IFAE

Institut de Física d'Altes Energies

Report of Activities

2011

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 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. Vuit 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 2011 la Divisió Experimental va treballar en nou projectes:

1. ATLAS, un gran experiment al Large Hadron Collider (LHC) del CERN. A l'any 2011 l'LHC i ATLAS han produit un factor >100 addicional de dades, i s'ha obtingut un gran nombre de resultats. A finals d'any, uns resultats preliminars van indicar la possible observació del famós bosó de Higgs.

2. Un grup de físics d'ATLAS que es dedica a potenciar l'aparell ha desenvolupat i provat éxitosament un nou tipus de detector amb Pixels, que s'instal·larà a l'any 2014.

3. CDF, un experiment de col·lisions antiprotó-protó en el Tevatron del Laboratori Nacional de Fermi (FNAL), en EUA, ha acabat de prendre dades a 2011. Analitzar les dades i publicar els resultats prendrà un altre parell d'anys.

4. L'experiment T2K, al Japó, ha aconseguit la primera observació de la transformació de neutrins del muó en neutrins de l'electró. Paral·lelament, ha continuat l'R&D per a experiments de desintegració doble-beta.

5. Han continuat les observacions de raigs gamma d'alta energia amb els dos telescopis MAGIC, al Roque de Los Muchachos (La Palma, Canàries. Al 2011, s'ha descubert que la emissió de raigs gamma del Granc és pulsada fins a energies de 400 GeV – fet que forçarà canvis als models d'emissió d'aquet pulsar.

6. Ha entrat en una fase avançada el disseny de CTA (Cherenkov Telescope Array), un sistema de 50-100 telescopis per a l'astrofísica amb raigs gamma que involucra instituts de tot el món. El co-spokesperson d'aquesta gran col·laboració és de l'IFAE.

7. A DES, un projecte de cosmologia observacional, amb grups d'EUA i del Regne Unit, s'ha acabat la construcció de una nova càmara de CCD, que s'ha instal·lat al telecopi Blanco, a Cerro Tololo, Xile. El grup de l'IFAE s'està preparant per les observacions, que començaran a finals de 2012.

8. PAU, una col·laboració espanyola coordinada per l'IFAE i finançada amb un projecte Consolider-Ingenio 2010, està

construïnt a l'IFAE una càmara de CCD que s'instal·larà al William Herschel Telescope WHT, al Roque de los Muchachos, per investigar el tema de l'energia fosca.

9. Al camp de la física mèdica, s'ha posat en marxa un projecte europeu, que ha obtingut un Advanced Grant per tal de desenvolupar una nova tècnica de tomografia d'emission de positrons. A 2011, l'empresa spinoff X-Ray Imatek ha comercialitzat i venut els seus primers productes.

Activitats científiques de la Divisió Teorica

La Divisió Teorica segueix tres línies d'investigació:

1. Física del Model Estàndard

A 2011, han continuat les investigacions sobre les desintegracions dels mesons B i del leptó tau, sobre interaccions mesòniques, teoria perturbativa quiral, i sobre la estructura de les correccions perturbatives de QCD, amb mètodes analitics.

2. Física més allà del Model Estàndard

A 2010 el grup de fisica "Beyond The Standard Model" (BSM) ha anat explorant les direccions següents: 1) fenomenologia d'escenaris BSM: Dimensions Extra, SuperSimetria, Física del Higgs, *Exòtica*; 2) Cosmologia: Bariogènesi Electrofeble, i física associada a transicions de fase cosmològiques.

3. Astrofisica i Cosmologia

L'objectiu de la recerca a la frontera entre la física de partícules i la cosmologia és fer servir els coneiximents dels fenòmens d'astrofísica i de cosmologia per tal de resoldre qüestions funamentals de física, i *vice versa*. Les recerques d'aquest grup s'han enfocat en tres temes: baryogènesis electrofeble, relativitat quàntica no-relativista, i matèria fosca.

1. About IFAE

1.1 Structure

The Institut de Física d'Altes Energies (IFAE) is a Consortium between 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. In 2010, it worked under the auspices of the Department of Innovation, Universities and Enterprise (DIUE) 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.

At present, this component of the Institute consists of six ICREA research professors (with continuing tenure) and two ICREA researchers.

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 is composed of three 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 three research professors and two investigators from ICREA. It collaborates with four UAB professors.

IFAE has also the status of a "University Institute" attached to UAB. This formula allows the personnel of IFAE to participate in the educational programme of UAB, in particular by giving doctoral courses.

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 use effectively 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 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 digital radiography. 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 aims at being 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 has been 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. The project was jointly approved in 2003 by The Spanish government in Madrid and the Catalan Government and its construction was completed in 2010.

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 now manages the Common Fund (maintenance and operation funds) of the MAGIC collaboration.

From 1999 to 2004 IFAE provided technical and administrative management of the contract between CERN and a Spanish company for the construction of the vacuum vessels of the ATLAS Barrel Toroid. This was a major project, with 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 by 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 early in 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 current Contract-Program covers the period from 2007 to 2012 included.

1.3 IFAE Governing Board - 2011

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

Josep Canós i Ciurana
Director General for Energy, Mines and Industrial Safety, Dept. Empresa I Ocupació

Carles Jaime Cardiel
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

Scientific Activities in 2011

OUTLINE

The Experimental Division

During 2011 the Experimental Division's activities focused on nine main projects, most of which are long-term efforts. These projects span the fields of High Energy Physics, Astrophysics and Cosmology; and include Applied Physics research, focused on the development of Detectors for Medical Applications.

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

ATLAS**,** a general-purpose experimental facility at the Large Hadron Collider of CERN, the European Center for Particle Physics, which began operations at the startup of the LHC in November 2009 and is in the middle of a very productive data run.

An ATLAS upgrade, complementing the facility with a new Pixel detector, in preparation of a major upgrade.

CDF, a proton-antiproton collider experiment at the Fermi National Accelerator Lab (Illinois, USA).which in 2011 completed data-taking.

T2K, a neutrino long base-line experiment in Japan. In addition, the group is developing novel technologies for detecting neutriniless double-beta decays .

In **Astrophysics**, a running experiment was upgraded, while a new very large facility is being designed:

MAGIC, an experiment in gamma-ray astrophysics and astroparticle physics is taking data at the Canary Islands, having completed a second telescope,that began operating in 2009.

CTA, a multi-telescope array to be built in this decade, is being designed and prototyped.

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

DES (Dark Energy Survey), built a camera for a telescope at Cerro Tololo (Chile) in order to perform cosmology studies by observing about 300 million galaxies. Observations are set to begin in 2012.

PAU (Physics of the Accelerating Universe) is a Spanish collaboration formed under the auspices of a Consolider project that will perform cosmology studies by observing the Northern sky with a new camera, to be located at the WHT telescope at La Aplma, Canarias.

On the **Medical Physics** front, a group continues the research initiated in 2002 with DearMama, a EU-funded project on breast cancer diagnostic techniques by digital radiography. These studies are carried out in collaboration with an IFAE spin-off company, X-Ray Imatek.

In 2010, this group obtained a prestigious ERC four-year grant, to explore a novel approach to Positron Emission Tomography.

The Theory Division

The activities of the Theory Division during 2011 fall into three broad lines: Standard Model, Beyond the Standard Model and Astroparticles/Cosmology.

Standard Model

The main research themes pursued in the Standard Model (SM) group of the IFAE theory division during 2011 were hadronic decays of the B mesons and the tau lepton, mesonic interactions, chiral perturbation theory - including higher-mass vector and scalar mesons in the framework of resonance chiral perturbation theory - as well as studying the structure of higher-order corrections in QCD perturbation theory through analytic methods like the Mellin-Barnes transformations.

Beyond the Standard Model

The main goal of research in Physics Beyond the Standard Model (BSM) at IFAE is to explore extensions of the Standard Model at the TeV scale and therefore testable at the LHC. During 2011 worked was done on theories with extra dimensions, Supersymmetry, the Higgs boson, the Lee-Wick theory, and electroweak baryogenesis.

Astroparticles/Cosmology

The general goal of this research line is to study theoretical issues in elementary particles and their interactions, particularly when they occur in an astrophysical or cosmological medium. In 2011, work focused on non-relativistic quantum gravity, new models for Dark Matter and Dark Energy, and on studying the magnetic properties of a certain type of superconductors using gravity/gauge-theory duality techniques.

2.1 ATLAS at the CERN LHC

Mario Martínez

Since 1993, the IFAE group has given major contributions to the construction of the ATLAS apparatus, its trigger system, its physics reconstruction software and preparatory physics studies. After first collisions at the end of 2009 at 900 GeV and 2.36 TeV, the machine increased the beam energy leading to proton-proton collisions at 7 TeV. In 2011, both the collider and the detector performed extremely well with a total integrated luminosity above 5 fb^{-1} as shown Figure 1.

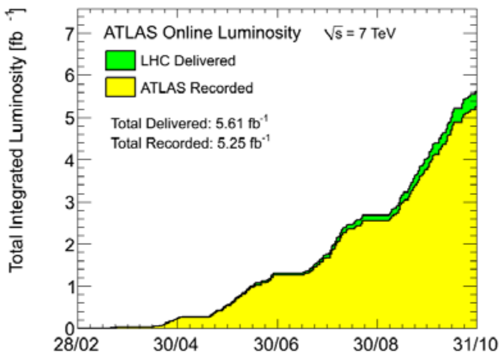


Fig 1: Total LHC delivered and ATLAS recorded luminosity in 2011.

This represents two orders of magnitude more data compared to what was collected in 2010. This large increase came at the price of a significant amount of pile-up events (up to 24 proton-proton collisions per crossing) that constitutes a challenge for

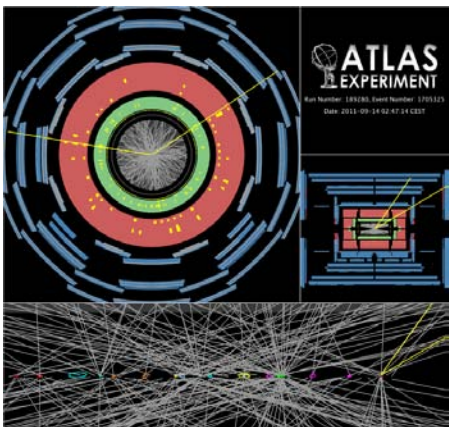


Fig 2: Display of a Z candidate decaying into two muons with 20 overlapping pile-up events.

the physics analyses. As an example, Figure 2 shows an event display corresponding to a candidate Z boson event with 20 reconstructed vertices.

This year, the IFAE group maintained its responsibilities in the operation and calibration of the TileCal calorimeter, in the activities related to the trigger system and the study of its performance, evolution of algorithms and trigger menu. The group played a leading role in various physics analysis fronts and kept its clear visibility within the experiment organizational chart. In particular, M. Bosman was Deputy Chair and is now Chair of the ATLAS Collaboration Board. Finally, in 2011 the group consolidated and enhanced the computing infrastructure in Barcelona, fundamental to maintain leadership in the different physics analyses.

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

Tilecal Hadron Calorimeter Activities

In 2011, the IFAE group continued its activities on calorimeter operation, calibration and data preparation. In addition, two postdoctoral members of the group acted as TileCal Run Coordinator and TileCal Calibration Coordinator.

The IFAE group holds to its commitments of full support of the TileCal "Minimum Bias" data calibration system in ATLAS. The system had detected the first signals in September 2010 and since then has been taking data continuously. The data are used to monitor 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, as reported in ATLAS-CONF-2011-116.

The extraordinary performance of the LHC in the year 2011 provided a priceless dataset, but resulted also in significant irradiation of the detector components, including TileCal PMTs. Monitoring of the detector stability as a function of time became especially important. In TileCal, this monitoring is performed by four dedicated calibration systems: charge injection, Cs137 calibration, Laser and Minimum Bias calibration system. All systems operate very well and give consistent results about the stability of the detector response in time, as illustrated in Figure 3, where variation in response of a given TileCal cell is shown as a function of time over the full year 2011. As a result, even small variations in the detector response are recovered to the baseline by the off-line corrections with an accuracy of 0.2%. Student G. González made his Master thesis on this subject in 2011.

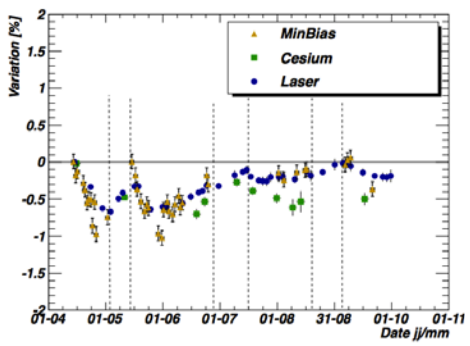


Fig 3: Variation in response of a given TileCal cell as a function of time measured by the Minimum Bias integrator, Cs137 and laser systems.

During the years 2009-2011, our group introduced and maintained a new technique that provides timing calibration of the TileCal read-out. Such calibration is useful both for accurate signal reconstruction and to eliminate non-collision backgrounds. The timing resolution was parameterized as a function of various observables, such as detected energy, as shown in Figure 4. This parameterization allows a more accurate simulation of the TileCal response in physics analysis where timing information is relevant, for example, in searches for delayed decays of heavy, slow particles. J. Montejo wrote his Master thesis on timing studies in TileCal in 2011.

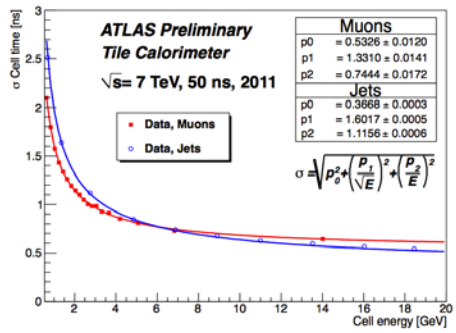


Fig 4: TileCal cell time resolution as a function of the cell energy in the 2011 collision data.

IFAE pursued the study of the E/p observable in TileCal with the sample of isolated hadrons collected by the ATLAS detector in 2010. Comparison of these distributions to the simulation, as illustrated in Figure 5, gives additional confidence in the accuracy of the detector calibration and in the capability of the simulation to reproduce the detector response to hadrons in the kinematic range of interest.

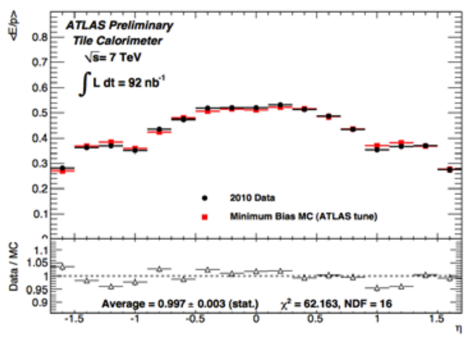


Fig 5: Mean value of the E/p variable as a function of pseudorapidity (η), integrated over the full momentum range for 2010 Data and Monte Carlo simulation. E refers to the energy deposited in the Tile Calorimeter ($|\eta| < 1.7$) by the isolated charged particles with momentum p and pseudorapidity η.

High level Trigger Operation

The IFAE group holds responsibilities in the ATLAS High Level Trigger (HLT) system comprising the software-based 2nd and 3rd level triggers which run in two large computer farms. IFAE played an important role in the overall coordination of trigger operations, in the commissioning of the infrastructure software and the integration of trigger algorithms helping to achieve an excellent efficiency during the data-taking. In 2011, the group continued the activities in the τ and jet triggers. I. Riu started to act as co-coordinator of the ATLAS trigger menu group.

In 2011, the τ-trigger activities focused on the understanding of the τ trigger efficiency using cosmic ray events as well as collision data with $Z \rightarrow \tau\tau$ candidates. Results of the trigger performance including the τ trigger (CERN-PH-EP-2011-078) were submitted to Eur. Phys. J. C, and have been presented in several conferences during these years by various members of the group. As an example, Figure 6 presents the τ trigger efficiency, as computed in $Z \rightarrow \tau\tau$ events collected in 2010, as a function of the τ transverse momentum compared between data and Monte Carlo simulation, showing good agreement within statistics.

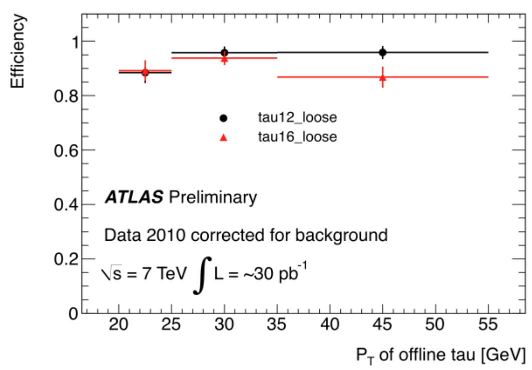


Fig. 6: The trigger efficiency of TAU12 and TAU16_loose trigger chains with respect to the τ transverse momentum for data and $Z \rightarrow \tau\tau$ decays simulation.

Before the data taking period started in 2011, an optimization of the τ trigger selection cuts was done by the IFAE group, and used during the whole 2011. Various members of the group have also edited conference notes. In particular, I. Riu has been the co-editor of the τ trigger performance conference note with data taken in 2010 while P. Casado is the co-editor of a similar one with 2011 data.

In 2011, IFAE continued the activities in the jet trigger initiated in 2009. During the last year, the group focused on the improvement of the jet algorithm implemented at the trigger level, with the aim to implement also online the anti-k_t algorithm used by the physics analyses. Given the Level 2 timing constraints, the anti-k_t algorithm cannot be used and a faster (fast-jet) implementation has been deployed. In addition to the deployment of new trigger algorithms, the group also contributed to the implementation of the jet trigger menu, in particular, in the preparation of the code configuration of the different trigger chains that compose the menu.

Physics Analyses

During the last two years, the IFAE group has maintained a very intense physics analysis activity in different fronts. The program in 2010 was initially characterized by a number of standard model (SM) measurements with the very first ATLAS data. This included: the study of charge multiplicity in minimum bias events, cross section measurements for inclusive jet production at high p_T, a detailed study of the internal jet structure, first measurements on Z boson plus jets production, and a first measurement of the top pair production cross section.

This was regarded as a first step toward a physics program focused on searches for new physics beyond the SM which started already in 2011. The IFAE group is now playing a leading role in: the search for new phenomena in events with energetic jets or photons in the final state together with large missing transverse energy; the search for new physics in top-quark final states and the study of top forward-backward charge asymmetry; and the search for the SM Higgs boson in the ZH and ttH channels.

Inclusive jet studies

During 2011, IFAE concluded the work on inclusive jet production. The study of the inclusive production of jets at large momentum transfer constitutes a stringent test of perturbative QCD (pQCD) predictions and is sensitive to the presence of new physics like, for example, quark compositeness. The measured cross sections using 2010 data are well described by pQCD predictions (see Figure 7). First results based on 17 nb-1 were published (EPJC 71 (2011) 1512) and later updated with the full 2010 dataset (arXiv:1112.6297, submitted to Phys. Rev. D).

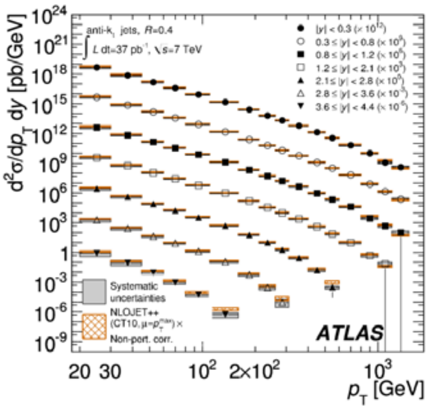


Fig 7: Measured jet inclusive cross section as a function of jet transverse momentum in different jet rapidity regions. The data are compared to next-to-leading order pQCD predictions.

IFAE was the driving force of a detailed study of the internal structure of jets in inclusive jet production processes. A detailed knowledge of the shape of the jet is crucial for a proper understanding of the phenomenology related to parton showers, underlying event contributions, and jet hadronization. The results were published in Phys. Rev. D 83, 052003 (2011), with M. Martinez as corresponding editor, and followed by additional comparisons with state-of-the-art Monte Carlo models in ATL-PHYS-PUB-2011-010. The overall body of work on inclusive jet production constituted the PhD. Thesis of F. Vives which was defended on October 2011.

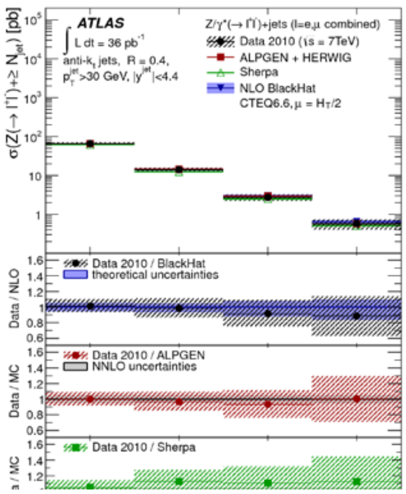
Studies of Z+jets

The mission of the LHC is to search for the Higgs boson and physics beyond the SM like, for example, supersymmetry (SUSY) and/or the presence of extra-dimensions. However, SM physics processes involving vector bosons (Zs and Ws) accompanied by jets constitute important backgrounds to these searches, and a precise measurement of those processes is therefore mandatory.

In 2011, the IFAE group continued the line of research based on the measurement of the jet production in events with a Z boson in the final state decaying into either the electron or the muon channels. The group played a leading role in the cross section measurements. Results were presented at the very first conferences in 2011.

M. Martinez was the corresponding editor of the conference notes (ATLAS-CONF-2011-001, ATLAS-CONF-2011-042). Final results with the full 2010 data and including the combination of electron and muon measurements (arXiv:1111.2690) were already accepted for publication in a long Phys. Rev. D. with M. Martinez as corresponding editor.

Figure 8 shows the measured inclusive Z-plus-jet production cross section (electron and muon channels combined) as a function of jet multiplicity compared to next-to-leading order (NLO) pQCD predictions and the predictions from different LO matrix elements plus parton shower Monte Carlo programs. The good agreement observed between the data and the SM predictions establishes a solid base for using these Monte Carlo codes in order to estimate the SM background in different searches for new physics. The work on Z+jet production constituted the PhD thesis of E. Pérez, defended in December 2011.



8 Fig: Measured inclusive jet cross section in Z+jet events as a function of the jet multiplicity. The data are compared to SM predictions.

Top Quark Physics

The top quark is the most strongly coupled particle 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 related to EWSB and strongly coupled to it.

Once the LHC started colliding protons, IFAE was among the few key groups involved in the "re-discovery" of the top quark at the LHC. The first measurement with collision data constituted the PhD Thesis of Volker Vorwerk (July 2011): "Measurement of Top Cross Section with 2.9 pb^{-1}" published in the European Physics Journal EPJC in early January 2011. M.Bosman was one of the editors of the paper and the related conference notes. This analysis was updated with 35 pb^{-1} for the Winter 2011 conferences and was included in a conference note (ATLAS-CONF-2011-035) with Ll. Mir among the editors. A high statistics measurement of the cross-section together with the R_b parameter with 1 fb^{-1} of data is under way with an expected precision of 5%.

The discovery of the top quark completed the third generation of fundamental fermions in the quark sector of the SM of particle physics. It is natural to ask whether heavier quarks may exist. A search for production of a pair of 4th generation quarks (t') has been carried out assuming that t' quarks decay exclusively into Wb. The analysis strategy is similar to that of the top pair analysis in the semileptonic final state and is based on 1 fb^{-1} of data (see Figure 9), resulting in an observed 95% C.L lower limit of mt' > 404 GeV. PostDoc C. Helsens and A. Juste are editors of the paper (arXiv:1202.3076), now submitted to Phys. Rev. Lett.

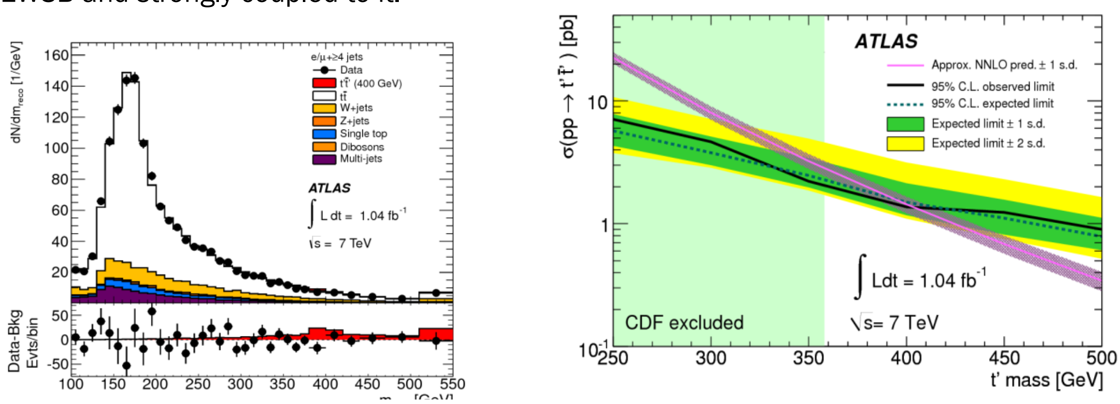


Fig 9: (left) Distribution of the invariant mass of the selected three jets system in the combined e/mu+4 jets channel; (right) Observed (solid black line) and expected (dashed blue line) 95% C.L. upper limits on the t't' cross section as a function of the t' mass.

Another extension of the analysis of t-tbar pair production is the measurement of the t-tbar charge asymmetry with 700 pb^{-1} of data. The measurement of the charge asymmetry provides a useful tool to test for the presence of new physics. The charge asymmetry A_C is defined as the asymmetry between the number of events with a positive, respectively negative, value of the difference between the top and antitop rapidities in the candidate t-tbar events (see Figure 10). The measured value of A_C is compatible with the expected SM asymmetry. This measurement is documented in a conference note (ATLAS-CONF-2011-106), and a paper with $1fb^{-1}$ is in preparation.

