IFAE

Institut de Física d'Altes Energies

Report of Activities

2010

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 2010, la relació formal amb la Generalitat s'ha portat a terme a través del Departament d'Innovació, Universitats i Empresa.

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 2010 la Divisió Experimental va treballar en nou projectes:

1. ATLAS, un gran experiment al Large Hadron Collider (LHC) del CERN. Al novembre de 2009 l'LHC va tornar a posar-se en marxa, i ATLAS ja té un gran nombre de resultats obtinguts amb les dades de 2010.

2. Tot preparant unes importants millores de ATLAS, que s'instal·laran cap a l'any 2020, s'ha endegat un grup que afegirà a l'experiment un detector de Pixels.

3. CDF, un experiment de col·lisions antiprotó-protó en el Tevatron del Laboratori Nacional de Fermi (FNAL), en EUA, que encara prendrà dades en 2011.

4. S'ha posat en marxa un nou experiment amb feixos de neutrins, al Japó, i ha continuat la preparació d'un experiment al Laboratori Subterrani de Canfranc, al Pirineu.

5. A MAGIC, un experiment d'astrofísica de partícules que detecta raigs gamma d'alta energia a l'observatori del Roque de Los Muchachos a les Canàries s'ha començat a prendre dades amb un segon telescopi, inaugurat a l'abril de 2009.

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.

7. DES, un projecte de cosmologia observacional, amb grups d'EUA i del Regne Unit. S'està construint una nova càmara, que s'instal·larà en un observatori de Xile.

8. PAU, una col·laboració espanyola coordinada per l'IFAE i finançada amb un projecte Consolider-Ingenio 2010. PAU equiparà el telescopi WHT, al Roque de los Muchachos, per investigar el tema de l'energia fosca.

9. Recerques de física mèdica, que han produït unes patents i nous aparells de radiografia digital, i una empresa spinoff, X-ray Imatek. A 2009, s'ha obtingut un "Advanced Grant" europeu per tal de desenvolupar una nova idea especialment prometedora.

Activitats científiques de la Divisió Teorica

Durant 2010 la Divisió Teorica va treballar en tres grans temes:

1. Física del Model Estàndard

El grup s'ha dedicat a investigacions sobre les desintegracions del leptó tau, interaccions mesòniques, teoria perturbativa quiral, i la estructura de les correccions perturbatives de QCD, amb mètodes analitics.

2. Més allà del Model Estàndard

A 2010 el grup de fisica "Beyond The Standard Model" (BSM) ha anat investigant tres direccions: models "soft wall" a cinq dimensions amb mètrica AdS , transicions de fase en teories RS, i models de Higgs compòsit.

3. Astrofisica i Cosmologia

Les recerques d'aquest grup s'han enfocat en tres arguments: 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 a legal entity with its own "juridical personality". 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

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 rejoined the CERN organization 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 the IFAE.

In the following years the experimental division of IFAE grew from a staff of 10 to its present strength of about 75. The experimental program has expanded both in the number of projects and in their scope. In 1992 the group was involved in just one experiment in high energy particle physics, ALEPH at LEP, while at present there are 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, later DIUE) 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 the computational side 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 to emphasize 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.

1.3 IFAE Governing Board - 2010

President

Joan Majó Roca

Commissioner for Universities and Research, D.I.U.E.

Members

Joan Roca Acín
Director General for Research, D.I.U.E.

Ramon Moreno Amich
Director of CERCA Program, D.I.U.E.

Carles Jaime Cardiel
Deputy Rector for Strategic Projects & Planning, U.A.B.

Ramon Pascual de Sans
Professor of Physics, U.A.B.

Joaquim Gomis Torné
Professor of Physics, U.B.

Director

Matteo Cavalli-Sforza
Research Professor, IFAE

Adjunct Director

Ramon Miquel Pascual
Research Professor, ICREA

2. Scientific Activities in 2010

Outline

The Experimental Division

During 2010 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.

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

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

T2K, a neutrino long base-line experiment in Japan, which also started in 2009. In addition, a new project to search for double-beta decay processes in the Canfranc underground laboratory was launched.

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, while completing a second telescope,that began operating in 2009.

CTA, a multi-telescope array to be built in the next decade, is being designed.

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), is building a camera for a telescope at Cerro Tololo (Chile) in order to perform cosmology studies by observing about 300 million galaxies.

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 an existing telescope.

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 late 2009, 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 2010 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 2010 were hadronic decays of 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. Worked was done on a particular generalization of the Randall-Sundrum (RS) 5D space construction, on the problem of electroweak baryogenesis in RS theories, and on the Higgs as the pseudo-Goldstone boson of a global symmetry.

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 2010, work has focused on electroweak baryogenesis, on non-relativistic quantum gravity, and on models for Dark Matter.

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. The year 2010 constituted the first full physics year at the LHC.

After first collisions at the end of 2009 at 900 GeV and 2.36 TeV, the energy of the machine was increased, leading to proton-proton collisions at 7 TeV. During 2010 the ATLAS experiment collected a total of about 45 pb^{-1}. This data sample already allowed the ATLAS experiment to carry out numerous physics analyses and, in some cases, exclude given scenarios for new physics beyond the limits set at the Tevatron in the USA. Figure 1 presents a mosaic of many ATLAS physics results based on 2010 data and Fig. 2 shows, as an example, an event display of a top quark pair production candidate.

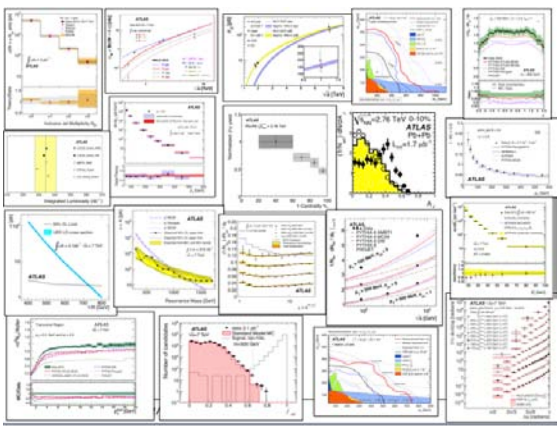

Fig. 1: Mosaic of some of the ATLAS physics results from 2010 data.

In 2010, the IFAE group maintained its responsibilities in the operations and calibration of the Tile calorimeter and the activities related to the trigger system and the study of its performance. The group played a leading role on several physics analysis fronts and kept a high level of visbility within the experiment's organizational chart. In particular, one of us (M. Bosman) was recently elected to become the Chair of the ATLAS Collaboration Board in 2012 and 2013, after being Deputy Chair in 2011.

Finally, in 2010 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 for the different activities of the group.

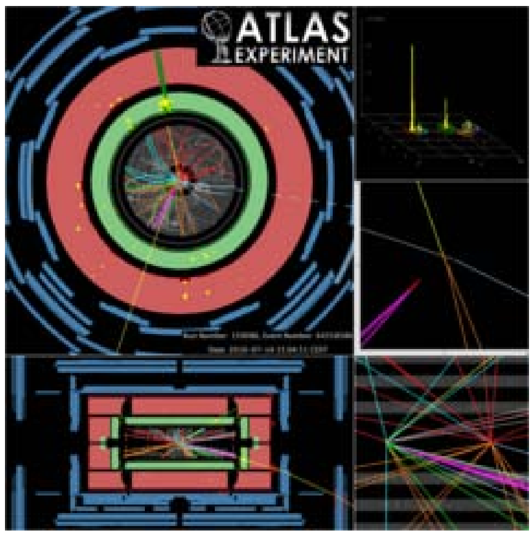

Fig.2: Event display of a top pair production candidate in the lepton+jets channel.

TileCal Hadron Calorimeter Activities

From the very beginning of the ATLAS experiment IFAE is committed to the operation of the central hadronic calorimeter of the ATLAS experiment, TileCal. In 2010, the IFAE group focused on calorimeter operation, calibration and data preparation. In particular, the group members served as TileCal Run Coordinator, Data Preparation Coordinator and Calibration Coordinator, all these positions being critical for the functioning of the TileCal system.

During the year 2010, TileCal demonstrated a very good performance: 99% availability for data taking and the average number of cells unavailable for physics measurements at 3%. The IFAE group members contributed most strongly to the detector operation, in particular maintaining the TileCal DAQ system and various detector performance monitors.

For all of 2010, TileCal provided data reconstruction with 100% efficiency. Moreover the data provided was of high quality. For example, based on the dedicated data sets the IFAE group has performed timing calibration with accuracy of 0.5nsec/channel (see Fig. 3). This timing calibration is needed for accurate triggering, to remove non-collision backgrounds (such as cosmics) and for accurate energy reconstruction. IFAE members have also developed an algorithm to treat non-Gaussian noise both in data and simulation. The major calibration system of TileCal is based on electronics designed, produced and maintained by the IFAE group. The time evolution of the TileCal response obtained with this system is shown in Fig. 4. Independent checks performed in 2010 with horizontal and cosmic muons have demonstrated the accuracy of global calibration to at least 4%, as illustrated in Fig. 5 and Fig. 6.

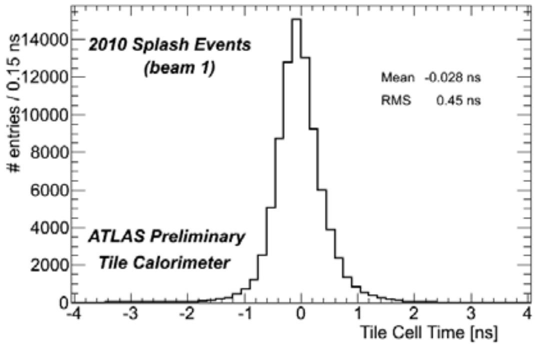

Fig. 3: Timing of TileCal signals recorded with single beam data on February 2010. Cell time distribution over several runs, after removing ~3% of cells without a proper time calibration.

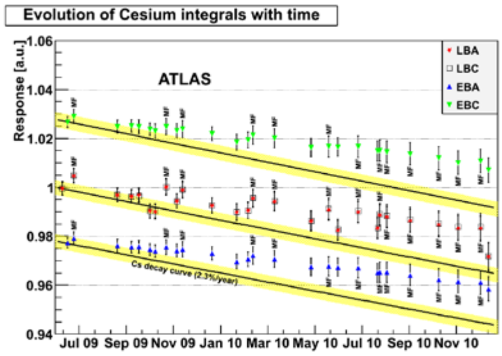

Fig. 4 Evolution of Tile response to radioactive Cesium as a function of time in all three calorimeter cylinders.

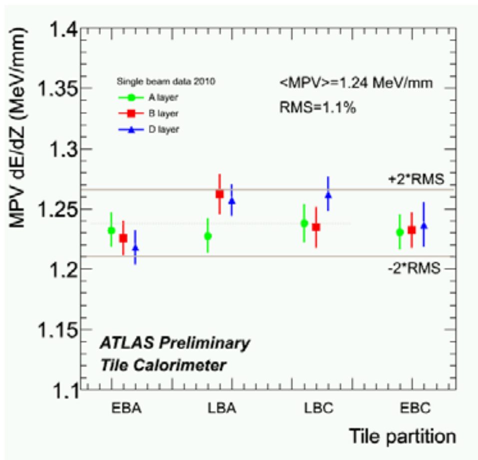

Fig. 5: TileCal MPV response to soft horizontal muons per radial layer of a calorimeter cylinder.

Studies of muons and hadrons from the LHC collisions have just started. These studies are potentially able to verify the accuracy of the energy calibration to the ultimate 1% level.

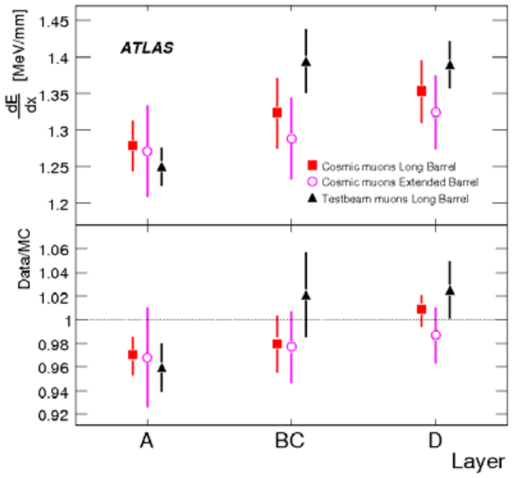

Fig. 6: TileCal truncated mean response to cosmic and test-beam muons shown per radial layer and, at the bottom, compared to Monte Carlo.

High Level Trigger Activities

The IFAE group holds responsibilities in the ATLAS High Level Trigger (HLT) system comprising the software-based 2nd and 3rd level trigger, which runs on two large computer farms. IFAE played a central role in the overall coordination of trigger operation, in the commissioning of the infrastructure software and in the integration of trigger algorithms helping to achieve an excellent efficiency already during the first data -taking period.

In addition, IFAE is responsible for the definition of the quantities used in the second level tau trigger chain. In 2010, the activities focused on the commissioning of the trigger logic using 7 TeV data, as well as on first attempts to measure the tau trigger efficiencies directly from data using events with Z bosons decaying into tau leptons. Figure 7 presents the distribution in data and simulations of the transverse energy (in the level 1 trigger) of the tau, demonstrating a

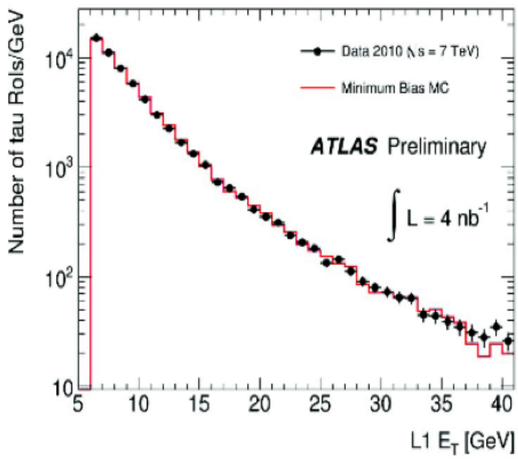

Fig 7 Transverse energy distribution of the tau candidates as determined using level-1 quantities

good understanding of the tau trigger quantities.

In 2010, IFAE continued the activities in the Jet trigger that were initiated in 2009. The group had a strong role in the studies related to the performance of the jet trigger in ATLAS using the 7 TeV data. Such activities turned out to be fundamental for the prompt analysis of the first data, and constituted a central piece of information necessary to obtain physics results, because many groups relied on the jet

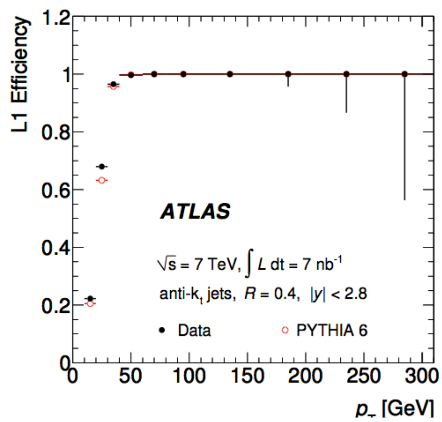

Fig. 8: Measured level-1 jet trigger efficiency in data compared to simulation.

trigger for the online selection of the data. As an example, Fig. 8 presents the jet trigger efficiency as a function of the transverse momentum of the jet, as determined by IFAE group members.

Physics Analyses

In 2010, the IFAE group maintained a multifarious and extremely active physics analysis effort on different fronts, mainly characterized by a number of standard model (SM) measurements with the very first ATLAS data. This includes: 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 of Z boson plus jets production, and a first measurement of the top pair production cross section. This is regarded as a first step toward a program focused on searches for new physics beyond the SM, which is already being developed at the time of writing this report. In all cases, the IFAE team has played a central role, thanks to the experience accumulated during the past years at the Tevatron experiments and to the detailed ATLAS preparatory work using simulated events.

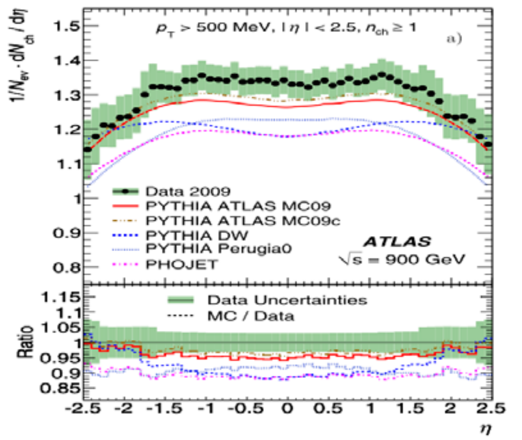

Fig. 9: Measured charged particle multiplicity in 900 GeV proton-proton collisions using the ATLAS data.

Minimum Bias interactions at 7 TeV

IFAE got involved in the measurement of charged particles multiplicity at 900 GeV, the first physics publication of ATLAS with proton-proton collision data (see Fig. 9).This was the subject of the PhD Thesis of M. Volpi, defended in December 2010.

Inclusive Jet Studies

The study of the inclusive production of jets at large momentum transfers constitutes a stringent test of perturbative QCD (pQCD) predictions and is sensitive to the presence of new physics like, for example, quark compositeness. Following the experience from the CDF experiment, members of IFAE have played a very significant role in similar studies at the LHC using the very first ATLAS data. Members of or group contributed to several aspects of the analysis, including: the jet energy calibration, the determination of the jet trigger efficiency curves, the study of the energy flows around jets, and acted as corresponding authors for some of the ATLAS papers and conference notes. The measured cross sections are well described by pQCD predictions (see Fig. 10). The results are given in an article that was accepted for publication in Eur. Phys. Journal C.During 2010, members of IFAE were also the driving force in a detailed study of the internal structure of jets in inclusive jet production processes, following similar studies carried out at the CDF experiment in the past. A detailed knowledge of the shape of the jet is crucial for a proper understanding of the phenomenology

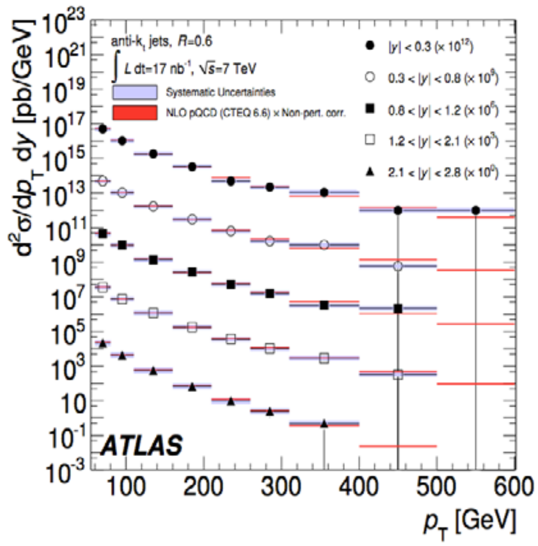

Fig. 10: Measured jet inclusive cross section as a function of jet transverse momentum in different jet rapidity regions. The data are compared to next-to-leading order pQCD predictions.

related to parton showers, underlying event contributions, and jet hadronization. Figure 11 shows one example of jet shape measurements. The data were compared to different predictions, and used as input in existing efforts to tune the QCD Monte Carlo generators to the ATLAS data. The results constitute an ATLAS article accepted for publication in Phys. Rev. D.

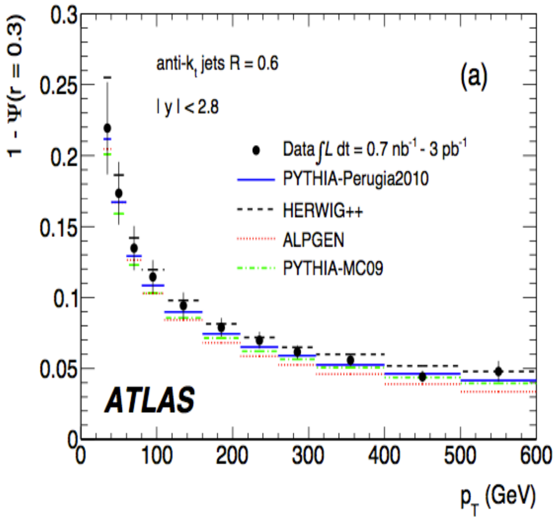

Fig. 11: The measured jet shape, 1 − Ψ(r = 0.3), as a function of the jet pT. The data are compared to different predictions.

Study of Z+jets Production

The mission of the LHC is to search for the Higgs boson and physics beyond the Standard Model (SM) like, for example, super-symmetry (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.

With the arrival of the first LHC data, 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 has been playing a leading role in the cross section measurements approved by the ATLAS collaboration to be presented during the first conferences in 2011, and members of IFAE act as corresponding editors of the relevant public notes.

Final results with the full 2010 data set are expected by spring 2011, to be promptly followed by their publication. Figure 12 presents inclusive jet cross-section measurements compared to different SM theoretical predictions in the channel in which a Z decays to muons.

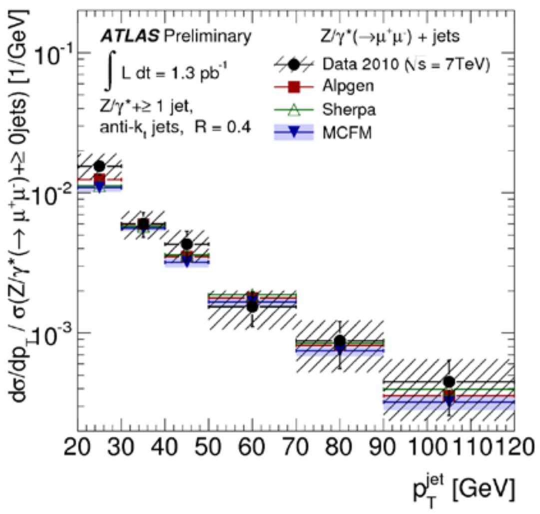

Fig. 12: Measured inclusive jet cross section in Z+jets production (muon channel) as a function of the jet transverse momentum. The data are compared to different SM predictions.

Top quark production

At hadron colliders, top quarks are dominantly produced in pairs via the strong interaction. This is the production mechanism that led to the top quark discovery by the CDF and D0 Collaborations at the Tevatron in 1995.

