Helmholtz Alliance – HA-101
Physics at the Terascale

Annual Report 2011

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Project Number	HA-101
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Scientific Manager	Prof. Dr. Christian Zeitnitz
Administrative Coordinator	Dr. Karsten Büßer
Coordinating Helmholtz Centre	DESY
Partners (enumeration)	DESY, KIT (Großforschungsbereich), RWTH Aachen, HU Berlin, U. Bonn, TU Dortmund, TU Dresden, U. Freiburg, U. Gießen, U. Göttingen, U. Hamburg, U. Heidelberg, KIT (Universitätsbereich), U. Mainz, LMU München, U. Rostock, U. Siegen, U. Würzburg, U. Wuppertal, MPI für Physik, München, U. Regensburg
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1 Summary: Project Development

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 für Physik, München. It is part of the international research programme which investigates the structure of matter with accelerators at the highest energies, the LHC as well as a future linear e^+e^- collider. It develops structures and supports cooperations that go beyond single sites and experiments and connects theory and experiment. It enables a more effective use of existing funding structures in Germany such as the research groups ATLAS and CMS. Its aim is to collect the expertise and strengths of the participating institutes in Germany, in order to strengthen, also in the long term, the international role of German particle physics. The Alliance has four scientific pillars: Physics Analysis, Grid Computing, Detector Development and Accelerator Physics.

In 2011 all the infrastructure of the Alliance has been available and was heavily used by the partner institutions. An especially heavy usage has been recorded for the test beam at DESY, the irradiation facility in Karlsruhe and the Tier-2 computing centres. The latter was due to the very good performance of the LHC accelerator and the corresponding large data volume to be processed for the data analysis of the experiments.

The last "Young Investigator Group (YIG)" has been established in 2011 at the University Göttingen in the area of theoretical particle physics. This rounds up the installation of the six YIGs in different particle physics related research areas:

- Dr. Stefan Gieseke, KIT: Monte Carlo Event Generator Development
- Dr. Jens Osterhoff, University Hamburg/DESY: Plasma Acceleration
- Jun.-Prof. Steffen Schumann, Georg-August University Göttingen: Theoretical Particle Physics and Collider Phenomenology
- Jun.-Prof. Arno Straessner, University Dresden: Detector Development and LHC Data Analysis
- Prof. Peter Uwer, Humboldt University zu Berlin: Phenomenology of Elementary Particle Physics beyond the Standard Model
- Prof. Wolfgang Wagner, Bergische Universität Wuppertal: LHC Data Analysis

All groups contribute substantially to the activities of the Alliance and obtained international visibility.

The fifth annual workshop of the Alliance took place in December 2011 in Bonn with approx. 300 participants. The abundance of results from the LHC experiments triggered very interesting studies of the working groups and made the workshop particularly interesting.
The school and workshop program attracted in total more than 1000 physicists at all levels, from students to high rank physicists, which shows the high visibility of the Alliance in the German community. Some of the topical workshops started to have participants from other countries as well. In general many of the schools have by now become part of the yearly schedule of particle physics events in Germany and are an integral part of the education of young physicists.

The Institute Assembly met twice in 2011. The first meeting was dedicated to the definition of most important topics to be funded in the years 2013/14. The second meeting, during the Annual workshop, focused on financial matters as well as the extension of the Alliance beyond 2012. The International Advisory Board met as well during the annual workshop in Dresden and provided important guidance for the final year of the current Alliance as well as beyond 2012. The Board strongly encouraged the management to pursue the continuation of the Alliance structures and infrastructure. The Alliance fellows and YIG leaders met to discuss matters from the viewpoint of young physicists.

Outreach activities of the Alliance focus on the financial support for the organization of the "Weltmaschine" Exhibition and the International Masterclasses. After the initial event in Berlin in 2008, the "Weltmaschine" Exhibition has been transformed into a traveling exhibition. In 2011 it has been shown in eight different locations all over Germany with over 25,000 visitors.

2 Management

The management structure of the Alliance reflects the different activities within the German high energy physics community. Experimental physicists from different experiments and theoretical physicsist are represented from Universities as well as research centres. The project boards are

responsible for the research topics of the Alliance, hence provide the management directly with first hand information about the corresponding activities.
The structure http://www.terascale.de/general_information/alliance_structure is very efficient and allows a close contact with all involved research areas and the partner institutions. Through frequent meetings of the Management Board it is possible to react quickly to developments and maintain the contact between the groups.
The International Advisory Board provided in 2011 guidance and support for the management.

Members of the Management Board

Chair	Christian Zeitnitz (University Wuppertal)
Members	Thomas Hebbeker (RWTH Aachen), Joachim Mnich (DESY), Markus Schumacher (University Freiburg), Dieter Zeppenfeld (TU Karlsruhe)
Ex-Officio	Ties Behnke (DESY), Karsten Büßer (DESY), Klaus Desch (University Bonn), Lutz Feld (RWTH Aachen), Herbert Dreiner (University Bonn), Eckhard Elsen (DESY), Matthias Kasemann (DESY), Ulrich Uwer (University Heidelberg),
Guest	Thomas Schörner-Sadenius (DESY)

3 Main Scientific Achievements

After the first year of data taking in 2010, the LHC accelerator at CERN performed outstandingly. In 2011 this lead to a huge amount of data available for the analysis of the experiments. The operation of the experiments went extremely smooth and the high level of understanding of the detectors allowed for a high sensitivity of the measurements. In consequence a large number of very interesting results were published already very shortly after the data had been collected. Alliance members have been involved in numerous analyses by the ATLAS, CMS and LHC-b experiment, hence are knowledgeable in all aspects of the measurements. This is important for the subsequent inclusion of the results into combined analyses within Alliance working groups. The amount of data available in 2011 quickly superseeded the 2010 data set and made precision measurements as well as extensive searches for new physics possible.
The published results are the basis for the Alliance working groups, which span experiments as well as experiment and theory. Multiple meetings of working groups took place in 2011. Especially active were the $M_{\tau\tau}$, the central jet veto and the lepton-flavour violation groups. The former LHC-D working groups, which existed already prior to the Alliance, met in the context of the Annual Alliance workshop.

The LHC accelerator will continue its operation until the end of 2012 and afterwards will go into a long shutdown of approx. 15 months. During this shutdown the experiment will install the first upgrades to the detectors. The preparation time is short and the involved Alliance groups are busy with corresponding activities.

The first publicised results were important and exciting for the Analysis project of the Alliance. This pillar of the Alliance brings together experimentalists from different experiments and theorists in order to interpret the data, helps to educate the young researchers to gain experience in different techniques (e.g. simulation and data analysis tools, statistics) and organises corresponding workshops and schools. Alliance members contributed to results from LHC as

well as the HERA experiments.
The preparation of the physics for a future linear collider (e.g. ILC) is another important topic within the analysis project. The "Linear Collider Forum", which was founded in 2010, had an exceptionally successful workshop in 2011 with approx. 100 including substantial international participants.

The high luminosity operation of the LHC accelerator lead to very high data rates of the LHC experiments, which in turn put substantial pressure on the computing infrastructure of the Worldwide LHC Computing Grid (WLCG). The Alliance co-financed so–called Tier-2 centres in Aachen, Freiburg, Göttingen, Munich and Wuppertal, in cooperation with the Tier-2 at DESY and the MPI Munich, performed extremely well and provided the experiments with the resources for the reconstruction, analysis and simulation of LHC events.

The TierI center for the ATLAS and CMS experiments in Germany is located at the KIT in Karslruhe. Data from CERN are sent to KIT, are processed, and significant simulation is done. The alliance contributes significantly to the Tier-2 ressources of ATLAS and CMS in Germany, which amount to approximately 10% (equivalent to about 5000 CPU-Cores and 7,5 PB of storage space) of the total Tier-2 resources deployed world-wide. About half of the Tier-2 resources in Germany are provided by centers at universities. In addition, a similar amount of resources for end-user analysis is provided by the National Analysis Facility, NAF, at DESY and by partners at universities. Within the World-Wide LHC Computing Grid, the German centres rank among the most reliable ones.

The preparations for the next big project in particle physics, the linear collider, continued through 2011. The development of high-gradient superconducting acceleration modules was one of the key areas. DESY is the worldwide leading laboratory in this area. Together with partners from the Alliance, the production of high grandient cavities has been improved substantially. The yield has been increased to well above 50 %. The aim in 2012 is to reach the goal of 90 % yield, which is mandatory for the efficient production of the cavities for the European XFEL. These are pratically identical to the ones required for the linear collider.
Simultaneously, the development of detectors for this future facility is ongoing. The Alliance is active in a few key technological areas, e.g. time projection chamber and hadron calorimeter. Through the Alliance, the basis of this research in Germany could be significantly broadened and some of the initiated projects have obtained funding from other agencies.

Members of the Alliance are among the leading institutes in preparing a coherent detector concept for a future linear collider. This detector concept, the ILD detector, submitted a letter of intent in 2009. Since then the ILD concept was asked to prepare a full technical design report by the end of 2012. Within the Alliance the linear collider community organised itself in the Linear Collider Forum, where the ongoing work towards this goal, the detector development work, and the physics studies are being discussed. A main focus of the work in the following year will be to understand the results from the LHC, and to study the impact these results will have on the physics case for the ILC. The Linear Collider Forum, through its working group focussing on the interpretation of LHC data, is very well positioned to make important contributions in this area. Especially the search for the Higgs boson at the LHC and the already very small remaining mass range will have a substantial impact on the ILC planning. By the end of 2012 we might already know, if the Standard Model Higgs Boson exists or not.

German theory groups have been active in 2011 in a wide array of particle physics research.

An internationally leading role is played in precision calculations for LHC phenomenology, where a number of technically challenging calculations have been presented in the areas of top quark physics, production and decay of weak gauge bosons, and flavor and Higgs boson production and properties.

