The Analysis Centre @ DESY

In the Helmholtz Alliance “Physics at the Terascale”

Thomas Schörner-Sadenius
(presented by Wolfgang Ehrenfeld)

SLUO LHC Workshop, SLAC
July 2009
DESY – Deutsches Elektronen-Synchrotron

DESY is active in the fields of accelerators, photon science and particle physics. DESY has ~1900 employees, including 600 scientists, at two sites in Germany and more than 3000 visitors from 40 countries each year.

DESY is a member of

Fifteen national research centres contribute to solving the major challenges facing society, science and industry today with strategically focused and programme-oriented cutting-edge research in the six core fields of Energy, Earth and Environment, Health, Key Technologies, Structure of Matter, Transport and Space.
After the end of HERA in June 2007, no own particle physics accelerator at DESY (host to all HERA activities until ~ 2014).

At the same time, shift of emphasis from HEP to photon science (DORIS, HASYLAB, PETRA-III, FLASH, X-FEL, …)

- Situation at DESY similar to SLAC.

At the same time, DESY decided to join BOTH LHC experiments

- (Strong) contributions to ATLAS and CMS from DESY; strong collaboration with U Hamburg (ATLAS/CMS) and Humboldt U, Berlin (ATLAS).

Furthermore, certain expertise at DESY that is not really supported at German universities (PDFs – HERA legacy, MC, statistics, …)

Need to redefine DESY’s role in German / global HEP environment, should best do so in close connection with universities and considering the needs of the (German) community (LHC and ILC)

… and suddenly …
HELMHOLTZ ALLIANCES

> Helmholtz Alliances
  - New German funding scheme for research topics of current interest.
  - Significant financial and material resources (5 MEuro / year).
  - Central insight: Complementarity of German universities and Helmholtz institutions like DESY (later).

> Research in the Alliances
  - Brings together universities, non-university research, and Helmholtz institutions.
  - Covers all fields of science (biology, physics, medicine, …)

> “Our” Terascale Alliance – initiated by DESY –
  - Was the second Alliance to be accepted.
  - Received 25 MEuros for 5 years (2007-2012) + ~50 MEuros from all partners
  - Created 25 tenure-track positions, 20 fellows and other infrastructure positions.
  - We are the first to answer all questions – and that is both rewarding and tedious.
  - Immediate questions: continuation of Alliance after end of funding period in 2012?
The Alliance was motivated by the complementarity of the Helmholtz institute DESY and German university institutes. In particular, DESY has long-term experience in

- Running large-scale facilities (accelerators, test beams, detector labs).
- Hosting and organising large groups of scientists (HERA!).
- Issues of general relevance like, for example, Monte Carlo and PDFs.

From the web page www.terascale.de: “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.”

“The Helmholtz Alliance ‘Physics at the Terascale’ is a structured research network comprising 18 universities, 2 Helmholtz institutes (DESY + FZK) and 1 Max Planck institute. The Alliance acts as a tool for a more effective collaboration, in particular between experimentalists and theorists.”
The Alliance was motivated by the complementarity of the Helmholtz institute DESY and German university institutes. In particular, DESY has long-term experience in

- Running large-scale facilities (accelerators, test beams, detector labs).
- Hosting and organising large groups of scientists.
- Issues of general relevance like, for example, Monte Carlo and PDFs.

From the web page www.terascale.de: “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.”

“The Strategic Helmholtz Alliance ‘Physics at the Terascale’ is a structured research network comprising 18 universities, 2 Helmholtz institutes and 1 Max Planck Institute. The Alliance acts as a tool for a more effective collaboration, in particular between experimentalists and theorists.”

Triple benefit expected:
- DESY to maintain role as central German particle physics lab.
- Universities to profit from DESY expertise and services.
- Community to profit from increased communication and networking. Hope: increased impact on LHC / ILC.

