

Annual Report

Funding Programme:	Helmholtz Young Investigators Groups
Project ID No.:	VH-NG-803
Project Title:	Approaching the Fundaments of Physics using Top Quarks at the LHC
Group Leader:	Yvonne Peters
Helmholtz Centre:	DESY/Hamburg
Participating University:	University of Manchester
Report Period (=Calendar Year):	01/2014-12/2014

1) Group Structure

Please report briefly on the structure and personnel development of your group.

My group currently consists of

- Cecile Deterre; postdoc, started 01.09.2012
- Ralph Schäfer; PhD student, started 01.10.2012
- Roger Naranjo; PhD student, started 01.07.2013
- Abigail O'Rourke, PhD student, started 01.09.2014

In addition, we were able to attract DESY fellows to work with our group:

- Sara Borroni, started in November 2012 (on maternity leave from Mai 2013 to February 2014) until August 2014
- Jay Howarth, started in October 2013
- Alberto Gascon, started in November 2014

The main work of the group consists of two areas: data analysis at ATLAS and tracking/tracker related activities. During 2014, Cecile Deterre and Abigail O'Rourke dedicated about half of their time on both projects, while the rest of the group members concentrated more on data analysis in the top quark sector. Jay Howarth dedicated a major fraction of his time on fast track trigger activities. Alberto Gascon spent almost 100% of his time on silicon tracker related activities.

2) Network

Please describe how you / your research group are integrated within the Helmholtz Centre and the partner university (e.g. as member of committees).

The group is fully integrated into the ATLAS group at DESY, especially working closely together with the colleagues working on simulation for the ATLAS upgrade and SCT activities. My team participates in the common meetings and discussions.

The group is well connected with my team at the University of Manchester, by having weekly common „top team meetings“ and working on complementary but similar topics. Since the two current PhD students (Roger Naranjo and Ralph Schaefer) will graduate at the University of Wuppertal, together with a University professor (P. Mättig) and myself, we also do regular meetings with P. Mättig.

The group is also well situated within the Atlas collaboration, with four of the members (Y. Peters, S. Borroni, C. Deterre, J. Howarth) being (or having been) editors of conference notes or papers. Furthermore, Cecile Deterre was made convener of the top properties group in

september 2014. Cecile Deterre and Abigail O'Rourke are also fully integrated within the ATLAS team working on the sonar DCS. In addition, we collaborate directly with colleagues from Saclay and Glasgow.

3) Satisfaction

How satisfied are you with the general working conditions provided by the Helmholtz Centre / partner university? Is there anything that meets your criticism?

I am very satisfied with the working conditions at the Helmholtz Centre. My team is fully integrated into the ATLAS group at DESY, while allowing autonomous working conditions at the same time. I am also very satisfied with the conditions at the University of Manchester, where I am fully integrated into the particle physics group.

4) Scientific Progress / Milestones

How has your work plan progressed? Which important milestones could be achieved during the report period? Is the progress of your work in accordance with original planning or has the work plan been changed?

My project consists of two parts: top quark physics and tracker upgrade related work. Both projects proceed well.

In terms of top quark physics, we work on various topics related to top quark properties. In particular, we work on top quark polarization and $t\bar{t}$ spin correlations, the $t\bar{t}$ charge asymmetry and modeling studies in the dilepton final state using 8TeV ATLAS data. Furthermore, Abigail and Jay started to prepare for an early-Run II (i. e. 13TeV LHC run) $t\bar{t}$ cross section measurement. Cecile and Alberto started to look into a search for 4-top final states.

In 2014, the measurement of $t\bar{t}$ spin correlations using 7TeV ATLAS data, in which Jay and Yvonne were involved, was published. Ralph currently works on performing a related analysis with a wider scope on 8TeV data. In this analysis, instead of only measuring a few observables related to spin correlation or top quark polarization, the full spin density matrix of top quark pair production is considered. The particular variables are provided by a theorist (Prof. W. Bernreuther). Currently Ralph works on unfolding the distributions and finalizing the systematic uncertainties. We plan to complete this analysis and publish it in 2015.

Cecile's analysis of the inclusive measurement of the $t\bar{t}$ charge asymmetry in dileptonic events using 7TeV data got finalized in 2014, and a paper was submitted to a journal in early 2015. Currently, an extended form of this analysis is performed on 8TeV data by Roger. In particular, we also perform differential measurements of the $t\bar{t}$ charge asymmetry. Several studies, in particular on the optimization of the reconstruction of $t\bar{t}$ events and studies of unfolding were performed in 2014 by Ralph and Roger and particular reconstruction methods and unfolding were picked. The optimization studies of the reconstruction methods were summarized in an internal ATLAS note. Publication of the $t\bar{t}$ charge asymmetry analysis in 8TeV is planned for 2015.

