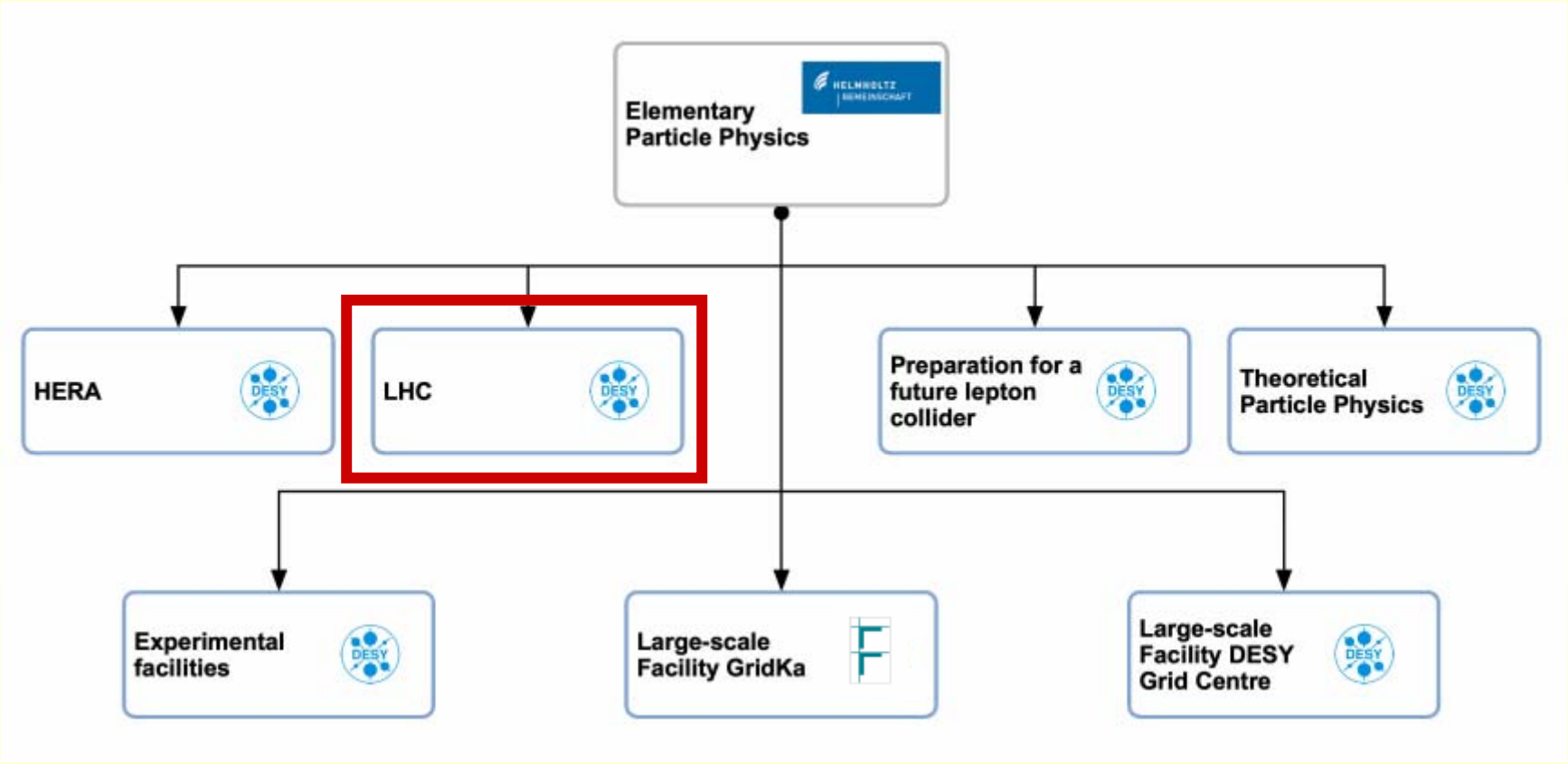
Program Topic: Large Hadron Collider



LHC

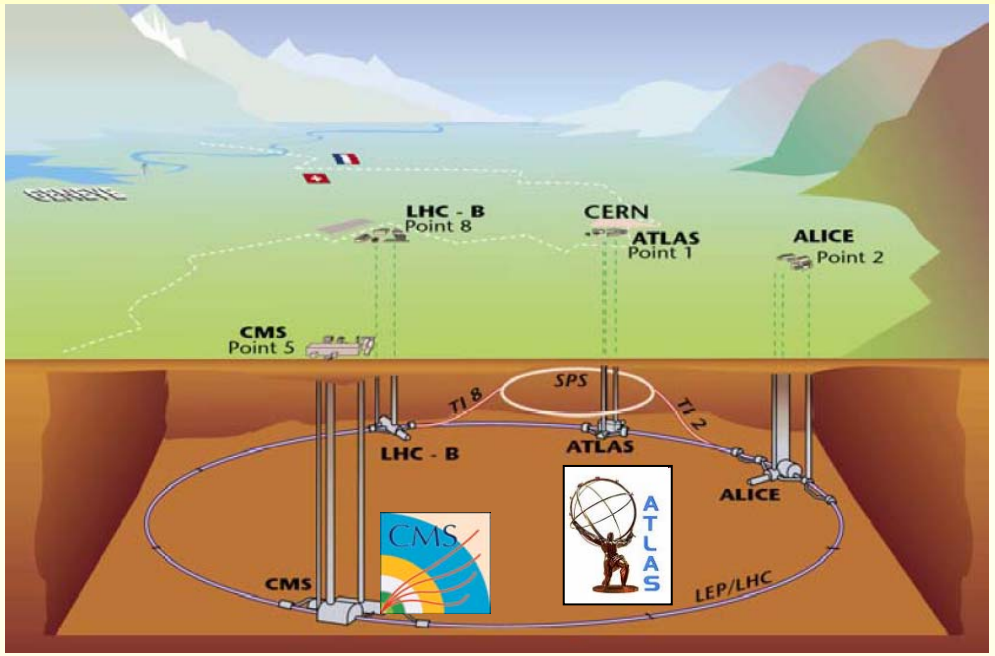
Large Hadron Collider

- 27 km storage ring
- proton beams @ energy 7 TeV,
- design luminosity 10^{34} s^{-1} cm^{-2}
- experiments : ATLAS, CMS, ALICE, LHCb

- next step to answer fundamental questions
- discoveries of the next decades

→ world-wide effort at the Terascale

→ bundles forces and resources internationally and nationally



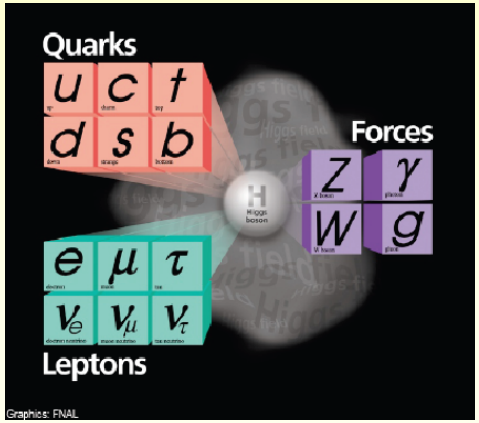
