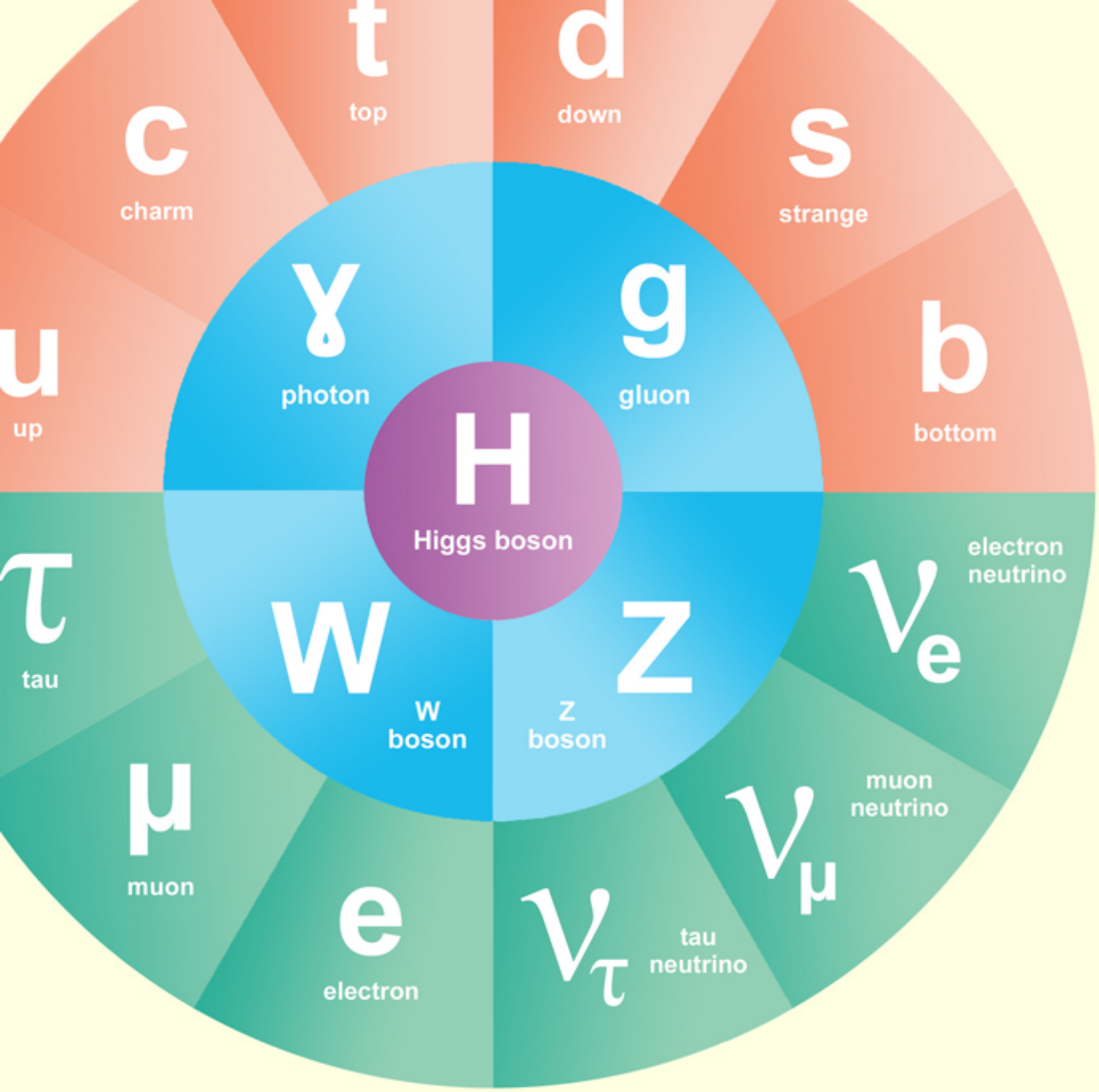

Annual Report 2015

Interuniversity Institute for High Energies

VUB iihe BRUXELLES BRUSSEL ULB

ANNUAL REPORT 2015

J. D'Hondt - L. Favart
Directors

VUB

http://www.iihe.ac.be

ULB

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 2015

The present report presents the research performed at the IIHE in 2015, 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 2015 the IIHE published with its national and international research partners about 130 journal papers.

The year 2015 was firstly marked by the Nobel Prize award for the discovery of neutrino oscillations, the second Nobel Prize award to particle physics in three years after the award in 2013 for the Brout-Englert-Higgs mechanism.

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. After a two-year upgrade, the LHC began the so-called Run 2, in June 2015, with a collision energy of 13 TeV — the highest energy ever achieved in a laboratory.

During 2015, 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), providing a bunch of new results.

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 5400 are fully analysed. 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. With a fifth event published in 2015, the ν_τ direct appearance is now established with a statistical significance of 5.1 σ.

The IIHE has initiated together with national and international colleagues the SoLid experiment at the BR2 nuclear reactor at the SCK-CEN (Mol, Belgium). A new detector has been deployed in 2014, followed shortly by the start of data taking. 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 parallel, the IIHE has started to investigate its possible future participation to the JUNO experiment, designed to establish the neutrino mass hierarchy.

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 deployed 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, from supernovae and from solar flares. 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 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 medical area the IIHE keeps on contributing to neutron metrology for future proton therapy centres.

To link the activities of their theoretical physics (TENA) and experimental particle physics (ELEM) groups, a phenomenology group has been settled by the VUB in 2014 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 worldwide LHC computing grid, with very high performance and stability.

On October 30th 2015, 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.

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, 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.

Since 2015 the IIHE benefits from the support of the China Scholarship Council (CSC) through the agreement between them and ULB, providing PhD scholarships to Chinese students to achieve their PhD at ULB.

1.3 The IIHE team in 2015

1.3.1 The ULB personnel

Academic and scientific personnel

Juan Antonio AGUILAR SANCHEZ	Chargé de cours	IceCube, ARA
Isabelle ANSSEAU	PhD student (Assistante ULB) since Feb.	IceCube
Patrizia BARRIA	Post-doc (IISN) until May	CMS, DAQ R&D
Daniel BERTRAND	honorary Directeur de Recherche F.R.S.-FNRS past IIHE co-director, Professeur de l'Université	IceCube
Hugues BRUN	Post-doc (IISN) since April	CMS
Cécile CAILLOL	PhD student (Aspirant F.R.S.-FNRS)	CMS
Barbara CLERBAUX	Directeur de Recherche F.R.S.-FNRS; part-time Chargée de Cours	CMS
Hugo DELANNOY	PhD student (FRIA) since January	CMS
Gilles DE LENTDECKER	Maître de Recherche F.R.S.-FNRS; Maître d'Enseignement	CMS, DAQ R&D
Valérie DE SMET	PhD student (FREDONE)	Instrumentation
Didar DOBUR	Post-doc (Marie Curie grant) until January	CMS
Jianmeng DONG	PhD student (CSC scholarship)	CMS DAQ R&D
Wenxing FANG	PhD student (CSC scholarship) since November	CMS

Giuseppe FASANELLA	PhD student (FRIA) cotutelle Rome University	CMS
Laurent FAVART	Directeur de Recherche F.R.S.-FNRS IIHE co-director, part-time Chargé de Cours	CMS, H1
Xuyang GAO	PhD student (CSC scholarship) since November	CMS
Reza GOLDOUZIAN	Post-doc (IISN) since Sept.	CMS
Anastasia GREBENYUK	Post-doc (PAI)	CMS
Kael HANSON	Chargé de Cours until November	IceCube, ARA
Tomas HREUS	collaborateur scientifique	H1, CMS
Georgia KARAPOSTOLI	Post-doc (PAI) since April	CMS
Thomas LENZI	PhD student (Aspirant F.R.S.-FNRS)	CMS
Alexandre LÉONARD	PhD student (Aspirant F.R.S.-FNRS) until June	CMS
Thierry MAERSCHALK	PhD student (IISN)	CMS, DAQ R&D
Pierre MARAGE	Professeur ordinaire émérite Prof. de l'Université, past IIHE co-director	Hist. of Science
Andrey MARINOV	Chargé de Recherche F.R.S.-FNRS	CMS, DAQ R&D
Kevin MEAGHER	Post-doc (IISN) since April	IceCube
Abdollah MOHAMMADI	Post-doc (IISN) until March	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) until Sept. cotutelle Rome Univ.	CMS
Yves PIERSEAUX	collaborateur scientifique	Hist. of Science
Elisa PINAT	PhD student (IISN)	IceCube
Nicolas POSTIAU	PhD student (Assistant ULB) since Sept.	CMS
Christoph RAAB	PhD student (IISN) since April	IceCube
Aidan RANDLE-CONDE	Post-doc (PAI)	CMS
Jean SACTON	Emeritus, Professeur ordinaire; past IIHE co-director	
Tomislav SEVA	Post-doc (IISN until January; PAI since Sept.	CMS
Zixuan SONG	PhD student (CSC scholarship) since Sept.	CMS, DAQ R&D
Raffaella TONCELLI	collaborateur scientifique	Hist. of Science
Catherine VANDER VELDE	Professeur de l'Université	CMS
Pascal VANLAER	Chargé de Cours	CMS
David VANNEROM	PhD student (Aspirant F.R.S.-FNRS) since Oct.	CMS
Pierre VILAIN	honorary Maître de Recherche F.R.S.-FNRS Professeur invité until Sept.	OPERA
Qun WANG	PhD student (CSC scholarship) since Sept.	CMS
Gaston WILQUET	honorary Maître de Recherche F.R.S.-FNRS; Professeur invité	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)	CMS

Master students

Diego BEGHIN	physics, since September	CMS
Hugo DEWITTE	physics, since September	CMS DAQ R&D
Camille GIAUX	physics, since September	CMS DAQ R&D
Baptiste HERREGODS	physics, until September	CMS DAQ R&D
Jérôme LEMAIRE	physics, since September	CMS DAQ R&D

Laurent LENAERTS	physics, until September	CMS
Nicolas POSTIAU	physics, until September	CMS

Engineers, Technical and Logistic Personnel

Samir AMARY	Computer scientist
Abdelhakim BOUKIL	Computer scientist
Patrick De Harenne	Technician, general support
Michael KORNTHEUER	Electronics
Alexandre LÉONARD	Logisticien de Recherche F.R.S.-FNRS since July
Fatimé PERO	Secretariat, 1/2-time
Shkelzen RUGOVAC	Computer scientist
Audrey TERRIER	Secretariat
René VANDERHAEGEN	Technician, electronics
Yifan YANG	ULB electronics

1.3.2 The VUB personnel

Academic and scientific personnel

Shimaa ABU ZEID	ERASMUS MUNDOS (PhD)	CMS
Lana BECK	FWO scientific collaborator (PhD)	CMS
Freya BLEKMAN	ZAP docent	CMS
Lionel BRAYEUR	FWO scientific collaborator (PhD)	IceCube
Martin CASIER	FWO scientific collaborator (PhD) until Oct.	IceCube
Nadir DACI	FWO scientific collaborator (post-doc)	CMS
Isabelle DE BRUYN	FWO scientific collaborator (PhD)	CMS
Karen DE CAUSMAECKER	FWO aspirant (PhD)	Pheno
Catherine DE CLERCQ	Professor-emeritus	IceCube
Jarne De Clercq	FWO scientific collaborator (PhD) since October	CMS
Krijn DE VRIES	FWO research fellow (postdoctoraal onderzoeker)	IceCube
Gwenhael DE WASSEIGE	FWO scientific collaborator (PhD)	IceCube
Kevin DEROOVER	FWO scientific collaborator (PhD)	CMS
Jorgen D'HONDT	ZAP hooglerrar; IIHE co-director	CMS & SoLid
Natalie HERACLEOUS	FWO scientific collaborator (post-doc) until June	CMS
Leonidas KALOUSIS	FWO scientific collaborator (post-doc) since Oct.	SoLid
James KEAVENEY	FWO Pegasus Marie-Curie research fellow until Sept.	CMS
Jan KUNNEN	FWO scientific collaborator (PhD)	IceCube
Steven LOWETTE	ZAP docent	CMS
Jan LUNEMANN	FWO scientific collaborator (post-doc)	IceCube
Giuliano MAGGI	FWO scientific collaborator (PhD)	IceCube
Alberto MARIOTTI	FWO Pegasus Marie-Curie till Sept. Pheno scientific collaborator (post-doc) since Oct. 10% ZAP research professor	Pheno
Kentarou MAWATARI	VUB scientific collaborator (post-doc); until Sept.	Pheno

	10% ZAP research professor	
Seth MOORTGAT	FWO aspirant (PhD student) since Oct.	CMS
Lieselotte MOREELS	FWO scientific collaborator (PhD)	CMS
Annik OLBRECHTS	FWO scientific collaborator (PhD)	CMS
Quentin PYTHON	FWO scientific collaborator (PhD)	CMS
Robert ROOSEN	Professor-emeritus	H1
Olaf SCHOLTE	10% ZAP Research Professor	IceCube
Dominic SMITH	FWO scientific collaborator (PhD) since July	CMS
Derek STROM	FWO scientific collaborator (post-doc)	CMS
Stefaan TAVERNIER	Professor-emeritus	Crystal Clear
Simona TOSCANO	FWO scientific collaborator (post-doc)	IceCube
Pantelis TZIVELOGLOU	VUB scientific collaborator (post-doc) until Sept.	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	
Gerrit VAN ONSEM	VUB scientific collaborator (post-doc) until Sept.	CMS
Isis VAN PARIJS	FWO scientific collaborator (PhD)	CMS
Simon VERCAEMER	IUAP scientific collaborator (PhD) VUB–UA	SoLid
Mathias VEREECKEN	FWO aspirant (PhD)	Pheno

Master students

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 technician
Rosette VANDEN-BROUCKE	Computer scientist - VSC
Bart Verleye	computer scientist – VSC since June

1.4 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. Igor Cherednikov, Dr. Xavier Janssen, Dr. Benoit Roland, Dr. Hans Van Haevermaet, Dr. Cristian Pisano, Dr. Yamiel Abreu, Dr. Ibrahin Piñera, Dr. Romain Rougny, Sara Alderweireldt, Tom Cornelis, Jasper Lauwers, Sten Luyckx, Pieter Taels, Merijn van de Klundert, Frederik Van der Veken, Sarah Van Mierlo, Alex Van Spilbeeck, Ir. Wim Beaumont, Simon Vercaemer.

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.

1.5 Departure of Professor Kael Hanson

Prof. Hanson has been hired at the University of Wisconsin-Madison to serve as director of the Wisconsin IceCube Particle Astrophysics Center and resigned from the the Université libre de Bruxelles.

Kael Hanson has been hired at ULB in Jan. 2009 in the realisation of the Science Faculty strategic plan to reinforce the experimental research in astroparticles at ULB, involved in the Amanda/IceCube experiment at the South Pole. During his six years at ULB, Prof. Hanson, as ULB particle astrophysics group leader, took major responsibilities within the IceCube Collaboration as "Data Acquisition Systems Lead" and "Detector Operations Coordinator". He was also one of the initiators of the neutrino radio-detection project ARA. Together with G. De Lentdecker he had major contributions to the development of the electronics laboratory of the IIHE. At the teaching level he was responsible of the astroparticle lectures and co-titular of the electronics lectures. He was also responsible of the laboratories of the second year of bachelor in physics.

The IIHE is grateful to him for his numerous contributions, his dedication, his friendship and his large impact in astroparticle research in our Institute.

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, D. Dobur, J. Dong, W. Fang, G. Fasanella, L. Favart, X. Gao, R. Goldouzian, A. Grebenyuk, N. Heracleous, T. Hreus, A. Kalogeropoulos, G. Karapostoli, J. Keaveney, T. Lenzi, S. Lowette, A. Léonard, T. Maerschalk, A. Marinov, A. Mohammadi, L. Moreels, A. Olbrechts, N. Postiau, Q. Python, A. Randle-Conde, T. Reis, T. Seva, Z. Song, D. Strom, S. Tavernier, W. Van Doninck, P. Van Mulders, G. Van Onsem, I. Van Parijs, C. Vander Velde, P. Vanlaer, D. Vannerom, B. Verbruggen, E. Verhagen, Q. Wang, Y. Yang, R. Yonamine, F. Zenoni, F. Zhang)

One of the two general-purpose detectors at CERN's Large Hadron Collider (LHC) is the Compact Muon Solenoid (CMS) experiment. The LHC provided proton-proton collisions during the so-called Run 1 in years 2010, 2011 and 2012, in the latter year for the first time at the record energy of 8 TeV. The analysis of these data allowed to perform precision tests of the Standard Model (SM). The increased understanding of the data, in combination with the higher

partonic cross sections created by higher collision energy, lead to about 500 CMS publications based on the LHC Run 1 data in international scientific journals.

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 2015 was key in the preparation of Run 2 at a LHC collision energy of 13 TeV. This second run started successfully in 2015 with 4.1 fb^{-1} of integrated luminosity of proton collisions delivered to CMS.

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 Study of 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 2015 to the SM scalar boson studies on two important area: 1) the study of the decay of the newly-discovered H boson into a pair of τ leptons in the HZ and HW associate production channel and search for additional scalar(s) in the $\tau^+\tau^-$ final state; 2) the study of the properties of the light scalar boson in the l^+l^- plus missing energy channel and the search for additional massive scalar(s) in that final state. These studies are detailed below.

Studies of the $H \to \tau^+\tau^-$ channel: The IIHE team leads the analysis of the $ZH \to l^+l^-\tau^+\tau^-$ channel, and contributed to the $WH \to e\mu\tau_h$ channel. These associated production of the scalar boson with a Z/W boson are important ways to measure the coupling of the scalar boson to fermions. The associate production channels are one of the significant inputs to the search for $H \to \tau^+\tau^-$ coupling, for which 3 standard deviation evidence was observed with a branching fraction consistent with the SM, albeit within large uncertainties, using the Run 1 dataset. The data to be collected from 2015 on should allow a more precise determination of this coupling. One of the IIHE PhD student was responsible of the combination of all searches for the SM scalar boson decaying to tau leptons in the associated production mode. The IIHE team was also involved in the search for a massive A/H/h boson decaying into a pair of tau leptons predicted by models with an extended scalar sector. This is the most powerful channel to uncover an MSSM scalar sector at the LHC. The team contributed to the decay channel where both taus decay into hadrons and a neutrino. In addition, three new Beyond the Standard Model (BSM) searches were performed for the first time using the 8 TeV data: (i) a search for a heavy pseudoscalar A boson in the $A \to Zh \to ll\tau\tau$ channel interpreted in the MSSM and in a 2HDM model; (ii) an analysis of a light pseudoscalar produced in association with a bb pair, $bbA \to bb\tau\tau$; (iii) a search for an exotic decays of the $h(125)$ GeV into light pseudoscalars $h \to aa \to \mu\mu\tau\tau$. The results of all these analyses have been published by the CMS Collaboration.
These analyses are supported by a detailed study of the performance of tau lepton reconstruction and selection algorithms: the selection efficiency and fake rate measurements are estimated using Drell-Yan $Z \to \tau\tau$ events, both for the 8 TeV and the 13 TeV CMS datasets.

