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Level 2 Missing Transverse Energy Studies at Low Luminosity

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Abstract

We present results trigger rates for the missing transverse energy trigger for low luminosity running ($2 \cdot 10^6 mb^{-1}$ Hz) of the CMS experiment.

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Contents

1 Introduction

We present results on low luminosity ($2 \cdot 10^7 mb^{-1} Hz = 2 \cdot 10^{33} cm^{-2} s{-}1$) trigger rates of the CMS experiment comparing generated, meausured and corrected measured quantities.

Such a trigger may be necessary for precision studies of supersymmetry, or for studies of supersymmetric higges which decay to tau leptons. We also present new results on rates for a L2.0 missing transverse energy and combined jets and missing transverse energy trigger.

2 Previous Level 1 studies

2.1 CMS studies

The rates for a level 1 missing transverse energy trigger have previously been presented in [1] and [2] for low and hig luminosity. Since then the low luminosity estimate has been changed from 10^{33} to $2 \times 10^{33} cm^{-2} s{-}1$. The updated results are presented in [3] .

For a missing E_T threshold of 120 GeV, they obtained a rate of 3 Hz.

2.2 ATLAS studies

The ATLAS collaboration has also studied rates for missing transverse energy triggers at the LHC[15]. They used $\hat{p}_t > 5 GeV/c$ "mini-jet" events and also `PYTHIA` minimum bias events. For pile-up they assumed 20 inelastic events per bunch crossing. They considered intime and out-of-time pileup, using an overlap of 3 bunches for the out-of-time pileup. They found that, at high luminosity, the most important contribution to fake missing E_T in the event comes from the intime pile-up events. The effect of out-of-time pile-up was found to be negligible.

In another study ([16]) they studied the missing E_T resolution for events with real missing E_T. They found that the largest contribution to the missing energy resolution cames from the addition of trigger tower noise, but that this effect could be reduced by an appropriate threshold cut on the trigger tower energies.

The most recent of their analyses is ([17]) that assumes 2.3 events per bunch crossing, intime and out-of-time pileup, using an overlap of 3 bunches for the out-of-time pileup.

For a missing E_T threshold of 120 GeV, they obtained a rate of 1.1 Hz. This low rate may be explained by the less (2.3 instead of 3.46) pile-up events and less (3+1 instead of 5+1+3) bunch crossings taken into account in their study.

3 The software and events used for the analysis

To do our studies on rates for missing transverse energy triggers, we used the code and data samples that were produced at FNAL (Fall 2001) "HLT" (Higher-Level Trigger), using `ORCA_4_5_2` .

ORCA_4_5_4 and the ntuple maker of the JetMET Physics Group (JetMetAnalysis version 2.05 [7]) were used to produce ntuples from simulated events of the CMS experiment. These events contain intime and out-of-time pile-up, from bunch crossing -5 to $+3$, 3.46 minimum bias pile-up events on the average each. Offline MET is calculated using the EcalPlusHcalTower objects, with a threshold of 100 MeV per tower, and using the full rapidity coverage of the CMS calorimeter. The Level 1 simulation is the same as was used in earlier study [3].

4 Variations of missing E_t trigger

We considered using also scalar E_t (the scalar sum of E_t) as a supplementary quantity for the missing E_t trigger. The main concern is that scalar E_t even more depends on noise, thresholds and other unexpected phenomena than missing E_t . The reasopn why we still think scalar E_t an important quantity is that missing E_t itself can not satisfactory distinguish between low missing E_t signal, like $120GeV/c^2$ invisible Higgs and low $\hat{p}_t$ QCD background. The reason for this the relatively bad resulotion of the calorimeter system for low energy hadrons, that dominate both these channels and the missing E_t resolution.

The way out for the uncertainty of scalar E_t can be for example calculating it from jets of a certain threshold (say $E_t > 30GeV$). Figure 1 shows the invisible Higgs and the low mass SUSY signal behind the QCD background using calorimeter tower scalar E_t (left) and jet scalar E_t (right) . Unfortunately it does not seem to verify using jet scalar E_t instead of calorimeter tower scalar E_t .

