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:

  - $p_T > 10$ 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 **??**. The available luminosity is shown, although the plots are normalised 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.

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

Data Set	N events	σ (pb)	Equivalent luminosity (pb^{-1})
QCD BCtoE [20< $\hat{p_T}$ <30]	432380	108330	3.9
QCD BCtoE [30< $\hat{p_T}$ <80]	840100	138762	6.1
QCD BCtoE [80< $\hat{p_T}$ <170	682720	9422.4	72.4
QCD EM Enriched [20< $\hat{p_T}$ <30]	6169999	1719150	3.6
QCD EM Enriched [30< $\hat{p_T}$ <80]	9054696	3498700	2.6
QCD EM Enriched [80< $\hat{p_T}$ <170]	2492814	134088	18.6
QCDJets $\hat{p_T}$ >170	3132800	25470	123.0

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	5351938	256514.4	25470	
N(e^-) $\geq$ 1	22120.98	13117.37	4.37	
N($jets$) $\geq$ 1	14783.29	7811.25	4.37	
HT ¿ 100 GeV	846.64	312.95	4.37	
HT ¿ 180 GeV	159.83	36.05	4.29	
Cutflow	QCD EM enriched	QCD BC$\rightarrow e$	QCDJets Pythia $\hat{p_T}$	W
All events	5351938	256514.4	25470	
N(e^-) $\geq$ 1	44807.39	1406.28	3.30	
N($jets$) $\geq$ 1	30089.89	920.40	3.30	
HT ¿ 100 GeV	1291.41	51.64	3.29	
HT ¿ 180 GeV	112.68	5.55	3.20	

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 **??** 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.
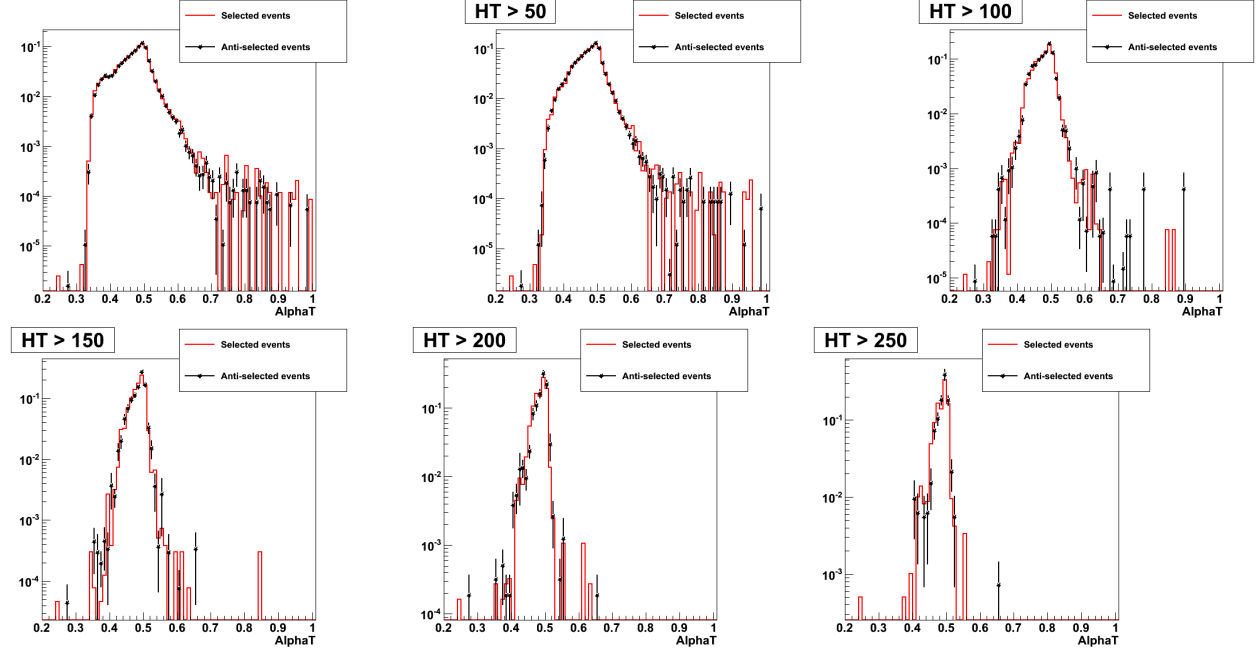

Figure 1: *The α_T distributions for selected (red) and anti-selected events (black) from inversion of the $\Delta\phi$ and $\Delta\eta$ ID Cutts, shown without HT cut (Top Left) and with progressive HT cuts (left-right, top-bottom). These distributions are normalised to unity for shape comparison. There 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.*

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 total number of events:

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

The "default" cut value here is the value prompted from the all-hadronic analysis, 0.55. Figure **??** 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.
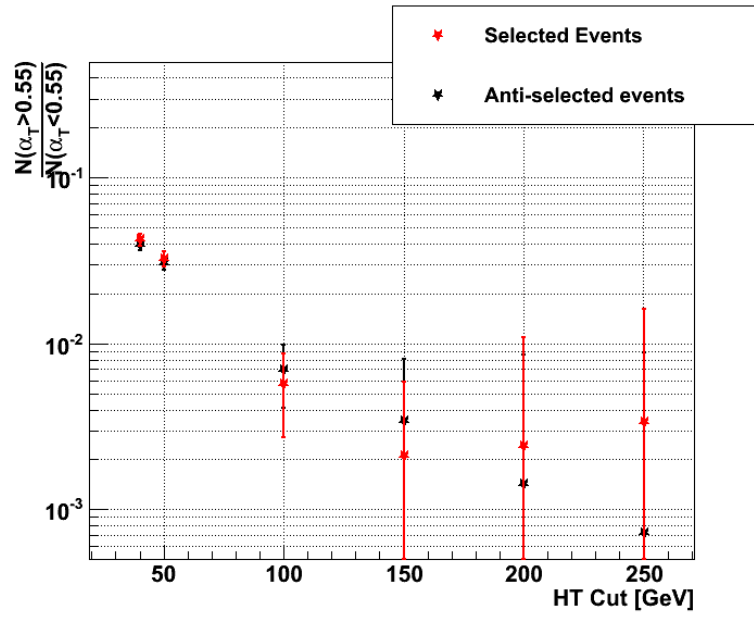
Figure 2: *The R_{α_T} versus the H_T cut applied for the QCD multi-jet background, shown for both selected and anti-selected events in the Delta ID Inversion method.*