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SDC
SOLENOIDAL DETECTOR NOTES

SDC LEVEL-I ELECTRON TRIGGER SIMULATION RESULTS

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W. Temple, S. Dasu, W. H. Smith, J. Lackey, T. Gorski
Department of Physics
University of Wisconsin
Madison WI 53706

Abstract

We report results, on the electron trigger transverse momentum thresholds and efficiencies, obtained using a fast Monte Carlo simulation of the SDC detector. Three trigger criteria considered are: 1) Cut on energy deposited in electromagnetic part of the calorimeter, 2) Cut on small hadronic to electromagnetic energy deposit ratio, 3) Cut on transverse isolation. All these trigger criteria are considered with and without track matching, and with additional requirements of hit flags in shower maximum detector. Calorimeter segmentations of 0.1×0.1 and 0.2×0.2 in $\eta - \phi$, and SSC luminosities of $10^{32}\text{cm}^{-2}\,\text{s}^{-1}$, $10^{33}\text{cm}^{-2}\,\text{s}^{-1}$ and $10^{34}\text{cm}^{-2}\,\text{s}^{-1}$, are considered. The best case transverse momentum threshold for electron trigger, at $10^{33}\text{cm}^{-2}\,\text{s}^{-1}$, attained by using all three cuts with track and shower maximum detector matching requirement for 0.1×0.1 $\eta - \phi$ segmentation, is 18 GeV with a 3 kHz nominal rate. For this best case, the efficiency for identifying electrons from Z decays, and top decays is 80% and 78% at 3 kHz rate. This inefficiency is primarily due to the electron energy threshold. However, the improvement due to shower maximum detector matching at the coarse level 1 stage is very small, i.e. about 1 GeV in threshold energies. These results degrade slowly as various criteria are relaxed. With only a high EM energy cut at 0.2×0.2 the threshold for 3 kHz rate degrades to 50 GeV, and the corresponding Z decay electron trigger efficiency decreases to 16%. Isolation is important to get good efficiency, particularly if matching track is not required. At high luminosity both transverse isolation and matching track are required to set thresholds below 30 GeV, with an acceptable rate of 10 kHz.

1 Introduction

Most important physical processes at the SSC require good lepton identification. In this study we concentrate on electron identification alone. The benchmark requirement for SDC is to detect 50% or more electrons from the W and Z boson decays. The majority of these electrons tend to have low p_t, i.e. in the range $p_t \leq 50 GeV$. In order to maintain high efficiency for W and Z bosons in the trigger, the threshold electron transverse momentum needs to be pushed lower. The trigger transverse energy thresholds remain the same as those required at the current Tevatron experiments, but the SSC luminosity is 2-4 orders of magnitude higher than at the Tevatron. Therefore, more stringent trigger requirements are needed at the SSC to maintain an acceptable rate to tape. However, the semi-leptonic quark decays in the QCD 2 jet events dominate the electron spectrum at low p_t, and the total rate for electrons needs to be kept low enough not to saturate the bandwidth available for next levels of trigger. Electrons from W and Z decays, and to some extent from Top quark decays, are isolated from the hadronic particles in the event. Requirements of small hadronic to electromagnetic energy deposit in calorimeter, and transverse isolation of electromagnetic energy from hadronic energy, provide efficient and simple triggers. The input rate of 10^8 interactions per second, and budgetary reasons, impose tight constraints on the sophistication of the First Level trigger algorithms. We have explored the electron trigger rates and efficiencies in a Monte Carlo simulation of the SDC baseline trigger design.[1, 2, 3] In our previous studies of electron trigger[1] we reported preliminary studies of trigger rates and efficiencies of identifying W and Z decay events. Here, we are reporting results of a more detailed study, based upon an updated Monte Carlo program.

2 Monte Carlo program

Particle four-vectors, for each simulated SSC proton-proton collision event at 40 TeV center of mass energy, are generated using ISAJET[4] Monte Carlo program. The results from these events are usually generated at various ranges of jet energies for different jet types, and are combined subsequently weighted by their cross sections. In all, 10000 Drell-Yan Z decays, 10000 events of Top quark decays and 165000 QCD 2 jet events, binned conveniently in a range of jet p_t values, were generated and put through our simulation program. Min-bias events, corresponding to 1.6 events per crossing at the nominal SSC luminosity, were separately generated, and added to these events. The mean weight was scaled suitably for other luminosities. The programs were run on the Physics and Detector Simulation Facility computers at the SSC lab, and they took several weeks of processing time to produce these results.

Our SDC detector simulation program[5] uses a simplified calorimeter geometry description and its parameterized response. Shower maximum detector response is also implemented by a simple parameterization. Tracking and muon detector response is only implemented as a threshold curve with gaussian track p_t smearing. Tracking of particles through the detector is performed using nominal magnetic field of the SDC central solenoid. All particles are tracked till the face of the calorimeter. Those particles with large enough lifetimes, to decay in flight, are decayed, and the remnants are tracked. Photons are converted in the material in the tracking volume. Bremsstrahlung of the photons is also handled. The response of the calorimeter is then calculated. The events were integrated over three beam crossings using a scintillator calorimeter shaping function from ZEUS collaboration.

The trigger response is then simulated for each event in a complete simulation of the electron pattern search logic[1]. Simulation of the trigger features included such details as digitization scale[6]. Calorimeter energies were transmitted on an 8-bit logarithmic scale from the detector, and then a pattern-logic electron trigger was fully simulated, as described in Ref. [1]. Where both track and shower max hits were required, tracks were matched to shower max hits before being matched to calorimeter towers. A shower maximum detector bin is 0.1×0.0125 in $\eta - \phi$. A matching track was required within the hit shower maximum bin or the nearest neighbour. For matching tracks to the calorimeter (whether they match with shower max or not), a matching track was required within the hit tower with a margin of 0.01 both in η and ϕ. This matching for the transverse isolation is done on a 0.2×0.2 $\eta - \phi$ scale, as designed in the proposed electronics[1]. These segmentations of shower maximum and tracking detectors is not the same as what is proposed in the Technical Design Report and we are in the process of implementing the true design. However, we hope that the results are not going to be substantially different, because the rate of multiple particles with track p_t greater than 10 GeV is small.

3 Electron production rates

Electrons are produced in hadron colliders mainly from the decays of heavy quarks, and from Drell-Yan process. Lower p_t electrons are also produced due to conversion of photons in the material of the detector. Figure 1 shows the production rates of electrons from various processes versus p_t. The p_t spectrum of electrons from W and Z boson decays is relatively soft. The p_t spectrum of the electrons from the top quark decays is somewhat harder. The p_t spectrum of the electrons in generic QCD 2-jet events is very soft, but the rates are very high. The tail from this distribution leaks in to the 10-100 GeV region with quite high rate. However, to achieve high efficiency ($> 50\%$) for triggering on electrons from W and Z boson and Top quark decays, one needs to push the electron trigger p_t threshold down to the level of 15-30 GeV. In addition, photons, and electrons from photon conversions, dominate at these low values of p_t. Photons can often produce fake electron triggers due to presence of pion tracks. Since these fake and conversion electrons are mostly in the jets, the cut on energies deposited in hadronic to electromagnetic sections, and transverse isolation are expected to improve the efficiency of triggering on electrons from the W and Z decays. Since the p_t spectra of electrons from the decays of W and Z are similar, we shall consider Z decays only in the rest of the article.

4 Nominal electron trigger rates and efficiencies

ISAJET generated event response in the SDC detector, simulated in our Monte Carlo, was put through the trigger algorithms. The rates of particles is plotted versus transverse energy deposited in the electromagnetic section of the calorimeter in Figure 2(a), for nominal SSC luminosity of 10^{33} cm^{-2} s^{-1}. For the purpose of comparing trigger performance, a nominal rate of 3 kHz is used as benchmark in this paper, because such a rate is consistent with allowing a total for 15 kHz for the sum of all calorimeter triggers. At this nominal 3 kHz rate the transverse energy threshold is found to be 44 GeV, without any additional cuts. Since a track pointing towards the calorimeter was not required this rate is dominated by photons at small values of transverse energy. This threshold is unacceptable at nominal SSC luminosity of 10^{33} cm^{-2} s^{-1} because it results in very low efficiency of 22% for identifying decay electrons from Z bosons, as shown in Figure 3(a). Note that this inefficiency is primarily due to the electron transverse energy threshold. When ratio of hadronic to electromagnetic energy deposited in the hit calorimeter tower is required to be less than 0.1 to enrich the electron sample, the trigger E_T threshold drops to 36 GeV at nominal luminosity and rate as shown in Figure 2(a). For this case the efficiency for identifying decay electrons from Z bosons is 44%. An additional requirement of transverse isolation of this electromagnetic energy cluster, using the logic design as described in Ref. [1], yields a further improvement of the threshold to 28 GeV, and Z decay electron efficiency to 62% for nominal rate and luminosity. Efficiency of triggering on electrons from Top decays with calorimeter information only is shown in Figure 4(a). These results show that a completely calorimeter based trigger will be sufficient to meet the SDC trigger goals at the nominal luminosity, provided transverse isolation and hadronic to electromagnetic energy cuts are used.

Since the rate of photons from π^0-decays dominates at low energies, it is planned to use the tracking detector data to enrich the electron rate. We have used a parameterized description of the tracking detector in our Monte Carlo as described earlier. The rate and efficiency data obtained from our studies are plotted in the Figures 2(b), 3(b) and 4(b) for nominal SSC luminosity of 10^{33} cm^{-2} s^{-1}. The requirement of a track pointing to the electromagnetic cluster drops the transverse energy threshold for nominal rate of 3 kHz by 4-10 GeV, and results in an improvement of Z and Top decay electron identification efficiency by 4-16%. Our results indicate a substantial improvement in the electron trigger rates and efficiencies, when matching tracks are required.

An additional electron-pion separation is achieved in the SDC detector by using a finely segmented shower maximum detector. About 40% of the hadrons do not interact in the calorimeter material before the shower maximum detector. For energies below 50 GeV there is clear separation of electron and pion shower maximum deposits. The baseline design for the SDC trigger system also includes this data but at the coarser granularity of 0.2×0.1 in $\eta - \phi$. However, we have used more finer segmentation of 0.1×0.0125 in $\eta - \phi$, for shower maximum detector in our simulation. The rate and efficiency data obtained after requiring the hits above a threshold in the shower maximum detector are plotted for all three cases are plotted in Figures 5 for nominal SSC luminosity of 10^{33} cm^{-2} s^{-1}. These data indicate a small improvement in the nominal 3 kHz rate of 1 GeV in transverse energy threshold, and 2-3% in Z-Top decay electron identification efficiency. The best transverse energy threshold achieved for nominal 3 kHz rate is 18 GeV with a corresponding Z decay electron identification efficiency of 80%. These simulations, in spite of finer granularity used, seem to indicate that shower maximum detector information at the coarser calorimeter scale does not have enough discrimination to be of much help in the Level-1 trigger.

