

Annual Report

Funding Programme:	Helmholtz Joint Research Groups
Project ID No.:	HCJRG-300
Project Title:	Novel Technologies for the Upcoming Silicon Micro-Strip Detector of the ATLAS Experiment at CERN
Principal Investigator:	Dr. Ingrid-Maria Gregor
Report Period (=Calendar Year):	01/2015-12/2015

1) Group Structure

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

The HCJRG-300 group "Novel Technologies for the Upcoming Silicon Micro-Strip Detector of the ATLAS Experiment at CERN" is, on the DESY side, lead by two senior scientists (Dr. Ingo Bloch, Dr. Ingrid-Maria Gregor). Two further DESY senior scientists (Dr. Marcel Stanitzki, Dr. Sergio Diez Cornell) are supporting the developments and the research of the group. Additionally, two postdoctoral and two PhD students are associated to the joint research group. The subject of their PhD thesis is closely tied to the planned research of this group.

One of the main tasks for the reporting period was the appointment of a postdoctoral researcher and a PhD student who are then dedicated to the research of this joint research group. This proved to be more challenging than we had anticipated and only towards the end of the first year we were able to recruit two excellent candidates.

Personnel employed for this joint research group:

- Postdoctoral researcher: Dr. Marko Milovanovic (starting date 01.12.2015)
- PhD student: Martin Stegler (starting date 17.08.2015)

2) Network/ Meetings

Please describe how the group works together. Have there been any international meetings organized by or attended by the group? What is the contribution of the group to the networking of international partners and the Helmholtz Centre?

The group works closely together and communicates predominantly via e-mail, video meetings and phone conferences. The contacts are on a regular weekly basis. Additionally, a number of very beneficial face-to-face meetings were arranged alongside various international meetings. For example, the senior scientists of the German and the Chinese partners did have a half a day meeting at CERN in May 2015. The principal investigators of both teams had a face-to-face meeting alongside the 10th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors in Xi'an (China).

Furthermore, was the principle investigator Dr. HongboZhu visiting DESY a number of times throughout the year 2015.

Additionally, two postdoctoral researchers from IHEP spent an extended stay in Zeuthen and Hamburg. Dr, Yi Liu spent about three months at DESY Zeuthen before moving to Hamburg and taking a position funded by the DESY-ONACPR program, while Dr. Jason Mansou remained in Zeuthen.

3) Scientific Progress / Milestones

How has your work plan progressed? What 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?

The progress of the project within this joint research group did not start as fast as anticipated during the proposal phase due to the late appointment of a postdoctoral researcher and a PhD student. Nevertheless, the associated PhD students made key contributions to the work packages. In the following the achievements of the three individual work packages are summarised.

WP1: Silicon micro-strip detector performance before and after irradiation:

Within this work package the construction of several prototype end-cap silicon strip modules was completed and first test beam studies were conducted. A preliminary test beam at the DESY-II electron test beam facility pointed to a problem in the synchronization of the various electronic components needed to read out the prototype modules. In the following weeks this problem was investigated in detail and a solution for this synchronization problem was quickly implemented in the setup. This improved setup was subsequently used in a study at the Diamond Light source test beam (RAL, UK). A further extensive test beam campaign with detailed studies at DESY and RAL is planned for 2016.

During this campaign alternative silicon sensor designs with embedded fan-ins in a second metal layer will be studied. This is performed in cooperation with CNM Barcelona (institute providing the silicon strip sensors). The preparation of the newly designed sensors for this study was started in fall 2015 and will continue throughout 2016. For the upcoming test beam studies elements of modules have been irradiated to irradiation doses expected at the end of the high luminosity phase of the LHC (HL-LHC). Modules are being constructed from those irradiated elements. Their behaviour will be evaluated in the scheduled test beam studies.

WP2: Thermal effects

This work package could only be started after a suitable PhD candidate was hired. He started in August 2015 at DESY and he accomplished a very fast start-up of the relevant simulations (based on final element calculations of the thermal behaviour). Detailed simulations were performed to describe the mechanical stress in the silicon micro-strip modules, which is expected due to the thermal cycles necessary in the ATLAS detector (temperature range +20°C to -20°C). This stress is introduced by differences in the thermal expansion coefficients of the various materials used for the module components. Additionally, initial studies to mitigate these mechanical stresses were conducted to enhance the overall performance and life-expectancy of these central components in the future ATLAS tracking detector. An interesting cross correlation has emerged – the currently most likely powering option (DC-DC, see WP3 below) leads to a localized heating effect on top of the ATLAS silicon strip modules, which will be dependent on the integrated luminosity (unit for the amount of particle interactions within the ATLAS detector). The detailed understanding of the impact of this effect on the silicon module performance will be greatly improved by the HCJRG studies and is essential for the success of the development of a future silicon strip detector for ATLAS.

WP3: Powering decision

In this work package the joint research group is concentrating on the implementation of the complex parallel powering concept called “DC-DC” for the end-cap area of the strip detector. In the reporting period a prototype DC-DC power board was developed. Based on these developments several thermo-mechanical dummy modules with prototype DC-DC powering boards were constructed to evaluate the thermal behaviour of the substructures holding the

modules. Special attention was paid to the mock modules loaded onto the substructure mimicking realistic silicon strip modules and thus their thermal load to the system. Furthermore, developments for the high voltage (HV) powering of the silicon sensors were started. Here specially developed aluminium ribbon tapes were tested for electrical connections to the backside of the silicon sensors. This originally not foreseen study was initiated after reliability issues arose with currently planned backplane powering scheme involving backplane contact with conductive epoxy resin. Also, the powering scheme work was extended to include studies for the high voltage isolation between the two adjacent silicon sensors on the substructure. A method involving poly-urethane coating showed the best initial results and will be pursued further. If this is successful, this would allow reducing the insensitive areas in the tracking coverage significantly, since without HV isolation the distance between two modules must include an isolating air gap in excess of 1 mm. This relatively large gap could now reduced to just a few micrometres.

4) Financial Plan / Time Schedule

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

Due to the delay in the appointment of the required personnel, the planned investments and costs for personnel was lower than planned. About 90 kEUR were not spent and moved into the next reporting period.

The group is looking into the possibility to increase the spending for 2016 by adding an additional PhD student to the project and thus catching up with the initially planned milestones of the project.

5) Publications of the Group

1. Characterization of silicon micro-strip detectors for the ATLAS Phase-II Upgrade with a micro-focused X-ray beam – arXiv:1603.04846
This publication is based on research conducted during the reporting period but was submitted in 2016; accepted by JINST (submission JINST_014P_0216 has been accepted for publication in JINST).

6) External Funding

- none -

7) Patent Applications

No. of pending/granted patents

- none -

8) Awards received by Group Members

No group member received an award in the reporting period.