IFAE

Institut de Física d'Altes Energies

Report of Activities

2013

MINISTERIO
DE ECONOMÍA
Y COMPETITIVIDAD

Unión Europea

Fondo Europeo
de Desarrollo Regional
"Una manera de hacer Europa"

CONTENTS

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 Coneiximent.

L'IFAE està estructurat en dues Divisions: Experimental i Teòrica. 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.

Activitats científiques de la Divisió Experimental

Durant 2013 la Divisió Experimental va treballar en vuit línies de recerca, la majoria de les quals son activitats de llarg termini. Aquests línies abarquen els camps de la Física de les Altes Energies, de l'Astrofísica i de la Cosmologia Observacional, i inclouen el desenvolupament de detectors per a Imatges Mèdiques i dos nous projectes d'instrumentació.

1. ATLAS, al Large Hadron Collider (LHC) del CERN. Al 2013 l'anàlisi de les dades sobre el bosó, descobert al 2012, ha portat a la conclusió que aquesta nova partícula té les caraterístiques esperades per un bosó de Higgs, la peça mancant del Model Estàndar. Ara l'LHC s'està reformant per tal d'arrivar, al 2015, a l'energia de 13 o bé 14 TeV, règim que obrirà perspectives de noves descobertes.

2. Un potenciament d'ATLAS, en preparació per a una gran renovació que tindrà lloc al final d'aquesta dècada. El grup de l'IFAE està desenvolupant un detector de semiconductors amb pixels, per a reconstruir les traces a la regió central i també a angles molt petits.

3. T2K, un experiment amb neutrins, al Japó. A 2012, desprès 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. Combinant aquestes dades amb els resultats de precisió dels reactors nuclears, s'ha obtingut la primera indicació de violació de CP amb leptons. Adicionalment, T2K ha donat les mesures més precises, fins ara, sobre la desaparició dels neutrins del muó.

4. MAGIC, al Roque de Los Muchachos (La Palma, Canàries) utilitza un sistema estereoscòpic de dos telescopis de 17 m de diàmetre, potenciat recentment. La recerca del grup d'IFAE s'enfoca en observacions de llarga durada de fonts potencials de senyals de matèria fosca. Aquesta activitat forma part del programa primari d'observacions de MAGIC, aprobat per la col·laboració a 2013.

5. CTA (Cherenkov Telescope Array), 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 y de fabricació de prototipos. IFAE està involucrat en aspectes cabdals d'aquest projecte, tant a nivells tècnics com a nivells de gestió.

6. La col·laboració DES (Dark Energy Survey), al telescopi Blanco a Cerro Tololo (Chile) va complertar a 2013 la seva fase de "verificació científica", va calibrar amb èxit el seu mètode per a mesurar el "red shift" i va endegar el seu programa de observar uns 300 milions de galàxies del cel Sud en 5 anys.

7. PAU (Physics of the Accelerating Universe), es una col·laboració espanyola coordinada per l'IFAE i finançada amb un projecte Consolider. PAU instal·larà una càmara, construida a l'IFAE, al Telescopi William Herschel a La Palma, Canàries, i farà un cartografiat amb mesures fotomètriques del "red shift" d'unes 30,000 galàxies per nit, per a mesurar paràmetres de l'energia fosca. La càmara s'acabarà i s'instal·larà a 2014.

8. A 2013, es van posar en marxa dos nous projectes, un amb detecció en un gas, amb

amplificació a microestructures, col·laborant amb l'Institut de Microelectrònica de Barcelona, i l'altre per a desenvolupar un fotodetector amb grafè, amb l'Institut Català de Fotònica.

9. El grup de l'IFAE d'Imatges Mèdiques està desenvolupant una tècnica novedosa de Tomografia amb Emissió de Positrons (PET) amb el finançament d'un Advanced Grant de l'ERC. El concepte es basa en un detector de CdTe amb segmentació tridimensional molt fina, que es llegeix amb ASICS dissenyats a l'IFAE. A més a més, el grup està desenvolupant altres aplicacions d'aquest concepte de detector, per a una Càmara Compton i per a Mammogràfia amb Emissió de Positrons (PEM).

Unes de les activitats d'aquest grup es duun a terme en col·laboració amb empresa spinoff X-Ray Imatek.

Activitats científiques de la Divisió Teorica

La Divisió Teorica segueix tres línies d'investigació: física del Model Estàndar, més allà del Model Estàndar, i Astrofísica & Cosmologia.

Física del Model Estàndard

Els temes principals investigats pel grup de física del Model Estàndard ("*Standard Model*", SM) a 2013 han sigut les desintegracions hadròniques del leptó τ, arrivant a un nou conjunt de determinacions d'α_S, i també un estudi del comportament a ordres superiors de la QCD perturbativa.

Física més allà del Model Estàndard

El grup de l'IFAE que es dedica a la física més allà del Model Estàndard ("*Beyond the Standard Model*", BSM) continua estudiant les dades experimentals sobre el bosó de Higgs per tal de treure'n les possibles conseqüències pel SM o més allà del SM. Per a comprendre quines escenaris de física BSM encara es queden o no oberts s'ha dut a terme un estudi sistemàtic de les contribucions més significatives aportades per estats pesats de BSM

A una línia de recerca differenta, s'han considerat extensions del sector Higgs del MSSM amb triplets SU(2). També s'ha estudiat com sortirien l'spectre de massa dels leptons carregats i neutres i els angles de *mixing* dels neutrins en models amb dimensions *extra* amb "*warp*".

Astrofísica i Cosmologia

L'astrofísica i la cosmología de particules son camps de recerca recents, a l'intersecció entre la física de partícules, l'astrofísica i la cosmologia. L'objectiu és aprofitar el nostre coneiximent dels fenòmens astrofísics i cosmològics per tal de trovar respostes a problemes fonamentals de física, i vice-versa. A 2013, els membres de la Divisió Teòrica de l'IFAE en aquesta àrea han continuat investigant els temes següents: models de matèria fosca, bariogènesis, l'origen de l'invariància de Lorentz, i les aplicacions de la correspondència entre *gauge* i gravetat.

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 Economics and Knowledge (Departament d'Economia i Coneiximent, 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 Adjunct Director and the Coordinator of the Theory Division are nominated by the Director and appointed by the Governing Board.

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 2013, 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 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. The Theory Division faculty is composed of five ICREA research professors and a Ramon y Cajal fellow. They share physical and human resources (postdocs and students) with the personnel from the 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.

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

1.2 IFAE Goals and History, briefly

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 both theoretical and experimental High Energy Physics. The origins of the consortium are in the Department of Theoretical Physics and in the Laboratory for High Energy Physics (LFAE) of UAB. The theoretical group was established in 1971, when 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 the UAB, particularly to effectively use the CERN laboratory, after Spain joined again 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 Theoretical Division also expanded its research program since the 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, the UAB, the 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 2006, the observational cosmology group of IFAE proposed the PAU (Physics of the Accelerating Universe) initiative, which was approved in 2007 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 large fraction of the Northern sky in order to measure parameters of cosmological interest by means of novel observational tools.

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 Institutes's personnel and funding. The scientific and academic goals are specified in a set of numerical indicators, which are reported on on 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 2013 IFAE was granted the 2012 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 will strengthen IFAE's activities and its capabilities to obtain additional funding.

1.3 European Funding

In 2013, the following projects recdeived funding from the European Union through the FEDER Programme ("Una manera de hacer Europa") managed y the Spanish Ministry of Economy and Competitiveness:

1. FPA2009-07474, *"Finalización y explotación de los telescopios MAGIC"*
   Investigador responsable: Juan Cortina

2. FPA2009-07496, *"Física en colisionadores hadrónicos con los experimentos ATLAS y CDF"*
   Investigador responsable: Mario Martinez Pérez

3. AYA2009-13936-C06-02, *"Cosmología con cartografiados extragalácticos"*
   Investigador responsable: Ramon Miquel

4. FPA2012-38713, *"Fisica en colisiones protón protón en el LHC usando el detector ATLAS"*
   Investigador responsable: Mario Martínez Pérez

5. FPA2012-39502, *"Explotación del upgrade de MAGIC"*
   Investigador responsable: Javier Rico

6. FPA2012-39684-C03-01, *"Cosmología y física fundamental con cartografiados estragalácticos"*
   Investigador responsable:Ramon Miquel

7. AYA2012-39620-C03-03, *"Cosmología con cartografiados extragalácticos: EUCLID"*
   Investigador responsable: Cristobal Padilla

8. EC2012-39150-C02-02, *"Detección de nanomoleculas mediante el uso de sensores gaseosos microestructurados"*
   Investigador responsable: Mokthar Chmeissani

T

1.4 IFAE Governing Board - 2013

President

Antoni Castellà i Clavé

Secretary General for Universities and Research, Dept. Economia i Coneiximent

Members

Josep Mª. Martorell i Rodó
Director General for Research, Dept. Economia i Coneiximent

Pere Palacín i Farré
Director General for Energy, Mines and Industrial Safety, Dept. Empresa I Ocupació

Lluís Tort i Bardolet, from 30 July 2012
Deputy Rector for Strategic Projects & Planning, Universitat Autònoma de Barcelona

Ramon Pascual de Sans
Professor of Physics, Universitat Autònoma de Barcelona

Joaquim Gomis Torné
Professor of Physics, Universitat de Barcelona

Director

Matteo Cavalli-Sforza
Research Professor, IFAE

Adjunct Director

Ramon Miquel Pascual
Research Professor, ICREA

2. Scientific Activities in 2013

OUTLINE

The Experimental Division

During 2013 the Experimental Division's activities focused on eight main projects, most of which are 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 two new instrumentation projects.

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

1. ATLAS**,** at the Large Hadron Collider (LHC) of CERN. In 2013 the analysis of data on the boson discovered in 2012 allowed to conclude that this new particle has the properties expected for a Higgs boson, the long-sought missing piece of the Standard Model. At this time the LHC is being upgraded in order to reach, in 2015, the cms energy of 13 or 14 TeV. 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 in the very forward regions.

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. When combined with precision data from reactor disappearance experiments this result shows the first indication of CP violation in the lepton sector. In addition, T2K gave the most precise measurements to-date of muon neutrino disappearance parameters.

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. IFAE's main research focus is deep observations of targets-of-opportunity for Dark Matter signatures. This activity is part of MAGIC's Key Observation Program, approved by the collaboration in 2013.

5. CTA, a worldwide collaboration that will build two multi-telescope observatories, in the Northern and Southern hemispheres, is now in in an advanced design and prototyping phase. IFAE is involved in major aspects of this project, at the technical and the top management levels.

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) completed in 2013 its science verification phase, successfully calibrated its red-shift measurement method and began its 5-year measurement program of about 300 million galaxies in the southern sky.

7. PAU (Physics of the Accelerating Universe) is a Spanish collaboration funded by a Consolider project. It will install its own custom-built camera at the William Herschel Telescope at La Palma, Canarias. PAU will carry out a photometric red-shift survey of about 30,000 galaxies/night in order to measure dark energy parameters. The camera will be completed and installed in 2014.

8. In 2013, In 2013, two new projects were started, one using a gaseos micropattern detector, in collaboration with the Barcelona Institute of Microelectronics, and the other to develop a graphene photodector, with ICFO, the Catalan Photonics Institute.

9. The **Medical Imaging** group is developing a novel approach to Positron Emission Tomography, funded by an ERC advanced grant. The approach is based on a finely pixelized CdTe detector, to be read out by a 100-channel ASIC designed at IFAE. In addition, the group is developing further applications of this detector concept to a Compton Camera and to Positron Emission Mammography.

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

The Theory Division

The activities of the Theory Division during 2013 continued along the usual 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 2013 were hadronic decays of the τ lepton, leading to a new set of determinations of α_S, as well as a study of the large-order behaviour of QCD perturbation theory.

2. Beyond the Standard Model

IFAE's BSM theory group continued studying the experimental data on the Higgs boson to extract possible implications forr SM and SM physics. To understand which windows for BSM physics are still open, or not, a systematic study of the leading contributions from heavy BSM states was carried out.

On a different research line, extensions of the Higgs sector of the MSSM by SU(2) triplets were studied. Also, the generation of the charged and neutral lepton mass spectrum and of neutrino mixing angles in warped extra-dimensional models was studied.

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 2013, the members of the Theory Division from this research area continued working on the following topics: dark matter models, baryogenesis, the emergence of Lorentz invariance, and applications of the gauge/gravity correspondence

2.1 ATLAS at the CERN LHC

Mario Martínez

Introduction

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.

In 2013 the LHC entered the first year of machine shutdown and carried out 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 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. Finally, in 2013 the IFAE group took the responsability of organizing the first Large Hadron Collider Physics Conference in Barcelona which is considered one of the most important topical conferences in the field.

In the following sections, some details are given on the different activities of the group.

TileCal Operations & Upgrade

In 2013, the IFAE group contributed strongly to the Tile calorimeter maintenance, calibration and data preparation.

In April 2013, the group started an effort on the calorimeter upgrade towards ever increasing luminosity delivered by the LHC. IFAE engineer, F.Grañena became responsible for all the mechanical issues related to the Tile demonstrator project. The demonstrator project will test various solutions of the upgraded read-out of the ATLAS calorimeters. In particular Ferran has completely redesigned the mechanical structure that hosts the Tile Calorimeter front-end read-out electronics, providing for enlarged reliability and reduced demand on the access conditions. This new mechanical structure is known as "mini-drawers". In 2013 IFAE has designed mini-drawer prototypes (shown on Figure 1 and Figure 2) that will be inserted in the ATLAS in summer 2014 for tests during the LHC Run II.

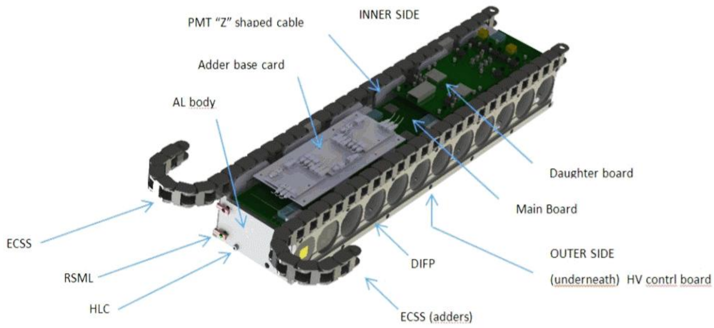


Fig. 1: 3D simulation of the mini-drawer.

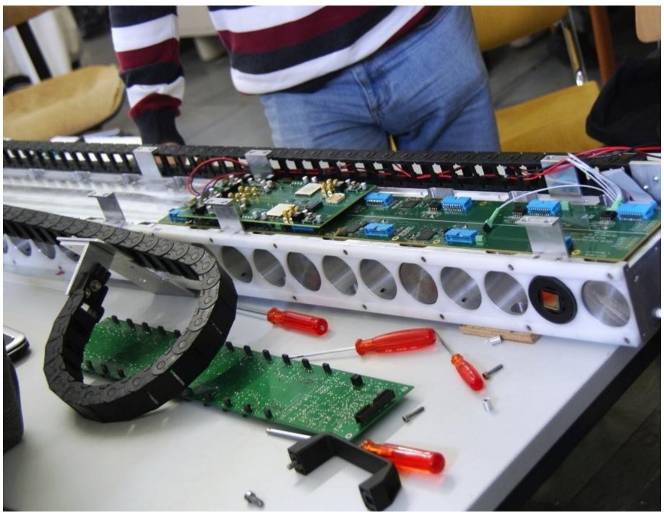


Fig. 2: Mini-drawer prototype

The IFAE group maintains its commitment to fully support the TileCal "Minimum Bias" data calibration system. The system is based on components developed exclusively at IFAE and serves to monitor on 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 have been equipped with redesigned integrators to test their performance during the LHC Run II.

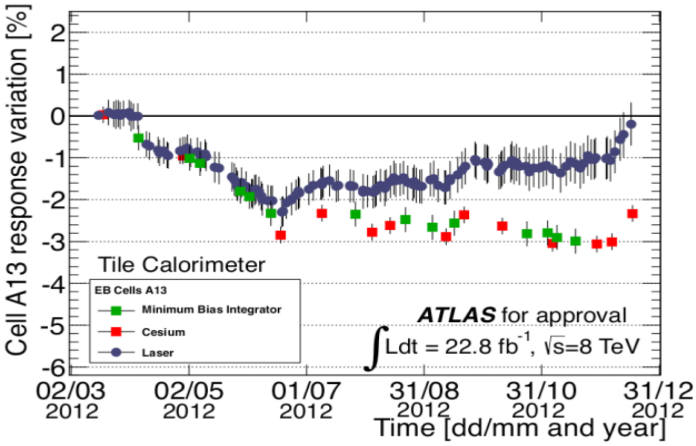


Fig. 3: Loss of the light yield in TileCal cells as a function of time seen by various Tile monitors in 2012.

IFAE PhD student Silvia Fracchia qualified for ATLAS authorship with the analysis of the data obtained by the system in 2012 to quantify the effect of the irradiation on the optical components of the Tile calorimeter. The results indicate detectable loss in the optics of the calorimeter, as shown in the Figures 3 and 4, as a function of the electrical charge collected by the "Minimum Bias" data calibration system in 2012. This work was rewarded by an oral presentation at the TIPP2014 conference.

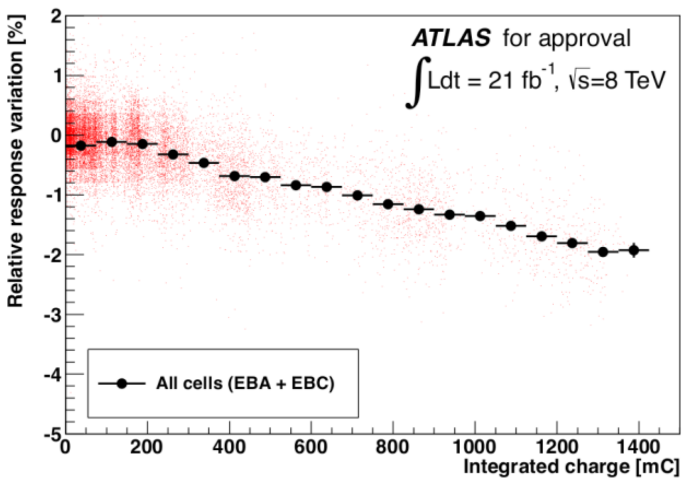


Fig. 4: Relative loss of the light yield in TileCal cells as a function of the electrical charge collected from these cells in 2012.

Trigger Operations & Upgrade

The IFAE group holds responsibilities in the ATLAS High Level Trigger (HLT) system, which includes software-based 2nd (L2) and 3rd level triggers which run in two large computer farms. During the ATLAS Run I period, IFAE played an important role in the overall coordination of trigger operations, in the coordination of the trigger menu and signatures group (I. Riu as co-coordinator), in the commissioning of the infrastructure software and integration of trigger algorithms, altogether helping to achieve an excellent trigger efficiency. Until the end of Run I in March 2013, the group continued the activities in the and jet trigger signatures.

After Run I, the τ trigger activities focused on the measurement of the data versus Monte Carlo trigger efficiency scale factors of the combination of a τ and missing transverse energy (MET) trigger objects. A tag-and-probe method using a selection of leptonic data events on the $\tau+\mu$ channel has been used. Efficiency scale factors of data over Monte Carlo have been provided as a function of both τ p_T and MET. They have been used in the search for charged Higgs bosons in the τ +jets final state, published in ATLAS-CONF-2013-090. P. Casado led the effort.

In 2015, after the current shutdown at CERN, it is expected that LHC will collide protons at a center-of-mass energy of around 13 TeV with a bunch-to-bunch spacing of 25 ns. In order to keep the event rate at Level-1 (L1) below the allowed maximum of 100 kHz, the trigger will need to adapt by increasing electromagnetic, hadronic and muon objects p_T thresholds. To avoid increasing them too much and keep events with Z or W bosons, a topological processor that will allow the combination of invariant masses of pairs of objects.

The IFAE group has contributed to the L1 topological trigger software tools, production of event samples and performance studies for different physics channels, including the challenging channel. Figure 5 shows the distribution of the minimum difference in azimuthal angle between the L1 MET and all L1 central jets for ZH signal and minimum bias events. Other studies include topological selections and trigger combinations for semi-leptonic pairs and charged Higgs boson in the τ +jets final state. These studies have been published in the TDAQ Phase-I Upgrade Technical Design Report in ATLAS-TDR-023 (CERN-LHCC-2013-018) and are taken into account in the design of the trigger menu for Run 2. V. Sorin qualified as an ATLAS author by working on that project.

In addition, the performance of the L2 partial jet scan (based on jets formed from a collection of cells from all the L1 Regions of Interest), developed by the IFAE group and used during Run 1, has been documented in ATL-COM-DAQ-2013-122.

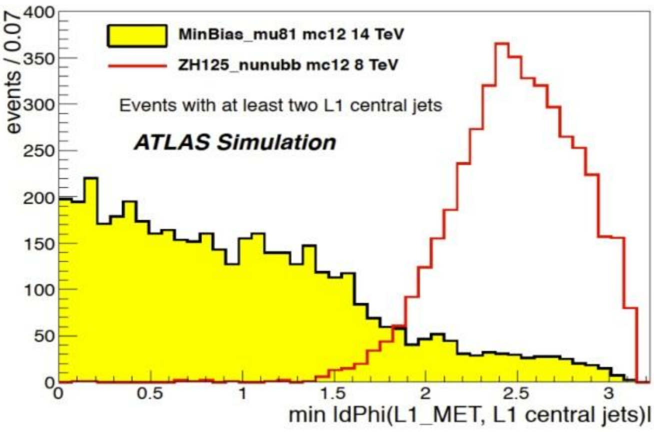


Fig. 5. Minimum difference in azimuthal angle between L1 MET and L1 central jets for ZH and minimum bias events.

Physics Analyses

IFAE continued to play a leading role on several physics research lines including the study of the recently discovered Higgs boson (both ttH and ZH channels), the search for Super-symmetry, Extra Spatial Dimensions, Dark Matter, and new phenomena in Top-quark final states. In the following we present some of the results obtained in 2013.

Search for Supersymmetry in Jet+X

The IFAE team continued to be a driving force in monojet analyses in ATLAS at 8 TeV, with postdoc Jalal Abdallah being the contact person of the analysis and Mario Martínez being the corresponding editor for journal papers and conference notes. The complete 7 TeV results, as published in JHEP 04 (2013) 75, and preliminary 8 TeV results, using 10 fb-1 of data, were part of Valerio Rossetti's PhD thesis, defended in summer 2013. This included exclusion limits on large extra dimensions (LED), dark matter (WIMPs) pair production, and the production of very light gravitinos in supersymmetry (SUSY).

In 2013, the team focused attention towards the 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. In particular, this includes the pair production of third-generation squarks (stop and/or sbottom) nearly degenerate in mass with the Lightest Super-symmetric Particle (LSP), usually identified as the lightest neutralino (χ^0_1).

Inclusive searches for squark and gluinos at the LHC led to the exclusion of gluinos and first- and second-generation squarks with masses below the TeV scale. In such scenario, much attention has been put on the search for third-generation squarks. This is strongly motivated by the need to address the hierarchy problem which in SUSY involves at least the presence of loop contributions from light stops (with mass below 1 TeV). In some SUSY models, the mixing of left- and right-handed scalar fields leads to a very light stop mass state.

The analysis makes use of the full 8 TeV dataset (20 fb^{-1}). The requirements on the jet p_T and missing transverse momentum have been re-optimized as a function of the stop and LPS masses. Data-driven strategies for background determination allowed for highly reduced systematic uncertainties. Figure 6 shows the measured leading jet p_T in monojet-like events compared with the background predictions. Good agreement is observed between data and expectations in the whole p_T range explored.

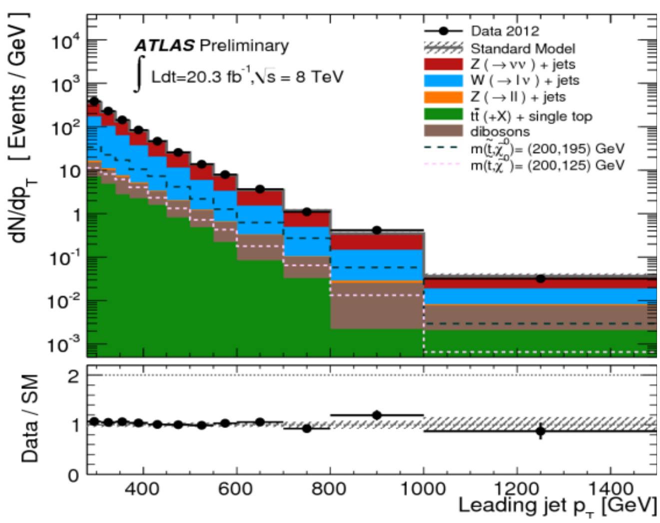


Fig. 6: Measured leading jet p_T in monojet final states compared with background predictions (taken from ATLAS-CONF-2013-068).

The results have been interpreted in terms of exclusion limits on the pair production of top squarks decaying into a charm quark and a LSP (→ c χ^0_1) with 100% branching fraction. The results have been combined together with a separate search in the non-degenerate scenario that selects charm-tagged jets in the final state (see Figure 7). Altogether, the results became a highlight of the EPS summer conference and were documented in ATLAS-CONF-2013-068, for which M. Martínez acted as corresponding editor. At the moment of preparing this report the monojet SUSY analysis is also being re-interpreted in different simplified models with compressed scenarios including: sbottom pair production, stop pair production in the so-called 4-body decay channel (→ Wb χ^0_1) to fill the exclusion gaps at low stop masses, as shown in Figure 7; squark-squark strong pair production; and chargino-neutralino electroweak production with nearly degenerate masses. The results will be part of several SUSY summary papers currently in preparation. This constitutes the PhD thesis of R. Caminal expected by fall 2014.

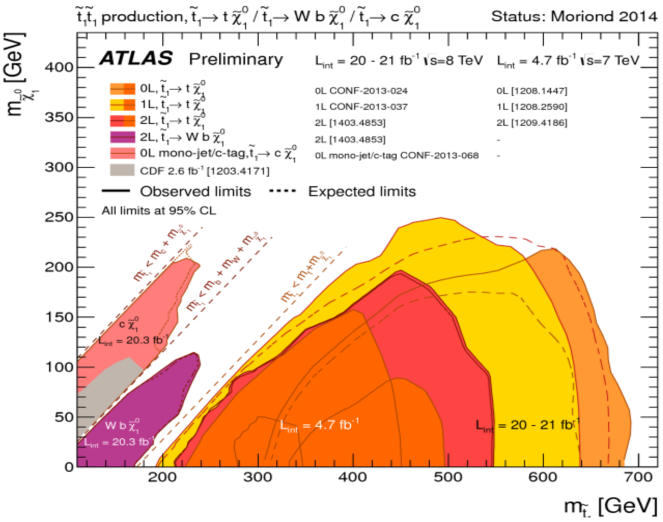


Fig. 7: Summary of 95% CL exclusion limits on scalar top mass versus neutralino mass by ATLAS for scalar top pair production and considering different decay channels. The monojet contribution enters at low masses for the stop.

Higgs Searches in VH (H → bb) channel

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. To date signals of significance greater than 6σ have been observed in its decays into two photons, WW and ZZ boson and so far its properties have been found consistent with those corresponding to a SM Higgs boson. However, to fully determine its nature, it is crucial to verify, or observe the predictions of its decay to fermions. In order to explore the direct coupling to fermions, ATLAS has performed studies on the decay of the Higgs boson into a bottom quark-antiquark pair or τ lepton-antilepton pair. In particular, IFAE played a leading role since 2012 in the analysis of the associate production of the Higgs with a Z boson, with the Higgs decaying into a pair of b quarks. Postdoc P. Francavilla has acted as contact person and editor of the most recent result, published for the summer conferences (ATLAS-CONF-2013-079), and the student G. González was invited to present the results in the fermion decays at the WIN2013 conference. The latter analysis, which makes use of the fully integrated luminosity accumulated during 2011 and 2012, has improved expected limits by 30% respect to the summer 2012 result. Having found no evidence of a SM Higgs boson it sets a 95% confidence-level upper limit of 1.4 times the SM Higgs boson cross section (see Figure 8). The group is now focused on final analysis improvements towards its publication. This measurement constitutes the PhD. Thesis of G. Gonzalez to be defended in autumn 2014.

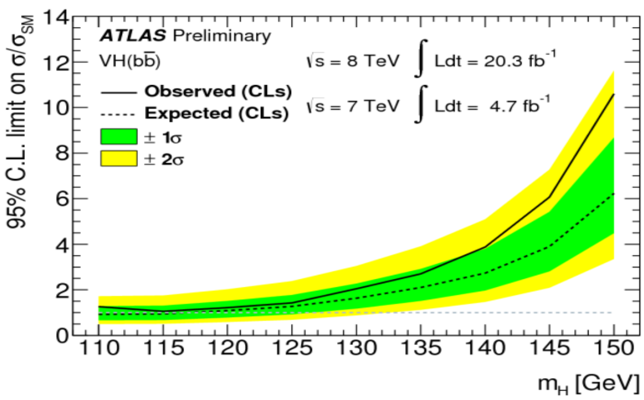


Fig. 8: Expected (dashed) and observed (solid) CLs limit on the normalised signal strength as a function of m_H for all channels for the combination of the 7 TeV and the 8 TeV datasets. Taken from ATLAS-CONF-2013-079.

Top Quark Physics

The top quark is the particle most strongly coupled to the electroweak symmetry-breaking sector (EWSB) of the standard model. This suggests that the top quark may play an active role in EWSB or offer a window of sensitivity to new physics (NP) related to EWSB and strongly coupled to it. IFAE is carrying out a competitive program of precision measurements and direct searches for NP in top quark final states with the goal of unraveling the underlying dynamics responsible for EWSB.

Precision Measurements

The observation of an unexpectedly large forward-backward (FB) asymmetry in top pair production by the CDF and D0 experiments, ~2σ above the SM predictions, constitutes one of the most tantalizing hints of NP in the top quark sector. The large top quark samples collected by the ATLAS experiment offer the exciting possibility of precise measurements that could shed light on the Tevatron anomaly. At the LHC, despite the charge-symmetric initial state, it is possible to define a charge asymmetry sensitive to the same underlying dynamics as the FB asymmetry at the Tevatron. However, this is quite a challenging measurement since at the LHC the expected asymmetry from NP would be quite small (~5-10%), which requires to develop strategies to enhance it, as well as keeping systematic uncertainties below 1%.