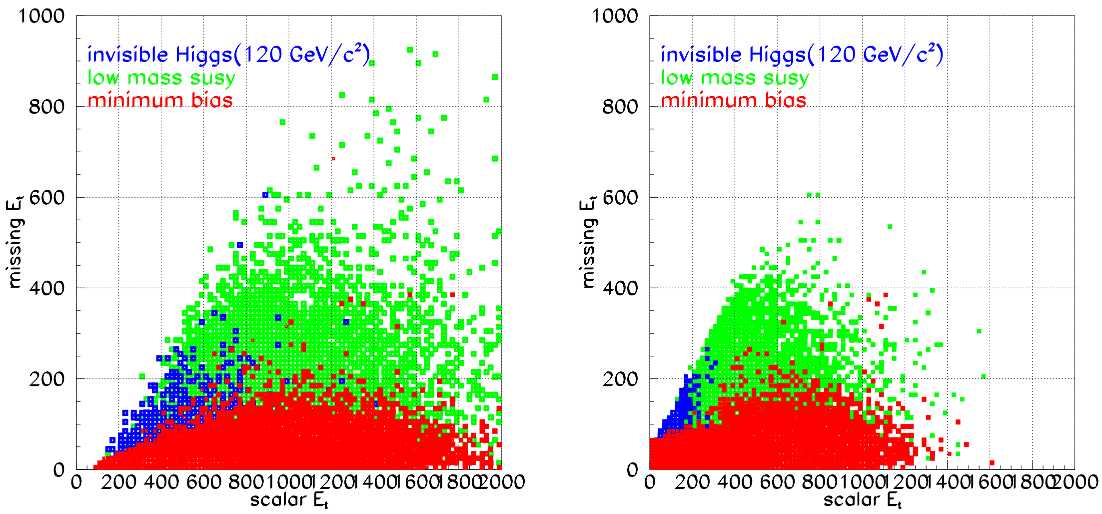


Figure 1: Missing E_t versus scalar E_t when the latter is calculated from towers (left) or jets (right) respectively.

Figure 1 also suggests what combined missing E_t - scalar E_t cut we have to use to achieve a good signal - background separation . We have to choose a curved cut along the edge of the background distribution .

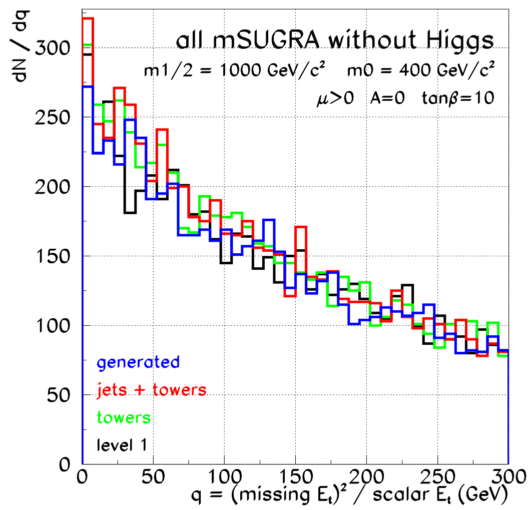
Replacing missing E_t with (missing E_t)^2 / (scalar E_t) as trigger variable may have multiple advantages. Its isobars on the (scalar E_t,missing E_t) are square root curves, so cutting on it will meet the good separation requrirement mentioned above. Scalar E_t is even more sensible to noise and threshold effects than missing E_t, so we can hope that (missing E_t)^2 has more similar behaviour to scalar E_t . It is well known anyhow that for QCD both the average and the standard deviation of missing E_t is proportional to the square root of scalar E_t . Also the change of missing E_t and scalar E_t is expected to be coherent if caused by threshold change or noise.

...seems to justify this expectations. It has much better correspondence of distributions calculated in different ways (generated, first and second level calorimeter) than simple missing E_t on ... We can consider the effect of different calculation methods similar to that of noise and threshold choice.

Figure 3 shows the correlation between (missing E_t)^2 / (scalar E_t) and missing E_t .

Figures 4 and 5 shows the distribution and the correlation for the invisible Higgs. The correspondence between the curves of different calculation methods is also apparently better than on ... for simple missing E_t .

