CMS trigger and data taking in 2010

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Cracow Epiphany Conference
On the first year of the LHC
10-12 January 2011, Cracow, Poland

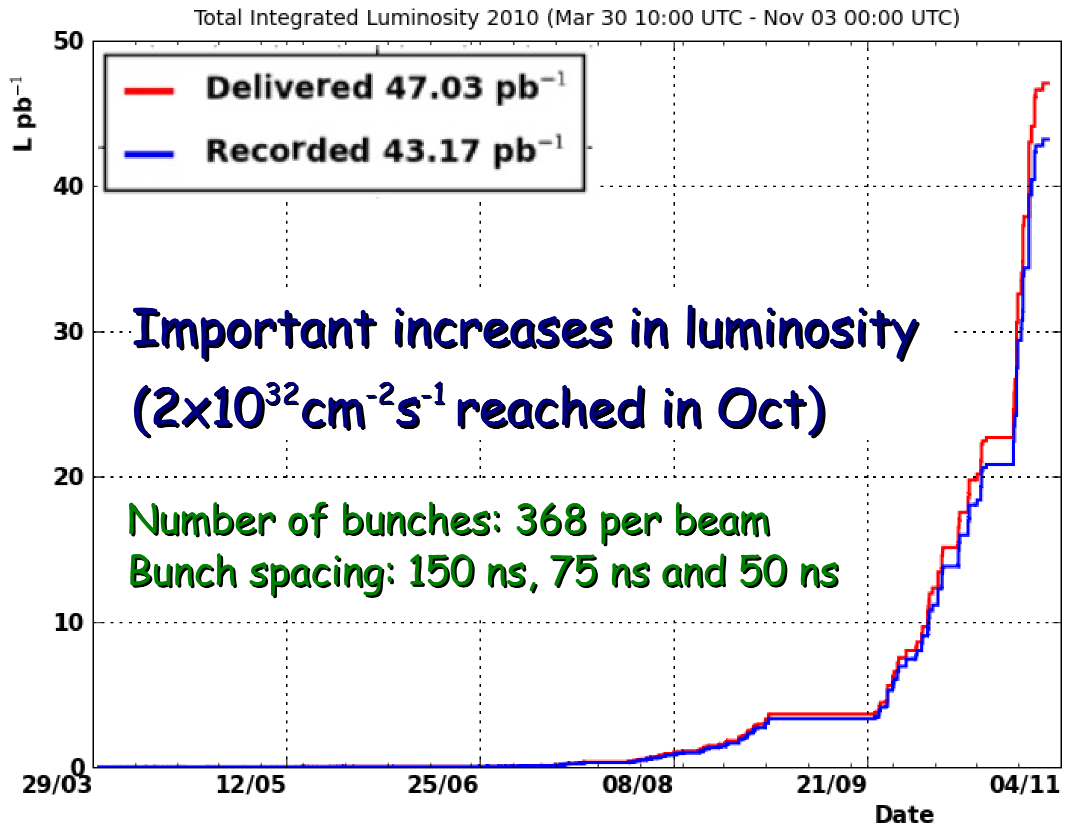
Outline

- LHC data taking by the CMS
- CMS trigger design
- Trigger efficiency results
- Trigger applications and achievements

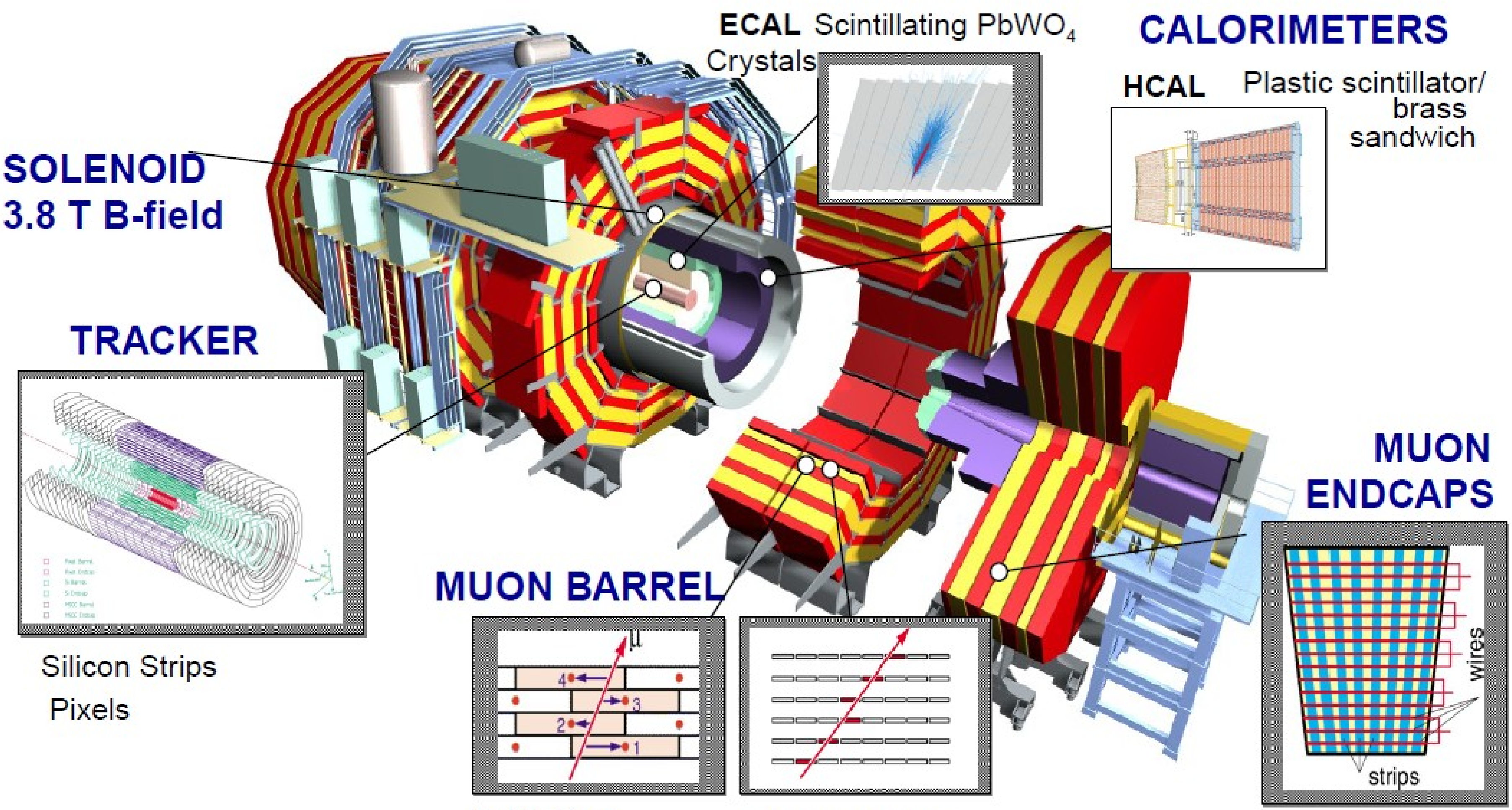
Physical results from 2010 CMS analyses in dedicated talks

LHC pp mode

- 7 TeV proton-proton collisions in 2010:
- **> 40/pb**
- Overall data recording efficiency 92%
- In 2009:
  - ~10/μb at 900 GeV
  - ~0.5/μb at 2360 GeV



Compact Muon Solenoid



Silicon Strips

Pixels

Drift Tubes (**DT**)

Resistive Plate Chambers (**RPC**)

Cathode Strip Chambers (**CSC**)

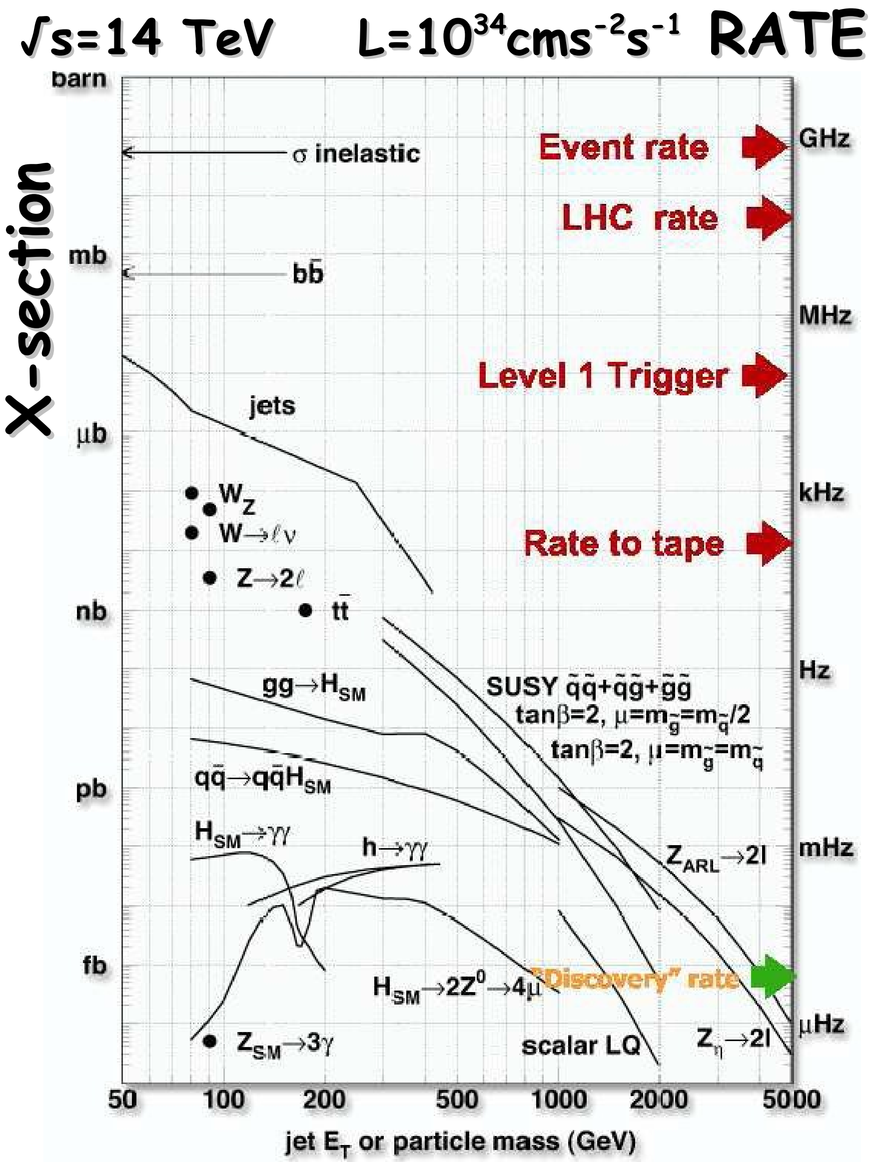
Resistive Plate Chambers (**RPC**)