Study of the $H \to ZZ \to l^+l^-\nu\bar{\nu}$ channel: 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. The first outcome of this search with 13 TeV data have been presented at the LHC Jamboree of December 2015 and new, model-independent limits on the production cross section have been prepared for presentation at Moriond 2016 (albeit still with limited sensitivity compared to the Run 1 results established by the group).
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. For the LHC Jamboree in December 2015, we derived the contribution of the instrumental background from Z+jet events using the γ+jet control triggers that we

designed; we also provided tables of NLO electroweak corrections to the ZZ background process.
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. In 2015, an IIHE post-doc has contributed to the LHC Higgs cross section working group by performing studies on how the theory prediction for the offshell cross section depended on the choice of parameters of the computation (factorization and renormalization scale, α_S and parton densities).
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 was published in the European Journal of Physics C (DOI: 10.1140/epjc/s10052-015-3706-0). The paper includes the strongest limits on anomalous γZZ and ZZZ couplings published. In 2015 IIHE members also study electroweak corrections to the WZ process, which include a contribution from the photon density in the proton, still poorly known today.

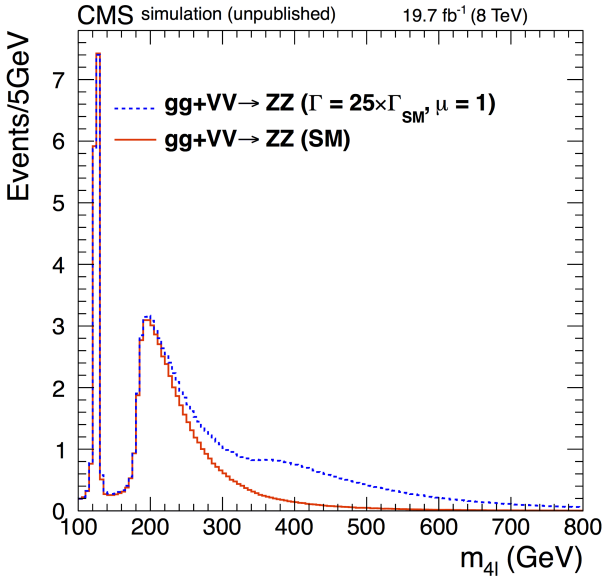

Figure 1: Distribution of the expected four-lepton reconstructed mass in full analysis mass range for the sum of the 4e, 4μ, and 2e2μ channels and for gg+VV→ZZ processes for a Higgs mass of 125.6 GeV. The expected distribution for a scenario corresponding to a scaling of the width by 25 together with μ=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.

The IIHE group contributed to the commissioning of the CMS high level trigger for the online selection of scalar bosons with the first data taken at 13 TeV in 2015. 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.

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.

2.1.2 Searches for high-mass resonances

Many scenarios beyond the Standard Model (SM) are expected to be manifest through the production of new heavy resonances, 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. Additional scalar sector (spin-0) resonances are also investigated. Several final states are being analysed by the IIHE team: the diphoton final state, the dilepton final state and the electron-muon decay channel; they are detailed below. These analysis are considered as HPA (High Priority Analysis) by CMS in particular at the begining of the Run 2 data taking where the new high energy frontier of 13 TeV allows to open cosiderably the phase space for discovery of massive new particles.
The electromagnetic calorimeter of CMS, the ECAL, is the main detector used in the diphoton and dilepton analyses. Expertise has been acquired in the ECAL calibration, resolution and linearity measurement. An important contribution concerns the ECAL energy scale and energy resolution estimation and corrections, in particular using the Z peak events from SM Drell-Yan process. In addition, the Brussels group has designed and developed a method based on the ECAL shower shape to cross check the ECAL calibration and linearity, and to correct for ECAL electronic readout saturation 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.
For both the diphoton and the dilepton analyses, preliminary results have been presented at the CERN Jamboree in December 2015.

Search for heavy resonances decaying to a photon pair: The IIHE contributed to the analysis searching for new phenomena in the diphoton spectrum at mass above 500 GeV, with in particular a dedicated development of the CMS electromagnetic calorimeter (ECAL) calibration. Simple selection criteria were optimised, requiring two high p_T and isolated photons in the final state. A small excess of events was observed at a mass of about 750 GeV both by the CMS and ATLAS experiments when analysing the 2015 data at 13 TeV. This excess has triggered many discussions in the particle physics community. The CMS results have been published in Phys. Rev. Lett. and was highlited as a "Editor's Suggestion". The excess was however not confirmed when analysing the first part of the data collected in 2016. An IIHE member, Prof. Barbara Clerbaux, was chairing the Analysis Review Committee (ARC) in CMS for the analyses of the 2015 and 2016 datasets, leading to 2 important CMS publications.

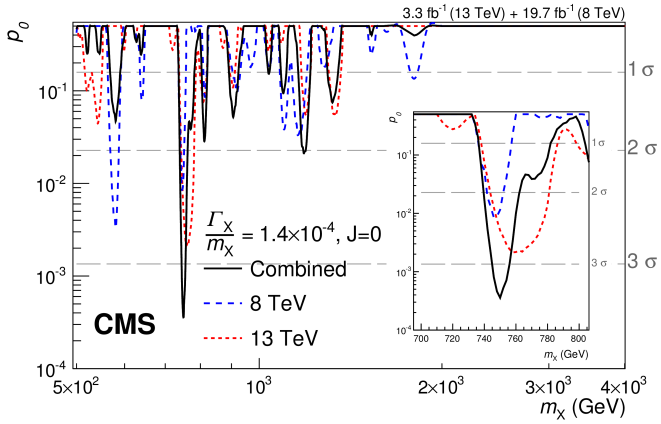

Figure 2: Observed background-only p values for narrow-width scalar resonances in the diphoton decay channel as a function of the resonance mass m_X, from the combined analysis of the 8 and 13 TeV datasets recorded in years 2012 and 2015 respectively. The results for the separate 8 and 13 TeV data sets are also shown. The inset shows an expanded region around $m_X = 750$ GeV.

Search for heavy resonances decaying to a lepton pair: Since 2006, physicists from the IIHE play a leading role in this channel; they initiated the creation of the HEEP (High Energy Electron Pairs) working group and were strongly involved in every step of the Run 1 CMS data analysis at 7 TeV and 8 TeV. The group participated to the 2015 data taking and analysis. No excess was observed in the 2015 datasets and limits at 95% Confidence Level (CL) on the new resonance production cross section have been determined. The dielectron and dimuon channel results were combined. The results on the CMS data at 13 TeV taken in year 2015 are ready for publication.
In parallel, the IIHE HEEP group has also studied the physics potential of the high luminosity run of the LHC (the

HL-LHC) for the high mass resonance search and characterisation, and has contributed to the CMS Technical Proposal (TP) 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. The CMS results on the Run 1 data analysis have been published in 2015.

2.1.3 Heavy flavour jet identification

A crucial ingredient for many analyses in CMS is the accurate identification of jets originating from b quarks. The importance of this topic is illustrated by the fact that about one third of all CMS publications relies on heavy flavour jet identification. At the IIHE, particularly the subjects of SM scalar and top quark physics, as well as many searches for beyond the standard model phenomena, rely heavily on the identification of heavy flavour jets. IIHE members have a leading role in the CMS collaboration in improving the b jet identification algorithms and developing charm quark identification algorithms as well as to commission heavy flavour tagging variables with the 13 TeV proton collision data. Under the leadership of FWO postdoc Petra Van Mulders as convener of the vertexing and heavy flavour identification group (BTV) in the Physics Coordination of the experiment, CMS managed to smoothly and successfully complete the many challenges in heavy flavour jet identification at the restart of the LHC in 2015.

2.1.4 Top quark physics

During the 2015 run of the Large Hadron Collider, at 13 TeV centre of mass energy, the CMS experiment collected an enormous sample containing top quarks in pair production as well as single production. In addition, some of the more challenging legacy papers requiring detailed analysis of the 2012 data collected at a centre of mass energy of 8 TeV was still ongoing.

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. IIHE physicists remained visible in a leading role in the top quark sector, with responsibilities such as the role of IIHE FWO Pegasus-Marie Curie postdoc Dr James Keaveney as convener of the top quark cross section subgroup. Other responsibilities were for example the visibility of the institute in the LHC top physics working group.

Using the 8 TeV dataset the IIHE group are involved in the preparation of 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, with substantial roles in CMS by senior IIHE members in the internal peer-review inside the collaboration.

Cross section of top quark pair processes: 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. To provide a final conclusion of the LHC Run 1 top quark physics programme, the final publication also included a measurement of the cross section ratio of top quark pair production in 7 and 8 TeV proton-proton collisions. In addition IIHE members are now preparing a differential measurement of the top quark production cross section.

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 and a result at world-leading accuracy is presented in the PhD thesis of Annik Olbrechts.

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 preparing an inclusive approach using the full LHC Run 2

dataset at 13 TeV centre of mass energy, 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 measure the width of the top quark: A team of IIHE physicists is performing a direct measurement of the top quark width in an attempt to constrain theories beyond the standard model. The top quark width is extracted by performing a likelihood template fit on the scaled top quark mass distribution, defined as the reconstructed top quark mass divided by the average top quark mass. With this strategy the dependency on the jet energy scale uncertainty is largely reduced. As a result, the dominant uncertainty is expected to come from modelling uncertainties. The large amount of data allows to employ tight selection requirements for instance on the number of observed jets to reduce the dependency on these uncertainties. In addition, the sensitivity of the analysis is enhanced by weighting each event taking into account the resolution on their reconstructed object four-momenta.

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 $1fb$ at 8 TeV and $9fb$ at 13 TeV, 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 CMS first paper focusing solely on SM-like production of four-tops was published in late 2014 and in collaboration with the IIHE phenomenology group the BSM signatures in this topology was explored in a follow-up phenomenology publication focusing on non-minimal Supersymmetry signatures decaying to four top quarks. Analysis of the 13 TeV data collected in 2015 will lead to an extremely competitive limit on Standard Model top quark production expected as a preliminary result in early 2016.

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. There are many different scenarios, and IIHE members are involved in searches for the production of top squark pairs using boosted techniques and related searches in jets+missing energy and monojet final states.
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. The analysis looking for these hypothetical particles using the 8 TeV data was published and as the sensitivity substantially increases with an increase in centre of mass energy, the analysis searching for these signatures in the 13 TeV data is currently in preparation.

2.1.5 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. Research activities at the IIHE to study it have in 2012.

Drell-Yan production associated with jets: The Drell-Yan production cross section on the Z peak with jet production is one of the central reference measurement at the LHC. The leptonic decay of the Z boson provides a background free and unbiased data selection to study in details the jet production and the reliability of its Monte Carlo simulation. The Drell-Yan cross section being known at 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 (2012 data) and 13 TeV (2015 data) measuring 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. First results at 13 TeV are shown in Fig. 3.

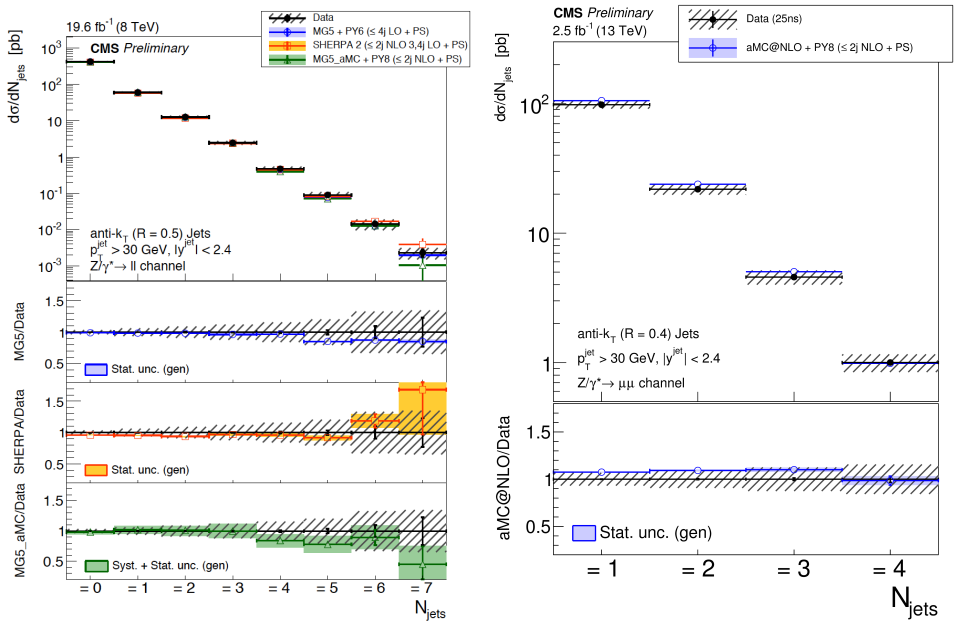

Figure 3: Measured cross section as a function of the jets exclusive multiplicity. a) at 8 TeV, b) at 13 TeV. The error bar represents the statistical uncertainty and the grey hatched band represents the total uncertainty including systematic and statistical uncertainties. The measurements are compared to different predictions.

2.1.6 Dark matter production at the Large Hadron Collider

Since 2013, the IIHE is actively involved in the search for signatures of direct dark matter (DM) production at the LHC. These searches for DM 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 was in maintenance mode, the IIHE team engaged in studies for dark-matter searches towards the next LHC run. In 2015, the CMS team contributed to the search for DM using events having large missing transverse momentum and one or more jets with high transverse momenta. Soon after the end of data taking, we quickly produced a public result (see Figure 4), contributed to the so-called December CERN Jamboree. Results are interpreted in terms of limits on DM production based on simplified models. On the experimental side, while playing a leading role in the collider searches for DM with the CMS experiment, an IIHE member, Prof. Steven Lowette, was co-managing a cross-experiment effort to organize and document, together with the theory community, the transition of the experiments to the use of these simplified benchmark models of DM. In parallel, an ongoing IIHE effort to search for strongly interacting dark matter was concluded and published, in collaboration with colleagues from the ULB phenomenology/theory department.

2.1.7 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.

2.1.8 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.

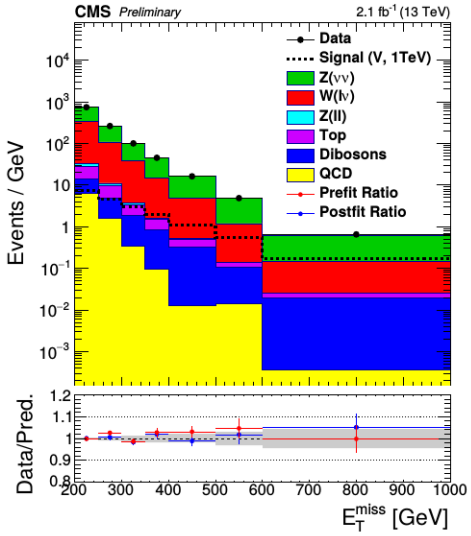

Figure 4: Missing momentum spectrum after selection for a monojet (or multijet) final state. The dominant backgrounds are invisible Z and W production, where in the case of the W the lepton is not identified. Data and background prediction are found to be in very good agreement.

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, Texas A&M, Wayne State University and Pekin University, 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.

2.2 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 25 FTE in 2015 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. The VFPS calibration and kinematic reconstruction results have been published in 2014 in [1].

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 confirm with better precision that the QCD-factorisation in photoproduced jets is broken, as illustrated in Fig. 5, and that this breaking is unrelated to diffractive proton disociation process. The results have been published in preprint [2] and submitted to JHEP.

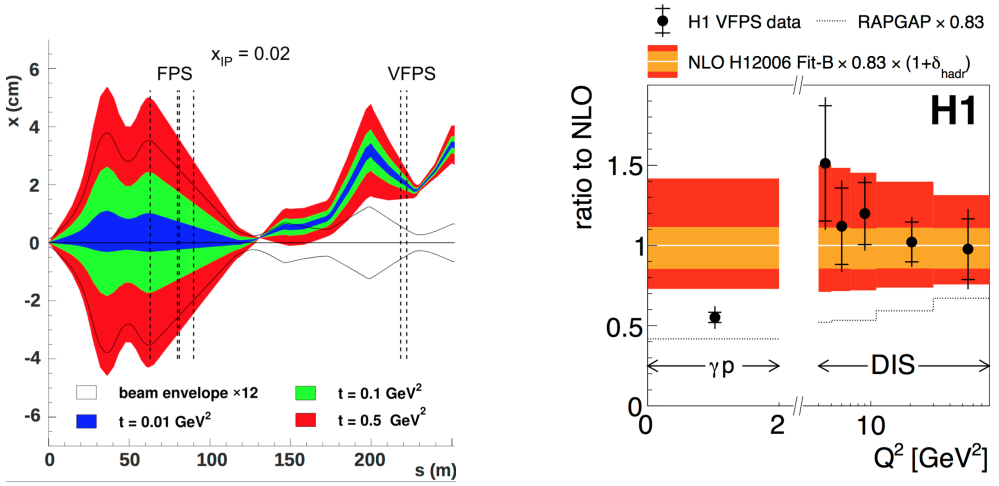

Figure 5: Left: VFPS location along the proton beam line (with horizontal profile). Right: VFPS diffractive dijet DIS and photoproduction cross section measurements normalised to the NLO calculation. Also shown is the double ratio of photoproduction to DIS cross sections, normalised to the corresponding ratio of NLO predictions.

Further results obtained by the H1-collaboration are:

- Combined H1 and ZEUS single-differential cross sections for inclusive $D^{*\pm}$-meson production in deep-inelastic ep scattering at HERA from their respective final data sets. These cross sections are combined phase-space region of photon virtuality $Q^2 > 5$ GeV^2, electron inelasticity $0.02 < y < 0.7$ and meson's transverse momentum $pT(D^*) > 1.5$ GeV and pseudorapidity $|\eta(D^*)| < 1.5$. Perturbative next-to-leadingorder QCD predictions are compared to the results.
- A combination of all inclusive deep inelastic cross sections previously published by the H1 and ZEUS collaborations for neutral and charged current $e^{\pm}p$ scattering for zero beam polarisation, corresponding to an integrated luminosity of about $1\,\mathrm{fb}^{-1}$. The combined cross sections were input to QCD analyses at leading order, next-to-leading order and at next-to-next-to-leading order, providing a new set of parton distribution functions, called HERAPDF2.0. The analysis was extended by including HERA data on charm and jet production, resulting in the variant HERAPDF2.0Jets. The inclusion of jet-production cross sections made a simultaneous determination of these parton distributions and the strong coupling constant possible, resulting in $\alpha_S(M_Z) = 0.1183 \pm 0.0009(\mathrm{exp}) \pm 0.0005(\mathrm{model/parameterisation}) \pm 0.0012(\mathrm{hadronisation})^{+0.0037}_{-0.0030}(\mathrm{scale})$. See Fig. 6

- A first measurement has been obtained of exclusive photoproduction of ρ^0 mesons associated with leading neutrons at HERA. The phase space of the measurement is defined by the photon virtuality $Q^2 < 2$ GeV^2, the total energy of the photon-proton system $20 < W_{\gamma p} < 100$ GeV and the polar angle of the leading neutron $\theta_n < 0.75$ mrad. The data are interpreted in terms of a double peripheral process, involving pion exchange at the proton vertex followed by elastic photoproduction of a ρ^0 meson on the virtual pion. In the framework of one-pion-exchange dominance the elastic cross section of photon-pion scattering, $\sigma^{\rm el}(\gamma\pi^+ \to \rho^0\pi^+)$, is extracted. The value of this cross section indicates significant absorptive corrections for the exclusive reaction.

