Helmholtz Alliance – HA-101
Physics at the Terascale

Annual Report 2013

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Project Number	HA-101
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1 Introduction

The Helmholtz Alliance "Physics at the Terascale" (www.terascale.de) is a network comprising the Helmholtz centres DESY and KIT, 18 German universities and the MPI for Physics in Munich. It is part of the international research programme of high-energy collider-based elementary particle physics that studies physics at the smallest directly accessible scale exploiting experiments at the Large Hadron Collider (LHC) and preparing future projects like the International Linear Collider (ILC), a planned e^+e^- collider. The goal of the Alliance is to strengthen, also on the long term, the international role of German particle physics. For this purpose, structures are developed and collaborations established that go beyond single sites and experiments — and across experiment and theory — and thus facilitate fruitful exchange and communication as well as the definition and exploitation of synergies. In its original setup, the Alliance had four pillars: physics analysis, grid computing, detector development, and accelerator physics.

1.1 Project Development

The initial Alliance funding from the Helmholtz "Initiative and Networking Fund" (IVF) consisted of 5 MEur per year and was supplemented by significant funds from the partner universities, mainly in the form of positions. This original funding came to an end at the end of 2012, and for the years 2013/14 a reduced funding of 0.5 MEur per year has been granted. This amount is supplemented by about 1 MEur from DESY base funding (used mainly for Alliance-relevant positions, computing infrastructures etc.) and by a similar amount from the university partners, mainly for the continuation of positions. As decided by the Institute Assembly of the Alliance, about 0.38 MEur per year of the Helmholtz money are used for three dedicated projects which will be described in more detail later in this report:

- "Enabling Technologies for Silicon Microstrip Tracking Detectors at the HL-LHC": Aachen, Berlin, DESY, Freiburg, Hamburg, KIT.
- "Inclusive and Semi-inclusive Constraints on the Parton Distributions at the LHC and the Study of Hard Processes": DESY, Freiburg, Hamburg, KIT, Mainz, Wuppertal.
- "Performance Optimisation for the Present and Next-generation HEP Data Analysis on the Grid": Aachen, DESY, Göttingen, KIT, Munich, Wuppertal.

The remaining Helmholtz funds of about 120 kEur per year are used for backbone purposes (event organisation, travel, guests etc.).

In 2013, despite the reduced funding, most Alliance projects proceeded well, and the related infrastructures were heavily used by all partner institutions. Examples are the DESY test beam, the irradiation facility at KIT and the Tier-2 centres plus the National Analysis Facility (NAF).

The Institute Assembly of the Alliance met during the 2013 annual meeting. It decided that the organisational structure of the Alliance, including the Project Boards, shall be maintained during the years 2013/14; all Project Board members were asked to remain in their position. In the light of new Helmholtz developments — specifically the Helmholtz portfolio topic "Accelerator Resaerch and Development" (ARD) — it was, however, decided to let the mandate of the Accelerator Project Board come to an end at the end of 2013. The portfolio topic ARD was designed to bundle and interconnect all German research activities in the field of accelerator development. The previous chair of the Accelerator Project Board was asked to join the Detector Project Board as a guest.

1.2 Annual Workshop 2013 in Karlsruhe

The seventh annual workshop of the Alliance took place in December 2013 in Karlsruhe with about 250 participants, indicating the continued strong interest of the Alliance community in the common discussions and activities. After the discovery of a Higgs boson and the awarding of the Nobel prize 2013 for the theoretical development of the Higgs mechanism, one focus was naturally on the respective achievements of the LHC and in particular on the interpretation of this new particle in the Standard Model and in theories beyond. A further important aspect was the interesting development of the ILC project for which the Technical Design Report was published in 2013 and a construction site selected. Among the internationally renowned speakers were Sachio Komamiya (chair of the Linear Collider Board LCH), Christoph Rembser

(CERN), Jim Virdee (former CMS spokesperson) and the theorists Nigel Glover (IPPP Durham) and Marcela Carena (Fermilab). A presentation on astroparticle physics and its increasingly important connections to our field of particle physics was given by Uwe Overlack (Mainz).