See Figure 6



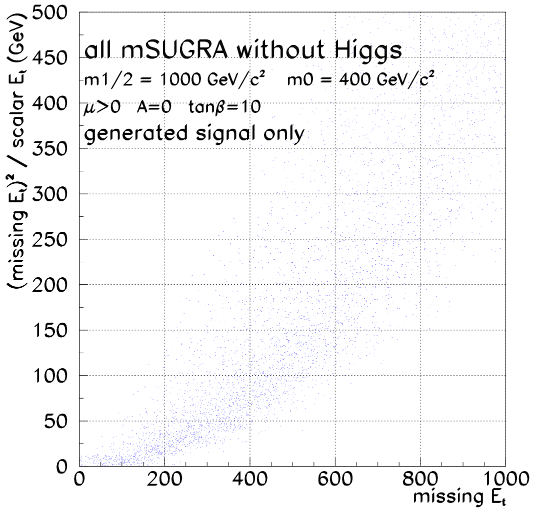
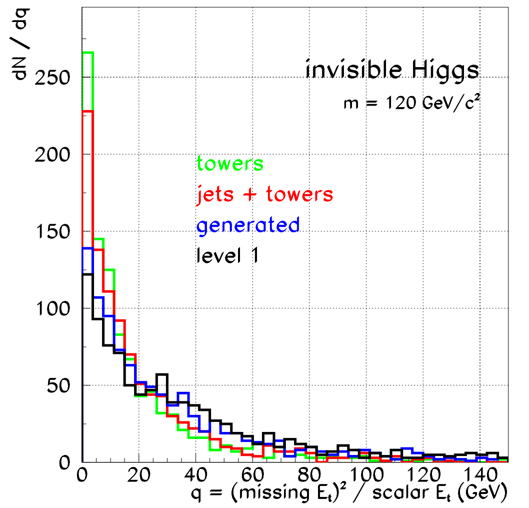


Figure 2: Rescaled (with missing E_t scalar E_t) missing E_t distribution of a high mass SUSY sample .

Figure 3: The background trigger rate at the 95% efficient missing transverse energy cut that belongs to the generated missing energy displayed



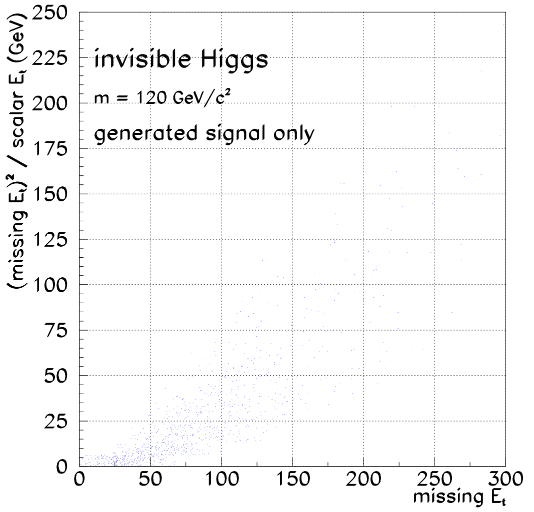


Figure 4: The 95% effective missing energy cut calculated from several quantities as a function of the generated missing energy

Figure 5: The background trigger rate at the 95% efficient missing transverse energy cut that belongs to the generated missing energy displayed

