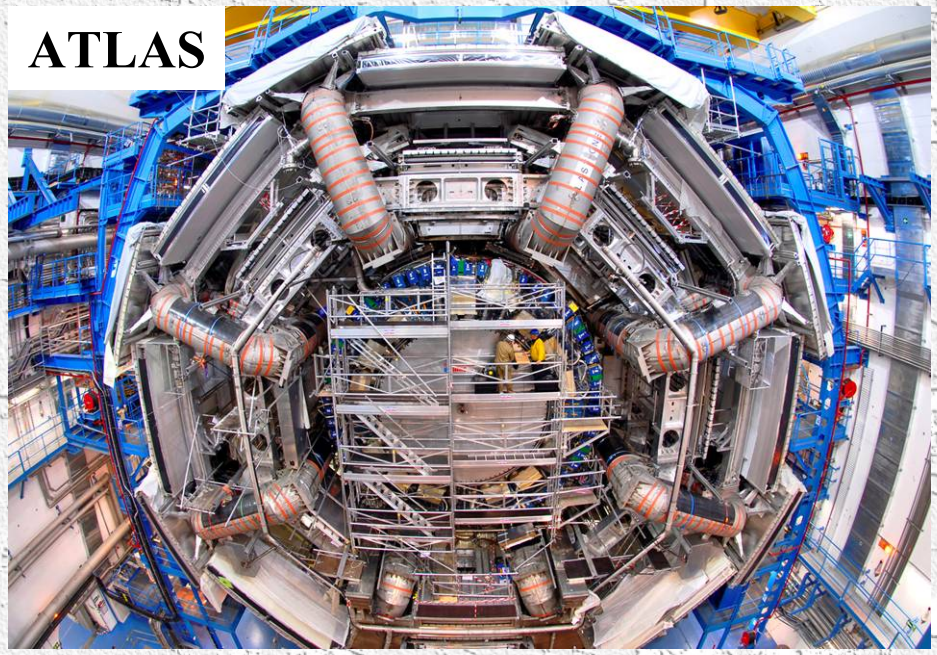
DESY Participation in LHC Experiments

Joachim Mnich
for the DESY ATLAS & CMS groups

63th Meeting of the DESY PRC
May 10, 2007

ATLAS



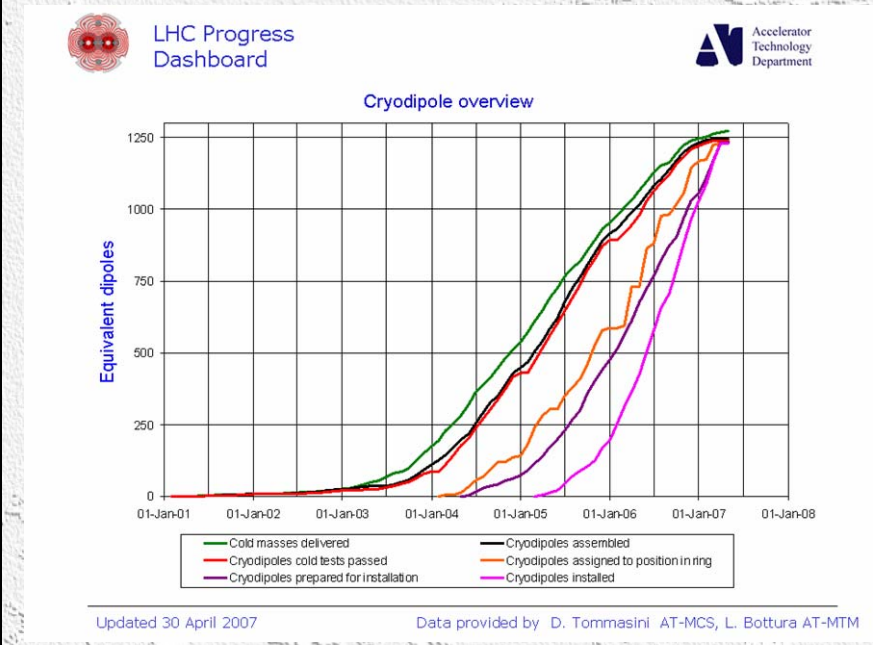
CMS

Outline

- Status and plans of
  - LHC machine
  - ATLAS detector
  - CMS detector
- DESY contributions to
  - Computing (Tier II, NAF)
  - ATLAS experiment
  - CMS experiment
- Outlook & Conclusions

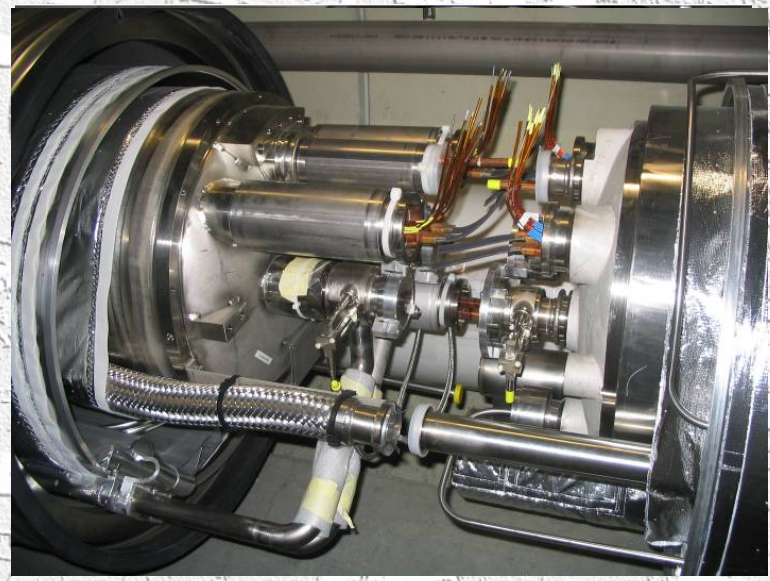
Status LHC

- All 1232 dipoles built and installed

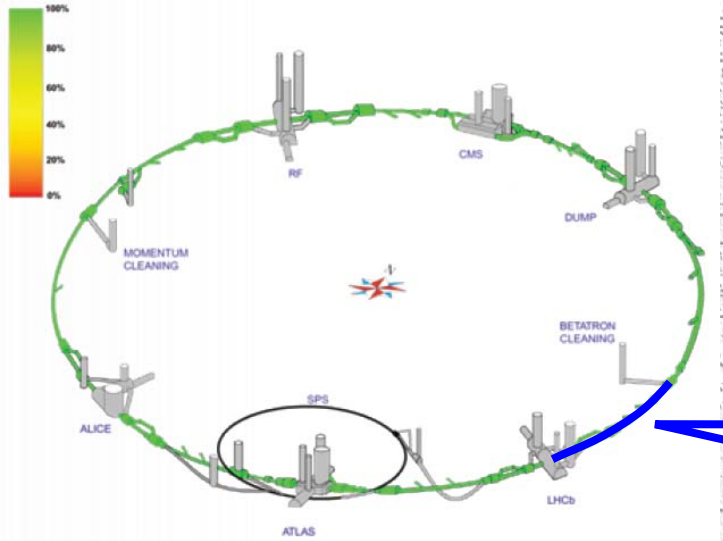


- Last dipole lowered on April 26, 2007

- All magnets prepared on schedule
- Interconnections on-going in 6 sectors
  - sector 7-8 ready
  - closure of 4-5 and 8-1 upcoming



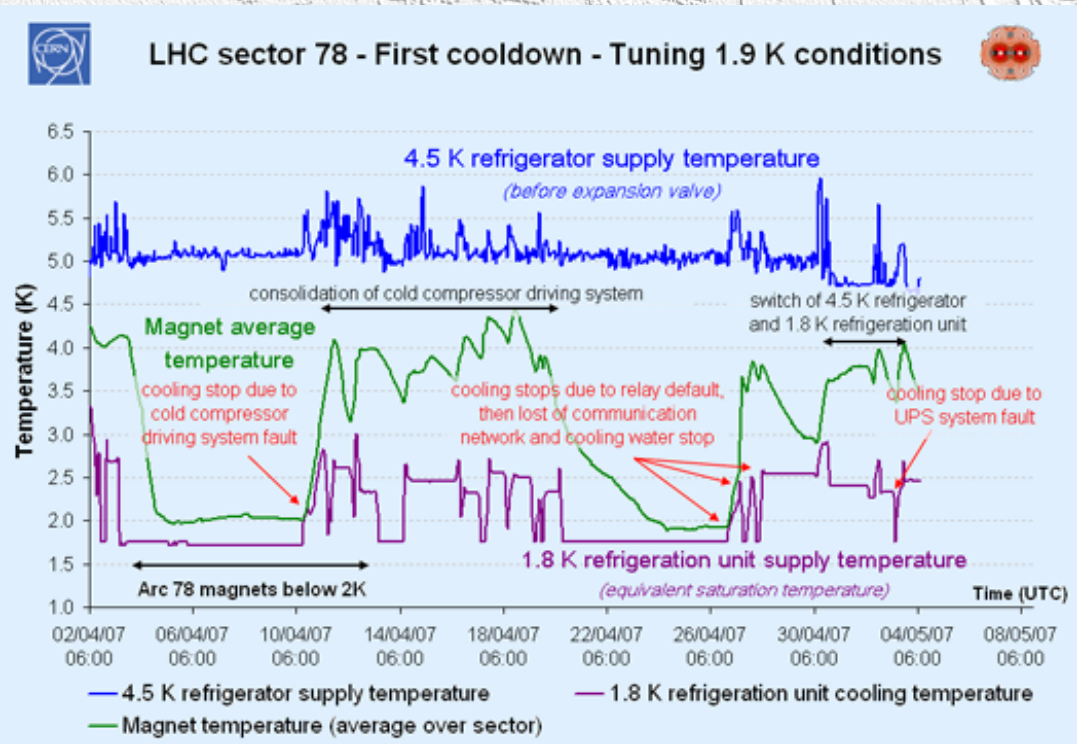
Status LHC



- **Cryogenics complete**

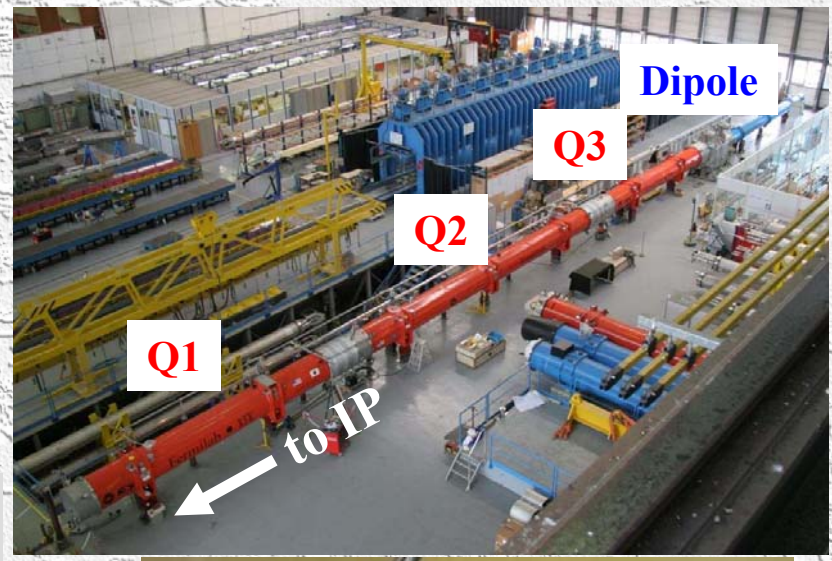
sector 7-8

- **First cooldown April 2007:**



Inner Triplet Quadrupoles

One hazard for the LHC schedule:
- **Low-β quadrupoles at IPs**
  Q1, Q2, Q3
- **Designed & built in collaboration**
  BNL, CERN, FNAL, KEK, LBNL



