Drell-Yan Backgrounds in the Inclusive Electron Sample

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I. INTRODUCTION

There is a small correction for Drell-Yan production in the inclusive electron sample. We explicitly removed $Z \rightarrow e^+e^-$ by combining each good central electron with ANY jet (EMFR > 0.85) in the event, and antiselecting on M(e-jet) in the range [80-115 GeV]. Given the expected Z rates, residual backgrounds from Z- e^+e^- in the Et < 25 inclusive spectrum should be negligible, even allowing for nominal inefficiency for finding the second (jet) leg of the Z. For low mass Drell-Yan ("photon $\rightarrow e^+e^-$ "), we do not have the Z-mass constraint, and we can identify these events only if both leptons are cleanly tagged in the central region. In this note we derive the expected background rate for DY events, using theory to extrapolate from the observed central-central sample to the full rate.

The low-mass DY events are identified by observing TWO central electron candidates, both isolated with isolation variable consistent with W and Z electrons. We then have to correct for cases where the second electron is not observed, (mainly) due to our $\eta < 0.7$ cut. We use the clean $Z \rightarrow e^+e^-$ sample as a check on QCD rates, and as a calibration for the effect of electron quality and isolation cuts. We also use the Z sample to estimate residual $Z \rightarrow e^+e^-$ BG's in the inclusive sample. For the high Et region (Et > 30), which is not used for b cross section determination due to the overwhelming background from W and Z decays, we develop a general ansatz to remove any residual Drell-Yan electrons (mainly W, Z decays) from the inclusive sample.

Finally, there is an additional Drell-Yan background from the chain decay [$W/Z \rightarrow \tau X, \tau \rightarrow e\, \nu\bar{\nu}$], which leads to isolated low Et electrons in the inclusive sample. We use the $W \rightarrow e\nu$ sample plus SM matrix elements to obtain an absolute prediction for this background.

II. η DEPENDENCE (PAPAGENO)

We use lowest order Papageno to get the following relative rates (we assume these do not change much in NLO order):

Table 1

Et	σ_γ	σCC_γ	σ_Z	σCC_Z
10-15	30.6	8.0	3.3	0
15-25	17.5	4.2	24.2	0
25-60	11.4	3.24	156.9	37.7
10-25*	30.8	7.7	26.0	0

The last row, labelled *, is corrected for the expected loss of electrons in the 12 GeV sample due to level-2 cuts. Here "σ" refers to the total number of events with $\eta_{min} <$ 0.7, and "σCC" to the total with $\eta_{max} < 0.7$; η_{min} and η_{max} are the min and max values for the two leptons, so $\eta_{max} < 0.7$ are central-central ("CC") events. The Et range refers to either electron (Pt (e^+) = Pt (e^-) in lowest order). Thus, given at least one lepton in η <.7 (this is the $\eta_{min} < .7$ sample), the probability is 0.25 (= 7.7/30.8) that the second lepton will also satisfy this requirement, for the photon DY events in Et = [10,25]. For Z's this ratio is 0.25 for Et > 25, the observed Z sample in CDF, but 0 for Et < 25 due the Z mass requirement.

We use the Papageno rates primarily to estimate the total photon DY rate ("σ_γ"), including central- noncentral ("C-NC"), given the observed photon central-central DY rate ("σCC_γ"). We also use the relative rates for the different Z decay topologies and also the Z/photon ratio, as a check on the Papageno model. We emphasize that Papageno is lowest order, and we expect (and observe) that the photon/Z ratio is somewhat larger in the data than in Papageno, presumably due to NLO corrections.

III. DETERMINATION OF EFFICIENCY FACTORS

We want to measure the overall contamination from photon and missed Z events in the inclusive electron sample, where the inclusive sample satisfies a common electron quality cut, and common fiducial cuts. In order to identify the DY

events, we need to further impose an isolation cut. We define an isolation variable, E_{iso}, as the sum in quadrature of Pt and Et in a cone of radius 0.7 around the lepton. We use W and Z decays to calibrate the E_{iso} distribution, to estimate backgrounds in our photon DY sample. Thus, we use the following quality cuts:

1) IG = 0,1 are standard CES + HAD/EM + E/P cuts
2) IGA = 0,1 refers to the isolation cut, $E_{iso} < 5$.
3) IGB = 0,1 refers to the combined electron quality and isolation cut, that is IGB = IG*IGA

(IG, IGA, IGB = 0/1 Denote Fail/Pass respective cuts.)

4) Fiducial cuts -
   a) abs (η) < 0.7 (Tower 0-6)
   b) abs (X) < 21.5 cm

From the Z sample we find that the efficiencies for these cuts are

a)	f	=	0.71 ± .06	Prob for IGB	= 1
b)	fa	=	0.94 ± .02	Prob for IGA	= 1 (isol. cut only)
c)	fb	=	0.76 ± .06	Prob for IG	= 1 (el. quality only).

In addition, from geometry

d)	R	=	0.878	Prob for passing dX < 21.5 cut.

The effect of the $\eta < 0.7$ cut is, of course, deduced from the Papageno rates.

We pause to explain how these efficiencies are derived. Consider the combined electron quality and isolation cut, with efficiency "f". We use $Z \rightarrow e^+e^-$, where both legs are in $\eta < 0.7$ and pass the fiducial cuts. We can have three classes of "CC" events:

fail-fail	(1-f)*(1-f)	=	S00
fail-pass	2(1-f)*f	=	S01
pass-pass	f*f	=	S11

We look only at the fail-pass and pass-pass rates, i. e. ignore Z's with both legs failing IGB = 1. In this sample, we count the total number of IGB = 1 electrons compared with the total number of electrons (TWO per event !), and we have

$$N(IGB = 1)/N(IGB = 0,1) = [S01 + 2S11]/[2S01 + 2S11] = 1/(2 - f)$$

In the data, out of 66 Z's we have

$$1/(2-f) = 102/132 \text{ (} E > 25, Z \rightarrow e^+e^- \text{ "CC" sample).}$$
$$\rightarrow f = 0.71 \pm .06$$

Next, by looking at the second leg of the central-central Z's, after requiring IGB = 1 for the first leg, we establish the efficiency of the isolation cut alone,

$$fa = 0.94 \pm .02 \text{ (96/102 leptons)}$$

Finally, combining these results and assuming f = fa*fb, we get

$$fb = 0.76 \pm .06$$

If we use the low-mass DY sample alone, requiring Et > 11 for both leptons in the "CC" sample, we get essentially the same results for these efficiencies. Starting with a sample of 32 pairs (64 leptons), where one leg satisfies IGB = 1, we get a total of 49 total IGB = 1 leptons, or

$$1/(2-f) = 49/64 \text{ (Et > 11 "CC" DY sample)}$$
$$\rightarrow f = 0.69 \pm .09$$

Similarly, the isolation cut efficiency (again requiring IGB = 1 for one leg) is:

$$fa = 0.92 \pm .04 \text{ (45/49 leptons)}$$

Thus f, fa, and fb are the same for the Z and low-mass DY "CC" samples. Figure 1 compares the E_{iso} distributions for W's, Z's, and low mass DY, where in the case of Z and DY, we have plotted the second lepton E_{iso}, after requiring IGB = 1 for the first

lepton. We also show the E_{iso} distribution for the full inclusive sample (shaded curve in Fig. 1c), scaled to match the number of DY leptons.