Azimuthal angle: ϕ

Polar angle: θ

Pseudorapitidy: $\eta = -\ln \tan(\theta/2)$

Motivation vs requirements

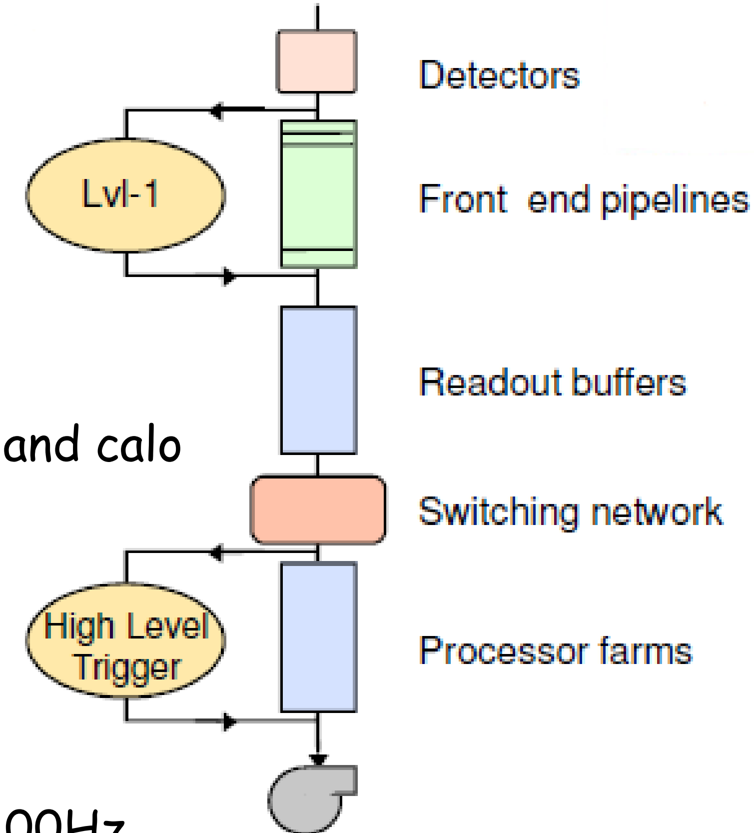


- LHC was built to study the origin of the EWK symmetry breaking and the BSM physics
- We reject most of the QCD data
- **Designed rate of the LHC 40MHz <=> trigger electronic frequency**
- Storage capability limited to **~O(100) MB/s** (for 1 event 1MB stored) → 100-300 events stored per sec
- Rate to tape O(**100) Hz**
- 5 orders of magnitude of rate to be rejected by the **TRIGGER**

State-of-the-art Trigger

CMS trigger based on two levels:

- **L1 – Level 1** rate: 40MHz to 100kHz
  - Customized and programmable electronics implemented in hardware
  - Uses coarse granularity data for muons and calo
  - Full detector data stored in buffers waiting for L1 decision, pipeline with latency, 3.2μs



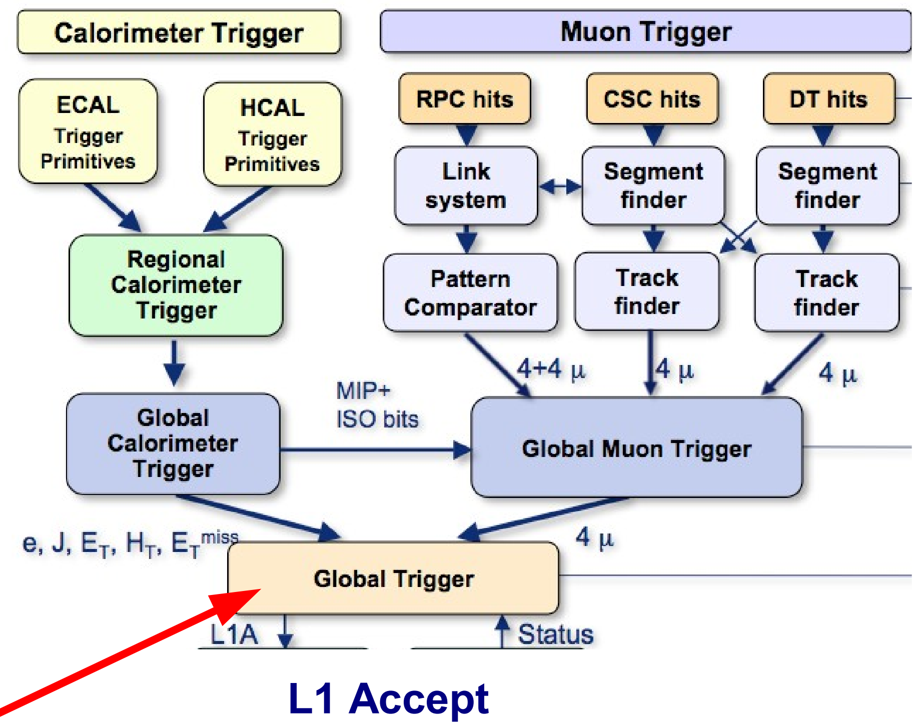
- **HLT – High Level Trigger** rate: to 100Hz
  - Software implemented on a large computing farm built from commercial processors
  - Reconstruct all physical objects in the whole event

L1 Global Trigger

L1 Architecture:

- **Local:** Calo trigger primitive (coarse evaluation of tower E_T), muon track segments
- **Regional:** build regional $e^{\pm}/\gamma$, jets (RCT), regional $\mu^{\pm}$ tracks (muons track finders)
- **Global:** (calo, muons):

sorting the best 4 L1 objects:
4 $e^{\pm}/\gamma$ (iso+non iso),
4 $\mu^{\pm}$,
4 jets, E_T^{miss}, E_T, H_T



L1 decision based on:

- physics algorithms combining L1 objects and/or technical triggers
  - up to 128 physics algorithms in parallel
  - up to 64 technical trigger signals from LHC beam counters, CMS beam scintillators

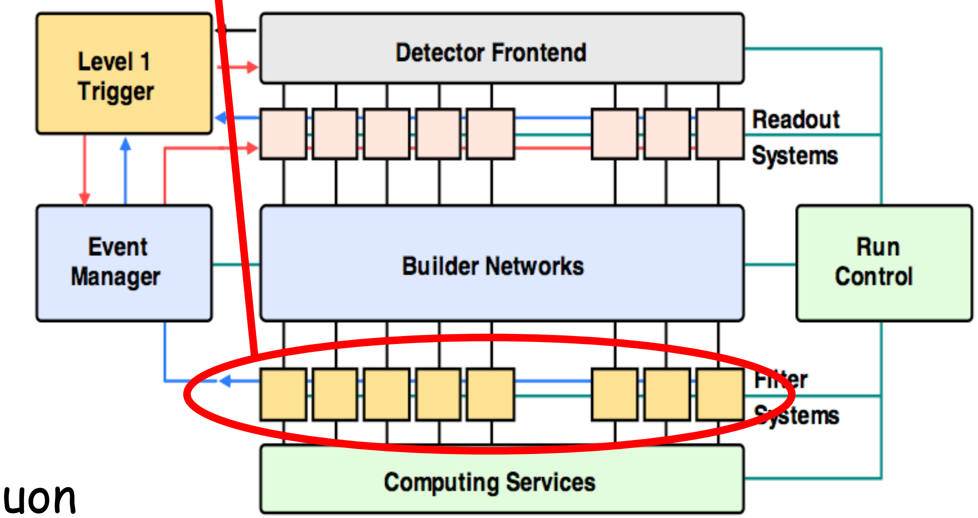
Final L1 decision: OR with pre-scaling + trigger rules

(e.g. no more than 1 Level 1 Accept per 75 ns)

HLT Architecture

HLT ↔ builder network and CPU farms

- software based running on ~5000 CPU farm
- Up to 150 trigger paths using full granularity data



- Internal sub-structure with rising complexity:
  - HLT seeded by L1 decisions
  - L2: re-reco calorimeter and muon system information from L1
  - L2.5: matches L2 objects with pixels
  - L3: matches L2.5 with reconstruction of full tracks in the tracker
- Evaluates the **full trigger menu** and subdivides processed data into the **data streams** wrt physics requirements, calibration, data quality

Software/computing performance

- Average time of the **HLT Full Path Menu** calculations: 40 ms
  - 2 Quad Core Intel(R) Xeon(R) 5430 processors
  - 2.66 GHz nominal frequency
  - 16 GB memory
- **There is enough flexibility in the HLT trigger menu to modify the average CPU time depending on the beam conditions**
- Average time to reconstruct the pp event ($2x10^{32}$ Lumi triggers): 2s
- During 2010 data taking by CMS:
  - L1 Trigger rates: 70 kHz (limited by HLT CPU time)
  - HLT output rates: 300-600 Hz

Trigger Commissioning in 2010

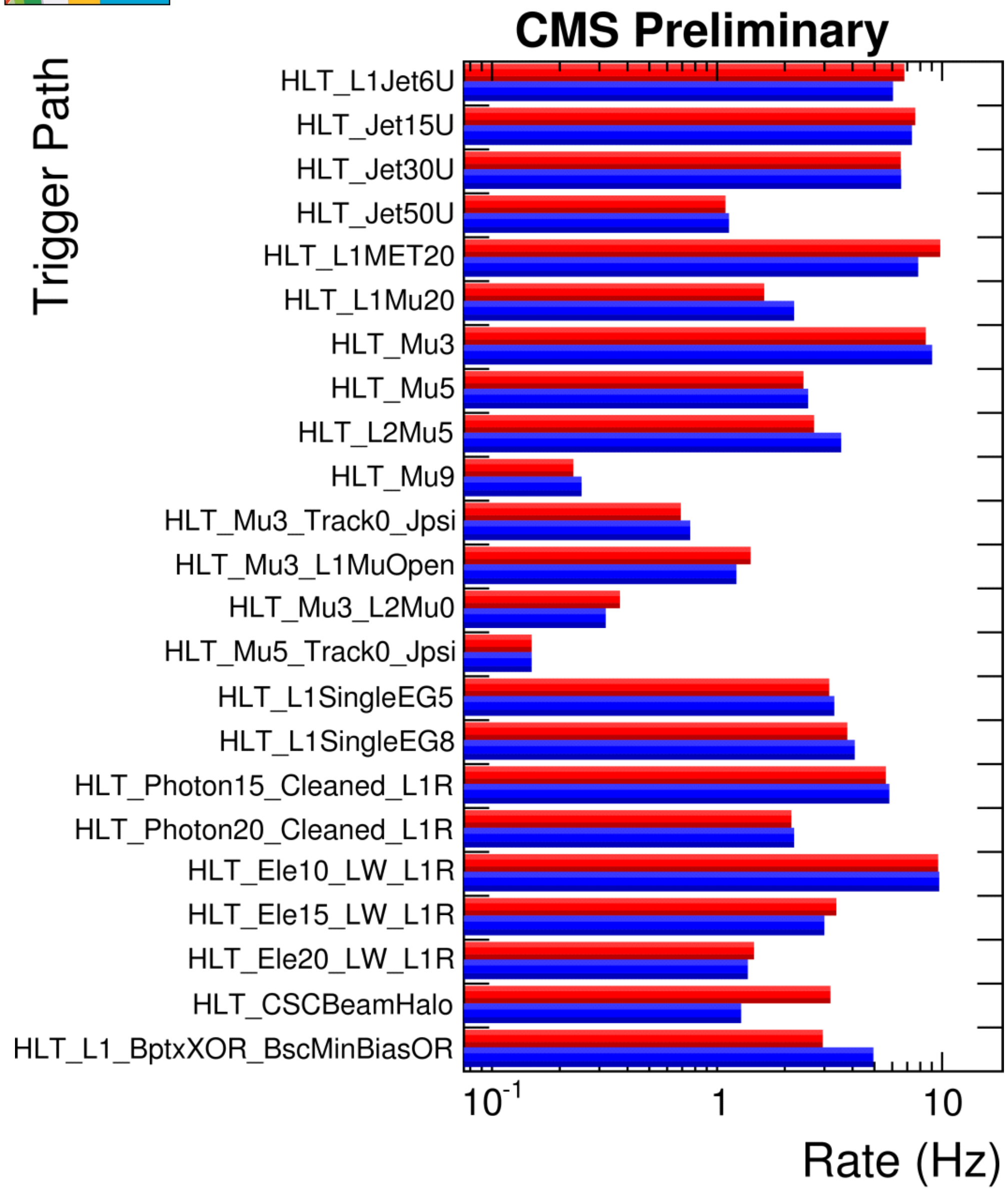
CMS operation was adopted to the LHC conditions

customizing **Trigger Menu (L1,HLT)**

a collection of different trigger paths (>100) using dedicated algorithms

- **Low luminosity regime:**
  - e.g.: 1E28,1E29,4E29 trigger menus
  - Trigger decision based on simple threshold cuts
  - No (or low) pre-scales
- **High(er) luminosity regime:**
  - e.g.:2E31, 6E31, 2E32 menus
  - More elaborated: require isolation and identification besides thresholds
  - Large pre-scales for selected trigger paths

HLT Rates



Trigger rates extrapolated from data

- Extrapolation uses data to predict future rates at higher instantaneous luminosities
- Most paths exhibit fairly linear behaviour vs luminosity
- Preparing menus for each twofold increase in luminosity

