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Search for Higgs in the $ZH \to \nu\nu b\bar{b}$ channel in Run II: Trigger Study I

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ABSTRACT

The possibility to use the Level 1 trigger in Run II for triggering on associative ZH production has been investigated. It is shown that using such event parameters as transverse muon momentum, transverse jet energy and event missing energy may allow to get acceptable background rate while keeping signal efficiency reasonably high.

I Introduction

It is well understood now that the one of the primary goals for the D0 experiment in the approaching Run II will be the search for Higgs production. By the time Run II starts it's expected that the best limit on the Higgs search will be provided by LEP II which will be able to rule out masses of the Higgs below $\sim 95 GeV$. In Run II with integrated luminosity of about 25 fb^{-1} it would be possible to see standard Higgs production if Higgs mass is not heavier than 120 GeV [1].

Study of the final states of the type ZX where Z decays into $\nu\nu$ and X decays into $b\bar{b}$ showed that the main backgrounds come from $t\bar{t}$ production, W and Z bosons, and QCD-produced $b\bar{b}$ and $c\bar{c}$ events [2] and there is some hope to use sets of cuts on the Level I trigger level to select signal events and suppress the background. Because of the huge difference in the cross sections in this case we have to worry about min-bias event background only which will produce fake triggers and forget for a moment about other physics backgrounds.

II Results

To study the trigger process $ZH \to \nu\nu b\bar{b}$, we have looked at two different signal samples and one background sample:

- signal sample of ZH events for μ triggers (S_μ). To generate those events Pythia has been used with $M_H = 90$ GeV, with forced decays of $Z \to \nu\nu$ and $H \to b\bar{b}$ and the following requirements for the accepted events: 1 or more muons with $|\eta| < 1.5$ and $p_T(\mu) > 1.5$ GeV. Out of 5000 generated events 1225 events, or 24.5%, survived those requirements. After that, the remaining signal sample has been processed through UPG_GEANT and UPG_TRG, both of versions February 97 [3]
- signal sample of ZH events for jet triggers (S_{jet}). To generate those events the same Pythia has been used with $M_H = 90$ GeV, with $Z \to \nu\nu$ and Higgs decaying naturally $H \to all$. About 10K events have been generated and processed through August 96 versions of UPG_GEANT and UPG_TRG
- for background rate estimates standard min-bias Run II trigger ntuple has been used [4] with multiple interactions taken into account for $\mathcal{L} = 2 \times 10^{32}$ cm^{-2}sec^{-1}

Then for signal samples we check efficiencies for different set of cuts, and for background - trigger rate. For the S_μ sample we required the presence of at least 1 muon and 1 jet and tried the following trigger variables available on the Level I framework: transverse momentum of muon, $p_T(\mu)$, and transverse energy of the jet, $E_T(jet)$. For the S_{jet} sample we required the presence of at least 2 jets and missing energy, and tried the following variables: transverse energy of the jet, $E_T(jet)$ and missing energy, M_{ET}. We have to note here that as $E_T(jet)$ we will be using the L1 trigger tower ET.

The family of trigger efficiency curves for the signal muon sample S_μ is shown in Fig. 1. Two parameters have been changed: $E_T(jet)$ and $p_T(\mu)$. The similar Level I trigger rate curves for min-bias event background is shown in Fig. 2. From those figures we may conclude that signal trigger efficiency does not depend much on the choice of $E_T(jet)$ and $p_T(\mu)$ cuts, while applying those cuts to the background sample reduce background trigger rate by more than two orders of magnitude. For example, for $E_T(jet) > 5$ GeV and $p_T(\mu) > 3$ GeV the signal trigger efficiency is still acceptable, $\epsilon \sim 0.6 \times 0.25 = 0.15$ and background trigger rate is about 100-150 Hz.

Trigger efficiency curves for the signal jet trigger sample S_{jet} for different choices of the variables $E_T(jet)$ and M_{ET} is shown in Fig. 3. Trigger Level I rate curves for min-bias event background for different values of the same variables is shown in Fig. 4. Again, from those figures we see that signal trigger efficiency changes by the factor of 2 in extreme case of changing $E_T(jet)$ and M_{ET} variables, while applying cuts on $E_T(jet)$ and M_{ET} to the background sample again reduces background trigger rate by more than two orders of magnitude. For example, for $E_T(jet) > 5$ GeV and $M_{ET} > 15$ GeV the signal trigger efficiency is high enough, $\epsilon \sim 0.7$ and background trigger rate is about 100 Hz.

