IFAE Report of Activities

Year 2008

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. La relació formal amb la Generalitat es porta a terme a través del Departament d'Innovació, Universitats i Empresa.

L'IFAE integra el seu propi personal amb personal dels Grups de Física Teòrica i de Física d'Altes Energies del Departament de Física de la UAB. L'IFAE està estructurat en dues Divisions: Experimental i Teòrica.

Aquest informe annual d'activitats es distribueix internacionalment i per tant està escrit en anglès. A la primera part figura una relació del personal de l'IFAE. A continuació, es relacionen les activitats institucionals, i finalment es descriu el desenvolupament de cadascuna de les línies d'investigació de l'IFAE.

Activitats científiques de la Divisió Experimental

Durant 2008 la Divisió Experimental va continuar la seva participació en vuit projectes:

1. ATLAS, un gran experiment en preparació per el Large Hadron Collider (LHC) del CERN. ATLAS està dissenyat per maximitzar les oportunitats de descobertes a la nova frontera d'altes energies del LHC.
2. CDF, un experiment de col·lisions antiprotó-protó en el Tevatron del Laboratori Nacional de Fermi (FNAL), en EUA. És l'accelerador de més alta energia del món fins la posta en marxa del LHC
3. La preparació d'un experiment amb neutrins, T2K, en un nou centre de Japó, i d'un experiment que vol aclarir la natural dels neutrins, al Laboratori Subterrani de Canfranc, al Pirineu.
4. MAGIC, un experiment d'astrofísica de partícules que detecta raigs gamma d'alta energia. MAGIC està situat a l'observatori del Roque de Los Muchachos a l'illa de La Palma a les Canàries. Actualment està prenent dades.
5. El disseny i la preparació de CTA, el pròxim gran sistema de telescopis per a l'astrofísica amb raigs gamma.
6. DES, un projecte de cosmologia observacional, amb grups d'EUA i del Regne Unit. S'està construint una nova càmara, que s'instal·larà a un telescopi en un observatori de Xile.
7. PAU, una col·laboració espanyola coordinada per l'IFAE i finançada amb un projecte Consolider-Ingenio 2010. PAU equipará un nou telescopi aprop de Teruel, per investigar el tema de l'energia fosca.
8. Recerques de física mèdica, que han produït unes patents i nous aparells de radiografia digital per al diagnòstic precoç del càncer de mama. D'aquestes activitats ha nascut una empresa spinoff, X-Ray Imatek.

Activitats científiques de la Divisió Teórica

Durant 2008 la Divisió Teòrica va continuar desevolupant les seves tres línies de recerca:

1. Física del Model Estàndard, desenvolupant prediccions sobre fenòmens observables al LHC, però també dirigint-se a problemes fonamentals de caràcter més formal.
2. Física més allà del Model Estàndard, perseguint idees amb bona motivació teòrica i amb conseqüències a l'escala d'energia del TeV, doncs comprovables al LHC.
3. Temes d'Astropartícules i de Cosmologia, estudiant les interaccions de les partícules en un entorn cosmològic, com per exemple el de l'Univers primordial: proprietats de la partícula Higgs, bariogènesis, leptogènesis.

En tots aquestes projectes el progrès ha superat o assolit les expectatives.

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". Functionally it depends from the Department of Innovation, Universities and Enterprises (DIUE, formerly DURSI) 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 integrates its own personnel with that of 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 five 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 formed by most of the members of the theory group of the Physics Department of the UAB, and by three ICREA research professors. The personnel of the Experimental Division is from IFAE itself, from the UAB and from ICREA, with two research professors and two investigators.

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 the 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 70. 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 themes of fundamental research: particle physics at high energy accelerators, gamma-ray astrophysics, and observational cosmology. In addition, there is a small but well-established line of applied physics, devoted to novel techniques in digital radiography.

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

An additional important development took place in 2003, driven by the strongly perceived need for remote handling of vast quantities of scientific data, not only for High-Energy physics experiments but also for astrophysical - facilities such as MAGIC. In 2003 three Spanish institutions, the UAB, the CIEMAT in Madrid and the Departament d'Universitats Recerca i Societat de la Informació (DURSI, now 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 scientific infrastructures, which might not have been possible otherwise. The most important among these activities are briefly recalled next:

1. 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, whose construction will be completed in 2010. The project was jointly approved in 2003 by the Spanish Government in Madrid and the Catalan Government.

2. 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.

3. 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.

4. 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

President
Blanca Palmada Félez, Commissioner for Universities and Research , D.I.U.E.
Members
Ramon Moreno Amich, Director General for Research, D.I.U.E
Jordi Marquet Cortés, Deputy Rector for Strategic Projects, 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 Full Research Professor, IFAE (since April 2008)

2. IFAE Personnel in 2008

IFAE complements its own staff (hired directly by the Institute) with personnel of the UAB and of ICREA. Below is a list of members of the Experimental and Theory Division of IFAE during 2008.

2.1 Experimental Division

Faculty

Martine Bosman	Research Professor, IFAE
Mª Pilar Casado	Adjunct Professor, UAB
Matteo Cavalli-Sforza	Research Professor, IFAE
Mokhtar Chmeissani	Research Professor, IFAE
Juan Cortina	Research Associate Professor, IFAE
José M. Crespo	Associate Professor, UAB
Manuel Delfino	Professor, UAB
Enrique Fernández	Professor, UAB
Sebastian Grinstein	Researcher (ICREA) (since 9/2008)
Ilya Korolkov	Research Associate Professor. IFAE
Manel Martínez	Research Professor, IFAE
Mario Martínez	Research Professor, ICREA
Ramon Miquel	Research Professor, ICREA
Mª Lluïsa Mir	Research Associate Professor, IFAE
Abelardo Moralejo	Researcher (Ramon y Cajal) IFAE
Cristóbal Padilla	Research Associate Professor, IFAE
Javier Rico	Researcher (ICREA) (since 1/2008)
Imma Riu	Researcher (Ramon y Cajal), UAB
Federico Sánchez	Research Associate Professor, IFAE

Engineering Staff

Otger Ballester	Electronic Engineer, IFAE
Miquel Barceló	Electronic Engineer, IFAE/MAGIC (CPAN)
Joan Boix	Electronic Engineer, IFAE (since 9/2008)
Laia Cardiel	Electronic Engineer, IFAE
Ferran Grañena	Mechanical Engineer, IFAE
Jose Mª. Illa	Electronic Engineer, IFAE
Carles Puigdengoles	Electronic Engineer, IFAE

Isaac Troyano (since 02/08)	Electronic Engineering student, CTA

Scientific Post-docs

Jalal Abdallah	ATLAS (since 9/2008)(CPAN)
Ulrike Blumenschein	ATLAS(until 05/2008)
Monica D'Onofrio	CDF (J. de la Cierva fellow)
Luca Fiorini	ATLAS (J. de la Cierva fellow)
Gabriel Jover	Neutrinos (since 1/2008)
Stefan Klepser	MAGIC (J de la Cierva fellow, since 12/2008)
Thorsten Lux	Neutrinos (J. de la Cierva fellow, since 12/2008)
Marino Maiorino	DES (IFAE)
Daniel Mazin	MAGIC (Marie-Curie EU scholarship)
Chistophe Ochando	ATLAS (CPAN) (since 11/2008)
Verónica Sorin	CDF (B. de Pinós fellow, since 11/2008)
Sergei Sushkov	ATLAS

Computer Scientists and Engineers

Andreu Pacheco	IFAE, Senior Computing Engineer
Yonatan Calderón	IFAE (since 2/2008)
Jaume Tomàs	IFAE

Doctoral Students

José Alcaraz	Neutrinos (Scholarship MEC-FPI)
Jelena Aleksic	MAGIC (Scholarship Generalitat, since 9/2008)
Daniel Bruckner	ATLAS (until 8/2008)
Stefano Camarda	CDF (Scholarship MEC/FPU, since 2/2008)
Manel Errando	Teaching Assistant UAB
Roger Firpo	MAGIC (Scholarship MEC-FPI, until 11/2008)
Lluis Galbany	Teaching assistant, UAB (since 9/2008)
Carolina Deluca	ATLAS (Scholarship Generalitat)
Gianluca De Lorenzo	ATLAS (Scholarship MEC-FPU)
Pol Martí	DES/PAU (since 9/2008)
Federico Nova	Neutrinos (Scholarship MEC-FPU)
Carlos Osuna	ATLAS (Scholarship MEC-FPI)

Estel Pérez	ATLAS (Scholarship MEC-FPU)
Neus Puchades	MAGIC (Scholarship MEC-FPI)
Ignasi Reichardt	MAGIC (since 1/2008)
Valerio Rossetti	ATLAS (since 11/2008)
Oriol Saltó	CDF (until 07/2008)
Ester Segura	ATLAS (Scholarship MEC-FPU)
Nuria Sidro	MAGIC (MAGIC, until 7/2008)
Francesc Vives	ATLAS (Scholarship MEC/FPU, since 3/2008)
Matteo Volpi	ATLAS (Scholarship Generalitat)
Diego Tescaro	MAGIC (Scholarship MEC-FPU)
Volker Vorkerk	ATLAS (Scholarship MEC-FPI)
Roberta Zanin	MAGIC (Scholarship MEC-FPU)

Administrative Personnel

Josep Gaya	IFAE/ UAB, Senior Administrator
Cristina Cárdenas	UAB/ IFAE, Secretary
Natalia Alonso	MAGIC/IFAE, Administrative Assistant
Alejandro Palomanes (since 03/08)	IFAE, Administrative Assistant
Marta Sánchez (since 12/08)	IFAE, Administrative Assistant
Ramon Santos (until 03/08)	IFAE, Administrative Assistant

Technicians

Alex González	Electronic Technician, IFAE
Javier Gaweda	Mechanical Technician, IFAE
Karl Kölle	MAGIC Telescope Manager

2.2 Theory Division

Faculty

Rafel Escribano	Research Assoc. Prof. (Ramón y Cajal), UAB
Jose Ramón Espinosa (since 10/2008)	Research Professor, ICREA
Josep Antoni Grifols	Professor, UAB
Mathias Jamin	Research Professor, ICREA
Eduard Massó	Professor, UAB
Joaquim Matias	Associate Professor, UAB

Antoni Méndez	Professor, UAB
Ramon Pascual	Professor, UAB
Santi Peris	Associate Professor, UAB
Antonio Pineda	Associate Professor, UAB
Alex Pomarol	Associate Professor, UAB
Mariano Quiros	Research Professor, ICREA

Scientific Post-Docs

Nikolas Brouzakis (since 9/2008)	Post-doc UniverseNet
Aldo Cotrone	Post-doc IFAE (at UB)
Gabriel Fernández	Post-doc Juan de la Cierva
Zhi-Hui Guo (since 9/2008)	Post-doc Flavianet
David Greynat (since 10/2008)	Post-doc IFAE (at UAB)
Thomas Konstandin	Post-doc UniverseNet
Alessio Provenza	Post-doc IFAE (at UAB)
Alberto Salvio	Post-doc IFAE
Juan José Sanz	Post-doc Juan de la Cierva
Felix Schwab	Post-doc DFG and BMBF
Maximillian Stahlhofen (since 9/2008)	Post-doc Flavianet

Visiting Scientists

Pedro Silva	Institut de Ciències de l’Espai

Doctoral Students

Joan Antoni Cabrer	Teaching Assistant
Oriol Domènech	Teaching Assistant
Pere Masjuan	Teaching Assistant
Marc Montull	Scholarship UAB (since 10/2008, PIF)
Germano Nardini	Scholarship MEC
Diogo R. Boito	Scholarship MEC
Marc Ramon	Scholarship UAB (PIF)
Javier Serra	Scholarship MEC

3. Institutional Activities in 2008

3.1 Diploma Theses

Experimental Division

Gianluca De Lorenzo
Title: *Inclusive Search for Gluino and Squark Production in Events with Multiple Jets and Large Missing Transverse Energy with the CDF Experiment at The Tevatron Collider*
Supervisor: Mario Martínez Perez
Date: 04/04/08

Lluis Galbany González
Title: *Tests of DES Charge Coupled Devices*
Supervisor: Ramon Miquel Pascual
Date: 10/04/08

Francesc Vives
Title: *Cosmic Calibration of TileCal Modules with Cosmic Muons*
Supervisor: Martine Bosman
Date: 17/04/08

Estel Pérez Codina
Title: *Optimization studies of the calorimetric second level trigger of the ATLAS experiment at the LHC.*
Supervisor: Martine Bosman
Date: 05/05/08

Theory Division

Javier Serra
Title: *Top Quark Compositeness*
Supervisor: Alex Pomarol
Date: 10/04/08

Oriol Domènech
Títle: *"Bariones" en modelos con dimensiones extra*
Supervisor: Alex Pomarol
Date: 10/06/08

Joan Antoni Cabrer
Title: *Coupling Constant Unification in the Standard Model and Supersymmetric Extensions*
Supervisor: Mariano Quirós
Date: 02/07/08

Diogo R. Boito
Title: *K π vector form factor, dispersive constraints and τ --->K π ν decays*
Supervisors: Matthias Jamin y Rafel Escribano
Date: 08/09/08

Marc Ramon
Title: *Introduction to QCD Factorization\newline for the exclusive process* B --> K* $l^+ l^-$
Supervisor: Joaquím Matias Espona
Date: 09/09/08

3.2 Doctoral Theses

Experimental Division

Nuria Sidro
Title: *Discovery and characterization of the binary system LS I+61 303 in very high energy gamma-rays with MAGIC.*
Supervisor: Javier Rico y Juan Cortina
Date: 05/06/08

Oriol Saltó Bauzà
Title: *Measurement of Inclusive Jet Cross Sections in Z/gamma to ee +jets Production in ppbar Collisions at sqrt (s) = 1.96 TeV with the CDF Detector*
Supervisor: Mario Martínez Pérez
Date: 27/06/08

Gabriel Jover Mañas
Title: *Measurement of the Multi-pion neutrino interaction cross section with the K2K SciBar detector*
Supervisor: Federico Sánchez Nieto
Date: 07/07/08

Theory Division

David Diego Castro
Title: *Supersymmetry and electroweak symmetry breaking from extra dimensions*
Supervisor: Mariano Quirós
Date: 28/06/08

Jorge Mondejar
Title: *QCD in the large Nc limit and effective field theories*
Supervisor: Antonio Miguel Pineda Ruiz
Date: 12/09/08

3.3 Publications

Experimental Division

Publications of the ATLAS Group

M. Bosman, M.P. Casado, C. Osuna, E. Perez and the ATLAS Tau Trigger group
Implementation and performance of the tau trigger in the ATLAS experiment
Acta Phys.Polon.Supp.1:421-424, 2008
ISSN 0587-4246

M.Bosman, M.P.Casado, H.Garitaonandia, C.Osuna, C.Padilla, E.Pérez, I.Riu, E.Segura, S.Sushkov with the ATLAS TDAQ group
Event reconstruction algorithms for the ATLAS trigger
T. Fonseca-Martin *et al*.
J.Phys.Conf.Ser.119:022022, 2008
ISSN 1742-6588

M.Bosman, M.P.Casado, H.Garitaonandia, C.Osuna, C.Padilla, E.Pérez, I.Riu, E.Segura, S,Sushkov with the ATLAS TDAQ group
Integration of the trigger and data acquisition systems in ATLAS
M. Abolins *et al.*
Published in J.Phys.Conf.Ser.119:022001, 2008
ISSN 1742-6588

C.Biscarat, O.Blanch, U.Blumenschein, M.Bosman, S.Bravo, M.P.Casado, M.Cavalli-Sforza, C.Deluca, E.Domingo, M.Dosil, X.Espinal, L.Fiorini, J.Flix, H.Garitaonandia, M.C.Iglesias, S.Jorgensen, I.Korolkov, M.Ll.Mir, L.Miralles, O.Norniella, C.Osuna, A.Pacheco, C.Padilla, I.Park, E.Perez, C.Puigendoles, I.Riu, H.Ruiz, O.Salto, C.Sanchez, E.Segura, S.Sushkov, F.Vives, M.Volpi.
The ATLAS Experiment at the CERN Large Hadron Collider
G. Aad *et al*. ATLAS Collaboration
JINST 3:S08003, 2008. ISSN 1748-0221

Combined performance tests before installation of the ATLAS Semiconductor and Transition Radiation Tracking Detectors
E. Abat *et al.* ATLAS SCT Collaboration
JINST 3:P08003, 2008

J.Abdallah, M.Bosman, M.P.Casado, M.Cavalli-Sforza, M.D'Onofrio, M.Dosil, X.Espinal, L.Fiorini, S.Jorgensen, I.Korolkov, M.Martinez, M.Ll.Mir, J.Nadal, C.Osuna, A.Pacheco, Cristobal Padilla, E.Perez, C.Puigendoles, I.Riu, E.Segura, S.Sushkov, F.Vives, M.Volpi, V.Vorwerk
Expected Performance of the ATLAS Experiment, Detector, Trigger and Physics
G. Aad *et al.*, ATLAS Collaboration, CERN-OPEN-2008-020, Geneva, 2008,
arXiv:0901.0512 , ISBN978-92-9083-321-5

M. Bosman for the ATLAS Collaboration
ATLAS Detector Status and Physics Startup Plans
Plenary talk at 34th International Conference on High Energy Physics (ICHEP 2008)
arXiv:0810.3184 [physics.ins-det]

M. Bosman, M.P. Casado, C. Osuna, E. Pérez and the ATLAS Tau Trigger group
Tau trigger at the ATLAS experiment
Contribution to 34th International Conference on High Energy Physics (ICHEP 2008)
arXiv:0810.0465 [hep-ex].

M.Bosman, M.P.Casado, H.Garitaonandia, C.Osuna, C.Padilla, E.Pérez, I.Riu, E.Segura, S,Sushkov with the ATLAS TDAQ group
The ATLAS Trigger - Commissioning with cosmic rays
M. Abolins *et al.*
J.Phys.Conf.Ser.119:022014, 2008

I. Riu, M. Bosman, C. Padilla, S. Sushkov with the ATLAS TDAQ group
Integration of the Trigger and Data Acquisition Systems in ATLAS
IEEE Trans.Nucl.Sci.55:106-112,2008

C. Borrego, M. Campos, J. Nadal, A. Pacheco, et al.
Experience running a distributed Tier-2 in Spain for the ATLAS experiment 2008
J. Phys.: Conf. Ser. 119 052026

C. Borrego, M. Campos, J. Nadal, A. Pacheco et al.
Distributed ATLAS computing activities in IBERIA
2nd Iberian Grid Infrastructure Conference
Proceedings ISBN 978-84-9745-288-5

L. Fiorini, N. Gollub
Event filter monitoring of the ATLAS Tile Calorimeter
J.Phys.Conf.Ser.119:042013, 2008

J. Abdallah, U. Blumenschein, L. Fiorini et al.
ATLAS Tile Calorimeter data quality assessment with commissioning data
J.Phys.Conf.Ser.119:032001, 2008

Publications of the CDF Group:

A. Attal, M. Cavalli-Sforza, G. De Lorenzo, M. D'Onofrio, S. Grinstein, M. Martínez, O. Saltó, V. Sorin
Inclusive Search for Squark and Gluino Production in p anti-p Collisions at $s^{1/2}$= 1.96TeV
A. Abulencia *et al*.The CDF Collaboration
Fermilab-Pub-08-526-E. arXiv:0811.2512

Search for Large Extra Dimensions in Final States Containing One Photon or Jet and Large Missing Transverse Energy Produced in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 101, 181602 (2008)

Forward-Backward Asymmetry in Top Quark Production in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. Lett. 101, 202001 (2008)

Search for the Flavor Changing Neutral Current Decay tau → Zq in p anti-p Collisions at $s^{1/2}$=1.96 TeV
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 101, 202001 (2008)

Measurement of b-jet Shapes in Inclusive Jet Production in p anti-p Collisions at $s^{1/2}$= 1.96 TeV
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. D78, 072005 (2008)

Measurement of the Inclusive Jet Cross Section at the Fermilab Tevatron p anti-p Collider Using a Cone-Based Jet Algorithm
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. D78, 052006 (2008)

Search for Heavy, Long-Lived Neutralinos that Decay to Photons at CDF II Using Photon Timing
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. D78, 032015 (2008)

Search for Doubly Charged Higgs Bosons with Lepton-Flavor-Violating Decays involving Tau Leptons
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. Lett. 101, 121801 (2008)

Search for Pair Production of Scalar Top Quarks Decaying to a tau Lepton and a b Quark in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. Lett. 101, 071802 (2008)

Search for Standard Model Higgs Boson Production in Association with a W Boson at CDF
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. D78, 032008 (2008)

Model-Independent and Quasi-Model-Independent Search for New Physics at CDF
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. D78, 012002 (2008)

Cross Section Measurements o High-p_t Dilepton Final-State Processes Using a Global Fitting Method
A. Abulencia *et al*., The CDF Collaboration
Phys. Rev. D78, 09120003 (2008)

Strong Evidence for ZZ Production in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 201801 (2008)

Search for the Higgs Boson in Events with Missing Transverse Energy and b Quark Jets Produced in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 211801 (2008)

First Run II Measurement of the W Boson Mass
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. D77, 112001 (2008)

Search for Third Generation Vector Leptoquarks in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. D77, 092001 (2008)

Search for Resonant tt-bar Production in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al*., The CDF Collaboraton
Phys. Rev. Lett. 100, 231801 (2008)

Measurement of Lifetime and Decay-Width Difference in B0(s) → J/ψ Φ Decays
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 121803 (2008)

Observation of the Decay $B^{\pm}_c \rightarrow J/\psi\ \pi^{\pm}$ and Measurement of the $B^{\pm}_c$ Mass
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 182002 (2008)

Measurement of Correlated bb-bar Production in p anti-p Collisions at $s^{1/2}$ = 1960 GeV
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. D77, 072004 (2008)

Two-particle Momentum Correlations in Jets Produced in p anti-p Collisions at $s^{1/2}$ =1.96 TeV T

Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. D77, 092001 (2008)

First Flavor-Tagged Determination of Bounds on Mixing-Induced CP Violation in $B_0 \rightarrow J/\psi\ \Phi$ Decays
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. Lett. 100, 161802 (2008)

Evidence for D^0-D^0-bar Mixing using the CDF II Detector
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. Lett. 100, 121802 (2008)

Search for Heavy Top-like Quarks Using Lepton Plus Jets Events in 1.96 TeV p anti-p Collisions
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. Lett. 100, 161803 (2008)

Measurement of Ratios of Fragmentation Fractions for Bottom Hadrons in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T.Aaltonen *et al*., The CDF Collaboration
Phys. Rev. D77, 072003 (2008)

Measurement of Inclusive Jet Cross Sections in $Z/\gamma^*(\rightarrow e^+e^-)$ +jets Production in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 102001 (2008)

First Measurement of the Production of a W Boson in Association with a Single Charm Quark in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al.*, The CDF Collaboraton
Phys. Rev. Lett. 100, 091803 (2008)

Search for $B^0_s \rightarrow \mu^+ \mu^-$ and $B^0_d \rightarrow \mu^+ \mu^-$ Decays in 2 fb^1 of p anti-p Collisions with CDF II
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 101802 (2008)

Observation of Exclusive Dijet Production at the Fermilab Tevatron p anti-p Collider
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. D77, 052004 (2008)

Limits on the Production of Narrow tt-bar Resonances in p anti-p Collisions at $s^{1/2}$=1.96 TeV
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. D77, 051102 (2008)

Search for Chargino-Neutralino Production in p anti-p Collisions at $s^{1/2}$ =1.96 TeV with high-p_t Leptons
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. D77, 052002 (2008)

Measurement of the Cross Section for W-boson Production in Association with Jets in p anti-p Collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. D77, 011108 (2008)

Cross Section Constrained Top Quark Mass Measurement from Dilepton Events at the Tevatron
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 062005 (2008)

A Direct Measurement of the W Boson Width in p anti-p collisions at $s^{1/2}$ =1.96 TeV
T. Aaltonen *et al.*, The CDF Collaboration
Phys. Rev. Lett. 100, 071801 (2008)

Observation of Orbitally Excited B_s Mesons
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 082001 (2008)

Search for Standard Model Higgs Bosons Produced in Association with W Bosons
T. Aaltonen *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 041801 (2008)

First Observation of the Decay B0(s) --> D(s)- D+_s and Measurement of Its Branching Ratio
A. Abulencia *et al*., The CDF Collaboration
Phys. Rev. Lett. 100, 021803 (2008)

Publications of the MAGIC Group:

J. Rico
The Variable Super-orbital Modulation of Cygnus X-1
Ap. J. Lett.683 (2008) L55-L58

J. Aleksic, J. Cortina, M. Errando, E. Fernández, R. Firpo, S. Klepser, M. Martínez, D. Mazin, A. Moralejo, N. Puchades, I. Reichardt, J. Rico, N. Sidro, D. Tescaro, and R. Zanin with the MAGIC Collaboration

Observation of Pulsed Gamma-Rays Above 25 GeV from the Crab Pulsar with MAGIC
E. Aliú *et al.*, The MAGIC Collaboration
Science 322 (2008) 1221

Very-High-Energy gamma rays from a Distant Quasar: How Transparent Is the Universe?
J. Albert *et al.*, The MAGIC Collaboration
Science 320 (2008) 1752

Probing quantum gravity using photons from a flare of the active galactic nucleus Markarian 501 observed by the MAGIC telescope
J. Albert *et al.*, The MAGIC Collaboration
Phys. Lett. B 668 (2008) 253

Implementation of the Random Forest Method for the Imaging Atmospheric Cherenkov Telescope MAGIC
J. Albert *et al.*, The MAGIC Collaboration
Nucl. Instr. Meth. A 588, 424 (2008)

First Bounds on the High-Energy Emission from Isolated Wolf-Rayet Binary Systems
E. Aliú *et al.*, The MAGIC Collaboration
Ap. J. Lett. 685 (2008) L71, and arXiv:0808.1832

Very High Energy Gamma-Ray Observations of Strong Flaring Activity in M87 in 2008 February
J. Albert *et al.*, The MAGIC Collaboration
Ap. J. Lett. 685 (2008) L23

Multi-wavelength (radio, X-ray and gamma-ray) observations of the gamma-ray binary LS I +61 303
J. Albert *et al.*, The MAGIC Collaboration
Ap. J. 684 (2008) 1351

Systematic search for VHE gamma-ray emission from X-ray bright high-frequency BL Lac objects
J. Albert *et al.*, The MAGIC Collaboration
Ap. J.681 (2008) 944, and arxiv:0706.4453.