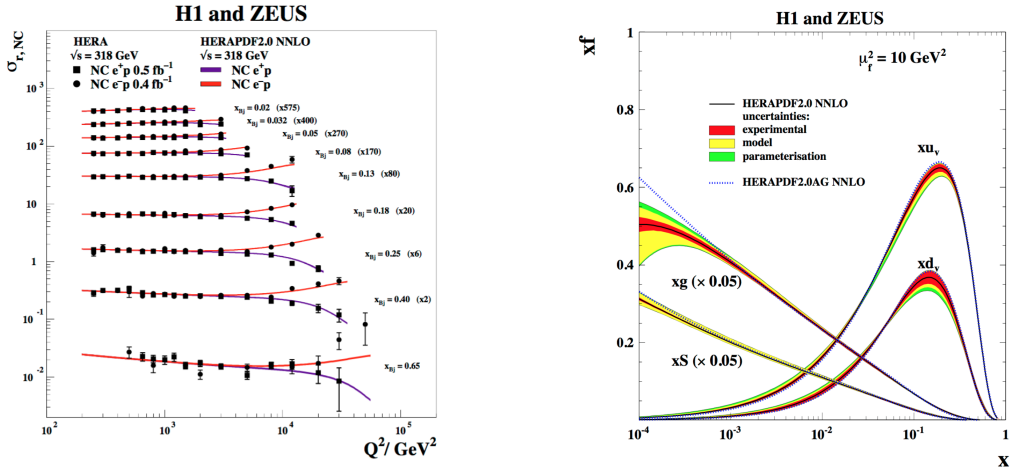

Figure 6: left: The combined HERA data for the inclusive NC e^+p and e^p reduced cross sections as a function of Q^2 for selected values of x at $\sqrt{s} = 318$ GeV with overlaid predictions of HERAPDF2.0 NNLO. right: The parton distribution functions of HERAPDF2.0 NNLO at a scale of 10 GeV^2. The gluon and sea distributions are scaled down by a factor 20.

References

[1] A. Astvatsatourov at al., Nucl. Instrum. Meth. A376(2014) 46-65.

[2] V. Andreev *et al.* [H1 Collaboration], "Diffractive Dijet Production with a Leading Proton in ep Collisions at HERA," JHEP **1505** (2015) 056.

[3] H. Abramowicz *et al.* [H1 and ZEUS Collaborations], "Combination of differential D$^{\pm}$ cross-section measurements in deep-inelastic ep scattering at HERA',' JHEP **1509** (2015) 149

[4] H. Abramowicz *et al.* [H1 and ZEUS Collaborations], "Combination of measurements of inclusive deep inelastic $e^{\pm}p$ scattering cross sections and QCD analysis of HERA data", Eur. Phys. J. C **75** (2015) no.12, 580

[5] V. Andreev *et al.* [H1 Collaboration], "Exclusive ρ^0 meson photoproduction with a leading neutron at HERA", [arXiv:1508.03176 [hep-ex]].

2.3 OPERA experiment (CERN CNGS1)

P. Vilain, G. Wilquet

The OPERA long baseline neutrino oscillation experiment has been designed to discover 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 domain of parameters space tested is the one primarily indicated by the atmospheric neutrinos experiments: compatible with full $\nu_\mu - \nu_\tau$ mixing and $|\Delta m^2_{32}| \approx 2.4\ eV^2$. The detector was installed in the underground Gran Sasso Laboratory of INFN (LNGS) and exposed to the CERN CNGS ν_μ beam, at a distance of 730 km. The design of the detector took into account two conflicting requirements: a large target mass to cope with

the minute neutrino interaction cross-section and the beam divergence over the baseline length on one hand and, on the other hand, 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.

In a total sample of 5408 fully analysed events located in the high resolution target, a fifth ν_τ candidate event, produced for the first time in a QE process, has been observed in 2015; see Figure 7. In four events the τ^- decays in the hadronic channel and one in the muonic channel [3]. (2.64 ± 0.53) signal and (0.25 ± 0.05) background events were expected in this sample and $\nu_\mu \rightarrow \nu_\tau$ oscillation in the appearance mode is therefore established with a statistical significance of 5.1 σ. With this discovery, the primary scientific goal the OPERA experimental project has been reached. The plan is to complete the analysis of the full data sample in the course of 2016.

Observing five or more candidates is compatible with an expectation of 2.89 events with a probability 17%. There is therefore 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. The results, presented in the 2014 report, are now published [4].

As part of an effort to further reduce the background on 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 [5].

Even though OPERA is a finishing experiment - the detector is currently being decommissioned - several physics topics are still under investigation and some of the studies will extend in 2017 : the determination of the leptonic number of the oscillated ν_τ; the multivariate analysis of a larger sample of ν_τ candidate events using looser kinematic and topological selection cuts; the beam ν_μ disappearance through oscillation; an extension of the search for a signal of exotic $\nu_\mu \rightarrow \nu_e$ oscillation in a significantly larger sample of events; the parametrisation of the annual modulation of the rate of cosmic muons; etc.

In 2015, the OPERA Collaboration included about 150 physicists from 30 institutions in 11 countries.

References

[1] The OPERA Collaboration, R. Acquafredda et al., JINST 4 (2009) P04018

[2] T. Adam et al., Nucl. Instrum. Methods A 577 (2007) 523-539

[3] The OPERA Collaboration, N. Agafonova et al., Phys. Lett. B 691 (2010) 138-145;
The OPERA Collaboration, N. Agafonova et al., JHEP 11 (2013) 036;
The OPERA Collaboration, N. Agafonova et al., Phys. Rev. D 89 (2014) 051102;
The OPERA Collaboration, N. Agafonova et al., Prog. Theor. Exp. Phys. 2014, 101C01;
The OPERA Collaboration, N. Agafonova et al., Phys. Rev. Lett. 115, 121802 (2015)

[4] The OPERA Collaboration, N. Agafonova et al., JHEP06 (2015) 06

[5] The OPERA Collaboration, N. Agafonova et al., arXiv1404.5933v3; accepted for publication by JINST

2.4 Astroparticle Physics with the IceCube Neutrino Observatory

(J. A. Aguilar, S. Amary, I. Ansseau, L. Brayeur, M. Casier, C. De Clercq, N. Van Eijndhoven, K. Hanson, D. Heereman, J. Kunnen, J. Lünemann, G. Maggi, K. Meagher, A. O'Murchadha, E. Pinat, C. Raab, O. Scholten, S. Toscano, K. D. de Vries, G. De Wasseige, P. Correa, M. Stuckens)

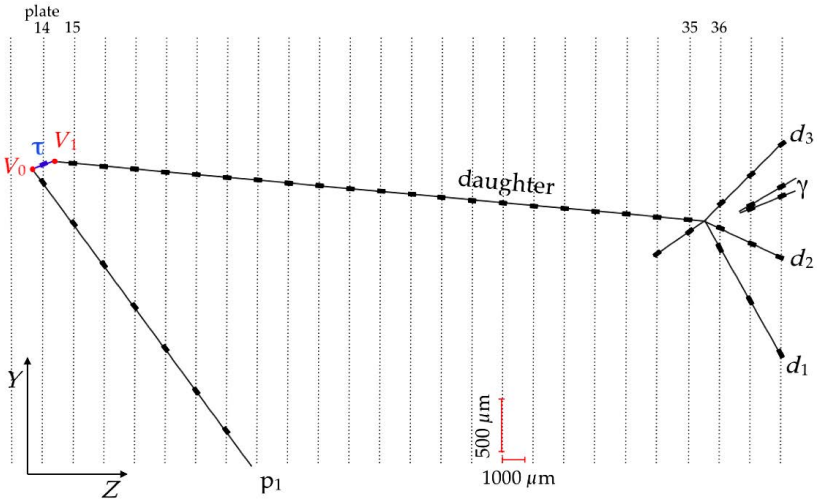

Figure 7: Event display of the fifth ν_τ candidate event in the horizontal projection longitudinal to the neutrino direction. The primary and τ^- decay vertices are indicated as V_0 and V_1, respectively. The black stubs represent the track segments as measured in the emulsion films. The primary interaction has a QE topology, the charged particle producing the primary track labelled p_1 being identified as a proton on the base of its energy loss. The decay daughter interacts and is a hadron.

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 identified 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. 8) 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.

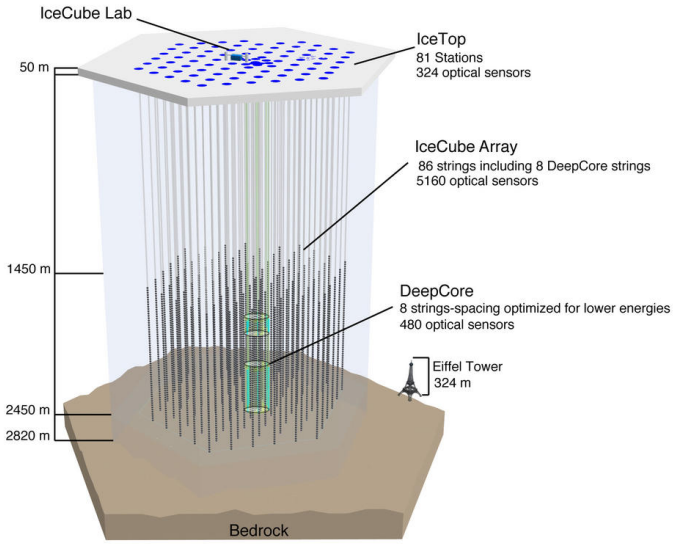

Figure 8: The IceCube observatory.

Sensitivity to lower energies can be obtained by a smaller spacing between adjacent sensors and to achieve this, the original IceCube detector has been extended with a dense core located at the deepest parts of the detector. This so called DeepCore detector consists of 8 strings arranged around the central IceCube string such that the distance between adjacent strings is 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 originate 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. Since then, about 50 high additional energy neutrinos from astrophysical origin have been observed. 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. 9).

2.4.2 Research areas at the IIHE

In 2015 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, flares from Active Galactic Nuclei or any transient phenomena. The activities of the IIHE in this field are several:
  - **Search for Gamma-Ray Bursts.**
    A first analysis (Nature **484** (2012) 351) has shown that Gamma Ray Bursts alone can not be the only

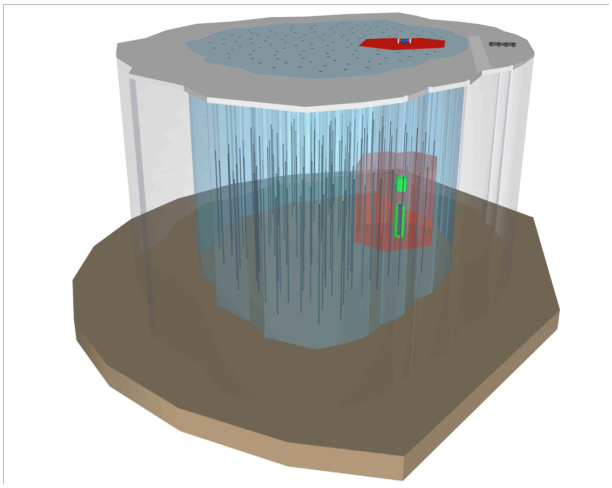

Figure 9: A possible *IceCube-Gen2* configuration. IceCube, in red, and the infill subdetector DeepCore, in green, show the current configuration

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. However the limits set by IceCube constrained the neutrino emission during the prompt phase of the GRB explosion. Other models suggest that neutrino emission could happen during other phases of the GRB, such as during the precursor or afterglow. At the IIHE a special analysis method for the study of these cataclysmic phenomena has been developed to search for neutrino emission in coincidence with GRBs in a model independent fashion. This analysis targeted long and short GRBs separately, in order to maximize the discovery potential. The results from the analysis of short and long GRBs have been published in the PhD thesis of Martin Casier (September 2015) and Lionel Brayeur (November 2015) respectively.

- **Stacking search for AGNs flares.**
  Another source of violent transient phenomena are Active Galactic Nuclei. In particular AGNs with jets pointing to us (called Blazars) are an interesting case due to their high variability. Blazars exhibit sudden sequences of multiple flares that may last from minutes to months. During 2015 we have initiated an analysis using the light-curve information from γ-ray as a time-template to search for neutrinos. The novelty of this analysis compared to previous analyses in IceCube, is that the list of AGNs is also stacked in order to search for a combined signal of all selected AGNs during their flaring periods.
- **Fast-response analysis.**
  In the same context of transient phenomena, but with a different approach, at IIHE we are developing an analysis to provide a fast-response from IceCube in case of an important astronomical event. Examples of past events of this nature are the tidal disruption event (GRB 110328A/Swift J1644+57), the Gravitational Wave detection (GW150914) or the intense flare from Blazar 3C 279 in June 2015. These events required a fast response to the astronomical community in order to provide the necessary input to evaluate the possibility of triggering follow-up observations.

- **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 of members of the IceCube, PAO and TA collaborations to perform an analysis of correlations with the arrival directions of the astrophysical neutrinos and UHECRs (JCAP 1601 (2016) no.01, 037).

- **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 are interested in Blazars. As already

mentioned these are a special class of AGNs where the jet is pointing towards the Earth. 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.**
  During 2015 a new analysis focusing on neutrino emission from extended regions was initiated at the IIHE. Some models predict neutrinos from extended regions like accelerators close to molecular-clouds or nearby star forming regions like the Cygnus region as a whole. The analysis to search for this extended regions 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°).

- **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 veto capabilities of the IceCube sensors surrounding DeepCore. That analysis yielded the most sensitive limits on spin dependent WIMP-nucleon cross sections. In recent years the IIHE group focused on the search for neutrino signals from WIMP annihilation in the center of the Earth. Initial results using one year of data provided limits that were one order of magnitude better compared to the previously published AMANDA (predecessor of IceCube) results. The results of this first IceCube analysis were published in the PhD thesis of Jan Kunnen (December 2015) and will appear soon in a paper under preparation. Efforts to extend this results is in preparation and efforts to extend this analysis to combine several years of data are also on-going.

- **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. Results from a first analysis of HitSpooling data were published in the PhD thesis of David Heereman (June 2015).

- **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 cosmogenic 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 cosmogenic neutrinos, but given the measured cosmic ray flux at high energies, 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. At the IIHE two efforts have been on-going during 2015. The Askaryan Radio Array (ARA) is a radio detector being deployed at the South Pole aiming at the radio detection of cosmogenic neutrino interactions with the antarctic ice. The IIHE has participated in the development of the timing and data acquisition system and

in the commissioning of the first detector elements as well as in the analysis of the data obtained with these first detector stations. Furthermore, a theoretical study was performed on the possible cosmic-ray air shower background signal for the Askaryan radio detectors. In addition to participating to the ARA experiment, an exploration of a novel detection principle based on the radio scattering by plasma induced by the neutrino interaction in ice is also pursued at the IIHE. This RADAR detection principle is in a feasibility study stage. Several promising experimental tests have been done at the facilities of the Telescope Array observatory in Utah.

- **R&D and design studies for IceCube-Gen2**
  The discovery of cosmic high-energy neutrinos has triggered feasibility studies for the extension of the existing IceCube observatory towards higher energies (so-called High Energy Array of IceCub-Gen2). On the other hand, in view of neutrinos oscillation studies and in particular the 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. Currently IIHE members are exploring the veto capabilities of several proposed designs for the future IceCube-Gen2. A coordinated R&D effort to exploit the potential offered by new technology, specially in photo-detection, has also started in IceCube. At IIHE we are interested in the possibilities offered by SiPMs and its application to a future IceCube-Gen2 design.

2.5 The ARA project

(Kael Hanson, Krijn de Vries, Aongus Ó Murchadha, Thomas Meures)

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.

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.

The ARA stations had had some hardware difficulties in the years after installation. The USB link between the DAQ and the on-board computer had broken several times for ARA01 and the DAQ box containing the surface electronics had been moved to the North for testing. During 2015, the link broke in rapid succession for both ARA02 and ARA03, leaving us without data for a period of several weeks. For a month in November-December 2015, A Ó Murchadha travelled to the South Pole to re-install the ARA01 DAQ box in the ice and perform calibration on all three stations (Figure 10). Additionally, new DAQ firmware that used PCIe rather than USB was installed on all stations. These activities resulted in the experiment recovering all three stations.

The broader IIHE radio team, including K. de Vries (VUB), and K. Hanson travelled to Delta, Utah in January of 2015 to use the Telescope Array calibration linac to perform initial tests on the hypothesis that a RADAR array could directly detect neutrino-generated electromagnetic cascades in ice (Figure 11). K. de Vries developed theory, A. Ó Murchadha worked on simulation and a DAQ, and K. Hanson detector hardware and instrumentation. An overview of the experiment was given at the International Cosmic Ray Conference (Proceedings of the 34th International Cosmic Ray Conference, PoS(ICRC2015)1168, The Hague 2015) and plans for a follow-up experiment are underway.

Figure 10: A. Ó Murchadha standing on top of the vault containing the ARA01 DAQ electronics

2.6 Instrumentation and electronics R&D

2.6.1 Data acquisition systems R&D activities

(P. Barria, G. De Lentdecker, J. Dong, 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. These developments initially performed within the EUDET project supported by the European Commission (EC) in the 6th Framework Program (FP6) have been pursued until 2015 within the framework of the EC FP7 AIDA (Advanced European Infrastructure for Detectors at Accelerators) project. The experience that the IIHE gained by developing DAQ systems in this framework has been a valuable asset to start new DAQ projects.

Since July 2011, the IIHE is contributing to the study of micro-pattern gaseous detectors with three GEM foils to replace standard Resistive Plate Chambers (RPC) in the forward region ($1.5 < |\eta| < 2.2$) of the CMS muon spectrometer for the LHC high luminosity phase, after 2020. In september 2015 the Technical Design Report (TDR) of the project has been endorsed by the CMS Collaboration and approved by the LHCC Committee, provding the green light for the installation of 144 Triple-GEM detectors in CMS during the 2nd long LHC shutdown in 2019-2020. Before

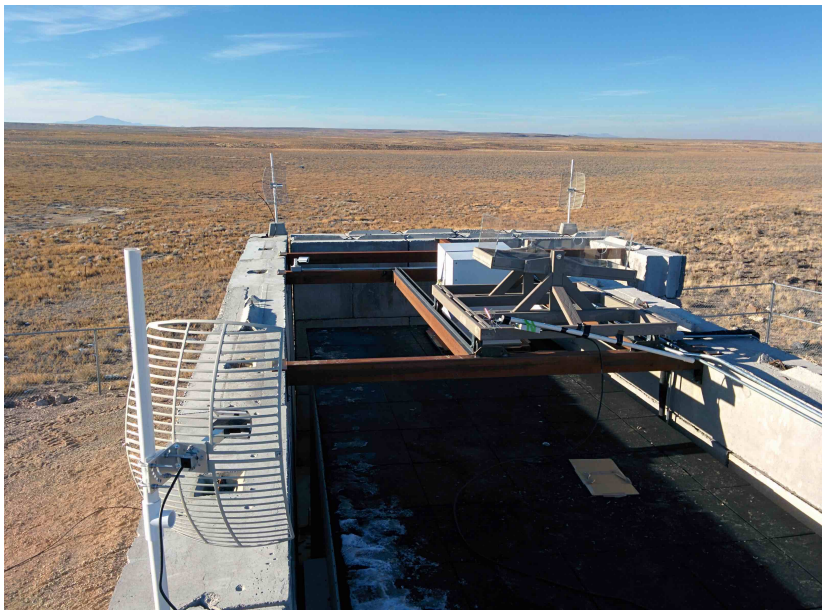

Figure 11: The Radar test array centered around the linac beam hole. The wooden mount is for the ice block.

that a series of 8 prototypes, called Slice Test, will be installed in the CMS detector during the winter 2016-2017. Since 2012 Dr. G. De Lentdecker is co-convener with P. Aspell (CERN) of the CMS GEM DAQ Electronics 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 12 shows the second 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. In December 2015 the IIHE has led a beam test at CERN with two CMS Triple-GEM detectors equipped with this new version of the electronics. The new readout system has been very reliable and efficient at 97%, even with a particle rate of 100 kHz per VFAT2 chip.

