IFAE

Institut
de Física
d'Altes
Energies

Report
of Activities
2014

Institució CERCA
Centres de Recerca de Catalunya

EXCELENCIA
SEVERO
OCHOA

IFAE

Institut
de Física
d'Altes
Energies

Report
of Activities
2014

CONTENTS

I PRESENTACIÓ

L'IFAE és un consorci entre la Generalitat de Catalunya i la Universitat Autònoma de Barcelona (UAB). El consorci va ser creat el 16 de juliol de 1991 pel decret 159/1991 del Govern de la Generalitat. Com a tal consorci, l'IFAE és una entitat legal amb personalitat jurídica pròpia. A partir de 2011 la relació formal amb la Generalitat s'ha portat a terme a través del Departament d'Economia i Coneixement.

L'IFAE està estructurat en dues divisions, experimental i teòrica, a més d'una divisió tècnica. Col·laboren amb el personal propi de l'IFAE els Grups de Física Teòrica i de Física d'Altes Energies del Departament de Física de la UAB. Nou científics d'ICREA contribueixen de forma important a les activitats de l'Institut.

Aquest informe anual d'activitats es distribueix internacionalment i, per tant, està escrit en anglès.

DIVISIÓ EXPERIMENTAL

Durant 2014 la Divisió Experimental va treballar en nou línies de recerca, la majoria de les quals són activitats a llarg termini. Aquests línies comprenen els camps de la Física d'Altes Energies, l'Astrofísica i la Cosmologia Observacional, i inclouen el desenvolupament de detectors per a imatges mèdiques i projectes d'instrumentació relacionats.

ATLAS, AL LARGE HADRON COLLIDER (LHC) DEL CERN

Al 2014 es va acabar l'anàlisi de la majoria de les dades de 2012, que van proporcionar una millora en la mesura de les propietats del bosó de Higgs, a més de límits més estrictes en la busca de física més enllà del Model Estàndard. Les obres de millora de l'LHC estan a punt de concloure, de tal manera que durant el més de juny de 2015 s'esperen les primeres col·lisions a la nova energia rècord de 13 TeV en el centre de masses, la qual cosa obrirà la possibilitat de noves descobertes.

Hem continuat les millores al detector ATLAS, tot preparant la gran renovació que tindrà lloc al final d'aquesta dècada. El grup de l'IFAE està desenvolupant un detector de semiconductors amb píxels, per a reconstruir les partícules carregades a la regió central i també a angles molt petits. El grup de l'IFAE ha fet contribucions crítiques a l'Insertable B-Layer (IBL) d'ATLAS, que inclou la primera aplicació de píxels 3D a un experiment de física d'altes energies i va ser instal·lat durant el 2014.

LA DIVISIÓ EXPERIMENTAL D'IFAE COMPRÈN ELS CAMPS DE LA FÍSICA D'ALTES ENERGIES, L'ASTROFÍSICA I LA COSMOLOGIA OBSERVACIONAL, I INCLOU EL DESENVOLUPAMENT DE DETECTORS AMB APLICACIONS MÈDIQUES, I ALTRES CAMPS CIENTÍFICS I INDUSTRIALS

T2K, UN EXPERIMENT AMB NEUTRINS A JAPÓ

Al 2012, després de recuperar-se del terrible terratrèmol de 2011, T2K va confirmar els seus resultats anteriors sobre la transformació de neutrins del muó en neutrins de l'electró. A més, al 2013 T2K va publicar les mesures més precises sobre la desaparició dels neutrins muònics. Al maig de 2014, T2K va començar a prendre dades amb un feix d'anti-neutrins. Els primers resultats s'esperen a l'estiu de 2015 i seran els més precisos del món en aquest canal.

MAGIC, AL ROQUE DE LOS MUCHACHOS (LA PALMA, CANÀRIES)

MAGIC utilitza un sistema estereoscòpic de dos telescopis de 17 m de diàmetre, millorat recentment. Al 2014 MAGIC va registrar la flamarada de raigs gamma més ràpida mai vista, la qual cosa va resultar en un publicació a la revista Science. A més, l'IFAE va liderar els esforços per a instal·lar un nou disparador topòlogic que permet de reduir el llindar d'energia de l'experiment i també nous filtres UV per a l'observació de la lluna, amb la idea de mesurar el quocient còsmic positró/electró, una recerca de gran interès ara mateix.

CTA (CHERENKOV TELESCOPE ARRAY)

CTA, una col·laboració que abarca tot el món i que construirà dos observatoris, als hemisferis Nord i Sud, està ja en una fase avançada de disseny i de fabricació de prototips. IFAE està involucrat en aspectes cabdals d'aquest projecte, tant a nivell tècnic com de gestió, i particularment en el disseny i prototipatge dels telescopis més grans. Espanya és el candidat líder per a albergar l'observatori nord de CTA, a l'illa de La Palma.

LA COL·LABORACIÓ DES (DARK ENERGY SURVEY), AL TELESCOPI BLANCO A CERRO TOLOLO (XILE)

DES va completar al 2014 la primera de les seves cinc temporades d'observació, que portaran a la mesura de la posició, desplaçament al roig i forma de prop de 300 milions de galàxies a l'hemisferi sud. Els primers resultats del període de verificació científica de 2012/13 es van publicar al 2014, i el primer article científic de DES va ser liderat des de l'IFAE.

PAU (PHYSICS OF THE ACCELERATING UNIVERSE)

PAU és una col·laboració espanyola coordinada per l'IFAE i finançada amb un projecte Consolider. PAU instal·larà una càmera, construïda a l'IFAE, al Telescopi William Herschel (WHT) a La Palma, Canàries, i farà un cartografiat amb mesures fotomètriques molt precises del desplaçament al roig, per tal de mesurar paràmetres de l'energia fosca. La càmera es va acabar de construir al 2014 i, després de ser testejada extensivament a l'IFAE, s'instal·larà al WHT al juny de 2015.

PROJECTES DE FÍSICA APLICADA

El grup de l'IFAE d'Imatges Mèdiques ha desenvolupat una tècnica nova de Tomografia amb Emissió de Positrons (PET) amb el finançament d'una Advanced Grant de l'ERC. El concepte es basa en un detector de CdTe amb segmentació tridimensional molt fina, que es llegeix amb un ASIC dissenyat a l'IFAE. Al 2014 es van produir els primers xips de VIP, els tests dels qual van demostrar que eren totalment operacionals. A més, el grup va començar una nova iniciativa (ERICA) en el camp de la detecció de línies de raigs X, amb aplicacions al control de qualitat i la seguretat. Algunes de les activitats d'aquest grup es duen a terme en col·laboració amb l'empresa spin-off de l'IFAE X-Ray Imatek.

Dos nous projectes d'instrumentació que es van posar en marxa al 2013, un sobre detecció en un gas amb amplificació a microestructures, col·laborant amb el Centre Nacional de Microelectrònica de Barcelona, i l'altre per a desenvolupar un fotodetector amb grafè, amb l'Institut Català de Fotònica, van produir els seus primers resultats al 2014.

DIVISIÓ TEÒRICA

Durant el 2014, la Divisió Teòrica va seguir tres línies d'investigació: Física del Model Estàndard, Física més allà del Model Estàndard, i Astrofísica i Cosmologia.

FÍSICA DEL MODEL ESTÀNDARD

Els temes principals investigats pel grup de física del Model Estàndard al 2014 han estat les desintegracions hadròniques del leptó τ, arribant a un nou conjunt de determinacions d'α_S; desintegracions semi-leptòniques del bosó B, amb implicacions per a física més enllà del Model Estàndard; i un estudi del comportament a ordres superiors de la QCD perturbativa.

LA DIVISIÓ TEORICA D'IFAE SEGUEIX TRES LÍNIES D'INVESTIGACIÓ: FÍSICA DEL MODEL ESTÀNDARD, FÍSICA MÉS ALLÀ DEL MODEL ESTÀNDARD, I ASTROFÍSICA I COSMOLOGIA

FÍSICA MÉS ENLLÀ DEL MODEL ESTÀNDARD

El grup teòric de l'IFAE que es dedica a la Física Més Enllà del Model Estàndard (BSM) continua estudiant les dades experimentals sobre el bosó de Higgs per tal de treure'n les possibles conseqüències per al Model Estàndard o més allà. Entre els temes destaquen els límits sobre els acoblaments del Higgs obtinguts fent servir la tècnica del grup de renormalització; estudis de producció del Higgs fora de la capa de masses; una cura per a les aparents divergències infraroges en el potencial de Higgs; i les conseqüències per a teories supersimètriques. Una línia de recerca diferent va identificar per què moltes dimensions anòmales en teories de camp efectives amb operadors de dimensió superior són zero a un "loop".

ASTROFÍSICA I COSMOLOGIA

L'astrofísica de partícules i la cosmologia són camps de recerca relativament nous, a la intersecció entre la física de partícules, l'astrofísica i la cosmologia. L'objectiu és aprofitar el nostre coneixement dels fenòmens astrofísics i cosmològics per tal de trobar respostes a problemes fonamentals de física, i vice-versa. Al 2014, els membres de la divisió teòrica de l'IFAE en aquesta àrea han continuat investigant els temes següents: bario-gènesi, dilatons naturalment lleugers i la seva relació amb el problema de la constant cosmològica, i aplicacions de la dualitat gravetat/teories gauge a problemes de matèria condensada.

1. ABOUT **IFAE**

1.1 STRUCTURE

The Institut de Física d'Altes Energies (IFAE) is a consortium of the Generalitat de Catalunya and the Universitat Autònoma de Barcelona (UAB). It was formally created on July 16, 1991, by Act number 159/1991 of the Government of Catalonia (Generalitat de Catalunya). As a consortium, the IFAE is an independent legal entity. Since 2011, it operates under the auspices of the Department of Economy and Knowledge (Departament d'Economia i Coneixement, DECO), of the Generalitat.

The governing bodies of the Institute are the Governing Board (Consell de Govern) and the Director. The general lines of activity, the hiring of personnel, the annual budget and the creation and suppression of Divisions are among the responsibilities of the Governing Board, which also appoints the Director from a list of candidates nominated by the Rector of UAB. The Director is responsible for the execution of the decisions of the Governing Board. Additional management personnel, such as the directors of the several divisions, are nominated by the Director.

THE INSTITUT DE FÍSICA D'ALTES ENERGIES (IFAE) IS A CONSORTIUM OF THE GENERALITAT DE CATALUNYA AND THE UNIVERSITAT AUTÒNOMA DE BARCELONA (UAB). IT WAS FORMALLY CREATED ON JULY 16, 1991

IFAE enjoys a close collaboration with the Theoretical and Experimental High Energy Physics Groups of the Department of Physics of the UAB. In addition, since the creation of ICREA, several investigators from this prestigious research institution have joined IFAE. As of the end of 2014, this component of the Institute consists of nine ICREA research professors, with continuing tenure.

Personnel of the Departments of Structure and Fundamental Constituents of Matter and of Fundamental Physics of Universitat de Barcelona (UB) were also members of IFAE, under the terms of an agreement between the Institute and UB established in 1992. This agreement was modified in 2003. Under the new terms, the cooperation between IFAE and the UB is focused on specific goal-oriented projects.

IFAE is structured in two divisions, experimental and theoretical, as well as a technical division. The theory division faculty is composed of five ICREA research professors and a Ramón y Cajal fellow. They share physical and human resources (postdocs and students) with the personnel from UAB. The personnel of the experimental division are mostly from IFAE itself, but it includes four research professors from ICREA. It collaborates with four UAB professors. The technical division includes a variable number of engineers and technicians.

IFAE also has the status of a "University Institute" attached to UAB. This formula allows the personnel of IFAE to participate in the educational programme of UAB, in particular by teaching Master courses in the Master in High Energy Physics, Astrophysics and Cosmology.

1.2 IFAE GOALS AND BRIEF HISTORY

As stated in the foundational Act 159/1991 of the Generalitat, the goal of IFAE is to carry out research and to contribute to the development of High Energy Physiscs from a theoretical, experimental and technological point of view. The origins of the consortium lie in the Department of Theoretical Physics and in the Laboratory for High Energy Physics (LFAE) of UAB. The theoretical group was established in 1971, soon after the university was founded. The Laboratory for High Energy Physics was created in 1984, in order to start research in experimental high-energy physics at UAB, particularly to effectively use the CERN laboratory, after Spain rejoined CERN in 1982. As mentioned in Act 159/1991, the existence of LFAE and of theoretical research groups in Catalonia, the desire to strengthen research in High Energy Physics, particularly in the experimental side, and the desire to collaborate in the Spanish Government's effort to develop this field, led the authorities of the Generalitat to create IFAE. In the following years the experimental division of IFAE grew from a staff of 10 to its present strength of about 85. The experimental program has expanded both in the number of projects and in their scope. In 1991 the division was involved in just one experiment in high-energy particle physics, ALEPH at LEP, while at present there are nine projects belonging to three main lines of fundamental research:

particle physics at high energy accelerators, gamma-ray astrophysics, and observational cosmology. In addition, there is a small but very active line of applied physics, devoted to novel techniques in medical imaging.

The theory division also expanded its research program since IFAE was created. There are at present three main lines of research: Standard Model physics, Beyond the Standard Model, and Astroparticles/Cosmology.

An additional important development took place in 2003, driven by the strongly perceived need for remote handling of vast quantities of scientific data, not only for high-energy physics experiments but also for astrophysical facilities such as MAGIC. In 2003 three Spanish institutions, UAB, CIEMAT in Madrid and the Departament d'Universitats Recerca i Societat de la Informació (DURSI, now DECO) of the Government of Catalonia, together with IFAE, jointly founded the Port of Scientific Information (PIC). This center is a focal point of the global computing grid for scientific projects requiring the processing of large amounts of data. PIC was chosen by the Spanish Ministry of Science and Education as a Tier-1 center for LHC computing. IFAE was charged by the other partner institutions with the administration of PIC. There is a very close collaboration with PIC on computational aspects of all IFAE experiments that are producing data or will do so in the near future. The scientific activities of PIC are described in its own reports.

It is worth emphasizing that, as an independent legal entity, IFAE can manage its own projects as well as certain external ones. These management activities have been a very visible contribution of IFAE to the development of Spanish scientific infrastructures, which might not have been possible otherwise. The most important among these activities are briefly recalled next.

From 1995 to 2001 the Synchrotron Light Laboratory of Barcelona (LLS) was administratively part of IFAE. The LLS was the organization that proposed and prepared the construction of ALBA, the Synchrotron Light Laboratory.

IFAE was responsible for the construction of the building that services the MAGIC telescopes at the Roque de los Muchachos site in the island of La Palma. IFAE also manages the maintenance and operation funds of the MAGIC collaboration.

From 1999 to 2004 IFAE managed the contract between CERN and a Spanish company for the construction of the vacuum vessels of the ATLAS Barrel Toroid. This very large project had a cost of about 3 million euro distributed over several years.

In 200t, the observational cosmology group of IFAE and others proposed the PAU (Physics of the Accelerating Universe) initiative, which was approved as a Consolider-Ingenio 2010 project. IFAE leads the PAU collaboration, comprised of several Spanish groups. The goal of this initiative is to survey a fraction of the Northern sky in order to measure parameters of cosmological interest by means of novel observational tools.

IN 2012 IFAE WAS GRANTED THE SEVERO OCHOA PRIZE, A DISTINCTION GIVEN BY THE SPANISH STATE TO THE BEST RESEARCH INSTITUTES IN THE COUNTRY

Since the past decade, the relationship between IFAE and the Generalitat of Catalonia is regulated under a Contract-Program, which codifies the support of the Institute from the Generalitat and the corresponding obligations of IFAE. Based on a strategic plan, the Contract-Program specifies the envisaged growth of the Institute's personnel and funding. The scientific and academic goals are specified in a set of numerical indicators, which are reported on a yearly basis. The past Contract-Program covered the period from 2007 to 2012 included. Since 2012, because of the current economic uncertainties, it is being extended one year at a time.

Finally, in 2012 IFAE was granted the Severo Ochoa prize, a distinction given by the Spanish state to the best research institutes in the country. The prize carries funding of 1 M€ a year for 4 years and is strengthening IFAE's activities and its capabilities to obtain additional funding. Manel Martínez is the scientific director of the Severo Ochoa award.

1.3 IFAE GOVERNANCE IN 2014

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ADJUNCT DIRECTOR

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ICREA Research Professor, IFAE

2. SCIENTIFIC **ACTIVITIES IN 2014**

2.1 OUTLINE

EXPERIMENTAL DIVISION

During 2014 the Experimental Division's activities focused on nine main projects, most of them long-term efforts. These projects span the fields of High Energy Physics, Astrophysics and Cosmology, and include the development of detectors for Medical Imaging applications as well as related instrumentation projects.

HIGH ENERGY PHYSICS

High Energy Physics is represented by three major, long-term projects:

1. ATLAS, at the Large Hadron Collider (LHC) of CERN. In 2014 most analyses of 2012 data were finished, leading to improved measurements of the Higgs boson properties, as well as stringent limits in the searches for physics beyond the Standard Model. At this time the LHC upgrade is about to be completed, and collisions at the higher center-of-mass energy of 13 TeV are expected to start in June 2015. This broader energy range will open the possibility of new discoveries.

2. The ATLAS upgrade, in preparation for a major renewal of the detector to take place at the end of this decade. Here the IFAE group focuses on pixelated semiconductor detectors for tracking in the central and very forward regions. The IFAE group has made critical contributions to the ATLAS Insertable B-Layer (IBL), which includes the first application of 3D pixels to a high-energy physics experiment and was successfully installed and commissioned in 2014.

3. T2K, a neutrino long base-line experiment in Japan. In 2012, after recovering from the devastating earthquake of 2011, T2K confirmed the earlier results on the oscillation of muon into electron neutrinos. In addition, T2K published in 2013 the most precise measurements to-date of muon neutrino disappearance parameters. In May 2014, T2K started a new run with anti-neutrinos. First results, expected in summer 2015, will be the world's more precise for this channel.

ASTROPHYSICS

IFAE's Astrophysics activities are centered on ground-based detection of very high-energy gamma rays from astrophysical and cosmological sources.

4. MAGIC, located on the Roque de los Muchachos on the Canary Island of La Palma, operates a recently upgraded stereoscopic system of two 17m diameter telescopes. In 2014 MAGIC recorded the fastest gamma-ray flare seen to date, resulting in a publication in Sciece, led by IFAE. Furthermore, IFAE led the efforts to install a new topogical trigger to lower the energy threshold and to install new UV filters for moon observation and the measurement of the cosmic positron/electron ratio, a topic of great current interest.

THE ACTIVITIES OF THE EXPERIMENTAL DIVISION FOCUS ON NINE MAIN PROJECTS THAT SPAN THE FIELDS OF HIGH ENERGY PHYSICS, ASTROPHYSICS AND COSMOLOGY, AND INCLUDE THE DEVELOPMENT OF DETECTORS WITH APPLICATIONS IN MEDICAL IMAGING, HIGH-ENERGY PHYSICS AND OTHER SCIENTIFIC OR INDUSTRIAL FIELDS

5. CTA, a worldwide collaboration that will build two multi-telescope observatories, in the Northern and Southern hemispheres, is now in an advanced design and prototyping phase. IFAE is involved in major aspects of this project, at the technical and the top management levels, and in particular in the design and prototyping for the largest telescopes in CTA. Spain is the leading candidate to host the CTA North observatory, in the Canary island of La Palma.

OBSERVATIONAL COSMOLOGY

The Observational Cosmology program at IFAE began by joining an existing project, DES. In 2007 a new project, PAU, was launched.

6. The DES (Dark Energy Survey) collaboration at the Blanco telescope in Cerro Tololo (Chile) successfully completed in 2014 its first of five seasons,

which will lead to the measurement of position, redshift and shape for about 300 million galaxies in the southern sky. The first results from the Science Verification season in 2012/13 became available in 2014, with the first DES science paper being led by IFAE.

7. PAU (Physics of the Accelerating Universe) is an IFAE-led Spanish collaboration funded by a Consolider-Ingenio 2010 project. It will install its own custom-built camera at the William Herschel Telescope (WHT) at La Palma, in the Canary Islands. PAU will carry out a very precise photometric redshift survey in order to measure dark energy parameters. The construction of the camera was finished in 2014, and, after being extensively tested at IFAE, the camera will be installed at the WHT in June 2015.

APPLIED PHYSICS

The focus of the applied physics research at IFAE is to develop sensor technologies with applications in medical imaging, high-energy physics and other scientific or industrial fields.

8. The Medical Imaging group has developed a novel approach to Positron Emission Tomography, funded by an ERC Advanced Grant. The approach is based on a finely pixelized CdTe detector read out by a 100-channel ASIC designed at IFAE. 2014 saw the production of the first VIP chips, with tests showing them to be fully operational. Furthermore, the group started a new initiative (ERICA) in the field of X-ray line detection with quality control and security applications.

Some of the activities of this group are carried out in collaboration with IFAE's spinoff company X-Ray Imatek.

9. Two new instrumentation projects initiated in 2013, one using a gaseous micro-pattern detector, in collaboration with the Barcelona Institute of Microelectronics, and the other to develop a graphene photodector, with ICFO, the Catalan Photonics Institute, produced their first results in 2014.

THE THEORY DIVISION

The activities of the Theory Division during 2014 continued along three lines: Standard Model Physics, Beyond the Standard Model and Astroparticles/Cosmology.

1. STANDARD MODEL PHYSICS

The main research themes pursued in the Standard Model (SM) group of the IFAE theory division during 2014 were hadronic decays of the τ lepton, leading to a new set of determinations of α_S; semi-leptonic decays of the B meson, with implications for Beyond the Standard Model (BSM) physics; development of Monte Carlo generators for background processes to BSM signatures; and the behavior of higher orders in QCD perturbation theory.

THE ACTIVITIES OF THE THEORY DIVISION FOCUS ON THREE LINES: STANDARD MODEL PHYSICS, BEYOND THE STANDARD MODEL AND ASTROPARTICLES & COSMOLOGY

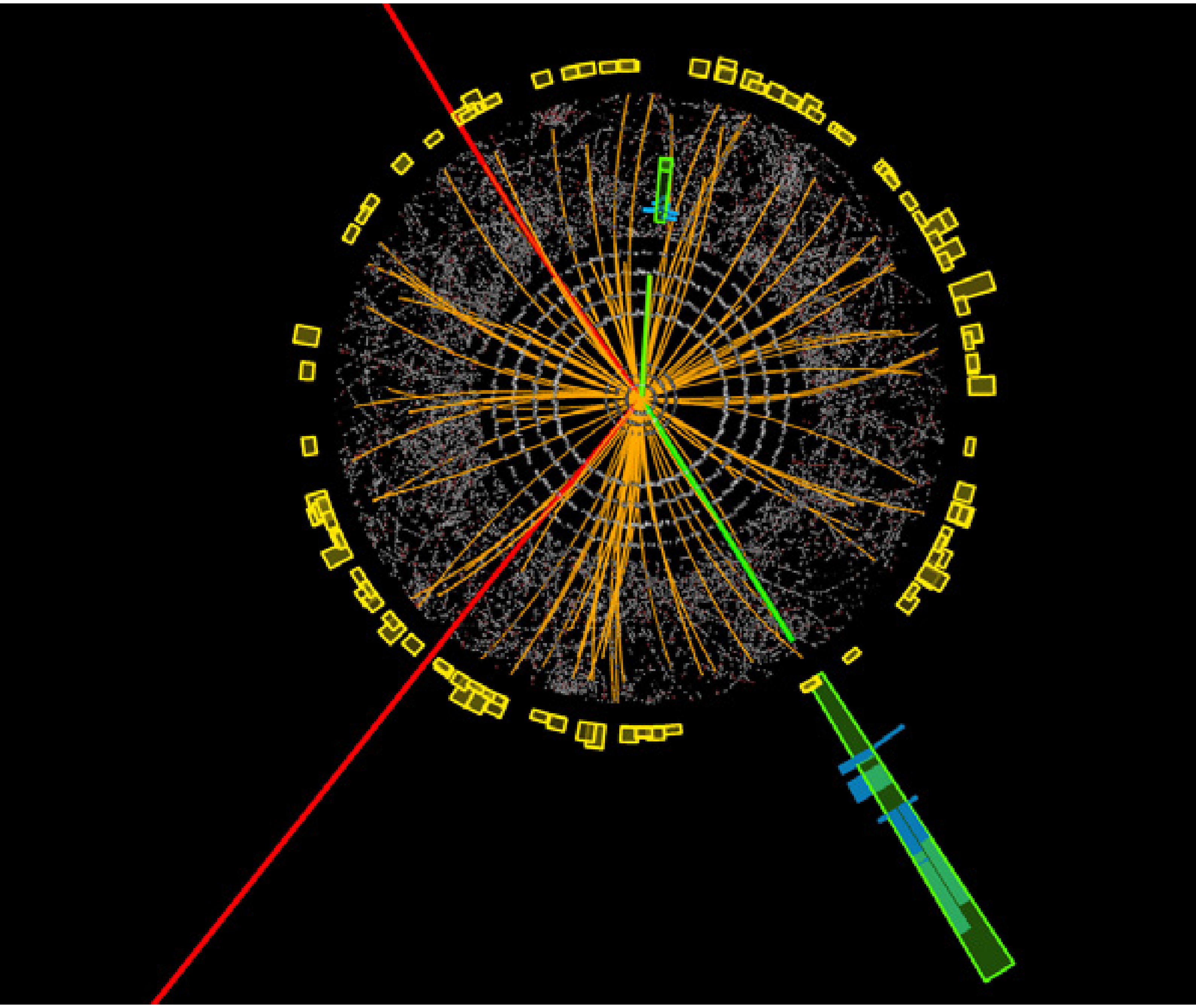
2. BEYOND THE STANDARD MODEL

IFAE's Beyond the Standard Model (BSM) theory group continued studying the experimental data on the Higgs boson to extract possible implications for SM and BSM physics. Topics include renormalization-group improved constraints on Higgs couplings; studies of off-shell Higgs production; a cure for the apparent infrared divergences in the Higgs potential; and consequences for supersymmetric models. A different research line identified why many anomalous dimensions in effective field theories with higher-dimensional operators vanish at the one-loop level.

3. ASTROPARTICLES/COSMOLOGY

Astroparticle physics and particle cosmology are recent fields of research at the intersection between particle physics, astrophysics and cosmology. The goal is to exploit our knowledge of astrophysical and cosmological phenomena to answer fundamental physics questions, and vice-versa. During 2014, the members of the Theory Division from this research area focused their work on the following topics: baryogenesis, naturally light dilatons and their relationship to the cosmological constant problem, and applications of the gauge/gravity correspondence to condensed matter problems.

I EXPERIMENTAL DIVISION



2.1 ATLAS AT THE CERN LHC

MARIO MARTÍNEZ

Since 1993, the IFAE group has given major contributions to the construction of the ATLAS apparatus, its trigger system, its physics reconstruction software and preparatory physics studies. During the last four years, with the arrival of the LHC Run I data, the IFAE group has carried out a strong physics program.

INTRODUCTION

In 2014 the LHC entered the second year of machine shutdown and continued the planned work on consolidation with the aim to come back on 2015 with an improved setup and increased center-of-mass energy in the collisions of 13 – 14 TeV. The IFAE group in ATLAS also continued the involvement in the TileCal and trigger operations and consolidation work. In addition, significant work has been made already on upgrade-related activities in both systems. In the physics analysis front, the group maintained the leadership in the different analyses. The group has been also very visible in important management positions. In the following sections, some details are given on the different activities of the group.

Fig. 1: J. Montejo testing the Tile calorimeter front-end electronics on the ATLAS detector.

IN 2014 THE IFAE ATLAS GROUP CONTRIBUTED TO THE TILE CALORIMETER MAINTENANCE, CALIBRATION AND TO THE PREPARATION TO THE RUN II DATA TAKING

TILECAL OPERATIONS & UPGRADE

In 2014, the IFAE group contributed most strongly to the Tile calorimeter maintenance, calibration and to the preparation to the Run II data taking. In particular, IFAE students worked on the repairs of the calorimeter read-out electronics in the experimental cavern (shown on Fig. 1) and played the leading roles in the analysis of the calibration data taken in 2014. In addition, IFAE postdoc, A. González, served in the demanding duty of Tile Deputy Run Coordinator.

In 2014, the group continued an effort in the calorimeter upgrade towards ever increasing luminosity delivered by the LHC. IFAE engineer, F. Grañena, has produced the second version of a new mechanical structure, known as “mini-drawers”, for the Tile demonstrator project. The demonstrator project will test various solutions of the upgraded read-out of the ATLAS calorimeters. In particular, F. Grañena had completely redesigned the mechanical structure that hosts the Tile Calorimeter front-end read-out electronics, providing for increased reliability and improving the access conditions. An assembly of the first prototype delivered from IFAE to CERN is shown in Fig. 2. Several mechanical modules will be delivered in 2015 for beam tests and for installation in the operating ATLAS detector

The IFAE group maintains its commitment to full support of the TileCal “Minimum Bias” data calibration system. The system is based on the components developed exclusively at IFAE and serves to monitor on a daily basis the stability of the Tile calorimeter response in time and, together with other luminosity monitors of ATLAS, to measure the luminosity delivered to the ATLAS detector by the LHC. I. Korolkov has redesigned one of the key components of the system, the integrator, to cope with 10 times higher machine luminosity. About 100 Tile channels in the gap region of the detector were equipped with newly redesigned integrators to test their performance during the LHC Run II. IFAE PhD student, C.Fischer, had obtained ATLAS authorship for developing a highly automatized analysis framework of the data obtained by the system and aimed at quantifying the effect of the irradiation on the optical components of the Tile calorimeter. The Run I results indicate detectable loss in the optics of the calorimeter, as shown in Fig. 3, as a function of the electrical charge collected by the "Minimum Bias" data calibration system in 2012.

TRIGGER OPERATIONS, PERFORMANCE & UPGRADE

During the Run I period, the IFAE group held responsibilities in the ATLAS High Level Trigger (HLT) system, software-based 2nd (L2) and 3rd level triggers running in two large computer farms. IFAE played an important role in the τ and jet trigger signatures groups, in the overall coordination of trigger operations, in the coordination of the trigger menu and signatures group, in the commissioning of the infrastructure software, and in the integration of trigger algorithms, altogether helping to achieve excellent trigger efficiency.

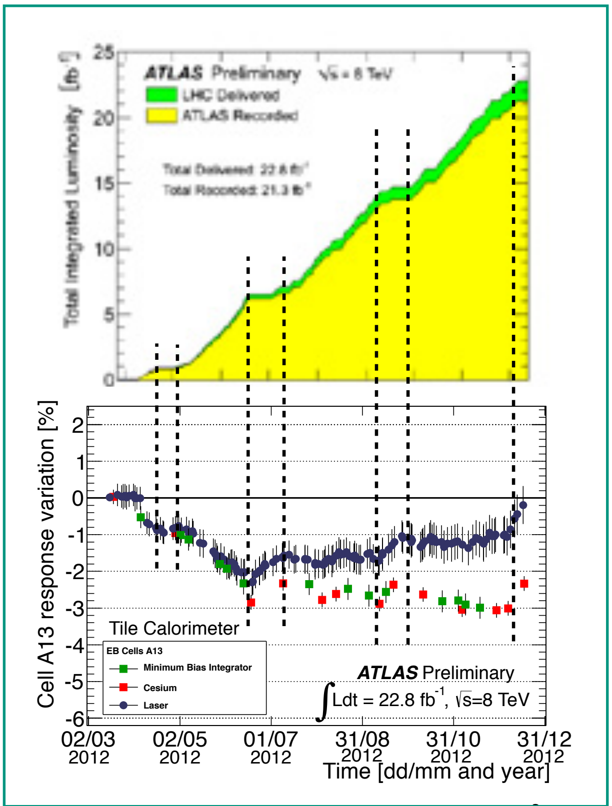


Fig. 3: (top) ATLAS total integrated luminosity profile. (bottom) Loss of the light yield in TileCal cells as a function of time seen by various Tile monitors in 2012.

Fig. 2: Mounting front-end electronics on the mechanical structure build at IFAE

After the Run I, the τ trigger activity focused on the measurement of the data-driven τ+MET trigger efficiencies (M. Bosman, M.P. Casado, Ll. Mir, I. Riu). A tag-and-probe method using a selection of leptonic top-(anti)top data events on the $\tau+\mu$ channel was used. Scale factors of data over Monte Carlo efficiencies have been provided as a function of the tau p_T (shown in Fig. 4) and MET. They have been used in the search for charged Higgs bosons in the τ +jets final state.

In order to cope with the challenging LHC conditions expected for Run II and beyond, the ATLAS trigger system has undergone an extensive upgrade during the shutdown. In particular a new Level-1 (L1) topological processor (L1Topo) has been installed and is currently being commissioned. The L1Topo processor will perform real-time event selection based on topological variables defined between trigger objects from the L1 muon and calorimeters trigger systems. Requirements on variables such as invariant masses or angular differences will allow to maintain relatively high trigger efficiency for key physics process involving W, Z and Higgs bosons. The physics performance studies published in the TDAQ Upgrade Phase I Technical Design Review in 2013 were performed by IFAE. In 2014, IFAE has taken a leading role in the simulation of the processor for both online and offline systems. In particular, IFAE is responsible of the simulation of all the L1To-

IN ORDER TO COPE WITH THE CHALLENGING LHC CONDITIONS EXPECTED FOR RUN II AND BEYOND, THE ATLAS TRIGGER SYSTEM HAS UNDERGONE AN EXTENSIVE UPGRADE DURING THE SHUTDOWN. IFAE HAS TAKEN A LEADING ROLE IN THE SIMULATION OF THE PROCESSOR FOR BOTH ONLINE AND OFFLINE SYSTEMS.

po algorithms for Run II (V. Sorín) and is participating in the validation of this simulation for processes involving jets as well as in the commissioning of the system, which involves the validation against the hardware trigger decision (Ll. Mir, I. Riu).

Since the arrival of postdoc N. Anjos in 2014, IFAE is also contributing in the jet trigger algorithms software upgrade for Run II. In particular, IFAE has taken the responsibility of the development of the jet cleaning infrastructure code, necessary to control sudden increases of events rate due to noise in the calorimeters, as well as the jet calibration code, which should improve the jet rejection. The jet calibration in the trigger closely follows what is done offline and is performed in various steps: pile-up suppression uses the jet area and event energy density to remove the low energy contributions from the soft underlying event; and the jet energy scale is corrected by jet p_T and eta dependent Monte Carlo extracted corrections. IFAE has configured the offline code to run online and to use the latest correction factors. IFAE also provides support to the jet trigger users.

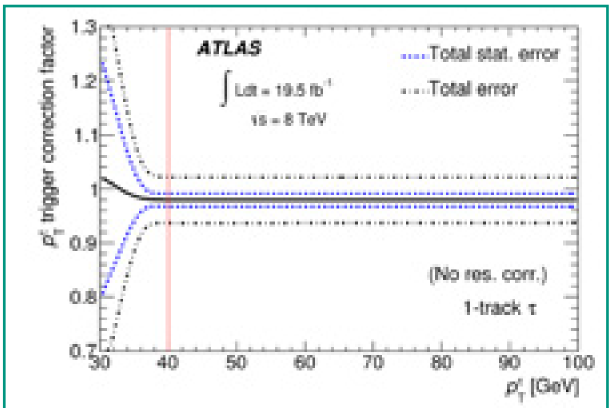


Fig. 4: Inclusive hadronic tau trigger data to simulation correction factors for one-prong tau candidates as a function of the tau transverse momentum. Published in JHEP03 (2015) 088.

PHYSICS ANALYSES

IFAE continued to play a leading role in several physics research lines including the study of the recently discovered Higgs boson (both ZH and ttH channels), the search for super-symmetry (SUSY), extra spatial dimensions, dark matter, and new phenomena in top-quark final states. The team focused on the completion of the Run I physics program, while playing already a leading role in the preparatory work for early Run II analyses. Altogether, this translated into five PhD theses completed in 2014-2015. In the following, we present some results recently obtained.

SEARCH FOR NEW PHENOMENA IN JET+X

The IFAE team continued to be a driving force in monojet analyses in ATLAS at √s= 8 TeV, with postdoc A. Cortés and J. Abdallah (former IFAE postdoc) being the contact persons of the monojet analyses in the ATLAS SUSY and Exotics working groups, respectively.

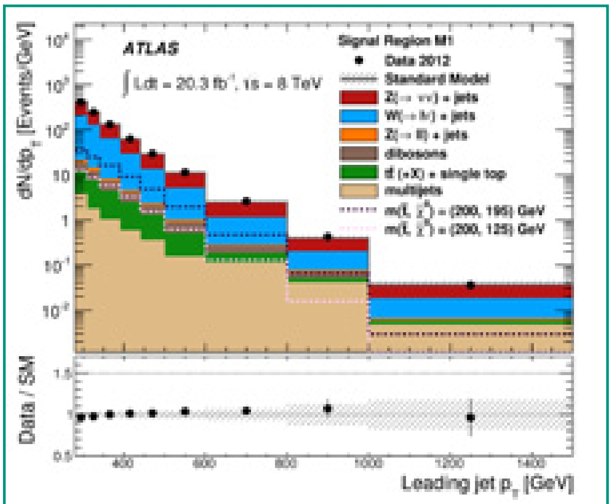


Fig. 5: Measured leading jet pT in monojet final states compared with background predictions. Published in Phys. Rev. D90, 052008 (2014).

