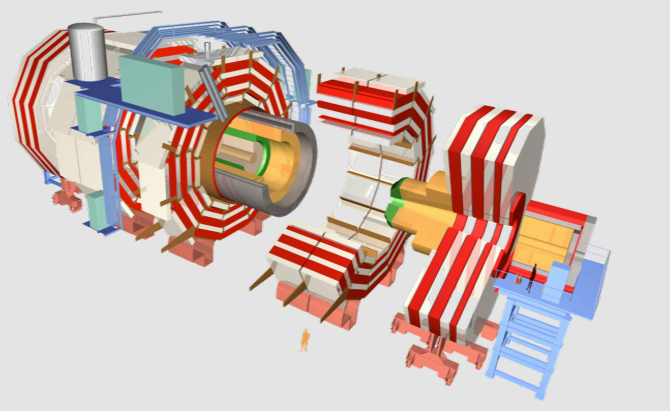

Trigger Issues for New Physics Searches in the CMS Experiment

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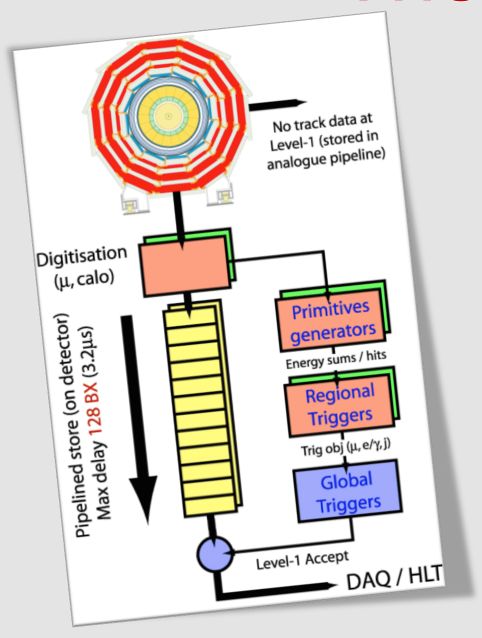
on behalf of the CMS Collaboration

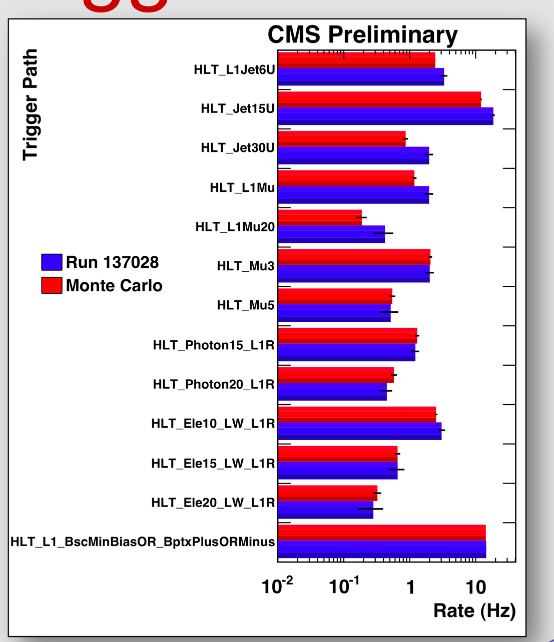
The CMS trigger system



- L1 hardware, fast objects from calorimeters and muon systems
- L2 and L3 merged into High Level Trigger (HLT)
- HLT (~5000 CPUs) accesses full event info (full granularity) seeded by L1 objects using "off-line quality" algorithms
- L1: 3.2 μs
- HLT: 100 ms/evt (50 ms/evt) for a L1 accept rate of 50 kHz (100 kHz)

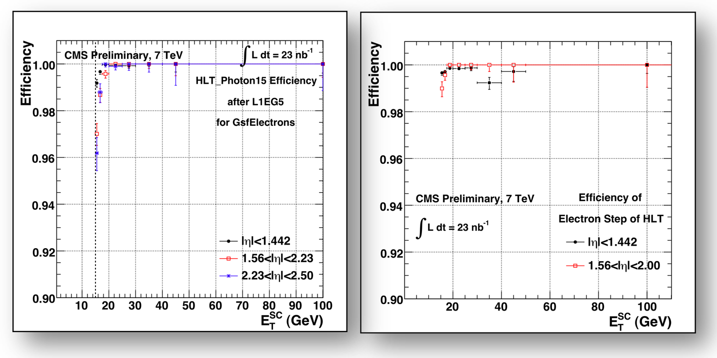
The CMS High Level Trigger

- General strategy:
  - ✓simplicity, inclusiveness, robustness, redundancy
- Startup table:
  - ✓single and double object triggers, with as low as possible thresholds
- Future evolution:
  - ✓more complex triggers, closer to analysis (e.g. cross triggers)



CMS trigger performance with pp at 7 TeV

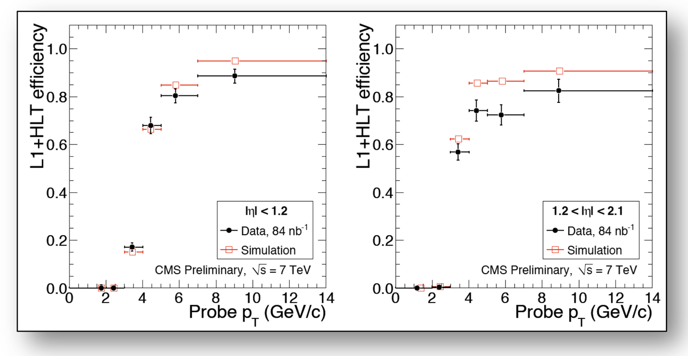
electrons/photons



Left: HLT_Photon15 efficiency for an offline reconstructed electron matched to a L1_SingleEG5 candidate as a function of E_T.