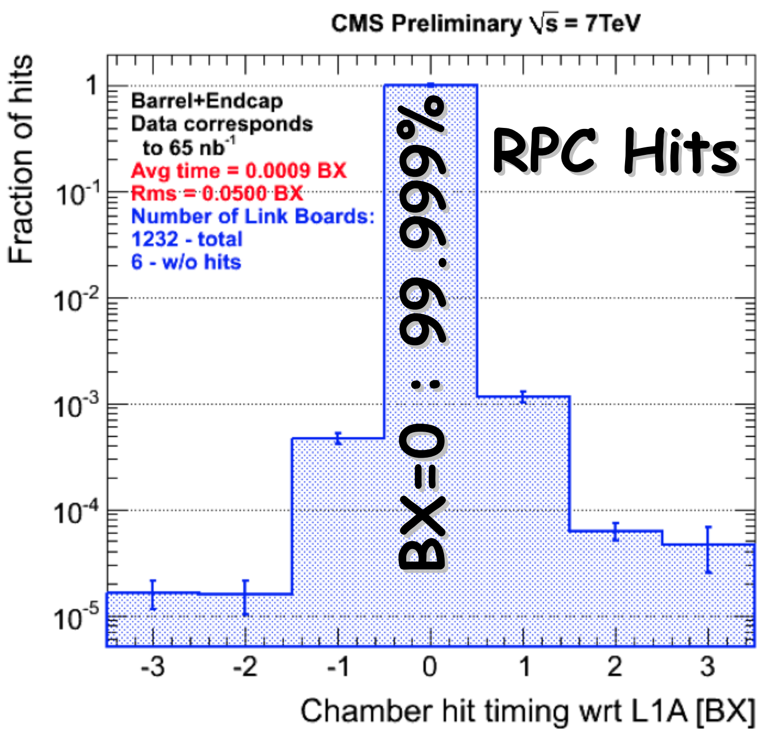
Measured rate: Rate from run @ L=4.6E29

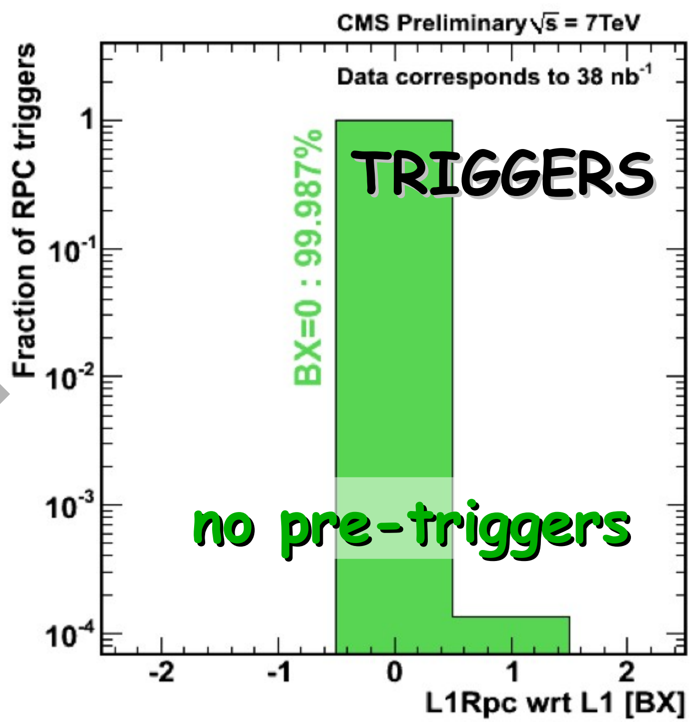
Extraplated rate: Rate from run @ L=1E29 scaled by factor 4.6

Trigger synchronization

- LHC is design to deliver one bunch crossing (BX) every 25 ns
- Trigger has to provide a correct BX assignment
- Optimization of the trigger synchronization allows for an overall efficiency increase

Example: L1 RPC trigger synchronization is in a very good shape

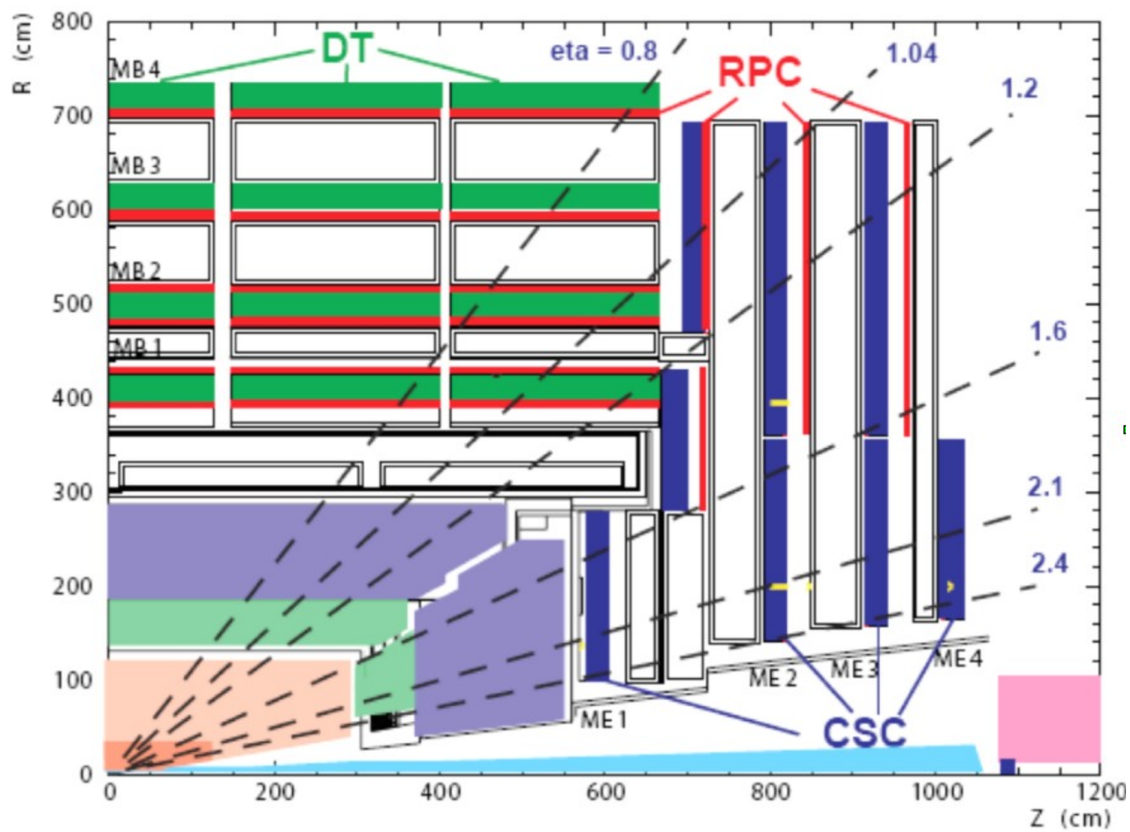




CMS Muon System

Muon Trigger System based on:

- Drift Tubes (DT) in the barrel
- Cathode Strip Chambers (CSC) in endcaps
- Resistive Plate Chambers (RPC) up to |η| < 1.6

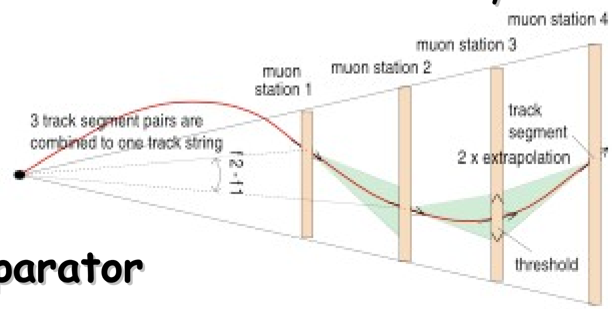


Muon trigger objects

L1 muons

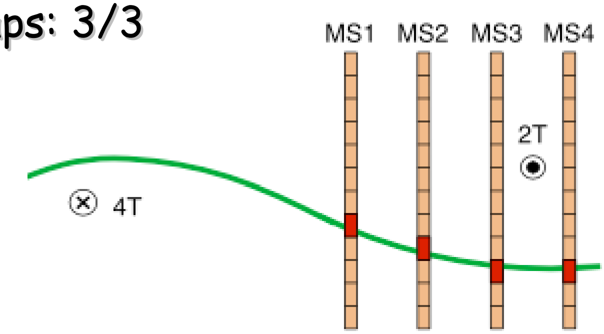
DT and CSC triggers

- Track segment identification
- Full track finder in the muon system



RPC Comparator

- Pattern matching
  barrel: 3 layers/4 or 4/6
  endcaps: 3/3



HLT muons

L2 Step

- Re-fit hits in the muon chambers with the full granularity
- Reco in L1 region of interest

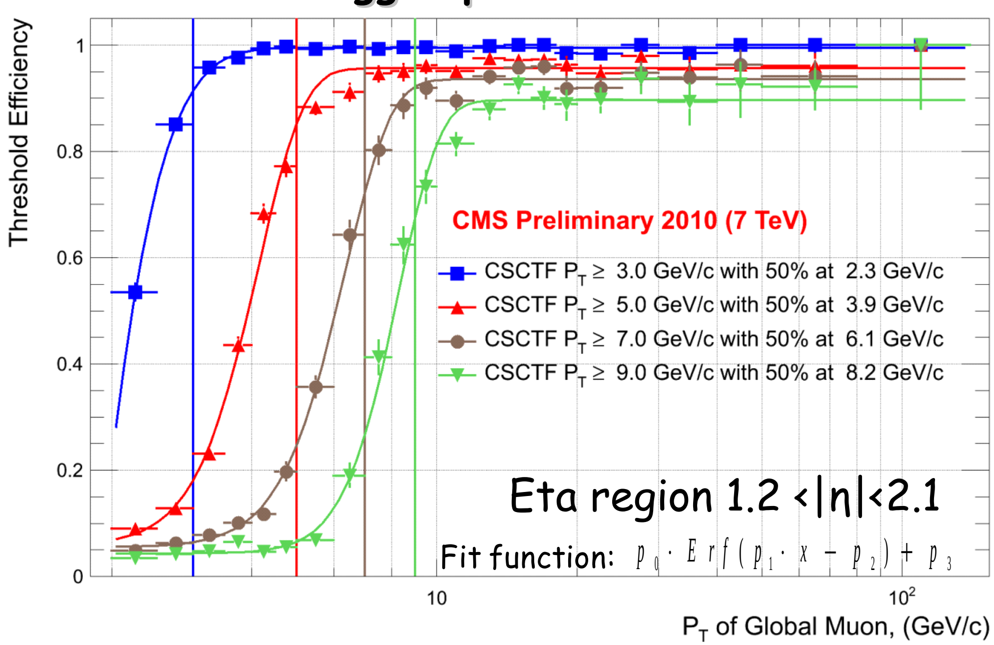
L3 Step

- Combine tracker hits with L2 objects:
  - **Include tracker hits**
  - **Matching tracker and muon informations**
  - **Better transverse momentum measurement**

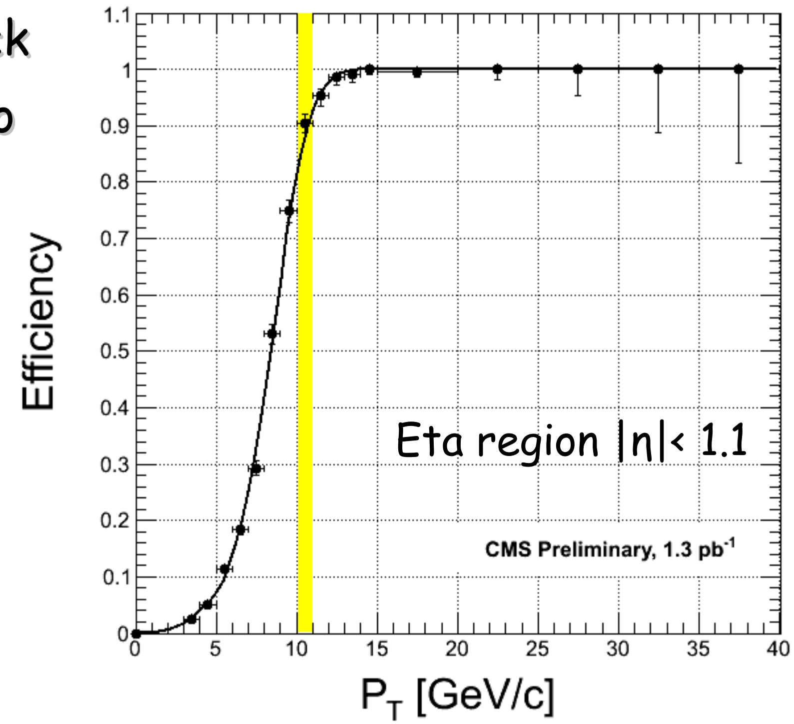
L1: DT, CSC Track Finder Efficiency

Threshold efficiency – probability that for reconstructed muon with momentum P_T, track finder assigns momentum greater or equal to the threshold value

