# SUSY Trigger Implementation

With the rapid increase of luminosity over the past year, the trigger strategy for the SUSY PAG has evolved from using a few general multi-purpose triggers to many analysis-specific triggers. At the start of data taking in 2010, luminosities were low enough to allow unprescaled single object triggers (Jets, Electrons, HT, MET, etc.) with sufficiently low thresholds to be efficient for collecting potential SUSY signal. With the luminosity growing by over two orders of magnitude last year and increasing by at least another order of magnitude this year, these simple objects are no longer viable for SUSY searches and a new set of dedicated analysis triggers have been put in place in the last 6 months.

The majority of this triggers are multiple object cross-triggers designed to keep the trigger rate low and the trigger fully efficient in the signal region. For example, the lowest unprescale HT trigger (HT150 uncorrected) was fully efficient for the offline cuts of the missing energy plus $\geq 3$ jets final-state search (which has an offline selection requiring 300 GeV of HT and 150 GeV of MHT), while this years lowest unprescale HT (HT450 corrected), would cut substantially into their signal region. This analysis now uses a dedicated cross-trigger requiring HT abot 250 GeV and MHT above 60 GeV to stay efficient in their signal region and keep the trigger rate low. There are now similar dedicated triggers for almost all the SUSY searches, and more continue to be added in every iteration of the trigger menu. I am involved at all levels of the trigger design process: designing the cuts to make the triggers sustainable; testing the performance of the triggers on data; implementing the triggers for integration in the menu; and monitoring the triggers once they have gone online.

# Dedicated Triggers for the SUSY Razr Analysis

The Razr is an extremely powerful search for SUSY-like signal, but it is quite difficult to capture efficiently with generic triggers because of its complicated topology. In 2010, the razr analysis was able to efficiently capture signal using pure HT triggers for the same broad selection as many other SUSY hadronic analyses. In 2011, however, the thresholds of existing trigger objects have become too high and would substantially cut into the razr signal region. To avoid this, a dedicated razr trigger has been developed to capture the razr signal region while excluding the QCD background to keep the rate low.

The razr trigger is able to target exactly the signal that the analysis wants and has become a model for other SUSY searches to emulate in their trigger strategies. Trigger-level jets and MET are used to calculate the R and $M_R$ variables in exactly the same way as the offline analysis; by doing a simple analysis cut at the trigger level, this analysis gains a very high purity signal sample directly from the trigger level. I studied the efficiency of this trigger on SUSY-like Monte Carlo (LM1) and defined the exact trigger cuts that make us fully efficient at the desired offline cuts (Fig 1).

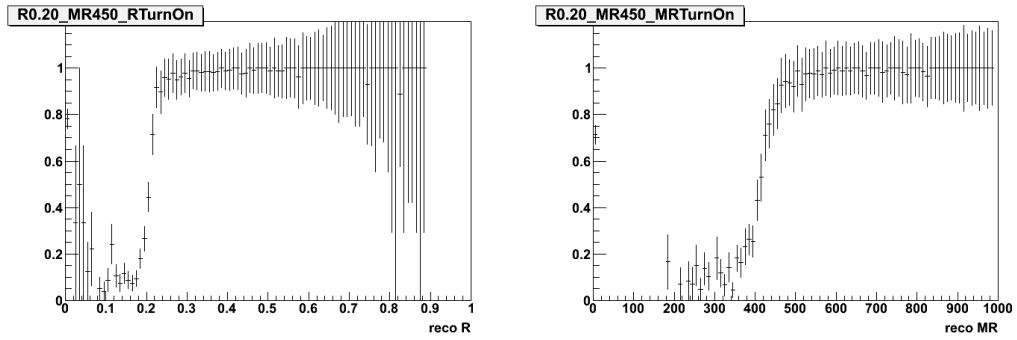


Figure 1: Left: Example turn-on curve for the HLT level R variable versus the Reco level R variable. Right: Example turn-on curve for the HLT level MR variable versus the Reco level MR variable.

