Proposal for the Establishment of a Helmholtz Alliance

"Physics at the Terascale"

"Physik an der Teraskala"

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Summary

Research in particle physics is motivated by the goal of attaining a fundamental description of the laws of physics, such as explaining the origin of mass and understanding the dark matter in the universe. Although fundamentally driven by the quest for knowledge, the ensuing research is performed at the edge of what is feasible technologically and hence drives the development of technology in many areas.

With the start-up of CERN's Large Hadron Collider (LHC) in 2007 and preparations for the International Linear Collider (ILC) in full swing, we expect revolutionary results explaining the origin of matter, unravelling the nature of dark matter and providing glimpses of extra spatial dimensions or grand unification of forces. Any of these insights would dramatically change our view of the world.

In order to optimally place German particle physics in an increasingly global environment, it is now the right moment to create new and improved structures for particle physics in Germany. This is the overarching goal of the proposed Alliance. A structured network comprising 17 universities, 2 Helmholtz institutes and 1 associated Max Planck institute will be created as a tool for a more effective collaboration, in particular between experimentalists and theorists. The Alliance will cover four Research Topics, addressing the fundamental questions of particle physics, distributed computing, novel detector development and accelerator science. An important aspect of the Alliance will be the creation of common infrastructures. All partners of the Alliance will contribute to and use these infrastructures for specific research projects.

The Alliance is part of a much broader truly international effort to explore the physics at the Terascale. It is the goal of the Alliance to strengthen the position of the German groups working in the field through this coherent ansatz. Only the Alliance as a whole with all partners can maximise the role of German research institutes in the international environment and also maximises the exploitation of the new or improved infrastructures created in the Alliance. This is where the Alliance is indispensable. It will allow completely new approaches in several areas:

1. Analysis platform for all partners in conjunction with long-lasting support in computing and analysis tools;
2. Close collaboration between experimentalists and theorists, including common projects;
3. Enlarged collaboration between the experiments, e.g. concerning analysis tools, statistical methods, hereby creating and using synergy effects;
4. Computing resources will be interlinked and supporting instruments developed and maintained for both experiments at the LHC and for ILC preparations;
5. New or improved infrastructures for novel detector development will be created;
6. It will broaden accelerator physics know-how at the universities and intensify accelerator development.

With particle physics scientifically at a turning point, it is now the right moment to enter new territory in Germany and to create new and improved structures and networks for the German institutes working at the energy frontier. Sustainability of the new structures is ensured by the Alliance partners already now promising 21 permanent positions covering all relevant areas of the proposal.

1 Framework Concept

1.1 Future challenges for research in particle physics

Particle physics is about to enter the Terascale, the energy regime of Tera electron Volt, opening up a new chapter in high-energy physics. With the start-up of CERN's Large Hadron Collider (LHC) in 2007 and preparations for the International Linear Collider (ILC) in full swing, we expect revolutionary results explaining the origin of matter, unravelling the nature of dark matter and providing glimpses of extra spatial dimensions or grand unification of forces. Any of these insights would dramatically change our view of the world and how it works.

1.1.1 Particle physics at a turning point

In the last 50 years, Elementary Particle Physics has made tremendous progress. Experiments at the large particle accelerators, mainly at CERN, DESY, Fermilab, SLAC and KEK have probed the structure of matter and the fundamental forces down to distances of one-thousandth of the proton radius (10^{-18} m). They have revealed three families of quarks and leptons as the elementary building blocks of matter. Based on quantum mechanics, general relativity and quantum field theory a fascinating and consistent description of matter and forces has been developed: the Standard Model of Elementary Particle Physics.

The Standard Model firmly predicts fundamentally new phenomena at the energy regime of Tera electron Volt. This Terascale will be investigated experimentally at the next generation of particle colliders where some of the most profound questions regarding our understanding of Nature and the Universe could be answered: (i) What is the origin of mass? (ii) Are the quarks and leptons the elementary building blocks of matter? (iii) Are the known forces unified? (iv) What is the origin of dark matter? (v) What is the origin of the matter-antimatter asymmetry in the universe?

The observation of the properties of the electro-weak force carriers clearly favours the so-called Higgs mechanism for the generation of mass. Its dynamic realisation, i.e. the question whether fundamental Higgs particles exist, can only be answered at Terascale colliders. If such a Higgs particle is discovered, a plethora of new questions about its properties needs to be answered. Should the Higgs mechanism be found not to exist, the Standard Model is not able to make any prediction beyond the Terascale, and new phenomena necessarily have to arise in this energy regime.

At the Terascale we expect answers to another long-standing question, the so-called hierarchy problem. There are 16 orders of magnitude of difference between the scale of electro-weak symmetry breaking, the Terascale, and the scale where quantum gravity becomes relevant, the Planck scale, which implies an extreme fine-tuning of parameters. Solutions to hierarchy problems should be accompanied by new particles accessible at Terascale colliders. The most prominent proposals are supersymmetry and models with extra space dimensions. Both paths offer fascinating possibilities for insight into physics at the very high scales connected with grand unification of forces and ultimately quantum gravity.

Within the supersymmetric framework, when extending the gauge couplings of the Standard Model to very high energies, the strong and electroweak forces indeed unify close to the Planck scale. This is a strong indication that supersymmetry might exist in nature. However, this is only the case if the supersymmetry spectrum lies at the Terascale, just where it is also required for the solution to the hierarchy problem. Thus we expect the supersymmetric masses to be in exactly the range for a discovery and later detailed investigations at the LHC and the ILC.

The possible existence of extra spatial dimensions, beyond the hitherto observed three, captivates the imagination. Within string theory such dimensions have already been extensively studied at very short distances. New theories, motivated by the hierarchy problem, propose that the effects of the extra dimensions might be visible at the length scales corresponding to the Terascale. To date gravity has not been measured in the laboratory at energy scales much above 10^{-3} eV. The hierarchy problem is resolved either by the large volume or the large curvature of the extra dimensions. In either case, the expected collider signatures might be clearly visible at the LHC, if such extra dimensions exist.

Modern cosmology has made breakthrough discoveries in recent years. Based on very precise measurements, this has led to a dramatically new and self-consistent view of the universe at large scales. Interestingly this picture makes several predictions which imply that the Standard Model is incomplete and which can be resolved by Terascale physics. The cosmological dark matter is most naturally explained by a weakly interacting massive particle (WIMP), with a mass at or just below the Terascale. Here the most promising candidate is the supersymmetric lightest neutralino. Furthermore, cosmology requires incomplete annihilation of matter and antimatter in order to explain the dominance of matter in today's Universe. No asymmetry of sufficient magnitude is present in the Standard Model.

The mechanism of electro-weak symmetry breaking, the quest for supersymmetry, or the alternative possibility of extra spatial dimensions are but a few examples which point to exciting new phenomena at the Terascale. The direct exploration of these fundamental questions is only possible with Teravolt particle colliders. Two possibilities are at hand: proton-proton collisions and electron-positron collisions. The experimental environment varies considerably. While proton colliders are very well suited to reach the highest energies, electron-positron colliders reach the highest precision due to the point-like nature of the colliding particles. Consequently, the experimental results of these two types of colliders have complemented each other in a very fruitful way in the past.

The proton-proton collider LHC will open the era of Terascale physics in 2008. The experiments ATLAS and CMS, whose focus is the direct exploration of phenomena at highest energies, were constructed in international collaboration. Each experiment comprises more than 1000 physicists, including scientists representing 16 German university groups and the MPI München. DESY joined both collaborations recently with research groups. The laboratory also provides significant computing expertise and resources for analysis and simulation (Tier-2). Forschungszentrum Karlsruhe´hosts the German Grid computing centre for data processing, storage and distribution (Tier-1) for both experiments.

The electron-positron collider ILC is proposed to complement the LHC with high-precision measurements. It is currently being designed in a Global Design Effort (GDE) with DESY playing a pioneering role in the development of the ILC. The TESLA collaboration based at DESY has advanced superconducting accelerator technology to high quality and technological maturity. This technology has been chosen for the ILC in an international competition. DESY, several German university groups and the MPI München have played key roles in the preparation of the ILC for many years, both in the formulation of the physics case as well as in the R&D for detector and accelerator concepts and components.

Data taking at the LHC will ramp up during the five years of the proposed Alliance. Following general estimates we anticipate about 1 fb^{-1} of data in 2008, several fb^{-1} in 2009 and further increases in subsequent years. These expectations determine the time-line for detector commissioning and physics analysis for the LHC. The Engineering Design Report for the ILC is anticipated for 2010 and is expected to lead into construction of the accelerator in the years following. First ILC data may then be available late in the decade.

1.1.2 Relevance and international position

Research in particle physics is motivated by its goal of attaining a fundamental description of the laws of physics, such as explaining the origin of mass or of understanding the dark matter in the universe. Fundamentally it is driven by the quest for knowledge. However, the ensuing research is performed at the edge of what is feasible technologically and hence it drives the development of technology in many areas. For instance, much of the modern advances in information technology, such as the invention of the World-Wide Web, high speed real-time computing and development of Grid technology, is strongly connected to the progress in particle physics. New particle detection techniques have applications in medical science. Developments in accelerator physics have led to the free electron laser and its use as a powerful light source for e.g. material science, chemistry and biology. Simulation tools developed in particle physics are used in areas as remote as the modelling of financial markets. These types of spin-offs are expected to continue and will be bolstered by the proposed Alliance.

Progress in research is directly tied to educational impact. Almost all of the best universities in the world participate in the LHC experiments and the preparatory work for the ILC, which truly form clusters of excellence. This fact underlines the worldwide unique potential and challenges for students working at the LHC. The exciting research attracts some of the brightest students into particle physics. They receive their education in an international environment and are challenged by forefront science, and they carry their technical and scientific expertise into subsequent employment in industry, at research institutes or universities. The Alliance will strengthen these educational aspects.

The Alliance will bring together Germany's main particle physics laboratory, DESY, Germany's main Grid centre, Forschungszentrum Karlsruhe (FZK), and 17 universities. It will thus exploit and enhance the expertise at two institutes of the Helmholtz Gemeinschaft, DESY and FZK and their links to universities.

The Alliance is part of a truly international effort to explore the physics at the energy frontier. It aims at optimal collaboration between all major German groups working in the field. Any comparison with other groups therefore has to be international in scope. Here the Alliance is competing with the premier groups worldwide: in the US, other European countries and the Far East. While German groups have individually been successful in this competition in the past, it is the goal of the present proposal to strengthen this position by improved collaboration between experimentalists and theorists in Germany, by tapping the synergy effects inherent in such a collaboration and by creating new or improved infrastructures.

1.2 The Helmholtz Alliance as a network of complementary excellence

The Alliance encompasses all German institutions working at the Terascale, representing the experimental and theoretical community. In this way, the Alliance makes particular use of their respective strengths. Only the Alliance as a whole with all partners maximises the role of German research institutes in the international environment and also maximises the exploitation of the new or improved infrastructures created in the Alliance.

Through the networking of the participating institutes of the Helmholtz Gemeinschaft, DESY and FZK, and the associated Max Planck Institute, with a large number of universities, crucial expertise and infrastructures of Helmholtz institutes on particle physics (DESY) and computing (FZK, DESY) are shared with universities. Specific elements of the Helmholtz institutes, like large infrastructures for computing and detector construction, are paired with the specific excellence in research of universities. Also the Alliance provides additional means for education and training of students and young researchers bringing them closer to the Helmholtz institutes. In short, the Alliance brings together the research groups in the field of particle physics at the energy frontier in Germany to increase the role and the impact of German institutes in today's large collaborations and global projects.

In a structured network several institutes will form the backbones of the different Research Topics within the Alliance and contribute through interlinked infrastructures and related expertise. All partners of the Alliance will contribute to and use these infrastructures. The concept is based on the long established model of shared infrastructures between DESY and the University of Hamburg, and extends this to all institutes working on 'Physics at the Terascale'. The Alliance will help to maintain and increase Germany's prominent role and visibility in an increasingly global context. It will establish a long-lasting structure in Germany, where all institutions cooperate closely.

Physics at the Terascale

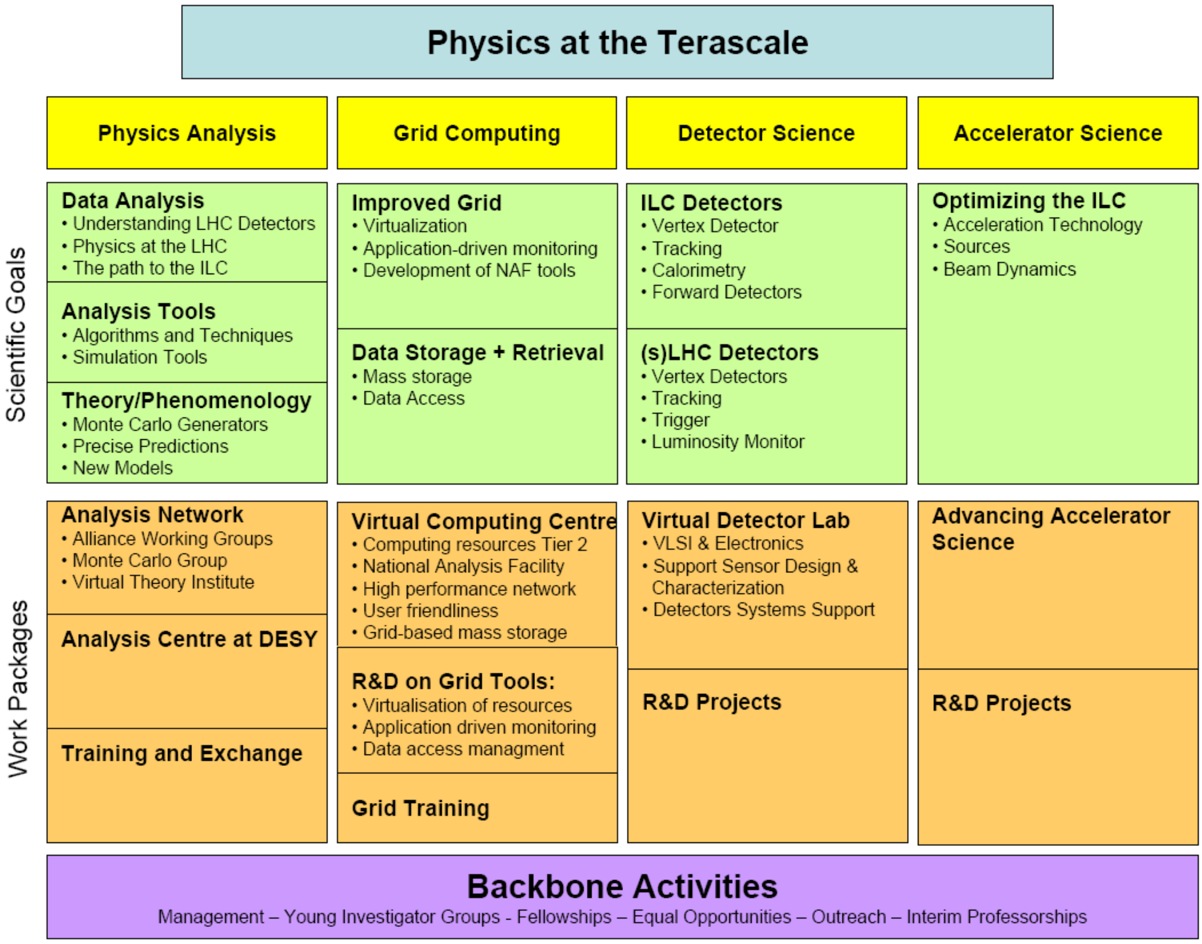


Figure 1: Structure of the Alliance 'Physics at the Terascale'

The Alliance consists of four Research Topics: Physics Analysis, Grid Computing, Detector Science and Accelerator Science (see Figure 1). Within each Research Topic, the scientific goals are defined which will be enabled through supporting elements and instruments. Within these elements and instruments work packages are defined. The overarching goal of the Alliance is the creation of distributed infrastructures in the first three Research Topics and to guarantee their long-standing usage by the Alliance partners. The initial funding through the Alliance will therefore mainly be used to create these supporting elements and instruments in particular where the long-term prospects are given. Some funding will also be used to allow specific projects of Alliance partners to use these infrastructures, in particular in the areas of analysis and detector development. This will help to place Germany at the forefront of the Terascale physics and enable the groups to foster their leading role in the new projects. The Alliance funding is mandatory to maintain and increase the role and visibility of German institutes in today's large collaborations and global projects.

The primary goal for Research Topic four is the building (or rebuilding) of the expertise on high energy accelerator physics at German universities. This is an important step to broaden research on accelerators and to keep Germany at the forefront of accelerator development without which progress in many areas of science would not be possible.

The activities in the four Research Topics will be supported by backbone activities comprising equal opportunity measures, outreach, interim professorships, workshops and tutorials. A pool of young researcher positions is foreseen, implementing Young Investigator Groups and long-term Fellowships in a way that is both essential for a successful scientific programme of the German Particle Physics community and as an attractive career opportunity for young scientists from within Germany and abroad.

Such new and strongly interlinked structures can only be achieved through the instruments supported by Alliance funds. On the one hand this will allow the concentration of complementary expertise at different institutes in all Research Topics of the Alliance as a coherent and targeted approach, creating synergies. On the other hand it will also allow the usage of these instruments and structures by all partners, exploiting synergies. Through the integration of DESY and universities, a coordination of physics analysis and development efforts will be achieved, for the first time in Germany. In turn it will allow an increased role and visibility of German particle physics internationally and particularly at CERN.

Sources for project funding for specific research topics are available in Germany through several sources, mainly through the instrument of the Verbundforschung (Federal Funding), in particular the Forschungsschwerpunkte (FSP, research centres) ATLAS and CMS, and through the DFG. Infrastructure is provided through institute funding.

There exists no mechanism to combine and make available infrastructures and instruments for a network of partners and this is where the Alliance is indispensable. It will allow completely new approaches in several areas:

1. Analysis platform for all partners in conjunction with long-lasting support in computing and analysis tools;
2. Close collaboration between experimentalists and theorists, including common projects;
3. Enlarged collaboration between the experiments, e.g. concerning analysis tools, statistical methods, hereby creating and using much synergy;
4. Computing resources will be interlinked and supporting instruments developed and maintained for both experiments at the LHC and for the ILC preparations;
5. New or improved infrastructures for novel detector development will be created;
6. Accelerator physics know-how will be broadened at the universities and accelerator development intensified.

1.3 The Helmholtz Alliance as an element for further structural development

1.3.1 Long-term scientific and structural objectives, continuation and further development beyond the funding period

Germany looks back on a successful history in particle physics research. Research institutes like DESY and MPI and many universities have made individual contributions to large experiments, to theory, to computing, and to accelerator research. In an evolving international environment the adaptation and improvement of structures are mandatory to assure the competitiveness of German research institutes and universities in future.

The overarching goal of the Alliance is the creation of new structures for particle physics in Germany. The structured network created through this Alliance will be an important step in the direction of a more effective structure in Germany. Several institutes will form the respective backbones of the different Research Topics within the Alliance and contribute through interlinked infrastructures and related expertise. This concept is based on examples of functioning networks between universities and research laboratories in Germany and other countries.

The Alliance will help to provide coherence in the scientific activities and will serve as a platform for increasing the visibility of particle physics. The coherent scientific approach will enhance the impact of Germany’s contributions to this field of science, exploit more efficiently the large investments at CERN and will help to increase the German influence in international science policy making.

The Alliance will help establishing a long-lasting structure in Germany, where all institutions cooperate closely and in a coordinated way. The initial duration of the Alliance will be used to set up the structures, to validate and adapt them where necessary to guarantee sustainability.

The benefit of this proposal and the interest in the creation of long-term prospects for it is demonstrated by the attached Letters of Intent and accompanying documents from the participating institutes. As of today 21 promises (15 from 9 different universities, 6 from DESY) for tenure track positions have been submitted and more are likely to come. Promises for sustainable access to infrastructures are given. This will allow the partners of the Alliance not only to maintain but also to further develop the structures created by the Alliance within all Research Topics beyond the initial period and to guarantee the long-term scientific objectives. This is an excellent chance for Germany to foster and increase its scientific standing in particle physics at the energy frontier and to broaden the education in accelerator physics for the benefit of future projects in many branches of science.

1.3.2 Compatibility with the structural and development plans of the Centres involved

This proposal fits well into the programme ‘Structure of Matter’ of the Helmholtz Gemeinschaft and it is an important step towards the closer networking between universities and research centres, a central mission of the Helmholtz Gemeinschaft. Physics at the Terascale will become the major theme of the program ‘Particle Physics’ at DESY during the next decades. The Alliance is therefore fully compatible with the structural and development plans of DESY in this research area. The same applies for the Tier-1 centre at FZK. Both centres are committed to the sustainability of this programme.

1.4 Outline of the Helmholtz Alliance for Particle Physics

With the Alliance 17 German universities working on LHC and ILC together with two institutes of the Helmholtz Gemeinschaft, DESY and FZK, and the associated partner MPI München will address the great challenges ahead. They will combine and coordinate their efforts under one organizational structure, securing and expanding their role and paving the way for future generations of particle and accelerator physicists by creating long-lasting structures and supporting instruments.

Regardless of the international nature of particle physics experiments and theory there is a need for a better regional and national cooperation among all members. The reasons are that the daily communication through working group meetings is simpler regionally, the allocation of financial resources and computing centres are organised on a national level and the degree of organization is more intense on a national level, like for example in the BMBF funded “Forschungsschwerpunkte”. The proposed Helmholtz Alliance is an ideal possibility to bundle effectively all the competencies available at German universities, Helmholtz Institutes and Max-Planck Institutes.

Below a short overview of the four Research Topics is given.

<u>Research Topic 1: Physics Analysis</u>

The analysis of LHC and later ILC data in conjunction with an intricate involvement of theory and phenomenology will be the key for uncovering Terascale phenomena. The physics studies will address all of the scientific questions raised above, eventually leading to a thorough understanding of the structure of Particle Physics at the Terascale and shedding light on even deeper connections such as the unification of forces and the open problems of cosmology. As members of the international particle physics community, all partner institutions of the Alliance will be active in this area. However, to make optimal use of the expertise and potential of the German contributions and to ensure their visibility in the context of world-wide collaborations additional support is required for long-lasting and common efforts on a national scale. Therefore, primary goals of the Alliance are to

- enable and support common projects and scientific exchange as well as to generate sustainable structures for LHC data analysis and phenomenology in a way that has not been possible by traditional funding structures;
- maintain and strengthen the universally acknowledged role of DESY and the German universities in all aspects of the ILC project.

Framework Concept

The main instrument for achieving these goals will be an Analysis Network of all participating institutions which allows for the formation of working groups tailored to the needs of individual research questions and which fosters the synergy between all participants. The Analysis Network rests on an Analysis Centre at DESY as an integral part of this network, serving as a central hub and providing important core competencies and services on a long-term basis. Of particular importance for the network is the collaboration of theorists and experimentalists. A Virtual Theory Institute will serve as a platform for work among the theorists in the Alliance but, at the same time, it will also pool theoretical and phenomenological expertise and provide easier access and better communication with experimental colleagues. A central element of the Analysis Network will be a National Analysis Facility (see Research Topic 2) to run analysis jobs either in batch mode or interactively.

The success of the experimental and theoretical groups in the analysis network rests on the influx of young scientists. The backbone instruments of the Alliance will provide a pool of Young Investigator Groups, accompanied by tenure-track and long-term fellow positions. The major part of this pool will be assigned to the research topic Analysis, with the intention of ensuring the continuing participation of top-quality young researchers in the physics programme of the Alliance. The young scientists will have an adequate representation in the organisation of the Analysis Network. With these measures, the Alliance ensures a long-lasting and sustainable engagement of German physicists in the challenging LHC and ILC projects.

Research Topic 2: Grid

The analysis of the vast amount of data that will be collected at the LHC requires new technologies in data distribution, processing and computing. A world-wide LHC Computing Grid (WLCG) has been formed to meet this challenge. A competitive Grid infrastructure in Germany demands substantial upgrades of resources and a broadening of expertise - an important precondition for efficient participation of the German groups in physics analyses.

The primary objectives of the proposed Grid projects are to help German institutes to set up internationally competitive structures and to play a leading role in the exploitation of the LHC data. Specifically, the Alliance aims at

- providing the German particle physics community with the computing resources for analyses, such as to be competitive in this respect with particle physicists in other countries;
- combining the Grid expertise at FZK and DESY with those at the universities, thereby strengthening and eventually broadening the capabilities of German Grid computing.

This also will enable the German community to contribute significantly to projects which advance current Grid technology to make it widely usable.

The general idea is to develop a nation-wide homogeneous computing environment spread over the Grid centres GridKa at FZK, DESY and the universities Aachen, Berlin, Freiburg, Göttingen, München, Wuppertal and MPI München. The Alliance will develop a powerful Virtual Computing Centre with upgraded resources for computing power and data storage at the Grid backbone institutes both as part of the worldwide WLCG effort and as a National Analysis Facility for sole use by the Alliance partners. The largest part and key responsibilities of this National Analysis Facility will be handled in the framework of the DESY Analysis Centre. In addition, the Alliance will set up a high bandwidth network between all its members. Furthermore, the Alliance will perform R&D on Grid tools that supplement the basic infrastructure, allow its optimization and render its usage more user-friendly.

Research Topic 3: Detector Science

Physics at the Terascale demands very powerful detectors for particles and radiation, which in many cases require fundamentally new developments. Both the ILC and the LHC luminosity upgrade programme (sLHC) put stringent demands on these new detectors, and long-term LHC operation will entail detector replacement.

Significant achievements have been reached in these areas in the past few years with major German contributions. Since, traditionally, Germany has not maintained a central facility for detector R&D, a major weakness of the current system has been the lack of long-term technical, engineering and scientific staff. Their contribution is needed to guarantee efficient operation and a continuous development of the infrastructure at the institutions participating in detector research.

In view of this situation, the Alliance will support detector development through several approaches. With the establishment of a Virtual Laboratory for Detector Technologies (VLDT), infrastructures for detector development will be improved, and existing ones will be used more efficiently. Secondly, through an intensified networking between the partners of the Alliance, core topics in detector developments will be targeted and worked upon in a coordinated fashion. The role of the Alliance here will be primarily one of coordination and provision of infrastructure, while the resources for individual research projects will come from several different sources. Lastly the Alliance will support novel directions and new projects in detector R&D on a limited scale, to help initiate new projects, form new cooperations between partners, and thus prepare the groups for a successful overall increase of the level of participation of German particle physics in the future projects.

Research Topic 4: Accelerator Science

The experimental progress of high-energy physics is largely determined by the availability of accelerators that provide the necessary centre of mass energy to the colliding particles with sufficient luminosity. It is important to develop novel concepts and technologies decades ahead of their realisation. It also requires to push technology to its limits. The Alliance will address some of these topics.

DESY has played a pioneering role in the world-wide endeavour for the concept of a linear e^+e^- collider. Its work on high gradient superconducting cavities is the basis for the international consensus on the design of the ILC and the technological foundation of the XFEL which is to be built at DESY. The Alliance is aiming to sustain the expertise on superconducting cavities for high-energy accelerators in Germany, to maintain the leading role of DESY for the TESLA technology, and to involve university groups in these developments, thus strengthening accelerator research in Germany.

A main focus of this proposal therefore is to broaden the basis of accelerator science in Germany. It will utilise the unique facilities available at DESY to make it easier for universities and students to take part in this enterprise.

