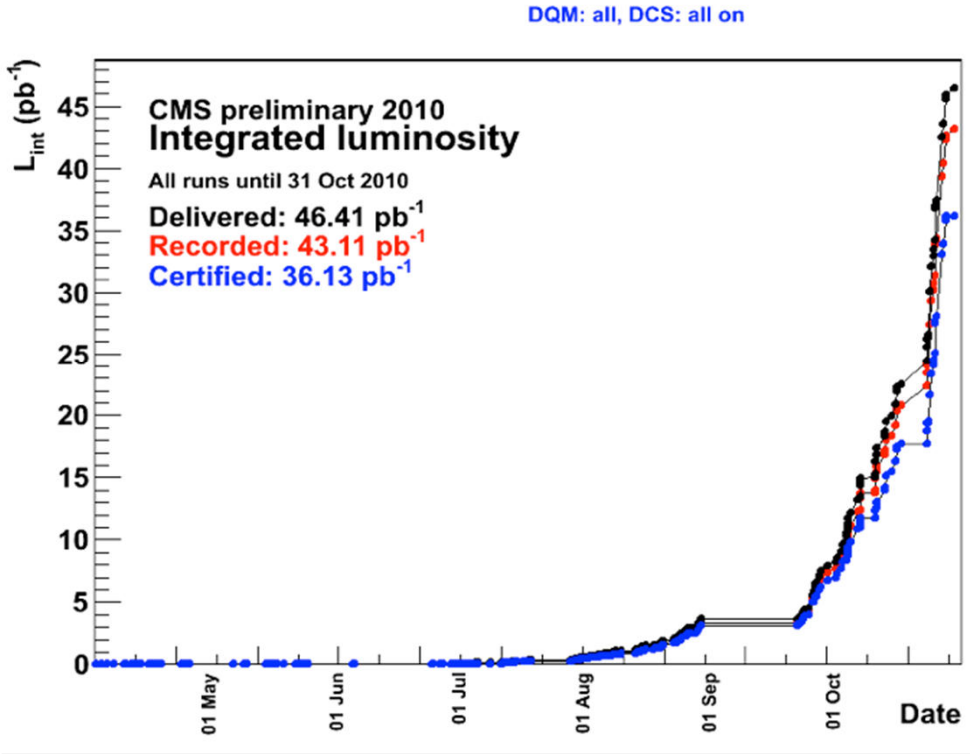
Status of CMS at DESY

Alexei Raspereza

on behalf of the DESY CMS Group

DESY PRC Meeting, *April 28th 2011*

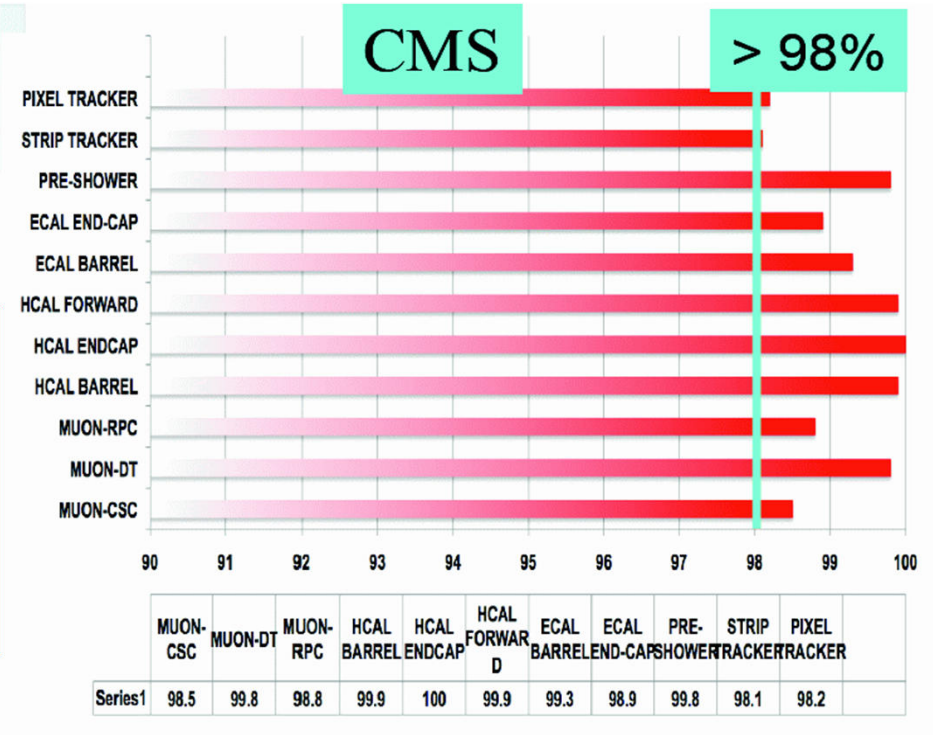
CMS Performance in 2010



data taking efficiency > 91%
determined with DQM tools

→ **key contribution from** DESY

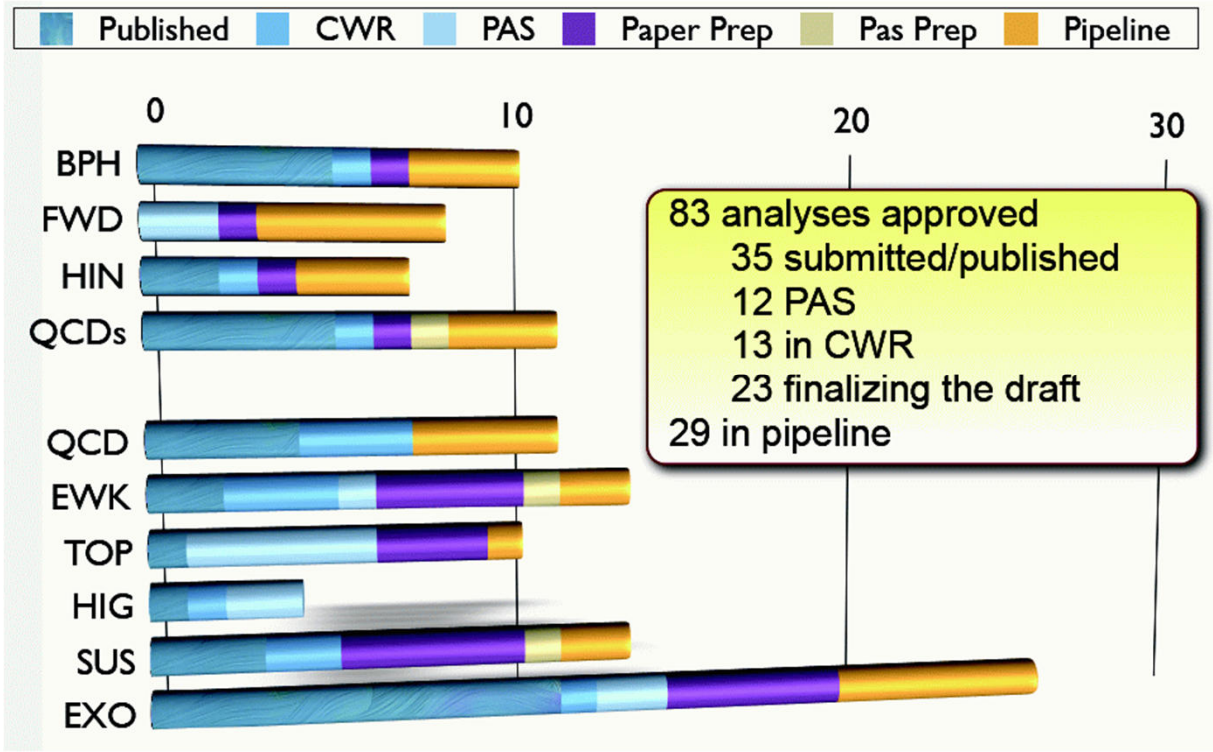
≈100M channels
>98% channels operational
→ robust event reconstruction



	MUON-CSC	MUON-DT	MUON-RPC	HCAL BARREL	HCAL ENDCAP	HCAL FORWARD	ECAL BARREL	ECAL END-CAP	PRE-SHOWER	STRIP TRACKER	PIXEL TRACKER
Series1	98.5	99.8	98.8	99.9	100	99.9	99.3	98.9	99.8	98.1	98.2

CMS Physics Results with 2010 Data

- 1 ARC chair for B-physics PAG
- 4 ARC members
- 1 editor : X(3872) paper CMS BPH-10-018
- 4 institutional paper reviews



DESY has contributed to 3 approved analyses

DESY CMS Group

- 23 staff (14 FTE), 23 post-docs (19FTE)
- 12 PhD students, 3 Undergraduate students
- engineers (mech.), technicians (mech. + elec.)