1.3 Summary and Future Directions

After five years of existence, the Alliance has reached most of its ambitious goals. In particular, German particle physics has been visible strengthened and is acting as a major partner in the global LHC effort. Ground-breaking progress at the energy frontier has been achieved during the course of the Alliance:

The LHC and its experiments worked beyond expectations. The Terascale has indeed undergone its first direct exploration. A Higgs boson has been discovered. Theoretical precision calculations using the most sophisticated techniques enabled this discovery by making precise predictionsÊfor the significant backgrounds. Mass scales up to 2–3 TeV are meanwhile directly probed in numerous final states. The stunning consistency of all oberservations with the Standard Model of particle physics raises deeper questions: What mechanism is responsible for the stabilisation of the Standard Model? Is there a stabilisation mechanism at all? Are there signatures of new physics that have not yet been probed by the LHC experiments? Is the discovered Higgs boson a new portal for new physics? Not only the direct study of the Higgs boson but also the precision study of Êthe top quark and of multiple gauge boson production now enable a much deeper understanding of electro-weak symmetry breaking. LHC exclusions are also contributing to the quest to find the origin of dark matter. Supersymmetry, still the most elegant candidate for a stabilisation of the SM, has not been observed in LHC Run 1, calling for a refinement of our expectations. In particular, the search for third-generation SUSY partners in the upcoming Run 2 will further, albeit not decisively, test whether it is indeed SUSY that stabilises the SM. The envisaged increase in centre-of-mass energy of the LHC by almost a factor two will open again completely new territory to be explored.

The challenge for the German comnunity and for the Alliance is now to maintain its important role in the exploration of Terascale physics. The momentum gained in the past few years needs to be maintained, and networking and the fostering of collaboration and cooperation in the Alliance spirit are keys to this goal. Of particular importance is the development of common projects (and the securing of the necessary funding) — always taking up the latest developments in a timely fashion and aiming to drive the field. Few such projects could indeed be initiated with the help of the (significantly reduced) additional funding in 2013. Many more such ideas are existing in the community — realising them is the great challenge for the Alliance and its partners in the coming years, and discussions in the framework in the Terascale Alliance and in the framework of the new Helmholtz programme "Matter and the Universe", together with the Alliances in astroparticle physics and in hadron and nuclear physics, HAP and EMMI.

2 Management

The management structure of the Alliance reflects the main activities of the German high energy physics community. Emphasis is placed on a broad involvement of as many partner institutions as possible.

The Project Boards of the Alliance are responsible for the Alliance research topics, have a steering and monitoring function and provide the management with first-hand information about ongoing activities, plans and ideas. As stated above, they have been maintained in the approved form, with the exception of the Accelerator Project Board.

The Management Board of the Alliance, through its regular meetings, can react swiftly to new developments. After the change of the Scientific Manager of the Alliance in December 2013, the Management Board has the following members:

Chair:	Thomas Schörner-Sadenius (DESY)
Members:	Thomas Hebbeker (RWTH Aachen), Joachim Mnich (DESY), Markus Schumacher (U Freiburg), Dieter Zeppenfeld (KIT)
Ex-officio:	Ties Behnke (DESY), Karsten Büßer (DESY), Klaus Desch (U Bonn), Lutz Feld (RWTH Aachen), Herbert Dreiner (U Bonn), Eckhard Elsen (DESY), Matthias Kasemann (DESY), Klaus Mönig (DESY)

3 Main Scientific Achievements

In 2013, the LHC was in its first long shutdown phase which will continue until Spring 2015. The data accumulated until the beginining of the shutdown are still being analysed. Exciting results on very different subjects are achieved almost on a daily basis, many of them with important contributions from Alliance partners. One focus of attention is Higgs physics — after the discovery of a Higgs boson in 2012 and the Nobel price for physics in 2013 for Englert and Higgs, the aim is now to measure the properties of the new particle with the highest precision possible at the LHC in order to identify the particle as the one Higgs boson predicted by the Standard Model of particle physics or to discover signs of new physics beyond the Standard Model. Many Alliance physicists are involved in this endeavour, both in the experiments and in theory. The latter is well represented by members of the Alliance working group on "BSM Parameter Fitting" which tries to assemble all relevant data from the LHC and elsewhere into a consistent picture of particle physics, thus testing models for new physics. Given that one of the large uncertainties on the Higgs theory predictions comes from uncertainties on the proton structure (parton distribution functions, PDFs), the prominent roles that the funded project "Inclusive and Semi-inclusive Constraints on the Parton Distributions at the LHC and the Study of Hard Processes" and the Alliance activities in the HERAFitter and PROSA projects take are justified. In this field, the Alliance can profit massively from expertise of physicists that earlier have worked at HERA. (More details about various activities in the Alliance research topics are given later.)

The LHC will restart its operation at increased energy and luminosity in 2015. Later shutdown phases are already scheduled, and the corresponding work on both the accelerator and the detector is ongoing. The Alliance is very active in the latter field, where a dedicated project "Enabling Technologies for Silicon Microstrip Tracking Detectors at the HL-LHC" has been funded. But not only do the detectors have to stand increased rates and radiation doses, also the computing and data analysis environment at the LHC must be made fit for the increased data rates. The Alliance has traditionally been strongly involved in LHC computing, not least via the Tier-1 centre at KIT (GridKa), the DESY Tier-2 and the National Analysis Facility (NAF) that proves to be an important tool for German particle physicists, giving them privileged access

to high-performance computing infrastructure. Furthermore, the Alliance has funded the Tier-2 structures at German universities. This Alliance Tier-2 financing has ended with the end of the original Alliance funding period in 2012, and currently paths towards alternative funding schemes are being explored.