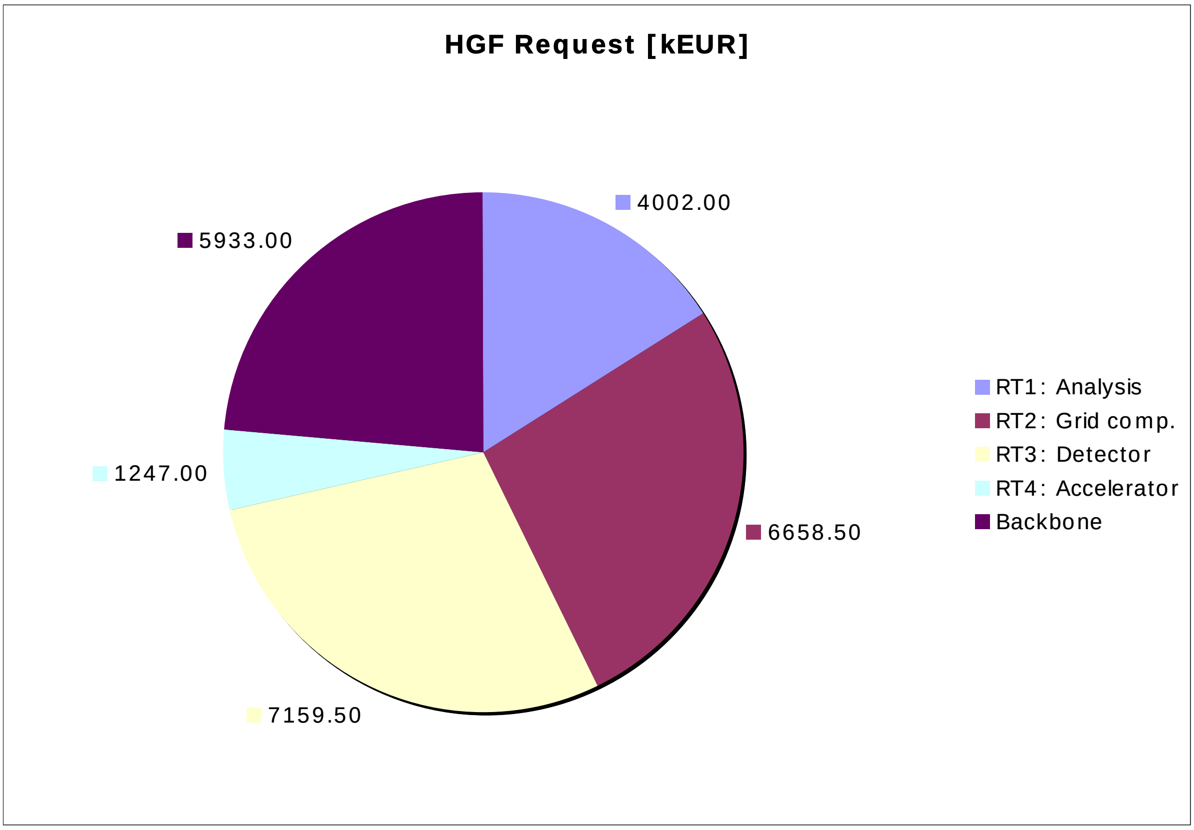
The Alliance will help German universities to participate in these activities. Close cooperation between DESY and the universities will ensure that universities can easily enter into the field of accelerator science. To this end the Alliance will:

- support the universities in the teaching of accelerator science, to broaden the base for accelerator science in Germany;
- increase accelerator research at Diploma and PhD level at DESY by inviting students from all partners.

The Alliance will take special measures to train and support young scientists involved in the field of accelerator science, advancing the role of Germany in high energy accelerator research.

The following pie chart shows the planned distribution of the requested funds across the four Research Topics and the backbone of the Alliance. It should be noted that the backbone contains support for all four Research Topics, in particular positions for young researchers. The accelerator research contains only seed money for personnel to build up accelerator science courses at universities. Here existing infrastructures will be used.

Framework Concept



2 Research Topics

2.1 Research Topic 1: Physics Analysis

Uncovering the fundamental structure of particle interactions at the Terascale requires a joint effort of experimental analysis and theoretical understanding. The institutions participating in the Alliance have a strong record in both areas. They have played a leading role in analysing and interpreting collider data from PETRA, LEP, SLC, SppS, Tevatron and HERA, and thus in shaping the Standard Model as our current understanding of particle physics. This expertise will be the basis for the Alliance to tackle today's key questions of particle physics which are also central to the research at the LHC and ILC: the origin of mass in electro-weak symmetry breaking, the possible existence of extended symmetries or extra dimensions and the nature of dark matter. A particular goal of the Alliance is to make a strong impact on the exploitation of the LHC and to explore the implications of the results on the future programme at the Terascale.

The Alliance will strengthen the ties between experimental data analysis and phenomenological developments. The phenomenological research will address precise predictions for processes at the LHC and the ILC together with ideas on Standard Model extensions. Out of this work suggestions for distinctive signatures of new physics should emerge, providing the basis for Monte Carlo generators to simulate physics processes. In close interaction Alliance scientists should study how these signatures can be observed in a detector. This kind of collaboration will be of high importance once discoveries have been made at the LHC. The Alliance will then provide a framework for theorists and experimentalists to work towards interpreting the discoveries in the light of a newly emerging theory beyond the Standard Model.

The main instrument of the Alliance will be an Analysis Network of all participating institutions which allows for the formation of working groups tailored to the needs of individual research questions and which fosters the synergy between all participants. The Analysis Network is based on the Analysis Centre at DESY as an integral part of this network, serving as a central hub and providing core competencies and services. Of particular importance for the Network is the collaboration between theorists and experimentalists. A Virtual Theory Institute will serve as a platform to coordinate work among the theorists in the Alliance, but at the same time it will also pool theoretical and phenomenological expertise and provide easier access and better communication with experimental colleagues. These tools will be complemented by guest programmes, workshops and tutorials for researchers at various levels of their careers. They are described in detail below.

2.1.1 Scientific case for the Research Topic

2.1.1.1 LHC and ILC data analysis as key to Terascale Physics

The combined analysis of data gained from previous collider and low-energy experiments has firmly established the Standard Model as an effective theory valid below the Terascale, but does not give a decisive hint for what lies beyond. There is a variety of theoretical models for physics at the Terascale. Further progress in the understanding of fundamental interactions therefore requires new experimental input, as will be delivered by data at the LHC and the ILC. Signatures of new physics have to be identified, isolated from the background, and new parameters have to be measured as precisely as possible in a coordinated effort between experimental analysis and theory.

While some signatures of new physics will be quite clean, the more typical search, in particular in the challenging hadronic environment of the LHC, requires an excellent understanding of the backgrounds from Standard Model sources. These backgrounds can be determined by calculating cross sections within perturbative QCD, by deducing them from LHC data in related channels or, most commonly, by a combination of these methods. The determination of the new physics parameters (masses, couplings etc.) similarly requires the combination of data with the results of complex theoretical calculations.

Research Topics

The major physics topics are the following:

- Higgs Physics: LHC data will decide whether electro-weak symmetry breaking is realized in a weakly-interacting or in a strongly-interacting scenario.
- Supersymmetry: Supersymmetric (SUSY) extensions of the Standard Model provide an attractive solution to the hierarchy problem and allow for gauge coupling unification if the masses of the SUSY particles are near the TeV scale, well within the reach of the LHC and the ILC.
- Alternative Scenarios: While SUSY is a very attractive extension of the Standard Model, theoretical research has brought up a wealth of viable alternatives, for instance electro-weak symmetry breaking by new strong interactions, or models with additional spatial dimensions or new symmetries.
- Standard Model: To achieve the main goal of the analysis of the LHC and ILC data, namely to unravel the mechanism of electro-weak symmetry breaking and to discover and explore new phenomena, an improvement in the description of Standard Model processes is mandatory.
- Top Quark: Within the Standard Model, the top quark is the heaviest particle, justifying its special role in Standard Model analysis at LHC and ILC.

2.1.1.2 Most important scientific goals

The overarching goal for the Alliance is to gain significant insight into Physics at the Terascale with a high degree of international impact and visibility. The goal shall be reached through establishing an Analysis Network between the partners which will be based on the Analysis Centre at DESY.

Table 1: Global areas of interest of the Alliance partners in Research Topic 1

	Data Analysis			Analysis Tools		Theory
	Detector	LHC	ILC	Experimental	Monte Carlo	
DESY	x	x	x	x	x	x*
RWTH Aachen	x	x	x	x	x	x
HU Berlin		x				
U Bonn	x	x	x		x	x
U Dortmund	x	x				x
U Dresden	x	x				x
U Freiburg	x	x	x		x	x
U Giessen	x	x				
U Göttingen	x	x	x	x		x**
U Hamburg	x	x	x			x
U Heidelberg	x	x				
U Karlsruhe	x	x	x		x	x
U Mainz	x	x				x
LMU München	x	x				x
U Siegen	x	x			x	x
U Wűrzburg		***			x	x
U Wuppertal	x	x			x	x
MPI München	x	x	x			x

* a leading scientist position is being filled
** new research group
*** the candidate for the professorship“Didaktik und Experimentalphysik” plans to participate

This research topic is structured into three categories:
A. Data Analysis aiming at the analysis of the data of the LHC experiments ATLAS and CMS and at the preparation for the physics analyses at the ILC.
B. Analysis Tools aiming at the development of tools and techniques which are common to the current and future experiments. Many of these tools are shared between experimental physics and theory or are provided by theory to the experiments.
C. Theoretical Predictions incorporating the theory effort necessary to explore Terascale physics. Within the Alliance, progress shall be made in the three major fields of precision calculations at higher orders, signature-driven phenomenology, and the development of new theories beyond the Standard Model.

These categories are strongly interrelated as for instance results of an experimental analysis influence the development of new models as well as the corresponding predictions for new phenomena, which in turn trigger new analyses. The participation of the Alliance partners in these three different categories is summarised in Table 1. The goals within the three categories are detailed below.

A. Data Analysis

Data analysis is a main focus of the Alliance and is performed by all partners. To a large extent it is funded by the BMBF and the DFG. However, the Alliance introduces new measures complementing those: Mainly through the Alliance Fellowship Programme and Young Investigator Groups, Alliance funds will provide a longer-term basis to reach these goals. The aim of the Alliance is to add instruments for a better collaboration between the partners, especially a much closer link between theory and experiment. Furthermore it will provide services which are not funded otherwise but which are important for the Alliance as a whole. Here the primary analysis tasks are summarized.

Understanding of the LHC detectors: Detector response and calibration

One of the largest challenges in LHC physics analysis is the understanding of the detectors which will be a main point particularly in the first years of the LHC. In spite of very careful studies of the subsystems before installation, the complete detector system can be understood only when all subsystems are in place, powered, and connected to the read out chain. An indispensable tool in this are Monte Carlo simulations of collider events.

The commissioning and calibration of detectors at hadron colliders typically exploits kinematic constraints in known physics processes. For example, the W-mass constraint in top-antitop events allows for the determination of the dominant experimental uncertainty in most analyses, the jet energy scale. Top-antitop events will also be used to study and quantify the performance of b-tagging algorithms, while the energy scale of electromagnetic calorimeters or lepton trigger efficiencies are best determined in events containing leptonic Z-decays. Consequently, the level of understanding of those physics processes and the quality of their theoretical description determines the ultimate precision with which the detectors can be calibrated and understood. Clearly, a strong collaboration of theorists and experimentalists in this area is required.

In summary, recording of sufficient ensembles of collision data is required to be able to formulate new physics results on the basis of statistical procedures. Detector calibration and understanding of its response through Monte Carlo simulations, and studies on measured data are needed to quantify the systematic uncertainties of these results. All this can only be mastered in a common effort of experimentalists and theorists who provide the experimental and theoretical tools for the analysis, and who communicate and work together on the actual challenges in dedicated expert teams.

LHC data analysis

The physics analysis of the LHC data is the central theme in this Research Topic. The alliance partners are currently preparing for these analyses and are involved in all major topics. Within the Alliance and with the help of the Analysis Network and the Analysis Centre at DESY, it is the goal to strengthen this effort significantly. Below, the major objectives of the main physics topics are briefly summarized.

Higgs Studies:
The search for the Higgs boson will be conducted in a number of production and decay channels. Most promising for a Standard Model type Higgs boson are production through gluon fusion and through vector boson fusion with the subsequent decay to pairs of W or Z bosons, photons or tau leptons. The signal rates have been calculated including higher order QCD corrections, with strong involvement of German groups. Backgrounds arise, for example, from W, Z, photon or tau pair production or from top quark decay. Also here, German experimental and theory groups have amassed considerable expertise which needs to be combined to perform fore-front Higgs analyses. After discovery, one major goal is the determination of Higgs boson couplings to gauge bosons and fermions from a combined fit to all measured rates. In some extensions of the Standard Model, like supersymmetry, additional Higgs resonances are predicted and a larger variety of search channels needs to be studied. Other models predict enhanced cross sections for vector boson pair production in vector boson fusion. These signatures can only be uncovered from the LHC data by a close interplay of theory and experiment.

Supersymmetry:
Analysing SUSY models is non trivial, as many model variants with a multidimensional parameter space and different experimental signatures have to be explored. Once a SUSY-like signal is established, a global parameter determination must be attempted, in the framework of an appropriate SUSY model. An important intermediate step is the measurement of masses or mass differences, for example through kinematical spectra of leptons produced in SUSY decay chains. For a reliable parameter determination it is mandatory that the measurements are matched by precise theoretical calculations. A close collaboration between theorists and experimentalists will be necessary to explore the many options and to identify the correct model through a determination of the unknown parameters.

Alternative Scenarios:
A wealth of viable alternatives to SUSY exists, most notably models with additional spatial dimensions or new symmetries which thereby attempt to solve the hierarchy problem. Signatures of these models often involve the existence of new gauge bosons and new heavy fermions. A promising analysis approach to cope with the multitude of different predictions is a model-independent search which is driven by final states rather then model predictions. A reliable prediction of Standard Model processes is necessary to establish a signal for new physics and to interpret such a signal within a given model.

Standard Model Measurements:
Standard Model processes constitute the wealth of data at high-energy colliders and an excellent understanding of their properties is necessary to establish the existence of new phenomena. Moreover, direct searches for new physics and new particles must be complemented by indirect constraints and precision tests of Standard Model properties, which require both accurate measurements as well as precision calculations.

Top Quark Studies:
Fundamental top quark properties will be studied with unprecedented precision, complementing the Tevatron measurements and providing strong sensitivity to Standard Model parameters such as the mass of the Higgs boson. In particular, the top-antitop spin correlations will be clearly accessible for the first time at the LHC. Those measurements will allow tests for alternative top quark production mechanism such as the decay of a Higgs boson or narrow heavy resonances. Top quark interactions with gauge bosons will be studied and possible indications for anomalous top quark decays via Flavour-Changing-Neutral-Currents or decays to a charged Higgs boson will be searched for. The large mass of the top quark suggests that it plays a very special role in the electroweak symmetry breaking.

The path to the ILC

The early physics results of the LHC will already shed first light on new Terascale phenomena as explained in the previous section. For the full exploration and understanding of these new phenomena a complementary instrument, the ILC, operating in the same energy regime will be needed. Within the Global Design Effort (GDE) the ILC machine and detectors are currently being designed at the technical level for an assessment around the year 2010.

The ILC is highly complementary to the LHC. The properties of particles can be measured much more precisely and with fewer model assumptions. For example, the mass of the top quark can be measured about a factor ten better than at the LHC. The coupling strengths of Higgs bosons to quarks, leptons and gauge bosons can be measured without model assumptions at the percent level. The tuneable beam energy and beam polarization can be exploited to characterize the new particles, e.g. within supersymmetry, with a precision suitable to pin down the free parameters of theories beyond the Standard Model and draw conclusions on their realisation in Nature.

It is a goal to contribute to the study of ILC physics and its interconnection with LHC data analysis in three areas:

1. Optimize machine parameters and detector layout
The technical design of accelerator and detectors requires continuous interplay with physics simulation studies. Choices of machine parameter, e.g. beam crossing angle, and detector layout, e.g. in the forward region, need to be based on concrete physics analyses.

2. Understand the implication of early LHC results for ILC parameters
The LHC will be able to pin down the mechanism of electro-weak symmetry breaking and possibly find evidence for supersymmetry or other new physics models and thus have impact on the ILC machine parameter. Within the Alliance, an effort will be made to inject LHC results into simulation studies for the ILC.

3. Precision predictions
Measurements at the ILC will often reach an experimental precision at the percent level and better. Interpretation of these measurements thus requires theoretical predictions of the same precision. This mandates significant advances in theoretical calculations at higher orders. It is a goal of the Alliance to put the existing competency in this field on a long-term basis.

All analysis tasks will be tackled within the Analysis Network. This will increase the number and quality of publications based on work led by German groups and finally give rise to a higher visibility of the German particle physics community.

B. Analysis Tools

In order to arrive at the goals of data analysis specified above a variety of common tools and techniques is necessary. It is a goal of the Alliance to strengthen the development of such tools, mainly in the field of Monte Carlo generators which is crucial for data analysis but as yet rather weakly represented in Germany. Similarly the Alliance will improve simulation of detector response and statistical analysis techniques. The new developments within the Alliance will to the best effort be coordinated with and integrated into the international developments in particular within the experimental collaborations. The Analysis Centre will provide service and support for the partners in the use of these tools.

Monte Carlo Tools

In order to compare the complex data generated by collider experiments with theoretical predictions, Monte Carlo programs are an indispensable tool. The term comprises a wide range of elements which must be interlinked for optimal theoretical support of physics analyses. The main elements in this chain are

- parton level programs which integrate cross sections as calculated within a fixed order of perturbation theory,
- parton shower generators which approximately describe the higher order emission of quarks and gluons in hard scattering events,
- hadronization programs which simulate the transition from quarks and gluons, the entities used in theoretical calculations, to the hadrons, leptons and photons observable in the detector,
- detector simulation programs which describe the interactions of hadrons, leptons and photons with the material of the detector and their decay.

A major goal of the theory activity within the Alliance is the improvement of the tools in the first three elements.

Parton level programs:

Many groups in Germany are performing perturbative calculations of scattering cross sections for processes described within the Standard Model or its extensions. The scattering particles are quarks and gluons – the partons inside the scattering protons of the LHC – as well as leptons and photons. The integrals over their possible configurations are performed by Monte Carlo techniques. These parton level programs range from automated tree level program generators like Alpgen, MadGraph, Sherpa and WHiZard/O'Mega, and programs implementing higher order corrections within the flexible Monte Carlo approach, to multi-loop programs providing integrated cross sections. The Alliance will be active in all three areas.

Among the automated tree level program generators, the combination WHiZard/O'Mega, has been developed by Alliance members now working in Freiburg, Siegen and Würzburg. The Alliance will provide support for these programs and continue their development. The support will include user training and aid for software installation in the analysis framework. New developments will simplify the implementation of complicated new physics scenarios, aiding the rapid response to new developments in phenomenology.

Parton shower and hadronization programs:

The second and third steps in the chain outlined above are typically combined into one program. The Pythia, Herwig and Sherpa programs are the three main ones which continue to be developed at present by international collaborations. Even though these programs constitute the indispensable link between theoretical calculations and experimental analysis, work in this area is confined to very few places in Germany, Herwig development in Karlsruhe being the major contender. Important theoretical development is needed in this area of event generators in order to improve the models used for hadronization, for the description of the underlying event, and for the optimal approximation of matrix element predictions by the parton shower. In particular this aspect of Monte Carlo development will be strengthened by the *Alliance*.

In addition to the radiative correction calculations which are being cast into the form of parton level Monte Carlo programs, further work is also needed for combining leading order calculations for processes with different numbers of partons in the final state. Ultimately, one would like to combine parton shower Monte Carlo generators with next-to-leading order calculations, to provide most accurate theoretical predictions for realistic collider observables. Work along these lines is currently performed at Aachen and Karlsruhe. The *Alliance* will also support work in these areas.

Statistical Methods

In recent years, the demand on mastering data analyses techniques has increased significantly. Cutting edge analyses rely on increasingly complex and sophisticated data treatment and statistical tools. Examples for the contemporary developments in analysis techniques are measurement methods such as the matrix element method, or the decision tree method, both successfully established and coded by the Tevatron experiments. New graphical methods in designing physics analyses in context with the automated reconstruction of physics processes represent major extensions of possibilities in data analysis.

The Alliance will respond to these changes through the common and coordinated development of analysis tools, their conservation and maintenance, and by establishing collaborative tools for communication and for conserving communication history. This will aid knowledge access and transfer, will enlarge the spectrum of choices for physicists performing analyses, and in consequence will be the starting point for new ideas in physics analyses. Furthermore the technical developments will enable physicists to concentrate more on their prime task in data analysis which is to interpret particle collision data in relation to the underlying physics.

C. Theory

In order to compare data at the LHC or the ILC with theoretical models, precise predictions for cross sections and decay rates, for particle spectra and for relations between particle interactions are needed. On the other hand, new data, discoveries and precision measurements from LHC and ILC will be interpreted by theory, models are to be excluded or refined, and eventually a new theory of Terascale physics will emerge.

Higgs Physics and the Standard Model: For a successful search for the Higgs boson and for a meaningful extraction of its properties from LHC and ILC data, signal as well as background rates have to be known including higher-order QCD and electro-weak corrections. Greatly extending the LEP physics programme which led to the indirect measurement of the top-quark mass, a global fit on all precision observables provided by LHC and later ILC is the way to judge the quality of the Standard Model, or any extension thereof, and thus indirectly pin down new particles or interactions that cannot be observed directly.

Signatures for New Physics: Whatever discoveries beyond the Standard Model will be made at the LHC and the ILC, in no case it will be clear from the beginning which direction Nature has chosen. Instead, various candidate models must be investigated and compared with data. For a meaningful comparison, many observables have to be known with higher-order accuracy. German theory groups have already played a significant role in higher-order calculations for the MSSM, a programme that either will be adapted to extract the actual model parameters if supersymmetry is found, or otherwise transferred to alternative models that emerge as preferred by data. Particularly important will be the discovery of missing pieces of a model such as the extra Higgs bosons of the MSSM. Depending on model properties and data, efficient search strategies have to be devised, a task that for a phenomenology as complex as that expected at the Terascale requires a close collaboration of theory and experiment in all aspects.

New Ideas: While a multitude of models for Terascale physics have been proposed by theory in the past, often based on concepts such as naturalness, simplicity or analogy (e.g., with QCD), Nature may have chosen a path that has not been considered in any detail yet, if at all. LHC and ILC data may contain surprises like an unexpected type of dark-matter particle, or provide answers to problems that are not obviously linked to the Terascale, such as the structure of flavour physics or even the connection to gravity. To cope with such possibilities requires flexibility and independence in the theory programme that however goes along with complete awareness about data interpretation and experimental possibilities. Clearly, close interaction between theory and experiment on a sustained basis is essential for success in this area.

A common feature of the physics goals described above is the need for the most precise theoretical predictions available. This is achieved through the calculation of radiative corrections to the various observables mentioned above, an endeavour in which theorists at most of the participating institutions are heavily involved, frequently as part of international collaborations. Examples for high precision calculations include predictions for Higgs resonance cross sections in gluon fusion and the prediction of cross sections for supersymmetric particles including contributions from heavy particles in the loops (SUSY QCD corrections). In all cases, the goal is to have theoretical corrections which are precise enough to match the experimental precision which can be reached at either LHC or ILC.

In order to provide optimal input to experimental analysis, the higher order calculations need to be interfaced to the Monte Carlo tools described in the previous section. While there exist solutions for one-loop QCD calculations, in particular the MC@NLO family of Monte Carlo programs, these tools are not versatile enough at present to be easily matched to most theoretical results. The *Alliance* will also work on this front and work on improved matching of higher order calculations with the event generators used in experimental analysis.

2.1.2 Existing competencies and infrastructure

2.1.2.1 Experience from previous Collider Experiments (HERA, LEP, Tevatron)

German groups have long standing experience in data analysis at colliders and the preparation of analyses at future machines. Over the past 20 years German groups have contributed to the colliders at the energy frontier, LEP, HERA and the Tevatron and they played central roles in the analysis. They have participated in all four LEP experiments, in both HERA experiments, and in both Tevatron experiments and assumed leading positions in the collaborations. This has prepared the community very well to embark on the challenging analyses at LHC and ILC.

2.1.2.2 Preparation of Data Taking at ATLAS and CMS

The German groups are heavily involved in the construction of the LHC detectors, ATLAS and CMS, and also a large effort in the preparation of the data analysis is going on. On the detector side this includes the development of reconstruction algorithms, the design and implementation of alignment and calibration procedures and the test of the full software chain. On the physics side analysis methods are being developed and tested with simulated data. This work is needed to optimize the detector and reconstruction algorithms, to test the full software chain, to identify missing theoretical calculations and software tools and to prepare for fast analyses and publications once real data exist. This effort includes all sub-detectors in which German groups are involved, central tasks and all physics fields of the LHC. As recognition of this work, several physics group conveners, editors of central documents and physics coordinator position have been assigned to members of the German groups.

2.1.2.3 ILC Physics studies

German groups have also played a leading role in the preparation of the ILC physics case. In 2001 the TESLA TDR was published under the leadership of DESY and strong contributions from other German groups. For the TESLA TDR, a full detector has been simulated in detail and the data have been analysed with full reconstruction algorithms. This work has been continued and the results will be included in the physics and detector part of the Detector Concept Report which is currently in preparation within the Global Design Effort. The European editor for the detector part and the experimental editor for the physics part are coming from Germany.

2.1.2.4 Theoretical Expertise

The German particle theory community is particularly strong in several topics: precision calculations of Standard Model and Beyond the Standard Model processes as well as the development of Beyond the Standard Model signatures and model building. The precision calculations involve higher order corrections and require sophisticated analytical and numerical techniques.

Alliance scientists have made major contributions in this area in the past and amassed profound expertise which in many cases is leading internationally. One focus of the German theory program are precision calculations for Higgs signal and background processes at the LHC, including for example the two-loop calculation of the inclusive Higgs cross section and one-loop calculations for more exclusive Higgs production channels, using methods pioneered by members of the Alliance.

German groups have played a leading role in calculating the two-loop corrections to Higgs masses and mixing angles, which are crucial for exploring the SUSY Higgs mechanism at the LHC and the ILC. Provided supersymmetry is realized in Nature, future colliders will provide a wealth of data on SUSY phenomena. German theory groups are providing the higher-order predictions that are needed for the determination of the supersymmetry Lagrange parameters from experimental data and play a leading role in the international supersymmetry parameter project (SPA) set up at DESY as a joint study of theorists and experimentalists to reconstruct the parameters of a fundamental theory at the unification scale. Members of the Alliance have also played a decisive role in precision calculations of Standard Model processes, which do not only constitute backgrounds for new physics searches but also provide important indirect constraints on Standard Model extensions.

Other than precision calculations of known processes it is also important to study what are the possible promising signatures of new physics, Higgs or beyond the Standard Model, at both the LHC and the ILC. For this it is essential to develop and investigate well-motivated extensions of the Standard Model (model building) as well as to extract the resulting new collider signatures. This prepares the ground for a potential discovery and also helps avoid bias in the experimental search. The most likely and most widely studied extension of the Standard Model is supersymmetry. From the beginning German groups have played an internationally leading role in the theoretical discovery and the development of supersymmetry. More recently German groups have led the way in analysing potential new signatures from supersymmetry related to R-parity violation or the supersymmetric dark matter candidate. They have also worked on extracting potentially characteristic signatures at the LHC and ILC resulting from supersymmetric models which are unified at a high energy scale (10^{16} GeV).

New physics may also reveal itself through the study of top quark properties. German theory groups have systematically studied higher-order corrections to top quark spin correlations at hadron colliders, which will be accessible for the first time at the LHC.

2.1.3 Work Packages

We aim at implementing three work packages to achieve the goals described above:

1. The creation of an Analysis Network which will strengthen the Alliance scientifically through a close and coordinated collaboration of all partners. Alliance funds will be used to create Young Investigator Groups (YIGs) and fellowship positions on selected topics within the Research Topic. Several of the positions will turn into new permanent professorships or permanent appointments at the participating universities.

2. The Analysis Network will be based on the Analysis Centre at DESY. The role of the Analysis Centre is to pool expertise and to provide long-term support and infrastructure for LHC data analysis and ILC physics preparation.

3. Increased Training and Exchange measures will be implemented taking advantage of DESY's infrastructure and the Alliance funds for the organisation of workshops and tutorials, for a guest program for international scientists, and for interim professorships.

2.1.3.1 WP1: Analysis Network

All participating institutions form the Analysis Network which is designed to foster collaboration and knowledge exchange within the experimental and the theory communities and, at least as importantly, between the theorists and experimentalists working on

Terascale physics. An integral part of the Analysis Network is the Virtual Theory Institute which provides a discussion forum for the theorists as a partner for the experimentalists.

2.1.3.1.1 Alliance Working Groups

By establishing special Alliance Working Groups the proposed Analysis Network will support cooperation among the scientists of the Alliance. These new working groups shall foster the communication between the physicists of the different partner institutes of the Alliance with respect to data analysis and its theoretical interpretation.

