, A., I*CHEP 2014 Summary: Theory Status after the First LHC Run*, 37th International Conference on High Energy Physics (ICHEP 2014), Valencia (Spain), July 2014 [arXiv:1505.01813].

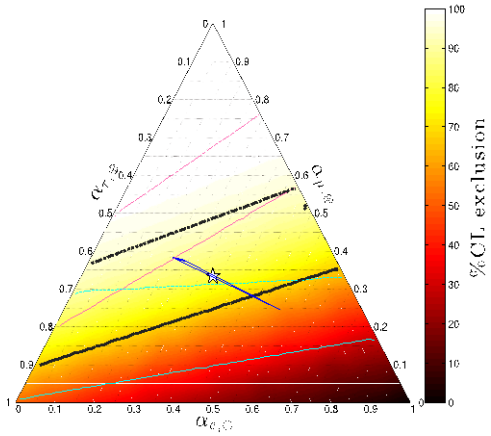
Main research grants (National Plan):

FUNDAMENTAL INTERACTIONS AND THEIR EXPERIMENTAL IMPLICATIONS (ref. FPA2011-23596)
PARTICLE PHYSICS PHENOMENOLOGY AT THE LHC AND FLAVOUR FACTORIES (ref. FPA2011-23778)
HADRONIC PHYSICS, FUNDAMENTAL INTERACTIONS AND NUCLEAR PHYSICS (ref. FPA2013-47443-C2-1-P)
PERTURBATIVE AND NON-PERTURBATIVE STUDIES OF THE STANDARD MODEL AND ITS EXTENSIONS (ref.FPA2011-23897)
FLAVOUR AND ORIGIN OF MATTER (ref. FPA2011-29678-C02-01)

Theoretical astroparticle physics and cosmology

The research topics of this line include cosmic rays, neutrinos, dark matter and dark energy theory and phenomenology. Some members are involved in international collaborations that study high-energy cosmic rays (Pierre Auger Observatory), solar neutrinos (Borexino) and the role of dark matter, neutrinos or dark energy in the cosmological large-scale structure (BOSS).

Concerning High Energy Neutrino Astronomy, theoretical researchers at IFIC were the first ones to perform a complete flavour analysis of the all-sky IceCube search. The search revealed, in its first data release, the detection of 28 veto-passing events (7 tracks and 21 showers) between 30 TeV and 1.2 PeV. The analyses of the IFIC team showed that, after accounting for the expected backgrounds, the canonical scheme (1 : 1 : 1) for the flavor ratios of the electron, muon and tau neutrinos is excluded at the 81% confidence level (C.L.) for a spectrum falling with the neutrino energy squared. If these results are confirmed by future High Energy Neutrino data, they may indicate a different production mechanism at the source, some exotic physics (as neutrino decay) or an overestimation of the atmospheric neutrino background and/or track misidentification in the event topology reconstruction analyses.

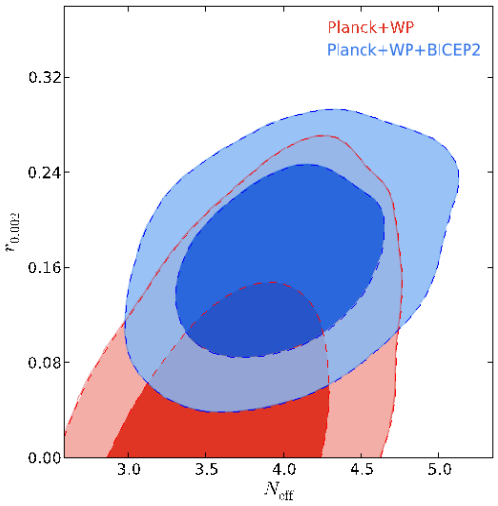


Ternary plot of the exclusion C.L. for all possible flavor combinations, as seen at Earth, given the 7 tracks and 21 showers resported at IceCube in their first high energy neutrino data release.

Other works by IFIC researchers were devoted to some aspects of indirect detection of dark matter. The Alpha Magnetic Spectrometer (AMS02) is one of the most advanced cosmic ray (CR) observatory, in operation at the International Space Station. Lately, CR observations showed that the positron fraction (PF) presents an unexpected rise above 50 GeV if only standard sources of electrons (e^-) and positrons (e^+), supernovae remnants (SNRs) and CR spallations, are considered. A possible explanation includes dark matter annihilation or decay as source of e^+. Moreover, there is another possible explanation for the rise of the PF: the pulsar population present in the Milky Way. The analysis of AMS02 data carried out by IFIC researchers revealed that astrophysical sources are fully consistent with the observations and some very loose constraints on the production mechanism can be extracted.

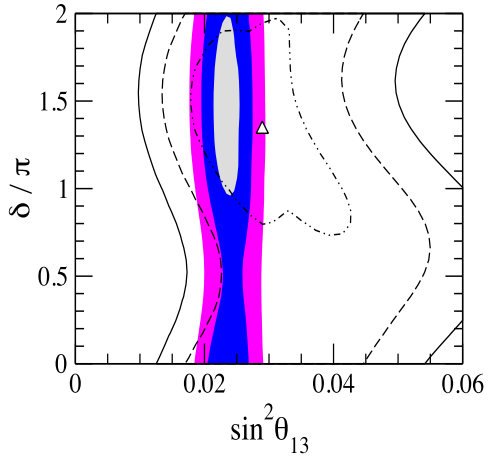
From the pure cosmological neutrino side, researchers at IFIC pioneered a work including the most recent cosmological data as of early 2014. The data included the BOSS large scale structure measurements and the claimed B-mode signal from the BICEP2 experiment.

In the minimal three active neutrino scenario, this analysis found a 95% CL upper limit on the sum of the three active neutrino masses of 0.22 eV. Also, a non-zero value for the sum of the three active neutrino masses of 0.3 eV was significantly favored (at more than 3 standard deviations) when adding the constraints from the Planck Cluster catalog on galaxy number counts. However, this preference disappeared almost completely when considering additional species, as thermal axions or massive sterile neutrinos.
A number of effective relativistic species (N_{eff}) close to 4 seemed to be favored by considering BICEP2 data. Nevertheless, the claimed BICEP2 signal has been recently identified as a galactic thermal dust foreground component by Planck polarization measurements, and without this signal all the cosmological measurements agree perfectly with the canonical expectation of N_{eff}=3.



Constraints in the N_{eff} parameter versus the scalar-to-tensor ratio r from Planck, WMAP polarization and BICEP2 data. The inclusion of the BICEP2 constraint shifts the contours towards Neff> 3.

Regarding neutrino oscillation measurements, a recent updated analysis of all experimental data has been performed by IFIC researchers. The most notable data sets that have been included are the new reactor neutrino oscillation measurements produced by Daya Bay, and RENO (corresponding to 217 and 403 days of data-taking, respectively) and appearance and disappearence results from the long-baseline experiments MINOS and T2K. The very good measurement of θ_{13} by reactor neutrino experiments, combined with the very precise measurement of θ_{23} and Δm_{31}^2 by LBL experiments, produces a slight preference for non-maximal θ_{23}, with the best-fit lying in the second octant. Again, combination of LBL appearance data with reactors seems to prefer a maximal CP-violating phase, $\delta = -\pi/2$, albeit with very small statistical significance.



Contours for $\Delta\chi^2$=1,4,9 in the θ_{13}-δ plane from the analysis of LBL data only (lines) and from the global fit (coloured regions), for normal hierarchy.