There are additional events in the low mass "CC" sample in which the second lepton has Et < 11 GeV. Most of these are probably $b\bar{b}$ or fake leptons, judging from the E_{iso} distributions. If we count all IGB = 1 leptons above 11 GeV (this is the signal sample), and then look at the partner lepton used for tagging, the rates are as follows:

1)	Partner Et > 11	Total	= 49 IGB = 1 leptons
			= 0 Background
2)	Partner Et < 11	Total	= 51 IGB = 1 leptons
			= 42± 5 background

The first category can contribute two leptons to the Et > 11 sample, the second category only 1. We have used the E_{iso} distribution, compared with that for $Z \rightarrow e^+e^-$ and the full Et > 11 inclusive sample, to estimate the (nonisolated) background rate. The E_{iso} distribution for the partner leptons are shown in Figs. 2a (Et >11) and 2b (Et < 11); the low Et partners in Fig. 2b are compared with the full inclusive distribution (solid curve, normalized to the Et < 11 event rate.) Thus, the inclusion of Et < 11 partners increases the total number of Et > 11 DY leptons in our sample by a factor

$$\frac{N(DY - \text{partner Et} > 5}{N(DY - \text{partner Et} > 11} = 58 \pm 5/49 = 1.18 \pm .10$$

Thus, we estimate the total "CC" rate for IGB = 1 DY leptons to be

$$N = 58 \pm 9 \ (Et > 11)$$
$$N = 54 \pm 9 \ (11 < Et < 30)$$

where the last entry excludes 4 leptons with Et > 30.

IV. OVERALL CORRECTIONS TO THE INCLUSIVE ELECTRON SPECTRUM

Figure 3 shows the Et distribution for the Et > 11 leptons from "CC" DY events (we plot all "CC" leptons, after requiring IGB = 1 for a single leg, 64 leptons total). Inclusion of the partner Et < 11 leptons does not change this spectrum. We

compare this with the Papageno spectrum, normalized to the observed rate, and including the level-2 trigger bias. The spectra are similar, and we can use Papageno to estimate the Et shape for this background in the inclusive sample.

Next we compute the full DY rate, including the (undetected) central-noncentral rates. We need to estimate the number of IG = 1 (not IGB = 1) events that end up in the inclusive sample. Denote σCC, σC_{NC}, and σ as the central-central, central- noncentral, and total rates, corresponding to the Papageno results in Table 1. Including the ϕ-crack fiducial cut (efficiency "R = .878" given above), we obtain the following relative rates:

1)	N_{CC}	(IGB = 1)	=	$\sigma CC * R*R * 2 * f$	(Number of CC IGB = 1 e±)
2)	N_{CC}	(IG = 1)	=	$\sigma CC * R*R * 2 * fb$	(Number of CC IG = 1 e±)
3)	N'_{CC}	(IG = 1)	=	$\sigma CC * R* (1-R) * 2 * fb$	(Number of CC IG = 1 e± with partner in ϕ-crack.)
4)	N_{CNC}	(IG = 1)	=	$\sigma C_{NC} * R * fb$	(Number of C-NC IG = 1 e±)

The first rate corresponds to the observed rate, 54 ± 9, of IGB = 1 good, isolated leptons in the total central-central DY pair sample. The second and third rates give the number of IG = 1, "good" but not necessarily isolated leptons. The fourth rate is that for partner leptons with abs (η) > 0.7.

The sum over categories (2)-(4) gives the total rate for IG = 1 leptons, with Et > 11, satisfying the ϕ-crack fiducial cuts and abs (η) < 0.7. With the above values of f, fa, fb, and R, we get the following numerical rates:

1)	N_{CC}	(IGB = 1)	=	$\sigma CC * 1.09$
2)	N_{CC}	(IG = 1)	=	$\sigma CC * 1.17$
3)	N'_{CC}	(IG = 1)	=	$\sigma CC * 0.16$
4)	N_{CNC}	(IG = 1)	=	$\sigma C_{NC} * 0.67 = \sigma CC * 2.00$

where we have used the Papageno ratio

$$\sigma C_{NC}/\sigma CC = 3.00$$

to obtain the category (4) rate relative to categories (1) - (3). The actual observed IGB = 1 lepton rate from the "CC" sample is

$$N_{CC}\,(IGB = 1) = \sigma CC * 1.09 = 54 \pm 9 \text{ IGB} = 1 \text{ events,}$$

This then yields a total expected IG = 1 rate of

$$\begin{aligned} N\,(\text{total}) &= N_{CC}\,(\text{observed}) * 3.34/1.09 \\ &= (54 \pm 9) * 3.08 \\ &= 166 \pm 28 \end{aligned}$$

This gives an overall correction of

$$166 \pm 28/14745 = 1.2 \pm .2\ \%$$

to the inclusive sample; note that the DY Et spectrum (cf Fig. 3) is flatter than the inclusive spectrum.

V. CROSS-CHECKS USING Z DECAY RATES

We can make further checks on the method by comparing the $Z \rightarrow e^+e^-$ sample with the Papageno rates in Table 1. Figure 4 shows the electron-jet mass spectrum for three event categories: (a) the CC dilepton sample with IGB = 1 required for at least one lepton, (b) all leptons with Et > 25 and IGB = 1, excluding those in (a), (c) all leptons with Et < 25 and IGB = 1, excluding any in (a). Normalizing to the dilepton sample, we can compare relative rates with Papageno:

Table 2

Category	N(observed)	N(Papageno)
(a) Dilepton	102	102 (fixed)
(b) Et > 25	170	189
(c) Et < 25	40	40

Thus, the topological rates are in reasonable accord with Papageno. Finally, from Table 1 we expect the ratio of IGB = 1 leptons from "CC" Z's and "CC" DY events, in lowest order with Et > 11 on both leptons, to be

$$N\,(DY)/N\,(Z) = 7.7/37.7 = 0.20$$

The observed ratio is

$$N\,(\text{obs. DY})/N\,(\text{obs. Z}) = 45/102 = .44 \pm .08$$

This is about twice as high a DY rate as the Papageno prediction.

VI. FNAL CORRECTIONS FOR PHOTON AND Z DECAY DRELL YAN (Et < 30)

Our final correction is then based on the total extrapolated rate of 166 ± 28 IG = 1 DY leptons in 11 < Et < 30. In addition, we expect some inefficiency for tagging the second (jet) leg of the Z, due to cracks in PEM, FEM, etc. We take this inefficiency to be 15 ± 15%. For Et < 25 (the region used for the b-cross section measurement), this translates into a total missed-Z IG = 1 background of

$$\begin{aligned} N\,(Z\text{ loss}) &= 40 \pm 6 * 0.15 \pm 0.15 * 1/.94 \\ &= 6 \pm 6 \text{ lost IG} = 1 \text{ Z leptons} \end{aligned}$$

This correction is negligible compared with that for photon Drell-Yan. For Et > 30, the "lost Z" background dominates, due to the rising Et spectrum for $Z \rightarrow e\pm$ as compared with the falling spectrum for photon Drell-Yan. Note that we expect some "lost Z's" (second lepton in a calorimeter crack) to end up in the $W \rightarrow e\nu$ sample, and we also expect some fraction of the $W \rightarrow e\nu$ sample to end up in the inclusive QCD electron sample, due to fluctuations on the M_{trans} variable. The 15 ± 15% "lost Z" rate is meant to include any residual leptons from W or Z decays that pass the W/Z removal cuts; the Et spectra for W and Z leptons are similar, so there is no need to separate these sources in detail.

