ODYSSEUS
Topwetenschap in Vlaanderen

Application Form

Odysseus-programme

Part A: Administrative Details and Project Summary

Administrative Details of Applicant

Family Name	Blekman	**Birth Family Name**	
First Name (s)	Freya		
Gender	Female x / Male	*Date of Birth*	(16/11/1974)
1st Nationality	Dutch	*2nd Nationality*	
Country of Residence	Switzerland	*Country of Birth*	Netherlands

Contact address

Street Name and number	Rue de Lausanne 87				
PO Box		Postal Code	1202	Cedex	
Town	Genève	Country	Switzerland		
Phone 1	+41 765467148	Phone 2		Fax	
e-mail	freya.blekman@cern.ch				

Qualifications

University degree	*Date of award (DD/MM/YYYY)*	09/02/2000
Doctorate	*Date of award (DD/MM/YYYY)*	01/04/2005
Full-time postdoctoral experience	*Number of months*	**In Oct 2008: 43 months**

Place of activity (previous 5 years)

From	2000	*To*	2005	*Country*	60 % Netherlands, 40% United States
From	2005	*To*	2007	*Country*	United Kingdom
From	2007	*To*	Now	*Country*	United States and Switzerland

Proposed start date of the Award		*(01/10/2009)*
Choose	*Odysseus Group I project*	*Odysseus Group II project*

Administrative Details of Host Institution

Name of host institution					
Name of research unit/department					
Local co-promotor					

Legal address

Street Name and Number					
Postal Code		*Town*		*Country*	
Phone 1		*Phone 2*		*Fax*	
Web site					

Part A: Administrative Details and Project Summary

Project Summary

Project title (maximum 100 characters)

New physics at the Energy Frontier: Supersymmetry search at the Compact Muon Solenoid

Project summary (maximum 300 words)

At the presently accessible energies, elementary particle interactions are well described by the Standard Model. The Standard Model however has some fundamental limitations, and is expected to be no longer valid at energies that are easily accessed by the Large Hadron Collider (LHC) when it starts operation in 2009 The LHC will collide protons at a centre-of-mass energy of 14 TeV, which is a factor 7 higher than Tevatron, the most powerful accelerator in operation Today.

. The LHC has been designed for the discovery of new physics in mind, with one of the key motivations the potential discovery of a range of new particles at higher interaction energy. There are many possible ways (some very spectacular) in which the breakdown of the Standard Model is predicted to be observable, but one of the most elegant solutions is the introduction of Supersymmetry. I propose to use the Compact Muon Solenoid (CMS) detector to examine the LHC data for new physics phenomena and Supersymmetry in specific. A particular background for Supersymmetric particle production at the LHC is the production of top quarks that mimic the production of new physics.

I am convinced that the discovery of new physics at the LHC will be done by detailed studies of well understood physics. The VUB/IIHE group already has a complementary activity in top quark physics, and I choose to focus on this particular experimental signature as it combines a solid experimental base in which I already have expertise with an environment in which Supersymmetry is very likely to be observed. If Supersymmetry or for that matter new particles, extra dimensions or additional symmetries exist in nature, top quark physics will be its background. I intend to use this event topology that is familiar to me as a gateway to more general Supersymmetric physics studies at CMS.

Total Budget Required (in €)				
Year	*Personnel*	*Travel* *Material Costs* *Consumables*	*Equipment*	*Total*
1				
2				
3				
4				
5				
Total				

Approved Budget (not to be filled in by the applicant):

APPLICANT DECLARATION

In completing this application for an Odysseus Project, I confirm that:

1. If a Odysseus project is offered,

- I will accept the terms and conditions applied by the sponsoring participating organisation.

- I will devote my full working time to activities directly related to the research in this application.

- I agree that the executive summary of my application may be used for press information purposes.

2. To the best of my knowledge and belief, the information in this application is correct.

Signature of the applicant*… ….. ……………****Date****……14 October 2008……………*

Host Institution Declaration

In submitting this application for an Odysseus Project, we confirm on behalf of the administrative authority of
[Name of host institution] that:

1. *We support ~~this application~~ and if a Odysseus Project is offered we guarantee to provide the award holder with the support, research infrastructure and access to facilities necessary to carry out the proposed research (See also Part E, Appendix 2).*

2. *We will accept the terms and conditions applied by the sponsoring participating organisation.*

3. *We are authorised to make this declaration on behalf of the administrative authority.*

4. *Annexes: A) - B) - C)*

   A) Reasons for the nomination (in English) in maximum 600 words.
   B) Title of the project in Dutch in max. 3 x 240 characters and/or spaces.
   C) Project outline in Dutch in max. 300 words.

Name rector…………………………………………..

Signature………………………………………………………....

Date…………………………………

Local co-promotor

Name in Block Capitals…………………………………………...

Signature………………………………………………………....
Date…………………………………………….

Name of applicant:

Host institution:

Case for Support

Parts B, C, D, E, F and Appendices

Note: ***Parts B, C, D and E*** should be completed in free style but you must address the numbered issues in each part (in number order). Furthermore you should do so in the context of the purpose of the scheme i.e. ***to enable excellent researchers that developed their career abroad to start up a research team or research line with an initial financial support with the purpose to integrate progressively in the Flemish research area***. Therefore, in addressing the issue you should attempt to demonstrate that ***you*** meet these criteria in terms of your track record, the research you are now proposing and the suitability of the host institution to contribute to these goals.

Part B: Background of the Applicant

Scientific track record (maximum 4 sides A4) to include:

B.1 Summary of results and conclusions of your recent work in the scientific area covered by the research proposal.

B.2 Information on current or past sources of research funding. Postdoctoral positions: name of the institution, address, name of the head, phone, email, date of the beginning, date of the end, name of the position hold.

B.3 Experience in working as an independent researcher, team leadership and project management.

B.4 Your ten most relevant publications.

B.5 Why the Odysseus project would be timely for you at this point in your career path.

B.6 Research collaborations (both national and international).

B.7 Information on prizes or special awards given in recognition of your scientific achievement.

B.8 Other.

Part C: Project Description

Provide a detailed project description (Max 10 sides A4 not including Work Plan; see C. 9) that addresses:

C.1 Overall aims and objectives of the research.

C.2 Proposed methodology to be used.

C.3 Novelty and groundbreaking character of the proposed research.

C.4 Management of the project.

C.5 Positioning of the project in the international context of research in this field.

C.6 Expected results in relation to the current international status of research in this field.

C.7 Impact and potential for promoting scientific innovation, both inside and outside the field.

C.8 Work Plan (maximum 1 side A4) Milestones and targets for the proposal.

Part D: Embedding of the team in the host-institution

D.1 Embedding of the team in the host institution

D.2 Embedding of the team in the existing teams

D.3 Multiplicator effect in the host institution

Part E: Financial Plan and Justification of Resources Awarded

Include a detailed budget for the 5-year period

Part F: Host Institution (maximum 1 side A4)

Include a statement on the host institution, covering your knowledge of its reputation and facilities, any existing or previous collaboration with it and the reason you have chosen it.

Appendix 1: CV of Applicant (10 sides A4 recommended)

Appendix 2: Letter from the Host Institution

This letter, signed by a person authorised by the administrative authority of the host research institution should describe the nature and level of support that will be available to the applicant for the duration of the award. The following should be included but the list is not exhaustive:

- The position offered to the applicant in the case the project is awarded.
- A description of the research infrastructure that will be made available (equipment, computing (normal and where relevant, high speed computing), fixed research infrastructure such as clean rooms etc. and the *level* of access to be given to them.
- Arrangements in place with other research institutions for access to their facilities which will be extended to the award holder.
- Technical support services for example materials or biological sample testing, calibration / technical support for instrumentation etc.
- Scientific support and encouragement from academic staff and other researchers in related areas of research or areas where synergy could be developed through collaboration.

