CDF/ANAL/TRIGGER/CDFR/6553
Version 1.0
September 9, 2003

Lepton+Track Triggers: Measurement of the Level 3 Trigger Efficiency for Taus

S. Baroiant,[a] M. Chertok,[a] M. Goncharov,[e] T. Kamon,[e] V. Khotilovich,[e] R. Lander,[a] T. Ogawa,[f] C. Pagliarone,[b] F. Ratnikov,[d] A. Safonov,[a] A. Savoy-Navarro,[c] J.R. Smith,[a] S. Tourneur,[c] E. Vataga[b]

(a) University of California, Davis
(b) INFN, Pisa, Italy,
(c) LPNHE-Universités de Paris 6&7/CNRS-IN2P3, France
(d) Rutgers University
(e) Texas A&M University
(f) Waseda University, Japan

Abstract

We present Level 3 efficiency measurement of the track leg in the lepton plus track trigger for tau using a jet sample. The sample has been selected by requiring the presence of at least one CdfTauObject. The trigger efficiency is measured as a function of $p_{\mathrm{T}}^{-1}$of tau seed track, $\Sigma^{iso}p_{\mathrm{T}}$, and $\Delta\theta^{in}$. The efficiencies at plateau are found to be $98.90 \pm 0.12(stat) \pm 0.72(sys)$ %, $98.95 \pm 0.11(stat) \pm 0.72(sys)$ %, and $99.01 \pm 0.13(stat) \pm 0.72(sys)$ % for 1, 2, and 3-prong events respectively.

1 Introduction

We have implemented three lepton plus track triggers, namely TAU_ELECTRON8_TRACK5_ISO, TAU_CMUP8_TRACK5_ISO, and TAU_CMX8_TRACK5_ISO [1, 2, 3]. All triggers listed above require a track object satisfying common isolation criteria at Level 3 (L3). In addition to being generic dilepton triggers, these triggers are highly efficient for selecting taus. The 5-GeV isolated track (IsoTrack) is expected to become a seed track of the tau object. In this note, we present results of the studies of the efficiency of the track (tau) part of the L3 trigger for selecting taus.

In the absence of a clean unbiased sample of taus, we had to use a sample of tau candidates dominated by fake taus. Naive counting of the number of events passing L3 over the number of events submitted for the test typically results in rather low "efficiency", main reason being that real taus have different topology than an "average fake". On the other hand, L3 has no means of distinguishing between real and fake taus either and, therefore, a detailed study of the sources and nature of L3 inefficiencies will lead to a parametrization that correctly takes into account these effects. Any unresolved effects then become the systematic uncertainty of the measurement, and a more thorough study will allow minimizing these uncertainties to an acceptable level.

2 Trigger Description and the Data Sample

2.1 Level-3 lepton plus track trigger selections

A brief description of the trigger is given here. The lepton plus track trigger requires 8-GeV/c lepton (e, μ) and 5-GeV/c IsoTrack at L3 (See Ref. [3] for details). The requirements for the IsoTrack leg are summarized in Table 1.

· $p_{\mathrm{T}}^{seed} \geq 5$ GeV/c (Seed Track)
· $\lvert\eta\rvert \leq 1.5$
· no track with $p_T > 1.5$ GeV/c and $\lvert\Delta z_0\rvert < 15$ cm in $0.175 \leq \Delta R \leq 0.524$

Table 1: L3 cuts for IsoTrack

Here $|\Delta z_0|$ is the distance in z along the beamline between the seed track and any other track. The angles are measures in radians, 0.175 radians corresponds to 10^0, and 0.524 radians corresponds to 30^0. The L3 cone definition is $\Delta R \equiv \sqrt{\phi^2 + \eta^2}$, where ϕ and η are track angles. Further we will refer to $\Delta R \leq 0.175$ cone as a L3 signal cone.

2.2 Data Sample

To avoid trigger biases, the data were stripped from the jet datasets (gjet08). We select events with one of the bits JET_20, JET_50, or JET_70 set. The jet triggers use calorimeter information only, while lepton+track triggers use exclusively tracks. Therefore the jet sample is not correlated with the lepton+track sample.

TauFinder Settings:	$\cdot$ Cluster $E_{\mathrm{T}} > 6$ GeV
	$\cdot$ Seed Track $p_{\mathrm{T}}^{seed} > 4$ GeV/c
Selections:	$\cdot \geq 1$ CdfTau
	$\cdot$ $Mass(trk + \pi 0) < 3.0$ GeV/c^2

Table 2: Pre-selection cuts for CdfTauObject

Signal Cone :	$0.000 < \theta < \alpha$
Isolation Annulus :	$\alpha < \theta < 0.524$
α :	0.05 (for $5.0/E^{clu} < 0.05$)
	$5.0/E^{clu}$ (for $0.05 < 5.0/E^{clu} < 0.175$)
	0.175 (10^0) (for $5.0/E^{clu} > 0.175$)

Table 3: Cone definition.

For pre-selection, we selected a sample of events with at least one loose tau candidate, as summarized in Table 2. For initial stripping we re-run TauFinderModule on-the-fly with $p_{\mathrm{T}}^{seed} > 4$ GeV/c and stripped events based on the newly created tau objects. After initial stripping, we drop all high-level objects, re-run L3 executable (v4.3.0) on the data, and then run Production (v4.8.4) again to have both L3 and Production level objects. The cone (signal and isolation) definition for production tau is different from L3 and is summarized in Table 3.

For the final efficiency measurement, we used events with high quality tau candidates by applying a set of cuts summarized in Table 4. These requirements are close to the standard tau quality cuts (See Ref. [4]). Note that despite of rather strict requirements the sample still consists of mainly jets faking taus.

For tau isolation, we require no reconstructed tracks with $p_{\mathrm{T}} > 1$ GeV/c inside the isolation annulus (we use a standard now sliding cone defined as in Table 3). In addition we require tau to be isolated in terms of L3 isolation (ΔR cone).

2.3 Matching L3 to Production

The efficiency depends on how well it is possible to match Level 3 isolated track to the Production tau. We adopted a very simple prescription for the matching: the isolated track must be inside the Tau signal cone, and $|\Delta z|$ between the track and the tau seed track is less then 15 cm. For more information see A.4.

