0.1 Suppressing QCD contributions to lepton + jets using α_T

Following the promising results of the α_T jet-balancing method previously described for the all-hadronic SUSY searches, it is a natural progression to look for extensions of this approach to the single-electron search, where a significant presence of QCD multi-jet backgrounds is expected.

The α_T variable is here defined as an N-object system where the set of objects is 1 electron and N-1 jets. This definition reproduces the kinematics of a di-jet system by contructing two pseudo-jets, which balance one another in H_T. The two pseudo-jets are formed from the combination of the N objects that minimizes the $\Delta H_T \equiv |H_{T,1} - H_{T,2}|$ of the pseudo-jets, and the resulting α_T is

$$\alpha_T = \frac{1}{2}\frac{H_T - \Delta H_T}{M_T} = \frac{1}{2}\frac{H_T - \Delta H_T}{\sqrt{H_T^2 - MH_T^2}}. \tag{1}$$

The basic selection for single electron events in the leptonic α_T approach has the follwoing requirements:

- Exactly one electron passing requirements as follows:
  - $p_T > 20$ GeV
  - $|\eta| < 2.4$
  - Passes the Cut Based ID formed by simple, yet robust, variables (these are the H/E, the super-cluster (SC) - track matching variables $\Delta\phi$,$\Delta\eta$, and shower shape variable $\sigma_{i\eta i\eta}$, Tracker Isolation, ECAL Isolation and HCAL Isolation[1]).
- The event is vetoed if there are any muons passing the following requirements:
  - $p_T > 15$ GeV
  - $|\eta| < 2.1$
  - Passes ID requirement: IsGlobalMuon
- A jet is rejected if it is found close to a tight and isolated electron within ΔR=0.5. The jet selection is as follows:
  - $p_T > 20$ GeV
  - $|\eta| < 5$
  - EMF <0.9

The analysis uses data samples for the QCD multi-jet background processes produced with the full simulation production for Physics at 7TeV with CMS. The Monte Carlo datasets used are detailed in Table 1. The available luminosity is shown, although the plots are normallised to 1pb^{-1}. We use the EMenriched and BCtoE samples which are designed to be enriched in electrons, in order to enhance statistics. In addition, as these samples only cover the region 20< $\hat{p_T}$ <170 GeV/c, we include the inclusive QCD Jets sample for the region $\hat{p_T}$ >170 GeV/c.

[1] The cut based ID selection cuts are chosen to correspond to an 80% efficiency in the $W \rightarrow e\nu$ analysis.

Data Set	N events	σ (pb)	Equivalent luminosity (pb^{-1})
QCD BCtoE [20< $\hat{p_T}$ <30]	432380	108330	3.99
QCD BCtoE [30< $\hat{p_T}$ <80]	840100	138762	6.05
QCD BCtoE [80< $\hat{p_T}$ <170	682720	9422.4	72.4
QCD EM Enriched [20< $\hat{p_T}$ <30]	6169999	1719150	3.59
QCD EM Enriched [30< $\hat{p_T}$ <80]	9054696	3498700	2.59
QCD EM Enriched [80< $\hat{p_T}$ <170]	2492814	134088	18.59
QCDJets $\hat{p_T}$ >170	3132800	25470	122.99

Table 1: *The Monte Carlo datasets used to investigate the Delta ID Inversion method in QCD backgrounds. The available Lumniosity is shown, although plots produced are normalised to 1pb^{-1} for the purpose of understanding near-reach of CMS.*

This section is dedicated to a first approach of commissioning the alphaT observable and study its behavior in pure fake electron events. It is therefore desirable to collect a suitable control sample which will be dominated by fake electrons and eliminate sources of prompt electron events (like W events). One way to obtain such a sample is using the anti-selection method on electron ID variables which are less correlated with the missing transverse energy. In this section, we investigate the possibility of inverting the $\Delta\eta$(trk-SC) and $\Delta\phi$ (trk-SC) id cuts in the electron selection. The anti-selected events in this method are collected with electrons that pass all selection id criteria except the $\Delta\phi$ (trk-SC) and $\Delta\eta$(trk-SC) ones.

In order to establish the anti-selection method above, we compare next the perfomance of the leptonic α_T as obtained from the control sample and the actual QCD events passing the electron criteria defined in the "signal" region. The cutflow for 1pb^{-1} is shown detailing number of events at each step for QCD and W samples, for selected in Table Xa and for anti selected in TableXb.

Cutflow	QCD EM enriched	QCD BC$\rightarrow e$	QCDJets Pythia $\hat{p_T}$	W
All events				
N(e^-) ≥ 1				
N($jets$) ≥ 1				

Cutflow	QCD Total	W	
All events			
N(e^-) ≥ 1			
N($jets$) ≥ 1			

As mentioned previously, SUSY events are expected to have high H_T. Therefore it is critical to understand the behaviour in leptonic α_T as a function of H_T. The plots in 1 show the normalised shape of distributions, both before an H_T cut and the evolution with HT. The selected and anti-selected distributions agree very well.