PHYSICS AT THE TERA SCALE
Helmholtz Alliance

Goals for this key element of the DESY program:

- research at the forefront of elementary particle physics
- maintain a fascinating in-house particle physics program
  → attract the brightest minds of the field
- provide competent and excellent support for German Universities

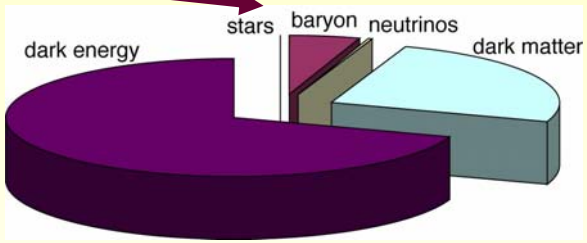
HELMHOLTZ ASSOCIATION

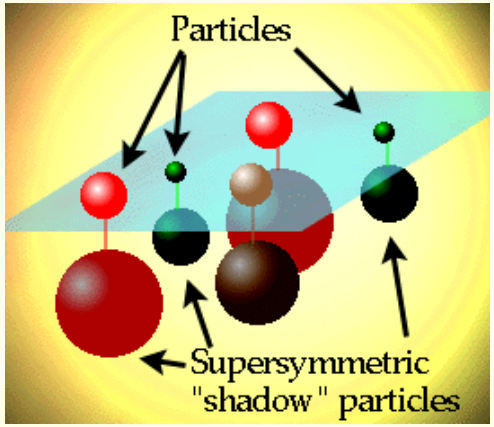
Scientific Relevance



Standard Model of Particle Physics:

