Report on the Mid Term Review of the Helmholtz Alliance "Physics at the Terascale"

Hamburg, 30 November – 01 December 2009

Table of Contents

Information provided to the Review Panel

The review panel has taken into account the following written information, submitted for its consideration:

- Physics at the Terascale Perspectives
- main performance Indicators on Project and Instrument Level
- Report on Resources
- Half year Report 2009
- Annual Report 2008
- Annual Report 2007
- Proposal for the Establishment of the TeraScale Alliance 04-2007
- Proposal Presentation 04-2007
- Articles published in refereed journals
- Articles not published in refereed journals
- presentations of the Helmholtz Association regarding the aims of the mid-term review

- the presentations of the Alliance participants
  - The Helmholtz Alliance Physics at the Terascale – scientific case, status and success, P. Mättig (Wuppertal) – Scientific Coordinator
  - Viewpoint of the young investigators, P. Uwer (HU Berlin)
  - Role/ meaning of the Alliance for the universities, A. Frey (Göttingen)
  - Role and meaning of the Alliance for DESY and KIT, I. Gregor (DESY)
  - Scientific, strategic and financial Perspectives of the Alliance; T. Behnke (DESY) – Scientific Coordinator

- the discussions with the Alliance participants in
  - the plenary session and
  - in small groups
  - clarification of remaining questions

Foreword

The Helmholtz Alliances aim to identify important new research topics and use them to achieve greater international visibility. Collaborations with external partners help create the critical mass required to develop topics of strategic importance to the Helmholtz Association. The Helmholtz Alliances make it possible to quickly identify new topics of interest and provide them with the necessary financial resources. This supplements the medium and long-term programme-oriented funding and thus contributes to fulfilling the mission of the Helmholtz Association.

Structural innovations are another important goal of the Alliances. The partnerships are intended to function as a network that, under the leadership of a Helmholtz Centre, integrates domestic and international partners from academia, non-university research and private enterprise. Helmholtz Centres draw on the Helmholtz Alliances to develop their core competencies in accordance with defining elements in their structural plans and development plans.

When the Helmholtz Alliances were established the conducting of a mid-term review was recommended, both with respect to each individual Alliance and to monitoring the success of the Helmholtz Alliances as a funding instrument The Aims of the mid-term review are:

1. to provide evaluations of existing scientific findings and potential future developments
2. to obtain and put into practice insights that will help ensure proper implementation of the projects in scientific, strategic and economic terms.
3. these perspectives will be used to identify success factors and draw conclusions for forthcoming Helmholtz Association funding.

The Helmholtz Association has elected the Review Panel for the Helmholtz Alliance "Physics at the Terascale".

Chairman of the Review Panel

Jos	**Engelen**	Netherlands Organisation for Scientific Research (NWO)	Den Haag, The Netherlands

Members of the Review Panel

Lyndon	**Evans**	CERN	Geneva, Switzerland
Neil	**Geddes**	STFC Rutherford Appleton Laboratory RAL	Didcot, U.K
Gino	**Isidori**	INFN Frascati National Laboratories	Frascati, Italy
Eberhard	**Jaeschke**	Helmholtz-Zentrum Berlin	Berlin, Germany
Peter	**Jenni**	CERN	Geneva, Switzerland
Eric	**Laenen**	NIKHEF	Amsterdam, The Netherlands
Terry	**Wyatt**	School of Physics and Astronomy University of Manchester	Manchester, UK

An overview about the delegates of the Government, of Partner Universities and of the Head Office of the Helmholtz Association participating in the evaluation can be found in the annex.

Executive Summary

The Helmholtz Alliance 'Physics at the *Terascale*' has succesfully achieved an efficient collaboration between the leading German groups in high energy physics. This has led and will further lead to highest quality ('world-class') results in *Terascale* physics (at the Large Hadron Collider at CERN and beyond). The research topics covered include: physics analysis; GRID computing; detector R&D; accelerator physics.

The Alliance has been very successful in developing instruments and in creating an environment offering opportunities to and attracting top class researchers, in particular also those at the beginning of their scientific career. It has set up a highly-motivating framework for students.

The Committee strongly recommends continuation of the Alliance along the present lines. The Committee is convinced that the Alliance should continue to play a structural role in the future. The Committee urges the partners to ascertain the future of the Alliance well before the current funding period expires.

