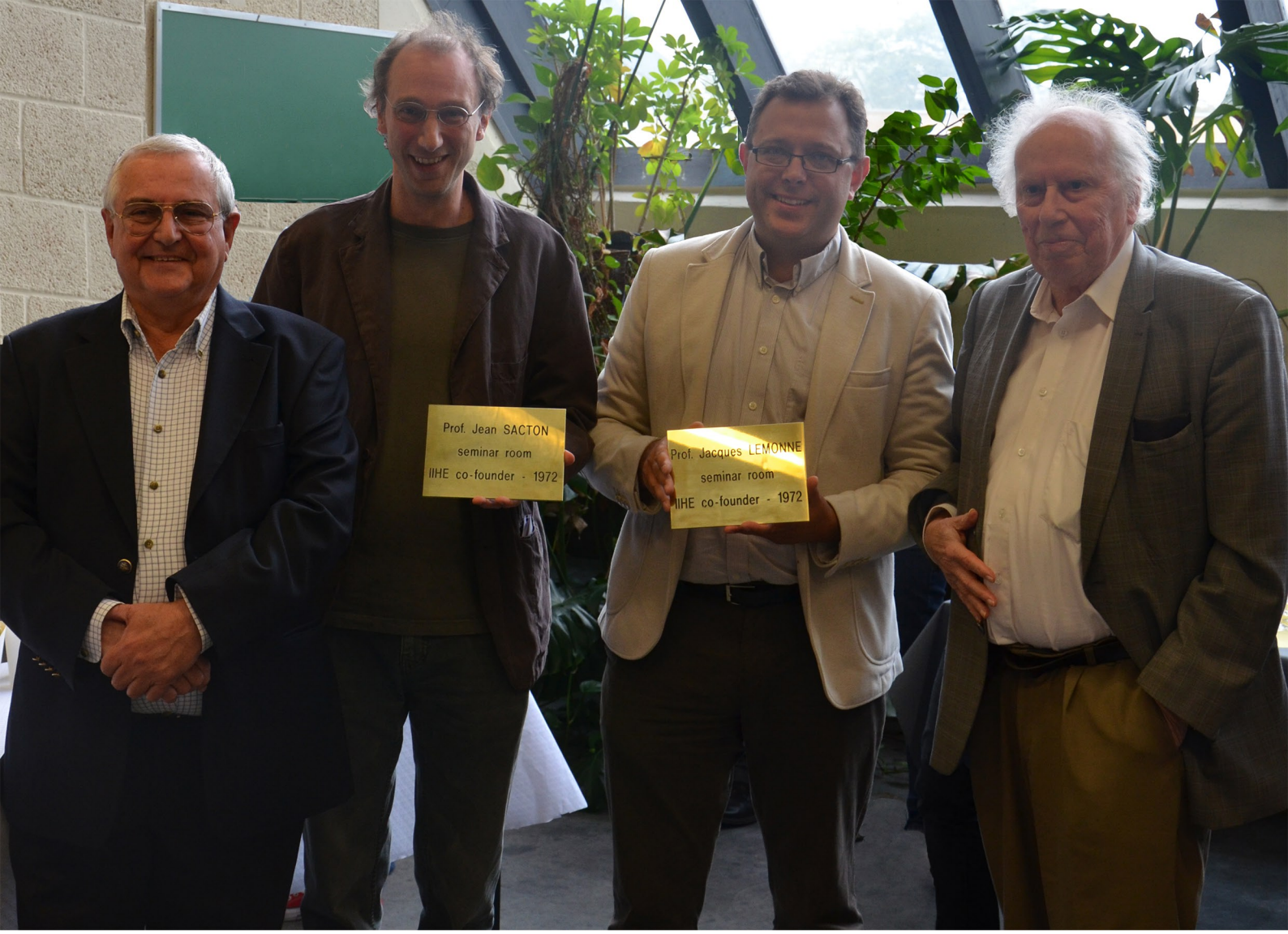

Annual Report 2014

iihe
BRUXELLES BRUSSEL

Vrije Universiteit Brussel

ULB UNIVERSITÉ LIBRE DE BRUXELLES

On September 26, 2014, we celebrated the inauguration of the IIHE seminar rooms in honour of the founders of the IIHE in 1972, namely Prof. Jean Sacton and Prof. Jacques Lemonne to whom both of our seminar rooms have been named.

Annual Report 2014

J. D'Hondt - L. Favart
Directors

Vrije Universiteit Brussel

http://www.iihe.ac.be

ULB UNIVERSITÉ LIBRE DE BRUXELLES

Contents

1 Introduction

1.1 The Interuniversity Institute for High Energies

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 untill recently 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 and to cosmology.

Astroparticle physics is devoted to the study of the structure of the Universe, using particles as messengers of astrophysical activity in the Universe and using the techniques developed in particle physics. All these experiments are performed in the framework of large to very large international collaborations (several hundreds to several thousands of 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.), which lead to break-through progress in industrial and medical applications.

1.2 Overview of 2014

The present report presents the research performed at the IIHE in 2014, that spans from the smallest accessible scales, below $10^{-19}m$ for e.g. the Brout-Englert-Higgs boson, quarks and neutrinos, to the largest scales above hundreds of thousands of light years for the source of ultra high energy neutrinos detected by IceCube. During the year 2014 the IIHE published with its national and international research partners about 140 journal papers.

The IIHE is deeply involved in the CMS experiment since its design phase in the early 1990's, and actively contributed to all aspects of this experimental project, i.e. building, operating and maintaining the CMS detector as well as to the data analysis for searches for new physics and precision measurements of the fundamental interactions and particle properties. All aspects of this work are done in collaboration with other Belgian and international teams. Since the first collisions in 2009, the LHC has performed extremely well, with steadily increasing luminosity. The so-called Run 1, started in 2010, accumulated proton collisions with a collision energy up to 8 TeV and has been ended in February 2013. Data taken in proton-proton collision mode were complemented Pb-Pb and proton-Pb data.

During 2014, in addition to operational activities around the detector and its continuous survey and calibration, the Brussels team in CMS contributed to physics analyses in the study of the Brout-Englert-Higgs boson, on top quark physics, dark matter searches, the search for supersymmetry, the search for new physics phenomena and precision measurements of the strong interaction (QCD) and the electro-weak interaction (EW).

The H1 experiment at the HERA electron-proton collider of 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 in the very forward proton spectrometer (VFPS). The measurements of H1 and ZEUS at HERA deeply modified our understanding of the proton structure in terms of quarks and gluons. Since the accelerator shut-down in 2007, the data analysis of the Brussels group focuses on the finalisation of the VFPS related measurements, providing new insights in Quantum Chromodynamics.

The IIHE has a long history of research in the field of neutrino (ν) physics. The OPERA experiment collected data between 2008 and 2012 accumulating in total about 16500 neutrino interactions in the target detector of which about 5800 have been located so far and 4700 are fully analyzed. With these data the OPERA experiment studies the ν_μ to ν_τ oscillation through the identification of ν_τ. The detector is installed in the underground Grans Sasso Laboratory (LNGS) and exposed to the CNGS neutrino beam produced at CERN, 730 km away. Among the 4 events observed in this first experiment of ν_τ direct appearance, one new event has been published in 2013.

Members of the IIHE have initiated together with national and international colleagues the SoLid experiment at the BR2 nuclear reactor at the SCK-CEN (Mol, Belgium). A new detector with a novel detection technique has been deployed in 2014, with first data taking at the end of 2014 and early 2015. These data are being analysed to commission the experiment for future reactor cycles. The intention is to measure neutrino oscillation processes at very short distances between 5 and 10 meter from the reactor source.

In the field of astro-particle physics, 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. Since 2011 the fully deployment IceCube detector operates as the largest ever built particle detector (1 km^3). The major research topics of the IIHE team are: the search for cosmic point sources, Dark Matter, high-energy neutrinos from transient events and for neutrinos from supernovae. The first hints of extra-terrestrial high-energy neutrinos came in April 2012 with the observation of two very high energy events (above 1000 TeV). Since then, with an intensified search more events have been found. This achievement marks the birth of neutrino astronomy.

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 for the ARA experiment. A major activity at the IIHE 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 chambers 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, SoLid) 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 Strategic Research Program. The main topics of research are supersymmetric models and their signatures at the LHC.

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 ice optical structure. For CMS computing, a "Tier- 2" cluster installed at the ULB-VUB Computing Centre is fully integrated in the world-wide LHC computing grid, with very high performance and stability.

On September 11th 2014, all the IIHE members attended the IIHE annual meeting, 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.

1.3 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). Additional supports comes from our collaboration with the Institut de Recherche de l'Institut Supérieur Industriel de Bruxelles (IRISIB) and Ion Beam Applications S.A. (IBA) for proton therapy.

1.4 The IIHE team in 2014

1.4.1 The ULB personnel

Academic and scientific personnel

Juan Antonio AGUILAR SANCHEZ	Chargé de cours since October	IceCube, ARA
Patrizia BARRIA	Post-doc (IISN)	CMS, DAQ R&D
Daniel BERTRAND	Directeur de Recherche F.R.S.-FNRS; Past IIHE co-director; Honorary, and Professeur de l'Université	IceCube
Cécile CAILLOL	PhD student (Aspirant F.R.S.-FNRS)	CMS
Barbara CLERBAUX	Maître de Recherche F.R.S.-FNRS; part-time Chargée de Cours	CMS
Gilles DE LENT-DECKER	Chercheur Qualifié F.R.S.-FNRS; Maître d'Enseignement	CMS, DAQ R&D
Valérie DE SMET	PhD student (FREDONE)	Instrumentation
Didar DOBUR	Post-doc (PAI)	CMS
Jianmeng DONG	PhD student (CSC scholarship since September)	CMS DAQ R&D
Giuseppe FASANELLA	PhD student (FRIA) Co-tutelle with Rome University	CMS
Laurent FAVART	Maître de Recherche F.R.S.-FNRS until September; Directeur de Recherche F.R.S.-FNRS since October; Part-time Chargé de Cours; IIHE director	H1, CMS
Anastasia GREBENYUK	Post-doc (PAI)	CMS
Kael HANSON	Chargé de Cours	IceCube, ARA
David HEEREMAN	PhD student (IISN until December)	IceCube
Tomas HREUS	Collaborateur scientifique	H1, CMS
Thomas LENZI	PhD student (Aspirant F.R.S.-FNRS)	CMS
Alexandre LÉONARD	PhD student (Aspirant F.R.S.-FNRS)	CMS

Thierry MAERSCHALK	PhD student (IISN)	CMS, DAQ R&D
Pierre MARAGE	Professeur ordinaire émérite; Professeur de l'Université since October; Past IIHE co-director	CMS, Hist. of Sc.
Andrey MARINOV	Chargé de Recherche F.R.S.-FNRS since October	CMS, DAQ R&D
Thomas MEURES	PhD student (IISN until September)	ARA
Abdollah MOHAMMADI	Post-doc (IISN)	CMS
David NDAYIZEYE	PhD student (Burundi grant)	Instrumentation
Aongus O'MURCHADHA	Chargé de Recherche F.R.S.-FNRS	IceCube, ARA
Luca PERNIÈ	PhD student (IISN) Co-tutelle with Rome University	CMS
Yves PIERSEAUX	Collaborateur scientifique	Hist. of Science
Elisa PINAT	PhD student (IISN)	IceCube
Aidan RANDLE-CONDE	Post-doc (PAI)	CMS
Thomas REIS	PhD student (IISN until December)	CMS
Jean SACTON	Emeritus, Professeur ordinaire; Past IIHE co-director	
Tomislav SEVA	Post-doc (IISN)	CMS
Rachel SIMONI	PhD assistant until September	
Laurent THOMAS	PhD student (FRIA until September)	CMS
Raffaella TONCELLI	Collaborateur scientifique	
Catherine VANDER VELDE	Professeur until September; Professeur de l'Université since October	CMS
Pascal VANLAER	Chargé de Cours	CMS
Erik VERHAGEN	PhD student (AIDA until April, then since September until November; PAI since May until August)	DAQ R&D
Pierre VILAIN	Honorary Maître de Recherche F.R.S.-FNRS; Professeur de l'Université	OPERA
Jian WANG	Post-doc (IISN) until December	CMS
Gaston WILQUET	Honorary Maître de Recherche F.R.S.-FNRS; Professeur de l'Université	OPERA
Ryo YONAMINE	Chargé de Recherche F.R.S.-FNRS	CMS, DAQ R&D
Florian ZENONI	PhD student (IISN)	CMS, DAQ R&D
Fengwangdong ZHANG	PhD student (CSC scholarship since September)	CMS

Master students

Patrick CONNOR	Student in physics, until September	CMS
Hugo DELANNOY	Student in physics, until September	CMS
Céline DE VOS	Student in physics, until September	IceCube
Gwenhaël DE WASSEIGE	Student in physics, until September	IceCube
Baptiste HERREGODS	Student in Physics engineer, since September	CMS DAQ R&D
Laurent LENAERTS	Student in physics, since September	CMS
Federico LUCCHETTI	Student in physics, until September	CMS DAQ R&D
Nicolas POSTIAU	Student in physics, since September	CMS
David VANNEROM	Student in Physics engineer, until September	CMS
Marco ZECCHIN	Student in physics, until September	CMS DAQ R&D

Engineers, Technical and Logistic Personnel

Samir AMARY	Computer scientist
Abdelhakim BOUKIL	Computer scientist
Patrick De Harenne	Technician, general support
Michael KORNTHEUER	Electronics
Fatimé PERO	Secretariat, 1/2-time
Shkelzen RUGOVAC	Computer scientist
Audrey TERRIER	Secretariat
René VANDERHAEGEN	Technician, electronics
Yifan YANG	ULB electronics

1.4.2 The VUB personnel

Academic and scientific personnel

Shimaa ABU ZEID	ERASMUS MUNDOS (PhD student)	CMS
Freya BLEKMAN	ZAP docent	CMS
Lionel BRAYEUR	FWO scientific collaborator (PhD student)	IceCube
Martin CASIER	FWO scientific collaborator (PhD student)	IceCube
Nadir DACI	FWO scientific collaborator (post-doc)	CMS
Isabelle DE BRUYN	FWO scientific collaborator (PhD student)	CMS
Karen DE CAUSMAECKER	FWO aspirant (PhD student)	Pheno
Catherine DE CLERCQ	ZAP hoofddocent (100% until September; 10% since October)	IceCube
Krijn DE VRIES	FWO scientific collaborator (post-doc) until September	IceCube
	FWO research fellow since October (postdoctoraal onderzoeker)	IceCube
Gwenhael DE WASSEIGE	FWO scientific collaborator (PhD student) since October	IceCube
Kevin DEROOVER	FWO scientific collaborator (PhD student)	CMS
Jorgen D'HONDT	ZAP hoofddocent; IIHE co-director	CMS & SoLid
Geraldina GOLUP	FWO scientific collaborator (post-doc)	IceCube
Natalie HERACLEOUS	FWO scientific collaborator (post-doc)	CMS
James KEAVENEY	FWO Pegasus Marie-Curie research fellow	CMS
Tae Jeong KIM	FWO scientific collaborator (post-doc) until February	CMS
Jan KUNNEN	FWO scientific collaborator (PhD student)	IceCube
Steven LOWETTE	ZAP docent	CMS
Jan LUNEMANN	FWO scientific collaborator (post-doc) since February	IceCube
Giuliano MAGGI	FWO scientific collaborator (PhD student)	IceCube
Alberto MARIOTTI	FWO Pegasus Marie-Curie research fellow since October	Pheno
Kentarou MAWATARI	VUB scientific collaborator (post-doc); 10% ZAP research professor	Pheno
Lieselotte MOREELS	FWO scientific collaborator (PhD student)	CMS

Bettina OEXL	VUB scientific collaborator (PhD student) until October 2014	Pheno
Annik OLBRECHTS	FWO scientific collaborator (PhD student)	CMS
Quentin PYTHON	FWO scientific collaborator (PhD student)	CMS
Robert ROOSEN	Professor-emeritus	H1
Olaf SCHOLTE	10% ZAP Research Professor	IceCube
Derek STROM	FWO scientific collaborator (post-doc)	CMS
Stefaan TAVERNIER	Professor-emeritus	Crystal Clear & CMS
Pantelis TZIVELOGLOU	VUB scientific collaborator (post-doc)	Pheno
Walter VAN DONINCK	Professor-emeritus	CMS
Nick VAN EIJNDHOVEN	ZAP hoogleraar	IceCube
Petra VAN MULDERS	FWO research fellow (postdoctoraal onderzoeker)	CMS & SoLid
	10% ZAP research professor	CMS & SoLid
Gerrit VAN ONSEM	FWO scientific collaborator (PhD student until September; Post-doc since October)	CMS
Isis VAN PARIJS	FWO scientific collaborator (PhD student)	CMS
Simon VERCAEMER	IUAP scientific collaborator (PhD student) 1/2 VUB – 1/2 UA	SoLid

Master students

Bert Verbruggen	Student in physics	CMS
Seth Moortgat	Student in physics	CMS

Engineers, Technical and Logistic Personnel

Jan DEBRUYNE	Technician, general support, 1/2 time
Olivier DEVROEDE	Computer scientist
Stéphane GERARD	Computer scientist - VSC
Marleen GOEMAN	Secretariat
Abdelhak OUCHENE	Computer scientist
Rosette VANDENBROUCKE	Computer scientist - VSC

1.5 With our greatest gratitude

Profs. Catherine De Clercq, Pierre Marage and Catherine Vander Velde have retired in 2014.

