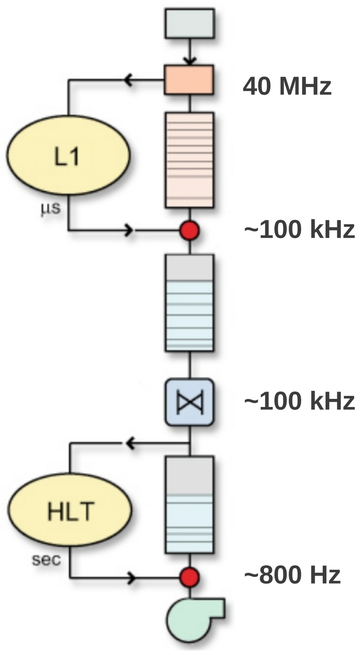
Valentina Gori, Università e INFN Firenze, on behalf of the CMS collaboration

The CMS High Level Trigger



The CMS experiment features a **two-level trigger**:

- first level (L1), hardware, selecting events to a maximum rate **~100 kHz**
  This upper limit is imposed by the CMS data acquisition electronics
- High Level Trigger (HLT), software, further reducing the rate to **~800 Hz**
  on average, for offline data storage on local disk or CMS Tier-0, of which:
  - an average rate of 400 Hz for prompt reconstruction within 48 hours ("core")
  - an average rate of 400 Hz for reconstruction in 2013 ("parking")

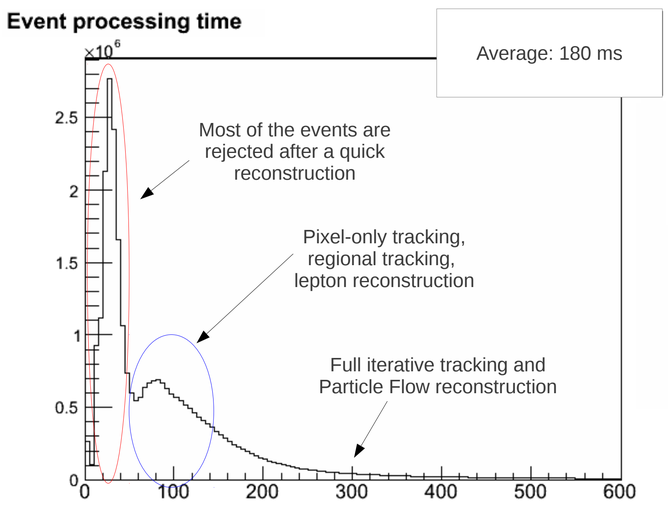
The CMS **High Level Trigger**:

- aims to maximize efficiency while keeping CPU-time and rate low
- its algorithms use the same software framework and most of the same reconstruction code used for offline reconstruction and analyses
- must be flexible to adapt to changes in data-taking conditions, like changes in luminosity or special conditions occurring during the CMS commissioning or dedicated LHC fills
- must provide on-line detector monitoring (→specific trigger paths for calibration and alignment)
- its performance should be robust with respect to changes in alignment and calibration constants
- should be stable with respect to pile up
- must work within a peak CPU time: 200 ms/evt @ 100 kHz input rate

HLT menu for 2012 (rate at L = 6·10^{33} cm^{-2} s^{-1})

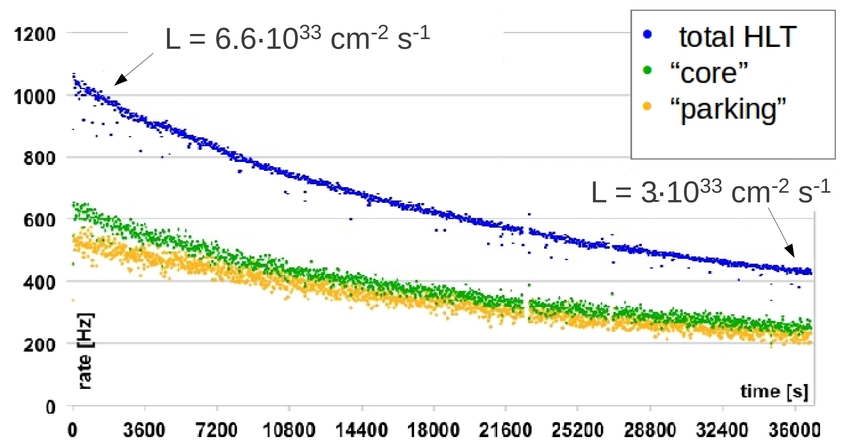
(Unprescaled) Object	Trigger Threshold (GeV)	Rate (Hz)	Physics
Single Muon	40	21	Searches
Single Isolated Muon	24	43	Standard Model (SM)
Double Muon	(17, 8) [13, 8 for parked data]	20 [30]	SM / Higgs
Single Electron	80	8	Searches
Single Isolated Electron	27	59	SM
Double Electron	(17, 8)	8	SM / Higgs
Single Photon	150	5	Searches
Double Photon	(36, 22)	7	Higgs
Muon + Ele x-trigger	(17, 8), (5, 5, 8), (8, 8, 8)	3	SM / Higgs
Single PFJet	320	9	SM
QuadJet	80 [50 for parked data]	8[100]	SM /Searches
Six Jet	(6 x 45), (4 x 60, 2 x 20)	3	Searches
MET	120	4	Searches
HT	750	6	Searches

