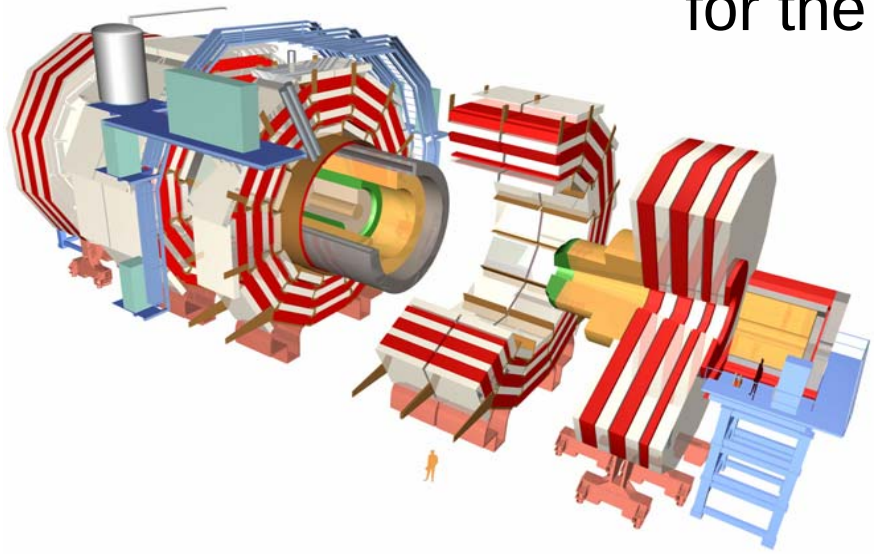
Status of CMS

Rainer Mankel

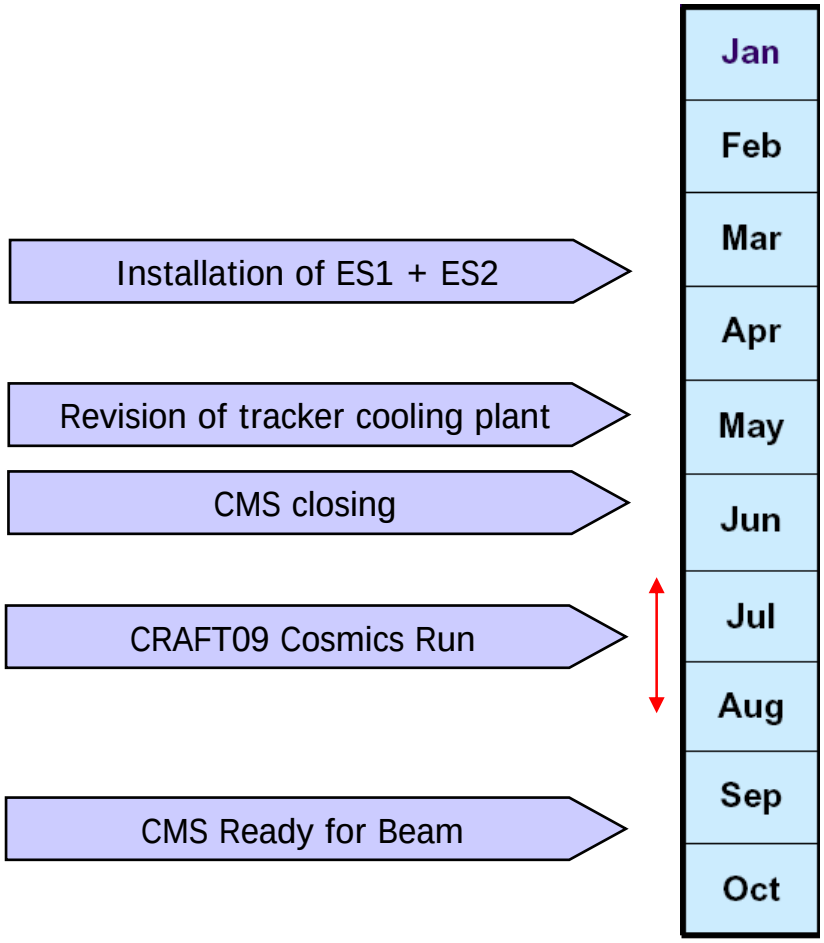
for the DESY CMS Group

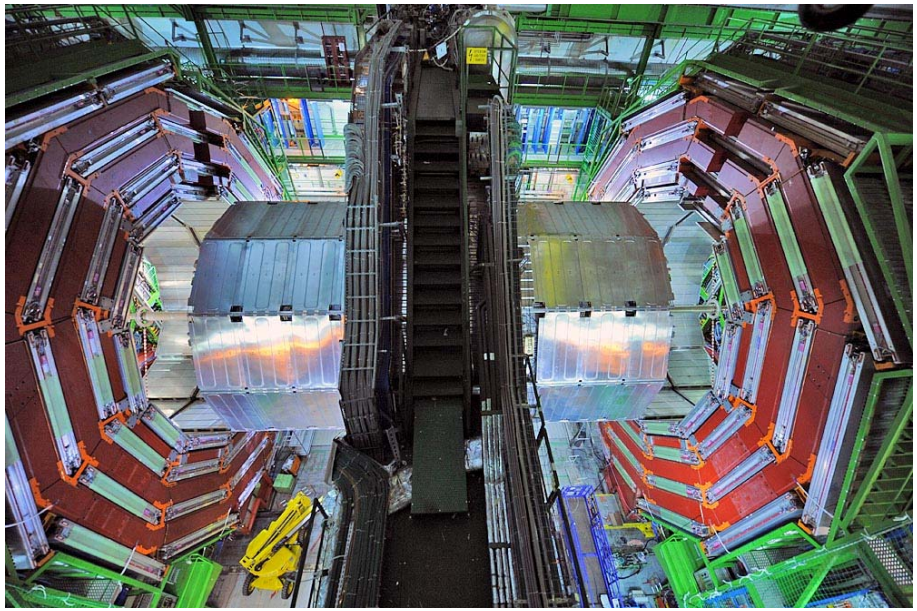
67. PRC Meeting

5-May-2009



Some Major Milestones in CMS Schedule (as of early April)





DESY at CMS

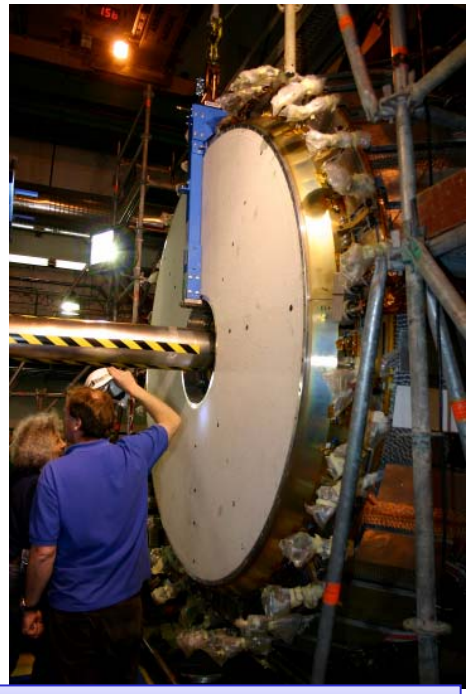
- Main activities:
  - High Level Trigger, Data Quality Monitoring, Computing, Tracker Alignment, CASTOR Calorimeter, Beam Condition Monitor, Physics
- Group structure (FTE):
  - 14 staff physicists, 9+3$^{(YIG*)}$ PostDocs, 8+3$^{(YIG*)}$ PhD students
  - 3 Helmholtz Young Investigator Groups (YIG)
    - * already including the two YIGs just starting their work
  - Technical help: engineers & technicians, workshops
- Coordinating responsibilities within CMS:
  - Deputy Technical Coordinator (L1)
  - Computing Coordinator (L1)
  - DQM Convener (L2)
  - Alignment/Calib. Convener (L2)
  - CASTOR Cal. Project Manager
  - Grid SW Deployment Coordinator
- This report focuses on activities in which DESY is involved

