



Introduction to HLT-Top Tutorial

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If after Tutorial you have questions, please do not hesitate to send them on: hn-cms-top-trigger (alias for CMS Top Trigger Studies) (low rate of emails)







- What is trigger system in CMS?
- What are the HLT constraints?
- Tutorial Phase:
 - What is an HLT menu/path?
 - How to run an HLT menu?
 - Which menu should I run?
- What should be done for a path integration?

Trigger System



- L1: hardware, firmware^{40 MHz} Quick readout of specific detectors (no tracker, no [yet] Muon iso)¹⁰
- L1 Latency: 3.2 μs

ipn

• HLT: High Level Trigger: software based (~10k CPUs) look at full event content of L1 selected events



Mean time per event HLT:
150 ms (depending on CPU)

Consecutive decision, what ever is not passing L1, will not be seen by HLT







• L1:

- Mix of FPGAs and ASICs
- Many copper parallel links
- Internal bandwidth constraints e.g. jet finding
- Detectors designed to accommodate: 100 kHz maximum L1 rate max latency 4 µ s



→ Very first decision step, need to have it correct!
 → L1 group is looking for (wo)manpower (→ ESP reward)
 → So far studies based on 2012 L1 Menu









- Decision of recording or not an event based on full event information.
- What is seen by HLT is RAW format of event:
- Various electronic signal coming from each subdetector
- $\rightarrow\,$ In order to decide if the event is interesting or not, need to interpret electronic signal into particles
- → Unpacking
- → Reconstruction of the event
- Selection of the event based on reconstruction infos
- → Same principle than offline physics analysis based on the same objects!
- Nuance: Offline reconstruction can take as much time as needed (currently ~35s), Online reco + Decision (ie: HLT) should be over within 150ms (mean value)!
- \rightarrow Not possible to do exactly the same, a few approximations are performed to speed up!



HLT Constraints



- Input rate is limited to 100 kHz at L1 (not by L1 trigger), by the limitation of the readout of the detectors (including the S-links limitation which connect the detectors with the event building)

- The maximum output rate of HLT, which may matter for some test run, is limited by the write speed, and the limit is few kHz at the nominal event size (and depends both on the event size and rate)

- The limit during nominal data taking comes from the downstream computing resources, and it is much smaller than the technical limit. So this limit is not a peak limit (events/s) but an average limit (events/day) which gets translated in events/s for convenience. Typically ~500Hz as reco time is ~35 s per events.

If event is not recorded, offline it is impossible to know the event is not there \rightarrow Crucial to make good decision!



Summary of HLT constraints



HLT should reject most of the events to select only ~1kHz 1kHz should be split within PAGs

→ Developing a path = rate calculation (Zeynep's talk) HLT is taking crucial decision! New physics can be missed because no decision algorithm was designed to keep such events (by default HLT reject events)

→ Developing a path = validation/efficiency (Kelly/ Hugues' talk)

HLT should do as well as offline reconstruction with a factor 100 less time!

→ Developing a path = time calculation (Javier's talk) Impossible to correct HLT at posteriori! If JES at HLT or alignment is not correct, events are gone

→ Developing a path = DQM (Federico's talk)



HLT ≠ RECO



- Most of the difference between HLT and Reco are in tracking (where most of the time is spent)
- → Order of the module/sequence crucial: first run what is discriminant and not time consuming.
- → Crucial work from HLT POGs to ensure that all final objects are as close as possible to reco ones.
- \rightarrow PAGs work start from HLT object definition blessed by POG.
- Aim is NOT to build the exact same analysis at HLT (normally looser cuts), only to make sure to record most interesting events!
- Example: Looking for ttbar events, pointless to record ALL events containing W's. Events as W+3/4jets are enough.

Selection at HLT



Looking for ttbar events, pointless to record ALL events containing W's. Events as W+3/4jets are enough.