The thresholds and efficiencies for a nominal 3kHz target rate, and a less conservative 10 kHz rate, are summarized in Tables 1 and 2, respectively.

10^{33} Luminosity 3 kHz Rate	E_T Threshold (GeV)	Z Efficiency (%)	Top Efficiency (%)
Cal Only			
E_T Cut Only	44.1	22.3	48.6
$H/E < 0.1$	35.5	44.0	57.9
Trans. Isol.	28.4	61.5	67.0
Cal+Track			
E_T Cut Only	40.0	31.7	52.4
$H/E < 0.1$	27.4	61.9	67.6
Trans. Isol.	18.8	77.9	76.9
Cal+Track+Shower			
E_T Cut Only	39.3	33.7	53.4
$H/E < 0.1$	26.0	65.1	69.5
Trans. Isol.	17.9	79.5	78.0

Table 1: Transverse energy thresholds for 3 kHz rate, at nominal luminosity, and, corresponding efficiencies for triggering on Z and Top quark decays.

10^{33} Luminosity 10 kHz Rate	E_T Threshold (GeV)	Z Efficiency (%)	Top Efficiency (%)
Cal Only			
E_T Cut Only	30.1	58.4	68.4
$H/E < 0.1$	24.5	70.6	73.9
Trans. Isol.	19.8	78.9	78.4
Cal+Track			
E_T Cut Only	25.7	67.1	73.0
$H/E < 0.1$	15.9	82.9	82.6
Trans. Isol.	11.4	87.0	84.7
Cal+Track+Shower			
E_T Cut Only	24.5	69.7	74.6
$H/E < 0.1$	14.8	84.2	83.7
Trans. Isol.	10.2	87.8	85.5

Table 2: Transverse energy thresholds for 10 kHz rate, at nominal luminosity, and, corresponding efficiencies for triggering on Z and Top quark decays.

5 Performance at high luminosity

It is conceived that at the later phase of SSC the luminosity of the machine will be increased upto 10^{34} cm^{-2} s^{-1}. The trigger components need to be designed, from the outset, with the capability to operate in such very high rate environment. At this luminosity calorimeter has, on average, energy from 13.6 min-bias events for each readout cycle. The simulated rates for this high luminosity case, including the min-bias contribution are plotted in the Figure 6 with and without track requirement. It is seen from these data that both transverse isolation and track matching are required to achieve a threshold less than 30 GeV. The efficiency of triggering on electrons from Z and Top decays is plotted in Figure 7. Satisfactory E_t threshold of 27 GeV, with an increased target rate of 10 kHz, and Z efficiency of 62% is achieved for the best case trigger, i.e. for the case of full transverse and longitudinal isolation with the use of tracking and shower maximum detectors. Electron trigger performance suffers significantly if some of the trigger criteria are not used. The thresholds and efficiencies for a nominal 10kHz target rate are shown in Table 3.

10^{34} Luminosity 10 kHz Rate	E_T Threshold (GeV)	Z Efficiency (%)	Top Efficiency (%)
Cal Only			
E_T Cut Only	60.2	7.2	31.8
$H/E < 0.1$	48.8	14.5	41.6
Trans. Isol.	38.5	35.2	52.6
Cal+Track			
E_T Cut Only	56.3	8.7	34.4
$H/E < 0.1$	40.5	30.4	49.9
Trans. Isol.	28.5	58.4	64.1
Cal+Track+Shower			
E_T Cut Only	55.8	9.0	34.9
$H/E < 0.1$	39.5	33.2	51.2
Trans. Isol.	26.7	61.7	66.0

Table 3: Transverse energy thresholds for 10 kHz rate, at high luminosity, and, corresponding efficiencies for triggering on Z and Top quark decays.

6 Performance at low luminosity

The early phase of SSC, the accelerator is likely to operate at lower luminosity of $10^{31} - 10^{32}$ cm^{-2} s^{-1}. We have simulated the trigger response for this lower luminosity in order to aid in the selection of the trigger electronics components for late staging. The Z and Top decay electron trigger efficiency curves, for the luminosity of 10^{32} cm^{-2} s^{-1}, are plotted in Figure 8 with calorimeter information only. From these results we can conclude that it is possible to attain acceptable rates and efficiency without the use of tracking at the initial low luminosity. The thresholds and efficiencies for a nominal 1kHz target rate are shown in Table 4.

10^{32} Luminosity 1 kHz Rate	E_T Threshold (GeV)	Z Efficiency (%)	Top Efficiency (%)
Cal Only			
E_T Cut Only	30.1	58.4	68.4
$H/E < 0.1$	24.5	70.7	73.9
Trans. Isol.	19.8	78.9	78.4
Cal+Track			
E_T Cut Only	25.7	67.1	73.0
$H/E < 0.1$	15.9	83.0	82.6
Trans. Isol.	11.4	87.0	84.8
Cal+Track+Shower			
E_T Cut Only	24.5	69.7	74.6
$H/E < 0.1$	14.8	84.1	83.6
Trans. Isol.	10.2	87.9	85.5

Table 4: Transverse energy thresholds for 1 kHz rate, at low luminosity, and, corresponding efficiencies for triggering on Z and Top quark decays.

7 Effect of coarse calorimeter segmentation

We have also studied the electron trigger response for coarser calorimeter segmentation of 0.2×0.2 in $\eta - \phi$. The efficiency curves for $10^{33}\mathrm{cm}^{-2}\ \mathrm{s}^{-1}$ and $10^{34}\mathrm{cm}^{-2}\ \mathrm{s}^{-1}$ luminosity are shown in Figure 9 with track requirement. Although the electron trigger seems to perform satisfactorily at the nominal luminosity, the performance of transverse isolation deteriorates at high luminosity. This deterioration is due to the stringent requirement of isolation over larger $\eta - \phi$ region.

8 Importance of Isolation

We have plotted the rates of hadrons and hadron-photon overlaps in a trigger tower for the nominal luminosity case for successesive trigger criteria in the Figure 10. As demonstrated in these plots, a single electromagnetic tower over threshold trigger is not clearly not sufficient to reject hadrons, for particle energies below 40 GeV at nominal SSC Luminosity. The shower shape information available from the longitudinal and transverse segmentation provides an additional handle. Electrons of energies below 40 GeV are expected to deposit almost all of their energy in a single electromagnetic trigger tower, when impinged in the center of the tower. Whereas, hadrons, even those that convert within the electromagnetic part of the calorimeter are likely to develop wider and more penetrating showers. A requirement of hadronic to electromagnetic energy deposit below 10% helps in reducing the false trigger rates considerably as shown in the Figure 10. Those hadrons that shower early in the electromagnetic compartment of the calorimeter may pass this 10% cut. However these hadronic showers are wider and they tend to leak into the neighbouring towers. In addition, most hadrons at SSC are produced in jets, and neighbouring towers are quite likely to contain hadronic energy. Therefore a cut on transverse isolation helps in reducing the rate of these hadrons as shown in the Figure 10. Both these isolation cuts tend to reject the electrons produced in jets, such as those from semi-leptonic decays of b and c quark mesons. The efficiency for identifying isolated electrons from Z and Top decays improves as illustrated earlier. For example, at the nominal luminosity, for 3 kHz rate, the transverse energy threshold improves from 35.5 GeV, with just longitudinal isolation, down to 28.4 GeV with the additional requirement of transverse isolation.

9 Importance of Tracking

Photons generated in the decays of neutral pions deposit their energy in the electromagnetic section of the calorimeter. The rate from such events is very large as shown in the Figure 11(a). The rate from these events is one of the dominant contributions to the Level 1 output. The rate limitation to 3 kHz results in a photon energy threshold of about 30 GeV for the nominal luminosity of SSC when both transverse and longitudinal isolation criteria are used. In order to push down the threshold for the electrons further down, one can require a stiff track matching the energy deposit. This results in a reduced threshold of 19 GeV for electrons as shown in Figure 2.. This track requirement is even more important at higher luminosity. Without the track requirement, the high luminosity electron trigger threshold cannot be pushed below about 39 GeV as shown in Figure 6.

10 Level 1 Output

Figure 10 indicates that the hadrons and hadron photon overlaps are successfully reduced to well below 100 Hz by the use of cut on hadronic to electromagnetic energy ratio, and transverse isolation. The dominant contamination of electron trigger, of about a kHz at 20 GeV, is due to photon conversions as shown in the Figure 11(b). These conversions can easily be tagged using the Silicon tracker and rejected in the Level-2 trigger. The kHz rate of photons can also be reduced by requiring more stringent isolation of the single photons in Level-2.

11 Summary

We conclude that the Monte Carlo simulation of the SDC baseline trigger performance is sufficient proof of adequate trigger functionality for the nominal SSC luminosity of 10^{33} cm^{-2} s^{-1} at 3 kHz target rate for single electrons. The performance is good even at higher SSC luminosity of 10^{34} cm^{-2} s^{-1} when target rate is increased to 10 kHz. In the SSC startup phase when the luminosity is lower some of the trigger criteria can be relaxed. The efficiencies for identifying Z and Top decay electrons at nominal, high and low luminosities for thresholds of 15, 20, 25 and 30 GeV electrons, are summarized in Table 5-6.

Rate(kHz) for 15 GeV E_T Threshold				Rate(kHz) for 20 GeV E_T Threshold			
Luminosity	10^{32}	10^{33}	10^{34}	Luminosity	10^{32}	10^{33}	10^{34}
Cal Only				Cal Only			
E_T Cut Only	7.1	70.6	713.9	E_T Cut Only	3.3	33.1	327.1
$H/E < 0.1$	4.4	43.7	442.0	$H/E < 0.1$	1.9	19.5	189.2
Trans. Isol.	4.3	28.1	256.2	Trans. Isol.	0.9	9.4	85.5
Cal+Track				Cal+Track			
E_T Cut Only	3.3	33.2	333.7	E_T Cut Only	1.8	18.1	181.7
$H/E < 0.1$	1.1	11.2	110.5	$H/E < 0.1$	0.6	6.4	63.1
Trans. Isol.	0.5	5.3	49.6	Trans. Isol.	0.3	2.5	23.6
Cal+Track+Shower				Cal+Track+Shower			
E_T Cut Only	2.7	26.9	272.4	E_T Cut Only	1.6	15.6	157.4
$H/E < 0.1$	1.0	9.8	96.8	$H/E < 0.1$	0.6	5.6	55.7
Trans. Isol.	0.5	4.6	44.2	Trans. Isol.	0.2	2.3	21.0

Table 5: Trigger rates at the three luminosities for 15 and 20 GeV transverse energy threshold.

