ANNUAL REPORT
2012

INTER-UNIVERSITY INSTITUTE
FOR HIGH ENERGIES

UNIVERSITÉ LIBRE DE BRUXELLES,
UNIVERSITÉ D'EUROPE

Vrije Universiteit Brussel

ANNUAL REPORT
2012

J. D'Hondt – P. Marage
Directors

http://www.iihe.ac.be

Table of Contents

I. Introduction

1. The Interuniversity Institute for High Energies (ULB-VUB)

The IIHE (ULB-VUB) was created in 1972 at the initiative of the academic authorities of the Université Libre de Bruxelles and the Vrije Universiteit Brussel. It is devoted to experimental research in elementary particle physics, using mainly high energy particle accelerators, and, more recently, in astroparticle physics with non-accelerator experiments.

The main goal of the experiments at accelerators, notably the CERN LHC, is the understanding of the strong, electromagnetic and weak interactions between the elementary building blocks of matter, which forms the standard model of particle physics, precision measurements of its parameters, the search for missing pieces in the standard model (notably the Brout-Englert-Higgs boson and neutrino oscillations), and the search for physics beyond the standard model, possibly related to the dark matter in the Universe.

Astroparticle physics is devoted to the study of the structure of the Universe, using the techniques developed in particle physics. All these experiments are performed in the framework of large to very large international collaborations (several hundred to several thousand physicists and engineers).

Fundamental contributions to the understanding of the Universe, particle and astroparticle physics experiments imply major R&D developments concerning particle detectors, computing and networking systems, frontier technologies in various fields (electronics, superconductivity, cryogenics, etc.), with lead to break-through progress in industrial and medical applications.

2. Overview of research at the IIHE in 2012 : a Grand Cru year

The present report presents the research performed at the IIHE in 2012, the year during which the inter-university institute celebrated its 40th anniversary and published with its national and international research partners about 130 journal papers.

In a research field where large infrastructures are carefully prepared during years or even decades, the year 2012 came as a *Grand Cru* year for the IIHE. The major research effort using accelerators has been devoted in 2012 to activities within the CMS collaboration at the CERN proton-proton Large Hadron Collider, in Geneva. Since the early 1990's, IIHE teams have actively contributed designing, building, operating and maintaining the CMS detector, in particular through the construction – in collaboration with other Belgian and international teams – of the inner tracking detector. Since the first collisions in 2009, the LHC has performed extremely well, with steadily increasing luminosity, and the data accumulated in 2012 at 8 GeV centre of mass energy proton-proton interactions have led to numerous scientific publications, as listed in this report.

The design of the CMS experiment was focused on the search for the scalar boson, the Brout-Englert-Higgs boson. Due to the successful data-taking and detailed understanding of the instrument, the CMS Collaboration together with the ATLAS Collaboration announced on July 4th 2012 that in the search for the Brout-Englert-Higgs boson a discovery of a new boson was made with a mass around 125 GeV. The press release from the CMS Collaboration is added in this introduction. This major achievement was quoted "Breakthrough of the Year 2012" by Science magazine. The groundbreaking research performed together with our national and international partners is recognized by the scientific community and during numerous occasions communicated to the society.

In addition to operational activities around the detector and its continuous survey and calibration, the Brussels team in CMS contributed to physics analyses in mainly four directions: (i) the search for the Brout-Englert-Higgs boson decaying in a pair of τ leptons and the study of multiboson production; (ii) top quark physics, including measurements of the standard model parameters and searches for effects beyond the standard model, in particular from supersymmetry; (iii) the search for new heavy resonances, as expected from several approaches beyond the standard model, notably grand unified theories and models with extra space dimensions; (iv) the study of the underlying event in hard interactions, in particular neutral strange particle production.

The H1 experiment at the HERA electron-proton collider DESY at Hamburg has taken data from 1992 to 2007, with major contributions of the IIHE team to detector building, operating and upgrading, in particular through the conception and installation in 2002 of the very forward proton spectrometer (VFPS), devoted to the detailed measurement of diffractive interactions. Since the accelerator shut-down in 2007, the data analysis by the H1 collaboration is steadily continuing, with the Brussels group very actively involved in the analysis of the VFPS

data, providing a new insight of Quantum Chromodynamics in the transition region from soft to hard interactions.

The OPERA experiment collected data until December 2012 accumulating in total about 16500 neutrino interactions in the target detector of which about 5800 have been located so far and 4700 fully analyzed. With these data the OPERA experiment aims to study the neutrino oscillation rate of muon-neutrinos to τ-neutrinos through the identification of τ-leptons. The detector is installed in the underground Grans Sasso Laboratory (LNGS) and exposed to the CNGS neutrino beam produced at CERN, 730 km away.

In the field of astroparticles, the IIHE has been involved in the search and measurement of interactions of ultra-high energy neutrinos from cosmic origin in the South Pole ice, since the start of this quest in the late 1990's with the AMANDA and IceCube experiments. During the year 2012 the fully deployment IceCube detector operated at one of the largest ever built detectors for particle astrophysics, including the Deep Core extension, with more densely placed detectors, aimed at extending the detection capacity to lower neutrino energies. The major research topics of the IIHE team are: (i) the search for cosmic point sources; (ii) the search for Dark Matter using neutrinos from WIMP particles; (iii) the detection of high-energy τ-neutrinos; (iv) the search for high-energy neutrinos from transient events; (v) the search for neutrinos from supernovae.

For the detection in the South Pole ice of "GZK" neutrinos, from the scattering of ultra-high energy cosmic rays off the cosmic microwave background, a sound-wave technique is being developed by the ARA experiment. A major activity of the IIHE group in conjunction with the R&D group of the IIHE has been the development of a digital communication circuit to permit the deployment of digitization electronics below the firn local to the antennas, under particularly stringent conditions.

Being devoted to experimental particle physics, the IIHE has always been very active in technical developments and instrumentation. This tradition points back to automatized bubble chamber and nuclear emulsion measurements, with important contributions to detectors at highest energy particle colliders (DELPHI at LEP, H1 at HERA and CMS at the LHC), in neutrino oscillation experiments (CHARM II, CHORUS, OPERA) as well as in the more recent astroparticle experiments (AMANDA, IceCube and ARA). Over the recent years, R&D activities are centred on the development of multi-purpose, very high-rate, robust and low-cost, industry-based data acquisition systems, aimed to particle and astroparticle experiments. The contributions have taken place in the framework of DAQ systems for a TPC prototype for a future linear collider detector, for the ARA experiment, and for the upgrade of the CMS muon spectrometer in the forward region. Also in the area of medical imaging techniques the IIHE keeps on contributing to the development of PET and PEM scanners.

To link the activities of their theoretical physics (TENA) and experimental particle physics (ELEM) groups, a phenomenology group has been settled by the VUB through a concerted action (GOA - Geconcerteerde OnderzoeksActies). The main topic of research is supersymmetric models and their signatures at the LHC, with in 2012 the main focus on the gravitino phenomenology at colliders as well as the implementation of new functionalities in tools like FeynRules and MadGraph/MadEvent.

Finally, large computing resources are requested by the experiments, in particular IceCube and CMS. The IceCube collaboration uses the IIHE cluster for large simulations of the complex ice optical structure. For CMS computing, a "Tier- 2" cluster installed at the ULB-VUB Computing Centre is fully integrated in the worldwide LHC computing grid, with very high performance and stability.

On November 9, 2012, all the IIHE members attended the annual meeting, held at the Business & Technology INCUBATOR (Site Arsenaal Brussels) in Brussels, where a review of the activities in the different experiments, in computing and in R&D were presented and discussed, together with the development plans for the coming years.

In 2012, the IIHE started a collaboration with the Institut de Recherche de l'Institut Supérieur Industriel de Bruxelles (IRISIB) and Ion Beam Applications S.A. (IBA) for proton therapy.

On October 19th 2012 a Symposium was organized in honour of Prof. Robert Roosen "A deeper look into matter" to celebrate his retirement. The announcement poster is added to this introduction. Together with international experts the rich career of Robert was illustrated from his *Licentiaat* in 1970 and his PhD degree in 1977 until his contributions to the H1 experiment at the HERA collider at DESY. In the H1 experiment he had a major role in the Belgian efforts ranging from constructing the instrument to the analysis of the collision data. The IIHE warmly thanks Robert for his invaluable contributions to the research of the institute that had an important international impact.

The research activities at the IIHE and the responsibilities of IIHE physicists in the experiments are further detailed below. These activities have led to the publication of numerous scientific articles, conference reports and technical notes.

3. IIHE funding

Research at IIHE has been supported by the Université Libre de Bruxelles (ULB), the Vrije Universiteit Brussel (VUB), the Fonds de la Recherche Scientifique (F.R.S-FNRS), the Fonds voor Wetenschappelijk Onderzoek-Vlaanderen (FWO), the Fonds pour la Formation à la Recherche dans l'Industrie et dans l'Agriculture (FRIA), the Instituut voor de Aanmoediging van Innovatie door Wetenschap en Technologie in Vlaanderen (IWT), the Belgian Federal Science Policy Office, the Odysseus programme and the European Union (FP7).

The IIHE is part of a newly approved (March 2012) IAP on "Fundamental Interactions" with a starting date in 2013. It is a grouping of several teams in Belgium working on the experimental, phenomenological and theoretical aspects of high-energy physics. The purpose of this IAP is to improve our understanding of fundamental interactions through a closer collaboration between Belgian research teams.

In 2012, the IIHE started a collaboration with IRISIB and IBA.

4. The IIHE team in 2012

a. ULB personnel

Academic and scientific personnel

Patrizia BARRIA	IISN Post-doc since June	CMS, DAQ R&D
Sabrina BECHET	Van Buren grant; PhD student until November	IceCube
Daniel BERTRAND	Directeur de Recherche F.R.S.-FNRS; Past IIHE co-director; Honorary, and Professeur de l'Université	Icecube
Cécile CAILLOL	Aspirant F.R.S.-FNRS since October	CMS
Federico CECCOPIERI	Collaborateur scientifique since July	H1
Barbara CLERBAUX	Maître de Recherche F.R.S.-FNRS; Part-time Chargée de Cours	CMS
Gilles DE LENTDECKER	Chercheur Qualifié F.R.S.-FNRS; Maître d'Enseignement	CMS, DAQ R&D
Valérie DE SMET	FREDONE PhD student, since July	Instrumentation
Laurent FAVART	Maître de Recherche F.R.S.-FNRS; Part-time Chargé de Cours	H1, CMS
Arnaud GAY	Chargé de Recherche F.R.S.-FNRS	CMS
Kael HANSON	Chargé de Cours IceCube	ARA
David HEEREMAN	IISN PhD student	IceCube
VON ZUYDTWYCK		
Tomas HREUS	Chargé de Recherche F.R.S.-FNRS	H1, CMS
Alexandre LEONARD	Aspirant F.R.S.-FNRS	CMS
Thierry MAERSCHALK	IISN PhD student	CMS, DAQ R&D
Pierre MARAGE	Professeur ordinaire ; IIHE co-director	CMS, Hist. of Sc.
Thomas MEURES	IISN PhD student	ARA
Abdollah MOHAMMADI	IISN Post-doc since April	CMS
Geoffrey MULLIER	Chercheur libre since October	DAQ R&D
David NDAYIZEYE	PhD student, since December	Instrumentation
Aongus O'MURCHADHA	IISN Post-doc since January	IceCube, ARA
Luca PERNIE	IAP PhD student until February; IISN PhD student since March; Co-tutelle with Rome University	CMS
Yves PIERSAUX	Collaborateur scientifique	Hist. of Science
Elisa PINAT	IISN PhD student since November	IceCube
Thomas REIS	IISN PhD student	CMS
Jean SACTON	Emeritus, Professeur ordinaire; past IIHE co-director	
Tomislav SEVA	IISN Post-doc since February	CMS
Laurent THOMAS	FRIA PhD student	CMS
Raffaella TONCELLI	Collaborateur scientifique	Hist. of Science
Catherine VANDER VELDE	Professeur	CMS
Pascal VANLAER	Premier Assistant until September; Chargé de Cours since October	CMS
Erik VERHAGEN	ARC PhD student	IceCube,CMS, DAQ R&D
Pierre VILAIN	Honorary Maître de Recherche F.R.S.-FNRS; Professeur de l'Université	OPERA
Jian WANG	IISN Post-doc since February	CMS
Gaston WILQUET	Honorary Maître de Recherche F.R.S.-FNRS; Professeur de l'Université	OPERA

Florian ZENONI	IISN PhD student	CMS, DAQ R&D

Master students

Cécile CAILLOL	Civil engineer, until June	CMS
Céline DE VOS	Physics, since September	IceCube
Thomas LENZI	Physics, since September	CMS DAQ R&D
Geoffrey MULLIER	Physics, until September	CMS R&D
Julien OLAST	Civil engineer, until June	CMS
Rachel SIMONI	Physics, since September	CMS

Engineers, technical and logistic personnel

Abdelhakim BOUKIL	Computer scientist, since June
Patrick DE HARENNE	Technician, general support
Michael KORNTHEUER	Electronics, since June
Fatimé PERO	Secretariat, ½-time
Shkelzen RUGOVAC	Computer scientist
Audrey TERRIER	Secretariat, since February
Edwin. TORISAEN	Computer scientist, until June
René VANDERHAEGEN	Technician, electronics
Yifan YANG	post-doctoral logistic support, F.R.S-FNRS until February; ULB computing electronics since March

b. VUB personnel

Academic and Scientific Personnel

Freya BLEKMAN	ZAP docent	CMS
Stijn BLYWEERT	FWO scientific collaborator (PhD student)	CMS
Debanjan BOSE	FWO scientific collaborator (post-doc) until October	IceCube
Lionel BRAYEUR	FWO scientific collaborator (PhD student)	IceCube
Stijn BUITINK	FWO scientific collaborator (post-doc) until January	IceCube
Martin CASIER	FWO scientific collaborator (PhD student)	IceCube
Priscila de Aquino	GOA-ELEM scientific collaborator (post-doc) since October	Pheno
Karen DE CAUSMAECKER	GOA-ELEM scientific collaborator (PhD student) until; September;FWO aspirant (PhD student) since October	Pheno
Catherine DE CLERCQ	ZAP hoofddocent	IceCube
Olivier DEVROEDE	FWO scientific collaborator (post doc) until August , ½ time	CMS
Jorgen D'HONDT	ZAP docent; IIHE co-director	CMS
Geraldina GOLUP	FWO scientific collaborator (post-doc) since May	IceCube
Rebecca GONZALEZ SAUREZ	FWO scientific collaborator (post-doc) until October	CMS
Philip GRAJEK	GOA-ELEM scientific collaborator (post-doc)	Pheno
Alexis KALOGEROPOULOS	FWO scientific collaborator (PhD student)	CMS
James KEAVENEY	FWO scientific collaborator (post-doc) until September; FWO Pegasus Marie-Curie research fellow since October	CMS
Jan KUNNEN	FWO scientific collaborator (PhD student)	IceCube
Mathieu LABARE	FWO scientific collaborator (post-doc)	IceCube
Joris MAES	Scientific collaborator (voluntarily) until April	CMS
Michael MAES	FWO scientific collaborator (PhD student)	CMS
Kentarou MAWATARI	GOA-TENA scientific collaborator (post-doc)	Pheno
Jon MILLER	FWO scientific collaborator (post-doc) since February	IceCube
Bettina OEXL	GOA-TENA scientific collaborator (PhD student)	Pheno
Annik OLBRECHTS	FWO scientific collaborator (PhD student)	CMS
Quentin PYTHON	FWO scientific collaborator (PhD student) since October	CMS
Robert ROOSEN	FWO onderzoeksdirecteur until March, Emeritus since April	H1
Erik STRAHLER	FWO scientific collaborator (post-doc) until June	IceCube
Stefaan TAVERNIER	Professor-emeritus	Crystal Clear CMS
Walter VAN DONINCK	FWO onderzoeksdirecteur, on leave of absence at CERN	CMS
Nick VAN EIJNDHOVEN	ZAP gewoon hoogleraar	IceCube
Petra VAN MULDERS	FWO scientific collaborator (post-doc) until September; FWO research fellow since October (postdoct)	CMS
Gerrit VAN ONSEM	FWO scientific collaborator (PhD student)	CMS

Master students

Ben DUMOULIN	Physics, until July	IceCube
Kevin DEROOVER	Physics, since September	CMS
Lieselotte MOREELS	Physics, since September	CMS

Isis VAN PARIJS	Physics, since September	CMS

Engineers, Technical and Logistic Personnel

Jan DEBRUYNE	Technician, general support, ½ time
Olivier DEVROEDE	Computer scientist since September
Stephane GERARD	Computer scientist - VSC
Marleen GOEMAN	Bookkeeping and secretariat
Abdelhak OUCHENE	Computer technician
Rosette VANDENBROUCKE	Computer scientist - VSC
Luc VAN LANCKER	Mechanical engineer

c. Associated institutes

The following members of the Particle Physics Group of Antwerp University (UA) have been working in close collaboration with the IIHE Institute:

Prof. Em. Dr. Eddi De Wolf, Prof. Dr. Pierre Van Mechelen, Prof. Dr. Nick Van Remortel, Prof. Dr. Albert De Roeck, Prof. Dr. Hannes Jung, Dr. Sunil Bansal, Dr. Igor Cherednikov , Dr. Dr. Xavier Janssen, Dr.Joris Maes (until 30/04/2012), Dr. Benoit Roland, Dr. Zlatka Staykova (until 29/02/2013), Sara Alderweireldt (FWO aspirant), Tom Cornelis, Sten Luyckx, Tom Mertens, Luca Mucibello (until 31/08/2012), Michele Selvaggi (until 30/06/2012), Romain Rougny (until 31/08/2013), Frederik Van Der Veken, Alex Van Spilbeeck, Hans Van Haevermaet, Ir. Wim Beaumont, Ir. Eric De Langhe, Sarah van Mierlo (administrative aid).

The following members of the Particle Physics Group of Mons University (UMons) are closely associated to the IIHE activities through the Académie Wallonie-Bruxelles (ULB-UMons): Prof. Evelyne Daubie, Dr. George Kohnen, Nikita Beliy, Florence Binet, Thierry Caeberts, Martine Fracas, Joseph Hanton, Michelle Lefebvre, Francis Lequeux.

5. Observation of a new particle with a mass of 125 GeV

A message from Cern :
CMS Experiment, 4 July 2012

Summary

In a joint seminar today at CERN and the "ICHEP 2012" conference[1] in Melbourne, researchers of the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC) presented their preliminary results on the search for the standard model (SM) Higgs boson in their data recorded up to June 2012.

CMS observes an excess of events at a mass of approximately 125 GeV[2] with a statistical significance of five standard deviations (5 sigma)[3] above background expectations. The probability of the background alone fluctuating up by this amount or more is about one in three million. The evidence is strongest in the two final states with the best mass resolution: first the two-photon final state and second the final state with two pairs of charged leptons (electrons or muons). We interpret this to be due to the production of a previously unobserved particle with a mass of around 125 GeV.

The CMS data also rule out the existence of the SM Higgs boson in the ranges 110-122.5 GeV and 127-600 GeV with 95% confidence level[4] – lower masses were already excluded by CERN's LEP collider at the same confidence level.

Within the statistical and systematic uncertainties, results obtained in the various search channels are consistent with the expectations for the SM Higgs boson. However, more data are needed to establish whether this new particle has all the properties of the SM Higgs boson or whether some do not match, implying new physics beyond the standard model.

The LHC continues to deliver new data at an impressive rate. By the end of 2012, CMS hopes to have more than triple its total current data sample. These data will enable CMS to elucidate further the nature of this newly observed particle. They will also allow CMS to extend the reach of their many other searches for new physics.

CMS Search Strategy

CMS analysed the full data sample of proton-proton collisions collected in all of 2011 and in 2012, up until June 18. These data amount to up to 5.1 fb-1 of integrated luminosity[5], at a centre-of-mass energy of 7 TeV in 2011 and up to 5.3 fb-1 at 8 TeV in 2012.

The standard model predicts that the Higgs boson lasts for only a very short time before it breaks up, or "decays", into other well-known particles. CMS studied five main Higgs boson decay channels. Three channels result in pairs of bosonic particles ($\gamma\gamma$, ZZ or WW) and two channels result in pairs of fermionic particles (bb or $\tau\tau$), where γ denotes a photon, Z and W denote the force carriers of the weak interaction, b denotes a bottom quark, and τ denotes a τ lepton. The $\gamma\gamma$, ZZ and WW channels are equally sensitive in the search for a Higgs boson around 125 GeV and all are more sensitive than the bb and $\tau\tau$ channels.