Technical Coordination & Detectors

Technical Coordination Highlight: Installation of the Preshower

The two separate ES+ Dees

Transporting the ES+ towards EE+

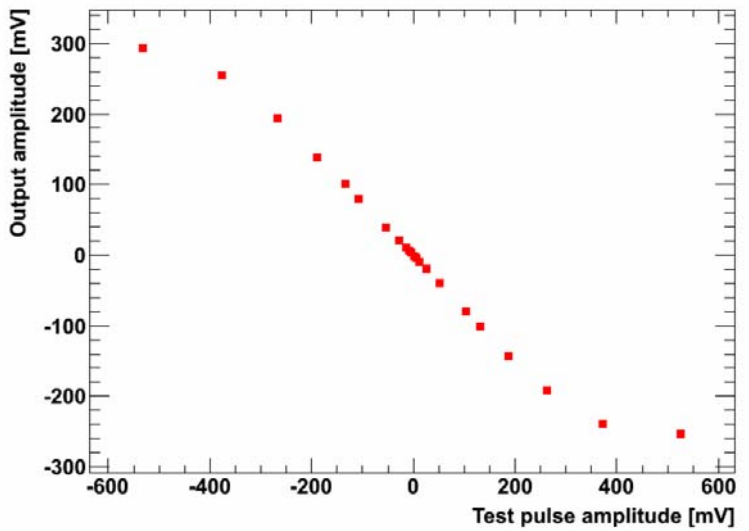


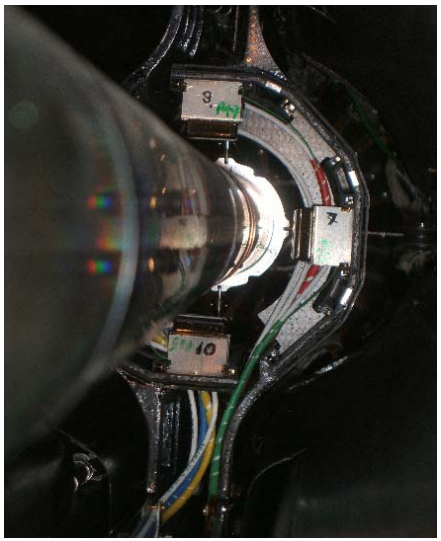
ES+ attached to support cone

- Preshower endcaps assembled a four “Dee’s”
  - delicate operation very close to beam pipe
  - both ES+ and ES- installed and commissioned by Easter
- Other important installations campaigns: refurbishing/upgrade of pixel detector cooling, revision & commissioning of tracker cooling plant

Beam Condition Monitor

- BCM1F: two arrays of four diamond sensors located outside of pixel tracker endcaps
  - spin-off from ILC FCAL R&D
  - also synergy with FLASH photon source
- After opening the detector in early 2009, the sensors have been reinstalled and tested
  - re-installation completed 2 days after Easter
  - analysis & comparison with last year's data is ongoing
  - system is fully operational





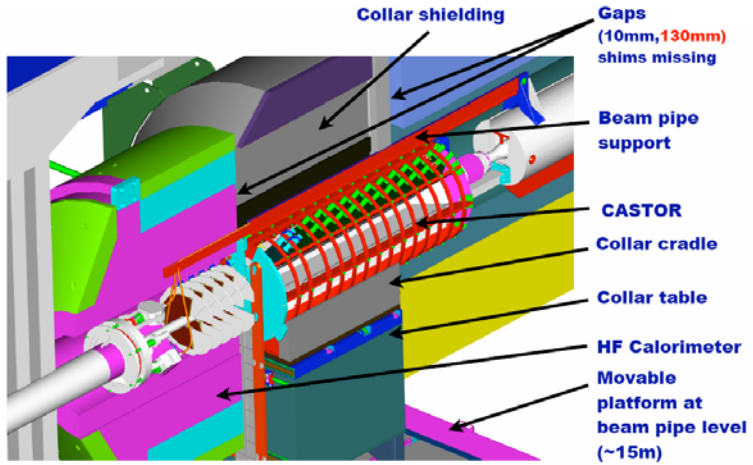
CASTOR Calorimeter

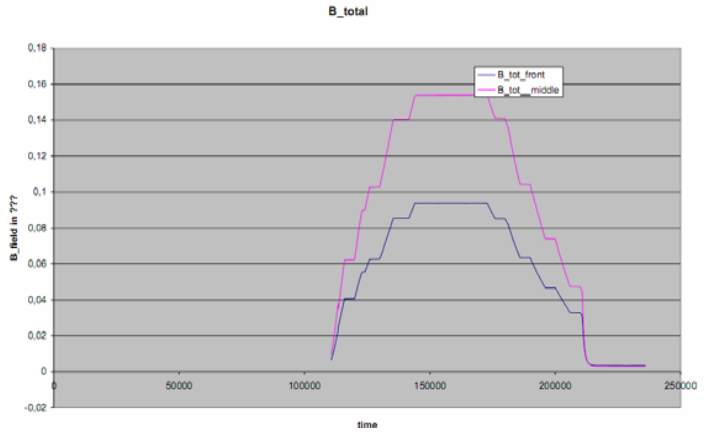
- CASTOR had been quickly & successfully installed in Sep 2008, but then suffered from unexpectedly high magnetic stray field in the CMS forward region
  - induced movements of CASTOR & its support close to the beam pipe → removed
- In the mean time, more detailed field measurements:
  - measured (max): 1500 Gauss
  - original simulation: 10 Gauss

➔ Foreseen dynode-type PMT cannot be used within this field

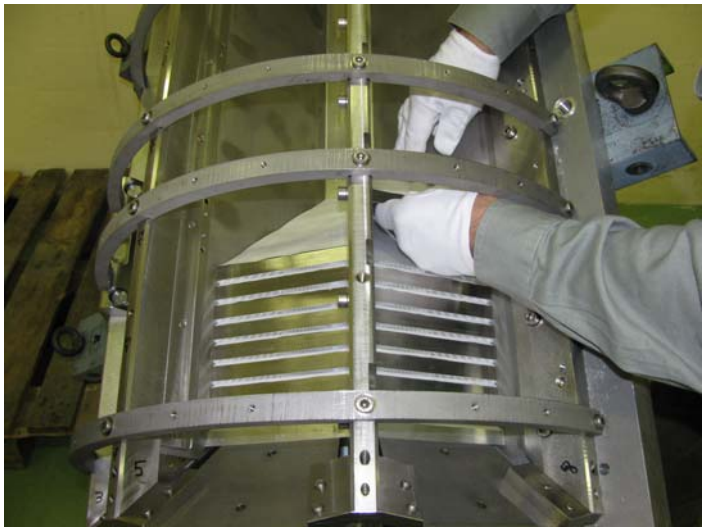
➔ Switch to fine-mesh PMTs (→1 Tesla)

