Triggering the eγ Calorimeter at the LHC

J. Paradiso

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Abstract

An efficient simulation of the eγ calorimeter has been constructed for the purpose of defining and evaluating an effective triggering scheme. The structure of the simulation package is discussed, and the assumed detector models are introduced. Several triggering cuts are derived, and their on-line implementation is outlined at trigger levels 1 and 2. Triggering efficiencies are given for simulated $H \rightarrow \gamma\gamma$ events with a 19-event minimum bias pileup. The rejection of QCD background is demonstrated by simulating over a million hard QCD events over pileup, and tracking them through the trigger logic. Single photon and photon pair rates are calculated for trigger sums calculated with tower sizes ($\Delta\eta \times \Delta\phi$) of (.05 x .05), (.1 x .1), and (.2 x .2), over energy thresholds ranging from 10 → 40 GeV. These results are interpreted to ascertain the effects of energy thresholds, topological cuts, and tower size on the trigger rate.

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1) Detector Model

Figure 1 shows a side-view of the proposed "eγ" electromagnetic calorimeter layout, as installed at the L3 interaction point. Since this study has dealt only with the calorimeter, the central tracker has been omitted. The eγ is assumed to be a crystal calorimeter, forming a barrel spanning $|\eta| < 1$. The barrel radius is set at 3 meters. The (lateral) crystal faces are each assumed to span 3 x 3 centimeters. The current crystal candidate is Cerium Fluoride, and the specified longitudinal span of 25 X_0 results in a crystal length of 42 cm, giving 1.6 λ of hadron interaction. The Moliere radius of CeF_3 is 2.63 cm. With such a fine-grained calorimeter at a 3 meter radius, the effects of piled-up interactions on resolution and pattern-recognition will be reduced considerably. The results of this study may be relevant to the application of materials other than CeF_3; the only crystal parameters used in the simulation are the number of interaction lengths and the Moliere radius (which is implicit in the shower-sharing scheme between crystals).

The crystal elements are oriented to project toward the interaction point, as indicated in Fig. 1. This results in each crystal spanning a constant $\Delta\eta$ interval of 0.01, and $\Delta\phi$ of approximately 0.01 radians (the $\Delta\phi$ crystal size was adjusted slightly from this value in order to fit several tower sizes onto the calorimeter geometry; the dimension used is $\Delta\phi = .0098$ radians, 2.95 cm). The $|\eta| < 1$ calorimeter thus contains 200 x 640 = 120,000 crystals.

A hadron calorimeter, of minimum granularity .05 x .05, is assumed to be located behind the crystal elements. The hadron calorimeter is assumed to absorb all hadron energy that was not deposited in the electromagnetic calorimeter (since this is the extent of the model used in this study, the particular calorimeter design is unimportant). The crystals are assumed to contain the entire electromagnetic shower, with no leakage through to the hadronic array.

Energy thresholds are tested on three sets of tower sums. The tower sizes adopted are .05 x .05 (5 x 5 crystals, 40 x 128 = 5,120 towers), .1 x .1 (10 x 10 crystals, 20 x 64 = 1,280 towers), and .2 x .2 (20 x 20 crystals, 10 x 32 = 320 towers).

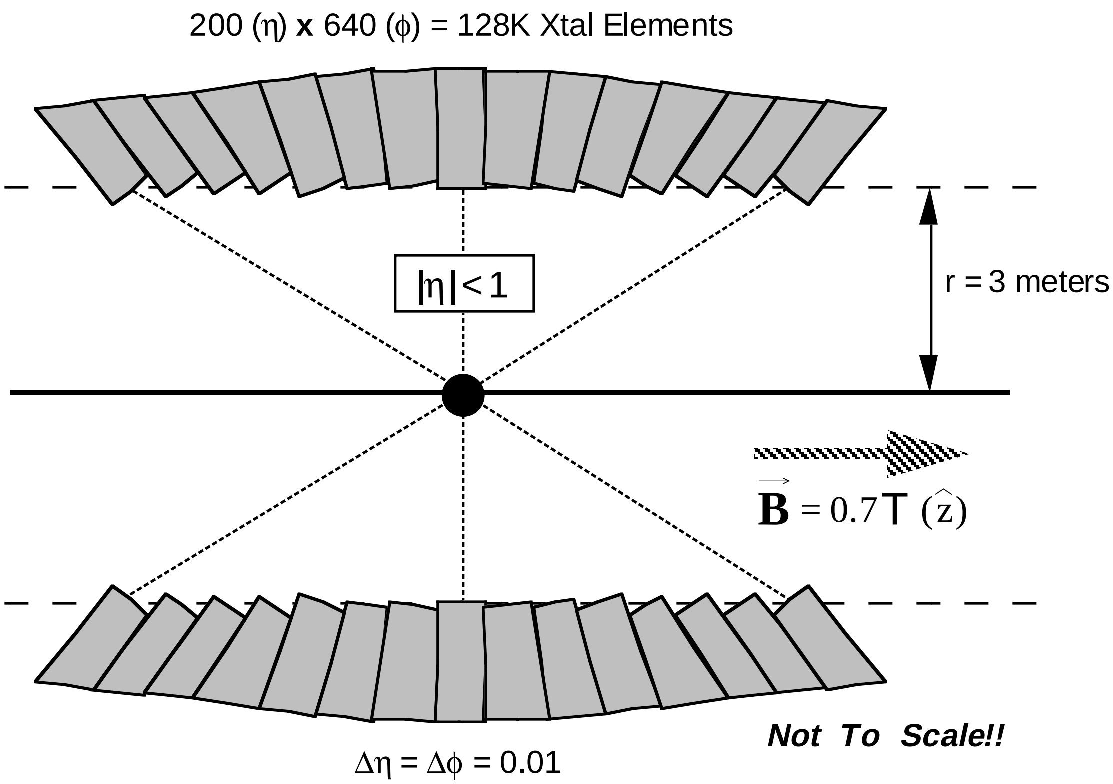


Figure 1: rθ View of the eγ Calorimeter

The detector is assumed to be immersed in a constant magnetic field of 0.7 Tesla, directed along the $\hat{z}$-axis. Figure 2 illustrates a simple means of determining the impact point of charged particles at the calorimeter's inner radius. Rather than iteratively calculating particle trajectories using a local Jacobian (i.e. the standard GEANT technique), the impact point can be readily calculated in closed form. Assuming that the radial displacement of the vertex is zero (σ_x, $\sigma_y \approx 200$ µm, which is insignificant here), the calorimeter impact point in rφ can be determined by solving the isosceles triangle given in Fig. 2 (the $p_\perp$ cutoff is implicitly maintained by requiring $r_c < 2\, r_p$ for the arcsine to be real). The impact point along the beam ($\hat{z}$) axis is then set by the particle's Larmor frequency, and may be calculated as:

$$z_{imp} = \frac{p_{\|}}{p_{\perp}} \Delta\phi_B\, r_p + z$$

where $p_{\|}$ is the $\hat{z}$-component of particle momentum (along the beamline), $p_\perp$ is the transverse momentum, $\Delta\phi_B$ is the bending angle, r_p the bending radius (as in Fig. 2), and z_V is the z-position of the interaction vertex (σ_Z = 5.5 cm. in this study). These calculations may be realized in a few lines of computer code, and execute promptly.

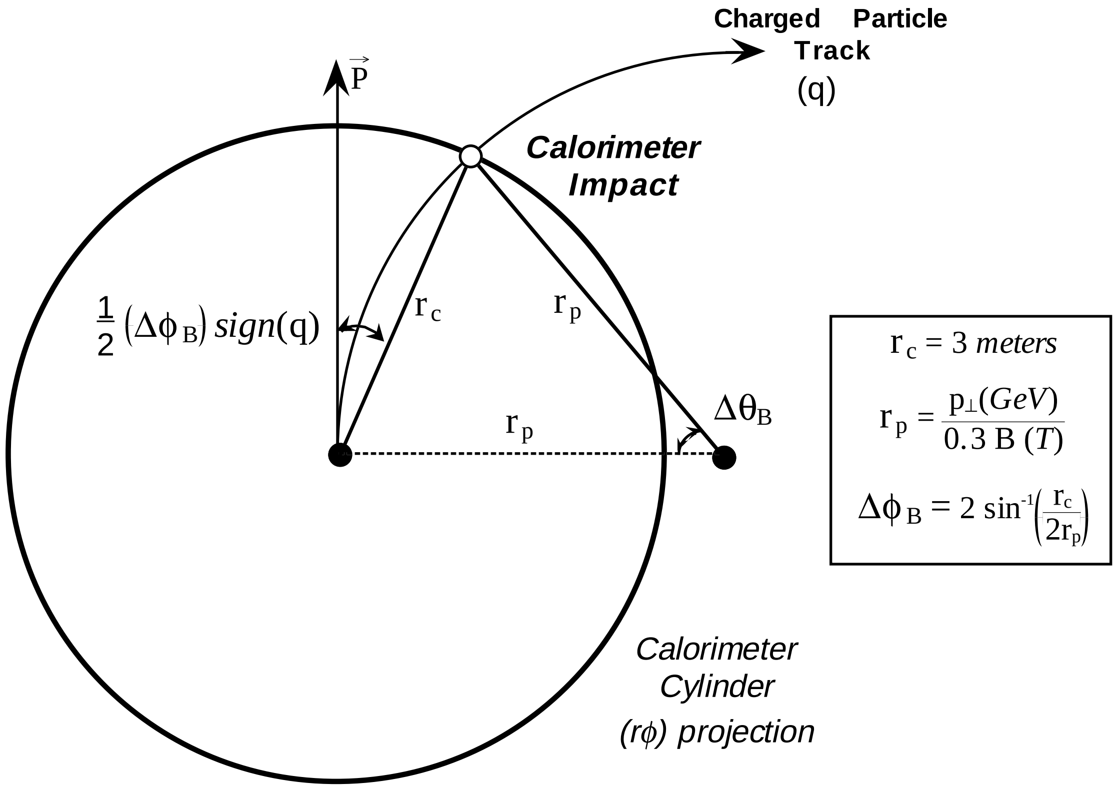


Figure 2: Simplified Tracking of Charged Particles

Electromagnetic showers were deposited in the crystal calorimeter according to a simple empirical model derived from the shower sharing behavior seen in the BGO crystals of the L3 electromagnetic calorimeter[1]. The concept is illustrated in Fig. 3. Electromagnetic showers are always assumed to be contained within a 3 x 3 crystal block. The energy of the electron or photon is assumed to be entirely dissipated within this block, and is distributed according to the matrix given in Fig. 3 when the middle crystal is hit dead-center. As the incident particle moves away from the center, the sharing between the 9 crystals in the block is skewed according to the plot given at the bottom of Figure 3. Since most of the energy deposit is highly local (i.e. a tightly peaked spatial distribution with long tails), no difference is injected into the sharing function for a particle incidence within ±0.75 cm (±25% of the crystal width) of the crystal center. For particles hitting outside this region, the nearby row of crystals share an increasing amount of shower energy, until they split the shower evenly at the border. This smearing is done separately for both coordinates (η and ϕ); i.e. first the columns, then the rows (of the 3 x 3 matrix in Fig. 3) are skewed by the offset of the incident particle from the nearest crystal center.

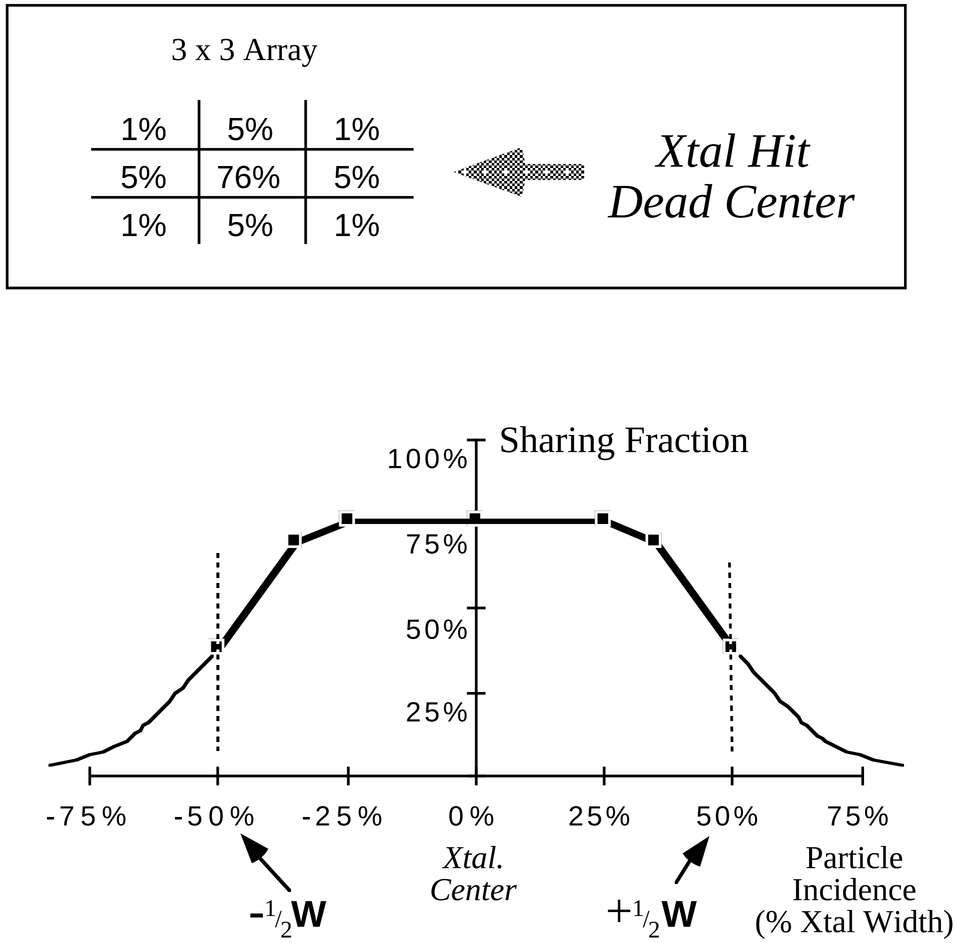


Figure 3: Electromagnetic Shower Sharing in the Crystal Calorimeter

Although this model suffers from a variety of shortcomings (i.e. no fluctuations in shower distribution or density are assumed, no leakage into the hadron calorimeter is modeled, etc.), it executes extremely quickly, and has sufficient integrity to yield an indication of trigger performance. As other, more sophisticated shower parameterizations are developed (i.e. [2]), they may be readily incorporated into the simulation software, which has been built in a modular fashion in order to enable ready replacement and updating of detector models.

Because electromagnetic showers are so well contained in the crystal calorimeter, simple assumptions such as given above retain some validity for electron and photon showers. The situation is quite different for hadron showers in the crystal calorimeter, however, which tend to be much more complicated and heavily fluctuated. In order to simulate the hadron response, an empirical model[3] was implemented, based on data from the L3 BGO and uranium calorimeters. The longitudinal shower development is

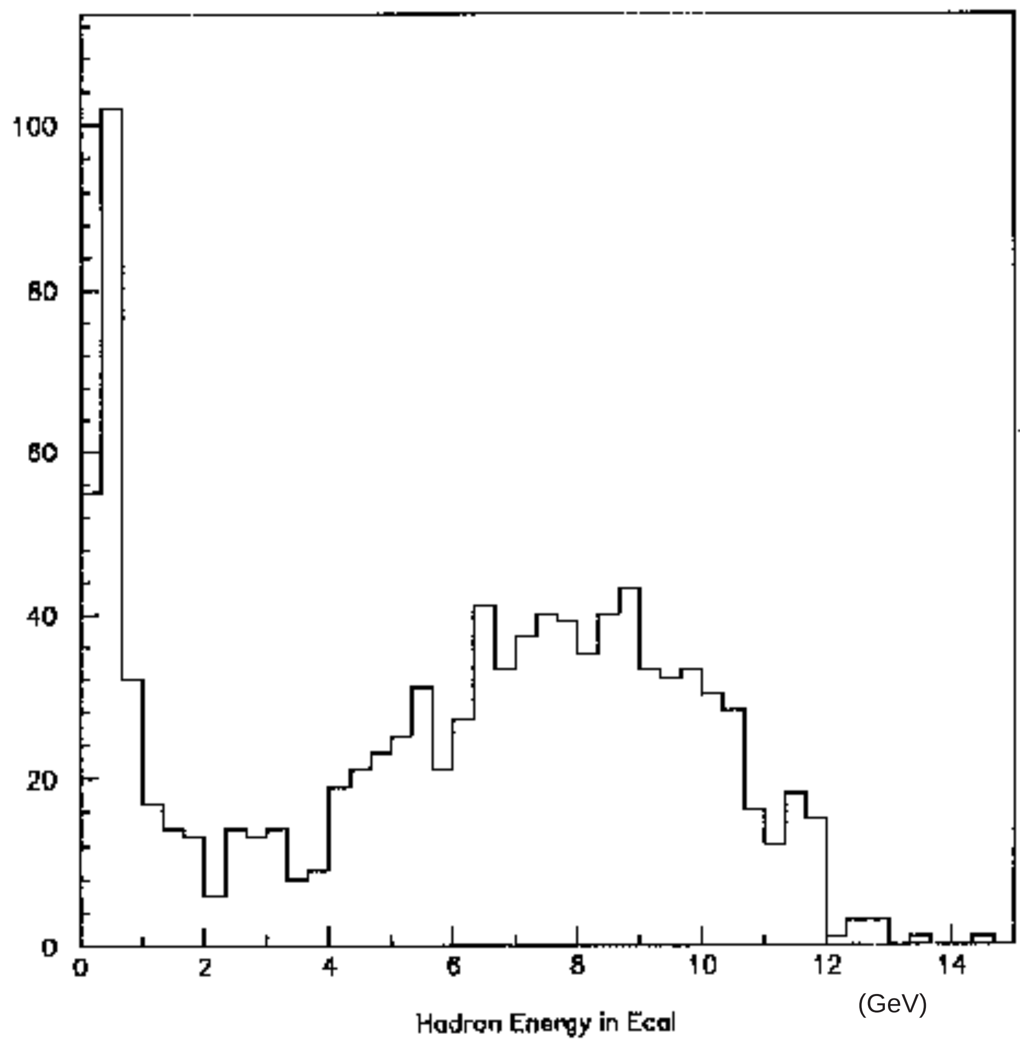


Figure 4: Energy Deposit in Crystal Calorimeter for 20 GeV Incident Hadrons

parameterized by a sum of decaying exponentials with a fluctuated offset. The shower is assumed to begin after the incident hadron penetrates the crystal to a depth distributed according to $e^{-x/\lambda}$, where λ = 26.2 cm for CeF_3. Before the shower begins, the hadron looses energy as a Landau MIP, with peak energy of 350 MeV[1]. The hadron energy deposit in the crystal calorimeter is scaled by a compensation factor (π/e) of 0.6, based on the L3 BGO data, and as could be expected with CeF_3 (Ref. [4]).

Fig. 4 shows the distribution of energy deposited in the crystal calorimeter for 20 GeV incident hadrons. One clearly sees the MIP peak at 350 MeV, resulting from hadrons traversing the crystal calorimeter without showering. The showering particles produce a broad energy distribution, peaking at 8 GeV. This broad peak is caused by the significant amount of hadron interaction length presented by the crystal calorimeter (1.6 λ); the shower maximum is thus frequently contained in the electromagnetic calorimeter (the Landau tail is also visible at the rightmost part of this distribution). When using a calorimeter equivalent to the L3 BGO (0.93 λ), the broad peak becomes a shoulder, and the distribution of Fig. 4 looks similar to the L3 data (i.e. Fig. 24 of Ref. [3]).

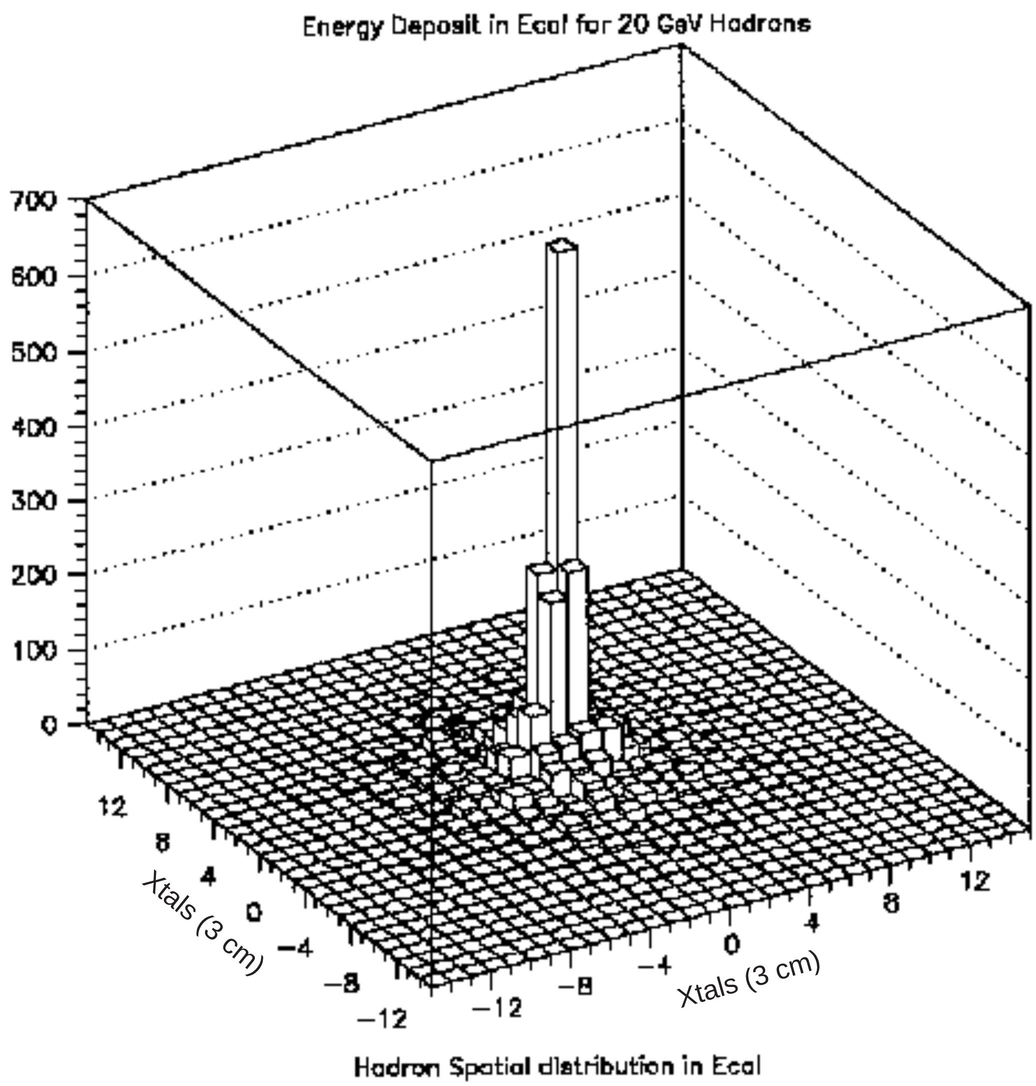


Figure 5: Lateral Energy Distribution for Hadron Showers in Crystal Calorimeter

The transverse distribution of the hadron shower in the electromagnetic calorimeter is generally highly fluctuated and grainy. In order to model the transverse shower development, guidance was again taken from Ref. [3]. The net energy deposited in the crystals by an incident hadron is assumed to be carried by a roughly equal mix of large (≈ 2 GeV ±30%) and small (≈ 360 MeV ±30%) quanta. These quanta are distributed according to the prescription in Ref. [3]; i.e. the large quanta are deposited within a Gaussian smear of σ = 11 cm from the point of hadron impact, and the smaller quanta are deposited within a wider zone (a "flat-top" Gaussian is used, with a width roughly double that of the large quanta; see [3]). This essentially results in a hadron shower with a hot core and long tails. This distribution can be seen in Fig. 5, which shows the lateral hadron energy spread over many incident particles (the plot axes are in units of 3 cm. crystals). Again, the distribution is much grainier than this on a shower-by-shower basis, since the energy is generally divided into a score or two of discrete quanta.

The shower parameterization is not performed for hadrons with energy under 525 GeV (1.5 MIP); in these cases, all hadron energy is dissipated in the impacted crystal.

While this model does exhibit much of the behavior expected from hadron interactions in the crystal calorimeter, the simulation would certainly benefit from a more involved parameterization and/or additional tuning. The software has been structured to readily accommodate an improved hadron interaction model.

A rudimentary hadron calorimeter model was adopted in this simulation. The crystal calorimeter is always assumed to fully contain electromagnetic showers. All hadron energy remaining after interaction in the crystals is assumed to be absorbed in the hadron calorimeter (i.e. full shower containment). The lateral shower distribution has the same form as in the electromagnetic calorimeter (i.e. hot core with long tails), normalized to a shorter hadron interaction length of λ = 10 cm (from a denser absorber). In particular, 90% of the remaining hadron energy is distributed in a Gaussian of σ = 4.2 cm, and 10% is deposited according to a "flat-top" Gaussian with roughly double width. Since the lateral granularity of the hadron calorimeter is much coarser (.05 x .05), the shower is not broken into quanta, as discussed above, but spread among a 3 x 3 cell array centered at the hadron impact.

Events were generated using PYTHIA at $\sqrt{s}$ = 16 TeV. A luminosity of 10^{34} was assumed, with a cross-section that resulted in an average pileup of 19 inelastic events. The chosen minimum bias description employs the standard "UA1" parameters[5], and is used to generate the piled up events. In order to save on execution time, a file was generated that contained relevant parameters from 20,000 minimum bias events. For each event that was analyzed, 19 events were superimposed from this minimum bias file. When all 20,000 such background events were read, and the end of file was encountered, the file was rewound and randomly offset (within 19 events), to provide a somewhat

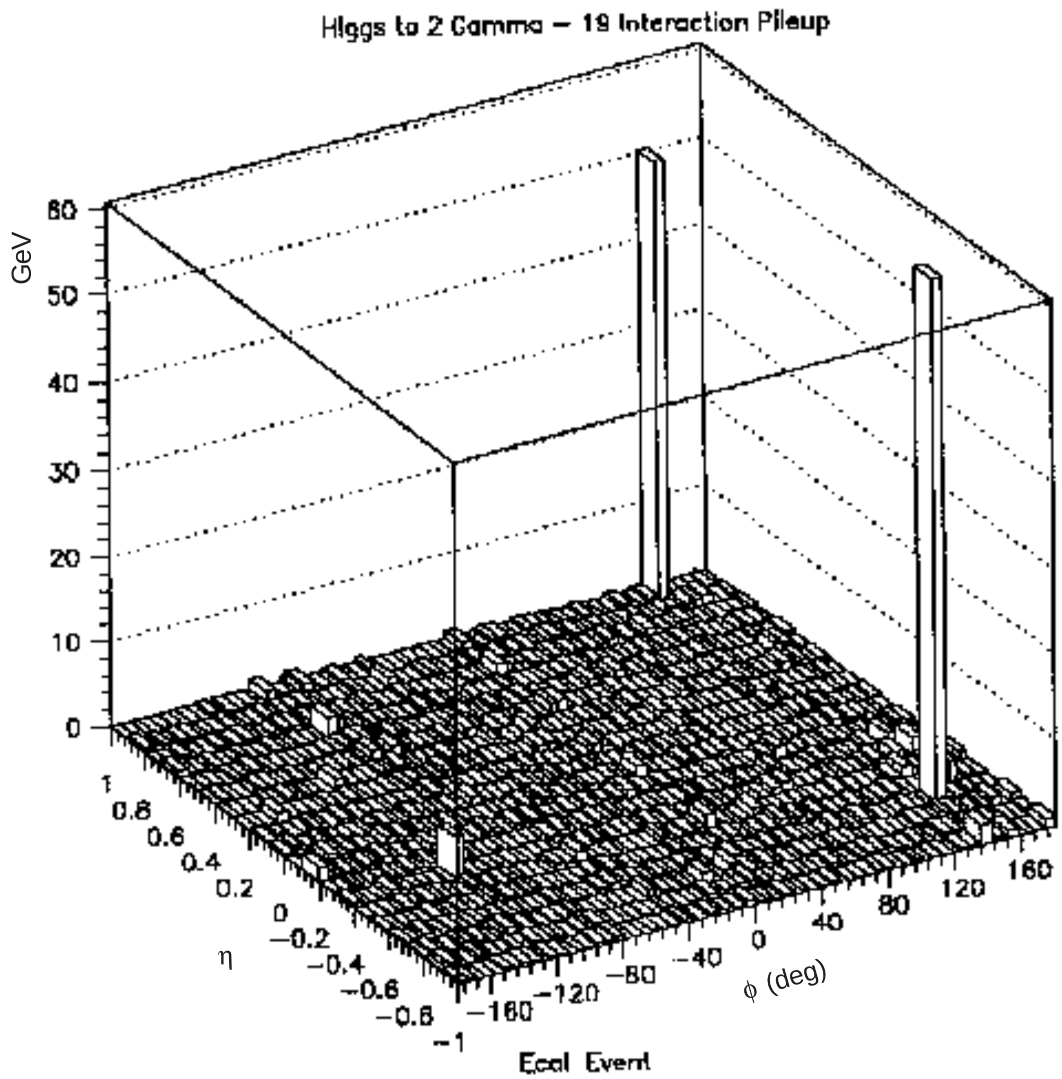
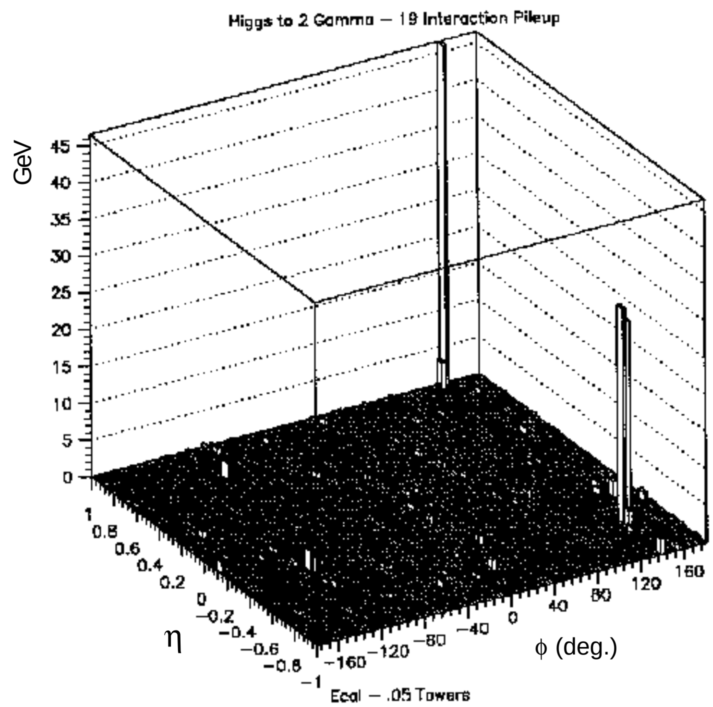


Figure 6: Sample H → γγ event in Crystal Calorimeter (.1 x .1 towers)

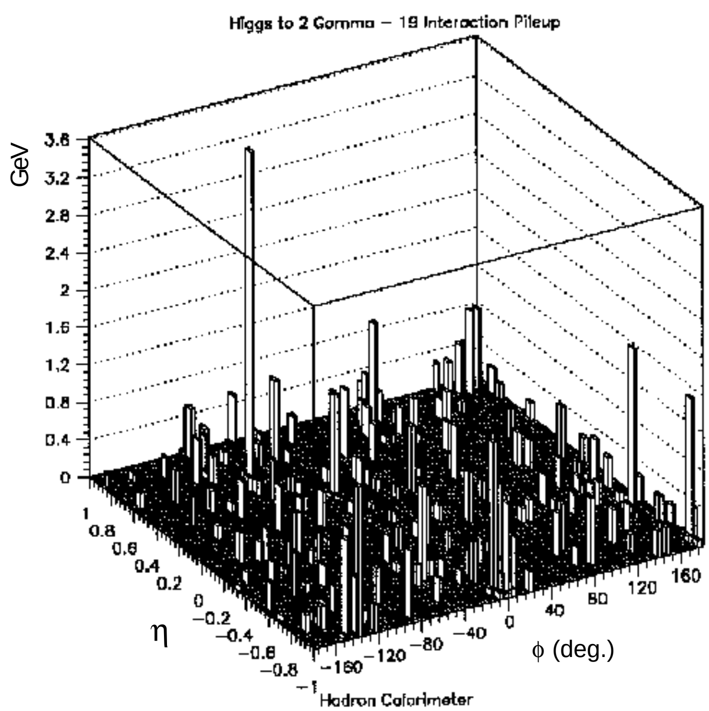
different minimum bias background. The results presented here include no detector noise in the models (although some of this effect is provided through the pileup background).

The simulation executes quite quickly. The average CPU time required per event (on the ETH IBM 3090) is of order 0.6 seconds (which includes the trigger processing and analysis described in the next section); a significant fraction of this interval is occupied by PYTHIA generation of the Higgs or QCD event under analysis.

