Muon Efficiency Corrections in ZEUS

Summerstudent Program 2007, DESY

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Abstract

This report will describe my project work during the DESY Summer Student Program 2007, which was the calculation of muon efficiency corrections in ZEUS.

Contents

1 Introduction

Becourse of the finite efficience of the ZEUS muon chambers, not every muon which hits the detector is seen by it. It is not possible to build a detector with an efficience of 100%. To simulate the detector, one has to take into account this finite efficiency to get proper results. In the ZEUS detector simulation this is not done completely, that meen some of the efficiencies are set to 1, so the number of muons seen in Monte Carlo is higher then in data. In order to compare the data with the simulation, one has to correct the Monte Carlo. Finding the correction factors (depending on the transvers momentum p_t and the pseudo-rapidity η) was the goal of my project work.

2 What is a muon in ZEUS?

A muon is a charged Minimum Ionizing Particle (MIP) with high penetration power. They yield tracks in the ZEUS inner tracking detectors and their curvature in the ZEUS solenoid field can be used to determine the muon momentum. Muons loose a well defiend amount of energy in the calorimeter along their trajectory. The range of a muon in iron is ~ 1 m/GeV and due to their high penetration power, muons are usually the only particles which can reach the different elements of the dedicaed muon systems.

3 Muon finders in ZEUS

There are different muon reconstruction algorithms which uses different detector components (e.g. calorimeter, muon chambers ...). We use the following muon finders:

- MV: uses calorimeter MIP information
- MPMATCH: uses forward muon detector
- BREMAT: uses barrel and rear muon detector
- MUBAC: uses backing calorimeter

In the analysis, we start from muons identified by MV and use this information to determine the efficiency of the other finders.

4 Dimuon events

We use dimuon events with exactly two muons in the final state and nothing else. These dimuon events have a very clean signature so we have low background. Also these events can be selected without using the muon chamber information.

We use eleastc J/Ψ and Bethe-Heitler events. The feynman graph of the J/Ψ production and decay is shown in figure 1. The feynman graph of the Bethe-Heitler process is shown in figure 2.

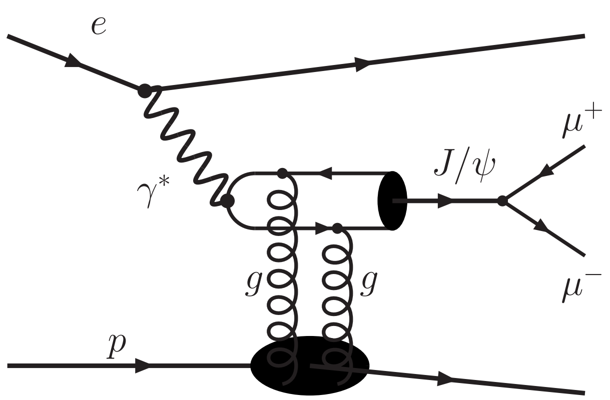

Figure 1: *J/Ψ production and decay*

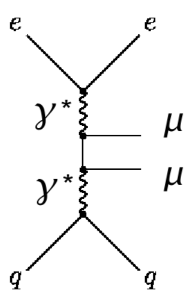

Figure 2: *Bethe-Heitler process*

5 Mixing of J/Ψ and Bethe-Heitler

5.1 Mass spectrum of the dimuon system

To find a proper mixing of the J/Ψ and Bethe-Heitler Monte Carlo samples, we use the invariant mass of the dimuon system. I had to vary the ratio until the sum of J/Ψ and Bethe-Heitler fits the data as best as possible (see figure 3). After finding a proper mixing factor, I used it to merge the J/Ψ and Bethe-Heitler samples with this weighting.