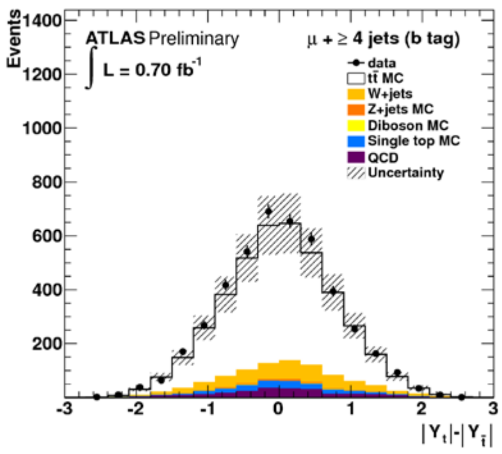


Fig 10: The measured distribution of the difference of rapidity between the top and anti-top quark before unfolding for the muon channel in events with more than 4 jets and at least one b-tagged jet.

The IFAE group is also adapting the analysis strategy to measure the t-tbar production cross-section in the semi-leptonic decay mode with a τ lepton identified in its hadronic decay mode with 2 fb^{-1} of data. In addition, members of IFAE contributed the measurement of the τ+MET trigger efficiency with $Z \rightarrow \tau\,\tau$ events for the search for a Charged Higgs in top decay (ATLAS-CONF-2011-138) with 700pb^{-1}.

Finally, IFAE organized the 4th International Workshop on Top Quark Physics, TOP2011, in Sant Feliu de Guixols in Sept. 2011.

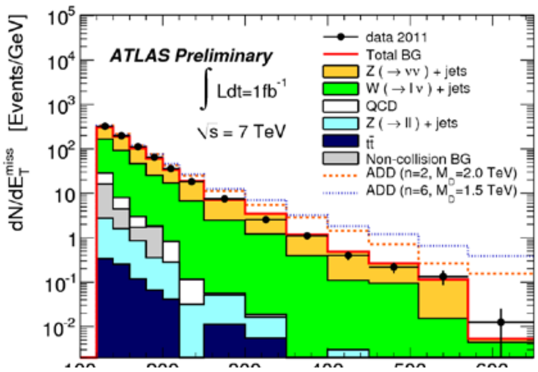
Search for new phenomena in mono-jet final states

The IFAE team has been the driving force in the mono-jet effort in ATLAS. This is onsidered the golden channel in the searches for large extra dimensions (LED) but also allows the access to a very rich SUSY-related phenomenology related to the production of WIMPS, SUSY Dark Matter candidates (for example, neutralino pair production), stop an sbottom pair production in compressed scenarios (with nearly degenerated squarks and the lightest neutralino), Gauge Mediated SUSY Breaking (GMSB) models with very light gravitino masses, and also invisible Higgs searches, among others.

First results based on the full 2010 data sample (approximately 30 pb-1) indicated a good agreement with the SM predictions and translated into stringent limits on the models with large extra dimensions well beyond Tevatron reach in terms of the number of extra spatial dimensions and the effective nth-dimension Planck scale. The results were published in Phys. Lett B705 (2011) 294-312. J. Abdallah acted as contact person of the ATLAS mono-jet group.

The 2010 results were immediately updated using a much larger data sample from 2011 ($1fb^{-1}$) leading to a further improvement of the limits on models with large extra dimensions, to the point that the validity of such models is now challenged. This result became one of the highlights of the EPS conference in 2011, for which ATLAS prepared a conference note (ATLAS-CONF-2011-096) with M. Martinez acting as corresponding editor (see Figure 11).

At the moment of writing this report, the IFAE group is focused on the analysis of the full 2011 data sample and the interpretation of the results in terms of the search for Dark Matter candidates and the production of SUSY particles in compressed scenarios. In addition, the group has recently initiated the work on mono-photon production for which IFAE is also playing a leading role with V. Giangiobbe acting as contact person and M. Martinez as corresponding editor.



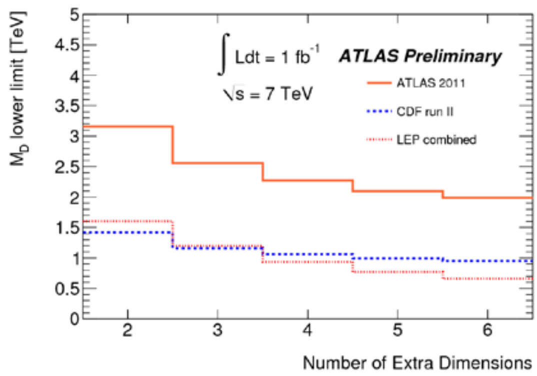


Figure 11: (left) Measured missing transverse energy distribution in mono-jets final state compared to SM predictions. (right) 95% CL limits on ADD LED models in terms of number of extra spatial dimensions versus the nth-dimension Planck scale.

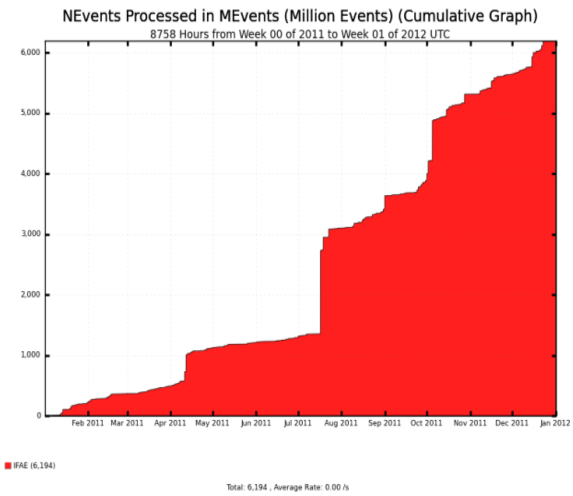


Fig 12: Number of events processed in the Tier2 farm in 2011.

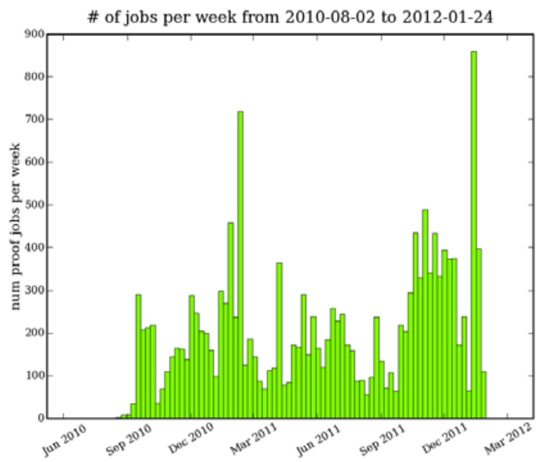


Fig 13: Number of Proof jobs processed by the Tier3 Farm in 2011.

Search for the SM Higgs

One of the main goals of the LHC is the search for the Higgs boson, the last piece of the SM that remains undiscovered. The analysis of the data delivered in 2011 by the LHC to the ATLAS and CMS experiments has produced a huge step forward in the quest for the Higgs boson. Most importantly, the experiment observes a suggestive excess of events around 126 GeV which would be consistent with the potential signal of a Higgs boson, although the observation is not yet statistically significant. If the observations are confirmed and a Higgs boson is observed in the vicinity of 126 GeV mass, the channels where the Higgs boson is produced in association with a W, a Z or a top-quark, with the Higgs decaying into a bbar pair, will be a central part of the Higgs program. The IFAE group is already working on the search for the Higgs boson using the 2011 data in the ZH and ttH channels, and this will become one of the main activities with the increase of the LHC energy and luminosity. At the time of preparing his document, the IFAE team in ATLAS is contributing very significantly to the ZH results to be presented at the winter conferences of 2012.

Computing Infrastructure

The Tier-2 and Tier-3 LHC computing infrastructure of IFAE provided efficient access to the GRID resources during 2011. All the infrastructure of the ATLAS Tier2 and Tier3 farms is hosted at Port d'Informaciò Científica (PIC) and 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 2011, the Tier 2 processed more than 6 billion events (see Figure 12), with an average of 26,000 jobs/week and peaks of 64,000 jobs/week. The CPU and storage capacity in 2011 reached about 5,160 HS06 CPU units and 520 TB, respectively.

In order to address the needs for the analysis of the full 2011 data sample (with an ATLAS data volume about 125 times larger than that in 2010) and in preparation for the incoming 2012 data, where another factor four increase in statistics is expected, the group progressively upgraded the Tier3 farm during 2011, with increased CPU and disk capacity. Currently the farm counts on 192 CPU cores and 200 TB of disk. Figure 13 shows, as an example, the number of jobs analyzed in the Proof farm from September 2010 to January 2012, presenting in general an increasing demand on local resources. On average, more than 50% occupancy was maintained through the time, with peaks approaching 100%, correlated to deadlines for conferences.

2.2 Pixels for ATLAS upgrades

SEBASTIAN GRINSTEIN

Introduction

Silicon pixel vertex detectors are the instrument of choice for tracking of charged particles close to the interaction point at collider experiments. The state of the art on this technology is hybrid detectors, in which sensor and read-out electronics are separate entities. Three of the Large Hadron Collider (LHC) experiments use vertex detectors based on this technology. Pixel detectors significantly enhance track impact parameter resolution which is critical for key LHC physics programs like searches for the Higgs boson and super-symmetric particles. As the LHC accelerator pushes the energy and luminosity frontiers, the pixel detectors will have to be upgraded to maintain their performance.

The pixel group at IFAE was formed in 2008 and has since joined the ATLAS planar and 3D pixel collaborations as well as CERN's RD50 collaboration. The aim of the group is to take a leading role in the construction of the new ATLAS pixel detectors: the Insertable B-Layer (IBL), to be installed in 2013/2014, and later upgrades of the inner silicon layers. During 2011 the group was responsible for the delivery and characterization of 3D sensors from the IBL pre-production run fabricated at CNM (Centro Nacional de Microelectronica - Barcelona), for part of the hardware for the high and low voltage distribution and monitoring system, and for the investigation of the hybridization technology (bump-bonding) of pixel assemblies for the IBL. Members of the group are in charge of coordinating the systematic characterization of 3D devices and also responsible for the reconstruction and analysis of the 3D test beam data, critical for the IBL sensor performance verification. On top of these IBL activities, the IFAE group is coordinating a common project with the CNM to develop new pixel technologies for the future sLHC upgrades. Recently, activities towards the ATLAS Forward Physics (AFP) program have been initiated. The AFP consists of pixel detectors located very close to the beam line, at a distance of 220 m from the center of the detector, to study a variety of forward physics processes.

The Insertable B-Layer

The ATLAS Inner Detector (ID) [1] provides charged particle tracking with high efficiency. The innermost sub-system of the ID is the Pixel Detector [2], which consists of three cylindrical barrel layers between 50 and 120 mm around the beam axis and three forward and backward endcap 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 and to compensate possible deterioration that the innermost layer of the Pixel Detector may suffer after the first years of operation, ATLAS will insert an additional pixel layer (Insertable B-Layer or IBL [3]) inside the current Pixel Detector during the LHC shutdown planned for 2013-2014. To improve the physics performance the material budget of the IBL has to be kept to a minimum. The IBL baseline design consists of 14 staves mounted directly on a new, smaller, beam pipe with a tilt angle of 14^{o} (see Fig. 1). The average radius of the sensitive area is 3.3 cm. Two sensor technologies have been studied for the IBL modules, planar and 3D sensors. Planar modules are interconnected to two front-end chips doubling their length in the z direction with respect to the 3D modules, which are read out by a single chip. The baseline stave layout combines planar and 3D sensors (in the forward region, see Fig. 1). Each stave is equipped with 20 modules (12 double-readout chip planar modules and 8 single-chip 3D modules). The IFAE group is working on the development of both planar and 3D technologies. However, since the group is coordinating a common project with the CNM, which is one of the production sites of 3D sensors for the IBL, most of the activity of the IFAE group during 2011 was related to 3D sensors.

The IBL will have to sustain high radiation doses until the replacement of the entire Inner Detector for the high luminosity LHC (foreseen around 2020). The IBL design assumes an integrated luminosity of 550/fb and a peak luminosity of $3{\cdot}10^{34}$/cm2·s to determine the sensor requirements. Including conservative safety factors, this translates into a NIEL dose of $5{\cdot}10^{15}$ neq/cm^2 (where neq represents a particle with the non-ionizing energy loss of a 1 MeV neutron). Up to this fluency, IBL modules are required to provide a hit efficiency in the active area > 97%. Other constraints to achieve this efficiency are the operational temperature, set at −15 ºC, and the maximum bias voltage, set at 1000 V. The power dissipation should not exceed 200 mW/cm^2 at the nominal temperature. Finally, the sensor design has to minimize the dead regions, in order to achieve this, both planar and 3D sensors target inactive edges of 200 μm.

To face the challenges of the radiation and high occupancy environment of the inner radii of the ATLAS ID, not only the current sensor technology will have to be upgraded. A new integrated readout circuit has been designed for the IBL. The readout chip used in the present detector, the FE-I3, was excluded from the IBL design because its active footprint is too small and its hit rate capability not high enough. The IBL will utilize the FE-I4 integrated circuit, designed in 130 nm technology which features an array of 80x336 pixels with a pixel size of 50x250 μm^2. The large size of the chip, 20.2x19.0 mm^2, leads to a larger active fraction than its predecessor (89% vs 74%). The sensors will be DC coupled to the chip with negative charge collection. The primary output rate is 160 Mb/s, four times faster than the output rate of the FE-I3 chip. Each readout channel contains an independent amplification stage with adjustable shaping, followed by a discriminator with independently adjustable threshold. The chip operates with an externally supplied clock, nominally 40 MHz. The time over threshold (ToT) with 4-bit resolution together with the firing time are stored for a latency interval until a trigger decision is taken. The first prototype of the chip (FE-I4A) was submitted in 2010 and studied with and without sensors, before and after irradiation, in laboratory and beam tests.

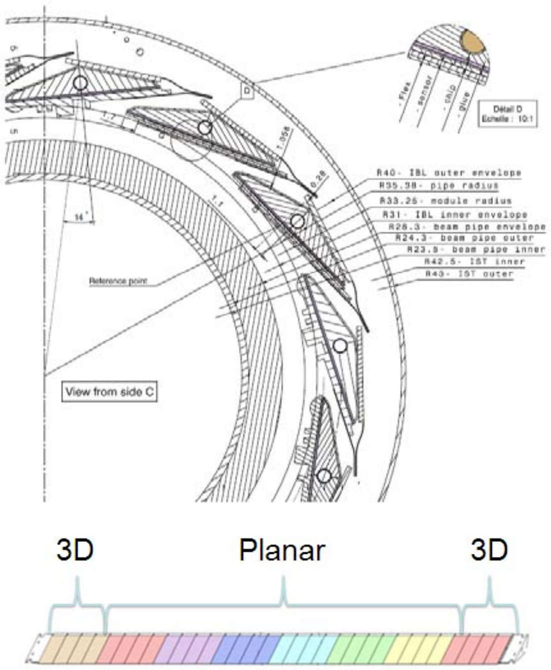


Fig 1: Top: Cross section detail of the IBL, beam pipe and IBL support tube. Distances are given in mm. Bottom: stave layout combining planar and 3D sensor technologies.

3D Sensors from Barcelona

IBL 3D sensors have been manufactured in two production facilities, CNM (Barcelona, Spain) and FBK (Italy), with the same specifications. The sensors are produced on a 230 μm thick wafer with a double sided process, i.e. the n- and p-type columns are etched from the opposite sides of the substrate. The pixel configuration consists of two n-type readout electrodes connected at the wafer surface along the 250 μm long pixel direction, surrounded by six p-type electrodes which are shared with the neighboring pixels, see Fig. 3. The CNM 3D sensor design features 210 μm long columns which are isolated on the n^+ side with p-stop implants. The edge isolation is accomplished with a combination of a n^+ 3D guard ring, which is grounded, and fences which are at the bias voltage potential from the ohmic side (see Fig. 3). The inactive edge region is about 200 μm long. The sensor quality before wafer dicing is evaluated on the 3D guard ring.

Characterization of IBL Devices

Several planar and 3D assemblies were irradiated in order to investigate the behavior of the devices after the radiation doses required for the IBL. Table 1 presents the CNM 3D pre-production samples which were irradiated. All the samples were characterized at IFAE and the beam test analysis carried out by IFAE students.

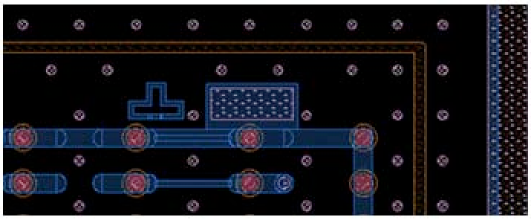


Fig 2: Detail of the CNM sensor mask. The two-electrode configuration is visible as well as the 3D guard fence. The electrodes do not penetrate the full thickness of the sensor in the CNM devices.

Sample	Irradiation Fluence	Testbeam
CNM 81	5E15 neq/cm2 (neutron)	Yes
CNM 82	5E15 neq/cm2 (neutron)	Yes
CNM 34	5E15 neq/cm2 (proton)	Yes
CNM 97	5E15 neq/cm2 (proton)	Yes
CNM 36	6E15 neq/cm2 (proton)	No
CNM 100	2E15 neq/cm2 (proton)	No

Table 1: CNM-Barcelona 3D samples used to evaluate the technology at laboratory and beam tests. Samples not irradaited were also used but are not included in the table.

Before the performance of the devices is studied in beam tests, it is necessary to determine the operational parameters in terms of electronics threshold settings and bias voltage. A low threshold setting is desirable to increase detection efficiency; however, the associated increase in noise could deteriorate the overall performance. Similarly, high bias voltages will increment the collected charge, but the increase on the leakage current could raise the device noise beyond acceptable levels. Both planar and 3D devices were found to be able to operate at thresholds as low as 1000 electrons with similar noise levels of around 150 electrons. A 1500 electron threshold was used in beam-tests, allowing a 500 electron safety margin in order to ensure low noise.

The bias voltage of irradiated planar devices should, in principle, be as high as possible to improve charge collection. Thus planar devices will be operated at 1000 V, the IBL maximum operational voltage. In the case of 3D sensors, the electrical constraints of IBL are easily met. However, the operational voltage has to be optimized to ensure good charge collection while maintaining acceptable noise levels. Fig. 3 shows the charge collection and noise occupancy for a proton irradiated CNM device (CNM 34) as a function of the bias voltage. The optimal voltage setting of 160 V ensures high charge collection efficiency while maintaining the noise level low.

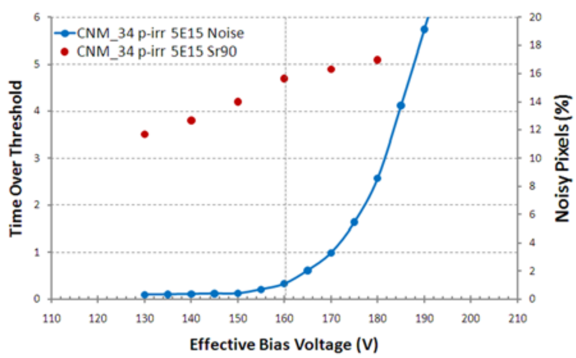


Fig 3: Charge collection and noise occupancy versus the effective bias voltage for a proton irradiated CNM device. A bias voltage of 160 V provides a charge collection close to the plateau, while maintaining a low level of noise.

Test-beam Studies of IBL Devices

Critical performance parameters of pixel devices, such as hit efficiency and position resolution, can only be determined at beam tests. Planar and 3D IBL devices were studied in the CERN north area with a 120 GeV π-beam from the Super Proton Synchrotron during June and September 2011. The IFAE played a major role in the beam test activities (being responsible for the CNM samples), and also during the reconstruction and data analysis.

The devices under test are placed between the EUDET [4] telescope planes. Data at different incidence angles, 0º and 15º, have been recorded to evaluate the device performance. The 15º data, taken with the devices rotated in the long pixel direction, correspond to the approximate expected incidence angle for the IBL configuration. The devices under test were cooled down to the IBL operational temperature. A picture of part of the setup is shown in Fig 4.

Fig 4: Planar and 3D devices mounted on the cooling box during the 2011 IBL beam tests at CERN. The second device from the left is CNM 34.

The hit efficiency is determined from extrapolated tracks on the devices, after track quality cuts have been applied. A hit on the device under test is searched for in a 3x3 pixel window around the track position. The hit efficiency for two CNM 3D devices is shown in Fig. 5. The efficiencies of the enabled pixels are combined to produce the efficiency map in the area corresponding to two pixels (centered at a single pixel). The top plot shows the results for a CNM neutron irradiated device (CNM 81) operated at a bias voltage of 160 V using perpendicular tracks. The inefficient areas associated to the p+ electrodes are clearly visible. This is not the case for the readout electrodes, which at this voltage, collect enough charge from the region that separates the electrode from the ohmic side to detect the passing particles. The overall efficiency for CNM81 under this configuration is 97.5%. The bottom plot of Fig. 5 shows the efficiency of a proton irradiated CNM device (CNM34) at 15º track incidence angle, operated at 160 V. The associated efficiency for this device in this configuration is 98.7%. The efficiency loss caused by the electrodes is expected to be larger at normal incidence, since the charge generated by particles going through the n+ and p+ columns is not collected. It is also interesting to note that the efficiency of similarly irradiated planar devices operated at 1000 V (and sensor temperature estimated a −15 ºC) was of 97.6% [5], while the results for a 3D FBK device irradiated to 5E15 neq/cm2 was of 95.6%.

The position resolution of the IBL detector will be critical for the ATLAS physics program. A preliminary estimation of the position resolution of the IBL devices has been carried out based on the residual distribution in two pixel clusters. The position of the device hit has been estimated using the ToT weighted mean of the clusters. For the CNM devices an estimated device position resolution of 9.5μm was obtained. The result includes the contribution from the track resolution and any residual misalignment of the system. Similar performances were observed in planar and 3D FBK devices.

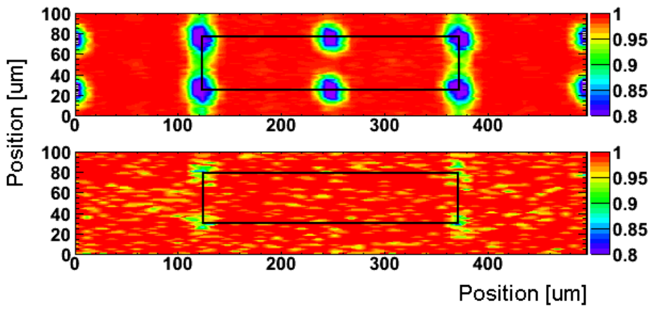


Fig 5: Hit efficiency pixel maps for two CNM 3D devices. The plot on the top shows the hit efficiency for perpendicular tracks for a neutron irradiated CNM 81 device operated at 160 V. The overall efficiency for this device is 97.5%. The bottom plot shows the efficiency for CNM 34 (proton irradiated) operated at 160 V (CNM34). The track incidence is 150 and the overall efficiency is 98.7%.

Summary

The ATLAS Collaboration will install a fourth pixel layer in 2013-2014. The IBL will be mounted directly on a new beam-pipe at an average radius of 3.3 cm. Two pixel technologies have been evaluated for the IBL, planar and 3D sensors. Planar and 3D sensor pre-productions have been completed and the devices have been characterized and investigated with beam tests. Both technologies performed within the IBL requirements after irradiation to fluencies of $5 \cdot 10^{15}$ neq/cm^2. As a result of the excellent performance of the CNM-Barcelona sensors the IBL baseline consists of a layout of 75% planar and 25% 3D sensors. Production of planar and 3D sensors, chips, modules and staves for the IBL has started.

Beyond IBL, in the short term, the IFAE pixel group is planning to take a major role in the AFP detector construction. Activities towards this end have already started. The group will also participate in sensor research activities toward future LHC upgrades. Particular focus will be given to the design of low mass, radiation-hard systems: optimizing the electrode spacing, investigating dual readout with alternative pixel layouts; active and slim edges to meet future material budget constraints and active column implantation in 3D sensors.

2.3 The Collider Detector at the Tevatron (CDF)

Verónica Sorin

The Tevatron is a proton-antiproton collider, located in the USA, at the Fermi National Accelerator Laboratory in the state of Illinois. It has been in operations for more than 20 years and ceased to provide collisions to its two multipurpose detectors, CDF and D0, on September 2011. The Tevatron was the highest energy particle collider until the year 2010, when the LHC started operations. The accelerator complex underwent several upgrades through the years. One of its milestones, the discovery of the top quark in 1995, occurred during the Run I period, in which the accelerator operated with a center-of-mass energy of 1.8 TeV. For Run II the Tevatron increased the energy to 1.96 TeV and its upgrades allowed to reach instantaneous luminosities up to $4x10^{32}/cm^2s$, surpassing the design values and delivering to the the design values and delivering to the experiments a total integrated luminosity above 10 fb^{-1}.

Two are the multipurpose detectors located along the Tevatron ring, CDF and D0. These experiments are international collaborations, with more than 500 researchers each. Detectors upgrades were also made by each collaboration in order to cope with the higher trigger and data rate established by the Tevatron during Run II. In particular the CDF detector improved the DAQ and readout electronics, its tracking capabilities, developed a powerful vertex-finding trigger and installed a time-of-flight detector, new forward calorimeters and increased angular coverage for muon detection. The CDF II detector is shown in Figure 1.