Simultaneous Multiwavelength Observations of the Blazar 1ES 1959+650 at a Low TeV Flux
G. Tagliaferri, J. Albert *et al.*
Ap. J. 679 (2008) 1029, and arXiv:0801.4029

Upper Limit for Gamma-Ray Emission above 140 GeV from the Dwarf Spheroidal Galaxy Draco
J. Albert *et al.*, The MAGIC Collaboration
Ap. J. 679 (2008) 428, and arXiv:0711.2574

MAGIC Observations of the Unidentified Gamma-Ray Source TeV J2032+4130
J. Albert *et al.*, The MAGIC Collaboration
Ap. J. 675 (2008) L25, and arXiv:0801.2391

VHE Gamma-Ray Observation of the Crab Nebula and its Pulsar with the MAGIC Telescope
J. Albert *et al.*, The MAGIC Collaboration
Ap. J. 674 (2008) 1037-1055

Publications of the Neutrino Group

J. Alcaraz, G. Jover, F. Sánchez
Search for Charged Current Coherent Pion Production on Carbon in a Few-GeV Neutrino Beam
K. Hiraide *et al.* SciBooNE Collaboration
Phys.Rev.D78:112004, 2008

J.Alcaraz, S. Andringa, X. Espinal, E. Fernández, G. Jover, F. Nova, A. Rodríguez, F. Sánchez
Measurement of single charged pion production in the charged-current interactions of neutrinos in a 1.3-GeV wide band beam
A. Rodriguez *et al.*, K2K Collaboration
Phys.Rev.D78:032003, 2008

Experimental study of the atmospheric neutrino backgrounds for $p \rightarrow e^{+} \pi^{0}$ searches in water Cherenkov detectors
S. Mine *et al.*, K2K Collaboration
Phys.Rev.D77:032003, 2008

Publications of the DES Group

Marino Maiorino et al.
Characterization of DECam focal plane detectors
Thomas Diehl et al. Proc. SPIE, A Vol.: 7021, 2008-06-23H

Publications of the PAU Group

E. Fernández and R. Miquel with the PAU Collaboration
Measuring Baryon Acoustic Oscillations along the line of sight with photometric redshifts: the PAU survey
N. Benitez *et al*.
arXiv:0807.0535 [astro-ph] (2008)

Other Publications

S. Klepser with IceCube Collaboration
Solar Energetic Particle Spectrum on 13 December 2006 Determined by IceTop
R. Abbasi *et al.*
Ap. J. Lett 689 (2008) L65-L68, 2008

R. Miquel with the Particle Data Group
Review of Particle Physics
C. Amsler *et al.* (Particle Data Group)
Phys. Lett. B667 (2008) 1

E. V. Linder and R. Miquel
Cosmological Model Selection: Statistics and Physics
Int. J. Mod. Phys. D17 (2008) 2315

E. Gaztañaga, R. Miquel and E. Sánchez,
First Cosmological Constraints on Dark Energy from the Radial Baryon Acoustic Scale
arXiv:0808.1921 [astro-ph] (2008)

Theory Division

I. Antoniadis, K. Benakli, A. Delgado and M. Quiros
A New Gauge Mediation Theory
Adv. Studies Theor. Phys. 2 (2008) 12, 645-672

A. Delgado, J. R. Espinosa, J.M. No and M. Quiros
The Higgs as a portal to plasmon-like unparticle excitations
JHEP 0804 (2008) 028

Phantom Higgs from Unparticles
JHEP 0811 (2008) 071

D. Diego and M. Quiros
Dirac vs. Majorana neutrino masses from a TeV interval
Nucl. Phys. B805 (2008) 148-167

M. Carena, G. Nardini, M. Quiros and C.E.M. Wagner
The Effective Theory of the Light Stop Scenario
JHEP 0810 (2008) 062

J. R Espinosa, T. Konstandin, J.M. No and M.Quiros
Some Cosmological Implications of Hidden Sectors
Phys. Rev. D 78 (2008) 123528

A. Pomarol and A. Wulzer
Stable skyrmions from extra dimensions
JHEP 0803:051-051, 2008

A. Pomarol and J. Serra
Top Quark Compositeness: Feasibility and Implications
Phys.Rev.D78:074026, 2008

P. Masjuan and S. Peris
A Rational approximation to <VV-AA> and its O(p6) low-energy constant
Phys. Lett. B663 (2008) 61

O. Cata, M. Golterman and S. Peris
Unravelling duality violations in hadronic tau decays
Phys. Rev. D77 (2008) 093006

P. Masjuan, S. Peris and J.J. Sanz Cillero
Vector meson dominance as a first step in a systematic approximation: the pion vector form factor
Phys. Rev D78 (2008) 074028

M. Jamin, V. Mateu
OPE-RchiT matching at order α_s: hard gluonic corrections to three-point Green functions
JHEP 0804 (2008) 040

M. Jamin, A. Pich, J. Portoles
What can be learned from the Belle spectrum for the decay $\tau \to V_\tau K_S \pi^-$
Phys. Lett. B664 (2008) 78

M. Beneke, M. Jamin
α_s and the τ hadronic width: fixed-order, contour-improved and higher-order perturbation theory
JHEP 0809 (2008) 044

R. Escribano
η' gluonic content and $J/\psi \to VP$ decays
Nucl. Phys. B Proc. Suppl. 181-182 (2008) 226-230

R. Escribano, P. Masjuan and J. Nadal
Linear sigma model predictions for $V \to S\gamma$ and $S \to V\gamma$ decays
Phys. Lett. B670 (2008) 27-31

R. Escribano
Update of $\eta\eta'$mixing from $J/\psi \to VP$ decays
AIP Conf. Proc. 1030 (2008) 368-373

R. Escribano, J. Matias and J. Virto
Sum rules for $B \to \pi\, \eta(\eta')$, $K\, \eta(\eta')$, $\eta(\eta')\, \eta(\eta')$ decays
Phys. Lett. B659 (2008) 870-877

U.Egede, T.Hurth, J.Matias, M.Ramon, W. Reece
New observables in the decay mode anti-B(d) → anti-$K^0_* l^+ l^-$
JHEP 0811 (2008) 032

P. J. Silva et al.
Euclidean analysis of the entropy functional formalism
Phys. Rev. D 16 2008

P. J. Silva
On uniqueness of supersymmetric black holes in AdS(5)
Class.Quant.Grav.25:195016,2008

J. Mondejar, A. Pineda
Breakdown of the OPE in the 't Hooft model
Phys. Rev. Lett. 101 (2008) 152002
$1/N_c$ and 1/n preasymptotic corrections to current-current correlators
JHEP 0806 (2008) 039

D. Nevado, A. Pineda
Forward virtual Compton scattering and the Lamb shift in chiral perturbation theory
Phys. Rev. C77 (2008) 035202

A. Pineda
The static potential in N=4 supersymmetric Yang-Mills at weak coupling
Phys. Rev. D(R) 77 (2008) 021701

3.4 Talks by IFAE Members

Experimental Division

U. Blumenschein
"*Jets and Jets+MET Studies at the LHC*"
QCD and High Energy Interactions,
Rencontres de Moriond
La Thuile (Italy), March 2008

M. Bosman
"*LHC Experiments*"
XXXVI International Meeting on Fundamental Physics
Baeza (Spain), February 2008
"*ATLAS Detector Status and Physics Startup Plans*",
34th International Conference on High Energy Physics
Philadelphia (US), July 2008
"*Top physics strategy @ LHC with the early data, concluding remarks*"
3rd Top Workshop @ Grenoble : from the TeVatron to ATLAS
Grenoble (France), October 2008

L. Cardiel
"Front-end electronics for the Dark Energy Camera (DECam)"
Poster, SPIE Astronomical Telescopes and Instrumentation 2008
Palais des Congrès Parc Chanot
Marseille (France), 2008

P. Casado
"*Tau Trigger in ATLFAST*"
ATLAS Workshop on Tau Lepton Physics
Dresden (Germany), May 2008
"*ATLAS: una herramienta para descubrir la física fundamental del universo mediante el Gran Colisionador de Hadrones (LHC)*"
Seminar, Societat Catalana de Tecnologia
Barcelona (Spain), July 2008
"*ATLAS Tau Trigger*"
10th International Workshop on Tau Physics
Novosibirsk (Russia), September 2008
"*Summary of the X-th International workshop on Tau Lepton Physics (Tau-08), Novosibirsk,22-25 Sep, 2008*"
Seminar IFAE
Barcelona (Spain), October 2008

M. Cavalli-Sforza
"*Ver las partículas en el LHC: el reto de los detectores*"
Conference at Maratón Científico sobre el LHC,
Museo Nacional de Ciencia y Tecnología
Madrid (Spain), January 2008
"*Highlights from the Int. Conf. of High Energy Physics 2008*"
CERN Scientific Policy Committee meeting,
September 2008
IFAE seminar, Barcelona (Spain), October 2008
"*El Large Hadron Collider i els seus detectors: reptes tecnològics, oportunitats de descobertes*"
Acadèmia de Ciències i Arts de Barcelona
Barcelona (Spain), November 2008

J. Cortina
"Two years of galactic observations with MAGIC"
Non-Thermal Hadronic Processes in Galactic Sources,
1st Heidelberg Workshop
Heidelberg (Germany), 14-16 January 2008

G. De Lorenzo
"Searches for physics BSM at CDF"
Lake Louise Winter Institute
Lake Louise (Canada), February 2008

C. Deluca
"Inclusive Prompt Photon Cross Section"
APS Meeting
Saint Louis, (USA), April 2008

M. D' Onofrio
"From the Tevatron to the LHC: what could lie beyond the SM?"
Invited Seminar, University of Oxford
Oxford (UK), October 2008
"Searches for SuperSymmetry at the Tevatron"
Invited Seminar, University of Liverpool
Liverpool (UK), September 2008
"SUSY searches at the Tevatron"
Invited Seminar, University of Rutgers
New Jersey (US), August 2008
"Measurement of the inclusive prompt photon cross section at CDF"
Poster, 34th International Conference on High Energy Physics (ICHEP 2008)
Philadelphia (US), July 2008
"Search for Squarks and Gluino Production at CDF"
Poster, 34th International Conference on High Energy Physics (ICHEP 2008)
Philadelphia (US), July 2008
"Measurement of the Inclusive Z+jet(s) Production Cross Section at CDF"
Poster, 34th International Conference on High Energy Physics (ICHEP 2008)
Philadelphia (US), July 2008
"SUSY searches at the Tevatron"
HEP Seminar, University of Chicago
Chicago IL (US), April 2008
"Jet Energy and Calibration with data at the CDF experiment"

3rd Top Workshop, from the Tevatron to ATLAS
Grenoble (France), October 2008
"SUSY Searches in jets final states at CDF"
34th International Conference on High Energy Physics (ICHEP 2008), Philadelphia (US), July 2008
"Measurements of Z+jets cross sections at CDF"
Berkeley Workshop on Boson+jets
Berkeley (US), March 2008
"Searches for Physics Beyond the Standard Model at CDF"
3rd Workshop on Monte Carlo Tools for Beyond the Standard Model Physics (MC4BSM-3)
CERN, Geneva (Switzerland), March 2008

M. Errando
"Discovery of very high energy gamma-rays from the flat spectrum radio quasar 3C 279 with the MAGIC telescope"
4th Heidelberg International Symposium on High Energy Gamma-Ray Astronomy
Heidelberg (Germany), July 7-11, 2008

E. Fernández
"The CERN Scientific Program"
Jornadas sobre la Participación Española en los Futuros Aceleradores Lineales
Santander (Spain), 15 January 2008
"El CERN y las Astropartículas en España"
Reunión sobre el CERN y las Instalaciones Relacionadas con el CERN.
MEC, Madrid (Spain), 14 February 2008
"The PAU (BAO) Survey"
43rd Rencontres de Moriond
La Thuile (Italy), 20 March 2008
"Partículas Elementales e Interacciones: una Frontera Científica"
Programa Ciencia Viva del Depart. de Educ., Cultura y Deporte del Gob. de Aragón
IES Bajo Aragón, Alcañiz (Spain),4 April 2008
"Buscando una aguja en un pajar"
Els Sopars amb Estrelles. Programa de divulgació de la ciencia
Observatori Fabra, Barcelona (Spain), 6 August 2008
"El LHC: Una Larga Historia Colectiva"
Conferència inaugural del curs 2008-2009 de la Societat Catalana de Física
Institut d'Estudis Catalans, Barcelona (Spain), 22 October 2008
"The CLIC Linear Collider"
Jornadas sobre la Participación Española en los Futuros Aceleradores Lineales
Santiago de Compostela (Spain), 16 October 2008
"El proyecto LHC"
Semana de la Ciencia, Instituto de Enseñanza Secundaria Pius Font i Quer
Manresa (Spain), 17 November 2008

L. Fiorini
"*ATLAS Commissioning with cosmic rays and first LHC beam*"
ATLAS Overview Week
CERN, Geneva (Switzerland), October 2008
"*ATLAS Commissioning with cosmic rays and first LHC beam*"
Seminar Valencia (Spain), October 2008

S. Klepser
"First Results from the IceTop Air Shower Array"
European Cosmic Ray
Košice (Slovakia), September 2008

T. Lux
"NEXT: R&D towards a Xenon High Pressure TPC"
Deutsche Physikalische Gesellschaft Meeting
Freiburg (Germany), 3 March 2008
"NEXT: A new Double Beta Decay Experiment"
Bonn Uninversity
Bonn (Germany), 13 November 2008

M. Martinez
"Very High Energy Gamma Astronomy: Where do we stand and where do we go?"
XXXVI International Spanish Meeting on Fundamental Physics
Baeza, Granada (Spain), February 4-8, 2008
"MAGIC Highlights"
Virtual Institute of Astroparticle Physics (VIA)
Via Internet, April 4, 2008
"Proposed Atmospheric monitoring for CTA"
Atmospheric Monitoring for Astroparticle Physics Workshop
Prague (Czech Republic), June 25 - July 4, 2008
"Towards the ground-based gamma-ray observatory CTA"
4th Heidelberg International Symposium on High Energy Gamma-Ray Astronomy
Heidelberg (Germany), July 7-11, 2008
"CTA: where do we stand and where do we go?"
CTA Meeting
Padova (Italy), November 2008
"Fundamental Physics with Cosmic Gamma Rays"
DISCRETE'08 Symposium on Prospects in the Physics of Discrete Symmetries
IFIC, Valencia (Spain),11–16 December 2008

M. Martínez Pérez
"ATLAS Prospects for W/Z+jets Production"
Berkeley Workshop on Boson+jets
LBL, Berkeley (US), March 2008
"Jets in CDF"
ATLAS-France Workshop on Jets
Paris (France), June 2008
"Experimental review on jets in hadronic collisions"
Hard Probes Conference 2008
La Toja (Spain), June 2008

“SM Tevatron Results and Prospects”
University of Lisboa
Lisboa (Portugal), June 2008

D. Mazin
"Cosmology via Extragalactic Background Light"
Invited talk given at the kick-off CTA meeting
Barcelona (Spain), January 2008
"Extragalactic Background Light: status and perspectives"
Workshop on AGN and Related Fundamental Physics in High-Energy Gamma Astronomy
Jeris (Finland), March 31 - April 05, 2008
"HESS and MAGIC data: Constraints on the Extragalactic Background Light fromVHE gamma-ray spectrand"
2nd International Complutense Seminar
Madrid (Spain), May 2008
"Constraints on Extragalactic Background Light from Cherenkov telescopes: status and perspectives for the next 5 years"
Scineghe08 (Science with the New Generation of High Energy Gamma-Ray Experiments)
Padova (Italy), October 2008

R. Miquel
“*Dark Energy: an Observational Primer”*
XXXVIth International Meeting on Fundamental Physics
Baeza (Spain), February 2008
“Dark Energy and the PAU Project”
Universitat de Barcelona
Barcelona (Spain), February 2008
“Measuring Baryon Acoustic Oscillations along the line of sight with photo-zs: the PAU survey”
International Workshop on Modern Cosmology
Benasque (Spain), July 2008
“Measuring Baryon Acoustic Oscillations along the line of sight with photo-zs: the PAU survey”
DES Collaboration Meeting
The Ohio State University
Columbus, OH (USA), November 2008

C. Padilla
“*Plans for trigger operations, including data-quality monitoring*”
ATLAS Overview Week
Bern (Switzerland), July 2008
“*Operational needs of Prompt Efficiency Measurements*”
ATLAS Trigger Efficiency Workshop
CERN, Geneva (Switzerland), July 2008

E. Pérez
“*Implementation and Commissioning of the ATLAS Tau Trigger*”
Poster IEEE NSS
Dresden (Germany), October 2008

J. Rico
"Computing at MAGIC: present and future"
ASPERA Meeting on Computing and Astroparticle
Paris (France), February 8, 2008
“Results of MAGIC on Galactic sources”
4th Heidelberg International Symposium on High Energy Gamma-Ray Astronomy
Heidelberg (Germany), July 7-11, 2008
"Status and recent results of MAGIC"
6th Workshop on Science with the New Generation of High Energy Gamma-Ray Experiments
Padova (Italy), October 8-10, 2008

I. Riu
“*HLT Commissioning*”
ATLAS Workshop on Tau Lepton Physics
Dresden (Germany), May 2008
“*Trigger experience with single beam*”
ATLAS Overview Week
CERN, Geneva (Switzerland), October 2008

O. Saltó
“*W/Z+jets and W/Z+HF”*
QCD 08
Montpellier (France), July 7-12, 2008

F. Sánchez
“The Next experiment”
Neutrino Oscillation Workshop (NOW 2008)
Otranto (Italy), September 2008

V. Vorwerk
“*Measurement of Tau Trigger efficiency with ttbar events*”
ATLAS Workshop on Tau Lepton Physics
Dresden (Germany), May 2008
“*Measurement of Tau Trigger efficiency with ttbar events*”
ATLAS Trigger Efficiency Workshop
CERN, Geneva (Switzerland), July 2008

Theory Division

M. Quiros
“The nature of the electroweak Higgs sector”
DISCRETE '08: Symposium on Prospects in the Physics of Discrete Symmetries
Valencia (Spain), 11-16 December 2008
“Electroweak Baryogenesis”
Early Universe thermometers
Padua (Italy), 6-8 February 2008
“Extra dimensions in Ecole de Gif 2008: Quelle nouvelle physique au LHC?”
École Polytechnique
Paris (France), September 2008
“Orbifold Breaking in Dual C-P Institute of High Energy physics: Gauge-Higgs Unification”

University of Comala
Colima (Mexico), January 2008

M. Jamin
"α_s and the τ hadronic width"
Tau 08
Novosibirsk (Russia), September 2008

R. Escribano
"η/η'mixing from V→Pγ and J/ψ→VP decays"
Symposium on Meson Physics
Cracow (Poland), 1-4 October 2008
"η' gluonic content from J/ψ ->VP decays"
International Workshop on e^+e^- Collisions from Phi to Psi (PHIPSI08)
Frascati (Italy), 7-10 April 2008
"Update of η/η'mixing from J/ψ →VP decays"
Workshop on Scalar Mesons and Related Topics
Lisbon (Portugal), 11-16 February 2008

J. Matias
"*Extracting the Bs - anti-Bs mixing angle from B--> VV decays and comments on the puzzling B→ K* l^+l^- decay"*
Second Workshop on Theory, Phenomenology and Experiments in Heavy Flavour Physics
Capri (Italy), June 2008

A. Pineda
"*Breakdown of the OPE in the 't Hooft model*"
T®opical QCD 2008
Port Douglas (Australia), August 2008
"Non-Relativistic QCD"
Benasque school
Benasque (Spain), July 2008

A. Pomarol
"*The composite Higgs Alternative"*
Aspen Winter Conference On Particle Physics
Aspen (USA), January 2008
"Baryon physics from five-dimensional Skyrmions"
String Theory Methods in QCD and Hadron Physics
Seattle (USA), March 2008
"*Implications of stable Skyrmions from extra dimensions"*
13th Summer Institute at Gran Sasso National Laboratory LNGS
Assergi (Italy), September 2008

3.5 Participation in External Committes

Martine Bosman:

- ATLAS Speakers committee.

Elected by ATLAS Collaboration Board.
From July 2005 to June 2008.
Member :July 2005 to June 2007 .
Chair :July 2007-June 2008

- European Committee for Future Accelerators (ECFA) .

Member of Plenary ECFA, since February 2006

- ATLAS Collaboration Board Chair's advisory committee.

Member since October 2007

- ATLAS Top quark Physics Working Group: co-convener ,since September 2007

Matteo Cavalli-Sforza:

- CERN Scientific Policy Committee.

Member. Appointed by Director General of CERN.
September 2002 – December 2008

- Member of Conseil scientifique du LPNHE - Laboratoire de Physique Nucléaire et de Hautes Energies, CNRS et Universités de Paris 6 et Paris 7.. Appointed by Director of LPNHE, 2005 -2008
- Chairman of Scientific Committee of the Laboratori Nazionali di Frascati of INFN Appointed by President of INFN, 2006-2009

Juan Cortina:

- Representative of IFAE in Collaboration Board of MAGIC experiment.
- Operations and Safety Coordinator of he MAGIC experiment, and as such member of the MAGIC Executive Board.
- Chairman of the Safety and Health Committee of the MAGIC experiment.
- Convener of Galactic Physics Working Group of MAGIC experiment, as such member of the Physics Board and the Time Allocation Committee
- Member of the steering committee of the Spanish Astroparticle Physics network RENATA.

Enrique Fernández:

- CERN Scientific Policy Committee.

Chair appointed by Council of CERN.
Since January 2008 (member of the committee since January of 2005)

- Peer Review Committee of ApPEC (Astroparticle Physics European Coordinating Committee).

