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Central Lepton ID Efficiencies for a Top Dilepton Analysis using Lepton + Track Z Boson Samples

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Abstract

We calculate the reconstruction and identification efficiencies of "tight" central leptons for the CEM,CMUP, and CMX categories. We then estimate the recontruction efficiencies of isolated tracks (track leptons or TL). Using these efficiencies we then calculate Drell-Yan production cross sections for a sample of 200 pb^{-1}.

Contents

1 Introduction

The purpose of this note is to evaluate the recontruction and identification efficiencies to be used in the lepton + track dilepton analysis and to validate the 200 pb^{-1} data sample.

The basic strategy is to use Z samples with one leg passing tight selections and the other leg passing very loose selections. The efficiencies are then estimated by calculating the fraction of events for which the second leg passes a set of selections. This fraction is corrected for backgrounds and biases introduced by the a priori selection of at least one tight lepton.

We follow the method of note 6281 [1] for electron efficiencies and describe the methodology we used for muon efficiencies. We perform the same calculation on Monte Carlo Drell Yan samples in order to derive data-to-MC scale factors.

In order to validate our dataset, we use these calculated efficiencies to measure Z production cross sections for the full dataset and compare relative cross sections between Run periods.

2 Event Selections

Our tight central lepton and isolated track selections are given in [2]. We describe below the selections used to identify "probe" leptons used in the denominator of our efficiency calculations.

2.1 Probe Electron Selections

The probe electron selections are given in table 1, and follow selections previously used by the Electron Task Force to compute efficiencies.

2.2 Probe Muon Selections

The probe electron selections are given in table 2, and loosely follow selections previously used by the Muon Recontruction group to compute recontruction and identification efficiencies.

Variable	cut
Electron type	defEmObject
E_t	>20 GeV
p_t	>10 GeV
Track $\|z_0\|$	$<$ 60 cm
abs(η)	<1.1
COT track quality	$\geq$ 20 axial and $\geq$ 16 stereo
Fiducial	Fidele = 4
Charge of leptons	opposite

Table 1: Probe electron identification cuts

Variable	cut
Muon type	defMuon
p_t	>20 GeV
Track $\|z_0\|$	$<$ 60 cm
abs(η)	<1.1
Em energy	<3 GeV
Had energy	<9 GeV
COT track quality	$\geq$ 20 axial and $\geq$ 16 stereo
Charge of leptons	opposite

Table 2: Probe muon identification cuts

2.3 Cosmics and conversions

For cosmic ray removal and conversion veto, we are using the standard Cosmic Ray Tagger and the conversion flag set in TopEventModule.

3 Efficiency Calculation results

For our calculations, we use the ztop0e and ztop0m Monte Carlo samples, each having about 300k events.

The formula for our tight electron efficiency calculation is given below:

$$\epsilon_T = \frac{2 \times N_{TT}}{N_{TP} + N_{TT}} \tag{1}$$

where N_{TP} is the number of tight-probe events and N_{TT} is the number of tight-tight events. N_{TP} is corrected for background contributions by counting the number of same-sign tight-probe events in the data sample and subtracting the estimated same-sign "physics" contribution using our Monte Carlo sample.

We note that our TL selections do not constitute a loose version of our tight selections because of the d0 cut used on TL candidates. The details of those calculations are given later.

3.1 Tight electron efficiency

For data, we obtain the following

- $N_{TP} = 4883$
- $N_{TT} = 3167$
- $\epsilon_T = .79 \pm 0.01$

For Monte Carlo, we obtain:

- $N_{TP} = 23577$
- $N_{TT} = 16370$
- $\epsilon_T = .82$

The resulting scale factor is: $.96 \pm 0.01$

3.2 Tight CMUP efficiency

For data, we obtain the following

- $N_{TP} = 3506$
- $N_{TT} = 824$
- $\epsilon_T = .38 \pm 0.01$

For Monte Carlo, we obtain:

- $N_{TP} = 19108$
- $N_{TT} = 5223$
- $\epsilon_T = .43$

The resulting scale factor is: $.88 \pm 0.02$

3.3 Tight CMX efficiency

For data, we obtain the following

- $N_{TP} = 1907$
- $N_{TT} = 219$
- $\epsilon_T = .21 \pm 0.01$

For Monte Carlo, we obtain:

- $N_{TP} = 1303$
- $N_{TT} = 10701$
- $\epsilon_T = .22$

The resulting scale factor is: 0.95 ± 0.05

3.4 Jet Multiplicity and Scale Factors

We now evaluate the scale factors above as a function of jet multiplicity.

For CEM electrons, we obtain the following scale factors:

- $\geq$1 jet bin: .94 $\pm$ 0.04
- $\geq$2 jet bin: .84 $\pm$ 0.06

For CMUP muons, we obtain the following scale factors:

- $\geq$1 jet bin: .82 $\pm$ 0.08
- $\geq$2 jet bin: .95 $\pm$ 0.15

For CMX muons, we observe no signifcant change in the scale factor for higher jet multiplicities.