These precision calculations are complemented by phenomenological investigations. Examples include the development of new tools and observables for Higgs boson properties, or for tests of supersymmetric models and more general models of electroweak symmetry breaking. Of particular importance for the analysis work within the Terascale Alliance is the development of Monte Carlo tools.

3.1 Milestones

The following table lists the milestones as specified in the proposal for 2011 and their status. For the Analysis as well as the Detector Project all milestones have been already been fulfilled in the previous years.

Date	Work Package	Milestone	Status
Grid Computing			
12/2010	WP1	Optimisation of data access	partially #1
Accelerator Physics			
12/2010	WP2	Improvement of beam profile diagnostics using laserwires, electro-optical sampling and beam position monitors	partially #2
06/2011		Improvement of cavity gradient in series production	OK #3
06/2011		Improvement of electron source emittance	partially #4
10/2012		Results from exploratory studies on plasma wakefield accelerators in close collaboration with MPI of Quantum Optics and investigation of experimental options at the University of Hamburg	OK #5

#1 The optimisation of the access to the LHC data at the different computing centres is only partially done. Due to the complex and constantly evolving usage of the resources by the physicists, the access is currently under scrutiny by the experiments. ATLAS is in the process to change the access concept substantially. The data access and distribution will very likely be revised frequently over the coming years.

#2 The transfer of S. Khan from DESY to Dortmund delayed the work on this topic. Therefore it has been addressed only partially.

#3 Already met 06/2010.

#3 Extended and still ongoing studies improved the understanding of the limiting effects. Milestone could be met only partially.

#5 Has been met already in 2011. The group of Jens Osterhoff established a strong experimental activity at DESY and Hamburg. The transfer of F. Grüner from Munich to the University Hamburg complements this activity.

4 Physics Analysis

Members of the Project Board

Chairs	Ulrich Uwer (University Heidelberg), Herbert Dreiner (University Bonn)
Members	Martin Erdmann (RWTH Aachen), Stefan Gieseke (TU Karlsuhe), Michael Kobel (TU Dresden), Klaus Mönig (DESY), Thomas Schörner-Sadenius (DESY), Peter Uwer (HU Berlin), Georg Weiglein (DESY)

The physics analysis activities of the Alliance are organised within the Analysis Project. Detailed analysis subjects, bridging theoretical and experiment-specific aspects, are addressed by the Analysis Working groups. The working groups try to join the efforts and the experience existing in the different theoretical and experimental partner institutes of the alliance. The four groups with widest scope are integrated in the Analysis Centre and profit from central manpower resources.

Educational aspects and the scientific communication are addressed by the Analysis Centre at DESY (WP 2) through a broad series of schools for master/diploma and doctoral students, expert workshops to bring together theoretical and experimental experts working on a specific subject, and regular seminars for the scientific information exchange (WP 3).

4.1 WP 1: Analysis Network

4.1.1 Analysis Working Groups

In addition to the four Analysis Centre working groups (see Sec. 4.2.1), the Analysis Project initiates and supports Analysis Working Groups focusing on well-defined physics topics and joining theoreticians and experimental physicists from at least two different experiments. Four of such groups currently exist, focusing on the following subjects:

- Invariant Mass of τ-lepton pairs - $m(\tau, \tau)$
- Neutrino masses and Lepton Flavor Violation (LFV) at the LHC
- Higgs production in association with heavy quarks
- Central Jet Veto (CJV)

The groups aim to develop and verify analysis strategies and profit from an intense exchange of analysis concepts and experiences between different experiments and, at the same time, from the dialogue with theorists about theoretical limitations or new theoretical concepts. All groups had several meetings in 2011.

The $m(\tau, \tau)$ group was again very active in the further development of techniques to extract the background from data, determine the signal shape by embedding/reweighting methods. These methods are actually utilized in ATLAS as well as CMS.

The central jet veto (CJV) method is a method to optimize 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. After a restart with two new chair persons (experimentalist Ulla Blumenschein and theorist Barbara Jäger) of the working group, first results have been presented and discussed during a workshop in Göttingen in June 2011 and at the Annual Alliance Workshop in Bonn.

The Lepton-Flavor Violation (LFV) working group ist studying the possibility of R-parity violating supersymmetric extensions of the Standard Model. Again experimental and theoretical physicsists are involved.

The working groups start to extend their reach by inviting more and more international guests. In addition physicists, who are not members of the Alliance, start to get interested and join the meetings.

4.1.2 Monte Carlo Group

The Monte Carlo group consists of a YIG in Karlsruhe, a tenure-track position in Wuppertal, both paid by the Alliance, the Monte Carlo part of the Analysis Centre and contributions from several German universities. The group contributes to several Monte Carlo generators used by the community. The group is involved in the core development of three frequently used MC generators: CASCADE, HERWIG++, WHIZARD. The Monte Carlo group put a strong emphasis on the tuning of the Monte Carlo generators. In both high-pt experiments, CMS and ATLAS, Alliance colleagues are strongly involved in the MC tuning activities.
Another important subject of the MC generator activity is the implementation of parton showers. The Alliance contributes here with fundamental research and developments, with the merging of NLO calculations with parton shower models, and with a number of other dedicated studies.

4.1.3 Virtual Seminars

In 2011 the Analysis Centre invited again internationally renowned theorists as the "Theorist of the Week" to DESY. These guests gave a seminar, which was broadcasted via the internet (EVO conference) to all partner institutions, and was available at DESY for discussions with theorists as well as experimentalists. This series of "virtual seminars" was complemented by national and international speakers, who were guests at partner institutions. In total, 11 virtual seminar talks were broadcasted (see Table 1 for details). Typically, between 5 and 10 institutes connected to the presentations.

4.2 WP 2: Analysis Centre at DESY

The Alliance Analysis Centre has shown to be very successful to strengthen the analysis collaboration between the Alliance partners and to improve the scientific communication. Following the example of the Terascale Alliance, laboratories such as CERN and Fermilab have established "LHC Physics Centres". The Alliance Analysis Center reflects this development by strengthening the relation to the new centres and by expanding its international cross links.

17 January	Marco Cirelli (CERN): Seeing signals of Dark Matter in cosmic rays?
24 February	Gennady Lykasov (JINR): The role of gluons in soft and hard pp collisions at high energies
01 March	Torbjörn Sjöstrand (Lund): Progress on event generation with Pythia 8
11 April	Jenny Thomas (University College London): The Minos Experiment: Results and Plans
23 May	Fabio Maltoni (Louvain-la-Neuve): AAA Phenomenology
14 June	Ian Shipsey (Purdue): Latest Results from CMS and the Impact of the LHC Physics Center at Fermilab
20. June	Michael Kraemer (Aachen): Theoretical Aspects of early SUSY searches at the LHC
07 July	Maria Ubiali (Aachen): NNPDF for experimentalists
21 July	Yuri Dokshitzer (Paris): Some entertaining aspects of Multiple Parton Interactions physics
12. September	Mrinal Dasgupta (Manchester): Theory of QCD jets
07 October	Naohito Saito (KEK): New Measurements of Muon g-2 and EDM with an Ultra-Cold Muon Beam at J-PARC

Table 1: Analysis Centre and virtual seminars in 2011

4.2.1 The Analysis Centre Groups

Detailed analysis subjects are addressed by the Analysis Working Groups. The working groups aim to join Alliance partners from different institutions, and from theory and experiment. The four working groups with the widest scope are integrated into the Analysis Centre. They address the following topics: Monte Carlo generators, statistic tools, parton distribution functions (PDFs) and SUSY / BSM parameter fitting.

The SUSY / BSM group was originally formed by Alliance members working on the interpretation of the available data in the context of new physics models and to discuss new developments and questions. Different programs exist in this context: GFitter, SFitter, Mastercode, Fittino, Prospino and HiggsBound. The group aims at common interfaces in order to simplify the usage of the packages and improve the maintainability as well. Members of the group are very active in the extraction of observables for physics beyond the Standard Model.

The determination of the "Parton-Density-Function" (PDF) is a major enterprise addressed by multiple collaborations around the world. The PDFs are essential for the LHC experiments in order to estimate productions rates of signal and background processes. Alliance members have contributed centrally to the progress in the field. Recently three sets of pdf functions, ABKM/ABM, HERAPDF and JR, have become available, which are used now by the LHC and Tevatron experiments. Often one of these PDFs provides the best description of the data.

The Statistics Tools group provided contributions to several larger packages and analysis tools. The multi-parameter fitting package Millepede is maintained by members of the group. Substantial contributions were made to various unfolding tools (authorship of TUnfold, contributions to ROOUnfold). Contributions by colleagues from Alliance institutes were made to the TMVA package and to the ROOSTATS development. Furthermore, the BAT project is supported by the Analysis Project.

The Monte Carlo group of the Analysis Centre is integrated into the corresponding activities at different partner institutions (see Sec. 4.1.2).

Furthermore, the groups organised numerous schools and workshops and are contributing to the overall education of the Alliance members, see Section 4.3.