Appendix 3: Letters of Recommendation (in English) in Support of Your Application

Two (no more, no less) letters are required. They should be from scientists of your choice who have a recognised well established international reputation in the area of your research. These letters should attempt to give an impartial assessment of your qualities related to the selection criteria.

The application form and all documentation required should be submitted to the **host university.**

B Background of Freya Blekman

My expertise lies in the following areas:

- **Top quark physics expert**, I am the developer of one of the leading data analyses in top quark physics at the Tevatron proton-antiproton collider at Fermilab. I am specialised in the use of hadron collider data for background modeling, the use of displaced vertexing for the identification of b quarks in a very high multiplicity hadron collider environment and have years of experience in the use of advanced analysis techniques like neural networks.
- **CMS expert,** the Compact Muon Solenoid is one of the two general purpose experiments at the Large Hadron Collider, starting operation in the near future. In the CMS collaboration I have made substantial contributions on the development of the reconstruction software as one of the software experts. I have a leading role in the detector installation and software development in the CMS collaboration and have in-depth knowledge of the detector and the reconstruction- and GRID software necessary to analyse the data that it produces.
- **Silicon based tracking expert**, I have already worked on the installation of two silicon based tracking detectors (the CMS pixel detector and the Dzero microstrip vertex detector) and have essential expertise on both the construction, commissioning and day to day operation of those. Tracking detectors, which are closest to the collision point, are used to measure the tracks of charged particles. The use of silicon technology provides an accurate measurement of the particle's momentum means that these detectors are instrumental for the identification of long-lived particles, the key example being b quark identification.

The following paragraphs describe my research career in more detail.

B.1 Freya Blekman: summary of recent work and results

The top (t) quark is the heaviest known elementary particle, it is about twice as massive as the next most massive particle (the Z boson) and over an order of magnitude more heavy than the bottom (b) quark, which is the second most massive quark. Top quark decays are well understood in the Standard Model, over 99% of them create a b quark and a W boson when they decay. Because of this well-defined branching fraction, top quark measurements are typically classified by the considered decay modes of the W boson. The very high top quark mass ($\approx 172\ \mathrm{GeV/c^2}$) severely limits the places where this fundamental particle can be studied. The Tevatron collider at Fermilab collides protons on antiprotons at an interaction energy of $2\ \mathrm{TeV}$ and is the only accelerator where top quarks are produced, but only in small numbers. The small number of available top quarks has made it impossible to study the properties of the top quark in detail. Generally considered the predecessor of the Large Hadron Collider (LHC), which will collide protons at $14\ \mathrm{TeV}$, the Tevatron is the only environment where hadrons are collided at high energy and intensity as by the LHC. The Dzero experiment is one of only two particle physics experiments at the Tevatron, and the collaboration includes more than 500 physicists from all over the world.

My Ph.D research was on the hadronic channel in top quark pair production at the Dzero experiment. Top quark production in the hadronic channel, when top quark pairs decay to six lighter quarks, is renowned for its overwhelming background; the dominating background of QCD multi-jet production being five orders of magnitude more common than the expected signal. I developed a method to successfully distinguish the top quark signal from its substantial background. The analysis, which was presented at several international conferences, was the first study performed in this particular channel at the Tevatron Run 2 energy of $2\ \mathrm{TeV/c^2}$. My methods were particularly successful due to their innovative combination of modern analysis techniques to disentangle signal and background. In the hadronic decay of top quark pairs, the separation of top signal from QCD multijet background is so difficult that, even after b-quark jet identification using secondary vertex tagging, it is necessary to use complex multivariate analysis techniques to isolate the signal. In this particular analysis I used a three-level artificial neural network to describe how 'top-like' observed events were. Multivariate techniques and particularly neural networks are very powerful tools that can only be used when the input data is extremely well understood. This meant that the use of neural networks, particularly the systematical studies required to confirm the analysis is unbiased, can be very cumbersome. However, when used with caution and some healthy scepticism, the use of a neural net can actually yield considerable gains in purity or efficiency over cut-based analysis techniques.

The multi-jet data was collected with a dedicated trigger, designed by me for the selection of events with many jets. Some of the unique problems with this background dominated analysis concerned the fact that the jets in some of the background events were actually coming from different original collisions, a problem that we will also have to deal with at the LHC, not every collision will consist of two hard proton collisions but some will! As we bias ourselves to keep events of this type we have to make sure we do not include these in our results. Energetic gluons are known to create quark pairs, also b quark pairs. This is one of the main backgrounds for many analyses that rely on the identification of b quarks as a way to reduce background. In hadronic top decays this is also the case, and unfoturnately the gluon splitting is enhanced in this type of topology due to the high energy scale of the events. To make things even more difficult, both gluon splitting and the aforementioned multiple interaction rate are very difficult to model in Monte Carlo simulation, which I solved by measuring these processes in background data before using them to predict the background contribution for hadronic top quark pairs.

During my Ph.D at Nikhef, also I spent two years at Fermilab working on the commissioning and installation of the Dzero experiment's silicon microstrip vertex detector (SVT) and authored the database software used to monitor and measure the response threshold of the SVT.

After a short project where I worked on quality tests of the ATLAS silicon microstrip tracker modules, I moved to Imperial College London, where I started working on the Compact Muon Solenoid (CMS) experiment, a project I had already worked in as a CERN summer student in 1999. The CMS collaboration is a truly international collaboration, and brings together over 2700 physicists from all five continents. In London I started working on the formation of a local CMS physics analysis group. This group focused on tau lepton reconstruction using particle-flow techniques and tau lepton triggering, both in the context of supersymmetric Higgs boson searches. The simulation of these processes led to the development and testing of complex computing infrastructure at the Imperial College GRID facilities. Such high performance computing facilities are also present at the IIHE in Brussels, and will be essential for the smooth analysis of the huge LHC data samples. As a CMS software expert I was responsible for providing the entire collaboration with a collection of physicist-aimed software tutorials. These very popular tutorials are still commonly used by the CMS collaboration and I am regularly requested required to provide tutorials for the analysis techniques necessary for the analysis of CMS collision data. In addition I co-authored a series of tutorials for the UK-CMS collaboration (over 150 people), providing a common training in grid and analysis software for all CMS graduate students and starting post-docs in the United Kingdom.

While at Imperial College I continued the measurement of the top quark pair production cross section in the all hadronic decay channel, using $450\ \mathrm{pb}^{-1}$ of Dzero data. While the Dzero collaboration has by now collected more than an order of magnitude more data, this measurement is still the most accurate Dzero cross section measurement in this particular top decay channel. The analysis, which is an extension of an analysis I performed during my Ph.D, is remarkable as it is almost completely independent of simulated information for the background modelling. Top production at the Tevatron is a rare process, but at the LHC an abundance of top quarks will be produced.

Currently, I am working as a research associate with Cornell University. One of the Cornell group's responsibilities in the Compact Muon Solenoid (CMS) collaboration is for the development and commissioning of the core software for the CMS pixel detector, the sub-detector closest to the collision point. I am permanently based at the European Particle Physics Laboratory CERN, where I am leading the CMS pixel detector performance software group. The pixel reconstruction software group is an international group of around 20 particle physicists, and I am daily involved in the supervision and support of both graduate students and postdocs. In my role as pixel convenor, I am responsible for the pixel reconstruction software, effectively for the conversion of the raw detector data to reconstructed hit locations where charged particles passed through our detector. My responsibilities also include the development and maintenance of the calibration software necessary for optimal hit reconstruction, database infrastructure, simulation of the pixel detector and data quality monitoring. In addition, I am also leading the pixel commissioning effort from the offline software side and am responsible for the organisation and training of pixel shifts. Before I accepted this responsibility, I authored the pixel calibration software and the database infrastructure that is used to calibrated the charge response of the CMS pixel detector (which is an analogue pixel detector meaning that every one of the 66 million pixels has a slightly different response curve), and was active as the pixel calibration and alignment and database contact in 2007.

