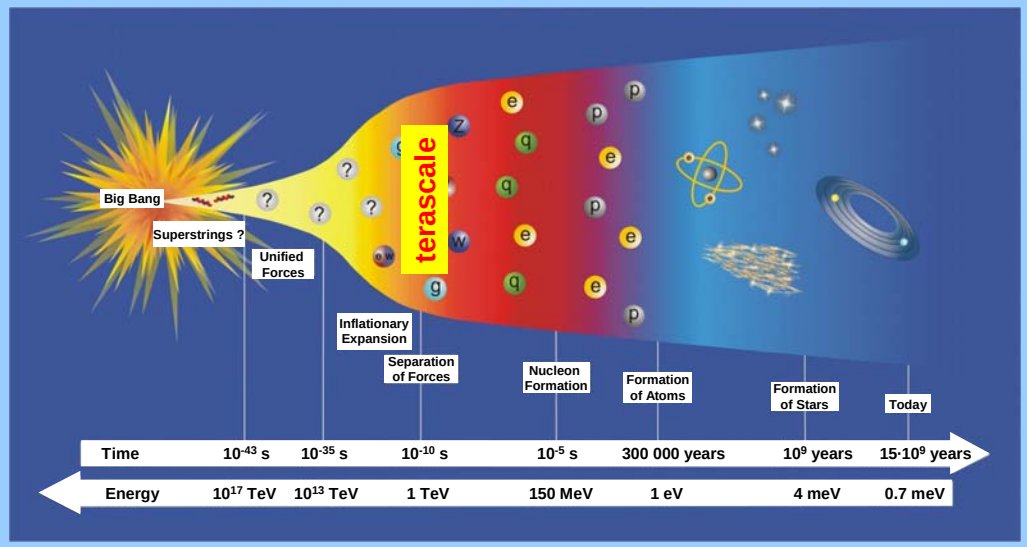
Particle and Astroparticle Physics at DESY

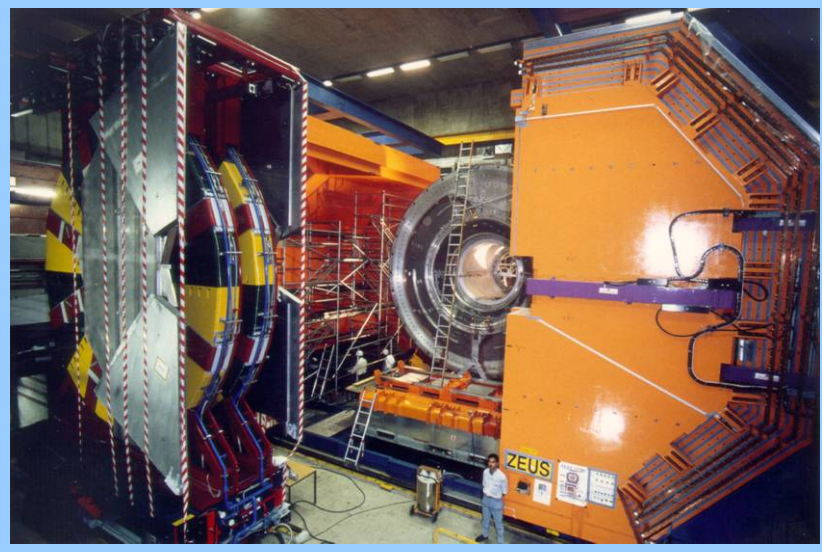
Status and Programme 2010-14

J. Mnich
Spokesperson HGF Programme Particle Physics

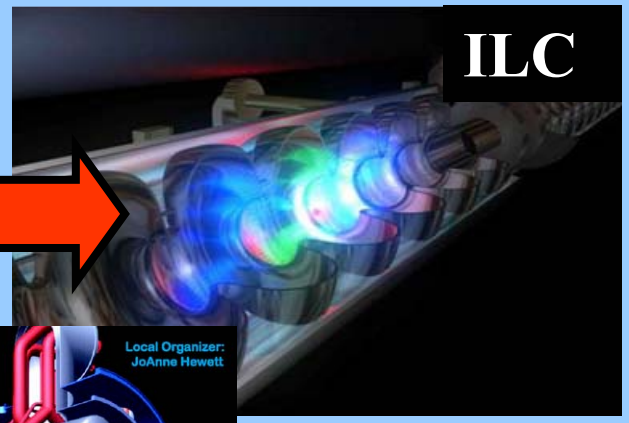
DESY WA
July 2008

(based on presentation at EWR in May 2008)