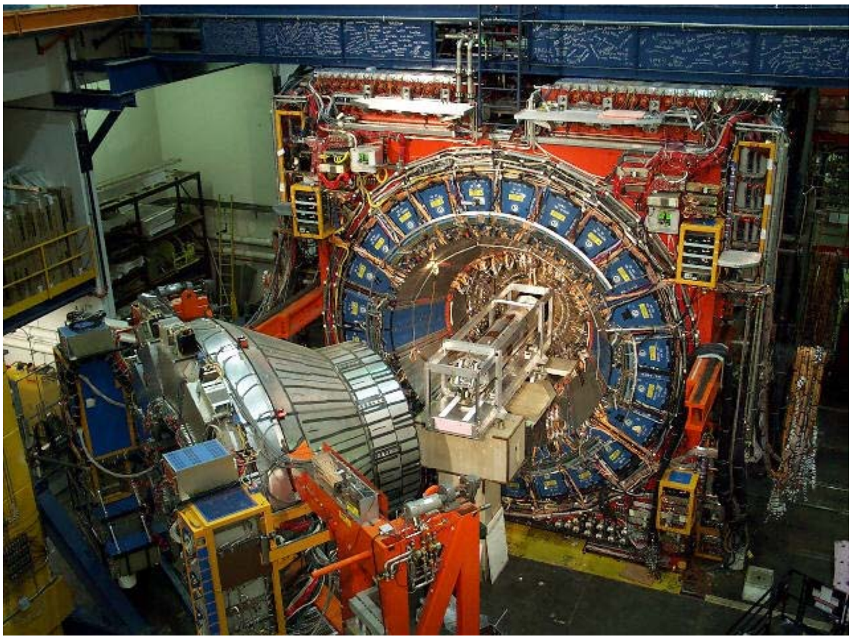


Fig.1 : The CDF Detector in Run II

Since IFAE joined the CDF experiment, the group has maintained an ambitious research program that along the years has focused on the study of events with jets of hadrons in the final state, multi-jet events with large missing transverse energy as a signature for new phenomena like, for example, super-symmetry and jet production associated with a Z boson, providing an exhaustive analysis of final states similar to those utilized for the search of the SM Higgs.

During the year 2011, the IFAE has maintained its responsibilities on quality monitoring (DQM) of the data used by CDF for physics analyses, in addition to a leading role in the analysis of jet production in association with a Z boson, as described below.

CDF detector operations: data quality monitoring

The IFAE group has been responsible of the data quality monitoring (DQM) at CDF. The control of the quality of the data taken forphysics analyses was considered in the CDF organization scheme as a detector subsystemand was managed by members of the IFAE group. The monitoring is performed at two levels, online and offline. The DQM online system provided a data quality diagnosis in real time, based on criteria determine as the result of the interaction with the sub-detector experts, for which dedicated monitors were developed (as shown in Figure 2) that run during data taking in the CDF control room.

The offline phase allowed for problems to be found that only larger statistics would show. Data was thus tested and its quality defined providing a new set of decisions that together with the online ones were used to establish *good run* lists to be used by the whole collaboration for physics analyses.

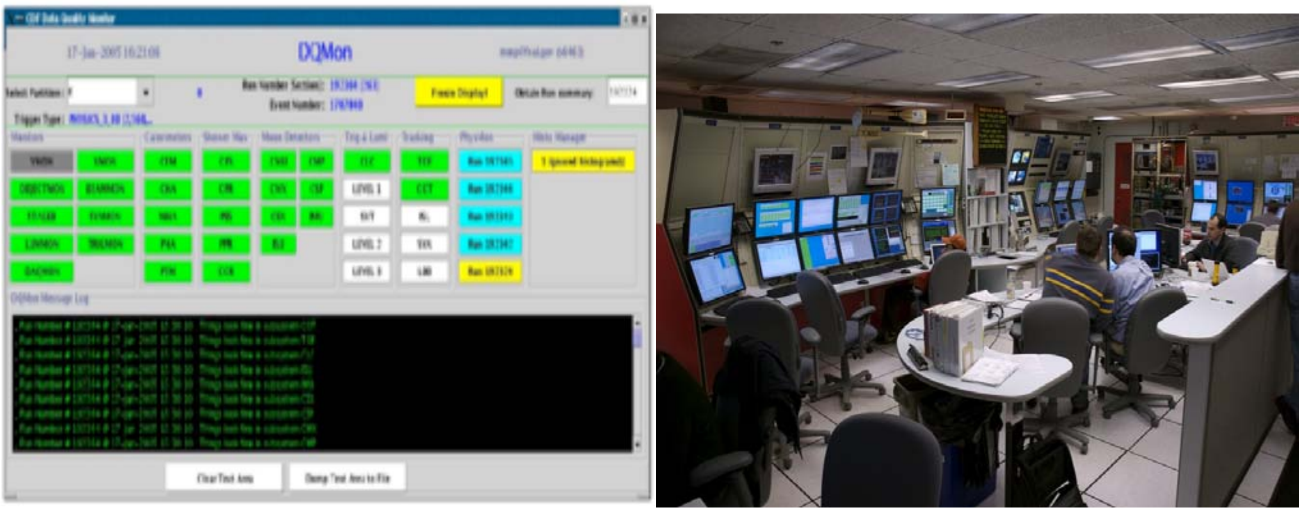


Fig.2 : Image of the DQM interface (left) running in the CDF control room (right) to inform the shift crew the status of each subsystem.

Physics program in CDF

In 2011, the group focused on the studies of Z+jets and Z+b-jet production in both the electron and muon decay channels. Precise measurements of these processes constitute fundamental tests of perturbative QCD (pQCD) and provide a clean sample to validate Monte Carlo predictions for background estimations in searches for new physics. These measurements are part of the legacy of the Tevatron.

The experience of members of the group in top quark physics has led to new results this area. In particular, S. Grinstein has worked on the simultaneous measurement of the cross section of top pair production and the b-tagging efficiency. This is the first use of a top sample for b-tagging *in situ* calibration. Results have been published in Physical Review D. Also a study of the top quark charge was produced by V.Sorin, having found data to be consistent with the standard model and excluding an exotic quark hypothesis (of -4/3 charge) at 99% CL. This result is to be submitted to Physical Review D for publication.

Z+jets final states

The group produced measurements of differential cross section for Z+jets production and compared them with state-of-the-art theoretical predictions (Fig. 3). Results were first produced for each decay channel, and later combined, increasing the available statistics to explore higher jet multiplicity bins and new observables. Using a data sample of 8 fb^{-1}, results have been presented in various international conferences. In some cases, by the student in charge of the analysis, S. Camarda, as for example at Moriond QCD 2011, or at workshops specialized on the subject, such as QCD@LHC and SM@LHC. These measurements constitute Camarda´s PhD. Thesis, which will be defended in spring 2012, and results will be submitted to Physical Review D for publication.

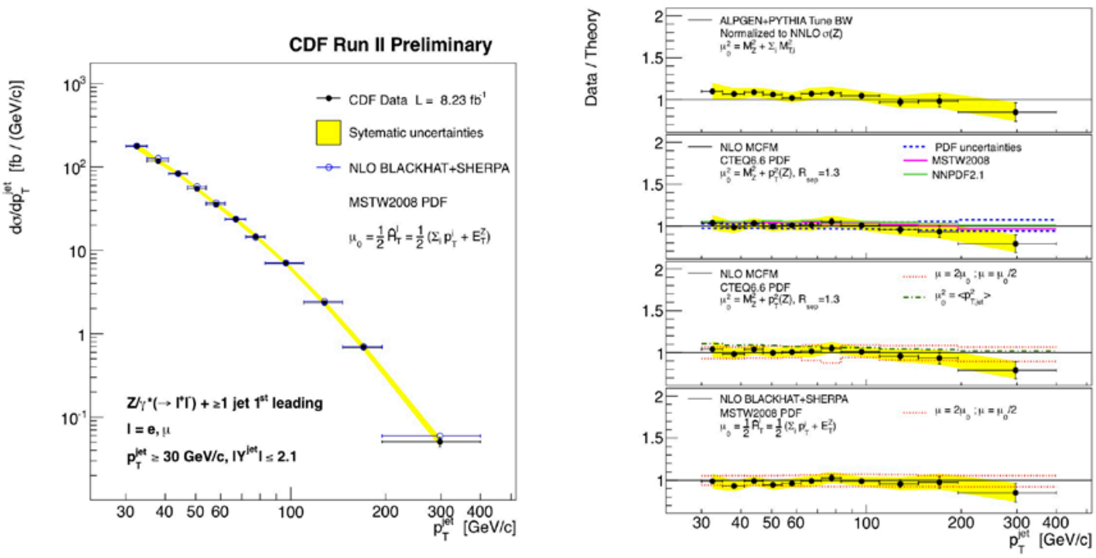


Fig. 3: Differential cross section measured as a function of the leading jet transverse momentum and comparison with NLO pQCD predictions and event generators (as presented at QCD@LHC workshop).

2.4 Neutrino Experiments at IFAE

FEDERICO SÁNCHEZ

Neutrino experiments in 2011

The discovery of neutrino masses and oscillations at the end of last century has greatly increased the interest of neutrino physics. The measurement of the neutrino oscillation parameters with the ultimate goal of measuring Charge-Parity violation (matter antimatter differences), the determination of the absolute neutrino mass and the neutrino nature (Dirac versus Majorana) are among the most important topics in future experimental roadmaps. IFAE neutrino group contributed to this research line during 2011 collaborating with neutrino oscillation measurements at the T2K experiment and to the neutrino nature experiments with the double-beta decay experiment NEXT and NEMO/SuperNEMO.

T2K

T2K is a neutrino oscillation experiment that consists in sending a conventional high intensity muon neutrino beam from the JPARC proton accelerator center in Tokai (Japan) to the SuperKamiokande experiment in Kamioka (Japan) located 295km away. The beam is 2.5^{0} off-axis to optimize the neutrino energy spectrum in searching for electron neutrinos appearance. Neutrinos are measured just after the production point at the near detector, 280m from production (ND280). The neutrino beam is composed mainly of neutrinos of the muon type, which are expected to transform into neutrinos of the τ type (not detectable in Super-Kamiokande) and of the electron type. The oscillation to electron neutrinos had not been observed and has the potential to measure for the first time the mixing parameter θ_{13}.

The near detector is a complex set of detectors embedded in a magnetic field. The detector is divided into two sections: the P0D, devoted to t detecting neutral pions and the charged particle trackers (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 Time Projection Chamber (TPC) in the tracker section and the preparation of the magnet. After the installation and successful operation of the detector during 2010, the IFAE group focused its efforts on the maintenance of the detectors and in data analysis.

The momentum spectrum of muons measured in the near detector is shown in Fig. 1.

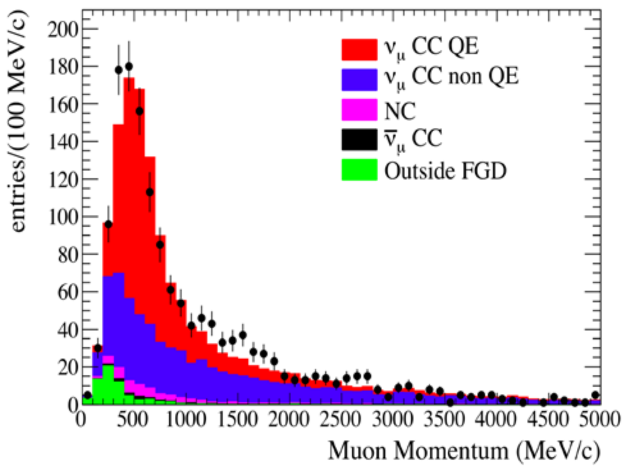


Fig 1. Muon momentum distribution for neutrino interactions at the T2K near detector and comparison with Monte Carlo predictions for different nutrino interaction modes.

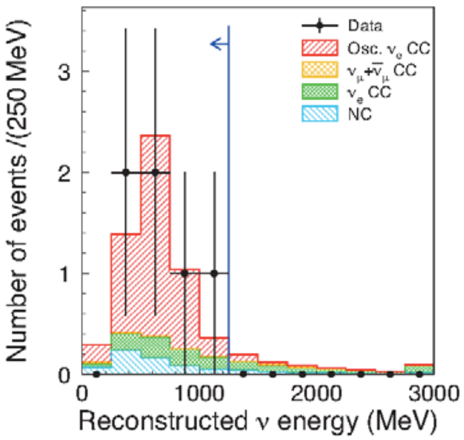


Fig 2 Reconstructed energy distribution for electron candidates detected at SuperKamiokande and the Monte Carlo prediction with the oscillation hypothesis.

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 started in February 2010 and continued until the summer break, in July 2010. Data taking resumed in November 2010 with higher beam intensity and ended abruptly in March 2011 with the terrible earthquake that shook the northeast coast of Japan. The operation of the near detector had been very successful, with up-time fractions higher than 90% at end of the run period. The total number of protons on target accumulated until March 2011 is 1.2 10^{20}. The rate increased significantly during the last running period reaching steady operation with beam power around 150 kW.

The IFAE neutrino group led the analysis of the inclusive charged current muon and electron neutrino interactions for neutrino flux normalization. A reanalysis of the data based on a better reconstruction algorithm was pursued by members of the IFAE group, while leading the efforts to measure the muon and electron neutrino charged current interactions. The muon-neutrino charged current measurements have been included in the official neutrino flux that is going to feed the oscillation analysis until summer 2012. Two members of IFAE were conveners of the muon neutrino and electron neutrino groups and the T2K Analysis Steering Group. This work has been published as part of the two main T2K papers in 2011, the first indication of electron neutrinos in a muon neutrino beam (Phys. Rev. Lett. 107, 041801 (2011)) and the muon neutrino disappearance paper. The analysis of the data resulted in six electron-like events over a background of 1.5, as shown in Fig. 2. This excess is interpreted as the first evidence of a non-vanishing θ_{13} PNMS mixing angle, (0.03 < $\sin^2(2\theta_{13})$ <0.28 at 90% C.L. for normal mass hierarchy.)

The muon disappearance analysis (Phys. Rev. D85 (2012) 031103), see Fig. 3), confirmed the results of previous SuperKamiokande and MINOS results albeit with less precision, see Fig. 4, showing the potential of the T2K off-axis configuration.

Further activities at the IFAE include the improvement of the TPC reconstruction and performance for data analysis, and the pioneering analyses of neutral current elastic, charged current multi-pion and charged current coherent reactions.

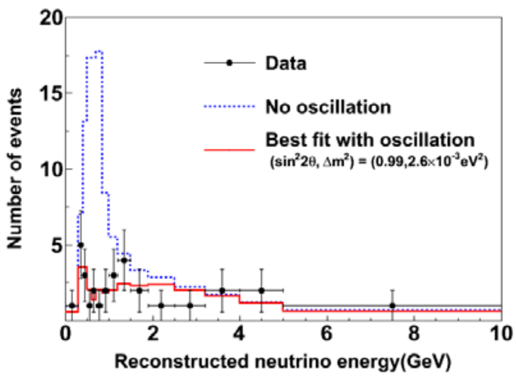


Fig 3. Reconstructed neutrino energy distribution of muon neutrino candidates at SuperKamiokande. The Monte Carlo show the prediction for oscillation and non-oscillation hypotheses.

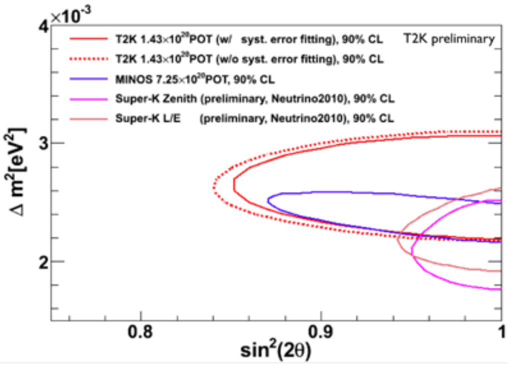


Fig 4. Fit result as function of the mixing angle and Δm^2 for the muon neutrino oscillation hypothesis as shown in Fig. 3. The T2K results are compared to MINOS and SuperKamiokande results.

Neutrino-less double beta decay

In standard double beta decay two neutrons in a nucleus disintegrate simultaneously producing two electrons and two anti-neutrinos. The so-called neutrino-less version is similar but without the emission of the anti-neutrinos. In this case, the emitted neutrino is absorbed and no neutrino appears in the final state. In this research line the IFAE group contributed to the NEMO/SuperNEMO and the NEXT experiments. SuperNemo is an experiment that continues the successful NEMO-3 experiment but with a larger isotope mass and sensitivity. SuperNemo uses a tracking detector in addition to a calorimeter to separately identify the two electrons, thereby reducing the background. The IFAE neutrino group developed the reconstruction software that has been adopted by the collaboration as the official software. This development and the application to NEMO experiment was the thesis topic of one member of the group in 2011. The algorithm was fully developed at IFAE and provides better performance than the official NEMO-3 reconstruction software. After goiving this contribution, IFAE left this collaboration to focus its efforts on another experiment.

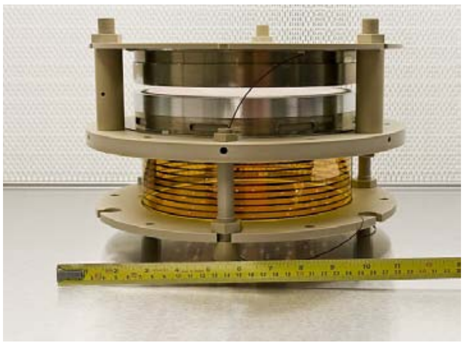


Fig 5. Field cage design for the large chamber prototype at IFAE.

The NEXT experiment is an ambitious project consisting in a large pressurized TPC filled with Xenon enriched with the double-beta emitter isotope. NEXT is a tracking detector able to identify electrons independently. The advantage with respect to the SuperNEMO approach is that the isotope, tracking and calorimeter devices are the same, thus avoiding losses in passive materials.

The IFAE and University of Zaragoza groups presented to the collaboration in May 2011 a proposal to build the experiment in stages using available technology (Micromegas). The proposal included a later upgrade to an electroluminescence readout technology when the funding would be available. This proposal was rejected by the collaboration in favor of an alternative one. The IFAE group felt that the technology adopted by the rest of the NEXT collaboration is not mature, lacking experimental and simulation results and as a consequence decided to leave the NEXT collaboration.

IFAE pioneered the development of a technology based on APDs for pixelated readout of electroluminescence for tracking and energy determination. The resolution obtained at IFAE with early prototypes using 5 APDs show the potential of this approach after reaching energy resolutions (FWHM 0.7% at 2.5MeV) that exceeds the goal of the NEXT experiment (FWHM 1.0% at 2.5 MeV).

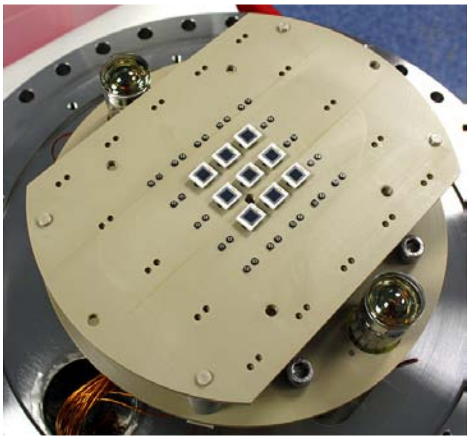


Fig 1. Design of the APD plane holding 9 APDs during stability test.

After leaving NEXT, the group decided to complete the tests of the electroluminescence technology by building and operating a larger time-projection chamber with a readout based on 25 APDs and 2 PMTs to detect prompt scintillating light. The design of the chamber was carried out in close collaboration with the CIEMAT; the chamber was built at IFAE. Its preliminary tests proved the stability of the chamber operation with voltages up to 20 kV. The chamber will be completed and operated at the beginning of 2012 and performance results are expected by the end of the same year. As a byproduct of these studies it has been proved that the same technology can be used for detecting electroluminescence in argon. This result shows the potential of this technology for future experiments; in particular, it may be relevant for the ArDM experiment.

2.5 The MAGIC Telescopes

Juan Cortina

MAGIC is the acronym of Major Atmospheric Gamma-ray Imaging Telescopes. The two MAGIC telescopes are located at the Roque de los Muchachos Observatory in the Island of La Palma (Canary Islands). They are devoted to studying the very high energy (VHE) gamma ray sky. This sky is bright with a class of rare astronomical objects which efficiently accelerate particles to energies in excess of 50 GeV. The study of these objects provides information about the physical mechanisms that produce such radiation. Furthermore the propagation of the radiation over cosmological distances is sensitive to the geometry and matter contents of the cosmos itself. Dark matter may also annihilate into VHE γ-rays, so the MAGIC telescopes may also help to shed light on its nature.

The two instruments detect the light indby the shower of particles generated in the upper atmosphere by the the incoming γ-ray. This light is reflected by segmented 17 m diameter mirrors and focused into the telescope cameras. The cameras are equipped with very fast and sensitive photo-detectors, which are processed by correspondingly fast (sub-ns) digitizers. By pointing the two telescopes in the same direction in the sky, the energy and direction of the incident γ-ray can be reconstructed with higher precision.

The IFAE group built the camera of the first telescope (MAGIC-I), which is the most sophisticated element in the instrument. A second telescope (MAGIC-II) joined MAGIC-I in 2009. MAGIC-II is located 85 m away from

Fig 1 (copyright R. Wagner): The second MAGIC telescope points at zenith shortly after sunset. The new 1039 photomultiplier camera is installed at a focal distance of 17 meter from the 17 meter diameter mirror dish. The MAGIC telescopes are equipped with the largest optical reflectors in the world. These huge photon collectors enable the telescopes to detect γ-rays in the energy band from 25 GeV to a few tens of TeV.

MAGIC-I. Working together in the so-called "stereoscopic" mode the two telescopes achieve a 2-3 times better flux sensitivity and improved angular and spectral resolution. Besides, MAGIC-II is equipped with more sensitive photosensors and faster sampling digitization (2-4 GHz). IFAE was once again responsible for a key element in the second telescope: it developed a good part of the readout system of MAGIC-II and its data acquisition software. Faster sampling digitization allows very detailed studies of the development of the particle shower and by measuring the time profile of the shower it allows rejecting night sky light background on the basis of its arrival time.

In addition our group is solely responsible for the central control software of the two telescopes and for the official data center. The MAGIC data center is crucial to realise the potential of the new instrument. With the advent of the second telescope, the instrument can produce as much as 1 TB of data a night. Sustaining such a data flow is only possible by applying the latest technology in data storage and data processing. The data center was installed and entered regular operation at the nearby Port d'Informacio Cientifica (PIC) in 2009.

During the past years, IFAE has taken a major role in a hardware upgrade of the telescopes, which involves the installation of a new camera in MAGIC-I and a new readout for both telescopes. IFAE has joined Universidad Complutense de Madrid and INFN Pisa to build the readout electronics and DAQ. Besides extending the number of channels in the camera of MAGIC-I, the new readout system will have negligible dead time, improved linearity and will be even more compact than the system recently built for MAGIC-II. Most of the IFAE contributions to the upgrade were installed in 2011, although the full upgrade will only be completed in Summer 2012. It is worth mentioning that a German "Otto Hahn" fellow working at IFAE serves as Project Manager for the whole upgrade program in the collaboration.

Another member of IFAE, Juan Cortina, was elected spokesperson of the MAGIC collaboration at the end of 2011.

Discovery of the first VHE γ-ray sources with the telescope system took place in the last months of 2009 and first months of 2010. The instrument has discovered numerous Active Galactic Nuclei along 2011 thanks to its improved flux sensitivity and reduced energy threshold. IFAE is deeply involved in extracting physics out of the VHE γ- ray observations with the two telescopes. In 2011 the MAGIC collaboration published ten journal articles; the IFAE group initiated or took a leading role in many of them. A PhD thesis and a master thesis were completed during this year.

Fundamental physics remains one of the key programs of MAGIC and of the IFAE group in particular. One of the most popular dark matter candidate particles, the neutralino, may pair-annihilate into VHE γ-rays. Regions of high neutralino density may thus be detectable with Cherenkov telescopes. MAGIC has searched for such signatures in the center of Segue 1, a dwarf Spheroidal galaxy orbiting our own Milky Way galaxy. The fraction of dark matter in the total mass of dwarf spheroidals is remarkably high and Segue 1 is also especially near to Earth, therefore one expects it to be one of the best candidates to detect VHE γ- rays from neutralino annihilations. However no evidence for the presence of dark matter was found.

Two members of IFAE have been instrumental in generating one of the highlights in the field of VHE astrophysics in 2011, namely the finding that pulsar emission extends beyond 100 GeV. The Fermi/LAT satellite detector has recently discovered tens of pulsars at 100 MeV- 10 GeV energies. Emission in these pulsars is consistent with the acceleration of primary electrons in the so-called "outer gap", which is at the outermost regions of the pulsar magnetosphere. Several years ago, a paper published by MAGIC in Science magazine had in fact isolated the "outer gap model" as the only feasible mechanism to produce VHE gamma rays, when it discovered that the Crab pulsar emitted γ- rays beyond 25 GeV. Now, in 2011, the VERITAS and MAGIC telescopes have provided evidence of γ- ray emission from the Crab pulsar much beyond 25 GeV. MAGIC observes pulsed emission up to the highest energy ever recorded for a pulsar: 400 GeV. And for the first time, a single instrument has produced an uninterrupted spectrum for a pulsar from some tens of GeV to 400 GeV.

The spectrum measured by MAGIC follows one single power law and is once again in conflict with the theoretical expectations. This spectrum essentially rules out the remaining "outer gap model" of γ- ray emission. Either this model is complemented with additional emission from other particles in the magnetosphere or the VHE γ- rays observed by MAGIC stem from outside the magnetosphere, such as for instance the region where particles leaving the pulsar get reaccelerated and generate the wind which powers the Crab Nebula.