Selected publications:

Barenboim, G.; Chun, E.J.; Lee, H.M., *Coleman-Weinberg inflation in light of Planck*, Phys. Lett. B 730, 81-88, DOI: 10.1016/j.physletb.2014.01.039 [arXiv:1309.1695]

Boucenna, M.S.; Morisi, S.; Shafi, Q.; Valle, J.W.F., *Inflation and majoron dark matter in the neutrino seesaw mechanism*, Phys. Rev. D 90, 055023 - 6pp, DOI: 10.1103/PhysRevD.90.055023 [arXiv:1404.3198]

Di Mauro, M.; Donato, F.; Fornengo, N.; Lineros, R.A.; Vittino, A., *Interpretation of AMS-02 electrons and positrons data*, J. Cosmol. Astropart. Phys. 4, 006 - 33pp, DOI: 10.1088/1475-7516/2014/04/006 [arXiv:1402.0321]

Forero, D.V.; Tórtola, M.A.; Valle, J.W.F., *Neutrino oscillations refitted*, Phys. Rev. D 90, 093006 - 10pp, DOI: 10.1103/PhysRevD.90.093006 [arXiv:1405.7540]

Giusarma, E.; Di Valentino, E.; Lattanzi, M.; Melchiorri, A.; Mena, O., *Relic neutrinos, thermal axions, and cosmology in early 2014*, Phys. Rev. D 90, 043507 - 17pp, DOI: 10.1103/PhysRevD.90.043507 [arXiv:1403.4852]

Mena, O.; Palomares-Ruiz, S.; Vincent, A.C., *Flavor composition of the high-energy neutrino events in IceCube*, Phys. Rev. Lett. 113, 091103 - 5pp, DOI: 10.1103/PhysRevLett.113.091103 [arXiv:1404.0017]

Racker, J.; Rius, N., *Helicitogenesis: WIMPy baryogenesis with sterile neutrinos and other realizations*, J. High Energy Phys. 11, 163 - 19pp, DOI: 10.1007/JHEP11(2014)163 [arXiv:1406.6105

Selected conference talks

Boucenna, S., *Inflation and majoron dark matter in the seesaw mechanism*, 17th Int. Conference From the Planck scale to the electroweak scale (PLANCK 2014), Paris (France), May 2014.

Lineros, R.A., *Constraints on the dark matter interaction sector via extra radiation contributions*, 37th Int. Conference on High Energy Physics (ICHEP 2014), Valencia (Spain), July 2014.

Mena, O., *Neutrinos and cosmology*, NuPhys2014:Prospects in Neutrino Physics, London (United Kingdom), December 2014

Palomares-Ruiz, S., *On the flavor composition of the high-energy neutrinos in IceCube*, 37th Int. Conference on High Energy Physics (ICHEP 2014), Valencia (Spain), July 2014.

Tórtola, M.A., *Updated three-neutrino oscillations parameters from global fits*, 37th Int. Conference on High Energy Physics (ICHEP 2014), Valencia (Spain), July 2014.

Vincent, A., *Hints and constraints from annihilating dark matter*, Invisibles Workshop 2014, Paris (France), July 2014.

Valle, J.W.F., *Neutrino pathways to cosmology*, 14th Int. Symposium on Frontiers of Fundamental Physics (FFP14), Marseille (France), July 2014.

Main research grants (National Plan):

ASTROPARTICLE AND HIGH ENERGY PHYSICS (ref. FPA2011-22975)
FUNDAMENTAL INTERACTIONS AND THEIR EXPERIMENTAL IMPLICATIONS(ref. FPA2011-23596)
FLAVOUR AND ORIGIN OF MATTER (ref. FPA2011-29678-C02-01)

3. PUBLICATIONS

We present the list of the **405 scientific papers** published by IFIC authors in journals indexed in ISI Web of Science, that are also available at the IFIC publication database (http://references.ific.uv.es/refbase) Here we include all records of type *paper*, *letter* or *review*, but not proceeding papers.

In each case, only the first 20 authors are listed (but we do include all authors with IFIC affiliation), and there is a link to the published version and electronic preprint, if available. For the experimental collaborations, all IFIC authors that appear at least in one paper in 2014 are indicated. Some papers appear twice if there are authors from both IFIC departments.

EXPERIMENTAL PHYSICS

AGATA Collaboration

IFIC authors: Gadea, A.

Isospin Character of Low-Lying Pygmy Dipole States in Pb-208 via Inelastic Scattering of O-17 Ions, Phys. Rev. Lett. 113, 012501 - 5pp, DOI: 10.1103/PhysRevLett.113.012501

Shape evolution in the neutron-rich osmium isotopes: Prompt gamma-ray spectroscopy of Os-196, Phys. Rev. C 90, 021301 - 6pp, DOI: 10.1103/PhysRevC.90.021301

Pygmy dipole resonance in Sn-124 populated by inelastic scattering of O-17, Phys. Lett. B 738, 519-523, DOI: 10.1016/j.physletb.2014.08.029

ANTARES Collaboration

IFIC authors: Barrios-Martí, J.; Bigongiari, C.; Emanuele, U.; Gómez-Gónzalez, J.P.; Hernández-Rey, J.J.; Lambard, G.; Mangano, S.; Sánchez-Losa, A.; Sánchez-Losa, A.; Tönnis, C.; Yepes, H.; Zornoza, J.D.; Zúñiga, J

Searches for clustering in the time integrated skymap of the ANTARES neutrino telescope, J. Cosmol. Astropart. Phys. 5, 001 - 14pp, DOI: 10.1088/1475-7516/2014/05/001 [arXiv:1402.2809]

A search for time dependent neutrino emission from microquasars with the ANTARES telescope, J. High Ener. Astrophy. 3, 41517, DOI: 10.1016/j.jheap.2014.06.002 [arXiv:1402.1600]

Constraining the neutrino emission of gravitationally lensed Flat-Spectrum Radio Quasars with ANTARES data, J. Cosmol. Astropart. Phys. 11, 017 - 12pp, DOI: 10.1088/1475-7516/2014/11/017 [arXiv:1407.8525]

Searches for Point-like and extended neutrino sources close to the Galactic Centre using the ANTARES neutrino Telescope, Astrophys. J. Lett. 786, L5 - 5pp, DOI: 10.1088/2041-8205/786/1/L5 [arXiv:1402.6182]

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ATLAS Collaboration

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BOOKS

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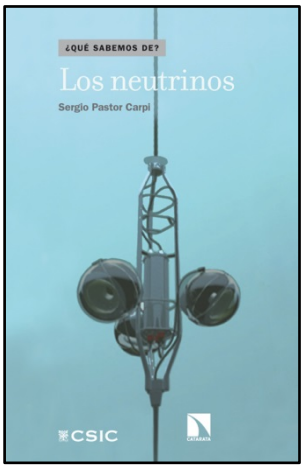


¿Qué sabemos de? Los neutrinos

by **Sergio Pastor Carpi**

Pub. CSIC – Libros de la Catarata

ISBN: 978-84-00-09863-6

4. 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 first of them, 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).

PH.D. THESES

In 2014 a total of 25 doctoral theses were presented with IFIC advisors. For those granted by Spanish Universities we include a link to the TESEO database.