- Quarks
- Leptons
- Forces





SUper

SYmmetry

Very successful

Verified with high precision measurements at LEP, Tevatron and HERA

Missing pieces:

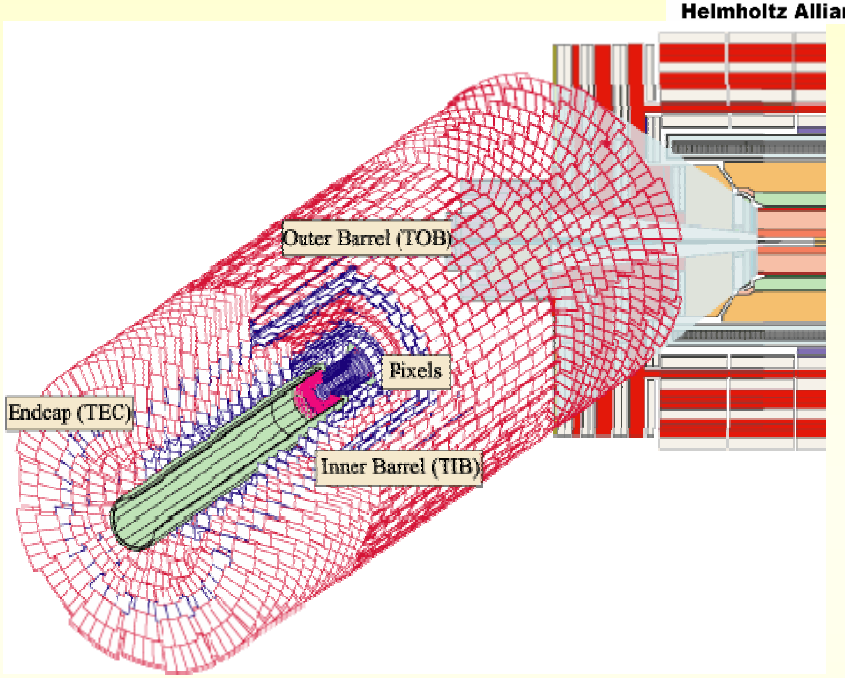
- **What is the origin of mass for the elementary particles → Higgs ?**
- **How to link to cosmology, dark matter, dark energy → SUSY ?**
- **How to integrate the fourth fundamental force, gravity ?**
- **Do all forces unify, if yes where and how ?**

Challenges

New generation of experiments:

- extremely big
- extremely complex

  eg. tracker alignment with
  50.000 free parameters
- extremely large data volumes



New generation of collaborations:

- ~2300 authors, ~180 institutes, ~40 countries
- international competitive environment with
  large contributions from many nations

→ challenge for DESY as national laboratory

→ new role for DESY as remote center

DESY @ LHC

DESY is one of the five major particle physics laboratories world-wide:

- vast experience in particle physics experiments & machines
- LHC: highest scientific relevance & largest German participation → decision for LHC

→ German groups & experiments highly welcomed DESY in 2006

Employ key characteristics of DESY:

- profound competence and knowledge in physics analyses
- construction & running of large experiments in all aspects
- comprehensive experience in computing: up-to-date level, original contributions
- senior DESY staff permanent → take over long-term responsibilities

Preparation for Physics*	Commissioning Technical Coordination* Integration	Trigger* DAQ Monitoring*	Computing* Grid*	Detectors*

→ DESY staff in important long-term responsible positions (*)

→ DESY has well established position in the experiments → high added value

Current Status

Preparation for Physics*	Commissioning Technical Coordination* Integration	Trigger* DAQ Monitoring*	Computing* Grid*	Detectors*

Searches for New Physics:

- Higgs
- SUSY

→ potential discoveries

Standard Model Physics:

- Top-quark: precise characterization @ LHC, signals of new physics via deviations from SM
- Electro-Weak Force: W- & Z-Bosons, esp. for calibration
- Strong Force (QCD): dominant processes @ LHC (crucial HERA input), background, signals of new physics

→ Key topics addressed with high potential for discoveries well embedded in the German landscape

- Basic ingredient for the education & training for tomorrow's physicists.
- Experienced seniors in close collaboration with German Universities
  → achieve strong input within international working groups.
- Attractive for Young Investigator Groups → 5 groups

