

L1 Performance

Plans for 2017 commissioning

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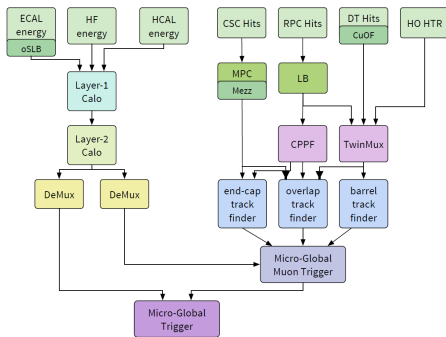
Tuesday 24th January 2017

CMS Run & DPG Commissioning Workshop

L1 Trigger in 2016

L1 Trigger in 2016

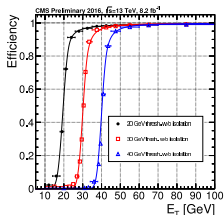
- Brand-new L1 trigger system – hardware, software, databases – for challenging conditions: increased luminosity, centre-of-mass energy, pileup
- Muon system: data are fed from muon detector systems to regional track finders for high resolution muon trigger
- Calorimeter system: data from single event are processed with one FPGA
- Global trigger: extendable for more conditions and more sophisticated quantities by adding resources
- Flexible and maintainable system for evolving CMS physics programme



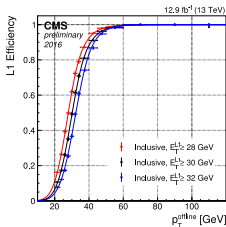
L1 Trigger performance in 2016

Calorimeter system: $e\gamma$, τ , jet, missing- E_T

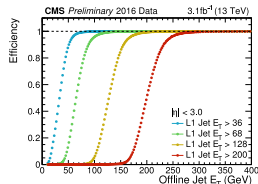
EG20,30,40



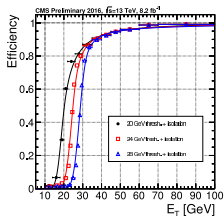
Tau28,30,32



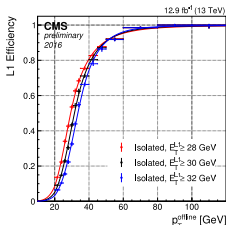
Central Jet36,68,128,200



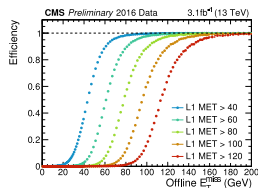
IsoEG20,24,28



IsoTau28,30,32



MET40,60,80,100,120

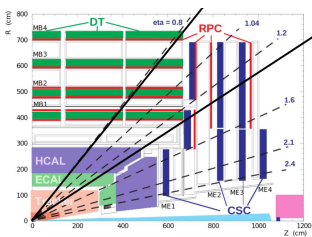


- Calorimeter trigger uses pileup mitigation

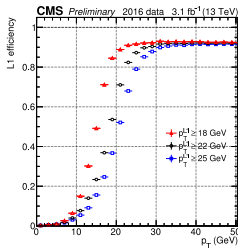
L1 Trigger performance in 2016

Muon system

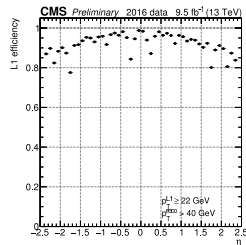
- Three muon track finders for different η regions
 - Barrel: $|\eta| < 0.83$
 - Overlap: $0.83 < |\eta| < 1.24$
 - Endcap: $1.24 < |\eta|$
- Global muon trigger receives muon tracks from regional finders, sorts by p_T /quality and cancels duplicates



MU18, 22, 25



MU22

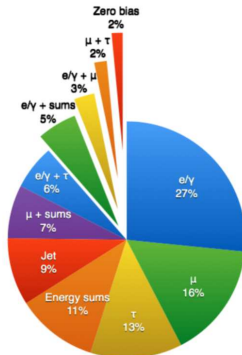


L1 Trigger in 2016

menu

- Thirteen revisions of pp L1 Menu in 2016
 - Started with 201 algorithms, ended with 267
 - Many threshold updates for increasing luminosity and calibration change
 - New MinBias HF triggers in v3 menu
 - Test introduction of new invariant mass triggers in v8 menu
- Three revisions of pPb L1 Menu in 2016
 - New Calorimeter Tower counting algorithm
 - Started with 171 algorithms, ended with 206
- Proved flexibility of the system – communication with TSG important
- Online DQM covering all the subsystems, starting from scratch
 - plots with emulation in most of the subsystems for comparison