4.3 WP 3: Training and Exchange

4.3.1 Schools and Workshops

Name	Date	Place	Participants
Introduction to Terascale Physics	21-25 Feb	Hamburg	39
Monte Carlo School	21-25 Feb	Hamburg	40
CAPP2011	21-25 Mar	Zeuthen	32
Statistics Tools School	4-8 Apr	Mainz	61
GEANT4 Training Event	10-13 May	Zeuthen	38
Software Development	26-30 Sep	Dresden	31
Data Combination and Limits	4-7 Oct	Hamburg	44
LHC Precision Predictions for Pedestrians (LPPP11)	10-13 Oct	Freiburg	50

Table 2: Schools organised by the Analysis Centre in 2011

Workshop	Date	Place
6th $m(\tau, \tau)$ Workshop	24/25 Mar	MPI Munich
Workshop on Top Quark Physics	7/8 Apr	Wuppertal
Workshop on neutrino masses and LFV@LHC	4-6 May	Hamburg
Workshop on SUSY / BSM working group	4-6 May	Hamburg
Central Jet Veto working group meeting	9/10 Jun	Göttingen
Rare b-Decays @ Low Recoil (bsll2011)	15/16 Jun	Hamburg
SM Benchmark Processes at Hadron Colliders	15-17 Jun	Zeuthen
Linear Collider Forum	14/15 Jul	MPI Munich
Single top / fourth generation quarks workshop	5/6 Sep	Hamburg
7th $m(\tau, \tau)$ Workshop	19/20 Sep	Göttingen
WHIZARD - Event Generation for LHC, ILC, CLIC	21-23 Nov	Hamburg
Linear Collider Forum	7 Dec	Bonn
Central Jet Veto working group meeting	8 Dec	Bonn

Table 3: Expert workshops organised within the framework of the Alliance in 2011

In 2011, the Analysis Centre organised - partly in collaboration with other panels - eight schools for students and young post-docs (see Table 2 for details). The participation was in general high and varied, depending on the topic, between 31 and 61 participants. The topics covered a range from very general introductory courses to very specific software issues. The feedback from the participants was good. It was pointed out that especially the hands-on parts of the schools and the tutorials have been particularly useful for many of the participants. It is envisaged to extend these elements in the future. In order to obtain a better picture of the wishes towards the Analysis Centre of the younger physicists within the Alliance, a detailed questionnaire was handed out to the community and answered by about 150 students, postdocs and seniors. All schools are evaluated by questionaires, which are analysed in detail in order to improve the concept and organisation.

Some non-Alliance workshops and schools receive financial support. This is due to the high importance to one of the Alliance topics. In 2011 the GridKa school has been supported for the fourth time. This is one of the most important schools for the GRID project and is organised by the KIT.

The expert workshop programme (see Table 3) was maintained at a high level in 2011, with 13 workshops (in the field of physics analysis) on different physics and technical topics organised at DESY and at other places. Some of these meetings (like those of the $M_{\tau\tau}$ working group) reflect specific activities of the German HEP community; others are due to the LHC-D meeting series, with most of the LHC-D groups organising a second, independent meetings besides their gatherings at the annual Alliance meeting in December. A highlight to mention was the workshop on "Standard Model Benchmark Processes at Hadron Colliders" which was held from 15-17 June at DESY Zeuthen and which attracted about 100 physicists, many of them working themselves on the forefront of the respective topics like PDFs, QCD or top physics. The workshop was the third in a series started at FermiLab in 2010; the Analysis Centre will contribute to a continuation of the series.

4.3.2 Further activities

A number of other and smaller activities are also organised and pursued by the Analysis Project and the Analysis Centre:

- The Analysis Centre organises the so-called "Theorist of the week" - visits of high-level theorists to DESY or other Alliance institutes during which a series of seminars and discussions are scheduled. In 2011 the following colleagues visited DESY, gave a seminar, visited the LHC groups at DESY and were available for informal discussions for one week: Mrinal Dasgupta, Yuri Dokshitzer, and Torbjörn Sjöstrand. This successful programme will be extended in 2012.

- The Analysis Centre organises special discussion events on hot physics topics - like for example a discussion on the "effect of NMC data on the PDFs" or similar. A large number of participants join these discussions via remote conferencing (e.g. EVO).

- The Analysis Centre and the Analysis Project Board provide, on request, funding for projects or travel support.

5 Grid Computing

Members of the Project Board

Chair	Matthias Kasemann (DESY)
Members	Günter Duckeck (LMU München), Volker Gülzow (DESY), Andreas Heiss (KIT), Thomas Kress (RWTH Aachen), Arnulf Quadt (University Göttingen), Günter Quast (TU Karlsruhe)

5.1 Tier-2 Centres in Germany

In 2011 the LHC experiments ATLAS and CMS each collected a luminosity of about 5 fb^{-1} of proton-proton collisions, an increase of more than a factor of 100 compared to 2010. These data were promptly distributed, stored and analysed in the Tier-1, Tier-2 and Tier-3 computing centres globally.

The German Tier-2 centres at the universities (Aachen, Freiburg, Göttingen, Munich and Wuppertal) are supported to a large extend by the Alliance. Together with the GRID centres at DESY, KIT and the MPI in Munich they build the German share of the world-wide LHC Computing grid (WLCG). They support LHC data analysis for the German scientists as well as contribute to the data production and analysis of the whole LHC experiments.

The increased LHC data volumes required substantial increases of computing and storage resources at the Tier-2 centres. These increases were provided in time for the successful and timely LHC data analysis. In ATLAS the German Computing Cloud is the 2nd biggest overall and is operating very reliably. For the CMS experiment the Aachen and DESY sites are among the most attractive sites for analysis, due to the reliable operation, the large storage and CPU resources provided and excellent networking connections.

Providing excellent networking connectivity is key to successful distribution and access to large volumes of data. The international LHCOne project aims to provide effective entry points into a network infrastructure that is intended to be private to the LHC Tiers. This infrastructure is addressing the connection needs of the LHC Tier-2 and Tier-3 sites, which have become more important in the emerging less-hierarchical computing models of the experiments. A prototype infrastructure was setup up, connecting German Tier-2 sites through the European Networking project GEANT with other international networking partners globally. Initially the Terascale Alliance institutes Aachen, DESY, KIT together with GSI and University of Frankfurt are connected with a 10/20 Gb infrastructure provided by the Deutsche-Forschungs-Netz (DFN). The LHCOne project is under active development and it is expected to connect all German Tier-2 centres in 2012 when it becomes production quality.

5.2 The National analysis Facility (NAF)

The NAF is located the DESY sites in Hamburg and Zeuthen. It provides resources for all steps of analysis for the LHC as well as for the ILC experiments.

The NAF consists of a large data store, interactive resources for fast turn-around, a fast file system and local batch resources. It is used for data processing, skimming, slimming, to produce ntuples and to plot results as well as for code development. It strengthens the analysis capabilities of the German groups substantially. The NAF was heavily used for analysis in 2011. With the accumulation of data starting in spring it became saturated (roughly 1500 concurrent jobs running) until substantially more resources were added in November. It is used by scientists from all German ATLAS, CMS and LHCb LHC sites as well as by the ILC experiment.

Regular coordination meetings of users and the operation team support the smooth operation of the NAF as well as planning for the future. Improvements and upgrades to the file system, further increases to the performance and reliability and extensions to the functionalities for interactive usage are ongoing.

5.3 Grid Development Projects

All German centres use the dCache storage system, which is supported by the Alliance support team. In 2011 two training workshops were organized in Göttingen and Karlsruhe to prepare and support release changes and new configuration requirements. Additional functionality became available through the use of new versions of storage protocols like NFS v4.1, WebDav and xrootd.

The “Happy Faces” monitoring product, which is developed with significant support from the Alliance, is in operation at most German Tier-2 centres. It allows real-time site monitoring and it acquires information automatically. Historical information is available for retrieval from a database for performance tuning and correlation studies. Developments in 2011 improved data base functionalities and performance. It is now also deployed at several non-German CMS Tier-1 sites.

The specific requirements concerning the software environment within the HEP community constrain the choice of resource providers for the outsourcing of computing infrastructure. The development of virtualization in High Performance Computing clusters and in the context of cloud resources is supported by the Alliance. The dynamic virtualization of worker nodes in common batch systems provided by ViBatch serves each user with a dynamically virtualized subset of worker nodes on a local cluster. The developments in 2011 provide transparent extensions by the use of common open source cloud interfaces like OpenNebula or Eucalyptus, launching a subset of the virtual worker nodes within the cloud.

6 Detector Development

Members of the Project Board

Chair	Lutz Feld (RWTH Aachen)
Members	Doris Eckstein (University Hamburg), Alexander Dierlamm (TU Karlsruhe), Ariane Frey (University Göttingen), Hans Krüger (University Bonn), Hans-Christian Schultz-Coulon (University Heidelberg), Felix Sefkow (DESY), Stefan Tapprogge (University Mainz)

6.1 WP 1: Virtual Laboratory for Detector Technologies

The Alliance operates a "Virtual Laboratory for Detector Technologies (VLDT)", comprising the branches WP 1.1 Electronics System Development, WP 1.2 Sensors: Materials, Design and Characterisation, and WP 1.3 Detector Systems: Development, Infrastructure and Testing. The VLDT is fully operational.

6.1.1 WP1.1 Electronics System Development

Participating institutes: Bonn, Heidelberg

The task of this work package is to make expensive and service-intensive infrastructure available to partners of the Alliance and to enable the community as a whole to make more significant and long-lasting contributions to future projects in the framework of physics at the Terascale.

Electronics system development relies on two kinds of expensive and service-intensive infrastructures: state-of-the-art and up-to-date software packages for CAE (in particular layout, synthesis and simulation) and test facilities for electronics systems (in particular high-speed and low-noise capability).

VLDT Node Bonn

Pixel Detector Chip Development
After the successful test of the new Pixel Chip FE-I4A, the production version for its first real application, the ATLAS Insertable B-Layer (IBL), was designed and submitted for manufacturing in 2011 in a joint effort together with LBNL Berkeley, University of Genoa, CPPM Marseille and NIKHEF. This chip (FE-I4B) contains only small changes and extensions with respect to the FE-I4A.

Chip Development for gaseous Tracking
In the scope of chip developments for gaseous tracking (TPC) a new test chip (Gossipo4, 14 mm^2, 130 nm CMOS) has been submitted. In this joint cooperation with NIKHEF and CERN the contribution of the Bonn group was the design of the in-pixel PLL which allows a time resolution of 1.6 ns. Some of the function blocks developed for the Gossipo chips will also be used in the TimePix3 development, a large multi-purpose readout chip with 256 $\times$ 256 pixels with a size of 55 μm $\times$ 55 μm (to be submitted in summer 2012).