CSC trigger performance



DT trigger performance



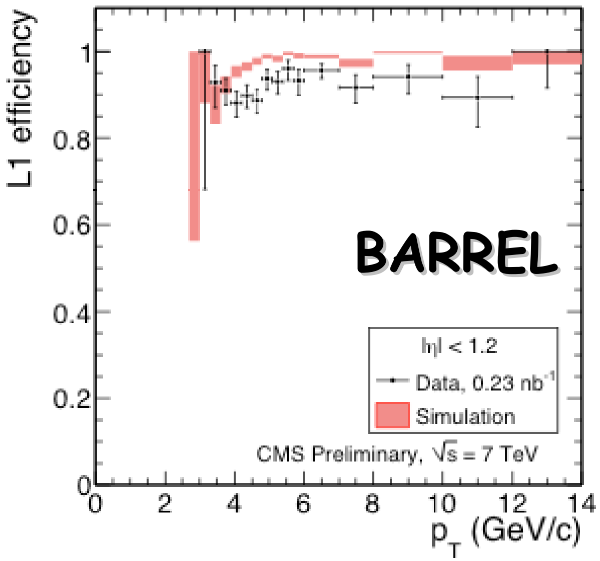
DTTF PT > 10 GeV/c from J/Psi

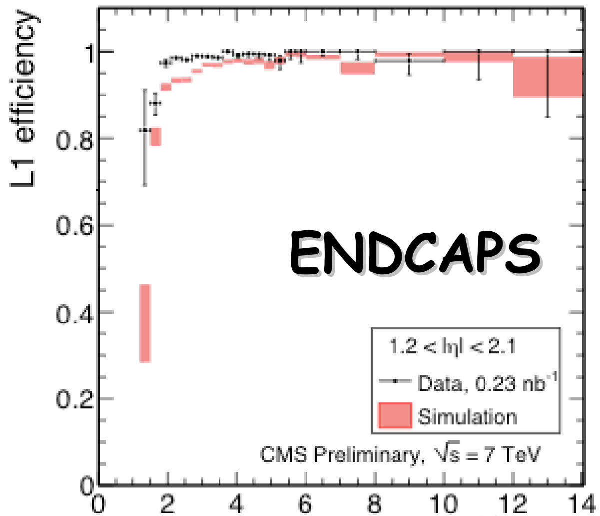
"Turn-on" expected to reach > 90% efficiency at the nominal cut

Muon trigger performance at start-up

L1 muons

HLT muons



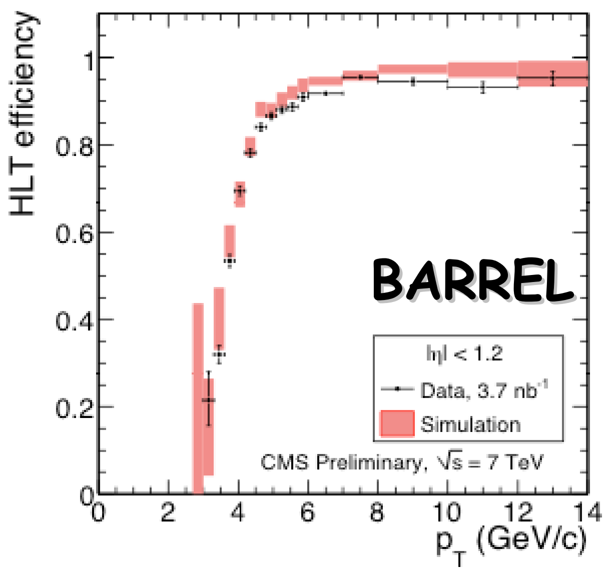


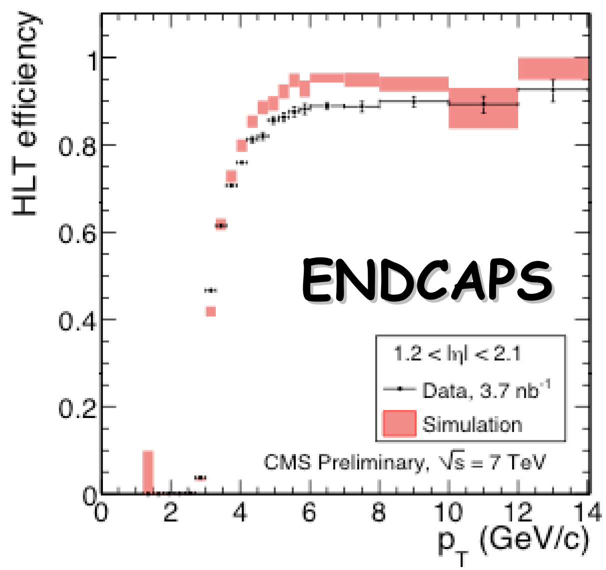
HLTμ efficiency PT>3GeV w.r.t L1 muon trigger

- Efficiency lower in data than in MC because of preliminary time synchronization of the muon detector at start-up

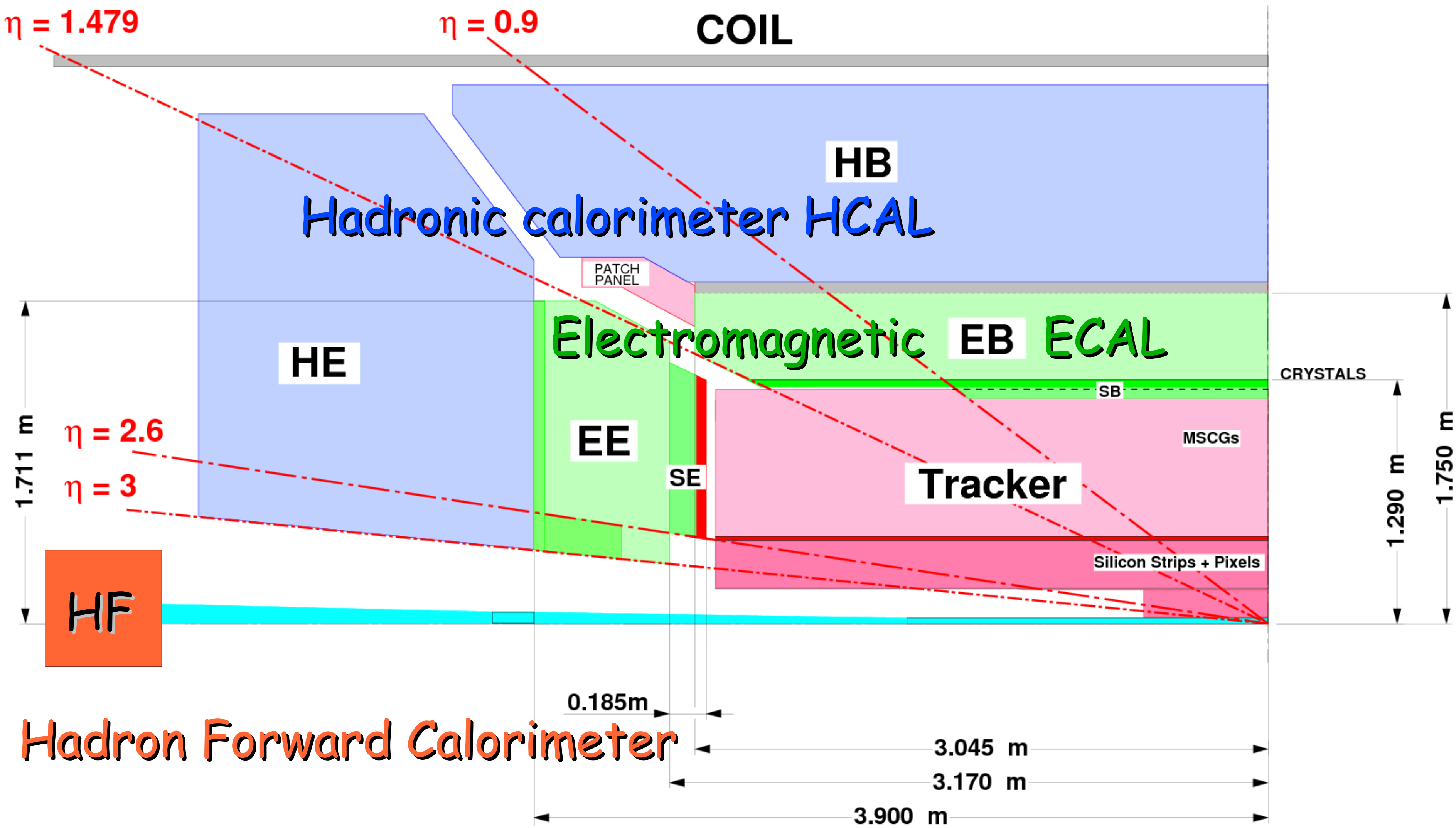
Efficiency L1 μ

- Minimum bias events
- Agreement Data/MC within 10%
- L1 eff in endcaps better in data because of special setting of CSC used at start-up to trigger on single muon segment





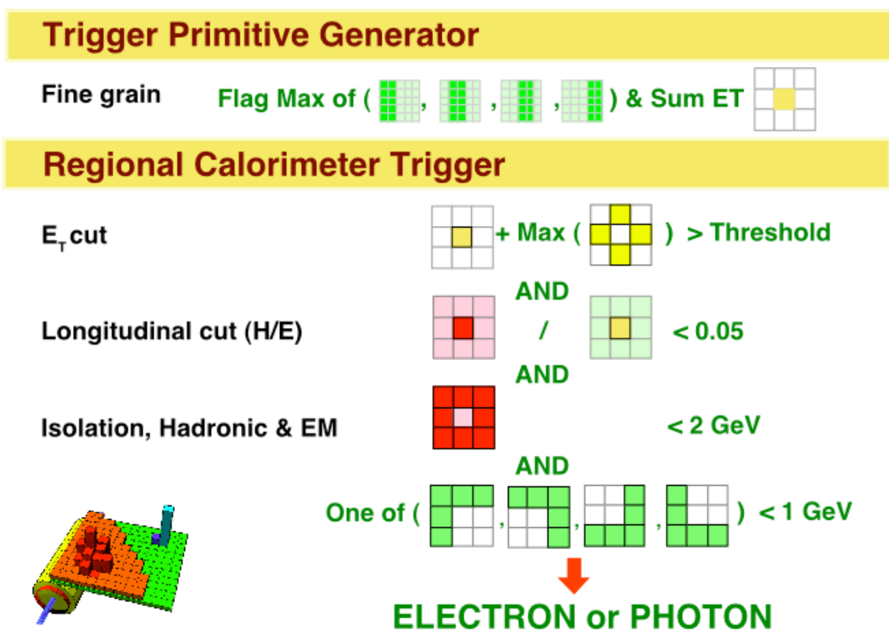
Calorimeter System



Hadron Forward Calorimeter

Photon and electron trigger objects

L1 e/gam



HLT e/gam

L2 Step

- Spatial matching of ECAL clusters with e/γ candidates at L1
- Superclusters are formed
- ET cut applied
- Calorimetric (ECAL+HCAL) isolation

L3 Photons

- Tight track isolation

L3 Electrons

- Electron track reconstruction
  - Spatial matching of ECAL cluster and pixel track
- Loose track isolation in a "hollow" cone