Besides my responsibilities in the pixel detector group, I am active in the CMS supersymmetry (SUSY) physics analysis group, where I was trained as one of the few experts in the use of On-Scale Effective Theory simulation. On-Scale Effective Theory (OSET) is a novel approach on searches for new physics, using a simplified description of particles to characterise observed signals independent of the underlying model, thus providing a empirical approach to the search for new physics at the Large Hadron Collider in close collaboration with the particle physics phenomenology community. As the LHC is currently not producing data, I am focusing on the development of the tools necessary to perform SUSY analysis once data becomes available. To improve the measurement of possible non-interacting particles (as for example the lightest supersymmetric particles), I am developing and implementing a new missing transverse energy (MET) significance algorithm with two graduate students from Cornell University. Our approach on the reconstruction of the MET takes into account the uncertainty on (un)clustered energy when the missing energy is calculated, thus providing a figure of merit on how likely the observed missing energy is consistent with a random fluctuation from zero. As a CMS reconstruction software expert I am also active in the development of analysis software in the experiment's Physics Analysis Tools group, which is responsible for the providing of the analysis software infrastructure for the entire CMS collaboration.

B.2 Current and past research positions

04/2007 - now: Research associate on CMS experiment at Cornell University's Laboratory for Elementary Particle Physics (LEPP). Director: Prof. James P. Alexander. Contact details: F.R. Newman Laboratory, Cornell University, Ithaca, NY 14853-5001, United States of America, phone: +1 (607) 255 5259, email: jpa6@cornell.edu.

04/2005 - 04/2007: Research associate on CMS and Dzero experiments at Imperial College London. Director: Prof. Jordan Nash. Contact details: Blackett Laboratory, Physics Department, Prince Consort Rd, London SW7 2BW, United Kingdom, phone: +44 (0)207 59 47823, email: j.nash@imperial.ac.uk. Supervisor: Prof. Geoff Hall, email: g.hall@imperial.ac.uk.

01/2005 - 04/2005: Research assistant on ATLAS experiment at Nikhef. Director: Prof. Frank Linde. Contact details: Nationaal instituut voor subatomaire fysica, Kruislaan 409, 1098 SJ Amsterdam, the Netherlands, phone: +31 (0) 20 592 5001, email: frank.linde@nikhef.nl.

04/2000 - 01/2005: PhD on Dzero experiment at Nikhef. Director: Prof. Frank Linde. Contact details: Nationaal instituut voor subatomaire fysica, Kruislaan 409, 1098 SJ Amsterdam, the Netherlands, phone: +31 (0) 20 592 5001, email: frank.linde@nikhef.nl. Supervisors: Prof. Frank Linde, Prof. Marcel Demarteau, email: demarteau@fnal.gov and Dr. Marcel Vreeswijk, email:marcel.vreeswijk@nikhef.nl.

1998 - 2000: Internship on LHCb experiment at Nikhef. Director: Prof. Frank Linde. Contact details: Nationaal instituut voor subatomaire fysica, Kruislaan 409, 1098 SJ Amsterdam, the Netherlands, phone: +31 (0) 20 592 5001, email: frank.linde@nikhef.nl. Supervisor: Jos Engelen, email: jos.engelen@cern.ch.

1999: CERN summer student on the CMS microstrip tracker. Worked with Alan Honma, Gigi Rolandi and Marcello Manelli. Supervisor: Jos Engelen, email: jos.engelen@cern.ch.

B.3 Leadership experience

I am currently the CMS offline pixel software convenor in the CMS tracker detector performance group. This level-2 management position includes a seat on the CMS tracker detector performance group steering committee and involves the steering of a group of tens of graduate students and postdocs from various universities, with the responsibility of the maintenance and development of all pixel reconstruction software, including clustering, databases, calibration, simulation and data quality monitoring and providing feedback for the commissioning activities. I also am leading the development of the missing transverse energy significance algorithm within the Cornell University group, which involves the remote supervision of two graduate students based in the United States.

I also gathered management experience during several occasions. For example: I am a member of the CMS outreach executive committee. In the past I was responsible for the supervision and work of summer students based at Imperial College, taught undergraduate physics laboratories. While based at Fermilab I was elected a graduate student representative for the Fermilab Graduate Student Association, which also meant I served one year on the Fermilab User Executive Committee. In 1994-1996 I served two years as a student member of the faculty council of the University of Amsterdam's Faculty of Physics. Privately I have been chair of running club LCH3 in London for one year in 2006 and have been trained as a Certified hockey trainer and coach (age group 10-18).

B.4 Ten most relevant publications by Freya Blekman

By convention, articles published by particle physics experiments list all collaboration members as authors in strict alphabetical order. This policy reflects the substantial efforts in detector construction and maintenance, data acquisition, data reconstruction and calibration that all collaborators contribute to and which is a prerequisite to any data analysis. I have been signing all CMS publications since 2006 and have been on the Tevatron Run 1 and 2 author lists for the Dzero experiments until summer 2008. As a member of the Dzero and CMS collaborations I have signed over 160 publications in international refereed journals. I will present the list of the most important publications to which I made a significant contribution separately from the full publication list. For a full list of my published papers I recommend http://www.slac.stanford.edu/spires.

1. **"The CMS experiment at the CERN LHC"**
   R. Adolphi *et al.* [CMS Collaboration], JINST **3**, S08004 (2008)

2. **"CMS technical design report, volume II: Physics performance"**
   G. L. Bayatian *et al.* [CMS Collaboration],J. Phys. G **34**, 995 (2007)

3. **"Evidence for production of single top quarks and first direct measurement of —V(tb)—"**
   V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. Lett. **98**, 181802 (2007)

4. **"Measurement of the $p\bar{p} \to t\bar{t}$ production cross section at $\sqrt{s}$ = 1.96-TeV in the fully hadronic decay channel"**
   V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. D **76**, 072007 (2007)

5. **"Measurement of the top quark mass in the dilepton channel"**
   V. M. Abazov *et al.* [D0 Collaboration], Phys. Lett. B **655**, 7 (2007)

6. **"Measurement of the t anti-t production cross section in p anti-p collisions at s**(1/2) = 1.96-TeV using secondary vertex b tagging"**
   V. M. Abazov *et al.* [D0 Collaboration],Phys. Rev. D **74**, 112004 (2006)

7. **"CMS physics: Technical design report"**
   G. L. Bayatian *et al.* [CMS Collaboration], CERN-LHCC-2006-001 (2006)

8. **"The upgraded D0 detector"**
   V. M. Abazov *et al.* [D0 Collaboration], Nucl. Instrum. Meth. A **565**, 463 (2006)

9. **"Measurement of the t anti-t production cross section in p anti-p collisions at s**(1/2) = 1.96-TeV using lepton + jets events with lifetime b-tagging"**
   V. M. Abazov *et al.* [D0 Collaboration] , Phys. Lett. B **626**, 35 (2005)

10. **"A precision measurement of the mass of the top quark"**
    V. M. Abazov *et al.* [D0 Collaboration], Nature **429**, 638 (2004)

B.5 Timeliness of Odysseus project

Over the last three and a half years I have occupied two postdoctoral positions at prestigious international universities and have already successfully managed a group of graduate students and postdocs in my position as CMS pixel detector performance group convenor. I now want to apply the knowledge I have acquired over this period to start my own small research team. This would require the embedding of this group in a dynamical institute with a international established reputation, thus providing me with the opportunity to gain the experience as an independent researcher. In the CMS collaboration there is room for an analysis effort in top-like SUSY analysis, and a group of several Ph.D. students, together with myself, would provide the critical mass to perform this task that would have high visibility in the CMS collaboration. The opportunities available for physics analysis such as will be available at the LHC are very rare, and starting this project at this time would allow me to take a leading role inside the CMS collaboration's SUSY analysis effort while taking the next step in my academic career. The possibility to start my own group will enable me to proof myself by doing independent research and to develop into a leading physicist in the field.