Member nominated by ApPEC Steering Committee.
Since January 2001

- Member of CVI (Comitato de Valutazione Interna) of the INFN.
Appointed by Director of INFN (Italy). 2006

Ilya Korolkov:

- Tile Calorimeter Institute Board Member. since August 2004
- Tile Electronics Commissioning coordinator, November 2006 to March 2008
- Tilecal calibration coordinator since November 2008

Manel Martínez:

- Chairman of the Collaboration Board of the MAGIC experiment, and as such member of the MAGIC Executive Board and Collaboration Board
- Member of the Scientific International Committee (CCI) of the Canarian Observatories
- Member of the Finance Sub-Committee (FSC) of the Canarian Observatories
- Astroparticle Physics Coordinator in the Executive Committee of the National Center for Particle, Astroparticle and Nuclear Physics (CPAN) Consolider Project
- Member of the Astroparticle Physics European Coordination (ApPEC) Peer Review Committee
- Member of the Astroparticle Physics European Strategy Roadmap Committee 2008
- Work Package Convener for Atmospheric Monitoring and Calibration of Cherenkov Telescope Array (CTA) project, and as such member of the CTA Executive Committee
- Member of the CTA Speakers Bureau
- Spanish Coordinator for the Dark Energy Survey Camera (DECAM) Project

Mario Martinez:

- Member of LHCC Committee at CERN since January 2005

Daniel Mazin:

- Convener of EBL - Cosmology working group in the Physics Working Package of CTA (Cherenkov Telescope Array)

Ramon Miquel:

- Member of the Management Committee of DES since 2007
- Member of the Steering Committee of the Dark UNiverse Explorer (DUNE)
Since 2007

Abelardo Moralejo:

- Software Coordinator of the MAGIC experiment, and as such member of the MAGIC Executive Board and Collaboration Board

Cristobal Padilla:

- Coordinator of the ATLAS Trigger Operations Group

Javier Rico:

- Convener of Galactic Physics Working Group of MAGIC experiment, as such member of the Physics Board and the Time Allocation Committee

Imma Riu:

- Co-convener of the ATLAS TDAQ Online Integration since May 2006
- TDAQ Institute Board Member: since 2007

Federico Sánchez:

- T2K Near detector Convener. Since 2004
- T2K Near detector reconstruction Convener. Since 2006
- T2K Near detector charged current muon neutrino Physics Convener. Since 2008

Andreu Pacheco:

- ATLAS Software Project Management Board (SPMB) .Member since 2007
- Management Board of the Spanish
Tier-2 Member since 2005

3.6 Seminars organized by IFAE

Date: 11/01/08
Title: Status of the LHCb experiment
Speaker: Tatsuya Nakada (CERN and EPFL)

Date: 14/01/08
Title: HESS Dark sources
Speaker: Emma De Oña (APC, Paris)

Date: 17/01/08
Title: Latest results on AGNs with HESS
Speaker: Martin Rane (MPK, Heidelberg)

Date: 18/01/08
Title: Implications of a cosmological first-order phase transition.
Speaker: Thomas Konstandin (IFAE)

Date: 1/02/08
Title: Light (or massless) B-L gauge boson, light scalar and neutrino physics
Speaker: Ann Nelson (University of Washington)

Date: 01/02/08
Title: The future of the Pierre Auger Observatory: northern site and upgrades
Speaker: Oscar Blanch (APC, Paris)

Date: 04/02/08
Title: A new accelerator for advanced research anc cancer therapy.
Speaker: Ken Peach (Director of John Adams Inst. For Accelerator Science, Univ. Oxford)

Date: 5/02/08
Title: Quantum Kolmogorov Complexity
Speaker: Barbara Kraus (Universität Innsbruck)

Date: 8/02/09
Title: BSM aspects of Flavour Physics
Speaker: Gustavo Branco (CFTP, Instituto Tecnico Superior)

Date: 29/02/08
Title: Can we disentangle among different models for nu-mass in the near future?
Speaker: Carla Biggio (Max-Planck-Institute fur Physics)

Date: 10/03/08
Title: Ice Top-Pet Cosmic Rays at the South Pole
Speaker: Stefan Klepser (DESY, Zeuthen)

Date: 11/03/08
Title: Some aspects of Yukawa couplings & CP violation
Speaker: Joaquim Silva-Marcos (Departamento de Fisica and CFTP, IST, Lisboa)

Date: 14/03/08
Title: Composition of the pseudoscalar eta and eta' mesons
Speaker: Christopher Thomas (Oxford University)

Date: 28/03/08
Title: Phenomenology of correlators with tensor sources
Speaker: Oscar Cata (LBNL, Berkeley)

Date: 25/04/08
Title: LEET effects in B-physics
Speaker: Micaela Oertel (Orsay)

Date: 15/05/08
Title: A theory of scalar mesons and X,Y particles
Speaker: Antonello Polosa (INFN Roma)

Date: 15/05/08
Title: Strong interactions and pairing in imbalanced Fermi gases: what can we learn from RF spectroscopy?
Speaker: Pietro Massignan (Utrecht Institute for Theoretical Physics)

Date: 16/05/08
Title: Quantum Gravity at the LHC
Speaker: Daniel Litim (Sussex University)

Date: 30/05/08
Title: The Standard Model Prediction for $\Gamma(\pi/K \rightarrow e \nu[\gamma]) / \Gamma(\pi/K \rightarrow \mu\nu [\gamma])$
Speaker: Ignasi Rosell (C.E.U. Valencia)

Date: 6/06/08
Title: Aspects of Gauge String Duality
Speaker: Carlos Nuñez

Date: 06/06/08
Title: Non-standard analysis techniques for IACT's
Speaker: Mathieu de Naurois (LPNHE, Paris)

Date: 13/06/08
Title: The US and the origins of CERN
Speaker: John Krige (Kranzberg Prof., Georgia Inst. of Technology)

Date: 18/06/08
Title: Using multidimensional complex analysis to evaluate Feynman diagrams
Speaker: D. Greynat (Univ. de Valencia)

Date: 19/06/08
Title: Neutron oscillations -- a window to parallel worlds?
Speaker: Zurab Berezhiani (Univ. L'Aquila & LNGS)

Date: 20/06/08
Title: Weak-coupling expansions in hot QCD
Speaker: York Schroeder (Bielefeld)

Date: 27/06/08
Title: Probing non standard Higgs sector with rare b -> s decays
Speaker: Ashutosh Kumar Alok (Tata Institute, Mumbai, India)

Date: 17/07/08
Title: Pulsars in gamma-rays and MAGIC
Speaker: Marcos López (INFN, Sezione di Padova)

Date: 25/07/08
Title: α_s and the τ hadronic width
Speaker: Matthias Jamin (IFAE&ICREA)

Date: 25/07/08
Title: The nucleon distribution amplitude - QCD sum rules meet latice
Speaker: Alexander Lenz (Regensburg University)

Date: 25/07/08
Title: Large-N Reduction in SU(N) Lattice Gauge Theories
Speaker: Steve Sharpe (Univ. of Washington, Seattle)

Date: 25/09/08
Title: Liquido de Quarks y Gluones
Speaker: C. Pajares (Univ. Santiago de Compostela)

Date: 26/09/08
Title: Dynamics of the entanglement between two oscillators
Speaker: Augusto Roncaglia (FCEyN U. Buenos Aires)

Date: 8/10/08
Title: New Physics search in Flavour: a Status Report
Speaker: Tobias Hurth

Date: 24/10/08
Title: Highlights of ICHEP 2008 in Philadelphia
Speaker: Matteo Cavalli-Sforza (IFAE)

Date: 31/10/08
Title: On the Role of “Intrinsic Charm” in Semi-Leptonic B meson Decays
Speaker: Sascha Turczyk (Siegen University)

Date: 14/11/08
Title: General Bosonic Perturbations in 6D Brane Worlds
Speaker: Alberto Salvio (IFAE)

Date: 21/11/08
Title: Supersymmetric type-II seesaw mechanism: CERN LHC and lepton flavor violating phenomenology
Speaker: Satoru Kaneko (CFTP, Instituto Superior Tecnico, Lisbon)

Date: 27/11/08
Title: Big Bang Nucleosynthesis as a way to constrain exotic physics
Speaker: Gianpiero Mangano (Università di Napoli and INFN, Napoli)

Date: 28/11/08
Title: Supergravity in the sky
Speaker: Laura Covi (DESY, Hamburg)

Date: 11/12/08
Title: Black Hole(-graphic) evaporation
Speaker: Oriol Pujolas (Theory Division, CERN)

Date: 12/12/08
Title: Seeing Dark Matter in the cosmic rays?
Speaker: Marco Cirelli (Institut de Physique Theorique, CNRS, Saclay)

Date: 15/12/08 (COLLOQUIUM)
Title: Antimatter and dark matter research: The Pamela space experiment
Speaker: Piergiorgio Picozza (INFN, Roma)

4. Brief Summary of Scientific Activities

4.1 Activities of the Experimental Division in 2008.

ATLAS at the CERN LHC

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. In the last few months of 2008 the Large Hadron Collider (LHC) saw the first beams, and ATLAS was shown to be fully operational. As is well known, an accident to the collider forced to suspend operations. The most recent contributions of our group are described here.

TileCal Hadron Calorimeter Activities

The TileCal activity of the IFAE group in 2008 focused on the Data Quality assessment, Detector Operation and Calibration. IFAE has contributed most significantly to the development of the DQ and the DAQ infrastructures of the Tile calorimeter. Many aspects of the detector have been monitored, from individual cells to cosmic muon tracks inside the TileCal. The analysis of Muon data allowed initial timing of the different parts of the calorimeter. On the other hand, the minimum bias monitoring system, main responsibility of the IFAE group in TileCal operations, was ready for the first beam. In addition, within a few days, the timing for all 10000 channels of the Tile calorimeter was adjusted with 0.3nsec precision and the gain calibration was checked with a precision of 4%. The minimum bias system is integrated both into the ATLAS luminosity monitoring framework and the Tile monitoring. During 2008, detailed studies on the performance of TileCal came to a conclusion. Test beam data were re-analyzed *ab initio* to properly understand a number of inconsistencies (at the few percents level) from previous studies. The precise determination of the pion response of the calorimeter has been fully reassessed and the results have been submitted for publication. This is in addition to the JINST paper on the ATLAS detector as-built.

HLT and Event Filter Activities

The IFAE group holds responsibilities in several aspects of the ATLAS Trigger system: development of the infrastructure of the software based third-level trigger (HLT), online integration of the trigger selection software, development and studies of the tau and jet/MET trigger performance, online operation of the Trigger. During 2008, the HLT farm was upgraded from 130 to 1000 nodes, and used in intensive technical runs and cosmic rays campaigns. Selection algorithms, developed offline, have been integrated and validated in the online environment. Several improvements of the Tau trigger selection have been achieved and aspects of the Jet trigger performance with the first beam data have been studied.

Central Data Quality (DQ) Activities

Since fall 2007, the IFAE group has a strong involvement in central DQ operations. The model that IFAE developed for CDF is used as input for the ATLAS design. IFAE coordinated DQ activities during 2008 cosmic data taking and organized a DQ workshop to define the ATLAS model for DQ operations and the definition of “good data” valid for physics analysis.

Preparation for Physics Analyses

The LHC will provide an excellent opportunity to search for physics beyond the Standard Model (SM) like, for example, super-symmetry (SUSY). Discovery of SUSY particles requires a good control of the SM processes. In most cases the background processes will have to be determined and/or validated using data. The physics processes, involving vector bosons accompanied by jets and the production of top quark pairs, constitute the main backgrounds to the SUSY search and in some cases are irreducible contributions. During 2008 the IFAE group in ATLAS has carried out two SM like proto-analyses, which will result in two PhD theses. The first analysis, focused on the measurement of the Z+jets cross section for events where the Z boson decays either into electrons or muons. The Monte Carlo measurements have been compared to NLO pQCD predictions. The main purpose of the second analysis was to explore top quarks pair production with subsequent decay in the channel t-tbar→W(qq')W($\tau_{had}\nu$)b-bbar, measuring its cross section and evaluating its importance as background for SUSY searches. During 2008 the top analysis has been also extended to the electron and muon channels, preparing for the early "rediscovery" of the top quark at LHC. In ATLAS, most the physics involves jets of hadrons in the final state. Therefore, a proper understanding of jet reconstruction and jet energy calibration is mandatory. This involves the study of physics and detector effects. The production of Z bosons and prompt photons in association with jets can be used to establish with good precision the absolute jet energy scale for jets in ATLAS, since in first approximation the transverse momentum of the jets is balanced by the bosons. This possibility has been explored. This study and the ones described above all form part of the recently published ATLAS comprehensive report "Expected Performance of the ATLAS Experiment, Detector, Trigger and Physics".

Preparations for ATLAS Computing

The computing infrastructure needed for the analysis of the data from the LHC experiments has been funded by the Spanish Programa Nacional de Física de Partículas since the beginning of this decade. It is embedded in the overall LHC computing model, in which the CERN computing facilities, referred to as Tier-0, distributes the data to over a dozen computer centers (called Tier-1 or T1) all over the world. The data will be analyzed by physicists over around 50 computer centers (also called Tier-2 or T2).

IFAE participates in the Spanish Tier-1 facility through the Port d'Informació Científica (PIC). It also contributes to a Tier-2 center, an analysis facility in collaboration with the groups from IFIC in Valencia and UAM in Madrid. The Tier-2 is a distributed facility working in the grid infrastructure as an autonomous system. The local T2 centers do not depend on each other; each contribution adds up to a joint facility for all Spanish physicists working on the ATLAS experiment. The IFAE T2 center is hosted close to the T1. During 2008 the availability and reliability of the Tier-2 facility at IFAE has exceeded 90%, thereby reaching the planned performance targets.
IFAE members are also contributing to the ATLAS central computing services in the areas of operation, physics and software validation as well as the organization, management, and documentation of ATLAS Offline Software Releases. The work in all these areas has been recently reported in the Computing in High Energy Conference in Prague (March 2009) with 3 contributions:

- Readiness of ATLAS Federated TIER-2 for the Physics Analysis of the early collision events at the LHC.
- Physics and Software Validation for ATLAS.
- Organization, Management, and Documentation of ATLAS Offline Software Releases.

The Collider Detector at the Tevatron (CDF)

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 has been upgraded: the center-of-mass energy has been increased (from 1.8 to 1.96 TeV) and its instantaneous luminosity has already achieved the Run II design value of $3.5\cdot10^{32}/cm^2\cdot s$. The Tevatron has already delivered a total integrated luminosity above 6 fb^{-1}.

In 2008, 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 and in particular supersymmetry. In addition, new measurements on prompt photon production have been carried out.

Final results on the search for squarks and gluinos in supersymmetry have been obtained based on 2 fb-1 of Run II data. The analysis was optimized in different regions in the gluino/squark mass plane. After selection cuts, no evidence of new physics is observed yet. The results extend the Run I exclusion limits on squark and gluino masses significantly. The results have been published in Physical Review Letters, and constituted the Master Thesis of G. De Lorenzo (April 2008).

In 2008, the group has also completed a study on Z+jets production. Precise measurements of this process constitute a fundamental test of perturbative QCD (pQCD) and provide a clean sample to validate Monte Carlo predictions for background estimations in searches for new physics. Measured cross sections, based on $1.7fb^{-1}$ of data, have been compared to pQCD NLO predictions. The results have been published in Physical Review Letters, and constitute the PhD Thesis of O. Saltó (June 2008).

During 2007 and 2008 members of IFAE have carried out a new measurement of the prompt photon cross section. The measurement of isolated high transverse momentum photons in the final state is sensitive to the presence of new physics like, for example, Gauge Mediated SUSY breaking, as well as providing information on the gluon distribution in the proton via the dominant production process with a gluon in the initial state. The measurements have been compared with NLO pQCD predictions and no signal of new physics has been observed. The results are about to be submitted to Physical Review Letters for publication, and will constitute the PhD Thesis of C. Deluca, to be defended in 2009.

Neutrino experiments at IFAE

The IFAE neutrino group is involved in two aspects of neutrino physics. On one side, the group is contributing to the new neutrino oscillation experiment, T2K, in Japan. The experiment is in the construction phase and is expected to start operation at the end of 2009. The contributions of the IFAE group to the T2K experiment focus on the near detector, specifically in the construction of the Time Projection Chamber (TPC) and the refurbishing of the old magnet that was donated by CERN to the European members in T2K.

The activities in the TPC project include the production and testing of the readout detectors, MicroMegas, done in collaboration with the University of Geneva, INFN Bari, IFIC, Saclay in Paris and CERN. IFAE members also provide the test bench for the front-end electronic modules produced in Saclay and the development of the data acquisition code for the test beams carried out at TRIUMF (Canada) during the last quarter of 2008.

Other activities include the development of the TPC reconstruction software and the coordination of the reconstruction group of the T2K near detector. One of us is also coordinating the physics analysis group for the neutrino charged current interactions. As a part of this effort, one group member is performing an analysis of the charged current quasi-elastic interactions in SciBoone. This experiment (in Fermilab) has a neutrino spectrum similar to that of T2K and it is built by a subgroup of T2K members to prepare for the physics studies of that experiment.

The contribution to the magnet refurbishing covers two areas. The first consists of the manifolds distributing the cooling water to the magnet coils that have been designed and built at IFAE. The group is also in charge of the slow control of the magnet that was implemented using industrial hardware. The slow control system monitors the running conditions of the magnet: temperature, cooling water temperature, coils voltage drop, etc In addition, it must detect anomalies, switch off magnet power and generate alarms.

The other aspect of the group's research activity is the search for the elusive neutrino-less double beta decay. IFAE has contributed to the understanding of the SuperNemo physics potential and has been one of the leading proponents of the new experiment NEXT. This ambitious experiment consists in a large pressurized TPC filled with Xenon enriched with an isotope that is a double beta emitter. The project was presented last year to the Laboratorio Subterráneo de Canfranc and the Expression of Interest was approved. The Spanish groups, including IFAE, applied to the Consolider Ingenio 2010 program and got a grant of 6 million euros for the construction of a 100 kg detector to be placed in Canfranc. The activities of IFAE in NEXT during 2008 included building a prototype that holds up to half a kilogram of Xenon for laboratory R&D.

Finally, in early 2008 the group was involved in the web-based “Recerca en Acció”, a program supported by AGAUR and the Direcció General de Reçerca of Generalitat de Catalunya. The purpose of this program is to inform the general public of the research done at Catalan scientific institutions. The program consists in following the activities of the research group on a weekly basis. This has been shown to be an effective way to get the public involved in the basic science.

The MAGIC Telescopes

MAGIC is the acronym of Major Atmospheric Gamma-ray Imaging Telescope. The telescope is located at the Roque de los Muchachos Observatory in the Island of La Palma of the Canary Islands (28.8ºN, 17.9ºW, 2200 m altitude). The goal of the experiment is the study of the very high energy gamma radiation arriving at the Earth from a relatively small number of sources. This study provides information about the mechanisms that produce such radiation, the most violent known in the cosmos. Furthermore the propagation of the radiation over cosmological distances is sensitive to the geometry and matter contents of the cosmos itself. MAGIC detects the light induced by the interactions of the incoming gamma rays with the upper atmosphere. This light is reflected onto a segmented mirror of 17m diameter and collected in the camera, located at the mirror’s focal point. The camera is equipped with very fast and sensitive photodetectors.

The IFAE group built the camera of the telescope and its control system, as well as the building housing the electronics and data taking equipment. The telescope started regular operation in 2004 and entered its fourth cycle of observations in 2008. Over the year 12 journal articles were published, two of them in Science magazine. IFAE has initiated or taken a leading role in several of them. A PhD thesis was completed during this year.

What follows is a summary of the publications in which IFAE has taken a leading role:

- Detection of the first and furthest (redshift z=0.5) quasar in the very high energy band, which has strong implications for the transparency of the Universe to gamma-rays and the density of the metagalactic radiation field. It was publish in Science.
- Possible implications on the scale of Quantum Gravity effects of the observation of time delays in the flare of an Active Galactic Nucleus.
- Multi-wavelength observations of the gamma-ray binary system LSI+61 303 and implications on the physical nature of the system.
- Observations of the TeV gamma-ray source J2032+4130, a very high energy source whose nature remains a mystery ten years after its discovery

In 2005 the MAGIC collaboration had begun construction of a second telescope, MAGIC-II, which is a technically improved clone of the original MAGIC-I. MAGIC-II is located 100 m away from MAGIC-I and will observe in coincidence. This “stereo” operation will allow improving the spectral and angular resolutions observations, to increase their sensitivity by a factor 2 and to reduce the energy threshold.

MAGIC-II is equipped with more sensitive photosensors and faster sampling digitization (2-4 GHz). IFAE is responsible for the optical reception of the camera’s analog signals, co-responsible for the readout and data acquisition, and responsible for the central control of the two-telescope system. In addition, the IFAE group organizes the set up and installation of the data center for the two telescopes. All of these sub-systems were produced, quality-controlled and installed on site during 2008, and entered a one year long commissioning phase in October 2008.

CTA: Why and How?

The “Cherenkov Telescope Array” (CTA), will be an advanced facility for ground based very- high-energy gamma ray astronomy, based on the observation of Cerenkov radiation. It builds on the knowledge of the Imaging Atmospheric Cherenkov Telescope technique gained from the H.E.S.S. and MAGIC facilities. From the successes of H.E.S.S. it exploits the concept of telescope arrays and stereoscopic analysis, with a projected further improvement of the current sensitivity by one order of magnitude. From the success of MAGIC it exploits the use of large telescopes to attain the lowest possible threshold. Both approaches were proved to be extremely successful for gamma rays of energies above few tens of GeV and have opened a new window in astronomy: the observation of the universe at the highest energies, to study in detail the most extreme astrophysical phenomena and fundamental physics.

The main wishes of the European VHE gamma ray community, to be fulfilled by CTA are:

- A broad energy coverage spanning four decades, from some 10 GeV to beyond 100 TeV
- A sensitivity at least one order of magnitude higher than any existing installation: better than 1 milliCrab at the intermediate energies.
- Two jointly operated observatories, with all-sky monitoring capability: the southern observatory would mainly be devoted to galactic studies.

The observatories capable of reaching such goals will require arrays of several tens of Cherenkov Telescopes, probably of two or three different sizes: a few large telescopes in a compact configuration for the lowest threshold, few tens of mid-size telescopes for the high-sensitivity intermediate-energy region, several tens of small telescopes spread over a large area for the highest energies. Actually, the present results obtained from 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 O(10 000) m^2 total mirror area. The total cost estimate is of the order of 150 million Euros.

CTA may discover and study in detail the spatial structure, light curve and energy spectra of about one thousand sources and, given the fast variability of many VHE gamma ray sources, should be in operation while Fermi-GLAST is still active. Indeed, both these facilities nicely complement each other. Operational overlap with the Fermi satellite mission will provide seamless coverage of 20 octaves of the energy of the spectrum.

In 2008 the CTA project met two very important milestones:

- On one hand, in January 2008 the CTA consortium decided to meet the challenge of designing an installation fulfilling the above goals. It began a Design Study which held in Barcelona its kick-off meeting, co-organized by IFAE.
- On the other hand, by mid 2008 the project was recognized as one of the most important future European Scientific Infrastructures by its inclusion in the ESFRI Roadmap. This feat, together with its inclusion as a high priority project in the European Astroparticle Physics roadmap by ASPERA and in the European Astrophysics roadmap by ASTRONET, makes CTA the most important future project in our field. IFAE members have played a critical role in all this process.

During 2008 the Design Study proceeded, organized in twelve Work Packages. IFAE members participated actively in several of them and coordinated the one on Advanced Techniques for Atmospheric-monitoring and Calibration (ATAC).

The DES (Dark Energy Survey) Project

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 red shifts 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 over 1000 distant type-Ia SuperNovae (SNe).

The DES Collaboration is building a large CCD camera (DECam), giving images covering 3 sq. deg. of the sky. The camera will be mounted 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 5 years (2011-2015).

The three Spanish groups, funded by the Program of Astronomy and Astrophysics, which is part of the National Plan of I+D+I, will build 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 (CBB) at CIEMAT, and the Master Control Board (MCB) and the Transition Board (TB) at IFAE.

During 2008, IFAE finished the initial design of the first version of the TB, whose final version will be done at CIEMAT. IFAE then concentrated on the MCB, producing versions v1 and v1.1. After solving some synchronization issues, a first functional version of the MCB was delivered to FNAL in late 2008.

In April 2008 Lluís Galbany presented his diploma thesis ("tesina"), based on the measurements of CCD properties that were described in the 2007 report.

In preparation for the analysis of DES supernova data, some members of IFAE, IEEC and CIEMAT joined in 2007 the program of spectroscopic monitoring of the SNe found in the Sloan Digital Sky Survey-II project, in a red shift range between 0.1 and 0.4. The group was awarded four full nights of observations at the Italian "Telescopio Nazionale Galileo" (TNG) in La Palma (Canary Islands) in fall 2007, which resulted in spectra of about 25 objects, including an extremely peculiar supernova, SN2007qd.

During 2008 all the spectra were reduced, producing flux-calibrated spectra that were sent to the central SDSS-II/SNe spectrum repository for their use in the common SDSS-II/SNe analyses. Furthermore, work started on the analysis and understanding of the properties of SN2007qd. Work is continuing analyzing the three nights of SN2007qd spectra available, in collaboration with colleagues from the University of Notre Dame in the United States, with the goal of writing a paper in 2009.

The PAU (Physics of the Accelerating Universe) Project

This project emerged in the context of 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, generally large teams involving several groups. To propose such a project, physicists from IFAE involved on Cosmology teamed up with other groups in Spain and proposed a project named PAU (Physics of the Accelerating Universe).

The ultimate objective of PAU is to carry out a large astronomical survey optimized to provide a competitive measurement of Baryon Acoustic Oscillations, as a probe of dark energy. The Survey, named PAUS (PAU Survey), will photometrically image an 8,000 square degrees area, using a telescope/camera combination with an "etendue" of 20 m^2 deg^2, equivalent to a 2m diameter telescope and a camera with a 6 deg2 field of view. With this system the plan is to measure the position and redshift of about 14 million red, early-type galaxies with L>L* and absolute magnitude up to 22.5 in the red-shift interval $0.1<z<0.9$. The expected precision in z for this sample is 0.003(1+z). With this precision it would be possible to measure the scale of BAO not only across the sky (transverse) but also along the line of sight (radial). To obtain this precision the survey area will be imaged with about 40 filters in the range of 4000 to 8000 Angstroms.

Just by itself, such a survey will deliver precisions of order 5% in the dark-energy equation of state parameter w, if assumed constant, and can determine its time derivative when combined with future CMB measurements. In addition, PAU will yield high-quality red shift and low-resolution spectroscopy for hundreds of millions of other galaxies, including a very significant high-red shift population. The data set produced by this survey will have a unique legacy value, allowing a broad range of astrophysical studies.

The Project was submitted to the Consolider Program in 2007 and was approved, with a starting date in January of 2008. IFAE is the Coordinating Institution of the Project, in which six more Spanish institutions are involved, namely: CIEMAT (Madrid), IAA (CSIC, Granada), IEEC (Barcelona), IFIC (Valencia), IFT (Madrid) and PIC (Barcelona). One of the main deliverables of the project is the construction of the large field-of-view camera and its system of filters. The camera will be mounted on a new telescope, The planned site, in the Javalambre Mountains, has been characterized and has very good observation conditions. The goal is to start the survey in 2011 and carry it out over a period of four years.