Precision Sensor Capacitance Measurement
Also in 2011 a precision pixel capacitance measurement chip (PixCap) was developed and successfully operated with a variety of different pixel sensors. In the scope of evaluating new detector technologies and materials, one important parameter for the performance of a readout chip is the detector capacitance. Since the typical values for a pixel sensor are quite small ($\approx$102 fF) it is not straight forward to measure them directly. The PixCap chip, which gets bump bonded to a sensor under test, has a charge pump based capacitance measurement circuit in each pixel which has a measurement accuracy of a few fF.

Chip Development for BELLE II

For the BELLE II experiment a first full size version of the data handling processor (DHP) for the DEPFET Pixel Vertex detector (PXD) has been submitted. This chip (DHP 0.2, 3.3 mm $\times$ 4.3 mm, 90 nm CMOS) will be used for the electrical test modules and the DEPFET prototype production. However issues with the availability of the 90 nm CMOS technology forced us to change the process for future chip developments. We have chosen TSMC 65nm which will also (most likely) be the process technology supported by CERN for future LHC developments. End of 2011 a first small chip with test structures was submitted in 65 nm technology (DHPT 0.1), in particular to verify the full custom designs (1.6 GHz PLL, Gigabit link driver, ADC, DACs). Also first test structures for analog front-end design in the scope of future ATLAS pixel developments have been implemented in this chip.

VLDT Node Heidelberg

The facilities of the Heidelberg VLDT node have been successfully operated throughout the year 2011. Several R&D projects were supported. As in 2010 these comprise projects on electronics development for particle-physics experiments (ATLAS, CALICE), generic research on readout ASICs for high-speed photo-detection instruments using Silicon-Photomultipliers (SiPMs) as e.g. needed for ToF measurements in HEP (PicoSec), as well as two interdisciplinary spin-off projects, one supported by the Future Emergent Technology (FET) initiative of the European Commission and one aimed to employ SiPMs for ToFPET applications (EndoToFPET US). Particular emphasis was put on the HEP activities, i.e. the ongoing research work for the ATLAS calorimeter trigger upgrade and the electronics development for the CALICE project. Corresponding results are reported elsewhere in this document.
Throughout 2011 two Heidelberg electronic developers where financed by the Alliance. Both worked entirely for projects supported by the VLDT. As the ASIC engineer (G. Sidlauskas) hired in 2010 unfortunately left Heidelberg in spring 2011, the position had to be refilled. His successor (Dr. V. Andrei) is mainly supporting the electronics development for the ATLAS trigger upgrade. The other developer (Dr. A. Grübl) is part of the VLDT personal since 2010 and designated head of the KIP electronic workshop thus guaranteeing a continuation of the VLDT activities also beyond the initial funding period of the Helmholtz Alliance. Special support for other Alliance partners was provided in form of individual training on FGPA and ASIC development whenever needed. For the coming Detector Workshop in spring 2012, a specific FGPA course was developed together with the VLDT node in Bonn. Finally, the infrastructure of the Heidelberg VLDT node was further extended by a modern SMD placer. Since beginning of 2012 it is fully operational and available to all Alliance partners if needed.

6.1.2 WP 1.2 Sensors: Materials, Design and Characterisation

Participating institutes: Dortmund, Hamburg, Karlsruhe

Sensor Characterisation at Hamburg

Since early 2010 an m-TCT set-up (multi-channel Transient Current Technique) is available which allows for a precise position- and time-sensitive characterization of strip, pixel and pad sensors. The setup has been used for measurements of external projects and projects of the

Hamburg University group. External groups using the setup were the CMS Pixel group from PSI, which studied the radiation hardness of CMS pixel sensors after irradiation with x-rays, the PSI AGIPD group, which investigated the front-end readout and the front-end protection of the AGIPD sensor, and a group from MPI Munich which investigated strip sensor of an own production of several thicknesses in terms of radiation hardness after proton-irradiation. Several theses within the group made use of the setup. Charge carrier lifetimes in different materials were investigated as well as the charge collection efficiency in radiation damaged devices. These investigations are performed in the framework of the CMS collaboration and within RD50. The study of charge amplification, a process which is currently regarded as a promising option to develop silicon sensors for applications in high radiation environments, was continued on radiation damaged epitaxial silicon pad sensors. The mTCT setup is also used to study surface charge losses in segmented silicon sensors before and after x-ray irradiation as a function of biasing history and environmental conditions (humidity).

Irradiation and Characterisation Facilities at Karlsruhe

The measurement infrastructure was used for CMS sensor R&D in view of the HL-LHC Upgrade. Measurements of silicon sensor parameters with two probe stations, Transient Current Technique analyses with diodes as well as charge collection studies on strip sensors with a beta source were performed routinely.
The expertise in performing irradiations was used by several groups as listed in WP3.1.
For the proton irradiation infrastructure a new irradiation box was designed, which can accommodate up to 4 layers of silicon devices (saving irradiation time and costs) providing homogeneous cooling of the structures.
The expertise in designing new sensors and test-structures was developed further.

6.1.3 WP1.3 Detector Systems: Development, Infrastructure and Testing

Participating institutes: Aachen, Bonn, DESY, Freiburg

Mobile Gas System in (Aachen)

For the development and test of gaseous particle detectors pure gas mixtures in various compositions have to be supplied. Ordering pre-mixed gas in bottles has the drawback that one has to wait until the delivery of the gas mixture. Depending on the composition and purity of the gas, this can take up to several weeks. For the test of the response of a detector to different gas mixtures this approach is not adequate. Using a gassystem, which can produce these gas mixtures itself, is much more flexible and saves waiting time.
The proposed gas system is designed as flexible as possible, i.e. one can change the gas composition anytime. The system is mainly designed for operating a small detector inside the laboratory, but it can also support detectors at a test beam facility. The gas mixture can contain up to three components from 0 % to 100 % with seven predefined gases, which are Ar, He, Xe, CO_2, CF_4, iC_4H_{10}/C_4H_{10} and CH_4. By using conversion constants also other gases can be used, allowing providing any gas mixture currently in use for particle detectors. Mixing is either done directly via high-precision flow meters or by filling a buffer volume gradually by the different gas components according to their partial pressure.

The system is separated into different functional loops of gas flow. The main loop containing a buffer volume and a circulation pump is connected to the other loops, like for example the purifier or the analysis loop, using 4/2 way valves. The system can be operated either in open mode, where the return gas from the detector is thrown, or in closed mode, where the return gas is purified and re-used again. The system must be able to handle flammable gases; hence large effort has been put into a proper design for explosion prevention. Hence, it is divided into a vented volume containing the gas loops and a second volume containing the electronics, hermetically separated from the first one.
After completing the specification of all features of the gas system the mechanical and electrical design is now fixed. The design was checked to be consistent with the European safety norms and is currently cross-checked by the CERN gas group. The commercially available components are selected and those parts, which are not commercially available, were designed and prototypes have been tested. The assembly of the gas system has started end of 2011, first operation of the system is planned for 2012.
A flexible control system has been developed which supports hardware interlock and multi-master communication via CAN-Bus. The control system software has been programmed and will soon be intergrated with the gas system hardware.

ELSA Testbeam and USBPix Testsystem (Bonn)

The official start of the direct electron beam extraction is still pending official approval. As an interim solution the parasitic use of an indirect electron beam at the photon tagger of the Crystal Barrel experiment is pursued. The MAPS based beam telescope (EUDET Telescope) which has been ordered has been commissioned at DESY and will be installed in Bonn in 2012. Also the distribution of USBpix based ATLAS FE-I4 test systems continued in 2011. Currently more than 80 systems in 15 groups are being operated. The USBpix system was also used to setup up FE-I3 and FE-I4 based multi-module telescopes.

Testbeams and Engineering Support (DESY)

The VLDT DESY provides test beams, support for test beam users, and engineering support for detector development.
The electron or positron test beams of DESY II were utilized by 18 groups in 2011. Prominent examples are 6 weeks of tests in the context of the ATLAS insertable b layer (IBL) upgrade, with strong participation of the Bonn and Göttingen groups, or the tests of a prototype scintillator detector of the Panda experiment developed for the FAIR facility at GSI, led by a team from Giessen university. Also the OLYMPUS collaboration was allocated many weeks for tests of their tracking devices, using GEM technology.
The studies for the thermal engineering of the IBL structures in support of the mechanical design activities in Wuppertal were completed in summer 2011, while the mechanical design and prototyping activities in preparation of the ATLAS silicon strip tracker upgrade were intensified.

6.2 WP 2: Detector R&D Projects

The alliance proposal contained five detector R&D projects which received funding during the first half of the alliance in order to initiate and strengthen collaboration and to prepare applications for other third-party funding. While one of the projects has been completed at the end of 2010 (WP2.5) work on the other four projects continues based on other funds. The collaboration of the participating institutes works well and very good progress has been made. The topics of these projects will remain of highest interest to the alliance.

6.2.1 WP2.1 Tracking Detectors for the ILC

Participating institutes: Aachen, Bonn, DESY, Mainz, Rostock, Siegen
In 2011 the LCTPC-Collaboration has made further improvements on the test setup at DESY, the large prototype (LP). So far, the superconducting 1 T-magnet had to be refilled manually from a dewar about every two weeks leading to malfunctions because of impurities blocking the flow in the cold volume. To allow the operation in a closed mode, cooling units and a compressor were to be added. Therefore, the magnet was transported back to its producer, Hamamatsu, in Japan, where the necessary changes have been implemented. It is expected back at the early spring 2012. In the mean time the DESY-group has implemented many mechanical and software upgrades of the setup. Also, a large effort was done by DESY to further develop the common analysis tool of the collaboration, MarlinTPC. For example, a new database for operation parameters was introduced.
A new GEM-readout module for the LP was developed at DESY and the University of Bonn. For this a new GEM geometry, innovative framing and gluing techniques were developed at DESY. The readout board was designed at the University of Bonn. A first test module was assembled in 2011 and operated in the test beam. Some shortcomings could be identified and an optimized version is planned for 2012.
The Universities of Bonn and Siegen are working closely together to study the readout of a TPC with GEMs as a gas amplification stage and a highly pixelized readout such as the CMOS pixel chip Timepix. Bonn is designing a new readout chain which is scalable to large numbers of chips. This readout electronics is planned to be the heart of an alternative readout module for the LP being fully equipped with about 100 Timepix chips and the triple GEM-stack developed by DESY. The University of Siegen, in contrast, has setup a laser test stand, where the tracks can be generated by UV-laser beams. The main goal of the setup is to study the dE/dx-measurements of various types of particles such as muons in cosmic rays, laser tracks and -rays from radioactive sources.
The University of Bonn is also exploring Micromegas as an alternative gas amplification structure in combination with the highly pixelized readout. New industrial post processing techniques allow the production of Micromegas grids directly on the chip, making an optimal alignment of the holes with the pixels possible. The technique was pioneered by the University of Twente on a single chip level, and has now been expanded to a wafer-based process. First samples of these highly integrated, mass produced detectors could be tested in 2011.
The RWTH Aachen has continued to construct a very precise and flexible gas system, which was used in several tests.