In 2014, the team concluded the Run I search for SUSY in compressed scenarios, for which the presence of an energetic jet from initial-state radiation plays a central role in selecting the SUSY signal, leading to monojet-like events (see Fig. 5). The results were published in Phys. Rev. D90, 052008 (2014), with M. Martínez acting as corresponding editor.

In scenarios with very massive (above 1-2 TeV) gluinos and first- and second-generation squarks, much attention has been put on the search for third-generation squarks. This is strongly motivated by the opportunity to address the hierarchy problem which in SUSY involves at least the presence of loop contributions from light stops (with mass below 1 TeV). The monojet results were interpreted in terms of exclusion limits on the pair production of top squarks decaying into a charm quark and a LSP ($\rightarrow c\,\chi^0_1$), stop pair production in the so-called 4-body decay channel ($\rightarrow Wb\,\chi^0_1$), and sbottom pair production. This made possible to fill the exclusion gaps at low stop masses, as shown in Fig. 6. Other SUSY interpretations include, for example, squark-squark strong pair production and chargino-neutralino electroweak production with nearly degenerate masses, which will be part of separate ATLAS SUSY summary papers to be concluded in 2015.

IN 2014 IFAE CONTINUED TO PLAY A LEADING ROLE IN SEVERAL PHYSICS RESEARCH LINES INCLUDING THE STUDY OF THE RECENTLY DISCOVERED HIGGS BOSON, THE SEARCH FOR SUPER-SYMMETRY (SUSY), EXTRA SPATIAL DIMENSIONS, DARK MATTER, AND NEW PHENOMENA IN TOP-QUARK FINAL STATES

The monojet search has been also interpreted in terms of gravitino production in gauge-mediated SUSY and other non-SUSY scenarios. This included exclusion limits on an invisibly decaying Higgs boson, models with large extra dimensions (LED), and effective models for dark matter (WIMPs) pair production. For the latter, a detailed study of the limited validity of the effective theory approach was carried out. The LHC results on dark matter searches nicely complement the exclusion limits obtained in direct detection experiments (see Fig. 7). The results were submitted for publication to Eur. Phys. J. C (arXiv: 1502.01518) with M. Martínez acting as corresponding editor. Altogether, this is collected in Roger Caminal's PhD thesis defended in February 2015.

This line of research is becoming one of he pillars of the LHC physics program for Run II. IFAE promises to maintain its leading role, as demonstrated by the fact that A. Cortés was recently appointed contact person of the ATLAS monojet analysis for Run II.

SEARCH FOR 3RD-GENERATION SQUARKS IN RUN II

In 2014, the IFAE team invested a significant effort in the preparation of the early Run II analyses, with emphasis on those searches for new phenomena that would immediately benefit from the increased centre-of-mass energy at the LHC Run II. This includes the search for 3rd -generation squarks in SUSY for which the production cross sections increase by factors 10 to 40 with respect to those in Run I. The IFAE team (A. Cortés, S. Fracchia, M. Martínez, M. Tripiana) played a leading role in such studies, recently presented in Moriond 2015 conference (ATLAS-PHYS-PUB-2015-005). As an example, Fig. 8 presents the discovery potential for a sbottom

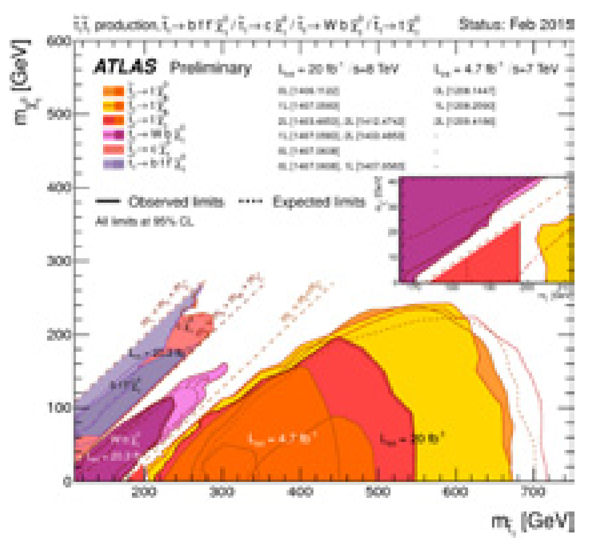


Fig. 6: Summary of 95% CL exclusion limits on scalar top mass versus neutralino mass by ATLAS (winter 2015) for scalar top pair production and considering different decay channels. The monojet contribution enters at low masses for the stop.

pair production signal (with sbottom decay into a bottom quark and a neutralino) as a function of the sbottom mass, for different total integrated luminosity values of up to 10 fb-1, corresponding to the first year of the Run II, and assuming a conservative 20% uncertainty on the background determination. An sbottom with a mass of 800 GeV could be within the reach for an early discovery.

Similar studies are being carried out for other SUSY discovery channels involving stop quarks. IFAE promises to play a leading role in the early Run II SUSY searches, as demonstrated by the fact that M. Tripiana (postdoc of IFAE) has been recently appointed co-convener of the SUSY 3rd-generation (stop/sbottom) SUSY working group in ATLAS.

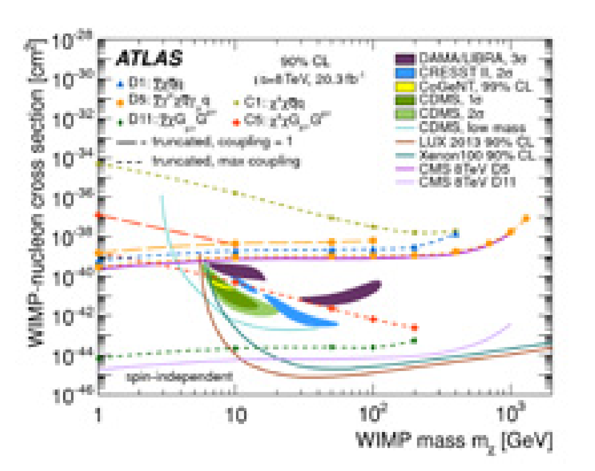


Fig. 7: Exclusion limits (90% CL) on the WIMP-nucleon cross section as a function of the WIMP mass for spin-independent interactions. The ATLAS limits are compared with results from direct detection experiments. Submitted for publication to EPJC (arXiv: 1502.01518).

HIGGS BOSON PHYSICS

Since July 2012, when the discovery of a new boson was announced at the LHC, an extensive physics program was impelled to measure the properties of this new particle. In particular, IFAE is playing a leading role since 2012 in the analyses involving the decay of the Higgs boson in a pair of bottom quarks. The team has considered both the VH and the ttH production channels, in which the Higgs boson is either produced in association with a W/Z boson or is radiated out of a top-(anti)top pair in the final state.

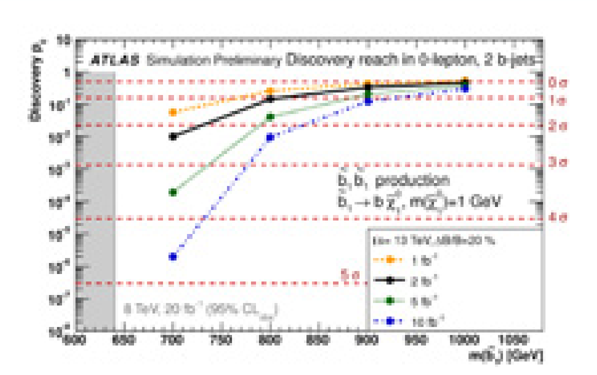


Fig. 8: Discovery potential for sbottom pair production as a function of the sbottom mass for several total integrated luminosity scenarios and assuming 20% systematic uncertainties. Taken from ATLAS-PHYS-PUB-2015-005.

SEARCH FOR VH PRODUCTION

In 2014, the group focused on final analysis improvements towards its publication in JHEP 01 (2015) 069. The final results include: the fully integrated luminosity accumulated during 2011 and 2012 at $\sqrt{s}$=7 TeV and $\sqrt{s}$=8 TeV, respectively; the use of both ZH and WH channels with different number of leptons in the final state; and two different approaches to search for the Higgs signal. The dijet invariant mass from the H → bb decay (see Fig.9) and a discriminator based on MVA (neural-network) techniques were used to search for the Higgs signals. The analysis involved the use of complex statistical tools and the handling of a delicate likelihood fit to hundreds of inputs. This allows constraining the background normalization and the systematic uncertainties, and to extract the Higgs signal. G. González and V. Sorín played a central role in the 0-lepton ZH channel (with the Z boson decaying into neutrinos) and in the understanding of the performance of the fit and the extraction of the final results.

Having found no evidence of a SM Higgs boson, the analysis sets a 95% confidence-level (CL) upper limit of 1.2 times the SM Higgs boson cross section and a Higgs signal strength (defined as the ratio of the measured signal yield to the SM expectation) of μ=0.530.4 (see Fig. 10). This measurement constituted the main topic of G. González PhD thesis defended in March 2015.

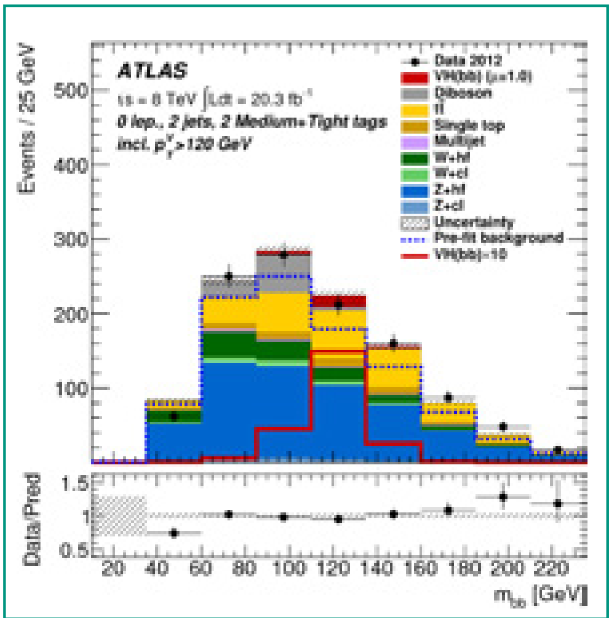


Fig. 9: The invariant mass of the two b-jets in the 0-lepton analysis in data compared with SM background expectations. The ZH signal is included for illustration. Published in JHEP01(2015) 069.

SEARCHES FOR TTH PRODUCTION

Of particular interest is the top-Higgs Yukawa coupling which, owing to the large top-quark mass, is close to unity, making the top quark the most strongly-coupled SM particle to the Higgs sector. Therefore, a measurement showing a significant deviation from the SM prediction may shed light on the underlying dynamics of electroweak symmetry breaking. In addition, a direct measurement of the top-Higgs Yukawa coupling is required for model-independent interpretations of loop-induced couplings of the Higgs boson, where the top quark becomes the main contributing SM particle.

The top-Higgs Yukawa coupling can be extracted by measuring the cross section for associated production of Higgs boson with a top-antitop quark

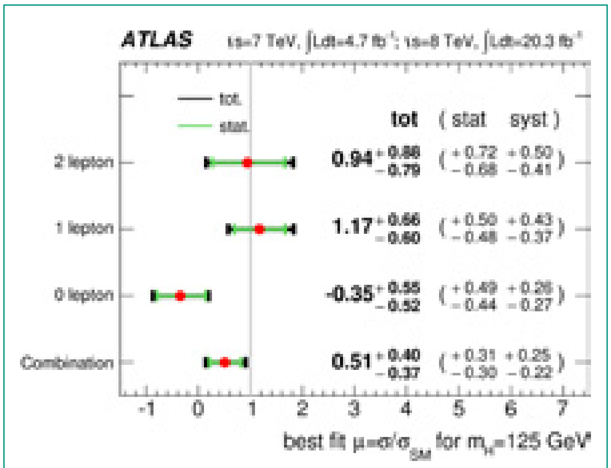


Fig. 10: The fitted values of the signal strength (VH channels) and their uncertainties for the individual channels and their combination. The green line shows the statistical uncertainty on the signal strength. Taken from JHEP 01 (2015) 069 .

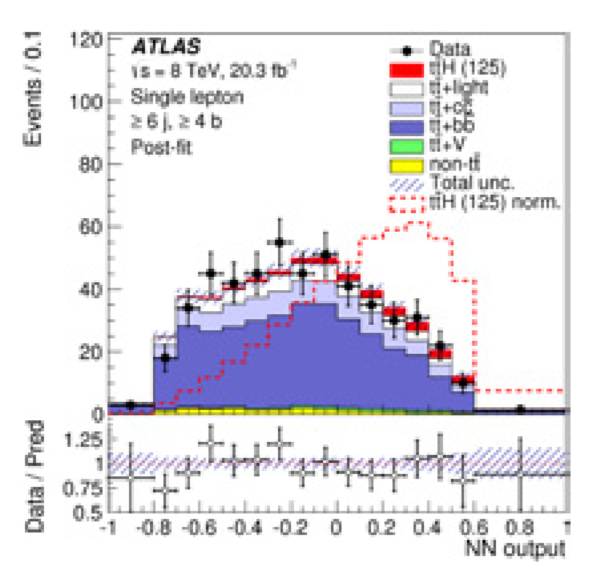


Fig. 11: NN distribution in the channel with ≥6 jets and ≥4 b-tags. The background is shown after the fit to data under the signal-plus-background hypothesis. The ttH signal distribution (solid red) is normalized to the best-fit signal strength. From arxiv: 1503.05066.

pair (ttH). Searches are being performed in many final states, depending on the top-quark and Higgs-boson decay modes. Since September 2013 A. Juste is coordinating these searches within one of the ATLAS Higgs working groups.

Over the least three years IFAE has led searches for ttH production with H→bb, in the single-lepton channel. The final-state state is characterized by one lepton and at least six jets, among which at least four are b-tagged. This analysis is very challenging due to the large background from tt+heavy-flavor jets production, affected by large uncertainties, as well as a large combinatorial background from the high-jet multiplicity, which makes very difficult the kinematic reconstruction of the final state. Over the years a very sophisticated search has been developed, considering multiple analysis channels to constrain the effect of systematic uncertainties, as well as using multivariate techniques for signal-to-background discrimination (see Fig. 11). At the time of the writing of this report the final result using 20.3 fb^{-1} of data at $\sqrt{s}$=8 TeV has been submitted for publication to Eur. Phys. J. C (arxiv: 1503.05066). No significant excess of events above the background expectation is found and an observed (expected) 95% CL upper limit of 3.4 (2.2) times the SM cross section is obtained. This represents the single most-sensitive ttH search to date. The ratio of the measured signal yield to the SM expectation is found to be μ=1.531.1 (see Fig.12). This result will be included in J. Montejo's PhD thesis (expected by June 2015).

Additional studies are underway on the application of large-radius jet reconstruction and jet substructure techniques to the subset of events where one of the top quarks and/or the Higgs boson have large boost, resulting in the collimation of its decay products. These techniques are expected to isolate kinematic regions with increased signal-to-background ratio and lead to better reconstruction of the Higgs boson mass with less combinatorial background. Postdoc T. Farooque is coordinating this analysis effort within the ATLAS Higgs group. This search will be included in M. Casolino's PhD thesis (expected by 2017).

TOP QUARK PHYSICS AND EXOTIC SEARCHES

IFAE is carrying out a competitive program of measurements of top-quark properties (e.g. tt charge asymmetry, flavor-changing neutral-current top-quark decays) and direct searches for physics beyond the SM (BSM) in top-quark final states (e.g. top-quark partners, 4-top quark signatures). This effort translated into two PhD theses by A. Succurro and F. Rubbo defended in 2014.

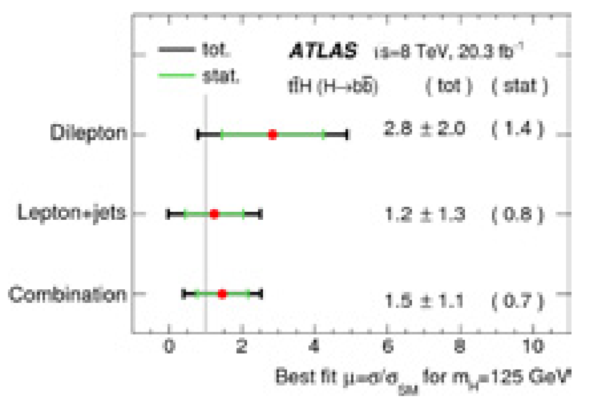


Fig. 12: The fitted values of the signal strength and their uncertainties (ttH channels) for the individual channels and their combination. The green line shows the statistical uncertainty on the signal strength. From arxiv: 1503.05066.

SEARCHES FOR VECTOR-LIKE QUARKS AND 4-TOPS

Many new physics models aimed at addressing some of the limitations of the SM involve the presence of exotic quarks, heavier than the top quark. A prominent example is weak-isospin singlets or doublets of vector-like quarks (VLQ), which appear in many extensions of the SM such as Little Higgs or extra-dimensional models. In these models a top-partner quark, for simplicity here referred to as T, often plays a key role in canceling the quadratic divergences in the Higgs boson mass induced by radiative corrections involving the top quark. At the LHC, these new heavy quarks would be predominantly produced in pairs via the strong interaction for masses below ~1 TeV. In the case of VLQs, several decay modes are possible, T→Wb, Zt and Ht, all with sizable branching ratios, resulting in a rich spectrum of possible final state signatures.

Since 2011, IFAE is playing a leading role in the program of heavy-quark searches in the single-lepton final state in ATLAS. The group has developed two complementary searches for vector-like quarks at $\sqrt{s}$=8 TeV, able to probe large portions of the branching ratio plane BR(T→Ht) vs BR(T→Wb) as a function of heavy quark mass (m_T). This allows searching for these particles in a quasi-model-independent way, a strategy that was pioneered by the group.

One search, referred to as TT→Wb+X, is designed to probe the region of high BR(T→Wb) and was optimized at higher m_T by exploiting the characteristic topology of boosted W bosons in the decay of heavy quarks. The other search, referred to as TT→Ht+X (with H→bb), is designed to probe scenarios with high BR(T→Ht), resulting is spectacular signatures with high jet and b-jet multiplicities. Both searches have been carried out using 20.3 fb^{-1} of data at √s=8 TeV and a preliminary result has been released at the time of the writing of this report (ATLAS-CONF-2015-012). No significant excess of events above the SM expectation is observed. The 95% CL observed lower limits on the T quark mass range between 715 GeV and 950 GeV for all possible values of the branching ratios into the three decay modes, representing the most stringent constraints to date (see Fig. 13).

In addition, the TT→Ht+X analysis is used to search for 4-top production, both within the SM and in several BSM scenarios (contact interaction within an Effective Field Theory, scalar gluon pair production, universal extra-dimensions compactified in the real projective plane), resulting in some of the most restrictive bounds on this process to date: e.g. scalar gluons decaying dominantly to tt and with mass below 1.1 TeV are excluded at 95% CL.

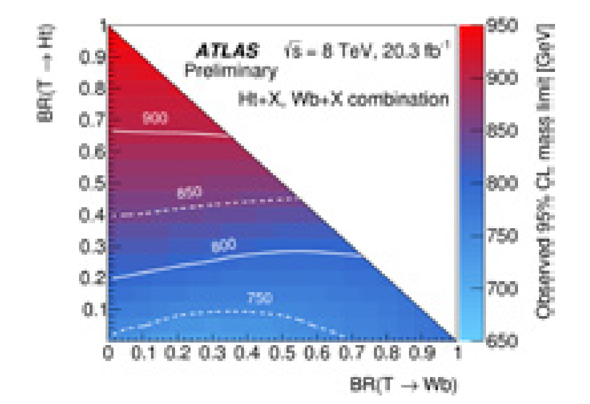


Fig. 13: Observed limit (95% CL) on the mass of the T quark from the the combination of the TT→Wb+X and TT→Ht+X searches, and presented in the plane of BR(T→Ht) versus BR(T→Wb). From ATLAS-CONF-2015-012.

These results will also be included J. Montejo's PhD thesis. A. Juste is acting as coordinator for these analyses and corresponding editor for this result, which is being prepared for publication.

SEARCH FOR A CHARGED HIGGS BOSON

Extensions of the Higgs sector can address some shortcomings of the Standard Model. Charged Higgs bosons are predicted in several non-minimal Higgs scenarios, such as two-Higgs-doublet Models in the Minimal Supersymmetric Standard Model (MSSM). The searches are naturally divided in two categories according to the H^+ mass. If lighter than the top quark, the H^+ is mainly produced in the decay of a top quark, and its prominent mode is $H^+\rightarrow\tau\mu$. One of the key elements of the analysis is the precise data-driven τ+MET trigger efficiency measurement performed by IFAE (M. Bosman, M.P. Casado, Ll. Mir, I. Riu). The 2012 data provide experimental bounds on the product of the branching ratio BR(t→H^+b) and the branching ratio of the H^+decay mode. Limits are set on parameters of the models. With Run 1 data, large areas of the MSSM parameter space have been excluded for a H+ with mass below 160 GeV (see Fig.14). The analysis is published in JHEP03 (2015) 088.

With Run 2 data the main focus of interest will turn to higher mass H^+ produced mainly in association with a top quark, with H^+→tb as prominent decay mode. The final state with a top quark pair and additional heavy flavor jets is similar to the final state used by IFAE for its top quark physics research line.

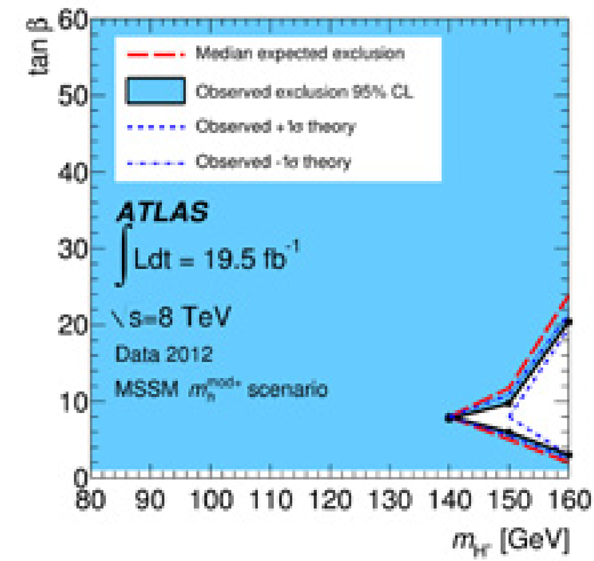


Fig.14: The 95% CL exclusion limits on tan β (ratio of the vacuum expectation values of the two doublets) as a function of m_{H^+} Published in JHEP03 (2015) 088.

COMPUTING INFRASTRUCTURE

The Tier-2 and Tier-3 LHC computing infrastructure of IFAE, under the supervision of A. Pacheco, provided efficient access to the analysis of the data recorded by the ATLAS detector during until the LHC long shutdown (LS1) in 2014.

All the infrastructure of the ATLAS Tier-2 and Tier-3 farms was hosted at Port d'Informació Científica (PIC) together with the Spanish ATLAS Tier-1, and fully integrated within its production services (like automatic cluster management, monitoring, etc.), providing a robust and stable environment that maximizes the availability of the facilities.

During 2014, the IFAE Tier-2 processed more than 4 billion events (see Fig. 15) and executed 1.5 million of jobs. The CPU capacity provided to the AT-

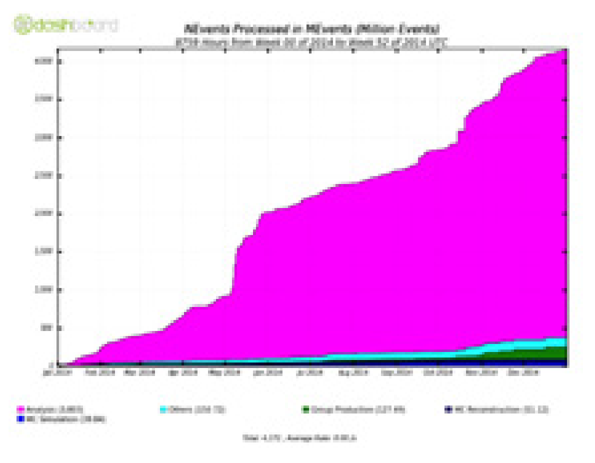


Fig. 15: Cumulative graph of the number of real data events processed in the IFAE Tier2 during year 2014. The Tier2 facility processed more than 4 billion events, more than 90% by data analysis jobs.

LAS collaboration by the Tier-2 in 2014 amounts to 45,368,640 HepSpec hours with 98% of reliability. In order to address the local needs for the analysis of the full Run1 ATLAS data samples the group progressively upgraded the Tier-3 farm with additional resources.

Currently the Tier-3 farm counts on more than 4000 HepSpecs of CPU power and 450 TB of disk, some of these resources are available in form of a proof parallel event-processing farm for the latest stages of analysis. As the farm is integrated with the ATLAS Tier-1 and Tier-2 facilities at PIC, it has local access to the whole farm of 4000 processors and local access to the 2,5 petabytes of ATLAS data stored. Before the key physics conferences the computing power and disk available for analysis is increased automatically thanks to the dynamic resource allocation of PIC.

Finally, A. Pacheco started the mandate as ATLAS Grid Data Processing coordinator to keep the available worldwide computing resources for the ATLAS experiment fully committed with the requirements from the physics coordination for Monte Carlo simulation, real data reprocessing, and derived production such as analysis-ready data.

DURING 2014, THE ATLAS-IFAE GROUP MAINTAINED THE VISIBILITY IN MANAGEMENT AND PHYSICS COORDINATION POSITIONS IN ATLAS

MANAGEMENT POSITIONS

During 2014, the group maintained its visibility in management and physics coordination positions in ATLAS: M. Bosman acted as deputy Chair of the ATLAS Collaboration; A. Cortés was appointed Co-contact person for the Run II monojet group; T. Farooque coordinated the boosted Higgs analysis efforts; A. Juste acted as Co-convener of the HSG8 Higgs subgroup; A. Pacheco acted as ATLAS Distributed Analysis Coordinator; M. Martínez acted as member of the ATLAS Publication Committee; C. Padilla is member of the ATLAS Speakers Committee; and M. Tripiana was appointed as Co-convener of the SUSY stop/sbottom subgroup.

2.2 PIXELS FOR ATLAS UPGRADES

SEBASTIÁN GRINSTEIN

As the LHC accelerator is improved to further probe the energy frontier, the pixel sensors and the associated front-end electronics have to be upgraded to maintain their performance. The Pixel group at IFAE was formed in 2008 and has since taken a leading role in the ATLAS pixel upgrade program. In parallel, the Pixel group is investigating and developing new technologies for the high-luminosity LHC era.

INTRODUCTION

In order to test the predictions of different theories of particle physics and high-energy physics, the LHC experiments need to identify and determine the path of the particles that are produced in the proton-proton collisions. Silicon pixel detectors are especially important for the precise determination of tracks and vertices, allowing the identification of b-jets (b-tagging).

In 2014 IFAE's Pixel Group main activities were related to the operation of the newly installed Insertable B-Layer (IBL), the qualification of a 3D pixel tracker for the ATLAS forward physics detector (AFP), and the development of innovative pixel technologies for very high luminosity colliders. All these activities are conducted in the framework of a Spanish (MINECO) project, led by IFAE, in collaboration with CNM (Centro Nacional de Microelectronica, Barcelona).

THE INSERTABLE B-LAYER

During the first long accelerator shutdown of 2013-2014, in which the machine was upgraded to deliver collisions at a center of mass energy of 13 TeV, ATLAS has extended the pixel detector by adding a fourth layer. The IBL consists of 14 staves mounted directly on the beam pipe with a tilt angle of 14°. Each stave is equipped with 32 pixel modules. The sensor technology for the IBL detector was chosen in 2011, and, thanks to the excellent results obtained by the IFAE group with the novell 3D sensor technology from CNM (Barcelona) and FBK (Trento), it was decided that 25% of the modules would be 3D devices, while the traditional planar technology would be used for the other 75%. The 3D wafers for the IBL were produced at CNM and FBK during 2012. In 2013 IFAE worked to ensure that the 3D sensors produced at Barcelona were successfully incorporated in the IBL. The IBL was inserted in May 2014. Due to the higher yield of the CNM sensor production, 64% of the 3D sensors installed in the IBL are from CNM.

THE PIXEL GROUP HAS MADE A CRITICAL CONTRIBUTION TO THE INSERTABLE B-LAYER (IBL), WHICH IS NOW INSTALLED IN ATLAS

During 2014 IFAE followed the commissioning of the new layer and participated in cosmic data taking to evaluate the performance of the detector (see Figure 1). As of the beginning of 2015, all pixel modules of the IBL are working. This is the first time the 3D technology is used in a high-energy physics experiment. It is a major milestone towards IFAE's long-term objective of making a significant contribution to the ATLAS HL-LHC upgrade foreseen for 2023.

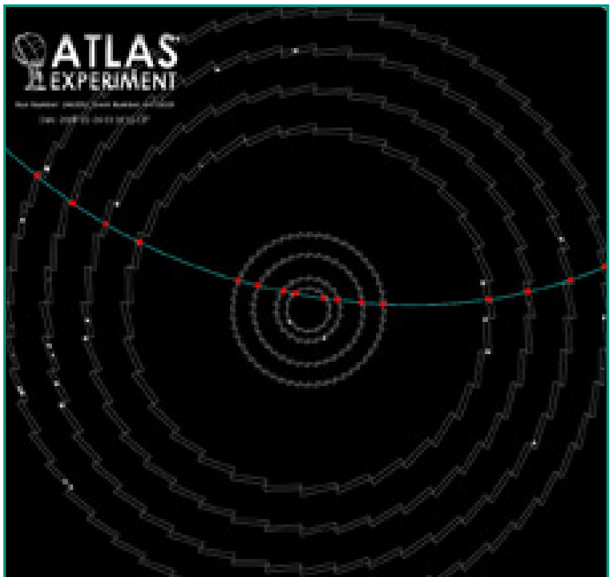


Fig. 1: A cosmic ray is shown passing through the IBL, the newly installed pixel layer of the ATLAS detector, in the presence of a solenoidal magnetic field.

THE ATLAS FORWARD DETECTOR

ATLAS plans to install a Forward Physics detector (AFP) in the 2015 or 2016 LHC shutdown, in order to identify diffraction-scattered protons at ~210 m from the interaction point. To this end, the AFP detector will include a high-resolution pixelated silicon tracking system combined with a timing detector for the removal of pile-up protons. The AFP tracker unit will consist of four pixel layers located in a Roman Pot 2-3 mm from the LHC proton beam. Two Roman Pot stations will be placed at each side of the ATLAS interaction point (at 204 and 212 m). The four stations will include a tracker array, while only the outer ones will contain time of flight detectors. Based on the successful production of CNM 3D sensors for the IBL, and after the qualification work carried out by IFAE, the Barcelona sensors were selected for the AFP tracker. The current AFP scenario foresees low-luminosity operation during short dedicated LHC runs, whereas the system can be upgraded at a later stage to take data at higher luminosities as part of the regular LHC runs.

THE 3D PIXEL MODULES OF THE ATLAS FORWARD PHYSICS DETECTOR (AFP) TRACKER WILL BE FABRICATED AT IFAE.

During 2013 and 2014, an intensive program to qualify the CNM 3D sensors for AFP was carried out by IFAE. The challenge was to prove that the inactive edge of the 3D sensors on the side facing the beam could be reduced to 100-200 μm and that the sensors could cope with the nonuniform dose expected in the high-luminosity scenario. CNM AFP prototypes were assembled and beam tests were carried out by IFAE at DESY in 2013 and in January 2014. The success of the effort concluded with a positive technical review conducted by the ATLAS management in March 2014. The results were presented at the ICHEP 2014, PIXEL 2014 (arXiv:1501.02076) and RESMDD14 conferences by different members of the group.

After the successful technical review of the individual components, the AFP collaboration needed to demonstrate the feasibility of the proposed detector by conducting a full system integration test-beam. The IFAE group led the effort to assemble tracker and time of flight detector prototypes with a common readout system. Beam tests were carried out in November 2014 at the CERN-SPS 120 GeV pion line. The AFP prototype consisted of five tracking planes and a timing system (based on quartz bars) as shown Figure 2. The fifth tracker plane placed behind the timing system allowed monitoring of particle interactions in the quartz material.

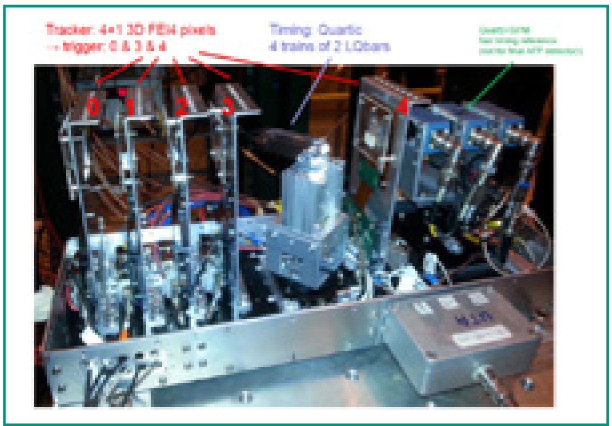


Fig. 2: The first integrated AFP prototype during the November 2014 beam test.

The beam tests demonstrated that the AFP prototype combining tracking and timing sub-detectors and a common readout performed successfully. Timing and tracking data were shown to be correlated (see Figure 3), while the system was able to achieve the overall position (10 μm) and timing (30 ps) resolutions required for low-luminosity operation. The results of this milestone achievement were presented to the ATLAS community by J. Lange, who also coordinated all the beam test and data analysis activities. Furthermore, most of the key results included in the AFP Technical Design Report were produced by the IFAE group. This effort concluded with the approval of AFP by the ATLAS Collaboration Board in early 2015.

AFP has now become an official ATLAS upgrade project in which IFAE plays a key role: we will provide the 3D sensors (produced at CNM), carry out the hybridization (the bump-bonding process to interconnect the pixelated sensors and front-end chips) and the assembly of the tracker modules. This effort will be recognized as an in-kind contribution of the institute towards the (phase-1) ATLAS upgrade. IFAE is also well represented in the AFP management structure: J. Lange is the run and test-beam coordinator, while S. Grinstein is in charge of the AFP tracker. Both are also members of the AFP management board.

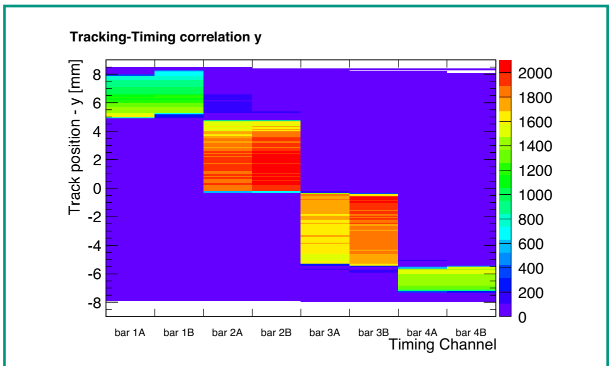


Fig. 3: The spatial correlation of the tracks in the pixel detector and the timing bars (placed directly behind the tracker) indicate the successful integration of the AFP detector prototype.

To carry out the production and assembly process of the AFP tracker, the IFAE clean room facility and the equipment therein becomes critical. During 2014 prototypes were mounted (bump-bonded and wire-bonded) and quality assurance tests were carried out. This qualification consisted of wire-bond pull tests as well as the electrical characterization of the modules. The assembly and quality control procedures rely heavily on the infrastructure of IFAE: the FC-150 flip-chipping machine, the AVT reflow oven, the Delvotec wire-bonding machine, the DAGE bond-tester and the Finetech pick-and place machine are frequently used by the IFAE group. The final AFP modules are expected to be mounted in 2015 (depending on the availability of components, which are being designed and produced by other institutions).

ATLAS PIXEL UPGRADE ACTIVITIES

The long-term aim of the IFAE Pixel group is to make a major contribution to the phase-2 pixel upgrade. To this end, the group is researching and developing new pixel technologies that can cope with the unprecedented radiation doses that the inner layers of the ATLAS pixel detector will face during the HL-LHC era.

The 3D technology has proven to be, to this date, the most radiation hard, but it is more expensive than the standard planar approach. However, for the innermost layer of the phase-2 detector, performance is expected to be the critical factor, making 3D detectors a viable candidate. IFAE is leading the 3D effort in ATLAS (S. Grinstein is the convener of the 3D group) and, in collaboration with CNM and the CERN RD50 collaboration, has launched sensor productions with the reduced pixel sizes that will be used for the upgraded detector. At the same time, IFAE is leading the efforts to qualify the 3D technology up to 2E16 n_{eq}/cm^2 (the target HL-LHC fluence). Detectors with intrinsic charge multiplication (Low Gain Avalanche Detectors or LGAD) could allow the fabrication of more radiation hard devices, if part of the charge amplification is retained after irradiation. Simple diode-like structures that exhibit charge multiplication up to moderate irradiation doses have been already successfully produced at CNM. In 2014, also more complex strip and pixel devices were produced with the LGAD technique for the first time. IFAE studied their performance in detail, but no charge multiplication was found (results were presented by student E. Cavallaro in RESMDD14). The production process has been recently optimized and new LGAD productions will be tested in 2015. For this purpose, a new transient-current-technique (TCT) setup is being commissioned at IFAE by undergraduate students. TCT allows insight into signal formation in semiconductor devices, and, in particular, the study of charge multiplication effects.