3 Major Sources of Inefficiency

We found several important effects that cause L3 to fail a seemingly good offline tau candidate. First, there are effects of angular resolution when an offline track is reconstructed by L3 with a slightly different angular parameters. For relatively "wide" tau candidates, it may lead to one of the tau tracks fall outside the signal cone defined by the seed track. If that happens, the formerly tau track becomes a background track and the event is vetoed by L3. We define a variable $\Delta\theta^{in}$

· Seed Tower $E_{\mathrm{T}} > 6$ GeV
· Seed Track $p_{\mathrm{T}} > 4$ GeV/c
· Seed Track $\lvert z_0 \rvert < 60$ cm
· $\lvert \Delta z_0^{\mathrm{pv}} \rvert$(Seed Track, Closest Primary Vertex) < 5 cm
· Seed Track $\lvert d_0^{cor} \rvert < 0.1$ cm
· $CalIso < 6.0$ GeV
· $p_{\mathrm{T}}(trk + \pi 0) \geq 4$ GeV/c
· $\lvert \eta \rvert \leq 1.0$
· $Mass(trk + \pi^0) < 1.8$ GeV/c^2
· $\xi \equiv E_{\mathrm{T}}^{had} / \Sigma \lvert p_{\mathrm{T}} \rvert > 0.1$
· No track (> 1.0 GeV/c) in isolation annulus
· No π^0 (> 0.5 GeV) in isolation annulus
· Fiducial for Seed Track
$9 \leq \lvert z_{\mathrm{CES}}(\mathrm{r{=}183.9cm}) \rvert \leq 230$ cm
$\lvert z_{\mathrm{COT}}(\mathrm{r{=}137cm}) \rvert \leq 150$ cm
$N_{\text{axial SL}}, N_{\text{stereo SL}} \geq 3$
· Fiducial in terms of L3 isolation
No track with $p_{\mathrm{T}} > 1.0$ GeV/c and $\lvert \Delta z_0 \rvert < 15$ cm
in $0.175 \leq \Delta R \leq 0.524$ around the Seed Track

Table 4: Offline τ quality cuts

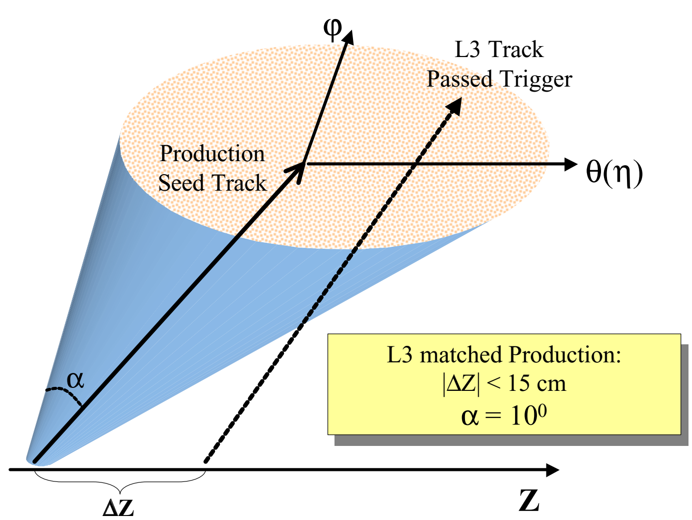

Figure 1: Matching between tracks at L3 and production. The selection is: $\alpha = 10^0$ and $\lvert \Delta z \rvert < 15$ cm.

as the minimum angle in θ between all tracks in the L3 signal cone of the tau candidate and the boundary of the signal cone [1] (See Fig. 2). The closer the track is to the boundary, the higher is the probability of the event to fail L3 trigger. The beauty of this variable is that it represents the track "resolution" in θ and is independent of η of the detector. Also, the measurement will apply to any size of the signal cone.

Another effect is related to L3 curvature resolution with respect to the offline. We break this effect into two pieces. In the first case, the seed track p_{T} sometimes can fluctuate below the L3 threshold of 5 GeV/c. This affects the resolution of the turn-on curve as a function of the seed track transverse momentum, p_{T}^{-1}. Second effect is related to the soft background tracks in $0.175 < \Delta R < 0.524$ being promoted by L3 to exceed the threshold of 1.5 GeV/c, at which point such track will violate the isolation requirement and the event will be vetoed. This effect is less trivial as it depends on the number of soft tracks in the isolation region and also has a non-linear contribution when many hits from these tracks can confuse L3 and make it combine unrelated hits into a new track with p_{T} above the threshold. We found that tracking isolation defined as a scalar sum of all COT tracks inside the cone $0.175 < \Delta R < 0.524$, called $\Sigma^{iso} p_{\mathrm{T}}$ (See Fig. 2), is a good variable to parameterize this effect [2]. See A.5 about how the total efficiency depends on the choice of $\Sigma^{iso} p_{\mathrm{T}}$ and $\Delta\theta^{in}$.

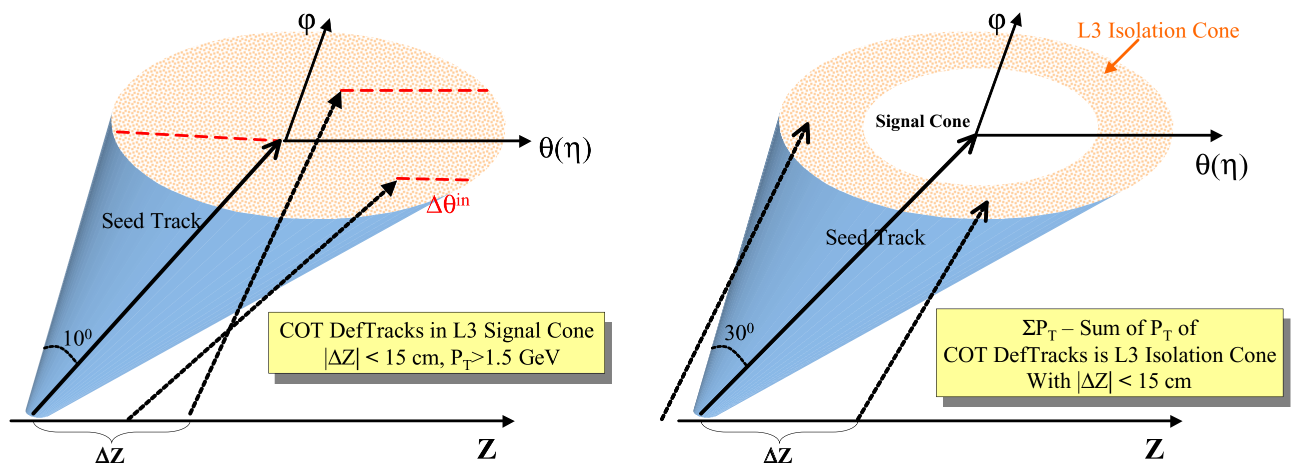

Figure 2: Definitions for $\Delta\theta^{in}$(left) and $\Sigma^{iso} p_{\mathrm{T}}$(right). $\Delta\theta^{in}$ is the minimal θ between tracks and the signal cone.

Furthermore, one should realize that tau candidates are essentially jets with tracks being close to each other, these tracks often overlap and have common hits complicating pattern recognition. These effects are always difficult to quantify. We chose to use the number of prongs in the tau candidate as a measure of the COT activity. The number of prongs might not be the best variable to account for pattern recognition effects, but it is a natural variable for taus, which determined

[1] The considered tracks all have $p_{\mathrm{T}} > 1.5$ GeV/c, and $|\Delta z| < 15$ cm from the seed track. We do not use stand-alone silicon tracks, which ensures that all considered tracks have at least one axial and one stereo super-layer.