Assessments and Recommendations of the Review Panel

Scientific Quality and Originality

A) PHYSICS ANALYSIS

In this research topic the Alliance aims to enable common projects, foster scientific exchange, generate thus far unavailable sustainable structures for LHC data analysis and phenomenology, and strengthen the key role of DESY and the German universities in preparing for future colliders.

The committee observes that the research carried out so far by the Alliance is outstanding, especially in the areas of Higgs and top physics, precision predictions for processes in the Standard Model, and beyond. The choices of these topics, together with the structures created to foster collaboration between theory and experiment, put the Alliance in a forefront position in the search for New Physics at the Terascale.

The new structures conceived by the Alliance in their proposal seem to work very well indeed. The committee is impressed with the large number of schools and workshops organized, and their popularity with and enthusiastic appreciation by students, who are actually beginning to request further schools on specific topics. In addition, the topical workshops that bring theoretical and experimental expertise together seems to be a very effective structure to address the coming challenges by LHC data analysis. It is positively noted that also these are increasingly organized through bottom-up initiatives, often by younger Alliance members.

A unique element is the Analysis Centre that has been set up at DESY. The committee believes this may be of key importance for the Alliance and its scientific goals. By providing common tools (Monte Carlo generators, Parton Distribution Functions, statistical methods), education and support, university groups have access to expertise that is necessary for high-quality research in this field. Particularly appreciated is the helpful attitude of its staff members. Although the real test of this Centre will happen in the coming years, the committee is confident that this will be a successful, valuable instrument that should be sustained. The fact that this Centre enables close theory-experiment collaboration, as well as inter-experiment fertilization, is seen as very positive by the Committee.

There can be no doubt that the Alliance and its structure bring major added value to German physics analysis at the Terascale.

B) GRID COMPUTING

Since the creation of the Alliance, the effectiveness of the German Tier-2 (T2) structures has improved measurably. There are two particular noteworthy aspects:

1) The funding, at least in part, of hardware resources at University T2 centres. This has leveraged additional 3rd party funding and explicitly supported the integration of these resources into a national, even international, infrastructure. This is vital for the LHC research programme and would have been impossible without the stimulus provided by the Alliance.

2) Leveraging the expertise at DESY and KIT in support of the University T2's, whether directly, through the federated T2 support model, or indirectly through improved services at the Tier-1 (T1) Centre. In particular, the long experience of DESY in supporting HEP computing has been, and should continue to be, exploited for the wider benefit of the German groups.

These actions have engaged an increased number of university groups directly with the wLCG activities, thereby increasing the German expertise and experience in this area. This will be vital to Germany fully exploiting the LHC.

The Alliance has also pursued a number of additional specific developments to date, many targeted at supporting the wider T2 and T3 communities and promoting sharing of expertise and experience across T1, T2 and T3 sites. Improving specific networking connections is a particular example where the Alliance has addressed an issue which is difficult to solve through local or regional measures.

The Alliance initiative in mass storage systems is noteworthy. Managing the very large data volumes required by HEP is clearly central to the successful exploitation of the LHC. It has been recognised by the wLCG that this subject is technically complex, more so than originally assumed, and that there is very limited expertise in this field. The Alliance has acknowledged this through its support of the dCache initiative led by DESY and has taken steps to improve and broaden expertise in this area through the fellowships devoted to grid storage. This area will remain important in the future and continued support in this area should be encouraged.

The National Analysis Facility (NAF) appears to have been very successful so far and has provided a means for researchers to become active in analysis activities without the need to first become grid computing experts. This is particularly valuable for researchers from smaller groups. There is a danger, however, that in insulating researchers from the complexities and challenges inherent in computing at the scale of the LHC, these challenges may increasingly be ignored, ultimately to the detriment of both German researchers and the LHC programme. The close integration of the NAF, and of the other emerging T3 centres, with the large (federated) DESY T2 centre is vital here. This will ensure that the NAF and T3s are appropriately integrated into wLCG and remain able to access LHC data efficiently.

The Alliance has clearly been able to bring a strategic national vision to coordination of computing activities focused on the LHC. This will be critical as Germany transitions to new organisational models around grid computing, with the traditional computer centres playing a major role going forward. HEP is likely to remain the largest grid user community for some time and it is essential that a strong community voice remain capable of influencing the wider grid developments. The Alliance must take care, however, to avoid simply duplicating activities undertaken elsewhere. The Alliance should work closely with other stakeholders to optimise programmes going forward. Developments at, for example, Göttingen and LMU are encouraging here.