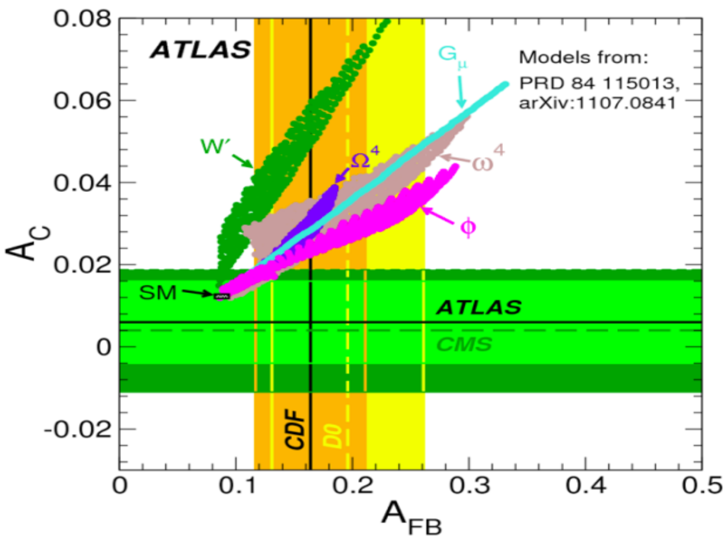


Fig. 9: Measured inclusive FB asymmetries from the Tevatron and charge asymmetries from the LHC, compared to predictions from the SM as well as predictions incorporating various potential new physics contributions. The horizontal (vertical) bands and lines correspond to the ATLAS and CMS (CDF and DO) measurements. Taken from JHEP 02 (2014) 107.

Since 2012 the group has been leading the measurement of the tt charge asymmetry in the semileptonic decay channel, performing inclusive measurements as well as differential measurements as a function of three relevant kinematic variables of the tt system (mass, transverse momentum and rapidity). The most recent measurements used the full dataset collected by ATLAS at √s=7 TeV, corresponding to an integrated luminosity of 4.7 fb^{-1} (see Figures 9 and 10). These results were published in JHEP 02 (2014) 107 and represent the most precise LHC measurements at √s=7 TeV. The group is currently focused on an improved measurement using the full dataset collected by ATLAS at √s=8 TeV, corresponding to an integrated luminosity of 20.3 fb^{-1}. F. Rubbo is the main analyzer and corresponding editor for this publication result. Both measurements, at √s=7 TeV and √s=8 TeV, will be included in F. Rubbo's PhD thesis (expected in Fall 2014).

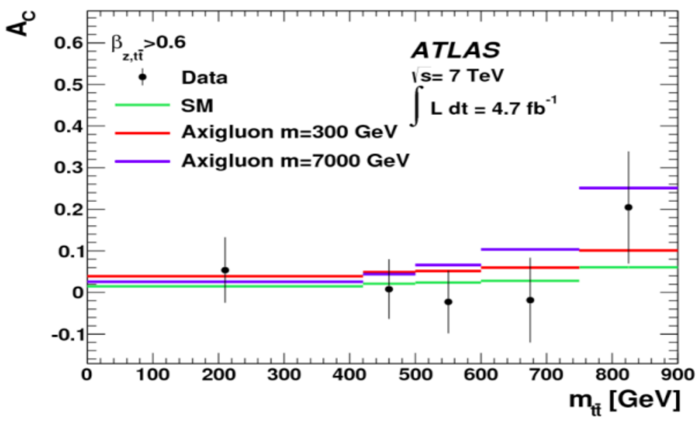


Fig. 10*:* Measured A_c as a function of m_{tt} after a requirement on the tt velocity (®z,tt) that increases the qq→tt fraction. The A_c values after the unfolding (points) are compared with the SM predictions (green lines) and the predictions for a colour-octet axigluon with a mass of 300 GeV (red lines) and 7000 GeV (blue lines) respectively. Taken from JHEP 02 (2014) 107.

Searches for Exotic Heavy Quarks

Many new physics models aimed at addressing some of the limitations of the standard model involve the presence of exotic quarks, heavier than the top quark. A prominent example is weak-isospin singlets or doublets of vector-like quarks, 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, the new heavy quarks would be predominantly produced in pairs via the strong interaction for masses below ~1 TeV. In the case of vector-like quarks, several decay modes are possible, T→Wb, Zt and Ht, all with sizable branching ratios, resulting in a very rich spectrum of possible final state signatures.

Since 2011, IFAE is playing a leading role in the program of heavy quark searches in the semileptonic final state in ATLAS. Following the two previous publications on searches for $TT \rightarrow W^+bW^-b$ at $\sqrt{s}=7$ TeV, the group has developed two complementary searches for vector-like quarks at $\sqrt{s}=8$ TeV, capable of probing 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 probing these scenarios in a more model-independent fashion, a strategy that was pioneered by the group.

018 and ATLAS-CONF-2013-060) and set some of the most restrictive existing bounds in these models (see Figure 11). These searches are also nicely complementary to other existing searches in multilepton final states, which sensitively probe high BR(T→Zt). These two results were included in A. Succurro's PhD thesis (February 2014) titled "Probing new physics at the LHC: searches for heavy top-like quarks with the ATLAS experiment". A. Juste acted as corresponding editor for both conference notes and will be the corresponding editor of the corresponding publication results using the full 20.3 fb^{-1} dataset at $\sqrt{s}=8$ TeV, which are being finalized.

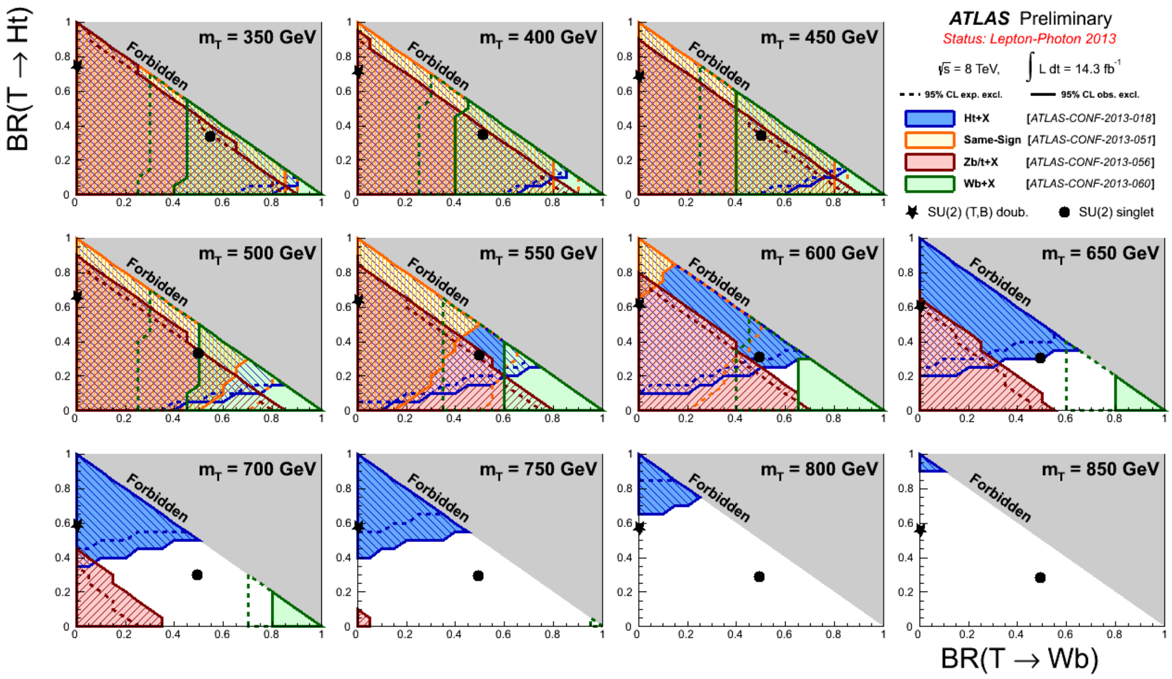


Fig. 11: ATLAS searches for vector-like T quarks with 14 fb-1 of 8 TeV data. Excluded regions are drawn sequentially for each of the analyses in chronological order and overlaid (rather than combined) in each of the figures.

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 in spectacular signatures with high jet and b-jet multiplicities. Both searches where carried out using 14.3 fb^{-1} of data at $\sqrt{s}=8$ TeV (ATLAS-CONF-2013-

Computing Infrastructure

The Tier-2 and Tier-3 LHC computing infrastructure of IFAE provided efficient access to the analysis of the data recorded by the ATLAS detector during Run I until the long shutdown in 2013.

All the infrastructure of the ATLAS Tier2 and Tier3 farms is hosted at Port d'Informaciò Científica (PIC) together with the Spanish Atlas Tier1, 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 2013, the IFAE Tier 2 processed more than 3,75 billion events and executed 1.4 million jobs. The CPU capacity provided to the Atlas collaboration by the Tier2 in 2013 amounts to 38,345,132 HepSpec hours, 150% higher than the pledged capacity with 97% of reliability (see Figure 12). In order to address the local needs for the analysis of the full 2012 and 2013 ATLAS data samples the group progressively upgraded the Tier3 farm during 2013, with additional resources.

Currently the Tier3 farm counts on more than 3500 HepSpecs of CPU power and 398 TB of disk. Some of these resources are available in form of a proof parallel event-processing farm for the lateststages of analysis. Before the key physics conferences the computing power and disk available for analysis is automatically increased thanks to the dynamic resource allocation of PIC.

Management positions

During 2013, the group maintained high visibility in management positions in ATLAS: M. Bosman was Chair of the ATLAS Collaboration Board; P. Francavilla was MET Co-convener ; A. Juste was appointed as Co-convener of the HSG8 Higgs subgroup ; A. Pacheco was ATLAS Distributed Analysis Coordinator; M. Martinez was appointed to the ATLAS Publication Committee; C. Padilla is a member of the ATLAS Speakers Committee; and I. Riu is Trigger Menu co-coordinator.

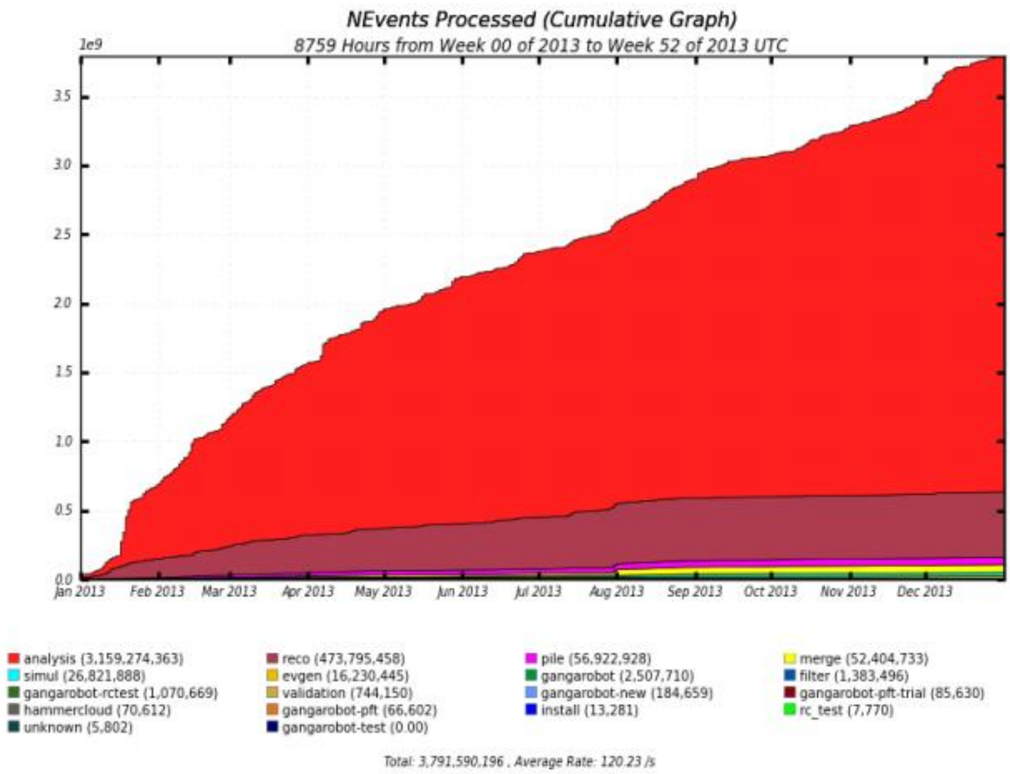


Fig. 12: Cumulative graph of the number of real data events processed in the IFAE Tier2 during 2013. The Tier2 facility processed 3.7 billion events, more than 85% by data analysis job.

2.2 Pixels for ATLAS Upgrades

Sebastian Grinstein

Introduction

In order to test the predictions of different theories of particle physics and high-energy physics, the LHC experiments need to determine the path of the particles that are produced in the proton-proton collisions. Pixel detectors play a critical role in these experiments, being especially important for the precise determination of track vertices, allowing, for instance, the identification of b-jets (b-tagging). The ATLAS Pixel Detector consists of more than 80M channels, each connected to a 50 μm x 400 μm pixel which collect the charge generated by the impinging particles. 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. During the first phase of the upgrade program, ATLAS will insert an additional pixel layer (Insertable B-Layer or IBL) into the current Pixel Detector. This step will take place during the on-going LHC shutdown (2014).

The Pixel group at IFAE was formed in 2008 and has since taken a leading role in the ATLAS pixel upgrade program. As described further in this report, in 2013 the two main areas of activities were related to the integration of 3D sensor modules for the IBL detector, and the construction and characterization of slim-edged 3D sensor prototypes for the ATLAS forward physics detector (AFP). As a member of CERN's RD50 collaboration, the group also participated in 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), to develop new pixel technologies for the future high luminosity LHC upgrades (HL-LHC).

The Insertable B-Layer

The innermost sub-system of the ATLAS Inner Detector (ID) is the Pixel Detector, which provides charged particle tracking with high efficiency. It consists of three cylindrical barrel layers with a radius between 50 and 120 mm around the beam axis and three forward and backward end-cap disks. The Pixel Detector significantly enhances track impact parameter resolution and therefore vertex reconstruction and b-tagging. To further improve the performance of the silicon system in view of the increasing instantaneous luminosity delivered by the LHC, ATLAS will insert an additional pixel layer, the IBL, inside the current Pixel Detector in 2014. The IBL consists of 14 staves mounted directly on a new, smaller, beam pipe with a tilt angle of 14º. Each stave is equipped with 32 read-out chips. The baseline sensor technology for the IBL detector was chosen in 2011 and, thanks to the excellent results obtained with the 3D sensors from CNM-Barcelona and FBK-Trento, 25% of the IBL modules will be 3D devices, the other 75% being planar. More than half of the 3D assemblies of the IBL have been produced at CNM during 2012. 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.

One of the main goals during 2013 was to ensure that the 3D sensors produced at Barcelona were successfully incorporated in the IBL. One major problem arose and was solved during the CNM 3D modules' testing. After fabrication at CNM, the best 3D sensor tiles of each wafer were selected using the method of measuring the 3D guard-ring (GR) current. The 3D-GR surrounds the area of the active pixels. During the first half of 2013 it became apparent that this selection method resulted in devices with poor electrical characteristics (low breakdown voltage). Further investigation showed that the breakdown of the sensors measured by the 3D-GR method was not well correlated with the breakdown measured after device assembly (bump-bonding and mounting on a “flex” readout board). To improve the quality of the 3D modules, all the unmounted CNM 3D sensors were returned to Barcelona and a re-selection of devices was carried out by measuring the electrical characteristics (IV-curve) of the full sensor with a probe-station. Using this method, 92 CNM sensors were selected for IBL and returned to IZM for bump-bonding. Consequently the yield of CNM module assembly increased and is now 62%, similar to FBK 3D devices, and only slightly lower than that of planar devices (75%). The selected modules were shipped to Geneva to be mounted in the final detector staves.

IFAE also participated in the IBL module testing and characterization prior to stave mounting. Some of these tests were conducted at IFAE (like the long-term functionality tests, described below) and others in collaboration with INFN-Genova and CERN. The tests at Genova included planar and 3D device evaluation after which the selected modules were sent to Geneva for stave assembly and then transported to CERN. At CERN the stave testing is carried out, to ensure the correct functionality of all components.

The long-term functionality test performed at IFAE was designed to identify mechanical and electrical problems which might appear after stressing the IBL modules with thermal cycles (between -20 ºC and +40 ºC). The stability of the noise, threshold and time-over-threshold calibration, as well as the power consumption of the modules were monitored during thermal cycling. Figure 1 shows four 3D devices inside a climate chamber during the long-term functionality test (top), and the threshold verification for a CNM device after 400 hrs of testing (bottom). During the measurements, no electrical or mechanical problem arising from the prolonged module testing while thermal cycling, was identified. This work was documented in an internal ATLAS note and was the topic of the Master thesis of I. López.

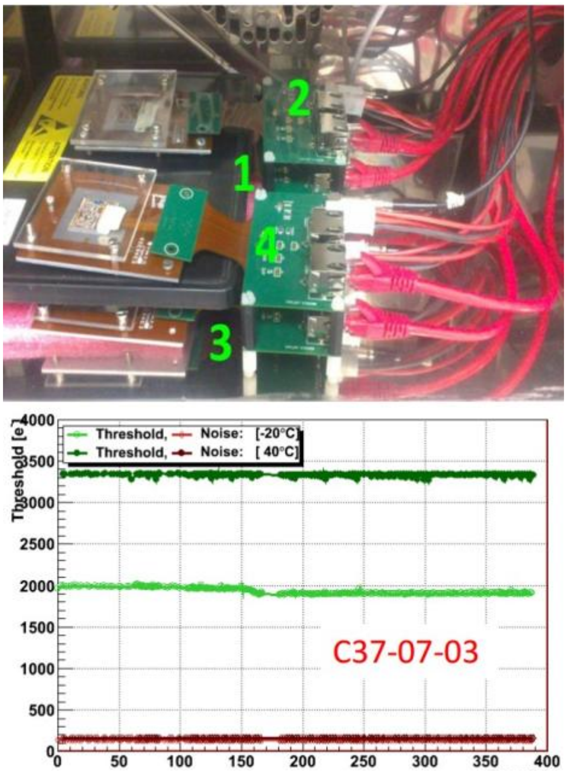


Fig. 1: Long term functionality test setup (top) and stability of threshold during 400 hours.

In September 2013, during stave testing at CERN, a critical problem was discovered: the wire-bond pads of the IBL modules (both planar and 3D) showed severe corrosion after the devices were subjected to very high humidity environments. This was discovered by accident when a stave cooling box used for testing was left open and ice formed directly on top of the modules. A task force to determine the cause of the problem and study ways to avoid wire-bond failures was launched. IFAE participated in these activities, in particular the group carried out an irradiation campaign at Ionisos-Spain to study the radiation hardness of different wire-bond coating materials. The group also studied the evolution of corroded modules during thermal and humidity cycling at IFAE. The task force traced the source of the problem to the presence of chlorine/fluor on the flex and implemented a series of procedures to ensure that the staves are not subjected to high humidity environments. Eighteen IBL quality staves have been already produced and are being mounted on the Inner Positioning Tube at CERN.

The ATLAS Forward Detector

ATLAS plans to install a Forward Physics detector (AFP) in order to identify diffraction-scattered protons at ~210 m from the interaction point in the 2015 LHC shutdown. The current AFP design foresees a high resolution pixelated silicon tracking system combined with a timing detector for the identification and removal of pile up protons. The AFP tracker unit will consist of an array of five pixel sensors placed 2-3 mm from the LHC proton beam. The proximity to the beam is essential for the physics sensitivity of the AFP experiment. Thus, there are two critical requirements for the AFP pixel detector: first, the dead region of the sensor side closest to the beam has to be minimized. Second, the device has to be able to cope with a very inhomogeneous radiation distribution. Based on the successful performance of CNM 3D productions for the IBL, the Barcelona sensors were selected to construct the first AFP prototypes.

During 2013 an intensive program to qualify the CNM 3D sensors for AFP was carried out by IFAE. One challenge was to reduce the inactive area of the IBL sensors on the critical side for AFP from the original 1.1 mm down to about 100 um (see Figure 2), and to prove that this "slimming" procedure does not affect the hit reconstruction efficiency of the pixels in the vicinity of the cut.

To fabricate the first AFP prototypes, four 3D sensors left over from the IBL production were slim-edged with a diamond saw cutter at CNM. The sensors were then bump-bonded at IZM and mounted at INFN-Genova (on flex circuits) and IFAE (on PCBs). After characterization at IFAE, the sensor performance was studied with a particle beam at DESY during June and July 2013. Figure 3 shows the edge reconstruction efficiency of an un-irradiated CNM AFP prototype in the area next to the slim-edge cut. It can be seen that an excellent efficiency is achieved up to a few microns of the end of the top pixel row. The efficiency then drops because the electric field is constrained by the 3D-GR which is set to ground potential to prevent the depletion region from reaching the edge of the sensor). The telescope position resolution of ~8 µm has not been subtracted from the plot.

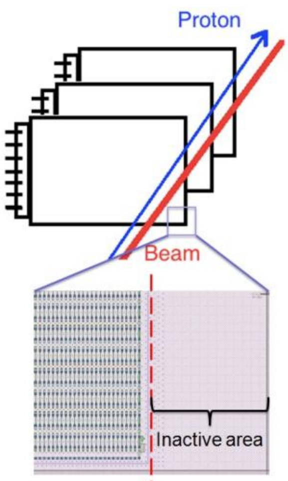


Fig. 2: Diagram showing the orientation of the beam and the side of the CNM 3D sensors that has to be slim-edged.

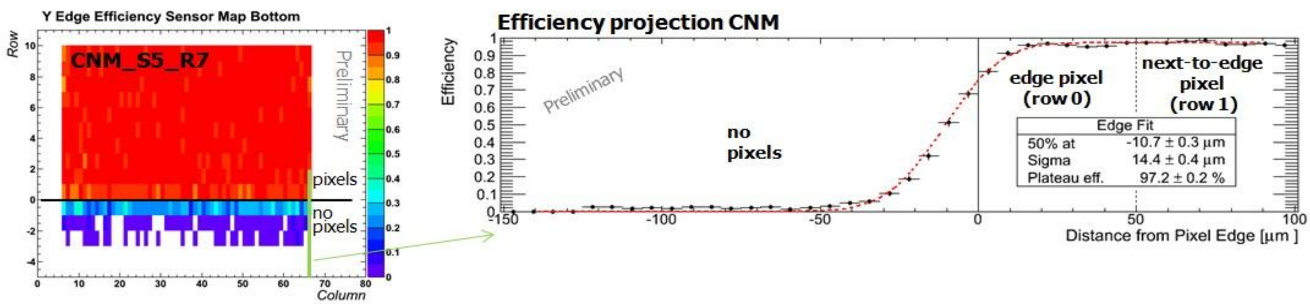


Fig. 3: The edge efficiency map of the area next to the slim-edge of a CNM AFP prototype is shown on the left, and the projection along the short pixel direction on the right.

Later, in December 2013, the devices were subjected to a non-uniform radiation dose, up to a fluence of $3x10^{15}$ neq/cm^2 at KIT (Germany). Beam tests were conducted in early 2014, and preliminary results show that at voltages of about 100 V and thresholds of 3000 electrons, there is no significant difference in the efficiency of the irradiated and non-irradiated regions.

The AFP project passed the ATLAS physics review in January 2014, and the technical review in March 2014. J. Lange's coordination of the CNM sensor qualification was a critical contribution to the effort. The current plan for AFP is to take data during dedicated low luminosity runs during LHC Run 2. This implies that the radiation dose seen by the 3D tracker would be a factor of 1000 smaller than the original expectation of $3x10^{15}$ neq/cm^2. However, the 3D tracker will offer the possibility of prolonged data taking at high luminosity as an option for the future.

Future Activities

The group aims to make a major contribution to the AFP detector, not only by providing sensors (which are already being fabricated at CNM) but final modules - i.e., the sensor integrated to the front-end chip and the main electronics board needed for readout. To this end, IFAE is acquiring machinery to assemble modules for the AFP tracker, which is scheduled for installation at the end of 2015.

In collaboration with CNM and RD50, activities towards future LHC upgrades have also been launched. In particular the group is involved in an R&D effort on thin planar and 3D devices with charge multiplication which could play a key role in the next generation of radiation hard and fast pixel detectors.

2.3 Neutrino Experiments at IFAE

FEDERICO SÁNCHEZ

Neutrino experiments in 2013

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 definitive 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.

T2K

In T2K a high-intensity, 2.5º 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 τ 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 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 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.

The IFAE group led the analysis of the inclusive Charged-current (CC) muon and electron neutrino interactions used for neutrino flux normalization. The 2012 results were already limited by systematic errors and a new selection strategy was proposed by our group and adopted by the T2K collaboration. The new selection separates events in three different categories depending on the number of pions observed in the detector in addition to the muon: zero, one or several pions (CCothers). This division allows to better constrain the systematic uncertainties and to reduce errors in the flux measurement.

Results of this selection of events are shown in Figure 1.

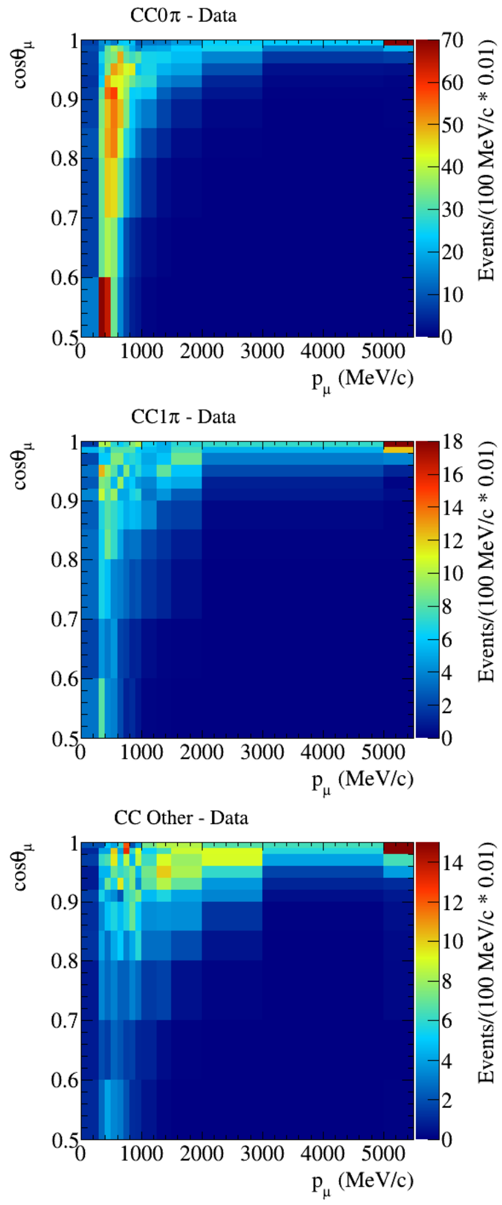


Fig. 1: Muon angle versus muon momentum distributions for neutrino interactions candidates for CC0 pions (top plot) CC1 pions (middle plot), and CCothers(bottom plot) in the T2K near detector. See text for definitions.

The selection of electron neutrino candidates was also improved by adding two event categories (and no more, due to the small event sample): CC-Quasi-Elastic-like events, CCQE, with only one electron observed in the detector, and CCnonQE, with more particles detected. The results are shown in Figure 2.

This work has been published as part of the two main T2K papers of 2013, the definitive observation of electron neutrinos in a muon neutrino beam (Phys. Rev. Lett. 112, 061802 (2014)) and the muon neutrino disappearance paper (arXiv:1403.1532). One member of IFAE acted as convener of the muon neutrino in 2013 and is at the moment member of the T2K Analysis Steering Group. The other major IFAE contribution has been the analysis of the intrinsic contamination of electron neutrinos in the beam. The results show good agreement with the predicted flux, as shown in Figure 2. This result has been recently submitted for publication (arXiv:1403.3140).

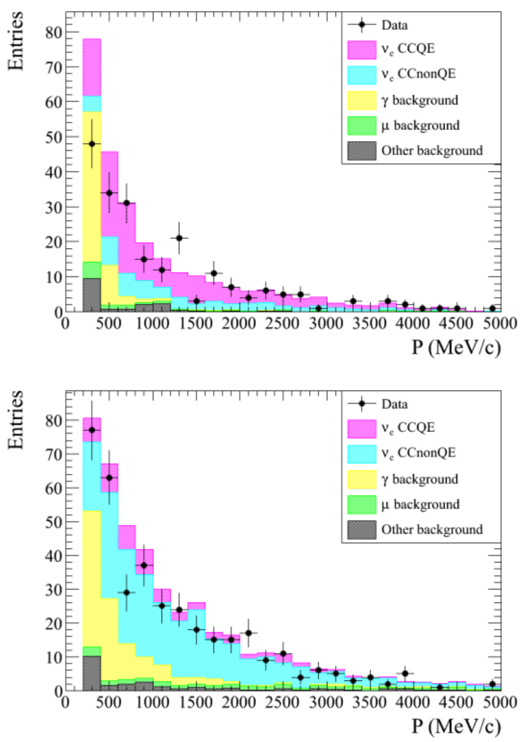


Fig. 2: Electron momentum from electron neutrino interaction candidates at the near detector and comparison with Monte Carlo predictions for CCQE (up) and CCnQE(down) samples.

The data collected in Super-Kamiokande until summer 2013 to measure electron neutrino appearance yield 28 electron-like events over a background the 4.9. This is a 7.9 σ excess that is interpreted as observation of a non-vanishing θ_{13} mixing angle.

The kinematical properties of the 28 events are compared to the MC predictions after oscillations in Figure 3.

This is the first time an explicit neutrino flavor transition is observed. This result has been combined with the measurements of θ_{13} from reactor experiments to obtain the first indication of CP violation in the lepton sector as shown in Figure 4. The result is not conclusive but shows the potential of T2K to perform this measurement in the future.

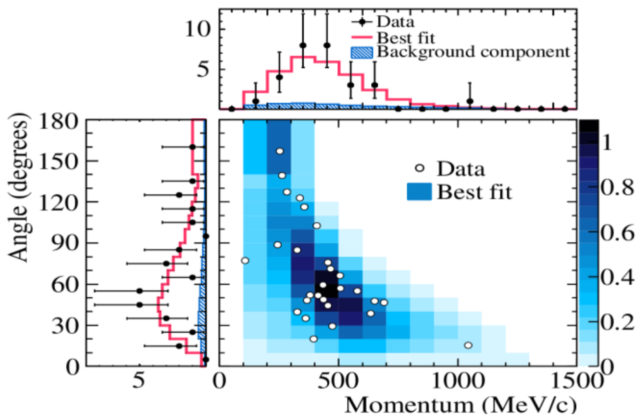


Fig. 3 Electron angle versus electron momentum for electron neutrino candidates detected at SuperKamiokande and the Monte Carlo prediction with the oscillation hypothesis with data collected until summer 2013.

The muon neutrino disappearance analysis has been also updated. The disappearance pattern in the far detector, shown in Figure 5, is very clear. The data deficit is explained in terms of the θ_{23} mixing angle and neutrino eigenstate mass difference (Δm^2_{23}). The T2K results are given in Figure 6; to-date, these are the most precise measurements of these parameters world-wide.

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 7.