Medical Imaging and Related R&D

A few years ago IFAE, in collaboration with three more outfits, Institut de Microelectrònica de Barcelona (CNM-IMB), UDIAT Centre Diagnostic, and EMSOR S.A. started the development of a 3D real-time breast biopsy machine (patent pending). After setting the specifications of the new device and completing the CAD drawings, the collaboration acquired a second-hand LoRad prone-biopsy machine and converted it to a state-of-art biopsy machine. The complete prototype was finished in 2008. It was presented at the 36th International Salon of Inventions 2008, held in Geneva, Switzerland and it was awarded the Silver Medal.

The current system is a research prototype that has a provisional CdTe sensor detector of 5cm x 5cm with spatial resolution of 100µm and a speed of 50 frames per second. With such a detector, the doctor can see the position of the needle inside the breast in real time as well as the exact position of the needle's tip with respect to the target tissue (potential cancerous tissue), with utmost clarity. Both patient and doctor will benefit from the 3D vision capability provided by this biopsy machine because it will very significantly reduce the time of the operation - and the trauma for the patient - from 30-40 minutes to around 10 minutes, and makes the intervention successful on the first attempt. The prototype 3D real-time breast biopsy machine has been designed to meet the wishes of the doctors at UDIAT centre diagnostic and hence we believe that many doctors performing a breast biopsy intervention will wish to have a machine like this.

On a related R&D project, IFAE and CNM are developing the bump-bonding process for pixel solid state detectors. The task of CNM is to develop the growth of the solder bumps on the pixel electrodes of the ASIC/detector, and IFAE to realize the Flip-Chip process. For this project IFAE uses the Suss Microtec FC150 bump-bonding machine, in collaboration with X-ray Imatek SL (see below). The FC150 was installed in the CNM class-100 clean room in early 2008 and soon thereafter the development of flip-chip/bonding process started. Since no active devices were used in this R&D yet, only passive tests are done for the time being. The bonding and the detaching processes were performed in sequence, with the result that practically all the pads (almost 100% yield) on the substrate were wetted by the PbSn solder bump which was on the chip. This shows that the bonding process was successful. The plan for 2009 is to continue the R&D with active devices such as the Medipix2 chip and pixel Si and CdTe detectors.

In 2008, a new line of research in medical imaging has started in IFAE with a focus on Nuclear medicine in general and Positron Emission Tomography (PET) in particular. A novel conceptual design for PET was produced and a patent application has been submitted. Further simulation studies carried out by a collaborating team from CIEMAT have found that such a PET device can achieve the same effective spatial resolution with 25 times less radiation exposure to the patient. IFAE in collaboration with CIEMAT and CNM-IMB have agreed on a long-term collaboration to develop prototypes in order to prove the concept.

X-Ray Imatek S.L. (XRI) is an IFAE spin-off that was created in 2006 to exploit the results of Dear-Mama, a past EU-FP5 funded project which was led by IFAE. It started its activities on the premises of IFAE with the support of the IFAE Governing Board and the UAB Technology Transfer office. The scope and the profile of X-Ray Imatek were highly evaluated by both CDTI and CIDEM. In 2007, X-ray Imatek was able to construct the mechanical part of the mammography sensor detector, which will provide a large size mammography image of 25cm x 30cm. XRI has now succeeded in finding a partner company to develop a dedicated mammography chassis for its mammography detector. More information can be found at www.xray-imatek.com .

4.2 Activities of the Theory Division in 2008

Standard Model

In the present LHC era Flavour Physics will play an important complementary role in the search for the fundamental theory that lies beyond the SM. The precision of our predictions in Flavour Physics depends crucially on deepening our understanding of QCD. Consequently, our lines of research in 2008 focused mainly on different aspects of QCD, from more LHC oriented research to more formal one, are:
i) duality violations in QCD;
ii) constructing new observables for LHCb based on the $B \to K^*(\to K\pi)l^+l^-$ decay channel;
iii) the weak mixing phase of the B_s system;
iv) α_s and the τ hadronic width;
v) K/π vector form-factors;
vi) the breakdown of the OPE in the t'Hooft model.

Beyond the Standard Model

The main goal of our research in Physics Beyond the Standard Model (BSM) is to explore extensions of the Standard Model proposed to supersede it at the TeV scale and therefore testable at the LHC.

We focus our efforts in particularly well motivated scenarios (Supersymmetry, extra dimensions) or in models that lead to unconventional collider signals (Unparticles, strongly coupled theories).
We also apply BSM techniques, like AdS/CFT to better understand QCD.

Astroparticles/Cosmology

The general goal of this research line is to study some of the theoretical issues in the physics of elementary particles and their interactions, particularly when when they take place in an astrophysical or cosmological medium.

In 2008, we have been working in baryogenesis. Specifically, we have studied baryogenesis in the electroweak transition in the minimal supersymmetric model, and also in some models of leptogenesis. Another topic we have been interested in the link between Higgs properties and physics in the early universe. Also, we should mention some work done on the gravitational properties of vacuum energies, relevant for the cosmological constant problem.

5. Scientific Activities in 2008

The Experimental Division

During 2008 the Experimental Division's activities focused on eight major 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 three major, long-term projects:

- ATLAS, a general-purpose experimental facility at the Large Hadron Collider of CERN, the European Center for Particle Physics, which will begin operation at the startup of the LHC and will have the first useful data by 2010.
- CDF,a proton-antiproton collider experiment currently taking data at the Fermi National Accelerator Lab (Illinois, USA);
- T2K, a neutrino long base-line experiment to take place in Japan, beginning 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 is being 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, to begin operations 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 Applied Physics front, a group continues the research initiated in 2002 with

- DearMama, a EU-funded project that developed a digital X-ray camera of high resolution and contrast with very small exposure of the patient to radiation. These studies are carried out in collaboration with an IFAE spin-off company, X-Ray Imatek.

The Theory Division

The activities of the Theory Division during 2008 fall into three broad lines: Standard Model, Beyond the Standard Model and Astroparticles/Cosmology.

Standard Model:

In the present LHC era Flavour Physics will play an important complementary role in the search for the fundamental theory that lies beyond the SM. The precision of our predictions in Flavour Physics depends crucially on deepening our understanding of QCD. Consequently, our lines of research in 2008 focused mainly on different aspects of QCD, from more LHC oriented research to more formal one.

Beyond the Standard Model:

The main goal of our research in Physics Beyond the Standard Model (BSM) is to explore extensions of the Standard Model proposed to supersede it at the TeV scale and therefore testable at the LHC. We focus our efforts on theoretically well motivated scenarios (Supersymmetry, extra dimensions) or in models that lead to unconventional collider signals (Unparticles, strongly coupled theories). We also apply BSM techniques, like AdS/CFT to better understand QCD.

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 2008, we have been working on baryogenesis. in the minimal supersymmetric model, on the link between Higgs properties and the early universe, and the gravitational properties of vacuum energies, relevant for the cosmological constant problem.

5.1 ATLAS at the CERN LHC

(Martine Bosman)

Since 1993, the IFAE group has given major contributions to the construction of the ATLAS apparatus, its trigger system, its physics reconstruction software, its software quality, its computing resources and preparatory physics studies.

TileCal Hadron Calorimeter Activities

The TileCal activity of the IFAE group in 2008 concentrated on the Data Quality assessment, Detector Operation and Calibration. IFAE has contributed most significantly to the development of the DQ assortment and the DAQ infrastructures of the Tile calorimeter building on the experience gained and on the software tools developed during the electronics refurbishment program carried out in 2007. Many aspects of the detector are now monitored, from individual cells to cosmic Muon tracks crossing the TileCal as shown in Figure 1.

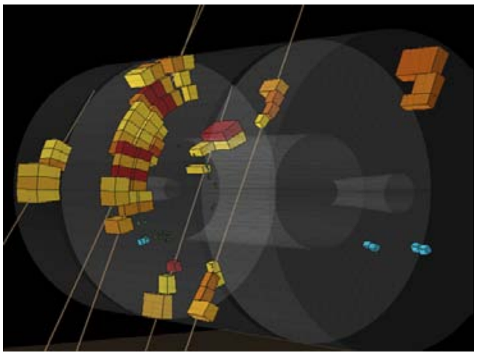


Figure 1 Cosmic Muons crossing the Tile Calorimeter.

The system is now capable of providing a sensible diagnosis of the quality of the data taken by the detector. In addition, the analysis of the cosmic Muon data allowed a first timing of the different parts of the calorimeter. This constituted the Master Thesis of IFAE student F. Vives, defended in spring 2008 (see Figure 2).

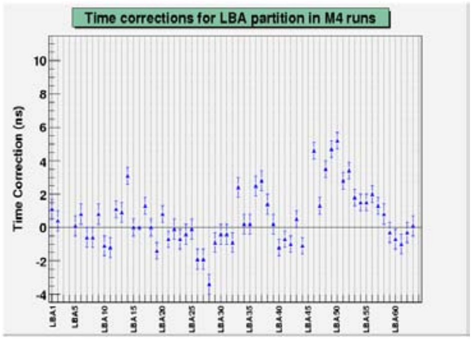


Figure 2. Adjustment of the timing of TileCal modules extracted from cosmic Muon data.

The first proton beam event was seen in ATLAS on September 10th, 2008 as shown in Figure.3.

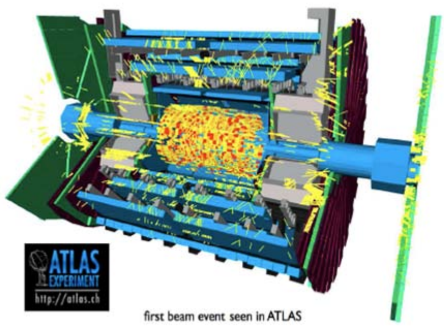


Figure 3. Beam event registered in ATLAS.

Figure 4. PostDoc L.Fiorini at the Tilecal desk (with other IFAE members behind) in the ATLAS counting room on Sept. 10.

The Tile calorimeter was in excellent shape on the days of the LHC beam, permitting to take immediate advantage of the data once available. Within a few days, IFAE group members were able to adjust the timing of all 10000 channels of the Tile calorimeter with 0.3nsec precision and check their gain calibration with a precision of 4%. On the other hand, the minimum bias monitoring system, main responsibility of IFAE group in Tile, was ready for the first beam. The system was fully calibrated in advance and its output was integrated in the minimum bias system both into the ATLAS luminosity monitoring framework and the Tile monitoring.

HLT and Event Filter Activities

The IFAE group holds responsibilities in several aspects of the ATLAS Trigger system: operation of the High Level Trigger (HLT) system comprising the software based 2nd and 3rd level trigger running in two large computer farms, development of the infrastructure software for the third-level trigger and online integration of the trigger selection algorithms. During 2008, the 3rd level trigger farm was upgraded from 130 to 1000 nodes, and used in intensive technical runs and cosmic rays campaigns. Selection algorithms, developed offline, have been integrated and validated in the online environment. IFAE was strongly involved in all these activities.

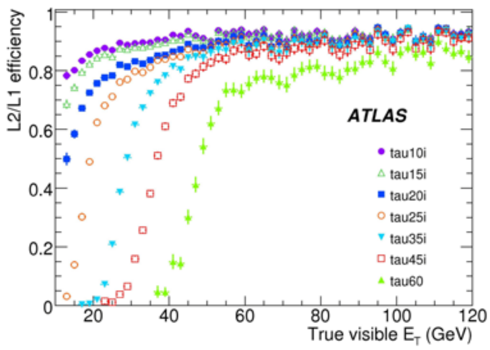


Figure 5. Efficiency of the 2nd level trigger for various settings of the parameters of the Tau lepton trigger (Master Th. E.Peréz July 2008).

In addition, IFAE is taking part in the development of Event Selection software, for the Tau lepton trigger and more recently also for the Jet trigger. During 2008, several improvements of the Tau trigger selection have been implemented (see Figure 5) and various aspects of the Jet trigger performance with the first beam data have been studied.

Central Data Quality (DQ) Activities

Since fall 2007, the IFAE group initiated an active involvement in central DQ operations. The model that IFAE developed for CDF is used as input for the ATLAS design. IFAE coordinated DQ activities during 2008 cosmic data taking and organized a DQ workshop to define the ATLAS model for DQ operations and the definition of "good data" valid for physics analysis.

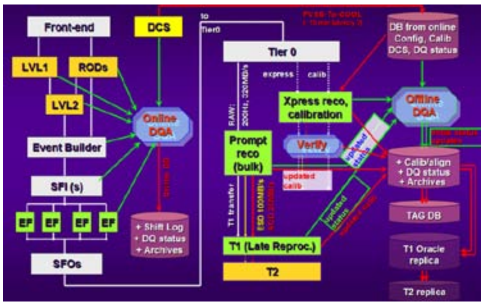


Figure 6. The Data Quality Monitoring model of ATLAS.

Software validation activities

IFAE members are also contributing to the ATLAS Software Infrastructure group in charge of the organization, documentation and management of the ATLAS Software. This software is mainly used to simulate the detector, to reconstruct and analyze the data. Specifically, the IFAE contribution is in the coordination of the offline software releases and the physics validation of the software.

A chart displaying the overall validation chain of ATASL simulation codes is in Figure y.

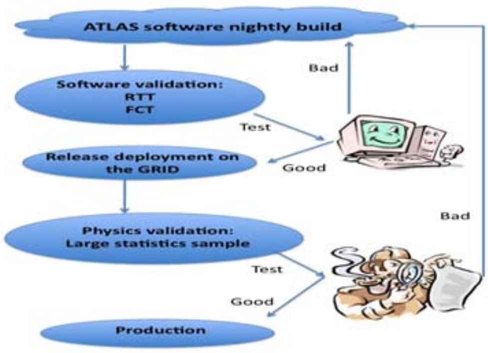


Figure x. Sketch of the ATLAS simulation validation chain.

The work in these areas has been reported recently in the Computing in High Energy Conference (March 2009) with two contributions: “Physics and Software Validation for Atlas” and “Organization, Management and Documentation of Atlas Offline Software Releases”.

Contribution to the Atlas distributed computing infrastructure

The computing infrastructure for the processing and analysis of the data from the LHC experiments has been funded by the “Spanish Programa Nacional de Física de Particulas” since 2002. The IFAE computing resources are integrated in the overall LHC computing model, in which the CERN computing facilities, referred to as Tier-0, distributes the data to over a dozen computer centers (called Tier-1) all over the world. The data will be analyzed by physicists over around 50 computer centers (also called Tier-2). The overall structure of the computing model of LHC experiments is shown in Figure y.

IFAE participates in the Spanish Tier-1 facility through the Port d’Informació Científica (PIC). It also contributes to the Spanish federated Tier-2 center; an analysis facility in collaboration with the groups from IFIC in Valencia and UAM in Madrid. The Tier-2 is a distributed facility working in the grid infrastructure as an autonomous system. The Spanish Tier-2 centers do not depend on each other; each contribution adds up to a joint facility for all Spanish physicists working in the Atlas experiment.

The IFAE part of the Spanish Tier-2 is located next to the Tier-1 at PIC in the Bellaterra Campus. Since 2008 the availability and reliability of the Tier-2 facility at IFAE has exceeded 90% thereby reaching the planned performance targets. The work in this area has recently been reported in the Computing in High Energy Conference (March 2009) with one contribution “Readiness of ATLAS Federated Tier-2 for the Physics Analysis of the early collisions at the LHC”.

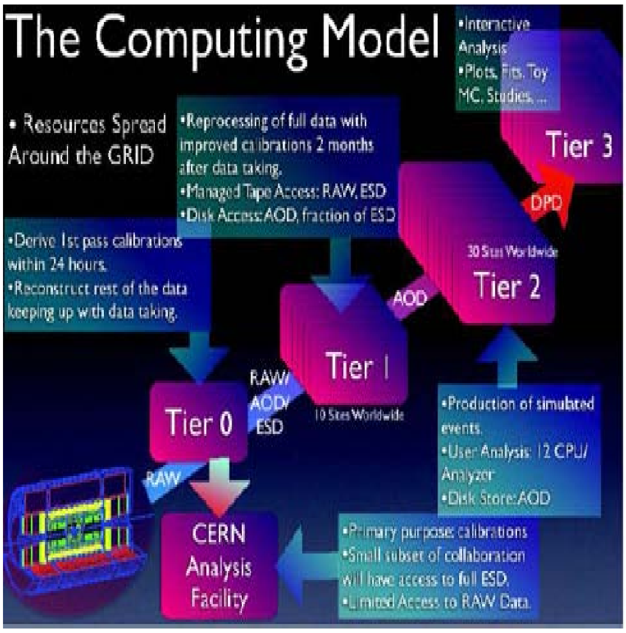


Figure y. Descriptive diagram of the computing model for the LHC experiments. IFAE contributes to the joint effort to operate the Spanish Tier1(PIC) and Tier2 facilies.

Preparation for Physics

The LHC will provide an excellent opportunity to search for physics beyond the Standard Model (SM) like, for example, supersymmetry (SUSY). At the LHC and depending on their mass, supersymmetric particles could be produced with large enough rate to be discovered. However, a good control of the SM processes will be mandatory before any claim of discovery can be made. There are at present many uncertainties in the properties and cross-sections of the standard processes at the LHC energies, and it is not expected that Monte Carlo (MC) predictions will achieve the required precision. In most of the cases the background processes will have to be determined and/or validated using data.

The physics processes involving vector bosons (Zs and Ws) accompanied by jets and the production of top quark pairs constitute the main backgrounds to SUSY searches and are, in some cases, irreducible contributions. During 2008 the IFAE group in ATLAS has carried out two SM analyses, on Z boson and top quark pair production. Each of them is the subject of a PHD thesis.

The production of a Z boson in association with jets, where the Z decays either through the electron or muon channel, has been studied (see Figure 7). Prospects for the measurement of the inclusive jet cross section in Z+n (n≥1,2,3,4) jets as a function of the transverse momentum of the leading or second leading jet have been obtained.

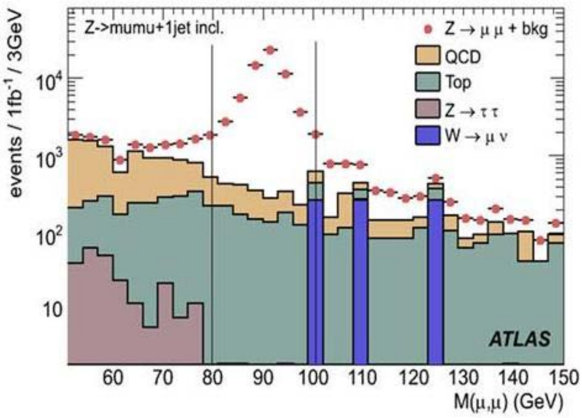


Figure 7. Reconstructed invariant mass of the Z boson decaying to a pair of muons. The main background contributions are shown.

Different Monte Carlo programs have been used and their results have been compared to next-to-leading order perturbative QCD predictions (see Figure 8). Data driven methods to determine the main contributing backgrounds have been assessed. Finally, several sources of systematic uncertainty have been evaluated, resulting in the jet energy scale uncertainty being the main limitation to the Z+jets cross section measurement.

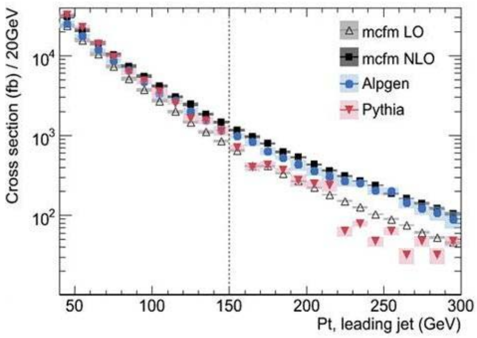


Figure 8. Prediction of the production cross section as a function of the transverse momentum of the leading jet for different Monte Carlo and theoretical predictions.

The main purpose of the top analysis was to explore top quark pair production with subsequent decay in the channel $W(qq')W(\tau_{had}\nu)b\bar{b}$, determining its cross section uncertainty and evaluating its importance as background for SUSY searches. The analysis carries out an exclusive reconstruction of the top decay in the final state. The main challenges are the presence of multiple neutrinos (from W and tau decays) in the final state and the high jet multiplicity, which combined with a large rate of jets misidentified as taus could lead to a large combinatorial background.

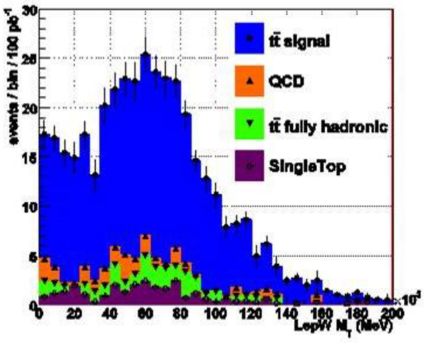


Figure 9. Transverse mass of the Tau lepton and Missing Transverse Momentum vector for an integrated luminosity of 100 pb^{-1}.

Thus special effort has been put in the tau identification algorithm and on the use of b-tagging. With the present selection, a signal-to-background ratio of about four is possible with an integrated luminosity of 100 pb^{-1}. With 1 fb^{-1} this ratio increases to eight.

During 2008 the top analysis has been extended to the electron and muon decays of the W, somewhat easier than the tau channel, in preparation for the "rediscovery" of the top quark at LHC with the first few pb^{-1} of data. The possibility of seeing the top signal without requirements on the missing transverse energy or b-tagging, which might not be well understood at the beginning of data taking, has been explored.

In ATLAS, most of the physics involves jets and hadrons in the final state. Therefore, a proper understanding of jet reconstruction and jet energy calibration is mandatory. This involves the study of physics and detector effects. The production of Z bosons and prompt photons in association with jets can be used to establish with good precision the absolute jet energy scale for jets in ATLAS since, in first approximation, the transverse momentum of the jets is balanced by that of the bosons. This possibility has been explored. This study as well as those described above is included in the recently published ATLAS comprehensive report "Expected Performance of the ATLAS Experiment, Detector, Trigger and Physics".

During 2008, detailed studies on calorimetry took place. Test beam data were reanalyzed ab *initio* to properly understand a number of inconsistencies (at the few percent level) from previous studies. The pion response, defined as the ratio of the reconstructed pion energy to the beam energy, was studied as a function of the energy, and the obtained results on the e/h parameter were found on agreement with previous measurements, once the data were corrected for longitudinal and transverse energy leakages. The pion data sets were also used to measure the fractional resolution as a function of energy. The values obtained were compared with GEANT4 simulations and the two were found to be in good agreement.

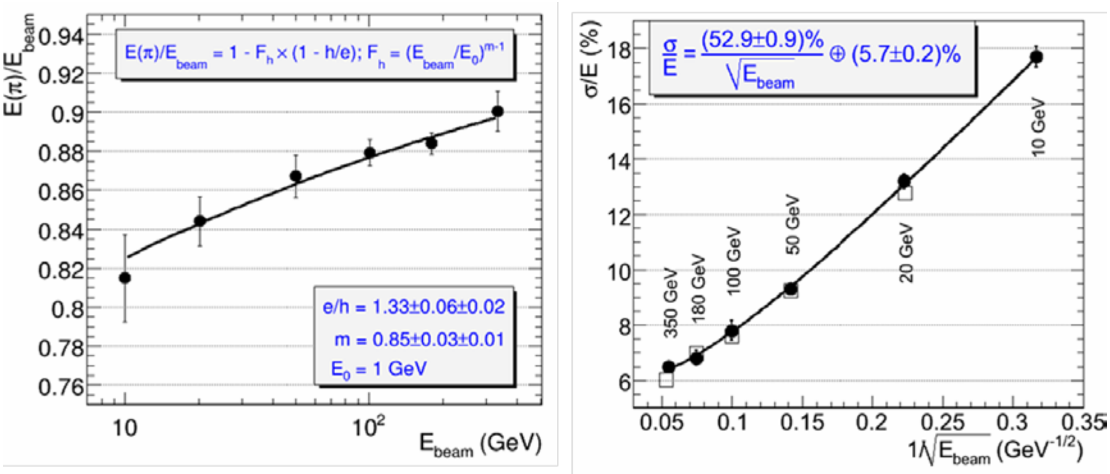
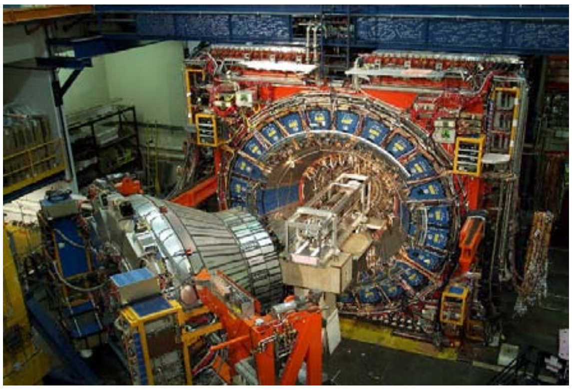


Figure 10. (Left) Pion response as a function of the energy of incident pions. (Right) Fractional energy resolution as a function of the incident energy. Experimental data (full circles) and GEANT4 simulations (open squares) are in reasonable good agreement. In both plots the lines show the fit with the parameters given

5.2 The Collider Detector at the Tevatron (CDF)

(Mario Martinez)

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 has been upgraded: the center-of-mass energy has been increased (from 1.8 to 1.96 TeV) and its instantaneous luminosity has already achieved the Run II design value of $3.5 \cdot 10^{32}/\mathrm{cm}^2\mathrm{s}$. The Tevatron has already delivered a total integrated luminosity above 6 fb^{-1} CDF after undergoing major upgrades. A new DAQ and trigger systems have been installed (where the latter includes an original setup which allows the detection online of secondary vertices), together with a new tracking chamber, new silicon tracker, a time-of-flight detector, new forward calorimeters and increased angular coverage for muon detection. The experiment has already collected about 5000 pb^{-1} (about fifty times more luminosity than that integrated in Run I) and it is expected to collect at least 8 fb^{-1} by the end of the Run II.