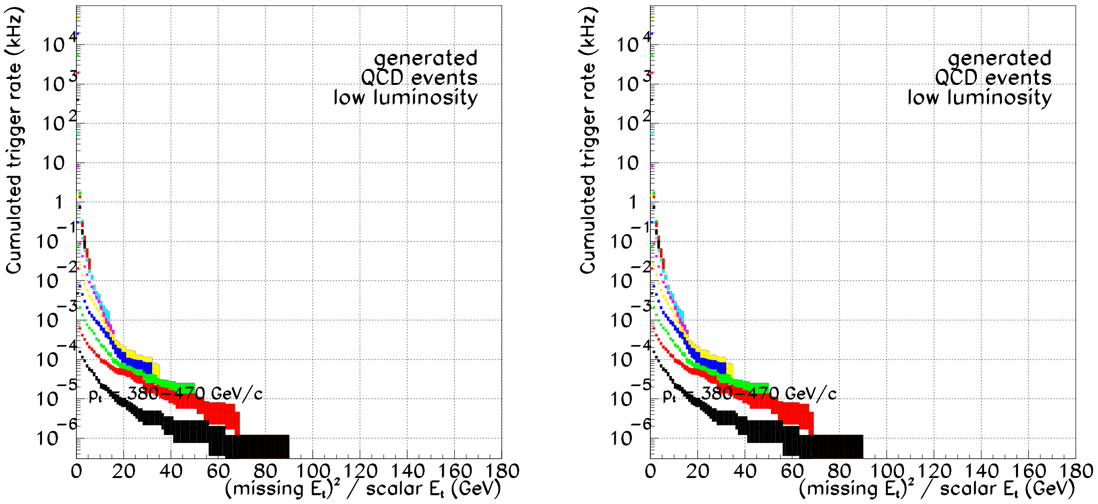


Figure 6: The cumulative generated (left) and reconstructed (right) jet + missing E_t trigger rate of QCD background events is shown as a function of the E_t cutoff on a logarithmic scale.

See Figure 7

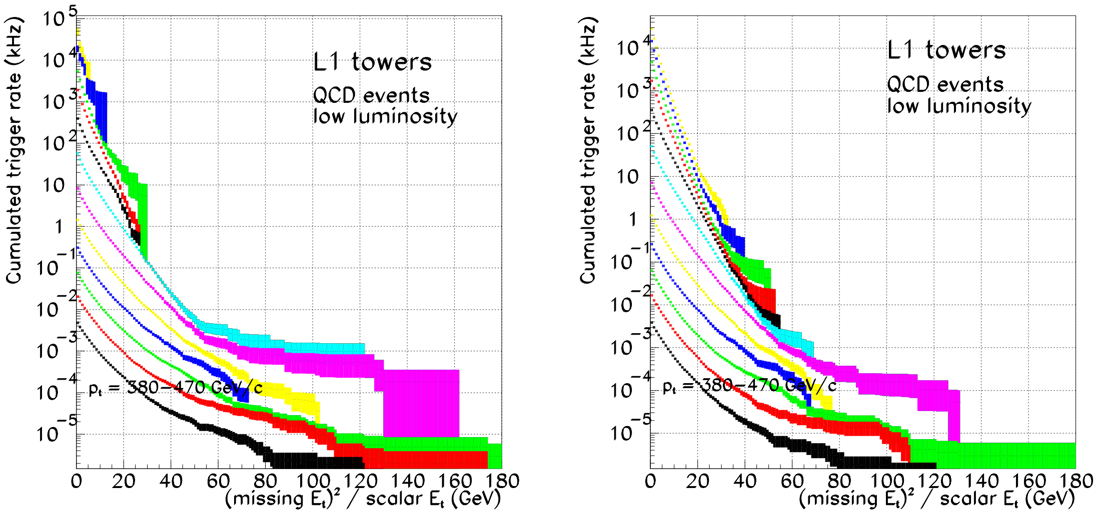


Figure 7: The cumulative generated (left) and reconstructed (right) jet + missing E_t trigger rate of QCD background events is shown as a function of the E_t cutoff on a logarithmic scale.

See Figure 8

See Figure 9

5 Discussion

Table 1 summarizes some of the cuts we have tried. The first group of 3 rows is the cuts that are always applied, the second and third groups are alternatives of each other, only one of the four cuts are applied at the same time. Absolute efficiencies are displayed, without generator level preselection.

Unfortunately after background reduction to about $1Hz$ the efficiency especially for the invisible Higgs becomes fairly low. At the same time this in case of this very low mass of $120GeV/c^2$ the alternative rescaled missing E_t

