

Enhancing the Rate Monitoring Tools of the CMS High Level Trigger

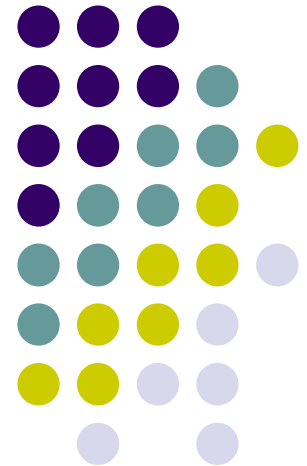
Marybeth Morris Beydler

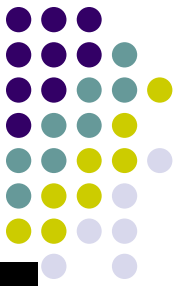
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Lannon

University of Notre Dame

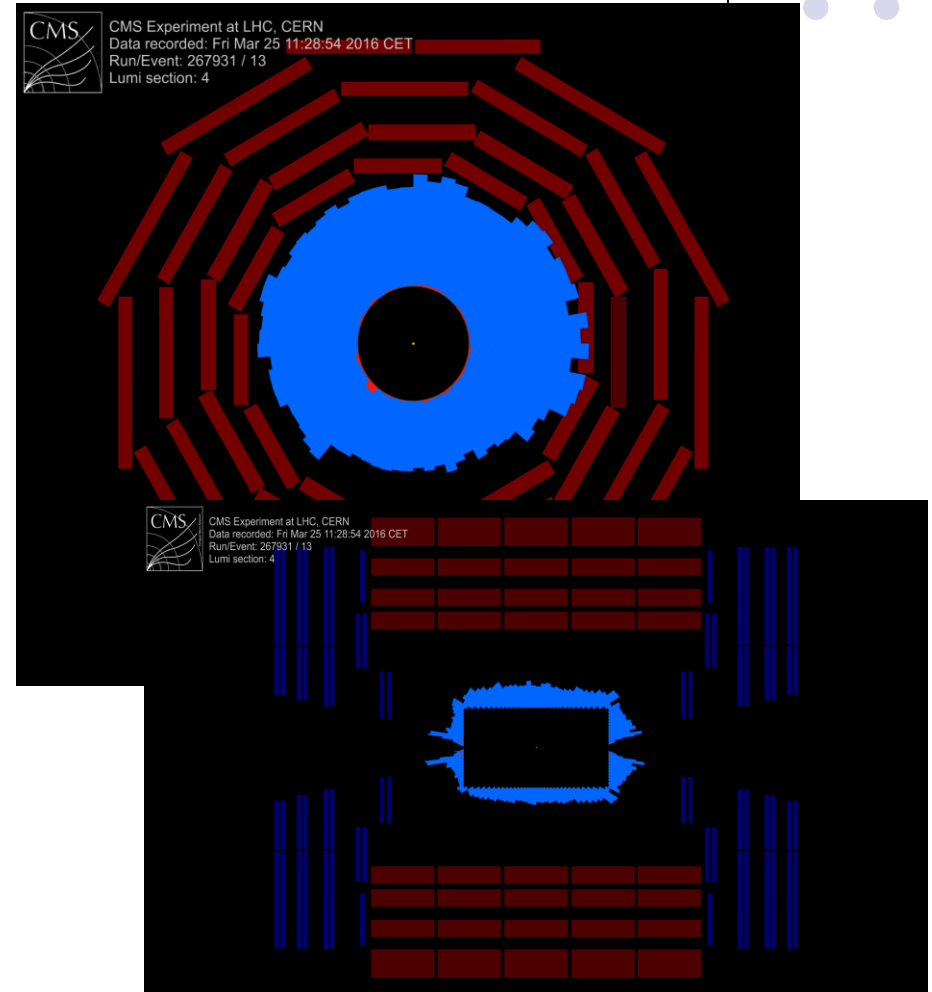
April 6, 2016

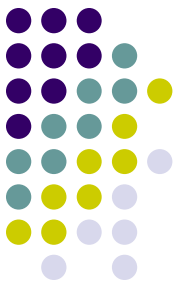




CMS: A Digital Camera

- CMS is like a large digital camera that takes a “snapshot” of the particle collisions.
- However, these collisions happen very rapidly (about 1 billion proton-proton interactions per second) so we need a trigger to decide which “images” to keep.