Catherine De Clercq
After having obtained a master degree ("Licentiaat Natuurkunde") at the University of Gent, Catherine De Clercq came to the VUB where she obtained her Ph.D. in 1981 on $K^- p$ studies using the hydrogen bubble chamber at Argonne National Lab (USA). After a short stay at Aachen, where she participated in the writing of the Letter of Intent for an experiment at the future Large Electron Positron (LEP) collider at CERN, Catherine returned to Brussels where the IIHE had just joined the DELPHI experiment. Here she participated in the development and testing of the forward muon detectors and in 1989 she moved to CERN for the installation, commissioning and exploitation of these detectors. After returning to Brussels and more than 10 years of LEP physics Catherine found the time right to make a switch. Together with her ULB colleague Daniel Bertrand she initiated in 2000 a new research line in Belgium, namely Astroparticle Physics. For this she joined the AMANDA cosmic neutrino experiment at the South Pole, where she introduced a search for dark matter particles in celestial bodies. The AMANDA experiment evolved into the IceCube neutrino observatory and under the guidance of Catherine the world's most stringent limits on dark matter spin dependent cross sections were obtained. Having been VUB director of the IIHE (2003-2011) and the PI for the VUB within the IceCube collaboration since the beginning, Catherine retired in 2014 but still remains active in physics research and various committees.

Pierre Marage
Pierre Marage obtained his Master in Physics in 1980 on charmed particle production from neutrino in the BEBC bubble chamber. In 1984 he obtains his PhD on the BEBC-WA59 CERN experiment, where he shows the first evidence of coherent interactions in charge current neutrino-nucleus interactions. Pierre Marage joins the E632 experiment at FermiLab in 1985 to study higher energy neutrino interactions and test the current structure, separating the axial and vectorial contribution in weak interactions (PCAC). Hired as "premier Assistant" at ULB in 1987, he joint the IIHE group working on the H1 experiment to be installed on the first electron-proton collider, HERA, located at DESY (Hamburg). He participates to the construction of a multiwire proportional chamber for the H1 trigger and prepares the data analysis of the first collisions, taking place in 1991. In a few years P. Marage becomes an expert recognised at an international level in high energy diffraction, in particular in the exclusive vector meson production. He convened the H1 physics group on diffraction, organised and animated conferences and workshops on the

field and supervised 5 PhD and 15 Master thesis on related topics between 1991 and 2002. In 2003 Pierre Marage is mandated Dean of the Science Faculty of ULB and afterward joins the CMS Collaboration on the LHC of CERN to study the search for new heavy vector bosons. Soon he becomes member of the CMS editorial committee for the first physics result publications. Pierre Marage is also active in the History and Philosophy of Sciences, and published, with G. Wallenborn the book *The Solvay Councils and the Birth of Modern Physics* and organises several large scale exhibitions in Brussels. Pierre Marage succeeded to Daniel Bertrand as Director of the Particle Physics Department and as ULB director of the IIHE. He became vice-rector for research of ULB in 2011 until his retirement in Sept. 2015.

Catherine Vander Velde
She performed her PhD study on charged kaon interactions in a bubble chamber and graduated in 1975. She further conducted studies of neutrino interactions in matter, then worked at CERN for two years at the intersection storage rings. She joined the Delphi experiment (1983-1992) at the Large Electron Positron collider (LEP) at CERN where she lead the working group in charge of the design of the muon trigger. From 1990 until her retirement, Catherine co-lead the Belgian team in the CMS experiment at the LHC, where in 2012 the scalar boson predicted by the Brout-Englert-Higgs mechanism has been experimentally discovered. She co-coordinated the production of a thousand of high-precision silicon tracking detectors at the IIHE. She is full professor of the ULB since 2002 and received the ULB Socrates price for exceptional pedagogical merits in 2010. Catherine was also a member of the scientific commission for high and low energies at the Interuniversity Institute for Nuclear Sciences, associated to the FRS-FNRS research fund. Catherine retired from the ULB in October 2014. She is still active in CMS, as a member of the publication committee for supersymmetry, and as a member of the CMS PhD award committee.

1.6 Associated institutes

The following members of the Particle Physics Group of Antwerp University (UA) have been working in close collaboration with the IIHE :
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. Albert Knutsson, Dr. Sunil Bansal, Dr. Igor Cherednikov, Dr. Xavier Janssen, Dr. Benoit Roland, Sara Alderweireldt, Tom Cornelis, Jasper Lauwers, Sten Luyckx, Tom Mertens, Pieter Taels, Merijn van de Klundert, Frederik Van der Veken, Hans Van Haevermaet, Sarah Van Mierlo, Alex Van Spilbeeck, Ir. Wim Beaumont, Ir. Eric De Langhe.

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):
Dr. Evelyne Daubie, Dr. George Kohnen, Nikita Beliy, Isabelle Ansseau, Thierry Caebergs, Martine Fracas, Gregory Hammad, Joseph Hanton, Michelle Lefebvre, Francis Lequeux.

2 Research activities, development and support

2.1 The CMS experiment at the CERN LHC

(S. Abu Zeid, F. Blekman, C. Caillol, B. Clerbaux, P. Connor, J. D'Hondt, I. De Bruyn, N. Daci, G. De Lentdecker, H. Delannoy, K. Deroover, O. Devroede, D. Dobur, G. Fasanella, L. Favart, A. Gay, A. Grebenyuk, G. Hammad, N. Heracleous, A. Kalogeropoulos, J. Keaveney, S. Lowette, A. Léonard, P. Marage, A. Mohammadi, L. Moreels, A. Olbrechts, L. Pernie, Q. Python, A. Randle-Conde, T. Reis, T. Seva, R. Simoni, D. Strom, S. Tavernier, L. Thomas, W. Van Doninck, P. Van Mulders, G. Van Onsem, I. Van Parijs, C. Vander Velde, P. Vanlaer, D. Vannerom, B. Verbruggen, E. Verhagen, J. Wang, Y. Yang, R. Yonamine, F. Zenoni.)

One of the two general-purpose detectors at CERN's Large Hadron Collider (LHC) is the Compact Muon Solenoid (CMS) experiment. The LHC produced proton-proton collisions in the LHC Run 1 in 2010, 2011 and 2012, in the

latter year for the first time at the record energy of 8 TeV. The analysis of this data allowed precision tests of the Standard Model (SM) and the increased understanding of the data, in combination with the higher partonic cross sections created by higher collision energy, allowed for now 400 publications in international scientific journals, of which 95 published in 2014.

The most important result in the LHC Run 1 is beyond doubt the observation of the last missing part of the SM, the BEH scalar boson predicted by R. Brout, F. Englert and P. Higgs at a mass of 125 GeV/c^2. While the discovery of the SM scalar boson is definitely the highlight of Run 1, the year 2014 was key in the preparation of Run 2 at a LHC collision energy of 13 TeV.

Starting February 2013, the LHC was stopped for about two years dedicated to an upgrade of the machine and the detectors. The modifications will allow running at 13 TeV, almost doubling the energy, with an instantaneous luminosity that will be around three times more than in 2011 while keeping at the same time the pile-up contribution from multiple collisions at a reasonable level. During this first long shutdown, the IIHE physicists developed an more detailed understanding of the 7 and 8 TeV CMS datasets while preparing the triggers and their analysis strategy for the changes to come at higher energy and luminosity. This includes some previously impossible research directions, which are only possible with higher collision energies or larger datasets.

Members of the IIHE were selected or elected for top-level managerial positions in the CMS Collaboration. Amongst others the position of Chairperson of the CMS Collaboration Board by Prof. Jorgen D'Hondt.

2.1.1 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 was designed, built, and installed in the CMS end caps to be operational after the long shutdown. The Forward RPC collaboration was enlarged for this purpose and now consists of groups from Belgium, CERN, China, India, Italy, Korea and Pakistan. A total of 200 chambers have been built and tested in India (Mumbai), Belgium (UGhent) and CERN. Two IIHE members were responsible for the mechanical design of the chambers and their integration into the CMS end caps.

2.1.2 Activities related to the CMS upgrades

In the years 2020, CERN has the goal to further increase the LHC luminosity by a factor 10 above the present design parameters. In these extremely intense experimental conditions, new detector technologies are needed, to which IIHE physicists are contributing.

In the context of the LHC high luminosity upgrade, a group of physicists at the IIHE is contributing to the feasibility study of installing micro-pattern gaseous detectors (Triple-GEM) in the most forward region of the muon spectrometer (pseudo-rapidity range $1.6 < |\eta| < 2.1$). Using this novel technology instead of the more established RPC detectors would substantially improve the triggering properties at high pseudo-rapidities. To achieve this, the IIHE team is designing, in collaboration with CERN, Saclay and Bari, a trigger and data acquisition system for the Triple-GEM detectors. More details are discussed in the R&D section of this document.

One of the necessary improvements to be able to operate in the increased intensity of the LHC upgrade is the replacement of the CMS tracker. To fully benefit from the performance of the LHC, this new tracker detector should also need to contribute to the first level of the online trigger system, which is currently not the case. At the IIHE there is a team of physicists contributing to the development of the reconstruction of tracks that will be used by the track trigger algorithms, including preparation of studies of the performance of the track reconstruction for different tracking detector geometries and the implantation of this code in the upgrade software. In addition there is a development of the electronics necessary to the tracker upgrade. This technology is related to the work being undertaken on the readout electronics for the CMS Triple-Gem detector and also further discussed in the Data acquisition and R&D section of this document.

2.1.3 Study for the SM scalar boson and of multi-boson production

Since the existence of the SM scalar was confirmed in 2012, the study of the SM scalar now involves questions such as whether this particle is the only element to be added to the SM in order to give masses to the particles, and questions regarding the consistency of the discovered particle with respect to SM predictions. The SM scalar could also interact with particles yet to be discovered, such as dark matter particles. Measurements of the properties of the SM scalar are thus essential to address. To obtain the maximal precision, the understanding of SM processes (EW and QCD) is crucial up to the highest possible precision.

The IIHE group contributed in 2014 to the SM scalar boson 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 $ZH \to l^+l^-\tau^+\tau^-$ channel; 2) the search for additional massive scalar(s); 3) the study of the properties of the light scalar boson in the l^+l^- plus missing energy channel; and 4) the calibration of the CMS electromagnetic calorimeter, which directly impacts measurements of the scalar boson in the $H \to \gamma\gamma$ channel. These studies were performed with the whole LHC Run 1 dataset, 5 fb^{-1} of data collected at 7 TeV center-of-mass energy and 20 fb^{-1} of data collected at 8 TeV.

The IIHE group also contributed to the preparation of the 2015 data taking for scalar boson studies. In particular, an IIHE member, Prof. Pascal Vanlaer, co-coordinated the development of the CMS high level trigger for the online selection of scalar bosons.

The IIHE team leads the analysis of the $ZH \to l^+l^-\tau^+\tau^-$ channel, one of the important ways to confirm the coupling of the scalar boson to fermions. The $ZH \to l^+l^-\tau^+\tau^-$ channel is one of the significant inputs to the search for $H \to \tau^+\tau^-$ channel, for which 3 standard deviation evidence was observed with a branching fraction consistent with the SM, albeit within large uncertainties. The data to be collected from 2015 on should allow a more precise determination of this coupling.

The $H \to ZZ \to l^+l^-\nu\bar{\nu}$ decay channel is the most sensitive final states for the possible observation of an additional heavy scalar with SM-like couplings, thanks to its large branching ratio compared to the decay into four charged leptons. The IIHE team is strongly involved in this search. Limits on the production of a heavy scalar have been set with the $H \to ZZ \to l^+l^-\nu\bar{\nu}$ channel alone, excluding a SM-like scalar particle up to a mass of 930 GeV/c^2 .

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 IIHE contributes to the search for such decays in the $ZH \to l^+l^-$ plus missing energy channel and a post-doc was co-editor of the corresponding analysis notes. This final states is the same as is used for the measurement of the ZZ production cross-section in the $l^+l^-\nu\bar{\nu}$ final state. The SM cross-section is predicted with good theoretical precision, but it could be enhanced at high Z boson momenta if anomalous γZZ and ZZZ triple gauge couplings exist. These couplings are constrained at the LHC with unprecedented sensitivity, in particular in the $ZZ \to 4l^{\pm}$ and $ZZ \to l^+l^-\nu\bar{\nu}$ channels. Figure 1 shows how these couplings can be used in a $H \to$ DMDM interpretation, which results in limits on the interaction cross section between dark matter candidates and nucleons.

The ZZ production cross section actually has a tiny but characteristic contribution from decays of off shell SM scalars. This contribution being closely related to the properties of the scalar boson, it can be exploited in a variety of ways. For instance, an upper limit on the off shell cross section can be reinterpreted as an upper limit on the decay width of the scalar boson, that is at least two orders of magnitude better than a direct measurement of the line shape. This measurement is complementary to the direct search for new decay modes of the SM scalar, and also puts a constraint on anomalous couplings of the SM scalar with SM particles. The IIHE has contributed in a leading way to setting the world best constraints on the decay width of the scalar boson using off shell decays. The figure shows how the off shell tail is enhanced when the total width is increased by a factor 25 compared to the SM prediction, while the cross section at the peak is constrained to be equal to the SM value. This analysis was presented as a hot topic in the Moriond 2014 conference and was published in Physics Letters B. The postdoctoral researcher from IIHE who lead the analysis in the $l^+l^-\nu\bar{\nu}$ final state, Jian Wang, was appointed as the contact person of the CMS experiment in the subworking group dedicated to offshell decays in the LHC Higgs cross section working group.

Measurements such as the off shell scalar contribution in the ZZ final state require excellent control of the SM background. IIHE members were the first to introduce electroweak corrections into the modeling of the ZZ differential cross section in an analysis at the LHC. The measurement of the ZZ cross section including electroweak corrections

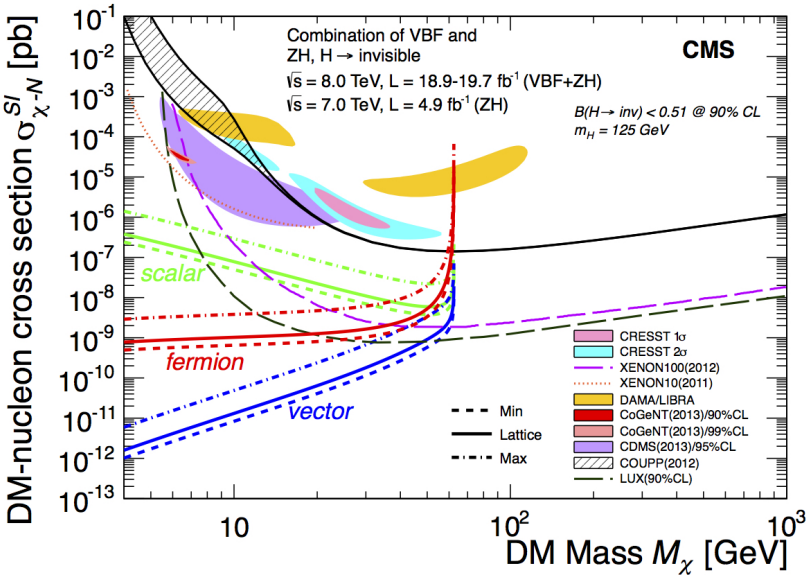

Figure 1: Upper limits on the spin-independent DM-nucleon cross section in Higgs-portal models, derived for m_H=125GeV and $B(H \to inv) < 0.51$ at 90% CL, as a function of the DM mass. Limits are shown separately for scalar, vector and fermion DM. The solid lines represent the central value of the Higgs-nucleon coupling, which enters as a parameter, and is taken from a lattice calculation, while the dashed and dot-dashed lines represent lower and upper bounds on this parameter. Other experimental results are shown for comparison, from the CRESST, XENON10, XENON100, DAMA/LIBRA, CoGeNT, CDMS II, COUPP, LUX Collaborations. (See References [70-78] in the paper, published in European Physical Journal C as doi:10.1140/epjc/s10052-014-2980-6).

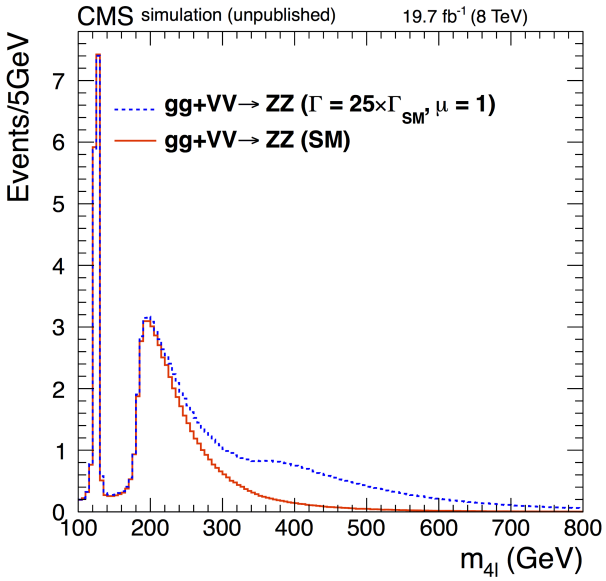

Figure 2: Distribution of the expected four-lepton reconstructed mass in full analysis mass range for the sum of the 4e, 4μ, and 2e2μ channels and for gg+VV→ZZ processes for a Higgs mass of 125.6 GeV. The expected distribution for a scenario corresponding to a scaling of the width by 25 together with mu=1 is also shown. This illustrates the expected change in gg+VV→ZZ production when changing the Higgs width and at the same time constraining the peak cross section to the SM expectation.

was submitted for publication in the European Journal of Physics C. The paper also includes the strongest limits on anomalous γZZ and ZZZ couplings published.

It is worth noting that for most of the SM scalar boson studies performed at the IIHE, a large increase in sensitivity is expected with the Run 2 data due to the increase in beam energy to 13 TeV.

2.1.4 Top quark physics

During the 2012 run of the Large Hadron Collider, at 8 TeV centre of mass energy, the CMS experiment collected an enormous sample containing top quarks in pair production as well as single production.