Trigger bandwidth allocation



- e/γ : 27%
- μ : 16%
- τ : 13%
- energy sums : 11%
- jet : 9%

Preparation for 2017

L1 Trigger in 2017

- Possible operation scenarios in 2017 (at the last Trigger workshop)

luminosity [$10^{34} \text{ cm}^{-2} \text{ s}^{-1}$]	pileup	comment
1.4 and/or 1.6	41-46	low luminosity
1.7 or 1.8	49-52	main target
1.9 or 2.0	55-58	ultimate luminosity
2.2	64	emergency setting

- Need to exploit the flexibility of the system further
 - Improve single object triggers
 - revisit parameters and working points for isolation, better calibration etc.
 - Use of cross triggers to mitigate higher thresholds of single object trigger
 - Use of new algorithms
- Initial L1 trigger menu to be delivered by May
 - Introduce new features by mid March
 - Implementation of new algorithms by end of April

L1 Trigger in 2017

- Provisional thresholds for main triggers

Seed	1.8×10^{34}	2.0×10^{34}	2.2×10^{34}
SingleEG	38	40	42
SingleEG $ \eta < 2.1$	36	38	–
SingleIsoEG $ \eta < 2.1$	34	36	–
DoubleEG	25, 12	25, 12	–
SingleMu	22	22	–
SingleMu $ \eta < 2.1$	22	22	–
DoubleIsoTau $ \eta < 2.1$	30	33	34
Total- H_T	320	360	380
Missing- E_T	105	115	120
SingleJet	180	180	–
DoubleJet $ \eta < 3.0$	112	112	–
QuadJet $ \eta < 3.0$	50	50	–

- Thresholds will be quite high for 2.2×10^{34} scenario
- Need help from PAGs to develop cross-trigger and use of new algorithms
 - Invariant mass
 - missing- E_T with HF
 - total- E_T with ECAL only

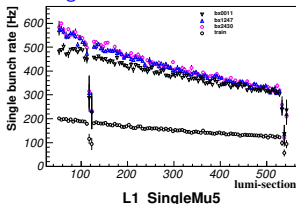
L1 rates in high-pileup run

luminosity of isolated bunches

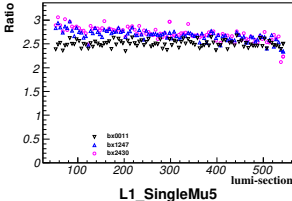
- Fill 5412 – 3 isolated bunches with very high-pileup, 2 x 48 bunch trains
- Assume muon rates linearly scale with luminosity
- Use ratio of muon trigger rates of isolated bunches to trains for estimating pileup of isolated bunches
- Pileup of train by “pccLUM15001”

ref: isolated bunch fill 5385

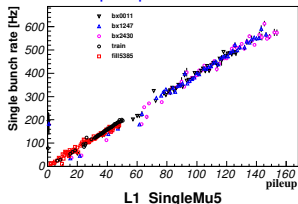
Single bunch rate vs lumi-section



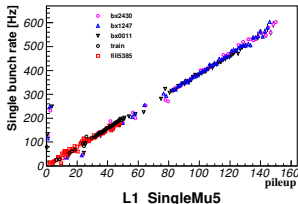
Ratio of isolated bunch to train rates



Scaled pileup of train with ratios

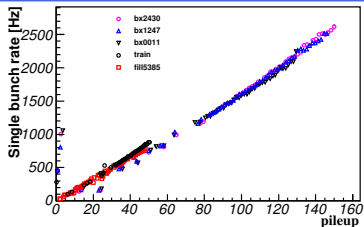


- Compare with pileup by BX luminosity
- Similar pileup dependence with less spreads
- pccLUM15001 used in the following plots

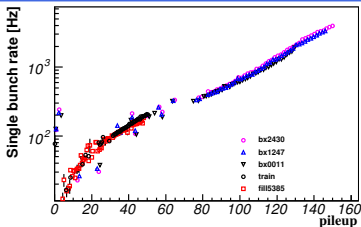


L1 rates in high-pileup run

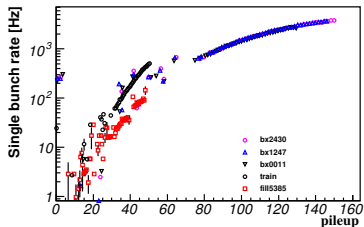
calorimeter triggers



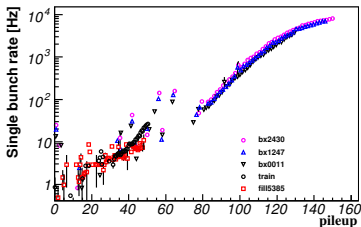
L1_SingleEG10



L1_SingleJet60



L1_ETM60



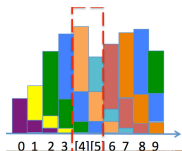
L1_HTT240

- Pileup dependence of rates for calorimeter triggers
- Clear OOT pileup effects in energy sum triggers