Rate(kHz) for 25 GeV E_T Threshold				Rate(kHz) for 30 GeV E_T Threshold			
Luminosity	10^{32}	10^{33}	10^{34}	Luminosity	10^{32}	10^{33}	10^{34}
Cal Only				Cal Only			
E_T Cut Only	1.7	17.2	172.6	E_T Cut Only	1.0	10.1	102.4
$H/E < 0.1$	0.9	9.4	94.0	$H/E < 0.1$	0.5	5.3	53.5
Trans. Isol.	0.4	4.3	40.0	Trans. Isol.	0.2	2.5	23.4
Cal+Track				Cal+Track			
E_T Cut Only	1.1	10.7	108.0	E_T Cut Only	0.7	6.8	68.7
$H/E < 0.1$	0.4	3.8	38.0	$H/E < 0.1$	0.2	2.4	23.8
Trans. Isol.	0.1	1.4	13.1	Trans. Isol.	0.1	0.9	8.8
Cal+Track+Shower				Cal+Track+Shower			
E_T Cut Only	1.0	9.5	96.7	E_T Cut Only	0.6	6.1	62.1
$H/E < 0.1$	0.3	3.3	33.6	$H/E < 0.1$	0.2	2.1	21.2
Trans. Isol.	0.1	1.3	11.6	Trans. Isol.	0.1	0.8	7.8

Table 6: Trigger rates at the three luminosities for 25 and 30 GeV transverse energy threshold.

We establish that transverse isolation, in addition to the cut on hadronic to electromagnetic energy ratio, is important to achieve the best transverse energy thresholds. At the nominal luminosity, the use of transverse and longitudinal isolation, drops the electron trigger threshold from 44 GeV down to 28 GeV for a rate of 3 kHz. At high luminosity, the threshold is 39 GeV for a 10 kHz rate. With the use of hadronic to electromagnetic energy ratio cut alone, the threshold can not be pushed below 48 GeV with calorimeter only trigger, without a substantial penalty in the trigger rate. Use of track matching in addition to transverse isolation, at high luminosity, enables a target threshold of 30 GeV with a rate of 10 kHz. We, therefore, conclude that transverse isolation criteria in first level trigger is needed. At high luminosity both transverse isolation and tracking are essential. Since the behaviour of tracking systemsm, at high luminosity, is not completely understood, we believe that it is prudent to build transverse isolation in to the calorimeter level-1 trigger from the outset.

References

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Figure 1: Electron production rates in the decays of (a) Generic QCD 2-Jet background (b) Top, (c) Drell-Yan Z and (d) Drell-Yan W events.

Figure 2: Electron rate from QCD 2-jet events, at nominal luminosity of 10^{33}cm^{-2} s^{-1}, obtained using (a) calorimeter information only and (b) calorimeter and track information.

Figure 3: Efficiency for identifying electrons from Z decays, at nominal luminosity of 10^{33}cm^{-2} s^{-1}, obtained using (a) calorimeter information only and (b) calorimeter and track information.

Figure 4: Efficiency for identifying electrons from Top decays, at nominal luminosity of 10^{33}cm^{-2} s^{-1}, obtained using (a) calorimeter information only and (b) calorimeter and track information.

Figure 5: (a) Electron rate from QCD 2-jet events at nominal luminosity of 10^{33}cm^{-2} s^{-1}obtained using calorimeter, track and shower maximum detector information. (b) Efficiency of identifying electrons from Z decays when shower maximum detector hits are required.

Figure 6: Electron rate from QCD 2-jet events at high luminosity of 10^{34}cm^{-2} s^{-1}obtained using (a) calorimeter information only and (b) calorimeter and track information.

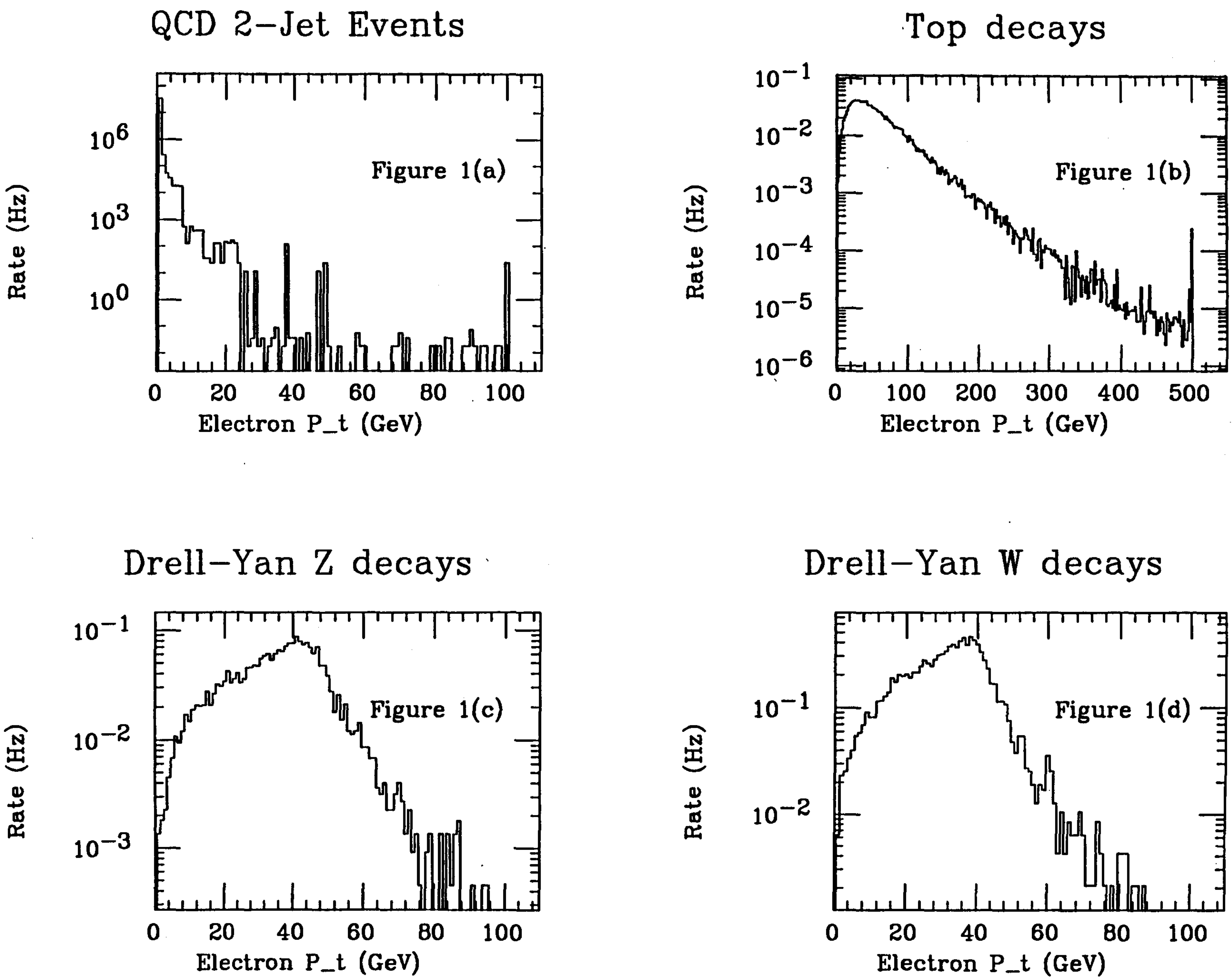
Figure 7: Efficiency for identifying electrons from (a) Z decays and (b) Top decays, at high luminosity of 10^{34}cm^{-2} s^{-1}, obtained using calorimeter and track information.

Figure 8: Efficiency for identifying electrons from (a) Z decays and (b) Top decays using calorimeter information only at initial low luminosity of 10^{32}cm^{-2} s^{-1}.

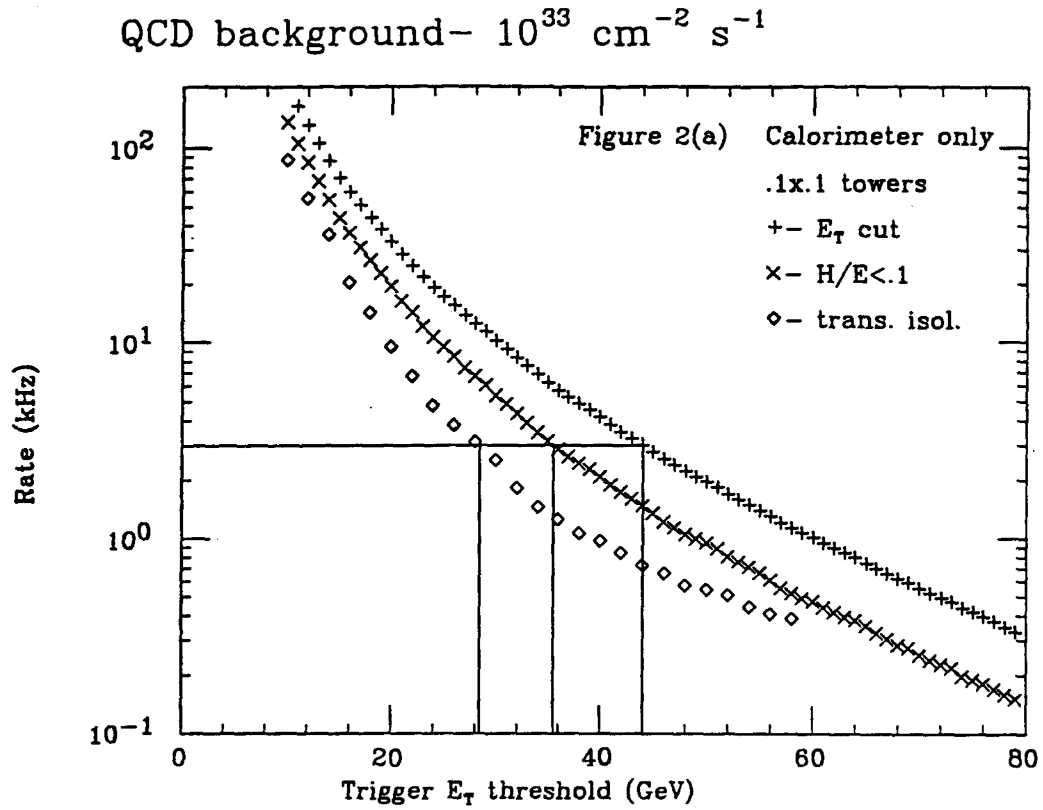
Figure 9: Comparision of the effects of calorimeter trigger tower size in terms of the efficiencies for identifying electrons from Z decays (a) at nominal luminosity of 10^{33}cm^{-2} s^{-1} and (b) at high luminosity of 10^{34}cm^{-2} s^{-1}.