This allowed IIHE physicists to measure and study very diverse aspects of the top quark sector, focusing not only on the SM but also on searches for physics beyond the SM. The strong role of the institute in the top physics community was also visible in leading roles, as for example Prof Freya Blekman's role as convener of the beyond-two-generations group, a dedicated physics group in the CMS experiment that focuses exclusively on BSM searches in the top quark sector.

Using the 8 TeV dataset the IIHE group is preparing legacy papers on the high precision measurements of the production and decay properties of the top quark (some of these will not be possible to be performed as accurately in future LHC runs due to the high luminosity conditions) as well as searches for new physics in top-like final states. This results in a physics programme that reveals going from SM measurements via BSM-sensitive top quark physics to direct searches:

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. The 8 TeV analysis was a significant improvement of the 7 TeV result, resulting in the most precise measurement of this quantity.

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.

Flavour-Changing Neutral Currents in the top quark sector: If new physics can not be directly observed at the LHC, it would in many cases still be possible to find evidence of such new physics processes through deviations to Standard Model rare processes. IIHE physicists are currently preparing an inclusive approach where all final states in top quark physics sensitive to Flavour-Changing Neutral Currents (FCNC) such as the rare decays $t \to Hc$ and $t \to Zc$, are examined and these processes are accurately measured in all possible final states. This work relies heavily on identification of charm quarks so the same team is also developing the CMS experiment charm quark tagger for the 13 TeV LHC run.

Using precision techniques to identify BSM contributions in the top quark sector: A team of IIHE physicists is studying if it is possible to constrain BSM processes using theory-driven precision tools such as the matrix element method (relying on numerical integration of the SM Lagrangian convoluted with resolution functions). In the last years major progress was made in the computational performance of these tools, and the IIHE team is collaborating with the MadGraph experts at IIHE and UCL to use the MadWeight tools for the matrix element method.

Search for single-top processes in the Wt channel: The production of a single top quark together with a W boson is a rare SM process that is sensitive to new physics and to the Vtb CKM matrix element. In addition this process is an important background to new physics searches. The 8 TeV analysis was performed in collaboration with University of Nebraska and Kansas State University, and resulted in the first discovery of this process, with a significance of over 5 standard deviations.

Search for production of four tops: The production of four top quarks, which in the SM is a very rare process with a cross section of the order of $1fb$, 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 paper focusing solely on SM-like production of four-tops is published and in collaboration with the IIHE phenomenology group the BSM signatures in this topology are explored.

Search for fourth generation chiral and vector-like quarks: Building on a 7 TeV search inclusively for fourth generation quarks (t' and b'), either in pair production or in single production, resulting in the publication of the world best limits were on the existence of a fourth generation in 7 TeV LHC data, the IIHE team is examining the 8 TeV data looking for vector-like heavy quarks that can be produced consistently with observed observed cross section and branching fractions of the BEH scalar. This very difficult search is presented in the PhD thesis of Gerrit Van Onsem.

Search for third generation supersymmetric particles: Supersymmetry is a popular extension of the SM, 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 IIHE analysis focused on identification of relevant observable topologies and the possibility to differentiate these from the SM background processes. The results are presented in the PhD thesis of Alexis Kalogeropoulos

Search for displaced production of top quarks: One of the possibilities why no new physics has been observed at the LHC is hypothesising 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.

2.1.5 Searches 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. IIHE physicists initiated the creation of the **HEEP (High Energy Electron Pairs) working group**. In years 2010-2014, the Brussels group was strongly involved in every step of the CMS data analysis at 7 TeV and 8 TeV.

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. 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, as well as an update of the results using part of the 2012 data at 8 TeV. The legacy paper, presenting final results of the full Run1 dataset analysis has been accepted for publication in JHEP journal. In parallel, the IIHE HEEP group is actively preparing the high energy run (at an energy of 13 TeV in the proton-proton centre of mass) data taking and analysis and are contributing to the CMS Technical proposal for the CMS phase 2 upgrade.

Searches for electron-muon resonances: In collaboration with ULB theorists, an additional 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. A CMS publication is in preparation.

2.1.6 SM precision measurements

To exploit the full discovery potential of CMS and to achieve the maximal precision on the BEH boson properties measurement, it is essential to reach the highest level of precision possible in SM physics area. For these reasons, the jet production associated to the Drell-Yan process is identified as a High Priority Analysis in CMS. In 2012, research activities at the IIHE have started to study it.

Drell-Yan production associated with jets: 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 IIHE group is leading the analysis at 8 TeV and has 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). The jet multiplicity as well as the different transverse momentum distributions are measured.

Double Parton Scattering: The amount and the phenomenological relevance of Double Parton Scattering (DPS) events, where two pairs of partons collide, become important for SM measurements 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, focusing on variables developed to enhance sensitivity to the DPS production.

2.1.7 Dark matter production at the Large Hadron Collider

Prof. Steven Lowette joined the IIHE in 2013, aiming to search in the upcoming high-energy run of the LHC for signatures of direct dark matter production in the CMS detector. These searches for dark matter production in the laboratory excellently complement the ongoing IIHE activities regarding dark matter, both in the IceCube experiment and in the phenomenology group. While the LHC is in maintenance mode a team of IIHE physicists started studies for dark-matter searches towards the next LHC run. In parallel, aiming for already collected data, an IIHE effort was initiated to search for strongly interacting dark matter, in collaboration with colleagues from the ULB phenomenology/theory department.

2.2 The H1 experiment - Study of ep collisions at HERA

(L. Favart, A. Grebenyuk, T. Hreus, X. Janssen, R. Roosen, T. Sykora and P. Van Mechelen)

Deep-inelastic lepton-nucleon scattering has played a key role in understanding the structure of the nucleons since the late 1960. The results of these experiments led to the development and verification of Quantum Chromodynamics (QCD), the gauge field theory of the strong interaction.

HERA (Hadron-Electron-Ringanlage) was the first machine in which leptons collided with protons in a storage ring. Operating with electrons/positrons of 27.5 GeV and protons of 820/920 GeV, the center-of-mass energy in these collisions was increased by a factor ten over the previous fixed-target experiments. The two main detectors installed in the interaction regions, H1 and ZEUS, were magnetic spectrometers with a nearly hermtic coverage, allowing a complete measurement of the lepton and hadronic final states.

HERA started in 1992 and during phase I, which lasted until 2002, delivered about 200 pb^{-1}. During phase II which started in 2004, after a 4-fold luminosity upgrade, until the closedown in 2007 HERA produced another 560 pb^{-1}. The analysis of the data is still ongoing and represents more than 30 FTE in 2014 in H1.

For the first HERA operation phase, the Belgian groups built the central outer proportional chamber, COP, and designed and built the readout for all MWPC's in H1 and related software. During phase II, the Belgian groups

took the responsability for the construction, installation, and running of the very forward spectrometer (VFPS). The detector composed of two movable stations - Roman pots - consists of scintillating fibre detectors allowing the reconstruction of low track multiplicity events. The stations are only moved close to the beam when the beam conditions are stable.
In recent years, the main activity of the group concerns the analysis of the VFPS data. In a first instance and prior to any physics analysis is the extraction of the diffractive track information from many datasets in which beam conditions and background change and different beam approches have to be accounted for. This analysis has now been finalised and the results are published [1]. The knowledge obtained from this analysis has led to a software package which links of raw VFPS data to the diffractive track parameters, required by the any physics analysis.

Applying the VFPS selection and the proton kinematic reconstruction algorithm, the cross section of dijets in deep-inelastic and photo production processes have been measured and their ratio determined. They confirme with better precision that the QCD-factorisation in photoproduced jets is broken, as illustrated in Fig. 3, and that this breaking is unrelated to diffractive proton disociation process. The results have been published in preprint [2] and submitted to JHEP.

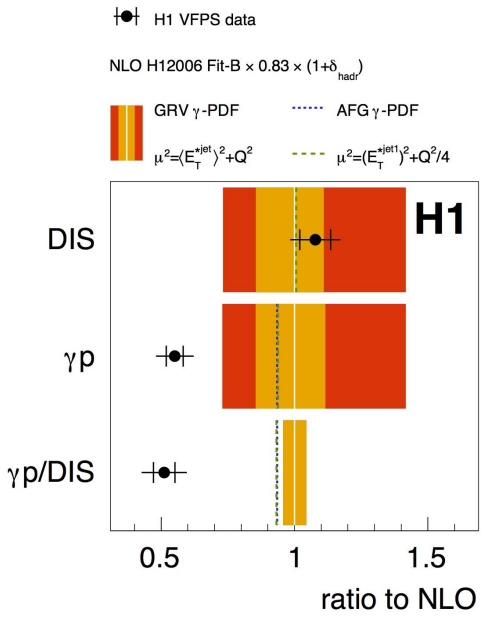

Figure 3: VFPS diffractive dijet DIS and photoproduction cross section measurements normalised to the NLO calculation. Also shown is the double ratio of photoproduction to DIS cross sections, normalised to the corresponding ratio of NLO predictions.

Further results obtained by the H1-collaboration are:

- Single- and double-diferential dijet cross sections are measured in diffractive deep-inelastic ep scattering without tagging the proton and hence complementary to the VFPS results. The data correspond to an integrated luminosity of 290 pb^{-1} and are characterized by photon virtualities, Q^2, in the interval $[4, 100]$ GeV^2 and proton fractional longitudinal momentum losses xp with $xp < 0.03$. Comparison of the cross sections with next-to-leading order QCD predictions based on difractive parton distribution functions has allowed to extract the value of the strong coupling constant.

- From the measurement of inclusive jet, dijet and trijet differential cross sections and comparison to QCD NLO calculations, the strong coupling constant is extracted, $\alpha_S(M_Z) = 0.1165 \pm (8)exp \pm (38)_{pdf,theo}$ and shown in Fig.4, whose precision is limited by missing higher orders (NNLO).

- Measurements of normalised cross sections for the production of photons and neutrons at very small angles with respect to the proton beam direction in deep-inelastic ep scattering at HERA have been obtained as a function of the Feynman variable x_F, and the virtual photon-proton centre of mass system, W, for both photons and

neutrons in the pseudorapidity range $\eta > 7.9$ and $6 < Q2 < 100$ GeV^2. Predictions of models for hadronic interactions of high energy cosmic rays are compared to the measured cross sections.

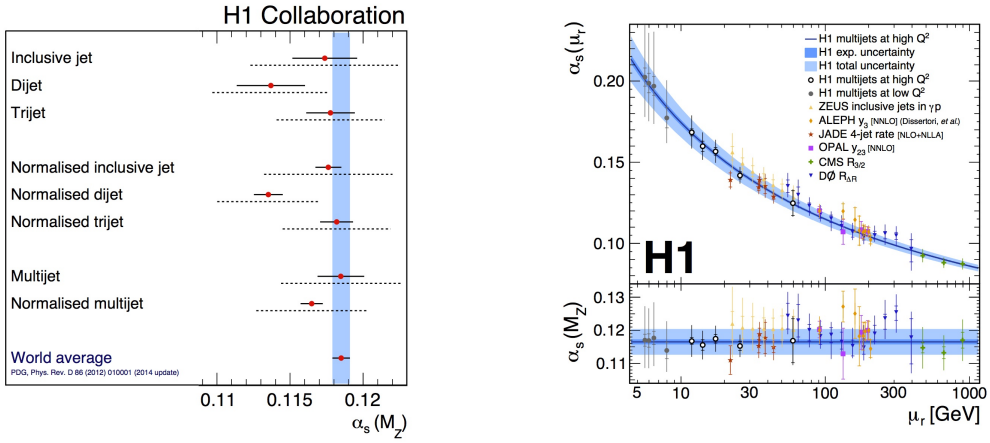

Figure 4: left: Comparison of α_S-values extracted from different jet cross section measurements to the world average value. right: new strong coupling $\alpha_S(\mu_R)$ H1 measurement compared to different measurements at different scales.

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2.3 OPERA experiment (CERN CNGS1)

(P. Vilain, G. Wilquet)

The OPERA experiment aims at detecting for the first time the direct appearance of ν_τ in a ν_μ beam with a large signal/noise ratio through the identification of the τ^- lepton produced in their CC interactions. The experiment will test the oscillation parameters space indicated by the atmospheric neutrinos experiments: compatible with full $\nu_\mu - \nu_\tau$ mixing and $|\Delta m^2_{32}| \approx 2.34\ eV^2$. The detector is installed in the underground Gran Sasso Laboratory (LNGS) and exposed to the CNGS neutrino beam produced at CERN, at a distance of 730 km. 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 the baseline length and a micrometric resolution to allow the detection of the short-lived tau lepton. More information on the detector may be found in previous reports and in [1]. Our group was more specifically involved in the conception, the construction, installation and running of the scintillating strips trackers that instrument the targets. [2].The physics run with a fully operational detector started in spring 2008 and ended in December 2012. The achieved integrated neutrino beam flux corresponds to 18×10^{19} pot, i.e. 80% of its nominal value . About 16 500 neutrinos interactions have been registered in the target.

In about 75% of the total statistics, four ν_τ candidate events have been observed [3], 3 where the τ^- decays in an hadronic mode and one in the muonic mode . (2.11 ± 0.42) signal and (0.23 ± 0.04) background events are expected in this sample and $\nu_\mu \to \nu_\tau$ oscillations in the appearance mode are therefore established with a statistical significance of

4.2 σ. The plan is to complete the analysis of the full data sample by the end of 2015. That of possible new candidate events might extend in 2016.

The procedure developed to detect particle decays occurring over distances of the order of 1mm from the neutrino interaction point has been applied to the search for charmed hadrons as these show similar mass, lifetime and decay topologies as the τ^- lepton. In the analysed subsample, 50 charm decay candidate events have been observed while 54 ± 4 are expected including background. This agreement in rate is further supported by the comparison between observed and simulated data for several relevant variables. This demonstrates that the detector performance and the full analysis chain applied to neutrino events are well reproduced by the OPERA simulation chain, thus validating the methods applied to the ν_τ appearance search [4].

The number of observed ν_τ candidate events is 4 and the number of expected events is 2.33 ± 0.42 including background. There is no evidence for a statistically significant excess or lack of ν_τ interactions to be attributed e.g. to $\nu_\mu - \nu_\tau$ oscillation induced by the mixing with a sterile neutrino. Limits have been established on the existence of such a neutrino in a so-called 3+1 framework where it is separated by a squared mass difference $\Delta m^2_{41} > |\Delta m^2_{31}|$. Such models are invoked to explain the excess of ν_e events in a ν_μ source at large Δm^2 observed by the LSND and MiniBooNE experiments as well as the so-called nuclear reactor and Gallium neutrino anomalies. At high Δm^2_{41} values, the measured 90% CL upper limit on the mixing angle $sin^2 2\theta_{\mu\tau} = 4|U_{\mu 4}|^2|U_{\tau 4}|^2$ ranges between 0.09 and 0.14, depending on the value of the two CP phases dependent angle $\phi_{\mu\tau} = Arg(U_{\mu 3}U^*_{\tau 3}U_{\mu 4}U^*_{\tau 4})$, equal to 0 or π if CP is conserved. The long baseline of the OPERA experiment allows extending the exclusion limits on Δm^2_{41} in the $\nu_\mu \to \nu_\tau$ appearance channel down to values $\approx 10^{-2} eV^2$ at large mixing, $sin^2 2\theta_{\mu\tau} > 0.5$ [5]; see Figure 5.

The flux ratio of positively to negatively charged muons produced in cosmic rays interaction has been measured by the spectrometers with an unprecedented precision in the high muon energy region up to 20 TeV, supporting the validity of Feynman scaling in the fragmentation region up to 200 TeV/nucleon [6].

As part of an effort to further reduce the background to the τ^- decays sample, a new method has been developed that allows measuring the sign of the muon charges by the magnetic spectrometers with an efficiency that exceeds 99.5% and therefore rejecting with the same efficiency muonic decays of charmed particles produced in ν_μ CC interactions where the primary muon is not identified [7].

In 2014, the OPERA Collaboration included about 150 physicists from 30 institutions in 11 countries.

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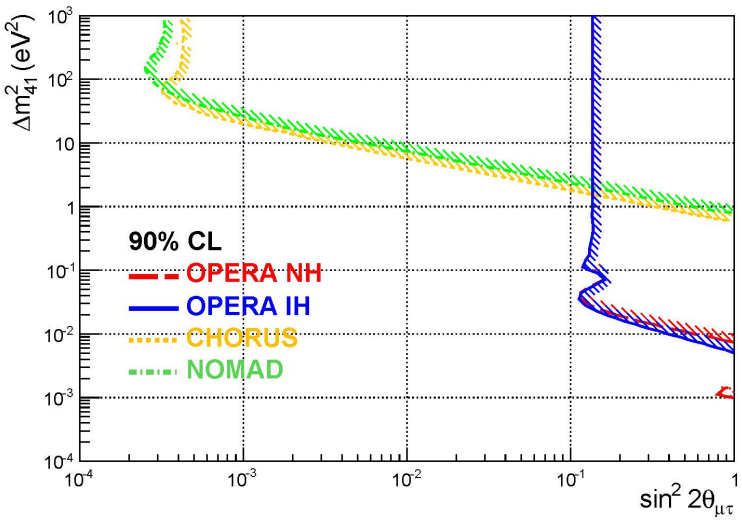

Figure 5: OPERA 90% CL exclusion limits in the Δm^2_{41} vs $sin^2 2\theta_{\mu\tau}$ parameters space for the normal (NH, dashed red) and inverted (IH, solid blue) hierarchy of the three standard neutrino masses. The exclusion plots by NOMAD and CHORUS are also shown. Bands are drawn to indicate the excluded regions.