Selection should be "loose" enough to record all signal events and all events needed for background estimation (or prescale path) BUT tight enough to reduce the rate: All inclusive $W \rightarrow I \nu$ (lepton is isolated) cannot be recorded as the rate would be ~200Hz [at 13 TeV] (1/5 of the full CMS bandwidth... VBF physics as all hadronics final states or searches with MET or non-isolated lepton would not be happy...). In the meantime strategy to estimate background should change (inverting isolation will be difficult)

→ Need to share and to tighten a bit...

→ Need to define a STRATEGY (within one PAG and over).



Scope of the Day



11

- Provide information on what is HLT
- How do I implement a HLT path?
- What are the criteria to get a HLT path integrated in a menu?
- → In order to go through the questions, we will work on a path: Isolated lepton + 1 B-jet (electron OR muon)
 → Got you familiarized with lepton at HLT, jets at HLT and B-tagging at HLT [3 major objects you will need to develop a "Top-path"]
- What we will not touch today:
- Full code for offline efficiency
- Efficiency value for 2012 paths etc
- Strategy for 2015 data taking (we give you the tools, you will have to do the thinking)







How do I rerun a HLT menu?

- Where do I find the infos?
- Which menu do I want to run?
- On which data should I run?

Major pages (for this part):

TSG: https://twiki.cern.ch/twiki/bin/viewauth/CMS/TriggerStudies How to run the latest menu: https://twiki.cern.ch/twiki/bin/view/CMSPublic/SWGuideGlobalHLT ConfDB Browser: http://j2eeps.cern.ch/cms-project-confdb-hltdev/browser/ HltGetConfiguration: https://twiki.cern.ch/twiki/bin/view/CMSPublic/SWGuideHltGetConfiguration? redirectedfrom=CMS.SWGuideHltGetConfiguration HLT Development hypernews: https://hypernews.cern.ch/HyperNews/CMS/get/hlt.html



What is a Menu?



Group of HLT paths + Event Content + Streams + Primary Dataset etc A POG/PAG developer: you need to care ONLY about HLT paths.

What is a HLT path?

It is a Path which contains Sequence and Module (mainly filters): process.HLT_IsoMu17_eta2p1_TriCentralPFNoPUJet45_35_25_v1 = cms.Path(process.HLTBeginSequence + process.hltL1sMu14Eta2p1 + process.hltPreIsoMu17eta2p1TriCentralPFNoPUJet453525 + process.hltL1fL1sMu14Eta2p1L1Filtered0 + process.HLTL2muonrecoSequence + process.hltL2fL1sMu14Eta2p1L1f0L2Filtered14Q + process.HLTL3muonrecoSequence + process.hltL3fL1sMu14Eta2p1L1f0L2f16QL3Filtered17 + process.HLTL3muoncaloisorecoSequenceNoBools + process.HLTL3muonisorecoSequence + process.hltL3crIsoL1sMu14Eta2p1L1f0L2f16QL3f20L3crIsoRhoFiltered0p15 + process.HLTPFnoPUL1FastL2L3ReconstructionSequence + process.hltIsoMu172p1JetCollectionsForLeptonPlusPFJetsNoPU + process.hltIsoMu172p1TriCentralPFNoPUJet25MuCleaned + process.hltIsoMu172p1DiCentralPFNoPUJet35MuCleaned + process.hltIsoMu172p1CentralPFNoPUJet45MuCleaned + process.HLTEndSequence

Mainly, sequences are defining reconstruction of objects and are provided by POG contacts. PAG should mainly work on filters module¹³



What is a Path?