6.2.2 WP 2.2: Calorimetry at the ILC

Participating institutes: DESY, Dresden, Heidelberg, MPI, Wuppertal

DESY, the universities Heidelberg and Wuppertal, and the Max Planck Institute for Physics in Munich collaborate on the development of a highly granular hadronic calorimeter for a future linear collider based on the scintillators and the novel silicon photo-multiplier (SiPM) technology. The effort used the common infrastructure provided by the virtual SiPM laboratory of the Alliance. In 2011 the activity was reinforced by the Mainz group who took over responsibilities for the design of common data acquisition components within the CALICE collaboration and for the development of integrated DAQ interface solutions for a full scale detector. In addition, the activities at Hamburg were strengthened when E. Garutti started in her new professorship at the university.
Progress towards a realistic detector prototype was made at all institutes. Munich tested first samples of novel SiPM structures on a wafer and developed, with Hamburg, new scintillator tiles which avoid a wavelength-shifting fibre for light collection, Heidelberg validated a new low noise preamplifier ASIC design with successful prototyping, Wuppertal finalized the design of an innovative embedded multi-channel optical calibration system, and at DESY beam tests of the self-trigger and timing functions were made at multichannel system level. All groups made visible contributions to test beam analysis and validation of hadronic shower simulation models.

6.2.3 WP 2.3: Trigger Developments for the SLHC

Participating institutes: Heidelberg, Mainz
The active work on the upgrade of the level-1 calorimeter trigger for the ATLAS experiment has been further pursued and enlarged by both groups. For the digitisation and preprocessing part the Heidelberg group has built several demonstrator modules of a new Multi-Chip-Module (nMCM), containining state-of-the-art FPGA processors and ADC chips to increase the flexibility in the signal processing. These modules have been tested extensively, including studies on the signal transmission to the digital parts of the calorimeter trigger. This is a major milestone towards a complete replacement in the long shutdown in 2013/14.
The Mainz group has designed and produced a demonstrator board for a topological processor, to be able to study critical issues of high speed optical transmission and the processing of complex topological algorithms in powerful high-end FPGAs. A series of extensive tests has been started and will continue in 2012. First topological algorithms have been implemented in firmware, as well as many functions for the configuration and control of this complex board. In 2012, a prototype of the topological processor board will be built to be able to deploy the topological trigger before the start of the high energy LHC run in 2014.

6.2.4 WP 2.4: Radiation-Hard Silicon Sensors for the SLHC

Participating institutes: Hamburg, Karlsruhe
The development of radiation hard silicon sensors is worked on within the frame of the RD50 Collaboration at CERN and the Central European Consortium (CEC), which is a R&D project to develop materials, technologies and simulations for silicon sensor modules at intermediate to large radii of a new CMS tracker for SLHC". In 2011 the CEC was administrated by Georg Steinbrück (Hamburg) and Marko Dragicevic (Vienna). The Consortium combines the efforts of the following institutes: Aachen, DESY, Hamburg, Karlsruhe, Louvain-la-Neuve, Santander, Warsaw, Vienna and Vilnius.

Within this collaboration Karlsruhe performs the irradiations with protons at the proton cyclotron at KIT, which is supported via WP1.2. The measurements concentrate on the effects of radiation on the sensor strip parameters as well as on the charge collection of mini-strip sensors of various materials and technologies. The measurements at Hamburg concentrate on the defect characterization using different spectroscopic techniques, charge collection, and pulse shapes for both pad and strip sensors.
The available equipment (TCT, mTCT) and the expertise in both institutes allow for measurements of the charge collection efficiency (CCE) and the extraction of electric field profiles and trapping times. These measurements are complemented both at Hamburg and Karlsruhe by simulations of the performance of silicon sensors after irradiation. The implementation of defects in T-CAD sensor simulations has started. Using different measurement techniques, like DLTS (Deep Level Transient Spectroscopy) and TSC (Thermally Stimulated Currents) it was possible to identify the defect levels responsible for the current behavior and for the effective doping profile in sensors in which the active volume was decreased by deep diffusion. Using the mTCT set-up (multi-channel Transient Current Technique) built-up and operated at Hamburg within WP1.2 charge multiplication in irradiated pad sensors and the charge collection in sensors with integrated fan-outs have been studied. In addition, a new setup is available allowing precision measurements of the charge collected in pad diodes using electrons from a radioactive source.

6.3 WP 3: New Detector R&D Projects

In September 2009 six new R&D projects were approved after a call for proposals and a competitive selection. These projects are complementary to the existing ones and focus more on the development of infrastructure.

6.3.1 WP 3.1: Irradiation and Characterisation of Read-out Components

Participating institutes: Karlsruhe
In addition to several irradiations performed in 2011 as listed below, investigations were started on how to implement defect models in T-CAD simulations. Just activating defect levels as identified by microscopic measurements (DLST, TSC) does not yield the device behavior as measured by macroscopic measurements (IV, CV, TCT, CCE). Simplified 2-3 trap models can only be tuned to reflect the results of few macroscopic measurements. None of the tested models resulted in a pronounced double-peak electric field profile as was deduced from several TCT measurements on irradiated diodes. More systematic work needs to be done.

Proton Irradiation

- HLL Munich, 21.1. (0:15h): ATLAS Pixel sensors on FE-I3 boards for mixed irradiation after neutron irradiation. Test of BCB isolation for voltages > 700V.
- Bonn, 8.2. (0:20h): pCVD diamonds with different metallization (TiW 200nm +Cu300nm, TiW 200nm+Au200nm)
- Freiburg, 11.3. (0:11h): Mixed irradiation with pions and protons

- Freiburg, 11.3., 18.3., 19.3. (3:44h): 3D silicon sensor up to 2^{16}
- Bonn, 6.4., 19.4. (3:34h): pCVD diamonds with different metallization (TiW 200nm +Cu300nm, TiW 200nm+Au200nm); higher fluence
- KIT, 1.6., 11.8. (1:06h): Irradiation tests of CMS Pixel ROCs
- HLL Munich, 20.6. (0:10h): Study of Solid Liquid Interdiffusion technique (SLID) modules
- Freiburg, 21.7. (0:15h): Mixed irradiation on planar sensors with pions and protons
- Bonn, 26.7. (0:21h): scCVD diamond with Cu/Au metallization
- Freiburg, 19.10., 2.11. (4:26h): Mini sensors for CCE measurements
- HLL Munich, 2.11. (0:45h): SCA with FE-I4 and thin n-in-p SOI sensor

Total: 15hours

X-ray Irradiations

- HLL Munich, 8.-9.10., 13.-19.12. (120h): Radiation hardness of DEPFET elements

Total: 120hours

6.3.2 WP 3.2: A Test bench for a fast data Transmission Line

Participating institutes: DESY, Heidelberg, Wuppertal
The activities for the fast readout test bench have been focused on two main items:
At the Physikalisches Institut Uni Heidelberg an FPGA (Field Programmable Gate Array) based transceiver card has been developed with the aim of probing the radiation tolerance of commercial optical transceivers and the fast serializer/de-serialializer FPGA. The card supports up to 3.125 Gbit/s in the current implementation, 6.375 Gbit/s FPGAs are available and can be used for an updated version of the card. Apart from the devices under test (FPGA and laser transceiver), radiation hard or tolerant components used for the current LHC (Large Hadron Collider) experiments have been used for the card, which will ease the interpretation of irradiation test results. The SFP (small form-factor pluggable) transceiver is exchangeable so that a variety of commercially available devices can be qualified for radiation tolerance. In the near future it is also foreseen to use the radiation hard transceiver and dual transmitter developed by the versatile link group at CERN/Fermilab. Beside the front-end transceiver test board, an eight channel 6.25 Gbit/s transceiver card mezzanine (SantaLuz) for a PCIe FPGA development board has been designed and produced at TU Dortmund. First tests have confirmed that all fast optical link channels on both the front-end transceiver card as well as the PCIe transceiver card are operational. So far the front end transceiver card has been tested up to 2 Gbit/s and all channels of the PCIe transceiver card up to 6.25 Gbit/s. Bit error rates have been measured for the PCIe card to be below $3\text{x}10^{-15}$ at 6.25 Gb/s. It is intended to carry out an irradiation campaign this year in order to qualify the FPGA serializer/de-serializer and the SFP optical

transceivers for a total ionizing dose of 50 -100 kRad (0.5 to 1kGy) and 1-2x10^{13}/cm2 1MeV equivalent Neutrons.
At the University of Wuppertal a first implementation of an FPGA based data transmitting protocol for optical data transmission has been developed. 8b/10b encoding, and signal manipulation in delay and duty cycle have been implemented into FPGA firmware and tested. The receiver part decodes the data correctly and bit error rate measurements become possible. The firmware has been tested to operate for array based links and can easily be reduced to single links as well. At the moment these tests are performed using an XILINX evaluation board equipped with either Spartan6 or Virtex5 devices. The step towards FPGAs delivering higher bandwidths is foreseen for this year. Several commercial optical components are under investigation. In addition to the SFP packaged transceivers in single channel version, there are test using quad SFPs (4 transceiver channels in one packaging) and SNAP12 twelve-channel arrays. Breakout boards being adapted to the FPGA multi pin connector standard have been designed and tested.
ZITI - University of Heidelberg at Mannheim evaluates the high-speed capability of XILINX FPGAs getting to the market now (i.e. Kintex 7) to see if these are of use for the envisaged test bench. It is foreseen to combine the firmware part and the hardware part into a fast FPGA setup during this year. The plan is to have bandwidth capability up to 10 Gbit/s available and converge into a common setup serving either single or array based links. A standard version of both is used at the moment as these are either the SFP single channel transceivers or the SNAP12 array based transmitters and receivers. The test bench shall provide a connection to either the one or the other and offer the standard optical component as the reference to be compared with devices under development. Depending on the commercial availability of the very fast FPGAs, either 6.25 Gbit/s or up to 10 Gbit/s will be implemented. Since most of the hardware development so far is on the same path as other projects in the groups, only a minor amount of the funding has been used until now. To be able to put the firmware developed so far on a specialized board, the development and production of this board including the appropriate adaptors will be paid by the given funding. Especially optical components, PCBs and FPGAs are in market survey, to be followed by an order soon.