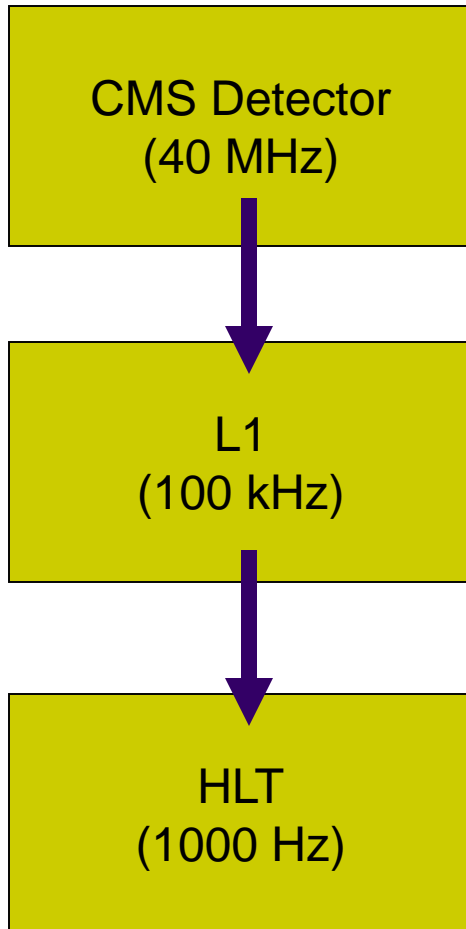


What Is Triggering?

- Deciding which “images” to keep!
- Trigger rate = how often a particular trigger fires, or decides an event should be kept.
- Trigger rate should increase linearly as the pile up increases.



CMS Triggering



- Two Part Trigger:
 - Level 1 Trigger
 - High Level Trigger
- Events must pass the L1 in order to make it to the HLT.
- Once at HLT, event goes through multiple algorithms and very basic reconstruction to determine whether the event should be kept.
- Very important because any analysis done offline depends on HLT efficiency!

Trigger Rate Monitoring Tools



- Rate monitoring tools are critical for CMS data taking.
- My project: To streamline run certification and enhance the tools used to monitor the trigger rate of the CMS trigger system.
- RateMon = Directory containing Rate Monitoring Tools

RateMon

Primary Mode
(Online)

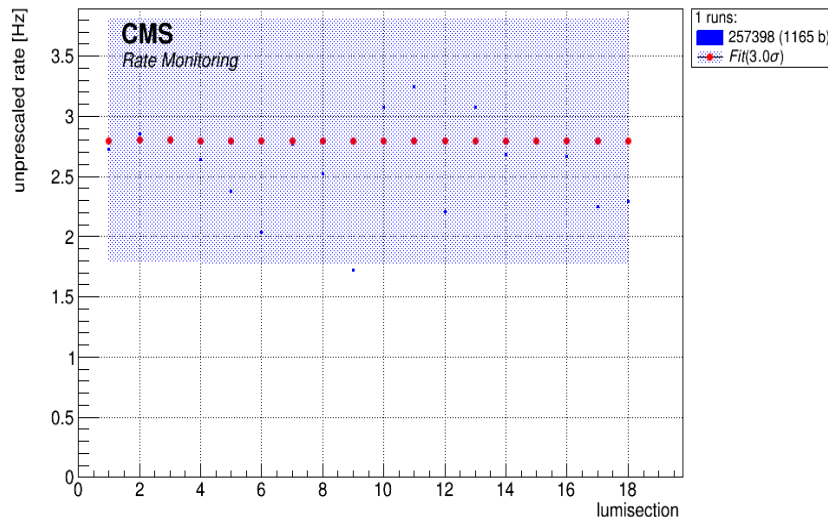
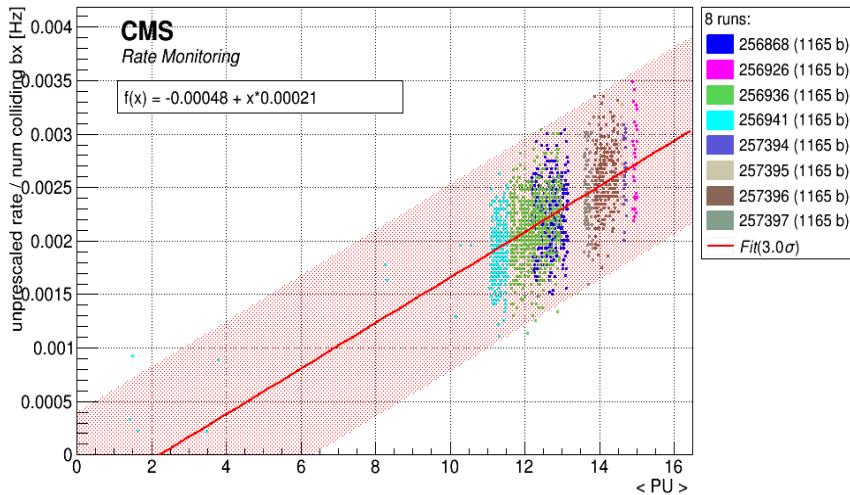
Certification Mode
(Offline)