In contrast with the Tevatron, the LHC will become a true top quark factory, producing millions of top quark pairs per year. This will enable an exhaustive program of precise measurements of top quark properties, as well as searches for new physics in the top quark sector. Indeed, the large top quark mass raises the tantalizing possibility that the top quark may play a key role in the mechanism of electroweak symmetry breaking or open a window to new physics effects.

In addition, top quark events constitute a major background to new physics signals such as those arising from supersymmetry or new exotic heavy quarks. Therefore, establishing the top quark signal with early data and measuring its production cross section is an essential stepping stone towards fully exploiting the top physics program and performing searches for new phenomena.

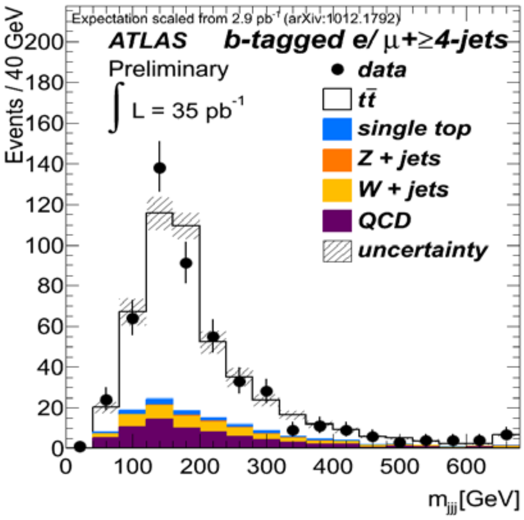

Fig. 13: Invariant mass distribution of the three-jet system corresponding to the hadronic top quark candidate in the data sample accumulated during the 2010 run.

The IFAE group is well positioned to carry out a competitive top physics program in ATLAS since several members of the group have extensive experience in top quark measurements at the Tevatron experiments (CDF and D0) and/or have strongly participated in the work of the ATLAS Top group. In 2010, members of IFAE played a leading role in the first measurement of the top pair production cross section at the LHC using the ATLAS data. The group focused in the "lepton+jets" channel, and looking for an electron or a muon in the final state.

In this channel, a characteristic top quark signal is observed above the background in the invariant mass distribution of the three-jet system corresponding to the top quark candidate decaying to hadrons (see Fig. 13).

The analysis makes use of b-jet identification (b-tagging) algorithms to improve the signal-to-background ratio, as the main background arises from W+jets production, with little heavy flavor content. This strategy allowed an early observation and first cross-section measurement of top-anti-top pair production with a data sample as small as 2.9 pb^{-1}. This work has been recently accepted for publication in Eur. Phys. Journal C. For this paper, members of the IFAE group acted as corresponding authors (see Fig. 14).

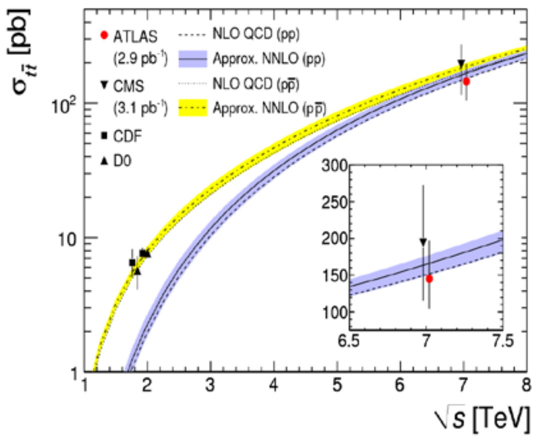

Fig. 14: Measured top pair production cross section as a function of centre-of-mass energy including recent results from ATLAS and CMS.

Searches for New Physics

In addition to the research lines discussed above, the IFAE group is already well involved in physics analyses that search for signatures of new physics beyond the SM using the 2010 data.

Members of IFAE are leading the search for SUSY and the presence of extra-dimensions in events with a high p_T jet and large missing transverse energy in the final state. Similarly, the IFAE team involved in top physics plays a central role in the searches for fourth-generation quarks. In both cases, results are expected by the winter conferences of 2011.

Computing infrastructure

The Tier-2 and Tier-3 LHC computing infrastructure of IFAE provided efficient access to the GRID resources during 2010. It gave support to all the analyses carried out at IFAE and the simulations requested by ATLAS for several of the analyses published by the collaboration. IFAE also significantly contributes to various areas of ATLAS central computing in the area of operations, physics and software validation, as well as software coordination, organization and documentation. 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 2010, the Tier 2 processed more than 2.5 billion events, with an average of 1000 jobs/week and peaks of 5000 jobs/week (see Fig. 15). The CPU and storage capacity in 2010 reached about 5000 HS06 CPU units and 520 TB, respectively.

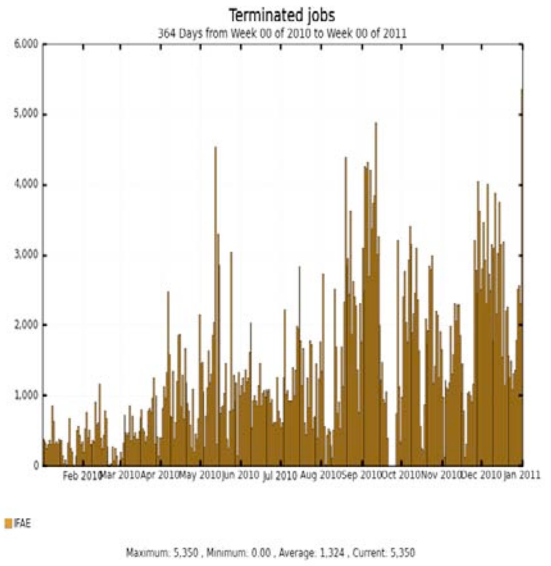

Fig. 15: Number of jobs per week processed in the Tier 2 computing farm in Barcelona in 2010.

In 2010, the capacity of the Tier 3 farm at PIC was enhanced in preparation for the incoming data, with the aim of providing the necessary computing infrastructure and services for ATLAS analysis at IFAE using local resources. The total CPU capacity of the ATLAS Tier3 is 2.66 k HS06 distributed among 16 blade servers. Given the large amount of data produced by the detector, the Tier3 has significant needs of disk storage. A disk server provides storage capacity to keep data generated by ATLAS at IFAE with a total capacity of 56 TB. Even after the successive filters applied on previous steps of the analysis performed on the grid, a typical Tier3 analysis job has to process millions of events.

Due to the heterogeneous nature of the computing jobs running on the ATLAS Tier3, different services were built to cover most of the use cases at IFAE:

• Interactive machines: they allow to work interactively with the ATLAS software providing a platform to develop, compile and debug the analysis software produced by physicists at IFAE.

• Batch system: it receives jobs sent by users, which are scheduled and run on a first come first in basis.

• Proof farm: it allows running analysis on a cluster-based parallel facility, where a master distributes the full set of events to analyze among different nodes in a way transparent to the user.

Figure 16 shows, as an example, the number of jobs analyzed in the Proof farm from September 2010 to December 2010, presenting in general an increasing demand on local resources.

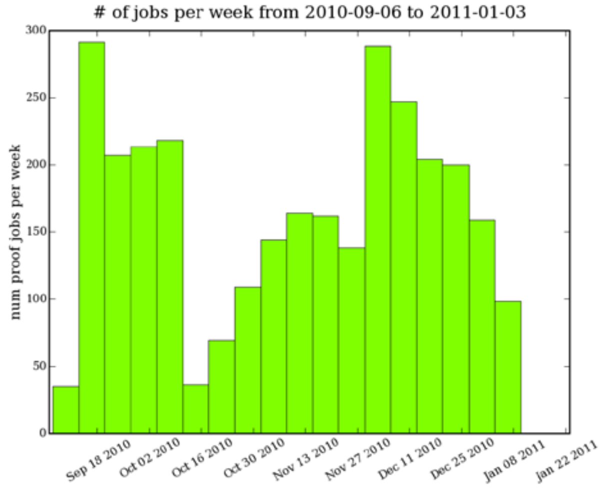

Fig. 16: Number of Proof analysis jobs per week processed in the Tier 3 computing farm in Barcelona in 2010.

2.2 Pixels for ATLAS upgrades

Sebastian Grinstein

Following the commissioning of the LHC and the initial data-taking period, CERN plans to further increase the accelerator design luminosity of 1×10^{34} cm^{-2} s^{-1} to 5×10^{34} cm^{-2} s^{-1} (super-LHC or sLHC). The particle fluxes going through the detectors will substantially increase and, consequently, the radiation damage received. In order to cope with this particle flux, the ATLAS Collaboration plans to add a new pixel layer (Insertable B-Layer - IBL) to the current pixel detector during the 2013 LHC shutdown. The objective is to improve the performance of the silicon system and compensate the possible deterioration that the present innermost layer of the pixel detector may suffer after the first years of running. Until complete replacement of the entire inner detector in 2017 or later, the IBL will have to sustain an estimated radiation dose of 5×10^{15} neq/cm^{2}. The ATLAS pixel upgrades will require the development of several new technologies to cope with the increase in radiation damage and detector occupancy and, at the same time, improve critical physics parameters such as impact parameter resolution. Two different promising sensor technologies, planar and 3D-sensors are currently under investigation for the new pixel layer. The IFAE group is working on the development of both these technologies.

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 upgraded ATLAS pixel detectors (both IBL and later upgrades).

The group is currently responsible for the delivery of 3D sensors for the IBL pre-production run (where IFAE is working in close collaboration with one production site, CNM-Barcelona), for part of the hardware for the high and low voltage distribution and monitoring system, and is investigating the hybridization technology (bump-bonding) of pixel assemblies for IBL.

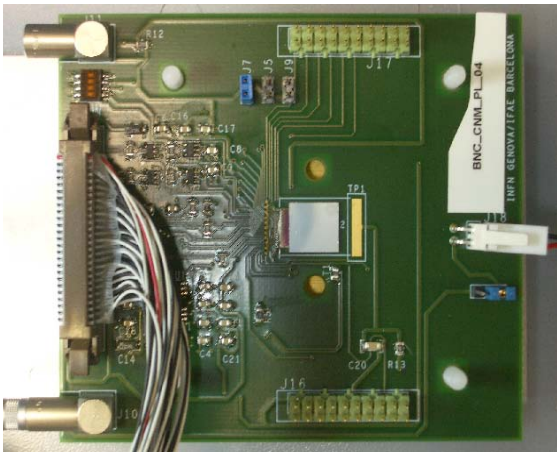

Fig. 1. Single chip assembly. A Barcelona n-on-p planar sensor bump-bonded to a FE-I3 chip is seen in the middle of the picture. The read-out card was designed by Genova-INFN and IFAE and produced in Barcelona

One member of the IFAE group is in charge of coordinating the systematic characterization of 3D devices for the on-going pre-production run. 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.

The current ATLAS pixel detector consists of n-type implants on n-type substrate. This design has been demonstrated to be able to deliver sufficient radiation hardness up to fluencies of ~1 x 10^{15} neq/cm^2. However, it requires the processing of both sides of the substrate: on the n-side the pixel structures are implanted, while in the p-side guard ring structures are needed to obtain a controlled potential drop towards the cut edge, to prevent a short though the conductive edge. This double side processing increases the difficulty of the production and thus the price of n-on-n sensors.

Sensors made on p-bulk are an interesting alternative to the more complex double-sided n-bulk sensors. Furthermore, n-on-p sensors are likely to replace the p-on-n technology of the current strip detectors, which performs poorly after high fluences. Therefore, IFAE,

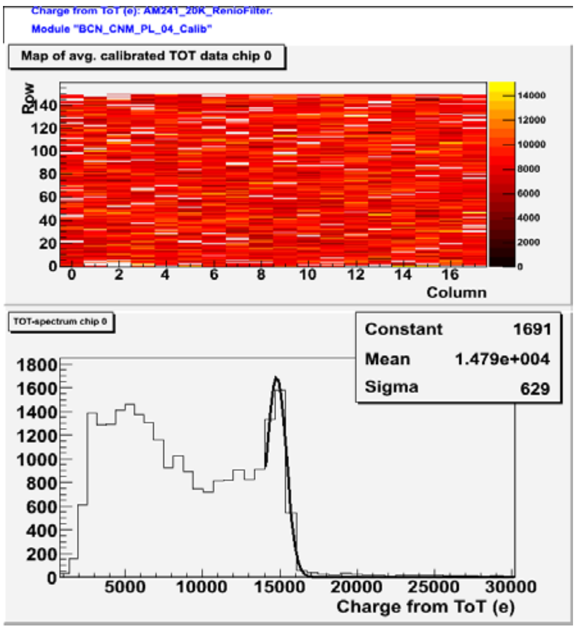

Fig. 2. The top plot shows the hit map of a planar n-on-p device from Barcelona when subjected to radiation from an Am^{241} source. The peak at 15k electrons which corresponds to the 59.7 keV photons indicates the correct calibration of the device

together with the CNM-Barcelona, has produced n-on-p sensor assemblies compatible with the current front end electronics of the ATLAS pixel detector, the FE-I3 read out chip. The sensors, produced at CNM, were bump-bonded by IFAE and then wire-bonded to a readout card designed by IFAE and Genova-INFN (see Figure 1).

Once wire-bonded, the device, or single chip-assembly, is ready to be characterized. Part of the characterization work can be performed at he IFAE pixel test-stand. This includes the measurement of leakage current, cross talk, noise, and minimum operable threshold. The planar n-on-p devices produced at Barcelona where found to have the expected behavior in terms of cross-talk (few percent), noise (130 electrons with a threshold of 3200 electrons), and minimum threshold (about 1500 electrons), however, the break down voltage of the production, of about 70V, is still too low. This could be caused by a higher than optimal inter-pixel isolation p-stop dose.

Finally, the critical test to of the performance of the devices is charge collection. Figure 2 shows the energy spectrum when exposing the single chip assembly to an Am^{241} source; the 59.7 keV photon peak is clearly visible.During July and October 2010, beam telescopes were used in the particle beam lines of the CERN SPS (Super Proton Synchrotron) to study planar pixel devices for the ATLAS upgrade. CERN's SPS accelerator provides high energy (120 or 180 GeV) pion beams for pixel characterization. These high momentum particle beams minimize the effect of multiple scattering, a pre-requisite for high precision tracking measurements. Several different pixel devices were studied during tese test-beam periods - produced at FBK-Italy, Stanford-USA, CiS-Germany and KEK-Japan - including two devices from Barcelona. A high resolution pixel telescope was used for track measurement. The telescope consisted of 6 planes equally distributed into two upstream and downstream arms separated by about 40 cm. The devices under test (DUTs) were located between the two telescope arms. The support structure provided the possibility of taking data and normal incidence or at 15^o (see Figure 4). More than 100 million events were collected during the beam-test periods. IFAE participated in the test-beam activities as well as in the data reconstruction. The data analysis, described below, was performed at IFAE and presented to the collaboration.

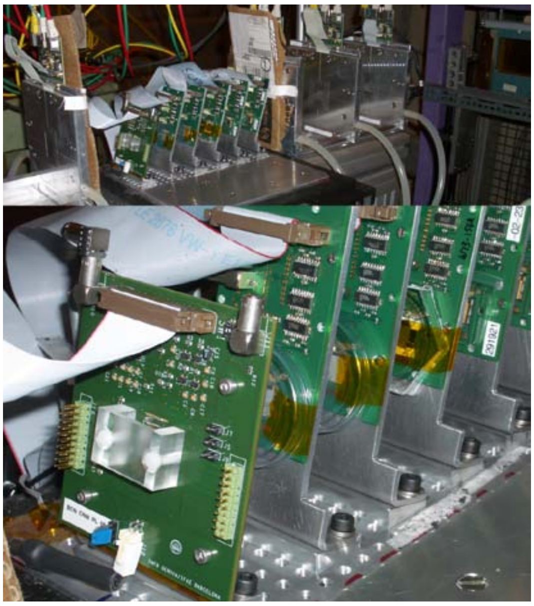

Fig. 3: Test-beam at CERN. Top: the devices under test (DUTs) can be seen between the telescope planes. The devices are arranged at 15°. The particle beam enters from the right. Bottom: the Barcelona device can be seen in the left most part of the picture.

Several analyses to study the performance of the device were carried out after the test beam. Most critical of these are the efficiency determination, the measurement of the position resolution and the edge performance studies. The efficiency of the IFAE devices is shown in Figure 4. Note that the edges are not included in the plot, but studied separately.

The hit reconstruction efficiency is of 99.8%, which is similar to the results obtained with other unirradiated devices. The tilt angle (0^o or 15^o) does not significantly change the efficiency.

Another critical parameter in the characterization of pixel devices, which can only be obtained in beam tests, is the position resolution, since a tracking system (the telescope in this case) is needed to reconstruct the particle trajectories. Figure 5

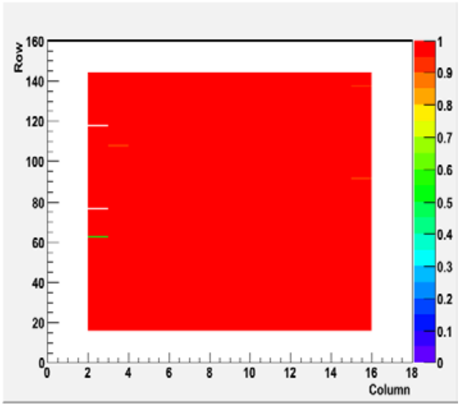

Fig. 4: Efficiency of one IFAE device. The overall hit efficiency is 99.8%. Note that pixels close to the edges are not considered in the efficiency calculation, but are treated separately.

shows the resolution in the short (50µm) pixel direction: the measured resolution of 4.3 µm is in good agreement with the results of other devices. Finally, the data was used to analyze the efficiency of the pixels in the edge region of the sensor. This analysis is still on-going, but as can be seen in Figure 6 the edge efficiency is quite high, 99.6% and the sigma of the half-Gaussian fit is 16 µm. It is worth noting that the high efficiency region extends towards the guard ring region, which means that the charge collection zone extends beyond the pixel area, reducing the dead area of the device.

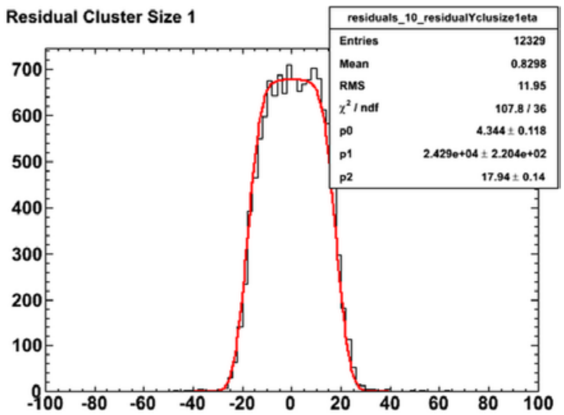

Fig. 5: Fitted residuals for one cluster hits. The fitted value indicates a resolution of about 4 µm. Consistent values are obtained for two cluster hits as well.

Though encouraging, the results presented here are not sufficient to establish the Barcelona devices as candidates for future upgrades. In order to investigate the radiation hardness of the planar n-on-p devices produced at Barcelona, two bare sensors were irradiated to $2.8x10^{15}$ and $5.0x10^{15}$ protons/cm^2 at CERN's PS irradiation facility. IFAE and CNM are collaborating in the characterization of these samples. The institutes are also collaborating in a new n-on-p sensor production with the aim of improving the breakdown voltage and to investigate edgeless technologies. Furthermore, CNM has recently produced 3D sensors, which will be characterized by IFAE in particle beams before and after being irradiated during 2011.

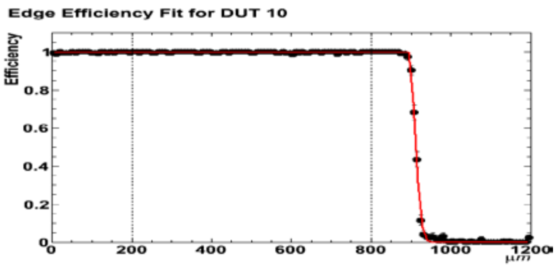

Fig. 6: Fit curve of the efficiency of the edge pixels. Even in these pixels, the Barcelona devices behave very well, with an efficiency of 99.6%. The Gaussian region has a sigma of 16.0 ± 0.4 µm. It can be noted that the flat region of high efficiency extends for about 100 µm into the guard ring region.

The IFAE pixel group is working in close collaboration with the Medical Imaging IFAE group on bump-bonding activities. Using the Suss Microtec FC150 bump-bonding machine, IFAE assembled devices based on sensors produced at CNM and CiS (Germany) using the current front end chip of the ATLAS pixel detector. The bonding yield is normally almost 100%. IFAE has also carried out bump-bonding studies on a new chip, the FE-I4, which will be used in the IBL. The FE-I4 chip fulfils the need to handle larger occupancies and bandwidths in the IBL. The size of the upgraded front-end (3.7 cm^2) is a factor of 4.5 larger than the current ASIC, making the flip-chipping process more challenging. To produce devices with a defect rate $<10^{-4}$ (IBL goal) the bow of the chips during the bonding cycle has to be controlled. IFAE and CNM have produced "dummy" FE-I4 assemblies in order to investigate the bump-bonding process needed for the IBL. These dummy devices are being used as mechanical samples for the IBL stave mounting tests at CERN (see Figure 7).

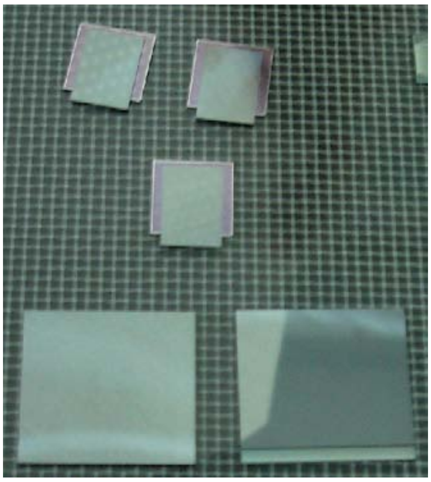

Fig. 7: Image of two dummy FE-I4 assemblies produced by CNM and IFAE (bottom). The three smaller assemblies in the top of the picture are FE-I3 devices. The assemblies are being used by the IBL installation team for mechanical testing.