We combine the Papageno Et spectrum for photon Drell-Yan, shown in Fig. 3, normalized to 166 ± 28 events, with that for "lost Z's" to estimate the total background rates. We compare these with the inclusive (W/Z subtracted) electron rates, after subtracting unseen conversions. We arrive at the following inclusive electron and Drell-Yan background rates:

Table 3

Et Bin	Photon DY	Lost Z	Inclusive e±	Ratio
11-15	54	0	8854	0.006 ± .001
15-20	60	1	3206	0.019 ± .003
20-25	31	4	556	0.063 ± .011
25-30	21	4	138	0.181 ± .039
30-40	18 ± 6	15	79	0.42 ± .21
40-60	0	23	35	0.66 ± .66

Here we take the errors on the "photon DY" to be ± 17%, for Et < 30 (cf 166 ± 28 total DY events), and the error on the "lost Z" leptons to be 100% of that rate. The "ratio" column gives the ratio of total background to the inclusive electron rate (after W/Z removal and subtraction of unseen conversions). Figure 5 shows the background ratio from this analysis (open points) plotted against Et. For Et < 30, we can approximate the background ratio (solid curve in Fig. 5) by the expression

$$\text{Drell-Yan/ Inclusive } e\pm = .0031 * \exp[(Et-10)/4.3]$$

As an independent check, we have examined the E_{iso} distributions in the above Et bins, to detect the production of "isolated" ($E_{iso} = 0$) electrons in the inclusive sample (after W, Z and unseen conversion subtraction). For the inclusive sample with Et < 30, we find that 75.5 ± 0.4% have $E_{iso} > 4$ GeV, whereas for the W/Z sample, this fraction is 10.4 ± 0.8 %. We assume that these fractions are independent of Et for both classes of events, and use the observed $E_{iso} < 4$ GeV fraction to estimate the number of isolated electrons in each Et bin. This method should detect all residual "isolated electron" backgrounds in the inclusive sample, including those from photon Drell-Yan and those from W/Z decays that survive the W/Z removal cuts. For Et < 25, the resulting isolated electron rates are consistent with zero, and also with the Drell-Yan analysis given above. For Et > 25, the E_{iso} spectra exhibit a distinct peak near zero, which grows with Et. For example, Fig. 6 compares the E_{iso} distributions for W/Z electrons (Et > 30) with those for inclusives (Et < 30); the inset shows the Et = 20-25 GeV bin which is the highest Et used for b cross section determination. Figure 7 shows the E_{iso} distributions for the higher Et

bins, compared with the total distribution for $11 < Et < 30$ (smooth curve). The emergence of an $E_{iso} = 0$ peak above 25 GeV is clear, and it is also clear that there is no evidence for significant isolated electron background below 25 GeV. We plot the isolated electron background fraction obtained from this method as solid points in Fig. 5. These points agree reasonably well with the Drell-Yan analysis.

VII. FURTHER DRELL-YAN REMOVAL FOR ET > 30 SAMPLE

For $Et > 30$ GeV, the Drell-Yan backgrounds (including misidentified W and Z) are more than 50% of the sample, both from the direct Drell-Yan and from the E_{iso} analyses. Altogether, after subtraction of unseen conversions, there are 114 electrons in $30 < Et < 60$. We do not use these for the b cross section, but we do show them in the inclusive electron spectrum. Rather than make a 50% correction, it is straightforward to remove the residual Drell-Yan events from this sample.

From the two analyses, we count the following number of background events in the 114 event sample

a) "Direct" DY analysis 56 ± 38

b) "E_{iso}" analysis 57 ± 9

We take the second number, which empirically includes all sources of isolated electrons, as our best background estimate ($50 \pm 8\%$). We next examine the W/Z removal variables, namely $M(e^+e^-)$ and "Y_{trans}", where

$$Y_{trans} = M_{trans}/\sqrt{Et} < 8$$

was used to remove W's. We observe the following rate correlations:

Table 4

Sample	$E_{iso} < 4$	$E_{iso} > 4$
(a) $M > 40$	33	9
(b) $M < 40$	34	38
(c) $M < 40$, $Yt = [0,4]$	6	24
(d) $M < 40$ $Yt = [4,8]$	28	14
(e) $M > 80$ or $Yt > 8$	1490	173

Samples (a,b,c,d) are Et > 30 inclusive electrons with W/Z removed (e.g. Yt < 8 and M < 80). Sample (e) is just the W/Z sample, which calibrates the E_{iso} distribution for isolated leptons, namely 10.4 ± 0.8 % satisfy $E_{iso} < 4$. If we examine the bulk inclusive sample, with Et > 11, M < 80, and Yt < 8, we can calibrate the Yt distribution for QCD electrons, namely

$$Yt = [0,4]/Yt = [0\text{-}8] = 0.616 \pm 0.004$$

We observe an excess of $E_{iso} < 4$ events in sample (a) (33 events), due to residual Drell-Yan pairs, and in sample (d) (28 events), due to residual $W \rightarrow e\nu$.

We first make the following consistency checks:

1) For sample (c), which eliminates both Drell-Yan pairs and residual W-> eν (Yt < 4), the E_{iso} distribution is consistent with that expected for QCD electrons, namely $E_{iso} > 4/All = 24/30 = 0.80 \pm .07$, consistent with the value 0.755 ± 0.004 found with the inclusive Et > 11 sample.
2) Comparing samples (c) and (d), with $E_{iso} > 4$ to remove residual $W \rightarrow e\nu$, we find that the Yt distributions are again consistent with that for QCD leptons. We observe the fraction Yt < 4/Yt < 8 = 24/24 + 14 = 0.63 ± .08, consistent with the value 0.616 ± 0.004 found for the Et > 11 inclusive sample.

Thus, within errors the E_{iso} and Yt distributions are consistent with the QCD electron sample, after making appropriate selections to remove residual W's and Drell-Yan pairs.

Using the nominal shapes for the E_{iso} and Yt distributions as quoted above, we can remove the residual isolated lepton backgrounds simply by removing events with:

$$E_{iso} < 4 \text{ .AND. } \{M > 40 \text{ .OR. } Yt = [4,8]\}.$$

This cut removes 33 + 28 = 61 events. This includes 31 + 24 = 55 genuine W/DY events plus 2 + 4 = 6 QCD electrons; in addition the $E_{iso} > 4$ samples (a) and (d), 9 + 14 = 23 events, include 3 + 3 = 6 W/DY events and 6 + 11 = 18 QCD electrons. Thus, within errors, this cut removes 6 QCD leptons but leaves 6 residual W/DY leptons in the final sample. Overall, this analysis shows that the Et > 30 sample includes a total of 61 ± 8 residual isolated leptons, to be compared with the predicted rate of 57

± 9 obtained from the E_{iso} distributions alone. Since all of these rates are consistent, we make the additional W/DY antiselection on the Et > 30 sample, and assume a correction factor of

$$\text{Background correction} = 0.0 \pm 0.15 \quad (= 0 \pm 9/114\text{-}61)$$

after W/DY antiselection.

