# Annual Report

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| **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:** | Uni Göttingen, now University of Manchester |
| **Report Period (=Calendar Year):** | 01/01/2013 - 31/12/2013 |

## 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

Additionally, we were able to attract two Desy fellows to work with our group:
- Sara Borroni, started in November 2012 (on maternity leave since Mai 2013)
- Jay Howarth, started in October 2013

The main work of the group consists of two areas: data analysis at ATLAS and tracking/tracker related activities. During 2013, Cecile Deterre, Ralph Schäfer and Roger Naranjo dedicated about half of their time on both projects, and the rest of the group members concentrated more on data analysis in the top quark sector.

## 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 connection with the University of Göttingen was mostly limited to myself. Issues arising with this connection were automatically resolved by the offer of a position at the University of Manchester to the group leader. The two current PhD students will graduate now at the University of Wuppertal, together with a University professor (P. Mättig) and myself. Regular meetings with the professor in Wuppertal are planned and have already been started in December 2013.

The group is also well situated within the Atlas collaboration, with three of the members (Y. Peters, S. Borroni, C. Deterre) being (or having been) editors of conference notes or papers for three of our analyses. Cecile Deterre is fully integrated within the ATLAS team working on the sonar DCS system as well as the ongoing ttbar charge asymmetry analysis. In addition, we form a strong collaboration with colleagues from Saclay, with whom we share a common framework. A further direct collaboration with colleagues from Manchester is currently being build up.

**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 very autonomous working conditions at the same time.
Since this report will be made public, I prefer to not put points of criticism concerning the conditions at the partner University of Göttingen into this document. The conditions at the University of Manchester I am very satisfied with, allowing me also autonomous working conditions while being fully integrated into the 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 very well.

The topics in top quark physics were slightly shifted compared to the original proposal. Instead of concentrating on spin correlations in single lepton events, we now perform a broader spectrum of top properties analyses in the dilepton final state. In particular, we are involved in spin correlation, ttbar charge asymmetry and top quark polarization in dileptonic events using 7TeV ATLAS data. The program is extended by continuation of the polarization and the charge asymmetry analysis in 8TeV ATLAS data. Furthermore, we just started the study of top quark modelling in dileptonic ttbar events using 8TeV ATLAS data (this corresponds to the project „refining of systematic uncertainties“ in the original proposal).

The spin correlation analysis in dilepton events using 7TeV data has been presented at the Top2013 workshop. The publication of this analysis is currently in progress, with a small delay due to waiting for the analysis in the single lepton final state. The group leader is editor of this analysis, together with a colleague from Göttingen and from Manchester, and Jay is the main analyser of the analysis in the dileptonic final state.

Our analysis of top quark polarization in ttbar events using 7TeV has been published in PRL in summer 2013. This has been the first published measurement of top polarization. Sara has been editor for this analysis, and the group leader was contact editor. Ralph and Sara were both the main analysers of top polarization in dileptonic events. Currently, we extend this analysis to 8TeV. While work is concentrating on setting up the selection for 8TeV, Ralph already worked on trying new variables to measure not only longitudinal but also transverse polarization of the top quark in ttbar events. We plan to have a preliminary result in 2014.

Cecile currently works on the publication of the ttbar charge asymmetry in dilepton events using 7TeV data. Together with a colleague from Saclay, she is main editor for the paper. The analysis particularly required studies of the unfolding procedure to be used in the procedure to get the charge asymmetry without detector effects. The note describing the analysis is currently in ATLAS internal review and the analysis should be published by summer 2014. We plan to continue and extend the charge asymmetry analysis using 8TeV data, where further variables are planned to be used to measure this quantity differentially and not only inclusive. This is planned to be the thesis topic of Roger, who started working on this in 2013. During summer 2013, we supervised a DESY summer student, Natascha Rupp, with whom we tried to explore the possibility to measure the forward-backward asymmetry using information of the boost direction of the ttbar system. This would be a completely new analysis, and her studies on simulated „true“ particle level showed that this idea can be promising. We plan to explore this further in 2014.