K. Borras (group leader),

G. Eckerlin (deputy group leader)

Physics analyses	**CMS detector upgrade**
CMS operations	**CMS Computing**

DESY CMS Physics Landscape

QCD Group

- Multiparton interactions/UE
- QCD at small x
- Forward energy flow
- PDF (HERAPDF)

SUSY Group

- dilepton analysis : e or μ same and opposite sign
- Development of analyses & tools for data interpretation in context of simplified models
- Development of official CMS DQM tools (within SUSY PVT)

Top Group

- $t\bar{t}$ cross section measurement in dilepton channels
- top mass extraction from cross section measurements
- study of $Zb\bar{b}$ production (within Electroweak group)
- b-tagging performance studies for pixel detector upgrade

Higgs group

- SUSY Higgs searches
  - $H \rightarrow \tau\tau$ inclusive
  - $(b)bH \rightarrow (b)bbb$
- $Z \rightarrow \tau\tau$ studies
- open charm production studies (within B-Physics group)
- IP based trigger development
- calibration of b-tagging algorithms with top pair events

Top Physics Group Activities

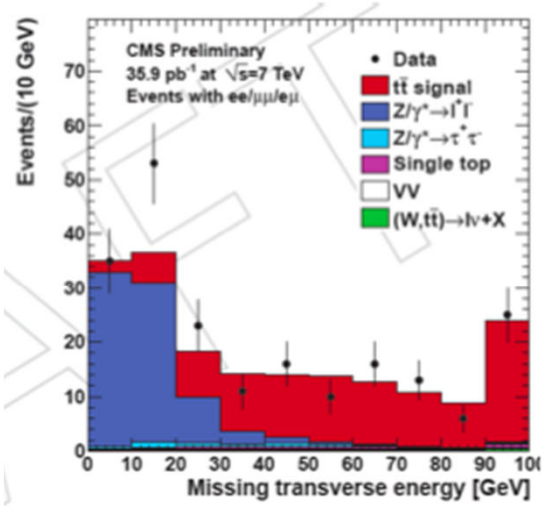
- $t\bar{t}$ cross section measurement in dilepton channel
  - μ+μ channel : cross-check analysis for CMS PAS TOP-10-005
    - supporting cross section measurement for "reference analysis"
    - uses kinematic reconstruction of top mass
    - alternative techniques of background estimation
  - e+μ analysis : analysis is awaiting approval
  - e+e analysis : just started
- cross section ratio $\sigma(pp \rightarrow t\bar{t})/\sigma(pp \rightarrow Z+X)$ measurement in dimuon channel ← **Novel in CMS**
- Study of $Zb\bar{b}$ production within Electroweak group (work in progress)
- Plans for 2011
  - Differential cross section measurements in dilepton channels
  - Top mass determination from cross section measurement

Top Pair Cross Section in Dilepton Channels

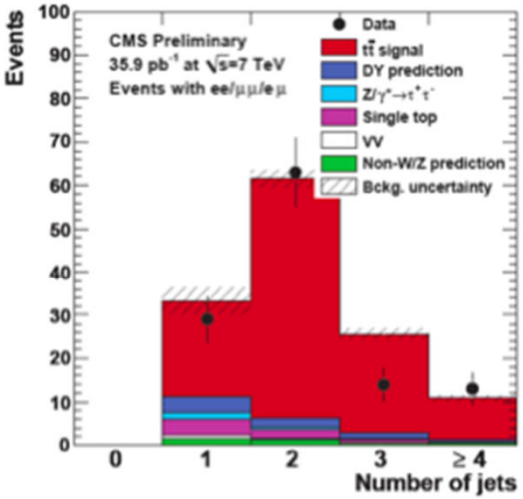
- Three different jet selections
  - N(jets)≥2 without b-taggaing
  - N(jets)≥2 with b-tagging
  - N(jets)=1 without b-tagging

PAS TOP-10-005 to be published as CMS paper

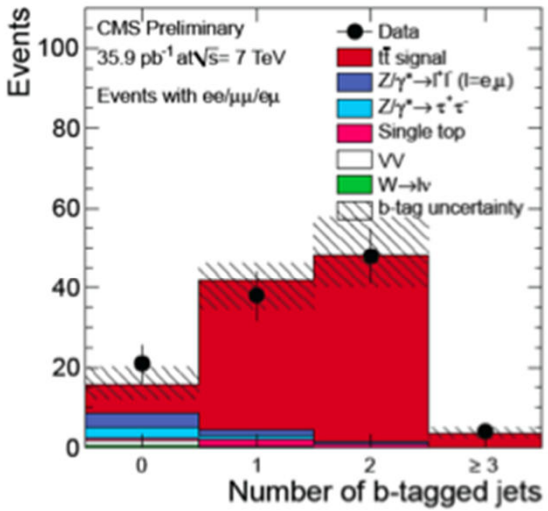
- Dedicated techniques to measure background from data



MET, before b-tag



N(jets), after b-tag



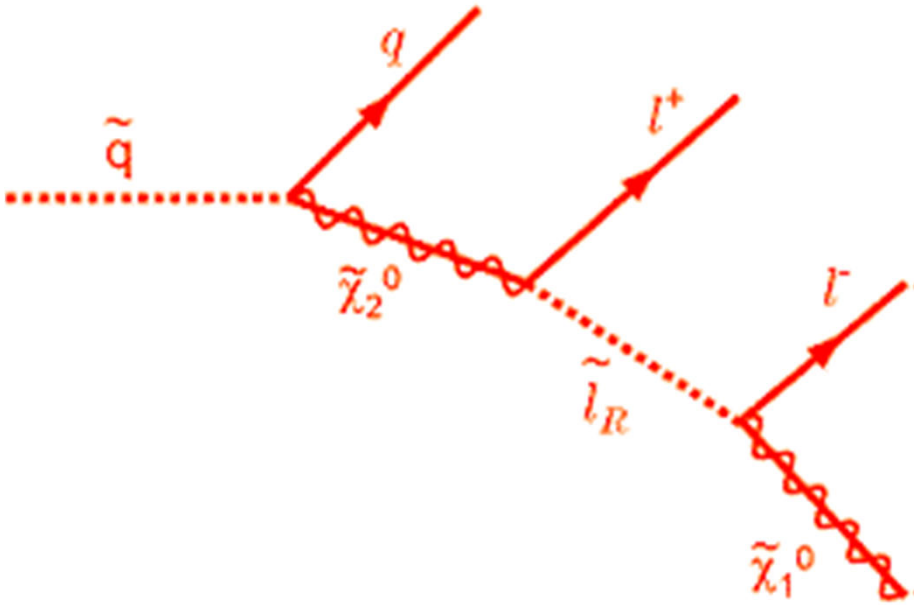
N(tags)

$$\sigma_{t\bar{t}} = 168 \pm 18\,(\text{stat.}) \pm 14\,(\text{syst.}) \pm 7\,(\text{lumi.})\ \text{pb}$$

$$\sigma_{t\bar{t}}/\sigma_{Z/\gamma^*} = 0.175 \pm 0.018\,(\text{stat.}) \pm 0.015\,(\text{syst.})$$

SUSY Group Activities

- Focus on analyses of dilepton final states
  - Same sign (SS) leptons
  - Opposite sign (OS) leptons
- Extension of dilepton analyses with b-tag
  - motivated by models with light gluino decaying predominantly into 3rd generation quarks

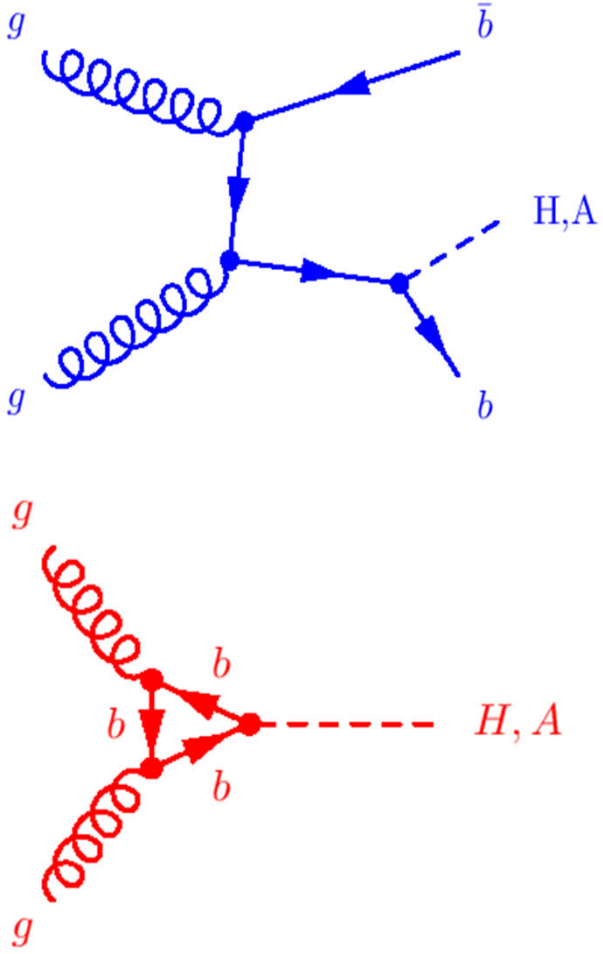


- Interpretation of data in context of simplified models
  - two model classes considered:
    - Models with light gluino decaying predominantly into 3rd generation quarks
    - RS, Technicolor, R_p-parity violating SUSY, KK states in UED