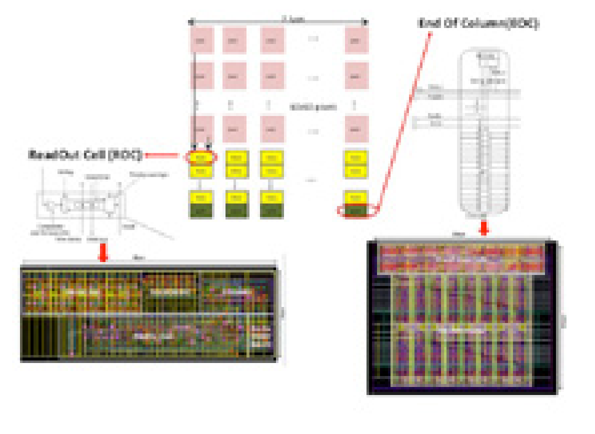


Fig. 4: Matrix of 60x50 pixels with readout electronics. The read out cell (ROC), as well as other digital blocks have been designed by IFAE.

IN THE HIGH LUMINOSITY LCH ERA, THE ATLAS PIXEL DETECTOR WILL FACE UNPRECEDENTED RADIATION DOSES. THE GROUP IS DEVELOPING NEW PIXEL TECHNOLOGIES TO COPE WITH THAT

Recently, ATLAS started to investigate the use of silicon devices produced in high-voltage CMOS technology (HVCMOS). In this standard process the electronics is placed inside deep n-wells while a depletion region can be grown on the same substrate to collect the charge generated by the incoming radiation. These “active” sensors can then be combined with more complex electronics (via DC or AC coupling) or be operated on their own (i.e., monolithic approach). IFAE is participating in the HVCMOS collaboration together with other institutions (Karlsruhe, Liverpool and University of Geneva) to create a demonstrator during 2015. Engineer R. Casanova is designing the digital readout electronics for a matrix of 60x50 pixels (see Figure 4). IFAE will also develop techniques to assemble HVCMOS devices in the framework of a Horizon-2020 project (AIDA-2020).

2.3 NEUTRINO EXPERIMENTS

FEDERICO SÁNCHEZ

For more than a decade IFAE has been contributing to several key experiments in this field, such as K2K, which obtained the first measurement of neutrino oscillations with a neutrino beam from an accelerator, and T2K, that presented in 2011 the first indication of the transformation of muon neutrinos into electron neutrinos, thereby demonstrating a non-zero value for the third mixing angle.

INTRODUCTION

The phenomenon of neutrino oscillations is solidly proved by many results obtained over the past two decades. For more than a decade IFAE has been contributing to several key experiments in this field, such as K2K, which obtained the first measurement of neutrino oscillations with a neutrino beam from an accelerator, and T2K, that presented in 2011 the first indication of the transformation of muon neutrinos into electron neutrinos, thereby demonstrating a non-zero value for the third mixing angle. In 2013 the T2K collaboration produced solid evidence of the transition of muon neutrinos to electron neutrinos, improved the measurement of the muon disappearance parameters and provided the first indication of charge parity (CP) violation in the lepton sector.

THE T2K COLLABORATION

In T2K a high-intensity, 2.5° off-axis neutrino beam from the JPARC proton accelerator center in Tokai (Japan) is sent to the SuperKamiokande experiment in Kamioka, 295 km away. The muon neutrino energy spectrum is optimized for searching the appearance of electron neutrinos. The beam is characterized at the near detector, 280 m after production (ND280). Neutrinos of the electron type (but not of the tau type) are detected in Super-Kamiokande. T2K has a rich neutrino physics program. At the moment it is the only experiment that measured the mixing parameter θ_{13} by detecting the appearance of electron-type neutrinos. The muon neutrino beam also allows measuring the mixing matrix element θ_{23} and the neutrino mass difference via muon neutrino disappearance. The experiment also contributes to the search for sterile neutrinos.

These measurements require a precise understanding of the neutrino flux and the cross sections of neutrinos with nuclei at energies around 1 GeV. The near detector complex was designed with these requirements in mind. It is a magnetic detector, consisting of two sections: the P0D that detects neutral pions and the charged particle tracker (FGD and TPC). The detector is surrounded by an electromagnetic calorimeter, ECAL, to measure photons

IN 2013 THE T2K COLLABORATION PRODUCED SOLID EVIDENCE OF THE TRANSITION OF MUON NEUTRINOS TO ELECTRON NEUTRINOS.

and a muon catcher (SMRD) to identify muons. The contributions of the IFAE group to the T2K experiment focused on the near detector, specifically in the construction of the tracker's Time Projection Chamber (TPC) and in the preparation of the magnet. After the installation and successful operation of the apparatus during 2010, the IFAE focused its efforts on the maintenance of the sub-detectors and on data analysis.

The JPARC accelerator provided the first neutrino beam in April 2009, and the near detector saw the first interactions in November 2009. The physics run

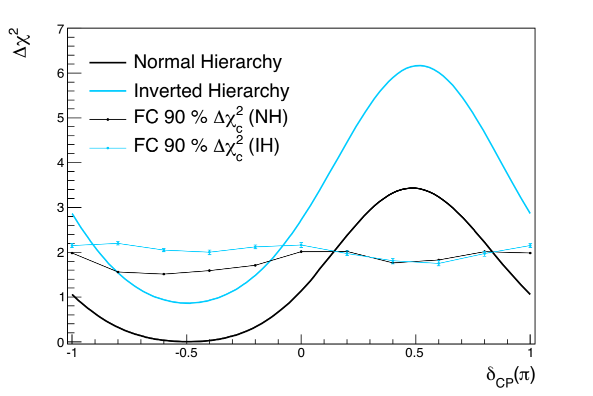


Fig. 1: Electron neutrino data likelihood represented as function of the CP violation phase angle for the two possible mass hierarchy solutions. The blue line represents the of 90% C.L. limit for the two signs of the mass splitting.

ANTINEUTRINO T2K'S RESULTS ARE EXPECTED TO BE THE WORLD'S MORE PRECISE MEASUREMENTS OF APPEARANCE AND DISAPPEARANCE OSCILLATIONS CHANNELS

began in February 2010 and continued until March 2011, stopped by the severe earthquake that shook the northeast coast of Japan. After recovery from earthquake damage the beam intensity increased significantly reaching steady operation around 250 kW in May 2013 with a total of 6.57×10^{20} protons on target. This accumulated flux represents only 10% of the total expected by T2K. Since May 2014, T2K has changed the polarity of the focusing magnetic horns to produce predominantly anti-neutrinos. Since then, T2K has been running in this mode accumulating antineutrinos to measure both the muon anti-neutrino disappearance and the electron anti-neutrino appearance. The anti-neutrino run will continue until June 2015 when the first results will be provided. These results are expected to be the world more precise results for both oscillation channels in anti-neutrinos. The first combined fit of neutrino and anti-neutrino appearance and disappearance channels will be also provided during the summer 2015. For this analysis, the muon neutrino selection at the near detector developed at IFAE in 2013 will still be used. The IFAE group led the analysis of the inclusive Charged-current (CC) muon and electron neutrino interactions used for neutrino flux normalization. During the year 2014, IFAE started to work on a new analysis to improve the CC results by integrating high angle tracks and reducing the background coming from pion-muon confusion in the detector. The new analysis is expected to be ready for 2016 oscillation results.

The search for neutrino oscillations on a very short baseline using the T2K near detector is another IFAE contribution. The transformation of muon neutrinos into electron neutrinos or the disappearance of the muon neutrinos at very short distances will provide indications on the existence of sterile neutrinos. In collaboration with other groups IFAE developed the first sterile oscillation search at T2K, searching for electron neutrino disappearance in the near detector. These results, already approved by the collaboration, allow reducing the oscillation parameter space allowed by previous experiments as shown in Figure 3. In 2014, IFAE started the analysis of muon neutrino disappearance at the near detector. This is an alternative method to search for sterile neutrinos in short base line oscillations as shown in Figure 4. The analysis will be published during 2015. The analysis will be extended in the future to consider at the same time muon neutrino disappearance, electron neutrino appearance and disappearance in a single analysis.

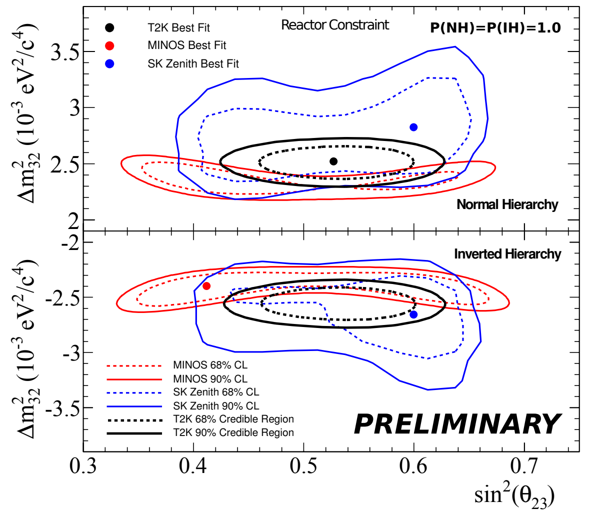


Fig. 2: T2K mixing angle and Δm^2 results for the muon neutrino oscillation hypothesis. The T2K results are compared to those from MINOS and SuperKamiokande.

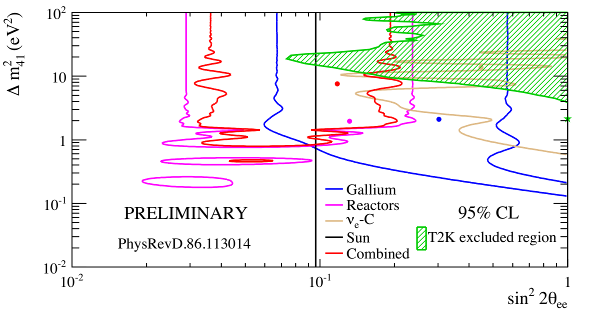


Fig. 3: Exclusion plot of sterile neutrino oscillation parameters from the T2K near detector electron neutrino disappearance analysis compared to previous results.

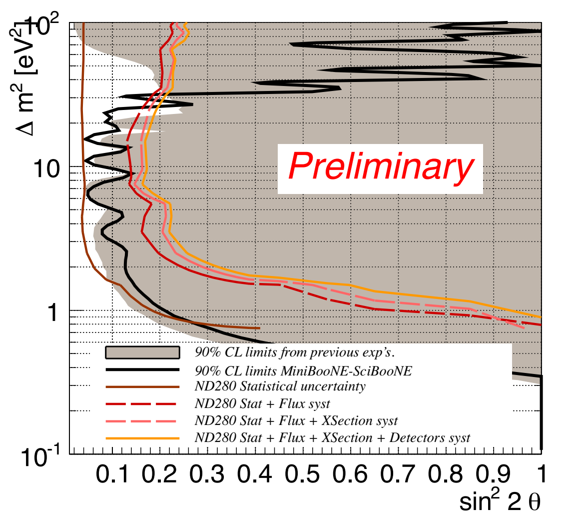


Fig. 4: Exclusion plot of sterile neutrino oscillation parameters from the T2K near detector muon neutrino disappearance analysis compared to previous results.

Additional activities at IFAE include the particle identification in the TPC that was revisited between years 2013 and 2014 to improve on the performance for high angle tracks in the TPC. IFAE also started to develop a technique to identify electric field distortions in the TPC. The distortion of the electric field drifting electrons in the TPC is an important source of uncertainties in the particle charge and momentum determination but also on the track momentum scale. The results are very promising, being able to reduce some of the systematic dependencies observed in track reconstructions as shown in Figure 5. IFAE also contributes to magnet and TPC maintenance tasks.

WA105

After the last years developments, the field of oscillation physics is gaining momentum towards the next goals: neutrino mass ordering and CP violation. Both goals are within reach at running experiments but will need a new generation of medium (300km) or long base (>1000km) line experiments to cover the majority of the parameter space.

IFAE joined in 2014, together with CIEMAT, the R&D towards this new generation of experiments. Among all possible projects, a large liquid argon tank at CERN (WA105) seems the most promising because it joins european groups around a CERN-based project and is a technology with large potential inside and outside particle physics. Both IFAE and CIEMAT have previous experience in the field which strengthens the potential impact of their contribution. The largest liquid argon tracking calorimeter ever built is the 600-ton ICARUS detector and a 40-kton Dune (previously LBNF project at Fermilab) detector represent a substantial scale-up in detector size. A mandatory milestone in view of future long-baseline experiments is a concrete prototyping effort towards the envisioned large-scale detectors, and an accompanying campaign of beam measurements aimed at assessing the performance and the systematic errors that will be affecting

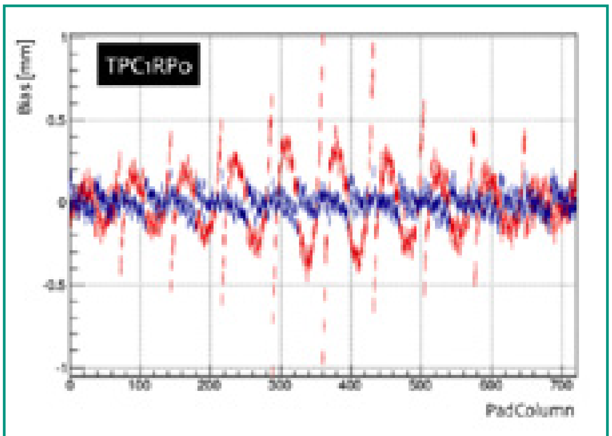


Fig. 5: Difference between the fitted particle trajectory and the TPC reconstructed electron cluster (Bias) as function of the detector location. Red points show the bias before the electrostatic model of the E field is applied, in blue after the correction is applied.

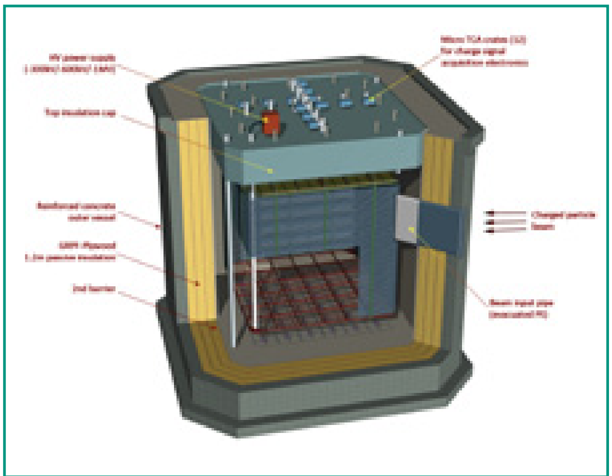


Fig. 6: Schematic representation of the TPC inside the cryostat. The inner detector has dimensions of 6x6x6m3.

the long-baseline physics program. In this respect, there is already an approved 5 year plan at CERN, the so-called CERN Neutrino Platform (CENF), to develop the technology for future long base line neutrino oscillation experiments. WA105, see Figure 6, is a 6x6x6 m^3 liquid argon detector being built at CERN for testing technical solutions. WA105 will make use of available particle accelerators at CERN to characterize the response of the detector to several particles. The exposure to different particles is a unique feature of the WA105 and an important added value that will help reducing uncertainties in future neutrino oscillation experiments.

2.4 THE MAGIC TELESCOPES

JAVIER RICO

MAGIC ("Major Atmospheric Gamma Imaging Cherenkov") is a system of two gamma-ray telescopes located at the Roque de los Muchachos Observatory, at the Canary Island of La Palma. The MAGIC telescopes are among the most powerful eyes to study the gamma-ray radiation coming from the most violent, non-thermal processes in our Universe

INTRODUCTION

The MAGIC telescopes are able to detect cosmic gamma rays in the very-high-energy (VHE) domain, i.e. in the range between ~50 GeV and ~50 TeV. Thanks to its large reflectors (17 meter diameter), plus high-quantum-efficiency and low noise photomultipliers (sensitive to a single photoelectron) MAGIC achieves a high sensitivity to Cherenkov light and hence a low energy threshold. Cherenkov images of the showers are used to reconstruct the calorimetric and spatial properties, as well as the nature of the primary particle.

VHE astronomy is one of the fundamental pillars of Astroparticle Physics. It is an essential tool to study fundamental phenomena in Astrophysics, Cosmology and High Energy Physics. VHE gamma rays are the most energetic form of electromagnetic radiation. They are produced in the most violent, non-thermal cosmic environments. Their main production mechanisms are radiation and interaction of accelerated charged particles, either electrons or protons. Thus, by studying gamma rays we learn about cosmic particle accelerators. Furthermore, VHE Gamma-ray Astronomy addresses questions of fundamental physics, such as the nature of dark matter, the intensity and evolution of the extragalactic background light, the quantum nature of Gravity, the origin of Galactic cosmic rays, or the composition of the cosmic electron-positron spectrum in the GeV-TeV scale.

VHE ASTRONOMY IS AN ESSENTIAL TOOL TO STUDY FUNDAMENTAL PHENOMENA IN ASTROPHYSICS, COSMOLOGY AND HIGH ENERGY PHYSICS. BY STUDYING GAMMA RAYS WE LEARN ABOUT COSMIC PARTICLE ACCELERATORS AND FUNDAMENTAL PHYSICS

At present, the most sensitive observations in this energy band are performed from Earth by the so-called Cherenkov Telescopes, of which MAGIC is one of the most advanced examples. The main background affecting the observations of gamma rays using this technique comes from the overwhelming flux of charged cosmic rays —about 100 times more abundant than gamma rays for intense sources—,

Fig. 1: The MAGIC telescope system preparing for observations at dawn. From left to right: MAGIC-II and MAGIC-I. Thanks to their large mirrors, the MAGIC telescopes working in stereoscopic mode are able to detect gamma rays of energies between ~50 GeV and ~50 TeV. They are powerful eyes to observe the most violent phenomena: the non-thermal Universe. Credit: MAGIC Collaboration.

reduced through the analysis of image properties. This technique is relatively new, with the first sources detected in the 1990s with the previous generation of Cherenkov telescopes. The second generation of instruments, including instruments like MAGIC, was designed to increase the flux sensitivity in the energy regime of tens to few hundred GeV. Thus, the first exploratory instruments were replaced in the 2000s by the current generation of facilities, which have revolutionized the field: gamma-ray source catalogues list now over hundred fifty sources and several new populations have been established. One of the main aims of MAGIC was pushing the energy threshold down to energies of tens of GeV. This has allowed an overlap with the energy range of the Fermi-LAT space telescope, thus filling the observational energy gap at tens of GeV.

IN 2014 IFAE HAS BEEN INVOLVED IN SEVERAL HARDWARE DEVELOPMENTS, LIKE THE NEW TOPOLOGICAL TRIGGER AIMED AT REDUCING THE ENERGY THRESHOLD, AND THE UV FILTERS FOR MOON OBSERVATIONS AND MEASUREMENTS OF THE COSMIC POSITRON/ELECTRON RATIO

THE MAGIC GROUP AT IFAE

The IFAE group joined the R&D effort towards the design and construction of the first MAGIC telescope in 1996, and built its photomultiplier camera, which has been operated until 2012. For the second telescope, IFAE contributed the production of key elements of the readout and data acquisition systems, like the receiver boards and the signal digitizers. IFAE also led a major hardware upgrade during 2011-2012, where all the electronics and the camera of the first telescope were replaced. In addition, since the beginning of the project, IFAE has full responsibility of the development, running and maintenance of the Central Control system. IFAE has also built and operates the MAGIC Data Center, which processes and serves ~300 TB/year of raw data and analysis products to the entire MAGIC Collaboration and has pioneered the use of Grid technology in Gamma-ray Astronomy. During 2014 we have continued maintaining and operating MAGIC and its Data Center service with no significant problems.

IFAE has maintained since the beginning a very high level of involvement in the management of MAGIC (for instance, M. Martínez and J. Cortina were in the past Spokesperson of the Collaboration). During 2014 it is worth highlighting that Dr. Oscar Blanch has been appointed as Deputy Spokesperson of the Collaboration. In addition, several members of the group serve in the Time Allocation Committee, the Technical and Software Boards, as the Convener of the Fundamental Physics Working Group and the Common Fund Manager.

HARDWARE DEVELOPMENTS

After the last major hardware upgrade in 2011-2012, MAGIC entered a phase of steady astronomical observations and physics exploitation of the telescopes. At MAGIC-IFAE we have been, however, involved in several hardware developments, aimed at expanding further the energy range and duty cycle of Cherenkov telescopes, which we have developed and tested in MAGIC during 2014, namely:

TOPO-TRIGGER

A new concept of trigger for lowering the energy threshold of MAGIC. It combines the information of the spatial distribution of the triggering images in both MAGIC cameras to distinguish shower images from accidental triggers caused by the light of the night sky, hence rejecting the latter. Cherenkov photons from cosmic-initiated showers are produced at a typical height of several kilometers above the telescopes and they illuminate similar regions of the camera of both telescopes (see Figure 2). On the other hand, the light of the night sky can produce triggers by accidental temporal coincidence of individual telescope triggers. With the Topo-trigger we add the spatial criterion to the trigger logic, hence discriminating low energy showers from accidental coincidences. We have carried out an activity together with the Max-Planck Institute in Munich and

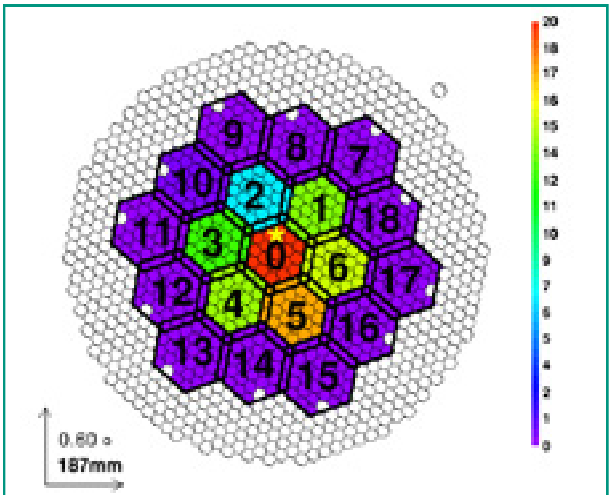


Fig. 2: The color scale shows the spatial distribution of triggering macro-cells in one of the MAGIC cameras for events triggering macro-cell #0 in the other MAGIC camera. Thin lines represent the camera pixels. Macro-cells are defined as groups of pixels whose combined signal is used to issue a level-0 trigger, and are depicted in the plot by thick lines and labeled with numbers. 99.4% of the macro-cells triggering in one telescope are within the first ring around macro-cell #0.

the INFN-Pisa MAGIC groups to develop this new concept. The technique has been demonstrated to work using Monte Carlo simulations, and confirmed with observations using the MAGIC telescopes. Thanks to the Topo-trigger we will be able to reject 85% of the accidental triggers while keeping 99% of the gamma-ray events. Thanks to this the energy threshold will be reduced by 8%. From IFAE we have led the Monte Carlo simulations and we have also participated in the hardware installation in La Palma and tests. The performance results will be published soon in a technical paper.

UV FILTERS FOR MOON OBSERVATIONS

MAGIC was designed to observe under moderate Moon illumination conditions. Thanks to its low-gain photo-multipliers tubes (PMTs), MAGIC performs observations under moonlight for 300-400 hours per year, about 25-30% of the total available observation time. This feature is unique to MAGIC among Cherenkov telescopes. In addition, by reducing the PMT high voltages, we can point the telescopes as close as ~5 degrees away from the Moon, and look for the deficit of electrons and positrons that it produces in the diffuse flux cosmic rays. The Earth/Moon system forms a natural spectrometer in which the Moon absorbs part of the cosmic rays, creating a localized deficit in the isotropic flux (the so-called "Moon shadow") and the Earth magnetosphere deflects the trajectory of the incoming particles by an angle that depends on its charge and momentum. MAGIC has recently established the feasibility of this technique to observe the shadow of electrons and positrons above ~500 GeV. The main drawback is the narrow time window (35 hours per year) in which these observations are possible. Considering the MAGIC sensitivity and the flux of cosmic electrons and positrons, this means spending several years to measure the electron deficit (shadow), and the impracticality of observing the positron shadow. However, by using UV-pass filters in front of the cameras, it is possible to observe under much stronger Moon illumination, thus dramatically expanding the available time window to up to ~200 h per year. This opens the possibility of observing the electron shadow with MAGIC during a single (year-long) observational campaign and, depending on the performance, could lead to measuring the positron shadow as well. During 2014, we have produced at IFAE and equipped both MAGIC cameras with removable UV-pass filters (see Figure 3). We have selected commercial inexpensive filters rejecting light above a wavelength of 420 nm and mounted them on lightweight frames built at IFAE that can be easily mounted and dismounted on the telescope cameras. We have performed test observations during the last months, from which we have computed a moonlight transmission of about 20%

Fig. 3: The MAGIC PMT camera before (left) and after (right) the installation of the UV-pass filters. MAGIC PMTs have low gain, which allows observation under moderate moonlight. Thanks to the filters MAGIC is now able to observe in every Moon phase and as close as ~4 degrees away from the Moon.

DURING 2014 THE MAGIC COLLABORATION HAS PRODUCED 16 SCIENTIFIC PAPERS, OUT OF WHICH IFAE MEMBERS HAVE LED 7, INCLUDING ONE IN SCIENCE. THIS WAS THE 5TH MAGIC PAPER PUBLISHED IN THAT JOURNAL, AND THE 4TH LED BY AN IFAE MEMBER.

and a Cherenkov light transmission of about 45%. This allows the observation of sources down to an angular distance of 5 degrees to the Moon, even during Full Moon. Thanks to this, we can record a total of ~700 more Moon hours per year and hence extend the duty cycle of MAGIC by about 50%, including nights when observations with Cherenkov telescopes are at the moment not feasible. We are currently evaluating the performance in terms of sensitivity and energy threshold under different moonlight intensities, as inferred from our test Crab Nebula observations and Monte Carlo simulations. This work is still ongoing, and we expect to have the first results for the 2015 summer conferences.

PHYSICS EXPLOITATION OF THE MAGIC DATA

Apart from these new technical developments, during 2014 IFAE has continued being one of the leading institutes in the physics exploitation of the MAGIC data. In 2013 the MAGIC Collaboration approved its Key Observation Program (KOP), composed of six different projects defining the main MAGIC scientific objectives until the end of its lifetime, expected in 4-5 years from now. The KOP projects are given maximum priority in terms of observation time and resources. A Principal Investigator (PI) proposes and leads each of the projects, and IFAE members are PIs for two of them.

During 2014, two new PhD students and a post-doctoral fellow (who has obtained a Marie Curie fellowship in the 2014 call) joined our group. In addition, one PhD student and one master student defended their theses:

•A. López Oramas (PhD, now post-doc at the IRFU institute at Saclay, France) presented a detailed characterization of the VHE emission from the compact binary system LS I +61 303, discovered by MAGIC, including a study of yearly flux variability and a search for super-orbital modulation of the gamma-ray emission in a multi-year observational campaign. VHE emission was also searched for in other compact binary systems, finding no evidence, and placing the most constraining limits for the emission of those objects.

•D. Guberman (master, now PhD student at IFAE) presented a feasibility study for the observation of the cosmic electron/positron shadow with MAGIC using UV-pass filters, based on state-of-the-art models for the geomagnetic field and the sensitivity of MAGIC to detect diffuse fluxes.

In addition, one of the group theses produced during 2013 (Optimized dark matter searches in deep observations of Segue 1 with MAGIC, by J. Aleksić) has been awarded publication in the Springer Theses series in recognition for its "scientific excellence and impact on research".

During 2014 the MAGIC Collaboration has produced sixteen scientific papers, out of which IFAE members have led seven (corresponding authorship). These include: the most constraining limits to dark matter properties above few hundred GeV from observations of dwarf satellite galaxies; the discovery of the least luminous pulsar wind nebulae in VHE gamma-rays; or the discovery of the fastest gamma-ray flares seen to date, produced in the vicinity of a super-massive black hole. The latter result was published in Science, being the fifth MAGIC paper published in that journal, and the fourth led by a member of MAGIC-IFAE group. We provide further details about this result in the following paragraphs.

FASTEST GAMMA-RAY FLARES SEEN TO DATE

In the night from 12 to 13 November 2012, the MAGIC gamma-ray telescopes were observing the Perseus cluster of galaxies (at a distance of about 260 million light-years) when they detected a very fast varying VHE signal coming from one of the galaxies in the cluster, known as IC310 (see Figure 4). As many other galaxies, IC310 hosts in its center a super-massive black hole of several million times the mass of the Sun, which sporadically produces intense gamma-ray flares. On this occasion, however, the brevity of the flares, lasting only for a few minutes, could not be explained by the usual emission mechanisms.

THE MAGIC TELESCOPES HAVE RECORDED THE FASTEST GAMMA-RAY FLARES SEEN TO DATE, PRODUCED IN THE VICINITY OF A SUPER-MASSIVE BLACK HOLE, AND EXPLAINED THIS PHENOMENON BY A MECHANISM SIMILAR TO THAT PRODUCING LIGHTNING IN A STORM. THIS RESULT WAS LED BY IFAE AND PUBLISHED IN SCIENCE.

The reason is that Relativity suggests that no object can emit for a time shorter than it takes light to cross it. The black hole in IC310 has a size of about 20 light-minutes, approximately three times the distance between the Earth and the Sun. This means that the black hole cannot produce a flare shorter than 20 minutes. However, the flares observed in IC310 lasted for less than 5 minutes.

Up until now, the gamma ray emissions from galaxies such as IC310 were believed to originate in the particle jets produced by the black holes. These jets are detected in many galaxies, and they expand for hundreds of thousands light-years. When a jet points directly towards the Earth, a relativistic effect, called "apparent super luminous motion", is produced, due to the similar speeds at which the emitter (jet particles) and the emission (the gamma rays) travel toward us. As a result, the measured intensity of the gamma-ray emission is higher, and its variability faster. However, this explanation does not apply to the case of IC310, as its jets do not point at us, and it can be deduced that the gamma rays must be created practically on the black hole itself. Based on these results, we have proposed a new mechanism, according to which this "gamma-ray storm" is produced in the vacuum regions created close to the black hole magnetic poles. Very intense electric fields appear in these regions, and are destroyed when they are filled again with charged particles. These particles are accelerated up to close the speed of light, subsequently transferring part of their energy to the photons they find in their way, thus converting them into gamma rays. The time needed for the light to cross one of these vacuum regions is of a few minutes, in agreement with the observations of IC310. In a certain way, it is similar to what happens in an electric storm: the potential difference is so large that it ends up discharging into a lightning. The black hole appears to be immersed in a storm of colossal proportions.

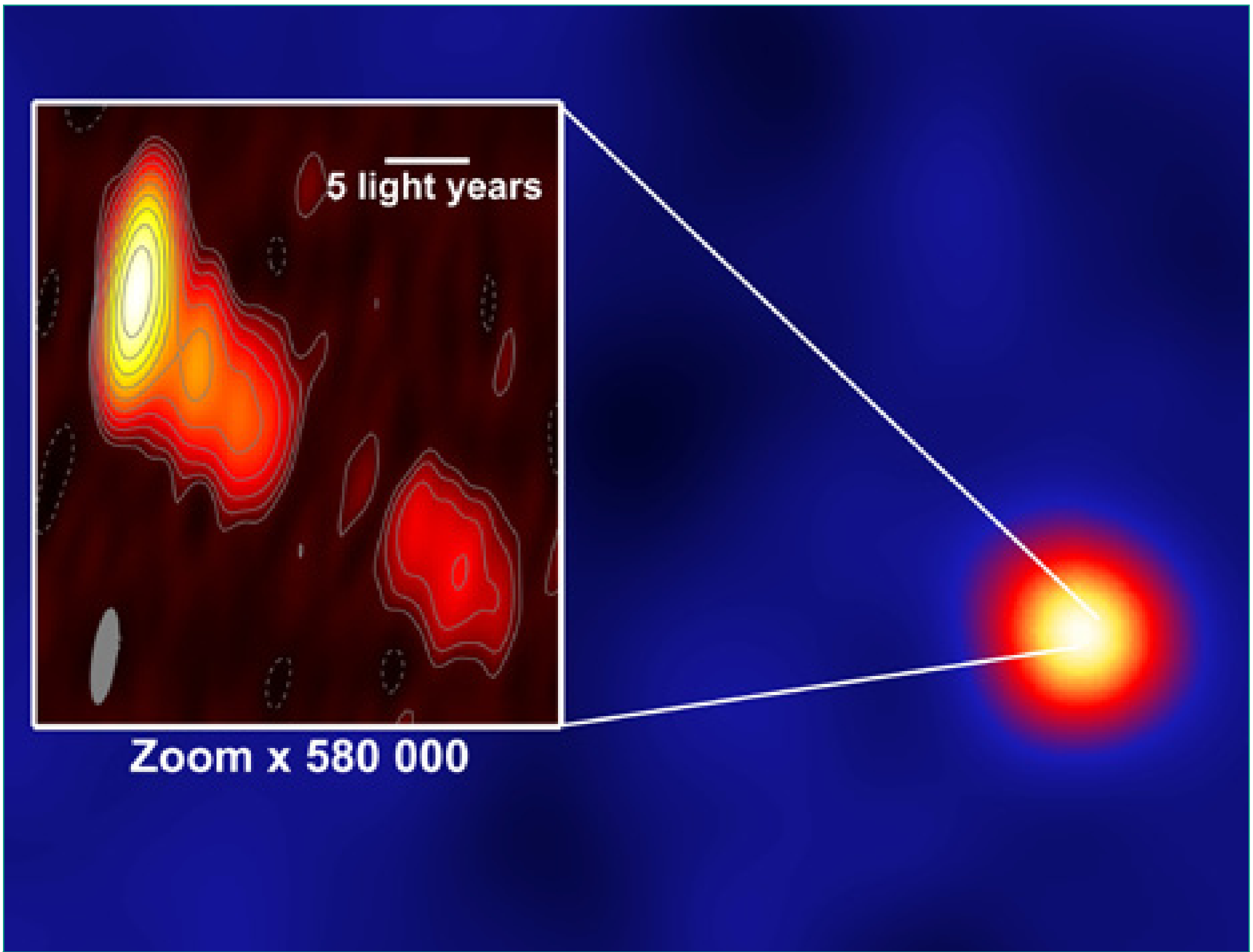


Fig. 4: Significance map (false color scale) of the Perseus cluster sky region in gamma rays observed in the night of November 12th, 2012, with the MAGIC telescopes. The bright source showed in the gamma ray image is IC 310. The insert shows the radio jet image of IC 310 at 5.0GHz obtained with the European VLBI Network (EVN) on October 29th, 2012. Contour lines (and false color scale) describe the structure of the jet departing from the central black hole. The ratio of the angular resolution between MAGIC and the EVN is 1:580000.

2.5 CTA: CHERENKOV TELESCOPE ARRAY

OSCAR BLANCH BIGAS

The Cherenkov Telescope Array (CTA) project is a worldwide initiative to build the next generation ground-based very-high-energy gamma-ray observatory. As an open observatory, it will serve a wide astrophysics community and will provide in-depth insight into the non-thermal high-energy universe.

INTRODUCTION

The present generation of imaging atmospheric Cherenkov telescopes (H.E.S.S., MAGIC, and VERITAS) in recent years opened the realm of ground-based gamma ray astronomy in the energy range above a few tens of GeV. The Cherenkov Telescope Array (CTA) will explore our Universe in depth in the domain of Very High Energy (VHE, E > 10 GeV) gamma-rays and investigate cosmic non-thermal processes, in close cooperation with observatories operating at other wavelengths of the electromagnetic spectrum, and with those using other messengers such as cosmic rays, neutrinos and gravitational waves.

Besides the anticipated high-energy astrophysics results, CTA will have a large discovery potential in key areas of astronomy, astrophysics and fundamental physics research. These include the study of the origin of cosmic rays and their impact on the constituents of the Universe, the investigation of the nature and variety of black hole particle accelerators, and the inquiry into the ultimate nature of matter and physics beyond the Standard Model, searching for dark matter and effects of quantum gravity.

The improvement in sensitivity is expected to match the development achieved by X-ray and low-energy (20 MeV-50 GeV) gamma-ray space-borne telescopes in recent decades. The design foresees a factor of about 10 improvement in sensitivity in the current very high energy gamma ray domain, from about 100 GeV to some 10 TeV, and an extension of the accessible energy range from few tens of GeV to above 100 TeV.

CTA is ranked as one of the top priorities by the European Astroparticle roadmap (ASPERA) and the European Astrophysics Roadmap (Astronet), and it is a recommended project for the next decade in the US National Academies of Sciences Decadal Review. Moreover, CTA was also reviewed and singled out amongst the ESFRI roadmap projects as one of the few to receive support from the European Union in the Horizon 2020 calls. It was also included as a High Priority Project in the Spanish Strategy for the participation in Scientific Infrastructures in 2010. In addition Spain is a candidate country to host the CTA North observatory that could be located in the "Observatorio el Roque de Los Muchachos" at La Palma island around the current MAGIC site.

SPAIN IS A CANDIDATE TO HOST THE CTA NORTH OBSERVATORY THAT COULD BE LOCATED IN THE "OBSERVATORIO EL ROQUE DE LOS MUCHACHOS"

MANAGEMENT IN CTA AND CTA-SPAIN

The year 2014 has been a year of changes and adaptation in CTA. The CTA-Observatory, that is expected to be the responsible entity to operate the two CTA sites, was created in spring and M. Martínez stepped down as co-spokesperson in fall 2014 after 5 years and a half serving as such. Critical decisions on the selection of the sites were done and negotiations for the one of the Southern Observatory started.