Experimental Physics

Measurement of neutrino induced charged current neutral pion production cross section at SciBooNE
Joan Català Pérez
Advisors: Michel Sorel, Juan José Gómez Cadenas
10 February, University of Valencia
TESEO: 1073085

Characterization of the optical properties at the ANTARES site using the Optical Beacon System. Influence on the detector performance
Harold Yepes Ramírez
Advisors: Juan J. Hernández Rey, Juan Zúñiga Román
13 June, University of Valencia
TESEO: 1094964

Neutron capture measurement of ^{54}Fe and ^{57}Fe at CERN n_TOF
Giuseppe Giubrone
Advisors: César Domingo Pardo, J. Luis Taín Enríquez
8 July, University of Valencia
TESEO: 1101576

Inner detector alignment and top-quark mass measurement with the ATLAS detector
Regina Moles-Valls
Advisors: Salvador Martí i García
16 May, University of Valencia
TESEO: 1083342

Search for CP violation in single top quark events with the ATLAS detector at LHC
María Moreno Llácer
Advisors: María José Costa Mezquita, José Bernabéu Alberola
23 June, University of Valencia
TESEO: 1099998

Measurement of the top quark pair production cross section in p-p collisions at center-of-mass energies of 7 TeV in final states with a τ lepton with ATLAS detector
María Teresa Pérez García-Estañ
Advisors: Susana Cabrera Urbán
10 September, University of Valencia
TESEO: 1109628

Measurement of the top quark pair production cross-section involving a τ & μ Studies with TileCal in ATLAS
Eva Valladolid Gallego
Advisors: María Victoria Castillo Giménez
24 November, University of Valencia
TESEO: 1124064

Joint analysis of three flavour neutrino oscillations combining the ν_e appearance and ν_μ disappearance channels in the T2K experiment
Lorena Escudero Sánchez
Advisors: Anselmo Cervera Villanueva, Konstantinos Andreopoulos
12 December, University of Valencia
TESEO: 1127382

Demonstration of electroluminescent TPC technology for neutrinoless double beta searches using the NEXT-DEMO detector
Francesc Monrabal Capilla
Advisors: Juan José Gómez Cadenas
19 December, University of Valencia
TESEO: 1125423

Determination of the top-quark pole mass using tt+1-jet events with the ATLAS detector at the LHC
Adrián Irles Quiles
Advisors: Juan Fuster Verdú, Peter Uwer
9 December, University of Valencia
TESEO: 1126545

The Back-End Electronics for the ATLAS Hadronic Tile Calorimeter at the Large Hadron Collider
Alberto Valero Biot
Advisors: Juan Antonio Valls Ferrer, Vicente González Millán
15 December, University of Valencia
TESEO: 1125345

Theoretical Physics

Deformed superspace and non-commutative supersymmetric field theory
Dalia Cervantes Cabrera
Advisors: M. Antonia Lledó Barrena
14 February, Autonomous University of Mexico

Neutrino masses and dark matter: a path to new physics
Juan Andrés Herrero García
Advisors: Arcadi Santamaría Luna, Nuria Rius Dionis
20 June, University of Valencia
TESEO: 1098114

Mixing of pseudoscalar-baryon and vector-baryon in meson-baryon interaction and the generation of resonances
Eugenio Javier Garzón Alama
Advisors: Eulogio Oset Báguena
26 June, University of Valencia
TESEO: 1099239

Phenomenology of two-Higgs-doublet models in the LHC era
Alejandro Celis Alas
Advisors: Antonio Pich Zardoya
18 June, University of Valencia
TESEO: 1096494

Investigation of molecular states with charm and beauty hadrons
Chu-Wen Xiao
Advisors: Eulogio Oset Báguena
14 July, University of Valencia
TESEO: 1100328

Measurement of the photon electroproduction cross section at JLab with the goal performing a Rosenbluth separation of the DVCS contribution
Alejandro Miguel Martí Jiménez-Argüello
Advisors: Santiago Noguera Puchol, Carlos Muñoz Camacho
11 July, University of Valencia
TESEO: 1102668

Quantum Walk and Wigner function on a lattice
Margarida Hinarejos Doménech
Advisors: Armando Pérez Cañellas, Mª Carmen Bañuls Polo
22 July, University of Valencia
TESEO: 1102506

Phenomenology of massive neutrinos: from oscillations to new physics
David Vanegas Forero
Advisors: M. Amparo Tórtola Baixauli, José W. Furtado Valle
26 September, University of Valencia
TESEO: 1113240

Neutrinos in GUTs and left right symmetry
Carolina Arbeláez Rodríguez
Advisors: Martin Hirsch, José Wagner Furtado Valle
13 October, University of Valencia
TESEO: 1115604

On implications of modified gravity models of dark energy
Zahara Gironés Delgado-Ureña
Advisors: Carlos Peña Garay, Olga Mena Requejo
19 December, University of Valencia
TESEO: 1128009

LHC Phenomenology and Neutrino Physics in GUT inspired SUSY
Laslo Alexander Reichert
Advisors: Martin Hirsch, José W. Furtado Valle
28 July, University of Valencia
TESEO: 1105170

Electroweak processes in nucleons and nuclei at intermediate energies
En Wang
Advisors: Juan Nieves Pamplona, Luis Álvarez Ruso
11 December, University of Valencia
TESEO: 1120017

Neutrino physics and dark matter
Mohamed Sofiane Boucenna
Advisors: José W. Furtado Valle, Stefano Morisi
10 November, University of Valencia
TESEO: 1122435

5. CONFERENCES, COLLOQUIA AND SEMINARS

CONFERENCES AND MEETINGS

IFIC researchers present their results in the main international conferences and workshops. A total of 300 contributions were presented in 2014: **256 talks** (31 invited) and **44 posters**.

We were very proud to organize **ICHEP 2014** in Valencia, on behalf of the Spanish particle and astroparticle physics community, the **most important international conference on particle physics**.

This was **the first time that ICHEP was held in Spain,** chaired by IFIC professor Juan Fuster.

The first three days of the conference were devoted to the **parallel sessions** (15 thematic workshops), where more than 500 works were presented. The second part of ICHEP 2014 included the **plenary sessions** that reviewed the various topical areas in the field. There were also special sessions about the future of accelerators, the 60th anniversary of CERN and the industry opportunities in particle physics facilities.

The discussions at ICHEP 2014 included the last results on the Brout-Englert-Higgs boson and the consequences of the results of the BICEP2 and Planck collaborations about the theory of cosmic inflation. IFIC professor Antonio Pich presented the theory highlights of the conference.

The meeting, with more than 1000 attendees, was a great success and for one week **Valencia was the world capital of particle physics**.

Here we highlight other conferences and workshops organized by IFIC members in Valencia or elsewhere:

14th AGATA Week at CSIC, 22-24 January
ATLAS Phase II Strip Tracker workshop, 3-7 February
XV Face to Face Meeting of the Spanish ATLAS Tier-2, 10-11 February
Workshop on $B_s \rightarrow \varphi\gamma$ decays at LHCb, 19-21 February
VANISH: VAlencia Neutrino Interaction ScHool/WorkSHop, 2-4 April
10th MultiDark Consolider Workshop, 2-4 April
1st GNN workshop on Indirect Dark Matter detection with Neutrino Telescopes, 10-11 April
Workshop on Advanced Low Emittance Rings Technology (ALERT 2014), 5-6 May
15th & 16th NEXT Collaboration Meetings, 15-16 May & 6-7 November
TAS Collaboration Meeting: Status and Perspectives, 26-28 June
Spanish Relativity Meeting (ERE 2014), 1-5 September
NUSTAR Week 2014, 22-26 September
IVICFA'S Fridays, series of MiniWorkshops: Theoretical Physics I (19 Sep), Experimental Physics (3 Oct), Computation in Physics (17 Oct), Theoretical Physics II (24 Oct) and Medical Physics (31 Oct)
Workshop: 50 years of Bell Inequalities, 3 November
TileCal Electronics Upgrade Workshop, 19-21 November

IFIC COLLOQUIA

Colloquia are **review talks** about a research topic for a general audience of IFIC members

Organizers: Germán Rodrigo and José Luis Taín

Evidence for high-energy extraterrestrial neutrinos at the IceCube detector
Francis Halzen (WIPAC, Univ. Wisconsin–Madison)
9 January

The gauge/gravity correspondence: linking General Relativity and Quantum Field Theory
Alfonso Vázquez Ramallo
(Univ. Santiago de Compostela)
11 April

Insights and puzzles in particle physics
Heinrich Leutwyler (Universität Bern)
14 May

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 2014 we hosted a total of **60 seminars** (some of them *webinars*). The complete list can be found at the IFIC's Indico webpage http://indico.ific.uv.es

Organizer: Jorge Portolés

6. TECHNOLOGY TRANSFER AND OUTREACH

TECHNOLOGY TRANSFER

Patents

- Patent P201231243, describing a procedure to **enhance radiological images by densitometric imaging**, and registered by the IFIC researchers Francisco Javier Albiol, Avelina Fernández and Germán Rodrigo, was granted for Spain and is currently under national evaluation for the United States and the European Union.
- Funding from Centro Nacional de Física de Partículas, Astropartículas y Nuclear (CPAN), with reference CPAN13-TR01, led to a new patent request in the field of **radiographic imaging** by the same research group.