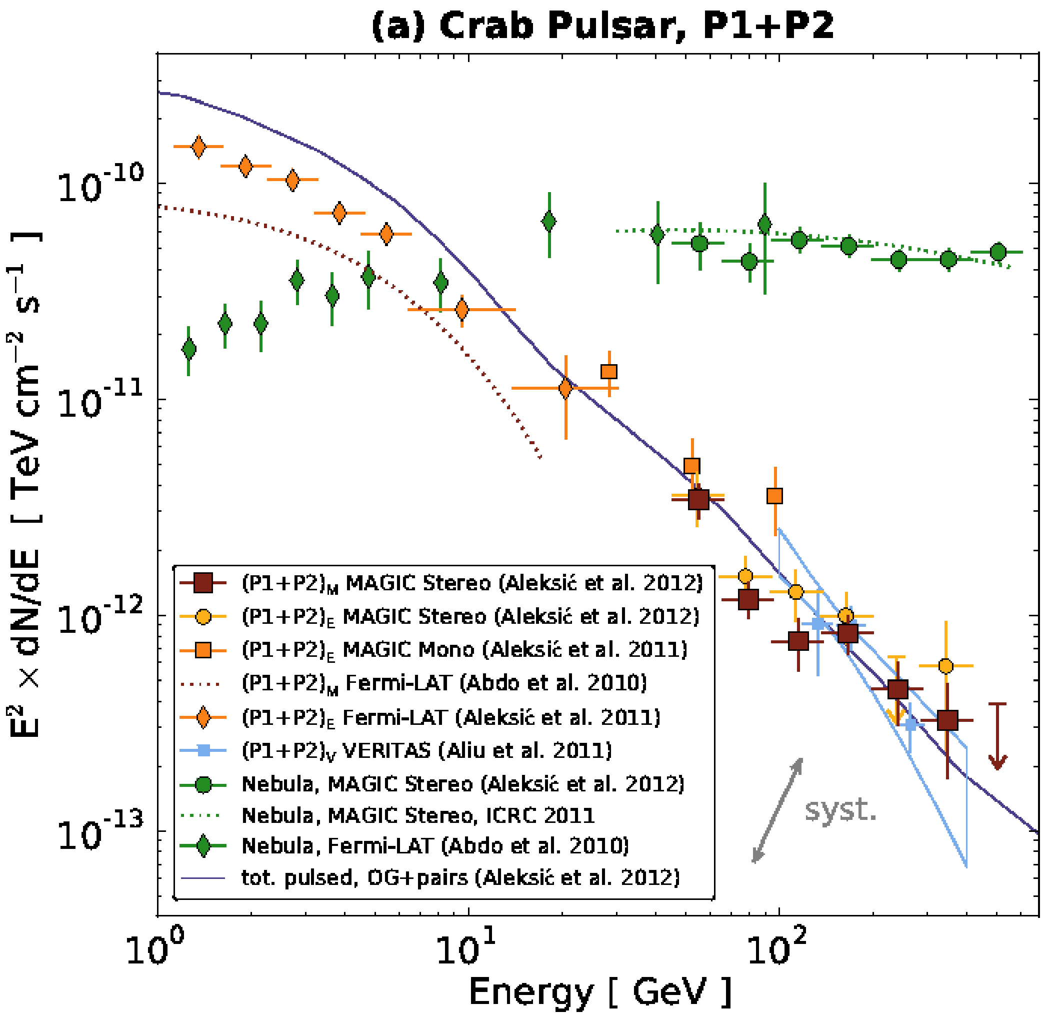


Fig 2: Compilation of spectral measurements of MAGIC, VERITAS and Fermi-LAT for the two emission peaks of the Crab pulsar together. The spectrum measured by MAGIC (orange, yellow and red symbols) from 25 GeV to 400 GeV follows a power law, in clear contrast with the expectations of the outer gap model of a sharp spectral cutoff at a few GeV.

2.6 CTA: Cherenkov Telescope Array

Manel Martínez

The Cherenkov Telescope Array (CTA) project is an initiative to build the next generation ground-based very high energy gamma-ray instrument. It will serve as an open observatory to 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 Very High Energy (VHE, E > 10 GeV) gamma-rays and investigate cosmic non-thermal processes, in close cooperation with observatories operating at other wavelength ranges of the electromagnetic spectrum, and those using other messengers such as cosmic rays and neutrinos.

Besides 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 design foresees a factor of 5-10 improvement in sensitivity in the current very high energy gamma ray domain of about 100 GeV to some 10 TeV, and an extension of the accessible energy range from well below 100 GeV to above 100 TeV.

CTA is included in the 2008 roadmap of the European Strategy Forum on Research Infrastructures (ESFRI). It is, among the “Magnificent Seven” large projects of the European strategy for astroparticle physics published by ASPERA, the one with the highest priority to start construction. It is also highly ranked in the “strategic plan for European astronomy” of ASTRONET. In addition CTA is a recommended project for the next decade in the US National Academies of Sciences Decadal Review.

This section summarizes the activities and achievements on the different subjects in which IFAE is participating in the CTA Project.

Management in CTA and CTA-Spain (Manel Martínez)

At the beginning of 2011 Manel Martínez was re-elected co-spokesperson of the CTA Consortium for the whole duration of the CTA Preparatory Phase, which is expected to end by 2014 when the construction phase shall start.

The year 2011 constituted the first year of the CTA Preparatory Phase, partially supported with funds from the FP7 EU program. During 2011 Manel Martinez, as member of the highest level management in CTA, contributed to establishing the CTA Project Office in Heidelberg and to all the project management decisions and reviewing processes carried out for the site selection, prototyping actions and preparation for construction and operation towards a Technical Design report that should be delivered to the funding agencies prior to starting construction.

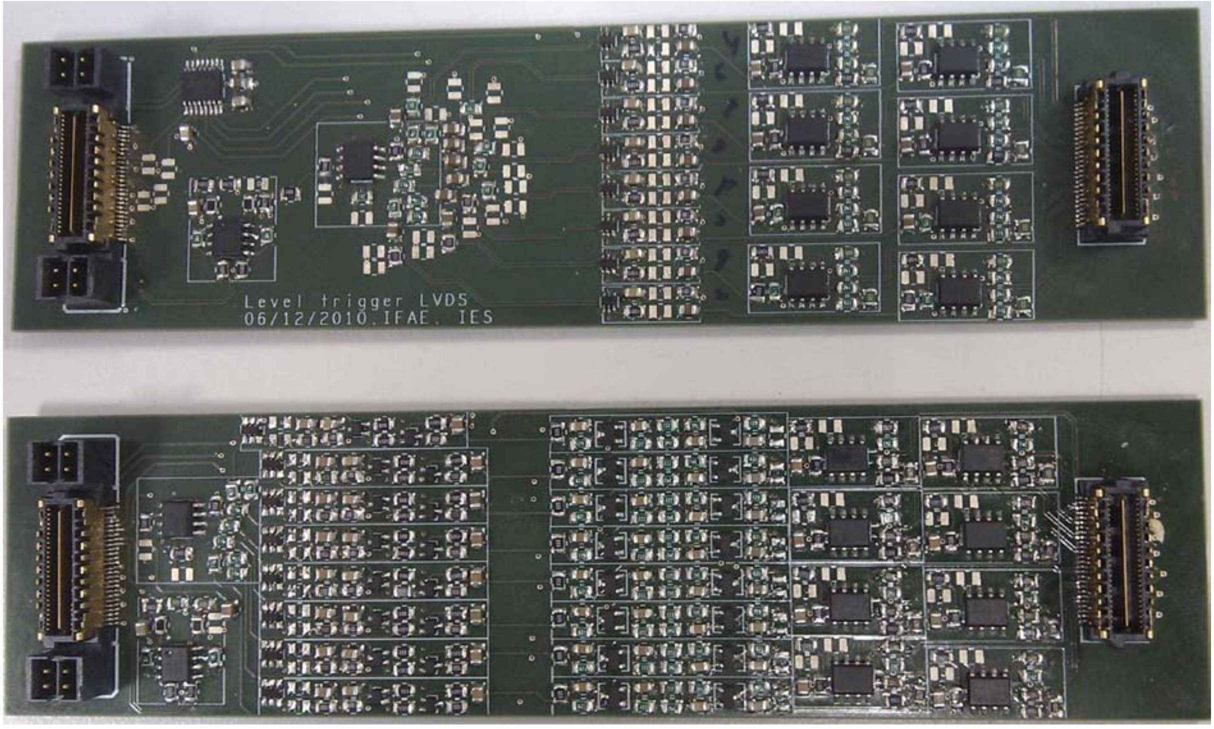


Fig 1: Level-0 trigger boards developed at IFAE.

During the year 2011 he also continued his role as Coordinator of the 9 Spanish groups that presently constitute the CTA-Spain Consortium. A few important achievements of CTA-Spain were:

-The preparation of a proposal of Tenerife as the site for the CTA-North observatory, approved by MICINN.
-The preparation of a detailed report proposing Tenerife as the site for the CTA-North observatory submitted to the CTA Consortium.
-The preparation of a coordinated application of the whole CTA-Spain to a MICINN program specific for ESFRI infrastructures, which was successful.
-A CTA General Meeting organized in Madrid in December 2011 with over 350 attendants.

Trigger Electronics (Oscar Blanch)

The general camera trigger strategy in current Cherenkov telescopes looks for an excess of signal localized in a relative small region of the camera in a few nanosecond time window. 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 hardware autonomous element: the cluster, 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. Two different Level-0 trigger boards (figure 1) have been developed, characterized and tested at IFAE. They are a compact, low cost and low power consumption implementation of concepts already used with great success in previously built Cherenkovtelescopes. The so-called Sum trigger Level-0 adds the analogue signal from all pixels in the cluster and sends the resulting signal to the Level-1 decision subsystem.

Before adding the signals from individual pixels, each of them goes through attenuator and clipping circuits (both slow-control adjustable). The former allows us to equalize all pixel gains with a precision better than 5%. The latter cuts signals greater than a given value, which limits the influence of after-pulses from the photosensors. The other concept implemented is the so-called majority trigger. This compares the signal from each pixel to a voltage threshold. If the signal is greater than the voltage, a gate, of width proportional to the time the pulse exceeds the threshold, is generated. The gates, generated in all pixels in all clusters, are analogically added. The amplitude of the added signal is proportional to the number of pixels with a signal above the threshold, and is sent to the Level-1 decision subsystem.

The level-0 trigger is just the first step of the camera trigger system planned for CTA. It follows the level-1 decision and the trigger distribution. The former uses the level-0 from several clusters to take a decision on triggering the camera. The latter distributes the camera trigger to all clusters so that the readout starts. The integration and test of the full trigger system has been done at IFAE (Figure 2). An automatic procedure based on Labview has been developed. It allows to test and characterize the full trigger system as well as to validate all the calibration processes that may be needed. Both the setup and the Labview routines should be the seed for the quality control and characterization that will be needed during the production phase.

Barcelona LIDAR (Oscar Blanch and Manel Martinez)

A LIDAR (LIght Detection And Ranging) is an optical remote sensing technology that can measure the distance to, or other properties, of a target 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 extended applications. The LIDARs installed in the CTA observatory will be used to monitor and characterize the atmosphere. This should allow both to reduce the systematic uncertainties one the imaging air Cherenkov technique and

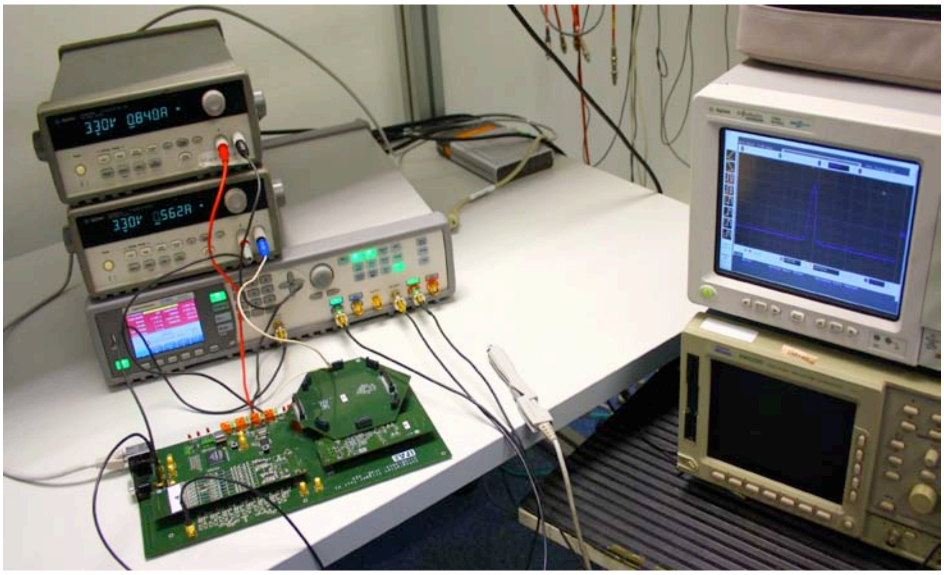


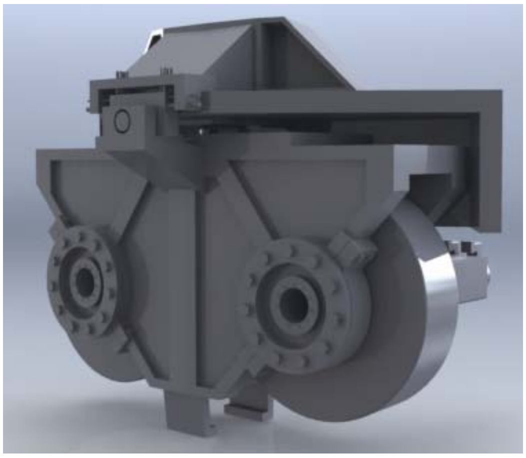
Fig 2: Set up to test and characterize the fully integrated trigger system foreseen for the CTA cameras.

to increase the duty cycle 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 implies the need of also using 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 around 10 km above ground.

IFAE had acquired two old telescopes with a 1.8 m diameter already installed in a standard ship container. They were part of the former CLUE experiment. One of them is sitting in the campus of the Universitat Autònoma de Barcelona and it is used to develop a Raman LIDAR that fulfils the needs of the CTA observatory. The main properties of the mirror like its reflectivity and point spread function were measured. While the former showed some deterioration, the latter is basically the same as when the mirrors where produced. The quality of the mirror was found to be still good enough to satisfy the needs of the LIDAR. Not only the mirror is being used but also the mechanical part of the telescopes and the motors steering its movement. In order to use this part of the apparatus a new control system was designed and spares for all components were identified. On the other hand, the laser and optical system to detect the light had to be designed from scratch. The conceptual design was completed during 2011, leading to a coaxial LIDAR with the optical detector installed behind the reflector surface. This implies that the light concentrated by the mirror in the focal plane should be brought to the optical detector. For that a liquid guide light, with higher transmittance than standard guide lights, is used. The properties of the liquid light guide were measured in the laboratory. The good transmittance was confirmed and it was tested that it hardly depends on the temperature and on the path it follows. On the other hand, the laser has been installed at the edge of the mirror on top of a structure that can be moved with an X-Y table. To make the system coaxial between the telescope axis and the laser, a system of two parallel mirrors is used.

Bogie, Central Axis and Foundation (Juan Cortina)

IFAE is responsible for the undercarriage, central axis and foundation of the CTA Large Size Telescopes. Different designs for the undercarriage have been under consideration during 2011 and a "track & wheel" type was selected as the most suitable one. Its geometry is based on several bogies, some of them equipped with tractor wheels, running on top of a curved rail anchored to a foundation and pivoting through a central axis (Fig. 3). In order to restrict the azimuth axis of the



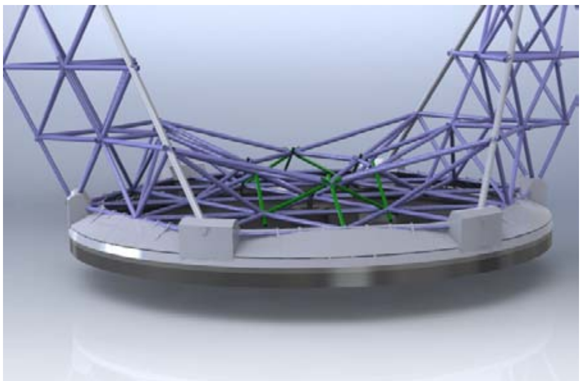
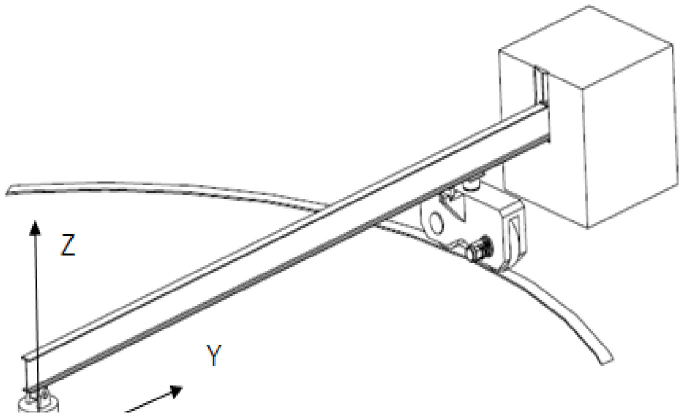


Fig 3: left : Bogie design, right: rail design

telescope a central bearing is foreseen. This will be inserted in the foundation through an aligned central axis. A detailed design of the bogie and rail is under way in collaboration with CDEI (Centre de Disseny d'Equips Industrials, UPC), with the aim of building a 1:1 prototype of one bogie and a section of the rail in 2012 (Fig. 4).

Fig 4: Test setup proposed by CDEI



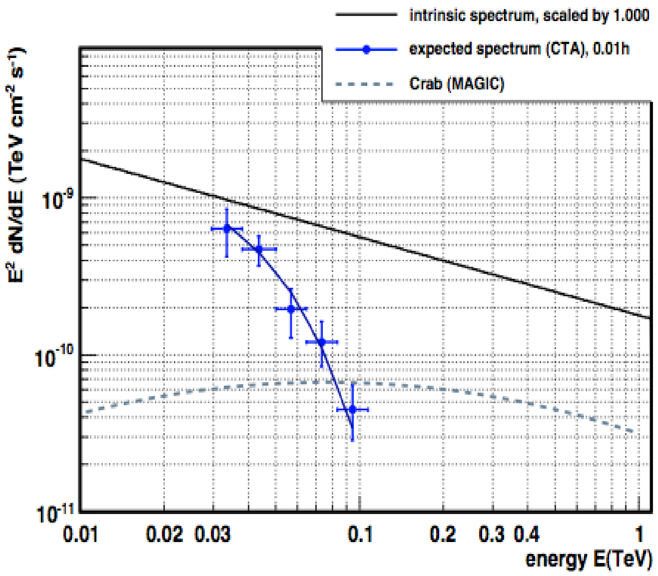


Fig 5: Simulated energy spectrum of GRB 080916C (z = 4.3) if measured with CTA.

CTA Physics Prospects (Daniel Mazin)

The activities of the physics group in CTA at IFAE in 2011 were focused on three different topics. The first topic, more technical, deals with developing of the tools, based on the ROOT code, to serve as an interface between Monte Carlo (MC) working group and Physics working group in CTA. In particular, the developed tools allow using performance files produced by the MC working group to realistically simulate the response of different CTA array layouts to specific physics cases, e.g. morphology studies of extended supernova remnants in gamma-rays or short duration gamma-ray bursts (GRBs). A release of the tools in Version 6 took place last year, featuring major improvements of aspects of the energy migration matrix and spatial offset response functions of the simulated arrays. The tools are widely used by the CTA consortium.

The second topic of the work done at IFAE in 2011 concerns simulations of CTA response to very distant sources like GRB 080916C at z=4.3. It turns out that for several CTA layouts, especially those that are optimized for low energy and foresee fast movement of the telescopes, detection and detailed energy spectrum studies of such extraordinary events become feasible (Fig. 5).

The simulation was done using the CTA array layout *B* (low energy threshold) and assuming EBL from Dominguez et al. (2011). The intrinsic spectrum is assumed to follow $2.9 \times 10^{-9} \times (E/\mathrm{TeV})^{-2.16} [\mathrm{TeV}^{-1}\mathrm{cm}^{-2}\mathrm{s}^{-1}]$ and the duration of the measurement is 45s (T0=55–100s, interval ”e”) as measured with *Fermi*/LAT (Abdo et al., 2009). A clear tion can be obtained and the spectral shape can be measured from 30 to 100 GeV.

The third and major work topic has been the preparation of an article for Astrophysics Journal Special Issue on CTA. As convener of the corresponding subgroup in CTA, D. Mazin led the efforts to summarize prospects of CTA for studies on Extragalactic Background Light and Cosmology. The article presents a detailed review on methods and results, which will become feasible once CTA goes online. The article went successfully through internal CTA review by the end of 2011 and has been submitted to the Journal in February 2012.

CTA Performance Studies (Abelardo Moralejo and Victor Stamatescu)

IFAE has been involved since late 2008 in the evaluation of the CTA performance through Monte Carlo simulations. The main task is the development of analysis methods, derived from those used for the MAGIC data, and their application to the assessment of the sensitivity, angular resolution and other characteristics of candidate CTA configurations. The results of these studies will play an important part in the final decisions concerning telescope parameters and the array layouts.

During 2011 we have carried out systematic studies of the overall performance of all the proposed CTA configurations using the official Monte Carlo library (Fig.6). We have for the first time evaluated in detail the off-axis response of CTA (Fig.7). The results obtained by the IFAE group have been widely used inside the consortium for the studies of the CTA Physics prospects.

At the same time, and given the strong involvement of IFAE in the design phase of the Large-Size Telescopes (LSTs), we have used a smaller dedicated MC production to study the low energy behaviour of the LST subarray, and check the influence of the individual telescope field of view and the camera pixel size in order to maximize the performance/cost ratio.

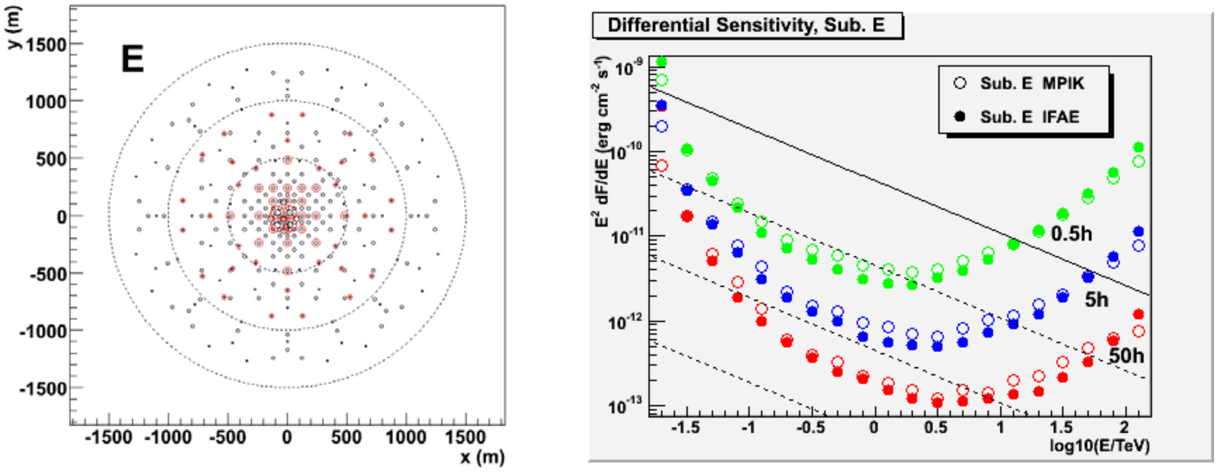


Fig. 6: Layout of one of the possible CTA configurations (red markers on the left plot) and expected flux sensitivity for different observation times (right).

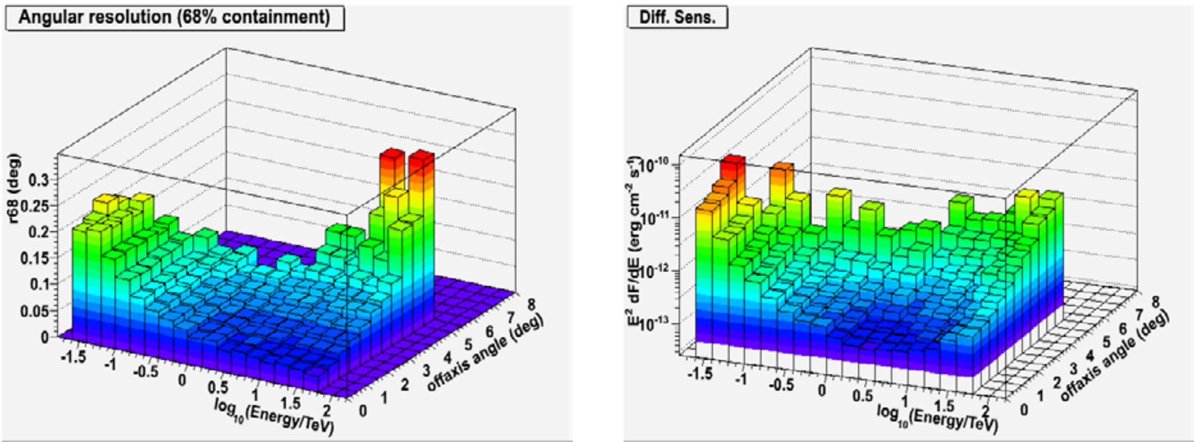


Fig. 7: off-axis performance of the same proposed layout shown in Fig. 1. Angular resolution (left) and flux sensitivity (right) are shown vs. the off-axis angle of incident gamma rays.

2.7 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), located also in the Bellaterra campus, and another at CIEMAT (Centro de Investigaciones Energéticas, Medio Ambientales y Tecnológicas) 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 square degrees of the southern galactic sky, measuring positions in the sky and redshifts of about 300 million galaxies and 10,000 galaxy clusters. Furthermore, another ~10 square degrees of the sky will be repeatedly monitored with the goal of measuring magnitudes and redshifts of about 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.

During 2011 the DES Collaboration has finished building a large CCD camera (DECam), giving images covering about 3 sq. deg. of the sky. The camera will be mounted during the first half of 2012 at the prime focus of the 4-meter Blanco Telescope, located at the Cerro Tololo Inter-American Observatory (CTIO) in Chile. In return, DES is granted 30% of all the observation time for five years (2012-2016). Figure 1 shows the completed DECam after being assembled in CTIO in fall 2011, while Fig. 2 shows the detail of the focal plane, integrating 70 2k x 4k red-sensitive CCDs.

The three Spanish groups, funded by the Astronomy and Astrophysics program 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

Fig 1: The completed DECam, shown here in CTIO in fall 2011. Note person for scale.

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 the 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 early 2011, in accordance with the schedule.

Since then, the group has focused on getting ready for the DES data analysis. At the time of this writing, the first DES science-quality data are expected by fall 2012. On top of the ongoing effort on supernova cosmology (described below), we have started to work on measurements of the large-scale structure of the universe, and, in particular, on methods for the precise and robust determination of the redshifts of the 300 million galaxies DES will observe, using photometric techniques. This choice is motivated by the parallel work on PAU (see section 2.8) and the ensuing need to optimally deploy the limited human resources of the rather small Observational Cosmology group at IFAE.