Higgs Group Activities

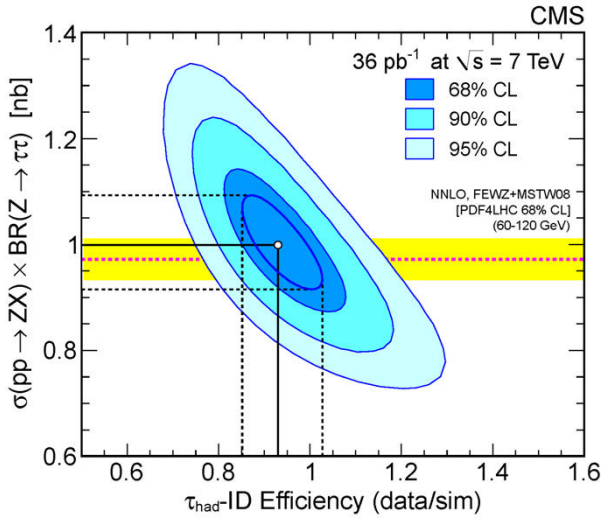
- Main focus : search for neutral supersymmetric Higgs bosons
- Inclusive H→ττ searches (advanced)
  - H→ττ→μμ+$\not{E}_T$ analysis **Novel in CMS**
  - studies of Z→ττ "standard candle"

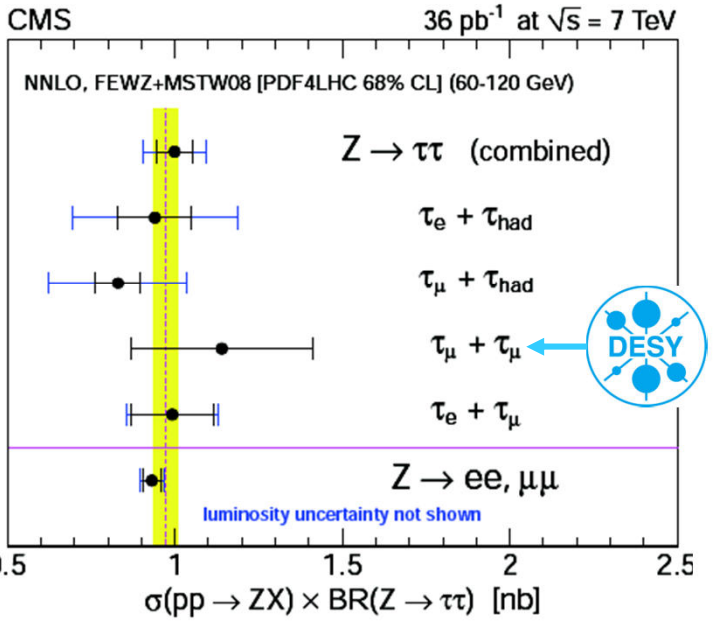
  → contribution to CMS publication
  - to be included in combination of Higgs search results for summer conferences
- (b)bH→(b)bbb searches (started)
  - development of IP based trigger
  - b-tagging essential : calibration of b-tagging algorithms with top pair events
- study of D meson production (inclusive and associated with jets) within B-physics group (work in progress)

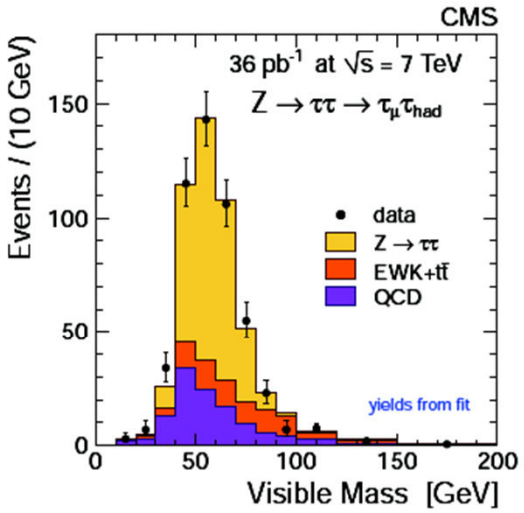


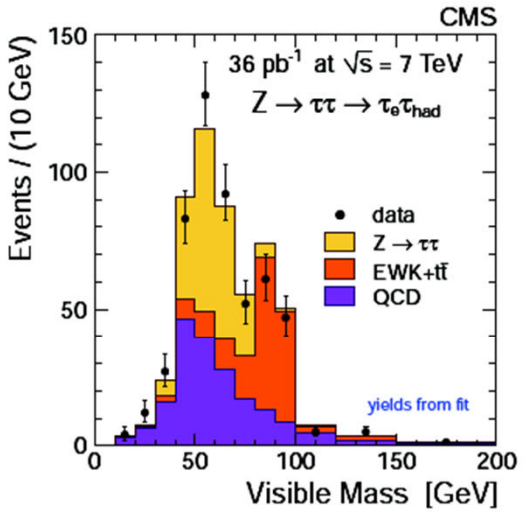
Study of Z→ττ "Standard candle"

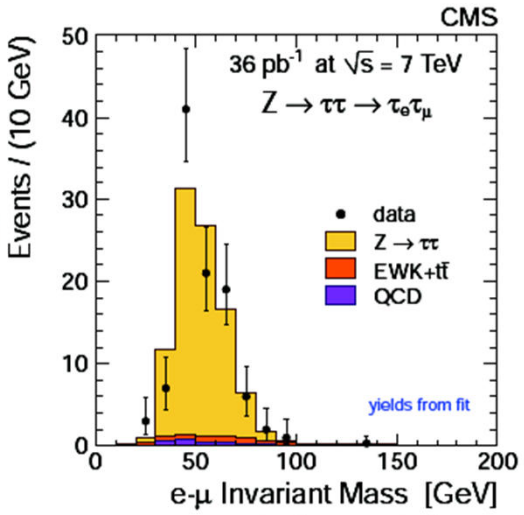
- **CMS paper arXiv:0227764, submitted to JHEP**