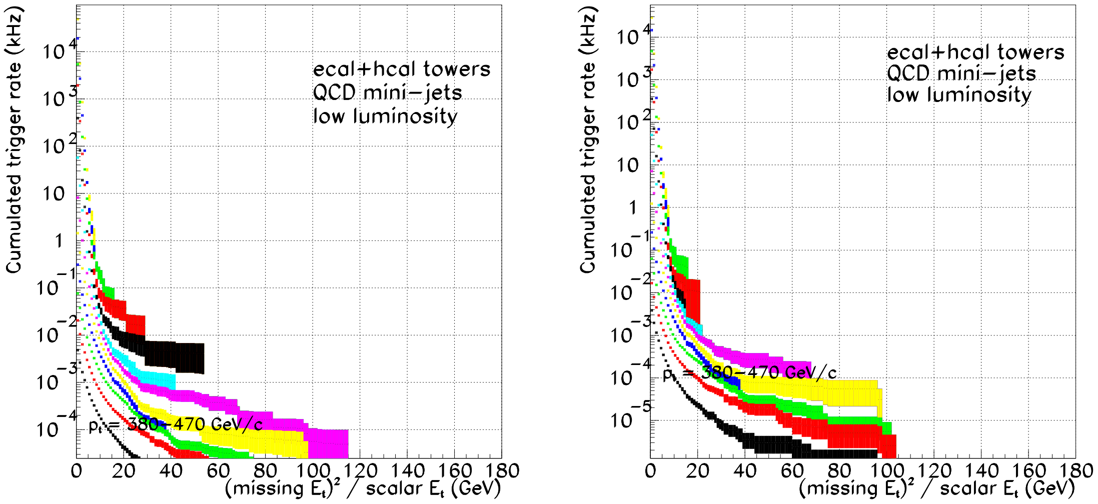


Figure 8: The cumulative generated (left) and reconstructed (right) jet + missing E_t trigger rate of QCD background events is shown as a function of the E_t cutoff on a logarithmic scale.

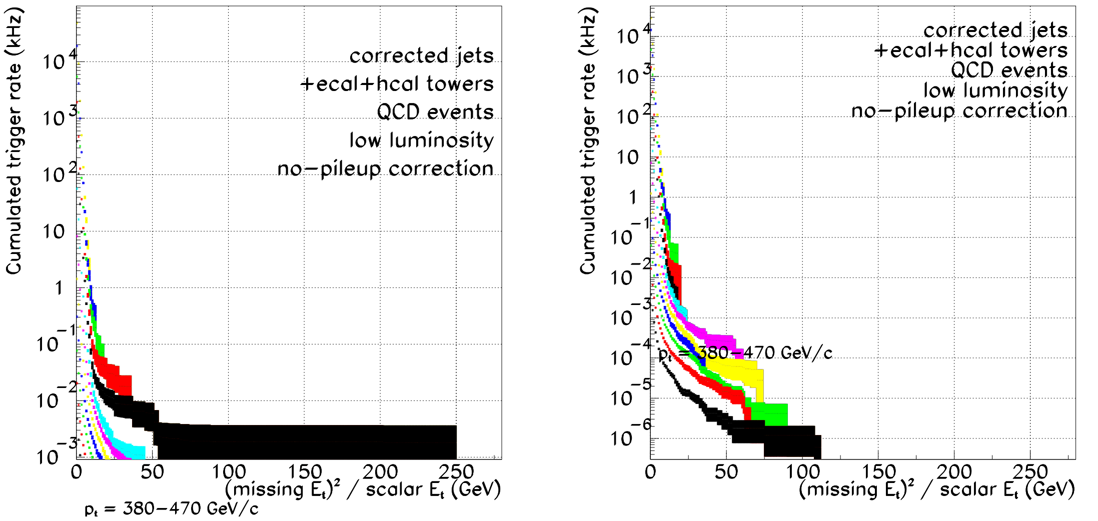


Figure 9: The cumulative generated (left) and reconstructed (right) jet + missing E_t trigger rate of QCD background events is shown as a function of the E_t cutoff on a logarithmic scale.

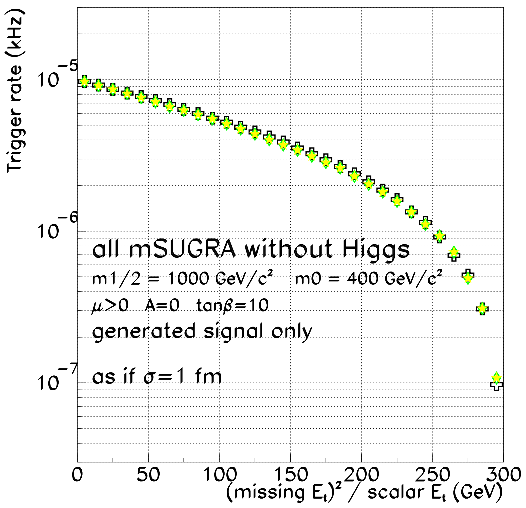


Figure 10: The 95% effective missing energy cut calculated from several quantities as a function of the generated missing energy