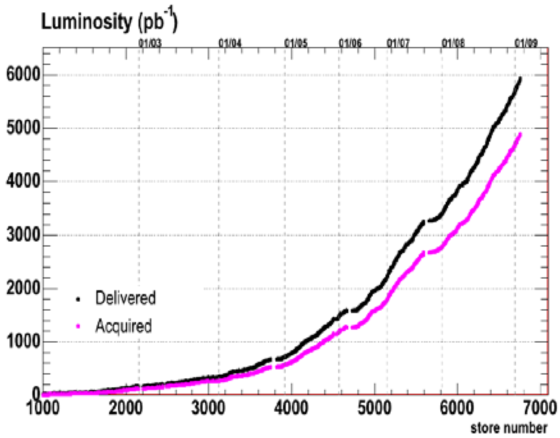


Figure: (left) Picture of CDF during the installation of the Silicon Detector into the tracking chamber. (right) Total delivered and on-tape luminosity (updated: January 2009).

DQM: data quality monitoring of the CDF data

The IFAE group in CDF has major responsibilities on quality monitoring (DQM) of the data used by CDF for physics analyses. The quality control is performed at two levels. Online, an automatic system alerts the CDF shift crew if faults are observed in the data. The online system is based on JAVA monitors that control the basic performance of the detector. The online diagnosis is available via Web and finally kept in ORACLE databases. Offline, after the data have been processed, a DQM system automatically checks the quality of the data using very high level physics objects (electrons, photons, muons, J/Psi, jets, etc) which, in addition to confirming the online diagnosis, detects possible errors introduced in the offline reconstruction codes or calibration constants. The final DQM decisions are employed to establish standard «good run» lists for the whole collaboration.

The DQM project requires a good knowledge of CDF, both of the hardware of the different detectors and of the offline reconstruction software. Moreover, the DQM activities involve a rather high level of initiative and coordination within CDF, which put IFAE members in a very visible position inside the collaboration. The DQM is considered in the CDF organization chart as one main «detector subsystem» and two IFAE members act as coordinators of the offline data validation activities.

Physics program of the IFAE group in CDF in 2008

In 2008, 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 and in particular super-symmetry. In addition, a new line of research on the study of inclusive prompt photon production was consolidated. These studies have led to 1 PhD Thesis and 1 Master Thesis in 2008.

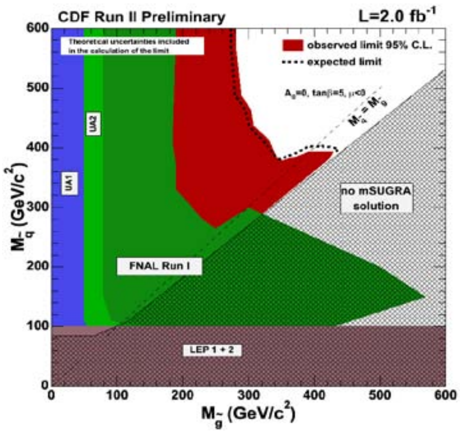
Search for Squarks and Gluinos

The search for new physics beyond the standard model and, in particular, supersymmetry, is one of the main goals of both the Tevatron and the LHC physics programs. At the Tevatron, the best sensitivity to the production of supersymmetric particles comes from the study of hadronic final states with multiple jets and large missing transverse energy. These topologies could correspond to the production of squarks and gluinos which decay producing cascades of gluons and quarks, which are detected as multiple jets in the final state. For those models where R-parity is conserved, the LSPs (Lightest Supersymmetric Particles) are considered stable and leave CDF undetected, producing a signal of large missing transverse energy.

This analysis requires in-depth knowledge of the jets and missing transverse energy distributions, since the selection cuts must reduce the background by several orders of magnitude. The state which is almost identical to that of supersymmetry. In order to avoid a posteriori biases in the measured distributions, the analysis is carried out using « blind » techniques, where a signal region is defined and removed from the study until all the elements of the analysis (selection criteria, background composition, systematic errors, etc..) are completely fixed.

Results have been obtained based on 2 fb^{-1} of Run II data. The analysis was optimized in different regions in the gluino/squark mass plane.

After selection cuts, no evidence of new physics is observed yet. The results significantly extend Run I exclusion limits on squark and gluino masses and have been presented in different international conferences. The results have been published in Physical Review Letters, and constituted the Master Thesis of G. De Lorenzo (April 2008).

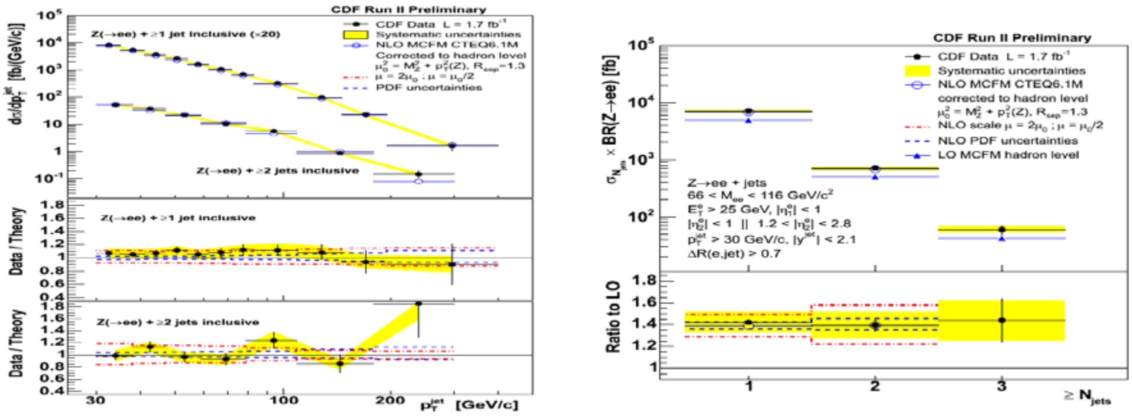


Squark/Gluino exclusion plane. The red band indicates the results from this analysis.

The inclusive analysis is being complemented by a search for super-symmetric partners of bottom and top quarks, particularly in light SUSY scenarios at large tanβ, and will require the identification of b-quark jets. More data and a complete scan of parameter space will either discovery SUSY or impose very stringent limits to the masses of squarks and gluinos.

Study of Z+jets Final States

Precise measurements on Z+jets production constitute a fundamental test of pQCD and provide a clean sample to validate Monte Carlo predictions for background estimations in searches for new physics. Preliminary studies, presented at several conferences, indicated that a good understanding of the hadronic final state in Z+jets production has been already achieved in the current Monte Carlo implementations.

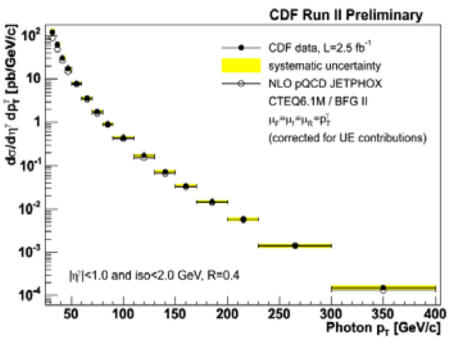


Measured Cross Sections compared to pQCD NLO predictions

Measured cross sections, based on 1.7fb^{-1} of data, have been compared to pQCD NLO predictions. The results have been published in Physical Review Letters, and constitute the PhD. Thesis of O. Saltó (June 2008).

Measurement of the prompt photon cross section in CDF

During 2008, members of IFAE in collaboration with the Fermilab Group have carried out a new measurement of the prompt photon cross section. The measurement of isolated high Pt photons in the final state is sensitive to the presence of new physics like, for example, Gauge Mediated SUSY breaking, as well as providing information on the gluon distribution in the proton via the dominant production process with a gluon in the initial state. The measurements have been compared with NLO pQCD predictions and no signals of new *physics have been observed. The results are about* to be submitted to Physical Review Letters for publication, and constitute the PhD Thesis of C. Deluca.



Measured Cross Section as a function of photon Pt.

Management positions in CDF and the transition towards the LHC

During the second part of 2008, the group in CDF started a coherent transition towards LHC physics. The IFAE/CDF group now constitutes a strongly coordinated team, with experience on hadron collider physics that should play an important role in ATLAS. M. D'Onofrio has been convener of the JES (Jet Energy/Resolution) Group and SUSY co-convener. V. Sorin acts as co-convener of the Top Properties Group in CDF. M. Martinez has been CDF QCD convener in CDF, has already been appointed in ATLAS as coordinator of DQ central operations, and acted as one of the referees for physics studies concerning background estimation for SUSY searches. S. Grinstein, former Silicon SubProject Leader, b-tagging convener in CDF and co-head of CDF online operations group, joined the group in ATLAS with a junior ICREA position. The experience and visibility of each of the members of the team lead us to expect a strong impact of the IFAE-CDF group when it moves on to ATLAS commissioning in 2009.

5.3 Neutrino Experiments at IFAE

(Federico Sánchez)

The announcement of the discovery of neutrino oscillations in atmospheric neutrinos, made by the Super-Kamiokande collaboration in 1998, revived interest in neutrino physics and in particular stimulated many new experiments which aim at elucidating the oscillation phenomenon. Super-Kamiokande also confirmed the "deficit" in the observation of solar neutrinos reported by many previous experiments. The final proof that this deficit is also due to neutrino oscillations was given by the SNO collaboration in 2002. These results imply that neutrinos have mass, albeit a very small one. The fact that neutrinos have very small mass compared to their partners (leptons) in the Standard Model is not understood theoretically.

The neutrino group at the IFAE was formed in 2002 with the aim of contributing to the measurement of the neutrino oscillation parameters at K2K and T2K. Since then, the group has also contributed to experiments of neutrino scattering with nuclei and neutrino-less double beta decays.

On one side, the group is contributing to the new neutrino oscillation experiment, T2K, in Japan. The experiment is expected to start operation at the end of 2009. The contributions of the IFAE group to the T2K experiment focus on the near detector, specifically on the construction of the time projection chamber and the refurbishing of the old magnet that was donated by CERN to the European members in T2K.

T2K is a so-called long base line experiment. A very intense muon neutrino beam is produced at a proton accelerator. The beam is measured near the production point (the near detector) to pin down its properties and then traverses 300 kilometers of soil until the Superkamiokande detector. The change in the neutrino nature over this distance due to interference phenomena opens the possibility to understand the properties of this particle. The accelerator (JPARC) is near Mito on the east coast of Japan while the far detector is located in a mine very close to Toyama on the west coast.

Figure 1 Picture of the first TPC module. IFAE has collaborated in the testing of the readout planes and the test beam carried out at the TRIUMF test beam facility.

IFAE joined the T2K experiment in 2002 together with its predecessor, the K2K experiment. IFAE has been contributing since then to the design and construction of the near detector for T2K while participating in running the K2K experiment.

Figure 2 Close up picture of a MicroMega installed in the first TPC. IFAE has purchased 20 of these modules and helped in its calibration.

The activities in the TPC project include production and testing of the detectors, MicroMegas, in collaboration with University of Geneva, INFN Bari, IFIC, the Saclay laboratories in Paris and CERN. Testing was performed by moving in a radioactive source and measuring the response of each detector pad. This provides very precise maps of gain and resolution to be used later on during physics runs.

IFAE provided one third of the total amount of MicroMegas needed for the TPC and is actively involved in the characterization of its performance in a testbench that the IFAE built at CERN, in collaboration with the University of Geneva. IFAE members also provide the test bench for the front-end electronic modules produced in Saclay. The group developed a board to test the production of the FEM electronic boards, the software and test protocol.

The group also provided the data acquisition code for the test beam runs at TRIUMF (Canada) during the last quarter of 2008, led the analysis of these data and coordinated these efforts worldwide. The TPC has shown an excellent performance during these tests, with tracking resolution and energy deposition better than the specifications. The acquisition code has been accepted as the default option for running in Japan.

Other activities include the development of the TPC reconstruction software and the coordination of the reconstruction group of the T2K near detector. The code was developed already in 2004 and has been improved and maintained over the last years. The reconstruction code includes the pattern recognition and the final track parameter fit based on a novel likelihood method that extracts the best resolution from the TPC. This method is the standard for the TPC reconstruction and has been used for more than a year in all performance studies of the near detector of T2K.

Some of us are also coordinating the physics analysis group for the neutrino charged current interactions, and performing an analysis of the

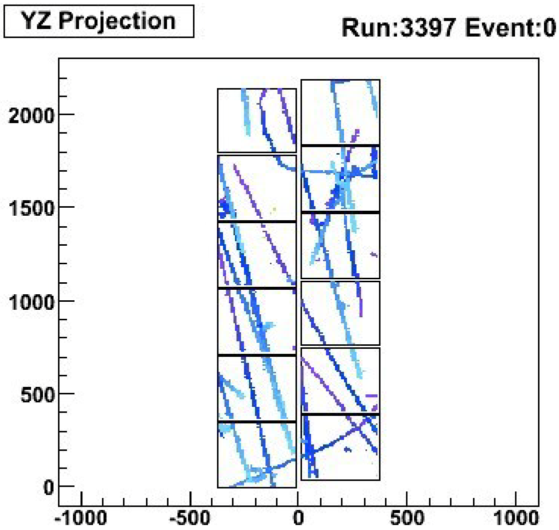


Figure 3 Cosmic ray shower seen by the first TPC module at the TRIUMF test beam.

charged current quasielastic interactions at SciBoone. This experiment has a neutrino spectrum similar to T2K and it is built by a subgroup of T2K members to anticipate the physics studies at the new experiment. The analysis topic is the measurement of the ν_μ Charged Current quasielastic (CCQE) interaction with Carbon. This reaction is critical for neutrino oscillation experiments at low energies (below 1GeV like T2K experiment) since it is the only one where one can reconstruct the energy of the neutrino allowing the experiments to measure the oscillation phenomena as a function of the neutrino energy. The CCQE cross section is modified by nuclear effects below 1 GeV and its actual value is very poorly known.

The contribution to the magnet refurbishing covers two areas. The manifolds distributing the cooling water to the magnet coils have been designed and constructed at IFAE. The system has been built to allow opening and closing the magnet without disconnecting the system, which would curtail the operation time.

Figure 4 Picture of the FEM test electronic board designed and produced at the IFAE.

IFAE is also in charge of the slow control of the magnet that was implemented based on industrial hardware from Siemens.

Figure 5 The magnet slow control system designed and built at the IFAE. The right rack holds the SIEMENS modules in charge of the monitoring.

The other major activity in the IFAE neutrino group is the search of the elusive neutrino-less double beta decay. IFAE has contributed to the understanding of the SuperNemo physics potential and has been one of the leading proponents of the new experiment NEXT.

The group collaborated with a group at IFIC-Valencia in coding the simulation and reconstruction software of SuperNemo, which would be the continuation of the NEMO experiment, currently taking data in the underground laboratory of the Frejus tunnel, near Modane, France. The experimental technique used by NEMO differs from conventional $\beta\beta0\nu$ experiments. Most of the current generation experiments are based on calorimetric detectors, where a double beta emitter crystal with very good calorimetric resolution such as Germanium (Ge) acts simultaneously as source and as detector. This technique profits from the excellent energy resolution of Ge, in order to observe a narrow peak in the end-point distribution of the $\beta\beta2\nu$ spectrum. The disadvantage is that the only signature to reduce background is the sum of the energies of the two electrons. A second disadvantage is that the experiment is limited to a single type of material. On the contrary, the technique developed by the NEMO experiment consists in separating the source (which is inserted, as a very fine foil, in the middle of the detector) from the detector itself, which is made of a tracking volume surrounded by a calorimeter. Thus, one measures the track and charge of the two electrons arising from the decay and their energy in the calorimeter. The advantage of the NEMO technique is that external backgrounds due to natural chains are very efficiently suppressed. In addition, one can use many different sources by changing the foil. The disadvantage of NEMO is that one cannot use crystals as calorimeters resulting in a very poor energy resolution of 10% to be compared with the 0.1% obtained with Germanium like detectors. During 2008, the IFAE group was adapting the SUPERNEMO tracking to the NEMO detector to validate the performance of the code and to be able to cross-check the tracking efficiency of the NEMO detector. This will be the topic of a thesis in 2010.

The NEXT experiment aims to overcome the disadvantages of the NEMO approach profiting from the idea of the tracking to reduce non double beta decay background. The experiment consists of a large pressurized TPC filled with enriched Xenon, an isotope that is a double beta emitter. The project was presented last year to the Laboratorio Subterráneo de Canfranc and was approved as an Expression of Interest. The Spanish groups, including the IFAE members, applied to the Consolider Ingenio 2010 program and got a grant of 6 million Euros for the construction of a 100 kg detector to be placed in Canfranc.

The conceptual design of the NEXT TPC follows the so-called SOFT approach (Separated Optimized Function TPC). The SOFT approach consists of reading the TPC using the electroluminescence (EL) technique and performing the tracking and energy measurements with two different technologies that optimize performance and cost. Electroluminescence is due to the emission of scintillation light when primary electrons, produced and drifted in the TPC, are accelerated before reaching the anode. This is a linear process allowing to almost reach the intrinsic energy resolution (limited by primary ionization fluctuations). This intrinsic resolution has been estimated from data to be about 0.4% at 2.5 MeV. The NEXT technology allows having excellent energy resolution, similar to solid state neutrino-less double beta decay experiments, but adding the advantages that the two emitted electrons are recognized as tracks and that the xenon gas can be constantly circulated and purified to reduce the contamination from natural radioactivity. The expected sensitivity as a function of exposure is shown in Figure 6 for different values of the energy resolution. The sensitivity reaches values below 150 meV for the effective neutrino mass ($m_{\beta\beta}$) for reasonable assumptions on exposure and resolution. This value is very competitive with the new generation of experiments.

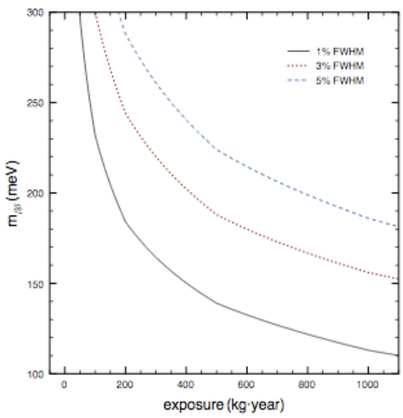


Figure 6 NEXT sensitivity to the effective neutrino mass ($m_{\beta\beta}$) *as a function of the exposure for three assumptions on the energy resolution.*

The activities of IFAE in NEXT included the building of a prototype able to hold up to half a kilogram of Xenon for laboratory R&D at 10 bar. IFAE members designed the pressure vessel and the field-forming structure that keeps a uniform electric field. The total volume of the TPC has been chosen such that an electron of 500 keV will be fully contained at the maximum pressure.

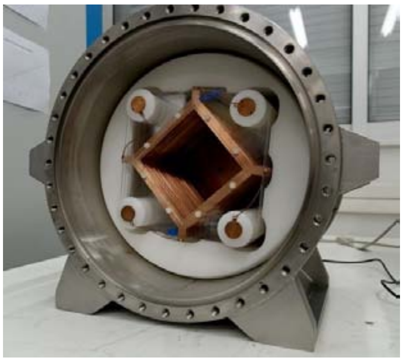


Figure 7 Picture of the NEXT TPC prototype built at IFAE. The external vessel is able to maintain 10 bars and the inner structure ensures the uniformity of the electric field.

The TPC has been tested with an Argon Isobutane mixture and GEM readout. The TPC will be equipped during 2009 with an electroluminescence (EL) readout plane using avalanche photodiodes (APD). This is a technology that has been very successfully used previously to read Xenon EL chambers. The IFAE group is testing the performance of the Hamamatsu APD 10937-8353 with light of 172nm produced during the EL process. This is a special production in which the dependency entry window was removed to allow the UV photons to reach the active area of the APD.

IFAE has also performed the first full simulations of properties of the NEXT gas. The dependence of the drift velocity and transverse diffusion on the applied field is a critical design parameter. Another activity, conducted with the University of Coimbra, has been the measurement of the electroluminescence light produced at 10bar with pure Xenon. The results, showing a good stability from 1 bar to 10 bar will be published in 2009.

Finally, in early 2008 the group was involved in the web-based “Recerca en Acció” program supported by the AGAUR and the Direcció General de Recerca of Generalitat de Catalunya. The purpose of this program is to show to the public the research done at Catalan scientific institutions. The program consists in following on a weekly basis the activities of the research group, while the basic science is illustrated to the general public. The contribution can be seen at http://www.recercaenaccio.cat/agaur_reac/AppJava/ca/projecte/071120-neutrins-.jsp?page=1.

5.4 The MAGIC Telescopes

(Juan Cortina)

MAGIC is the acronym of "Major Atmospheric Gamma-ray Imaging Cherenkov telescope" and consists of two twin telescopes located at the Roque de los Muchachos Observatory in the Canarias island of La Palma (28.8 N, 17.9 W, 2200 m altitude, Figure 3). The goal of the experiment is the study of gamma-rays at very high energies (VHE), above tens of GeV, where the flux is too low to be measured by satellite detectors and necessitates the huge collection areas of ground based Cherenkov telescopes. Observations with MAGIC are key to understand the rare processes and physical systems in the Universe that accelerate particles and generate radiation at these energies. Such physical systems count among the most violent known in the Cosmos. Furthermore the propagation of the radiation over cosmological distances is sensitive to the geometry and matter contents of the cosmos itself.

MAGIC detects the light induced by the interactions of the incoming gamma rays with the upper atmosphere. This light is reflected onto two 17m diameter segmented mirrors and collected in the cameras, located at the focal point. The cameras are provided with very fast and sensitive photo-detectors and digitizers.

The MAGIC group at IFAE built the camera of the first telescope and its control system, as well as the house where the electronics and data taking equipment are installed. The first telescope was inaugurated in October 2003 and was commissioned during 2004. In 2008 the telescope entered its fourth year of regular observations. The second telescope, essentially a clone of the first one, finished installation in 2008 and is currently in its commissioning phase. IFAE, along with the group at INFN Pisa, is responsible for the ultrafast readout system for this second telescope. In addition IFAE is in charge of the overall control of the two telescopes.

MAGIC published twelve journal papers in 2008, many of which were initiated or had strong participation of IFAE physicists. Some highlights are briefly described next.

The binary system LS I +61^0 303 established by IFAE as a gamma–ray source.back in 2006 and published in Science magazine. After discovering variable VHE emission from the binary system LS I +61 303, we have re-observed this source together with the radio interferometers MERLIN, e-EVN and VLBA, and the X-ray telescope Chandra. The observations were carried out during October and November 2006 and have unveiled different properties of the system that will help elucidate the origin of the non-thermal emission (jet or pulsar wind), currently under passionate debate. Comparing our radio images at different angular scales with those obtained in the past, we have found a high level of periodicity and stability of the processes behind the radio emission at the milliarcsecond (mas) scale and discarded the presence of a persistent, large scale (~100 mas) jet. Also, our results point to the existence of one population of particles producing the radio emission and a different one producing the X-ray and TeV emissions. Furthermore, we have produced, for the first time, a quasi-simultaneous energy spectrum including radio, X-ray and TeV bands, which will serve as input for the theoretical models aiming at describing the nature of this peculiar object. A researcher at IFAE was co-responsible for the paper (J. Albert et al., Astrophys. J. 684 (2008)1351). A PhD thesis was completed in 2007: "Discovery and characterization of the binary system LSI +61°303 in VHE gamma-rays with MAGIC", by Nuria Sidro, who was the discoverer of this source. This thesis has given rise to two high impact publications in 2006 and 2009.

We detected emission of very high energy gamma rays from the quasar 3C279. The quasar's red shift of z~0.5 corresponds to more than twice the distance of any object previously observed at VHE. 3C279 is also the first quasar ever discovered in this energy range. Quasars and all active galactic nuclei emit radiation across the entire electromagnetic spectrum from radio wavelengths to very high energy gamma-rays.