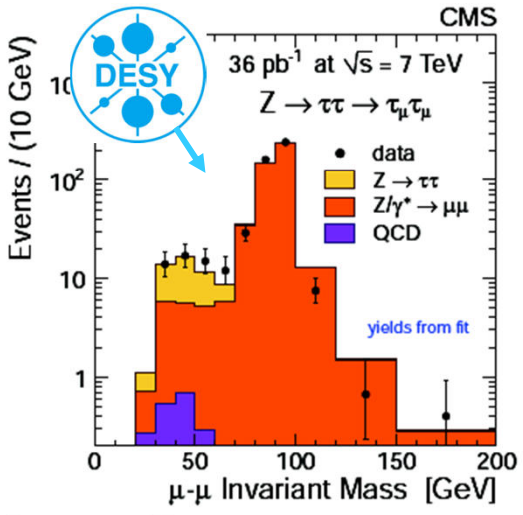












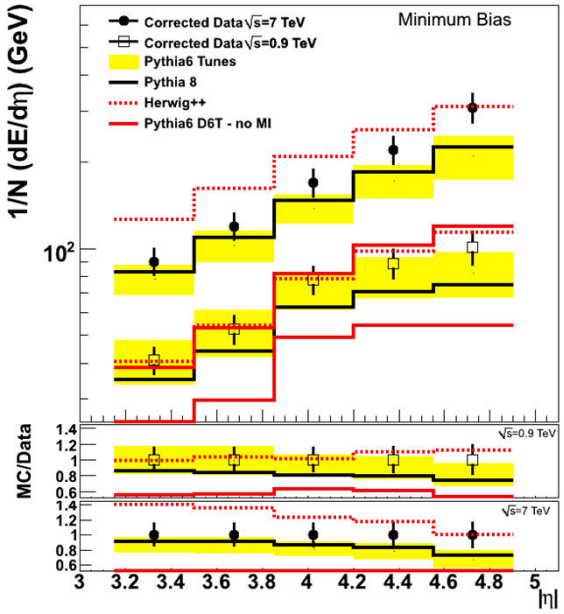
QCD - Forward Physics

Forward Energy Flow in Minimum Bias and Dijet Events @ 0.9 and 7 TeV

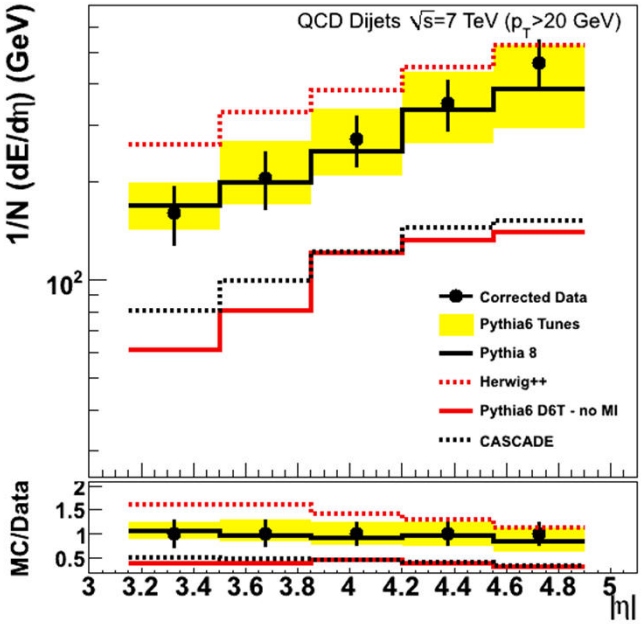
Official CMS PAS: CMS-FWD-10-011

Analysis performed exclusively at DESY

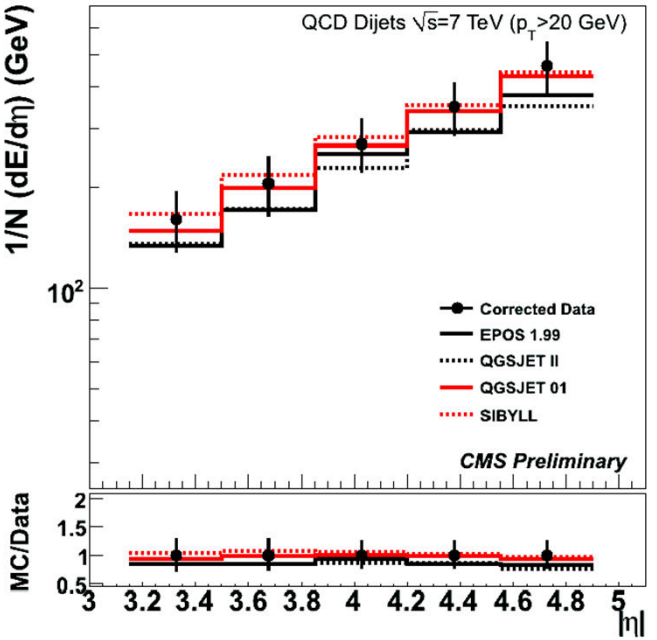
MinBias events
Data vs. Pythia tunes



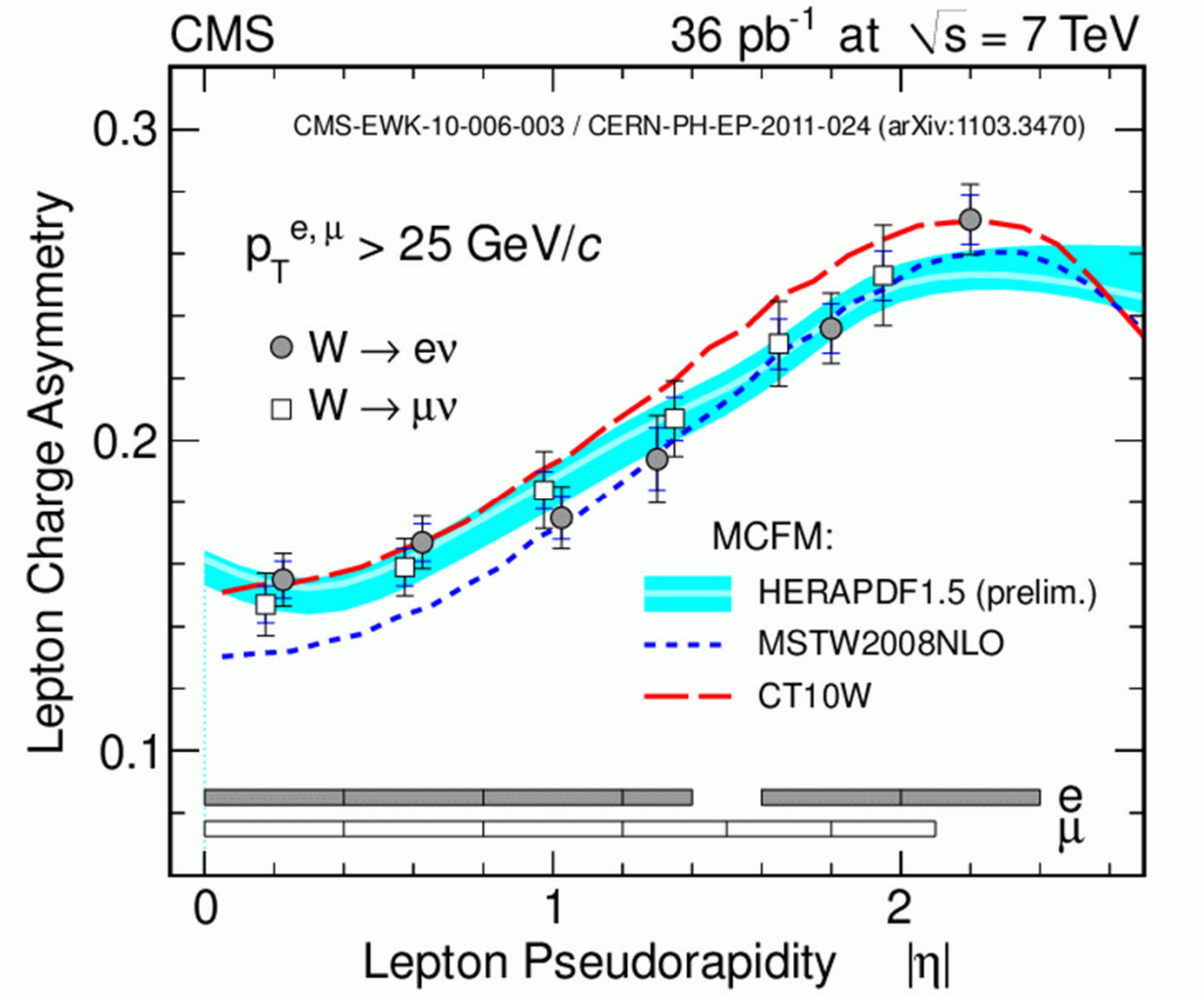
Dijet events at 7 TeV
Data vs. Pythia tunes



Dijet events at 7 TeV
Data vs. Cosmic Ray MC



HERA PDFs for LHC



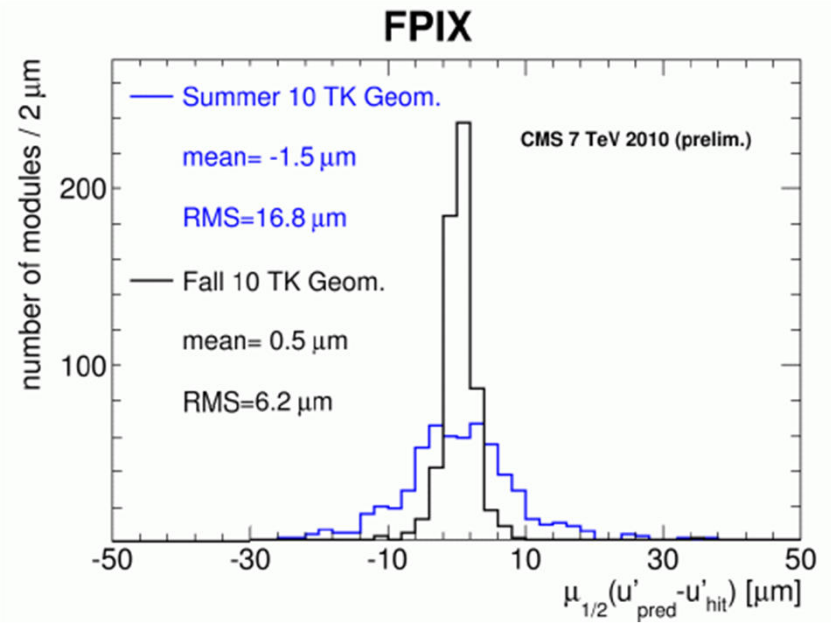
Following HERA legacy in advertising usage of HERAPDFs in CMS