Figs. 6 shows the energy deposited in the electromagnetic calorimeter from a H → γγ event, with a Higgs mass of 100 GeV (the crystals in this plot are lumped into .1 x .1 towers). The two photons from the Higgs decay (of roughly 50 GeV each) are clearly visible, and quite isolated.



a) Electromagnetic Calorimeter



b) Hadron Calorimeter

Figure 7: Sample H → γγ event in EM and Hadron Calorimeters

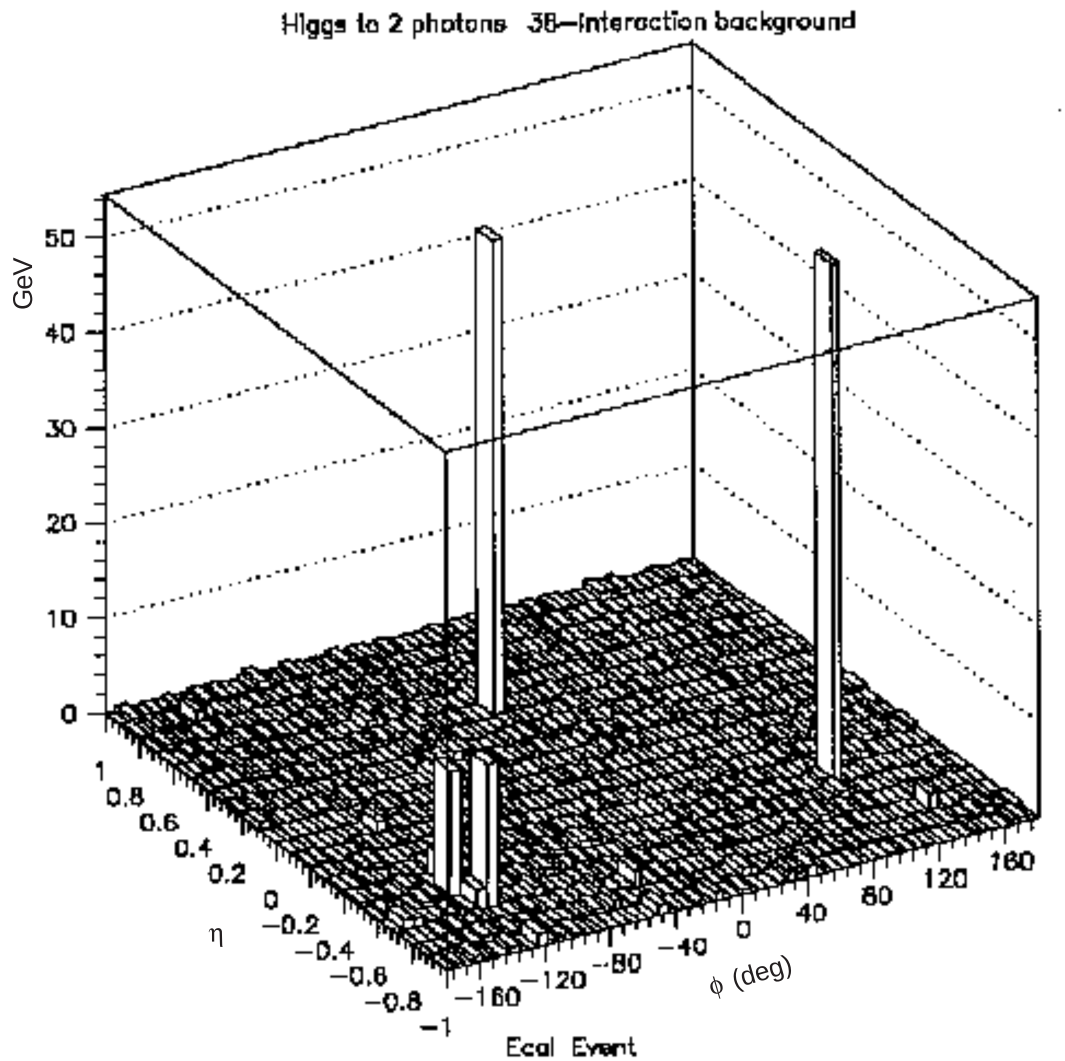
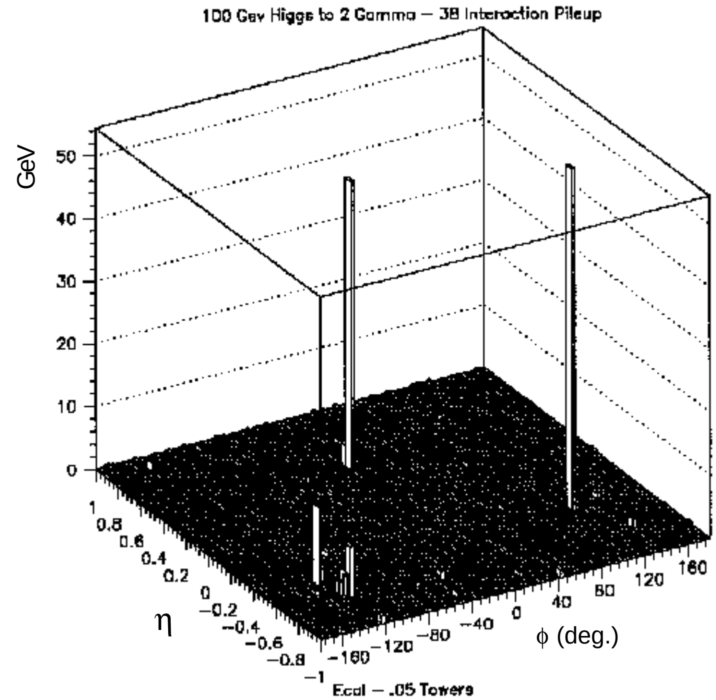
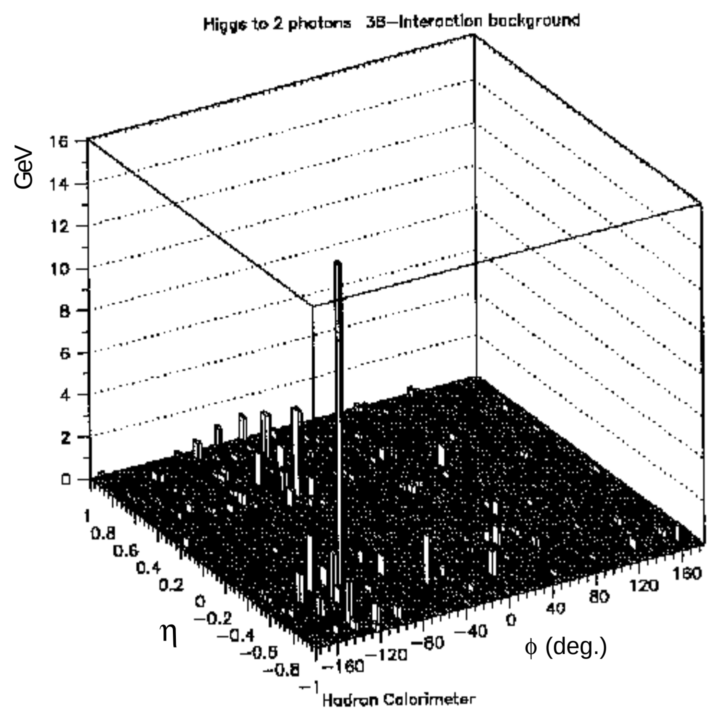


Figure 8: H → γγ event in Crystal Calorimeter (.1 x .1 towers) with Double Pileup

The upper plot of Fig. 7 shows the electromagnetic calorimeter with finer towers (.05 x .05). The energy of the photon near $\eta \approx 1$ is mainly contained within a single tower, but the energy of the photon near $\eta \approx -1$ is split nearly evenly between adjacent towers. The hadron calorimeter deposits (also at .05 x .05) are shown in the lower plot of Fig. 7. Considerable activity is seen, but looking at the small scale on the vertical axis, no large deposits are present; clearly, most of the energy deposited in this event is electromagnetic.



a) Electromagnetic Calorimeter



b) Hadron Calorimeter

Figure 9: H → $\gamma\gamma$ event in EM and Hadron Calorimeters with Double Pileup

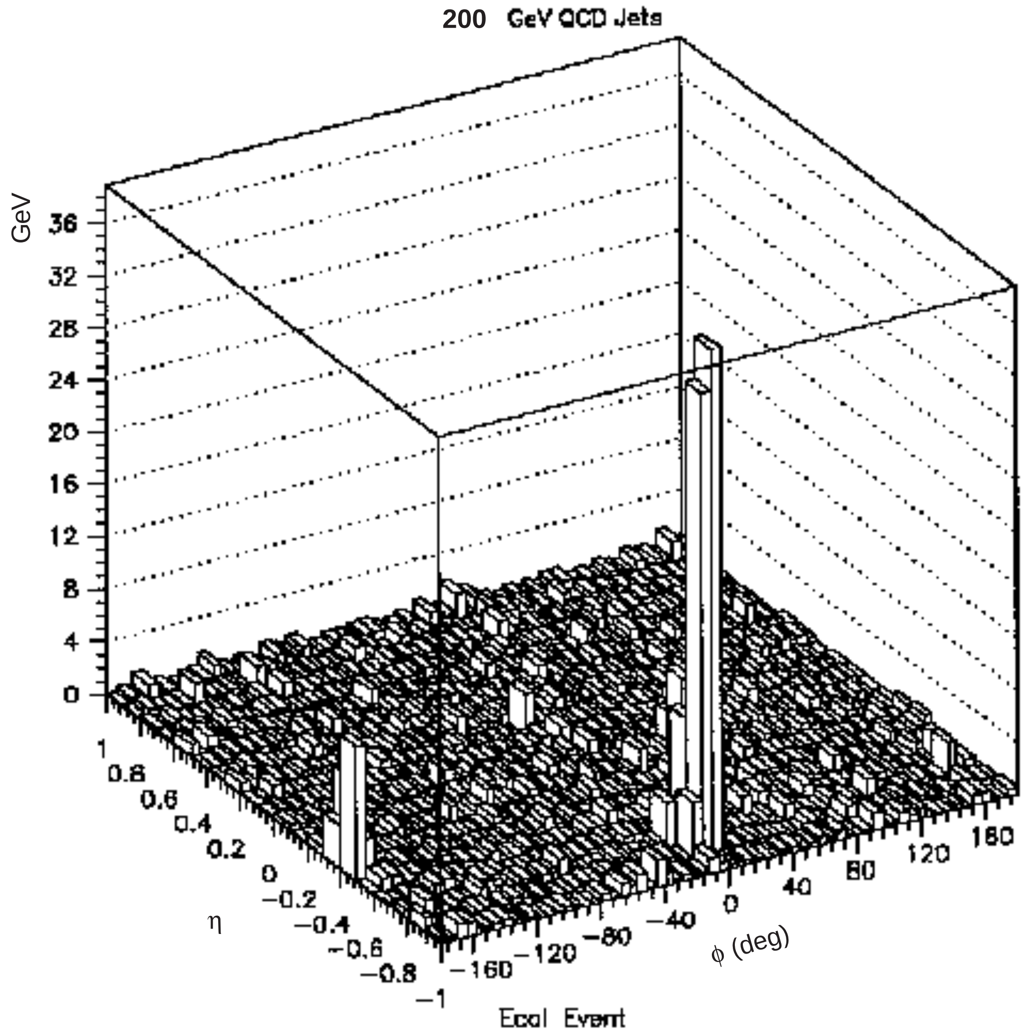
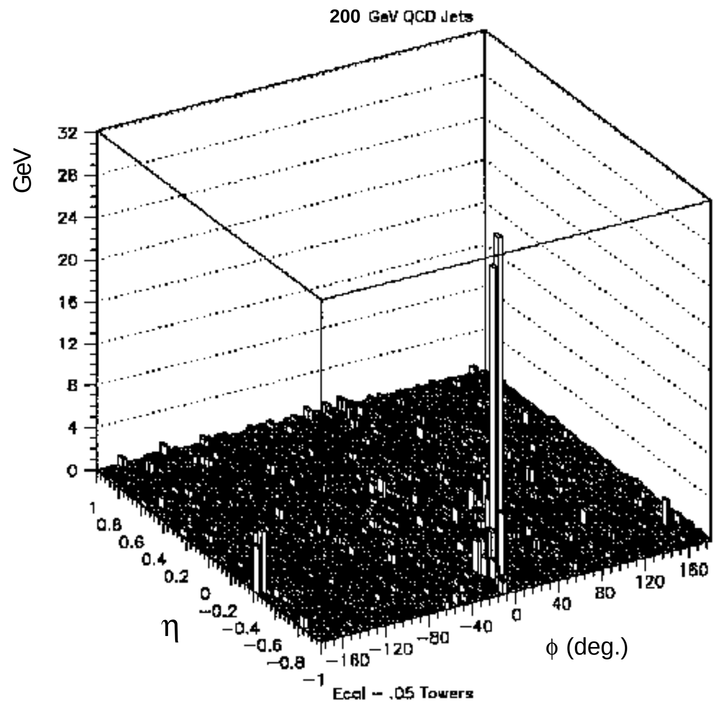


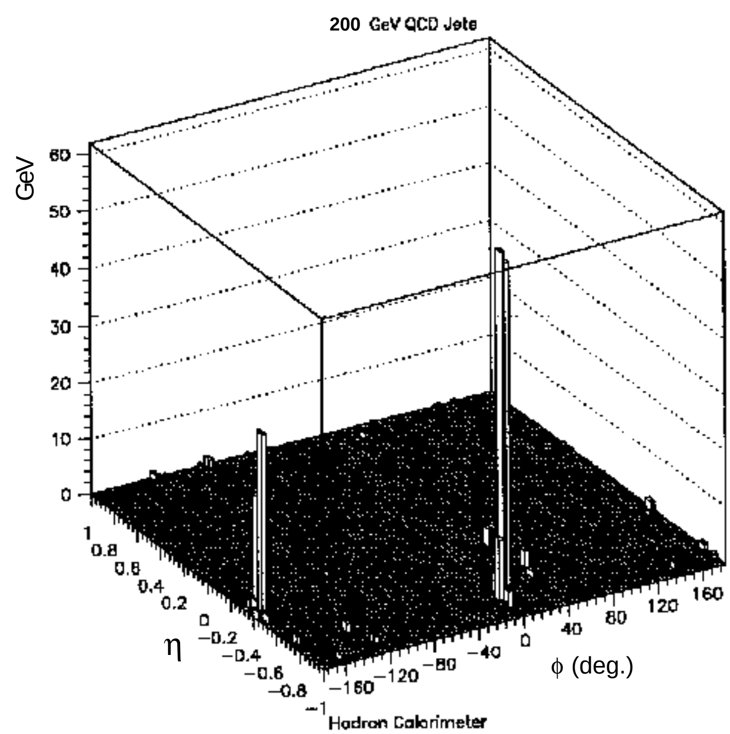
Figure 10: QCD event in Crystal Calorimeter (.1 x .1 towers)

Another 100 GeV H → γγ event is shown in Figs. 8 & 9, this time superimposed over double pileup (38 minimum bias events). Since the photons in this event are not strictly back-to-back, they are accompanied by a recoil jet, which is visible at lower left in the lego plots. The energy of the recoil is distributed over a wider region, and is associated with a significant deposit in the hadron calorimeter, as can be noted in Fig. 9b.

A background event (generated from 200 GeV QCD jets) is shown in Figs. 10 & 11. Two energy deposits can be clearly noted. Neither EM cluster is isolated, and both are accompanied by considerable hadron calorimeter energy. This event appears asymmetric (i.e. the energy of the cluster near $\phi = 0$ is larger than that near $\phi = 180°$). Since both clusters are directed toward negative η, a third jet at $\eta > 1$ (thus outside the calorimeter boundary) probably balances the energy.



a) Electromagnetic Calorimeter



b) Hadron Calorimeter

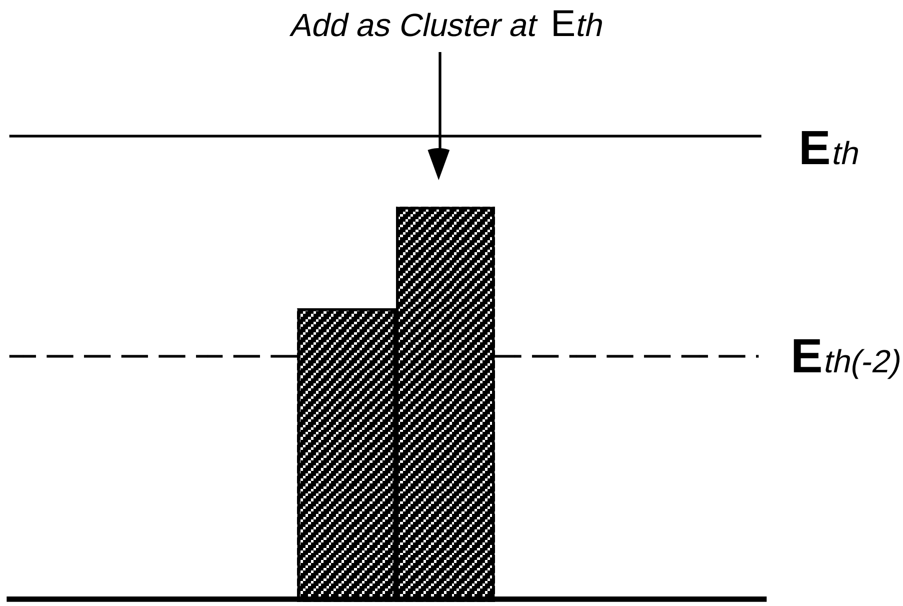
Figure 11: QCD event in EM and Hadron Calorimeters

2) Trigger Structure and Analysis

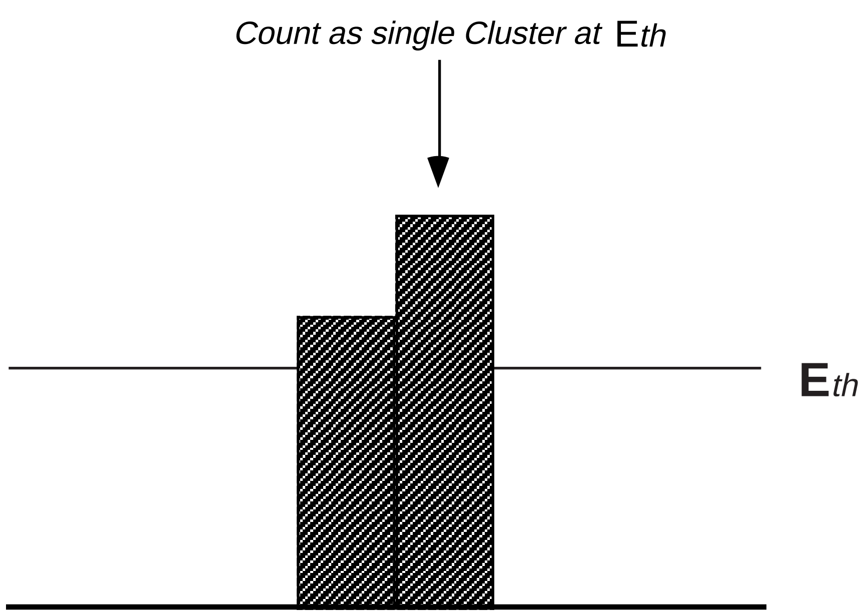
After an event is loaded into the pixel arrays representing the electromagnetic (EM) and hadron calorimeters, as discussed above, a triggering analysis procedure is invoked. The crystals in the EM calorimeter ("ECAL") are first summed into towers of dimension .05 x .05, .1 x .1, and .2 x .2, in order to observe the effects of tower size on the triggering rate. "Hot" towers are identified that surpass an energy threshold of 10, 15, 20, 30, 40, or 50 GeV. Each such "cluster" that is found is represented by a pointer to the highest-energy contained .05 x .05 subtower. In a typical event, most such clusters (at various energy levels and tower sizes) point to the same set of subtowers; i.e. they all arise from the same set of energy deposits. The topological trigger cuts (i.e. isolation, hadron energy veto, etc.) are then applied to these energy deposits, creating a set of veto flags. The number of clusters surviving the trigger cuts at various energy thresholds may then be efficiently tracked, and "Higgs" candidates, with a pair of clusters above a given energy threshold, can be identified. This logic is applied in the trigger analysis of the simulation data, and is not meant to be used in the on-line trigger itself, which will be highly parallel and pipelined; the pointer scheme is used to efficiently emulate the trigger on a sequential off-line computer.

The handling of adjacencies can be important in trigger schemes using fixed tower sums, particularly with small tower sizes (such as .05 x .05). Fig. 12 shows the simple adjacency-handling technique that has been adopted in the trigger analysis used here. If two adjacent towers are above a given energy threshold, as indicated in Fig. 12b, they are made to count as one cluster, assumed to be located at the highest energy tower. If, on the other hand, two adjacent towers are both under a given energy threshold, but above a lower threshold (here assumed to be 2 levels smaller; i.e. 20\10, 30\15, 40\20, & 50\30 GeV), they are made to count as one cluster at the higher threshold, located at the tower with highest energy. This was only performed for energy thresholds of 20 GeV and above; i.e. clusters could not be added that were below the 10 & 15 GeV thresholds.

This logic was seen to produce significant improvement in the efficiency of the Higgs trigger with the small (.05 x .05) tower size. As expected, it becomes less effective and necessary with larger tower sizes. The addition of clusters at lower energy thresholds can begin to considerably increase the background trigger rate for the larger towers; since the effective tower size is now double the original, twice the pileup is included in the energy sum, leading to an elevated trigger. The adding/deleting of adjacent clusters per Fig. 12 should be readily implementable in a pipelined digital trigger.

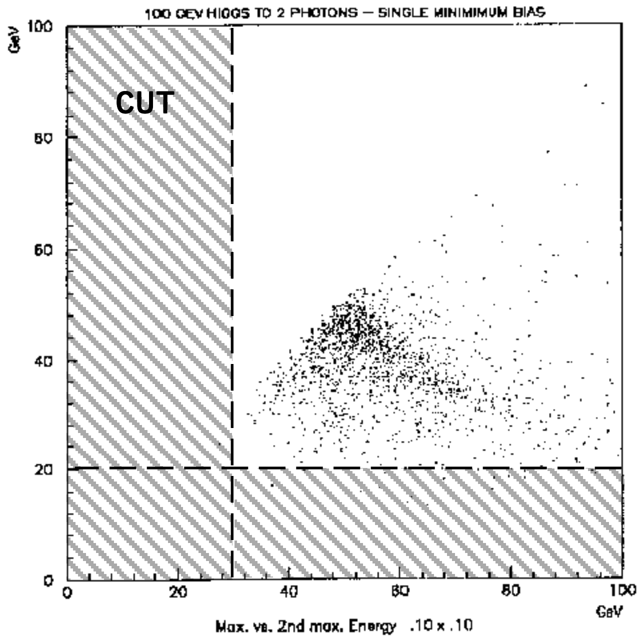


a) Two Adjacent Clusters Under Energy Threshold

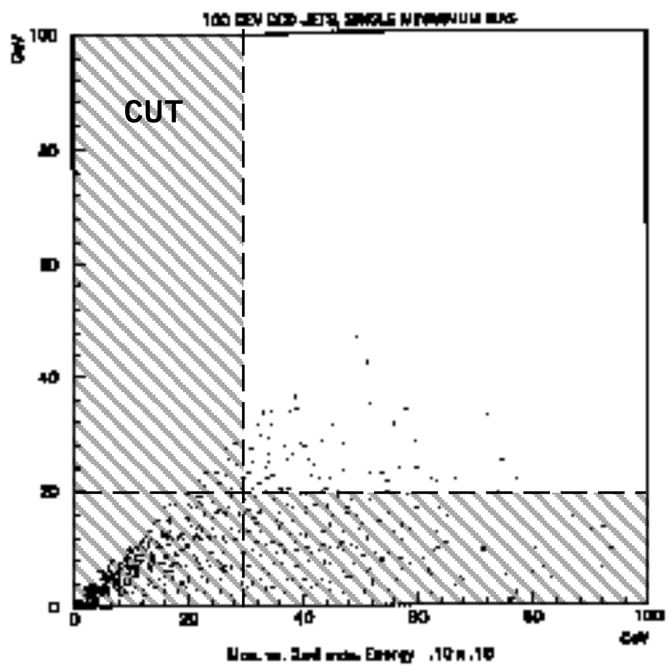


b) Two Adjacent Clusters Over Energy Threshold

Figure 12: Logic to Handle Adjacent Clusters



H → γγ , 100 GeV



100 GeV Jets

Figure 13: Energy Thresholds for "Seezlike" Cut

All energy thresholds and values used in this study are in units of transverse energy (E_T). It is assumed that the output of each crystal (or hadron calorimeter cell) is first passed through a lookup table that scales by sin(θ), as is the standard practice.

Clusters passing the energy thresholds are submitted to a series of five topological cuts. The first two, "Block Isolation" and "Block Hadron Veto" may be pipelined and implemented in a Level 1 trigger scheme. The following two cuts, "Centered Isolation Cone" and "Centered Hadron Veto" will require a global access to calorimeter data (i.e. fixed tower sums are not sufficient), thus are slated for Level 2. The last cut ("Charged Energy Veto") requires data from a central tracker, and would be realized in Level 2 or Level 3. Each trigger cut is discussed independently below. Trigger thresholds are set using clusters from simulated 100 GeV $H \rightarrow \gamma\gamma$ events (for the accepted data) and 100 GeV QCD jets (for the background).

Figure 13 shows scatter plots for the largest (horizontal axis) vs. next largest (vertical axis) ECAL energy cluster in an event. Higgs data is plotted at top, QCD background at the bottom. The lower energy deposited by the QCD events is evident. Since a trigger must be sensitive to other processes besides Higgs photons, the results presented in the next section track the simulated events through several different energy thresholds. When looking explicitly for a Higgs, however, the results of Fig. 13 provide guidance. The gray regions in Fig. 13 represent the regions eliminated by a cut that demands one photon over 20 GeV and another over 30 GeV. This retains the vast majority of Higgs data, and rejects most QCD background. These cuts are a bit more relaxed than those used in the study of Ref. [6], which demanded one photon above 25 GeV and another beyond 40 GeV These cuts were seen to lower the trigger efficiency for the 100 GeV Higgs events modeled here (the cut may be made more stringent if one assumes a Higgs with higher mass), thus looser cuts were retained (the ensuing trigger rate on 20/30 GeV pairs is still sufficiently low, as presented in the next section).

The first topological cut to be attempted is the block isolation. This cut assumes that the crystals are summed into towers of dimension .05 x .05, which in turn are summed into .2 x .2 supertowers. The logic is depicted in Fig. 14. First, the highest-energy .05 tower (the gray tower with the "R") is removed from the .2 supertower sum. If the hottest crystal inside the hot .05 tower does not reside at the tower's edge, then this is sufficient. Otherwise, the adjacent .05 tower that is closest to the hottest crystal is also removed (provided that the .05 tower to be removed is still contained in the .2 supertower sum), thus compensating for shower sharing across subtower boundaries. In cases where the hottest crystal is at a corner, the current logic removes the 3 nearest .05 subtowers, although this may not be necessary in practice.

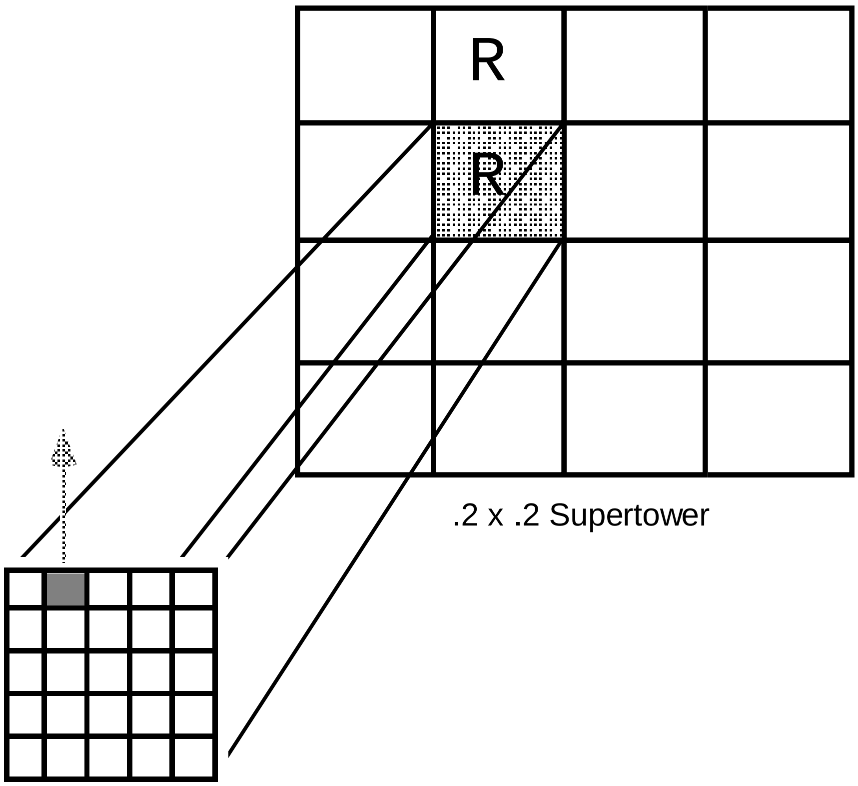


Figure 14: The "Block Isolation" Cut

Using a fully digital or hybrid digital/analog trigger scheme, block isolation may be implemented and pipelined in several fashions. One method is to compare various sums inside the hottest .05 subtower. This is illustrated in Fig. 15. The top row shows a comparison of two sums; one of the outside edges, and one of the 3 x 3 center. If the center has a higher energy than the edges, then only this .05 subtower need be removed from the .2 sum. If the edges dominate the energy, the shower will bleed over to an adjacent subtower, and one can pursue a few different strategies. The simplest method may be to merely compare the energies of all adjoining .05 subtowers, and subtract the highest-energy neighbor from the .2 sum. Another technique may be to continue using the information contained in the crystals composing the hottest .05 subtower, as illustrated in the first ELSE block of Fig. 15. The first step in this scheme is to determine which side of the .05 subtower is closest to the shower. Three-crystal sums are compared to determine which edge (or corner) is dominated by the shower. The adjacent .05 cluster may then be identified and subtracted. If the shower energy is concentrated in a corner crystal, then the particular corner is identified, and the 3 adjacent .05 blocks can be subtracted.

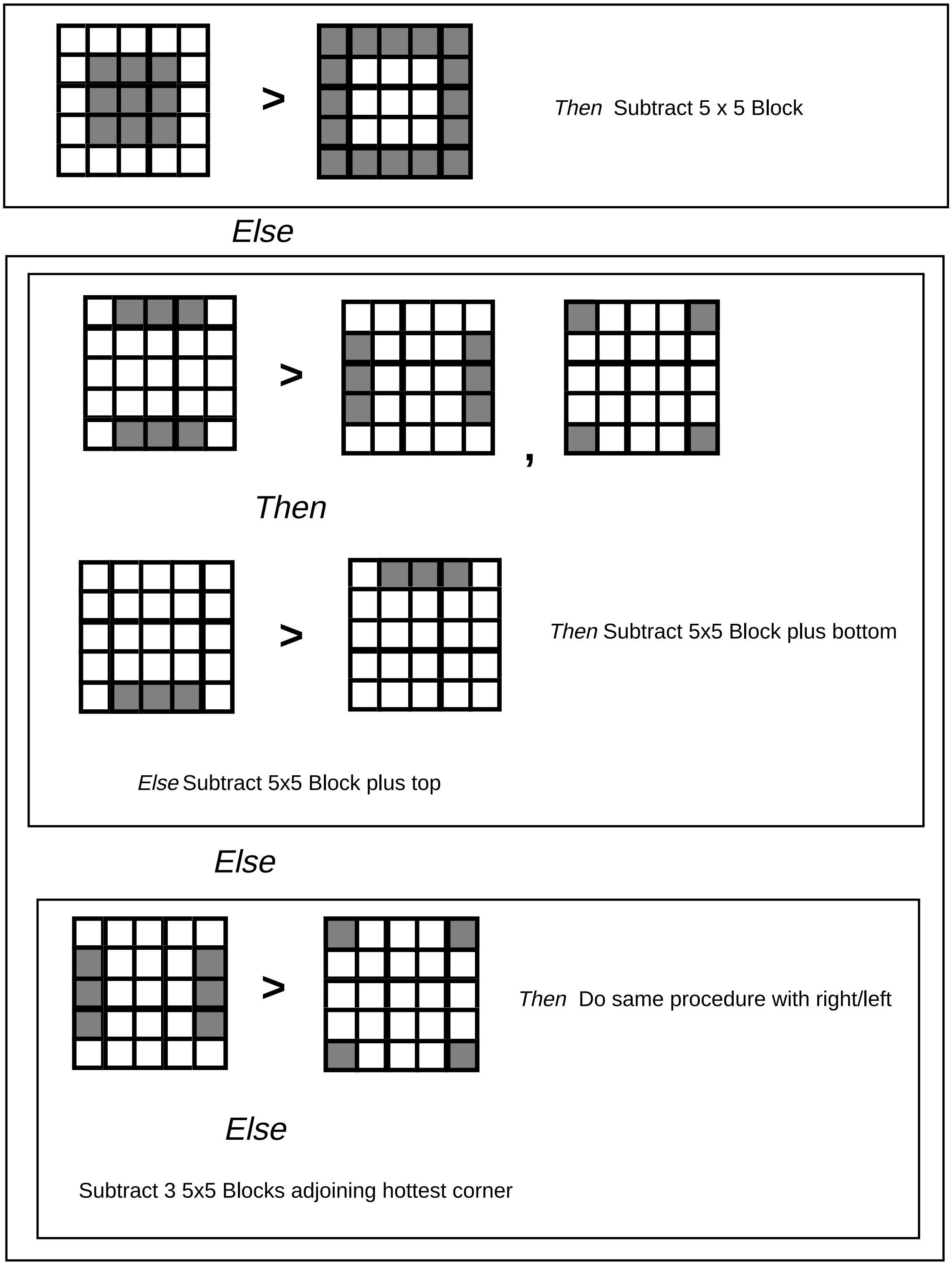


Figure 15: Possible Pipelined Implementation of Block Isolation

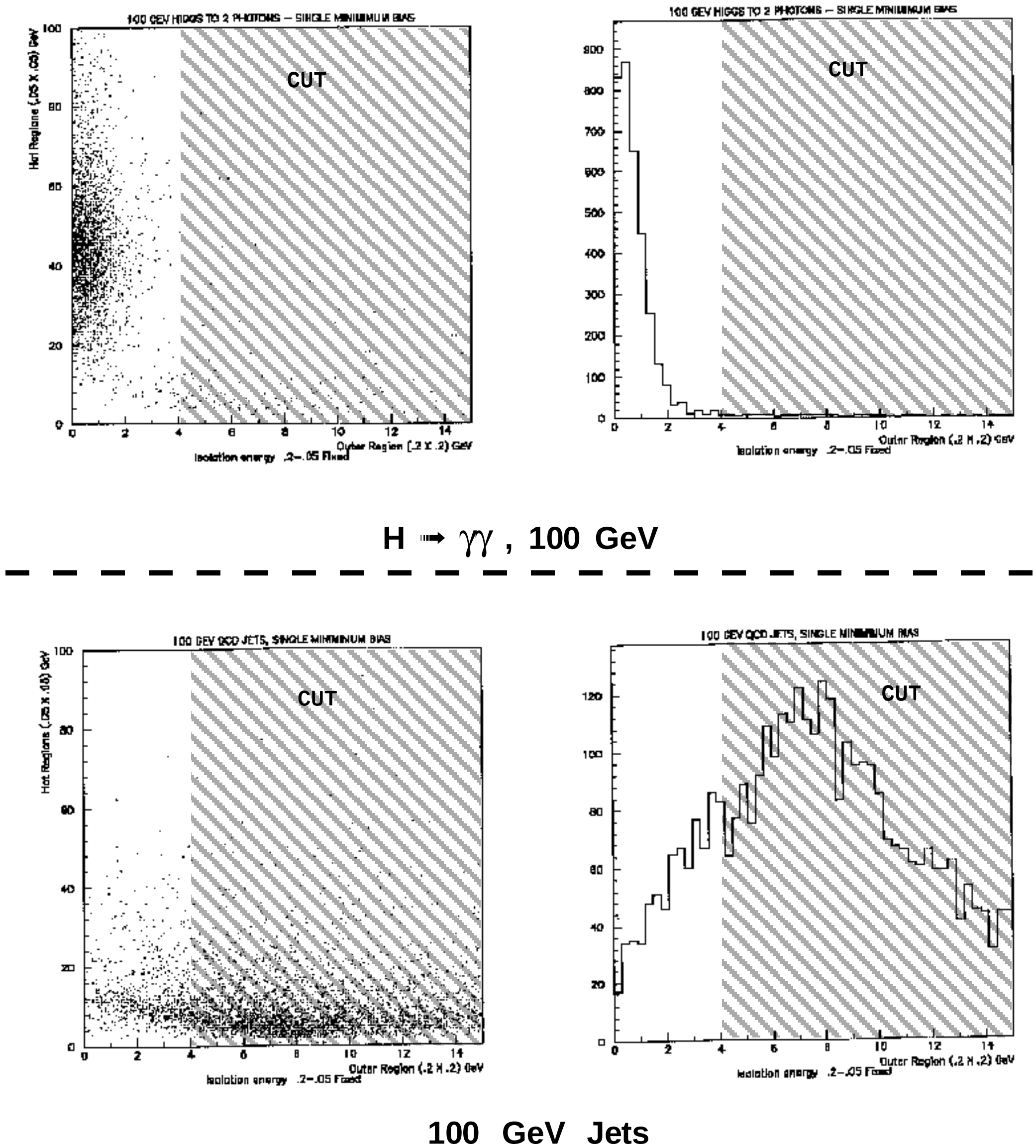


Figure 16: Block Isolation Thresholds

The block isolation scheme doesn't care where the hot .05 subtower falls in .2 supertower; it can be near the center or near the edge. This process can thus be readily "hardwired"; i.e. each .2 supertower will execute a pipelined block isolation calculation after every beam crossing. As will be seen in the following section, the block isolation cut is very useful at reducing the output rate of the level 1 trigger. A much more powerful isolation cone cut can then be attempted at level 2.