2.3 The Collider Detector at the Tevatron (CDF)

VERÓNICA SORIN

At the Tevatron, proton-antiproton collisions are produced with a center-of-mass energy of 1.96 TeV. After the discovery of the top quark in 1995, the Tevatron was upgraded: the center-of-mass energy was increased (from 1.8 to 1.96 TeV) and its instantaneous luminosity has now surpassed the Run II design value of $3.5 \cdot 10^{32}/cm^2 \cdot s$. The Tevatron has already delivered a total integrated luminosity above 10 fb^{-1}.

Numerous upgrades to the CDF detector were also carried out for the Run II. Principal among them were the improvement of its tracking capability and a powerful vertex-finding trigger.

In order to cope with the higher trigger and data rate, improvements to the readout electronics and DAQ were performed as well. The CDF II detector is shown in Figure 1.

In 2010, the IFAE group in CDF has maintained its responsibilities on quality monitoring (DQM) of the data used by CDF for physics analyses. In addition the IFAE group continued its research program based on the study of events with jets of hadrons in the final state, and multi-jet events with large missing transverse energy as a signature for new phenomena like, for example, super-symmetry and SM Higgs.

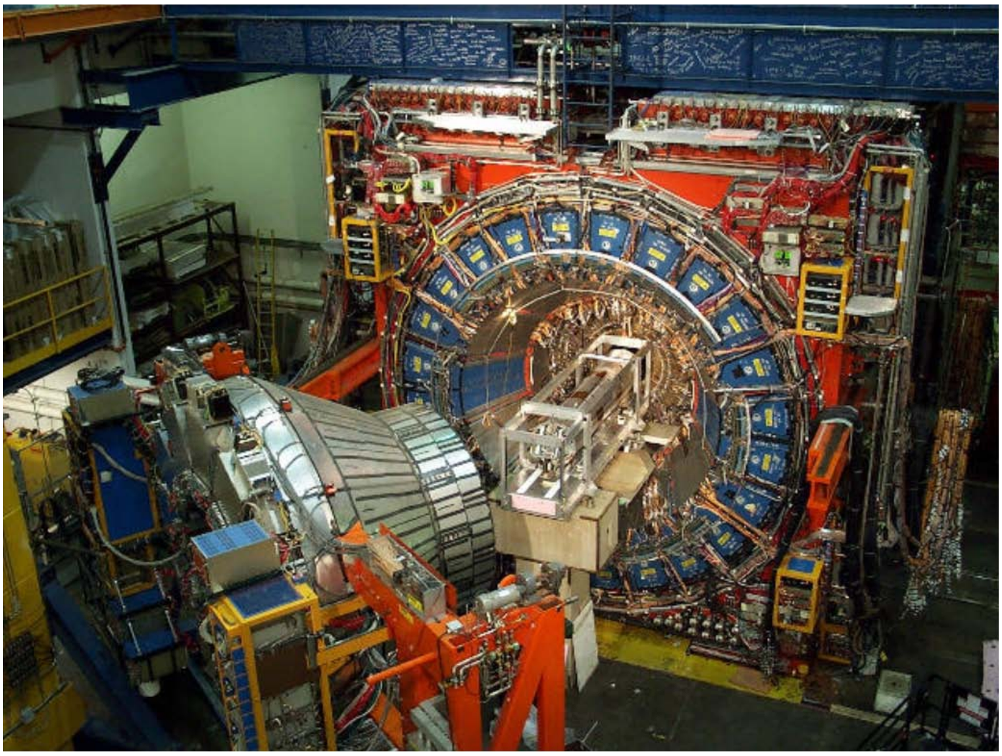

Fig.1 : The CDF Detector in Run II.

In the year 2009, final results on the search for squarks and gluinos in super-symmetry obtained based on 2 fb^{-1} of Run II data were published in Physical Review Letters. The inclusive search has its natural continuation in a dedicated search for direct bottom squark pair production. Preliminary results in this topic were first presented in the Lepton-Photon conference in 2009 while final measurements were published in Physical Review Letters in 2010. This publication included new improved limits on the mass of the sbottom particle as shown in Figure 2. All results are part of the PhD. Thesis by Gianluca de Lorenzo defended in July 2010.

In 2010, the group continued studies on 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 analyses have naturally translated into entry points to collaborate in searches for the standard model (SM) Higgs boson in the ZH associated channel, with identical hadronic final state.

Using a data sample of 6 fb^{-1}, members of IFAE have completed a new measurement of the inclusive production of jets in association with a Z boson, with Z decaying into a muon-antimuon pair. Measured cross sections were found to be well described by pQCD NLO predictions including non-perturbative corrections. Preliminary results have been presented at ICHEP (International Conference in High Energy Physics) in July 2010 (see Figure 3). Recently the group has updated the measurement in the electron channel, a work previously published based on 1.7 fb^{-1} of data, to the same integrated luminosity as for the muon channel. These results are about to be submitted to Physical Review D and will be the subject of the PhD thesis of Stefano Camarda, to be defended in 2012.

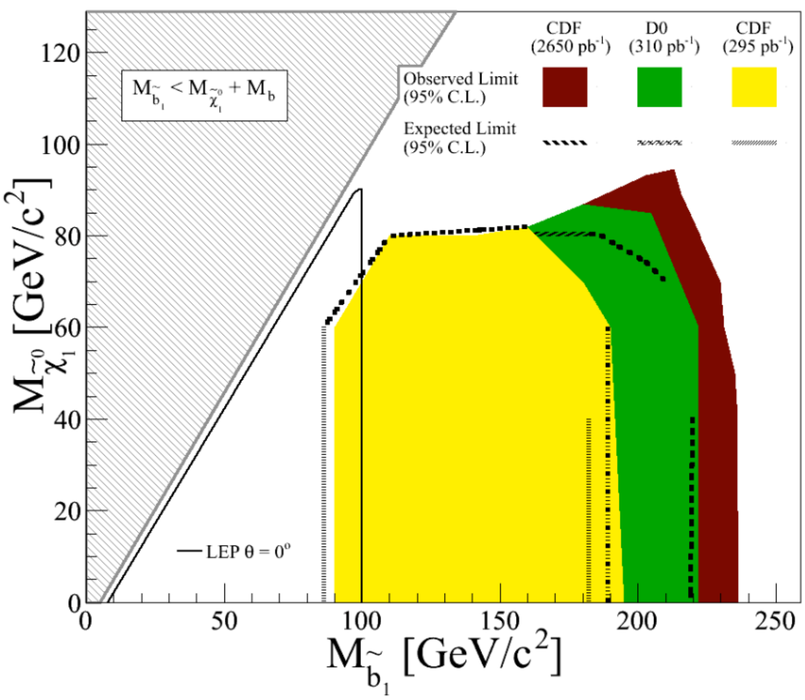

Fig. 2: Exclusion plane for sbottom pair production as a function of sbottom and neutralino (as published in Phys. Rev. Letter).

Studies of associated production of a Z boson with one or more b-jets are currently in progress. This process is important not only because it provides a test of pQCD predictions, but also because it constitutes the largest background to the search of the SM Higgs boson in the ZH mode with the Higgs decaying into a bottom and antibottom quarks pair. Therefore it is essential to understand its description by the current theoretical calculations. The analysis, built on the framework used for the Z+jets study, explores techniques to distinguish the flavor of a jet. Results in this subject will be included in the thesis of Lorenzo Ortolan.

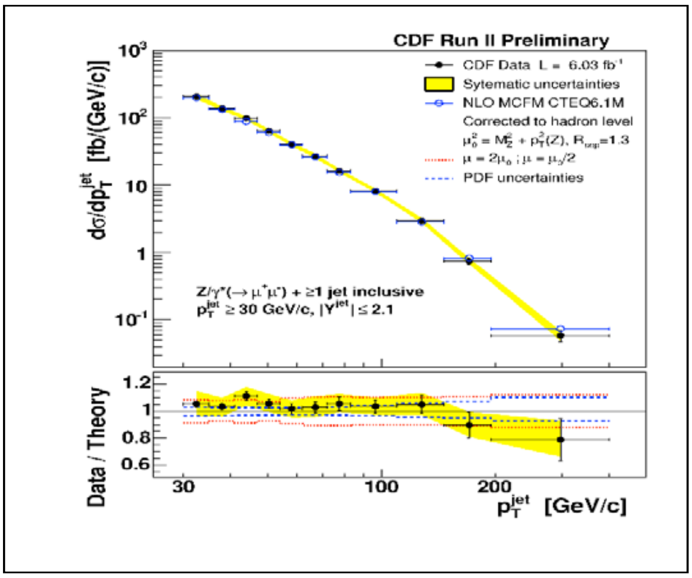

Fig. 3: Measured inclusive cross section as a function of $p_{T\ jet}$, compared to NLO pQCD predictions (as presented in the ICHEP conference in 2010).

2.4 Neutrino Experiments at IFAE

FEDERICO SÁNCHEZ

Since the discovery of neutrino masses and oscillations at the end of the 1990s, the interest in neutrino physics has been growing mainly in four aspects: measurement of the neutrino oscillation parameters with the ultimate goal of measuring CP violation (matter-antimatter differences), determination of the neutrino mass scale, determination of its nature (Dirac versus Majorana) and the measurement of neutrino nucleus cross sections that are fundamental for the determination of neutrino oscillation parameters. The IFAE neutrino group is involved in this effort contributing to neutrino oscillation measurements with the T2K experiment and to experiments on the nature of neutrinos with the double beta decay experiment NEXT.

T2K

T2K is a neutrino oscillation experiment whereby a conventional high intensity muon neutrino beam is sent from the JPARC proton accelerator center in Tokai (Japan) to the SuperKamiokande experiment in Kamioka (Japan) located 295km away, see Figure 1. Neutrinos are measured close to the production point at the near detector (N280) located 280m away. The neutrino beam is composed mainly of neutrinos of the muon type which are expected to transform into neutrinos of the electron type and of the tau type (that cannot be detected in Superkamiokande). The oscillation into electron neutrinos has not been observed yet, and has the potential to measure for the first time the mixing parameter θ_{13}.

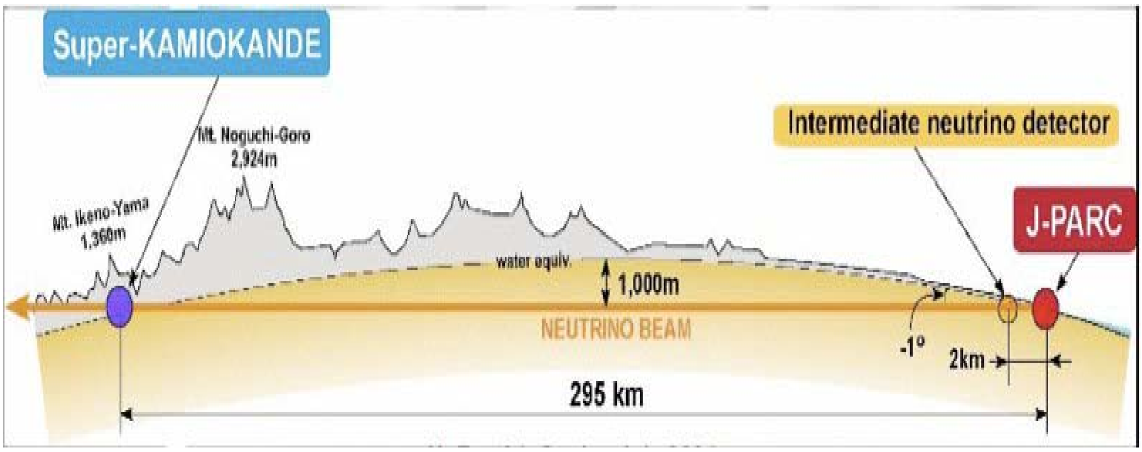

Fig. 1 Concept of the T2K experiment and its geographical locations.

The near detector is embedded in a magnetic field and is comprised of several sub-detectors, each one serving a different function: P0D to detect neutral pions, the FGD and TPC mainly for charged tracks, ECAL to measure photons and the 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) and the preparation of the magnet.

The TPC was assembled in TRIUMF and moved to its final location in the JPARC laboratory at the end of 2009; there it was readied for the first physics runs. IFAE contributed to the integration of the TPC modules taking care of the Data Acquisition System (DAQ). IFAE also continued developing the TPC reconstruction software and coordinating the event reconstruction group of the T2K near detector.

The IFAE group designed and built the magnet cooling water distribution system, at the IFAE workshop, and then installed it and commissioned at N280. The system allows to open and close the magnet without disconnecting the cooling pipes, thereby simplifying the procedure and the maintenance of the detector. The system has been operated at nominal conditions since then without any failure or leak.

The IFAE neutrino group is responsible for the magnet slow control. The slow control system monitors the running conditions of the magnet: temperature, cooling water temperature, coils voltage drop, cooling water flow, cooling water system status, power converter status, altogether more than 60 parameters are monitored simultaneously. If the system detects anomalies in the operation it switches off magnet power and generates the corresponding alarm.

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 July 2010 followed by the summer break. Data taken was resumed in November with higher beam intensity. The operation of the near detector was very successful with uptime higher than 90% at the end of the run period. The total number of protons on target accumulated until July 2010 is shown in Figure 2. The first event at the far detector was recorded on the 24th of February 2010 and is shown in Figure 3. A near detector event with a multiple-track interaction in one of the FGDs is shown in Figure 4. Thanks to the excellent performance of the TPC detectors events with multiple tracks can be resolved.

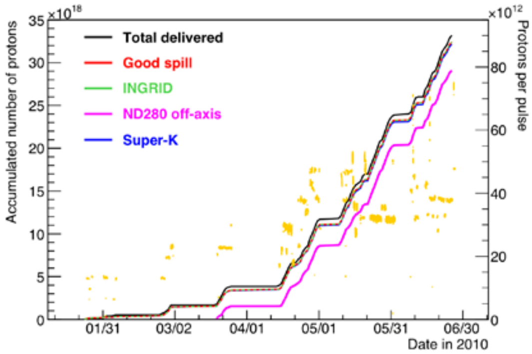

Fig. 2. Number of protons on target accumulated by the T2K experiment during the first half of the 2010 run.

The IFAE group contributed to the evaluation of the TPC performance with the early data. The results are published in arXiv:1012.0865. The achieved point resolution as a function of the drift distance (distance the electrons drifted in the gas before detection) is very close to the MonteCarlo prediction as shown in Figure 5.

The IFAE neutrino group also pioneered the analysis of the charged current events in the near detector, has been responsible for studying charge misidentification during reconstruction. In addition one of its members is the convener of the muon neutrino analysis group at T2K.

The IFAE neutrino group also contributed to the analysis of the data obtained with the SciBoone experiment at Fermi National Laboratory in Chicago (USA), which was operated in the year 2008. The main topic of the analysis was the determination of the charged urrent quasi-elastic neutrino-nucleus cross section. J. L. Alcaraz defended his thesis in October 2010 and it is preparing the publication of the analysis.

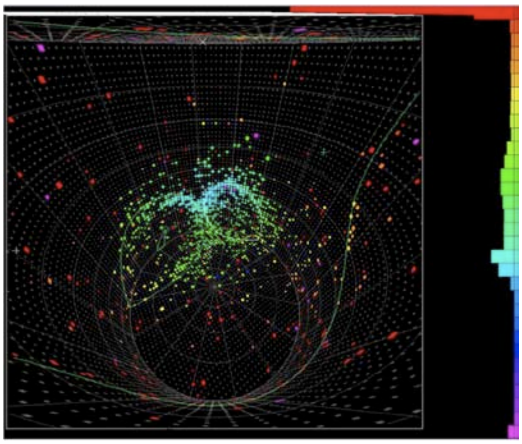

Fig. 3. First observed neutrino interaction from the T2K beam recorded the 24th of February 2010. It shows two rings, each one produced by an electron. The event is compatible with π^0 production by a neutral current interaction.

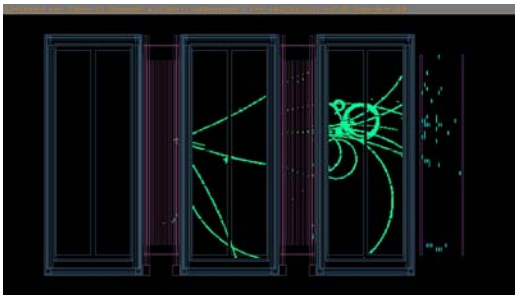

Fig.4.Event display showing a multi-track interaction in the Fine-Grain Detector (FGD) and the tracks detected in the TPC volumes.

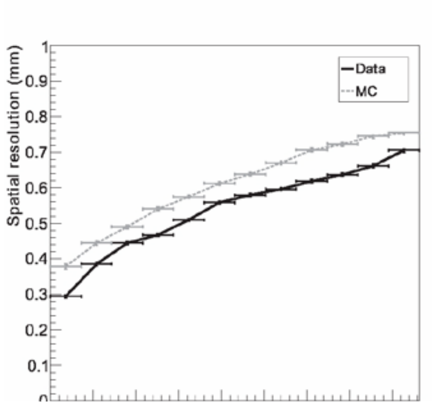

Fig.5.TPC point resolution as a function of the distance drifted by electrons in the TPC gas.

Neutrino-less double beta decay

The other aspect of the group's research activity is the search for the neutrino-less double beta decay. In standard double beta decay two neutrons in a nucleus disintegrate simultaneously to 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 (anti) neutrino is absorbed as a neutrino. In this field of neutrino physics IFAE contributed to the Nemo/SuperNemo and the NEXT experiments.

SuperNemo continues the successful NEMO-3 experiment but with a larger isotope mass and sensitivity. SuperNemo uses a tracking detector in addition to a calorimeter in order to identify both electrons separately and thus reduce backgrounds. The IFAE neutrino group developed the reconstruction software that was adopted by the collaboration as the official software. This development and the application to the NEMO experiment is the thesis topic of a member of the group, to be defended in 2011. The algorithm was entirely developed at IFAE and provides better performance than the official Nemo3 reconstruction software.

Fig. 6. NEXT R&D chamber at the IFAE laboratory with gas piping and purification getters. The ch amber is hosting 5 APD's.

The NEXT experiment is a very ambitious project consisting in a large pressurized TPC filled with Xenon enriched with an isotope that is a double beta emitter. NEXT is also a tracking detector able to identify electrons independently. The advantage with respect to the SuperNemo approach is that source, tracking and calorimeter devices are the same, thereby reducing the losses in the passive materials and improving the energy resolution by almost a factor of 10.

IFAE has concentrated on the development of the readout technology for the electroluminescence light (EL), based on Avalanche Photodiodes (APD) produced by Hamamatsu. These devices are directly sensitive to Xenon scintillating light in the deep ultraviolet regime (172nm). The IFAE group developed a gas system including vacuum and purification system for Xenon, as well as a drift chamber, built at the IFAE workshop,

equipped with electroluminescence readout and corresponding electronics, shown in figure 6.

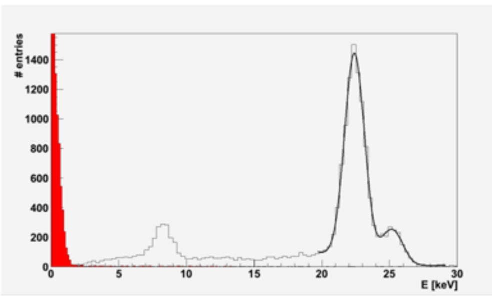

Fig. 7. The energy resolution, 7.2% FWHM for 22 KeV gammas, at a pressure of 1.65 bar. The red peak on the left is the signal from pedestals indicating that a very low detection threshold is possible with such a readout.

The system was finalized in 2009 and started data acquisition in 2010. First tests were performed with a single APD and commercial electronics. Taking advantage of this experience the light detection system was eventually upgraded to 5 APDs, read out by

Fig. 8. The pressure vessel of the 30 APD chamber.

custom made electronics developed and built By the electronic department of the IFAE. o our knowledge it is the first time that a multi-APD readout was used for the readout of an EL detector. Measurements were performed in the pressure range of 1 to 1.65 bar scanning a wide range of parameters. The best results for the energy resolution was 7.2 % FWHM at 22 keV at 1.65 bar indicating that this readout technology could provide the performance required by the NEXT experiment, as shown in figure 7.

The results of this study were presented at the 5th Symposium on Large TPCs for Low Energy Rare Events in Paris (arXiv:1102.0731).

In parallel to these measurements a larger chamber capable of containing about 30 APDs and 2 PMTs was designed in collaboration with a group from the CIEMAT, Madrid. Whereas the vessel was already available at IFAE, the field cage and sensor planes needed to be designed. The design phase is now finished and the production of the parts has begun, see figure 8.

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 are efficient enough to accelerate particles to energies in excess of 50 GeV. The study of these objects provides information about the challenging 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 annihilate into VHE□amma rays, hence the MAGIC telescopes may shed light on its nature.