Young Investigator Groups for LHC

Philip Bechtle (Spring 2007)

Identification of New Physics with High-Energy Colliders

DESY – Uni Hamburg – Uni Bonn

ATLAS / ILC

Ulrich Husemann (Spring 2008)

Top as Key to LHC Physics

DESY – Uni Berlin

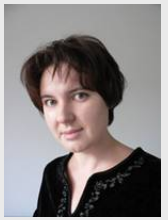
ATLAS

Katerina Lipka (Spring 2008)

Physics of Gluons and Heavy Quarks from HERA to LHC

DESY – Uni Hamburg – Uni Mainz

HERA / CMS



Isabell Melzer-Pellmann (Spring 2009)

Supersymmetry at the Terascale

DESY – Uni Hamburg

CMS

Alexei Raspereza (Spring 2009)

Probing electroweak Symmetry Breaking at the LHC: Higgs Physics with the CMS Detector

DESY – IEKP Karlsruhe

CMS

Current Responsibilities

CMS:

- Computing Coordinator (top level)
- Deputy Technical Coordinator (top level)
- Data Quality Monitoring Coordinator
- Calibration & Alignment Coordinator
- CASTOR Calorimeter Project Leader
- Grid-Software deployment Coordinator
- Chairs: ECoM (Evolution of CMS Computing Model)

ATLAS:

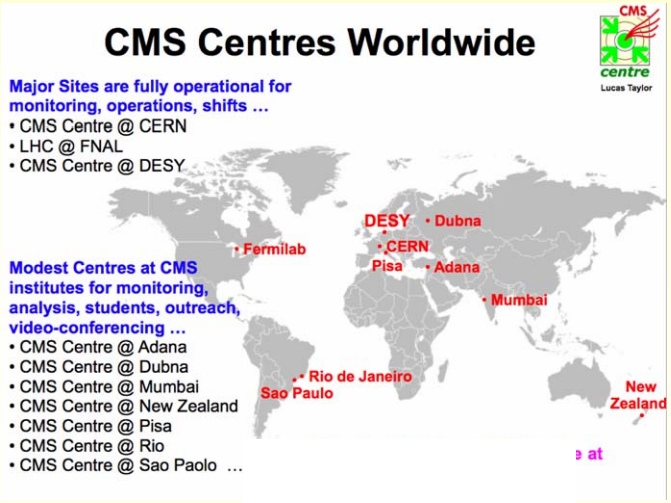
- Monte Carlo Convener
- Monte Carlo Generator Software Coordinator
- Trigger Configuration Coordinator
- Trigger Monitoring Coordinator
- Prompt Reconstruction Organization Coordinator
- Chairs: NUC (NAF User Comm), GELOG (German LHC outreach)
- ATLAS-D SUSY working group convener