Summarizing the obtained results one could conclude that triggering at Level I on the $\mu + Jet$ sample (using $E_T(jet)$ and $p_T(\mu)$ cuts) and on the $jets + missing\ E_T$ sample (using $E_T(jet)$ and M_{ET} cuts) looks rather promising. But here we have to make a couple of comments regarding confidence in the obtained background trigger rates:

- statistics used for the min-bias background trigger rate estimate were rather pure, especially at low p_T region up to 10 GeV and should be considerable increased. Work on that project is in progress now.
- comparing results on min-bias trigger rates obtained with UPG_TRG Ntuple for the set of Level I triggers existed in Run I and adjusted to the Run I conditions ($\mathcal{L} = 10^{31}$ cm^{-2}sec^{-1}, bunch crossing of 3.5 μsec and cross section of 57 mB) showed that MC calculations are much lower then measured rates, especially for triggers where missing E_T has been used (see Table 1). Therefore careful study is needed to understand better this problem.

The next step in our study of the possibility to optimize the trigger strategy for the process $ZH \to \nu\nu b\bar{b}$ will be looking at the Level II trigger conditions to find other ways to improve background rejection without loosing signal efficiency.

Table 1: Comparison of the measured in Run I Level 1 trigger rates (V10.5) and calculated rates using conditions of the Run I.

Trigger Configuration	Rates measured (Hz)	Rates calculated (Hz)
EM_2_MED	21	3.4
EM_1_MON	310	64.6
JET_2_MED	200	36.8
MISSING_ET	0.71	0.027
JET_3_MISS	6.3	0.49

References

1. Report of the Tev-2000 Study Group, editors D. Amidei, R. Brock, Fermilab-Pub-96/082.
2. D. Hedin and V.Sirotenko, Limits on the Production of ZX and Third Generation Leptoquark using Dimuon Events, D0 note 3106, October 18, 1996.
3. UPG_GEANT is in the area d0$beta:[upg_geant.feb97] and as UPG_TRG the version UPG_TRG_FEB97_D0USER.EXE in d0$beta:[upg_trg] has been used.
4. J. Blazey, S. Gerber, UPG_TRG Ntuple, private communication.