[2] The considered tracks all have $|\Delta z| < 15$ cm from the seed track. We do not use stand-alone silicon tracks, which ensures that all considered tracks have at least one axial and one stereo super-layer.

our choice.

There are a number of less prominent effects affecting the efficiency that we noticed but chose to ignore in the final parameterization to avoid over-complicating things. As an example, sometimes L3 will pick up wrong stereo super-layers and make a track with very different $\cot\theta$. If such "new" track accidentally falls into the tau isolation cone, the event will be vetoed. Sometimes (especially for cases when the seed track has less than 4/4 stereo/axial super-layers) this effect can even move the seed track very far from it's original position and the tau will not be found.

4 Methodology

4.1 General Definition of Efficiency

We define efficiency as: .

$$\varepsilon(\vec{x}) = \frac{N_{\tau\ cand}^{pass\ L3}(\vec{x})}{N_{\tau\ cand}(\vec{x})}$$

where N_τ is the number of taus passing offline ID selection used in physics analysis. $N_{\tau\ cand}^{pass\ L3}$ is the number of taus passing the selection and also having a matched L3 isolated track firing the trigger.

This is valid for the absolute efficiency,[3]. For relative efficiency, contributing tau candidates in the numerator and denominator are also required to pass L2 trigger requirements (XFT track). We define a relative efficiency of L3 finding a tau candidate as a probability of a good tau candidate with parameters denoted as $\vec{x}$ to pass L3 requirements:

$$\varepsilon^{rel}(\vec{x}) = \frac{N_{\tau\ cand}^{pass\ L3:L2}(\vec{x})}{N_{\tau\ cand:L2}(\vec{x})}$$

We define a tau candidate matched if there was an isolated track passing trigger requirements is found by L3 inside the tau signal cone.

The choice of parameters used to define the efficiency is determined by the major sources of inefficiency as described in Section 3.

4.2 Math Formalism

We can write the transformation of the original or "true" distribution to the observed one in the formal way:

$$B(\vec{x}) = E_{ff}(\vec{x}) \times A(\vec{x}).$$

Or, redefining for the efficiency:

$$E_{ff}(\vec{x}) = \frac{B(\vec{x})}{A(\vec{x})},$$

[3]By absolute efficiency we denote the L3 efficiency for unbiased events, i.e. when no preceding selections at lower levels of the trigger were applied. Then relative efficiency is defined as efficiency of L3 for events that have passed trigger requirements at lower levels of the trigger.

where $B(\vec{x})$ is the observed distribution in multi- dimensional space $\vec{x}$, $A(\vec{x})$ is the true distribution, and $E_{ff}(\vec{x})$ is the efficiency function. The observed distribution projected into one variable can be calculated by integrating out other dimensions:

$$E_{ff}^{obs}(x_n) = \frac{\int E_{ff}(\vec{x}) \times A(\vec{x}) d\vec{x}^{\ n-1}}{\int A(\vec{x}) d\vec{x}^{\ n-1}}.$$

In case when the efficiency function can be factorized, the above formula can be re-written as:

$$E_{ff}^{obs}(x_n) = \frac{\int (\prod_{i=1}^{n} E_{ff}(x_i)) \times A(\vec{x}) d\vec{x}^{\ n-1}}{\int A(\vec{x}) d\vec{x}^{\ n-1}}.$$

If within the whole phase space one selects a region where all the efficiencies except the n-th are nearly flat: $E_{ff}(x_i) \simeq K_i = constant$, the previous equation gives the following relationship between the observed and true efficiencies:

$$E_{ff}^{obs}(x_n) = \frac{E_{ff}(x_n) \int (\prod_{i=1}^{n-1} E_{ff}(x_i)) \times A(\vec{x}) d\vec{x}^{\ n-1}}{\int A(\vec{x}) d\vec{x}^{\ n-1}} \simeq (\prod_{i=1}^{n-1} K_i) \times E_{ff}(x_n) = K \times E_{ff}(x_n),$$

where $K \equiv \prod_{i=1}^{n-1} K_i$. Thus measured efficiency will differ from the genuine efficiency due to that variable by a nearly constant factor. If it were possible to select a region where efficiencies are fully efficient without significant loss in statistics, one will get an exact result with $K = 1$.

In this note we follow the recipe described here. First we find variables that contribute independently to the overall efficiency. As explained in Section 3, these variables are $\Delta\theta^{in}$, tracking isolation $\Sigma^{iso}p_{\mathrm{T}}$, and the inverted transverse momentum of the seed track p_{T}^{-1}. Then we select a region where all efficiencies due to other variables are flat, measure the efficiency as a function of that variable

$$E_{ff}(x_n) = \frac{B(x_n)}{A(x_n)}, \tag{1}$$

and at the end present the total efficiency as:

$$E_{ff} = K \prod_{i=1}^{n} E_{ff}(x_i). \tag{2}$$

We perform a multidimensional fit to extract the overall parameter K. After it we use a Monte Carlo method in which we take the original distribution of all events $A(\vec{x})$ and produce the fake "observed" distribution $B(\vec{x})$ by throwing random numbers according to the overall efficiency function. At the end we compare the simulated inclusive[4] efficiency in each dimension to the one derived directly from the data to validate the assumption that the efficiency is uncorrelated in the phase space we chose. We introduce the slope into the error function when fitting for the $p_{\mathrm{T}}^{-1}$of the seed track to account for the slope in inclusive p_{T}^{-1} distribution.

[4]The "inclusive" efficiency is the efficiency distribution when no additional cuts are applied to select a flat region in other dimensions.

5 Results

In this section we present the distributions and fit results of the efficiencies as a function of p_{T}^{-1} of the tau seed track, $\Delta\theta^{in}$, and $\Sigma^{iso}p_{\mathrm{T}}$ in isolation cone. Each individual distribution we fit with the functions described below.

The function used to fit the transverse momentum of the tau seed track is the standard error function convoluted with the first degree polynomial:

$$\varepsilon_p(p_{\mathrm{T}}^{-1}) = K_p \times \varepsilon_p^{sh}(p_{\mathrm{T}}^{-1}) = K_p \times (1 - S_p \cdot (p_{\mathrm{T}}^{-1} - 1/10)) \times freq\left(\frac{p_{\mathrm{T}_0}^{-1} - p_{\mathrm{T}}^{-1}}{2\sigma_p}\right), \tag{3}$$

where K_p is the efficiency at $p_{\mathrm{T}}^{-1} = 0.1$ (GeV/c)$^{-1}$, S_p is the slope of the efficiency at plateau region, and the “sh” superscript stands for the “shape” of the distribution. We fit $\Delta\theta^{in}$ distribution with the standard error function:

$$\varepsilon_\Delta(\Delta\theta^{in}) = K_\Delta \times \varepsilon_\Delta^{sh}(\Delta\theta^{in}) = K_\Delta \times freq\left(\frac{\Delta\theta^{in}{}_0 - \Delta\theta^{in}}{2\sigma_{\Delta\theta^{in}}}\right). \tag{4}$$