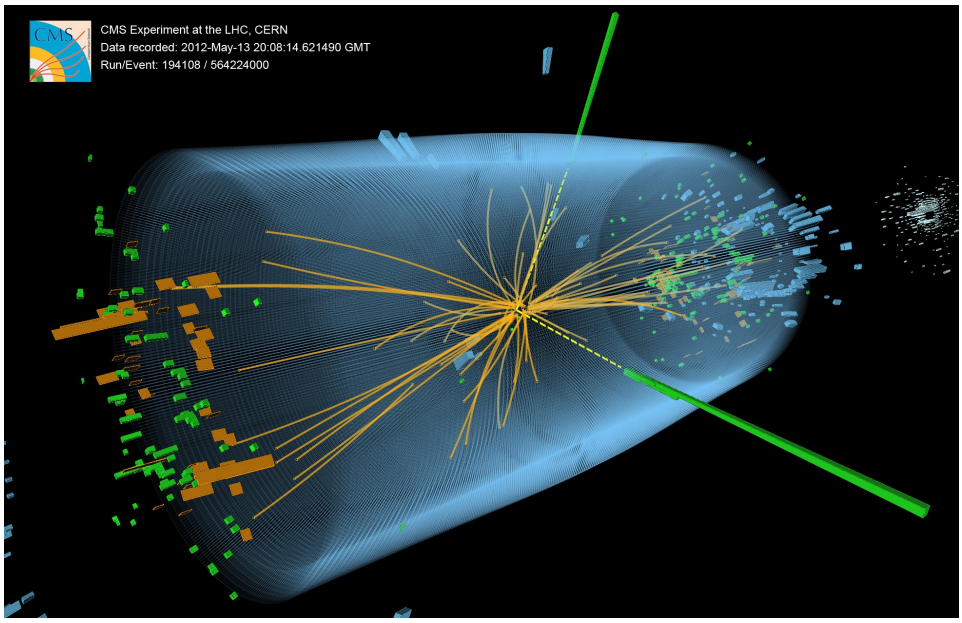


Figure 1. *Event recorded with the CMS detector in 2012 at a proton-proton centre of mass energy of 8 TeV. The event shows characteristics expected from the decay of the SM Higgs boson to a pair of photons (dashed yellow lines and green towers). The event could also be due to known standard model background processes.*

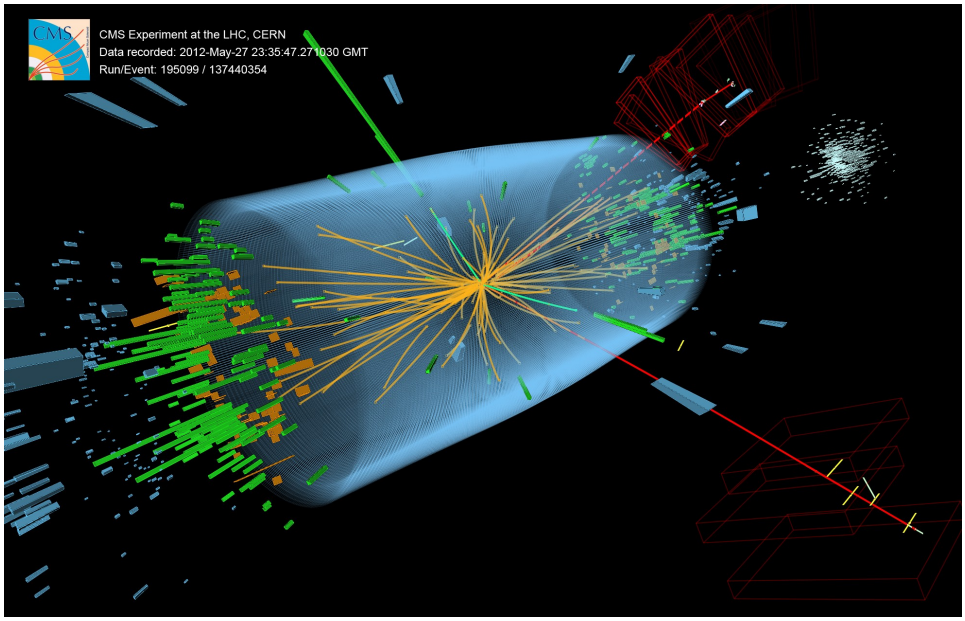


Figure 2. *Event recorded with the CMS detector in 2012 at a proton-proton centre of mass energy of 8 TeV. The event shows characteristics expected from the decay of the SM Higgs boson to a pair of Z bosons, one of which subsequently decays to a pair of electrons (green lines and green towers) and the other Z decays to a pair of muons (red lines). The event could also be due to known standard model background processes.*

The γγ and ZZ channels are especially important as they both allow the mass of the new particle to be measured with precision. In the γγ channel the mass is determined from the energies and directions of two high-energy photons measured by the CMS crystal electromagnetic calorimeter (ECAL, Figure 1). In the ZZ channel the mass is determined from the decays of the two Zs to two pairs of electrons, or two pairs of muons, or a pair of electrons and a pair of muons (Figure 2). These are measured in the ECAL, inner tracking and muon detectors.

The WW channel is more complex. Each W is identified through its decay to an electron and a neutrino or a muon and a neutrino. The neutrinos pass through the CMS detectors undetected, so the SM Higgs boson in the WW channel would manifest itself as a broad excess in the mass distribution, rather than a narrow peak. The bb channel has large backgrounds from standard model processes, so the analysis searches for events in which a Higgs boson is produced in association with a W or Z, which then decays to electron(s) or muon(s). The ττ channel is measured by observing τ decays to electrons, muons and hadrons.

CMS Results Summary

The CMS data sample should be sensitive enough to completely exclude the mass range 110–600 GeV at 95% confidence level, if the SM Higgs does not exist. In fact, the CMS data do rule out the existence of the SM Higgs boson in two broad mass ranges of 110–122.5 GeV and 127–600 GeV with 95% confidence level.

The range of 122.5–127 GeV cannot be excluded because we see an excess of events in three of the five channels analysed:

- **γγ channel**: the γγ mass distribution is shown in Figure 3. There is an excess of events above background with a significance of 4.1 sigma, at a mass near 125 GeV. The observation of the two-photon final state implies that the new particle is a boson, not a fermion, and that it cannot be a "spin 1" particle.
- **ZZ channel**: Figure 4 shows the mass distribution for the four leptons (two pairs of electrons, or two pairs of muons, or the pair of electrons and the pair of muons). Accounting also for the decay angle characteristics, it yields an excess of 3.2 sigma above background at a mass near 125 GeV.
- **WW channel**: a broad excess in the mass distribution of 1.5 sigma is observed.
- **bb and ττ channels**: no excess is observed.

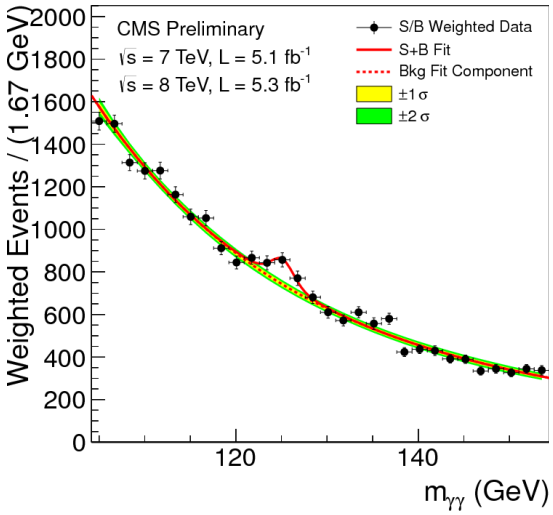


***Figure 3**. Di-photon (γγ) invariant mass distribution for the CMS data of 2011 and 2012 (black points with error bars). The data are weighted by the signal to background ratio for each sub-category of events. The solid red line shows the fit result for signal plus background; the dashed red line shows only the background.*

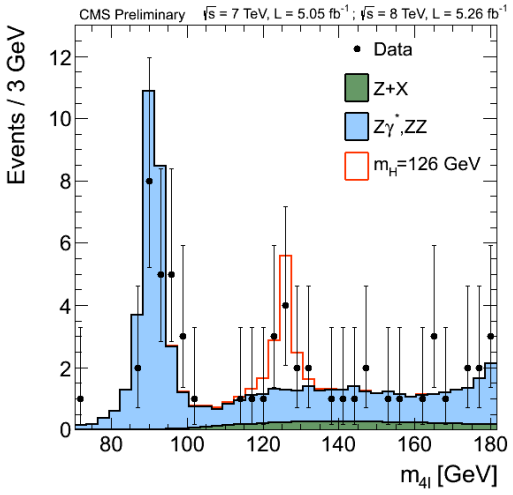


***Figure 4**. Distribution of the four-lepton reconstructed mass for the sum of the 4e, 4μ, and 2e2μ channels. Points represent the data, shaded histograms represent the background and un-shaded histogram the signal expectations. The distributions are presented as stacked histograms. The measurements are presented for the sum of the data collected at centre of mass energies of 7 TeV and 8 TeV.*

The statistical significance of the signal, from a combined fit to all five channels (Figure 5), is 4.9 sigma above background. A combined fit to just the two most sensitive and high-resolution channels (γγ and ZZ) yields a statistical significance of 5.0 sigma. The probability of the background alone fluctuating up by this amount or more is about one in three million.

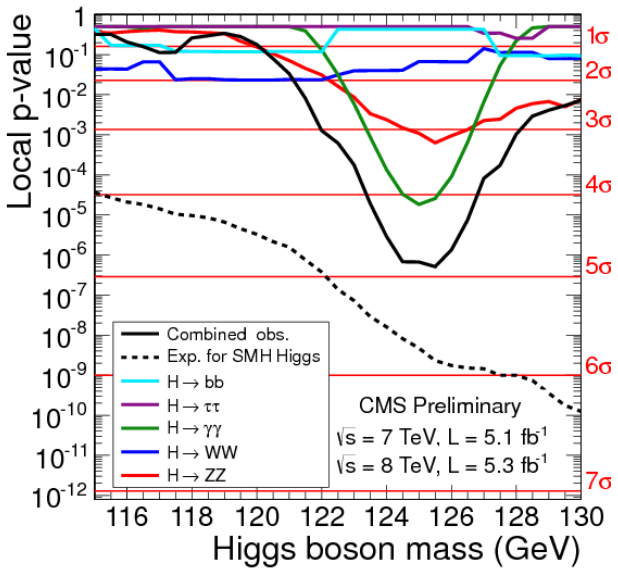


***Figure 5**. The observed probability (local p-value) that the background-only hypothesis would yield the same or more events as are seen in the CMS data, as a function of the SM Higgs boson mass for the five channels considered. The solid black line shows the combined local p-value for all channels.*

The mass of the new particle is determined to be 125.3 +/- 0.6 GeV, independent of any assumptions about the expected relative yields of the decay channels. The measured production rate (σDAT) of this new particle is consistent with the predicted rate (σSM) for the SM Higgs boson: σDAT/σSM = 0.80 +/- 0.22.

Great care has also been taken to understand numerous details of the detector performance, the event selection, background determinations and other possible sources of systematic and statistical uncertainties. The 2011 analysis[6] showed an excess of events at about 125 GeV. Therefore, to avoid a potential bias in the choice of selection criteria for the 2012 data that might artificially enhance this excess, the 2012 data analysis was performed "blind"[7], meaning that the region of interest was not examined until after all the analysis criteria had been fully scrutinized and approved.

- As a general cross-check, the analyses were performed by at least two independent teams. A number of other features reinforce confidence in the results:
- The excess is seen at around 125 GeV in both the 2011 data sample (7 TeV) and the 2012 data sample (8 TeV);
- The excess is seen at the same mass in both the high-resolution channels (γγ and ZZ);
- The excess seen in the WW is consistent with one that would arise from a particle at 125 GeV;
- The excess is seen in a range of final states involving photons, electrons, muons and hadrons.

The preliminary results presented today will be refined, with the aim of submitting them for publication towards the end of the summer.

Future plans

The new particle observed at about 125 GeV is compatible, within the limited statistical accuracy, with being the SM Higgs boson. However, more data are required to measure its properties such as decay rates in the various channels (γγ, ZZ, WW, bb and ττ) and ultimately its spin and parity, and hence ascertain whether it is indeed the SM Higgs boson or the result of new physics beyond the standard model.

The LHC continues to perform extremely well. By the end of 2012, CMS expects to more than triple its total data sample, and hence to probe further the nature of this new particle. If this particle is indeed the SM Higgs boson, its properties and implications for the standard model will be studied in detail. If it is not the SM Higgs boson, CMS will explore the nature of the new physics that it implies, which may include additional particles that are observable at the LHC. In either case, searches will also continue for other new particles or forces that can be observed in future runs of the LHC at higher beam energies and intensities.

About CMS

More information: http://cern.ch/cms or contact: cms.outreach@cern.ch.

CMS is one of two general-purpose experiments at the LHC that have been built to search for new

physics. It is designed to detect a wide range of particles and phenomena produced in the LHC's high-energy proton-proton and heavy-ion collisions and will help to answer questions such as: "What is the Universe really made of and what forces act within it?" and "What gives everything mass?" It will also measure the properties of well-known particles with unprecedented precision and be on the lookout for completely new, unpredicted phenomena. Such research not only increases our understanding of the way the Universe works, but may eventually spark new technologies that change the world in which we live as has often been true in the past.

The conceptual design of the CMS experiment dates back to 1992. The construction of the gigantic detector (15 m diameter by nearly 29 m long with a weight of 14000 tonnes) took 16 years of effort from one of the largest international scientific collaborations ever assembled: 3275 physicists (including 1535 students) plus 790 engineers and technicians, from 179 institutions and research laboratories distributed in 41 countries all over the world.

[1] ICHEP is the 36th International Conference on High Energy Physics, Melbourne, Australia from 4-11 July, 2012. The results will be presented jointly: in person at CERN and by real-time video link to ICHEP.

[2] The electron volt (eV) is a unit of energy. A GeV is 1,000,000,000 eV. In particle physics, where mass and energy are often interchanged, it is common to use eV/c2 as a unit of mass (from E = mc2, where c is the speed of light in vacuum). Even more common is to use a system of natural units with c set to 1 (hence, E = m), and use eV and GeV as units of mass.

[3] The standard deviation describes the spread of a set of measurements around the mean value. It can be used to quantify the level of disagreement of a set of data from a given hypothesis. Physicists express standard deviations in units called “sigma”. The higher the number of sigma, the more incompatible the data are with the hypothesis. Typically, the more unexpected a discovery is, the greater the number of sigma physicists will require to be convinced.

[4] Confidence level is a statistical measure of the percentage of test results that can be expected to be within a specified range. For example, a confidence level of 95% means that the result of an action will probably meet expectations 95% of the time.

[5] http://news.stanford.edu/news/2004/july21/femtobarn-721.html

[6] http://cms.web.cern.ch/news/cms-search-standard-model-higgs-boson-lhc-data-2010-and-2011

[7] http://cms.web.cern.ch/news/blinding-and-unblinding-analyses

6. With our greatest gratitude

Symposium in honour of Robert Roosen

"A deeper look into matter"

19th of Oct 2012 - 14h-16h
Promotiezaal VUB - D2.01
Campus Oefenplein, Brussel

"Robert Roosen at the IIHE"
Prof. Catherine De Clercq

"Charm & Beauty experiments"
Prof. em. Stefaan Tavernier

"The H1 experiment at HERA"
Prof. Eckhard Elsen (DESY)

"The legacy of HERA"
Prof. Sergey Levonian (DESY)

Reception from 16h – at the IIHE

iihe BRUXELLES BRUSSEL | Vrije Universiteit Brussel

II. Research activities, development and support

1. The CMS experiment at the CERN LHC

(F. Blekman, S. Blyweert, B. Clerbaux, G. De Lentdecker, V. Dero, O. Devroede, J. D'Hondt, L. Favart, A. Gay, R. Gonzalez Suarez, G. Hammad, T. Hreus, A. Kalogeroploulos, J. Keaveney, A. Léonard, J. Maes, M. Maes, P. Marage, A. Olbrechts, L. Perniè, Q. Python, A. Raval, T. Reis, S. Tavernier, L. Thomas, C. Vander Velde, W. Van Doninck, P. Vanlaer, L. Van Lancker, P. Van Mulders, G. Van Onsem, Y. Yang, F. Zenoni.

The following members of Antwerp and Mons universities are also members of CMS:

W. Beaumont, N. Belyi, L. Benucci, K. Cerny, E. Daubie, Th. Caeberts, I. Cherednikov, E. De Langhe, A. Deroeck, E. De Wolf, D. Druzhkin, X. Janssen, H. Jung, Th. Maes, L. Mucibello, B. Roland, R. Rougny, M.Selvaggi, F. Van Der Veken, H. Van Haevermaet, P. Van Mechelen, N. Van Remortel)

a. CMS operation and management

The Compact Muon Solenoid (CMS) experiment is one of the two general purpose experiments situated at the Large Hadron Collider (LHC) at CERN. In 2010, the LHC, started to produce proton-proton collisions at a centre of mass energy of 7 TeV. In 2012, the energy was raised to 8 TeV. In 2010, 2011 and 2012, CMS collected data corresponding to integrated luminosities of 36 pb^{-1}, 5.1 fb^{-1} and 19.6 fb^{-1} respectively. The analysis of these data, allowed numerous tests and precision measurements of the Standard Model (SM) at an unprecedented energy, without seeing any sign of new physics, beyond the SM. This is pushing the limits of new physics theories toward higher scale, stimulating a revision of theoretical ideas. These analyses already lead to more than 200 publications. The most important result is by no way the observation, at a mass of 125 GeV/c^2, of the scalar boson predicted by R. Brout, F. Englert and P. Higgs, being the last missing piece of the SM. The High Energy and Particle Physics Division of the European Physical Society awarded its 2013 Prize to the ATLAS and CMS collaborations for this discovery. The prize recognizes the collective efforts of the two collaborations, as well as those of three physicists, P. Jenni, M. Della Negra and T. Virdee, who led the teams that designed, constructed and commissioned the detectors.

Precise measurements of the properties of the scalar boson and detailed studies of the mechanism giving mass to elementary particles have still to be performed and the search for manifestations of new physics will continue, requiring higher energies and higher luminosities. Since February 2013, the accelerator is stopped for a period of about two years, in order to upgrade both the machine and the detectors. The modifications will allow running at 13 TeV, almost doubling the energy, with an instantaneous luminosity that might reach up to 2 x 10^{34}/cm²/s, about 3 times more than in 2011, keeping at the same time, the event pile-up rate at a manageable level.

During this long shutdown of the machine, the physicists from the IIHE are fully exploiting the data taken at 7 and 8 TeV. They are studying the SM of particles, in particular, the new boson, and they continue their searches for new physics. In parallel, they are updating the triggers and their analyses to account for the changes in the detector and for the expected higher energy and higher luminosity. In addition, they are implementing new lines of investigations that will become possible.

b. RPC construction

Since 2011 the Forward Resistive Plate Chamber (RPC) upgrade plan has been embedded into the Upgrade Technical Design Report of the CMS experiment. A fourth RPC station is to be designed, built and installed in the CMS end caps to be operational after the long shutdown in 2013. The Forward RPC collaboration has been enlarged for this purpose and now consists of groups from Belgium, CERN, China, India, Italy, Korea and Pakistan. A total of 200 chambers will be built and tested in India (Mumbai), Belgium (UGhent) and CERN. Two IIHE members (W. Van Doninck and L. Van Lancker) are responsible for the mechanical design of the chambers and their integration into the CMS end caps.

c. CMS upgrades

The Forward Muon Upgrade

The completion of the CMS muon spectrometer in the most forward region (pseudo-rapidity range $1.6 < |\eta| < 2.1$) is presently prepared in CMS, in view of the LHC high luminosity upgrade. A group of physicists at the IIHE is contributing to the study of installing micro-pattern gaseous detectors (Triple-GEM) instead of Resistive Plate

Chambers (RPC). For this project, the IIHE team is designing, in collaboration with CERN, Saclay and Bari, the trigger and data acquisition system of these new detectors. For more details see the Data acquisition system R&D section of this document.

The Tracker Upgrade

In the years 2020, CERN's objectives are to further increase the LHC luminosity by a factor ten above the present LHC design value. For these harsh experimental conditions, the CMS tracker will need to be replaced. In addition, to fully benefit from the performance of the LHC, the new tracker will have to contribute to the first level of the online trigger system of the experiment. Consequently the concept a track trigger meaning a new geometry and a new data acquisition system is under study.

Since 2012, a small team of physicists is contributing to the development of the reconstruction of the tracks to be used by the track trigger algorithms. This implies the study of the performance of the track reconstruction with different tracker geometries. The IIHE is also following the electronics development related to the Tracker Upgrade. Indeed the technologies (xTCA, Versatile Link, GBT) currently studied for the future trigger and data acquisition system of the new CMS tracker are the same as the one that will be used for the CMS Forward Muon Upgrade (see the Data acquisition system R&D section of this document).

d. Search for the Brout-Englert-Higgs boson and study of multi-boson production

In July 2012, the discovery of a new particle of mass around m_H=125 GeV/c^2 and with properties consistent with those of the standard model Brout-Englert-Higgs scalar boson was announced. Whether this particle is the only element to be added to the standard model in order to give masses to the elementary particles, is one of the fundamental open questions to be addressed at the LHC. Also, now that its existence is established, the roles of the scalar field in nature, for instance in the evolution of the universe, can be studied in more detail.

The IIHE group contributes to these studies on the following important aspects: 1) the study of the decay of the newly-discovered, "light", boson into a pair of τ leptons in the ZH->$l^+l^-\tau^+\tau^-$ channel; 2) the search for an additional massive scalar in the H->ZZ->l^+l^- + missing energy channel, and 3) the calibration of the CMS electromagnetic calorimeter, which directly impacts the search for a light scalar boson in the H->γγ channel. These studies are performed with the whole LHC RUN1 dataset, 5fb^{-1} of data collected at 7 TeV center-of-mass energy and 20 fb^{-1} of data collected at 8 TeV.

The IIHE team leads the analysis of the ZH->$l^+l^-\tau^+\tau^-$ channel, and as such, contributes to the study of the coupling of the scalar boson to fermions. The ZH->$l^+l^-\tau^+\tau^-$ channel adds significantly to the total sensitivity of the search for H->$\tau^+\tau^-$ decays. With the complete LHC RUN1 dataset, the H->$\tau^+\tau^-$ signal was established with 3 sigma significance and with a branching fraction consistent with the standard model, although with a large uncertainty. The RUN2 data to be collected from 2015 on should allow a more precise determination of this coupling.

The H->ZZ->l+l-νν decay channel is the most sensitive for a heavy scalar with standard model-like couplings, thanks to its large branching ratio compared to the decay into four charged leptons. The ULB team is strongly involved in this search, with collaborators from CERN and from Purdue university. Strong limits on the production of a heavy scalar have been set with the H->ZZ->l+l-νν channel alone, excluding a standard model-like scalar up to a mass of 930 GeV/c^2. The limits are also re-interpreted in the framework of non-standard electroweak symmetry breaking scenarios, for instance in terms of limits on the mixing of an additional electroweak-singlet scalar with the light scalar boson. A theoretical challenge at high mass is the proper accounting of the large decay width and the interference with the standard model ZZ background. A post-doc has contributed to the third CERN yellow report of the LHC Higgs cross-section working group on this subject. It is worth noting that a large increase in sensitivity is expected with RUN2 data, from the high beam energy (13 TeV).

Being susceptible to couple to all massive particles, the scalar boson could decay into yet-undiscovered non-interacting particles such as those postulated to be responsible for the dark matter of the universe. The group is now contributing strongly to the search for such decays in the ZH->l^+l^- + missing energy channel and a post-doc is co-editor of the corresponding analysis notes.