L1 rates in high-pileup run

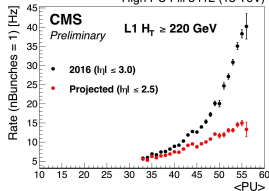
Cartoon of HB/HE signal shape

in 25 ns train

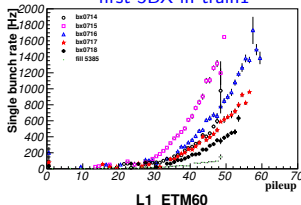


η restricted HTT

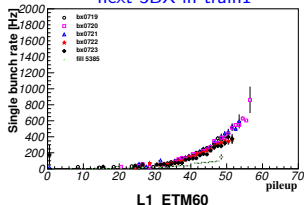
High PU Fill 5412 (13 TeV)



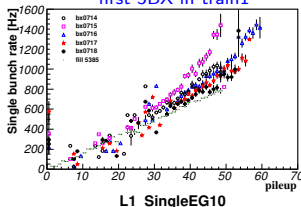
first 5BX in train1



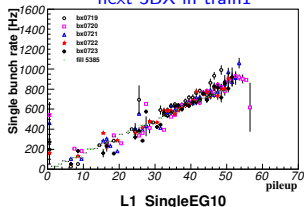
next 5BX in train1



first 5BX in train1



next 5BX in train1



- Naively expects some dependence on relative position of BX in train
- First bunches in a train show higher rates – sizable effects in energy sum triggers
- High-pileup run study ongoing and being used for L1 menu preparation in 2017

Ongoing trigger object improvements in 2017

- $e\gamma$
 - ECAL TP – optimisation of spike killing algorithm
 - Optimisation of isolation criteria¹, shape veto, calibration, etc.
 - H/E as a function of E_T/η
- μ
 - New p_T assignment algorithms in BMTF and EMTF
 - Algorithm improvement in OMTF
 - ϕ at IP by uGMT
- τ
 - Optimisation of isolation criteria¹
 - Introduction of shape veto
- Energy sums
 - Missing- E_T with pileup subtraction, better calibration
- jet
 - jet seed threshold optimisation, better calibration

- Data Tier for L1 Trigger Study
 - μ : Zmu skim - RECO (shared with Muon POG)
 - e/γ : ZElectron RAW-RECO
 - τ : MuTau skim - RECO (shared with TAU POG)
 - Working on
 - (Parked) ZeroBias RAW with only trigger FEDs
 - SingleMuon skim for Missing- E_T
- DQM: Use physics objects for turn-on curves etc.
 - Online
 - Automatic check for warnings and errors - possibly with sound alarms
 - Complete comparison with emulation
 - Offline
 - Make it available to shifter for offline certification
 - RelVal
 - Development ongoing, possible deployment in end February or soon after

- DOCs
 - DOC2 – monitoring of rates as a function of PU and performance with Online DQM then filling the prompt certification within 24h using express streams
 - DOC3 – monitoring of performances with offline DQM then fill the run registry for the final certification, also performs release validation with RelVal DQM
- Offline software
 - All L1 offline development available by the end of 2016 (l1t-integration-v89.20) has been merged in CMSSW_9_0_X
 - New development branch available – l1t-integration-CMSSW_9_0_0_pre2
 - Validating L1T emulation from DB payloads
 - New algorithm developments will be merged in CMSSW_9_0_X in timely manner

- Up to date development status in 2017 is available at;
 - Trello - <https://trello.com/b/d47BysEC/timeline-for-2017>
- L1 DPG requests/issues are tracked at;
 - JIRA - <https://its.cern.ch/jira/projects/CMSLITDPG/summary>
 - L1 menu requests
 - L1 menu deployment
 - L1 object performance improvement
 - L1 object performance issues
 - New algorithm development

- Will exploit flexibility of the system to cope with higher luminosity expected in 2017
- Try to keep thresholds low for CMS physics programme
- Need help from POGs and PAGs to develop level-1 menu
- Will detect possible problems early with improved DQM