All large collaborations like ATLAS, CMS or those concerned with the study of ILC physics have developed their own (international) working group structure. In spite of this, young members of these collaborations, e.g. PhD and master students, often experience a lack of guidance especially when starting their research work. This is particularly true for students getting involved in software development or data analysis since this requires a broad knowledge on many experimental aspects. With the approach of LHC start-up it becomes more and more evident that meetings and tutorials on an international level are not sufficient to answer 'every-day questions'; many countries have therefore already initiated new collaborative structures in order to improve communication on the national scale. By introducing a new working group structure, the Alliance will adopt a strategy with the goal of strengthening the role of the German particle physics groups inside the different collaborations.

A single partner of the Alliance generally cannot provide expertise on all aspects of a data analysis or its theoretical interpretation. An obstacle is that experts are often non-permanently employed and the available expertise can migrate, eventually leaving a severe knowledge gap within the group.

In the framework of the Alliance, expertise on all aspects of the data analysis shall be made available to all partners. Therefore the Analysis Network will form Alliance Working Groups to reach the following goals:

- better coordination of the analysis activities among partners of the Alliance;
- provision of direct guidance for PhD and diploma students concerning all aspects of their analysis; this guidance will be given by the experienced members of each working group many of which will be provided through the Fellowship and Young Investigator Group program of the Alliance;
- improved communication through regular meetings of these working groups during which questions concerning the progress of the analysis as well as 'every-day problems' can be tackled.

As the existing collaborative structures established within the large high-energy experiments already now entail a large number of meetings, the following features are envisioned to guarantee efficient work:

1. The Alliance Working Groups should have a small size in order to guarantee effective communication; typically such a group should consist of two or three experienced researchers and up to five PhD and diploma students.

2. Each Working Group should focus on a specific, well restricted area of the analysis of high-energy physics data or their theoretical interpretation. This restriction will allow for small groups as required above.

3. Within each Working Group as much expertise as possible on an analysis topic should be combined involving physicists from the different partner institutes of the Alliance. Long-term expertise on experiment-specific aspects like data reconstruction or software issues should be provided to the working groups through the Analysis Centre.

4. The work of the postdocs within the Working Groups should be recognized by an official mandate of the Alliance. The composition of the working groups, their tasks, the responsibilities of their members and the results should be made public through the World

Wide Web such that they become relevant for future job applications of the working group members.

5. In order to guarantee a close collaboration between the members of the Alliance Working Groups frequent meetings are mandatory. In order to reduce travelling between the partner institutions, this will only be feasible through modern communication media like video- or desktop-conferencing.

2.1.3.1.2 Monte Carlo group

We will install a Young Investigator Group in the area of parton shower and hadronization Monte Carlos which should work as part of the international effort to improve event generators. Close interaction with theorists developing parton level Monte Carlo tools and with experimentalists using and validating the parton shower and hadronization programs is of utmost importance for this group. The University of Karlsruhe provides this environment and is envisaged as its home.

Because of the central role which is played by parton shower and hadronization programs in the experimental analyses, substantial technical support for the experimental groups in this area is highly desirable. One task of the YIG would be to share in providing this support, in addition to the scientific work of further developing the underlying theory and implementing it in the programs. The service tasks of Monte Carlo support require additional support staff, which would naturally be housed at the proposed Analysis Centre at DESY. The international character of the experimental collaborations as well as of the event generator development effort implies that this support would also be extended to international collaborators.

Support of experimentalists should not be confined to the area of event generators, however. The Alliance will also foster closer collaboration between theorists and experimentalists and this collaboration will be used to make available to interested parties the Monte Carlo tools developed by theorists at all levels. In order to facilitate this exchange, the Virtual Theory Institute will set up a common repository of Monte Carlo programs which have been developed by the theorists in the Alliance. The repository would invite contributions from authors outside the Alliance as well. The programs in the repository will continuously be updated as needed.

2.1.3.1.3 Virtual Theory Institute

Discovering and exploring Terascale physics at the LHC and the ILC requires both the understanding of theoretical aspects of new physics models as well as precision calculations for collider observables that can be confronted with experiment. German theory groups have made highly significant contributions to particle theory and are thus in a position to take an internationally leading role in LHC and ILC phenomenology. However, in order to fully exploit the potential of the individual particle physics theory groups and to provide maximum support for the experimental data analyses, the expertise and research activities at the various institutes should be co-ordinated and pooled. To meet this challenge we propose to create a Virtual Theory Institute within the Alliance. The Virtual Theory Institute would provide a structure that facilitates and stimulates the communication, interaction and collaboration among the various theory groups and promotes the development and provision of analysis tools, in particular Monte Carlo tools as detailed above.

The pooling of expertise will make it easier for the experimentalists to identify experts and discussion partners when a specific analysis requires theoretical input or the use of specialized theory tools like higher order perturbative calculations. This implies that members of the Virtual Theory Institute will also participate in the Analysis Working Groups described above. At the same time, specific theory problems may be best tackled by forming dedicated theory working groups.

To foster communication and interaction and to stimulate joint research projects the Virtual Theory Institute will organize regular seminars held at different institutes and broadcast through video-conference facilities. These seminars should provide a platform for members of the Virtual Institute to communicate their expertise and research activities within the Alliance, and shall also include presentations from invited external speakers. The virtual theory seminar series should be integrated into the activities of the Analysis Network including joint theoretical-experimental talks, for example on analysis tools and data interpretation.

2.1.3.1.4 Resources

For the Analysis Network the following positions are foreseen:
- Two Young Investigator Groups and nine fellowships in theory
- Two Young Investigator Groups and eight fellowships in experiment.

The two experimental YIGs will be based in Dresden and Wuppertal. The YIGs in theory will be established in Göttingen and Karlsruhe. This allows Göttingen to start a new research area with a professorship in phenomenology. Four fellowships are already assigned one each to Würzburg, Siegen, DESY and Wuppertal. In all cases, the institutions which have already been assigned YIGs or fellowships have agreed to provide a tenure track option to the fellows or the leaders of the YIG. This feature is unique in the German particle physics landscape and guarantees top quality applicants for these positions. The remaining fellowships will be assigned by the management and the Institute Assembly at a later stage.

2.1.3.2 WP2: Analysis Centre at DESY

To enhance the analysis activity for the LHC and preparation for the ILC in Germany, the Alliance will establish an Analysis Centre at DESY. This centre will concentrate expertise on several basic aspects of LHC and ILC analyses and will provide key infrastructure.

The topics of the Analysis Centre are planned to be:
1. The provision of computing resources for data analysis, Monte Carlo generation and theoretical studies via the formation of a common National Analysis Facility.
2. Coverage of general issues of Monte Carlo production.
3. Coverage of general analysis tools related to statistical analysis, general reconstruction algorithms and graphical tools.
4. Introduce the outstanding expertise at DESY on the proton structure obtained at HERA.
5. Methods of documentation, collaborative tools and knowledge preservation.

2.1.3.2.1 National Analysis Facility

A central element of the Analysis Centre infrastructure will be a computing facility to run analysis jobs.

The LHC experiments have defined a computing model which relies on the Grid paradigm. It consists of a Tier-0 centre at CERN, a few large Tier1 centres distributed over the world and many smaller Tier-2 centres, about five of them located in Germany. This is described in detail in Research Topic 2. This model assures that the data are reconstructed centrally and a sufficient amount of simulation is generated. However, the model assigns only limited resources for analysis of the data. In all analysis models the output of the official reconstruction is further reduced into some kind of data format that is tailored to the needs of a single analysis group. These data can then be analysed further by the members of the groups.

Because of the large luminosity and the large cross section for strong interactions huge datasets are produced by the LHC experiments. Even the datasets that are needed for the physics analyses are so large that they can no longer be stored easily on the computer system of an average participating institute. Physics analysis therefore requires a collaborative effort unprecedented in the past.

Within the Analysis Centre a National Analysis Facility is planned. This facility would enable batch work as well as interactive data analysis. It should have a large amount of disc space available and has to be capable to run the experimental software at all levels. Raw and high level reconstruction data are needed with a limited amount to test and develop new algorithms, e.g. for data calibration. The simulation chain is requested to simulate events special to a given analysis. In addition, the full set of compressed reconstruction data (AOD) from the official production must be accessible to write the group specific data. The requirements and tasks of this part of the facility are similar to a Tier-2 centre, however it will primarily be used by the Alliance partners to ensure efficient and fast analysis work. Similar concepts of private computing power in addition to the one provided for the experiments is followed in many countries participating in LHC experiments.

In addition to batch processing the facility also has to provide the possibilities for parallel interactive work. For effective analysis work a fast response time is needed. With the large data samples at the LHC this is only possible if the analysis can be performed in parallel on many machines. The technical realisation and the needed resources for the National Computing Facility will be described within Research Topic 2.

In addition to the National Computing Facility the participating institutes will have Tier-3 installations mainly for their local use. As a service to the Alliance they will open these machines to the Alliance partners within the same experiment. This allows a much more efficient use of storage space because it can be shared by one analysis group spanning over several institutes requiring the same data. The restriction to the same experiment reduces the work in software maintenance and is reasonable because the analysis groups are also restricted to one experiment.

2.1.3.2.2 Monte Carlo User Support and Tuning

Several tools are needed by everybody for a successful physics analysis and shall be provided centrally at the Analysis Centre. This applies to various standard generators used for ILC and LHC physics as well as for all aspects of detector simulation.

One important set of tools are Monte Carlo generators that are provided by theory groups within the Alliance as described in WP1. However, all Monte Carlo programs that are used for LHC physics contain parts that are not calculable from first principles but are built from ad-hoc assumptions and contain free parameters that have to be tuned to the experimental data. The situation is further complicated by the fact that these parameters can absorb shortcomings in the real theoretical predictions of the programs and in the description of the detectors so that the tuning becomes dependent on the simulated processes and the experiments. This tuning has to be adapted regularly following improvements in the description of the hard processes or in the understanding of the detectors.

A small group of people within the Analysis Centre at DESY will take care that the necessary and up-to-date tuning is available and will help members of the Alliance if they have special requirements. This group will also provide guidance in the choice of generators for a given analysis and organise the needed Monte Carlo productions if they are not done centrally by the experiments. This group will consult and coordinate wherever appropriate with Monte Carlo experts in the experiments and world-wide.

2.1.3.2.3 Statistical Tools

Another area where common tools are needed is statistical analysis. A large number of tools exists already in the different experiments, and they have to be collected and made available for the community. Also for this a group of people is needed that collects the tools, implements them into the experimental framework and provides guidance to the analysis physicists.

All experimental tools depend on the implementation of a specific experiment, ATLAS and CMS in our case. The experiments do not allow that physicists are members of both collaborations simultaneously. Therefore different people have to be foreseen to do the work for the two experiments although some level of collaboration is extremely useful. On the other hand the most efficient way to provide these services is in an environment where these tools are also needed for specific analyses. It is therefore foreseen that this group is co-financed by DESY and the Alliance and that the people in this group share their time between research and the analysis tools. Two positions from the Alliance are needed to fulfil these tasks.

2.1.3.2.4 Parton Densities and HERA

Over the last 15 years the electron-proton accelerator HERA at DESY has collected a great wealth of data which led to new insight into the structure of the proton and the nature of the strong force, new and supplemental information on electro-weak interactions, as well as numerous results on searches for new physics beyond the Standard Model.

The greatly improved knowledge on the proton structure provided by HERA is of particular importance for the LHC and the analysis of proton-proton scattering. It is essential for any proton-proton cross section calculation as it determines the accuracy with which rate predictions for specific reactions can be made. Only if the event rates from Standard Model processes can be predicted with sufficient precision, an observed deviation from theoretical expectations can be claimed to originate from new physics phenomena. Among the partners of the Alliance there exists substantial expertise on HERA physics, especially on the measurement of the proton structure and the corresponding parton distributions. This expertise will be a key input for the understanding of future proton-proton scattering data to be recorded by the LHC experiments.

Precise knowledge of parton distribution functions (PDFs) might not be sufficient for a thorough understanding of all aspects of the LHC data, however, as the PDFs have to be extrapolated from HERA to LHC energies. In principle this procedure is well understood, but new concepts might be needed due to the extremely high parton densities at LHC. This is studied within the framework of the HERA-LHC workshop, in which many partners of the Alliance are involved. The continuation of these studies also far beyond the end of the HERA running will be strongly supported by the Alliance, as it will become especially important for the LHC physics once precision is an issue.

2.1.3.2.5 Collaborative Tools

Concerning access to and conservation of expert knowledge, we will implement a web-based information system filled and maintained by the members of the Alliance. A small board of three physicists, one theorist and one physicist from each LHC experiment will supervise the contributions to the pages, requesting changes and updates when necessary.

2.1.3.2.6 Resources

From the Alliance budget two technical positions at DESY are requested and sustainability is provided. The holders of these positions are supposed to provide the required expertise on Monte Carlo generators and statistics tools to guide the members of the Alliance. In addition they should coordinate the web-based documentation. The hardware required for the National Analysis Facility is detailed in the description of Research Topic 2.

2.1.3.3 WP3: Training and Exchange

Increased training and exchange measures aim in particular at young researchers to provide them with necessary knowledge and skills to contribute to the Alliance goals quickly. A dedicated Alliance guest programme is foreseen to bring international highly qualified scientists to Germany to complement the Alliance expertise and further increase the international collaboration. The instrument of interim professorships on the one hand will enable German university professors to take over limited-term high-level responsibilities within the LHC experiments and elsewhere while at the same time, it offers young researchers the possibility to acquire important skills in teaching.

2.1.3.3.1 Tutorials and Workshops

The central expertise and the good infrastructure at DESY will be used for meetings, tutorials and workshops. This includes introductory courses for young students to familiarise them with particle physics and common analysis techniques as well as expert discussions on special topics of LHC and ILC physics, publication workshops and workshops of experimentalists and theorists of several weeks addressing major new developments. These meetings will be complemented by specialised meetings outside DESY.

Formats intended in the framework of the Alliance are:

1. Introductory Tutorials – Tutorials typically lasting one to two weeks with the purpose of providing new master and PhD students of the Alliance with a general introduction to an experiment or a theoretical field.
2. Expert Tutorials – Advanced tutorials on specific software, analysis and phenomenology issues. This format will generally last a few days and is aimed at diploma and PhD students as well as young post-docs.
3. PhD/Master Training Workshops – Long-duration visits of new master and PhD students starting in a particular research field. Purpose of this workshop format – which may last up to several months – is to bring new students in contact with the experienced members of their Analysis Working Groups typically located at a different partner institute of the Alliance. The guidance and support provided during these special workshops will put new students of the Alliance directly on the right track for their work.
4. Publication Workshops – At the final stage of an experimental or theoretical analysis done by several groups many discussions and intense studies are necessary before publication is possible. This work can best be done if the people involved meet for a few weeks at a single place.
5. Expert Workshops – General workshops on specific topics. Such workshops typically last a few days and may include theorists and experimentalists from different collaborations. Typical examples for this kind of format are the workshops proposed in the framework of the Virtual Theory Institute or the so-called LHC-D workshops, which were introduced two years ago by KET.

2.1.3.3.2 Guest Programme

The upcoming start of the LHC will provide numerous challenges and opportunities in terms of detector commissioning, data analysis preparation, software and tools development and activities in theoretical particle physics. In order to improve the strategic position of the German community it is considered most profitable to fund a guest programme that provides the opportunity to invite highly skilled particle physics experts relevant for the Alliance in order to complement the expertise present in Germany, foster the degree of European and international collaboration, and improve the training of PhD students and post-docs at the German particle physics institutions.

The Alliance Guest Programme enables the member institutions to invite highly qualified scientists, scholars and academics working abroad to complete an Alliance-funded stay of 1-6 months at their institutes. The visit should focus on joint cooperative projects by the guest and host on a topic of relevance for the Alliance where the guest or visiting professor can offer significant expertise. By assuming teaching and training duties, guests will contribute to providing a clear international dimension to the research-oriented training of young researchers in the host departments and the Alliance.

To ensure that the special knowledge and skills of international researchers participating in this program of excellence become accessible to a wider audience in Germany, the Alliance provides travel allowances for the guest to visit other interested research institutes of the Alliance in Germany, to participate in the Alliance workshops and theory seminars.

The list of planned stays of Alliance guests enables researchers, institutes, departments and faculties in Germany to contact visitors and hosts and to invite the guests to their institutions. Applications may be submitted at any time to the Alliance management board.

2.1.4 Milestones

The milestones we plan to achieve in work packages of this research topic take into account a realistic start-up scenario of the Alliance as well as the anticipated schedule of the LHC machine and detectors. The schedule and topics of LHC data analysis are embedded in the international efforts and collaborations.

Work Package	Date	Milestone
WP1	07/2007	Call for the YIGs and the first round of fellow appointments.
	10/2007	Constitution of the Virtual Theory Institute
	12/2007	The majority of the positions advertised in 07/2007 should be filled
	12/2007	Call for theory fellowships to be filled in 10/2008
	07/2008	Second call for Alliance fellowships and YIGs
WP2	10/2007	Analysis Centre at DESY ready for access by and interaction with Analysis Working Groups
WP3	09/2007	First version of collaborative tools (Web and Wiki pages) available
	10/2007	Start of the regular seminar programme of the Virtual Theory Institute
	01/2008	Integration of the ongoing LHC-D workshop series in the Alliance workshop programme
	04/2008	Start of the semi-annual Alliance tutorials and workshops: Tutorial on LHC physics and detectors
	10/2008	Workshop on state-of-the-art analysis techniques and Monte Carlo generators. Topics of subsequent workshops will be decided taking into account the first results from LHC

2.1.5 Resource Planning

Financial Representation						
centre/partner: all topic: Analysis	2007	2008	2009	2010	2011	2012
	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
Total project costs[1)]	1,620.1	3,735.6	4,315.6	4,339.6	4,351.2	2,102.7
thereof personnel costs	1,467.1	3,531.6	4,111.6	4,140.6	4,152.2	2,000.7
thereof financed through institutional funding	1,516.1	3,068.6	3,184.6	3,213.6	3,225.2	1,539.7
thereof financed through third party funding	75.0	145.0	145.0	140.0	140.0	70.0
requested IVF[2)] funding	29.0	522.0	986.0	986.0	986.0	493.0

[1)] including general and administrative costs, internal services etc.
[2)] Impuls- und Vernetzungsfonds = Initiative and networking fund

Reconciliation of requested IFV funding into expenses ***(for information only)***	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
costs requested through IVF	29.0	522.0	986.0	986.0	986.0	493.0
noncash expenditures (depreciation)	0.0	0.0	0.0	0.0	0.0	0.0
Investments	0.0	0.0	0.0	0.0	0.0	0.0
Expenses	24.2	435.0	821.7	821.7	821.7	410.8

Personnel *(for information only)*	FTE	FTE	FTE	FTE	FTE	FTE
Personnel (financed through IVF)						
Scientists	0.50	8.00	15.00	15.00	15.00	7.50
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	0.00	1.00	2.00	2.00	2.00	1.00
Personnel (financed through institutional or third party funding)						
Scientists	24.35	51.00	53.00	53.50	53.70	25.55
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	0.60	1.20	1.20	1.20	1.20	0.60

2.2 Research Topic 2: Grid Computing for Physics at the Terascale

2.2.1 Scientific case for the Research Topic

The analysis of the vast amount of data that will be collected at the LHC requires new technologies in data distribution, processing and computing. The LHC experiments adopted the Grid paradigm and have successfully developed a system of worldwide computing, the WLCG ('Worldwide LHC Computing Grid'). With the start of data taking at the LHC, Grid technology will face an unprecedented challenge in terms of number of computing jobs and users to be served as well as the huge size of data handling. In Germany, major Grid facilities have been built. Still, also compared with the amount of CPU power and storage capacity in other countries, there more resources for Grid computing in Germany are required.

The primary objectives of the proposed Grid projects within this Alliance are

- to allow German institutes and universities to participate in the WLCG;
- to provide the German particle physics community with an internationally competitive computing structures such that its groups can play a leading role in the exploitation of the LHC data.
- to become a major contributor to Grid technology

To assure these goals, the different expertise on Grid computing at the FZK, DESY and the universities should be brought together with the aim of building a coherent structure for the analysis of LHC data. Such a structure will put German institutes in an excellent position to both play a leading role in unravelling the basic structure of matter and to become a major contributor to Grid technology. Both aspects lay foundations for further forefront research projects.

According to the computing models for the LHC experiments, the data flow from the source, the LHC detectors, to the desktops of the analyzing physicists proceeds via several hierarchical levels (so-called Tier centres). Tier-0 to Tier-2 centres are well defined in the Computing Technical Design Reports of the LHC experiments ATLAS and CMS. Their resources will be available to the collaboration as a whole. The Tier-3 centre, consisting of computer clusters at universities and institutes, still is to be shaped to optimize the analysis environment.

The Computing Technical Design Reports specify the total amount of resources for the Tier-1 and Tier-2 centres to be pledged to the WLCG. Whereas the German community has a strong Tier-1 centre in GridKa at the Forschungszentrum Karlsruhe, the expected 3 average ATLAS, respectively 1.5 average CMS Tier-2 centres are not realised yet. Those centres should be pledged to the WLCG and serve the whole collaboration.

In addition to those WLCG resources, there is the need for additional CPU and storage capacity in Germany to be competitive in physics analysis. To provide the required computing resources to the German groups will be a key element of the Alliance thus laying the basis for them to play a leading role in the data analysis. To realise this aim a National Analysis Facility (NAF), embedded in the LHC Grid, will be established.

In addition to the intelligent allocation of resources, the Grid is also a technological challenge. The Alliance intends to contribute to the future development of Grid tools. In particular it aims at integrating the expertise at DESY, FZK and the universities for contributions to the Grid middleware.

2.2.1.1 Most important goals of the planned work

A competitive Grid infrastructure in Germany demands substantial upgrades of existing resources and a broadening of expertise as an important precondition for an efficient participation of the German groups in physics analyses. The Alliance aims at providing the German particle physics community with the computing resources for analyses. It also combines the Grid expertise at FZK and DESY with those at the universities, thereby strengthening and eventually broadening the capabilities of German Grid computing. This will enable the German community to contribute significantly to projects, which advance current Grid technology to make it widely usable. This integration of infrastructure and expertise of universities into a German Grid structure for particle physics is an important asset of the Alliance.

The general goal is to develop a nationwide homogeneous computing environment, a 'Virtual Computing Centre' spread over GridKa, DESY and the universities Aachen, Berlin, Freiburg, Göttingen, München, Wuppertal and MPI München. The Alliance will upgrade necessary resources for general networking, computing power and data storage for the Grid backbone institutes. The Alliance will set up a high bandwidth network between all its members, the universities and the Tier-1 and Tier-2 centres.

The Alliance will perform R&D on Grid tools that supplement the basic infrastructure, allow its optimization and render its usage more user-friendly. Important key projects have been identified, where funding of personnel and infrastructure would have a large impact on the construction of a powerful Grid structure in Germany. For optimal benefit, all computing resources within the Alliance have to operate in a coordinated way based on a common Grid structure. Therefore all university groups must get acquainted with the usage of Grid tools and will need to integrate their local computing infrastructures as Tier-3 centers into the middleware framework set by the WLCG. Further benefits will arise by building up a high-bandwidth network infrastructure, with the possibility of forming a virtual private network across the Alliance.

In particular the Alliance will concentrate on the following goals:

- Develop the needed Grid infrastructure into a Virtual Computing Centre which includes the Tier-1, Tier-2, and Tier-3 centers, the National Analysis Facility to provide the needed computing resources for batch and interactive analysis by individual physicists and a high performance network between all collaborating institutes;
- Further development of Grid structures and tools in order to optimize the reliability and utilization of the computing resources;
- Provide Training, workshops and schools in order to train Grid users and site administrators.

2.2.2 Existing competencies and infrastructure

Whereas Grid computing had a slow start in Germany, significant progress has been achieved during the last years. Several universities and centres are participating in the computing of either the CMS or ATLAS experiments and GridKa is by now a world-wide highly acknowledged Tier-1 centre in the WLCG. Since about two years DESY acts as a Tier-2 centre both for ATLAS and CMS with excellent efficiency.

The Tier-2 centres at the universities in Aachen, Freiburg, München and Wuppertal have already made major steps and investments to host and run a Tier-2 site. Some have made important contributions to running Grid computing in experiments at HERA or the Tevatron.

Several sites are by now well known in Grid developments and are participating in various projects like SAM-Grid, D-Grid, EGEE 2, GridPP and OSG and therefore have acquired significant expertise in using Grid techniques and contributed internationally well received tools to Grid computing. DESY is one of the main developers of the dCache-System. Wuppertal is one of the main sites in developing user-oriented monitoring tools for gLite. München, DESY and Karlsruhe have contributed significantly to the ATLAS or CMS Grid environments.

All sites do have an adequate technical infrastructure to host the investment in terms of space, cooling, power available, which is part of the contributions. Significant personnel to operate the installations will be contributed by the partners.

2.2.3 Work packages and expected results

2.2.3.1 WP 1: Establishing a Virtual Computing Centre

The proposed Virtual Computing Centre in Germany consists of the Tier-1 and Tier-2 centres as part of the WLCG, the National Analysis Facility and a high performance network. To operate and efficiently use these resources personnel for management and development is required.

2.2.3.1.1 Computing Resources for Tier-2 centres

Coordinating partners: RWTH Aachen, U Freiburg, LMU München, U Wuppertal

The foreseen computing capacity for the ATLAS experiment in Germany consists of three average Tier-2 centres. DESY and MPI München will fund and operate 1.5 of these computing centres. Three university sites, Wuppertal, Freiburg and München, each intend to setup and operate half an average ATLAS Tier-2. The CMS experiment plans to provide the capacity of 1.5 average Tier-2 centres in Germany. One will be contributed by DESY and the remaining half is foreseen at Aachen.

2.2.3.1.2 National Analysis Facility

Participating partners: DESY, FZK, U Göttingen, LMU München, U Karlsruhe, HU Berlin

The German Tier-1 and Tier-2 computing centres provide the required resources for the WLCG for the ATLAS and CMS experiment. As pointed out above, for internationally competitive physics analyses the German scientists will need additional national resources for batch and interactive analysis.

In the framework of the Alliance a NAF will be set up which will be located at DESY. It will be operated in the framework of the DESY Tier-2 centres together with HU Berlin. Depending on actual needs and advances in the network infrastructure, the facility might be distributed later over the institutional resources and may include Tier-3 centres. The required resources have been estimated to be equivalent to 1.5 average Tier-2 centre, with a special focus on data storage (see “Analysis Centre” in Research Topic 1). They are detailed in Table 2.

Table 2: Planned resource for the National Analysis Facility

	2007	2008	2009	2010	2011	2012
CPU [kSI2k]	110	280	540	800	1180	1720
Disk [TB]	70	180	360	580	920	1440
Tape [TB]	100	300	600	800	1200	1500

2.2.3.1.3 High Performance Network

The key part of the infrastructure is an excellent network infrastructure, which allows physicists to access computing resources and data without any major restrictions in terms of bandwidth. This is achieved by setting up a network infrastructure between all partners. This infrastructure is proposed to consist of a meshed Virtual Private Network (VPN) for the particle physics community. On the basis of existing structures, mainly the DFN-managed XWiN as a National Research and Education Network, the Tier-1 and the Tier-2 centres will be connected via 10 Gb/s links. For all Tier-3 centres a 1 Gb/s link should be sufficient. All these links should be in place by 2008.

The technical solution to this may be realised either by traffic shaping over IP or by dedicated additional links. A traffic driven routing scheme needs to be developed in order to have high and guaranteed bandwidth available when and where needed. Existing connections of e.g. universities should be included in this scheme.

At the beginning, these links will be implemented according to the needs of the groups, where proper solutions will have to be defined in cooperation with the university computer centers, which usually own the gateway to the wide area network (e.g. XWiN). It is expected, that the available networking bandwidth will double every 1½ years.

2.2.3.1.4 Operation and User – Friendliness of the Virtual Computing Centre

A) Operational Tasks:
The following operational tasks are considered to be the key elements of the Virtual Computing Centre:

- redundancy of (Grid-) services
- remote access to tape-systems available at the larger sites
- (Grid-based) common user administration
- accounting and billing
- technical and user support
- coordinated procurements
- coordinate the utilisation of the resources for the different tasks of the experiments' data analysis chain (e.g. reprocessing, simulation, analysis)

Many technical and organizational issues still have to be solved. Basic elements of the virtual centre are developed already in the context of the EGEE and D-Grid projects, which can be used as a starting point for the implementation of the Virtual Computing Centre.

B) Development of collaborative and interactive tools:
Distributed, interactive data analysis on the Grid is one of the main applications for experimental particle physics. A very active developer community, which is located both directly in the experiments as well as in several international Grid projects (EGEE, OSG, GridPP, dGrid) is working in this field. The currently developed tools must reach stability and the performance required for routine user applications in the next two years.