The IIHE team also contributes to the measurement of the ZZ production cross-section in the l+l-νν final state. The SM cross-section is predicted with good theoretical precision, but it could be enhanced at high Z boson p_T if anomalous γZZ and ZZZ triple gauge couplings exist. These couplings are constrained at the LHC with unprecedented sensitivity, in particular in the ZZ->4l+/- and ZZ->l+l-νν channels.

e. Top physics

During the 2012 run of the Large Hadron Collider at 8 TeV centre of mass energy, the CMS experiment collected an enormous sample of top quarks, pair produced as well as singly produced. This allowed the IIHE team to measure and study diverse aspects of the top quark sector of not only the Standard Model, but also in models beyond the Standard Model. The strong role of the institute in the top physics community was strengthened by the appointment of Freya Blekman as convener of the beyond-two-generations group, a dedicated physics group in the CMS experiment that focuses exclusively on exotica searches in the top quark sector.

Cross section of top quark pair processes at 8 TeV : As a continuation of the 7 TeV production cross section measurement effort, the previously developed method to simultaneously measure the b-tagging efficiency and the cross section after b-tagging was used to provide a measurement on 8 TeV, in collaboration with the Universiteit Gent.

Top quark mass and difference between top and anti-top quark masses : The ideogram technique was applied to measure the mass of the top quark. Using the electric charge of the lepton, the top quark or the anti-top quark can be separated, resulting in the most precise measurement of this quantity. Applying this method on the 8 TeV data, the IIHE team will provide a significant improvement to the sensitivity of this analysis.

Measurement of the W helicity in top quark decays : Using the distribution of the angle of the lepton and the top quark in top quark pair events, the helicity fractions of the W boson can be extracted. A precise measurement was obtained in collaboration with the CIEMAT (Madrid) group. These fractions have been interpreted to search for anomalous couplings of the top quark. The data does not show evidence for these anomalous couplings.

Search for single-top processes in the Wt channel : A paper was published on the 7 TeV dataset observing evidence of over 3 standard deviations consistent with the rare SM process of Wt production, currently the worlds most stringent limits on this process. The 8 TeV analysis will be performed in collaboration with University of Nebraska and Kansas State University, anticipating an observation of this process.

Search for fourth generation chiral and vector-like quarks : A novel analysis has been designed and deployed to search inclusively for fourth generation chiral quarks (t' and b'), either in pair production or in single production. When coherently searching for an excess in all possible production processes, resulting in the publication of the world best limits were on the existence of a fourth generation in 7 TeV LHC data. The obtained limits for chiral fourth generation quarks are consistent with the observed cross section and branching fractions of the Brout-Englert-Higgs standard model scalar.

In extensions of the standard model it is also possible to have particles such as vector-like quarks, which are not excluded by the observation of the SM scalar and display similar signatures as chiral fourth generation quarks. It is expected that with the 8 TeV dataset vector-like quarks can be excluded up to the point where the theory becomes non-perturbative.

Search for third generation supersymmetric particles : Supersymmetry is a popular extension of the standard model, but invokes a large set of new parameters. Simplified benchmark models are developed to allow a general interpretation. Studies have been made to search for the specific model where a pair of stop particles is produced directly, without an intermediate gluino or squark. The relevant observable topologies are studied and the possibility to differentiate these from the standard model processes is outlined.

Search for production of four tops : The production of four top quarks, which in the standard model is a very rare process with a cross section of the order of 1 fb, could be greatly enhanced by many new physics models, including Supersymmetry, but also more exotic models where gluon couplings are enhanced due to additional particles in the QCD sector. Depending on the physics model, these signatures will not display the typical Supersymmetry signature with large transverse missing energy. The first search for SM-like production of four-tops is currently in preparation, in collaboration with the IIHE phenomenology group for the BSM signatures.

Search for displaced production of top quarks : One of the possibilities why no new physics has been observed at the LHC is hypothesizing that the Supersymmetry particles have a longer than expected lifetime before they decay. Such events would be rejected by nominal searches, which require that the SM decay products originate from the collision point. An analysis searching for these signatures in the 8 TeV data is currently in preparation.

The above results were presented at international conferences and will be the basis of journal publications. Using the LHC 8 TeV dataset collected in 2012 we are preparing legacy papers on high precision studies of the

production and decay properties of top quarks at the LHC as well as searches for new physics beyond the standard model resulting in top-quark like final states.

f. Study of the Drell-Yan process and search for high mass resonances

Many scenarios beyond the Standard Model (SM) are expected to be manifest through the production of new heavy resonances and modifications of the spectrum of high mass charged lepton pairs, typically above 1 TeV. For example, massive gravitons or new massive gauge bosons, Kaluza-Klein recurrences, are expected in the framework of extra spatial dimension models, as well as new heavy Z bosons in Grand Unified Theories. Since 2006, physicists from the IIHE play a leading role in the preparation and the coordination of the physics analyses in the di-electron final state. They initiated the creation of the **HEEP (High Energy Electron Pairs) working group**, which has first defined the analysis strategy using simulations: the full analysis chain was designed and studied using MC simulations, then applied to the CMS data. In years 2010-2012, the Brussels group was strongly involved in every step of the CMS data analysis at 7 TeV and 8 TeV. In 2012, research activities have started to study the jet production associated to the Drell-Yan process.

Event selection, selection efficiency and backgrounds: The selection was designed to have a high efficiency (in view of the small expected number of signal events) while rejecting the multijet background from QCD processes, mainly thanks to electron identification and electron isolation criteria. Special attention has been given to the optimisation of the selection for running conditions at high instantaneous luminosity of 2012, with in average 21 interactions per beam bunch crossing (PU). The expertise of the Brussels group in electron reconstruction is well established: a postdoctoral researcher has been nominated in 2012 as Exotica e/γ contact responsible. The selection efficiency and the remaining background in the final sample were estimated from the data themselves, in order to be as independent as possible of Monte-Carlo simulations. The selection efficiency was measured using the "tag and probe method", at the Z pole and at high mass. The backgrounds coming from top-antitop production and from multijet production (QCD processes) were estimated with the "electron-muon" and the "fake-rate" methods, respectively.

Electromagnetic calorimeter (ECAL) Calibration: The electromagnetic calorimeter of CMS, the ECAL, is the main detector used in the HEEP analysis. Expertise has been acquired in the ECAL calibration, resolution and linearity measurement. The Brussels group has designed and developed a method based on the ECAL shower shape to cross check the ECAL calibration and linearity at very high energy. This sophisticated method is the only one available at very high energy and is crucial for the control of the ECAL response in view of the search for new physics at high energy. Another contribution concerns the ECAL resolution estimation, in particular using the Z peak events from SM Drell-Yan process.

Limits on new physics: Studies were devoted to developing tools to estimate the CMS five-sigma discovery potential for heavy resonances, as well as the 95% Confidence Level (CL) on the resonance production cross section in case of the absence of signal. In collaboration with ULB theorists, an analysis was performed to search for high mass resonances decaying into electron-muon pairs. The data were found to be in agreement with the SM expectation, and limits on new physics parameters for different models have been put. The dielectron and dimuon channel results were combined. The results on the CMS data at 7 TeV taken in year 2010 (luminosity of 35 pb^{-1}) and in year 2011 (luminosity of 5.0 fb^{-1}) have been published. An update of the results using part of the 2012 data at 8 TeV is also published. The IIHE HEEP group is presently finalizing the analysis based on the full 2011-12 dataset. Preliminary results have been presented at the Moriond 2013 conference, and final results are expected to be published end of 2013 in a long paper.

Drell-Yan production associated with jets: Since February 2012, a new study was started on the Drell-Yan production associated with jets. The good control of Z+jets is very important in both the high mass resonance searches and the Brout-Englert-Higgs (BEH) searches and studies, performed at the IIHE. The Drell-Yan production cross section in hadron-hadron collision is known at the NNLO in QCD. The confrontation of the measurement to theoretical predictions provides a stringent test of perturbative QCD. Furthermore, the very high energy of the LHC allows producing many jets in the events. In particular Z events with more than 2 jets are frequently produced but beyond the scope of NNLO predictions. Alternative approaches are developed in Monte Carlos to predict many jets production. The group measured the Z+jet cross section for up to 7 jets with transverse momenta above 30 GeV and compared it to different Monte Carlo predictions (MadGraph, Sherpa and Powheg) with 8 TeV data collected in 2012. The jet multiplicity as well as the different transverse momentum distributions are measured. The amount and the phenomenological relevance of Double Parton Scattering (DPS) events, where two pairs of partons collide, become important for many searches and measurements of expected (BEH) as well as beyond the Standard Model physics, in particular with the coming data at 13 TeV. The study of V+2 jets, where V is a W or Z boson, is of particular interest for the understanding of DPS, with the V produced by a pair of partons

and the 2 jets produced by another pair of partons. This process has been measured for the case of a Z boson by the group in the 7+8 TeV data collected in 2011-12, focusing on variables developed to enhance sensitivity to the DPS production.

2. The H1 experiment – Study of ep collisions at Hera

(F. Ceccopieri, L. Favart, T. Hreus, X. Janssen, R. Roosen, and P. Van Mechelen)

Following the discovery of pointlike constitutents in the proton at SLAC, during the late 1960 years, a series of neutrino and muon deep inelastic scattering (DIS) experiments was performed in order to study further the partonic structure of nucleons and also to develop and test Quantum Chromodynamics (QCD), which had been put forward as the gauge field theory of the strong interaction of confined quarks and gluons.

HERA collided electrons (and positrons) off protons with energies of resp. 27.5 GeV and 820/920 GeV in an underground tunnel at DESY (Hamburg). The main reasons for HERA to provide a much deeper understanding of proton's structure than the fixed target experiments of the eighties was the much higher center of mass energy and well equipped detectors with almost 4 pi acceptance as the H1 detector, allowing to measure both the scattered electron and the hadronic final state in many details.

After 15 years of successful operation, the HERA accelerator was shutdown permanently on July 2007 and the HERA experiments were dismantled in the subsequent year 2008. During its lifespan between 1992 and 2007, a total luminosity of about 500 pb^{-1} was accumulated. The analysis of the collected data is still ongoing and is very actively pursued (more than 40 FTE in 2012 in H1).

For the second phase of HERA, the Belgian group took on the responsability for the construction, the installation and the runing of the Very Forward Proton Spectrometer (VFPS).

The spectrometer, installed in 2004 in the HERA tunnel at 220m downstream from the H1 interaction point, consists of two stations with two scintillating fiber detectors independently approaching the beam during stable conditions.

The main activities of the group were and still are related to the VFPS. Primary issues prior to any physics analysis to be addressed are related to track reconstruction, determination of the proton momentum and background estimates. A thorough analyis [1] has shown that:

- the mean VFPS track reconstruction efficiency is 96%;
- the scattered proton energy and transverse momentum are reconstructed respectively with a relatve precision of a few per mil and an absolute precision of 100 MeV;
- Background due to tracks recorded by the VFPS in conjunction with an non-diffractive DIS event are found to be less than 2%.

These studies have led to a first measurement of the diffractive proton structure function, F2D(3), the results of which have been presented by the H1 Collaboration and complement existing data.

The diffractive dijet cross section with proton detected in the VFPS has been measured in the electro-production regime. First results, presented at the DIS2011 conference indicate a good agreement with the QCD prediction.

Analysis of dijet events in diffractive photo-production, confirms with improved precision the factorisation breaking previously observed in photo-production without tagging the scattered proton. The proton transverse momentum dependence is accessible for the first time.

[1] A. Astvatsatourov et al., "The H1 Very Forward Proton Spectrometer at HERA", internal H1 note H1-01/13-637 (Jan 2013), submitted to Nucl. Instrum. Methods.

3. The Opera experiment

(G. Wilquet, P. Vilain)

The only experimental evidence today that there exists physics beyond the Standard Model (SM) is still the fact that neutrinos have masses, even though very tiny compared to the other fermions. This is known through the observation of the neutrino oscillation phenomenon in which the neutrino flavour oscillates between ν_e, ν_μ and ν_τ as neutrinos propagate away from their source. This in turn implies that flavour and mass eigenstates mix. Adding masses to neutrinos may be a rather trivial extension of the SM if mass is generated through the same type of coupling as for the other fermions, this only implying the existence of light partners of opposite chirality and otherwise non-observable because being sterile. Massive neutrinos have no conserved quantum number allowing

distinguishing particles from antiparticles besides the lepton number. It is common believe, however, that the apparent lepton number conservation in the neutrino sector is an experimental artefact resulting from both the smallness of their mass and the complete violation of parity in weak interactions. It is therefore commonly admitted that neutrinos are Majorana fermions identical to their antiparticles and that the mechanism explaining the smallness of the masses of the three known neutrinos, the so-called See-saw mechanism, includes additional couplings and associates them to heavy partners with masses approaching the energy scale of the Grand Unification Theory of electro-weak and strong interactions.

Not only is the mass matrix of the neutrinos pointing to new physics but also the large mixings between mass and flavour eigenstates is at contrast with those existing in the quark sector. The measured CP violation phase in the quarks mixing matrix is known to be too small to explain why the asymmetry that must have existed in the early universe between matter and antimatter has led to a universe essentially consisting of matter. The very non-diagonal neutrino mixing matrix may include a large CP violation phase so far not accessible to measurement. These facts point to physics well beyond the SM. In particular, they are the ingredients of the so-called lepto-genesis model of baryons, a possible explanation to the matter-antimatter asymmetry in the very early universe.

The OPERA experiment aims at detecting for the first time the direct appearance of ν_τ in a ν_μ beam through the identification of the τ^- lepton produced in their CC interactions in the oscillation parameters space indicated by the atmospheric neutrinos experiments. The detector is installed in the underground Gran Sasso Laboratory (LNGS) and exposed to the CNGS neutrino beam produced at CERN, 730 km away. The design of the detector takes into account two conflicting requirements: a large target mass to cope with the minute neutrino interaction cross-section and a micrometric resolution to allow the detection of the short-lived τ lepton. The target is made of 150000 basic units called bricks each consisting of 56 lead plates of 1 mm thickness that provide the mass interleaved with emulsion films that provide the spatial resolution, for a total mass of 1250 tons. Bricks are assembled in walls and the target is instrumented with the Target Tracker (TT): 62 pairs of planes of horizontal and vertical plastic scintillator strips having their signal collected by WLS fibres and read by multi-anode PM tubes. They are aimed to trigger the DAQ, measure the trajectories of charged particles through the target, locate bricks where neutrino interactions occurred and provide coarse calorimetric information. The instrumented target is divided into two identical super-modules. Downstream of each of these, a magnetic spectrometer identifies and measures the momentum and the charge of the penetrating muons. The dipole magnets are instrumented internally by planes of Resistive Plate Chambers (RPC) and externally by stations of high precision streamer tubes to measure the bending of the tracks [1]. Our group was more specifically involved in the conception, construction, installation and running of the TT together with two groups of IN2P3 (IPHC, Strasbourg and LAPP, Orsay), the universities of Bern and Neuchâtel, and JINR, Dubna [2]. A study of the performances of the electronic detectors is available in [3].

The physics run with a fully operational detector started in spring 2008 and ended in December 2012. About 16 500 neutrinos interactions have been registered in the target of which about 5800 have been located so far and 4700 fully analysed. The achieved integrated neutrino beam flux corresponds to 80% of its nominal value.

The analysis of the 2008-2009 data is completed and that of the 2010-2011 data is steadily going on. For the 2010 sample, the analysis is restricted to events with an increased signal probability: NC events (i.e. events without a detected muon in the final state) and CC events with a muon momentum smaller than 15 GeV/c. For 2011, only the NC events are being analysed so far. The observation of a first ν_τ candidate event with the τ^- decaying into one prong has been published in [4]. The most probable decay mode is $\tau^- \rightarrow \rho^- (\pi^-\pi^0)\, \nu_\tau$ where the two γ from the π^0 decay are observed and their energies measured in the bricks. The description of a second ν_τ candidate event with the τ^- decaying into three charged hadrons will be published soon together with an improved computation of the statistical significance of the observation based on final estimations of the detection efficiencies and the backgrounds, the main sources of which being charged charmed particle decays where the primary muon is unidentified and secondary hadron interactions at short distance from the primary vertex. It relies in particular on a comprehensive simulation of the scanning procedure applied to Monte-Carlo data and on improved efficiencies in the identification of very low momentum muons and in the detection of large angle nuclear fragments emitted in secondary hadron interactions. At the time of writing, a third ν_τ candidate event with the ν_τ decaying this time into a muon has been identified. Preliminary information on the two new candidate events and on the re-evaluations of the efficiencies, backgrounds and significance is available in [5].

A by-product of the experiment is the search for ν_e appearance in the ν_μ beam. In a standard 3-flavour neutrino families framework, the large contamination of the beam in ν_e (almost 1% in terms of CC interactions) makes the analysis very insensitive to a measurement of the small mixing angle θ_{13} recently measured to be different from 0

by the Daya Bay, Reno and Double-CHOOZ nuclear reactors experiments ($\sin^2 2\theta_{13}$=0.098). A total of 19.8 ν_e background interactions are expected, of which 19.4 resulting from the beam contamination, where 19 are observed. Yet, this measurement further limits the parameter space available for a non-standard ν_e appearance in a ν_μ source as suggested by the results of the LSND and MiniBooNE experiments that imply the existence of at least one additional flavour of sterile neutrino. It further constrains the still allowed region around $\Delta m^2 = 5\times10^{-2}$ eV^2. For large Δm^2 values, the 90% C.L. upper limit on $\sin^2 2\theta$reaches 7.2×10^{-3}. With the increase in sample size and improvements in the analysis, OPERA should be able to access the parameter region comparable to its sensitivity below $\sin^2 2\theta = 5.0\times10^{-3}$. This result has been submitted to publication [6].

The study of high energy muons and neutrinos produced in cosmic ray interactions in the atmosphere is another very valuable by-product of this underground experiment. The flux ratio of positively to negatively charged muons has been measured with an unprecedented precision in the high energy region of 1.5 to 2 TeV [7]. An improved analysis, combined with a substantial increase in statistics, is in preparation.

In September 2011 the measurement of the neutrino velocity by the OPERA Collaboration has been released [8]. The astonishing result was that the more than 15 thousand neutrinos detected by the apparatus exhibit a tiny although significant difference with respect to the expected velocity: CNGS neutrinos reach OPERA about 60 nanoseconds before the time light would take to travel the same distance, indicating a neutrino velocity higher than the speed of light c in vacuum by about 20 parts per million, $(v\text{-}c)/c = (2.37 \pm 0.32\ (\text{stat.}) \pm {}^{+0.34}_{-0.24}\ (\text{sys.}))$ $\times10^{-5}$,with an overall significance of 6.2 σ.

In order to perform this study, the OPERA Collaboration, together with experts from CERN and metrology institutions, performed a series of high precision measurements of distance and of neutrino time of flight. The distance between the origin of the neutrino beam and the OPERA detector was measured with an uncertainty of 20 cm over the 730 km travel path. The neutrino time of flight was determined with an accuracy of less than 10 nanoseconds by using sophisticated instruments including advanced GPS systems and atomic clocks. The time response of all elements of the CNGS beam line and of the OPERA detector has been measured with great precision, as well.

To exclude possible systematic effects related to the statistical treatment of the neutrino creation and arrival time distributions, a two-week long beam test was performed in October 2011 with a dedicated SPS proton beam. The modified beam consisted of a single extraction including four bunches about 3 ns long (FWHM) separated by 524 ns and thus allowing to unambiguously associate each neutrino event to its corresponding proton bunch. A total of 20 events were retained, leading to a mean neutrino time of flight in very good agreement with the one obtained in the main analysis.

At this point, it is essential to note that the OPERA Collaboration, if it has indeed reported a measurement on the neutrino velocity larger that the speed of light c measured in vacuum (or at least in a medium free of ordinary matter), which is usually taken as the limiting speed limit of special relativity, it has however never claimed experimental evidence of the violation of special relativity. Instead, the last paragraph of the preprint writes: “In conclusion, despite the large significance of the measurement reported here and the robustness of the analysis, the potentially great impact of the result motivates the continuation of our studies in order to investigate possible still unknown systematic effects that could explain the observed anomaly. We deliberately do not attempt any theoretical or phenomenological interpretation of the results.” This statement has been systematically repeated as an obligation made to speakers in conclusion to the many seminars and conference contributions that have followed the release of this questioning result.

In the course of our investigations, two instrumental problems have then been identified. The first one has to do with the frequency of the oscillator of the main OPERA clock that slightly departs from its nominal value. Correcting for this effect leads to an increase of about 10 ns of the neutrino arrival time anticipation. The main problem, leading to an apparent neutrino arrival time anticipation of about 75 ns, is a difference of 75 ns between the measurements made at the time the instrumentation was calibrated in 2006 and 2007 and those made end of 2011, after the 3-year period of data taking, in the time taken to transfer the GPS signal along a 10 km long optical fibre from the LNGS external laboratory to the OPERA data acquisition system. The cause of the mismatch between measurements has then been identified: a short fibre serving as interface between the long fibre and the LPI converting the analogue optical signal into a digital electronic signal was not properly connected. This in turn has generated a delay to the time at which the optical signal integrated by a photodiode crosses the threshold imposed to the digital signal generation. After the short interface fibre was properly reconnected, the measured time transfer delay was found identical to that obtained in 2006 and 2007 at the nanosecond level. From time coincidences between horizontal cosmic muon signals recorded in the OPERA and the nearby LVD detectors, it has been found that the misconnection dates from the second half of 2008, i.e. after the two calibration

measurements were done in 2006 and 2007 and before the beginning of the data taking period in spring 2009. For which reason this fibre was disconnected and then incorrectly reconnected will remain unknown. This demonstrates that assuming the stability of the time transfer delay over a period of several years at a level adequate for the purpose of the neutrino velocity measurement was a sensible and by no mean presumptuous assumption. It however also shows that not having remeasured this time delay has been the mistake that has led to the release of a wrong measurement of the neutrino velocity. The corrected value of the neutrino velocity measurement $(v\text{-}c)/c = (2.7 \pm 3.1\ (\text{stat.}) \pm {}^{+3.4}_{-3.3}\ (\text{sys.})) \times 10^{-6}$ compatible with the speed of light in vacuum has been published in [9].