We have adapted the Bayesian Photo-Z (BPZ) package, which is the primary code we use to study the photometric redshift capabilities of the PAU camera (again, see 2.8), to the characteristics of the DES galaxy sample, and have obtained encouraging results when running it on several simulated DES galaxy catalogues. Figure 3 shows the resolution achieved in the photometric measurement of the redshifts in one of these simulated samples. The resolution is comparable with the best that can be obtained with other competing methods.

In preparation for the analysis of DES supernova data, some members of IFAE, ICE and CIEMAT joined in 2007 the program of spectroscopic follow-up of the supernovae found in the Sloan Digital Sky Survey-II project, in the redshift range between 0.1 and 0.4.

The group was awarded four full nights of observations at the Italian “Telescopio Nazionale Galileo” (TNG) in the Roque de los Muchachos observatory in La Palma (Canary Islands) in fall 2007. The observations resulted in spectra of about 25 objects, including an extremely peculiar supernova, SN2007qd. Many of these spectra have been used in a number of SDSS-II/SNe analyses, with the ensuing papers already published. More are in progress.

During 2010 we published a paper on the analysis of the properties of SN2007qd, in collaboration with colleagues from the University of Notre Dame in the United States. In 2011 we finished an analysis studying the dependence of the photometric properties of type-Ia supernovae with their distance to the center of their host galaxies. This distance can serve as a proxy for local galaxy properties, such as local metallicity, local star-formation rate, etc. It has been observed that supernova

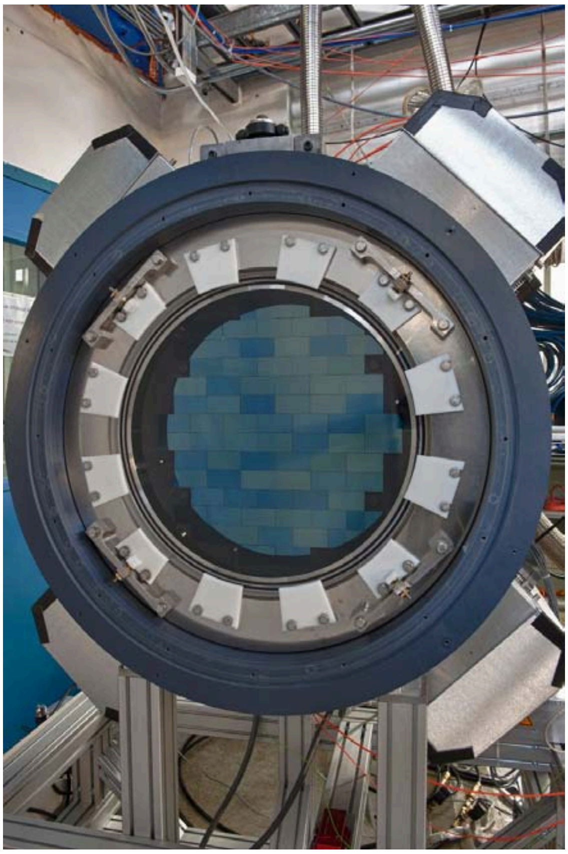


Fig 2: The complete focal plane of DECam in CTIO in fall 2011. The area covered by the 70 2k x 4k CCDs is almost 50 cm in diameter.

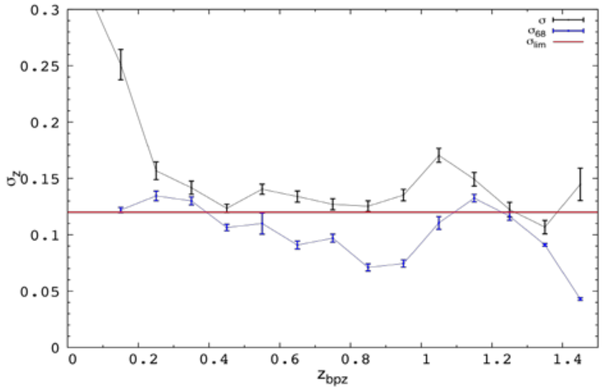


Fig 3: Expected redshift resolution in DES as a function of the measured redshift. The black points correspond to the root mean square of the distribution of the differences between real and measured redshifts, while the blue points correspond to the area encompassing 68% of this distribution. The difference is due to substantial non-Gaussian tails. The horizontal red line corresponds to the DES requirement.

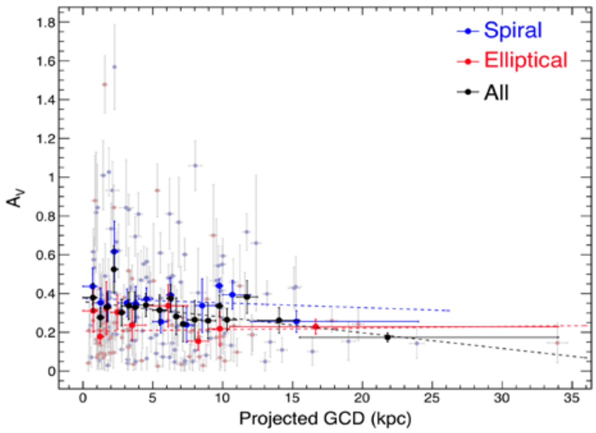


Fig 4: The amount of extinction, as measured by the parameter A_V, as a function of the projected distance between the supernovae (SNe) and their host galaxies, in kiloparsecs. SNe in elliptical galaxies are marked in red and SNe in spiral galaxies in blue. Each individual supernova is shown as a small dot, and the bold points indicate the mean values in each bin. The black bold points include both samples. The dotted lines show the best fit to the mean values. For spirals galaxies, richer in dust, A_V can be seen to decrease with increasing distance from the supernova to the center of its host.

properties do depend on the global properties of their host galaxies. Since these properties evolve with redshift, this dependence, if not corrected, would lead to systematic errors in the use of supernovae as cosmological distance indicators. Hence the interest in looking for similar effects depending on local galaxy properties. Our study indicates that, after the usual light-curve standardization, the supernova brightness does not depend on its distance to the center of the galaxy, although some other properties, like the amount of extinction by dust, do, as can be seen in Fig. 4. A paper with this study has just been submitted to The Astrophysical Journal.

Furthermore, a PhD thesis based on these two supernova analyses was presented at UAB in fall 2011, the first thesis produced in IFAE's Observational Cosmology group. Our institutional involvement in the governance of DES has been kept at a high level. During 2011 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.

2.8 The PAU (Physics of the Accelerating Universe) Project

CRISTOBAL PADILLA

PAU is a project funded by the Consolider Ingenio 2010 Program of the Spanish Ministry of Research and Innovation. The aim of the Consolider Program is 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), and after its approval in the summer 2007, it effectively started in early 2008. The work here described has been carried out in close collaboration with the IEEC and CIEMAT Teams in PAU a well as with the PIC Team in what concerns data management.

The scientific focus of the project during the first year and a half was the preparation to carry out a large astronomical survey optimized to provide a competitive measurement of Baryon Acoustic Oscillations as a probe of dark energy. Originally, the survey was intended for a two-meter telescope being built in Javalambre, Teruel. However, as it became clear that the telescope would not be available before the end of the Consolider project, in 2009 we started to investigate other options more in line with the Consolider timescale.

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). The WHT is a 4m telescope currently being run by the ING Consortium (formed by the Netherlands, Spain and the UK). This telescope is fully operational and is

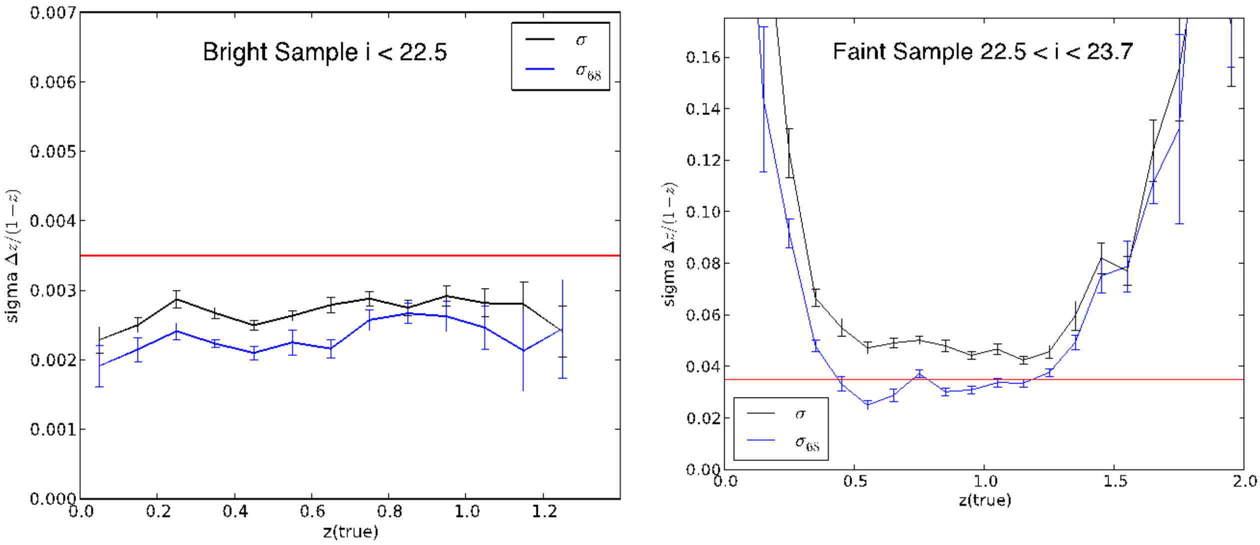


Fig 1: Resolution in redshift scaled by (1+z) as a function of the real redshift. Different colors represent different ways of computing the dispersion of the measured redshift with respect to z_{true}. The left plot represents the bright sample (i<22.7) and the right one the faint sample (22.7 < i < 24). The red lines represent the desired precision limit.

very well maintained, with a dedicated staff of about 40 persons. 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. In its meeting on May 26^{th} 2010, the ING board approved the status of visitor instrument for PAUCam and the Memorandum of Understanding was finally signed in early 2012.

The proposed instrument covers the entire FoV of the telescope with 18 2k x 4k fully-depleted red-sensitive Hamamatsu CCDs with 15□m 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 0.3 to 1 □m.

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. In the last few years a filter optimization study was performed ending up with a preferred solution with 42 narrow filters 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 first 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 (compared to spectroscopic surveys like BOSS) with a high redshift accuracy (compared to broadband photometric surveys like 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 DES and BOSS.

During 2011 a lot of information exchange with the ING team has taken place in order to fully understand the requirements for the installation of the camera in the WHT. One of the main issues is the weight limitation of 235 Kg for the instrument, which has resulted in building the camera enclosure with carbon fiber as opposed to aluminum, as it is usually made in this type of instruments. Additionally, the geometry of the camera is curved in order to minimize the wall thickness while still maintaining the needed strength. The mechanical design has been finalized in 2011 and various reviews with the ING team have taken place in order to validate the final design. Figure 3 shows a sketch of the camera installed in the prime focus of the WHT, with its swan neck (which carries all the electrical, computing and cooling services) also built in carbon fiber. The mechanical production is ongoing and is scheduled to be finalized by fall 2012.

To arrive to the needed vacuum levels of ~10^{-6} ppm, two pumps are foreseen. A turbo-molecular pump (Navigator V 301) that can operate while the camera is fixed, and a Saes Getter GP500 pump that can operate while the camera is in operating mode and must be moved with the telescope. The temperature of -100ºC needed to operate the CCD's is achieved with a set of two Polycold (Cryotiger) PCC PT30. Nitrogen cooling will also be possible when the camera is not installed in the WHT.

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 (fig. 4). One lift will carry the filters needed for the PAU survey. The other will carry a set of standard broad band 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 inside a clean room and will require the transportation of the camera to the IFAE laboratories.

In order to validate the materials and movable parts of the camera, a test set-up was built. It is shown in fig. 5, where one can see the simulated focal plane (black piece to the left) and a tray inside its parking position (right) moved by the lead screw attached to a magnetic feed-through to the outside motor.

The studies made with this setup served to validate and optimize various aspects of the PAU camera: the materials chosen to build the trays do not outgas, the lead screws do not produce dust when moved, the possible material contraction when cooling the system does not affect the operation and the active cooling of the trays is needed to minimize the filter temperature stabilization time before observation starts.

The scientific CCDs were received in September 2011. Two set-ups (one at CIEMAT and another at IFAE) have been validating the CCDs since then and have reproduced most of the results of the datasheet from Hamamatsu Photonics. Two of the main results are shown in fig. 6, where one can observe that the PAU team reproduced the expected linearity of the CCDs and the photon transfer curve. The continuous tests have resulted in the optimization of the preamplifier design, which is now almost ready for final manufacturing.

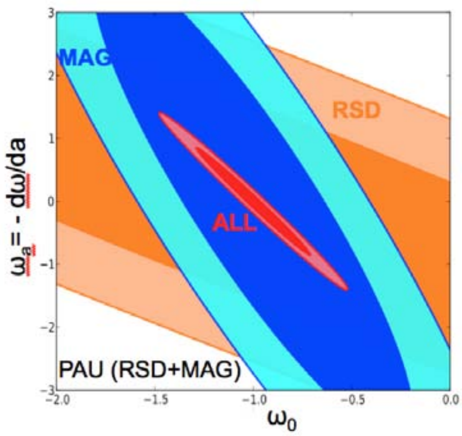


Fig 2: Contours (68% and 95% CL) for the dark energy equation of state parameter now, w_o and its evolution, w_a that can be achieved with a PAU survey of 200 deg^2 using redshift-space distortions (RSD, orange), weak-lensing magnification (MAG, blue) and combined (ALL, red).

Software and computing have also evolved favorably. The messaging system for the control and monitoring system has been finalized and a complete skeleton of the system has been integrated. Several control modules have been tested in situ in the different test set-ups. The interface with the WHT control is in place and the infrastructure for the computing needed for the data reduction is being installed at the ING.

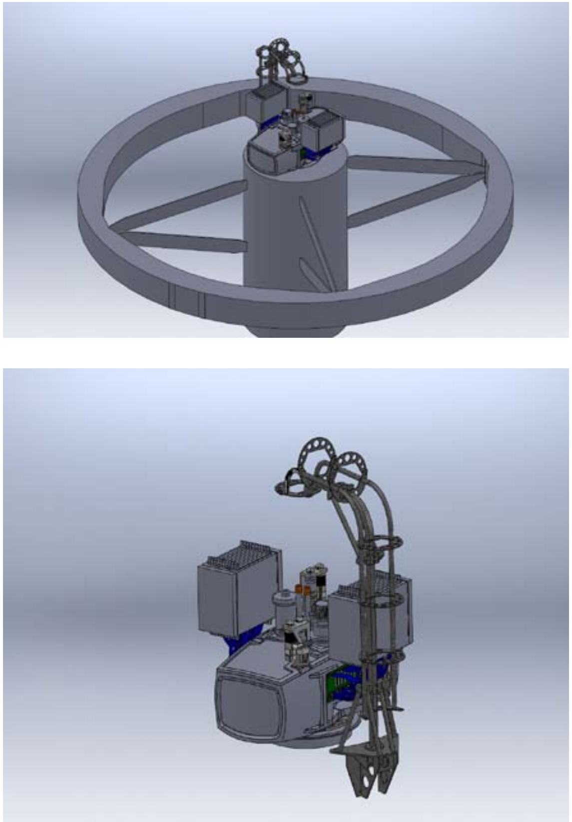


Fig 3: Overall external view of PAUCam as installed in the prime focus of the WHT (top) where the light from the telescope enters the camera from the bottom and, a detail of the camera and its swan neck with the two electronics readout crates on yop (bottom plot).

During 2011, it also became evident that PAU could provide important information for Euclid, the recently approved European Space Agency class M mission to be launched by the end of the decade within its 2015-25 Cosmic

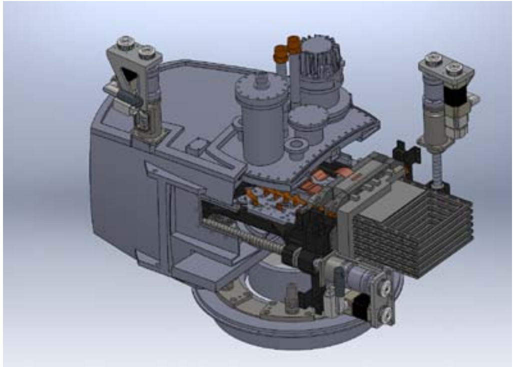


Fig 4: Detail of the interior of the PAU Camera with its movable filter trays inside the cryostat.

Vision Programme to carry out a comprehensive extragalactic survey from space and make progress in the understanding of the matter and energy content of the Universe. PAU can contribute by accurately measuring photometric redshifts for Euclid galaxies, and by helping calibrate the photometric redshifts provided by other broadband galaxy surveys.

We schedule installation of the PAU Camera in the WHT by the end of 2012. It is an ambitious yet possible goal that requires final commissioning of the camera in November after a complete assembly and tests during Autumn 2012. The PAU Camera will be a novel instrument that should probe the dark energy, produce interesting data for the EUCLID mission and be available for use to other astronomers during 2013.

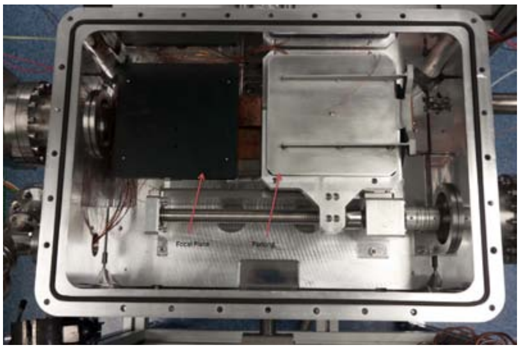


Fig 5: Test set-up to validate the conceptual design of the PAU Camera and the materials that need to go inside.

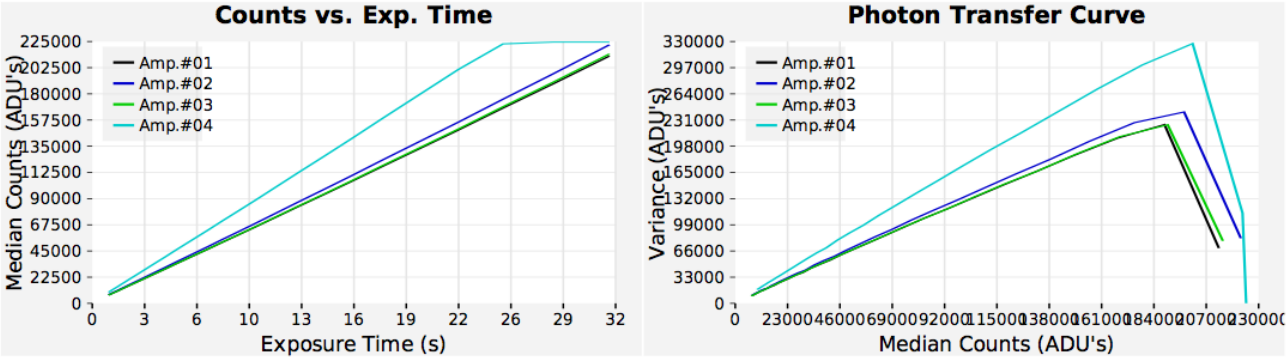


Fig. 6: Number of counts versus the exposure time (showing a good linearity for the 5 amplifiers of the scientific CCD) and the photon transfer curve.

2.9 Medical Physics

Mokhtar Chmeissani

In 2011, the medical imaging team in IFAE has worked on many fronts, related to the bump-bonding pixel detectors, mammography PET, Compton Gamma Camera, front end electronics, and provided support for X-Ray Imatek to launch its first commercial product.

Bump-bonding

Cd(Zn)Te pixel sensors require low-temperature soldering (less than 160 degrees Celsius) to avoid the diffusion of the metal (pads or solder) into the bulk of the semiconductor. We achieved a successful bonding cycle flip-chipping and bonding a CdTe pixel detector to a dedicated ASIC with a pixel pitch of 100µm. The know-how of this process has been transfer to X-Ray Imatek to use and provide flip-chip services for this type of detectors.

For the VIP project, given that the pixel pitch of the sensor is 1mm, the bump-bonding deposition is not a demanding process. We deposited low temperature solder paste of BiSn and InAg on dummy substrates that mimic the future VIP chip and pixel CdTe detector. We obtained excellent results with both types of solder materials; however BiSn seems to have an overall better yield. In figure 1 one can see dummy assemblies with BiSn solder bumps.

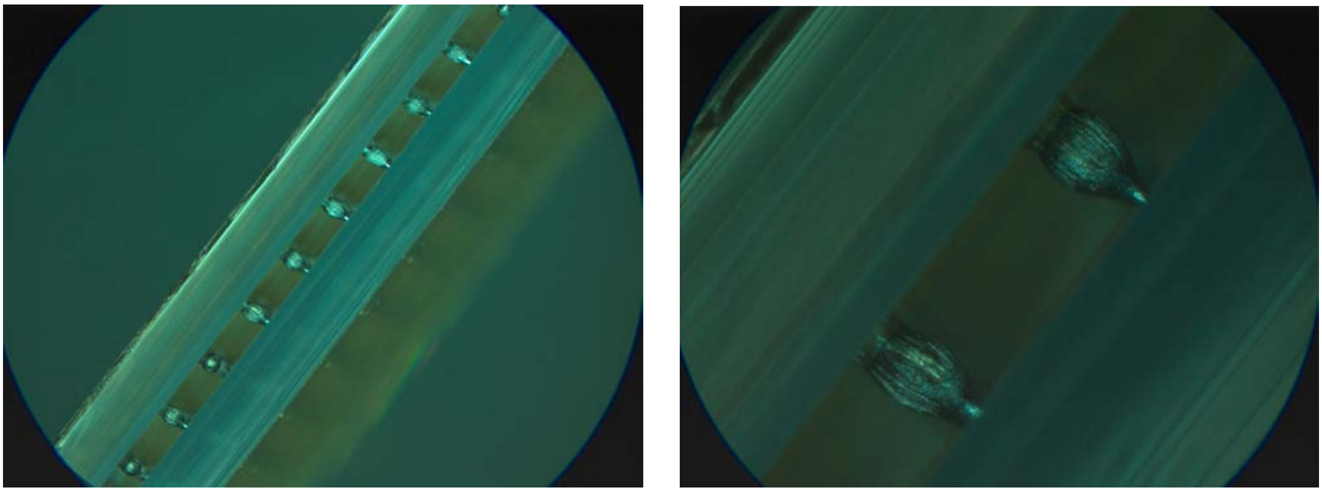


Fig 1 shows the side edge of an assembly of pixel dummy substrate to mimic the VIP pixel detector with a pixel pitch of 1mm. On the right-hand side one can see the magnified image inside the red rectangle. The BiSn solder bumps are elongated at a separation of 400µm between the two glass substrates. The yield of this process is 100% at a separation of 200µm. However when depositing solder paste using a stencil process, the amount of solder is more than needed, which and may increase the dead material in the active area. Using 50µm diameter solder bumps should be enough for the PET pixel CdTe but for this size of solder bumps we need to use more sophisticated equipment that IFAE will acquire in 2012.

The use of pixel CdTe detectors for brain PET applications has been extended to the field of mammography-PET and Compton Gamma Cameras. We simulated a mammography- PET detector, in a configuration similar to that of Naviscan, considered the best mammography-PET in the market but we used a pixel CdTe detector conceptual design, *à la* VIP , instead of scintillating crystals. Our results show that for similar dose of FDG-18, we can achieve better spatial resolution. 1.5mm x 1.5mm x 1.5mm compared to 2mm x 6mm x 2mm. This means the target tissue is located in space volume 7 times smaller, which favorably impacts the medical procedure to precisely insert the biopsy needle. We expect to publish these results in 2012.

With pixel CdTe sensors packed with VIP geometry it will be possible to construct a Compton Camera for medical imaging as shown in Fig. 2. The absorber is made of pixelat CdTe with a 4cm effective thickness. With a pixel pitch of 1mm x1mm x 2mm there are about 450 active CdTe voxels per cm^3.

$$\cos\theta = 1 - m_e c^2 \cdot \left(\frac{1}{E_\gamma - E_{\text{scatterer}}} - \frac{1}{E_\gamma}\right)$$

The The Compton equation allows calculating the scattering angle θ from the energy deposited in the scattering detector $E_{\text{scatterer}}$, and the initial gamma's energy. Knowing the positions where the scattering and the photoelectric absorption processes took place one can define a cone on which the gamma source is located, as shown in Fig. 3a. One needs at least 3 scattered events to obtain the location of the gamma source from the intersection of the 3 cones as can be seen in Figure 3b.

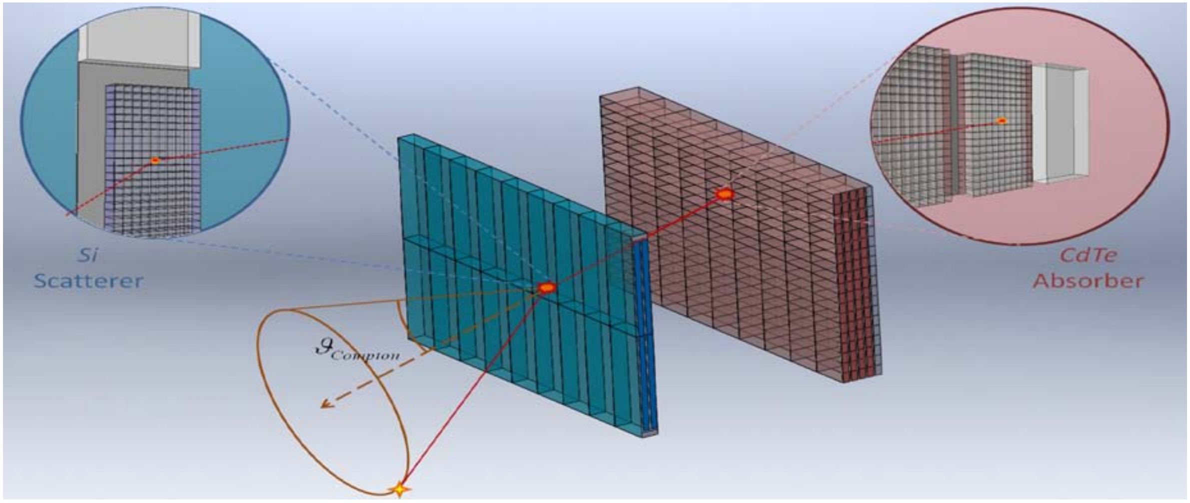
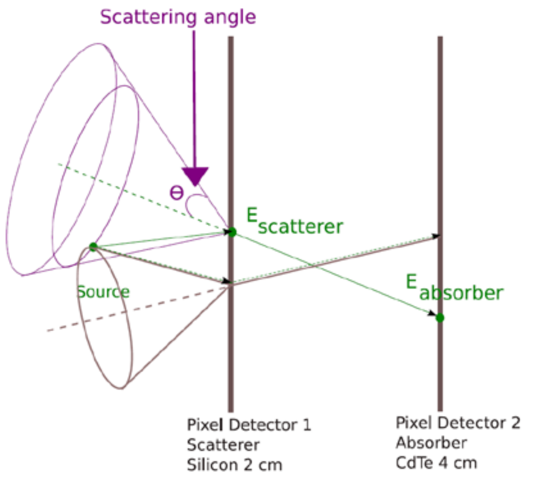


Fig 2. Shown is the VIP Compton Gamma Camera. The scattering detector is made from pixeatedl Si with an effective thickness of 2cm and the absorber is made of pixelated CdTe with an effective thickness of 4cm.