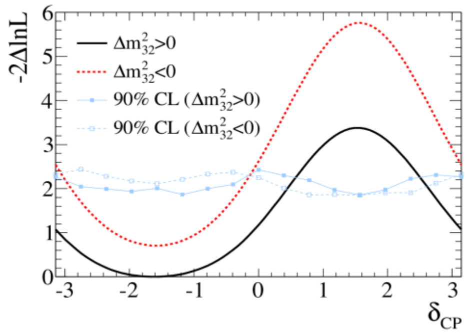


Fig. 4. Electron neutrino data likelihood represented as function of the CP violation phase angle for the two possible mass hierarchy solutions. The blue line represents the of 90% C.L. limit for the two signs of the mass splitting.

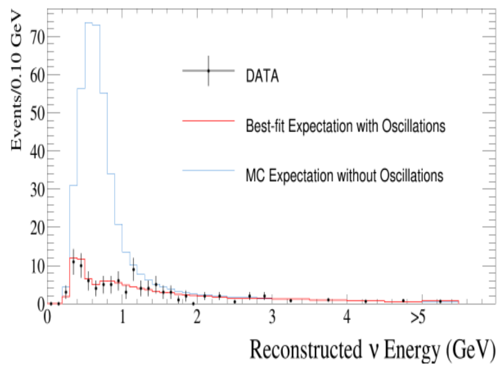


Fig. 5. Reconstructed muon neutrino energies in SuperKamiokande compared with Monte Carlo predictions assuming oscillation (red line) or no oscillation (blue line). The analysis includes data collected until summer 2013.

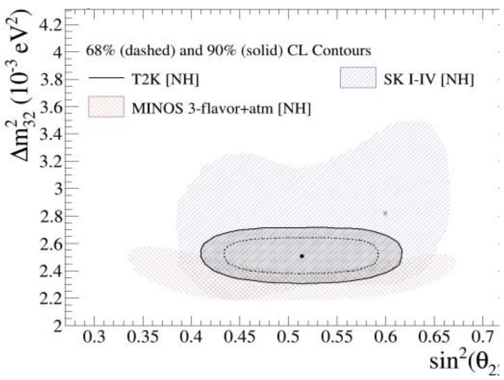


Fig. 6. T2K mixing angle and Δm^2 results for the muon neutrino oscillation hypothesis. The T2K results are compared to those from MINOS and SuperKamiokande.

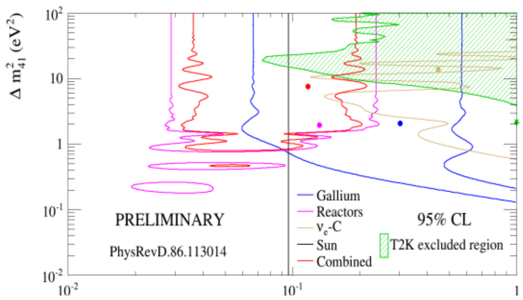


Fig. 7: Exclusion plot of sterile neutrino oscillation parameters from the T2K near detector electron neutrino disappearance analysis compared to previous results.

In addition, the IFAE group has begun searching for muon neutrino disappearance at the near detector. The results are expected by end of 2014.

Additional activities at IFAE include improving track reconstruction and particle identification in the TPC and software developments like fully integrating the ND280 analysis into the T2K flux-fitting algorithm. IFAE also contributes to magnet and TPC maintenance tasks.

R&D on electroluminescence detection with a Time Projection Chamber

IFAE pioneered the use of APDs for pixelated readout of electroluminescence signals. This technique has great potential for precise tracking and energy measurements. With early prototypes using 5 APDs the group's results indicate an energy resolution characterized by a FWHM of 0.7% at 2.5 MeV.

During 2013, the IFAE neutrino group continued the development of this technology building and operating a larger time projection chamber with light readout based on 25 APD and 2 PMT. The inner electric field forming structure of the detector is shown in Figure 8.

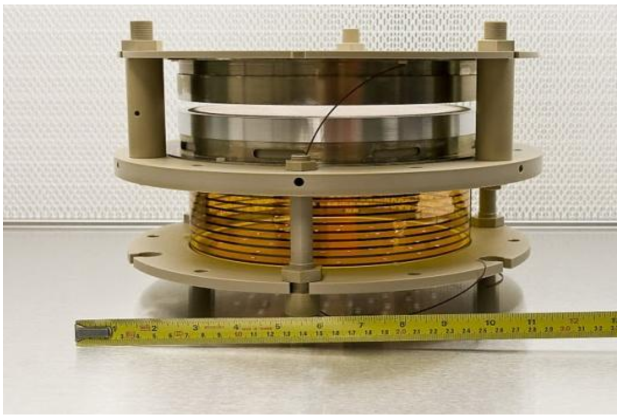


Fig. 8: Time Projection Chamber with electroluminescence detection built at IFAE.

The results are almost final and will be published in 2014. The energy resolution achieved with this prototype is 4.6% FWHM at 60keV, as seen in Figure 9. This result is already better to the one achieved with a smaller TPC and denser photosensor coverage and proves the potential of this technology for tracking calorimeters.

The group has started looking into possible industrial applications for this novel technology.

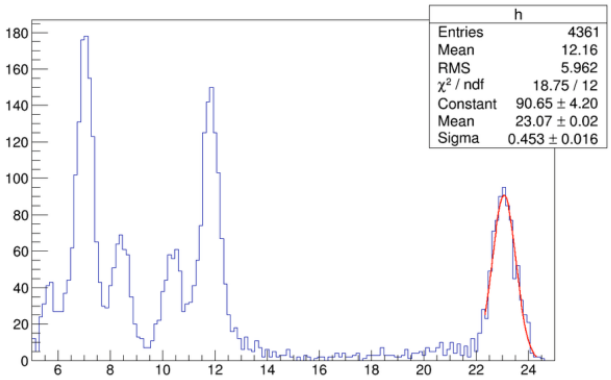


Fig. 9: Energy spectrum of 241Am X-rays observed with IFAE's xenon TPC. Five X-ray signals are detected. The highest-energy peak (60 KeV) has a FWHM of 4.6%.

2.4 The MAGIC Telescopes

Javier Rico

MAGIC ("Major Atmospheric Gamma Imaging Cherenkov") is a new generation, two-telescope system located at the Roque de los Muchachos Observatory, at the Canary Island of La Palma. Each MAGIC telescope achieves a high light sensitivity (and therefore low energy threshold) because it is equipped with a reflector of large diameter (17 meters) and a camera with high quantum efficiency and sensitivity to single photoelectrons, able to detect cosmic gamma rays in the very-high-energy (VHE) domain, i.e. in the energy range between ~50 GeV and ~50 TeV.

At present, the most sensitive observations in this energy band are performed from Earth by the Imaging Air Cherenkov Telescopes (IACTs), of which MAGIC is one of the most advanced examples. IACTs image the Cherenkov light produced in the electromagnetic showers initiated by cosmic radiation in our atmosphere.

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—, reduced through the analysis of image properties. Using this technique, over a dozen sources were detected in the 1990s with the previous generation of IACTs. Instruments like MAGIC were 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 about 150 sources and several new populations have been established. But MAGIC was more ambitious: it aimed at 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.

Fig. 1: The MAGIC telescope system preparing for observations at dawn. From left to right: MAGIC-I and MAGIC-II. 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.

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 since 2004. For the second telescope, IFAE contributed in the production of key elements of the readout and data acquisition systems, like the receiver boards and the signal digitizers. In addition, since the beginning of the project, IFAE has full responsibility of the development, running and maintenance of the Central Control system. The Central Control integrates the complex ensemble of all the sub-systems for both telescopes, allowing and coordinating their operation during the astronomical observations and data taking. IFAE has also built and operates the MAGIC official Data Center, which processes and serves ~300 TB/year of raw data and analysis products to the entire MAGIC Collaboration. The Data Center uses the same Grid technology developed for the LHC, and used in the TIER-1 infrastructure for the ATLAS, CMS and LHCb experiments at the Port d'Informació Científica (PIC). MAGIC, in collaboration with PIC, pioneered in 2004 the use of Grid technologies in astroparticle research, an approach that is now being followed by other projects, like the Cherenkov Telescope Array (CTA). MAGIC has been one of the main actors in the Astronomy and Astrophysics applications section of the EGEE projects.

Initially, MAGIC was composed of a single telescope, MAGIC-I, which has been in operation since 2004. A second telescope, MAGIC-II, an improved clone of the first one, was added in 2009 (see in Figure 1 a picture of the current system of two MAGIC telescopes). By ways of the stereoscopic technique, the flux sensitivity of the MAGIC two-telescope system was improved by a factor of 2, and its angular and spectral resolutions were significantly enhanced. In 2011 we started a major upgrade of the telescopes, aiming at improving their sensitivity, stability and robustness, by making the hardware of both telescopes essentially equal, thereby also rendering the maintenance and operation easier and less expensive. It is worth mentioning that a former IFAE member (the German "Otto Hahn" Dr. Mazin) served, during his stay at our group, as Project Manager for the whole upgrade program in the collaboration. The upgrade has consisted of three phases:

- During the first phase, in 2011, we replaced the signal digitizers of both telescopes by new ones consisting of 2-4 GSamples/s readout based on Domino-Ring-Sampler (DRS) version-4 chip. The new digitizers display a more linear response, shorter dead-time and lower noise than the previously ones. IFAE actively participated in their characterization, both in the lab and once installed in the telescopes. This phase also included the installation of new receiver boards for MAGIC-I, designed, produced, installed and maintained by IFAE in collaboration with the Universidad Complutense de Madrid.

- During 2012, we performed the second phase of the upgrade, consisting in replacing the old camera of MAGIC-I by a new one. The new camera has 1039 pixels, compared to 577 of the old one, and matches the geometry and trigger area of MAGIC-II.

- In 2013, we have commissioned the whole system after the exchange of the camera of MAGIC-II. In addition, the third and last stage has taken place: both telescopes have been equipped with a "sum-trigger" (a novel concept developed in MAGIC which allows for a lower energy threshold) covering the total conventional trigger area. This new trigger system is currently being commissioned. In parallel, the Data Center, which is one of the main responsibilities of our group, has been upgraded to be able to cope with the foreseen increase in the data volume due to the new trigger system. In addition, we have set a fully automatic transfer of all data products through the Internet, using grid-integrated customized servers installed at PIC and MAGIC site. Thanks to that, we have eliminated the need of using magnetic tapes for transferring the raw data to the Data Center, making the system faster and more robust.

After this major hardware upgrade, we have now entered a phase of steady astronomical observations and physics exploitation of the telescopes. During 2013, the Collaboration has undertaken a process for defining the MAGIC Key Observation Program (KOP), composed of five scientific projects granted maximum priority in observation time and resources for the next five years. The five KOP projects were selected by a committee of experts after a call for proposals and discussion within the Collaboration. Dr. Rico is the Principal Investigator of one of them.

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 non-thermal processes happening in the most violent cosmic environments, the so-called “non-thermal Universe”. The main production mechanisms of gamma rays are radiation and interaction of accelerated charged particles, either electrons or protons.

resulting from the interaction of accelerated protons with the interstellar matter. Therefore, by studying gamma rays we learn about cosmic particle accelerators. Furthermore, VHE Gamma-ray Astronomy addresses questions of fundamental physics. With gamma-ray instruments we study the origin of Galactic cosmic rays, or the composition of the cosmic electron-positron spectrum in the GeV-TeV scale. By observing the gamma-ray emission from sources at cosmological distances, we learn about the intensity and evolution of the extragalactic background light, and perform tests of Lorentz Invariance. Moreover, we can search for dark matter by looking for gamma rays produced by its annihilation or decay in over-density sites.

During 2013, the MAGIC Collaboration has produced 4 scientific papers, out of which 1 has been led by IFAE members (corresponding authorship). These numbers are a fraction of ~1/3 lower than the average yearly scientific production of MAGIC, mainly because of the lower amount

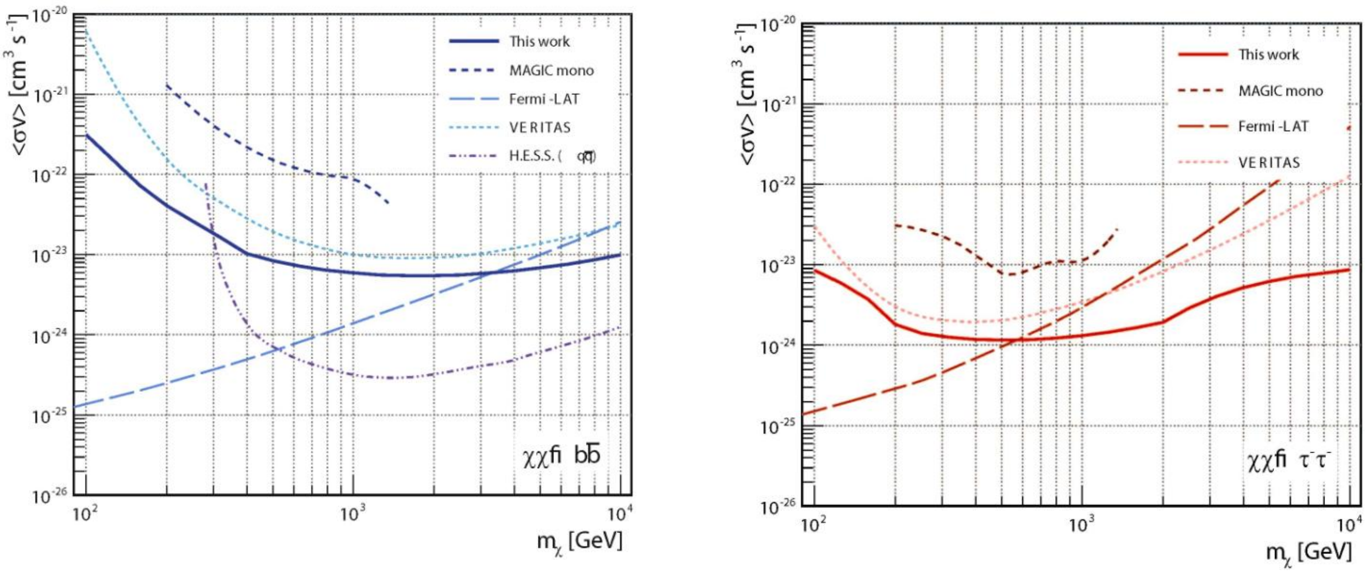


Fig. 2: MAGIC upper limits to the dark matter annihilation cross-section as a function of the dark matter particle mass for different annihilation channels: a) annihilation into a pair of b and anti-b bosons; b) annihilation into a pair of ▯+ and ▯- leptons. MAGIC results are labeled as “This work”, and are compared to the results obtained by MAGIC-I stand alone observations (“MAGIC mono”), and recent results by the VERITAS telescope on observations of Segue 1 (“VERITAS”), the gamma-ray telescope onboard the Fermi satellite obtained from observations of 25 dwarf satellite galaxies (“Fermi-LAT”), and observations of H.E.S.S. on the Galactic Center (“H.E.S.S. qq”).

Accelerated electrons may produce gamma rays in the presence of magnetic fields, matter, or ambient photons. In addition, gamma rays may be also produced in the decay of the neutral pions

of data acquired in the recent years due to the hardware upgrade described above, and have shown clear signs of recovery in the early weeks of 2014. In addition, MAGIC-IFAE members have participated in 3 additional, non-MAGIC scientific papers, all at the first-author level.

Two Ph.D. students of the group defended their thesis during 2013, both of which containing some of the most important results obtained by the collaboration in the recent years.

Dr. Giavitto presented the first detection with MAGIC of the emission from the Crab pulsar up to energies of 400 GeV. This result has changed completely our view about how accelerated electrons in pulsars interact with their magnetic fields to produce electromagnetic radiation, and has been the origin of a wealth of new theoretical works about the topic.

The thesis of Dr. Aleksić consisted in dark matter searches using MAGIC data. We highlight her work in more detail in the following paragraphs.

Dark matter is an unknown, as yet unidentified type of matter, which accounts for about 85% of the total mass content in the Universe. Determining the nature of dark matter is one of the most exciting and difficult tasks of modern science. After many years of accumulating evidence for its existence –mainly from the observations of its gravitational effects on galaxies, galaxy clusters, and the anisotropies of the Cosmic Microwave Background–, experiments have reached the sensitivity needed to explore its nature. In most of the suggested hypothesis, the dark matter particles should annihilate or decay into standard particles, including photons rays. If dark matter consists of weakly interacting particles, with a mass between 100 GeV and several TeV, there is the possibility to detect the primary or secondary gamma rays produced in their annihilation and/or decay at over-density sites.

The MAGIC telescopes can search for such dark matter signature in the 50 GeV - 50 TeV energy range. Suitable targets (dark matter over-densities) are the Galactic centre, local dark matter clumps, satellite dwarf spheroidal galaxies and galaxy clusters.

MAGIC has concentrated its search on one of the most promising candidates, the dwarf spheroidal galaxy Segue 1, which has a mass-to-light ratio estimated to the order of 1000. We have led one of the most ambitious observational programs with MAGIC so far, consisting in 3-years observations of this satellite galaxy. This project also included the development and implementation of a novel analysis technique based on likelihood maximization, optimized for signals with characteristic spectral features of different dark matter theoretical scenarios. This novel analysis technique features a sensitivity improvement of a factor ~2 in searches for signals of dark matter origin (compared to the standard analysis). We published the description and characterization of the likelihood analysis for Cherenkov telescopes during 2012. Thanks to that, we could produced the most constraining bounds to dark matter properties for masses above several hundred GeV from observations of satellite galaxies, thereby setting a new landmark in the research field (see Figure 2). This work was developed by Dr. Aleksić as part of her Ph.D. thesis at IFAE, and was accepted for publication in the Journal of Cosmology and Astroparticle Physics (JCAP) in 2013.

2.5 CTA: Cherenkov Telescope Array

OSCAR BLANCH

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.

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 and neutrinos.

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 about a factor of 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 is a recommended project for the next decade in the US National Academies of Sciences Decadal Review. Moreover, CTA has recently been reviewed and singled out amongst the ESFRI roadmap projects as one of the few to receive support from the European Union in the coming Horizon 2020 calls to be ready for construction in 2015. It has also been 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 Tenerife.

Management in CTA and CTA-Spain

In 2013 Manel Martinez continued as the CTA-Consortium co-spokesperson and therefore part of top-level management of the CTA project.

During 2013 the CTA-Consortium passed two crucial milestones: the first complete review requested by the funding agencies, the Preliminary Technical Design Report, and the site ranking provided by the Consortium to the Resource Board. The spokespersons of CTA have been leading in person both the review and the ranking. Additionally, the preparatory phase is expected to finish in 2014 and the CTA management has already been preparing the transition to the construction and operation phases.

During 2013 Manel 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 as the backbone of the CTA-Spain consortium.

Additionally, at the beginning of 2013 the Large Size Telescope (LST) project within CTA was reorganized and an Executive Board that meets every week was stablished. Miquel Barceló was elected project manager and Oscar Blanch stayed as coordinator of the camera for the LST. They both belong to the LST Executive Board, work on the verification and control of the requirements and specifications for the LST and guide the hardware development towards solutions ready for production during 2014 or early 2015.

Camera Electronics

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. Based on the experience of building a solution with components for the Level-0 trigger, IFAE collaborated with the Institute of Cosmos Sciences University of Barcelona (ICC-UB) towards an ASIC with Level-0 functionalities. IFAE defined the requirements and characterized the produced ASICs (see Figure 1). Those ASICs will provide the Level-0 trigger for the so-called Sum trigger, a majority trigger or even a digital trigger. The Level-0 Sum trigger 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.

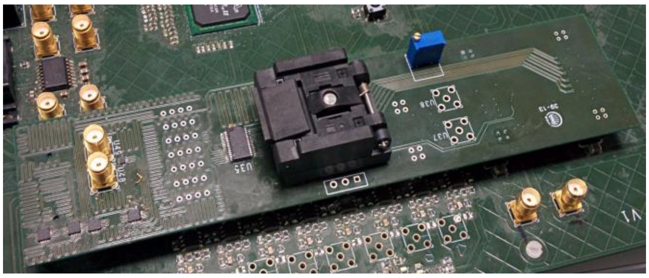


Fig.1: Test board (including the socket with the ASIC) to test and characterize the new level-0 ASIC.

Additionally, the delays of each pixel signal must be adjustable in order to compensate for possible time differences including the PMT transit times. This development took place at IFAE, resulting in a low-power-consumption, inexpensive solution, which has been adapted to be used with the level-0 ASIC. The time offset of each pixel can be adjusted in 250 ps steps within a range of 6 ns. This step size is fine enough to preserve the performance, while the range is sufficient to compensate the time differences among pixels.

The LIDAR

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. LIDARs will be installed in the CTA observatory in order 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 1.8 m diameter telescopes, part of the former CLUE experiment, already mounted in a standard ship container. One of them is installed on the campus of the Universitat Autònoma de Barcelona and is being used to develop a Raman LIDAR that fulfills the needs of the CTA observatory. In addition to the telescope, to obtain a LIDAR one needs the following elements: a laser, an alignment system to make the laser beam parallel to the telescopes axis, a light guide to transmit the light collected by the mirror from the focal plane to the optical detector, and the optical detector itself. During 2013, all elements have been produced and installed in the telescope (see Figure 2). Although the optical detector is a simplified version of the final one, expected to be ready in 2014, the available system already allows to begin commissioning the Raman LIDAR.

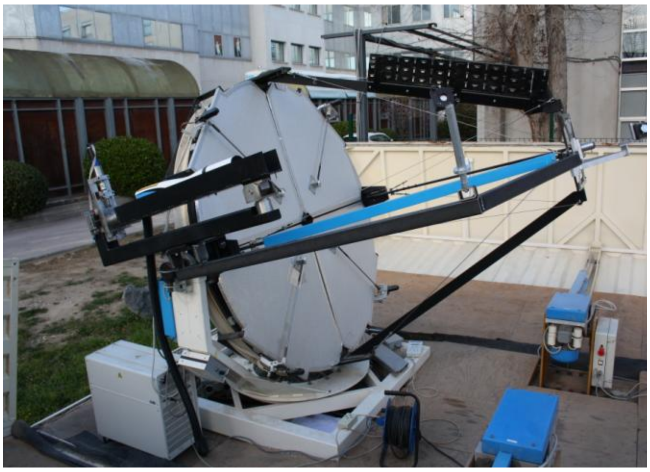


Fig. 2: The CLUE telescope with all elements installed to transform it into a LIDAR.

The Bogies, 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 rotate on its azimuthal axis on such an undercarriage, that consists of a set of wheels (assembled into "bogies"), motors, a ground support structure and a concrete foundation. The overall structure has already been designed at IFAE (see Figure 3). Very relevant to the design is the fact that the telescope's weight is small enough that strong winds are expected to lift it. A prototype of one bogie and a section of the rail will be built at the mechanical workshop of IFAE in 2014 (Figure 4). The subsequent static and dynamical tests will allow to find any problem of the current design and partiallyly validate it before building the remaining 5 bogies of the prototype LST in 2014 and 2015.

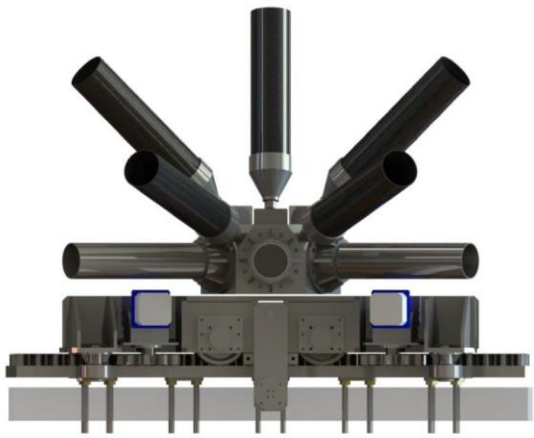


Fig. 3: Present design of the CTA Large Size Telescope bogie.

Estimating the performance of CTA in the candidate sites

The activities of the Monte Carlo working group at IFAE were focused on the computation of the expected performance of CTA in the different candidate sites, a key factor in the ranking of sites set up by the CTA Consortium.

The differences between sites found at IFAE are compatible with the differences found by other analyses within the Consortium, however the IFAE analyses came up with higher sensitivities for all sites.

The performance studies for the different sites indicated that the effect of some parameters, like the geomagnetic field intensity and orientation, is stronger in an instrument as sensitive as CTA, than previously expected. This is particularly true at the lowest gamma-ray energies and opened new perspectives in the development of analysis methods, which are now being explored at IFAE.

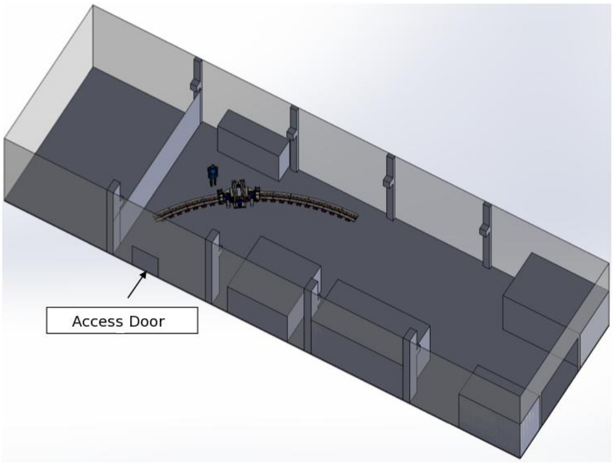


Fig. 4: Foreseen bogie test setup in the IFAE workshop

Data Management

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

In the last years IFAE participated in the activities related to the Data Model. IFAE has been in charge of the subgroup modeling the Instrument Response Functions (IRF), with strong links with other parts of the CTA project, such as the Monte Carlo or the Science Gateway. We defined the high- and mid-level requirements, made a comparative study of existing solutions, and began defining the specifications of the CTA Data Model. All this work was used tin writing the CTA Preliminary Technical Design Report.

CTA upgrade: SiPM

IFAE has been closely collaborating with Max-Planck-Institut fur Physik in Munich investigating the possible use of Silicon Photomultipliers (SiPMs) in large Cherenkov telescopes.

Such novel light detection devices have multiple advantages over PMTs, to-date the classical light sensors in Cherenkov astronomy: SiPMs have higher photon detection efficiency (PDE), better single photoelectron resolution, lower operation voltage, are insensitive to ambient magnetic fields, and can work under strong moon illumination. They were already successfully used in a small test Cherenkov telescope, FACT.

On the other hand, the disadvantages of SiPMs, such as optical cross-talk, high sensitivity to long-wavelength NSB light, high dark currents and strong temperature dependence might prove problematic for large Cherenkov telescopes such as MAGIC or the LSTs of the future CTA observatory.

The basic parameters (pulse width and shape, photon detection efficiency, optical cross-talk and dark current rate) for a few models of available SiPMs have been measured in order to to select one for a prototype module to be tested in MAGIC.

2.6 DES : Dark Energy Survey Project

Ramon Miquel

Since 2005, a group at IFAE, together with a group at ICE (Institut de Ciències de l'Espai), also located 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). The main goal of the 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 photometric redshifts (photo-zs) 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-Ia 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.

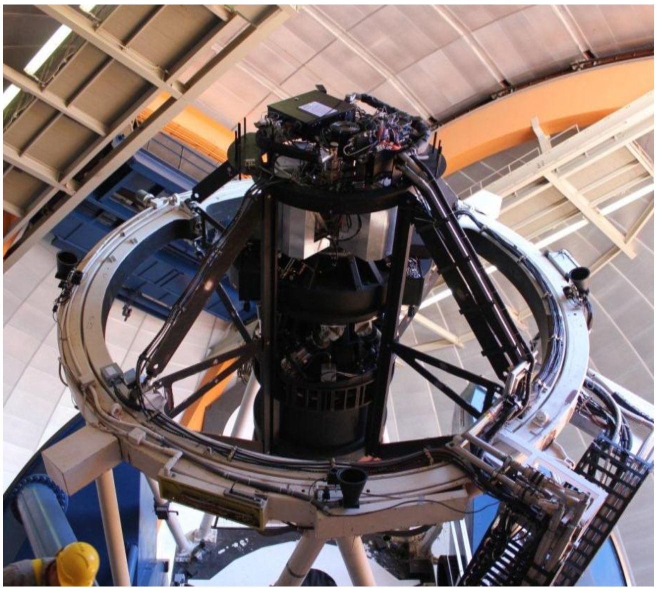


Fig. 1: The complete DES camera, DECam, installed at the prime focus of the Víctor M. Blanco telescope at the Cerro Tololo Interamerican Observatory (CTIO) in Chile.

The 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.

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 Figure 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.

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 late August, 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. The data taken are still being reduced at the time of this writing.

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-zs 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-zs: 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.

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 is being 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 is leading 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-zs, the spectroscopic galaxy sample needs to be re-weighted to mimic the DES-SV photometric sample in all magnitudes and color. The IFAE group has demonstrated that a simple weighting procedure in the *g-r* vs. *i* plane achieves this goal. Figure 2 shows the preliminary results of a study of the properties of the $(z_{phot} - z_{spec})$ distribution using three popular photo-z codes. Dotted lines represent the DES requirements on the resolution and outlier fractions of the distribution. Even with these preliminary data, some codes already fulfill all requirements up to almost the nominal DES depth.

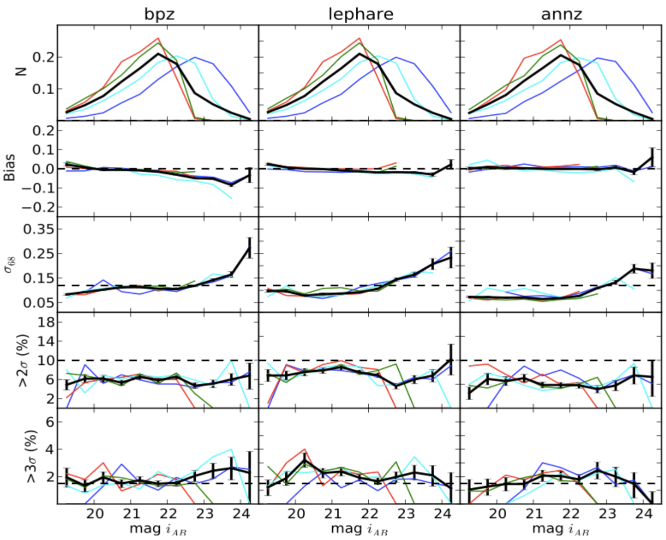


Fig. 2: Preliminary results of the calibration of the DES-SV photo-zs using three photo-z codes: BPZ (left column), LePhare (center) ANNz (right). The colors correspond to galaxies with spectroscopic redshifts in the following fields: VVDS-02hr (blue), VVDS-f14 (red), CDF-S (cyan), COSMOS (green) and total (black). From top to bottom, and as a function of the apparent magnitude measured in the *i* band: distribution of the number of galaxies; bias of the $(z_{phot} - z_{spec})$ distribution; resolution; percentage of galaxies with photo-zs more than two standard deviations (σ) away from the spectroscopic redshift; the same at three σ. The dotted lines in the bottom three rows represent the DES requirements.

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 point of the photo-z calibration procedure.

Figure 3 shows preliminary results for the real *z* (understood as the *z* measured spectroscopically) distribution for galaxies in three photo-z bins defined with the ANNz code. The tails of the distributions are important, but are well under control.

