PORES Application

Thesis Title: Search for Physics Beyond the Standard Model with Vector Boson Scattering at the ATLAS Experiment

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1 Collaboration Details

1.1 CERN

CERN is the European Organization for Nuclear Research located near Geneva, Switzerland. It is the worlds largest particles physics laboratory with over 6500 visiting scientist, from 80 nations.

The Experimental Particle Physics group within the Physics department in a member of the ATLAS collaboration. ATLAS is a particle physics experiment located at CERN. From mid 2008 onwards, data will be recorded at energies previously unaccessible to particle physicists allowing the potential for a range of new physics discoveries. It will reveal new information about the fundamental nature of matter and its interactions. In November this year one month of data will be collected at lower energies with the primary goal of improving our understanding of the detector.

1.2 Overseas Supervisor

While at CERN I will be supervised by Dr Antonio Limosani. Dr Limosani is a mâitre assistant at the University of Geneva. He has worked on both the Belle experiment in Japan and ATLAS experiment at CERN. Please refer to the accompanying letter for confirmation of his supervision.

1.3 Formal Agreement

The Experimental Particle Physics group at the University of Melbourne have a formal collaboration agreement with CERN. The group has been involved in the ATLAS collaboration since 1994, when it joined as a founding member. From 1994 until the present, research at the university has been funded through a series of ARC grants. The current grant provides funding until 2010.

1.4 Proposed Dates of Travel

I plan to be at CERN for six months from 1st August, 2007 until 31st January, 2008. The duration of this travel will allow me to be at CERN for an extended period of time and witness the late 2007 data taking run at ATLAS.

1.5 Nature of the Collaboration

Since the collaboration with ATLAS began in 1994 the Experimental Particle Physics group has contributed to the experiment in a number of ways. We constructed a large number of Silicon Tracker Modules, a key part of the Inner Detector of ATLAS. We will also be responsible for a part of the CERN computing grid.

All members of the group on ATLAS from Melbourne spend some time at CERN and over the past 13 years have played important roles in hardware and software development, as well as physics analysis. Additionally, PhD students on ATLAS are required to complete a service task for the experiment. This is typically a year of work which contributes to the running of the experiment. My service task is a calibration of the hadron energy scale. My visit will continue the strong collaboration that already exists. While at CERN I can represent the group, for example during meetings, and also report back to Melbourne the events and news from ATLAS. The Experimental Particle Physics group plans to continue this collaboration for the foreseeable future and the number of students and staff involved is increasing.

2 Outline of Research Project

Although predictions from the Standard Model (SM) of particle physics has been in astonishing agreement with precision measurements of electroweak interactions, the mechanism of electroweak symmetry breaking (EWSM) is not yet known. The SM predicts a scalar potential with a non-zero vacuum expectation value which spontaneously breaks electroweak symmetry, giving mass to the W and Z gauge bosons. It is hoped that the scalar boson associated with this mechanism, the Higgs boson, will be discovered with the Large Hadron Collider (LHC) when 14TeV proton-proton collisions begin in 2008. Two general purpose detectors ATLAS and CMS are being built for the LHC and will be capable of observing the Higgs in the favored mass range, 114 GeV - 186 GeV. However, if the Higgs is not found in the mass region below 1 TeV as expected the mechanism for EWSB maybe studied via vector boson scattering. High mass resonances in the WZ and WW channels are predicted by a number of Beyond Standard Model theories in which dynamical EWSB occurs. The goal of my research will be to examine the extent to which the ATLAS detector at the LHC can measure or limit the existence of high mass vector-boson pair resonances.

Particular attention will be played to the role of jets in these events. As the dominant W decay is into quarks, jets play an important role in the reconstruction of the resonant mass. Any measurement of jet energy will be restricted by the accuracy of the absolute jet energy scale. Thus, part of this research will be a calibration study. Specifically, the calibration of the single hadrons energy scale with use of the E/p method. This is a method in which the accurate measurement of momentum, p, from the inner tracker will be transfered to the calorimeter energy measurement, E. This will be done using isolated pions from minimum bias (soft interactions).