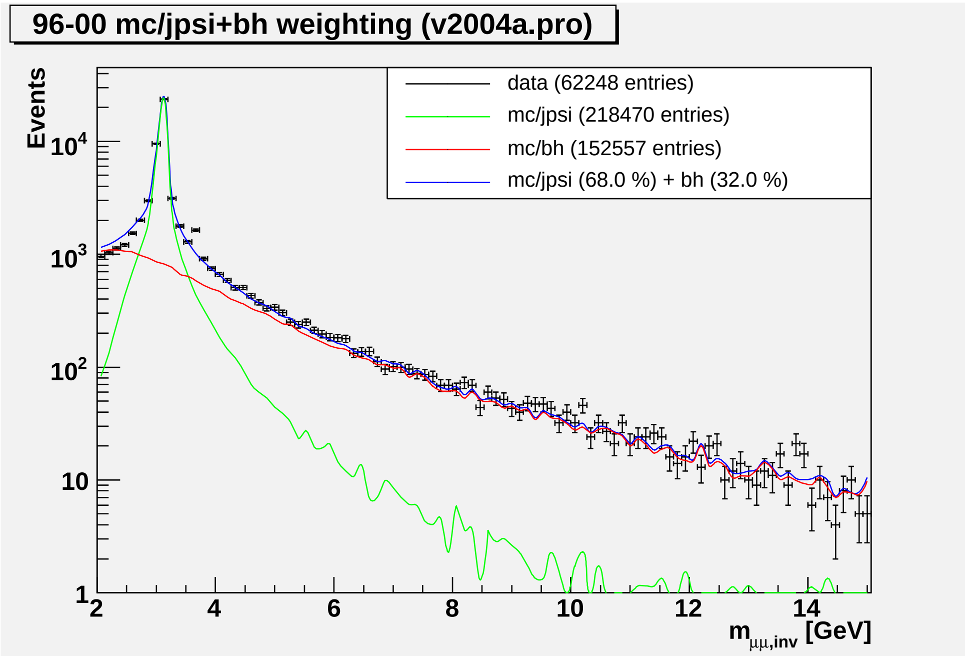

Figure 3: *mass spectrum of the dimuon system, used to find a prooper weighting of J/Ψ and BH*

5.2 Muon p_t spectrum

The efficiency of the ZEUS muon systems depends on the muon transverse momentum p_t. It is impotant to have the same muon p_t spectrum in data and Monte Carlo, because we calculate the efficiency for p_t bins with finite width.

To check the weighting of J/Ψ and Bethe-Heitler, I looked at the muon p_t spectrum to check that the Monte Carlo fits the date here also. One can see in figure 4, that this the case, so the weighting seems to be okay.