With the discovery of a Higgs boson, the physics case for the next large project in high energy physics — an e^+e^- linear collider — has been considerably strengthened. Numerous Alliance partners are involved in the preparation of accelerator, physics and detectors of the International Linear Collider (ILC); they have as a common platform the "Alliance Linear Collider Forum" that organises workshops (typically two meetings per year) and, since 2013, also a school on linear collider physics.

The ILC is the most realistic option for a next large project in high energy physics. In 2013, its Technical Design Report was published, and a potential construction site for the machine was selected by the Japanese high energy physics community. On the ILC accelerator side, the development of high-gradient superconducting radio-frequency cavities is one of the key areas, and DESY is the worldwide leading laboratory in the field. Together with Alliance partners, the production process of such cavities could be substantially improved.

The detector developments for the ILC are progressing well. The Alliance is active in a number of key areas, such as the time projection chamber the and the hadron calorimeter. Through the Alliance, the basis of this research could be significantly broadened. Members of the Alliance are also among the leading institutes in preparing a full coherent detector concept for the ILC or for other linear colliders. A "Detector Baseline Document" has been submitted together with the ILC TDR, and Alliance physicists were crucially involved in its preparation.

The highly esteemed school and workshop programme of the Alliance was continued in 2013, with again many hundreds of physicists at all career levels participating in discussions, training events and scientific exchange.

The focus in the following years will be to assess the impact of the newest LHC data (especially in the Higgs field) on the physics potential and performance of the ILC; the Linear Collider Forum is a natural place to discuss these issues in the Alliance context and also on an international level.

4 Funded Projects

4.1 "Enabling Technologies for Silicon Microstrip Tracking Detectors at the HL-LHC (PETTL)"

Aachen, Berlin, DESY, Freiburg, Hamburg, KIT.

During its extension into the years 2013 and 2014, one project from the area of detector development is funded by the Alliance. It has been selected by the international advisory panel from a number of very good proposals. The title of this project is "Enabling Technologies for Silicon Microstrip Tracking Detectors at the HL-LHC", abbreviated as "PETTL". While the tracking detectors of the ATLAS and CMS experiments have shown excellent performance in Run 1 of LHC data taking and are expected to continue to do so during LHC operation at design luminosity, both experiments will have to exchange their tracking systems when the LHC is upgraded to the high-luminosity LHC around the year 2023. The new tracking systems

need to operate in an environment in which both the hit densities and the radiation damage will be about an order of magnitude higher than today. In addition the new trackers need to contribute to the first level trigger in order to maintain a high data-taking efficiency for the interesting processes. Novel detector technologies have to be developed to meet these very challenging goals.

Since the challenges are very similar for both experiments, the PETTL project aims to foster the collaboration between the German ATLAS and CMS tracker groups, from universities and Helmholtz centres, during the ongoing R&D phase. This collaboration across experiment boundaries is a very good example of the benefits and the unique role of the Alliance. A number of key areas of mutual interest have been identified, including the exchange of experience gained in the development and construction of the current tracking systems.

All German groups active in the development of new tracking systems for ATLAS and CMS are members of the PETTL project: RWTH Aachen (CMS), Humboldt University Berlin (ATLAS), DESY Hamburg and Zeuthen (ATLAS and CMS), Freiburg University (ATLAS), Hamburg University (CMS), and the Karlsruhe Institute of Technology (CMS). The Alliance funding provides for two positions which are split into four half positions and complemented by the host institutes. In addition some invest money is available to cover irradiation costs.

The project has been structured into five work packages which are described in the following. Three workshops are foreseen during the two years, complemented by regular smaller meetings of the individual work packages. The first workshop took place from 28 Februar to 1 March 2013 at Mainz[1], together with the Alliance Detector Workshop. It consisted of a session on "Lessons learned from design, construction and operation of current LHC tracking detectors" and a session on planning of the work in the project. The second workshop takes place on 6/7 March 2014 at Göttingen, again together with the Alliance Detector Workshop. This combination of meetings has proven to be useful since it gives the general audience of the detector workshops the opportunity to attend the PETTL sessions. The final workshop will take place at DESY, towards the end of 2014. It is planned to compile the main results of the project in a report which will be published at the beginning of 2015.