A key feature for the success are large scale tests on sites, which are foreseen to support distributed data analysis, in order to investigate bandwidth requirements, data access patterns and job placement strategies. Data distribution is handled by the experiment-specific distributed data management systems. Direct input data access to different storage element types on the sites needs to be studied and improved. For interactive analysis further properties need to be optimized to reduce the response latency to a level required for interactive tasks, e.g. prompt task scheduling or dedicated queue set-up. The NAF together with selected Tier-2 and Tier-3 sites enables the setup of a large scale distributed test bed.

An effective collaboration within the Alliance will require to utilize Grid-based interactive collaborative tools. These tools will enable collaborating physicists, located at different institutes, to use common and experiment specific analysis tools interactively over the network. The evaluation of several available software packages has already started. Further development will be required in order to adapt the tools to the need of the Alliance.

In order to construct and implement the National Analysis Facility computing hardware and personnel will be needed to operate the centre as well as to develop and improve the mentioned tools:

- Personnel for operation: 1 technical FTE per year
- Interactive analysis tools: 5.5 FTE - years in total, spread over 3 years

2.2.3.1.5 Development and deployment of a Grid-based mass storage system

Participating Partner: DESY, FZK, LMU München, RWTH Aachen

Grid-enabled mass storage systems provide the backbone of the LHC data management and storage. Storage Elements (SE), being the abstraction of such systems, receive data from remote sources through well defined interfaces by various wide area transfer protocols and make data available for local random access. They prepare data produced locally for shipment to remote sites. One of the most prominent Storage Elements, operated at the majority of Tier-1 centres and at a variety of Tier-2 centres, particularly in Germany, is the dCache SE, developed as a joined project between DESY Hamburg and the Fermi National

Laboratory (Batavia, USA). During the regular WLCG service challenges, some missing functionality has been identified. The most requested topics to be addressed, are the following:

1. The interface between tertiary storage (e.g. tape) systems and disk based storage requires significant improvement in a 24/7 production environment, like the LHC computing, with high sustained data rates. Even though Tier-2 sites are not supposed to store data permanently, it may be desirable to store data intermediately on tertiary storage to avoid unnecessary wide area data transfers, in case disk storage is running short.

2. All currently used storage systems are bottlenecks for physics data analysis at data volumes typical for the LHC. While storage systems in use do not yet scale accordingly, the design for improving dCache in that area is well understood, but development and implementation are still required.

3. Though dCache manages storage spaces from the very small to the very large, this flexibility causes issues in setting up, controlling and maintaining such a system. Further experience is required to optimize dCache for local use at small to medium size. The goal of this task is to create a dedicated team to provide the required knowledge to support German site administrators at the universities in installing, customizing and operating dCache installations. DESY should become the hub for a strongly coupled inter-site dCache operation. Satellite storage caches are planned to be installed at the associated smaller sites which would be controlled automatically using remote access mechanisms.

The required personnel consist of:

- Scientific engineer: 1 FTE DESY and 1 FTE FZK
- Scientific personnel: 0.5 FTE RWTH Aachen, 0.5 FTE LMU München

2.2.3.1.6 Coordination and Management

The virtual computer centre needs a light but efficient management structure. Typical operational problems should be discussed on a technical level by regular meetings of the fabric managers. More strategic issues should be covered by the Project Boards.

The required personnel consist of: Virtual Organization specific coordination: 8 FTE years.

2.2.3.2 WP 2: Development of Grid Tools and Optimization of Grid Components

This chapter describes the actual development activities foreseen within the Alliance for new Grid components as well as the further improvement and optimization of existing tools. The further development of the essential current components (e.g. Grid-based mass storage, virtualization and application driven monitoring) will mainly be addressed in the first 2-3 years of the Alliance. New development (e.g. Data Access) will only start in 2010.

2.2.3.2.1 Virtualization of resources

Coordinating Partners: Karlsruhe, FZK

The integration of Tier-3 sites at universities is often complicated by the fact that these resources are shared between different groups, sometimes across institute or faculty boundaries. This structure makes it difficult to provide the common hardware and software basis needed for the present Grid middleware and – to a lesser extent – for the experimental software. The WLCG middleware services (gLite) need to be deployed on several separate servers or operating system instances and require a certain version of Scientific Linux to be installed on. On the other hand, for small Grid installations, a single server provides the necessary computing power for all required gLite services. Another problem often encountered is the integration of the Grid services with the existing local cluster software (like the batch system). A very promising way to address both these problems is virtualization of these services, i.e. the implementation in separate virtual machines on a single hardware server. Based on experience gained at GridKa and in a prototype installation at the University Karlsruhe, we plan to develop an easy to install, operating system independent method to deploy all necessary Grid services on a minimum of hardware using virtualization techniques.

Scientific personnel: 1 scientific FTE, 2007-2009.

2.2.3.2.2 Application driven Monitoring

Participating Partner: FZK, Karlsruhe, Wuppertal

Monitoring of resources and jobs will be of utmost importance, once the operational stage of the LHC Grid has been reached. The aim of this work package is to allow for a fast identification of misbehaviour of any of the components and to establish a central facility to have a continuous overview over the status of the Grid system in Germany. Monitoring systems are also important for the operations crews at the Grid sites to spot local problems.

GridKa presently supports services for eight experimental communities with differing requirements concerning CPU usage, I/O bandwidth to disk and tape and wide-area network connectivity with different levels of priority. The fair allocation of these shared resources and real-time monitoring of the performance of each individual service is of prime importance for optimal functioning, as it allows for prompt identification of problems with critical services. The identification of experiment and job specific problems and data access bottlenecks is essential to ensure the efficient usage of the computing resources. The Grid middleware, the experimental software and the local logging output of the various services provide most of the information needed, however, appropriate filtering and human interfaces for an efficient extraction of the relevant information are missing at present. One aim therefore is the development and implementation of such a monitoring system, taking into account the experiment-specific environments of the ATLAS and the CMS experiments.

To understand the data flows and the use of the resources in the German Grid community, a system should be established to record the usage, the interaction between the Grid centres and the transfer of jobs and data to and from other countries. This system should allow real-time information about the status of the system and provide an analysis framework to study trends and aid error identification. An additional 0.5 full time equivalent scientist is needed for the overall monitoring system from the second year onwards.

Scientific personnel:

- ATLAS 0.5 scientist FTE, 2007-2009
- CMS 0.5 scientist FTE, 2007-2009
- Grid performance monitoring 0.5 scientists FTE, 2010-2012

2.2.3.2.3 Improved Data Access Management

Participating Partners: U Wuppertal, RWTH Aachen

The currently available data management within gLite contains only very basic functionalities. For an efficient and long term operation, additional components will be required. An automatic evaluation of the needed resources to store the data will require additional information about the data usage:

- local and regional data distribution,
- used data volume,
- data transport and
- frequency of usage.

An automatic system could optimize the utilization of the storage space and the access to the data by replicating frequently accessed data and removing unnecessary replica. An additional use case is an automatic procedure to evaluate the correctness of replicated data, the restoration of corrupted data and the verification of the metadata catalogue. The optimization of the data access has to start after the initial ramp-up of the LHC computing.

We estimate 1 FTE starting in 2010.

2.2.3.3 WP 3: Training, Workshops and Schools

Participating Partners: All participating Institutes

For the successful exploitation of the Grid structures by scientists from all universities participating in the LHC program, it is essential to provide education and training on access to the Grid and Grid application development. Furthermore, computer centres at universities must be integrated as Tier-3 centres into the Grid, requiring knowledge also in the administration of Grid sites in the WLCG context. The partners of the proposed Alliance will provide training material for seminars and schools and provide practical help.

We propose to include such activities as dedicated sessions in the annual GridKa School on Grid Computing, and, in addition, to offer special workshops and training sessions at interested institutional sites. Funding for PhD students within the Alliance for participation in international Grid schools and workshops (e.g. the GGF International Summer School of Grid Computing and the CERN School of Computing) is also foreseen.

2.2.4 Milestone and Resource Planning

Work Package	Date	Milestone
WP1	10/2007	Tier-2 centres operational with first batch of resources
	10/2007	NAF operational with first batch of resources
	01/2008	Start of High Performance Network
	12/2007	Grid-based mass storage system data service set up
	12/2008	Easy to install dCache
WP2	12/2009	Virtualization of resources: virtual recipes and data monitoring tools availabe
	01/2010	Virtualization of resources: First tools for data access available
	01/2010	Optimization of data access starting
WP3	10/2007	Start of Grid training activities

Based on the procurement of similar computing resources at several large sites in recent years, a detailed cost calculation for hardware and operation of a Tier-2 site has been performed. The following ingredients for the hardware costs (valid in 2007) are used:

- CPU cost of 640 € per kSI2k (CPU benchmark unit)
- Storage cost of 1354 € per TB
- 12% additional costs for infrastructure, such as racks, switches, LAN, etc.

The operational costs for the Tier-2 centres will be provided by local funding resources at the universities. These costs are substantial, at a level similar to the hardware procurement costs. For the cost calculation the following assumptions have been made:

- Power consumption (including cooling): CPU = 62 W/kSI2k, Storage=100 W/TB (Power cost = 0.15 €/kWh)
- Manpower for basic setup and maintenance = 1.5 FTE
- Costs for shared WAN connection to X-WIN = 40 k€
- Infrastructure (Housing) = 20 k€.

Personnel and Infrastructure costs are assumed constant, while for power, networking and hardware a cost reduction of a factor of two is assumed every two years due to expected technological progress. In addition to the operational costs, all Tier-2 sites provide substantial local funding of hardware resources for the start-up phase. For all Tier-2 sites a basic setup of typically 150 kSI2k CPU and 50 TB disk space is provided by the corresponding institute for 2006 and 2007.

The ATLAS and CMS Tier-2 sites, at the mentioned universities, require funding for CPU and storage hardware in the years 2008-2012. This is balanced by own resources of the sites for the initial investments to ensure the start-up and the continuing operational costs.

Furthermore, the Tier-2 sites provide the personnel for setup, maintenance and operation of the facility, which corresponds to 1.5-2 FTE per site.

Financial Representation						
centre/partner: all topic: Grid	2007	2008	2009	2010	2011	2012
	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
Total project costs[1)]	2,568.8	4,358.3	4,237.5	4,058.7	3,912.1	2,086.1
thereof personnel costs	747.1	1,711.0	1,856.0	1,682.0	1,566.0	772.9
thereof financed through institutional funding	1,808.3	2,812.8	2,606.3	2,337.0	2,303.8	1,253.8
thereof financed through third party funding	189.0	319.0	285.0	300.0	240.0	108.0
requested IVF[2)] funding	571.5	1,226.5	1,346.2	1,421.7	1,368.3	724.3

[1)] including general and administrative costs, internal services etc.
[2)] Impuls- und Vernetzungsfonds = Initiative and networking fund

Reconciliation of requested IFV funding into expenses ***(for information only)***	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
costs requested through IVF	571.5	1,226.5	1,346.2	1,421.7	1,368.3	724.3
noncash expenditures (depreciation)	31.7	102.9	191.8	307.3	495.3	308.6
Investments	518.3	888.3	826.7	756.7	575.8	250.0
Expenses	476.3	1,022.1	1,121.8	1,184.8	1,140.3	603.6

Personnel *(for information only)*	FTE	FTE	FTE	FTE	FTE	FTE
Personnel (financed through IVF)						
Scientists	1.25	5.50	7.00	6.50	5.00	2.50
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	0.50	2.00	2.00	2.00	2.00	1.00
Personnel (financed through institutional or third party funding)						
Scientists	9.20	19.00	20.00	17.50	17.00	8.05
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	2.80	4.80	4.80	4.80	4.80	2.80

2.3 Research Topic 3: Detector Developments

Experiments at future colliders require very powerful detectors. Both major future projects, the ILC and the upgrade of the LHC (sLHC), will need significant advances in detector technology. At the ILC, precision detectors will be the focus of the developments, while for sLHC extremely radiation-hard and robust technologies will be needed.

The Alliance will support detector development in several ways. Through establishment of a Virtual Laboratory for Detector Technologies (VLDT), common infrastructures for detector development will be improved, and made available to all partners of the Alliance. This VLDT will form the basis for a new structure for detector development in Germany. Secondly the Alliance will support novel directions and new projects in detector R&D through an intensified network and project support on a limited scale, to help initiate new projects, form new cooperations between partners, and thus act as a seed for the participation of German groups in future particle physics projects.

Together these measures are designed to increase the visibility of German groups in the field of detector developments, ensure a long lasting well-developed infrastructure in Germany for these activities and make the developments available to other fields of research and applications.

2.3.1 Scientific Goals

Modern experiments in Particle Physics rely on unique detectors and detection elements that are the result of many years of R&D. Only in rare cases can these be bought simply “off the shelf”. Detector instrumentation has become an important part of particle physics, within which also many spin-off developments into other branches of science are produced. Typical development times for detector systems easily exceed ten years, with an additional five to eight years for the construction of the eventual detector, and occupy substantial human and technical resources over long periods.

The detectors for the proposed Physics at the Terascale are particularly demanding. They will need to be able to cover the whole range of phenomena expected – from the measurement of lifetimes in the picosecond range to the precise measurement of energies in the hundreds of GeV range.

The ILC will deliver collisions at a high rate, with final states containing many particle, multiple jets and complicated topologies, which have to be precisely reconstructed. For the vertex detector systems, new pixel detector technologies are needed which combine small pixels, high speed and thin detectors. For the tracker the most challenging developments are needed in the realisation of a large volume time projection chamber, which reaches accuracies that are approximately an order of magnitude better than previously achieved. In the calorimeter system new technologies are needed to provide very small cells and a large number of samplings of the energy deposited along the particle track. At the ILC particular emphasis is given to the precision of the reconstruction of the events recorded, while for most components radiation hardness of the components is of less concern.

The currently installed experiments at the LHC will require some additions like the luminosity system. In 2015 an upgrade of the LHC towards higher luminosity, the sLHC is planned, which requires detectors that withstand radiation doses of at least an order of magnitude higher. At the same time an increased collision rate and an increased particle density will require components with higher segmentation as well as readout and trigger systems with higher bandwidth. At the moment the technologies to meet these challenging requirements are not available. The new technologies must be combined with developments to significantly reduce the passive material, compared to the currently installed detectors, as well as to improve the power, cooling and mechanical support systems.

At both the ILC and at the sLHC for all detector systems, cooling, power distribution, mechanical structures etc. need to be designed and developed, such that they do not compromise the anticipated performance. In addition, at the sLHC the reliability of the detector systems becomes increasingly important. Maintenance, especially of the innermost detectors, is close to impossible, requiring that the systems operate reliably for many years.

In the following the broad range of projects in which members of the Alliance are involved is briefly summarised. The role of the Alliance is also to ensure that the activities within the work packages are well coordinated and that the infrastructure provided by the Alliance is optimally used. In both fields, ILC and LHC R&D, additional new projects are in the planning phase and will emerge in the course of the Alliance. It is also a goal of the Alliance to foster such new projects and provide initial funding to bring them into a state where additional third party funding can be requested.

ILC Detector R&D

- **Vertex Detector**

For the silicon vertex detector several competing technologies exist which aim at keeping the amount of material at an absolute minimum. Two very promising, albeit very challenging, technologies are addressed by Alliance partners. The Bonn group develops the DEPFET pixel technology together with Mannheim and MPI München and other international partners. The University of Hamburg and DESY work on monolithic active pixel detectors (MAPS) within an international collaboration. Both technologies have reached a maturity level such that decent size prototype pixel matrices can be operated in test-beams with excellent performance in many aspects. However, both are far from being ready for the construction of a pixel vertex detector. In particular, the high expected hit rate of 80 hits/mm^2/bunch-train at the ILC and the corresponding fast frame readout speed, the ILC radiation levels, and the low mass module design including the thinning of sensors and electronics, impose major challenges.

Research Topics

- **Tracking**

A large Time Projection Chamber (TPC) with Micropattern Gas Detectors (MPGDs) readout is proposed as main tracking detector. Within the Alliance a coordinated effort towards a TPC with Gas Electron Multiplier (GEM) readout will be performed. The Alliance partners DESY, Aachen, Siegen and Rostock in close cooperation with the international LCTPC collaboration intend to pursue the design, construction, and beam-test of an advanced end-plate for a TPC within the EUDET project, equipped with large area GEM based readout. An integral part of these activities will be the development of highly integrated electronics for the readout. Alternatively Bonn and Freiburg are pursuing to the readout of a TPC replacing the pad plane with an integrated pixel readout chip. This will allow for unprecedented granularity of the end-plate, and at the same time promises a further reduction the material in the endplate. Both concepts will profit greatly from the infrastructure provided by the Alliance, as the development will encompass the design, fabrication and test of customised readout chips on a large scale.

- **Calorimeter**

ILC calorimetry will make the step from integrating devices towards high resolution imaging of electromagnetic and hadronic showers. This step is mandatory in order to provide the necessary reconstruction of the full kinematics of electron-positron events. Imaging requires a large number of sensors embedded into the absorbing material and a correspondingly large number of electronic readout channels. As part of the international CALICE collaboration groups from DESY, Heidelberg and Wuppertal participate in the development of a novel concept for a hadronic calorimeter. It is based on a traditional scintillator–steel sampling calorimeter, but read out with novel silicon-based photo detectors (SiPM). Such devices have only very recently become available in larger quantities, and at affordable cost. These devices allow the area of the readout cells to be reduced by one order of magnitude, by embedding the photo sensor into the scintillator.

- **Forward Instrumentation**

While most detectors for the ILC do not suffer from large radiation doses, this is not the case for the devices in the very forward direction. Here backgrounds from beam-beam interactions are too intense for current silicon detectors to survive. Alternative solutions are therefore being investigated. CVD-Diamond detectors are a promising alternative which is pursued by groups at DESY, Freiburg and Dresden. The University of Hamburg will study the ultimate limit of the survival of silicon sensors in the environment of intense electron and photon irradiation.

Closely related to the forward instrumentation are the many aspects of the diagnostics of the beam at the interaction point. Work here focuses on fast, high precision calorimeters to be used as beam monitors, in the measurement of the radiation from the interaction, and in the measurement of other quantities like polarisation. The work for this project will greatly profit from the improved infrastructure available to design and obtain the special purpose readout chips needed to operate these fast calorimeters.

(s)LHC Detector R&D

- **New sensors and sensor materials**

For operation at the sLHC the main challenge for the ATLAS and CMS detectors will be to design and build improved tracking systems. The present pixel and strip detector technologies are inadequate for the sLHC rate and radiation levels and new sensor materials and layouts have to be investigated. Among the options presently discussed are so-called 3D silicon pixel sensors, CVD-diamond as material for pixels, n+ on p sensors grown by the magnetic Czochralski technique, as well as epitaxial silicon. The aim is to provide the necessary input for a decision on the silicon trackers upgrades. This work is embedded in large international collaborations. It includes the exploration of new materials, e.g. CVD diamond, to develop within existing materials new more radiation hard sensor concepts (e.g.

3D sensors) and to pursue defect engineering, to better understand and control the radiation hardness properties of materials.

The tools developed in WP1.2 will be used to optimize the sensor design for given material properties and predict their long-term performance for given irradiation and temperature scenarios.

- **Detector readout chips (pixels and strips)**

For the sLHC a new generation of readout chips using new CMOS technologies (130 nm or even 90 nm) have to be developed. The Bonn group intends to continue to contribute to the development of the next generation of pixel readout chips. While these deep-submicron technologies are believed to be intrinsically radiation hard due to their small feature size and correspondingly thin gate oxides, issues at sLHC to be newly addressed are single event upset (SEU) tolerance, transistor gate punch-through by heavy particles, as well as triggering. The latter is a formidable challenge.

- **Modules and Powering**

Modules are the units out of which the detectors are assembled. They contain the sensors, the chips as well as interface functionality. The major challenges for module development are the simultaneous requirements of low material budget, minimum power and robustness. This includes thin sensors and readout chips as well as mechanical issues. If bump-bonding is involved for pixel detectors, thinned readout chips with many tiny bumps are non-trivial. A research will be carried out together with industry.

In order to reduce the amount of material and cabling, while ensuring a stable and ripple free DC power, new concepts, such as serial powering and DC-DC conversion are presently being studied. In both cases, this electronics functionality has to be developed at the chip level. For serial powering shunt and linear regulators with a homogeneous distribution of their characteristics have to be devised. For DC-DC converters appropriate circuits with little ripple and low power at the chip level are necessary.

- **Level-1 Trigger Development**

The upgraded sLHC will challenge the development of first level trigger systems, which will have to cope with increased event rates and at the same time adapt to the new requirements that will most likely emerge from the analysis of the first LHC data taking period. The development will require very advanced mixed-signal VLSI design combined with a high degree of configurability in the digital parts (FPGAs) and compactness to arrive at economically feasible solutions.

2.3.2 Existing competencies and infrastructures

The partners of the proposed Helmholtz Alliance can look back on a long history of major contributions to detector development and construction. DESY has been a centre for the construction of the detectors for the DESY synchrotron, the DORIS and PETRA storage rings, and later for the HERA electron-proton collider. German universities have contributed to most major experiments in particle physics at laboratories worldwide, in particular to all four detectors ALEPH, DELPHI, L3, and OPAL at LEP and to the H1 and ZEUS detectors at HERA. Most partners have contributed to the construction of the LHC detectors. Over the last years DESY together with German universities has played a major role in the development work for a detector at the ILC.

The major contributions to the construction of ATLAS and CMS were the following. German groups have contributed to the development of radiation tolerant silicon crystals and to the development and construction of the central trackers for both ATLAS and CMS. They have played a central role in the development and the design of the pixel tracker for ATLAS, and developed and built a significant part of the silicon tracking detector for CMS. Sizeable contributions have been made to the alignment systems needed for these detectors by several universities. Alliance partners contributed to the construction of the ATLAS Liquid-

Argon calorimeter and the construction of the CMS and ATLAS muon systems. Custom-made fast mixed-signal trigger systems have been designed and built by German groups in the ATLAS experiment. DESY, which recently joined the LHC experiments, has taken on core responsibilities in the high level trigger and data acquisition system for ATLAS and CMS.

For R&D towards a detector at the ILC, DESY and several of the Alliance partners have made major contributions to key detector components: vertex detector, charged particle tracking, calorimetry and forward instrumentation. Partners of the Alliance are involved in the development of a new technology for a pixel-based silicon vertex detector for the ILC. Bonn together with the MPI München are leading the development of the DEPFET technology for detector applications. DESY and University of Hamburg contribute to the development and characterisation of pixel detectors based on the MAPS (Monolithic Active Pixels Sensors) technology. For charged particle tracking at the ILC, R&D towards a large volume Time Projection Chamber (TPC) is pursued. During the last years, DESY together with German groups have been involved in the development of a high performance TPC for the ILC. The calorimeter system is a particular challenge at the ILC, since it has to be able to reconstruct charged and neutral particles individually even in the core of a jet. The DESY group has been leading the development of a granular scintillator calorimeter, read out with novel photon detectors based on silicon sensors.

Over the years substantial infrastructures have been built up at DESY and at the universities. DESY is providing to the community electron test-beams, together with the infrastructure to operate prototype detectors in the beams. Engineering facilities, large-scale construction and assembly facilities are also available to the community. Technical groups support the design and construction of detectors in the area of detector electronics, mechanics, and assembly.

Triggered primarily by demands for the LHC detector construction, silicon detector and chip development and testing facilities have been built up at several places. Bonn has become a leading centre for the development of pixel detectors and associated electronics. Heidelberg, in cooperation with the MPI for Nuclear Physics Heidelberg, has developed considerable expertise in the area of analogue, digital and mixed-signal ASIC and system development. The universities of Hamburg and Karlsruhe have set up labs for the study of radiation damage, sensor characterisation and module production.

In 2006 an initiative co-funded by the European Commission (EUDET) has started which will invest into the further development of the detector development infrastructure in Europe. The German community will profit from a significant upgrade of the DESY test beam facilities, which will be equipped with a modern superconducting large bore magnet, a high-precision thin silicon pixel telescope, and an upgraded DAQ and control system.

2.3.3 Workpackages and Expected Results

The two major projects, sLHC and ILC lay out a program of detector development which will easily span the next decade. The goal of this part of the Alliance is to enable German groups to play a significant role for these and possibly other future projects. Many groups are working already on some projects within the topics covered by the Alliance.

The activities are organised in two workpackages:

- WP 1: A Virtual Laboratory for Detector Technology (VDLT)
- WP 2: A focussed research programme on advanced detector developments

2.3.3.1 WP1: The Virtual Laboratory for Detector Technologies

A central part of the Alliance is the formation of a Virtual Laboratory for Detector Technologies (VLDT). It will form the backbone of a network which will ensure a visible, efficient and long-lasting contribution of German groups to the future projects ILC and sLHC. The VLDT will develop, provide and maintain infrastructures, and make them available to the Alliance. It will have three branches, electronics system development, sensor development and general detector test facilities. The central nodes of the VLDT will be DESY, Bonn and

Heidelberg, where also major upgrades of the infrastructure will be realised. Additional infrastructure will be made available to the Alliance by the universities Aachen, Dortmund, Freiburg, Hamburg and Karlsruhe. Other institutes are encouraged to contribute infrastructure as well. All Alliance partners involved in detector development, design and construction will profit from the VLDT.

2.3.3.1.1 WP1.1: Electronics System Development

Modern experiments increasingly depend on highly complex electronics systems for signal processing, readout, triggering and control. Such systems depend on the availability of custom designed VLSI chips, configurable logic, advanced mounting and packaging technologies as well as massive software and firmware support to fulfil the demanding requirements physics puts on the detectors. Developments needed go far beyond the sole design and construction of electronics hardware. They also include overall system aspects, large-scale testing and system simulations at all levels. The VLDT will provide infrastructure for electronics system development at two main locations, Bonn and Heidelberg, with further installations at Hamburg, Karlsruhe and DESY.

Bonn has built up a significant infrastructure for silicon detector and ASIC electronics development. The installation at the moment consists of a 300 m^2 laboratory area with clean-room facility, technical infrastructure and personnel. The laboratory specialises in the development of semiconductor pixel detectors for particle tracking as well as for biomedical imaging. The capability exists for the development of custom-designed ASIC chips in modern CMOS technologies (250 nm and 130 nm) as well as dedicated pixel module and system developments. The laboratory is equipped with modern chip and detector development infrastructure, which include two fully automatic wire bonders, three wafer probe stations, and facilities for laser and X-ray based sensor tests.

The Department of Physics at Heidelberg has been operating the “Heidelberg ASIC Laboratory for Microelectronics” jointly with the local Max-Planck-Institute (MPI-K) since 1996. The laboratory has designed and built more than 100 digital, analogue and mixed-signal VLSI chips for R+D projects and for applications in major particle and nuclear physics experiments. It is currently supported by two full-time engineers and has typically 15-20 users at any given time. The laboratory is located in the new Kirchhoff-Institut für Physik (KIP) which houses a clean-room with automatic wire-bonding and wafer test equipment as well as a class 100 clean-room for wafer processing and lithography. Particular emphasis it is put on the ability to integrate VLSI chips into complete electronic signal processing systems. For that purpose the laboratory provides placing, soldering and micro-inspection tools for multi-chip modules, fine grid BGA packages and SMD components. A full suite of design and simulation software is available to develop and simulate electronic circuits from the physics of individual components to the system level.

The competencies and equipment of the two groups are to a large degree complementary. Together they cover most areas of electronics design required for the next generation of experiments at the Terascale.

The work of the electronics system development facility will be supported by Alliance funds through the provision of additional person power, and funds to upgrade the facilities. It is planned to add seven full time staff members, four at Bonn and two at Heidelberg and one at DESY, who will provide support for Alliance members. In order to make this a sustainable effort these positions need to be permanent, and continue beyond the anticipated duration of the Alliance. At the moment university positions are reserved at the different locations to offer tenure to most of the new staff. At Bonn four completely equipped work places will be made available to member of the Alliance, together with investments for necessary software tools and laboratory equipment. At Heidelberg places for three users will be installed together with a full suite of software tools to support up to six additional users and additional laboratory equipment.

In addition to supporting staff at the different sites of the VLDT, the Alliance will support members from partner institutions for short and longer visits at the sites. In this way a transfer of knowledge in addition to the utilisation of the central facilities will be made possible. It is encouraged that scientists trained at the central facilities take their knowledge home to continue work. Emphasis is placed on the training of young researchers, students and postdocs, in these high technology areas. Through the backbone activities the Alliance has reserved funds to enable these activities.