Over the remaining years of the Alliance, the focus on the data access and optimisation for analysis is appropriate. However, more effort should perhaps be focused directly on working towards longer term commitments or support for those aspects where the Alliance has shown clear added value and which can not currently be supported easily by other means, e.g.:

- Facilitating T2 hardware investments integrated into a national or international infrastructure

- Exploiting existing expertise at DESY and KIT in direct support of the T2 and T3/NAF activities
- Providing high level strategic vision and coordination of the T1+T2+T3 infrastructure.
- Supporting and sustaining strategically important expertise such as that in large scale data management.

C) DETECTOR R&D

German groups associated with the Alliance are doing a large amount of world-class work in the area of detector research and development (R&D). This work has a high international profile, and establishes a strong position of leadership for German groups, both in planning for upgrades to the LHC detectors and in preparations for detectors at a future high energy electron-positron collider. The Alliance has also been open to exploitation of the relevant detector technologies beyond the field of energy frontier collider physics, for example, in areas such as DAQ and detector electronics for the European XFEL and a possible DEPFET-based pixel detector for the Belle-II detector.

The provision of common infrastructure and the associated technical support staff under the auspices of the Alliance has been extremely successful in promoting substantially increased collaboration among groups from different universities and laboratories. The committee strongly supports the long term aim that university groups who have been thus enabled to begin new programmes in detector R&D are ultimately successful in bidding for project funds from other sources, such as BMBF. Given the long lead times to be expected in procuring equipment and appointing staff, the committee supports the choice to commit most of the resources early on in the cycle. Nevertheless, the recently completed second call for "project" funding has been used to provide valuable additional items of common infrastructure and support. Furthermore, we see the Alliance as performing a useful role as a Joint Research Unit (JRU), coordinating applications for EU funding, the administrative overhead for which would be beyond the resources of individual university groups.

The committee views continued strength in detector R&D as an essential element in maintaining an appropriate balance of expertise within the German particle physics community and ensuring diverse interests and skills in the cohort of new PhD students entering the field.

As DESY adapts to its new role in German particle physics after the closure of the HERA accelerator, the committee sees the maintenance of facilities for large-scale detector construction and integration as an essential function that the laboratory should continue to fulfil.

A high quality and valuable programme of basic detector R&D can already be foreseen to extend well beyond the current end in 2012 of the Alliance funding. When the Alliance was first established, 2012 was a natural timescale on which to expect the first significant discoveries from the LHC experiments. These will be needed before concrete plans can be drawn up for the appropriate set of upgrades to the LHC experiments and a choice can be made between the options for a future high energy electron-positron collider. Given the current status of the LHC, 2014 now seems to be a more realistic timescale on which to be taking such decisions. The committee sees considerable potential benefit in continued funding for common infrastructure and support in the area of detector R&D in Germany beyond 2012. This would enable the German particle physics community to be well equipped to take the necessary strategic decisions on future activities in detector construction and R&D when the appropriate time comes.

Strategic Relevance

General Remarks

The Alliance is an effective organizational structure for conducting research in high energy physics in a coherent, nationally coordinated way. It greatly helps in consolidating a strong international position for its partners.

Evaluation of the strategic relevance of the Alliance

The Alliance effectively optimizes the return on investment in High Energy Physics. It does this through developing common infrastructures, through networking and through young investigator and fellowship programmes, and through a rich educational programme with training for students.

The Alliance has defined four research pillars that form the framework for the scientific programme of 'Physics at the Terascale'. This structure allows an effective coverage of all the activities. In particular this allows the German high energy physics groups to fully exploit the physics potential of the LHC. The investments, the design and construction work and the preparation for physics analysis are about to pay off.

The Alliance was very successful in:

- promoting collaboration between theorists and experimentalists in physics analysis; in developing analysis 'tools' (e.g. parton distribution functions; statistical tools) for common use

- effectively creating T2 centers for the Worldwide LHC Computing GRID, at DESY and also at various universities. In particular the latter would not have been possible without the Alliance

- in creating, maintaining and 'networking' infrastructure for detector R&D

- in connecting to the SC RF cavity production (and qualification) work for the European XFEL, keeping this unique expertise available for ILC; in starting activities at various universities to train the future generation of accelerator physicists.