WP1: Exchange of Experience The aim of this work package is to exchange the experience gained during the design, construction and operation of the current ATLAS and CMS tracking systems, to summarise different approaches, and to analyse weak and strong points. This was the main topic of initial workshop, at which seven experts reported on the design and construction of the silicon-strip modules, the barrel and end-cap detector systems and their integration, and the running experience, for ATLAS and CMS. It became apparent that many lessons can be learned from this past experience which are sometimes very similar for the two experiments, but sometimes also different and very interesting for the other experiment. The main lessons have been compiled in a document which will be part of the PETTL report. These lessons will be confronted with the ongoing developments for the new tracking systems at the second workshop.

WP2: Radiation Hardness of Silicon Sensors The silicon sensors for the new ATLAS and CMS tracking systems have to be a factor of ten more radiation hard than the ones currently

[1] `https://indico.desy.de/conferenceDisplay.py?confId=7063`

in operation. Development work in this area is ongoing within ATLAS and CMS. The PETTL project aims to combine results obtained in the two collaborations in order to achieve a more complete and accurate understanding. One aspect is the thorough evaluation and combination of the silicon-sensor radiation damage actually measured in the ATLAS and CMS trackers, which should allow for more realistic extrapolations to the operating conditions at the high-luminosity LHC. The main focus, however, is on the joint analysis of radiation effects, based on results obtained within the experiments and by additional lab measurements in areas of particular interest to both experiments. It turned out that in addition to the by now rather well known silicon bulk damage, radiation induced changes at the surface of the devices play a very important role. Such effects have been observed by both collaborations and work is ongoing to understand the mechanisms and the implications for the design of the silicon sensors for the new tracking systems. One particularly interesting mechanism is intrinsic charge multiplication due to high electric fields at the surface. This could lead to an improved detector signal but it may also have adverse effects on detector noise and stability. Detailed comparisons of charge collection and loss mechanisms and on the stability of operation of such devices are ongoing. These studies should help to improve device simulations and first encouraging results have been reported.

WP3: Low-Mass System Design The measurement accuracy of silicon tracking detectors is affected by the multiple scattering of particles in the detector material itself. Low-mass system design is therefore a key requirement for successful operation of these detectors. The general work program which is ongoing in ATLAS and CMS is rather diverse and includes investigations on novel low-mass materials, novel production techniques, new detector module and system design concepts, powering, communications, cooling, electronic hybrids, and more. The PETTL project helps to exchange information between the two collaborations and aims to support these developments in areas of particular interest to the participating German groups. This includes the exploration and testing of novel low-mass materials like carbon foams, metal carbon composites as well as more classical carbon sandwich structures, for which a lot of results are now becoming available and which can be used for improved detector designs. Glue connections are used in many places and the boundary conditions imposed by the available glues are quite important for the design options and the assembly process. PETTL aims to qualify UV curing glues for tracking detector systems, in particular for the assembly of ASICs and silicon sensors. Due to the very short curing time such glues would simplify and accelerate the assembly considerably. However, the radiation hardness and compatibility of these glues with the components and procedures has to be demonstrated. This work is ongoing.

WP4: Automated Precision Assembly Procedures Silicon detectors achieve micrometer precision in the measurement of particle tracks. Although software based alignment corrections have proven to be very powerful, the assembly precision of the detectors is still essential. When silicon tracking information is to be used at the first trigger level, software alignment is difficult or impossible to use, depending on the implemented scheme. On the other hand, the new tracking systems will be composed of tens of thousands of silicon sensors. The development of automated and precise assembly techniques is required and can partly be based on the experience obtained in the construction of the current tracking systems. Within PETTL, this

experience from ATLAS and CMS has been collected and compared, and the requirements for the new detector systems have been analysed. Options for automation are being explored with industry. Ideas for precision assembly of silicon sensors into modules and larger structures are under discussion and being tested on prototypes. A method for the precise metrology of double sided objects in which silicon sensors have to be aligned with high precision back-to-back is under development.

WP5: Irradiations Radiation testing of silicon sensors as well as novel materials and components is essential in the qualification process. PETTL provides access to the Karlsruhe cyclotron and other irradiation sources. In 2013 five irradiation campaigns have been performed to support the development work described above.

4.2 "Inclusive and Semi-inclusive Constraints on the Parton Distributions at the LHC and the Study of Hard Processes"

DESY, Freiburg, Hamburg, KIT, Mainz, Wuppertal.

This project is a joint effort carried by German theory and experimental groups from ATLAS and CMS. It aims at achieving a new level of precision in the knowledge of the nucleon substructure and the other central parameters of QCD, which is of instrumental importance for the deeper understanding of the Standard Model and possible extensions. Thereby, in the searches for new physics the signals will be improved and the understanding of the backgrounds refined. One example is the Higgs boson in the analysis of which many QCD aspects like the strong coupling α_s or the gluon distribution in the proton are crucial.