Figure 10: The rate of (a) hadrons and (b) hadron-photon overlaps, are plotted versus E_T for various trigger cuts, to show the trigger rejection.

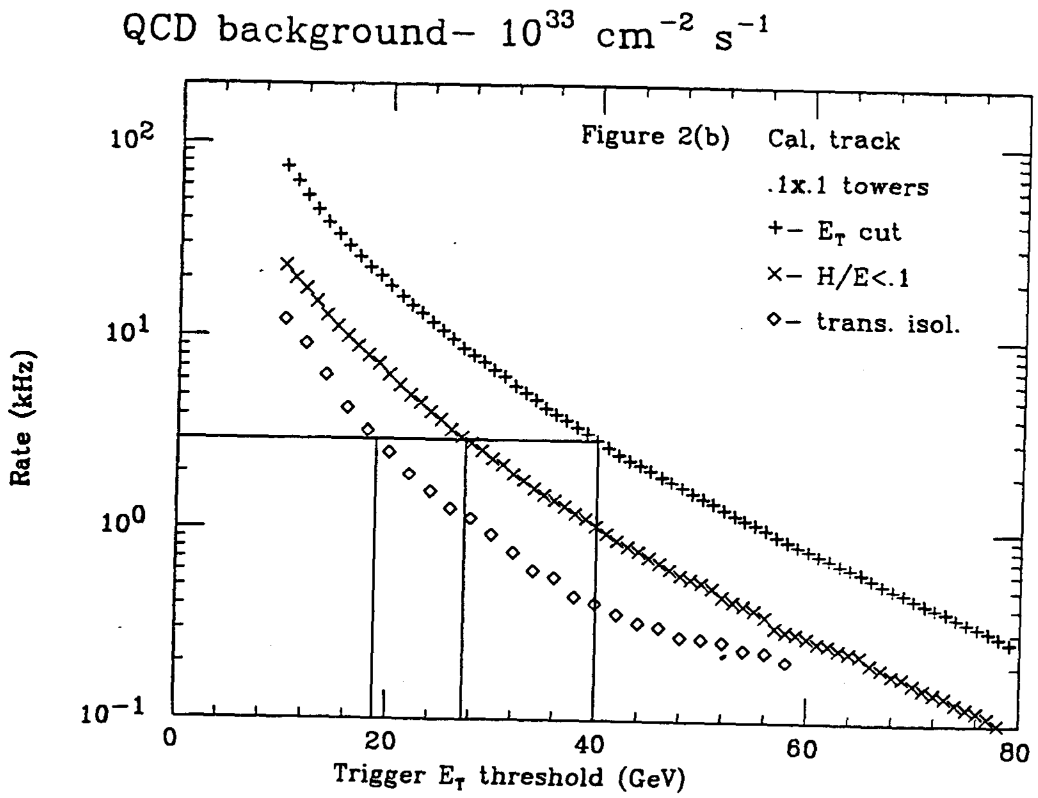
Figure 11: The rate of (a) photon-conversions and (b) photons, are plotted versus E_T for various trigger cuts, to show that Level-1 trigger sample is dominated by conversion photons, and photons.



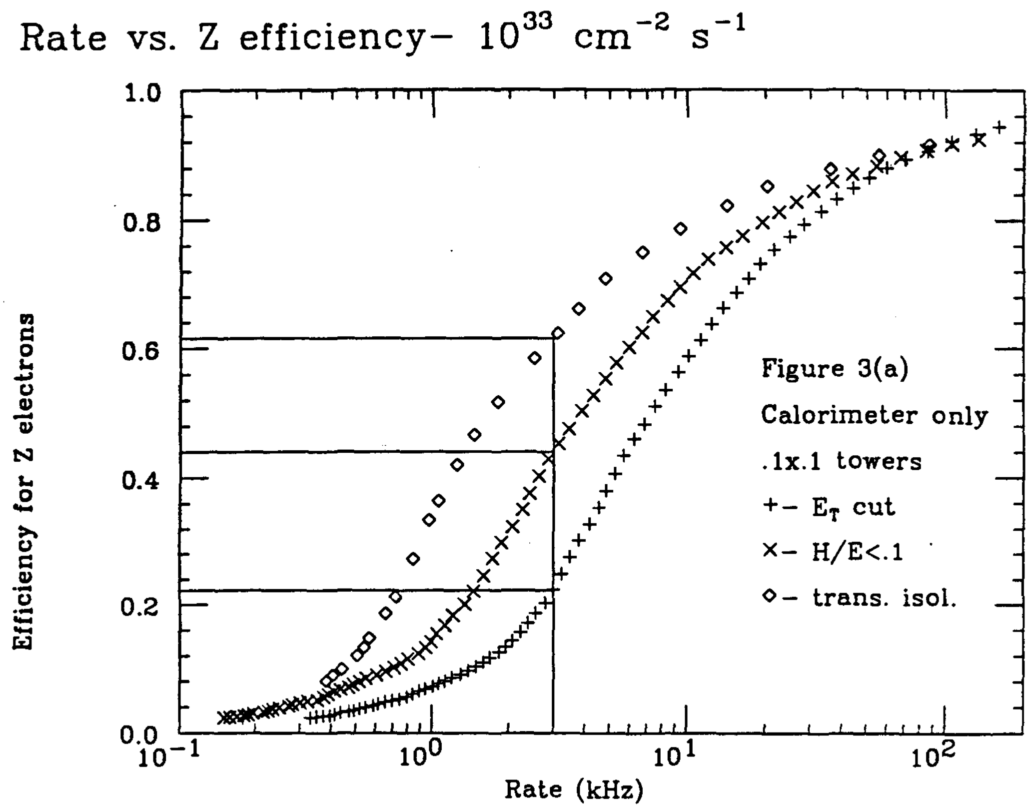
QCD 2-Jet Events
Figure 1(a)
Rate (Hz)
10^6
10^3
10^0
0 20 40 60 80 100
Electron P_t (GeV)
Top decays
Figure 1(b)
Rate (Hz)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0 100 200 300 400 500
Electron P_t (GeV)
Drell-Yan Z decays
Figure 1(c)
Rate (Hz)
10^{-1}
10^{-2}
10^{-3}
0 20 40 60 80 100
Electron P_t (GeV)
Drell-Yan W decays
Figure 1(d)
Rate (Hz)
10^{-1}
10^{-2}
0 20 40 60 80 100
Electron P_t (GeV)

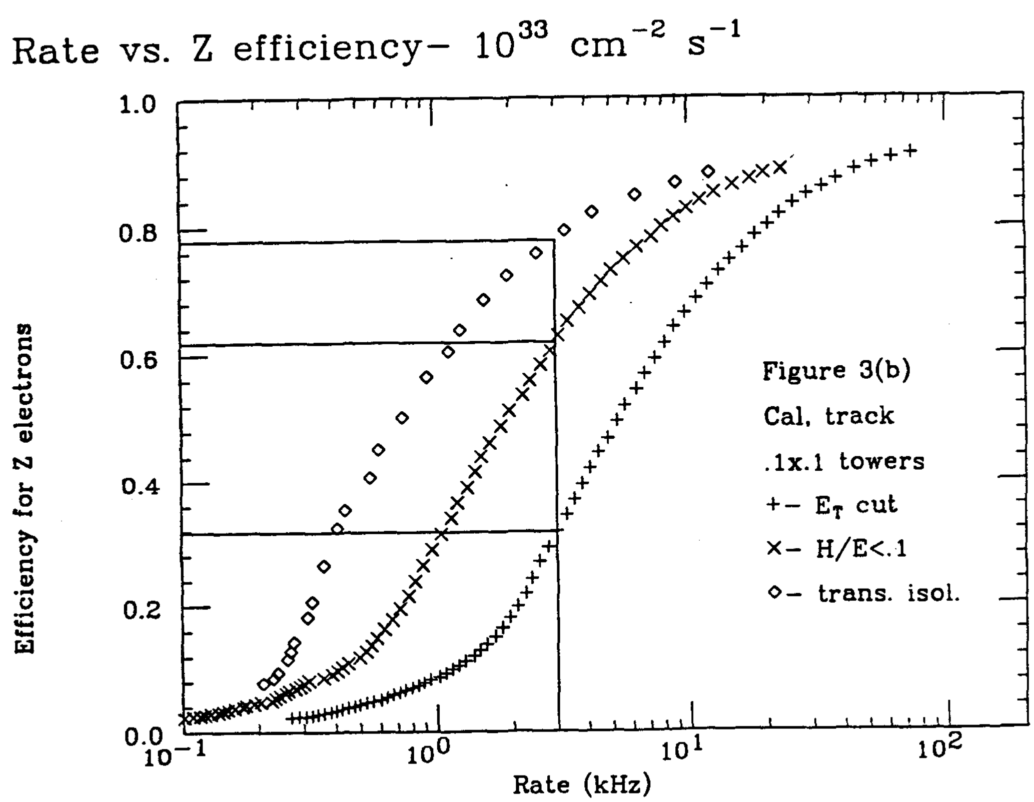


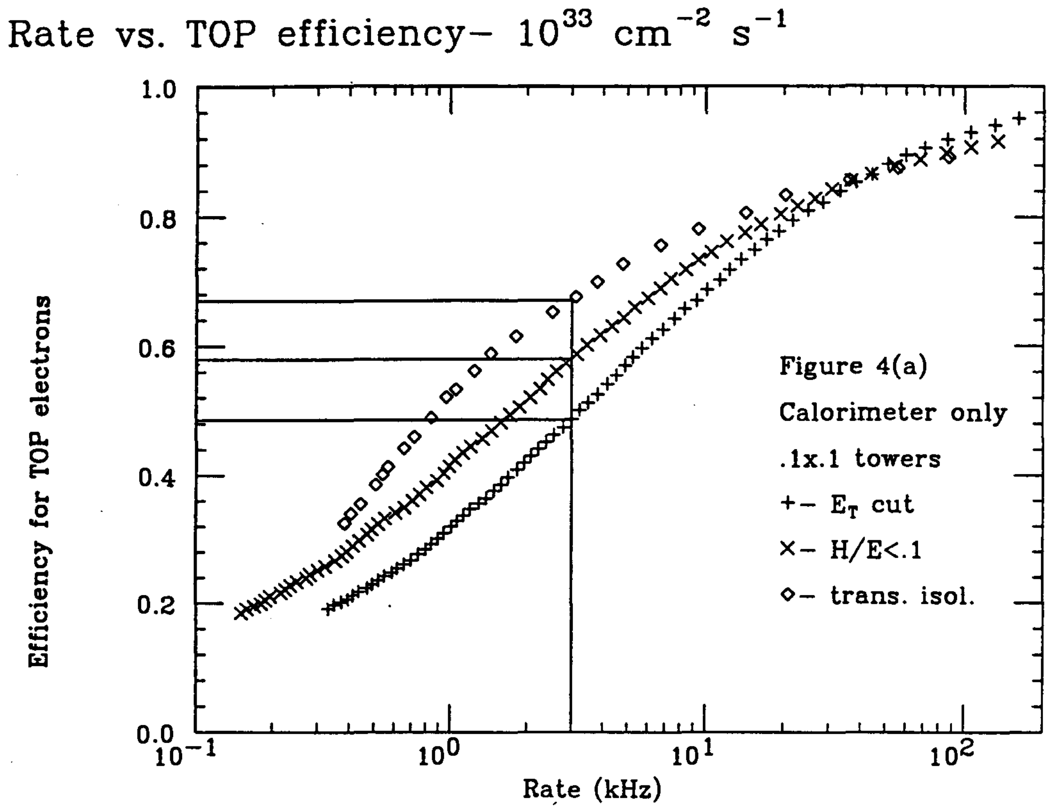
QCD background– 10^{33} cm^{-2} s^{-1}
Figure 2(a)
Calorimeter only
.1x.1 towers
+– E_T cut
×– H/E<.1
◇– trans. isol.
Rate (kHz)
Trigger E_T threshold (GeV)