The Alliance is essential for organizing its partners to encourage and support a long term perspective in high energy physics (which is an important example of the large-scale research sometimes referred to as 'big science').

The Workshops and Schools organized by the Alliance are very important for building capacity and excellence.

The fellowships and young investigator groups introduced by the Alliance are particularly attractive because the network offered by the Alliance and the long term perspective provide excellent conditions for such groups to flourish.

D) ACCELERATOR PHYSICS

Given the small fraction of the funding in accelerator physics, it cannot be expected that it will have the same visibility as the other three pillars. The available funds are well used, mainly for the education of young people in accelerator science through sponsoring attendance at schools and lectures in universities. One of the difficulties in the teaching of accelerator science at the university undergraduate level is the need for a formal curriculum to be recognized in order to be able to award credits. However, it seems that there is no problem in attracting bright young people and this initiative will certainly help in training the new young generation of accelerator scientists that will be needed in the future.

There are possibilities to extend the education of the best students to Doctorate level by collaborating with large accelerator laboratories as DESY and CERN. It was noted that the construction of the European XFEL will give a unique opportunity to advance the science and understanding of superconducting cavities during the production of the 800 cavities needed for the XFEL and this would be an ideal subject for thesis work. The panel does recommend, however, that accelerator science should be regarded as a wider field to be fostered with care, regardless of the final energy of the accelerators. Young enthusiastic scientists will also 'grow up' at smaller machines and be an invaluable asset to the community. The panel was pleased in this context to note that the "White Spots" are now gradually disappearing as full professorships in accelerator physics have already been or will be staffed soon at several German universities.

Two Young Investigator posts in accelerator science have recently been opened, at the University of Hamburg and at the Humboldt University Berlin. This will open up the possibility of close collaboration with DESY in advanced accelerator R&D.

Annex

To ensure a fair and comparable process for all the Helmholtz Alliances to be evaluated the President of Helmholtz Association has nominated delegates to participate in the review.

Delegates from the government, partner universities and of the Helmholtz Association

University	**Cremers**, Armin B.; University Bonn, Deputy Rector for Finances
Federal Government	**Pantea**, Monica; Subdivision 71, BMBF
State Government	**Gruner**, Brigitte; Behörde für Wissenschaft und Forschung, Hamburg
Helmholtz Association President	**Mlynek**, Jürgen
Managing Director	**Zettl**, Rolf
Scientific Vice-President	**Stöcker**, Horst; Representative Research Field Structure of Matter
Administrative Director	**Schmidt**, Andreas; Helmholtz-Zentrum für Umweltforschung UFZ, Leipzig
Head Strategy	**Dittmer**, Stephanie
Representative Research Field	**Opitz**, Ricarda; Research Field Structure of Matter
Representative of Helmholtz Alliances	**Schulze**, Andreas; Head-Office Coordinator for the Helmholtz-Alliances

Backbone

Another novel structural element in the Alliance is the concept of YIGs. This instrument has created high quality research groups, at strategic locations, that are very active, visible, and are essential in making the Alliance structure sustainable in the long term. The open, tenure-track based hiring procedure, the extra resources from the Alliance, and the commitments from the universities, have attracted candidates of the highest level, and contributed to the international visibility of the Alliance. The panel feels this is a clear success of the Alliance and is an instrument that is definitely worth preserving beyond 2012.

The panel has observed that the Alliance Fellows are of high quality, and are very well integrated into the wider programme. In particular the non-tenured five-year positions are seen, also by the Fellows themselves, as giving the independence, and scope to engage in longer term research projects that can be very beneficial for their personal development.

Another successful instrument is the creation of interim professorships, allowing German physicists to take up leading roles in the experiments and thereby contribute significantly to the Alliance's international visibility.

The panel was pleased to note that the Alliance has been inventive in promoting concrete equal opportunity conditions.

Finally, an originally unforeseen, but valuable instrument was the call for proposals for attributing unspent funds on projects that foster collaboration between different institutes.

The organisational structure of the Alliance is credible and effective. On the one hand it aggregates executive responsibilities in a well defined way, on the other hand it guarantees broad support from the stakeholders.

Specific recommendation

The Committee strongly recommends continuation of the Alliance along the present lines. The Committee is convinced that the Alliance should continue to play a structural role in the future. The Committee urges the partners to ascertain the future of the Alliance well before the current funding period expires.