DESY Long-term Strategy in Particle Physics

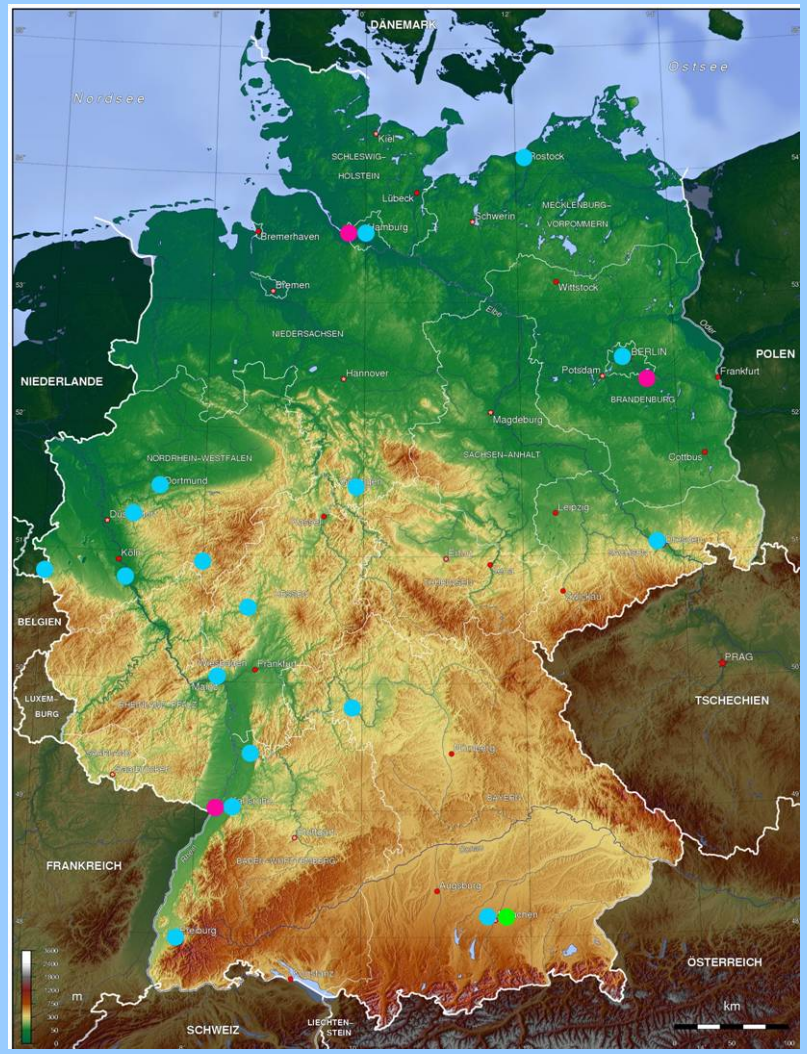


- accelerators
- detectors
- physics

+ support through strong theory group
+ computing infrastructure
+ testbeam & other infrastructures

Helmholtz Alliance "Physics at the Terascale"

- **DESY particle physics is embedded in Alliance**



- **Network between**
  - **2 Helmholtz Centres**
  - **17 Universities**
  - **1 Max-Planck Institute**

+

- **Restructuring particle physics in Germany**
- **Concept is receiving strong interest in other European countries**

Key Elements of the Alliance

Particle Physics at the
Energy Frontier

Instrumentation at the
Technology Frontier

DESY:
Analysis Centre
(HERA → LHC → ILC
+ Theory)

Basis for the next 5 years period

DESY:
Infrastructure
Engineering
R&D for (s)LHC
R&D for ILC

Detector Development

DESY:
TIER 2,
National Analysis
Facility

GRID Computing

DESY:
Infrastructure
R&D
Lectures, courses

Accelerator Science

DESY is assuming a new role for particle physics in Germany

Particle Physics 2010 to 2014

Activities within the Alliance

will be continued

- **possibly with changing emphases**
- **depending on the schedules of the respective projects**