A new dedicated two-week run with a beam of narrow bunches this time separated by 100 ns instead of 524 ns and consequently a larger event sample has taken place in spring 2012 using an upgraded setup that also exploited an independent timing system based on the RPC and improved the measurement time accuracy at the ns level. This allowed putting stringent limits on the muon neutrino velocity with respect to the speed of light of $-1.8 \times 10^{-6} < (v\text{-}c)/c < 2.3 \times 10^{-6}$ at 90% C.L. [10]. This new measurement confirms with higher accuracy the revised result.

In 2012, the OPERA Collaboration included about 150 physicists from 30 institutions in 11 countries. One of us (G. W.) has chaired the OPERA Collaboration Board since 2008 and until June 2012 and is a member of its Editorial Board.

[1] The OPERA Collaboration, R. Acquafredda et al., JINST 4 (2009) P04018.
[2] T. Adam et al., Nucl. Instrum. Methods A 577 (2007) 523-539.
[3] The OPERA Collaboration, N. Agafonova et al., New J. Phys. 13 (2011) 053051.
[4] The OPERA Collaboration, N. Agafonova et al., Phys. Lett. B 691 (2010) 138-145; The OPERA Collaboration, N. Agafonova et al., New J. Phys. 14 (2012) 033017.
[5] "Results from OPERA", M. Nakamura on behalf of OPERA collaboration, Talk given at the Neutrino 2012 Conference, Kyoto, Japan (2012); "Results of the OPERA experiment", G. De Lellis on behalf of the OPERA Collaboration, Seminar given at LNGS, April 2013 https://agenda.infn.it/getFile.py/access?resId=0&materialId=slides&confId=6176.
[6] The OPERA Collaboration, N. Agafonova et al., arXiv:1303.3953v1[hep-ex], submitted to JHEP.
[7] The OPERA Collaboration, N. Agafonova et al., Eur. Phys. J. C 67 (2010) 25–37.
[8] The OPERA Collaboration, T. Adam et al., arXiv:1109.4807v1[hep-ex].
[9] The OPERA Collaboration, T. Adam et al., JHEP10(2012)093
[10] The OPERA Collaboration, T. Adam et al., JHEP01(2013)153

4. Astroparticle Physics with the IceCube Neutrino Observatory

(S. Bechet, D. Bertrand, D. Bose, L. Brayeur, M. Casier, C. De Clerq, N. Van Eijndhoven, G. Golup, K. Hanson, D. Heereman, J. Kunnen, M. Labare, J. Miller, T. Meures, E. Pinat)

Astroparticle Physics revolves around phenomena that involve (astro)physics under the most extreme conditions. Black holes with masses a billion times greater than the mass of the Sun, accelerate particles to velocities close to the speed of light. The produced high- energy particles may be detected on Earth and as such provide us insight in the physical processes underlying these cataclysmic events.

Having no electrical charge and interacting only weakly with matter, neutrinos are special astronomical messengers. Only they can carry information from violent cosmological events at the edge of the observable universe directly towards the Earth. Furthermore, since they are hardly hindered by intervening matter, they are the only messengers that can provide information about the central cores of cosmic accelerators like Gamma Ray Bursts (GRBs) and Active Galactic Nuclei (AGN), which are believed to be the most violent cosmic events and the sources of the most energetic Cosmic Rays. Identification of related neutrino activity would unambiguously indicate hadronic activity and as such provide clues to unravel the nature of these mysterious phenomena.

Another mystery of the Universe is the illustrious Dark Matter, which has not yet been observed but which would explain various observed phenomena. According to some models, this dark matter may consist of Weakly Interacting Massive Particles (WIMPS) which can annihilate among themselves. In these annihilation processes some of the produced particles are high-energy neutrinos. Since these WIMPS are expected to get trapped in gravitational fields, there may be large concentrations of them at the center of massive objects like the Earth, the Sun or the Galactic Center. Consequently, observation of high-energy neutrinos from these objects could provide indirect evidence for the existence of these dark matter particles.

At the IIHE, we are involved in a world wide effort to search for high-energy neutrinos originating from cosmic phenomena or from dark matter particles. For this we use the IceCube neutrino observatory at the South Pole, the world's largest neutrino telescope which has now been taking data for several years.

a. The IceCube observatory

IceCube (http://www.icecube.wisc.edu) is a neutrino telescope consisting of an array of optical sensors, located in the icecap of the South Pole at depths between 1450 and 2450 m. The sensors are arrayed on vertical cables, called strings, each of which comprises 60 sensors spaced by 17 m. In the horizontal plane, the strings are arranged in a triangular pattern such that the distance between adjacent strings is always 125 m. The overal configuration (see fig. 1) exhibits a hexagonal structure, which is the result of extensive optimisation procedures based on simulation studies.

At the end of 2010 the full 86-string detector, including its DeepCore extension (see here after), has been completed and started to take data, representing an operational observatory with an instrumented volume of 1 km^3.

Due to the geometrical configuration outlined above, the energy sensitivity for IceCube is ranging from a few hundred GeV up to several PeV. However, based on theoretical calculations the cosmic sources of interest are expected to yield an E^{-2} power law energy spectrum for the produced neutrino flux, whereas most of the neutrinos originating from dark matter particles are also expected to have energies below the IceCube detection threshold. This implies that extending the sensitivity to lower energies will provide a significant increase in the neutrino detection potential.

Sensitivity to lower energies can be obtained by a smaller spacing between adjacent sensors and to achieve this, IceCube has been extended with a dense core located at the deepest parts of the detector. This so called DeepCore extension consists of 8 additional strings arranged around the central IceCube string such that the distance between adjacent strings will be 72 m as opposed to the 125 m standard IceCube string spacing. Each DeepCore string has 50 sensors at 7 m spacing covering depths between 2100 and 2450 m and 10 sensors at 10 m spacing between 1750 and 1860 m. With this DeepCore extension the lower energy threshold has been pushed down by an order of magnitude to about 20 GeV. Furthermore, located at these large depths and completely surrounded by standard IceCube strings, an efficient trigger and veto system may be developed such that the Deep Core sensors provide sensitivity over the full 4π solid angle. This allows investigation of sources in the Southern hemisphere, including the Galactic center and the black hole within it.

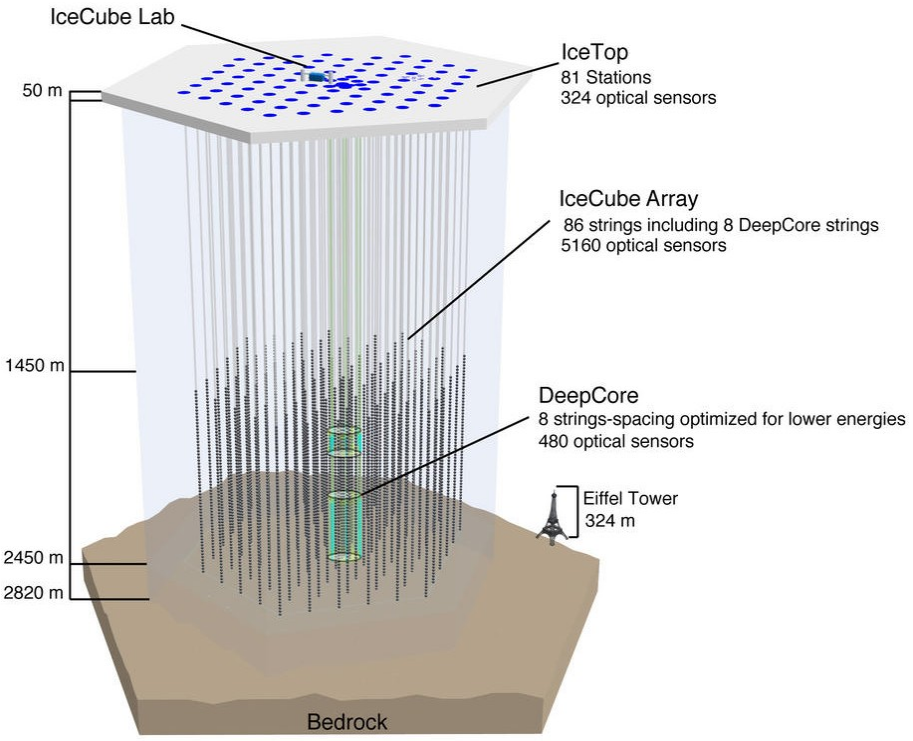


Figure 1 : The IceCube observatory

b. Research areas at the IIHE

In 2012 the IIHE was involved in the following IceCube related (astro)physics topics :

Search for cosmic point sources.

This research comprises a full sky search for ”hot spots” of neutrino production with a novel statistics method which has been developed at the IIHE. Identification of such ”hot spots” on the neutrino sky would enable us to locate the sources of the most energetic cosmic ray particles.

Dark matter searches.

In these studies the focus is put on neutrino signatures from WIMPs located in the center of the Earth or the Sun. The IIHE team took the lead in the search for high-energy neutrinos from the Sun when the source was above the horizon. This was possible thanks to the performant veto capabilities of the IceCube sensors surrounding DeepCore. The analysis yielded the most sensitive limits on spin dependent WIMP- nucleon cross sections.

Detection of high-energy τ neutrinos.

The production of high-energy ν^{τ} particles in astrophysical processes is negligible. However, due to neutrino oscillations a ν^{τ} component may be present in the overall neutrino flux. Identification of these ν^{τ} particles in the IceCube data would enable us to validate various neutrino oscillation scenarios. The IIHE group investigated two distinct signatures of possible ν^{τ} interactions.

Detection of a diffuse flux of very energetic cosmic neutrinos.

So far, all detected high-energy neutrinos originate from particle interactions in the Earth’s atmosphere. These so called atmospheric neutrinos represent an irreducible background in our search for neutrinos of cosmic origin. Due to the fact that the energy spectrum of these atmospheric neutrinos is relatively soft, compared to the E^{-2} cosmic spectrum, a cosmic neutrino signal might be detected by focusing on observation of events of Very High Energy (VHE), well above the flux of atmospheric neutrinos. Our group at the IIHE is involved in such a search for very energetic neutrino events.

Search for high-energy neutrinos from transient events.

This study is aimed at the identification of high-energy neutrino production in relation with Gamma Ray Bursts or flares of Active Galactic Nuclei. A first analysis (Nature 484 (2012) 351) has shown that Gamma Ray Bursts alone can not be the sources of the very energetic cosmic rays which we observe at the Earth and this, rather shocking, result has also ruled out a large number of theoretical models. Consequently, the search is open for new, yet unknown candidates among which are the Active Galactic Nuclei. At the IIHE a special analysis method for the study of these cataclysmic phenomena has been developed and with the current and future data of the full IceCube observatory we have the possibility of observing neutrinos from these processes for the first time in history with unprecedented sensitivity.

Detection of neutrinos from supernova explosions.

Since the observation of the supernova 1987A in the Magelanic Cloud, a nearby dwarf galaxy, it is known that in the collapse of a heavy star neutrinos are produced at a very early stage. Such an event may provide a large flux of neutrinos at the Earth, which can be detected by IceCube with a specialised data acquisition system. Since IceCube is continuously observing the full sky, this would allow to provide a so called supernova alert to induce follow up programs with other instruments all over the world and in space. An early observation is essential to allow to study the full process of a supernova event, from the very first flash until the last afterglow, in order to gain insight in the underlying (astro)physical processes.

Detection of Ultra-high energy (GZK) neutrinos.

The most energetic cosmic ray particles will be destroyed by interactions with the Cosmic Microwave Background Radiation (CMBR) on their journey through the Universe. These interactions should be a source of very energetic neutrinos, but on basis of cosmic ray flux measurements the associated neutrino flux is expected to be extremely low. Consequently, a very large detector area is required to detect a substantial amount of these particles. To achieve this, a detector R&D program has been initiated to investigate the feasibility of using an area of about 80 km^2 equipped with radio detection systems to observe these GZK neutrinos. The project is called the Askaryan Radio Array (ARA) and at the IIHE we have participated in the development of the timing and data acquisition system and are currently involved in the commissioning of the first detector elements and analysis of

the obtained data.

5. The ARA project

(K. Hanson, Y. Yang, A. O'Murchadha, T. Meures, M. Korntheuer)

a. Project Background

The Askar'yan Radio Array (ARA) Collaboration is a group of over 30 scientists and engineers from institutions in Australia, Europe, Israel, Japan, Taiwan, and the USA engaged in the construction of an ultrahigh-energy neutrino telescope currently located at the geographic South Pole. The array uses the 3 km-thick polar ice sheet as a target mass for the extremely feeble flux of cosmogenic neutrinos which is predicted to arise from scattering of cosmic ray protons with energies in excess of 1019 eV off of the cosmic microwave background radiation. Neutrinos interacting in the ice sheet create energetic electromagnetic (EM) showers. Because of matter-antimatter asymmetry, a negative charge excess forms within these showers which emits coherent radiation at radio frequencies. The RF emission propagates freely through the ice which has attenuation lengths of order 1 km at frequencies of 100 MHz to 1 GHz. Simulations of the physics of the radio emission and propagation through the ice indicate that a large array of RF antennas deployed in the ice should be sensitive to transient pulses from EM cascades above approximately 1017 eV. In order to achieve detection rates of a few cosmogenic neutrinos per year, an array of extremely large scale covering more than 100 km^2 is required.

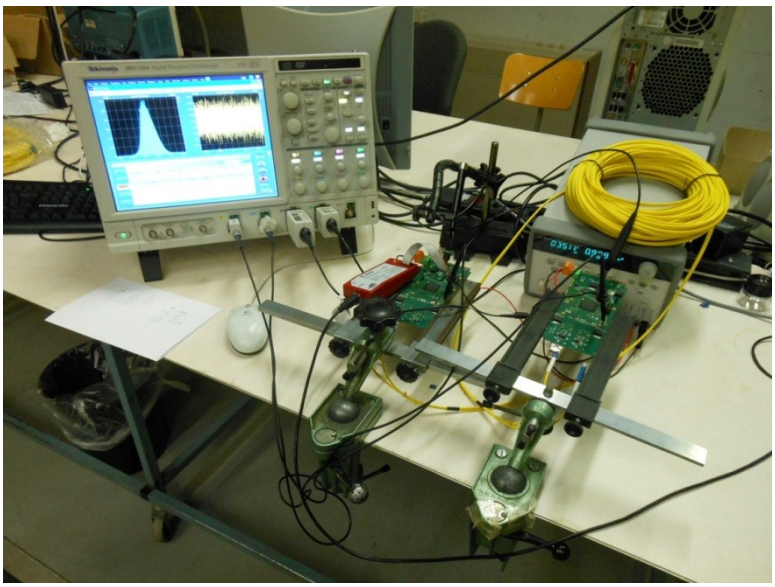
b. Achievements in 2012

Following a successful deployment of the ARA TestBed in 2011 and data collection from this station which has extended uninterrupted to the present day, procurement and assembly of the ARA station #1 hardware began in mid-2011 and the first ARA station was deployed in January 2012. The ARA hot water drill prototype encountered several difficulties during the hole production for the first station resulting in the full number of holes delivered to instrumentation but drilled to depths of 100 m instead of the planned 200 m. Nevertheless, it was decided to proceed with instrumentation deployment. The ARA station #1 hardware returned event triggers North for two months until a fault developed in the on-board computer which prevented further data taking during the 2012 season from this station. Despite this setback, the ARA collaboration pushed ahead with development of improved instrumentation for the 2nd and 3rd ARA stations which were eventually successfully deployed in 2013 along with an upgraded station #1 on-board computer to return this instrument to service. In addition, the ARA Collaboration published results of the TestBed data run from the previous season [1].

The IIHE ARA group continued to focus on development of an improved system for digital transmission of the RF impulses received at the antennas deployed 100-200 m below the surface to the processing electronics on the snow surface. Extending the work done in previous years, the group has developed fiber optic based circuits for high speed digital data transmission and precision synchronization of distributed clocks across the data transmission link. The fiber optic physical layer has demonstrated a much higher level of performance as compared to the earlier electrical physical layers: data rates in excess of 500 Mbit/sec and clock synchronization precision of less than 10 ps have been demonstrated in laboratory testing at IIHE. These improvements come at only modest increase in cost and power. A prototype system running the IIHE laboratory is show in the figure below.

Additionally, Thomas Meures deployed a second time to South Pole to join the ARA drilling team. The improved ARA hot water drill executed the drilling plan without major issues and delivered all planned holes to the ARA instrumentation deployment team at the specified depth of 200 m during the 2012-2013 ARA deployment season.

[1]Design and Initial Performance of the Askaryan Radio Array,
P. Allison et al. (ARA Collaboration), Astropart. Phys., 35 (2012) 457.



IIHE clock transfer send and receive PCBs undergoing performance evaluation in the IIHE electronics laboratory.

6. DAQ

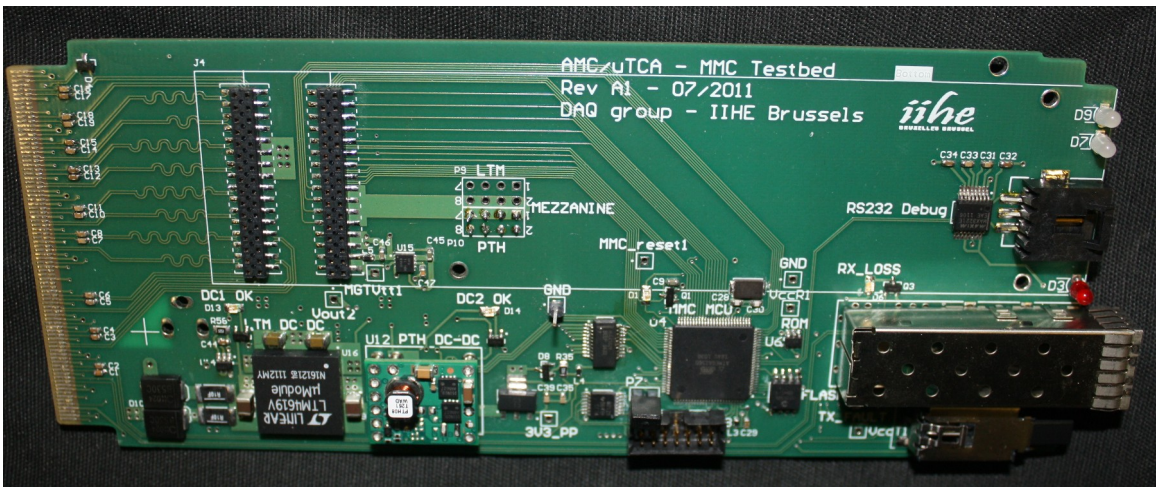
a. Data acquisition systems R&D activities

(G. De Lentdecker, K. Hanson, Th. Maerschalk, Th. Meures, E. Verhagen, Y. Yang)

Since 2007, the IIHE has started an R&D program in the field of data acquisition (DAQ) systems for future experiments in particle and astroparticle physics. Modern technologies allow to design a DAQ architecture independent of the detector technology to which the DAQ system will be connected, providing freedom to the choice of the future experiment. In addition the future particle and astro-particle experiments plan to use the most advanced technologies from the telecommunication and the digital programmable electronic industries: the Advanced Telecom Computing Architecture (ATCA or micro-TCA) standard and Field Programmable Gate Arrays (FPGA). The choice of the IIHE to start such a R&D program has been driven by the fact that the laboratory has a large expertise in the development of DAQ systems for the major experiments in particle and astroparticle physics (DELPHI, H1, CMS, ICECube).

To conduct these developments in a concrete case, the laboratory started a collaboration with the University of Lund (Sweden) and CERN to develop the DAQ system for a large prototype of Time Projection Chamber (TPC) that could be installed at a future linear electron-positron collider (ILC or CLIC), where the FPGAs and ATCA technologies will be largely used. Therefore the experience that the IIHE is gaining by developing DAQ systems in this framework will be a valuable asset for a probable participation of the laboratory in any future experiment in particle or astro-particle physics.

These developments initially performed within the EUDET project supported by the European Commission (EC) in the 6th Framework Program (FP6) are now pursued in the framework of the EC FP7 AIDA (Advanced European Infrastructure for Detectors at Accelerators) project which started on the 1st of February 2011. In AIDA, the DAQ system has been identified as a key component and the design of a common DAQ system to all ILC or CLIC sub-detectors is now one of the main targets. In this project the IIHE is contributing to the development of the TPC DAQ prototype, by including components of the new micro-TCA standard to make it more flexible and easily adaptable to other detector technologies and other experiments. This should be achieved by designing Advanced Mezzanine Cards (AMC) equipped with FPGAs with Giga-bit Ethernet and PCIexpress connections to the micro-TCA backplane. The figure below shows the first board prototype built at the IIHE and which was used as test bench during 2012.



First micro-TCA Advanced Mezzanine Board (AMC) built at the IIHE

Since July 2011, the IIHE is also contributing to the study of installing micro-pattern gaseous detectors instead of Resistive Plate Chambers (RPC) in the forward region ($1.6<|\eta|<2.1$) of the CMS muon spectrometer for the LHC high luminosity phase, after 2017. In this project the IIHE is contributing to the implementation of signal processing methods to be implemented in the new front-end ASIC to achieve a time resolution better than 7 ns. Moreover the IIHE is responsible for the design of the trigger and DAQ system of the new detectors. The new readout system will be based on the micro-TCA standard as well as the new optical link, called Versatile Link, and the GBT chipset, both developed by CERN for the CMS tracker upgrade.

In addition, since the CMS Collaboration is currently planning to use the new micro-TCA standard as the baseline for all the detector electronics upgrades of the experiment, our laboratory, together with the University of Antwerpen, is also studying a general issue: the remote configuration and programming of the FPGAs that will equip the AMCs mounted in the micro-TCA crates. This study is of interest for other experiments as well, where the detectors and the electronics are spread over a large area and cannot be easily accessed.