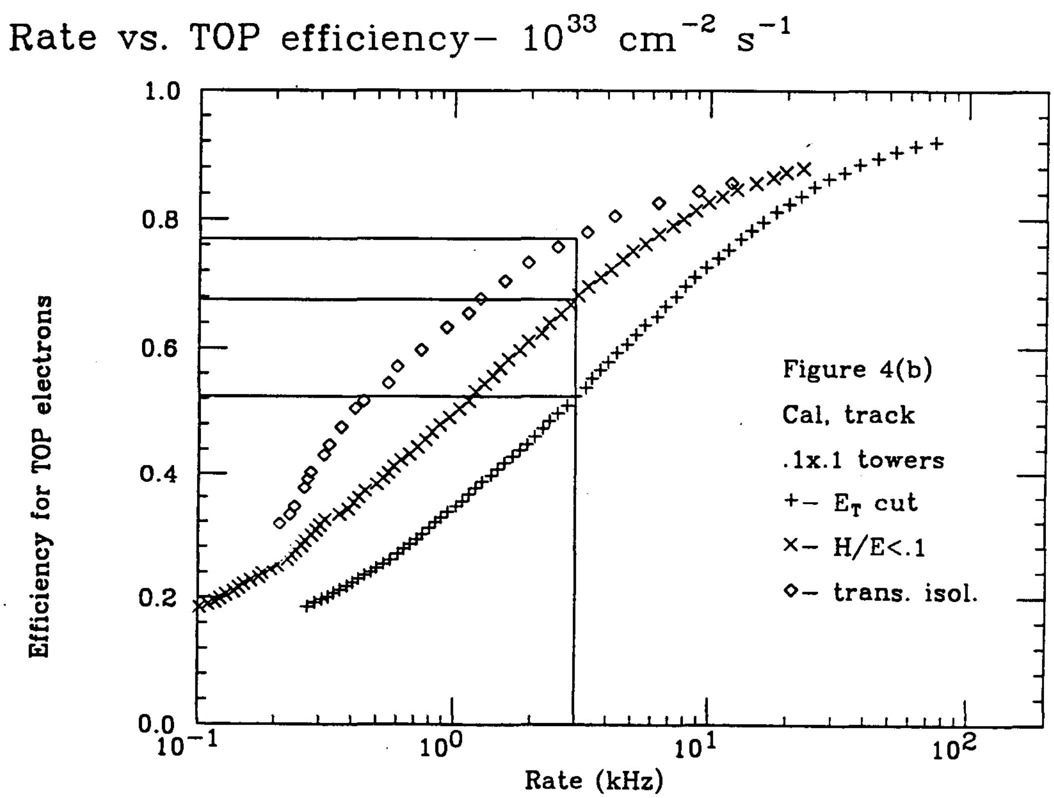


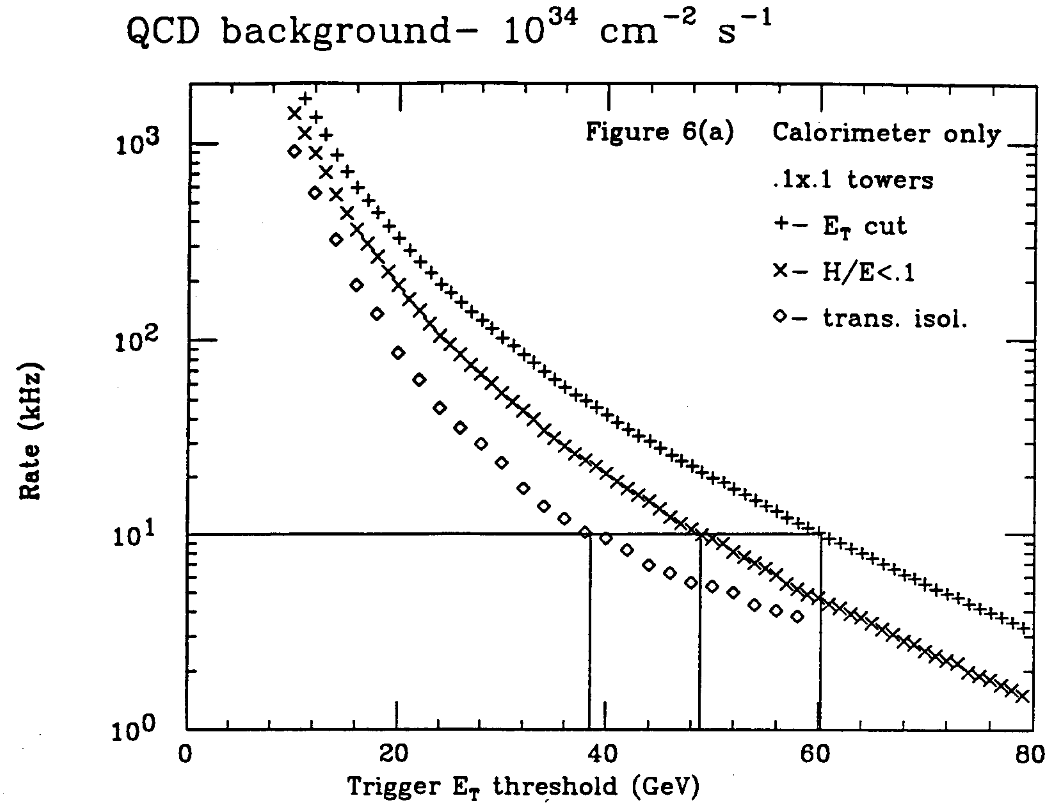
QCD background– 10^{33} cm^{-2} s^{-1}
Figure 2(b)
Cal. track
.1x.1 towers
+– E_T cut
×– H/E<.1
◇– trans. isol.
Rate (kHz)
Trigger E_T threshold (GeV)


Rate vs. Z efficiency– 10^{33} cm^{-2} s^{-1}
Efficiency for Z electrons
Rate (kHz)
Figure 3(a)
Calorimeter only
.1x.1 towers
+– E_T cut
×– H/E<.1
◇– trans. isol.

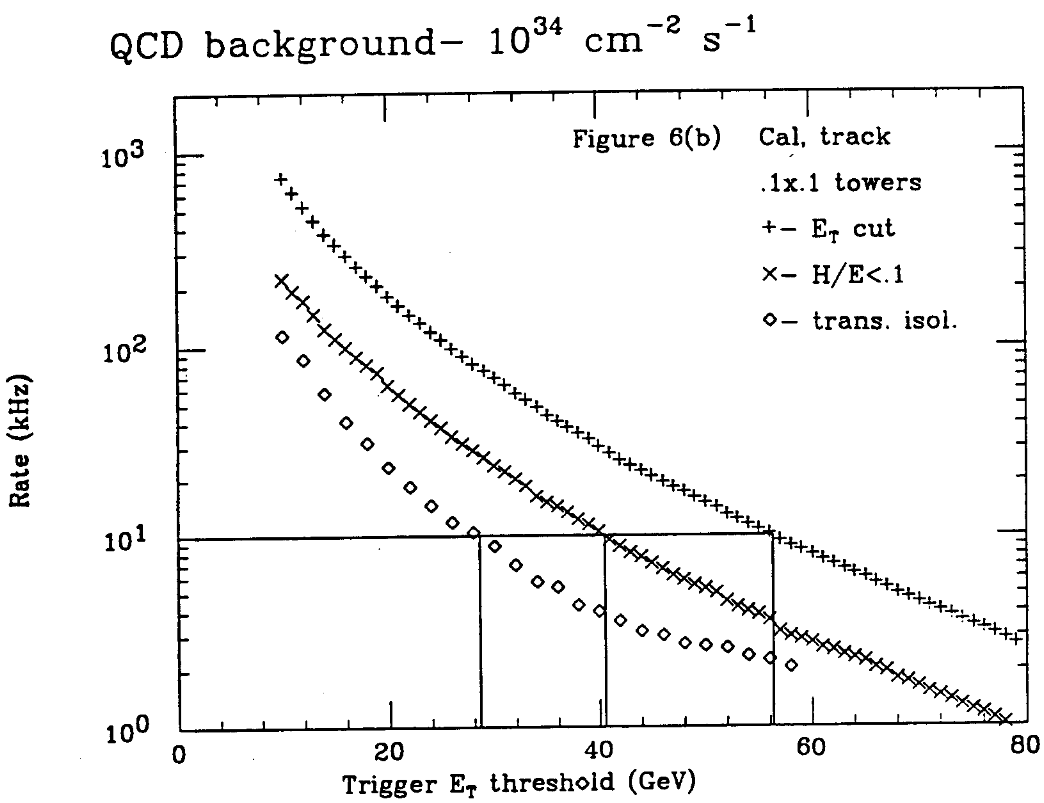

Rate vs. Z efficiency– 10^{33} cm^{-2} s^{-1}
Efficiency for Z electrons
Rate (kHz)
Figure 3(b)
Cal, track
.1x.1 towers
+– E_T cut
×– H/E<.1
◇– trans. isol.


Rate vs. TOP efficiency– 10^{33} cm^{-2} s^{-1}
Efficiency for TOP electrons
Rate (kHz)
Figure 4(a)
Calorimeter only
.1x.1 towers
+– E_T cut
×– H/E<.1
◇– trans. isol.


Rate vs. TOP efficiency– 10^{33} cm^{-2} s^{-1}
Efficiency for TOP electrons
Rate (kHz)
Figure 4(b)
Cal, track
.1x.1 towers
+– E_T cut
×– H/E<.1
◇– trans. isol.