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

The IFAE group built the camera of the first telescope (MAGIC-I). The camera 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

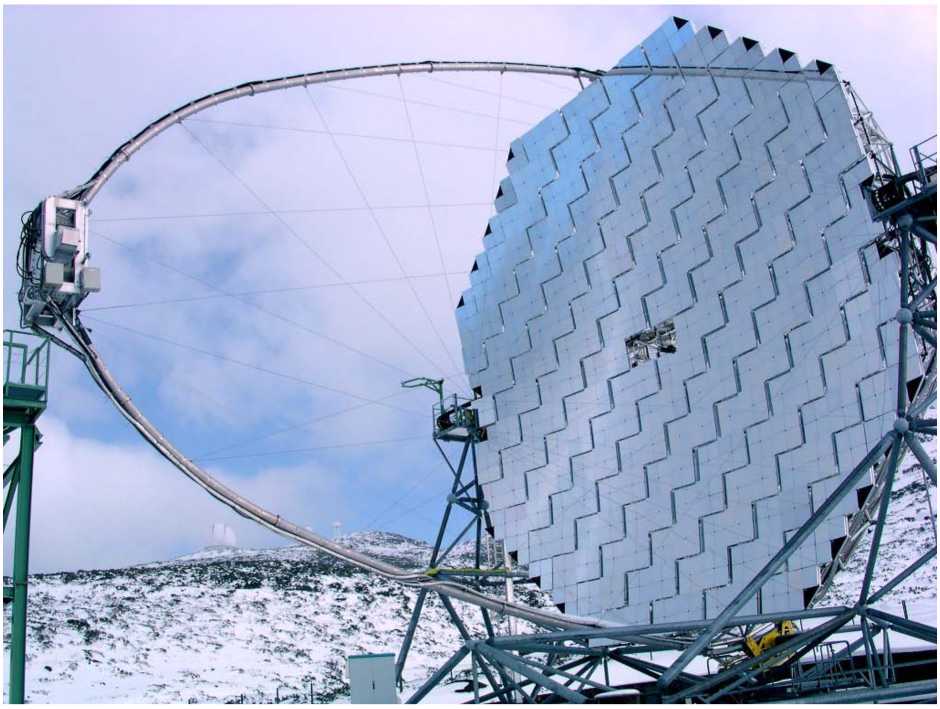

Fig. 1 (copyright R. Wagner): The first MAGIC telescope after a snowstorm at the Roque de los Muchachos observatory. Severe weather conditions are common at the site and drive the design of some the telescope elements. The two instruments are equipped with the largest optical telescope reflectors in the world. Each of them has a diameter of 17 m. These huge photon collectors allow the telescopes to detect gamma rays in the energy range from 25 GeV to a few tens of TeV.

MAGIC-I. The two telescopes work together in the so-called “stereoscopic” mode to 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 to study in great detail in the development of the particle shower in the atmopshere. By measuring the time profile of the shower and rejecting night sky light background on the basis of its arrival time, an article led by a member of the IFAE group and the PhD thesis mentioned below have shown that the sensitivity of a Cherenkov imaging telescope can be significantly improved. In addition our institute is solely responsible for the central control software of the two telescopes and 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 year, it successfully handled the increase in data output of the telescopes, processed the data and delivered the results to all the institutes in the collaboration.

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 during 2010 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 2010 the MAGIC collaboration has published ten journal articles and the institute has initiated or taken a leading role in many of them. A PhD thesis was completed during this year.

Fundamental physics remains high in the list of priorities 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 become detectable with Cherenkov telescopes. MAGIC has searched for such signatures in the center of the Perseus cluster of galaxies. Thanks to its huge mass and relatively short distance, the central region of the cluster may turn out as a bright source of VHE γ-rays. However no evidence for the presence of dark matter was found.

Luckily enough, the observation revealed a new source of gamma rays in the same cluster of galaxies, and one of a class of rare sources: radio galaxies. Most of the extragalactic sources of VHE γ-rays known to date belong to the so-called “blazar” class of galaxies. Blazars display jets where particles get accelerated and produce in turn VHE γ-rays. They are especially bright in this spectral band because the jet points within a few degrees of the direction of the observer. Due to the bulk relativistic motion of the plasma in the jet the energy and luminosity of emitted photons are boosted by relativistic effects. Radio galaxies, on the other hand, also display a jet but this jet does not point to the observer, so they were never promising candidates to emit at these high energies. The fact that it has been detected by MAGIC means that a new mechanism to accelerate particles may be at work.

IC-310 is only the third VHE radio galaxy discovered to date, and the first source of the so-called “head-tail” type. Head-tail radio galaxies display a radio morphology consisting of a bright head, close to the optical galaxy and a fainter, elongated tail. In the standard explanation, the jets are bent towards one direction creating the “head” structure. At larger distances they fan out in a characteristic tail that extends over many tens to hundreds of light-years. When the flow of the intracluster medium impacting these galaxies is supersonic, the pressure of the medium

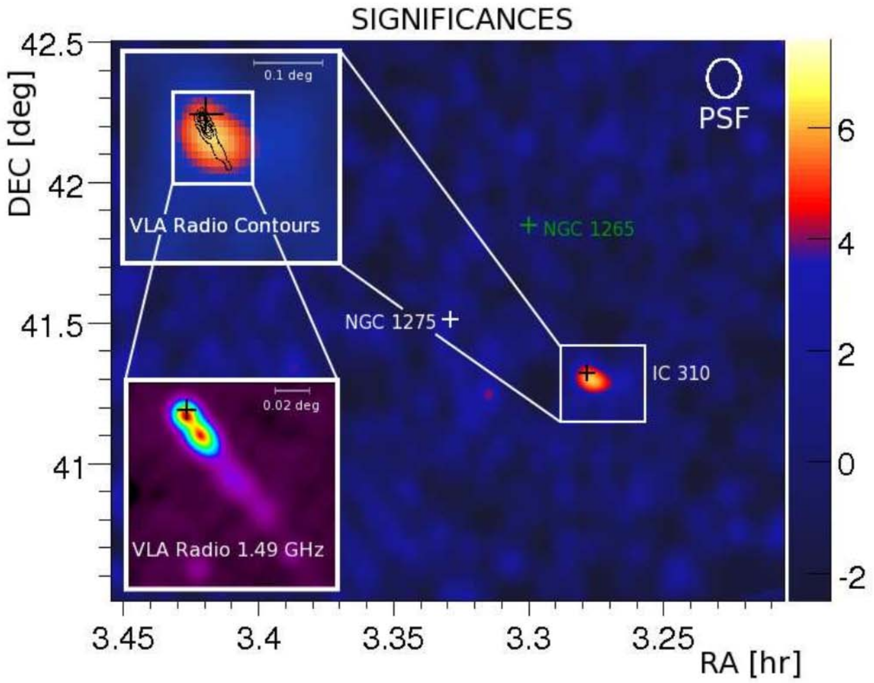

Fig. 2: A map in VHE gamma ray band of the Perseus cluster of galaxies, in 2008-2010. Significant emission is discovered in the position of the head-tail radiogalaxy IC-310. The top left box zooms into this area of the map and also displays in black contours the elongated morphology observed in radio by VLA.

causes the jets to bend and generate the “tail”.Even more surprisingly, the same observation revealed a second source. This is an unlikely event in this energy range, where sources are extremely rare: two sources of VHE gamma rays are present in the same (extragalactic) field of view of the MAGIC telescope only due to the fact that the Perseus cluster concentrates many objects within a few million light-years. This second source is in fact the central galaxy of the cluster, NGC 1275, which is a massive and extremely variable active galactic nucleus.

Further new findings have followed over the year. Members of the group have also studied in more detail galactic objects such as the microquasar Cyg X-3, which has been recently recognized to be variable at GeV energies on the scale of a few days, and two sources of an unknown nature, which have been reported to emit at extremely high energies, in excess of 10 TeV. The group is currently busy with a full upgrade of the telescopes. MAGIC-I will be equipped in Summer 2011 with a new 1039 photomultiplier camera, a clone of the camera of MAGIC-II. The electronics for both telescopes will also be upgraded at the same time to use a morecompact and reliable digitization chip. 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.

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. IFAE is again joining forces with the INFN-Pisa group, but this time also with the group at Universidad Complutense of Madrid to build the optical receiver boards for this upgrade. The design and prototyping of the electronic components for a new version of the optical receiver boards were completed atIFAE in 2010. The new boards were modified to enable a new trigger system with a much lower energy threshold for the detection of VHE γ-rays, down to energies of 25 GeV. Production of all the new boards started at the end of the year, in time for quality control and delivery in Spring 2011.

2.6 CTA: Cherenkov Telescopes Array

MANEL MARTINEZ

The "Cherenkov Telescope Array" (CTA) will be an advanced facility for ground-based VHE gamma-ray astronomy using Cherenkov detectors (see reference 1). It builds on the successful imaging atmospheric Cherenkov telescope techniques developed by the H.E.S.S., MAGIC and VERITAS collaborations. From H.E.S.S. and VERITAS, it exploits the progress made with telescope arrays and stereoscopic analysis that routinely improves telescope sensitivity by at least an order of magnitude. From MAGIC, it borrows the application of large telescopes to achieve the lowest possible threshold. Both approaches were proved to be extremely successful for gamma rays of energy above few tens of GeV and provide access to a broad range of astrophysical phenomena and fundamental physics themes, including detailed observations of the Universe at some of the largest energies to-date.

With these goals in mind, the CTA installation should have the following features:

a-Improved sensitivity at TeV energies (better than existing telescopes by oret han a factor of 10), allowing deeper observations and The discovery of many more sources.

b-Large detection area, enabling higher detection rates in less time. This feature is critical to obtain well-sampled light curves and a better characterization of transient phenomena.

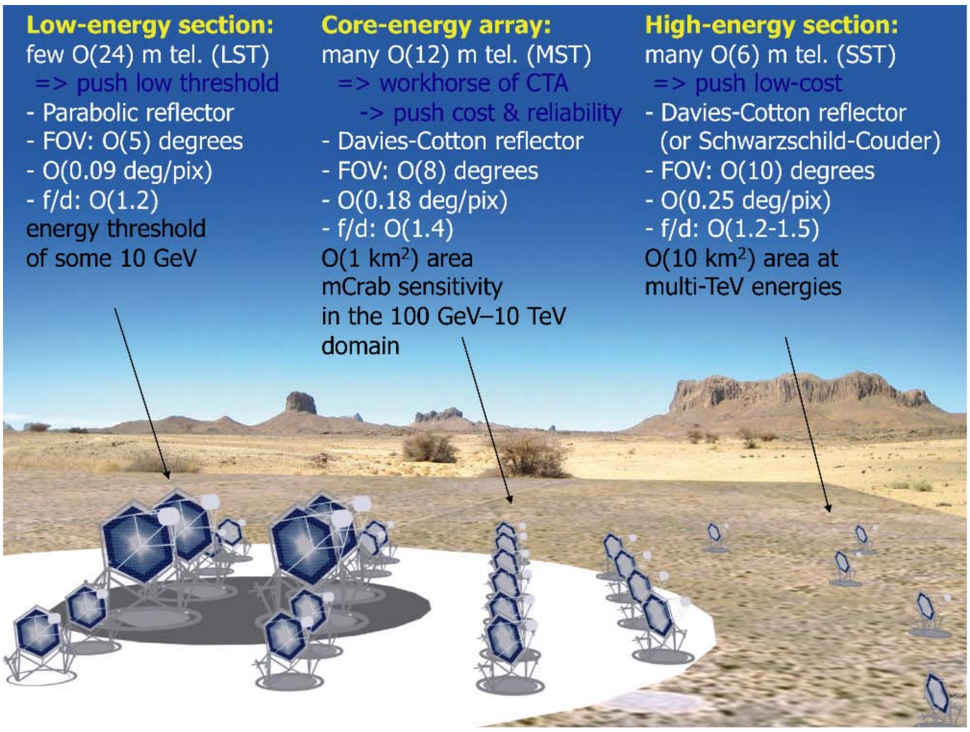

Fig. 1. An artist's view of the layout of a CTA site (not to scale) with a few baseline design numbers coming from the "Design Concepts for the Crerenkov Telescope Array CTA" document.

c-Higher angular resolution, which shall improve morphological analyses and as a result will provide a richer study of the structure of extended sources.

d-A low energy threshold (< 30 GeV), which is necessary for detailed studies of the pulsar emission mechanisms, distant AGNs, and dark matter signatures, as well as to provide a critical overlap with the energy region already covered by Fermi-LAT.

e-Sensitivity at the highest energies (>100 TeV), to allow the precise determination of the cut-off region of Galactic accelerators and to provide overlap with the future surveys at TeV energies performed by surface detector arrays such as HAWC.

f-Wide field of view. To provide detailed studies of extended sources and the realization of high sensitivity and wide energy band surveys.

Obtaining the performance features outlined for the CTA Observatory will require the deployment of an array made up by several tens of Cherenkov telescopes divided into three different sizes: a handful of large-sized telescopes (24-meter diameter) aligned in a compact configuration that will reach the specified low-energy threshold, a few tens of middle-sized telescopes (12-meter diameter) with emphasis on the high-sensitivity intermediate-energy region, and finally several tens of small-sized telescopes (6-meter diameter) arranged over a large area for the highest energy photons. The present results of Monte Carlo simulations, validated with H.E.S.S. and MAGIC data, suggest that such a system will probably consist of about 50 to 100 telescopes with a total of about 100,000 to 200,000 electronics channels and a total mirror area of about 10,000 m^2. The overall cost estimate is around 150 million Euro. This concept has been studied in detail during the "Design Study" phase of CTA and the outcome is the details provided in Fig.1.

Ultimately, CTA has the potential of discovering and studying in detail the spatial structure, light curves and energy spectra of ~1000 sources. The ideal scenario is one whereby CTA starts operating while Fermi-LAT is still active, as the two installationsnicely complement each other. Operational overlap with the Fermi satellite mission will provide seamless coverage of 20 octaves of the spectrum.

CTA was included in the ESFRI 2008 updated roadmap and ASPERA-ApPEC lists it among the highest priority future European astroparticle physics installations in its roadmap. In addition, CTA was also included with high priority among the future astrophysics facilities by the ASTRONET roadmap.

During 2010 the CTA project met two very important milestones:

1) On one hand, by mid 2010 the Design Study phase for CTA reached completion and a document entitled "Design Concepts for the Cherenkov Telescope Array" (see ref. 1) coordinated by Prof. Werner Hofmann (MPI Heidelberg) and Prof. Manel Martinez (IFAE Barcelona) compiling all the work done so far, was made public.

2) On the other hand, by mid 2010 the CTA Consortium started a three-year Preparatory Phase partially supported with funds from the FP7 EU program. The goal of this new phase is to be ready to start construction of the CTA Observatories by 2014.

Meanwhile, during spring 2010 the VHE gamma ray astronomy groups from USA (about 100 scientists from 20 institutions) along with groups from Brazil and India joined officially the CTA Consortium, that reached a number of about 750 scientists from all around the globe, the largest ever assembled together for an Astroparticle Physics project, making it a truly global scientific endeavour.

The main activities at IFAE during this period have concentrated in the following subjects:

1.-The design, development and characterization of different electronic solutions for the trigger system of the cameras of the CTA telescopes. IFAE has the responsibility of the design of the low level trigger for all the telescopes of CTA (see Figure 2).

2 - Starting the detailed design and prototyping work for the camera for the Large Size Telescopes of CTA (LST) that has begun in the new phase of CTA (the "Preparatory Phase").

3.-The continuation of the design and characterization work for the Raman LIDAR that is being developed at the moment at IFAE using a special container plus a 1.8 meter diameter telescope from the old CLUE experiment, and the construction of some of its subsystems (see Figure 3), like for example, the control system of the telescope, the control system of the laser and the system of alignment of the laser.

4.- Development of Monte Carlo simulations of different configurations from the matrices of telescopes of diverse types and characteristics to study the optimization of the diverse parameters for a considered fixed cost of the matrix of telescopes.

5.- Studies of the potential of CTA on physics themes such as Observational Cosmology and searches for Dark Matter.

6.- Studies of the energy needs of CTA and of the possible use of alternative energies.

Besides these activities, the IFAE group has organized or co-organised:

1.- A meeting in Barcelona of the Executive Committee of CTA

2.- A meeting in IFAE of the members of the work group ATAC of CTA that work in the development of Raman LIDARs.

3.- Meetings of the Working Groups on electronics and photosensors and of the Monte Carlo for CTA .

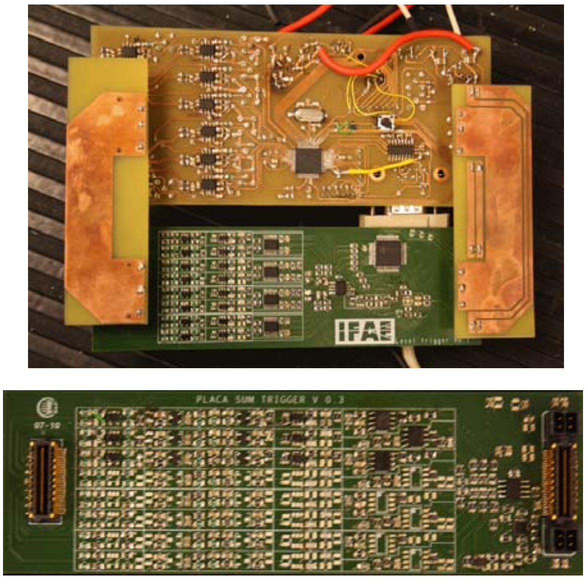

Fig. 2. Two prototypes of ultrafast trigger modules developed at IFAE for pixel clusters of CTA. The upper one is based upon the analogue sum of clipped signals. The lower one uses a digital majority of individual channel comparators. Both concepts are being evaluated at IFAE.

In addition:

1.- We have participated very actively in the general meetings of CTA and meetings of working groups of many different subjects.

2.- We have participated in diverse workshops, congresses and meetings of committees representing CTA in htese venues.

3.- We have organized the meetings of CTA-Spain, and co-organized "Jornadas abiertas de la RIA (Red de Infraestructuras de Astronomia)" on CTA in Barcelona in spring of 2010. As a result of this meeting, RIA decided to create an specific group for CTA.

Despite the large cuts suffered in budget and duration of funding requested for CTA in 2010, the IFAE group succeeded in having a very prominent role and a very visible presence in the international project development of CTA in 2010, as evidenced by the fact that Manel Martinez was re-elected Co-Spokesperson of camera for Large Size Telescopes (LST) CTA until the end of the Preparatory Phase in

coordinator of the work package on the during 2013, Oscar Blanch was appointed the Preparatory Phase of CTA, while the physics working group coordinator for Extragalactic Background Light continues to be Daniel Mazin.

Fig. 3 Some of the elements of the Raman LIDAR being built at IFAE for CTA: the CLUE container plus a 1.8 meter diameter telescope, the QUANTEL Brilliant Nd-YAG laser of 360mJ/pulse @ 1064 nm with a frequency tripler, and the LUMATEC liquid lightguide series 300 with 8mm diameter and 3200mm length.

Ref. 1. "Design Concepts for the Cherenkov Telescope Array CTA", arXiv: 1008.3703v1, Hofmann, W. and Martinez, M. corresponding authors.

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) 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 15,000 galaxy clusters.

Furthermore, another 10 square degrees of the sky will be repeatedly monitored with the goal of measuring magnitudes and redshifts of about 2000 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.

The DES Collaboration is in the final stages of building a large CCD camera (DECam), giving images covering about 3 sq. deg. of the sky. The camera will be mounted in 2011 at the prime focus of the 4-meter Blanco Telescope, located in Cerro Tololo in Chile. In return, DES is granted 30% of all the observation time for five years (2012-2016). Figure 1 shows DECam being put together at Fermilab during the fall of 2010.

The three Spanish groups, funded by the Program of Astronomy and Astrophysics, which is part of the National Plan of R+D+I,

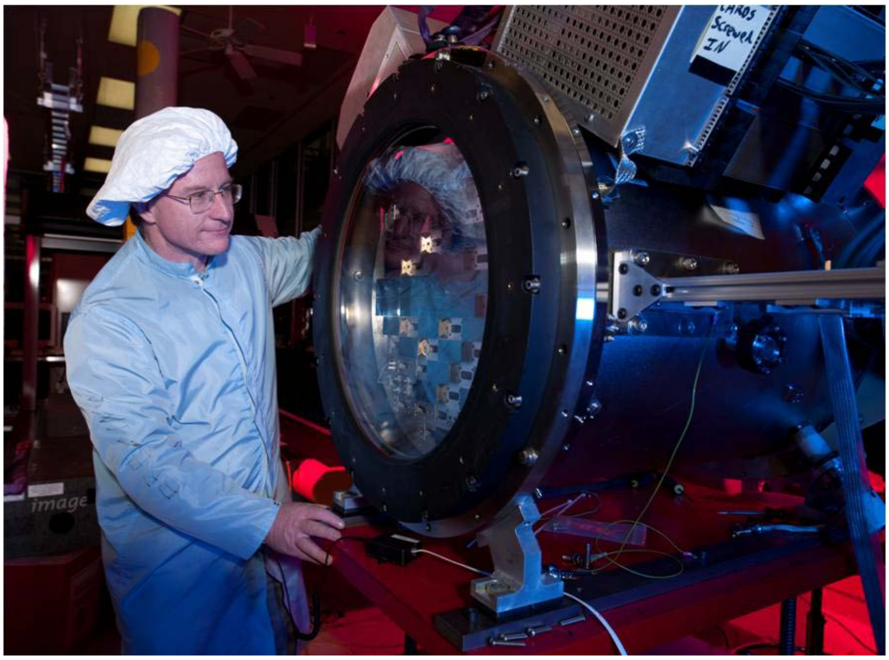

Fig. 1: DECam being assembled at Fermilab during 2010.

have built the whole set of read-out electronics boards of DECam, and have designed three out of the four main boards: the Clock and Bias Board (CB) at CIEMAT, the Master Control Board (MCB) at IFAE, and the Transition Board (CBT) for the CB at IFAE and CIEMAT.

During 2010, IFAE launched the production of the MCBs, of the 12-channel Data Acquisition Boards (ACQ), designed at Fermilab, and of their associated transition boards (ACQT). The final production started in February 2010, and was finished in early summer. All in all, IFAE produced 10 MCBs, and 28 each of ACQs and ACQTs. Figure 2 shows one of the MCB cards designed and produced at IFAE. After the production, the boards were programmed, thoroughly tested, and shipped to Fermilab for their integration into DECam. The last shipment took place in August 2010, in agreement with IFAE's commitments towards DES. During the fall of 2010 during an extended visit to Fermilab two IFAE engineers participated in the integration and first commissioning of the whole read-out chain.

Since DES should produce the first science-quality data at the end of 2011 or beginning of 2012, we started in 2010 to get ready for the data analysis. 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 that DES will observe using photometric techniques. We have adapted the Bayesian Photo-Z (BPZ) package to the characteristics of the DES galaxy sample and have obtained very 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 a 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.