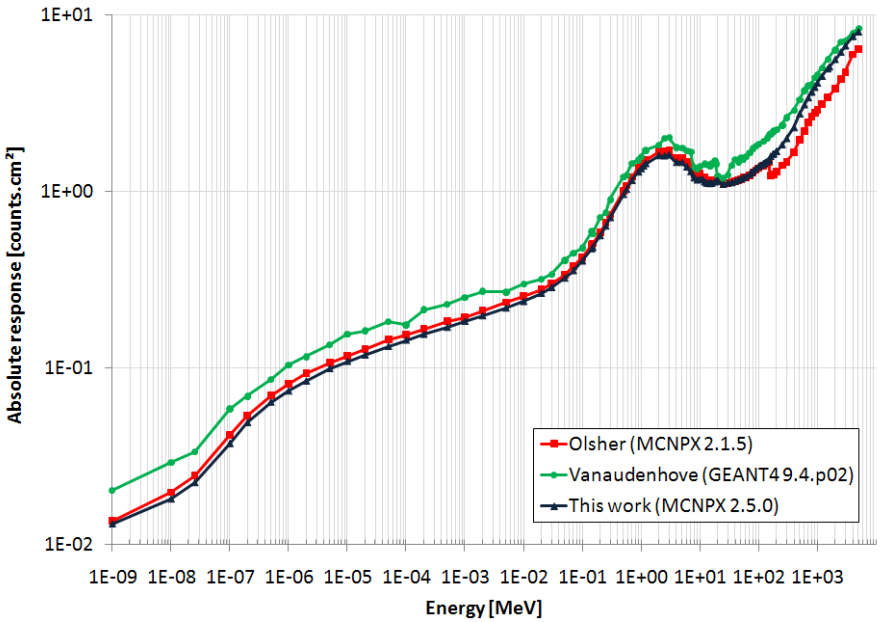
The laboratory is also involved in DAQ R&D for astro-particle experiments: since 2010, DAQ developments have started for the Askaryan Radiotelescope Array (ARA) project, where the detectors will be spread over an area of several km^2 in the South Pole ice. One of the major activities undertaken by the IIHE has been the development of a digital communication circuit to permit the deployment of digitization electronics below the firn local to the antennas. The system requires that this communication infrastructure transmits at least 500 Mb/sec and additionally distributes a synchronous clock signal with a skew jitter of less than 50 ps. After a first solution using a modified Ethernet PHY and CAT5/6 twisted pairs, the group is now investigating an improved system which uses optical fiber transceivers and gigabit transceiver blocks (GTPs) routinely built into FPGA devices. See the “ARA project” chapter of this document for more details.

b. Measurement of the high-energy neutron dose in protontherapy

(G. De Lentdecker, V. De Smet)

Protontherapy uses proton beams with energies typically between 50 and 230 MeV to treat cancerous tumors very efficiently, while protecting as much as possible surrounding healthy tissues from radiation damage. Protons interacting with matter inevitably induce secondary radiation from which all people inside the protontherapy center have to be protected. The ambient dose equivalent H*(10) in such a facility is mainly due to neutrons, which can have energies up to 230 MeV. Although various dose monitoring systems sensitive to high energy neutrons have already been developed, the response function of these detectors is often insufficiently characterized, and so are the calibration factors appropriate for the specific neutron spectra encountered inside a proton therapy facility.

Since 2012 the IIHE is collaborating with the Institut de Recherche de l'Institut Supérieur Industriel de Bruxelles (IRISIB) and Ion Beam Applications S.A. (IBA) to study the response function of the extended-range rem meter WENDI-2 from thermal energies up to 5 GeV. Extensive Monte Carlo simulations using the MCNPX 2.5.0 software have been performed on the IIHE cluster. A good match has been obtained with equivalent simulation results found in literature. As a first step towards the characterization of the WENDI-2 response in continuous neutron fields, MCNPX simulations have also been carried out for the case-study of a bunker around an 18 MeV H^- cyclotron, which involves neutron fields from thermal energies up to 18 MeV. In the coming year, test beams with quasi mono-energetic neutron beams are planned.



Simulation results of the WENDI-2 absolute response function. Ref: Olsher R.H. et al., WENDI: An improved neutron rem meter, Health Physics 79 (2), pp. 170-181 (2000).

7. Development of radiation detectors for biomedical imaging applications: the Crystal Clear and ClearPEM projects.

(S. Tavernier)

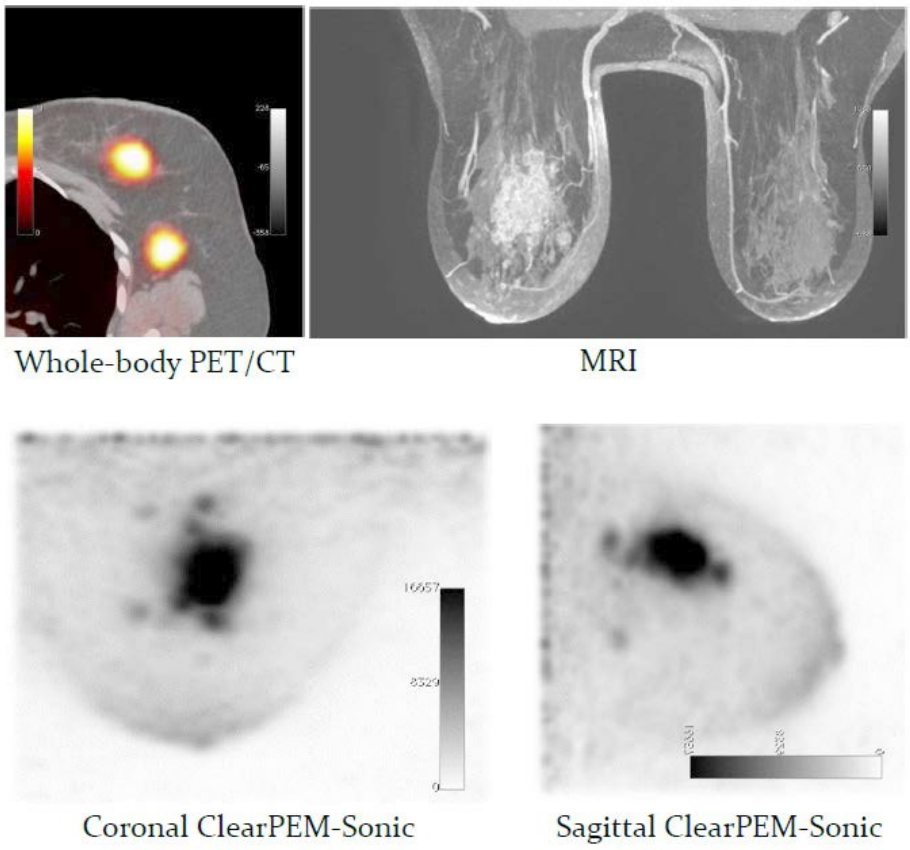
Positron Emission Tomography (PET) is one of the important medical imaging techniques. It differs from other imaging techniques like radiography, Computed Tomography (CT) of Magnetic Resonance Imaging (MRI) because it is sensitive to the molecular processes in the body. Therefore it is often referred to as "molecular imaging".

From its inception, PET has continually benefited from new developments in radiation detection for fundamental research in high energy physics, first using sodium iodide crystals, then using the improved performance from bismuth germinate (BGO), and more recently using superior materials such as lutetium oxyorthosilicate doped with cerium (LSO:Ce). These new scintillators are faster and produce more light than BGO. The arrival of pure solid-state photodetectors with superior performance is on the verge of completely changing the field of PET instrumentation. Such solid-state photodetectors are more compact, more easily subdivided in small pixels, and potentially less expensive than PMTs. Among other advantages, such solid-state photodetectors allow a significant improvement of the time measurement. It therefore becomes possible to use the arrival time difference information to determine the position of the positron annihilation along the line of light of the two 511 keV gamma rays. This leads to a dramatic reduction in the image noise, allowing better images to be obtained with a lower radiation dose to the patient.

Since a few years there has also been a steadily growing interest in using PET for mammography studies. Existing clinical PET systems are not optimized for this application, and the development of dedicated Positron Emission Mammography (PEM) scanners, which are designed and optimized for this application, can lead to valuable clinical applications. The biomedical instrumentation group of the IIHE participated in the design and construction of the ClearPEM dedicated breast imager since the beginning in 2000. This instrument is based on the use of APDs as photodetectors. At that time these were the only solid-state photodetectors available. Two more or less identical prototype PEM scanners were build and are presently installed in in the Hôpital de la Timone (Université de la Méditerranée Aix-Marseille) and in the Hospital of the University of Coimbra. Phase one clinical trials are in progress at both institutions with about 20 patients in each case. The figures below show a picture of the ClearPEM machine installed in Marseille and an example of a patient study.

Very recently a new generation of solid state photodetectors as become available: the silicon photomultiplier (SiPM). This new device offers very superior performance compared to APDs, and are less expensive. It is therefore anticipated that APDs will rapidly be replaced everywhere by SiPMs. Tavernier is presently leading the development of a new generation of dedicated ClearPEM breast imager based on the use of SiPMs. This work is done in collaboration with LIP (Lisbon), CERN, University Milano Bicocca and number of other groups.

View of the ClearPEM dedicated Breast PET imager installed at the Hôspital de la Timone, Marseille.



Example of a breast images obtained during the phase one clinical trial of the ClearPEM scanner. In this figure we see the images obtained with the ClearPEM scanner, and the comparison with the Whole body PET/CT image, and the MRI image (left breast on the MRI image) for the same breast in the same patient. Notice that the image obtained with the ClearPEM shows satellite lesions around the main cancerous lesion. These satellite lesions are not visible on the Whole body PET image, demonstrating the superior spatial resolution of the ClearPEM.

8. Phenomenology

(F. Blekman, P. de Aquino, K. De Causmaecker, C. De Clercq, J. D'Hondt, P. Grajek, A. Kalogeropoulos, K. Mawatari, B. Oexl)

In the course of 2010 the theoretical physics (TENA) and experimental particle physics (ELEM) groups of

VUB obtained a GOA (Geconcerteerde OnderzoeksActies) funding from the university, to start a phenomenology research group to link those groups. The promoters of the project are B. Craps (TENA), C. De Clercq (ELEM), J. D'Hondt (ELEM) and A. Sevrin (TENA). The leader of the group is K. Mawatari. This group has a close collaboration with F. Maltoni and his group from UCL.

The main topic of research is supersymmetric models and their signatures at the Large Hadron Collider (LHC) – see http://we.vub.ac.be/dntk/GOA.html. The project is to study the supersymmetry breaking mechanism on a formal theoretical level, explore the phenomenology of sometimes novel models, and provide methods to observe the signatures within particle collisions at the LHC.

In 2012, while we had continued the gravitino phenomenology at colliders (JHEP1210(2012)008, P. de Aquino, F. Maltoni, K. Mawatari, B. Oexl; JHEP1206(2012)096, R. Argurio, K. De Causmaecker, G. Ferretti, A. Mariotti, K. Mawatari and Y. Takaesu), the observation of a SM-like scalar at the LHC triggered a lot of studies on the related issues, e.g. the spin/parity characterisation (JHEP01(2013)148, C. Englert, D. Goncalves-Netto, K. Mawatari, T. Plehn). We had a successful 3-day Brussels-Kobe-Glasgow joint workshop on the LHC physics at the IIHE in September.

In addition, K. Mawatari presented the next-to-leading order cross section calculation for new physics processes in the fully automized MadGolem framework (PRD85(2012)114024 with D. Goncalves-Netto, D. Lopez-Val, T. Plehn, I. Wigmore).

9. Computing and networking

(F. Blekman, A. Boukil, O. Devroede, J. D'Hondt, S. Gerard, K. Hanson, G. Kohnen (Umons), A. Ouchene, S. Rugovac, E. Torisaen, P. Vanlaer, R. Vandenbroucke)

a. Local computing resources

(coordinator: K. Hanson)

Computing

The local computing facility consists of a computing cluster containing 300 cores which uses the OpenPBS batch queuing system to handle job submission. In addition, a specialized graphics processing (GPU) platform which contains the recent Tesla processing engine from NVIDIA was installed.

Physicists are equipped with laptop computers.

Storage

The storage server which was purchased in 2009 by the IceCube group was installed into the IIHE cluster in 2010, providing 63 TB of disk space for users. At the end of 2010 IceCube purchased another 96 TB J4500 storage array. This storage will in large part be put to use to store IceCube experimental and simulated data: the level 2 reduced data set for the data runs of 2010 alone occupies over 50 TB.

b. IceCube computing

The IceCube collaboration relies on its collaborating institutions to provide computing resources to generate simulated data sets. These data sets require vast amounts of CPU and because of the complexities of simulating the complex ice optical structure present, require compute hosts with at least 2 GB RAM per core to hold the "photon tables" which describe the complicated photon transport coefficients.

The IIHE cluster, described above, has been used by the IceCube Simulation Production group, under the local supervision of A. Marotta and G. Kohnen, to process more than 25000 simulation jobs for a total CPU time of over 5000 CPU-days.

Additionally, the cluster is used to filter the data coming back from recent seasons for analysis by the IceCube researchers.

For scalability reasons, the IceCube cluster was moved to the VUB-ULB computing data center. This to make more efficient use of the power and cooling infrastructure. Additionally, the cluster was connected via a 1Gb/s up-link to the internet for faster download of the relevant data.

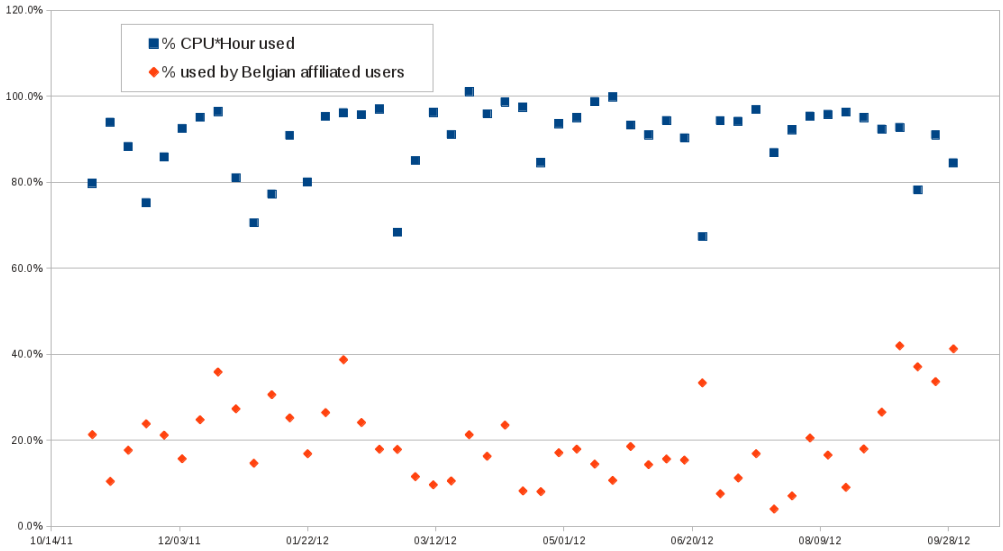
c. Large scale computing for CMS and TIER-2 cluster

Distributed computing based on Grid technology is the solution chosen by CERN for the storage and the analysis of the large amounts of data that are produced by the LHC experiments. The IIHE computing team is involved in several national and international Grid projects. A CMS "Tier-2" cluster has been installed since 2006 and is fully integrated in the worldwide LHC computing grid (W-LCG) of computing centres since 2007. In 2008, the Brussels Tier-2 cluster was moved to the ULB-VUB Computing Centre, to benefit from scale savings due to shared electric power, air conditioning and high-bandwidth networking infrastructures with the ULB-VUB high-performance computing equipment.

The Brussels Tier-2 contributes significantly to the computing resources of the CMS collaboration. It hosts the contributions of the UA, UGent, UMons, ULB and VUB universities, and is funded by the F.R.S.-FNRS and by the FWO. It is part of a "federated Tier-2"computing centre, together with another Tier-2 site at UCL. The two sites support the analyses of the ~65 Belgian CMS physicists, and have been a crucial tool in 2010 and 2011 to allow Belgian physicists contributing in an important way in the analyses of the LHC data.

The Tier-2 keeps track of the specifications given by CMS in order to fulfill its role to provide enough storage and computing power to the physicists. Therefore the Tier-2 needed to expand in 2012:

- Computing power was extended to 19TFlops (or 14.000HepSpec06 units) both by adding extra memory to existing equipment and the purchase of new calculation nodes. This allows the Tier-2 to provide 1850 computing jobs sots.
- Storage was upgraded and reached the level of 1.1PB in 2012.



Use of processing power in number of batch slots occupied times hours per day. The use of the cluster in interactive mode is not inclued in the graph.

The level of use of the data processing power deployed at Brussels is shown in the figure above. The site is occupied at 90% (averaged over working and non-working days).

The Brussels Tier-2 team counted in 2011 three IT scientists (Sh. Rugovac, F.R.S.-FNRS; O. Devroede, UGent/VUB; S. Gérard, VSC, part time). Pascal Vanlaer, seconded by G. Bruno (UCL), is in charge of the Belgian federated Tier-2 sites and the representative to the W-LCG and CMS computing boards. O. Devroede is the technical coordinator of the Belgian Tier-2 sites. In addition, IIHE members act as representatives of ULB and VUB in regional bodies promoting the deployment of large computing infrastructures in Belgium, the Consortium des Equipements de Calcul Intensif (CECI) in the Wallonia-Brussels Federation, and the Vlaams Supercomputer Centrum (VSC) in Flanders.

10. Communication and outreach

The IIHE continuously stimulates and supports researcher to initiate and participate in activities to disseminate our research results. Numerous members of the IIHE therefore had the opportunity to give public lectures on both small and large scale, and at a variety of venues in Belgium. We have also welcomed many groups of young students from secondary schools to follow workshops and lectures in our institute. The

participation to the international Master Classes in Particle Physics is a prime example. At the VUB, these are organized by IPPOG, the International Particle Physics Outreach Group in which Jorgen D'Hondt represents Belgium. At the ULB, they are organized twice a year by Gilles De Lendtecker for about 60 students. We also participate in national and international programs concerning science communication, and our researchers do follow regularly courses to disseminate their research to a wider audience.

Our researchers have also guided many groups for visits at CERN, ranging from children to politicians. Every year we also take the physics students from both the VUB and ULB for a detailed visit to CERN.

Certainly around the discovery of a new particle at CERN the IIHE with our national partners took the initiative for a national press conference covering this groundbreaking result in science. This achievement was thereafter covered by all major media channels in Belgium, resulting in a large number of media appearances of our IIHE researchers.

11. Technical and administrative work

a. Workshop

(J. De Bruyne, P. de Harenne, M. Korntheuer, R. Vanderhaeghen, L. Van Lancker and Y. Yang ; coordinator : G. De Lentdecker).

L. Van Lancker was responsible for the design of the additional RPC muon chambers which will be installed in the CMS detector during the next shutdown. He was also involved in the preparation of the installation procedure.

Y. Yang was responsible for the development of a test DAQ system based on the recent micro-TCA technology in the framework of the preparation of new detectors for future experiments. He was involved in the design of an FPGA based board. He also participated to the development of the readout of the ARA neutrino detector.

R. Vanderhaeghen and M. Korntheuer were in charge of the maintenance of the electronic workshop.

b. Secretariat

The secretarial work and the general administrative and logistic support of the experiments were in charge of M. Goeman and A. Terrier, with the collaboration of J. De Bruyne, P. De Harenne and F. Pero.

J. De Bruyne and P. De Harenne provided daily support for numerous tasks; F. Pero was in charge of ULB travels.

The organisation of the annual meeting of the IIHE Brussels on November 9 was in the hands of J. D'Hondt and P. Vanlaer, with support from M. Goeman.

III. Activities of IIHE members

1. Contributions to experiments

a. Responsibilities in experiments

Stijn Blyweert
TOP-JetMET object expert CMS.

Lionel Brayeur
Analysis referee, member IceCube GRB.

Barbara Clerbaux
Co-coordinator CMS HEEP (High energy electron pairs) group.

Catherine De Clercq
Principal Investigator for VUB IceCube Collaboration Board,
Member IceCube Executive Committee,
Liaison officer IceCube International Oversight and Finance Group,
Member IceCube Spokesperson Search Committee.

Laurent Favart
Shift Leader CMS data taking.

Kael Hanson
Member IceCube IceCube Executive Board,
Lead IceCube Data Acquisition Group,
Member IceCube Supernova Working Group,
Responsible ARA Detector communications / timing.

Tomas Hreus
Convener (CMS L3 position) CMS Tracker DQM Group.

Alexis Kalogeropoulos
Central DCS swifter CMS DCS,
Swift Leader / P5 CMS,
CMS Generators Group MadGraph Coordinator CMS CMS.

Abdollah Mohammadi
Editor of the ZH(ττ) analysis, CMS ZH (H to ττ) analysis team,
τ ID and fake rate responsible CMS τ physics object group.

Catherine Vander Velde
Member CMS Collaboration Board
Member CMS Finance Board
Member CMS Tracker Institution Board
CMS – ULB Team Leader

Pascal Vanlaer
Higgs PAG trigger contact person CMS Higgs PAG,
ULB vice-team leader CMS Collaboration Board,
Tier-2 representative CMS CMS Computing.

Walter Van Doninck
Coordinator CMS Muon FW RPC.

Gaston Wilquet
Chairperson OPERA Collaboration Board,
Member OPERA Editorial Board.

b. Presentations in collaboration meetings

Patrizia Barria
XDAQ: starting point - CERN, Geneva, Switzerland 03/10/2012,

Online software - CERN, Geneva, Switzerland 07/11/2012.

Stijn Blyweert
Effect of PU on Top Mass measurement - High PU meeting, CERN 23/01/2012,
Top quark mass analysis plans from Brussels - Top Mass Meeting, CERN 16/03/2012,
JetMET objects in the Top PAG - CMS Top PAG, CERN 03/04/2012,
JetMET recommendations for top analyses - Top Quark Meeting, CERN 12/06/2012,
Differential Top Mass measurement with a 1D Ideogram method (l+jets) - Top Mass Meeting, CERN 28/09/2012,
Top quark mass analysis plans from Brussels - Top Mass Meeting, CERN 05/10/2012,
Differential Top Mass studies at Generator Level - Top Mass Meeting, CERN 23/11/2012,
First look at top-antitop mass difference wit 8 TeV data - Top Mass Meeting, CERN 21/12/2013.