VIII. REMOVAL OF τ DECAY ELECTRONS

We can compute directly the feeddown from $W/Z \rightarrow \tau\nu$ decays, followed by $\tau \rightarrow e\, \nu\bar{\nu}$. We use two spectra obtained directly from the data: (a) the Et spectrum for "W" electrons, defined by $Y_{tran} > 8$ and $E_{iso} < 4$, with standard electron quality cuts; (b) the missing Et spectrum from the same sample, requiring Et > 30 to guarantee a pure sample. For each electron Et bin, we replace the electron with a τ, and integrate over τ decays ($\tau \rightarrow e\, \nu\bar{\nu}$). For this integration, we assume the τ is polarized 100% along the direction defined by -P(τ). Then the differential decay rate, in the τ rest frame, is given by

$$dR = A * [\, 1 + B \cos(\theta)\,],$$
$$A = e*e*(3 - 2e) \quad (e = 2E(\text{electron})/M\tau)$$
$$B = [1\text{-}2e]/[3\text{-}2e]$$
$$\theta = \text{polar angle between decay electron and the } \tau \text{ spin direction.}$$

We integrate over E(electron), θ, and azimuthal angle φ in the τ rest frame, and lorenz boost back to the laboratory frame, to obtain the daughter Et spectrum in the laboratory. Thus, for each Et(τ) bin, we have an Et (electron) spectrum, and for each Et (electron) we have the contribution from the τ decay neutrinos to the total missing Et. We add this contribution to the spectrum for the difference, $E_t - E_t$, already obtained for the primary $W \rightarrow e\nu$ decay. We then determine, for each Et(electron) bin the fraction that will pass the transverse mass cut. Physically, the τ decay gives a low Et electron, with approximately balanced away-side missing Et; the smearing of the net missing Et is assumed to be the same as that for the $W \rightarrow e\nu$ events.

Figure 8 shows the Et spectrum for $W \rightarrow e\nu$ (solid points), and (scaled times 10), the Et spectrum for the τ decay electrons. The full histogram is for all τs, the shaded is for the same τ's after the $Y_{tran} < 8$ requirement. To get the contribution from $Z \rightarrow \tau\tau$, we can multiply the $W \rightarrow \tau\nu$ rate by the ratio

$$R = (Z \rightarrow e)/(W \rightarrow e) * .033/.105 = 0.05$$

which is a small correction to a small background. The total $\tau \rightarrow$ electron background, corresponding to the shaded histogram in Fig. 8, is:

Table 5

Et Bin	τ fraction
10-15	0.002
15-20	0.015
20-25	0.030
25-30	0.030
30-60	0.030

where the above fractions are with respect to the inclusive electron rates given in Table 3.

IX. CONCLUSION

We combine the Drell-Yan backgrounds from e^+e^- production (Table 3) with those from $W \rightarrow \tau$ (Table 5) to obtain the following Drell-Yan correction factors for Et < 30.

Table 6

Et Bin	Drell-Yan Correction
10-15	0.008 ± .002
15-20	0.029 ±- .006
20-25	0.093 ± .020
25-30	0.211 ± .039

These are applied to the b cross section rates as follows:

$$Nb = Nsub * [1 - F_{\pi} - F_{dy}] * [1 - Fch],$$

Nsub	=	Inclusive electrons after subtraction of unseen conversions, and removal of W/Z electrons.
F_π	=	Fake hadron fraction
F_{dy}	=	Drell-Yan fraction given above.
F_{ch}	=	Charm fraction

The correction factors are all Et dependent. Further, since F_π and F_{ch} are correlated, we determine Nb corresponding to the three overall charm fractions 10, 20, and 30 % (e.g. 20 ± 10%). Thus we obtain the following contributions to the uncertainty on Nb:

1) Statistical error on Nsub.
2) Drell-Yan error
3) Uncertainty on unseen conversion rate
4) Uncertainty on F_π for $F_c = 0.20$ fixed.
5) Systematic uncertainty on F_π
6) Correlated uncertainty from $F_c = 0.20 \pm 0.10$ (e.g. taking into account the F_{ch} - F_π correlation.)

For example, in the Et bin 20-25, the overall systematic and statistical uncertainty is 11%, to be compared with the 9.3 ± 2.0% Drell-Yan correction for this bin. For the lower Et bins, the Drell-Yan correction is small compared with the (average) overall uncertainty of ± 11%.

Above 30 GeV, the residual Drell-Yan and W/Z leptons are a large fraction of the event rate, as shown in Fig. 5. Furthermore, the systematic errors on these backgrounds would be nearly 100% if we relied on the explicit subtraction of Drell-Yan plus "unseen Z's", due to our assumption that the "unseen Z's" correspond to 15 ± 15% of the observed Z rate. Therefore, for Et > 30, we analyze the correlations between the E_{iso}, M (e^+e^-) and M_{trans} variables, in order to arrive at simple cuts that explicitly remove the remaining isolated electrons in the inclusive electron sample; for $E_{iso} < 4$ events, we antiselect on M > 40 or Y_{trans} ($=M_{trans}/\sqrt{(Et)}$) > 4. This cut leaves an overall systematic error of ± 15% on the Et > 30 rate for QCD electrons.

Figure Captions

Figure 1 Isolation variable distributions for W, Z and Drell-Yan electrons (a,b,c); shaded plot in (c) shows this distribution for full inclusive sample, scaled to same number of events as Drell-Yan sample.

Figure 2 Isolation distribution for partners with Et > 11 (a) and < 11 (b) GeV; solid curve in (b) is for full inclusive sample.

Figure 3 Et spectrum for Drell-Yan electrons (both partners, requiring Et > 11 for partner), with Papageno prediction (solid curve).

Figure 4 $M(e^+e^-)$ distribution for di-electron sample (a), single electrons with Et > 25 (b), and electrons with Et < 25 (c).

Figure 5 Estimated Drell-Yan fraction from dielectron plus Papageno analysis (open points), and from isolation variable analysis (solid points).

Figure 6 Isolation distribution for $W \rightarrow e\nu$ and full inclusive sample, normalized in percent, and (inset) same for the 20-25 GeV Et bin (highest bin used for b cross section).

Figure 7 Isolation distributions for four Et intervals, with full inclusive sample shown as solid curve.

Figure 8 Observed electron spectrum for $W \rightarrow e\ \nu$ events (solid points), corresponding spectrum for $\tau \rightarrow e\ \nu\nu$ (histogram, scaled X10), and corresponding spectrum after imposing transverse mass cut to reject $W \rightarrow e\nu$ (shaded histogram, scaled X10).