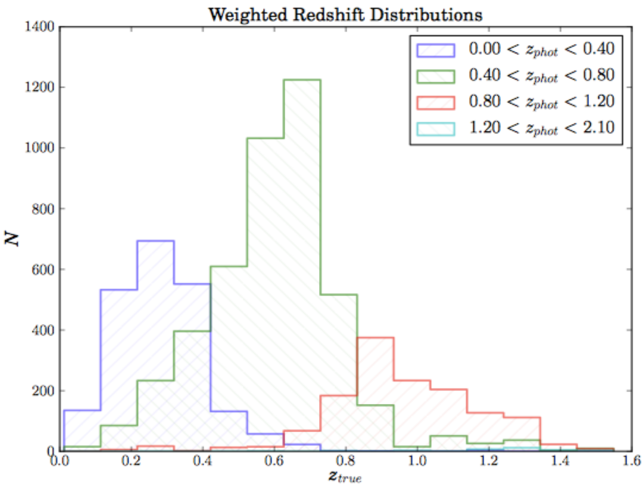


Fig. 3: Preliminary weighted distributions of the real redshift (understood as the redshift measured spectroscopically) for galaxies in the DES-SV calibration fields, in three photo-z bins defined as $0 < z_{phot} < 0.4$ (blue), $0.4 < z_{phot} < 0.8$ (green) and $0.8 < z_{phot} < 1.2$ (red). The distribution for a fourth bin with $1.2 < z_{phot} < 2.1$ (cyan) is barely visible. The photo-zs are obtained with the ANNz package.

In parallel, and related to this work, two members of the group have completed a study of the effect that selecting galaxies according to the quality of its photo-zs has on the measurement of the angular auto- and cross-correlations in their positions, and of the technique to correct this effect. Figure 4 displays the galaxy angular auto-correlation in four photo-z bins in the publicly available Mega-Z catalog, which contains about a million luminous red galaxies (LRGs) extracted from the Sloan Digital Sky Survey (SDSS). The upper plots show the measured correlations, as galaxies with better and better quality photo-zs are selected. Clearly, there is a dramatic effect. The figures below show the results after the proposed correction. Now all measurements agree well with the predictions, regardless of the selection. The figure is taken from P. Martí, R. Miquel, A. Bauer, E. Gaztañaga, MNRAS 437 (2014) 3490 [arXiv:1308.6500 [astro-ph.CO]].

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.

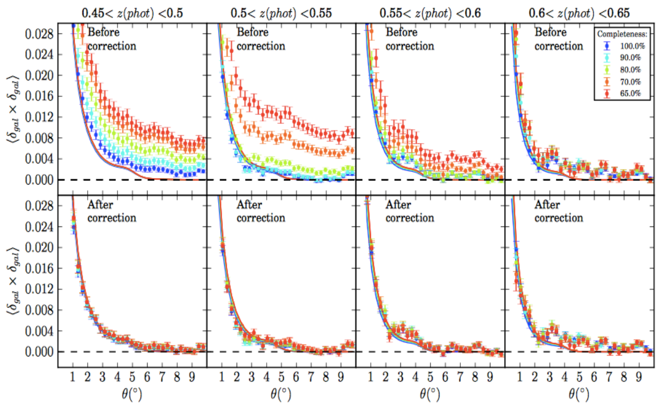


Fig. 4: Measurements of the galaxy angular auto-correlation (points with error bars) in four photo-z bins (from left to right: $0.45 < z_{phot} < 0.50$, $0.50 < z_{phot} < 0.55$, $0.55 < z_{phot} < 0.60$, and $0.60 < z_{phot} < 0.65$) for galaxies in the Mega-Z SDSS catalog, containing about one million luminous red galaxies (LRGs). Different colors denote results obtained applying different selections in the quality of the photo-z determination. Top: results before any correction. Bottom: results after the correction described in P. Martí, R. Miquel, A. Bauer, E. Gaztañaga, MNRAS 437 (2014) 3490. The corrections bring into agreement all measurements using different photo-z quality criteria. The curves correspond to the predictions obtained using, for each photo-z bin, the real redshift distribution, calibrated using the 2SLAQ spectroscopic catalog. The photo-zs have been obtained with the BPZ code. The figure is extracted from the mentioned article.

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 using catalogs of simulated galaxies confirms the feasibility of the measurement. Figure 5 presents the simulated measurement in a patch of DES-SV size (150 sq. deg.) of the angular cross-correlation between the positions of galaxies with $0.3 < z_{phot} < 0.5$ and the shapes of galaxies with $0.6 < z_{phot} < 1.1$. The observed cross-correlation is due to the gravitational lensing effect. 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 $0.3 < z_{phot} < 0.5$ is proportional to $b^2(z)$, by combining the two measurements one can extract both $b(z)$ and $r(z)$ independently. Currently members of the IFAE group are working on this measurement with the actual DES-SV data.

In 2013 our institutional involvement in the governance of DES has been kept at a high level. During 2013 a member of the IFAE group was a member of both the DES management committee and the publication board, and also chaired the DES speakers' bureau, the committee that chooses speakers to represent DES in conferences and workshops. Another member of IFAE belonged to the DES builders' committee, which grants paper authorship rights to the members of DES who have made substantial contributions to its infrastructure.

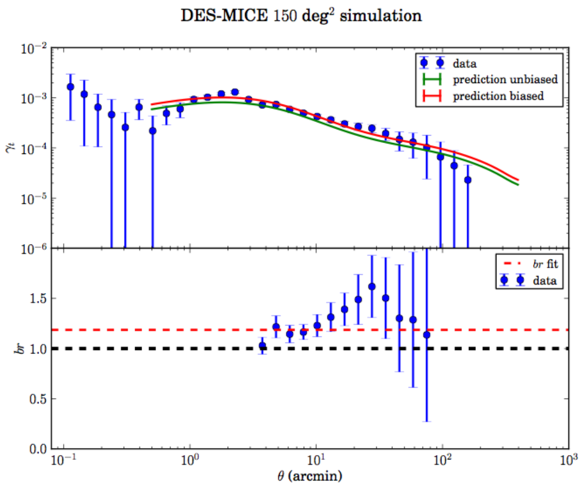


Fig. 5: Top: Measurement of the angular cross-correlation between the position of galaxies in a simulation of the DES-SV area with photo-z between 0.3 and 0.5 (lenses) and the shape of the galaxies in the same simulation with photo-z between 0.6 and 1.1 (sources). The blue dots represent the measurements, with errors estimated using jackknife, the green line shows the theoretical prediction for a distribution of lenses made of dark matter, while the red line refers to a distribution of lenses made of galaxies and includes bias *(b)* and stochasticity *(r)*. Bottom: Ratio between the simulated data and the prediction for dark matter. The dashed red line represents the value of the product *b* times *r* (assumed constant) that best fits the data. When the angular separation is large, the finite size of the region (150 sq. deg.) makes the error bars grow ("sample variance"), while when the angular separation is very small the errors increase because there are fewer galaxies within each region of a given angular size ("shot noise"). The measurements at different angular separations are highly correlated.

2.7 The PAU (Physics of the Accelerating Universe) Project

Enrique Fernández

PAU is 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 has been extended twice, first for a period of one year, until the end of 2013, and then for 6 months, until June of 2014, when it will finish. The work here described 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.

The strategic goal of the project was to carry out an internationally competitive experiment on the study of the accelerated expansion of the Universe (hence the acronym PAU). Scientifically that entailed two main tasks: to carry out a large galaxy redshift survey and to build an appropriate instrument for that purpose. 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 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 1º in diameter with 85% light collection efficiency (of which 40’ have 100% efficiency). 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 finally signed in early 2012.

PAUCam will cover the entire FoV of the telescope with 18 2k x 4k fully-depleted red-sensitive Hamamatsu CCDs with 15 μm 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.

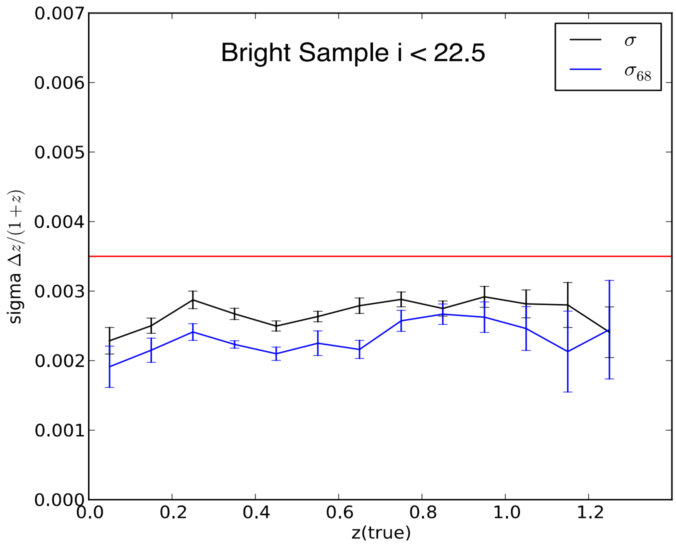


Fig. 1: Resolution in redshift scaled by (1+z) as a function of the real redshift for bright galaxies (i_{amb}<22.7). Different colors represent different ways of computing the dispersion of the measured redshift with respect to t_{rue}.

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 42 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. Figure 1 shows the expected resolution as a function of redshift for the bright set of galaxies. Being able to provide large quantities of precise redshifts for all objects in the field makes PAUCam a unique instrument.

A survey performed with PAUCam can 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.

Combining the constraints on the dark-energy equation of state parameter *w* that can be obtained from redshift-space distortions with those from weak-lensing magnification leads to the forecast shown on Figure 2, which is comparable (and complementary) to the constraints that will be obtained with the ongoing DES and BOSS surveys.

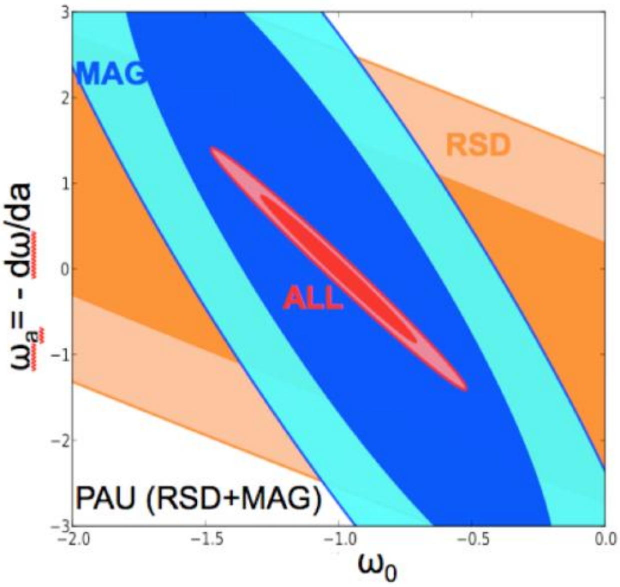


Fig. 2: Contours (68% and 95% CL) for the dark energy equation of state parameter now, w_0 and its evolution, w_a that can be achieved with a PAU survey of 200 deg[2] using redshift-space distortions (RSD, orange), weak-lensing magnification (MAG, blue) and combined (ALL, red).

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 -100ºC. 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. Particularly important will be the cooling of the CCD focal plane, which is being studied and will soon be designed.

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 that can be used by other astronomers. Additionally, a system to install a filter outside the camera enclosure is foreseen. This system will allow any user to plan its observations independently of the camera maintenance plan, which will need to be done in a clean room and will require the transportation of the camera to the IFAE laboratories.

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.

The scientific CCDs were received in September 2011. Two set-ups (one at CIEMAT and another at IFAE) have been validating the CCDs all throughout 2012 and 2013. Systematic characterization started in 2013. A metrology table was designed and commissioned in-house and a small cryostat, also

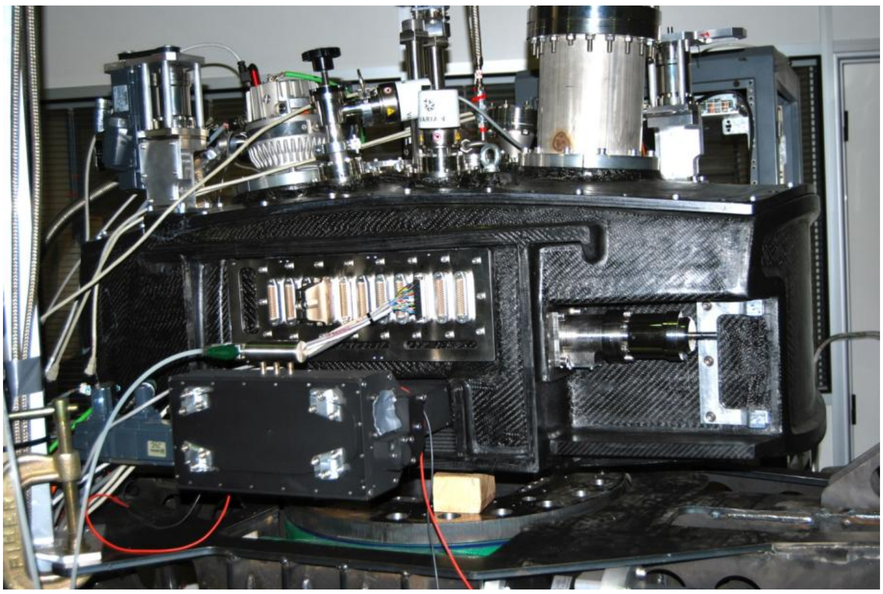


Fig. 3: Photograph of PAUCam with most of the components already mounted.

made of Carbon fiber, was also constructed to test two CCDs at a time. All of them have now been characterized and the specifications have been met. We have been able to reproduce most of the results of the datasheet from Hamamatsu Photonics. A problem, which took some time to solve, was the level of noise from the CCDs. Introducing a differential pre-amplifier in the front-end of the electronics solved this problem. Noise levels corresponding to 5-6 electrons have now been achieved and the electronics power dissipation is also within the specifications. A photograph of the camera can be seen in Figure 3.

The Data Management System consists of a large collection of algorithms, written in Python and C++, which manage the data from the raw images taken at the telescope to the final data products needed for scientific analysis. The software is complicated, as it has to take care of the use of many filters producing images, taken at different times that have to be merged for their use in analysis. The software also contains a Public Pipeline that will allow external users of the camera to reconstruct their data. This system has advanced considerably during 2013, to the point of being submitted to Data Challenges. The data challenges consist on the ingestion of simulated data into the system, which is then evaluated for overall performance.

The installation and commissioning of PAUCam at the WHT telescope is planned for September and October of 2014.

2.8 New Instrumentation Projects

THORSTEN LUX & FEDERICO SÁNCHEZ

In 2013 two new projects were started, in collaboration with two Catalan research centers, the Centro Nacional de Microelectrònica (CNM) and the Institut de Ciències Fotòniques (ICFO). The purpose of these initiatives is to develop sensor technologies with applications in high-energy physics and other scientific or industrial fields. Both of them exploit synergies with these research centers.

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 existing MPGD prototypes in order to obtain higher robustness against sparks 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.

During the first year of the project IFAE focused on the design of the test bench to characterize the new sensor. This includes the mechanical design (see Figure 1) and the modification of existing readout electronics in cooperation with X-Ray Imatek.

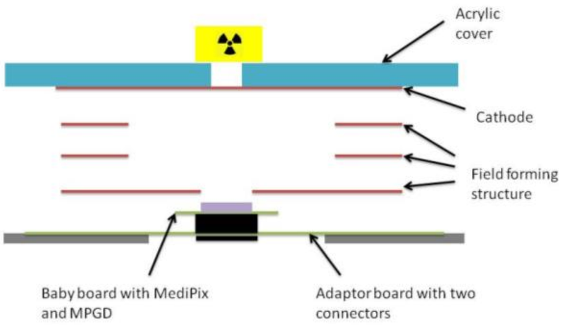


Fig. 1: Schematic sketch of the Si-MPGD test chamber. The copper rings produce a uniform electric field between the MediPix chip on the bottom and the cathode, mounted on the cover. The MediPix including the MPGD is mounted on a "Baby" board which is assembled on the "Adaptor" board. The function of this board is to ensure the gas tightness of the detector. The electronics is installed outside of the detector. (Outer gas enclosure not shown).

In addition, the IFAE group was involved in the simulation of the Si-MPGD in order to determine the optimal geometry of the parts to be manufactured at CNM, as shown in Figure 2.

In 2013 the project became more international. As a member of the RD51 collaboration, the IFAE group contacted other European groups working in this field and together with CNM, worked on the failure analysis of some of their devices. Funding for a related project has been requested from the Qatar foundation in collaboration with two Qatari groups. The outcome of this proposal will be known in May 2014.

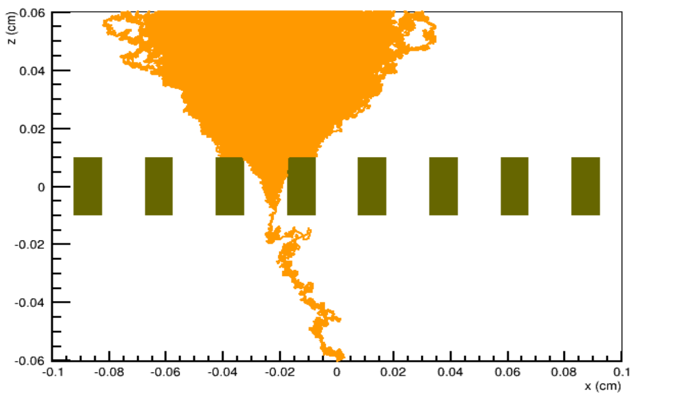


Fig. 2: Simulation of charge amplification in a GEM for optimization of the sensor geometry. A single electron drifts from below to one of the GEM holes, where avalanche multiplication takes place.

Development of Graphene Light Sensors

Graphene is a novel material with several extraordinary electrical and mechanical properties. Research on graphene is being performed by many groups world-wide. The intense interest of this research is underscored by the fact that that the European Commission declared graphene to be one of its flagship technologies.

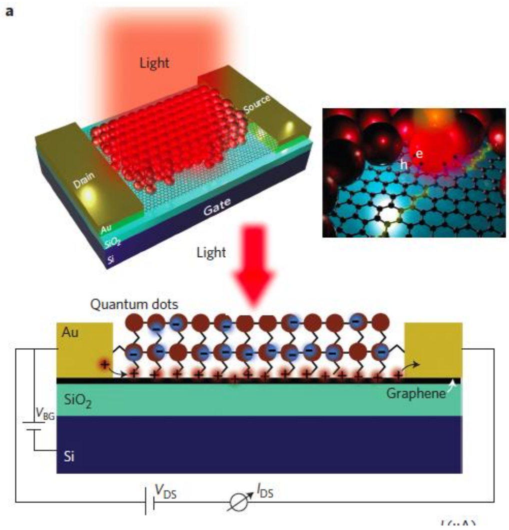


Fig.3: Layout of the photosensor .

ICFO research groups are developing graphene for light detection. The ICFO approach, shown in Figure 3, is based on a layer of graphene deposited on a Si/SiO_2 substrate. Nanoparticles known as quantum dots are deposited onto the graphene in a dense-packed geometry. The size of these particles defines the wavelength threshold at which the detector is sensitive, as shown in Figure 4. In the absence of light the sensor has a resistance of a few kOhm. When the sensor is exposed to light, the resistance of the graphene layer is reduced in proportion to the light intensity.

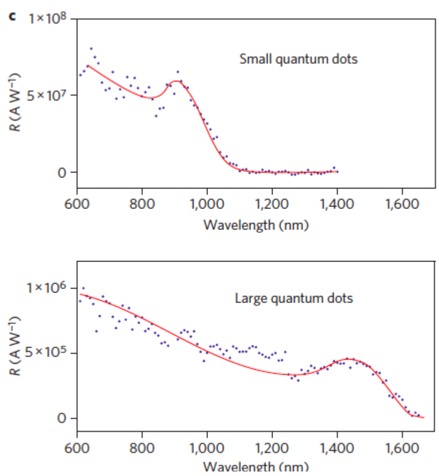
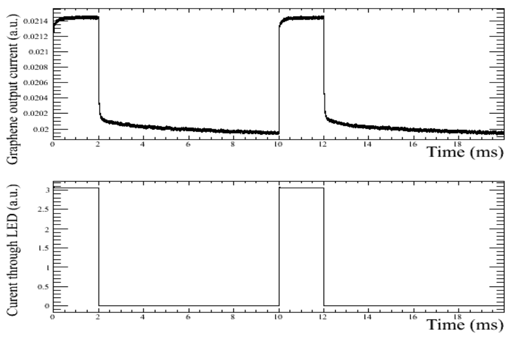


Fig. 4: Response of the photosensors vs. wavelength.

This technology allows detecting infrared photons and if made cost-effective opens opportunities of fabricating cheap commercial infrared cameras.

In 2013, the IFAE neutrino group established contact with the ICFO group led by Frank Koppens. From IFAE, the motivation was to test alternatives to avalanche photodiodes for the readout of electroluminescence detectors and to study potential applications of this kind of sensors in high-energy physics. It turned out that the expertise of our two institutions is complementary. ICFO is the expert in this type of sensor technology while IFAE has experience in readout electronic design and system integration, as well as ASIC chip design, thanks to the VIP project. These synergies have become the basis of a collaboration between the two institutes with the aim of developing an ASIC readout for infrared cameras. This research is funded at IFAE using funds from the Severo Ochoa award. In addition, together with partners from industry, a proposal was submitted to a FP7 call. At the time of writing this report, the first sensors are at IFAE and are being characterized. Figure 5 shows the readout setup and the first recorded signals.

Fig. 5: Top: Readout setup at IFAE Bottom: Output photosensor current (top) and input light pulse (bottom).



2.9 Medical Imaging

MOKHTAR CHMEISSANI

In 2013 the Medical Imaging group focused on advancing the VIP (Voxel Imaging PET) project. The main fronts of activity were completing the VIP-PIX ASIC, preparing the infrastructure for packaging the VIP module detector and characterization of the detector itself. The duration of the VIP project has been extend from 4 to 5 years to compensate for the delay in the VIP-PIX chip production.

The exploration of further applications of the VIP concept continued, with extensive simulations of the performance of a VIP-based Compton Camera and of a VIP PET Mammography device.

The VIP-PIX ASIC

2013 was dedicated to finalizing the design of the VIP-PIX chip. We have produced 2 prototype samples. The first sample with 4x4 pixels was produced to study the performance of one pixel response in a realistic environment with possible cross talk from neighboring pixels. The ASIC was controlled externally. This turned out to be an excellent way to debug the design and to discover its weak points. For the 2nd sample we went to the full design, but limited to 4x4 pixels. The second prototype has all the components of the final version of the VIP-PIX except for consisting of 4x4 instead 10x10 pixels. These two prototypes are shown in Figure 1.

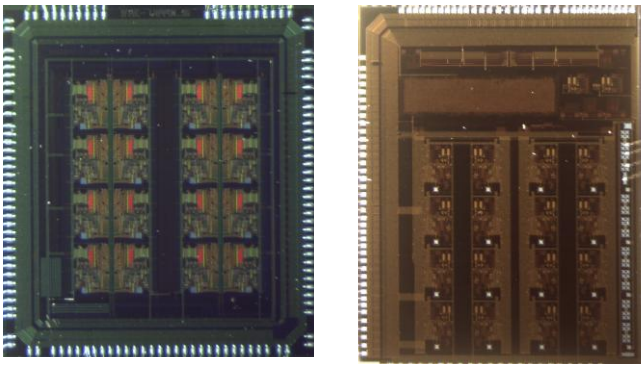


Fig. 1: Left panel: the VIP-Proto1 which has 4x4 smart pixels. Right panel: the VIP-Proto2 also with 4x4 smart pixels but now including the digital backend which can seen on top as a rectangle of 3mm x 0.6mm.

The 2nd prototype has it is own digital back-end to program and read out the chip. In addition, it includes a temperature sensor with a precision of 0.4 degrees, as shown in Figure 2. This information is important because the leakage current of the CdTe is a very sensitive function of temperature, therefore it must be kept at or near its optimum working point. Furthermore, a TDC provides for each event a time stamp with a resolution better than 1 ns, needed to label two-gamma coincidences within a time window of 20 ns.

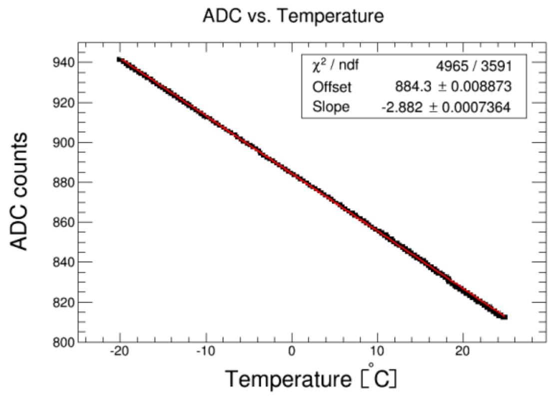


Fig. 2: The linearity of the temperature sensor on the VIP-Proto-2 which measure the chip temperature to 0.4 degrees.

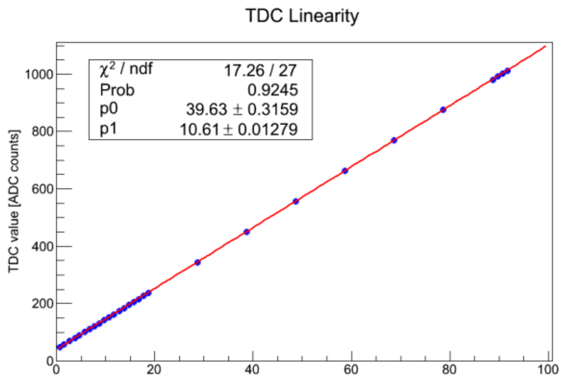


Fig. 3: The linearity of the Time to Digital Converter on the VIP-Proto-2, providing a time stamp for every event to better than 1 ns.

The energy resolution obtained on Co^{57} can be seen in Figure 4.

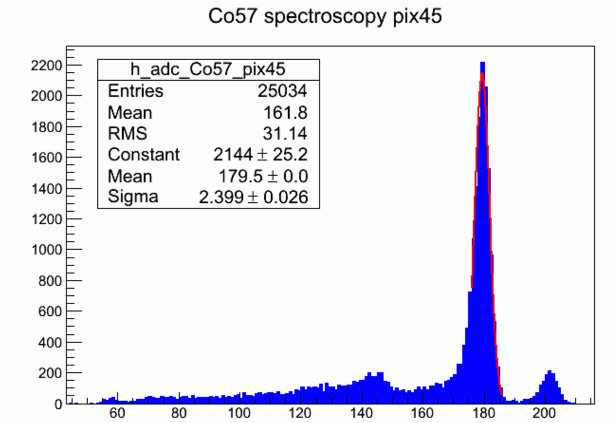


Fig. 4: Spectrum of Co^{57} with one pixel of VIP-Proto2 using Schottky pixel CdTe detectors at room temperature and a bias of 1000V. The detector is 2mm thick. The peaks at 122 keV and 136.5 keV are well separated, better than in Fig. 7, where a VATAGP7 chip was used for the readout.

By the end of 2013, the design of the full VIP-PIX was completed. The plan is to submit it for production in the first quarter of 2014. The engineering run of the VIP ASIC will produce twelve 8" wafers. This numbers of wafers has enough VIP-PIC chips to make the VIP PET prototype sector.

The functional diagram of the individual pixel circuitry and the overall layout of the ASIC are shown in Figure 5.

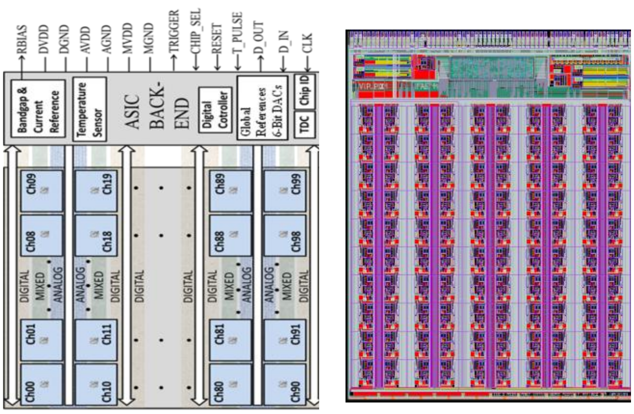


Fig. 5: The VIP-PIX architecture is shown on the left and the full 10x10 pixel layout on the right. The size of the chip is 10mm x 13mm.

Characterizing the CdTe Detector

Despite the fact that the VIP-PIX chip was not ready at the start of the 2013, we embarked on testing a 10x10x2mm^3 real-size detector and with a pixel pitch of 1 mm. The detector was bonded to a glass substrate with BiSn solder bumps. The CdTe-glass substrate assemblies were done with our FC150 flip-chip machine. The test setup and the spectroscopy results can be seen below in Figures 6 and 7. Importantly, the CdTe detector was at room temperature and the bias voltage was 500V/mm. The spectroscopy results are excellent. The detector was operated in a zero-humidity environment by flushing it with N_2 gas.

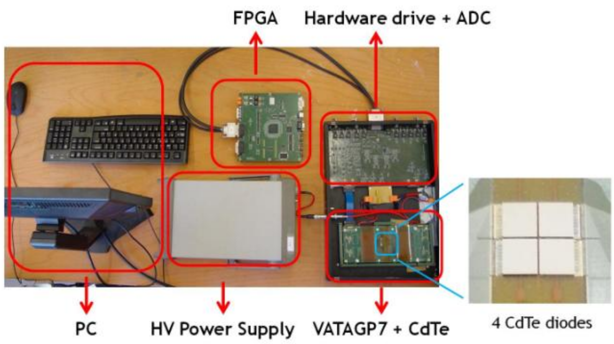


Fig. 6: The test bench setup to evaluate four CdTe pixel detectors. Each has 99 pixels of 1x1mm^2 and 2mm thickness. The readout chip is a VATAGP7. CdTe detectors are kept in an enclosed box with N_2 gas flow to reduce the humidity and the leakage current

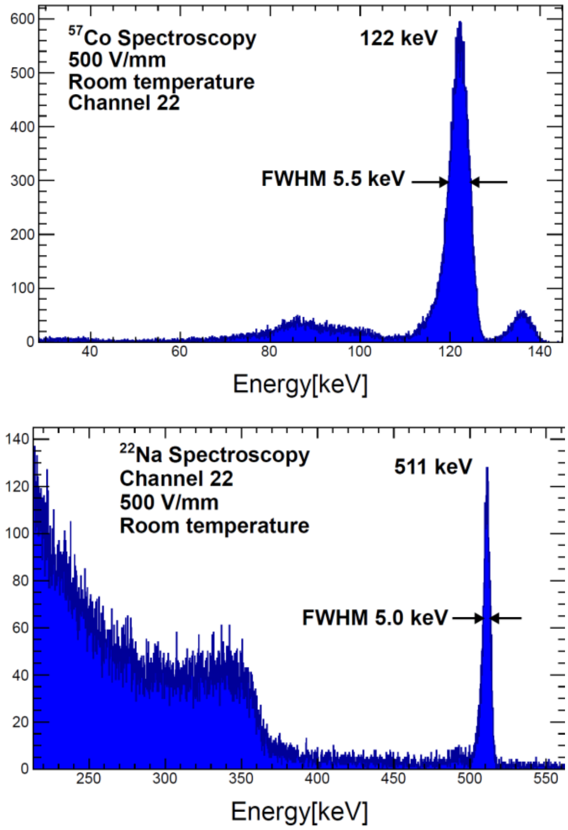


Fig. 7: On the top is the spectroscopy of Co^{57} and on the bottom is spectroscopy of Na^{22}. One can achieve less than 1% of FWHM at 511 KeV and room temperature. This is to show that it is possible to achieve such excellent energy resolution with the VIP PET detector.