The response of the data and background to the block isolation cut is depicted in Fig. 16. Clusters from the Higgs events are shown at top, and the QCD background is shown at the bottom. The lower axis of all plots is the isolation energy; i.e. the energy of

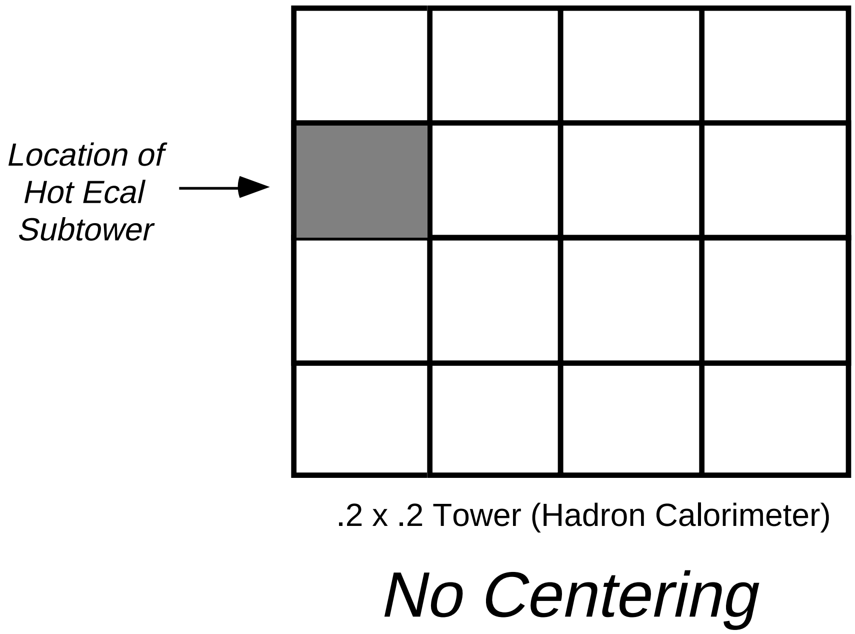
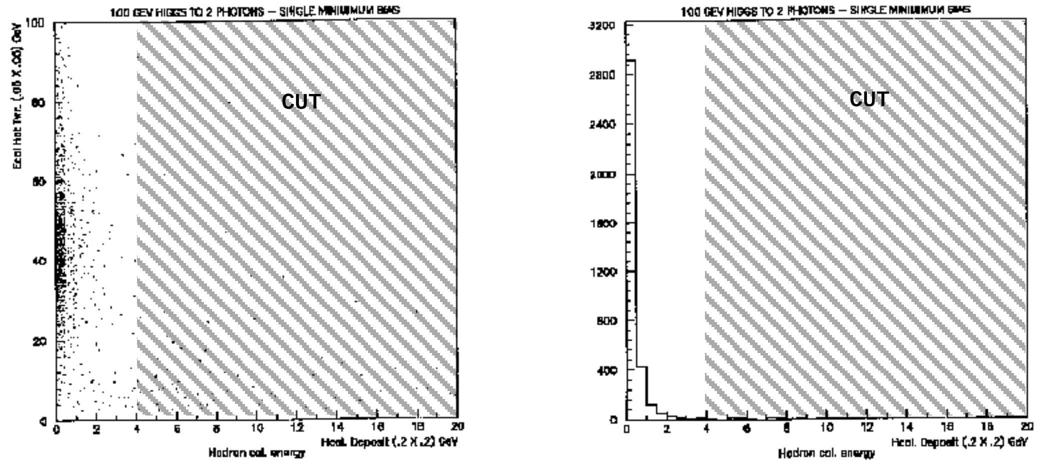


Figure 17: Example of the Block Hadron Calorimeter Veto

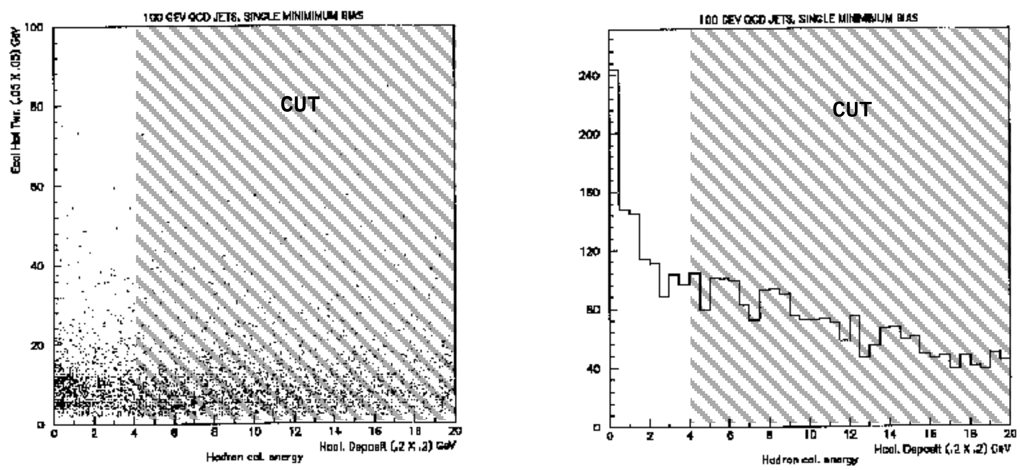
the .2 supertower with the hot .05 subtower (and possibly a neighbor) subtracted. The vertical axis of the scatter plots shows the energy of the hot .05 subtower. The histograms are projections of the scatter plots onto the horizontal axis. The grayed-out region represents the clusters that are cut out by the adopted isolation cut on the residual energy of E > 4 GeV. An energy-dependent cut may produce some benefit here; i.e. demand lower isolation energy when the hot .05 subtower energy is small. For this to be effective, however, the isolation cut will have to be tightened (for low-energy clusters) below the current 4 GeV, which may be problematic for trigger implementation (the value of 4 GeV used here is probably already too low, particularly when considering the presence of difficult-to-model correlated noise in the tower sums). With this factor under consideration, the flat cut at 4 GeV was retained.

The tail seen at high isolation energy for the Higgs clusters (top row of plots) does not necessarily arise from the Higgs photons. All clusters found in the Higgs events are plotted in these graphs, including those due to recoil jets that can occasionally appear (as seen in Figs. 11 & 12). The Higgs trigger efficiency is thus somewhat better than these plots may indicate.

The next cut to be attempted is the Block Hadron Calorimeter Veto. This cut is very simple, and is illustrated in Fig. 17. A cut is made on the energy contained in the .2 x .2 hadron calorimeter tower sum located behind a candidate electromagnetic cluster.



H → γγ , 100 GeV



100 GeV Jets

Figure 18: Threshold Setting for Block Hadron Calorimeter Veto

If this energy is greater than a preset threshold, the cluster is considered hadronic in nature, and rejected. As with the block isolation (and as depicted in Fig. 17), this cut is essentially hardwired for level 1 operation; i.e. the hadron calorimeter sum is not centered on the hot .05 electromagnetic cluster.

Figure 18 shows the distributions of Higgs data and QCD background. The horizontal axis (in all plots) is the energy of the .2 x .2 hadron calorimeter tower behind the candidate electromagnetic cluster (the vertical axis of the scatter plots is the energy of this cluster). One can readily see that, as expected, the Higgs photons deposit very little hadron energy, compared with the QCD background. The shaded region denotes the

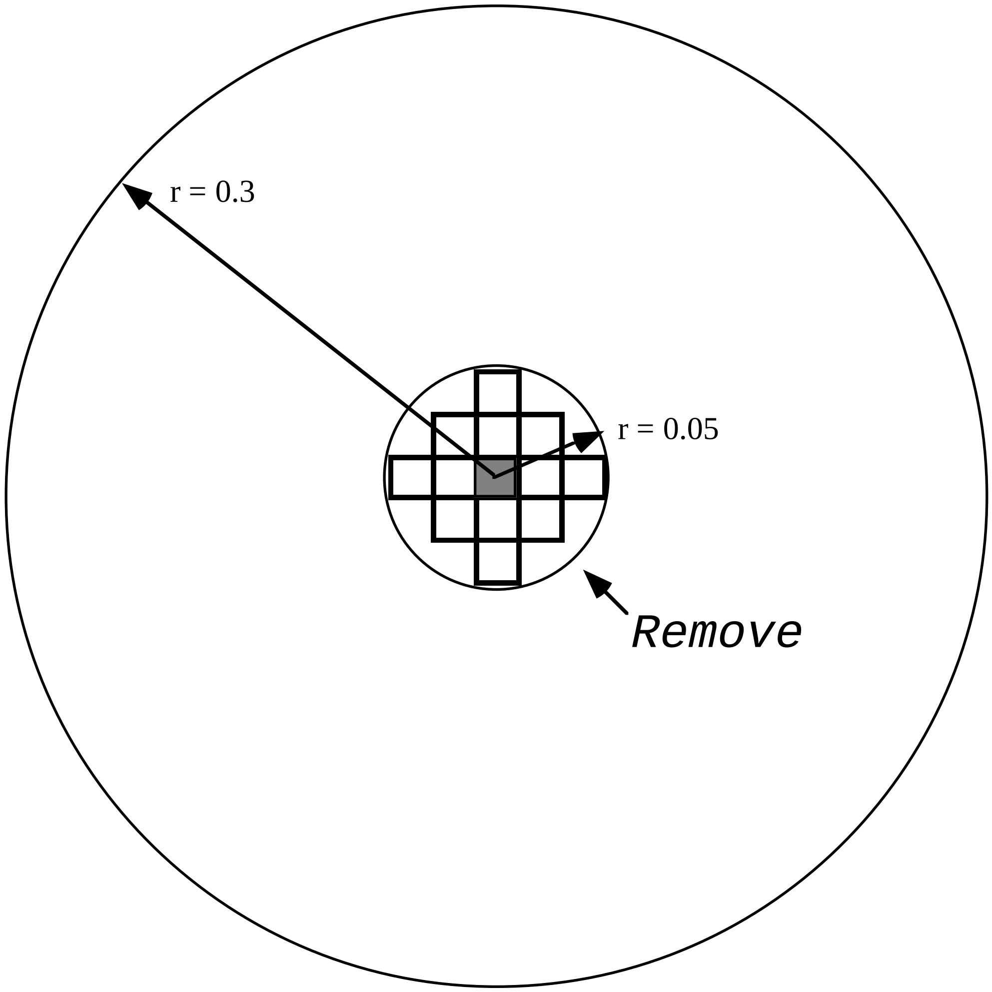


Figure 19: The Isolation Cone

clusters that are be removed by the adopted cut of E < 4 GeV (beware; this threshold may indeed be somewhat low for actual implementation in situations with correlated detector noise and pickup problems).

The remaining trigger cuts no longer use the established tower structure, hence must be applied at trigger level 2 or level 3. The first of these cuts is a repeat of the isolation procedure, except we now isolate crystals within a radius r < .05 of the hottest crystal in a cluster candidate (approved by level 1) from a concentric circle of radius r < .3. The level 1 trigger, in this scenario, would present the location of its candidate clusters to the level 2 trigger, which would proceed to read out all of the crystals (which are now digitized to full precision) within a radius r < .3, and form the needed sums. The implementation is outlined in Fig. 19. For cases with portions of the .3 disk lying outside of the $|\eta| < 1$ acceptance, the partial sum of crystals within r < .3 is normalized up by the

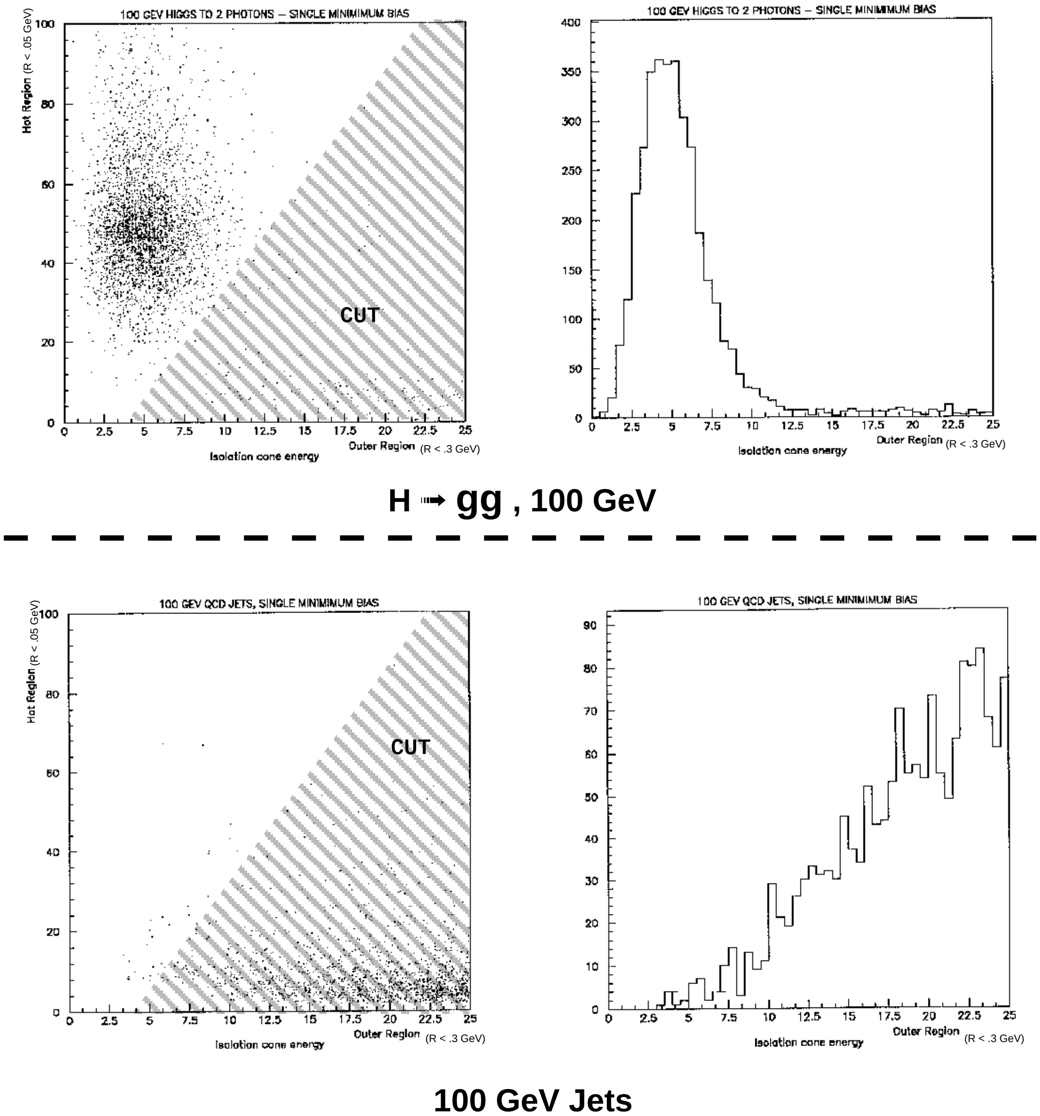


Figure 20: Data and Background Distributions for Isolation Cone

fraction of missing area (i.e. the segment of the disk that's outside of the calorimeter). This could also be performed by adopting a threshold that depends on the location of the center crystal (i.e. the threshold would drop as the center nears the edge of the calorimeter, where full disks of r < .3 are no longer possible).

The data and background distributions for this cut are shown in Fig. 20. The horizontal axes are the energy in the .3 cone (with the hot core of .05 subtracted). The vertical axis of the scatter plots is the energy of the hot .05 core. In order to properly separate the data from background, an energy-dependent cut has been adopted; a cluster is rejected if it has an isolation energy greater than $[4 + (E_{cone} - E_{ctr})/5]$ in GeV, where E_{cone} is the energy in the 0.3 disk, and E_{ctr} is the energy in the hot .05 disk. This has been

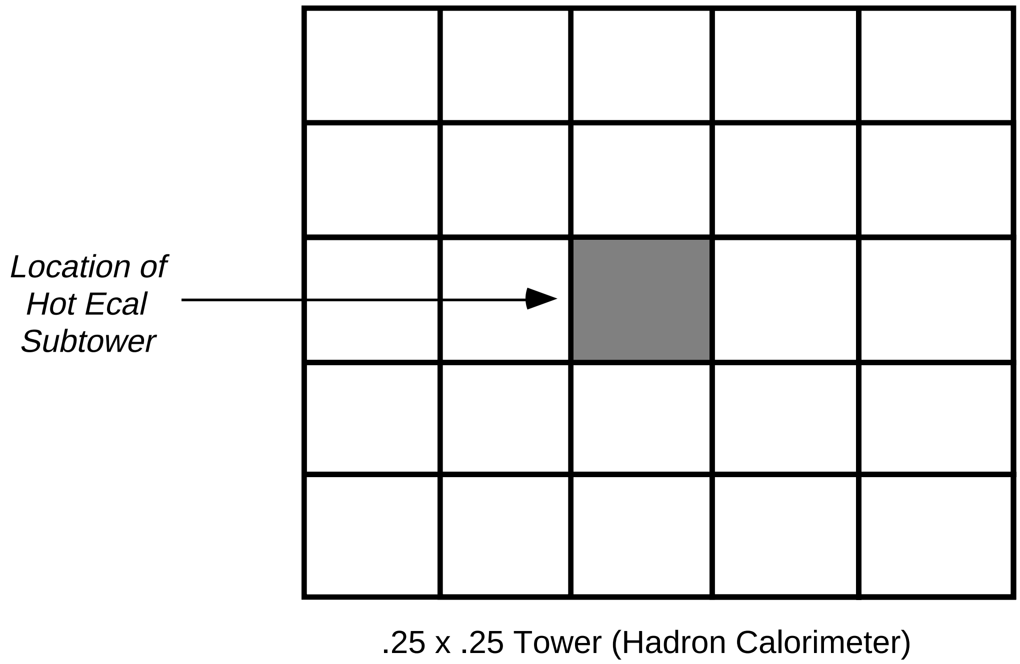


Figure 21: The Centered Hadron Calorimeter Cut

used with the tests at 10^{34} (19-event pileup); for higher luminosity, the bias term is increased to preserve the Higgs detection efficiency (i.e. for 38-event pileup, the bias of 4 is increased to 8.5). This cut is extremely powerful at removing the QCD background, as can be noted in the data & background separation in Fig. 20 (the Higgs photons are clearly isolated in comparison to the QCD background; much of the tail in the Higgs plot is due to jets accompanying some of the Higgs events), and as will be demonstrated in the next section.

Figure 21 illustrates the operation of the "centered hadron calorimeter" cut. This cut operates exactly as its title suggests; an energy sum of dimension .25 x .25 is taken over a region of the hadron calorimeter centered at the location of the .05 electromagnetic subtower sum that produced a cluster candidate. This is similar to the "block hcal veto" cut applied at level 1, except that the hadron calorimeter sum is now centered on the EM cluster, thus it doesn't employ a fixed tower structure, and is assumed to be run at level 2. No provision is currently made for cases where the EM cluster candidate is located at the edge of the calorimeter (i.e. near $|\eta| \approx 1$). Improved performance may be attained by making the energy threshold a function of cluster position (or by normalizing the energy sum, as was done with the isolation cone).

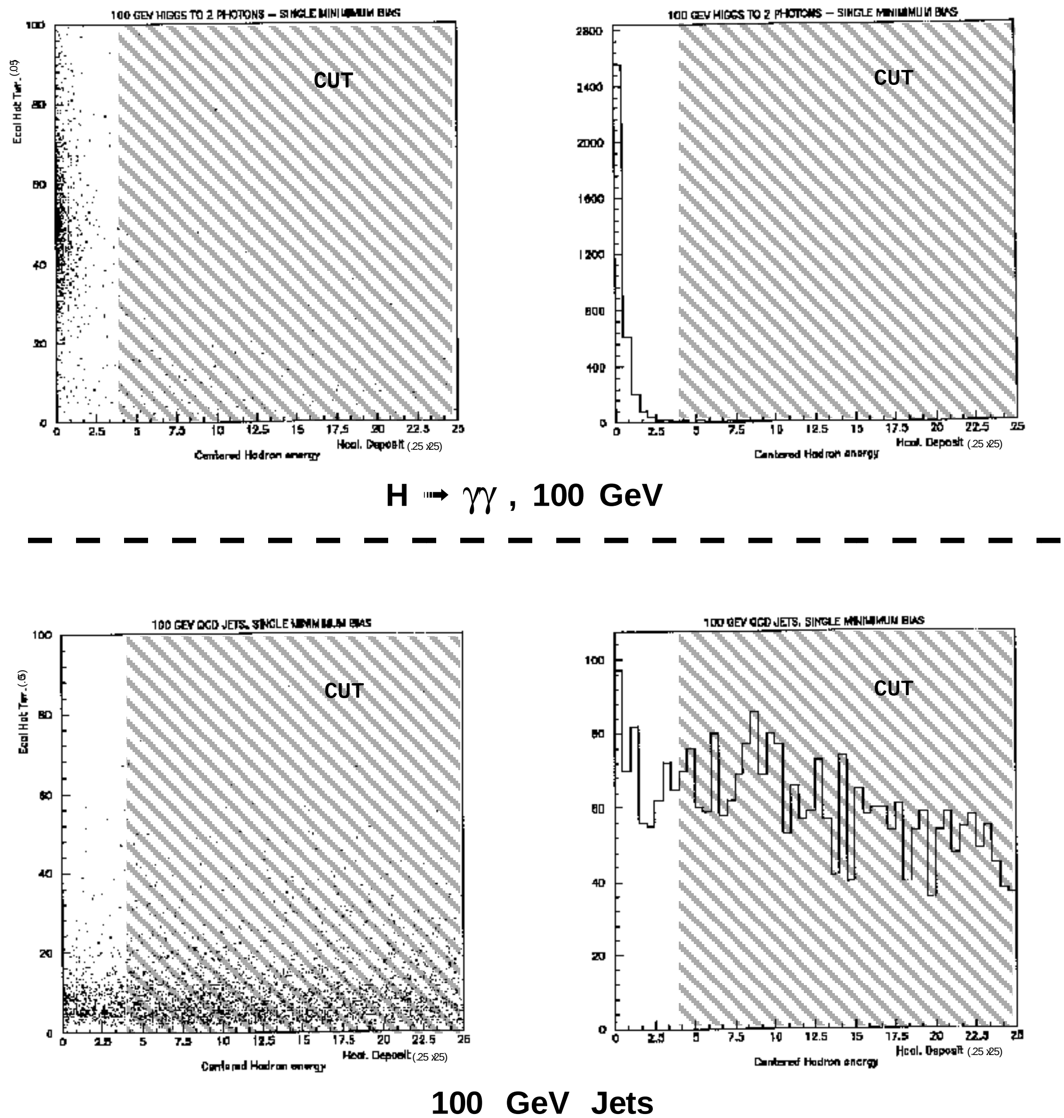
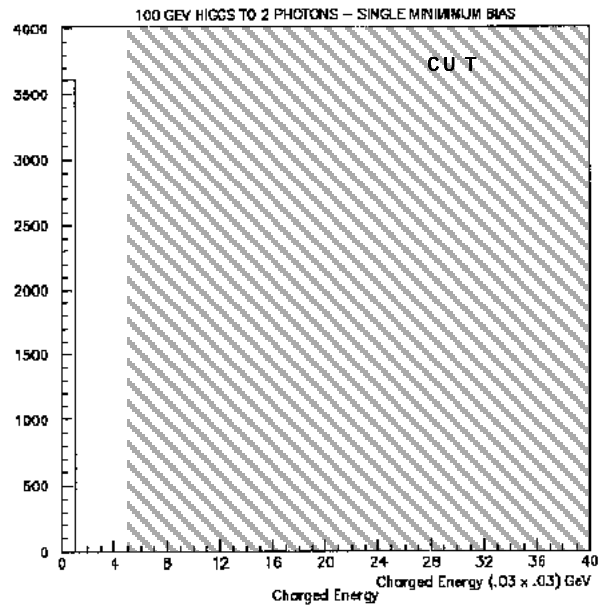


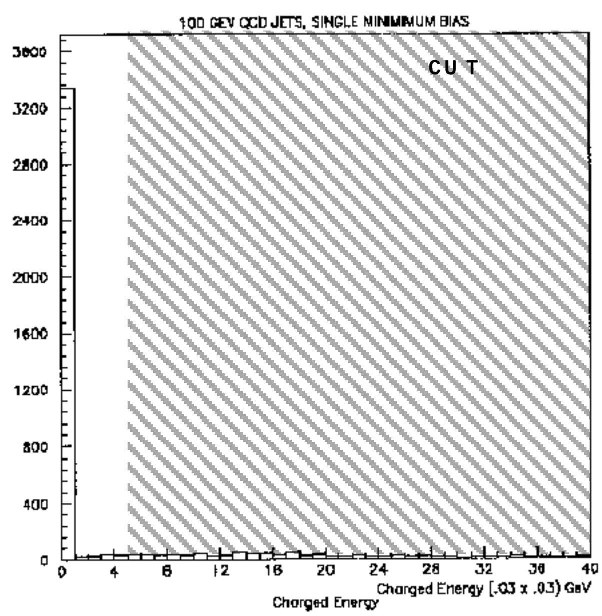
Figure 22: Data and Background Distributions for Centered Hcal Veto

Figure 22 shows the data and background distributions. The horizontal axes show the centered .25 x .25 hadron calorimeter energy sum. The vertical axis of the scatter plots shows the energy of the hot .05 tower in the electromagnetic calorimeter. Clusters which flunk the adopted cut at 4 GeV are in the grayed-out region at right (4 GeV may be a bit tight in practice if correlated detector noise is considered). A clear separation between data and background is seen (less background passes this cut than escaped the block Hcal veto of Fig. 18).

The action of the final trigger cut is shown in Figure 23. This is a cut on charged tracks that impact the calorimeter within a block of 3 x 3 crystals centered at the hottest crystal in a cluster (assuming that we're detecting photons, we veto on associated charged



H → γγ, 100 GeV



100 GeV Jets

Figure 23: Higgs & QCD Distributions for Charged Energy Cut

tracks; if the goal is to detect electrons, such charged tracks would be required). The ECAL cluster is rejected if it is impacted by charged tracks of 5 GeV or more. This cut assumes that some reconstruction has been performed on central tracker data, which will be a nontrivial task at the LHC (thus it would be run at level 2 or level 3).

Fig. 23 shows a histogram taken against the charged energy associated with the ECAL cluster candidate. The 5 GeV cut is indicated (the grayed region is rejected). The background (which is seldom isolated; the jets are broad) has a long tail that is totally lacking in the Higgs data. The cut can be tightened and still retain efficiency, however this cut doesn't remove much data (it will mainly serve to separate electrons from photons), thus it was kept conservative.

The implementation of these cuts, particularly those applied at level 1, will depend closely on the data acquisition techniques. For instance, if the front-end electronics on the crystals require several beam crossings to digitize a signal (and the trigger is all digital), a filtering algorithm will have to be run on the data to identify cluster candidates with beam crossings. If, however, a prompt calorimeter signal can be fast-shaped with enough accuracy (i.e. 8 bits) for the trigger during each beam crossing, it could be flash-digitized, removing any time ambiguity.

The amount of processing that can be performed directly in an analog fashion is currently under debate. The .05 subtowers are comprised of 25 crystals; these may be candidates for an analog sum. The larger towers (i.e. the .2 x .2) involve too many elements (i.e. 400), making an analog sum highly improbable. Digital sums can be carried out in standard sequential fashion (i.e. using adder trees or a pipelined adder).

The trigger cuts described in this report would be implemented at Levels 1 & 2, and mainly serve to remove the dominant background from QCD jets. The next tier of background is due to isolated π° particles, which should be produced somewhere near 1 kHz (beyond 20 GeV energy) at a luminosity of 10^{34} (see Fig. 24; these are singles rates, the rates of isolated π° pairs will be extremely low). This background might be attenuated, if desired, by more complicated cuts running in a level 3 (or augmented level 2) trigger; i.e. finding features that may be indicative of two overlapping photon showers, recognizing π° showers via classifiers such as neural networks, etc. Such algorithms are a topic of active research, and are being developed and tested at currently running experiments. Unfortunately they are beyond the scope of the current study, which has focused mainly on the higher-level trigger.

The efficiency of the trigger cuts on $H \to \gamma\gamma$ events was tested by running PYTHIA for 100 GeV Higgs, and tracking the events through all cuts. Results are shown in Table 1 for a luminosity of 10^{34} (19-event minimum bias pileup) and in Table 2 for double luminosity (38-event pileup). Because of the limited η coverage of the calorimeter, there is an intrinsic 80% acceptance loss in $H \to \gamma\gamma$ events; i.e. only 20% of the generated events have both photons in the calorimeter. This factor has been normalized out of the data in Tables 1 & 2, which show the percentages of Higgs events (with both photons in the calorimeter) that pass the various cuts. The first column lists the energy threshold applied to the calorimeter cluster (at least two clusters of the given energy are required). Three rows of data are associated with each energy threshold, corresponding to the trigger tower size that is used. The bottom set of rows (the "Seezlike Cut") requires one photon to have at least 20 GeV and the other to have at least 30 GeV (as was introduced with Fig. 13). This is assumed to be the cut applied to identify Higgs candidates.

Each column lists the "topological" cut that is applied. The first 6 columns show the response to each cut applied separately (the "Raw" column has no associated topological cut, and shows the percentage of events that pass the energy thresholds). The two columns at right have several cuts working at once. The "Prompt Cuts" are the block isolation and the block hadron calorimeter veto cuts, which would be applied at level 1. The "All Cuts" column shows the percentage of events that pass all cuts applied together (as would be output from level 2).

Looking at the "Seezlike" rows of Table 1, we can see that these cuts are roughly 95% efficient (when all are applied together), with a small efficiency increase (1.5%) when enlarging the trigger sums from .05 towers to .2 towers These figures include the proximity conditions outlined in Fig. 12, which increased the trigger efficiency by ≈ 7% for .05 towers and ≈ 1.5% for .2 towers (this effect is mainly seen on the 30 GeV cluster; the efficiency increase for .05 clusters at a 20 GeV threshold is only ≈ 1.6%). The small .05 towers are thus able to produce an effective Higgs trigger, provided that the adjacency condition is properly taken into account.

The most restricting cut is the centered isolation cone; this produces most of the 5% loss in net efficiency. This cut is highly effective at reducing background, however, as will be illustrated in the next section.

Table 2 shows the results for double minimum bias background (38-event pileup). Here we see that the Higgs trigger has become roughly 91% efficient. This loss in efficiency is distributed across all cuts (the isolation cone thresholds have been increased, as was discussed previously). Some of this efficiency may be recovered by adjusting the various cut thresholds (although the 90% passage rate may well be adequate).

H → γγ

Events: 1735

m = 100 GeV

% Passing Cuts

19 MB Pileup

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
2 Hits								
10 GeV (.05)	95.27	96.71	97.29	94.76	97.12	97.58	96.54	94.01
10 GeV (.1)	97.35	97.64	98.21	95.68	98.04	98.50	97.46	94.93
10 GeV (.2)	98.73	98.21	98.79	96.20	98.62	99.14	98.04	95.45
20 GeV (.05)	95.27	96.71	97.29	94.76	97.12	97.58	96.54	94.01
20 GeV (.1)	97.35	97.64	98.21	95.68	98.04	98.50	97.46	94.93
20 GeV (.2)	98.73	98.21	98.79	96.20	98.62	99.14	98.04	95.45
30 GeV (.05)	76.60	81.67	82.02	80.58	81.90	82.25	81.50	80.00
30 GeV (.1)	83.57	85.53	85.88	84.27	85.76	86.22	85.36	83.69
30 GeV (.2)	88.07	88.01	88.53	86.74	88.41	89.16	87.84	86.11
40 GeV (.05)	40.00	42.59	42.82	42.07	42.82	42.94	42.48	41.79
40 GeV (.1)	50.37	51.53	51.93	51.12	51.93	52.05	51.41	50.72
40 GeV (.2)	57.41	57.41	57.81	56.95	57.81	58.33	57.23	56.43
Seezlike Cut								
20/30 GeV (.05)	97.46	96.71	97.29	94.76	97.12	97.58	96.54	94.01
20/30 GeV (.1)	98.56	97.64	98.21	95.68	98.04	98.50	97.46	94.93
20/30 GeV (.2)	99.19	98.21	98.79	96.20	98.62	99.14	98.04	95.45

Table 1: Efficiencies for $H \rightarrow \gamma\gamma$ at m_H = 100 GeV, 19-event pileup

H → γγ

Events: 1605

m = 100 GeV

% Passing Cuts

38 MB Pileup

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
2 Hits								
10 GeV (.05)	96.32	95.45	97.13	93.33	96.32	97.94	94.83	90.40
10 GeV (.1)	98.01	96.26	98.01	94.02	97.20	98.82	95.64	91.03
10 GeV (.2)	99.13	96.76	98.63	94.45	97.82	99.38	96.20	91.46
20 GeV (.05)	96.32	95.45	97.13	93.33	96.32	97.94	94.83	90.40
20 GeV (.1)	98.01	96.26	98.01	94.02	97.20	98.82	95.64	91.03
20 GeV (.2)	99.13	96.76	98.63	94.45	97.82	99.38	96.20	91.46
30 GeV (.05)	77.07	80.19	81.74	79.19	80.93	82.24	79.75	76.82
30 GeV (.1)	83.18	83.68	85.48	82.68	84.61	86.04	83.24	80.12
30 GeV (.2)	88.85	87.66	89.60	86.48	88.72	90.34	87.17	83.61
40 GeV (.05)	39.88	41.06	41.99	41.25	41.68	42.31	40.87	39.94
40 GeV (.1)	49.72	49.91	50.97	49.66	50.47	51.40	49.53	47.91
40 GeV (.2)	59.88	58.75	60.19	58.50	59.50	60.75	58.38	56.39
Seezlike Cut								
20/30 GeV (.05)	98.13	95.45	97.13	93.33	96.32	97.94	94.83	90.40
20/30 GeV (.1)	98.82	96.26	98.01	94.02	97.20	98.82	95.64	91.03
20/30 GeV (.2)	99.44	96.76	98.63	94.45	97.82	99.38	96.20	91.46

Table 2: Efficiencies for H → γγ at m_H = 100 GeV, 38-event pileup

3) Trigger Rates

As can be seen in Fig. 24 (Ref. [7]), jets are the predominant background to the H ➜ γγ process at the level 1/2 level triggers. In order to ascertain the effect of the QCD background on the photon/electron trigger rates, PYTHIA was run to produce hard QCD events in various production energy windows, as summarized in Table 3 (the actual PYTHIA deck used can be seen in the subroutine "SETPTA", that is listed in Appendix 2). The cross-sections at which such background is produced (see Table 3) were taken from the PYTHIA simulations, and are plotted in Fig. 25 (the top curve in Fig. 24 is taken for $|\eta| < 2$, while the data of Fig. 25 were generated for $|\eta| < 10$; remember that all energies quoted here are transverse; i.e. E_T). These cross-sections were scaled by a luminosity of 10^{34} to derive the production rates given in Table 3. The number of simulated events generated at each energy are also listed in Table 3, together with a "bin width" (i.e. interval between successive production energies, used in the integrations; the 50 GeV width assumed beyond 200 GeV is a crude approximation to a higher-energy tail). The "minimum rate" is the raw rate divided by the number of events, thus is essentially the smallest rate that the statistics can reach.

The percentage of events passing the energy thresholds was nearly identical for production energies below 15 GeV (the minimum energy threshold is set at 10 GeV in the trigger); at these low energies, any trigger rate is caused primarily by the 19 piled-up minimum bias events (to validate this, additional runs were taken at 5 GeV [175684 events] & 10 GeV [163209 events]). The "0 GeV" row represents a run that only looked at minimum bias events, and reflects the low-energy background.