March 27th:
- **Pressure test of inner triplet at IP5 failed**
- **Support structure failed to withstand longitudinal forces**

Actions:
- **Reinforce support structure:**
  add cartridges to take longitudinal forces
- **Repair can be done in-situ (except IP5)**
- **Repeat pressure test in June 07**

LHC Schedule

- **LHC: very good progress, but some delays accumulated**
- **Engineering run in 2007 at 900 GeV questionable/unlikely**
- **New LHC schedule mid May**
- **2008: First collisions at 14 TeV in June?**
- **Prospects:**
  - **2008 integrated luminosity O(1 fb^{-1}) possible**
  - **2009 few fb^{-1}**

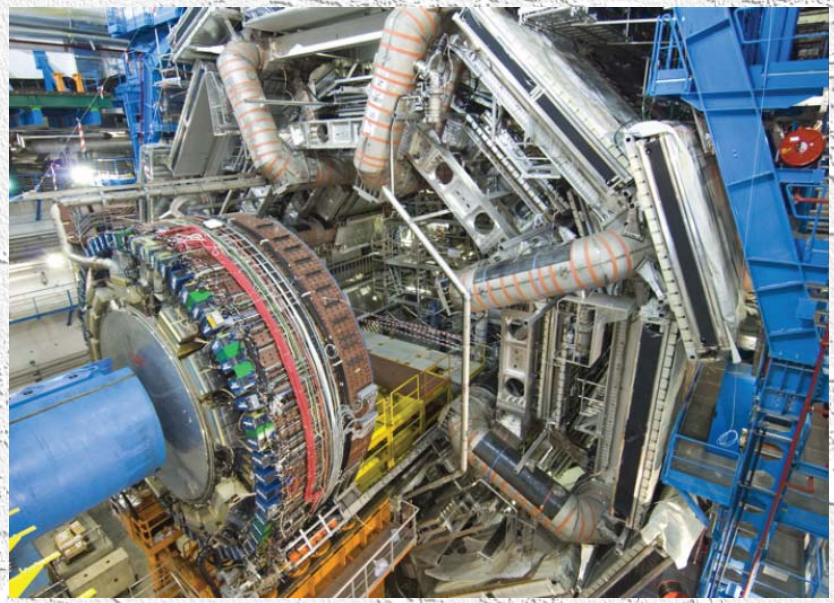
L. Evans, 23 April 2007

- Before the IT problem, we were about 5 weeks behind schedule.
- Once the full extent of the damage is known and the in-situ repair validated, we will publish a new schedule. It now looks unlikely that the engineering run can occur at the end of the year but all effort will be made to maintain a physics run in 2008 as foreseen.

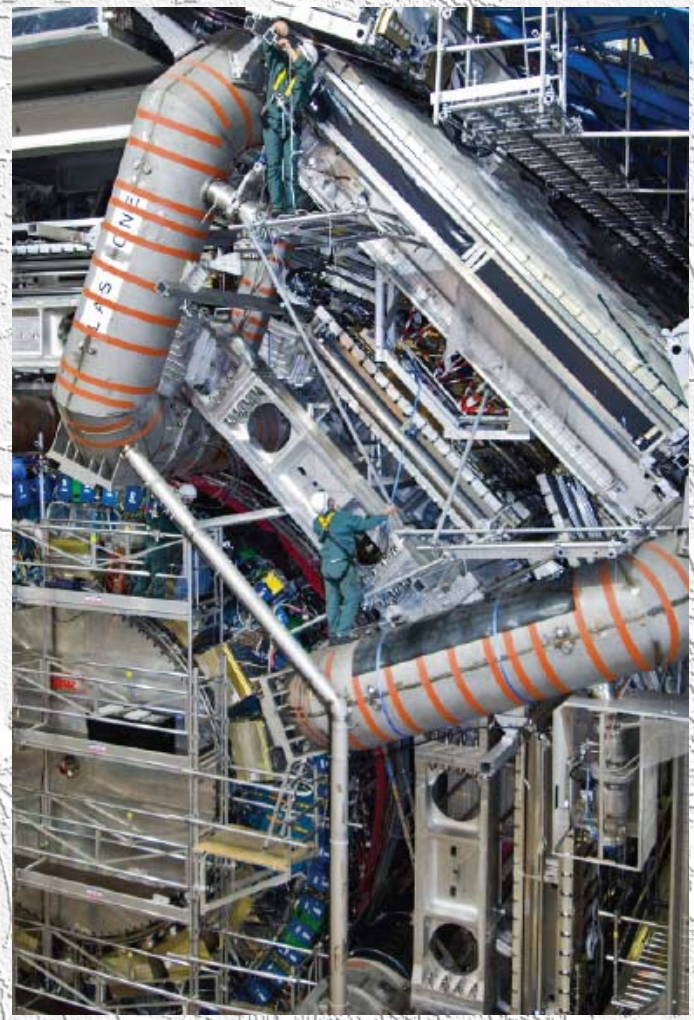
Status LHC Detectors

ATLAS: on track for LHC physics

- all calorimeters installed

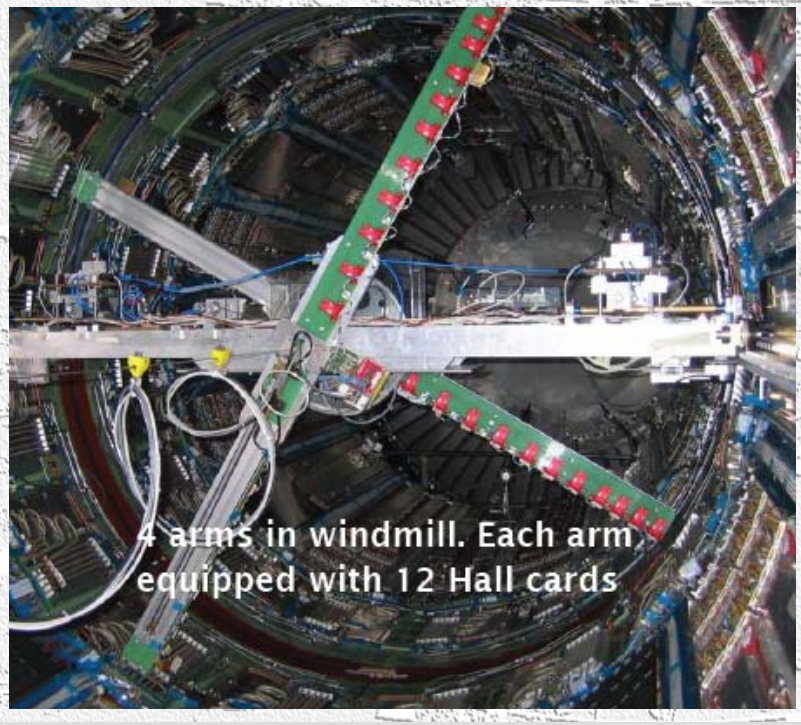


- 99% of barrel μ chambers installed



Status ATLAS

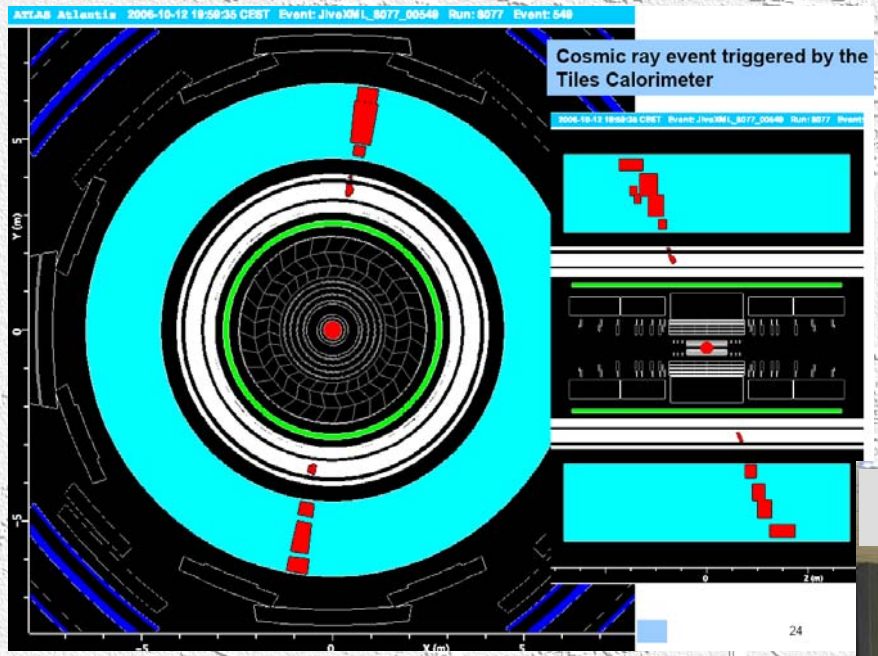
- Magnets
  - barrel toroid tested sucesfully (11/06)
  - inner solenoid:
    tested & field map taken



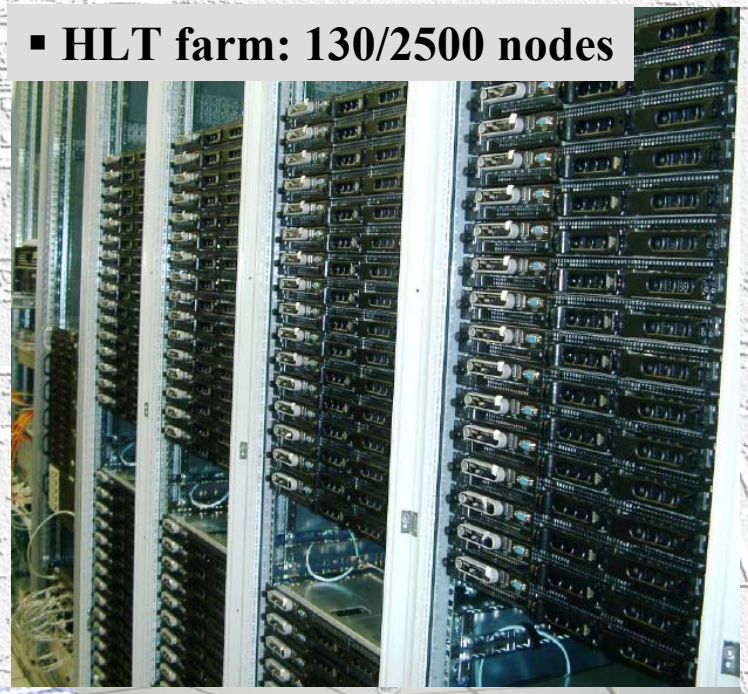
- 1 endcap toroid sucessfully tested (03/07)
  moved to IP1
- 2nd follows in June