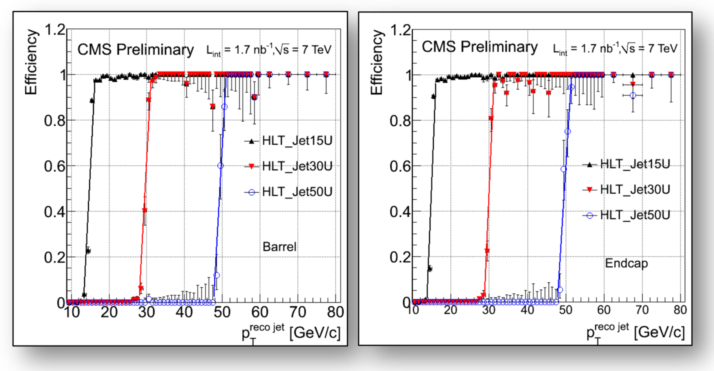
Right: the HLT_Ele15LW efficiency for an offline reconstructed electron which passes HLT_Photon15 as a function of E_T [3]

muons



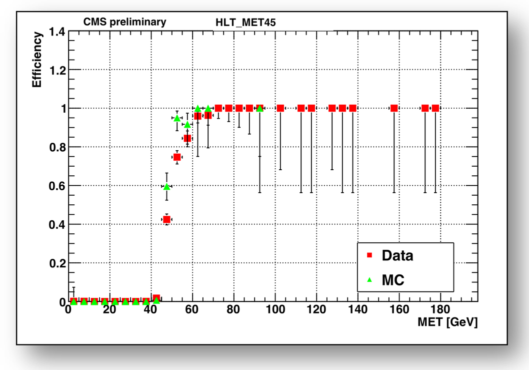
Tag and Probe efficiency for data compared to simulation. The absolute trigger efficiency is shown as a function of p_T for HLT with L3 threshold at 3 GeV/c in the barrel (left) and endcap (right) [4]

jets



Efficiency for offline jets to pass the triggers HLT_Jet15, HLT_Jet30, and HLT_Jet50. Right: efficiency as a function of offline p_T for events in the barrel. Left: efficiency as a function of offline p_T for events in the endcap.

MET

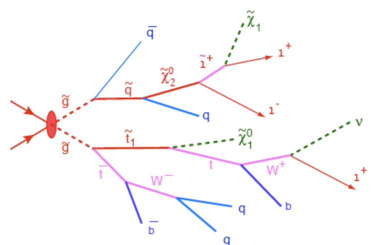


Met Trigger efficiency as a function of offline missing E_T for events recorded with L1 MET20 to pass HLT MET45.

Triggers for New Physics searches

SUSY

- Jets, Missing Transverse Energy (+ leptons) expected in the final states



Purely Hadronic Final States

Low Luminosity

- Jet and MET triggers, high efficiency for many scenarios

High Luminosity

- Multi-Jet triggers: exploit the topology to keep the rate low with low thresholds
- HT trigger: $HT = \sum|p_T^{jet}|$. Can replace multijet trigger.
- b and tau triggers efficient for some scenarios (sbottoms, stops, large tanβ)

Leptonic Final States

Low Luminosity

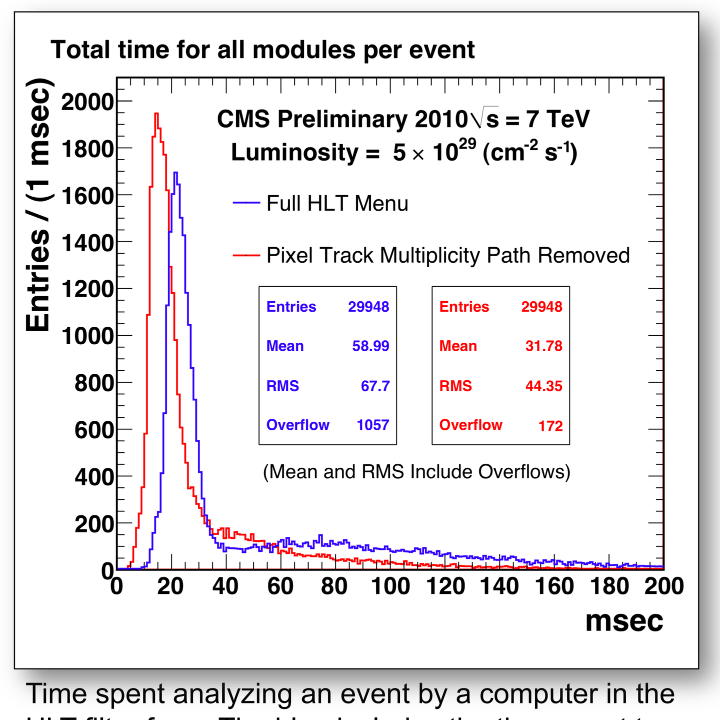
- Single and double lepton triggers, high efficiencies for low thresholds
- Hadronic triggers can be exploited for leptonic analyses too, given the presence of Jets and MET in all type of events