Despite, reducing the participation on the CTA-Consortium global management, IFAE has consolidated its leading role in the Large Size Telescope (LST) project. J. Cortina has became the Co-Principal Investigator of the project and M. Martínez the chair of the Steering Committee, while O. Blanch keeps coordinating the effort to built the cameras for the LSTs. The LST team is planning to built the first telescope starting in 2015 and having first light in September 2016.

It is also worth mentioning that J. Rico became the chair of the Speakers' and Publication Office of CTA.

Additionally, M. Martinez also continued as the leader of the 9 Spanish groups that presently constitute the CTA-Spain Consortium. It is fair to say that the CTA-IFAE group acted globally as the backbone of the CTA-Spain consortium.

IFAE HAS CONSOLIDATED ITS LEADING ROLE IN THE LARGE SIZE TELESCOPE (LST) PROJECT

SELECTION OF THE SITE FOR THE NORTHERN CTA OBSERVATORY

The full CTA-Spain Consortium has been proposing the Canary islands as the site for the Northern CTA Observatory since the very beginning. Two options were put forward, the Observatorio de Izaña (OI, Tenerife) and the Observatorio del Roque de los Muchachos (ORM, La Palma), although preference was given to the former because of larger available space and better accessibility of Tenerife. Beginning 2014, some doubts were expressed about the OI and CTA-Spain started to work hard to recover the proposal of La Palma. A detailed proposal addressing all possible criticism was built for the ORM and presented to the CTA Consortium and the Resource Board. IFAE had a leading role defining the possible locations of the totality of telescopes expected to be installed in the Northern CTA Observatory (see Figure 1). Possible degradations of the sensitivity due to the exact characteristics of the terrain where the telescopes would be installed were addressed by detailed Monte Carlo simulations. The results showed that the slightly modified footprint of the array of telescopes needed at the ORM would not produce any degradation of the expected sensitivity (see Figure 2).

In parallel, the LST project decided with the agreement of the full CTA Consortium to use the ORM as the site for the first LST that would produce its first light in 2016. The telescope is both a prototype and one of the 8 LSTs in total that will equip the CTA observatories. It will be installed in one of the foreseen positions for the LSTs in case ORM is chosen as the final site for the Northern CTA Observatory.

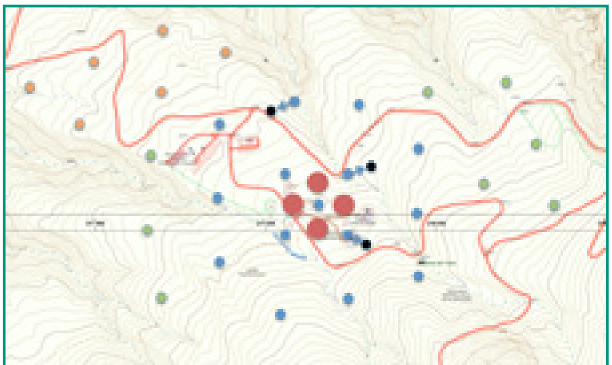


Fig. 1: Proposed footprint of the array to be installed in the Observatorio el Roque de los Muchachos.

CAMERA ELECTRONICS AND INTEGRATION

The general camera trigger strategy in current Cherenkov telescopes is based on looking for an excess of signal localized in a relative small region of the camera within a time window of a few nanoseconds. This approach allows reducing the trigger rate due to Night Sky Background (NSB) accidentals, whereas the trigger efficiency for gamma-like events remains high due to the compactness of their associated camera image.

The Level-0 trigger is responsible for collecting the signals from all pixels of the smallest autonomous hardware element: a module, which for the CTA camera will consist of 7 pixels. These signals are treated and then added together before being sent to the Level-1 decision trigger. IFAE collaborated with the Institute of Cosmos Sciences -University of Barcelona (ICC-UB) towards an ASIC with the functionalities of the Level-0, which was tested and qualified by IFAE during 2014. These ASICs are able

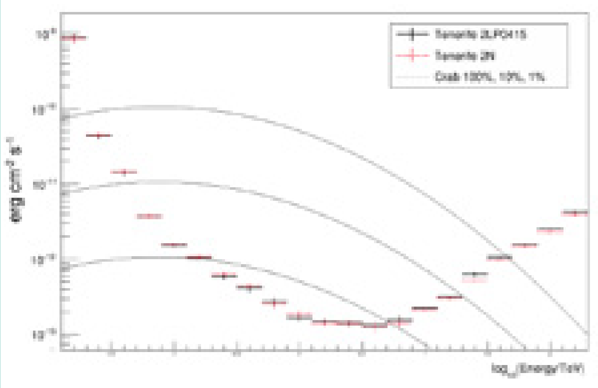


Fig. 2: Differential sensitivity of the baseline array (red, 2N) and the one proposed for the Observatorio el Roque de los Muchachos (black, 2LP0415).

to provide the Level-0 trigger for the so-called Sum trigger, a majority trigger or even a digital trigger. The Sum trigger Level-0 adds the analogue signals from all pixels in the module and sends the resulting signal to the Level-1 decision subsystem. Before adding the signals from individual pixels, each of them goes through a gain adjustment and clipping (both adjustable at the slow-control level). The former allows to equalize all pixel gains with a precision better than 5%. The latter cuts signals greater than a given value. The level-0 for the majority trigger compares the signal from each pixel to a voltage threshold. If the signal is greater than the threshold voltage, a gate, of width proportional to the time the pulse exceeds the threshold, is generated. The gates, generated in all pixels in the module, are analogically added. The amplitude of the added signal is proportional to the number of pixels with a signal above the threshold, and is sent to the Level-1 decision subsystem. The first version of the ASIC was shown to fulfill all the requirements and validated for final production. In parallel, IFAE developed the software and procedure to do the quality control for massive production.

Additionally, IFAE joined the exclusive club of producing ASICs for the trigger system to be installed in the CTA cameras. The signal from each module of 7 pixels has to be replicated and sent to the neighbor modules. The fanout based on components that was in charge of the replication stretched beyond the maximum required the signals. Hence, an alternative fanout was needed and had to be ready for massive production in 2015. A join effort of engineers and physicist from IFAE made possible to have a working solution based on an ASIC with the same technology than the others used in CTA, which reduces the final cost. The ASIC fanout is ready for massive production whenever is needed.

In parallel to the trigger developments, IFAE is responsible for the integration of the full camera. In this context, we have been testing PMTs and the readout system with the aim to start preparing the setup for the integrations, characterization and validation of the first camera to be built during 2015 and tested the first half of 2016. Additionally we worked on defining the power distribution inside the camera and we started to program the control software for the camera.

IFAE IS RESPONSIBLE FOR THE INTEGRATION OF THE FULL CAMERA OF THE LARGE SIZE TELESCOPE. THE TELESCOPE IS BOTH A PROTOTYPE AND ONE OF THE 8 LSTS IN TOTAL THAT WILL EQUIP THE CTA OBSERVATORIES

THE LIDAR

A LIDAR (LIght Detection And Ranging) is an optical remote-sensing technology that can measure the distance to a target and more of its properties by illuminating the target with pulses from a laser. Although it has also been used for other applications, the first LIDAR systems were used for studies of atmospheric composition, structure, clouds, and aerosols. This is still one of its most common applications. The LIDARs installed in the CTA observatory will be used to monitor and characterize the atmosphere. This should allow to reduce the systematic uncertainties affecting the imaging air Cherenkov technique and to increase the duty cycle of observations by correcting for the atmospheric conditions. Although LIDARs are commercially available, they do not meet the requirements set by CTA. To reduce the systematic uncertainties at the desired level, the atmospheric absorption should be known with a precision of about 5%. This entails the need to also use Raman lines, which have much less intensity. Furthermore, one needs to characterize the atmosphere up to the altitude where the Cherenkov photons are produced, which is about 10 km above ground.

IFAE had acquired two old telescopes with a 1.8 m diameter already installed in a standard ship container. They were part of the former CLUE experiment. One of them is installed on the campus of the Universitat Autònoma de Barcelona (UAB) and it has been used to develop a Raman LIDAR that fulfills the needs of the CTA observatory in collaboration with the UAB. In addition to the telescope, one needs the following elements to transform it into a LIDAR: a Laser, an alignment system to have the laser beam parallel to the telescopes axis, a light guide to transmit the light collected by the mirror from the focal to the optical detector, and the optical detector itself. In 2014, we finally got the all the permission from the relevant authorities to start the commissioning campaign shooting the laser at maximum power. Preliminary results showed the expected performance.

THE BOGIE, CENTRAL AXIS AND FOUNDATION

IFAE is in charge for the undercarriage of the LST structure, the foundations of the telescope and the central pin for azimuth rotation. The structure of the Large Size Telescope will move in its azimuth axis on an “undercarriage”. The undercarriage consists of wheels (assembled into “bogies”), a set of motors, a ground support for the wheels and a concrete foundation. All this has already been designed at IFAE. Very relevant to the design is the fact that the telescope is so light that strong winds are expected to lift it up. A prototype of one bogie and a section of the rail was built at the mechanical workshop of IFAE in 2014 (Figure 4). A set of static and dynamical tests were defined to be able to spot possible problems with the current design and partly validate it before building the remaining bogies of the first LST. This validation process will finish by mid 2015.

Figure 4: Detail of some of the pieces built at IFAE for the prototype of a rail section of one bogie.

DATA MANAGEMENT

VHE gamma-ray astronomy is evolving with CTA away from the old model of collaboration-led experiments towards that of a public observatory, where guest observers will submit observation proposals and have access to the corresponding data, software for scientific analysis and support services. The CTA Data Management project is in charge of developing the services and infrastructures needed to handle the large amount of data generated by the CTA observatory, and must fulfill the requirements of a public observatory.

In the last years IFAE has participated in the activities related to Data Model. IFAE has been responsible of the subgroup devoted to the model for the Instrument Response Functions (IRF), with strong links with other parts of the CTA project, such as Monte Carlo or the Science Gateway. Based on the work that led to define the high- and middle-level requirements as well as the specifications that will define the CTA Data Model, we have produced the first version of a framework that describes the IRF. This will be instrumental for the analysis of CTA data and developing this activity will help IFAE to have a leading role in physics exploitation of CTA.

2.6 THE DES PROJECT (DARK ENERGY SURVEY)

RAMON MIQUEL

Since 2005, a group at IFAE, together with a group at ICE (Institut de Ciències de l'Espai), located also in the Bellaterra campus, and another at CIEMAT (Centro de Investigaciones Energéticas, Medio Ambientales y Tecnológicas) and Universidad Autónoma de Madrid (UAM) in Madrid, collaborates in the DES (Dark Energy Survey) international project, led by Fermilab (USA).

INTRODUCTION

The main goal of the DES project is to survey 5000 squared degrees of the southern galactic sky in five optical and near-infrared bands (grizY) to unprecedented depth (i_{AB} ~ 24), measuring positions in the sky, shapes and distances of about 300 million galaxies and 10,000 galaxy clusters up to redshift z ~ 1.4. Furthermore, another ~30 square degrees of the sky are repeatedly monitored with the goal of measuring magnitudes and redshifts of over 3000 distant type-la supernovae.

These measurements will allow detailed studies of the properties of the so-called "dark energy" that drives the current accelerated expansion of the universe, using mainly four techniques: galaxy clustering on large scales, weak gravitational lensing, galaxy-cluster abundance, and supernova distances. The four probes are complementary both in their dependence on the properties of dark energy and on their sensitivity to different systematic effects, which therefore will be possible to keep under tight control.

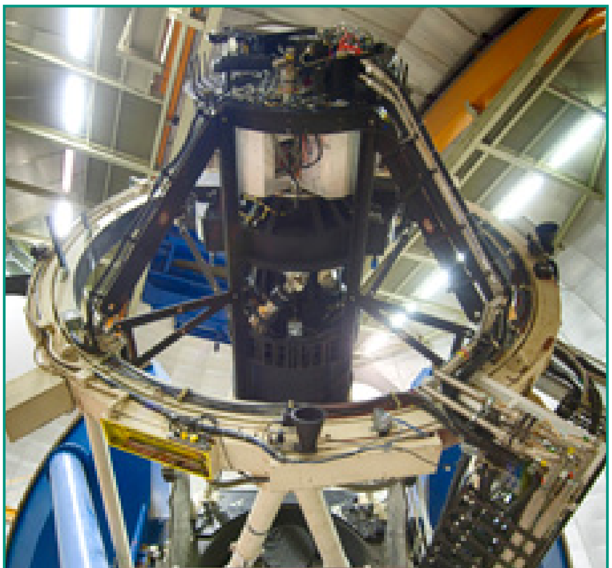


Fig. 1: The complete DES camera, DECam, installed at the prime focus of the Víctor M. Blanco telescope at the Cerro Tololo Interamerican Observatory (CTIO) in Chile.

THE GOAL OF DES IS TO MEASURE 300 MILLION GALAXIES AND 10.000 GALAXY CLUSTERS UP TO REDSHIFT Z~1.4. THESE MEASUREMENTS WILL ALLOW DETAILED STUDIES OF THE PROPERTIES OF THE "DARK ENERGY" THAT DRIVES THE CURRENT ACCELERATED EXPANSION OF THE UNIVERSE

THE DARK ENERGY CAMERA

To carry out this program, the DES collaboration has built one of the largest cameras in the world, the Dark Energy Camera (DECam) with 70 CCDs with a total of 570 Mpixels and a very large 3 sq. deg. field of view. The camera was installed in summer 2012 at the prime focus of the 4-meter Víctor M. Blanco Telescope in the Cerro Tololo Interamerican Observatory (CTIO) in Chile. In return for providing the camera, DES is granted 525 nights, 30% of all the observation time for five years. The completed DECam can be seen in Fig. 1, after being installed at the Blanco prime focus.

DECam saw its first light in September 2012 and was commissioned during the fall of 2012. The three Spanish groups, funded by both the Astronomy and Astrophysics and the Particle Physics programs within the National Plan of R+D+i, built the whole set of read-out electronics boards of DECam, and designed three out of the four main boards: the Clock and Bias Board (CB) at CIEMAT, the Master Control Board (MCB) at IFAE, and the Transition

Board (CBT) for the CB at IFAE and CIEMAT. All in all, IFAE produced 10 MCBs, and 28 each of ACQs and ACQTs. After the production, the boards were programmed and thoroughly tested at IFAE, and then shipped to Fermilab, where IFAE engineers participated in the integration and first commissioning of the whole read-out chain of DECam. All this work was finished in late 2010, in accordance with the schedule.

IN 2014 THE DES GROUP FOCUSED ON THE ANALYSIS OF THE DATA TAKEN IN THE DES SCIENCE VERIFICATION PERIOD, WHICH PROVIDED SCIENCE-QUALITY IMAGES FOR OVER 150 SQ. DEG. AT THE NOMINAL DEPTH OF THE SURVEY

A "Science Verification" (SV) period of observations, lasting until late February 2013, followed the DECam commissioning phase, and provided science-quality images for over 150 sq. deg. at the nominal depth of the survey. These data were processed, reduced and calibrated by the DES Data Management (DESDM) system, and, in August 2013, the data became available to the collaboration for science validation and the first science analyses. The first DES complete season, of a total of five, started in late August 2013 and went on until mid February 2014. This resulted in the imaging of about 1800 sq. deg. to about half the nominal depth of the survey. The data was reduced and made available in late 2014. The observations of the second season took place between August 2014 and February 2015, and the data taken are still being reduced at the time of this writing. In 2014 most of the effort of the IFAE group and DES as a whole was put into the analysis of the data taken in the DES-SV period.

THE DES MEASUREMENTS

The techniques DES uses to measure the properties of dark energy have the distance to the observed galaxies as a necessary ingredient. The distance determination is carried out from the redshift (z) of the galaxies, which in turn is obtained by photometric techniques using the flux in the five DES filters, resulting in the so-called photometric redshift, or photo-z. For the photo-z's to be useful for cosmological studies, they need to be calibrated, understanding in detail the statistical properties of the distribution of the differences between true redshifts and photo-z's: its mean value (bias), width (resolution), and tails (outlier fraction). For this calibration process, one needs to have a large set of galaxies with spectroscopic redshift measurements, ideally with a galaxy population reproducing that in the photometric survey.

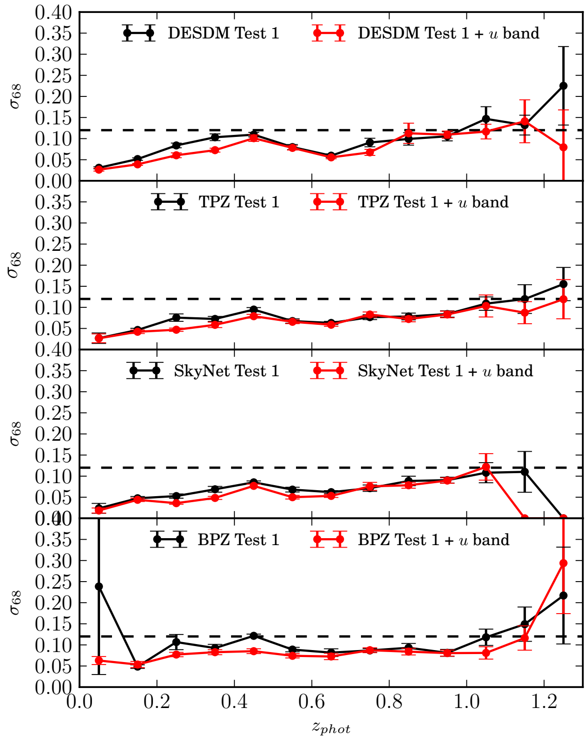


Fig. 2: Results from the calibration of the DES-SV photometric redshifts (photo-z's) using four representative photo-z codes. The plots show the photo-z resolution as a function of photo-z value. Black points correspond to the DES filter system, while for the red dots the u band, available in DECam but not used for DES, has been added. Dashed lines represent the DES requirement. TPZ and SkyNet (developed by Chris Bonnett at IFAE) fulfill the requirement in the whole photo-z range. Taken from C. Sánchez et al. (DES Collaboration), *Photometric redshift analysis in the Dark Energy Survey Science Verification data*, MNRAS 445 (2014) 1482.

During the SV period, four ~1 sq. deg. fields with extensive spectroscopic coverage by previous surveys, such as VVDS, zCOSMOS or ACER, were observed, resulting in close to a million galaxies with DECam 5-band photometry, with over 15,000 of them having secure spectroscopic redshift information. This sample was used to characterize the precision of several photo-z algorithms, and also to provide estimates for the true spectroscopic redshift distribution in several photo-z bins, which is needed for galaxy clustering and weak lensing tomographic studies with the main DES-SV galaxy sample. The IFAE group had a leading role in this photo-z calibration effort, leveraging the expertise built during the design phase of the PAU Survey (see chapter 2.7).

Although the set of galaxies with spectroscopy in the calibration fields reaches the DES limiting magnitude i_{AB} ~ 24, their magnitude and color distributions are markedly different from those of the galaxies in DES-SV. Therefore, before proceeding to the calibration of the photo-z's, the spectroscopic galaxy sample needs to be re-weighted to mimic the DES-SV photometric sample in all magnitudes and color. The IFAE group demonstrated that a simple weighting procedure in the g-r vs. i plane achieves this goal. Figure 2 shows the results of a study of the width of the (z_{phot} – z_{spec}) distribution using four representative photo-z codes. Dotted lines represent the DES requirements on the photo-z resolution. Even with these data from the Science Verification period, the TPZ and SkyNet (developed by Chris Bonnett, a post-doctoral researcher at IFAE) codes already fulfill the requirement in the whole photo-z range.

For the cosmological studies using either galaxy-galaxy angular auto-correlations or weak lensing tomography in well-defined photo-z bins, rather than knowing the redshift of each individual galaxy, one needs to know the true redshift distribution of the galaxies in each photo-z bin. This becomes, then, a second aspect of the photo-z calibration procedure. The histograms in Fig. 3 show the measurements of the real z (understood as the z measured spectroscopically) distributions for galaxies in six photo-z bins defined using four different photo-z codes. The red distributions correspond

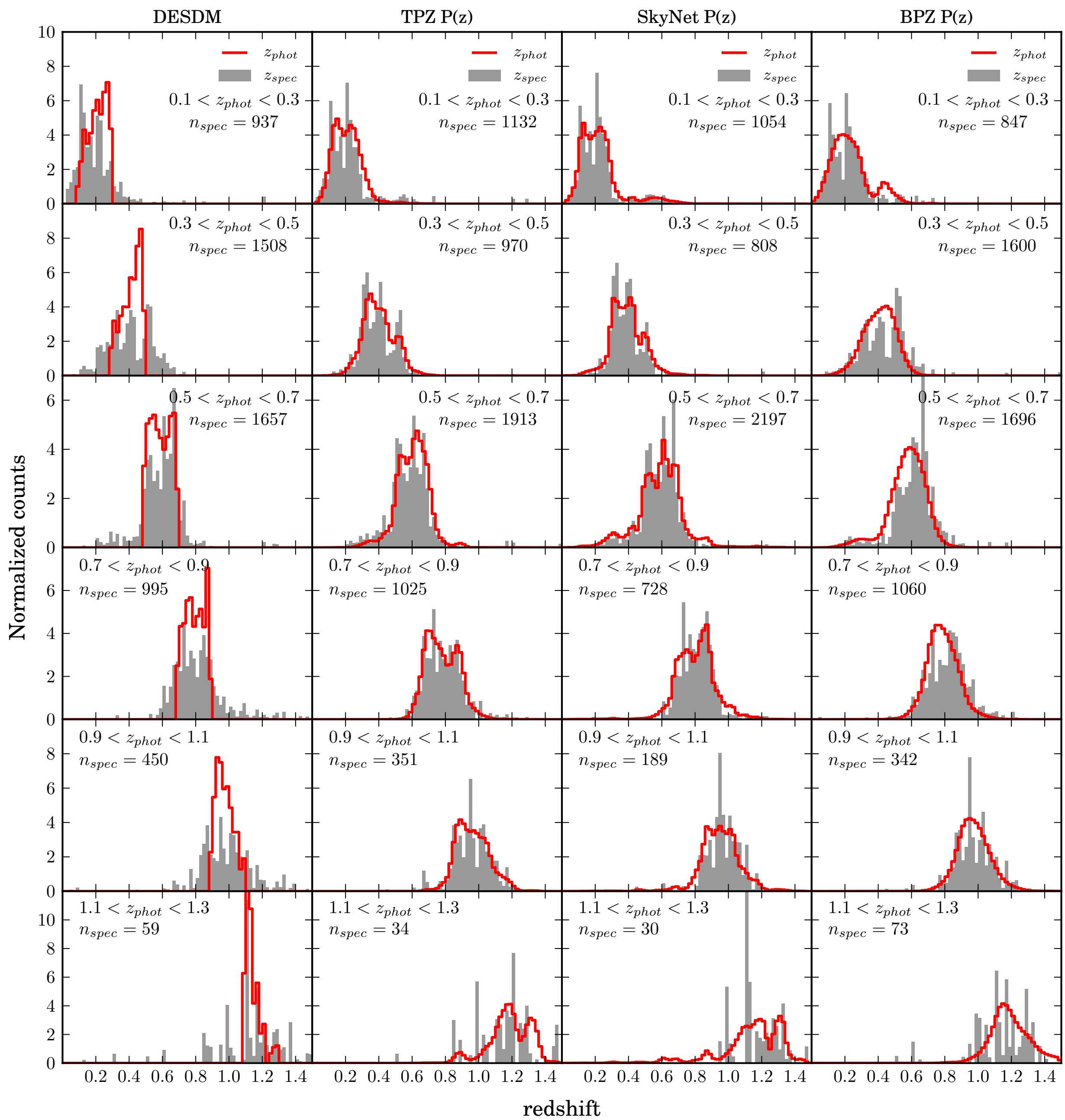


Fig. 3: Real redshift (understood as spectroscopic redshift) distributions (histograms) of the DES-SV calibration galaxies, split into six photo-z intervals of width 0.2, between 0.1 and 1.3. In red we show the photo-z distributions obtained with the four selected photo-z codes. The reweighting procedure mentioned in the text has been previously applied. Both TPZ and SkyNet manage to reproduce well the underlying redshift distributions. Taken from C. Sánchez et al. (DES Collaboration), *Photometric redshift analysis in the Dark Energy Survey Science Verification data*, MNRAS 445 (2014) 1482.

to photo-z distributions for the galaxies in each bin according to each code. All codes except DESDM return a probability density function (pdf) for the photo-z of each galaxy, and hence the distributions shown correspond to the stacking of those pdf's. Again, the distributions returned by TPZ and Sky-Net match quite closely the underlying spectroscopic distribution (after the reweighting procedure mentioned above). Figures 2 and 3 are taken from C. Sánchez et al. (DES Collaboration), *Photometric redshift analysis in the Dark Energy Survey Science Verification data*, MNRAS 445 (2014) 1482, the first published DES science paper, whose first author was Carles Sánchez, a PhD student at IFAE.

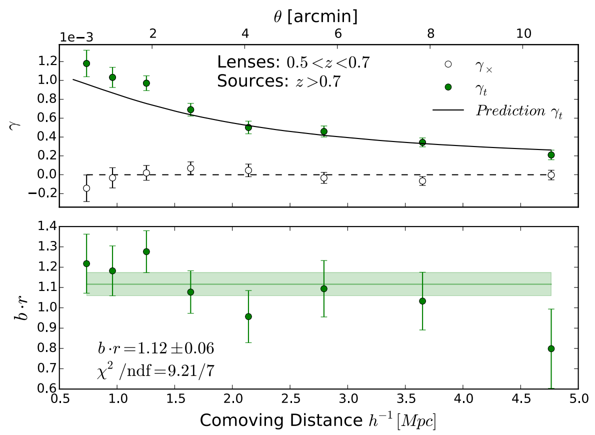


Fig. 4: Top: Preliminary measurement of the angular correlation between the position of galaxies in the DES-SV dataset with photo-z between 0.5 and 0.7 (lenses) and the shape of the galaxies in the same dataset with photo-z beyond 0.7 (sources). The green dots represent measurements using the ellipticity component tangential to the line joining each pair of galaxies, with errors estimated using jackknife; the black line shows the theoretical prediction for a distribution of lenses made of dark matter, therefore with bias (b) and stochasticity (r) both equal to 1. The open black points represent the measurements using the perpendicular ellipticity component, which should not show any correlation and serves as a systematic check. Bottom: Ratio between the data and the prediction for dark matter. The green band represents the values of the product b times r (assumed constant) that best fit the data. The x axis displays both the co-moving distance (bottom scale) and the projected angular separation (top scale) between each pair of galaxies. The measurements at different angular separations are highly correlated. Taken from Judit Prat's MSc thesis.

Beyond photo-z calibration, IFAE, together with the groups at ICE, CIEMAT and UAM, is concentrating its analysis work on probing dark energy through its influence on the large-scale structure (LSS) of the matter distribution in the universe. One of the strengths of DES lies on its ability to combine results from different measurements of cosmological interest. In particular, the combination of, on the one hand, the measurement of the angular auto-correlation between positions of low-z galaxies and, on the other, that of the cross-correlation between the position of low-z galaxies (lenses) and the shapes of high-z galaxies (sources) provides valuable information about the relationship between the distributions in space of galaxies and (mostly dark) matter. This relationship is generally parameterized through the bias b(z), which relates the amplitudes of both fields, and the stochasticity, r(z), which relates the phases. A first study in 2013 using catalogs of simulated galaxies confirmed the feasibility of the measurement. In 2014 the analysis with the DES-SV data has proceeded, and preliminary results are shown in Fig. 4, which presents the measurement in the

**THE DES-IFAE GROUP IS PROBING DARK ENERGY THROUGH ITS INFLUENCE ON THE LARGE-SCALE STRUCTURE OF THE MATTER DISTRIBUTION IN THE UNIVERSE.
THE ABILITY OF DES TO COMBINE RESULTS FROM DIFFERENT MEASUREMENTS OF COSMOLOGICAL INTEREST PROVIDES VALUABLE INFORMATION ABOUT THE RELATIONSHIP BETWEEN THE DISTRIBUTIONS IN SPACE OF GALAXIES AND DARK MATTER**

DES-SV data (~135 sq. deg.) of the angular cross-correlation between the positions of galaxies with $0.5 < z_{phot} < 0.7$ and the shapes of galaxies with $z_{phot} > 0.7$. The observed cross-correlation is due to the gravitational lensing effect which distorts ("shears") the galaxy shapes. The lower panel shows the product of the bias, b(z), and stochasticity, r(z), both assumed independent of angular separation. Since the auto-correlation between the positions of galaxies with $0.5 < z_{phot} < 0.7$ is proportional to $b^2(z)$, by combining the two measurements one can extract both b(z) and r(z) independently. This analysis has been performed in three photo-z bins, and Fig. 5 shows the evolution with redshift of the preliminary measured values of the product of b(z) with r(z), showing the expected rise with redshift. A DES paper based on these measurements is currently being written, led by IFAE scientists.

One of the challenges of deep imaging like that in DES is the discrimination between stars and galaxies, since the observed sizes of far away galaxies become comparable to those of stars, after the blurring created by the atmosphere and the telescope and camera optics. In DES, this is done using a classification scheme that combines several measured and reconstructed parameters of detected objects. The calibration of the algorithm is based on true (spectroscopic) properties of a limited number of stars and galaxies, resulting in an estimated ~2% stellar contamination in the selected galaxy sample (black star in Fig. 6). Jelena Aleksić, a post-doctoral researcher at IFAE, has developed a novel method for star/galaxy separation that involves both the Balrog package that she has co-developed and the above-mentioned SkyNet package. Balrog is a Python package that embeds simulated stars and galaxies into real astronomical images, allowing a robust determination of the completeness and purity of any algorithm that attempts to select galaxies in the DES images. By feeding a large number of image properties to an artificial neural network algorithm in SkyNet, the star/galaxy separation can be substantially improved and the performance of the algorithm can be assessed with Balrog.

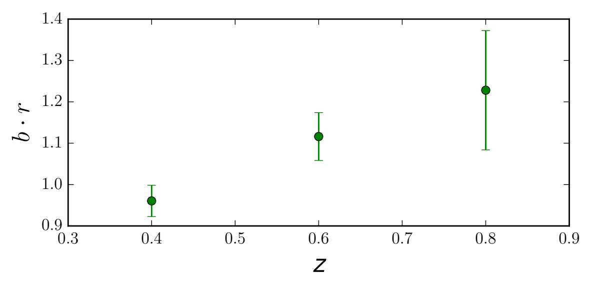


Fig. 5: Preliminary determination of the product b(z) * r(z) from galaxy-galaxy lensing measurements in the DES-SV dataset. One can observe the expected increase of b(z) with redshift z. Taken from Judit Prat's MSc thesis.

Figure 6 shows the preliminary stellar contamination vs. completeness of the selected galaxy sample. The black star marks the values obtained with the default DES classifier. The red line represents the results obtained with SkyNet, where each point corresponds to a different cut in the probability that the object is a star. The red star marks the cut in probability that optimizes a certain combination of completeness and purity of the selected galaxies. The new algorithm provides a factor of two reduction in stellar contamination for the same galaxy completeness. Depending on the science needs, this can be further reduced (e.g., if choosing a 99% completeness, the stellar contamination can drop to ~0.6%).

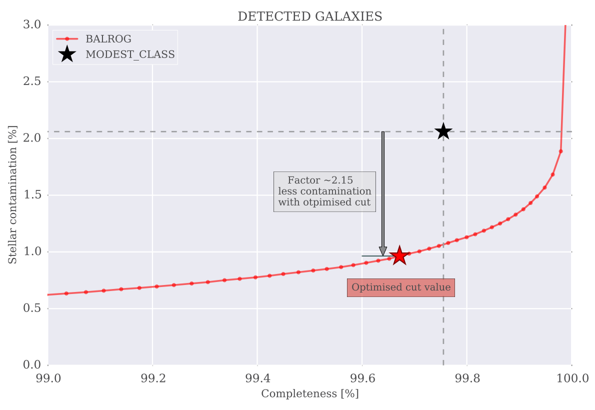


Fig. 6: Preliminary stellar contamination as a function of galaxy completeness (red line) for a SkyNet-based algorithm, assessed using Balrog. The black cross marks the results obtained with the default DES algorithm. For a similar galaxy completeness value, the algorithm developed by Jelena Aleksić achieves a factor two lower stellar contamination.

IN 2014 IFAE'S INSTITUTIONAL INVOLVEMENT IN THE GOVERNANCE OF DES HAS BEEN KEPT AT A HIGH LEVEL, A MEMBER OF THE IFAE GROUP BEING A MEMBER OF THE DES MANAGEMENT COMMITTEE, THE PUBLICATION BOARD, AND THE DES BUILDERS' COMMITTEE

MANAGEMENT POSITIONS

In 2014 our institutional involvement in the governance of DES has been kept at a high level, with a member of the IFAE group being a member of the DES management committee, the publication board, and the DES builders' committee, which grants paper authorship rights to the DES participants who have made substantial contributions to its infrastructure.

2.7 THE PAU PROJECT: PHYSICS OF THE ACCELERATING UNIVERSE

ENRIQUE FERNÁNDEZ

The goal of the PAU project is to prepare an internationally competitive experiment on the study of the accelerated expansion of the Universe led by Spanish groups. Scientifically that entails two main tasks: to build an appropriate instrument for that purpose (a large field of view camera, the main deliverable of the project) and to prepare, scientifically, technically and organizationally, to carry out a large galaxy redshift survey.

INTRODUCTION

PAU was a project funded by the Consolider Ingenio 2010 Program of the Spanish Ministry of Research and Innovation. The goal of the Consolider Program was to strategically fund scientifically competitive projects proposed by Spanish research groups, with the potential to advance in specific areas of science. The project was submitted to the Consolider Program early in 2007 by a collaboration of research groups from IFAE and six other Spanish Institutions, namely: CIEMAT (Madrid), IAA (CSIC, Granada), IEEC (Barcelona), IFIC (Valencia), IFT (Madrid) and PIC (Barcelona). It was approved in the summer of 2007, and effectively started in early 2008. It was extended twice, first for a period of one year, until the end of 2013, and then for two periods of 6 months each. As a Consolider Project, PAU has finished at the end of 2014. The work described here has been carried out in close collaboration with the IEEC and PIC groups, also located at the campus of Universitat Autònoma de Barcelona, and the CIEMAT and IFT/UAM groups in Madrid.

Originally the project focused in a survey to measure Baryon Acoustic Oscillations as a probe of dark energy for a planned 2.5m diameter telescope in Spain. However it became clear that the time scale for the construction of that telescope was longer than that of PAU, which led us to investigate other options during part of 2009.

In late 2009 it became clear that there was the possibility of installing an imaging instrument at the prime focus of the William Herschel Telescope (WHT) in La Palma. This is a 4m-diameter telescope (part of the Isaac Newton Group) formerly belonging to the UK and now run by a Consortium of the Netherlands, Spain and the UK.

The WHT has a field of view (FoV) of 1° in diameter with 85% light collection efficiency (of which 40' have 100% efficiency, see Fig. 1). In April 2010 a formal proposal was sent to the board of the ING in order to install the PAU Camera (PAUCam) at the WHT as a visiting instrument, with the provision that it could also be used by interested members of the WHT community of users, when not dedicated to the PAU survey. At their meeting on May 26th 2010, the ING board approved the status of visitor instrument for PAUCam and the Memorandum of Understanding was signed in early 2012.

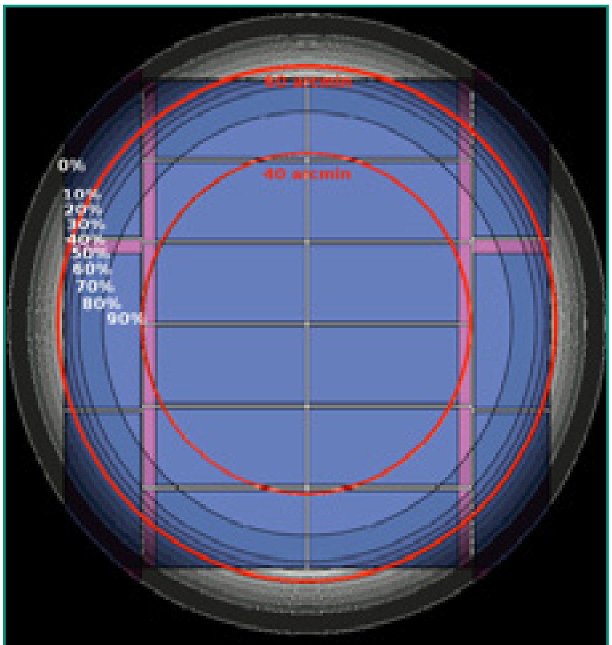


Fig. 1: Scheme of the position and coverage of PAUCam's CCDs. The Moon was put in the center of the image, to give an idea of its size.

THE PAU CAMERA

PAUCam will cover the entire FoV of the telescope with 18 2k x 4k fully-depleted red-sensitive Hamamatsu CCDs with 15 μm^2 pixels giving a 0.26"/pixel plate scale. The camera will use 40 narrow-band filters and the six standard ugrizY wide-band filters, taking advantage of the excellent sensitivity of the Hamamatsu CCDs across the entire wavelength range from 300 to 1000 nm.