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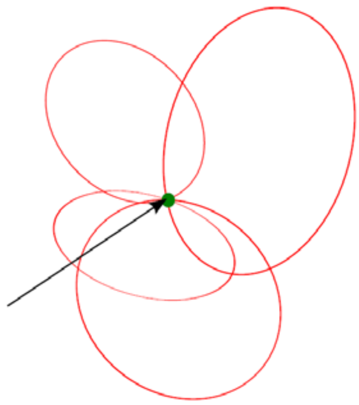
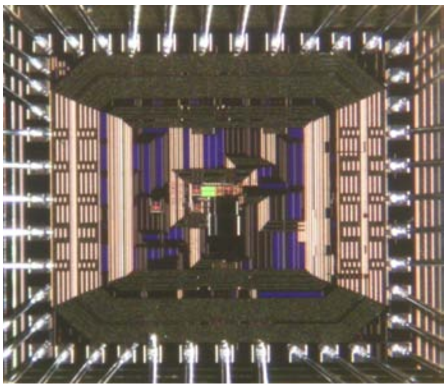


b

Figure 3.a schematically illustrates the construction the cones for each gamma-ray event using Compton scattering information. Figure 3.b shows how to locate the gamma source by the intersection of several cones.

Therefore in order to obtain a high-performance Compton Gamma Camera one needs fine granularity of the scattering and photoelectron absorption detectors which in addition must have excellent energy resolution. For 511keV photons the VIP Compton gamma camera has a sensitivity of **12 CPS/kBq,** which is **100 times** more than that of a pinhole Gamma Camera and a resolution of **0.8mm** (FWHM), much smaller than the 5mm spatial resolution provided by standard gamma cameras. In 2011 much progress towards the design of the VIP chip was made. The design is based on TSMC 0.25μm technology. The test results of the pixel cell prototype displayed in Fig. 4 show that the output of the shaped signal has a resolution better than 10 bits, the target design to achieve an energy resolution of 1keV.



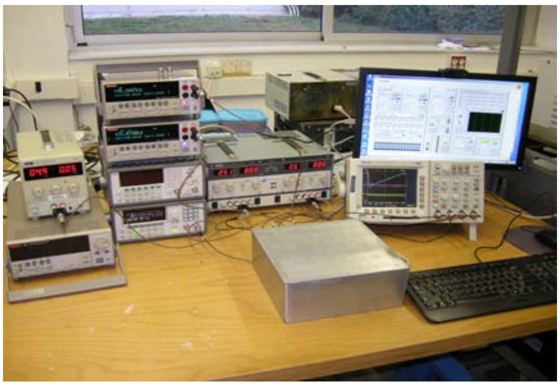


Fig. 4. On the left-hand side one can see the VIP pixel design, measuring 2mmx 2mm. The active part is less than 200μm x 200μm. On the right-hand-side is shown the chip test setup based on Labview data acquisition.

X-ray Imatek SL

2011 was a difficult but positive year for X-Ray Imatek. Due to the economy's situation it was decided to to stop the development of the mammography. However this decision forced the company to design, produce and begin selling a different product before the end of the year. This was possible thanks to the knowledge and experience gathered over the past decade.

The first commercial product developed by X-Ray Imatek is the XRI-UNO. A picture of the device is shown in Fig. 5. This state-of-the-art X-ray detector consists of a single Timepix chip bump-bonded to a 300 µm silicon sensor. It can take more than 300 frames per second and it is very simple to install and to run. The XRI-UNO comes with its own software allowing the user to take images with the detector in a matter of minutes.

The XRI-UNO is primarily sold as a research tool for X-ray imaging; several university groups have already purchased this detector. It can also be used as a demonstrator of the capabilities of the Timepix chip, especially if a company wants to learn the photon counting technology. Several companies have bought the XRI-UNO and are interested in using its technology.

In 2011, X-Ray Imatek has also begun offering its flip-chip services. The company offers custom-tailored flip-chip services to clients who bring their own ASIC and sensor. Flip-chipping on silicon and cadmium telluride are available. In addition, flip-chip services especially developed for the Medipix chip (which requires high density bumps) are available. XRI sold several Medipix/sensor assemblies to different clients.

Selling the first X-Ray Imatek products marks an important milestone. The expectations for 2012 are very positive. Furthermore, X-ray Imatek has embarked in a software development kit (SDK) whereby users can build around the Medipix chip applications to address their needs. Also, it started the work on an XRI-CUATRO device that will have four chips side-by-side thereby offering an imaging area of almost 8 cm^2.

Fig. 5: Image of the XRI-UNO device.

2.10 Standard Model

Matthias Jamin

The Standard Model (SM) group 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, precise values of fundamental SM parameters are essential inputs and beyond-SM physics should show up as clashes in pure SM predictions. During 2011, the main research fields in our group were hadronic decays of the B meson and the τ lepton, mesonic interactions, chiral perturbation theory, also including higher-mass vector and scalar mesons in the framework of resonance chiral perturbation theory, as well as studying the structure of higher-order corrections in QCD perturbation theory through analytic methods like Mellin-Barnes transformations.

In the field of hadronic B decays, we have presented a new systematic approach to constrain the Wilson coefficients of the electromagnetic dipole operator (O_7, C_7), the semileptonic operators (O_9, O_{10}), and their chirality-flipped counterparts. We considered a complete set of observables like $B \to X_s\mu\mu$, $B \to X_s\,\gamma$, isospin and CP asymmetry in $B \to K^*\gamma$, as well as the forward-backward asymmetry in $B \to K^*ll$. We have provided semi-numerical expressions for all these observables. Analysing the sign of the Wilson coefficient C_7 using this procedure was relevant for the forward-backward asymmetry. The absence of a zero in C_7 was pointed out last year as a possible first signal of New Physics. Recent experimental analyses disfavoured this possibility in agreement with our theoretical analysis.

Investigations of QCD at relatively low energies can be conveniently performed through the study of hadronic decays of the τ lepton, 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 still retains its perturbative character. 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. Moreover, the recently improved measurements of the τ decaying into strange final states opened the possibility to also determine parameters in this sector, like the strange quark mass and the quark-mixing-matrix element V_{us} .

In 2011, we completed the first determination of α_s from hadronic τ decays that includes in a self-consistent way all non-perturbative effects such as higher-order terms in the operator product expansion (OPE), as well as Duality Violations (DVs) of the quark-hadron duality. Though these effects are suppressed compared to the purely perturbative contribution, at the level of current precision, they can no longer be neglected. Our analysis was based on the original OPAL 1998 τ decay data, obtained at the LEP accelerator at CERN. Such data are in principle also available from the ALEPH collaboration. However, in the course of our study we discovered an inconsistency in the error correlations provided by the ALEPH group, such that the publicly available data should presently not be used.

In practice the determination of α_s proceeds through fits of all theoretical parameters, that is, α_s and OPE parameters, as well as DV parameters, to weighted integrals of the measured τ decay spectral functions (so-called moments), integrated up to an energy s_0. An example is shown in Figure 1 where fits ar e shown with the weight function *w(x)* = 1 in the moment integrals. The much better description of the data with fits that include DVs (blue and red lines) clearly points to the necessity of including them. Fits to higher-moment weight functions are also possible, but less reliable due to the very strong correlations of the employed moments. An analysis of updated OPAL data is currently under way, together with a study of possible improvements with the available, but not yet analyzed, BaBar and Belle τ decay data.

Analyzing hadronic interactions, the hadronic decay η'→ηππ was studied in the frameworks of large-N_c Chiral Perturbation Theory (ChPT), at lowest and next-to-leading order, and Resonance Chiral Theory (RChT) in the leading $1/N_c$ approximation. Higher order effects such as π-π final-state interactions were taken into account through a detailed unitarization procedure. The inclusion offinite -width effects in the case of RChT was also discussed. The Dalitz plot distribution and the differential branching ratio were computed in both approaches. A typical result for the Dalitz plot distribution is shown in Figure 2. The predicted Dalitz plot parameters obtained from the different treatments were compared with the most recent measured values. It was found that the η'→ηππ branching ratios are easily understood, while the Dalitz plot parameters require the inclusion of π-π loops in order to achieve a reasonable agreement. Our final predictions agree with the experimental measurements. Our results should be of relevance for present and future experimental analyses of these decays.

Analytical tools have proved useful to study the behaviour of higher-order perturbative corrections. With the help of the Mellin-Barnes transform, we showed how to simultaneously resum the expansion of a heavy-quark correlator around $q^2 = 0$ (low-energy), $q^2 = 4m^2$ (threshold, where m is the quark mass) and $q^2 = -\infty$ (high-energy) in a systematic way. We exemplified the method for the perturbative vector correlator at $O(\alpha_s^2)$ and $O(\alpha_s^3)$. We showed that the coefficients, Ω(n), of the Taylor expansion of the vacuum polarisation function in terms of the conformal variable ω admit, for large n, an expansion in powers of 1/n (up to logarithms of n) that we can calculate exactly. This large-n expansion has a sign-alternating component given by the logarithms of the OPE, and a fixed-sign component given by the logarithms of the threshold expansion in the external momentum q^2. Using this method, we reconstruct the two-point correlators in the vector, axial, scalar and pseudoscalar channels from the Taylor expansion at $q^2 = 0$, the threshold expansion at $q^2 = 4m^2$ and the OPE at $q^2 \to -\infty$, where m is the heavy quark mass. The reconstruction is analytical and

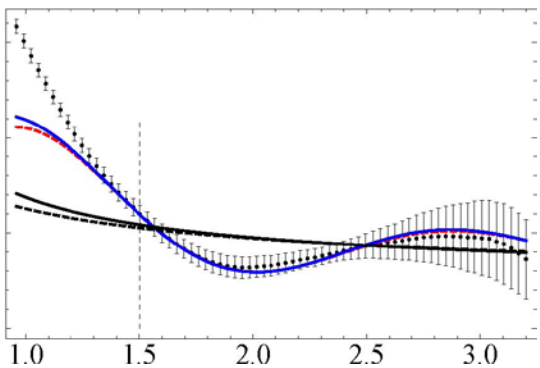


Fig. 1: Fit to the w(x) = 1 spectral integral for the vector channel. The blue and red (solid) lines show a fit including duality violations for fixed-order as well as contour-improved perturbation theory. The much flatter solid and dashed black lines represent the corresponding pure OPE result omitting DVs.

systematic and is controlled by an error function that becomes smaller as more terms in those expansions are known. Furthermore, we discussed the possible validity in QCD of a relation between Green functions that has been recently suggested by Son and Yamamoto, based on a class of AdS/CFT-inspired models of QCD. Our conclusion is that the relation in question is unlikely to be implemented in QCD.

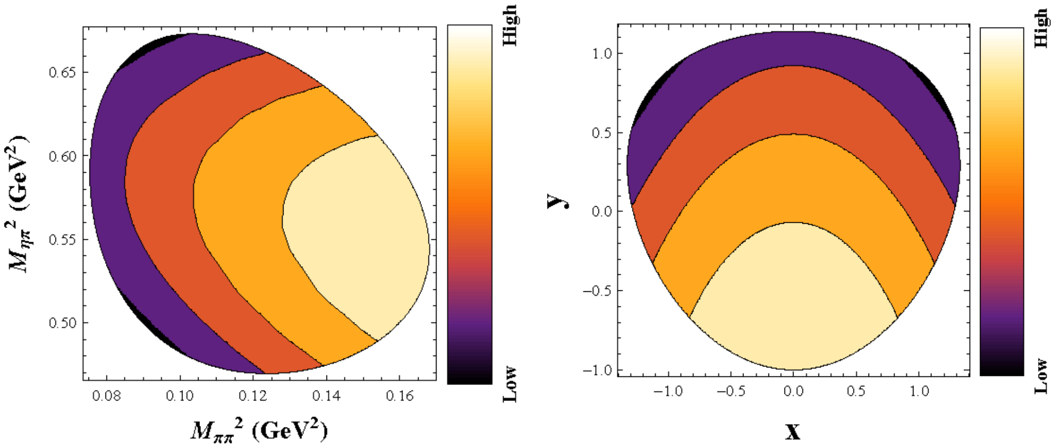


Fig. 2: Dalitz plot distribution of $\eta'\to\eta\pi\pi$ supplemented by rescattering effects, in terms of the invariant masses $M^2(\eta\pi)$ and $M^2(\pi\pi)$ (left) and the kinematical variables X and Y (right). Larger values are shown lighter.

2.11 Beyond the Standard Model

José Ramón Espinosa

In the field of Physics Beyond the Standard Model (BSM), we continued exploring the following lines. 1) BSM phenomenology: Extra Dimensions, Supersymmetry, Higgs Physics, Exotics. 2) Cosmology: Electroweak Baryogenesis and the physics associated to cosmological phase transitions.

1) BSM Phenomenology

Extra Dimensions: We proposed a mechanism to suppress dangerous contributions to the electroweak precision observables in 5D warped models (from Kaluza-Klein (KK) modes to the T parameter), without the need for an extended 5D gauge sector. The main ingredient is a modification of the AdS metric in the vicinity of the infrared (IR) brane corresponding to a strong deviation from conformality in the IR of the 4D holographic dual. This gravitational background is generated by a bulk stabilizing scalar field which triggers a natural solution to the hierarchy problem. Depending on the model parameters, gauge-boson KK modes can be consistent with present bounds from electroweak precision tests for $m > 1$ TeV at 95% CL. The model contains a light Higgs mode which unitarizes the 4D theory.

In the same context, we also examined the possibility of making a heavy SM Higgs compatible with electroweak precision measurements. If the Higgs boson propagates in the 5D bulk, the KK modes of the gauge bosons can compensate for the Higgs boson contribution to oblique parameters while their masses lie within the range of the LHC (fig .1). The little hierarchy between KK scale and Higgs mass essentially disappears and the naturalness of the model greatly improves with respect to the AdS (Randall-Sundrum) model. In fact, the fine-tuning is better than 10% for all values of the Higgs boson mass. Comparison with current experimental data on R_b, FCNC and CP-violating operators shows that the behavior of the model is better than the RS model.

Supersymmetry: We proposed the minimal (Least) version of the Supersymmetric Standard Model which can solve the hierarchy problem in the same way as the so-called Minimal Supersymmetric Standard Model (MSSM) and can solve some of its problems. Supersymmetry breaking is gauge mediated to the first two generations whose sfemions get masses of order 10 TeV and also mediated by gravity, which generates masses for all sfermions, higgsinos and gauginos at the TeV scale and can provide appropriate values to the μ and $B\mu$ parameters by D-term effective operators. LHC phenomenology is characterized by the fact that only third generation squarks and sleptons are present.

Higgs Physics: We updated the instability and metastability bounds of the SM electroweak vacuum after the recent ATLAS and CMS Higgs results. For M_H=124--126 GeV, the Higgs potential develops an instability around 10^{11} GeV, with a lifetime much longer than the age of the Universe (fig. 2), although with the current precision, stability up to the Planck scale cannot be excluded. Stability at finite temperature sets an upper bound on the reheat temperature after inflation. A Higgs mass in the range 124--126 GeV is compatible with very high values of the reheating temperature, without conflict with mechanisms of baryogenesis such as leptogenesis. We derive an upper bound on the mass of heavy right-handed neutrinos by requiring that their Yukawa couplings do not destabilize the Higgs potential.

We have also used these data to update the stringent limits on the parameter space of some composite Higgs models, in which Higgs phenomenology at the LHC can deviate significantly from the SM. Exotics: The Lee-Wick (LW) SM offers a new solution to the hierarchy problem. We studied its peculiar UV behaviour and showed how quadratic divergences in the Higgs mass cancel as a result of the unusual dependence of LW fields on the Higgs background. We examined the energy evolution of the Higgs quartic coupling lambda above the LW scale. In contrast with the SM case, for any Higgs mass, λ grows monotonically and hits a Landau pole beyond the Planck scale (never turning negative in the UV). Then, the perturbativity and stability bounds on M_H disappear.

2. Cosmology

Electroweak Baryogenesis: The generation of the observed baryon asymmetry may have taken place during the electroweak phase transition, thus involving physics testable at LHC, a scenario called electroweak baryogenesis. We have shown that the magnetic field which is produced in the bubbles of a first order phase transition endangers the baryon asymmetry produced in the bubble walls by lowering the sphaleron energy and then making easier the wash out of the baryon asymmetry. We applied this study to the MSSM, showing that even for moderate values of the magnetic field, the Higgs mass required to preserve the baryon asymmetry is below the experimental bound.

We also addressed EW baryogenesis in composite Higgs models, showing that modifications to the Higgs and top quark sectors can play an important role in generating the baryon asymmetry. We showed that composite Higgs models with a light singlet scalar (as in the model based on the SO(6)/SO(5) coset) have all the necessary ingredients for viable baryogenesis. In particular, the singlet leads to a strongly first-order electroweak phase transition and introduces new sources of CP violation in dimension-five operators involving the top quark. We discussed the amount of baryon asymmetry produced and the experimental constraints on the model.

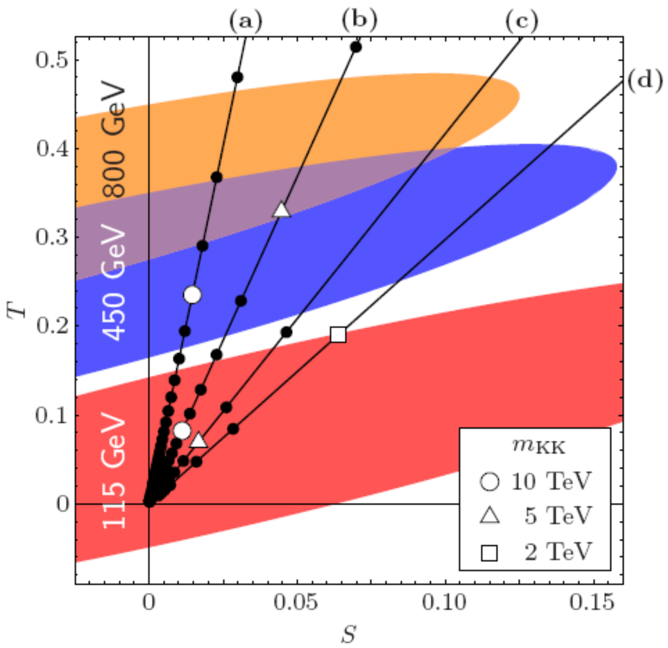


Fig. 1: 95% CL regions in the (S,T) plane for different values of the Higgs mass. Rays (a) and (b) correspond to a Randall-Sundrum metric with a localized and a bulk Higgs, respectively. Rays (c) and (d) correspond to a deformed metric model with two different deformations of the AdS metric. Dot spacing is 1 TeV, and increasing values of the KK masses correspond to incoming fluxes.

Strong Phase Transitions: We thoroughly studied how one scalar singlet can lead to a strong first-order EW phase transition for realistic values of the Higgs mass. We identified all regions in parameter space that develop a transition strong enough to avoid sphaleron wash-out of the baryon asymmetry and have reached a very good theoretical control and understanding of the different possible mechanisms that achieve this. We identified a new such mechanism, based on a flat direction developing at the critical temperature, which could operate in other models.

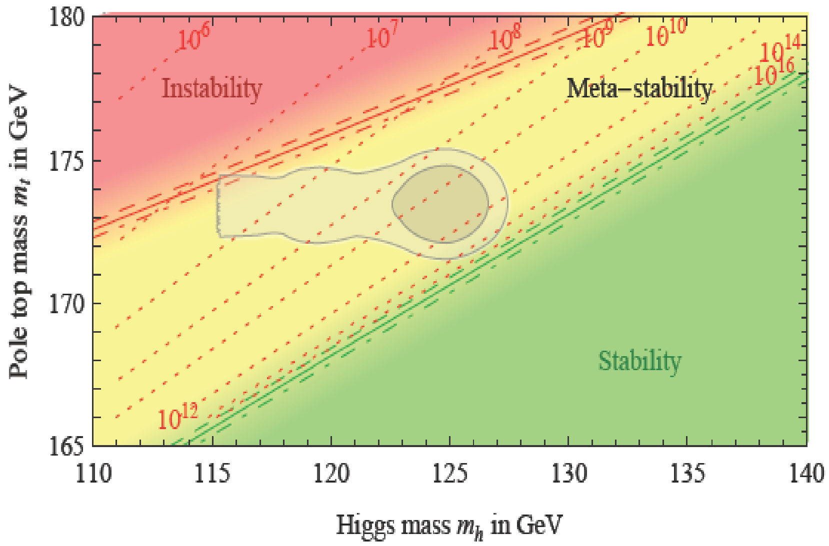


Fig. 2 : Measured value of the top mass and preferred range of m_h compared to the regions corresponding to absolute stability, meta-stability and instability of the SM vacuum. The three boundaries lines corresponds to $\alpha_s(M_Z)$ = 0.1184+- 0.0007, and the grading of the colors indicates the size of the theoretical errors. The dotted contour-lines show the instability scale in GeV assuming $\alpha_s(M_Z)$ = 0.1184.

2.12 Astroparticles & Cosmology

Oriol Pujolàs

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. The key questions addressed range from what is causing the late-time acceleration of the universe, can it be that gravity is modified at large distances, to what is the nature of dark matter, what are the properties of neutrinos, what is the origin of cosmic rays, or what is the physics responsible for baryogenesis. During 2011, the work done by the members of the Theory Division in this research area can be divided in the following topics:

Dark Matter

We have proposed and studied a new type of Dark Matter (DM) model where the DM particle is the pseudo-Nambu-Goldstone boson (pNGB) associated with an approximate symmetry of the neutrino seesaw sector. PNGBs are naturally light, spin-zero particles that can be interesting DM candidates. The PNGB, θ, acquires couplings to the SM fields through the so-called Higgs-portal since a small coupling to the Higgs is radiatively induced by the neutrino Yukawa couplings. By virtue of this interaction, (i) the pNGB acquires a mass m_θ proportional to the electroweak scale, and (ii) the observed DM relic density can be generated by the freeze-in of the pNGBs with mass $m_\theta \sim 3$ MeV. Alternatively, the coupling of the pNGB to heavy sterile neutrinos can account for the DM relic density, in the window 1 keV < m_θ < 3 MeV. We also concluded that the pNGBs decays into light fermions are suppressed by the seesaw scale, making such pNGBs sufficiently long-lived to indeed play the role of DM.

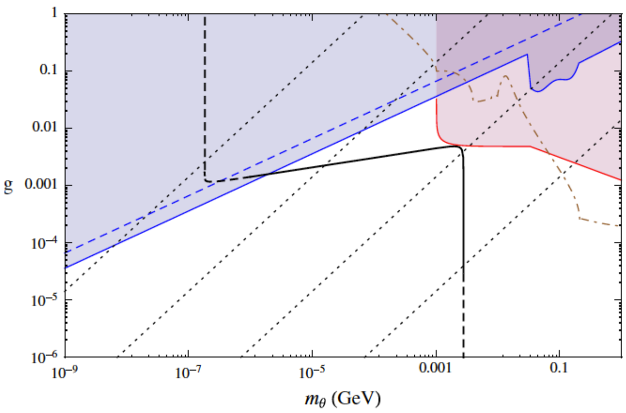


Figure 1a

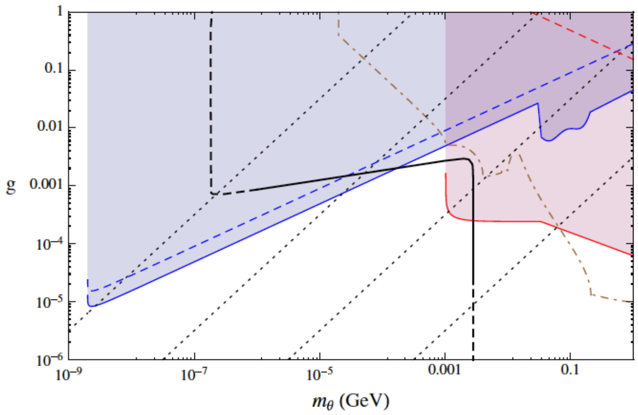


Figure 1b

Fig 1: Constraints on the DM lifetime in the g-m_ϑ plane (with g the Yukawa coupling), for light-neutrino mass m_ν=0.05eV (Fig. 1a) and m_ν=1eV (Fig. 1b). The thick black curves are the correct DM relic density. The dotted vertical lines correspond to constant values of the sterile neutrino mass. The blue solid (dashed) lines are the upper bounds on g from DM decays into neutrinos coming from astrophysics and cosmology (from the Universe lifetime); the blue shaded regions are excluded. The red solid lines are the analogous bounds for DM decays into e+e-; the red shaded regions are also excluded. The brown dashed--dotted lines are conservative estimates of the upper bound on g from DM decays into photons.

include a light scalar with peculiar derivative self-interactions that allow it to violate the null energy condition while presenting no instabilities. This permits a novel cosmological behaviour that is relevant for the late-time acceleration of the universe. A simple model of this type is the *Kinetic Gravity Braiding,* which was previously proposed by us. This model generically exhibits kinetically-driven late-time attractors that approach an accelerating universe from a (stable) phantom phase. We have further studied this type of models reformulating them in the language of the effective hydrodynamic expansion. We have found that despite being non-dissipative DE models, they can be interpreted as an imperfect fluid with a form of diffusion. Physically, the over-densities of scalar quanta diffuse away with a characteristic time according to a non-linear equation. These results are useful both to clarify the nonlinear dynamics of these models, and for the analysis of the cosmological perturbations of these models especially beyond the linear approximation.