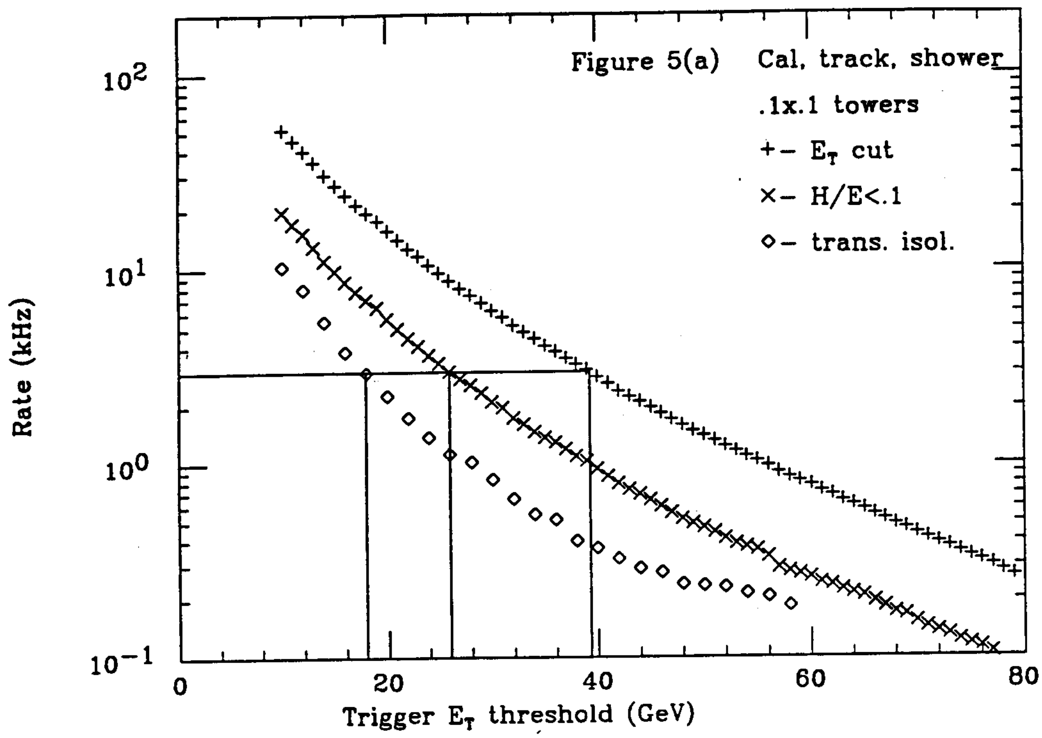


QCD background- 10^{34} cm^{-2} s^{-1}
Figure 6(a)
Calorimeter only
.1x.1 towers
+– E_T cut
×– H/E<.1
◇– trans. isol.
Rate (kHz)
Trigger E_T threshold (GeV)

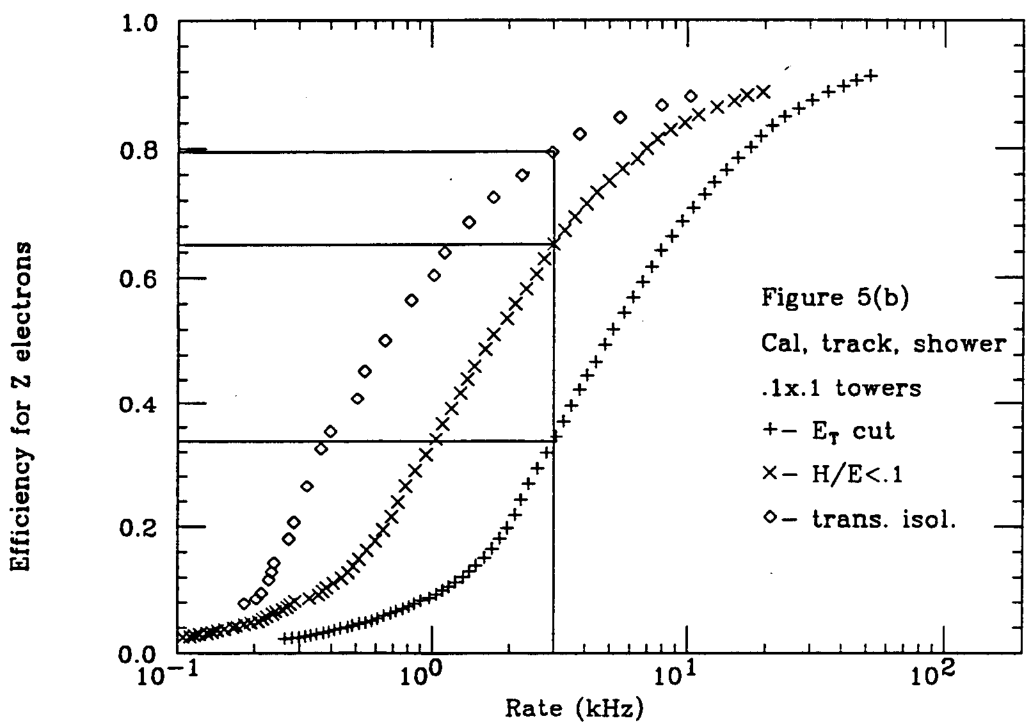


QCD background- 10^{34} cm^{-2} s^{-1}
Figure 6(b)
Cal, track
.1x.1 towers
+– E_T cut
×– H/E<.1
◇– trans. isol.
Rate (kHz)
Trigger E_T threshold (GeV)

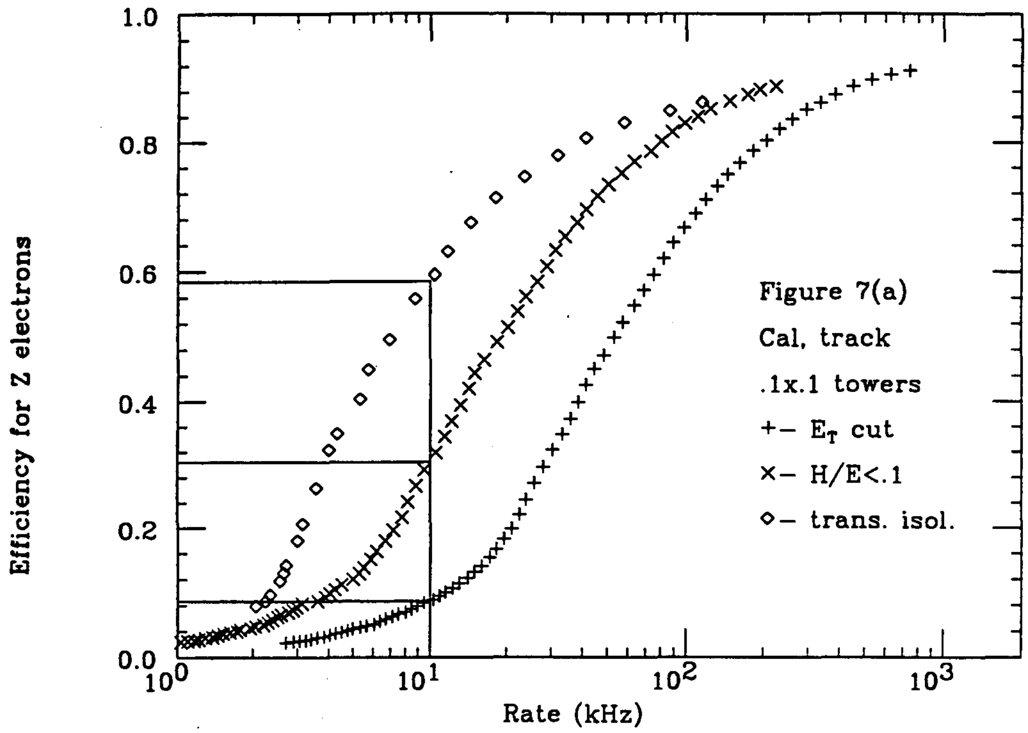
QCD background– 10^{33} cm^{-2} s^{-1}



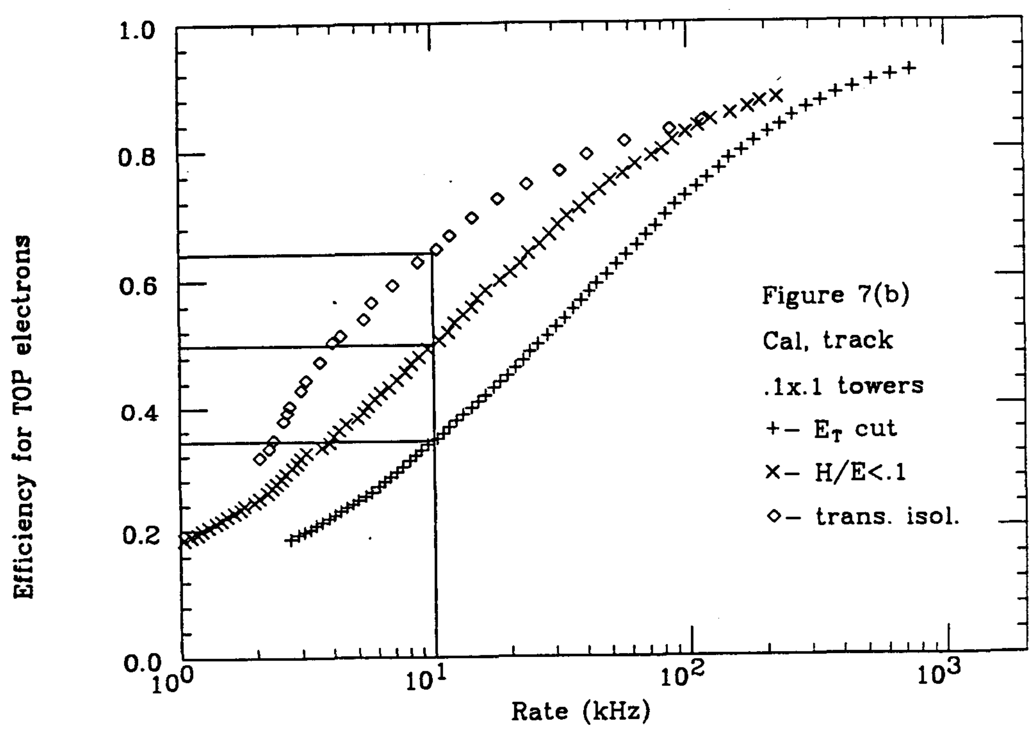
Rate vs. Z efficiency– 10^{33} cm^{-2} s^{-1}