2.3.3.1.2 WP1.2: Sensors: Materials, Design and Characterisation

As pointed out before, an important part of the development of novel detector systems is the development of radiation hard sensor materials, and the simulation and characterisation of sensors. These studies are also of high relevance to experiments at other facilities, outside the immediate scope of the Alliance, e.g. the X-FEL facility in DESY. At Hamburg and Karlsruhe unique expertise and infrastructure for the study and the improvement of the radiation tolerance of silicon detectors has been built up, which will be made available to the VLDT. In addition close contacts to and collaborations with irradiation facilities at reactors and accelerators, institutes working on radiation damage of solids, as well as solid-state groups for characterising the initial silicon sensors have been established.

Various techniques are available at Hamburg and Karlsruhe for diode and for defect characterisation in the temperature range 4-300 K. The facilities include probe stations, measurement microscopes, temperature controlled boxes, closed cycle cryostats, etc., as well access to wafer cutting and bonding. In addition test stands for measurements with radioactive sources as well as visible and IR-photons have been set up. There are close connections to the neutron irradiation facility in Karlsruhe. An important asset is the expertise in post irradiation thermal treatment, which allows the defect kinetics to be studied as well as predictions of the long-term behaviour of the sensors in experiments to be made. The techniques available in the laboratories allow the macroscopic damage, of main interest for the users, to be related to the microscopic damage which is required to understand the physics of radiation damage and to improve the radiation tolerance by defect engineering and optimised detector design.

One scientist will be added to the existing laboratory in Hamburg to help members from other Alliance institutes with their projects of sensor characterisation and radiation damage. Some funds will be available to contribute to the continuous upgrade of the laboratory. The main anticipated upgrade projects are a multi-channel TCT and an extension of the capability to handle 6” double sided wafers. One technical support person will be added to the staff at Karlsruhe, who will support Alliance members in their work at the facility.

At Dortmund the DEBE facility has been built up to study the surface damage of sensors under intense electromagnetic radiation. This facility will be opened to members of the Alliance, together with supporting infrastructure. The Alliance will support this activity through person power to maintain the equipment and to support external users in the utilisation of the DEBE facility.

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

Detector development requires a broad spectrum of support facilities in many technical areas. During the development of novel detector technologies frequent tests of prototypes with particle beams of well known properties are crucial. The existing DESY facilities will be further developed for the Alliance by strengthening the available resources with dedicated engineering staff available to members of the Alliance.

DESY operates three electron test-beams with energies up to 6 GeV. One of these beams hosts the EUDET test-beam infrastructure, from which the Alliance will greatly profit. This infrastructure consists of a superconducting magnet, which can provide fields up to 1.2 Tesla, in a volume of approximately 0.5 m^3. The magnet is mounted transverse to the beam, and can be moved in both the horizontal and the vertical directions. The EUDET facility provides a TPC test setup, and a flexible framework for tests with calorimetric readout systems. A high precision silicon pixel telescope will be installed in the beam and is available for tests of small detector components, and as an auxiliary tracker for the TPC setup. A second silicon telescope is available for use in a parallel beam-line. Alliance funds will be used to improve the support for external groups, by supporting a dedicated beam-line physicist.

The development of large scale detector systems for the ILC and the sLHC requires a significant amount of integration work, to ensure a coherent system even though it is built by many partners. DESY can look back upon significant experience in this area from the construction, installation and operation of the HERA detectors. This experience in the form of engineering staff will be made available to the Alliance members, and coordinated through the VLDT.

At the ELSA storage ring in Bonn, a 3.5 GeV electron test-beam is available. It will be equipped with a silicon strip detector telescope, and provide additional test-beam resources to partners of the Alliance.

Detector development requires many additional components, which are essential for a successful program. The Alliance will strive to provide as many of such components as possible to its members, to make it simpler for individual groups to start new programs and participate in the different activities. A core activity of German groups in detector developments is the investigation of gaseous tracking detectors. RWTH Aachen will develop and contribute to the Alliance a mobile gas supply unit, which mixes and monitors gases for detector tests e.g. at test beams or in laboratories.

Developing modern detectors requires not only advanced construction techniques, but also state-of-the art measurement technology. At Freiburg a large coordinate measurement stand is available, which can be used on objects as large as 6.5x1.5x1.5 m^3. This facility, coordinated through the VLDT, will be made available to members of the Alliance. Table 3 shows examples of projects of the Alliance members and for the envisaged use of the VLDT.

2.3.3.2 WP2: Detector R&D Projects

For the next decade detector development projects will focus on the upgrade of the LHC and the ILC. The Alliance will support new activities in this area through well focussed, but limited R&D projects. These projects are designed to allow groups to enter into these emerging fields, establish themselves in the international context, and gain first experience. The funding should serve to finance initial studies necessary to make an application for further third party funds outside the Alliance which can then extend and firmly establish the programmes. These five projects are described below. In addition a limited pool of resources is foreseen to support selected novel projects during the duration of the Alliance.

2.3.3.2.1 WP2.1: Tracking Detectors for the ILC

European groups play an important role in the development of a novel time projection chamber for the ILC. The Alliance will broaden the support for this program by funding the participation of four universities in this program. The groups in Aachen, Mainz, Siegen and Rostock, together with DESY, will make a coordinated effort to maintain and enhance a visible contribution of the German groups to this programme. The Alliance will fund projects which should enable the groups to bid eventually for the construction of an endplate including readout modules for the TPC prototype, which is currently planned to be built in the years 2010 and beyond. The development of these modules involves advanced mechanical design, to develop light-weight support structures, electrical design, to ensure proper electrical properties of the module, and an excellent understanding of the properties of a GEM based amplification system. The development of the readout electronics will involve the development and design of a novel analogue amplifier and the development of a digital signal processing chip, to process the signals from the TPC, and to reduce the data volume.

Research Topics

Table 3: Examples of projects and envisaged use of the VLDT infrastructure by Alliance partners.

		Relevant VDLT infrastructure		
Institute	R&D Topic	WP 1.1	WP 1.2	WP 1.3
DESY	ILC TPC development	X		X
	ILC TPC readout electronics	X		
	ILC HCAL SiPM readout	X		X
	ILC HCAL engineering prototype			X
	ILC polarimeter	X		X
Aachen	ILC TPC studies	X		X
	sLHC Silicon detectors	X	X	
	sLHC tracker system R&D	X	X	X
	ILC vertex detector R&D			X
Bonn	ILC TPC readout electronics	X		X
	(s)LHC/ILC gaseous pixel detector	X		X
	sLHC pixel detector	X	X	X
	ILC DEPFET pixel detector	X		X
Dortmund	Radiation.hard pixel sensors		X	
Dresden	ILC forward detetector electronics	X		
Freiburg	sLHC tracker upgrade, Si sensors	X	X	X
	sLHC electronics	X	X	
	Gaseous detectors for future collider expts.	X		X
Giessen	LHC forward detectors		X	X
Göttingen	ATLAS pixel upgrade	X		X
	ILC pixel detector	X		X
Hamburg	New sensors/sensor materials		X	X
Karlsruhe	sLHC/ILC silicon strips and pixels	X	X	X
Mainz	ATLAS electronics for trigger upgrade	X		
	ILC electronics GEM TPC	X		X
München	sLHC muon chambers	X		X
Rostock	ILC TPC development	X		X
Siegen	ILC tracking detectors	X		X
Wuppertal	ATLAS DCS chip for an pixel upgrade	X		
	Pixel support structures			X
	ILC hadronic tile calorimeter	X		X

The Alliance will contribute to funding of the following tasks:

- Development of a GEM readout module for the LC-TPC prototype: Aachen, Siegen with DESY: The group at Aachen will investigate the feasibility of including a gating scheme in such a module. Siegen, in close collaboration with DESY will develop a mechanical model for such a readout module, and prototype this.
- Development of readout electronics for a GEM based TPC: Mainz, Rostock with DESY: Standard readout electronics for a TPC is based on fast digitisers. Rostock wants to develop a TDC based readout, which promises higher packing densities, combined with lower power consumption. The processing of the signals from the endplate has to be done very close to the frontend, to reduce the data volume. The group at Mainz wants to develop a digital signal processor for this task.

Both activities will heavily use the infrastructures in particular at Bonn, Heidelberg and DESY, to support the development work.

2.3.3.2.2 WP2.2: Calorimetry at the ILC

The hadronic calorimetry is one of the main challenges faced by a detector at the ILC. To broaden the participation of German groups in this effort, groups in Heidelberg, Wuppertal and DESY will increase their participation in the R&D towards the demonstration of the feasibility of a large scale hadronic tile-calorimeter directly read out with silicon photo-detectors. It is planned to extend the ongoing work in this area to sensors working in a different frequency regime to significantly simplify the scintillator-tile silicon photo-multiplier system. A major part of the project will be the demonstration that such a system can be calibrated and controlled at an adequate level. The work will be done in close cooperation with industry and partner institutions in particular in Russia. The partners will again profit significantly from the infrastructures available from the VLDT, to contribute to the development of silicon photo-multipliers, SiPM, and its associated readout electronics.

In addition to the hadronic calorimeter significant challenges exist in the instrumentation of the very forward calorimeters at the ILC. Here radiation hardness and speed are of utmost importance. Novel calorimeter techniques rather different from the ones used in the main part of the calorimeter are needed. Dresden together with DESY plans to investigate the feasibility of semi-conductor technologies for a calorimeter in this region and develop fast readout electronics. The work will include the investigation of novel detector materials like special silicon crystals or diamond.

In detail the following tasks will be covered by R&D projects funded by the Alliance:

- Development of novel calibration algorithms for a SiPM based hadronic calorimeter: Wuppertal and DESY
- Development of radiation hard and high speed calorimeter technologies for the forward direction at the ILC.

2.3.3.2.3 WP2.3: Trigger Developments for the sLHC

The groups in Heidelberg and Mainz have in the past played a major role in designing and building the ATLAS level-1 calorimeter trigger. With the likely upgrade of the LHC to higher luminosities the trigger front-end and pattern recognition concepts will have to be revised to cope with higher rates and to adapt to new insights from the first years of LHC physics. The Heidelberg and Mainz groups propose a new concept for a fast and highly compact mixed-signal front end device for the recognition of physics objects, which is very flexible and configurable. The work towards a detailed technical design will be carried out together with the international project partners in ATLAS. The work will involve mixed-signal VLSI design and the use of latest technology for configurable logic devices (FPGAs) to develop prototypes of a system design. The work proposed will profit heavily from the improved infrastructure provided by the Alliance.

2.3.3.2.4 WP2.4: Radiation hard silicon sensors for the sLHC

The upgraded LHC will need significantly upgraded tracking detectors. Even the present pixel detectors will require a partial exchange after a few years of running at the LHC. The approach is to improve both the intrinsic radiation hardness of the material and to make the sensor design more radiation tolerant. Hamburg will pursue p-doped and epitaxial silicon, as well as the optimization of the design for radiation hardness. Karlsruhe will contribute by carrying out proton and neutron irradiation and subsequent sensor characterisation.

These results will be used by Hamburg and Karlsruhe in collaboration with the Paul Scherrer Institut (CH) to develop a prototype pixel detector (sensor and hybrid readout) for precision tracking for fluences in excess of 10^{16} 1 MeV equivalent $n \cdot cm^{-2}$. The work will be pursued within the framework of the CMS collaboration, but will profit from the collaboration and infrastructures of the Alliance. In addition, Karlsruhe will build and characterize prototype silicon strip modules made with the magnetic Czochralski method.

2.3.3.2.5 WP2.5: Luminosity and Forward Detectors for LHC

Giessen is working as part of the ATLAS collaboration on the determination of the pp-Luminosity using elastic scattering measured with the Roman Pot ALFA detector system in the forward region. The technical feasibility and experimental method have been recently demonstrated in a Technical Design Report. The expertise gained in Giessen from previous projects on scintillating fibre detectors will be deployed for the construction of a tracking detector instrumenting the Roman Pots for the luminosity measurement. The program to be achieved within the funding period covers the production of the detector, its operation and the data analysis to calibrate the absolute luminosity. It also includes the option of exploring new detectors in the very forward region. DESY is presently considering to join the efforts. The work proposed will benefit from the infrastructure provided by the Alliance, in particular the design and test facilities.

2.3.4 Milestones

Work Package	Date	Milestone
WP1	01/2008	First 50% of additional positions for the VLDT filled
	01/2008	First round of new infrastructures acquired
	01/2009	All positions for VLDT filled and VLDT fully operational
WP2	07/2009	End of first phase of the five new R&D projects, ready to apply for third party funding

2.3.5 Resource Planning

Financial Representation centre/partner: all topic: Detector	2007	2008	2009	2010	2011	2012
	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
Total project costs[1)]	2,087.8	5,046.9	5,207.8	4,353.5	4,284.8	2,249.7
thereof personnel costs	1,503.3	3,461.0	3,752.0	3,421.0	3,421.0	1,817.8
thereof financed through institutional funding	1,530.3	3,195.7	3,215.7	3,179.7	3,101.0	1,623.8
thereof financed through third party funding	25.0	46.0	44.0	44.0	44.0	22.0
requested IVF[2)] **funding**	532.5	1,805.3	1,948.2	1,129.8	1,139.8	603.9

[1)] including general and administrative costs, internal services etc.
[2)] Impuls- und Vernetzungsfonds = Initiative and networking fund

Reconciliation of requested IFV funding into expenses ***(for information only)***	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
costs requested through IVF	532.5	1,805.3	1,948.2	1,129.8	1,139.8	603.9
noncash expenditures (depreciation)	5.8	21.9	52.6	98.2	131.5	69.9
Investments	218.3	753.3	354.2	303.3	145.0	55.8
Expenses	443.8	1,504.4	1,623.5	941.5	949.9	503.3

Personnel ***(for information only)***	FTE	FTE	FTE	FTE	FTE	FTE
Personnel (financed through IVF)						
Scientists	1.75	8.50	10.50	6.00	6.00	3.00
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	2.75	7.50	10.50	9.00	9.00	5.00
Personnel (financed through institutional or third party funding)						
Scientists	11.00	22.30	22.30	22.80	22.80	11.75
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	13.60	28.20	28.45	27.70	27.70	15.30

2.4 Research Topic 4: High Energy Accelerator Physics

2.4.1 Scientific case for the Research Topic

The tools of physics at the Terascale are powerful accelerators and sophisticated experiments. The experimental progress of the field is vastly determined by the availability of accelerators that provide the necessary centre of mass energy and luminosity. With lead times for construction of new facilities of the order of a decade it is important that the technological limits are pushed to the extreme. The Alliance will address some of these topics, include them into accelerator physics training at German universities and expand this branch of science in general. This is mandatory in order to keep Germany at the forefront of accelerator development without which progress in many areas of science would not be possible.

The technology of electron storage rings becomes prohibitive at energies exceeding that of LEP II. The synchrotron radiation losses cannot be substituted by the available RF-power. Since a long time it has been realised that very high-energy electron colliders are to be built as linear accelerators where the beams are extremely well focussed to provide the necessary interaction rate. After the collision the beams are so disrupted that their energy cannot easily be recovered and they are disposed of in appropriate beam dumps.

The accelerating technology for the International Linear Collider (ILC) has been chosen in an international selection process (ITRP 2004) after the TESLA collaboration had demonstrated accelerator gradients exceeding 35 MV/m for 1.3 GHz cavities and at the same reduced the cost by a factor of five. The ILC will require some 16,000 cavitites at the highest gradient to reach energies of 250 GeV and more per beam in a cost effective way. This is a focus of the R&D programme for the ILC to which the Alliance will contribute.

Key to the success of a linear collider is the achievement of ultra-low emittance. With the main linac providing no cooling ultimately the dimensions of the beams at the collision point are determined by the cooling provided in the damping ring.

2.4.1.1 Most important goals of the planned work

2.4.1.1.1 Advancing Accelerator Science in the Curricula of German Universities

With the recent improvements and specializations of accelerators and their applications in basic science, medicine, biology and material science the demand for experienced accelerator scientists has seen a tremendous surge. The German academic system has not yet reacted sufficiently to counteract this shortage. The primary goal of the Alliance will be the building (or rebuilding) of accelerator science at German universities. To this end lectures and courses will be offered at universities and support will be given to carry out Diploma and PhD theses at the respective experimental facilities. Special summer student courses are foreseen.

2.4.1.1.2 Research in high gradient superconducting RF cavities

The ILC will be built using superconducting cavities of the same type as will be used for the XFEL at DESY. The operation point envisaged for the ILC is a gradient of 35 MV/m, some 10 MV/m higher than the planned gradient for the XFEL. Such cavities have been produced in small quantities; however, the production process is not yet sufficiently understood to guarantee high yield at high gradient and favourable cost. This research intends to address some of the critical points in a dedicated research programme interwoven with the activities on cavities for the XFEL.

Wuppertal is collaborating with DESY for a long time to reduce parasitic field emission from metal surfaces, in particular niobium and copper. The gradients required by high energy accelerators are often limited by field emitters. The understanding of the nature of these emitters and their reduction by improved surface preparation methods is an important goal in the optimisation of the ILC cavities.

For efficient operation of cavities several control mechanisms have to be implemented. Examples for the engagement of the University of Hamburg are the dynamic compensation of Lorentz-force detuning and an adaptive digital feed-forward system including a digital finite state machine for the entire radio frequency system.

2.4.1.1.3 Optimisation of electron and positron sources

Novel sources for both electrons and positrons will be needed to meet the quality and intensity demands of the ILC.

The electron source, pioneered at the SLC in Stanford (USA), will be based on a photo-induced polarised gun. In principle, these guns yield an excellent time structure suitable for the ILC, possibly a very low emittance and highly polarised electrons. The Alliance will address specific topics: the choice of cathode material to increase the longevity of the cathode in the high flux environment. The emittance of the source can possibly be reduced when a pulsed gun is driven by photo-enhanced field emission, which produces a forward directed beam.

The positron source is based on a thin target driven by a polarised photons from a ~150 m long helical undulator. To meet the intensity demands of the ILC the undulator has to be driven by a 150 GeV beam for which the electron beam of the ILC will be used. Yield optimisation studies for the positron source are proceeding on a worldwide scale. In the past DESY has engaged in understanding the positron collection behind the target and in the understanding of the polarisation transfer to the positrons.

2.4.1.1.4 Beam dynamics, diagnostics and controls

The ILC demands a complete assessment of the beam dynamics in order to optimise production and transport of the low emittance beam. After initial optical alignment it will be necessary to employ beam based alignment techniques to achieve the required beam dimensions at the interaction point.

Understanding the damping beam physics is crucial to reach the demanding emittance requirements. For the present layout of the machine the damping ring has to achieve the required emittance within the 200 ms inter-train interval. Some of the most critical effects are related to electron cloud and fast ion effects both of which may have a detrimental effect on the beam once ultra low dimensions have been achieved. Currently DESY is engaged in simulation studies for the damping ring programme of the ILC and profits from the experience gained in other high performance storage rings. DESY is collaborating with KEK in Japan to participate in the experimental study of fast ion effects. The goal of the programme is to benchmark simulation codes against experimental results in order to reliably predict the behaviour of the ILC damping ring. The facilities at Bonn (ELSA) and possibly DESY (HERA) may help to corroborate the theoretical assessments with experimental data. For that matter Bonn will install a multi-bunch feedback system in their ring.

Elaborate beam diagnostics is key to achieving collisions of the tiny bunches at the ILC. The beams in the ILC will be monitored by many cavity-type beam position monitors, stripline monitors and laserwires. Laserwires are novel nearly non-invasive instruments which measure beam parameters by analysing scattered photons from a laser beam brought into collision with the particle beam. Such laserwire experiments have been carried out in several high-performance beam lines and constitute an active field of research. They are also foreseen for the PETRA III electron beam for photon science. DESY has taken up the laserwire research together with the John-Adams Institute (UK). They jointly operate a laser at the existing PETRA beam line and optimize its performance.

Using the infrastructure of the Compton-polarimeter, which will be set up this year at the ELSA accelerator, Bonn will be able to demonstrate the measurement of the transverse phase space distribution and beam polarization. They will employ the very same set-up which is based on the detection of Compton backscattered laser photons with a position-sensitive counting silicon microstrip detector.

The main goal of this part of the programme will consist in turning the laserwire measurements into a routine measuring device for beam diagnostics.

2.4.2 Existing competencies and infrastructure

2.4.2.1 DESY

For many decades DESY has been operating a host of accelerators at its site: electron and proton linacs, synchrotrons and storage rings. The 7.5 GeV DESY synchrotron serves as an injector for the DORIS storage ring (light source), for HERA via PETRA and in the future for the PETRA III light source. More recently DESY has built the first FEL operating in the few hundred Angstrom region, FLASH, using the superconducting RF technology developed in the context of the TESLA collaboration. The same concept will be carried over to the XFEL, a 3.5 km FEL, which allows for high brilliance experiments in the X-ray regime. The mission of DESY in the German research landscape is to develop and operate accelerators that cannot be realised within the context of e.g. universities and to provide access to these facilities.

Looking more specifically at the recent developments in accelerators on the DESY site one recognizes several modifications and extensions of the complex that are of relevance for this proposal:

- In the course of 2007 DESY will introduce a further superconducting RF accelerating module into the FLASH facility such as to increase the energy of the FEL. A further increase in energy (still shorter wavelength) can be achieved by installing higher gradient cavities. The development of such cavities is of considerable interest for the ILC.
- The construction of the XFEL necessitates some thousand cavities that have to be built. The principle has been developed at DESY; these cavities are used at the FLASH facility. Over the next few years DESY will gain considerable understanding of the production process in order to attain high gradients reliably. The Alliance will develop a scheme to extend the gradients to the ones required by the ILC.

The main assets at DESY in the field of accelerator developments are its large infrastructure and the availability of experts in virtually all branches of accelerator physics and technology. One of the main motivations for the Alliance consists in fostering the access to these resources such as to enable the education of skilled accelerator experts.

2.4.2.2 Bonn

The University of Bonn commands a respectable set of accelerators within the premises of the university. There are two S-band linacs: LINAC I (20 MeV) will be equipped with a thermionic gun, a subharmonic prebuncher and travelling wave buncher (SBTF) which allows single pulse generation. LINAC II (25 MeV) can be operated with polarized electrons. A 1.6 GeV 50 Hz booster synchrotron (AG combined function) and a FODO storage ring with fast ramping capability (6.5 GeV/s) are available for experiments.

Bonn is operating a polarized electron source which features a 50 kV-gun operated in the space charge limit with adjustable perveance. The gun is driven by pulsed or cw Ti:Sapphire laser which is typically operated with 100 mA/1 µs at a repetition rate of 50 Hz. The polarisation of 80% is achieved in a strained layer super lattice. The existing load-lock will be extended to allow for rapid testing of crystals such as fast loading from atmosphere, heat cleaning at up to 600°C and activation by caesium and oxygen under high voltage. The Bonn group has been developing high intensity sources for more than 15 years. They will thus be able in advancing the optimisation of the source and participate in characterising the cathode material. A Compton polarimeter will be installed in the interaction region of the ELSA storage/stretcher ring and will be equipped with position sensitive detectors to allow for accurate polarisation measurements.

Accelerator lectures form an integral part of the Bonn curriculum and are complemented by seminars. Diploma and PhD theses in accelerator physics concentrate on developments at ELSA. Typical software tools for accelerator developments are available in house.

The major accelerator competencies in Bonn comprise electron sources, polarized beams in circular machines, treatment of closed orbit distortions in a fast ramping storage ring and slow extraction on the third harmonic. The simulation tool activities concentrate on accelerator optics and RF cavities and include particle tracking.

2.4.2.3 Hamburg

The Accelerator Physics group of the Institute for Experimental Physics at Hamburg works on scientific issues relevant for the design and operation of accelerators at DESY in Hamburg and Zeuthen. The work is done in close contact with the DESY accelerator division and is integrated in several international collaborations. Both institutes have considerably profited from these close ties. In the past, the development of the superconducting magnets for HERA and the improvement of the TESLA cavities to the level of performance that is currently experienced at FLASH constitute indispensable contributions to the success of the accelerator programme at DESY.

Recent work of the group includes:

- High accelerating gradients and low level control in superconducting cavities;
- Beam induced oscillations in superconducting resonators;
- Experimental determination of charge distribution (transverse and longitudinal) of low emittance, high density electron bunches;
- Measurement of wakefields due to surface roughness in tight vacuum pipes and development of beam collimation systems;
- Electro-optical sampling of ultra-short electron bunches and synchronization on the scale of fs over distances exceeding 100 m;
- Electron beam dynamics in presence of coherent synchrotron radiation generated in bunch compressor systems.

The group has several years of experience in the field of bunch lengths measurement of very short electron bunches, including phase space tomography techniques. Together with the pioneering expertise in numerical simulation of electron beam dynamics this will serve to explore the electron beam parameters for the ILC.

The group is strongly involved in the design and operation of FLASH, the former TESLA Test Facility, and in the future XFEL laboratory. Concerning instrumentation of beam lines the University of Hamburg has played a key role in fast timing methods which are relevant for FELs and for the ILC.

The available infrastructure naturally coincides with the infrastructure available at DESY. It is complemented by a number of hardware components for advanced electron beam diagnostics like a laser system for electro-optical sampling and an infrared-undulator for bunch length diagnostics. The offices and laboratories of the physics department engaged in accelerator science and technology are situated at the DESY site and many offices are shared between DESY and university people. This close contact serves in an optimum way another important asset that the university adds to the DESY infrastructure, namely the education of students in the field of accelerator science.

2.4.2.4 Wuppertal

At the University of Wuppertal the long-term expertise in accelerator physics is focusing on the development of superconducting cavities with high field gradients and Q-values for long-pulse or cw operation. In the past significant contributions have been made to the high gradient programme of TESLA at DESY. Currently the improvement of niobium properties is pursued by means of advanced surface analysis techniques, which help to understand and avoid field limiting defects.

The main test vehicle is a unique UHV DC field emission scanning microscope (FESM) with integrated SEM and Auger electron spectroscopy for local emitter analysis as well as ion gun and high temperature furnace for emitter treatments. Metallic samples up to 28 mm diameter prepared with relevant cleaning techniques (e.g. at FLASH) can be scanned up to surface fields of 250 MV/m without destruction of the emitters which are then locally studied by Fowler-Nordheim and surface analysis.

The nature of the remaining emitters found on high quality Nb samples can be further investigated by means of two commercial instruments locally available. A high resolution (nm) ex-situ SEM with EDX (Philips XL30) images the morphology and reveals the composition of the emitters. An optical profilometer with AFM (FRT Microprof) measures the surface roughness and particulate contamination down to the nm scale. Both instruments provide guidance for the optimization of surface preparation techniques.

Various thin-film deposition techniques (e-beam and thermal evaporation, DC and RF sputtering, etc.) with appropriate quality control instrumentation are available to develop new cathode materials for high brightness electron sources based on photo-enhanced field emission. Their electronic band structure will be measured by an existing X-ray and UV photo-electron spectroscope (VG XPS/UPS) and correlated to the FESM results under Laser illumination.

Condensed matter physics is one of the three major research areas in physics at Wuppertal. Regular lectures on solid state and surface physics are given for Bachelor and Master students, as well as specialized lectures and seminars on X-ray physics, nanoelectronics and thin film applications for Master and PhD students.

2.4.2.5 Aachen

RWTH Aachen is applying for installation of an ion-therapy centre, using protons, carbon and heavier ion species, for the medical department. Depending on the outcome of the approval procedure for the ion-therapy centre the Alliance plans to foster the instalment of a professorship covering high-energy accelerators physics topic in Aachen. It will be advanced and further developed by the physics department with participation from the technical division.

While this machine does not address the physics questions relevant to the Terascale it does assume a key role in promoting the education of prospective accelerator scientists. A machine that has to be developed from grounds-up poses challenges that are hard to be paralleled by any existing and operating machine. The question of technology, e.g. cyclotron or synchrotron, the treatment of non-relativistic beams, the design of an ion source and the layout of a machine complex suitable for medical treatment are all challenges that are all highly educational for new students entering the field.

2.4.3 Work packages and expected results

2.4.3.1 WP1: Advancing Accelerator Science at German Universities

Participating institutes: U Bonn, DESY, U Hamburg, U Wuppertal

In the past, DESY has contributed to the teaching of accelerator science mostly through accelerator summer schools. Regular lectures at outside universities have been an exception. In the framework of the Alliance DESY will make an effort to promote the topic at German universities and will encourage physicists with educational skills to contribute to the curriculum of external universities. DESY staff will give an initial lecture on accelerator science in Göttingen during the summer term 2007. The Alliance will extend such lectures to other interested universities. Also, block courses will be offered together with practical courses at the participating institutes, e.g. internships at DESY.