The totals listed in Table 3 represent integrated sums; the "minimum rate" listed here is the sum of the minimum rates averaged between adjacent rows and scaled by the bin width at each production energy ≥ 15 GeV (the minimum bias row gives the generic low-energy background at the 66 mHz beam crossing rate, and is added in separately). Since the cross-sections are decreasing at least exponentially, this is a crude trapezoidal integration (assuming a linear dependence between data points), and may produce an over-estimate. The bin widths are reasonably narrow here, however, thus integration errors should not prove more significant than other error sources (i.e. errors in the assumed production rates, PYTHIA, etc.). The minimum rate of 200 Hz (for single photons) that is reached by these statistics (single-event level) is well within the assumed 10 kHz level 1 trigger output.

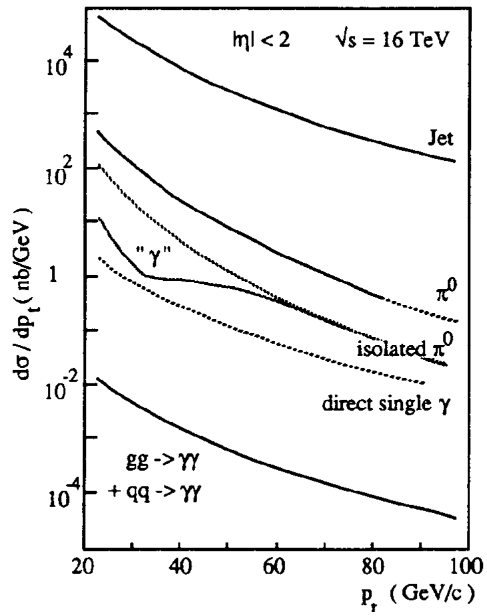


Figure 24: Production Cross Sections for H → γγ Background

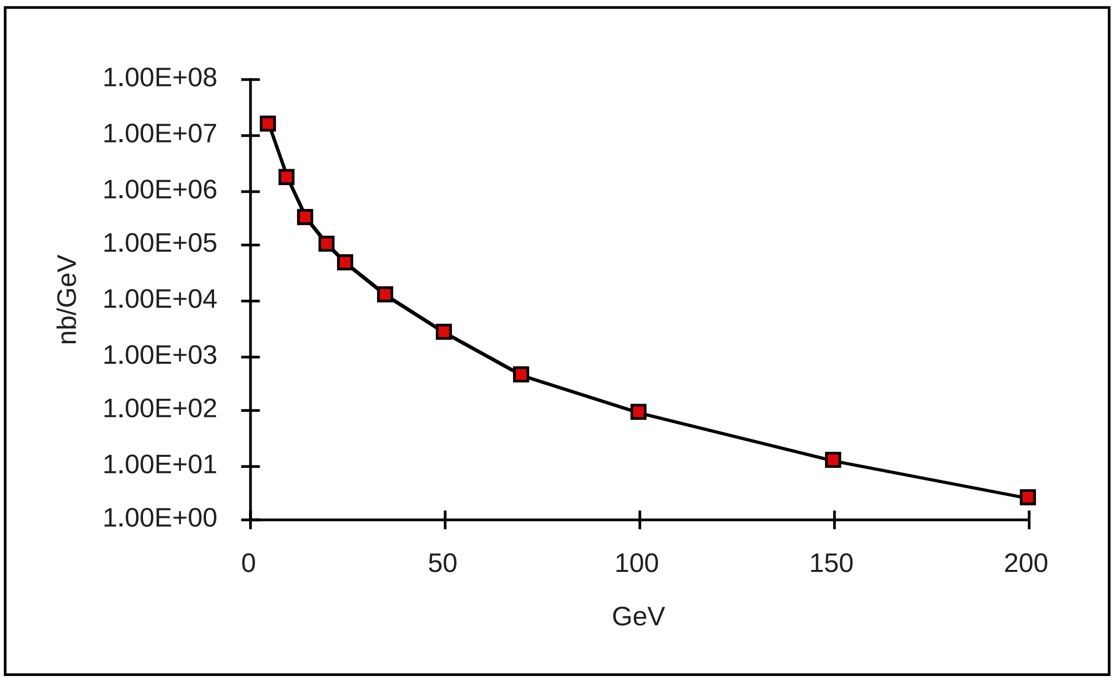


Figure 25: Calculated Cross-Section for Jet Background to H → γγ

Production Energy (GeV)	Bin Width (GeV)	Number of Events	Cross Section (nb/GeV)	Raw Rate	Minimum Rate
				hz/GeV	*hz/GeV*
15	5	155493	3.30E+05	3.30E+06	21.2
20	5	150064	1.00E+05	1.00E+06	6.66
25	10	147710	4.50E+04	4.50E+05	3.05
35	15	70692	1.20E+04	1.20E+05	1.700
50	20	68117	2.50E+03	2.50E+04	0.367
70	30	64846	4.60E+02	4.60E+03	0.071
100	50	62931	9.20E+01	9.20E+02	0.015
150	50	59392	1.20E+01	1.20E+02	0.0020
200	50	3238	2.70E+00	2.70E+01	0.0083
				hz	*hz*
0		114821		6.60E+06	57.5
				hz	*hz*
Totals		897304		1.87E+07	197.4

Table 3: Statistics of Background Simulations

The rate calculation is performed in several steps. First, events are tracked through the various cuts, and a table is generated at each production energy giving the fraction of generated events that are accepted. In order to decouple the rates arising from the 19 piled-up minimum bias events from the overlaid QCD jet event, the fraction of events generated by the minimum bias "0 GeV" run that passed the cuts is subtracted from the corresponding fraction calculated at a higher production energy. This difference is then normalized by the assumed production rate (from Fig. 25, scaled by a luminosity of 10^{34}), yielding the contribution to the trigger rate at a given production energy. These rate contributions are then integrated over all production energies, and added with the rate expected from the minimum bias events (the "0 GeV" run), to form a net trigger rate. This process is illustrated via Eqs. 1 & 2 below:

$f_0 = (N_{accept})/(N_{Gen})$ *for minimum bias ("0 GeV" run)*

$f_p = (N_{accept})/(N_{Gen})$ *at QCD production energy "E_p"*

1)

$$\left.\frac{dR}{dp_\perp}\right|_{E_p} = (f_p - f_0)\left(\left.\frac{d\sigma}{dp_\perp}\right|_{E_p}\right) \boldsymbol{L}$$

2) $$R = \int_0^{\infty} \left(\frac{dR}{dp_\perp}\right) dE_p + (f_0)\,(66\ \mathrm{Mhz})$$

Equation (2) assumes that the minimum bias events (simulated here as 19 simultaneous events) occur at the beam crossing rate of 66 mHz. This correction becomes significant at the lower production energies (i.e. 20 GeV and less), where the collective minimum bias processes begin to compete with the overlaid QCD event. By performing the subtraction of Eq. 1, the calculated rates show the effect of the overlaid QCD event acting together with the minimum bias pileup background; the effects of the minimum bias events by themselves is thus eliminated, and added separately in Eq. 2.

The event flow for each production energy is given in Appendix 1, where a set of tables is presented showing the event flow for each cut, the percentage of events passing the cuts, and the differential rates (in Hz/GeV). The format of these tables is similar to that used in Tables 1 & 2; i.e. the "Raw" column assumes no cuts applied, the following 5 columns assume that only the labeled cut is acting on the "raw" data, the "Prompt Cuts" are the block isolation and block hadron veto together, and the "All Cuts" boasts the concerted action of all 5 cuts. The first 4 sets of rows show the data for single-hits at varying energy threshold (i.e. at least one deposit of the quoted tower size & energy in an event), and the following 5 sets of rows are data for dual-hits (i.e. at least two deposits of the quoted tower size & energy in an event). The bottom set of rows is our candidate Higgs trigger that was derived from the data of Fig. 13; i.e. one cluster of 20 GeV and another of 30 GeV.

The data in all percentage and rate tables (except for the "0 GeV" set) have the minimum bias contribution subtracted, as illustrated in Eq. 1.

Some of this data is summarized in Figs. 26, 27, & 28, which illustrate the action of the various cuts at minimum bias and 50\200 GeV QCD production energies. These plots basically show a row of the corresponding table in Appendix 1; i.e. the percentage of generated events passed by the cuts are plotted for each tower size (a legend for the mapping of tower size to plot symbol/shading is given on the figures at upper right). The cut corresponding to each location on the horizontal axis is listed on the upper left plot. Each row of Figs. 26, 27 & 28 are taken at the listed production energy, and each column reflects clusters passing the listed energy threshold(s).

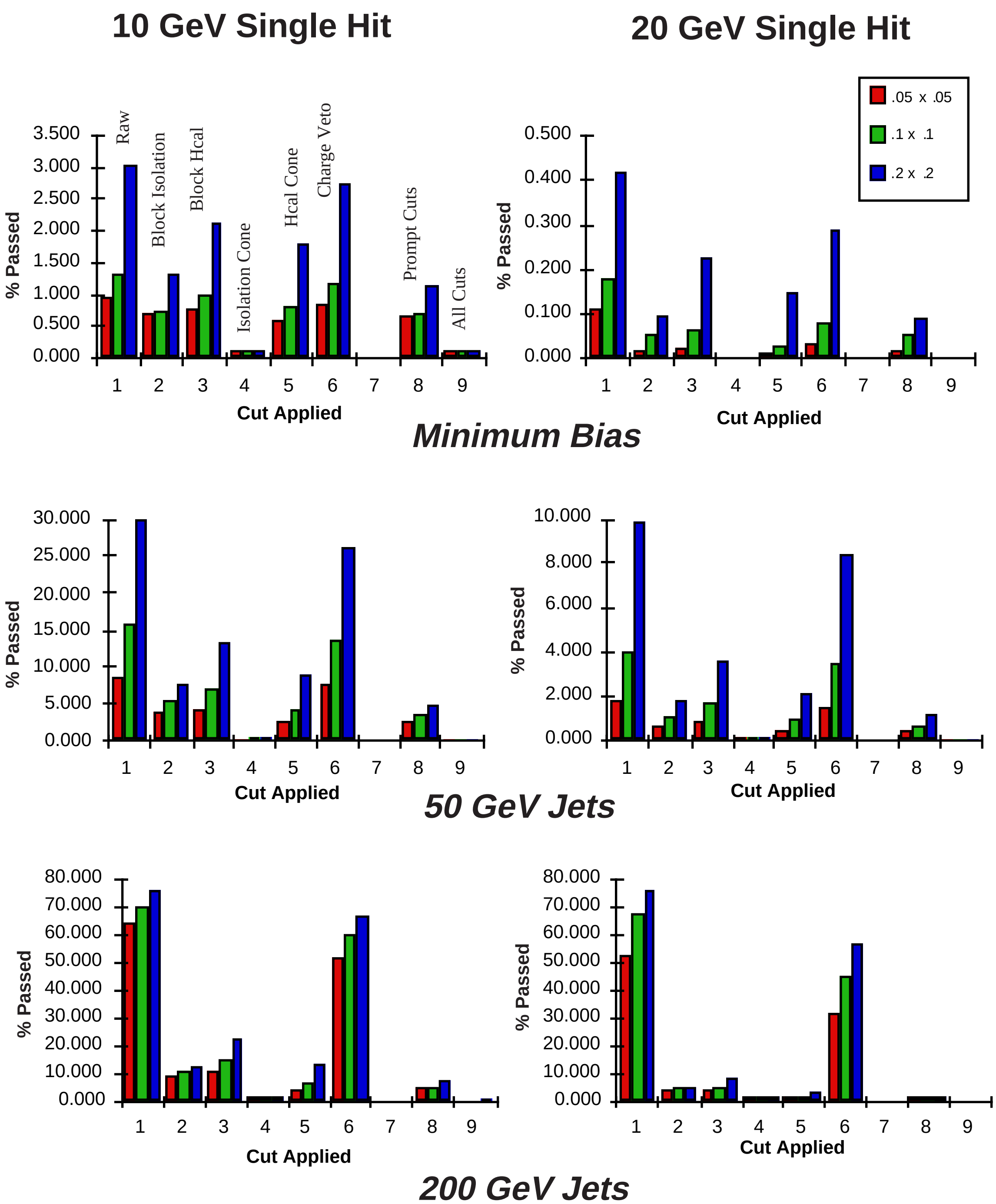


Figure 26: Action of Trigger Cuts on Generated Events

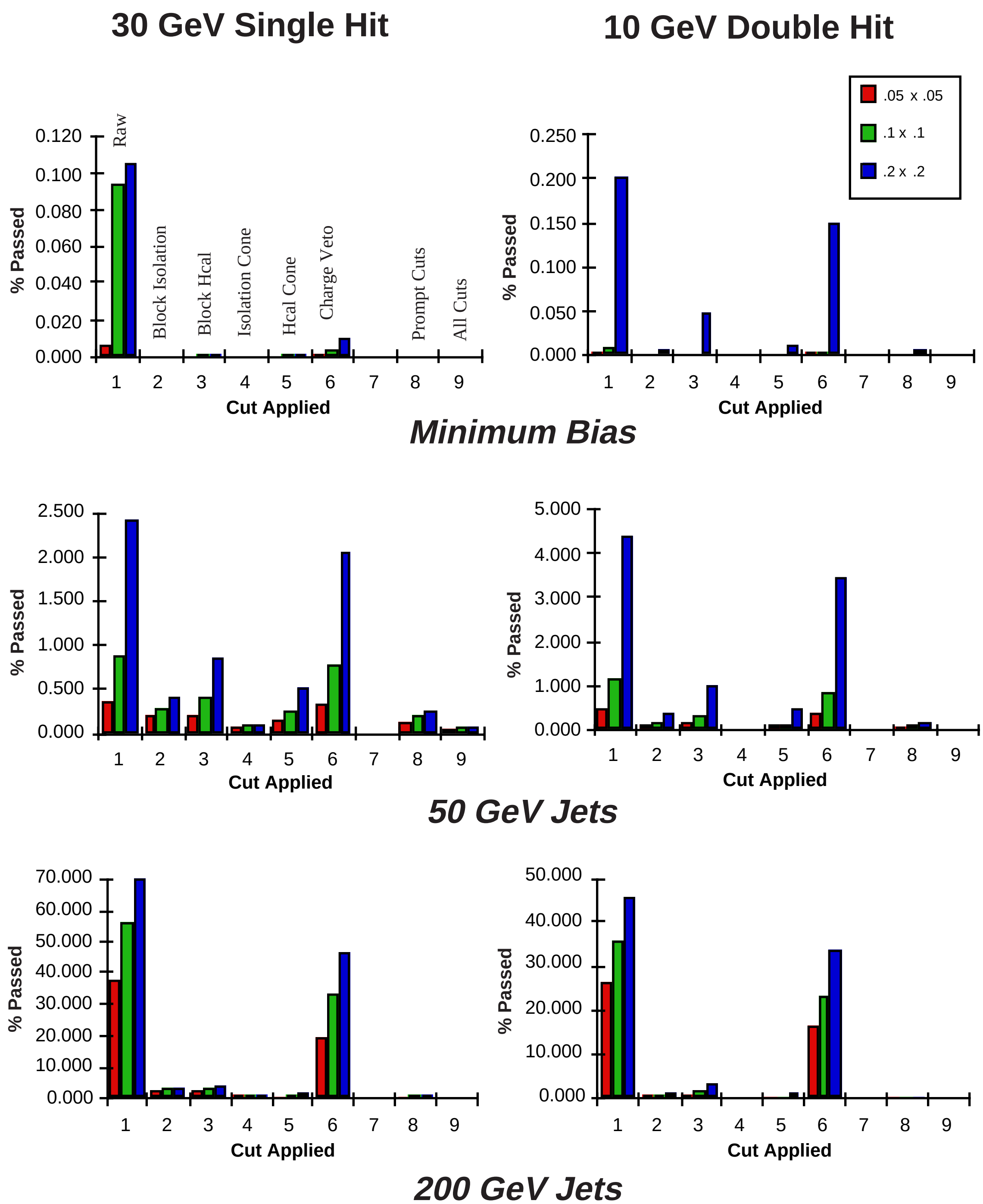


Figure 27: Action of Trigger Cuts on Generated Events

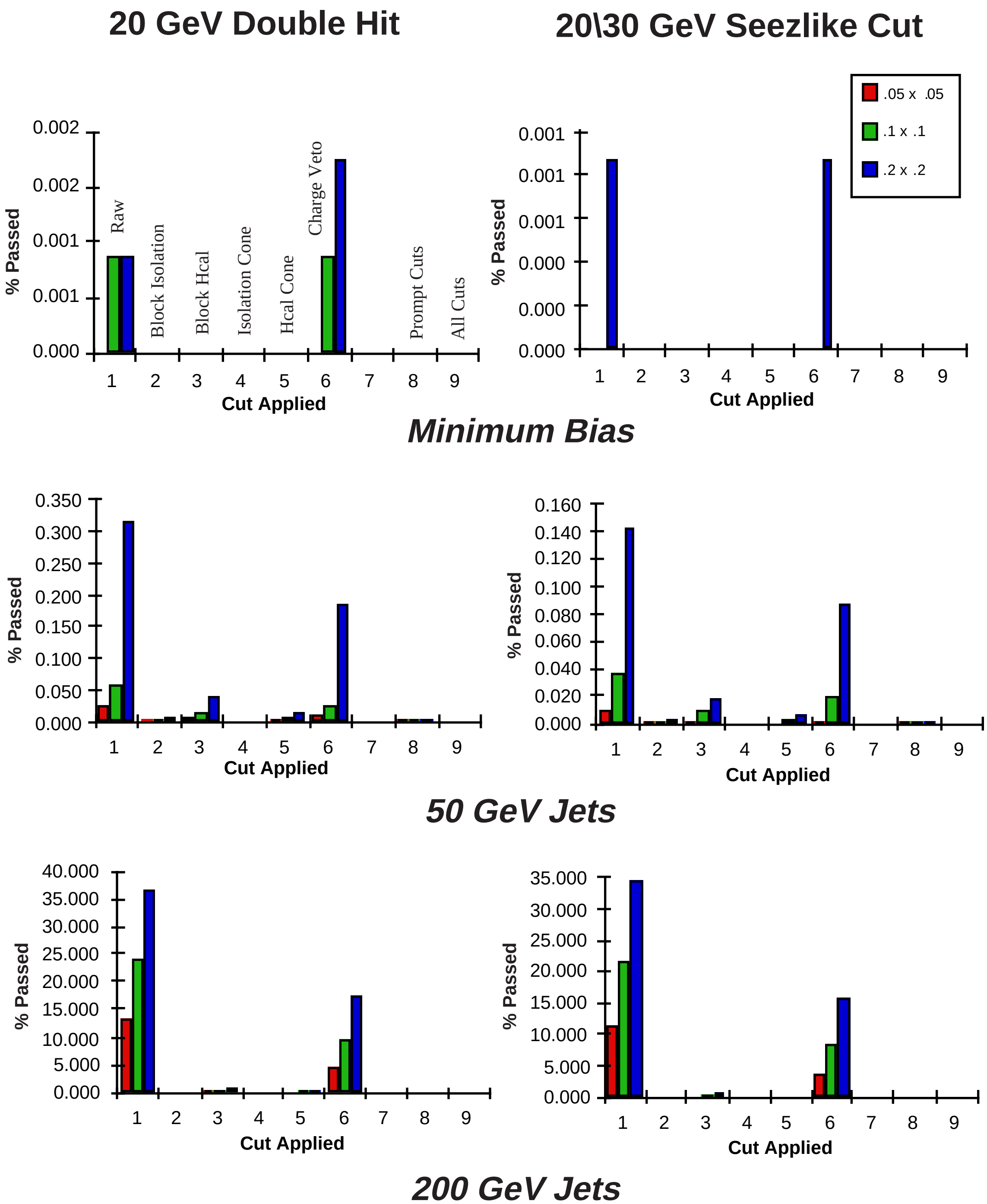


Figure 28: Action of Trigger Cuts on Generated Events

The change in rate with tower size is immediately obvious; the large tower size leads to an increase in trigger rate. This effect is much more pronounced at lower production energies, where the larger sums are needed to pass the energy thresholds. The relative action of the various cuts can also be ascertained through these plots. The most effective cut is the centered isolation cone (cut #4), which reduces the rates from all tower sizes to roughly identical amounts. Although block isolation (#2) is seen to perform a little better than the block hadron veto (#3), both seem to operate at a similar rejection ratio. Their collective action does achieve some additional rate reduction (i.e. they don't always reject the same events), as can be seen by the lower acceptance of the "Prompt Cuts" (#8). This is particularly evident at the higher production energy, where all cuts have greater effect (the isolation and deposited hadron energies extend well above the cut thresholds). The "Charged Energy Veto" (#6) is seen to introduce comparatively little rate attenuation, as expected from the discussion in the previous section (Fig. 23).

These cuts are seen to be very effective in eliminating cluster pairs (see Figs. 27, 28), where each cut can square its attenuation factor in the absence of cluster energy correlation.

The next stage of the calculation is the integration of differential rate over all production energies, as outlined in Eq. 2. This has been accomplished via Tables 4-6, which respectively show raw rates (no cuts), rates passing the prompt cuts, and rates passing all cuts. Each column in the body of the table shows the rates resulting from the labeled production energy (extracted from the analogous column of the tables in Appendix 1). Excepting the "0" column, these rates have their minimum bias contribution subtracted, as in Eq. 1. Residuals within ± a few events were set to zero to avoid introduction of noise from the limited sample of minimum bias events. This resulted in essentially no contribution from the data taken at 5 & 10 GeV, which were dominated by the minimum bias pileup. A possible exception, however, was seen in the single-cluster rate exceeding a 10 GeV threshold after all cuts (Table 6, first row), where a potentially significant excess of events surpassed the minimum bias sample. The origin of this effect is unknown (i.e. the superimposed QCD event generated by PYTHIA tends to be slightly more often isolated than the minimum-bias-only sample?). Because the production rates are so large in this energy region, the relatively small number of excess events doubled the integrated rates calculated in this row of Table 6.

Raw Rates

Jet Energy (GeV)	0	5	10	15	20	25	35	50	70	100	150	200	Net Rate
Hit Energy													
1 Hit	*Hz*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz*
10 GeV (.05)	62,999	0	0	4,346	5,728	5,478	3,996	2,168	901	318	64	17	282,091
10 GeV (.1)	88,061	0	0	8,581	11,094	10,688	7,698	3,944	1,486	459	77	19	492,649
10 GeV (.2)	201,413	0	0	27,989	30,204	27,249	17,538	7,491	2,259	580	86	20	1,132,548
20 GeV (.05)	7,128	0	0	0	173	428	487	448	291	144	43	14	41,393
20 GeV (.1)	11,669	0	0	0	464	999	1,163	1,005	603	269	63	18	83,972
20 GeV (.2)	27,591	0	0	445	1,957	2,996	3,333	2,445	1,213	427	79	21	199,430
30 GeV (.05)	402	0	0	11	6	40	69	90	89	57	24	10	9,651
30 GeV (.1)	6,208	0	0	0	32	104	177	221	200	123	43	15	26,429
30 GeV (.2)	6,898	0	0	0	74	276	481	603	465	241	63	19	51,729
40 GeV (.05)	0	0	0	0	0	12	17	19	28	24	13	7	3,439
40 GeV (.1)	3,104	0	0	0	0	23	0	58	70	55	26	11	10,396
40 GeV (.2)	3,851	0	0	0	0	48	73	146	169	120	45	16	20,107
2 Hits													
10 GeV (.05)	115	0	0	6	29	96	108	114	95	57	20	7	10,531
10 GeV (.1)	517	0	0	102	175	303	301	287	224	117	31	10	25,496
10 GeV (.2)	13,278	0	0	449	920	1,212	1,329	1,101	594	223	44	12	91,954
20 GeV (.05)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	7.6	8.5	6.3	3.6	1,213
20 GeV (.1)	57.5	0.0	0.0	0.0	0.0	0.0	2.3	14.5	29.4	29.0	15.2	6.4	3,480
20 GeV (.2)	57.5	0.0	0.0	0.0	0.0	5.2	41.4	78.7	114.9	83.0	27.3	9.8	10,282
30 GeV (.05)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.2	1.6	1.3	250
30 GeV (.1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	3.3	5.2	5.5	3.5	836
30 GeV (.2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	15.5	20.4	13.6	6.7	2,458
40 GeV (.05)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.5	67
40 GeV (.1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.0	1.8	1.6	265
40 GeV (.2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	2.1	4.8	5.9	3.9	843
Seezlike Cut													
20/30 GeV (.05)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	3.8	5.0	4.5	3.0	784
20/30 GeV (.1)	0.0	0.0	0.0	0.0	0.0	3.0	1.7	8.8	15.2	19.1	12.3	5.8	2,394
20/30 GeV (.2)	57.5	0.0	0.0	0.0	0.0	6.1	8.5	35.2	64.3	61.0	24.3	9.2	6,779
Bin Width (GeV)	5.00	5.00	5.00	5.00	5.00	10.00	15.00	20.00	30.00	50.00	50.00	50.00	

Table 4: Differential Rate Integration for Raw Data (No Cuts)

The result of the rate integration is given in the rightmost column. The integration is performed in a trapezoidal fashion, with the average rate between adjacent columns scaled by their energy difference ("bin width"), and summed across the table. The "0" column is not scaled in this fashion, but added directly, since it gives the minimum bias contribution, which is already in absolute Hz (in order to account for the segment of the production energy integral between 0 and 5 GeV, half of the 5 GeV rate is added into the integral, thus assuming a linear decay to zero at 0 GeV; this contributes only in the case mentioned above, since the 5 GeV rates are otherwise zero). Admittedly, the linear integration is crude, but since the production energy bins are tightly clustered where the rates change most quickly, it shouldn't produce unreasonable results.

Rates After Prompt Cuts

Jet Energy (GeV)	0	5	10	15	20	25	35	50	70	100	150	200	Net Rate
Hit Energy													
1 Hit	*Hz*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz*
10 GeV (.05)	42,708	0	3,634	4,134	3,785	3,023	1,681	607	153	38.1	5.9	1.3	160,509
10 GeV (.1)	44,490	0	5,293	7,064	5,714	4,528	2,444	853	201	46.8	6.7	1.5	221,618
10 GeV (.2)	73,345	0	18,256	14,156	10,078	7,996	3,986	1,220	266	57.0	7.8	2.0	426,432
20 GeV (.05)	1,035	0	0	13	90	219	187	113	37	10.1	1.8	0.4	8,942
20 GeV (.1)	3,276	0	0	17	117	368	285	169	52	13.6	2.2	0.5	15,210
20 GeV (.2)	5,748	0	0	246	455	723	517	284	78	18.6	2.7	0.6	28,986
30 GeV (.05)	0.0	0.0	0.0	0.0	20.0	33.5	30.6	32.3	12.2	4.0	0.8	0.2	1,821
30 GeV (.1)	0.0	0.0	0.0	0.0	20.0	51.8	45.8	45.5	16.7	5.5	1.1	0.2	2,565
30 GeV (.2)	0.0	0.0	0.0	0.0	40.0	70.1	78.1	60.6	24.5	7.2	1.3	0.3	3,751
40 GeV (.05)	0.0	0.0	0.0	0.0	0.0	9.1	11.9	7.3	4.4	2.0	0.4	0.1	568
40 GeV (.1)	0.0	0.0	0.0	0.0	0.0	12.2	11.9	11.4	6.6	2.7	0.6	0.2	754
40 GeV (.2)	0.0	0.0	0.0	0.0	0.0	18.3	11.9	16.5	9.2	3.5	0.7	0.2	993
2 Hits													
10 GeV (.05)	0.0	0.0	0.0	0.0	33.3	33.5	27.2	12.5	4.6	1.2	0.2	0.1	1,155
10 GeV (.1)	0.0	0.0	0.0	0.0	53.3	67.0	40.7	20.2	6.3	1.6	0.3	0.1	1,869
10 GeV (.2)	0.0	0.0	0.0	47.3	163.0	123.6	86.4	37.8	11.4	2.6	0.4	0.1	4,136
20 GeV (.05)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.37	0.07	0.06	0.01	0.00	11
20 GeV (.1)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.37	0.14	0.04	0.02	0.00	13
20 GeV (.2)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.37	0.50	0.13	0.03	0.00	26
30 GeV (.05)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
30 GeV (.1)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0
30 GeV (.2)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
40 GeV (.05)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
40 GeV (.1)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
40 GeV (.2)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Seezlike Cut													
20/30 GeV (.05)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.37	0.00	0.03	0.01	0.00	8
20/30 GeV (.1)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.37	0.07	0.03	0.01	0.00	10
20/30 GeV (.2)	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.37	0.14	0.10	0.02	0.00	15
Bin Width (GeV)	5.00	5.00	5.00	5.00	5.00	10.00	15.00	20.00	30.00	50.00	50.00	50.00	

Table 5: Differential Rate Integration for Events Passing Prompt Cuts

Figs. 29-33 show differential rates as a function of production energy (the rows of Tables 4-6). Since the minimum bias contribution is subtracted from these rates, they can be seen to approach zero at low energy (where the pileup takes over); the only exception to this is the top plot of Fig. 33, which shows the 10 GeV "All Cuts" case that was described earlier.

Rates After All Cuts

Jet Energy (GeV)	0	5	10	15	20	25	35	50	70	100	150	200	Net Rate
Hit Energy													
1 Hit	*Hz*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz/GeV*	*Hz*
10 GeV (.05)	7,128	4,801	2,161	553	659	388	147	43	7.3	1.5	0.3	0.05	53,773
10 GeV (.1)	7,185	3,407	2,533	779	724	439	160	47	8.3	1.7	0.3	0.05	50,819
10 GeV (.2)	7,645	5,010	3,224	1,207	854	512	175	51	9.4	1.9	0.4	0.09	66,383
20 GeV (.05)	0.0	0.0	0.0	106.1	53.3	76.2	47.5	21.7	3.69	0.79	0.09	0.03	2,472
20 GeV (.1)	0.0	0.0	0.0	106.1	66.6	85.3	61.1	23.5	3.90	0.86	0.10	0.03	2,818
20 GeV (.2)	0.0	0.0	0.0	127.3	106.6	121.9	64.5	24.6	4.40	0.91	0.11	0.03	3,474
30 GeV (.05)	0.00	0.00	0.00	0.00	6.66	12.19	15.28	11.01	1.84	0.57	0.06	0.02	582
30 GeV (.1)	0.00	0.00	0.00	0.00	6.66	18.28	20.37	13.95	2.13	0.57	0.07	0.02	750
30 GeV (.2)	0.00	0.00	0.00	0.00	6.66	24.37	22.07	15.41	2.41	0.60	0.07	0.02	851
40 GeV (.05)	0.00	0.00	0.00	0.00	0.00	6.09	10.19	3.67	1.06	0.42	0.05	0.02	285
40 GeV (.1)	0.00	0.00	0.00	0.00	0.00	6.09	10.19	4.04	1.35	0.45	0.06	0.02	300
40 GeV (.2)	0.00	0.00	0.00	0.00	0.00	9.14	10.19	5.14	1.63	0.48	0.06	0.02	350
2 Hits													
10 GeV (.05)	0.00	0.00	0.00	0.00	0.00	3.05	0.00	0.00	0.00	0.00	0.00	0.00	23
10 GeV (.1)	0.00	0.00	0.00	0.00	0.00	3.05	0.00	0.00	0.07	0.00	0.00	0.00	25
10 GeV (.2)	0.00	0.00	0.00	0.00	0.00	6.09	0.00	0.00	0.07	0.00	0.00	0.00	48
20 GeV (.05)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
20 GeV (.1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
20 GeV (.2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
30 GeV (.05)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
30 GeV (.1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
30 GeV (.2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
40 GeV (.05)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
40 GeV (.1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
40 GeV (.2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Seezlike Cut													
20/30 GeV (.05)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
20/30 GeV (.1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
20/30 GeV (.2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Bin Width (GeV)	5.00	5.00	5.00	5.00	5.00	10.00	15.00	20.00	30.00	50.00	50.00	50.00	

Table 6: Differential Rate Integration for Events Passing All Cuts

The distributions can also be seen to broaden with increasing energy threshold (i.e. higher energy clusters are created more often at higher production energies), particularly for the uncut and prompt-cut data. The effect of tower size is also readily obvious; the raw energy-level trigger rates due to the .2 x .2 tower sums (Figs. 29,30) are much higher than those at smaller tower sizes. The prompt cuts relieve this situation somewhat (Figs. 31,32), and the data processed through all cuts (Fig. 33) brought the rates from all 3 tower sums into near agreement.