Whereas most of the emission can travel through the Universe without being absorbed, the flux of VHE gamma rays is attenuated by pair-production in interactions with low energy photons of the extragalactic background light (EBL). The EBL comprises the history of all light produced by stars and galaxies in the Universe and is, therefore, of great interest as a record of cosmological structure formation. The detection of VHE gamma-ray emission from a source at such a distance as 3C279 constrains current theories about the density of the EBL. The Universe appears more transparent at cosmological distances than believed, precluding significant contributions from light other than from sources observed by current optical and infrared telescopes. This work was led by a Marie Curie fellow at IFAE and published in Science magazine:(Science 320 (2008) 1752).

In early 2008 while carrying out a monitoring program of the close-by, giant radio galaxy M87, the MAGIC telescope detected a rapid flare in VHE γ-rays. The flux was found to be variable above 350 GeV on a timescale as short as 1 day. The highest measured flux reached 15% of the Crab nebula flux. We observed a rather complex flare structure with several substantial changes of the flux level during the total 13-day observing period. The flux at lower energies (150 GeV to 350 GeV), instead, is compatible with being constant. The observed day-scale flux variability at VHE prefers the M87 core as source of the emission and implies that either the emission region is very compact (just a few Schwarzschild radii, see Figure 1) or the Doppler factor of the emitting blob is rather large in case of a non-expanding emission region. IFAE was also responsible for this study (Astrophys. J. 685 (2008) L23.)

The MAGIC telescope observed the region around the distant blazar 3C66A in August-December 2007 for more than 50 hours. The observations resulted in the discovery of a gamma-ray source (MAGIC J0223+430), at energies above 150 GeV, coinciding with the nearby radio galaxy 3C66B. Although the association of the signal with the blazar 3C66A cannot be excluded (chances lying around 15% if including systematic uncertainties), 3C66B is the more likely source of the emission. The measured energy spectrum has a relatively hard photon index of about 3 and extends up to 2 TeV. This gives additional support to 3C66B as source: for 3C66A a much softer energy spectrum would be expected. If the radio galaxy 3C66B is confirmed as the source of the observed VHE gamma rays, it would be the second radio galaxy (after M87) emitting VHE gamma rays, and would establish radio galaxies as a new class of VHE gamma-ray emitting sources. A PhD student of the IFAE group was responsible for this analysis (Astrophys J Lett 692, 2008, L29).

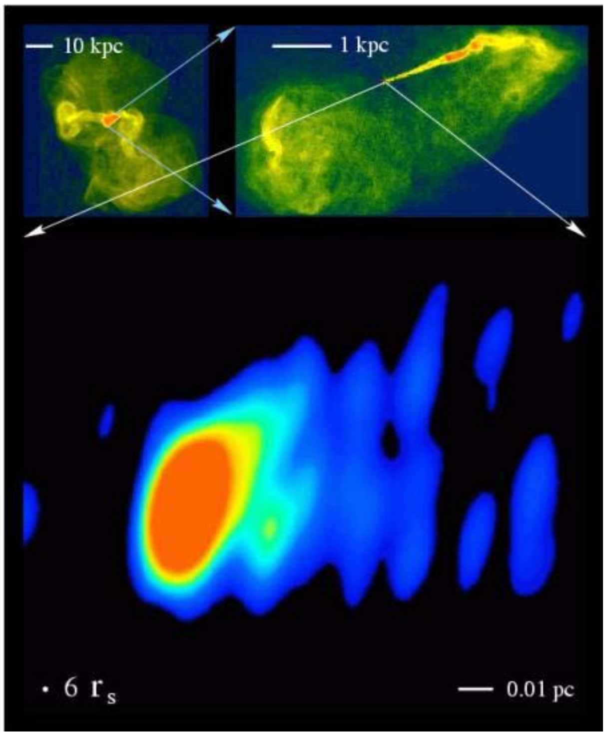


Figure 1 The above image shows views of the active galactic nucleus M87 at different length scales. The bottom image is a 7mm (43GHz) radio VLBA image of the very central regions of the jet deep in the heart of the elliptical galaxy. This image shows that M87's jet is formed within a few tenths of a light-year of the galaxy's core. The small circle labeled 6Rs shows six times the Schwarzschild Radius, (radius of the event horizon) for the galaxy's super-massive black hole. That length corresponds to slightly more than 9 times the size of our Solar System. The gamma-ray emission detected by MAGIC may arise from this small region around the central black hole. The top two images are from the Very Large Array, and show the radio jet and lobes at much larger scales. Image courtesy of NRAO/AUI.

The Crab pulsar is a fast rotating (about 30 times per second), highly magnetized neutron star, that powers the famous Crab Nebula, located at around 2,000 parsecs from the Earth. It is the remnant of a supernova explosion that occurred in 1054 A.D. At its core is a neutron star of a few solar masses, which is about 10 km in diameter. Its magnetic field is more than 10^{12} times stronger than that of the Earth. The mechanism of the pulsed electromagnetic emission is an open fundamental question. All Crab pulsar emission models predict that the energy spectrum of the pulsed emission drops off sharply somewhere between a few GeV and a few tens of GeV.

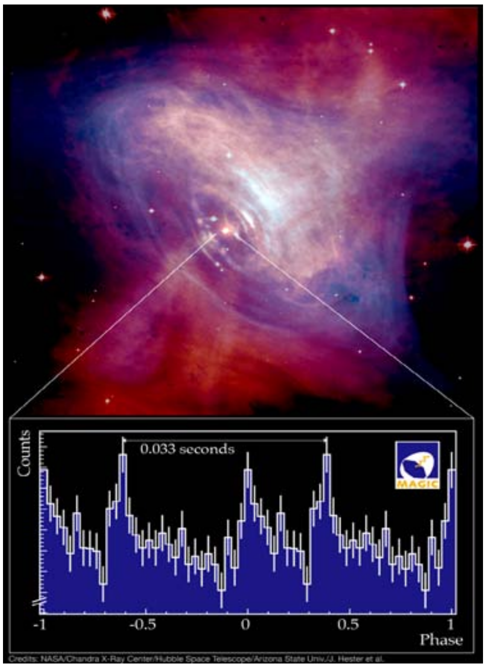


Figure 2 MAGIC has detected pulsed emission of very high energy gamma rays from the Crab pulsar. The composite picture shows the Crab Nebula in optical and X-rays. The phaseogram (flux evolution folded with the time period of the pulsar) below shows the regular pulsation with a period of 0.033 seconds as seen by MAGIC.

The MAGIC measurements reveal that the drop-off in the emitted radiation occurs at relatively high energies above 30 GeV, which indicates that the emission must occur far out in the pulsar's magnetosphere. All models in which the emitting region is located close to the pulsar surface (e.g., the so-called “polar cap” model) are ruled out. A strong attenuation of the emission at high energies can result as a consequence of the strong opacity encountered by high-energy photons when they interact with ambient low-energy photons or high-intensity magnetic fields. The present results provide key constraints to all Crab pulsar models and were published in Science (Vol. 322, pg.1221-1224).

Work started in 2005 to construct a second MAGIC telescope (MAGIC-II), which, in coincident operation with the original MAGIC-I, improves the spectral and angular resolutions, and noise rejection. It should deliver a factor of two improvement in sensitivity and a lower energy threshold. Most of the systems of the telescope finished the design and prototyping phase and started production in 2007 with the aim of final installation before inauguration in September 2008 (see Figure 3 for the status of the telescope at the end of 2007). MAGIC-II, in principle, should as closely as possible resemble MAGIC-I, but new technologies and experience with MAGIC-I suggested changes in several areas, all aiming at the best possible performance for low-energy showers with their modest photon yield: advanced photo sensors with higher sensitivity, increased camera area instrumented homogeneously with small-size pixels, mirror elements with larger surface, improved non-interfering mirror adjustment, digital signal readout with improved time resolution.

IFAE also developed the readout and data acquisition of MAGIC-II in cooperation with the INFN Pisa group. The readout of the telescope uses the so-called DOMINO chip with a 2-4 GHz sampling rate. The DAQ software and the software to control the DOMINO VME boards were developed at IFAE and successfully installed in 2008.The group at IFAE is entirely responsible for the reception of the analogue optical signals produced at the camera of MAGIC-II, the signal conditioning of these signals for the digitalization, and the level-0 trigger (trigger discriminators). The optical reception of the signals of the 1039 channels of the camera takes place in a system of 60 VME boards. Each of them is a 10-layer controlled-impedance PCB hosting 24 channels. After several years of design and prototyping at IFAE, the receiver electronics were produced by two external companies beginning of 2008, quality-controlled at the institute in spring 2008, transported to La Palma and installed at the MAGIC control house in August. Commissioning tests began in fall-2008.

Figure 3 A picture of the two MAGIC telescopes after full installation of MAGIC-II (on the right) in Summer 2008 at the Roque de los Muchachos observatory. On the right, the electronics control building. The telescopes are currently in their commissioning phase and shall start regular operation in 2009. On the background, the domes of two optical telescopes: the Italian 3.6m Galileo Telescope (left) and the Spanish GRANTECAN 10.4m telescope (right).

The group is responsible for the extension of the central control software of the two-telescope system as well; in addition it coordinates the data center for the two telescopes. The data center was set up in collaboration with the other Spanish groups and is hosted at the nearby Port d'Informació Científica (PIC).

5.5 CTA: Why and How?

(Manel Martínez)

Gamma Ray astronomy is one of the fundamental pillars of Astroparticle Physics. It is an essential tool to address the study of fundamental phenomena in Astrophysics, Cosmology and High Energy Physics, the so-called "Non-thermal Universe".

Among all the techniques explored in the past decades for the ground observation of High Energy Cosmic Gamma Rays, one emerged as the most successful: the imaging of the Cherenkov light produced in the electromagnetic showers initiated by cosmic radiation entering our atmosphere. Using this technique, over a dozen sources were detected at energies above 300 GeV in the nineties. This was the starting point for ground-based gamma-ray astronomy, which this year celebrates, the 20th anniversary since its first discovery: the Crab Nebula by the Whipple Observatory in Arizona.

Nevertheless, very-high-energy gamma-ray astronomy has witnessed a major breakthrough just recently with the physics results obtained by ground-based instruments such as MAGIC during the last few years. These results have impressively demonstrated the huge physics potential of this field, not only in the area of astrophysics, but also in particle physics and cosmology. However, it also became apparent that the performance of current instruments is not sufficient to tap the full physics potential. The answer of the European VHE energy community to that challenge is the Cherenkov Telescope Array (CTA), a next-generation, more sensitive and more flexible facility, able to serve a large community of users.
So far, Cherenkov telescopes such as H.E.S.S. or MAGIC were considered "experiments", requiring dedicated experts to analyze and fully exploit their data. Both the communities of astronomers and of astroparticle physicists feel that the time is ripe to construct a next-generation VHE gamma-ray observatory, which will boost sensitivity and resolution beyond that of the current instruments, and will provide observatory services and tools, thus making VHE gamma-ray astronomy accessible to the entire community.

The "Cherenkov Telescope Array" (CTA) will be an advanced facility for ground based very-high-energy gamma ray astronomy, based on the observation of Cerenkov radiation (see reference 1). It builds on the mastery of the Imaging Atmospheric Cherenkov Telescope technique developed by the H.E.S.S. and MAGIC installations. From the successes of H.E.S.S. it exploits the concept of telescope arrays and stereoscopic analysis for improving the current sensitivity by one order of magnitude. From the success of MAGIC it exploits the use of large telescopes to attain the lowest possible threshold. Both approaches have proven to be extremely productive for gamma rays of energies above few tens of GeV and have opened wide a new window in astronomy: the detailed study of the universe at the largest energies to study the most extreme astrophysical phenomena and fundamental physics (see references 2 and 3 for a discussion of the future science prospects for VHE gamma ray astronomy with Galactic and Extragalactic sources respectively).

The main wishes of the European VHE gamma ray community to be fulfilled by CTA are (see Figure. 1):

1) Broad energy coverage: four decades, from some tens of GeV to beyond 100 TeV
2) Sensitivity at least one order of magnitude better than any existing installation: better than 1 mieliCrab at the intermediate energies.
3) Two observatories, operated coherently, for all-sky monitoring capability: a northern observatory with emphasis on extragalactic studies and a southern one mainly for galactic studies.

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

a) High sensitivity at TeV energies (a factor 10 above present values) and therefore deeper observations and discovery of many more sources.
b) High detection area and therefore higher detection rates, which shall allow a much better study of transient phenomena.

c) Improved angular resolution, which shall enable better morphology analysis and therefore better study of the structure of extended sources.
d) Low threshold (a few tens of GeV), instrumental for the detailed study of Pulsars, distant AGNs, source mechanisms and to provide a good overlap with the energy region covered by Fermi-GST.
e) High energy reach (PeV and beyond) which shall allow the precise determination of the cut-off region of Galactic accelerators and an overlap with the survey at TeV energies performed by future surface detector arrays such as HAWC.
f) Wide field of view, which should allow the detailed study of extended sources and the realization of high sensitivity and wide energy band surveys.

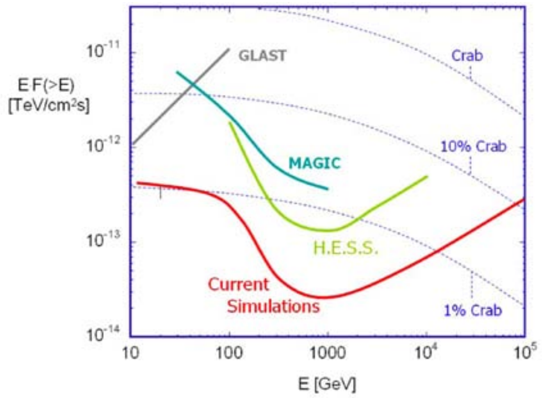


Figure 1- The goal sensitivity of the CTA installation

Reaching such performance values will require building observatories consisting in an array of several tens of Cherenkov Telescopes, probably of two or three different sizes: a few large telescopes in a compact configuration for the lowest threshold, few tens of mid-size telescopes for the high-sensitivity intermediate-energy region, several tens of small telescopes spread on a large area for the highest energies (see Figure 2). The results presently obtained from 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 O(10,000) m^2 total mirror area.

The major technological challenges in this endeavour are the development of cost effective, robust and reliable electronics, telescope structures, drive systems and mirrors, complemented by a sophisticated optimization of the array layout based on simulations.

Nevertheless, although CTA should mainly build on the technologies already demonstrated by H.E.S.S and MAGIC and therefore no "vigorous" R & D may be needed. CTA will build also on technology not-yet-demonstrated in this field such as:

- Mass production and reliability
- Low energy array (MAGIC-II, H.E.S.S.-2)
- New photo sensors and electronics
- -Atmospheric monitoring and calibration integration
- Data handling and observatory concept

CTA may discover and study in detail the spatial structure, light curve and energy spectra of around one thousand sources and, given the fast variability of many VHE gamma ray sources, shall be in operation while Fermi-GST is still active since both installations nicely complement each other. Operational overlap with the Fermi satellite mission will provide seamless coverage of 20 octaves of the spectrum. Moreover, coordination with similar efforts in the USA with the AGIS concept (see reference 4) is underway.

Project history, status and plans

The unification of the efforts of the European VHE gamma ray community (and especially of its two major collaborations, H.E.S.S. and MAGIC) towards the definition of a common future facility was already recommended by the ApPEC Peer Review Committee back in 2003.

Building upon the success of H.E.S.S. and MAGIC, by the end of 2005 the first concept of a future European installation, already dubbed CTA, was submitted for inclusion in the ESFRI roadmap. ESFRI considered that the CTA project was not yet mature enough in 2006, but included it in the list of emerging projects and finally as a full ESFRI entry for the 2008 updated roadmap. Presently ASPERA-ApPEC gives full support to CTA, listing it among the highest priority future European Astroparticle physics installations in the ApPEC roadmap. In addition, CTA has also been included with high priority among the future astrophysics facilities by the ASTRONET roadmap.

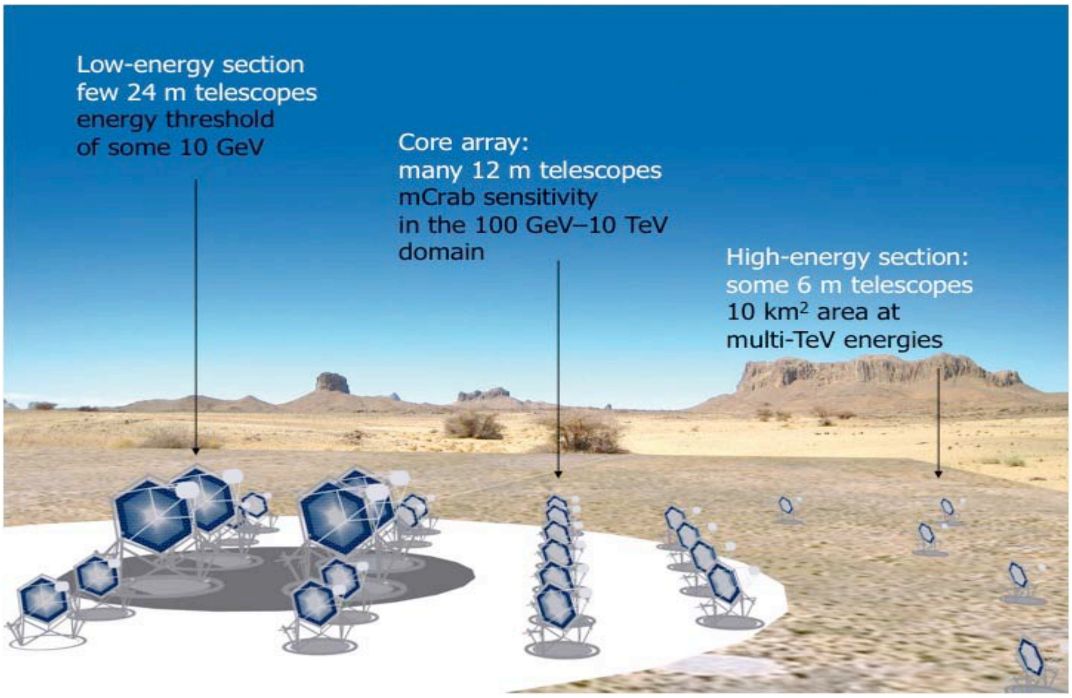


Figure .2 A sketch of the possible layout of a CTA site (not to scale).

Meanwhile activities to fully define CTA started in spring 2006 in a first meeting in Berlin where several working groups began working for the preparation of a Letter of Intent. This activity continued with several working groups and general meetings until spring 2007 when in a general meeting in Paris it was decided to submit an application for Design Study funds to the FP7 EU program. The application was submitted in May 2007 but the final (negative) answer was not been received until June 2008. In the meantime work on the design of CTA continued and in early 2008, in a general CTA meeting in Barcelona, is was decided to follow the 3-year work-package organizational scheme created for the FP7 application (see Figure 3), and continue the Design Study no matter on the outcome of the FP7 application. At that time it was also decided to act as a consortium although the Memorandum of Understanding, already circulating as a draft, is to be approved by May 2009.

The CTA Technical Design Report should be ready by the end of 2010 and then a "Preparatory Phase" consisting in building prototypes for the 2 or 3 different telescope types should be going on during 2011 and 2012.

Work Packages:

WP1	MNG	Management of the design study
WP2	PHYS	Astrophysics and astroparticle physics
WP3	MC	Optimization of array layout, performance studies and analysis algorithms
WP4	SITE	Site evaluation and site infrastructure
WP5	MIR	Telescope optics and mirror
WP6	TEL	Telescope structure, drive, control
WP7	FPI	Focal plane instrumentation, mechanics and photo detectors
WP8	ELEC	Readout electronics and trigger
WP9	ATAC	Atmospheric monitoring, associated science & instrument calib.
WP10	OBS	Observatory operation and access
WP11	DATA	Data handling, data processing, data management and access
WP12	QA	Risk assessment and quality assurance, production planning

Figure 3 List of Work Packages for the CTA Design Study.

CTA presently includes over 350 scientists from the most prestigious research centers over all of Europe led by the Max Planck Institute in Heidelberg. Nevertheless, Japan has already applied for participation and very likely USA will join forces in the coming years converting CTA into a worldwide effort.

IFAE participation in CTA

In the CTA project, the members of the IFAE gamma-ray group have been deeply involved and very active since its conception. This is why the kick-off meeting of the CTA Design Study took place in 2008 in Barcelona organized by the Spanish groups. For instance, before the Design study began, Manel Martinez was convenor of the Camera Working group together with Pascal Vincent from France (responsible for the construction of the H.E.S.S. cameras) for the first definition of the project (Letter of Intent). Later, for the Design Study two Spaniards have been assigned important responsibilities: Diego Torres from ICE-CSIC is convener for the Physics Work Package and Manel Martinez was convener for the ATAC Work Package (Advanced Techniques for Atmospheric-monitoring and Calibration) and was a member of the CTA Executive body.

Apart from the scientific, technological and industrial relevance of CTA for a country like Spain, another key issue is that the Canary Islands are a prime candidate site for hosting the CTA-North Observatory. Therefore, from the strategic point of view a decisive participation of the Spanish community in this project may be instrumental for having such an installation in Spain.

CTA has attracted eight Spanish groups which have joined the two “Acciones Complementarias” (FPA2007-30012-E and FPA2007-31120-E) that funded the Spanish participation so far and that were coordinated by IFAE.

Finally all the Spanish groups already working or willing to work in VHE gamma ray astronomy coordinated their efforts under the leadership of IFAE to identify a clear contribution from Spain in which most of the groups with construction capabilities could cooperate actively. This main contribution has been identified as the camera for the prototype of the large telescopes. IFAE was the first institute in the world that built a camera for a large Cherenkov telescope (and so far is still the only large camera active in normal operation). The cameras for large telescopes are challenging because of the requirement of reaching the lowest possible detection thresholds and the large number of channels. IFAE already got a successful expertise by constructing the camera of MAGIC-I and the ultrafast readout electronics for MAGIC-II and will work in a coordinated manner with the teams of groups at UCM, ICE-UB and CIEMAT for this purpose.
In addition the IFAE group is very active in other areas of R&D for CTA such as advanced technologies for atmospheric monitoring and calibration, development of trigger instrumentation and schemes, telescope characteristics and array layout studies, site surveying and physics prospect analyses.

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5. 6 The 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, Medioambientales 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 sq. deg. of the southern galactic sky, measuring positions in the sky and redshifts of about 300 million galaxies and 15000 galaxy clusters. Furthermore, another 10 sq. deg. of the sky will be repeatedly monitored with the goal of measuring magnitudes and redshifts of over 1000 distant type-Ia SNe. 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 building a large CCD camera (DECam), giving images covering 3 sq. deg. of the sky. The camera, shown in Figure 1, will be mounted 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 5 years (2011-2015).

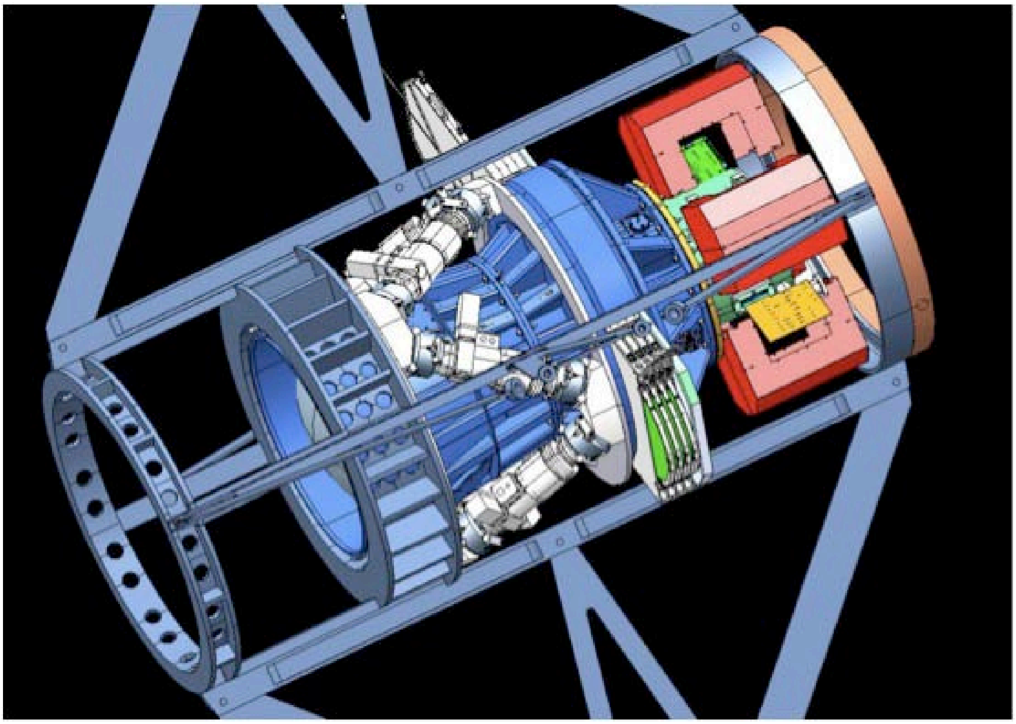

Figure 1 A three-dimensional model of DECam, the camera being built by DES

The three Spanish groups, financed by the Program of Astronomy and Astrophysics, which is part of the National Plan of I+D+I, will build 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 (CBB) at CIEMAT, the Master Control Board (MCB) and the Transition Board (TB) at IFAE.