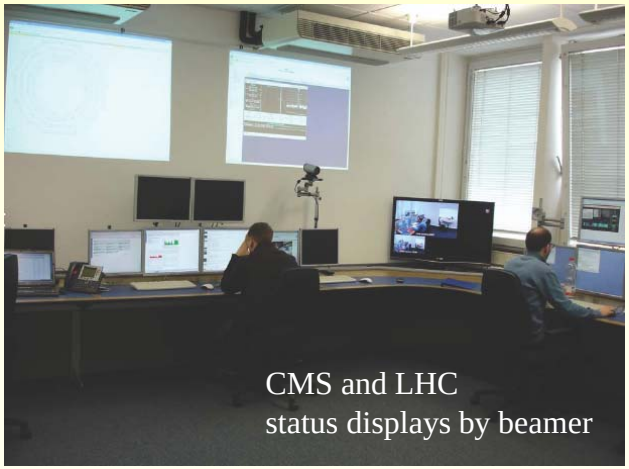
Extraordinary high share

DESY makes a difference to the experiments

Remote Center @ DESY

One cornerstone in the strategy of DESY to play a key role from remote





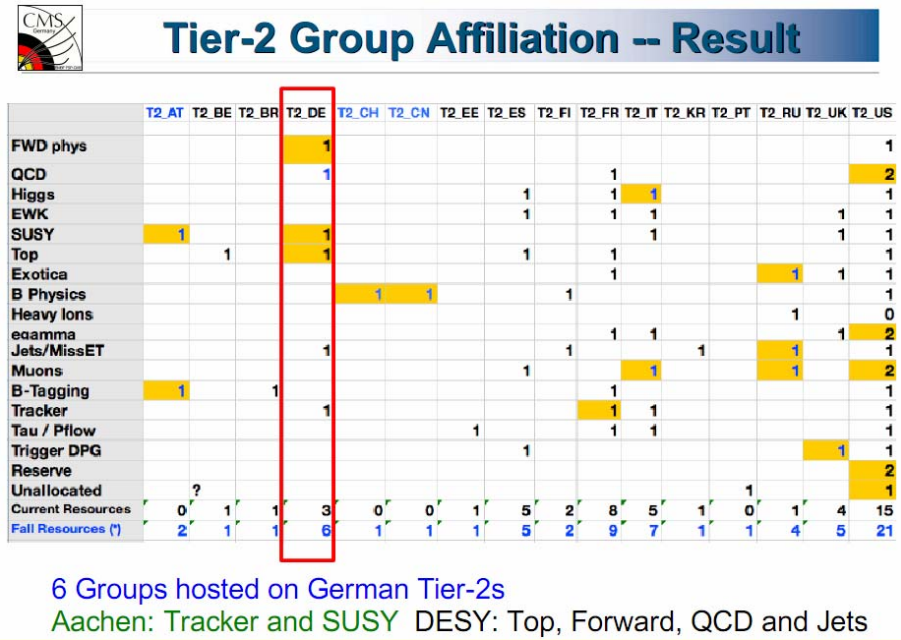
DESY is one of the three major sites worldwide fully operational !

- Data Quality Monitoring:
  - 1/3 of all daily shifts (together with Uni Hamburg) in 2008 cosmic runs
  - Offline shifts for re-processed data
- Plans:
  - Calibration & Alignment Monitoring, Data Acquisition
  - Computing (Tier-1,Tier-2, MC production)

Experiment Computing

Activities:

- essential contributions to the complicated computing models of the experiments
- distribution of software to more than 50 centers within < 24h
- important data sets @ DESY with optimal access
- define data formats
- MC event generators
- fast shower simulations



6 Groups hosted on German Tier-2s
Aachen: Tracker and SUSY DESY: Top, Forward, QCD and Jets

- National Analysis Facility:
  - important tool to facilitate data analysis for German university groups
  - installation of latest software, user support, accounting ...

DESY provides central services for experiment specific tasks

Current Contributions to Detectors

Presently only limited commitment in dedicated areas:

ATLAS Participations:

- **ALFA detectors: luminosity measurement, preparation for forward physics with near beam detectors, strong overlap with HERA physics**
- **Pixel: participation in commissioning & simulation, trigger → future activity**

CMS Participations:

- **CASTOR calorimeter (funded with HRJRG*): study underlying event and multiple interactions, strong overlap with small-x physics at HERA**
- **Beam Condition Monitor: protection for tracker, diamond sensors from ILC-FCAL → low costs – big impact**

* Helmholtz-Russia-Joint-Research Group

Next Funding Period

Increase DESY's contribution to LHC:

- **Fulfill long-term commitments**
- **Physics**
- **Detector upgrades**

Preparation of physics analyses → performing physics analyses

- physics topics top-quark, QCD, electro-weak, SUSY, Higgs
- strengthening input from Young Investigator Groups

Preparations for LHC upgrades

- R&D for tracking upgrade → annual research field budget increment
- Construction of new trackers: ATLAS pixel, CMS tracker (strixel)
  → application for a capital investment project in future