Currently, most effort of Ralph, Roger and Jay goes into the preparation of the 8TeV dilepton selection. Several ingredients (background modelling, specific choices of lepton IDs, etc.) still need to be worked on (not only in our team – this is a top group wide effort in ATLAS).

In additional to physics analyses, we are also involved in various activities concerning the ATLAS tracker. Cecile worked on a project of a sonar detector control system, and the implementation and performance study of a cluster splitting algorithm for the upgraded ATLAS pixel detector, which is planned for the high-luminosity upgrade. She gained her authorship qualification for these projects in November 2013, and plans to continue with the sonar detector control system project. Ralph got involved into the study of the service routing for the tracking system for the 2022 detector upgrade, which by now is mostly finished. He got his authorship qualification for this project in November 2013. Roger got started with the integration of the Lorentz angle measurement in the SCT prompt calibration loop, where he works in close collaboration with colleagues at DESY.

In addition to these activities, the group leader is member of two editorial boards in ATLAS. Furthermore, the group leader and Cecile are members of the D0 collaboration. The group leader is serving as D0 representative of the „Tevatron+LHC Top Properties Combination Group“, plus chair of a D0 editorial board for top antitop quark production cross section analyses and 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 summary, we have changed the work plan of the original proposal slightly to work on timely top properties analyses. This enabled us to achieve earlier publications and a broader progress than foreseen in the outlined milestones in the proposal (in the proposal the first publication of an analysis of our group was foreseen a year later then we managed to do in reality). Therefore, the progression of the work plan so far is better than expected, despite the delay in employing PhD students.

**5) Financial Plan / Time Schedule**
*Can you comply with the financial plan and time schedule or do you see a need for adjustment?*

It took somewhat longer than originally planned to fill the PhD positions. The second PhD started only in July 2013 (instead of January 2013 as planned), and the third PhD position (originally planned to be sponsored by Göttingen and filled mid 2013) was not filled yet, partially due to the group leader's switch of institutes. One of the DESY fellows (Sara Borroni) was instead funded by my grant during the time of her intense work with my group.

The finance plan does not require an adjustment though, and the plan is to fill the PhD position as soon as possible (potential candidates to start in summer 2014 are already available).

We fully comply with the time schedule so far.

**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?*

Until October 2013 I have been Juniorprofessor at the University of Göttingen. Since October 2013, I hold a position as Senior Research Fellow (equivalent W2; tenure track) at the University of Manchester.

**7) Teaching Activities of the Group Leader**

- March 2013: Lecture and tutorials on “Hypothesis testing” at the Terascale Statistics school, Hamburg, Germany. The tutorials were performed together with Cecile Deterre.
- Summer term 2013: Lecture plus tutorials (2V+2Ü per week) on “Physics of Particle Accelerators” at the University of Göttingen.

In addition, I participated in a one-year certificate program for academic teaching at the University of Göttingen and got the “Göttinger Zertifikat für Hochschuldidaktik” in September 2013.

Besides my own teaching activities, Ralph Schäfer has been undergraduate lab course assistant for about 2 weeks (“Blockkurs”) in summer 2013 at the University of Göttingen.

## 8) Publications of the Group

**Publications (with major own contributions):**

1) F. Deliot, Y. Peters and V. Sorin, “Top Quark Physics at the Tevatron”, Int. J. Mod. Phys. A 28, 1330013 (2013).

2) S. Borroni, Proceedings on “Measurement of top quark polarisation with the ATLAS experiment”, LHCP, Barcelona, Spain, Mai 2013, EPJ Web of Conferences 60, 20015 (2013).

3) C. Deterre et al., Proceedings on “A custom on-line ultrasonic gas mixture analyzer with simultaneous flowmetry developed for use in the LHC-ATLAS experiment“, ANIMMA, Marseille, France, June 2013, submitted to Transactions on Nuclear Science.