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

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

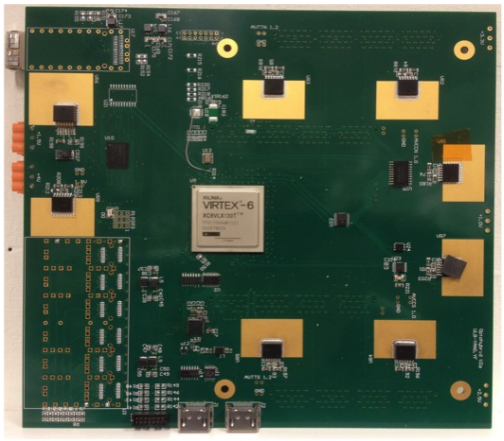

Figure 12: Second version of the CMS GEM FPGA-based opto-hybrid board built at the IIHE

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) and neutron spectrometry measurements with an extended-range Bonner Sphere Spectrometer (BSS) have been performed inside and around the Fixed-Beam Treatment Room at the proton therapy facility of Essen, in Germany. The analyses of these measurements are ongoing. These measurements should definitely shed light on the WENDI-2 response at such high energies (see Fig 13), 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.

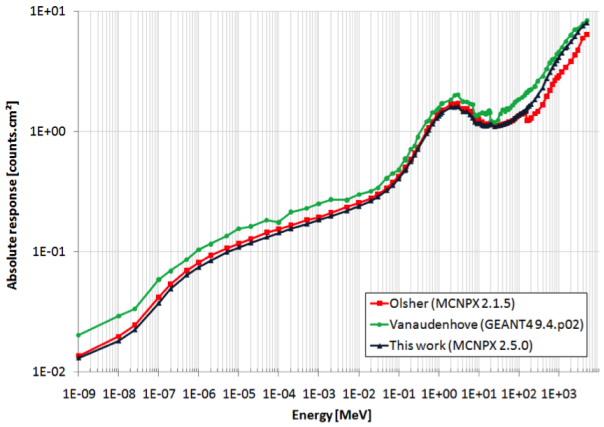

Figure 13: Simulation results of the WENDI-2 absolute response function. Ref: Olsher R.H. et al., WENDI: An improved neutron rem meter, Health Physics 79 (2), pp. 170-181 (2000).

2.7 The SoLid experiment

(J. D'Hondt, L. Kalousis, 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 ($n +^6 Li \rightarrow^3 H + \alpha + 4.78\ MeV$). 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 2015, the collaboration consisted out of about 45 researchers connected to 10 institutes in the US, UK, France and Belgium. We contributed to the operation and data analysis of the first submodule in particular for reducing the excessive noise observed in some of the readout channels, for measuring backgrounds induced by cosmic muons and for the identification of neutrons.

2.8 The JUNO experiment at Jiangmen (China)

(B. Clerbaux, J. Dong, L. Favart, Y. Yang)

Neutrino physics today is one of the major challenges of our understanding of nature, and is a very active research area, in particular related to the observation of neutrino oscillations, with the 2015 Nobel prize of physics awarded to Takaaki Kajita and Arthur McDonald for this discovery. The very nature of these particles is still unknown and some key measurements still need to be performed. The IIHE laboratory has a long tradition in long baseline neutrinos physics with the participation to the CHARM2, CHORUS and OPERA experiments using neutrino beams from CERN, and it is presently very active in the IceCube and Solid experiments. In year 2014, three staff persons (B. Clerbaux, L. Favart and Y. Yang) from the IIHE-ULB were at the initiative to investigate a possible participation to the Jiangmen Underground Neutrino observatory (JUNO) experiment, based in China. In addition to its strong tradition in neutrino physics, the IIHE has a recognized expertise in detector R&D and instrumentation, in particular in state-of-the-art electronics and data acquisition system (DAQ). Investigation discussions and contacts of the ULB group with the JUNO collaboration over the last two years have been particularly fruitful, leading to design studies on the back-end electronics system by the ULB group. In parallel, physics activities and potential of the JUNO experiment have been investigated by the group. In that context, ULB became an "observer member" of the JUNO collaboration in July 2014, and an "official member" in January 2015.

The JUNO experiment uses a large liquid scintillator detector aiming at measuring antineutrinos issued from nuclear reactors at a distance of 53 km and has as main goal to determine the neutrino mass hierarchy, after 6 years of data taking. The detector consists of 20 ktons of liquid scintillator contained in a 35 m diameter acrylic sphere, instrumented by more than 17000 20-inch photomultiplier tubes (PMT). Two vetoes are foreseen to reduce the different backgrounds: a 20 ktons ultrapure water Cerenkov pool around the central detector instrumented by 2000 20-inch PMTs will tag events coming from outside the neutrino target, and a muon tracker will be installed on top of the detector (top muon veto) in order to tag cosmic muons and validate the muon track reconstruction. The top muon veto will use the OPERA experiment target tracker currently being decommissioned, in which IIHE has been a contributor. The JUNO civil construction started in 2015 and the RD for the detector is ongoing. The start of the data taking is expected at the end of 2020.

The JUNO electronics system will have to cope with signals from 17000 large (20-inch) PMTs and 34000 small (3-inch) PMTs of the central detector as well as 2000 PMTs installed in the surrounding water pool. It consists of

mainly two parts: (i) the front-end electronics system, attached to each PMT and performing analog signal processing, and (ii) the back-end electronics system, sitting outside water and consisting of DAQ and trigger units for digital signal processing. Several options were studied and proposed by the ULB team in 2015 for the back-end electronics. An important challenge is to ensure very high reliability of the system. Due to the big amount of connections between the front-end and back-end electronics system and the complexity of the signal combination, the ULB group proposed to use back-end cards (BEC) as a concentrator and a bridge between the two parts. The design is still ongoing but the general concept has been accepted by the JUNO collaboration. The ULB work in JUNO is already appreciated and visible in the collaboration. Y. Yang is presently officially responsible (L3 manager) for the DLU (Data Link Unit) for JUNO and B. Clerbaux was proposed to be a member of the JUNO executive board (top management).

2.9 Phenomenology

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

The phenomenology of Beyond Standard Model physics is nowadays an elemental topic of investigation in high energy physics. The Large Hadron Collider (LHC) at CERN is exploring the fundamental physics at very high energy and will provide new informations about the dynamics at the base of the electroweak scale. At the same time, several experiments are looking for understanding the nature of the dark matter that populates our universe, through direct and indirect detection.

The Pheno group at IIHE pursues outstanding research on Beyond Standard Model phenomenology, including supersymmetry and its signals at LHC, as well as simplified models for dark matter and their experimental signatures.

The Pheno group has started in 2010 under the 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. Now it is part of the Strategic Research Program "High Energy Physics" (HEP@VUB) whose purpose it to strengthen the research activity in high energy physics among the existing groups at VUB: Collider physics (CMS), Astroparticle physics (IceCube), and Theoretical high-energy physics (TENA).

In 2015 the Pheno group comprised two 10% Prof.-90% Postdoc (A. Mariotti and K. Mawatari), one Postdoc (P. Tzivelolgou) and two PhD students (K. De Causmaecker and M. Vereecken). During 2015 the group has produced 11 scientific papers published on international peer reviewed Journals.

One of the main topic of investigation has focused on supersymmetric theories and their signals at LHC. The studies include formal aspects of supersymmetric gauge theories, formulation of new phenomenological scenarios, and study of simplified models and their experimental signatures.

In [1] we explained a recent excess observed by the ATLAS collaboration in terms of a supersymmetric model characterized by the presence of a new light fermionic particle, the pseudo-goldstino. In [2] and [3] we analyzed properties of supersymmetric models exhibiting interesting features in the flavour structure. In particular in [2] we studied the phenomenology of non-minimal flavour violation in the squark sector and their compatibility with the experimental constraints by means of a Markov Chain Monte Carlo scanning technique. In [3] we explored a new collider signature associated to supersymmetric models with flavour violation in the up and top squark sector, i.e. same sign tops at LHC. In [4] and [5] we investigated collider signatures related to non-conventional models of supersymmetry, respectively scenarios with very light gravitino and models with additional colored scalar particles, the sgluons. The investigation of the sgluons and their LHC signatures has been a joint project involving both members of the Pheno group and members of the CMS group at IIHE. Finally in [6] we studied formal aspects of a recent conjecture relating scattering amplitudes of a supersymmetric quantum field theory to volumes of an associated auxiliary space, the amplituhedron.

Another relevant topic of investigation has been the study of simplified models for dark matter and their phenomenology [7, 8, 9]. In [7] we explored the parameter space of the singlet-doublet model, where the Standard Model is extended minimally with a pair of doublet fermions and a singlet fermion to include a viable dark matter candidate. Such model encodes several well motivated UV completions, such as supersymmetry and composite models for dark matter. In [9] we studied higher order predictions for dark matter simplified models with s-channel mediators for LHC phenomenology, providing one of the first example of higher-order QCD corrections in realistic simulations of dark matter models at colliders.

Finally, the group has also performed investigations on the subject of the Brout-Englert-Higgs boson characterization [10, 11], for instance by developing Rosetta [11], a tool capable of translating different basis for Higgs effective field theory.

References

[1] S. P. Liew, A. Mariotti, K. Mawatari, K. Sakurai and M. Vereecken, Phys. Lett. B **750** (2015) 539 doi:10.1016/j.physletb.2015.09.035 [arXiv:1506.08803 [hep-ph]].

[2] K. De Causmaecker, B. Fuks, B. Herrmann, F. Mahmoudi, B. O'Leary, W. Porod, S. Sekmen and N. Strobbe, JHEP **1511** (2015) 125 doi:10.1007/JHEP11(2015)125 [arXiv:1509.05414 [hep-ph]].

[3] M. Backovic, A. Mariotti and M. Spannowsky, JHEP **1506** (2015) 122 doi:10.1007/JHEP06(2015)122 [arXiv:1504.00927 [hep-ph]].

[4] F. Maltoni, A. Martini, K. Mawatari and B. Oexl, JHEP **1504** (2015) 021 doi:10.1007/JHEP04(2015)021 [arXiv:1502.01637 [hep-ph]].

[5] L. Beck, F. Blekman, D. Dobur, B. Fuks, J. Keaveney and K. Mawatari, Phys. Lett. B **746** (2015) 48 doi:10.1016/j.physletb.2015.04.043 [arXiv:1501.07580 [hep-ph]].

[6] S. Franco, D. Galloni, A. Mariotti and J. Trnka, JHEP **1503** (2015) 128 doi:10.1007/JHEP03(2015)128 [arXiv:1408.3410 [hep-th]].

[7] L. Calibbi, A. Mariotti and P. Tziveloglou, JHEP **1510** (2015) 116 doi:10.1007/JHEP10(2015)116 [arXiv:1505.03867 [hep-ph]].

[8] D. Abercrombie *et al.*, arXiv:1507.00966 [hep-ex].

[9] M. Backovic, M. Krämer, F. Maltoni, A. Martini, K. Mawatari and M. Pellen, Eur. Phys. J. C **75** (2015) no.10, 482 doi:10.1140/epjc/s10052-015-3700-6 [arXiv:1508.05327 [hep-ph]].

[10] F. Demartin, F. Maltoni, K. Mawatari and M. Zaro, Eur. Phys. J. C **75** (2015) no.6, 267 doi:10.1140/epjc/s10052-015-3475-9 [arXiv:1504.00611 [hep-ph]].

[11] A. Falkowski, B. Fuks, K. Mawatari, K. Mimasu, F. Riva and V. sanz, Eur. Phys. J. C **75** (2015) no.12, 583 doi:10.1140/epjc/s10052-015-3806-x [arXiv:1508.05895 [hep-ph]].

[12] G. C. Cho, T. Kono, K. Mawatari and K. Yamashita, Phys. Rev. D **91** (2015) no.11, 115015 doi:10.1103/PhysRevD.91.115015 [arXiv:1503.05678 [hep-ph]].

2.10 Computing and networking

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

2.10.1 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).

2.10.2 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 been upgraded from 400 to 1000 CPU cores. 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.

2.10.3 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 to allow Belgian physicists contributing in an important way in the analyses of the LHC data.

In 2015, the T2 had 2400 job slots for a total of 25TFLOPS (or 19.000HepSpec06 units). Attached to this, a mass storage system of 2.3 PB is found. Figure 15 shows the usage of the site over the last 5 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 2015 a higher utilization of the site is again seen due to the increased LHC activity.

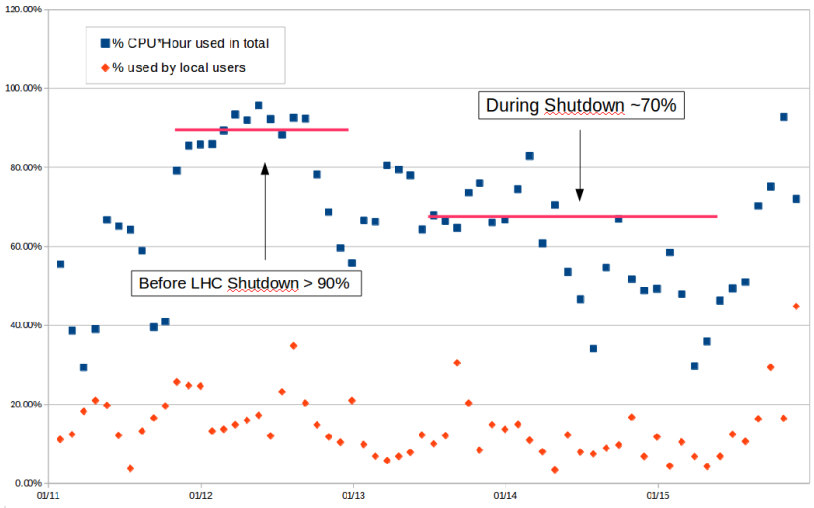

Figure 14: CPU usage of the T2 over the last 5 years.

In 2015, the Brussels Tier-2 team counted four IT scientists (S. Rugovac, F.R.S.-FNRS; O. Devroede, VUB; S. Gérard, VSC, part time; Romain Rougny, UA). Pascal Vanlaer (ULB), 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.

2.11 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.

In 2015, the IceCube masterclass has welcomed 40 students (20 FR + 20 NL) on March 18th. The students had the opportunity to learn more about astroparticle physics, cosmic ray physics and the IceCube neutrino detector through several activities and calls. This masterclass has been organized together with several European and North American universities. A very broad program was presented to the students, starting from a detailed introduction to IceCube in the morning including hands on web exercises, where in the afternoon the students had the opportunity to perform both experimental as well as theoretical exercises treating real IceCube data.

Figure 15: IIHE IceCube Master Class 2015.

2.12 Technical and administrative work

2.12.1 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.

2.12.2 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

Isabelle Ansseau

- contact person for the Vertical Event Filter

Juan Antonio Aguilar Sánchez

- IceCube local group leader and IceCube Institutional Board member, IceCube Muon group coordinator, Member of the IceCube Coordination Committee

Patrizia Barria

- Convener of Detector Response Modeling and Test Beam analysis subgroup for the CMS GEM Collaboration
- Desy, 17-21 November 2014 Facilitator CMS Upgrade School (CUPS2014)
- GEM Test Beam analysis group contact for the GEM Collaboration.
- I also provided supervision and guidance for students performing Test Beam analysis as one of the topics of their PhD theses.
- October 2014 Review for a NIM Nuclear Instruments and Methods Paper.
- Organizer and coordinator for the last two GEM Test Beam campaigns at CERN SPS H2 and H4 beam lines.
- September 2014 Facilitator CMS GEM Training Sessions

Freya Blekman

- Member of CMS Supersymmetry group Publication Committee

Hugues Brun

- CMS Muon HLT (High Level Trigger) convener until September 2015
- CMS Muon POG (Physics Object Group) Convener since September 2015
- Shift at CMS shift leader (equivalent to 4.10 weeks of service work in 2015)

Barbara Clerbaux

- ARC Chair for Diphoton search analysis in CMS (HIG-15-004)
- Member and Chair of various Analysis Review Committees (ARC) in EXO and Higgs groups in CMS
- 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 contact

Isabelle De Bruyn

- Calibration of the Tracker DCU chips
- DQM: Use TH2Poly objects in Tracker Maps
- DQM: implement Phase 2 Upgrade Outer Tracker plots
- Shift Leader shifts
- 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

Jarne De Clercq

- Setting up the lab in preparation of tracker phase II activities

Gilles De Lentdecker

- CMS Tracker Institution Board member
- Convener of the CMS GEM DAQ & Electronics Working Group

Krijn De Vries

- Radar scattering experiment TA-ELS, Delta, Utah, United States: Coordination of simulations and analysis, on site data taking.

Gwenhaël De Wasseige

- SFNews coordination + contact person
- Snow depth measurements for IceTop coordination + contact person

Hugo Delannoy

- Developer for the tracker DQM
- Shifts : tracker DQM offline. Shifter and expert on-call.
- Validator and developer 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

Anastasia Grebenyuk

- ARC member of SMP-14-018: Zgamma + 2 jets production in EWK processes and aQG
- Contact person of SMP-15-010: Z+jets differential cross sections at 13 TeV
- Convener of the Soft QCD and MPI and Run2 preparation subgroups of the FSQ PWG

- participated in the DCS shifts at p5

Georgia Karapostoli

- CMS central shift leader
- Co-leader of the CMS HZZ2l2nu Higgs Working Group
- L2 convenor in the Trigger coordination area of CMS (convenor of the Strategy for Trigger evolution and Monitoring / STEAM)

James Keaveney

- ARC member of SMP-13-012
- ARC member of TOP-13-017
- Central DCS shifter
- Computing operation shifter
- Convener of the Top cross section group
- Generator contact to TOP PAG
- RIVET contact to TOP PAG

Jan Kunnen

- Preparation of the online Vertical Event Filter for the 2015 season

Steven Lowette

- CMS delegate to the LHC Dark Matter Forum
- Convener of the MC&Interpretations subgroup of the Exotica PAG in CMS
- Member of Analysis Review Committees in CMS
- Member of the CMS SUSY Publication Committee
- Member of the CMS Thesis Award committee
- VUB representative in the CMS Tracker Insitution Board

Alexandre Léonard

- Investigating an artificial Retina processor for track reconstruction at the LHC crossing rate for the CMS upgrade in view of the HL-LHC.