R&D projects

- Patent P201231243, described above, generated in 2014 two R+D projects in collaboration with the company IST Medical, who holds the license, to explore the potentialities of the technology.
- The IFIC researchers Francisco Javier Albiol and Germán Rodrigo are participating in the development of tools for the **analysis and modelling of the time evolution of power usage in the Spanish electrical grid**. Their work concluded during 2014 and it is expected to generate a license contract along the coming year.
- The IFIC Gamma and Neutron Spectroscopy group was awarded an R+D contract to develop specific detectors for the **characterisation of radioisotope-contaminated environments**. The leading researcher for this project is César Domingo Pardo.

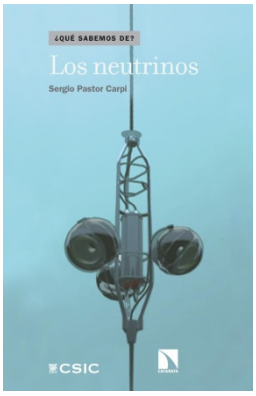
Services to external companies or institutions

- The Electronics Unit provided **micro welding services** to Alibava Systems SL.
- IFIC provided **measurement and assessment of the radon levels** to Iberdrola Generación SA in two of their power plants following instruction IS-33 of the Consejo de Seguridad Nuclear.
- IFIC provided **services on LHC consolidation work** to CERN under collaboration agreement no. KE2023/TE, and engineering consulting advice for the same aim under collaboration agreement no. KE2022/TE. Ángeles Faus-Golfe was the principal investigator at IFIC for both projects.

OUTREACH MATERIAL

In May 2014 a 5x3-meter panel was ordered by the ATLAS group to be installed on a wall on the first floor of the experimental building, where several other outreach materials are exhibited. The panel displays the LHC tunnel in near-real size and it can be used as a backdrop to take photographs as if you were in the LHC tunnel. The panel has been quite popular among visitors, both during high school visits and as an attraction on the open day of the Institute (see below).

Books



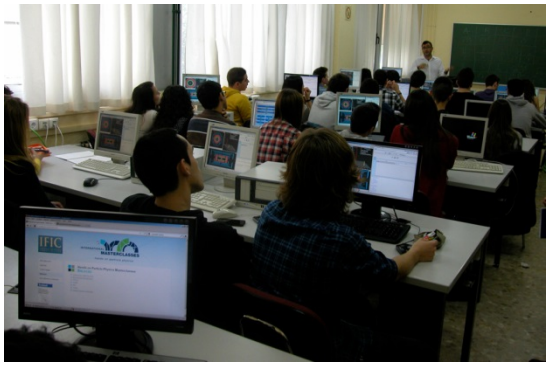
Two outreach books were published by members of IFIC during 2014:

- Sergio Pastor published Los neutrinos, a monograph reviewing the eventful history of these particles, their unusual properties and the techniques we use to study them.
- Jesús Navarro published Física Cuántica. El principio de incertidumbre. Heisenberg as a special edition of the journal National Geographic. This book explains the birth of the quantum theory focusing especially on the role played by Werner Heisenberg.

OUTREACH ACTIVITIES

In January 2014 the Institute hired Alberto Aparici to coordinate our outreach activities and to help in communication tasks, especially on our website and through our social media profiles. The overall supervision of the Institute's outreach policy corresponds to the Outreach Committee.

International Masterclasses: hands on particle physics



On March 25th the Institute hosted a new edition of the International Masterclasses sponsored by CERN. Thirty-six high school students attended a session where they learned to interpret the events recorded in a high-energy physics experiment. Using real data kindly provided by ATLAS they studied the internal structure of the proton and looked for the Higgs boson, sharing then their results via videoconference with other groups of students, in this case from three French institutions. The call for the Masterclass was responded by high schools from all over our region, and the students who finally attended the event came from a variety of towns, some of them rather distant: Valencia, Castellón, Puçol, Alcàsser, Paterna, Xirivella, La Pobla de Farnals, Alaquàs and Pinoso. The coordinator for this edition of the Masterclass was Santiago González de la Hoz, but twelve more members of IFIC were involved in helping the students with the exercise and giving introductory talks during the morning session.

Guided tours for students

The Institute offers guided tours to our facilities for groups of students interested in particle physics. This tours, usually spanning a whole morning, consist on a short presentation about particle physics 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), then a coffee break and after that the students are guided through three laboratories selected among seven options: ANTARES/Km3NET, NEXT, ATLAS-Silicon, ATLAS-TileCal, Medical Physics, GRID-Computing centre and Gamma Spectroscopy. Alberto Aparici is the main responsible and coordinator for these visits, and usually he also plays the role of maître-de-cérémonie, but each experiment provides one or two people who can share their expertise with the students during their visit to the labs.

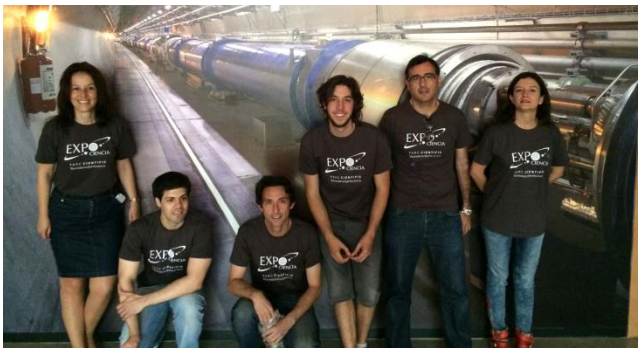
Overall, twenty-six members of IFIC were involved during the year 2014.

The total number of visiting schools during 2014 was twelve, from towns all over our region: Valencia, Sagunto, Villena, La Vall d'Uixó, Riba-Roja, Puçol, Orihuela. Most of them 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. A few visits were arranged directly by members of IFIC, and there were six special visits: advanced students from ESTALMAT and VLC/Campus, young students from the Universitat de València summer program (La Nau Jove), students from the Faculty of Physics of UV and exchange students from High School #1517 in Moscow.