6.3.3 WP 3.3: Development of Novel Powering Concepts for Tracking Detectors

Participating institutes: Aachen
High performance tracking detectors like the ones considered for operation at the upgraded LHC need a novel powering concept. Large currents have to be supplied to the front-end ASICs without excessive losses while the cables have to respect tight constraints on space and material budget. One of these novel concepts is DC-DC conversion close to the front-end ASICs. Aachen has developed, in collaboration with a group at CERN, DC-DC converters for applications in upgraded pixel and tracking detectors at the LHC. In 2011 a further reduction of noise emissions by the converters was achieved by layout optimizations and by implementation of a low mass metallic shielding. Different design options for this shielding have been investigated. Also the mass of the converter was further reduced which is important for applications inside the active detector volume. For the first time extensive system tests with pixel modules powered by DC-DC converters have been performed and it was demonstrated that DC-DC powering is possible without disturbing the proper operation of the pixel modules. This confirmed the

expectations from previous measurements of the emitted noise spectra and from measurements with silicon strip modules. A concept for the integration of a DC-DC powering scheme into the upgraded CMS pixel detector has been developed including slow control and cooling, and system tests of this implementation are ongoing. Comparisons of the DC-DC powering scheme with the alternative serial powering scheme have been updated based on the results obtained by the ATLAS collaboration. The conclusion still holds that both schemes are viable in general and have their specific advantages and disadvantages which have to be balanced with overall system considerations for any given use case.

6.3.4 WP 3.4: Ageing and Background Sensitivity of Particle Detectors

Participating institutes: Munich
Since March 2010 seven irradiation campaigns, each lasting between 3 and 8 days, have been performed. Large area detectors have been irradiated with fast neutrons (E¿10 MeV) at rates representative of those expected at the high luminosity LHC, and with 20 MeV protons. Two beam lines have been set-up at the Garchinger Tandemlabor.

Neutron Irradiation Beam Line
Break-up of 20 MeV deuterons on low-Z nuclei and 30 MeV He^{++} ions on a Be targert deliver neutrons of an average energy of 10 MeV with a Gaussian spread of 5 MeV. While the first reaction delivers higher rates and slightly higher neutron energies the second reaction produces less gamma background. A neutron flux of up to 10^7 n/cm^2 s can be achieved in 30 cm distance from the production target, following a 1/r^2 law. A detector area of about 1000cm^2 can be irradiated with less than 20 % variation in intensity.

Proton Irradiation Beam Line
Irradiation with 20 MeV protons is used to simulate the effect of high energy neutrons on gas filled detectors. Low beam intensities in the order of 10 fA are necessary for these studies which requires special equipment. Ageing and radiation hardness studies can be conducted with beam intensities of up to 1000 nA. In both cases the beam is spread either vertically or horizontally over up to 7 cm using a wobbler magnet system running at frequencies up to 800 Hz. This requires a special beam optics. The detectors under test are located right at the end of the beam pipe where the beam exits through a 200 micron thick Mylar foil. The first beam periods in 2010 have been used to set up and characterize both beam lines. Different reactions have been investigated and neutron flux densities, angular distributions and energy spectra have been measured. Once the beams had been commissioned the following experiments have been conducted:

- Ageing studies of ATLAS MDT drift tubes, comparing the standard gas mixture (Ar:CO_2 93:7) and an alternative mixture based on Ar, CO_2, and N_2. Using a 20 MeV proton beam of 105 nA it was possible to deposit in a single night the amount of charge in the detector which is expected for 10 years of operation of drift tubes in ATLAS. Both gas mixtures did not show ageing.
- High rate proton irradiation of diamond detectors: alliance members from TU Dortmund irradiated an area of 3×4 mm^2 of a pCVD diamond detector which is being developed

for a beam condition monitor in the LHCb experiment with a 400 nA beam of 20 MeV protons.

- Proton Irradiation of a scintillating fiber detector: alliance members from TU Dortmund studied the radiation hardness of scintillating fibers and SiPMs using 20 MeV protons.
- Light response of $LaBr_3$:Ce crystals to 30 MeV alpha ions, in collaboration with Moscow State University.
- Myon efficiency and tracking resolution of 15 mm drift tubes in a 20 MeV proton background field, in collaboration with MPI Munich.
- Comparison of the sensitivity of 15 mm drift tubes and micromegas detectors to high energy neutrons, study of the analogue signal shape induced by neutrons in 15 mm drift tubes, in collaboration with CERN and MPI Munich.
- Study of the analogue signal shape induced by 20 MeV protons in 15 mm drift tubes, determination of the read-out band width under proton irradiation, ageing studies, in preparation.

6.3.5 WP 3.5: Virtual SiPM Laboratory

Participating institutes: Aachen, DESY/Hamburg, Heidelberg, MPI, Wuppertal
Throughout 2011 the Virtual SiPM Laboratory (VSL) - initiated by the Helmholtz Alliance in 2009 to strengthen the research efforts on SiPMs (Silicon Photomultipliers) within Germany - has been active in many areas of SiPM research. As planned the VSL was extended in 2011 by an additional research group from Aachen. The present activities of the VSL members comprise:

- CALICE Analog HCAL project (DESY, Munich, Heidelberg, Wuppertal)
- SiPM characterisation and testing (DESY, Heidelberg, Munich)
- Development of SiPM readout electronics (Heidelberg)
- SiPM response modeling and simulation of combined Scintillator/SiPM systems (Aachen, DESY, Munich, Heidelberg)
- Optical calibration of SiPMs (DESY, Wuppertal)
- Medical application of SiPMs (DESY, Heidelberg)

Of these activities financial support was granted for the following: (a) the ASIC development by funding the submission of several test chips (Heidelberg), (b) the design and construction of a portable SiPM training platform for students and newcomers in this research field (DESY/Hamburg), (c) the adaptation and further development of available infrastructure (Wuppertal), (d) work on the CALICE AHCAL calibration system (Wuppertal), and (e) the simulation of scintillator/SiPM systems (Aachen). The status of the supported projects is as follows:

ASIC Development
The development on both SiPM readout chips, KLAUS and STiC, was continued throughout 2011. The KLAUS chip (Version 2.0), dedicated to high-granular calorimetry with low-power consumption high signal-to-noise ratio (SNR) and large dynamic range, has been thoroughly tested and shown to have a factor of three higher SNR than the SPIROC chip presently used by the CALICE collaboration. Interest in this chip has been expressed by several institutes (e.g. University Giessen, Stefan-Meyer-Institut Wien, Shinshu University). At the Stefan-Meyer-Institut the chip is used for development work for the PANDA-Project (GSI); Shinshu plans to test KLAUS for their scintillating ECAL project (CALICE). A final version of the chip is in preparation and shall be used for the third generation of the SPIROC readout chip; the integration of the KLAUS circuit into SPIROC will be done in close collaboration with LAL Orsay. The second chip (STiC) developed in Heidelberg is aimed at fast readout of SiPMs used in ToF-measurements in HEP and medical applications. After the promising test results from STiC 1.0 obtained in 2010, an improved version (STiC 2.0) has been designed and submitted in summer 2011; it includes a TDC originally developed at the ZITI, Heidelberg (Institut für Technische Informatik) and shall e.g. be used in the EU-funded EndoToFPET US project; interest in this new chip was also expressed by several other research groups working on fast photon detection with SIPMs (e.g. PANDA DIRC, ATLAS AFP). After delivery of STiC 2.0 first tests unfortunately revealed a failure of the SPI interface on the chip, due to errors in the internal clock circuits. A new submission is thus needed. This is planned for spring 2012.

SiPM Portable Test-Stand
The development of the test-stand was completed in the first half of 2011. It consists of a light tight box hosting the device-under-study, fixed with mechanical holders in front of a clear fiber, a miniaturized LED including steerable pulser and a power source with current readout. The system is complemented by a waveform sampling data acquisition system installed in a compact PC. The system, which weights in total about 4 kg, is flexible to mount and easy to transport. The data acquisition provides an easy interface for users, the possibility to store waveforms and tools for basic waveform analysis. It provides several measurement possibilities of SiPM parameters, e.g. dark rate, cross-talk, gain, IV curve, signal decay time, etc. The first test-stand has been delivered to the University of Bonn and is in operation for a practicum experiment. One further test-stand is in use at the University of Hamburg. On request, the test-stand can be duplicated and made available to Alliance members.