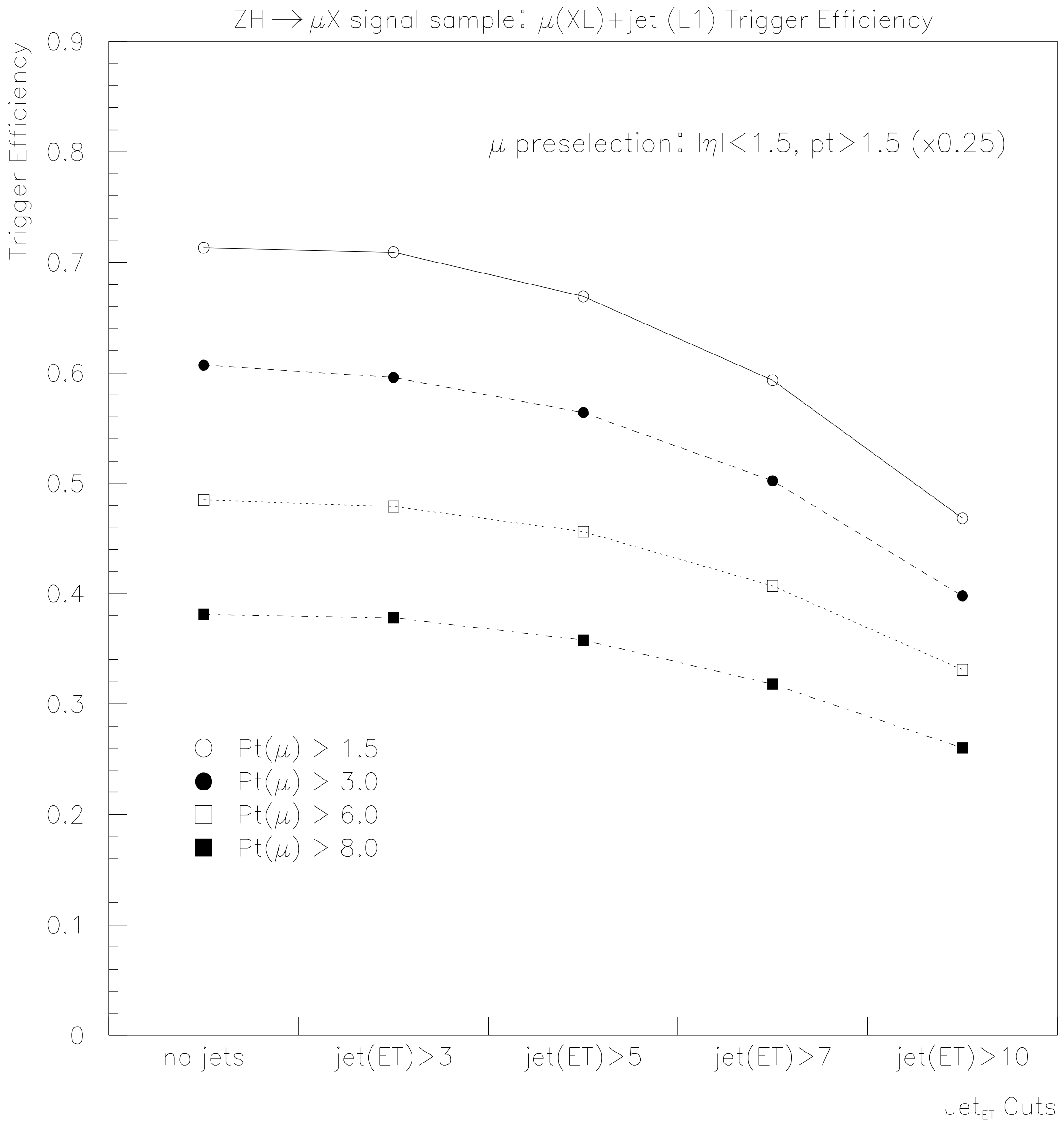

Figure 1: Trigger efficiencies for signal muon sample S_μ as a function of $E_T(jet)$ and $p_T(\mu)$.

