Proposal for a Alliance

Physics at the Terascale

Network of complementary excellence between

2 Helmholtz Centres
17 Universities
1 Max Planck Institute

Present today:
Univ Desch, Herten, Krämer, Mättig, Meier, Quadt, Zeppenfeld
DESY Behnke, Heuer, Mnich, Wagner
FZK Heiss
Vision

- Revolutionary advances in understanding the microcosm
- Connect microcosm with early Universe

Particle Physics at the Energy Frontier with highest collision energies ever will change our view of the universe
Key Elements

Particle Physics at the Energy Frontier

Instrumentation at the Technology Frontier

Physics Analysis

Detector Development

GRID Computing

Accelerator Science
Particle Physics at the Energy Frontier

Progress in theory and experiment over the past decades

**Standard Model of Particle Physics**

- **Matter** particles: Quarks and Leptons
- **Force carriers**: Gauge Bosons

Excellent theory tested down to $10^{-18}$ m at (sub) per mille level

However:

- **Missing corner stone**: Higgs-Boson
- **Many open questions**
  → to be addressed at the Terascale
    close collaboration particle physics ↔ astro(particle) physics
Particle Physics at the Energy Frontier

Standard Model valid only for about 5% of the universe

Experimental and theoretical evidence for new physics at scale of one TeV

Mystery of Dark Matter

- What is the universe made of?
- Particles produced copiously at the big bang?
- Supersymmetry provides a candidate for Dark Matter to be discovered at the Terascale
Origin of Mass and Supersymmetry

Higgs particle:
- What is the origin of mass?
- Do fundamental particles acquire their mass through the Higgs mechanism?
- Is space filled with an omnipresent energy field?

- If so it can be studied at the Terascale
- If not new phenomena must appear

Supersymmetry:
- Symmetry between forces and matter?
- Mirror world of new supersymmetric particles?
  New shadow world like antimatter?
- Supersymmetry as key to resolve clash between Einstein’s general relativity and quantum mechanics, i.e. the worlds of large and small scales?

- Experiments at the Terascale will provide answers
Extra Dimensions and Grand Unification

Extra Space Dimensions:
- Mystery of vastly different scales of electroweak force (0.1 TeV) and gravity ($10^{16}$ TeV)
- Gravity scale lowered through extra spatial dimensions to 1 TeV? Curled up on small distances?
- Particles living in extra dimensions could be detected at the Terascale

Grand Unification:
- Why are there three different fundamental interactions?
- one truly fundamental interaction of universal strength?
- Insight to be gained at the Terascale
Accelerators are unique, tailored high-tech devices
Require many years of R&D at technology frontier

High energies
High collision rates

Berlin 25/04/2007
Detectors are unique, tailored high-tech devices
Require many years of R&D at technology frontier

Large scales
High precision
HEP in Germany - past and present

Particle Physics: international with national contributions in large collaborations
Particle Physics projects: long-term (~ 20 years)

Strong contributions from German Universities, MPG and DESY to forefront experiments and physics at CERN and DESY

Examples from colliders at DESY:
Evidence for Matter-Antimatter transformation at DORIS
Discovery of the gluon (carrier of the strong force) at PETRA
Detailed Structure of the Proton at HERA

Excellent expertise in accelerator science at DESY

Excellent expertise in computing at DESY, FZK, Universities
HEP in Germany – future challenges

- end of HERA:  
  turning point for HEP in Germany

- particle physics at the energy frontier  
  is becoming global in all its areas

stay competitive with high impact  
→ restructuring demands for HEP in D:

Join all forces of complementary excellence in all areas (analysis, computing,  
detector, accelerator) in a long-lasting structure and strong sustained infrastructures  
to improve on

- support physics analysis (tools and techniques)  
- coordination of infrastructures with long term sustainability  
- coordination of manpower in particular for young physicists  
- coordination of novel R&D projects  
- focussed support for GRID developments  
- support of accelerator science at the universities
The Alliance: nationwide coherence in HEP

Universities:
- special infrastructure
- specialised expertise
- scientific diversity
- young blood

Helmholtz Centres:
- large infrastructure
- general engineering
- strategic research
- longterm support

Combine complementary strengths: share infrastructure + expertise
Establish sustainable network of 17 universities, DESY, FZK

**German Particle Physics @ Terascale:**
a coherent nationwide organisation of research

**UNIQUE CHANCE TO RE-STRUCTURE GERMAN PARTICLE PHYSICS FOR TOMORROW’S CHALLENGES**
Physics at the Terascale

**Scientific Goals**

**Physics Analysis**
- Data Analysis
  - Understanding LHC Detectors
  - Physics at the LHC
  - The path to the ILC
- Analysis Tools
  - Algorithms and Techniques
  - Simulation Tools
- Theory/Phenomenology
  - Monte Carlo Generators
  - Precise Predictions
  - New Models

**Grid Computing**
- Improved Grid
  - Virtualization
  - Application-driven monitoring
  - Development of NAF tools
- Data Storage + Retrieval
  - Mass storage
  - Data Access