B.6 Research collaborations

Of the past eight years I have spent approximately two years at Fermilab (Chicago, USA), two years at Imperial College (London, UK) and two years at the European Centre for Particle Physics (CERN, Geneva, Switzerland) and have been a member of two international collaborations (D0 and CMS). I have presented both my own work as well as the collaborative effort of the both Tevatron collaborations (around 1200 physicists) and ATLAS and CMS (over 5000 physicists) at several international conferences and attended various international summer-schools and workshops.

Particle physics is a very international field, and my collaboration with Imperial College has continued both in the field of Calibration and Alignment of the CMS tracker, something the Imperial College group is very active in for the CMS microstrip detector while I am responsible for the same activity for the pixel detector. The Imperial College and Cornell University groups are already collaborating in the preparation for SUSY searches at CMS, and extending this collaboration when I start my own small research group should be a very smooth process. I also still have excellent contacts with my Dutch colleagues, which for example resulted in a seat on the Ph.D. defence committee of M. Anastasoaie at the Radboud Universiteit Nijmegen in 2008. My research network is particularly suited for the subject proposed here, as the SUSY analysis efforts at the two competing LHC experiments are led by two experimental groups I have very close contacts with: Imperial College at CMS and the competing group at Nikhef for ATLAS.

B.7 Awards and Prizes

A world-wide collaboration of 2700 physicists awarded me the pixel detector performance convenorship I currently hold. In the competitive environment of international Particle Physics collaborations the selection of conference speakers is also done on an award basis, and I have been chosen several times to represent not only my own but also collaborations that I do not work in myself (for example CDF and Dzero or ATLAS and CMS).

C Project description

C.1 Overall objectives

The theory describing the smallest constituents of matter, also known at the Standard Model (SM), has been very successful at describing the interactions of elementary particles. The standard model combines three (quantum) forces of nature, providing a unified framework to describe electro-magnetism and the weak and strong nuclear forces. Despite the predictive power of the standard model, most physicists are convinced that the model is incomplete and incapable to describe nature at energies above approximately 0.5 TeV. One key component of the Standard Model, the elusive Higgs boson, has still not been discovered. The Standard Model has the additional flaw that, even when the Higgs boson is included, some key parameters of the model have to be chosen at specific values for the model to stay valid at higher energies. The artificial fine-tuning of parameters in combination with incapability to answer questions on the fundamental creation of matter at the early stages of the existence of our universe has led to a wide spectrum of theoretical extensions Beyond the Standard Model. Most of these involve the introduction of new interactions, additional spatial dimensions or physical symmetries that appear at energies above 0.5 TeV. The goal of this Odysseus project proposal is to develop methods to examine Nature at energies where the Standard Model is no longer valid, thus probing the physical properties of the world around us at unprecedented energies and by doing this providing new understanding of the fundamental properties of matter. The LHC collider which is starting up at CERN in 2009 will be the first experimental environment where the flaws of the standard model can be examined, and I intend to focus my activities on the the development of tools and techniques necessary in the search for Supersymmetry (SUSY), one of the more natural extensions of the Standard Model.

C.1.1 Theoretical motivation for Supersymmetry

The most general extension of the Standard Model, the Minimal Supersymmetric Standard Model (MSSM) does not assume any particular Supersymmetry (SUSY) breaking mechanism[1]. In the MSSM, every SM particle acquires a supersymmetric partner, differing by a half-unit in spin. MSSM models increase the minimal required number of Higgs bosons from one to four, as two Higgs doublets are needed to give masses to up-type and down-type quarks and their supersymmetric partners. In addition the most widely studied models include the interaction with the gravitational force. The inclusion of the last of the four known forces in a unifying theory is obviously a very compelling one, and typically gravity is used as a mediator for the symmetry breaking in the MSSM. Despite many excellent efforts, SUSY has not yet been observed at any of the previous or current particle physics experiments.

One of the currently most popular MSSM breaking paradigms, mSUGRA, predicts that SUSY breaking happens in a hidden sector, which is then mediated to the visible sector described by MSSM via gravitational interactions. In the mSUGRA framework the masses, mixings, and decays of all SUSY particles are determined in terms of five parameters: the common scalar mass m_0, the common fermion mass $m_{1/2}$, the common trilinear coupling A_0 at the grand unification energy scale, the ratio $\tan\beta$ between the vacuum expectation values of the two Higgs doublets, the sign of the Higgsino mass parameter μ. Due to R parity conservation in mSUGRA models every SUSY event has two lightest SUSY particles which are massive and stable but undetectable, thus causing SUSY decay chains to be incomplete and not adequate for mass measurements. Exclusive supersymmetric signals may be extracted from the kinematic limits of various variables. Different regions of mSUGRA five dimensional parameter space have been proposed as SUSY benchmarks and studied at both CMS and its sister experiment ATLAS[2]. In most of this parameter space the event topology created by mSUGRA consists of energetic leptons, jets and large transverse missing energy. This is the same signature as in top quark production, which is very often the dominant background. The proposed project aims to discover for the first time the effects of SUSY in particle collisions, and to unravel the nature of this new symmetry.

In addition to the Supersymmetric top-like scenarios, a collection of alternative models with top-like signatures currently exists; for example models including various flavors of additional heavy quark production, the possibility of an additional fourth generation of massive fermions (as predicted by certain Grand Unification Theories), two-Higgs-doublet scenarios, models with heavy exotic vector-like quarks like the beautiful mirrors model and Little Higgs models, particularly those in the context of large extra dimensions with conserved T-parity, all predict the production of new physics that will result in top-like event topologies.

Nature itself provides one of the most compelling arguments for the existence of a SUSY-like mechanism. The existence of non-discovered particles can be derived from cosmological considerations, specifically from the occurrence of Dark Matter[3]. Weakly interacting massive particles (WIMPs) with masses between $10\ \mathrm{GeV}$ and a few TeV can be calculated to be consistent with the observed fraction of dark matter as measured from cosmological principles. The currently best motivated WIMP candidate is the lightest superparticle (LSP) in supersymmetic models like the MSSM. To conclude, the most likely LSP is expected to be a neutral superpartner to one of the standard model particles and the possible observation of SUSY at the LHC will open doors to further studies on dark matter, both by dedicated experiments but also by providing the input to the next generation of particle physics experiments at the next linear collider.

C.1.2 Experimental context

The Large Hadron Collider (LHC) expands the energy frontier for the search for new physics by almost an order of magnitude. Currently, the world's most energetic accelerator is the Tevatron at Fermilab, which at an interaction energy of $2\ \mathrm{TeV}$ will be dwarfed by the LHC operating energy of $14\ \mathrm{TeV}$. The center of mass energy of the LHC reaches well into the area where the Standard Model is known to be no longer valid, and the search for new phenomena at these unprecedented energies is an established part of the LHC physics program. The Large Hadron Collider is planned to start operation in early 2009, and is designed for proton-proton and lead-lead collisions at an unprecedented interaction energy of 14 TeV. At one of the four interaction points the Compact Muon Solenoid (CMS) is situated. CMS is a general purpose high energy physics experiment, and is designed for the optimal identification of the full potential of LHC physics, including the Standard Model (SM) Higgs boson, searches for various flavours of Supersymmetric particles, new massive vector bosons and more exotic physics models. In addition, CMS also has a heavy ion programme, focusing on more stringent tests of the liquid-like behaviour of hot nuclear matter[4].