During 2008, IFAE finished the design of the first version of the TB, whose final design is being done at CIEMAT. IFAE then concentrated on the MCB, producing versions v1 and v1.1. After solving some synchronization issues, a first functional version of the MCB (Figure 2) was delivered to FNAL in late 2008.

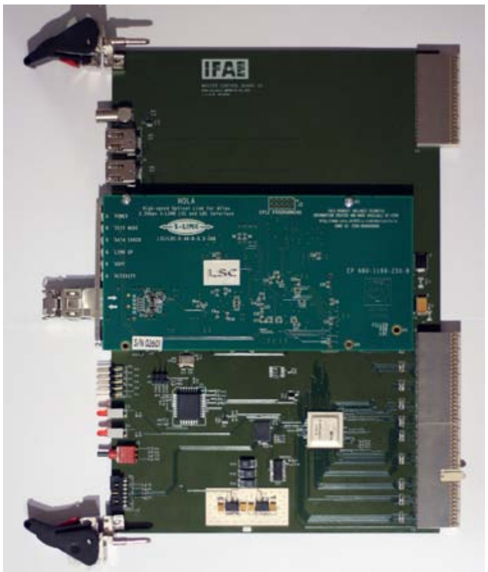

Figure 2 A view of one of the Master Control Boards (MCB) produced at IFAE

In preparation for the analysis of DES supernova data, some members of IFAE, IEEC and CIEMAT joined in 2007 the program of spectroscopic monitoring of the SNe found in the Sloan Digital Sky Survey-II project, in a red shift range between 0.1 and 0.4. The group was awarded four full nights of observations in Fall 2007, which resulted in spectra of about 25 objects, including an extremely peculiar supernova, SN2007qd.

During 2008 all the spectra were reduced, producing flux-calibrated spectra that were sent to the central SDSS-II/SNe spectrum repository for their use in the common SDSS-II/SNe analyses. Furthermore, work started on the analysis and understanding of the properties of SN2007qd. Figure 3 shows the SN2007qd spectrum taken by IFAE members three days past maximum light, together with a synthetic spectrum that reproduces the most salient features of the data. Work is continuing analyzing this and three other SN2007qd spectra available, in collaboration with colleagues from the University of Notre Dame in the United States, with the goal of writing a paper in 2009.

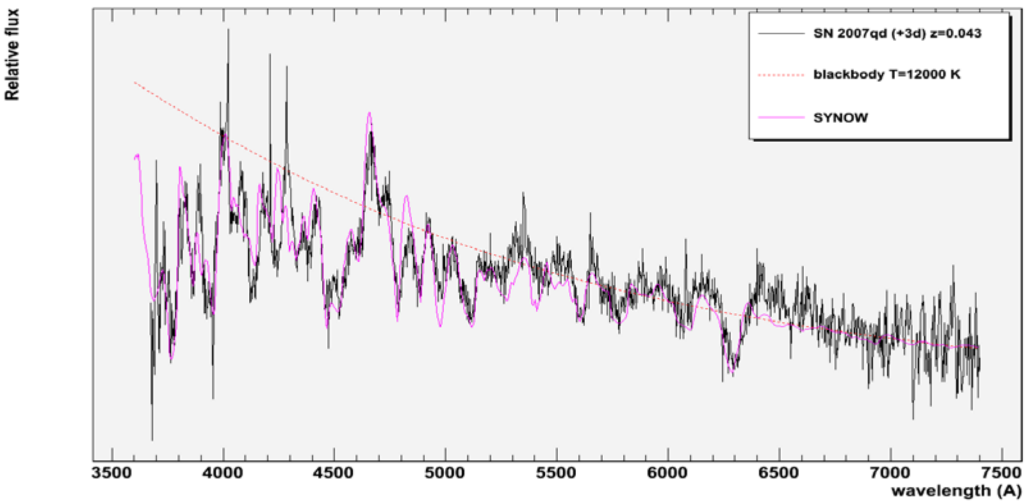

Figure . Spectrum of supernova SN2007qd, at redshift z=0.043, taken on November 5th 2007 at TNG, and shown in its rest frame. An analytical calculation of the spectrum reproducing most features in the spectrum is superimposed (pink line).

5.7 The PAU Project (Physics of the Accelerating Universe)

(Enrique Fernández)

The PAU (Physics of the Accelerating Universe) project aims at improving our understanding of Dark Energy, the putative component of the universe which causes an increase in its expansion rate. The project is funded by the Consolider Ingenio 2010 Program of the Spanish Ministry of Science and Innovation (MICINN), a special program that finances groups for five years in projects with the potential of being internationally highly competitive.

The project was approved in 2007, starting on 1/10/07, and is being carried out by a group at IFAE (Laia Cardiel, Enrique Fernández, Josep Antoni Grifols, Eduard Massó, Ramon Miquel, Marino Maiorino and Pol Martí) together with groups from more Spanish Institutions, namely CIEMAT (Madrid), IAA (Granada), ICE-IEEC (Barcelona), IFT-UAM (Madrid), IFIC-UV (Valencia) and PIC (Barcelona). IFAE is the Coordinating Institution and one of us (EF) is the overall Coordinator.

The primary objective of PAU is to do a large galaxy survey with the objective of measuring the expansion rate of the universe as a function of time or, more precisely, of red-shift, which is the quantity directly observed when measuring the light of distant galaxies. This history of the expansion rate is embodied in the quantity H(z), the Hubble constant as a function of red-shift.
During the last decade cosmological observations, mainly of the cosmic microwave background, of large scale structure and of various distance indicators, led to the emergence of the Standard Cosmological Model. In this model the universe has a flat geometry and is made mostly of three components: ordinary baryonic matter (4%), dark matter (23%) and dark energy (73%). The equations of General Relativity then lead to the following equation

$$\frac{H^2(z)}{H_0^2} = \Omega_M (1+z)^3 + (1-\Omega_M)(1+z)^{3(1+w)},$$

where H_0 is the present value of the Hubble constant, Ω_M is the density of matter (baryonic and non baryonic) in terms of the critical density and *w* (assumed constant) is the equation of state parameter of dark energy, which relates its pressure to its energy density by the equation of state

$$p = w(t).\rho$$

In the PAU Survey we propose to measure the expansion rate H(z), thus providing a relation between Ω_M and *w*. A measurement of H(z) constrains the value of the other quantities to an allowed region, generally an ellipse in the Ω_M versus *w* plane. In 2005 the Dark Energy Task Force committee in the US ranked future projects in dark energy according to their ability to reduce the area of the Ω_M - *w* ellipse. As we will see below PAU ranks very well with respect to other planned projects in this scheme. Other goals of the PAU project are the study of dark energy from the theoretical physics point of view and the organization of educational and outreach activities, both within the team, given the different backgrounds of those involved, and towards society in general.

A large galaxy survey

Originally the main objectives of the PAU project were to construct an instrument consisting of a very wide-field CCD camera (~ 6 deg^2) for galaxy photometric red-shift measurements using a large number of narrow-band filters, and to prepare a large galaxy survey, of about 8000 deg^2 and up to z=0.9 in red-shift, installing such an instrument in a 2 meter class telescope. The telescope would be an existing telescope, suitably modified, or, preferably, an entirely new telescope, fully dedicated to the survey in an initial phase. This ambitious plan can be carried out in phases, starting for example with a demonstrator instrument to test the main ideas, before proceeding to the full scale construction.

There are two innovations in this proposal. One is to achieve high accuracy red-shift measurements by means of photometry with many filters. Another is that, when doing so, one does not need to define a priori the target galaxies, in contrast with spectroscopic measurements, and thus any galaxy in the field of view is recorded (as allowed by its magnitude limit).

With a large survey of these characteristics one could measure accurately the Baryon Acoustic Oscillations (BAO) scale as a function of red-shift, which can be related to H(z). BAO have their origin in the density fluctuations created by acoustic waves generated by primordial perturbations in the photon-baryon plasma before recombination. After recombination the photons decouple and propagate freely. We see the effect of the primordial perturbations in the temperature fluctuations of the CMB. At recombination the acoustic waves stall. The peaks in the density waves are the seeds of large scale structure. As a result there should be a correlation between the densities of matter and the scale of the sound horizon distance at recombination. This scale can be determined from CMB observations and is equal to r_{BAO}=146.8±1.8 Mpc (or r_{BAO}=105.7±1.3 h^{-1} Mpc for h=0.72) comoving, for a flat ΛCDM Universe. This distance constitutes a "Standard Ruler" and its measurement at different red-shifts gives information on the expansion history of the Universe.

The BAO scale can be determined from a galaxy survey. The angular position and red-shift of galaxies give a measurement of the clustering of mass in three dimensions. The BAO signature will show up as a peak in the two-point correlation function of the mass distribution. In such a survey one does not need in principle the absolute flux or shape of the galaxies. On the other hand there are effects that can give rise to systematic uncertainties. First, there is the issue of biasing: the light from galaxies is a biased estimator of the matter content. Second, non-linear physics enters in galaxy formation, and third, there are red-shift distortions induced by peculiar velocities. However all these effects predominantly tend to change the amplitude of the correlations but not the position of the peak. From this point of view BAO, as a probe of dark energy, is less affected by systematic uncertainties than other probes, as some recent reports (from the Dark Energy Task Force in the US and from ESO in Europe) have pointed out. In any case, its systematic uncertainties are different from those of other methods.

On the other hand, since the scale is very large, its observation requires sampling of the mass distribution over very large volumes and therefore very large surveys.

The BAO scale has been observed in the Sloan Digital Sky Survey data, as an excess in the two-point correlation function of the mass distribution, with the mass traced by Luminous Red Galaxies (LRG) in a sample of about 45,000 LRGs, with spectroscopically determined red-shifts.

The distance can in principle be measured "radially", along the line of sight, and "in angle", across that line, as an angular distance. The two distances are related differently to the expansion rate H(z). The radial distance is given by

$$dr(z) = \frac{c}{H(z)} dz$$

while the angular distance is proportional, for a flat universe, to an integral of *H(z)*,

$$d_A(z) = \frac{c}{1+z} \int_0^z \frac{dz'}{H(z')}$$

The different dependence of the distance scale on H(z) translates into a different precision in the determination of the cosmological parameters depending on whether the information comes from the line of sight or from the angular distance. Roughly speaking the volume of a galaxy survey providing radial information needs to be only 10% of the volume needed if only the transverse information is available, to obtain similar precision in the cosmological parameters. Observationally then one has two competing aspects: covering a large volume is more easily done with a photometric survey, but measuring the BAO scale in the radial direction requires to measure *z* with precision, which can be better achieved with spectroscopic observations.

During 2008 the scientific case for a large survey to measure BAO photometrically, in particular in the radial direction, was put on firm basis and the main ideas were published [Benítez et al., arXiv:0807.0535 (astro-ph), published in the Astrophysical Journal 691, 249-260 (Jan. 2009)].

The precision needed in the determination of the red-shift has been estimated from simulations.

They show that a precision in z of the order of 0.003(1+z) is nearly optimal. A smaller precision will smear the peak of the correlation function while a higher precision does not add significantly, as other effects, such as red-shift space distortions and non-linearities can introduce uncertainties comparable to this value.

The high precision is possible by targeting Luminous Red Galaxies (LRGs) as tracers of mass. These galaxies have a characteristic break in their spectrum at approximately 4000Å in their rest frame. The proposed PAU camera will have 42 filters, covering between 4000Å and 8000Å, supplemented by two wide filters similar to the SDSS u and z bands. Simulations show that this would allow the determination of the position of this break with the required 0.003(1+z) precision.

The proposed survey will be carried out with a telescope/camera combination with an étendue of about 20 m^2deg^2, equivalent to a 2 m telescope equipped with a 6 deg^2-field of view camera, and covering 8000 deg^2 in the sky in four years. With this survey it is expected to measure positions and red-shifts of over 14 million LRGs up to 22.5 absolute magnitude in the red-shift interval 0.1 < z < 0.9. This population has a number density n > 10^{-3} $(Mpc/h)^{-3}$ galaxies within the 9 $(Gpc/h)^3$ volume to be sampled, ensuring that the error in the determination of the BAO scale is not limited by shot noise.

The potential of this survey has been evaluated with the Dark Energy Task Force figure of merit criterion, that is, the reduction of the area in the ellipse of the Ω_M - w plane (see Benítez et al. for more details). The result is in Figure 1.

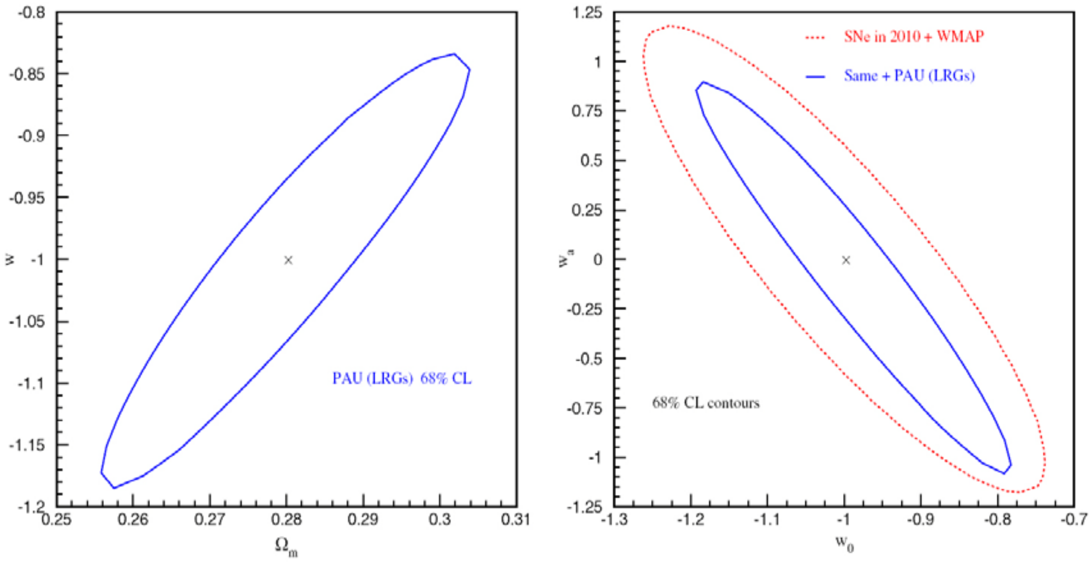

Figure 1. Left: 68% confidence-level contours in the Ω_m–w plane, using only PAU data, assuming a flat universe and a constant equation of state w. Right: 68% confidence-level contours in the w_0-w_a plane for the world combined data from SNe and WMAP in about 2010, and after adding PAU data to the data set. The area of the contour decreases by about a factor of 3. A flat universe has been assumed.

In addition to firming up the scientific case, over the last year progress has taken place in several aspects of the design of the survey, in particular in the camera and data management subprojects.

The work on the camera (coordinated by F. Castander) was organized into sub-groups, each responsible for a corresponding Work Package.

The main achievements are the following:

Conceptual Design

Starting with the science requirements the instrument requirements have been analyzed. A critical review of similar projects was done to learn about their experience and to consider possible solutions for the design. Programs were written to interface with simulations to define the number of CCDs, the number of filters, the filter characteristics, and others. Arriving to a final design requires settling the telescope to be used.

Survey Planning and Strategy

There is an on-going activity running simulations, but final definition needs decisions on camera and telescope designs. Estimations of survey duration have been completed.

CCD production

Three possibilities were studied: e2v, LBNL and Hamamatsu. Conversation took place with all of them. There was a visit by members of the team to LBNL and Fermilab to discuss the LBNL option. Representatives of e2v-UK and Hamamatsu-Spain visited Barcelona to maintain both commercial and technical discussions.

CCD testing

A setup station is being set up in Barcelona (IFAE and ICE). CIEMAT is also planning to set up another test station in Madrid. All the experience with the DECam (the camera of the DES project) will be incorporated into the work on this item and on the electronics below.

Electronics

Some electronics components have been bought and there is ongoing work to study the adequacy of the Monsoon DECam (DES) system for the PAU camera.

Mechanics

A detailed critical study of other camera concepts to study possible solutions for the PAU camera has taken place. Both a preliminary design and a preliminary budget are being prepared. The preliminary design is in Figure 2

Cooling

Different solutions, based on cryocoolers, are being considered and a full thermal model of the camera is being implemented.

Filters.

The camera will have about 40 narrow band filters. Several providers have been contacted and preliminary quotes are in hand.

Control System

A study is ongoing on the applicability of the DECam system to the PAU camera.

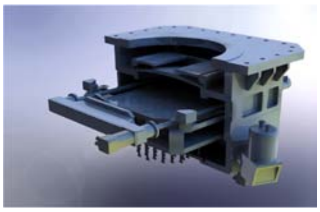

Figure 2. CAD conceptual model of the PAU Camera. The system to change the filters has been fully designed.

Progress has also taken place in other aspects of the PAU Survey, particularly in the Data Management aspect (coordinated by E. Gaztañaga). A scheme of the overall flow of data and of some of the tasks in progress is in Figure 3. A Survey as the one proposed by PAU will give high-quality red-shift measurements for millions of galaxies, other than the LRGs targeted for BAO. The data will contain a wealth of information, of interest not only for cosmological but also for other astrophysical studies.

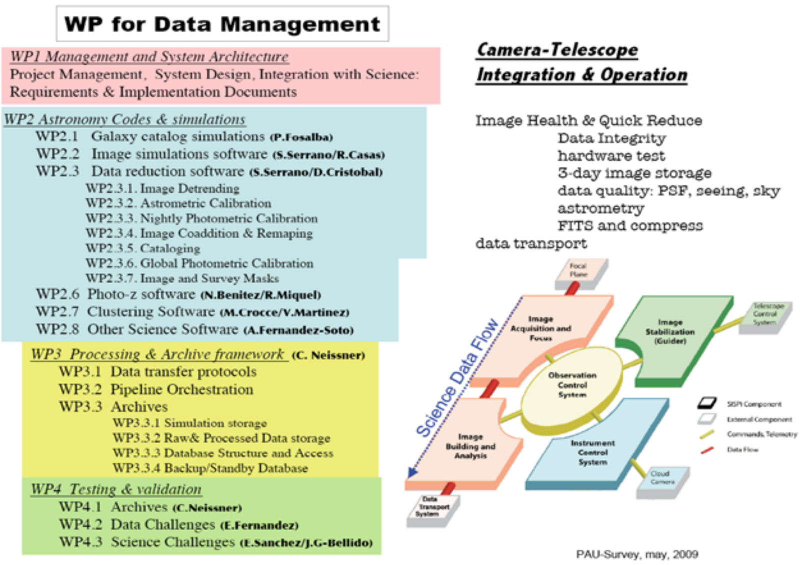

Figure 3. A scheme of the Data Management plan.

5.8 Medical Imaging and Related R&D

(Mokhtar Chmeissani)

Medical Imaging 2008

A few years ago, IFAE, in collaboration with other three institutes, Centro Nacional de Microlectrónica (CNM-IMB), UDIAT Centre Diagnostic, and EMSOR S.A. started the development of a 3D real-time breast biopsy machine (patent pending). After setting the specifications of the new device and completing the CAD drawings, the collaboration acquired a second-hand LoRad prone biopsy machine and converted it to a state-of-the art biopsy machine. The complete prototype was completed in 2008 and can be seen in Figure 1

Figure 1 The complete 3D biopsy prototype machine stationed in the X-ray room in IFAE.

The system was presented at the 36th International Salon of Inventions 2008, held in Geneva, Switzerland and it was awarded the Silver Medal. A copy of the certificate award can be seen in Figure 2.

The complete system is a research prototype that has a provisional CdTe detector of 5cm x 5cm with a spatial resolution of 100µm and a speed of 50 frames per second. With such a detector, the doctor can see the position of the needle inside the breast in real time as well as the exact position of the needle's tip with respect to the target tissue (potential cancerous tissues) with the best clarity thanks to the 3D vision capability provided.

Figure 2 the certificate for the silver medal award given for the 3D biopsy system

Both the patient and the doctor will benefit from such a biopsy machine because it will reduce the time of operation (and the trauma for the patient) significantly, from 30-40 minutes to around 10 minutes, and increase the success rate of the intervention. The prototype 3D real-time breast biopsy machine has been designed to meet the wishes of the doctors at UDIAT Centre Diagnostic, hence we believe that many doctors performing a breast biopsy intervention will wish to have a machine like this.

Bump-bonding Processes

On a related R&D project, IFAE, CNM, and X-ray Imatek SL (XRI) are developing the bump-bonding process for pixel solid state detectors. The task of CNM is to develop the growth of the solder bumps on the pixel electrodes of ASIC/detector, and IFAE's is to do the Flip-Chip process. For this project IFAE uses the Suss Microtec FC150 bump-bonding machine in collaboration with X-ray Imatek SL. The FC150 was installed in the CNM (class-100) clean room in early 2008 and soon thereafter the development of flip-chip/bonding process started. No active devices were used in this R&D, only passive tests were conducted. We did the bonding of the chip to the substrate and then followed up by detaching them.

We have managed to obtain welding of almost 100% of the substrate pads by the PbSn solder bump placed on the chip. This indicates that the bonding process was successful. The results are illustrated in Figures 3a, 3b, and 3c. We performed the flip-chip and bonding processes on the ATLAS FEI3 chip to ATLAS pixel sensor as mechanical samples since both the chips and the sensors were not operational. From these tests, which were done by late 2008, we achieved a better than 99% yield of good pixel contact per sensor

To further consolidate our know-how of the flip-chip the bump-bonding processes, IFAE and CNM submitted a successful, one year project proposal for the FPA program, Plan-Nacional 2009, to continue the same R&D and to extend it to active devices such as Medipix2 chip and its pixel Si sensor as well as to bump-bond the ATLAS pixel chip FEI3 to the ATLAS pixel sensor using PbSn and SnAg solder bumps. We expect in 2009 to report very good news on this front since we have achieved excellent results in 2008 with mechanical samples for both Medipix2 and ATLAS FEI3 assemblies.

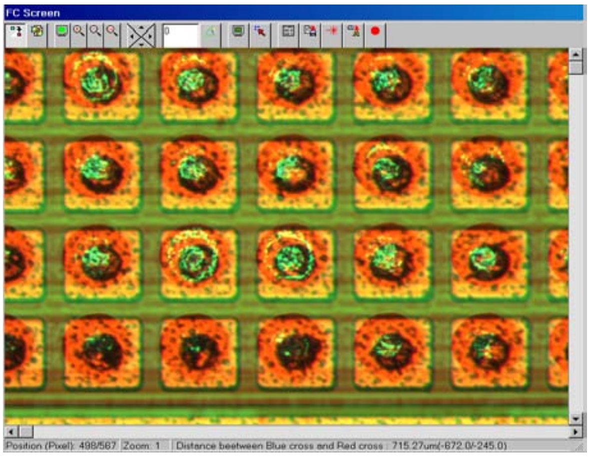

Figure 3a ˙The superimposed images from the FC150 of both the substrate (in red) and the chip (in green) aligned after the detaching step. The field of view is limited to 4x 6 pixels of 55um in pitch.

Nuclear Medicine

In 2008, a new line of research in medical imaging started in IFAE with a focus on Nuclear medicine in general and Positron Emission Tomography (PET) in particular. A novel PET conceptual design was conceived and a.patent application was submitted. The new PET design is based on a pixellated High Z Solid State detector in which one will be able to detect the 511 keV photons with excellent energy resolution

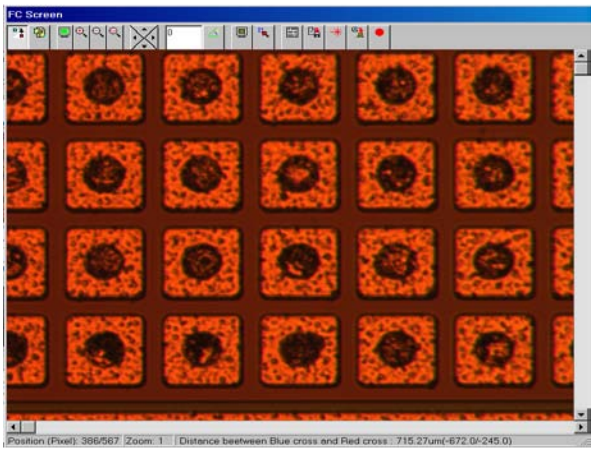

Figure 3b The image of the same field of view as in Figure 3a, but only the substrate is visible. One can see the dark color inside the each pixel pads indicating that those pads have been stained by the PbSn bumps.

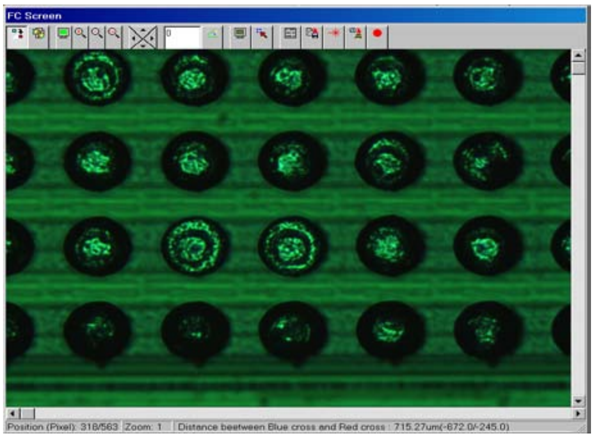

Figure 3c The same as in Figure 3b but here only the image of chip with the bumps is visible. One can see that each of the PbSn bumps has been smacked.