2.4 Astroparticle Physics with the IceCube Neutrino Observatory

(J. A. Aguilar, S. Amary, L. Brayeur, M. Casier, C. De Clercq, N. Van Eijndhoven, G. Golup, K. Hanson, D. Heereman, J. Kunnen, J. Lünemann, G. Maggi, T. Meures, A. O'Murchadha, E. Pinat, O. Scholten, R. Simoni, K. De Vries, G. De Wasseige, I. Ansseau, C. De Vos, J. Bekx, S. Verheyen)

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.

2.4.1 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 overall configuration (see Fig. 6) exhibits a hexagonal structure, which is the result of extensive optimization procedures based on simulation studies. At the end of 2010 the full 86-string detector, including its DeepCore extension (see here after), was completed and started taking 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.

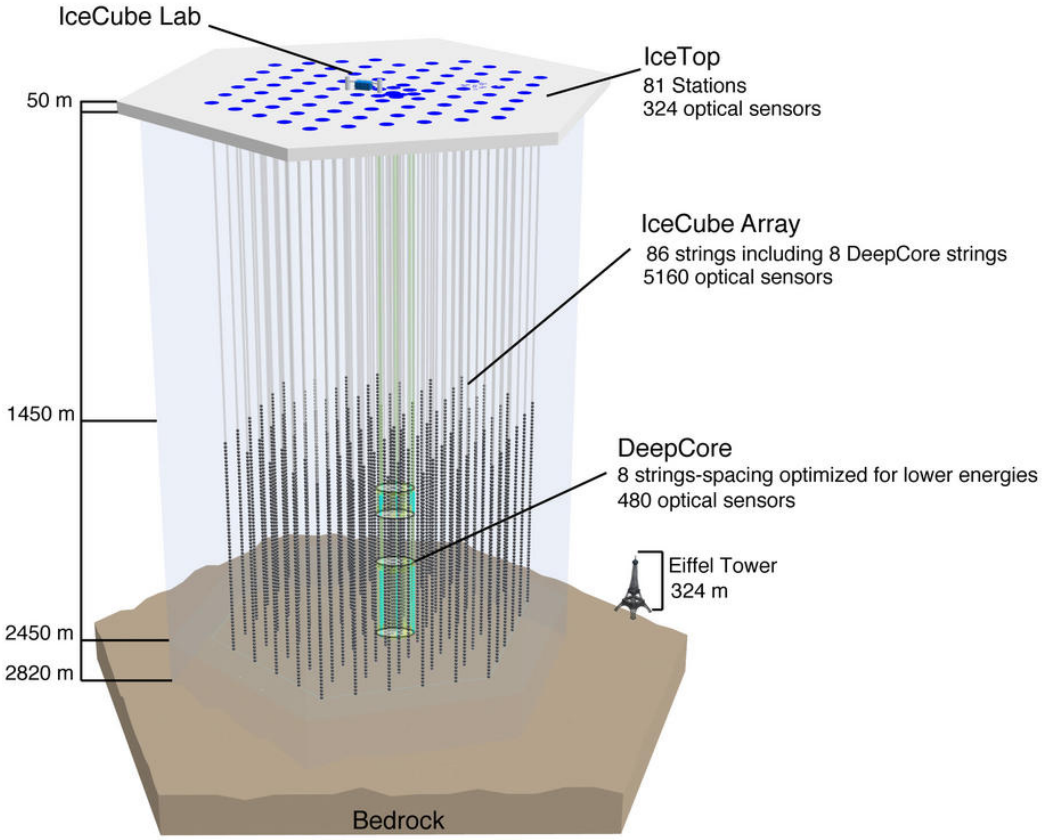

Figure 6: The IceCube observatory.

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 DeepCore 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.

Most of the high-energy neutrinos detected in IceCube are originated from cosmic-ray particle interactions in the Earth's atmosphere. However, in 2013 IceCube detected a neutrino flux component incompatible with the atmospheric background hypothesis. The analysis of three years of data using sophisticated veto techniques resulted in an astrophysical neutrino flux of the level of 10^{-8} GeV cm^{-2} s^{-1} sr^{-1} per neutrino flavor (Science **342** (2013) 1242856). This achievement was awarded the title *Breakthrough of the year 2013* by the Physics World magazine. The level of this flux implies a much richer hadronic activity in the non-thermal Universe than previously expected. However, the current size of the IceCube observatory limits its ability to identify the sources of these high energy neutrinos. For this reason expansions of the current detector are already planned. The second generation of IceCube, *IceCube-Gen2*, will be a future installation including a 10 km^3 volume expansion of detection volume of the clear Antarctic ice (Fig. 7).

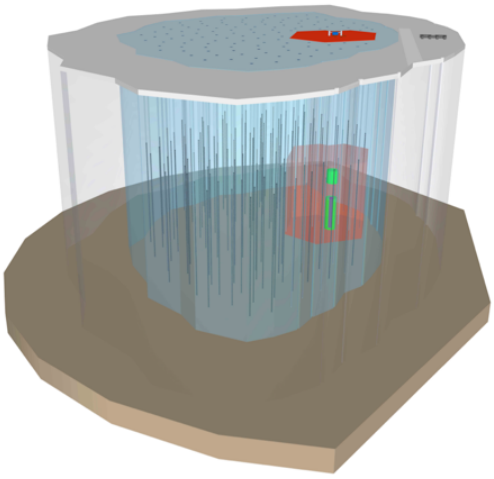

Figure 7: A possible *IceCube-Gen2* configuration. IceCube, in red, and the infill subdetector DeepCore, in green, show the current configuration

2.4.2 Research areas at the IIHE

In 2014 the IIHE was involved in the following IceCube related (astro)physics topics:

- **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 only sources of the very energetic cosmic rays which we observe at 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 objects for the first time in history with unprecedented sensitivity.

- **Ultra-High Energy Cosmic Ray and neutrino correlations.**
  As of now, the high energy neutrino flux measured by IceCube is compatible with a diffuse and isotropic emission. However, it is reasonable to assume that if part of these neutrinos have an Extra-Galactic origin, their directions might correlate with those of the ultra-high energy cosmic rays (UHECRs) measured in experiments like the Pierre Auger Observatory (PAO) and Telescope Array (TA). The IIHE group is involved in a working group consisting on members of IceCube, PAO and TA collaborations to perform an analysis of correlations with the arrival directions of the astrophysical neutrinos and UHECRs.

- **Search for cosmic point sources.**
  Apart from the correlation studies mentioned above, this research also comprises a full sky search for "hot spots" of neutrino production. Identification of such "hot spots" on the neutrino sky would enable us to locate the sources of the most energetic cosmic ray particles. At the IIHE we focus on a special class of Active Galactic

Nuclei (AGN) called Blazars. These AGN are steady sources of very energetic electromagnetic radiation for which the jet is aligned along our line of sight. However, instead of selecting the sources which are brightest in γ-rays as was done in previous analyses, we focus on the ones which are bright in radio flux but rather dim at more energetic radiation. The idea is that in this way we will be able to select dust obscured Blazars, where the dust provides an additional target for high-energy neutrino production. Together with a novel statistics method which has been developed at the IIHE we intend to achieve a better sensitivity for neutrino detection of these objects.

- **Search for extended neutrino emission.**
  Starting in December a new analysis focusing on neutrino emission from extended regions was initiated at the IIHE. This analysis is an evolution of the point source analysis in which the source is now assumed to cover a significant extension of the sky (from 1° up to 5°). Additionally the diffuse Galactic Plane emission will be investigated. Diffuse neutrino emission from the Galactic Plane is considered one of the guaranteed sources of neutrinos as corroborated by the diffuse signature of π^0 generated γ-rays observed in experiments like Fermi.

- **Dark matter searches.**
  In these studies the focus is put on neutrino signatures from WIMPs located in the center of our Earth or Sun. In a previous analysis the IIHE team took the lead in the search for high-energy neutrinos from our Sun when the source was above the horizon. This was possible thanks to the performant veto capabilities of the IceCube sensors surrounding DeepCore. That analysis yielded the most sensitive limits on spin dependent WIMP-nucleon cross sections.
  Currently at the IIHE a procedure is being developed to search for WIMP signals from the centre of the Earth and preliminary results indicate that the sensitivity may be improved by about two orders of magnitude compared to previous IceCube searches.

- **Detection of neutrinos from supernova explosions.**
  Since the observation of the supernova 1987A in the Magellanic 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 Earth, which can be detected by IceCube with a specialized 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. At the IIHE a special data acquisition procedure, dubbed HitSpooling, has been developed which will significantly increase the sensitivity for an early detection of these phenomena.

- **Neutrinos from solar flares.**
  Since the end of the eighties and in response to an increase in the total neutrino flux in the Homestake experiment in apparent coincidence with major solar flares, solar neutrino experiments are trying to identify neutrinos produced during these sudden flashes of energy. To date no confirmation of an increase in the neutrino rate due to solar flares has been found. A new analysis proposed at the IIHE is studying the feasibility of using IceCube to search for solar flare neutrinos in coincidence with observations of electromagnetic radiation (i.e. X-rays, gamma rays and radio) from these events. Although related to a different astrophysical phenomenon, the analysis technique shares many aspects with the supernova neutrino analysis. Detection of neutrinos from solar flares will open a new window on these phenomena and increase our insight in the underlying 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 in the commissioning of the first detector elements. Currently an analysis of the data obtained with these first detector stations is being performed.

- **R&D for detector extensions**
  The discovery of cosmic high-energy neutrinos has triggered feasibility studies of extending the existing IceCube

observatory towards higher energies. However, in view of neutrino oscillation studies and in particular investigation of the neutrino mass hierarchy, also an extension towards lower energies (the so called PINGU project) is being examined. Both these extensions involve extensive detector R&D efforts in which the IIHE team participates via the development of new readout and data acquisition techniques. Furthermore, between the energy ranges of IceCube and the above mentioned ARA detector there exists an energy gap which is currently not covered by any detector. At the IIHE we are studying an innovative technique based on radar reflection in order to detect showers of very energetic neutrinos in the ice which would fill this gap in energy coverage.

2.5 The ARA project

(Kael Hanson, Yifan Yang, Krijn de Vries, Aongus Ó Murchadha, Thomas Meures, Michael Korntheuer)

The Askar'yan Radio Array (ARA) Collaboration is an international collaboration of over 30 scientists and engineers from institutions in 7 countries. The goal of the collaboration is the construction of a telescope capable of detecting neutrinos with energies in excess of 10^{18} eV. The project makes use of the 3 km-thick ice sheet at the geographic South Pole as a target for the cosmic neutrinos, which should interact in the ice and create a high-energy electromagnetic cascade. It is thought that such a cascade should produce sufficient radio emission to be detectable by radio antennas in the ice. Measurements of the attenuation length of radio-frequency waves indicate that antennas should be sensitive to interactions occurring up to a kilometer away. Consequently, the ultimate goal is a 37-station array covering over 100 km^2, which is expected to be able to detect (at the order of several events per year) the small flux of ultra-high energy neutrinos produced in interactions between ultra-high energy cosmic rays interacting with the cosmic microwave background radiation. A detection of this flux would have profound implications for our knowledge of the production, propagation, and composition of ultra-high energy cosmic rays.

In addition to a prototype "Testbed" station, there are currently 3 ARA stations installed at the South Pole. Each station consists of 4 radio antennas on each of 4 strings approximately 200-300 m deep in the ice.

T. Meures wrote and defended a PhD thesis entitled "Development of a sub-glacial array of radio antennas for the detection of the flux of GZK neutrinos." This required not only a thorough calibration of the principal waveform digitization chip used by the ARA stations, but also the calibration of the station and antenna locations in the ice. Additionally, the thesis introduced a new neutrino interaction vertex reconstruction algorithm, based on Bancroft's Method and using the speed and power of numerical linear algebra (Figure 8).

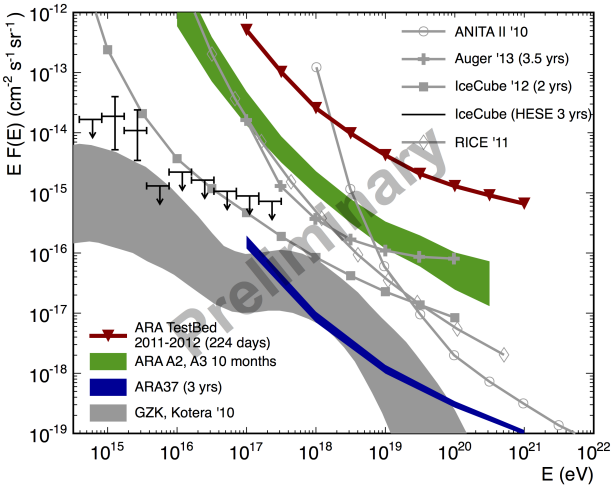

Figure 8: Predited cosmogenic neutrino fluxes and current experimental limits. The green band represents the limit set by T Meures with 10 months of ARA2-3 data.

The IIHE team continued its management of the detector systems at Pole, taking over management of the deep-ice stations. T. Meures identified a malfunctioning channel and rewrote the DAQ software to allow masking from the trigger. A Ó Murchadha updated the data processing software to allow the main South Pole ARA server to process

multiple runs at once. With the IIHE team in the lead, the electronics lifetime of the deep stations rose from õ60% in 2013 to over 98% in 2014.

In the realm of future detector development, the IIHE radio team also looked into the possibility of being able to detect neutrino-induced plasmas directly, using radar scattering. Based on an initial paper (Astropart.Phys.60:25-31,2015, arXiv:1312.4331), K. de Vries developed theory, A. Ó Murchadha worked on simulation, and K. Hanson detector hardware and instrumentation, in preparation for a January 2015 real-world test at the Telescope Array linac in Delta, Utah.

2.6 Instrumentation and electronics R&D

2.6.1 Data acquisition systems R&D activities

(P. Barria, G. De Lentdecker, K. Hanson, M. Korntheuer, A. Marinov, Th. Lenzi, A. Leonard, Th. Maerschalk, Th. Meures, E. Pinat, E. Verhagen, Y. Yang, R. Yonamine)

Since 2007, the IIHE has started an R&D program in the field of data acquisition (DAQ) systems for future experiments in particle and astro-particle 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 astro-particle 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.

Since July 2011, the IIHE is also contributing to the study of micro-pattern gaseous detectors with three GEM foils to replace standard Resistive Plate Chambers (RPC) in the forward region (1.5¡——¡2.2) of the CMS muon spectrometer for the LHC high luminosity phase, after 2018. This project, called the CMS GEM upgrade, is well supported by the CMS Collaboration: a couple of detectors will be installed in the CMS detector during the winter 2016-2017 before the installation of the full system, counting 144 detectors, during the 2nd long LHC shutdown in 2018-2019. Since 2012 Dr. G. De Lentdecker is the convener of the CMS GEM DAQ group.

In this project the IIHE is leading 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 to the architecture design the IIHE is also responsible for the design of an opto-electronic board that will be located on the GEM detectors. Fig 9 shows the first prototype of this board called opto-hybrid. The board is equipped with an FPGA connected on one side to 24 front-end VFAT2 chips and on the other side to the backend micro-TCA electronics through several optical fibers. This board being located on the detector, it has to be tolerant to the radiation. Therefore single event upset mitigation techniques are being investigating by the group.

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 km2 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.

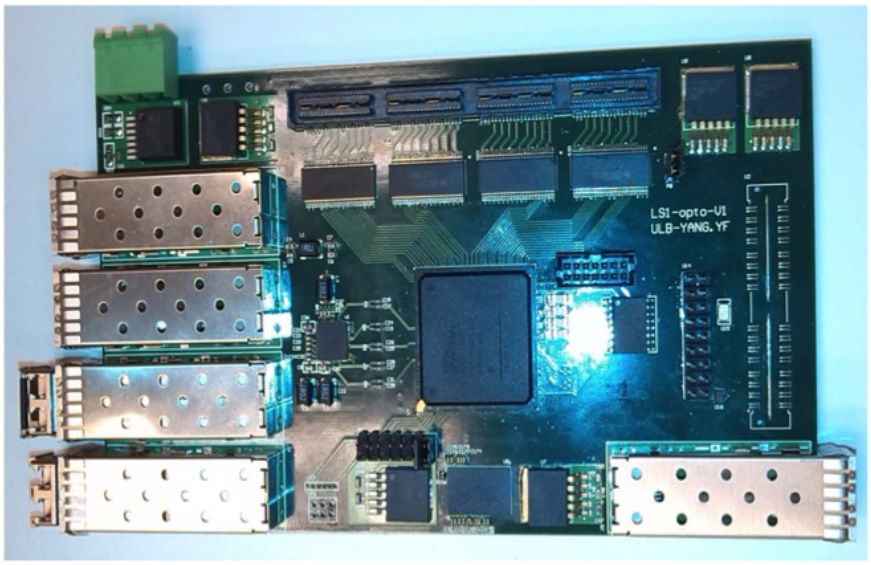

Figure 9: First CMS GEM FPGA-based opto-hybrid board built at the IIHE

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.

2.6.2 Measurement of the high-energy neutron dose in protontherapy

(G. De Lentdecker, V. De Smet, D. Ndayizeye)

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 are now routinely been running 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 2014, test beams with quasi mono-energetic neutron beams have been performed, up to very high energies (170 MeV). These measurements should shed light on the WENDI-2 response at such high energies (see Fig **??**), relevant for the protontherapy applications. The data are being analyzed with MCNPX as well as the GEANT4 simulation toolkit commonly used within the particle physics community.