- http:///cnvssumcvs.cern.ch/cgi-bin/cmssw.cgi/CMSSW/HLTrigger/Configuration/python/HLT_GRun_cff.py?view=markup&pathrev=CMS
- HLT_IsoMu17_eta2p1_TriCentralPFNoPUJet45_35_25_v1
- \rightarrow Name of the path (convention: should contain the major selection as pt and eta cut)
- HLTBeginSequence, HLTEndSequence
- → Standard HLT sequence which define input and output of path, should ALWAYS be present in a path.
- hltL1sMu14Eta2p1 = cms.EDFilter("HLTLevel1GTSeed",
- → Typical filter on L1 seeds, need to modify the L1seed name saveTags = cms.bool(True),

\rightarrow Make sure that L1 object is saved in the event to be able to match reco object with it

L1SeedsLogicalExpression = cms.string("L1_SingleMu14er"),

\rightarrow Name of the L1 seeds you want to use for this path

- L1MuonCollectionTag = cms.InputTag("hltL1extraParticles"),
- L1UseL1TriggerObjectMaps = cms.bool(True),
- L1UseAliasesForSeeding = cms.bool(True),
- L1GtReadoutRecordTag = cms.InputTag("hltGtDigis"),
- L1CollectionsTag = cms.InputTag("hltL1extraParticles"),
- L1NrBxInEvent = cms.int32(3),
- L1GtObjectMapTag = cms.InputTag("hltL1GtObjectMap"),
- L1TechTriggerSeeding = cms.bool(False)
- \rightarrow Normally you do not touch the other parameters...

What is a Path?



hltPreIsoMu17eta2p1TriCentralPFNoPUJet453525 = cms.EDFilter("HLTPrescaler", L1GtReadoutRecordTag = cms.InputTag("hltGtDigis"), offset = cms.uint32(0)

 \rightarrow This filter should ALWAYS be in a path right after the L1 selection: Allow the possibility to prescale a path: if rate of a path is too large but you cannot reduce it by selecting tighter than the way to do is to record only 1/N of the event. N is the prescale factor (un-prescale path is N=1). Prescale paths are used for efficiency calculation or background studies (side band...) HLTL2muonrecoSequence, process.HLTL3muonrecoSequence, HLTL3muoncaloisorecoSequenceNoBools, HLTL3muonisorecoSequence: \rightarrow Not going in the details: Standard sequences provided by HLT Muon POG (should be as identical as offline reco sequences) HLTPFnoPUL1FastL2L3ReconstructionSequence \rightarrow Not going in the details: Standard sequences provided by HLT JetMet POG hltL1fL1sMu14Eta2p1L1Filtered0, hltL2fL1sMu14Eta2p1L1f0L2Filtered14Q, hltL3fL1sMu14Eta2p1L1f0L2f16QL3Filtered17, hltL3crIsoL1sMu14Eta2p1L1f0L2f16QL3f20L3crIsoRhoFiltered0p15, hltIsoMu172p1JetCollectionsForLeptonPlusPFJetsNoPU, hltIsoMu172p1TriCentralPFNoPUJet25MuCleaned, hltIsoMu172p1DiCentralPFNoPUJet35MuCleaned, hltIsoMu172p1CentralPFNoPUJet45MuCleaned

→ This is what PAG should define!!!



Order of module



Should save timing:

→ Run first what is quick and allow to reject easily
→ Keep in the latest phase the sequence which are time consuming: relying on tracking (B-tag etc)
→ Build a collection, select on it immediately to reduce the flow of event at the next step

Normally we start by building leptons and then other tracking object (Pflow jets etc)

If too many modules, you can build your "own" sequence (easy to read later on).