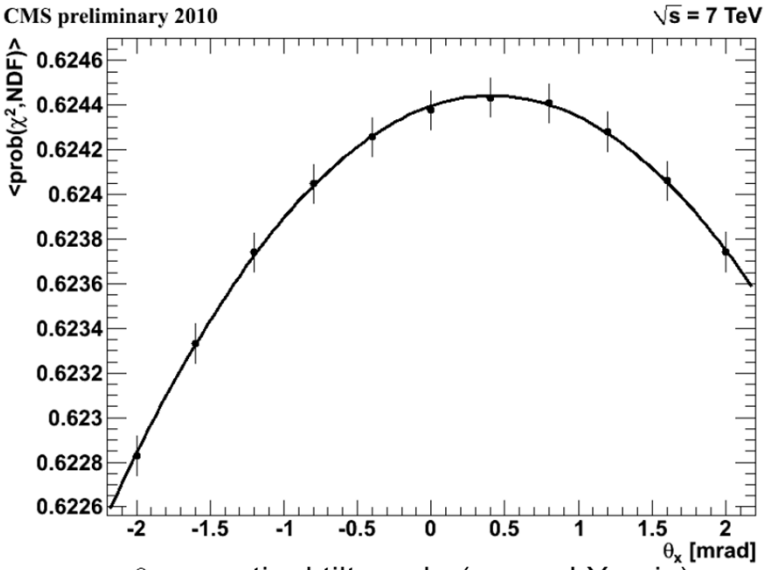
CMS Operations by DESY

- Alignment
  - Tracker alignment
  - Relative global alignment of tracker and muon chambers
- Data Quality Monitoring
  - Offline, MC & release validation
  - Data certification
- Detector operations
  - CASTOR forward calorimeter
  - Fast beam condition monitor (BCMF1)

Alignment in 2010

- Best alignment of CMS with Millepede-II accounted for time-dependence in part of the alignment parameters → seven intervals
  - pixel barrel half-layer parameters separate for each interval
  - significant improvement compared to ICHEP10 alignment
- Tracker tilt angle relative to magnetic field determined
  - only indication for small vertical tilt (~300 μrad)
- Comprehensive tracker alignment paper planned for end of this year





θ_X = vertical tilt angle (around X axis)

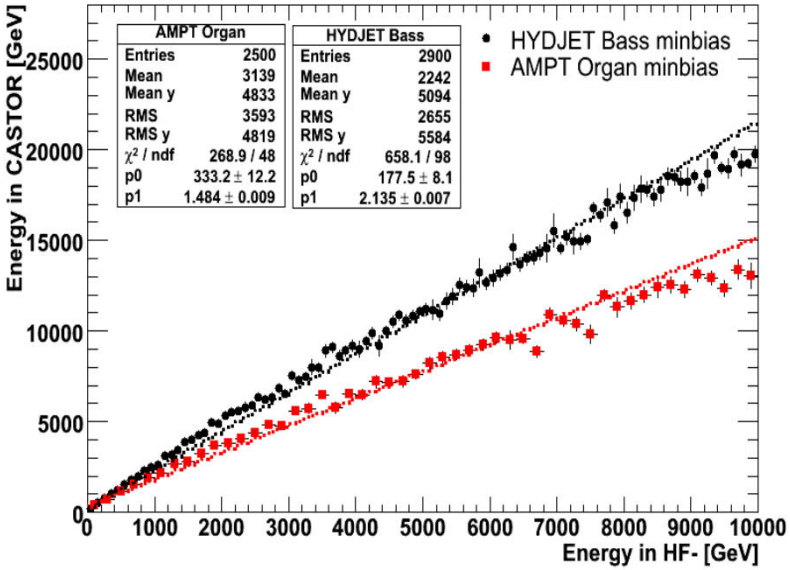
DESY Contributions to DQM

- Offline DQM operations
  - Reprocessing (Tier-1)
  - MC production (Tier-2)
- Offline DQM code integration
  - All MC and physics DQM
- Physics DQM
  - SUSY
- CMS data certification
  - official good run lists
- DQM shifts
  - Daily at DESY remote center

DESY CMS Remote Center

CASTOR Calorimeter

- Smooth data-taking in 2010 pp and HI running and in 2011 pp running
- Halo-muon intercalibration → uniform treatment of 2010 dataset (pp & HI): gain corrections, list of bad channels
- Study correlation between HF and CASTOR → absolute calibration with high statistics



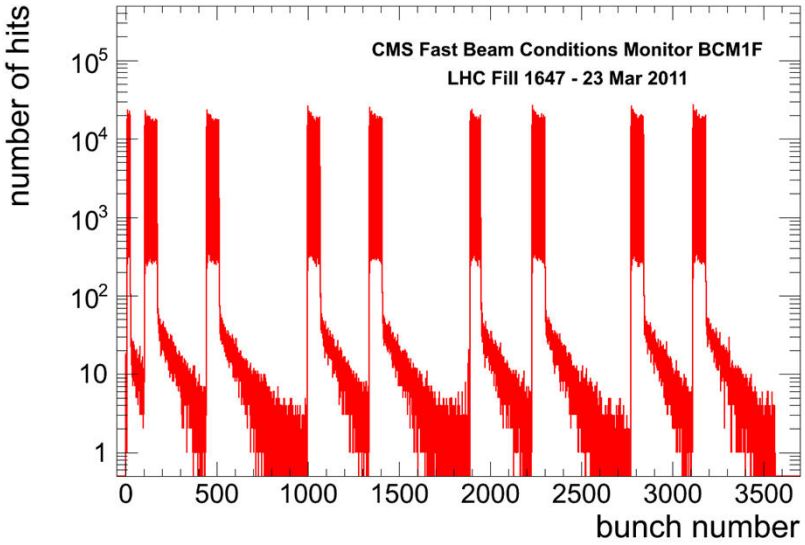
Passed successfully review on future running in January:

- Measured radiation rates in agreement or lower than predictions → available shielding sufficient for higher luminosity in 2011
- Present status and physics case solid enough to proceed with CASTOR for special low luminosity and HI data taking at 14TeV

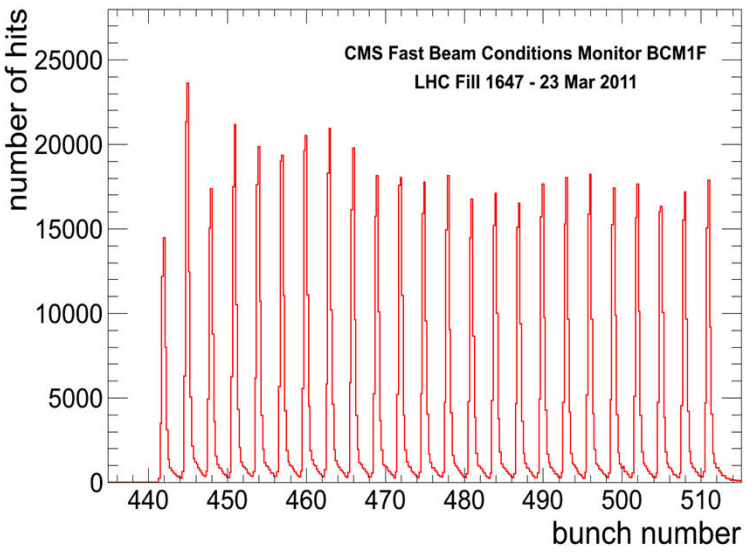
BCM1F Status

- system was taken to operation before beam circulation

Bunch trains per orbit

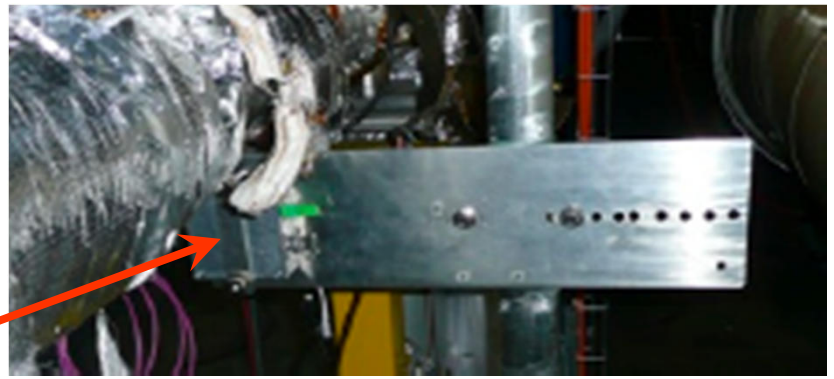


One train resolved



MoU between DESY and CERN :
DESY delivers 8 modules based on CVD diamond sensor for LHC halo monitoring