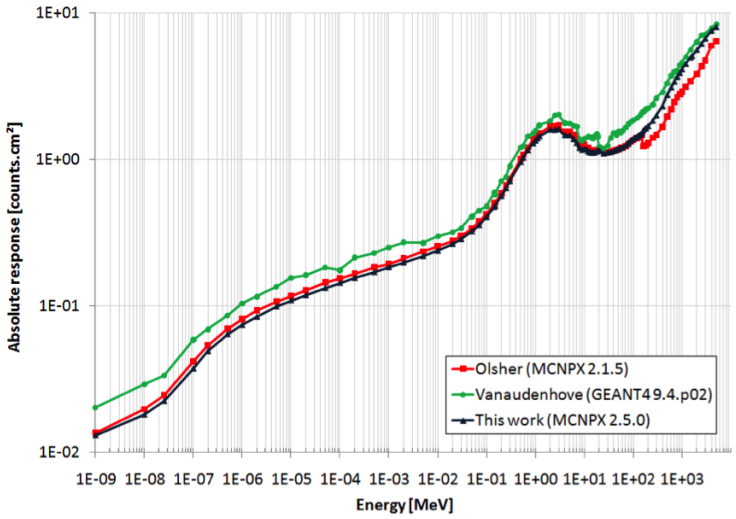

Figure 10: Simulation results of the WENDI-2 absolute response function. Ref: Olsher R.H. et al., WENDI: An improved neutron rem meter, Health Physics 79 (2), pp. 170-181 (2000).

2.7 The SoLid experiment

(J. D'Hondt, P. Van Mulders, S. Vercaemer)

The researchers involved in the SoLid experiment aim to search for Short baseline neutrino Oscillations with a novel Lithium-6 composite scintillator (SoLid). The highly segmented plastic scintillation detector coated with Lithium-6 is designed to provide a measurement of the rate of electron antineutrinos at very short baseline distances between 5 and 11 metres from the BR2 research reactor core in SCK-CEN at Mol. This measurement will provide confirmation or exclusion of the so-called reactor anomaly present in the ratio of the observed to predicted number of electron antineutrino events at short baseline distances.

The detector consists of PVT scintillator cubes of 5cmx5cmx5cm coated with ${}^6LiF : ZnS$ to detect $\bar{\nu_e} + p \rightarrow n + e^+$. The antineutrinos produced by the reactor interact with the protons of the detector material and produce a neutron and positron. The positron will quickly annihilate with one of the electrons in the detector. While the neutron will be captured by the Lithium-6 ($n +^6 Li \rightarrow^3 H + \alpha + 4.78MeV$). The combination of the signal from the positron annihilation and the delayed neutron capture allows for a clear identification of the antineutrino interaction. Two fibers pass through each cube to read it out, which provides a precise localization of where the interaction happened. The light is collected at the fiber end using MPPCs. An other advantage of this novel detector design is that it is easily scalable.

In 2014, the collaboration consisted out of about 40 researchers connected to 8 institutes in the UK, France and Belgium. At the IIHE, we organized the second SoLid collaboration meeting in September. We participated in the construction of a first submodule of the SoLid detector, which was installed at the BR2 reactor in November. Furthermore, we contributed to the commissioning, operation and data analysis of the prototype in particular for the reconstruction of muons and the identification of neutrons, but also for the measurement of the light attenuation throughout the fibres using radioactive sources.

2.8 Phenomenology

(K. De Causmaecker, A. Mariotti, K. Mawatari, B. Oexl, P. Tziveloglou, M. Vereecken)

In October 2010 a new phenomenological research activity started at the VUB in order to link between the existing theoretical (TENA) and experimental (ELEM) groups through phenomenological projects at first focused on supersymmetric theories. This was an initiative titled "Supersymmetric models and their signatures at the Large Hadron Collider" financed through a five-year "Geconcerteerde Onderzoeksactie" (GOA) research project at the VUB.

The initiative has been re-assured by a new approval of another five-year action which continues the development of the phenomenological research from 2013. This initiative is named "High Energy Physics Research Center" at the VUB (HEP@VUB) and comprises the main groups working on high energy physics; Collider physics (CMS), Astroparticle physics (IceCube), and Theoretical high-energy physics.

The main topic of research is supersymmetric models and their signatures at the Large Hadron Collider (LHC). 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 2014, we had explored missing-energy signatures with multi-leptons (PLB731(2014)7, D'Hondt, De Causmaecker, Fuks, Mariotti, Mawatari, Petersson, Redigolo), multi-photons (JHEP04(2014)126, Ferretti, Mariotti, Mawatari, Petersson), or mono-photon (EPJC74(2014)2909, Mawatari, Oexl) at the LHC as well as at the ILC in general gauge mediated SUSY breaking scenarios. P. Tziveloglou and his colleagues also studied Dirac-type gauginos in low scale SUSY breaking scenarios (NPB884(2014)632, NPB889(2014)650). B. Oexl summarized her 4-year PhD study on gravitino production at colliders as her PhD thesis.

After the discovery of a SM-like scalar boson at the LHC in 2012, studies of its properties is one of the first priority of the high-energy community. In collaboration with the group of F. Maltoni at UCL, K. Mawatari had investigated all the main Higgs production processes at next-to-leading order QCD plus parton-shower accuracy, including non-standard-model couplings (EPJC74(2014)2710, EPJC74(2014)3065). One of the plots in the paper EPJC74(2014)2710 was selected as a cover page of volume 74 of European Physics Journal C (see Fig. 11).

In addition, K. Mawatari with the MadGolem colleagues presented the next-to-leading order cross section calculation for third generation squark production (PRD90(2014)075007) in the fully automized MadGolem framework.

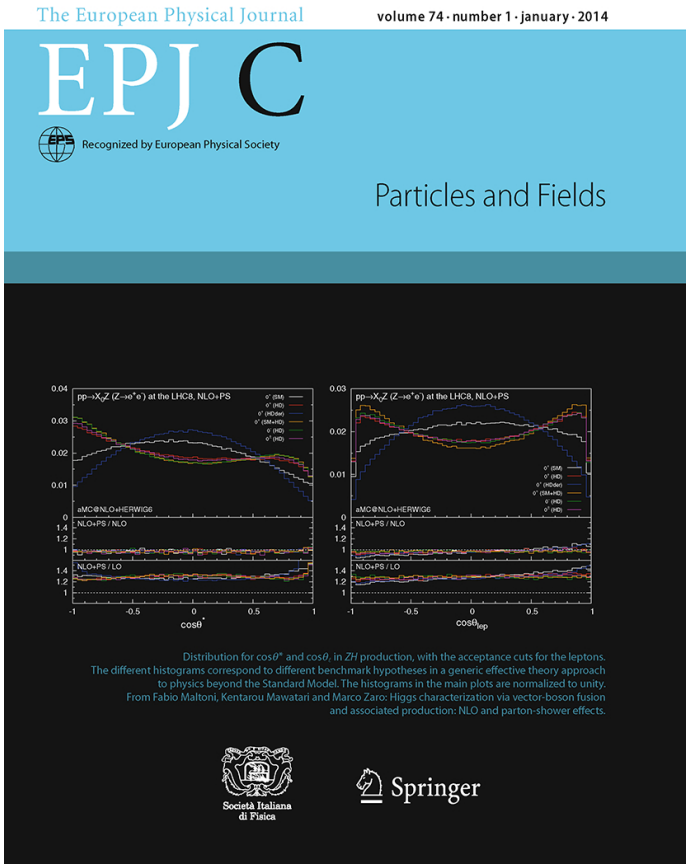

Figure 11: Cover page of the European Physics Journal C vol.74 (2014).

2.9 Computing and networking

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

2.9.1 Local computing resources

The IIHE hosts a range of general IT services like a web server, DNS and DHCP servers. Most servers have been migrated to a virtual environment based on VMWARE. The implemented solution consists of 2 hypervisors running the virtual machines. The images are kept on a central NAS server. To Guarantee the machines against short power breaks, the infrastructure was connected to an 8kVA UPS (uninterruptible power supply).

2.9.2 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.

The IceCube cluster has 460 cores and 1392TB of RAM. It uses the OpenPBS batch queuing system to handle job submission. In addition, specialized graphics processing (GPU) platforms containing the recent Tesla processing engine from NVIDIA are used to simulate photon propagation in ice. The Cluster also has 100TB of mass storage attached to it.

The cluster is mainly used by the IceCube Simulation group and by local users for data analysis.

2.9.3 Large scale computing for CMS and TIER2 cluster

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.

Presently, the T2 has 1864 job slots for a total of 19TFLOPS (or 14.000HepSpec06 units). Attached to this, a mass storage system of 1.2 PB is found. Figure 12 shows the usage of the site over the last 4 years. In 2012, the site was optimized and so was filled for an average of 90%. On 14 February 2013, the LHC was shut down for maintenance and upgrade works. The effect of the shutdown is clearly seen in the figure: the site was used for an average of 60% in 2013 and 2014.

In 2014, the Brussels Tier-2 team counted three IT scientists (S. Rugovac, F.R.S.-FNRS; O. Devroede, VUB; S. Gérard, VSC, part time). Pascal Vanlaer, seconded by G. Bruno (UCL), is in charge of the Belgian federated Tier-2 sites and is 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.

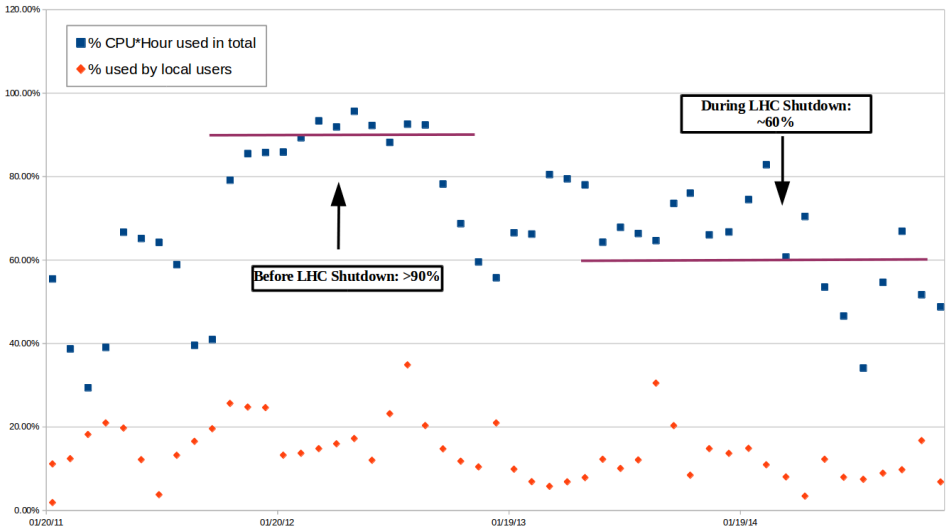

Figure 12: CPU usage of the T2 over the last 4 years. The effect of the LHC long shutdown in 2013 and 2014 is clearly seen in a reduced need for CPU

2.10 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 organised by Freya Blekman in the framework of IPPOG, the International Particle Physics Outreach Group in which Jorgen D'Hondt represented Belgium until the Summer of 2014. 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. Members of the IIHE are active in valorisation activities on social media such as Youtube videos, google hangouts and twitter, with particularly the video activities regularly reaching tens of thousands of views.

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 ULB and VUB for a detailed visit to CERN.

Members of the IIHE have been awarded for science communication.

2.11 Technical and administrative work

2.11.1 Workshop

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

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.

2.11.2 Secretariat

The secretarial work and the general administrative and logistic support of the experiments were in charge of A. Terrier and M. Goeman, 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.

3 Activities

3.1 Contributions to experiments

3.1.1 Responsibilities in experiments

Patrizia Barria

- Convener of Detector Response Modeling and Test Beam analysis subgroup for the CMS GEM Collaboration

Freya Blekman

- Beyond-Two-Generations Resonances group subconvener 4-month replacement due to parental leave
- Beyond-Two-Generations convener

Barbara Clerbaux

- Member of the publication committee board for the EXOTICA and B2G groups
- ULB Deputy representative at the CMS board

Jorgen D'Hondt

- Chairperson of the CMS Collaboration Board
- Chairperson of the CMS International Committee
- Member of the CMS Collaboration Board
- Member of the CMS Executive Board
- Member of the CMS Management Board
- Member of the CMS Steering Committee of the Tracker Phase-2 Upgrade
- Member of the CMS Tracker Institution Board
- Member of the International Advisory Committee for CMS Schools
- Secretary of the CMS Collaboration Board

Nadir Daci

- Exotica trigger validation

Isabelle De Bruyn

- Commissioning of the CMS Strip Tracker during LS1
- DQM: implement Phase 2 Upgrade Outer Tracker plots
- Tracker on-call shifts

Catherine De Clercq

- Belgian liaison in the IceCube International Oversight and Finance Group IOFG
- PI of VUB in the IceCube collaboration board

Gilles De Lentdecker

- Convener of the CMS GEM DAQ & Electronics Working Group

Hugo Delannoy

- Validator for the SMP trigger at HLT

Laurent Favart

- Internal CMS referee (ARC)
- Internal H1 referee
- Member of the H1 Physics Board
- Shift Leader - CMS data taking

Kael Hanson

- Member IceCube Executive Board

James Keaveney

- ARC member of SMP-13-012
- ARC member of TOP-13-017
- B-tagging contact for TOP PAG
- CMS B-tagging contact for TOPLHCWG
- Generator contact for TOP PAG

Jan Kunnen

- Preparation of the online Vertical Event Filter for the 2014 season
- Testing of the 2014 data, with the focus on events tagged by the Vertical Event Filter

Steven Lowette

- Convener of the MC&Interpretations subgroup of the Exotica PAG in CMS
- Member of Analysis Review Committees in CMS
- Member of the CMS Thesis Award committee
- VUB representative in the CMS Tracker Insitution Board

Giuliano Maggi

- IceCube Monitoring shift, 17-24 March, 2014

Thomas Meures

- ARA remote station operation

Lieselotte Moreels

- CMS Tracker DOC shifts
- Commissioning of the CMS tracker during LS1
- Implementation of data quality monitoring (DQM) plots for the phase II upgraded tracker

Aidan Randle-conde

- Z' search analyst in the CMS EXO group
- 2014 CMS Trigger Studies Group Workshop (Brussels), Organiser
- DCS Central Shifts in the CMS Control Room (14 shifts total)
- Egamma (high energy electrons) Contact for the CMS EXO group

Thomas Reis

- Egamma HLT release validation developments in CMS
- Release validation coordination for STEAM in CMS

Derek Strom

- Convener of the CMS Silicon Strip Tracker DAQ and Online Group

Nick Van Eijndhoven

- Contact person for the IceCube Direct Walk (multi)track reconstruction
- Internal referee for IceCube publications
- Member of the IceCube Gamma Ray Burst working group
- Member of the IceCube muon working group
- Member of the IceCube point source working group

Petra Van Mulders

- Convener of the BTV POG in the CMS collaboration
- Member of the institutional board of the SoLid collaboration

Isis Van Parijs

- Commissionning of the tracker during LS1
- DQM: Phase 2 Outer Tracker plots
- Tracker DOC shifts

Catherine Vander Velde

- CMS-ULB Team Leader, till 30/9/2014
- CMS Collaboration Board member, till 30/9/2014
- CMS Finance Board member, till 30/11/2014
- CMS Tracker Institution Board member, till 30/9/2014
- Member of the CMS Thesis awards committee, since 1/10/2014
- Member of the CMS editorial board for publications on supersymmetry

Pascal Vanlaer

- CMS ULB Deputy team leader
- CMS ULB team leader since 15 november 2014
- Co-convener of CMS Higgs trigger study group
- Member of CMS analysis review committees (ARCs)
- Physicist in charge of the ULB-VUB CMS Tier-2 computing cluster

Gaston Wilquet

- Internal referee for OPERA publications
- Member of the Collaboration Board of OPERA

3.1.2 Presentations in collaboration meetings

Lionel Brayeur

- Event selection using reconstruction combination - IceCube - Banff, Canada from 02/03/2014 to 08/03/2014
- Search for long GRB neutrinos - IceCube - Geneva, Switzerland from 13/09/2014 to 20/09/2014

Barbara Clerbaux

- Study of Z' properties at the HL-LHC - CMS EXOTICA week - Madrid 14/11/2014

Gilles De Lentdecker

- CMS GEM DAQ & Trigger electronics: status and plans - CMS - Texas A&M 09/02/2014
- CMS GEM project: detector & electronics update - CMS - CERN 03/09/2014

Geraldina Golup

- HESE-UHECRs crosscorrelation analysis - IceCube - Geneva, Switzerland 15/09/2014

James Keaveney

- Paper talk of TOP-13-012: Search for Standard Model four top production at 8 TeV in the lepton + jets channel - CMS - CERN 20/05/2014

Jan Kunnen

- Status of the Earth WIMP search - IceCube - Geneva, Switzerland from 14/09/2014 to 19/09/2014
- Status of the Earth WIMP search - IceCube - Banff, Canada from 02/03/2014 to 08/03/2014

Steven Lowette

- Improvements for the Monojet Analysis - CMS - CERN, Switzerland 14/10/2014
- Status of Dark Matter Searches, Prospects for Run 2 - CMS - CERN, Switzerland 16/10/2014

Alberto Mariotti

- Pheno Group: prospects and plans - Pheno - IIHE - VUB Brussels 07/11/2014

Thomas Meures

- ARA data analysis - ARA - Maryland University - USA 14/06/2014

Elisa Pinat

- BPSK signalling with Filter Board - IceCube Spring Collaboration Meeting - Banff, Canada 04/03/2014

Aidan Randle-conde

- EGM recent developments - CMS Week - Miami, FL, USA 15/12/2014
- High E_T electrons: Status and work to do - CMS - CERN 03/10/2014
- Status of trigger and offline id for high-pT electrons - CMS EXO - CIMEAT, Madrid, Spain 13/11/2014

Pantelis Tziveloglou

- Activities of the PHENO group - PHENO GROUP - IIHE - Overijse 11/09/2014
- Majorana masses vs Dirac masses in Supersymmetry - HEP@VUB - Brussels 25/09/2014

3.2 Completed Master and PhD theses

Barbara Clerbaux

- Laurent THOMAS
  Search for new heavy narrow resonances decaying into a dielectron pair with the CMS detector
  Phd thesis ULB, October 2014.
- David Vannerom
  Search for new resonance in the electron-muon decay channel
  Master thesis ULB, June 2014.