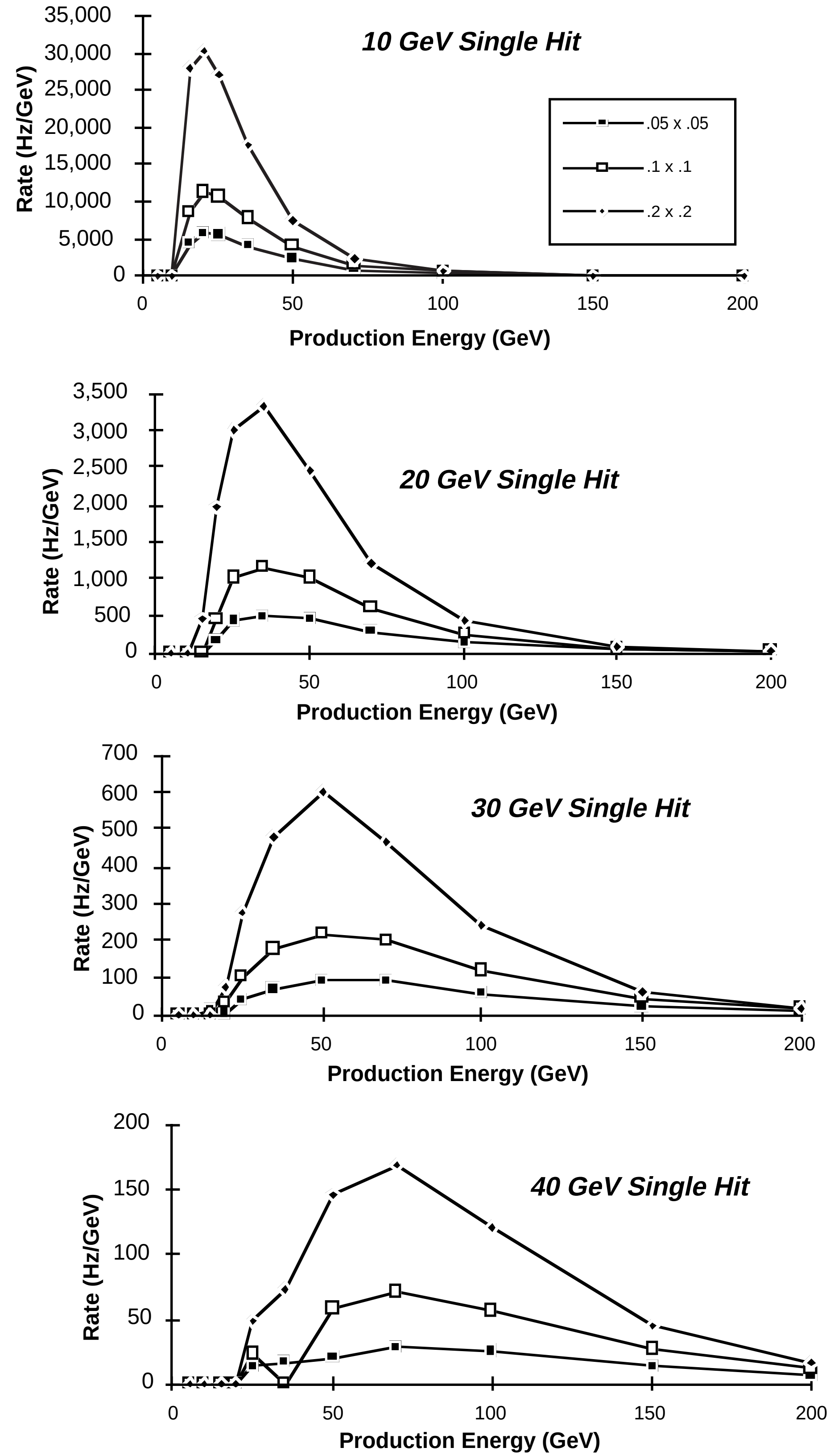


Figure 29: Differential Rate for Raw Data (No Cuts); Minimum Bias Subtracted

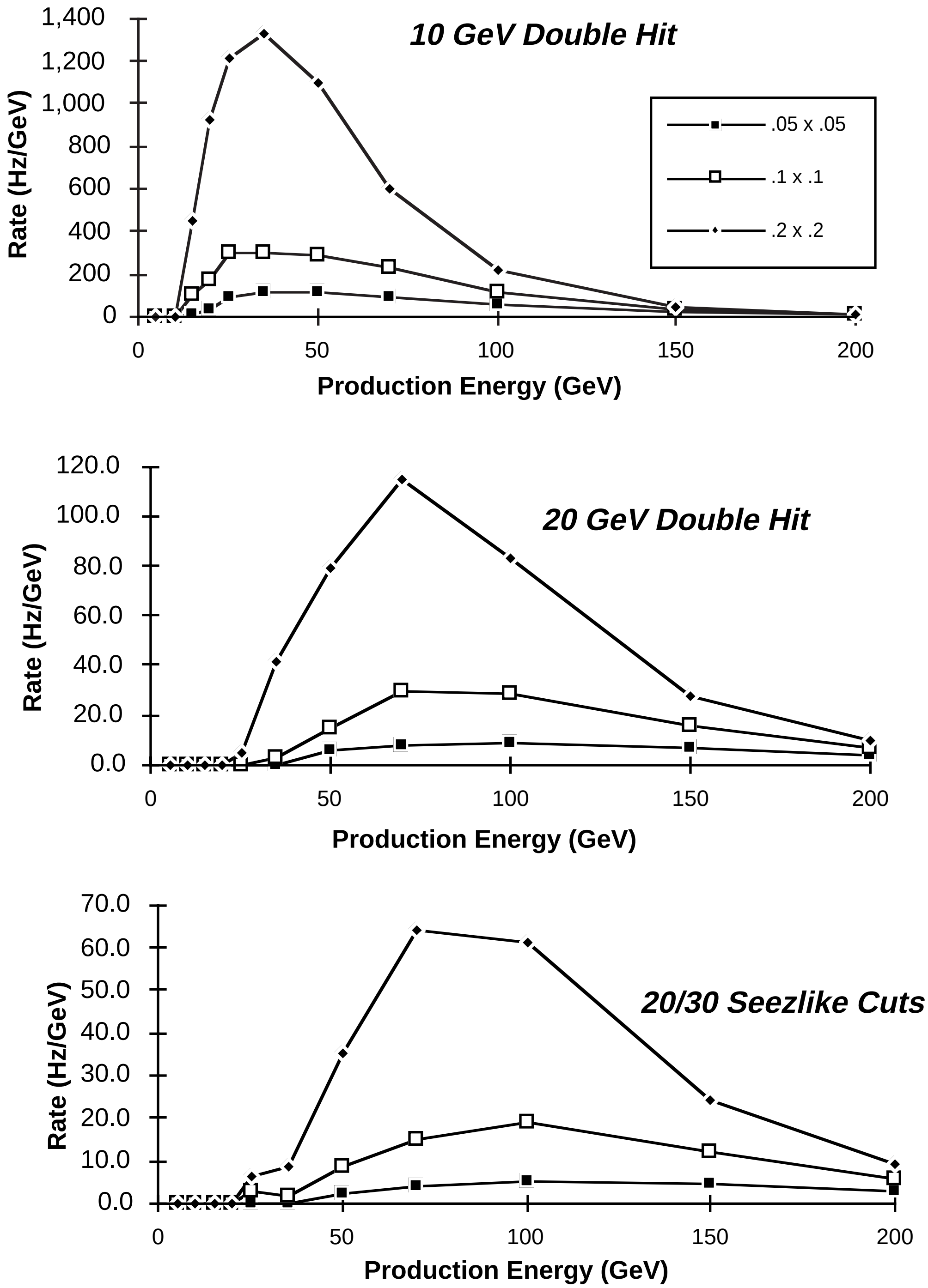


Figure 30: Differential Rate for Raw Data (No Cuts); Minimum Bias Subtracted

Since no events (within our statistics) survived with at least two clusters passing all topological cuts, cluster pair plots can not be provided for the "All Cuts" situation. The statistics can be seen to become limited at the higher energy thresholds (particularly for cluster pairs), producing some jitter in the corresponding plots.

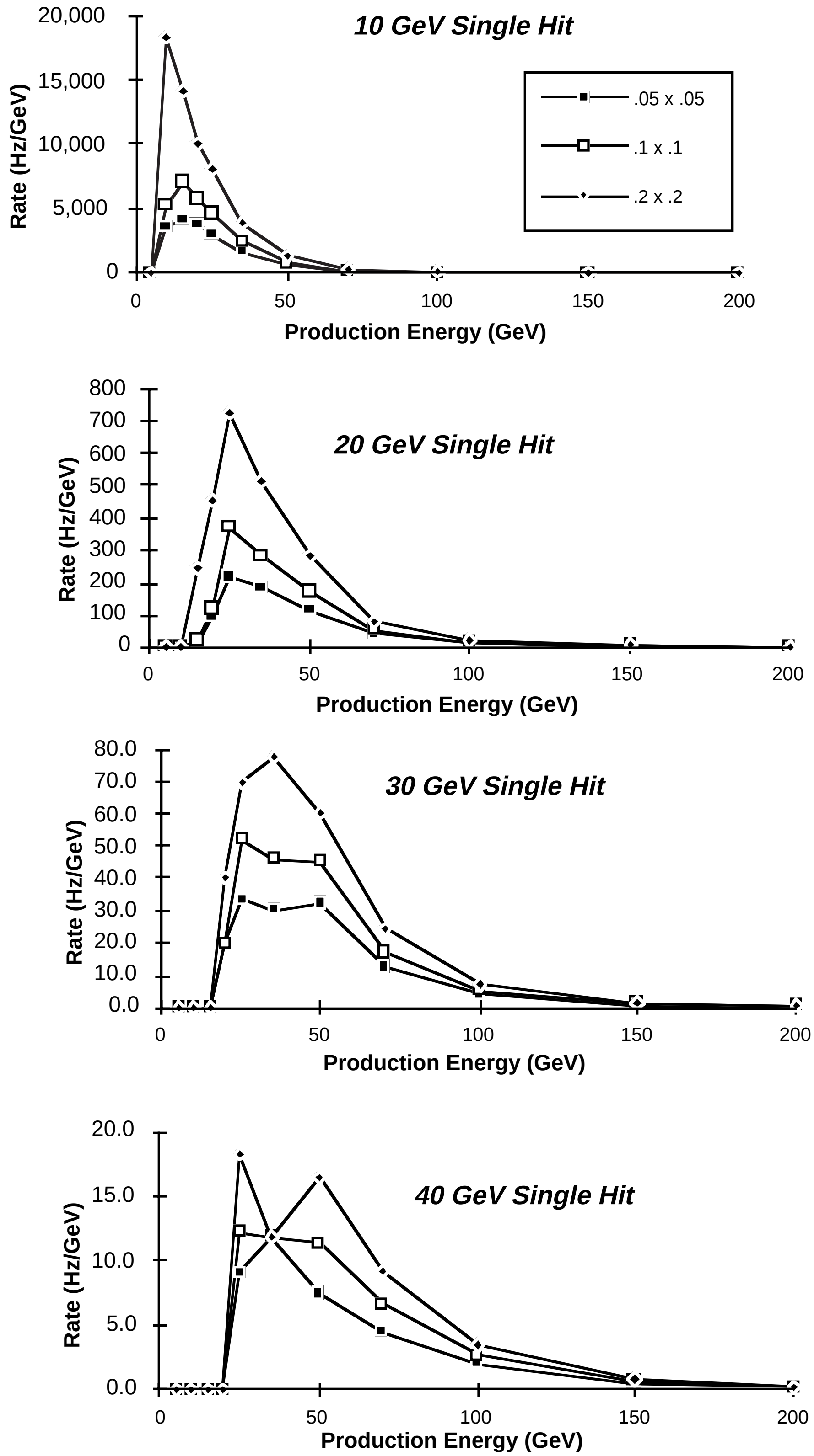


Figure 31: Differential Rate for Events Passing Prompt Cuts; Minimum Bias Subtracted

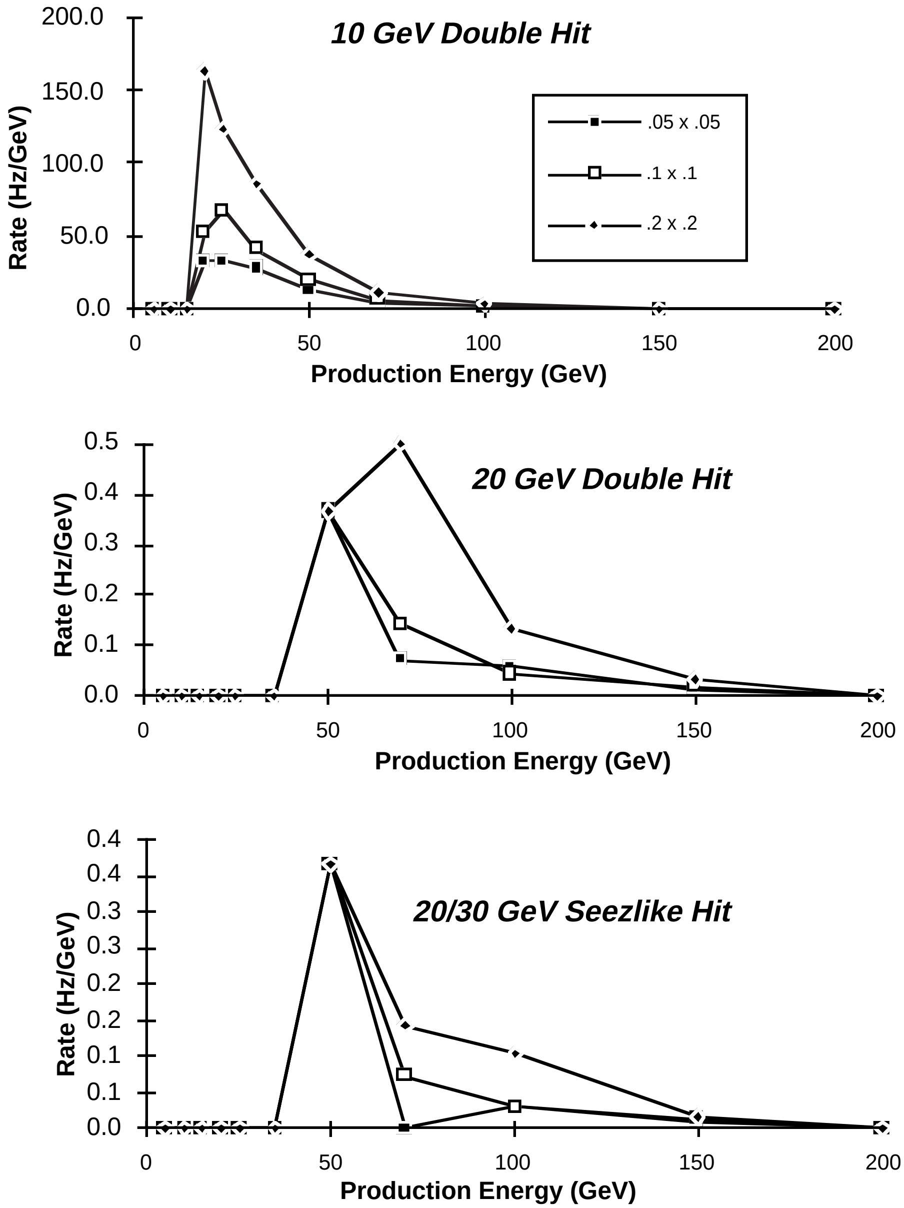


Figure 32: Differential Rate for Events Passing Prompt Cuts; Min. Bias Subtracted

As can be ascertained from the above discussions, the rates at lower energy thresholds are sensitive to the means by which the data at the lower production energies are blended with the minimum bias estimation. Since the 19 piled-up minimum bias events assumed in these tests came from a fixed sample of 20,000 events stored on disk (which were paired sequentially, with random offset at each rewind), the minimum bias statistics may begin to become exhausted in these results (runs could extend to over 150K events). A more reliable estimate of the low-threshold rate can be gleaned through a larger minimum bias sample (or using random-access combinatorics on the event file).

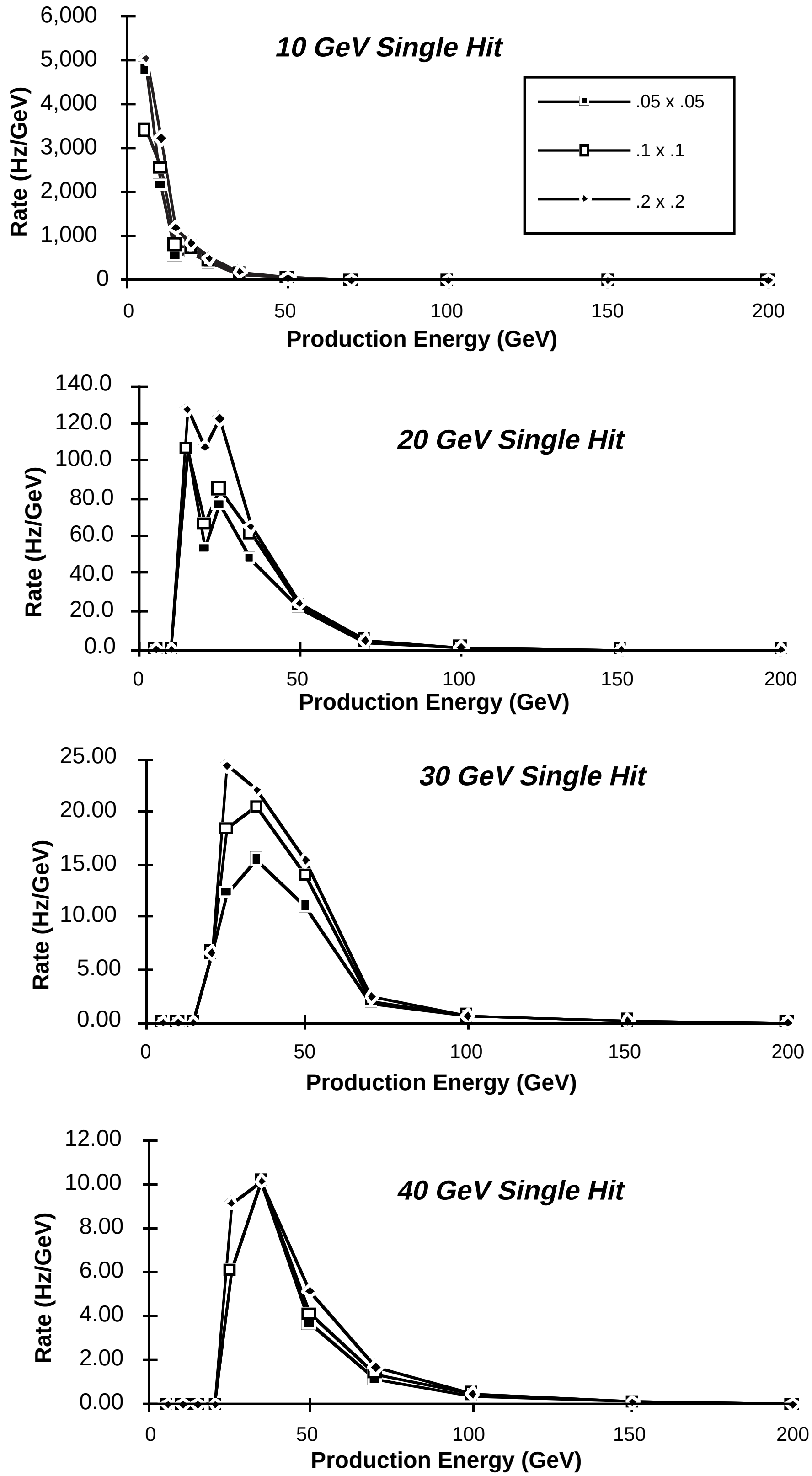


Figure 33: Differential Rate for Events Passing All Cuts; Min. Bias Subtracted

Net Rates (Hz)			
Cuts Applied	**No Cuts (Raw)**	**Prompt Cuts Only**	**All Cuts Together**
Hit Energy			
1 Hit	*Hz*	*Hz*	*Hz*
10 GeV (.05)	282,091	160,509	53,773
10 GeV (.1)	492,649	221,618	50,819
10 GeV (.2)	1,132,548	426,432	66,383
20 GeV (.05)	41,393	8,942	2,472
20 GeV (.1)	83,972	15,210	2,818
20 GeV (.2)	199,430	28,986	3,474
30 GeV (.05)	9,651	1,821	582
30 GeV (.1)	26,429	2,565	750
30 GeV (.2)	51,729	3,751	851
40 GeV (.05)	3,439	568	285
40 GeV (.1)	10,396	754	300
40 GeV (.2)	20,107	993	350
2 Hits			
10 GeV (.05)	10,531	1,155	23
10 GeV (.1)	25,496	1,869	25
10 GeV (.2)	91,954	4,136	48
20 GeV (.05)	1,213	11	0
20 GeV (.1)	3,480	13	0
20 GeV (.2)	10,282	26	0
30 GeV (.05)	250	0	0
30 GeV (.1)	836	0	0
30 GeV (.2)	2,458	0	0
40 GeV (.05)	67	0	0
40 GeV (.1)	265	0	0
40 GeV (.2)	843	0	0
Seezlike Cut			
20/30 GeV (.05)	784	8	0
20/30 GeV (.1)	2,394	10	0
20/30 GeV (.2)	6,779	15	0

Table 7: Summary of Integrated Rates

Normalized Net Rates (Hz) from Ref. [8]			
Cuts Applied	**No Cuts (Raw)**	**Isolation/Leakage (R=5)**	**Isolation/Leakage (R=20)**
Hit Energy			
1 Hit	*Hz*	*Hz*	*Hz*
20 GeV (.1)	76,667	15,000	4,000
20 GeV (.2)	103,333	21,667	5,333
30 GeV (.1)	11,667	2,333	667
30 GeV (.2)	17,667	3,667	1,000
40 GeV (.1)	2,000	400	100
40 GeV (.2)	4,667	1,000	250
2 Hits			
10 GeV (.1)	11,111		
10 GeV (.2)	28,889		
20 GeV (.1)	1,111		
20 GeV (.2)	4,000		
30 GeV (.1)	111		
30 GeV (.2)	222		

Table 8: Rates from the studies of Ref. [8], normalized to $|\eta| < 1$

Table 7 compiles the integrated rates for the raw data, events passing prompt cuts, and events passing all cuts (the last columns of Tables 4-6). The single-cluster rates listed in Table 7 are generally seen to agree within a factor of two with the single-photon rates summarized from analogous studies in Ref. [8], as presented in Table 8 (these rates were run over a wider acceptance of $|\eta| < 3$, thus they have been scaled by $^1/_3$ to enable a comparison with our results, which are valid only over $|\eta| < 1$). The two columns at right in Table 8 require the data to pass isolation and hadron leakage cuts; the cuts are set tighter in the rightmost column. A discrepancy can be noted in the raw single-photon rates at 30 and 40 GeV thresholds, where our data in this Table 7 can significantly exceed the rates of Table 8, particularly at the large tower size. Some of this effect is due to the adding of adjacent towers below threshold, as was discussed with Fig. 12a (i.e. two adjacent towers under the energy threshold can count as one tower above threshold). Whereas this technique can realize a significant gain in trigger efficiency with the small tower size, it has little benefit for towers of .1 x .1 and larger, where it may also inject considerable background (i.e. the effective tower sum is taken over a doubled area!). The 30 and 40 GeV rates come into agreement after isolation (or at the .05 x .05 tower size), indicating that the excess triggering is caused by wide-area integration.

The data of Ref. [8] only provides cluster pair data before isolation and veto cuts. In order to compensate for the reduced rapidity range of our data, the rates in Table 8 have been scaled by $^1/_9$. The raw data from Table 7 is seen to exceed the normalized data of Table 8 (by a factor of 2-3 at 10 & 20 GeV thresholds, and by an order of magnitude or so at 30 GeV). This discrepancy can be due to a variety of sources; i.e. if the two clusters are correlated (which may often be the case), the normalization of $^1/_9$ may be too large for the comparison between rapidity intervals. The larger excess rate at 30 GeV is also due to the integration of pileup over large towers, as was discussed above.

The topological cuts are effective in reducing the cluster pair rates, as can be seen in Table 7. The candidate Higgs trigger ("Seezlike Cut" at 20/30 GeV) produced a raw rate of under a kilohertz (.05 tower sum), which reduced to under 10 Hz after the prompt Level 1 cuts, and resulted in a rate that was unmeasurably low with the current statistics after the application of all cuts. In general, this was noted when requiring pairs with energies above 20 GeV per cluster; no events of this sort were seen to be passed by the trigger cuts acting in combination, resulting in a sub-Hz rate.

Table 7 gives some guidelines for establishing triggering conditions. If the level 1 trigger output is desired to be maintained below 10 kHz, single lepton/photon thresholds should be kept beyond 30 GeV (lower thresholds may be used only if demanding other detector events [i.e. a muon] that will lower the net rate), and pair thresholds can operate reasonably down to 10 GeV (again, the PYTHIA results may vary significantly in their accuracy, and the rate normalization can become uncertain at the low energy thresholds, so one must beware...).

Figs. 34 and 35 summarize the rates of Table 7. Fig. 34 shows the rates plotted as a function of effective trigger level (i.e. "Raw", "Prompt" [=L1], and "All Cuts" [=L2]) and tower size. Fig. 35 shows the rates plotted as a function of energy threshold, where a near-exponential dependence can be observed.

In addition to examining the trigger rate, these simulations have also tracked the detector occupancy. For all types of events, the mean calorimeter occupancy was on the order of 58,000 crystals (.01 x .01 elements, having some energy deposited; no threshold applied) with a σ of 530 crystals. Demanding a minimum energy of 350 MeV (1 MIP), dropped the mean occupancy to 280 crystals (σ = 30) for minimum bias events, with an increase noted in QCD events (i.e. mean = 330 crystals, σ = 50 for 100 GeV jets).

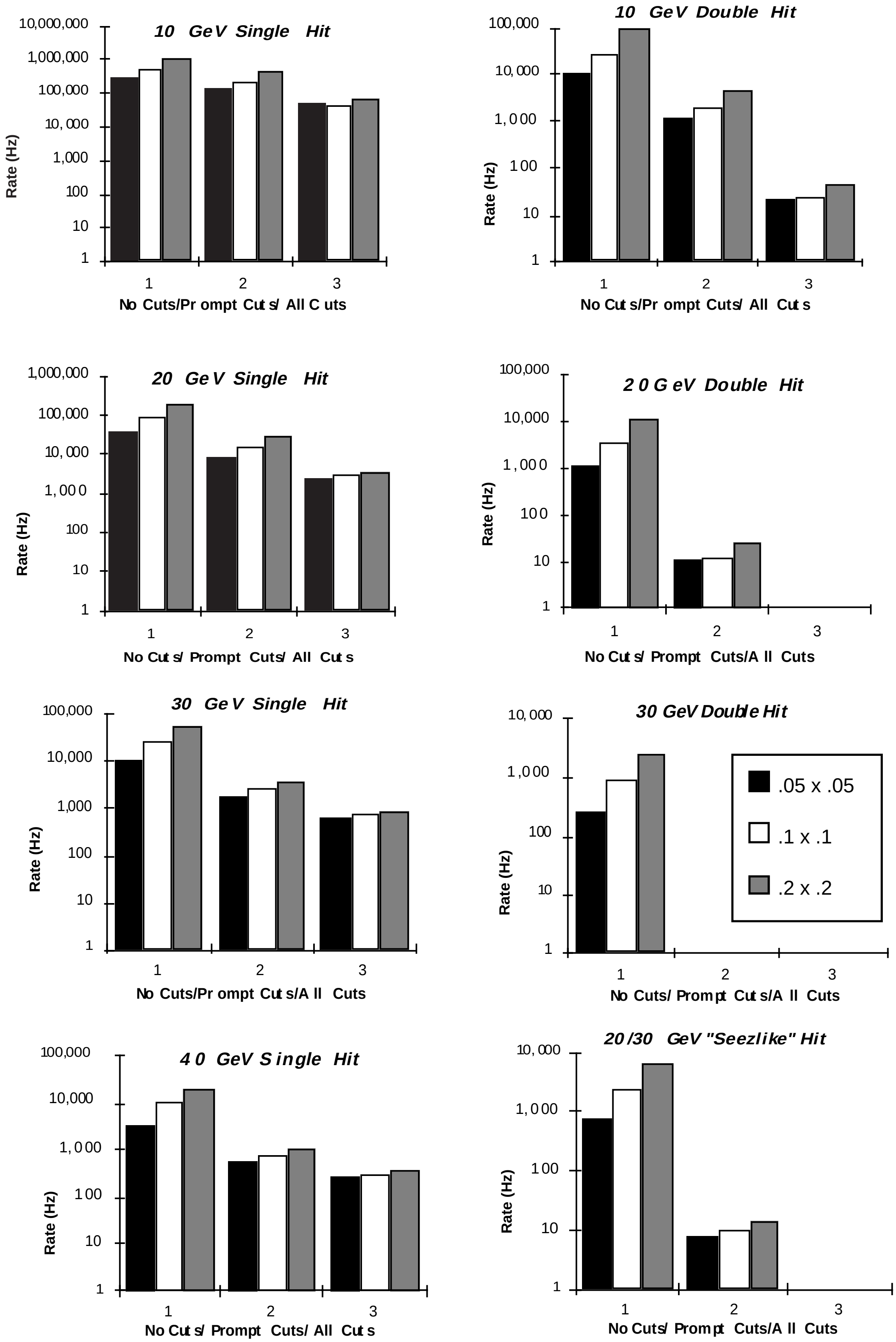


Figure 34: Trigger rates as a function of trigger level and tower size

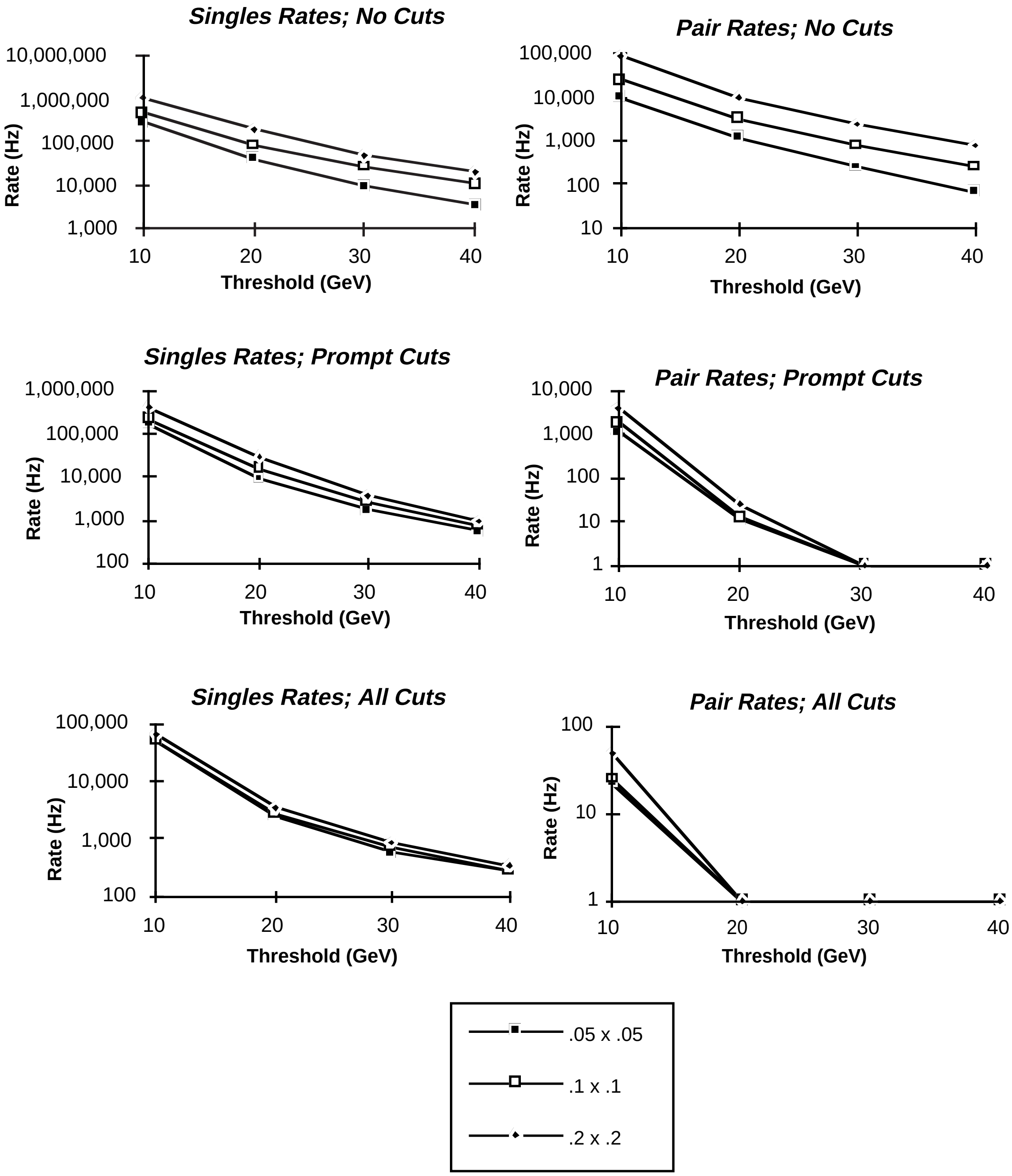


Figure 35: Trigger rates as a function of energy threshold

4) Conclusions and Suggestions

The implementation of a pair of Level 1 trigger cuts (uncentered "block" isolation and hadron leakage veto) are seen to reduce the trigger rates of the eγ calorimeter to a reasonable level. The most effective cut at reducing jet background is a centered isolation cone of radius 0.3, applied at level 2.

Trigger rates were sensitive to tower size (particularly after the raw energy thresholds and coarse level 1 cuts). The performance of the small .05 x .05 tower was seen to be significantly superior. With an adjacency provision that recovers the full trigger efficiency, the smaller towers are much less sensitive to background and pileup.

The trigger rates at low energy thresholds are quite sensitive to the normalization assumed at low production energies. The low-threshold rates quoted here will become significantly more accurate if the minimum bias event sample (a 20,000 event file) is augmented. The pileup can be better modeled by determining the number of accumulated events by a Poisson distribution, rather than assuming this to be constant at the mean value of 19 (the main effect here will be to increase the raw trigger rate for large towers; a 5% reduction in Higgs trigger efficiency was noted when doubling the pileup to 38 events). In addition, no noise model was assumed in this simulation (aside from the intrinsic energy deposits from a 19-event pileup); these rates may well increase with added detector noise, particularly considering the large sums involved in creating the .2 x .2 towers.

5) References

1) Denes, P., Personal Communication, Nov., 1991.

2) Toth, J., Parameterization studies for electron showers based on DESY models, Proc. of eγ Meetings, Winter, 1991/1992.

3) Arefiev. A. et. al., "Analysis and Simulation of Hadronic Showers in a Uranium Gas-Sampling Calorimeter", CERN-EP/89-109, August, 1989.

4) Plyaskin, V., Personal Communication, Nov. 1991.

5) Nessi, F., Proc. of eγ Meetings, Nov., 1991.

6) Seez, C. et. al., "Photon Decay Modes of the Intermediate Mass Higgs", Proc. of the Aachen Large Hadron Collider Workshop, Oct. 1990, Vol. II, pg. 474.

7) Colas, J. et. al., "Calorimetry at the LHC", Proc. of the Aachen Large Hadron Collider Workshop, Oct. 1990, Vol. I, pg. 370.

8) Hellman, S. et. al., "Trigger Rates at the LHC", Proc. of the Aachen Large Hadron Collider Workshop, Oct. 1990, Vol. III, pg. 72.

6) Appendix 1: Event Flow Tables

Note: The "% Passed" and "Rates" tables have the minimum bias contributions subtracted for all production energies excepting the "0 GeV" minimum bias run.

Jet Energy: 0 GeV *# Events:* 114821 *Rate (hz/GeV):* 6.60E+06

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	1096	797	883	125	659	980	743	124
10 GeV (.1)	1532	844	1162	127	921	1351	774	125
10 GeV (.2)	3504	1512	2445	136	2046	3166	1276	133
20 GeV (.05)	124	18	23	0	12	32	18	0
20 GeV (.1)	203	58	72	0	27	90	57	0
20 GeV (.2)	480	104	258	0	167	329	100	0
30 GeV (.05)	7	0	0	0	0	1	0	0
30 GeV (.1)	108	0	1	0	1	3	0	0
30 GeV (.2)	120	0	1	0	1	11	0	0
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	54	0	0	0	0	2	0	0
40 GeV (.2)	67	0	0	0	0	3	0	0
2 Hits								
10 GeV (.05)	2	0	0	0	0	2	0	0
10 GeV (.1)	9	0	0	0	0	2	0	0
10 GeV (.2)	231	5	54	0	12	169	5	0
20 GeV (.05)	0	0	0	0	0	0	0	0
20 GeV (.1)	1	0	0	0	0	1	0	0
20 GeV (.2)	1	0	0	0	0	2	0	0
30 GeV (.05)	0	0	0	0	0	0	0	0
30 GeV (.1)	0	0	0	0	0	0	0	0
30 GeV (.2)	0	0	0	0	0	0	0	0
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	0	0	0	0	0	0	0	0
40 GeV (.2)	0	0	0	0	0	0	0	0
Seezlike Cut								
20/30 GeV (.05)	0	0	0	0	0	0	0	0
20/30 GeV (.1)	0	0	0	0	0	0	0	0
20/30 GeV (.2)	1	0	0	0	0	1	0	0

Jet Energy: 0 GeV *# Events:* 114821 *Rate (hz/GeV):* 6.60E+06

% Passing Cuts

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	0.955	0.694	0.769	0.109	0.574	0.854	0.647	0.108
10 GeV (.1)	1.334	0.735	1.012	0.111	0.802	1.177	0.674	0.109
10 GeV (.2)	3.052	1.317	2.129	0.118	1.782	2.757	1.111	0.116
20 GeV (.05)	0.108	0.016	0.020	0.000	0.010	0.028	0.016	0.000
20 GeV (.1)	0.177	0.051	0.063	0.000	0.024	0.078	0.050	0.000
20 GeV (.2)	0.418	0.091	0.225	0.000	0.145	0.287	0.087	0.000
30 GeV (.05)	0.006	0.000	0.000	0.000	0.000	0.001	0.000	0.000
30 GeV (.1)	0.094	0.000	0.001	0.000	0.001	0.003	0.000	0.000
30 GeV (.2)	0.105	0.000	0.001	0.000	0.001	0.010	0.000	0.000
40 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.047	0.000	0.000	0.000	0.000	0.002	0.000	0.000
40 GeV (.2)	0.058	0.000	0.000	0.000	0.000	0.003	0.000	0.000
2 Hits								
10 GeV (.05)	0.002	0.000	0.000	0.000	0.000	0.002	0.000	0.000
10 GeV (.1)	0.008	0.000	0.000	0.000	0.000	0.002	0.000	0.000
10 GeV (.2)	0.201	0.004	0.047	0.000	0.010	0.147	0.004	0.000
20 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20 GeV (.1)	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000
20 GeV (.2)	0.001	0.000	0.000	0.000	0.000	0.002	0.000	0.000
30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Seezlike Cut								
20/30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.2)	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000

Jet Energy: 0 GeV *# Events:* 114821 *Rate (hz/GeV):* 6.60E+06

Luminosity: 1.00E+34
 # Evebts per Crossing: 19

Rates (Hz/GeV)

Min. Rate (hz/GeV): 5.75E+01

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	62,999.	45,812.	50,756.	7,185.	37,880.	56,331.	42,708.	7,128.
10 GeV (.1)	88,061.	48,514.	66,793.	7,300.	52,940.	77,657.	44,490.	7,185.
10 GeV (.2)	201,413.	86,911.	140,540.	7,817.	117,606.	181,984.	73,345.	7,645.
20 GeV (.05)	7,128.	1,035.	1,322.	0.	690.	1,839.	1,035.	0.
20 GeV (.1)	11,669.	3,334.	4,139.	0.	1,552.	5,173.	3,276.	0.
20 GeV (.2)	27,591.	5,978.	14,830.	0.	9,599.	18,911.	5,748.	0.
30 GeV (.05)	402.	0.	0.	0.	0.	57.	0.	0.
30 GeV (.1)	6,208.	0.	57.	0.	57.	172.	0.	0.
30 GeV (.2)	6,898.	0.	57.	0.	57.	632.	0.	0.
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	3,104	0	0	0	0	115	0	0
40 GeV (.2)	3,851	0	0	0	0	172	0	0
2 Hits								
10 GeV (.05)	115.	0.	0.	0.	0.	115.	0.	0.
10 GeV (.1)	517.	0.	0.	0.	0.	115.	0.	0.
10 GeV (.2)	13,278.	287.	3,104.	0.	690.	9,714.	287.	0.
20 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20 GeV (.1)	57.	0.	0.	0.	0.	57.	0.	0.
20 GeV (.2)	57.	0.	0.	0.	0.	115.	0.	0.
30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
Seezlike Cut								
20/30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.2)	57.	0.	0.	0.	0.	57.	0.	0.