Purpose: To Plot the trigger rate as a function of pile up for multiple runs and create a fit to use in Certification mode.

Purpose: To plot the trigger rate as a function of lumisection of a single run with a fit from primary mode. Also, produces a plot that shows the number of good and bad trigger paths in the run.

HLT_DoubleEle33_CaloldL_GsfTrkIdVL

HLT_DoubleEle33_CaloldL_GsfTrkIdVL



Process of Run Certification

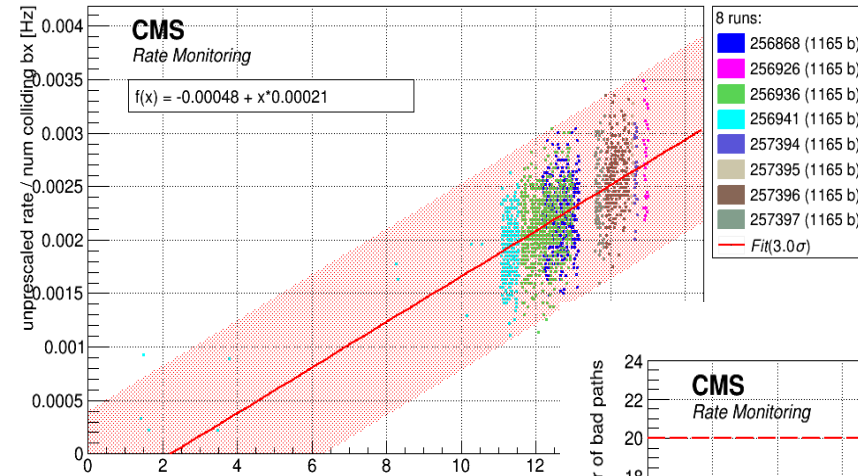
HLT_DoubleEle33_CaloldL_GsfTrkIdVL

Step 1: Make fit in primary mode from certified “good” runs.

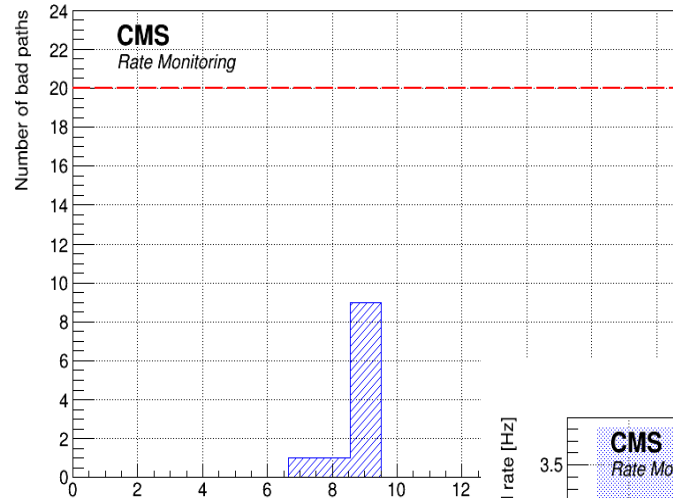
Step 2: Use fit to run the certification mode.

Step 3: Examine middle plot for each run.