Infrastructure
A test stand built in Wuppertal consists of a xy-table, which allows scanning scintilltor tiles optically and is utilized to perform tests of the calibration channels of the AHCAL read-out boards. Especially the LED light yield, homogeneity of the calibration system and the SiPM response are under investigation. The whole test stand is temperature controlled; hence the temperature dependence of the response can be studied as well. A second test setup has been installed in order to study the yield and time structure of LED light signals with a photomultiplier and the long time stability of the UV-LEDs. In the framework of the VSL and the AIDA project, the MPI Munich has established a high-resolution SiPM scanning setup, which has successfully demonstrated the capability to measure the active area ("fill factor") on a pixel-by-pixel basis over the full sensor surface. In addition, based on the LED system developed at Wuppertal, MPI

is constructing a test stand to measure the influence of the photon propagation in scintillators on the timing properties of plastic scintillator-SiPM systems.

CALICE Calibration System
Wuppertal developed the calibration circuit for the scintillating tiles of the CALICE analog hadronic calorimeter (AHCAL). The circuit provides a very small amount of charge to produce a short (few nsec) long light pulse by means of a UV LED. By means of the single photon response determination, the system allows to correct for the temperature and voltage dependence of the SiPM response. The circuit has been implemented on the new read-out boards of the AHCAL and is intensively under test at DESY, in the laboratory and in the electron test beam. Test boards have been made available to other members of the VSL.

Simulation
Aachen is developing a concept for a fast muon tag detector for the HL-LHC upgrade which will be needed to support the level-one track triggering on muons. The concept involves scintillator tiles with wavelength-shifting fibers and SiPM readout. A similar scheme is pursued by the CMS HCAL group who will upgrade the outer hadron calorimeter readout with SiPMs. For this development Aachen has simulated the light transport inside so called "light mixers" which are employed to homogenize the light coming from the wavelength-shifting fibers over the active area of the SiPM in order to guarantee the optimal usage of the dynamic range. Various types of light mixers have been studied and a promising candidate has been selected by the HCAL group. As a next step Aachen is optimizing the scintillator tile design and preparing a setup to test the tile's efficiency and response to muons. Furthermore, a prototype detector is being implemented into the CMS software framework for the HL-LHC simulations. Heidelberg is also working on simulations of combined scintillator/SiPM systems using Geant4 and a newly developed custom made SiPM simulation. An essential part of the studies is the simulation of the SiPM response which has been developed during the last year in Heidelberg. First simulation results show excellent agreement with SiPM characterization measurements in the full dynamic range of the sensors. A corresponding publication is in preparation. This simulation is not only important in order to model the signal generated by the scintillation light, but also offers a tool to study the effects of different noise sources on the SiPM signal and optimize the SiPM operation conditions for specific applications. Several institutes (e.g. DESY/Hamburg, MPI München) expressed their interest in using this simulation for their studies.

6.3.6 WP 3.6: Bump Bonding for Flip-Chip Development

Participating institutes: Heidelberg
The PacTech solder bumper can add individual solder bumps at a pitch of $< 100\mu$m to devices which cannot be ordered with commercial solder bumps. It has been used for prototyping in various projects, two of which are briefly highlighted here:

- The Belle-II PXD collaboration develops a large DEPFET pixel detector module, which relies on flip-chip mounting of several steering and readout chips directly onto the thinned detector silicon. Solder balls are mandatory to reduce the mounting pressure on the thin and fragile devices. The SWITCHER steering chips are manufactured in a high-voltage semiconductor technology for which solder bumps are not commercially available (at least for the low volume multi-project submission). The in-house bumping is a flexible and cost effective solution compared to an engineering run. The SWITCHER chips as well as another interface chip have first been populated with gold-stud bumps to provide a solderable surface. The PacTech solder balls are then placed on top of the flattened gold bumps.

- The goal of the XNAP project (X-ray Nanosecond APD Pixels) is a fast 2D X-ray detector consisting of a segmented avalanche photo detector bump bonded to a fast counting pixel readout ASIC. Solder balls are required because the APDs are very pressure sensitive. The first assemblies consist of an "interposer" PCB to which APD and ASIC are solder bumped on both sides. A bigger solder volume was required to successfully mount the chip to the substrate, which was easily provided by the flexible PacTech bumper by stacking 2 balls onto each gold stud. The assemblies have recently been operated successfully at the ESRF using a micro focus X-ray tube.

6.4 Detector Workshops

The 4th Alliance Detector Workshop took place at DESY 15-17, March 2011. With 83 participants it was very well attended. For the first time two schools were offered in the framework of this workshop: one on silicon photomultipliers and one on radiation hard silicon, each comprising of lectures and hands-on sessions. These schools were very well received and shall be retained as part of future workshops. The workshop contained topical sessions on silicon detectors, gaseous detectors, and spin-offs, as well as a discussion on the future of the alliance. The 5th Alliance Detector Workshop took place at Bonn 14-16, March 2012. It was attended by 76 participants and was again very successful. The school, this time on FPGAs, was overbooked and will likely be repeated at a later occasion. This workshop had topical sessions on new technologies, low mass system design, and calorimetry. Both the topical sessions and the schools of these workshops were found very useful as they bring people working on these topics in different experiments together and stimulate fruitful exchange of knowledge and opinions. The next detector workshop will be held at Mainz in spring 2013.

7 Accelerator Physics

Members of the Project Board

Chair	Eckhard Elsen (DESY)
Members	Ralf Assmann (CERN), Wolfgang Hillert (University Bonn), Shaukat Khan (TU Dortmund), Günter Müller (University Wuppertal), Alan Caldwell (MPI-Munich)

Participating Institutes: DESY, Bonn, Dortmund, Hamburg, Wuppertal, MPI-Munich and CERN

The accelerator project in the Alliance "Physics at the Terascale" continued its main mission: to educate young researchers in the field of accelerator physics. PhD Students were active in all centres and contributed decisively to the scientific progress.

DESY physicists continued to engage in the university lectures on accelerator physics in Göttingen. The individual centres and universities engaged in the activities described below; a comprehensive overview of the activities was given at the Annual Meeting in Bonn where many students contributed with their results.

7.1 Bonn

Beam diagnostics:
For in situ measurements of beam polarisation and transverse intensity profiles a Compton polarimeter was set up. It is based on a counting silicon microstrip detector including dedicated read-out electronics which was further improved with respect to signal processing and read-out. The operation of the polarimeter is still suffering from a malfunction of the two-beam solid-state frequency-doubled laser system. A general overhaul and improvement of this laser system has started with the help of a well experienced company specialised in the development of components for disk lasers. It is planned to restart the operation of the improved polarimeter in the fall of 2012. It will allow for precise polarimetry within minutes of measuring time.

Non-destructive measurement of beam intensity and position in the ultra-low current regime was optimised and calibrated and is routinely operated. RF cavities operating with TM010 and TM110 modes respectively generate intensity and position dependent signals which are down-converted and fed into lock-in amplifiers for further signal processing with small bandwidth. A position recording with a precision and long term stability of approximately 0.1 mm is achieved routinely at a bandwidth of 10 Hz, even for beam currents down to 100 pA. With the help of this diagnostic tool beam shifts during the extraction phase can be monitored online and successfully corrected for. The achieved ultimate system performance is mostly limited by thermal noise. A significant further improvement requires a change from normal to superconducting resonators.

A synchrotron radiation monitor recording the UV (wavelength 200 nm) part of the emitted synchrotron radiation was developed and constructed. It is based on a water cooled mirror built from Al alloy. The deformation of the mirror, caused by the absorption of the high energetic part of the synchrotron radiation, could be significantly reduced by an optimised cooling technique of the thin mirror surface plate, which was soldered to the support and cooling block in an HV oven. The commissioning of the monitor and the dedicated beam line have started end of 2011.

Beam dynamics:
Causes of beam instabilities were investigated at the stretcher ring ELSA. Higher-order modes of the accelerating cavities (of type PETRA) were found to be one of the major sources. Meanwhile HOM damping is performed by water loads which were installed at the waveguides close to the fundamental mode couplers. A modified cooling system was developed which will allow for a shift of the operating temperature of the cavities and hence the resonant frequencies of the most harmful HOMs to prevent them from exciting coherent beam instabilities. This system will be installed by the end of 2012.

Beam instabilities can be successfully suppressed using active feedback methods to damp the excitation of coherent beam oscillations. For this purpose, longitudinal and transverse state-of-the-art bunch by bunch feedback systems, consisting of dedicated beam position monitors, FPGA-based signal processing and broad-band kickers, were installed and investigated at ELSA. To allow for the required band-pass filtering of the individual bunch oscillations applied in the

FPGA units, the synchrotron and the betatron tunes were stabilised during the fast energy ramp. After proper timing of the feedback components and optimisation of the filter parameters coherent bunch oscillations could be successfully damped during the whole acceleration cycle operating with beam currents up to 50 mA. Work is ongoing to further improve the feedback settings. A single bunch operation of the stretcher ring was successfully set up by cleaning of all but one bunches with the help of the feedback system.

Test areas:

A new injection system, capable of generating long (up to 3 μs) and short (down to 1 ns) electron pulses was successfully set up at the existing LINAC I. The transfer line to the booster synchrotron was renewed, based on detailed optics simulations. A test area, dedicated for irradiation of detector electronics and target material, was set up at this transfer line. First irradiations have been performed successfully in the end of 2010 and were continued in 2011.

After finishing detailed simulations of the optics of a new external 3.5 GeV electron beam line at the stretcher ring ELSA which is dedicated for detector testing, the required components (beam pipe, beam position monitors, magnet supports, etc.) were constructed and the preparation of the area (civil construction) has been started. All power supplies required for the bending and focusing magnets of the beam line have been purchased and transferred to the experimental area. The required cooling circuits have been installed and will be connected to the magnets in 2012. All magnet supports and the bending dipole magnet are already installed. First beam in the experimental area is expected by end of 2012.