Lionel Brayeur
Comparison between Dwalk and PoleMuonLlhFit - Berkeley, California, USA 20/03/2012,
Comparison between Dwalk and PoleMuonLlhFit - Aachen, Germany 02/09/2012.

Martin Casier
Bayesian approach for the statistical analysis of the Point Source measurement - Berkeley, USA 21/03/2012.

Gilles De Lentdecker
GEM project Status Report - CMS Upgrade Week, CERN, Geneva 05/10/2012.

Kael Hanson
The DAQ Walk 2012-2013 - IceCube Collaboration Meeting, Aachen 30/09/2012,
DOMHub Upgrade : Long-Term Planning - IceCube Collaboration Meeting, Aachen 30/09/12.

David Heereman Von Zuydtwyck
Improvement to sndaq in IceCube: HItSpooling - Berkeley, USA 20/03/2012,
HitSpool Status Update - Aachen, Germany 04/10/2012.

Tomas Hreus
Strip tracker results - CRAFT12 Jamboree, CERN, Geneva, Switzerland 16/03/2012,
DPG contribution on data taking from an offline perspective - Tracker Week Meeting, CERN 17/07/12.

Thomas Meures
Downhole digitization - National Taiwan University, Taipei 10/02/2012,
Status report on the Southpole wireless test 2011-2012 - Maryland University, USA 19/04/2012.

Abdollah Mohammadi
Seach for SM H Boson in decay of a pait of τ associated with Z/W boson (approval Talk) - CERN 12/08/2012.

Thomas Reis
EXO-12-015 Pre-Approval - CERN, CH 07/07/2012,
Z' --> l l (EXO-12-015) - Rome, IT 09/10/2012.

Laurent Thomas
Search for Resonances in the Dilepton Mass (electron part) - Geneva (Switzerland) 23/02/2012.

Pascal Vanlaer
Measurement of Strange Particle Production in Underlying Events in proton-proton collisions at 7 TeV - CERN 03/07/2012,
Search for the standard model Higgs boson in the H to ZZ to 2l 2nu final state in pp collisions at 7 and 8 TeV - CERN 07/06/2012.

Walter Van Doninck
Many – CERN, Geneva, Switzerland.

Petra Van Mulders
Commissioning of the CSV tagger in CMS - CERN, Geneva, Switzerland various occasions,
Inclusive search for a fourth generation of quarks - CERN, Geneva, Switzerland various occasions.
CSV retraining status - BTV meeting, CMS week, Geneva Switzerland 12/12/2012,*Update on the MVA retraining framework and a commissioned LR-based CSV* - BTV meeting, CMS week, Geneva Switzerland 27/06/2012,
Pre-approval of EXO-11-098 (inclusive t'/b' search) - ToplikeBSM meeting, CERN, Geneva, Switzerland 04/05/2012,
EXO-11-098 Approval Presentation: Search for inclusive b' or t' production - ICHEP Approval Marathon, CERN, Geneva, Switzerland 19/06/2012.

2. Completed Master and PhD theses

Sabrina Bechet
Détection d'un flux diffus de neutrinos tauiques d'origine cosmique dans le détecteur IceCube
PhD thesis, ULB, Promotor : Kael Hanson, October 2012.

Cécile Caillol
Recherche du boson scalaire de Brout-Englert-Higgs dans le canal H→ZZ→2l2v : étude des données 2011 du détecteur CMS
Master thesis, ULB, Promotor : Barbara Clerbaux, June 2012.

Ben Dumoulin
Bayesian evaluation of high-energy neutrino emission by Active Galactic Nuclei with the IceCube 40-string configuration.
Master thesis, VUB, Promotor Nick Van Eindhoven, June 2012.

Geoffrey Mullier
Étude de détecteurs Triple-GEMs pour la mise à niveau du spectromètre à muons de l'expérience CMS po
Master thesis, VUB, Promotor : Gilles De Lendtecker, September 2012.

Julien Olast
Mesure de la section efficace de production ZZ au LHC.
Master thesis, ULB, Promotor : Pascal Vanlaer and J.-M. Sparenberg, September 2012.

3. Representation in scientific councils and committees

Barbara Clerbaux
Member FRIA jury - physics commission,
Organisator Invited seminars at the IIHE,
Principal Investigator Convention IAP "fundamental interactions", ULB-exp node.

Catherine De Clercq
Chair Belgian selection committee of CERN fellows,
Chair FWO Expert Panel W&T2 Fysica,
Member representant of the FWO ApPEC steering committee,
Member representant of FWO ASPERA Eranet Governing Board,
Member NIKHEF Scientific Advisory Committee,
Member IISN commission des Hautes et Basses Energies,
Chair Belgian selection committee of CERN fellows,
Member CERN European Strategy update Preparatory Group,
Member organisation comittee of the Belgian-Dutch-German summer school.

Gilles De Lentdecker
President ULB representative Belgian Physical Society.

Laurent Favart
Member H1 executive committee,
Member SPS and PS experiments Committee,
Member H1 Physics Board,
Member FNRS delegate IOFG (International Oversight and Finance Group).

Pierre Marage
Member FWO - Commissie E5 (Subatomaire Fysica),
Membre titulaire Comite national de Logique, de Philosophie
Coorganisateur Séminaire Fukushima un an après, Penser la Science, ULB.

Catherine Vander Velde
Member- Plenary European Committee of Future Accelerator (PECFA)
Member- Commission FNRS- IISN- Hautes et basses énergies
Chairperson of the ACCU- CERN, and Belgian delegate

Pascal Vanlaer
Board member ULB representative Consortium des equipements de calcul intensif,
Member ULB experimental particle physics FRS-FNRS doctoral school on Physics and Astrophysics (PandA).

Walter Van Doninck
Member EPS HEPP Board,

Belgian Scientific Delegate CERN Council.

Nick Van Eijndhoven
Member Coordinator for exp. Neutrino Astronomy Scientific Programme Committee for the International Cosmic Ray Conference (ICRC).

4. Diffusion of scientific results

a. Oral presentations at conferences and schools

Priscila de Aquino
From Gravitons to Gravitinos - UNICAMP (Internal Seminar), Campinas, Brazil 10/10/2012.

Gilles De Lentdecker
Latest Results of the ILC Large TPC Prototype (LPTPC) - KEK, Tsukuba, Japan 13/11/2012.

Kael Hanson
Astroparticle Physics at 90 Degrees South - University College London 15/10/2012.

Luca Perniè
ZZ cross section measurement at CMS experiment and aTGC limits - Belgium Netherlands Dutchland (BND) doctoral school 30/09/2012

Stijn Blyweert
Top Quark Mass Measurements at the LHC - La Thuile, Italy 16/03/2012.

Cécile Caillol
ZH->ll τ τ search - UCL 23/11/2012.

Barbara Clerbaux
Search for the Standard Model scalar boson at CMS and searches for new physics at the LHC - Bonn, Germany 26/03/12.

Karen De Causmaecker
Gauge-mediated supersymmetry breaking and goldstini phenomenology - FeynRules workshop, Mont Sainte-Odile 67530 Ottrott 30/03/2012,
Gauge-mediated supersymmetry breaking and goldstini phenomenology - BPS meeting, Brussels 30/05/2012,
Gauge-mediated supersymmetry breaking and goldstini phenomenology - Theory at the Sea, Oostduinkerke 08/06/2012,
Generating SUSY Mass Spectrum Generators - Institut d'Etudes Scientifiques de Cargese, Corsica 23/08/2012,
Mass Diagonalisation - MadGraph Meeting, Natal, Brazil 07/10/2012.

Laurent Favart
Exclusive vector meson production: from high to low energies - XII HADRON PHYSICS, Bento Goncalves, Brazil 24/04/2012,
Parton Distribution Functions - Belgian-Dutch-German graduate school in particle physics (BND 2012), Bonn (D) - 4h lecture 25/09/2012.

Kael Hanson
Development of a Clock Distribution System for Sub-Nanosecond Time Synchronization over Long Distances - RT2012 Conference Berkeley 09/06/12,
Extending the IceCube DAQ System by Integration of the Generic High-Speed Sorter Module TESS - RT2012 Berkeley CA 09/06/12.

Tomas Hreus
Measurement of strangeness production in the underlying event and comparison with simulations - Fourth International Workshop on Multiple Partonic Interactions at the LHC, CERN, Geneva, Switzerland 04/12/2012,
Strangeness production in the UE - Soft QCD mini workshop, CERN, Geneva, Switzerland 12/04/2012.

Alexis Kalogeropoulos
SUSY in CMS - Natal,Brazil 05/10/2012,
3rd Generation Studies in CMS - Bonn,Germany 28/3/2012.

Jan Kunnen
Looking for Earth WIMPs with the IceCube Neutrino Detector - Dark Attack, Ascona, Switzerland 19/07/2012.

Kentarou Mawatari
Collider signatures of goldstini in gauge mediation - Pittsburgh 08/05/2013,

Particle physics life in the LHC era - Oostduinkerke 09/06/2013,
Top window for dark matter - Kobe University Brussels European Centre 07/09/2012,
Collider signatures of goldstini in gauge mediation - IIHE 08/09/2012,
TauDecay - Natal 07/10/2012,
X>ττ for spin/parity determination - ULB 20/12/2012.

Thomas Meures
Post-IceCube mission: The Askar'yan Radio Array - Chiba University, Tokyo, Japan 22/02/2012,
Status of the Askaryan Radio Array and recent results – UCL 11/05/2012,
The Askar'yan Radio Array - VUB, Brussels 30/05/2012,
The Askar'yan Radio Array - Erlangen, Germany 20/06/2012.

Abdollah Mohammadi
MSSM Higgs (neutral charged) search at LHC - ICEPP, the University of Tokyo, Tokyo 20/11/2012,
Search for SM Higgs Boson at CMS - Institute for Physics and Mathematics (IPM), Tehran, Iran 26/12/2012.

Bettina Oexl
Jets plus missing energy in light gravitino production at the LHC - Belgian Physics Society meeting 2012, Brussels 30/05/2012,
Jets plus missing energy in light gravitino production at the LHC - Theory at the Sea meeting 2012, Oostduinkerke 09/06/2012,
Light gravitino production in association with gluinos at the LHC - Cargese 2012 Summer School, Cargese, France 23/08/2012,
Light gravitino production in association with gluinos at the LHC - Workshop on LHC physics, VUB, Brussels 08/09/2012.

Thomas Reis
Z' Searches with Electrons in CMS - Bonn, DE 30/09/2012.

Petra Van Mulders
Search for new fermions and new bosons (on behalf of CMS, ATLAS and Tevatron) - Štrbské Pleso, Slovakia 14/09/2012,
An inclusive search for fourth generation b' and t' quarks - Leinsweiler 26/03/2012,
Summary of MVA activities for b-taggers - Lisbon, Portugal 04/09/2012,

Gerrit Van Onsem
Measurement of the top-antitop mass difference (CMS) - Melbourne, Australia 05/07/2012.

Jian Wang
High-mass scalar boson search and anomalous triple gauge coupling - Inter-university Attraction Pole: Fundamental Interactions, Brussels 20/12/2012.

Yifan Yang
Research of long distance clock distribution system - Oxford 19/09/2012.

Nick Van Eijndhoven
IceCube : Catching ghost particles at the South Pole, Invited talk, Beta Excellent, Rotterdam, The Netherlands, 29/03/2013,
IceCube : Exploring the final frontier, Invited talk, Belgium Physical Society, Brussel, Belgium, 30/05/2012.

b. Poster presentations at conferences and schools

Stijn Blyweert
Measurement of the top mass difference with CMS - Winchester, U.K. 19/09/2012.

Lionel Brayeur
Studying high energy Gamma Ray Bursts and Active Galactic Nuclei emission - Paris, France 03/07/2012.

Karen De Causmaecker
Elusive Supersymmetry: Collider Signatures of Goldstini in Gauge Mediation - Cern, Geneva 25/06/2012,
Elusive Supersymmetry: Collider Signatures of Goldstini in Gauge Mediation - MadGraph Meeting, Natal, Brazil 07/10/2012.

Gilles De Lentdecker
Development of the data acquisition system of a large TPC for the ILC - Berkeley, CA, USA 14/06/2012.

Jan Kunnen
Looking for Earth WIMPs with the IceCube Neutrino Detector - Dark Attack, Ascona, Switzerland 18/07/2012,
Looking for Earth WIMPs with the IceCube Neutrino Detector - ISAPP Summer School, Paris 09/07/2012.

Abdollah Mohammadi
Search for SM Higgs Boson associated with W and Z boson decaying to a pair of taus at CMS - Kyoto University, Japan 15/11/2012.

Bettina Oexl
Light gravitino production in association with gluinos at the LHC - MCnet-LPCC SummerSchool, CERN, Geneva, Switzerland 24/07/2012,
Light gravitino production in association with gluinos at the LHC - Feynrules/MadGraph School on LHC physics 01/10/2012.

Thomas Reis
Search for Resonances in the Dielectron Mass Distribution in pp Collisions at $\sqrt{s}$ = 7 TeV - Brussels, BE 30/05/2012.
Search for Resonances in Dilepton Mass Spectra in pp Collisions at $\sqrt{s}$ = 8 TeV - Lisbon, PT 03/09/2012.

Laurent Thomas
Search for Resonances in the Dielectron Mass Distribution in pp Collisions at $\sqrt{s}$ = 7 TeV - Brussels 30/05/2012.

5. Scientific training

a. Attendance to conferences and workshops

Patrizia Barria
CMS GEM Electronics Meeting - CERN from 10/07/2012 to 11/07/2012,
CMS GEM Electronics Meeting - CERN Oral presentation Session chair-personfrom 02/10/2012 to 03/10/2012,
GEM Upgrade Workshop IV - CERN Oral presentation from 05/11/2012 to 07/11/2012,
Workshop on Higgs Searches - Louvain-La-Neuve from 22/11/2012 to 23/11/2012.

Stijn Blyweert
Rencontres de Moriond QCD and High Energy Interactions - La Thuile, Italy Oral presentation from 10/03/2012 to 17/03/2012,
5th International Workshop on Top Quark Physics - Winchester, U.K. Poster from 16/09/2012 to 21/09/2012.

Lionel Brayeur
IceCube Collaboration meeting - Berkeley, California, USA Oral presentation from 19/03/2012 to 23/03/2012,
IceCube Collaboration meeting - Aachen, Germany Oral presentation from 01/09/2012 to 05/09/2012.

Cécile Caillol
Higgs search in Belgium mini-workshop - UCL from 22/11/2012 to 13/11/2012,
IAP meeting - ULB from 20/12/2012 to 20/12/21012.

Martin Casier
Work at the South Pole for the IceCube experiment - South Pole, Antarctica from 25/12/2012 to 20/01/2013,
IceCube Collaboration Meeting - Aachen, Germany from 01/10/2012 to 05/10/2012,
NSE - PhD Day - Brussels, Belgium Oral presentation Poster from 08/06/2012 to 08/06/2012,
Belgian Physical Society Annual Meeting - Brussels, Belgium Poster from 30/05/2012 to 30/05/2012,
IceCube Collaboration Meeting - Berkeley, USA Oral presentation from 19/03/2012 to 23/03/2012.

Barbara Clerbaux
XX International Workshop on Deep- Inelastic Scattering and Related Subjects (DIS2012) - Bonn, Germany Oral presentation from 26/03/12 to 30/03/12,
General meeting of the IUAP on fundamental interactions - ULB, Brussels from 20/12/12 to 20/12/12,
STOA, open session : Unlocking the Mysteries of the Universe at CERN - European Parlement Brussels, Belgium from 27/11/12 to 27/11/12,
Higgs search in Belgium, Mini-workshop - UCL, Belgium Session chair-personfrom 22/11/12 to 23/11/12,
Solvay Workshop, The Quantum Quest : a Fascinating Journey (Celebration of François Englert's 80th B - ULB, Belgium from 05/11/12 to 07/11/12,
CMS Physics week - Lisbon, Portugal from 04/09/12 to 07/09/12,
General meeting of the Belgian Physical Society BPS - VUB, Brussels from 30/05/12 to 30/05/12,
General meeting of the PANDA doctoral school - UCL, Belgium from 11/05/12 to 11/05/12,
XLVIInd Rencontres de Moriond, session electroweak interactions and unified theories - La Thuile, Italy Session chair-personfrom 03/03/12 to 10/03/12,
General meeting of the Inter-university Attraction Pole IAP on fundamental interactions - ULB, Brussels Session chair-personfrom 03/02/12 to 03/02/12.

Karen De Causmaecker
FeynRules 2012 workshop: towards NLO - Mont Sainte-Odile, 67530 Ottrott Oral presentation from 25/03/2012 to 30/03/2012,

MadGraph meeting 2012 - Natal, Brazil Oral presentation Poster from 30/09/2012 to 08/10/2012.

Priscila de Aquino
Meeting: Higgs Cross Section Working Group - CERN/ Switzerland from 05/12/2012 to 06/12/2012.

Catherine De Clercq
BPS General Scientific Meeting - VUB, Brussels Conference organisation from 30/05/2012 to 30/05/2012,
Open Symposium European Strategy Preparatpry Group - Krakow Session organizer Session title:Astroparticle Physics, Gravitation and CosmologyConference organisation Session chair-personfrom 9/09/2012 to 12/09/2012,
A deeper look into matter, Symposium in honour of Robert Roosen - VUB, Brussel Oral presentation from 19/10/2012 to 19/10/2012,
Kick-off meeting IAP VII/37: Fundamental Interactions - ULB, Brussel from 20/12/2012 to 20/12/2012,
Meeting of IAP VI/11 : Fundamental Interactions - ULB, Brussels Session chair-personfrom 03/02/2012 to 03/02/2012.

Gilles De Lentdecker
IEEE Real Time Conference 2012 - Berkeley, CA, USA Poster from 11/06/2012 to 15/06/2012.

Laurent Favart
XII HADRON PHYSICS - Bento Goncalves, Rio Grande do Sul, Brazil Oral presentation Session chair-personfrom 22/04/2012 to 27/04/2012.

Geraldina Golup
General Scientific Meeting 2012 of the Belgian Physical Society - Brussels, Belgium from 30/05/2012 to 30/05/2012,
Meeting of the IceCube Collaboration - Aachen, Germany from 01/10/2012 to 05/10/2012,
SpacePart12 - 4th International Conference on Particle and Fundamental Physics in Space - Geneva, Switzerland from 05/11/2012 to 07/11/2012.

Kael Hanson
IEEE Realtime Conference - Berkeley CA Oral presentation Poster from 09/06/12 to 15/06/12,
EuroSciPy 2012 - Brussels Conference organisation from 23/08/12 to 27/08/12,
Brussels IceCube Boot - Brussels Oral presentation Conference organisation from 04/09/12 to 06/09/12.

David Heereman Von Zuydtwyck
German Physisicts Society Meeting - Göttingen, Germany from 28/02/2012 to 02/03/2012,
IceCube Collaboration Meeting - Berkeley, USA Oral presentation from 18/03/2012 to 25/03/2012,
BPS Annual Meeting - Brussels, Belgium Poster from 30/05/2012 to 30/05/2012,
Summer School of AstroParticle Physics - Nijmegen, Netherlands from 25/07/2012 to 03/08/2012,
Summer School of AstroParticle Physics - Nijmegen, Netherlands from 25/07/2012 to 03/08/2012,
IceCube Collaboration Meeting - Aachen, Germany Oral presentation from 01/10/2012 to 06/10/2012,
PandA, Louvain la Neuve.

Tomas Hreus
Fourth International Workshop on Multiple Partonic Interactions at the LHC - Geneva, Switzerland Oral presentation from 03/12/2012 to 07/12/2012,
Soft QCD mini workshop - CERN, Geneva, Switzerland Oral presentation from 12/04/2012 to 13/04/2012.

Alexis Kalogeropoulos
CMS Week - CERN/Geneva Oral presentation from 18/02/2013 to 23/02/2013,
Deep Inelastic Scattering conference 2012 - Bonn,Germany Oral presentation from 28/3/2012 to 30/3/2012,
MCNet - CERN/Geneva Poster from 28/6/2012 to 28/8/2012.

Jan Kunnen
IceCube Spring Collaboration Meeting - University of California, Berkeley California Oral presentation from 19/03/2012 to 23/03/2012,
IceCube Fall Collaboration Meeting - RWTH Aachen, Germany Oral presentation from 01/10/2012 to 05/10/2012,
Dark Attack 2012 - Ascona, Switzerland Oral presentation Poster from 15/07/2012 to 20/07/2012,
Exotic Workshop with Neutrino Telescopes - Centre de Physique des Particules de Marseille, France from 03/04/2013 to 05/04/2013.

Michael Maes
Physics at the LHC 2012 - Vancouver, Canada Oral presentation from 03/06/2012 to 10/06/2012,
CMS Week - CERN, Geneva, Switzerland from 27/02/2012 to 02/03/2012,
CMS Physics Week - CERN, Geneva, Switzerland from 16/04/2012 to 20/04/2012.

Kentarou Mawatari
IAP meeting - ULB from 03/02/2012 to 03/02/2012,
2012 Phenomenology Symposium - Pittsburgh Oral presentation from 07/05/2012 to 09/05/2012,
Loopfest XI - Pittsburgh from 10/05/2012 to 12/05/2012,

MadGraph Spring 2012 - Pittsburgh Session chair-personfrom 10/05/2012 to 12/05/2012,
BPS meeting - VUB from 30/05/2012 to 30/05/2012,
Theory at sea - Oostduinkerke Oral presentation from 09/06/2012 to 09/06/2012,
Kobe-BXL LHC workshop - Kobe University Brussels European Centre / IIHE Oral presentation Conference organisation Session chair-personfrom 06/09/2012 to 08/09/2012,
MadGraph meeting 2012 - Natal Oral presentation from 05/10/2012 to 08/10/2012,
Top@BXL - IIHE from 26/10/2012 to 26/10/2012,
IAP meeting - ULB Oral presentation from 20/12/2012 to 20/12/2012.