And for the $\Sigma^{iso}p_{\mathrm{T}}$ a simple first degree polynomial is used:

$$\varepsilon_I(\Sigma^{iso}p_{\mathrm{T}}) = K_I \times \varepsilon_I^{sh}(\Sigma^{iso}p_{\mathrm{T}}) = K_I \times (1 - S_{Iso} \cdot \Sigma^{iso}p_{\mathrm{T}}). \tag{5}$$

Variables p_{T}^{-1}, $\Delta\theta^{in}$, and $\Sigma^{iso}p_{\mathrm{T}}$ are independent of each other, therefore we present the total efficiency as

$$\varepsilon_{tot} = K \times \varepsilon_p \times \varepsilon_\Delta \times \varepsilon_I = K_{tot} \times \varepsilon_p^{sh} \times \varepsilon_\Delta^{sh} \times \varepsilon_I^{sh}, \tag{6}$$

where K_{tot} is the total scaling factor that absorbs 3 other factors K_p, K_Δ, and K_I. So at the end we are left with 7 parameters for a selected number of prongs.

We start with identifying in each dimension a region where the efficiency is flat. Then by selecting flat regions in two other dimensions it is easy to find the true efficiency for the variable of interest. The standard cuts used for the flat efficiency region selection in each variable are:

$$p_{\mathrm{T}}^{-1} < 0.18, \quad \Delta\theta^{in} > 0.12, \quad \Sigma^{iso}p_{\mathrm{T}} < 0.3.$$

Figure 3 shows the $\Delta\theta^{in}$ and $\Sigma^{iso}p_{\mathrm{T}}$ variables fitted with the corresponding functions. Figure 4 shows the p_{T}^{-1} distribution for 1, 2, and 3 prongs. The fit results are summarized in Table 6. Given an event with p_{T}^{-1}, $\Delta\theta^{in}$, and $\Sigma^{iso}p_{\mathrm{T}}$ one can calculate L3 efficiency by calculating the total efficiency according to Eq. 6. Figure 6 shows an inclusive efficiency plots for p_{T}^{-1} for 1, 2, and 3-prong tau candidates for the case when the efficiency is simulated according to Eq. 6. The true inclusive efficiency for the same events is shown on Fig. 5. The overall scaling factor K_{tot} quoted in the Table 6 is obtained from the 3-dimensional fit when all shapes in each variable are fixed. The simulated shapes are very close to the true ones, which facilitates the previously made claim that all three variables are independent of each other and therefore the total efficiency can be factorized.

Effect	Negative	Positive
Matching Angle	-0.50%	+0.60%
Matching $\|\Delta z\|$	-0.05%	+0.05%
Number of Super-layers	-0.04%	+0.40%
Total	-0.5%	+0.72%

Table 5: Systematic uncertainties.

5.1 Systematic uncertainties

The largest systematic uncertainty comes from the selection of the matching requirements. From Fig. 3 the upper estimate on the angular resolution is $\sigma(\Delta\theta^{in}) = 0.014$ radians[5]. In the matching we use 0.175 radians (or 10^0), which is somewhat arbitrary. We estimate the uncertainty on the matching angle requirement to be between 0.175 and 0.042 (which is 3 sigmas of angular resolution) radians. From the matching requirement study on Fig. 7 the uncertainty at 0.042 radians corresponds to the systematic error on the total efficiency of 0.5%.

The resolution on the difference between L3 and Production in z measurement is roughly about 1 cm [6]. It follows from Fig. 7 that the systematic error due to the uncertainty on the Δz matching requirement is negligible compared to the 0.5%. Both of the above effects lower the efficiency, and therefore contribute only to the negative part of the systematic.

Another source of uncertainty comes from the "goodness" of the tau object. When selecting a seed track for tau we require the seed track to have 3 COT axial and 3 COT stereo super-layers. The efficiency goes up by 0.6% if we change the requirement to 4 superlayers. This is the the dominant source of uncertainty in the positive direction.

The matching requirement contributes to the systematic uncertainty on the positive side if one removes the matching or makes the matching angle very large. The efficiency goes up by 0.4% in either case. The total positive systematic uncertainty is equal to 0.72%.

We have measured the tau efficiency to be about 99% with the total systematic uncertainty of -0.5% and $+0.72\%$. This is consistent with the fact that we measured L3 electron efficiency to be 99.5% because the tau object is more complicated, and therefore it's efficiency should not be greater than that of the electron. We use the largest uncertainty of 0.72% as a total estimate of the systematic uncertainty.

We summarize all of the above studies of systematic uncertainties in the Table 5.

6 Summary

We measure the efficiency of tau for the requirement of track leg in the lepton plus track triggers. The absolute trigger efficiency is consistent with the relative efficiency if one takes into account the preceding L1 and L2 triggers. For data analysis, e.g. $Z \to \tau\tau$, we use

$$\begin{aligned} \epsilon_{L3}^{1\ prong}(=K_{tot}) &= 98.90 \pm 0.12(stat) \pm 0.72(sys)\ \%, \\ \epsilon_{L3}^{2\ prong}(=K_{tot}) &= 98.95 \pm 0.11(stat) \pm 0.72(sys)\ \%, \end{aligned} \tag{7}$$

[5]This is the resolution that we get from the fit to $\Delta\theta^{in}$ distribution, do not confuse with COT angular resolution.

Parameter	1 Prong	2Prongs	3 Prongs
${\Delta\theta^{in}}_0$		$-0.009^{+0.002}_{-0.003}$	
$\sigma_{\Delta\theta^{in}}$		$0.012^{+0.0018}_{-0.0014}$	
S_{iso}		$-0.0105^{+0.0009}_{-0.001}$	
$p_{\mathrm{T}_0}^{-1}$	$0.1998^{+0.0006}_{-0.0005}$	$0.2000^{+0.0012}_{-0.0001}$	$0.1998^{+0.0016}_{-0.0012}$
σ_p	$0.0022^{+0.0005}_{-0.0004}$	$0.0036^{+0.0010}_{-0.0007}$	$0.0032^{+0.0017}_{-0.0011}$
S_p	$-0.08^{+0.04}_{-0.04}$	$-0.07^{+0.04}_{-0.04}$	$-0.06^{+0.06}_{-0.07}$
K_{tot}	$0.9890^{+0.0011}_{-0.0012}$	$0.9895^{+0.0011}_{-0.0011}$	$0.99012^{+0.0013}_{-0.0013}$

Table 6: Efficiencies.

$$and\ \epsilon_{L3}^{3\ prong}(= K_{tot}) \quad = \quad 99.01 \pm 0.13(stat) \pm 0.72(sys)\ \%$$

for seed $p_{\mathrm{T}}^{seed} > 8$ GeV/c.