→ provide sustainability beyond 6/2012

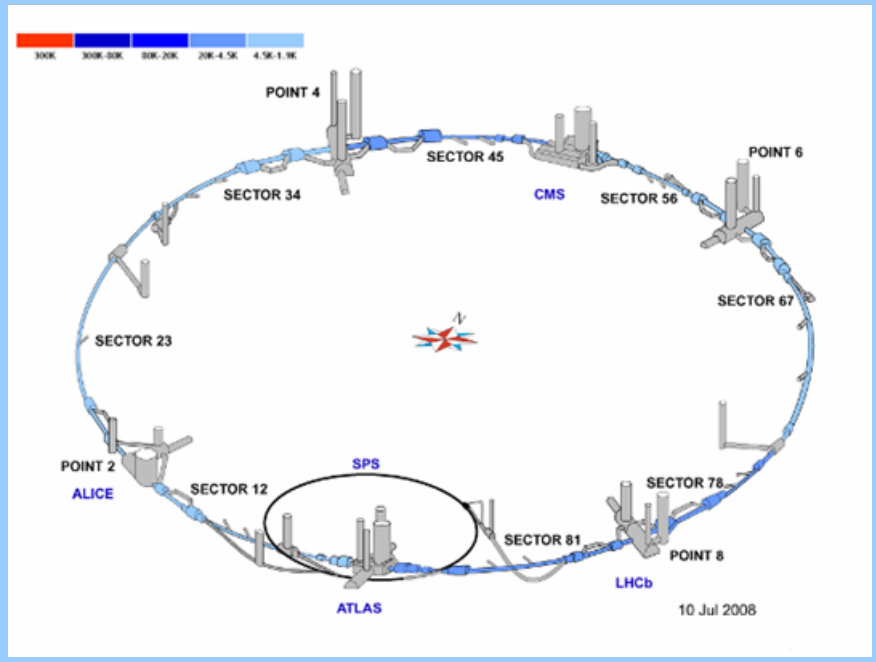
Activities in Theory (not part of the Alliance)
will be continued

Particle Physics at the Terascale
Key elements:

- **LHC and luminosity upgrades**
- **Linear Collider**

Large Hadron Collider (LHC)

- **Cool down of the machine: 8/8 sectors (being) cooled down**



- **First beam August 2008**
- **First collisions fall 2008**
- **Inauguration October 21, 2008**
- **Accelerator needs expert manpower for commissioning**
- **Nominal luminosity 10^{34} needs continued effort (LHC and injector chain)**

Present schedule for the LC preparations

ILC Reference Design Report published summer 2007

Accelerator schedule:

- **Technical Design Phase 1 (TDP1) until 2010**
  addressing most urgent topics like acc. gradient

- **Technical Design Phase 2 (TDP2) until 2012**
  addressing remaining important topics

Detector schedule:

- **LoIs for Detector Concepts 4/2009**
- **Evaluation of the LoIs by IDAG**
- **Continuation of Detector R&D**

to be expected: Detector Concept Documents 2012

CLIC conceptual design report expected for 2010
official cooperation ILC/CLIC

Particle Physics at DESY 2010 to 2014

HERA
LHC and LHC upgrade
ILC
Theory

. . . embedded in and
continuation of the Alliance

Programme Sketch Particle Physics

HGF-Research Field Structure of Matter

Programme: Elementary Particle Physics

Spokesperson: Joachim Mnich (DESY)
Co-Spokesperson: Reinhard Maschuw (FZK)

Participating Research Centres

Helmholtz Centre	Contact	Email
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I. Major Goals and Overall Strategy

The goal of Elementary Particle Physics is to develop a deeper understanding of the fundamental forces and building blocks of matter and of the structure of space and time, which determine how the universe evolved from its beginnings to the complex structure observed today. These questions directly connect the physics at the smallest and the largest length scales of our universe and thus link the particle and astroparticle programmes at DESY. With the imminent start-up of the Large Hadron Collider (LHC) at CERN particle physics will go beyond the frontier of electroweak symmetry breaking and enter the Terascale, the energy range of Tera electron volts. We expect to derive explanations on the origin of matter, the nature of dark matter, further insights on extra dimensions and the grand unification of forces, all of which will change our view of the world and its interaction at a fundamental level.

The **European Strategy for Particle Physics**, as approved in 2006 by CERN Council, has set the road map for the field. German particle physicists and DESY have provided major input to this strategy. The programmes described below are therefore fully integrated in this strategy.