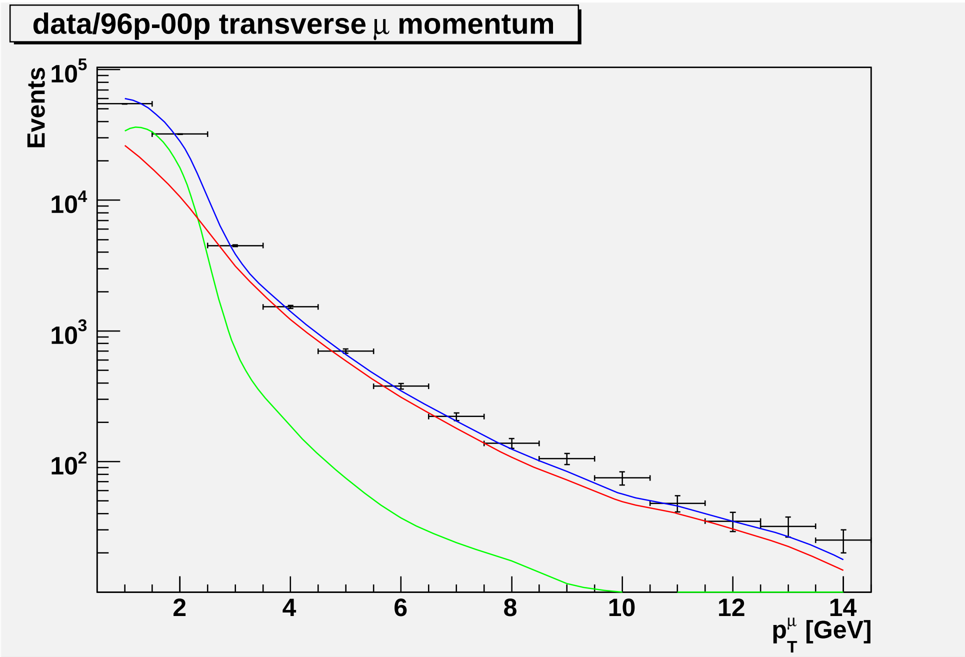

Figure 4: *muon p_t spectrum*

6 Muon efficiency

6.1 Definition of the efficiency

We start from muons identified by MV, so the efficiency of the muon finders is defined as the quotient of the number of muons seen by the finder + MV and the number of muons seen by MV.

6.2 Binning

The efficiency depends on the muon momentum (mainly the transverse momentum) and the angle of incidence, so we calculate the efficiencies for different bins in the transverse momentum p_t and the pseudo-rapidity η.

As an example, I show the plots for MUBAC with 1.6 GeV $\leq p_t \leq$ 1.7 GeV.

6.3 Efficiency of the muon finders in Monte Carlo and data

In the first step we count all muons identified by MV on the one hand and all muons identified by MV and the finder. Figure 5 shows the plot for one MUBAC p_t bin as an example.

By dividing these histograms, one gets the efficiency of the finders in Monte Carlo and data (figure 6).

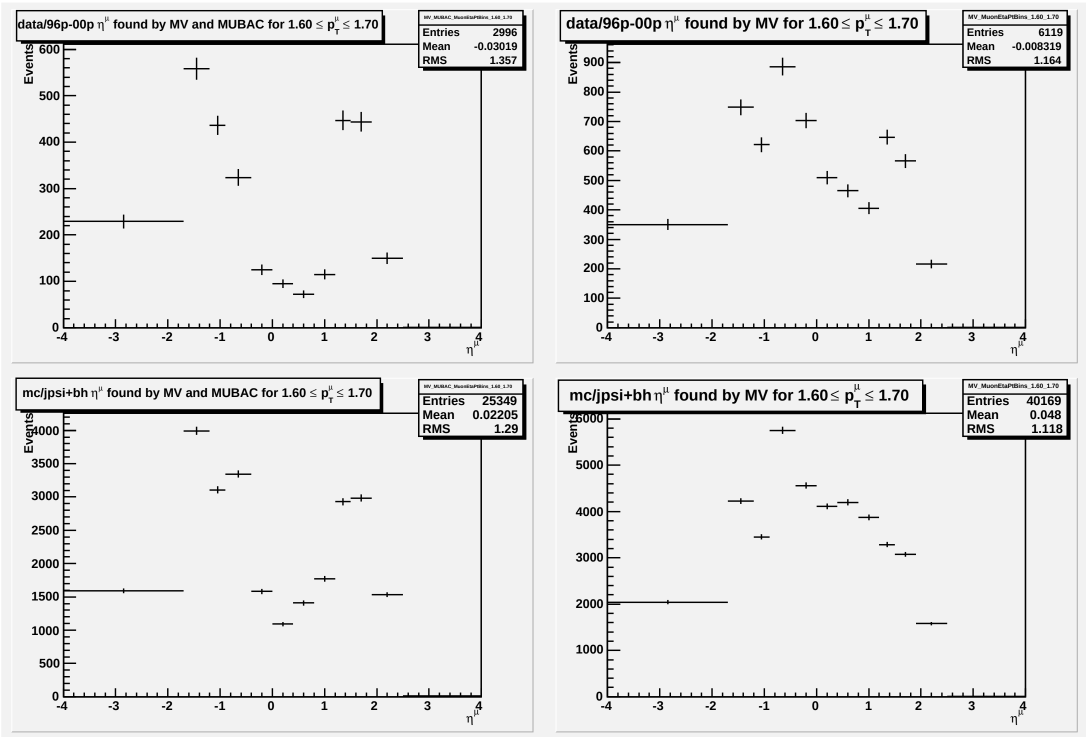

Figure 5: *muons found by MV+MUBAC and muons found by MV (upper: data, lower: MC)* $(1.6\ GeV \leq p_t \leq 1.7\ GeV)$

6.4 Efficiency correction between Monte Carl and data

The efficiency correction between Monte Carl and data is the quotient of the date efficiency and the Monte Carlo efficiency, so we get the correction factors by dividing the data and Monte Carl efficiency histograms.