7.2 DESY

Superconducting RF cavities:

Worldwide progress in achieving higher accelerating field in superconducting rf-cavities is impressive. The effort at DESY has concentrated on improving the yield of industrially produced cavities which exceed 35 MV/m, the target gradient for the ILC and well above the standard for the European XFEL. The findings over the past few years led to a recipe for manufacture that holds the promise of reaching very high fields and is identical for the European XFEL and the ILC and. Limitations arise from residual surface defects and from field emitters that emerge at very high fields.

The automated optical inspection system OBACHT with a high-resolution camera system has been commissioned during 2011 and has been in routine operation since at DESY. The so-called reference cavities for mass-production of XFEL have been examined with OBACHT; the feedback on quality of welds of the niobium half-cells proved invaluable in establishing the production line. Future applications include monitoring of the quality of production and search for defects.

Images are automatically processed with two goals. The initial goal is to characterise the surface in a quantitative manner in terms of roughness, size and number of optical features. Such measurements will give feedback on the uniformity of the production process and on changes of the industrial parameters. The second goal addresses the search for defects, i.e. irregularities of a few millimetre down to a few $10 \mu m$ size. Such defects are obviously rare and can be searched for by comparing to templates and average surface structure. The algorithms are being refined.

Other tools are in operation for examination of cavity behaviour. Second sound is now a

well-established technique at DESY to locate the origin of a quench at the outer surface of a cavity. Second sound traces the area of heat injection by triangulating the second sound signal. The system has been commissioned by a PhD student of the Terascale.
Preparation of Plasma-Wakefield Experiments:
The engagement of DESY in the new field of plasma-wakefield acceleration has received an additional boost with the instalments of Profs. B. Foster and F. Grüner at Hamburg university. The details of the programme are described further below in the section of Hamburg University.

7.3 Dortmund

TU Dortmund joined the accelerator project when Prof. S. Khan, originally Hamburg, became the chair of accelerator physics in Dortmund albeit with no Terascale Alliance funds assigned.

As one of the directors of the Centre for Synchrotron Radiation (DELTA) his interest lies in the combination of electron beams and femtosecond laser pulses including the associated diagnostics. A field of research includes the Optical Replica Method pioneered at DESY at FLASH to which he contributed actively.

7.4 Hamburg

During the year 2011 the Helmholtz Young Investigator Group for Plasma Acceleration Techniques headed by J. Osterhoff has been to full capacity. Two PhD students and two postdocs are supported by funding from the Alliance and complemented by two additional postdocs from DESY focussing on simulation work.

With the additional advent of Prof. F. Grüner and Alexander von Humboldt Professor B. Foster the topic "Plasma Wakefield Acceleration" (PWA) has received additional support at Hamburg university and DESY. Meanwhile a joint experimental programme has been conceived which addresses near-term experiments and long-term preparations for key experiments in PWA. The programme utilises various experimental opportunities at DESY: the REGAE facility will be a source of MeV-energy velocity-bunched electrons for injection into a plasma generated by a 200 TW laser. Electron-beam-based plasma excitation and acceleration will be initially tested at PITZ (DESY-Zeuthen) which profits from the superb properties of their photo-cathode gun. Experiments at FLASH are planned in Hamburg. They will utilise appropriately shaped, 1 GeV electron bunches to excite a plasma by the beam or inject into a laser-generated plasma. The goal of this sequence of experiments is to understand and optimise the plasma for beam acceleration (10 GeV/m) and beam focusing.

Extensive simulation work has been carried out to evaluate the requirements and the properties of the plasma under various conditions. The calculations vary considerably for the respective set-ups typically because of the different excitation mechanisms and the need for consideration of varying phase velocities. In all cases PIC-simulation codes are used.

The development of plasma cells has been continued. Acceleration experiments have been carried out at the Draco laser facility at the HZ Dresden-Rossendorf; further tests are planned at Lund and at the Helmholtz Institute Jena. Hamburg has also engaged in the EuroNNAc, a European network for plasma wakefield acceleration that comprises all major research labs in Europe active in the field.

7.5 Wuppertal (BUW)

Research in high gradient superconducting RF cavities:
In order to clarify the origin and activation mechanisms for parasitic field emission of niobium surfaces, during 2011 the systematic FE investigations at BUW were performed on large-crystal and single-crystal samples prepared at DESY and JLab (US). Cavities made from large-crystal niobium (grain size > cm) are considered for ILC as an alternative to the actual polycrystalline ones to achieve higher accelerating fields. Such samples with only few grain boundaries and less defects are well-suited for FESM/SEM correlation studies on processing and annealing effects of emitters.

Four such high purity (RRR > 300) samples prepared at DESY (employing BCP $40\mu m$ and HPR) were sequentially tested and in-situ heated for typical times and temperatures (24 h at 122°C, 2 h at 400°C, 2 h at 800°C). With increasing temperature a strong increase of the emitter number density at reduced field levels caused by activated particulates (56%), scratches (30%) and other defects (14%) was observed which hint for a strong influence of the niobium oxide on the parasitic FE. After an additional EP ($150\ \mu m$) of these samples, further heating cycles and measurements are planned to reveal the activation mechanism.

The correlation between surface roughness and parasitic FE was measured on four other single-crystal samples prepared with different BCP ($20, 40, 80,$ and $120\mu m$) at JLab and HPR at DESY. The decreasing number of emitters with increasing BCP proves that even single crystal niobium has a damage layer of at least $80\mu m$ which must be removed to avoid parasitic FE.

Optimisation of electron and positron sources:
In 2011 the UHV-based system for photo-induced field emission spectroscopy (PFES) was first used to study the influence of green CW laser irradiation on the achievable current and electron energy distribution from p-Si cathodes with tip arrays. Due to the limited number of free carriers, the current-voltage curves show a saturation range which stabilises the FE current and is highly photosensitive. Moreover, electric field penetration leads to the multiplication of charges and finally to the destruction of the p-Si tips. Therefore, such cathodes might only be useful for applications which require a fast switchable electron source over large areas.

In parallel to these measurements the PFES system was completed with a tuneable pulsed laser (0.5-5.5 eV, >1 mJ in 3 ns, 10 Hz). The systematic investigation of PFE from flat single-crystal Au and Ag cathodes as function of the electric field (up to 400 MV/m) and photon energy has been started. First resonances of the quantum efficiency have been found which clearly hint for band structure effects and might be suitable for the development of ultrahigh brightness electron sources.

7.6 CERN and Max-Planck-Institute Munich

The activities on plasma wakefield acceleration at CERN and MPI are thematically related to the PWA experiments mentioned above; however, they are not funded by the Terascale Alliance. They are mentioned here since they initiated considerable networking for exchange of ideas.

Proton driven plasma wakefield acceleration:
Under the leadership of the Max-Planck Institute Munich a Letter of Intent (LoI) to carry out a proton-driven plasma wakefield experiment using the SPS beam of CERN has been submitted

by an international collaboration. Such an experiment could probe the self-excitation of the wakefields in a long gas cell. The LoI has found approval for the next planning stages and the collaboration is proceeding towards a detailed technical design aiming for experiments in 2016.

Such experiments use a long proton bunch and thus complement the experiments planned at DESY. There is a lively exchange of experimental and theoretical ideas between the approaches.

8 Backbone Activities

8.1 Interim Professorships

The substitute for the scientific manager at the University of Wuppertal continues to be funded via this scheme.

8.2 International Networking

The visits of Dr. Mrinal Dasgupta (University of Manchester), Dr. Yuri Dokshitzer (Universite´ Paris-VI) and Prof. Torbjörn Sjöstrand (Lund University). as the "Theorist of the Week", were financed by the Alliance through the Analysis Centre.

Travel cost for internationally renowned speakers at workshops and the annual meeting has been provided by the Alliance.

8.3 Equal Opportunities

The dual career support was successfully used for the fellows in Hamburg, Freiburg, Karlsruhe.

8.4 Outreach

The very successful exhibition "Weltmaschine" was transformed in 2009 into a travelling exhibition. In 2011 the Alliance provided again financial support for the organisation (G. Hörentrup).

Many Alliance partners participated in the particle physics Master Classes that are organised world-wide each year. The Alliance is supporting the organisation of the international Master Classes, which is located at the TU Dresden (U. Bilow).

There are also many activities involving Alliance members and schools, ranging from lectures and physics days to visits to schools (e.g. "rent a scientist").

9 Personnel

Personnel funded by the Helmholtz grant:

	Male	Female
PhD students	21	2
Scientists	50	14
Technical personnel	6	2

Other personnel involved in the Helmholtz Alliance projects in 2011:

	Male	Female
Diplom/Master students	144	37
PhD students	255	56
Post-docs	131	27
Senior scientists	57	5
Technical personnel	53	5

The head of the sixth Young Investigator Group took up his appointment in September in Göttingen.

10 Publications

The complete list of Alliance-related publications is attached to this report. In total there were 521 papers published in refereed journals, 955 conference contributions and proceedings, preprints and other publications.

11 Dissertations and Habilitations

26 (4 female) PhD theses on Alliance-related topics were completed in 2011. There was 1 habilitations.

12 New Cooperations and Activities

Most of the new cooperations and activities within the Alliance are detailed in the sections on Physics Analysis, Grid Computing, Detector Development and Accelerator Physics.

Alliance funding was important in the successful involvement in the Advanced European Infrastructures for Detectors at Accelerators (AIDA) project. The project is co-funded by the European Commission within Framework Programme 7. AIDA (http://cern.ch/aida) addresses the upgrade, improvement and integration of key research infrastructures in Europe, developing advanced detector technologies for future particle accelerators, as well as transnational access to facilities that provide these research infrastructures.

13 Teaching

As mentioned above, the Alliance organised schools on Terascale physics, Monte Carlo, Statistics and software techniques. The high attendance and success of the schools shows that the Alliance clearly fills a need within the whole particle physics community. These activities will be continued and expanded further in 2011.

The lecture series on "Physics of Particle Accelerators" was again held in Göttingen in 2011. As a result, both BSc and Diploma students have started theses in this area.

Helmholtz Alliance – HA-101
Physics at the Terascale

Articles published in refereed journals

8th May 2012

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