Alliance topics play major role in DESY’s future planning.
# THE ALLIANCE “PHYSICS AT THE TERASCALE”

## Physics at the Terascale

<table>
<thead>
<tr>
<th>Scientific Goals</th>
<th>Physics Analysis</th>
<th>Grid Computing</th>
<th>Detector Science</th>
<th>Accelerator Science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data Analysis</td>
<td>Improved Grid</td>
<td>ILC Detectors</td>
<td>Optimizing the ILC</td>
</tr>
<tr>
<td></td>
<td>• Understanding LHC Detectors</td>
<td>• Virtualization</td>
<td>• Vertex Detector</td>
<td>• Acceleration Technology</td>
</tr>
<tr>
<td></td>
<td>• Physics at the LHC</td>
<td>• Application-driven monitoring</td>
<td>• Tracking</td>
<td>• Sources</td>
</tr>
<tr>
<td></td>
<td>• The path to the ILC</td>
<td>• Development of NAF tools</td>
<td>• Calorimetry</td>
<td>• Beam Dynamics</td>
</tr>
<tr>
<td></td>
<td>Analysis Tools</td>
<td>Data Storage + Retrieval</td>
<td>(s)LHC Detectors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Algorithms and Techniques</td>
<td>• Mass storage</td>
<td>• Vertex Detectors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Simulation Tools</td>
<td>• Data Access</td>
<td>• Tracking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Theory/Phenomenology</td>
<td></td>
<td>• Trigger</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Monte Carlo Generators</td>
<td></td>
<td>• Luminosity Monitor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Precise Predictions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• New Models</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Work Packages

<table>
<thead>
<tr>
<th>Analysis Network</th>
<th>Virtual Computing Centre</th>
<th>Virtual Detector Lab</th>
<th>Advancing Accelerator Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Alliance Working Groups</td>
<td>• Tier 2</td>
<td>• VLSI &amp; Electronics</td>
<td>• R&amp;D Projects</td>
</tr>
<tr>
<td>• Monte Carlo Group</td>
<td>• National Analysis Facility</td>
<td>• Support Sensor Design &amp; Characterization</td>
<td></td>
</tr>
<tr>
<td>• Virtual Theory Institute</td>
<td>• High performance network</td>
<td>• Detectors Systems Support</td>
<td></td>
</tr>
</tbody>
</table>

### Analysis Centre at DESY

- Training and Exchange
- R&D on Grid Tools:
  - User friendliness
  - Collaborative & Interactive tools

### Grid Computing

- R&D Projects
- Grid Training

### Detector Science

- (s)LHC Detectors
  - Vertex Detectors
  - Tracking
  - Trigger
  - Luminosity Monitor

### Accelerator Science

- Optimizing the ILC
  - Acceleration Technology
  - Sources
  - Beam Dynamics

## Backbone Activities

- Management
- Young Investigator Groups
- Fellowships
- Equal Opportunities
- Outreach
- Interim Professorships

---

W. Ehrenfeld / T. Schörner-Sadenius | The Analysis Centre@DESY | July 2009 | Page 7
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.

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.

Analysis Centre centered around / built on DESY staff with specific expertise in the fields of MC, statistics, PDFs.

Need to integrate manpower from other institutes in order to form a “network”
“REQUESTS” TO THE ANALYSIS CENTRE

> General community support
  - Ideas ranging from 24h helpdesk for all analysis-related questions to using all DESY fellows / postdocs for general service … and alike
  - More realistically: Create central activities at DESY from which all can profit.
  - Idea needs to mature further.

> “Centre of excellence” for analysis-related questions
  - Which topics to focus on?

> Concentrate on issues of general relevance not covered at universities (ATLAS+CMS!)

> In all activities, avoid strong emphasis on a particular experiment
  - Politically not wanted
  - Danger of duplicate funding → forbidden under German funding schemes.
More concretely …

> Education: organisation of schools, workshops, trainings on all analysis-related issues.