Giuliano Maggi

- Member of the IceCube Software Strike Team since June 2015

Andrey Marinov

- Technical Coordinator of the CMS GEM group

Kevin Meagher

- IceCube Software Development Team

Thomas Meures

- ARA remote station operation and maintenance

Lieselotte Moreels

- CMS Tracker: DCU Calibration

- CMS Tracker DOC shifts
- CMS Tracker DQM-on-call shifts
- DQM: Integration of TH2Polys in Tracker Maps
- DQM: Phase II outer tracker plots

Elisa Pinat

- South Pole deployment, detector runs responsible

Aidan Randle-conde

- Analysis of Z' → ee search at CMS.
- Egamma EXO contact (CMS)
- Shift Leader on CMS experiment

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

- DQM: Phase 2 Outer Tracker plots
- Tracker DOC shifts

Catherine Vander Velde

- Member of the CMS Thesis awards committee
- Member of the CMS editorial board for publications on supersymmetry

Pascal Vanlaer

- CMS ULB team leader
- 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

David Vannerom

- Member of the STEAM rates group (substructure of the Trigger Studies Group of CMS)

Gaston Wilquet

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

3.1.2 Presentations in collaboration meetings

Isabelle Ansseau

- An Update for the Vertical Event Filter - IceCube - Copenhague 13/10/2015

Juan Antonio Aguilar Sánchez

- Highlights of the Muon Working Group - IceCube - Copenhagen, Denmark 15/10/2015

Patrizia Barria

- Beam Test Software TURBO amoreSRS - CMS GEM Collaboration Workshop VIII - CERN 25/03/2014
- Beam Test planning - CMS GEM Collaboration Workshop IX - CERN 16/07/2014
- Beam Test preparation status - CMS GEM Collaboration Workshop IX - CERN 15/07/2014
- Preparation of hardware and DAQ system for 2014 Test Beam efforts - CMS GEM Collaboration Workshop VIII - CERN 24/03/14
- Test Beam preparation and organization - CMS GEM Collaboration Workshop IX - CERN 14/07/2014

Nadir Daci

- Exotica trigger status - CMS Trigger Workshop - Padova (Italy) from 09/03/2015 to 13/03/2015
- Monojet EA: status report - CMS Physics Week - CERN 10/02/2015

Isabelle De Bruyn

- Approval: Phase 2 Outer Tracker DQM Plots - CERN/Brussels 06/02/2015

Giuseppe Fasanella

- Approval of Early Dielectron Resonance Search at High Mass EX0-15-005 - CMS - CERN 11/12/2015

Anastasia Grebenyuk

- Approval of SMP-15-010: Z+jets differential cross sections at 13 TeV - CMS - CERN 09/12/2015
- Subgroup report at the FSQ annual worshop: Soft QCD and MPI group: Run 1 analyses summary - CMS - CERN 09/04/2015

Georgia Karapostoli

- A Level-1 Menu study for the Phase II Trigger Upgrade of CMS - IIHE - Universite Libre de Bruxelles 04/06/2015

Steven Lowette

- Simplified Models for Dark Matter Searches - CMS - Venice, Italy 13/11/2015

Lieselotte Moreels

- Approval: Phase II Outer Tracker plots - CMS - CERN/Brussels 06/02/2015

Elisa Pinat

- Extended Sources Search with IceCube - IceCube Collaboration Meeting - Copenhagen from 10/10/2015 to 18/10/2015

Christoph Raab

- Sensitivity of PINGU to DM models - IceCube - Copenhagen, Denmark 13/10/2015

Aidan Randle-conde

- HEEP preapproval - CMS - CERN 10/11/2015

Pantelis Tziveloglou

- Gamma Rays Illuminate Singlet Doublet Model - CP3, UCL - Louvain-la-Neuve 13/04/2015
- Signatures of Top Flavour-changing dark matter - TU Wien - Vienna 27/11/2015
- Singlet Doublet Model: Dark matter searches and collider constraints - HEP@VUB - Brussels 11/06/2015

Isis Van Parijs

- Approval: Phase 2 Outer Tracker DQM plots - CMS - CERN-BRUSSEL 06/02/2015

Qun Wang

- Search for Diboson Resonance decaying into pairs of boosted W and Z at 13 TeV EXO-15-002 - CMS - CERN-building 40 14/12/2015

Yifan Yang

- Backend electronics consideration - JUNO - Beijing 11/07/2015

Fengwangdong Zhang

- Measurement of the differential cross section of Z boson production in association with jets in proton - proton collisions at $\sqrt{s} = 13$ TeV - CMS - CERN 17/11/2015

3.2 Completed Master and PhD theses

Barbara Clerbaux

- Luca PERNIE
  Measurement of the SM ZZ cross section in the 2l2n channels
  Phd thesis, ULB, September 2015.
- Thomas REIS
  Search for new massive resonances decaying to dielectrons or electron-muon pairs with the CMS detector
  Phd thesis, ULB, February 2015.

Catherine De Clercq

- Jan Kunnen
  A Search for Dark Matter in the Center of the Earth with the IceCube Neutrino Detector
  Phd thesis, VUB, December 2015.

Gilles De Lentdecker

- Baptiste Herregods
  Contribution a l'etude de detecteurs equipes de GEM pour les upgrades du spectrometre a muons de CMS
  Master thesis, ULB, September 2015.
- Erik Verhagen
  Development of the new trigger and data acquisition system for the CMS forward muon spectrometer upgrade
  Phd thesis, ULB, March 2015.

Laurent Favart

- Laurent Lenaerts
  Etude de la section efficace Drell-Yan à faible impulsion transverse du boson Z dans les interactions proton-protons à $\sqrt{s} = 8$ TeV
  Master thesis, ULB, June 2015.

- Alexandre Léonard
  Measurement of Z boson production in association with jets at the LHC and study of a DAQ system for the triple-GEM detector in view of the CMS upgrade
  Phd thesis, ULB, June 2015.

Nick Van Eijndhoven

- Jan Kunnen
  A Search for Dark Matter in the Center of the Earth with the IceCube Neutrino Detector
  Phd thesis, VUB, December 2015.
- Martin Casier
  Search for High-Energy Neutrino Production in Short Gamma Ray Bursts with the IceCube Neutrino Observatory
  Phd thesis, VUB, November 2015.

Pascal Vanlaer

- Nicolas Postiau
  Etude de la production de paires de bosons Z à grande masse invariante dans les collisions proton-proton à 8 TeV dans l'expérience CMS
  Master thesis, ULB, June 2015.
- Luca Pernie
  Measurement of the SM ZZ cross section in the 2l2n channels
  Phd thesis, ULB, September 2015.

3.3 Representation in scientific councils and committees

Daniel Bertrand

- Member of the scientific committee (Particle and Astropartcle) of the French National Research Agency (ANR)

Freya Blekman

- FWO expert panel

Barbara Clerbaux

- Adviser for the NWO for the Innovational Research Incentives Scheme
- Jury FRIA of the Belgian FNRS

Jorgen D'Hondt

- Belgian representative in Restricted European Committee for Future Accelerators (RECFA)
- Member of the FWO Committee for International Collaboration
- Member of the NWO selection committee for the VICI grants
- Member of the VUB committee for Future Education Innovations
- Member of the VUB selection committee for grants for Education Projects
- Member of the VUB steering group for setting up an Honour Program
- 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 FNRS scientific committee 'hautes et basses energies'

- Representative of FWO in the ApPEC General Assembly
- Representative of FWO in the CERN Resources Review Board
- member of the scientific and the organising committee of the Solvay-Francqui workshop 'Neutrinos: from Reactors to the Cosmos'

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)

Steven Lowette

- Member of the organizing committee of the Belgian-Dutch-German Graduate School in Particle Physics

Pierre Marage

- Membre titulaire Comité national de Logique, de Philosophie et d'Histoire des Sciences

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

- 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

Shimaa Abu Zeid

- Flavor Changing Neutral Currents in top pair decay (same sign di-lepton final state), Brussels-Strasbourg-CBNU top quark physics workshop on FCNC - Chonbuk N. University, Jeonju, Korea from 28/05/2015 to 30/05/2015

Patrizia Barria

- Status report on the CMS forward muon upgrade with Large-size Talks at International Conferences Triple-GEM detectors, IEEE 2014 - Seattle, WA USA from 08/11/2014 to 15/11/2014

Hugues Brun

- CMS Trigger in Run II, LHCP 2015 - Saint Pétersbourg from 31/08/2015 to 05/12/2015

Cécile Caillol

- Higgs decays to leptons, SUSY2015 - Lake Tahoe, California from 24/08/2015 to 30/08/2015

Barbara Clerbaux

- Overview of Indirect Dark Matter searches in IceCube, Dark Matter at Cairo - Cairo, Egypt from 14/12/2015 to 18/12/2015
- Searches for resonant and non-resonant new phenomena in CMS, "The European Physical Society Conference on High Energy Physics, EPS-HEP2015 - Vienna, Austria from 22/07/2015 to 29/07/2015
- The CMS Run2 status, IIHE Annual Meeting - Namur, Belgium 30/10/2015

Isabelle De Bruyn

- Dark Matter Searches in the Monojet, Monophoton and Monolepton Final States at CMS, Lake Louise Winter Institute 2015 - Lake Louise, Canada from 15/02/2015 to 21/02/2015

Gilles De Lentdecker

- Status report of the upgrade of the CMS muon system with Triple-GEM detectors, Frontier Detectors for Frontier Physics, 13th Pisa meeting on Advanced Detectors - Elba, Italy from 24/05/2015 to 30/05/2015

Krijn De Vries

- Macroscopic modelling of radio emission from particle cascades, GRAND workshop - LPNHE, Paris, France from 09/02/2015 to 11/02/2015
- On the feasibility of RADAR detection of high-energy cosmic neutrinos, 34th International Cosmic Ray Conference - The Hague, The Netherlands from 30/07/2015 to 06/08/2015
- Radar detection of high-energy neutrino induced particle cascades in ice, The IceCube Particle Astrophysics Symposium 2015 - UW, Madison, Wisconsin, United States from 04/05/2015 to 06/05/2015
- The cosmic ray air shower signal in Askaryan radio detectors, The IceCube Particle Astrophysics Symposium 2015 - UW, Madison, Wisconsin, United States from 04/05/2015 to 06/05/2015

Hugo Delannoy

- $H \rightarrow ZZ \rightarrow 4l$ analysis (student project at the CMS Data Analysis School), CMS DAS - Bari, Italy 23/01/2015
- High mass scalar search in HZZ22 (status and first results for Jamboree), Jamboree-iihe - Brussels, Belgium 17/12/2015

Giuseppe Fasanella

- Dielectron resonance search in Run2 (plenary talk0, EXO workshop - Venice from 12/11/15 to 14/11/15
- Search for new physics with top partners (invited talk), CMS Italia - Pavia from 25/11/2015 to 27/11/2015
- Search for pair production of vector-like partners of the top quark (T), Les Rencontres de Physique de la Vallée d'Aoste - La Thuile from 01/03/15 to 07/03/15

Laurent Favart

- Recent HERA results on hard diffraction, LISHEP 2015 - Manaus (Brazil) from 02/08/2015 to 09/08/2015

Anastasia Grebenyuk

- CMS Forward and Small-x QCD Physics Results, QCD15 - Montpellier, France 29/06/2015
- MPI@LHC: MB and UE working group Introduction, MPI@LHC - Trieste, Italy 23/11/2015

Georgia Karapostoli

- Searches for Direct Production of Dark Matter at the LHC, LHCP2015 - St Petersburg Russia 02/09/2015

Steven Lowette

- Accelerator Searches for New Physics in the Context of Dark Matter, TAUP 2015 - Torino, Italy 08/09/2015
- Review of the LHC Dark Matter Forum Report, CERN LPCC LHC Dark Matter Working Group - CERN, Switzerland 10/12/2015
- Summary of the LHC Dark Matter Forum Report, HEP@VUB Meeting - Brussels 08/10/2015
- The CMS Phase-II Tracker Upgrade, IAP WP8 Meeting - Antwerp 19/11/2015

Alberto Mariotti

- Goldstini and the Z-peaked ATLAS excess, GGI workshop - Florence, Italy 04/09/2015
- On neutral naturalness, Shaping UV Physics BSM - Durham (IPPP), UK 14/07/2015
- Signs of tops from highly mixed stops, Theory at the Sea - Ostende 22/05/2015
- Signs of tops from highly mixed stops, Planck 2015 - Ioannina, Greece 27/05/2015
- Status of SUSY after LHC8, BPS meeting - Liege University 13/05/2015

Kevin Meagher

- Six Years of Observations of The Crab Nebula With VERITAS, International Cosmic Ray Conference - Den Haag, Netherlands 03/07/2015

Aidan Randle-conde

- Massive resonances searches at the LHC, University of Liverpool Seminar - University of Liverpool 28/10/2015
- Searches for heavy resonances at the LHC (ATLAS/CMS), Blois 2015 - Blois, France 01/06/2015

Derek Strom

- CMS Silicon Strip Tracker Readiness for LHC Run II, Trento 2015: Trento Workshop on Advanced Silicon Radiation Detectors 2015 - Trento, Italy from 17/02/2015 to 19/02/2015
- Measurements of Heavy Flavour Properties at ATLAS and CMS, Moriond/QCD: 50th Rencontres de Moriond on - La Thuile, Italy from 21/03/2015 to 28/03/2015

Pantelis Tziveloglou

- Gamma Rays Illuminate Singlet Doublet Model, GDR 2015 - Saclay, France 31/03/2015
- Singlet Doublet Model: Dark matter searches and collider constraints, PLANCK 2015 - Ioannina, Greece 28/05/2015
- Singlet Doublet Model: Dark matter searches and collider constraints, Invisibles15 - Madrid 22/06/2015

Nick Van Eijndhoven

- Exploring the Universe with Neutrinos, Lepton-Photon 2015 (invited review talk) - Ljubljana, Slovenia from 17/08/2015 to 22/08/2015

Pascal Vanlaer

- TLAS+CMS combined H boson mass measurement, search for offshell decays and for high-mass scalars, 4th Inter- national Conference on new Frontiers in Physics - Kolymbari, Greece from 23/08/2015 to 25/08/2015

Florian Zenoni

- Triple GEM detector sensitivity simulations with Geant4 for the CMS Forward Muon Upgrade at CERN LHC, APS April Meeting 2015 - Baltimore, MD (USA) 11/04/2015

3.4.2 Poster presentations at conferences and schools

Cécile Caillol

- Search for a light pseudoscalar decaying to tau leptons, EPS2015 - Vienna, Austria from 19/07/2015 to 25/07/2015

Isabelle De Bruyn

- Monitoring Tools for the CMS Upgraded Outer Tracker Detector, Lake Louise Winter Institute 2015 - Lake Louise, Canada from 15/02/2015 to 21/02/2015
- Simplified SIMPs and the LHC, Colloquium: Physics after the 2013 Nobel Prize - Paleis der Academien, Brussels 28/03/2015
- Simplified SIMPs and the LHC, MCnet summer school - Spa from 30/08/2015 to 04/09/2015

Gwenhaël De Wasseige

- Evaluation of expected solar flare neutrino events in the IceCube observatory, Hinode meeting - Belfast from 12/09/2015 to 19/09/2015
- Evaluation of expected solar flare neutrino events in the IceCube observatory, ICRC - Den Haag from 29/07/2015 to 06/08/2015

Jianmeng Dong

- A High Bandwidth and versatile Advanced Mezzanine Card, TWEPP - Lisbon from 28/09/2015 to 02/10/2015

Giuseppe Fasanella

- Search for heavy neutral resonances decaying in dielectron pairs, LHCC - CERN 08/03/2015

Giuliano Maggi

- Dust Obscured Blazars as Sources of High Energy Neutrino, ICRC 2015 - Den Hague, The Netherlands from 30/07/2015 to 06/08/2015

Luca Pernie

- Simulation studies on precise timing information during High Luminosity LHC, LHCC - CERN 03/03/2015

Elisa Pinat

- Extended Sources Search with IceCube, ICRC2015, International Cosmic Ray Conference - The Hague from 30/07/2015 to 06/08/2015

Simona Toscano

- Using muon rings for the optical throughput calibration of the SST-1M prototype for the Cherenkov Telescope Array , 34th International Cosmic Ray Conference - De Hague from 30/07/2015 to 06/08/2015

Nick Van Eijndhoven

- A search for neutrinos from Gamma Ray Bursts with the IceCube Neutrino Detector, ICRC 2015 - The Hague, The Netherlands from 30/07/2015 to 06/08/2015
- Evaluation of expected solar flare neutrino events in the IceCube observatory, ICRC 2015 - The Hague, The Netherlands from 30/07/2015 to 06/08/2015
- Search for high-energy neutrinos from dust obscured Blazars, ICRC 2015 - The Hague, The Netherlands from 30/07/2015 to 06/08/2015

Ryo Yonamine

- Study of the spatial resolution for binary readout detectors, Frontier Detectors for Frontier Physics 13th Pisa Meeting on Advanced Detectors - Isola d'Elba (Italy) from 24/05/2015 to 30/05/2015

Fengwangdong Zhang

- Performance of the CMS Jets and Missing Transverse Energy Trigger for the LHC Run 2, EPS-HEP2015 - Vienna, Austria from 22/07/2015 to 29/07/2015

3.5 Scientific training

3.5.1 Attendance to conferences and workshops

Samir Amary

- 20th Quattor Workshop - Orsay, France from 29/09/2015 to 01/10/2015
- 19th Quattor Workshop - Grenoble, France from 03/03/2015 to 05/03/2015

Isabelle Ansseau

- Solvay-Francqui Workshop - Neutrinos, from reactors to the cosmos - Bruxelles from 27/05/2015 to 29/05/2015

Juan Antonio Aguilar Sánchez

- International Cosmic Ray Conference, 2015 - The Hague, The Netherlands from 30/07/2015 to 06/08/2015

Barbara Clerbaux

- CMS EXOTICA workshop - CMS EXOTICA group - Venice, Italy from 12/11/2015 to 14/11/2015
- General meeting of the IAP - Inter-university Attraction Pole IAP on fundamental interactions - ULB, Brussels 19/06/2015
- General meeting of the IAP - Inter-university Attraction Pole IAP on fundamental interactions - UAntwerpen, Belgium 18/12/2015
- Meeting of the IAP - WP8 : Future experiments - Inter-university Attraction Pole IAP on fundamental interactions - UAntwerpen, Belgium 19/11/2015
- JUNO electronics meeting - JUNO Collaboratino - APC Paris, France from 16/04/2015 to 17/04/2015
- JUNO electronics meeting - JUNO Collaboration - Padova, Italy from 23/06/2015 to 25/06/2015
- JUNO Collaboration meeting - JUNO Experiment - Guangzhou, China from 09/01/2015 to 15/01/2015
- The 50th Rencontres de Moriond - Session electroweak interactions and unified theories - La Thuile, France from 14/03/2015 to 21/03/2015