Jorgen D'Hondt

- Alexis Kalogeropoulos
  Search for direct stop quark pair production at the LHC with the CMS experiment
  Phd thesis VUB, January 2014.

Gilles De Lentdecker

- M. Zecchin
  Characterization of a Triple-GEM Detector Prototype for the CMS Muon Upgrade with GEM Detectors
  Master thesis ULB, September 2014.
- F. Lucchetti
  Study of a Triple GEM detector for the upgrade in the forward region of the CMS muon system at the LHC
  Master thesis ULB, June 2014.

Laurent Favart

- Patrick Connor
  Etude du processus de Drell-Yan à haute masse invariante au LHC à $\sqrt{s} = 8$ TeV
  Master thesis ULB, June 2014.

Kael Hanson

- Thomas Meures
  Development of a sub-glacial array of radio antennas for the detection of the flux of GZK neutrinos
  Phd thesis ULB, December 2014.
- Gwen de Wasseige
  Search for GeV Neurinos from Solar Flares with the IceCube Neutrino Observatory
  Master thesis ULB, June 2014.

Nick Van Eijndhoven

- Celine De Vos
  Optimisation of event selection for the IceCube Gamma Ray Burst analysis
  Master thesis ULB, June 2014.

Petra Van Mulders

- Gerrit Van Onsem
  Search for new heavy quarks with the CMS detector at the Large Hadron Collider
  Phd thesis VUB, May 2014.
- Bert Verbruggen
  Study of the modelling of top quark events with the CMS experiment
  Master thesis VUB, June 2014.

Pascal Vanlaer

- Hugo Delannoy
  Etude de la production de paires de bosons W de meme charge au LHC avec les donnees proton-proton a 8TeV dans l'experience CMS
  Master thesis ULB, January 2014.

3.3 Representation in scientific councils and committees

Freya Blekman

- FWO expert panel

Barbara Clerbaux

- Jury FRIA of the Belgian FNRS for the Physics panel

Jorgen D'Hondt

- Belgian representative in Restricted European Committee for Future Accelerators (RECFA)
- Belgian representative in the International Particle Physics Outreach Group (IPPOG)
- Member of the FWO Committee for International Collaboration
- Permanent member of the International Advisory Board of the workshop series
- President of the Jonge Academy of Belgium (Flanders)
- Promotor of the Strategic Research Program

Catherine De Clercq

- Member of the Belgian committee for the selection of CERN fellows
- Member of the FNRS scientific committee 'hautes et basses energies'
- Member of the FWO Interuniversitaire Werkgroep Wetenschap en Technologie
- Member of the board of the BND doctoral school
- Representative of FWO in the ApPEC General Assembly
- Representative of FWO in the CERN Resources Review Board

Gilles De Lentdecker

- Vice-President of the Belgian Physical Society

Laurent Favart

- FNRS delegate to the IOFG (International Oversight and Finance Group) of the IceCube experiment
- Member of the Belgian committee for the selection of CERN fellows
- Member of the board of the BND doctoral school
- Representative of the FNRS at the ApPEC (Astroparticle Physics European Consortium)

Pierre Marage

- Membre titulaire Comité national de Logique, de Philosophie

Nick Van Eijndhoven

- Adviser for the National Research Foundation (NRF), South Africa
- Member (Coordinator for exp. Neutrino Astronomy) Scientific Programme Committee for the International Cosmic Ray Conferences (ICRC)

Catherine Vander Velde

- Chairperson of the ACCU CERN and delegate for Belgium, till 10/3/2014
- Member Commission FNRS-IISN

Pascal Vanlaer

- Representative of the ULB in the CECI interuniversity high-performance computing infrastructure (FUNDP, UCL, ULB, ULg, UMons)

Gaston Wilquet

- FNRS delegate to the OPERA Funding Agencies Board

3.4 Diffusion of scientific results

3.4.1 Oral presentations at conferences and schools

Samir Amary

- IT activities, IIHE Annual Meeting 2014 - Overijse, Belgium 11/09/2014
- Software Introduction, IceCube Boot Camp 2014 - IIHE 16/06/2014

Freya Blekman

- B2G Run 2 preparation, 2nd B2G Run2 Preparation workshop - FNAL, USA from 23/10/2014 to 25/10/2014
- CMS Data Analysis School, CMS Data Anlysis School - Fermilab, USA from 12/01/2014 to 17/01/2014
- CMS Data analysis school, CMS Data analysis school - CERN from 19/01/2014 to 24/01/2014
- CMS Exotica workshop, - CIEMAT, Madrid, Spain from 12/11/2014 to 14/11/2014
- LHC physics and the Top Quark, Advanced Workshop on LHC Physics and Cosmology - Cairo, Egypt from 10/02/2014 to 13/02/2014
- Lessons learned from searches for BSM physics with top as a background, Topical workshop on top quark differential distributions - Cannes, France 20/09/2014
- Searches for BSM in final states with 3rd Generation Particles, 26th Rencontres de Blois on - Blois, France 20/05/2014

Barbara Clerbaux

- Overview of Physics results at CMS, QFPP2014: Questioning Fundamental Physical Principles - CERN, Geneva, Switzerland from 06/05/2014 to 09/05/2014

Nadir Daci

- Dark Matter searches in CMS, Kubec 2014 - Brussels 28/08/2014
- Dark Matter searches in CMS, Kruger 2014 - Kruger Park (South Africa) 09/12/2014

Karen De Causmaecker

- EFT and Automatic Calculation of Anomalous Dimensions in FeynRules, FeynRules workshop - Durham, IPPP 14/07/2014
- Multilepton signatures of GMSB at the LHC, GDR Terascale@Palaiseau - Paris, Ecole Polytechnique 03/06/2014
- Non-minimal flavor violation in supersymmetry, Theory at Sea 2014 - Oostende 15/04/2014

Gilles De Lentdecker

- CMS Muon Upgrades for HL-LHC, ACES Electronics Workshop 2014 - CERN 19/03/2014
- Electronics for Muon upgrades, CMS Upgrade School - DESY 18/11/2014

Krijn De Vries

- IceCube group at IIHE/VUB: AGN/GRB, KUBEC - Brussels 28/08/2014
- On the feasibility of radar detection of high-energy neutrino-induced cascades in ice, ARENA 2014 - Annapolis, United States 11/06/2014
- The EVA code: Macroscopic modeling of radio emission from air showers, LOFAR meeting - Nijmegen, Netherlands 04/02/2014

Hugo Delannoy

- The DarkLight experiment (student project at the 2014 BND School), 2014 BND School - Kerkrade, Netherlands 03/09/2014

Laurent Favart

- Parton Distribution Functions and Low x Physics, Joint Belgian Dutch German Graduate School (BND 2014) - Rolduc Abbey, Kerkrade (NL) from 27/09/2014 to 29/09/2014

Geraldina Golup

- Joint IceCube-Pierre Auger-Telescope Array point source analysis, UHECR 2014 Symposium - Springdale, Utah, USA from 13/10/2014 to 15/10/2014
- Latest results from the IceCube Neutrino Telescope, Vulcano Workshop 2014: Frontier Objects in Astrophysics and Particle Physics - Vulcano, Italy from 18/05/2014 to 24/05/2014
- Search for neutrinos from AGN with the IceCube Observatory, 2nd CosPa Meeting - Ghent, Belgium 12/06/2014

Kael Hanson

- High Energy Neutrino Astronomy at the South Pole, Colloquium - IFAE, Barcelona, Spain 24/03/2014

James Keaveney

- Experimental systematic uncertainties (and object reconstruction) on top physics, TOP 2014 - Mandelieu, France from 29/09/2014 to 03/10/2014

Jan Kunnen

- Looking for Dark Matter in the center of the Earth with IceCube, Astroparticle Physics 2014 - Amsterdam, Netherlands 24/06/2014

Steven Lowette

- Achievements and Prospects of the CMS Experiment at the TeV Energy Scale, General Scientific Meeting of the Belgian Physical Society - Leuven, Belgium 14/05/2014
- Exploring Nature at the Energy Frontier: The BEH Boson Discovery and Beyond, Celebration of 60 years of CERN - Brussels, Belgium 16/12/2014
- Search for Dark Matter at CMS, International Conference on High Energy Physics (ICHEP 2014) - Valencia, Spain 04/07/2014
- Search for Dark Matter at the LHC, Third Meeting of the Belgian CosmoParticle physics network - Liege, Belgium 19/11/2014

Alberto Mariotti

- Gauge Mediation of Exact Scale Breaking, SUSY conference 2014 - Manchester 22/07/2014
- Gauge Mediation of Exact Scale Breaking – Invited Talk, University of Sussex - Brighton 03/02/2014
- Gauge Mediation of Exact Scale Breaking – Invited talk, Mainz Institute for Physics - Mainz 27/05/2014
- The geometry of on shell diagrams – Invited talk, Queen Mary University - London 17/04/2014

Kentarou Mawatari

- CP violation in ttH, CKM2014 - Vienna 11/09/2014
- Effective theory approach in H-boson coupling determination, SM@LHC2014 - Madrid 09/04/2014
- Four-fermion interactions with more than one Majorana particles, FeynRules Workshop - Durham 17/07/2014
- Higgs characterisation in the effective field theory approach, VBF Workshop - Warwick 05/06/2014
- Higgs characterisation via the FeynRules and MadGraph5 aMC@NLO frameworks, MC4BSM2014 - Daejeon 23/05/2014
- Higgs characterisation via the FeynRules and MadGraph5 aMC@NLO frameworks, SUSY2014 - Manchester 21/07/2014

- Is this the Brout-Englert-Higgs boson?, Theory @ sea - Oostende 15/04/2014
- Light gravitino productions at the LHC, ERC LHC-theory meeting - Geneva 17/10/2014
- MadGraph5 aMC@NLO for e+e-, FCC-ee (TLEP) Physics Workshop - Paris 28/10/2014
- MadGraph5 aMC@NLO for linear colliders, ILC Workshop - Grenoble 01/12/2014
- Mono-X signals in light gravitino production, KUBEC dark matter workshop - Brussels 27/08/2014

Thomas Meures

- First data analysis steps for the Askaryan Radio Array stations, ARENA 2014 - Annapolis - USA 12/06/2014

Quentin Python

- Search for Displaced Supersymmetry using the Compact Muon Solenoid Detector, Swiss Physical Society - Fribourg, Switzerland from 30/06/2014 to 02/07/2014

Aidan Randle-conde

- Study of systematic errors on the scalar boson mass, International Workshop on Future Linear Colliders - Belgrade, Serbia 07/10/2014

Thomas Reis

- Search for Massive Resonances in Dilepton Mass Spectra at CMS, BPS meeting - Leuven, BE 28/05/2014
- Search for New Heavy Resonances with Leptons at CMS, PandA doctoral school - Brussels, BE 22/05/2014
- Search for new massive resonances decaying to two charged leptons at CMS, Les Rencontres de Physique de la Vallée d'Aoste - La Thuile, IT from 23/02/2014 to 01/03/2014

Pantelis Tziveloglou

- Flavour Models with Dirac Gauginos, SUSY14 - Manchester 14/07/2014

Nick Van Eijndhoven

- IceCube : Hot Physics with a Cool Experiment, Physics Colloquium - Gent University, Belgium 24/03/2014
- IceCube : Neutrinos from Hell (invited talk), Marie Curie Symposium - Nijmegen, The Netherlands 09/05/2014
- IceCube : The Birth of Neutrino Astronomy, IUAP meeting - Leuven, Belgium 19/12/2014
- IceCube : The Birth of Neutrino Astronomy (invited talk), The Quantum Universe - Groningen, The Netherlands from 16/04/2014 to 17/04/2014

Gerrit Van Onsem

- Search for vector-like T quarks in final states with leptons at CMS, Workshop on vector-like quarks 2014 - DESY, Hamburg, Germany 16/09/2014
- Top-partner searches at the LHC, LPCC workshop: the top-charm frontier at the LHC - CERN, Geneva, Switzerland 14/01/2014

Pascal Vanlaer

- Status of Higgs triggers, CMS Higgs plenary meeting - CERN 19/08/2014

Yifan Yang

- Development of the readout system for LCTPC for the future ILC, Topical Workshop on Electronics for Particle Physics 2014 - Aix En Provence, France from 22/09/2014 to 26/09/2014

3.4.2 Poster presentations at conferences and schools

Cécile Caillol

- Hadronic tau identification at CMS, ESHEP14 - Garderen, The Netherlands from 18/06/2014 to 01/07/2014

Gilles De Lentdecker

- Development of the data acquisition system for the Triple-GEM detectors for the upgrade of the CMS forward muon spectrometer, TWEPP2014 - Aix-en-Provence 22/09/2014

Krijn De Vries

- A Bayesian approach for counting experiment statistics applied to a neutrino point source analysis, Neutrino 2014 - Boston, United States 03/06/2014

James Keaveney

- Search for Standard Model production of four top quarks with CMS, TOP 2014 - Mandelieu, France from 29/09/2014 to 03/10/2014

Luca Pernie

- ZZ cross-section mea- surement and limits on anomalous neutral triple gauge couplings at the CMS detector., LHCP - New York from 02/06/2014 to 06/06/2014

Thomas Reis

- Search for new Massive Resonances in Dilepton Mass Spectra in pp Collisions at $\sqrt{s} = 8$ TeV with CMS, LHCC meeting - CERN, CH 05/03/2014
- Search for new Resonances in Dielectron and Dimuon Mass Spectra at $\sqrt{s} = 8$ TeV with CMS, ICHEP 2014 - Valencia, ES from 02/07/2014 to 09/07/2014

Yifan Yang

- Development of a multi-points wireless temperature monitoring system for optohybrid for CMS GEM project, Topical Workshop on Electronics for Particle Physics 2014 - Aix En Provence, France from 22/09/2014 to 26/09/2014
- Development of the Readout System for Triple-GEM Detectors for the CMS Forward Muon Upgrade, 19th real-time conference - Nara, Japan from 26/05/2014 to 30/05/2014

3.5 Scientific training

3.5.1 Attendance to conferences and workshops

Shimaa Abu Zeid

- Flavor Changing Neutral Current (FCNC) of Top Quark - 1st Workshop - Strasbourg - France from 02/02/2014 to 03/02/2014
- Flavor Changing Neutral Current (FCNC) of Top Quark - 2nd Workshop - Brussels - Belgium from 04/05/2014 to 05/05/2014
- TOP2014 - The 7th International Workshop on Top Quark Physics - Cannes - France from 29/09/2014 to 03/10/2014

Samir Amary

- 17th Quattor Workshop - Amsterdam, Netherlands from 17/03/2014 to 19/03/2014
- 18th Quattor Workshop - Madrid, Spain from 30/09/2014 to 02/10/2014

Freya Blekman

- Attendant & discussion session leader - Rencontres de Moriond EW 2014 - La Thuile from 15/03/2014 to 22/03/2014
- CMS Collaboration week - Miami from 15/12/2014 to 19/12/2014
- Invited expert, session convener & discussion session leader - Rencontres de Vietnam: Physics at the LHC and Beyond - Quy Nhon, Vietnam from 10/08/2014 to 17/08/2014
- TOP2014 - 7th International Workshop on Top-Quark Physics - Cannes-Mandelieu, France from 28/09/2014 to 03/10/2014

Abdelhakim Boukil

- Belnet IPv6 Workshop - Brussels, Belgium from 20/02/2014 to 21/02/2014
- CERN visit with BA3 students - Cern, Geneva from 25/03/2014 to 27/03/2014

Cécile Caillol

- La Thuile 2014 - La Thuile, Italy from 23/02/2014 to 01/03/2014

Barbara Clerbaux

- CMS EXOTICA Workshop - Madrid, Spain from 11/11/2014 to 14/11/2014
- JUNO-Euope Workshop - Milan, Italy 09/07/2014
- Scalar Search and Study in Belgium - Brussels, Belgium from 23/01/2014 to 24/01/2014
- Workshop on electronics - Aachen 20/10/2014
- Z' search workshop - CERN 03/10/2014

Nadir Daci

- CMS Trigger Studies Group - Trigger Workshop - Brussels from 26/05/2014 to 29/05/2014

Isabelle De Bruyn

- 2nd CosPa Meeting - Gent 12/06/2014
- 3rd CosPa Meeting - Liège 19/11/2014
- CMS Physics Week - CERN from 13/10/2014 to 17/10/2014
- Dark Matter @ LHC - Oxford from 25/09/2014 to 27/09/2014
- General Scientific Meeting 2014 of the Belgian Physical Society - KU Leuven 28/05/2014
- IAP meeting - KU Leuven 19/12/2014
- Monojet miniworkshop - CERN 14/10/2014

Karen De Causmaecker

- EFT in FeynRules - FeynRules workshop - Durham, IPPP from 14/07/2014 to 18/07/2014
- GDR Terascale@Palaiseau - Ecole Polytechnique, Paris from 02/06/2014 to 04/06/2014
- Recasting LHC analyses using MadAnalysis5 - Mini-workshop MadAnalysis 5 - LPSC Grenoble from 08/09/2014 to 12/09/2014
- Theoretical physics in Flanders - Theory at Sea - Oostende from 14/04/2014 to 15/04/2014

