European Organization for Nuclear Research

Summer Student Project

The Efficiency of electron identification in Underlying events problem

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1 Introduction

In a Hadron Collider the background evaluation task is very important and complicated. In particular, in Drall-Yan and High Transverse Momentum Jet production, *Underlying Events* are significant.

The Underlying Events (UE) are all that you see in a Hadron Collider event which are not coming from the primary hard scattering process. So, aside from a q-qbar pair annihilating to give you a pair of leptons for example, there are tracks and calorimeter energy coming from the non-scattering fragments of the two beam particles, potentially from other partons in the same beam particles which interact along with the primary ones, and other beam particles which happen to interact.

Let us consider Z-decay to the two leptons, played important role in current researches. For any lepton distributions to be correct, we should account for the efficiency of lepton reconstruction and identification.

The purpose of the present work is to evaluate efficiency of electron identification using *Tag and Probe* method.

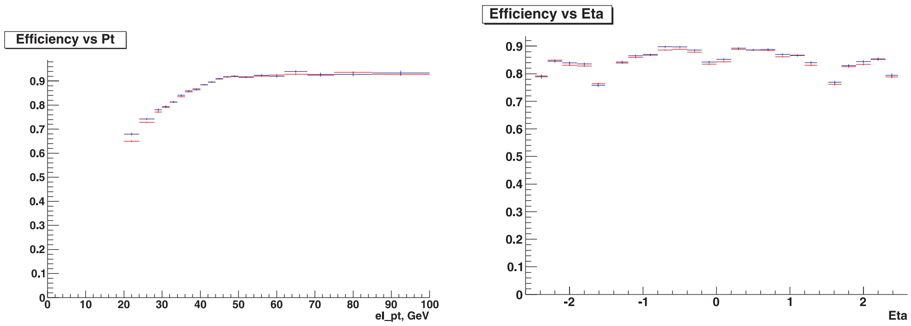
2 The statement of subProblem. The efficiency of electron identification.

Let us regard identification process. We have the special algorithm of identification of electrons - *Quality cuts*. According to the special manual - *BaseLine Selection* [BLS], if we have two candidates to electrons with opposite charge, to be sure that they are Z-decay electrons, it is necessary to set the next cuts:

1. Invariant mass cut: $|(P_{e+} + P_{e-})^2 - M_Z| < 25GeV$
2. Isolation criterion: $\frac{E_{con20}}{E_{tot}} < 15\%$
3. Algorithm of reconstruction cut: $Author = 1 \quad or \quad Author = 3$
4. passing **Medium With Track Match Algorithm**

where E_{con20} is the sum extended over all clusters in a cone of $\delta R < 0.3$.

To evaluate the efficiency of that algorithm (efficiency of electron identification), we should apply *Quality cuts* to the clean sample of electrons from Z decay, then the ratio of amount of electrons passed quality cuts e.g. identified as electrons to whole amount of electrons efficiency required.



(a) The distribution on P_t (b) The distribution on Eta

Figure 1: The efficiency of electron identification on Monte Carlo data: Results obtained using two analysis methods are presented by different colors: red - the direct MC-truth matching, blue - *Tag and Probe* method

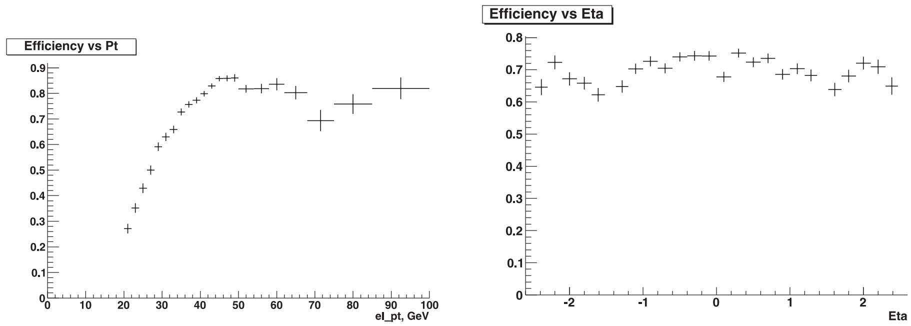
We will observe electrons having certain direction and the momentum only, e.g.