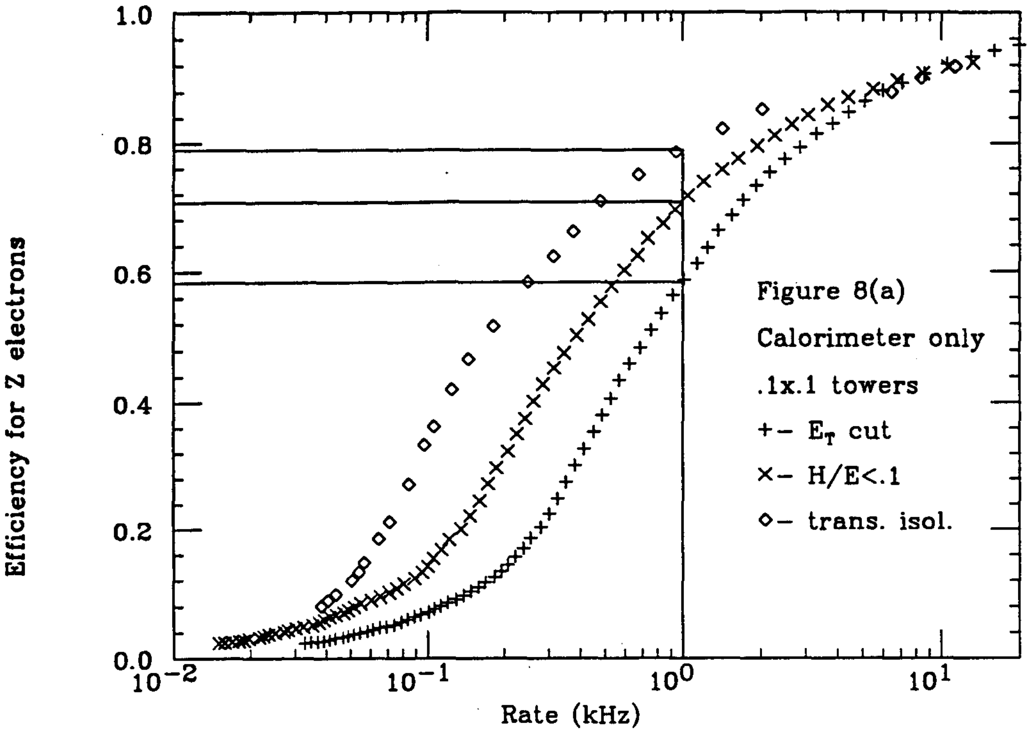
Rate vs. Z efficiency– 10^{34} cm^{-2} s^{-1}



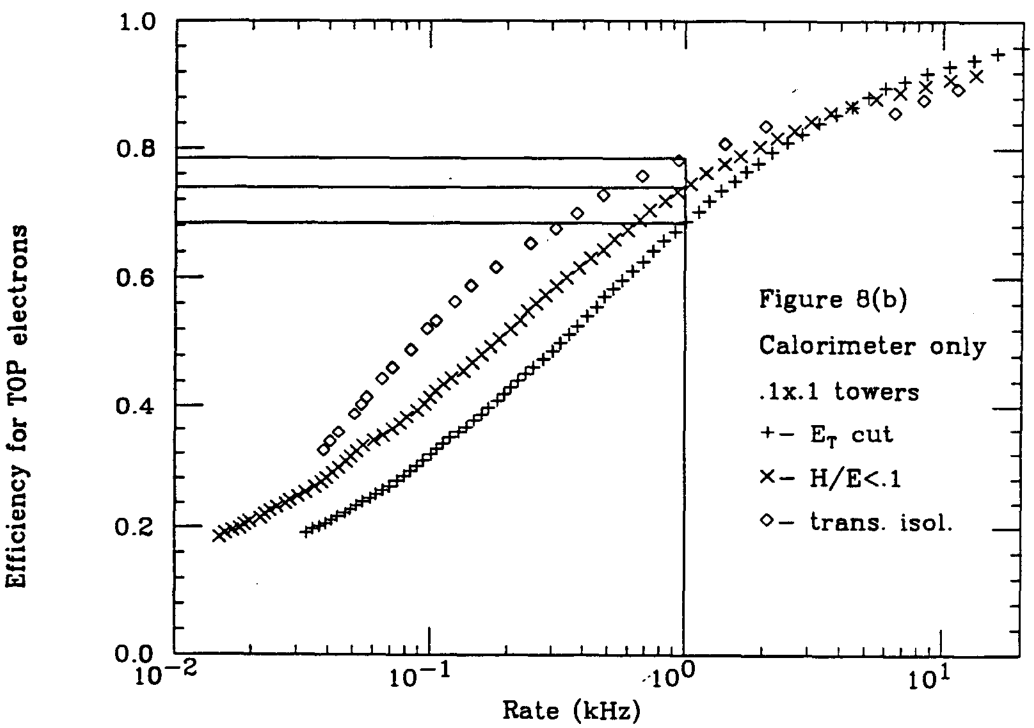
Rate vs. TOP efficiency– 10^{34} cm^{-2} s^{-1}



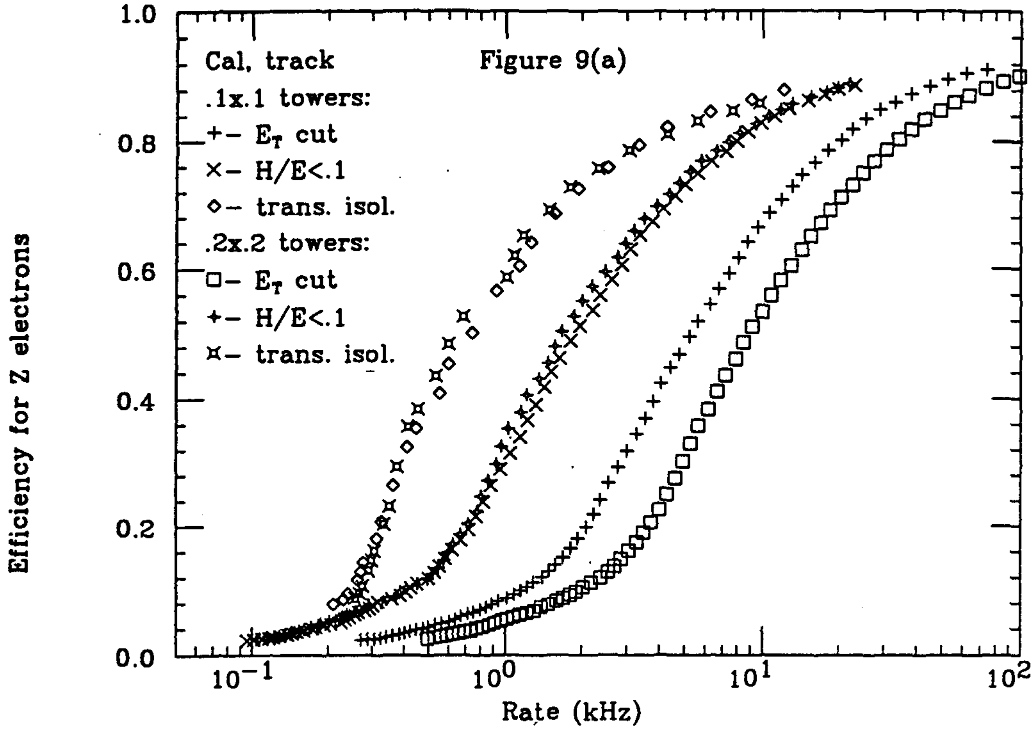
Rate vs. Z efficiency– 10^{32} cm^{-2} s^{-1}



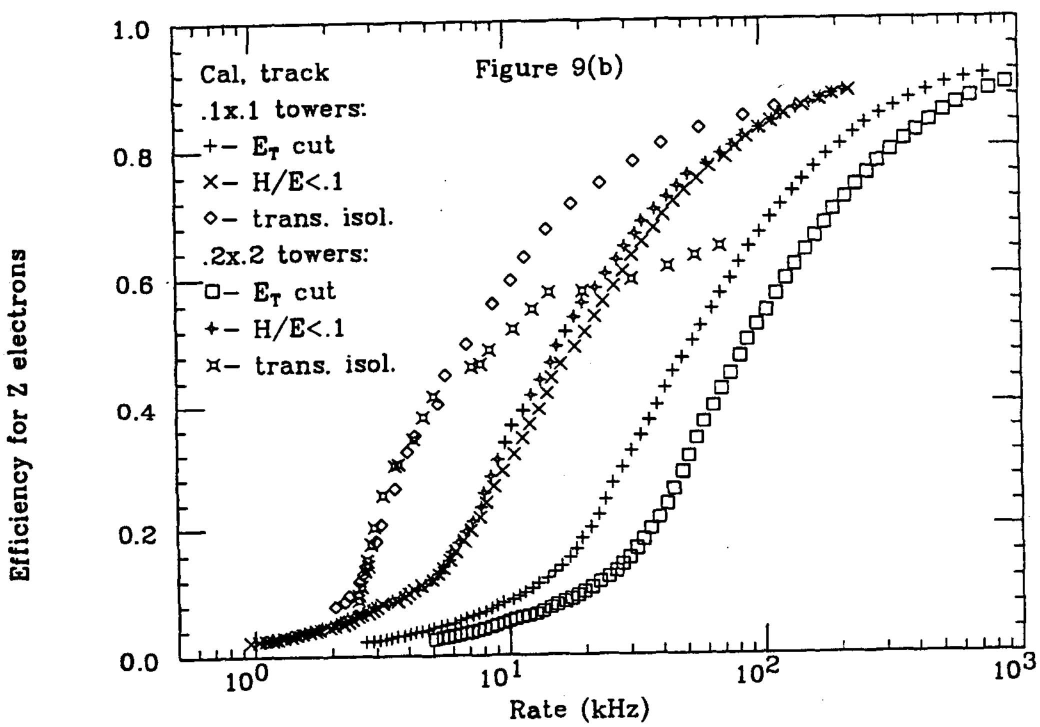
Rate vs. TOP efficiency– 10^{32} cm^{-2} s^{-1}