Even more than the confirmation of existence of the elusive Higgs boson, the discovery of SUSY or similar phenomena would be landmark advance in particle physics. Discovery of SUSY or similar phenomena would also affect the wider physics community, as it would have significant cosmological implications considering the nature of dark matter. The LHC was designed to confirm or rule out the existence of most SUSY scenarios, but past studies suggest that, even at LHC energies, most likely SUSY scenarios are very rare. In many cases the topology will also mimic already known processes, particularly top quark production creates a very similar event signature. This gives a compelling argument for a detailed study of top quark production in parallel to the optimisation of the analysis techniques necessary for a SUSY search. A team of several graduate students and the already present expertise in the very respectable top quark physics group at VUB/IIHE will make it possible to combine the search for new physics with an in-depth understanding of the top quark background, a combination which is rare to find in a single institute. This "SUSY team" will either discover effects of SUSY in the proton collisions or exclude the presence of SUSY in nature

C.2 Proposed methodology

To make optimal use of the LHC physics potential, the distinguishing features of the CMS detector are a 4 Tesla superconducting solenoid, a full silicon-based inner tracking system and a scintillating crystals-based electromagnetic calorimeter. In order to obtain sufficient signal events the LHC must operate at unprecedented energy, luminosity and event rate, producing 110 PetaByte of data a year. This requires a new paradigm in data storage and analysis, which is provided by a worldwide grid of computational and storage resources made available to physicists for their research.

The topic of interest of this proposal is to examine the LHC collider data for the production of Supersymmetry, in particular when mimicking top quark production. The study provides a window to a plethora of potential new physics processes, for example many Supersymmetric models produce signatures with top-like signatures. If SUSY were to exist in nature as a perfect symmetry, the masses of the supersymmetric partners of the already discovered SM particles would be identical to the SM particles' masses. The fact that these supersymmetric partners have not been observed implies that Supersymmetry is a broken symmetry. The nature and scale of this symmetry breaking is the object of study of many phenomelogical models. If supersymmetry exists at the weak scale, it is possible to observe at least a significant fraction of the new particles at LHC energies.

One of the key areas where the LHC's physics potential is most significant is in the production of heavy particles, particularly the production rates of top quarks are unprecedented with respect to the Tevatron, thus providing access to high statistics top quark samples. For the first time this makes it possible to actually examine top quark pair production as a background to even more rare processes. I propose a strategy that consists of a search for anomalies in a specific experimental signature (the production of high energy leptons, jets and missing transverse energy) rather than focus on the predictions from a specific model. This method is relatively model-independent, requires a good but most SUSY processes that will identify new physics are rare and will suffer from large backgrounds of well-understood physics. The complex topology of top quark events events is identical to this signature and since virtually no other processes can mimic such a final state it provides an excellent window to new physics. To examine the top quark sample for a small SUSY contribution I intend to use again a combination of topological analysis, secondary vertex tagging and multivariate techniques. The availability of a large sample of top quark events makes it also possible to use data for the modelling of the background of our SUSY search. This approach is sensitive to predictions from many new models simultaneously and creates an experimental environment from which it is possible to discover the first signs of the breakdown of our current understanding of particle interactions and a first glimpse of the fundamental physics that takes over.

To summarize, I propose the following methodology to search for SUSY

- I intend to search for SUSY in events with leptons, jets and missing transverse energy. This is an event signature that is sensitive for a large range of SUSY models and this topological approach will provide a relatively model-independent method to search for new physics.

- The development of reconstruction tools for necessary for this SUSY search will be a combined effort with the VUB/IIHE top quark physics group as top quarks and the SUSY signal we search for display identical event topologies.

- Particularly at LHC startup, the detector will be performing sub-optimal. The already present detector expertise will be essential for optimisation, calibration and tuning of the reconstruction software. This will be an important part of our contribution to the CMS collaboration's effort to produce high-quality physics results.

- The level and shape of the background to our search will be dominated by Standard Model processes, particularly top quark physics [5]. I intend to use the large top quark samples available at the LHC to model this background from the data itself, and only rely on Monte Carlo simulation when this data-driven method does not yield the appropriate accuracy.

- The data-driven methods will be tested on Monte Carlo simulation. Such a "closure test" will confirm that our background model works.

- The separation of signal and background will be done by a combination of event topology variables and neural network techniques. These are the same techniques used at the Tevatron for the isolation of complex final states in for example top quark physics[6].

- When a possible SUSY signal is observed, it is essential to confirm its presence in other event topologies, which is likely to lead to an involvement in the SUSY analysis effort of other final states. On-Scale Effective Theory techniques will be used to predict which other events should be examined, after which the data will be tested against the candidate model.

Only time will tell whatever kind of new physics will be discovered at the LHC, but the heavy quark sector is one of the most likely candidates for observation of new physics processes. In this proposal I have elaborated on a few of the many channels where effects from new particles or interactions are expected to manifest themselves. The approach presented here defines a solid experimental research programme to look for signs of new physics at the LHC. Once a signal is discovered, the reconstruction of the underlying models and parameter set(s) that describe the observations is a task that requires close collaboration between experimental and theoretical physicists and my status as a CMS expert on the application of On-Scale Effective Theory in searches for new physics will be instrumental in this process.

C.3 Novelty and groundbreaking character

Most SUSY models introduce a large number of new fundamental particles and the sheer variety of available SUSY models makes it a priori difficult to predict what SUSY production at the LHC will look like. This range in possible physics signatures makes it possible to try more novel data analysis techniques:

- The LHC is in a unique position to confirm or exclude the almost all SUSY extensions to the Standard Model. The impact of a SUSY discovery would have groundbreaking implications on our view of particle physics and cosmology, and will create a paradigm shift from the current Standard Model to a more general theory of everything. Depending on the kind of SUSY discovered, it will be possible to draw conclusions on the number of dimensions in our universe, the nature of dark matter, the creation of our universe and the unification of gravity with the current quantum field theories in a Grand Unification Theory. The LHC will most likely not be powerful enough to do precision measurements to these phenomena.
- The observation of SUSY would be the determining factor in the design of the future international linear collider (ILC). The ILC would be the obvious location for precision studies, providing a clean environment and superior accelerator and detector design.
- This is the first time top quark production will be a background for possible new physics signatures. Commissioning the CMS detector using one of the more difficult experimental signatures requires an exceptional understanding of the entire detector, and my experience as a CMS software expert and in the details of the tracking sub-detectors will provide me with a unique advantage when isolating the top quark samples necessary for a SUSY search.
- Data-driven analysis techniques will be essential for the modelling of top quark data to high accuracy. My experience from the Tevatron using these data driven background modelling of top-like events is an essential component of this proposal, there are only a few handfuls of particle physicists in the world that have actually used these techniques in hadron collider data analysis, and only the LHC can produce data samples large enough to require the use these techniques instead of the commonly used Monte Carlo simulations.
- The use of general search strategies in particle physics is one of the recent developments in particle physics. I intend to focus on a specific experimental topology rather than on predictions from a given model. Given the wealth of predicted new physics phenomena at the LHC, I think that searching for such signals in a specific experimental signature forms a more solid basis for a search than focussing on the predictions from a specific model. I made a strategic choice to look for top quark pair production since it provides sensitivity to several models simultaneously.