> Scientific contributions to the LHC and ILC programmes.
   - “Product development” in fields of general interest (to German HEP and LHC/ILC communities): MC, PDF, statistics tools, …
   - Installation of three working groups focusing on MC, PDF, Statistics Tools (research, production development, support, …)
   - Problem: creation of “added value” – activities in the Analysis Centre have to be more than (only) the sum of all single activities before – not trivial!

> Networking, bringing people together, exploitation of synergies
   - Define, via talking to ~everybody, potential issues of general interest and start activities (workshops, discussions, working groups, …)
   - Try to achieve overview of activities in German HEP community.

> Support and service
   - See slide before … to be better defined …
> Insight: many techniques etc. not covered during university studies, and many schools (CERN, CTEQ, SLAC, etc.) aim more at overview and physics than details and techniques
   ➔ design education programme for various levels (from beginners’ school to expert workshops)

> Set up rather rich program of schools and workshops on MC, PDF, statistics, on detector understanding + physics objects, …

> Numerous further ideas around (scientific computing, introduction to HEP, …)

> So far excellent feedback (schools with up to 120 participants, on average feedback is highly encouraging).

➔ We feel that we really found a gap in the education of our young people and, with our events, prepare them better for their work in the experiments.
EDUCATION
> Set-up of (so far) **3 working groups** focusing on issues of general importance that are not (really covered) elsewhere and where DESY has long-term experience:

- Monte Carlo generators
- Parton distribution functions
- Statistics Tools

> For all groups: define program which

- Is based on DESY expertise
- Has impact on / relevance for the field
- Can connect to ongoing LHC / ILC activities
- Remark: not an easy task!

> Try to form networks by inviting (more and more) people from the universities to join our activities.
Monte Carlo group

- Good mixture between phenomenology and experiment
- Understanding of parton showers and underlying event, tuning activities both inside and across the experiments (political issues).
- PDF4MC
- Unintegrated PDFs and kT factorisation

Statistics Tools group (all activities just starting)

- Close contact with ROOT math developers, CMS and ATLAS statistics committees, etc., and projects that are considered necessary / valuable by all.
- LVMINI and APLCON: fitting tools
- Unfolding tools
- Benchmarking of various fitting and limit tools.
- Strong collaboration with Göttingen, Mainz, DESY, Karlsruhe, MPI, …

PDFs

- Open-source NNLO PDF evolution code project
Aim of the Alliance: improve communication between institutes, between experiments, and between theory and experiment.

For this purpose started a number of “analysis working groups” (with travel budget) which combine people from different backgrounds:

- Jet veto in vector-boson fusion
- Tau-tau final states in Higgs physics
- Heavy flavours and new physics
- Lepton flavour violation

Organise specific workshops, which might evolve into an analysis working group:

- Single top and fourth generation quarks
- Workshop on NLO calculations
- Institute on parton showers and resummations

Hope is to increase efficiency of our work, to receive fruitful new impulses for existing activities, and to start new, promising activities.
December 2008: visit from B. Klima (FNAL, LPC) to learn about Fermilab’s strategy to establish an US-CMS centre @ FNAL.

Conclusion 1: it is important to get into the experiments and do something useful for them.

- Young people (and all contributors) get their credits mainly via the experiments.
- Once people in the experiments see that you do something useful for them, they start taking you seriously, and you will receive more important tasks and more manpower. → pick small, but important tasks and provide results to the experiments.

Conclusion 2: situation at SLAC (ATLAS) or FNAL (CMS) not really comparable to DESY situation.

- The Alliance / Analysis Centre (at DESY) set up to work across the experiments.
- Extremely difficult to define such areas of common interest.
- Question of credits: non trivial for work NOT explicitly done in the collaborations; work in / for the Analysis Centre like an additional service task → difficult to communicate and to win new manpower.
“Theorist of the week”: successful concept at LPC / FermiLab. Trying to establish something similar at DESY, based on the insight that we experimentalists can never talk too much to theorists (and vice versa).