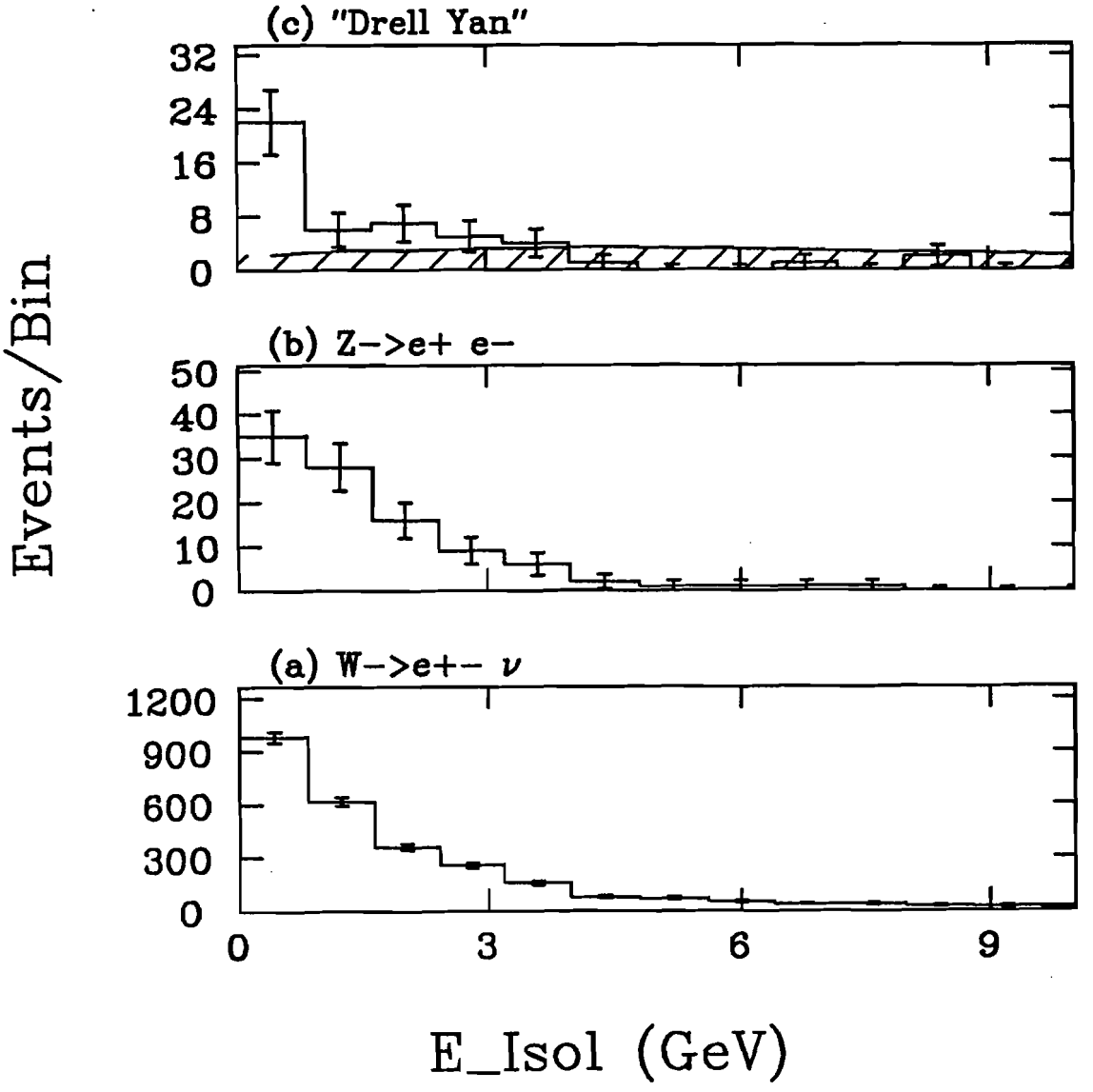
(c) "Drell Yan"
32
24
16
8
0
(b) Z->e+ e-
50
40
30
20
10
0
(a) W->e+- ν
1200
900
600
300
0
0
3
6
9
Events/Bin
E_Isol (GeV)

Figure (1)

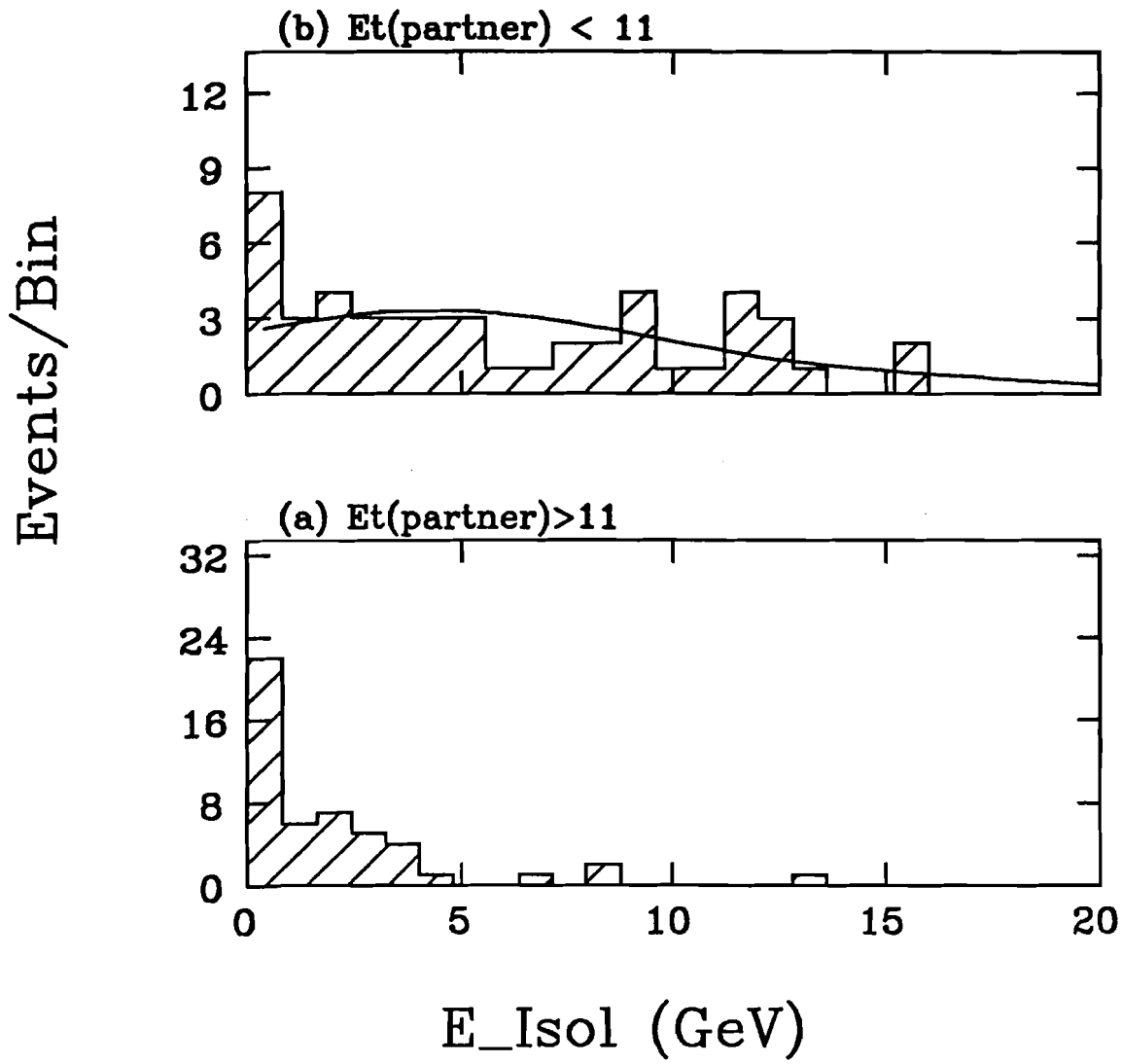
(b) Et(partner) < 11
12
9
6
3
0
Events/Bin
(a) Et(partner)>11
32
24
16
8
0
0
5
10
15
20
E_Isol (GeV)

Figure (2)