Trigger performance using unbias event sample

Unbiased events collected in a special (EGMonitor) dataset using ECAL Activity triggers:

- seeded by minimum bias BSC (Beam Scintillation Counter) L1 triggers
- reconstruct ECAL super-clusters

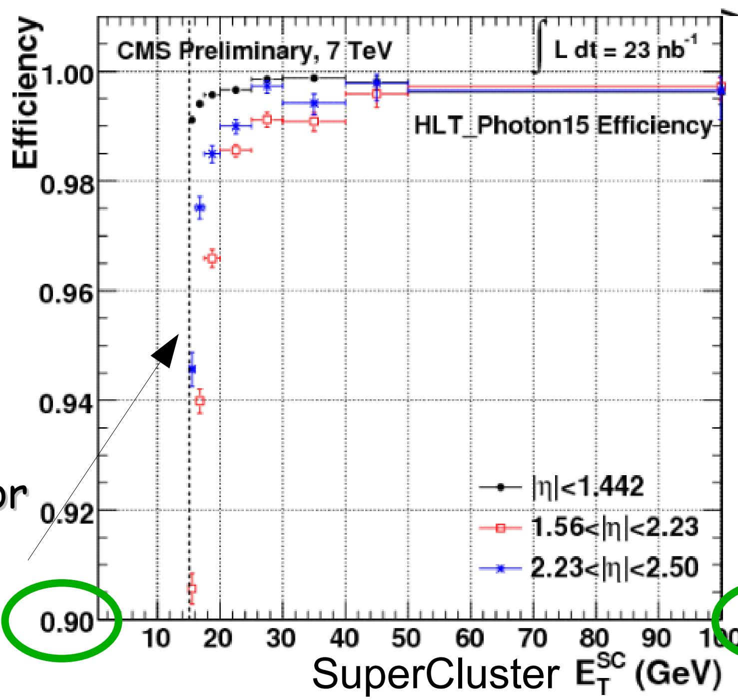
Efficiency for a trigger path (T) =

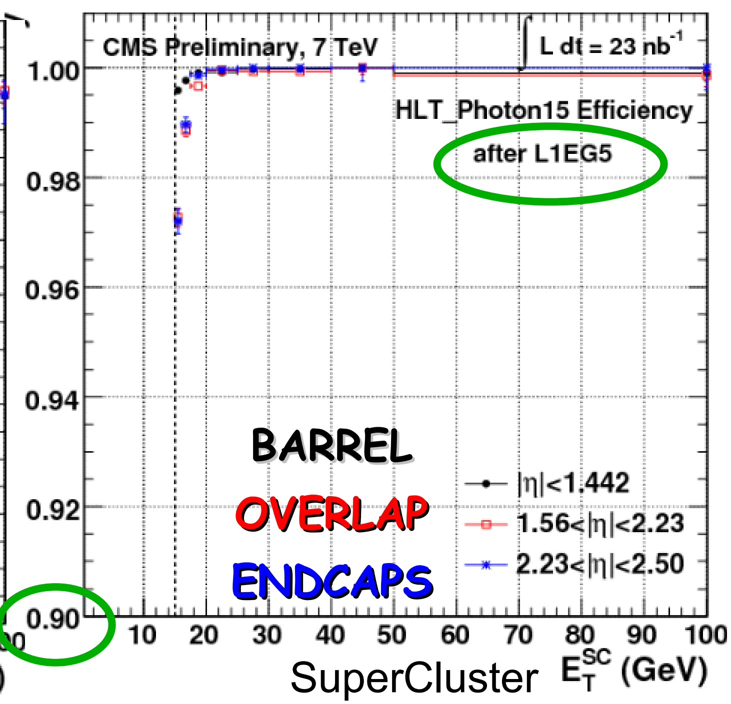
Number of events firing trigger path (T) / Total number of events

Photon trigger with E_T^{thres}>15 GeV at HLT

Study in the start-up conditions (un-prescaled paths)

Trigger is performing well and a turn-on of the HLT trigger clearly seen for p_T > 15 GeV





Tag and probe method

$Z \rightarrow e^+e^-$

Use the **Z mass resonance** to select lepton: **electron pairs** and probe the efficiency of a particular selection criteria

- **Tag**: lepton passing very tight selection with very low fake rate (<<1%)
- **Probe**: lepton passing softer selection and pairing with Tag object in a way that the invariant mass of tag and probe combination is consistent with the Z resonance

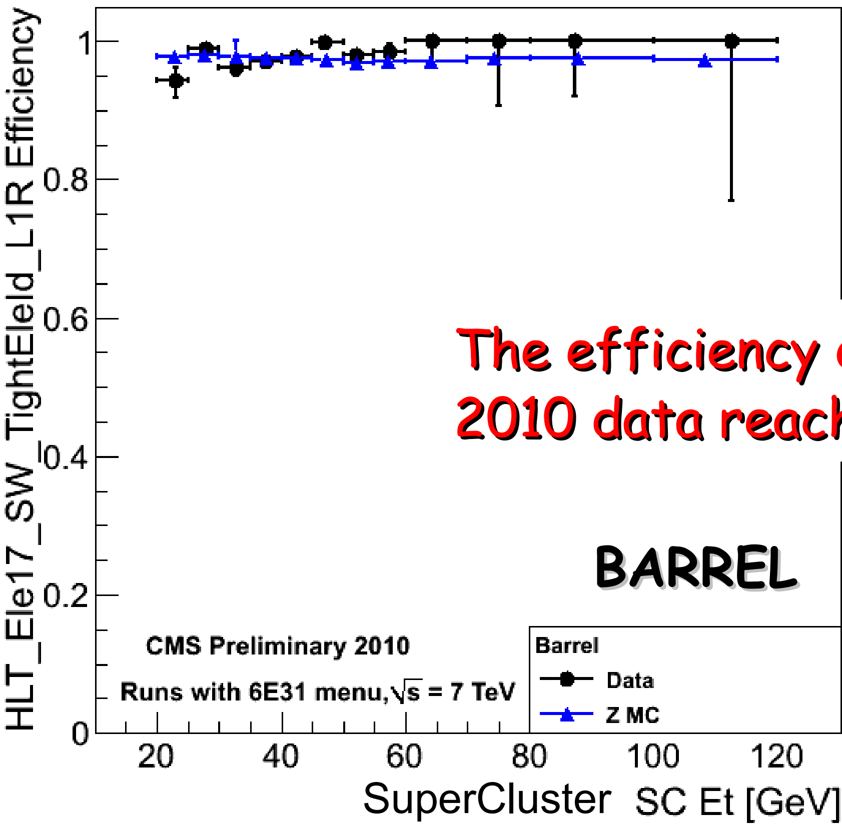
- **Efficiency** = N_{pass}/N_{all}

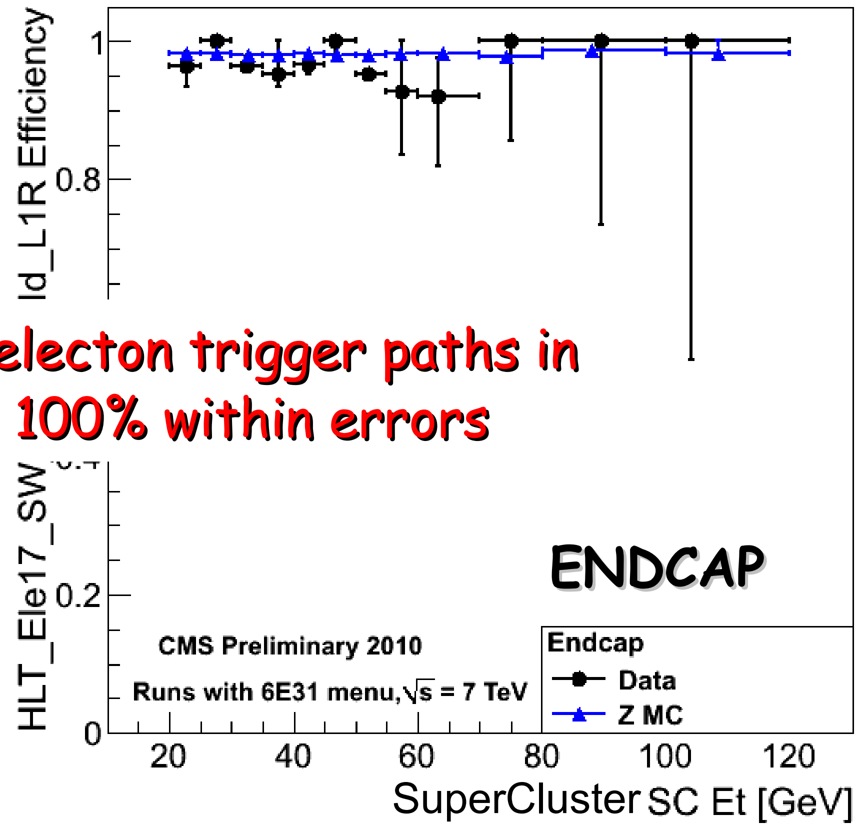
$N_{pass} \rightarrow$ number of probes passing the selection criteria

$N_{all} \rightarrow$ total number of probes counted using the resonance

Tag and Probe Results
for the high luminosity regime: 6E31 HLT Menu

Electron (ET [Tresh]>17 GeV) with Tighter Calorimeter-based Electron ID+Isolation at HLT

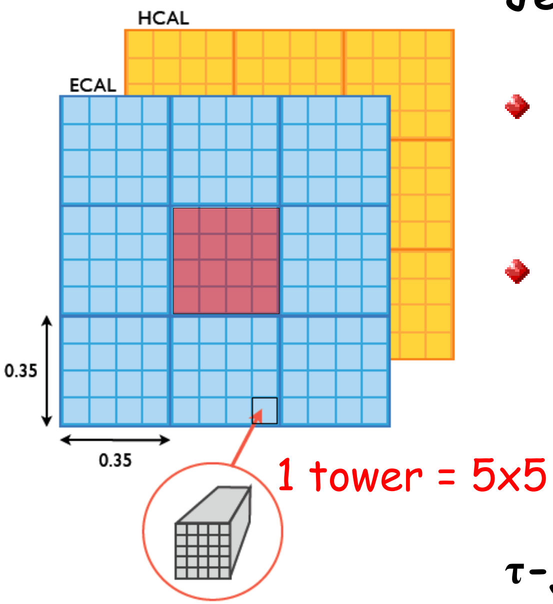




The efficiency of electon trigger paths in 2010 data reaches 100% within errors

Jets, τ-jets, E_T^{miss} trigger objects

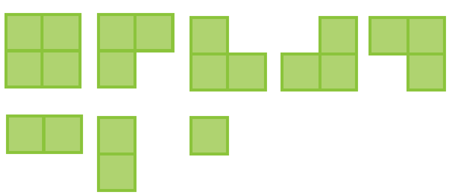
L1 jets



Jets |η| < 5

- 12x12 trigger tower E_T sums in 4x4 region steps
- Central $E_{T\ sum}$(4x4) > others

τ-jets |η| < 3



- Redefined jets if energy matches a tau-pattern denoting a narrow jet

HLT jets

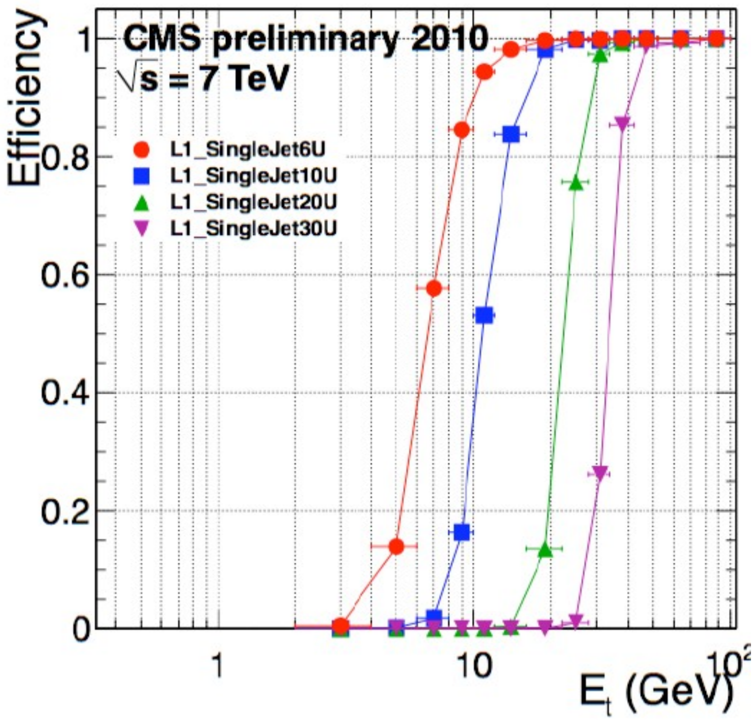
- Recalculated energy and position using an iterative cone jet algorithm inside cone ΔR=0.5