“Discussion weeks”: inviting, for a few days, few experts for intense discussion and work. Useful experience with a few (mostly theory-based) events.

Web and WIKI

- Slow start for documentation of Alliance-related projects.

“Knowledge Database”: effort to get overview of (all) activities in the Alliance, with the aim of

- Providing easier flow of information and contacts for interested people
- Avoiding doubling of work and effort

Newsletter: alliance and analysis centre

- Inform collaborators and build team / community spirit
“A central element of the Analysis Centre infrastructure will be a computing facility to run analysis jobs.”

The German National Analysis Facility (NAF)

Provide additional resources for efficient and fast analysis work. Resources should be similar to a 1½ standard T2 centre with more emphasis on data storage and data access

Provided resources are mainly for users from Terascale Alliance institutes
NAF DESIGN

> Shared facility for ATLAS, CMS, LHCb and ILC analysis activities

> Built around the existing T2 infrastructure at DESY

> Interactive and batch resources
  - Main focus on end user analysis in the LHC era
  - Fast response for large data samples
  - PROOF

> Additional Grid resources with high priority access
  - Private MC production
  - Standard ntuple production

> Further resources available for dedicated services
  - ATLAS: Oracle based TAG and Conditions database
NAF BUILDING BLOCKS

- Interactive
- Local Batch
- Proof
- NAF Grid
- Grid Cluster
- AFS
- Parallel Cluster FS
- Dedicated space
- DESY Grid dCache Storage
- Grid-ftp, SRM

gsissh → Interactive
qsub → Local Batch
grid-submit → NAF Grid

NAF

AFS/ Kerberos
scp

Interconnect
NAF BUILDING BLOCKS

- Interactive
- Local Batch
- Proof
- NAF Grid
- Grid Cluster
- AFS
- Parallel Cluster FS
- Dedicated space
- DESY Grid dCache Storage
- Grid-ftp, SRM

gsissh → Interactive
qsub → Local Batch
grid-submit → NAF Grid

AFS/ Kerberos
scp

~1700 cores
~800 cores
~900 cores
~100 TB
~1 PB
~1 PB
The NAF should be the infrastructure of the analysis centre. What can we do to make it more than just an ordinary computing facility? How do we support analysis work on the NAF?

The hardware design focus on fast and efficient data processing

- Do the user know how to use it?
- For example have they heard about PROOF?
- How about integration into experiment software framework?

Our ideas so far

- Provide end user support including some experiment specific tools
- Tutorials and education
- Develop tools for more efficient end user analysis
- Integrate experiment tools better into end user analysis

What does the user need in the end for a full size LHC analysis?
ACHIEVEMENTS

> Active working groups!
  - MC, Statistics Tools, and PDFs, with rich research programmes.
  - Good connections to relevant communities ➔ good opportunities for impact!

> Well-accepted education programme!
  - Past schools well received. Some lessons learned.
  - Rich future programme currently under discussion / being organised.
  - Open for suggestions and wishes!

> Analysis Working groups
  - Some are active, some are not
  - More ideas around. Necessity? Feasibility?

> … and more:
  - Web and WIKI, discussion / discussion weeks, and more projects being designed.

> The Analysis Centre: a useful structure with widely accepted goals, large resources and (potentially?) significant impact!
HANDICAPS AND CHALLENGES (very short)

  - Permanent support for facilities and positions?
  - Slow start
  - Some things need time to settle and get accepted (5 years are a good time scale)
- Doubling of information and structure?
- Acceptance of DESY as strong partner in the Alliance
  - Analysis Centre of the Alliance (at DESY) – not DESY’s Analysis Centre!
- Question of credits for contributions?
- The “experiment-unspecific” approach as a general obstacle for Alliance activities in the analysis field?
- ...

- Data will change the situation!