The project covers the following topics:

1. improvement of the parton distribution functions [all groups];
2. analysis of the DIS structure function $F_2^{c\bar{c}}(x, Q^2)$ [DESY, Hamburg];
3. analysis of LHC $W^{\pm}$ and Z production and new constraints on the sea quark density [DESY, Freiburg, Mainz];
4. analysis of Drell–Yan data [DESY, Freiburg, Mainz];
5. analysis of the LHC jet data [DESY, KIT, Hamburg];
6. top production (single top and $t\bar{t}$) [Wuppertal, DESY, Hamburg];
7. precision measurement of $\alpha_s(M_Z^2)$ [all groups];
8. precision measurement of m_c and m_t [DESY, Hamburg, Wuppertal].

Already the first year of this project — that joins two DESY and five German university groups — has led to a series of new results in the field of precise NNLO analyses of the world data on deep inelastic scattering (DIS), Drell–Yan, di-muon production, jet physics, $t\bar{t}$ and single-top production, including results from ATLAS, CMS and LHCb. Using all these inputs,

the knowledge of the parton distribution functions (PDFs) has been improved significantly, in particular for the sea quarks, and a stabilisation of the strong coupling α_s was obtained. Furthermore, a precision determination of the mass of the charm quark, m_c, could be performed. The present ABM12 parton distributions, which incorporate all these improvements, consequently deliver good predictions for physics processes at the LHC. One example is the excellent prediction (prior to the measurement!) of the $W^{\pm}$ and Z cross sections as measured by the CMS experiment.

First publications concern the ABM12 analysis on PDFs and a refined measurement of $\alpha_s(M_Z^2)$. In a common paper of the groups at DESY and Hamburg an improved measurement of m_c and $\alpha_s(M_Z^2)$ from DIS data has been achieved. Different groups contributed to analysis tools and data analysis of the top-quark data to improve the present knowledge of m_t, which is an ongoing effort. Single top quark production has been measured and analysed. This process also delivers a measurement of the CKM matrix element $|V_{tb}|$. During the coming work of the project further refinements, with particular emphasis on LHC jet data, are planned. Here, NLO analyses have been performed in detail. However, it is known that — due to the precision of the LHC data — NNLO analyses are necessary. The corresponding analysis tools will be available very soon. Again one expects that the value of $\alpha_s(M_Z^2)$ is further improved, perhaps using LHC data only. Furthermore, much better constraints will be obtained for the gluon distribution function.

A first annual meeting of the project, at which results from all participating groups were presented, was held at Liebenberg (Germany) in October 2013.

4.3 "Performance Optimisation for the Present and Next-generation HEP Data Analysis on the Grid"

Aachen, DESY, Göttingen, KIT, Munich, Wuppertal.

At a steering workshop in June 2013, initial progress in the 5 work packages after 6 months was reviewed and the work ahead coordinated. At the Alliance annual workshop in December 2013, significant progress was reported in all areas. The project is coordinated by regular project coordination phone conference. The next project workshop is scheduled for 10-12 May 2014 at DESY in Hamburg.

WP1: Development of Reliable and High-Performance Access to LHC Data through the dCache Project The goal of this project is to make cache storage available to everyone. In order to allow scientists who are registered at their local sites to access scientific data anywhere in Germany, identity providers are established at KIT, DESY and GSI. A demonstrator federated storage system was implemented to assess the performance and functionality for accessing and moving data between sites. Next milestones are to extend the access to storage systems to more sites connected by the German Research Network DFN and to work on the data security aspects.

WP2: Performance Monitoring of Grid Jobs, Sites and Services The infrastructure monitoring system "Happy Face" is in use at several centers. Historical data are made available in a database. It monitors the full spectrum of hardware, software and service gathering

information from remote and local sites. Ongoing tasks are developments of new information gathering modules and adapting existing modules to evolving services. In addition the package installation and update procedures are improved. The development of web services to provide the desired data in different format and time frames is completed. Job execution monitoring ("JEM") is developed and a customisable job-centric monitoring system run by users to measure parameters like CPU load, network traffic, free RAM and free disk space. It is a powerful tool to debug, monitor and oversee analysis jobs executing on the grid. Achievements in 2013 are the full integration into the ATLAS analysis software. It is easy to use and provides results as soon as the job ends.