Fig. 1 is a scheme of how the Moon will be imaged in the PAUCam focal plane. The CCDs are the blue rectangles in the background. The central part of the focal plane (the 8 CCDs marked by the yellow dashed rectangle), are almost entirely within the 40 arcmin fully illuminated field of view. Only the images from these CCDs will be used for science. The rest of the CCDs, wich are vigneted, will be used for guiding and pointing, as well as for the extra photons, when possible.

As a survey camera, PAUCam can cover ~2 deg^2 per night in all filters, delivering low-resolution (R~50) spectra for ~30000 galaxies, ~5000 stars, ~1000 quasars, ~10 clusters per night. The resolution in redshift z depends on the exact number, width and location of the narrow filters. A filter optimization study was carried out, converging in a solution with 40 narrow band filters (~ 10nm wide in wave length) covering the range between ~470 and ~830 nm. With this configuration PAUCam will be able to deliver very precise redshifts (σ_z~0.0035x(1+z)) for all galaxies with magnitude i_{AB} below 22.7, at the same time providing typical photometric redshift precision (σ_z~0.035x(1+z)) for galaxies with i_{AB} between 22.7 and 24.

PAUCAM IS ABLE TO PROVIDE LARGE QUANTITIES OF PRECISE REDSHIFTS FOR ALL OBJECTS IN THE FIELD OF VIEW. A PAUCAM SURVEY CAN COMBINE A LARGE GALAXY DENSITY WITH A HIGH REDSHIFT ACCURACY TO PROVIDE A HIGHLY COMPETITIVE DETERMINATION OF THE DARK ENERGY PARAMETERS

What makes PAUCam a unique instrument is to be able to provide large quantities of precise redshifts for all objects in the field of view. A survey performed with PAUCam can therefore combine a large galaxy density (larger than typical spectroscopic surveys such as BOSS) with a high redshift accuracy (higher than typical broadband photometric surveys such as DES) to provide a highly competitive determination of the dark energy parameters.

Our studies have centered in two dark-energy related observables: redshift-space distortions and weak-lensing magnification, for which PAU is uniquely suited.

- Redshift-space distortions originate in the peculiar velocities of galaxies, which trace the surrounding matter density fields. By measuring anisotropies in the galaxy 2-point correlation function, it is possible to determine the growth of structure at any given redshift, a most sensitive probe of dark energy. The relevant scales (~10 Mpc/h) are well matched to the redshift precision that PAUCam can deliver.

- Weak-lensing magnification affects the measured galaxy number density. In this case, the main observable is the cross-correlation between galaxies in different redshift bins as a function of angular separation. This is sensitive to dark energy through both the growth of structure in the universe and its geometry.

For the details of the reach of these observables and of the possible combination of measurements of the same area, combining photometric and "low resolution spectroscopic" (such as PAU), we refer to E. Gaztañaga et al., MNRAS, 422(2012) 2904. The combination of a deep photometric survey with a more shallow spectroscopic or PAU-like photometric survey of the same area, can give very competitive results, even with a relatively small (200 deg^2) surveyed area.

PAUCAM DESIGN AND CONSTRUCTION

Most of the details of installing PAUCam at the WHT, both technically and administratively, were planned during 2011. One of the main issues is the camera weight limitation of 235 Kg, which has resulted in a design in which the camera enclosure has been built with carbon fiber as opposed to aluminum, which is the usual material in this type of instruments. Additionally, the walls of the camera are curved in order to minimize the wall thickness while still maintaining the needed strength. The mechanical design was finalized in 2011.

PAUCam construction started in 2012 after successful design and prototyping. At the end of 2012 most of the major components were in hand and construction was well underway. The Carbon fiber body was built by injecting the material into a mold designed and fabricated in-house at the IFAE. The injection of the Carbon fiber into the mold took place at the enterprise Magma-Composites, located in Alcañiz, Teruel, during 2012. Once the camera body was back at the IFAE, all the tests done with the full-size Alluminum prototype were repeated. It was found out that some of the joints were not completely vacuum tight. After careful debugging and interaction with the construction company, this problem was solved.

The construction continued during 2013 as planned. Two major issues are the cooling and the vacuum systems needed to operate the camera. The vacuum during operations will be achieved with a getter pump (a Saes Getter GP500 model). The level obtained in the lab with the actual camera body and this pump is 10^{-7} ppm (higher than that needed for operations, which is 10^{-6} ppm). When the camera is off the main focus an additional turbo molecular pump (Navigator V 301 model) will be operated.
The PAUCam operating temperature will be of

about -100°C. This will be achieved with a set of two Polycold (Cryotiger) PCC PT30. Nitrogen cooling will also be possible when the camera is not in use and out of the WHT prime focus.

One of the key elements of the PAU camera is the positioning of the filter trays inside the camera enclosure to place them as close as possible to the CCD sensors therefore maximizing the FoV coverage. In order to accomplish this, a system of two tray lifts, each of them with seven trays, is installed. One lift will carry the filters needed for the PAU survey. The other will carry a set of standard broadband filters (the u g r i z y set) that can be used by other astronomers. Additionally, a system to install a filter outside the camera enclosure is foreseen.

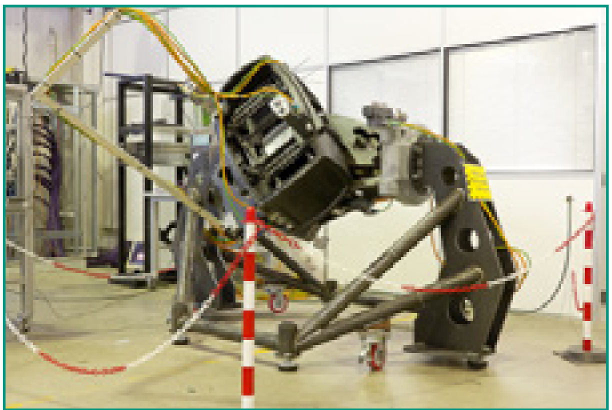


Fig. 2: The telescope simulator, with PAUCam mounted on it. The camera is open, and most of the elements are not installed inside.

Many studies of the materials, the cooling, the vacuum and the system to move the trays were done with a test setup made in aluminum, with a size similar to that of the actual camera. Also tested with this setup were many aspects of the control system, which involves a large amount of software. All these tests took place during 2011 and 2012, before the arrival of the final camera body. Many more tests have been done with the actual body of the camera during 2013. At every instance the control software, which is also a major deliverable of the project, has also been used to do these tests.

At the end of 2013 all major systems of the camera were finalized and the assembly had started. The focal plane mechanics, the cooling, the vacuum system, the filter-tray assembly and many other mechanical systems of the camera had been tested in the lab. On the other hand the acquisition of the narrow band filters took longer than anticipated and this was the main reason for asking for an extension of the project

Finalizing PAUCam requires not only to design and to manufacture the camera but also to test that it is working correctly, according to specifications. In our case it has been very important to build the so-called "Telescope Simulator". The simulator is a device that interfaces telescope and camera as in the actual WHT telescope. The device creates two rotation axes and can bring the camera to virtually every position that will be used in the actual survey. The simulator was also very useful to study the routes for cables from the camera to the outside. Figure 2 is an actual photograph of the device with the camera mounted on it.

We had planned to install the camera during 2014B, but in July of 2014 we had an unexpected problem reading the CCDs, which effectively caused another delay in the installation. The problem appeared when making tests of the complete system: the images had dark spots, which looked very much like droplets of ice. A visual inspection of the CCDs was consistent with this hypothesis.

After this problem we tried to understand in detail what caused it. The first measure was to remove the focal plane and storage it safely. For the tests it was substituted by a "dummy" focal plane, with 3 mounted chips, one "scientific" and two "engineering" CCDs. Despite the many tests done we have not been able to reproduce the problem. One of the operations was to bake out the entire focal plane for an extended time period. This has been very effective and also points to the most probable cause of the problem: a small leak in the camera vessel that went unnoticed or a sudden change in pressure due to a microscopic release of gas trapped in the camera walls. In fact small and sudden decreases in the camera pressure had been detected. The number of those micro-leaks decreased dramatically after the bake-out. After several months of tests all the camera components were re-assembled again. Figure 3 is a photograph of the interior of the camera, where one can see very prominently the system to cool the focal plane (in Copper) and also part of the tray elevator system. The commissioning of the camera at the telescope is scheduled for June 4-7 of 2015. The camera is now being tested mechanically and electronically and these tests will continue until it is sent to La Palma by the end of April.

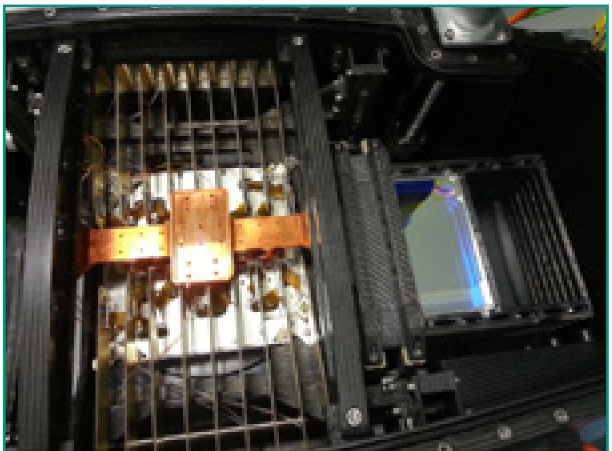


Fig. 3: A photograph of PAUCam being assembled. The focal plane will be mounted on top of the Copper cross clearly visible in the photograph. On the right one can see the filter trays (of that side). The long screws are part of the system that moves the trays.

2.8 THE EUCLID PROJECT

CRISTÓBAL PADILLA

Euclid is a mission for the European Space Agency (ESA) Cosmic Vision (CV) 2015-25 programme to explore how the Universe evolved over the past 10 billion years to address questions related to fundamental physics and cosmology on the nature and properties of dark energy, dark matter and gravity, as well as on the physics of the early universe and the initial conditions which seed the formation of cosmic structure.

INTRODUCTION

The satellite is expected to be launched in the first quarter of 2020 by a Soyuz ST-2.1B rocket and then travel to the L2 Sun-Earth Lagrangian point for a six years mission. To accomplish its goals, Euclid will carry out a wide survey of 15,000 deg^2 of the sky free of contamination by light from the Milky Way and the Solar System and a 40 deg2 deep survey to measure the high-redshift universe. The complete survey represents hundreds of thousands of images and several tens of Petabytes of data. Euclid will observe about 10 billion sources out of which more than one billion will be used for weak lensing. Several tens of million galaxy redshifts will be also measured and used for galaxy clustering. With these images Euclid will probe the expansion history of the Universe an the evolution of cosmic structures by measuring the modification of shapes of galaxies induced by gravitational lensing effects of dark matter and the 3-dimension distribution of structures from spectroscopic redshifts of galaxies and clusters of galaxies.

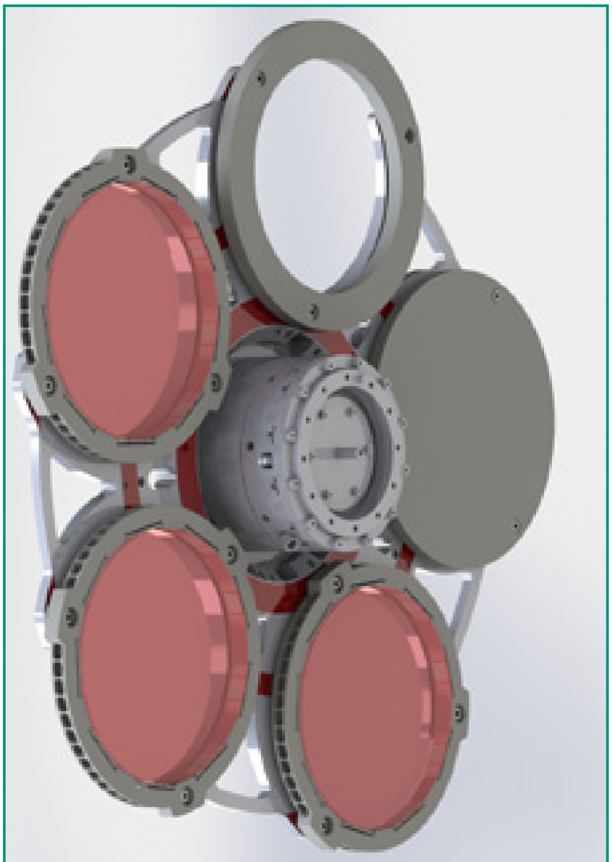


Fig. 1: The Filter Wheel Assembly (FWA) of the NISP Instrument. One can see the three filtres, the open and closed position and the Cryomechanism installed in the center of the wheel.

EUCLID WILL PROBE THE EXPANSION HISTORY OF THE UNIVERSE BY CARRYING OUT A WIDE SURVEY OF GALAXIES IN 15,000 DEG2 OF THE SKY. IT WILL BE LAUNCHED IN THE FIRST QUARTER OF 2020 AND THE MISSION WILL LAST SIX YEARS

THE EUCLID INSTRUMENTS

Euclid will be equipped with a 1.2 m diameter Silicon Carbide (SIC) mirror telescope made by Airbus Defense and Space feeding 2 instruments, VIS and NISP, built by the Euclid Consortium. These instruments are a high quality panoramic visible imager (VIS), a near infrared 3-filter photometer (NISP-P) and a slitless spectrograph (NISP-S).

IFAE has team up with the ICE (Institut de Ciències de l'Espai) and the PIC (Portal d'Informació de Catalunya) to participate in the simulation, in the science performance studies, the Spanish Science Data Center and the NISP Filter Wheel Assembly (FWA). During these years, the IFAE has concentrated efforts on the FWA development of the NISP.

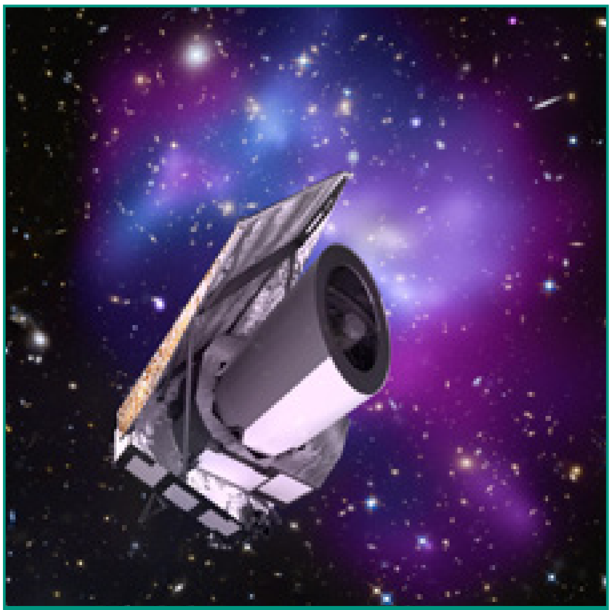


Fig. 3: Artist View of the Euclid satellite (Copiright ESA)

IFAE IS RESPONSIBLE FOR THE FILTER WHEEL ASSEMBLY (FWA) OF THE SPECTROMETER AND PHOTOMETER (NISP) INSTRUMENT OF EUCLID

The Near Infrared Spectrometer and Photometer (NISP) instrument aims at providing near infrared (between 1000 and 2300 nm) photometry of all galaxies observed by VIS and near infrared low resolution spectra and redshifts of them. The near infrared photometry will be combined with VIS data to derive redshifts and rough estimates of distances of galaxies seen by VIS. The near infrared spectra will be used to derive accurate redshifts and distances of galaxies and how they changed over the last 10 billion years.

The NISP focal plane is composed of a matrix of 4x4 2000x2000 teledyn TIS H2RG detectors covering a field of view of 0.53 deg^2. The spectroscopic channel will be equipped with 4 different low resolution near infrared grism. The photometric channel will be equipped with 3 broad band filters (Y, J and H). The NISP-FWA, that is responsibility of the IFAE, is the system responsible to position the corresponding filter in the image to be taken by Euclid.

The FWA is composed of the Filter Wheel (FW) the Filter Mounts where the 3 filters are glued and the Cryomechanism (CM), which is responsible to move the wheel into the selected position. The FWA should also have, in addition to the 3 filters, an open position and a shutter (closed) position.

The developments implies thorough engineering studies in order to ensure the FWA will withstand the vibrations that will suffer during launching and the thermal conditions in the open space. Thorough testing on the gluing and assembly procedure are needed to ensure the thermal stresses are correctly taken into account and the optical quality of the filters are maintained during the whole life of the Euclid mission. The manufacturing and assembly procedures need to be controlled to ensure they are reproducible. In order to accomplish all these, several models of the FWA will be constructed and tested. The IFAE has already produced a Bread Board model (BBM) that has been successfully tested and has made a lot of essays of the gluing procedure. During the next years, the assembly and manufacturing procedures will be fully qualified and additional models, approaching to the Flight Model will be built.

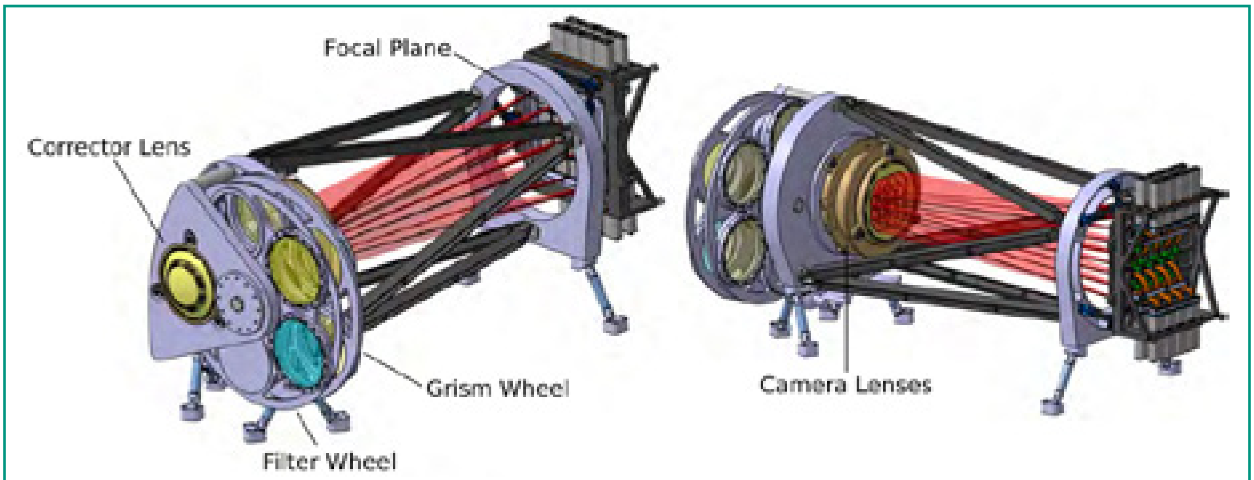


Fig. 2: Artistic view of the NISP Instrument. The FWA is mounted in front and select the filter that its positioned in the light path coming from the mirror before being detected in the Focal Plane

2.9 APPLIED PHYSICS

MOKHTAR CHMEISSANI & THORSTEN LUX

The focus of the applied physics research at IFAE is to develop sensor technologies with applications in medical imaging, high-energy physics and other scientific or industrial fields by exploting the valuable knowledge available at IFAE and fostering collaborations with other research centres in Catalonia like the Centro Nacional de Microelectronica (CNM) or the Institut de Ciències Fotòniques (ICFO) , medical centers like Hospital Parc Tauli, or companies like XRI and Multiscan Technologies.

INTRODUCTION

IFAE's medical imaging group is focused mainly on the development of new generation of Positron-Emission-Tomography (PET) Scanner that will resolve many intrinsic limitations that are embedded in the current PET devices. The group has experience in semiconductor pixel detectors technology and its use in digital medical imaging. Semiconductor pixel detectors are used in many detectors in the field of High Energy Physics and the aim of our research line is to mold this existing technology into a useful form to serve the interest of the public.

In this section we also summarize new instrumentation projects which arose from other IFAE projects and exploit synergies between different IFAE groups and with other research institutes in Catalonia and have the potential to develop into larger projects with time.

2014 WAS THE YEAR OF THE VIP CHIP PRODUCTION. TWELVE VIP WAFERS WERE ORDERED FOR THE PRODUCTION OF 18 VIP PET MODULES. THE TESTS HAVE SHOWN THAT VIP CHIP IS FULLY OPERATIONAL

VOXEL IMAGING PET (VIP)

The Voxel Imaging PET (VIP) Pathfinder project proposes a novel concept of PET to overcome the intrinsic limitations of the current state-of-the-art PET devices. It uses a stack of semiconductor pixel detectors to form a true 3D sensor which provides excellent energy and spatial resolution beside high detection efficiency when compared to current state-of-the-art of PET devices. Additionally, because of the orientation of the sensors within the design, the signals are not affected by a strong magnetic field, thus making it possible to be used for hybrid PET/MRI imaging systems. Though the VIP project is focusing on PET scanners, the concept can be extended to be used for PEM scanners and Compton gamma cameras.

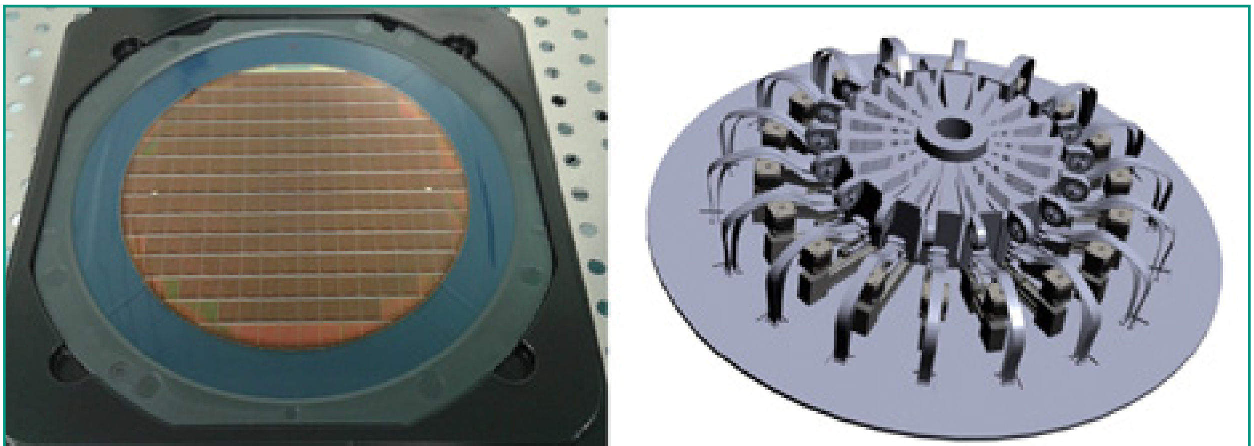


Fig 1: On the left hand side one can see the VIP wafer on dice tape. On the right hand side one can see the schematic of VIP PET ring with 18 VIP modules

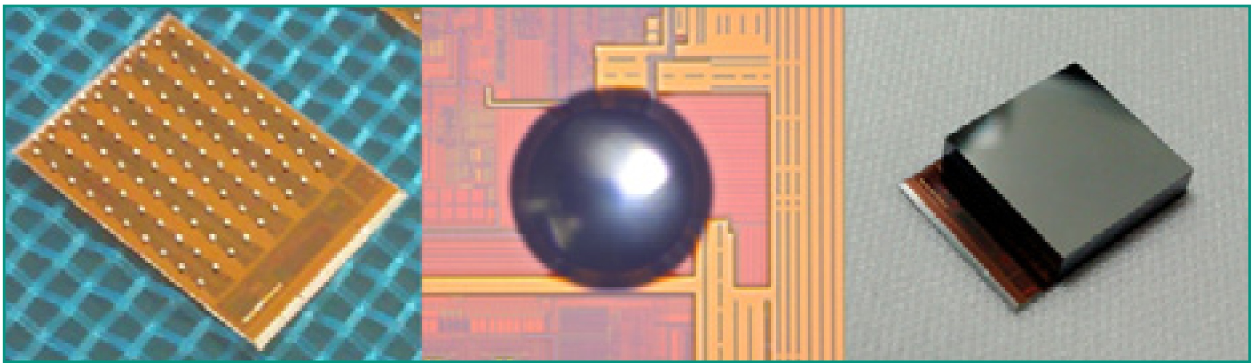


Fig 4: On the left one can see a single VIP chip (10mm x 13mm) and the UBM (gold) deposited at the input of each pixel. In the center one can see the 250um BiSn solder ball deposited on one of the input pixels. On the right one can see the VIP "sensor" which has a 10mm x 10mm x 2mm pixel CdTe detector bonded to a VIP chip via bump-bonding process.

VIP WAFER

2014 was the year of the VIP Chip production. Twelve VIP wafers were ordered for the production of 18 VIP PET modules (see figure5), to form one single ring of 13cm in diameter and 2.7cm in Z direction as shown figure 1.

The tests have shown that the VIP chip is fully operational with the exception of a few minor problems that effectively have no impact on the full test of VIP ring. It was a great success to have a successful engineering run from the first submission. One of the minor problems with the VIP chip, is the number of dead pixels. The chip has 100 pixels, an array of 10 x 10. Each pixel has 10 bits SAR ADC with low noise, equivalent to 0.5 least significant bit and this can be translated to 70e-. On average the chip has 7% of the channels with broken ADCs. A dead pixel means less detection efficiency but one can correct for this defect. The timing resolution is better than 1 nsec. The overall performance of the VIP chip is very good and will fulfill the needs of the VIP project specially when it comes to energy and timing-coincidence resolutions, as shown in figure 2. Testing individual VIP sensors have shown, on average, excellent energy resolution of 3.5% FWHM @ 122keV and 2.4% FWHM @ 511keV.

THE IFAE-MEDICAL IMAGING GROUP HAS MOUNTED AND WIRE-BONDED 4 VIP SENSORS. 18 VIP MODULES WILL BE ASSEMBLED IN 2015 TO FORM ONE PET RING WITH 720,000 CHANNELS

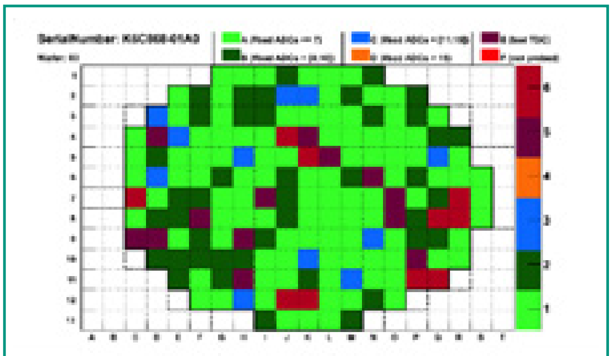


Fig. 3: A typical VIP wafer map after testing it with the probe machine.

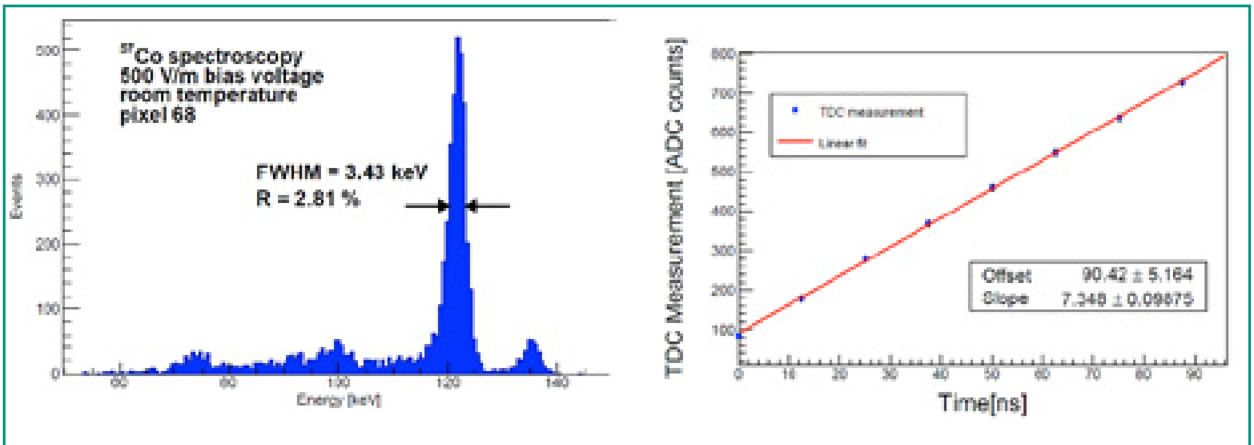


Fig 2: On the left hand side, one can see the spectroscopy of ^{57}Co and the clear separation of the two peaks at 122keV and 136keV. On the right hand side one can TDC response for various predefine Δt values. The sensitivity is 0.1nsec/bit and the overall timing resolution is 1nsec.

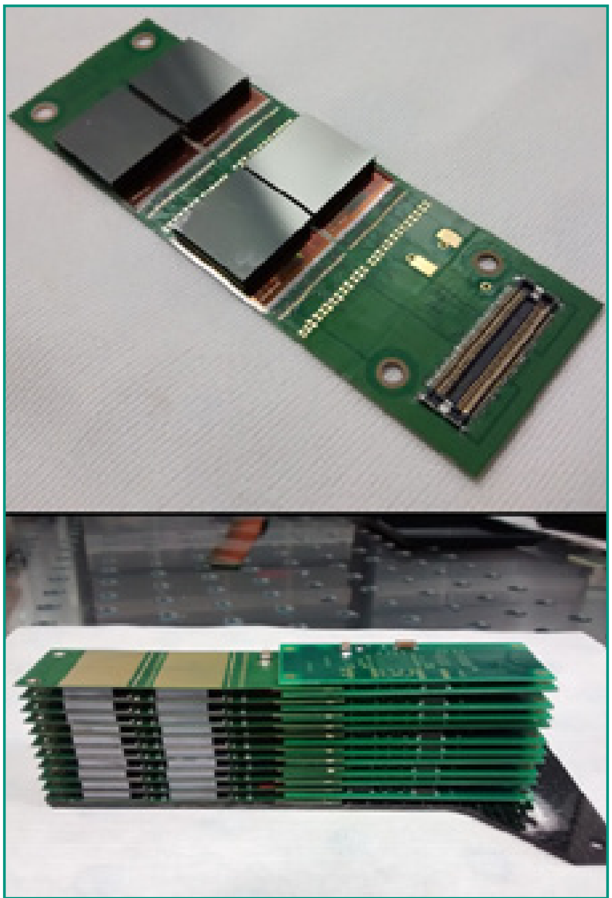


Fig 5: On the top one can see a single layer of the VIP module with 4 VIP sensors mounted on 255µm thick PCB. On the bottom one can see the VIP module, a stack of 10 layers, with the total of 40 VIP sensors. The VIP module has 4000 voxel sensors, and each voxel has the size of 1mm x 1mm x 2mm

The wafers were first probed by theVIP team using the wafer probe station at CNM-IMB. In figure 3 one can see the typical result from a VIP wafer. Over all we have enough VIP chips with 7 dead channels or less to make the full VIP ring.

VIP MODULE

The VIP wafers are processed at IZM-Fraunhofer for under-bump-metallization (UBM) at the I/O pixel pads, a prerequisite step for the deposition of solder and later thinning the wafer to 200um. In the IFAE clean room we deposited 250µm BiSn solder bumps on the VIP-chip using the Pactech SB2-SM. The CdTe pixel detector was bonded to the VIP-Chips using the XRI flip-chip machine FC150 to form what we call the VIP sensor, shown in figure 4.
The IFAE-Medical imaging group mounted and wire-bonded four VIP sensors to a thin (255um) flex PCB to form what we call the VIP single layer module as shown in figure 5. 11 VIP single layer modules are stacked on top of each other to form the VIP module as shown in figures 5 and 6. This module has 4000 voxels (channels), each has a CdTe detector of 1mm x 1mm x 2mm. 18 modules like this will be assembled in 2015 to form one PET ring with 720,000 channels (see figure 1).

THE ERICA PROJECT

The Energy Resolving LIne CAmera (ERICA), is a project funded by the Spanish Ministerio de economía y Competitividad, and is carried out in collaboration with X-Ray Imatek SL, and Multiscan Technologies SL, to develop a dedicated pixel sensor for X-ray line scan imaging applications in the field of quality control and security. The R&D is focused on the development of a dedicated ERICA chip which will be connected to pixel CdTe sensor via solder bump bonds. For this type of applications one does not need very small pixel size like the one used for mammography. For this reason it was decided to go for a pixel size of 220µm x 220µm. Although this size looks relatively large, it will eventually be one of the smallest, if not the smallest, pixel sensor with direct X-ray conversion. By direct X-ray conversion we mean the mechanism of converting the energy of the X-ray photon into electric signal. Instead, the commonly used sensors are based on scintillator detectors, such as Cesium Iodide (CsI) that convert the X-ray photon into tens of visible photons, coupled to CCD sensors to convert the visible photons into electric signal. The ERICA sensor approach is to use a high Z semiconductor detector, such as CdTe, connected to the ERICA chip by bump bonding. This will increase the electric signal by a factor of 100 and make it possible to measure the energy of every X-ray photon and thus to operate in photon counting mode.

For most of the X-ray line scan application, the maximum energy of the X-ray photon is 160keV. For this reason the ERICA frontend amplifier has been designed with dynamic range up to 200keV to avoid saturation.

In medical imaging, one can achieve excellent image quality when using dual energy subtraction technique. In such imaging modality, the object is imaged by soft X-ray energy and high X-ray energy and from the two energy levels one can extract very detailed images of the soft tissues, such as lungs,

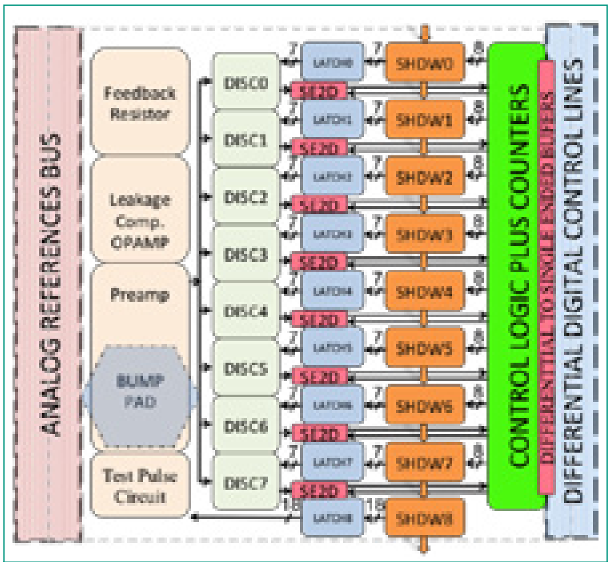


Fig 6. ERICA single pixel block diagram

THE ENERGY RESOLVING LINE CAMERA (ERICA), IS A PROJECT TO DEVELOP A DEDICATED PIXEL SENSOR FOR X-RAY LINE SCAN IMAGING APPLICATIONS IN THE FIELD OF QUALITY CONTROL AND SECURITY

and the hard tissue, such as the chest bones. This technique is also applied in some X-ray line scan machines. Given that ERICA chip is a photon counting chip, it has the capability to measure the energy of each X-ray photon and group them into multi-energy bins in one go. The number of the energy bins is effectively limited by the energy resolution of the sensor on one side, which is the combination of the resolution of the preamplifier + the detector response. and the pixel size on the other hand. For this reason we have found that 8 energy bins is a good compromise to have the spectroscopic informatiion stored in the 8 energy bins and maintain a spatial resolution of 220μm x 220μm. Fig. 6 shows the block diagram of single ERICA pixel. The expected size of ERICA chip is 4.4mm x 7.4mm as one can see in figure 7. To make a 10cm line camera, 24 ERICA sensors are needed. The current design of the front-end can handle a flux of 250kHz photons per pixel or 5.2MHz/mm^2.

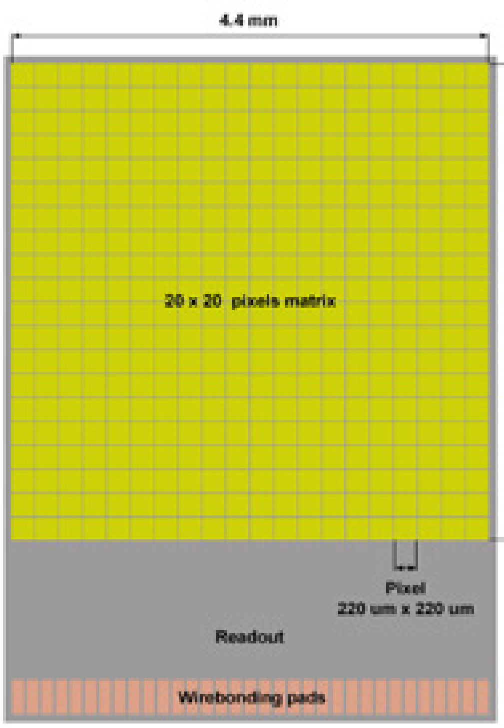


Fig. 7: Schematic layout of the ERICA chip. It has an array of 20x20 pixels with total size =4.4mm x 7.4mm

Since ERICA sensor will be operating in a line scan, its data acquisition should have zero dead-time to avoid any loss of data, because the scan belt will not stop during data transfer from the sensor to the PC. For this reason each pixel has two counters/energy level, one to read and one to count. We expect to have a working prototype by the end of 2015.