Tracker @ superLHC

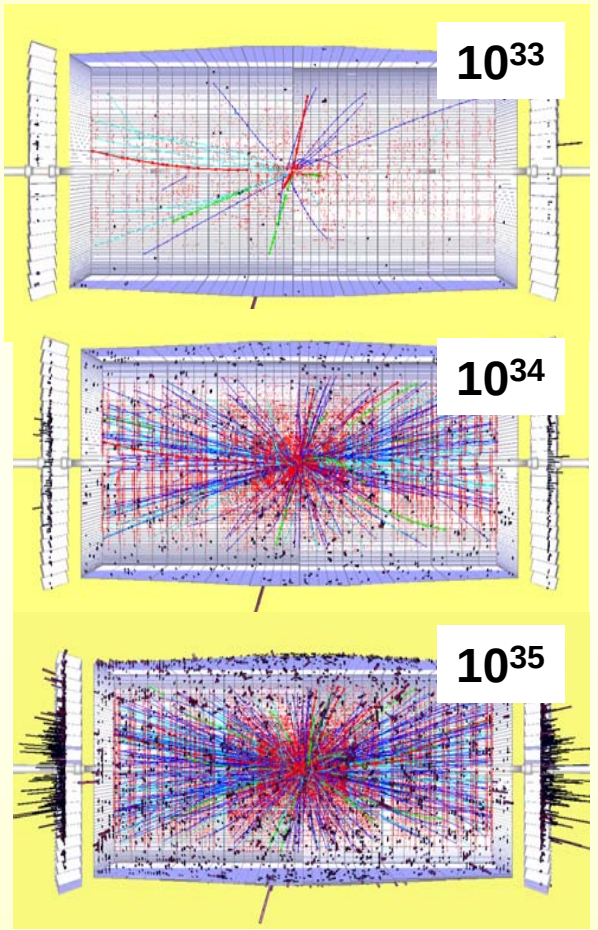
New Physics very rare signals:

→ LHC not sufficient

→ upgrade in luminosity (~interactions) & energy

Tracker Challenge:

- occupancy
- radiation hardness



German groups:

- delivered major contributions to the present trackers
- plan for / are active in strong participation in tracker upgrade:
  - ATLAS pixel: Uni Bonn, Dortmund, Wuppertal, Siegen, MPI Physics et al.
  - CMS Si-Tracker: Uni Hamburg, Karlsruhe, Aachen

Contributions to Detector Upgrade

DESY's added value:

- special expertise in engineering & common developments
- appropriate infrastructure for prototypes on realistic scale

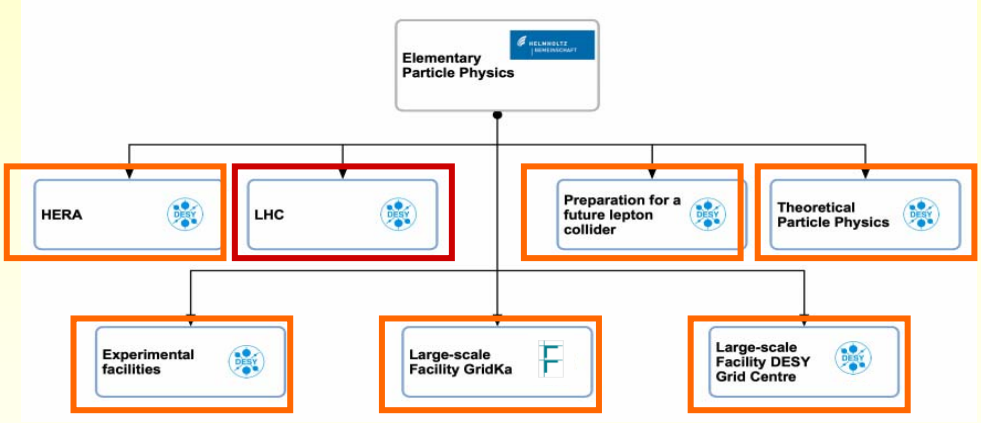
→ well suited to tackle these aspects successfully

→ in close collaboration with and giving support to German university groups
Helmholtz Alliance virtual detector lab

DESY plans for strengthening support by complementing with German activities:

- **System integration aspects** (reduction of non-sensitive material: powering schemes, cooling; optical data transmission)
- **Special engineering** (finite element calculations for mechanical support & cooling)
- **Construction of prototypes & testbeam**
- **Sensor material and design** (radiation hardness, occupancy)
- **Simulation studies for design optimization** (physics, occupancy, alignment, tracking)