Timing



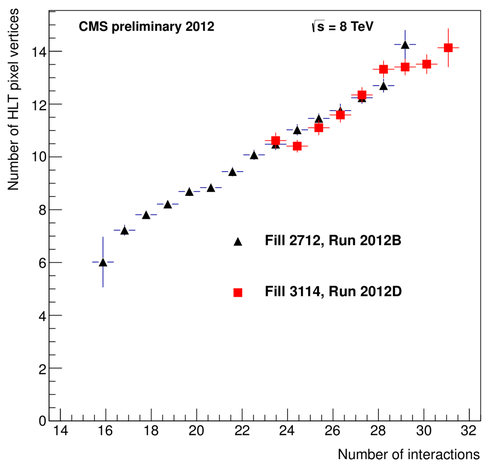
Timing during a short run taken in November 2012 (average luminosity ~ 7·10^{33} cm^{-2} s^{-1})

Trigger rates



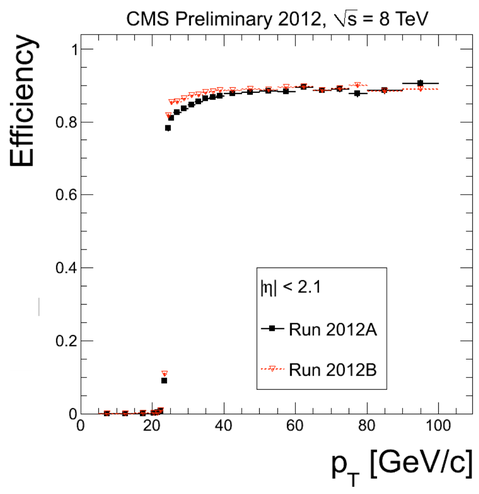
HLT rate for the first ten hours of a long recent fill
Average "core" rate: 380 Hz in the inst. luminosity range shown

Vertices reconstruction



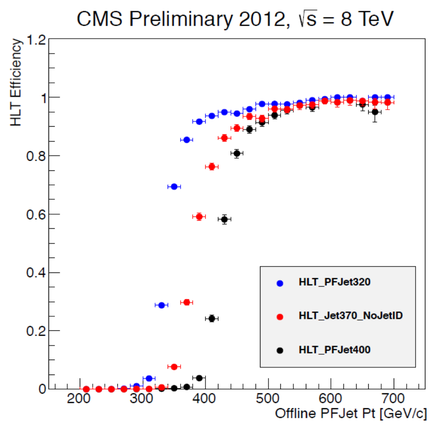
Number of pixel vertices reconstructed at HLT.
The number of interactions is calculated from the bunch luminosity as measured by the forward calorimeters (HF).

Muon track reconstruction



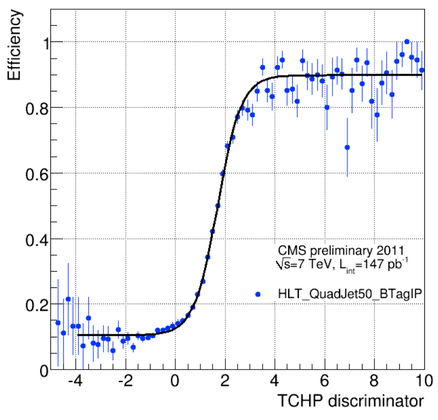
HLT_IsoMu24 trigger path efficiency calculated with respect to the offline reconstruction.