HLT E_T^{miss}

- Algebraic sum of all calorimeters objects and muons

Jet trigger performance

L1 jets



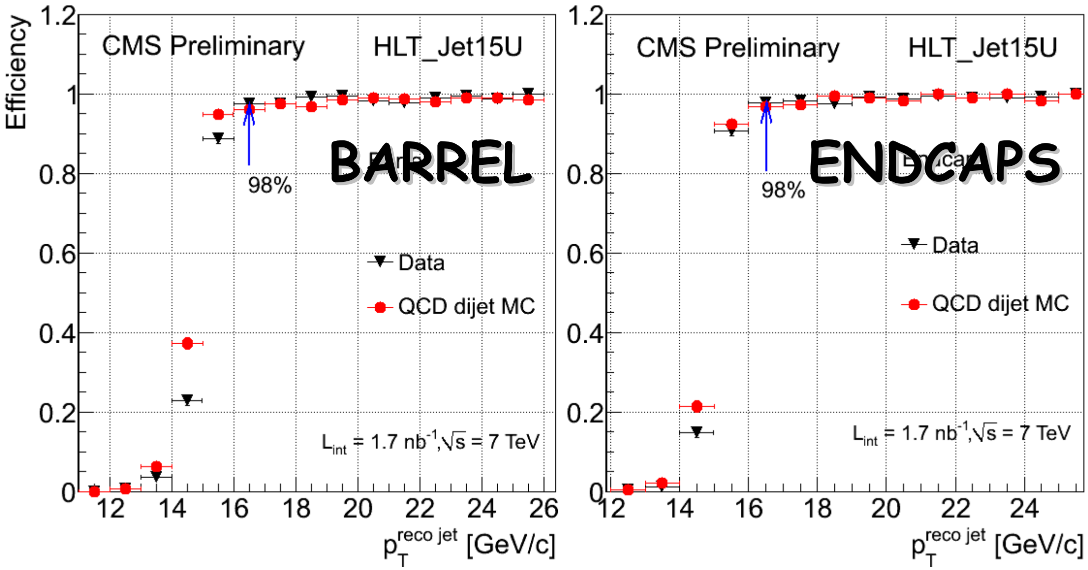
L1 jet efficiency vs offline jet E_t

- Minimum bias events
- Leading offline jet matched to a L1 jet with dR < 0.5
- Offline jet cuts (loose jet Id, ET>10 GeV, |η|<2.6)

HLT jets

HLT jet efficiency to pass HLT

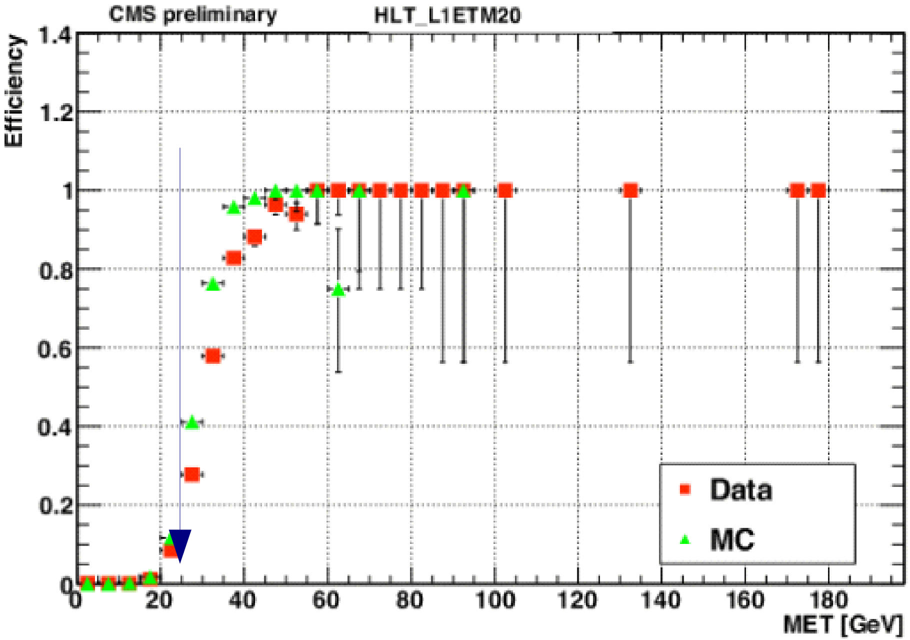
- Compared to Monte Carlo
- Events passing L1 open muon triggers (unbiased)
- Eff for HLT jet matching offline: ΔR(HLT-jet, offline jets) < 0.1



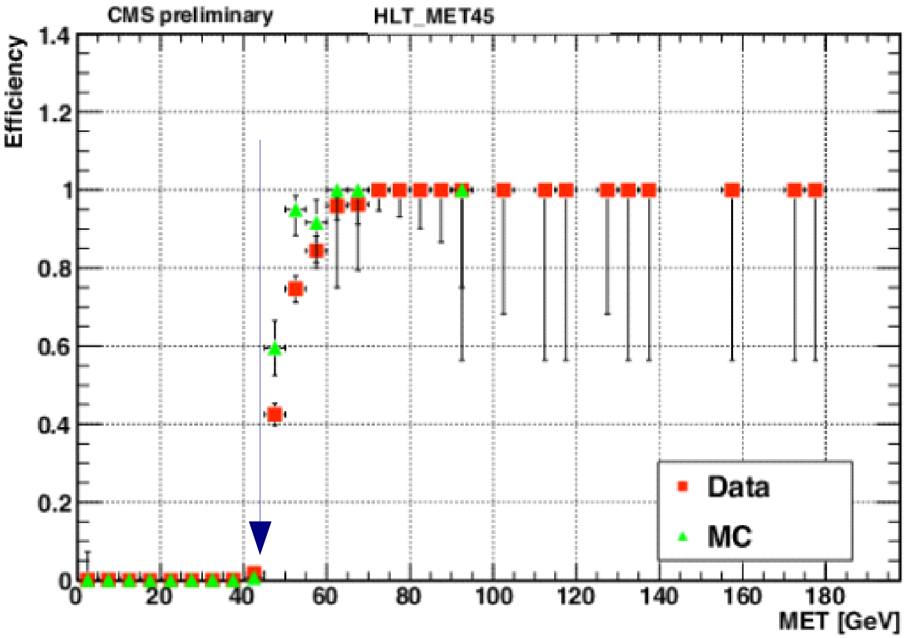
E_T^{miss} trigger performance

- Efficiencies for offline Et^{miss} (MET) object from the calorimeter system to pass HLT trigger
- Good agreement data and MC

HLT Et^{miss} > 20 GeV if it passes L1 JET > 6 GeV



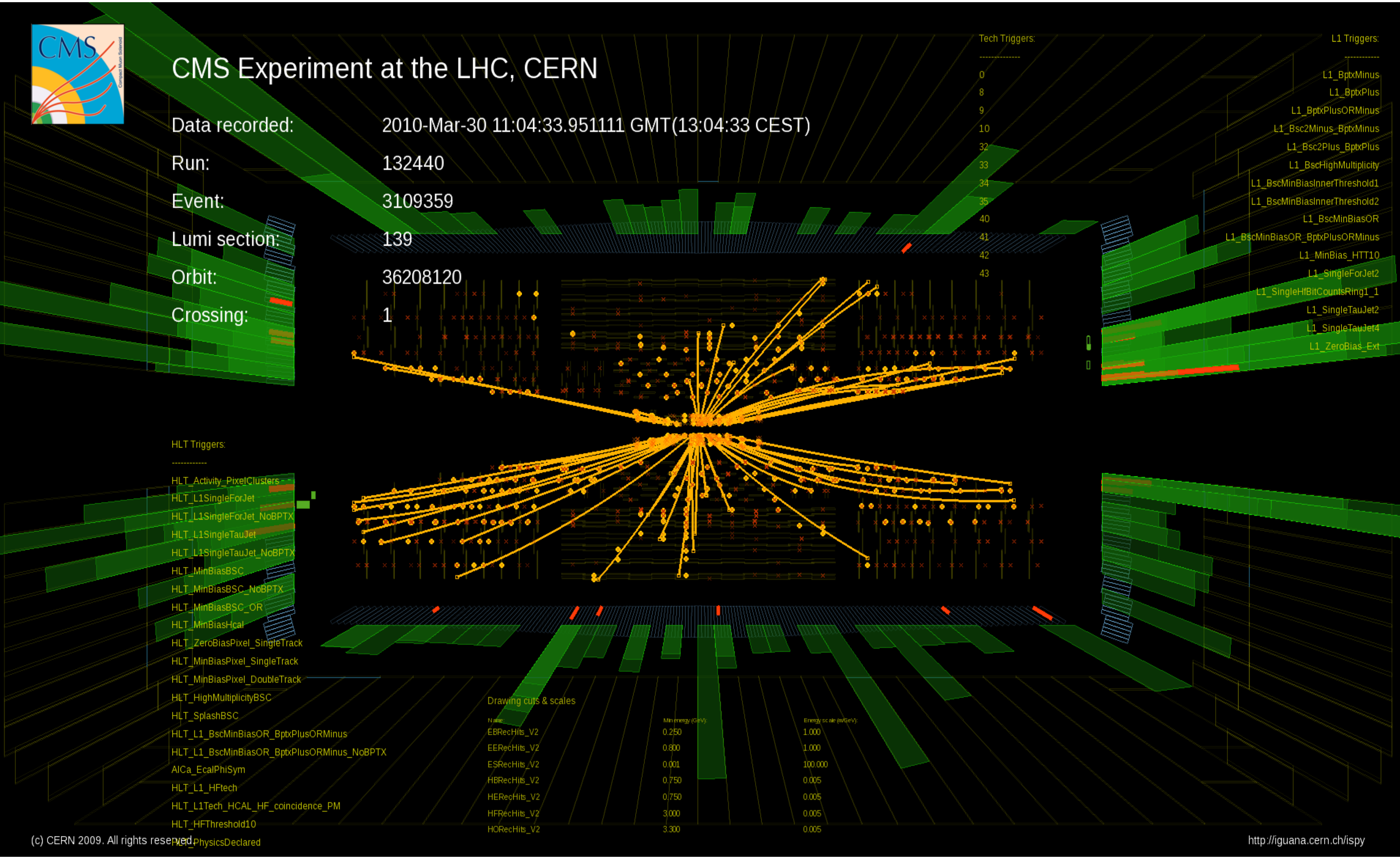
HLT Et^{miss} > 45 GeV if it passes L1 MET > 20 GeV



Dataset: ~11/nb

Monte Carlo: **QCD_Pt15**

Trigger applications



Minimum Bias triggers

The LHC initial phase with luminosities: (10^{28} - 10^{31}) $cm^{-2}s^{-1}$
gave opportunity to study **soft physics** properties
(without pileup) with the Minimum Bias triggers

Used (e.g.) to study charged-particle multiplicity in pp collisions
Phys. Rev. Lett. 105, 022002 (2010)