In order to demonstrate the power of HT in α_T tail-reduction, we introduce the variable R_{α_T} which is defined as the ratio of the number of events passing the α_T cut over the number of events

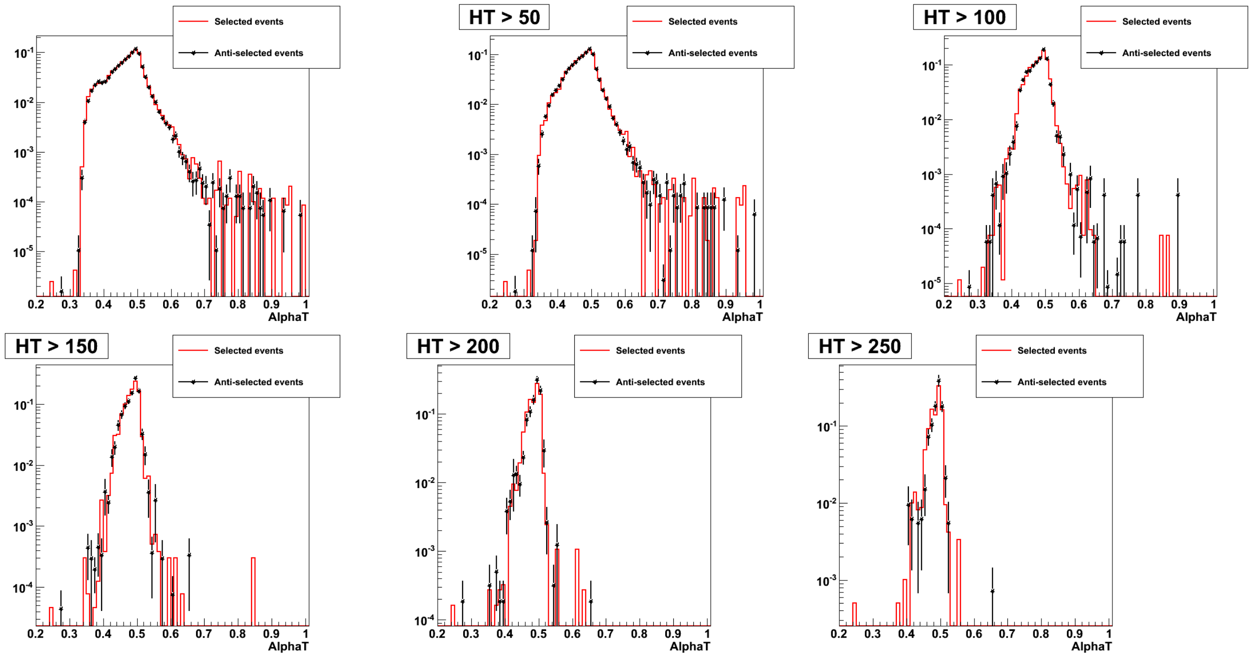

Figure 1: *The α_T distributions for selected (red) and anti-selected events (black) from inversion of the $\Delta\phi$ and $\Delta\eta$ ID Cutts, shown without HT cut (Top Left) and with progressive HT cuts (left-right, top-bottom). These distributions are normalised to unity for shape comparison. There is good agreement between the selected and anti-selected samples regardless of HT requirement, and the high α_T tails reduce as expected when moving to higher HT cuts.*

failing it:

$$R_{\alpha T} = \frac{N(\alpha_T > 0.55)}{N(\alpha_T < 0.55)} \tag{2}$$

The "default" cut value here is the value prompted from the all-hadronic analysis, 0.55. Figure 2 shows a plot of R_{α_T} as a function of the H_T cut applied. As the H_T requirement increases, R_{α_T} decreases in an exponential manner. The selected and anti-selected events from the electron id inversion method are in good agreement.

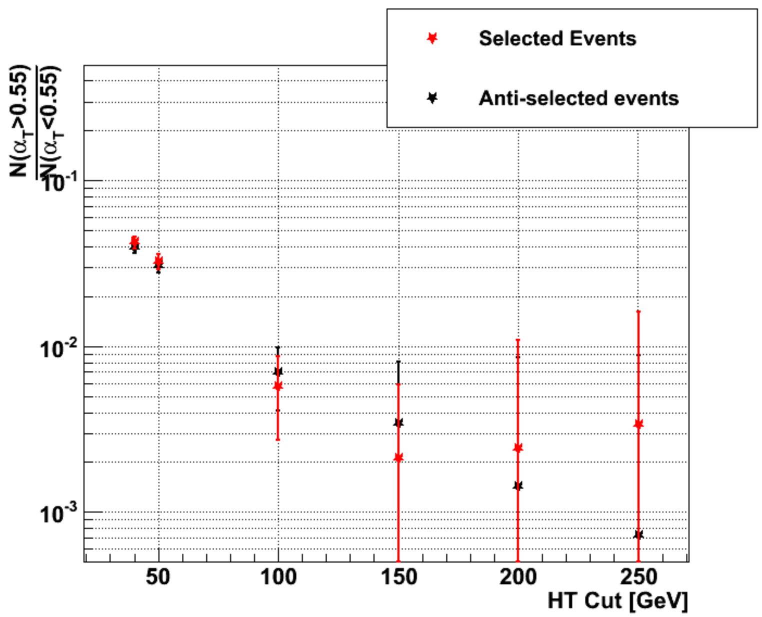

Figure 2: *The R_{α_T} versus the H_T cut applied for the QCD multi-jet background, shown for both selected and anti-selected events in the Delta ID Inversion method.*