Particle Flow jets



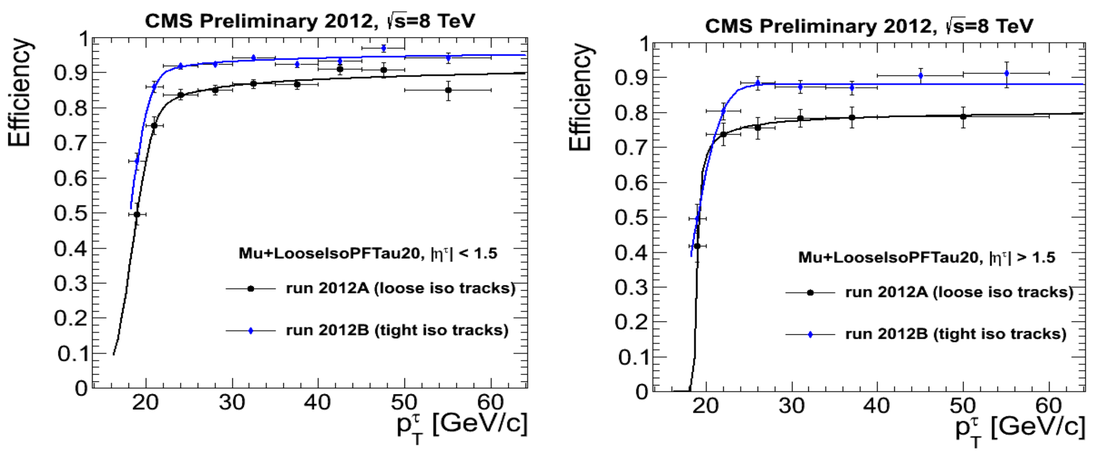
Turn-on cuve measured vs. offline Particle Flow jet pT.
Trigger efficiency measured on an unbiased data sample from Run2012C.

b-tagging



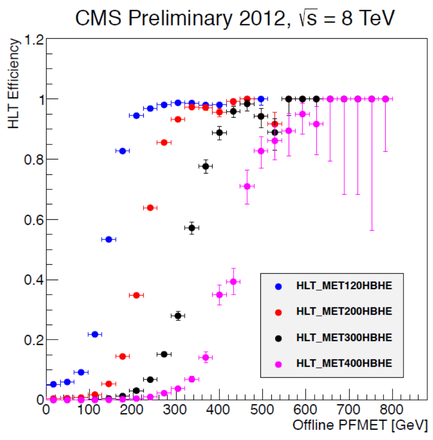
Turn-on curve of the Track Counting High Purity (TCHP) discriminator efficiency at HLT, with respect to the same variable computed offline.
The TCHP b-tagging discriminator is the third highest impact parameter significance for the tracks associated to a jet.
The online cut for this HLT path is TCHP > 2.

Isolated Particle Flow Tau

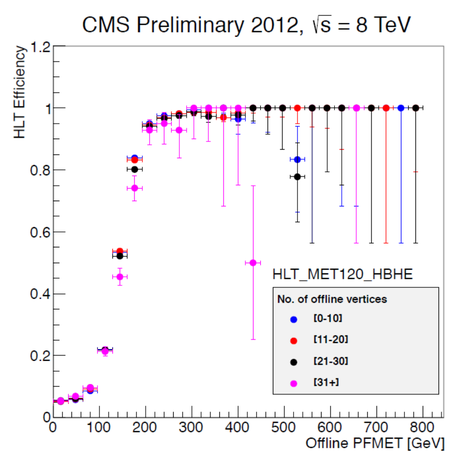


Efficiency measured using tag-and-probe technique with $Z \rightarrow \tau^+\tau^-$, $\tau \rightarrow \mu\, \nu\, \nu$ + τ-hadr using an unbiased dataset for the T&P.
- Difference in efficiency between run 2012A and 2012B: different quality criteria of isolation
- Different efficiency in barrel (|η|<1.5) and endcap (|η|>1.5): detector effects

MET



Turn-on curves for MET triggers measured vs. offline Particle Flow (PF) MET



Turn-on curves for HLT_MET120_HBHE trigger, in bins of different pileup (based on # offline vertices): PU has no effect on trigger turn-on.