Open Day of the Scientific Park: Expociència 2014

The Scientific Park where IFIC is located schedules every year an open day when the public is encouraged to visit our facilities and many activities and demonstrations are programmed. The event is called Expociència, and in 2014 this 6th edition was scheduled for May 24th. IFIC contributed with six activities, including a videoconference from the ATLAS cavern at CERN. Overall, thirty-seven members of IFIC participated this year, and more than 4,500 people attended the event. Here follows a list of the activities organised by IFIC:

IFIC ORGANISERS	**ACTIVITY**
J. Barrios, A. Sánchez, J. Zornoza, J. Zúñiga	Observa el universo desde las profundidades del mar: Telescopios de neutrinos
V. Álvarez, A. Simón, M. Querol, F. Monrabal	Cocinando en el Ártico
C. García, S. González, S. Cabrera, P. Fernández, E. Torró, R. Molés, J. Jiménez, G. Sborlini, D. Álvarez	ATLAS, un gigante para atrapar partículas
J. Barrio, M. Trovato, C. Solaz, G. Llosá, J.F. Oliver	Física médica: haciendo visible lo invisible
J. Agramunt, A. Algora, C. Domingo, V. Guadilla, A. Montaner, S.E.A. Orrigo, J.L. Taín, E. Valencia, M.D. Jordán	¿Somos radiactivos?
C. García, S. González, A. Aparici, J.E. García, C. Escobar	Buscadores del bosón de Higgs: a 100 metros bajo tierra



Public lectures

Talks at High Schools: Física de Partículas en el Instituto

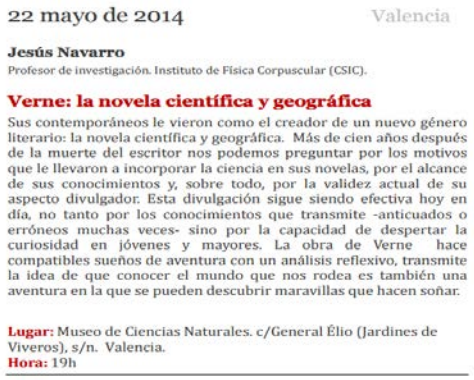
The Centro de Partículas, Astropartículas y Nuclear (CPAN) encourages its member institutions to offer popular talks to local high schools and coordinates the organisation of the events. In 2014 IFIC offered thirty-two such talks on three different topics: the Higgs boson, astroparticles and applications of nuclear physics. Overall, fifteen members of IFIC participated in this activity. Here follows a list of the towns where the talks were given and the people involved:

Topic	Places	Speakers
Higgs boson	Valencia, Quart de Poblet, Burjassot, La Pobla de Farnals, Manises, Novelda, Vila-Real, Cheste, San Vicent del Raspeig, Alaquàs, Benimodo	C. García, J. Salt, E. Torró, M. Villaplana, S. Martí, A. Irles, E. Romero
Astroparticles	Almàssera, Sagunto, Alaquàs, Cheste, San Antonio de Benagéber, Villena, Valencia, La Vall d'Uixó, El Campello, La Pobla de Farnals, Puçol, Petrer	S. Pastor, M. Tórtola, J. Zornoza
Nuclear Physics	Alcàsser, Almussafes, Valencia, Benetússer, Manises, Puçol, Burjassot	C. Domingo, J.L. Taín, A. Montaner, B. Rubio, A. Algora

Other public talks

Several members of IFIC gave a total of 14 public lectures for various official or casual gatherings. Here is a list of them:

Speaker	Context	Title
A. Pich	Cycle “Nobel Prizes 2013” (Octubre Center, Valencia)	El bosó de Higgs
J. Zornoza	Conferences of the Faculty of Physics (Universitat de València)	Telescopios de neutrinos: una nueva forma de observar el Universo
M.A. Sanchis	Intercampus Debate Cycle (Faculty of Law, UV)	De la clonación y células madre a las terapias: implicaciones éticas y jurídicas
B. Rubio	Conferences of the Chilean Committee for Nuclear Energy (Santiago de Chile)	Estudios de Desintegraciones Beta de Núcleos Exóticos
J.J. Gómez Cadenas	CONEC Talks (Valencia)	Paisaje con neutrinos, paisaje sin neutrinos
B. Rubio	Conference for the International Women’s Day (IFIC)	Las cosas han cambiado. ¿Han cambiado las cosas?
J. Bernabeu	Archaeological and Ethnographic Museum (Xàbia)	Les fronteres de la Física: Cosmologia i Partícules
J.A. de Azcárraga	Opening Conference for the Doctorate programme (UJI, Castellón de la Plana)	El mundo según la ciencia: Einstein, Darwin y Wegener
A. Aparici	Cycle “Astronomía en el Castillo” (Almansa)	Inflación
A. Pich	RSEF Conferences (Faculty of Mathematics, UCM, Madrid)	El bosón de Higgs: una ventana en la frontera del conocimiento
J. Navarro	Museum for Natural Science (Valencia)	Verne: la novela científica y geográfica
A. Aparici	Cultural Week of the Astronomy Association of UV	Inflación y universo primigenio
A. Pich	Science Week of the Faculty of Mathematics (UV)	Explorant els secrets del bosó de Higgs
A. Ferrer	Public discussion Campus de Burjassot Library	Orígenes de la informática en la Universidad de Valencia



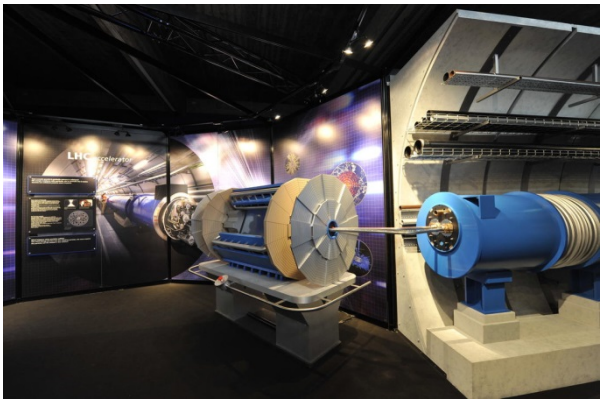
Additionally, Alberto Aparici collaborates with the Universitat de València programme for seniors and in that context he offered seven short talks during the year 2014, with the following topics: supernovae, the evolution of the first animals, the outer Solar System, cosmic inflation, how the brain encodes our position in space (2014 Nobel Prize in Medicine or Physiology), the process of formation of planets and General Relativity in the movie Interstellar. These talks had an attendance of around 100 people.

Outreach activities connected to ICHEP 2014

The International Conference on High Energy Physics (ICHEP) was organised for the first time in Spain in Valencia in 2014 and was hosted by IFIC. In order to engage the public in ICHEP's research fields several outreach actions were set up in Valencia during winter, spring and summer 2014, and IFIC helped with the organisation and logistics.

Accelerating Science exhibition

The Príncipe Felipe Science Museum in Valencia hosted the exhibition *Accelerating Science*, sponsored by CERN, which also celebrated the 60th anniversary of CERN itself. The exhibition consisted of more than 400 m^2 of outreach materials that guided the visitors from the early universe to the LHC experiments, explaining how particle physics helps to understand both the very first



moments of the cosmos and the realm of atoms and nuclei. The exhibition also reviewed how the technology initially developed for particle physics research has found its way into medical therapy, worldwide communication through internet and big data analysis. Finally, the visitors had also the opportunity to learn about the main open questions in particle physics and how these questions are being addressed at CERN. IFIC helped by arranging the arrival of the exhibition with CERN and the Museum, and was responsible for the adaptation of the texts into Spanish. The exhibition remained in Valencia for two months and was visited by tens of thousands of people.

Cycle of conferences *Enigmas of matter and the universe: Science, Technology, Society*

A series of conferences aimed to the general public were hosted by Universitat de València and sponsored by ICHEP 2014. The conferences were mainly focused on the transfer of knowledge from particle physics research to other areas, and how this process yields technological applications that many of us may have used without noticing their origin. The cycle also featured two talks on the frontiers of knowledge in high-energy physics. IFIC participated by providing the logistics and arranging with Universitat de València the most appropriate venues for each part of the programme. Here is a complete list of all the conferences in this cycle:

Speaker	Title
Francisco Javier Cáceres	LA INDUSTRIA DE LA CIENCIA
Isabel Béjar	EL CERN, CIENCIA SIN FRONTERAS
Manuel Delfino	LA INVESTIGACIÓN EN INFORMÁTICA PARA VER PARTÍCULAS QUE ACABA EN NUESTROS MÓVILES Y ORDENADORES
David García Cerdeño	CAZADORES DE MATERIA OSCURA
Caterina Biscari	ACELERADORES, MÁQUINAS PARA DESCUBRIR Y SERVIR
Antonio Pich	EL BOSÓN DE HIGGS: UNA VENTANA EN LA FRONTERA DEL CONOCIMIENTO
Gabriela Llosá, Marisa Cubells	APLICACIONES EN MEDICINA DE LA FÍSICA DE PARTÍCULAS
Jose Manuel Pérez	TECNOLOGÍAS DERIVADAS DE LA INVESTIGACIÓN EN FÍSICA DE PARTÍCULAS

IFIC IN THE MEDIA

In 2014 the members of IFIC produced 62 pieces for several media, from newspaper articles to news on TV. From them, 13 were written documents, 44 were audio pieces and 5 were videos.