Once the LHC has pin pointed in which way nature has solved the problems currently present in the Standard Model, it is important to already start thinking ahead towards the next generation of accelerators. The particle physics community is currently studying the possibilities and physics reach of the next accelerator machine, which is known as the International Linear Collider (ILC). The ILC will be an electron-positron collider, providing a very clean environment to perform precision measurements at whatever physics will be observed by the LHC. Physics feasibility studies for this environment are currently ramping up, and in the longer term a contribution to this effort, particularly one related to tracking detectors, would be a natural continuation of the research program I present in this proposal.

C.4 Management of project

The management of this project deals mainly with the coordination of the PhD students and the funding required for their studies. Only a limited amount of financial means will be required for hardware and computer funding, for which I will collaborate with colleagues within the CMS team at the VUB/IIHE. For the management of my team I will have to follow up closely the evolution of the computer facilities at the VUB/IIHE as they are an essential part of the project. From my previous experience in large collaborations I have learned that it is very important to create a dynamic group in which different PhD students are gathered around a general topic, being the search for new physics with CMS at the LHC. Within the CMS group at the VUB/IIHE, I will focus on the coherence of the research team and stimulate this by creating joint discussion platforms. The choice of the specific research topics of the PhD students is therefore a crucial aspect and the weekly supervision of the progress of the individual students is a key management activity for the success of the whole team. Because of the work within large international collaborations, I will follow the evolution of the research in a broad sense, and pro-actively prepare my team to react on the latest trends. Obviously a close connection has to be found with the existing Top Quark team at the VUB/IIHE. Both teams will reinforce each other in a unique way by sharing physics expertise within a joint software platform. This will be managed together with the leaders of the other research teams at the VUB/IIHE. Also connections will be made with research teams in the domain of theoretical physics relevant for the analyses performed in the proton collisions. This will proceed via regular informal meetings to the benefit of both sides and should result in a deeper understanding and a better interpretation of the new physics to be discovered.

C.5 International context

The international context of particle physics means that the research proposed here is inherently impossible without international collaboration. The collision data will be collected at the European Laboratory for Particle Physics CERN, and the CMS collaboration consists of people come from 183 institutes in 38 countries, spanning Europe, Asia, the Americas and Australasia. My connections with some of the strongest groups in this collaboration, Imperial College London and Cornell University, will provide ample opportunities for building a solid foundation for international collaboration. The outcome of the SUSY search proposed in this project will also affect to which international fields a close connection will arise, as the theoretical and cosmological implications of the existence of SUSY depend heavily on the type of SUSY breaking formalism used.

C.6 Expected results

CMS is designed as a general-purpose detector, keeping in mind not only the more popular hypotheses but also aiming to study whatever happens when particles collide at high energies, even if the results are like nothing we expect. Any new particles produced at LHC energies are likely to decay into particles that we know well and that CMS can detect. In this way, whatever physics emerges at such high energies, CMS is in an ideal position to study it. I believe that the research strategy presented in this proposal will yield a substantial number of LHC physics papers, starting with early calibration of the detector with top physics and then moving on to more complicated analysis strategies and searches. Particularly if unexpected phenomena are produced this could launch a revolution in physics, and challenging our ideas about the world at the most basic level, and the search strategy proposed here is flexible enough to be able to scrutinise and test the LHC data for new physics theories while still keeping a solid ground in already expected and well-understood processes like top quark production.

C.7 Possible impact on innovation

Particle physics needs very sophisticated instruments using technologies that often exceed the available industrial know-how. Many of the previously developed technologies have already made our daily lives more efficient, practical and comfortable, for example the world wide web and most medical imaging applications are directly derived from particle physics applications.

Particle physics at the LHC requires such substantial computing resources that a new computing model had to be innovated: Grid computing. The ultimate aim of grid computing is to provide access to all resources such that the physicist-user does not need to know where their work is carried out, providing the next step in computing infrastructure. The outcome of this project will also determine the strategy of future theoretical research in particle physics, and advancement in theory goes hand in hand with the application of these new principles in society. The discoveries made at the LHC will determine the future of high energy physics and science as a whole, and the new physics that the LHC will discover will eventually yield applications that future generations will consider part of modern day convenience.

C.8 Work plan

To effectively make an impact in a large collaboration like CMS it is essential to be able to build on previous experience. The VUB group has a leading role in the calibration and commissioning of the CMS experiment using top quark physics and in the preparation for precision measurements in the top quark sector. I intend to extend this activity to the search for SUSY, which will be greatly aided by the current top quark activities as the goal of high quality data is common for both SUSY and top physics. Once well understood data samples are in hand it will be possible to use these to search for behaviour that is not consistent with physics described by the Standard Model.

The group I will lead, the "VUB SUSY team", will initially focus on our background. As top physics is one of the dominant backgrounds, collaboration with the existing top physics group at IIHE/VUB will be instrumental in this effort. As the proposed project will commence when the initial commissioning of the CMS detector will be complete, the focus will be mostly on the modelling of background using data. I propose a research program comprising the following steps:

1. Isolate an unbiased top quark sample that can be used for searches for new physics, focusing on SUSY signals but not excluding other possible models. This requires very detailed studies of the selection criteria (including triggers) with which CMS selects its top quarks. Obviously the re-discovery of the top quark at the LHC is part of this program and the Ph.D student working on this effort will work in very close collaboration with this ongoing effort in the CMS top physics community, but focusing on possible obvious non Standard Model behaviour.

2. The required time to collect this data depends both on the LHC schedule and on the nature of the possible SUSY-breaking mechanism in nature, which leads to a wide range of predictions of how many years of LHC data taking are needed for a possible SUSY discovery. The majority of models predict a discovery would be possible after a several years of data collection, providing the correct time scale for a Ph.D. project.

3. Once a sample is isolated, the most likely way to observe new physics will be by measuring the properties of the top quark system, for example by measuring the differential cross section as a function of transverse momentum, (pseudo) rapidity or mass of the system. Top quark production is described by Quantum Chromodynamics, which at these mass scales has already severely constrained the properties of the physical system. Measurement of these distributions by itself is already a novel physics result, but the examination of these distributions for new physics provides the additional interest for an outstanding Ph.D. thesis with the possibility to be part of an entire new age of discovery in particle physics.

4. When new physics is observed at the LHC, there will most likely be many different models that describe the same event topology. This will lead to more elaborate SUSY studies whch will most likely not take place in the top quark topology. I envision that the use of OSETs will be one of the key tools that the experimental and theoretical community will use to exchange possible models, and intend to use the available tools in the OSET framework (for example marmOSET, which is interfaced to the CMS reconstruction software) to their full advantage to narrow down the number of possible models explaining a possible deviation from Standard Model predictions.

Each of these steps and the corresponding calibrations will result in an early CMS paper on LHC data and should lead to an excellent opportunity for graduate student projects. The promise of possible detection of new physics is a very compelling field in particle physics, which will surely aid us to attract excellent graduate students to work on this effort.

D Embedding of the team in the host-institution

D.1 Embedding of the team in the host institution

The "SUSY search team" proposed will become part of the research activities at the Particle Physics group of the VUB (dienst ELEM) which is embedded within the Inter-university Institute for High Energies (IIHE). It will reinforce the institution in a unique way. The institution is member of the CMS collaboration since the start and has over the last decennia invested strongly in the construction of the CMS hardware facilities. During the last years also an important investment is made in a computing centre for the analyses of the collision data collected by the CMS detector. Recently the construction and preparation activities at the VUB/IIHE shifted towards physics analyses studies. Teams are being put in place to guarantee a rewarding scientific return of the investments made in this general CMS project. All tools are in place to embed the "SUSY search team" within the VUB/IIHE and to let the VUB/IIHE take part in maybe the most important discoveries in particle physics for this generation.