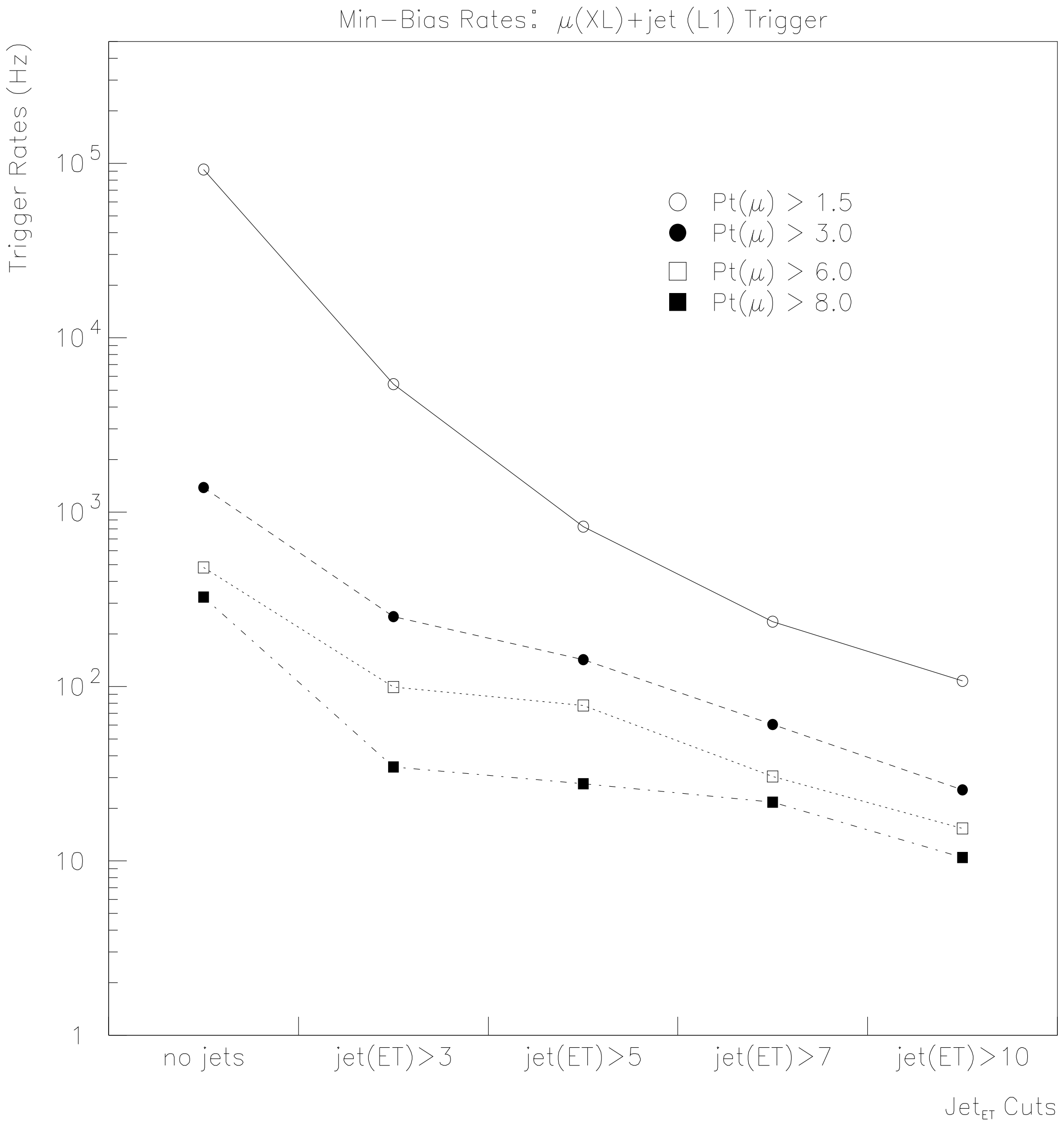

Figure 2: Trigger rates in Hz for background min-bias sample as a function of $E_T(jet)$ and $p_T(\mu)$.

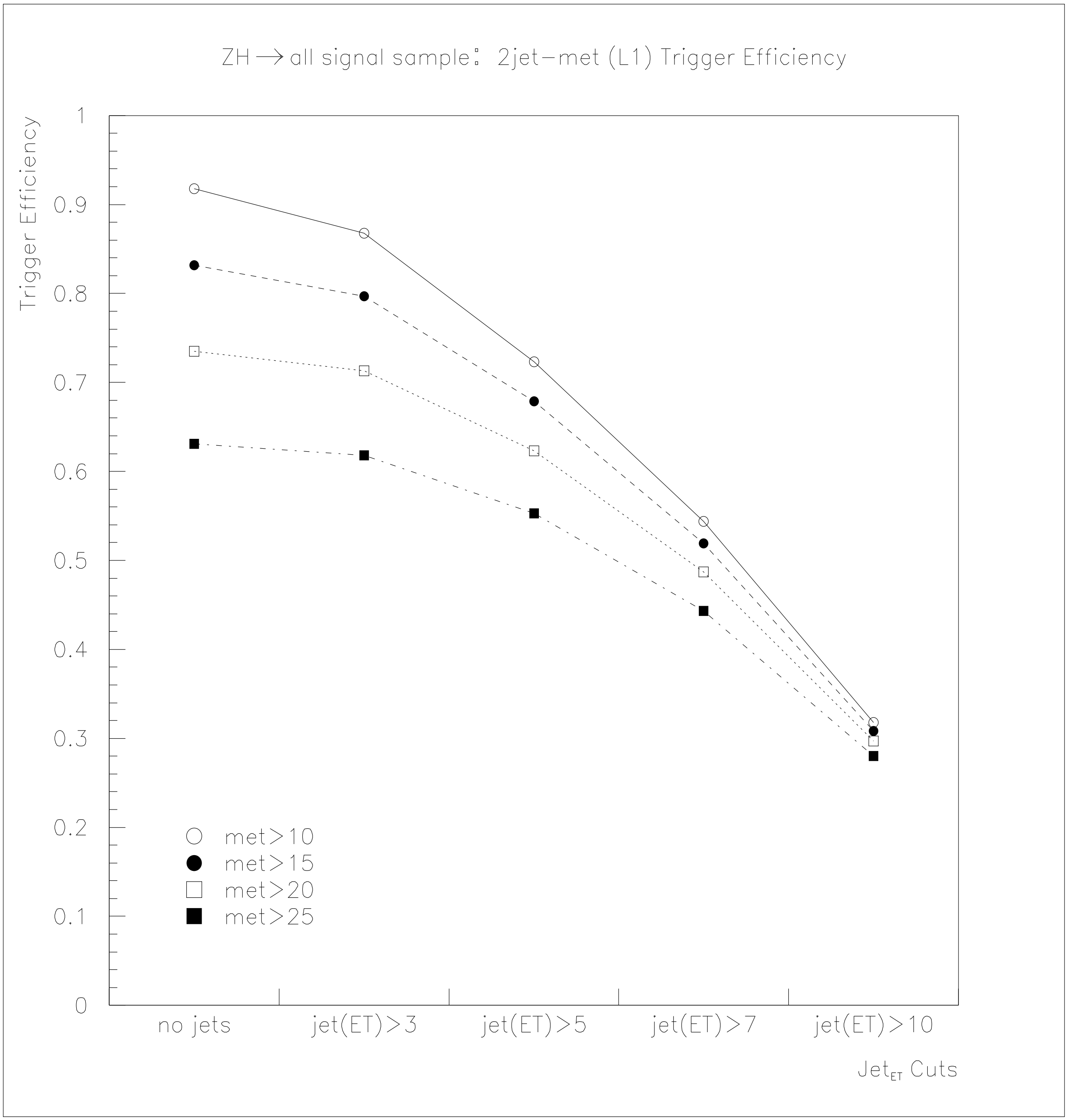

Figure 3: Trigger efficiencies for signal jet sample S_{jet} as a function of $E_T(jet)$ and M_{ET}.