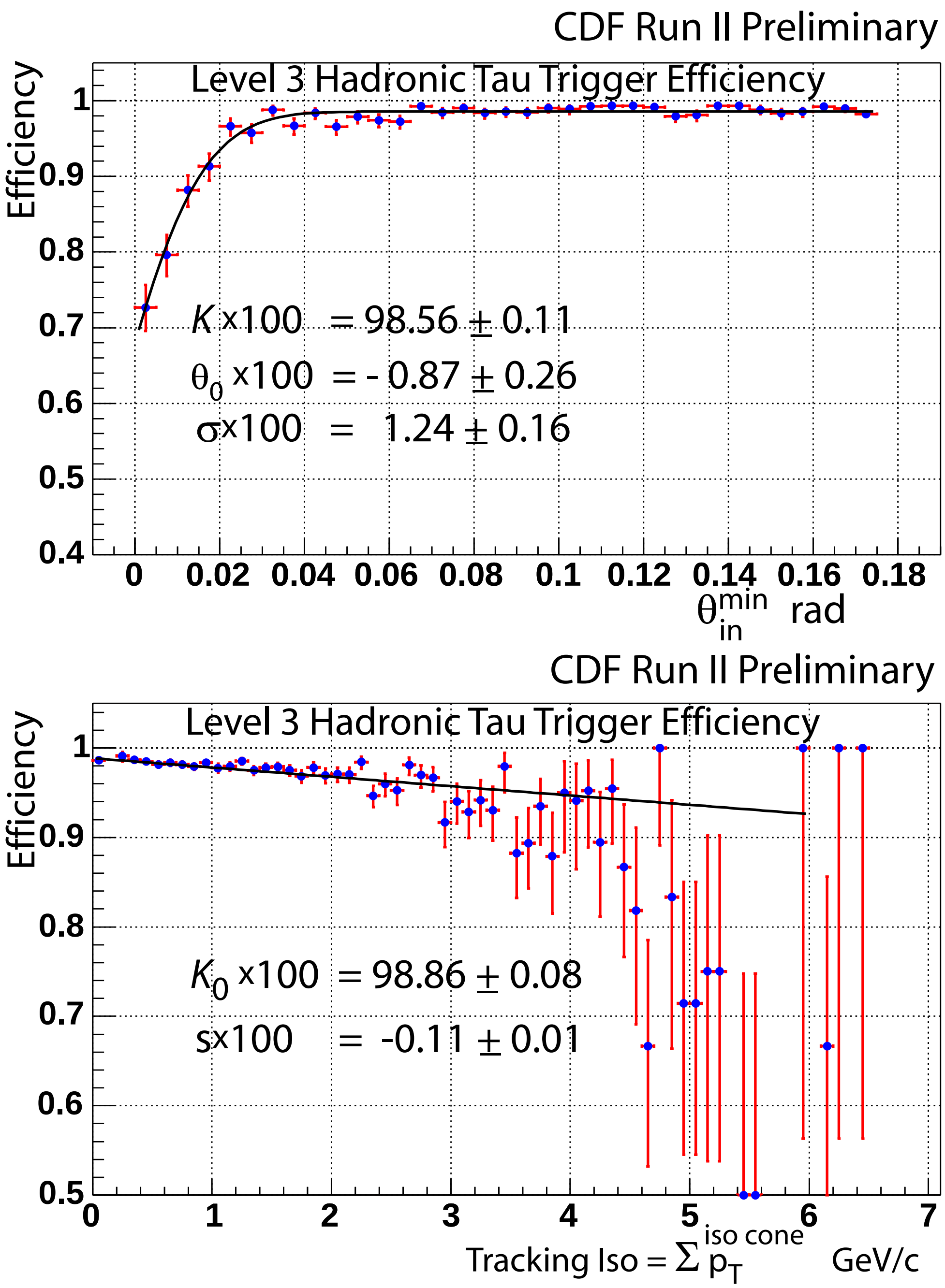

Figure 3: Efficiency for $\Delta\theta^{in}$and $\Sigma^{iso}p_{\mathrm{T}}$for any number of prongs; standard cuts are applied.