Written articles

Author/Contributor	Medium	Title
J.J. Gómez Cadenas	El País	Ignóralo hasta que desaparezca
J. Zornoza, J.F.W. Valle	El Mundo	La búsqueda de lo desconocido
J. Navarro Salas	Levante	Un descubrimiento en la encrucijada del Big Bang
J.J. Gómez Cadenas	Jot Down	Interstellar, a debate Universo 2.0 Aliens, videojuegos y el gato de Schrödinger El espía que surgió del frío
F. Martínez Vidal	Mètode	Estadística en física de partículas: su papel en el descubrimiento del bosón de Higgs
J. Navarro Salas	Mètode	A conversation with Leonard Parker
F. Monrabal, J.J. Gómez Cadenas	Jot Down	Interview with Pablo Artal
J.A. de Azcárraga	Revista Española de Física	Fotones, iones y gatos cuánticos: en torno a la visita del Nobel Serge Haroche a la RSEF
J.J. Gómez Cadenas, F. Monrabal	Jot Down	Interview with Francis Halzen
J. Fuster	Mètode	Interview

Radio pieces

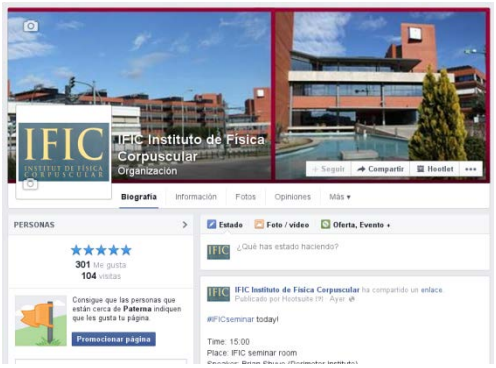
Author/Contributor	Medium	Title
G. Barenboim	Onda Cero	Interview on parallel universes and string theory
J.J. Gómez Cadenas	Cadena Ser	Interview about neutrinos, nuclear energy and environmentalism
B. Rubio	MediaUni	Interview about rare nuclear decays
J. Navarro Salas	MediaUni	Interview about black holes and Hawking radiation
A. Aparici	Onda Cero	40 radio pieces about science in the show La Brújula de la Ciencia

Videos / TV pieces

Author/Contributor	Medium	Title
J. Bernabeu	La Sexta	Interview on hadrontherapy
C. Peña Garay	(own production)	Neutrino, measuring the unexpected
A. Aparici	MediaUni	Interview about time travel
J.L. Taín, A. Algora	MediaUni	Interview on a new gamma calorimeter
P. González	(production for UV)	Naturaleza cuántica del electrón

SOCIAL MEDIA

The Institute exposure in the social media experienced a boost during 2014. The followers on Twitter and Facebook grew substantially and new Google+ and YouTube profiles were created. We tested for the first time the possibility to record systematically the seminars offered in the Institute, with promising results. We also used our social profiles to announce the events taking place at IFIC (seminars, conferences, colloquia), with a positive response from the public.



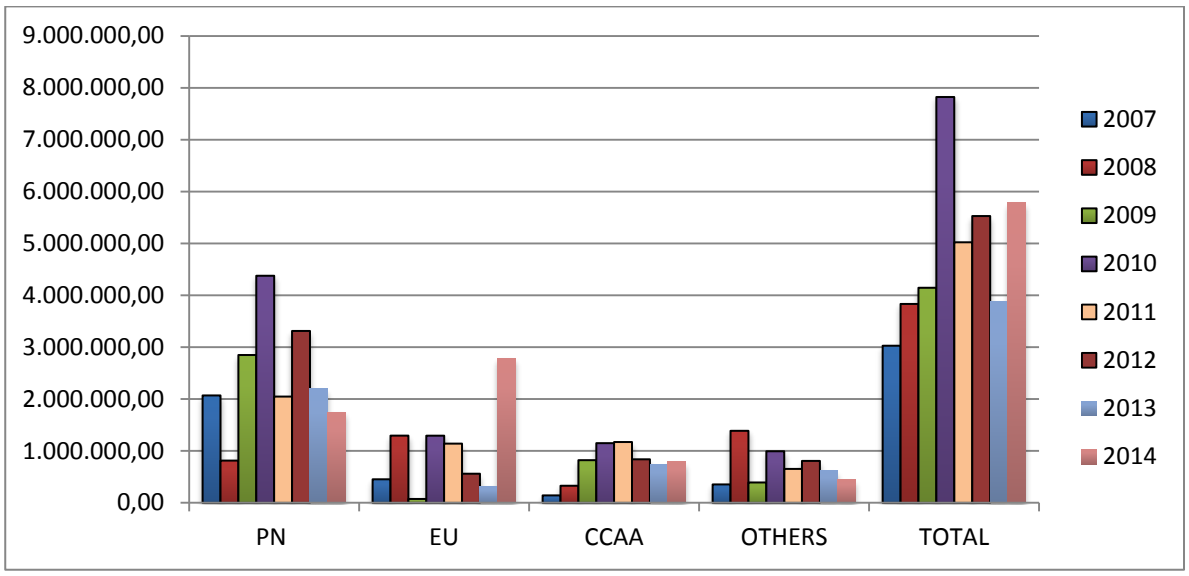
Here follow some figures about the evolution of our social media profiles through 2014:

- Our Facebook page gained 250 likes during 2014, growing from approximately 50 to 300 by the end of the year.
- Our Twitter account experienced a similar growth, getting from 30 in the first days of January to more than 250 by December.
- Our Google+ profile was successfully created and linked to our Google Maps page, allowing monitoring our activity in all Google products through Google My Bussiness. The total number of followers by the end of the year was 27.
- We created a YouTube channel associated to our Google+ page, and we uploaded a few simple outreach content and several seminars recorded by Alberto Aparici and Roberto Lineros. The channel reached 18 subscribers and more than 600 visualisations in less than three months.

Overall, our presence in the social media was significantly increased during the year 2014, and the various initiatives started during this period are liable of substantial growth in the near future.

7. FUNDING

In this section we include all research grants that were active during the whole or part of 2014, funded by European (EU), national (PN), regional (CCAA) or other agencies.



Evolution of IFIC funding by financial agencies (in euros, CONSOLIDER projects excluded)

NATIONAL PLAN PROJECTS

Funded by the *Ministerio de Economía y Competitividad* (MINECO) of the Spanish Government, typically for three years.