Jet Energy: 15 GeV *# Events:* 155493 *Rate (hz/GeV):* 3.30E+06

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	1689	1275	1408	210	1135	1513	1201	194
10 GeV (.1)	2479	1480	1987	233	1463	2228	1381	206
10 GeV (.2)	6064	2743	4490	269	2977	5551	2395	237
20 GeV (.05)	155	27	28	5	16	35	25	5
20 GeV (.1)	273	81	100	6	35	122	78	5
20 GeV (.2)	671	164	377	7	175	484	147	6
30 GeV (.05)	10	0	0	0	0	0	0	0
30 GeV (.1)	141	0	0	0	0	0	0	0
30 GeV (.2)	150	0	0	0	0	7	0	0
40 GeV (.05)	2	0	0	0	0	0	0	0
40 GeV (.1)	71	0	0	0	0	0	0	0
40 GeV (.2)	88	0	0	0	0	0	0	0
2 Hits								
10 GeV (.05)	3	3	0	0	0	3	0	0
10 GeV (.1)	17	3	2	0	1	7	0	0
10 GeV (.2)	334	11	105	0	32	250	9	0
20 GeV (.05)	0	0	0	0	0	0	0	0
20 GeV (.1)	0	0	0	0	0	0	0	0
20 GeV (.2)	0	0	0	0	0	0	0	0
30 GeV (.05)	0	0	0	0	0	0	0	0
30 GeV (.1)	0	0	0	0	0	0	0	0
30 GeV (.2)	0	0	0	0	0	0	0	0
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	0	0	0	0	0	0	0	0
40 GeV (.2)	0	0	0	0	0	0	0	0
Seezlike Cut								
20/30 GeV (.05)	0	0	0	0	0	0	0	0
20/30 GeV (.1)	0	0	0	0	0	0	0	0
20/30 GeV (.2)	0	0	0	0	0	0	0	0

Jet Energy: 15 GeV *# Events:* 155493 *Rate (hz/GeV):* 3.30E+06

% Passing Cuts

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	0.132	0.126	0.136	0.026	0.156	0.120	0.125	0.017
10 GeV (.1)	0.260	0.217	0.266	0.039	0.139	0.256	0.214	0.024
10 GeV (.2)	0.848	0.447	0.758	0.055	0.133	0.813	0.429	0.037
20 GeV (.05)	0.000	0.002	0.000	0.003	0.000	0.000	0.000	0.003
20 GeV (.1)	0.000	0.002	0.002	0.004	0.000	0.000	0.001	0.003
20 GeV (.2)	0.013	0.015	0.018	0.005	0.000	0.025	0.007	0.004
30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.05)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 Hits								
10 GeV (.05)	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
10 GeV (.1)	0.003	0.002	0.001	0.000	0.001	0.003	0.000	0.000
10 GeV (.2)	0.014	0.003	0.020	0.000	0.010	0.014	0.001	0.000
20 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Seezlike Cut								
20/30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Jet Energy: 15 GeV | *# Events:* 155493 | *Rate (hz/GeV):* 3.30E+06

Luminosity: 1.00E+34
Cross Section: (nb/GeV) 3.30E+05

Rates (Hz/GeV)

Min. Rate (hz/GeV): 21.2228

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	4,346.	4,153.	4,504.	864.	5,148.	3,945.	4,134.	553.
10 GeV (.1)	8,581.	7,153.	8,773.	1,295.	4,579.	8,456.	7,064.	779.
10 GeV (.2)	27,989.	14,759.	25,020.	1,800.	4,378.	26,816.	14,156.	1,207.
20 GeV (.05)	0.	56.	0.	106.	0.	0.	13.	106.
20 GeV (.1)	0.	52.	53.	127.	0.	3.	17.	106.
20 GeV (.2)	445.	492.	586.	149.	0.	816.	246.	127.
30 GeV (.05)	11.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.05)	42	0	0	0	0	0	0	0
40 GeV (.1)	0	0	0	0	0	0	0	0
40 GeV (.2)	0	0	0	0	0	0	0	0
2 Hits								
10 GeV (.05)	6.	64.	0.	0.	0.	6.	0.	0.
10 GeV (.1)	102.	64.	42.	0.	21.	91.	0.	0.
10 GeV (.2)	449.	90.	676.	0.	334.	449.	47.	0.
20 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
20 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
Seezlike Cut								
20/30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.

Jet Energy: 20 GeV *# Events:* 150064 *Rate (hz/GeV):* 1.00E+06

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	2292	1689	1888	285	1513	2074	1539	261
10 GeV (.1)	3667	2109	2879	302	2369	3346	1869	272
10 GeV (.2)	9112	3786	6563	347	5661	8357	3180	302
20 GeV (.05)	188	41	52	10	39	65	37	8
20 GeV (.1)	335	99	147	13	95	182	92	10
20 GeV (.2)	921	219	572	21	410	722	199	16
30 GeV (.05)	10	3	4	0	4	4	3	1
30 GeV (.1)	146	3	7	0	7	7	3	1
30 GeV (.2)	168	6	17	0	16	26	6	1
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	62	0	0	0	0	0	0	0
40 GeV (.2)	74	0	0	0	0	0	0	0
2 Hits								
10 GeV (.05)	7	6	6	0	5	5	5	0
10 GeV (.1)	38	14	17	0	14	24	8	0
10 GeV (.2)	440	48	151	0	87	337	31	0
20 GeV (.05)	0	0	0	0	0	0	0	0
20 GeV (.1)	0	0	0	0	0	0	0	0
20 GeV (.2)	0	0	0	0	0	0	0	0
30 GeV (.05)	0	0	0	0	0	0	0	0
30 GeV (.1)	0	0	0	0	0	0	0	0
30 GeV (.2)	0	0	0	0	0	0	0	0
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	0	0	0	0	0	0	0	0
40 GeV (.2)	0	0	0	0	0	0	0	0
Seezlike Cut								
20/30 GeV (.05)	0	0	0	0	0	0	0	0
20/30 GeV (.1)	0	0	0	0	0	0	0	0
20/30 GeV (.2)	0	0	0	0	0	0	0	0

Jet Energy: 20 GeV *# Events:* 150064 *Rate (hz/GeV):* 1.00E+06

% Passing Cuts

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	0.573	0.431	0.489	0.081	0.434	0.529	0.378	0.066
10 GeV (.1)	1.109	0.670	0.907	0.091	0.777	1.053	0.571	0.072
10 GeV (.2)	3.020	1.206	2.244	0.113	1.990	2.812	1.008	0.085
20 GeV (.05)	0.017	0.012	0.015	0.007	0.016	0.015	0.009	0.005
20 GeV (.1)	0.046	0.015	0.035	0.009	0.040	0.043	0.012	0.007
20 GeV (.2)	0.196	0.055	0.156	0.014	0.128	0.195	0.046	0.011
30 GeV (.05)	0.001	0.002	0.003	0.000	0.003	0.002	0.002	0.001
30 GeV (.1)	0.003	0.002	0.004	0.000	0.004	0.002	0.002	0.001
30 GeV (.2)	0.007	0.004	0.010	0.000	0.010	0.008	0.004	0.001
40 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 Hits								
10 GeV (.05)	0.003	0.004	0.004	0.000	0.003	0.002	0.003	0.000
10 GeV (.1)	0.017	0.009	0.011	0.000	0.009	0.014	0.005	0.000
10 GeV (.2)	0.092	0.028	0.054	0.000	0.048	0.077	0.016	0.000
20 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Seezlike Cut								
20/30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Jet Energy: 20 GeV   *# Events:* 150064   *Rate (hz/GeV):* 1.00E+06

Luminosity:	1.00E+34
Cross Section: (nb/GeV)	1.00E+05

Rates (Hz/GeV)

Min. Rate (hz/GeV): 6.6638

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	5,728.	4,314.	4,891.	811.	4,343.	5,286.	3,785.	659.
10 GeV (.1)	11,094.	6,703.	9,065.	906.	7,765.	10,531.	5,714.	724.
10 GeV (.2)	30,204.	12,061.	22,441.	1,128.	19,905.	28,116.	10,078.	854.
20 GeV (.05)	173.	116.	146.	67.	155.	154.	90.	53.
20 GeV (.1)	464.	155.	353.	87.	398.	429.	117.	67.
20 GeV (.2)	1,957.	554.	1,565.	140.	1,278.	1,946.	455.	107.
30 GeV (.05)	6.	20.	27.	0.	27.	18.	20.	7.
30 GeV (.1)	32.	20.	38.	0.	38.	21.	20.	7.
30 GeV (.2)	74.	40.	105.	0.	98.	77.	40.	7.
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	0	0	0	0	0	0	0	0
40 GeV (.2)	0	0	0	0	0	0	0	0
2 Hits								
10 GeV (.05)	29.	40.	40.	0.	33.	16.	33.	0.
10 GeV (.1)	175.	93.	113.	0.	93.	143.	53.	0.
10 GeV (.2)	920.	276.	536.	0.	475.	774.	163.	0.
20 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
20 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
Seezlike Cut								
20/30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.

Jet Energy: 25 GeV *# Events:* 147710 *Rate (hz/GeV):* 4.50E+05

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	3208	2209	2518	336	2000	2924	1948	287
10 GeV (.1)	5479	2919	4023	361	3210	5003	2482	305
10 GeV (.2)	13452	5234	9147	407	7614	12304	4266	339
20 GeV (.05)	300	116	132	35	106	165	95	25
20 GeV (.1)	589	230	320	41	223	425	194	28
20 GeV (.2)	1601	440	960	55	710	1353	366	40
30 GeV (.05)	22	14	12	8	10	17	11	4
30 GeV (.1)	173	21	25	11	21	32	17	6
30 GeV (.2)	245	31	66	14	60	101	23	8
40 GeV (.05)	4	4	3	3	3	4	3	2
40 GeV (.1)	77	5	6	3	6	7	4	2
40 GeV (.2)	102	7	9	4	7	13	6	3
2 Hits								
10 GeV (.05)	34	12	21	1	15	25	11	1
10 GeV (.1)	111	26	52	1	35	82	22	1
10 GeV (.2)	695	65	280	2	162	587	47	2
20 GeV (.05)	0	0	0	0	0	0	0	0
20 GeV (.1)	1	0	0	0	0	0	0	0
20 GeV (.2)	3	0	0	0	0	0	0	0
30 GeV (.05)	0	0	0	0	0	0	0	0
30 GeV (.1)	0	0	0	0	0	0	0	0
30 GeV (.2)	0	0	0	0	0	0	0	0
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	0	0	0	0	0	0	0	0
40 GeV (.2)	0	0	0	0	0	0	0	0
Seezlike Cut								
20/30 GeV (.05)	0	0	0	0	0	0	0	0
20/30 GeV (.1)	1	0	0	0	0	0	0	0
20/30 GeV (.2)	2	0	0	0	0	0	0	0

Jet Energy: 25 GeV *# Events:* 147710 *Rate (hz/GeV):* 4.50E+05

% Passing Cuts

Hit Energy	***Raw No cuts***	**Block Isolation**	**Block Hcal Veto**	**Centered Isolation Cone**	**Centered Hcal Veto**	**Charged Energy Cut**	**Prompt Cuts**	**All Cuts**
1 Hit								
10 GeV (.05)	1.217	0.801	0.936	0.119	0.780	1.126	0.672	0.086
10 GeV (.1)	2.375	1.241	1.712	0.134	1.371	2.210	1.006	0.098
10 GeV (.2)	6.055	2.227	4.063	0.157	3.373	5.573	1.777	0.114
20 GeV (.05)	0.095	0.063	0.069	0.024	0.061	0.084	0.049	0.017
20 GeV (.1)	0.222	0.105	0.154	0.028	0.127	0.209	0.082	0.019
20 GeV (.2)	0.666	0.207	0.425	0.037	0.335	0.629	0.161	0.027
30 GeV (.05)	0.009	0.009	0.008	0.005	0.007	0.011	0.007	0.003
30 GeV (.1)	0.023	0.014	0.016	0.007	0.013	0.019	0.012	0.004
30 GeV (.2)	0.061	0.021	0.044	0.009	0.040	0.059	0.016	0.005
40 GeV (.05)	0.003	0.003	0.002	0.002	0.002	0.003	0.002	0.001
40 GeV (.1)	0.005	0.003	0.004	0.002	0.004	0.003	0.003	0.001
40 GeV (.2)	0.011	0.005	0.006	0.003	0.005	0.006	0.004	0.002
2 Hits								
10 GeV (.05)	0.021	0.008	0.014	0.001	0.010	0.015	0.007	0.001
10 GeV (.1)	0.067	0.018	0.035	0.001	0.024	0.054	0.015	0.001
10 GeV (.2)	0.269	0.040	0.143	0.001	0.099	0.250	0.027	0.001
20 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20 GeV (.2)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Seezlike Cut								
20/30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.1)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.2)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Jet Energy: 25 GeV | *# Events:* 147710 | *Rate (hz/GeV):* 4.50E+05

Luminosity: 1.00E+34
Cross Section: (nb/GeV) 4.50E+04

Rates (Hz)/GeV

Min. Rate (Hz/GeV): 3.0465

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	5,478.	3,606.	4,211.	534.	3,510.	5,067.	3,023.	388.
10 GeV (.1)	10,688.	5,585.	7,702.	602.	6,170.	9,947.	4,528.	439.
10 GeV (.2)	27,249.	10,020.	18,284.	707.	15,178.	25,076.	7,996.	512.
20 GeV (.05)	428.	283.	312.	107.	276.	377.	219.	76.
20 GeV (.1)	999.	473.	693.	125.	574.	942.	368.	85.
20 GeV (.2)	2,996.	933.	1,914.	168.	1,509.	2,833.	723.	122.
30 GeV (.05)	40.	43.	37.	24.	30.	48.	34.	12.
30 GeV (.1)	104.	64.	72.	34.	60.	86.	52.	18.
30 GeV (.2)	276.	94.	197.	43.	179.	265.	70.	24.
40 GeV (.05)	12	12	9	9	9	12	9	6
40 GeV (.1)	23	15	18	9	18	13	12	6
40 GeV (.2)	48	21	27	12	21	28	18	9
2 Hits								
10 GeV (.05)	96.	37.	64.	3.	46.	68.	34.	3.
10 GeV (.1)	303.	79.	158.	3.	107.	242.	67.	3.
10 GeV (.2)	1,212.	178.	641.	6.	447.	1,126.	124.	6.
20 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
20 GeV (.2)	5.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
Seezlike Cut								
20/30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.1)	3.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.2)	6.	0.	0.	0.	0.	0.	0.	0.

Jet Energy: 35 GeV *# Events:* 70692 *Rate (hz/GeV):* 1.20E+05

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	3029	1793	2050	222	1523	2729	1448	163
10 GeV (.1)	5478	2476	3411	233	2554	4903	1916	171
10 GeV (.2)	12489	4166	7217	253	5610	11149	3134	185
20 GeV (.05)	363	163	185	39	129	269	121	28
20 GeV (.1)	810	283	409	53	281	664	203	36
20 GeV (.2)	2259	501	1147	62	796	1969	366	38
30 GeV (.05)	45	23	24	10	23	38	18	9
30 GeV (.1)	171	39	54	16	43	97	27	12
30 GeV (.2)	357	68	133	18	98	260	46	13
40 GeV (.05)	10	8	7	7	7	10	7	6
40 GeV (.1)	11	10	10	8	10	23	7	6
40 GeV (.2)	84	10	22	8	19	46	7	6
2 Hits								
10 GeV (.05)	65	23	40	1	23	55	16	0
10 GeV (.1)	183	36	82	1	53	147	24	0
10 GeV (.2)	925	84	311	1	189	763	54	0
20 GeV (.05)	0	0	0	0	0	0	0	0
20 GeV (.1)	2	0	0	0	0	1	0	0
20 GeV (.2)	25	0	5	0	2	16	0	0
30 GeV (.05)	0	0	0	0	0	0	0	0
30 GeV (.1)	0	0	0	0	0	0	0	0
30 GeV (.2)	0	0	0	0	0	0	0	0
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	0	0	0	0	0	0	0	0
40 GeV (.2)	0	0	0	0	0	0	0	0
Seezlike Cut								
20/30 GeV (.05)	0	0	0	0	0	0	0	0
20/30 GeV (.1)	1	0	0	0	0	0	0	0
20/30 GeV (.2)	5	0	0	0	0	3	0	0

Jet Energy: 35 GeV *# Events:* 70692 *Rate (hz/GeV):* 1.20E+05

% Passing Cuts

Hit Energy	***Raw No cuts***	**Block Isolation**	**Block Hcal Veto**	**Centered Isolation Cone**	**Centered Hcal Veto**	**Charged Energy Cut**	**Prompt Cuts**	**All Cuts**
1 Hit								
10 GeV (.05)	3.330	1.842	2.131	0.205	1.580	3.007	1.401	0.123
10 GeV (.1)	6.415	2.767	3.813	0.219	2.811	5.759	2.036	0.133
10 GeV (.2)	14.615	4.576	8.080	0.239	6.154	13.014	3.322	0.146
20 GeV (.05)	0.406	0.215	0.242	0.055	0.172	0.353	0.155	0.040
20 GeV (.1)	0.969	0.350	0.516	0.075	0.374	0.861	0.238	0.051
20 GeV (.2)	2.778	0.618	1.398	0.088	0.981	2.499	0.431	0.054
30 GeV (.05)	0.058	0.033	0.034	0.014	0.033	0.053	0.025	0.013
30 GeV (.1)	0.148	0.055	0.076	0.023	0.060	0.135	0.038	0.017
30 GeV (.2)	0.400	0.096	0.187	0.025	0.138	0.358	0.065	0.018
40 GeV (.05)	0.014	0.011	0.010	0.010	0.010	0.014	0.010	0.008
40 GeV (.1)	0.000	0.014	0.014	0.011	0.014	0.031	0.010	0.008
40 GeV (.2)	0.060	0.014	0.031	0.011	0.027	0.062	0.010	0.008
2 Hits								
10 GeV (.05)	0.090	0.033	0.057	0.001	0.033	0.076	0.023	0.000
10 GeV (.1)	0.251	0.051	0.116	0.001	0.075	0.206	0.034	0.000
10 GeV (.2)	1.107	0.114	0.393	0.001	0.257	0.932	0.072	0.000
20 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20 GeV (.1)	0.002	0.000	0.000	0.000	0.000	0.001	0.000	0.000
20 GeV (.2)	0.034	0.000	0.007	0.000	0.003	0.021	0.000	0.000
30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Seezlike Cut								
20/30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.1)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20/30 GeV (.2)	0.007	0.000	0.000	0.000	0.000	0.004	0.000	0.000

Jet Energy: 35 GeV	*# Events:* 70692	*Rate (hz/GeV):* 1.20E+05

Luminosity:	1.00E+34
Cross Section: (nb/GeV)	1.20E+04

Rates (Hz)/GeV

Min. Rate (Hz/GeV): 1.6975

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	3,996.	2,211.	2,557.	246.	1,897.	3,608.	1,681.	147.
10 GeV (.1)	7,698.	3,321.	4,576.	263.	3,373.	6,911.	2,444.	160.
10 GeV (.2)	17,538.	5,492.	9,696.	287.	7,385.	15,617.	3,986.	175.
20 GeV (.05)	487.	258.	290.	66.	206.	423.	187.	48.
20 GeV (.1)	1,163.	420.	619.	90.	449.	1,033.	285.	61.
20 GeV (.2)	3,333.	742.	1,677.	105.	1,177.	2,999.	517.	65.
30 GeV (.05)	69.	39.	41.	17.	39.	63.	31.	15.
30 GeV (.1)	177.	66.	91.	27.	72.	162.	46.	20.
30 GeV (.2)	481.	115.	225.	31.	165.	430.	78.	22.
40 GeV (.05)	17	14	12	12	12	17	12	10
40 GeV (.1)	0	17	17	14	17	37	12	10
40 GeV (.2)	73	17	37	14	32	75	12	10
2 Hits								
10 GeV (.05)	108.	39.	68.	2.	39.	91.	27.	0.
10 GeV (.1)	301.	61.	139.	2.	90.	247.	41.	0.
10 GeV (.2)	1,329.	137.	471.	2.	308.	1,119.	86.	0.
20 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20 GeV (.1)	2.	0.	0.	0.	0.	1.	0.	0.
20 GeV (.2)	41.	0.	8.	0.	3.	25.	0.	0.
30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
30 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.1)	0.	0.	0.	0.	0.	0.	0.	0.
40 GeV (.2)	0.	0.	0.	0.	0.	0.	0.	0.
Seezlike Cut								
20/30 GeV (.05)	0.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.1)	2.	0.	0.	0.	0.	0.	0.	0.
20/30 GeV (.2)	8.	0.	0.	0.	0.	5.	0.	0.

Jet Energy: 50 GeV *# Events:* 68117 *Rate (hz/GeV):* 2.50E+04

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	6556	2954	3419	298	2170	5713	2094	192
10 GeV (.1)	11656	4054	5552	312	3507	10126	2783	203
10 GeV (.2)	22490	6109	10393	336	7155	19695	4082	219
20 GeV (.05)	1295	480	582	99	360	1057	318	59
20 GeV (.1)	2859	763	1170	108	675	2381	495	64
20 GeV (.2)	6947	1276	2633	121	1516	5899	834	67
30 GeV (.05)	249	123	130	45	96	214	88	30
30 GeV (.1)	667	189	267	56	171	529	124	38
30 GeV (.2)	1715	264	570	64	344	1396	165	42
40 GeV (.05)	51	26	28	14	25	46	20	10
40 GeV (.1)	189	50	68	18	51	136	31	11
40 GeV (.2)	437	67	127	21	88	346	45	14
2 Hits								
10 GeV (.05)	311	61	98	1	43	247	34	0
10 GeV (.1)	786	111	191	1	83	582	55	0
10 GeV (.2)	3137	237	701	1	332	2427	106	0
20 GeV (.05)	15	2	3	0	2	5	1	0
20 GeV (.1)	40	2	8	0	3	17	1	0
20 GeV (.2)	215	4	25	0	9	127	1	0
30 GeV (.05)	0	0	0	0	0	0	0	0
30 GeV (.1)	1	0	0	0	0	0	0	0
30 GeV (.2)	12	0	1	0	0	6	0	0
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	0	0	0	0	0	0	0	0
40 GeV (.2)	1	0	0	0	0	0	0	0
Seezlike Cut								
20/30 GeV (.05)	6	1	1	0	0	1	1	0
20/30 GeV (.1)	24	1	6	0	2	13	1	0
20/30 GeV (.2)	96	2	12	0	4	59	1	0

Jet Energy: 50 GeV *# Events:* 68117 *Rate (hz/GeV):* 2.50E+04

% Passing Cuts

Hit Energy	***Raw No cuts***	**Block Isolation**	**Block Hcal Veto**	**Centered Isolation Cone**	**Centered Hcal Veto**	**Charged Energy Cut**	**Prompt Cuts**	**All Cuts**
1 Hit								
10 GeV (.05)	8.670	3.643	4.250	0.329	2.612	7.534	2.427	0.174
10 GeV (.1)	15.777	5.216	7.139	0.347	4.346	13.689	3.412	0.189
10 GeV (.2)	29.965	7.652	13.128	0.375	8.722	26.156	4.881	0.206
20 GeV (.05)	1.793	0.689	0.834	0.145	0.518	1.524	0.451	0.087
20 GeV (.1)	4.020	1.070	1.655	0.159	0.967	3.417	0.677	0.094
20 GeV (.2)	9.781	1.783	3.641	0.178	2.080	8.374	1.137	0.098
30 GeV (.05)	0.359	0.181	0.191	0.066	0.141	0.313	0.129	0.044
30 GeV (.1)	0.885	0.277	0.391	0.082	0.250	0.774	0.182	0.056
30 GeV (.2)	2.413	0.388	0.836	0.094	0.504	2.040	0.242	0.062
40 GeV (.05)	0.075	0.038	0.041	0.021	0.037	0.068	0.029	0.015
40 GeV (.1)	0.230	0.073	0.100	0.026	0.075	0.198	0.046	0.016
40 GeV (.2)	0.583	0.098	0.186	0.031	0.129	0.505	0.066	0.021
2 Hits								
10 GeV (.05)	0.455	0.090	0.144	0.001	0.063	0.361	0.050	0.000
10 GeV (.1)	1.146	0.163	0.280	0.001	0.122	0.853	0.081	0.000
10 GeV (.2)	4.404	0.344	0.982	0.001	0.477	3.416	0.151	0.000
20 GeV (.05)	0.022	0.003	0.004	0.000	0.003	0.007	0.001	0.000
20 GeV (.1)	0.058	0.003	0.012	0.000	0.004	0.024	0.001	0.000
20 GeV (.2)	0.315	0.006	0.037	0.000	0.013	0.185	0.001	0.000
30 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.1)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30 GeV (.2)	0.018	0.000	0.001	0.000	0.000	0.009	0.000	0.000
40 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.2)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Seezlike Cut								
20/30 GeV (.05)	0.009	0.001	0.001	0.000	0.000	0.001	0.001	0.000
20/30 GeV (.1)	0.035	0.001	0.009	0.000	0.003	0.019	0.001	0.000
20/30 GeV (.2)	0.141	0.003	0.018	0.000	0.006	0.087	0.001	0.000

Jet Energy:	50 GeV	*# Events:*	68117	*Rate (hz/GeV):*	2.50E+04
Luminosity:	1.00E+34				
Cross Section: (nb/GeV)	2.50E+03			Min. Rate (Hz/GeV):	0.3670

Rates (Hz/GeV)

Hit Energy	***Raw No cuts***	**Block Isolation**	**Block Hcal Veto**	**Centered Isolation Cone**	**Centered Hcal Veto**	**Charged Energy Cut**	**Prompt Cuts**	**All Cuts**
1 Hit								
10 GeV (.05)	2,168.	911.	1,063.	82.	653.	1,883.	607.	43.
10 GeV (.1)	3,944.	1,304.	1,785.	87.	1,087.	3,422.	853.	47.
10 GeV (.2)	7,491.	1,913.	3,282.	94.	2,181.	6,539.	1,220.	51.
20 GeV (.05)	448.	172.	209.	36.	130.	381.	113.	22.
20 GeV (.1)	1,005.	267.	414.	40.	242.	854.	169.	23.
20 GeV (.2)	2,445.	446.	910.	44.	520.	2,093.	284.	25.
30 GeV (.05)	90.	45.	48.	17.	35.	78.	32.	11.
30 GeV (.1)	221.	69.	98.	21.	63.	193.	46.	14.
30 GeV (.2)	603.	97.	209.	23.	126.	510.	61.	15.
40 GeV (.05)	19	10	10	5	9	17	7	4
40 GeV (.1)	58	18	25	7	19	49	11	4
40 GeV (.2)	146	25	47	8	32	126	17	5
2 Hits								
10 GeV (.05)	113.7	22.4	36.0	0.4	15.8	90.2	12.5	0.0
10 GeV (.1)	286.5	40.7	70.1	0.4	30.5	213.2	20.2	0.0
10 GeV (.2)	1,101.0	85.9	245.5	0.4	119.2	854.0	37.8	0.0
20 GeV (.05)	5.5	0.7	1.1	0.0	0.7	1.8	0.4	0.0
20 GeV (.1)	14.5	0.7	2.9	0.0	1.1	6.0	0.4	0.0
20 GeV (.2)	78.7	1.5	9.2	0.0	3.3	46.2	0.4	0.0
30 GeV (.05)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 GeV (.1)	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 GeV (.2)	4.4	0.0	0.4	0.0	0.0	2.2	0.0	0.0
40 GeV (.05)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 GeV (.1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 GeV (.2)	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Seezlike Cut								
20/30 GeV (.05)	2.2	0.4	0.4	0.0	0.0	0.4	0.4	0.0
20/30 GeV (.1)	8.8	0.4	2.2	0.0	0.7	4.8	0.4	0.0
20/30 GeV (.2)	35.2	0.7	4.4	0.0	1.5	21.7	0.4	0.0

Jet Energy: 70 GeV *# Events:* 64846 *Rate (hz/GeV):* 4.60E+03

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	13327	4250	4833	340	2584	11248	2572	173
10 GeV (.1)	21820	5573	7366	363	3985	18340	3269	188
10 GeV (.2)	33830	7644	12145	391	7591	29195	4477	208
20 GeV (.05)	4175	1063	1214	160	589	3290	531	52
20 GeV (.1)	8621	1580	2158	170	969	6854	759	55
20 GeV (.2)	17366	2341	4280	183	2078	14099	1158	62
30 GeV (.05)	1257	320	383	99	214	962	172	26
30 GeV (.1)	2887	497	726	112	353	2224	236	30
30 GeV (.2)	6618	732	1418	124	658	5199	346	34
40 GeV (.05)	393	114	130	52	86	300	62	15
40 GeV (.1)	1017	179	260	64	152	733	93	19
40 GeV (.2)	2418	261	492	74	259	1842	129	23
2 Hits								
10 GeV (.05)	1341	152	200	0	83	935	65	0
10 GeV (.1)	3168	233	399	1	137	2182	89	1
10 GeV (.2)	8498	427	1186	1	483	6135	164	1
20 GeV (.05)	107	3	11	0	9	47	1	0
20 GeV (.1)	415	11	21	0	7	200	2	0
20 GeV (.2)	1620	31	92	0	33	927	7	0
30 GeV (.05)	13	0	2	0	2	4	0	0
30 GeV (.1)	46	1	2	0	2	18	0	0
30 GeV (.2)	218	2	15	0	6	119	0	0
40 GeV (.05)	0	0	0	0	0	0	0	0
40 GeV (.1)	8	0	0	0	1	2	0	0
40 GeV (.2)	29	0	1	0	1	16	0	0
Seezlike Cut								
20/30 GeV (.05)	53	2	5	0	5	21	0	0
20/30 GeV (.1)	214	5	7	0	3	104	1	0
20/30 GeV (.2)	906	16	52	0	16	532	2	0

Jet Energy: 70 GeV *# Events:* 64846 *Rate (hz/GeV):* 4.60E+03

% Passing Cuts

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	19.597	5.860	6.684	0.415	3.411	16.492	3.319	0.159
10 GeV (.1)	32.315	7.859	10.347	0.449	5.343	27.106	4.367	0.181
10 GeV (.2)	49.118	10.471	16.600	0.485	9.924	42.265	5.793	0.205
20 GeV (.05)	6.330	1.624	1.852	0.247	0.898	5.046	0.803	0.080
20 GeV (.1)	13.118	2.386	3.265	0.262	1.471	10.491	1.121	0.085
20 GeV (.2)	26.362	3.520	6.376	0.282	3.059	21.456	1.699	0.096
30 GeV (.05)	1.932	0.493	0.591	0.153	0.330	1.483	0.265	0.040
30 GeV (.1)	4.358	0.766	1.119	0.173	0.543	3.427	0.364	0.046
30 GeV (.2)	10.101	1.129	2.186	0.191	1.014	8.008	0.534	0.052
40 GeV (.05)	0.606	0.176	0.200	0.080	0.133	0.463	0.096	0.023
40 GeV (.1)	1.521	0.276	0.401	0.099	0.234	1.129	0.143	0.029
40 GeV (.2)	3.670	0.402	0.759	0.114	0.399	2.838	0.199	0.035
2 Hits								
10 GeV (.05)	2.066	0.234	0.308	0.000	0.128	1.440	0.100	0.000
10 GeV (.1)	4.878	0.359	0.615	0.002	0.211	3.363	0.137	0.002
10 GeV (.2)	12.904	0.654	1.782	0.002	0.734	9.314	0.249	0.002
20 GeV (.05)	0.165	0.005	0.017	0.000	0.014	0.072	0.002	0.000
20 GeV (.1)	0.639	0.017	0.032	0.000	0.011	0.308	0.003	0.000
20 GeV (.2)	2.497	0.048	0.142	0.000	0.051	1.428	0.011	0.000
30 GeV (.05)	0.020	0.000	0.003	0.000	0.003	0.006	0.000	0.000
30 GeV (.1)	0.071	0.002	0.003	0.000	0.003	0.028	0.000	0.000
30 GeV (.2)	0.336	0.003	0.023	0.000	0.009	0.184	0.000	0.000
40 GeV (.05)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40 GeV (.1)	0.012	0.000	0.000	0.000	0.002	0.003	0.000	0.000
40 GeV (.2)	0.045	0.000	0.002	0.000	0.002	0.025	0.000	0.000
Seezlike Cut								
20/30 GeV (.05)	0.082	0.003	0.008	0.000	0.008	0.032	0.000	0.000
20/30 GeV (.1)	0.330	0.008	0.011	0.000	0.005	0.160	0.002	0.000
20/30 GeV (.2)	1.397	0.025	0.080	0.000	0.025	0.820	0.003	0.000

Jet Energy: 70 GeV   *# Events:* 64846   *Rate (hz):* 4.60E+03

Luminosity: 1.00E+34
Cross Section: (nb/GeV) 4.60E+02

Rates (Hz/GeV)