Karen De Causmaecker

- Workshop on MadAnalysis5 - Workshop on MadAnalysis5 - LPSC Grenoble from 16/02/2015 to 20/02/2015

Jarne De Clercq

- Tracker upgrade week - CERN, Geneva from 09/11/2015 to 13/11/2015

Catherine De Clercq

- International Cosmic Ray Conference, ICRC 2015 - The Hague, the Netherlands from 30/07/2015 to 06/08/2015
- COSPA network meeting - Belgian Cosmo-particles network - Université de Mons 20/05/2015
- COSPA network meeting - Belgian Cosmo-particles network - Vrije Universiteit Brussel 18/11/2015
- Fundamental Interactions IAP meeting - Belgian IAP VII/37 'Fundamental Interactions' - Universiteit Antwerpen 18/12/2015
- Fundamental Interactions IAP meeting - Belgian IAP VII/37 'Fundamental Interactions' - ULB, Brussels 19/06/2015
- Solvay-Francqui workshop - Neutrinos: from Reactors to the Cosmos - Université Libre de Bruxelles from 27/05/2015 to 29/05/2015

Gilles De Lentdecker

- HEP-EPS European Physical Society Conference on High Energy Physics - Chairman of the Detector RD and Data Handling session - Vienna, Austria from 22/07/2015 to 29/07/2015

Krijn De Vries

- 34th International Cosmic Ray Conference - Cosmic Ray physics - The Hague, The Netherlands from 30/07/2015 to 06/08/2015
- GRAND workshop - Giant Radio Array for Neutrino Detection - LPNHE, Paris, France from 09/02/2015 to 11/02/2015
- IceCube collaboration meeting - IceCube - UW, Madison, Wisconsin, United States from 25/04/2015 to 03/05/2015
- The IceCube Particle Astrophysics Symposium 2015 - Particle Astrophysics - UW, Madison, Wisconsin, United States from 04/05/2015 to 06/05/2015

Hugo Delannoy

- IIHE seminar - Lot of various internal seminar at IIHE on high energy physics - IIHE, Belgium from 01/01/2015 to 31/12/2015

Kevin Deroover

- FCNC workshop III - Chonbuk N. University, Jeonju (South-Korea) from 28/05/2015 to 30/05/2015

Olivier Devroede

- 9th International dCache Workshop - dCache mass storage system - Amsterdam from 18/05/2015 to 20/05/2015

Giuseppe Fasanella

- EXO Workshop - Exotica Workshop - Venice from 12/11/2015 to 14/11/2015

Laurent Favart

- COSPA network meeting - VUB, Brussels 18/11/2015
- IAP - fondamental interaction General meeting - Antwerpen 18/12/2015
- JUNO Collaboration meeting - Guangzhou, China from 09/01/2015 to 15/01/2015
- IAP - fondamental interaction General meeting - ULB, Brussels 19/06/2015
- Solvay-Francqui IAP meeting - From reactor to the Cosmos - ULB, Brussels from 27/05/2015 to 29/05/2015

Stéphane Gérard

- EGI Conference 2015 : Engaging the Research Community towards an Open Science Commons - Lisbon from 18/05/2015 to 22/05/2015
- GridKa School 2015 : Big Data - Virtualization - Modern Programming - Karlsruhe from 07/09/2015 to 11/09/2015
- EGI Community Forum 2015 : Building Next Generation e-Infrastructures through Communities - Bari from 09/11/2015 to 13/11/2015

Steven Lowette

- TAUP 2015 Conference - Torino, Italy from 07/09/2015 to 11/09/2015
- CMS Exotica Workshop - Venice, Italy from 12/11/2015 to 14/11/2015
- Fermilab Dark Matter at Future Colliders Workshop - Chicago, USA from 04/12/2015 to 06/12/2015

Giuliano Maggi

- IceCube Fall Collaboration Meeting 2015 - Collaboration Meeting - Copenhagen, Denmark from 10/10/2015 to 18/10/2015
- IceCube Spring Collaboration Meeting 2015 - Collaboration Meeting - Madison, US from 25/04/2015 to 02/05/2015

- IceCube Software Strike Team Workshop - IceCube Software Workshop - Colorado, US from 15/06/2015 to 19/06/2015

Alberto Mariotti

- 39th Johns Hopkins Workshop - Theory Challenges in the LHC era - Gothenburg, Sweden from 12/08/2015 to 14/08/2015

Elisa Pinat

- American Physical Society Meeting - American Physical Society Meeting - Baltimore from 11/04/2015 to 14/04/2015
- International Cosmic Ray Conference, ICRC2015 - International Cosmic Ray Conference, ICRC2015 - The Hague from 30/07/2015 to 06/08/2015

Nicolas Postiau

- UIAP meeting - Antwerpen 18/12/2015
- IIHE annual meeting - Namur 30/10/2015

Christoph Raab

- 34th International Cosmic Ray Conference - Den Haag, Netherlands from 30/07/2015 to 06/08/2015
- Solvay-Francqui Workshop on - Brussels from 27/05/2015 to 29/05/2015
- Meeting of the Belgian Inter-University Attraction Pole network on fundamental interactions - Antwerpen 18/12/2015
- IceCube Collaboration Fall Meeting 2015 - Copenhagen, Denmark from 10/10/2015 to 16/10/2015
- IceCube Collaboration Spring Meeting 2015 - Madison, WI, USA from 25/04/2015 to 03/05/2015
- Fifth CosPa Meeting - The High-Energy Universe - Brussels 18/11/2015
- IceCube Software Bootcamp - Workshop on software development and IceCube software - Copenhagen, Denmark from 17/10/2015 to 18/10/2015

Simona Toscano

- 34th International Cosmic Ray Conference - De Hague from 30/07/2015 to 06/08/2015

Petra Van Mulders

- 4 travels of a 2-3 days to one of the member universities of the SoLid collaboration - UK, France, Belgium 2015
- On average 10 travels of 2 to 5 days per year to CERN for meetings and discussions - CERN, Geneva, Switzerland 2015

Yifan Yang

- CMS GEM workshop - CMS - Geneva from 22/04/2015 to 23/04/2015
- CMS GEM workshop - CMS - Geneva from 06/10/2015 to 08/10/2015
- CMS beam test - CMS - Geneva from 20/10/2015 to 23/10/2015
- CMS beam test - CMS - Geneva from 01/11/2015 to 03/11/2015
- JUNO 6th collaboration meeting - JUNO - Beijing from 09/07/2015 to 15/07/2015
- JUNO electronics workshop - JUNO - Padova from 28/10/2015 to 30/10/2015
- JUNO europeen meeting - JUNO - Paris from 16/04/2015 to 17/04/2015
- JUNO electronics workshop - JUNO - Padova from 23/06/2015 to 25/06/2015
- JUNO annual meeting - JUNO - Guangzhou from 08/01/2015 to 15/01/2015
- TWEPP2015 - electronics design in high energy physics experiments - Lisbon from 28/09/2015 to 02/10/2015

Fengwangdong Zhang

- Lyon JetMET workshop at Run2 restart - Lyon, France from 08/07/2015 to 10/07/2015

3.5.2 Attendance to schools

Shimaa Abu Zeid

- The Belgian Dutch German summer school (BND 2015) - Participant - RWTH Aachen - Physikalisches Institut B - Germany from 31/08/2015 to 11/09/2015

Isabelle Ansseau

- PandA doctoral school day - Umons 22/10/2015

Patrizia Barria

- - CMS GEM School - CERN, Switzerland from 23/06/2014 to 27/06/2014
- - CMS Upgrade School (CUPS) - DESY from 17/11/2014 to 21/11/2014
- - RD51 Electronics School - CERN, Switzerland from 03/02/2014 to 05/02/2014

Isabelle De Bruyn

- MCnet summer school - Spa, Belgium from 30/08/2015 to 04/09/2015

Karen De Causmaecker

- MadGraph School on Collider Phenomenology - MadGraph School on Collider Phenomenology - Shanghai Jiao Tong University from 22/11/2015 to 28/11/2015

Hugo Delannoy

- BND school - BND school - Heimbach, Germany from 31/08/2015 to 11/09/2015
- CMS Data Analaysis School - CMS Data Analaysis School - Bari, Italy from 19/01/2015 to 23/01/2015

Giuseppe Fasanella

- BND - BND school - Heimbach from 31/08/2015 to 11/09/2015

Thierry Maerschalk

- the international school of trigger and data acquisition 2015 - trigger and data acquisition - Rio de Janero, Brazil from 28/01/2015 to 05/02/2015

Seth Moortgat

- BND summer school 2015 - High Energy Physics: Theory and Experiment - Heimbach, Germany from 31/08/2015 to 11/09/2015

Nicolas Postiau

- BND - Summer school for particle physics - Heimbach from 31/08/2015 to 11/09/2015

Romain Rougny

- Gridka school - Big Data, Cloud Computing and Modern Programming - KIT, Karlsruhe, Germany from 07/09/2015 to 11/12/2015

David Vannerom

- - BND school - Heimbach, Germany from 31/08/2015 to 11/09/2015

Matthias Vereecken

- - GGI lectures on the theory of fundamental interactions 2015 - GGI institute, Florence from 12/01/2015 to 29/01/2015

- - Summer School on Particle Physics - ICTP, Trieste from 15/06/2015 to 26/06/2015

Qun Wang

- PandA Ph.D. School - Annual meeting of the PandA Ph.D. School - UMONS, Plisnier 22/10/2015

Fengwangdong Zhang

- - BND summer school 2015 - Heimbach, Germany from 31/08/2015 to 11/09/2015
- - Monte Carlo school 2015 - DESY, Hamburg from 13/04/2015 to 17/04/2015

3.5.3 Invited seminars at the IIHE

- **Prof. Stijn Buitink**
  23 Jan - *IIHE invited seminar: Cosmic ray mass composition with LOFAR*
- **Prof. Karl-Ludwig Klein**
  29 Jan - *IIHE invited seminar: High-energy particles at and from the Sun*
- **Dr. Melissa Uchida**
  06 Feb - *IIHE invited seminar: The Muon Ionization Cooling Experiment (MICE)*
- **Dr. Alberto Mariotti**
  13 Feb - *IIHE invited seminar: Highly mixed stops: theory and phenomenology*
- **Dr. Roberto Franceschini**
  27 Feb - *IIHE invited seminar: Post-LHC SUSY*
- **Prof. Anna Catherine Hayes-Sterbenz**
  12 Mar - *Joint IIHE / ULB PhysTh seminar: Current status of reactor neutrino fluxes and the implications for the anomaly*
- **Dr. Christoph Delaere**
  13 Mar - *IIHE invited seminar: CMS - en route for run 2*
- **Prof. Michele Papucci**
  27 Mar - *IIHE topical seminar: Reinterpreting LHC searches for physics beyond the Standard Model: lessons learned from Run I*
- **Dr. Nick Barlow**
  10 Apr - *IIHE invited seminar: Searches for New Physics with long-lived particles at ATLAS*
- **Prof. Alexei N Safonov**
  15 Apr - *IIHE topical seminar: LHC: Searching for the Hidden Sectors of the Universe*
- **Dr. Petra Van Mulders**
  17 Apr - *IIHE invited seminar: The SoLid experiment*
- **Dr. Ronan McNulty**
  22 May - *IIHE invited seminar: Central Exclusive Production of single and double charmonia in pp collisions*
- **Dr. Victoria Martin**
  29 May - *IIHE invited seminar: But is it the Standard Model scalar? Searches for BEH boson to fermions at ATLAS*
- **Dr. Juan de Dios Zornoza**
  05 Jun - *IIHE invited seminar: ANTARES and KM3NeT: the sight of the neutrino sky from the Mediterranean*
- **Ms. Rachel Rosten**
  18 Jun - *IIHE topical seminar: A Search for Long-Lived Neutral Particles Decaying to Jets in the ATLAS Hadronic Calorimeter*
- **Dr. Konstantinos A. Petridis**
  03 Jul - *IIHE invited seminar: New physics searches using b-¿sll transitions at LHCb*

- **Mr. Antonio Castelli**
  01 Sep - *Topical seminar: Measuring the Higgs boson mass using event-by-event uncertainties*
- **Mr. Denys Lontkovskyi**
  09 Sep - *Topical seminar: Precision measurements of jet production at HERA*
- **Dr. Alex Martyniuk**
  02 Oct - *IIHE invited seminar: Search for diboson resonances at ATLAS using boson-tagged jets*
- **Dr. Maria Cepeda Hermida**
  12 Oct - *Topical seminar: Search for Lepton Flavour Violating Higgs decays in CMS*
- **Dr. Wouter Verkerke**
  16 Oct - *IIHE invited seminar: Constraints on Higgs boson couplings from a combination of ATLAS and CMS measurements*
- **Prof. Javier Albacete**
  06 Nov - *IIHE invited seminar: Novel QCD effects at high collision energies and their phenomenological implications*
- **Dr. Sezen Sekmen**
  13 Nov - *IIHE invited seminar: New Directions in SUSY Searches at LHC*
- **Dr. Vieri Candelise**
  17 Nov - *IIHE topical seminar: Associated production of a Z boson and b jets in proton-proton collisions at 8 TeV in CMS*
- **Dr. Anatael Cabrera**
  10 Dec - *IIHE topical seminar: 13 Reactor Neutrinos Physics and Beyond*
- **Dr. Domenico della Volpe**
  11 Dec - *IIHE invited seminar: The new generation of gamma-ray observatory: the Cherenkov Telescope Array*
- **Prof. Laurent Favart**
  17 Dec - *IIHE topical seminar: JamborIIHE*

3.6 Teaching and academics activities

3.6.1 Teaching activities

Isabelle Ansseau

- ULB - XP : Experimentarium, (0/0/48/0) BA1 Hour at the museum of physics - for high school student
- ULB - PHYS-F-103 : Physique, (0/24/0/12) BA1 Physics Exercices for BA1 Info
- ULB - PHYS-F-104 : Physique 1, (0/12/0/12) BA1 Physics Exercices for BA1 Géo
- ULB - PHYS-F-205 : Physique 2, (0/0/21/10) BA2 Physics Laboratory for BA2 BIO
- ULB - PHYS-F-110 : Physique I, (0/0/16/8) BA1 Physics laboratory for BA1 PHYS
- ULB - PHYS-F-110 : Physique I, (0/0/16/8) BA1 Physics laboratory for BA1 CHIM
- ULB - PHYS-F-210 : Physique II, (0/0/72/30) BA2 Physics laboratory for BA2 PHYS
- ULB - PHYS-F-110 : Physique générale 1 et 2, (0/0/40/20) BA1 Physics Laboratory for BA1 CHIM

Juan Antonio Aguilar Sánchez

- ULB - PHYS-F314 : Electronique, (12/0/0/0) BA3
- ULB - PHYS-F210 : Laboratoires, statistique appliquée à la physique expérimentale et projet, (0/0/72/40) BA2
- ULB - PHYS-F311 : Laboratoires et Stage de recherche , (0/0/72/30) BA3
- ULB - PHYS-F467 : Physique des Astroparticules , (24/24/0/24) MA1 MA2

Freya Blekman

- VUB - WE-DNTK-mobility : Coordinator external mobility, (0/0/0/20) MA1 MA2 coordinate the assignment of the obligatory mobility courses (6 ECTS credits)
- VUB - WE-DNTK-12965 : EXPERIMENTELE FYSICA, (10/0/70/40) BA1 This is the obligatory experimental physics laboratory for students in the first year of the Ba1
- 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

Barbara Clerbaux

- ULB - PHYS-F416 : Interactions fondamentales et particules, (18/12/12/0) MA1
- ULB - PHYS-F311 : Laboratoires + stage + Visite annuelle du CERN, (0/0/36/24) 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) MA1 MA2

Jarne De Clercq

- ULB - WE-DNTK-... : Fysica: Inleiding mechanica, (0/0/8/8) BA1

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-6508 : High Energy Astrophysics, (0/18/0/0) MA1

Gwenhaël De Wasseige

- VUB - WE-DNTK-006329 : Experimentele fysica, (0/0/84/0) BA1 Labs

Hugo Delannoy

- ULB - PHYS-F311 : Laboratoires et Stage de recherche, (0/0/72/0) BA3 Laboratoire de physique des particules
- ULB - PHYS-F110 : Physique générale I et II, (0/0/42/0) BA1 Laboratoire de Physique générale

Kevin Deroover

- VUB - WE-DNTK-1001388CNR : Experimentele stralings- en kwantumfysica, (0/0/48/40) BA2
- VUB - WE-DNTK-1015332ANR : Fysica: inleiding mechanica, (0/0/14/14) BA1
- VUB - WE-DNTK-1010221BNR : Statistische verwerking van experimentele gegevens, (0/0/0/2) 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

Giuseppe Fasanella

- ULB - PHYS-F416 : Introduction to Standard Model, (0/0/15/5) MA1

Laurent Favart

- ULB - PHYS-F305 : Introduction à la Physique des Particules, (24/0/0/0) BA3 Physique
- ULB - PHYS-F477 : Physique auprès des collisionneurs, (24/0/0/0) MA1 MA2 Physique
- ULB - PHYS-F311 : Visite annuelle du CERN, (0/0/0/24) BA3 Physique

Thomas Lenzi

- ULB - PHYS-F420 : Détection de particules, acquisition et analyse de données, (0/0/12/0) MA2
- ULB - PHYS-F314 : Electronique, (0/0/20/0) BA3
- ULB - PHYS-F305 : Physique des particules et Physique Nucleaire, (0/12/0/0) BA3

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-1001 : Histoire des Sciences, Guerre et Développement, (24/0/0/0) BA1 BA2 BA3 MA1 MA2

Alberto Mariotti

- VUB - 4015689FNR : Subatomic Physics 2, (26/0/0/0) MA1

Seth Moortgat

- VUB - WE-DNTK-11330 : Fysica: Inleiding Mechanica, (0/32/0/0) BA1 Introductory course on Physics for non-physics students (biology, bio-ingeneer,...): Exercises

Lieselotte Moreels

- VUB - WE-DNTK-1001388CNR : Experimentele stralings- en kwantumfysica, (0/0/48/32) BA2 Lab sessions in which the students prepare and perform some of the basic experiments related to radi
- VUB - WE-DNTK-1015332ANR : Fysica: Inleiding Mechanica, (0/14/0/52) BA1 Introductory Mechanics course for non-physicists
- VUB - WE-DNTK-1010221BNR : Statische verwerking van experimentele gegevens, (0/10/0/8) BA2 Introduction to statistical concepts concerning data analysis

Elisa Pinat

- ULB - PHYS-F-311 : Laboratoire de physique generale approfondie, (0/0/80/16) BA3

Nicolas Postiau

- ULB - PHYS-F-104 : Physique 1, (0/24/0/0) BA1
- ULB - PHYS-F-110 : Physique Générale I et II, (0/44/0/0) BA1
- ULB - PHYS-F-201 : Thermodynamique, (0/24/0/0) BA2

Christoph Raab

- ULB - PHYS-F482 : Techniques avancées de physique expérimentale, (0/2/8/40) MA1 Developed and led exercises/lab on statistical data analysis.