Experimental Physics

Image quality and quantification in positron emission tomography
Ref. FPA2010-14891
PI: Magdalena Rafecas López
176,781 € (Jan 2011 – Jul 2014)

High-resolution gamma spectroscopy: the path to AGATA
Ref. FPA2011-29854-C04-02
PI: Andrés Gadea Raga
356,950 € (Jan 2012 – Jun 2015)

The NEXT project: energy and trajectory measurements
Ref. FIS2012-37947-C04-03
PI: José Díaz Medina
119,340 € (Jan 2013 – Dec 2015)

Nuclear structure, applications and astrophysics: the path to FAIR
Ref. FPA2011-24553
PI: Alejandro Algora
644,930 € (Jan 2012 – Dec 2015)

Participation in the T2K experiment
Ref. FPA2011-29823-C02-01
PI: Anselmo Cervera Villanueva
281,325 € (Jan 2012 – Sep 2015)

Contributions to the ATLAS experiment at the Large Hadron Collider
Ref. FPA2012-39055-C02-01
PI: Carmen García García
1,064,700 € (Jan 2013 – Dec 2015)

Participation of IFIC in the ANTARES and KM3NET neutrino telescopes
Ref. FPA2012-37528-C02-01
PI: Juan J. Hernández Rey
237,510 € (Jan 2013 – Dec 2015)

Contributions to the hadronic tile calorimeter of the ATLAS detector
Ref. FPA2012-32843
PI: J. Antonio Valls Ferrer
477,360 € (Jan 2013 – Dec 2015)

Construction of the NEXT experiment at the Canfranc Underground Laboratory
Ref. FIS2012-37947-C04-01
PI: Juan J. Gómez Cadenas
299,520 € (Jan 2013 – Dec 2014)

Development of new detectors and physics studies for future colliders in particle physics
Ref. FPA2013-48387-C6-5-P
PI: Juan Fuster Verdú
229,900 € (Jan 2014 – Dec 2015)

Spanish participation in the LHCb experiment at CERN: physics explotation and upgrade
Ref. FPA2013-48020-C3-2-P
PI: Fernando Martínez Vidal
78,650 € (Jan 2014 – Dec 2015)

Participation in the development of new accelerator technologies for future colliders in particle physics
Ref. FPA2013-47883-C2-1-P
PI: Ángeles Faus Golfe
72,000 € (Jan 2014 – Dec 2015)

Spanish Distributed Tier-2 for the ATLAS experiment (LHC) Phase 3 and its role in the management and processing of big data
Ref. FPA2013-47424-C3-1-R
PI: José Salt Cairols
1,252,350 € (Jan 2014 – Dec 2016)

Theoretical Physics

Particle physics phenomenology at the LHC and flavour factories
Ref. FPA2011-23778
PI: Antonio Pich Zardoya
372,680 € (Jan 2012 – Dec 2015)

Perturbative and non-perturbative studies of the Standard Model and its extensions
Ref. FPA2011-23897
PI: Vicent Giménez Gómez
152,460 € (Jan 2012 – Dec 2015)

Flavour and origin of matter
Ref. FPA2011-29678-C02-01
PI: Pilar Hernández Gamazo
249,260 € (Jan 2012 – Dec 2015)

Astroparticle and high energy physics
Ref. FPA2011-22975
PI: José W. Furtado Valle
258,940 € (Jan 2012 – Dec 2015)

Quantum black holes, supergravity and cosmology
Ref. FIS2011-29813-C02-02
PI: M. Antonia Lledó Barrena
100,430 € (Jan 2012 – Dec 2015)

Fundamental interactions and their experimental implications
Ref. FPA2011-23596
PI: Francisco J. Botella Olcina
450,120 € (Jan 2012 – Dec 2015)

Nuclear and hadron physics at intermediate energies
Ref. FIS2011-28853-C02-01
PI: Manuel Vicente Vacas
212,960 € (Jan 2012 – Dec 2015)

Effective theories in nuclear and hadron physics
Ref. FIS2011-28853-C02-02
PI: Juan M. Nieves Pamplona
163,350 € (Jan 2012 – Dec 2015)

Studies on quantum structure and dynamics of atomic, nuclear and electronic systems
Ref. FIS2011-28617-C02-02
PI: Jesús Navarro Faus
24,200 € (Jan 2012 – Dec 2014)

Hadronic models, fundamental interactions and nuclear physics
Ref. FPA2013-47443-C2-1-P
PI: Pedro González Marhuenda
84,700 € (Jan 2014 – Dec 2016)

CONSOLIDER PROJECTS

Coordinated by IFIC:

Centro nacional de Física de Partículas, Astropartículas y Nuclear (CPAN)
Ref. CSD2007-00042
PI: Antonio Pich Zardoya
10,000,000 € (Oct 2007 – Jun 2015)

Canfranc Underground Physics (CUP)
Ref. CSD2008-00037
PIs: M. Concepción González García (ICC Barcelona) / Juan J. Gómez Cadenas
6,000,000 € (Dec 2008 – Dec 2014)

With participation of IFIC groups:

Physics of the Accelerating Universe (PAU)
Ref. CSD2007-00060
PI: Enrique Fernández Sánchez (IFAE Barcelona)
IFIC PIs: Carlos Peña Garay / Olga Mena Requejo
Oct 2007 – Dec 2014

Multimessenger Approach for Dark Matter Detection (MultiDark)
Ref. CSD2009-00064
PI: Carlos Muñoz (Univ Autónoma Madrid)
IFIC PIs: Juan J. Hernández Rey / José W. Furtado Valle
Dec 2009 – Dec 2015

OTHER NATIONAL PROJECTS

Radiation detectors for medical imaging
Ref. SEIC2010-00020
PI: Magdalena Rafecas López
129,447.59 € (Jun 2011 – Jun 2014)

New instrumentation techniques for monitoring the beam position in the Drive Beam of CLIC
Ref. SEIC2010-00028
PI: Ángeles Faus Golfe
129,447.59 € (Jun 2011 – May 2014)

R&D for linear collider detectors: Ultra-thin vertex and tracking detectors
Ref. SEIC2010-00038
PI: Carlos Lacasta Llácer
129,447.59 € (Jul 2011 – Jun 2014)

Contribution to the design of the SuperB final focus region and related studies
Ref. SEIC2010-00052
PI: Ángeles Faus Golfe
129,447.59 € (Jun 2011 – May 2014)

Development of a trigger system and data adquisition for the tileCal upgrade in ATLAS
Ref. EIC-CERN-2011-0005
PI: J. Antonio Valls Ferrer
125,950 € (Feb 2012 – Jan 2015)

R&D for linear collider detectors: Ultra-thin vertex and tracking detectors
Ref. EIC-CERN-2011-0019
PI: Juan Fuster Verdú
125,950 € (Feb 2012 – Feb 2015)

Development of neutron detectors for nuclear structure, astrophysics and applications
Ref. PRI-PIMNUP-2011-1348
PI: Alejandro Algora
70,000 € (Nov 2011 – Nov 2014)

Development of a trigger system and data adquisition for ATLAS at the SLHC project (CERN)
Ref. AIC-A-2011-0775
PI: Luca Fiorini
128,124.50 € (Dec 2011 – Dec 2014)

Contribution to the total absorption spectrometer of the DESPEC Collaboration at NUSTAR (FAIR)
Ref. AIC-A-2011-0696
PI: Alejandro Algora
225,900 € (Dec 2011 – Jun 2015)

Spanish participation 2011-2012 in particle, astroparticle and nuclear physics experiments
Ref. AIC-B-2011-0640
PI: Antonio Pich Zardoya
3,227,918 € (Aug 2011 – Feb 2015)

Commission for Infrastructures of Particle Physics and Accelerators (network CIFPA)
Ref. FPA2014-52623-REDT
PI: Antonio Pich Zardoya
30,000 € (Dec 2014 – Nov 2015)

Limits of General Relativity
Ref. CSIC i-LINK 0780
PI: Gonzalo Olmo Alba
23,000 € (Jan 2014 – Dec 2014)

Halo collimation and Collimation Wakefiels studies in ATF2
Ref. CSIC i-LINK 0704
PI: Ángeles Faus Golfe
29,800 € (Jan 2014 – Dec 2014)

Outreach activities related to ICHEP 2014
Ref. FCT-13-6889
PI: Juan Fuster Verdú
35,000 € (Sep 2013 – Nov 2014)

ERC PROJECTS

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)