Status ATLAS

- Trigger and DAQ system
  - installation & commissioning
  - cosmic data



- HLT farm: 130/2500 nodes



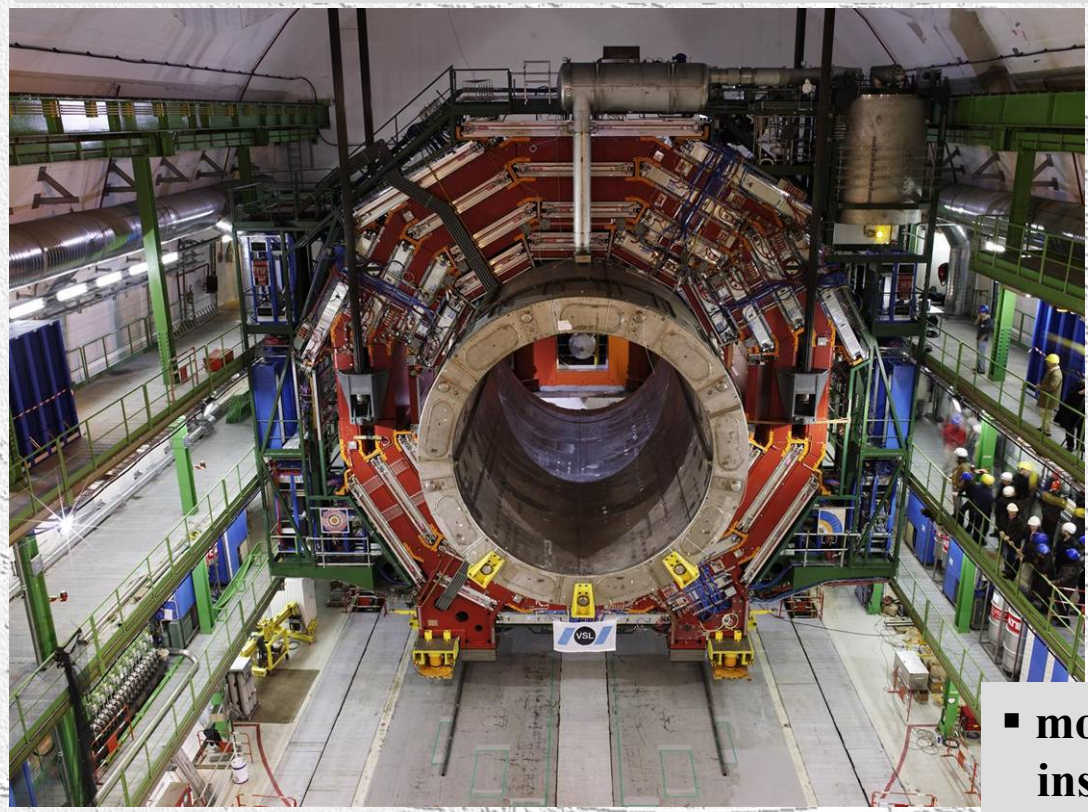
- ATLAS control room

Summary status ATLAS:
- in general on track to be ready in fall
- some items on critical path

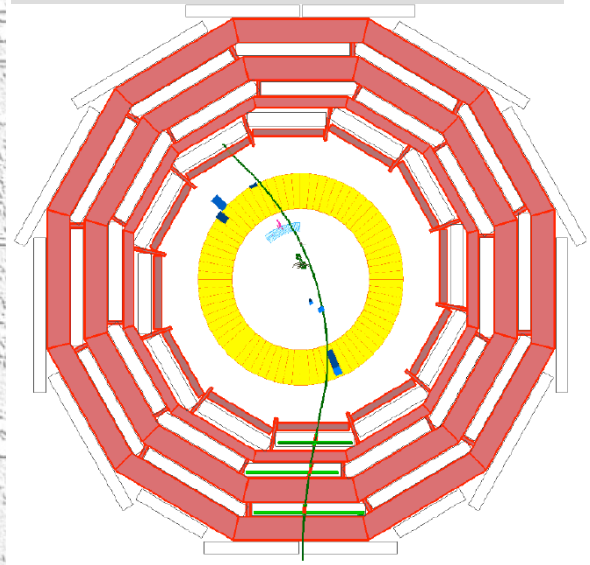
Status LHC Detectors

CMS:

- **solenoid sucessfully operated at 4 Tesla (11/06), field map**
- **lowering of central magnet slice (YB0) on February 28th**



Cosmic from magnet test



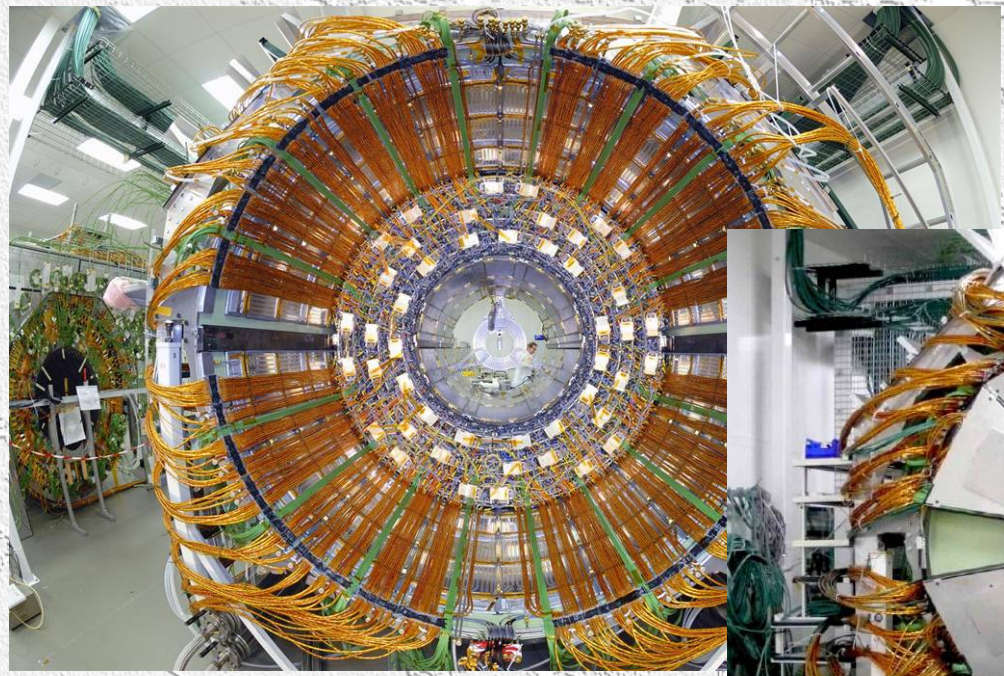
- **most μ chambers installed**

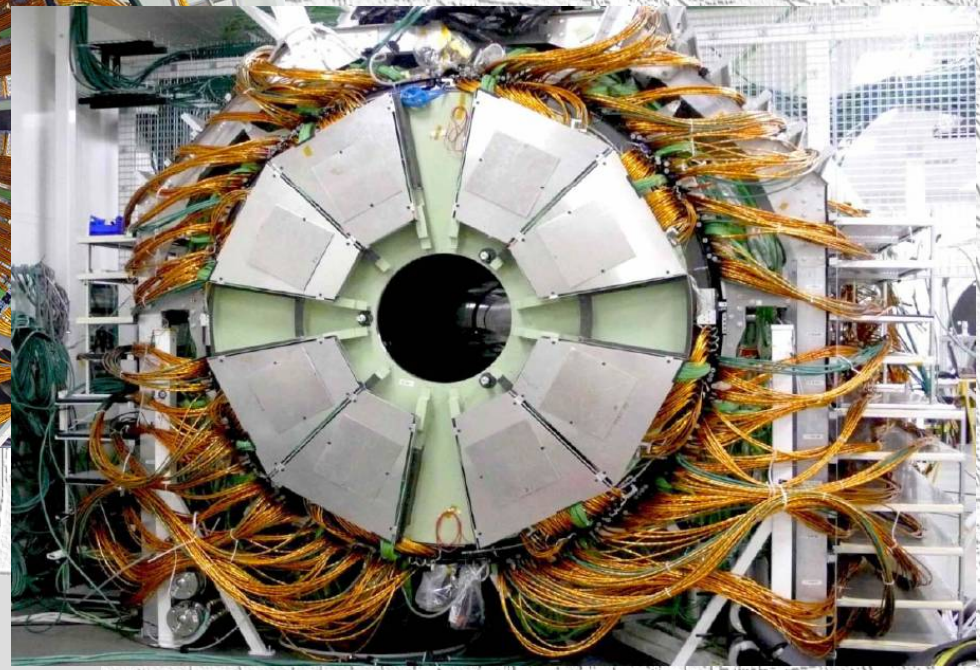
- **5/13 heavy pieces still to be lowered but all of known type**
- **2nd endcap cabled, tested & commissioned on surface**

Status CMS

- Silicon tracker ready
  - under test at surface
  - to be installed in August 2007

CMS tracker:
- ≈ 220 m² of Si sensors
- 10.6 million Si strips
- 65.9 million Si pixel





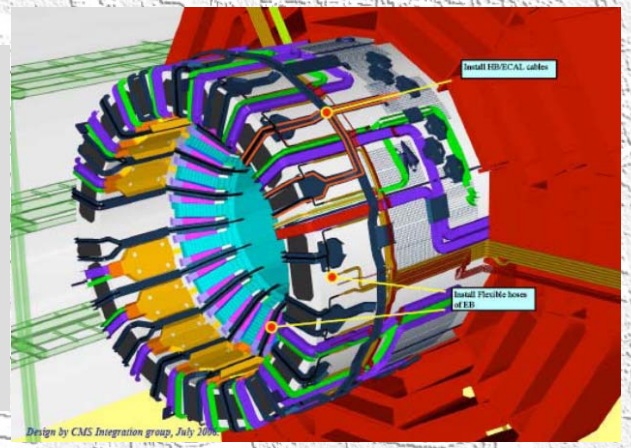
- Pixel detector:
  - 2/3 of modules produced
  - ready for installation end 2007

Status CMS

- ECAL:
  - barrel crystal production and module assembly completed
  - installation May/June
  - endcap crystal prodcution started
  - full endcaps ready for 2008 physics run

- Trigger and DAQ:
  - is progressing well
  - 400/2000 HLT PC (being) installed
  - global run May/June

- Summary status CMS:
  - on track for taking data in fall
  - on critical path:
    installation of services on YB0
  - complete detector (+ Pixel + ECAL endcaps) ready for 2008 run



DESY Contributions to LHC

Short reminder:

- **Spring 2005: DESY strategy group on external experiment recommended participation in LHC experiment (ATLAS/CMS)**
- **Two pillars:**
  - **I Computing: Tier-II centres for ATLAS and CMS operational since 2006**
  - **II Experimental groups**

- **Summer 2005: discussions with ATLAS and CMS to identify opportunities for DESY**
  Results:
  - **Physics**
  - **High Level Trigger and DAQ**
  - **Software**
  - **Commissioning & Technical Coordination**
  - **On smaller scale: forward detector & physics**
  - **Later: sLHC detector upgrades**

- **Fall 2005: directorate decision to join both, ATLAS and CMS**
- **2006: DESY accepted in CMS and ATLAS**

Computing for LHC @ DESY

- Today's hardware resources (Hamburg + Zeuthen)
  - ≈ 600 CPU Cores, 1 KSPECint2K
  - ≈ 280 TB Disk Storage