The pursuit of this strategy requires accelerators capable of colliding particles at extremely high energies, complex detectors able to record the collision products, cutting edge information technologies like the Grid, and the development of the underlying theoretical concepts. These elements have been outlined in the European Strategy: Exploitation of the LHC, followed by a linear electron-positron collider for which the International Linear Collider (ILC) is well prepared to serve energies of up to 1 TeV and, to reach later even higher energies, CLIC, for which R&D is being pursued. Particle physics promises to continue to have a major impact on many other fields of science and society, as it did in the past.

With the end of **HERA** operation in 2007 a major change for German particle physics has occurred. Until then Germany, through DESY, maintained a worldwide visible leadership role in the field of particle physics by providing unique research facilities, such as PETRA, where the gluon was discovered, and HERA, which provided a precise knowledge of the structure of the proton and the strong force. In order to maintain this visibility and to optimally place German particle physics in an increasingly global environment, the **Helmholtz Alliance "Physics at the Terascale"** has been initiated to create new and improved structures for particle physics in Germany. A structured network comprising DESY and FZK, 17 universities and one Max Planck institute has been set up as a tool for a more effective collaboration, in particular between experimentalists and theorists. This concept has raised strong interest in other countries. The DESY activities in particle physics are to a very large extent embedded in this Alliance and the laboratory is committed to ensure the sustainability of the new structures beyond the duration of the Alliance.

A key element to the success of particle physics is the provision of the **scientific infrastructure**. Within Germany, DESY provides world-class expertise on **accelerators**, large **detector** systems and **computing** for particle physics experiments and constitutes a centre of excellence for particle physics theory, while FZK is operating the Tier 1 computing infrastructure for all four LHC experiments. These facilities attract

HERA

- **Analysis of the complete data sets 1992-2007**
- **Topics:**
  QCD, EW, PDFs, …

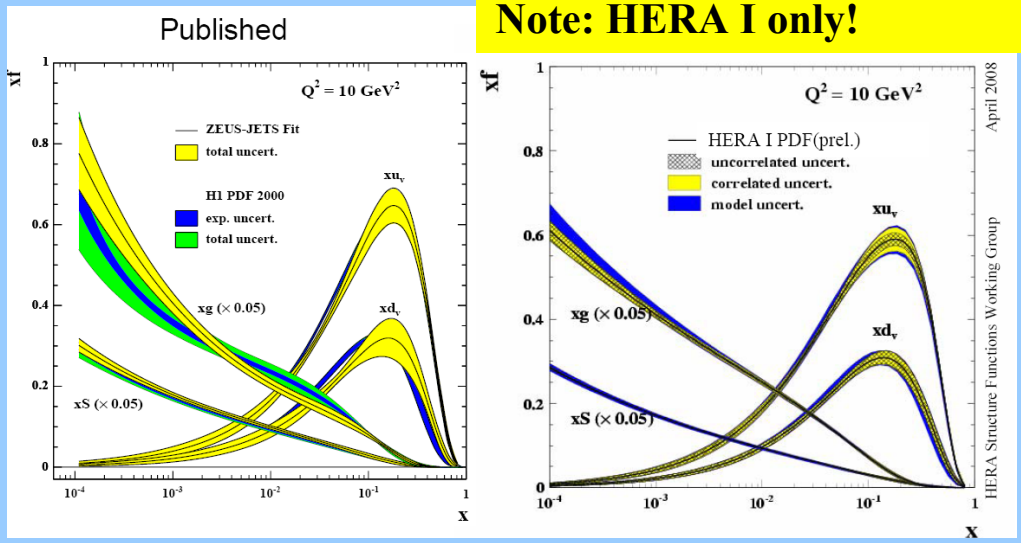
→ **combination of H1 & ZEUS reduction of statistical and systematic errors**