Thomas Meures
International workshop on Particles and Radiation from Cosmic Accelerators CA2012 - Chiba University, Tokyo, Japan Oral presentation from 20/02/2012 to 22/02/2012,
Meeting of the Belgian Physical Society - VUB, Brussels Oral presentation from 30/05/2012 to 30/05/2012,
ARENA 2012 - Erlangen, Germany Oral presentation from 19/06/2012 to 22/06/2012,
PandA - U.C.L. Oral presentation from 11/05/2012 to 11/05/2012,
ARA hardware workshop - National Taiwan University, Taipei Oral presentation from 09/02/2012 to 12/02/2012,
ARA collaboration meeting - Maryland University, USA Oral presentation from 18/04/2012 to 20/04/2012,
IceCube Collaboration Meeting - RWTH-Aachen, Germany from 01/10/2012 to 01/10/2012.

Abdollah Mohammadi
Hadron Collider Physics (HCP2012) - Kyoto University (Japan) Poster from 12/11/2012 to 16/11/2012,
Higgs Coupling (HC2012) - ICEPP, the University of Tokyo, Tokyo Oral presentation from 18/11/2012 to 20/11/2012,
Workshop on Latest CMS results - Institute for Physics and Mathematics (IPM), Tehran, Iran Oral presentation from 26/12/2012 to 26/12/2012,
IIHE annual meeting - Brussels, Belgium Oral presentation, 09/11/2012

Bettina Oexl
Belgian Physics Society meeting - Brussel Oral presentation from 30/05/2012 to 30/05/2012,
Theory at the Sea 2012 - Oostduinkerke Oral presentation from 08/06/2012 to 09/06/2012,
Workshop on LHC physics - VUB, Brussel Oral presentation from 06/09/2012 to 08/09/2012,
MadGraph meeting 2012 - Natal, Brazil Poster from 05/10/2012 to 08/10/2012,
IIHE annual Meeting - Brussels from 09/11/2012 to 09/11/2012.

Luca Perniè
CMS week - Lisbon from 03/09/2012 to 07/09/2012,
Annual meeting of the PANDA (particles AND astrophysics doctoral school) - UCL, Louvain-La-Neuve, Belgium from 11/05/2012 to 12/05/2012,
IAP national meetings - Bruxelles from 03/01/2012 to 03/01/2012.

Thomas Reis
CMS Exotica Workshop - Rome, IT Oral presentation from 09/10/2012 to 10/10/2012,
CMS Week - Lisbon, PT Poster from 03/09/2012 to 07/09/2012,
Meeting of the Belgian Physical Society - Brussels, BE Poster from 11/05/2012 to 11/05/2012.

Laurent Thomas
Meeting of the Belgian Physical Society - Brussels Poster from 30/05/2012 to 30/05/2012,
CMS week in Lisbon - Lisbon (Portugal) from 03/09/2012 to 07/09/2012,
CMS Exotica Workshop in Roma - Roma (Italy) from 09/11/2012 to 10/11/2012.

Edwin Torisaen
Federation R&E Belnet - Brussels 15/03/2012,
VMware Forum 2012 - Brussels 12/05/2011.

Pascal Vanlaer
Journées jeunes chercheurs 2012 - Munster, France Conference organisation from 02/12/2012 to 08/12/2012,
Advanced statistics for discoveries - IIHE (ULB-VUB) Conference organisation from 20/04/2012 to 22/04/2012,
IIHE annual meeting - VUB industry incubator Conference organisation from 09/11/2012 to 09/11/2012.

Gerrit Van Onsem
Fourth fermion generation and single-top production workshop 2012 - Leinsweiler, Germany from 26/03/2012 to 28/03/2012,
CMS physics week - Geneva, Switzerland from 17/04/2012 to 20/04/2012,
International Conference on High Energy Physics (ICHEP 2012) - Melbourne, Australia Oral presentation from 02/07/2012 to 12/07/2012.

Yifan Yang
Askaryan Radio Array meeting - Taiwan Oral presentation from 07/02/2012 to 13/02/2012,
AIDA first annual meeting - Desy,Hamburg Oral presentation from 27/03/2012 to 30/03/2012,
3rd ASPERA Computing and Astroparticle Physics workshop - Hannover from 02/05/2012 to 04/05/2012,

8th Conference on Ph.D. Research in Microelectronics&Electronics - Aachen from 12/06/2012 to 15/06/2012,
Topical Workshop on Electronics for Particle Physics - Oxford Oral presentation from 16/09/2012 to 22/09/2012.

b. Attendance to schools

Lionel Brayeur
ISAPP - Paris from 03/07/2012 to 13/07/2012,
IceCube Bootcamp - Brussels from 04/09/2012 to 06/09/2012.

Martin Casier
Boot Camp of the IceCube Collaboration - Brussels, Belgium from 04/09/2012 to 06/09/2013,
ISAPP - Paris, France from 02/07/2012 to 14/07/2012.

Karen De Causmaecker
MCnet-LPCC Summer School on Monte Carlo Event Generators for LHC - Cern, Geneva from 23/06/2012 to 27/06/2012,
International School Cargese 2012: Across the TeV frontier with the LHC - Institut d'Etudes Scientifiques de Cargese, Corsica from 20/08/2012 to 01/09/2012.

David Heereman Von Zuydtwyck
Summer School of AstroParticle Physics - Nijmegen, Netherlands from 25/07/2012 to 03/08/2012.

Alexis Kalogeropoulos
The 2012 FeynRules/MadGraph School on LHC phenomenology - Natal,Brazil from 29/09/2012 to 09/10/2012.

Jan Kunnen
ISAPP Summer School - Paris, France from 02/07/2012 to 12/07/2012.

Kentarou Mawatari
The 2012 FeynRules/MadGraph School on LHC Phenomenology - Natal from 30/09/2012 to 05/10/2012.

Thomas Meures
Statistics for discoveries - IIHE Brussels from 24/04/2012 to 25/04/2012.

Bettina Oexl
MCnet-LPCC SummerSchool on Monte Carlo Event Generators for the LHC - CERN, Gevena, Switzerland from 23/07/2012 to 27/07/2012,
Cargese 2012: Across the TeV frontier with the LHC - Cargese, France from 20/08/2012 to 01/09/2012,
The 2012 FeynRules/MadGraph School on LHC phenomenology - Natal, Brazil from 30/09/2012 to 05/10/2012.

Annik Olbrechts
BND summer school - Bonn, Germany from 21/09/2012 to 02/10/2012.

Luca Perniè
BND summer school - Bonn from 21/09/2012 to 02/10/2012.

Thomas Reis
CMS Data Analysis School - Pisa, IT from 23/01/2012 to 27/01/2012,
PandA Doctoral School - Louvain-la-Neuve, BE from 11/05/2012 to 11/05/2012,
BND Summer School - Bonn, DE from 21/09/2012 to 02/10/2012.

Laurent Thomas
CMS Data Analysis School - Pisa (Italy) from 23/01/2012 to 27/01/2012,
Advanced statistics for discoveries - Brussels from 24/05/2012 to 25/05/2012.

c. Invited seminars at the IIHE

Mikael Hult (21 January)
Gamma-ray spectrometry 225m underground – developments, possibilities and applications

Abdollah Mohammadi (12 March)
Tau at CMS (From τ Lepton and τ in SM measurements to τ Role in Discovery)

Hughes Brun (14 March)
Photons reconstruction and identification in the CMS experiment at the LHC. Application to Brout-Englert-Higgs boson searches in the H→γγ channel.

Arabella Martelli (15 March)
First measurement of the WZ production cross section with the CMS detector at the LHC

Prof. Ronan McNulty (11 May)
Tests of the Standard Model in the Forward Region at the LHC

Dr. Yoshi Uchida (25 May)
T2K status and results

Dr. Patric Muggli (31 May)
POSTPONED : Plasma Wakefield Accelerator Experiments with CERN Proton Bunches

Dr. Sahal Yacoob (01 June)
Measurement of the W Boson Mass at D0

Dr. Geraldina Golup (15 June)
Search for signatures of magnetically-induced alignment in the arrival directions measured by the Pierre Auger Observatory

Dr Jaap Velthuis (22 June)
Overview and use of MAPS (Title TBC)

Dr. Gijs Nelemans (12 September)
Gravitational wave Astrophysics

Dr. David Lopez-Val (28 September)
Heavy particles at the LHC: NLO predictions & automated tools

Krijn De Vries (15 October)
Probing cosmic rays by radio emission from air showers

Dr. Gennaro Corcella (25 October)
Supersymmetric contributions to Z' decays

Dr. Duc Boa Ta (23 November)
Single top quark measurements at the LHC

Dr. Tracey Berry (30 November)
Search for High-mass dilepton resonances with the ATLAS detector

6. Teaching and academic activities

a. Teaching activities

Lionel Brayeur
Muon lab, (0/0/16/2) 3 Part time.

Martin Casier
WE-DNTK-14089 : *Excercise sessions*, (24hours) BA1 Full time.

Barbara Clerbaux
PHYS-F416 : *Interactions fondamentales et particules*, (18/0/0/0) MA1 Part time,
PHYS-F310 : *Stage dans un service du département*, (0/0/10/0) BA3 Part time,
PHYS-F312 : *Laboratoire de physique des particules*, (0/0/36/0) BA3 Full time.

Karen De Causmaecker
1010837BNR : *Elektrodynamica en speciale relativiteit*, (0/26/0/26) 2nd bachelor Full time.

Jorgen D'Hondt
Experimentele stralings- en kwantumfysica
Statistische verwerking van experimentele gegevens
Inleiding tot de Kwantumfysica
Statistische fysica
Subatomic Physics II
Extensions of the Standard Model
Experimental Techniques in Particle Physics

Olivier Devroede
Exercises Matlab, (6) 1BA Full time,
Object Oriented Programming (C++) for Physicists, (10/10/0/30) 1 +2 Ma Full time.

Catherine De Clercq
WE-DNTK-12521 : *Astroparticle physics*, (13/13/0/0) master fysica VUB Full time,
WE-DNTK-13971 : *Externe mobiliteit A (coordination)*, MA Physics Full time,
WE-DNTK-14101 : *Experimentele Fysica*, (0/0/78) 1BA Fysica en Sterrenkunde Full time,
WE-DNTK-14089a : *Fysica: trillingen, golven en thermodynamica*, (0/0/78) 1BA Fysica en Sterrenkunde Part time.

Gilles De Lentdecker
PHYS-F-314 : *Electronics*, (12/6/36) BA3 Part time,
PHYS-F-312 : *Laboratoire de physique des particules*, (0/0/72) BA3 Part time.

Laurent Favart
PHYS-F477 : *Physique aupres des collisioneurs hadroniques*, (24/0/0/12) MA1-2 Full time,
PHYS-F102 : *Laboratoire de physique generale I et II*, (0/0/24/0) BA1 Full time.

Kael Hanson
PHYS-F467 : *Particle Astrophysics*, (24/24/0/0) 2012 Full time,
PHYS-F311 : *Laboratoire de Physique Générale Approfondie*, (0/0/96/0) 2012 Full time,
PHYS-F314 : *Electronique*, (12/6/24/0) 2012 Full time.

Jan Kunnen
Experimentele Fysica, (0/0/40/40) Ba 1 Part time.

Pierre Marage
HIST-F-500 "Histoire des Sciences et Epistémologie" (24/0/0/0) MA-didact., AESS Full time,
COMM-B-515 "Questions d'actualité des sciences (MA2 Journalisme et communication)" (8/0/0/8) MA2 Part time,
HIST-F-101 "Histoire des Sciences" (24/0/0/0) BA Full time.

Thomas Reis
PHYS - F312 : *Laboratoire de physique des particules*, (0/0/30/2) BA3 Full time.

Robert Roosen
WE-DNTK-14315 : *Subatomic Physics II*, (15/0/0/15) Part time
WE-DNTK-14538 : *Elements of the History of Natural Sciences*, (20/0/0/20) Part time

Laurent Thomas
PHYS-F-416 : *Interactions fondamentales et particules (exercises)*, (0/12/0/0) MA1-2 Full time,
Supervision of the internship of a high school student, (3 days) High School Full time.

Catherine Vander Velde
PHYS-F-101 : Physique générale I – Mécanique, (48/0/12) BA1-chimie, physique, mathématique et polyvalente en sciences ,
Coordinator : *Objectif réussite- physique*, BA1-toutes sections
PHYS-F-305 : *Introduction à la physique des particules - aspects expérimentaux*, (24/0/12) BA3-physique Part time
PHYS-F-420 : *Méthodes expérimentales de la physique des particules*, (12/0/0) MA2-physique Part time
PHYS F416 : *Interactions fondamentales et particules*, (18/0/0/0) MA1
CAPAES - physique

Pascal Vanlaer
PHYS-F104 : *Physique 1*, (72/0/0/0) BA1 Full time,
PHYS-F420 : *Détection de particules, acquisition et analyse de données*, (6/0/24/0) MA 1/2 Full time,
PHYS-H-303 : *Projets de bibliographie de 3e annee Ingenieur civil physicien*, (0/0/0/12) BA3 Full time,
PHYS-F101 : *Laboratoires de physique générale*, (0/0/36) BA1 Full time,
PHYSF435 : *Stage de recherche*, (12/0/0/0) MA1 Full time,
PHYSF310 : *Stage de recherche*, (12h) BA3 Full time.
PHYS-F205 "Physique 2" (24/0/0/0) BA2 Full time

Walter Van Doninck
ELEM II : *The Standard Model*, (15 hours) 2012 Part time.

Nick Van Eijndhoven
6406 : *Experimental Study of the Micro and Macrocosmos*, (26/26/0/0) 2012 Full time,
6331 : *Subatomic Physics I : Introduction to Nuclear and Particle Physics*, (26/26/0/0) 2012 Full time.

Petra Van Mulders
1010183ANR : *Mechanica*, (0/26/0/100) 1 BA Full time.

Gerrit Van Onsem
WE-DNTK-11545 : Inleiding tot de Kwantumfysica (WPO), (0/26/0/30) 2012 Part time.

b. Membership to academic jurys

Barbara Clerbaux
Ph.D. thesis Université Joseph Fourier L.P.S.C. (Grenoble), France "Performances du calorimètre électromagnétique et recherche de nouveaux bosons de jauge dans le canal by Emmanuel LAISNE"
Referee,
Master thesis ULB "Recherche du boson scalaire de Brout-Englert-Higgs dans le canal H→ZZ→2l2v" by Cécile Caillol
Promotor.

Catherine De Clercq
Ph. D. Vrije Universiteit Brussel "CCD photometry of variable stellar sources by Taavi Tuvikene"
President.

Gilles De Lentdecker
PhD Thesis Universiteit Gent "Feasibility Study of a GEM Based Muon System for the CMS Detector at the Large Hadron Collider by A. Marinov"
Referee,
Master Thesis ULB "Étude de détecteurs Triple-GEMs pour la mise à niveau du spectromètre à muons de l'expérience CMS po by G. Mullier"
Promotor.

Kael Hanson
PhD ULB "Search for τ Neutrinos with the IceCube Detector by Sabrina Bechet"
Promotor,
Master ULB "Modelling of space-dependent effects in the decay and generation of excitons in a single-layer organ by Olmo Nieto Silleras"
Member.

Kentarou Mawatari
Master KUL "Phenomenology of Scalar Top Pair Production at the LHC by Thomas in't Veld"
Promotor.

Pascal Vanlaer
Master thesis ULB "Mesure de la section efficace de production ZZ au LHC" by Julien Olast.
Promotor

c. Representation in academic councils and committees

Barbara Clerbaux
Chairperson ULB Physics departement,
Member Commission pédagogique facultaire,
Chairperson Commission de classement 1ere assistant.

Jorgen D'Hondt
Director IIHE-VUB
Belgian delegate in ECFA
Belgian delegate in RECFA
Belgian delegate in IPPOG
President of the Physics Department VUB
Representative of the Physics Department in the Council of the Faculty of Science VUB
Chair of the Education Board of the Faculty of Science VUB
Representative of the Physics Department in the Education Board of the Faculty of Science VUB
Member of the Education Board of the VUB
Representative of the Physics Department in the PhD committee of the Faculty of Science VUB
Chair of the Advisory Board of the Physics Department VUB
Member of the FWO Committee for International Collaboration
Member of the Collaboration Board in CMS
Secretary of the Collaboration Board CMS
Principle Investigator in CMS for the VUB
Chair of the Career Committee in CMS
Chair of the International Committee in CMS
Member of the Tracker Institution Board in CMS
Member of the Steering Committee for the Tracker Phase-2 Upgrade in CMS

Principle Investigator of the Strategic Research Program "High-Energy Physics" at the VUB
President of the Young Academy of Belgium (Flanders)
Permanent member of the International Advisory Board for the International Top Quark workshops
Chairing in total 8 editorial boards of publications in CMS

Olivier Devroede
Member Vakgroepraad Fysica.

Catherine De Clercq
President examencommissie Master Fysica VUB,
Secretary examencommissie eerste Bachelor Fysica VUB,
Secretary Examencommissie Voorbereidingsprogramma Master Fysica en Sterrenkunde,
Member Facultaire Commissie Middelen en Personeel,
Member Werkgroep Fysica Practica,
Chairperson Vrouwenraad VUB,
Member VLIR Taakgroep Learning Outcomes Fysica en Sterrenkunde.

Laurent Favart
President Jury de Master en Physique de l'ULB.

Pierre Marage
Directeur de section Institut des Hautes Etudes de Belgique,
Vice-president Centre de Culture scientifique de l'ULB a Charleroi - Parentville,
Membre du CA Altair, asbl d'Histoire des Sciences attachee a l'ULB,
Membre du Conseil d'Administration Institut national des Radioelements, Fleurus,
Vice-recteur pour la politique académique et la recherche ULB,
Membre du CA FNRS et FRSM,
Membre Conseil de la Politique scientifique, Bruxelles-Capitale.

Laurent Thomas
Scientific representative Board of the Faculty of Sciences (ULB).

Catherine Vander Velde
Member Commission d'attribution des Crédits pédagogiques du Département de Physique
Member of the « Observatoire de BA1 »
Member of the jury “examen d’admission à l’université”
President of physics BA jury

Pascal Vanlaer
Member Commission de classement Assistants' du departement de Physique,
President ULB-VUB computing center user committee,
Member Observatoire de la premiere annee universitaire (BA1) en sciences, ULB.

Nick Van Eijndhoven
Chairperson, Faculty coordinator Committee to prepare the 2013 educational audit.

Gaston Wilquet
Expert for the Swiss National Science Foundation and for the University of Bern

7. Vulgarisation and outreach

Martin Casier
Master Classes - 10/03/2012.

Barbara Clerbaux
Oral presentation in Master Classes - 24/03/2012,
Observation of a new particle at mass of 125 GeV - Organisation of a video transmission of CERN seminars, followed by a Press conference - interviews 04/07/12.

Catherine De Clercq
Member of the Flemish Physics Olympiads Committee - Physics Olympiads since 2005.

Gilles De Lentdecker
Organizer of Master Classes - 10/03/2012,
Organizer of Master Classes - 24/03/2012.

Michael Maes
Guiding visit to the CMS experiment - 29/05/13.

Kentarou Mawatari
Electric power generation - Visit at the Japanese School of Brussels 02-03/07/2012.

Thomas Meures
Explanation of ARA to high school students - Master Classes 24/03/2012.

Pierre Marage
Concernant la nouvelle particule découverte au CERN - interviews (RTBF-radio, RTBF-TV, RTL TVI, Télé-Bruxelles) sept. et nov. 2012,
Rencontre avec... - Emission TV Télé-Bruxelles 1/12/2013,
Le boson de Brout-Englert-Higgs, et les succès du CERN - Editorial L'Artichaut, organe du CEPULB, déc. 2012 déc. 2012,
La naissance de la physique moderne, racontée au fil des Conseils Solvay - Conférence, inauguration de l'exposition « Remue-méninges », CCS, Parentville 30/1/2012,
Les combats de Galilée - Formation en Philosophie, CAL-Charleroi 8/2/2012,
Le sabbat des sorcières - Émission radio « Ouï dire » sur « La Première » 15, 22, 29 mai et 5,
L'histoire des particules, de l'électron au boson - émission Semences de Curieux, RTBF-1 04, 11,18, 25 nov. 2.

Laurent Thomas
Master Classes in Particle Physics - 24/03/2012,
Research vulgarisation during an event organized by the Cercle des Sciences (ULB) - Oral presentation 21/03/2012.

Catherine Vander Velde
Présentation de CMS pour le Ministre Nollet - CERN, 20/2/2012
Le LHC, le nouvel accélérateur du CERN, quelles réponses nous apportera-t-il ? - Jette, 15/3/2012
Comprendre de quoi nous sommes faits et d'où nous venons : comment et pourquoi ? - Conférence pour le BES, ULB, 23/3/2012.

Pascal Vanlaer
Recherche du boson de Brout-Englert-Higgs au grand collisionneur de hadrons LHC du CERN - Oral presentation to the Association des Ing'enieurs de l'ULB (AIrBr) 04/12/2012,
Découverte d'une particule compatible avec le boson de Higgs - Press conference 04/07/2012.
Master classes 24/03/2012

Walter Van Doninck
Guide - CMS Visits many.