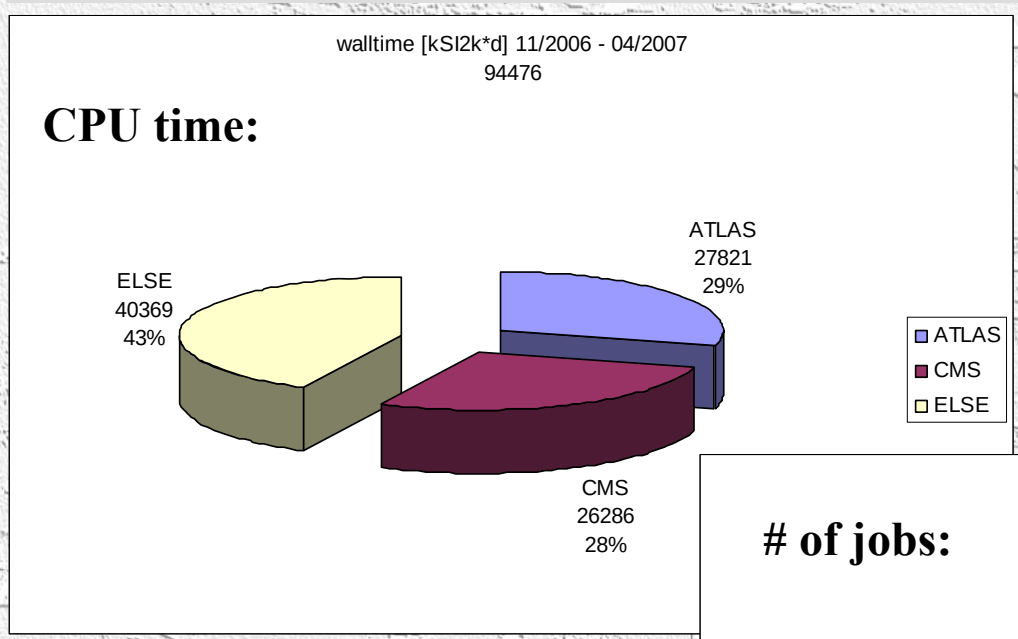
- Tape-Storage: not mandatory but highly welcome @ Tier II's
  - 2x SUN SL8500 Library
  - installed at DESY in Jan 07
  - up to 10000 Cartridges
- Currently 30 drives LTO3
  24 data/6 backup
  LTO3 400 GB/Cart, 120 MB/s

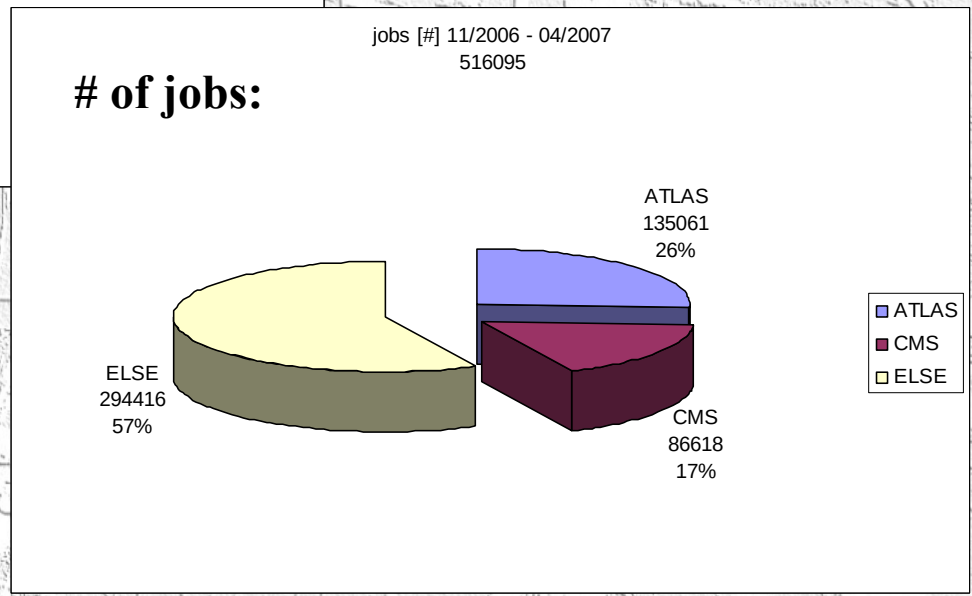
- 10 Gbit/s connection HH-ZN in preparation
- 1 Gbit/s WAN connectivity, 10 Gbit/s in preparation

In summary: well equipped Tier-II centres for ATLAS and CMS

Computing for LHC @ DESY

- **Resource usage:**
  - ≈ 1/3 ATLAS
  - ≈ 1/3 CMS
  - ≈ 1/3 others (H1, ZEUS, ILC, Amanda, …)





DESY Planned Tier-II Resources

- **Official DESY MoU commitments: average Tier-II per experiment**

		2007	2008	2009	2010	2011	2012
CPU/kSI2k	ATLAS	80	580	900	1720	2300	2900
	CMS	300	600	1000	1800	2300	
disk/TB	ATLAS	45	260	440	740	1040	1300
	CMS	50	170	340	530	850	

- **About 80% used for worldwide simulation/analysis**
- **A National Analysis Facility (NAF) is needed for German research groups**

National Analysis Facility @ DESY

- A national resource to set ATLAS and CMS scientists into a competitive position, other countries do have one.
  - Accessible for all national ATLAS and CMS groups
  - Tier 0 - Tier II's have other obligations
  - Have direct access to relevant datasets, stored @ the NAF

- A batch processing facility for Analysis
- A facility to provide the possibilities for parallel interactive work.
- Calculated to serve ~ 200 scientists (Top, SUSY, Higgs, SM, Exotics)
- Minimum about the size of an average Tier II
- Tape Storage attached in addition
- Starting distributed at both DESY sites but is open to be enlarged
- DESY is capable to run the NAF 24x7

- Funding & implementation of NAF
  → HGF Strategic Alliance 'Physics at the Terascale' (see below)

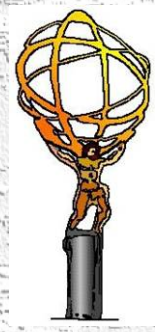
Plans for LHC Computing

- For the Tier II's:
  - The installation is well on track, just follow the upgrade plan
  - Participation in experiment's „computing tests" (i.e. CSA etc.)
  - Including LHCb into Tier-II operations

- For the NAF:
  - Organisational concept → part of Alliance
  - Agreement on resource usage → part of Alliance
  - Definition of the software stack → ATLAS/CMS
  - Integration into the DESY infrastructures → DESY IT/DV

  - Start procurements → DESY IT/DV
  - First operation end 2007 → DESY IT/DV

DESY Contributions to ATLAS



- The DESY-ATLAS group consists at present of
  - 7 staff physicists,
  - 5 postdocs and
  - 5 PhD students
- Close collaboration with
  - IT-Hamburg and DV-Zeuthen
  - Uni Hamburg (1 Junior Professor)
  - Humboldt University Berlin
- Our tasks in ATLAS are usually common projects of DESY and the university groups

DESY: ATLAS Physics

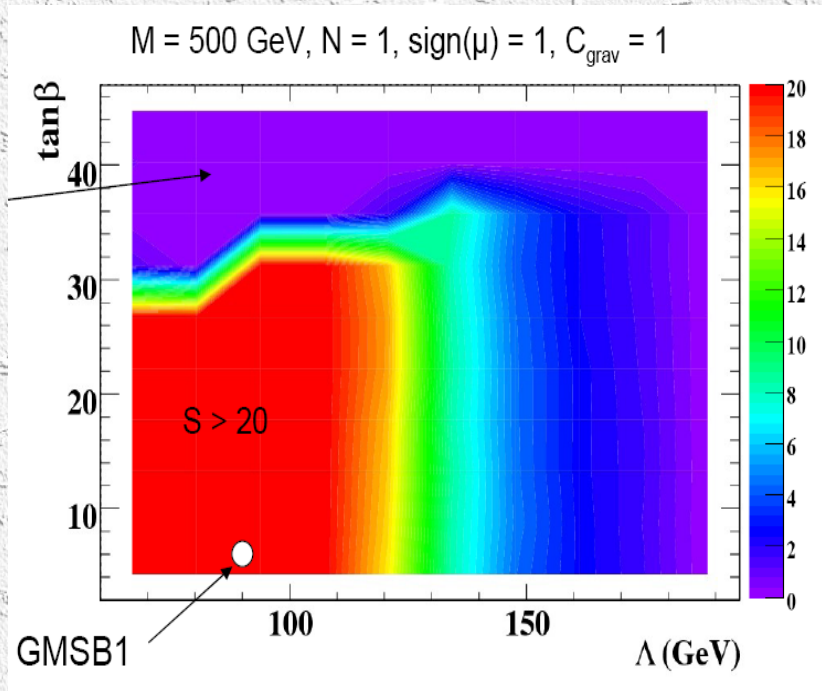
- Main areas:
  - SUSY (next slide)
  - Standard Model analyses
  - Top physics

- SUSY work already ongoing
- Other fields are more in the starting phase
- Standard Model work can profit strongly from HERA experience

DESY: ATLAS SUSY Studies

- Tools:
  - production of ATLAS standard "high pT"- ROOT trees on local DESY cluster
  - usage of generic ROOT based analysis frame-work: "SFrame"
    - implemented in collaboration with CERN Trigger group
    - used already by several other ATLAS groups (for top physics, SUSY, …
- Physics:
  - first steps in MC-study: Discovery potential for GMSB with di-photons:

- Signal significance after parameter scan:

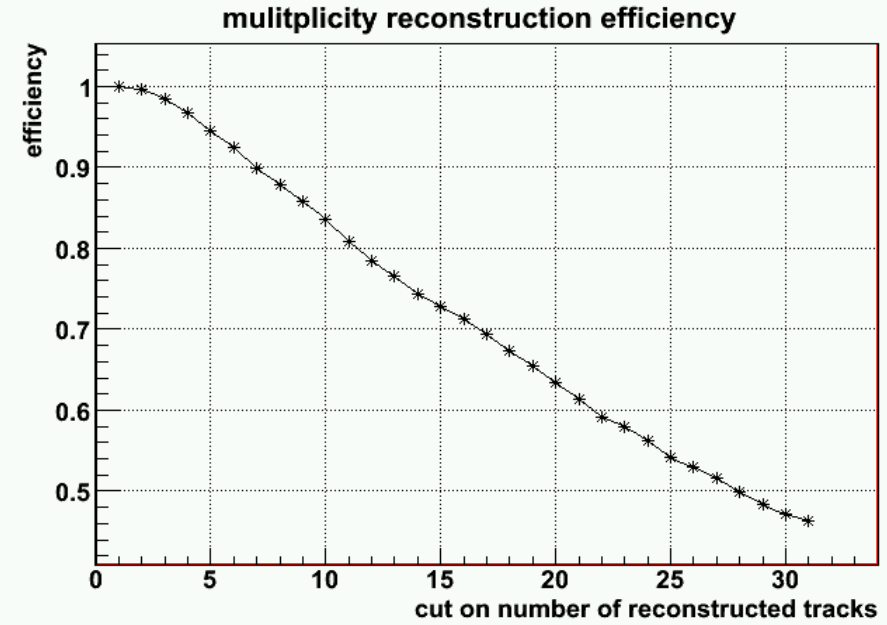


- Further physics studies:
  - Study of triggers for SUSY
  - Determination of electron trigger efficiencies from real data ($Z \rightarrow ee$, "tag and probe"- method)

DESY: ATLAS Minimum Bias Trigger

- Subtract pile-up at high luminosities
  → study minimum bias events at low luminosity

- Foreseen in Pilot Physics Run with $L = 10^{31}\ cm^{-2}s^{-1}$



- Trigger concept :
  - random selection at level 1
  - perform tracking at higher trigger level

- Preliminary results
  - efficient algorithm for low p_T track reconstruction
  - well within the time constraints of trigger
  - multiplicity cut gives good efficiency