Image reconstruction in a VIP Compton Camera

Several reconstruction algorithms can be used for Compton Camera simulations. To list some of them: *Ordered Subset Expectation Maximization (OSEM), List-mode (LM), Origin Ensemble (OE), and LM-OSEM*. However the level of these algorithms is relatively primitive when compared to results one can achieve with PET or CT image reconstruction programs. The reason for this is that the Compton Camera community is small and thus the research and investment in this field have been limited.

The Compton Camera can provide, in principle, a full 3D image of the object from a single imaging position. However in real life this is not possible because of systematic errors from the detector energy and spatial resolutions, as well as the Doppler broadening due to the atomic motion of the scattered electron. To overcome this limit one should take the image of the body from two angles or use two Compton Cameras simultaneously as shown in Figure 8.

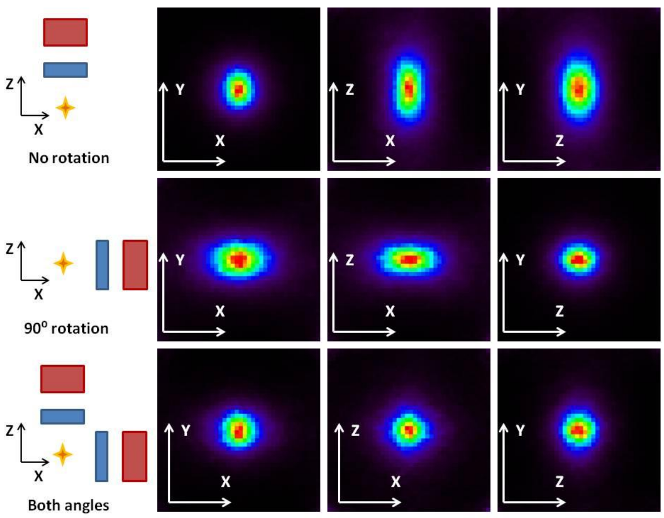


Fig: 8. The red object is the scattered photon absorber - in this case, the CdTe pixel detector. The blue object is the scatterer, in this case a Si pixel detector. The star is the point source being imaged. A single view produces a distorted image. When combining two views one can achieve a spatial resolution for a point source of 3.1 mm in X, Y and Z.

The VIP team developed its own image reconstruction algorithms for the VIP Compton Camera. Reconstructing the image of a Derenzo phantom it obtained a resolution of 1.5 mm, as shown in Figure 9. This is a very important achievement as no previous work was able to reach such a high resolution with a Derenzo phantom.

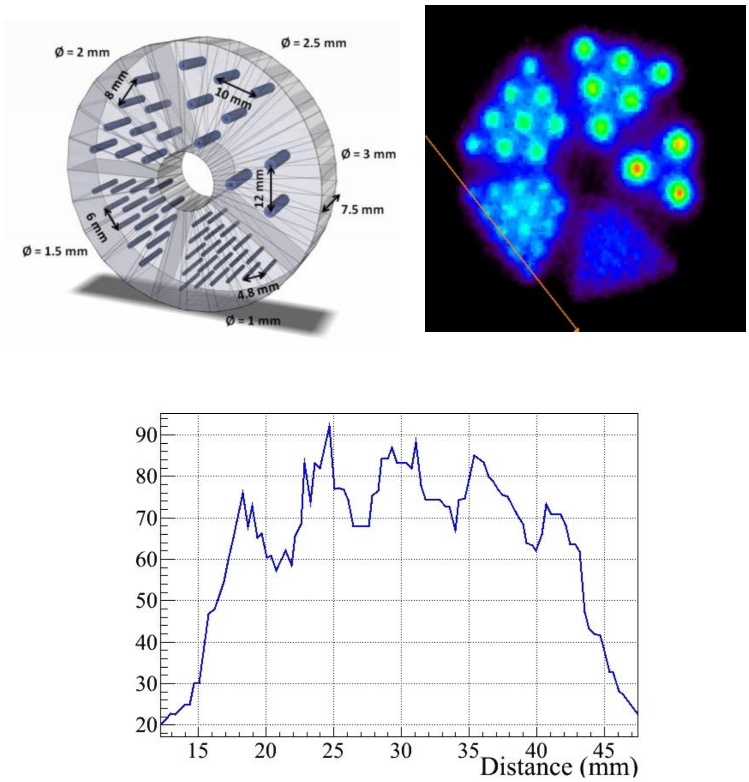


Fig. 9: Top left panel: a Derenzo phantom with7.5 mm long holes of various diameters filed with ^{18}F-FDG radiotracer. Top right panel: the image reconstructed with the VIP Compton Camera using the LM-OSEM algorithm. The radiotracers in the 1.5 mm holes are clearly seen. Bottom panel: the profile signal on a line crossing a set of 1.5mm holes. One can clearly see each hole.

Another test was carried out to also evaluate the performance of the VIP Compton Camera with the LM-OSEM reconstruction algorithm using a more realistic phantom. We used the image of a slice of a human brain from a CT scan. This provides the image in the medical standard DICOM file format and contains the corresponding density map of the brain slice. An activity of 10^5 Bq of ^{18}F-FDG in the grey matter in the brain slice was simulated. Collecting 34 million events with our simulated VIP

Compton Camera we were able to reconstruct the image in Figure 10. One can see clearly the brain white/grey matter in some detail.

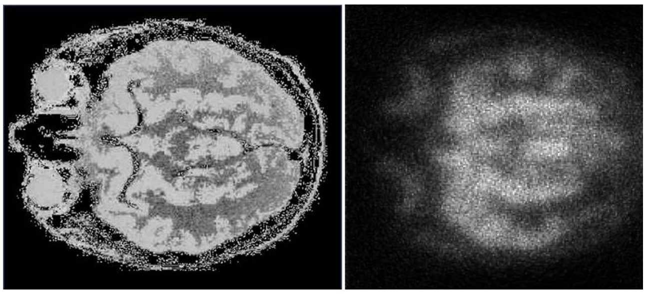


Fig. 10: Left panel: the DICOM image of a brain slice from a CT scan. Riight panel: the same brain slice seen by simulated VIP Compton Camera using 10^5 Bq of ^{18}F-FDG radiotracer.

VIP PET Mammography (PEM)

The VIP PEM device we simulated is based on the design of the Naviscan commercial device but instead of using scintillator crystals we use pixel CdTe detectors coupled to a VIP-PIX chip. Naviscan is the only PEM machine having USA FDA approval. To evaluate the VIP PEM performance, we simulated a phantom positioned in two different orientations as shown in Figure 11. In both orientations the spatial resolution of the VIP PEM allows us to detect the 1 mm hole in the phantom, as shown in Figures 12, 13 and 14.

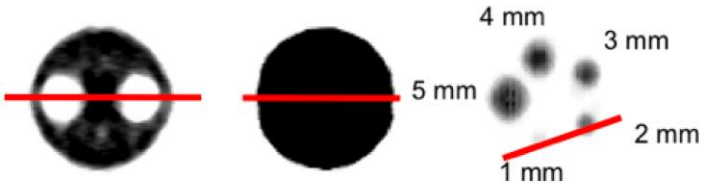


Fig. 12: On the left is the image of the top part of the phantom. In the center, the image of the middle part of the phantom is shown. On the right is the image of the 5 tubes with different diameters located at the bottom of the phantom. The image profiles displayed in Figures 13 and 14 are taken along the red lines.

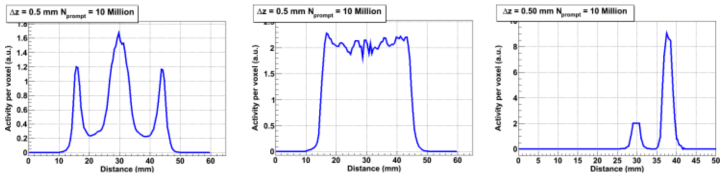


Fig. 13: The three histograms are for the case when the phantom is positioned upright. On the left is the profile along the line passing across the top part of phantom. One can clearly differentiate "hot" and "cold" areas. In the center is the profile along the line across the middle part of the phantom. The image of that region is very uniform as expected. On the right is the profile along the line passing across two tubes in the lower part of the phantom. The 1 mm tube is clearly detected.

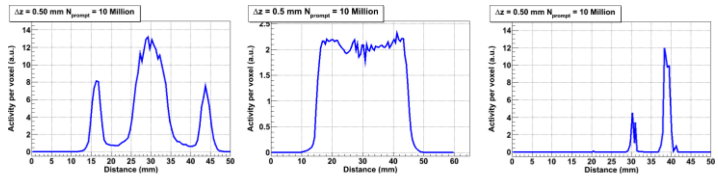


Fig. 14: Same as in Figure 13, but in this case the phantom is placed horizontally. The quality of the images is about the same as in the up-right position. This is not achievable with the Naviscan PEM device.

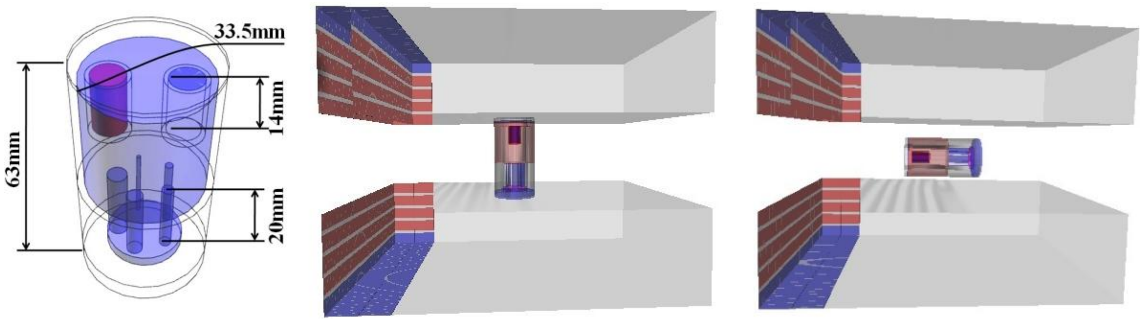
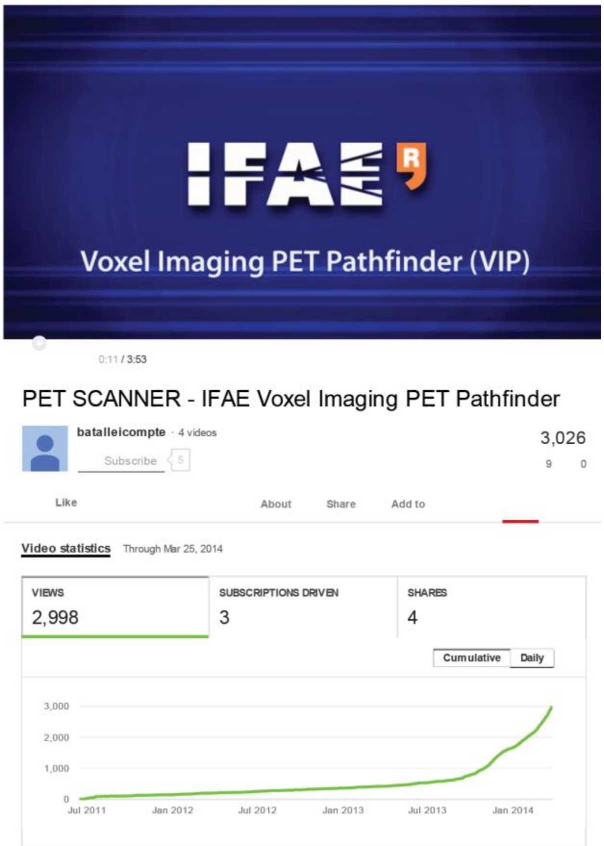


Fig. 11: On the left panel one can see the phantom. Center and right panels: shown are the VIP-PEM and the phantom between the two paddles. In one case the phantom is positioned upright and in the other the phantom is positioned horizontally.

VIP Public Relations

Public interest in VIP project has grown with time, experiencing a very steep rise since summer 2013. Below is a screen dump from the *youtube* web page where VIP PET is presented in 4 min video clip. At the bottom one can see statistics on the number of views, that has to grown by a factor of six since summer 2013.



2.10 X-Ray Imatek

Mokhtar Chmeissani & Carlos Sánchez

The year 2013 has been an important check point for X-Ray Imatek in confronting and adapting to its particular market sector. Sales have grown less than projected, only 20% more than in 2012, but several significant goals were met from which important future sales are expected.

The company's business line has been diversified and its custom services have been boosted, in preparation for increased demand expected from the 50% increase in the sales of assemblies since the previous year. This increase offered an opportunity to introduce further complementary services that it was already possible to do in-house, such as Medipix wire-bonding and full-detector assembly. Thanks to that, at the end of the year the company received the first request to supply over 50 complete detectors to be commercialized by a third party. This offer gives XRI the opportunity to face the practical problems that could arise with a large production of detectors.

During 2013 XRI began offering the first units of the XRI-QUATRO, based on a Medipix2 Quad system with an individual Si sensor. With this new product it was necessary to develop processes to improve the yield on this type of assemblies. Now, the XRI-QUATRO is the product in greatest demand from our catalogue.

On the R&D front, XRI has been working with high-Z (GaAs and CdTe) sensors for Medipix2. In order to reduce the high production costs of these items efforts have been made to improve the handling of these components and the performance of the flip-chip process. It seems likely that in 2014 GaAs sensors will be added to XRI's standard products catalogue.

In addition, the design of a new version of the XRI standard readout platform, the SXRI Series, was initiated. This new family of devices will contain many of the improvements suggested by our customers. Probably the SXRI series will be released by mid-2014; it will introduce several advances in speed and performance when compared with the current Medipix-based detectors on the market.

The company increased its staff with a Software Engineer. His main objective is to fix bugs from the current GUI and to create a new one for the newly developed products. In addition, a full-time software designer will help the company in facing new challenges where software must play a crucial role.

As to commercial actions, the company attended two of the most important conferences worldwide in the field of radiation detectors, iWoRID and IEEE2013, held in Paris and Seoul respectively. Furthermore, collaborative actions with IFAE were incremented, combining our exhibits in the 2013 Large Hadron Colliber Physics Conference in May and in the Festa de la Ciència i la Tecnología in June. These initiatives increased the visibility of XRI where many of its potential costumers usually go.

2014 Forecast

The market's interest in our technology seems to be growing, but it matures very slowly, therefore accurate predictions of what the winning products will be are difficult.

In any case, in 2014 the volume of sales is expected to grow 100%. The new developments are expected to bring the first rewards by the fourth quarter, and the OEM services are expected to grow dramatically in comparison with past years. In addition, several sales that were expected to take place in 2013 were eventually delayed to the first quarter of 2014.

The company needs to improve industrial market penetration, and to further promote its activities as an OEM service provider and custom product developer. To reach this goal, X-Ray Imatek plans to join networks like SECPho, a Southern European cluster focusing on photonic technologies applied to industrial environments.

The company also envisages corporate alliances with key partners that should allow it to reach markets in which it wishes to increase its share, such as food inspection and medical imaging.

2.11 Standard Model

Matthias Jamin

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 2013, the central research field in our group was hadronic decays of the τ lepton and the behaviour of higher orders in QCD perturbation theory.

Hadronic decays of the τ lepton provide an interesting avenue to studying QCD at relatively low energies, because at the scale of its mass $M_\tau \approx$ 1.8 GeV, QCD effects are already sizeable, but the expansion in powers of α_S still generally retains its perturbative character though to a certain extent depends on the observable in question. For this reason, in the last ten years the analysis of hadronic τ decays already played an important role in the extraction of QCD parameters, and in particular the determination of α_S from τ decays significantly influences the world average of this parameter.

In 2013, in collaboration with Martin Beneke and Diogo Boito we investigated the perturbative behaviour of many moments that have been employed in α_S extractions in the past. The pertinent observables in the analysis of hadronic τ decays are integrals of the fully inclusive differential decay distributions, the so-called spectral functions, which until today have only been provided by the ALEPH and OPAL collaborations at the CERN LEP collider, weighted with analytic functions that place different emphasis on different regions in energy, thereby exploring the structure inherent in the spectral functions.

Besides the weight function $w_\tau=(1-x)^2(1+2x)$, where $x=s/M_\tau^2$ and s the centre-of-mass energy squared of the hadronic system, that naturally arises from the kinematics of phase space integrals in the total τ hadronic width, traditionally additional weights with further powers of x and/or (1-x) had been employed to increase or suppress the higher-energy region close to the τ mass. One drawback of such weights, however, is that with additional powers in x also higher-dimensional contributions in the operator product expansion (OPE) get enhanced, since a power x^n in the weight function is related to an operator contribution of dimension 2(n+1). For example the kinematic weight w_τ enhances operators of dimension 6 and 8, whereby for R_τ the dimension-6 QCD condensate represents the dominant non-perturbative OPE contribution. Furthermore the behaviour in perturbation theory in α_S of these moments had not been investigated in much detail.

This gap was filled by our work in which the perturbative behaviour of 17 τ moments was studied in the framework of 2 models for the higher-order perturbative behaviour of the QCD Adler function which were introduced by Beneke and Jamin previously. The models reflect the known renormalon structure of the Borel transform of the Adler function and reproduce the analytically known leading perturbative coefficients. In the central model all residues of the incorporated renormalon poles take their natural values while in a second model the leading infrared renormalon pole related to the gluon condensate is artificially suppressed in order to gauge possible model dependence though the latter behaviour in true QCD appears less likely since no mechanism for such a suppression is known. Furthermore, the dependence of the α_S determination on the resummation prescription of scale logarithms in finite-order perturbation theory were studied for the two most common schemes: fixed-order perturbation theory (FOPT) versus contour-improved perturbation theory (CIPT).

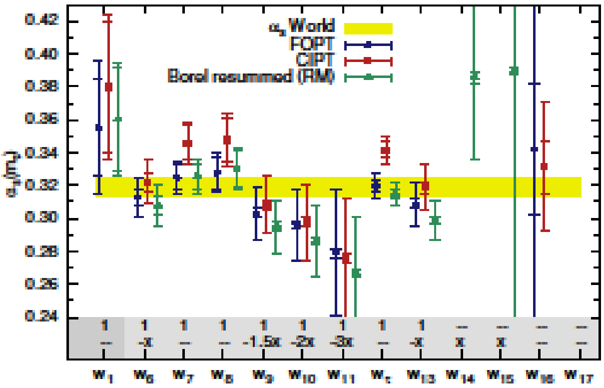


Fig. 1: Determinations of $\alpha_s(M_\tau)$ from several τ spectral moments as described in the text. Blue, red and green lines correspond to FO, CI and Borel resummed perturbation theory respectively. Inner errors are purely experimental while outer errors include an estimate of theoretical uncertainties. The yellow bar indicates the current world average for $\alpha_s(M_\tau)$.

Figure 1 provides a graphical account of the influence of choosing different moments on the extraction of $\alpha_s(M_\tau)$, comparing with the present world average, displayed as the yellow bar. Blue, red and green lines correspond to FO, CI and Borel resummed perturbation theory respectively. Inner shown errors are purely experimental, while outer errors include an estimate of theoretical uncertainties resulting from the perturbative series and non-perturbative terms. If an entry is missing, no reasonable value for $\alpha_s(M_\tau)$ could be extracted from the corresponding moment. This in particular happens for the moments w_{14} to w_{17} which were the ones employed in the classic ALEPH and OPAL analyses. The lack of stable solutions can be traced back to the rather problematic perturbative behaviour of those moments.

Most reliable results are obtained from the total τ hadronic width R_τ, related to the weight w_τ. However, this weight by itself is not sufficient for a complete self-consistent determination of all occurring parameters, since, as was already discussed in the 2012 IFAE Report, further non-perturbative OPE and duality violation parameters have to be fitted simultaneously. One such moment which might be included, being very sensitive to the duality violation parameters is the moment $w_1=1$, though, as seen from Figure 1 in this case the influence of experimental uncertainties is very big because the higher-energy region close to the kinematic end-point is not suppressed.

A detailed discussion of all studied moments can be found in the original publication. Still, interestingly, another feature of the weight function that substantially influences the perturbative behaviour of the related moment is the occurrence of a linear term in x which is related to the dimension-4 gluon condensate. In Figure 1, a potential linear in x term for a particular weight is indicated in the lower line of the grey band at the bottom of the figure. Generally, weights with such a term have larger inherent perturbative uncertainties.

A follow up investigation employing earlier fits to the OPAL non-strange τ hadronic spectral functions was performed in collaboration with D. Boito, M. Golterman, K. Maltman and S. Peris. Relating the difference of the vector and axial vector QCD correlation functions $\Pi_{V-A}(Q^2)$ at small Q^2 to the corresponding low-energy expansion in chiral perturbation theory, the effective chiral couplings L_{10}^{eff} at order p^4 and C_{87}^{eff} at order p^6 in the chiral expansion could be extracted. As a by-product of the analysis also the dimension-6 and dimension-8 contributions to the V-A correlator in the framework of the OPE could be estimated. Our result for the dimension-6 coefficient is displayed as the upper line of Figure 2 and compared to earlier determinations in the literature.

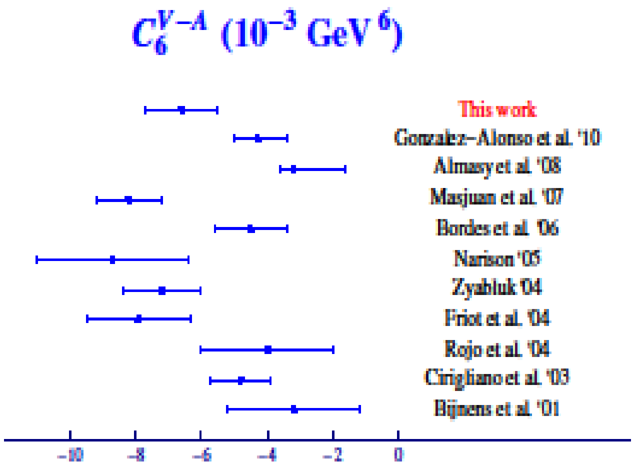


Fig. 2: Dimension-6 operator product expansion contribution to the V-A correlation function as extracted from fits to the OPAL hadronic τ decay spectral functions, and comparison to previous results in the literature.

The last work that shall be mentioned in this context concerns another investigation of the large-order behaviour of QCD perturbation theory and was performed in collaboration with and as the Master thesis of Ernest Alsina Ballester. Analogously to a previous computation of the scalar gluonium two-point correlation function in the so-called large-β_0 approximation, we calculated the corresponding expansion in α_S for the pseudoscalar gluonium correlator to all orders in perturbation theory. The large-β_0 approximation is interesting because it exhibits the renormalon structure of the Borel transform of the corresponding correlator, and also gives at least an indication of the size of higher-order perturbative terms. Furthermore, the pseudoscalar gluonium potentially has an interesting phenomenology as it is expected to mix with the η' meson. It was found, however, that for the gluonic correlation function the perturbative expansion breaks down already at scales of the order of several GeV so that no QCD sum rule analysis of the respective systems appears possible.

2.12 Beyond the Standard Model

José Ramón Espinosa

Identification of the Higgs profile

The discovery of the Higgs boson by ATLAS and CMS at the LHC, announced in July 2012, has been the most important event in particle physics in decades. IFAE's theory group continues to be very active in studying the experimental data to try and understand the properties of this particle and to extract possible implications both for the Standard Model (SM) and for physics beyond it.

Christophe Grojean has made significant progress towards the identification of the Higgs couplings. First, in a paper in collaboration with J. Elias-Miró and S. Gupta, he showed how the Higgs observables are related to other observables with the renormalization group evolution. In a second paper, he also proposed to study the distribution of the Higgs transverse momentum in its production by fusion of gluons in order to disentangle the long and short distance contributions to this process.

He has also studied the prospects of various future facilities for what concerns the measurements of the Higgs couplings. He has also made some connections between the Higgs rates and degrees of compositeness of light generation quarks. And he has done a thorough study of the parameter space of models of composite tops.

IFAE postdoc R.S. Gupta studied how well future colliders should measure Higgs boson mass and self-coupling to have an impact on discovery of new physics or an impact in how we understand the role of the Higgs boson in nature. The conclusion was that the LHC's stated ability to measure the Higgs boson to better than 150 MeV will be as good as we will ever need to know the Higgs boson mass in the foreseeable future. On the other hand, the self-coupling will likely need to be measured to better than 20% to see a deviation from the SM expectation. This is a challenging target for future collider and upgrade scenarios.

Extensions of the Standard Model (BSM)

With the experimental discovery of the Higgs at the LHC in 2012, experiments have finally addressed all aspects of the Standard Model (SM). At this stage, it was important to understand which windows for beyond the SM (BSM) physics are still open, and which are instead closed.

J.Elias-Miró, J.R. Espinosa and E. Massó (in collaboration with A. Pomarol, UAB) performed such a systematic study of the leading contributions from possible heavy BSM states on Higgs physics using higher-dimensional operators. Operators were separated into different groups constrained at different levels. This analysis allows to assert in a model-independent way where BSM effects can appear in Higgs physics. Under certain well-motivated assumptions, it was found that 8 CP-even plus 3 CP-odd Wilson coefficients parametrize the main impact in Higgs physics, as all other coefficients are constrained by non-Higgs SM measurements.

They have also calculated the most important renormalization effects, which describe operator mixing from the heavy scale down to the electroweak scale. This allows us to find the leading-log corrections to the predictions for the Higgs couplings in specific models, such as the MSSM or composite Higgs, which were found to be significant in certain cases. These calculations will also be extremely useful at the next run of the LHC and at the Next Linear Collider.

The theoretical exploration of extensions of the Standard Model that address some of the problems and pitfalls of the Standard Model is one of the driving forces of research in the field. It is especially interesting when theoretically well-motivated extensions lead to observable deviations, with respect to the predictions of the Standard Model that can be searched for in accelerator experiments like the LHC.

Along this line, Mariano Quirós has studied extensions of the Higgs sector of the Minimal Supersymmetric Standard Model, MSSM, by SU(2) triplets. This addition alleviates the little hierarchy problem, and naturally allows for enhancements in the diphoton decay rate of the lightest CP-even Higgs, h. A light extended Higgs sector is considered. It turns out that there is a parameter region at small tanβ where the CP-even Higgs sector looks SM-like at colliders, except for loop-induced corrections.

Mariano Quirós, in collaboration with IFAE students (L. Cort and M. García) has also considered extensions with SU(2) triplets with a (global) custodial symmetry which prevents a tree-level contribution to the T-parameter even in the presence of relatively large vacuum expectation values for the triplet neutral components.

Electroweak mechanisms in warped spaces

Mariano Quirós considered the generation of the hierarchical charged-lepton spectrum and anarchic neutrino masses and mixing angles in warped extra dimensional models with Randall-Sundrum metric. This work classified all possible cases giving rise to realistic spectra for both Dirac and Majorana neutrinos. An anarchic neutrino spectrum requires a convenient bulk symmetry broken by boundary conditions on both UV and IR branes. A case of particular interest that was considered is that of Majorana neutrinos with continuous bulk symmetry.

2.13 Astroparticles & Cosmology

ORIOL PUJOLÀS

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 range from the origin and nature of dark energy, dark matter, neutrinos and baryogenesis to the properties of modified gravity models and developing the applications of the gauge/gravity correspondence. During 2013, the work done by the members of the Theory Division in this research area can be divided in the following topics.

Baryogenesis

The Higgs discovery at the LHC has a direct impact on models of baryogenesis. Electroweak baryogenesis may only be realized in the MSSM in the presence of light stops, and with moderate or small mixing between the left- and right-handed components. Consistency with the observed Higgs mass demands the heavier stop mass to be much larger than the weak scale. Moreover the lighter stop leads to an increase of the gluon-gluon fusion Higgs production cross-section, which seems to be in contradiction with indications from current LHC data. M. Quirós has shown that this tension may be considerably relaxed in the presence of a light neutralino, satisfying all present experimental constraints.

With the Higgs discovery, it is also important to reexamine the new possible roles that this boson may have in cosmology. Of course, the Higgs sector already plays a crucial part both in electroweak baryogenesis and leptogenesis, but new aspects may emerge for instance when trying to relate the Dark matter and baryonic sectors. Existing baryogenesis scenarios rely on either generating a baryon asymmetry directly or generating a lepton asymmetry that is reprocessed into baryon number. Similarly, asymmetric dark matter scenarios often rely on dark matter particles carrying baryon or lepton number which gets interconverted between the two sectors. A Higgs number asymmetry is the third kind of asymmetry that can be generated in the SM. G Servant, has explored a new mechanism – dubbed Higgsogenesis – where a Higgs asymmetry in the early Universe generates dark or baryonic matter. Two different cosmological scenarios arise: i)

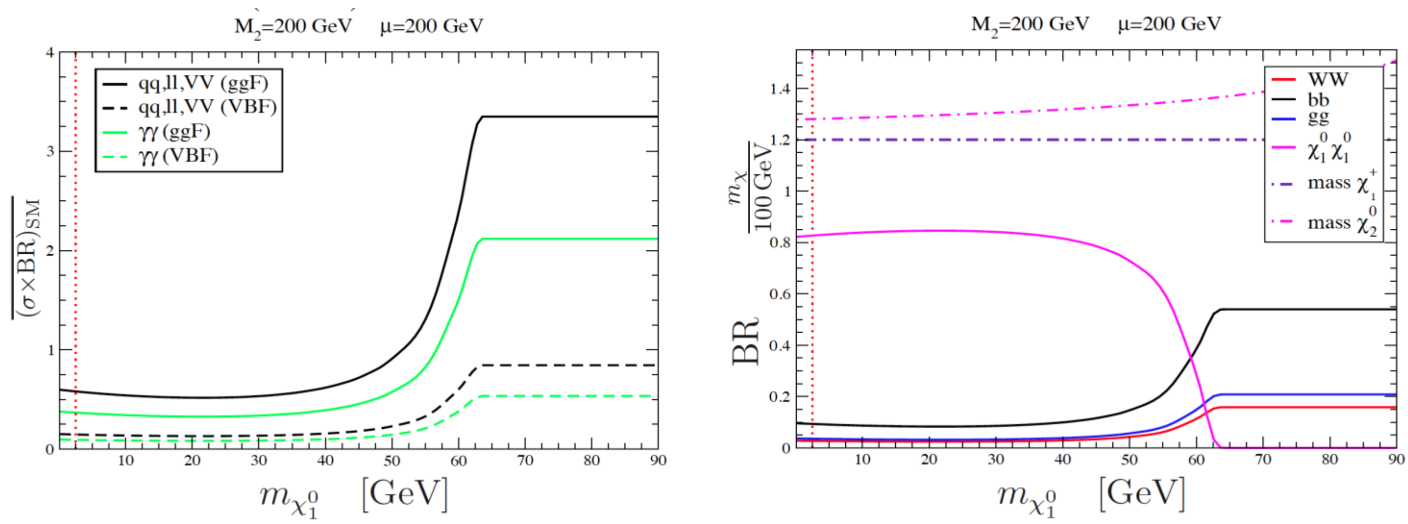


Fig.1: (σ×BR)/(σ×BR)SM of the Higgs (left panel) and BR of the Higgs (right panel, channels with BR< 0.1 are omitted) as a function of the neutralino mass m(χ_1^0) for a representative parameter choice. The Higgs mass is about 125 GeV. The lightest chargino and next-to-lightest neutralino (lower and upper dot-dashed lines in the right panel) are heavier than the light stop. On the left (right) of the vertical dotted line the stop can decay with a real (virtual) W boson.

asymmetric DM can naturally result from a primordial B − L asymmetry through Higgs charge transfer; and ii) inversely, a primordial DM asymmetry can generate a Higgs asymmetry, which in turn generates the B asymmetry. One advantage of this mechanism is that it does not new cosmological scenario where the Higgs chemical potential mediates asymmetries between visible and dark matter sectors, either generating a baryon asymmetry from a dark matter asymmetry or vice-versa.