When using CdTe, for example, it is possible to achieve an energy resolution of 1% FWHM and this will allow us to eliminate scattered photons which have lost more than 5keV. This will allow keeping only the highest quality events for image reconstruction. The new PET device has many

advantages with respect to ordinary crystal PET devices especially when it comes to the Signal to Noise Ratio (SNR), which we expect to be around 30 times better than that of an ordinary PET device. Simulation studies using Geant4, carried out by the CIEMAT team (P. Arce et al.) found that such a PET device can achieve the same effective spatial resolution with 25 times less radiation dose when compared to a crystal PET. This new PET device is very compact in geometry and immune to any magnetic field, thus it will be an ideal device for brain imaging with dual modality MRI+PET. Furthermore, the design can be extended to SPECT and other types of Gamma cameras with spectroscopic energy resolution and no parallax effect since it is a true 3D sensor detector, as shown in Figure 4a, 4b, and 4c.
IFAE, CIEMAT and Centro Nacional de Microelectrónica (CNN-IMB) have agreed to collaborate on a project to develop a few modules to prove the concept in the coming years

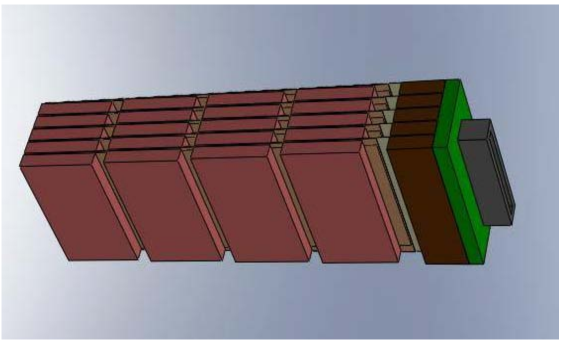

Figure 4a An example of one module of pixellated PET detector of CdTe. Its approximate dimensions are 11mm x 20mm x 50mm and it has 5000 voxels each 1mm x1mmx2mm.

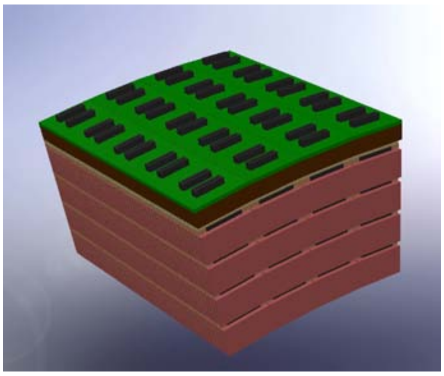

Figure 4b An example of one super module of pixellated PET detector of CdTe. Its approximate dimensions are 80mm x 50mm x 100mm and it has 160000 voxels each is 1mm x1mmx2mm dimensions

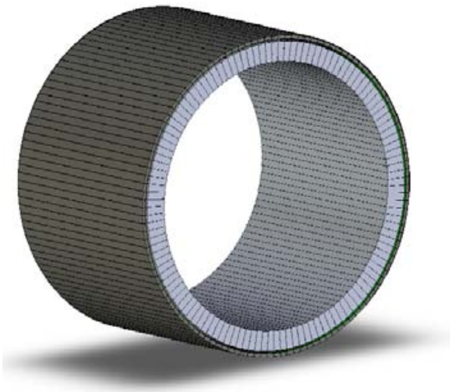

Figure 4c An example of a full PET scanner made of pixellated CdTe detectors

Spin-off

X-ray Imatek SL (XRI) is an IFAE spin-off, and was created in 2006 to exploit the results of Dear-Mama, an EU-FP5 funded project. Currently it is based on the premises of IFAE with the support of the IFAE governing board, and the UAB technology transfer office. The scope and the profile of X-Ray Imatek were highly evaluated by both CDTI and CIDEM. In 2008 IFAE allocated resources to help XRI in the development of an industrial prototype of Dear-Mama detector. IFAE has built the Motherboard that holds an array of the Medipix2 sensors, see Figure. 5, and the box that houses it with relevant components as one can see in Figure 6.

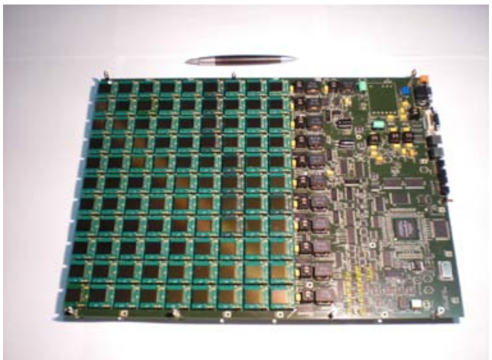

Figure 5 The motherboard of the Dear-Mama machine which was designed by IFAE. It holds an array of Medipix2 sensors to make 30cm x 24cm mammography images.

While XRI is waiting for its dedicated mammography machine which is designed specifically to fit the industrial Dear-Mama detector, expected in early 2010, IFAE has built at its mechanical workshop a simple X-ray machine, to allow XRI to evaluate the basic parameters of the Dear-Mama detector as one can see in Figure 6. More information can be found at www.xray-imatek.com.

Figure 6 A simple mammography X-ray system that provides a simple platform for evaluating the Dear-Mama detector.

5.9 Standard Model

(Joaquim Matias)

Duality Violations (DVs) represent the failure of the Operator Product Expansion to describe QCD correlators on the physical axis. Although it has never been thoroughly analyzed, this complication affects the determination of α_S in hadronic τ decays. After introducing a physically motivated *ansatz* for duality violations, we estimate their possible size by fitting this *ansatz* to the τ experimental data provided by the ALEPH collaboration.

The quality of the fit turns out to be better than expected. Contrary to a rather common belief, our conclusion is that these data do not exclude significant duality violations in τ decay. This may imply an additional systematic error in the value of $\alpha_S(m_\tau)$, extracted from τ decay, which we estimate to be as large as $\alpha_S(m_\tau) \sim 0.003 - 0.010$.

LHC requires, now more than ever, a permanent effort to re-think our strategies in order to disentangle QCD from New Physics effects. Precision in Flavour Physics is essential but useless if the real experimental sensitivity at LHCb is not explored. This is the framework for the second research line developed in collaboration between a theoretical and an experimental group: the construction and analysis of a set of new observables, called AT2, AT3 and AT4 based on the K* spin amplitudes of the golden decay channel $B \to K^*(\to K\pi)l^+l^-$. We focused in the low-dilepton mass region using the QCD Factorization approach at NLO.

These observables represents a new approach in the field, because they are not only sensitive to the presence of New Physics, by minimizing the impact of hadronic uncertainties, but they also give hints on specific types of New Physics, especially those driven by the right-handed currents. Moreover, we explore the experimental sensitivities at LHCb (10 fb^{-1}) and Super-LHCb (100 fb^{-1}) based on a full angular fit method. One of the most interesting observables is AT2, which basically measures the interference between the

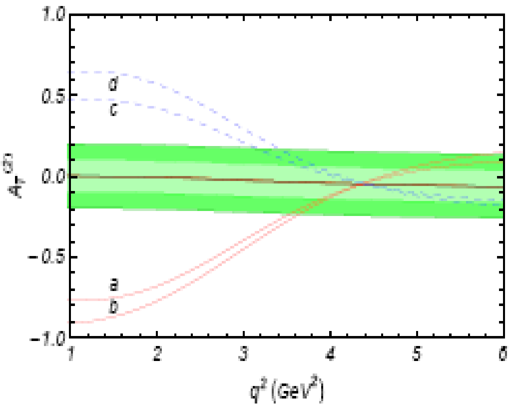

Figure.1 AT2 as a function of the squared dimuon mass. Green bands are the SM prediction at NLO in QCDF including Lambda/mb corrections. The curves labelled a-d correspond to different SUSY scenarios.

perpendicular and parallel spin amplitudes of the K* in the above mentioned decay.
It has driven a lot of experimental attention, and is shown in Figure 1

Recent claims of tensions between the measurement of the weak mixing angle of the B_s/anti-B_s system and its SM prediction led us to develop three different strategies to extract this weak mixing phase ϕ_s using $B \to VV$ decays ($B_s \to K^*$ anti-K^*, $B_s \to \phi$ anti-K^* and $B_s \to \phi\phi$). These penguin-mediated decays are computed in the framework of a new combined QCD-Factorisation/Flavour Symmetry Method. This constitutes our third research line. The determination of α_S from hadronic τ decays was revisited in our fourth line of research, with a special emphasis on the question of higher-order perturbative corrections and different possibilities of resumming the perturbative series with the renormalization group: fixed-order (FOPT) vs. contour-improved perturbation theory (CIPT). The two approaches lead to systematic differences in the resulting α_S. On the basis of a model for higher-order terms in the perturbative series, which incorporates well-known structure from renormalons, it is found that while CIPT is unable to account for the fully resummed series, FOPT smoothly approaches the Borel sum. From the comparison to the total τ hadronic width, in FOPT one then finds $\alpha_S(M_Z)$ = 0.1185+0.0014-0.0009.

In the context of hadronic τ decays, recent experimental data for the differential decay distribution of the decay $\tau^- \to \nu_\tau K_S \pi^-$ by the Belle collaboration are described by a theoretical model which is composed of the contributing vector and scalar form factors $F_+^{K\backslash\pi}$ (s) and $F\_^{K\backslash\pi}$ (s). Both form factors are constructed such that they fulfill constraints posed by analyticity and unitarity. A good description of the experimental measurement is achieved by incorporating two vector resonances and working with a three-times subtracted dispersion relation in order to suppress higher-energy contributions. The resonance parameters of the charged K*(892) meson can be extracted, with the result M(K*) = 892.0 ± 0.9 MeV and Γ_{K*} = 46.2 ± 0.4 MeV. Finally, employing the thrice-subtracted dispersion relation allows to determine the slope and curvature parameters of the vector form factor $F_+^{K\backslash\pi}$ (s) directly from the data.

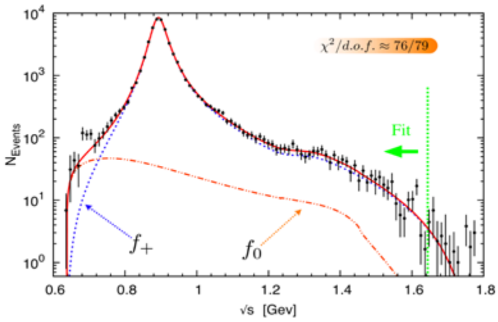

Figure 2 *Main fit result to the Belle data for the differential decay distribution of the decay $\tau^- \to \nu_\tau K_S \pi^-$. The full fit including vector form factor and scalar form factor is displayed as the solid line. The separate vector and scalar contributions are shown as the dashed and dotted lines respectively.*

while improving the prediction with the help of the model yields $\alpha_S(M_Z)$ = 0.1180+-0.0008.

Finally, the last line of research focuses on deep inelastic scattering in the't Hooft model. Being solvable, this model allow to directly compute the moments associated with the cross section at next-to-leading order in the $1/Q^2$ expansion. The same computation is performed using the operator product expansion and it was found that all the terms match in both computations except for one in the hadronic side, which is proportional to a non-local operator. The basics of the result suggest that a similar phenomenon may occur in four dimensions in the large N_c limit.

5.10 Beyond the Standard Model

(José Ramón Espinosa)

The main goal of our research in Physics Beyond the Standard Model (BSM) is to explore extensions of the Standard Model (SM) proposed to supersede it at the TeV scale and therefore testable at the LHC. We focus our efforts in particularly well motivated scenarios or in models that lead to unconventional collider signals. We also apply BSM techniques like AdS/CFT to better understand QCD. During 2008 we have made progress along the following lines:

Unparticles

Recently there has been a lot of interest in the phenomenology of extensions of the Standard Model with an extra sector which becomes conformally invariant in the infrared. Although there is no direct theoretical motivation to assume that such a sector exists, conformal symmetry is a paradigmatic example of a symmetry that can emerge in the infrared due to quantum corrections and when such sector is coupled to the SM very unconventional signals are expected at colliders as the new sector is not describable in terms of the usual particle language (thus the name of unparticle stuff).

We have focused on the very relevant case of a coupling between the SM Higgs and a scalar unparticle operator of non-integer dimension $d < 2$. We have shown how electroweak symmetry breaking can be affected and how a mass gap in the unparticle sector (which can be described as a continuum tower of scalar fields) is generated due to such coupling. We also find that the spectrum can contain an unparticle pole reminiscent of a plasmon resonance that mixes with the SM Higgs (which is made much broader), leading to two resonances with Higgs properties (see Figure 1). Such unparticle features could be explored experimentally through their mixing with the Higgs.

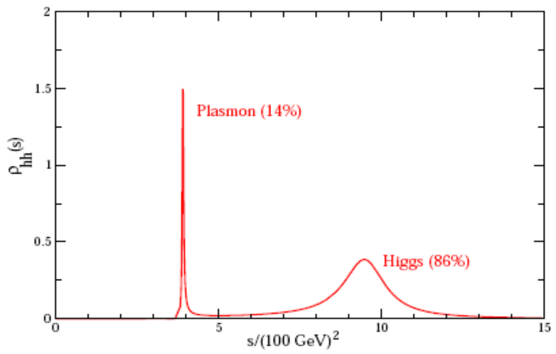

Figure.1: Spectral function showing a plasmonic Unparticle resonance mixed with a broad Higgs as a result of a Higgs-Unparticle coupling. The percentage of Higgs composition of each resonance is given in parenthesis.

We also find that in some cases a new isolated state can generically appear in the spectrum near or below the mass gap. Such a state (which we call phantom Higgs) is a mixture of Higgs and unparticles and therefore has universally reduced couplings to fermions and gauge bosons. This phenomenon could cause the mass of the lightest Higgs state accessible at colliders to be much smaller than the mass expected from the SM Lagrangian.

Coupling of unparticle operators to Standard Model particles opens up the possibility of unparticle decays into standard model fields. We studied this issue by analyzing the pole structure (and spectral function) of the unparticle propagator finding an isolated pole below the unparticle mass gap (showing that the theory would be unstable without a mass gap). If that pole lies below the threshold for decay into two standard model particles the pole corresponds to a stable unparticle state (and its width is zero). For mass above threshold the width is non zero and related to the unparticle decay rate into Standard Model particles.

Alternative Neutrino Masses

We analyzed a scenario in which right-handed neutrinos make part of a strongly coupled conformal field theory and acquire an anomalous dimension $\gamma < 1$ at a large scale Λ. Their Yukawa couplings become irrelevant at the fixed point and they are suppressed at low scales giving rise naturally to a small (sub-meV) Dirac neutrino mass which breaks the conformal invariance. Neutrino Yukawa couplings can be sizable at electroweak scales and therefore the invisible decay of the Higgs in the ν - anti ν channel can be comparable to the c - anti c and τ - anti τ modes leading to an interesting Higgs phenomenology. If lepton number is violated in the conformal theory an irrelevant Majorana mass operator for right-handed neutrinos appears for $\gamma > ½$ giving rise to an inverse see-saw mechanism. In this case light sterile neutrinos do appear and neutrino oscillation experiments are able to probe our model.

We also investigated the nature (Dirac vs. Majorana) and size of left-handed neutrino masses in a supersymmetric 5D model compactified in the interval $[0,\pi R]$, where quarks and leptons are localized on the boundaries while the gauge and Higgs sectors propagate in the bulk of the fifth dimension. Supersymmetry is broken by Scherk-Schwarz boundary conditions and electroweak breaking proceeds through radiative corrections. Right-handed neutrinos propagate in the bulk and have a general 5D mass M, which localizes the zero modes towards one of the boundaries, and arbitrary boundary terms. We found that for generic boundary terms left-handed neutrinos have Majorana masses. However for specific boundary configurations left-handed neutrinos are Dirac fermions as the theory possesses a conserved global U(1) symmetry which prevents violation of lepton number. The size of neutrino masses depends on the localization of the zero-modes of right-handed neutrinos and/or the size of the 5D neutrino Yukawa couplings. Left-handed neutrinos in the sub-eV range require either MR~10 or Yukawa couplings $\sim 10^{-3}$R, which make the 5D theory perturbative up to its natural cutoff.

Composite top and Higgs

In models of electroweak symmetry breaking in which the SM fermions get their masses by mixing with composite states, it is natural to expect the top quark to show properties of compositeness. We have studied the phenomenological viability of having a mostly composite top. We have shown that present experimental constraints can allow for a high degree of top compositeness. We have also studied the implications of having a composite top at the LHC, focusing on the process $pp \to t$ - anti t t - anti t (b - anti b) whose cross-section is enh hanced at high-energies.

We have also studied models of electroweak symmetry breaking based on a composite Higgs boson. These scenarios have been investigated in the framework of 5D warped models that, according to the AdS/CFT correspondence, have a 4D holographic interpretation in terms of strongly coupled field theories. We have explored the implications of these models at the LHC.

AdS/QCD

In a simple holographic model for QCD in which the Chern-Simons term is incorporated to take into account the QCD chiral anomaly, we have shown that baryons arise as stable solutions which are the 5D analogs of 4D skyrmions. We have performed a numerical determination of several static properties of the nucleons and have found satisfactory agreement with data.

5. 11 Astroparticles/Cosmology

(Eduard Massó)

The general goal of this research line is to study some of the theoretical issues in the physics of elementary particles and their interactions, particularly when they take place in an astrophysical or cosmological medium. In these media one has processes that are suppressed in laboratory conditions, or at least they occur differently. Thus, the results that we obtain in our research complement and enrich the information obtained in laboratory experiments. In fact, flow goes both ways: data from laboratory experiments can illuminate the physics of some of the aspects of star and universe evolution.

Our work is phenomenology-oriented and thus it is intimately linked to experiments, both laboratory-type (high energy accelerators as LEP and LHC at CERN, low energy detectors, etc.) and observational (ground-based and satellite borne telescopes, etc).

It is very widely recognized that the fields of Astroparticles and Particle Cosmology are in progressive expansion. One major discovery has been neutrino oscillations, detected from the analysis of atmospheric and solar neutrinos. This is very important for neutrino physics, in which we have been involved since many years and is one of the main activities of our group. Other recent discoveries with impact in our field refer to the anisotropies of the microwave background, and the determinations of distances to supernovas. The emerging scenario from the analysis of all these observations is very interesting, and one is faced by very fundamental questions. With our research we would like to contribute to these developments.

We list our main research efforts in 2008:

1) We have examined the gravitational properties of Lamb shift energies. Using available experimental data we showed that these energies have a standard gravitational behavior at the level of $\approx 10^{-5}$. We are motivated by the point of view that Lamb shift energies may be interpreted as a consequence of vacuum fluctuations of the electromagnetic field, since in this case we are testing the gravitational properties of quantum fluctuations. Our result might be of interest in relation to the problem of the zero-point energy contribution to the cosmological constant. Indeed, the problem presupposes that the zero-point energy gravitates as all other forms of energy, and this supposition is what we test.

2) Electroweak baryogenesis provides an attractive explanation of the origin of the matter-antimatter asymmetry that relies on physics at the weak scale and thus is testable at present and near future high-energy physics experiments. Although this scenario may not be realized within the Standard Model, it can be accommodated within the MSSM provided there are new CP-violating phases and the lightest stop mass is smaller than the top quark mass. In this work we provide an evaluation of the values of the stop ($m_{\tilde{t}}$) and Higgs (m_H) masses consistent with the requirements of electroweak baryogenesis based on an analysis that makes use of the renormalization group improved Higgs and stop potentials, and including the dominant two-loop effects at high temperature. We find an allowed window in the ($m_{\tilde{t}}$, m_H) plane, consistent with all present experimental data, where there is a strongly first-order electroweak phase transition and where the electroweak vacuum is metastable but sufficiently long-lived. In particular we obtain absolute upper bounds on the Higgs and stop masses, $m_H \leq 127$ GeV and $m_{\tilde{t}} \leq 120$ GeV, implying that this scenario will be probed at the LHC.

3) We have discussed some cosmological implications of extensions of the Standard Model with hidden sector scalars coupled to the Higgs boson. We put special emphasis on the conformal case, in which the electroweak symmetry is broken radiatively with a Higgs mass above the experimental limit. Our refined analysis of the electroweak phase transition in this kind of models strengthens the prediction of a strongly

first-order phase transition as required by electroweak baryogenesis. We further studied gravitational wave production and the possibility of low-scale inflation as well as of a viable dark matter candidate.

4) Electroweak baryogenesis in the minimal supersymmetric extension of the Standard Model may be realized within the light stop scenario, where the right-handed stop mass remains close to the top quark mass to allow for a sufficiently strong first order electroweak phase transition. All other supersymmetric scalars are much heavier to comply with the present bounds on the Higgs mass and the electron and neutron electric dipole moments. Heavy third generation scalars render it necessary to resum large logarithm contributions to perform a trustable Higgs mass calculation. We have studied the one--loop RGE-improved effective theory below the heavy scalar mass scale and obtained reliable values of the Higgs mass. Moreover, assuming a common mass $\tilde{m}$ for all heavy scalar particles, and values of all gaugino masses and the Higgsino mass parameter about the weak scale, and imposing gauge coupling unification, a two-loop calculation yields values of the mass $\tilde{m}$ in the interval between three TeV and six hundred TeV. Furthermore for a stop mass around the top quark mass, this translates into an upper bound on the Higgs mass of about 150 GeV. The Higgs mass bound becomes even stronger, about 129 GeV, for the range of stop and gaugino masses consistent with electroweak baryogenesis. The collider phenomenology implications of this scenario are discussed in some detail.

5) During a strongly first-order phase transition gravitational waves are produced by bubble collisions and turbulent plasma motion. We analyzed the relevant characteristics of the electroweak phase transition in the nMSSM to determine the generated gravitational wave signal. Additionally, we have worked on correlations between the production of gravitational waves and baryogenesis. We concluded that the gravitational wave relic density in this model is generically too small to be detected in the near future by the LISA experiment. We also considered the case of a "Standard Model" with dimension-six Higgs potential, which leads to a slightly stronger signal of gravitational waves.

6) We discuss scalar triplet leptogenesis in a specific left-right symmetric seesaw model. We show that the Majorana phases that are present in the model can be effectively used to saturate the existing upper limit on the CP-asymmetry of the triplets. We solve the relevant Boltzmann equations and analyze the viability of triplet leptogenesis. It is known for this kind of scenario that the efficiency of leptogenesis is maximal if there exists a hierarchy between the branching ratios of the triplet decays into leptons and Higgs particles. We show that triplet leptogenesis typically favors branching ratios with not too strong hierarchies, since maximal efficiency can only be obtained at the expense of suppressed CP-asymmetries.

7) We reexamine the production of gravitational waves by bubble collisions during a first-order phase transition. The spectrum of the gravitational radiation is determined by numerical simulations using the "envelope approximation". We find that the spectrum rises as $f^{3.0}$ for small frequencies and decreases as $f^{-1.0}$ for high frequencies. Thus, the fall-off at high frequencies is significantly slower than previously stated in the literature. This result has direct impact on detection prospects for gravity waves originating from a strong first-order electroweak phase transition at space-based interferometers, such as LISA or BBO. In addition, we observe a slight dependence of the peak frequency on the bubble wall velocity.

8) We assume the validity of the Standard Model up to an arbitrary high-energy scale and discuss what information on the early stages of the Universe can be extracted from a measurement of the Higgs mass. For $M_H < 130$ GeV, the Higgs potential can develop an instability at large field values. From the absence of excessive thermal Higgs field fluctuations we derive a bound on the reheating temperature after inflation as a function of the Higgs and top masses. Then we discuss the interplay between the quantum Higgs fluctuations generated during the primordial stage of inflation and the cosmological perturbations, in the context of landscape scenarios in which the inflationary parameters scan. We show that, within the large-field models of inflation, it is highly improbable to obtain the observed cosmological perturbations in a Universe with a light Higgs. Moreover, independently of the inflationary model, the detection of primordial tensor perturbations through the B-mode of CMB polarization and the discovery of a light Higgs can simultaneously

occur only with exponentially small probability, unless there is new physics beyond the Standard Model.

9) We use cosmic microwave background and large scale structure data to test a broad and physically well-motivated class of inflationary models: those with flat tree-level potentials (typical in supersymmetry). The non-trivial features of the potential arise from radiative corrections which give a simple logarithmic dependence on the inflaton field, making the models very predictive. We also consider a modified scenario with new physics beyond a certain high-energy cut-off showing up as non-renormalizable operators (NRO) in the inflaton field. We find that both kinds of models fit remarkably well CMB and LSS data, with very few free parameters. Besides, a large part of these models naturally predict a reasonable number of e-folds. A robust feature of these scenarios is the smallness of tensor perturbations ($r < 10^{-3}$). The NRO case can give a sizeable running of the spectral index while achieving a sufficient number of e-folds. We use Bayesian model comparison tools to assess the relative performance of the models. We believe that these scenarios can be considered as a standard physical class of inflationary models, on a similar footing with monomial potentials.