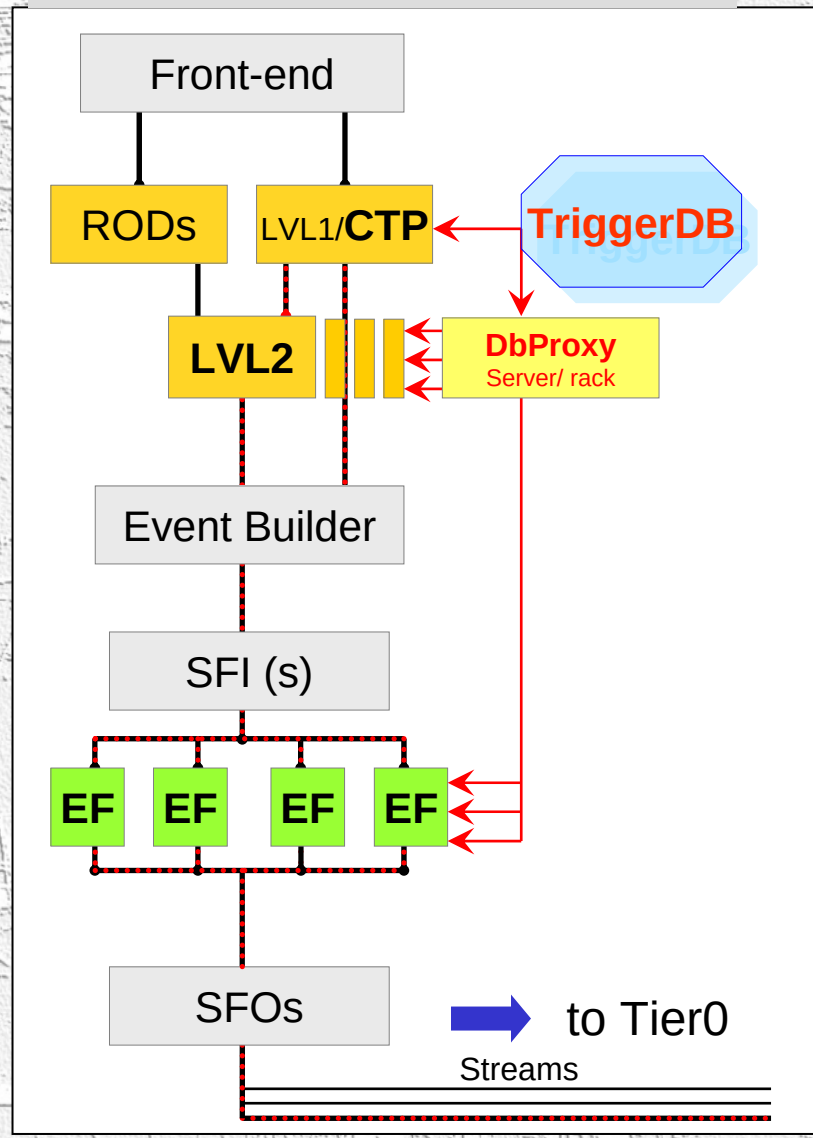
DESY: ATLAS Trigger

- **Trigger Configuration System**

- **Use-cases**
  - **set-up of full trigger (LVL1+HLT) at "run start"**
  - **archival of all trigger settings**
  - **transfer of settings to offline data analysis for decoding of trigger decision**
  - **configuration of MC production on the grid**

- **Components:**
  - **Trigger Database**
  - **SW components for fast online/offline distribution of parameters**
  - **Data storage in AOD/ ESD/ TAG**
  - **DB population SW:**
  - **expert GUI for modifications, etc.**
  - **scripts for DB upload**
  - **DB browsing GUI**
  - **…**

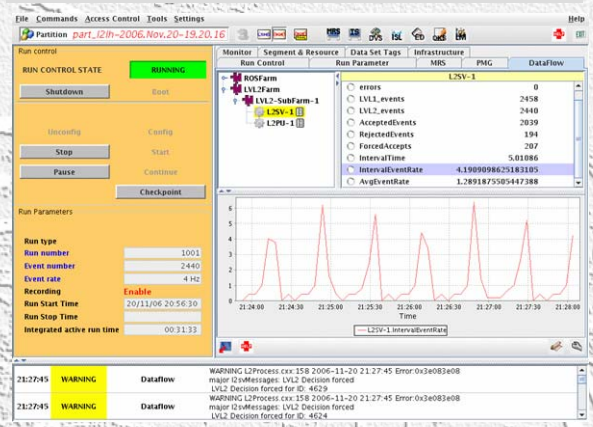
- **Online distribution schematic:**



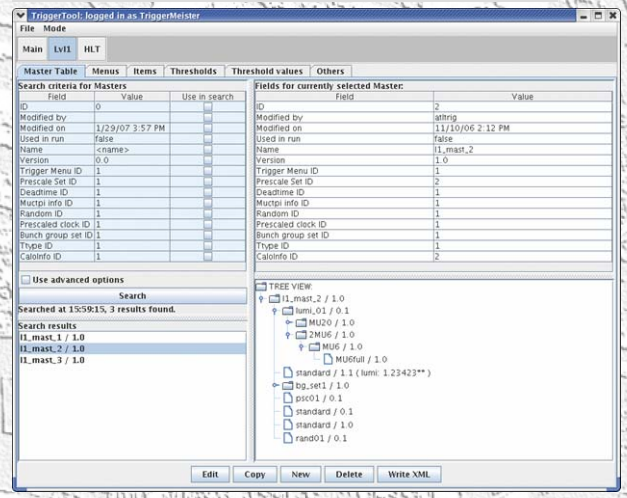
DESY: ATLAS Trigger

- **Major contributions of DESY Group to Trigger Configuration System:**
  - **test of DB performance on local DB server at DESY**
  - **test of full system in "technical runs" and Large Scale Test (LST) at the pit**
    - tested 9 trigger slices on ~400 HLT nodes
    - scalability: OK !
  - **definition and implementation of data formats for offline trigger analysis in AOD/ ESD/ TAG**
  - **improvement of expert GUI ("Trigger Control Center")**
  - **"Prescale Calculator" ala H1 (to be fully integrated)**
  - **…**

- **Screen shot: Run Control during LST**



- **Screen shot: Trigger Control Center**



DESY: ATLAS Trigger

High Level Trigger Monitoring:

- **Aspects of monitoring of the High Level Trigger:**
  1. **Data Quality (DQ) monitoring**
  2. **Trigger Rate Monitoring and presentation**
  3. **Operational Monitoring**

1. DQ monitoring

- **aim: avoid faulty data taking, spot problems and their sources online**
- **Monitor information e.g. event selection variables, spectra of reconstructed objects, etc. for each trigger slice**
  (Trigger calculation at both LVL2 and EF is organised into slices which look for specific signatures, e.g. muon or e/gamma.)
- **Coordinate DQ monitoring among slice development groups: identify overlap between slices check for missing DQ tests**
- **Collect DQ information on a distributed system**

DESY: ATLAS Trigger

2. Trigger Rate Monitoring and presentation

- monitoring of events accepted by each Trigger chain after each step (part of HLTsoftware running on each farm node)
- Rate calculation (based on information from all farm nodes)
- HLT presenter: presentation of LVL1 Rates, Trigger Rates of HLT subfarm status in the control room!

3. Operational Monitoring Display

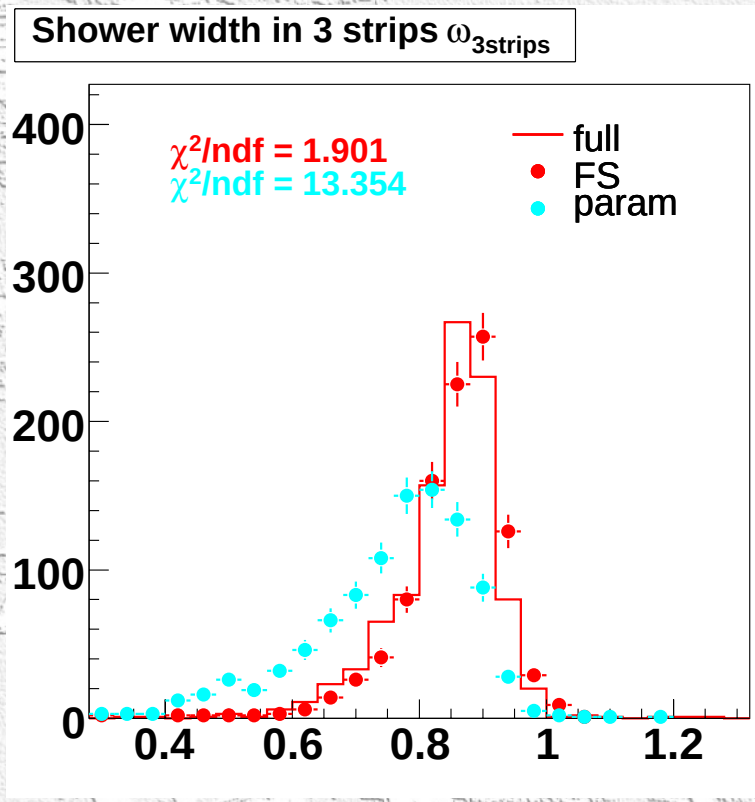
- aim:monitor and display status of the ATLAS Trigger/DAQ system
- e.g event size, #active nodes, …

- flexible generic display:
- display sum, average or
- standard deviation history
- of any information
- available by T/DAQ
- configurable for expert or shift

DESY: ATLAS ECAL Software

- Electromagnetic showers in LAr Calorimeter

- A novel technique for fast simulation of electromagnetic showers, "Frozen Showers" (FS).
- Factor of ≈ 10 improvement in speed, similar to traditional GFLASH-like parameterization (param) but much better shower shape description if compared to full GEANT4 simulation.



- Overall factor of ≈ 2 speed improvement for typical physics events.
- Included in the latest simulation version, to be validated by physics groups.