Fig. 2: One of the Master Control Board (MCB) cards for the DECam produced at IFAE in 2010.

During 2010, we finished the analysis of the properties of SN2007qd, in collaboration with colleagues from the University of Notre Dame in the United States. We concluded that SN2007qd is a clear type-Ia supernova, a member of a small family of extremely sub-luminous type Ia's that explode through a deflagration (sub-sonic) event rather than a detonation (super-sonic) event. The family comprises at least three other fast-declining sub-luminous supernovae: SN2002cx, SN2005hk, SN2007qd, and SN2008ha.

Figure 4 shows measured spectra of the four supernovae at about 10 days past maximum brightness.

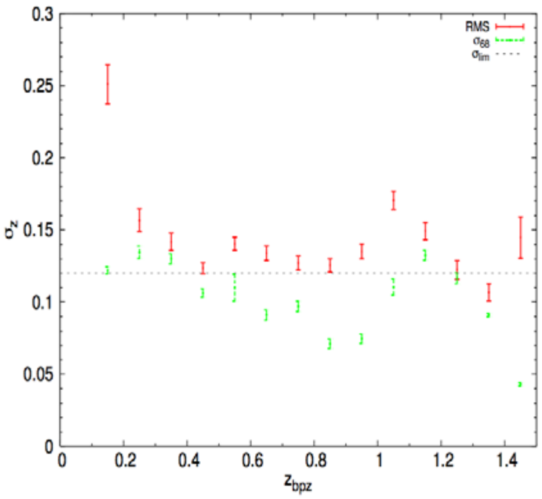

Fig. 3: Expected redshift resolution in DES as a function of the measured redshift. The red points correspond to the root mean square of the distribution of the differences between real and measured redshifts, while the green points correspond to the area encompassing 68% of this distribution. The difference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

The similarity of the four spectra is evident, indicating that these four supernovae belong to the same family of events. In particular, our study demonstrates that, contrary to previous claims (Valenti et al., Nature, 459, 674 (2009)), SN2008ha is also a type-Ia supernova. Our work was published in The Astrophysical Journal.

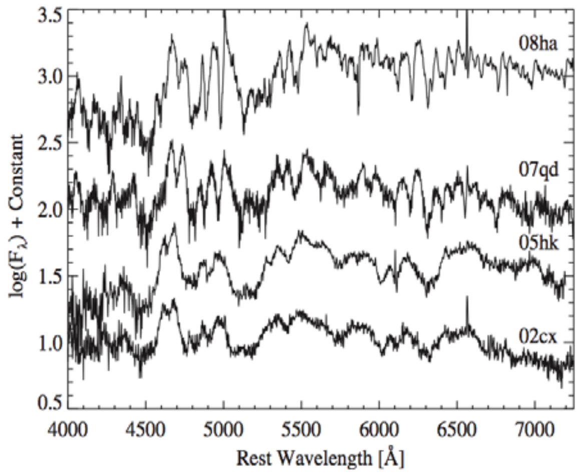

Fig. 4: Normalized spectra of four peculiar SN Ia, observed at about 10 days past máximum brightness. The four spectra show clear similarities, particularly among 07qd and 08ha.

Our institutional involvement in the governance of DES has continued to grow. A member of the IFAE group seats on the DES management committee and on its publication board, and also chairs the DES speakers' Bureau, the committee that chooses speakers to represent DES in conferences and workshops. Another member of IFAE belongs 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

Ramon Miquel

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 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 until fall 2012 at the earliest (the year in which the Consolider project finishes) 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).

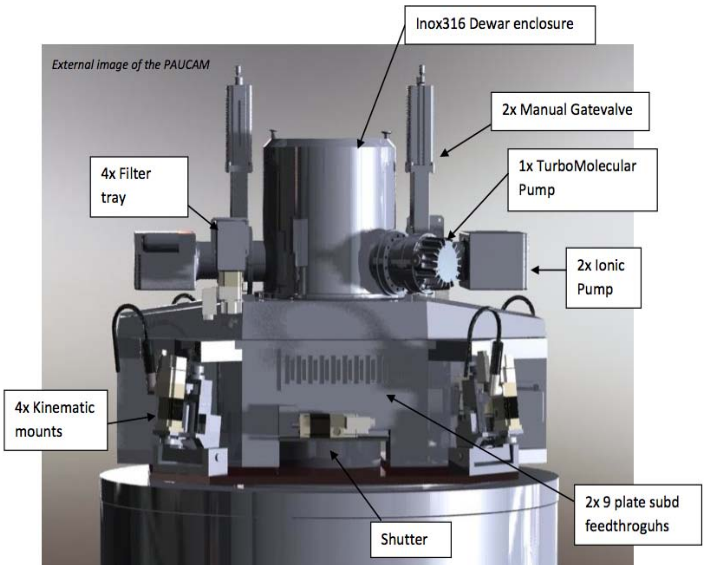

Fig. 1: Overall external view of PAUCam. The light from the telescope enters the camera from the bottom.

This telescope is fully operational and is very well maintained, with a dedicated staff of about 40 persons. The WHT has a field of view (FoV) of 1º 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 26th 2010, the ING board approved the status of visitor instrument for PAUCam.

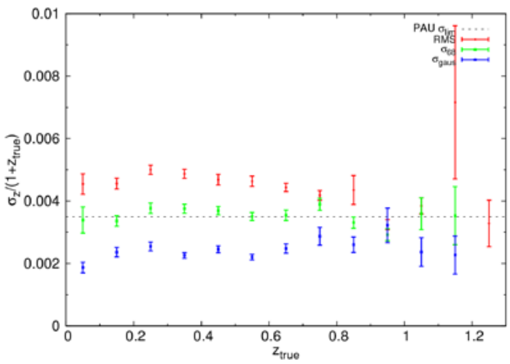

Fig. 2: Resolution in redshift scaled by (1+z) as a function of the real redshift. Different colors represent different ways of computing the dispersion of the measured redshift with respect to z_{true}.

The proposed instrument covers the entire FoV of the telescope with 18 2k x 4k fully-depleted red-sensitive Hamamatsu CCDs, with a 0.26”/pixel plate scale and 15 μm pixels. 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 μm. An overall view of the camera is shown in Figure 1.

During 2010 the base design, including mechanics, cryogenics, vacuum, read-out electronics, control system, etc., has been finalized, and several time-critical components (for instance, the CCDs) have been ordered.

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. During 2010 a filter optimization study was performed ending up with a preferred solution with 36 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 22.5, at the same time providing typical photometric redshift precision (σ_z~0.035x(1+z)) for galaxies with i_{AB} between 22.5 and 23.7. Figure 2 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.

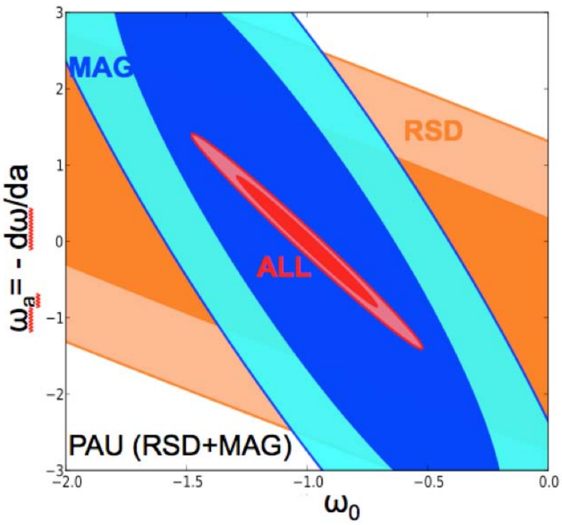

Fig. 3: Contours (68% and 95% CL) for the dark energy equation of state parameter now w0 and its evolution wa that can be achieved with a PAU survey of 200 deg2 using redshift-space distortions (RSD, orange), weak-lensing magnification (MAG, blue) and combined (ALL, red).

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.

Indeed:

* 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 3, which is comparable (and complementary) to the constraints that will be obtained with DES and BOSS.

2.9 Digital Radiography

MOKHTAR CHMEISSANI

In 2010 the medical physics group worked on three fronts: R&D on bump-bonding pixel chips, new devices for nuclear medicine, and activities in collaboration with X-Ray Imatek.

Bump-bonding

We continue our R&D on the flip-chip process, extending it to indium bumps with the reflow process. In Figure 1 one can see an array of indium bumps with a pitch of 55 μm after the flip-chip operation (top left) and then detaching the sensor from the chip. The bumps are clearly flattened because of the compression during the flip-chip and bonding operation.

We have achieved excellent wetting by indium of the Under Bump Metal (UBM) pads. This can be seen in the top right and bottom figures. The two images are taken from the same area but with different angles and magnifications. The disc seen on the top of one of the bumps is the UBM which was pulled away from the sensor pads and stuck to a bump. Next to it one can see the absence of a bump. In this case the indium bump was pulled away from its pad on the chip and but stuck to the UBM pad on the sensor. This indicates an excellent wetting between the Indium bump and the UBM. This is an Important milestone for low-temperature flip-chipping, which is needed in order to obtain pixel CdTe detectors.

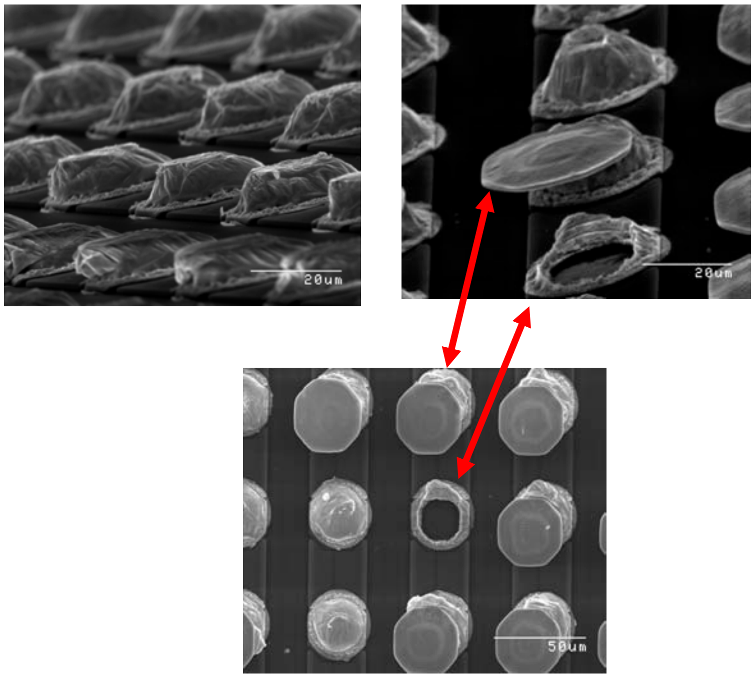

Fig. 1: The top left image shows an array in indium bumps after flip-chipping/bump-bonding and then detaching the chip. The top right and bottom images are of the same area of the Medipix2 chip but with different viewing angles and magnifications. In this region the contact between the UBM and the bumps is excellent.

Besides developing the indium bump-bonding process, we continued supporting the R&D activities in RD50, a collaboration of which the ATLAS pixel group is a member. Figure 2 shows the flood image of a 150 µm thick Si sensor bonded to a Medipix2 chip using the X-ray Imatek flip-chip machine.

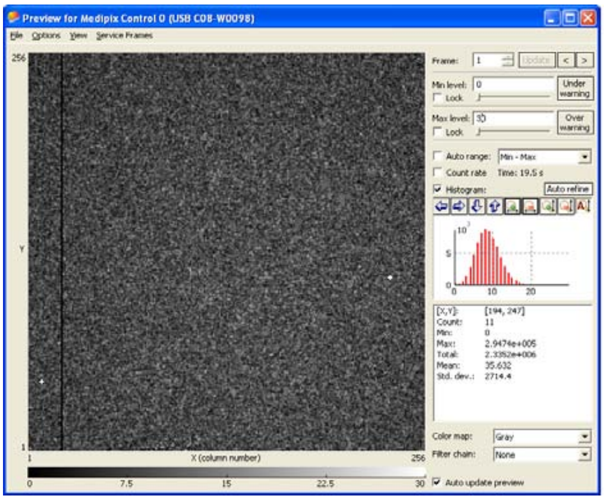

Fig. 2: Flood image of a Medipix2 chip bonded to a 150 µm Si sensor. One can see that all the pixels were bonded. The vertical column that shows dead pixels is due to malfunctioning of the Medipix2 chip itself and not to bump-bonding.

Nuclear Medicine

In July 2010, the European Research Commission's Advanced Grant for the VIP project was signed between IFAE, the host institute, and the European Research Council.

We have started to set the specification of a dedicated readout frontend ASIC for a CdTe detector with a pixel pitch of 1mm. The design has started using the TSMC 0.25um technology. Each channel will have a dynamic range of up to 1 MeV in the Si detector, with a resolution of 1keV (implying a 9 bit ADC) and one TDC per ASIC with a timing resolution better than 1 nanosecond. With the VIP ASIC we expect the PET coincidence time window to be 20 nanoseconds, with an occupancy of 0.1%/channel at 10 MBq.

In parallel we started to evaluate the response of individual coplanar detector for the purpose of finding the working point in terms of HV bias and CdTe temperature that achieves optimal energy resolution. Energy and time resolution are crucial merit figures for any PET scanner. In our case, the better the energy resolution, the higher is the power to reject scattered events. In figure 3 one can see preliminary spectroscopy result for Co57 using 750µm thick coplanar CdTe at 500V bias and at room temperature. The achieved resolution is 2.5%, FWHM at 122keV. We aim for a better energy resolution at higher value for the bias HV and at a temperature close to zero degrees Celsius.

By design, in the VIP scanner the electric field within the pixel CdTe detector is parallel to the scanner axis. Therefore when the scanner is placed in the Magnetic Resonance (MR) scanner, the MR magnetic field is parallel to the electric field in the pixel CdTe detector. Hence there will be no impact on charge collection in pixels. This makes the operation of the VIP scanner fully compatible with strong magnetic fields, a crucial feature for dual modality imaging i.e. using PETs inside MR scanners.

This is an excellent tool for several frontier applications, brain imaging being one example. To verify this fact, we inserted a Medipix2 chip bonded to an 800µm thick pixel CdTe detector with 55um pixel pitch into a Tesla superconducting magnet at DESY, Hamburg. Considering that the charge has to drift a distance 800µm, which is almost 14 times the pixel pitch, one can easily detect changes in the charge drift by measuring the displacement of the centroid of the drifted charge.

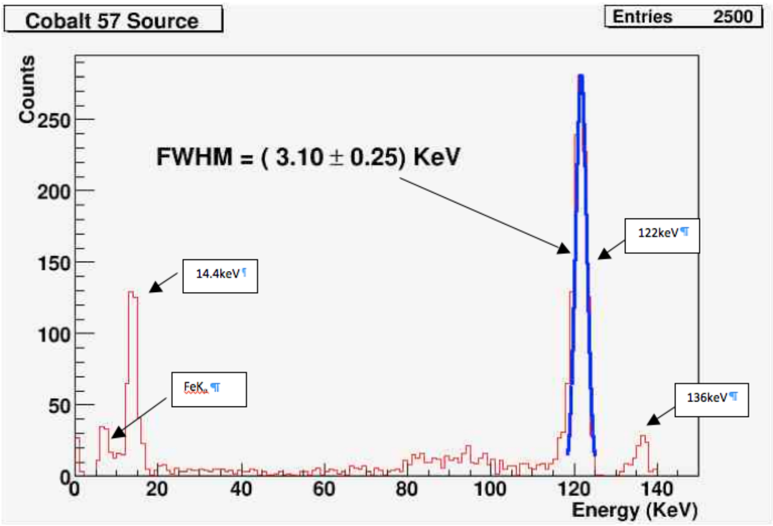

Fig. 3: Spectrum from a Co^{57} source obtained with a 0.75 mm thick CdTe detector operated at room temperature. The FWHM of the 122 keV line is about 2.5%.

pixels with a radioactive Am^{241} source and collected data at 0 Tesla and at 4 Tesla. The results, shown in Figure 5, indicate that the profile of charge collection on the 9 pixels has not changed. This confirms that CdTe pixel sensors as planned for the VIP scanner will operate in strong magnetic fields without problems.

Fig. 4: Insertion of a Medipix 2 CdTe sensor in a 4 Tesla magnetic in DESY, Hamburg.

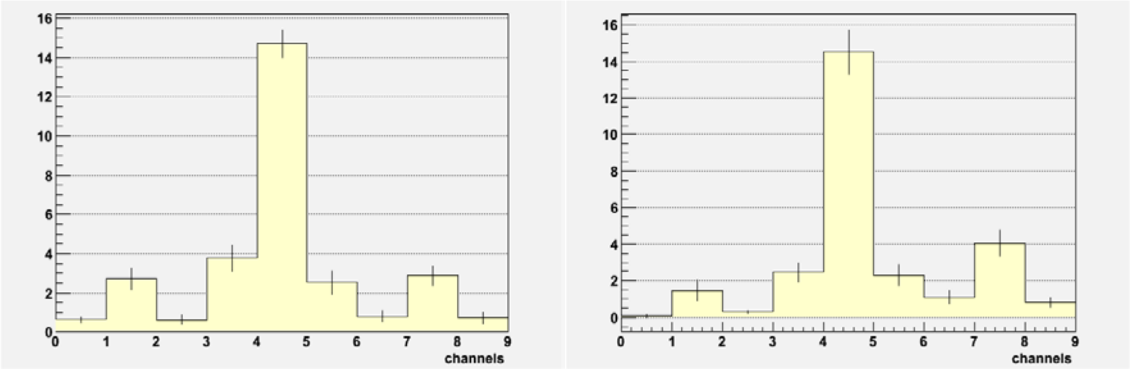

Fig. 5: The distribution of the charge collected on the array of 3x3 pixels biasing the CdTe detector at 100V. The data of left/right hand side histogram was taken at 0/4 Tesla. Within the statistical fluctuations, the two histograms are compatible and no shift of charge from one pixel to another is seen (the drift distance is the detector thickness, 800 µm and the pixel pitch is 55 µm.

X-ray Imatek SL

X-ray Imatek SL is an IFAE spinoff developing a full mammography prototype based on CdTe. CdTe is an excellent X-ray absorber – a sensor 0.5 mm thick can detect 100% of the X-rays with energies up to 50 keV. This is an interesting figure of merit for the use of such a detector in dual energy subtraction mode or to extend the use of sensor from normal digital mammography to Tomosynthesis. The mechanical part of the full mammography machine is expected to be ready by July 2011 and the full sensors of 30cm x 24cm based on pixel CdTe detector coupled to Medipix2 chip to be ready in October 2011.

In parallel to the work on the mammography system, X-ray Imatek SL is developing asmall-area 10cm x 13cm prototype detector for radiography of breast biopsy specimens. One expects a clear image due to the fact the sensor operates in counting mode and the spatial resolution is 55 µm. Preliminary imagesshow clearly the micro-calcifications as can be seen in Figure 6.

In 2010, X-Ray Imatek SL moved from the IFAE building and rented an office space of 70 m^2 on the campus of UAB, within a walking distance from IFAE lab, in order to provide enough working place for its staff while maintaining its easy access to the IFAE infrastructure.

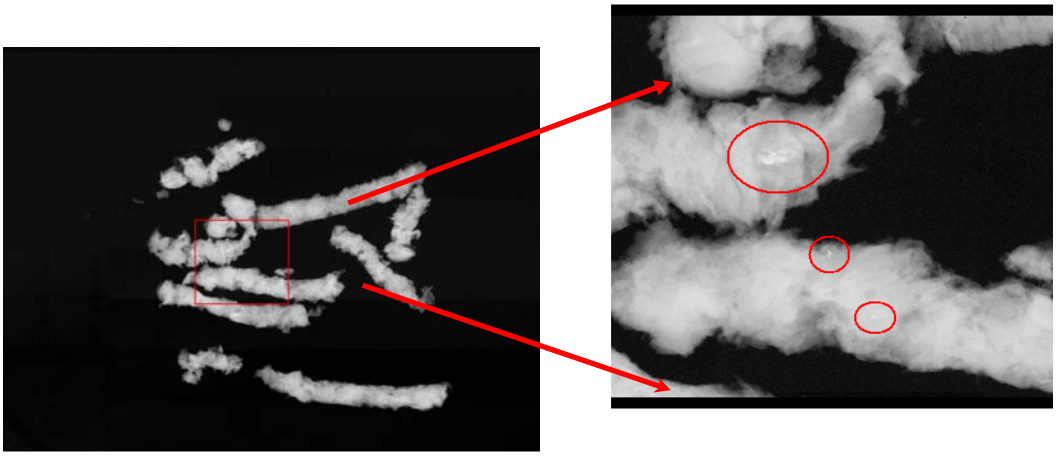

Fig. 6: On the left-hand side, the radiography of a breast specimen using the X-Ray Imatek detector. On the right-hand side, the zoom-in of the same image in the zone of interest where one can see scattered microcalcifications of different sizes.

2.10 Standard Model

MATTHIAS JAMIN

The main fields of research pursued in the Standard Model (SM) group of the IFAE theory division during 2010 were hadronic decays of the τ 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 Mellin-Barnes transformations.

A rather convenient energy scale for the investigation of QCD at relatively low energies is the mass of the τ lepton, $M_\tau \approx$ 1.8 GeV, because at this scale the sensitivity to QCD effects is already sizeable, but the expansion in powers of α_s still retains perturbative character. For this reason, in the last ten years the analysis of hadronic τ decays 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 means to also determine parameters in this sector, like the strange quark mass and the quark-mixing-matrix element V_{us}.

Large amounts of data became available from the B-factory experiments BaBar and Belle which although primarily designed for the study of B-meson decays, being e^+e^- machines, also produce a huge number of τ pairs. The new high-precision data also necessitate an improved understanding of hadronic τ decays into exclusive final states. Such an improvement was laid out for the decay $\tau \to K\pi\nu_\tau$ in the last year. The analysis also included additional information on the leptonic decays K_{e3} in a different kinematical region. It furthered our understanding of the $K\pi$ scalar and vector form factors $F_0^{K\pi}(s)$ and $F_+^{K\pi}(s)$, respectively, provided precise values for mass and width of the K^* resonance and paved the way for similar analyses with three hadrons in the final state in the future.