Given its vicinity to DESY and its accelerators the University of Hamburg is an ideal gateway to engage in teaching accelerator science. Conversely, this activity has attracted several excellent young accelerator scientists to DESY. In this spirit the Alliance will install a YIG at the University of Hamburg with tenure track option at DESY. The group should contribute to advance cavity based acceleration and also engage in laser-based application. Following the great success of the Linear Collider School 2006 in Japan the Alliance plans to install a summer student programme for selected topics in accelerator science under the leadership of the Young Investigator.

PhD and Diploma theses often rely on experimental data obtained at one of the research centres. DESY will expand support and supervision of such work for which several people with adequate academic qualifications are available. The thesis topics will be intimately connected to the R&D projects described in the following.

2.4.3.2 WP2: R&D Projects

2.4.3.2.1 WP2.1 Research in high gradient superconducting RF cavities

Participating institutes: DESY, U Hamburg, U Wuppertal

The XFEL at DESY is currently entering the construction phase. The cavity production process requires an effort both by DESY and industry that is engaged. The understanding of the limiting factors for cavity gradient is largely left to the research institutes. Wuppertal will contribute decisively to the understanding of the origins of the field emission process that is often limiting the maximum gradient. Possible improvements by means of actual and new surface preparation techniques like dry-ice cleaning will be systematically investigated with FESM and SEM/EDX measurements on Nb samples. DESY will add staff from the existing research division to support the rapid exchange of results and ideas on the cavities testing. The goal is to develop a process that guarantees a high yield of high gradient cavities.

Efficient operation of the superconducting accelerator requires sophisticated low-level radio-frequency control including an adaptive digital feed-forward system to compensate the non-linear detuning of superconducting cavities. It also includes a digital finite state machine for the entire RF system. Both DESY and the University of Hamburg are engaging in this field and plan to extend the field further. There are requirements for the efficient operation of FLASH, XFEL and at the same time, the ILC requires a sophisticated load-levelling scheme for the cavities. For instance, the concept of a leading pilot bunch with the option of fast beam abort for the successive bunches necessitates a very detailed control of the feed-forward system.

The field of SCRF is a key component for the realisation of the ILC. With DESY engaging massively in the production of cavities for the XFEL the universities of Hamburg and Wuppertal will bring complementary scientific support to enable a serious study of the gradient limiting effects in the production process.

2.4.3.2.2 WP2.2 Optimisation of electron and positron sources

Participating institutes: U Bonn, DESY, U Wuppertal

DESY has engaged in the development of low-emittance electron sources in the context of the FLASH and XFEL source. Such a source provides both intensity and time structure to support the accelerating aspects of the ILC. The ILC will demand a highly polarised GaAs source to support the generation of polarised electron beams. The University of Bonn will contribute to this endeavour in testing specific cathode materials and suggesting different materials for use at the ILC. Alternatively, the brightness of the electron source might be improved if field emission through the RF fields in the gun cavity can be combined with the photo-induced process. Such a photo-enhanced field emission (PEFE) would generate fs-short bunches with ultra-low emittance. Various materials will be investigated with the FESM under laser irradiation at Wuppertal. It is expected that PEFE cathodes will be developed which are much more stable in an accelerator environment than the actual photocathodes.

DESY has concentrated on the optimisation of polarized positrons captured behind a thin target. The polarized photons for the positron source are produced in a helical undulator which excites a 150 GeV electron beam. The positron capture rates and polarization transfer have to be optimized while maintaining good electron yield.

2.4.3.2.3 WP2.3 Beam dynamics

Participating institutes: U Bonn, DESY

Beam dynamics at the ILC has been and continues to be studied to assure the delivery of the beams to the interaction with the required luminosity. Beyond the success of this programme it will be necessary to further understand the dynamics and limitations that could arise from beams exiting the accelerator housing inadvertently. Collimation studies are required to further advance this aspect of the ILC. In general this work is both relevant to optimise luminosity performance and to develop a full fledged machine protection system.

DESY is currently engaged in a programme of fast ion instability studies where the focus lies on understanding the growth time of such beam excitations. Code to study the interaction of a rigid beam with an oscillatory ion cloud in the potential of the beam (weak-strong approximation) has been developed. With more features currently being implemented there is a clear need to confront the simulations with experimental data. The Advanced Test Facility (ATF) at KEK provides an ideal experimental test ground to verify the calculations. DESY has thus decided to participate in the ATF test programme to collect the necessary data. The universities of Bonn and Hamburg will participate in this programme and may send students to KEK for a limited time such as to take part in the experiments.

DESY will shut down the HERA accelerator in summer 2007 and the storage ring PETRA will be devoted to synchrotron radiation research inhibiting its present use as an injector for HERA. An impact assessment of a direct injector from the synchrotron DESY into HERA is currently being carried out. If the approach seems feasible and is accepted at DESY, electrons and positrons could be injected into HERA and dedicated beam studies could be performed. Matching almost perfectly the circumference of the foreseen ILC damping ring, HERA is a natural place for dedicated studies of damping ring issues. Once injection into HERA becomes feasible again a whole wealth of applications for machine physics becomes thinkable. This work package would devote considerable efforts into understanding what use the facility could provide for addressing issues of damping ring physics

2.4.3.2.4 WP2.4 Beam diagnostics and controls

Participating institutes: U Bonn, DESY, U Hamburg

Beam diagnostics is crucial for the development of new demanding accelerators. The non-destructive sampling of the beam dimensions using laser beams is a key tool in understanding the beam position and its transverse size. The basic principle of these so called laserwires has been demonstrated at a few accelerators around the world. In analogy to a conventional wire a well-focussed laser beam is swept through the horizontal and vertical dimension of the beam. Initial experiments have been carried out at the PETRA storage ring and it is planned to convert the existing laserwire experiment into a routine tool for the lightsource PETRA III. Likewise it is foreseen to use a laserwire to assess the beam dimensions at the ATF facility in KEK where the normalized emittance of the ILC will be produced. Hamburg has engaged in these activities and will demonstrate the use of laserwires. Bonn plans to use a Compton-polarimeter to measure transverse size and polarisation of the stored electrons in the ELSA accelerator using a position sensitive micro-strip detector.

The longitudinal dimensions can be assessed with electro-optical sampling methods that are already in use at the FLASH facility. Such techniques will have to be adapted to assess the longitudinal extent of the ILC beams after leaving the bunch compressors. Diffraction radiation is another technique that is successfully applied in Hamburg for beam diagnostics.

Synchronisation of the 30 km long ILC is a major challenge when it comes to maintaining the stability of the timing signal over long distances and long periods of time to synchronize RF gun, superconducting RF resonators, diagnostics devices and the bunch crossing at the interaction point. DESY and the University of Hamburg in a collaboration with MIT/Boston have gained substantial expertise in novel timing techniques based on fibre lasers as master oscillators and a signal distribution via length-stabilized optical fibres on the level of 10 fs. Further developments and tests in a realistic accelerator environment (i.e. FLASH at DESY) are underway. This programme will be continued and applied to the ILC.

Both DESY and the University of Hamburg have engaged in accelerator simulation studies to understand the limitations of the availability of large accelerator complexes. The necessity for such an approach has arisen once the number of components of a facility reaches a level that is amenable to statistical analysis. The results of such an analysis will identify the weak spots in the system and promises considerable improvement of the availability and hence luminosity of the ILC and other machines.

2.4.3.2.5 WP2.5 Laser Plasma Acceleration

Participating institutes: U Hamburg

Future high-energy accelerators may profit from the high electric fields produced by multi-TW and PW lasers, either as table-top positron sources or as accelerating devices with unprecedented gradients. A recent breakthrough was the demonstration of electron acceleration to 1 GeV by laser pulses within a 3.3 cm gas-filled capillary at the LBNL (Berkeley). In order to improve the quality and stability of laser-accelerated beams in view of practical applications, contacts between DESY, providing accelerator know-how, and the MPI of Quantum Optics (Garching), where laser-wakefield experiments are conducted, have been established and are of mutual benefit. The Alliance will extend these activities in an exploratory manner. The Hamburg group can immediately contribute to the field laser-plasma acceleration with theoretical studies and engage in simulations in collaboration with institutes already operating high-power lasers. The group will so be prepared for serious experimental activities should additional funds be made available.

2.4.4 Milestones

Work Package	Date	Topic
WP1	04/2007	First lectures on accelerator science at external universities
	07/2007	Support for PhD theses and if required for Diploma theses with support for experimental studies
WP2	12/2008	Optimisation of capture yield of undulator based positron source
	12/2008	Results from theoretical studies on beam based alignment techniques under realistic operating conditions
	12/2009	Results from studies on collective effects including electron cloud and fast-ion instabilities
	06/2010	Implementation and test of an advanced low-level RF control system for 1.3 GHz cavities
	12/2010	Improvement of beam profile diagnostics using laserwires, electro-optical sampling and beam position monitors
	06/2011	Improvement of cavity gradient in series production
	06/2011	Improvement of electron source emittance
	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

2.4.5 Resource Planning

Financial Representation						
centre/partner: all topic: Accelerator	2007	2008	2009	2010	2011	2012
	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
Total project costs[1)]	163.8	487.1	574.1	588.6	518.6	244.8
thereof personnel costs	150.8	461.1	548.1	562.6	504.6	237.8
thereof financed through institutional funding	134.8	269.6	269.6	269.6	257.6	128.8
thereof financed through third party funding	0.0	0.0	0.0	0.0	0.0	0.0
requested IVF[2)] funding	29.0	217.5	304.5	319.0	261.0	116.0

[1)] including general and administrative costs, internal services etc.
[2)] Impuls- und Vernetzungsfonds = Initiative and networking fund

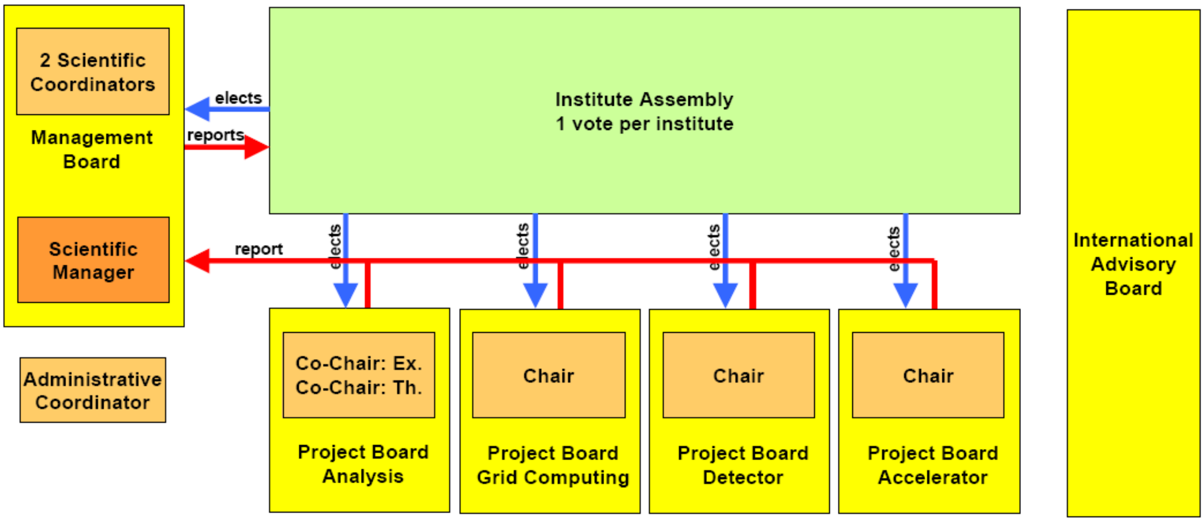
Reconciliation of requested IFV funding into expenses *(for information only)*	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
costs requested through IVF	29.0	217.5	304.5	319.0	261.0	116.0
noncash expenditures (depreciation)	0.0	0.0	0.0	0.0	0.0	0.0
Investments	0.0	0.0	0.0	0.0	0.0	0.0
Expenses	24.2	181.3	253.8	265.8	217.5	96.7

Personnel ***(for information only)***	FTE	FTE	FTE	FTE	FTE	FTE
Personnel (financed through IVF)						
Scientists	0.50	3.75	5.25	5.50	4.50	2.00
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	0.00	0.00	0.00	0.00	0.00	0.00
Personnel (financed through institutional or third party funding)						
Scientists	2.10	4.20	4.20	4.20	4.20	2.10
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	0.00	0.00	0.00	0.00	0.00	0.00

3 Backbone Activities

3.1 Management: Organisation and responsibilities

The organisational structure of the Alliance is modelled after the experience gained from large particle physics collaborations and large collaborative projects funded by the EU. It will be light but effective with clear personal responsibilities as sketched below:



The Alliance is represented by two Scientific Coordinators. In addition major management responsibilities will be taken over by: the scientific manager, the Chairs of the four Projects, i.e. the Research Topics, all advised by their respective boards, and the administrative coordinator. The main governing body of the Alliance is the Institute Assembly where all strategic decisions on research and funding will be taken. Each university and each research centre has two representatives, ideally one from theory and one from experiment, but only one vote. It elects the relevant bodies of the Alliance and possibly decides on new institutes. It meets at least once per year.

The Scientific Coordinators of the Alliance act as the main scientific contact with the Helmholtz Gemeinschaft and with the participating institutes. They will coordinate the work of the Alliance between Institute Assemblies. The coordinator from the universities will be elected by the Institute Assembly, the one from DESY will be selected by the DESY directorate. The Scientific Coordinators will be assisted by a Scientific Manager who will be selected by the management board and will be hosted by DESY. The Scientific Manager will have to be approved by the Institute Assembly. She/he will have to closely follow the progress of the Alliance, be responsible for the day-to-day contact with the partners and prepare decisions in accordance with the two Scientific Coordinators.

The Alliance will also be helped by an Administrative Coordinator who is responsible for the management of the budget of the Alliance and the administration of tasks and funds.

In addition, the Scientific Coordinators will be supported by four scientists who, together with the coordinators, form the Management Board. These four scientists will be elected by the Institute Assembly. Without voting rights the Management Board will also comprise the chairs of the projects, the Scientific Manager and Administrative Coordinator. The Management Board will discuss the progress and critical items of the Alliance typically on a monthly basis. The management board can install additional committees for specific tasks (e.g. a selection committee for the Alliance fellowships, etc). The Institute Assembly will need to approve the boards before they can become active. The Management Board will select the fellows based on recommendations from special committees and will approve the funding of the leaders of the Young Investigator Groups selected by the university boards. It will also decide on spending issues for the projects based on the recommendation of the project boards.

Each of the four Research Topics will be directed by one (two in the case of the Physics Analysis topic, a theorist and an experimentalist) Project Chairs who will be responsible for the respective project (i.e. Research Topic). Project Boards will assist the Chairs for each of the projects. The Institute Assembly elects the members of the Project Boards which in turn chooses their respective Chair. These boards have typically six members. They should be chosen to ensure a balance between the members of the Alliance, between the different regions and interests. The Chairs of the Project Boards will have to closely follow the progress of the Alliance and the global progress in the respective field. It will make recommendations to the Management Boards on issues of funding and evolution of research directions and suggest topical workshops. It will also evaluate the use and needs for general Alliance infrastructure. The outcome of these considerations will be reported to the Management Board for approval.

The program of the Alliance is reviewed in regular intervals by an International Advisory Board, consisting of distinguished scientists from CERN, ATLAS, CMS, WLCG, the GDE, one each from North America and Asia, and a representative of the German "Komitee für Elementarteilchenphysik" (KET). This will ensure the best possible cooperation within the different world-wide activities and should help to enhance the visibility and effectiveness of the Alliance. The members of this board will be informed about the activities of the Alliance, and make recommendations to the management for the future programme, the performance of the Alliance and possible shortcomings. The members of the international Advisory Board are appointed by the Institute Assembly upon a proposal from the management board.

3.2 Interim Professorships

In the past, many significant contributions have been made to modern particle physics experiments in large international collaborations by German senior scientists and university professors. Most of these contributions were made based at the home institutions in Germany with frequent visits to the experiments. An even better return of German investment and a higher visibility could have been achieved if German university professors had been given the opportunity to spend longer periods at CERN and, for example, take on the responsibility as spokesperson. In the era of LHC data taking and data analysis, with a much increased size of the international collaborations there is the need to allow university professors from theory or experiment to spend one or two semesters based at CERN in order to

- be able to make significant and highly visible contributions to the LHC experiments, in particular during the most exciting start-up phase of those discovery experiments;
- be in a position to fill experiment-wide positions of high responsibility such as sub-detector project leaders, physics group conveners or higher level management such as physics coordinators etc.;
- best exploit the LHC data by an improved ratio of senior physicists, experienced in the physics of data analyses, to junior physicists based at CERN or the home institutions, who are very skilled in the data analysis software and Grid computing;
- represent German interests in experiment committees. Experience with growing international collaborations, for example at the Tevatron, have shown the increasingly important role of senior scientists of the home community.

Regular responsibilities of physics professors in the German university system make it difficult or impossible to take on these tasks and responsibilities in the large international collaborations. In order to provide them with opportunities equivalent to the ones offered in other European countries, a programme is proposed that allows senior physicists to go on a sabbatical to CERN while their home institutes responsibilities be taken care of by an interim professor. Learning from examples of our European neighbours, where senior physicists can spend significant periods at CERN, sponsored by IN2P3 (France) or INFN (Italy), the Helmholtz Alliance offers interim professorships at the level of 2 full positions per year (corresponding to 80 kEuro/year), i.e. covering 4 semesters, in order to replace established particle physics professors for a limited period of 1 or 2 semesters each at their home institutions in their research and teaching responsibilities. This programme gives the junior members of the Helmholtz Alliance the opportunity to gain teaching and organisational experience as interim professors and hence improve their qualification for future job applications. The first use case of this scheme is Freiburg starting in 2008.

3.3 Promotion of Young Researchers: Goals and strategy

The Alliance will use two instruments to promote young researchers in the field: fellowships and Young Investigator Groups.

The fellowships will be announced internationally, in general with a wide scope where the applicants have the freedom to propose a subject of their work within the tasks of the Alliance and an institute where they want to be sited. In case of tenure track positions applications will be invited for the corresponding institute and subject. The best candidates will be pre-selected by a selection board from the applications received with some balance between subjects and institutes. The list of candidates needs to be confirmed by the management board. The final decision on the acceptance of one of the pre-selected candidates lies with the university the candidate intends to work with. The fellows will be offered a position of up to five years duration which can be shared between two institutes by changing changing the partner institute at midterm. In most cases the appointment will be tenure-track with a review before becoming permanent after the initial five-year duration. They will also be given a travel budget on their own to increase their independence. Presently 17 fellowships are foreseen, however we aim at increasing the number of fellowships by co-financing some between the Alliance and a partner institute. Some of the fellowships are attributed to partners at start of the project and the remaining positions fill a pool which supplies later calls for application.

The Young Investigator Groups (YIG) are modelled after the successful Helmholtz Nachwuchsgruppen. They will be advertised internationally with the goal of recruiting the best candidates in the fields. Each group will be provided by an annual sum of 150 KEuro which includes her/his own salary and money to hire additional personnel. Travel funds and some investment money will be made available from the Alliance. The positions of the leaders of the YIG will be tenure track positions, ensured by the hosting institutions. The leaders will have the status of junior professors at the hosting institution, or an equivalent position.

The candidates will be selected by the university with outside member(s) of the Alliance being on the selection board. To ensure that the holders of these positions integrate well into the program of the Alliance the final decision on the funding of the selected candidates lies with the management board. The Young Investigators will be encouraged and supported to assume leading roles within the program. This should give them excellent starting conditions for their career but also increase the visibility of the Alliance as a whole.

Some fellowships and YIGs are attributed to partners which promise tenure track now and will be advertised immediately. The remaining positions fill a pool which supplies later calls for applications.

3.4 Equal opportunities: Goals and strategy

All members of the Alliance are committed to provide equal opportunities for particle physicists at all stages. As in other fields of science we realise that, although the fraction of female PhD students is increasing, the fraction of female post-docs and professors is still marginal.

Without compromising in the scientific quality we will be working towards increasing the participation of female physicists in research. Based upon the well established procedures at the centres of the Helmholtz Gemeinschaft and the universities the hiring of personnel will be done with special attention to the goal of increasing the number of woman in science. To ensure this appropriate gender representation in selection boards will be assured in accordance with the equal opportunity commissioner of either a HGF centre or university. Furthermore we intend to give female physicists a high visibility and take particular care in supporting them in their careers

However, even if female scientists are selected and supported, we observe that a major obstacle lies in the role they adopt in families. We are therefore particularly committed to taking account the responsibilities and constraints of a young family, such that family and research become compatible, both for male and female scientists.

Apart from the fact that tenure track positions, which are one of the basic elements of this research proposal, will help to relieve young scientists from uncertainties about their future at a time when they normally establish a family, we foresee special funds to help young scientists to accommodate research and family in parallel.

a. In many cases the attraction of highly qualified young researchers is hampered by the fact that no adequate positions are available for their partners. The Alliance will create a fund to help in giving a position also for the spouse, even if working in another field. We intend to provide funding for up to half of a post-doc position, expecting the other half to come from the host university.

Another major obstacle for staying within science is the time intensive care for young children. To allow mothers and fathers of young children to continue their research as smoothly as possible, the Alliance will provide funds for

b. Teleworking, i.e. a high bandwidth internet connection and corresponding hardware and infrastructure;
c. Places in regular child care facilities;
d. Memberships in family service organisation (like P.M.E.) who can support child care on short notice even if regular care is impossible as in case of illness of a child, to provide the scientist with the opportunity to attend conferences and in general to continue her or his work;
e. Additional paid leaves of up to five working days to allow parents to take care of their children in case of emergency, following examples in private enterprises.

3.5 Research Transfer

An important goal of the Alliance is the training of young scientists in cutting edge techniques – from computational techniques to high technology detector and accelerator applications. These highly trained and motivated young researchers leaving the Alliance will be one of the major assets and results of the work. The scientific results from the Alliance work will be made publicly available through publication in scientific journals. The Alliance will make a special effort to promote the use of open access journals, and use preferentially those to publish the work of the Alliance. Results will also be presented at scientific workshops and conferences. Where applicable close cooperation with industry will be maintained and ensured that the knowledge is transferred to industry.

3.6 Communications

3.6.1 Internal Communication

A key objective of the Alliance is the provision of infrastructures for members of the Alliance to increase their productivity and impact in the large future projects LHC and ILC. An important aspect of this is an excellent communication between the partners to make them aware of the different infrastructures available, to help them in planning the usage of the infrastructures, and to help in managing the accounts of the different facilities. To this end a comprehensive WEB based information system will be created, which combines information on the different infrastructure with tools to apply for time and resources to use them.

3.6.2 Outreach

The results of research in Elementary Particle Physics affect the public directly as they touch the basic questions about the origin and the future of the universe, and reveal the fundamental constituents of matter and the principles of forces between them. Bringing these results as cultural knowledge for everybody to the public has to be therefore an integral part of particle physics research. The need for public outreach can be judged from the huge success of outreach events like those which started in the Science Week “Reise zum Urknall” in the “Year of Physics 2000”, and continued in the years after. Most of the Alliance partners do already have several regular outreach events, especially for high school students, like “Saturday morning Physics” or “Hands on Particle Physics Masterclasses”. However, only few of these events, like the Masterclasses, are centrally coordinated, in many cases ideas and tools for public outreach could be shared more efficiently. The activities proposed by the Alliance will build upon the existing efforts for LHC and ILC.

The Allianz plans to initiate a coordinated outreach effort, with specific actions and materials for each of the target groups ranging from students and teachers over politicians and policy makers to the general public. While on the one hand junior and senior scientists themselves are expected to participate in public outreach, also special events for multipliers, like science journalists or teachers are planned, similar to the German LHC Journalist day in November 2006, organized by DESY PR in cooperation with other members of the Allianz. Tools and events, which are currently only existing at one or few Allianz partners, like the “Particle Physics Show” in Bonn or models of particle accelerators at DESY or Dresden should be copied or made available to the other partners.

One specific measure of outreach will be design and production of a ‘Science Bus’ with hands-on exhibits and explanations aimed at school kids. This bus is supposed to visit schools in the cities or the neighbourhood of Alliance partners where students from the partner institutes will accompany the exhibits. In this way, important particle physics topics will be used to introduce pupils to basic physics.

To implement and maintain this program, a half-time position of a communication officer will be created, who works in close contact with the outreach contact persons of the Allianz partners, with the corresponding outreach committees and with the PR officers of MPI München and DESY.

3.7 Resources Planning

Financial Representation						
centre/partner: all topic: Backbone	2007	2008	2009	2010	2011	2012
	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
Total project costs[1)]	129.0	547.0	1,502.0	1,502.0	1,502.0	751.0
thereof personnel costs	29.0	237.0	962.0	962.0	962.0	481.0
thereof financed through institutional funding	0.0	0.0	0.0	0.0	0.0	0.0
thereof financed through third party funding	0.0	0.0	0.0	0.0	0.0	0.0
requested IVF[2)] funding	129.0	547.0	1,502.0	1,502.0	1,502.0	751.0

[1)] including general and administrative costs, internal services etc.
[2)] Impuls- und Vernetzungsfonds = Initiative and networking fund

Reconciliation of requested IFV funding into expenses ***(for information only)***	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
costs requested through IVF	129.0	547.0	1,502.0	1,502.0	1,502.0	751.0
noncash expenditures (depreciation)	0.0	0.0	0.0	0.0	0.0	0.0
Investments	0.0	0.0	0.0	0.0	0.0	0.0
Expenses	107.5	455.8	1,251.7	1,251.7	1,251.7	625.8

Personnel *(for information only)*	FTE	FTE	FTE	FTE	FTE	FTE
Personnel (financed through IVF)						
Scientists	0.50	4.00	16.50	16.50	16.50	8.25
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	0.00	0.00	0.00	0.00	0.00	0.00
Personnel (financed through institutional or third party funding)						
Scientists	0.00	0.00	0.00	0.00	0.00	0.00
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	0.00	0.00	0.00	0.00	0.00	0.00

The planned distribution of backbone funds across the different themes is shown in the pie chart below. Most of the budget will be spent for the promotion of young researchers via fellowships or Young Investigator Groups. Whereas funding for the positions already allocated to institutes is accounted for in the respective research topics the positions here will be advertised and allocated in a second or even third call for applications between six and eighteen months after the start of the Alliance. Topics and institutes will be defined in the Institute Assembly, the selection of candidates is described in the respective chapters.

Support of interim professorships and equal opportunities is an important aspect of the backbone activities and represents a sizeable fraction of the funding. Details are given in the respective chapters.