Petra Van Mulders
Info verstrekken aan toekomstige studenten Natuurkunde - Infodag VUB

IV. Publications

1. Refereed journals and conference proceedings

a. Pheno

Light Gravitino Production in Association with Gluinos at the LHC
OEXL Bettina, MAWATARI Kentaro, Maltoni Fabio, de Aquino Priscila
JHEP, vol.1210, pp.008

Collider signatures of goldstini in gauge mediation
ARGURIO Riccardo, DE CAUSMAECKER Karen, FERRETTI Gabriele, MARIOTTI Alberto, MAWATARI Kentaro, Takaesu Y.
JHEP 1206 (2012) 096, vol.2012, n. 6,

Sgluon pair production to next-to-leading order
MAWATARI Kentaro, Goncalves Netto Dorival, Lopez-Val David, Plehn Tilman, Wigmore IoanPhys. Rev. D, issue 85, pp.114024

b. H1

Measurement of the diffractive longitudinal structure function F(L)(D) at HERA
F. D. Aaron et al., Eur.Phys.J. C72 (2012) 1836

Measurement of the Azimuthal Correlation between the most Forward Jet and the Scattered Positron in Deep-Inelastic Scattering at HERA
F. D. Aaron et al., Eur. Phys. J. C72 (2012) 1910

Measurement of Dijet Production in Diffractive Deep-Inelastic Scattering with a Leading Proton at HERA
F. D. Aaron et al., Eur. Phys. J. C72 (2012) 1970

Inclusive Measurement of Diffractive Deepinelastic Scattering at HERA
F. D. Aaron et al., Eur. Phys. J. C72 (2012) 1974

Measurement of Inclusive and Dijet D* Meson Cross Sections in Photoproduction at HERA
F. D. Aaron et al., Eur. Phys. J. C72 (2012) 1995

Inclusive Deep Inelastic Scattering at High Q2 with Longitudinally Polarised Lepton Beams at HERA
F. D. Aaron et al., JHEP 1209 (2012) 061

Measurement of Beauty and Charm Photoproduction using Semi-muonic Decays in Dijet Events at HERA
F. D. Aaron et al., Eur. Phys. J. C72 (2012) 2047

Measurement of Beauty Photoproduction near Threshold using Di-electron Events with the H1 Detector at HERA
F. D. Aaron et al., Eur. Phys. J. C72 (2012) 2148

Determination of the Integrated Luminosity at HERA using Elastic QED Compton Events
F. D. Aaron et al., Eur. Phys. J. C72 (2012) 2163

Combined inclusive diffractive cross sections measured with forward proton spectrometers in deep inelastic ep scattering at HERA
F. D. Aaron et al., Eur. Phys. J. C72 (2012) 2175

c. PET

Limits on the spatial resolution of monolithic scintillators read out by APD arrays
VAN DER LAAN D.J., MAAS M.C., BRUYNDONCKX PETER, Schaart Dennis
issue Phys. Med. Biol. 57 (2012) 6479-6496., vol.57, pp.6479 - 6496, published by Physics in Medicine and Biology

d. Opera

Momentum measurement by the multiple Coulomb scattering method in the OPERA lead-emulsion target
N. Agafonova et al., The OPERA Collaboration, New J. Phys. 14 (2012) 013026

Search for n_m-n_t oscillation with the OPERA experiment in the CNGS beam
N. Agafonova et al., The OPERA Collaboration, New J. Phys. 14 (2012) 033017

Measurement of the neutrino velocity with the OPERA detector in the CNGS beam
T. Adam et al., The OPERA Collaboration, JHEP 10 (2012) 093

e. ARA

Design and Initial Performance of the Askaryan Radio Array,
P. Allison et al. (ARA Collaboration), Astropart. Phys., 35 (2012) 457.

An extended-range Ethernet and clock distribution circuit for distributed sensor networks.
K. Hanson, T. Meures, and Y. Yang, J. Inst. 7 (2012) 01086.

f. IceCube

Background Studies for Acoustic Neutrino Detection at the South Pole. IceCube collaboration, Astroparticle Physics 35 (2012) 312 (arXiv:1103.1216).

Time-Dependent Searches for Point Sources of Neutrinos with the 40-String and 22-String Configurations of IceCube.
IceCube collaboration, Astrophysical Journal 744 (2012) 1 (arXiv:1104.0075).

Neutrino Analysis of the September 2010 Crab Nebula Flare and Time-Integrated Constraints on Neutrino Emission from the Crab using IceCube.
IceCube collaboration, Astrophysical Journal 745 (2012) 45.

Observation of an Anisotropy in the Galactic Cosmic Ray Arrival Directions at 400 TeV with IceCube.
IceCube collaboration, Astrophysical Journal 746 (2012) 33.

Searches for Periodic Neutrino Emission from Binary Systems with 22 and 40 Strings of IceCube.
IceCube collaboration, Astrophysical Journal 748 (2012) 118 (arXiv:1108.3023).

MultiYear Search for Dark Matter Annihilations in the Sun with the AMANDA-II and IceCube detectors.
IceCube collaboration, Physical Review D85 (2012) 042002.

An absence of neutrinos associated with cosmic-ray acceleration in gamma-ray bursts.
IceCube collaboration, Nature 484 (2012) 351 (arXiv:1204.4219).

Search for utrahigh-energy τ neutrinos with IceCube.
IceCube collaboration, Physical Review D86 (2012) 022005 (arXiv:1202.4564).

Searching for Soft Relativistic Jets in Core-collapse Supernovae with the IceCube Optical Follow-up Program.
IceCube and ROTSE collaboration, Astronomy and Astrophysics 539 (2012) A60 (arXiv:1111.7030).

The Design and Performance of IceCube DeepCore.
IceCube collaboration, Astroparticle Physics 35 (2012) 615 (arXiv:1109.6096).

Use of Event-Level Neutrino Telescope Data in Global Fits for Theories of New Physics.
IceCube collaboration and P. Scott et al., J. of Cosmology and Astroparticle Physics 11 (2012) 057 (arXiv:1207.0810).

g. CMS

Forward Energy Flow, Central Charged-Particle Multiplicities, and Pseudorapidity Gaps in W and Z Boson Events from pp Collisions at 7 TeV.
CMS Collaboration (Chatrchyan et al.)
Eur.Phys.J. C72 (2012) 1839,

Centrality dependence of dihadron correlations and azimuthal anisotropy harmonics in PbPb collisions at √SNN = 2.76 Tev
CMS Collaboration (Chatrchyan et al.)
Eur.Phys.J. C72 (2012) 2012, vol.72, n. 5,

Suppression of non-prompt J/ψ, prompt J/ψ, and Y(1S) in PbPb collisions at √s NN = 2.76 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1205 (2012) 063,

Study of W boson production in PbPb and pp collisions at √s NN = 2.76 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B715 (2012), issue 1-3, vol.715, pp.66 - 87,

Search for heavy long-lived charged particles in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B713 (2012) 408-433, issue 3-4, vol.713, pp.408 - 433,

Observation of a new Ξ b baryon
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 108 (2012) 252002, issue 25, vol.108,

Search for the standard model Higgs boson decaying into two photons in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B710 (2012) 403-425, issue 3, vol.710, pp.403 - 425,

Jet momentum dependence of jet quenching in PbPb collisions at √s NN=2.76 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B712 (2012) 176-197, issue 3, vol.712, pp.176 - 197,

Measurement of the cross section for production of b b-bar X, decaying to muons in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1206 (2012) 110, vol.2012, n. 6,

Search for anomalous ft production in the highly-boosted all-hadronic final state
CMS Collaboration (Chatrchyan et al.)
JHEP 1209 (2012) 029,

Search for third-generation leptoquarks and scalar bottom quarks in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1212 (2012) 055,

Search for supersymmetry in hadronic final states using MT2 in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)

JHEP 1210 (2012) 018,

Measurement of the top-quark mass in tt̄ events with dilepton final states in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Eur.Phys.J. C72 (2012) 2202,

Search for heavy lepton partners of neutrinos in proton-proton collisions in the context of the type III seesaw mechanism
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B718 (2012) 348-368, issue 2, vol.718, pp.348 - 368,

Search for Bs0→μ+μ- and B0→μ+μ- decays in pp collisions at √s=7TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1204 (2012) 033, vol.2012, n. 4,

Performance of CMS muon reconstruction in pp collision events at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JINST 7 (2012) P10002, vol.7,

Measurement of the electron charge asymmetry in inclusive W production in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 109 (2012) 111806, issue 11, vol.109,

Search for pair production of first- and second-generation scalar leptoquarks in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev. D86 (2012) 052013, issue 5, vol.86,

Search for physics beyond the standard model in events with a Z boson, jets, and missing transverse energy in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B716 (2012), issue 2, vol.716, pp.260 - 284,

Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B716 (2012) 30-61, issue 1, vol.716, pp.30 - 61,

Combined results of searches for the standard model Higgs boson in pp collisions at √s = 7 TeV.
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B710 (2012) 26-48, pp.26 - 48,

Measurement of the top quark pair production cross section in pp collisions at sprt(s)=7 TeV in dilepton final states containing a τ
CMS Collaboration (Chatrchyan et al.)
Phys.Rev. D85 (2012) 112007, issue 11, vol.85,

Inclusive b-jet production in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1204 (2012) 084, issue 4, vol.2012, n. 84,

Measurement of the charge asymmetry in top-quark pair production in proton-proton collisions at √s = 7 TeV.
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B709 (2012) 28-49,

Observation of Z decays to four leptons with the CMS detector at the LHC
CMS Collaboration (Chatrchyan et al.)
JHEP 1212 (2012) 034,

Search for leptonic decays of W′ bosons in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1208 (2012) 023, vol.2012, n. 8,

Measurement of the Λ b cross section and the Λ- b to Λ b ratio with J/ψΛ decays in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B714 (2012) 158-179, issue 2-5, vol.714, pp.136 - 157,

Measurement of the relative prompt production rate of chi(c2) and chi(c1) in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Eur.Phys.J. C72 (2012) 2251,

Study of the inclusive production of charged pions, kaons, and protons in pp collisions at √s=0.9, 2.76, and 7 TeV
CMS Collaboration (Chatrchyan et al.)
Eur.Phys.J. C72 (2012) 2164,

Search for a fermiophobic Higgs boson in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1209 (2012) 111,

Search for a light pseudoscalar Higgs boson in the dimuon decay channel in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys. Rev. Lett., issue 12, vol.109,

Azimuthal anisotropy of charged particles at high transverse momenta in PbPb collisions at √s NN=2.76TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 109 (2012) 022301, issue 2, vol.109,

Jet Production Rates in Association with W and Z Bosons in pp Collisions at √s = 7 TeV.
CMS Collaboration (Chatrchyan et al.)
JHEP 1201 (2012) 010,

Measurement of the mass difference between top and antitop quarks.
CMS Collaboration (Chatrchyan et al.)
JHEP 1206 (2012) 109, vol.2012, n. 6,

Search for large extra dimensions in dimuon and dielectron events in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B711 (2012) 15-34, issue 1, vol.711, pp.15 - 34,

Search for heavy Majorana neutrinos in μ ±μ ±+jets and e ±e ±+jets events in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B717 (2012) 109-128,

Measurement of isolated photon production in pp and PbPb collisions at √s NN = 2.76 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B710 (2012) 256-277,

Search for Dark Matter and Large Extra Dimensions in pp Collisions Yielding a Photon and Missing Transverse Energy
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 108 (2012) 261803, issue 26, vol.108,

Search for heavy bottom-like quarks in 4.9 inverse femtobarns of pp collisions at √s = 7 TeV.
CMS Collaboration (Chatrchyan et al.)
JHEP 1205 (2012) 123, vol.2012, n. 5,

Measurement of the Production Cross Section for Pairs of Isolated Photons in pp collisions at √s = 7 TeV.
CMS Collaboration (Chatrchyan et al.)
JHEP 1201 (2012) 133,

Search for stopped long-lived particles produced in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1208 (2012) 026, vol.2012, n. 8,

Search for the standard model Higgs boson in the H → ZZ → l +l -τ +τ - decay channel in pp collisions at √s = 7 Te
CMS Collaboration (Chatrchyan et al.)
JHEP 1203 (2012) 040, vol.2012, n. 3,

Measurement of the Z/γ*+b-jet cross section in pp collisions at 7 TeV.
CMS Collaboration (Chatrchyan et al.)
JHEP 1206 (2012) 126, vol.2012, n. 6,

Measurement of the single-top-quark t-channel cross section in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1212 (2012) 035,

Ratios of dijet production cross sections as a function of the absolute difference in rapidity between jets in proton-proton collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Eur.Phys.J. C72 (2012) 2216,

Search for heavy neutrinos and W[R] bosons with right-handed couplings in a left-right symmetric model in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 109 (2012) 261802,

Search for the standard model Higgs boson produced in association with W and Z bosons in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1211 (2012) 088,

Search for the standard model Higgs boson decaying to bottom quarks in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B710 (2012) 284-306, issue 2, vol.710, pp.284 - 306,

Measurement of jet fragmentation into charged particles in pp and PbPb collisions at √s NN = 2:76 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1210 (2012) 087,

Exclusive photon-photon production of muon pairs in proton-proton collisions at √s = 7 TeV.
CMS Collaboration (Chatrchyan et al.)
JHEP 1201 (2012) 052,

Measurement of the underlying event activity in pp collisions at √s=09 and 7 TeV with the novel jet-area/median approach
CMS Collaboration (Chatrchyan et al.)
JHEP 1208 (2012) 130, vol.2012, n. 8,

Search for the standard model Higgs boson in the H → ZZ → l +l -τ +τ - decay channel in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1203 (2012) 081, vol.2012, n. 3,

Search for the standard model Higgs boson in the decay channel H→ZZ→4l in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 108 (2012) 111804, issue 11, vol.108,

Measurement of the top-quark mass in tt̄ events with lepton+jets final states in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1212 (2012) 105,

A search for a doubly-charged Higgs boson in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Eur.Phys.J. C72 (2012) 2189,

Search for supersymmetry in events with b-quark jets and missing transverse energy in pp collisions at 7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev. D86 (2012) 072010, issue 7, vol.86,

Search for anomalous production of multilepton events in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1206 (2012) 169, vol.2012, n. 6,

Search for a Higgs boson in the decay channel H → ZZ* → qqℓ-ℓ-+ in pp collisions at p√s = 7TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1204 (2012) 036, vol.2012, n. 4,

Search for microscopic black holes in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1204 (2012) 061, vol.2012, n. 4,

Search for high-mass resonances decaying into τ-lepton pairs in pp collisions at √s = 7TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B716 (2012) 82-102, issue 1,

Measurement of the tt̄ production cross section in the dilepton channel in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1211 (2012) 067,

Combined search for the quarks of a sequential fourth generation
CMS Collaboration (Chatrchyan et al.)
Phys.Rev. D86 (2012) 112003, issue 11, vol.86,

Search for three-jet resonances in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B718 (2012), issue 2, vol.718, pp.329 - 347,

Inclusive search for squarks and gluinos in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)

Phys.Rev. D85 (2012) 012004,

Search for new physics in events with same-sign dileptons and b-tagged jets in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1208 (2012) 110,

Measurement of the pseudorapidity and centrality dependence of the transverse energy density in pb-pb collisions at √s NN=2.76TeV
CMS Collaboration (Chatrchyan et al.)
Phys. Rev. Lett., issue 15, vol.109,

Measurement of energy flow at large pseudorapidities in pp collisions at √s=0.9 and 7 TeV.
CMS Collaboration (Chatrchyan et al.)
JHEP 1111 (2011) 148 - Erratum-ibid. 1202 (2012) 055,

Search for signatures of extra dimensions in the diphoton mass spectrum at the Large Hadron Collider
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 108 (2012) 111801, issue 11, vol.108,

Search for narrow resonances in dilepton mass spectra in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B714 (2012) 158-179, issue 2-5, vol.714, pp.158 - 179,

Search for quark compositeness in dijet angular distributions from pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1205 (2012) 055, vol.2012, n. 5,

J/ψ and ψ (2S) production in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1202 (2012) 011,

Performance of τ-lepton reconstruction and identification in CMS.
CMS Collaboration (Chatrchyan et al.)
JINST 7 (2012) P01001,

Measurement of the inclusive production cross sections for forward jets and for dijet events with one forward and one central jet in pp collisions at √s = 7 TeV.
CMS Collaboration (Chatrchyan et al.)
JHEP 1206 (2012) 036,

Observation of sequential Upsilon suppression in PbPb collisions
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 109 (2012) 222301, issue 22, vol.109,

Measurement of the Rapidity and Transverse Momentum Distributions of Z Bosons in pp Collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev. D85 (2012) 032002,

Search for a W' or Techni-ρ decaying into WZ in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 109 (2012) 141801, issue 14, vol.109,

Study of the dijet mass spectrum in pp→W+jets events at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 109 (2012) 251801, issue 25, vol.109,

Measurement of the underlying event in the Drell-Yan process in proton-proton collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Eur.Phys.J. C72 (2012) 2080,

Search for new physics with same-sign isolated dilepton events with jets and missing transverse energy
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 109 (2012) 071803, issue 7, vol.109,

Search for electroweak production of charginos and neutralinos using leptonic final states in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1211 (2012) 147,

Search for dark matter and large extra dimensions in monojet events in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1209 (2012) 094,

Search for the standard model Higgs boson decaying to a W pair in the fully leptonic final state in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B710 (2012) 91-113, issue 1, vol.710, pp.91 - 113,

Search for resonant ft production in lepton+jets events in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1212 (2012) 015,

Study of high-pT charged particle suppression in PbPb compared to pp collisions at sqrt(sNN)=2.76 TeV
CMS Collaboration (Chatrchyan et al.)
Eur.Phys.J. C72 (2012) 1945, vol.72, n. 3,

Search for exclusive or semi-exclusive photon pair production and observation of exclusive and semi-exclusive electron pair production in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1211 (2012) 080,

A new boson with a mass of 125-GeV observed with the CMS experiment at the Large Hadron Collidor
CMS Collaboration (Chatrchyan et al.)
Science, vol.338, n. 6114, pp.1569 - 1575,

Search for charge-asymmetric production of W ' bosons in top pair + jet events from pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B717 (2012), issue 4-5, vol.717, - 351,

Search for pair produced fourth-generation up-type quarks in pp collisions at √s=7 TeV with a lepton in the final state
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B718 (2012), issue 2, vol.718, pp.307 - 328,

Search for new physics with long-lived particles decaying to photons and missing energy in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1211 (2012) 172,

Inclusive and differential measurements of the ft charge asymmetry in proton-proton collisions at 7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B717 (2012), issue 1-3, vol.717, pp.129 - 150,

Shape, transverse size, and charged hadron multiplicity of jets in pp collisions at 7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1206 (2012) 160,

Search for a light charged Higgs boson in top quark decays in pp collisions at √s = 7 TeV
CMS Collaboration (Chatrchyan et al.)
JHEP 1207 (2012) 143, vol.2012, n. 7,

Search for neutral Higgs bosons decaying to τ pairs in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B713 (2012) 68-90, issue 2, vol.713, pp.68 - 90,

Search for heavy, top-like quark pair production in the dilepton final state in pp collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Lett. B716 (2012) 103-121, issue 1,

Search for new physics in the multijet and missing transverse momentum final state in proton-proton collisions at √s=7 TeV
CMS Collaboration (Chatrchyan et al.)
Phys.Rev.Lett. 109 (2012) 171803, issue 17, vol.109

2. Refereed public and internal documents

Search for High Mass Resonances Decaying to Electron Pairs at 8 TeV with the Full 2012 dataset
Working Group: EXO with: B. Clerbaux, Sh. Elgammal, A. Gay, P. Vanlaer CMS AN-2012/415

Study of Double Parton Scattering with Z+jets events at 7 TeV
L. Favart et al. CMS AN-2012/401

Search for a high-mass Higgs boson in the H → ZZ → 2l 2v decay channel in pp collisions with the CMS detector
Working Group: HGGS with: Cecile Caillol , Barbara Clerbaux , Laurent Favart , Alexandre Leonard , Luca Pernie,

P. Vanlaer , F. Zenoni CMS AN-2012/371

Top quark mass measurement with L_xy- and muon pT-based methods in the muon+jets channel.
C. Caillol, M. Mulders, E. Palencia, P. Silva CMS AN-2012/360

High Et electron selection presentation and optimisation in case of high pile-up conditions
L. Thomas, B. Clerbaux CMS AN-2012/258

Statistical Inference in a Search for a Narrow Resonance
Working Group: EXO: A. Gay, B. Clerbaux L. Thomas P. Vanlaer T. Reis, CMS AN-2012/185

Search for High Mass Resonances Decaying to Electron Pairs at 8 TeV
Working Group: EXO, B. Clerbaux, A. Gay, P. Vanlaer CMS AN-2012/171

Measurement of ZZ production cross section at 7 and 8 TeV and anomalous gauge couplings limits in 2l2v decay channel
B. Clerbaux, L. Pernie, P. Vanlaer, J. Wang, CMS AN-2012/148

Search for the Higgs boson in the H → ZZ → 2l 2v decay channel in pp collisions with the CMS detector
C. Caillol , B. Clerbaux , L. Favart , A. Leonard, P. Vanlaer , F. Zenoni, CMS AN-2012/138

Searches for the standard model scalar boson in CMS and for new physics in ATLAS and CMS
B. Clerbaux for the ATLAS and CMS Collaborations CMS CR-2012/130

Search for Invisible Higgs Decays in the ZH→ll\+ MET channel
B. Clerbaux, L. Pernie, T. Seva, P. Vanlaer,CMS AN-2012/123

Search for third-generation stop squarks pair with stop heavier than top, in single lepton and missing transverse energy, at sqrt s = 8 TeV
A. Kalogeropoulos, J. D'Hondt, P. Van Mulders, CMS AN-2012/443,

Combined measurement of the ttbar cross section and the b-tagging efficiency using lepton+jet events at √s8TeV
M. Maes, J. D'Hondt, CMS AN-2012/186,

Measurements of the b-tagging efficiency using muon+jets events at 8Tev
M. Maes, J. D'Hondt, CMS AN-2012/432,

Study of the kinematic dependence of the top mas and contraints on colour reconnection
S. Blyweert, J. D'Hondt, CMS AN-2012/483,

Inclusive search for a fourth generation of quarks with the CMS experiment
P. Van Mulders, G. Van Onsem, CMS AN-2012/11,

Measurement of W-Helicity fractions using single-top events in pp collisions at sqrt s = 7 TeV
J. D'Hondt, CMS AN-2012/272,

Measurement of the W-helicity fractions using t-channel single-top topology in pp collisions at sqrt[s]=7 TeV
J. D'Hondt, CMS AN-2012/469,

Search for vector-like coupling to light quarks
G. Van Onsem, J. D'Hondt, P. Van Mulders, CMS AN-2012/323,

Measurement of the inclusive top-pair production cross section in the semi-leptonic muon and electron channels using data from the 2012 data taking period
J. D'Hondt, M. Maes, CMS AN-2012/220,

Measurement of the W polarisation in semi-leptonic top-pair decays using 5 fb^-1 of data at √s = 7 TeV
J. D'Hondt, A. Olbrechts, CMS AN-2012/477,