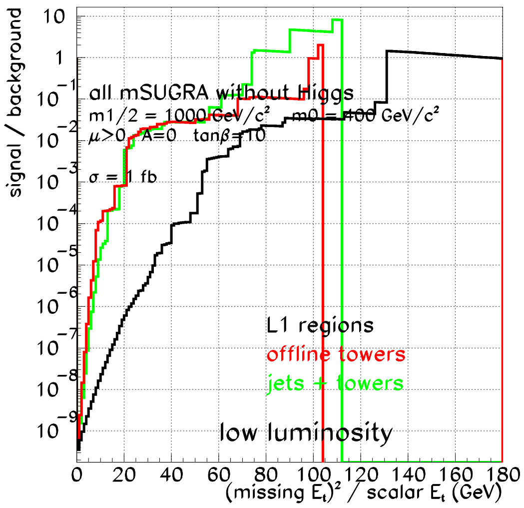


Figure 11: The background trigger rate at the 95% efficient missing transverse energy cut that belongs to the generated missing energy displayed

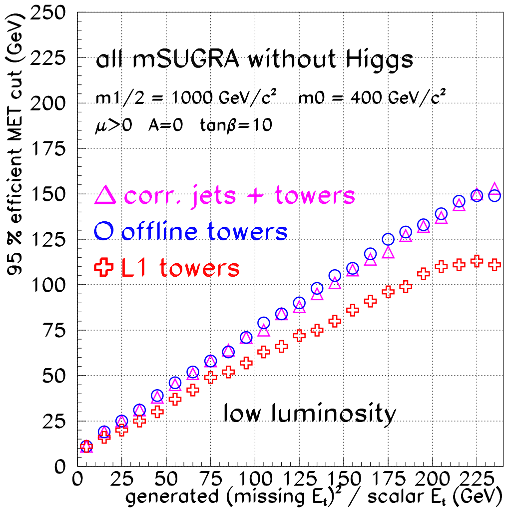


Figure 12: The 95% effective missing energy cut calculated from several quantities as a function of the generated missing energy

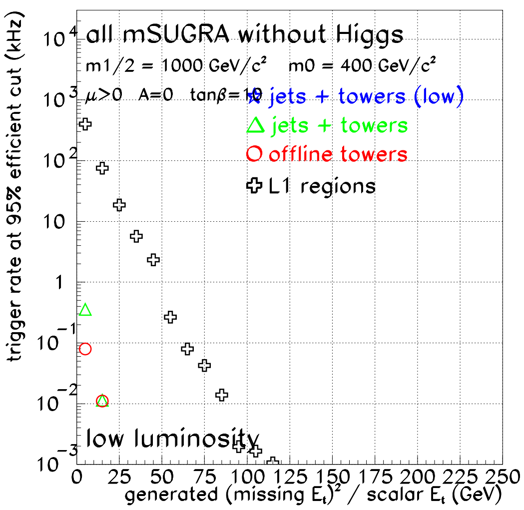
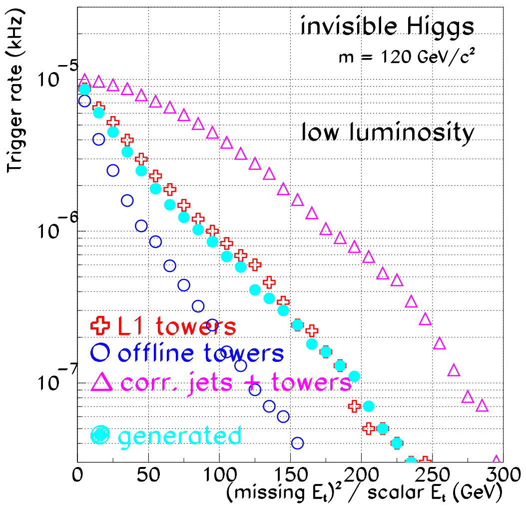


Figure 13: The background trigger rate at the 95% efficient missing transverse energy cut that belongs to the generated missing energy displayed