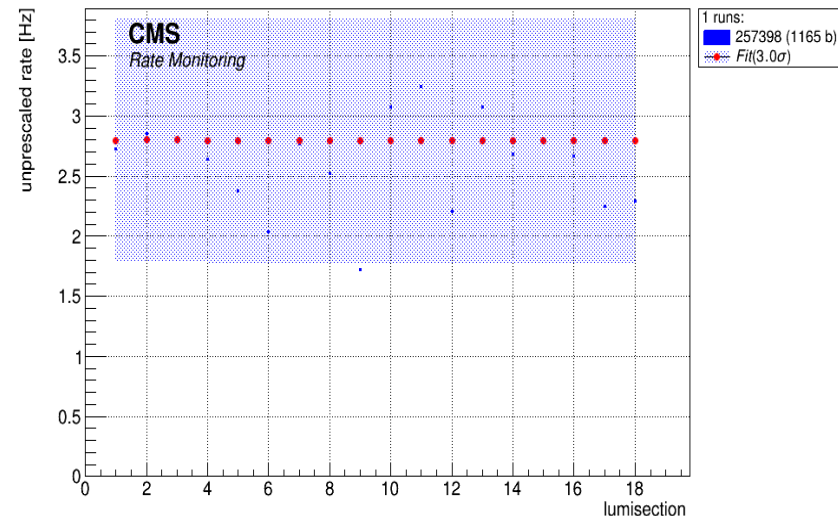
Step 4: Go through triggers (bottom plot) of especially problematic runs and double check WBM and DQM Run Registry to see if any known issues were detected.



Run 257398



HLT_DoubleEle33_CaloldL_GsfTrkIdVL



Enhancements to Primary Mode



- Conducted a study to find out which non-linear function fits the trigger rates best.
- Best fit is realistic and selected by having the lowest mean squared error (MSE).
- RateMon selects a linear fit unless a non-linear fit is specifically requested or the linear fit has the lowest MSE.
- Understanding non-linear triggers important because we need to be aware of triggers that increase non-linearly, as it is a sign that there is extra stuff happening in the detector and is saving too much.

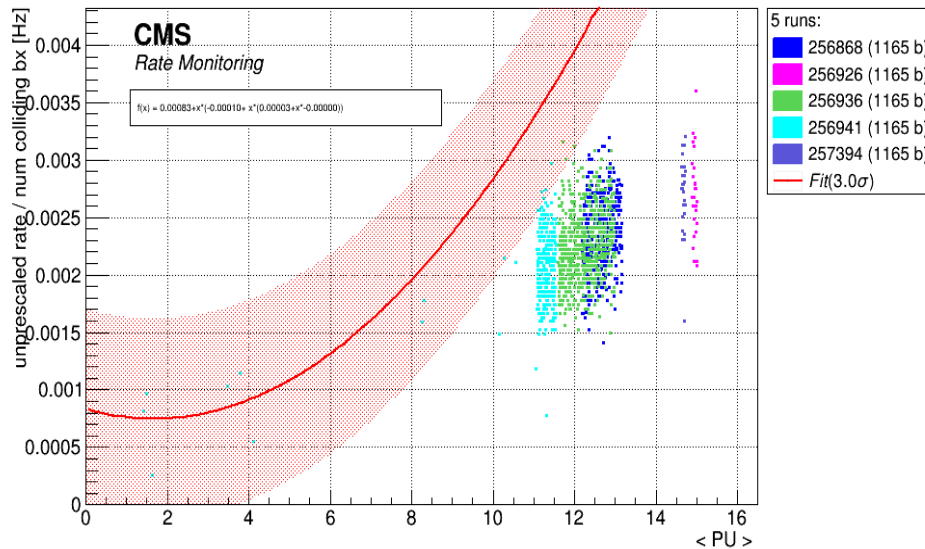


Results from Non-Linear Fitting Study

- Approximately 400 HLT triggers and 100 L1 triggers
- Losers: Exponential Fit and Cubic Fit
- Winners: Quadratic and Linear