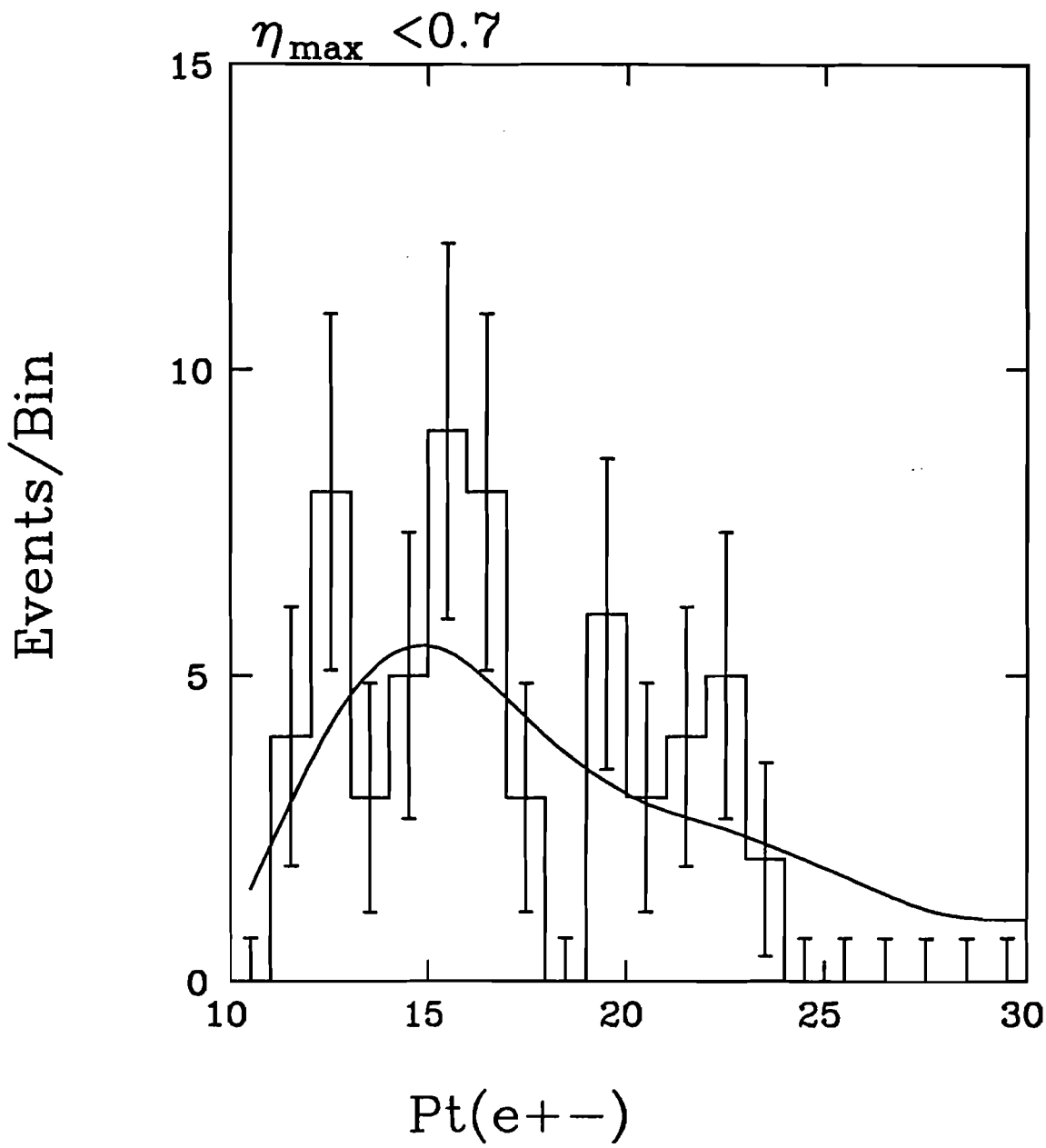

Figure (3)

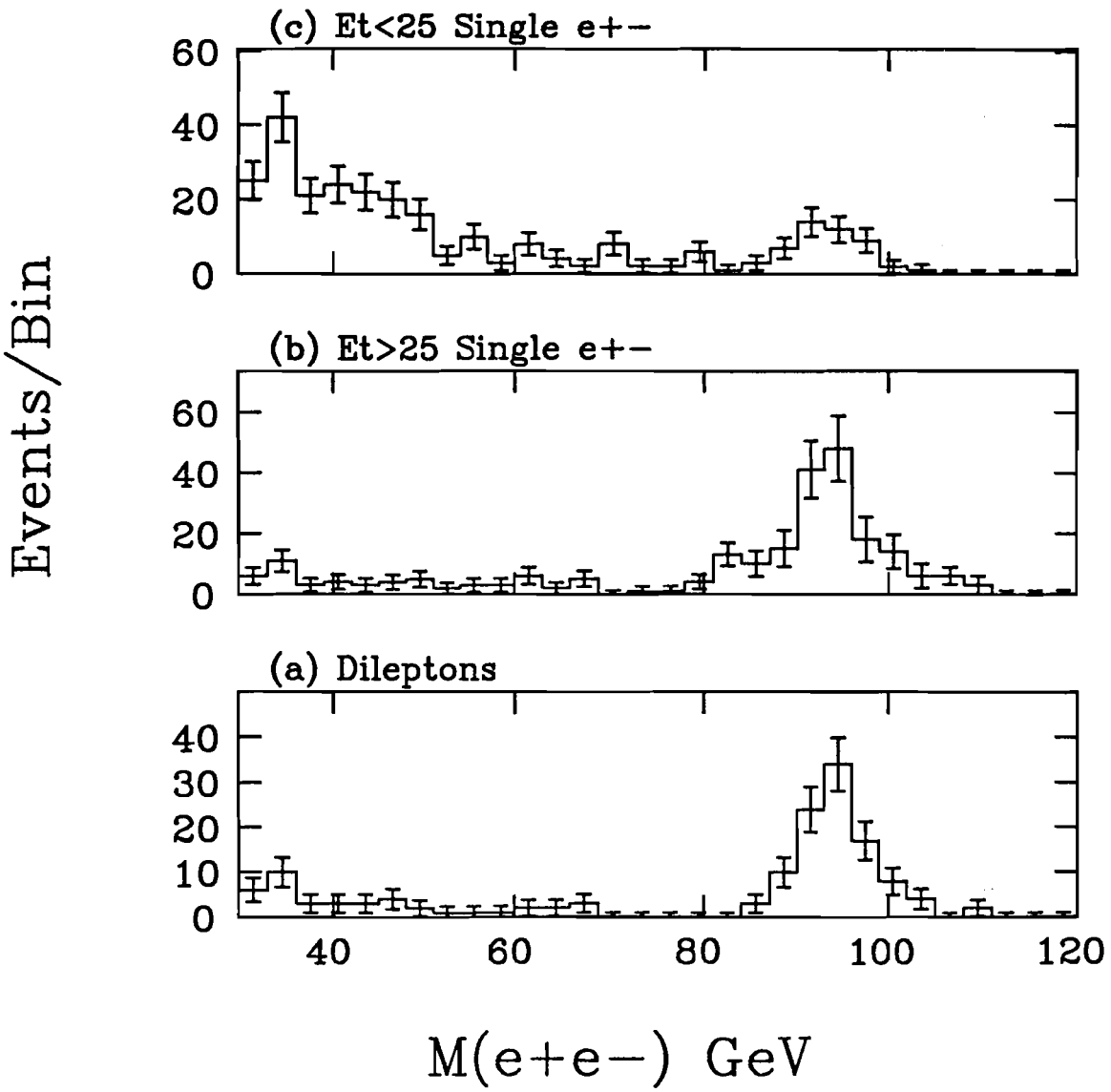
(c) Et<25 Single e+-
(b) Et>25 Single e+-
(a) Dileptons
Events/Bin
M(e+e-) GeV
0
20
40
60
10
30
40
60
80
100
120

Figure (4)