4) The ATLAS collaboration, “Measurement of top quark polarization in top-antitop events from proton-proton collisions at sqrt(s) = 7 TeV using the ATLAS detector”, Phys. Rev. Lett. 111, 232002 (2013).

5) Y. Peters, Proceedings on “Top Quark Mass Measurements at the Tevatron”, EPS2013, Stockholm, Sweden, July 2013 (arXiv:1309.5783[hep-ex]).

6) S. Adomeit and Y. Peters, Proceedings on “V+jets Background and Systematic Uncertainties in Top Quark Analyses”, Top2013, Durbach, Germany, September 2013 (arXiv:1311.7305[hep-ex]).

7) Ralph Schäfer, Proceedings on “Measurement of top quark polarization in dileptonic top-antitop quark events using the ATLAS detector”, Top2013, Durbach, Germany, September 2013.

8) 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”, ATLAS-CONF-2013-101, September 2013.

9) T. Aaltonen et al. [CDF and D0 collaborations], “Combination of measurements of the top-quark pair production cross section from the Tevatron Collider”, arXiv:1309.7570 (submitted in 2013, accepted by PRD in 2014).

Besides these, Cecile and myself are authors of all D0 publications from 2013, and Jay, Sara and myself are authors of all ATLAS publications in 2013. Since November 2013, Cecile and Ralph are both officially ATLAS authors.

**Public talks at conferences and seminar talks:**

1) Yvonne Peters, “Auf den Spuren der Masse”, Seminar for participants of the physics Olympiad semi-finals, DESY, Hamburg, January 2013.

2) Yvonne Peters, “Neueste Ergebnisse vom LHC: Das Higgs und andere Schwergewichte”, Seminar to the friends and supporters of DESY (VFFD), DESY, Hamburg, January 2013.

3) Cecile Deterre, "Top charge asymmetry measurement in the dilepton channel with 7 TeV data in ATLAS", DPG spring meeting, Dresden, Germany, March 2013.

4) Ralph Schäfer, “Measurement of top quark polarisation in the dileptonic decay channel of ttbar events with the ATLAS detector”, DPG spring meeting, Dresden, Germany, March 2013.

5) Cecile Deterre, "Top charge asymmetry and polarisation measurements in ATLAS", seminar at CPPM Marseille, France, March 2013.

6) Cecile Deterre, "A custom on-line ultrasonic gas mixture analyzer with simultaneous flowmetry developed for use in the LHC-ATLAS experiment", ANIMMA, Marseille, France, June 2013.

7) Yvonne Peters, „Top Quark Mass Measurements at the Tevatron“, EPS2013, Stockholm, Sweden, July 2013.

8) Yvonne Peters, „V+jets background and systematic uncertainties", Top2013, Durbach, Germany, September 2013.

9) Yvonne Peters, „Top Quark Polarization at the LHC“, LHC Physics Discussion, DESY, Hamburg, September 2013.

10) Yvonne Peters, „Top Quark Properties at ATLAS“, PASCOS 2013, Taipei, Taiwan, November 2013.

**Poster presentations at conferences:**

1) Sara Borroni, “Measurement of top quark polarisation with the ATLAS experiment”', LHCP, Barcelona, Spain, May 2013.

2) Ralph Schäfer, “Measurement of top quark polarization in dileptonic top-antitop quark events using the ATLAS detector”, Top2013, Durbach, Germany, September 2013.

## 9) External Funding

The group leader received an ERC starting grant in July 2013 (1.16M Euros over 5 years). This grant will be hold at the University of Manchester, working on a complementary topic to my Helmholtz group’s activities. This complementarity results in a direct collaboration with my young investigator group at DESY and therefore aims at strengthening both activities.

## 10) Patent Applications

*No. of pending/granted patents*

No patents were applied for during 2013.

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

Sara Borroni won the best poster award at the LHCP conference in May 2013.

The group leader has been offered a position as Senior Research Fellow at the University of Manchester. The position started in October 2013. It was agreed that the group leader can

spend a large fraction of her time at DESY and continue with the young investigator group at DESY in the same way as before with Göttingen.