DESY: ATLAS Computing

- Grid tools & Computing

- DESY runs a Tier-II centre and participates in the running of the ATLAS GRIDKA-cloud

- Also started support for ATLAS core services:
  Active participation in the management, monitoring and bug tracking of the Distributed Data Management system (DDM) and the Raw Data Object (RDO) datasets

- Contributions to make the ATLAS event generators compatible with 64bit architecture

DESY Contributions to CMS

- **DESY CMS group**
  Four main activities:

I. Physics

- **Top physics**
- **Underlying event & mulitple interactions**

II. HLT & DAQ

- **HLT supervisor**
- **Data Quality Montoring**

III. Technical Coordination

- **Management**
- **Technical help**
- **Commissioning Beam Radiation Monitor**

IV. Computing & Software

- **Management**
- **Software instal. & MC production**
- **Tracker Alignm. (with Uni HH)**

Other activities:

- **Contribution to CASTOR forward calorimeter**
  - **design & construction for testbeam (summer 2007)**
  - **connection to HERA physics (proton structure)**

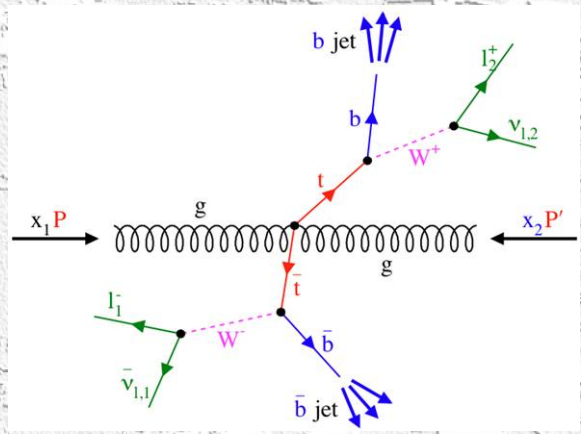
DESY: CMS Physics

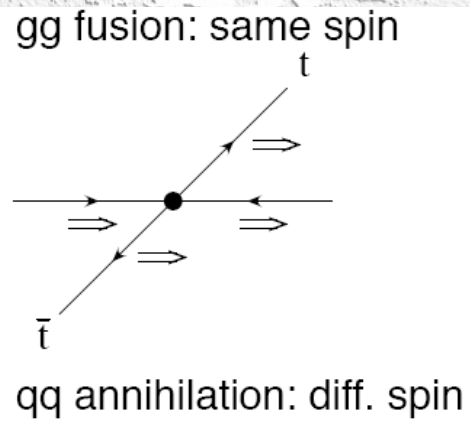
Standard Model Physics:

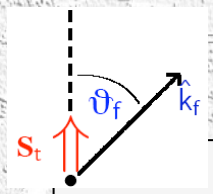
- Physics TDR
- Top Physics
  - Spin Correlations
  - differential xs
  - NLO generators

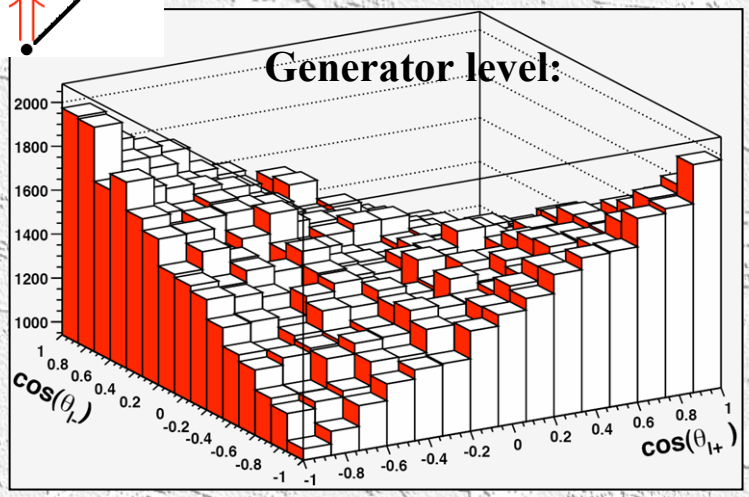
- LHC is top factory
  ≈ 1 top pair per second

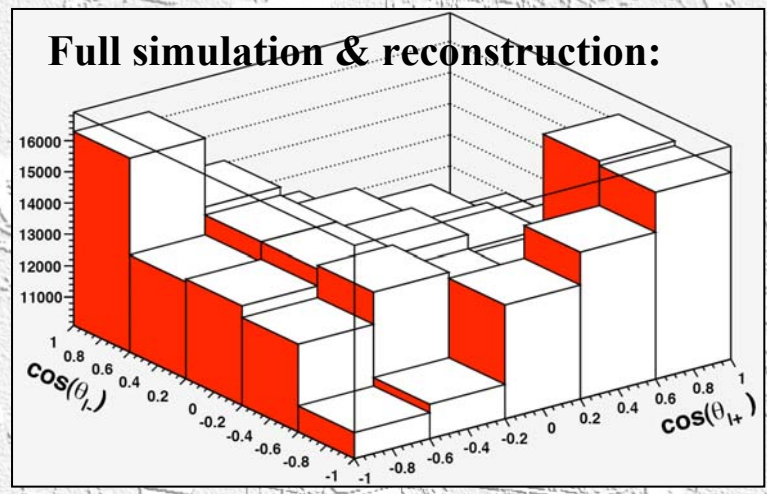
- Example top spin correlations:
  - spin information transfered to decay products
  - production: ≈ 90% gluon-gluon fusion
    ≈ 10% quark annihilation









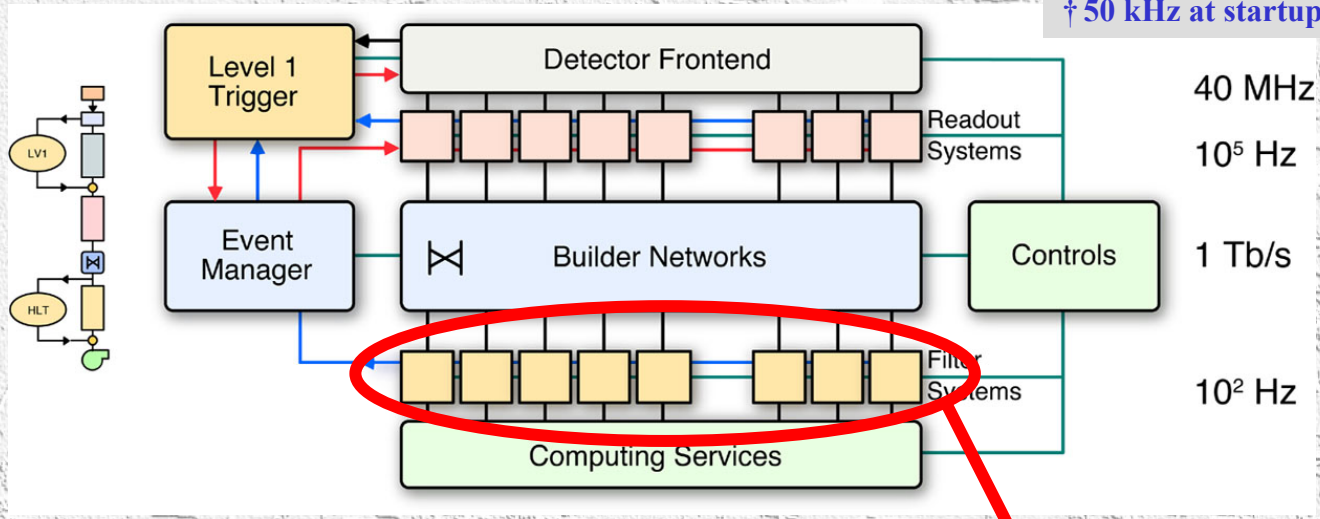


DESY: CMS High Level Trigger

- **High Level Trigger and DAQ**

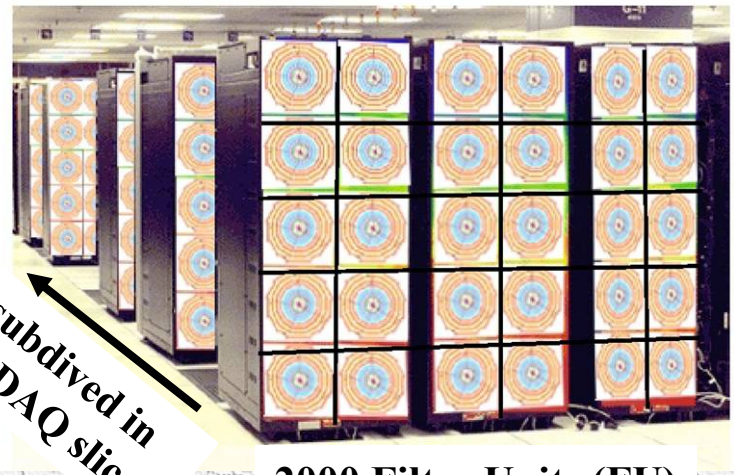
Collision rate	40 MHz
Level-1 max. trigger rate	100 kHz†
Average event size	≈ 1 Mbyte

† 50 kHz at startup (DAQ staging)



DESY responsibility:

- HLT Supervisor (HLTS)
  - act as FU function manager (FM)
    - drive run control commands
    - distribute configuration
  - collect statistics from FU
  - provide prescaler service
  - provide online monitoring of HLTS



2000 Filter Units (FU)

DESY: CMS High Level Trigger

Status HLTS:

- Single slice FM version available and installed at CERN
- used for CMS cosmic tests

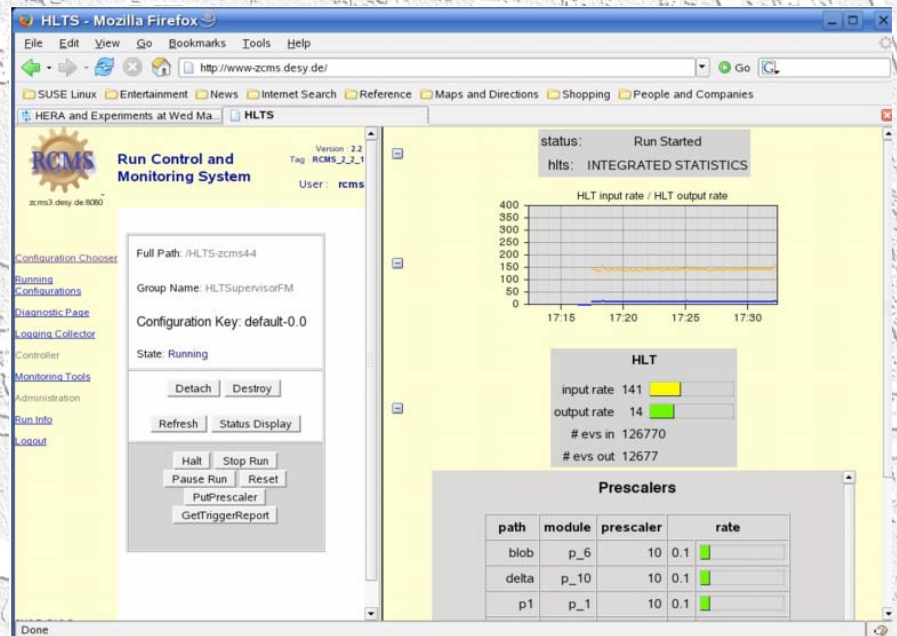
- Extension to multi-slice operation
  - working in DESY test system
  - being implemented at CERN

Database configuration tool

- tested at DESY
- now working at CERN

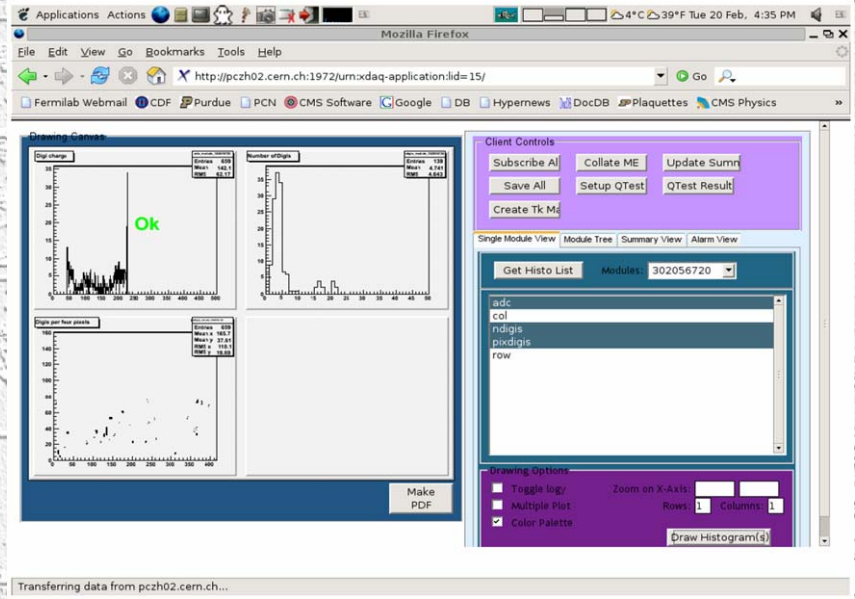
Monitoring status:

