

Annual Report

<b>Funding Programme:</b>	Helmholtz Young Investigators Groups
<b>Project ID No.:</b>	VH-NG-1103
<b>Project Title:</b>	Search for dark matter and other new physics with the Higgs boson at the ATLAS experiment
<b>Group Leader:</b>	Dr. Sarah Heim
<b>Helmholtz Centre:</b>	DESY
<b>Participating University:</b>	Hamburg
<b>Report Period (=Calendar Year):</b>	01/2017-12/2017

**1) Group Structure**

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

Throughout 2017, the group consisted of

group leader	Sarah Heim, since September 2016
postdoctoral fellow	William Leight, since October 2016
graduate student	Fang-Ying Tsai, since November 2016
graduate student	Namgyun Jeong, since December 2016

Work areas during 2017

Work on ATLAS data analysis

- Differential Higgs cross-sections in the  $H \rightarrow ZZ^* \rightarrow 4l$  channel: Sarah Heim, William Leight, Namgyun Jeong.
- $ll + MET$  search: Sarah Heim, Fang-Ying Tsai

Work on ATLAS detector performance

- improvements of the missing transverse momentum calculation: Sarah Heim, Fang-Ying Tsai
- Electron identification and efficiencies: Sarah Heim
- muon software: William Leight

Work on ATLAS Upgrade (new inner silicon detector):

- strip module building: Sarah Heim, William Leight
- strip petal mechanical tests: Sarah Heim, Namgyun Jeong.

## 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 YIG is well integrated in the DESY ATLAS group. Some examples are below.

One of the topics of Kerstin Tackmann's group (former YIG) is differential cross-sections in the  $H \rightarrow \gamma\gamma$  channel (and since 2017 also in the  $H \rightarrow ZZ^* \rightarrow 4l$  channel). This fits very well to the  $H \rightarrow ZZ^* \rightarrow 4l$  projects of Sarah Heim's YIG, and the groups discuss in weekly meetings and collaborate on subprojects.

Close collaboration exists with the group of Beate Heinemann and Pieter Everaerts, who work also on the  $ll + MET$  search and have fellows and students on related analyses. Weekly meetings are held in this context and common projects are worked on.

Close collaborations also exist regarding the hardware work on the new ATLAS inner silicon detector ongoing at DESY, in particular with Sergio Diez-Cornell, Dario Ariza and Soeren Ahrens. This also includes collaboration with people working on this at DESY Zeuthen.

Furthermore the members of the YIG take part in meetings and discussions with the CMS and theory groups at DESY.

The University of Hamburg has granted the group leader the right to supervise and graduate PhD, master and bachelor students and in summer 2017 Sarah Heim taught 4 hours at a summer school organized by the University of Hamburg (Particles, Strings & Cosmology).

The YIG plays an active part in the ATLAS collaboration, through work and organizing roles in the Higgs, muon and missing transverse momentum performance groups, as well as the upgrade group.

## 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 conditions. The DESY ATLAS group provides a very supportive environment with people to talk to whenever I have questions or concerns, and a lot of opportunities for collaboration. The opportunity to do work on the new ATLAS inner silicon detector, afforded by the existing expertise and the evolving DAF (detector assembly facility) is very exciting. The students benefit from the offered workshops, schools, and lectures by the Hamburg PIER graduate school.

#### 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?*

According to plan, both graduate students finished their **qualification tasks** at the ATLAS experiment, which are 0.5-1 year long service-type projects, with which the students qualify to become authors on ATLAS papers. Fang-Ying Tsai's qualification task is officially done, while we are waiting for the final sign-off for Namgyun Jeong.

Fang-Ying Tsai focused on the improvement of the electron-hadronic jet overlap removal in the missing transverse momentum calculation at ATLAS. This is an important ingredient to the II+MET search that is foreseen to be her PhD topic.

Namgyun Jeong performed mechanical tests (3-point bending and vibration) on some subcomponents (petals) of the new ATLAS inner silicon detector. These test are important, as they will validate simulations of these components.

**Papers** were published in 2017, using LHC data from 2015 and 2016) in the context of the  $H \rightarrow ZZ^* \rightarrow 4l$  analyses (Will Leight, Sarah Heim, Namgyun Jeong). All  $H \rightarrow ZZ^* \rightarrow 4l$  analyses used the background estimates performed by Will Leight. The group played a leading role in the differential cross section paper (**J. High Energ. Phys. (2017) 2017: 132**). Sarah Heim was the editor and Will Leight performed many steps of the analysis. Furthermore Will Leight and Sarah Heim worked on the combination of the  $H \rightarrow ZZ^* \rightarrow 4l$  and  $H \rightarrow \gamma\gamma$  differential cross section measurements, which improves the uncertainties significantly with respect to the individual channel results. The differential cross sections are valuable inputs to probing the Standard Model nature of the Higgs boson. For the combination paper, Sarah Heim is paper editor, and Will Leight performs many parts of the combination, becoming an expert on statistical combination tools. This paper is currently in collaboration review.

In recognition of his work Will Leight was selected event selection and background contact by the  $H \rightarrow ZZ^* \rightarrow 4l$  group.

Sarah Heim is contact person for questions regarding electrons in the ATLAS Higgs group.

Sarah Heim also served as **electron identification and efficiency subconvener** in the ATLAS collaboration for most of 2017. In this role she coordinated measurements of electron reconstruction and identification efficiencies, which are used by all analyses on ATLAS that involve electrons. In November, a 4-day **electron/photon workshop** was organized by Sarah Heim and Kerstin Tackmann at DESY, where ca. 70 experts of the ATLAS collaboration gathered and discussed new developments in this field.

As in the last year, Will Leight served as ATLAS **muon reconstruction software convener**.

Furthermore Sarah Heim and Will Leight have started building and testing **prototype modules** of the new ATLAS inner silicon detector. This involves for example collaboration with the central workshop to produce tools and gluing with a robotic and a hand-held dispenser.

Sarah Heim also supported Sergio Diez Cornell's work regarding the commissioning of the new DAF (**detector assembly facility**, a class 6 clean room), which will be used for module assembly and testing of the new inner silicon detector.

So far, the work agrees well with the original plan, with a bit less involvement in electrons, but the addition of muon performance work, thanks to Will Leight's expertise. This fits very well, as all planned analyses have both electrons and muons in the final state.

**5) Financial Plan / Time Schedule**

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

The travel expenses in 2017 were very close to the planned amount. Small investments were performed for ATLAS upgrade module building, more expenses are expected in the future.

**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 do not hold a (junior) professorship, as this is not offered to YIG leaders by the University of Hamburg. In the future I do consider a habilitation at the University of Hamburg, but not currently.

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

University of Hamburg Summer School on "Particles, Strings & Cosmology": 4 lectures on the Higgs boson

**8) Publications of the Group**

Measurement of inclusive and differential cross sections in the  $H \rightarrow ZZ^* \rightarrow 4l$  decay channel in pp collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector (J. High Energ. Phys. (2017) 2017: 132)

Sarah Heim, William Leight, and Fang-Ying Tsai are authors on publications by the ATLAS collaboration.

**9) External Funding**

No external funding was applied for.

**10) Patent Applications**

*No. of pending/granted patents*

No patent application was submitted.

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

No awards/appointments were received.