Jay worked on a modeling analysis in $t\bar{t}$ events using 8TeV data, where we work in collaboration with Judith Katzy from DESY. The progress on the analysis is slower than expected due to issues with understanding pile-up subtraction and features in the tracking. The exact plan on how to progress with this analysis will be discussed in 2015.

In september, Abigail started her PhD with our team, with the plan to work on differential and fiducial $t\bar{t}$ cross section measurements in dileptonic $t\bar{t}$ events using 13TeV data. Since the timing of her PhD is in sync with the new Run II startup of LHC, the initial step is the involvement in early-data inclusive $t\bar{t}$ cross section measurements using same-flavour dileptonic events. She works together with Jay, exploring different possibilities of increasing the

sensitivity of the channel. Her work is a continuation of studies performed by Jay and two summer students (Harrison Schreek and Philippe D'Argent) in summer 2014. The overall early data $t\bar{t}$ cross section measurement is done in close collaboration with other ATLAS members and my team in Manchester.

In november 2014, we started to look into a search in the top sector for Run II, as was the plan according to my original proposal. In particular, Alberto and Cecile started to perform sensitivity studies on a maximally symmetric 2HDM model, in which a heavy Higgs is produced in association with a pair of top quarks, and itself decays into a top quark pair, resulting in a 4-top final state. The model was developed by theorists in Manchester, with whom we are in close contact. Experimentally, the plan is to explore same-sign dileptonic events. Currently I try to find a PhD student to strengthen this effort (I had a PhD student starting on it in 2014, but this did not work out unfortunately).

Overall, the progress on the top quark-related analysis is very good, and in accordance with the plan.

In addition to physics analyses, we are also involved in various activities concerning the ATLAS tracker. Cecile works on a project of a sonar detector control system, in which also Abigail is involved since september 2014, in order to acquire her authorship qualification. Roger finished his work on the integration of the Lorentz angle measurement in the SCT prompt calibration loop, where he worked in close collaboration with colleagues at DESY. Ralph was based at CERN from may to october, and Roger from november to december, in order to gain a better insight into operations and participate in control room shifts (for „milestone runs“ to prepare for the Run II start-up). Alberto spends most of his time on re-establishing the 24 hour calibration loop of the SCT, and Jay is very involved in fast track trigger (FTK) work.

In addition to these activities, the group leader was member of an editorial board and chair of another editorial board in ATLAS. Furthermore, the group leader and Cecile are members of the D0 collaboration. The group leader was serving as D0 representative of the „Tevatron+LHC Top Properties Combination Group“ until september 2014, plus chairs an D0 editorial board for top antitop quark production cross section analyses and is member of the D0 editorial board for top quark properties analyses. Cecile is member of the D0 editorial board for top quark properties analyses. In september 2014, Cecile became co-convener of the top quark properties group within ATLAS.

In summary, we have adjusted the work plan of the original proposal slightly to work on timely top quark analyses. On the top quark properties measurement side, the progress is better than expected in the original proposal. On the side of a search in the top sector (which was planned for Run II), the delay and issue of employing PhD students caused a lower involvement than expected. I plan to fix this issue in 2015. In terms of tracker upgrade, I plan to employ a PhD student in summer 2015 (candidate identified) to enhance the progress on this part also.

5) Financial Plan / Time Schedule

Can you comply with the financial plan and time schedule or do you see a need for adjustment?

Unfortunately there was an issue with one of the PhD students that I took on in September 2014, leaving this position still unfilled. The plan is to take on two more PhD students in summer 2015, to compensate for this issue (I am currently looking for candidates. At least one I have identified, who would work on tracker upgrade).

The finance plan does not require an adjustment though, and the plan is to fill the PhD position as soon as possible. Due to the delay in PhD starting dates, it is likely that I require to apply for an extension of half a year of my YIG after the end of the 5 years.

6) Status

Do you hold a joint Junior Professorship or a W2/W3 Professorship? Do you aim for such a position? What is the status of your negotiations in this respect?

I hold a position as Senior Research Fellow (equivalent W2; tenure track) at the University of Manchester.

7) Teaching Activities of the Group Leader

- Spring term 2014 and winter term 2014/2015: first year tutorials at the University of Manchester.
- Since beginning of the academic year 2014/2015 (in september 2014) I run four different MPhys projects (with a pair of 4th year undergraduate students working on each project) at the University of Manchester.
- 30 minute lecture about „The Higgs and the LHC“ to physics students at the University of Manchester, as well as to different age school children at Nuclear Physics Schools (Headstart and Smallpiece).