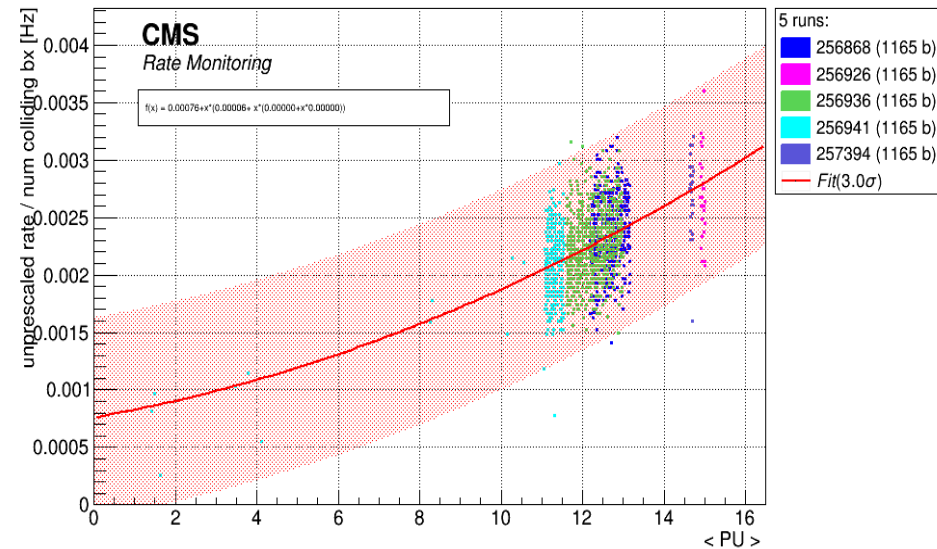
BEFORE (Charlie)

HLT_AK8PFJet360_TrimMass30



AFTER (Marybeth)

HLT_AK8PFJet360_TrimMass30





Enhancements to Certification Mode

- Certification mode extensively debugged.
- Text file produced by certification mode is easier to read now and includes more useful information

```
mbeydler@xplus067: Certification_18-uns_2016-04-05_14_24]$
mbeydler@xplus067: Certification_18-uns_2016-04-05_14_24]$
mbeydler@xplus067: Certification_18-uns_2016-04-05_14_24]$ ls
certificationSummaries.root      CertificationSummary_run256941.png  CertificationSummary_run257398.png  CertificationSummary_run257490.png  run256868  run257395  run257400  run257399
certificationSummary_run256868.png  CertificationSummary_run257394.png  CertificationSummary_run257399.png  CertificationSummary_run257531.png  run256926  run257396  run257461  run257613
certificationSummary_run256868_run257614.LxL  CertificationSummary_run257395.png  CertificationSummary_run257400.png  CertificationSummary_run257599.png  run256936  run257397  run257487  run257614
certificationSummary_run256926.png  CertificationSummary_run257396.png  CertificationSummary_run257461.png  CertificationSummary_run257613.png  run256941  run257398  run257490
certificationSummary_run256936.png  CertificationSummary_run257397.png  CertificationSummary_run257487.png  CertificationSummary_run257614.png  run257394  run257399  run257531
mbeydler@xplus067: Certification_18-uns_2016-04-05_14_24]$
mbeydler@xplus067: Certification_18-uns_2016-04-05_14_24]$
-----
Run Number: 257398
TRIGGERS: BAD LUMISECTION(S)
HLT_AK8D1PFJet250_200_TrimMass30_BTagCSV0p45: [[9,9]]
HLT_DoubleEle33_CaloIdL_GsfTrkIdVL: [[9,9]]
HLT_DoubleMediumIsoPFTau35_Trk1_eta2p1_Reg: [[9,9]]
HLT_Ele105_CaloIdVT_GsfTrkIdT: [[9,9]]
HLT_Ele27_WPLoose_Gsf: [[8,9]]
HLT_HT650: [[9,9]]
HLT_IsoMu27: [[9,9]]
HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL: [[16,16]]
HLT_Mu45_eta2p1: [[9,9]]
HLT_PFH800: [[7,7], [9,9]]
# OF BAD PATHS : LUMISECTION(S)
9 : [9]
1 : [7, 8, 16]
BAD LS SUMMARY:
---- Total bad LS: 4 ( bad LS: >= 1 trigger(s) deviating more than 3 sigma from prediction )
---- Total LS: 18
---- Fraction bad LS: 22.2222222222
BAD PATH SUMMARY:
---- Total Bad Paths: 12.0
---- Total Possible Paths: 360.0
---- Fraction that are Bad Paths: 3.3
-----
Run Number: 257399
```



Conclusion/Further Work

- Rate monitoring tools improved for 2016 data taking!!! 😊
- Certification process streamlined and simplified thereby making it more reliable, ensuring that problems with data are detected.
- Further work: Continue to vastly simplify output for the user by putting all of the certification mode plots in one file.