A fit to the model presented in Boito et al, JHEP 1009 (2010) 031 to Belle data is displayed in Figure 1.

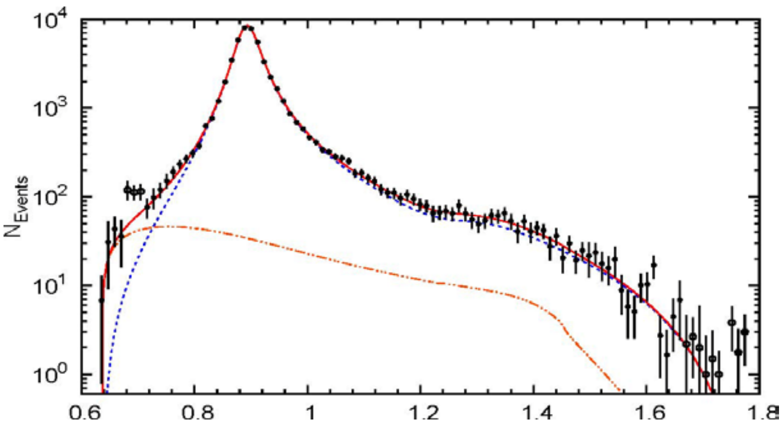

Fig. 1: Fit result for the spectrum of $\tau \to K\pi\nu\tau$. The data are from the Belle collaboration. The solid red line represents the fulfit including contributions from $F_0^{K\pi}(s)$ and $F_+^{K\pi}(s)$. The scalar contribution alone is represented by the dot-dashed orange line whereas the dashed blue line gives the vector contribution.

Precision determinations of α_s from hadronic τ decays require the computation of contour integrals in the complex energy plane down to the physical, Minkowskian axis. However, QCD perturbation theory, even augmented by the Operator Product Expansion (OPE), is unable to describe the bound-state or resonance spectrum. For this reason, close to the physical axis additional contributions have to be taken into account which go under the name of Duality Violations (DVs). In our ongoing project to determine the strong coupling together with QCD condensate corrections, a simultaneous fit of weighted integrals of τ decay spectral distributions is performed. Experimental data in principle are available from the ALEPH and OPAL collaborations. However, in the course of our study we discovered an inconsistency in the error correlations provided by the ALEPH group. For this reason, even though afflicted by larger uncertainties, presently the analysis is carried out with OPAL data. Preliminary results have been presented in Boito *et al.*, arXiv:1011.4426, and in Figure 2 the comparison of the weight with a trivial weight function $w(x) = 1$ is shown, which clearly demonstrates that DVs need to be included for a consistent description of the data.

Higher-order perturbative corrections for heavy-quark correlators quite often are no longer available in a fully analytical form, due to the complexity of the required Feynman integrals. In these cases, the full function has to be reconstructed from expansion in different energy regions, namely at low energy around $q^2 = 0$, at high energy for $q^2 \to \infty$, and close to the quark-antiquark threshold. These reconstructions can be systematized and improved with the help of Mellin-Barnes transformations, which was illustrated in the example of the heavy-quark vector correlator and the estimation of the constant $K^{(2)}$, governing the threshold expansion at order $O(\alpha_s^2)$.

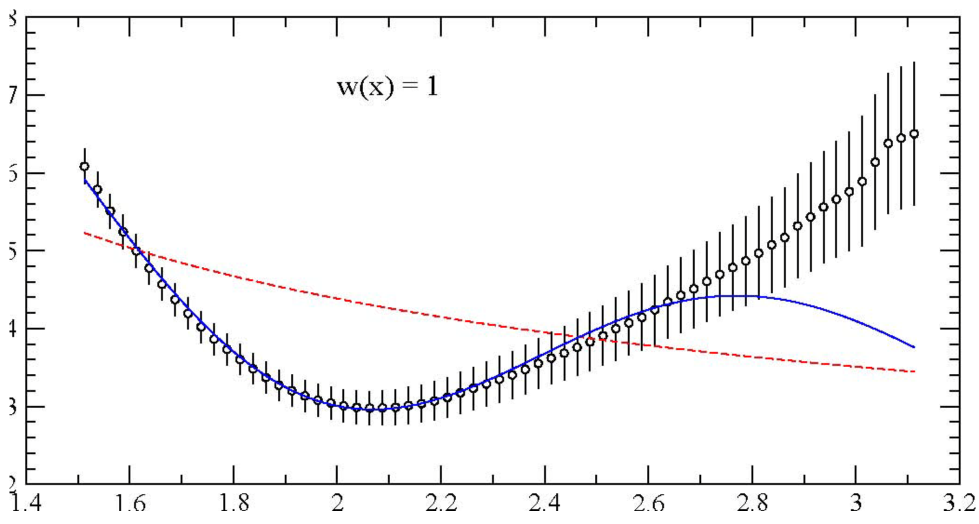

Fig. 2: Fit to the $w(x) = 1$ spectral integral for the vector channel. The blue (solid) line shows a fit including duality violations, while the red (dashed) line represents the pure OPE result.

Finally, work in our group has been performed in the framework of chiral perturbation theory. On the one hand, the low-energy chiral expansion is nowadays known up to order p^6. However, as the chiral perturbation theory is non-renormalisable, at each order in the perturbative expansion an increasing number of chiral constants appear. At $O(p^6)$, their number is so large that it is impossible to solely fix them from experiment. An additional source of information is the behaviour of correlation functions in resonance chiral perturbation theory, which was exploited some of our publications. The scalar meson system and its implications on the structure of flavour were investigated in further publications (see the list in Chapter 4 of this document).

2.11 Beyond the Standard Model

MARIANO QUIRÓS

Theories going Beyond the Standard Model (BSM) of Electroweak and Strong interactions aim to solve some of the fundamental theoretical problems which appear in the Standard Model (SM). In particular we can stress the instability of the Higgs sector against UV physics (including gravity beyond the Planck scale), the flavor problem, the origin of baryons.

In 2010 the BSM IFAE Theory Group attacked some of these problems working along the following three main lines: 1) A generalization of the Randall-Sundrum (RS) warped 5D space construction to models where the IR Boundary is replaced by a naked singularity in the metric. We have pursued this approach, which has been dubbed ***"soft-wall"***. 2) The problem of ***electroweak baryogenesis in RS*** theories and its relation with the origin of baryons and gravitational waves produced in a first-order phase transition. 3) The Higgs as the pseudo-Goldstone boson of a global symmetry is another elegant solution to the hierarchy problem and gives rise to a ***composite Higgs boson***. We studied such a composite Higgs boson, which has distinctive signatures with respect to that of the SM.

1) Soft walls. We have proposed a general class of five-dimensional soft-wall models with AdS metric near the ultraviolet brane and four-dimensional Poincaré invariance, where the infrared scale is determined dynamically. A large UV/IR hierarchy can be generated without any fine-tuning, thus solving the electroweak/Planck scale hierarchy problem. Generically, the spectrum of fluctuations is discrete with a level spacing (mass gap) provided by the inverse length of the wall, similar to RS1 models with Standard Model fields propagating in the bulk. The first graviton KK modes are shown in Fig. 1.

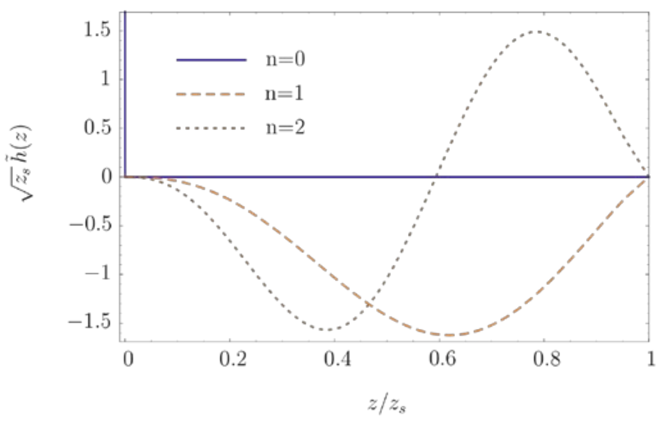

Fig.: 1. KK-graviton profiles in the z frame. The massless mode (n=0) is peaked near the brane. The two first massive modes (n=1,2) are also shown.

Furthermore two particularly interesting cases arise. They can describe: a) a theory with a continuous spectrum above the mass gap which can model unparticles corresponding to operators of a CFT where the conformal symmetry is broken by a mass gap, and; b) a theory with a discrete spectrum provided by linear Regge trajectories as in AdS/QCD models. We have also given a constructive recipe of how to obtain superpotentials W that accomplish the stabilization of the hierarchy, as shown in the following Table:

$W(\phi)$	$\leq \phi^2$	$> \phi^2$ $< e^{\phi}$	e^{ϕ}	$e^{\phi}\phi^{\beta}$ $0 < \beta \leq \frac{1}{2}$	$> e^{\phi}\phi^{\frac{1}{2}}$ $< e^{2\phi}$	$\geq e^{2\phi}$
y_s	∞	finite				
z_s	∞				finite	
mass spectrum	continuous		continuous w/ mass gap	discrete		
				$m_n \sim n^{2\beta}$	$m_n \sim n$	
consistent solution	yes					no

2) Phase transition in RS theories. We also study radion stabilization in the compact Randall-Sundrum model by introducing a bulk scalar field, as in the Goldberger-Wise mechanism, but (partially) taking into account the back-reactions from the scalar field on the metric. Our generalization reconciles the radion potential found by Goldberger and Wise with the radion mass obtained with the so-called superpotential method where back-reaction is fully considered.

Moreover we study the holographic phase transition and its gravitational wave signals in this model. The improved control over back-reactions opens up a large region in parameter space and leads, compared to former analysis, to weaker constraints on the rank N of the dual gauge theory. We conclude that in the regime where the 1/N expansion is justified, the gravitational wave signal is detectable by LISA, as shown in Fig. 2.

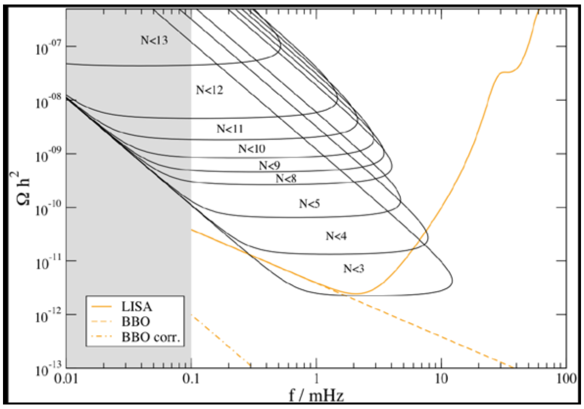

Fig. 2. The regions denote the possible positions of the peak of the gravity wave spectrum, depending on the parameter N. The signal will be detected by LISA, BBO or BBO.

In summary, we found that in the regime of large back-reactions the deeper radion potential leads to a significantly weaker phase transition and numerically the absolute limit N<13 applies. In addition, we reanalyzed the gravitational wave spectrum produced by the first-order phase transition. We conclude that as long as stringy corrections can be neglected (specifically N>3), the model leads to a stochastic background of gravitational radiation that can be observed by LISA. Again, see Figure 2.

3) ***Composite Higgs*****.** The Higgs boson production cross-sections and decay rates depend, within the Standard Model, on a single unknown parameter, the Higgs mass. In composite Higgs models where the Higgs boson emerges as a pseudo-Goldstone boson from a strongly-interacting sector, additional parameters control the Higgs properties, which then deviate from the SM values. These deviations modify the LEP and Tevatron exclusion bounds and significantly affect the searches for the Higgs boson at the LHC. In some cases, all the Higgs couplings are reduced, which results in deterioration of the Higgs searches; however the deviations of the Higgs couplings may also allow an enhancement of the gluon-fusion production channel, leading to higher statistical significances. The search in the $H\to\gamma\gamma$ channel can also be substantially helped by an enhancement of the branching fraction for the decay of the Higgs boson into a pair of photons, as shown in Figure 3.

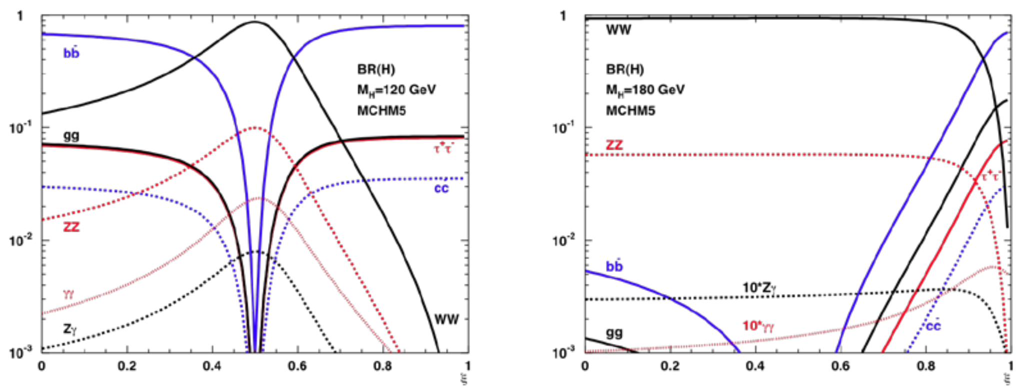

Fig. 3:. The branching ratios of MCHM5 as a function of ξ for M_H=120 GeV (left) and M_H=180 GeV (right).

2.12 Astroparticles & Cosmology

Oriol Pujolàs

Particle astrophysics and particle cosmology are relatively recent fields of research, at the intersection between particle physics, astronomy and cosmology. They aim at exploiting our knowledge of astrophysical and cosmological phenomena to answer fundamental physics questions, and vice-versa. Some of the key questions addressed are: what is the nature of dark matter and dark energy, what are the possible modifications of gravity, what is the role of neutrinos in the universe, what is the origin of cosmic rays, what is the physics responsible for baryogenesis, etc. During 2010, the work done by the members of the Theory Division can be divided in the following topics:

Electroweak Baryogenesis

One of the difficulties to fit the observed baryon asymmetry within the Standard Model (SM) is that the CP violation in the SM is not enough in hot big bang models, which motivates the introduction of new CP violation sources beyond the SM. An intriguing possibility, though, is that the SM may provide enough CP violation in *cold* models. We have studied this case by discussing a model where the EW phase transition occurs at the end of low-scale hybrid inflation with only the SM CP violation. We found that the baryon asymmetry can indeed be large, which which makes this a promising new scenario for EW baryogenesis.

One of the key aspects of EW baryogenesis with a first-order phase transition is the hydrodynamics of bubble growth. Observables like the baryon asymmetry itself and the gravity wave signal generated during the phase transition depend very sensitively on parameters like e.g. the bubble wall velocity. We performed a model-independent study for different expansion regimes (deflagrations, detonations, hybrids and runaway solutions). We computed the bubble wall velocity, ξ_w, and the efficiency of the kinetic energy transfer, κ, in all regimes (see Figure 1). We clarified the condition determining the runaway regime and pointed out that in most models with strong first-order phase transitions this modifies the expectations for the gravity wave signal.

Non-Relativistic Quantum Gravity

The recent proposal by P. Horava of a non-relativistic (and therefore Lorentz-violating) but renormalizable quantum field theory of gravity has attracted a lot of attention. The current status of this proposal is that there exists at least one formulation of Horava's idea which is free from basic pathologies and which passes all known observational tests. Still, there are many aspects of the model that need further analysis, like the mechanism to approximately recover Lorentz invariance at low energies, the

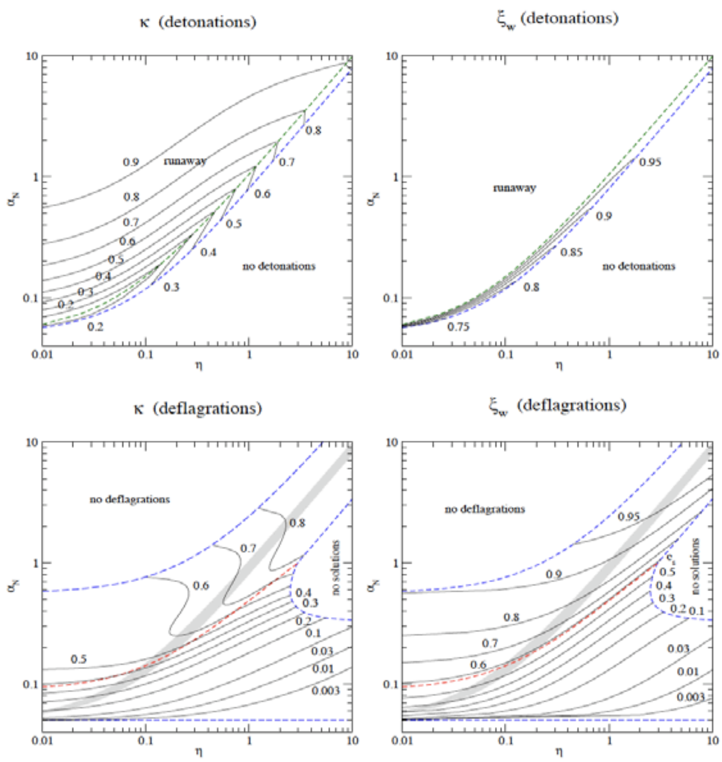

Fig. 1: Contours for ξ_w and κ in the η-α_N plane, where η and α_N characterise the strength of the phase transition and the amount of friction respectively. Blue lines mark the transition to regions without solutions. Green lines mark the boundaries between stationary and runaway solutions. Red lines mark the transition from subsonic to supersonic deflagrations (hybrids). The gray band is the detonation region. Only a small band in the η-α_N plane leads to pure detonations. In a large region, hybrids coexist with runaway solutions. Hence, most likely solutions are either deflagrations or runaway solutions.

question of whether the model is renormalizable beyond the power-counting criterion, the physics of black holes in this model (which in principle should be qualitatively different from those in General Relativity), how the cosmology is modified, etc. In 2010, members of our group have studied the cosmological aspects of the model. Concretely, we made a phase-space analysis of the homogeneous cosmological solutions and inferred typical behaviour both for early and late times. We found that bouncing solutions can occur rather generically at early times and that in order to have acceptable accelerating late-time cosmologies the so-called detailed-balance condition on the model parameters needs to be broken.

Dark Matter

The nature of Dark Matter is one of the most important open questions in modern physics. We have studied the possible interplay between Dark Matter and fundamental physics, in particular the question of unification. Specifically, we analyzed a simple Dark Matter model that could take care of improving the unification of couplings in the absence of supersymmetry. Indeed, we showed that a dark matter particle alone at the TeV scale can improve gauge coupling unification, raising the unification scale up to the lower bound imposed by proton decay. In addition, dark matter stability can follow from the grand unified symmetry. Within reasonably simple unified models, a unique candidate satisfying these two properties is singled out: a fermion isotriplet with zero hypercharge, member of a 45 (or larger) representation of SO(10). The proton decay rate into $e^+ \pi^0$ is predicted to be close to the present bound.