→ **impact of HERA results on LHC**

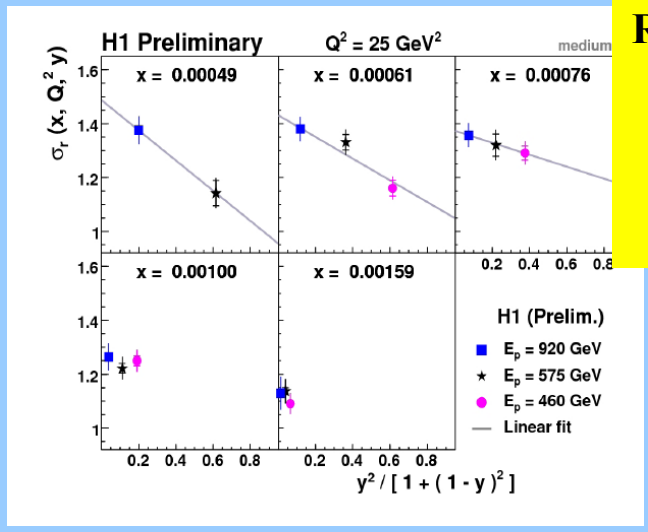
HERA analyses are key element of Analysis Centre

Computing requirements:
- **exploit Grid (LCG)**
- **HERA into NAF**

Combination of PDF results
Note: HERA I only!



Reduced E_p in 2007:
→ measurement of F_L directly sensitive to gluon density
→ LHC



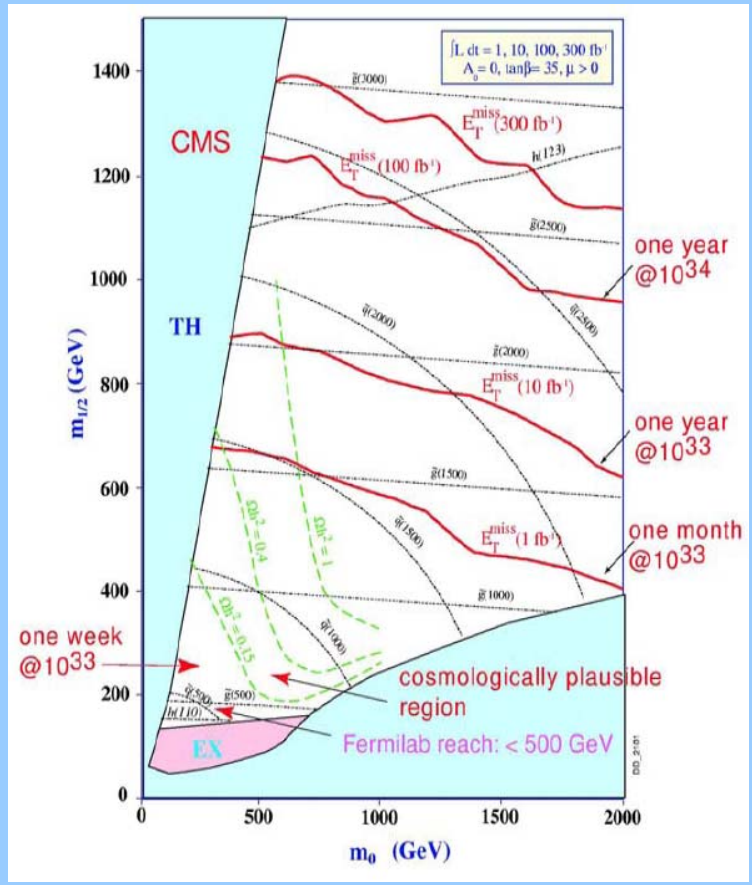
DESY in LHC: ATLAS and CMS

1) Physics Analysis

proton structure & QCD (HERA input)
Top physics
EW physics (= W/Z)
Higgs physics
New physics (SUSY)

2) LHC centre at DESY

comprising machine and experiments
„online“ monitoring
complementing „offline” Analysis Centre



3) Contributions to data taking and physics preparations

shifts, trigger, data quality monitoring, alignment

4) Computing

support for Tier-2 (ATLAS/CMS/LHCb) and NAF

LHC: ATLAS and CMS

5) Detector contributions

ATLAS: **ALFA (Luminosity calibration)**

CMS: **BCM (= beam condition monitors)**

CASTOR (physics interesting for DESY should be essentially done when LHC reaches 10^{33})

6) Improvements of baseline detectors

to be discussed

7) sLHC preparation:

candidates for DESY involvement:

tracker (strong German university groups ATLAS and CMS)

high level trigger (evolution of current activity, synergy with ILC, involvement of German groups in ATLAS)

International Linear Collider (ILC)