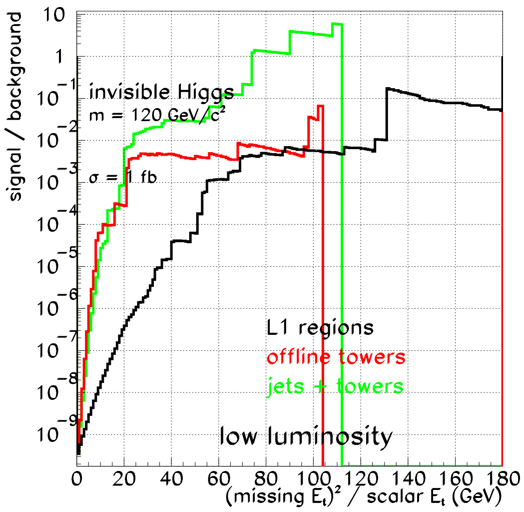
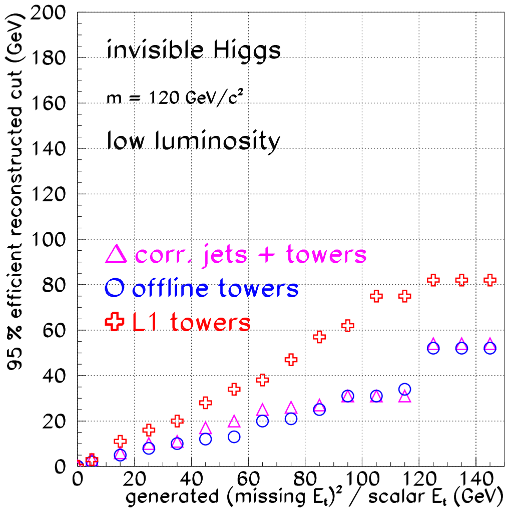


Figure 14: The 95% effective missing energy cut calculated from several quantities as a function of the generated missing energy

Figure 15: The background trigger rate at the 95% efficient missing transverse energy cut that belongs to the generated missing energy displayed



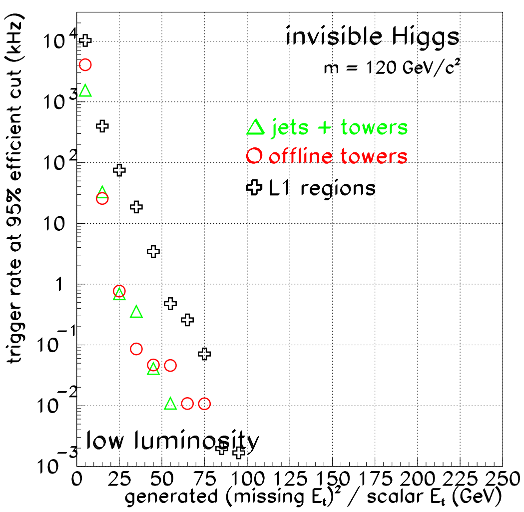


Figure 16: The 95% effective missing energy cut calculated from several quantities as a function of the generated missing energy

Figure 17: The background trigger rate at the 95% efficient missing transverse energy cut that belongs to the generated missing energy displayed

Table 1: Efficiency change through the cut row.

Cut	invisible Higgs	low mass SUSY
$E_t^{jet(gen,rec)} > 30GeV$	0.885 ± 0.030	0.995 ± 0.010
$E_t^{tower(max)}/E_t^{\Delta R} < 0.94$	0.884 ± 0.030	0.986 ± 0.010
$\Delta\Phi(jet(1) \pm met) > 0.10$	0.784 ± 0.028	0.923 ± 0.010
$E_t^{mis} > 110GeV$	0.207 ± 0.014	0.642 ± 0.008
$(E_t^{mis})^2/E_t^{scalar} > 20GeV$	0.248 ± 0.015	0.550 ± 0.007
$E_t^{mis} > 120GeV$	0.171 ± 0.013	0.603 ± 0.008
$(E_t^{mis})^2/E_t^{scalar} > 25GeV$	0.198 ± 0.014	0.489 ± 0.007

cut performs better than for channels of mass above $200GeV/c^2$. Optimizing these cuts is still necessary after getting rid of the know Monte Carlo bugs of the software.

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