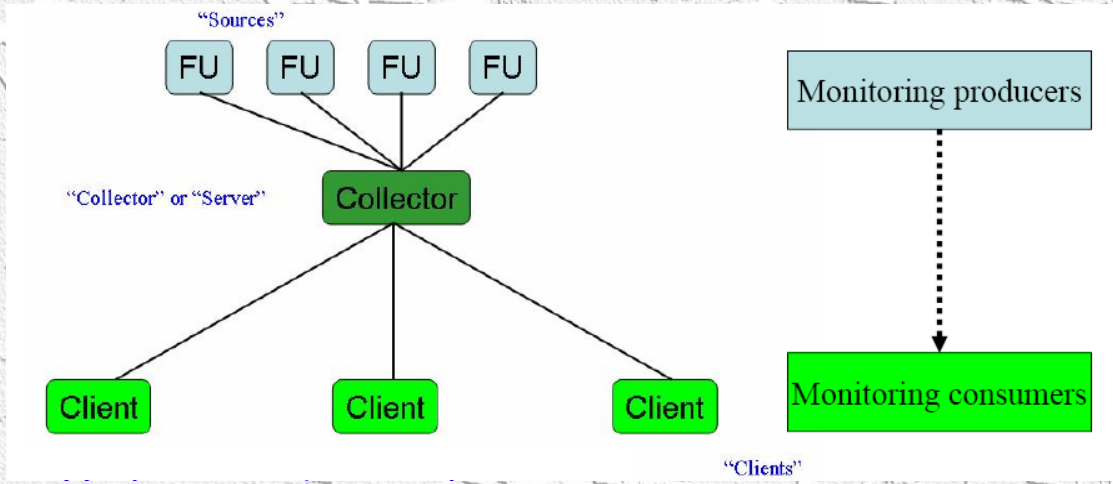
- based on ZEUS system
- using web tools



DESY: CMS Data Quality Monitoring

- Data Quality Monitoring
  - Part of HLT & DAQ activity
  - Coordination
  - Expect to contribute to software and remote operation centre

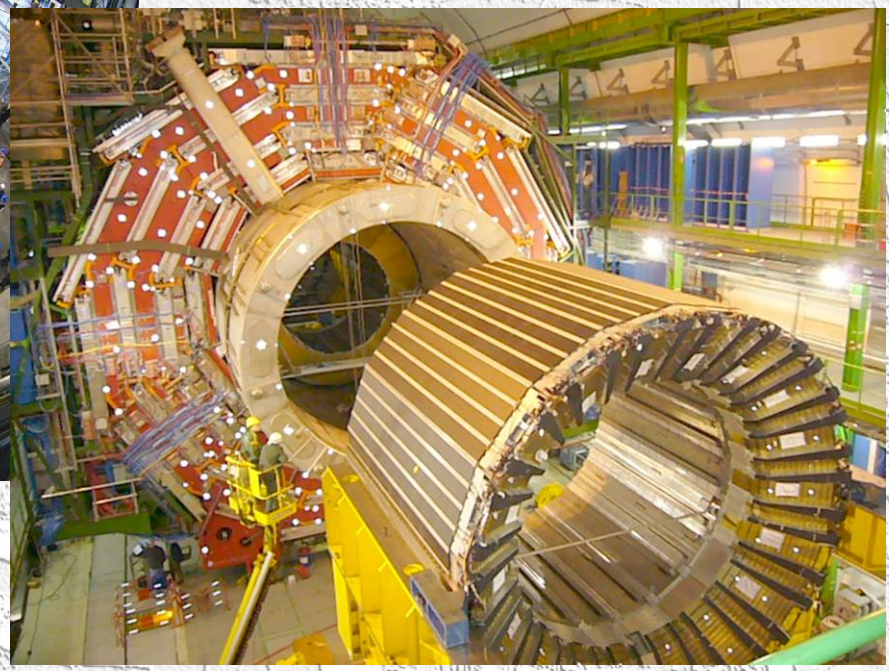




DESY: CMS Technical Coordination

Technical Coordination

- **W. Zeuner: deputy TC & master of CMS cavern**
  coordination of magnet test,
  installation schedule, YB0 services, …
- **2 DESY technicians at CERN (May – June):**
  - **pre-cabling of tracker**
  - **ECAL installation**



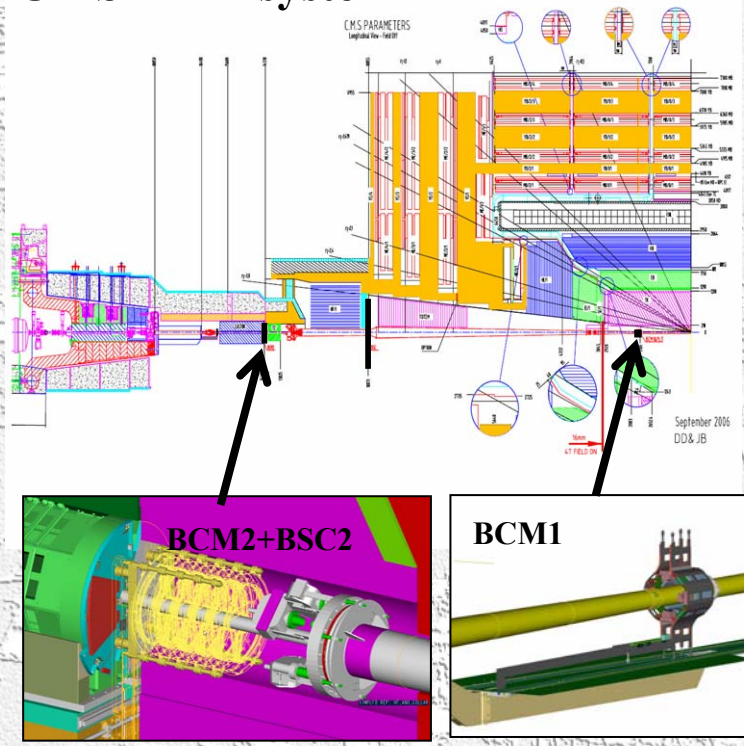
DESY: CMS Beam Radiation Monitor

Planned contribution to CMS BRM system:

- commissioning of BCM1
- alignment & calibration

- bunch-by-bunch readout or fast sampling
- optimisation of beam conditions and luminosity
- beam dump trigger

CMS BRM system



Synergy ILC FCAL and CMS BCM1:

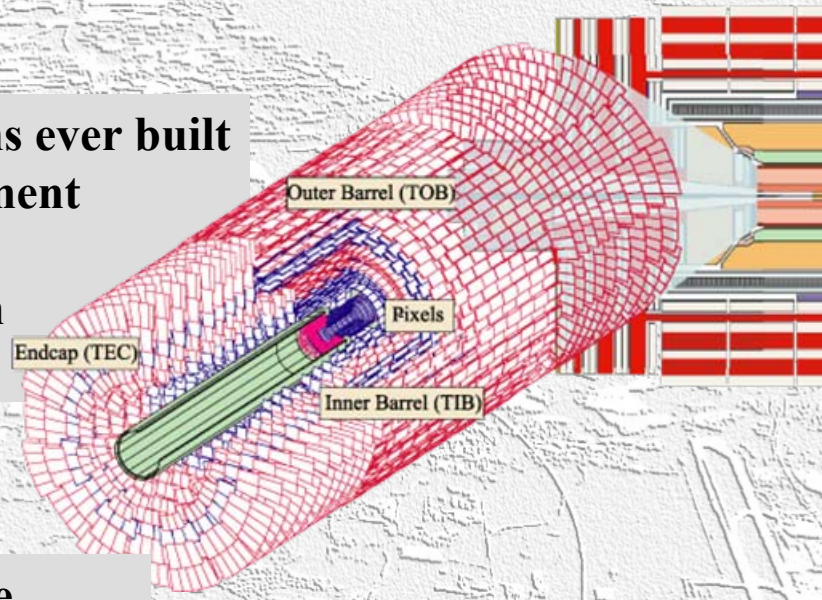
- application of diamond sensors in harsh environment
- fast readout and luminosity optimisation

- experience from single crystal diamond near ZEUS beam pipe

DESY: CMS Tracker Alignment

CMS Tracker Alignment:

- One of the most complex tracking systems ever built
  performance depends critically on alignment
- CMS goals
  - 100 μm from cosmics & laser system
  - 15 μm after first 60 days



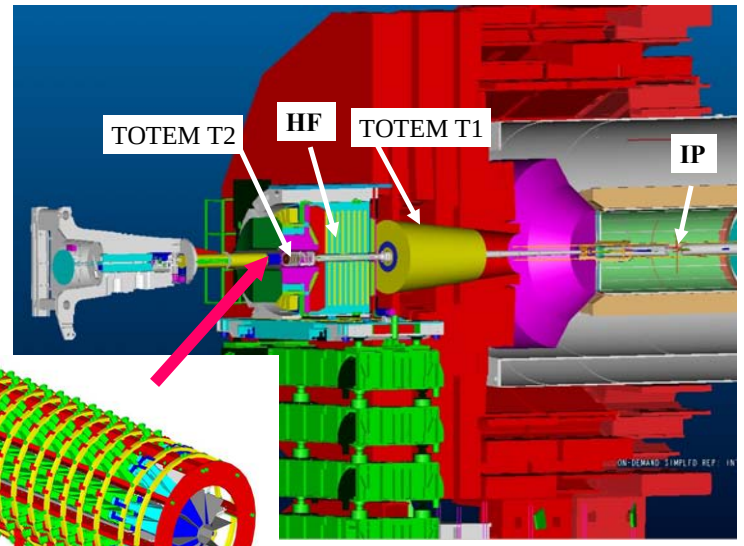
- > 50000 alignment parameters need to be
  determined with optimal precision
- Very promising method:
  Millepede II global fit (developed by V. Blobel)

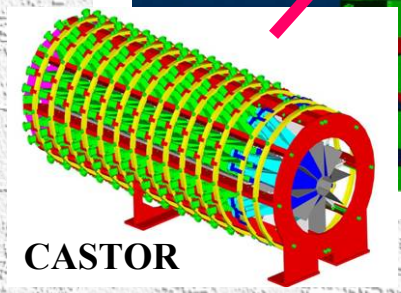
Plans:

- invest experience of HERA experiments (→ Millepede)
  in close collaboration with CMS group of Univ. Hamburg
- CMS Tracker Alignment Workshop in Hamburg May 2007
  jointly organized by DESY & Univ. Hamburg

DESY: CMS CASTOR

- Plans for contribution to CMS FWD calorimeter CASTOR
- Tungsten-Quartz-Cerenkov at $5.2 < \eta < 6.6$

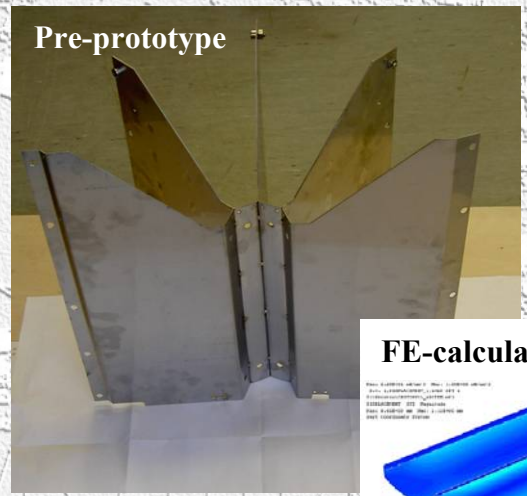


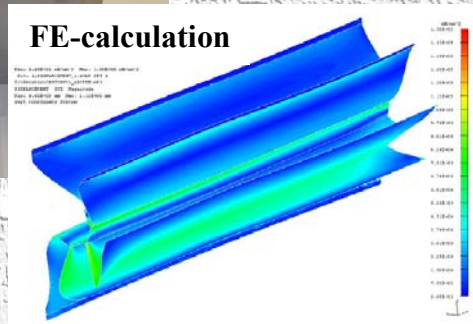

CASTOR

- DESY Physics Interest:
  - proton structure (→ HERA)
  - underlying event
  - multiple interactions