Non-relativistic quantum gravity

One of the topics that have attracted most attention recently regarding gravity is Horava's proposal of a renormalizable non-relativistic quantum field theory of gravity. The current status of the model is that there exists at least one consistent and weakly coupled formulation of the proposal that is compatible with all known observational tests. As such, this represents a new paradigm for gravitational physics, and many aspects of the proposal require further analyses. Most notably, the mechanism to approximately recover Lorentz invariance at low energies, the question of whether the model is renormalizable beyond power-counting, the physics of black holes, or the impact on cosmology. In 2011, members of our group have studied two aspects of the proposal:

i) The robustness of the setup. We have examined several consistency issues present in three formulations of non-relativistic gravity: Horava's projectable theory, the so-called healthy non-projectable extension (previously proposed by some of us), and a new extension related to ghost condensation. We found that the only model which is free from instabilities and strong coupling is the non-projectable one. We also elaborated on the phenomenology of the latter. In particular, we obtained the parameters of the post-Newtonian expansion in this model and showed that they are compatible with current observations.

ii) The issue of the couplings to matter. This is a key point both for the phenomenology and for the proper definition of the model, since the breakdown of Lorentz invariance invalidates the usual notion of minimal coupling. We described two approaches to bypass this problem. One is based on the identification of a new U(1) gauge symmetry and, hence, to a new notion of minimal coupling. The other approach relies on the midi-superspace parameterization of the matter stress-energy tensor. We studied the phase space of non-relativistic cosmology in the presence of general matter couplings, and found that the gravitational non-linearities can change the effective equation of state of matter. We also found that bouncing solutions can occur rather generically, and that in order to have acceptable accelerating late-time cosmologies the so-called *detailed-balance condition* must be broken.

Holographic superconductors

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-like theories to heavy ion collisions, quantum liquids and high-temperature superconductivity. In connection with the latter, we have studied the magnetic response of the two types of strongly coupled superconductors that can be easily modeled using holographic techniques, namely those with a conducing normal phase or with an insulating normal phase. We have found that superconductors arranged in a cylindrical geometry present a sharply distinct response to a cylinder-threading magnetic flux: the phase diagram of the superconductivity phase-transition exhibits a different periodicity in the magnetic flux for the two types of materials. Interestingly enough, this prediction may be experimentally tested in the near future.

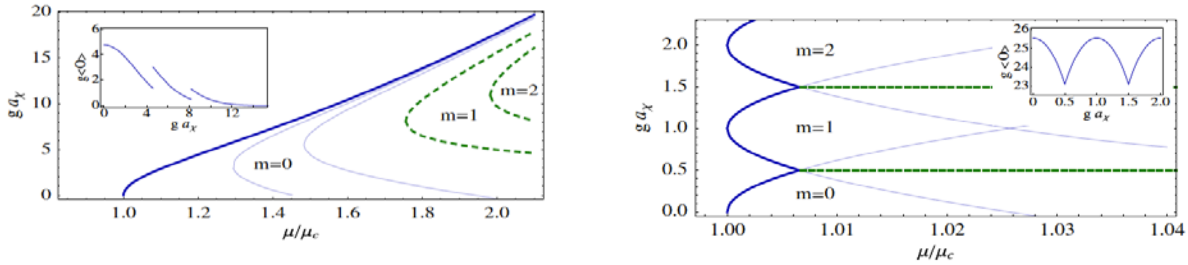


Fig 2: *Phase diagrams for the holographic conductor-superconductor transition (Fig 2a) and for the holographic insulator-superconductor transition (Fig 2b). The vertical axis is the magnetic flux, and the horizontal axis is the chemical potential. The inset depicts the order parameter, <O>, as a function of magnetic flux.*

Figure 2a

Figure 2b

3.Personnel in 2011

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	Researcher, 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, Mª Lluïsa	Research Associate Professor, IFAE
Moralejo, Abelardo	Research Associate Professor, IFAE
Padilla, Cristóbal	Research Associate Professor, IFAE
Rico, Javier	Researcher, ICREA
Riu, Imma	Research Associate Professor, IFAE
Sánchez, Federico	Research Associate Professor, IFAE
Sorin, Verónica	Researcher, Ramon y Cajal, IFAE

Engineering Staff

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
Grañena, Ferran	Mechanical Engineer, IFAE
Hernandez, Carles	Software Engineer, PAU (since 16.09.2011)
Illa, Jose Mª.	Electronic Engineer, IFAE
Lopez Morillo, Luis	Mechanical Engineer Student, PAU
Macias, Jose Gabriel	Microelectronics Designer, VIP
Maiorino, Marino	Engineering Physics, IFAE
Pio, Cristobal	Software Engineer (since 15.02.2011)
Puigdengoles, Carles	Electronic Engineer, IFAE
Troyano, Isaac	Electronic Engineer, IFAE, CPAN ,CTA

Computer Scientists

Campos, Marc	IFAE
Guino Feijoo, Alex	IFAE
Pacheco, Andreu	IFAE, Senior Computing Engineer

Technicians

Arteche, Carlos	Mechanical Technician, PAU
Colombo, Eduardo	MAGIC
González, Alex	Electronic Technician, IFAE
Gaweda, Javier	Mechanical Technician, IFAE

Scientific Post-Docs

Abdallah, Jalal	ATLAS, CPAN
De Lorenzo, Gianluca	VIP

Demirkoz, Bilge	ATLAS (until 10/02/2011)
Doro, Michele	MAGIC, CPAN
Fiorini, Luca	ATLAS, J. de la Cierva fellow (until 28/02/2011)
Francavilla,Paolo	ATLAS (since 1.11.2011)
Gerbaudo,Davide	ATLAS (since 1.09/2011)
Giangobbe,Vicent	ATLAS (since 4.04.2011)
Garczarczyk, Markus	MAGIC
Helsens, Clément	ATLAS
Ieva, Michela	Neutrinos (Beatriu de Pinos from 01/11/11)
Jover, Gabriel	Neutrinos (until 21/12/2011)
Klepser, Stefan	MAGIC, J. de la Cierva fellow
Kolstein, Machiel	VIP (since 16/05/2011)
Lux, Thorsten	Neutrinos , J. de la Cierva fellow
Mazin, Daniel	MAGIC, Otto Hahn Fellow
Meoni, Evelin	ATLAS
Osuna, Carlos	ATLAS (until 10/09/2011)
Ostman, Linda	DES, PAU (until 21/10/2011)
Sitarek, Julian	MAGIC,CTA , Juan de la Cierva fellow (since 16/09/2011)
Stamatescu, Victor	CTA

Doctoral Students

Ariño, Gerard	VIP (since 5/10/2011)
Aleksic, Jelena	MAGIC,CTA, Generalitat FI
Borrego, Carlos	ATLAS
Calderón, Yonatan	VIP
Camarda, Stefano	CDF
Caminal, Roger	ATLAS
Caravaca, Javier	Neutrinos
Castillo, Raquel	Neutrinos
Conidi, M. Chiara	ATLAS
Galbany, Lluis	DES Teaching assistant UAB (until 21/10/2011)

Gonzalez, Adiv	MAGIC, CTA, (since 14/11/2011)
González Parra, Garoe	ATLAS , (Scholarship FPI)
Giavitto, Gianluca	MAGIC, CTA
Harb, Ali	PIXELS
López Coto, Ruben	MAGIC, CTA (since 1.09.2011)
Lopez Orama, Alicia	MAGIC, CTA , FPI
Martí, Carlos	Neutrinos
Martí, Pol	DES, PAU
Mikhaylova, Ekaterina	VIP
Montejo, Javier	ATLAS (Beca Caixa)
Nadal, Jordi	ATLAS
Ortolan, Lorenzo	CDF
Ozsahin, Ilker	VIP (since 12/05/2011)
Pérez, Estel	ATLAS (Scholarship MEC-FPU) (until 39/11/2011)
Reichardt, Ignasi	MAGIC , CTA
Rossetti, Valerio	ATLAS (Scholarship MEC-FPU)
Rubbo, Francesco	ATLAS (since 1.01.2011)
Sanchez Alonso, Carlos	DES/PAU (since 1.11.2012)
Succurro, Antonella	ATLAS
Tsiskaridze, Shota	ATLAS
Vives, Francesc	ATLAS (until 31/07/2011)
Tescaro, Diego	MAGIC
Uzun, Dilber	VIP (since 12.05.2011)
Vorkerk, Volker	ATLAS (Scholarship MEC-FPI) (until 30/06/2011))
Zanin, Roberta	MAGIC (until 30/09/2011)

Administrative Personnel

Barquet, Andrea	IFAE, Med. Physics Administrative Assist. (until 16/06/2011)
Cárdenas, Cristina	IFAE, UAB Secretary
Gaya, Josep	IFAE, UAB Senior Administrator

Sanchez, Marta	IFAE, Administrative Assistant
Strauch, Sara	MAGIC, IFAE Administrative Assistant

Theory Division

Faculty

Escribano, Rafel	Associate Professor, UAB
Espinosa, Jose Ramón	Research Professor, ICREA
Jamin, Matthias	Research Professor, ICREA
Massó, Eduard	Professor, UAB
Matias, Joaquim	Associate Professor, UAB
Méndez, Antoni	Professor, UAB
Pascual, Ramon	Professor, UAB
Peris, Santi	Associate Professor, UAB
Pujolàs, Oriol	Researcher, Ramon y Cajal, IFAE-UAB
Quirós, Mariano	Research Professor, ICREA

Scientific Post-Docs

Biggio, Carla	Post doc IFAE, CPAN
Frigerio, Michele	Post-docIFAE (until 19/10/2011)
Jora, Renata	Post-doc IFAE (until 9/09/2011)
Mejias, Eugenio	Juan de la Cierva UAB (since 10.01.2011)
Riva, Francesco	Post doc IFAE (since 12.01.2011)
Roig, Pablo	Post doc IFAE (since 1.09.2011)
Silva, Pedro	Post-doc Institut de Ciències de l'Espai
Varagnolo, Alvise	Post-doc IFAE (until 4.10.2011)
Virto, Javier	Post doc UAB (since 9.01.2011)

Doctoral Students

Boito, Diogo R	Scholarship MICINN (until 01.10.2011)
Cabrer, Joan Antoni	Scholarship MICINN (until 01.12.2011)
Domènech, Oriol	Scholarship MICINN
Elias; Joan	Scholarship UAB (PIF)
Krug , Sebastian	Scholarship MICINN (since 9.01.2011)
Montull, Marc	Scholarship UAB (PIF)
Peset, Clara	Scholarship MICINN
Ramon, Marc	Scholarship UAB (PIF)
Serra, Javier	Scholarship MICINN (until 01.02.2011)
Wiechers, Michael	Scolarship Erasmus (since 01.08.2011)

4. Institutional Activities in 2011

4.1 Final Master & Diploma Projects

Experimental Division

Daniel Garrido Terrats
The effect of molecular and aerosol atmospheric profiles on the performance of the MAGIC telescopes
Julio 2011
Co-advisor: A. Moralejo (with M. Doro, UAB)

4.2 Doctoral Theses

Experimental Division

Luis Galbany

Supernova studies in the SDSS-II/SNe survey: spectroscopy of the peculiar SN 2007qd, and photometric properties of type-Ia supernove as a function of the distance to the host galaxy
October 2011
Advisor : Ramon Miquel

Federico Nova
Development of a tracking software for the SuperNEMO experiment and measurement of Mo-100 half-life for double-beta decay with the NEMO3 experiment
January 2011
Advisor: Federico Sanchez

Estel Perez
First measurement of the Z+jets production cross section with the ATLAS experiment at the LHC
December 2011
Advisor: Mario Martinez/Sebastian Grinstein

Francesc Vives
Study of Inclusive Jet Production and Jet Shapes in proton-proton collisions at $\sqrt{s}$ =7 TeV using the ATLAS Detector
October 2011
Advisor: Mario Martinez

Volker Vorkerk
Measurement of the top quark pair production cross section fecha
July 2011
Advisor: Aurelio Juste

Roberta Zanin
Observations of the Crab pulsar wind nebula and microquasar candidates with MAGIC
September 2011
Advisor: Juan Cortina

Theory Division

Diogo Boito
QCD phenomenology with tau and charm decays
September 2011
Advisor: Rafel Escribano/Matthias Jamin

Joan Cabrer
Studies on Generalized Warped 5D Models
December 2011
Advisor:Mariano Quirós

4.3 Publications

Experimental Division

Publications ATLAS Group

ATLAS Collaboration, G. Aad et al.,
Search for new phenomena in final states with large jet multiplicities and missing transverse momentum using $\sqrt{s}$ =7 TeV pp collisions with the ATLAS detector
JHEP 1111 (2011) 099

ATLAS Collaboration, G. Aad et al.,
Search for massive colored scalars in four-jet final states in $\sqrt{s}$ =7 TeV proton-proton collisions with the ATLAS detector
Eur.Phys.J.C 71 (2011) 1828

ATLAS Collaboration, G. Aad et al.,
Search for the Standard Model Higgs boson in the decay channel H -> ZZ(*) -> 4l with the ATLAS detector
Phys.Lett. B705 (2011) 435-451

ATLAS Collaboration, G. Aad et al.,
Measurement of the inclusive and dijet cross sections of b-jets in pp collisions at $\sqrt{s}$ =7TeV with the ATLAS detector
Eur.Phys.J.C 71 (2011) 1846

ATLAS Collaboration, G. Aad et al.,
Measurement of the jet fragmentation function and transverse profile in proton-proton collisions at a center-of-mass energy of 7 TeV with the ATLAS detector at the LHC
Eur.Phys.J.C 71 (2011) 1795

ATLAS Collaboration, G. Aad et al.,
Search for the Higgs boson in the H->WW-lνqq decay channel in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
Phys.Rev.Lett. 107 (2011) 231801

ATLAS Collaboration, G. Aad et al.,
Search for a Standard Model Higgs boson in the mass range 200-600 GeV in the H->ZZ->llvv final state with the ATLAS detector
Phys.Rev.Lett. 107 (2011) 221802

ATLAS Collaboration, G. Aad et al.,
Search for a heavy neutral particle decaying into an electron and a muon using 1 fb^{-1} of ATLAS data
Eur.Phys.J.C 71 (2011) 1809

ATLAS Collaboration, G. Aad et al.,
Search for the Higgs boson in the two photon decay channel with the ATLAS detector at the LHC
Phys.Lett. B705 (2011) 452-470

ATLAS Collaboration, G. Aad et al.,
Measurement of the Z to $\tau\tau$ cross section with the ATLAS detecto
Phys.Rev. D84 (2011) 112006

ATLAS Collaboration, G. Aad et al.,
Search for dilepton resonances in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
Phys.Rev.Lett. 107 (2011) 272002

ATLAS Collaboration, G. Aad et al.,
Search for a heavy gauge boson decaying to a charged lepton and a neutrino in 1 fb^{-1} of pp collisions at $\sqrt{s}$ =7 TeV using the ATLAS detector
Phys.Lett. B705 (2011) 28-46

ATLAS Collaboration, G. Aad et al.,
Inclusive search for same-sign dilepton signatures in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
JHEP 1110 (2011) 107

ATLAS Collaboration, G. Aad et al.,
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4.4 Outreach Activities

Jelena Aleksić
- *Talk for 3rd year students on the prospects on doing the PhD in Physics*
  IFAE, May 2011

Oscar Blanch Bigas
- *Els telescopis MAGIC: els fotons més energètics*
  Associació d'Astronomia de Valldoreix i Sant Cugat, Gener 2011
- *L'Univers*
  Virolai High School, June 2011
- *Guided visit to IFAE for high school students*
  IFAE, June 2011

Matteo Cavalli-Sforza
- *Els neutrins superen la velocitat de la llum?*
  Interview with Catalunya Radio, September 2011
- *Els neutrins i la velocitat de la llum*
  Conferència a Escola Projecte, Barcelona, November 2011

Juan Cortina
- *Demostration of film "Universo Extremo"*
  Aster astronomical association, Barcelona, Feb 2011
- *Online article at National Geographic España about MAGIC telescopes*
  http://www.nationalgeographic.com.es/2011/01/17/detectores_violencia_cosmica.html

Enrique Fernández
- *Neutrinos de Origen Cósmico*
  Conference Series organized by Associació Astronómica

St. Cugat-Valldoreix. Casal de Cultura, St. Cugat del Vallés, April 2011

- *El LHC: La magia cuántica de las partículas elementales*
  Conference Series organized by Consejo de Salud de Villaviciosa. Villaviciosa, August 2011
- *Las partículas en el Universo*
  Public Conference organized in connection with the Workshop Asturpac-2011.Centro Niemeyer, Avilés, November 2011
- *Entrevistas a propósito de la conferencia "La magia cuántica de las partículas elementales"*
  Periódicos El Comercio de Gijón Agosto 2011 y La Nueva España de Oviedo, Agosto 2011
- *Observational Cosmology in Spain*
  Presentation at the Restricted European Committee for Future Accelerators (R-ECFA) Madrid, Ministerio de Ciencia e Innovación, October 2011
- *Un universo en expansión acelerada*
  Conferencia-Coloquio en Universitat de les Illes Balears Palma de Mallorca, Noviembre 2011

Eduard Massò

- *L'univers accelerat*
  Invited talk, Nobel Prize series, Institut Estudis Catalans, Barcelona, December 2011

Gonzalo Merino

- *Objectius i fonaments científics de les principals àrees de recerca en les que el centre hi participa, així com el paper fonamental que hi juguen les Tecnologies de la Informació*
  Visitas guiadas a grupos de estudiantes, Nov 2011, PIC, UAB, Bellaterra

Lluisa Mir

- *Presentación de resultados sobre la búsqueda del Higgs por ATLAS y CMS*
  Racó de l'Expert, Barcelona TV, December 2011

Abelardo Moralejo

- *MAGIC-MultiDark Summer student program*
  10 days stay at the MAGIC site with two graduate students

Oriol Pujolàs

- *Entrevista sobre resultat de Opera (Neutrinos)*
  Diari de Girona, September 2011
- *Entrevista sobre resultat de Opera (Neutrinos)*
  Diari de Mallorca, September 2011

Federico Sánchez

- *Oscilaciones de neutrinos en el experimento T2K*
  Noviembre 2011, Sala de Graus

4.5 Conference Proceedings

Experimental Division

Proceedings ATLAS Group

Jalal Abdallah
Exotics Searches for New Physics with the ATLAS Detector
PANIC11conference reference: ATL-PHYS-PROC-2011-109

Carlos Borrego et al.
Aggregated monitoring and automatic site exclusion of the ATLAS computing activities: the ATLAS Site Status Board
Iberian Grid Infrastructure Conference IBERGRID 2011

Garoé González Parra on behalf of the ATLAS collaboration
Integrator based readout in Tile Calorimeter of the ATLAS experiment
TIPP 2011 - Technology and Instrumentation for Particle Physics 2011, Physics Procedia

Pilar Casado
Performance of the ATLAS Tau Trigger system with 7 TeV pp collisions at the LHC" by ATLAS Collaboration, ATL-DAQ-PROC-2011-037, 2011 IEEE Nuclear Science Symposium and Medical Imaging Conference, 23-29 October 2011, Valencia, Spain

Estel Perez Codina
Physics at LHC 2011 Measurement of the cross section for Z/gamma production in association with jets in pp collisions at* $\sqrt{s} = 7$ *TeV with the ATLAS Detector*
Perugia, Italy, June 6-11th, 2011

Mario Martínez et al.
BOOST 2011 Workshop,
Princeton, USA, arXiv:1201.0008

Mario Martínez
Search for new phenomena in events with a monojet and large missing transverse momentum at the LHC using the ATLAS detector
HCP2011 Conference, Paris, arXiv:1202.0158

Antonella Succurro
The ATLAS Tile Hadronic Calorimeter performance in the LHC collision era
Physics Procedia Ms. Ref. No.: TIPP11-D-11-00040R1

Clément Helsens
Top Physics with the ATLAS detector
July 14 , arXiv:1107.2899v1 [hep-ex] 2011

Paolo Francavilla, on behalf of the ATLAS Collaboration
Measurement of the inclusive jet cross section with the ATLAS detector
Incontri di Fisica delle Alte Energie
April 27-29, 2011, Perugia, Italy
DOI: 10.1393/ncc/i2011-11098-1

Paolo Francavilla
Experiences on QCD Monte Carlo simulations: a user point of view on the inclusive jet cross-section simulations
Jet Reconstruction and Spectroscopy at Hadron Colliders, April 18-19, 2011, Pisa, Italy, J.Phys.Conf.Ser. 323 (2011) 012016

Paolo Francavilla on behalf of the ATLAS Collaboration
Measurement of single and multi-jet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with ATLAS
2011 Europhysics Conference on High Energy Physics-HEP 2011, July 21-27, 2011
Grenoble, Rhône-Alpes France, PoS (EPS-HEP2011)278

Proceedings Pixels Group

S.Grinstein
Overview of the ATLAS Insertable B-Layer (IBL) Project of the 8th International Hiroshima Symposium on the Development and Application of Semiconductor Tracking Detectors (HSTD-8), NIMA54345 (accepted for publication, 0.1016/j.nima.2012.03.043)

S. Grinstein
Overview of Silicon Pixel Sensor Development for the ATLAS Insertable B-layer (IBL)
Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC), 2011 IEEE, 1986-1991, 10.1109/NSSMIC.2011.6154405

Proceedings CDF

Veronica Sorin
W/Z+jets at the Tevatron
Proceedings of the XXIII Recontres de Blois

Lorenzo Ortolan
Z+jets Results from CDF
Proceedings PoS (EPS-HEP 2011) 323

Stefano Camarda
W/Z+Jets and W/Z+HF Production at the Tevatron
Proceeding for XLVI Rencontres de Moriond QCD

Proceedings Neutrinos

C.Giganti
New Results from T2K Experiment
International Europhysics Conference of High Energy Physics, EPS-HEP 2011, Grenoble, July 21-27 2011 Proceedings submitted to: PoS(EPS-HEP2011)089

C.Giganti
ND280 TPC contribution to recent T2K results
2nd International Conference on Micro Pattern Gaseous Detectors. Kobe (Japan) 29 August - 1 September 2011 Proceedings submitted to: JINST_013P_1211

Proceedings MAGIC Group

S. Klepser for the MAGIC collaboration
The MAGIC Telescopes - Status and Recent Results
Proc. SciNeGHE 2010 Trieste, Il Nuovo Cimento C 34 (2011) 3

S. Klepser, J. Krause, M. Doro for the MAGIC coll.
Mapping the extended TeV source HESS J1857+026 down to Fermi-LAT energies with the MAGIC telescopes
Proc. 32nd ICRC, Beijing, China, 2011

S. Lombardi, K. Berger, P. Colin, A. Diago Ortega, S. Klepser, for the MAGIC coll
Advanced stereoscopic gamma-ray shower analysis with the MAGIC telescopes
Proc. 32nd ICRC, Beijing, China, 2011

T. Saito, M. López, G. Giavitto, S. Klepser, T. Schweizer, R. Zanin for the MAGIC coll.
Observations of the Crab pulsar with the MAGIC telescopes
Proc. 32nd ICRC, Beijing, China, 2011

S. Klepser and K. Saito for the MAGIC coll.
Stereoscopic Observations of the Blazar 3C 66A with the MAGIC Telescopes
Proc. 32nd ICRC, Beijing, China, 2011

R. Zanin, D. Mazin, E. Carmona, P. Colin, J. Cortina, T. Jogler, S. Klepser et al. for the MAGIC coll.
MAGIC measurement of the Crab Nebula spectrum over three decades in energy
Proc. 32nd ICRC, Beijing, China, 2011

E. Carmona, J. Sitarek, P. Colin, M. Doert, S. Klepser, S.,Lombardi, M. Lopez, A. Moralejo, S. Pardo, V. Scalzotto, R. Zanin, for the Magic Collaboration
Performance of the MAGIC Stereo System
Proc. 32nd ICRC, Beijing, China, 2011

J. Aleksić on behalf of the MAGIC Collaboration,
Indirect Dark Matter Searches with the MAGIC Telescopes
PoS(EPS-HEP2011)063, Grenoble, France, 2011

J. Aleksić, M. Doro, S. Lombardi, D. Nieto on behalf of the MAGIC Collaboration
Segue 1: the best dark matter candidate dwarf galaxy surveyed by MAGIC
Proc. 32nd ICRC, Beijing, China, 2011

D. Nieto, J. Aleksić, J.A. Barrio, J.L. Contreras, M. Doro, S. Lombardi, N. Mirabald, A. Moralejo, S. Prado, J. Rico, F. Zandanel, on behalf of the MAGIC Collaboration
The search for galactic dark matter clump candidates with Fermi and MAGIC
Proc. 32nd ICRC, Bejing, China, 2011

I. Reichardt, J. Krause, E. Carmona on behalf of the MAGIC Collaboration
Probing proton acceleration in W51C with MAGIC
Proc. of the Cosmic rays and their interstellar medium environment conference, Montpellier, France, June 26-July 1, 2011

J. Krause, I. Reichardt, E. Carmona on behalf of the MAGIC Collaboration
Probing proton acceleration in W51C with MAGIC
Proc. of the 2011 Fermi Symposium, Rome, Italy, May 2011

E. Carmona, J. Krause, I. Reichardt on behalf of the MAGIC Collaboration
Probing proton acceleration in W51C with MAGIC Proc. 32nd ICRC, Beijing, China, 2011

J. Rico,
Gamma-Ray Astronomy: Implications for Fundamental Physics
PoS (EPS-HEP2011)049

R. Zanin, O. Blanch, P. Bordas, T. Jogler, J. Cortina, P. Munar, J.M. Paredes, M. Ribó, V. Zabalza on behalf of the MAGIC Collaboration
MAGIC results on binary systems
Proc. 3rd HEPRO, Barcelona, 2011

R. Zanin, T. Saito, V. Zabalza, P. Bordas, T. Jogler, J. Cortina, J.M. Paredes, M. Ribó, J. Rico on behalf of the MAGIC Collaboration
Search for VHE signals from microquasars with MAGIC
Proc. 32nd ICRC, Beijing, China, 2011

Proceedings Medical Physics Group

Y. Calderon, M. Kolstein, D. Uzun, G. De Lorenzo, M. Chmeissani, P. Arce, G. Ario, E. Cabruja, M. Canadas, J. G. Macias-Montero, R. Martinez, E. Mikhaylova, I. Ozsahin and C. Puigdengoles.
Modelling, Simulation, and Evaluation of a Compton Camera Based on Pixelated Solid-State Detector
IEEE Nuclear Science Symposium and Medical Imaging Conference, Valencia, Spain, 2011. ISBN: 978-1-4673-0119-0, pages 2708-2715.