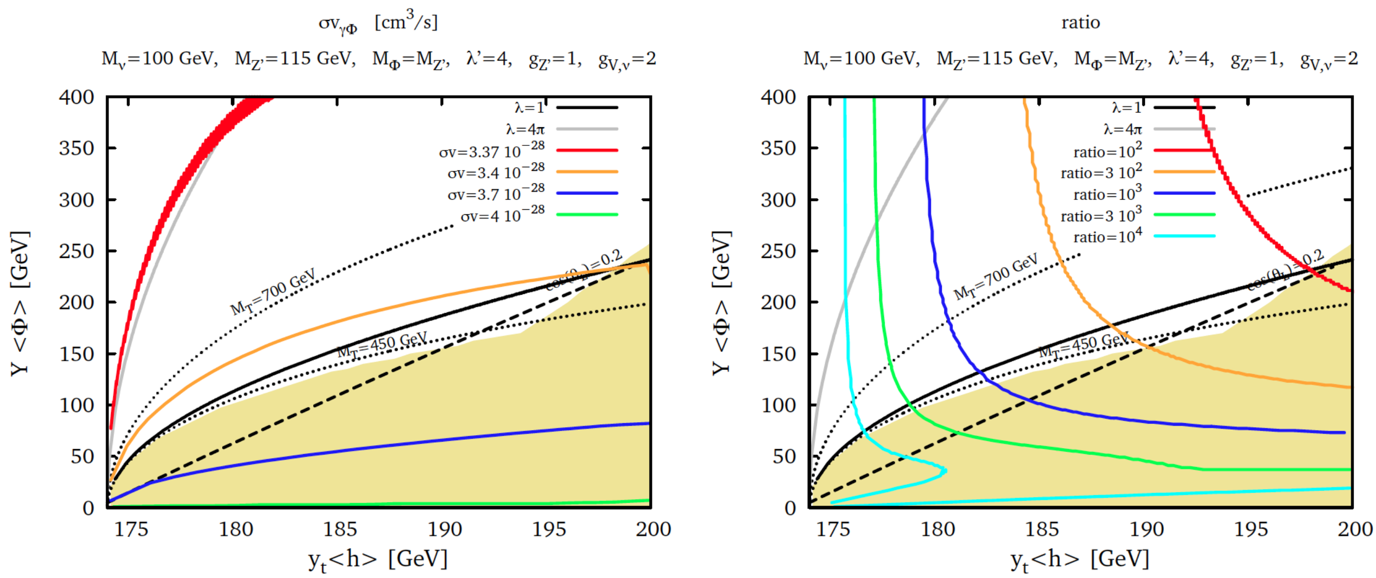


Fig. 2: Line signal rates and ratio to continuum for two choices of DM masses as a function of the coupling and mass parameters, in the s-channel mediator fermion DM model. The shaded region is excluded by EW precision tests. In the bottom plots, the choice of the DM and Z⁰ masses guarantees that the correct relic abundance is obtained for essentially the whole plane.

require new baryon or lepton number violating interactions beyond EW sphalerons, relying instead only on interactions between the Higgs and the dark sector.

Dark matter

Weakly-Interacting Massive Particles (WIMPs) are one of the leading candidates for dark matter. Their annihilation in our galaxy can lead to smoking gun signatures within the sensitivities of Fermi and Hess II instruments. In the last year, we have mapped out the kinds of theories that naturally produce prominent line features, paying special attention to the 1-loop continuum generated together with the gamma-ray lines. We studied generic classes of models in which DM is a fermion that annihilates through an s-channel mediator that is either a vector or scalar and identified the coupling and mass conditions under which large line signals occur. We also proposed a

Emergence of Lorentz Invariance

During 2013, we have built and studied models that realize Lorentz invariance as an emergent symmetry. A well-known property of the renormalization group (RG) flow is that under certain conditions the low-energy fixed points exhibit accidental (or emergent) symmetries – symmetries that are not present in the microscopic theory. An interesting possibility is that Lorentz invariance might be one such emergent symmetry. This is relevant not only to particle physics but also to condensed matter, since there are already several materials (the most famous of which is graphene) that are close to realizing this phenomenon. In fact, the phenomenon turns out to operate under surprisingly general conditions. However in weakly coupled theories the approach to Lorentz invariance at low energies is too slow to be relevant for particle physics phenomenology. This motivates the study of this mechanism in theories that undergo strong dynamics, since the emergence phenomenon can then be much faster. We have studied how efficient the emergence is in strong dynamics models that admit a gravity dual, by constructing holographic RG flows and analyzing their excitation spectra. We found that the RG flow towards Lorentz invariance is indeed accelerated, and that at low energies the deviations from Lorentz invariance are small and display a number of distinct signatures.

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 2013, We have studied i) holographic models with a naturally light dilaton and the holographic renormalization group flows; ii) the impact of chiral anomalies on relativistic fluids, including the general characterization of transport properties in relativistic fluids up to second order; iii) the holographic RG flows from non-relativistic (Lifshitz) fixed points to Lorentz invariant points.

3.Personnel in 2013

IFAE complements its own staff (hired directly by the Institute) with personnel of ICREA and collaborates with personnel from the UAB as shown in the following list.

Experimental Division

Faculty

Blanch, Oscar	Researcher, Ramon 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, Sebastian	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, Ramon y Cajal, IFAE

Engineering Staff

Abril, Oscar	Electronic Engineer, IFAE, CTA
Ballester, Otger	Electronic Engineer, IFAE
Barceló, Miquel	Electronic Engineer, IFAE (at present, CTA Project Engineer)
Boix, Joan	Electronic Engineer, CTA
Cardiel Sas, Laia	Electronic Engineer, IFAE
Garcia Gil, Rafael	Mechanical Engineer, IFAE,MAGIC-CTA (since Feb. 2013)
Garcia Rodriguez, Jorge	Electronic Engineer, IFAE, VIP (since Apr. 2013)
Grañena, Ferran	Mechanical Engineer, IFAE
Illa, Jose Mª.	Electronic Engineer, IFAE
Jimenez Rojas, Jorge	Electronic Engineer, IFAE
Lopez Morillo, Luis	Mechanical Engineering Student, IFAE, PAU
Macias, José Gabriel	Microelectronics Designer, VIP
Maja, Ester	Software Engineering Student, IFAE (since Jan. 2013)
Pio, Cristobal	Software Engineer, CTA
Puigdengoles, Carles	Electronic Engineer, IFAE

Computer Scientists

Campos, Marc	IFAE
Guinó Feijoo, Alex	IFAE
Pacheco, Andreu	IFAE, Senior Applied Physicist (Computing)

Technicians

Arteche, Carlos	Mechanical Technician, PAU
Benedico, David	Mechanical Technician, IFAE (since Mar. 2013)
Colombo, Eduardo	Support Technician, MAGIC
González, Alex	Electronic Technician, IFAE
Gaweda, Javier	Mechanical Technician, IFAE

Scientific Post-Docs

Abdallah, Jalal	ATLAS, CPAN (until Aug. 2013)
Aleksić, Jelena	MAGIC, (until Sept. 2013) DES-PAU (UAB) (since Oct. 2013)
Bonnet, Christopher	DES (since Dec. 2013)
Bordoni, Stefania	Neutrinos
Camprecios, Jordi	CTA (since Oct. 2013)
Cortes, Arely	ATLAS (since Apr. 2013)
De Lorenzo, Gianluca	VIP
Farooque, Trisha	ATLAS (since Sep. 2013)
Francavilla, Paolo	ATLAS (until Dec. 2013)
Giangiobbe, Vincent	ATLAS
Garczarczyk, Markus	MAGIC (until Mar. 2013)
Helsens, Clément	ATLAS (until Oct. 2013)
Herrera, Javier	MAGIC (since Mar. 2013)
Ieva, Michela	Neutrinos, Beatriu de Pinos
Kolstein, Machiel	VIP
Lange, Joern	Pixels (since Oct. 2013)
Le Menedeu, Eve	ATLAS
Lux, Thorsten	Neutrinos , Juan de la Cierva
Micelli, Andrea	Pixels (until Dec. 2013)
Sitarek, Julian	MAGIC CTA , Juan de la Cierva
Stamatescu, Victor	MAGIC CTA (until Jun. 2013)
Will, Martin	MAGIC (since Jun. 2013)

Doctoral Students

Ariño, Gerard	VIP
Calderón, Yonatan	VIP
Caminal, Roger	ATLAS
Caravaca, Javier	Neutrinos, FPI
Casolino, Mirko	ATLAS (since Jan 2013)
Castillo, Raquel	Neutrinos

Conidi, Mª. Chiara	ATLAS (until Feb. 2013)
Fernández, Alba	MAGIC FPI (since Sep. 2013)
Fischer, Cora	ATLAS, FPI (since Nov.2013)
Fracchia, Silvia	ATLAS
García, Alfonso	Neutrinos, FPI
Gonzalez, Adiv	MAGIC-CTA
González Parra, Garoe	ATLAS, FPI
Guberman, Daniel	MAGIC-CTA (since Dec. 2013)
López Coto, Ruben	CTA, FPI
López Orama, Alicia	MAGIC, FPI
López Paz, Ivan	Pixels
Lostao, Albert	Neutrinos (until Jul. 2013))
Martí, Pol	DES-PAU (until Dec. 2013)
Mikhaylova, Ekaterina	VIP
Montejo, Javier	ATLAS, FPU
Nadal, Jordi	ATLAS (until Jun. 2013)
Ozsahin, Ilker	VIP (until Jul. 2013)
Rossetti, Valerio	ATLAS, FPU (until Jul. 2013)
Rubbo, Francesco	ATLAS
Sanchez Alonso, Carles	DES, PAU
Succurro, Antonella	ATLAS
Tsiskaridze, Shota	Pixels, FI
Uzun, Dilber	VIP

Administrative Personnel

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

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	Post doc IFAE (since Nov. 2013)
Gupta, Sandeepan	Post doc IFAE
Hofer, Lars	Post doc IFAE (since Oct. 2013)
Roig, Pablo	Post doc IFAE (until Aug. 2013)
Silva, Pedro	Post doc Institut de Ciències de l'Espai

Doctoral Students

Baggioli, Matteo	Scholarship PIF (since Feb. 2013)
Domènech, Oriol	Scholarship MICINN (until Jan. 2013)
Elias, Joan	Scholarship MICINN
García Pepin, Mateo	Scholarship PIF (since Feb. 2013)
Krug, Sebastian	Scholarship MICINN
Ramon, Marc	Scholarship UAB (PIF) (until Aug. 2013)
Peset, Clara	Scholarship MICINN
Wiechers, Michael	Scholarship Erasmus (until Jan. 2013)
Zhong, Yuan	Chinese Scholarship Council (since Sep. 2013)

4. Institutional Activities in 2013

4.1 Final Master & Diploma Projects

Experimental Division

Iván López
Long term burn in tests of IBL 3D pixel modules
September 2013.
Supervisor: Sebastian Grinstein

Carles Sánchez
Photometric Redshifts With Training-Based Methods for Galaxy Surveys with Multiple Narrow-Band Filters
February 2013
Supervisor: Ramon Miquel

Theory Division

Ernest Alsina Ballester
The pseudoscalar gluonium correlator: large-beta_0
June 2013
Supervisor: Matthias Jamin

4.2 Doctoral Theses

Experimental Division

Jelena Aleksić
Optimized Dark Matter Searches in Deep Observations of Segue 1 with MAGIC
June 2013
Supervisors: Manel Martinez and Javier Rico

Mª Chiara Conidi
Measurement of the ttbar production cross-section in the tau+jets final state at sqrt(s) = 7 TeV with the ATLAS detector at the LHC
May 2013
Supervisor: Martine Bosman

Gianluca Giavitto
Observing the VHE Gamma-Ray Sky with the MAGIC telescopes: the Blazar B3 2247+381 and the Crab Pulsar
February 2013.
Supervisors: Daniel Mazin and Juan Cortina

Valerio Rossetti
Search for new phenomena in events with one energetic jet and large missing transverse momentum in proton-proton collisions at sqrt(s) = 7 and 8 TeV with the ATLAS detector
July 2013
Supervisor: Mario Martinez

4.3 Publications

Experimental Division

Publications ATLAS Group

ATLAS Collaboration
Measurement of the top quark pair production charge asymmetry in proton–proton collisions at $\sqrt{s}$ = 7 TeV using the ATLAS detector
J. High Energy Phys. 02 (2014) 107

ATLAS Collaboration
Measurement of the mass difference between top and anti-top quarks in pp collisions at $\sqrt{s}$ = 7 TeV using the ATLAS detector
Phys. Lett. B 728 (2014) 363-379

ATLAS Collaboration
Search for dark matter in events with a hadronically decaying W or Z boson and missing transverse momentum in pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector
Phys. Rev. Lett. 112 (2014) 041802

ATLAS Collaboration
Search for new phenomena in photon+jet events collected in proton--proton collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector
Phys. Lett. B 728 (2014) 562-578

ATLAS Collaboration
Search for Microscopic Black Holes in a Like-sign Dimuon Final State using large Track Multiplicity with the ATLAS detector
Phys. Rev. D 88 (2013) 072001

ATLAS Collaboration
Search for direct third-generation squark pair production in final states with missing transverse momentum and two b-jets in $\sqrt{s}$ = 8 TeV pp collisions with the ATLAS detector
J. High Energy Phys. 10 (2013) 189

ATLAS Collaboration
Search for new phenomena in final states with large jet multiplicities and missing transverse momentum at $\sqrt{s}$ = 8 TeV proton-proton collisions using the ATLAS experiment
J. High Energy Phys. 10 (2013)

ATLAS Collaboration
Search for excited electrons and muons in $\sqrt{s}$ = 8 TeV proton-proton collisions with the ATLAS detector
arXiv:1308.1364; CERN-PH-EP-2013-131.- Geneva : CERN, 2013 : New J. Phys. 15 (2013) 093011

ATLAS Collaboration
Dynamics of isolated-photon plus jet production in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
Nucl. Phys. B 875 (2013) 483-535

ATLAS Collaboration
Measurement of jet shapes in top-quark pair events at $\sqrt{s}$ = 7 TeV using the ATLAS detector
Eur. Phys. J. C 73 (2013) 2676

ATLAS Collaboration
Measurement of the top quark charge in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
J. High Energy Phys. 11 (2013) 031

ATLAS Collaboration
Measurement of the differential cross section of B+ meson production in pp collisions at $\sqrt{s}$ = 7 TeV at ATLAS
J. High Energy Phys. 10 (2013) 042

ATLAS Collaboration
Evidence for the spin-0 nature of the Higgs boson using ATLAS data
Phys. Lett. B 726 (2013) 120-144 Elsevier

ATLAS Collaboration
Measurements of Higgs boson production and couplings in diboson final states with the ATLAS detector at the LHC
Phys. Lett. B 726 (2013) 88-119

ATLAS Collaboration
Measurement of the Azimuthal Angle Dependence of Inclusive Jet Yields in Pb+Pb Collisions at $\sqrt{s_{NN}}$ = 2.76 TeV with the ATLAS detector
Phys. Rev. Lett. 111 (2013) 152301

ATLAS Collaboration
Performance of jet substructure techniques for large-R jets in proton-proton collisions at $\sqrt{s}$ = 7 TeV using the ATLAS detector
J. High Energy Phys. 09 (2013) 076

ATLAS Collaboration
Measurement of the distributions of event-by-event flow harmonics in lead--lead collisions at $\sqrt{s_{NN}}$ = 2.76 TeV with the ATLAS detector at the LHC
J. High Energy Phys. 11 (2013) 183

ATLAS Collaboration
Triggers for displaced decays of long-lived neutral particles in the ATLAS detector
J. Instrum. 8 (2013) P07015

ATLAS Collaboration
Search for resonant diboson production in the $WW/WZ \rightarrow l\nu jj$ decay channels with the ATLAS detector at $\sqrt{s}$ = 7 TeV
Phys. Rev. D 87 (2013) 112006 APS

ATLAS Collaboration
Measurement of the production cross section of jets in association with a Z boson in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
J. High Energy Phys. 07 (2013) 032

ATLAS Collaboration
Search for non-pointing photons in the diphoton and EmissT final state in $\sqrt{s}$ = 7 TeV proton-proton collisions using the ATLAS detector
Phys. Rev. D 88 (2013) 012001

ATLAS Collaboration
Measurement of the inclusive jet cross-section in pp collisions at $\sqrt{s}$ =2.76 TeV and comparison to the inclusive jet cross-section at $\sqrt{s}$ =7 TeV using the ATLAS detector
Eur. Phys. J. C 73 (2013) 2509

ATLAS Collaboration
Measurement with the ATLAS detector of multi-particle azimuthal correlations in p+Pb collisions at $\sqrt{s_{NN}}$ =5.02 TeV
Phys. Lett. B 725 (2013) 60-78

ATLAS Collaboration
Search for third generation scalar leptoquarks in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
J. High Energy Phys. 06 (2013) 033

ATLAS Collaboration
Characterisation and mitigation of beam-induced backgrounds observed in the ATLAS detector during the 2011 proton-proton run
J. Instrum. 8 (2013) P07004

ATLAS Collaboration
Improved luminosity determination in pp collisions at $\sqrt{s}$ = 7 TeV using the ATLAS detector at the LHC
Eur. Phys. J. C 73 (2013) 2518

ATLAS Collaboration
Search for WH production with a light Higgs boson decaying to prompt electron-jets in proton-proton collisions at $\sqrt{s}$ =7 TeV with the ATLAS detector
New. J. Phys.: 15 (2013) , pp. 043009

ATLAS Collaboration
Search for a light charged Higgs boson in the decay channel $H^+ \rightarrow c^s$ in $t\bar{t}$ events using pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
Eur. Phys. J. C 73 (2013) 2465

ATLAS Collaboration
Measurement of the cross-section for W boson production in association with b-jets in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
J. High Energy Phys. 06 (2013) 084

ATLAS Collaboration
Measurement of kT splitting scales in $W \rightarrow l\nu$ events at $\sqrt{s}$ =7 TeV with the ATLAS detector
Eur. Phys. J. C 73 (2013) 2432

ATLAS Collaboration
Measurements of $W\gamma$ and $Z\gamma$ production in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector at the LHC
Phys. Rev. D 87 (2013) 112003

ATLAS Collaboration
A Particle Consistent with the Higgs Boson Observed with the ATLAS Detector at the Large Hadron Collider
CERN-PH-EP-2012-303.- Geneva : CERN, 2012 - 8 p.
Science 338 (2012) 1576-1582

ATLAS Collaboration
Measurement of hard double-parton interactions in $W(\rightarrow l\nu)$+ 2 jet events at $\sqrt{s}$ =7 TeV with the ATLAS detector
New J. Phys. 15 (2013) 033038

ATLAS Collaboration
Search for long-lived, multi-charged particles in pp collisions at $\sqrt{s}$ =7 TeV using the ATLAS detector
Phys. Lett. B 722 (2013) 305-323

ATLAS Collaboration
Search for single b-quark production with the ATLAS detector at $\sqrt{s}$ =7 TeV
Phys. Lett. B 721 (2013) 171-189

ATLAS Collaboration
Multi-channel search for squarks and gluinos in $\sqrt{s}$ =7 TeV pp collisions with the ATLAS detector
Eur. Phys. J. C 73 (2013) 2362

ATLAS Collaboration
A search for prompt lepton-jets in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
Phys. Lett. B 719 (2013) 299-317

ATLAS Collaboration
Observation of Associated Near-side and Away-side Long-range Correlations in $\sqrt{s_{NN}}$ =5.02 TeV Proton-lead Collisions with the ATLAS Detector
Phys. Rev. Lett. 110 (2013) 182302

ATLAS Collaboration
Search for charged Higgs bosons through the violation of lepton universality in $t\bar{t}$ events using pp collision data at $\sqrt{s}$ = 7 TeV with the ATLAS experiment
J. High Energy Phys. 03 (2013) 076

ATLAS Collaboration
Search for a heavy narrow resonance decaying to $e\mu$, $e\tau$, or $\mu\tau$ with the ATLAS detector in $\sqrt{s}$ = 7 TeV pp collisions at the LHC
Phys. Lett. B 723 (2013) 15-32

ATLAS Collaboration
Measurement of Upsilon production in 7 TeV pp collisions at ATLAS
Phys. Rev. D 87 (2013) 052004

ATLAS Collaboration
Measurement of the $t\bar{t}$ production cross section in the τ jets channel using the ATLAS detector
Eur. Phys. J. C 73 (2013) 2328

ATLAS Collaboration
Search for new phenomena in events with three charged leptons at $\sqrt{s}$ = 7 TeV with the ATLAS detector
Phys. Rev. D 87 (2013) 052002

ATLAS Collaboration
Measurement of ZZ production in pp collisions at $\sqrt{s}$ =7 TeV and limits on anomalous ZZZ and ZZγ couplings with the ATLAS detector
J. High Energy Phys. 03 (2013) 128

ATLAS Collaboration
Search for resonances decaying into top-quark pairs using fully hadronic decays in pp collisions with ATLAS at $\sqrt{s}$ = 7 TeV
J. High Energy Phys. 01 (2013) 116 Springer

ATLAS Collaboration
Measurement of isolated-photon pair production in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
J. High Energy Phys. 01 (2013) 086

ATLAS Collaboration
Searches for heavy long-lived sleptons and R-Hadrons with the ATLAS detector in pp collisions at $\sqrt{s}$ = 7 TeV
Phys. Lett. B 720 (2013) 277-308

ATLAS Collaboration
Search for contact interactions and large extra dimensions in dilepton events from pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
Phys. Rev. D 87 (2013) 015010

ATLAS Collaboration
Search for supersymmetry in events with photons, bottom quarks, and missing transverse momentum in proton-proton collisions at a centre-of-mass energy of 7 TeV with the ATLAS detector
Phys. Lett. B 719 (2013) 261-279

ATLAS Collaboration
Search for Extra Dimensions in diphoton events using proton-proton collisions recorded at $\sqrt{s}$ = 7 TeV with the ATLAS detector at the LHC
New J. Phys. 15 (2013) 043007

ATLAS Collaboration
Search for long-lived, heavy particles in final states with a muon and multi-track displaced vertex in proton-proton collisions at $\sqrt{s}$ =7 TeV with the ATLAS detector
Phys. Lett. B 719 (2013) 280-298

ATLAS Collaboration
A search for high-mass resonances decaying to $\tau^+\tau^-$ in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
Phys. Lett. B 719 (2013) 242-260

ATLAS Collaboration
Measurement of Z boson Production in Pb+Pb Collisions at $\sqrt{s_{NN}}$ =2.76 TeV with the ATLAS Detector
Phys. Rev. Lett. 110 (2013) 022301

ATLAS Collaboration
Jet energy resolution in proton-proton collisions at $\sqrt{s}$ = 7 TeV recorded in 2010 with the ATLAS detector
Eur. Phys. J. C 73 (2013) 2306

ATLAS Collaboration
Measurement of angular correlations in Drell-Yan lepton pairs to probe Z/γ^* boson transverse momentum at $\sqrt{s}$ =7 TeV with the ATLAS detector
Phys. Lett. B: 720 (2013) , pp. 32–51

ATLAS Collaboration
Search for the neutral Higgs bosons of the Minimal Supersymmetric Standard Model in pp collisions at $\sqrt{s}$ =7 TeV with the ATLAS detector
J. High Energy Phys. 02 (2013) 095

ATLAS Collaboration
Search for pair production of heavy top-like quarks decaying to a high-P_T W boson and a b quark in the lepton plus jets final state at $\sqrt{s}$ =7 TeV with the ATLAS detector
Phys. Lett. B 718 (2013) 1284-1302

ATLAS Collaboration
Search for doubly-charged Higgs bosons in like-sign dilepton final states at $\sqrt{s}$ = 7 TeV with the ATLAS detector
Eur. Phys. J. C 72 (2012) 2244

ATLAS Collaboration
Search for pair-produced massive coloured scalars in four-jet final states with the ATLAS detector in proton-proton collisions at $\sqrt{s}$ = 7 TeV
Eur. Phys. J. C 73 (2013) 2263

ATLAS Collaboration
Search for pair production of massive particles decaying into three quarks with the ATLAS detector in $\sqrt{s}$ = 7 TeV pp collisions at the LHC
J. High Energy Phys. 12 (2012) 086

ATLAS Collaboration
Search for anomalous production of prompt like-sign lepton pairs at $\sqrt{s}$ = 7 TeV with the ATLAS detector
J. High Energy Phys. 12 (2012) 007

ATLAS Collaboration
Search for dark matter candidates and large extra dimensions in events with a jet and missing transverse momentum with the ATLAS detector
J. High Energy Phys. 04 (2013) 075

ATLAS Collaboration
Search for R-parity-violating supersymmetry in events with four or more leptons in √s = 7 TeV pp collisions with the ATLAS detector
J. High Energy Phys. 12 (2012) 124

ATLAS Collaboration
Measurement of W^+W^- production in pp collisions at √s =7 TeV with the ATLAS detector and limits on anomalous WWZ and WWγ couplings
Phys. Rev. D 87 (2013) 112001

ATLAS Collaboration
Search for direct chargino production in anomaly-mediated supersymmetry breaking models based on a disappearing-track signature in pp collisions at √s =7 TeV with the ATLAS detector
J. High Energy Phys. 01 (2013) 131

ATLAS Collaboration
ATLAS search for new phenomena in dijet mass and angular distributions using pp collisions at √s =7 TeV
J. High Energy Phys. 01 (2013) 029

TileCal Collaboration; J. Abdallah et al.
Mechanical construction and installation of the ATLAS tile calorimeter.
JINST 8 T11001, Nov 2013 doi:10.1088/1748-0221/8/11/T11001

TileCal Collaboration; J. Abdallah et al.
The optical instrumentation of the ATLAS Tile Calorimeter.
JINST 8 P01005, Jan 2013 doi:10.1088/1748-0221/8/01/P01005

Publications CDF Group

Aaltonen et al, The CDF Collaboration
A Precise Measurement of the W-Boson Mass with the Collider Detector at Fermilab
Phys. Rev. D. November 4, 2013. Fermilab-Pub-13-515-E. arXiv: 1311.0894.

T. Aaltonen et al, The CDF Collaboration
First Search for Exotic Z Boson Decays into Photons and Neutral Pions in Hadrons Collisions
Phys. Rev. Lett. November 13, 2013. Fermilab-Pub-13-509-E. arXiv: 1311.3282.

T. Aaltonen et al., The CDF Collaboration
Measurement of the Leptonic Asymmetry in t anti-t Events Produced in ppbar Collisions at √s - 1.97 TeV
Phys. Rev. D 88, 072003 (2013). ArXiv: 1308.1120.

T. Aaltonen et al, The CDF
Collaboration Search for a Dijet Resonance in Events with Jets and Missing Transverse Energy in p anti-p Collisions at √s = 1.96 TeV
Phys. Rev. D. 88, 092004 (2013). arXiv: 1310.7267.

T. Aaltonen et al., The CDF Collaboration
Indirect Measurement of $\sin 2\theta_W$ (M_W) Using e^+e^- Pairs in the Z-Boson Region with p anti-p Collisions at a Center-of-Momentum Energy of 1.96 TeV
Phys. Rev. D 88, 072002. arXiv: 1307-0770.

T. Aaltonen et al., The CDF Collaboration,
Evidence for a Bottom Baryon Resonance Λ_b in CDF Data*
Phys. Rev. D 88, 071101. ArXiv: 1308.1760.

T. Aaltonen et al, The CDF Collaboration
Study of Orbitally Excited B Mesons and Evidence for a New $B\pi^+$ Resonance
Phys. Rev. D. Sep. 23, 2013. Fermilab-Pub-13-393-E. arXiv: 1309.5961.

T. Aaltonen et al., The CDF Collaboration,
Observation of D^0-D^0 bar Mixing Using the CDF II Detector
Phys. Rev. Lett. 111, 231802. arXiv: 1309.4078.

T. Aaltonen et al., The CDF and D0 Collaboration
Combination of CDF and D^0 W-Boson Mass Measurements
Phys. Rev. D 88, 052018. arXiv: 1307.7627.

T. Aaltonen et al., The CDF Collaboration
Search for the Production of ZW and ZZ Boson Pairs Decaying into Charged Leptons and Jets in Proton-Antiproton Collisions at √s = 1.96 TeV
Phys. Rev. D 88, 092002 (2013). arXiv: 1310.0086.

T. Aaltonen et al, The CDF Collaboration,
Search for Trilepton New Physics and Chargino-Neutralino Production at CDF
Phys. Rev. Lett. Sep. 28, 2013. Fermilab-Pub-13-446. arXiv: 1309.7509.

T. Aaltonen et al., The CDF Collaboration,
Searches for the Higgs Boson Decaying to $W^+ W^- \to l^+\nu l^-\nu$ with the CDF II Detector
Phys. Rev. D. 88, 052012 (2013). arXiv: 1306.0023.

T. Aaltonen et al., The CDF Collaboration
Higgs Boson Studies at the Tevatron
Phys. Rev. D 88, 052014 (2013). arXiv: 1303.6346.

T. Aaltonen et al, The CDF Collaboration
Combination of Searches for the Higgs Boson using the Full CDF Data Set
Phys. Rev. D. 88, 052013 (2013). arXiv: 1301.6668.

T. Aaltonen et al, The CDF Collaboration,
Combination of Measurements of the Top-Quark Pair Production Cross Section from the Tevatron Collider
Phys. Rev. D. Sep.29, 2013. Fermilab-Pub-13-432-E. arXiv: 1309.7570.