Min. Rate (Hz/GeV): 0.0709

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	901.	270.	307.	19.	157.	759.	153.	7.
10 GeV (.1)	1,486.	362.	476.	21.	246.	1,247.	201.	8.
10 GeV (.2)	2,259.	482.	764.	22.	457.	1,944.	266.	9.
20 GeV (.05)	291.	75.	85.	11.	41.	232.	37.	4.
20 GeV (.1)	603.	110.	150.	12.	68.	483.	52.	4.
20 GeV (.2)	1,213.	162.	293.	13.	141.	987.	78.	4.
30 GeV (.05)	89.	23.	27.	7.	15.	68.	12.	2.
30 GeV (.1)	200.	35.	51.	8.	25.	158.	17.	2.
30 GeV (.2)	465.	52.	101.	9.	47.	368.	25.	2.
40 GeV (.05)	28	8	9	4	6	21	4	1
40 GeV (.1)	70	13	18	5	11	52	7	1
40 GeV (.2)	169	19	35	5	18	131	9	2
2 Hits								
10 GeV (.05)	95.0	10.8	14.2	0.0	5.9	66.2	4.6	0.0
10 GeV (.1)	224.4	16.5	28.3	0.1	9.7	154.7	6.3	0.1
10 GeV (.2)	593.6	30.1	82.0	0.1	33.8	428.4	11.4	0.1
20 GeV (.05)	7.6	0.2	0.8	0.0	0.6	3.3	0.1	0.0
20 GeV (.1)	29.4	0.8	1.5	0.0	0.5	14.1	0.1	0.0
20 GeV (.2)	114.9	2.2	6.5	0.0	2.3	65.7	0.5	0.0
30 GeV (.05)	0.9	0.0	0.1	0.0	0.1	0.3	0.0	0.0
30 GeV (.1)	3.3	0.1	0.1	0.0	0.1	1.3	0.0	0.0
30 GeV (.2)	15.5	0.1	1.1	0.0	0.4	8.4	0.0	0.0
40 GeV (.05)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 GeV (.1)	0.6	0.0	0.0	0.0	0.1	0.1	0.0	0.0
40 GeV (.2)	2.1	0.0	0.1	0.0	0.1	1.1	0.0	0.0
Seezlike Cut								
20/30 GeV (.05)	3.8	0.1	0.4	0.0	0.4	1.5	0.0	0.0
20/30 GeV (.1)	15.2	0.4	0.5	0.0	0.2	7.4	0.1	0.0
20/30 GeV (.2)	64.3	1.1	3.7	0.0	1.1	37.7	0.1	0.0

Jet Energy: 100 GeV *# Events:* 62931 *Rate (hz/GeV):* 9.20E+02

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	22333	5370	6014	396	2787	18114	3012	171
10 GeV (.1)	32208	6765	8608	417	4195	26390	3628	184
10 GeV (.2)	41565	8433	13018	448	7762	35494	4600	206
20 GeV (.05)	9949	1647	1842	226	731	7262	701	54
20 GeV (.1)	18509	2345	3103	237	1170	13791	963	59
20 GeV (.2)	29500	3110	5249	248	2222	23106	1325	62
30 GeV (.05)	3872	680	742	162	330	2751	275	39
30 GeV (.1)	8463	983	1292	173	482	6074	373	39
30 GeV (.2)	16572	1324	2248	186	870	12380	491	41
40 GeV (.05)	1651	301	345	113	164	1162	136	29
40 GeV (.1)	3813	453	610	126	258	2674	184	31
40 GeV (.2)	8217	620	1021	140	413	5990	236	33
2 Hits								
10 GeV (.05)	3882	235	357	0	109	2554	84	0
10 GeV (.1)	7988	340	635	0	182	5281	107	0
10 GeV (.2)	15369	548	1526	1	549	10927	178	0
20 GeV (.05)	582	15	16	0	2	237	4	0
20 GeV (.1)	1984	23	47	0	7	905	3	0
20 GeV (.2)	5679	48	175	0	32	3037	9	0
30 GeV (.05)	83	1	1	0	1	20	0	0
30 GeV (.1)	358	4	6	0	2	148	0	0
30 GeV (.2)	1394	8	22	0	2	698	0	0
40 GeV (.05)	9	0	0	0	0	1	0	0
40 GeV (.1)	70	1	1	0	1	24	0	0
40 GeV (.2)	330	2	7	0	1	161	0	0
Seezlike Cut								
20/30 GeV (.05)	342	10	9	0	0	148	2	0
20/30 GeV (.1)	1307	16	33	0	0	604	2	0
20/30 GeV (.2)	4173	34	102	0	0	2231	7	0

Jet Energy: 100 GeV *# Events:* 62931 *Rate (hz/GeV):* 9.20E+02

% Passing Cuts

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	34.534	7.839	8.787	0.520	3.855	27.930	4.139	0.164
10 GeV (.1)	49.846	10.015	12.666	0.552	5.864	40.758	5.091	0.184
10 GeV (.2)	62.997	12.084	18.557	0.593	10.552	53.644	6.198	0.212
20 GeV (.05)	15.701	2.601	2.907	0.359	1.151	11.512	1.098	0.086
20 GeV (.1)	29.235	3.676	4.868	0.377	1.836	21.836	1.481	0.094
20 GeV (.2)	46.459	4.851	8.116	0.394	3.385	36.430	2.018	0.099
30 GeV (.05)	6.147	1.081	1.179	0.257	0.524	4.371	0.437	0.062
30 GeV (.1)	13.354	1.562	2.052	0.275	0.765	9.649	0.593	0.062
30 GeV (.2)	26.229	2.104	3.571	0.296	1.382	19.663	0.780	0.065
40 GeV (.05)	2.624	0.478	0.548	0.180	0.261	1.846	0.216	0.046
40 GeV (.1)	6.012	0.720	0.969	0.200	0.410	4.247	0.292	0.049
40 GeV (.2)	12.999	0.985	1.622	0.222	0.656	9.516	0.375	0.052
2 Hits								
10 GeV (.05)	6.167	0.373	0.567	0.000	0.173	4.057	0.133	0.000
10 GeV (.1)	12.685	0.540	1.009	0.000	0.289	8.390	0.170	0.000
10 GeV (.2)	24.221	0.866	2.378	0.002	0.862	17.216	0.278	0.000
20 GeV (.05)	0.925	0.024	0.025	0.000	0.003	0.377	0.006	0.000
20 GeV (.1)	3.152	0.037	0.075	0.000	0.011	1.437	0.005	0.000
20 GeV (.2)	9.023	0.076	0.278	0.000	0.051	4.824	0.014	0.000
30 GeV (.05)	0.132	0.002	0.002	0.000	0.002	0.032	0.000	0.000
30 GeV (.1)	0.569	0.006	0.010	0.000	0.003	0.235	0.000	0.000
30 GeV (.2)	2.215	0.013	0.035	0.000	0.003	1.109	0.000	0.000
40 GeV (.05)	0.014	0.000	0.000	0.000	0.000	0.002	0.000	0.000
40 GeV (.1)	0.111	0.002	0.002	0.000	0.002	0.038	0.000	0.000
40 GeV (.2)	0.524	0.003	0.011	0.000	0.002	0.256	0.000	0.000
Seezlike Cut								
20/30 GeV (.05)	0.543	0.016	0.014	0.000	0.000	0.235	0.003	0.000
20/30 GeV (.1)	2.077	0.025	0.052	0.000	0.000	0.960	0.003	0.000
20/30 GeV (.2)	6.631	0.054	0.162	0.000	0.000	3.545	0.011	0.000

Jet Energy:	100 GeV	*# Events:*	62931	*Rate (hz):*	9.20E+02
Luminosity:	1.00E+34				
Cross Section: (nb/GeV)	9.20E+01			Min. Rate (Hz/GeV):	0.0146

Rates (Hz/GeV)

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	318.	72.	81.	5.	35.	257.	38.	2.
10 GeV (.1)	459.	92.	117.	5.	54.	375.	47.	2.
10 GeV (.2)	580.	111.	171.	5.	97.	494.	57.	2.
20 GeV (.05)	144.	24.	27.	3.	11.	106.	10.	1.
20 GeV (.1)	269.	34.	45.	3.	17.	201.	14.	1.
20 GeV (.2)	427.	45.	75.	4.	31.	335.	19.	1.
30 GeV (.05)	57.	10.	11.	2.	5.	40.	4.	0.6
30 GeV (.1)	123.	14.	19.	3.	7.	89.	5.	0.6
30 GeV (.2)	241.	19.	33.	3.	13.	181.	7.	0.6
40 GeV (.05)	24.	4.	5.	2.	2.	17.	2.	0.4
40 GeV (.1)	55.	7.	9.	2.	4.	39.	3.	0.5
40 GeV (.2)	120.	9.	15.	2.	6.	88.	3.	0.5
2 Hits								
10 GeV (.05)	56.74	3.44	5.22	0.00	1.59	37.32	1.23	0.00
10 GeV (.1)	116.71	4.97	9.28	0.00	2.66	77.19	1.56	0.00
10 GeV (.2)	222.83	7.97	21.88	0.01	7.93	158.39	2.56	0.00
20 GeV (.05)	8.51	0.22	0.23	0.00	0.03	3.46	0.06	0.00
20 GeV (.1)	29.00	0.34	0.69	0.00	0.10	13.22	0.04	0.00
20 GeV (.2)	83.01	0.70	2.56	0.00	0.47	44.38	0.13	0.00
30 GeV (.05)	1.21	0.01	0.01	0.00	0.01	0.29	0.00	0.00
30 GeV (.1)	5.23	0.06	0.09	0.00	0.03	2.16	0.00	0.00
30 GeV (.2)	20.38	0.12	0.32	0.00	0.03	10.20	0.00	0.00
40 GeV (.05)	0.13	0.00	0.00	0.00	0.00	0.01	0.00	0.00
40 GeV (.1)	1.02	0.01	0.01	0.00	0.01	0.35	0.00	0.00
40 GeV (.2)	4.82	0.03	0.10	0.00	0.01	2.35	0.00	0.00
Seezlike Cut								
20/30 GeV (.05)	5.00	0.15	0.13	0.00	0.00	2.16	0.03	0.00
20/30 GeV (.1)	19.11	0.23	0.48	0.00	0.00	8.83	0.03	0.00
20/30 GeV (.2)	61.01	0.50	1.49	0.00	0.00	32.62	0.10	0.00

Jet Energy: 150 GeV *# Events:* 59392 *Rate (hz/GeV):* 1.20E+02

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	32324	6453	6532	527	2735	25344	3281	176
10 GeV (.1)	39141	7484	8703	547	4093	32032	3733	188
10 GeV (.2)	44167	8797	12365	582	7308	37874	4528	214
20 GeV (.05)	21256	2484	2255	357	716	13792	878	56
20 GeV (.1)	31359	3194	3349	368	1096	21872	1130	61
20 GeV (.2)	39375	3807	5083	383	2064	29480	1396	68
30 GeV (.05)	11808	1276	1084	294	335	7022	418	38
30 GeV (.1)	21225	1748	1661	302	510	13353	530	41
30 GeV (.2)	31137	2113	2524	310	828	21296	655	43
40 GeV (.05)	6496	713	613	247	218	3722	220	32
40 GeV (.1)	12942	1026	955	262	290	7663	298	34
40 GeV (.2)	22222	1244	1450	272	446	14303	367	34
2 Hits								
10 GeV (.05)	9921	407	480	1	114	6031	97	1
10 GeV (.1)	15262	554	741	1	184	9802	134	1
10 GeV (.2)	21721	742	1588	3	529	15031	198	1
20 GeV (.05)	3141	37	39	0	4	1090	6	0
20 GeV (.1)	7538	76	85	0	12	3041	10	0
20 GeV (.2)	13530	102	209	0	46	6640	15	0
30 GeV (.05)	786	4	6	0	0	210	0	0
30 GeV (.1)	2723	16	23	0	1	930	3	0
30 GeV (.2)	6728	23	49	0	6	2736	1	0
40 GeV (.05)	209	2	1	0	0	60	0	0
40 GeV (.1)	914	4	4	0	1	287	0	0
40 GeV (.2)	2937	9	18	0	1	1106	1	0
Seezlike Cut								
20/30 GeV (.05)	2222	24	25	0	1	773	5	0
20/30 GeV (.1)	6097	54	63	0	8	2421	6	0
20/30 GeV (.2)	12026	76	143	0	28	5761	8	0

Jet Energy: 150 GeV *# Events:* 59392 *Rate (hz/GeV):* 1.20E+02

% Passing Cuts

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	53.470	10.171	10.229	0.778	4.031	41.819	4.877	0.188
10 GeV (.1)	64.569	11.866	13.641	0.810	6.089	52.757	5.611	0.208
10 GeV (.2)	71.314	13.495	18.690	0.861	10.523	61.012	6.513	0.244
20 GeV (.05)	35.681	4.167	3.777	0.601	1.195	23.194	1.463	0.094
20 GeV (.1)	52.623	5.327	5.576	0.620	1.822	36.748	1.853	0.103
20 GeV (.2)	65.879	6.319	8.334	0.645	3.330	49.350	2.263	0.114
30 GeV (.05)	19.875	2.148	1.825	0.495	0.564	11.822	0.704	0.064
30 GeV (.1)	35.643	2.943	2.796	0.508	0.858	22.480	0.892	0.069
30 GeV (.2)	52.322	3.558	4.249	0.522	1.393	35.847	1.103	0.072
40 GeV (.05)	10.938	1.200	1.032	0.416	0.367	6.267	0.370	0.054
40 GeV (.1)	21.744	1.728	1.608	0.441	0.488	12.901	0.502	0.057
40 GeV (.2)	37.357	2.095	2.441	0.458	0.751	24.080	0.618	0.057
2 Hits								
10 GeV (.05)	16.703	0.685	0.808	0.002	0.192	10.153	0.163	0.002
10 GeV (.1)	25.689	0.933	1.248	0.002	0.310	16.502	0.226	0.002
10 GeV (.2)	36.371	1.245	2.627	0.005	0.880	25.161	0.329	0.002
20 GeV (.05)	5.289	0.062	0.066	0.000	0.007	1.835	0.010	0.000
20 GeV (.1)	12.691	0.128	0.143	0.000	0.020	5.119	0.017	0.000
20 GeV (.2)	22.780	0.172	0.352	0.000	0.077	11.178	0.025	0.000
30 GeV (.05)	1.323	0.007	0.010	0.000	0.000	0.354	0.000	0.000
30 GeV (.1)	4.585	0.027	0.039	0.000	0.002	1.566	0.005	0.000
30 GeV (.2)	11.328	0.039	0.083	0.000	0.010	4.607	0.002	0.000
40 GeV (.05)	0.352	0.003	0.002	0.000	0.000	0.101	0.000	0.000
40 GeV (.1)	1.539	0.007	0.007	0.000	0.002	0.483	0.000	0.000
40 GeV (.2)	4.945	0.015	0.030	0.000	0.002	1.862	0.002	0.000
Seezlike Cut								
20/30 GeV (.05)	3.741	0.040	0.042	0.000	0.002	1.302	0.008	0.000
20/30 GeV (.1)	10.266	0.091	0.106	0.000	0.013	4.076	0.010	0.000
20/30 GeV (.2)	20.249	0.128	0.241	0.000	0.047	9.700	0.013	0.000

Jet Energy: 150 GeV	*# Events:* 59392	*Rate (hz):* 1.20E+02
Luminosity: 1.00E+34 *Cross Section: (nb/GeV)* 1.20E+01	Rates (Hz/GeV)	Min. Rate (Hz/GeV): 0.0020

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	64.	12.	12.	0.93	4.8	50.	5.85	0.23
10 GeV (.1)	77.	14.	16.	0.97	7.3	63.	6.73	0.25
10 GeV (.2)	86.	16.	22.	1.03	12.6	73.	7.82	0.29
20 GeV (.05)	43.	5.00	4.53	0.72	1.43	28.	1.76	0.11
20 GeV (.1)	63.	6.39	6.69	0.74	2.19	44.	2.22	0.12
20 GeV (.2)	79.	7.58	10.00	0.77	4.00	59.	2.72	0.14
30 GeV (.05)	24.	2.58	2.19	0.59	0.68	14.	0.84	0.08
30 GeV (.1)	43.	3.53	3.35	0.61	1.03	27.	1.07	0.08
30 GeV (.2)	63.	4.27	5.10	0.63	1.67	43.	1.32	0.09
40 GeV (.05)	13.	1.44	1.24	0.50	0.44	8.	0.44	0.06
40 GeV (.1)	26.	2.07	1.93	0.53	0.59	15.	0.60	0.07
40 GeV (.2)	45.	2.51	2.93	0.55	0.90	29.	0.74	0.07
2 Hits								
10 GeV (.05)	20.0	0.82	0.97	0.00	0.23	12.2	0.20	0.00
10 GeV (.1)	30.8	1.12	1.50	0.00	0.37	19.8	0.27	0.00
10 GeV (.2)	43.6	1.49	3.15	0.01	1.06	30.2	0.39	0.00
20 GeV (.05)	6.3	0.07	0.08	0.00	0.01	2.2	0.01	0.00
20 GeV (.1)	15.2	0.15	0.17	0.00	0.02	6.1	0.02	0.00
20 GeV (.2)	27.3	0.21	0.42	0.00	0.09	13.4	0.03	0.00
30 GeV (.05)	1.6	0.01	0.01	0.00	0.00	0.42	0.00	0.00
30 GeV (.1)	5.5	0.03	0.05	0.00	0.00	1.88	0.01	0.00
30 GeV (.2)	13.6	0.05	0.10	0.00	0.01	5.53	0.00	0.00
40 GeV (.05)	0.42	0.00	0.00	0.00	0.00	0.12	0.00	0.00
40 GeV (.1)	1.85	0.01	0.01	0.00	0.00	0.58	0.00	0.00
40 GeV (.2)	5.93	0.02	0.04	0.00	0.00	2.23	0.00	0.00
Seezlike Cut								
20/30 GeV (.05)	4.49	0.05	0.05	0.00	0.00	1.56	0.01	0.00
20/30 GeV (.1)	12.32	0.11	0.13	0.00	0.02	4.89	0.01	0.00
20/30 GeV (.2)	24.30	0.15	0.29	0.00	0.06	11.64	0.02	0.00

Jet Energy: 200 GeV *# Events:* 3238 *Rate (hz/GeV):* 2.70E+01

Number of Events

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	2109	328	382	51	155	1679	176	10
10 GeV (.1)	2327	375	502	53	247	1983	201	10
10 GeV (.2)	2553	460	785	58	497	2247	277	14
20 GeV (.05)	1707	129	120	35	39	1030	46	3
20 GeV (.1)	2188	156	182	39	57	1476	61	3
20 GeV (.2)	2473	180	270	38	115	1852	71	3
30 GeV (.05)	1208	72	64	32	24	625	23	2
30 GeV (.1)	1805	92	99	35	33	1066	28	2
30 GeV (.2)	2267	114	140	35	54	1494	37	2
40 GeV (.05)	782	45	43	26	15	373	17	2
40 GeV (.1)	1353	61	59	29	19	713	19	2
40 GeV (.2)	1905	71	85	30	27	1154	23	2
2 Hits								
10 GeV (.05)	848	24	29	1	7	532	8	0
10 GeV (.1)	1157	22	52	1	15	756	6	0
10 GeV (.2)	1486	38	114	1	37	1102	12	0
20 GeV (.05)	431	1	5	1	2	142	0	0
20 GeV (.1)	773	2	10	1	4	305	0	0
20 GeV (.2)	1170	3	17	1	9	563	0	0
30 GeV (.05)	158	1	1	1	2	41	0	0
30 GeV (.1)	421	0	1	1	2	124	0	0
30 GeV (.2)	799	0	4	1	5	297	0	0
40 GeV (.05)	65	1	0	1	0	11	0	0
40 GeV (.1)	188	0	0	1	0	52	0	0
40 GeV (.2)	473	0	1	1	1	153	0	0
Seezlike Cut								
20/30 GeV (.05)	363	1	3	1	1	116	0	0
20/30 GeV (.1)	698	1	8	1	2	266	0	0
20/30 GeV (.2)	1105	2	15	1	3	514	0	0

Jet Energy: 200 GeV *# Events:* 3238 *Rate (hz/GeV):* 2.70E+01

% Passing Cuts

Hit Energy	*Raw No cuts*	Block Isolation	Block Hcal Veto	Centered Isolation Cone	Centered Hcal Veto	Charged Energy Cut	Prompt Cuts	All Cuts
1 Hit								
10 GeV (.05)	64.178	9.436	11.028	1.466	4.213	50.999	4.788	0.201
10 GeV (.1)	70.531	10.846	14.491	1.526	6.826	60.065	5.533	0.200
10 GeV (.2)	75.793	12.889	22.114	1.673	13.567	66.637	7.443	0.317
20 GeV (.05)	52.610	3.968	3.686	1.081	1.194	31.782	1.405	0.093
20 GeV (.1)	67.396	4.767	5.558	1.204	1.737	45.505	1.834	0.093
20 GeV (.2)	75.956	5.468	8.114	1.174	3.406	56.909	2.106	0.093
30 GeV (.05)	37.301	2.224	1.977	0.988	0.741	19.301	0.710	0.062
30 GeV (.1)	55.650	2.841	3.057	1.081	1.018	32.919	0.865	0.062
30 GeV (.2)	69.908	3.521	4.323	1.081	1.667	46.130	1.143	0.062
40 GeV (.05)	24.151	1.390	1.328	0.803	0.463	11.519	0.525	0.062
40 GeV (.1)	41.738	1.884	1.822	0.896	0.587	22.018	0.587	0.062
40 GeV (.2)	58.774	2.193	2.625	0.926	0.834	35.637	0.710	0.062
2 Hits								
10 GeV (.05)	26.187	0.741	0.896	0.031	0.216	16.428	0.247	0.000
10 GeV (.1)	35.724	0.679	1.606	0.031	0.463	23.346	0.185	0.000
10 GeV (.2)	45.691	1.169	3.474	0.031	1.132	33.886	0.366	0.000
20 GeV (.05)	13.311	0.031	0.154	0.031	0.062	4.385	0.000	0.000
20 GeV (.1)	23.872	0.062	0.309	0.031	0.124	9.419	0.000	0.000
20 GeV (.2)	36.133	0.093	0.525	0.031	0.278	17.386	0.000	0.000
30 GeV (.05)	4.880	0.031	0.031	0.031	0.062	1.266	0.000	0.000
30 GeV (.1)	13.002	0.000	0.031	0.031	0.062	3.830	0.000	0.000
30 GeV (.2)	24.676	0.000	0.124	0.031	0.154	9.172	0.000	0.000
40 GeV (.05)	2.007	0.031	0.000	0.031	0.000	0.340	0.000	0.000
40 GeV (.1)	5.806	0.000	0.000	0.031	0.000	1.606	0.000	0.000
40 GeV (.2)	14.608	0.000	0.031	0.031	0.031	4.725	0.000	0.000
Seezlike Cut								
20/30 GeV (.05)	11.211	0.031	0.093	0.031	0.031	3.582	0.000	0.000
20/30 GeV (.1)	21.557	0.031	0.247	0.031	0.062	8.215	0.000	0.000
20/30 GeV (.2)	34.126	0.062	0.463	0.031	0.093	15.874	0.000	0.000

Jet Energy: 200 GeV *# Events:* 3238 *Rate (hz/GeV):* 2.70E+01

Luminosity: 1.00E+34
Cross Section: *(nb/GeV)* 2.70E+00

Rates (Hz/GeV)

Min. Rate (Hz/GeV): 0.0083

Hit Energy	***Raw No cuts***	**Block Isolation**	**Block Hcal Veto**	**Centered Isolation Cone**	**Centered Hcal Veto**	**Charged Energy Cut**	**Prompt Cuts**	**All Cuts**
1 Hit								
10 GeV (.05)	17.33	2.55	2.98	0.40	1.14	13.77	1.29	0.05
10 GeV (.1)	19.04	2.93	3.91	0.41	1.84	16.22	1.49	0.05
10 GeV (.2)	20.46	3.48	5.97	0.45	3.66	17.99	2.01	0.09
20 GeV (.05)	14.20	1.07	1.00	0.29	0.32	8.58	0.38	0.03
20 GeV (.1)	18.20	1.29	1.50	0.33	0.47	12.29	0.50	0.03
20 GeV (.2)	20.51	1.48	2.19	0.32	0.92	15.37	0.57	0.03
30 GeV (.05)	10.07	0.60	0.53	0.27	0.20	5.21	0.19	0.02
30 GeV (.1)	15.03	0.77	0.83	0.29	0.27	8.89	0.23	0.02
30 GeV (.2)	18.88	0.95	1.17	0.29	0.45	12.46	0.31	0.02
40 GeV (.05)	6.52	0.38	0.36	0.22	0.13	3.11	0.14	0.02
40 GeV (.1)	11.27	0.51	0.49	0.24	0.16	5.94	0.16	0.02
40 GeV (.2)	15.87	0.59	0.71	0.25	0.23	9.62	0.19	0.02
2 Hits								
10 GeV (.05)	7.07	0.20	0.24	0.01	0.06	4.44	0.07	0.00
10 GeV (.1)	9.65	0.18	0.43	0.01	0.13	6.30	0.05	0.00
10 GeV (.2)	12.34	0.32	0.94	0.01	0.31	9.15	0.10	0.00
20 GeV (.05)	3.59	0.01	0.04	0.01	0.02	1.18	0.00	0.00
20 GeV (.1)	6.45	0.02	0.08	0.01	0.03	2.54	0.00	0.00
20 GeV (.2)	9.76	0.03	0.14	0.01	0.08	4.69	0.00	0.00
30 GeV (.05)	1.32	0.01	0.01	0.01	0.02	0.34	0.00	0.00
30 GeV (.1)	3.51	0.00	0.01	0.01	0.02	1.03	0.00	0.00
30 GeV (.2)	6.66	0.00	0.03	0.01	0.04	2.48	0.00	0.00
40 GeV (.05)	0.54	0.01	0.00	0.01	0.00	0.09	0.00	0.00
40 GeV (.1)	1.57	0.00	0.00	0.01	0.00	0.43	0.00	0.00
40 GeV (.2)	3.94	0.00	0.01	0.01	0.01	1.28	0.00	0.00
Seezlike Cut								
20/30 GeV (.05)	3.03	0.01	0.03	0.01	0.01	0.97	0.00	0.00
20/30 GeV (.1)	5.82	0.01	0.07	0.01	0.02	2.22	0.00	0.00
20/30 GeV (.2)	9.21	0.02	0.13	0.01	0.03	4.29	0.00	0.00