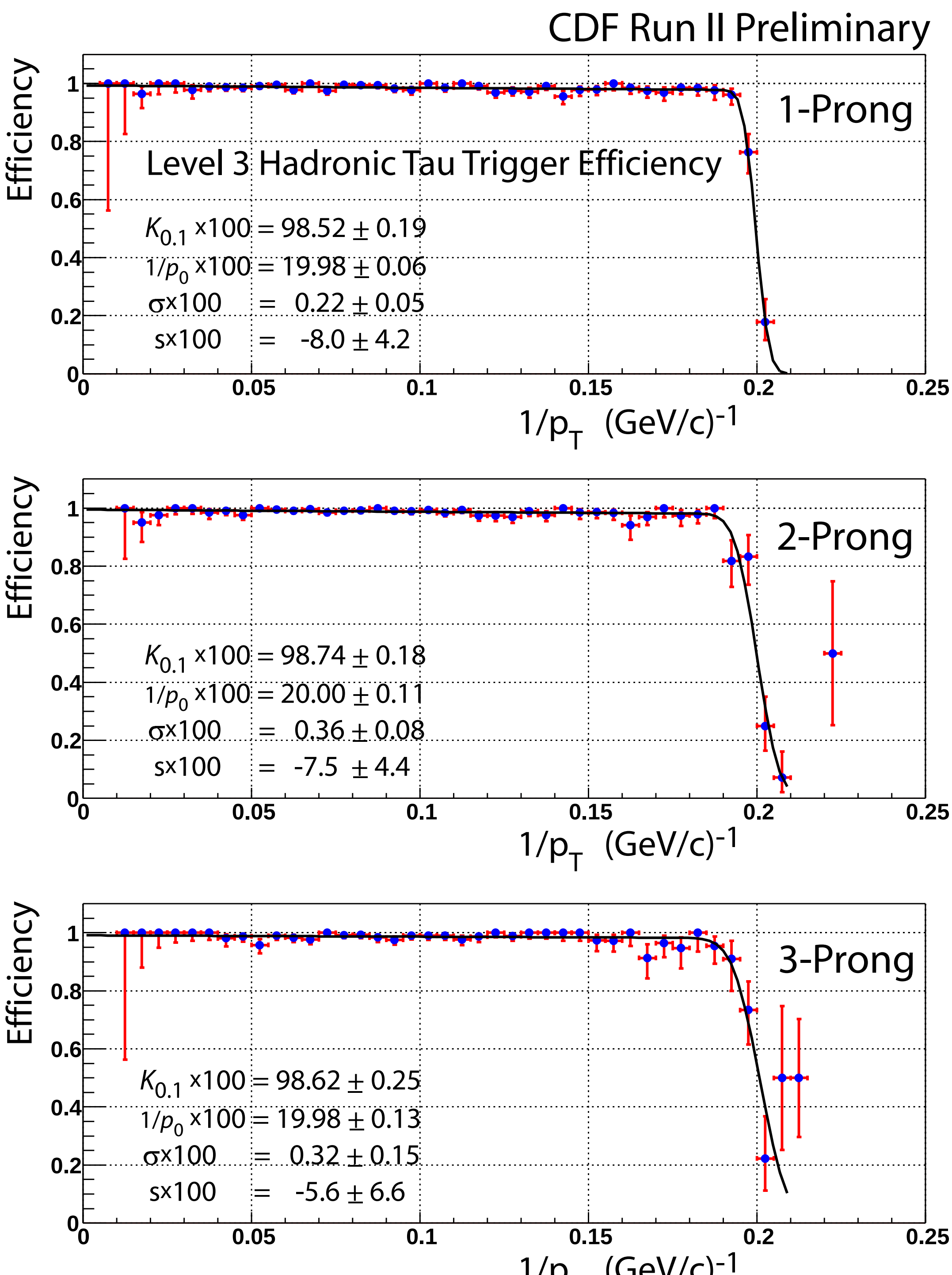

Figure 4: Efficiency for p_T^{-1} for 1, 2, and 3-prong events; standard cuts are applied.

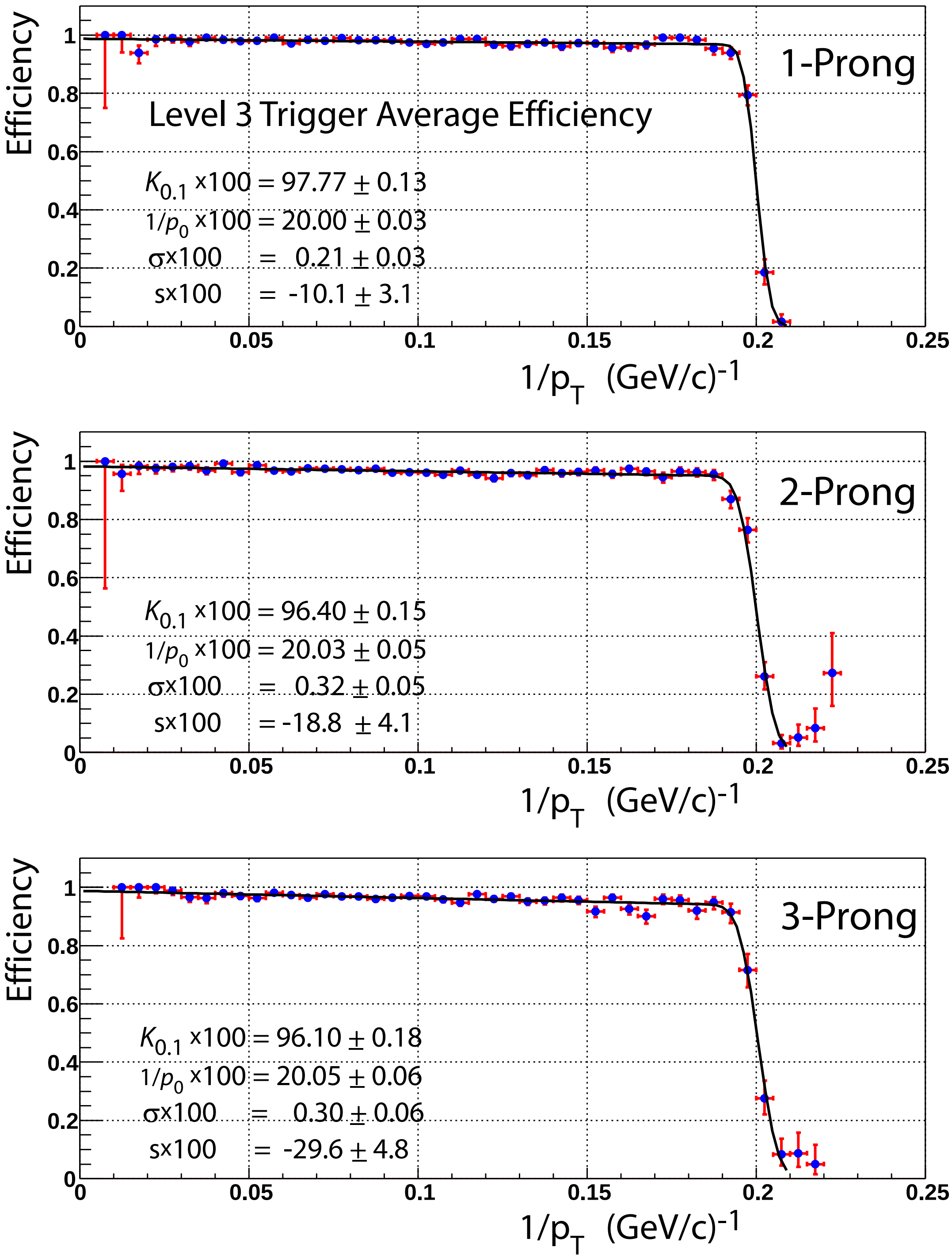

Figure 5: Inclusive efficiency as a function of p_T^{-1} for 1,2, and 3-prong events.