- ➔ equip CASTOR using 1/5 of the PMTs from H1 backward calorimeter (SpaCal) for initial data taking (2009/10)
- ➔ change inclination of PMT tubes to compensate for B field angle
  - ➔ 45° → 30° with respect to beam pipe
- ➔ consider radiation-hard version of fine-mesh PMT for long-term running





CASTOR (cont'd)

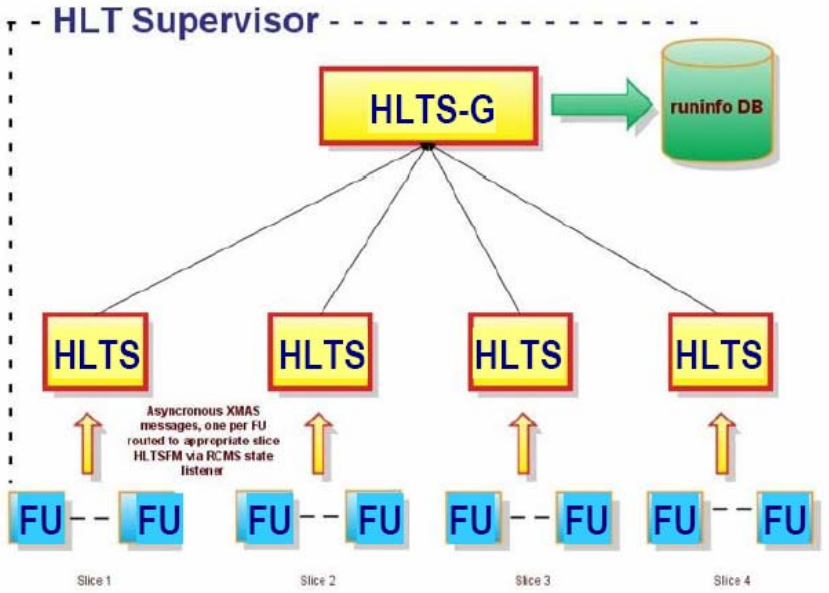


- CMS Technical Coordination has reviewed & approved modifications to CASTOR design
- Both CASTOR halves assembled with radiation-hard quartz & tungsten plates
- Test beam measurements for calibration of new setup will be performed in May
- Installation foreseen in June 2009
  - very challenging schedule

HLT, Alignment & DQM

High Level Trigger Supervisor (HLTS)

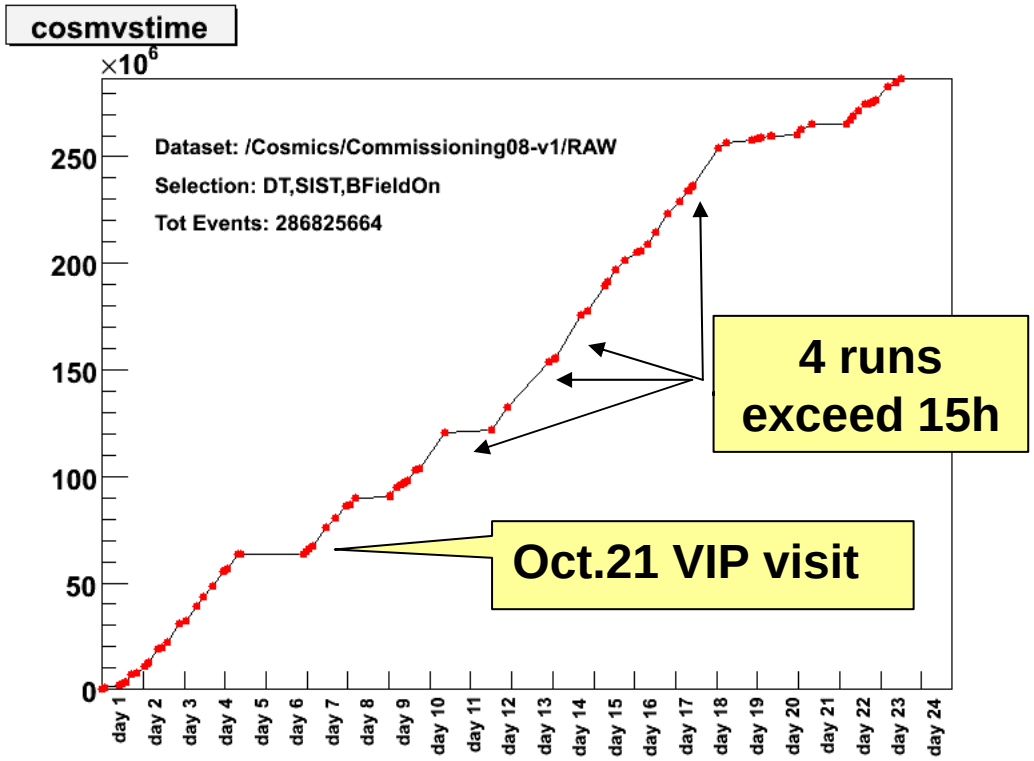
- HLT Supervisor (HLTS)
  - Run Control and configuration of Filter Units (FUs), rate monitoring
  - configuration database and browser, online book keeping of HLT configurations
  - extensively used for cosmic runs
  - essential for offline production applications
- Refactored version has been deployed in spring 2008 & used during extended cosmic running



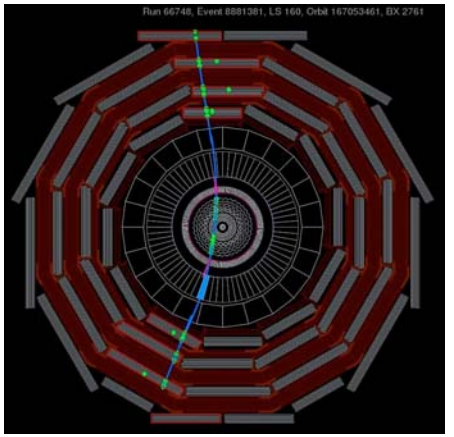
- Recent development: integration of L1 scalars
  - needed to control data-taking rate with LHC collisions
  - current status: test setup in place on pre-series cluster
  - full-scale integration test of L1 changes will proceed soon

Long Cosmics Run with Magnetic Field: CRAFT

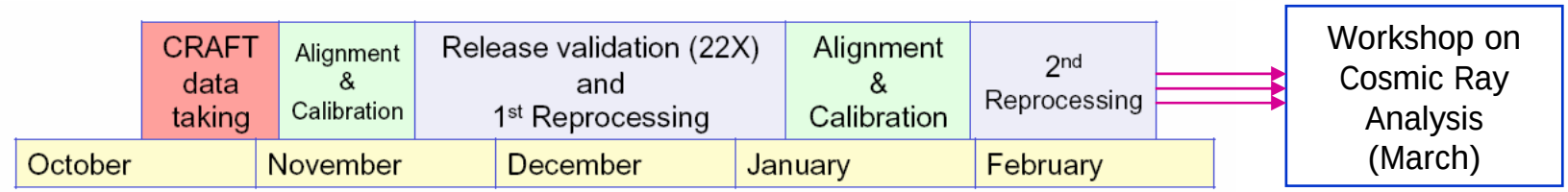
- Ran 4 weeks continuously from 13-Oct to 11-Nov
  - 19 days with B=3.8T
- 370M cosmic events collected in total
- 290M with B=3.8T and with strip tracker and DT in readout
  - 194M with all components in
- 1/3 of DQM shifts at DESY CMS centre