Catherine De Clercq

- Dark Matter - Third CosPa meeting - University of Liège, Belgium 19/11/2014

Gilles De Lentdecker

- CMS GEM project - 9th CMS GEM Workshop - CERN from 14/07/2014 to 18/07/2014
- CMS GEM project - 8th CMS GEM Workshop - CERN from 24/03/2014 to 28/03/2014
- Fourth Common ATLAS CMS Electronics Workshop for LHC Upgrades - ACES 2014 - CERN from 18/03/2014 to 20/03/2014
- Topical Workshop on Electronics for particle Physics - TWEPP 2014 - Aix-en-Provence from 22/09/2014 to 26/09/2014

Krijn De Vries

- ARENA 2014 conference - Annapolis, United States from 09/06/2014 to 12/12/2014
- IceCube collaboration meeting - Geneva, Switzerland from 14/09/2014 to 19/12/2014
- IceCube collaboration meeting - Banff, Canada from 02/03/2014 to 08/12/2014
- Neutrino 2014 conference - Boston, United States from 02/06/2014 to 07/12/2014

Kevin Deroover

- FCNC workshop I - Strasbourg, France from 03/02/2014 to 04/02/2014
- FCNC workshop II - Brussels, Belgium from 04/06/2014 to 05/06/2014
- TOP 2014 - Cannes, France from 28/09/2014 to 03/10/2014

Geraldina Golup

- UHECR 2014 Symposium - UHECR 2014 Symposium - Springdale, Utah, USA from 13/10/2014 to 15/10/2014
- Vulcano Workshop 2014: Frontier Objects in Astrophysics and Particle Physics - Vulcano Workshop 2014: Frontier Objects in Astrophysics and Particle Physics - Vulcano, Italy from 18/05/2014 to 24/05/2014

Stéphane Gérard

- Big Data & Open Data - Big Data & Open Data Workshop (ERF-AISBL) - Brussels from 07/05/2014 to 08/05/2014
- Grid and HPC computing - Cloud - EGI Community Forum - Helsinki from 19/05/2014 to 23/05/2014

James Keaveney

- Pre TOP 2014 topical workshop - Pre TOP 2014 topical workshop - Mandelieu, France from 26/09/2014 to 28/09/2014

Jan Kunnen

- Astroparticle Physics - Astroparticle Physics 2014 - Amsterdam, Netherlands from 23/06/2014 to 28/06/2014

Giuliano Maggi

- Fall IceCube collaboration meeting - CERN, Geneva, Switzerland. from 14/09/2014 to 19/09/2014
- Spring IceCube collaboration meeting - Banff, Canada. from 02/03/2014 to 08/03/2014

Alberto Mariotti

- Dark Matter - Third CosPa Meeting - Liege University 19/11/2014
- Formal aspects of supersymmetric gauge theories - Gauge theories: quivers, tilings and Calabi-Yaus - Edinburgh – International Center for Mathematical science from 12/05/2014 to 16/05/2014
- Formal aspects of supersymmetric gauge theories - Grassmannian Geometry of Scattering Amplitudes - Caltech – California from 08/12/2014 to 12/12/2014

Kentarou Mawatari

- Higgs characterisation - Higgs couplings 2014 - Torino 30/09/2014

Thomas Meures

- ARA collaboration meeting - ARA collaboration meeting - Maryland University from 13/06/2014 to 14/06/2014
- Future experiments for neutrino detection - ARENA 2014 - Annapolis from 09/06/2014 to 12/06/2014

Lieselotte Moreels

- Belgian Physical Society meeting - BPS - Leuven, Belgium 28/05/2014
- GIT tutorial - CERN, Switzerland 10/01/2014
- Top quark physics - TOP2014 - Cannes-Mandelieu, France from 28/09/2014 to 03/10/2014

Elisa Pinat

- Technology and Instrumentation - TIPP2014, International Conference on Technology and Instrumentation in Particle Physics - Amsterdam from 02/06/2014 to 06/06/2014

Quentin Python

- CMS Exotica Workshop at CIEMAT - CMS Exotica Workshop - Madrid, Spain from 12/11/2014 to 14/11/2014

Thomas Reis

- 37th International Conference on High Energy Physics - Valencia, ES from 02/07/2014 to 09/07/2014
- General Scientific Meeting of the Belgian Physical Society 2014 - Leuven, BE 28/05/2014
- Results and Perspectives in Particle Physics - Les Rencontres de Physique de la Vallée d'Aoste - La Thuile, IT from 23/02/2014 to 01/03/2014

Stefaan Tavernier

- A Compact Detector Module for Time of Flight PET and the Associated DAQ system - IEEE NSS-MIC conference - Seattle, United States 15/11/2014
- Asymmetric Data Acquisition System for an Endoscopic PET-US Scanner - 19th real time conference - Nara, Japan from 26/03/2014 to 30/03/2014
- Performance Evaluation of a PET/MR Detector Based on the ClearPEM Technology - IEEE NSS-MIC conference - Seattle, United States 15/11/2014

Petra Van Mulders

- On average 2 travels of a few days to one of the member universities of the SoLid collaboration - UK, France, Belgium 2014
- On average 10 travels of 2 to 5 days per year to CERN for meetings and discussions - CERN, Geneva, Switzerland 2014

Gerrit Van Onsem

- The top-charm frontier at the LHC - LPCC workshop: the top-charm frontier at the LHC - CERN, Geneva, Switzerland from 13/01/2014 to 17/01/2014
- Top quark physics - 7th International Workshop on Top Quark Physics (TOP 2014) - Cannes, France from 29/09/2014 to 03/10/2014

Isis Van Parijs

- Belgian Physical Society meeting - BPS - Leuven 28/05/2014
- CMS data analysis school - CMS DAS - CERN from 13/01/2014 to 18/01/2014
- FCNC workshop - Strassbourg from 03/02/2014 to 04/02/2014

- FCNC workshop - Brussels from 04/06/2014 to 05/06/2014
- Git tutorial at CERN - CERN 10/01/2014
- Top quark physics - TOP2014 - Cannes-Mandelieu from 28/09/2014 to 03/10/2014

Pascal Vanlaer

- Brout-Englert-Higgs boson studies - Higgs Couplings 2014 - Torino from 01/10/2014 to 03/10/2014

Matthias Vereecken

- CosmoParticle physics in Belgium - Cospa meeting - ULg 19/11/2014

Gaston Wilquet

- Neutrino Oscillation Wokshop NOW - Neutrino Oscillation Wokshop NOW - Otrento, Italy from 07/09/2014 to 14/09/2014

Ryo Yonamine

- Analytic Examination of Spatial Resolution with Binary Readout - GEM Workshop IX - CERN from 14/07/2014 to 18/07/2014

3.5.2 Attendance to schools

Shimaa Abu Zeid

- BND School - Belgian Dutch German graduate school in particle physics - Kerkrade - Netherlands from 25/08/2014 to 05/09/2014
- CMS Data Analysis School - CERN - Geneva from 13/01/2014 to 18/01/2014

Lionel Brayeur

- Machine Learning Algorithm - Dortmund, Germany from 29/09/2014 to 02/10/2014

Cécile Caillol

- ESHEP14 - Garderen, The Netherlands from 18/06/2014 to 01/07/2014

Isabelle De Bruyn

- CMS data analysis school - CERN from 13/01/2014 to 18/01/2014
- Git tutorial at CERN - CERN 10/01/2014
- Joint Belgian Dutch German Graduate School (BND school) - Rolduc, The Netherlands from 25/08/2014 to 05/09/2014

Karen De Causmaecker

- More than Higgs – Effective Theories for Particle Physics - PSI Zuoz Summerschool - Zuoz from 17/08/2014 to 23/08/2014

Hugo Delannoy

- Joint Belgian Dutch German Graduate School (BND 2014) - Kerkrade, Netherlands from 25/08/2014 to 05/09/2014

Kevin Deroover

- CMS Data Analysis SChool - CERN (Geneva, Switzerland) from 13/01/2014 to 18/01/2014
- Joint Belgian Dutch German Graduate School - Kerkrade, Netherlands from 25/08/2014 to 05/09/2014

Geraldina Golup

- CORSIKA School 2014 - CORSIKA School 2014 - Lauterbad Freudenstadt, Germany from 19/10/2014 to 23/10/2014

Giuliano Maggi

- Corsika school 2014 - Freudenstadt-Lauterbad, Germany from 19/10/2014 to 23/10/2014

Lieselotte Moreels

- CMS Data Analysis School - CMSDAS - CERN, Switzerland from 12/01/2014 to 18/01/2014
- Strong interactions - BND school - Rolduc, the Netherlands from 25/08/2014 to 05/09/2014

Elisa Pinat

- Cosmic Ray Astrophysics - ISCRA, International School on Cosmic Ray Astrophysics - Erice, Italy from 04/07/2014 to 11/07/2014
- IceCube training - IceCube European BootCamp - Brussels from 16/06/2014 to 20/06/2014

Quentin Python

- BND School, QCD - BND School - Rolduc, Netherlands from 25/08/2014 to 05/09/2014

Aidan Randle-conde

- CMS Data Analysis School - CERN, Geneva, Switzerland from 13/01/2014 to 18/01/2014

Thomas Reis

- PandA doctoral school - Brussels, BE 22/05/2014

Florian Zenoni

- International school of trigger and data acquisition 2014 - Budapest, Hungary from 28/01/2014 to 05/02/2014
- Science Communication Society 2014 - La Morra, Italy from 07/09/2014 to 12/09/2014

3.5.3 Invited seminars at the IIHE

- **Prof. Johanna Stachel**
  14 Feb - *IIHE invited seminar: Exploring the QCD phase diagram at the LHC with ALICE*
- **Prof. Rupert Leitner**
  21 Feb - *IIHE invited seminar: Neutrino oscillations and the Daya Bay experiment*
- **Dr. Sarah Malik**
  07 Mar - *IIHE invited seminar: Shedding light on Dark Matter at CMS*
- **Prof. Pilar Hernandez**
  28 Mar - *IIHE invited seminar: Outlook in Neutrino Physics*
- **Prof. Jo van den Brand**
  04 Apr - *IIHE invited seminar: Advanced Virgo: Probing the dynamics of spacetime*
- **Dr. Didier Contardo**
  11 Apr - *IIHE invited seminar: The CMS Experiment Upgrades for the High Luminosity LHC*
- **Dr. Jian Wang**
  14 May - *IIHE invited seminar: BEH boson width using CMS h-¿ZZ events*
- **Dr. Christian Schwanenberger**
  27 May - *IIHE invited seminar: Single top quarks at the Tevatron and observation of the s-channel production mode*

- **Prof. Fabrizio Palla**
  03 Jun - *IIHE topical seminar: Challenges and opportunities for a First Level Trigger based on Silicon Trackers for the High Luminosity LHC*
- **Dr. Max Baak**
  06 Jun - *IIHE invited seminar: The global electroweak fit: status and prospects*
- **Prof. Xiaoshan Jiang**
  13 Jun - *IIHE invited seminar: The introduction of JUNO experiment and the status of its electronics*
- **Dr. Moritz McGarrie**
  04 Jul - *IIHE topical seminar: Natural SUSY and the 125.5 GeV Higgs*
- **Dr. Mark Dierckxens**
  10 Oct - *IIHE invited seminar: Space Weather and Solar Energetic Particles*
- **Prof. Jun Cao**
  22 Oct - *JUNO: A Multi-purpose Neutrino Observatory*
- **Prof. Christine Davies**
  31 Oct - *IIHE invited seminar: Stress-testing the Standard Model with lattice QCD*
- **Prof. Claude Duhr**
  14 Nov - *IIHE topical seminar: Towards gluon-fusion at N3LO*
- **Prof. Joerg Jaeckel**
  05 Dec - *IIHE invited seminar: WISPy Cold Dark Matter (note unusual time due to emeriti symposium in afternoon)*
- **Dr. Kevin Meagher**
  08 Dec - *IIHE topical seminar: Observations of the Crab Nebula with VERITAS and the Cherenkov Telescope Array*

3.6 Teaching and academic activities

3.6.1 Teaching activities

Freya Blekman

- VUB - IR-BIO-6763 : Measurement Techniques in Nuclear Science, (20/0/0/40) MA1 MA2 Optional course for students in the Master Biomedical Engineering
- VUB - WE-DNTK-7136 : Simulation of Physics Phenomena and Detectors in Modern Physics, (15/25/10/20) MA1 MA2 Course preparing students for their masters project, combining simulation/computing with physics to

Lionel Brayeur

- VUB - 4016549FNR : Muon Lab, (0/0/16/2) MA1

Cécile Caillol

- ULB - PHYS-F101 : Physique générale I et II, (0/36/0/0) BA1 Bachelier en sciences mathématiques

Barbara Clerbaux

- ULB - PHYS-F416 : Interactions fondamentales et particules, (36/12/12/0) MA1
- ULB - PHYS-F312 : Laboratoire de physique des particules + Visite annuelle du CERN, (0/0/36/24) BA3
- ULB - PHYS-F310 : Stage dans un service du département, (0/0/0/36) BA3

Isabelle De Bruyn

- VUB - WE-DNTK-006317 : Fysica: trillingen, golven en thermodynamica, (0/0/34/30) BA1

Karen De Causmaecker

- VUB - 1015238ANR : Fysica: trillingen, golven en thermodynamica, (0/36/0/0) BA1

Catherine De Clercq

- VUB - WE-DNTK-12521 : Astro-particle physics, (13/13/0/0) MA2
- VUB - WE-DNTK-14101 : Experimentele fysica, (0/0/78/0) BA1
- VUB - WE-DNTK-14089a : Fysica:trillingen, golven, thermodynamica, (0/0/78/0) BA1
- VUB - WE-DNTK-13971a : Mobiliteit A, (0/0/0/26) MA2

Gilles De Lentdecker

- ULB - PHYS-F314 : Electronics, (12/6/18/0) BA3 Introduction to electronics
- ULB - PHYS-F205 : General Physics II, (0/12/0/0) BA2 Exercices of electromagnetism for Biologists
- ULB - PHYS-F312 : Particle Physics Laboratory, (0/0/36/0) BA3 Laboratory in Particle Physics

Krijn De Vries

- VUB - WE-DNTK-... : Fysica: inleiding mechanica, (0/28/0/0) BA1

Hugo Delannoy

- ULB - PHYS-F-104 : Physique I (mécanique, ondes et optique), (0/48/0/0) BA1 GEOL, BIOL2
- ULB - PHYS-F-110 : Physique générale I et II, (0/84/12/0) BA1 CHIM1-POLY, CHIM2

Kevin Deroover

- VUB - WE-DNTK-1001388CNR : Experimentele stralings- en kwantumfysica, (0/0/48/40) BA2
- VUB - WE-DNTK-1010221BNR : Statistische verwerking van experimentele gegevens, (0/0/0/4) BA2

Olivier Devroede

- VUB - WE-DNTK-14101 : Experimentele Fysica, (0/12/0/0) BA1 First Matlab Course
- VUB - 4015950FNR : Object Oriented Programming (C++) for Physicists, (12/12/12/60) MA1 MA2

Laurent Favart

- ULB - PHYS-F305 : Introduction à la Physique des Particules, (24/0/0/0) BA3 Physique
- ULB - PHYS-F102 : Laboratoires de Physique générale I et II, (0/0/36/0) BA1 Physique

James Keaveney

- VUB - 1015267BNR : Statistische fysica, (2/0/0/3) BA3 Problem solving sessions

Jan Kunnen

- VUB - 1015265ANR : Experimentele fysica, (0/0/64/64) BA1 introductory labs for physics students

Steven Lowette

- VUB - 4015948FNR : Experimental Techniques in Particle Physics, (32/20/0/99) MA1 MA2
- VUB - 4012730CNR : Extensions of the Standard Model, (36/0/0/99) MA1 MA2
- VUB - 4015029ENR : External Mobility B, (0/0/0/99) MA2

Pierre Marage

- ULB - HIST-F-101 : Histoire des Sciences, (24/0/0/0) BA1

- ULB - HIST-F-500 : Histoire des Sciences et Epistémologie, (24/0/0/0) MA2

Lieselotte Moreels

- VUB - WE-DNTK-1001388CNR : Experimentele stralings- en kwantumfysica, (0/0/48/48) BA2 Lab sessions in which the students prepare and perform some of the basic experiments related to radi
- VUB - WE-DNTK-1010221BNR : Statische verwerking van experimentele gegevens, (0/10/0/15) BA2 Introduction to statistical concepts concerning data analysis

Elisa Pinat

- ULB - PHYS-F-311 : Laboratoire Rayonnement, (0/0/80/16) BA3

Aidan Randle-conde

- ULB - PHYS-F-416 : AFB measurement of CMS data, (3/0/9/0) MA2 Calculation and analysis of the forward-backqard asymmetry for dielectrons at CMS

Thomas Reis

- ULB - PHYS - F312 : Laboratoire de physique des particules, (0/0/60/1) BA3 Cherenkov radiation

Nick Van Eijndhoven

- VUB - WE-DNTK-6406 : Experimental Study of the Micro and Macrocosmos, (13/13/0/0) BA3
- VUB - WE-DNTK-6331 : Subatomic Physics I : Introduction to Nuclear and Particle Physics, (26/26/0/0) BA3

Petra Van Mulders

- VUB - 1010183ANR : WPO Mechanica, (0/22/0/22) BA1

Gerrit Van Onsem

- VUB - 004136 : Inleiding tot de Kwantumfysica, (0/26/0/26) BA2

Isis Van Parijs

- VUB - WE-DNTK-14094 : Fysica: elektromagnetisme, (0/36/0/72) BA2

Catherine Vander Velde

- ULB - XXX : Coordinatrice Objectif réussite - physique, (0/0/0/12) BA1 toutes sections
- ULB - PHYS-F-416 : Interactions fondamentales et particules, (18/0/0/0) MA1 physique
- Other - XXX : Introduction to Particle Physics, (18/6/0/0) BA3 MA1 MA2 Physics at Beijing University