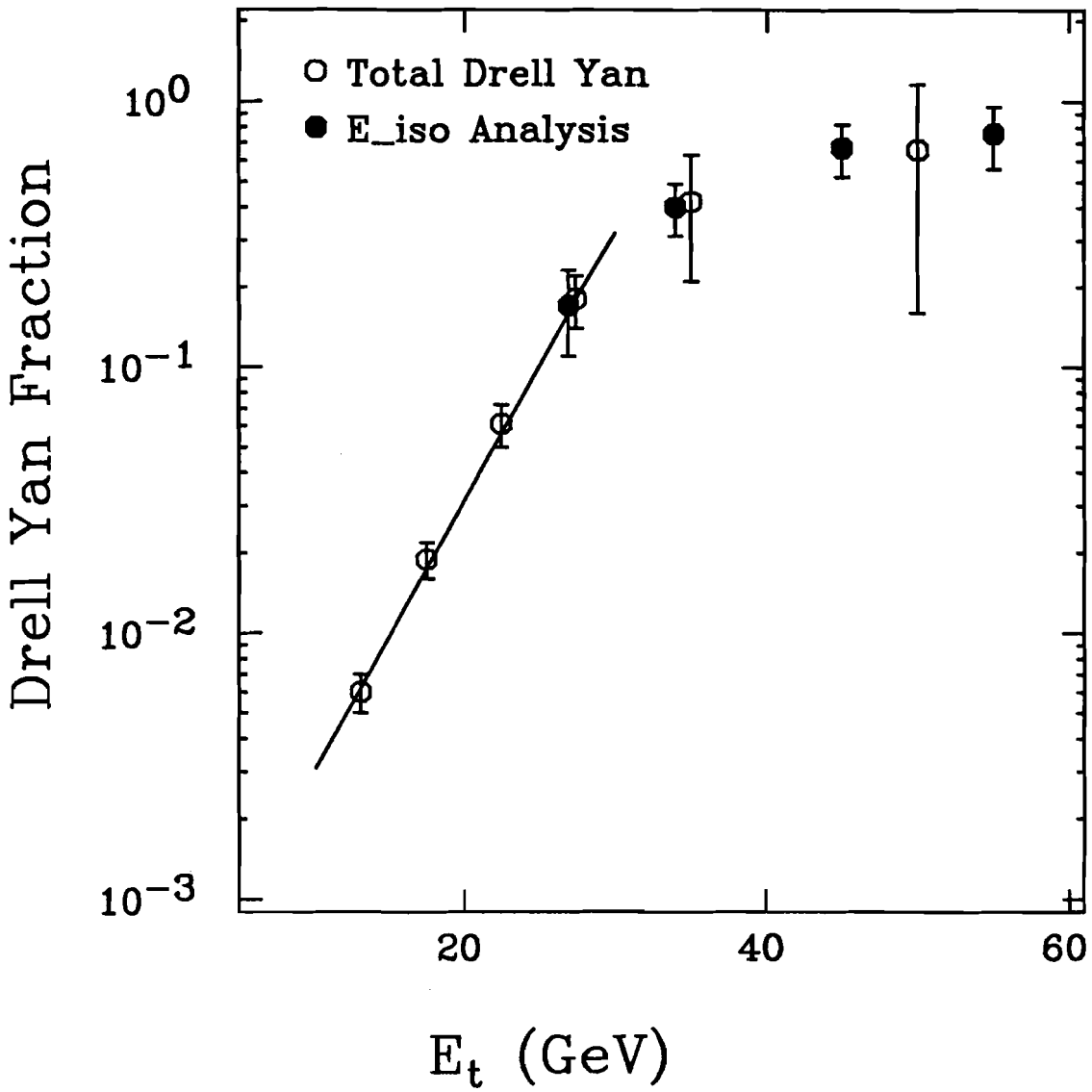
Total Drell Yan
E_iso Analysis
Drell Yan Fraction
10^0
10^{-1}
10^{-2}
10^{-3}
20
40
60
E_t (GeV)

Figure (5)

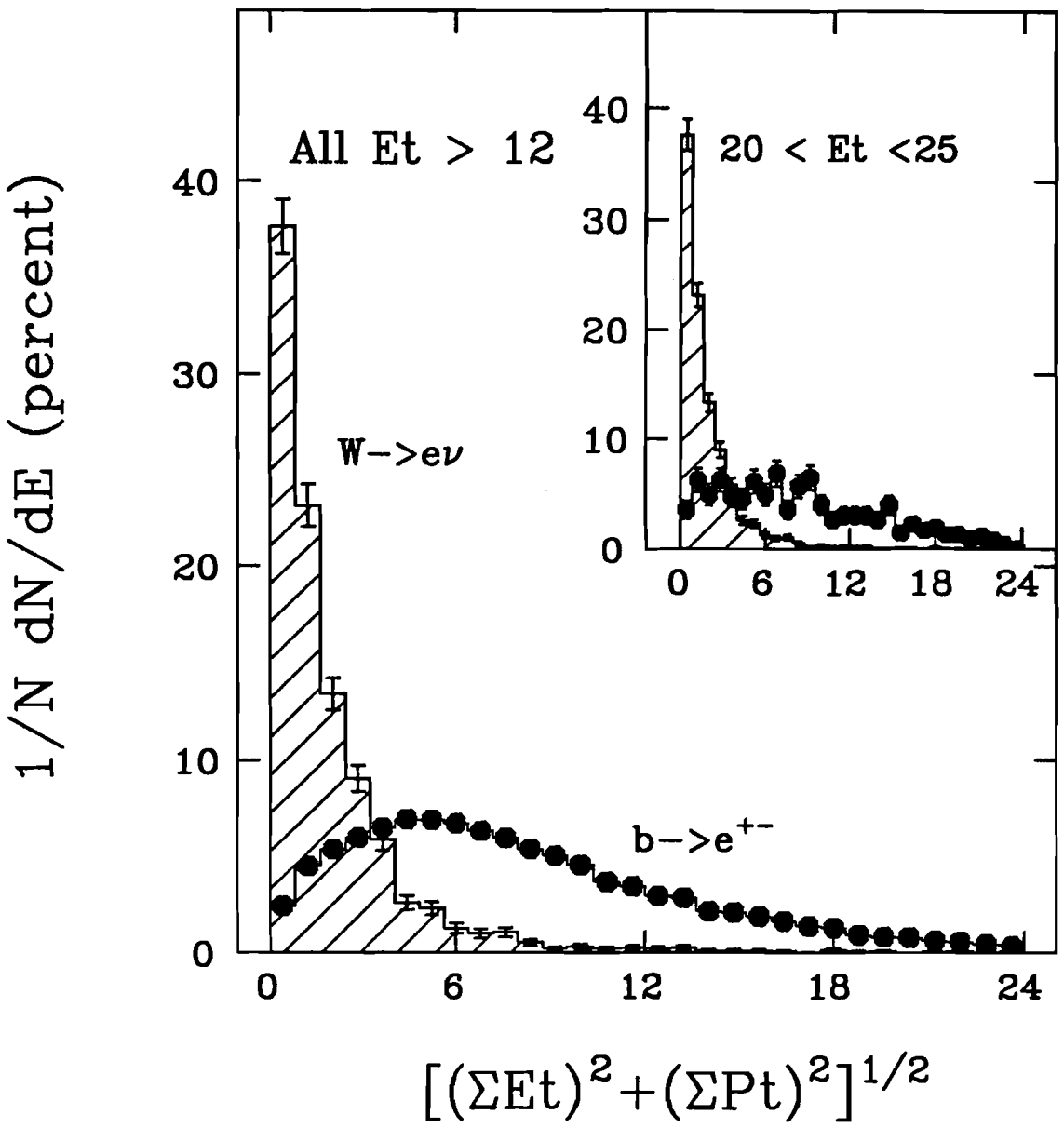
All Et > 12
20 < Et <25
W->eν
b->e+-
1/N dN/dE (percent)
[(ΣEt)2+(ΣPt)2]1/2
0
10
20
30
40
0
6
12
18
24

Figure (6)