NEW INSTRUMENTATION PROJECTS

In this section we summarize instrumentation projects which arose from other IFAE projects and exploit synergies between different IFAE groups and with other research institutes in Catalonia and have the potential to develop to larger projects with time. The two projects are related to gas detector R&D, one aims on the development of a Si-MPGD and is carried out in collaboration with the institute Centro Nacional de Microelectronica (CNM) and the other is related to electroluminescence detectors for X-ray detection.

DEVELOPMENT OF SI-MICRO-PATTERN GAS DETECTORS COUPLED TO A MEDIPIX ASIC

The goal of this project is to develop a sensor using the MediPix chip to read out an integrated silicon Micro Pattern Gas Detector (MPGD). With funding from the Plan Nacional it is planned to upgrade an existing MPGD prototypes in order to obtain higher spark resistivity and allow operation at cryogenic temperatures. In parallel, various applications are being explored, such as tissue-equivalent-proportional-counters (TEPC) used to study the interaction between radiation and human tissue and applications for beam monitoring in proton beam therapy centers.

The project profits from knowledge available at the IFAE and the neighboring research center CNM. Over the last few years the IFAE neutrino group at IFAE accumulated valuable knowledge on the operation of gas detectors including those with MPGD readout. On the other hand, the medical imaging group has expertise in the operation of the MediPix chip and the group from CNM completes the team with its experience in processing silicon.

In 2014 we finished at IFAE the design studies about the geometry of the Si-MPGDs and the production of the samples was started at CNM. Establishing the production process was the main task during 2014. While testing the samples at IFAE we found several issues related to the production which CNM tried to eliminate in successive production runs. The main challenge is the high voltage stability of the samples. At the end of 2014 the first samples withstanding more than 1000 V without significant leakage current were produced. However, these samples were simplified in the design and these advances have to be integrated in a complete Si-MPGD. This will be the task for 2015.

THESE PROJECTS EXPLOIT THE TECHNOLOGIES DEVELOPED AT IFAE OVER THE LAST FEW YEARS. THE NEUTRINO GROUP HAS ACCUMULATED VALUABLE KNOWLEDGE ON THE OPERATION OF GAS DETECTORS AND THE MEDICAL IMAGING GROUP HAS EXPERTISE IN THE OPERATION OF THE MEDIPIX CHIP

Besides of the geometry simulations we at IFAE also finished the construction of the test chamber (Figure 8). The design of the chamber follows a multi-purpose approach so that the chamber will allow to test various ideas in the future with different kinds of electronics, commercial single channel readouts based on NIM amplifiers and MCA as also pixel readouts like the MediPix or the VIP chip. In fact, at the end of 2014 the first test with the latter and standard GEMs were performed to study if the VIP chip (see Medical Imaging section) also could be used for the readout of gas detectors. For 2015 measurements with an improved setup are planned.

HIGH PRESSURE AND ELECTROLUMINESCENCE DETECTORS R&D

Over the last years we built up at IFAE a gas detector laboratory for high pressure and electroluminescence detectors. In 2014 we finished an extensive study about the possibility to use Avalanche Photo Diodes (APDs) for the readout of an electroluminescence (EL) detector filled with xenon at almost 4 bar. The study provided an excellent result for the energy resolution of 5.2% FWHM for the 59.5 keV peak from Am-241. Figure 9 shows the APD readout plane used in the study and the Am-241 spectrum (red: raw data, blue: after calibration).

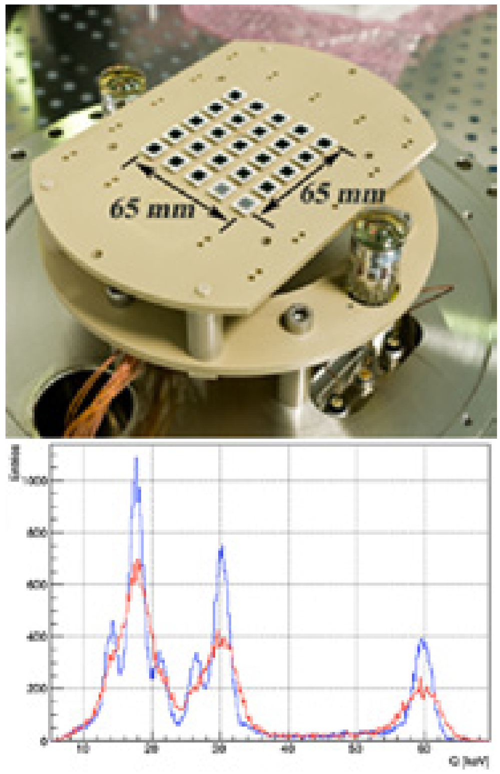


Fig. 9: (Top) APD readout plane (Bottom) measured spectrum before (red) and after applying the inter-calibration method (blue). The best result was 5.2% FWHM at 59.5 keV.

A full Monte Carlo simulation based on Geant4 was developed which not only reproduces the measurement result but also allows extrapolating to higher pressures and denser packed sensors. It turned out that with an improved readout, energy resolution of 2-3% FWHM could be achieved. In addition to energy measurements we also determined the achievable point resolution to 0.5 mm using cosmic rays crossing the chamber. A track is shown in Figure 10. The results from the tests of the detector were submitted to JINST and was accepted for publication. The study was a basis for a proposal of an ERC Consolider Grant in the field of medical imaging that passed the first phase but was rejected in the

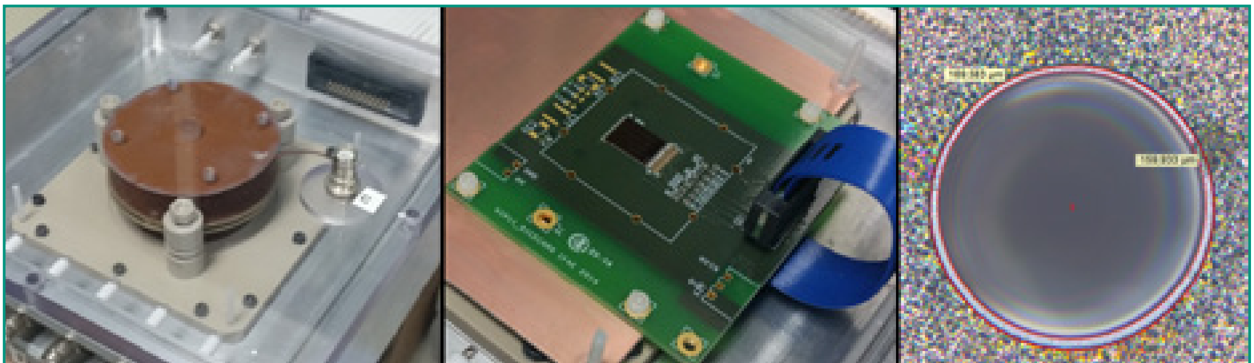


Fig. 8: (Left) The test chamber. (Middle) Installation of the VIP chip in the detector for first tests. (Right) Photo of the hole of one of the samples. One can see the surrounding aluminum, the “rim”, an area around the hole without metal, and the hole. The hole diameter is 80 μm.

DURING 2014, IFAE DEVELOPED IN COLLABORATION WITH ICFO THE READOUT ELECTRONICS FOR GRAPHENE LIGHT SENSORS. IN PARALLEL, THE GROUP AT ICFO STARTED TO WORK TOWARDS THE PRODUCTION OF LARGE GRAPHENE SENSORS SUITABLE FOR TESTS IN THE ELECTROLUMINESCENCE CHAMBERS AT IFAE

2nd evaluation stage. It is planned to resubmit the proposal in the next call after providing additional proof for the conceptual design idea.

For the setup several plans exist for the near and medium term future. The used APDs are also directly sensitive to VUV photons from argon (128 nm) what makes them possibly interesting for various applications. Until now argon light was detected using wavelength shifter, mainly Tetraphenyl butadiene (TPB), coated on the detector walls and the PMTs. Sensors directly sensitive to this kind of light and with fine pixels could be an improvement to current systems. For 2015, tests with a graphene light sensor are foreseen. During 2014, IFAE developed in collaboration with ICFO (Barcelona) the readout electronics for this kind of sensors. In parallel, the group at ICFO started to work towards the production of large graphene sensors suitable for tests in one of the EL chambers at IFAE.

Finally tests in the framework of WA105 and possibly future neutrino cross section detector based on a high pressure TPC are planned with this setup (see Neutrino section).

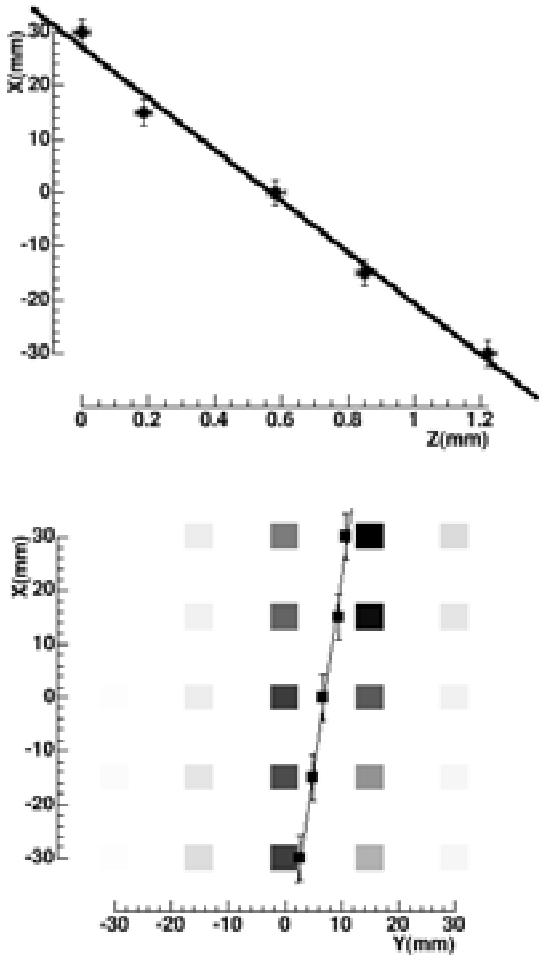


Fig. 10: View of a reconstructed real cosmic muon crossing the detector sensitive area, (Bottom) in the xy plane and (Top) in the xz plane.

2.10 X-RAY IMATEK

ALBERT SANCHO, CEO

X-Ray Imatek S.L. is a technological company focused on the field of Photon Counting Detectors based on the successful Medipix2/Timepix chip developed at CERN, Switzerland. Its technology improves the performance of existing products for different applications such as Homeland Security, Industrial Inspection, Life Sciences, mCT, Medical Imaging or Fundamental and Applied Research.

INTRODUCTION

Year 2014 has been full of changes and new challenges for X-Ray Imatek, both in the production and the management sides. In this report we bring an overview of the most important milestones, achievements and other relevant internal changes.

NEW RECRUITMENTS

The X-Ray Imatek's internal staff has grown from 3 to 5 people hired directly by the company. Now we've completed a high skilled team to face new projects and developments. We've incorporated Jesús Martínez as a new Hardware Engineer, in charge of FPGA programming and design of the new electronic readouts, and Manuel Lestón as a Lab Technician, with much experience and knowledge in microelectronics.

On the management side, Carlos Sánchez has left the company and has been replaced by Albert Sancho, CTO, who has taken his role as the brand new CEO of X-Ray Imatek. However, Carlos has been supporting the company even after his leaving in some important projects, since he is maintaining his position on the management board.

THE X-RAY IMATEK'S INTERNAL STAFF HAS GROWN FROM 3 TO 5 PEOPLE HIRED DIRECTLY BY THE COMPANY. NOW WE'VE COMPLETED A HIGH SKILLED TEAM TO FACE NEW PROJECTS AND DEVELOPMENTS

NEW DEVELOPMENTS

On 2014 we have introduced a new family of Medipix detectors, the eX Series. Originally aimed to substitute the current XRI Series, the new eX products provide a higher performance and customizing options to scientists and technicians in medium to large facilities, like synchrotrons. The eX is able to run any kind of detector from the Medipix and Timepix family, from Timepix to Me-

dipix 3RX. The final specifications were presented on latest IEEE NSS/MIC conference in Seattle, with encouraging feedback by its potencial users.

TWO NEW PROJECTS IN THE PIPELINE

During year 2014, X-Ray Imatek received founding for two R+D projects in different public funding programs.

The first one was ERICA "Energy Resolving Line Camera" inside the Retos-Colaboración program promoted by MINECO. This project aim is to design and develop a new photon counting detector camera suitable for the Food Inspection market needs. The project is made by a collaboration between X-Ray Imatek, IFAE and MultiScan, a private company specialized in machinery for Industrial Inspection. This is describen in more detail in the prevous section.

The second project was granted by the Eurostars program for SMEs and is being done in collaboration with Amsterdam Scientific Instruments, a spin-off company from NIKHEF, Netherlands. The project title is ASPECT "A New In-Vivo Spectral CT", and its aim is to build a mCT scanner capable of provide spectral information based on the Medipix and Timepix ASICs family.

Both projects will finish at the end of year 2016 and it will represent an important part of the daily work schedule of the company until then.

FORECAST 2015

Due to that year 2014 has been pretty intensive in developments and projects, we will focus year 2015 on getting a return of the investments. Hence, the commercial actions will take a very important role in comparison with the rest of R&D activities of the company.

These are some of the actions to be taken:
- Create a complete company product portfolio.
- New website
- Attending the iWoRiD conference in Hamburg and the IEEE NSS/MIC in San Diego.
- Regarding the products line, X-Ray Imatek is planning to become a Medipix 3 official vendor with a production license from CERN.

I

THEORY DIVISION

$$M^2W^+_\mu W^-_\mu - \frac{1}{2}\partial_\nu Z^0_\mu \partial_\nu Z^0_\mu - \frac{1}{2c_w^2}M^2 Z^0_\mu Z^0_\mu - \frac{1}{2}\partial_\mu A_\nu \partial_\mu A_\nu - \frac{1}{2}\partial_\mu H \partial_\mu H$$
$$\frac{1}{2}m_h^2 H^2 - \partial_\mu\phi^+\partial_\mu\phi^- - M^2\phi^+\phi^- - \frac{1}{2}\partial_\mu\phi^0\partial_\mu\phi^0 - \frac{1}{2c_w^2}M\phi^0\phi^0 - \beta_h[\frac{2M^2}{g^2}$$
$$\frac{2M}{g}H + \frac{1}{2}(H^2+\phi^0\phi^0+2\phi^+\phi^-)] + \frac{2M^4}{g^2}\alpha_h - igc_w[\partial_\nu Z^0_\mu(W^+_\mu W^-_\nu -$$
$$W^+_\nu W^-_\mu) - Z^0_\nu(W^+_\mu\partial_\nu W^-_\mu - W^-_\mu\partial_\nu W^+_\mu) + Z^0_\mu(W^+_\nu\partial_\nu W^-_\mu -$$
$$W^-_\nu\partial_\nu W^+_\mu)] - igs_w[\partial_\nu A_\mu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - A_\nu(W^+_\mu\partial_\nu W^-_\mu -$$
$$W^-_\mu\partial_\nu W^+_\mu) + A_\mu(W^+_\nu\partial_\nu W^-_\mu - W^-_\nu\partial_\nu W^+_\mu)] - \frac{1}{2}g^2 W^+_\mu W^-_\mu W^+_\nu W^-_\nu +$$
$$\frac{1}{2}g^2W^+_\mu W^-_\nu W^+_\mu W^-_\nu + g^2c_w^2(Z^0_\mu W^+_\mu Z^0_\nu W^-_\nu - Z^0_\mu Z^0_\mu W^+_\nu W^-_\nu) +$$
$$g^2s_w^2(A_\mu W^+_\mu A_\nu W^-_\nu - A_\mu A_\mu W^+_\nu W^-_\nu) + g^2 s_w c_w[A_\mu Z^0_\nu(W^+_\mu W^-_\nu -$$
$$W^+_\nu W^-_\mu) - 2A_\mu Z^0_\mu W^+_\nu W^-_\nu] - g\alpha[H^3 + H\phi^0\phi^0 + 2H\phi^+\phi^-] -$$
$$\frac{1}{8}g^2\alpha_h[H^4 + (\phi^0)^4 + 4(\phi^+\phi^-)^2 + 4(\phi^0)^2\phi^+\phi^- + 4H^2\phi^+\phi^- + 2(\phi^0)^2H^2]$$
$$gMW^+_\mu W^-_\mu H - \frac{1}{2}g\frac{M}{c_w^2}Z^0_\mu Z^0_\mu H - \frac{1}{2}ig[W^+_\mu(\phi^0\partial_\mu\phi^- - \phi^-\partial_\mu\phi^0) -$$
$$W^-_\mu(\phi^0\partial_\mu\phi^+ - \phi^+\partial_\mu\phi^0)] + \frac{1}{2}g[W^+_\mu(H\partial_\mu\phi^- - \phi^-\partial_\mu H) - W^-_\mu(H\partial_\mu\phi^+$$
$$\phi^+\partial_\mu H)] + \frac{1}{2}g\frac{1}{c_w}(Z^0_\mu(H\partial_\mu\phi^0 - \phi^0\partial_\mu H) - ig\frac{s_w^2}{c_w}MZ^0_\mu(W^+_\mu\phi^- - W^-_\mu\phi^+)$$
$$igs_wMA_\mu(W^+_\mu\phi^- - W^-_\mu\phi^+) - ig\frac{1-2c_w^2}{2c_w}Z^0_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) +$$
$$igs_wA_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) - \frac{1}{4}g^2W^+_\mu W^-_\mu[H^2 + (\phi^0)^2 + 2\phi^+\phi^-] -$$
$$\frac{1}{4}g^2\frac{1}{c_w^2}Z^0_\mu Z^0_\mu[H^2 + (\phi^0)^2 + 2(2s_w^2-1)^2\phi^+\phi^-] - \frac{1}{2}g^2\frac{s_w^2}{c_w}Z^0_\mu\phi^0(W^+_\mu\phi^- +$$

2.11 STANDARD MODEL

MATTHIAS JAMIN

The Standard Model of particle interactions is one of the major achievements of fundamental science. Within this framework a wide range of phenomena can be described to an impressive degree of accuracy. As a matter of fact, few are the branches of Physics where the predictive power of a theory has been tested to such a level of precision.

INTRODUCTION

The Standard Model (SM) subgroup of the IFAE theory division investigates the phenomenology of particle physics within the realms of the Standard Model. Even if physics going beyond the SM is expected, suggested for example by the presence of dark matter or neutrino masses, precise values of the fundamental SM parameters like couplings and masses are essential inputs for predictions within the SM, and beyond-SM physics should show up as clashes between those predictions and the experimental measurements. During 2014, the central research fields in our group were semi-leptonic decays of the B meson, hadronic decays of the tau lepton, development of Monte Carlo generators and the behaviour of higher orders in QCD perturbation theory.

SEMI-LEPTONIC DECAYS OF THE B MESON

The semi-leptonic decay $B\to K^*(\to K\pi)\mu^+\mu^-$ constitutes one of the most exciting channels for the search for physics beyond the SM since the data released in 2013 by the LHCb collaboration has indicated significant deviations from SM expectations. In order to be able to draw solid conclusions on potential high-scale new-physics effects, it is crucial that uncertainties from non-perturbative QCD, which mainly enter through $B\to K^*$ form factors and resonant $c\bar{c}$ intermediate states, are under control and properly included in the theory predictions. In the limit of large hadronic recoil the a priori seven $B\to K^*$ form factors can be expressed in terms of two soft form factors. Because of this property it is possible to construct a set of optimised observables in such a way that the form factors cancel at leading order in α_s and Λ_{QCD}/m_b.

The reduced form-factor dependence renders such optimised observables sensitive to subleading power corrections of order Λ_{QCD}/m_b for which the cancellation mechanism breaks down as they violate the large-recoil symmetries. In collaboration with Sébastien Descotes-Genon, Joaquim Matias and Javier Virto, Lars Hofer has developed a systematic

PRECISE VALUES OF STANDARD MODEL PARAMETERS ARE ESSENTIAL INPUTS FOR PREDICTIONS

method to supplement a calculation based on soft form factors by including factorisable power corrections, i.e. power corrections to the decomposition of the full form factors (calculated from light-cone sum rules) in terms of the two soft form factors. We have studied the impact of the renormalisation scheme chosen to define the soft form factors, and have demonstrated that QCD uncertainties from factorisable power corrections can substantially be reduced by a suitable choice of scheme. Based on our method we have calculated SM results for the complete set of angular observables, including also an estimate of non-perturbative charm-loop effects.

The experimental extraction of the coefficients of the angular distribution of $B\to K^*(\to K\pi)\mu^+\mu^-$ is hampered by S-wave pollution, i.e. by events originating from $B\to K^*_0(\to K\pi)\mu^+\mu^-$ with K^*_0 being a broad scalar resonance. In collaboration with Joaquim Matias we have identified symmetries of the amplitude that imply two relations among the angular coefficients of the S-wave. These relations can on the one hand be used to derive model-independent upper bounds on the corresponding angular coefficients, on the other hand they can be integrated in an experimental Monte-Carlo study and thus help to model the S-wave background.

HADRONIC DECAYS OF THE TAU LEPTON

Hadronic decays of the tau lepton are an interesting source of information for Quantum Chromo Dynamics at low energy. Inclusive decay rates as well as inclusive decay spectra allow access to fundamental parameters of the SM like the QCD coupling α_s, the strange quark mass, or QCD condensates that

arise in the framework of the operator product expansion (OPE). Furthermore, hadronic parameters like masses and widths of hadronic resonances can be extracted by studying exclusive decay spectra for particular final states. This allows in particular to investigate the hadronisation of QCD currents.
Regarding the description of exclusive decays of the tau lepton into two final state mesons, previously a representation was developed by our group that combines constraints from dispersion theory, chiral perturbation theory at low energy as well as information on the high-energy behaviour of the involved form factors as well as their analytic structure. This representation was successfully applied to describe the decay spectrum of the decay $\tau^- \rightarrow K_S \pi^- \nu_\tau$ as measured by the Belle collaboration and was used to extracted the mass and width of the K*(892) resonance with good precision and to a lesser extent also the parameters of the excited K*(1410) resonance.

Subsequently, our description was applied to the decay $\tau^- \rightarrow K^- \eta^- \nu_\tau$, also measured by the Belle collaboration, which allowed to confirm the mass and width of the K*(1410). These two independent analyses lead to the idea to perform a combined fit to both decay channels as the former is more sensitive to the contribution of the K*(892) resonance while the latter, due to the higher energy threshold, receives larger contributions from the K*(1410) state. The corresponding analysis was performed in collaboration with Rafel Escribano, Sergi González-Solís, and Pablo Roig and our central fit to Belle data is displayed in Figure 1. It is observed that the dispersive representation provides a very good description of the experimental decay spectra.

Regarding the mass of the K*(1410) resonance a considerable improvement as compared to the previous analyses could be achieved, where the mass is defined as the real part of the complex resonance pole position. A comparison to older analyses is displayed in Figure 2. On the other hand, the uncertainties on the width of the K*(1410) could only

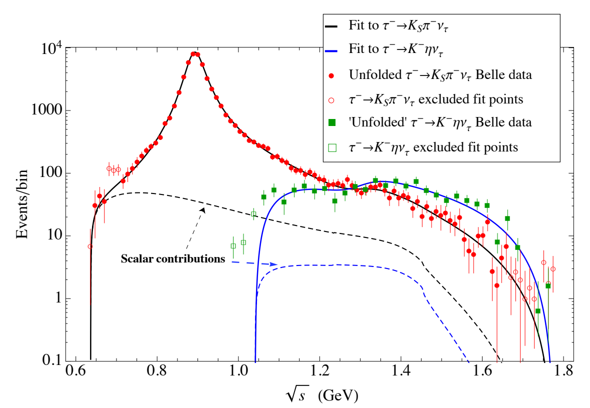


Fig 1: Belle $\tau^- \rightarrow K_S \pi^- \nu_\tau$ (red circles) and $\tau^- \rightarrow K^- \eta \nu_\tau$ (green squares) data as compared to our best fit results (black and blue solid lines). The small scalar contributions which only play a role for the Kπ channel at low energy have been depicted by the dashed lines.

THE SEMI-LEPTONIC DECAY OF THE B MUON IS AN EXCITING LINE OF RESEARCH FOR PHYSICS BEYOND THE STANDARD MODEL

be improved mildly. Concerning the future it would really be interesting if the B-factories could also measure the isospin companion decay $\tau^- \rightarrow K^- \pi^0 \nu_\tau$ in order to corroborate our findings. The corresponding isospin violations are currently under theoretical investigation.

Furthermore, we applied an analysis method previously developed for the extraction of the strong QCD coupling from the OPAL data to the recently revised ALEPH data for non-strange hadronic tau decays. Our analysis yields the values $\alpha_s(M_T)$ = 0.296 3 0.010 using fixed-order perturbation theory, and $\alpha_s(M_T)$ = 0.310 3 0.014 using contour-improved perturbation theory. Averaging these values with our previously obtained values from the OPAL data, we find $\alpha_s(M_T)$= 0.303 3 0.009, respectively, $\alpha_s(M_T)$ = 0.319 3 0.012. We presented a critique of the analysis method employed previously, for example in analyses by the ALEPH and OPAL collaborations, and compared it with our own approach. The conclusion is that non-perturbative effects limit the accuracy with which the strong coupling, an inherently perturbative quantity, can be extracted at energies as low as the tau mass. Our results further indicate that systematic errors on the determination of the strong coupling from analyses of hadronic τ-decay data have been underestimated in much of the existing literature.

MONTE CARLO GENERATORS

Collider signatures of new physics (like SUSY cascade decays) and their backgrounds typically involve many particles in the final state. The complexity of NLO calculations tremendously grows with the number of external particles, and for large particle multiplicities high standards with respect to numerical stability and CPU efficiency have to be met by the computational tools. Therefore we are working on the development of powerful tools for the amplitude generation (the NLO generator RECOLA developed in collaboration with Stefano Actis, Ansgar Denner and Sandro Uccirati), as well as for the calculation of one-loop tensor integrals (the integral library COLLIER developed in collaboration with Ansgar Denner and Stefan Dittmaier).

As a first application of the NLO generator Recola, Lars Hofer, in collaboration with Ansgar Denner, Andreas Scharf and Sandro Uccirati, has calculated electroweak corrections to the production of a charged lepton pair in association with two hard jets for the LHC run at 13 TeV, including the complete set of partonic channels as well as all off-shell effects. We found the electroweak corrections to be small on the total cross section (~-(2-3)%), while they can amount up to ~-30% in the tails of some distributions because of large Sudakov logarithms.

THE STANDARD MODEL GROUP AT IFAE IS WORKING ON POWERFUL MONTECARLO GENERATOR TOOLS FOR NEW PHYSICS

QCD PERTURBATION THEORY

The last work that shall be mentioned concerns the behaviour of QCD correlations functions at large orders in the perturbative expansion which is assumed to comprise an asymptotic series. In the past, in collaboration with Martin Beneke, the behaviour of the light-quark vector correlation function has been investigated and a model for its large order behaviour was constructed, based on available information for the analytic structure of the Borel transformed correlator, simultaneously matching the model to the analytically known low order perturbative coefficients. The viability of the model could be tested by comparing to the so-called large-β_0 approximation which is known to share essential features of the full QCD result though probably not its precise detailed behaviour.

Another important two-point correlation function is the scalar correlator which for example plays an important role in the Higgs decay into quarks, or the extraction of quark masses from QCD sum rules. Therefore, it would be very interesting to also have available estimates of the large order behaviour of this correlation function. A complication compared to the vector correlator is the fact that in contrast to the vector current which is a renormalisation group invariant object, the renormalisation group properties of the scalar current are linked to the quark mass. As a consequence, already the large-β_0 approximation for the scalar correlation function is considerably more complicated. Still, work on a model for the all-order perturbative behaviour of the scalar correlator is in progress and should be available in the near future.

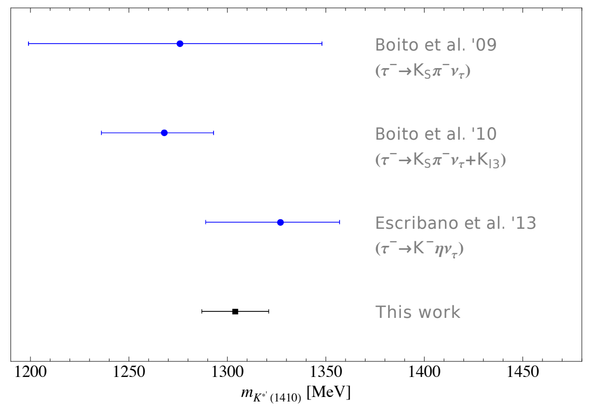


Fig 2: Comparison of our result for the mass of the K*(1410) resonance as compared to previous extractions of this quantity.

2.12 BEYOND STANDARD MODEL

JOSÉ RAMÓN ESPINOSA

A number of strong theoretical and experimental reasons indicate that the Standard Model (SM) is an effective theory, derived from a deeper theory of more fundamental character, and only valid up to a limited range of energy. Current experiments, notably at the LHC, are enlarging that energy range in search for new phenomena that cannot be explained within the SM.

INTRODUCTION

The Beyond the Standard Model (BSM) subgroup of the IFAE theory division works at the high energy frontier exploring what theories might supersede the Standard Model and what experimental implications they would have.

Perhaps the most pressing theoretical puzzle ahead concerns the nature of electroweak symmetry breaking: to determine the physics responsible for the pattern of the electroweak forces and the masses of elementary particles we see in nature. The recent discovery of the Higgs boson by the LHC is giving us precious information to advance in the understanding of this fundamental problem. The work of the subgroup during 2014 focused on the following topics.

SCALING & TUNING OF EW & HIGGS OBSERVABLES

Christophe Grojean, Sandeepan Gupta and Joan Elias-Miró, in collaboration with David Marzocca, studied deformations of the SM via higher dimensional operators. In particular, they explicitly calculated the one-loop anomalous dimension matrix for 13 bosonic dimension-6 operators relevant for electroweak and Higgs physics. These scaling equations allow to derive Renormalization Group-induced bounds, stronger than the direct constraints, on a universal shift of the Higgs couplings and some anomalous triple gauge couplings by assuming no tuning at the scale of new physics, i.e. by requiring that their individual contributions to the running of other severely constrained observables, like the electroweak oblique parameters or $\Gamma(h\to\gamma\gamma)$, do not exceed their experimental direct bounds (see Figure).

OFF-SHELL HIGGS PROFILE

As for any other quantum particle, the existence of the Higgs boson is not limited to its mass shell. Recently, the CMS and ATLAS collaborations reported the differential cross-section measurement of $pp\to Z^{(*)}Z^{(*)}\to 4l$, at high invariant-mass of the ZZ system. This process receives a sizable contribution from a Higgs produced off-shell by gluon fu-

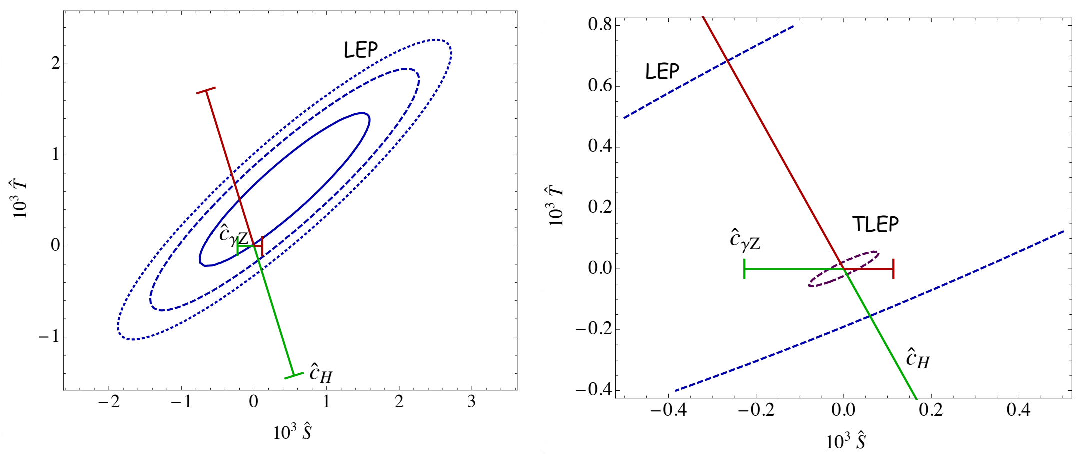


Fig. 1: RG-bounds on EW/Higgs data. The blue line represents the 68% (solid), 95 (dashed) and 99%(dotted) CL bounds on S and T. The straight lines represent the RG-induced contribution to the oblique parameters from the weakly constrained observable couplings, divided in Higgs couplings. The length of the lines corresponds to their present 95% CL direct bounds.

sion due to the intricate structure of the Higgs couplings to gauge boson longitudinal polarizations. Christophe Grojean in collaboration with Aleksandr Azatov, Ayan Paul and Ennio Salvioni showed that this channel can be used to resolve the long- and short-distance contributions to Higgs production by gluon fusion and can thus be complementary to pp→htt in measuring the top Yukawa coupling.

ONE-LOOP NON-RENORMALIZATION RESULTS IN EFTS

In Effective Field Theories (EFTs) with higher-dimensional operators many anomalous dimensions vanish at the one-loop level for no apparent reason. With the use of supersymmetry, and a classification of the operators according to their embedding in super-operators, Joan Elias-Miró and José R. Espinosa, in collaboration with Alex Pomarol, were able to show why many of these anomalous dimensions are zero. The key observation was that one-loop contributions from superpartners trivially vanish in many cases under consideration, making supersymmetry a powerful tool even for non-supersymmetric models. They showed this in detail in a simple U(1) model with a scalar and fermions, and explained how to extend this to SM EFTs and the QCD Chiral Langrangian. This provides an understanding of why most “current-current” operators do not renormalize “loop” operators at the one-loop level, and allows one to find the few exceptions to this ubiquitous rule.

THE RECENT DISCOVERY OF THE HIGGS BOSON BY THE LHC IS GIVING US PRECIOUS INFORMATION TO ADVANCE IN THE UNDERSTANDING OF ELECTROWEAK SYMMETRY BREAKING.

CURING THE INFRARED PROBLEMS OF THE HIGGS POTENTIAL

The Higgs effective potential in the Standard Model (SM), calculated perturbatively, generically suffers from infrared (IR) divergences when the (field-dependent) tree-level mass of the Goldstone bosons goes to zero. Such divergences can affect both the potential and its first derivative and become worse with increasing loop order. J.R. Espinosa and Joan Elias-Miró showed that these IR divergences are spurious, performing a simple resummation of all IR-problematic terms known (up to three loops) and explaining how to extend the resummation to cure all such divergences to any order. The method is of general applicability and would work in scenarios other than the SM.

ELECTROWEAK SYMMETRY BREAKING IN SUPERSYMMETRIC MODELS AFTER THE HIGGS DISCOVERY

Mariano Quirós has explored the consequences of the electroweak breaking condition on the mass of supersymmetric partners, and the scale at which supersymmetry breaking is transmitted, for arbitrary values of the supersymmetric parameters tan(beta) and the stop mixing Xt, which follow from the Higgs discovery with a mass mH ≈ 125 GeV at the LHC.

He has also shown the general form of the MSSM focus point solution, for different values of the messenger scale and the ratio of gaugino and scalar masses. The possibility of inducing a light stop as a result of the renormalization group running from high energies has been studied.

Finally an extension of the minimal supersymmetric standard model with a zero hypercharge triplet has been considered and the effect that such a particle has on stop decays. It is found that the fermion triplet can greatly affect the branching ratios of the stops, even in the absence of a direct stop-triplet coupling. In this model the alignment limit, by which the light Higgs properties are those of the Standard Model even in the presence of an enlarged light Higgs sector, can be found as it is shown in the attached Figure 2.

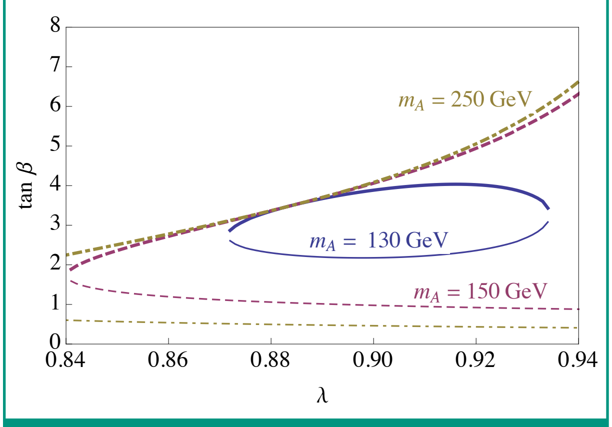


Fig. 2: Example of regions in parameter space of the supersymmetric model with a triplet model that give the right Higgs mass (125 GeV) for different values of the pseudoscalar mass as indicated.

2.13 ASTROPARTICLES & COSMOLOGY

ORIOL PUJOLÀS

The Astroparticles and Cosmology group studies the properties of elementary particles and their interactions in astrophysical and cosmological settings. Many things can be learned about particle physics in these settings because they allow to access processes that are very difficult to reproduce in the laboratory. We are interested in: axion physics, neutrinos (atmospherical and solar), phase transitions in the early universe, dark matter and, of course, dark energy.