High Luminosity

- Hadronic triggers and HT trigger show a better efficiency than the leptonic ones in many scenarios
- Cross triggers to retain high signal efficiency at large luminosities

Other Beyond the Standard Model scenarios

- Some events (e.g. black holes) can time out the HLT. Ensure that high multiplicity events pass time budget is critical.
- Very high pt muons and electrons from heavy objects: lepton trigger performance must be ensured up to very large pt values.
- Displaced vertices (Hidden Valley): outside-in muon algorithms.
- Heavy Stable Charged Particles:
  - ✓muon triggers for fast particles (β>0.6)
  - ✓MET trigger for slow particles and for HSCP emerging neutral from the calorimeters
  - ✓jet trigger for HSCP accompanied by hadronic activity
  - ✓dedicated triggers under study

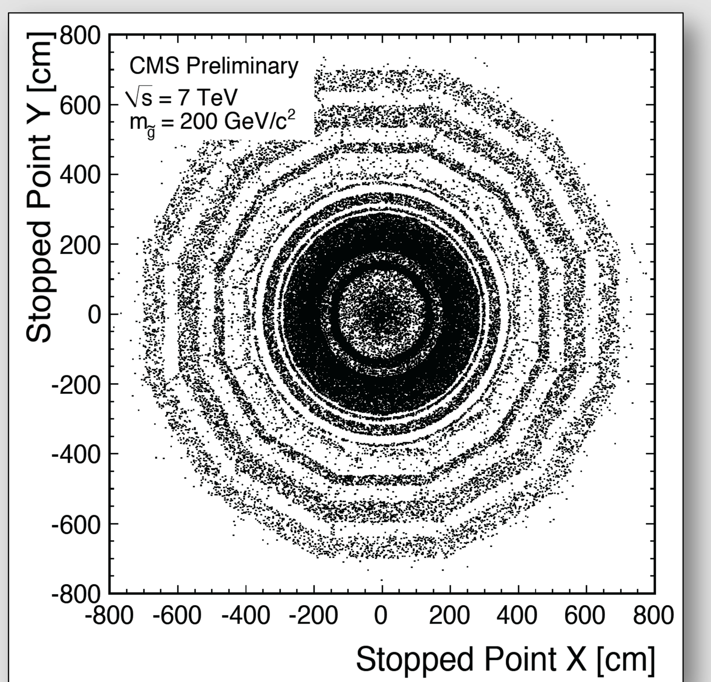


Time spent analyzing an event by a computer in the HLT filter farm. The blue includes the time spent to run the high-multiplicity pixel track trigger. Pixel unpacking + tracking is run on every L1-accept. The red line plot excludes that module.

- Express stream used as source for the "Exotica hotline", a tool to select on a daily basis events with strange topology indicative of detector malfunction or maybe a hint of new physics.

An example: the stopped gluino search

- In some models, decay time so long that the particles can be trapped in the detector and decay some time later (from μs to months)
  - ✓some supersymmetric models
  - ✓"hidden valley" scenarios
  - ✓grand unified theories (GUTs)
  - ✓split supersymmetry
- CMS is most sensitive to production processes proceeding via the strong interaction, with a relatively large cross-section at the LHC.
- A dedicated trigger is needed [5].



Simulation of R-hadron stopping points for m(gluino) = 200 GeV, and √s = 7 TeV.

- Trigger strategy:
  - ✓search for particles during periods of no p-p collisions:
    - o Interfill triggers (when the beam is really off):
      - not yet used in current analysis
    - o Beamgap triggers:
      - use a beam position monitor (BPTX) to request the absence of beam

- Calorimeter trigger (particles trapped in the HCAL)
  - ✓L1 Jet, $p_T > 10$ GeV, $|\eta| < 3$
  - ✓HLT Jet $p_T > 20$ GeV, $|\eta| < 3$
  - ✓Rate: ~3 Hz
  - ✓essentially, request a jet when the beam is off
  - ✓Signal Efficiency: ~70% for particles stopping in the calorimeter
- Discovery possible from lifetimes ~100 ns to months (12 orders of magnitude)

References

[1] CMS Collaboration, JINST 3 S08004

[2] CMS Collaboration, Eur. Phys. J. C 46, 605–667 (2006)

[3] CMS Collaboration, CMS-DP-2010-032

[4] CMS Collaboration, CMS-PAS-MUO-10-002

[7] CMS Collaboration, CMS-PAS-EXO-10-003