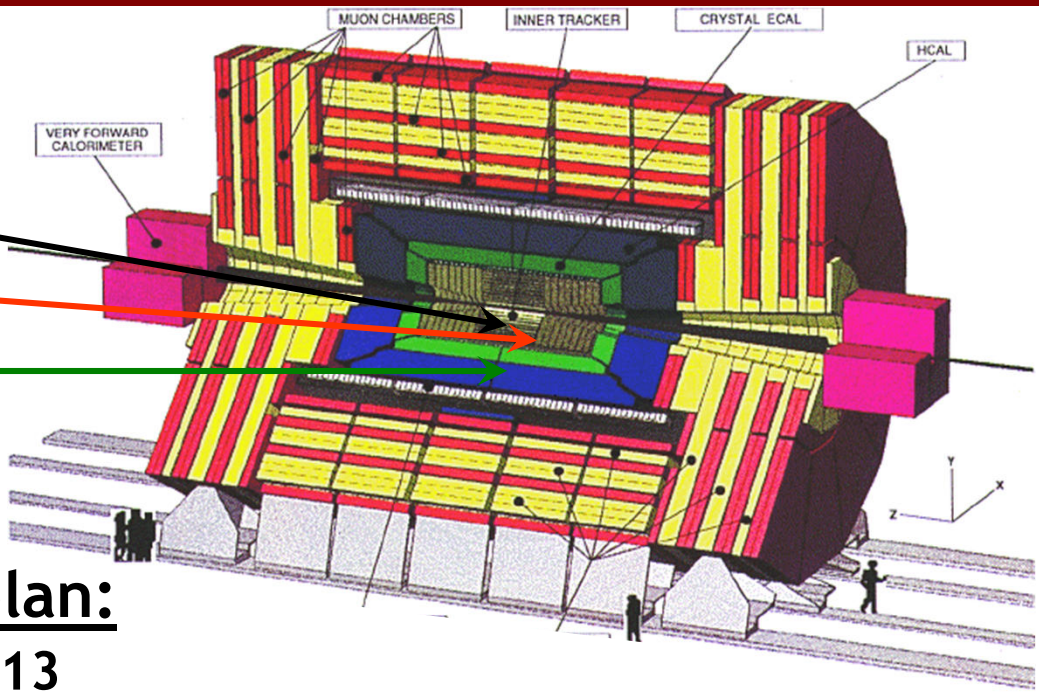
First module installed at LHC Point 8



CMS Detector Upgrade

DESY contributions

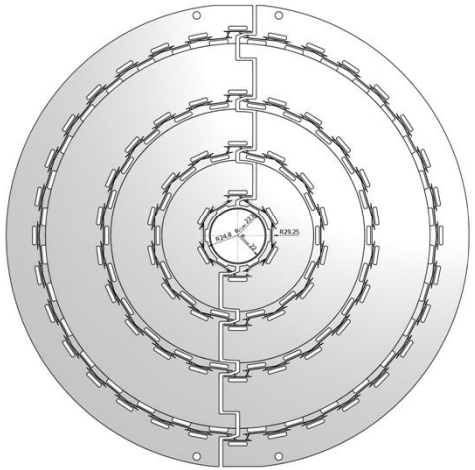
- Pixel
- Tracker
- HCAL

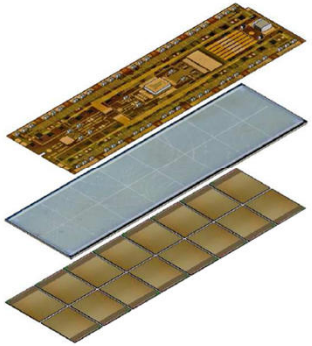


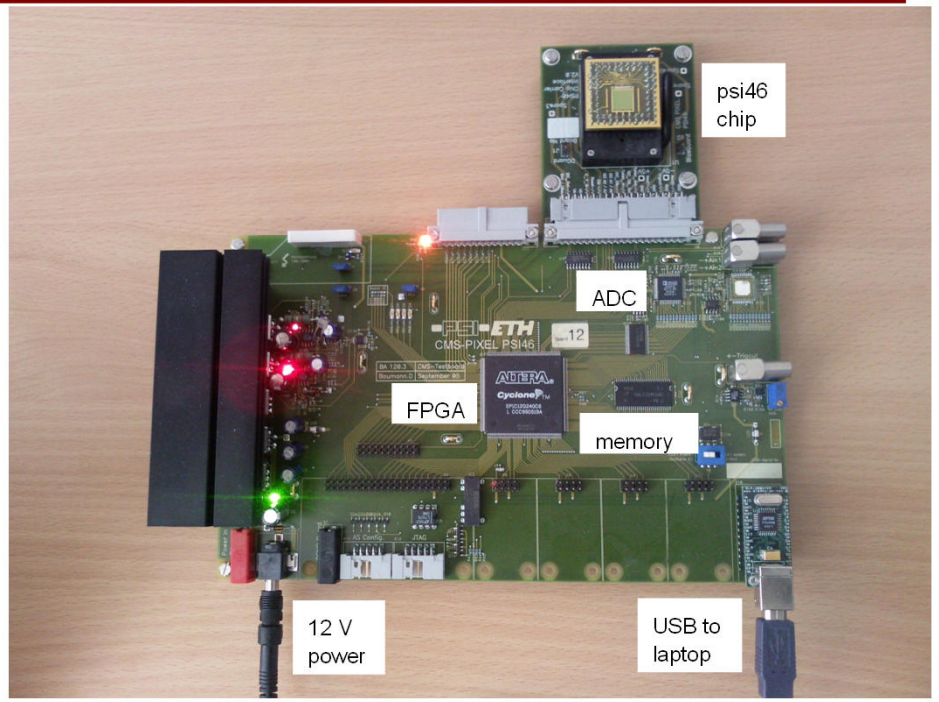
Presently discussed plan:

- Data taking until mid 2013
- Shut down mid 2013 - end 2014
  - HCAL Outer upgrade with SiPMs & BE electronics
- Extended winter technical stop 2016
  - Installation of new pixel detector with enhanced capabilities
- Shut down ~2018
  - HCAL upgrade with SiPMs
- Shut down ~2020/22
  - Replacement of the whole tracker

Phase 1 : CMS Barrel Pixel Detector Upgrade







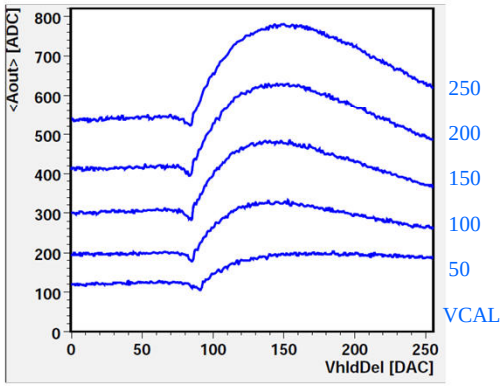
- 4 layers (3 in present version)
- inner layer at 30 mm (44 in present version)
- less material in tracking volume
- new readout chip for $2 \cdot 10^{34}/cm^2/s$

- D-Consortium will build layer 4 (50% by DESY)
- 350 modules : assemble, test and calibrate