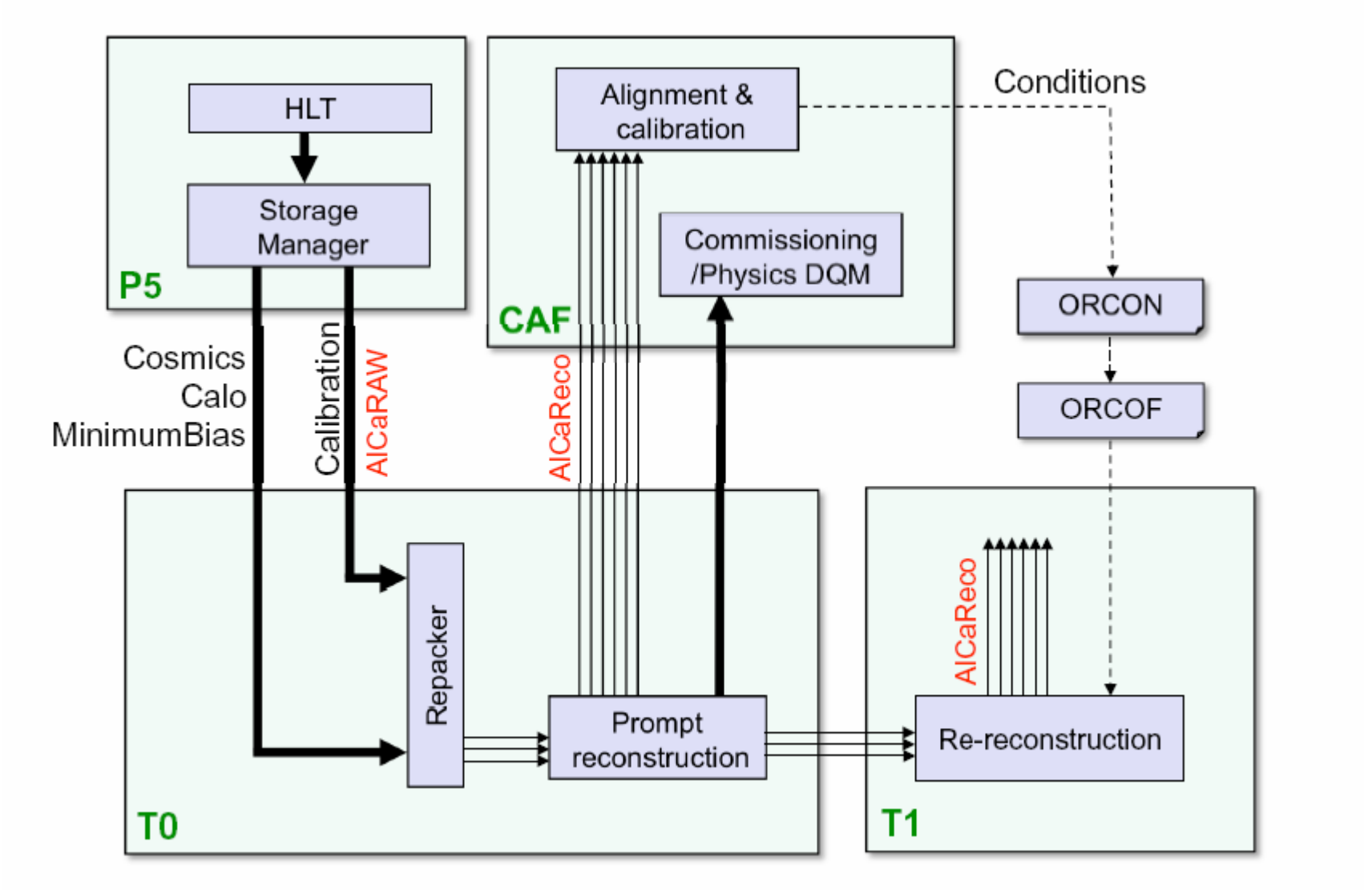
Alignment & Calibration in Cosmics Run (CRAFT)



- CRAFT cosmics run has been instrumental & exceedingly powerful for commissioning alignment & calibration
  - first large cosmics data sample with magnetic field on
    - momentum cuts
    - rigorous multiple scattering treatment
  - first opportunity for serious pixel tracker alignment
- Successfully commissioned & performed a large range of our alignment & calibration workflows with real data
  - comprehensive set of alignment & calibration constants
  - validation & sign-off procedures in place
  - routinely operation of calibration & reprocessing cycles
  - updated alignment/calibration to be used for startup of collisions



Alignment & Calibration Workflow in CRAFT

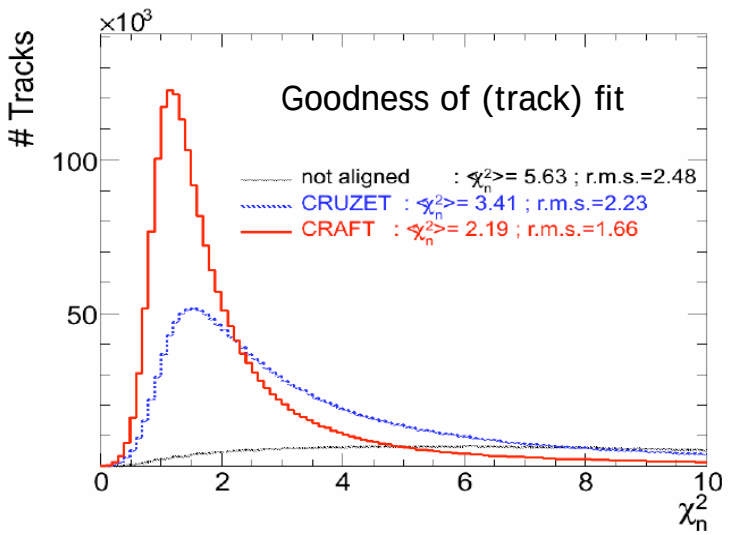


Tracker Alignment with Cosmics Data

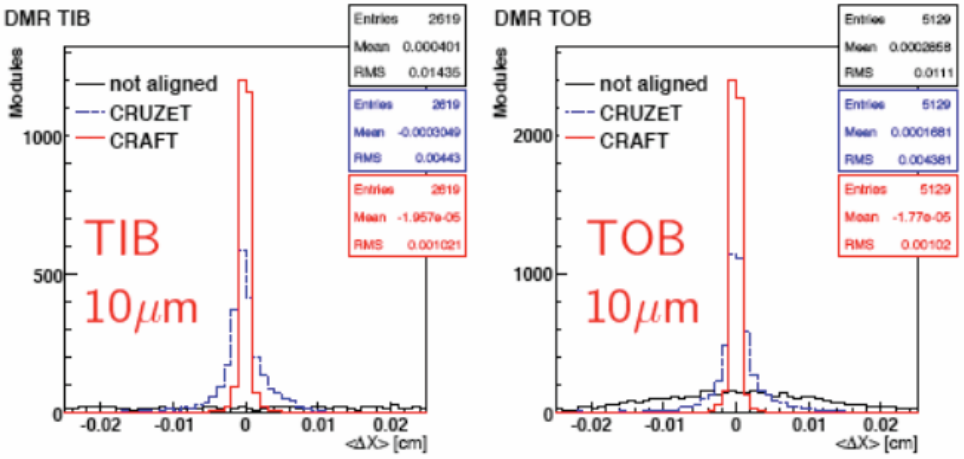
- Based on HIP and MillePede-II alignment algorithms
- Continuous improvement of methodology
  - synchronous update of Lorentz angle calibration & alignment constants essential