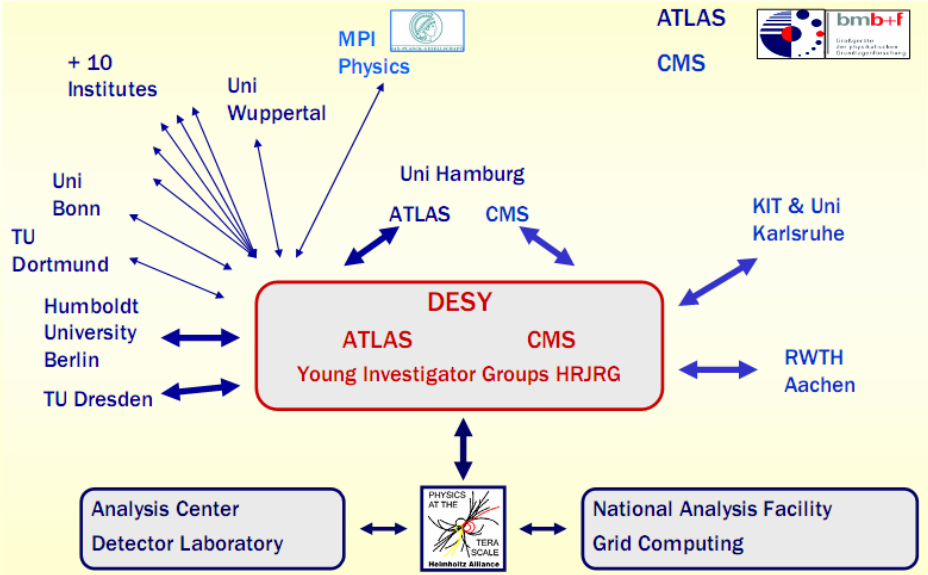
Net-Working



Examples:

- HERA – LHC workshop (~ 4y)
- BCM @ CMS ←→ FCAL @ ILC (&FLASH)
- Testbeam for detectors @ (s)LHC
- Grid-Computing for HERA/LHC/ILC
- Close contact between exp. & theory

→ efficient use of resources



Examples:

ATLAS:

- Research Training center Uni Berlin + Uni Dresden
- Pixel: Universities Bonn, Dortmund, Wuppertal, Siegen, MPI Physics

CMS:

- Alignment: Uni Hamburg + Karlsruhe
- Tracker: Uni Hamburg + Karlsruhe + Aachen

→ well embedded in German landscape

DESY – LHC Groups in the Helmholtz Alliance

DESY's LHC groups in the Helmholtz Terascale Alliance:

- **Strong involvement in the Analysis Center:**
  - organization of alliance workshops
  - organization of alliance schools and support for specific analysis tasks especially for PhD students and PostDocs
  - present topics: MC generators, statistics, proton structure function
  - provision of specific tools and MC tunings
- **Strong involvement in the NAF:**
  - contributions to the NAF development
  - experiment specific NAF software and user support
  - setup and operation of TAG/Cond DB for German ATLAS user
  - software tutorials for LHC-D
- Common projects on physics and trigger
- **LHC upgrade R&D** embedded in alliance (detector lab, testbeam, engineering)
- Organization of German LHC outreach events

Strong support for building up a new structure for the research field

German Contribution to LHC

- CERN: Germany strongest contributor
- ATLAS: 18 institutes, 11% of funding, 2nd largest nation
- CMS: 6 institutes, 6% of funding, 4th largest nation

Funding of LHC experiments (approximate picture):

- University funding:
  - permanent staff (Prof. & PostDoc) → teaching
  - laboratory & technical staff
- Government – BMBF:
  - dominantly investment
  - temporary staff (students)
- MPI Physics
- DFG: Research Training Groups, Collaborative Research Centers

Funding from Helmholtz Association:

- DESY particle physics program
- Helmholtz Terascale Alliance (~80% Universities, ~20% DESY)
  - bundling forces & resources in Germany, collaboration with Universities
  - Analysis Center, Computing, Detector Lab
- Young Investigator Groups
- Special funds from initiatives like the HRJRG

Summary

The LHC program is the

- key element to maintain an attractive in-house particle physics program for the next funding period and beyond,
- opens the possibility to participate and even take up leading roles for discoveries in the next decade.

Employ DESY specific characteristics → successful strategy → use for the future

The DESY LHC groups had a very successful start in the LHC experiments proven by many important coordinating positions with long-term responsibility

DESY plans to increase the LHC involvement in close collaboration with the German Universities (Helmholtz Alliance):

- Physics
- Detector Upgrades

B A C K U P

DESY Research Topics for the LHC

- Searches for New Physics:
  - Higgs → discovery & characterization of couplings
  - SUSY → discovery of new classes of elementary particles & interactions

- Standard Model Physics:
  - Top-quark: discovery @ Tevatron,
    precise characterization @ LHC,
    deviations from SM give access to signatures of new physics
  - Electro-Weak: W- & Z-Bosons, esp. for calibration
  - QCD: dominant processes @ LHC (strong HERA input), background
    deviations from SM give access to signals of new physics