3. Personnel in 2010

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
Boix, Joan	Electronic Engineer, IFAE
Cardiel, Laia	Electronic Engineer, IFAE
Gamboa, Andres	Electronic Engineering Student, IFAE (until 08/2010)
Grañena, Ferran	Mechanical Engineer, IFAE
Illa, Jose Mª.	Electronic Engineer, IFAE
Lopez Morillo, Luis	Mechanical Engineer Student, IFAE,PAU (since 09/2010)
Macias, Jose Gabriel	Microelectronics Designer, Medical Physics (since 11/2010)
Puigdengoles, Carles	Electronic Engineer, IFAE
Troyano, Isaac	Electronic Engineer, IFAE, CPAN

Computer Scientists

Campos, Marc	IFAE (since 03/2010)
Calderón, Yonatan	IFAE(until 11/2010)
Guino Feijoo, Alex	IFAE (since 12/2010)
Pacheco, Andreu	IFAE, Senior Computing Engineer
Tomás, Jaume	IFAE (until 02/2010)

Technicians

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

Scientific Post-Docs

Abdallah, Jalal	ATLAS, CPAN
De Lorenzo, Gianluca	Medical Physics (since 09/2010)
Demirkoz, Bilge	ATLAS

Doro, Michele	MAGIC, CPAN (since 06/2010)
Fiorini, Luca	ATLAS, J. de la Cierva fellow
Garczarczyk, Markus	MAGIC
Helsens, Clément	ATLAS
Ieva, Michela	Neutrinos (since 02/2010)
Jover, Gabriel	Neutrinos
Klepser, Stefan	MAGIC, J. de la Cierva fellow
Lux, Thorsten	Neutrinos , J. de la Cierva fellow
Maiorino, Marino	DES
Mazin, Daniel	MAGIC, Otto Hahn Fellow
Meoni, Evelin	ATLAS
Osuna, Carlos	ATLAS (since 01/2010)
Ostman, Linda	DES, PAU
Stamatescu, Victor	CTA (since 06/2010)

Doctoral Students

Alcaraz, Jose Luis	Neutrinos (until 09/2010)
Aleksic, Jelena	MAGIC
Calderón, Yonatan	Medical Physics (since 12/2010)
Camarda, Stefano	CDF
Caminal, Roger	ATLAS (since 10/2010)
Caravaca, Javier	Neutrinos (since 09/2010)
Castillo, Raquel	Neutrinos (since 05/2010)
Conidi, M. Chiara	ATLAS
Galbany, Lluis	DES Teaching assistant UAB
González Parra, Garoe	ATLAS , (Scholarship FPI)
Giavitto, Gianluca	MAGIC, CTA
Lopez Orama, Alicia	MAGIC, CTA (since 02/2010)
Martí, Carlos	Neutrinos
Martí, Pol	DES, PAU (until 09/2010)
Mikhaylova, Ekaterina	Medical Physics (since 09/2010)

Nadal, Jordi	ATLAS
Nova, Federico	Neutrinos (until 12/2010)
Ortolan, Lorenzo	CDF
Pérez, Estel	ATLAS (Scholarship MEC-FPU)
Reichardt, Ignasi	MAGIC
Rossetti, Valerio	ATLAS (Scholarship MEC-FPU)
Succurro, Antonella	ATLAS (since 02/2010)
Tsiskaridze, Shota	ATLAS (since 11/2010)
Vives, Francesc	ATLAS (since 05/2010)
Tescaro, Diego	MAGIC
Volpi, Matteo	ATLAS (until 12/2010)
Vorkerk, Volker	ATLAS (Scholarship MEC-FPI)
Zanin, Roberta	MAGIC

Administrative Personnel

Barquet, Andrea	IFAE, Med. Physics Administrative Assistant (since 11/2010)
Cárdenas, Cristina	IFAE, UAB Secretary
Gaya, Josep	IFAE, UAB Senior Administrator
Palomanes, Alejandro	IFAE, Administrative Assistant (until 06/2010)
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
Grifols, Josep Antoni	Professor, UAB
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 (Since 10/2010)
Brouzakis, Nikolas	Post-doc UniverseNet (until 09/2010)
Frigerio, Michele	Post-doc
Guo, Zhi-Hui	Post-doc Flavianet
Greynat, David	Post-doc IFAE (until 10/2010)
Jora, Renata	Post-doc IFAE
Salvio, Alberto	Post-doc IFAE (until 10/2010)
Sanz, Juan José	Post-doc Juan de la Cierva
Silva, Pedro	Post-doc Institut de Ciències de l'Espai
Stahlhofen, Maximilian	Post-doc Flavianet
Varagnolo, Alvise	Post-doc IFAE

Doctoral Students

Boito, Diogo R	Scholarship MICINN
Cabrer, Joan Antoni	Scholarship MICINN
Domènech, Oriol	Scholarshipc MICINN
Krug, Sebastian	Scholarship MICINN
Montull, Marc	Scholarship UAB (PIF)
Peset, Clara	Scholarship UAB (PIF)
Ramon, Marc	Scholarship UAB (PIF)
Serra, Javier	Scholarship MICINN

4. Institutional Activities in 2010

4.1 Final Master/Diploma Projects

Experimental Division

Alicia López Oramas
Development and description of a Raman LIDAR,
July 2010
Advisor: O. Blanch Bigas

4.2 Doctoral Theses

Experimental Division

Matteo Volpi
Charged particle multiplicities in pp interactions at $\sqrt{s}$ = 900 GeV and $\sqrt{s}$ = 7 TeV measured with the ATLAS detector at the LHC,
Dec 2010
Advisor: Ilya Korolkov

Gianluca De Lorenzo
Search for the Production of Gluinos and Squarks with the CDF II Experiment at the Tevatron Collider,
Jul 2010
Advisor: Mario Martinez

Diego Tescaro
TeV gamma-ray observations of nearby Active Galactic Nuclei with the MAGIC telescope: exploring the high energy region of the multiwavelength picture,
Jul 2010
Advisor: Abelardo Moralejo

José Luis Alcaraz
Measurement of the absolute CCQE muon neutrino cross-section at the SciBooNE experiment
Oct 2010
Advisor: Federico Sánchez

4.3 Publications

Experimental Division

Publications ATLAS Group

G. Aad et al., The Atlas Collaboration
Readiness of the ATLAS Liquid Argon Calorimeter for LHC Collisions
EPJC 70 (2010) 723

G. Aad et al., The Atlas Collaboration
Drift Time Measurement in the ATLAS Liquid Argon Electromagnetic Calorimeter using Cosmic Muons
EPJC 70 (2010) 755

G. Aad et al., The Atlas Collaboration
Charged-particle multiplicities in pp interactions at $\sqrt{s}$ = 900 GeV measured with the ATLAS detector at the LHC
Phys Lett B 688, 1, 21

G. Aad et al., The Atlas Collaboration
The ATLAS Inner Detector commissioning and calibration
EPJC 70 (2010) 787

G. Aad et al., The Atlas Collaboration
The ATLAS Simulation Infrastructure
EPJC 70 (2010) 823

G. Aad et al., The Atlas Collaboration
Performance of the ATLAS Detector using First Collision Data
JHEP 09 (2010) 056

G. Aad et al., The Atlas Collaboration
Commissioning of the ATLAS Muon Spectrometer with Cosmic Rays
EPJC 70 (2010) 875

G. Aad et al., The Atlas Collaboration
Readiness of the ATLAS tile calorimeter for LHC collisions
EPJC 70 (2010) 1193

G. Aad et al., The Atlas Collaboration
Search for New Particles in Two-Jet Final States in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC
Phys. Rev. Lett. 105, 161801

G. Aad et al., The Atlas Collaboration
Search for Quark Contact Interactions in Dijet Angular Distributions in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC
Phys. Lett. B694 (2011) 327-345

G. Aad et al., The Atlas Collaboration
Measurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS detector,
EPJC 71 (2011) 1-59

G. Aad et al., The Atlas Collaboration
Measurement of the $W \rightarrow l\nu$ and $Z/\gamma^* \rightarrow ll$ production cross sections in proton-proton collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector
JHEP 12 (2010) 060

G. Aad et al., The Atlas Collaboration
Observation of a centrality-dependent dijet asymmetry in lead-lead collisions at $\sqrt{s_{NN}}$ = 2.76 TeV with the ATLAS detector at the LHC
Phys. Rev. Lett. 105, 252303

G. Aad et al., The Atlas Collaboration
Study of energy response and resolution of the ATLAS barrel calorimeter to hadrons of energies from 20 to 350 GeV
NIM A 621 (2010) 134-150

G. Aad et al., The Atlas Collaboration
Measurement of Pion and Proton Response and Longitudinal Shower Profiles up to 20 Nuclear Interaction lengths with the ATLAS Tile Calorimeter
NIM A 615 (2010) 158-181

G. Aad et al., The Atlas Collaboration
Study of the response of the ATLAS central calorimeter to pions of energies from 3 to 9 GeV
NIM A 607 (2009) 372-386

G. Aad et al., The Atlas Collaboration
Testbeam studies of production modules of the ATLAS Tile Calorimeter
NIM A 606 (2009) 362-394

G. Aad et al., The Atlas Collaboration
Study of energy response and resolution of the ATLAS barrel calorimeter to hadrons of energies from 20 to 350 GeV
NIM A 621 (2010) 134-150

Publications CDF Group

T. Aaltonen et al., The CDF Collaboration
Measurement of the WW + WZ Production Cross Section using a Matrix Element Technique in Lepton + Jets Event
Phys. Rev. D82, 112001 (2010). arXiv: 1008.4404

T. Aaltonen et al., The CDF Collaboration
Improved Search for a Higgs Boson Produced in Association with $Z \rightarrow l^+ l^-$ in p anti-p Collisions at $\sqrt{s}$ =1.96 TeV
Phys. Rev. Lett. 105, 251802 (2010). arXiv: 1009.3047

T. Aaltonen et al., The CDF Collaboration
Top Quark Mass Measurement in the Lepton + Jets Channel Using a Matrix Element Method and in situ Jet Energy Calibration
Phys. Rev. Lett. 105, 252001 (2010). arXiv: 1010.4582

T. Aaltonen et al., The CDF Collaboration
Direct Top Quark Width Measurement at CDF
Phys. Rev. Lett. 105, 232003 (2010). arXiv: 1008.3891

T. Aaltonen et al., The CDF Collaboration
Diffractive W and Z Production at the Fermilab Tevatron
Phys. Rev. D82, 112004 (2010). arXiv: 1007.5048

T. Aaltonen et al., The CDF Collaboration
Observation of Single Top Quark Production and Measurement of |V(tb)| with CDF
Phys. Rev. D82, 112005 (2010). arXiv: 1004.1181.

T. Aaltonen et al., The CDF Collaboration
Updated Search for the Flavor-Changing Neutral-Current Decay D0 $\rightarrow \mu^+ \mu^-$
Phys. Rev. D82, 091105 (2010). Fermilab-Pub-10-337-E. arXiv: 1008.5077.

T. Aaltonen et al., The CDF Collaboration
Search for Supersymmetric Partner of the Top Quark in p anti-p Collisions at $\sqrt{s}$ =1.96 TeV
Phys. Rev. D82, 092001 (2010). arXiv: 1009.0266.

T. Aaltonen et al., The CDF Collaboration
Search for R-Parity Violating Decays of τ Sneutrinos to eμ, $\mu\tau$, and eτ Pairs in p anti-p Collisions at $\sqrt{s}$ =1.96 TeV
Phys. Rev. Lett. 105, 191801 (2010). arXiv: 1004.3042.

T. Aaltonen et al., The CDF Collaboration
Measurement of the Top Pair Production Cross Section in the Dilepton Decay Channel in p anti-p Collisions at $\sqrt{s}$ =1.96 TeV
Phys. Rev. D82, 052002 (2010). arXiv: 1002.2919.

T. Aaltonen et al., The CDF Collaboration
Search for Anomalous Production of Events with Two Photons and Additional Energetic Objects at CDF
Phys. Rev. D82, 052005 (2010). arXiv: 0910.5170

T. Aaltonen et al., The CDF Collaboration
Search for New Physics with a Dijet Plus Missing E_t Signature in p anti-p Collisions at $\sqrt{s}$ =1.96 TeV
Phys. Rev. Lett. 105, 131801 (2010). arXiv: 0903.2850

T. Aaltonen et al., The CDF Collaboration
Measurement of $d\sigma/dy$ of Drell-Yan e^+e^- Pairs in the Z Mass Region from p anti-p Collisions at $\sqrt{s}$ =1.96 TeV
Phys. Lett. B, 692 (2010). arXiv: 0908.3914

T. Aaltonen et al., The CDF Collaboration
Measurement of $Z\gamma$ Production in p anti-p Collisions at $\sqrt{s}$ =1.96 TeV
Phys. Rev. D82, 031103 (2010). arXiv: 1004.1140.

T. Aaltonen et al., The CDF Collaboration
Studying the Underlying Event in Drell-Yan and High Transverse Momentum Jet Production at the Tevatron
Phys. Rev. D82, 034001 (2010). arXiv: 1003.3146

T. Aaltonen et al., The CDF Collaboration
Search for the Production of Scalar Bottom Quarks in p anti-p Collisions at $\sqrt{s}$ *=1.96 TeV*
Phys. Rev. Lett. 105, 081802 (2010). arXiv: 1005.3600.

T. Aaltonen et al., The CDF Collaboration
Exclusion of an Exotic Top Quark with -4/3 Electric Charge Using Soft Lepton Tagging
Phys. Rev. Lett. 105, 101801 (2010). arXiv: 1006.4597.

T. Aaltonen et al., The CDF Collaboration
Measurement of W-Boson Polarization in Top-quark Decay in p anti-p Collisions at $\sqrt{s}$ *=1.96 TeV*
Phys. Rev. Lett. 105, 042002 (2010). Fermilab-Pub-10-041-E.
arXiv: 1003.0224.

T. Aaltonen et al., The CDF Collaboration
Study of Multi-Muon Events Produced in p anti-p Collisions at $\sqrt{s}$ *=1.96 TeV*
Eur. Phys. J. C68 :109-118,2010

T. Aaltonen et al., The CDF Collaboration
Search for a New Color-Octet Vector Particle Decaying to t anti-t Collisions at $\sqrt{s}$ *=1.96 TeV*
Phys. Lett. B, 691 (2010). Fermilab-Pub-09-578-E.
arXiv: 0911.3112

T. Aaltonen et al., The CDF Collaboration
Search for WW and WZ Resonances Decaying to Electron, Missing E_T*, and Two Jets in p anti-p Collisions at* $\sqrt{s}$ *=1.96 TeV*
Phys. Rev. Lett. 104, 241801 (2010). Fermilab-Pub-10-096-E.
arXiv: 1004.4946

T. Aaltonen et al., The CDF Collaboration
Combined Tevatron Upper Limit on $gg \rightarrow H \rightarrow W^+W^-$ *and Constraints on the Higgs Boson Mass in Fourth-Generation Fermion Models*
Phys. Rev. D82, 011102 (2010). arXiv: 1005.3216

T. Aaltonen et al., The CDF Collaboration
Measurement of the W^+W^- *Production Cross Section and Search for Anomalous WWg and WWZ Couplings*
Phys. Rev. Lett. 104, 201801 (2010). arXiv: 0912.4691

T. Aaltonen et al., The CDF Collaboration
Search for Pair Production of Supersymmetric Top Quarks in Dilepton Events from p anti-p Collisions at $\sqrt{s}$ *=1.96 TeV*
Phys. Rev. Lett. 104, 251801 (2010). arXiv: 0912.1308.

T. Aaltonen et al., The CDF Collaboration
First Measurement of the Ratio $\sigma_{tt\text{-}bar}/\sigma_{Z/\gamma^* \rightarrow ll}$ *and Precise Extraction of the tt-bar Cross Section*
Phys. Rev. Lett. 105, 012001 (2010). arXiv: 1004.3224

T. Aaltonen et al., The CDF Collaboration
Search for Single Top Quark Production in p anti-p Collisions at 1.96 TeV in the Missing Transverse Energy Plus Jets Topology
Phys. Rev. D81, 072003 (2010). arXiv: 1001.4577

T. Aaltonen et al., The CDF Collaboration
A Search for the Higgs Boson Using Neural Networks in Events with Missing Energy and b-quark Jets in p anti-p Collisions at $\sqrt{s}$ *=1.96 TeV*
Phys. Rev. Lett. 104, 141801 (2010). arXiv: 0911.3935

T. Aaltonen et al., The CDF Collaboration
Measurement of the b-jet Cross Section in Events with a W Boson in p anti-p Collisions at $\sqrt{s}$ *=1.96 TeV*
Phys. Rev. Lett. 104, 131801 (2010). arXiv: 0909.1505

T. Aaltonen et al., The CDF Collaboration
Measurement of the Top Quark Mass and p anti-p → tt-bar Cross Section in the All-Hadronic Mode with the CDF II Detector
Phys. Rev. D81, 052001 (2010). arXiv: 1002.0365

T. Aaltonen et al., The CDF Collaboration
Measurement of the WW+WZ Production Cross Section using Lepton+Jets Final State at CDF II
Phys. Rev. Lett. 104, 101801 (2010). arXiv: 0911.4449

T. Aaltonen et al., The CDF Collaboration
Search for New Bottomlike Quark Pair Decays QQbar $\rightarrow (t\ W^{-/+})(t\text{-}bar\ W^{+/-})$ *in Same-Charge Dilepton Events*
Phys. Rev. Lett. 104, 091801 (2010). arXiv: 0912.1057

T. Aaltonen et al., The CDF Collaboration
Search for Technicolor Particles Produced in Association with a W Boson at CDF
Phys. Rev. Lett. 104, 111802 (2010). arXiv: 0912.2059

T. Aaltonen et al., The CDF Collaboration
Study of the Associated Production of Photons and b-quark Jets in p anti-p Collisions at $\sqrt{s}$ *=1.96 TeV*
Phys. Rev. D81, 052006 (2010). arXiv: 0912.3453

T. Aaltonen et al., The CDF Collaboration
Measurement of the Λ^0_b *Lifetime in* $\Lambda^0_b \rightarrow \Lambda^+_c\ \pi^-$ *Decays in p anti-p Collisions at* $\sqrt{s}$ *=1.96 TeV*
Phys. Rev. Lett. 104, 102002 (2010). arXiv: 0912.3566

T. Aaltonen et al., The CDF Collaboration
Measurements of the Branching Fraction Ratios and CP Asymmetries in $B^{\pm} \rightarrow D_{CP} K^{\pm}$ *Decays in Hadron Collisions*
Phys. Rev. D81, 031105 (2010). arXiv: 0911.0425

T. Aaltonen et al., The CDF Collaboration
Measurement of the Top Quark Mass in the Dilepton Channel using m_{T2} *at CDF*
Phys. Rev. D81, 031102 (2010). arXiv: 0911.2956

T. Aaltonen et al., The CDF Collaboration
Inclusive Search for Standard Model Higgs Boson Production in the WW Decay Channel Using the CDF II Detector
Phys. Rev. Lett. 104, 061803 (2010). arXiv: 1001.4468.

T. Aaltonen et al., The CDF Collaboration
Measurement of the tt-bar Production Cross Section in p anti-p Collisions at $\sqrt{s}$ *=1.96 TeV using Soft Electron b-Tagging*
Phys. Rev. D81, 092002 (2010). arXiv: 1002.3783

T. Aaltonen et al., The CDF Collaboration
Search for Supersymmetry with Gauge-Mediated Breaking in Diphoton Events with Missing Transverse Energy at CDF II
Phys. Rev. Lett. 104, 011801 (2010). arXiv: 0910.3606

Publications PIXELS Group

P. Hansson, et al.,
3D Silicon Pixel Sensors: Recent Test Beam Results,
Nucl. Instrum. Meth. A doi:10.1016/j.nima.2010.06.321.

H. Gjersdal, et al.,
Tracking Efficiency and Charge Sharing of Full 3D Silicon Sensors at Di erent Angles in a 1.4 Tesla Magnetic Field,
Nucl. Instrum. Meth. A doi:10.1016/j.nima.2010.04.083.

Publications MAGIC Group

M. Raue & D. Mazin
A Potential of the next generation VHE instruments to probe the EBL (I): The low- and mid-VHE
Astroparticle Physics Vol.34, Issue 4 (2010) 245-256

J. Aleksic et al., (the MAGIC collaboration)
Observations of the Blazar 3C 66A with the MAGIC Telescopes in Stereoscopic Mode
Ap. J. Lett. 726 (2010) 58

J. Aleksic et al., (the MAGIC collaboration)
MAGIC Upper Limits for Two Milagro-detected, Bright Fermi Sources in the Region of SNR G65.1+0.6)
Ap. J.725 (2010) 1629-1632

J. Aleksic et al., (the MAGIC collaboration)
Search for an extended VHE gamma-ray emission from Mrk 421 and Mrk 501 with the MAGIC Telescope
Astron. Astrophys.524 (2010) 77

J. Aleksic et al., (the MAGIC collaboration)
Detection of very high energy gamma-ray emission from the Perseus cluster head-tail galaxy IC 310 by the MAGIC Telescopes
Ap. J. Lett. 723 (2010) L207-212

J. Aleksic et al., (the MAGIC collaboration)
Simultaneous multi-frequency observation of the unknown redshift blazar PG 1553+113 in March-April 2008
Astron. Astrophys.515 (2010) A76

J. Aleksic et al., (the MAGIC collaboration),
MAGIC TeV gamma-ray observations of Markarian 421 during multiwavelength campaigns in 2006
Astron. Astrophys. 519 (2010) 32

J. Aleksic et al., (the MAGIC collaboration)
MAGIC Constraints on Gamma-ray emission from Cygnus X-3
Ap. J. 721 (2010) 843-855

J. Aleksic et al., (the MAGIC collaboration)
MAGIC observation of the GRB 080430 afterglow
Astron. Astrophys. 517 (2010) A5

J. Aleksic et al., (the MAGIC collaboration)
Search for Very High Energy Gamma-ray Emission from Pulsar-Pulsar Wind Nebula Systems with the MAGIC Telescope
Ap. J. 710 (2010) 828

J. Aleksic et al., (the MAGIC collaboration)
MAGIC Gamma-ray Telescope Observation of the Perseus Cluster of Galaxies: Implications for Cosmic Rays, Dark Matter, and NGC 1275)
Ap. J. 710 (2010) 634

J. Rico for the MAGIC Collaboration
Results from galactic observations with MAGIC
Int. J. Mod. Phys. D19 (2010) 1023-1029

Reichardt, Ignasi and De Cea, Elsa.
Telescopios MAGIC
Investigación y Ciencia 407 (Agosto 2010)

Publications Neutrino Group

E.D.Freitas et al.
Secondary scintillation yield in high-pressure xenon gas for neutrinoless double beta decay ($0\nu 2\beta$) search
Phys.Lett. B684 (2010) 205-210

Y.Kurimoto et al. (SciBoone Coll.)
Improved measurement of neutral current coherent π^0 production on carbon in a few-GeV neutrino beam
Phys.Rev. D81 (2010) 111102

Y.Kurimoto et al, (Sciboone Coll.)
Measurement of Inclusive Neutral Current Neutral π^0 Production on Carbon in a Few-GeV Neutrino Beam
Phys.Rev. D81 (2010) 033004

J.Argyiades et al. (SuperNemo Collaboration)
Results of the BiPo-1 prototype for radiopurity measurements for the SuperNEMO double beta decay source foils
NIM A A622:120-128, 2010

R.Arnold et al. (SuperNemo Collaboration)
Probing New Physics Models of Neutrinoless Double Beta Decay with SuperNEMO
EPJC 70:927-943, 2010

Publications DES Group

C.B. D'Andrea et al.
Type II-P Supernovae from the SDSS-II Supernova Survey and the Standardized Candle Method
Ap. J. (2010) 708, 661

B. Dilday et al.
Measurements of the Rate of Type Ia Supernovae at Redshift ~< 0.3 from the SDSS-II Supernova Survey
Ap. J. (2010) 713, 1026

B. Dilday et al.
A Measurement of the Rate of Type Ia Supernovae in Galaxy Clusters from the SDSS-II Supernova Survey
Ap. J. (2010) 715, 1021

C.M. McClelland et al.
The Subluminous Supernova 2007qd: A Missing Link in a Family of Low-Luminosity Type-Ia Supernovae
Ap. J. (2010) 720, 704

H. Lampeitl et al.
The Effect of Host Galaxies on Type Ia Supernovae in the SDSS-II Supernova Survey
Ap. J. (2010) 722, 566

Publications PAU Group

K. Nakamura et al. (Particle Data Group)
Review of Particle Physics
Journal of Physics G (2010) 37, 075021

S. Schael et al. (Aleph Collaboration)
Search for neutral Higgs bosons decaying into four taus at LEP2
JHEP 1005:049,2010.