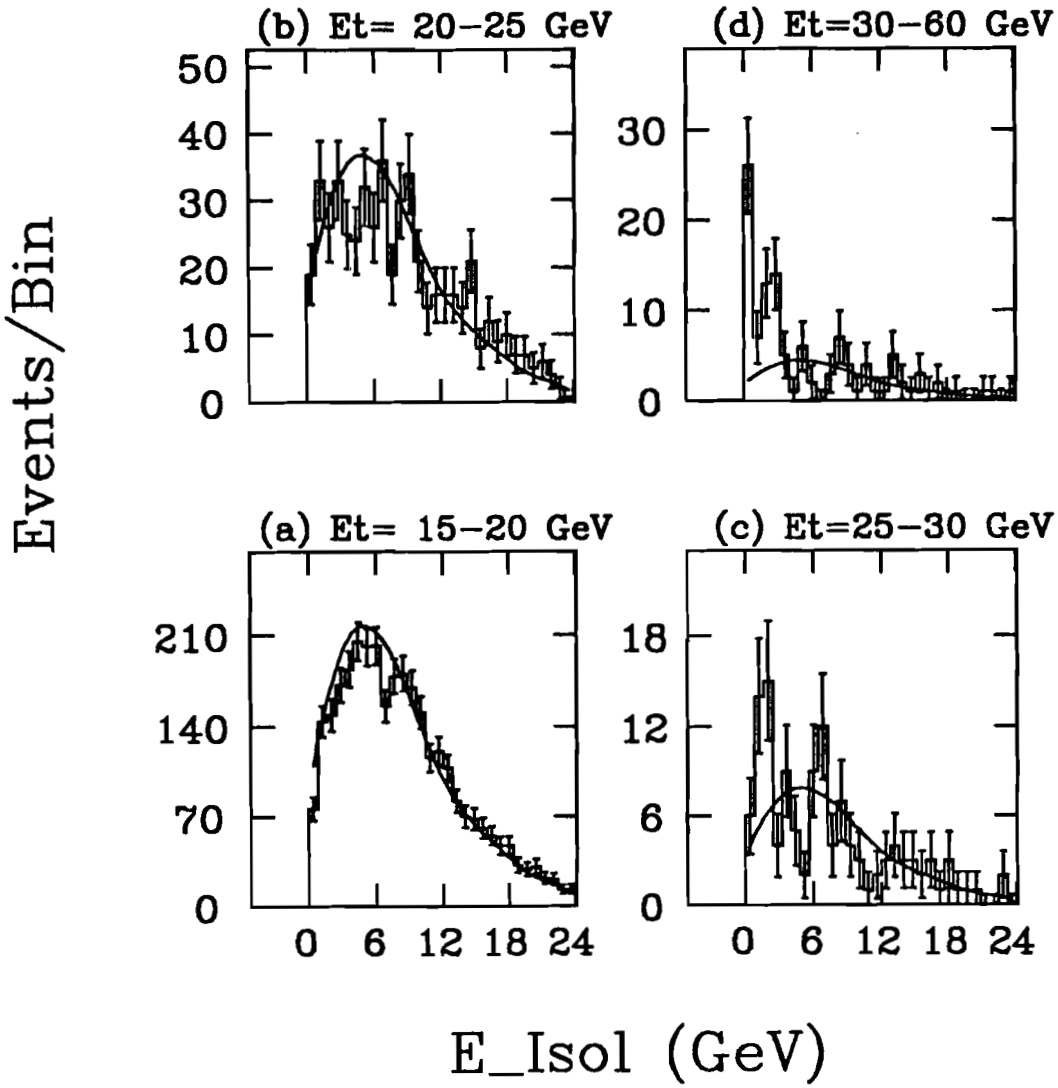
(b) Et= 20-25 GeV
(d) Et=30-60 GeV
(a) Et= 15-20 GeV
(c) Et=25-30 GeV
Events/Bin
E_Isol (GeV)
0
6
12
18
24

Figure (7)

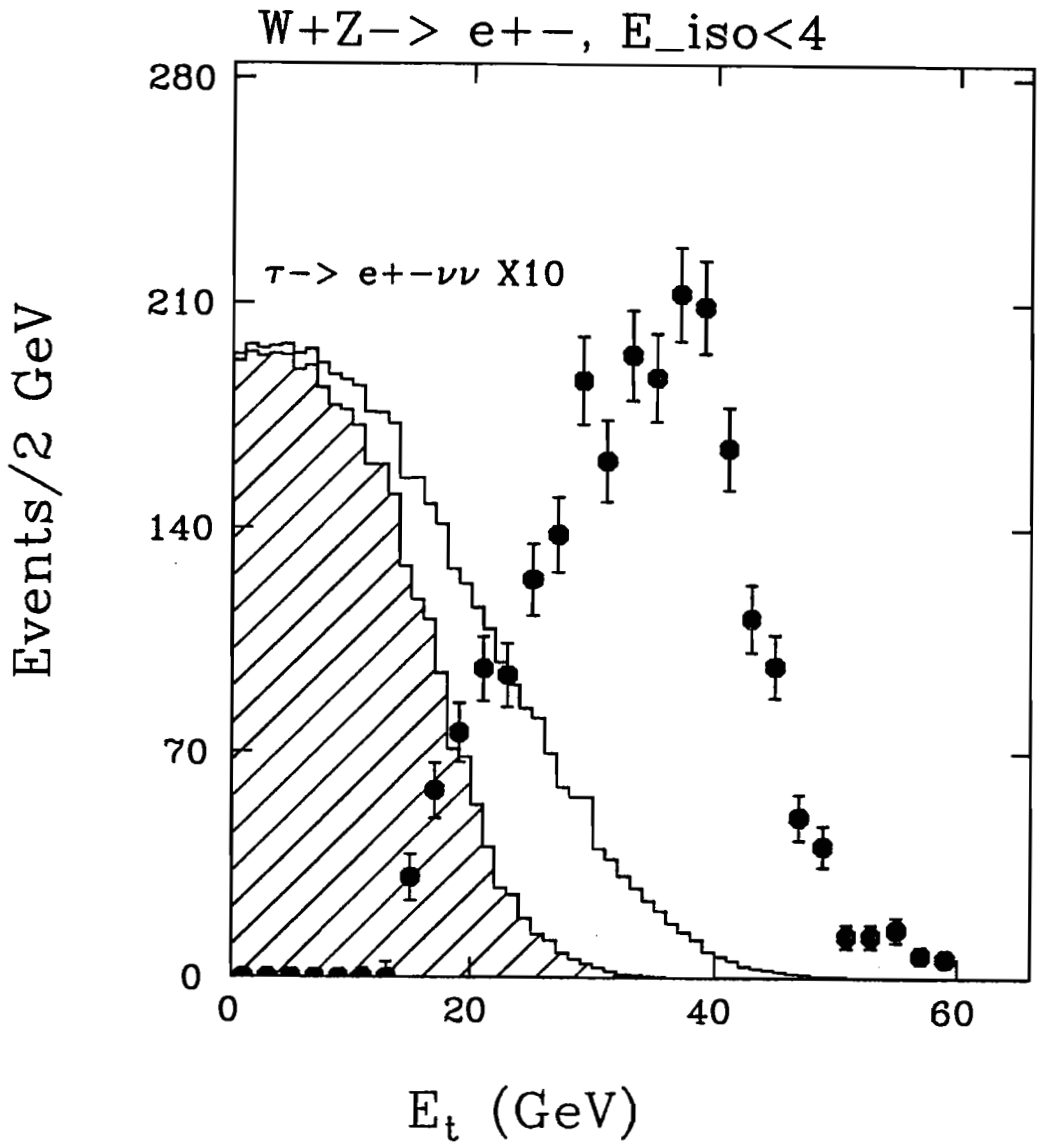

Figure (8)