➔ Steady improvement of alignment quality

from unaligned → CRUZET (cosmics at 0T) → CRAFT alignment

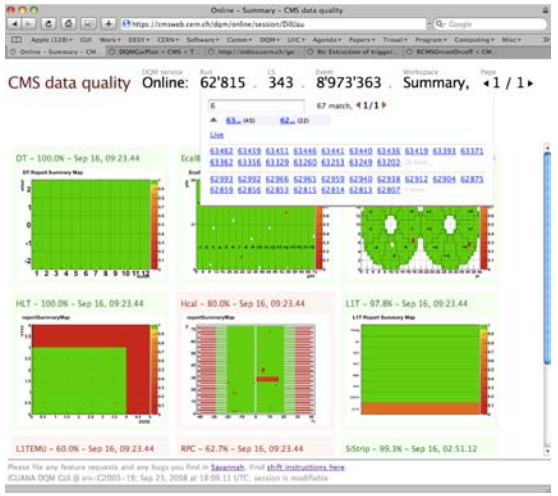


Medians of residual distributions for Tracker Inner and Outer Barrel



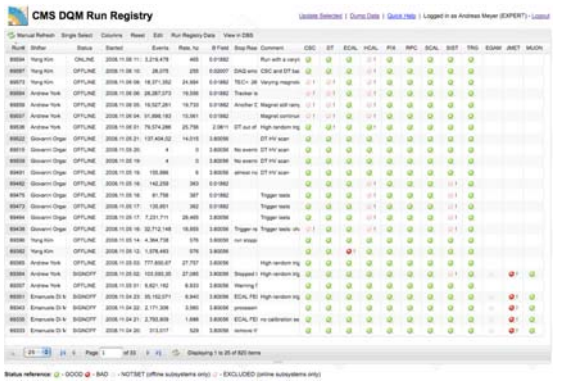
Data Quality Monitoring (DQM)

- Coherent Data Quality Monitoring across CMS:
  - online DQM (real time)
  - prompt Reconstruction (Tier-0)
  - reprocessings (Tier-1 and 2)
- Data Certification:
  - 24/7 operation by central DQM shifts
  - weekly sign-off (confirmation of results by experts)
- Progress in 2008:
  - offline DQM has been fully implemented
  - routine production of DQM results during reconstruction
  - regular data certification cycle (sign-off) established



Web-based GUI for online and offline DQM by experts and shifts

CMS Run Registry: Good Run Lists based on certification of hardware (detector) and software (reconstruction)



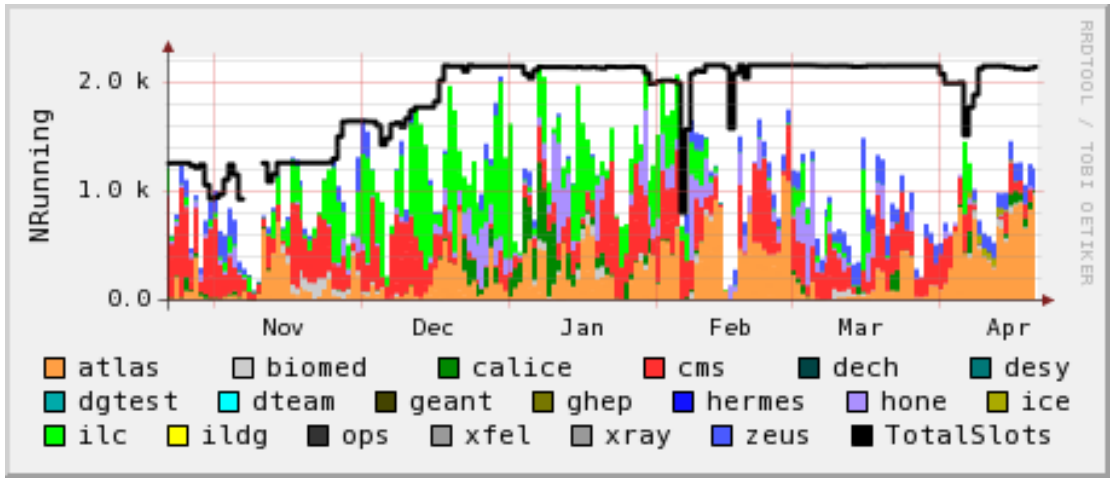
The CMS Centre at DESY

- At DESY, one of the three major sites worldwide is fully operational
  - two additional consoles added recently
- Regular (daily) remote DQM shifts during CMS global data-taking
  - shift persons from DESY and Hamburg University
  - currently ongoing for mid-week global runs
  - offline shifts for reprocessed data
- Future plans:
  - computing shifts (Tier-1, Tier-2, MC production)
  - sustain 1/3 of data-taking shifts
  - shifts for reprocessed data

Computing & Physics

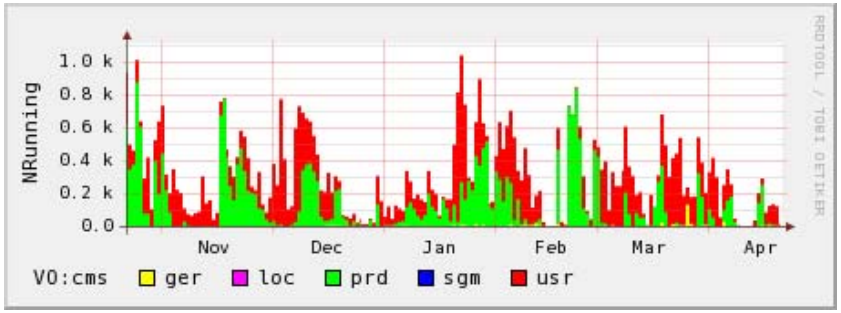
LHC Computing at DESY

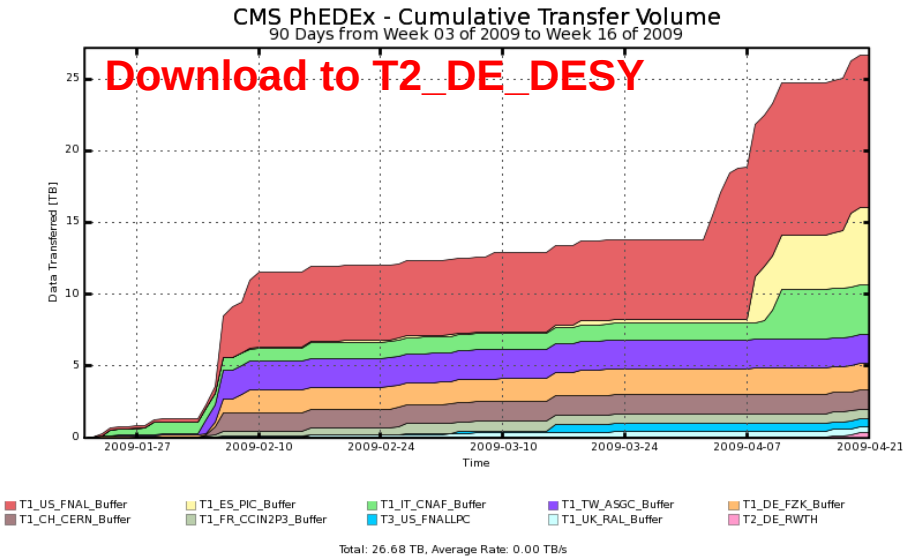
[showing only DESY-HH part of traffic]