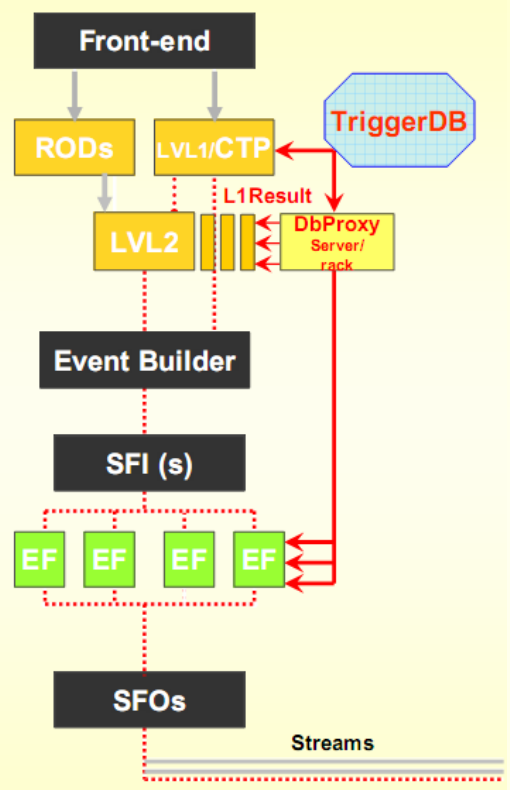
Key topics for discoveries in the next decades addressed

Research into the structure of matter at the energy forefront
possible with exceptional qualifications of DESY
→ very good position for competent input and leadership

Trigger

Incredible high collision rate → filter is crucial

40 MHz beam bunch crossing rate with up to 20 interactions → down to ~100 Hz logging rate → different filter levels



Responsibilities & contributions in various areas:

- trigger configuration and steering, archiving
- monitoring on Tier-0 and CERN Analysis Facility
- supervisor for event filter farm (~2000 PC's)
- clever trigger algorithms

Goals:

- Adapt to changing boundary conditions: LHC machine parameters, rapidly increasing data rate, evolution of physics program
- Operation and maintenance in parallel to improvement and partially new development
- Development of new & efficient trigger algorithms
- Develop direct connection of trigger to hardware (eg. track trigger)

Monitoring

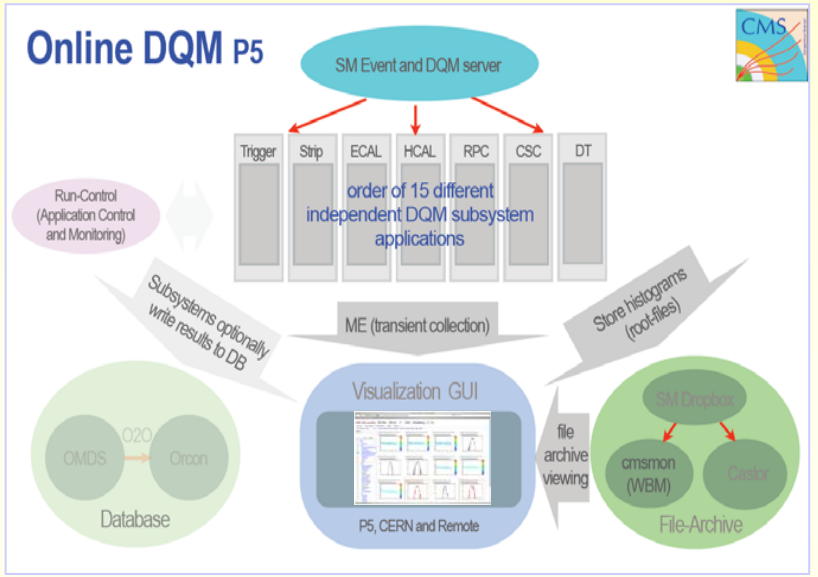
Activities highly visible in daily operation of the experiment

Data Quality Monitoring:

- crucial to ensure excellent data
- framework developed & successful

Goal: further expansion from

- online to offline and archive,
- Tier-0 → Tier-1 & Tier-2,
- data to MC samples,
- detector to physics quantities



Calibration & alignment:

- precise calibration and alignment of tracker on micron-level pivotal for prime analysis results
- algorithms & framework proven to work within short time constrain

Goal:

- develop new strategies & algorithms for large data samples
- in parallel: phase transition from preparation to streaming with high reliability