INTRODUCTION

Astroparticle physics and particle cosmology are recent fields of research at the intersection between particle physics, astrophysics and cosmology. The main goal is to exploit our knowledge of astrophysical and cosmological phenomena to answer fundamental physics questions. The key questions addressed include the origin and nature of dark energy, dark matter, the matter-antimatter asymetry of the universe, the strong CP problem and the applications of modified gravity models and the gauge/gravity correspondence. During 2014, the work done by the members of the Theory Division in this research area can be divided in the following topics.

BARYOGENESIS, STRONG CP PROBLEM & DARK MATTER

Three of the key motivations for physics beyond the standard model are i) to understand the generation of the matter-antimatter asymmetry of the Universe, ii) the origin of Dark Matter, and iii) the strong CP problem. During 2014 G. Servant has shown that, provided the electroweak phase transition is delayed to temperatures below the GeV scale, the QCD axion can at once solve the strong CP problem, account for Dark Matter and be responsible for the matter-antimatter asymmetry in the context of cold electroweak baryogenesis. This can occur naturally if the Higgs couples to an O(100) GeV dilaton, as expected in some models where the Higgs is a pseudo-Nambu-Goldstone boson of a new strongly interacting sector at the TeV scale.

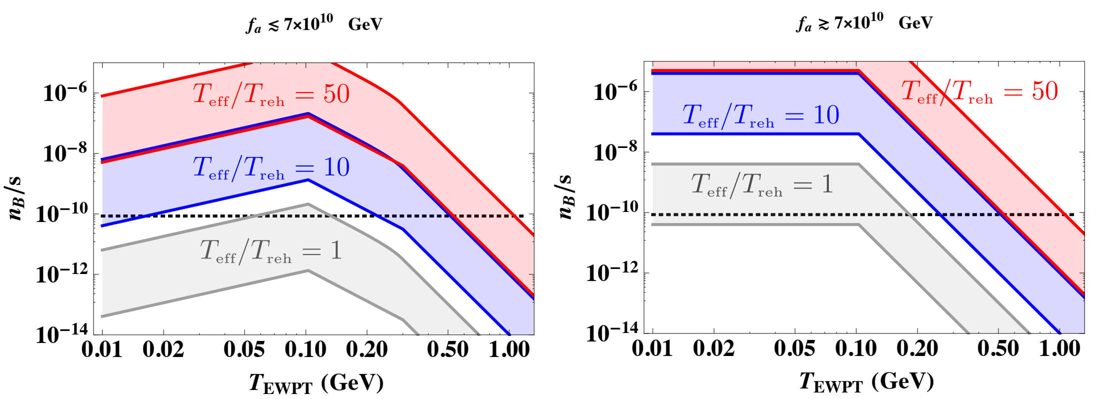


Fig. 1: Today's baryon asymmetry as a function of the EW phase transition temperature T_{EWPT} compared with measured value (dotted line). T_{eff} characterizes the efficiency of non-thermal baryon number violation and can be much larger than the actual temperature. It depends on the amount of Higgs quenching and is computed in lattice simulations. The case $T_{eff}=T_{reh}$ and $T_{eff} \sim T_{EWPT}$ that characterizes standard EW baryogenesis is unfeasible as T_{reh}~$O(m_H) >> \Lambda_{QCD}$. The cases with $T_{eff} = T_{reh} \geq 10$ can easily account for a large B asymmetry and correspond to a quenched EWPT, as in cold EW baryogenesis. Each band corresponds to varying the initial angle Θ_i in the range $[10^{-2}, \pi/2]$. Left: $m_a \geq 3_{HEW} \sim 3 \times 10^{-14}$ GeV, oscillations start at T = 0.3 GeV in the supercooling era before the EWPT. Right: $m_a \leq$ 3HEW, the axion is frozen to its initial value until after reheating.

THE PROBLEM OF REALIZING A NATURALLY LIGHT DILATON CAN GIVE VERY VALUABLE INSIGHTS TOWARDS THE RESOLUTION OF THE TRUE COSMOLOGICAL CONSTANT PROBLEM.

In this scenario, the matter-antimatter asymmetry is produced by i) large Higgs quenching to produce Higgs winding number, ii) unsuppressed CP violation (from QCD) at the time of quenching to bias a net baryon number, and iii) a reheat temperature Treh below the sphaleron freeze-out temperature T~130 GeV to avoid washout of B by sphalerons. A Higgs-dilaton coupling can naturally delay the EWPT to temperatures $T_{EWPT} \leq \Lambda_{QCD}$ and fulfill these conditions.

The experimental tests of this scenario are of three different types: the usual QCD axion searches, LHC searches for an additional dilaton-like scalar field coupled to the Higgs, and a stochastic millihertz gravity wave background detectable by eLISA.

NATURALLY LIGHT DILATONS

The spontaneous breaking of conformal invariance is an interesting problem for two reasons: first, it represents a symmetry-breaking pattern that protects the mass of the associated Goldstone boson, the dilaton, and as such provides a new way to realize a naturally light scalar particle. Such a light scalar can be relevant for a number of phenomenologically interesting questions such as realizing a Higgs impostor (now quite disfavoured by LHC constraints), or to assist Baryogenesis in minimal extensions of the Standard Model (such as the one in the previous subsection). Additionally, the problem of realizing a naturally light dilaton is analogous in many ways to the Cosmological Constant problem and so it can give very valuable insights towards the resolution of this fundamental problem.

An important piece of progress in this connection arose in 2010 when R Contino, A Pomarol and R Rattazzi (CPR) realized that it is possible to have naturally a light dilaton in strongly coupled sectors obtained as nearly marginal deformations of some Conformal Field Theories (CFTs). In 2014, O. Pujolas together with E. Megias used the Gauge/Gravity duality to construct the first models of a naturally light dilaton that require a single scalar CFT operator. The dilaton in these models is generically suppressed by the beta function, in line with the CPR proposal. This work clarified several non-perturbative aspects of the holographic renormalization group flows such as the computation of condensates and the holographic beta function. The adaptation of the CPR proposal to the Cosmological Constant problem has also been investigated.

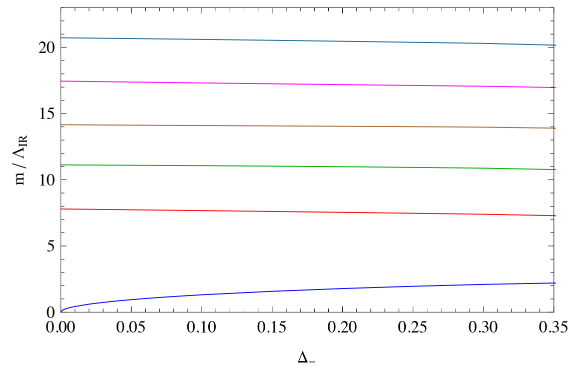


Fig. 3: Spectrum of a typical soft wall model as a function of Δ_- – the dimension of the nearly-marginal coupling λ. The first 6 modes are depicted. The lightest mode – the dilaton – scales like $m^2_{dil} \sim \Delta_-$.

APPLICATIONS OF THE GAUGE/GRAVITY CORRESPONDENCE

The holographic (or gauge/gravity) duality has become nowadays a powerful tool to study strongly coupled systems and has found numerous applications, ranging from modeling QCD and heavy ion collisions to quantum liquids and high-temperature superconductivity. During 2014, O. Pujolas in collaboration with PhD student M. Baggioli have studied i) the application of Massive Gravity theories to model realistic strongly coupled materials with momentum disipation; ii) the holographic Renormalization Group flows that exhibit an emergent Lorentz invariance.

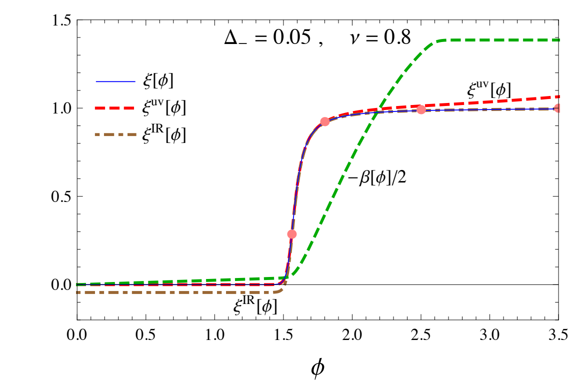


Fig. 2: The dilaton wave function $\xi(\varphi)$ as a function of the φ–coordinate and (minus) the beta function. The continuous blue line is the wave function obtained numerically, and the red and brown dashed lines are their UV- and IR- analytical approximations. The dilaton wavefunction switches on at the condensation threshold φ_{cond}, which allows to identify it with the fluctuation of the condensate.

3. PROJECTS **IN 2014**

ACTIVE PROJECTS

EUROPEAN COMMISSION

1. 250207
   Voxel Imaging PET Pathfinder
   Mokthar Chemeissani
2. 262053
   The Preparatory Phase for the Cherenkov Telescope Array (CTA-PP)
   Manel Martínez
3. 631962
   Higgs precision era at the LHC
   Christophe Grojean

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

1. CSD2007-00060
   La Física del Universo Acelerado
   Enrique Fernández
2. FPA2010-22060-C02-01
   Desarrollo y construccion de detectores pixels para las mejoras IBL y sLHC del experimento ATLAS
   Sebastián Grinstein
3. FPA2010-21816-C02-02
   Implantación del Sistema de Computación Tier1 Español para el Large Hadron Collider Fase III
   Manuel Delfino
4. FPA2010-21919-C03-02
   Tier-2 Distribuido Español para el experimento Atlas (LHC) Fase 2
   Andres Pacheco Pages
5. FPA2010-22056-C06-01
   Participación española en la Fase de Preparación del "Cherenkov Telescope Array" (CTA): proyecto del IFAE.
   Manel Martínez
6. AIC-A-2011-0660
   Participación Española en la Fase Preparatoria del Cherenkov Telescope Array (CTA)
   Manel Martínez
7. FPA2011-29823-C02-02
   Participación en el experimento T2K
   Federico Sánchez
8. FPA2011-25948
   Física de las Interacciones Fundamentales
   Mariano Quirós
9. AYA2012-39620-C03-03
   Cosmología con cartografiados extragalácticos: EUCLID
   Cristobal Padilla
10. FPA2012-39684-C03-01
    Cosmología y física fundamental con cartografiados estragalácticos
    Ramon Miquel
11. FPA2012-38713
    Fisica en colisiones protón protón en el LHC usando el detector ATLAS
    Mario Martínez Pérez
12. FPA2012-39502
    Explotación del upgrade de MAGIC
    Javier Rico
13. TEC2012-39150-C02-02
    Detección de nanomoleculas mediante el uso de sensores gaseosos microestructurados
    Mokthar Chemeissani
14. SEV-2012-0234
    Centro de Excelencia Severo Ochoa
    Manel Martínez
15. FPA2013-48082-C2-1-R
    Implantación del Sistema de Computación Tier1 Español para el Large Hadron Collider Fase IV
    Manuel Delfino
16. FPA2013-47424-C3-3-R
    Tier-2 Distribuido Español para el experimento Atlas (LHC) Fase 3 y su papel en la gestión y procesamiento de grandes cantidades de datos
    Andres Pacheco Pages
17. JCI-2011-10019
    Beca postdoctoral Juan de la Cierva
    Julien Sitarek
18. FPA2013-48381-C6-1-P
    Participación española en el diseño y prototipado del Cherenkov Telescope Array: proyecto del IFAE
    Abelardo Moralejo
19. FPA2013-47986-C3-1-P
    Cosmología y física fundamental con cartografiados extragalácticos
    Ramon Miquel
20. FPA2013-48308-C2-1-P
    Detectores de pixels actuales y futuros para el experimento ATLAS
    Sebastián Grinstein

AGÈNCIA DE GESTIÓ D'AJUTS UNIVERSITARIS I DE RECERCA

1. 2014 SGR 696
   Grups de recerca consolidats: IFAE ATLAS
   Aurelio Juste
2. 2014 SGR 1308
   IFAE-Astropartícules
   Oscar Blanch
3. 2014 SGR 1177
   Particle Detectors and Instrumentation group at IFAE
   Sebastián Grinstein

4. KNOWLEDGE & TECHNOLOGY **TRANSFER IN 2014**

IFAE performs frontier research in particle physics, astrophysics, and cosmology, fields of knowledge requiring advanced engineering, electronics and software technologies not existing in the market. IFAE research & engineering teams develop their own technology, transferring it to industry by means of joint ventures, partnerships, R&D agreements, technical services based on singular scientific infrastructures, training sessions, consultancy, licensing and spin-off creation.

As its Statutes state, Technological Development is one of IFAE's main goals, and thus is reflected in its programme-contract with the Department of Economy and Knowledge of the Catalan Government, where over 30% of the follow-up evaluation is linked to indicators for knowledge and technology transfer.

2014 TECH. TRANSFER OUTPUT AT IFAE

0.4M€	1	8
PUBLIC-PRIVATE R&D PROJECT FINANCED	EUROPEAN PATENT APPLICATION FILED	CONTRACT RESEARCH PROJECTS & SERVICES SUPPLIED BY IFAE

CONTRACT RESEARCH & SERVICES

- 0.5M€ in a Contract for a service agreement signed with CERN.
- 0.6M€ in Grants for the provision of services by Port d'Informació Científica (PIC), administratively a unit of IFAE.
- 8 Customers (3 of them new).
- 3 Confidential Disclosure Agreements signed with private entities (engineering, electronics and consulting sectors).
- 3 Institutional & Portfolio Presentations, including in the Industrial Meeting: SPAIN at CERN (Switzerland).

PROTECTION, VALORISATION AND LICENSING

- 2 Disclosure of Inventions evaluated (electronics and medical sector).
- 1 European Patent Application filed (energy sum with photon counting method, with uses in food inspection and security cameras).
- 4 Patents in force on Medical Physics. 1 of them in National Phase entry, USA (device for detecting highly energetic photons).
- 1 Patent License (radiation detector for material composition analysis).
- 1 Public-private project financed (MINECO - Retos Colaboración). A 3-year project worth over 0.4 M€. 54% of this funding was granted to IFAE's spin-off company, X-Ray Imatek.
- 2 Proof of Concept Proposals submitted (MINECO - Explora): readout electronics for graphene based sensors and HV-CMOS technology for communication applications.

COLLABORATIVE RESEARCH

- 5 Company Letters of support received (SENER, YMAGING, INNOQUANT, INTELLIGENT PHARMA, X-Ray Imatek), supporting the P-SPHERE Project, a European Applied Research Project submission (H2020 - COFUND), coordinated by UAB.
- 1 Memorandum of Understanding Fusió-CAT Initiative signed with 15 Public Entities (IREC, BSC, CIMNE, IQS, ICMAB-CSIC, ASCAMM, ICFO, CITCEA-UPC, GREENER-UPC, CDEI-UPC, IRI, CIEFMA, CD6, UPC and IREC) to collaborate in the area of fusion research by developing (micro)electronics, mechanical solutions and control software technologies.
- 1 Business & Management Plan elaborated to finance the participation of the 10 national research centers that are members of CTA-Spain (CIEMAT, IAC, ICC-UB, ICE-CSIC, IEEC, UCM-GAE, UCM-ELEC, IFAE, UJA) in the CTA-North International Project.

IFAE'S SPIN-OFF

- 1 Spin-off Project of Industrial Development assessed for the participation in an SME Instrument H2020 call developing a prototype of a new X-Ray detector.

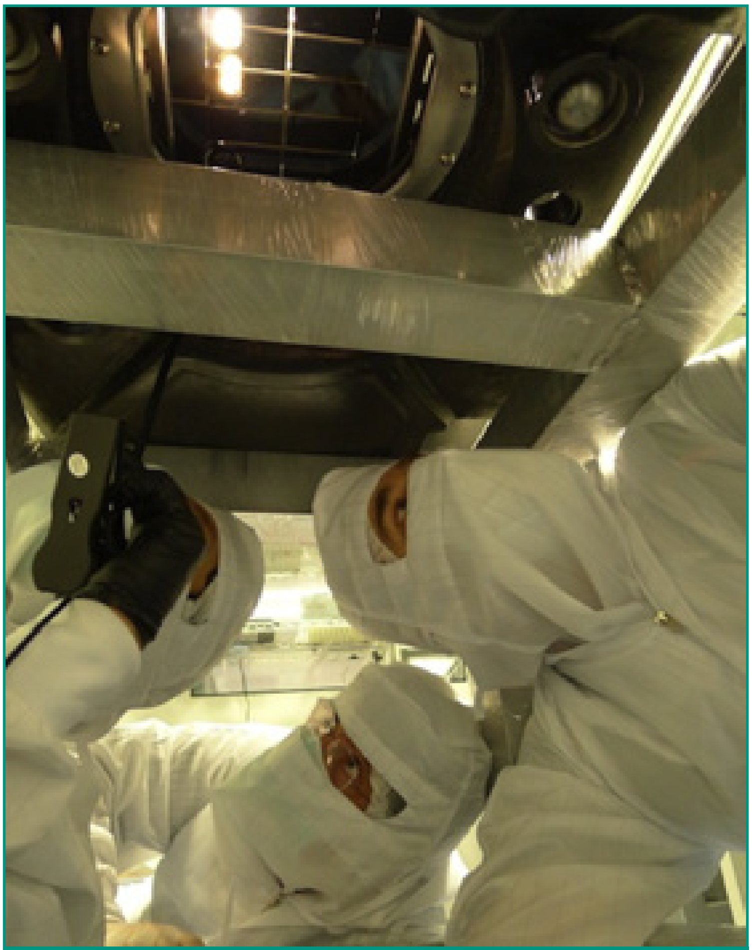


Fig. 1: IFAE engineers assembling the PAUCam astronomical camera in IFAE's clean room, which occupies 44 m^2 in 3 rooms: class 1000 / 10000 / 100000.

5. PERSONNEL **IN 2014**

EXPERIMENTAL DIVISION
FACULTY

Blanch, Òscar	Researcher, Ramón y Cajal, IFAE
Bosman, Martine	Research Professor, IFAE
Casado, Mª. Pilar	Associate Professor, UAB
Cavalli-Sforza, Matteo	Research Professor, IFAE
Chmeissani, Mokhtar	Research Professor, IFAE
Cortina, Juan	Research Associate Professor, IFAE
Crespo, José Mª.	Professor, UAB
Delfino, Manuel	Professor, UAB
Fernández, Enrique	Professor, UAB
Grinstein, Sebastián	Research Professor, ICREA
Juste, Aurelio	Research Professor, ICREA
Korolkov, Ilya	Research Associate Professor, IFAE
Martínez, Manel	Research Professor, IFAE
Martínez, Mario	Research Professor, ICREA
Miquel, Ramon	Research Professor, ICREA
Mir, Lluïsa Mª.	Research Associate Professor, IFAE
Moralejo, Abelardo	Research Associate Professor, IFAE
Padilla, Cristóbal	Research Associate Professor, IFAE
Rico, Javier	Researcher, IFAE
Riu, Imma	Research Associate Professor, IFAE
Sánchez, Federico	Research Associate Professor, IFAE
Sorin, Verónica	Researcher, Ramón y Cajal, IFAE

SCIENTIFIC POST-DOCS

Aleksić, Jelena	DES, PAU, UAB
Bonnet, Christopher	DES
Bordoni, Stefania	NEUTRINOS
Cortes, Arely	ATLAS
De Lorenzo, Gianluca	VIP
Farooque, Trisha	ATLAS
Giangiobbe, Vincent	ATLAS (until Jun. 2014)
Goncalvez dos Anjos, Nuno	ATLAS, Beatriu de Pinos (since Jun. 2014)
Herrera, Javier	MAGIC

Ieva, Michela	NEUTRINOS, Beatriu de Pinos (until Feb. 2014)
Kolstein, Machiel	VIP
Kovács, Andras	DES, Severo Ochoa (since Oct. 2014)
Lange, Joern	ATLAS-Pixel, Severo Ochoa
Le Menedeu, Eve	ATLAS
Lux, Thorsten	NEUTRINOS
Sitarek, Julian	MAGIC, CTA, Juan de la Cierva
Tripiana, Martin	ATLAS (since Aug. 2014), Severo Ochoa
Valery, Loic	ATLAS (since Nov. 2014)
Ward, John	MAGIC, CTA
Will, Martin	MAGIC

DOCTORAL STUDENTS

Ariño, Gerard	VIP, Severo Ochoa Scholarship
Bourguille, Bruno	NEUTRINOS, Severo Ochoa Scholarship
Calderón, Yonatan	VIP (until Jun. 2014)
Caminal, Roger	ATLAS
Caravaca, Javier	NEUTRINOS, FPI Scholarship (until Sep. 2014)
Casolino, Mirko	ATLAS, FI Scholarship
Castillo, Raquel	NEUTRINOS
Cavallaro, Emanuele	ATLAS-Pixel, SO-La Caixa Scholarship (since Apr. 2014)
Fernández, Alba	MAGIC, FPI Scholarship
Fischer, Cora	ATLAS, FPI Scholarship
Fracchia, Silvia	ATLAS
García, Alfonso	NEUTRINOS, FPI Scholarship
Gonzalez, Adiv	MAGIC, CTA
González Parra, Garoe	ATLAS, FPI Scholarship
Guberman, Daniel	MAGIC, CTA Severo Ochoa Scholarship
López Coto, Ruben	CTA, FPI Scholarship
López Orama, Alicia	MAGIC, FPI Scholarship (until Nov. 2014)
López Paz, Ivan	ATLAS-Pixel, Severo Ochoa Scholarship
Mikhaylova, Ekaterina	VIP (until Nov. 2014)
Montejo, Javier	ATLAS, FPU Scholarship
Nogués, Leyre	MAGIC, CTA, SO Scholarship (since Nov. 2014)
Palacio, Joaquin	MAGIC, Severo Ochoa Scholarship (since Jan. 2014)
Prat, Judit	DES (MSc student since Oct. 2014)
Rizzi, Chiara	ATLAS, Severo Ochoa-La Caixa Schol. (since Oct. 2014)
Rodriguez Perez, Andrea	ATLAS Severo Ochoa Scholarship (since Sep. 2014)
Rubbo, Francesco	ATLAS, FI Scholarship (until Nov. 2014)
Sanchez Alonso, Carles	DES, Severo Ochoa Scholarship
Succurro, Antonella	ATLAS (until Feb. 2014)
Tsiskaridze, Shota	ATLAS-Pixel, FI Scholarship
Tutusaus, Isaac	DES (MSc student since Sep. 2014)

Uzun, Dilber	VIP (until Jun. 2014)
Vielzeuf, Pauline	DES, PAU Severo Ochoa-La Caixa S. (since Sep. 2014)
Viruez, Raul	NEUTRINOS (MSc student since Oct. 2014)
Vo, Jonathan	NEUTRINOS, Severo Ochoa Scholarship

THEORY DIVISION
FACULTY

Espinosa, José Ramón	Research Professor, ICREA
Jamin, Matthias	Research Professor, ICREA
Grojean, Christophe	Research Professor, ICREA
Pascual, Ramon	Professor Emeritus, UAB
Pujolàs, Oriol	Researcher, Ramon y Cajal, IFAE-UAB
Quirós, Mariano	Research Professor, ICREA
Servant, Géraldine	Research Professor, ICREA

SCIENTIFIC POST-DOCS

Bertuzzo, Enrico	IFAE (until Nov. 2014)
Gupta, Sandeepan	IFAE (until Oct. 2014)
Hofer, Lars	IFAE
Panico, Giuliano	Severo Ochoa (since Oct. 2014)
Silva, Pedro	ICE (IEEC-CSIC) (until Mar. 2014)

DOCTORAL STUDENTS

Baggioli, Matteo	PIF Scholarship
Elias, Joan	FPU Scholarship
García Pepin, Mateo	PIF Scholarship
Sergi González-Solís	FPI Scholarship
Krug, Sebastian	FPU Scholarship
Montull, Marc	PhD Student (unitil Mar.2014)
Daniel Moreno	Severo Ochoa Scholarship
Peset, Clara	PIF Scholarship
Riembau, Marc	Severo Ochoa-La Caixa Schol. (since Apr. 2014)
Vantalon, Thibaud	Severo Ochoa Scholarship (since Apr. 2014)
Zhang, Yuan	Chinese Scholarship Council
Yang, Ke	Chinese Scholarship Council

TECHNICAL SERVICES
ENGINEERING STAFF

Abril, Oscar	Electronics Engineer
Ballester, Otger	Electronics Engineer
Barceló, Miquel	Electronics Engineer (until Aug. 2014)

Boix, Joan	Electronics Engineer
Cardiel Sas, Laia	Electronics Engineer
Casanova, Raimon	Electronics Engineer
Garcia Gil, Rafael	Mechanical Engineer
García Rodríguez, Jorge	Electronics Engineer
Grañena, Ferran	Mechanical Engineer
Illa, José Mª.	Electronics Engineer
Jimenez Rojas, Jorge	Electronics Engineer
Lamesans, Mikel	Mechanical Engineer (since Jan. 2014)
Lopez Morillo, Luis	Mechanical Engineering Student
Macias, José Gabriel	Microelectronics Designer
Maja, Ester	Software Engineering Student
Martínez, Óscar	Engineer (since Nov. 2014)
Pio, Cristóbal	Software Engineer
Puigdengoles, Carles	Electronics Engineer

COMPUTER SCIENTISTS

Campos, Marc	Computer Scientist
Guinó Feijoo, Alex	Computer Scientist
Pacheco Pages, Andres	Senior Applied Physicist (Computing)

TECHNICIANS

Arteche, Carlos	Mechanical Technician
Benedico, David	Mechanical Technician
Colombo, Eduardo	Support Technician
González, Alex	Electronics Technician
Gaweda, Javier	Mechanical Technician

RESEARCH SUPPORT

TECHNOLOGY TRANSFER

Esparbé, Isaac	Technology Transfer Manager (since Mary 2014)

PROJECTS OFFICE

Balza, Marta	Research Project Manager (since Feb. 2014)

ADMINISTRATION

Cárdenas, Cristina	UAB Secretary
Gaya, Josep	UAB Senior Administrator
Jiménez, Elizabeth	Administrative Assistant
Gomez, Marta	Administrative Assistant
Strauch, Sara	Administrative Assistant

6. INSTITUTIONAL **ACTIVITIES IN 2014**

In this section we list the institutional activities undertaken by IFAE in 2014. This includes the scientific output produced at IFAE such as scientific publications, conference proceedings, doctoral theses and talks in international conferences as well as other activities such as outreach activities and seminars and colloquia organized at IFAE.

2014 SCIENTIFIC OUTPUT AT IFAE

138
NUMBER OF INDEXED JOURNAL ARTICLES

92.8%
% ARTICLES IN FIRST QUARTILE JOURNALS

5.6
AVERAGE JOURNAL IMPACT FACTOR (IF)

TOP 5 JOURNALS (BY IF) WHERE IFAE PUBLISHED IN 2014	NUMBER OF ARTICLES
Science (IF 31.48)	1
Physical Review Letters (IF 7.73)	19
Astrophysical Journal (IF 6.28)	1
Journal Of High Energy Physics (IF 6.22)	32
Physics Letters B (IF 6.02)	8

TOP 5 JOURNALS WHERE IFAE PUBLISHED MORE FREQUENTLY	
Physical Review D (IF 4.86)	32
Journal Of High Energy Physics (IF 6.22)	32
Physical Review Letters (IF 7.73)	19
European Physical Journal C (IF 5.44)	15
Astronomy & Astrophysics (IF 4.48)	11

DOCTORAL THESES: 9

NUMBER OF PRESENTATIONS AT INTERNATIONAL CONFERENCES: 104

6.1 MASTER & DOCTORAL THESES IN 2014

MASTER & DIPLOMA THESES

EXPERIMENTAL DIVISION

Daniel Guberman
Observing the shadowing of the Cosmic Ray electron flux with the MAGIC telescopes: a feasibility study. September 2014
Advisors: Abelardo Moralejo and V. Bosch-Ramon

Raúl Viruez
Construcción y caracterización de un banco de pruebas para la caracterización de sensores microbulk MicroMegas. September 2014
Advisors: Thorsten Lux, Federico Sánchez

THEORY DIVISION

Víctor Cáncer-Castillo
Natural Dark Energy and the Cosmological Constant problem. July 2014
Advisor: Oriol Pujolàs

DOCTORAL THESES

EXPERIMENTAL DIVISION

Yónatan Calderon
Design, Development, and Modeling of a Compton Camera Tomograph Based on Room Temperature Solid State Pixel Detector. April 25 2014
Thesis advisor: Mokhtar Chmeissani, Machiel Kolstein

Javier Caravaca
Measurement of the electron-neutrino component of T2K beam and search for electron-neutrino disappearance at the Near Detector. July 2014
Thesis advisor: Federico Sanchez, Claudio Giganti

Alicia López Oramas
Multi-year Campaign of the Gamma-Ray Binary LS I +61° 303 and Search for VHE Emission from Gamma-Ray Binary Candidates with the MAGIC Telescopes. September 2014
Thesis advisor: òscar Blanch

Pol Martí
Precise photometric redshifts with narrow-band filters, quality cuts and their impact on the measured galaxy clustering. May 2014
Thesis advisors: Ramon Miquel and Enrique Fernández.

Ekaterina Mikhaylova
Voxel Imaging PET Pathfinder: a Novel Approach to Positron Emission Tomography Based on Room Temperature Pixelated CdTe Detector. June 2014
Thesis advisor: Mokhtar Chmeissani, Gianluca de Lorenzo

Francesco Rubbo
Measurements of the charge asymmetry in top quark pair production at the LHC with the ATLAS detector. November 2014
Thesis advisor: Aurelio Juste

Antonella Succurro
Probing new physics at the LHC: searches for heavy top-like quarks with the ATLAS experiment. February 2014
Thesis advisor: Aurelio Juste

Dilber Uzun
Modeling, Simulation, and Evaluation of a High Resolution VIP Positron Emission Mammography Scanner Based on Pixelated Semiconductor Detector. June 2014
Thesis advisor: Mokhtar Chmeissani, Gianluca de Lorenzo

THEORY DIVISION

Andrea Thamm
Effective Lagrangian perspectives on electroweak symmetry breaking. August 2014
Thesis advisors: Christophe Grojean and Riccardo Rattazzi

6.2 IFAE PUBLICATIONS IN 2014

EXPERIMENTAL DIVISION

PUBLICATIONS BY THE ATLAS GROUP

1. G. Aad et al., (ATLAS Collaboration)
Search for neutral Higgs bosons of the minimal supersymmetric standard model in pp collisions at √s=8 TeV with the ATLAS detector
J. High Energy Phys. 11 (2014) 056

2. G. Aad et al., (ATLAS Collaboration)
Search for pair and single production of new heavy quarks that decay to a Z boson and a third-generation quark in pp collisions at √s=8 TeV with the ATLAS detector
J. High Energy Phys. 11 (2014) 104

3. G. Aad et al., (ATLAS Collaboration)
Search for non-pointing and delayed photons in the diphoton and missing transverse momentum final state in 8 TeV pp collisions at the LHC using the ATLAS detector
Phys. Rev. D 90 (2014) 112005

4. G. Aad et al., (ATLAS Collaboration)
Measurement of distributions sensitive to the underlying event in inclusive Z-boson production inpp collisions at √s=7 TeV with the ATLAS detector
Eur. Phys. J. C 74 (2014) 3195

5. G. Aad et al., (ATLAS Collaboration)
Search for long-lived neutral particles decaying into lepton jets in proton--proton collisions at √s=8 TeV with the ATLAS detector
J. High Energy Phys. 11 (2014) 088

6. G. Aad et al., (ATLAS Collaboration)
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 (2014) 112015

7. G. Aad et al., (ATLAS Collaboration)
A measurement of the ratio of the production cross sections for W and Z bosons in association with jets with the ATLAS detector
Eur. Phys. J. C 74 (2014) 3168

8. G. Aad et al., (ATLAS Collaboration)
Measurement of the total cross section from elastic scattering in pp collisions at √s=7 TeV with the ATLAS detector
Nucl. Phys. B 889 (2014) 486-548

9. G. Aad et al., (ATLAS Collaboration)
Search for the lepton flavor violating decay $Z \rightarrow e\mu$ in pp collisions at √s = 8 TeV with the ATLAS detector
Phys. Rev. D 90 (2014) 072010

10. G. Aad et al., (ATLAS Collaboration)
Measurement of flow harmonics with multi-particle cumulants in Pb+Pb collisions at √sNN=2.76 TeV with the ATLAS detector
Eur. Phys. J. C 74 (2014) 3157

11. G. Aad et al., (ATLAS Collaboration)
Fiducial and differential cross sections of Higgs boson production measured in the four-lepton decay channel in pp collisions at √s=8 TeV with the ATLAS detector
Phys. Lett. B 738 (2014) 234-253

12. G. Aad et al., (ATLAS Collaboration)
Search for new resonances in $W\gamma$ and $Z\gamma$ Final States in pp Collisions at √s=8 TeV with the ATLAS Detector
Phys. Lett. B 738 (2014) 428-447

13. G. Aad et al., (ATLAS Collaboration)
Search for new particles in events with one lepton and missing transverse momentum in pp collisions at √s=8 TeV with the ATLAS detector
J. High Energy Phys. 09 (2014) 037

14. G. Aad et al., (ATLAS Collaboration)
Search for Scalar Diphoton Resonances in the Mass Range 65-600 GeV with the ATLAS Detector in pp Collision Data at √s=8 TeV
Phys. Rev. Lett. 113 (2014) 171801

15. G. Aad et al., (ATLAS Collaboration)
Measurements of jet vetoes and azimuthal decorrelations in dijet events produced in pp collisions at √s =7 TeV using the ATLAS detector
Eur. Phys. J. C 74 (2014)

16. G. Aad et al., (ATLAS Collaboration)
Measurement of the production cross-section of $\psi(2S) \rightarrow J/\psi(\rightarrow \mu^+\mu^-)\pi^+\pi^-$ in pp collisions at √s=7 TeV at ATLAS
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2. T. Aaltonen (Helsinki Inst. of Phys.) et al. (CDF Collaboration)
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2. K.Abe et al. (T2K Collaboration)
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1. A. Bauer, E. Gaztañaga, P. Martí, R. Miquel
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1. P. Martí, R. Miquel, F. J. Castander, E. Gaztañaga, M. Eriksen, C. Sánchez
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2. G Ariño-Estrada, M Chmeissani, G de Lorenzo, M Kolstein, C Puigdengoles, J García and E Cabruja.
Measurement of Mobility and Lifetime of Electrons and Holes in a Schottky CdTe Diode.
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3. M Kolstein, G Ariño, M Chmeissani and G De Lorenzo.
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2. M. Carena, C. Grojean, M.Kado and V.Sharma
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3. R. Contino, M. Ghezzi, C. Grojean, M. Mühlleitner and M. Spira
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5. J. Elias-Miró, C. Grojean, R.S. Gupta and D. Marzocca
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6. A. Delgado, M. Quirós, C. Wagner
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7. A. Delgado, M. Quirós, C. Wagner
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8. A. Delgado, M. Garcia and M. Quirós,
Electroweak and supersymmetry breaking from the Higgs discovery
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9. J. de Blas, A. Delgado, B. Ostdiek and M. Quirós
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JHEP 1401 (2014) 177

10. E. Megías and O. Pujolas
Naturally light dilatonsàfrom nearly marginal deformations
JHEP 1408 (2014) 081

11. G.Servant
Baryogenesis from Strong CP Violation and the QCD Axion
Phys. Rev. Lett. 113 (2014) 17, 171803

6.3 OUTREACH ACTIVITIES IN 2014

EXPERIMENTAL DIVISION

OSCAR BLANCH

- Talk “La història de l’Univers”, at Escola Sant Julià for school students. Arboç, 6 November 2014
- Member of the Jury in Science Project organized in the High School Virolai (Barcelona), March 2014.

CHRISTOPHER BONNETT

- "Applying Machine Learning to the photometric redshift problem in Cosmology." Machine Learning Meetup, Barcelona, 14/01/2015

MARTINE BOSMAN

- CERN/Fundación Principe de Asturias challenge for schools. Prize ceremony and visit of IFAE for Catalan participants

JAVIER CARAVACA

- Seminar: “Los neutrinos: las particulas invisibles.”, 10th April 2014, INS Cambrils, Cambrils (Tarragona)

MIRKO CASOLINO

- CERN guide for visitors
- Supervisor of International Masterclass for the ATLAS experiment
- Supervisor assistant for CMS Masterclass

MATTEO CAVALLI-SFORZA

- Supervision of two research projects of local high-school students (Particle Accelerators, "Cold fusion"). Fall 2014
- Organization of visit by group of Dutch college students, April 2014

ARELY CORTÉS

- CERN, el bosón de Higgs y otros misterios del Universo, XVI Simposio Internacional de Física. Monterrey, México. Febrero 2014

JUAN CORTINA

- "Gamma rays at IFAE", talk at IFAE for Dutch students, April 2014.

ENRIQUE FERNÁNDEZ

- "The dark side of the universe: dark matter and dark energy." Conference cycle on "The secrets of Particles" organized by CERN and by the BBVA Foundation, Madrid 23/April/2014.
- "More on cosmic inflation", Regular seminar cycle organized by the "AstroBanyoles" Association (Science and Astronomy Association of Pla de l'Estany). Museu Darder, Banyoles, Girona, 13/December/2014.
- Interview within the Program “Espai i Terra” (TV3) on the occasion of the 60th anniversary of CERN (8/10/2014).