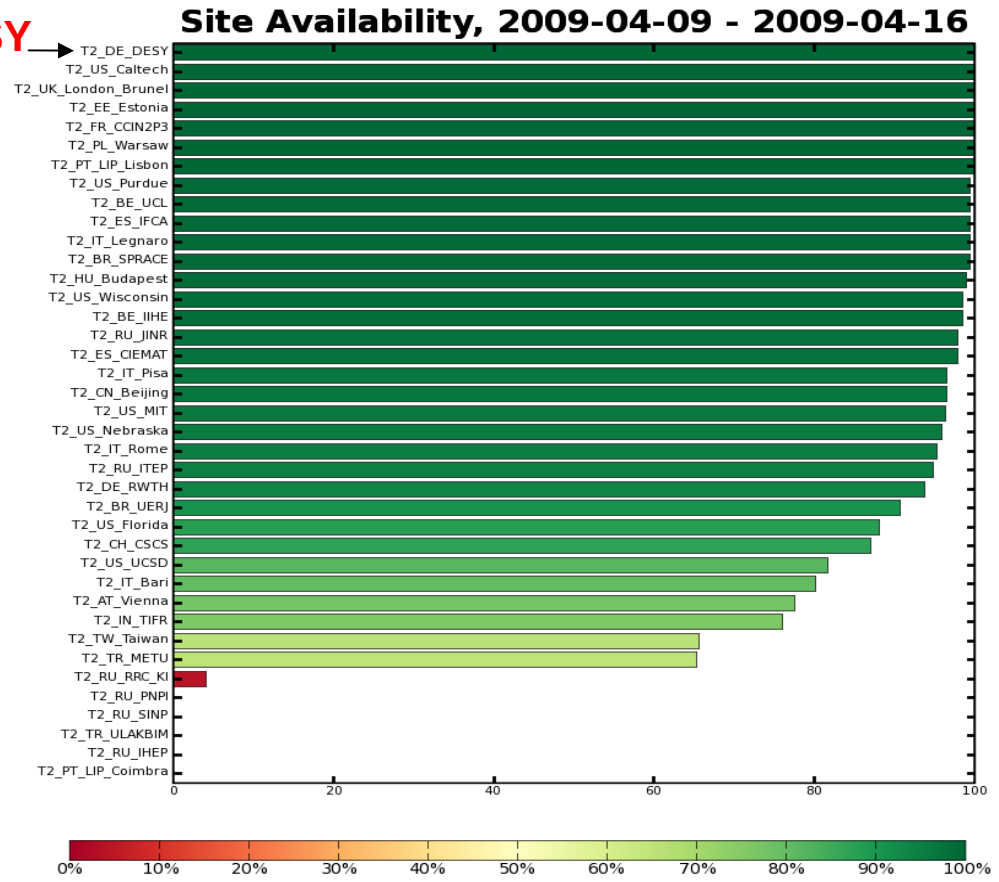
- Upgrade of Tier-2 computing resources
  - CPU: in total 2600 cores for all supported projects
    - 30% each for ATLAS + CMS (controlled by fair-share)
  - Disk: ~700 TB
  - all pledges fulfilled

Performance of CMS-Tier 2 at DESY



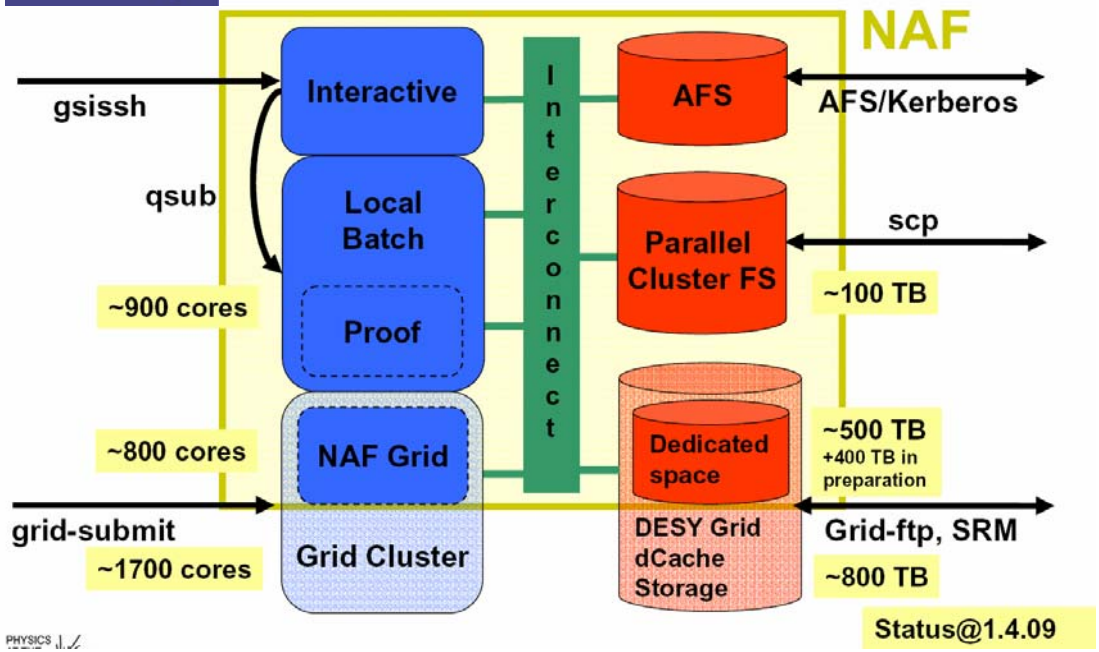


T2_DE_DESY

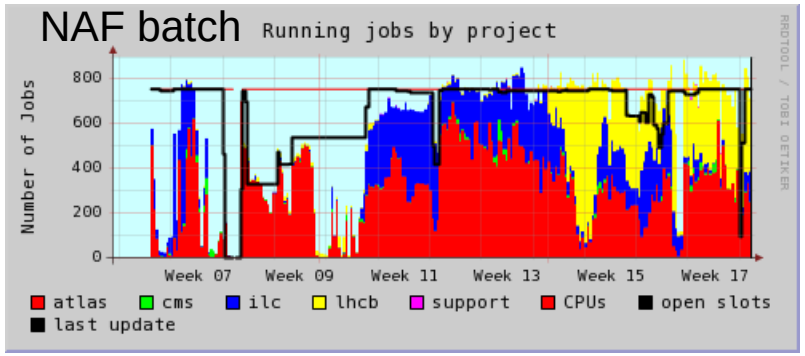


➔ Excellent reliability performance. DESY usually among the top five.