Pascal Vanlaer

- ULB - PHYS-F420 : Détection de particules, acquisition et analyse de données, (12/0/24/0) MA1 MA2 Physique
- ULB - PHYS-F102 : Laboratoires de Physique Générale, (0/0/42/0) BA1 Physique, Chimie, Année polyvalente
- ULB - PHYS-F104 : Physique 1, (72/0/0/0) BA1 Biologie, Géographie, Géologie
- ULB - PHYS-F205 : Physique 2: Electricité et magnétisme, (24/0/0/0) BA2 Biologie, Géographie, Géologie

Matthias Vereecken

- VUB - 004134 : Elektrodynamica en speciale relativiteit, (0/26/0/0) BA2

Florian Zenoni

- ULB - PHYS-F-312 : Laboratoire de physique des particules, (2/0/70/10) BA3

3.6.2 Membership to academic juries of Master and Phd theses

Freya Blekman

- Phd thesis - VUB, August 2014 - Federico Galli : Applications of the AdS/CFT correspondence to non-equilibrium physics at strong coupling
  Secretary
- Phd thesis - UGent/VUB, July 2014 - Nele Callebaut : Background field and time dependence effects in holographic models
  Secretary
- Phd thesis - IPNL (Lyon), June 2014 - Sébastien Brochet : Recherche de physique au-delà du Modèle Standard dans le secteur du quark top et calibration de l'échelle en énergie des jets avec l'expérience CMS du LHC
  Referee
- Phd thesis - Lund University, December 2014 - Anthony Hawkins : Search for anomalous production of prompt same-sign lepton pairs and doubly charged Higgs bosons with the ATLAS detector
  Referee
- Phd thesis - VUB, January 2014 - Alexis Kalogeropoulos : Search for direct stop quark pair production at the LHC with the CMS experiment
  Referee
- Phd thesis - ULB, October 2014 - Laurent Thomas : Search for new heavy narrow resonances decaying into a dielectron pair with the CMS detector
  Referee
- Phd thesis - VUB, May 2014 - Gerrit Van Onsem : Search for new heavy quarks with the CMS detector at the Large Hadron Collider
  Secretary

Barbara Clerbaux

- Phd thesis - ULB, December 2014 - Tiziana Scarna : Gamma-Ray Lines from the Dark Side of Matter December 2014
  Secretary
- Phd thesis - Université de Montpellier 2, France, November 2014 - Michael Ughetto : Recherche de production électrofaible supersymétrique dans des cascades de désintégration contenant un boson de Higgs avec le détecteur ATLAS au LHC
  Referee

Catherine De Clercq

- Phd thesis - Vrije Universiteit Brussel, July 2014 - Bettina Oexl : Gravitino production at colliders
  President
- Phd thesis - Université de Mons, June 2014 - Isabelle Ansseau : Recherche de neutrinos d'une masse d'un TeV provenant de l'annihilation de matière noire au centre de la terre avec IceCube
  Referee

Gilles De Lentdecker

- Phd thesis - ULB, December 2014 - Thomas MEURES : Development of a sub-glacial array of radio antennas for the detection of the flux of GZK neutrinos
  Secretary
- Phd thesis - ULB, October 2014 - Laurent THOMAS : Search for new heavy narrow resonances decaying into an dielectron pair with the CMS detector
  Secretary

Steven Lowette

- Phd thesis - VUB, July 2014 - Bettina Oexl : Gravitino Production at Colliders
  Secretary
- Phd thesis - VUB, January 2014 - Alexis Kalogeropoulos : Search for Direct Stop Quark Pair Production at the LHC with the CMS Experiment
  Referee
- Phd thesis - VUB, June 2014 - Laurent Annaert : Stability of the MSSM scalar potential and false vacuum decay
  Referee
- Phd thesis - VUB, June 2014 - Bert Verbruggen : Study of the modelling of top quark events with the CMS experiment
  Referee
- Phd thesis - VUB, June 2014 - Jens Convents : Temporal analysis of spatial coherence in pulsed broad-area vertical-cavity surface-emitting lasers
  Referee

Kentarou Mawatari

- Phd thesis - Vrije Universiteit Brussel, July 2014 - Bettina Oexl : Gravitino production at colliders
  Referee
- Phd thesis - Vrije Universiteit Brussel, June 2014 - Bert Verbruggen : Study of the modeling of top quark events at the CMS experiment
  Referee

Nick Van Eijndhoven

- Phd thesis - VUB, January 2014 - Alexis Kalogeropoulos : Sear for direct stop quark pair production at the LHC with the CMS experiment
  President

3.6.3 Representation in academic councils and committees

Freya Blekman

- IIHE website coordinator, Other
- PR responsible Physics department, VUB
- Secretary Bachelors Exam Committee, VUB
- Secretary Masters Exam Committee, VUB
- Seminar organiser IIHE, Other

Barbara Clerbaux

- Laureator for the Doctor Honoris Causa awarded by the ULB to P.W. Higgs, June 27-29th, 2014, Edinburgh, ULB
- Membre de la commission pédagogique facultaire, ULB
- Vice-presidence of the Physics Department, ULB

Jorgen D'Hondt

- Chairperson of the Education Committee of the Faculty of Science, VUB
- Chairperson of the Legal Appeal Committee of the Faculty of Science, VUB
- Chairperson of the Selection Committee for new assistant hirings in the Department of Physics, VUB
- Delegate of the Faculty of Science in the Education Council of the VUB, VUB

- Member of the Gender Committee of the Faculty of Science, VUB
- President of the Physics Department, VUB

Catherine De Clercq

- Chair of the Womens council of VUB, VUB
- Chair of the examination committee of the Master in Physics and Astronomy, VUB
- DNTK member of the Commissie Middelen en Personeel of the Science faculty, VUB
- Member of the Gender committee of the Science Faculty, VUB
- Member of the examination committee of the Bachelor in Physics and Astronomy, VUB
- Member of the working group on the new physics practicals, VUB
- chair of the selection committee of seven 0.10FTE professors in the physics department, VUB
- member of the selection committee of a full-time ZAP at UGent, Other

Gilles De Lentdecker

- Membre de la commission enseignement du d'epartement de physique, ULB

Laurent Favart

- Secretary of the Doctorate Committee, ULB
- ULB - President of the Jury for the Admission in MA in Physics - until Sept. 2014, ULB
- ULB - President of the Jury for the Master in Physics - until Sept. 2014, ULB

Steven Lowette

- Afgevaardigde DNTK in facultaire doctoraatscommissie, VUB
- Lid van de examencommissie Master, VUB
- Verantwoordeljke internationalisering DNTK, VUB

Pierre Marage

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

Nick Van Eijndhoven

- Astroparticle Physics coordinator within the High-Energy Physics strategic research programme, VUB
- Chair of the Physics and Astronomy curriculum board, VUB
- Committee member c.q. Physics and Astronomy contact person for plagiarism control, VUB
- Coordinator of the follow up programme concerning the educational audit, VUB
- Member of the Advisory Board of the VUB Physics department, VUB
- Member of the Education Board of the VUB Faculty of Science, VUB

- Member of the evaluation board for the VUB institutional review, VUB

Gerrit Van Onsem

- Opleidingsraad fysica (education council physics); representing VUB alumni, VUB

Catherine Vander Velde

- Membre - Observatoire de BA1, jusqu'au 30/9/2014, ULB
- Membre - jury de l'examen d'admission à l'université, ULB
- Présidente du jury du BAC en physique et de sa commission d'admission, jusqu'au 30/9/2014, ULB

Pascal Vanlaer

- Coordinator of the Physics department in the AEQES higher-education quality assessment process in the French community, ULB
- President of the users committee of the ULB-VUB computing center, ULB

3.7 Vulgarisation and outreach

Freya Blekman

- CERN visit VUB students - CERN - 18/02/2014
- Coordination Open days VUB/Physics - VUB - 15/02/2014
- Coordination Open days VUB/Physics - VUB - 27/04/2014
- Coordination Open days VUB/Physics - VUB - 22/03/2014
- Hangout with CERN: Youtube ask-a-scientist (organisation & on-screen) - Youtube - 08/07/2014
- Hangout with CERN: Youtube ask-a-scientist (organisation & on-screen) - Youtube - 19/06/2014
- School visit KA Ninove - VUB - 07/01/2014
- TEDxCERN streaming at VUB - VUB - 24/09/2014
- VUB Responsible Flemish Physics Olympiad - Leuven - 26/04/2014
- VUB Responsible Flemish Physics Olympiad - VUB - 19/02/2014
- VUB Responsible Flemish Physics Olympiad - VUB - 29/03/2014

Cécile Caillol

- CERN60 exhibition - Palais des Académies, Brussels - 18/12/2014

Barbara Clerbaux

- CERN visit with Francois Englert - CERN - 23/02/2014
- Conférence : Le boson de Brout-Englert-Higgs : de sa prédicIon en 1964 à sa découverte au CERN en 2012 - Charleroi - 25/11/2014
- Conférence : Le fameux Boson de Brout-Englert-Higgs : sa récente découverte au LHC du CERN - Braine-le-Comte - 04/11/2014
- Conférence : Recherche et découverte du boson de Brout-Englert-Higgs au LHC du CERN - La Louvière, Belgium - 26/02/2014
- Masterclass 2014 - Brussels - 29/03/2014
- Organisation of the exhibition : 60 years of science for peace - Palais des Académies, Brussels - 16/12/2014

Jorgen D'Hondt

- Annual prize from the VUB on - VUB - 2014

Nadir Daci

- CMS Masterclasses - Brussels - 29/03/2014

Isabelle De Bruyn

- Visit of CERN and CMS by Urania - CERN - CMS - 20/09/2014

Catherine De Clercq

- IceCube Masterclass coordinator - IIHE(ULB-VUB), Brussels - 21/05/2014
- coordination of the making of a 5-min animation movie on IceCube in 6 languages - Brussels - 31/12/2014
- projection and public discussion of the IceCube dome movie 'Chasing the Ghost particle' - Planetarium, Brussels - 17/10/2014
- talk: IceCube, neutrino's uit de kosmos gevangen in het ijs, en de link naar donkere materie - VVS Capella, Hoegaarden, Belgium - 04/11/2014
- talk given: IceCube: neutrino's uit de ruimte gevangen in het ijs - Meeting of the Belgian Senate, Brussels - 13/03/2014

Gilles De Lentdecker

- Master Class of Particle Physics - IIHE - 29/03/2014

Krijn De Vries

- IceCube high-school campus visit - Brussels - 18/03/2014
- IceCube masterclass - Brussels - 21/05/2014

James Keaveney

- Panel discsussion on particle physics - Dublin, Ireland - 13/11/2014

Steven Lowette

- Campusbezoek secundaire school: workshop LHC - VUB - 10/02/2014
- Campusbezoek secundaire school: workshop LHC - VUB - 27/02/2014
- Campusbezoek secundaire school: workshop LHC - VUB - 11/03/2014
- Public lecture: - Turnhout, Belgium - 18/11/2014
- VUB Herfstkamp: workshop LHC - VUB - 27/10/2014

Elisa Pinat

- IceCube Masterclasses - Brussels, Belgium - 21/05/2014

Aidan Randle-conde

- Comedy Collider - CERN, Geneva, Swizterland - 13/06/2014

Nick Van Eijndhoven

- Various campus visits, workshops and autumn camp - VUB (throughout the year) - 27/10/2014

Petra Van Mulders

- Multiple interviews in the written press as well as for the national radio broadcasting channel after my selection as convener of the b-jet identification group in the CMS collaboration - Brussels - 2014

Isis Van Parijs

- Information about studying physics at the VUB - Sint Donatusinstituut, Merchtem - 09/05/2014

Catherine Vander Velde

- Highlights of Belgian Contributions to CERN - Palais des Académies, Bruxelles (60th years CERN) - 16/12/2014
- La Recherche du Boson de Brout, Englert et Higgs au LHC - Institut des Hautes Etudes de Belgique (IHEB), ULB - 18/02/2014

Pascal Vanlaer

- Forum du journal Le Soir - http://studioweb.lesoir.be/sciences/ - 2014

4 Publications

4.1 Refereed journals and conference proceedings

4.1.1 CMS

1. *Alignment of the CMS tracker with LHC and cosmic ray data*
   S. Chatrchyan *et al.* [CMS Collaboration]
   JINST **9** (2014) P06009

2. *Constraints on the Higgs boson width from off-shell production and decay to Z-boson pairs*
   V. Khachatryan *et al.* [CMS Collaboration]
   Phys. Lett. B **736** (2014) 64

3. *Description and performance of track and primary-vertex reconstruction with the CMS tracker*
   S. Chatrchyan *et al.* [CMS Collaboration]
   JINST **9** (2014) 10, P10009

4. *Determination of the top-quark pole mass and strong coupling constant from the t t-bar production cross section in pp collisions at* $\sqrt{s}$ *= 7 TeV*
   S. Chatrchyan *et al.* [CMS Collaboration]
   Phys. Lett. B **728** (2014) 496

5. *Event activity dependence of Y(nS) production in* $\sqrt{s_{NN}}$*=5.02 TeV pPb and* $\sqrt{s}$*=2.76 TeV pp collisions*
   S. Chatrchyan *et al.* [CMS Collaboration]
   JHEP **1404** (2014) 103

6. *Evidence for the 125 GeV Higgs boson decaying to a pair of* τ *leptons*
   S. Chatrchyan *et al.* [CMS Collaboration]
   JHEP **1405** (2014) 104

7. *Evidence for the direct decay of the 125 GeV Higgs boson to fermions*
   S. Chatrchyan *et al.* [CMS Collaboration]
   Nature Phys. **10** (2014) 557

8. *Evidence of b-Jet Quenching in PbPb Collisions at* $\sqrt{s_{NN}} = 2.76\,TeV$
   S. Chatrchyan *et al.* [CMS Collaboration]
   Phys. Rev. Lett. **113** (2014) 13, 132301

9. *Identification techniques for highly boosted W bosons that decay into hadrons*
   V. Khachatryan *et al.* [CMS Collaboration]
   JHEP **1412** (2014) 017

10. *Inclusive search for a vector-like T quark with charge* $\frac{2}{3}$ *in pp collisions at* $\sqrt{s}$ *= 8 TeV*
    S. Chatrchyan *et al.* [CMS Collaboration]
    Phys. Lett. B **729** (2014) 149

11. *Measurement of associated W + charm production in pp collisions at* $\sqrt{s}$ *= 7 TeV*
    S. Chatrchyan *et al.* [CMS Collaboration]
    JHEP **1402** (2014) 013

12. *Measurement of differential cross sections for the production of a pair of isolated photons in pp collisions at* $\sqrt{s} = 7\,TeV$
S. Chatrchyan *et al.* [CMS Collaboration]
Eur. Phys. J. C **74** (2014) 11, 3129

13. *Measurement of four-jet production in proton-proton collisions at* $\sqrt{s} = 7\,TeV$
S. Chatrchyan *et al.* [CMS Collaboration]
Phys. Rev. D **89** (2014) 9, 092010

14. *Measurement of Higgs boson production and properties in the WW decay channel with leptonic final states*
S. Chatrchyan *et al.* [CMS Collaboration]
JHEP **1401** (2014) 096

15. *Measurement of higher-order harmonic azimuthal anisotropy in PbPb collisions at* $\sqrt{s_{NN}}$ *= 2.76 TeV*
S. Chatrchyan *et al.* [CMS Collaboration]
Phys. Rev. C **89** (2014) 4, 044906

16. *Measurement of inclusive W and Z boson production cross sections in pp collisions at* $\sqrt{s}$ *= 8 TeV*
S. Chatrchyan *et al.* [CMS Collaboration]
Phys. Rev. Lett. **112** (2014) 191802

17. *Measurement of jet fragmentation in PbPb and pp collisions at* $\sqrt{s_{NN}} = 2.76\ TeV$
S. Chatrchyan *et al.* [CMS Collaboration]
Phys. Rev. C **90** (2014) 2, 024908

18. *Measurement of Prompt* $\psi(2S) \to J/\psi$ *Yield Ratios in Pb-Pb and* $p-p$ *Collisions at* $\sqrt{s_{NN}}$ *= 2.76TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. Lett. **113** (2014) 26, 262301

19. *Measurement of prompt* J/ψ *pair production in pp collisions at* $\sqrt{s}$ *= 7 Tev*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1409** (2014) 094

20. *Measurement of pseudorapidity distributions of charged particles in proton-proton collisions at* $\sqrt{s}$ *= 8 TeV by the CMS and TOTEM experiments*
S. Chatrchyan *et al.* [CMS and TOTEM Collaborations]
Eur. Phys. J. C **74** (2014) 10, 3053

21. *Measurement of the* $t\bar{t}$ *production cross section in pp collisions at* $\sqrt{s} = 8\ TeV$ *in dilepton final states containing one* τ *lepton*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **739** (2014) 23

22. *Measurement of the* $t\bar{t}$ *production cross section in the dilepton channel in pp collisions at* $\sqrt{s}$ *= 8 TeV*
S. Chatrchyan *et al.* [CMS Collaboration]
JHEP **1402** (2014) 024

23. *Measurement of the* $W\gamma$ *and* $Z\gamma$ *inclusive cross sections in pp collisions at* $\sqrt{s} = 7\,TeV$ *and limits on anomalous triple gauge boson couplings*
S. Chatrchyan *et al.* [CMS Collaboration]
Phys. Rev. D **89** (2014) 9, 092005

24. *Measurement of the muon charge asymmetry in inclusive pp $\to$ W + X production at $\sqrt{s}$ = 7 TeV and an improved determination of light parton distribution functions*
S. Chatrchyan *et al.* [CMS Collaboration]
Phys. Rev. D **90** (2014) 3, 032004

25. *Measurement of the production cross section for a W boson and two b jets in pp collisions at $\sqrt{s}$=7 TeV*
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