WP3: Virtualisation Techniques and the Management of Job Submission and Workflows in Distributed Computing Infrastructures The LHC experiments are consolidating their analysis workflows. To prepare for the next round of data analysis starting in 2015 they investigate and and are investing into new technologies for job submission, site performance optimisation for analysis and the use of new file systems for fast high-performance data analysis. Technologies like gliteInWMS, HammerCloud FAX testing, ARC-CE for HPC and CREAM CE and Hadoop for parallel data analysis are successfully evaluated. In 2014, the assessments will be summarised and recommendations for 2015 data analysis will be derived.

WP4: Improvement of Networking Connections in Germany and the International Connectivity The original LHC data model has evolved away from a strict hierarchical model; analysis data are accessed remotely from any site world-wide. For LHC data analysis the LHC open network environment ("LHCone") complements the LHCOPN which connects CERN and the Tier-1 centers. The objective of LHCone is to provide entry points into a network that is private to the LHC Tier-1/Tier-2/Tier-3 sites for data analysis. The LHCone status in November 2013 was that world-wide more than 120 sites are connected. In Germany DESY, KIT, GSI, RWTH Aachen and University of Wuppertal participated. Software-defined networking is a research activity performed within LHCone. It will allow central control of network traffic without requiring physical access to the networking hardware.

WP5: General Support for Site Operations, Training and Schools The cooperation between the participating sites is a very important building block of the computing infrastructure for LHC data analysis. The German dCache support team provides support to German dCache users. The 11th International GridKa Computing School was held 26–30 August 2013 and was attended by 140 participants. It is one of the leading summer schools for advanced computing techniques in Europe. It is organised by KIT and the Alliance "Physics at the Terascale".

5 The Alliance Research Topics

From its start in 2007, the Alliance rested on the pillars of its four research topics: physics analysis, Grid computing, detector development, and accelerator research. In the following, short reports are given for the activities in each of these topics (reports on the dedicated projects financed with Helmholtz interim funding have been given further up).

5.1 Research Topic "Physics Analysis"

Members of the Analysis Project Board:

Chairs: Herbert Dreiner (U Bonn), Klaus Mönig (DESY)

Members: Martin Erdmann (RWTH Aachen), Stefan Gieseke (KIT), Stephanie Hansmann-Menzemer (U Heidelberg), Michael Kobel (TU Dresden), Thomas Schörner-Sadenius (DESY), Peter Uwer (HU Berlin), Georg Weiglein (DESY)

The Alliance activities in the research topic "Physics Analysis" and organised to a large extent by the Alliance Forum (that was formerly called Analysis Centre). Among these activities are working groups and networks on various topics as well as the organisation of most of the Alliance-related events like schools and workshops.

Currently the following groups and networks are active and supported by the Alliance Forum:

- PDF group: The Alliance Forum actively supports a wide range of actvities in the field of parton distribution functions. Specific emphasis is placed on the HERAFitter and PROSA projects which are supported with dedicated personnel. The HERAFitter project is an open source QCD fit framework used to extract PDFs and assess the impact of new data on them. The framework includes modules allowing for a various theoretical and methodological options, capable to fit a large number of relevant data sets from HERA, Tevatron and LHC. It is already used in many analyses at the LHC. PROSA is a collaborative effort between high-energy physicists in experiment and theory, from DESY, German universities, and international partners, that aims at advancing the interpretation of proton collision data from the CERN Large Hadron Collider (LHC) and elsewhere. Both efforts — HERAFitter and PROSA — make excellent use of the expertise present at DESY and help to ensure the rich HERA heritage in the field of proton structure.

- The $m_{\tau\tau}$ group is working on the further development of techniques for the measurement of Higgs bosons in the τ decay channel. Topics are e.g. the extration of backgrounds from data or the determination of signal shapes. The group is working across the borders of the LHC experiments and includes experimentalists and theorists. It typically meets twice per year.

- The central jet veto (CJV) method can be used to optimise the extraction of interesting Standard Model electroweak processes, which are in addition an important background to the corresponding production of Higgs bosons at the LHC. Members of the corresponding working group that brings together physicists from both ATLAS and CMS are in frequent contact. However, the focus currently is on preparing the relevant analyses for the next LHC run — a task that is typically carried out within the experimental collaborations. Plans for future common activities and workshops are being made.

- Monte Carlo network: Monte Carlo activities form an inportant part of the physics portfolio of the Alliance. These activities range from generic theory developments over generator-specific implementation to applicatons in data analysis like Monte Carlo paremeter tuning. The colleagues from all Alliance institutes working in this field form a loose network that is in constant loose contact and typically meets during the annual Monte Carlo school and the annual Alliance workshop.

- BSM parameter fitting network: After the discovery of a Higgs boson, the role of BSM parameter fitting activities has become even more prominent. The Alliance and its partner institutions are particularly well represented in this field, contributing to a large number of leading activities and tools.