Status of the National Analysis Facility (NAF)



- Ramp-up of the NAF infrastructure according to plan
- ATLAS & LHCb use the NAF batch facility intensively
  - also used by non-LHC groups (e.g. ILC)
- CMS uses the Grid part of the NAF (not shown)



➔ Generally, LHC computing is operating very smoothly at DESY

Physics Analysis

- The physics contributions of DESY to the CMS experiment are closely linked to the overall structure in Germany
  - close cooperation also with DESY theory group
- Presently mainly preparatory
  - these activities need to expand to actually perform analyses on real data

CMS	Aachen	DESY	Hamburg	Karlsruhe
SUSY	X	X	X	X
Higgs	X	X		X
BSM	X			X
SM-QCD		X		X
SM-top	X	X	X	X
SM-bottom	X			
SM-tau	X			

- Top physics
  - precision measurements with high statistics (1 ttbar / s at 10^{33} $cm^{-2}s^{-1}$)
  - 2 PhD theses + 1 diploma thesis finalized in 2008
- QCD and small-x physics
  - key point: parton dynamics / proton structure
    - saturation, multi-parton scattering, underlying event
  - very early measurement (with ~ 1 pb^{-1} of good data)
  - directly connected to CASTOR, rich experience from HERA

Ramping-Up Physics: Young Investigator Groups

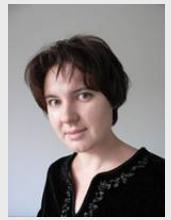
- Very attractive field for Young Investigator Groups
- Already existing YIG will address top production with first LHC data
  - top quark characteristics
  - measurement of top cross section
- New: Higgs search
  - origin of mass
  - crucial test of standard model
- New: Search for Supersymmetry
  - candidate particles for dark matter
  - possible unification of fundamental forces
- Direct interplay with Helmholtz Alliance “Physics at the Terascale”
  - National Analysis Facility (NAF)
  - Analysis Centre

Katerina Lipka (Spring 2008)

Physics of Gluons and Heavy Quarks from HERA to LHC

DESY – Uni Hamburg – Uni Mainz

HERA / CMS



Alexei Raspereza (Spring 2009)

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

DESY – IEKP Karlsruhe

CMS

Isabell Melzer-Pellmann (Spring 2009)

Supersymmetry at the Terascale

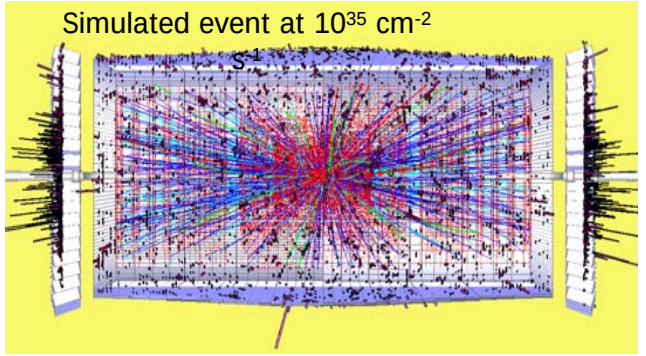
DESY – Uni Hamburg

CMS

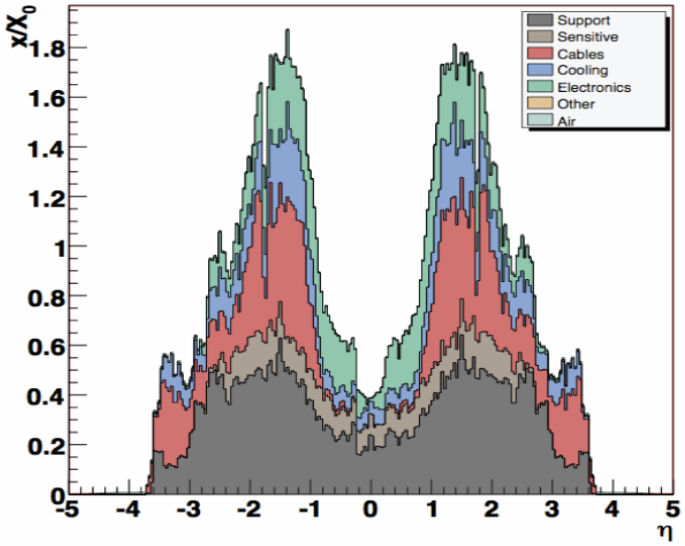
Detector Upgrade (Update)

Detector Upgrades for sLHC: Tracker

- Main challenges:
  - much higher track density per bunch crossing
    - increase granularity to keep occupancy low
    - sensors with short strips (strixels)
  - tracker should be included in L1 trigger
    - ➔ module design
  - important constraint: material budget
- DESY joined Central European Consortium for sensor qualification & design



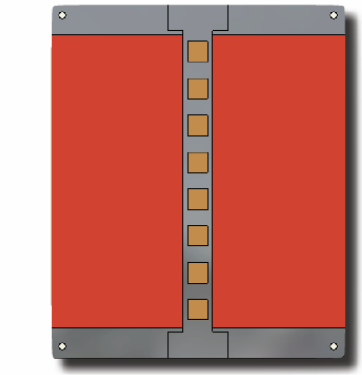
material (present CMS tracker)



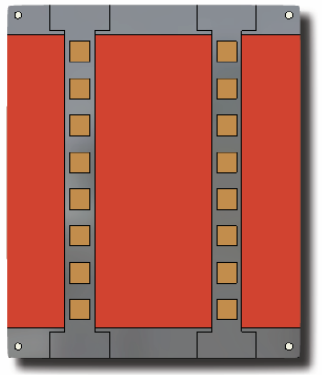
Tracker Upgrade for sLHC: DESY Involvement

- Sensor aspects
  - measurements of test structures & prototype sensors
  - development of common database for all measurements
  - understanding and assistance in simulations of the sensor behavior
  - using two fully equipped labs in Zeuthen
- Study integration aspects, optimizing
  - mechanical stability
  - thermal layout → CO_2 based cooling scheme

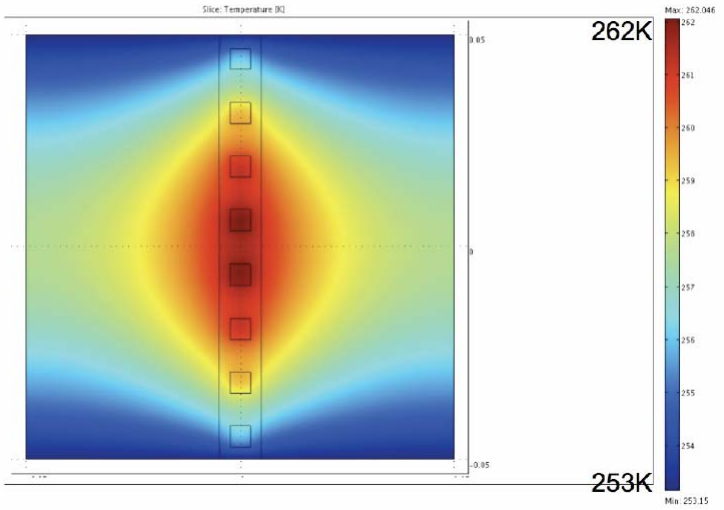
  with Finite Element calculations
- As soon as person power available, participate in simulations of tracker