Theory Division

Alok, A. Dighe, D. Ghosh, D. London, J. Matias et al.,
*New-physics contributions to the forward-backward asymmetry in B ---> K** $\mu^+ \mu^-$
JHEP 1002:053, 2010

G. Amelino-Camelia, F. Archilli, D. Babusci, D. Badoni, G. Bencivenni, J. Bernabeu, R. A. Bertlmann, D. R. Boito *et al.*
Physics with the KLOE-2 experiment at the upgraded DAΦNE
Eur. Phys. J. C68 (2010) 619-681, [arXiv:1003.3868 [hep-ex]].

D. Blas, O. Pujolas and S. Sibiryakov
Comment on `Strong coupling in extended Horava-Lifshitz gravity',
Phys. Lett. B 688:350-355, 2010

D.R. Boito, R. Escribano et al.,
Physics with the KLOE-2 experiment at the upgraded DAPHNE,
EPJC 68:619-681,2010.

D.R. Boito, R. Escribano and M. Jamin,
$K\pi$ vector form factor constrained by $\tau \to K\pi\nu_\tau$ and K_{l3} decays,
JHEP 1009:031,2010

J. A. Cabrer, G. von Gersdorff and M. Quiros
Soft-Wall Stabilization ,
New J. Phys. 12 (2010) 075012, arXiv:0907.5361 [hep-ph].

S. Carloni, E. Elizalde, P. J. Silva
An analysis of the phase space of Horava-Lifshitz cosmologies.
Class.Quant.Grav.27:045004,2010.

C. Deffayet, O. Pujolas, I. Sawicki and A. Vikman
Imperfect Dark Energy from Kinetic Gravity Braiding,
JCAP 1010:026, 2010

O. Domenech et al.,
Emergent Gauge Fields in Holographic Superconductors.
JHEP 1008 (2010) 033.

U. Egede, T. Hurth, J. Matias, M. Ramon, W.Reece
The exclusive $B \to K^*(\to K\pi)\ l^+l^-$ decay: CP conserving observables
Acta Physica Polon. B3:151-157, 2010

R. Escribano
$J/\psi \to VP$ decays and the quark and gluon content of the η and η'
Eur. Phys. J. C65:467-473,2010

J. R. Espinosa, T. Konstandin, J.M. No, G. Servant
Energy Budget of Cosmological First-order Phase Transitions.,
JCAP 1006:028,2010. CERN-PH-TH-2010-027, Abr 2010. 36pp. arXiv:1004.4187 [hep-ph]

J.R. Espinosa, C. Grojean, M. Muhlleitner
Composite Higgs Search at the LHC.
CERN-PH-TH-2010-020, KA-TP-08-2010,
Mar 2010. 32pp.
JHEP 1005:065,2010.
e-Print: arXiv:1003.3251 [hep-ph]

J. R. Espinosa, T Konstandin, J M. No, G Servant
Energy Budget of Cosmological First-order Phase Transitions.
JCAP 1006:028,2010.

M. Frigerio, T. Hambye,
Dark matter stability and unification without supersymmetry.
Phys.Rev.D81:075002,2010.

S. Friot, D. Greynat
Non-perturbative asymptotic improvement of perturbation theory and Mellin-Barnes representation
SIGMA 6 (2010) 079, [arXiv:0907.5593 [hep-th]].

Fariborz, R. Jora, J. Schechter, M. N. Shahid
Are three flavors special?
Phys. Rev. D83 (2011) 034018, [arXiv:1012.4868 [hep-ph]].

D. Greynat and S. Peris
Resummation of Threshold, Low- and High-Energy Expansions for Heavy-Quark Correlators.
Phys.Rev.D82:034030,2010.

R. Jora
About flavor, spin and color
Phys. Rev. D82 (2010) 056005, [arXiv:1004.3660 [hep-ph]].

R. Jora, J. Schechter, M. N. Shahid
Doubly perturbed S_3 neutrinos and the s_{13} mixing parameter
Phys. Rev. D82 (2010) 053006, [arXiv:1006.3307 [hep-ph]].

T. Konstandin, G. Nardini and M. Quiros,
Gravitational Backreaction Effects on the Holographic Phase Transition,
Phys. Rev. D82 (2010) 083513, arXiv:1007.1468 [hep-ph]

P. Masjuan and S. Peris
Padé Theory applied to the vacuum polarization of a heavy quark.
Phys.Lett.B686:307-312,2010.

J. J. Sanz-Cillero, J. Trnka
High energy constraints in the octet SS-PP correlator and resonance saturation at NLO in $1/N_c$, Phys. Rev. D81 (2010) 056005, [arXiv:0912.0495 [hep-ph]].

A. Tranberg, A. Hernandez, T. Konstandin, M. G. Schmidt.
Cold electroweak baryogenesis with Standard Model CP violation.
Phys. Lett. B690:207-212,2010.

4.4 Outreach Activities

Oscar. Blanch Bigas
- *Les partícules més energétiques de l'univers: l'Observatori Pierre Auger,*
  Associació Astronòmica Valldoreix-Sant Cugat, Jan 2010

Matteo Cavalli-Sforza
- *The LHC: Exploring the mysteries of Matter, Force and Space at a new frontier*
  Grande Conférence da la Mission Culture Scientifique et Technique, University of Luxembourg, Mar 2010
- *L'estructura íntima del Cosmos*
  Cafés científics a la Casa Orlandai, Mar 2010.
- *Cap al descobriment dels secrets de la materia: el CERN i el Large Hadron Collider*
  Residència d'Investigadors del CSIC, Barcelona
  Cicle de conferències "Desafiaments del segle XXI: la veu de la ciència", Apr 2010.
- *Explorant la nova frontera de la física al Large Hadron Collider del CERN*
  Associació Astrònomica Valldoreix-Sant Cugat Jun 2010

Juan Cortina, Ll. Font (UAB):
- *Organization of outreach talk at UAB about neutrino telescopes by J. de D. Zornoza*
  Nov 2010 ("Semana Europea de las Astropartículas")
- *Interview for National Geographic Spain about MAGIC telescopes*,
  Sep 2010.
- *Interview for RNE-Canarias about MAGIC telescopes*,
  Oct 2010

MAGIC Group
- *Poster display at Science Faculty*, UAB
  Sept 28/Oct 18 2010 ("Semana Europea de las astropartículas").

Manel Martinez:
- *L'Univers MAGIC*

CaixaForum, Palma de Mallorca Nov 2010

Ramon Miquel
- *Antimatèria, materia fosca, dimensions extres:el que els acceleradors ens ensenyen sobre l'origen i composició de l'univers*
  Associació Astronòmica Valldoreix-Sant Cugat, Mar 2010

Mª. Lluisa Mir
- *Entrevista en TV,. el "Racó de l'expert" de "Barcelona sobre LHC*
  Mar 2010

4.5 Conference Proceedings

Experimental Division

Proceedings ATLAS Group

L. Fiorini
ATLAS tile calorimeter data preparation for LHC first beam data taking and commissioning data.
Prepared for 17th International Conference on Computing in High Energy and Nuclear Physics (CHEP 09),
Prague, Czech Republic, 21-27 Mar 2009. Published in J.Phys.Conf.Ser.219:022030,2010.

M. Volpi
Minimum bias physics with ATLAS
Lake Louise Winter Institute 2010
15th-20th February 2010 - Alberta, Canada

R. Casas et al.,
The PAU Camera
Proc.SPIE Int.Soc.Opt.Eng. 7735:773536, 2010.

T. Shaw et al.
System Architecture of the Dark Energy Survey Camera Readout Electronics

FERMILAB-CONF-10-175-PPD
Presented at SPIE Astronomical Instrumentation,
San Diego, California, 27 June -2 July 2010

Proceedings Pixels Group

A. La Rosa, et al.,
Preliminary results of 3D-DDTC pixel detectors for the ATLAS upgrade
Proceeding of Science PoS (RD09) 032.

E. Bolle, et al.
3D Pixel - Recent results
Proceedings of Science PoS (Vertex2009) 016 (2010)

S. Grinstein,
W/Z+Jet and W/Z+Heavy Flavor Jet Production at the Tevatron
Proceedings of the 45th Rencontres de Moriond (QCD and High Energy Interactions 2010), La Thuile, Italy,
March 13-20, 2010

Proceedings MAGIC Group

R. Firpo, P. Tallada, I. Reichardt, J. Rico, M. Delfino, N. Tonello
The MAGIC data processing pipeline (poster)
To appear in proc. of CHEP'2010 (Taipei, Taiwan)

R. Zanin
MAGIC observations of Cygnus X-3 (talk)
Proc.of HEGP (New York, USA)

S. Klepser for the MAGIC collaboration
The MAGIC Telescopes: Status and Recent Results (invited talk).
To appear in proc. of SciNeGHE Workshop (Trieste, 2010)

Proceedings DES Group

B.L. Flaugher et al.
Status of the Dark Energy Survey Camera (DECam) Project
FERMILAB-CONF-10-214-A
Prepared for SPIE Astronomical Instrumentation, San Diego, California, 27 June -2 July 2010.

Theory Division

Proceedings

D.R. Boito, R. Escribano and M. Jamin,
Constraining the Kπ vector form factor by $\tau \to K \pi \nu_\tau$ and K_{l3} decay data,
Nucl.Phys.Proc.Suppl.207-208:148-151,2010

D.R. Boito, O. Cata, M. Golterman, M. Jamin, K. Maltman, J. Osborne, S. Peris
Duality violations in tau hadronic spectral moments.
Nov 2010.
e-Print: arXiv:1011.4426 [hep-ph]. To appear in the proceedings of the 11th International Conference on Tau Lepton Physics, Manchester, UK, 13-17 Sep. 2010.

J. J. Sanz-Cillero
One loop predictions for the pion VFF in Resonance
Chiral Theory, AIP Conf. Proc. 1317 (2011) 116-121, [arXiv:1009.6012 [hep-ph]].

J. J. Sanz-Cillero
Scalar and pseudoscalar correlators in Resonance Chiral Theory
Nucl. Phys. Proc. Suppl. 207-208 (2010) 236-239
[arXiv:1009.3446 [hep-ph]].

4.6 Talks by IFAE Members and Collaborators

Experimental Division

Jelena Aleksic
- *Towards the First Public Repository in VHE Gamma-ray Astronomy*
  IX Reunion Cientifica SEA, Madrid, 2010

Oscar Blanch Bigas
- *Real Time aplications in Astroparticle physics*
  IEEE Real Time workshop, Lisbon, Portugal, May 2010

Martine Bosman
- *ATLAS First Results*
  XXXVII International Meeting on Fundamental Physics, La Palma, Spain, February 2008

Stefano Camarda
- *W/Z+jets.*
  ICHEP, Paris, France, July 2010

Matteo Cavalli-Sforza
- *The IFAE research program* Seminar
  Taller d'Altes Energies, Universitat de Barcelona
  September 2010

Juan Cortina
- *Cherenkov Telescope results on gamma-ray binaries .*
  Workshop on The High-Energy Emission from Pulsars and their Systems (HEEPS), Sant Cugat, Spain, April 2010

Gianluca de Lorenzo

- *Searches for Squarks and Gluinos in Jets and Missing Energy Final States at CDF*
  SUSY2010, Bonn, Germany, August 2010
- *SUSY searches at the Tevatron.*
  Moriond QCD conference, La Thuile, March 2010

Sebastian Grinstein

- *W/Z+Jets and W/Z+HF Production at the Tevatron*
  Moriond QCD, La Thuile , Italy, March 2010

Stefan Klepser

- *The MAGIC Telescopes: Status and Recent Results*
  SciNeGHE Workshop, Trieste, September 2010

Ilya Korolkov

- *ATLAS results on QCD.*
  IHEPLHC2010, October 2010, Russia

Alicia López Oramas:

- *Development of a Raman LIDAR*
  Atmospheric Monitoring Workshop, Madison, United States, September 2010

Thorsten Lux

- *A Multi-APD readout for EL detectors*
  Fifth symposium on large TPCs for low energy rare event detection, 14-17 December 2010. Paris (France)

Manel Martinez:

- *Highlights from MAGIC observations of AGNs.*
  International Conference on Accretion and Outflows in Black Hole systems, October 2010, Kathmandu, Nepal

Mario Martinez

- *QCD(Jets, W/Z+jets…)*
  HCP2010, Toronto, Canada, August 2010
- *High pt jet physics at the Tevatron*
  Workshop on Spectroscopy with hadron jets, Pisa, Italy, April 2010.
- *CDF studies of V+Jets Tools for the LHC Workshop*
  CERN, April 2010
- *QCD physics at the Tevatron*
  Hadron Collider Physics, Toronto, Canada, August 2010
- *Boson+jets at CDF, MCTools for LHC Workshops.*
  CERN, May 2010.

Daniel Mazin

- *Constraints on Extragalactic Background Light using Very High Energy Gamma-rays* (invited talk)
  Cosmic Radiation Fields Workshop, Desy, amburg, November 2010

Abelardo Moralejo:

- *The CTA project*
  International Meeting on Fundamental Physics, La Palma, February 2010

Javier Rico

- *Results from galactic observations with MAGIC (invited talk)*
  Int. J. Mod. Phys. D19 (2010) 1023-1029

Inma Riu

- *Performance of the ATLAS Trigger with Proton Collisions at the LHC*
  CHEP, Taipei, Taiwan, 20 October 2010

Valerio Rossetti

- *Commissioning of the ATLAS Tile Hadronic Calorimeter with cosmic muons, single beams and first collisions*
  CALOR2001, China, May 2010.

Federico Sánchez

- *Neutrino physics: the landscape today*
  Fifth symposium on large TPCs for low energy rare event detection, 14-17 December 2010. Paris (France)
- *Status of neutrino oscillations & recent results.*
  EuroScience Open Forum 2010,July 2-7 Torino (Italy).

Veronica Sorin

- *Top quark properties at the Tevatron*
  XLVth Rencontres de Moriond QCD (2010)

Matteo Volpi

- *Minimum bias physics with ATLAS*
  Lake Louise Conference, Alberta, February 2010.

Roberta Zanin

- *Observations of Cygnus X-3 with the MAGIC telescope*
  Workshop on High Energy Galactic Physics, Barnard Inst./Columbia U., New York, May 2010

Theory Division

D. R. Boito, O. Catà, M. Golterman, M. Jamin, K. Maltman, J. Osborne, S. Peris:

- *Duality violations in τ hadronic spectral moments*
  Talk presented at Tau 2010, Manchester, UK, [arXiv:1011.4426 [hep-ph]]

D. R. Boito, R. Escribano, M. Jamin:

- *Improving the $K\pi$ vector form factor through K_{l3} constraints*
  Talk presented at Quark Confinement and Hadron Spectrum IX, Madrid, Spain, [arXiv:1012.3493 [hep-ph]].

Joan Cabrer

- *Warped Electroweak Breaking without Custodial Symmetry*. Talk Given at the Ecole Polytechnique, Paris (France), 30 November 2010.

Michele Frigerio

- *Dark matter stability and unification without supersymmetry* . Rencontres de Physique de Particules, IPNL, Lyon, France, January 2010;
- *GUT and leptogenesis: a predictive class of models.*
  Indirect searches for new physics at the time of LHC, G. Galilei Institute, Florence, Italy, March 2010;

Oriol Pujolàs

- *Dark Energy from Kinetic Gravity Braiding in "Rencontres Theoriciennes",* Paris, Dec 2010

Mariano Quirós

- *Soft Walls.* Invited talk at Plenary Session in 10th Hellenic School and Workshops on Elementary Particle Physics and Gravity: Corfu Summer Institute on the Standard Model and Beyond-Cosmology, Aug 29-Sep 5, 2010, Corfu (Greece)
- *EWSB from a Standard Model bulk Higgs*. Invited talk at Plenary Session in Planck 2010: From the Planck scale to the Electroweak scale, 31 May- 4 June, 2010, CERN (Switzerland)
- *EWSB from a bulk Higgs, Invited talk at Plenary Session in XLVth Rencontres de Moriond: Electroweak Interactions and Unified Theories.* March 6-13 2010, La Thuile (Italy); in 2010
- *A Radion-Induced Supercooled Electroweak Phase Transition.* Talk Given at the Ecole Polytechnique, Paris (France), 19 October 2010.
- *Soft-wall stabilization and electroweak symmetry breaking,* Talk given at the Crete Center for Theoretical Physics, University of Crete, 23 February 2010, Heraklion (Greece

Pedro Silva

- *Holographic superfluids and superconductors* Iberian Strings 2010, Porto 10-12 Feb 2010
- *Hořava Gravity and matter Cosmology, the Quantum Vacuum, and Zeta Functions* Barcelona, 8-10th March, 2010
- *Emergent photons in AdS superconductors* XVIth European Workshop on String Theory 2010 Madrid June 14-18 2010
- *Dynamical gauge fields in AdS/CMT* AdS4/CFT3 and the Holographic States of Matter Workshop GGI Institute Florence, 15-10-2010 to 30-11-2010

4.7 Participation in External Committees

Experimental Division

Martine Bosman

- Member of Plenary European Committe for Future Accelerators

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.
- Deputy Spokesman of MAGIC experiment,
- Member of the MAGIC Executive Board.
- Miembro del comité gestor de la red de Astropartículas RENATA

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 since 2007
- Chair of DES Speaker's Bureau

Abelardo Moralejo

- Chair of the Speakers' bureau of the MAGIC collaboration

Javier Rico

- Member of MAGIC Time Allocation Committee

Inma Riu.

- Member ATLAS TDAQ Speakers Committee

Federico Sanchez

- Spanish representative in the Institute Board of experiment T2K
- Co-Convener of detector ND280 del experimento T2K
- Co-Convener of muon neutrino physics group of experiment T2K
- Coordinator of reconstruction group of detector ND280 of T2K

- European coodinator of analysis group ofdetector ND280
- IFAE representative in the Institute Board of experiment NEXT
- Member o f Steering Committee del experimento NEXT.

Verónica Sorin

- Co-convener CDF Top Group, 2009-April 2010

4.8 Colloquia

John Gunion, UC Davis
The LHC and beyond
January 2010

Mokhtar Chmeissani, IFAE
Medical imaging research at IFAE since 1998 , accomplishments and outlook
February 2010

Clara Matteuzzi, Univ Milano-Bicocca
The Status of Flavour Physics in the LHC Era
March 2010

Federico Sanchez, IFAE
Phenomenology of Neutrino Masses
April 2010

Diego Torres, ICREA/IEEE
Physics prospects of CTA
June 2010

Christian Bauer, LBNL Berkeley
Effective Theory Predictions for LHC Processes
October 2010

Marco Pallavicini, Università di Genova and INFN
Solar neutrino physics and the Borexino experiment
December 2010

4.9 IFAE Seminars

Aurelio Juste, ICREA-IFAE
Searches for the Higgs Boson at the Tevatron
January 2010

Emma de Oña Wilhelmi, Max-Planck Institut für Kernphysik
Future of galactic gamma-ray astronomy in the light of the latest Hess, Magic, Veritas and Fermi results.
January 2010

Ignasi Reichardt, IFAE
The Magic data center fits (in the astronomical community)
February 2010

Stephane Lavignac, IPHT, SACLAY
Unification and gauge mediation
February 2010

Joan Antoni Cabrer, IFAE
Soft-Wall Models
February 2010

Alvise Varagnolo, IFAE
A particle physicist's first look at quantum information
February 2010

Daniele Tommasini , Dept. of Applied Physics, University of Vigo
Particle Physics experiments with high power lasers
February 2010

Thomas Teubner, Liverpool university
G-2 of the muon: touchstone of the standard model, keyhole to new physics
March 2010

Javier Virto , Universidad La Sapienza & INFN Roma
Meson mixing and decay in the MSSM at two loops
March 2010

Bastian Kubis, Bonn University
Rescattering effects in $\eta \to 3\pi$ *decays*
March 2010

Antonio Delgado, Notre Dame, Indiana
Unitarity applied to hidden sector processes
May 2010

David Greynat, IFAE
Unification of expansions
May 2010

Benedict von Harling, University of Melbourne
A warped model of dark matter
June 2010

Javi Virto, IFAE
Solving Steiner's 200 year old problem
June 2010

Michele Redi, CERN, Geneva
Partially supersymmetric composite Higgs models
July 2010

Roberto Vega Morales, Northwestern university
Beautiful mirrors at the LHC
July 2010

Thorsten Feldmann , Technische Universitt Munchen
Variations on minimal flavor violation
July 2010

Giovanni Villadoro, CERN, Geneva
Low scale flavor gauge symmetry
September 2010

Francesco Benini , Princeton University
Holographic D-save superconductors and spectral functions
October 2010

Christian Bauer , LBL Berkeley
Constraining new physics contributions to the width difference in the B_s system
October 2010

Sebastian Krug, IFAE
Yang-Mills theory in 2+1 dim Schrödinger wave functional and Hamiltonian treatment by Karabali, Kim and Nair
October 2010

Kin-Ya Oda, Osaka University
Universal extra dimensions on projective sphere
October 2010

Subhendra Mohanty, Physical Research Laboratory, Ahmedabad
Sommerfeld effect in dark matter
October 2010

Arthur Hebecker, University of Heidelberg
Precision gauge unification from extra Yukawa couplings
October 2010

Salva Rychkov, ENS & UPMC, Paris
The structure of 4d conformal field theories
November 2010

Alessio Celi, UB
The emergence of Dirac physics in Graphene
November 2010

Martin Hirsch, IFIC, Valencia)
Neutrinoless double beta decay neutrino mass versus exotic contributions
November 2010

Luca Merlo , TUM Munich
Discrete symmetries and the flavour problem
November 2010

Jelena Aleksic, IFAE
Dark matter in galaxies
December 2010

Luca di Luzio , SISSA, Trieste
New aspects of symmetry breaking in grand new unified theories
December 2010

Jose Bernabeu, IFIC Valencia
New physics from W polarisation in top quark decays
December 2010

Juan Racker, UB
Leptogenesis without violation of B-L
December 2010

Jerjej F. Kamenik, Jozef Stefan Institute
Searching for new physics with top quark decays
December 2010