5.2 Research Topic "Grid Computing"

Members of the Grid Computing Project Board:

Chair:	Matthias Kasemann (DESY)
Members:	Andreas Heiss (KIT), Guenter Duckeck (LMU Munich), Volker Guelzow (DESY), Thomas Kress (RWTH Aachen), Arnulf Quadt (U Göttingen), Guenter Quast (KIT), Markus Schumacher (U Freiburg),Christian Zeitnitz (U Wuppertal)
KET coordination:	Torsten Harenberg (U Wuppertal), Stefan Kluth (MPI Munich), Thomas Kuhr (KIT), Peter Malzacher (KIT), Michael Schmelling (MPI Heidelberg), Hartmut Stadie (U Hamburg)

Computing and the distributed computing infrastructure is of strategic importance for the success of the LHC experiments. Germany is involved in a leading role providing substantial capacity with a very reliable performance. The mandate of the Grid Project Board was extended to become the "Computing Board" to reflect the extension to all computing aspects for HEP data analysis in Germany. This enables the Computing Board as a communication and coordination forum for German Computing for all HEP Data analysis.

In 2013 one workshop was organised in Wuppertal (5 June 2013) to discuss the status of computing for data analysis and to exchange ideas and to steer future directions.

On request of the German representation of the particle physicists (ÒKommittee fŸr ElementarteilchenphysikÓ) the Computing Board delivered a report in September 2013 on the status and outlook of computing for HEP in Germany. The report describes in detail the German infrastructure for LHC computing, the usage and the needs of the experiments for the next five years. It includes the estimates for data analysis of the Belle-2 experiment.

5.3 Research Topic "Detector Development"

Detector development within the Alliance is coordinated by the Detector Project Board. The current **members of the Detector Project Board** are given in the folllowing table:

Chair:	Lutz Feld (RWTH Aachen)
Members:	Alexander Dierlamm (KIT), Ariane Frey (U Göttingen), Hans-Christian Schulz-Coulon (U Heidelberg), Doris Eckstein (DESY), Felix Sefkow (DESY), Hans Krueger (U Bonn), Stefan Tapprogge (U Mainz)
Accelerator Project:	Eckhard Elsen (DESY)

A specific focus of the "Detector Development" topic is on the PETTL project which for the years 2013/14 receives significant support from Helmholtz funds. This project with its five workpackages is described in detail in section 4.1.

As in the past years, the session dedicated to detector developments was a particular focus of the Alliance annual meeting in Karlsruhe in December. A stimulating plenary presentationon the first day of teh workshop on "LHC detectors - from design to performance" had stimulated the audience's appetite for a more in-depth discussion of LHC detectors, and consequently the detector session consisted of presentations on the status and performance of the major subsystems of the ATLAS and CMS detectors (pixel detectors, trackers, calorimetry, muon systems). The session provided an excellent overview of the detectors and their future upgrades both for newcomers and also for more senior colleagues. A presentation on the LHCb detector completed the programme.

5.3.1 Detector Workshop 2013

The annual Detector Workshop of the Alliance is a popular and unique forum to present detector developments within the Alliance and to discuss the challenges of future projects. In 2013 the workshop was held at Mainz University (26 February - 1 March)[2]. With 86 participants it was again very well attended. This time the focus was put on "First lessons learned at LHC on radiation damage", "Particle flow and implications on detector design", and "Track triggers - challenges and solutions". The workshop was accompanied by a school on FPGA programming, which was offered again due to the large demand observed in 2012. At the time of writing of this report, the detector workshop 2014 had also already taken place at Göttingen University[3]. This will be reported on in the 2014 report.

5.4 Research Topic "Accelerator Research"

As described above, the mandate of the Accelerator Project Board ended at the end of 2013. Until then, it had the following members:

Chair:	Eckhard Elsen (DESY)
Members:	Allen Caldwell (MPI Munich), Günter Müller (U Wuppertal), Wolfgang Hillert (U Bonn), Ralph Assmann (CERN/DESY), Shaukat Khan (U Dortmund)

The accelerator activities initiated in the framework of the Alliance — among them research into the production process of high-gradient superconducting radio-frequency cavities for the ILC — continued successfully. The novel topic "plasma wakefield acceleration" is concentrating on the construction of a beamline at the FLASH II project: FLASHForward aims at using the superb FLASH electron beam to explore the concept in detail. Research groups of DESY, Hamburg University and HZDR held a workshop on the topic in Wismar in 2013, which was attended by more than 50 people.

6 Backbone Activities

In 2013, approximately 120 kEur of the annual funding of 0.5 MEur, together with a similar amount from DESY base funding, are used for backbone purposes, and here mainly for the organisation of events, and for guests and travels.