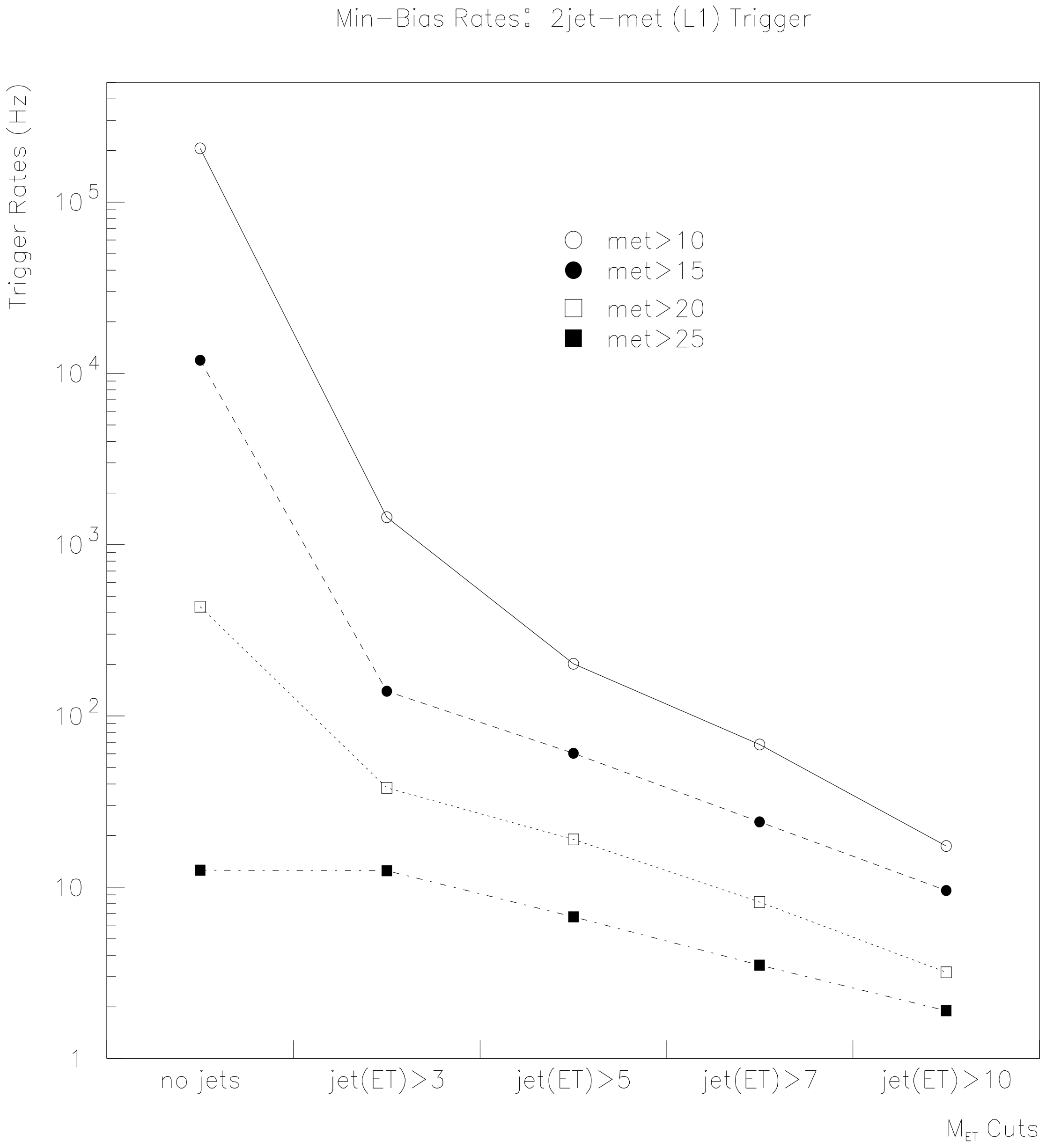

Figure 4: Trigger rates in Hz for background min-bias sample as a function of $E_T(jet)$ and M_{ET}.