- DESY contributions to CERN testbeam (Summer 2007)
  - Pre-prototype for mechanics tests
  - FE calculations

- Contributions to final system to be discussed


Pre-prototype


FE-calculation

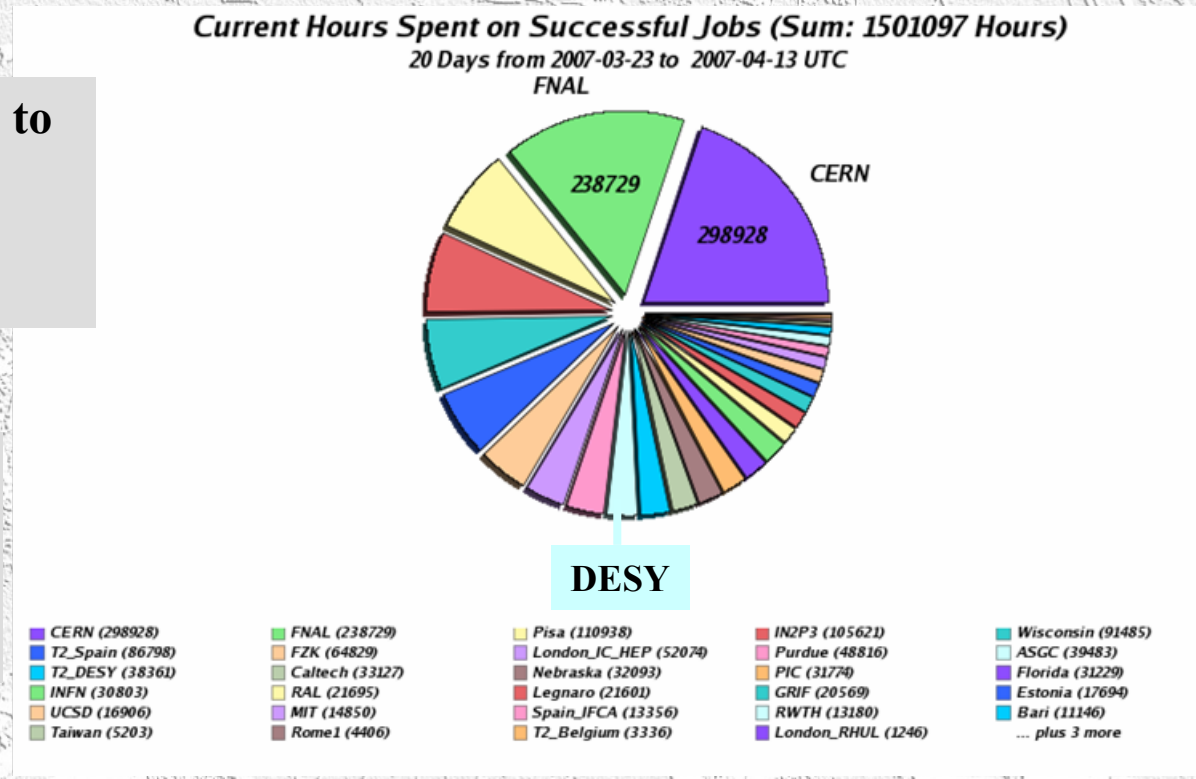
DESY: CMS Computing

- CMS Tier-II at DESY:
  - good collaboration between DESY and German universities
    e.g. software installation and maintenance
  - strong support from DESY IT group

Significant contribution to CMS computing:
- CSA06: 25 million event (≈ 1/3) by German group (DESY+Aachen)
  with large contribution from DESY/Aachen Tier-II

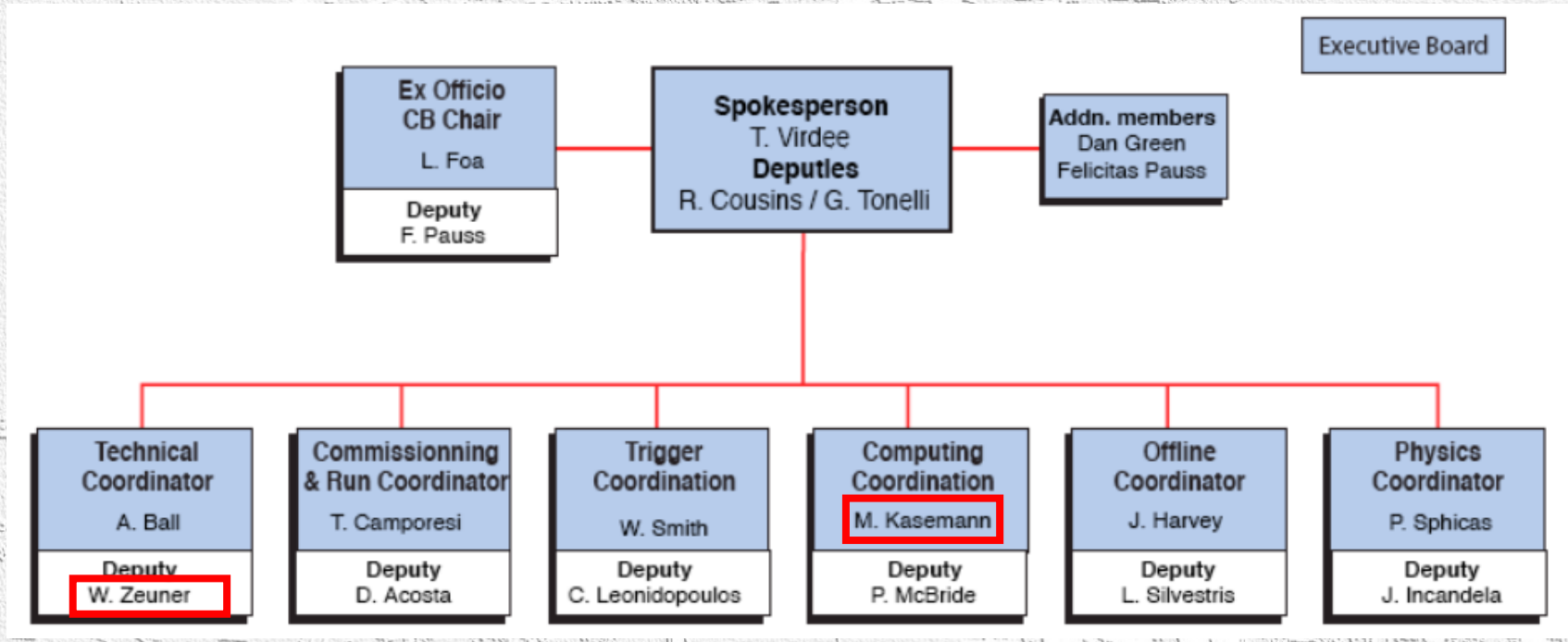
- CSA07: prepare Tier-II to host analysis data sets
- DESY participates in transfer commissioning

- M. Kasemann: CMS Computing Coordinator



DESY in CMS Management

- Representation in the CMS management
  - 2 DESY physicists in the Executive Board



- Other coordination tasks:
  - A. Meyer — Data Quality Monitoring
  - JM — Top Physics
  - NN — Computing Integration Coordination

Outlook and Plans

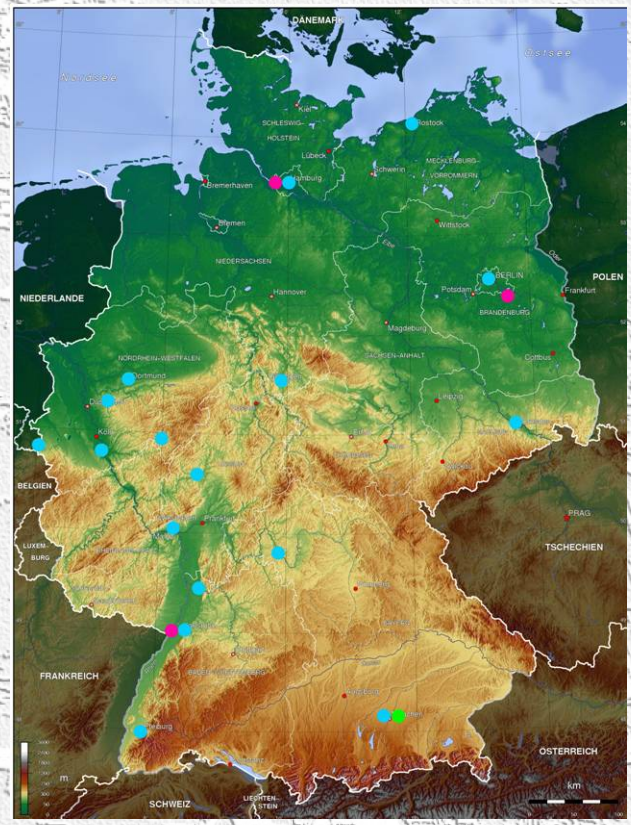
- **Future Plans of the DESY ATLAS & CMS groups:**

- **ATLAS**
  - **Current activities will be continued**
  - **Largely intensify physics analysis work**
  - **Probably start some hardware contribution to the ATLAS luminosity monitor (ALFA) with new manpower**
  - **Contributions to ATLAS upgrade are under discussion**

- **CMS**
  - **Develop current activities**
  - **Plan contribution to CMS remote operation room at Meyrin**
  - **Investigate feasibility of remote operation room at DESY, in particular for Data Quality Monitoring**
  - **Participation in detector upgrades (sLHC, …) will be discussed in due time**

Outlook: HGF Strategic Alliance

- **Proposal for a HGF Strategic Alliance**
  ‚Physics at the Terascale‘
  between DESY, GridKa, MPI
  and 17 German universities



Includes:
- **Analysis Center at DESY (LHC, ILC)**
- **National Analysis Facility at DESY**
- **Tier-II at universities**
- **Virtual Theory Institute**
- **Virtual Detector R&D Labs (ILC, sLHC)**
- **Accelerator**

- **Received excellent evaluation:**

All reviewers unanimously stated that this initiative can be taken as a model case of a Helmholtz Alliance.

There was great enthusiasm for the proposal “Physics at the Terascale”, which is recommended for funding without any restrictions.

Most important:
- **will restructure German HEP landscape**
- **intensify collaboration between DESY and universities and strengthen the role of DESY (for LHC and ILC)**

Summary & Conclusions

- LHC machine and experiments make good progress towards completion
  - some setbacks on the schedule, e.g. 2007 engineering run
  - but first 14 TeV runs still foreseen for summer 2008

- DESY is member of both large LHC collaborations ATLAS and CMS
  - both DESY group make already visible contributions
  - activities concentrated on:
    Physics, High Level Trigger & DAQ, Computing & Software,
    Technical Coordination

- Operational Tier-II centres for both experiments
  - strong contributions to LHC computing

- Outlook:
  - Tier-II centres buildup according to plans
  - ATLAS and CMS groups will develop their activities
  - HGF Strategic Alliance:
    intensified collaboration with other German LHC groups