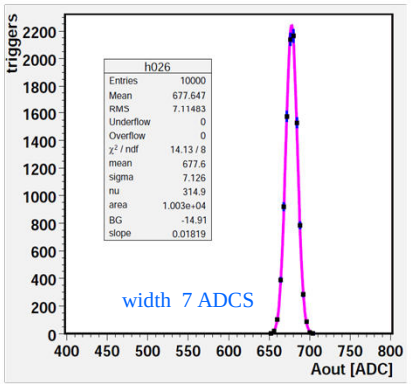
- bump bonding study under way

- PSI test board in operation at DESY
- verify current PSI64 readout chip

Sample & hold timing



Test pulse one pixel

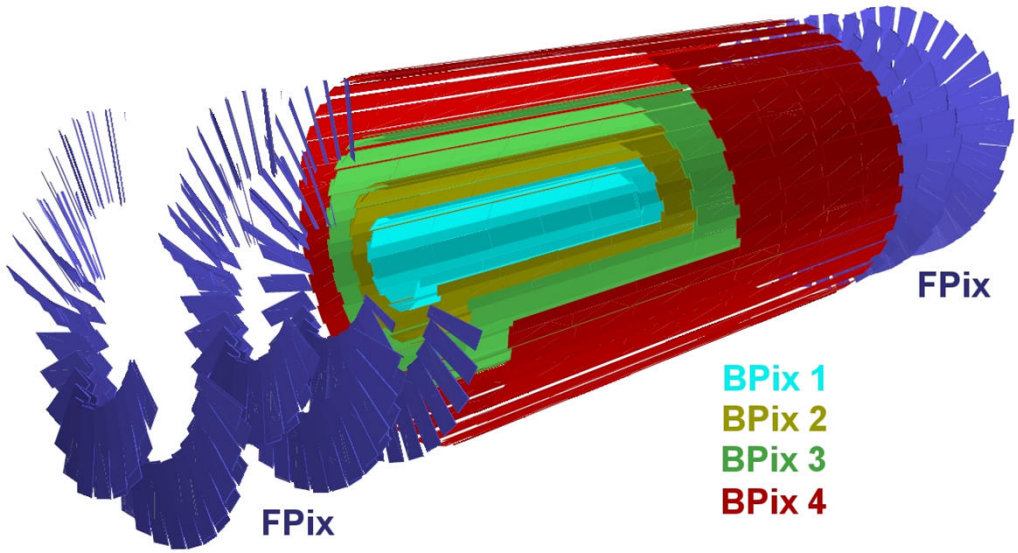


Phase 1 : Pixel Upgrade Simulation @ DESY

New pixel detector
4 barrel layers / 3 endcap disks and reduced material budget

DESY Activities

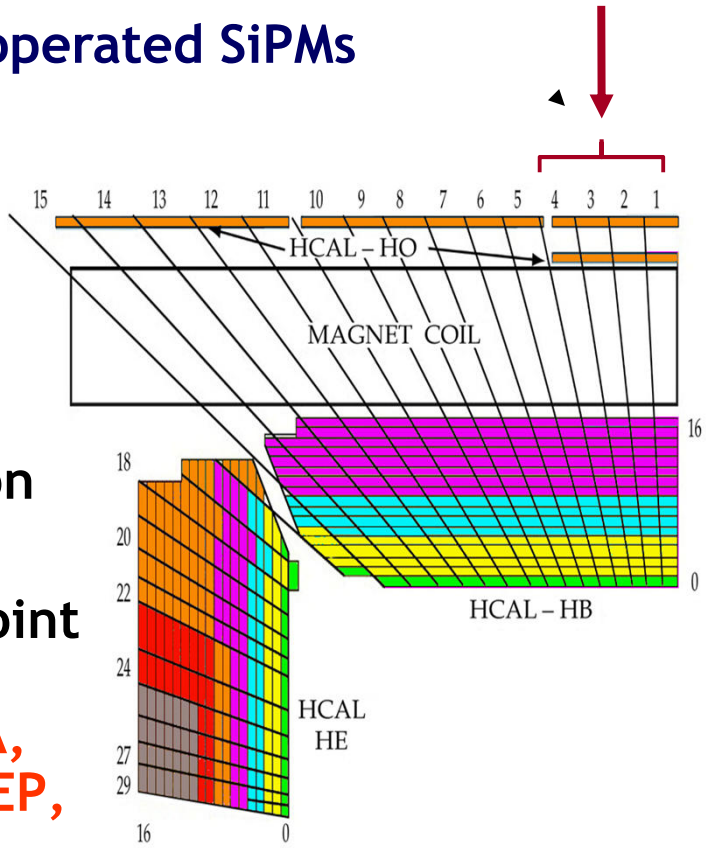
- Development and maintenance of tracking software for the upgraded pixel detector
- Commissioning of tracking software for high pile-up scenarios
- Investigating of tracking and b-tagging performance in HLT with upgraded pixel detector



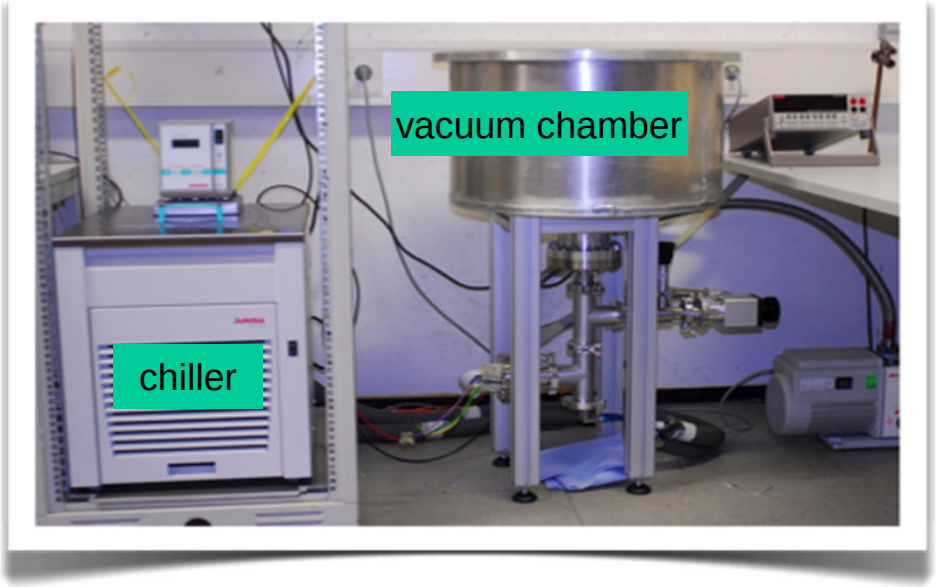
HCAL Upgrade with SiPMs & μ-TCA

DESY Contributions

- **HCAL Outer Ring 0**
  - 1000 SiPMs (funds from Landes-Excellence Cluster)
  - Test stand at DESY for optical studies of the light mixer
  - Simulation studies and analyses of already operated SiPMs
- **HCAL Upgrade**
  - μ-TCA: develop prototype, run in parallel with optical splitters for one HCAL φ-slice, HF and CASTOR
  - SiPMs studies: simulation for physics, contribution to integration and operation aspects
  - New application for Helmholtz-Russia Joint Research Group will be submitted: "SiPM at LHC-CMS and LC-CALICE, μ-TCA, SUSY Searches with CMS" with DESY, ITEP, MSU and RWTH Aachen



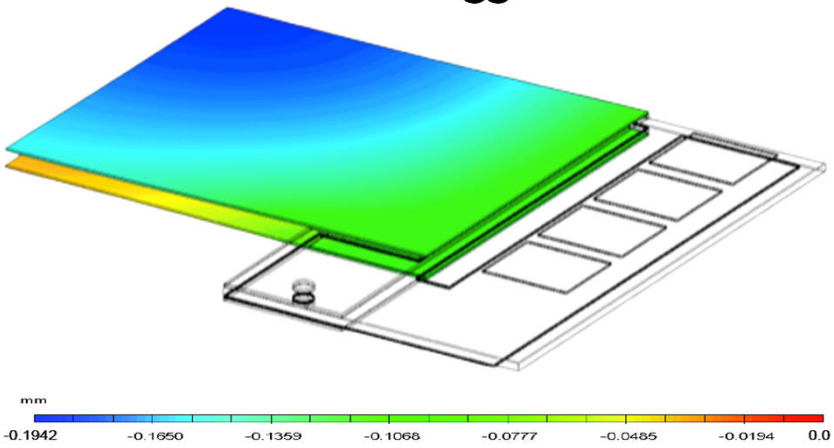
Phase 2 : Tracker Upgrade R&D



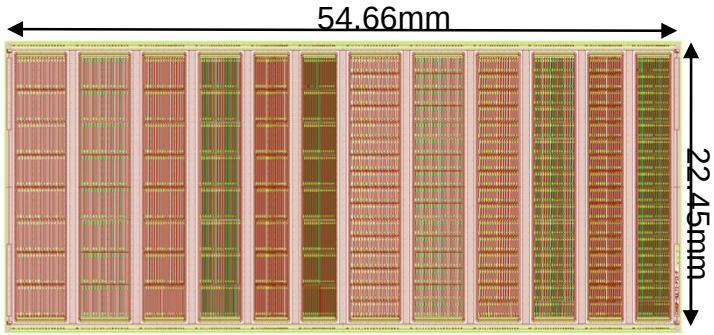
- **Improved thermal measurement setup under commissioning**
  - Support finite element calculations
  - Characterization of novel materials
  - Test prototype modules