T. Aaltonen et al., The CDF Collaboration
A Direct Measurement of the Total Decay Width of the Top Quark
Phys. Rev. Lett. 111, 202001 (2013). arXiv: 1308.4050.

T. Aaltonen et al., The CDF Collaboration
Exclusion of Exotic Top-Like Quarks with -4/3 Electric Charge Using Jet-Charge Tagging in Single-Lepton t anti-t Events at CDF
Phys. Rev. D 88, 032003. arXiv: 1304.4141.

T. Aaltonen et al, The CDF Collaboration
Production of K_s K^*(892) and phi (1020) in Minimum Bias Events and K_s and Λ in Jets in p anti-p Collisions at √s = 1.96 TeV
Phys. Rev. D 88, 092005 (2013). arXiv: 1308.3371.

T. Aaltonen et al., The CDF Collaboration,
Signature-Based Search for Delayed Photons in Exclusive Photon Plus Missing Transverse Energy Events from p anti-p Collisions with √s = 1.96 TeV
Phys. Rev. D 88, 031103 (2013). arXiv: 1307.0474.

T. Aaltonen et al., The CDF Collaboration
Search for Pair Production of Strongly Interacting Particles Decaying to Pairs of Jets in p anti-p Collisions at √s = 1.96 TeV
Phys. Rev. Lett. 111, 031802 (2013). arXiv: 1303.2699.

T. Aaltonen et al., The CDF Collaboration
Top-Quark Mass Measurement in Events with Jets and Missing Transverse Energy Using the Full CDF Data Set
Phys. Rev. D 88, 011101. ArXiv: 1305.3339.

T. Aaltonen et al., The CDF Collaboration
Measurement of the Cross Section for Direct-Photon Production in Association with a Heavy Quark in p anti-p Collisions at $\sqrt{s} = 1.96$ *TeV*
Phys. Rev. Lett. 111, 042003. arXiv: 1303.6136.

T. Aaltonen et al., The CDF Collaboration
Differential Cross Section $d\sigma/d(\cos\theta_t)$ *for Top-Quark-Pair-Production in p anti-p Collisions at* $\sqrt{s} = 1.96$ *TeV*
Phys. Rev. Lett. 111, 182002 (2013). arXiv: 1306.2357.

T. Aaltonen et al., The CDF Collaboration
Measurement of $R = BR(t\rightarrow W_b)/BR(t\rightarrow W_q)$ *in Top-Quark-Pair Decays using the Lepton+Jets Events and the Full CDF Run II Data Set*
Phys. Rev. D 87, 11101(R) (2013). arXiv: 1303.6142.

T. Aaltonen et al., The CDF Collaboration,
Search for Supersymmetry with Like-Sign Lepton-Tau Events at CDF
Phys. Rev. Lett. 110, 201802 (2013). arXiv: 1302.4491.

T. Aaltonen et al., The CDF Collaboration
Measurement of the top quark forward-backward production asymmetry and its dependence on event kinematic properties
Phys. Rev. D 87, 092002 (2013).arXiv: 1211.1003.

T. Aaltonen et al., The CDF Collaboration,
Measurement of the Top-Quark Pair Production Cross-Section in Events with Two Leptons and Bottom-Quark Jets Using the Full CDF Data Set
Phys. Rev. Lett. 88, 091103 (2013). arXiv: 1304.7961.

T. Aaltonen et al., The CDF Collaboration,
Search for $B_s\rightarrow\mu^+\mu^-$ *and* $B_d\rightarrow\mu^+\mu^-$ *Decays Using the Full CDF Run II Data Set*
Phys. Rev. D 87, 072003 (2013). arXiv: 1301.7048.

T. Aaltonen et al., The CDF Collaboration
Measurement of the cross section for prompt isolated diphoton production using the full CDF Run II data sample
Phys. Rev. Lett. 110, 101801 (2013). arXiv: 1212.4204.

T Aaltonen et al, The CDF Collaboration
Search for a Two-Higgs-Boson Doublet Using a Simplified Model in ppbar Collisions at $\sqrt{s} = 1.96$ *TeV*
Phys. Rev. Lett. 110, 121801. arXiv: 1212.3837.

T. Aaltonen et al, The CDF Collaboration
Search for Resonant Top-Antitop Production in the Lepton Plus Jets Decay Mode Using the Full CDF Data Set
Phys. Rev. Lett. 110, 121802 (2013). arXiv: 1211.5363

T. Aaltonen et al, The CDF Collaboration
Updated Search for the Standard Model Higgs Boson in Events with Jets and Missing Transverse Energy Using the Full CDF Data Set
Phys. Rev. D 87, 052008 (2013). arXiv: 1301.4440.

T. Aaltonen et al., The CDF Collaboration,
Measurement of the Mass Difference Between Top and Anti-Top Quarks
Phys. Rev. D 87, 052013 (2013). arXiv: 1210.6131.

T. Aaltonen et al., The CDF Collaboration,
Measurement of W-Boson Polarization in Top-Quark Decay Using the Full CDF Run II Data Set
Phys. Rev. D 87, 031104(R) (2013). arXiv: 1211.4523.

T. Aaltonen et al., The CDF Collaboration
Search for the Higgs Boson in the All-Hadronic Final State Using the Full CDF Data Set
J. High Energy Phys. 02 (2013) 004. arXiv: 1208.6445.

T. Aaltonen et al., The CDF Collaboration,
Observation of the Production of a W Boson in Association with a Single Charm Quark
Phys. Rev. Lett. 110, 071801 (2013). arXiv: 1209.1921.

Publications PIXELS Group

S. Grinstein, I. Lopez, A. Micelli, S. Tsiskaridze, et al.,
Beam test studies of 3D pixel sensors irradiated non-uniformly for the ATLAS forward physics detector
Nucl. Instrum. Meth. A, Volume 730, 28–32, 2013.

C. Da Vià, S. Grinstein, et al.,
3D active edge silicon sensors: Device processing, yield and QA for the ATLAS-IBL production
Nucl. Instrum. Methods A, 699, 18–21, 2013.

C. Da Vià, S. Grinstein, et al.,
Future trends of 3D silicon sensors
Nucl. Instrum. Methods A, 731, 201–204, 2013.

G. Pellegrini, S. Grinstein, I. Lopez, A. Micelli, S. Tsiskaridze, et al.,
Recent results on 3D double sided detectors with slim edges
Nucl. Instrum. Methods A, 731, 198-200, 2013.

V. Fadeyev, S. Grinstein, et al.,
Scribe–cleave–passivate (SCP) slim edge technology for silicon sensors
Nucl. Instrum. Methods A, Volume 731, 260-265, 2013.

Publications Neutrino Group

K.Abe et al. T2K Collaboration,
Measurement of Neutrino Oscillation Parameters from Muon Neutrino Disappearance with an Off-axis Beam
Phys.Rev.Lett. 111 (2013) 211803

K.Abe et al. T2K Collaboration,
Evidence of Electron Neutrino Appearance in a Muon Neutrino Beam
Phys.Rev. D 88 (2013) 032002

K.Abe et al., T2K Collaboration,
Measurement of the Inclusive $\nu\mu$ *Charged Current Cross Section on Carbon in the Near Detector of the T2K Experiment*
Phys.Rev. D 87 (2013) 092003

K.Abe et al., T2K Collaboration,
The T2K Neutrino Flux Prediction
Phys.Rev. D 87 (2013) 012001

R. Gran et al.
Neutrino-nucleus quasi-elastic and 2p2h interactions up to 10 GeV
Phys.Rev. D 88 (2013) 113007

Publications MAGIC/CTA Group

J. Aleksić et al. (the MAGIC Collaboration)
The simultaneous low state spectral energy distribution of 1ES 2344+514 from radio to very high energies
Astron. Astrophys. 556 (2013) UNSP A67

J. Aleksić et al. (the MAGIC Collaboration)
Very high energy gamma-ray observation of the peculiar transient event Swift J1644+57 with the MAGIC telescopes and AGILE
Astron. Astrophys. 552 (2013) A112

J. Aleksić et al. (the MAGIC Collaboration)
Observations of the magnetars 4U 0142+61 and 1E 2259+586 with the MAGIC telescopes
Astron. Astrophys. 549 (2013) A23

G. Pedaletti, V. Stamatescu et al.
On the potential of the Cherenkov Telescope Array for the study of cosmic-ray diffusion in molecular clouds
Astron. Astrophys. 550 (2013) A123.

M. Szanecki, J. Sitarek et al.
Influence of the Geomagnetic Field on the IACT detection technique for possible sites of CTA observatories
Astropart. Phys. 45 (2013) 1-12

J. Sitarek et al.
Analysis techniques and performance of the Domino Ring Sampler version 4 based readout for the MAGIC telescopes
NIMA 723 (2013) 109

W. Bednarek & J. Sitarek
Gamma-rays from nebulae around binary systems containing energetic rotation-powered pulsars
MNRAS 430 (2013), 2951

W. Bednarek & J. Sitarek
High-energy emission from the nebula around the Black Widow binary system containing millisecond pulsar B1957+20
Astron. & Astroph. 550 (2013), 39

L. A. Tejedor, M. Barceló, J. Boix, O. Blanch , R. López) et al.
An Analog Trigger System for Atmospheric Cherenkov Telescope Arrays
IEEE Trans.Nucl.Sci 60 (2013) 3, 2367-2375

K. Bernlöhr et al.
Monte Carlo design studies for the Cherenkov Telescope Array
Astropart. Phys. 43 (2013) 171-188

Publications DES Group

H. Campbell et al. (SDSS-II Collaboration)
Cosmology with Photometrically-Classified Type Ia Supernovae from the SDSS-II Supernova Survey
Astrophys.J. 763 (2013) 88

Publications Medical Physics

Jose-Gabriel Macias-Montero et al.
A 2D 4x4 Channel Readout ASIC for Pixelated CdTe Detectors for Medical Imaging Applications
2013 IEEE Nuclear Science Symposium and Medical Imaging Conference Record (NSS/MIC), Seoul, South Korea, Oct. 27-Nov. 2 2013

Gerard Arino et al.
Characterization of a Module with Pixelated CdTe Detectors for Possible PET, PEM and Compton Camera Applications
Preprint: JINST 184P-1113 [IWORID2013]

Machiel Kolstein et al.
Evaluation Of List-Mode Ordered Subset Expectation Maximization Image Reconstruction For Pixelated Solid-state Compton Gamma Camera With Large Number Of Channels
Preprint: JINST 041P-1013 [IWORID2013]

Yonatan Calderón et al.
Evaluation of Compton Gamma Camera Prototype Based on Pixelated CdTe Detector
Preprint: JINST 049 1113 [IWORID2013]

Ekaterina Mikhaylova et al.
Optimization, Evaluation, And Comparison Of Standard Algorithms For Image Reconstruction With The VIP-PET
Preprint: JINST 089P-1013 [IWORID2013]

Dilber Uzun et al.
Evaluation of a Dedicated LM-OSEM Algorithm For The Reconstruction Of Images With The VIP-PEM System
Preprint: JINST 014P-1013 [IWORID2013]

Jose-Gabriel Macias et al.
VIP-PIX: a Low Noise Readout ASIC for Pixelated CdTe Gamma-Ray Detectors for Use in the Next Generation of PET Scanners.
Nuclear Science, IEEE Transactions on Volume:60 , Issue: 4, p 2898-2904, 2013

Gerard Ariño et al.
Energy and Coincidence Time Resolution Measurements of CdTe Detectors for PET
JINST Feb. 2013

Gianluca De Lorenzo et al.
Pixelated CdTe Detectors to Overcome Intrinsic Limitations of Crystal Based Positron Emission Mammographs
JINST Jan. 2013

Machiel Kolstein et al.
Evaluation of Origin Ensemble algorithm for image reconstruction for pixelated solid-state detectors with large number of channels
Journal of Instrumentation Apr. 2013

Publications Theory Division

N. Brouzakis and M. Quirós,
Unitarity and singular backgrounds
Phys. Rev. D88 (2013) 096007 [arXiv:1309.3402 [hep-ph]].

L. Cort, M. Garcia and M. Quirós,
Supersymmetric Custodial Triplets
Phys. Rev. D88 (2013) 075010 [arXiv:1308.4025 [hep-ph]].

I. Masina and M. Quirós
On the Veltman Condition, the Hierarchy Problem and High-Scale Supersymmetry
Phys. Rev. D88 (2013) 093003 [arXiv:1308.1242 [hep-ph]].

A. Delgado, G. Nardini and M. Quirós
A Light Supersymmetric Higgs Sector Hidden by a Standard Model-like Higgs
J. High Energy Phys 1307 (2013) 054 [arXiv:1303.0800 [hep-ph]].

G. von Gersdorff, M. Quirós, and M. Wiechers
Neutrino Mixing from Wilson Lines in Warped Space
J. High Energy Phys 1302 (2013) 079 [arXiv:1208.4300 [hep-ph]].

M. Carena, G. Nardini, M. Quirós,and C. E. M. Wagner
MSSM Electroweak Baryogenesis and LHC Data
J. High Energy Phys 1302 (2013) 001 [arXiv:1207.6330 [hep-ph]].

D. G. Dumm and P. Roig
Dispersive representation of the vector form factor of the pion confronted to Belle data
Eur. Phys. Jour. C73 (2013) 2528, e-Print: arXiv:1301.6973 [hep-ph].

P. Roig, A. Guevara and G. López Castro
The weak radiative pion vertex in $\tau^- \to \pi^- l^+ l^- \nu_\tau$ decays (l=e, μ)
Phys. Rev. D88 (2013) 033007, e-Print: arXiv:1306.1732 [hep-ph].

I. Nugent, T. Przedzinski, P. Roig, O. Shekhovtsova and Z. Was
Resonance Chiral Lagrangian currents and experimental data for $\tau \to \pi^- l^+ l^- \nu_\tau$
Phys. Rev. D88 (2013) 093012, e-Print: arXiv:1310.1053 [hep-ph].

P. Roig and J. J. Sanz-Cillero
Consistent high-energy constraints in the anomalous QCD sector
Phys. Lett. B (in press), e-Print: arXiv:1312.6206 [hep-ph].

M. Beneke, D. Boito and M. Jamin
Perturbative expansion of tau hadronic spectral function moments and α_s extractions
J. High Energy Phys 1301 (2013) 125, arXiv:1210.8038 [hep-ph].

D. Boito, M. Golterman, M. Jamin, K. Maltman and S. Peris
Low-energy constants and condensates from the tau hadronic spectral functions
Phys. Rev. D 87 (2013) 094008, arXiv:1212.4471 [hep-ph].

G. Bednik, O. Pujolas, S. Sibiryakov
Emergent Lorentz invariance from Strong Dynamics: Holographic examples
J. High Energy Phys 1311 (2013) 064 e-Print: arXiv:1305.0011 [hep-th]

S. Descotes-Genon, J. Matias, J. Virto
Understanding the $B \to K^* \mu^+\mu^-$ anomaly
Phys. Rev. D88 (2013) 074002.

S. Descotes-Genon, T. Hurth, J. Matias, J. Virto
Optimizing the basis of $B \to K^* l^+ l^-$ observables in the full kinematic range
J. High Energy Phys 1305 (2013) 137

S. Descotes-Genon, J. Matias, M. Ramon, J. Virto
Implications from clean observables for the binned analysis of $B \to K^* \mu^+\mu^-$ at large-recoil
J. High Energy Phys 1301 (2013) 048.

G.Servant and S.Tulin
Baryogenesis and Dark Matter through a Higgs Asymmetry
Phys. Rev. Lett. 111, 151601 (2013) arXiv:1304.3464 [hep-ph].

C.Jackson, G.Servant, G. Shaughnessy, T.Tait and M.Taoso
Gamma-rays from Top Mediated Dark Matter annihilations
J. Cosmol. Astropart. Phys.1307, 006 (2013). [arXiv:1303.4717[hep-ph]].

C.Jackson, G.Servant, G. Shaughnessy, T.Tait and M.Taoso
Gamma-ray lines and one-loop continuum from s-channel Dark Matter annihilations
J. Cosmol. Astropart. Phys. 1307,021 (2013) [arXiv:1302.1802 [hep-ph]].

C. Grojean, E. Salvioni, M. Schlaffer and A. Weiler
Very boosted Higgs in gluon fusion
J. High Energy Phys arXiv:1312.3317 [hep-ph].

J. Elias-Miro, C. Grojean, R.S. Gupta and D. Marzocca
Scaling and tuning of EW and Higgs observables
J. High Energy Phys arXiv:1312.2928 [hep-ph].

R. Contino, C. Grojean, D. Pappadopulo, R. Rattazzi and A. Thamm
Strong Higgs interactions at a Linear Collider
arXiv:1309.7038 [hep-ph]
J. High Energy Phys 1402 (2014) 006.

C. Grojean, O. Matsedonskyi and G. Panico
Light top partners and precision physics
arXiv:1306.4655 [hep-ph],
J. High Energy Phys 1310 (2013) 160.

C. Delaunay, C. Grojean and G. Perez
Modified Higgs Physics from Composite Light Flavors
arXiv:1303.5701 [hep-ph],
J. High Energy Phys 1309 (2013) 090.

R. Contino, M. Ghezzi, C. Grojean, M. Mühlleitner and M. Spira
Effective Lagrangian for a light Higgs-like scalar
arXiv:1303.3876 [hep-ph],
J. High Energy Phys 1307 (2013) 035.

C. Grojean, E. Jenkins, A. Manohar and M. Trott
Renormalization Group Scaling of Higgs Operators and $\Gamma(h \to \gamma\gamma)$
arXiv:1301.2588 [hep-ph],
J. High Energy Phys 1304 (2013) 016.

4.4 Outreach Activities

Experimental Division

Oscar Blanch Bigas

- *La historia de l'Univers*
  Escola Virolai, November 2013

Martine Bosman

- *El CERN més enllà del Higgs*
  Taula Rodona: Inauguración de la exhibición del CERN
  CosmoCaixa, 7 Marzo 2013
- *La caza del Bosón de Higgs,*
  Centre de Cultura Contemporània de Barcelona (CCCB)
  Festival Kosmopolis 2013, 16 Marzo 2013
- *La búsqueda del Bosón de Higgs*
  Astrobanyoles, Agrupación d'Astronomia y de Ciencia de pla de l'estany
  Museu Darder, Banyoles13 November 2013
- *La búsqueda del Bosón de Higgs y la Física de Partículas*
  IX Jornadas Jovellanos de Divulgación Científica
  Instituto ES Jovellanos Centro de Cultura Antiguo
  Instituto de Gijón November 2013

Matteo Cavalli-Sforza

- *Entrevista a la revista Alma*
  La Caixa, February 2013
- *Entrevista Diari Sabadell*
  March 2013
- *La descoberta del bosó de Higgs, perqué es tant important?*
  Fundació Bosch y Cardellach, Sabadell, March 2013
- *El descobriment del bosó de Higgs*
  Fira de Ciencia, Barcelona June 2013
- *La Física de Partículas desde los '50 hasta el Higgs*
  AASCV November 2013

Enrique Fernández

- *El Bosó de Higgs*
  Aula d'Extensió Universitaria per a la Gent Gran de Sabadell", Centre de Cultura de Caixa Sabadell, Sabadell (Spain), February 2013. Title: (3 talks).
- *La Expansión del Universo*
  IX Jornadas Jovellanos de Divulgación Científica (Fronteras de la Ciencia)", Centro de Cultura Antiguo Instituto, Gijón, November 2013.
- *La Piedra Angular de la Física de Partículas (El Bosón de Higgs)*
  Conferències-Col·loqui: els Premis Nobel 2013", UAB, Bellaterra (Spain), November 2013

Silvia Fracchia

- *Linux e la ricerca scientifica: perché gli scienziati scelgono l'open source*
  Talk at an Italian high school ITIS Caramuel, Vigevano (Italy), 26 October 2013

Sebastián Grinstein

- *Cómo funcionan los experimentos de física de partículas?*
  CaixaForum (Barcelona), 22nd October 2013, and
  CaixaForum (Lleida) 19th November 2013.
- *¿Como sabemos de que esta hecho el universo?*
  18a Semana de la Ciencia, SE CRP del Maresme III (talk for high school students), Masnou (Barcelona), 28th November 2013.
- *Sebastian Grinstein, fisic*
  Entrevista, Suplement Dominical - Lectura SEGRE (Lleida).

Aurelio Juste

- *Probing the Higgs Sector from the Top*
  High Energy Physics Seminar, Saclay (IRFU/SPP), Paris, France, December 9, 2013.
- *The Higgs Boson Discovery: a Solution to a Massive Problem*
  CAFPE Colloquium, Universidad de Granada, Granada, Spain, January 15, 2013.
- *A la recerca de la masa :L'instrument científic més gran mai construït*
  Cicle of conferences part of the temporal exhibition
  CosmoCaixa, Barcelona, Spain, March 12, 2013.
- *El bosón de Higgs y la frontera de la Física*
  IES Rovira Forns, Santa Perpetua de Moguda, Spain, December 12, 2013.

Alicia López Oramas

- *Introducción a la astronomía de rayos gamma*
  Collège d'Espagne, Cité Universitaire de Paris, December 2013

Thorsten Lux

- *Demonstration of a Cloud Chamber*
  Exhibition in "Festa de la la Ciència i la Tecnologia"
  15th-16th June 2013

Mario Martinez

- *The Higgs Boson*
  High School Outreach Talk, INS Guillem de Berguedà (Berga), 30/11/2012
- *A la búsqueda de la materia oscura*
  Public Lecture at CosmoCaixa, Barcelona, 23/03/2013

Ramon Miquel

- *El bosó de Higgs: la partícula del buit*
  VI Jornada de Divulgació de la Relativitat, Museu de la Ciència i de la Tècnica de Catalunya, Terrassa (Spain), February 2013
- *El bosó de Higgs: la partícula del buit*
  Setmana de la Ciència, IES Joaquim Blume, Esplugues de Llobregat (Spain), November 2013.

Lluisa Mir

- *L'instrument científic més gran mai construït*
  Co-organizer of temporal exhibition and activities
  CosmoCaixa, March 8-26 2013
- *De què està fet l'univers?*
  Co-organizer of course: "Una introducció a la física de partícules i la cosmologia", CosmoCaixa, October 8 - November 26 and CaixaForum Lleida, November 5 - December 2013
- *La partícula de Higgs*
  Outreach talk for H.S. students within the Els dissabtes de la Ciència program, UAB, March 2013

Cristóbal Padilla

- El Gran Col.lisionador d'Hadrons del CERN
  CosmoCaixa, Marzo del 2013.

Imma Riu

- *La recerca i el descobriment del bosó de Higgs*
  Jornada d'actualitat i difusió científica
  Talk at mNACTEC Terrassa, November 2013

Federico Sánchez

- *Los neutrinos: las particulas invisibles*
  15th March 2013, Seminar INS Montmeló (Barcelona)
- *Los neutrinos: las particulas invisible*
  15th April 2013, Seminar Col·legi La Presentació. Arenys de Mar (Barcelona)
- *Los neutrinos: las particulas invisibles*
  18th November 2013, Seminar:INS Castelló d'Empúries (Girona)
- *Neutrinos: las particulas (casi)invisibles*
  CosmoCaixa Barcelona, 13th November 2013

Theory Division

C. Grojean and L. Vacavant

- *A la recherche du boson de Higgs*
  Flammarion, April 2013. Popular book,about 8000 copies sold

4.5 Conference Proceedings

Experimental Division

Proceedings ATLAS Group

Andreu Pacheco
Lessons learned from the ATLAS performance studies of the Iberian Cloud for the first LHC running period
20th International Conference on Computing in High Energy and Nuclear Physics" 2013. M Kaci et al., October 2013, Amsterdam

M. Bosman, I. Riu, A. Juste, M. Martinez, V. Sorin, Ll. Mir,
Editors of proceedings for LHCP2013, Large Hadron Collider
Conference Proceeding, EPJ Web of Conferences, Vol 60 , 2013-11-26

I. Riu
The ATLAS Detector Performance Results
Proceedings EPS-HEP 2013, Stockolm Jul. 2013.

F. Rubbo
The Design and Performance of the ATLAS jet trigger
Volume 60 of EPJ Web of Conferences, 2013.

F. Rubbo
Top quark pair properties: spin correlation, charge asymmetry and complex final states at LHC in ATLAS
Volume 60 of EPJ Web of Conferences, 2013.

M.P. Casado on behalf of the ATLAS and CMS collaborations.
Higgs results from ATLAS and CMS
Nucl. Phys. B (Proc. Suppl.). 245, pp. 101 - 108. Elsevier Science, 01/01/2013. ISSN 0920-5632

J. Montejo
Search for the standard model Higgs boson produced in association with top quarks and decaying to bb at $\sqrt{s}$=7TeV
EPJ Web of Conf. http://dx.doi.org/10.1051/epjconf/20136020028

R. Caminal
Searches for monojets and monophotons with the ATLAS detector
DIS2013, POSCI, DIS2013, 119.

R. Caminal
Search for pair produced top squarks decaying into a charm quark and the lightest neutralinos in pp collisions at 8 TeV with the ATLAS detector at the LHC
PoS(EPS-HEP 2013)111

V. Sorin
Inclusive and differential top quark production at the Tevatron.
PoS(EPS-HEP 2013).

M. Martinez
Search for Dark Matter at the LHC
Journal of Physics Conference Series, 460, - (2013)

Ll. Mir
ttbar plus jets measurements
Plenary Session Top 2013, Durbach, Germany, September 2013
DESY Proceedings.

A Succurro
Searches for fourth generation vector-like quarks with the ATLAS detector
EPS-HEP2013

A. Succurro
Search for pair-produced Vector-Like Quarks with the ATLAS detector
LHCP2013

Proceedings MAGIC Group

R. López-Coto, O. Blanch Bigas, J. Cortina
Search for TeV gamma-ray emission from AE Aqr coincident with high optical and X-ray states with the MAGIC telescopes
Proceedings of the 33rd ICRC (2013)

O.Blanch Bigas, M.Martínez, A.López-Oramas
The IFAE/UAB and LUPM Raman LIDARs for the CTA Observatory
Proceedings of the 33rd ICRC (2013)

A.López-Oramas, O.Blanch Bigas, J.Cortina
Observation of VHE gamma-ray binaries with the MAGIC Telescopes
Proceedings of the 33rd ICRC (2013)

J. Aleksić, J. Rico, M. Martinez and S. Lombardi
Deep survey of Segue 1 dwarf spheroidal galaxy with the MAGIC Telescopes
Proceedings(EPS-HEP 2013) 389

J. Aleksić, J. Rico and M. Martinez,
Optimized analysis method for indirect dark matter searches with Imaging Air Cherenkov Telescopes
Proceedings(EPS-HEP 2013) 005

J. Aleksić, S. Lombardi, J. Rico and M. Martinez
Deep observations of Segue 1 dwarf spheroidal galaxy with the MAGIC Telescopes
Proceedings of the 33rd ICRC (2013)

J. Aleksić, J. Rico and M. Martinez
Optimized analysis method for indirect dark matter searches with Imaging Air Cherenkov Telescopes
Proceedings of the 33rd ICRC (2013)

V. Stamatescu,
Recent MAGIC results on Galactic sources of VHE gamma-rays
Proceedings of the 48th Rencontres de Moriond (2013)

J. Krause, V. Stamatescu and S. Klepser
MAGIC reveals structures in the gamma-ray emission of the unidentified gamma-ray source HESS J1857+026
Proceedings of the 33rd ICRC (2013)

A. Moralejo,
Fundamental Physics with Imaging Atmospheric Cherenkov Telescopes
Proceedings of the 48th Rencontres de Moriond "Very High Energy Phenomena in the Universe" (2013)

J. Sitarek, A. Moralejo V. Stamatescu et al. (for the MAGIC Collaboration)
Physics performance of the upgraded MAGIC telescopes obtained with Crab Nebula data
Proceedings of the 33rd ICRC (2013)

J. Sitarek & W. Bednarek
Anisotropic Inverse Compton e^\pm pair model for the gamma-ray emission from the blazar PKS 1510-089
Proceedings of the 33rd ICRC (2013)

J. Sitarek, M. Gaug, D. Mazin, R. Paoletti, D. Tescaro
Performance and analysis techniques of the MAGIC telescopes' DRS4-based readout
Proceedings of the 33rd ICRC (2013)

N. Godinovic, J. Sitarek et al. (for the MAGIC Collaboration)
The MAGIC Data Quality Check Software
Proceedings of the 33rd ICRC (2013)

D. Eisenacher, J. Sitarek et al. (for the MAGIC Collaboration)
The Aftermath of an Exceptional TeV Flare in the AGN Jet of IC 310
Proceedings of the 33rd ICRC (2013)

U. Barres de Almeida, J. Sitarek et al. (for the MAGIC Collaboration)
Latest results and multiwavelength observations of FSRQs: 3C 279 and PKS 1510-089
Proceedings of the 33rd ICRC (2013)

F. Borracci, J Sitarek et al. (for the MAGIC Collaboration)
MAGIC results and multiwavelength observations of Mrk 501 flare in June 2012
Proceedings of the 33rd ICRC (2013)

M. Szaneck, J. Sitarek et al (for the MAGIC Collaboration)
Geomagnetic field and altitude effects on the performance of future IACT arrays
Proceedings of the 33rd ICRC (2013)

Roberta Zanin, Julian Sitarek, Abelardo Moralejo, Victor Stamatescu et al. (for the MAGIC Collaboration
The MAGIC analysis and reconstruction software
Proceedings of the 33rd ICRC (2013)

Daniel Mazinet, Julian Sitarek, Juan Cortina, Jose Maria Illa, Manel Martinez et al. (for the MAGIC Collaboration)
Towards SiPM camera for current and future generations of Cherenkov telescopes
Proceedings of the 33rd ICRC (2013)

W. Bednarek & J. Sitarek
Gamma-rays from nebulae around binary systems containing energetic pulsars
Proceedings of the 33rd ICRC (2013)

Daniel Mazin, Julian Sitarek et al. (for the Magic Collaboration)
Upgrade of the MAGIC telescopes
Proceedings of the 33rd ICRC (2013)

Proceedings CTA Group

M. Doro, O. Blanch, A. Lopez-Oramas, M. Martinez et al. (for the CTA consortium)
Towards a full Atmospheric Calibration system for the Cherenkov Telescope Array
Proceedings of the 33rd ICRC (2013)

M. Barcelo, O. Blanch, J. Boix, R. Lopez-Coto et al.(for the CTA Consortium)
An Analog Trigger System for Atmospheric Cherenkov Telescope Arrays
Proceedings of the 33rd ICRC (2013)

H. Kubo, M. Barceló, O. Blanch, J Boix et al. (for the CTA Consortium)
Development of the Photomultiplier-Tube Readout System for the CTA Large Size Telescope
Proceedings of the 33rd ICRC (2013)

Carlos Delgado, Oscar Blanch et al. (for the CTA Consortium)
Mechanics and cooling system for the camera of the Large Size Telescopes of the Cherenkov Telescope Array (CTA).
Proceedings of the 33rd ICRC (2013)

K. Bernlo, O. Blanch, R. Lopez Coto, A. Moralejo, V. Stamatescu et al. (for the CTA Consortium)
Progress in Monte Carlo design and optimization of the Cherenkov Telescope Array
Proceedings of the 33rd ICRC (2013)

G. Ambrosi, M. Barceló, O. Blanch, J. Boix, J. Cortina, M. Martinez, A. Moralejo, V. Stamatescu et al (for the CTA Consortium)
The Cherenkov Telescope Array Large Size Telescope
Proceedings of the 33rd ICRC (2013)

A. López Oramas, O. Abril, O. Blanch, J. Boix, M. Martinez et al (for the CTA Consortium)
The IFAE/UAB and LUPM Raman LIDARs for the CTA Observatory
Proceedings of the 33rd ICRC (2013)

Theory Division Proceedings

E. Ruiz Arriola (Granada U.), E. Megias (Barcelona, Autonoma U. & Barcelona, IFAE), L.L. Salcedo (Granada U.).
From Chiral quark dynamics with Polyakov loop to the hadron resonance gas model
Proceedings, AIP Conf.Proc. 1520 (2013) 185-190 e-Print: arXiv:1207.4875

P. Roig
$\tau^- \to \pi^- (\eta,\eta') \nu_\tau$ *decays*
Proceedings of the Moriond QCD13, within the Moriond Conference Proceedings Series.