EUROPEAN PROJECTS

Solving Challenges in Nuclear Data (CHANDA)
FP7-EURATOM-FISSION, Ref. 605203
Project Coordinator: Enrique M. González Romero
IFIC PI: José Luis Taín Enríquez
193,992.50 € (Dec 2013 – Nov 2017)

HL-LHC: High Luminosity Large Hadron Collider
FP7 Design Study, Ref. 284404
Project Coordinator: Lucio Rossi
IFIC PI: Ángeles Faus Golfe
162,572.64 € (Nov 2011 – Oct 2015)

Advanced European Infrastructures for Detectors at Accelerators (AIDA)
FP7 Research Infrastructures, Ref. 262025
Project Coordinator: Iván Vila Álvarez
IFIC PI: Marcel A. Vos
127,555 € (Feb 2011 – Jan 2015)

Enhanced European Coordination for Accelerator Research & Development (EuCARD-2)
FP7 Research Infrastructures, Ref. 312453
Project Coordinator: Svetlomir Stavrev
IFIC PI: Ángeles Faus Golfe
20,000 € (May 2013 – Apr 2017)

Design of a pan-European Infrastructure for Large Apparatus studying Grand Unification, Neutrino Astrophysics and Long Baseline Neutrino Oscillations
FP7 Design Study, Ref. 284518
Project Coordinator: André Rubbia
IFIC PI: Juan J. Gómez Cadenas
54,000 € (Sep 2011 – Aug 2014)

Study of Strongly Interacting Matter (HadronPhysics3)
FP7 Research Infrastructures, Ref. 283286
Project Coordinator: Carlo Guaraldo
IFIC PI: Santiago Noguera Puchol
51,000 € (Jan 2012 – Dec 2014)

Integrated Sustainable Pan-European Infrastructure for Researchers in Europe (EGI-InSPIRE)
FP7 Research Infrastructures, Ref. 261323
Project Coordinator: Steven Newhouse
IFIC PI: José Salt Cairols
118,709 € (May 2010 – Apr 2014)

European NoVel Imaging Systems for ION therapy (ENVISION)
FP7 Health, Ref. 241851
Project Coordinator: Manjit Dosanjh
IFIC PI: Carlos Lacasta Llácer
383,140.48 € (Feb 2010 – Jul 2014)

Advanced particle phenomenology in the LHC era (LHCPhenoNet)
FP7 Marie Curie Initial Training Network
Ref. PITN-GA-2010-264564
Project Coordinator: Germán Rodrigo García
505,765.16 € (Jan 2011 – Dec 2014)

European particle Physics Latin American NETwork (EPLANET)
FP7 Marie Curie Int. Research Staff Exchange Scheme
Ref. PIRSES-2009-GA-246806
Project Coordinator: Luciano Maiani
IFIC PI: Antonio Ferrer Soria
104,000 € (Feb 2011 – Jan 2016)

Towards systematization of NNLO theoretical predictions for advanced phenomenology at the LHC (CRUNCHLOOPS)
FP7 Marie Curie Intra-European Fellowship
Ref. PIEF-GA-2011-298582
Fellow: Grigorios Chachamis
IFIC PI: Germán Rodrigo García
168,896,.0 € (Oct 2012 – Sep 2014)

Research Training in 3D Digital Imaging for Cancer Radiation Therapy (ENTERVISION)
FP7 Marie Curie Initial Training Network
Ref. PITN-GA-2010-264552
Project Coordinator: Manjit Dosanjh
IFIC PI: Carlos Lacasta Llácer
243,718 € (Feb 2011 – Jan 2015)

Invisibles: Neutrinos, Dark Matter and Dark Energy Physics
FP7 Marie Curie Initial Training Network
Ref. PITN-GA-2011-289442
Project Coordinator: Belén Gavela
IFIC PI: Pilar Hernández Gamazo
342,307 € (Apr 2012 – Mar 2016)

Multi-leg precision calculations and advanced phenomenology in the LHC era (Multi-leg@LHC)
FP7 Marie Curie Intra-European Fellowship
Ref. PIEF-GA-2011-298960
Fellow: Francisco Campanario Pallás
IFIC PI: Germán Rodrigo García
205,854 € (Mar 2013 – Feb 2015)

CDTI/INNPACTO PROJECTS

INNPACTO project
Ref. IPT-2011-1918-020000
Company: Industrias Jose Tamarit Moreno SL
IFIC PI: Juan J. Hernández Rey
169,784 € (May 2011 – Dec 2014)

REGIONAL PROJECTS

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

From LHC physics to the keys of the primordial Universe in the era of data
Ref. PROMETEOII/2013/017
PI: José Bernabeu Alberola
120,000 € (Jan 2014 – Dec 2014)

Neutrino telescopes in the Mediterranean
Ref. PROMETEOII/2014/079
PI: Juan J. Hernández Rey
61,000 € (Jan 2014 – Dec 2014)

LHC physics: search for new interactions in the high-energy frontier
Ref. PROMETEOII/2013/007
PI: Antonio Pich Zardoya
115,000 € (Jan 2014 – Dec 2014)

Hadronic and nuclear physics
Ref. PROMETEOII/2014/068
PI: Eulogio Oset Báguena
29,000 € (Jan 2014 – Dec 2014)

Astroparticle and high energy physics
Ref. PROMETEOII/2014/084
PI: José W. Furtado Valle
58,000 € (Jan 2014 – Dec 2014)

Perturbative and non-perturbative studies of the Standard Model and its extensions
Ref. PROMETEOII/2014/087
PI: Arcadi Santamaria Luna
12,000 € (Jan 2014 – Dec 2014)

Experimental activity for the studies of nuclear structure with AGATA and its complementary detectors
Ref. PROMETEOII/2014/019
PI: Andrés Gadea Raga
62,000 € (Jan 2014 – Dec 2014)

Experiment ATLAS experiment at RUN 2 of the LHC: alignment and upgrade of the inner detector. Physics of the top quark
Ref. PROMETEOII/2014/016
PI: Salvador Martí García
36,000 € (Jan 2014 – Dec 2014)

Institut Valencià d'Investigació Cooperativa en Física Avançada (IVICFA)
Ref. ISIC/2012/020
PI: José Bernabeu Alberola
60,000 € (Jan 2014 – Dec 2014)

Noninvasive 3D gamma camera
Ref. GV/2013/131
PI: César Domingo Pardo
5,880 € (Jan 2014 – Dec 2014)

Hyperpure germanium detector
Ref. PPC/2014/007
PI: José Díaz Medina
45,900 € (Jan 2014 – Dec 2014)

Flavour and origin of matter
Ref. PROMETEOII/2014/050
PI: Nuria Rius Dionís
59,000 € (Jan 2014 – Dec 2014)

Quark structure of matter
Ref. PROMETEOII/2014/066
PI: Santiago Noguera Puchol
20,000 € (Jan 2014 – Dec 2014)

Theoretical and experimental approach to the search for new physics with heavy flavours in the LHC era and other B factories
Ref. PROMETEOII/2014/049
PI: Francisco J. Botella Olcina
75,000 € (Jan 2014 – Dec 2014)

Participation of IFIC in the ANTARES and KM3NET neutrino telescopes
Ref. ACOMP/2014/287
PI: Juan J. Hernández Rey
9,600 € (Jan 2014 – Dec 2014)

Conference ICHEP 2014
Ref. AORG/2014/013
PI: Juan Fuster Verdú
12,000 € (Jan 2014 – Dec 2014)

Development of detectors for Compton telescopes
Ref. GV/2013/133
PI: Gabriela Llosá Llácer
6,000 € (Jan 2014 – Dec 2014)

Activities related to the 60th anniversary of CERN
Ref. PPC/2014/008
PI: Juan J. Hernández Rey
7,980 € (Jan 2014 – Dec 2014)