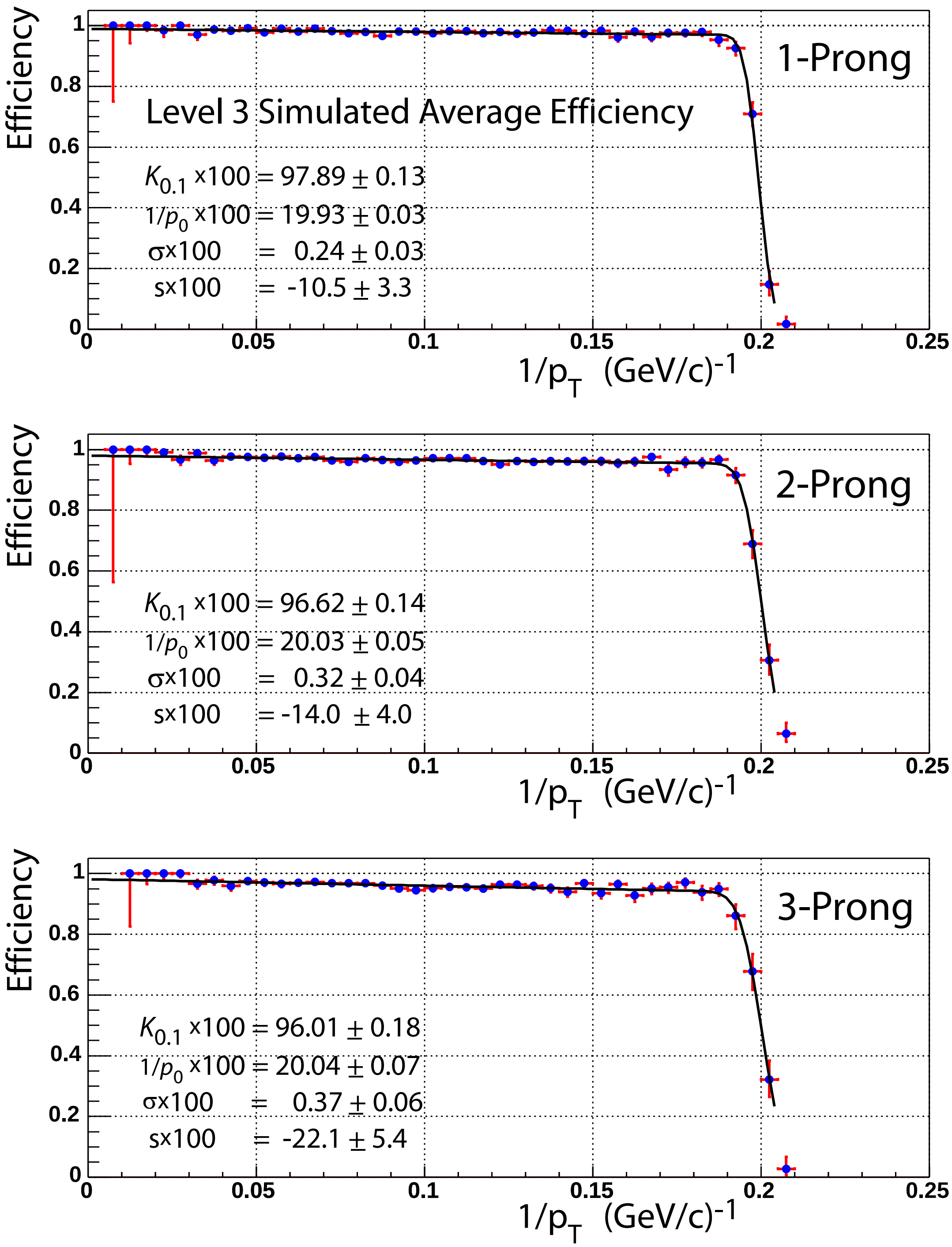

Figure 6: Inclusive simulated efficiency as a function of p_T^{-1} for 1, 2, and 3-prong events.

References

[1] M. Chertok *et al.*, "Lepton + Track Trigger for Run II: A New Approach for Triggering on Dilepton -Electron Case-," CDF Note 4807.

[2] J. Done *et al.*, "Lepton + Track Trigger for Run II: A New Approach for Triggering on Dilepton -Muon Case-," CDF Note 5157.

[3] S. Baroiant *et al.*, "Update on the Lepton + Track Trigger in Run II -Definitions and Physics Goals-," CDF Note 6325.

[4] S. Baroiant *et al.*, "Understanding the $Z \to \tau\tau$ Signal in Run 2 Data and Background Techniques," CDF Note 6498.

[5] S. Baroiant *et al.*, "XFT Efficiency for the Isolated Track Leg of the Electron+Track Trigger," CDF Note 6510.

[6] The CDF IIb Collaboration, "The CDF IIb Detector Technical Design Report," CDF Note 6261.

[7] S. Baroiant *et al.*, "Measurement of the 8 GeV Inclusive Electron Level 3 Trigger Efficiency Using Conversions," CDF Note 6324.

[8] S. Baroiant *et al.*, "Measurement of Electron Trigger Efficiencies for Level1 and Level2 8 GeV Triggers," CDF Note 6257.

[9] A. Anastassov *et al.*, "Extraction of $Z \to \tau\tau$ Signal using Run II Lepton + Track Trigger -Electron Channel-," CDF Note 6402.

A Appendix

A.1 No XFT at L2

For the trigger paths that do not require XFT trigger we do not require tau seed track to match an XFT track [5]. The results are in Table 7. The fit results are very close to the numbers with XFT requirement.

Parameter	1 Prong	2Prongs	3 Prongs
${\Delta\theta^{in}}_0$		$-0.008^{+0.002}_{-0.003}$	
$\sigma_{\Delta\theta^{in}}$		$0.0119^{+0.0016}_{-0.0013}$	
S_{iso}		$-0.0106^{+0.0009}_{-0.0010}$	
$p^{-1}_{\mathrm{T}_0}$	$0.1997^{+0.0004}_{-0.0004}$	$0.1996^{+0.0007}_{-0.0007}$	$0.1993^{+0.0008}_{-0.0008}$
σ_p	$0.0023^{+0.0004}_{-0.0003}$	$0.0030^{+0.0006}_{-0.0005}$	$0.0022^{+0.0009}_{-0.0006}$
S_p	$-0.07^{+0.04}_{-0.04}$	$-0.07^{+0.04}_{-0.04}$	$-0.06^{+0.06}_{-0.07}$
K_{tot}	$0.9883^{+0.0012}_{-0.0011}$	$0.9890^{+0.0011}_{-0.0011}$	$0.9899^{+0.0013}_{-0.0013}$

Table 7: Efficiencies with no XFT requirement.

A.2 Single Primary Vertex

We measured the efficiency for events with no more than one primary vertex. This is done in case the Monte Carlo has difficulties to simulate events with multiple vertices. The results are in Table 8.

Parameter	1 Prong	2Prongs	3 Prongs
${\Delta\theta^{in}}_0$		$-0.011^{+0.003}_{-0.004}$	
$\sigma_{\Delta\theta^{in}}$		$0.013^{+0.002}_{-0.002}$	
S_{iso}		$-0.0086^{+0.0009}_{-0.0010}$	
$p_{\mathrm{T}_0}^{-1}$	$0.1999^{+0.0007}_{-0.0006}$	$0.2003^{+0.0014}_{-0.0011}$	$0.1992^{+0.0020}_{-0.0016}$
σ_p	$0.0022^{+0.0006}_{-0.0004}$	$0.0037^{+0.0011}_{-0.0008}$	$0.0044^{+0.0030}_{-0.0013}$
S_p	$-0.05^{+0.04}_{-0.04}$	$-0.08^{+0.04}_{-0.04}$	$-0.006^{+0.062}_{-0.068}$
K_{tot}	$0.9914^{+0.0011}_{-0.0012}$	$0.9909^{+0.0011}_{-0.0011}$	$0.9908^{+0.0013}_{-0.0013}$

Table 8: Efficiencies for 1 Primary Vertex.

A.3 Single Primary Vertex, no XFT at L2

Here we quote the results for the single vertex events with no XFT matching. See Table 9.