E. Mikhaylova, M. Canadas, G. De Lorenzo, M. Chmeissani, P. Arce, G. Arino, E. Cabruja, Y. Calderon, M. Kolstein, J. G. Macias-Montero, R. Martinez, I. Ozsahin, C. Puigdengoles and D. Uzun.
Simulation of Pseudo-clinical conditions and image quality evaluation of PET scanner based on Pixelated CdTe detector
IEEE Nuclear Science Symposium and Medical Imaging Conference, Valencia, Spain, 2011. ISBN: 978-1-4673-0119-0, pages 2716-2722

G. Arino, M. Chmeissani, C. Puigdengoles, G. De Lorenzo, R. Diener, P. Arce, E. Cabruja, Y. Calderon, M. Canadas, M. Kolstein, J. Macias-Montero, R. Martinez, E. Mikhaylova, I. Ozsahin and D. Uzun
Characterization of CdTe Detector for Use in PET.
IEEE Nuclear Science Symposium and Medical Imaging Conference, Valencia, Spain, 2011. ISBN: 978-1-4673-0119-0, pages 4598-4603

P. Arce, J. I. Lagares, L. Harkness, L. Desorgher, G. De Lorenzo, Y. Abreu and Z. Wang.
GAMOS: an Easy and Flexible Way to Use GEANT4
IEEE Nuclear Science Symposium and Medical Imaging Conference, Valencia, Spain, 2011. ISBN: 978-1-4673-0119-0, pages 2230-2237

Theory Division Proceedings

D.R. Boito, O. Catà, M. Golterman, M. Jamin, K. Maltman, J. Osborne, S. Peris
Duality violations in τ hadronic spectral moments,
Nucl. Phys. Proc. Suppl. 218 (2011) 104-109

D.R. Boito, R. Escribano, M. Jamin
Improving the $K\pi$ vector form factor through K_{l3} constraints
AIP Conf.Proc. 1343 (2011) 271-273

M. Jamin
Recent progress in hadronic τ decays
Nucl. Phys. Proc. Suppl. 218 (2011) 98-103

D.R. Boito, R. Escribano, M. Jamin
The $K\pi$ vector form factor and constraints from K_{l3} decays
Proc. of CKM 6, Warwick, UK, arXiv:1101.2887 [hep-ph].

D.R. Boito, O. Catà, M. Golterman, M. Jamin, K. Maltman, J. Osborne, S. Peris
Duality violations in hadronic τ decays and the value of α_s
Proc. of Precision measurements of $\pi\pi_{S,}$ Munich, Germany, arXiv:1103.4194 [hep-ph]

D.R. Boito, O. Catà, M. Golterman, M. Jamin, K. Maltman, J. Osborne, S. Peris
Duality Violation and the $K\pi\pi$ Electroweak Penguin Operator Matrix Elements from Hadronic τ Decays
Proc. of PANIC11, MIT, Cambridge, USA, arXiv:1110.5562 [hep-ph]

D.R. Boito, O. Catà, M. Golterman, M. Jamin, K. Maltman, J. Osborne, S. Peris
On the Extraction of the Strong Coupling constant from Hadronic τ Decay
Proc. of Lattice 2011, Lake Tahoe, USA, arXiv:1111.5040 [hep-lat]

Michele Frigerio, Thomas Hambye, Eduard Massó
Sub-GeV dark matter as pseudo-Goldstone from the seesaw scale
e-Print: arXiv:1107.4564 [hep-ph], to be published in PRX December 2011

4.6 Talks by IFAE Members and Collaborators

Experimental Division

ATLAS

Jalal Abdallah
- *Exotics/SUSY at ATLAS*
  CPAN WorkShop, Barcelona November 2011
- *Exotics Searches for New Physics with the ATLAS Detector*
  PANIC 2011 Boston, USA, July 2011

Bilge Demirkoz
- *ATLAS and CMS results on SUSY*
  Patras 2011, Greece, June 2011
- *Multijet production and measurement of the internal jet structure*
  PLHC 2011 Perugia, Italy June 2011

Clément Helsens
- *Top Physics at ATLAS*
  FPCP 2011 Israel, May 2011

Mario Martínez
- *ATLAS CPAN WorkShop*
  Barcelona, November 2011
- *Parton shower modeling using ATLAS jet shapes measurements*
  Boost 2011, Princeton, USA, May 2011

Evelin Meoni
- *QCD physics at ATLAS*
  LaThuile, Italy, February 2011

Jordi Nadal
- *t-tbar cross-section measurements (lepton+jets/all jets)*
  Top2011, Sant Feliu, Girona, September 2011

Francesc Vives
- *Inclusive jet cross section measurement in ATLAS*
  Pisa Jet 2011 Pisa, Italy, April 2011

PIXELS

Sebastian Grinstein
- *Type 2 Cable Status*
  ATLAS-IBL General Meeting, CERN, February 2011
- *Experience with 3D sensors*
  Invited talk, Planar Sensor Pixel Meeting, CERN, October 2011
- *3D sensors: Measurements on Built Assemblies",*
  ATLAS-IBL General Meeting, CERN, June 2011
- *Overview of Silicon Pixel Sensor Development for the ATLAS Insertable B-Layer (IBL)*
  2011 IEEE Nuclear Science Symposium, Valencia, Spain, October 2011
- *Overview of the ATLAS Insertable B-Layer (IBL) Project*
  Hiroshima Symposium on the Development of *Semiconductor Detectors*
  Taipei, Taiwan, December 2011

Ali Harb
- *Characterization of CNM FE-I4 3D Double-Sided Sensors*
  19th RD50 Workshop, CERN, 21st-23th November 2011

Isaac Troyano
- *Type 2 Cables*
  ATLAS-IBL General Meeting, CERN, 8th June 2011

Shota Tsiskaridze
- *September Beam Test Results and Plans for 2012*
  ATLAS-IBL General Meeting, CERN, 15th-17th February 2012
- *Testbeam Results of CNM 3D FE-I4 Devices*
  19th RD50 Workshop, CERN, 21st-23th November 2011

CDF

Stefano Camarda
- *W/Z+Jets and W/Z+HF production*
  Moriond QCD LaThuile, Italy, March 2011
- *V+Jets at the Tevatron*
  Durham Workshop on QCD, Durham, UK, April 2011
- *W/Z+Jets at CDF*
  QCD at LHC workshop, Scotland, August 2011
- *W/Z+Jets production at the Tevatron*
  QCD at LHC workshop, St Andrews , Scotland, August 2011
- *V+jets at the Tevatron Standard Model Processes at the LHC*
  Durham, UK, April 2011
- *W/Z+Jets production at the Tevatron*
  Moriond QCD, La Thuile, Italy, March 2011

Lorenzo Ortolan
- *Z+jets Results from CDF*
  EPSHEP Conference, Grenoble, France, July 2011

Veronica Sorin
- *Resumen resultados Tevatron*
  CPAN Workshop, Barcelona, November 2011
- *W/Z+Jets and W/Z+HF production at the Tevatron*
  Blois Conference, Blois, France, May 2011
- *W/Z+jets at the Tevatron*
  Recontres de Blois, Blois, France, June 2011
- *Results from the Tevatron*
  Jornadas CPAN, Barcelona, November 2011

Neutrinos

Javier Caravaca
- *Medida del flujo de neutrinos electronicos en el experimento T2K*
  Bienal de Fisica, Santander, Septiembre 2011

Raquel Castillo
- *Experimentacion en fisica de neutrinos*
  Bienal de Fisica, Santander, Septiembre 2011

Claudio Giganti

- *New results from T2K experiment*
  EPS HEP 2011, Julio 2011
- *Recent Results from T2K*
  III CPAN days, November 2011, Barcelona
- *First results from the T2K experiment*
  IFAE/EXP SEMINAR, March 2011, Barcelona
- *The T2K Experiment*
  Seminar at Laboratoire de Physique Nucléaire et de Hautes Energies (LPNHE), April 2011, Paris
- *Recent oscillation results from T2K*
  XIV Roma Tre Topical Seminar on Subnuclear Physics, Hot Topics in Neutrino Oscillations: a Clue to Physics Beyond the Standard Model, December 2011, Rome, Italy

Michela Ieva

- *T2K non-oscillation neutrino physics with near detectors*
  Lomonosov Conference, Moscow (Russia), August 2011

Carlos Martin

- *Constriccion de un detector TPC de Xenon a alta presion*
  Bienal de Fisica, Santander, September 2011

Federico Sánchez

- *Neutrino physics: experiments*
  Bienal de Fisica, IMFP 2011, Canfranc, Febrero 2011
- *Measuring θ_{13}: T2K & Double Chooz*
  CPAN days, Barcelona, November 2011
- *2011 IEEE Nuclear Science Symposium*
  Valencia, Spain, October 2011
- *Hiroshima Symposium on the Development of Semiconductor Detectors*
  Taipei, Taiwan, December 2011
- *From Sitges to Dehra-Dun: a personal view of the needs and situation of neutrino nucleus interactions.*
  7th International Workshop on Neutrino-Nucleus Interactions in the Few-GeV Region: NuInt 2011, Dehra-Dun (India) , March 2011

MAGIC /CTA

Jelena Aleksic

- *Indirect Dark Matter Searches with the MAGIC Telescopes*
  Workshop on Indirect Dark Matter Searches Hamburg (Germany), June 2011
- *The best dark matter candidate dwarf galaxy surveyed by MAGIC*
  32nd International Cosmic Ray Conference, Beijing (China), August 2011
- *Indirect Dark Matter Searches with the MAGIC Telescopes*
  The 2011 Europhysics Conference on High Energy Physics, Grenoble (France) July 2011

Juan Cortina

- *Highlights of the MAGIC telescopes*
  32nd International Cosmic Ray Conference, Beijing (China), August 2011

Roger Firpo

- *A data transfer system for MAGIC based on gLite FTS and multiVAC*
  Computing and Astroparticle Physics - 2nd ASPERA workshop, Barcelona (Spain) May 2011

Stefan Klepser

- *Mapping the extended TeV source HESS J1857+026 down to Fermi-LAT energies with the MAGIC telescopes*
  32nd International Cosmic Ray ConferenceBeijing (China) August 2011
- *Phase-resolved Crab pulsar measurements from 25 to 400 GeV with the MAGIC telescopes*
  12th International Conference on Topics in Astroparticle and Underground Physics, Munich (Germany), September 2011

Abelardo Moralejo

- *Status of indirect dark matter searches with MAGIC*
  4th Multidark Consolider workshop Madrid (Spain), April 2011

Ignasi Reichardt

- *Probing proton acceleration in W51C with MAGIC Cosmic rays and their interstellar medium environment*
  Montpellier (France), June 2011

Javier Rico

- *Gamma ray astronomy: implications on fundamental physics*
  The 2011 Europhysics Conference on High Energy Physics, Grenoble (France), July 2011
- *Gamma Ray Astronomy 3*
  1st Symposium on Physics in Collision, Vancouver (Canada), August 2011

Roberta Zanin

- *MAGIC measurement of the Crab Nebula spectrum over three decades in energy*
  32nd International Cosmic Ray Conference, Grenoble (France), August 2011
- *MAGIC results on binary systems*
  High Energy Phenomena in Relativistic Outflows III, Barcelona (Spain), June 2011

DES/PAU

Enrique Fernández

- *Observational Cosmology in Spain*
  Presentation to the Restricted European Committee for Future Accelerators (R-ECFA), Madrid, October 2011
- *Un universo en expansión acelerada*
  Colloquium at Universitat de les Illes Balears, Palma de Mallorca, November 2011

Lluís Galbany

- *Type-Ia Supernova Properties as a Function of the Distance to the Host Galaxy in the SDSS-II/SNe Survey, Supernovae and their Host Galaxies*
  Sydney (Australia), June 2011

Pol Martí

- *Photo-z Study for the PAU at WHT Survey*
  Azores School on Observational Cosmology, Terceira (Portugal), August 2011

Ramon Miquel

- *The PAU at WHT Survey*
  Very Wide Field Surveys in Light of Astro 2010, Baltimore (USA), June 2011.

Medical Physics

Mokhtar Chmeissani

- …*Novel Conceptual PET design based on Pixel CdTe detectors*
  European Congress of Radiology (ECR), Vienna, Austria, March 2011

Theory Division

Matthias Jamin

- *A new determination of alpha_s from tau decays*
  Phi2Psi 11, Novosibirsk, Russia, September 2011

Joaquim Matias

- *Some hot topics in B physics*
  Benasque meeting of Flavour Physics Network
  Benasque, January 2011
- *New generation of observables for* $B \to K^* l^+ l^-$
  WOMP-NURT, La Habana, Cuba, February 2011

Mariano Quirós

- *Bulk Higgs in Warped Extra Dimensions*
  Talk at Plenary Session in International Conference Scalars 2011, August 2011, University of Warsaw (Poland)
- *Improving Naturalness in Warped EWSB*
  Talk at Plenary Session in Planck 2011
- *From the Planck scale to the Electroweak scale*
  31 May 2011, Lisbon (Portugal)
- *EWBG in the MSSM*
  Review talk at Electroweak Baryogenesis in the Era of the LHC, May 2011, Department of Particle Physics and Astrophysics, Weizmann Institute of Science, Rehovot, Israel

Oriol Pujolàs

- *Non-relativistic Quantum Gravity*
  Progress on Old and New Themes in Cosmology (PONT) 2011, 18-22/4/11 Avignon, France
- *Emergent Lorentz Invariance*
  Workshop on Infrared Modifications of Gravity, 26-30/10/11, ICTP Trieste, Italy
- *Non-relativistic Quantum Gravity*
  Particle Physics, Nuclear Physics and Astroparticle Physics (Dual year Russia-Spain, 8-11/11/11, Universitat de Barcelona, Barcelona

4.7 Participation in External Committees

Experimental Division

Martine Bosman

- Member of Plenary European Committe for Future Accelerators
- Deputy Chair of the ATLAS Collaboration Board
- Member of the ATLAS Executive Board

Matteo Cavalli-Sforza

- Member of Restricted European Committe for Future Accelerators
- Chair of Scientific Committee, Laboratori Nazionali di Frascati, Italia
- Member of Scientific Committee Laboratoire de Physique Nucleaire et d`Hautes Energies Paris France

Juan Cortina

- Representative of IFAE in Collaboration Board of MAGIC experiment
- Elected Spokesman of MAGIC experiment in December 2011
- Deputy representative for Astroparticle Physics in Executive Committee of CPAN (Centro Partículas, Astropartículas y Nuclear)

Enrique Fernández:

- Chair of Evaluation Committee of the ASPERA (Astro-Particle Physics ERA Net) 2nd call for Proposals
- Member of the Evaluation Committee of the National Program for Accelerators and Particle Physics (FPA) of the National Plan of R&D
- Member of the "APpEC Scientific Advisory Committee
- Member of the Comitato di Valutazione Internazionale of the Italian INFN (National Institute for Particle, Astroparticle and Nuclear Physics)
- Member of the ILC (International Linear Collider) PAC (Program Advisory Committee)
- Member of SAC (Scientific Advisory Committee) of ASPERA/ApPEC
- Member of ILC-PAC (International Linear Collider Program Advisory Committee
- Member of the International Advisory Board of the International Doctorate Network in Particle Physics, Astrophysics and Cosmology (IDPASC)
- President of Second ASPERA Call Evaluation Committee
- Miembro de la Comisión de Evaluación de los Proyectos del Programa Nacional de Física de Altas Energías del Plan Nacional de I+D+i

Stefan Klepser:

- Deputy Software Coordinator of the MAGIC experiment
- Member of the MAGIC Software Board
- Occasional member of MAGIC Collaboration Board

Ilya Korolkov

- Co-convener ATLAS TileCal Calibration Group

Manel Martínez

- Co-Spokesman of the CTA collaboration
- Member of the CTA Speakers Bureau
- Spanish Delegate in the Astroparticle Working Group of the Global Science Foundation of OECD
- Member of the Scientific Advisory Committee of ApPEC
- MAGIC Common Fund Administrator
- Member of the MAGIC Collaboration Board

Mario Martinez

- Representative of IFAE in Collaboration Board of ATLAS
- Representative of IFAE in CDF Executive Board.
- Member of CDF Speakers Committee

Daniel Mazin

- Upgrade manager of MAGIC experiment
- Member of the MAGIC Executive Board and Collaboration Board
- Member of MAGIC Time Allocation Committee
- Member of MAGIC Technical Board
- Member of MAGIC Speakers Bureau
- Convener of physics subgroup of CTA "EBL and cosmology

Ramon Miquel

- Member of the Management Committee of DES
- Chair of The DES Speakers´ Bureau

Abelardo Moralejo

- Chair of the Speakers' bureau of the MAGIC collaboration
- Representative of IFAE in the CTA consortium board
- Member of the software board of the MAGIC collaboration
- Member of the project general board of the MultiDark CONSOLIDER

Javier Rico

- Member of MAGIC Time Allocation Committee
- Coordinator of MAGIC Data Center

Inma Riu

- Spanish Delegate in the Advisory Committee of CERN Users
- Deputy chair of the ATLAS Speakers Committee Advisory Board
- Co-convener of the ATLAS trigger menu and signatures group

Federico Sanchez

- Co-Convener of detector ND280 del experimento T2K
- Co-Convener of muon neutrino physics group of experiment T2K
- IFAE representative in the Institute Board of experiment NEXT
- Member of the T2K Analysis Steering Group
- Coordinator of Neutrino Activities in the Red Nacional de Astroparticulas (RENATA)

Verónica Sorin

- CDF Spokesperson election committee

4.8 Colloquia in 2011

The ALBA synchrotron light source
Speaker: Ramon Pascual (CELLS-ALBA synchrotron, IFAE and UAB)
January 17

Nanoscience and nanotechnology at a glance
Speaker: Jordi Pascual (ICN,UAB)
March 28

Status of neutrino oscillations and sterile neutrinos
Speaker: Michele Maltoni (UAM/CSIC)
May 2

Very early cosmology: current understanding and future prospects
Speaker: Valery Rubakov (INR, Moscow).
November 7

Oscilaciones de neutrinos en el experimento T2K
Speaker: Dr Federico Sanchez (IFAE)
November 16

4.9 IFAE Seminars in 2011

Particle Hunting at LHC
Speaker:Luca Fiorini (IFAE)
January 12

Non-linear SUSY and MSS
Speaker: Emilian Dudas (Ecole Polytechnique, Palaiseau)
January 14

Bubble Growth in Cosmological Phase Transitions
Speaker: Jose-Miguel No (IPhT, Saclay)
January 17

Electroweak light from Dark Matter annihilation
Speaker: Alfredo Urbano (INFN & Univ. of Salento, Lecce, & IFAE, Barcelona)
January 21

The dilaton, a Higgs impersonator
Speaker : Alex Pomarol
January 26

The Complex Structure of Scattering Amplitudes
Speaker: Pierpaolo Mastrolia (University of Salerno)
January 28

GUT models from F-theory compactifications
Speaker: Timo Weigand (University of Heidelberg)
February 11

Non-Perturbative Thermal QCD: Gluon Condensates and AdS/QCD
Speaker: Eugenio Megias (Univ. of Heidelberg and IFT, UAM/CSIC, Madrid)
February 18

A not so Elementary Higgs
Speaker: Christophe Grojean (CERN, Geneva & IPhT, Saclay)
February 21

Anomalies: the good, the bad and the ugly
Speaker: Francesco Riva
February 23

Low Energy Aspects of Conformal Technicolor with Weak Scale SUSY
Speaker : Jamison Galloway (U. La Sapienza, Rome & U. of California, Davis)
Februrary 25

Searching for new physics in top-pair and four-top production at the LHC
Speaker: Geraldine Servant
March 11

Flavour antisymmetry and new physics in the early LHC era
Speaker: Ben Gripaios (CERN, Geneva)
March 18

First results from the T2K experiment
Speaker: Claudio Giganti (IFAE/CPAN)
March 21

Amptotic safety
Speaker: Roberto Percacci (SISSA & INFN, Trieste)
March 25

Composite Unification
Speaker : Michele Frigerio
March 30

Ghost Condensates, Galileons and Supersymmetry
Speaker: Jean-Luc Lehners (Max Planck, Albert Einstein Institute, Golm)
April 1

WISPy signals from the sky
Speaker: Javier Redondo (MPI, Munich)
April 15

Compton Imaging: From Concept to Application
Speaker: Dr. Laura Harkness (University of Liverpool)
April 27

Galaxy Redshift Surveys : Using our local Universe to understand the accelerated expansion
Speaker: Martin Crocce (IEEC)
May 4

Fermionic Quantum Criticality from AdS String Theory
Speaker: Koenraad Schalm (Instituut-Lorentz for Theoretical Physics,University of Leiden)
May 6

Galilean symmetry in the effective theory of inflation: new shapes of non-Gaussianity
Speaker: Jorge Noreña (Institut de Ciències del Cosmos, U de Barcelona)
May 13

Duality Violations in tau decays
Speaker : Diogo Boito (IFAE)
May 15

The Higgs Potential in the Type II Seesaw Model
Speaker: Gilbert Moultaka (CNRS & University of Montpellier)
May 20

Gluon-fusion pair production of sleptons as a test of SUSY
Speaker: Francesca Borzumati (Tohoku Univ. Sendai)
May 25

Mathematica más allá de las Matemáticas
Speaker: Guillermo Sánchez de León (Universidad de Salamanca)
May 27

Asymmetric Dark Matter via Leptogenesis
Speaker: E. Fernandez Martinez (CERN, Geneva)
May 27

Technically natural dark energy from Lorentz breaking
Speaker: Serguey Sibiryakov (INR, Moscow)
June 6

A split SM embedding in SO(10), minimal type-II seesaw, and tree-level gauge mediation
Speaker: Andrea Romanino (SISSA, Trieste)
June 10

Duality Violations in tau decays
Speaker : Diogo Boito (IFAE)
May 15

Non-Abelian Semi-Local Vortices, from (S)QCD to Condensed Matter
Speaker: Walter Vinci (University of Minnesota)
June 17

The Little-Parks Effect and Quantum Hair on Holographic Superconductors
Speaker: Marc Montull
June 22

The Higgs: status and perspectives
Speaker: Abdelhak Djouadi (Universite de Paris Sud, Orsay)
July 1

LHC tests of the Tevatron t tbar asymmetry
Speaker: J.A. Aguilar-Saavedra (Universidad de Granada)
July 6

Neutrino masses from Kahler operators and broken SUSY
Speaker: Filipe R. Joaquim (CFTP, Lisbon)
July 8

Reconciling thermal leptogenesis and gravitino by the strong CP problem and its observation
Speaker: Jasper Hasenkamp (University of Hamburg)
September 16

Review of the situation with neutrino mass models and prospects – emphasis on S(3) symmetry
Speaker: Prof.H.Sugawara (the Japan Society for the Promotion of Science and former director of KEK)
September 19

ATLAS Selected Results
Speaker: Mario Martinez (IFAE)
September 23

Extraordinary phenomenology from warped flavor triviality
Speaker: Cedric Delaunay (CERN)
October 5

New hadronic currents in Monte Carlo Generators
Speaker: Pablo Roig (IFAE)
October 6

Counting Invisible Particles at the LHC
Speaker: Rakhi Mahbubani (CERN)
October 14

Boosted objects and subjects at the LHC
Speaker: Jon Butterworth UCL (London)
October 18

Light Neutralino Dark Matter in the MSSM
Speaker: Lorenzo Calibbi (Max Planck Institut fuer Physik, Munich)
October 21

The role of the entropy in the unitarization of Gravity at large UV regimes
Speaker: Pedro Silva
October 26

Emergent Lorentz Invariance
Speaker: Oriol Pujolàs (IFAE)
October 28

Very early cosmology: current understanding and future prospects
Speaker: Valery Rubakov (INR, Moscow).
November 7

Lepton magnetic moments: precision tests of the Standard Model
Speaker: Massimo Passera (INFN Padova)
November 18

The neutrino oscillation story according to MINOS
Speaker: R. Gran (University of Minnesota)
November 21

H -> gamma gamma, revisited
Speaker: Rafel Escribano
November 23

Complementarity in dark matter searches
Speaker: David G. Cerdeño (Instituto de Fisica Teorica, UAM/CSIC, Madrid)
November 25

Simultaneous measurement of the ttbar pair production cross section and the Rb parameter in the ATLAS experiment
Speaker : Jordi Nadal (IFAE)
Novemeber 30

Making the sneutrino a Higgs with a U(1)R lepton number
Speaker: Claudia Frugiuele (Carleton University, Canada)
December 2

Gravitational Anomaly and Transport
Speaker: Eugenio Megias
Wednesday December 14

The discrete composite Higgs
Speaker : Giuliano Panico (ETH, Zurich)
December 16

First results from the Double Chooz experiment
Speaker: Pau Novella (CIEMAT) that has been very active in the analysis of the data
December 19

On the factorization of the scattering of W bosons
Speaker: Roberto Franceschini (University of Maryland)
December 19