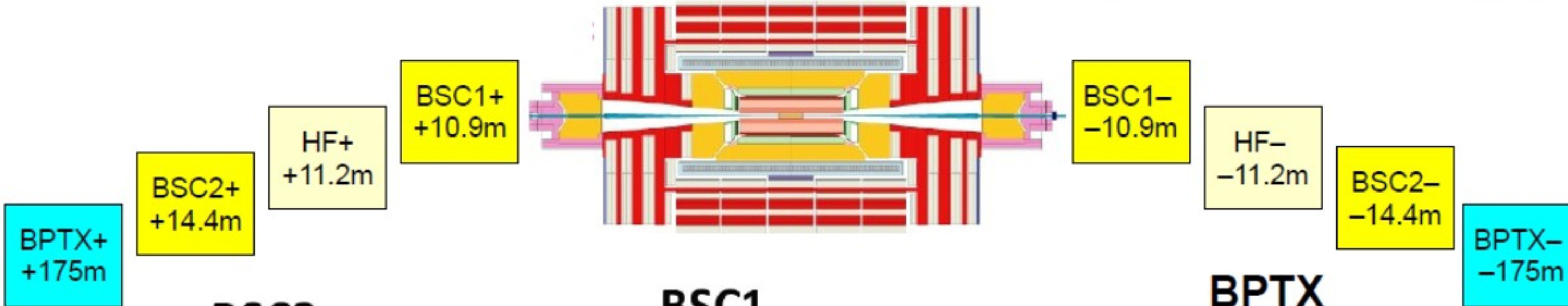
Minimum Bias trigger accept if:

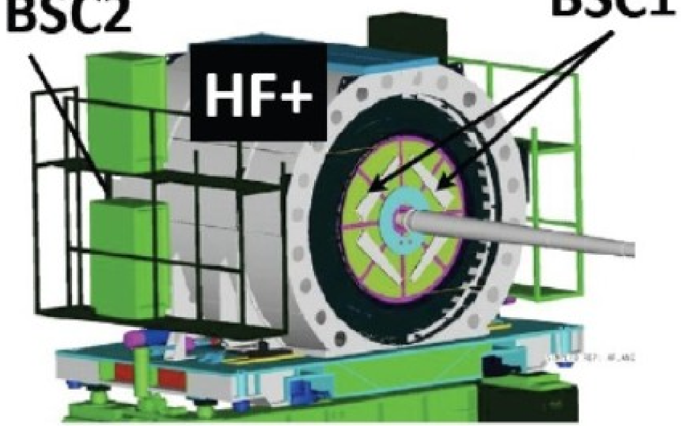
- **Any hit** in the beam scintillator counters (BSC) and
- **Filled bunch** passing the beam pickups (BPTX)

Offline event selection:

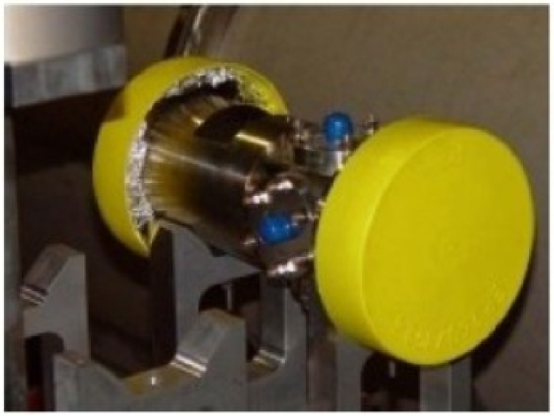
- More than 3 GeV energy deposits in both sides of the HF
- Rejection of the beam halo using BSC timing

Minimum Bias trigger detectors





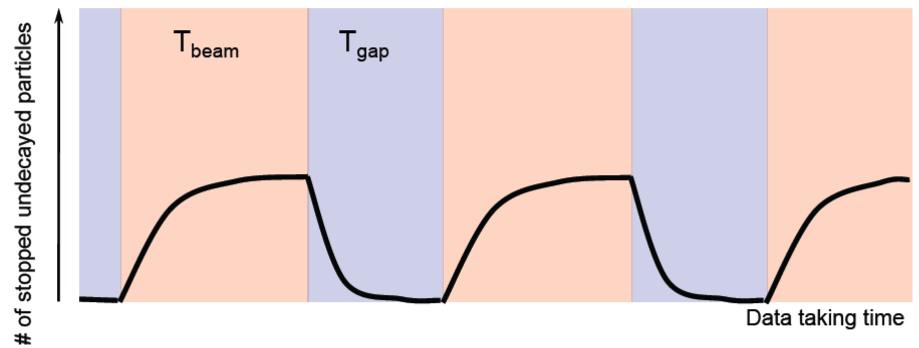
BPTX



- **HF** – Hadron Forward Calorimeter
- **BSC** – Beam Scintillator Counters (hit and coincidence rate, MIP detection eff >96%)
- **BPTX** – Beam Pick-up Timing for the eXperiments monitors (precise info about bunch structure and timing of the incoming beam, res. 0.2 ns)

Dedicated trigger of bunch gaps

- We search for the **decays of stopped (in the material of the detector) particles** during quiescent periods of LHC **when there are no collisions**



Benchmark model: Split-SUSY predicts quasi-stable **gluinos (R-hadrons)**

Decay **gluino → gluon + neutralino** is suppressed due to heavy squark masses

(R-hadron → jet + X after seconds, minutes, hours, days.....)

- R-hadron decay is sufficiently jet-like
  → **HCAL jet trigger** applied
- This trigger is active when there are BX without proton bunches
  → **BPTX veto** used

Special trigger implementation

- L1: **L1_SingleJet10U_NotBptxC**
  - Calorimeter jet trigger to trigger on stopped particle decays in HCAL
    - **L1 jet with ET > 10 GeV and |η| < 3.0**
  - Beam pick up system (BPTX) during periods of no pp collisions
    - **Veto on BPTX coincidence**
  - **Rate ~ 90 Hz**
- HLT: **HLT_StoppedHSCP_8E29**
  - Basic **HCAL noise rejection**:
    - Reject if a single HPD has E_T>10 and its two neighbours have E_T<1 GeV
    - Reject if there is an readout-box (4HPDs) with $E(HPD_{max})$ > 50 GeV and $E(HPD_{min})$ > 20% of $E(HPD_{max})$

Scintillation light is detected by the hybrid photodiode (HPD)

  - Reconstruct jets from HCAL towers
    - **HLT jet with E > 20 GeV and |η| < 3.0**
  - **Rate ~ 3.3 Hz**

Background rejection

- Beam background sources removed by:
  - BPTX veto (reject pp collisions)
  - BX number veto (reject events in ±2,±1 BX wrt BX in which collision occurred)
  - Halo veto (reject beam-halo muon events)
  - Vertex veto (reject events with one or more reconstructed primary vertices; removes out-of-time pp collision events due to satellite bunches)
- Cosmics removed by:
  - Veto events containing reconstructed muons
  - Cuts optimized on cosmic data from 2008; confirmed with 2009 cosmic data, 2009/10 collision data
- Instrumental noise removed by restrict jets requirements:
  - $E_T > 50$ GeV (to suppress noise fluctuations and energetic deposits from cosmic rays)
  - $|\eta| < 1.3$ and 60% of jet energy contained in ≤ 6 HCAL towers for the leading jet

Counting experiment

- The search looks for evidence of long-lived particles produced in 7 TeV pp collisions with L = 10/pb
  - Peak instantaneous luminosity = **10^{32}cm^{-2}s^{-1}**
  - Search interval corresponds to 62h of the LHC operation
- Observed counts in search samples compatible with background expectation

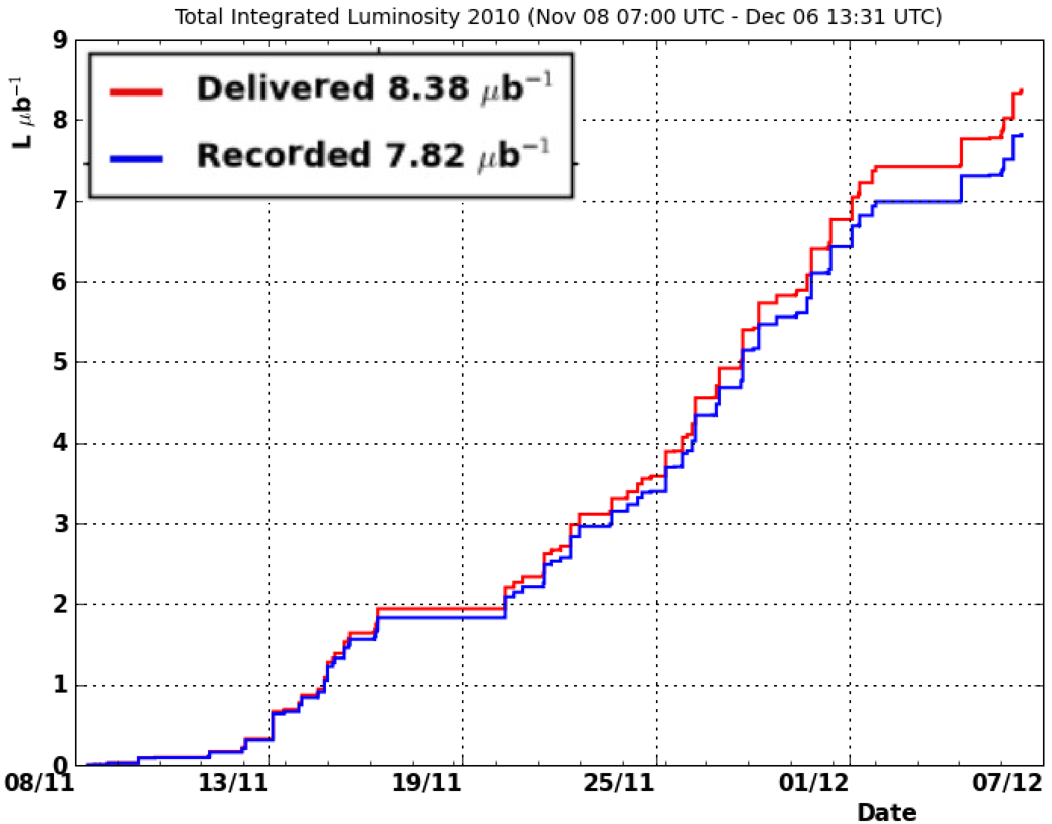
Lifetime [s]	Expected Background ($\pm$ stat. $\pm$ syst.)	Observed
1×10^{-7}	$0.8 \pm 0.2 \pm 0.2$	2
1×10^{-6}	$1.9 \pm 0.4 \pm 0.5$	3
1×10^{-5}	$4.9 \pm 1.0 \pm 1.3$	5
1×10^{6}	$4.9 \pm 1.0 \pm 1.3$	5

- No significant excess above background
- Set limits (95% CL) on gluino-pair production over 13 orders of magnitude of gluino lifetime
- Exluded gluinos with **mass < 370 GeV/c2 for lifetimes 10μs-1000s** assuming:
  - Mass difference of gluino and the lightest neutralino > 100 GeV
  - BR (gluino → g + neutralino) = 100%

More details tomorrow in the talk of P. Zalewski

LHC Heavy Ion mode

- Pb-Pb collisions in 2010 at $\sqrt{s_{NN}} = 2.76$ TeV
- Collected **~8/µb**
- Overall data recording efficiency 93%
- HLT output rates: ~200 Hz (PbPb)
- Average time to Reco Heavy Ion event: 11 s



Number of bunches: 137 per beam
Peak luminosity: 3×10^{25} cm^{-2}s^{-1}
Bunch spacing: 75 ns and 50 ns

HI trigger conditions

For Pb-Pb collisions the special minimum bias trigger was used:

- **L1_HcalHfCoincPmORBscMinBiasThresh1_BptxAND**
  - At least 1 BSC segment fired on each side
  - OR at least one HF tower on each side above the firmware threshold
  - Protected by BPTX (collision bunch crossings only)

- **HLT_MinBiasHfOrBSC** (pass-through of L1 seed)
  - greater than 97% acceptance for hadronic inelastic collisions

- Special run without B field

Used (e.g.) to study Pb-Pb jet quenching in Pb-Pb collisions
Draft CMS NOTE HIN-10-004