1. Pseudorapidity cut: $|\eta| \in (0, 1.37) \cup (1.52, 2.47)$
2. Momentum cut: $P_T > 20GeV$

It is important to notice that the correct four-momenta of electron forms on the track information and the cluster measurements in such way: if the track has more than 4 hits on pixal + SCT detectors then the direction of electron is reconstructed on the track information but energy - on cluster date, otherwise all quantities are taken from the cluster informations.

2.1 Tag and Probe method

For the clean electron samples to be produced *Tag and Probe* method has been used. The meaning of *Tag and Probe* [ATL] method is illustrated below. We started with the collection of electrons - candidates to electrons selected before. After Z decay we have two electrons. Setting high cuts (Tight Algorithm and Isolation), we find electron in an event. Let it have a label TAG. We are sure this electron to be from Z decay. So, the second electron from Z decay can be found using the fact that the invariant mass of TAG and PROBE electrons is approximately equal to the mass of Z boson. The electrons found in this way have label PROBE and form the clean sample of electrons.



(a) The distribution on P_t (b) The distribution on Eta

Figure 2: The efficiency of electron identification on ATLAS-Data

Now we can estimate the efficiency of identification on that sample. The result obtained is shown in Fig. 1

2.2 The proof of correctness of the result on MC data

The creation of clean electronic samples can be produced using truth MC data. The simplest way to form the clean sample of electron is to find electrons from Z decay in electron collection directly. We have MC truth data, so we can match the documentation truth-electrons from Z decay and electrons from the collection. In this case electrons found is certainly electrons from Z boson. And sample required is formed.

In this case matching is controversial. In the present work matching procedure is produced by comparing truth-electrons from Z-decay and electrons from the collection, in (η, ϕ) - space. The restriction on $dR = \sqrt{\eta^2 + \phi^2}$ is equal to 0.2. If more than one candidate satisfied $dR < 0.2$, then we select one, which has the closest momentum to the truth-electron from Z-decay.

The result is shown in Fig. 1. The total efficiency is 0.854 ± 0.005 in both methods.

3 Using Tag And Probe method on ATLAS-data

To estimate efficiency required on data we can use *Tag and Probe* method. Furthermore, we should select events when detector worked properly (*GoodRun-List* data11 7 TeV.AllYear.xml has been used). The larError event flag should be OK and triger (EFe20 medium) should be passed.

Result is shown as Fig. 2. The total efficiency is 0.706 ± 0.01.

4 Error

We suppose the distribution of the amount of electrons (N) in the clean sample to be Poisson Distribution. The variance of this quantity is equal to $\sqrt{\frac{1}{N}}$. The amount of electrons passed *Quality Cuts* has the same kind of distribution. The efficiency evaluated (ϵ) is the ratio of those quantities, so the variance should be $\sqrt{\frac{\epsilon(1-\epsilon)}{N}}$

It is necessary to calculate systematic error, but it hasn't been done in the present work.

5 Summary

In summary, the efficiency of identification has been evaluated, but the result observed is not right and final. The slump, we can see in the Fig. 2(a) at $60GeV$-region, is more than we wait, and efficiency at region of low Pt is too low than one expected. It is obvious that this problem needs more carefull analysis. The finding of the reason of such results and the evaluation of systematic error are tasks for the future work.

References

[ATL] The ATLAS Collaboration (April 24, 2011). *ATLAS NOTE, Supporting Document for egamma Paper*

[BLS] The ATLAS Collaboration *Baseline Selection for rel16 for the W/Z Physics Group. Version 1.1*