AURELIO JUSTE

- Outreach talk at high schools within the program "Dia de la Ciencia a les Escoles", within "La Semana de la Ciencia" (Oct 14-23, 2014).
- "The Higgs Boson and the Frontiers of Physics", Sala d'actes de l'Ajuntament de Balaguer, Balaguer, Spain, November 19, 2014. Participating high schools: IES Vedruna Balaguer, Escola Pia Balaguer, Institut Almata, Institut Ciutat de Balaguer.
- Outreach talks at high schools within the program "El CPAN en el Instituto", "The Higgs Boson and the Frontiers of Physics", IES Salvador Espriu, Barcelona, Spain, December 10, 2014. Institut de Begues, Begues, Spain, May 16, 2014.
- Outreach talks at high schools (personal initiative). "The Higgs Boson and the Frontiers of Physics",IES Estela Iberica, Santa Perpetua de Moguda, Spain, November 21, 2014. IES Rovira Forns, Santa Perpetua de Moguda, Spain, November 21, 2014. IES Terrassa, Terrassa, Spain, October 30, 2014. IES Nicolau Copernic, Terrassa, Spain, March 19, 2014. Escola Cultura Practica, Terrassa, Spain, February 26, 2014.
- Outreach talk within the program "Els dissabtes de la Fundacio Oms". "The Higgs Boson and the Frontiers of Physics", Col.legi Oms i de Prat, Manresa, Spain, April 5, 2014.
- Outreach talk within the program "Els Dissabtes de la Fisica 2013-14" The Higgs Boson and the Frontiers of Physics", Departament de Física, Universitat Autònoma de Barcelona, Bellaterra, Barcelona, Spain, March 8, 2014.

ALICIA LÓPEZ-ORAMAS

- "Astrofísica de partículas: los rayos gamma. La cara más violenta del Universo", talk at IFAE for local Catalan students, April 2014.

THORSTEN LUX, FEDERICO SANCHEZ

- “Ciència entre tots”, 26th April 2014, Girona (Spain)

MARIO MARTÍNEZ

- "El bosón de Higgs y la frontera de la física", Talk in High School Col•legi Sant Josep de Tàrrega
- "El bosón de Higgs y la frontera de la física", Talk in High School Institut Maria Rúbies, Lleida

EVE LE MENEDEU

- Supervision of Atlas visits at CERN (2 per month)

RAMON MIQUEL

- "El Dark Energy Survey: status i primers resultats", Agrupació Astronòmica Valldoreix-Sant Cugat, Sant Cugat del Vallès, Spain, November 25, 2014.

LLUÏSA-MARIA MIR

- IFAE's coordinator of the talks "El CPAN en el instituto". Throughout the year.
- Organizer of the conferences "De què està fet l'univers?" Spring 2014.
- "Introduction to particle physics and cosmology". Public talk at Caixaforum's and development of a digital platform (http://agenda.obrasocial.lacaixa.es/ca/-/cl-de-que-esta-hecho-el-universo)
- Class on Hypatia (ATLAS reconstruction program) to high-school teachers. February 14.
- Organizer of the celebration of the CERN contest finals - Premio Príncipe de Asturias en el IFAE. May 22.
- "Els repositoris, les solucions pràctques per complir els mandats de l'Open Access" Round table at the 4th ACER's autumn school. November 13.

JAVIER RICO

- Talk "Astronomía Gamma", at the "CERN - Fundación Príncipe de Asturias Contest"' awards ceremony, for school and high-school students. IFAE, 22 may 2014.
- Interview for an article about dark matter results by MAGIC published in the ICHEP2014 conference newsletter, 5 July 2014 (http://ichep2014.es/sites/default/files/NEWSLETTER%203_5jul2014.pdf)
- Interview for an article about dark matter published at the June 2014 issue of the journal Muy Interesante
- Guide for visit of Master Degree students in Astronomy from KU Leuven University and API Amsterdam Institute to MAGIC site. La Palma, October 2014

IMMA RIU

- "El boso de Higgs i la frontera de la física", Sant Hilari Sacalm, CPAN al Instituto, April 2014
- "La recerca i el descobriment del Bosó de Higgs", Sant Cugat, Associació Astronòmica Sant Cugat-Valldoreix, September 2014

FEDERICO SÁNCHEZ

- Seminar: "Los neutrinos: las particulas invisibles.", 18th February 2014, INS Guillem de Bergudá, Berga (Barcelona)
- Seminar: "Los neutrinos: las particulas invisibles.", 25th March 2014, Caixa Forum (Tarragona).

THEORY DIVISION

CHRISTOPHE GROJEAN

- "The Higgs boson: an odyssey in the heart of matter", New Physics Korea Institute, Jeju, KR, 16/09/14 talk for Korean undergraduate students "Seeds program"
- "Voyage(s) dans le noir", Cargese, FR, 18/07/14 Public lecture
- "Cosmologie et physique des particules: questions croisées" Francis Bernardeau et Christophe Grojean Reflets de la physique 40 (2014) 9

GÉRALDINE SERVANT

- "The role of the Higgs in baryogenesis theories", Cargese, IESC, public lecture, July 18 2014, Voyage dans le noir: matiere noire, energie noire et antimatiere.

6.4 TALKS BY IFAE MEMBERS IN 2014

ATLAS GROUP

ROGER CAMINAL

- “Searches for supersymmetry in resonance production and R-parity violating prompt signatures with the ATLAS and CMS detector”, ICHEP2014, València, July 2014.
- “Search for supersymmetry in compressed scenarios with the ATLAS detector at the LHC”, VI Jornadas CPAN, Sevilla, October 2014.
- “Search for supersymmetry in compressed scenarios with the ATLAS detector at the LHC”. Jornadas CPAN Sevilla, Oct. 2014.
- Search for pair-produced third-generation squarks in compressed supersymmetric scenarios using monojet-like final states in pp collisions at sffl=8 TeV with the ATLAS detector at the LHC. Valencia, Spain, Jul 2014

MIRKO CASOLINO

- “Selected HSG8 key perspectives”, ATLAS Higgs Workshop, Rome, April 2014.
- HSG8 Workshop November 2014 @ CERN tt+jets/HF Modeling and Systematics

ARELY CORTÉS

- “Searches for mono-X at the LHC”, DIS2014, Warsaw, April 2014.

TRISHA FAROOQUE

- “Searches with boosted tops”, Boost 2014, University College London, August 2014

SILVIA FRACCHIA

- “Irradiation effect on the response of the scintillators in the ATLAS Tile Calorimeter”, TIPP-2014, Amsterdam, June 2014.

VINCENT GIANGIOBBE

- “New physics searches in ATLAS and relation to astroparticle physics”, AstroParticle-Physics 2014, Amsterdam, June 2014.

AURELIO JUSTE

- "Searches for $t\bar{t}H$ at the LHC", Higgs Days at Santander 2014 Workshop, Instituto de Fisica de Cantabria, Santander, Spain, September 7-12, 2014.
- "Experimental review of $t\bar{t}H$ searches", The Flavor of Higgs Workshop, Weizmann Institute for Science, Rehovot, Israel, June 23-26, 2014.
- "Status and prospects for $t\bar{t}H$ searches at the LHC", After the Discovery: Hunting for a Non-Standard Higgs Sector Workshop, Centro de Ciencias de Benasque Pedro Pascual, Benasque, Spain, April 6-18, 2014.

EVE LE MENEDEU

- “Hot topic”, Moriond-EWK Conference 2014, LaThuile, March 2014.
- Search for $t\bar{t}H$, $H\to b\bar{b}$ production in ATLAS. Moriond 2014. MArch 2014

MARIO MARTÍNEZ

- "Higgs Results at the LHC", TAE 2014 HEP school, Centro de Ciencias de Benasque Pedro Pascual, Benasque, Spain, September 2014.

VERONICA SORÍN

- “ATLAS Trigger Challenges for Run 2”, VI CPAN days, Sevilla, 20-22 October 2014.

PIXELS GROUP

EMANUELE CAVALLARO

- Measurements of LGAD Segmented Devices for high energy physics, 10th International Conference on Radiation Effects on Semiconductor Materials, Detectors and Devices (RESMDD14), Florence, Italy, 8-10 October 2014.

SEBASTIAN GRINSTEIN

- The ATLAS Forward Proton Detector (AFP), 37th International Conference on High Energy Physics (ICHEP 2014), Valencia, Spain, 2-9 July 2014.
- 3D Pixel Detectors at ATLAS, 23rd International Workshop on Vertex Detectors (Vertex 2014), Macha Lake, Czech Republic, 15-19 September 2014.

JOERN LANGE

- 3D silicon pixel detectors for the ATLAS Forward Physics (AFP) experiment, 9th Trento Workshop on Advanced Silicon Radiation Detectors, Genova, Italy, 26-28 February 2014.
- 3D Pixel Detectors for the AFP Experiment, International Workshop on Semiconductor Pixel Detectors for Particles and Imaging (PIXEL 2014), Niagara Falls, Canada, 1-5 September 2014.

IVÁN LOPEZ

- 3D Pixels for the AFP Experiment, 10th International Conference on Radiation Effects on

Semiconductor Materials, Detectors and Devices (RESMDD14), Florence, Italy, 8-10 October 2014.

- Experience with CNM 3D sensors for the ATLAS IBL, 9th Trento Workshop on Advanced Silicon Radiation Detectors, Genova, 26-28 February 2014.

NEUTRINO GROUP

STEFANIA BORDONI

- "Short baseline ν_e appearance@nuPRISM. nuPRISM workshop, Vancouver, Canada. 24th July 2014.
- "Highlights from the T2K experiment", NNN2014, Paris (France). 5th November 2014.
- "Highlights from the T2K experiment". GDR Neutrino Marseille, France. 27th November 2014. (Invited)

JAVIER CARAVACA

- "Short base line oscillation measurements at T2K", " NuFact 2014, Glasgow (UK), 25-30 August 2014

RAQUEL CASTILLO

- "T2K off-axis Cross Section measurements" NuFact 2014, Glasgow (UK), 25-30 August 2014

FEDERICO SÁNCHEZ

- "Neutrino Interactions: experiments", TMEX 2014, 3rd 5th September 2014. Warsaw (Poland) (Invited)
- "Review of Neutrino Interactions", Neutrino 2014, June 1st June 7th 2014, Boston (USA) (Invited)
- Neutrino activities in neutrino cross-sections" ICFA neutrino Panel. Paris, 8 Janury 2014. (Invited)

MAGIC/CTA GROUP

JELENA ALEKSIĆ

- Dark Matter Searches with MAGIC RENATA Meeting, Laboratorio Subterraneo Canfranc, Spain, June 9-11, 2014

ÒSCAR BLANCH

- VHE photon propagation and determination of the cosmological constants. 10th Workshop "Science with the New Generation of High Energy Gamma-ray Experiments" (SciNeGHE 2014), Lisbon, Portugal. June 4-6, 2014
- Gamma rays: MAGIC and CTA ,XLII International Meeting on Fundamental Physics (IMFP14), Benasque, Spain. January 27-31, 2014

JUAN CORTINA

- The MAGIC legacy to next generation of IACTs: results and prospects. VULCANO Workshop 2014, "Frontier Objects in Astrophysics and Particle Physics", May 18-24, 2014, Vulcano Island, Sicily, Italy.

RUBÉN LÓPEZ-COTO

- The non-thermal universe at the highest energies: TeV gamma-ray astronomy with the MAGIC telescopes, Weekly seminars at the Instituto de Astrofísica de Andalucía (IAA), Granada, Spain. October 30, 2014
- Discovery of TeV gamma-ray emission from the pulsar wind nebula 3C 58 ,Rome International Conference on Astro-Particle physics (RICAP), Noto, Italy. September 30 - October 3, 2014
- MAGIC highlights , Rome International Conference on Astro-Particle physics (RICAP), Noto, Italy. September 30 - October 3, 2014
- MAGIC highlights , Very High Energy Phenomena in the Universe (VHEPU), Quy Nhon, Vietnam. August 3-9, 2014

MANEL MARTINEZ

- The CTA data strategy, APIF Meeting, Paris, France, May 15-16, 2014
- The future of CTA-Spain: to be or not to be , RENATA Meeting, Laboratorio Subterraneo Canfranc, Spain, June 9-11, 2014
- The future of CTA-Spain: may be ! VI CPAN Days, Sevilla, Spain, October 20-22, 2014

JAVIER RICO

- Overview of MAGIC results, 37th International Conference on High Energy Physics (ICHEP2014), Valencia, Spain. July 2-9, 2014
- Dark Matter Searches with MAGIC , Astroparticle Physics 2014. Joint TeVPA/IDM Conference. Amsterdam (The Netherlands) June 23-28, 2014.
- Review of Dark Matter searches with the Cherenkov telescopes, 10th Workshop "Science with the New Generation of High Energy Gamma-ray Experiments" (SciNeGHE 2014), Lisbon, Portugal. June 4-6, 2014
- Indirect Dark Matter searches with dwarf galaxies. CTA Extragalactic & Fundamental Physics Science Key Program meeting, MPI Münich, Germany, February 10-11, 2014

JULIAN SITAREK

- Insights into the particle acceleration of a peculiar gamma-ray radio galaxy IC 310, 5th Fermi Symposium, Nagoya, 20-24 Oct 2014. A cycle of 4 invited seminars in Kyoto University, Oct 2014: Insights into the particle acceleration of a peculiar gamma-ray radio galaxy IC 310, What gamma-ray observations can tell us about intergalactic magnetic fields ? Detection by the MAGIC telescopes of the farthest very high energy gamma-ray source, S3 0218+35, thanks to its delayed gravitationally lensed emission. Very high energy gamma-ray follow-up observations of novae and dwarf novae with the MAGIC telescopes
- Invited seminar in University of Barcelona, Feb 2014: What gamma-ray observations can tell us about intergalactic magnetic fields

DES/PAU GROUP

JELENA ALEKSIĆ

- Dark Energy Survey: Status and First Results RENATA Meeting, Laboratorio Subterraneo Canfranc, Spain, June 9-11, 2014.

CHRISTOPHE BONNETT

- Using neural networks to estimate redshift distributions. An application to CFHTLenS Statistical Challenges in 21st Century Cosmology: IAUS306, Lisbon, Portugal, May 25-29, 2014

RAMON MIQUEL

- Dark Energy Survey: Status and First Results Meeting on Fundamental Cosmology, Caleta de Fuste,Fuerteventura, Spain, June 5-6, 2014.
- The PAU Survey at the WHT Meeting on Fundamental Cosmology, Caleta de Fuste,Fuerteventura, Spain, June 5-6, 2014.
- Observational Cosmology, Taller de Altas Energías, Centro de Ciencias Pedro Pascual, Benasque, Spain, September 15-26, 2014.
- Dark Energy: Galaxy Surveys, APPEC SAC Meeting, Université Paris Diderot, Paris, France, November 3-4, 2014.
- Dark Energy Survey: First Results, Dark Side of the Universe 2014, University of Cape Town, Cape Town, South Africa, November 17-21, 2014.
- Dark Energy Survey: Status and First Results Seminar, Laboratoire Univers et Particules Montpellier, Montpellier, France, November 27, 2014.

CARLES SÁNCHEZ

- Photometric redshift analysis in the DES-SV data, National Astronomy Meeting (NAM), University of Portsmouth, UK, June 23-26, 2014.

VIP GROUP

GIANLUCA DE LORENZO

- Measurement of the energy and time resolution of the novel VIP CdTe detector for PET applications. IWORID-2014, Trieste, Italy

THEORY DIVISION

JOAN ELÍAS-MIRÓ

- “Higgs Windows to new Physics through d=6 operators”, Seminar Particle Theory, Harvard University, Cambridge (MA), US.
- “Higgs Windows to new Physics through d=6 operators”, Seminar Particles and Fields, Boston University, Boston (MA), US.

JOSÉ RAMÓN ESPINOSA

- Effective Field Theories for BSM. Lectures at Taller de Altas Energías TAE14, Sep. 15-26, 2014, Benasque (Spain).
- Topical Workshop: Rethinking Naturalness, “Electroweak Vacuum Stability after LHC8”, Dec. 17-19, 2014, Lab. Nat. Frascati (Italy)
- Strong and Electroweak Matter 2014, “The Stability of the Electroweak Vacuum in Light of LHC Data”, July 14-18, 2014, EPFL, Lausanne (Switzerland).
- Pascos 2014, “The Stability of the Standard Model Vacuum” June 22-27, 2014, Warsaw (Poland).
- Planck 2014, “The Stability of the Electroweak Vacuum”, May 26-30, 2014, Paris (France).
- Searching for Simplicity, PCTS Workshop, “The Stability of the Electroweak Vacuum”, May 12-15, 2014, Princeton (USA).
- Progress on Old and New Themes in cosmology (PONT 2014), “The Stability of the Standard Model Vacuum”, April 14-18, 2014, Avignon (France).
- After the Discovery: Hunting for a Non-Standard Higgs Sector, “The Case against Higgs Inflation”, Benasque Workshop, April 7-18, 2014, Benasque (Spain).
- High precision fundamental constants at the TeV scale, “Implications of Mtop for EW Vacuum Stability”, MITP Workshop, March 18-21, 2014, Mainz (Germany).
- Exploiting the Higgs breakthrough, Royal Society Meeting, “The Stability of the Electroweak Vacuum.”, Jan. 22-23, 2014, Chicheley Hall, Chicheley (UK).

CHRISTOPHE GROJEAN

- "Beyond the Standard Higgs", `Before, behind and beyond the discovery of the Higgs boson' Royal Society scientific meeting, London, UK, 21/01/14
- "Precision frontier at high energies", Future Circular Collider Study Kickoff Meeting, Geneva, CH, 12/02/14
- "Scaling of Higgs observables", Beyond the Standard Model 2014, Tsukuba, JP, 04/03/14
- "HEP theory: today and tomorrow", 26th Rencontres de Blois, Blois, FR, 19/05/14
- "FCC-ee phenomenology", 7th FCC-ee/TLEP physics workshop, Geneva, CH, 20/06/14
- "Still life: Standard Model Higgs boson and beyond", Astroparticle Physics 2014, Amsterdam, NL, 26/06/14
- "Physics of the Brout-Englert-Higgs boson: theory", ICHEP 2014, Valencia, SP, 07/07/14
- "Higgs and EW interpretation - theory (SM and BSM)", PANIC2014, Hamburg, DE, 25/08/14
- "Higgs effective field theory", Higgs Days 2014, Santander, SP, 10/09/14
- "Beyond the Standard Model Beyond the LHC", LCWS14, Belgrade, SR, 06/10/14
- "Higgs - theory", ECFA High Luminosity LHC Experiments Workshop 2014, Aix-les-Bains, FR, 21/10/14

- "Quo Vadis Higgs?", BSM Higgs Workshop, Batavia, USA, 5/11/14
- "Higgs physics and the future", Naturalness 2014, Rehovot, IL, 16/11/14
- "Higgs physics", SILAFAE, Medellin, CO, 24/11/14
- "The world with 100/fb data from the LHC", 8th Annual Meeting of the Helmholtz Alliance Physics at the Terascale', Hamburg, DE, 3/12/14

ORIOL PUJOLÀS

- Naturally light dilatons, holographically", ICTP Trieste, Italy, April 10th 2014
- "Naturally light dilatons, holographically", SNS Pisa, Italy, June 11th 2014
- "Massive gravity and the holographic Polaron", EPFL Lau- sanne, Switzerland, October 20th 2014.
- "Massive gravity and the Metal-Insulator transition", ICCUB Christmas Meeting 2014, Barcelona U, Barcelona, December 18th 2014.

MARIANO QUIRÓS

- Naturalness in the SM and Beyond, Colloquium at ICTP-SAIFR, 17 December 2014, Sao Paulo, Brazil.
- Quarks and leptons in warped space, Talk at ETH, Zurich, Switzerland, April 15th, 2014
- EWSB with custodial triplets, Talk at CP3-Origins and the University of Suthern Denmark, March 24th, 2014
- MSSM EWBG and LHC data, Talk at the University of Geneva, Switzerland, March 21st, 2014
- Electroweak vacuum Series of lectures (5 hours) delivered at the V FERRARA INTERNATIONAL
- SCHOOL NICCOLO CABEO 2014, "Vacuum and symmetry breaking: from the quantum to the cosmos", Ferrara, Italy, May 19-23, 2014
- SUSY Custodial Higgs Triplets and breaking of universality, Plenary talk at IVICFA Meeting "Theoretical Physics II", 24 October 2014, IFIC, Valencia, Spain
- Supersymmetric Custodial Higgs Triplets and Breaking of Universality, Plenary talk at "Physics Challenges in the face of LHC-14", 26 September 2014, IFT/CSIC-UAM, Madrid, Spain
- EWSB and Custodial Triplets, Plenary talk at the Conference, "Going On After the LHC8", 11-16 August 2014, ICTP-SAIFR, Sao Paulo, Brazil.
- Naturalness in the SM and Beyond Plenary talk at the Conference, "Status of the SM after the first LHC phase", University of Warsaw, Warsaw, Poland, 7-8 April 2014

GÉRALDINE SERVANT

- Lectures on "Fundamental concepts in particle physics''. CERN, Summer student programme, July 8-10 2014.
- "Dark Matter-Baryogenesis connection: status after LHC run 1 and future tests", Paris, 7th Symposium on large TPCs for low-energy rare event detection, Dec. 15-17 2014.
- "Higgs and its implications for baryogenesis" London, Queen Mary University, `Interplay of Particle and Astroparticle Physics IPA 2014' workshop, August 18-22 2014.
- Baryogenesis from Strong CP Violation and the QCD Axion.", Paris,`PLANCK 2014 conference, From the Planck scale to the EW scale', May 26-30 2014.
- "WIMP Theory" Stockholm, May 13, 2014 `Latest results in Dark Matter research' Workshop.
- "The role of the Higgs in baryogenesis theories", IFAE, Barcelona, Colloquium, Feb. 24, 2014:

6.5 PARTICIPATION IN EXTERNAL COMMITTEES IN 2014

EXPERIMENTAL DIVISION

ÒSCAR BLANCH

- Member of the Common Service Committee of "Observatorio El Roque de los Muchachos"
- Deputy Spokesman of MAGIC Collaboration.
- Member of the MAGIC Executive Board
- Member of the MAGIC Technical Board
- Member of the MAGIC Collaboration Board
- Convener of LST-CAM working group in CTA
- Member of the LST Executive Board
- Representative of IFAE in Consortium Board of CTA collaboration

CHRISTOPHE BONNETT

- Convenor of the Photometric Redshift for Weak Lensing science working group in DES

MARTINE BOSMAN

- Member of Plenary ECFA (European Committee for Future Accelerators
- Member of CERN Associates and Fellows Committee
- Member Comisión de Infraestructuras de Física de Partículas y Aceleradores (CIFPA) Mineco – Spain
- Ex-officio member of the ATLAS Collaboration Executive Board Deputy Chair of ATLAS Collaboration Board
- Member of Equal Opportunities committee of European Physical Society
- Member of Expert Panel of FWO (Flanders Research Foundation - Belgium)

MATTEO CAVALLI-SFORZA

- Chair, Aeres Review Committee of the Laboratoire Univers et Particules – Montpellier
- Spanish Representative, Restricted European Committee for Future Accelerators
- Member, Joint ECFA/EPS-HEPP Committee on the Evaluation of HEP Physicists
- Member, Jury of the "La Vanguardia de la Ciencia" Prize for 2014
- Member, Jury of the 1st ACER Prize for Promotion of Science

JUAN CORTINA

- Member of the MAGIC Technical Board.
- Member of the MAGIC Safety Board
- Member of the MAGIC Time Allocation Committee
- Representative of MAGIC at IAC Comité Científico Internacional (Cádiz, Nov 2014)
- Member of CTA LST Executive Board
- Member of CTA LST Steering Committee

SEBASTIAN GRINSTEIN

- Convenor of the 3D Pixel ITk ATLAS group
- Member of the AFP Management Board
- Member of the ATLAS Pixel Institute Board
- RD50 Institute Leader (Radiation hard semiconductor devices for very high luminosity colliders - CERN)
- AIDA-2020 Governing Board representative for IFAE

ENRIQUE FERNÁNDEZ

- Member of International Doctorate Network in Particle Physics, Astrophysics and Cosmology-Program Advisory Committee, (IDPASC-PAC)
- Member of Scientific Advisory Board of the Institute of Physics of the University of Freiburg, Germany

AURELIO JUSTE

- Co-organizer of the "HSG8 Workshop", CERN, Switzerland, November 13-14, 2014
- Member of the International Advisory Committee of the "13th International Symposium Frontiers of Fundamental and Computational Physics (FFP14)", Marseille, France, July 15-18, 2014
- Co-organizer of the workshop "After the Discovery: Hunting for a Non-Standard Higgs Sector", Centro de Ciencias de Benasque Pedro Pascual, Benasque, April 6-18, 2014
- Spanish National Evaluation and Foresight Agency (ANEP). Evaluation of Research Proposal submitted to ANR. Remote referee for the Evaluation Committee "Physique subatomique, sciences de l'Univers, structure et histoire de la Terre" of the French National Research Agency
- Member of the Scientific Committee of OCEVU (Origins, Constituents, and Evolution of the Universe) LabEx, France

ILYA KOROLKOV

- Member, Tile Calorimeter Collaboration Institution Board.
- Member, Tile Calorimeter Management Board.
- Member, ATLAS Calorimeter Upgrade Review Committee.

JOERN LANGE

- Member of AFP Management Board as AFP testbeam coordinator
- 3D ITk pixel testbeam contact
- RD50 deputy institute representative (Radiation hard semiconductor devices for very high luminosity colliders - CERN)

RUBEN LÓPEZ-COTO

- Member of the MAGIC software board

MANEL MARTÍNEZ

- Co-Spokesman of CTA Consortium (until Sep.2014)
- Chair of the CTA LST Steering Committee
- Member of MAGIC Time Allocation Committee (TAC)
- Spanish Delegate in APIF (Astroparticle Physics International Forum) of OECD
- Member of the Scientific Advisory Board of the Helmholtz alliance for Astroparticle Physics (HAP)
- Member of the Commitee for Infrastructures of the FPA National Program (CIFPA)
- Member of the committee for CTA of the Research Infrastructures for Astronomy committee (RIA)

MARIO MARTINEZ

- IFAE Representative at ATLAS Collaboration Board
- Member of ATLAS Publication Committee at CERN
- Member of International Advisory Committee (LHCP 2014 Conference)
- Acting as Referee for ANEP Spanish Agency
- Acting as Referee for Physical Review Journal
- Part of Organizing committee of HASCO (Hadron Collider Physics School) in 2014. ERASMUS-IP project as partner (DE-2013-ERA/MOBIP-3-29749-1-16)

RAMON MIQUEL

- Member of the Scientific Advisory Committee of the Astroparticle Physics European Consortium (APPEC)
- Member of the DES Management Committee
- Member of the DES Publication Board
- Member of the DES Builders' Committee
- Member of the PAU Executive Board
- External rapporteur to the scientific council of the Laboratoire Univers et Particules de Montpellier

ABELARDO MORALEJO

- Member of the MAGIC Speakers' bureau
- Member of the MAGIC software board
- Deputy convener of the CTA MC working group
- Member of ANEP's Ramón y Cajal evaluation panel

ANDRES PACHECO PAGES

- Member of the ATLAS Distributed Computing Coordination Committee
- Deputy member of the ATLAS International Computing Board
- Representative of IFAE in the RedIRIS Academic Network
- Acting as Referee for ANEP Spanish Agency
- Member of the IBERGRID2014 Program Committee

CRISTOBAL PADILLA

- Member of the ECFA Detector Pannel Committee.

JAVIER RICO

- Representative of IFAE at MAGIC Collaboration Board
- Coordinator of MAGIC Data Center
- Manager of MAGIC Common Fund
- Convener of the MAGIC Astroparticles & Fundamental Physics Working group
- Member of CTA's Speakers And Publications Office (SAPO)

IMMA RIU

- Member of the "ECFA HL-LHC Trigger, Online and Offline Computing" preparatory group
- Organizing panel chair ATLAS Trigger workshop in Sesimbra (Portugal), March 2014
- Member of Thesis Committee: "Measurement of the top quark pair production cross section in proton-proton collisions at center-of-mass energies of 7 TeV in final states with a τ lepton with the ATLAS detector". María Teresa Pérez García, Universitat de Valencia, September 2014.

FEDERICO SÁNCHEZ

- Member of the Interim International Executive Board (iiEB) at Fermi National Board to form the new ELBNF collaboration.
- Member of the T2K Executive Committee.
- Member of the T2K Institutional Board.
- Member of the WA105 Institutional Board.

JULIAN SITAREK

- Deputy Software Coordinator of the MAGIC experiment (up to July 2014)
- Software Coordinator of the MAGIC experiment (since July 2014)
- Member of the MAGIC Software Board
- Member of the MAGIC Technical Board
- Member of the MAGIC Executive Board
- Technical advisor to the MAGIC Time Allocation Committee
- Technical advisor to the MAGIC Key Observation Programs Evaluation Committee
- (ex-officio) member of the Collaboration Board of MAGIC
- Co-convener of the MAGIC AGN group

VERONICA SORIN

- CDF Spokesperson Election Committee
- ATLAS L1TOPO algorithms coordinator

THEORY DIVISION

CHRISTOPHE GROJEAN

- French "Agence National de la Recherche"
- Member of the steering committee of the Higgs Cross Section Working Group
- Convener of the physics WG, Linear Collider Collaboration
- Deputy convener of the phenomenology WG, TLEP steering committee

ORIOL PUJOLÀS

- Member of Thesis committee for Sebastian Krug, UAB, January 2014, "The Yang-Mills Vacuum Wave Functional in 2+1 Dimensions", PhD advisor: A. Pineda
- Member of Thesis committee for Javier Caravaca Rodriguez, UAB, June 2014, "Measurement of the electron-neutrino component of the T2K beam and search for electron-neutrino disappearance at the T2K Near Detector", PhD advisor: F. Sánchez

GÉRALDINE SERVANT

- Organizer of Cargese Summer School, MultiTeV Probes of the Standard Model and beyond with the LHC, July 14-26, 2014
- Organizer of PONT d'Avignon 2014 conference, Progress on Old and New Themes in Cosmology, Avignon, April 14-18 2014
- Convener of the "BSM/Cosmology" sessions of the International Workshop on Future Linear Colliders LCWS 2014, Belgrade, October 6-10 2014.
- Convener of the "Particle Physics" sessions of the TeVPA/IDM Astroparticle Physics 2014 conference, Amsterdam, June 23-28 2014.
- Member of the Scientific Committee of the Institut d'Etudes Scientifiques de Cargese. Bi-annual reviews of school and workshop proposals. (June and October 2014)
- Member of the Program Advisory Committee of the Munich Institute for Astro- and Particle Physics (MIAPP). Annual review of workshop proposals. (November 2014)
- Member of the evaluation panel NT-3 (subatomic physics, space physics and astronomy) of the Swedish Research Council (VR). Annual review of research grant applications. (August 2014)
- Member of Thesis committee for Mikael Chana, U. Granada, June 24, 2014, "Collider signatures of a non-standard Higgs sector", PhD adv.: J. Santiago

6.6 IFAE COLLOQUIA & SEMINARS IN 2014

IFAE COLLOQUIA

1. QCD made easy: the quest for accuracy
February 3 2014
Stefano Frixione (CERN & EPFL Lausanne)

2. The role of the Higgs in baryogenesis theories
February 24 2014
Géraldine Servant (IFAE - ICREA)

3. High Energy Neutrino Astronomy at the South Pole
March 24 2014
Kael Hanson (Université Libre de Bruxelles)

4. Hunting for Axions and WISPs with cutting-edge photon sensors
May 19 2014
Cantatore Giovanni (Trieste Universita & INFN)

5. 103 years ago, Ernest Rutherford discovered the nucleus and subatomic physics
September 29 2014
Fabrice Feinstein (LUPM Université Montpellier)

6. Vade retro Standard Model Higgs
October 20 2014
Christophe Grojean (IFAE-ICREA)

7. TH status after ICHEP2014: Searching for New Physics at the next LHC run
November 24 2014
Toni Pich (IFIC & U Valencia)

8. "That's the story": Prof. Roy Glauber remembers the making of the atomic bomb
December 15 2014
José Ignacio Latorre (Universitat de Barcelona), Maria Teresa Soto-Sanfiel (UAB)

IFAE SEMINARS

1. Searching for light dark matter with NOVA
January 10 2014,
Claudia Frugiuele (Fermilab)

2. Schwinger effect in de Sitter space
January 17 2014
Jaume Garriga (Universitat de Barcelona)

3. Signatures of the inert doublet dark matter model
January 24 2014
Alejandro Ibarra (Munich Tech. U)

4. Imprints of the Standard Model in the Sky
February 21 2014,
Daniel Figueroa (U de Geneve)

5. Summary of CMS results in the first 3 LHC years
March 3 2014
David d'Enterria (CERN)

6. Non-relativistic particles in a thermal bath
March 7 2014
Antonio Vairo (Munich Tech. U)

7. Backreaction in extended theories of gravity
March 14 2014
Alvaro de la Cruz Dombriz (UCM)

8. On the non-linear scale of cosmological perturbation theory
March 20 2014
Thomas Konstandin (DESY)

9. Inflation, BICEP2, and an interesting discrepancy with Planck
March 27 2014,
Prof. Lorenzo Sorbo (U.Mass Amherst & TPT-CEA Paris)

10. Massive gravity and extensions
March 28 2014
David Pirtskhalava (Scuola Normale Superiore,Pisa)

11. Radion-Dilaton/Higgs in light of the LHC
April 4 2014
Anibal Medina (University of Melbourne)

12. Split SUSY Radiates Flavor
April 25 2014, Daniel Stolarski (CERN)
Daniel Stolarski (CERN)

13. A sterile neutrino at MiniBooNE, MicroBooNE and IceCube
April 28 2014
Manel Masip (Universidad de Granada)

14. BSM Primary effects
May 8 2014,
Sandeepan Gupta (Ifae)

15. Heavy Vector Triplets: Bridging Theory and Data
May 9 2014,
Andrea Thamm (EPFL Lausanne)

16. On the validity of effective field theory for dark matter searches at LHC
May 16 2014,
Enrico Morgante (U de Geneve)

17. Superfluids, type-II NG bosons and AdS/CFT"
May 25 2014,
Amadeo Jimenez Alba (IFT UAM)

18. The MSSM and color- and charge- breaking minima
May 29 2014.
Jose Eliel Camargo Molina (Universität Würzburg)

19. High scale mixing unification with Dirac neutrinos
May 30 2014,
Gauhar Abbas (IFIC, Valencia)

20. The Dilaton and its many Faces
June 3 2014,
Javi Serra (Cornell U)

21. Effective field theory approach to top-quark physics at NLO accuracy
June 6 2014,
Cen Zhang (U C Louvain)

22. A Long-Baseline Neutrino, Proton Decay and Supernova Facility Hosted in the US
June 26 2014,
Robert J. Wilson (LBNE Collaboration Co-Spokesperson Colorado State University)

23. The Slow Gravitino
June 27 2014,
Karim Benakli (LPTHE, Paris)

24. Higgs mediated lepton flavour violation
September 5 2014, 2:00pm - Seminar room
Alejandro Celis (IFIC,Valencia)

25. QCD axion with high scale inflation
September 19 2014,
Kiwoon Choi (director of IBS Center for Theoretical Physics of the Universe, Daejeon)

26. A new experiment to search for axion dark matter
September 19 2014,
Javier Redondo (Max Planck Inst, Munich)

27. Generating X-ray lines from annihilating dark matter
September 26 2014,
Lucien Heurtier (CPHT Ecole Polytechnique Paris)

28. Emerging Jets From a Dark Sector
October 10 2014,
Pedro Schwaller (CERN)

29. Inflation from broken scale invariance
October 17 2014,
Csaba Csaki (Cornell U)

30. EFT approach to Flavour and Dark Matter
October 21 2014,
Andreas Crivellin (U Bern)

31. Minimal Dark Matter and future colliders
October 27 2014,
Filippo Sala (IPhT, Saclay)

32. News From Muonic Atoms
October 31 2014,
Aldo Antognini (ETH Zurich)

33. Models with small cosmological constant at finite temperature
November 11 2014,
Speaker: Bithika Jain (Syracuse U)

34. Massive gravity from spontaneous symmetry breaking
November 14 2014,
Diego Blas (CERN)

35. A Higgs or the Higgs? A detailed look at the anomalous Higgs couplings
November 21 2014,
Shankha Banerjee (HRI Allahabad India)

36. Atomic dark matter
November 25 2014,
Kalliopi Petraki (NIKHEF Amsterdam)

37. Understanding the Large Scale Structure of the Universe through Symmetries
November 28 2014,
Toni Riotto (Geneva U)

38. Standard Model vacuum stability with a 125 GeV Higgs
December 5 2014,
Stefano Di Vita (MPI Munich)

39. On Flavour and Naturalness of Composite Higgs Models
December 11 2014,
Alexei Matsedonskyi (SNS Pisa)

40. Axions in SUSY
December 12 2014,
Lorenzo Ubaldi (Bonn U)

41. Dark matter and flavor
Decemeber 18 2014,
Fady Bishara (Cincinnati U and Fermilab)

42. New ways to search for right-handed current in $B \to \rho l \bar{\nu}$ decay
December 19 2014,
Sascha Turczyk (U Mainz)

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