Electron Charge Misidentification in the ATLAS Detector

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A reliable identification of the charge of leptons in the SUSY context is of great importance, considering one promising signature in superparticle search is the same-sign dilepton signal, due to a strong rejection of Standard Model background. We have conducted an analysis of electron charge misidentification in the ATLAS detector [1].

An overview of the magnitude of the charge misidentification rates in the $Z \to ee$ and $t\bar{t}$ Monte Carlo samples is given in table 1. It shows that the charge misidentification rate remains about the same magnitude across samples for electrons that are subject to the same quality cuts. In table 1 charge misidentification rates for 'medium' and 'tight' electrons are shown for each sample.

Sample	IsEM	Misid. Rate $[10^{-3}]$
$Z \to ee$	Medium	4.38 ± 0.10
	Tight	2.41 ± 0.09
$t\bar{t} \to$ non all-hadronic	Medium	4.72 ± 0.17
	Tight	2.30 ± 0.13

Table 1: Overview of the magnitude of charge misidentification probabilities in the $Z \to ee$ and $t\bar{t}$ Monte Carlo samples, with 526501 and 359836 truth electrons in 346450 and 560700 events respectively.

While the numbers in table 1 give an idea of its magnitude they do not show that the charge misidentification rate is a function of the pseudorapidity, i.e. the angle between the beam axis and the electron in question. It turns out that in the $Z \to ee$ sample the charge misidentification rate in the region $-0.5 < \eta < 0.5$ is around $1 \cdot 10^{-3}$ while for greater η values it rises almost exponentially to values of $2 \cdot 10^{-2}$ for $\eta = \pm 2.5$. The high dependence of charge misidentification on the pseudorapidity of the electrons leads to the assumption that bremsstrahlung and conversion processes play an important role, because they become more likely with increasing pseudorapidity since more detector material has to be traversed.

Simulation of the full detector response followed by a full reconstructionon of the Monte Carlo simulated data showed a higher number of reconstructed tracks in the vicinity of a reconstructed electron, in the case its charge was misidentified, compared to the average number of nearby tracks for all reconstructed electrons. This observation could be explained by bremsstrahlung and subsequent conversion of the bremsstrahlung photons that would give rise to the additional observed tracks.

Also this model suggests a possible mechanism leading to charge misidentification, if the track of an electron from a converted bremsstrahlung is associated to the electron candidate and this conversion electron carries the opposite charge with respect to the original electron. This assumption was tested by comparing the Monte Carlo energy of the highest energetic conversion electron with an opposite charge with respect to the original electron to the momentum of the track of the charge misidentified electron. The ratio of these two quantities is shown in figure 1 for the $Z \to ee$ sample. The large peak at 1 indicates that the above assumption holds in a high number of cases.

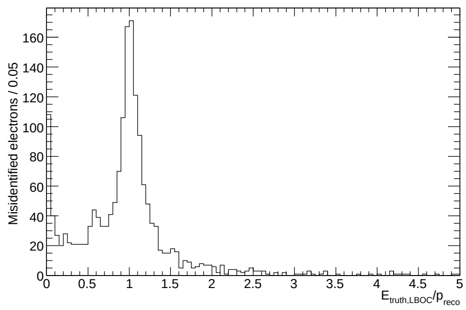

Fig. 1: Ratio of the Monte Carlo truth energy of the highest energetic conversion electron with an opposite charge with respect to the original electron and the momentum of the track of the charge misidentified electron for the $Z \to ee$ sample.

It was further looked at ways to reduce the charge misidentification rate. A cut on the transverse impact parameter, which describes the distance of the closest approach of the track to the beam axis, reduced the charge misidentification rate in the Monte Carlo datasets to 80%, while reducing the electron reconstruction efficiency by only 10%. The requirement that there are no additional reconstructed tracks in the vicinity of the reconstructed electron showed comparable performance.

With the prospect for real ATLAS detector data in the near future, it was looked at how to measure the charge misidentification rate from real data with a tag-and-probe approach using Z^0 decays. Taking the tag misidentification rates into account the estimates for the probe charge misidentification rate could be improved. The tag misidentification rates were determined by a maximum likelihood method. Figure 2 shows the results of the tag-and-probe method with and without taking the tag electron charge misidentification rates into account, in addition to the rate determined from Monte Carlo information.

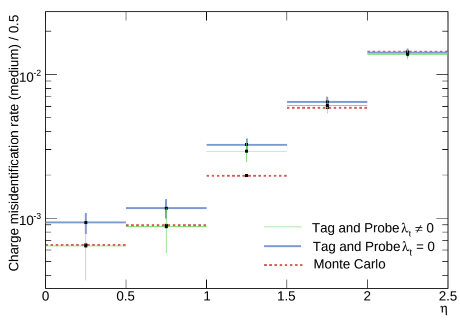

Fig. 2: Charge misidentification rates for medium electrons in the $Z \to ee$ sample for five η bins. The results of a tag-and-probe with and without taking tag electron charge misidentification rates λ_t into account are shown in addition to the rate determined from Monte Carlo information.

References

[1] M. Wichmann, diploma thesis, LMU München, 2008