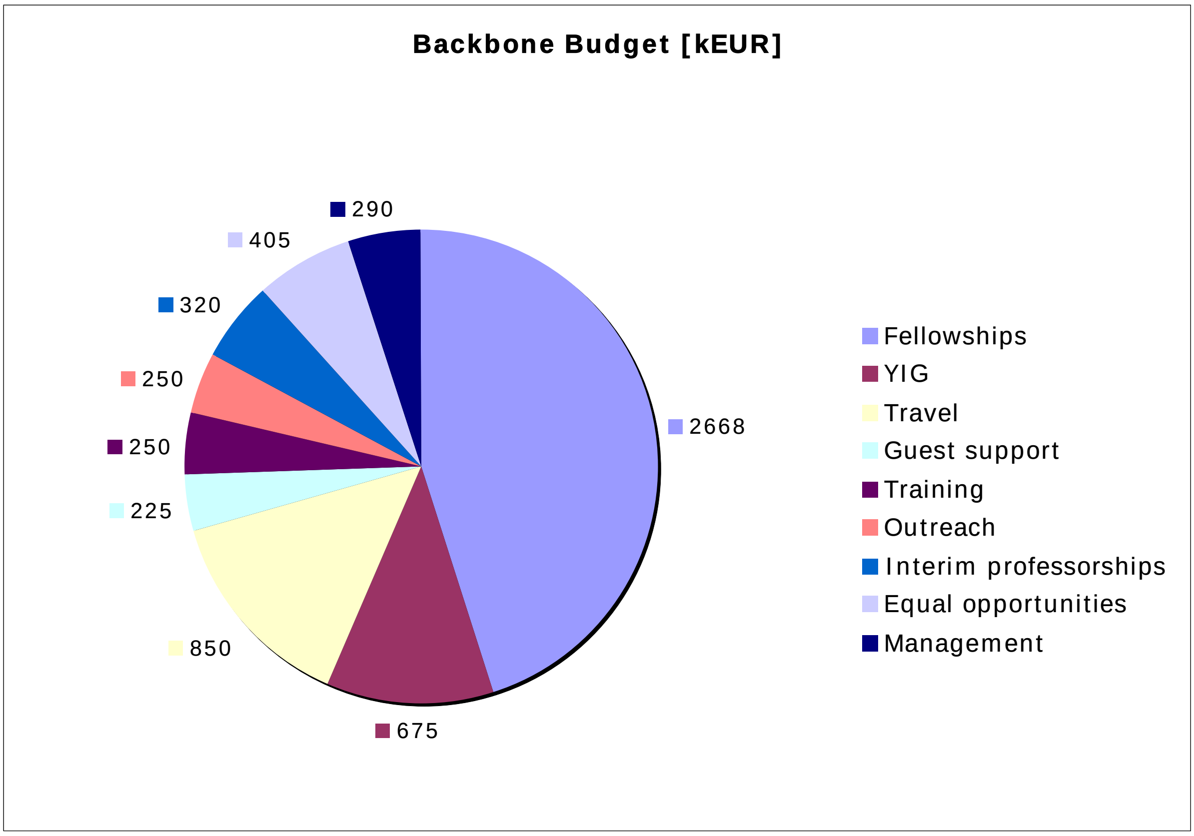
Funds are foreseen for travel between partners. They will be allocated yearly by the Institute Assembly and distributed to the institutes. Some fraction of these funds will also be allocated to the YIGs and fellows to support their independence.

Training comprises tutorials, workshops schools and special student programmes in all four Research Topics. Already established programmes will not be duplicated but complemented or combined. Funds will be allocated on a yearly basis following the project proposals. Emphasis will be given to the training of young scientists also fostering their independence.

The guest programme applies to all four Research Topics, see RT1 for details. It aims at bringing together eminent scientists for lectures and work topics to the Alliance partners, ideally to several partners in turn or for combined projects.

The funding allocated for management accounts for the Scientifc Manager.

Backbone Activities



4 Appendix

4.1 Leading researchers within the Helmholtz Alliance

Prof. Dr. Rolf-Dieter Heuer (DESY) *1948

Scientific career

University	Diploma in Physics, Univ. Stuttgart, Nuclear Physics	1969-1974
PhD	Dr. rer. nat. Univ. Heidelberg, experiment at DESY	1975-1977
Post-Doc	Post-doc and Univ. Assistant, Univ. of Heidelberg	1977-1983
	Staff member, CERN	1984-1994
Senior Scientist	Leading Scientist, CERN	1995-1998
Current position	Professor, Univ. of Hamburg	1998- now

Field of Research: Experimental Particle Physics. Worked on experiments at DESY (DESY-Heidelberg-Experiment at DORIS, JADE at PETRA) and CERN (OPAL-Experiment at LEP), spokesman of OPAL from 1994 to 1998. Study of e^+e^- reactions. Development of experimental techniques. Construction and running of large detector systems, coordination and management of experiments.

Selected publications

1) *Electron-Positron-Colliders*, invited Talk, Proceedings of LP01, World Scientific
2) *Measurement of Charged Triple Gauge Boson Couplings using W-Pairs at LEP,* Eur.Phys.J. C, 33 (2004) 463
3) *Search for the Standard Model Higgs Boson at LEP,* Phys.Lett. B565 (2003), 614
4) *Search for the Single Production of Doubly-Charged Higgs Bosons and Contributions on their Couplings from Bhabha Scattering,* Phys.Lett. B577 (2003) 93
5) *Search for Nearly Mass Degenerate Charginos and Neutralinos at LEP,* Eur.Phys.J. C29 (2003), 479

Dr. Sven-Olaf Moch (DESY) *1968

Scientific career

University	Diploma in Physics, Univ. Hamburg	1988-1994
PhD	Dr. rer. nat. Univ. Hamburg, Theory at DESY	1994-1997
Post-Doc	NIKHEFAmsterdam and Univ. Karlsruhe	1997-2002
	Staff member, CERN	1984-1994
Senior Scientist	DESY Zeuthen	2002-2005
Current position	Leader of Helmholtz Junior Research Group Zeuthen	2005- now

Field of Research: Theoretical Particle Physics. Phenomenology and precision predictions for colliders, in particular QCD corrections for hard scattering processes. Relevant contributions to structure functions in deep-inelastic scattering at higher orders in QCD and to the scale evolution of parton distributions from HERA to the LHC energies. Expertise in computational physics, large scale computer algebra and mathematical aspects of precision phenomenology. Coordination and organization of workshops and schools.

Selected publications:

1) Higher-order soft corrections to lepton pair and Higgs boson production, Phys.Lett. B631 (2005), 48
2) The three-loop splitting functions in QCD: The singlet case, Nucl.Phys B691, (2004) 129
3) The three-loop splitting functions in QCD: The non-singlet case, Nucl.Phys. B688, (2004) 101
4) Two-loop amplitudes with nested sums: Fermionic contributions to e+e- -> qqg, Phys.Rev. D66, (2002) 114001
5) Nested sums, expansion of transcendental functions and multi-scale multi-loop integrals, J.Math.Phys. 43, (2002) 3363

Appendix

Klaus-Peter Mickel (FZK)	***1944**

Scientific career

University	Diploma in Physics, University of Karlsruhe	1963-1970
Employments	Group and department leader in the central Computing Centre, University of Karlsruhe	1970-1979
	IT division leader, Ernst Klett publishing and printing, Stuttgart	1979-1988
	IT division leader, Vereinigte Motor-Verlage, Stuttgart	1988-1995
Current position	Head of the central IT division and head of the Institute for Scientific Computing at Forschungszentrum Karlsruhe	1996-now

Field of Research: Management and organisation of large IT and Grid projects

Selected publications

1) Erfahrungen mit Produktionsgrids am Beispiel des LHC-Computing-Grid (LCG), PIK – Praxis der Informationsverarbeitung und Kommunikation, 29: 140-145, 2006
2) GridKa – The Grid-Computing Centre Karlsruhe, to appear in FZKA-Nachrichten, Jahrgang 38, 3/2006
3) The German Grid Initiative D-Grid – Status and Perspectives, 4. International Symposium on Grid Computing, Academia Sinica, Taipei, 2006 (invited Talk)
4) D-Grid and the D-Grid Integration Project, 2. VIOLA-Workshop, Bonn, 2006 (invited talk)
5) Die Helmholtz-Gemeinschaft deutscher Forschungszentren und ihre IT-Landschaft, Annual conference of the IT-leaders of the Max-Planck Gesellschaft, Göttingen, 2005, to appear in GWDG-Bericht 69/2005

Prof. Dr. Achim Stahl (RWTH Aachen)	***1962**

Scientific career

University	Diploma in Physics, University of Tübingen	1982-1989
PhD	Dr. rer. nat. University of Tübingen	1992
Employments	Research Assistant, University of Bonn	1992-1996
	Feodor-Lynen fellow (Humboldt-foundation), SLAC	1996-1998
	Research Assistant, University of Bonn	1998-2001
	Leading Scientist, DESY	2001-2004
Current position	Full Professor at RWTH Aachen	2004-now

Field of Research: Detector Development with silicon and gaseous trackers, search for new physics at the LHC, physics with tau leptons, neutrino physics, application of particle physics technologies in radiation therapy of tumors, Grid computing.

Selected publications

1) Physics with Tau Leptons, Springer Tracts in Modern Physics, Vol. 160.
2) CP-Violation in the Production of TAU Leptons at TESLA, Eur. Phys. J. C27 (2003) 33.
3) The BaBar electromagnetic calorimeter, Nucl. Inst. And Meth. A 409 (1998) 615.
4) Particle Data Booklet, S. Eidelman et al., Physics Letters B592, 1 (2004).

Prof. Dr. Michael Krämer (RWTH Aachen)	*1966

Scientific career

University	Diploma in Physics, Univ. Mainz	1986-1991
PhD	Dr. rer. nat. Univ. Mainz, theoretical physics	1991-1995
Employments	Research Associate, DESY, Hamburg	1994-1996
	Research Associate, RAL, UK	1996-1998
	Research Associate, CERN	1998-1999
	Lecturer & Reader, Univ. Edinburgh, UK	1999-2004
Current position:	Professor for Theoretical Particle Physics, RWTH Aachen	2004-now

Field of Research: Theoretical particle physics. Precision calculations for collider physics, LHC and ILC phenomenology. Higgs and gauge-boson physics, production and decay of supersymmetric particles and physics beyond the Standard Model.

Selected publications

1) M. Krämer et al., NLO QCD jet production with parton showers and hadronisation, PRD 73 (2006) 014022
2) S. Dittmaier et al., Higgs radiation off bottom-quarks at the Tevatron and the LHC, PRD 70 (2004) 074010
3) W. Beenakker et al., NLO QCD corrections to ttH production in hadron collisions, NPB 653 (2003) 151
4) W. Beenakker et al., Higgs radiation off top-quarks at the Tevatron and the LHC, PRL 87 (2001) 201805
5) W. Beenakker et al., The production of neutralinos/charginos at hadron colliders, PRL 83 (1999) 3780
6) M. Krämer et al., Pair production of leptoquarks at the Tevatron, PRL 79 (1997) 341

Prof. Dr. Thomas Lohse (HU Berlin)	*1956

Scientific career

University	Diploma in Physics, Univ. Dortmund, Particle Physics	1976-1982
PhD	Dr. rer. nat., Univerity of Dortmund, experiment at CERN	1982-1985
Employments	CERN Fellow	1985-1987
	Max Kade Research Fellow at SLAC, Stanford University	1988-1989
	Staff member, CERN	1989-1992
	Senior Scientist, MPI for Nuclear Physics, Heidelberg	1992-1994
Current position	Full Professor, Humboldt University Berlin	1994- now

Field of Research: Experimental Particle Physics: Experiments HERA-B (heavy quark production in pN collisions, physics coordination 98-00), ATLAS (Standard Model tests and searches for new physics). Detector development (radiation hard tracking technology), development of trigger and DAQ systems. Astroparticle Physics: VHE-Gamma-Ray physics with H.E.S.S.

Selected publications

1) I. Abt et al., Phys. Rev. D73 (2006) 052005
2) I. Abt et al., Phys. Lett. B683 (2006) 13
3) I. Abt et al., hep-ex/0607046 (2006)
4) F. Aharonian et al., Phys. Rev. Lett. 97 (2006) 221102
5) H. Albrecht et al., Nucl. Instr. Meth. A515 (2003) 155

Appendix

Prof. Dr. Klaus Desch (U Bonn)	***1964**

Scientific career

University	Diploma in Physics, Univ. Bonn, Exp. Particle Physics	1984-1992
PhD	Dr. rer. nat. Univ. Bonn, ZEUS experiment at DESY	1992-1995
Post-Doc	Post-doc Univ. Bonn, ATLAS and OPAL experiements	1995-1997
	Fellow, CERN, OPAL experiment	1998-1999
Scientific Assistant	Univ. Hamburg, OPAL expt, TESLA project, H1 expt.	1999-2004
Professor	Univ. Freiburg, ATLAS experiment	2005-2006
Current position	Professor, Univ. Bonn, ATLAS expt. and ILC det. R&D	2006- now

Field of Research: Experimental Particle Physics. Worked on experiments at DESY (ZEUS, H1, Linear Collider Physics and Detectors) and CERN (OPAL experiment at LEP, ATLAS experiment). Study of electron-positron reactions, in particular searches for Higgs Bosons in Standard Model and Beyond Standard Model scenarios, Searches for Supersymmetry, Gauge Boson Self Couplings. Development of statistical techniques (multivariate selections, novel opitmization techniques), Detector R&D on gaseous detectors for future colliders (pixelized readout of micro-pattern gas detectors). Coordination experience: Physics working group convenor in OPAL and ECFA-LC study, Activity coordinator of EUDET EU-I3-Initiatve.

Five relevant publications

1) *Observation of hard scattering in photoproduction at HERA*, Phys.Lett.B297 (1992) 404.
2) *Search for Higgs bosons in e+ e- collisions at 183-GeV*, Eur.Phys.J.C7 (1999) 407.
3) *Physics interplay of the LHC and the ILC* Phys. Rept. Phys. Rept. 426 (2006) 47.
4) *Determination of MSSM parameters from LHC and ILC,* Eur.Phys.J.C46 ((2006) 533.
5) *Triple-GEM operated in different gases with highly …* Nucl. Instr. Meth. A 572 (2007) 157

Prof. Dr. Herbert K. Dreiner, PhD (U Bonn)	***1962**

Scientific career

University	Vordiplom+2 Semesters, Bonn University	1981-1984
	Graduate Studies University of Wisconsin, Madison	1984-1989
PhD	PhD University of Wisconsin, Madison, String Theory	1989
Post-Doc	DESY Theory Group,	1989-1990
	Oxford University, Theory Group	1990-1993
	ETH-Zuerich, Theory Group	1993-1995
Senior Scientist	Senior Scientific Officer Rutherford Lab.	1996-2000
Current position	Professor, Bonn University	2000- now

Field of Research: Theoretical Elementary Particle Physics. String Theory, phenomenology and model building. Main focus has been supersymmetric signals at colliders, as well as supersymmetry model building. Higgs signatures at the LHC as well as astroparticle physics. Involvement in Outreach programs.

Selected publications

1) Supersymmetric NLO QCD corrections to resonant slepton production and signals at the Tevatron …, H.K. Dreiner, S. Grab, , M. Kramer, M.K. Trenkel, Phys.Rev.D75:035003,2007.
2) Discovery potential of radiative neutralino production at the ILC, H.K. Dreiner, O. Kittel, U. Langenfeld, Phys.Rev.D74:115010,2006;
3) Parton shower simulations of R-parity violating supersymmetric models, H.K. Dreiner, P. Richardson, M.H. Seymour, JHEP 0004:008,2000; hep-ph/9912407.
4) How to find a Higgs boson with a mass between 155-GeV - 180-GeV at the LHC.
M. Dittmar, H.K. Dreiner, Phys.Rev.D55:167-172,1997.
5) R-parity violation at HERA, J. Butterworth, H.K. Dreiner, Nucl.Phys.B397:3-34,1993.

Prof. Dr. Claus Gössling (U Dortmund) *1951

Scientific career

University	Diploma in Physics, Univ. Hamburg, Particle Physics	1971-1977
PhD	Dr. rer. nat. Univ. Hamburg, EMC,NA2 at CERN	1978-1982
Post-Doc	Staff member, CERN	1983-1989
Current position	Professor, U Dortmund, chair of experimental physics	1989- now

Field of Research: Experimental Particle Physics. Worked on experiments at DESY (F21 at the DESY-Synchrotron), CERN (UA2, NOMAD, HARP, ATLAS), spokesman of RD2 from 1990 to 1996. Study of muon-nucleon reactions, participation in the discovery of the intermediate bosons W+- and Z, searches for heavy neutrinos, study of top-quark physics. Development of silicon tracking detectors

Selected publications

1) C. Gößling et al., , Nucl. Instrum. Meth. A 465 (2000) 77-82
2) P. Astier et al., Phys. Lett. B 506 (2001) 27 – 38
3) P. Astier et al., Nucl. Phys. B 611 (2001) 3 - 39
4) P. Astier et al., Phys. Lett. B 570 (2003) 19 - 31
5) C.Gößling, O.Krasel et al., IEEE Trans. Nucl. Sci. 51 (2004) 3055-3062

Prof. Dr. Gudrun Hiller (U Dortmund) *1966

Scientific career

University	Diploma in Physics, U Hamburg/DESY, ParticlePhysics	1985-1991
PhD	Dr. rer. nat. Univ. Hamburg, DESY Theory	1995-1998
Post-Doc	Post-doc LNF Frascati	1998-1999
	Research Associate, SLAC, Stanford	1999-2002
	C1-Position (wiss. Ass.) , LMU München	2002-2005
Scientific Associate	CERN Theory Group (on leave from LMU)	2004-2005
Current position	Professor, Univ. of Dortmund	2005- now

Field of Research: Theoretical Particle Physics. Worked on Standard Model tests with rare processes, supersymmetry, also beyond the minimal model, Higgs effects in b-physics, Flavor and CP violation, Flavor for the LHC.

Selected publications

1) *G.Buchalla, G.Isidori and G.Hiller, Phys.Rev. D63:014015, 2001.*
2) G.Hiller and M.Schmaltz, Phys.Lett.B514:263-268, 2001.
3) G.Hiller, invited plenary talk at FPCP 2003, 3-6 June 2003 - LMU 17/03, hep-ph/0308180.
4) G. Hiller, Phys.Rev.D70:034018,2004.
5) S.Dittmaier, G.Hiller, T.Plehn and M.Spannowsky, DO-TH 06/14.

Appendix

Prof. Dr. Michael Kobel (U Dresden)	***1961**

Scientific career

University	Diploma in Physics, Erlangen Univ.	1980-1986
PhD	Dr. rer. nat. Univ. Erlangen, experiment at DESY	1986-1991
Employments	CERN Fellow,	1991-1993
	Research Associate C1, Freiburg University	1993-1998
	Professorship Substitute, Bonn University	1998-1999
	Associate Professor C3, Bonn University	1999-2006
Current position	Full Professor W3, Technical University Dresden	2006- now

Field of Research: Experimental Particle Physics. Study of electron-positron and proton-proton reactions, precision electroweak measurements, analysis coordination, searches for Higgs Bosons in and beyond the Standard Model, development of experimental techniques, coordination of national and international outreach activities

Selected publications

1) OPAL Collaboration, G. Abbiendi et al., Eur. Phys. J. C49, (2006) 457.
2), LEP Electroweak Working Group, LEP Collab., SLD Collab., Physics Reports 427 (2006)
3), OPAL Collaboration, G. Abbiendi et al., Eur. Phys. J. C.45 (2006) 1.
4) OPAL Collab., G. Abbiendi et al., Eur. Phys. J.C33 (2004) 173.
5) “Evaluation of high school students' exposure to modern particle physics in exhibitions, university workshops, and in the classroom”, M.Kobel, Europhysics News, Volume 34/3, May 2003.

Prof. Dr. Gregor Herten (U Freiburg)	***1955**

Scientific career

University	Diploma in Physics, RWTH Aachen, experiment at DESY	1975-1980
PhD	Dr. rer. nat. RWTH Aachen, experiment at DESY	1980-1983
Post-Doc	Fellow at CERN	1984-1986
Assistant Professor	Massachusetts Institute of Technology, USA	1986-1991
Associate Professor	Massachusetts Institute of Technology, USA	1991-1992
Professor	University of Freiburg, Physics department	1992-now
	Vice-Rector, University of Freiburg	1995-1999

Field of Research: Experimental Particle Physics. Mark-J experiment at DESY: LEP experiments L3, OPAL and LHC experiment ATLAS Member of CERN Council, IUPAP-C11 chairman. Study of electron-positron reactions, discovery of gluon jets, electroweak interference, measurement of b-quark properties, search for new particles, precise measurements of electroweak interactions, development of experimental techniques, e.g. large precise muon chambers for LHC, optical alignment systems, drift gas studies and gas systems for high background measurements, coordination and management of experiments, supervisor of 46 diploma and PhD theses.

Selected publications

1) Measurement of Neutral-Current Four-Fermion Production at LEP2, Phys. Lett. B544 (2002) 259-273.
2) Measurement of Z/gamma* production in Compton scattering of quasi-real photons, Eur. Phys J. C24 (2002) 1-15.
3) W boson polarization at LEP2, Phys.Lett.B585:223-236 (2004).
4) Tests of the standard model and constraints on new physics from measurements of fermion pair production at 189 GeV to 209 GeV at LEP, Eur.Phys.J. C33 (2004), 173.
5) Search for neutral MSSM Higgs bosons at LEP, Eur. Phys. J. C 47, 547-587 (2006)

Prof. Dr. Jochum Johan van der Bij (U Freiburg)	***1955**

Scientific career

University	Doctorandus Rijksuniversiteit Utrecht	1974 - 1979
PhD	Utrecht, research at University of Michigan	1979 - 1983
Employments	Post-doc NIKHEF, Amsterdam	1983 - 1985
	Post-doc Fermilab	1985 - 1987
	CERN fellow	1987 - 1989
	Universitair Docent, Hoofddocent, Univ. van Amsterdam	1989 - 1991
	Visiting scientist DESY	1990
Current position	Professor, University of Freiburg	1991 - now

Field of research: Elementary particle phenomenology, Higgs physics, weak interactions, radiative corrections, higher dimensions.

Selected publications :

1) C. P. Buszello et al., Eur. Phys. J. C32(2004) 209.
2) R. Bonciani et al., Nucl. Phys. B701(2005) 280.
3) M. Duehrssen et al., JHEP 0505 (2005) 064.
4) J.J. van der Bij, Phys. Lett. B636(2006) 56.
5) F. Gianotti et al., Eur. Phys. J. C39(2005) 293.

Prof. Dr. Michael Düren (U Giessen)	***1957**

Scientific career

University	Diploma in Physics, RWTH Aachen, Particle Physics	1976-1983
PhD	Dr. rer. nat., RWTH Aachen, EMC experiment at CERN	1984-1987
Employments	Post-doc at MPI for Nuclear Physics, Heidelberg	1988-1993
	Univ. Assistant at Univ. Erlangen-Nürnberg	1993-1999
	Temporary Professorship, University Bayreuth	1999-2001
Current position	Full Professor, University of Giessen	2001- now

Field of Research: Experimental Particle and Hadron Physics. Study of spin, momentum and flavour distributions of quarks in the nucleon, generalized parton distributions. Polarization and polarimetry of HERA. Construction of a scintillating fibre tracker. Software and physics coordinator of HERMES.

Selected publications

1) A. Airapetian et al., Phys.Rev.Lett. 94 (2005) 012002.
2) A. Airapetian et al., Phys.Rev. D71 (2005) 012003.
3) A. Airapetian et al., Phys.Lett. B585 (2004) 213.
4) A. Airapetian et al., Phys.Rev.Lett. 92 (2004) 012005.
5) D.P. Barber et al., Phys.Lett. B343 (1995) 436.

Appendix

Prof. Dr. Arnulf Quadt (U Göttingen)	***1969**

Scientific career

University	Diploma in Physics, U Bonn, Particle Physics	1990-1993
PhD	Doctor of Philosophy, Univ. of Oxford, expt. at DESY	1993-1996
Employments	Post-doc, Univ. of Oxford, experiment at DESY	1997-1998
	Research Fellow and Staff member, CERN	1999-2001
	Assistent Prof. & Habilitation, Univ. of Bonn	2001-2006
	Visit.Ass. Prof. & Humboldt Fellow, U Rochester/NY	2003-2005
	Interim Prof., Univ. of Göttingen	2005-2006
	Heisenberg Fellow, MPI München, exp. at CERN	2006
Current position	Full Professor, University of Göttingen	2006- now

Field of Research: Experimental Particle Physics. Study of electron-positron, e±-proton and proton-(anti)-proton reactions, QCD and proton structure, searches for Higgs boson and physics beyond the Standard Model, top quark physics, development of experimental techniques. Construction and running of large detector systems, coordination and management of experiments, Young Physicists Prize' of the European Physical Society.

Selected publications

1) S. Chekanov et al., Eur. Jour. Phys. C21 (2001) 443-471
2) The LEP-Higgs Working Group, Phys. Lett. B565 (2003) 61-75
3) The LEP-Higgs Working Group, Eur. Phys. Jour. C47 (2006), 547-587
4) V. M. Abazov et al., Phys. Rev. D74 (2006) 092005
5) A. Quadt et al., Nucl. Instrum. Methods A 438 (1999) 472
6) W.-M. Yao et al., Jour. of Phys. G33 (2006) 1
7) A. Quadt, Top Quark Physics at Hadron Colliders, Eur. Phys. Jour. C48 (2006) 835-1000

Prof. Dr. Robert Klanner (U Hamburg)	***1945**

Scientific career

University	Study of Physics at TU-München, Diploma work at CERN	1964-1969
PhD	Dr. rer. nat. LMU-München, experiments at CERN and Protvino, Russia, thesis advisor Prof. Dr. U. Meyer Berkhout	1970-1973
Post-Doc	Research Ass./Ass.Prof, Univ. of Illinois, Urbana Champ.	1973-1975
Senior Scientist	Max Planck Inst für Physik, Guest Visitor at CERN	1975-1984
	Leading Scientist at DESY	1984-1996
	Research Director at DESY	1999- 2004
Current position	Professor for Experimental Physics, Univ. of Hamburg	1996- now

Field of Research: Experimental Particle Physics. Worked on experiments at CERN, DESY, Fermilab and Protvino; spokesperson for experiments NA-12/32 at CERN and ZEUS at DESY; study of strong interactions and of heavy quarks; development of precision silicon detectors, calorimetry and readout electronics; construction of large detector systems, coordination and management of experiments.

Five relevant publications

1) E. Belau et al., Nucl. Instrum. Meth. 217:224-228, 1983.
2) J. Breitweg et al., Eur. Phys. J. C7: 609-630, 1999.
3) G. Bondarenko et al., Nucl. Instrum. Meth. A442: 187-192, 2000.
4) D. Dannheim et al.,A505: 663-682, 2003.
5) W. Adam et al., Instrum. Meth. A543: 463-482, 2005.

Prof. Dr. Shaukat Khan (U Hamburg)	***1958**

Scientific career

University	Diploma in nuclear physics, Univ. Heidelberg	1978-1985
PhD	Univ. Heidelberg, experiments at MAMI (Mainz)	1985-1987
Post-Doc	Post-doc at MPI für Kernphysik (Heidelberg)	1987-1993
	member of the ARGUS collaboration at DESY	1989-1993
Senior Scientist	accelerator physicist at BESSY (Berlin)	1993-2006
Current position	Professor, Univ. of Hamburg	2006- now

Fields of Research: experimental nuclear and particle physics, work in nuclear reactions (with experiments at MPI Heidelberg, FZ Karlsruhe and MAMI, Mainz), data acquisition, silicon strip detectors, radiation background studies, experiments with internal targets (ARGUS and HERA-B at DESY). Since 1993, accelerator physics, participation in the construction and operation of the synchrotron light source BESSY II, impedance and instability studies, construction of bunch-by-bunch feedback systems, generation of ultrashort synchrotron radiation pulses (design, construction, commissioning, project coordination). Since 2006, professor at Univ. Hamburg, work on laser-based diagnostics at FLASH.
.

Selected publications

1) S. Khan, *Collective Phenomena in Synchrotron Radiation Sources*, Springer-Verlag (2006)
2) S. Khan, K. Holldack, T. Kachel, R. Mitzner, T. Quast, , Phys. Rev. Lett. 97 (2006), 074801
3) K. Holldack, S. Khan, R. Mitzner, T. Quast, Phys. Rev. Lett. 96 (2006), 054801
4) K. Holldack, T. Kachel, S. Khan, R. Mitzner, T. Quast, Phys. Rev. ST Accel. Beams 8 (2005)
5) S. Khan, Proceedings of the 2005 Particle Accelerator Conference (2005), 590

Prof. Dr. Bernd A. Kniehl (U Hamburg)	***1961**

Scientific career

University	Diploma in Physics, U Karlsruhe,	1981-1987
	Certificate of Advanced Studies, U Cambridge, UK	1984-1985
PhD	Dr. rer. nat., MPI for Physics and TU München	1987-1989
Employments	Research Associate, UW Madison	1989-1991
	Research Associate, DESY Hamburg	1991-1992
	Assistant, Habilitation and “Privatdozent”, U Hamburg	1992-1994
	Staff Member and “Privatdozent”, MPI and TU München	1994-1999
Current position	Full Professor (C4), University of Hamburg	1999-now

Field of Research: Theoretical particle physics with focus on phenomenology; higher-order perturbative calculations in quantum field theory; precision tests of the Standard Model; Higgs-boson phenomenology; formulation of low-energy and decoupling theorems; theory of fragmentation; development of non-relativistic QED and QCD in higher orders and applications to bound-state phenomena and threshold dynamics; theory of heavy quarks and quarkonia; renormalization in the presence of unstable particles and flavour mixing.