M. Jamin
Strong coupling from τ lepton decays,
Mod. Phys. Lett. A28 (2013) 1360006, Proceedings of "International Conference on Determination of Fundamental Parameters of QCD", Singapore, 2013.

D. Boito, M. Golterman, M. Jamin, K. Maltman and S. Peris
Low-energy constants and condensates from the V-A spectrum
Proceedings of "International Workshop on e^+e^- collisions from φ to ψ 2013", Rome, Italy, 2013.

D. G. Dumm and P. Roig
Dispersive analysis of $\tau \to \pi^- \pi^0 \nu_\tau$ Belle data
e-Print: arXiv:1301.7167 [hep-ph]. To appear in the Proceedings of the TAU12 Conference, to be published in Nucl.Phys.Proc.Suppl.

S. Descotes-Genon and P. Roig
Modelling duality violations
To appear in the Proceedings of the TAU12 Conference, to be published in Nucl.Phys.Proc.Suppl.

4.6 Talks and Posters by IFAE Members and Collaborators

Experimental Division

ATLAS Group

Jalal Abdallah
- Searches for monojets and monophotons with the ATLAS detector
  Barcelona, LHCP2013, May 2013.

Martine Bosman
- *Top Quark Properties in ATLAS*
  SUSY2013, Trieste, August 2013.

Roger Caminal
- *Search for Scalar Top Quarks in the final states with two charm jets and missing transverse momentum at sqrt(s) = 8 TeV*
  Poster EPS-HEP2013, Stockholm, July 2013.
- *Searches for monojets and monophotons with the ATLAS detector*
  DIS2013, April 2013.

Pilar Casado
- *Higgs results from ATLAS and CMS,*
  Hadron Structure '13 Slovakia, June 2013.
- *$H^+ \to \tau^+\nu$: present and future trigger issues (τ +MET, single-lepton)*
  ATLAS HSG6 workshop, Rehovot, Israel, May 2013

Areley Cortes
- *SUSY at ATLAS*
  invited talk. XIV Mexican Workshop on Particles and Fields 2012 Oaxaca, Mexico, 25-29 Nov, 2013

Garoé Gonzalez,
- *Search for the Higgs boson in VH(bb) and in the $\tau\tau$ channel using the ATLAS detector*
  WIN2013, September 2013.
- *Search for the Higgs boson in VH (H->bb) channel using the ATLAS detector*
  CPAN Days November 2013, Santiago de Compostela.

Aurelio Juste
- *Experimental Summary*
  6th International Workshop on Top Quark Physics (TOP 2013), DESY, September 2013.
- *Experimental constraint from LHC on exotic physics*
  EPNT13, Marseille, April 2013.
- *Current and Future Collider Searches/Constraints on Dark Matter*
  News from the Dark Workshop, Montpellier, December 4-6, 2013.
- *Topological Clustering at High Luminosity in ATLAS*
  ATLAS Hadronic Calorimeter Calibration Workshop, Chicago, USA, September 23-26, 2013.
- *Searches for $\tau\tau H$ production at the LHC*
  Implication of LHC Higgs-Like Signals Workshop, Aspen Center for Physics, Aspen, USA, August 11-September 1, 2013.
- *Tevatron Constraints on the Higgs Boson*
  Higgs Hunting 2013, Orsay, France, July 25-27, 2013.
- *Higgs Boson Physics at ATLAS LHC, the First Part of the Journey*
  Conference associated to the research program Exploring TeV Scale New Physics with LHC Data of the Kavli Institute for Theoretical Physics, University of California, Santa Barbara, USA, July 8-12, 2013.
- *Top Quark Physics*
  XLI International Meeting on Fundamental Physics, Santander, Spain, May 20-24, 2013.

Ilya Korolkov
- *Integrator system of ATLAS calorimeter*
  Data Processing Workshop, CERN, September 2013.
- *Review of recent results from ATLAS*
  V CPAN Days, Santiago de Compostela, Spain, November 2013.

Mario Martinez
- *ATLAS Monophoton Results*
  Dark Matter at the LHC Workshop, Chicago University, September 2013.
- *Overview of ATLAS Results*
  PACT Workshop "Fundamental Physics, CMB and LSS in the light of Planck satellite and DES, IFT/UAM-Madrid, October 2013.
- *Mono-X searches*
  LPC-SUSY-NEF, Fermilab, Nov 2013.
- *Search for Dark Matter Production at the LHC*
  IFIC, Valencia, March 2013
- *Highlights from the CDF experiment at the Tevatron*
  International Conference on New Frontiers in Physics, Creta, August 2013.

Lluisa Mir
- *ATLAS: performance, upgrades and physics results*
  XVI International Meeting on Fundamental Physics, Santander, May 2013.
- *ttbar plus jets measurements*
  Plenary Session Top 2013, Durbach, Germany, September 2013.

Javier Montejo
- *Top quark production in the ATLAS detector of the LHC*
  SUSY2013, Trieste, August 2013.
- *Search for a Higgs boson produced in association with a top pair using the ATLAS detector*
  Poster, LHCP2013, Barcelona, May 2013.

Andreu Pacheco
- *The ATLAS Distributed Analysis System*
  IVICFA's Fridays: Supercomputing and GRID.
  10 Octubre 2013 (Charla Invitada).
- *The ATLAS Distributed Analysis System*
  Talk at 20th International Conference on Computing in High Energy and Nuclear Physics 2013, October 2013, Amsterdam

Imma Riu
- *The ATLAS Detector - Performance Results*
  EPSHEP 2013, Stockholm, July 2013.

Valerio Rossetti
- *Search for new phenomena in monojet events with the ATLAS detector*
  Poster, Barcelona, LHCP2013, May 2013.

Francesco Rubbo

- *The Design and Performance of the ATLAS jet trigger*
  Poster, LHCP2013, Barcelona, May 2013.
- *Top quark pair properties: spin correlations, charge asymmetry and complex final states at LHC in ATLAS*
  LHCP2013, Barcelona, May 2013.

Verónica Sorin

- *Inclusive and differential top quark production at the Tevatron*
  EPS-HEP conference, Stockholm, July 2013.

Antonella Succurro

- *Search for pair-produced Vector-Like Quarks with the ATLAS detector*
  Poster, Barcelona, LHCP2013, May 2013.
- *Searches for fourth generation vector-like quarks with the ATLAS detector*
  EPS-HEP2013, Stockholm, July 2013.
- *Search for heavy top, including VLQ in ATLAS*
  V CPAN Days November 2013, Santiago de Compostela.

PIXELS Group

Sebastián Grinstein

- *Characterization of 3D CNM prototypes for the ATLAS forward detector*
  Invited section talk at 8th Trento Workshop on Advanced Silicon Radiation Detectors (3D and p-type)
  Trento, Italy, 18 February 2013.

Joern Lange

- *Beam test results of 3D pixel devices for forward tracking*
  23rd RD50 Workshop, CERN, Geneva, 13-15 November 2013.

Iván López

- *Characterization and Beam Test Results of Non-Uniformly Irradiated 3D Pixel Sensors for HEP Experiments*
  Advancements in Nuclear Instrumentation Measurement Methods and their Applications (ANIMMA), 2013 Marseilles, France, 23-27 June 2013.

Andrea Micelli

- *3D Pixel Sensors for Diffractive HEP Experiments*
  ATINER 1st International Conference Athens, Greece, 22-25 July 2013.

Neutrino Group

Federico Sánchez

- *Recent T2K results*
  CERN seminar, 22nd October 2013

MAGIC /CTA Group

Jelena Aleksić

- *Deep survey of Segue 1 with MAGIC*
  EPS HEP 2013, Stockholm, Sweden, July 17-24, 2013.
- *Deep observations of Segue 1 dwarf spheroidal galaxy with the MAGIC Telescopes*
  33rd ICRC, Rio de Janeiro, Brazil, July 2-9, 2013.
- *Latest on Dark Matter Searches with MAGIC*
  8th MultiDark Consolider Workshop, Granada, Spain, April 17-19, 2013

Oscar. Blanch

- *The Cherenkov Telescope Array Large Size Telescope*
  33rd ICRC, Rio de Janeiro, Brazil, July 2-9, 2013.
- *MAGIC latest results*
  RICAP'13, Rome, Italy, May 22-24, 2013.

Juan Cortina

- *Nine years of Physics with the MAGIC telescopes*
  Invited Colloquium at IFT Madrid, March 1st 2013.

Alicia López Oramas

- *Observation of VHE gamma-ray binaries with the MAGIC Telescopes*
  33rd ICRC, Rio de Janeiro, Brazil, July 2-9, 2013.

Abelardo Moralejo

- *Status of axion-like particle searches with very high energy gamma-ray telescope*
  8th MultiDark Consolider Workshop, Granada, Spain, April 17-19, 2013
- *Fundamental Physics with Imaging Atmospheric Cherenkov Telescope*
  48th Rencontres de Moriond "Very High Energy Phenomena in the Universe", La Thuile, Italy, March 9-16, 2013.

Javier Rico

- *Indirect Dark Matter searches with the MAGIC telescopes*
  Workshop "What are we learning from the gamma-ray sky? University of Minneapolis, Minnesota, USA, October 10-12, 2013.

Julian Sitarek

- *Physics performance of the upgraded MAGIC telescopes obtained with Crab Nebula data*
  33rd ICRC, Rio de Janeiro, Brazil, July 2-9, 2013.
- *The MAGIC Data Quality Check Software*
  33rd ICRC, Rio de Janeiro, Brazil, July 2-9, 2013.

Victor Stamatescu

- *Recent MAGIC results on Galactic sources of VHE gamma-rays*
  Rencontres de Moriond, VHEPU Session, 2013, La Thuile, Italy, March 9-16, 2013.

DES/PAU Group

Ramon Miquel

- *Dark energy studies: Galaxy surveys*
  Meeting of the AstroParticle Physics European Consortium (APPEC) Scientific Advisory Committee, Paris (France), October 2013.

Carles Sanchez

- *Measuring σ_8, bias and stochasticity in DES-SV MICE simulations*
  in International School of Physics Enrico Fermi, New Horizons for Observational Cosmology, Varenna (Italy), June 2013.

Theory Division Talks

Christophe Grojean

- *A tour of electroweak scale physics in the light of recent LHC results*
  Lectures at the master level on 6h, April-May 2013, EPFL
- *Higgs boson physics*
  Lectures at the ITEP winter school, Moscow, February 2013.
- *LHC implications for Higgs and BSM physics*
  Lectures at the ICTP Spring school, Trieste, March 2013.
- *Quo Vadis Higgs?*
  Max Planck Institute for plasma physics, Munich, October 18, 2013
- *Quo Vadis Higgs?*
  Physics Department, Humboldt University, Berlin, October 29, 2013
- *Quo Vadis Higgs?*
  Physics Department, University of Vienna, October
- *Quo Vadis Higgs?*
  Physics Department, Brussels University, November 29, 2013
- *Quo Vadis Higgs?*
  seminar, IPMU, Tokyo University, January 23, 2013
- *Study of the Higgs boson*
  CLIC workshop, CERN, January 29, 2013
- *Top connections to Higgs and New Physics*
  CERN CMS physics group meeting, February 25, 2013
- *Resolving degeneracies in Higgs coupling identification*
  Seminar, Padova U., September 24, 2013
- *Effective Higgs at the LHC*
  Zurich Phenomenology Workshop "Particle Physics in the LHC era", Switzerland, Jan. 2013
- *The Higgs boson: an odyssey in the heart of matter*
  Japanese-French Frontiers of Science Symposium, Japan, Jan. 2013
- *Extended Higgs sector*
  ACP winter conference, USA, March 2013
- *LHC: theoretical perspectives*
  LHC France 2013, Annecy, France, April 2013
- *Linear Collider Physics Outlook*
  European Linear Collider Workshop ECFA 2013, Hamburg, Germany, May 2013
- *Composite Higgs*
  Higgs and BSM @ the LHC conference, ICTP, Trieste, Italy, June 2013
- *The scalar sector of the SM and beyond*
  The 2013 European Physical Society Conference on High Energy Physics, Stockholm, Sweden, July 2013
- *Resolving Higgs coupling puzzles Why m_H = 126 GeV?*
  Workshop, Madrid, Spain, September 2013
- *Partially Strong VV Scattering*
  Anomalous Quartic Gauge Coupling Workshop, Dresden, Germany, October 2013
- *Single top and New Physics*
  CMS single top workshop, Naples, Italy, December 19

Matthias Jamin

- *Strong Coupling from Tau Lepton Decays,*
  ITP, Vienna University, 6. June 2013.
- *QCD Studies in Tau Decays*
  ITP, Vienna University, 12. December 2013.
- *Perturbation Theory for the Tau Hadronic Width*
  ITP, Vienna University, 17. December 2013.
- *Strong coupling from τ-lepton decays*
  International Conference on Determination of the Fundamental Parameters of QCD, Singapore, March 2013.
- *Strong coupling from τ-lepton decays*
  2nd Workshop: Tau Lepton Decays, Cracow, Poland, September 2013.
- *Fits to $\tau \to K\pi\, \nu_\tau$ decays*
  2nd Workshop: Tau Lepton Decays, Cracow, Poland, September 2013.

Oriol Pujolàs

- *Emergent Lorentz Invariance*
  Nottingham University, March 8th 2013.
- *The Uses of Holography: from superconductivity to emergent symmetries*
  Genoa University , Italy, July 11 2013.
- *Emergent Lorentz Invariance*
  Invited talk at "Focus week on Gravity and Lorentz violations" KAVLI-IPMU, Tokyo Japan, Feb 18-22, 2013.
- *Emergent Lorentz Invariance*
  Invited talk at "Gauge/Gravity Duality" Max Planck Inst, Munich, July 28 - Aug 2, 2013.
- *Emergent Lorentz Invariance*
  Invited talk at "Mathematics and Physics of the Holographic Principle", Isaac Newton Inst, Cambridge, UK, Sept 16-20, 2013.
- *Emergent Lorentz Invariance*
  Plenary talk at "Particle and Nuclear Physics at all scales, Astroparticle Physics and Cosmology", Saint Petersburg State Univ., Saint Petersburg, Sept 18-22, 2013.

Mariano Quirós

- *Supersymmetric Custodial Triplets*
  LPTHE, University of Paris VI, Jussieu, November 28th 2013
- *Quarks and Leptons in Warped Space*
  IFIC and Department of Theoretical Physics, University of Valencia, February 28th 2013
- *The SM in a Warped Dimension*
  Plenary talk at the Conference "PacoFest 2013: Scientifc Symposium, University of Granada, Granada, Spain, November 22nd 2013
- *SM Higgs in non-decoupled Supersymmetry*
  Plenary talk at the Conference "LHC-The First Part of the Journey", KITP, University of California Santa Barbara, CA, USA, July 8-12, 2013.
- *SM-like Higgs in non-decoupled SUSY*
  Invited talk at the Workshop on "BSM after the first run of LHC",Galileo Galilei Institute, Florence, June 2013
- *The LHC Higgs window to EWBG*
  Invited Talk at "The first three years of the LHC", 18-22 March 2013,Mainz Institute for Theoretical Physics, Mainz, Germany
- *A SM-like Higgs from Supersymmetry*
  Invited Talk at Plenary Session in "Luis Ibanez Fest", IFT CSIC/UAM, Universidad Autonoma de Madrid, Madrid, Spain, March 15th 2013
- *Beyond the Standard Model: Non-supersymmetric*
  Taller de Altas Energias (TAE) 2013, September 26th 2013, Centro de Ciencias Pedro Pascual, Benasque, Spain

Pablo Roig

- *New τ physics measurements that should be performed at the present and future facilities*
  Third Workshop on Flavour Physics in the LHC Era: Theoretical and Experimental Views. IFIC, Valencia, 4-6 February, 2013.
- *τ to π $(\eta,\eta')\nu_\tau$ decays*
  XLVIIIth Rencontres de Moriond session devoted to QCD And High Energy Interactions, La Thuile (Aosta) - Italy. 9-16 March, 2013. Participation with a conference grant covering accommodation expenses.
- *Are isospin corrections in τ^- to $\pi^-\pi^0\,\nu_\tau$ decays understood?*
  13th meeting of the Radio MonteCarLow WG, ECT* Trento,

Italy. 10-12 April 2013 (including a day on R-measurement at BES-III).

- *Weak radiative pion vertex in τ^- to $\nu^- l^+ l^- \nu_\tau$ decays*
  14th meeting of the Radio MonteCarLow WG, Roma, 13-14 September 2013.
- *Resonance Chiral Lagrangians and hadronic currents theoretical uncertainty*
  2nd Workshop on Tau lepton decays: hadronic currents from Belle, BaBar data and LHC signatures, Krakow, 16-20 September 2013.
- *A precise determination of the $K^*(1410)$ resonance parameters through τ^- to $K^- \eta\ \nu_\tau$ decays*
- *XIV Mexican Workshop on Particles and Fields*, Oaxaca, 25-29 November 2013.

Géraldine Servant

- *Recent developments in Dark Matter/ Cosmology with implications for collider physics at CERN*
  8th CERN-Fermilab Hadron Collider Physics Summer School, 30 August 2013.
- *Dark Matter: Theory*
  Stockholm EPSHEPP 2013, the biennial Europhysics conference on High Energy Physics, July 23, 2013: invited plenary talk
- *Gamma ray lines from Dark Matter annihilations.*
  DESY, Theoretical colloquium, Feb. 6, 2013.
- *Dark matter and the matter-antimatter asymmetry of the universe: Are they related?*
  DESY, Hamburg U., Colloquium, Oct. 18, 2013:

4.7 Participation in External Committees

Experimental Division

Oscar Blanch

- Member of the MAGIC Executive Board
- Convener of LST-CAM working group in CTA
- Safety and Operations coordinator of the MAGIC experiment
- Member of the LST Executive Board

Martine Bosman

- ATLAS Collaboration Board Chair
- Member of Plenary ECFA (European Committee for Future Accelerators)
- Member of the selection board of CERN PH fellows and associates
- Member of Committee: Selección de Becas de La Caixa – Europa
- Member of Committee: Comisión de Infraestructuras de Física de Partículas y Aceleradores (CIFPA)

Matteo Cavalli-Sforza

- Chair, Scientific Committee, Laboratori Nazionali di Frascati, INFN (Italy)
- Chair, AERES Review committee LPNHE, Paris (France)
- Spanish Representative, Restricted European committee for future Accelerators

Juan Cortina

- Spokesman of MAGIC Collaboration
- Representative for Astroparticle Physics in Executive Committee of CPAN (Centro Partículas, Astropartículas y Nuclear).

Paolo Francavilla

- ATLAS MET group convener.

Roger Firpo

- Member of the MAGIC software board

Sebastian Grinstein

- ATLAS 3D R&D Collaboration Test-beam coordinator
- 3D Sensor publications bureau member
- IBL Executive Institute Board member

Aurelio Juste

- Member of the Scientific Committee of the OCEVU LabEx (Origins, Constituents, and EVolution of the Universe), France.
- Co-convener of the HSG8 subgroup of the ATLAS Higgs Physics group (since September 2013).
- Referee for the Evaluation Committee "Subatomic Physics and related theories, astrophysics, astronomy and planetology" of the French National Research Agency (April 2013).
- Referee for ERC Starting Grant 6th Call (January-December 2013).
- 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-convener of the "ttH" session at the ATLAS Higgs WG (N)NLO MC and Tools Workshop for LHC Run2, CERN, Geneva, Switzerland, December 16-17, 2013.
- Co-convener of the "High Luminosity" session at the ATLAS Hadronic Calorimeter Calibration Workshop, Chicago, USA, September 23-26, 2013.
- Co-convener of the "Top and Electroweak Physics" parallel session at the EPSHEP Conference (EPS-HEP 2013), Stockholm, Sweden, July 18-24, 2013.
- Scientific advisor for the research program "Exploring TeV Scale New Physics with LHC Data" at the Kavli Institute for Theoretical Physics, University of California, Santa Barbara, USA, April 29-July 26, 2013.
- Member of the Program Committee of the Large Hadron Collider Physics 2013 conference (LHCP 2013), Barcelona, Spain, May 13-18, 2013.

Ilya Korolkov

- IFAE representative in the Tile IB board and IFAE leader in Tile calorimeter construction and operation.

Manel Martínez

- Co-Spokesman of CTA Consortium
- Spanish Delegate in APIF (Astroparticle Physics International Forum) of OECD.
- Member of the Scientific Advisory Committee of ApPEC.
- Member of the "Expert Committee" for the FPA National Program.

Mario Martinez

- Representative of IFAE in Collaboration Board of ATLAS
- Representative of IFAE in Collaboration Board of CDF
- Member of International Advisory Committee Physics LHC Conference 2014 Columbia University, New York, June 2014
- Chair of the First Large Hadron Collider Physics Conference (LHCP2013)
- Referee of Physical Review D Journal
- Chair of the TAE Spanish School for High Energy Physics, Benasque, September 2013
- Referee for ANEP evaluation panel of Spanish HEP projects.

Abelardo Moralejo

- Representative of IFAE at the CTA Consortium Board (until November 2013)
- Chair of the MAGIC Speakers' bureau(until June 2013)
- Member of the MAGIC software board

- Co-convener of the CTA Monte Carlo working group

Ramon Miquel

- Member of the Scientific Advisory Committee of the AstroParticle Physics European Consortium (APPEC).
- Chair of the Speakers' Bureau of the DES Collaboration
- Member of the DES Management Committee
- Member of the DES Publication Board

Andreu Pacheco

- Atlas Distributed Computing Coordination (ADC-Coord)
- Worldwide LHC Collaboration Board (WLCG-CB) as deputy representative.

Cristobal Padilla

- Member of the ATLAS Speakers Committee
- Member of the ECFA detector Panel

Javier Rico

- Representative of IFAE in Collaboration Board of MAGIC experiment
- Member of the MAGIC Time Allocation Committee
- Coordinator of MAGIC's Data Center
- Manager of MAGIC Common Fund (since November 2013)
- Convener of the MAGIC Astroparticles & Fundamental Physics Working group
- Member of CTA's Speakers And Publications Office (SAPO)
- Member of the CTA Review Panel for Data Management and Array Control

Imma Riu

- Spanish representative in the Advisory Committee of CERN Users
- ATLAS Trigger menu co-coordinator

Federico Sánchez

- Member of the T2K speakers board
- Member of the T2K Executive Committee
- Member of the T2K near detector executive committee

Julian Sitarek

- Deputy Software Coordinator of the MAGIC experiment
- Member of the MAGIC Software Board
- Member of the MAGIC Technical Board
- Co-convener of the MAGIC AGN WG (since December 2013)

Verónica Sorin

- CDF Spokesperson election committee

Victor Stamatescu

- Member of MAGIC Software Board

Theory Division External Committees

Christophe Grojean

- Member of the Commission Consultative de Spécialistes de l'Université Paris XI.
  Editor of Scientific Reports published by Nature publishing group

Pablo Roig

- Member of the WG on Radiative Corrections and Monte Carlo Generators for low-energy Physics,

Géraldine Servant

- Member of the Scientific Committee of the Institut d'Etudes Scientifiques de Cargese. Bi-annual reviews of school and workshop proposals.
- Member of the Program Advisory Committee of the Munich Institute for Astro- and Particle Physics (MIAPP). Annual review of workshop proposals.

4.8 IFAE Colloquia in 2013

Grating-based phase-contrast X-ray imaging and its application in mammography
December 16 2013
Speaker: Dr. Thilo Michel (Erlangen Centre for Astroparticle Physics Friedrich-Alexander University, Erlangen-Nuremberg)

New oscillation results from T2K
November 25 2013
Speaker: Stefania Bordoni (IFAE)

Leptogenesis
November 4 2013
Speaker: Thomas Hambye (U Libre de Bruxelles)

The muon anomalous magnetic moment, a view from the lattice
July 8 2013
Speaker: Maarten Golterman (San Francisco State University, UAB & IFAE)

First Planck results and cosmological implications
May 6 2013
Speaker: Julien Lesgourgues (EPFL, CERN, LAPTh)

Towards Gravitational-Wave Astronomy
April 15 2013
Speaker : Alicia Sintes (U Illes Balears)

Shaping magnetic fields: cloaking, concentration, and transmission of magnetic energy
March 11 2013
Speaker: Àlvar Sanchez (UAB)

Quo Vadis Higgs?
January 14 2013
Speaker: Cristophe Grojean (IFAE - ICREA)

4.9 IFAE Seminars in 2013

UV Completions of Composite Higgs Models with Partial Compositeness
January 18 2013
Speaker: Marco Serone (SISSA & INFN, Trieste)

Back and forth from Supergravity to Condensed Matter
January 30 2013
Speaker: Francesco Aprile

Muon g-2 from tau and e+e- data and rho-gamma mixing
February 2013
Speaker: Fred Jegerlehner (DESY, Zeuthen)

Predictions for high energy emission from the nebula around the Black Widow binary system containing millisecond pulsar B1957+20
February 5 2013
Speaker: Julian Sitarek (IFAE)

Higgslike dilaton
February 1 2013
Speaker: Brando Bellazzini (Padova - Saclay)

Top Partners Hunting
February 8 2013
Speaker: Andrea De Simone (SISSA, Trieste)

Muon anomalous magnetic moment (MAMM): a 2.3 to 4.8 sigma discrepancy (or isospin breaking in tau->pi pi nu_tau decays)
February 20 2013
Speaker: Pablo Roig

New transport properties of holographic superfluids
February 27 2013
Speaker: Daniel Fernandez

Surprises of the pQCD application to the low-energy data
March 1 2013
Speaker: D. V. Shirkov (Dubna, JINR)

Understanding Heavy Quark-AntiQuark System by Perturbative QCD
March 8 2013
Speaker: Yukinari Sumino (Tohoku U)

Indirect dark matter searches
March 15 2013
Speaker: Francesc Ferrer (Washington University, St. Louis)

Comments on the top quark forward backward asymmetry
March 22 2013
Speaker: Michael Trott (CERN)

Searching for spectral features in the gamma-ray sky
April 2013
Speaker: Alejandro Ibarra (Technische Universität München)

Polyakov loop, hadron resonance gas model and thermodynamics of QCD.
April 6 2013
Speaker: Eugenio Megías (Universitat Autònoma de Barcelona)

Dense quark matter and hedgehog black holes
April 10 2013
Speaker: Prem Kumar (Swansea U)

Supersoft SUSY at the LHC
April 12 2013
Speaker: Adam Martin (CERN)

SNc=1,2,3,....infinity! (and tetraquarks)
April 17 2013
Speaker: Santi Peris

Composite Higgs vs LHC data
April 30 2013
Speaker: Andrea Wulzer (INFN Padova)

Dark radiation from particle decay: cosmological constraints and opportunities
May 2 2013
Speaker:Joern Kersten

Implementation of RChL results at low energy MC generators for tau decays and e+e- annihilation
May 8 2013
Speaker: Olga Shekhovtsova (IFJ PAN, Cracow)

Holography with momentum dissipation
Friday May 10 2013
Speaker: David Vegh (CERN)

Positivity constraints on chiral low-energy constants for pion-nucleon scattering
May 22 2013
Speaker:Juan Jose Sanz-Cillero

Viability of light-Higgs strongly-coupled scenarios
May 24 2013
Speaker: Juan José Sanz-Cillero (U. Autónoma de Madrid)

A possible new phase in gauge-fixed Yang-Mills theory
June 7 2013
Speaker: Maarten Golterman (San Francisco State University, UAB & IFAE)

Effective field theory of unstable top
June 14 2013
Speaker: Alexander Penin (University of Alberta)

Compositeness: an EFT framework and applications to collider physics
July 2013
Speaker: Oscar Catà (LMU, Munich)

Emergent Lorentz Invariance from Strong Dynamics
July 5 2013
Speaker:Oriol Pujolas (IFAE & Universitat Autonoma de Barcelona)

Dispersive model connecting light scalar meson poles with their Regge trajectories
July 12 2013
Speaker: Jenifer Nebreda (Yukawa Institute for Theoretical Physics)

Features of higher-derivative scalar theories
July 23 2013
Speaker: Nikolaos Tetradis (University of Athens)

Graphene nano-photonics and carrier dynamics
July 29 2013
Speaker: Frank Koppens (ICFO)

Photons in a cold axion background
September 20 2013
Speaker: Domenec Espriu (Universitat de Barcelona)

LHC phenomenology of the minimal PGB Higgs
September 26 2013
Speaker: Leandro da Rold (Centro Atómico Bariloche & Balseiro Inst.)

The Unbearable Lightness of Being: Direct detection of light dark matter
September 27 2013
Speaker: Felix Kahlhoefer (University of Oxford)

Hot topics in heavy-flavor physics
October 8 2013
Speaker: Diego Guadagnoli (LAPTh Annecy)

Finite Theories Before and After the Discovery of a Higgs Boson at the LHC
October 18 2013
Speaker: George Zoupanos (National Technical University Athens & IFT Madrid)

Flavorful Naturalness
October 25 2013
Speaker: Gilad Perez (CERN)

Flavour and high-pT physics in the precision era of the LHC
October 31 2013
Speaker: Lars Hofer (IFAE)

Higgs naturalness and scale invariance
November 15 2013
Speaker: Witold Skiba (Yale U & CERN)

Four basic ways of creating dark matter through a portal
November 13 2013
Speaker: Thomas Hambye (U Libre de Bruxelles)

Exploring the Hidden Sector @ Low Energies
November 22 2013
Speaker: Joerg Jaeckel (U Heidelberg)

Composite Weak Bosons and the New Boson at the LHC
December 3 2013
Speaker: Harald Fritzsch (LMU, Munich)

The elusive gluon at the LHC
December 10 2013
Speaker: José Santiago (U. Granada & CAFPE)

Review on the muon (g-2) contributions
December 20 2013
Speaker: Pere Masjuan (Mainz Univ.)