D.2 Embedding of the team in the existing teams

The IIHE has about 65 members of which half are connected to the VUB. The institution has a long and outstanding tradition in collider physics research, with recent examples like the DELPHI experiment at the LEP collider (CERN) and the H1 experiment at the HERA collider (DESY). The most important experiment in which the institution does participate is the CMS experiment at the LHC collider (CERN). About half of the members of the IIHE are connected to this experiment. Other members of the IIHE participate in the following experiments: IceCUBE, H1, OPERA and PET. There is a clear link between the astro-particle physics experiments and the collider experiments for the search of new phenomena like the effects of supersymmetry. This link is also extended to Belgian theorists via the IAP framework "Fundamental Interactions".

The CMS group made important contributions to the construction of the Tracker system of the experiment. Today, two strong physics analysis teams are present: the Top Quark team and the High Energetic Electron Pair (HEEP) team. The HEEP team is mainly coordinated by the ULB members of the IIHE and has a very specific research goal. The Top Quark team, coordinated by Prof. Jorgen DHondt (VUB), has about 10 members and consists out of several master students, PhD students and post-docs. This team is prepared to analyse the first collision data accumulated by the CMS experiment and to test and understand the Standard Models top quark sector. This will result in a solid basis to search for new physics ones we have understood the already known processes in 14 TeV proton collisions. The top quark processes are the dominant background for most of the search analyses at the LHC. Because initially the LHC laboratory is constructed to search for new physics phenomena at the highest energies, it is important that in parallel a new team is prepared to search for these new physics phenomena. The "SUSY search team" proposed is the adequate strategy to complement the already existing teams. Its team leader has a long experience in performing physics analyses at hadron colliders (Tevatron at Fermilab, Chicago, and LHC at CERN). Dr. Blekmans past experience in studies concerning top quark processes, will in a natural way make a strong link to the already existing Top Quark team. This close collaboration within the IIHE is highly wanted in order to remain a laboratory at the frontline of particle physics research. A strong dual team, studying the already known processes and searching for new phenomena beyond these processes, is a pre-requisite to obtain in the highly international environment a rewarding return for the large investments made over the last decennia. The preparation of the physics analyses of the CMS collision data have started some years ago and the analyses themselves will continue certainly until 2015. The observed or not observed phenomena will require an interpretation in a broad sense, hence will need a broad discussion forum touching fields like cosmology and particle physics theory. This discussion forum is present at the VUB and consists out of theorists (B.Craps and A.Sevrin at the VUB) and the astro-particle physicists at the VUB/IIHE. This motivates not only why the VUB needs a "SUSY search team", but also why it is one of the rare excellent places to host such a team.

D.3 Multiplicator effect in the host institution

The current CMS team, coordinated by Prof. Jorgen DHondt, studies the already known processes in the 14 TeV collisions of the LHC because this is a pre-requisite to search for new phenomena. The new team proposed goes beyond this and will prepare different physics analyses. This is a highly attractive domain for new students and post-docs, hence it will complement and strengthen the research attraction pole of the VUB/IIHE. The recent media attention obtained by the start of the LHC experiment, brings an interesting return to the university in number of students and general outreach to the society. The research aim of the "SUSY search" project, being the discoveries of new puzzle pieces of our understanding of Nature, will be covered even more in the media feeding therefore in a unique way the broad discussion in the society on the origin and the evolution of the Universe. Because the outcome of the search for new phenomena at the LHC experiments itself will determine the future of particle physics research, it is essential to participate in this activity. The proposed team leader, Dr. Blekman, has expertise in physics analyses at the current hadron collider. This is complementary to the expertise at the VUB/IIHE and will therefore bring new creative ideas to the lab. The close collaboration between the Top Quark team and the SUSY search team, is a perfect platform to stimulate discussion among young researchers and an excellent environment for frontline research.

The outcome of the proposed LHC project will define the parameters of a new generation of accelerators. In its medium-long term strategy, the VUB/IIHE wishes to participate in the general R&D to construct these new colliders and detectors. The recent expertise of Dr. Blekman in the R&D of silicon based tracking detectors is an excellent basis and could strengthen her link with the VUB/IIHE in the long term. Her expertise will provide the needed multiplicator effect at the VUB/IIHE for new front-line research projects at particle colliders.

E Financial Plan and Justification of Resources Awarded

Year	Student salary	Service work	Computing	CMS Fee	CMS Weeks	Workshops	Consumables	total
1	90.0	12.0	10.0	10.0	14.4	9.0	5.0	150.4
2	92.7	12.4		10.0	14.4	9.0	5.0	143.5
3	95.5	12.7		10.0	14.4	9.0	5.0	146.6
4	98.3	13.1	6.7	10.0	14.4	9.0	5.0	156.5
5	101.3	13.5		10.0	14.4	9.0	5.0	153.2
							total	750.1

Table 1: Budget in kilo euro

The important investments in the construction of the LHC and the CMS detector are already covered by governmental contracts and/or several FWO projects. For the physics analyses proposed in this project, an adequate computing facility needs to be built and maintained. This is partially being financed by current FWO projects into a so-called TIER2 facility for the CMS teams. The remaining financial plan consists of the hiring of personnel and a travel budget. The financial plan is summarized in the table below. The budget for each PhD student is 30k euro per year, but should include a yearly indexation of 3%. Beyond the resources provided by the TIER-2 facility, each of the three PhD students participating in the project, will need a personnel computer adequate to study large datasets locally. Each system is about 2500 euro to be updated on average every three years. The students will work for a fraction of their time at CERN, because the regulations of the CMS collaboration foresees at least three months of service work for each collaborator (expenses: 3000 euro per student for three months per year). Also this amount needs to be indexed every year by 3% inflation.

Identical to the students, for the project leader, an adequate computer system and a stay of three months per year at CERN are part of the financial plan. For the leader also an annual fee has to be paid to the CMS collaboration of about 10k euro.

On average 6 internal collaboration weeks (workshops) are foreseen by the CMS collaboration at CERN. For this either the Belgian apartments can be used or simple hotels foreseen by CERN. The cost is about 600 euro per person per week, resulting for leader and students together in 4 x 6 x 600 = 14.4k euro per year for the team. Each student will visit an external workshop on average every year and for the leader this will be about 3 every year. For each workshop an average budget of 1500 euro should be foreseen.

Small items will be purchased frequently and are taking into account by a yearly budget of 5k euro.

F Host institution

The VUB/IIHE has an extensive tradition in research at particle colliders and has recently acquired an excellent international visibility via its research in for example Top Quark physics. This is the result of a good planning of divers research projects over the last decennia and the settlement of a young and dynamic team. This decennia is dominated in particle physics by the start of the LHC experiment and the exploration of its proton collision data at 14 TeV. The VUB/IIHE has strongly invested in this direction both financially and in human resources. Examples for this are the construction of the TIER-2 computing facilities and the preparation of solid analysis teams. The host institution provides therefore a excellent platform for me to develope my leadership skills to steer a small team. The search for effects which confirm or not the existence of supersymmetry in nature need a close link to studies of collision processes which are known to exist. The search strategy proposed via final state topologies depend crucially on the understanding of the dominating background which involve top quarks. For this the VUB/IIHE has a very strong group, and is the most optimal one to connect my research team with. The activities in astro-particle physics and theoretical particle physics at the VUB will make a natural connection to the topics in the proposed SUSY search team, which will make it possible to make very broad interpretations of the obtained results.