1) **ILD concept**
   - performance studies and optimisation after LoI
   - software development
   - enhance collaboration with Japan and CERN (synergy with CLIC)

2) **Project office** (if co-funded by EU)
   for ILD development
   as the European part of an international project office
   & for preparation of combined test beam (detector slice as proposed in FP7 project DevDet)

3) **Detector R&D**
   - Vertex
   - Time Projection Chamber (TPC)
   - HCAL (CALICE)
   - Forward Calorimetry

synergy with LHC
sLHC
CLIC
applications in other fields, e.g.
photon science, medicine

International Linear Collider (ILC)

4) DESY test beam

for (DESY) detector R&D, Alliance and possible future EU projects

5) Detector Lab

provide facility for detector R&D and construction as foreseen within Alliance (for ILC, sLHC, etc….)

6) Accelerator (ILC)

- exploit synergies with XFEL
- continue strong position in GDE
- Machine Detector Interface

- continued engagement in superconducting cavity development (HiGrade project funded by EU within FP7 program)
- continue selected activities from EuroTeV

Theory

1. **Phenomenology**
   QCD and standard model processes at the LHC
   Higgs physics and supersymmetry at LHC and ILC
   Precision studies for colliders
   leading role in Alliance Analysis Centre and Virtual Theory Institute

2. **Particle Cosmology**
3. **Unified Theories**
4. **String theory and non-perturbative Physics/QCD**
5. **String theory and applied mathematics**

Other Topics 2010 and beyond

Under discussion:

1. ALPS or more general:
search for low mass particles

2. OLYMPUS (BLAST)
Nuclear Physics Experiment at DORIS to
'Definitively determine contributions of multiple photon exchange in elastic lepton-nucleon scattering'

→ both topics not part of the main particle physics roadmap
could be part of the ‚PuF' (Programme independent funding)

Programme Sketch Astroparticle Physics

Research Field "Structure of Matter"
Program Astroparticle Physics
2010-2014

Participating Helmholtz Centers:

Helmholtz Center	Contact	Email
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Forschungszentrum Karlsruhe	Johannes Blümer	Johannes.Bluemer@ik.fzk.de

Contents:

Summary

The Research Field *Structure of Matter* is composed of four programs

- Elementary Particle Physics
- Astroparticle Physics
- Physics of Hadrons and Nuclei
- Photons, Neutrons and Ions

The proposed research within the Helmholtz Program *Astroparticle Physics* has been developed on the basis of the results from the current funding period 2005-2009 in accordance with the ApPEC Roadmap for European astroparticle physics. They consist of five program topics:

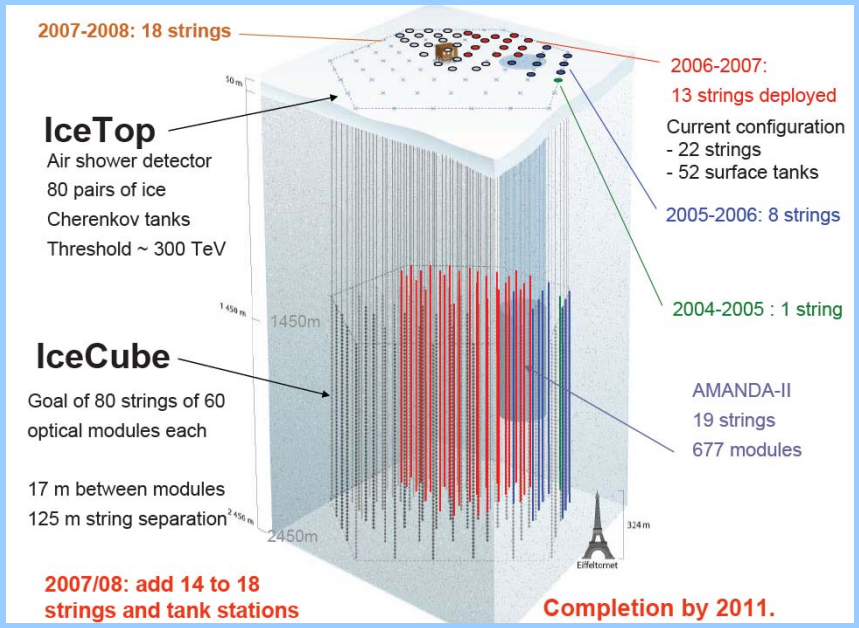
1. **Ultra-high energy cosmic rays.** The Pierre Auger Observatory is recording data of the highest quality since 2004 and is delivering already first exciting science results. The measurements will be continued. It is planned to construct a second, larger observatory on the Northern hemisphere. Two Young Investigator Groups work on multi-messenger analyses and on the radio-detection of cosmic-ray showers.
2. **High-energy neutrino astrophysics.** The IceCube neutrino telescope will be completed and therefore guarantees a wealth of results in the next program period, including the new aspect of multi-messenger analysis, the combination of neutrino astronomy with particle and gamma-ray astronomy.
3. **High-energy gamma-ray astronomy.** In the multi-messenger context, DESY is participating in the preparatory work for the large Cherenkov Telescope Array (CTA). A Young Investigator Group is currently participating in MAGIC.
4. **Direct search for Dark Matter.** FZK is currently participating in the European Dark Matter experiment EDELWEISS. The search for Dark Matter is planned to become a major research field within the Program Astroparticle Physics, which will be reflected by a leading role of Forschungszentrum Karlsruhe in the European project EURECA.
5. **Neutrino physics.** The KATRIN experiment will conduct its measurements in the next program period. The experiment is unique worldwide and of great significance, since it has the highest sensitivity on measuring the neutrino mass or setting the best limits.