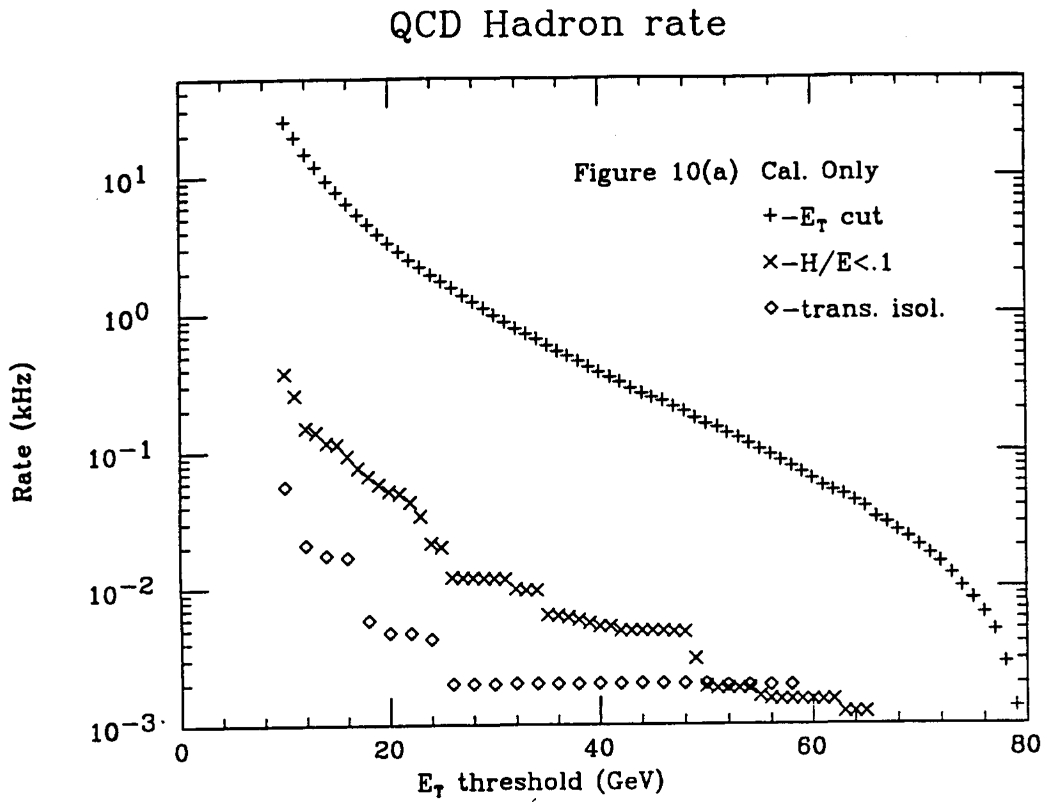


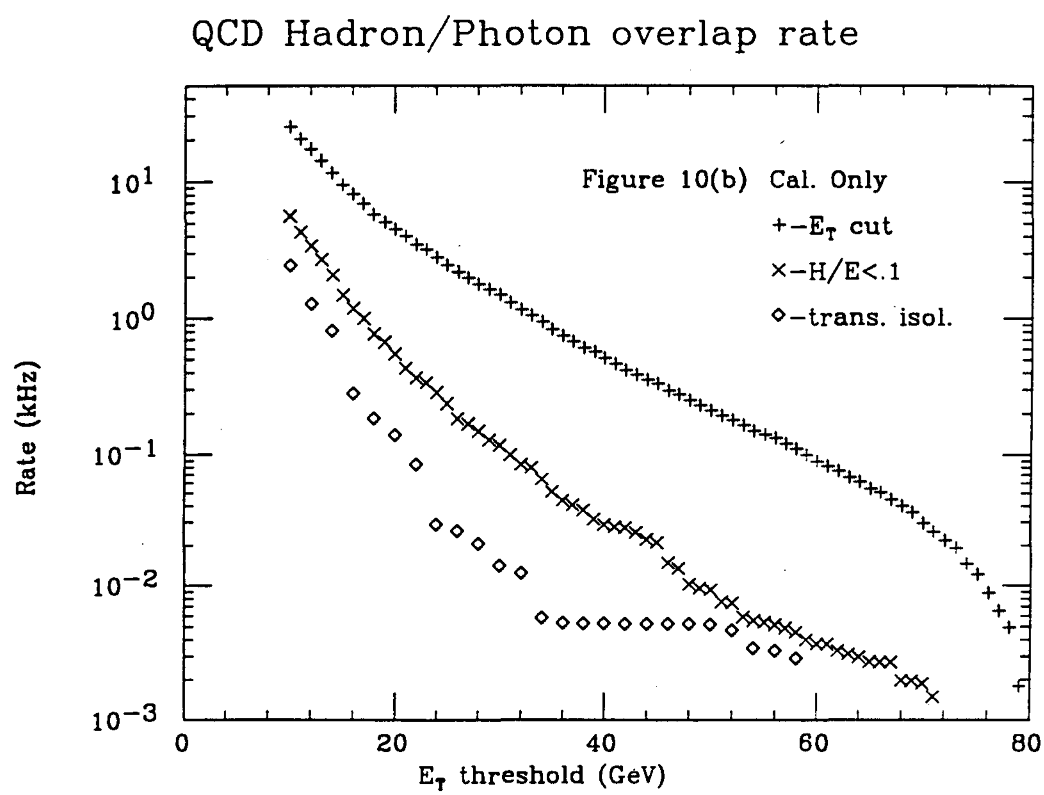
Rate vs. Z efficiency– 10^{33} cm^{-2} s^{-1}

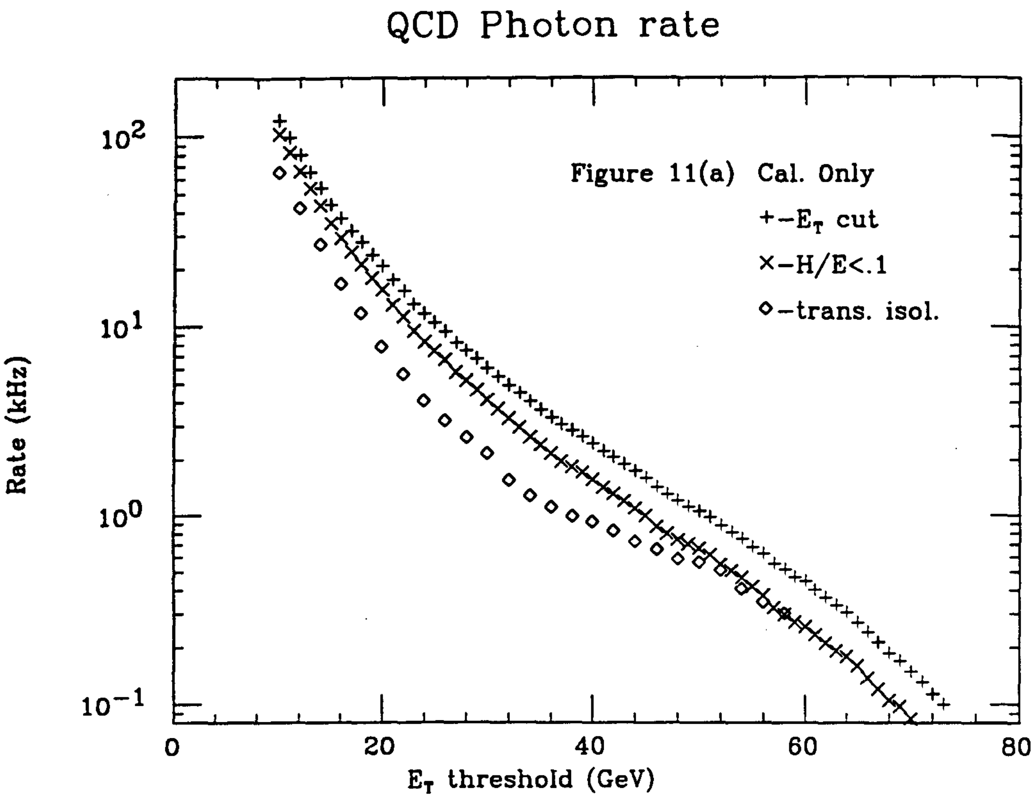


Rate vs. Z efficiency– 10^{34} cm^{-2} s^{-1}

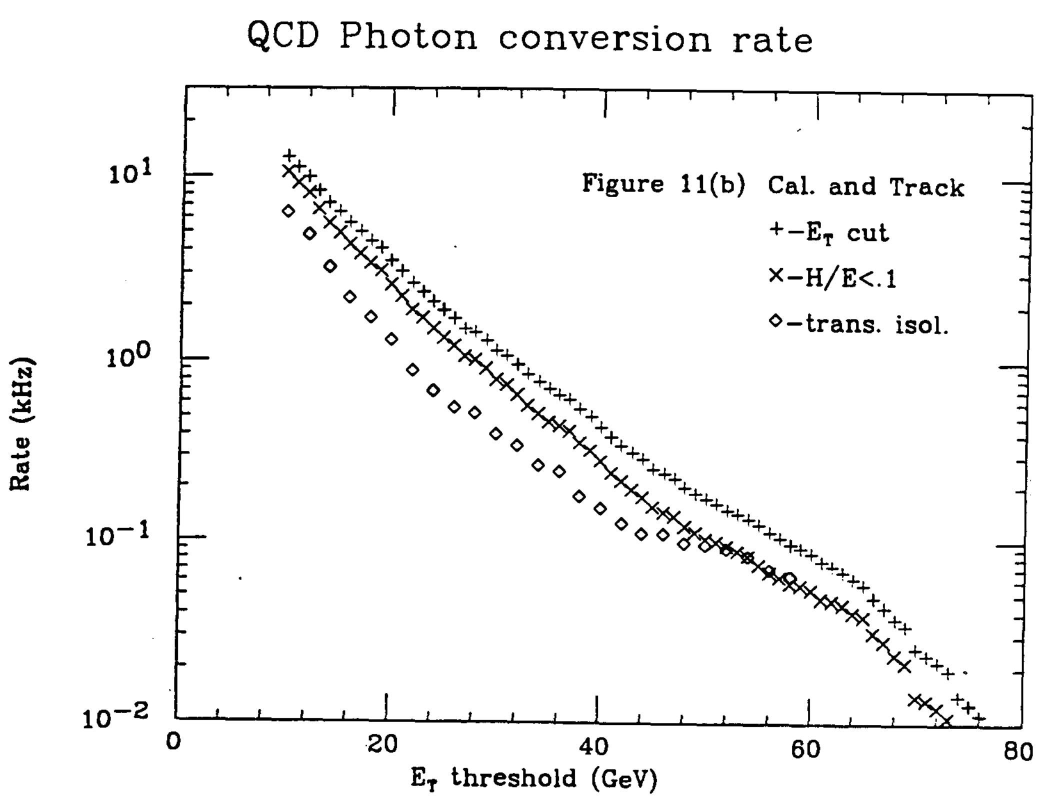



QCD Hadron rate
Figure 10(a) Cal. Only
+–E_T cut
×–H/E<.1
◇–trans. isol.
Rate (kHz)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
0
20
40
60
80
E_T threshold (GeV)


QCD Hadron/Photon overlap rate
Figure 10(b) Cal. Only
+–E_T cut
×–H/E<.1
◇–trans. isol.
Rate (kHz)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
0
20
40
60
80
E_T threshold (GeV)



QCD Photon rate
Figure 11(a) Cal. Only
+–E_T cut
×–H/E<.1
◇–trans. isol.
Rate (kHz)
E_T threshold (GeV)



QCD Photon conversion rate
Figure 11(b) Cal. and Track
+–E_T cut
×–H/E<.1
◇–trans. isol.
Rate (kHz)
E_T threshold (GeV)