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Date of birth	16 November 1974

Academic Career

2007-	Research associate at Cornell University (CMS experiment)
2005 - 2007	Research associate at Imperial College London (CMS / D0 experiments)
2005	Research assistant at Nikhef, Amsterdam (ATLAS experiment)
2000 - 2005	PhD experimental High Energy Physics at Nikhef, Amsterdam (D0 experiment). Subject: top quark pair production in proton antiproton collisions
1993 - 2000	Diploma experimental physics at Universiteit van Amsterdam (LHCb experiment) Experimental work: LHCb outer tracker R&D

Research Experience

2008 - 2009	CMS: Pixel offline software (also known as Detector Performance Group) convenor. Responsible for all offline and high-level trigger pixel reconstruction software, i.e. simulation, digitization and reconstruction of clusters, data quality monitoring, databases and calibration.
2008	CMS: Pixel Alignment & Calibration contact person. Responsible for coordination and maintenance of the alignment and calibration, including interaction with alignment and calibration activities in the other sub-detectors and the offline software experts. Editor for the Pixel Alignment and Calibration section of the 2008 Computing Service challenge Report.
2008	CMS: Author of the missing transverse HT significance algorithm in the CMS Physics Analysis Tools group. This algorithm uses reconstructed objects instead of raw unclustered energy and is expected to be more robust for initial data taking.
2007 - 2008	CMS: Co-author of a missing transverse energy significance algorithm, a novel approach that uses the compatibility with zero missing energy as a an additional measurement in the reconstruction, thus increasing the discriminative power for separating signal from background in events with missing transverse energy.

2007 - 2008	CMS: Pixel database contact person. Responsible for the filling and maintenance of the CMS pixel databases including development, maintenance and release management.
2007 - 2008	CMS: Author of the calibration software for the CMS pixel detector. Author of the CMS pixel gain & pedestal database and the software that measures the values of these for each separate pixel.
2007 - 2008	CMS: Developer in the CMS Physics Analysis Tools (PAT) group, focusing on documentation and analysis examples.
2007	CMS: Measurement of the tau jet energy scale in the 2007 CMS computing challenge
2005 - 2007	CMS: Responsible for the development and testing of Grid-based analysis at the Imperial College Tier 2. Analysis focus: particle flow reconstruction and tau lepton identification, leading towards Higgs boson physics in various tau channels. Author of the CMS reconstruction software tutorials and CMS reconstruction software expert .
2005 - 2007	D0: Primary (and only) author of the analysis used to measure the top quark pair cross section in the all hadronic channel, using 450 pb^{-1} of D0 data. This analysis uses secondary vertex reconstruction for b-jet identification in combination with a topological analysis and multivariate techniques, and is still the most accurate D0 cross section in this particular top decay channel.
2005	ATLAS: Silicon module electronics tests for the SCT end caps.
2002 - 2005	D0: Measurement of the top quark pair cross section in the all-hadronic channel on early Tevatron data samples. Responsible for the development of top quark physics triggers in multi jet events.
2001 - 2003	D0: global data acquisition and tracker commissioning expert. Author of the D0 tracker pedestal database and its monitoring software. Participated in the installation and testing of 10 % of the D0 microstrip tracker.
1999	CMS: Development gantry robot used in microstrip tracker module bonding.
1998 - 2000	LHCb: Prototype testing for the outer tracker drift chamber.

Research skills

➔ Expert on silicon based particle physics detectors. Leading role in the commissioning of the CMS pixel detector and major contributor to networks. Familiar with b-quark identification in high energy, high multiplicity environments, both using soft muon and secondary vertex tagging.

- ➔ Excellent communication skills. Very experienced in working in large international collaborations. Affinity with education and very experienced in student supervision.
- ➔ Very experienced C(++) and Unix programmer. Ten years of in-depth use of the ROOT analysis software. Familiar with MacOS, MS Windows, LaTeX, Power point, HTML, python, ORACLE/SQL and Visual Basic. CMS offline software expert.

Conferences, colloquia, lectures etc.

2008	Conference talk at Position Sensitive Detectors 2008: "The CMS pixel detector"
	Conference talk at Top 2008: "Search for gluinos in top-stop production at ATLAS and CMS"
	Invited Speaker at *FOSFOR* popular science lecture series: "CERN and the LHC"
	CMS software tutorials at the Turkish Atomic Energy Agency, Ankara, Turkey
	Member of PhD defence committee at Radboud University (Nijmegen, the Netherlands). Subject: Higgs searches in b-bbar decay channel at Tevatron (D0), using Neural Networks for b-quark identification, defended by C.M.Anastasoaie
2007	CERN-EIROforum lecture on "particle physics at CERN", one hour lecture at the final of the European contest of Young Scientists
	CMS software tutorials: Two-day tutorials for all CMS collaborators in the United Kingdom (January) Three-day tutorial CMS101 at Cornell University (May) CMS software tutorials for the CERN summer students (July)
	Graduate student lectures at Imperial College: Analysis strategies at hadron colliders (3 hours)
	Seminar "Top quark pair production in the hadronic decay channel" at Cornell University (USA), Bristol University (UK), Vrije Universiteit Brussel (Belgium)
2006	Conference talk at FNAL users meeting: "Top quark mass measurement and search for single top at CDF and Dzero"
	Seminar "Top physics at D0: analysis at the energy frontier" at Imperial College
2005	Conference talk at HEP2005: "The inclusive differential cross sections of p anti-p ---> Upsilon(1S) at s**(1/2) = 1.96-TeV"
	Conference talk at HEP2005: "Measurement of the branching fractions of B to narrow D** states and other semi-leptonic b decays at D0"
2004	Conference talk at Dutch Physical Society Annual Scientific meeting: "Measurement of the top quark pair cross section at D0"
	Colloquium "Top quark physics at D0", University of Liverpool
2002	Talk at Nikhef Scientific annual meeting: "The road to top physics at D0"
	Conference talk at American Physical Society April Meeting: "Top quark pair production in the all-jets channel at D0"

Schools and conferences (if not listed above)

2008	On-Scale Effective Theory and model-independent searches at the LHC, CERN
2008	CERN media training for TV interviews during LHC startup, CERN
2006	YETI: Monte Carlo techniques beyond leading order, Durham
2003	ECFA/DESY linear collider workshop, Amsterdam
2002	ICHEP'02, Amsterdam
2002	NATO/ASI summer school, St. Croix, US Virgin Islands
2001	Erasmus summer school on Electro-weak QED, Couvin, Belgium
2000	Erasmus summer school on QCD, Monschau, Germany
1999	CERN summer student programme

Other relevant experience

Outreach

- Member of CMS outreach executive committee. Responsible for the Dutch language version of the CMS brochure.
- Various newspaper and television interviews.
- Presented many popular science lectures on Particle Physics for the general public.
- Registered CERN guide. CMS guide during the CERN open day 2008.
- Science ambassador for the SET-Routes program, a European Commission program focusing on the improvement of science role models and gender bias during high school science education.
- Outreach activities at Imperial College include supervision of work placements for high school students, master classes and poster sessions.
- Outreach activities at Fermilab include presentations of cryogenic and magnetic physics phenomena for large groups, experimental tour guide and presentations in Washington DC for members of the US house of representatives
- Demonstrator at the International Physics Fair of the University of Amsterdam, including performances at the 40th anniversary of CERN

Leadership

CMS Pixel DPG convenor, CMS tracker DPG steering committee, CMS pixel commissioning task force, CMS outreach executive committee, Officer of Fermilab's Graduate Student Association, Member of Fermilab's User Executive Committee, Chair of running club LCH3 in London, Member of the Faculty council of the University of Amsterdam's Faculty of Physics, Certified hockey trainer and coach (age group 10-18)

Teaching

- At CERN:
- Many CMS software tutorials.
- At Imperial College: Graduate student lectures on hadron collider analysis. Responsible for the supervision of two PhD students. Third year laboratory on Johnson electronics noise. Supervision of summer students.
- Second year Nuclear Physics laboratory at University of Amsterdam
- Part time teacher at PPI in Amsterdam (students age 12-18)

Hobbies

Playing hockey, running, reading, painting/drawing, seeing live music