3.5 TL d0 scale factor

Because we do not require our good run list to include silicon, our d0 cut efficiency depends on the fraction of the data in our sample that has good silicon runs. The efficiency of this cut using only the COT is about 40%. Here we measure this efficiency in the Monte Carlo (where silicon is always on) and in the 200 pb^{-1} data sample. We measure the fraction of probe electrons and muons that pass our 250μm d0 cut:

- electron data = .88
- electron MC = .93
- electron scale factor = .95 $\pm$ 0.01
- muon data = .90
- muon MC = .95
- muon scale factor = .95 $\pm$ 0.01

These scale factor values are consistent with a previous calculation that used the W no-track sample.

3.6 TL efficiencies

Our baseline TL efficiency was given above. However, because of material differences in the data and the simulation, we calculated a mass cut efficiency scale factor for both muons and electrons. We will need this efficiency later when we use a mass window between 76 and 106 GeV to select our Z boson events. The mass cut efficiency values are given below:

- muon data = 1.00
- electron data = .94 ± 0.01

To cross check our electron TL efficiency calculations we applied the d0 and track isolation requirements on the TCL which made the TL selections a subset of the TCL selections. We then used the following formula to estimate the efficiency:

$$\epsilon_T = \frac{N_{TL} + N_{TT}}{N_{TP} + N_{TT}} \tag{2}$$

using this formula on both data and MC, we derived a scale factor of $.92 \pm 0.02$, which is consistent with the product of the d0 cut efficiency and the mass cut efficiency given previously.

For the analysis we will use a TL scale factor of 0.95 that accounts only for the d0 cut efficiency differences in data and MC. The mass cut efficiency for electrons will only be taken into account in our TCL(CEM)-TL Z cross section measurement below.

A systematic uncertainty on the TL isolation efficiency of 6% was calculated as a function of the number of jets using a W sample innote 6532 [2]. We will use this value as our global TL efficiency uncertainty since the uncertainties calculated here would not contribute significantly.

4 Cross sections

We use the following formula to calculate our cross sections:

$$\sigma_Z = \frac{N_{obs} - N_{bkg}}{(sf_i) A\epsilon\mathcal{L}} \tag{3}$$

The acceptance times efficiency ($A\epsilon$) is derived from MC and the relevant efficiency scale factors (sf_i) calculated above are applied. The generation of

sample	126 pb^{-1} sample	73pb^{-1} Summer sample
CEM-CEM	226$\pm$ 5	220 $\pm$ 9
CEM-TL	227$\pm$ 5	223$\pm$ 7
CEM-Central cluster	250$\pm$ 5	250$\pm$8
CMUP-CMUP	180$\pm$7	184$\pm$11
CMUP-TL	203$\pm$ 4	209$\pm$6

Table 3: Raw Z cross section for 2 data taking periods

Sample	Cross section (pb)
CEM-CEM	243 $\pm$ 7
CEM-TL	252 $\pm$ 5
CMUP-CMUP	238 $\pm$ 12
CMUP-TL	247 $\pm$ 7
CMX-CMX	237 $\pm$ 30
CMX-TL	251$\pm$ 13

Table 4: Z cross section mesurements for the 200 pb^{-1} data sample.

our MC samples used an invariant mass cut of M_{ll} >30 GeV/c^2. For the denominator of the acceptance, we use only events that have an invariant mass at HEPG level of $66 < M_{ll} < 116$.

4.1 Validation of Data vs Run Period

Since the goal of this section is to compare cross sections in various data taking periods, we use the acceptance and efficiency straight from the Monte Carlo simulation with the exception of the relevant d0 cut efficiency for the period. We also neglect trigger efficiencies. Table 3 lists our results:

We conclude that the results obtained using the summer data are consistent with our previous data sample.

4.2 Final Central Lepton Cross Sections for 200 pb^{-1} Sample

Table 4 contains the Z boson cross sections for the 200 pb^{-1} sample which were calculated using the efficiencies obtained previously. We use the trigger efficiencies reported in [2] for the TCL-TL categories of 96% for CEM, 93% for CMUP, and 98% for CMX. The trigger efficiencies for the TCL-TCL are calculated using the single rate efficiencies and then taking into account the fact that we had two triggerable tight leptons.

5 Conclusion

We measured the tight central lepton and isolated track efficiencies using samples of Z boson candidates. We used these efficiencies to calculate Z cross sections for different lepton samples in 200 pb^{-1} of data. We also measured cross sections for two different data takingperiods and found them to be consistent with each other.

References

[1] Y.K. Kim, G. Manca *Z to electrons Cross Section measurement with Run II data* , 2003. CDF note 6281

[2] D. Glenzinski et al. *Signal and Background Acceptance for a Top Dilepton Analysis using the Tight Lepton + Isolated Track Sample Cross-Section Measurement*, 2003. CDF note 6532

[3] M. Coca, P. Tipton, E. Halkiadakis, A. Hocker, R. Eusebi, P. Koehn, M. Kruse, U. K. Yang, *Acceptance Estimate for the Winter 2003 Top Dilepton Cross-Section Measurement*, 2003. CDF note 6301