Aidan Randle-conde

- ULB - PHYS-F416 : AFB measurement on CMS, (0/0/9/0) BA1 Analysis of 13 TeV CMS data to measure AFB in the Drell-Yan channel

Robert Roosen

- VUB - 4015954ENR : Elementen van de geschiedenis van de natuurwetenschappen, (30/0/0/0) MA2

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 - PHYS-F-416 : Interactions fondamentales et particules, (18/0/0/0) MA1 physique

Pascal Vanlaer

- ULB - PHYS-H303 : Contraintes sur la largeur du boson scalaire, (0/0/12/0) BA3 Projet de bibliographie
- ULB - PHYS-F420 : Détection de particules, acquisition et analyse de données, (12/0/24/0) MA1 MA2 Physique
- 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
- ULB - PHYS-F110 : Physique générale, (0/0/24/0) BA1 laboratoires de physique section Chimie

David Vannerom

- ULB - PHYS-F104 : Physique Générale, (0/36/0/0) BA1

Matthias Vereecken

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

Ryo Yonamine

- ULB - PHYS-F311 : Laboratoires et Stage de recherche, (0/0/24/0) BA3

Florian Zenoni

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

Fengwangdong Zhang

- ULB - PHYS-F312 : Particle Physics Laboratory, (0/0/60/0) BA3 Cosmic muon arch experiment

3.6.2 Membership to academic juries of Master and Phd theses

Juan Antonio Aguilar Sánchez

- Phd thesis, - ULB, February 2015 - Erik Verhagen : Development of the new trigger and data acquisition system for the CMS forward muon spectrometer upgrade
  Secretary

Barbara Clerbaux

- Master thesis, - ULB, June 2015 - Nicolas Postiau : Etude de la production de paires de bosons Z à grande mass invariante dans les collisions pp à 8 TeV auprès de l'expérience CMS
  Referee
- Phd thesis, - UCL Louvain-La-Neuve, October 2015 - Lucia PERRINI : Search for Higgs bosons decaying to tau leptons with the CMS experiment at the LHC
  Referee
- Phd thesis, - UCL Louvain-La-Neuve, October 2015 - Andrey POPOV : Search for anomalous Higgs boson production in association with single top quarks using the CMS detector
  Referee

Catherine De Clercq

- Phd thesis, - Université Libre de Bruxelles, July 2015 - David Heereman von Zuydtwyck : Hitspooling: An Improvement for the Supernova Neutrino Detection System in IceCube
  Referee
- Phd thesis, - Vrije Universiteit Brussel, November 2015 - Martin Casier : Search for High-Energy Neutrino Production in Short Gamma Ray Bursts with the Ice-Cube Neutrino Observatory
  President

Gilles De Lentdecker

- Phd thesis, - ULB, July 2015 - David Heereman Von Zuydtwyck : HitSpooling: An Improvement for the Supernova Neutrino Detection System in IceCube
  Secretary
- Phd thesis, - ULB, June 2015 - Alexandre Leonard : Measurement of Z boson production in association with jets at the LHC and study of a DAQ system for the Triple-GEM detector in view of the CMS upgrade
  President
- Master thesis, - ULB, June 2015 - Alexander Bowles : Méthode pour estimer le temps de cristallisation sur base de la relation de Stockes-Einstein via spectroscopie diélectrique
  Referee

Krijn De Vries

- Phd thesis, - KVI-CART, University of Groningen, February 2015 - Wendy Docters : Unraveling the mysteries of high-energy cosmic rays using radio detection
  Referee

Laurent Favart

- Phd thesis, - Université de Mons, December 2015 - Nikita Beliy : Search for top s-quarks in bottom s-quark production in R-parity violating supersymmetric models with the CMS detector
  Referee

Steven Lowette

- Phd thesis, - UCLouvain, September 2015 - Suzan Basegmez : A New Method for Mapping Detector Material in Situ and a Matrix Element Approach to the Search for Heavy Di-Muon Resonances at the LHC
  Referee

- Phd thesis, - VUB, December 2015 - Jan Kunnen : A Search for Dark Matter in the Center of the Earth with the IceCube Neutrino Detector
  President

- Master thesis, - VUB, June 2015 - Mehdi Delanoeije : Black hole evaporation and the information paradox - Complementarity, fuzzballs and firewalls
  Referee

- Phd thesis, - VUB, November 2015 - Martin Casier : Search for High-Energy Neutrino Production in Short Gamma Ray Bursts with the IceCube Neutrino Obervatory
  Secretary

- Phd thesis, - ULB, February 2015 - Thomas Reis : Search for new massive resonances decaying to dielectrons or electron-muon pairs with the CMS detector
  Referee

- Phd thesis, - UGent, May 2015 - Nadja Strobbe : The Razor Boost analysis - Another step in the hunt for new physics at CMS
  Referee

Alberto Mariotti

- Master thesis, - VUB, June 2015 - Seth Moortgat : Development of new charm-tagging methods for the search for Flavour Changing top-quark dark matter interactions at the LHC
  Referee

- Master thesis, - VUB, June 2015 - Saskia Demulder : Integrability in the AdS/CFT correspondence: lambda-deformation and integrable interpolations
  Referee

- Phd thesis, - Mons University, December 2015 - Nikita Beliy : Search for top s-quarks in bottom s-quark production in R-parity violating supersymmetric models with the CMS detector
  Referee

Nick Van Eijndhoven

- Phd thesis, - UGent, February 2015 - Abd Al Karim Haj Ismail : Measurement of the Cosmic Ray Energy Spectrum between 500 TeV and 100 PeV with IceTop
  Referee

Petra Van Mulders

- Master thesis, - Vrije Universiteit Brussel, June 2015 - Seth Moortgat : Development of new charm-tagging methods for Flavour Changing top-quark dark matter interactions at the LHC
  Referee

- Phd thesis, - Universiteit Gent, August 2015 - Guillaume Garcia : Top quark mass measurement in the electron+jets decay channel using the Matrix Element Method
  Referee

Pascal Vanlaer

- Phd thesis, - ULB, June 2015 - Romain Deschamps : Evolution of low and intermediate mass stars in binary systems: a new look at Algol systems
  Secretary

- Phd thesis, - ULB, February 2015 - Thomas Reis : Search for new massive resonances decaying to dielectrons or electron-muon pairs with the CMS detector
  Secretary

3.6.3 Representation in academic councils and committees (in universities)

Isabelle Ansseau

- Bureau du conseil du département de physique, ULB
- Conseil de faculté des sciences, ULB
- Conseil du département de physique, ULB

Freya Blekman

- IIHE website coordinator, Other
- Organiser open days etc Department of physics, VUB
- PR chairperson VUB faculty of science and bio-engineering, VUB
- Secretary Bachelors Exam Committee, VUB
- Secretary Masters Exam Committee, VUB
- Seminar organiser IIHE, Other

Barbara Clerbaux

- Elected as the representative of Academic Staff at the ULB university board (CA - , ULB
- Member of the "Commission administrative" of the ULB, ULB
- Member of the Faculty pedagogic committee, ULB
- Member of the Faculty promotion committee, ULB
- Members of Faculty full time academic position search committee, ULB
- Representative of the ULB rector at the Scientific Olympiads proclamation, 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
- 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

Catherine De Clercq

- Chair of the Womens council of VUB, VUB
- DNTK member of the Commissie Middelen en Personeel of the Science faculty, VUB
- Member of the Gender committee of the Science Faculty, VUB

Gilles De Lentdecker

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

Laurent Favart

- Membre de la commission doctorat, ULB
- Membre de la commission du Plan stratégique, ULB
- Membre de la commission facultative de recrutement académique d'astroparticules, ULB

Thomas Lenzi

- Représentant du corps scientifique dans la commission d'enseignement du département de Physique, ULB
- Représentant du corps scientifique dans le conseil de Physique, ULB

Steven Lowette

- Afgevaardigde DNTK in facultaire doctoraatscommissie, VUB
- Afgevaardigde DNTK in facultaire gendercommissie, VUB
- Lid van de examencommissie Master, VUB
- Verantwoordeljke internationalisering DNTK en afgevaardigde in de facultaire commissie internationalisering, VUB

Pierre Marage

- Directeur de section Institut des Hautes Etudes de Belgique, Other
- Membre du CA Altair, asbl d'Histoire des Sciences attachee a l'ULB, 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

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

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

- Organisation career event for IIHE particle physics students and postdocs - VUB, 12/02/2015
- Organiser Flemish version of CERN masterclass at VUB - VUB, 17/03/2015
- VUB contact person Flemish Physics Olympiad - Belgium, 11/02/2015

Barbara Clerbaux

- 60-years of Science for peace, large public and school exhibition at the occasion of the 60 years birthday of CERN, 3 weeks of exhibition, 16/12/2014-09/01/2015, organiser - Palais des Académies, Brussels, 01/01/2015
- Co-organisator to the interdisciplinary workshop - ULB, Brussels, 16/10/2015
- Contribution (with a talk) to the interdisciplinary workshop - ULB, Brussels, 09/03/2015

- Large public Colloquium, Particle physics after the 2013 Nobel Prize, A Colloquium dedicated to François Englert, co-organiser - Palais des Académies, Brussels, 28/03/2015

Catherine De Clercq

- talk : Het IceCube Neutrino Observatorium op de Zuidpool - Volkssterrenwacht Beisbroek, Brugge, Belgium, 07/01/2015

Krijn De Vries

- IIHE IceCube masterclass - masterclass - Full day - Brussels, Belgium, 18/03/2015
- IceCube - High school visit talk - 2h - IIHE, Brussels, Belgium, 23/10/2015
- IceCube - talk - 2h - Volkssterrenwacht Urania, Hove, Belgium, 24/11/2015
- New Physics beyond the Standard model - masterclass - IceCube 2h - University of Maastricht, Maastricht, The Netherlands, 09/03/2015

Gwenhaël De Wasseige

- IceCube masterclass organization - IIHE, 18/03/2015

Giuseppe Fasanella

- Search for heavy neutral resonances decaying in dielectron pairs - Bruxelles, 27/03/15

Steven Lowette

- BrightClub - Brussels, 13/10/2015
- Internationale dag industriele wetenschappen UHasselt/KULeuven - Diepenbeek, 31/03/2015
- Lezing Volkssterrenwacht Mira - Grimbergen, 26/09/2015
- VUB Campusbezoek - VUB, 15/01/2015
- VUB Campusbezoek - VUB, 27/04/2015
- VUB Campusbezoek - VUB, 05/03/2015
- VUB Campusbezoek - VUB, 03/02/2015

Lieselotte Moreels

- Guide at exhibition - Brussels, Belgium, from 06/01/2015 to 08/01/2015

Elisa Pinat

- Chasing the Ghost Particle - Planetarium, Brussels, 04/12/2015
- Chasing the Ghost Particle, forum discussion with students - VUB, Brussels, 17/02/2015
- IceCube Masterclass - IIHE Brussels, 18/03/2015

Nick Van Eijndhoven

- IceCube : Extreme Science at the South Pole (talk show) - Naturalis, Leiden, The Netherlands, 25/09/2015
- IceCube Masterclass - VUB, 18/03/2015
- Various campus visits, workshops and autumn camp - VUB (throughout the year), 15/01/2015

Petra Van Mulders

- CERN: zoektocht naar de fundamentele bouwstenen van het universum - Hasselt, 27/10/2015
- Multiple interviews in the written press as well as for the national radio broadcasting channel - Brussels, 2015
- PechaKucha presentation at campusTalks, VUB - Brussels, 10/03/2015

Catherine Vander Velde

- La découverte du boson de Brout, Englert et Higgs au LHC - CEPULB - ULB, 22/01/2015

Pascal Vanlaer

- Printemps des sciences: Invité lors de la projection du film - Maison de la Culture de Namur, 26/03/2015
- Que nous apporte la physique des particules ? - Antenne interuniversitaire ULB- UCL, Woluwé-St-Lambert, 10/02/2015

4 Publications

4.1 Refereed journals and conference proceedings

4.1.1 CMS

1. *Angular coefficients of Z bosons produced in pp collisions at $\sqrt{s}$ = 8 TeV and decaying to $\mu^+\mu^-$ as a function of transverse momentum and rapidity*
   V. Khachatryan *et al.* [CMS Collaboration]
   Phys. Lett. B **750** (2015) 15

2. *Combined Measurement of the Higgs Boson Mass in pp Collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS and CMS Experiments*
   G. Aad *et al.* [ATLAS and CMS Collaborations]
   Phys. Rev. Lett. **114** (2015) 19180

3. *Comparison of the Z/γ + jets to γ + jets cross sections in pp collisions at $\sqrt{s} = 8$ TeV*
   V. Khachatryan *et al.* [CMS Collaboration]
   JHEP **1510** (2015) 12

4. *Constraints on parton distribution functions and extraction of the strong coupling constant from the inclusive jet cross section in pp collisions at $\sqrt{s} = 7$ TeV*
   V. Khachatryan *et al.* [CMS Collaboration]
   Eur. Phys. J. C **75** (2015) no.6, 28

5. *Constraints on the pMSSM, AMSB model and on other models from the search for long-lived charged particles in proton-proton collisions at $\sqrt{s}$ = 8 TeV*
   V. Khachatryan *et al.* [CMS Collaboration]
   Eur. Phys. J. C **75** (2015) no.7, 32

6. *Constraints on the spin-parity and anomalous HVV couplings of the Higgs boson in proton collisions at 7 and 8 TeV*
   V. Khachatryan *et al.* [CMS Collaboration]
   Phys. Rev. D **92** (2015) no.1, 01200

7. *Differential cross section measurements for the production of a W boson in association with jets in proton–proton collisions at $\sqrt{s} = 7$ TeV*
   V. Khachatryan *et al.* [CMS Collaboration]
   Phys. Lett. B **741** (2015) 1

8. *Distributions of Topological Observables in Inclusive Three- and Four-Jet Events in pp Collisions at $\sqrt{s}$ = 7 TeV*
   V. Khachatryan *et al.* [CMS Collaboration]
   Eur. Phys. J. C **75** (2015) no.7, 30

9. *Evidence for Collective Multiparticle Correlations in p-Pb Collisions*
   V. Khachatryan *et al.* [CMS Collaboration]
   Phys. Rev. Lett. **115** (2015) no.1, 01230

10. *Evidence for transverse momentum and pseudorapidity dependent event plane fluctuations in PbPb and pPb collisions*
    V. Khachatryan *et al.* [CMS Collaboration]
    Phys. Rev. C **92** (2015) no.3, 03491

11. *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) no.13, 13230

12. *Impact of low-dose electron irradiation on* n^+p *silicon strip sensors*
W. Adam *et al.* [CMS Tracker Group Collaboration]
Nucl. Instrum. Meth. A **803** (2015) 10

13. *Limits on the Higgs boson lifetime and width from its decay to four charged leptons*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **92** (2015) no.7, 07201

14. *Long-range two-particle correlations of strange hadrons with charged particles in pPb and PbPb collisions at LHC energies*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **742** (2015) 20

15. *Measurement of diffraction dissociation cross sections in pp collisions at* $\sqrt{s}$ *= 7 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **92** (2015) no.1, 01200

16. *Measurement of electroweak production of two jets in association with a Z boson in proton-proton collisions at* $\sqrt{s} = 8\,TeV$
V. Khachatryan *et al.* [CMS Collaboration]
Eur. Phys. J. C **75** (2015) no.2, 6

17. *Measurement of J/ and (2S) Prompt Double-Differential Cross Sections in pp Collisions at* $\sqrt{s}$*=7TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. Lett. **114** (2015) no.19, 19180

18. *Measurement of jet multiplicity distributions in* $\mathrm{t\bar{t}}$ *production in pp collisions at* $\sqrt{s} = 7\,TeV$
S. Chatrchyan *et al.* [CMS Collaboration]
Eur. Phys. J. C **74** (2015) 301

19. *Measurement of the* $pp \to ZZ$ *production cross section and constraints on anomalous triple gauge couplings in four-lepton final states at* $\sqrt{s}$ *=8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **740** (2015) 25

20. *Measurement of the cross section ratio* $\sigma_{\mathrm{t\bar{t}b\bar{b}}}/\sigma_{\mathrm{t\bar{t}jj}}$ *in pp collisions at* $\sqrt{s}$ *= 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **746** (2015) 13

21. *Measurement of the differential cross section for top quark pair production in pp collisions at* $\sqrt{s} = 8\,TeV$
V. Khachatryan *et al.* [CMS Collaboration]
Eur. Phys. J. C **75** (2015) no.11, 54

22. *Measurement of the inclusive 3-jet production differential cross section in proton–proton collisions at 7 TeV and determination of the strong coupling constant in the TeV range*
V. Khachatryan *et al.* [CMS Collaboration]
Eur. Phys. J. C **75** (2015) no.5, 18

23. *Measurement of the production cross section ratio $\sigma(Xb2(1P))$ / $\sigma(Xb1(1P)$ in pp collisions at $\sqrt{s}$ = 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **743** (2015) 38

24. *Measurement of the ratio of the production cross sections times branching fractions of $B_c^{\pm} \to J/\psi\pi^{\pm}$ and $B^{\pm} \to J/\psi K^{\pm}$ and $\mathcal{B}(B_c^{\pm} \to J/\psi\pi^{\pm}\pi^{\pm}\pi^{\mp})/\mathcal{B}(B_c^{\pm} \to J/\psi\pi^{\pm})$ in pp collisions at $\sqrt{s}$ = 7 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1501** (2015) 06

25. *Measurement of the underlying event activity using charged-particle jets in proton-proton collisions at $\sqrt{s}$ = 2.76 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1509** (2015) 13

26. *Measurement of the W boson helicity in events with a single reconstructed top quark in pp collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1501** (2015) 05

27. *Measurement of the Z boson differential cross section in transverse momentum and rapidity in proton–proton collisions at 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **749** (2015) 18

28. *Measurement of the Z Production Cross Section in pp Collisions at 8 TeV and Search for Anomalous Triple Gauge Boson Couplings*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1504** (2015) 16

29. *Measurements of differential and double-differential Drell-Yan cross sections in proton-proton collisions at 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Eur. Phys. J. C **75** (2015) no.4, 14

30. *Measurements of jet multiplicity and differential production cross sections of Z+ jets events in proton-proton collisions at $\sqrt{s}$ = 7 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **91** (2015) no.5, 05200

31. *Measurements of the* Z Z *production cross sections in the* 2l2ν *channel in proton–proton collisions at $\sqrt{s}$ =* 7 *and* 8 TeV *and combined constraints on triple gauge couplings*
V. Khachatryan *et al.* [CMS Collaboration]
Eur. Phys. J. C **75** (2015) no.10, 51

32. *Measurements of the $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ differential cross sections in pp collisions at $\sqrt{s}$ = 7 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **749** (2015) 1

33. *Nuclear Effects on the Transverse Momentum Spectra of Charged Particles in pPb Collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Eur. Phys. J. C **75** (2015) no.5, 23

34. *Observation of the rare $B_s^0 \to \mu^+\mu^-$ decay from the combined analysis of CMS and LHCb data*
V. Khachatryan *et al.* [CMS and LHCb Collaborations]
Nature **522** (2015) 6