[2] https://indico.desy.de/conferenceDisplay.py?confId=7001
[3] https://indico.desy.de/conferenceDisplay.py?confId=9389

6.1 Schools and Workshops

The education, training and networking aspects of the Alliance have always been considered extremely important, and they are considered to be very successful. Consequently, the Alliance programme on schools, workshops and other events has been maintained in 2013. Most of the events have been organised in the framework of the Alliance Forum; however, the Alliance has also been active as a sponsor and external co-organiser in a number of events. The following tables list the various 2013 events together with their number of participants.

Name	Date	Place	Participants
Fast Detector Simulation	15-17 Jan	Zeuthen	30
Introduction to Terascale Physics	25 Feb - 1 Mar	Hamburg	27
Computer Algebra and Particle Physics	11-15 Mar	Zeuthen	40
Introduction to Statistics	18-22 Mar	Hamburg	47
Monte Carlo School	5-9 Aug	Göttingen	49
GridKa School	26-30 Aug	Karlsruhe	140
Linear Collider School	7-9 Oct	Hamburg	65
C++ School 2013	11-15 Nov	Hamburg	61
MC Methods in Analysis and Statistics	18-22 Nov	Munich	80

Table 1: Alliance schools in 2013

The numbers of participants party include lecturers, tutors etc. For the school on "Computer Algebra and Particle Physics" the Alliance acted as a sponsor. The Monte Carlo school was organised together with the MCNet EU training network. The school on "MC Methods in Analysis and Statistics" was organised together with the Alliances in astroparticle physics (HAP) and in the physics of hadrons and nuclei (EMMI).

Name	Date	Place	Participants
Monte Carlo Methods	19-21 Feb	Hamburg	49
6th Alliance Detector Workshop	26 Feb - 1 Mar	Mainz	86
Workshop on GPUs	15-16 April	Hamburg	53
SUSY Workshop	6-8 May	Hamburg	64
PSR13: Event Generators and Resummation	15-17 July	Durham (UK)	40
Anomalous Quartic Gauge Couplings	30 Sep - 2 Oct	Dresden	47
Linear Collider Forum 2013	9-11 Oct	Hamburg	65
7th Annual Workshop	2-4 Dec	Karlsruhe	245

Table 2: Alliance workshops in 2013

The workshop "PSR13 — Event Generators and Resummation" was organised together with the

IPPP Durham and the University of Manchester. Besides these events, others were sponsored that cannot be listed in detail.

6.2 "Theorist of the Month" Programme

In 2013, the Alliance Forum maintained its programme of the "Theorist of the Months". This is a concept installed in order to improve the exchange between theory and experiment and to strengthen the theory background of experimental Ph.D. students. The Theorist of the Month will spend about one week at DESY or any other Alliance institute and in this time give a seminar on his/her research topic, be available for all kinds of theory questions and discussions, and at the end of his/her stay summarise the discussions and questions of the week. The 10 theorists that visited DESY in 2013 are listed in the following table. The "Theorist of the Month" programmme will be maintained in 2014.

Name	Institute	Date
Nigel Glover	IPPP Durham	22-25 Jan 2013
Michael Krämer	RWTH Aachen	25 Feb - 1 Mar 2013
Iain Stewart	MIT	25-29 Mar 2013
Matteo Cacciari	LPTHE Paris	15-19 Apr 2013
Michele Papucci	LBNL Berkeley	22-26 Apr 2013
Stefano Frixione	CERN	20-23 May 2013
Paolo Nason	U Milano	28-31 May 2013
Francesco Hautmann	U Oxford	17-21 June 2013
Werner Porod	U Würzburg	26-30 Aug 2013
Fabio Maltoni	UC Louvain	21-23 Oct 2013

Table 3: Theorists of the Month 2013

6.3 Guests, Travel Support, etc.

In addition to its programme of the "Theorist of the Month", the Alliance Forum organised, facilitated and funded several guests staying at Alliance institutions as well as trips of Alliance members to conferences and workshops at different locations.

7 Personnel

Personnel funded by the Helmholtz grant:

	Male	Female
Ph.D. students	2.5	3
Scientists	6	0
Technical personnel	1	0

Other personnel involved in the Helmholtz Alliance projects in 2013:

	Male	Female
Diploma / Master students	97	28
Ph.D. students	187	52
Post-docs	98	33
Senior scientists	84	24
Technical personnel	49.5	8

8 Publications

The complete list of Alliance-related publications is attached to this report. In total there were 422 papers published in refereed journals.

9 Dissertations

31 (9 female) Ph.D. theses on Alliance-related topics were completed in 2013, and 11 (3 female) habilitation theses.