Within the Program, theoretical work in astroparticle physics will be conducted in close cooperation at the Universities of Karlsruhe and Potsdam.

Astroparticle Physics at DESY

- Present and future activities
  - IceCube in full swing
  - 50% of detector installed & operational

- DESY hardware activity
  DOM production mostly completed
- Test of acoustic neutrino detectors at IceCube



Astroparticle Physics after 2010

Multi-messenger approach:

- complement high energy neutrino with high energy gamma-ray astrophysics

IceCube:

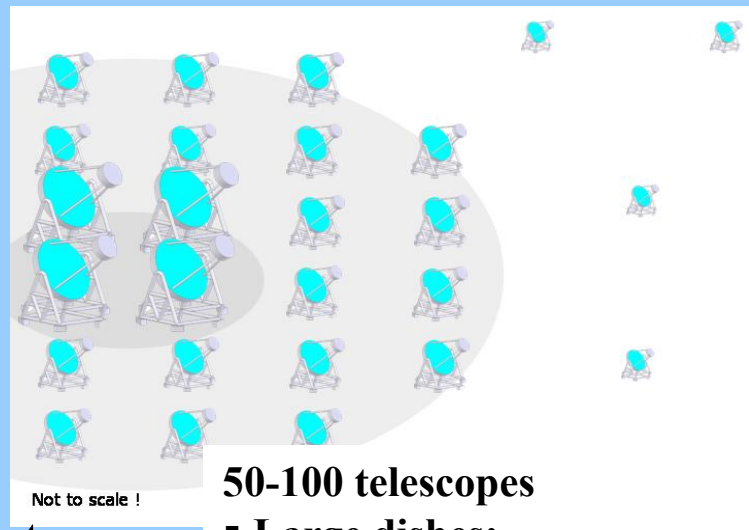
- Complete construction
  antartic summer 2010/11
- Analysis, e.g.
  - search for astrophysical sources
  - WIMPs and other exotic particles
  - spectrum & composition of cosmic rays

Cherenkov Telescope Array (CTA):

- preparation: participation in MAGIC
  through HGF Young Investigator Group
- participation in CTA prototype phase
  - design & optimization
  - contribution to array operation centre
- plans for construction phase to be worked out later

Astro(particle) physics theory:

- joint professorship with Potsdam university



50-100 telescopes

- Large dishes:
  low energy
- Small dishes, 10 km² area:
  low-flux, high energies

Summary

Particle Physics in Germany is entering new era

- **end of HERA experimental programme**
- **start up of LHC**

- **restructuring German particle physics → Helmholtz Alliance**
- **new role for DESY**
- **key element: sustain new structures after end of Alliance**

Projects for 2010-14 (and beyond)

- **form an exciting (astro)particle physics programme**
- **serve as the basis for discussion**
- **are a natural continuation of the present projects and of the Alliance**
- **link astroparticle and particle physics**
  the largest and the smallest scales in the universe

Flexibility should be built into the proposal to allow shifting emphasis and adjustments of resources