- **Extension for optical deformation measurements under way**

finite element analysis for mechanical deformations of a trigger module



Multi-Pixel Sensors (DESY, CERN, Bari), responsibility within CEC

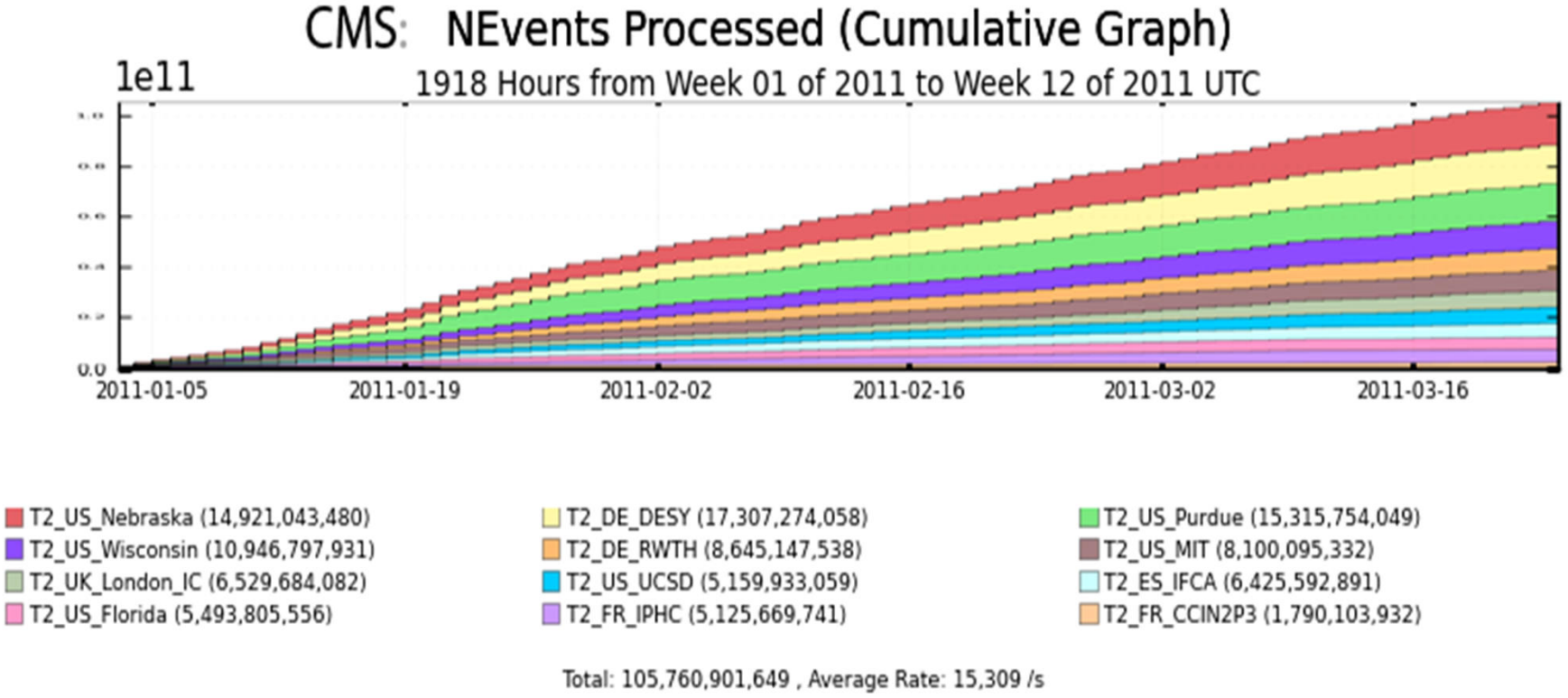


12 different technologies/geometries

- 3 sensors measured during testbeam at FNAL
- 25 sensors in preparation for testbeam at CERN (September 2011)

CMS Computing at DESY

- **Processes events for data anaysis at CMS Tier-2 centres January-March 2011:**

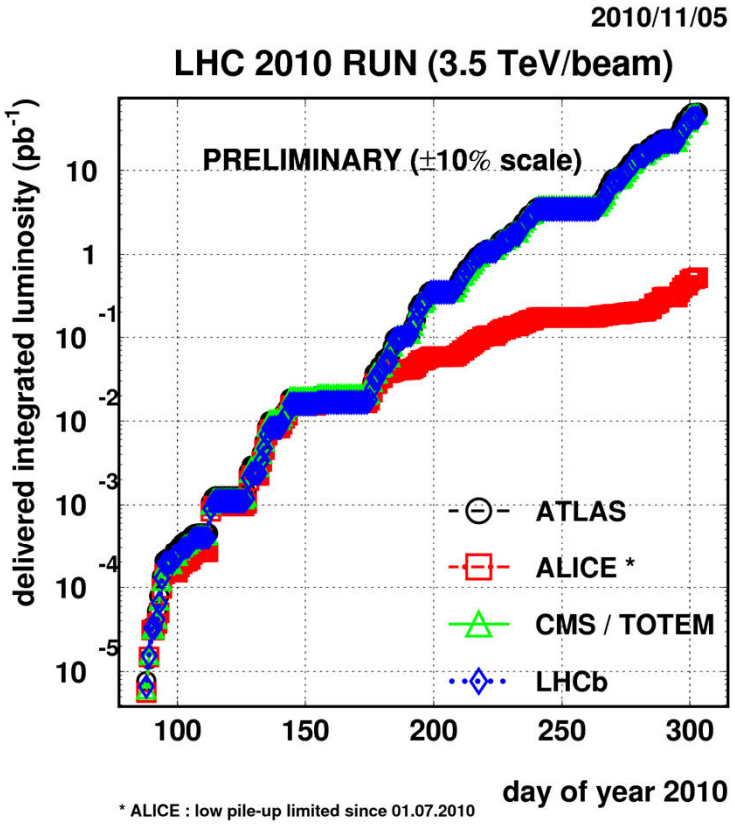


- **DESY ranks number one**
- **the other German Tier-2, Aachen, is number five**

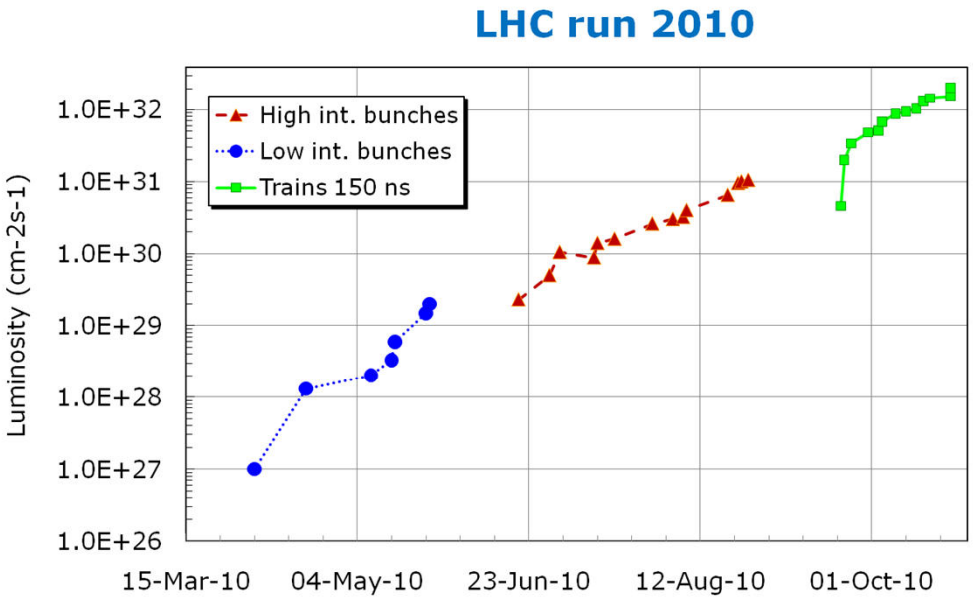
Summary

- Impressive first year of LHC running at 7 TeV with excellent performance of CMS detector
- Rich physics has been harvested in 2010 with substantial contribution from DESY group
  - measurement of top pair production cross-section
  - study of $Z \rightarrow \tau\tau$ as "standard candle" for Higgs$\rightarrow\tau\tau$ searches
  - investigation of forward energy flow
- DESY takes an active part in operations of CMS detector
  - Data Quality Monitoring
  - tracker alignment
  - operations of BCM1F and CASTOR calorimeter
- … and CMS upgrade program
  - pixel detector and tracker
  - HCAL
- … and management of CMS computing resources (DESY_T2, GRID, NAF)
- Exciting time is awaiting us and CMS group at DESY will strive to be at front-line of research carried out at LHC

Backup. LHC Operation in 2010



Peak luminosity > 2×10^{32} $cm^{-2}s^{-1}$



Parameter	2010	Nominal
Beam energy	3.5 TeV	7 TeV
N (protons/bunch)	1.1×10^{11}	1.15×10^{11}
k_b (no. bunches)	368 (348 coll/IP)	2808
L ($cm^{-2}s^{-1}$)	2×10^{32}	10^{34}

Backup. LHC Running in 2011

Baseline for 2011: 2 ·1032 s-1/cm-2 peak, 1 fb-1 total

A more optimistic expectations following experience of 2010 LHC running

Days	Hübner Factor	Fills with ns	kb	N/b e11	ε μm	L s^{-1}/cm^2	Stored energy MJ	L Int fb^{-1}
160	0.3	150	368	1.2	2.5	~5.2e32	~30	~1.9
135	0.2	75	936	1.2	2.5	~1.3e33	~75	~2.7
					2	~1.6e33		~3.3
					1.8	~1.8e33		~3.7
125	0.15	50	1404	1.2	2.5	~2.0e33	~110	~2.8

Possible integrated Luminosity of 2-3 fb^{-1}

Coordination Roles within CMS Collaboration

- **Management**
  - M. Kasemann : Deputy Chair of Collaboration Board
- **Physics**
  - H. Jung : convenor of the Forward Physics Group
  - K. Borras : CMS Conference Committee
- **Computing**
  - M. Kasemann : Chair of CMS Computing Resource Board
  - C. Wissing : GRID software deployment coordinator
- **Data Quality Monitoring**
  - Dirk Krücker : Organizer of remote DQM shifts (L3)
  - J. Olzem : DQM for MC simulation (L3)
- **Tracker**
  - G. Eckerlin : Phase 1 Tracker Upgrade Management Board, Tracker Finance Board

Coordination Roles within CMS Collaboration

- Alignment
  - G. Flucke : Tracker Alignment Convenor
  - A. Mussgiller : Alignment Software Coordinator (L3)
- CASTOR Calorimeter
  - K. Borras : Project Leader, HCAL Steering Committee
- BCM1F operations, LHC
  - W. Lohmann
- CEC Sensor Qualifying
  - W. Lange