Figure 7 shows the efficiency correction factors in a two-dimensional histogram depending on the transvers momentum p_t and the pseudo-rapidity η. In an analysis, these factors have to applied to the Monte Carlo to describe the data correctly.

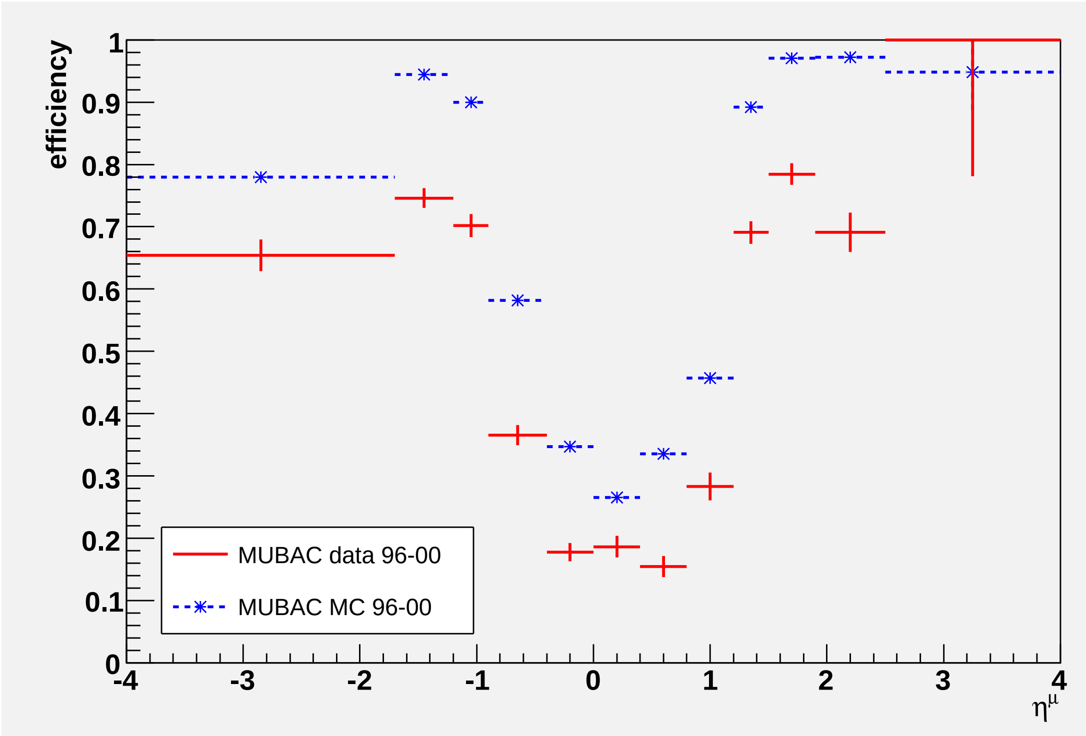

Figure 6: *MUBAC efficiency* $(1.6\ GeV \leq p_t \leq 1.7\ GeV)$

6.5 Application of the correction factors

The corrections should be applied at analysis level to the Monte Carlo samples. The data is never changed. For each muon and finder combination, the correction factor is taken from the corresponding histogram bin (depending on finder, muon p_t and η). This correction factor acts as a survival probability, so the finder information will be deleted if a created random number is above the correction factor. After applying all corrections to a muon candidate, one has to check if it still pass the quality cuts.