35. *Performance of Electron Reconstruction and Selection with the CMS Detector in Proton-Proton Collisions at $\sqrt{s}$ = 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JINST **10** (2015) no.06, P0600

36. *Performance of Photon Reconstruction and Identification with the CMS Detector in Proton-Proton Collisions at $\sqrt{s}$ = 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JINST **10** (2015) no.08, P0801

37. *Performance of the CMS missing transverse momentum reconstruction in pp data at $\sqrt{s}$ = 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JINST **10** (2015) no.02, P0200

38. *Precise determination of the mass of the Higgs boson and tests of compatibility of its couplings with the standard model predictions using proton collisions at 7 and 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Eur. Phys. J. C **75** (2015) no.5, 21

39. *Production of leading charged particles and leading charged-particle jets at small transverse momenta in pp collisions at $\sqrt{s}$ = 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **92** (2015) no.11, 11200

40. *Pseudorapidity distribution of charged hadrons in proton-proton collisions at $\sqrt{s}$ = 13 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **751** (2015) 14

41. *Search for a charged Higgs boson in pp collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1511** (2015) 01

42. *Search for a Higgs Boson in the Mass Range from 145 to 1000 GeV Decaying to a Pair of W or Z Bosons*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1510** (2015) 14

43. *Search for a light charged Higgs boson decaying to $c\bar{s}$ in pp collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1512** (2015) 17

44. *Search for a pseudoscalar boson decaying into a Z boson and the 125 GeV Higgs boson in $^+b\bar{b}$ final states*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **748** (2015) 22

45. *Search for a Standard Model Higgs Boson Produced in Association with a Top-Quark Pair and Decaying to Bottom Quarks Using a Matrix Element Method*
V. Khachatryan *et al.* [CMS Collaboration]

Eur. Phys. J. C **75** (2015) no.6, 25

46. *Search for a standard model-like Higgs boson in the $\mu^+\mu^-$ and e^+e decay channels at the LHC*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **744** (2015) 18

47. *Search for dark matter, extra dimensions, and unparticles in monojet events in proton–proton collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Eur. Phys. J. C **75** (2015) no.5, 23

48. *Search for Decays of Stopped Long-Lived Particles Produced in Proton–Proton Collisions at $\sqrt{s} = 8\,TeV$*
V. Khachatryan *et al.* [CMS Collaboration]
Eur. Phys. J. C **75** (2015) no.4, 15

49. *Search for diphoton resonances in the mass range from 150 to 850 GeV in pp collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **750** (2015) 49

50. *Search for disappearing tracks in proton-proton collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1501** (2015) 09

51. *Search for Displaced Supersymmetry in events with an electron and a muon with large impact parameters*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. Lett. **114** (2015) no.6, 06180

52. *Search for heavy Majorana neutrinos in $\mu^\pm\mu^\pm$+ jets events in proton-proton collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **748** (2015) 14

53. *Search for Lepton-Flavour-Violating Decays of the Higgs Boson*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **749** (2015) 33

54. *Search for Long-Lived Neutral Particles Decaying to Quark-Antiquark Pairs in Proton-Proton Collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **91** (2015) no.1, 01200

55. *Search for long-lived particles that decay into final states containing two electrons or two muons in proton-proton collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **91** (2015) no.5, 05201

56. *Search for Monotop Signatures in Proton-Proton Collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. Lett. **114** (2015) no.10, 10180

57. *Search for Narrow High-Mass Resonances in Proton–Proton Collisions at $\sqrt{s}$ = 8 TeV Decaying to a Z and a Higgs Boson*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **748** (2015) 25

58. *Search for neutral color-octet weak-triplet scalar particles in proton-proton collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1509** (2015) 20

59. *Search for neutral MSSM Higgs bosons decaying into a pair of bottom quarks*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1511** (2015) 07

60. *Search for new physics in events with same-sign dileptons and jets in pp collisions at $\sqrt{s}$ = 8 TeV*
S. Chatrchyan *et al.* [CMS Collaboration]
JHEP **1401** (2014) 16

61. *Search for new resonances decaying via WZ to leptons in proton-proton collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **740** (2015) 8

62. *Search for pair-produced resonances decaying to jet pairs in proton–proton collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **747** (2015) 9

63. *Search for physics beyond the standard model in dilepton mass spectra in proton-proton collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1504** (2015) 02

64. *Search for Physics Beyond the Standard Model in Events with Two Leptons, Jets, and Missing Transverse Momentum in pp Collisions at sqrt(s) = 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1504** (2015) 12

65. *Search for physics beyond the standard model in final states with a lepton and missing transverse energy in proton-proton collisions at sqrt(s) = 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **91** (2015) no.9, 09200

66. *Search for quark contact interactions and extra spatial dimensions using dijet angular distributions in proton–proton collisions at $\sqrt{s}$ = 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **746** (2015) 7

67. *Search for resonances and quantum black holes using dijet mass spectra in proton-proton collisions at $\sqrt{s} = 8$ TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **91** (2015) no.5, 05200

68. *Search for resonant pair production of Higgs bosons decaying to two bottom quark–antiquark pairs in proton–proton collisions at 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **749** (2015) 56

69. *Search for stealth supersymmetry in events with jets, either photons or leptons, and low missing transverse momentum in pp collisions at 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **743** (2015) 50

70. *Search for supersymmetry in the vector-boson fusion topology in proton-proton collisions at* $\sqrt{s} = 8$ *TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1511** (2015) 18

71. *Search for Supersymmetry Using Razor Variables in Events with b-Tagged Jets in pp Collisions at* $\sqrt{s} = 8$ *TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **91** (2015) 05201

72. *Search for supersymmetry with photons in pp collisions at* $\sqrt{s}$*=8TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **92** (2015) no.7, 07200

73. *Search for the production of dark matter in association with top-quark pairs in the single-lepton final state in proton-proton collisions at* $\sqrt{s} = 8$ *TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1506** (2015) 12

74. *Search for the standard model Higgs boson produced through vector boson fusion and decaying to* $b\bar{b}$
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **92** (2015) no.3, 03200

75. *Search for Third-Generation Scalar Leptoquarks in the* $t\tau$ *Channel in Proton-Proton Collisions at* $\sqrt{s} = 8$ *TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1507** (2015) 04

76. *Search for vector-like T quarks decaying to top quarks and Higgs bosons in the all-hadronic channel using jet substructure*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1506** (2015) 08

77. *Searches for supersymmetry based on events with b jets and four W bosons in pp collisions at 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **745** (2015)

78. *Searches for Supersymmetry using the* M_{T2} *Variable in Hadronic Events Produced in pp Collisions at 8 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
JHEP **1505** (2015) 07

79. *Searches for third-generation squark production in fully hadronic final states in proton-proton collisions at* $\sqrt{s} = 8$ *TeV*
V. Khachatryan *et al.* [CMS Collaboration]

JHEP **1506** (2015) 11

80. *Study of Final-State Radiation in Decays of Z Bosons Produced in pp Collisions at 7 TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. D **91** (2015) no.9, 09201

81. *Study of vector boson scattering and search for new physics in events with two same-sign leptons and two jets*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Rev. Lett. **114** (2015) no.5, 05180

82. *Study of W boson production in pPb collisions at* $\sqrt{s_{\rm NN}} = 5.02$ *TeV*
V. Khachatryan *et al.* [CMS Collaboration]
Phys. Lett. B **750** (2015) 56

83. *Study of Z production in PbPb and pp collisions at* $\sqrt{s_{\rm NN}} = 2.76$ *TeV in the dimuon and dielectron decay channels*
S. Chatrchyan *et al.* [CMS Collaboration]
JHEP **1503** (2015) 02

4.1.2 H1

1. *Combination of differential* $D^{\pm}$ *cross-section measurements in deep-inelastic ep scattering at HERA*
H. Abramowicz it et al. [H1 and ZEUS Collaborations]
JHEP f 1509 (2015) 149

2. *Combination of measurements of inclusive deep inelastic* $e^{\pm}p$ *scattering cross sections and QCD analysis of HERA data*
H. Abramowicz it et al. [H1 and ZEUS Collaborations]
Eur. Phys. J. C f 75 (2015) no.12, 580

3. *Diffractive Dijet Production with a Leading Proton in ep Collisions at HERA*
V. Andreev it et al. [H1 Collaboration]
JHEP f 1505 (2015) 056

4.1.3 IceCube

1. *A Combined Maximum-Likelihood Analysis of the High-Energy Astrophysical Neutrino Flux Measured with IceCube*
M. G. Aartsen et al [IceCube Collaboration]
Astrophysical Journal 809 (2015) 98

2. *Atmospheric and Astrophysical Neutrinos above 1 TeV Interacting in IceCube*
M. G. Aartsen et al [IceCube Collaboration]
Physical Review D91 (2015) 022001

3. *Detection of a Type IIn Supernova in Optical Follow-up Observations of IceCube Neutrino Events*
M. G. Aartsen et al [IceCube Collaboration]
Astrophysical Journal 811 (2015) 52

4. *Determining Neutrino Oscillation Parameters from Atmospheric Muon Neutrino Disappearance with Three Years of IceCube DeepCore Data*
   M. G. Aartsen et al [IceCube Collaboration]
   Physical Review D91 (2015) 072004

5. *Development of a General Analysis and Unfolding Scheme and its Application to Measure the Energy Spectrum of Atmospheric Neutrinos with IceCube*
   M. G. Aartsen et al [IceCube Collaboration]
   European Physical Journal C75 (2015) 116

6. *Evidence for Astrophysical Muon Neutrinos from the Northern Sky with IceCube*
   M. G. Aartsen et al [IceCube Collaboration]
   Physical Review Letters 115 (2015) 081102

7. *Flavor Ratio of Astrophysical Neutrinos above 35 TeV in IceCube*
   M. G. Aartsen et al [IceCube Collaboration]
   Physical Review Letters 114 (2015) 171102

8. *Measurement of the Atmospheric ν_e Spectrum with IceCube*
   M. G. Aartsen et al [IceCube Collaboration]
   Physical Review D91 (2015) 122004

9. *Multipole Analysis of IceCube Data to Search for Dark Matter Accumulated in the Galactic Halo*
   M. G. Aartsen et al [IceCube Collaboration]
   The European Physical Journal C75

10. *Search for Dark Matter Annihilation in the Galactic Center with IceCube-79*
    M. G. Aartsen et al [IceCube Collaboration]
    European Physical Journal C75 (2015) 492

11. *Search for Prompt Neutrino Emission from Gamma-Ray Bursts with IceCube*
    M. G. Aartsen et al [IceCube Collaboration]
    Astrophysical Journal Letters 805 (2015) L5

12. *Searches for Small-Scale Anisotropies from Neutrino Point Sources with Three Years of IceCube Data*
    M. G. Aartsen et al [IceCube Collaboration]
    Astroparticle Physics 66 (2015) 39-52

13. *Searches for Time Dependent Neutrino Sources with IceCube Data from 2008 to 2012*
    M. G. Aartsen et al [IceCube Collaboration]
    Astrophysical Journal 807 (2015) 46

14. *The IceCube Neutrino Observatory - Contributions to International Cosmic Ray Conference 2015 Part V: Neutrino Oscillations and Supernova Searches*
    M. G. Aartsen et al [IceCube Collaboration]
    Contributions to the 34th International Cosmic Ray Conference, The Hague, The Netherlands, 30 July - 6 August 2015

15. *The IceProd Framework: Distributed Data Processing for the IceCube Neutrino Observatory*
    M. G. Aartsen et al [IceCube Collaboration]
    Journal of Parallel and Distributed Computing 75 (2015)

4.1.4 JUNO

1. *JUNO Conceptual Design Report*
   Z. Djurcic it et al. [JUNO Collaboration]
   arXiv:1508.07166 [physics.ins-det]

4.1.5 OPERA

1. *Discovery of au Neutrino Appearance in the CNGS Neutrino Beam with the OPERA Experiment*
   N. Agafonova it et al. [OPERA Collaboration]
   Phys. Rev. Lett. f 115 (2015) no.12, 121802

2. *Limits on muon-neutrino to tau-neutrino oscillations induced by a sterile neutrino state obtained by OPERA at the CNGS beam*
   N. Agafonova it et al. [OPERA Collaboration]
   JHEP f 1506 (2015) 069

4.1.6 PHENO

1. *Anatomy of the Amplituhedron*
   A. Mariotti et al.
   JHEP **1503** (2015) 128

2. *Dark Matter Benchmark Models for Early LHC Run-2 Searches: Report of the ATLAS/CMS Dark Matter Forum*
   D. Abercrombie et al.
   arXiv:1507.00966 [hep-ex]

3. *General squark flavour mixing: constraints, phenomenology and benchmarks*
   K. De Causmaecker et al.
   JHEP **1511** (2015) 125

4. *Higgs production in association with a single top quark at the LHC*
   K. Mawatari et al.
   Eur. Phys. J. C **75** (2015) no.6, 267

5. *Higher-order QCD predictions for dark matter production at the LHC in simplified models with s-channel mediators*
   K. Mawatari et al.
   Eur. Phys. J. C **75** (2015) no.10, 482

6. *Probing top-philic sgluons with LHC Run I data*
   L. Beck, F. Blekman, D. Dobur, J. Keaveney, K. Mawatari et al.
   Phys. Lett. B **746** (2015) 48

7. *Rosetta: an operator basis translator for Standard Model effective field theory*
   K. Mawatari et al.
   Eur. Phys. J. C **75** (2015) no.12, 583

8. *Search for Kaluza-Klein gravitons in extra dimension models via forward detectors at the LHC*
   K. Mawatari et al.

Phys. Rev. D **91** (2015) no.11, 115015

9. *Signals of a superlight gravitino at the LHC*
K. Mawatari et al.
JHEP **1504** (2015) 021

10. *Signs of Tops from Highly Mixed Stops*
A. Mariotti et al.
JHEP **1506** (2015) 122

11. *Singlet-Doublet Model: Dark matter searches and LHC constraints*
A. Mariotti, P. Tziveloglou et al.
JHEP **1510** (2015) 116

12. *Z-peaked excess in goldstini scenarios*
A. Mariotti, K. Mawatari, M. Vereecken et al.
Phys. Lett. B **750** (2015) 539

4.2 Refereed public and internal documents

1. *An MCMC study of general squark flavour mixing in the MSSM*
K. De Causmaecker et al.
PoS EPS-HEP2015 (2015)

2. *Angular correlations of Z+jets events in pp collisions at central mass of 8 TeV*
F. Zhang, L. Favart, A. Leonard, T. Seva
CMS AN-2015/033

3. *Combination of b-tagging efficiency measurements for the Legacy Rereco of 2011 data at 7 TeV pp collision*
P. Van Mulders et al.
CMS AN-2015/043

4. *Dielectron resonance search in Run 2 at $\sqrt{s}$ = 13 TeV pp collisions*
B. Clerbaux, G. Fasanella, W. Fang, R. Goldouzian, A. Randle-Conde, T. Reis, P. Vanlaer et al.
CMS AN-2015/222

5. *Differential cross section measurements for the production of a Z boson in association with jets in proton-proton collisions at $\sqrt{s}$ = 13 TeV*
L. Favart, A. Grebenyuk, T. Seva, F. Zhang et al.
CMS AN-2015/219

6. *Differential cross section of the production of a W boson in association with jets at $\sqrt{s}$ = 13 TeV*
L. Favart, A. Grebenyuk, T. Seva, F. Zhang et al.
CMS AN-2015/247

7. *ECAL gain switch validation study with electrons*
B. Clerbaux, G. Fasanella et al.
CMS AN-2015/015

8. *General squark flavour mixing : constraints, phenomenology and benchmarks*
K. De Causmaecker et al.
Journal of High Energy Physics, Vol. 2015, No. 11, 125 (2015)

9. *HEEP Selection efficiency Scale Factor Study for CMS in Run 2*
B. Clerbaux, W. Fang, R. Goldouzian, A. Randle-Conde et al.
CMS AN-2015/320

10. *Implementation and training of a multivariate b-tagging algorithm using secondary vertex, jet probability and soft lepton information*
P. Van Mulders et al.
CMS AN-2015/145

11. *Inclusive WIMP searches using alphaT in final states with jets and missing transverse momentum at $\sqrt{s}$ = 13 TeV pp collisions*
F. Blekman, D. Smith et al.
CMS AN-2015/279

12. *Preparations for a dielectron resonance search in Run 2 at $\sqrt{s}$ =13 TeV pp collisions*
B. Clerbaux, W.Fang, G. Fasanella, A. Randle-Conde, T. Reis, P. Vanlaer et al.
CMS AN-2015/058

13. *Search for a BSM Higgs boson decaying to a pair of light bosons with two muons and two taus in the final state*
C. Caillol, B. Clerbaux et al.
CMS AN-2015/124

14. *Search for a high mass scalar boson decaying into a pair of Z bosons in the 2l2nu final state.*
P. Vanlaer, H. Delannoy, G. Karapostoli, H. Brun et al.
CMS AN-2015/208

15. *Search for Displaced Supersymmetry in Dilepton Final States at 13 TeV*
F. Blekman, Q. Python et al.
CMS AN-2015/206

16. *Search for Four Top Quarks Production at 13 TeV in the Dilepton Channel*
F. Blekman, L. Beck, D. Lontkovskyi et al.
CMS AN-2015/127

17. *Search for invisible Higgs bosons in $pp \to ZH \to 2l + MET$ channels at $\sqrt{s}$ =13 TeV*
H. Brun, B. Clerbaux, H. Delannoy, G. Karapostoli, N. Postiau, P. Vanlaer et al.
CMS AN-2015/322

18. *Search for new physics in final states with jets and missing transverse momentum in $\sqrt{s}$ = 13 TeV pp collisions with the α_T variable*
F. Blekman, D. Smith et al.
CMS AN-2015/004

19. *Search for New Physics in the Monojet Final State*
S. Lowette, B. Clerbaux, N. Daci, I. De Bruyn, D. Vannerom et al.
CMS AN-2015/072

20. *Search for new physics in the monojet final state in CMS at $\sqrt{s}$ = 13 TeV*
S. Lowette, B. Clerbaux, D. Vannerom, I. De Bruyn, N. Daci et al.
CMS AN-2015/232

21. *Search for scalar top quark pair production in the dilepton final state at $\sqrt{s}$ = 13 TeV*
D. Dobur, S. Lowette et al.
CMS AN-2015/266

22. *Search for standard model four-top-quark production at 13 TeV in the single lepton+jets channel*
L. Beck, F. Blekman, D. Lontkovskyi, J. Keaveney et al.
CMS AN-2015/128

23. *Studies of two Egamma tag and probe HLT trigger paths for CMS in Run 2*
W. Fang, A. Randle-Conde, B. Clerbaux et al.
CMS AN-2015/143

24. *Study of future prospects of searches for massive dielectron resonances at CMS for different detector scenarios in Phase I and Phase II at $\sqrt{s}$ = 14 TeV*
B. Clerbaux, A. Randle-Conde et al.
CMS AN-2015/057

25. *Training and performance of the CSVv2 tagger*
P. Van Mulders, S. Abu Zeid, G. Van Onsem, K. Deroover et al.
CMS AN-2015/103