**Detector Science**
- ILC Detectors
  - Vertex Detector
  - Tracking
  - Calorimetry
  - Forward Detectors
- (s)LHC Detectors
  - Vertex Detectors
  - Tracking
  - Trigger
  - Luminosity Monitor

**Accelerator Science**
- Optimizing the ILC
  - Acceleration Technology
  - Sources
  - Beam Dynamics

**Work Packages**

**Physics Analysis**
- Analysis Network
  - Alliance Working Groups
  - Monte Carlo Group
  - Virtual Theory Institute
- Analysis Centre at DESY
- Training and Exchange

**Grid Computing**
- Virtual Computing Centre
  - Tier 2
  - National Analysis Facility
  - High performance network
- R&D on Grid Tools:
  - Mass storage
  - Collaborative & Interactive tools
  - User friendliness
- Grid Training

**Detector Science**
- Virtual Detector Lab
  - VLSI & Electronics
  - Support Sensor Design & Characterization
  - Detectors Systems Support
- R&D Projects

**Accelerator Science**
- Advancing Accelerator Science
  - R&D Projects

**Backbone Activities**
- Management – Young Investigator Groups - Fellowships – Equal Opportunities – Outreach – Interim Professorships
Preparation for future challenges:

- huge international collaborations
  LHC: 2000 scientists from 150 institutes
- higher data rates
- new physics
- more complex signatures
  identify 1 event in \(10^9\)
- extreme precision (ILC)

Examples for analysis tools:

- complex pattern recognition
- novel statistical methods
- complicated algebraic methods for theory
- Monte Carlo simulation
- Lasting new collaborative structures for visible German impact on LHC and ILC physics
- Cooperation theorists - experimentalists
Grid Computing 1

A New Computing Paradigm

The LHC data challenge:
- 7 Petabyte of data/year
- 100000s of jobs/day
- 40000 CPUs
- 6000 users
- all continents

Start-up of LHC: endurance test of unprecedented dimensions

Universities + FZ Karlsruhe + DESY: Build a network of competence in Germany

Strengthen & expand IT expertise by Grid R&D
Fast and easy data access + CPU resources ==> precondition for competitive data analysis

- Develop a distributed National Analysis Facility
- High bandwidth connection between all Alliance partners
- Distributed resources to be part of the World - Wide Grid
Detector Development 1

Detectors are unique, tailored high-tech devices
Require many years of R&D at the technology frontier
many years of continuous high performance operation

Challenges:

Excellent precision, granularity, radiation resistance for large detector sizes

Alliance

• invest in common key infrastructures ("virtual lab", expand existing laboratories in BN, HD + facilities at DESY, HH, KA)
• open these key infrastructures to all partners of the Alliance
• training in key technologies for graduate students, engineers and scientists
• coordinate future large scale R&D efforts (sLHC and ILC)
Detector Development 2

Major Infrastructures:

- VLSI chip design + microelectronics system development (BN, HD)
- Semiconductor sensor materials, design, characterization (HH, KA)
- Large scale detector systems, engineering, development, testbeams (DESY, AA, BN, FR)

-- will be used for novel R&D projects (mainly 3rd party funded) towards LHC upgrade and towards ILC
-- provide excellent training ground for students
- broaden scope of the accelerator science at the universities
- increase links between universities and DESY
- increase education in accelerator science at universities (model: UK)  
  e.g. through support of lectures from DESY
- trigger a number of small R&D projects which open up novel directions,  
  are interesting for students, and motivate more involvement in accelerator science  
  (example: novel accelerator technologies, accelerator applications at the ILC)
Instruments

- Structural Elements:
  National Analysis Facility, Theory network, virtual institutes, infrastructures

- Promotion of Young Researchers:
  - Young Investigator Groups (tenure track)
  - Fellowships (many tenure track)
    -- model UK, fairly large degree of freedom,
    build-in mobility important, high profile projects
  - Technical Physicist / Engineer (tenure)
  - close cooperation with Graduate Schools
  - training, special lectures

- Equal opportunity (new measures)

- Teaching buy-out

- Outreach
Promises for Tenure

21 promises for tenure positions
(from technicians to professorships)
more are coming

Alliance personnel: Helmholtz request 54 FTE
Institute contribution: 131 FTE
(average per year)
- structure modelled after large HEP collaborations and EU projects
- light, but with clear personal responsibilities
Funding

Total Budget: 73 M Euro
HGF Request: 25 M Euro

Distribution of requested funds across research topics and backbone activities:

- Personnel: 15 M Euro
- Detector: 7159.50 kEUR
- Grid Comp.: 6658.50 kEUR
- Analysis: 4002.00 kEUR
- Accelerator: 1247.00 kEUR
- Backbone: 5933.00 kEUR

HGF funds mainly for:
- young researchers (theory and experiment) and collaborative efforts assuring long-term coverage
- creation of shared infrastructures for computing and detector R&D
- develop accelerator science
Summary

The Alliance will

-establish a new structure for particle physics in Germany
-create novel network of excellence between all Helmholtz-, University- and MPG-institutes working at the energy frontier across the whole of Germany
-provide excellent training grounds for young researchers
-create sustainable infrastructures at the technology frontier

with the vision

to play an internationally leading role in forefront research with the expectation of revolutionary scientific results today and tomorrow