Parameter	1 Prong	2Prongs	3 Prongs
${\Delta\theta^{in}}_0$		$-0.009^{+0.003}_{-0.003}$	
$\sigma_{\Delta\theta^{in}}$		$0.0126^{+0.0019}_{-0.0016}$	
S_{iso}		$-0.0085^{+0.0009}_{-0.0010}$	
$p_{\mathrm{T}_0}^{-1}$	$0.1997^{+0.0005}_{-0.0004}$	$0.2000^{+0.0008}_{-0.0008}$	$0.1989^{+0.0010}_{-0.0010}$
σ_p	$0.0022^{+0.0004}_{-0.0003}$	$0.0029^{+0.0007}_{-0.0008}$	$0.0028^{+0.0014}_{-0.0008}$
S_p	$-0.03^{+0.04}_{-0.04}$	$-0.08^{+0.04}_{-0.04}$	$-0.02^{+0.07}_{-0.07}$
K_{tot}	$0.9905^{+0.0011}_{-0.0012}$	$0.9904^{+0.0011}_{-0.0011}$	$0.9905^{+0.0013}_{-0.0013}$

Table 9: Efficiencies for 1 Primary Vertex without XFT.

A.4 Matching L3 to Production

Matching Production Taus to L3 isolated tracks is a non-trivial task. We use a very simple algorithm: if L3 track lies in the Tau isolation cone and has z distance from the seed track less than 15 cm, then we say that the match is found. The matching parameters are somewhat arbitrary and chosen to coincide with L3 trigger requirements. To study the effects of our selection, we calculate the total efficiency as a function of matching angle and z.

The top of the Fig. 7 shows the efficiency dependence on the matching angle. The efficiency curve becomes flat at 10 degrees and does not depend on the value of the angle.

The bottom of the Fig. 7 shows the efficiency dependence on the D distance from the seed track. The efficiency curve becomes flat and does not depend on z at 15 cm, which coincides with L3 trigger definition.

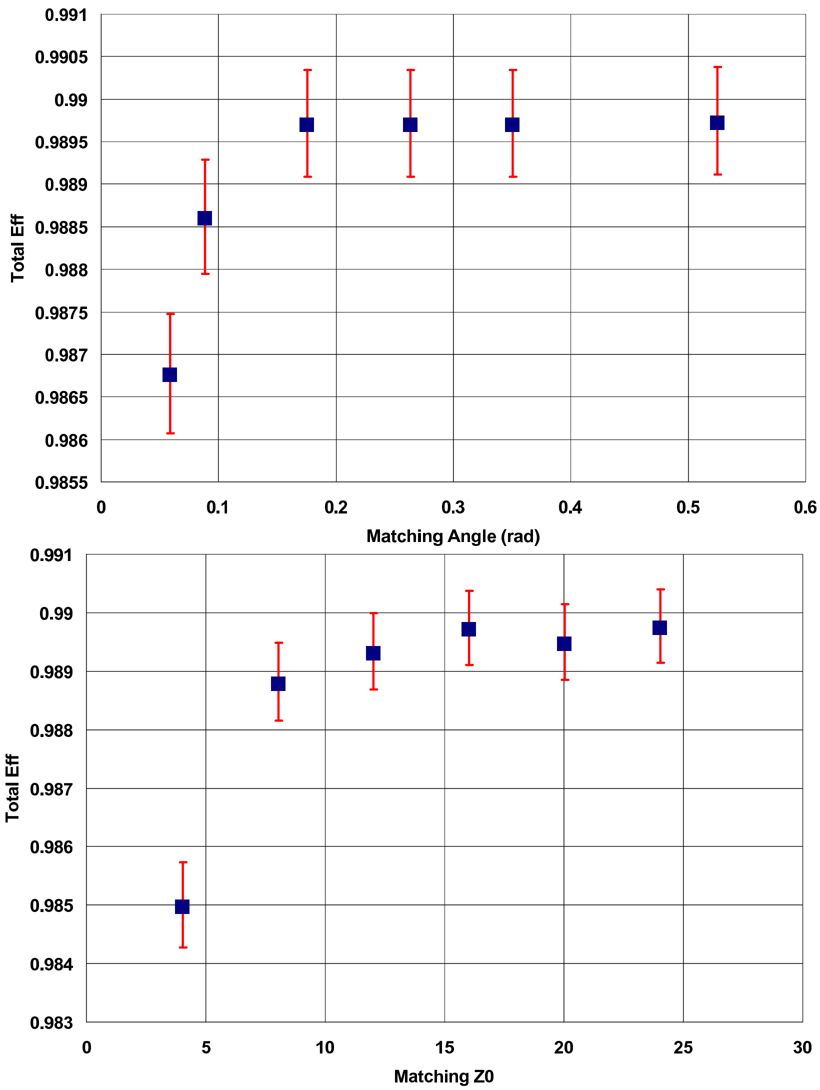

Figure 7: Efficiency as a function of matching angle is on the top, efficiency as a function of $|\Delta z|$ is on the bottom.

A.5 $\Sigma^{iso} p_{\mathrm{T}}$ and $\Delta\theta^{in}$ definitions

The definitions for $\Sigma^{iso} p_{\mathrm{T}}$ and $\Delta\theta^{in}$ affect the final efficiency. If one changes $|\Delta z|$ or p_{T} cuts it affects $\Sigma^{iso} p_{\mathrm{T}}$ and $\Delta\theta^{in}$ calculation and, as a result, the total efficiency. On the Fig. 8 we show the total efficiency as a function of $|\Delta z|$ cut. The efficiency flattens out at $|\Delta z| = 15$ cm and $p_{\mathrm{T}} = 1.5$ GeV/c. Amazingly, this coincides with L3 tau definition. The minimum p_{T} cut affects only $\Delta\theta^{in}$ variable definitions, so the trend is not so obvious for the total efficiency. We would like to point out that this study should not be used for systematic uncertainty estimate, but used only as an illustration that variable definitions are optimal.

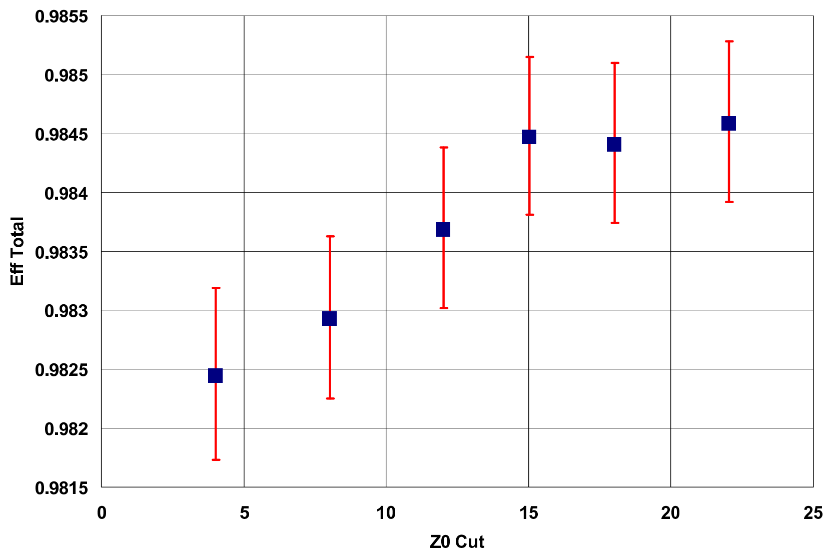

Figure 8: Efficiency as a function of $|\Delta z|$ cut.