## Trigger Menu Integration

In 2011 I am an on-call expert for the HLT. The responsibilites of this position involve integrating, testing and deploying HLT menus; monitoring trigger rates and taking corrective action if necessary; communicating with run coordination and the subdetector experts; and responding to emergencies involving the trigger system. The trigger system has to serve many different needs within a fixed bandwidth budget, and the HLT on-call is responsible to make sure that this is happening correctly.

## Implementing HCal Noise Cleaning at the HLT

I have been working in coordination with the HCal Noise Working Group to bring the HCal Noise cleaning developed for the offline reco to the trigger level. Cleaning algorithms are used offline to clean noise in the HF and in the HBHE, and bringing them to the trigger level will aid the physics goals of the whole collaboration: by reducing the noise rate at the HLT in the HCal, we are able to sustain some triggers that would otherwise need a higher threshold and thus lose acceptance. At the same time, these filters need to be safe because events rejected at the HLT can never be recovered, unlike the offline reco.

The HBHE Noise filter uses a new variable designed by the HCal Noise WG ( (TS4-TS5)/(TS4+TS5), described elsewhere) to filter noisy events. To keep this cleaning safe at the HLT, the cleaning is only applied to events with at most 2 RBXs about 20 GeV; this eliminates events which are triggered only by noise, but accepts real events that happened to coinvide with HCal Noise. Figure 2 shows the rejection of events by the HBHE Noise filter at the HLT as a function of the HLT reconstructed MET; the left plot shows all events, where we see that the cleaned HLT MET becomes a smoother exponential after the cleaning, and the "Noise" bin, where the HLT was not able to reconstruct a vertex, where we remove many (70%) of the events. Two examples of the utility of this cleaning are the $H \to bb$ analysis, which uses a MET100 trigger for one of its final states, and the monojet analysis, which uses a MET80+CentralJet80 trigger. Both of these triggers have large noise contamination from HBHE Noise, which drives the trigger rates too high. Without the noise cleaning, both of these triggers will soon be prescaled and these analyses will lose their primary physics triggers.

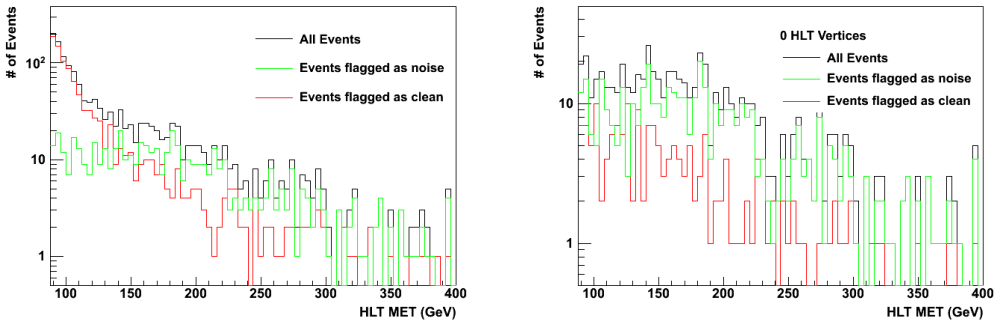


Figure 2: Events Accepted (red) and rejected (green) by the HBHE Noise filter as a function of the HLT reconstructed MET for all events (left) and events without a reconstructed vertex at the HLT, which are noise (right).

Bringing the HF noise filter was prompted by the observation that noise in the HF had a non-negligable contribution to the rate of single jet triggers. At the moment, all sum triggers are calculated in the barrel only, so HF noise only shows up in the jet trigger rate. Enabling the HF cleaning reduces the rate of Jet triggers by about 20% for the Jet240 trigger, but more importantly reduces the rate in the HF by more than 70%, all of which is noise. In addition to the rate reduction, by showing that the HF cleaning eliminates most of the noise in the HF, the option to bring the

HF back to trigger level sums is more viable. This is especially important for the MET object; the exotica group has shown that almost half of the MET80_CentralJet80 trigger rate is from fake MET events introduced by excluding the HF from the MET, so we expect the HF cleaning to have the ultimate effect of a big reduction in the rate of this trigger.