Summary

- **CMS Trigger worked well and delivered a good quality data for analysis**
- All **L1 triggers** were enabled in collisions runs
- L1 trigger synchronization was in a very good shape
- Trigger efficiency agreed at the expected level with MC simulations
- **Performances sharp turn-on curves in a good agreement with simulation**
- HLT CPU timing and rates understood

- Trigger menus successfully accommodated increase of the LHC luminosity

→ **Trigger is well prepared for running in 2011 with expected 1/fb (or 5/fb)**

References

- CMS L1 Trigger Control System **CMS NOTE 2002/033**
- The CMS High Level Trigger **EPJ Nov. 2005 0512077**
- Performance of muon identification in pp collisions at sqrt(s) = 7 TeV
  CMS PAS MUO-10-002
- Electromagnetic calorimeter commissioning and first result with 7 TeV data
  CMS-NOTE-2010-012
- Search for Stopped Gluinos in pp collisions at sqrt(s) = 7 TeV
  CMS-EXO-10-003

Trigger Menu 2E32

Physics Runs 149442 containing a particular trigger and prescale

TriggerName	Prescale	EffectiveLumi nb^{-1}
L1Tech_BPTX_plus_AND_minus_instance1.v0	40009	0.010707779805940138
L1Tech_BPTX_plus_OR_minus.v0	40009	0.010707779805940138
L1Tech_BSC_HighMultiplicity.v0	200	2.142037811279295
L1Tech_BSC_minBias_threshold1.v0	26203	0.016349561586683166
L1Tech_HCAL_HBHE_totalOR.v0	1	428.407562255859
L1Tech_RPC_TTU_RBst1_collisions.v0	4800	0.08925157546997062
L1Tech_RPC_TTU_pointing_Cosmics.v0	1	428.407562255859
L1_BptxMinus_NotBptxPlus	40009	0.010707779805940138
L1_BptxPlus_NotBptxMinus	40009	0.010707779805940138
L1_BptxXOR_BscMinBiasOR	48000	0.008925157546997062
L1_BscMinBiasOR_BptxPlusANDMinus	4800	0.08925157546997062
L1_DoubleEG2	216	1.9833683437771248
L1_DoubleEG5	1	428.407562255859
L1_DoubleForJet10U_EtaOpp	1	428.407562255859
L1_DoubleJet30U	1	428.407562255859
L1_DoubleMu3	1	428.407562255859
L1_DoubleMuOpen	1	428.407562255859
L1_DoubleMuTopBottom	1	428.407562255859
L1_DoubleTauJet14U	1	428.407562255859
L1_ETM20	1	428.407562255859
L1_ETM30	1	428.407562255859
L1_ETM70	1	428.407562255859
L1_ETT100	72	5.950105031331375
L1_ETT140	10	42.8407562255859
L1_ETT60	600	0.7140126037597649
L1_HTM30	100	4.28407562255859
L1_HTT100	1	428.407562255859
L1_HTT200	1	428.407562255859
L1_HTT50	1	428.407562255859
L1_Mu3_EG5	1	428.407562255859
L1_Mu3_Jet10U	1	428.407562255859
L1_Mu3_Jet6U	1	428.407562255859
L1_Mu5_Jet6U	1	428.407562255859
L1_QuadJet8U	1	428.407562255859
L1_SingleEG10	1	428.407562255859
L1_SingleEG12	1	428.407562255859
L1_SingleEG15	1	428.407562255859
L1_SingleEG2	960	0.4462578773498531
L1_SingleEG20	1	428.407562255859
L1_SingleEG5	96	4.462578773498531
L1_SingleEG8	1	428.407562255859
L1_SingleIsoEG10	1	428.407562255859
L1_SingleIsoEG12	1	428.407562255859
L1_SingleIsoEG15	1	428.407562255859
L1_SingleIsoEG5	96	4.462578773498531
L1_SingleIsoEG8	1	428.407562255859
L1_SingleJet10U	96	4.462578773498531
L1_SingleJet10U_NotBptxOR	1	428.407562255859
L1_SingleJet20U	1	428.407562255859
L1_SingleJet30U	1	428.407562255859
L1_SingleJet40U	1	428.407562255859
L1_SingleJet50U	1	428.407562255859
L1_SingleJet60U	1	428.407562255859
L1_SingleJet6U	1200	0.35700630187988247
L1_SingleMu0	1	428.407562255859
L1_SingleMu10	1	428.407562255859
L1_SingleMu14	1	428.407562255859
L1_SingleMu20	1	428.407562255859
L1_SingleMu3	1	428.407562255859
L1_SingleMu5	1	428.407562255859
L1_SingleMu7	1	428.407562255859
L1_SingleMuOpen	200	2.142037811279295
L1_SingleTauJet10U	96	4.462578773498531
L1_SingleTauJet20U	1	428.407562255859
L1_SingleTauJet30U	1	428.407562255859
L1_SingleTauJet50U	1	428.407562255859
L1_TripleJet14U	1	428.407562255859
AlCa_EcalEta	6	71.40126037597649
AlCa_EcalPhiSym	7	61.20108032226557
AlCa_EcalPi0	8	53.55094528198237
AlCa_RPCMuonNoHits	10	42.8407562255859
AlCa_RPCMuonNoTriggers	10	42.8407562255859
AlCa_RPCMuonNormalisation	10	42.8407562255859
DQM_FEDIntegrity_v2	100	4.28407562255859
HLTDQMResultsOutput	10	42.8407562255859
HLTMONOutput	40	10.710189056396475
HLT_Activity_CSC	15	28.5605041503906
HLT_Activity_Ecal_SC17	35	12.240216064453113
HLT_Activity_Ecal_SC7	700	0.6120108032226557
HLT_BTagMu_DiJet10U_v3	60	7.14012603759765
HLT_BTagMu_DiJet20U_Mu5_v3	5	85.6815124511718
HLT_BTagMu_DiJet20U_v3	20	21.42037811279295
HLT_BTagMu_DiJet30U_v3	3	142.80252075195298
HLT_DiJet20U_Meff180U_v3	1000000	4.284075622558896E-4
HLT_DiJetAve100U_v3	5	85.6815124511718
HLT_DiJetAve15U_v3	10	42.8407562255859

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Physics Run: 149442 containing a particular trigger and prescale

HLT_DiJetAve30U_v3	900	0.47600840250651
HLT_DiJetAve50U_v3	120	3.570063018798825
HLT_DiJetAve70U_v3	45	9.520168050130199
HLT_DoubleEle5_SW_Upsilon_L1R_v2	6	71.40126037597649
HLT_DoubleIsoTau15_OneLeg_Trk5_v4	8	53.55094528198237
HLT_DoubleJet15U_ForwardBackward_v3	40	10.710189056396475
HLT_DoubleJet25U_ForwardBackward_v3	4	107.10189056396474
HLT_DoubleMu0	120	3.570063018798825
HLT_Ele10_SW_L1R_v2	210	2.0400360107421855
HLT_Ele12_SW_TighterEleId_L1R_v2	25	17.13630249023436
HLT_Ele17_SW_Isol_L1R_v2	220	1.9473071011629954
HLT_Ele17_SW_L1R_v2	600	0.7140126037597649
HLT_Ele22_SW_L1R_v2	260	1.6477213932917654
HLT_ExclDiJet30U_HFOR_v3	10	42.8407562255859
HLT_GlobalRunHPDNoise	3000	0.142802520751953
HLT_HT100U_v3	80	5.355094528198237
HLT_HT130U_v3	5	85.6815124511718
HLT_HT50U_v3	10	42.8407562255859
HLT_HcalPhiSym	2	214.2037811279295
HLT_IsoMu11_v4	10	42.8407562255859
HLT_IsoMu9_v4	15	28.5605041503906
HLT_Jet100U_v3	10	42.8407562255859
HLT_Jet15U_HcalNoiseFiltered_v3	20	21.42037811279295
HLT_Jet15U_v3	20	21.42037811279295
HLT_Jet30U_v3	1800	0.238004201253255
HLT_Jet50U_v3	240	1.7850315093994125
HLT_Jet70U_v3	45	9.520168050130199
HLT_L1DoubleMuOpen	1200	0.35700630187988247
HLT_L1ETT100	800	0.5355094528198238
HLT_L1Jet10U	450	0.95201680501302
HLT_L1Jet6U	100	4.28407562255859
HLT_L1MET20	1800	0.238004201253255
HLT_L1Mu20	400	1.0710189056396475
HLT_L1Mu7_v1	1200	0.35700630187988247
HLT_L1MuOpen_AntiBPTX_v2	15	28.5605041503906
HLT_L1MuOpen_DT_v2	14	30.600540161132784
HLT_L1MuOpen_v2	140	3.0600540161132783
HLT_L1SingleEG8	11000	0.038946142023259904
HLT_L1Tech_BSC_HighMultiplicity	300	1.4280252075195299
HLT_L1Tech_BSC_halo	5	85.6815124511718
HLT_L1Tech_BSC_halo_forPhysicsBackground	5	85.6815124511718
HLT_L1Tech_BSC_minBias	5	85.6815124511718
HLT_L1Tech_BSC_minBias_OR	5	85.6815124511718
HLT_L1Tech_HCAL_HF	5	85.6815124511718
HLT_L1Tech_RPC_TTU_RBst1_collisions	12	35.700630187988246
HLT_L1_BPTX	100	4.28407562255859

HLT_L1_BPTX_MinusOnly	10	42.8407562255859
HLT_L1_BPTX_PlusOnly	10	42.8407562255859
HLT_L1_BptxXOR_BscMinBiasOR	5	85.6815124511718
HLT_L2DoubleMu0	140	3.0600540161132783
HLT_L2Mu0_NoVertex	20000	0.021420378112792 95
HLT_L2Mu30_v1	30	14.2802520751953
HLT_L2Mu7_v1	240	1.7850315093994125
HLT_MET45_v3	60	7.14012603759765
HLT_MinBiasPixel_SingleTrack	1000000	4.2840756225585896E-4
HLT_Mu0_v2	8000	0.05355094528198237
HLT_Mu11	20	21.42037811279295
HLT_Mu13_v1	10	42.8407562255859
HLT_Mu3_Track3_Jpsi_v3	40	10.710189056396475
HLT_Mu3_Track5_Jpsi_v3	4	107.10189056396474
HLT_Mu3_v2	1800	0.238004201253255
HLT_Mu5	600	0.7140126037597649
HLT_Mu5_L2Mu0	30	14.2802520751953
HLT_Mu5_Track0_Jpsi_v2	80	5.355094528198237
HLT_Mu7	120	3.570063018798825
HLT_Mu9	30	14.2802520751953
HLT_MultiVertex6_v2	1000	0.42840756225585896
HLT_MultiVertex8_L1ETT60_v2	3000	0.142802520751953
HLT_Photon10_Cleaned_L1R	100	4.28407562255859
HLT_Photon20_Cleaned_L1R	400	1.0710189056396475
HLT_Photon20_Isol_Cleaned_L1R_v1	440	0.9736535505814977
HLT_Photon20_NoHE_L1R	1240	0.3454899695611766
HLT_Photon30_Cleaned_L1R	90	4.760084025065099
HLT_Photon50_Cleaned_L1R_v1	15	28.5605041503906
HLT_Photon50_NoHE_L1R	200	2.142037811279295
HLT_PixelTracks_Multiplicity100	1000000	4.2840756225585896E-4
HLT_PixelTracks_Multiplicity70	1000000	4.2840756225585896E-4
HLT_PixelTracks_Multiplicity85	1000000	4.2840756225585896E-4
HLT_QuadJet15U_v3	40	10.710189056396475
HLT_QuadJet20U_v3	10	42.8407562255859
HLT_R010U_MR50U	1000	0.42840756225585896
HLT_R030U_MR100U	1000000	4.2840756225585896E-4
HLT_R033U_MR100U	1000000	4.2840756225585896E-4
HLT_RP025U_MR70U	1000000	4.2840756225585896E-4
HLT_RPCBarrelCosmics	500	0.8568151245117179
HLT_Random	600	0.7140126037597649
HLT_ZeroBias	5	85.6815124511718
HLT_ZeroBiasPixel_SingleTrack	1000000	4.2840756225585896E-4
NanoDSTOutput	10	42.8407562255859