An example



a value (later on during the day). For the moment a quick overview:

```
saveTags = cms.bool( False ),
  CSCTFtag = cms.InputTag( "unused" ),
  PreviousCandTag = cms.InputTag( "hltL1sMu14Eta2p1" ), \leftarrow L1 object collection
  MinPt = cms.double( 0.0 ), \leftarrow L1 pt cut you want to apply
  MinN = cms.int32(1), \leftarrow Minimal number of L1 object passing the cuts
  MaxEta = cms.double(2.1), \leftarrow L1 eta cut you want to apply
  SelectQualities = cms.vint32(),
  CandTag = cms.InputTag( "hltL1extraParticles" ),
  ExcludeSingleSegmentCSC = cms.bool( False ))
HLTL2muonrecoSequence 

Building L2 Muon collection
hltL2fL1sMu14Eta2p1L1f0L2Filtered140 = cms.EDFilter( "HLTMuonL2PreFilter", ← Filter type
  saveTags = cms.bool(True), \leftarrow Saving L2 object passing this filter for offline matching ability
  MaxDr = cms.double(9999.0),
  CutOnChambers = cms.bool( False ),
  PreviousCandTag = cms.InputTag( "hltL1fL1sMu14Eta2p1L1Filtered0" ), ← Collection of candidates passing
previous filter
  MinPt = cms.double( 14.0 ), \leftarrow L2 pt cut you want to apply
  MinN = cms.int32(1), \leftarrow Minimal number of L1 object passing the cuts
  SeedMapTag = cms.InputTag( "hltL2Muons" ),
  MaxEta = cms.double(2.1), \leftarrow L2 eta cut you want to apply
  MinNhits = cms.vint32(0, 1, 0, 1),
  MinDxySig = cms.double( -1.0 ),
  MinNchambers = cms.vint32(0),
  AbsEtaBins = cms.vdouble( 0.9, 1.5, 2.1, 5.0 ),
  MaxDz = cms.double(9999.0),
  CandTag = cms.InputTag( "hltL2MuonCandidates" ),
  BeamSpotTag = cms.InputTag( "hltOnlineBeamSpot" ),
  MinDr = cms.double( -1.0 ),
  NSigmaPt = cms.double( 0.0 ),
  MinNstations = cms.vint32(0, 2, 0, 2))
```

Creating a release area



In 2012, data were taken with CMSSW_5_2_X online correspondence offline is CMSS_5_2_9 (or 5_3_X):

```
# if using bash
export SCRAM_ARCH=slc5_amd64_gcc462
# if using [t]csh
setenv SCRAM_ARCH slc5_amd64_gcc462
```

```
cmsrel CMSSW_5_2_9
cd CMSSW_5_2_9/src
cmsenv
```

```
checkdeps -a
scram b -j4
#if using bash
hash —r
#if using [t]csh
rehash
```



Which Menu?



Menu is a number of python parameters → Depending on the code (ie release) All release is having a compatible menu: Last pp menu is in CMSSW_5_2_9 (and higher), so simply do: addpkg HLTrigger/Configuration

Menu is under: test/OnData_HLT_8E33v2.py (need to change input files) But usually we take it from the database [known as ConfDB] itself (which is used to handle the high number of paths etc): hltGetConfiguration /online/collisions/2012/8e33/v2.0/HLT --full -offline --data --process TEST --globaltag auto:hltonline > hlt.py Change InputFile to: /store/group/comm_trigger/TriggerStudiesGroup/Skims/Top/ SingleMuDS/pickevents_SemiMuon10k_1_1_Bbo.root

Then run:

cmsRun hlt.py

NB: Always use "H or P" global tag when rerun the HLT to get the same conditions.





Yeah!!!! You have the latest 2012 pp HLT Menu!!!!



TrigReport Path Summary									
TrigReport	Trig	Bit#	Run	Passed	Failed	Error Name			
TrigReport	1	1	295	14	281	0 HLT_Ele25_	CaloIdVT_CaloIsoVL_TrkIdVL_TrkIsoT_TriCentralPFNoPUJet30_v3		
TrigReport	1	2	295	19	276	0 HLT_Ele25_	CaloIdVT_CaloIsoVL_TrkIdVL_TrkIsoT_TriCentralPFNoPUJet45_35_25_		
TrigReport	1	3	295	11	284	0 HLT_Ele25_	CaloIdVT_CaloIsoVL_TrkIdVL_TrkIsoT_TriCentralPFNoPUJet50_40_30_		

→ 19 events have passed HLT_Ele25_CaloIdVT_CaloIsoVL_TrkIdVL_TrkIsoT_TriCentralPFNoPUJet45_35_25_v1 over 295 events

want to run another menu.



List of menu in 2012:

http://fwyzard.web.cern.ch/fwyzard/hlt/2012/summary

With online release (back up slide about online release vs offline release). For each HLT important online release it exists an offline release.