Selected publications

1) B.A. Kniehl, Nucl. Phys. B347 (1990) 86-104
2) B.A. Kniehl, Phys. Rept. 240 (1994) 211-300
3) B.A. Kniehl, A. Sirlin, Phys. Rev. Lett. 81 (1998) 1373-1376
4) M. Klasen, BA. Kniehl, L.N. Mihaila, M. Steinhauser, Phys. Rev. Lett. 89 (2002) 032001
5) B.A. Kniehl, A.V. Kotikov, A.I. Onishchenko, O.L. Veretin, Phys. Rev. Lett. 97 (2006) 042001

Appendix

Prof. Dr. Karlheinz Meier (U Heidelberg)	***1955**

Scientific career

University	Diploma in Physics, Univ. Hamburg, Particle Physics	1975-1981
PhD	Dr. rer. nat. Univ. Hamburg, JADE experiment	1981-1984
Employments	Research Fellow, CERN, UA2 Experiment	1984-1986
	Staff Member, CERN, UA2 Experiment	1986-1990
	Staff Member, DESY, H1 Experiment	1990-1992
Current position	Chair Experimental Physics, University of Heidelberg	1992-today

Fields of Research: Experimental Particle Physics : Perturbative and non-perturbative QCD in ep and pp-collisions. Experimental test of QFT for high energy scattering of hadrons in the framework of the H1 and ATLAS experiments. Particle Physics Instrumentation : Calorimetry, Development and operation of digital, analog and mixed-signal VLSI circuits for particle physics experiments. Biophysics: Research on analog and mixed-signal VLSI systems emulating the neural microcircuit. Experimental study of novel computing concepts.
Management Experience: Founding Director of the Kirchhoff-Institut für Physik and the ASIC Laboratory for Microelectronic in Heidelberg, Dean of the Heidelberg Physics Department (2 years), Vice-Rector of Heidelberg University (3 years), Chair of the European Committee for Future Accelerators (ECFA) since 2007.

Selected publications

1) J. Alitti et al., Z. Phys. C - Particles and Fields 49, 17-28 (1991)
2) C. Adloff et al., Phys. Lett. B544, 35-43 (2002)
3) A. Stellberger et al., Nucl. Instr. Meth. A515 (2003) 545-562
4) J. Garvey et al. Nucl. Instr. Meth. A512 (2003) 506-516
5) J. Schemmel et al., Analog Integ. Circ. and Sign. Proc., 3 (2004)
6) M. Loose et al., IEEE J. of Sol. State Circoits, Vol. 36 (2001)

Prof. Dr. Thomas Müller (U Karlsruhe)	***1953**

Scientific career

University	Diplom in Physics, Univ. Bonn, Particle Physics	1973-1979
PhD	Dr. rer. nat. Univ. Bonn; UA5 exp. at CERN	1980-1983
Employments	CERN Fellow EP Division; UA1 exp. at CERN	1984-1985
	Staff member, CERN; UA1 exp. at CERN	1986-1990
	SSC Fellow; SDC exp. at the SSC	1991-1992
	Assist., Associate & Full Prof. at UCLA; CDF expt FNAL	1990-1996
Current position	Full Professor, U Karlsruhe; CDF & CMS expt. CERN	1996-now

Field of Research: Experimental Particle Physics. Study of Proton-Antiproton and Proton-Proton reactions, EWK and Top Quark Physics, searches for the Higgs Boson, development of experimental techniques. Construction of large detector systems, coordination and management of experimental groups, spokesperson of US-CMS in 1994-1996 and of DCMS in 1998-2003, Dean of Physics in Karlsruhe 2004-2006.

Selected publications

1) CMS Collaboration, Nucl.Instrum.Meth.A408:119-127,1998
2) M. Erdmann (ed.) & Th. Muller (ed.). Berlin, Germany: Springer (2003) 527
3) J. Kaminski, et al., Nucl.Instrum.Meth.A535:201-205,2004
4) S. Abdullin, et al., Eur.Phys.J.C39S2:41-61,2005
5) CDF Collaboration, Phys.Rev.D71:012005,2005

Prof. Dr. Dieter Zeppenfeld (U Karlsruhe) *1956

Scientific career

University	Univ. Münster	1975-1977
	Diploma in Physics, Univ. München	1977-1980
PhD	Dr. rer. nat. Univ. München	1981-1984
Post-Doc	Post-doc at DESY, Hamburg	1984-1986
	Assistant Scientist, Univ. of Wisconsin, Madison, USA	1986-1989
Professor	Univ. of Wisconsin, Madison, USA	1989-2005
Current position	Professor, Univ. of Karlsruhe	2004- now

Field of Research: Theoretical Particle Physics. Electroweak and strong interactions, in particular at hadron and lepton colliders. Higgs search and study of electroweak symmetry breaking. Radiative corrections to collider processes. Strategies for observing physics beyond the Standard Model

Selected publications

1) Measuring Higgs boson couplings at the LHC, Phys. Rev. D62, 013009 (2000)
2) Next-to-leading order jet distributions for Higgs boson production via weak-boson fusion, Phys. Rev. D68, 073005 (2003)
3) Next-to-leading order QCD corrections to W+W- production via vector-boson fusion, JHEP 0607, 015 (2006)
4) Anomalous Higgs boson couplings in vector boson fusion at the CERN LHC, Phys. Rev. D74, 095001 (2006)
5) Monte Carlo studies of the jet activity in Higgs + 2jet events, JHEP 0610, 016 (2006)

Prof. Dr. Stefan Tapprogge (U Mainz) *1967

Scientific career

University	Diploma in Physics, Univ. Heidelberg, NA45 experiment at CERN	1987-1992
PhD	Dr. rer. nat. Univ. Heidelberg, H1 experiment at DESY	1993-1996
Employments	Post-doc, Univ. of Heidelberg, H1 experiment at DESY	1997
	Research Fellow, CERN, ATLAS experiment at CERN	1998-2000
	Senior Scientist, Helsinki Institute of Physics, ATLAS and TOTEM experiments at CERN and CDF experiment at Fermilab	2001-2003
Current position	Associate Professor, University of Mainz, D0 experiment at Fermilab and ATLAS experiment at CERN	2004- now

Field of Research: Experimental Particle Physics. Study of electron-proton, proton-(anti)proton and heavy ion reactions, precision measurements and searches for physics beyond the Standard Model, development of experimental techniques (especially for triggering and data acquisition as well as for detection of leading particles). Coordination of experimental projects and working groups

Selected publications

1) G. Agakishiev et al., Phys.Rev.Lett. 75 (1995) 1272
2) T. Ahmed et al., Phys.Lett. B348 (1995) 681
3) S. Aid et al., Nucl.Phys. B470 (1996) 3
4) C. Adloff et al., Z.Phys. C74 (1997) 191
5) D. Acosta et al., Phys.Rev.Lett. 93 (2004) 072001

Appendix

Prof. Dr. Matthias Neubert (U Mainz) *1962

Scientific career

University	Diploma in Physics, Univ. Heidelberg	1984-1988
PhD	Dr. rer. nat., Univ. Heidelberg, theoretical physics	1988-1990
Habilitation	Univ. Heidelberg	1993
Post-Doc	Research scientist, Univ. Heidelberg	1990-1991
	Research scientist, SLAC	1991-1993
Senior scientist	Staff member, CERN	1993-1998
	Visiting professor, Stanford Univ.	1999
Faculty	Professor of physics, Cornell Univ.	1999- now
Current position	Professor of Physics, Mainz Univ.	2006- now
Adjunct professor	Univ. Heidelberg	1998- now

Field of Research: Theoretical elementary particle physics, focus phenomenology. Fields of linterest: quantum field theory, QCD, flavor physics and CP violation, heavy quarks, effective field theory, physics beyond the Standard Model. Director, Cornell Institute for High-Energy Phenomenology (2003-2006). Editor, Journal of High-Energy Physics and European Physical Journal C (1997-now). Associate Editor, Reviews of Modern Physics (2001-2004). Consultant for US National Science Foundation, Department of Energy, HEPAP, University Research Foundation. Organizer of several international conferences.

Five relevant publications

1) *Threshold resummation in momentum space from effective field theory*, T. Becher and M. Neubert, Phys. Rev. Lett. 97: 082001 (2006)
2) *Neutrino masses and mixings in nonfactorizable geometry*, Y. Grossman and M. Neubert, Phys. Lett. B 474, 361 (1999)
3) *QCD factorization for $B \to \pi\pi$ decays: Strong phases and CP violation in the heavy-quark limit*, M. Beneke, G. Buchalla, M. Neubert, and C.T. Sachrajda, Phys. Rev. Lett. 83, 1914 (1999)
4) *QCD anatomy of $B \to X_s\gamma$ decays*, A.L. Kagan and M. Neubert, Eur. Phys. J. C 7, 5 (1999)
5) *Heavy quark symmetry*, M. Neubert, Phys. Rep. 245, 259 (1994)

Prof. Dr. Dorothee Schaile (LMU München)	***1954**

Scientific career

University	Diploma in Physics, U Freiburg, Particle Physics	1972-1978
PhD	Dr. rer. nat. Univ. Freiburg, experiment NA6 at CERN	1979-1982
Post-Doc	Post-doc Univ. of Freiburg,	1982-1984
	Fellow at CERN	1984-1987
Hochschulassistent	Freiburg University, Habilitation 1991	1987-1993
Heisenberg Fellow	Weizmann Institute, Rehovot and CERN	1993-1996
Current position	Chair Experimental Elementary Particle Physics, LMU München	1996- now
	Director Maier-Leibnitz-Laboratorium der LMU and TU München	2001-2002 2005-2006

Field of research: Experimental Particle Physics: Experiments at CERN (NA6 at SPS, OPAL at LEP, ATLAS at LHC) and Fermilab (D0 at TeVatron); spokesperson of the LEP Electroweak Working Group (1993-1996); study of high energy collider reactions, in particular, precision tests of electroweak interactions, origin of particle masses, symmetry between matter and forces; detector development (NA6 hydrogen live-target, OPAL Jet-Chamber, ATLAS muon detector); Grid-computing for LHC.
Five relevant publications

1) *Measurement of the mass and width of the W boson*, G. Abbiendi et al. (OPAL Collaboration), Eur.Phys.J.C45:307-335,2006.
2) *Search for the Higgs boson in H → WW(*) decays in p anti-p collisions at s**(1/2) = 1.96 TeV*, V.M. Abazov et al. (D0 Collaboration), Phys.Rev.Lett.96:011801,2006.
3) *Search for supersymmetry via associated production of charginos and neutralinos in final states with three leptons,* V.M. Abazov et al. (D0 Collaboration), Phys.Rev.Lett.95:151805,2005.
4) *Precise determination of the Z resonance parameters at LEP: 'Zedometry'*, G. Abbiendi et al.(OPAL Collaboration), Eur.Phys.J.C19:587-651,2001.
5) *Tests of the electroweak theory at LEP*, D. Schaile, Fortsch.Phys.42:429-484,1994.

Appendix

Prof. Dr. Henning Schröder (U Rostock)	***1945**

Scientific career

University	Diploma in Physics, U Freiburg, Nuclear Physics	1964-1969
PhD	Dr. rer. nat. U Freiburg, Nuclear Physics	1970-1973
Post-Doc	Univ. Assistant, U Freiburg	1973-1976
	Postdoc at MPI Heidelberg at CERN	1974-1977
Senior Scientist	Scientist, DESY	1977-1999
Current position	Professor, U Rostock	1999- now

Field of Research: Experimental Particle Physics. Worked on experiments at DESY (DASPII and ARGUS at DORIS, HERA-B-Experiment at HERA), and at present working on OPERA (LNGS)and BABAR(SLAC), spokesman of ARGUS from 1990 to 1996, physics and software coordinator at ARGUS from 1978 to 1990. Study of electron-positron reactions, in particular states containing heavy quarks and searches for neutrino oscillations. Development of experimental techniques, e.g. TDC readout. Coordination and management of experiments, 1997 W.K.H.Panofsky Prize in Experimental Particle Physics.

Selected publications

1) *Spectroscopy and Decays of Heavy Quarks*, invited Talk, Proceedings of ICHEP88, Springer
2) *BB-Mixing* in *B Decays,* edited by S.Stone, 1994, World Scientific
3) *Observation of B0B0bar,* Phys.Lett. B192 (1987), 245
4) *Reconstruction of semileptonic b to u Decays,* Phys.Lett. B255(1991) 297
5) *Measurement of the Decay B0 to D*-l+neutrino,* Phys.Lett. B197(1987) 452

Prof. Dr. Markus Schumacher (U Siegen)	***1970**

Scientific career

University	Diploma in Physics, Univ. Bonn, OPAL exp.	1994-1996
PhD	Dr. rer. nat. Univ. Bonn,	1996-1999
Employments	Research Fellow, DESY Hamburg	1999-2001
	Hochschulasistent, Univ. Bonn	2001-2006
Current position:	Professor, University of Siegen	2006-now

Field of Research: Experimental Particle Physics. Study of electroweak symmetry breaking, Higgs physics at LHC (now) and LEP (past) and ILC (past and future). R&D for tracking detectors at ILC (past and now). Convenor of "Overall Detector Performance Group for ILC" July 2002 to August 2005. Convenor of ATLAS Higgs Working Group since July 2005.

Selected publications

1) Electron-Positron-Colliders, invited Talk, Proceedings of LP01, World Scientific
2) G. Abbiendi et al., Eur.Phys.J.C33 (2004) 463
3) R. Barate et al., Phys.Lett. B565 (2003), 614
4) G. Abbiendi et al., Phys.Lett.B577 (2003) 93
5) V. Andreev et al., Nucl. Instr. Meth. A566 (2006) 144

Prof. Dr. Wolfgang Kilian (U Siegen)	*1966

Scientific career

University	Diploma in Physics, TU Darmstadt, Th. Particle Physics	1986-1991
	Dr. rer. nat. TU Darmstadt, Th. Particle Physics	1991-1994
Post-Doc	Post-doc, DESY	1994-1996
	Post-doc, Univ. of Heidelberg	1996-1998
	Post-doc and Univ. Assistant, Univ. of Karlsruhe	1998-2003
	Staff member and Helmholtz Y.I.Group Leader, DESY	2003-2006
Current position	Professor, Univ. of Siegen	2006- now

Field of research: Theoretical Particle Physics, Phenomenology. Areas of interest: Electroweak interactions, Higgs physics, strongly interacting W bosons, Little-Higgs models, Supersymmetry, Monte-Carlo simulation (main author of WHIZARD). Earlier work on B physics, higher-order corrections, diffraction.

Selected publications

1) Strongly Interacting Vector Bosons at TeV e+e- Linear Colliders, Phys.Rev. D57 (1998) 1553
2) Testing Higgs Self-Couplings at e+e- Linear Colliders, Eur.Phys.J. C10 (1999) 45
3) The Low-Energy Structure of Little Higgs Models, Phys.Rev. D70 (2004) 015004
4) Split Supersymmetry at Colliders, Eur.Phys.J. C39 (2005) 229
5) SUSY Simulations with Off-Shell Effects for LHC and ILC, Phys.Rev. D73 (2006) 055005

Prof. Dr. Reinhold Rückl (U Würzburg)	*1945

Scientific career

University	Diploma (Dipl. Phys.) in Physics, U München	1966-1971
PhD	Dr. rer. nat., Univ. München and MPI München	1972-1976
Habilitation	Dr.rer.nat.habil. in Theoretical Physics, U München	1984
Employments	Adjunct Assistant Professor, UCLA	1976-1978
	Postdoctoral Fellow, MPI of Physics, München	1978-1980
	Associate Professor, Univ. Bielefeld	1980-1981
	Scientific Assistant, Univ. München	1981-1983
	Scientific Associate, CERN, Geneva	1983-1984
	Assistant Professor, Univ. München	1984-1985
	Scientific Associate, DESY, Hamburg	1985-1988
	Associate Professor, Univ. München and MPI München	1989-1996
Current position	Full Professor, Chair of Theoretical Physics, U Würzburg	1996-now

Field of Research:
Theoretical particle physics, quantum field theory, standard model of leptons and quarks, supersymmetry, extra dimensions, non-commutative geometry, collider physics, neutrino and flavour physics

Selected publications

1) T. Binoth, S. Karg, N. Kauer, R. Rückl, Phys. Rev. D74 (2006) 113008
2) A. Alboteanu, T. Ohl, R. Rückl, Phys. Rev. D74 (2006) 096004
3) A. Mück, L. Nilse, A. Pilaftsis, R. Rückl, Phys. Rev. D71 (2005) 066004
4) F. Deppisch, H. Päs, R. Redelbach, R. Rückl, Phys. Rev. D69 (2004) 054014
5) F. Deppisch, H. Päs, A. Redelbach, R. Rückl, Y. Shimizu, Eur. Phys. J. C28 (2003) 365

Appendix

Prof. Dr. Peter Mättig (U Wuppertal)	***1949**

Scientific career

University	Diploma in Physics, University of Bonn,	1969-1976
PhD	Dr. rer. nat. University of Bonn	1979
Employments	Postdoc RWTH Aachen,	1979-1980
	DESY	1980-1985
	IPP Canada in Ottawa and Geneva	1985-1989
	CERN	1989-1990
	University of Bonn	1989-1995
	Weizmann Institute (Israel)	1995-2001
Current position	Full Professor, University of Wuppertal	2001-now

Field of Research: TASSO experiment at PETRA, OPAL at LEP, work on QCD and Jet Physics, Non-Standard Higgs Physics. D0 experiment at Tevatron and ATLAS at LHC: Top Quark Physics, Extra Dimensions, Grid Computing, Pixel Detectors.

Selected publications

1) V.M. Abazov et al., First direct two-sided bound on the BO(s) oscillation frequency, submitted to Phys.Rev.Lett. 2006.
2) V.M. Abazov et al., Phys.Rev.D72, (2005) 011104.
3) G. Abbiendi et al., Phys.Lett.B499, (2001) 38.
4) G. Alexander et al., Z.Phys.C52 (1991) 175.
5) R. Brandelik et al., Phys.Lett.B86, (1979) 243.

Prof. Dr. Robert Harlander (U Wuppertal)	***1970**

Scientific career

University	Diploma in Physics, Univ. Karlsruhe	1991-1995
PhD	Dr. rer. nat. Univ. Karlsruhe, Theor. Particle Physics	1995-1998
Post-Doc	Post-doc, Univ. Karlsruhe	1998-1999
	DFG Fellow, Brookhaven Nat'l Laboratory, USA	1999-2001
	Fellow, CERN	2001-2003
	Emmy Noether Junior Research Group, Univ. Karlsruhe	2003-2005
Current position	Professor, Univ. Wuppertal	2005- now

Field of research: Theoretical particle physics and phenomenology. Radiative corrections to precision observables at hadron and lepton colliders. Higgs physics, supersymmetry, perturbative QCD. Contributions to the precise prediction Higgs production cross sections at the Large Hadron Collider in the Standard Model and in supersymmetry. Development and application of methods and tools for the evaluation of radiative corrections.

Selected publications

1) Recent theoretical progress on Higgs production, invited talk, Proc. of HCP2002, Springer
2) Next-to-next-to-leading order Higgs production at hadron colliders, with W.B. Kilgore, Phys. Rev. Lett. 88 (2002) 201801
3) Virtual corrections to $gg \to H$ to two loops in the heavy top limit, Phys. Lett. B492 (2000) 74
4) Supersymmetric Higgs production in gluon fusion at next-to-leading order, with M. Steinhauser, JHEP 0409 (2004) 066.
5) Two-loop matching coefficients for the strong coupling in the MSSM, with L. Mihaila and M. Steinhauser, Phys. Rev. D72 (2005) 095009

Prof. Dr. Siegfried Bethke (MPI München)	***1954**

Scientific career

University	Diploma in Physics, Univ. Heidelberg	1975-1980
PhD	Dr. rer. nat. Univ. Heidelberg, experiment at DESY	1980-1983
Employments	Univ. Assistant, Univ. of Heidelberg,	1983-1986
	Lynen Fellow of Humboldt Foundation at Lawrence Berkeley Lab	1987-1989
	Heisenberg Fellow of DFG at CERN	1989-1993
	Full Professor at III. Phys. Institute, RWTH Aachen	1993-1999
Current position	Director at Max-Planck-Institute of Physics, München	1999- now
	Honorary Professor at Technical University München	2000- now

Field of Research: Experimental Particle Physics at high energy colliders; development of particle detectors; experimental tests of Quantum-Chromodynamics.

Leibniz Award of the German Science Foundation (DFG), 1995

Selected publications

1) *Experimental Tests of Asymptotic Freedom*, hep-ex/0606035, to appear in Prog. Part. Nucl. Phys.
2) α_s *at Zinnowitz 2004,* Nucl. Phys. Proc. Suppl. 135 (2004) 345.
3) *QCD Studies at LEP*, Phys. Rept. 403-304 (2004) 203-220.
4) S.B., Z.Kunszt, D.Soper, W.Stirling*, New Jet Cluster Algorithms…*, Nucl.Phys. B370 (1992) 310.
5) W. Bartel et al., JADE Collab., *Exp. Studies on Multi-Jet Production…*, Z.Phys. C33 (1986) 23.

Prof. Dr. Wolfgang Hollik (MPI München)	***1951**

Scientific career

University	Diploma in Physics, U Würzburg, Theor Physics	1970-1976
PhD	Dr. rer. nat. U Würzburg, Theor. Physics	1976-1979
Post-Doc	DFG Project U Würzburg	1979-1983
	Assistant, U Hamburg	1983-1989
	Habilitation, U Hamburg	1989
	Scientific Associate, CERN	1989
Senior Scientist	Staff member, MPI München	1990-1993
Professor	Full Professor, U Karlsruhe	1993-2002
Current position	Director at MPI München	2002-now

Field of Research: Theoretical Particle Physics. Work on: precision electroweak physics, quantum effects in the Standard Model, phenomenology of Supersymmetry, Higgs physics, loop calculations and automatized calculations of high-energy processes at colliders, tests of the Standard Model and of the supersymmetric Standard Model at hadron colliders and electron-positron colliders. Head of Institute of Theoretical Physics at Karlsruhe University 1993-2002. Scientific Member of the Max Planck Society since 2002. Honorary Professor at the Technical University Munich since 2005. Managing Director of MPI for Physics since April 2006.

Selected publications

1) *The Higgs boson masses and mixings of the complex MSSM in the Feynman-diagrammatic approach*, JHEP 02 (2007) 047

Appendix

2) *The effective electroweak mixing angle with two-loop bosonic contributions,* Nucl. Phys. B 765 (2007) 154
3) *Electroweak Precision observables in the Minimal Supersymmetric Standard Model,* Phys. Reports 426 (2006) 265
4) *Towards high-precision predictions for the MSSM Higgs sector,* Eur. Phys. J. C (2003) 133
5) *Electroweak Physics,* Acta Phys. Polon. 35 (2004) 2533

4.2 Overall resource planning

Financial Representation

centre/partner: all topic: all	2007	2008	2009	2010	2011	2012
	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
Total project costs[1)]	6,569.5	14,174.9	15,837.0	14,842.4	14,568.8	7,434.3
thereof personnel costs	3,897.3	9,401.7	11,229.7	10,768.2	10,605.8	5,310.2
thereof financed through institutional funding	4,989.5	9,346.6	9,276.2	8,999.9	8,887.6	4,546.1
thereof financed through third party funding	289.0	510.0	474.0	484.0	424.0	200.0
requested IVF[2)] funding	1,291.0	4,318.3	6,086.8	5,358.5	5,257.2	2,688.2

[1)] including general and administrative costs, internal services etc.
[2)] Impuls- und Vernetzungsfonds = Initiative and networking fund

Reconciliation of requested IFV funding into expenses *(for information only)*	TEUR	TEUR	TEUR	TEUR	TEUR	TEUR
costs requested through IVF	1,291.0	4,318.3	6,086.8	5,358.5	5,257.2	2,688.2
noncash expenditures (depreciation)	37.5	124.8	244.4	405.5	626.8	378.5
Investments	736.7	1,641.7	1,180.8	1,060.0	720.8	305.8
Expenses	1,075.8	3,598.5	5,072.4	4,465.5	4,381.0	2,240.2

Personnel *(for information only)*	FTE	FTE	FTE	FTE	FTE	FTE
Personnel (financed through IVF)						
Scientists	4.50	29.75	54.25	49.50	47.00	23.25
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	3.25	10.50	14.50	13.00	13.00	7.00
Personnel (financed through institutional or third party funding)						
Scientists	46.65	96.50	99.50	98.00	97.70	47.45
Doctoral students	0.00	0.00	0.00	0.00	0.00	0.00
Scientific support personnel	17.00	34.20	34.45	33.70	33.70	18.70

Participation of the partners

	Total costs in sum by each partner	**thereof financed through IVF**	**thereof financed through own funding**
	TEUR	TEUR	TEUR
Total	73,426.8	25,000.0	48,426.8
Partner 1: Deutsches Elektronen-Synchrotron	11,111.0	5,112.0	5,999.0
Partner 2: Forschungszentrum Karlsruhe	1,592.0	464.0	1,128.0
Partner 3: Rheinisch-Westfälische Technische Hochschule Aachen	8,758.8	1,317.0	7,441.8
Partner 4: Humboldt-Universität zu Berlin	1,270.0	100.0	1,170.0
Partner 5: Rheinische Friedrich-Wilhelms-Universität Bonn	5,665.1	1,788.0	3,877.1
Partner 6: Universität Dortmund	1,580.0	247.0	1,333.0
Partner 7: Technische Universität Dresden	2,345.0	780.0	1,565.0
Partner 8: Albert-Ludwigs-Universität Freiburg	2,879.7	810.5	2,069.2
Partner 9: Justus-Liebig-Universität Giessen	257.5	107.5	150.0
Partner 10: Georg-August-Universität Göttingen	5,004.5	812.0	4,192.5
Partner 11: Universität Hamburg	3,669.5	1,337.0	2,332.5
Partner 12: Ruprecht-Karls-Universität Heidelberg	2,360.0	1,130.0	1,230.0
Partner 13: Universität Karlsruhe (TH)	6,069.2	1,282.0	4,787.2
Partner 14: Johannes Gutenberg-Universität Mainz	944.0	122.5	821.5
Partner 15: Ludwig-Maximilians-Universität München	3,988.5	868.5	3,120.0
Partner 16: Universität Rostock	497.5	107.5	390.0
Partner 17: Universität Siegen	2,710.0	487.0	2,223.0
Partner 18: Bayerische Julius-Maximilians-Universität Würzburg	896.8	290.0	606.8
Partner 19: Bergische Universität Wuppertal	5,894.7	1,904.5	3,990.2
Backbone	5,933.0	5,933.0	0.0

Appendix

Participation of the topics		Total costs in sum by each topic	thereof financed through IVF	thereof financed through own funding
		TEUR	TEUR	TEUR
Total		73,426.8	25,000.0	48,426.8
Topic 1:	Analysis	20,464.8	4,002.0	16,462.8
Topic 2:	Grid	21,221.4	6,658.5	14,562.9
Topic 3:	Detector	23,230.6	7,159.5	16,071.1
Topic 4:	Accelerator	2,577.0	1,247.0	1,330.0
	Backbone	5,933.0	5,933.0	0.0

4.3 List of participating institutions and associated partners

Participating Helmholtz Centres*	**Location**
Deutsches Elektronen-Synchroton (DESY)	Hamburg & Zeuthen
Forschungszentrum Karlsruhe (FZK)	Karlsruhe
Participating universities*	**Location**
Rheinisch-Westfälische Technische Hochschule Aachen	Aachen
Humboldt-Universität zu Berlin	Berlin
Rheinische Fridrich-Wilhelms-Universität Bonn	Bonn
Universität Dortmund	Dortmund
Technische Universität Dresden	Dresden
Albert-Ludwigs-Universität Freiburg	Freiburg
Justus-Liebig-Universität Giessen	Giessen
Georg-August-Universität Göttingen	Göttingen
Universität Hamburg	Hamburg
Ruprecht-Karls-Universität Heidelberg	Heidelberg
Universität Karlsruhe (TH)	Karlsruhe
Johannes Gutenberg-Universität Mainz	Mainz
Ludwig-Maximilians-Universität München	München
Universität Rostock	Rostock
Universität Siegen	Siegen
Bayerische Julius-Maximilians-Universität Würzburg	Würzburg
Bergische Universität Wuppertal	Wuppertal
Associated partners**	**Location**
Max-Planck-Institut für Physik	München

* Institutions which are applying for funding from the Initiative and Networking Fund
** Institutions or enterprises without funding from the Initiative and Networking Fund

4.4 Declaration of each participating institution on the provision of resources