Another application of minimum bias events is the calibration of transverse missing energy, E_T^{miss}. The resolution of this quantity will be studied. A good measurement of E_T^{miss} is needed for any mass reconstruction involving final state neutrinos. For example, in vector boson scattering this includes channels in which a W or Z decay into neutrinos. Additionally, many Beyond Standard Model theories such as supersymmetry predict the existence of new heavy weakly interacting particles which could potentially be produced at the LHC. In such situations, a signature of the new physics is large E_T^{miss}. Distinguishing this from background would require an understanding of any detector effects which lead to fake high E_T^{miss} in SM events.

Thus, there are two distinct areas of study proposed. The later of these has the potential to influence the outcome of the former.

- A physics analysis for vector boson scattering in the absence of a low mass Higgs.

- A study of calibration using minimum bias events with an aim to contribute to the precision of measurements with the ATLAS calorimeters.

3 Benefits

Studying in Geneva will allow me to collaborate closely with a number of people, attend meetings and have access to resource not available in Australia. The high energy particle physics community within Australia is small and as a result all students need to travel abroad to their experiment for an extended period of their PhD. This is essential for recognition and feedback from collaborators. I have already been at CERN for a short visit of less than three months. While this was an invaluable experience it was not long enough for me to fully utilize the expertise present at CERN.

The major benefits of the planned trip are summarized below.

- To be present when the first data from ATLAS is collected and see a running experiment. This is particularly relevant to my project as one of goals of this initial run is calibration using minimum bias events.
- To have on-site access to experts within my field of study. Both experimental and theoretical. Currently there is no one in Australia working in either area of my research project (Jet Calibration and Vector Boson Scattering).
- To gain feedback on my work. For example I will be able present at fortnightly meeting at CERN for the Jet Reconstruction group.
- To gain visibility for myself, the Experimental Particles Physics group and the University of Melbourne. Participation at CERN by previous PhD students has gain the University a strong reputation which I would like to continue.

4 Budget Justifications

Below is an explanation for the estimated costs of travel as given in the attached form. For all estimates a currency exchange rate of 1.000 AUD = 0.983 CHF was assumed (taken on 26/03/2007).

4.1 Expenses

Airfares - $2934 A quote for a return trip from Melbourne to Geneva is attached. The quote was the cheapest obtained by my travel agent and includes all airport taxes.

Visa Fees, Travel Insurance, Airport Taxes - $64 Stays in Switzerland beyond 90 days require a visa for Australian passport holders. The cost of a student visa application is $64. Travel Insurance is automatically provided by the School of Physics. The cost of airport taxes in included in the airfares quote above.

Accommodation, Bond, Utilities - $4800 The Experimental Particle Physics group at Melbourne rent an apartment close to Geneva. The cost per person per month is $800. No bond or utility payments are required.

Food - Per Diem - $10,200 The standard per diem for students from the group travelling to Geneva is 55 CHF per day. This is equivalent to AU $1700 per month. This amount includes general living expenses, primarily food but also travel unrelated to work, clothing, entertainment and miscellaneous expenses. I believe this amount is justifiable as, from my previous trip experience, the daily costs in Geneva are in general more than Melbourne.

Regular Transport Costs - $0 The apartment rented by the Experimental Particle Physics group is within walking distance to CERN so no regular transport costs are required.

4.2 Available Funds

Australian Postgraduate Award - $5442 I receive an APA scholarship of $1629 per month. However, my financial obligations within Australia limit the amount available for the proposed trip. $722 is needed per month to pay rent, utilities and donations in Melbourne.

Departmental Contribution - $6800 The Experimental Particle Physics group has a DEST grant for travel to experiments. From this they have agreed to contribute $6800 towards my proposed trip to CERN. An accompanying letter from Dr Elisabetta Barberio will support this.

4.3 Funds Requested

The difference between available funds ($12242) and trip expenses ($17,998) is $5756. I therefore request the maximum amount of $5,000 towards this trip.

5 Attachments

This application should contain the following documents:

1. Completed PORES application form
2. Detailed explanation of the trip including:
    - Details of the collaboration.
    - An outline of my research project.
    - Expected benefits of travel.
    - A justification of the estimated budget and fund request.
3. Letter indicating acceptance of supervision.
4. Airfares quote
5. Statement of support from my supervisor Dr. Elisabetta Barberio.

6. Completed budget proforma.
7. Copy of my academic transcript.
8. Copy of my CV.

If there are any queries about this application please contact me via phone: 8344 6310 or email: ndavidson@ph.unimelb.edu.au.

Thank you,

Nadia Davidson.