7 Results

During my stay at DESY, I calculated the efficiency correction factors for the HERA I 1996-2000 data using a ROOT/GUTCODE environment and they are ready for use. Igor Rubinsky continues the calculations for HERA II. Achim Geiser repeats the analysis using a POW environment to cross-check the results and to provide the correction factors also for POW users.

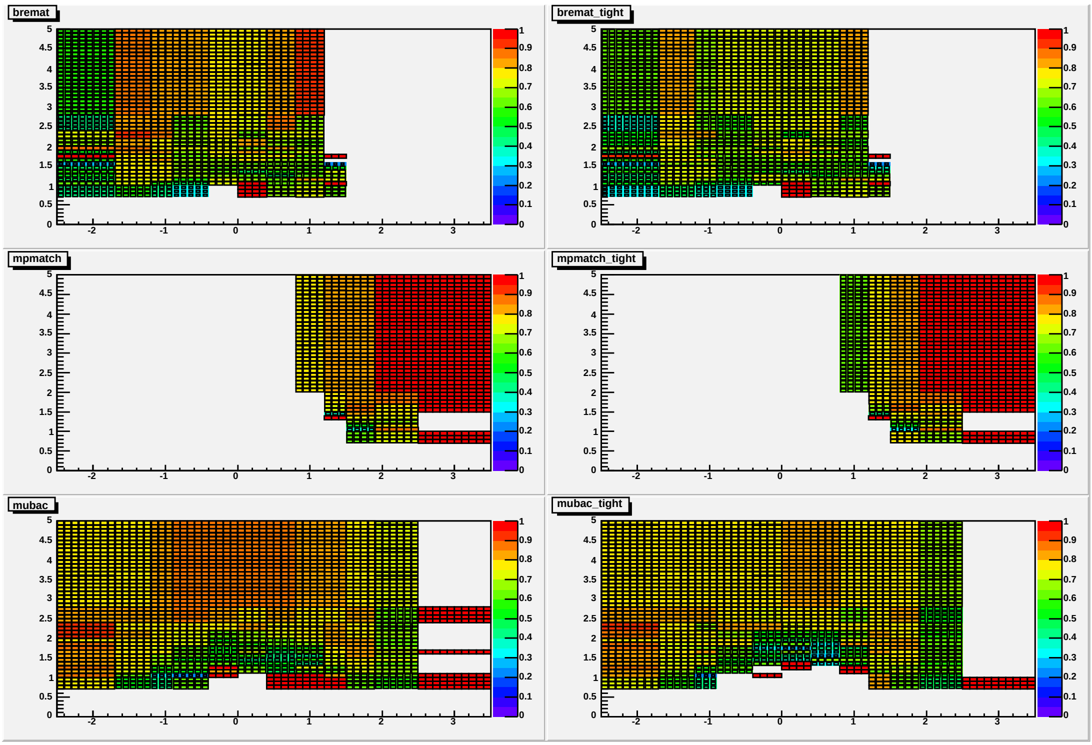

Figure 7: *Efficiency correction factors for the three muon finders BREMAT, MPMATCH and MUBAC in the* $\eta - p_t$ *- plane (left: LOOSE cuts, right: TIGHT cuts)*

The muon efficiency corrections are needed for some upcoming papers and will hopefully used in many future anaysis. A ZEUS note about it will be published soon.

8 Acknowledgements

I would like to thank my supervisor Achim Geiser, as well as Igor Rubinsky, Benjamin Kahle and Ingo Bloch, who all helped me a lot.

References

[1] A. Geiser, *GMUON - a general ZEUS muon finder*, ZEUS note 06-016.

[2] M. Corradi, *Efficiency corrections for the Muon finders BREMAT and MPMATCH2*, ZEUS note 04-006.

[3] A. Bertolin, R. Brugnera, M. Turcato, *Study of the GLOMU and BREMAT Muon-Finders Efficiencies*, ZEUS note 05-022.

[4] I. Bloch, *Measurement of beauty production from dimuon events at HERA/ZEUS*, Ph.D. thesis, Hamburg, Germany, DESY-THESIS-2005-034, DESY, 2005.