- 1 sensor (100 mm x 100 mm)
- 2 x 1024 x 5 cm strixels
- ~ 95 um pitch



- 1 sensor (100 mm x 100 mm)
- 4 x 1024 x 2.5 cm strixels
- ~ 95 um pitch



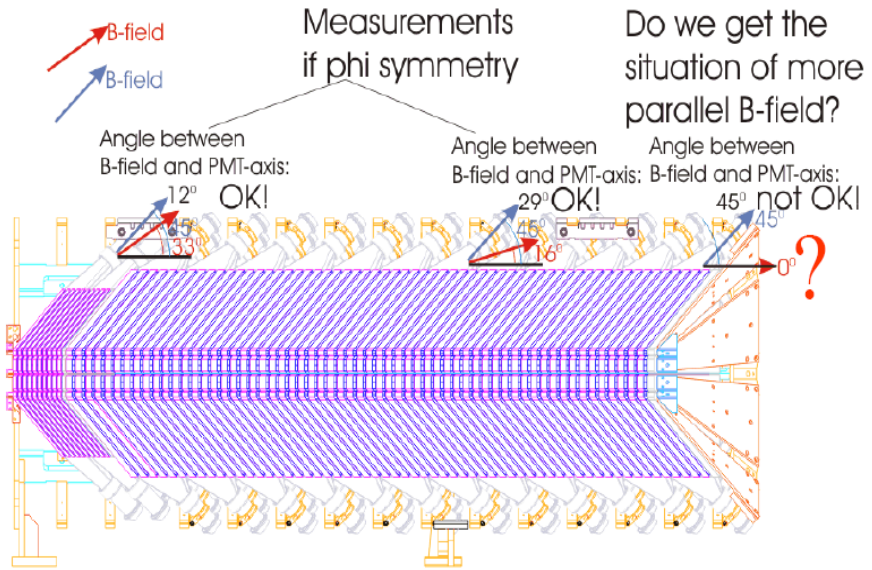
Summary

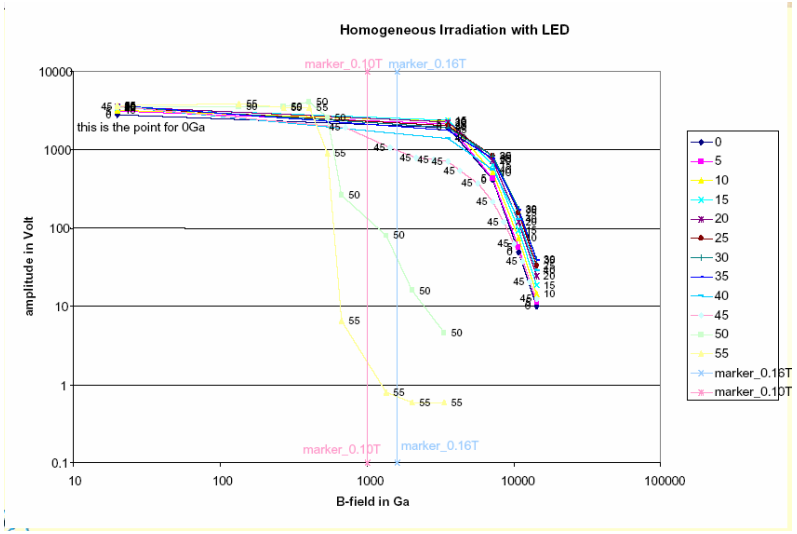
- CMS experiment is completing shutdown maintenance & last steps of installation
  - including CASTOR & BCM reinstallation
- Past months have been used intensively for important commissioning exercises
  - very notably 4-week CRAFT cosmics run
  - invaluable experience for commissioning alignment/calibration & DQM
  - final touches to HLT infrastructure
- DESY LHC computing in very good shape
- Participation in detector upgrade program is taking shape
- New Young Investigator Groups (YIG) with attractive physics program starting up now
- DESY-CMS group preparing well for analysis of first LHC data

- -- Backup Material --

CASTOR (cont'd)

- Radial field component poses another problem:
  - at high magnetic field, the former Spacal PMTs are limited to a B field inclination of $\leq 35^{o}$
  - this angle is exceeded in parts of the acceptance





Computing (cont'd)

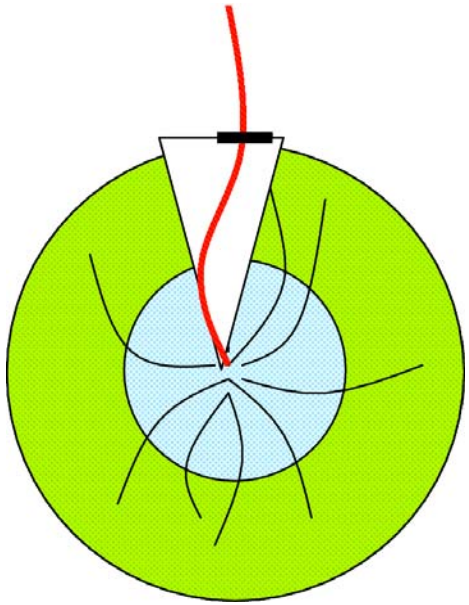
- National Analysis Facility (NAF)
  - for German CMS physicist, production-grade end-user analysis functionality
    - improve competitiveness of German CMS groups by facilitating data analysis
  - large synergies with Tier-2 center
  - plans for further use of NAF for specific data analysis operations
    - e.g. developments for alignment (under discussion with Hamburg Univ., Karlsruhe and Aachen)
- Distribution of experiment-specific computing coordination & services among German institutions

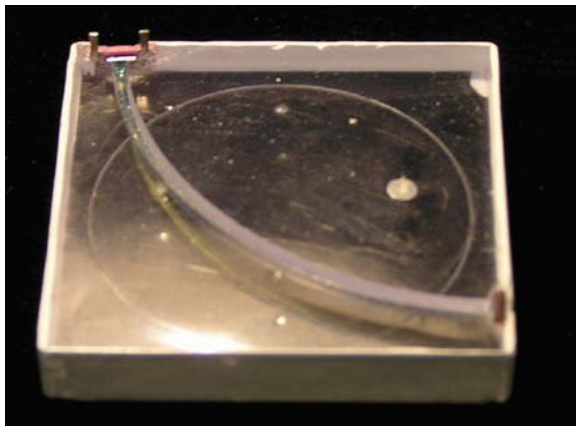
CMS	Aachen	DESY	Hamburg	Karlsruhe
Tier-1		X		XXXX
Tier-2	XXX	XX	XX	
CMS-D	XX	X	XX	
Coordination	X	XX		

BCM Upgrade

- Preparation for sLHC (2010-2014)
  - R&D for radiation hard sensors (e.g. CVD diamond, GaAs)
  - redesign of BCM1F to cope with higher fluxes (fast monitor)
  - development and test of components for BCM1F
  - application for YIG has been approved
- Synergy with the R&D for a future linear e+e-- collider (FCAL):
  - all R&D topics are embedded in international projects (BMBF-JINR, CARAD)
  - collaboration with Uni Karlsruhe (YIG)

Muon Track Tagger (MTT)





- Combine tracks from the tracker with a ‘space point’ in an additional scintillator tile layer
  - better p_T resolution already within L1 trigger (as presently in HLT)
- ➔ Exploit the expertise collected within the ILC calorimetry R&D
  - analog HCAL with scintillator tiles
  - system aspects of modules with SiPM readout (interplay of sensors with electronics, calibration and monitoring)

CRAFT: Alignment/calibration & Data Reprocessing

	CRAFT data taking	Alignment & Calibration	Release validation (22X) and 1st Reprocessing	Alignment & Calibration	2nd Reprocessing
October		November	December	January	February

Tracker alignment and APEs	(See next slide)
DT and CSC alignment	Track-based and optical alignment
DT tTrig and vDrift	Improved reconstruction in MB1s Wh+-2 for B on
CSC gains, pedestals, noise and crosstalk	Based on test pulse data
Hcal pedestals and gains	
ECAL intercalibration and ADCToGeV for endcaps	Based on lab measurements of light yield, VPT gain and quantum efficiency
SiStrip gains, Lorentz angle and bad channels	Includes masking of modules with high cluster occupancy
SiPixel gains and Lorentz angle	

- Very comprehensive set of alignment & calibration constants
- Validation & sign-off procedures in place
- Routinely operation of calibration & reprocessing cycles

DQM & Data Certification: End-to-End Workflow