In the meantime, 5_2_9 and 5_3_X release are able to run any 2012 menu.

Online release: CMSSW_5_2_X_onlpatchY_ONLINE

→ Offline: CMSSW_5_2_X_hltpatchY For each "online" menu (starting with /cdaq/) an "offline" version exists: /cdaq/physics/Run2012/7e33/v2.1/HLT

→ /online/collisions/2012/7e33/v2.1/HLT (last version is not changing physics only prescale so it can be ignored)

So let's try!

cmsrel CMSSW_5_2_4_hltpatch3

cd CMSSW_5_2_4_hltpatch3/src

cmsenv

hltGetConfiguration /online/collisions/2012/7e33/v2.1/HLT --full --offline --data --process TEST --globaltag auto:hltonline > hlt.py cmsRun hlt.py





Yeah!!!! I am able to run with ANY HLT Menu!!!!



Offline selection based on HLT bits



- Previous HLT menu have been run in a process named "TEST". Over data the process is named as HLT.
- In order to select events passing your HLT path at the time of RECO or PAT simply use:
- https://twiki.cern.ch/twiki/bin/view/CMS/TriggerResultsFilter

Or via:

- import HLTrigger.HLTfilters.hltHighLevel_cfi
- MyTriggerSelection =
- HLTrigger.HLTfilters.hltHighLevel_cfi.hltHighLevel.clone(
- HLTPaths = ['HLT_MyPath'],
- TriggerResultsTag ="TriggerResults::TEST"

Steps by Steps To Do List

- Define a trigger strategy:
 - > Have ideas on how to measure efficiency from data
 - Ideas of main path for signal
 - > Ideas for paths for background determination from data
 - > Ideas of quantities to monitor in DQM
 - \rightarrow In Top group, try to step up a page for brainstorming:

https://twiki.cern.ch/twiki/bin/viewauth/CMS/TopTriggerStrategy13TeV

- Code a trigger path:
 - Develop path in ConfDB
 - > Measure efficiency on your signal
 - > Measure expected rate
 - Measure timing of the path
 - Develop the corresponding DQM
- Send all the information to your HLT-Top contact
 - We will integrate all paths (regroups all paths and make sure they are corehent)
- Present the proposal in TSG meeting (will push for PHD to give talk when possible)
- Things are regularly improving, please expect to have to iterate over 25





Conclusion

Quick introduction given, more to follow! Please do not hesitate to ask question during the talk if things are not clear.

10:20 - 11:00	Measurement of offline efficiency ("theory") 40'					
	Speaker: Kelly Beernaert (Ghent University (BE))					
	Material: Slides 🔂					
11:00 - 11:10	Coffee					
11:10 - 11:50	Matching HLT object to Reco object (Tutorial) 40'	-				
	Speaker: Hugues Louis Brun (Universidad de Oviedo (ES))					
11:50 - 12:00	UTB/UTC 10'	•				
	Speakers: mia tosi (Universita' degli Studi di Padova & INFN), Mia Tosi (Universita' degli Studi di Padova e INFI (IT))	N				
12:00 - 12:50	Coding in ConfDB 50'	-				
	Speaker: Javier Fernandez Menendez (Universidad de Oviedo (ES))					
12:50 - 14:00	Lucnh					
14:00 - 15:00	Measuring Rate/Timing and Optimisation of HLT paths 1h0'	-				
	Speakers: Zeynep Demiragli (Brown University), Zeynep Demiragli (Brown University (US))					
15:00 - 15:10	Coffee					
15:10 - 16:10	DQM at HLT 1h0'	-				
	Speaker: Dr. Federico De Guio (CERN)					
16:10 - 16:40	Summary of TSG workshop 30'	-				
	Speaker: Simone Gennai (Universita & INFN, Milano-Bicocca (IT))					



Helping Crew Faces





Andrea Bocci



Matteo Sani



Maria Cepeda



Antonio Tropiano





BackUp