In addition, I participated in courses of the „New Academics Programme“ (NAP), required for new academics at the University of Manchester (I plan to be finished with the NAP in 2015).

Besides my own teaching activities, Cecile Deterre has been undergraduate lab course assistant for about 1 week (“Blockkurs”) in summer 2014 at the University of Wuppertal.

Furthermore, I participated in various outreach activities (e. g. at the Museum of Science and Industry in Manchester).

8) Publications of the Group

Publications (with major own contributions):

- 1) The ATLAS collaboration, "Measurements of spin correlation in top-antitop quark events from proton-proton collisions at $\sqrt{s}=7$ TeV using the ATLAS detector", Phys. Rev. D. 90, 112016 (2014).
- 2) Y. Peters, Proceedings on "Tevatron Top-Quark Combinations and World Top-Quark Mass Combination", Top2014, Cannes, France, October 2014 (arXiv:1411.0820 [hep-ex]).
- 3) Y. Peters, Proceedings on "Top Quark Studies at D0", BEACH2014, Birmingham, England, July 2014 (arXiv:1408.2257[hep-ex]).
- 4) R. Baites et al., "A Custom Online Ultrasonic Gas Mixture Analyzer With Simultaneous Flowmetry, Developed for the Upgraded Evaporative Cooling System of the ATLAS Silicon Tracker", IEEE TNS, vol. 61, pp. 2059- 2065 (2014).
- 5) C. Deterre and L. Mijovic, "Proceedings on „Measurement of the charge asymmetry in dileptonic $t\bar{t}$ events with the ATLAS detector at $\sqrt{s}=7$ TeV", Top2014, Cannes, France, October 2014 (arXiv:1412.0570[hep-ex]).
- 6) R. Schäfer, Proceedings on "Top quark pair properties - spin correlations, top quark pair asymmetry and complex final states using the ATLAS detector at the LHC", DIS, Warschau, Poland, April 2014, PoS(DIS2014)145.

In addition, several analyses, where one of the team members was editorial board chair of

member, were published in refereed journals in 2014 (not listed). Also, Tevatron combinations were published during the time Yvonne served as D0 representative of the Tevatron+LHC top properties combination group (also not listed). Furthermore, Cecile and myself are authors of all D0 publications from 2014, and Cecile, Jay, Sara, Ralph and myself are authors of all ATLAS publications in 2014. Since July 2014, Roger is also officially ATLAS author.

Public talks at conferences and seminar talks:

- 1) N. Naranjo, "Charge asymmetry measurement at 8 TeV in the dilepton channel.", DPG spring meeting, Mainz, Germany, March 2014.
- 2) R. Schäfer, "Service routing and material description for the Phase II upgrade of the ATLAS Inner Tracker (ITk)", DPG spring meeting, Mainz, Germany, March 2014.
- 3) R. Schäfer, "Top quark pair properties - spin correlations, top quark pair asymmetry and complex final states using the ATLAS detector at the LHC", DIS, Warschau, Poland, April 2014.
- 4) C. Deterre, "Top properties and new physics studies, charge/FB asymmetries, W helicity, top polarization", SM@LHC, Madrid, Spain, April 2014.
- 5) Y. Peters, "Top Quark Properties at D0", BEACH 2014, Birmingham, England, July 2014.
- 6) Y. Peters, "Review of recent Tevatron and world combinations", Top2014 workshop, Cannes, France, September 2014.
- 7) J. Howarth, "Top2014 summary", Particle Physics Seminar at the University of Manchester, Manchester, England, October 2014; and at LHC Seminar, DESY, Germany, October 2014.
- 8) Y. Peters, "Top Quarks: Selected TOPics", CAFPE Seminar at the University of Granada, Granada, Spain, November 2014.

Poster presentations at conferences:

- 1) J. Howarth, "Top2014: Spin correlation in Dileptonic ttbar events", Top2014, Cannes, France, September 2014.
- 2) C. Deterre, "Measurement of the charge asymmetry in dileptonic ttbar events with the ATLAS detector at sqrt(s)=7 TeV", Top2014, Cannes, France, September 2014.

9) External Funding

No additional external funding was acquired in 2014.

10) Patent Applications

No. of pending/granted patents

No patents were applied for during 2014.

11) Awards received by Group Members / Professorship Appointments offered to Group Leader

The group leader already has a tenure track position of a W2-equivalent at the University of Manchester.