7) Appendix 2: Software Listing for Trigger/Detector Simulation

This program runs in FORTRAN on the ETH IBM 3090 system. It uses PATCHY only to reference common blocks. PYTHIA55 and JETSET73 are currently needed. Upon startup, the program reads the number of events to generate, a code for the PYTHIA process to simulate (0 = minimum bias 1 = QCD Jets, 2 = Higgs to $\gamma\gamma$ *,), two parameters used by PYTHIA (the Higgs mass and width [code 2], or the upper and lower* $p_\perp$ *limits on the generator [code 1], ignored for code 0), and the number of minimum bias events to overlay for pileup. These parameters are generally read from a file by a batch job. The PYTHIA process is initialized in the routine "SETPTA".*

```
+exe, cra*.
+option, mapasm.
+use, xtals, t=exe.
+patch,xtals.
+deck,pyhgcdes.
+keep,paw.
      parameter(ihcore=500000)
      common/pawc/ hmemor(ihcore)
+KEEP,LUJETS.
      COMMON/LUJETS/N,K(4000,5),P(4000,5),V(4000,5)
      SAVE /LUJETS/
+KEEP,PYSUBS.
      COMMON/PYSUBS/MSEL,MSUB(200),KFIN(2,-40:40),CKIN(200)
      SAVE /PYSUBS/
+KEEP,PYPARS.
      COMMON/PYPARS/MSTP(200),PARP(200),MSTI(200),PARI(200)
      SAVE /PYPARS/
+KEEP,LUDAT2.
      COMMON/LUDAT2/KCHG(500,3),PMAS(500,4),PARF(2000),VCKM(4,4)
      SAVE /LUDAT2/
+KEEP,LUDAT3.
      COMMON/LUDAT3/MDCY(500,3),MDME(2000,2),BRAT(2000),KFDP(2000,5)
      SAVE /LUDAT3/
+KEEP,LUDATR.
      COMMON/LUDATR/MRLU(6),RRLU(100)
      SAVE /LUDATR/
+keep,param.
      common/param/ nevread,h0mas,lfn,nbiasav
+keep,field.
      common/field/ bfield,ifield
+keep,epara.
      common/epara/ r0,d0,rp,zp,etamax,tetamin,tetakrit,alfa,talfa
     >,  z1,z2,z3,r1a,r1b,r2a,r2b,r3a,r3b,x0,rm,rscale,cthc,eta00,
     >xtalw0,pi2,pi,rint,x0int,totx0,totint,r00,r02
C
      COMMON/ECAP/ NOXTE(500),XTEWP(500),XTEWT(500),XTEWPC(500)
C           --- ENDCAP VARIABLES ---
C   NOXTE = NO. OF XTALS IN ENDCAP THETA DIVISION
C   XTEWP = XTAL WIDTH (CM) IN PHI
C   XTEWT = LOWER THETA OF XTAL
C   XTEWPC = XTAL WIDTH (CM) IN PHI
C
       COMMON/BARREL/NZD,XTBLWZ(500),XTBLWT(500),NCB,XTBLWPC,XTBLWPR,
     . XTBLWP2,XTBLWN
C
C   NZD = # XTALS IN HALF-BARREL Z
C   NCB = # XTALS IN BARREL PHI
C   XTBLWZ = XTAL WIDTH (CM) IN Z
C   XTBLWT = XTAL WIDTH (RAD) IN THETA
C   XTBLWN = XTAL WIDTH IN ETA
C   XTBLWPR = XTAL WIDTH (RAD) IN PHI
C   XTBLWPC = XTAL WIDTH (CM) IN PHI
C
      COMMON/SHOWER/XTLSHR(3,3),etabrk,xtalw2,xtlwbk,etabr0,debk,
     .phifac
C
+keep,image.
      parameter (iet=200,iph=640,iehh=40,iphh=128,ietoh=5)
      common/image/ecal(iph,iet),hcal(iphh,iehh),rchrg(iph,iet),
     .etacrd(iet),phicrd(iph),noemp,nohad,nomip,nhp,nhe,emip,rmipn
+keep,hadprm.
      common/hadprm/ihlng,a,b,c,a1,b1,ab0,ab1,sigbig,ihlat,rmiph,
     .rbig,rsmall,pieff,gevs,xx0,hadsml(3,3),rihw,esep,smalle,bige,
     .hadbig(3,3),nfac,rmipct,rbigs,rsmalls,ett,edephd
+keep,trgstf.
      parameter (ie10=20,ip10=64,ie15=15,ip15=48,ie20=10,ip20=32)
      parameter (itrnp=40,mxp=10,ntwr=3,ntwr1=4,nlevs=6,mxc=25)
      parameter (mxcts=11,ntry=22,nctsq=5)

common/trgstf/twr05(iphh,iehh),twr10(ip10,ie10),twr15(ip15,ie15),
     .twr20(ip20,ie20),iptn(2,mxp,nlevs,ntwr),nclx(nlevs,ntwr),
     .epeak(2,ntwr),etwr(nlevs),etwr2(nlevs),itrz(2,ntwr1),
     .IPROX(MXP,NLEVS,NTWR),NPROX(NLEVS,NTWR),CETA(IET),
     .ISEEZ(ntry,NTWR),nseez(ntry,ntwr),iocc0,iocc1,e1sz,e2sz,
     .ntegy(ntry,nlevs,ntwr),ntegp(ntry,nlevs,ntwr),ixcls(2,mxc),
     .iptcls(mxp,nlevs,ntwr),nclst,ixlvl(2,mxp,nlevs,ntwr),
     .IXEC(2,MXC),NCIRCLE,ETRAD,NKCR(61),ICRDR(61,61),IADADJ,
     .ipsz(2),iseq(nctsq,2),sinhad(iehh),rpile,
     .nuladj(nlevs,ntwr),iptvto(mxp,nlevs,ntwr),
     .nxtptr(2,mxp,nlevs,ntwr),icuts(mxcts,mxc)
+deck,main.
      PROGRAM XTALS
+seq,paw.
+seq,lujets.
+seq,pysubs.
+seq,pypars.
+seq,ludat2.
+seq,ludat3.
+seq,ludatr.
+seq,param.
+seq,epara.
+seq,field.
+seq,image.
+seq,hadprm.
+seq,trgstf.
      parameter (maxcmp=3000)
      DIMENSION PP(5),RVD(5),RV(5)
      DIMENSION EGYH(2),ETAH(2),MISLEV(NLEVS),MISEGY(NLEVS),
     .xhist(5),xnormh(5),nhist(5)
      dimension
ppimp(3),ecalout(maxcmp),hcalout(maxcmp),ichout(maxcmp)
      character*80 fnamin,fnamout,fnamhis,fnamplt
      character*40 ctit(mxcts+1)

      data piq/3.1415927/
      DATA FNAMIN/'MINBIAS OUT A1'/
      DATA FNAMOUT/'EVENTS OUT'/
      DATA FNAMHIS/'XTALS HISX A'/
      DATA FNAMPLT/'XTALS HIGZ T'/

      data ctit/'No Cuts','Block Isolation (.2 -.1)',
     .'Block Isolation (.2 -.05)','Block Isolation (.1 -.05)',
     .'Block Isolation (.2 -.05) + Adj; E < 3',
     .'Block Isolation (.2 -.05) + Adj; E < 4',
     .'Hadron Cal.; E < 2','Hadron Cal.; E < 4',
     .'Charged Egy; Ec < 5','Isolation Cone (.3); E < 10',
     .'Hardron Cal. Cone; E < 2','Hadron Cal. Cone; E < 4'/

      call hlimit(ihcore)

      lfn=20       ! Unit no. for lund random storage...

C     OPEN (UNIT=10,FILE=FNAMIN,STATUS='OLD')
c
c     call vmcms('filedef 3 disk hplegos higz t (xtent 150' iret)
c     open (unit=3,form='unformatted',recl=4096,file=fnamplt,
c    .  access='direct',status='unknown')
c
c     open (unit=11,file=fnamout
c    >,status='new',form='unformatted')
c
      do j = 1,1010     ! initialize random no. generator
      r = ranf()
      enddo
c
* skip records on the output file
      nskipou=0
      if(nskipou.gt.0) then
      do i=1,nskipou
      read(11)
      enddo
      print *,' nskipou=',nskipou
     >,' record was skipped on the out.file'
      endif

      pi = piq
      pi2 = pi/2.

      n2540 = 0
      MISSZ = 0
      NHGOOD = 0
      NPRSEZ = 0

      NEVGET    = 1
      idohgz = 1                 !  No. events over minimimum bias

      nskip     = 0
      nevread   = 0

      nbiasav   = 19
c     nbiasav = 38

      sigxy    = 0.002
c     sigz     = 5.5

      read(10) ifield,bfield,rscale,sigz
      read(10) r00,eta00,rv0,rv1

* set geom parameters
      call ugeom
c
      call mhini      ! Book histograms
      call trgint     ! Initialize trigger algorithms/operations
      CALL TSTSHR     ! Set up electromagnetic shower sharing
      call starthad   ! Set up hadronic shower model
      call testhad    ! Check it out...
c     call hprint(201)
c     STOP 'Test for Hadrons completed!'
c
C
```

```
      write (7,*)  ' *** Geometry initialized ***'
C
C     STOP 'TEST OVER... DIAGNOSTIC FOR GEOMETRY'
C
* ini PYTHIA
c     iprcs = 0     !  (min bias)
c     IPRCS = 1     !  QCD JETS (RANGE BET. ELL AND EHH)
      IPRCS = 2     !  HIGGS -> GAMMA GAMMA
c     iprcs = 3     !  Higgs -> e+ e- e+ e-
c     iprcs = 4     !  Higgs -> mu mu mu mu
c
c     ell = 80.
c     ehh = .0021
      ell = 100.  !  Higgs mass (GeV)
      ehh = .0025 !  Higgs width
c     ell = 120.
c     ehh = .003
c     ell = 150.
c     ehh = .01
c
c     ELL = 195       !  LOWER PT LIMIT
c     EHH = 205       !  UPPER PT LIMIT

      READ (5,*) NEVGET,IPRCS,ELL,EHH,NBIASAV
      PRINT *,' --- INPUT PARAMETERS ----'
      PRINT 32,NEVGET,NBIASAV
32    FORMAT('  # EVENTS TO DO:',I10,'   # OVERLAPS PER MIN.
BIAS:',I3)
      PRINT 36,IPRCS,ELL,EHH
36    FORMAT('  PROCESS:',I2,'    EL,EH:',2F10.3)
      if (nbiasav.le.19) then
      rpile = 4.
      else
      rpile = 4 + (nbiasav - 19) * 4.5/19.  ! Pileup-dependent cut for
iso. con
      endif

      print *,'Value of energy cut for isolation cone:',rpile

      PRINT *,'---------------------------'

      call setpta(iprcs,ell,ehh)       ! Set up PYTHIA

*         Loop for Generated Event....

1     continue

      call timed(t0x)

      if(nevread.eq.nevget) goto 889

       call timel(tleft)
       if(tleft.lt.5.) then
         print *,' Run stop because of time limit'
         goto 889
       endif

* get minim. bias ev.

      nbias = nbiasav
C     call poissn(float(nbiasav),nbias,ier)

      call clrcal    ! Clear out calorimeter sums
      itrk1 = 0

C     CALL SHOOT(NBIAS)    ! TEST ROUTINE TO SHOOT IN DISCRETE
PARTICLES

      itrk2 = 0
      itrk3 = 0
      noemp = 0
      nohad = 0
      nomip = 0
      rvd(1) = 0.
      rvd(2) = 0.
      rvd(3) = 0.
      intrk = 0

      do ib=1,nbias+idohgz
      ibev=ib
      ierrx = 0

      if(ib.gt.nbias) then
332   continue
c     print *,'About to call pythia; cycle:',ib
      call pyevnt
      call luedit(2)

c   Look only at z-smear at this point (others are small).
c     call norran(rx)
c     call norran(ry)
      call norran(rz)
c     rv(1)=sigxy*rx
c     rv(2)=sigxy*ry
      rv(3)=sigz *rz
      rvd(3) = rv(3)
c
      if (iprcs.eq.2) then     ! Higgs event selected
      mseta = 0
      do i = 1,2                          ! Look at the Higgs photons
      kl = klu(i,2)
      if (kl.ne.22) then
       print *,'Higgs Decay Particle not photon:',i,kl
       goto 332   ! skip out
      endif
      sqrr = p(i,1)**2 + p(i,2)**2
      sqm = sqrt(sqrr)
      tti = p(i,3)/sqm
      zddx = tti * r0 + rvd(3)
      egyh(i) = p(i,4) * sqm/sqrt(p(i,3)**2+sqrr) ! Et
      if (abs(zddx).gt.d0) mseta = mseta + 1   ! Make sure they hit
      enddo
      if (mseta.ne.0) then
      missz = missz + 1              ! Skip if a Higgs misses
      goto 332
      endif
      else
      if (iprcs.ge.3) then      ! Higgs into 4 leptons (look for 2 e)
      mseta = 0
      egyh(1) = -5.
      egyh(2) = -5.
      do i = 1,4       ! Look at first 4 particles
      kl = klu(i,2)
      if (iabs(kl).eq.11) then ! An electron??
      sqrr = p(i,1)**2 + p(i,2)**2
      sqm = sqrt(sqrr)
      rlmr = sqm/(0.0003 * bfield)    ! Lamour Radius (cm)
      if (rlmr.gt.r02) then         ! Particle hits detector
c     tth = sqm/p(i,3)    ! Polar angle
c     zimp = r0/tth + rvd(3)  ! Linear impact pt. (no x,y vtx smear)
      dltang = asin(r02/rlmr)! Rotation from initial tangent
      zddx = 2. * rlmr * dltang * p(i,3)/sqm + rvd(3)  ! curved impact
      if (abs(zddx).le.d0) then  ! Inside detector?
      miseta = miseta + 1   ! Now is the no. of hits
      egg = p(i,4) * sqm/sqrt(p(i,3)**2+sqrr) ! Et
      if (egg.gt.egyh(1)) then  ! Find 2 highest Energy electrons that
made it
      egyh(2) = egyh(1)
      egyh(1) = egg
      else
      if (egg.gt.egyh(2)) egyh(2) = egg
      endif
      endif
      endif
      endif
      enddo
      if (mseta.lt.2) then   ! Should see at least 2 of 'em
      missz = missz + 1              ! Skip if a Higgs misses
      goto 332
      endif
      endif
      endif
c
      else      ! Read min. bias out of file...
776   read(10,end=777) n,rvd(3),rv1,rv2

      endif

      itrk1 = itrk1 + n
* Look at individual final-state tracks

      do i = 1,n

      if (ib.gt.nbias) then
      do j=1,5
      pp(j)  = p(i,j)
      enddo
      icharge=klu(i,6)/3
      kf = klu(i,2)

      else             ! Read min-bias from file....

      read(10) kbx,pp(1),pp(2),pp(3)
      ichm = kbx/100000
      icharge = ichm - 2
      kf = kbx - ichm * 100000
      pp(4) = sqrt(pp(1)**2 + pp(2)**2 + pp(3)**2)  ! Add in rest
mass???
      endif

c     add in vertex from pythia  ! Not used w. simple tracking
c     intrk = 0
c     do j = 1,3
c     vvx(j) = v(i,j)/10.
c     enddo
c     if (abs(vvx(1)).gt.r0) then
c     intrk = 1
c     vvx(1) = sign(r09,vvx(1))
c     endif
c     if (abs(vvx(2)).gt.r0) then
c     intrk = 1
c     vvx(2) = sign(r09,vvx(2))
c     endif
c     if (abs(vvx(3)).gt.d0) then
c     intrk = 1
c     vvx(3) = sign(d09,vvx(3))
c     endif
c     ierrx = ierrx + intrk
c     do j = 1,3
c     rvd(j) = rv(j) + vvx(j)
c     enddo
c
c     T R A C K I N G   C O D E
c
      iout = 1      ! flag for particle in/out of calorimeter (set
out)
c     rvd(3) = rv(3) + v(i,3)/10.  ! z-vertex from PYTHIA; not used
here.
      sqm = sqrt(pp(1)**2 + pp(2)**2)
c     print *,'Charge, particle:',icharge,kf
c
      if(ifield.eq.0.or.icharge.eq.0) then  ! straight tracks
c     call impact(rvd,pp,ppimp,iout)  ! Handles detailed geometry
      tth = sqm/pp(3)    ! Theta angle
      ppimp(3) = r0/tth + rvd(3)  ! Impact pt. (no x,y vtx smear)
      if (abs(ppimp(3)).le.d0) then  ! Inside detector?
      ppimp(1) = r0 * pp(1)/sqm   ! then get x,y
      ppimp(2) = r0 * pp(2)/sqm
      iout = 0
      endif
      else
c     call bimpact(icharge,bfield,rvd,pp,ppimp,iout) ! Detailed
tracking
c  Simple tracking code below for intercept w. cylinder.
      rlmr = sqm/(0.0003 * bfield)    ! Lamour Radius (cm)
      if (rlmr.gt.r02) then         ! Particle hits detector
c     tth = sqm/pp(3)    ! Polar angle
c     zimp = r0/tth + rvd(3)  ! Linear impact pt. (no x,y vtx smear)
      dltang = asin(r02/rlmr)! Rotation from initial tangent
      ppimp(3) = 2. * rlmr * dltang * pp(3)/sqm + rvd(3)  ! curved
impact
      if (abs(ppimp(3)).le.d0) then  ! Inside detector?
c     print *,'z line,curve,pt,pp:',zimp,ppimp(3),sqm,pp(3)
      angtot = atan2(pp(2),pp(1))
c  -- Check sign on this term (magnetic deflection)
      angtot = angtot + dltang * sign(1.,pp(3)) * icharge
      ppimp(1) = r0 * cos(angtot)    ! then get x,y
      ppimp(2) = r0 * sin(angtot)
      iout = 0
      endif
      endif
      endif
c
c     Fill Calorimeter arrays!!
c
      if(iout.eq.0) then   ! Track makes it into calorimeter!
       itrk2 = itrk2 + 1
         tth = atan2(sqrt(ppimp(1)**2 + ppimp(2)**2),ppimp(3))
         etatrk = -alog(abs(tan((tth/2.))))*sign(1.,tth)
         phitrk = atan2(ppimp(2),ppimp(1))
c        print *,' kf:',kf,' Phi:',phitrk,' eta:',etatrk,' tth:',tth
         if (abs(etatrk).lt.eta00) then
c         call hfill(301,phitrk,0.,1.)
c         call hfill(302,etatrk,0.,1.)
         itrk3 = itrk3 + 1
          if ((kf.eq.22).or.(iabs(kf).eq.11)) then
           call egshwr(etatrk,phitrk,pp(4),icharge)
          elseif (iabs(kf).eq.13) then
```

```
          call domip(etatrk,phitrk,icharge)
         else
        call dohadron(etatrk,phitrk,pp(4),icharge)
       endif
      else
C
C  *** Endcap code will go here!! ***
C
       endif
      endif

      enddo

c     print *,'No. tracks:',n-imin+1,'  klu:',klu(0,1),klu(0,2),
c    .'  vtx clip:',ierrx
c
c      Higgs analysis below...
c
      if (iprcs.ge.2) then     ! Higgs event selected
      if (ib.gt.nbias) then    ! This is the higgs...
      n40 = 0
      n25 = 0
      do i = 1,nlevs
      mislev(i) = 0
      enddo
      n25 = 0
      do i = 1,2        ! Look at the Higgs photons
      if (egyh(i).gt.e1sz) n40 = 1  ! Seez Cuts...
      if (egyh(i).gt.e2sz) n25 = n25 + 1
      do L = 1,nlevs
      if (egyh(i).le.etwr(L)) mislev(L) = mislev(L) + 1  ! Too little
E
      enddo
      enddo
      n2540 = n25 + n40   ! Seez
      if (n2540.eq.3) nprsez = nprsez + 1
      do L = 1,nlevs
      if (mislev(L).ne.0) misegy(L) = misegy(L) + 1
      enddo
      endif
      endif

      enddo

c     print *,'Track Count:',itrk1,itrk2,itrk3
c     print *,'No. elect/gams:',noemp,'  No. hads:',nohad,
c    .'  No. mips:',nomip

* Check out compression routines....
c
c     call cmpres(nce,ecalout,maxcmp,ecal,iovf,0)
c     call cmpres(nch,hcalout,maxcmp,hcal,iovf,1)
c     call cmpres(ncc,ichout,maxcmp,rchrg,iovf,1)
c
c     print *,'Ecal,Hcal,Chg:',nce,nch,ncc
c     do ll=1,nce
c     print *,'Eval:',ecalout(ll)
c     enddo
c     print *,'-----'
c     do ll=1,nch
c     print *,'Hval:',hcalout(ll)
c     enddo
c     print *,'-----'
c     do ll=1,ncc
c     print *,'Ival:',ichout(ll)
c     enddo
c
      if (iprcs.ge.2)
     .print *,'Higgs Energies:',egyh(1),egyh(2)
      call timed(ttx)
**********************************************
      call trigger    ! do the trigger simulation....
**********************************************
c     if (iseez(1,3).eq.1) goto 575    ! Trap an interesting event...


      call timed(t1x)

      nevread = nevread + 1

      if (nevread.lt.50) print 389,ttx+t1x,t1x
389   format(' Net time for event:',f10.4,'  trigger:',f7.4)

      goto 1   !  Event loop.....

777   print *,'End of min. bias file; Rewound and offset'
      REWIND 10
      rz = ranf()
      rz = rz * nbiasav/1.5  ! offset so different interactions...
      iz = rz + 1
      read(10) i1,y1,y2,y3
      read(10) i1,y1,y2,y3
      DO IWW = 1,IZ
      read(10) i1,y1,y2,y3
      DO JWW = 1,I1
      read(10) i2,y1,y2,y3
      enddo
      enddo
      goto 776         !  Resume...
c
575   continue
889   print *,' ---- Number of ev. processed=',nevread
      write(6,103) bfield,r00,d00,r0,d0,rp,zp,rscale
103   format(/'Main param:bfield,r00,d00,r0,d0,rp,zp,rscle='
     >,/8f10.3/)

      close(10)
c     close(11)
      write (7,*)  ' *** Events finished!! ***'

c     if (iprcs.ge.2) then  ! Higgs
      if (iprcs.lt.2) then  ! Assume no Higgs present if switched off
      do i = 1,nlevs
      misegy(i) = nevread
      enddo
      endif
      print *,'-------------- H i g g s   A n a l y s i s  -------'
      rpch = missz
      rpch = rpch/(nevread+missz)
      print 214,nevread+missz,nevread,missz,rpch*100.
      print *,'# Seez triggers expected:',nprsez
      do i = 1,nlevs
      print 18,i,etwr(i),misegy(i)
18    format(' Level #',i2,'  Egy:',f7.2,'  #Evts w. low E:',i6)
      enddo
214   format(' Tot:',i5,'  Passed:',i5,'   Missed:',i5,'  %:',f10.2)

      do m = 1,ntry   ! Look at all cut combos
      print *,'**************************************************'
      if (m.le.mxcts+1) then
      print *,ctit(m)
      else
      k00 = mxcts + 1
      k00 = m - k00
      L0 = 1
      if (m.gt.mxcts+nctsq+1) L0 = 2
      k00 = k00 - (L0-1)*nctsq
      do n = 1,k00
      mtt = iseq(n,L0)+1
      print *,ctit(mtt)
      enddo
      endif
      print *,'**************************************************'

      do j = 1,ntwr
      print *,'Tower #:',j
      F = NSEEZ(M,J) * 100.
      f = f/nevread
      print 17,nseez(m,j),nprsez - nseez(m,j),f
17    format(' #Seez trigs. present:',i5,'   missed:',i5,'  %: ',
     .f7.3)
      enddo
      print *,'________________________________________________'
      do i = 1,nlevs
      print *,'Level:',i,'    Energy:',etwr(i)
      do j = 1,ntwr
      f = ntegp(m,i,j)
      f = 100. * f/nevread     ! Get % Accepted
      print 19,j,ntegy(m,i,j),ntegp(m,i,j),
     .nevread-ntegp(m,i,j)-misegy(i),f
19    format(' Twr#',i2,'   # Higgs Trgs.:',i5,'   Prox. corrected:',
     .i5,'  # Missed:',i5,'   % Accepted: ',f7.3)
      enddo
      print *,'--------------------------------------------------'
      enddo
c     endif

      f = nevread
      print *,'------------ Energy Trigger vs. # hits -----------'
      do i = 1,ntwr
      print *,'   T o w e r  N o. ',i
      do j = 1,nlevs
      in1 = 1000 + (i-1)*10 + (m-1)*30 + j
      do kk = 1,4
      xhist(kk) =  hi(in1,kk)
      enddo
      xhist(5) = 0.
      do kk = 5,30
      xhist(5) = xhist(5) + hi(in1,kk)
      enddo
      do kk = 1,5
      nhist(kk) = xhist(kk)
      gg = xhist(kk)
      if ((kk.gt.1).and.(kk.lt.5)) then
      do nn = kk+1,5
      gg = gg + xhist(nn)
      enddo
      endif
      xnormh(kk) = 100.* gg/f
      enddo
      print 241,etwr(j),nhist,xnormh
241   format(' Egy:',f7.2,'  Trgs (0-4): ',5(i5,2x),'  %  ',
     .5(f7.3,2x))
      enddo
      enddo
      enddo

c     call histdo
      call hprint(201)
      call hprint(7)
      call hprint(17)
      call hprint(8)
      call hprint(15)
      call hprint(6)
      call hprint(9)
      call hprint(16)
      call hprint(10)
      call hprint(11)  ! Emin 1 vs. Emin 2
      call hprint(12)
      call hprint(13)
      call hprint(4)  ! Occupancy
      call hprint(5)


c     call lulist(2)
c     stop 'test!'
      call hdelet(ihlng)
      call hdelet(ihlat)
      call capture(hcal,itrz(1,2),itrz(2,2))
      call hcopy(1,3,'Hadron Calorimeter')
c     call capture(ecal,itrz(1,1),itrz(2,1))
c     call hprint(1)
      call capture(twr05,itrz(1,2),itrz(2,2))
      call hcopy(1,2,'Ecal - .05 Towers')
c     call hprint(1)
      call capture(twr10,itrz(1,3),itrz(2,3))
c     call hprint(1)
c     call capture(twr15,itrz(1,4),itrz(2,4))
c     call hprint(1)
c     call capture(twr20,itrz(1,4),itrz(2,4))
c     call hprint(1)

      call hrput(0,fnamhis,'nt')
      call pystat(1)
      call pystat(4)
      call pystat(5)

       open(lfn,file='rlusave',status='unknown',
     .form='unformatted')
       call rluget(lfn,0)
       close(lfn)
      print *,' last lund random nu=',mrlu

c      open(lr,file='norsave',status='old',form='formatted')
c     call norrut(iseed1,iseed2)
c      write(lr,*) iseed1,iseed2
c      close (lr)
      print *,' last norran random number : iseed1,2=',iseed1,iseed2
       call timel(tleft)
      print *,'Time remaining:',tleft

      stop

      end

      subroutine shoot(nbias)
c     routine to test out particle and tower models
c
```

```
      nbias = 0                    ! Test with discrete particles
      call dohadron(.5,1.,30.,0)
      call dohadron(-.5,1.,30.,0)
      call dohadron(.1223,1.034,30.,0)
      call dohadron(-.1223,1.034,30.,0)
      call egshwr(.5,-1.,30.,0)
      call egshwr(-.5,-1.,30.,0)
      call egshwr(.173,-1.,30.,0)
      call egshwr(-.175,-1.,30.,0)

      return
      end

      subroutine capture(arr,idx,idy)
c     capture an event in a histogram
+seq,epara.
+seq,image.
+seq,trgstf.
      dimension arr(idx,idy)
      save iflf
      data iflf/0/
c
      if (iflf.eq.1) call hdelet(1)
      iflf = 1
      call hbook2(1,'Ecal  Event',idx,-180.,180.,idy,-eta00,eta00,0)
c     call hbpro(1,0)
c     call hbpro(2,0)
      call hpak(1,arr)

c     call hscale(1,5.)

c     call hplint(0)
c     call hplcap(-3)
c     call hplego(1,30.,30.)
c
      return
      end

      SUBROUTINE SETPTA(IM,EL,EH)
C
C     SETS UP PYTHIA
C
+seq,pysubs.
+seq,pypars.
+seq,ludat2.
+seq,ludat3.
+seq,ludatr.
+seq,param.
C
      pmas(6,1) = 140.        ! Top Quark
C
c
      if (im.eq.0) then        ! minimum bias
      print *,'++++++  Minimum bias selected from PYTHIA +++++'
* for minimum bias  prod.
c     msel=2
* minimum bias from UA1/Franchesca
      msel = 0
      msub(11) = 1
      msub(12) = 1
      msub(13) = 1
      msub(28) = 1
      msub(53) = 1
      msub(68) = 1
      msub(95) = 1
c
      mstp(81) = 1
      mstp(82) = 4
      mstp(2) = 2
      mstp(33) = 3
      mstp(82) = 1.9
      mstp(85) = 0.9
      mstp(86) = 0.9
c
      elseif (im.eq.1) then   ! QCD Jets
      print *,'++++ Hard QCD Processes selected from PYTHIA ++++'
      print *,'---- Momentum cuts:',el,eh
      msel = 0
      msub(11) = 1
      msub(12) = 1
      msub(13) = 1
      msub(28) = 1
      msub(53) = 1
      msub(68) = 1
      ckin(3) = el
      ckin(4) = eh
c
      else         ! Higgs production
C     HIGGS MASS STUFF....
      PRINT *,' H I G G S !*******************'
      msel = 16
      kfh0 = 25
c     kfh0c = kfh0
      KFH0C = LUCOMP(KFH0)
      pmas(kfh0c,1) = el        ! Mass
      pmas(kfh0c,2) = eh        ! Width
      print *,' H I G G S *******************'
      print *,'H0 mass, width:',el,eh
C
      if (im.eq.2) then
      print *,'+++++ Higgs -> 2 gamma ++++++'
      iskp = 14
      else
      iskp = 17
      endif
c
      ient = mdcy(kfh0c,2)
      do i = 1,17
      if (i.ne.iskp) mdme(ient+i-1,1) = 0
      enddo
c
      if (im.ge.3) then
      if (im.eq.3) then
      print *,'++++++++ Higgs -> e+ e- e+ e-     chosen ++++'
      iskp = 156
      else
      print *,'++++++++ Higgs -> mu+ mu- mu+ mu-     chosen ++++'
      iskp = 158
      endif
      do i = 148,153
      mdme(i,1) = 0
      enddo
      do i = 156,161
      if (i.ne.iskp) mdme(i,1) = 0
      enddo
      endif
      endif
c
C
      PRINT *,'PYTHIA INITIALIZATION....'

      call pyinit('cms','p','p',16000.)

* set starting valu for random number generator
       open(lfn,file='rlusave',status='unknown',
     .form='unformatted')
       CALL RLUSET(LFN,0)
       close(lfn)
       print *,' starting random numb for lund=',mrlu

      return
      end
c
+deck,egshwr
      subroutine egshwr(etatrk,phitrk,e,ic)
+seq,epara.
+seq,image.
      save emeff
c     data emeff/0.96/   ! Electro-mag. efficency
      data emeff/1./
c
      noemp = noemp + 1
      call getcrd(ne,np,etatrk,phitrk)
      if (ic.ne.0) rchrg(np,ne) = rchrg(np,ne) + e
      xoff = etatrk - etacrd(ne)
      yoff = phitrk - phicrd(np)
      yoff = yoff * phifac   ! correct for xtal assymetry (phi,eta)
      if (abs(xoff).gt.xtalw2) then
c     print *,'EM  (eta) offset problem;e,p:',ne,np
c     print *,'Offsets:',xoff,yoff
c     print *,'coords:',etatrk,phitrk
c     print *,'Calc.:',etacrd(ne),phicrd(np)
      xoff = sign(xtalw2,xoff)
      endif
      if (abs(yoff).gt.xtalw2) then
c     print *,'EM (phi) offset problem;e,p:',ne,np
c     print *,'Offsets:',xoff,yoff
c     print *,'coords:',etatrk,phitrk
c     print *,'Calc.:',etacrd(ne),phicrd(np)
      yoff = sign(xtalw2,yoff)
      endif
      egy = e * emeff
      call spread(xoff,yoff)
      do k=1,3
      ice = (k-2)+ne
      if ((ice.le.nzd).and.(ice.gt.0)) then
      do j=1,3
      icp = (j-2)+np
      if (icp.gt.ncb) icp = icp - ncb
      if (icp.le.0) icp = ncb + icp
      ege = xtlshr(j,k) * egy
      ecal(icp,ice) = ecal(icp,ice) + ege
c     print *,'EM: ph,et,eg:',icp,ice,ege
      enddo
      endif
      enddo
c     print *,'EM; xoff,yoff:',xoff,yoff,' nc,ne,np:',ic,ne,np
c
c     hadronic spillover here???
c
      return
      end
+deck,domip.
      subroutine domip(etatrk,phitrk,ic)
+seq,image.
c
      call getcrd(ne,np,etatrk,phitrk)
      nomip = nomip + 1
      if (ic.ne.0) rchrg(np,ne) = rchrg(np,ne) + e
      ecal(np,ne) = ecal(np,ne) + qmip(e)
      nep = 1 + (ne-1)/ietoh
      npp = 1 + (np-1)/ietoh
      hcal(npp,nep) = hcal(npp,nep) + qmip(e-ecal(np,ne))
      return
      end
c
      function qmip(z)
+seq,image.
c
c     Gen. Landau fluctuatied MIP
c
      xm = ranlan(ranf())
      if (xm.lt.-3.5) xm = -3.5
c     if (xm.gt.8) xm = 8.
      qm = (3.5 + xm) * rmipn
      if (qm.gt.z) qm = z
      if (qm.lt.0) qm = 0
c     print *,'Landau out:',qm
      qmip = qm
      return
      end
+deck,starthad.
      subroutine starthad  ! Initialize hadron deposition in
calorimeter
+seq,image.
+seq,epara.
+seq,hadprm.
      dimension hlong(25),bglarr(3),smlarr(3)
      save hlong
      data hlong/0.,0.,.45,.41,.33,.25,.19,.13,.095,.070,.050,.040,
     .0.025,.020,.015,.012,.009,.005,.003,.002,.001,0,0,0,0/
c
      ihlng = 161     ! set longitudinal shower scale fluctuation
      call hbook1(ihlng,'Longitudinal Fluctuation',25,0.,5.,0)
      call hpak(ihlng,hlong)
c
      a = 0.2         ! longitudinal fit coefs. (CERN EP/89-109)
      b = 0.1
      c = 5.56
      a1 = 0.045
      b1 = 0.7
      ab0 = a + b
      ab1 = a1 + b1
c
      rintu = 10.   ! interaction length in uranium (cm)
      sig0 = 4.2    ! sigma of high-eng. lateral fluctuation (cm)
      fs = rint/rintu  ! ratio of interaction length in xtal/U
      fsc = fs/xtalw0  ! above in xtal widths (cm)
      sigbig = sig0 * fsc ! corrected high-e. sigma (for xtal)
c
      smalle = 1.6      ! Energy of small eng. tail quanta (MIPs)
      bige = 10.4       ! Energy of big eng. core quanta (MIPs)
c
      ihlat = 162   ! make histogram of small energy lateral shower
dst.
      inobns = 10 * ietoh
      call hbook1(ihlat,'Lateral Fluctuation (sml. e)',inobns,
     .-25*fsc,25*fsc,0)
```

```
      rl = 10 * fsc  ! cutoff for flat top (10 cm in U)
      call hix(ihlat,1,xl)
      call hix(ihlat,2,xh)
      dx = (xh - xl)/2.
      do k = 1,inobns
      call hix(ihlat,k,xl)
      xl = xl + dx
      if (abs(xl).gt.rl) then
      g = exp(-0.5*(xl/sigbig)**2) ! Gaussian tails
      g0 = g
      else
      g = g0  ! Flat top
      endif
      call hfill(ihlat,xl,0,g)
      enddo
c                              ! code to make 3 x 3 smearing of had
cells
      sig10 = 10./sig0
      ritl = freq(-sig10)   ! tail
      extop = exp(-0.5*(10./sig0)**2)   ! Value of flat top
      rihw = ietoh * xtalw0    ! width (cm) of hadron calorimeter
cells
      rbs = 0
      rls = 0
      do k = 1,3
      rictr = (k - 2.5) * rihw
      rpq = rictr/sig0
      rpp = rpq + rihw/sig0
      rp1 = abs(rpq)
      rp2 = abs(rpp)
      r = freq(rpp) - freq(rpq)      ! gaussian smear for big energy
      rbs = rbs + r
      bglarr(k) = r
      if ((rp1.lt.sig10).or.(rp2.lt.sig10)) then
      if ((rp1.lt.sig10).and.(rp2.lt.sig10)) then
      r = extop * (rpp - rpq)
      elseif (rp1.lt.sig10) then
      r = extop * (sig10 - rpq) + ritl - freq(-rp2)
      else
      r = extop * (sig10 + rpp) + ritl - freq(-rp1)
      endif
      endif
      rls = rls + r
      smlarr(k) = r
      enddo
      do k=1,3                       ! Normalize
      bglarr(k) = bglarr(k)/rbs
      smlarr(k) = smlarr(k)/rls
      enddo
      do k = 1,3                     ! Form 2-dim sharing block
      do j = 1,3
      hadsml(j,k) = smlarr(k) * smlarr(j)
      hadbig(j,k) = bglarr(k) * bglarr(j)
      enddo
      enddo
c
      print *,'Small energy Hadron spreading....'
      do j = 1,3
      print *,hadsml(j,1),hadsml(j,2),hadsml(j,3)
      enddo
      print *,'Large energy Hadron spreading....'
      do j = 1,3
      print *,hadbig(j,1),hadbig(j,2),hadbig(j,3)
      enddo
c
      pieff = 0.6                    ! H to e/g pulse height diff in
ecal
      nfac = 2                       ! number of big vs. small quanta
      esep = (smalle/bige)/nfac      ! Energy sharing (low e vs. high
e)
      rmiph = emip                   ! Energy of a MIP in Ecal (GeV)
      rbig = rmiph * bige            ! Energy of large E quanta
      rsmall = rmiph * smalle        ! Energy of small E quanta
      rbigs = rbig * pieff
      rsmalls = rsmall * pieff
      rmipct = 1.5 * rmiph          ! Cutoff for assuming MIP in ecal
      gevs = rsmall + nfac * rbig    ! Net energy for summed quanta
      rlplan = 0.058      ! plane width in int. lengths (for U cal)
c     xx0 = totint * 2/rlplan  ! scaled length of ecal (for
exponentials)
      xx0 = totint/rlplan  ! Mistake in Paper (better w/o factor 2)
      ett = exp(-totint)
c
      print *,'---- Hadron model initialized!! ----'
c     call hprint(ihlat)
c     call hprint(ihlng)
c
      return
      end
+deck,dohadron.
      subroutine dohadron(etatrk,phitrk,e,ic)
+seq,image.
+seq,epara.
+seq,hadprm.
      save ww1
      data ww1/1/
c
c     print *,'----------------- Hadron!!! -----------------'
      call getcrd(ne,np,etatrk,phitrk)
      nohad = nohad + 1
      if (ic.ne.0) rchrg(np,ne) = rchrg(np,ne) + e
      edephd = 0.
c
c    Electromagnetic calorimeter
c
c     ec = e * pieff         ! scale by e/h efficiency
c     print *,'HH ne,np,e,cor:',ne,np,e,ec
      if (e.lt.rmipct) then
      ecal(np,ne) = ecal(np,ne) + e  ! tiny energy deposit
c     print *,'MIP level!; fill and exit'
      return
      endif
c
      rxc = hrndm1(ihlng)   ! Get longitudinal scaling from dist.
      stp = -alog(0.00001+ranf())/totint  ! first interaction pos.
c     print *,'scl,strt:',rxc,stp
      if (stp.gt.1) stp = 1
      if (stp.lt.0) stp = 0
      xxp = (1.- stp) * xx0    ! Interaction lengths during shower
      bta = 0.163 * alog(e)  ! calculate energy dependance of scalef
      rlxb = rxc * (xxp + bta)  ! get argument of exponentials
      btl = rxc * bta   ! get argument for exponential integral
      de0 = c * ((exp(-a*btl)/a)-(exp(-ab0*btl)/ab0)) +
     .(exp(-a1*btl)/a1)-(exp(-ab1*btl)/ab1)
      de1 = c * ((exp(-a*rlxb)/a)-(exp(-ab0*rlxb)/ab0)) +
     .(exp(-a1*rlxb)/a1)-(exp(-ab1*rlxb)/ab1)
      dlte = (de0 - de1)/de0 ! Fraction of energy deposited in ecal
c
c     print *,'de0,de1,dlte:',de0,de1,dlte
      if ((dlte.lt.0).or.(dlte.gt.1)) then
c     print *,'Delta E wrong!!:',dlte,e,rlxb,rxc
      if (dlte.lt.0) dlte = 0
      if (dlte.gt.1) dlte = 1
      endif
      edepm = stp * qmip(e)     ! Energy deposited before interaction
      edep = dlte *(e - edepm)  ! MIP energy during non interaction
      edephd = edepm + pieff * edep
c     print *,'Edd:',edephd,edepm,edep
c
      ecal(np,ne) = ecal(np,ne) + edepm   ! Add in pre-interaction
      dltec = edep * pieff   ! scale by e/h efficiency
c     print *,'edep,dltec:',edep,dltec
      if (dltec.lt.rmipct) then
c     print *,'Tiny Deposit:',dltec+edepm,'  fill & exit'
      ecal(np,ne) = ecal(np,ne) + dltec ! tiny energy deposit
      edephd = edepm + dltec/pieff
      goto 10
      endif
c
      rn = edep/gevs   ! calculate # of quanta produced
      n = rn
      e0 =  n * (nfac * rbig + rsmall)   ! energy delivered by big
quanta
      exc = edep - e0                  ! residual
      rxc = exc/rsmall
      nxc = rxc
      ex0 = exc - nxc * rsmall        ! residual not taken up by small
q
      nxc = nxc + n                   ! true # of small quanta
      nbb = nfac * n                  ! number of big quanta
c
      rbb = nbb
      rxc = nxc
c     print *,'# quanta(S,B),xces:',nxc,nbb,ex0
c
      edhd = 0.
      do k = 1,nbb                    ! do over big quanta
      call norran(rxl)                ! gaussian smear
      rxl = rxl * sigbig              ! lateral smear distance
      rdg = 2. * pi * ranf()          ! Random nos. for angle
      yct = rxl * sin(rdg) + ne       ! x,y coords (crystal #)
      xct = rxl * cos(rdg) + np
      ixct = xct
      iyct = yct
      if ((iyct.gt.0).and.(iyct.lt.nzd)) then
      if (ixct.gt.ncb) ixct = ixct - ncb
      if (ixct.le.0) ixct = ncb + ixct
      rbigsf = rbigs * (0.7 + 0.6 * ranf())  ! Fluctuate the quanta
      ecal(ixct,iyct) = ecal(ixct,iyct) + rbigsf ! add in big quanta
      edhd = edhd + rbigsf
c     print *,'-- Bfill:',iyct,ixct,rbig
      endif
      enddo
c
      do k = 1,nxc+1        ! Small quanta
      ed = rsmalls * (0.7 + 0.6 * ranf())  ! Fluctuate the quanta
      if (k.gt.nxc) ed = ex0*pieff  ! Last one is net residual
      if (ed.gt.0) then
      rxl = hrndm1(ihlat)   ! Get lateral position fm. distribution
      rdg = 2. * pi * ranf()          ! Random nos. for angle
      yct = rxl * sin(rdg) + ne       ! x,y coords (crystal #)
      xct = rxl * cos(rdg) + np
      ixct = xct
      iyct = yct
      if ((iyct.gt.0).and.(iyct.lt.nzd)) then
      if (ixct.gt.ncb) ixct = ixct - ncb
      if (ixct.le.0) ixct = ncb + ixct
      ecal(ixct,iyct) = ecal(ixct,iyct) + ed    ! add in sml quanta
      edhd = edhd + ed
c     print *,'++ Sfill:',iyct,ixct,ed
      endif
      endif
      enddo
      edephd = edepm + edhd/pieff
c
c    Hadron calorimeter
c
10    continue
      ehad = e - edephd              ! energy left for had cal.
      edephd = (edephd - edepm) * pieff + edepm
c     print *,'//// Hcal energy:',ehad
      if (ehad.le.0) return  ! stop if no more
      mhe = 1 + (ne-1)/ietoh     ! get hadron coords.
      mhp = 1 + (np-1)/ietoh
      if (ehad.le.rmiph) then   ! small deposit; no smear
c     print *,'Small hadron energy:',mhe,mhp,ehad
      hcal(mhp,mhe) = hcal(mhp,mhe) + ehad
      return
      endif
      esml = ehad * esep   ! How much energy in small E. tail?
      ebg = ehad - esml    ! Energy in hot core
      do i = 1,3
      idx = 2 - i + mhe
      if ((idx.gt.0).and.(idx.le.nhe)) then
      do j = 1,3
      jdx = 2 - j + mhp
      if (jdx.le.0) jdx = nhp + jdx
      if (jdx.gt.nhp) jdx = jdx - nhp
      es = esml * hadsml(i,j)
      eb = ebg * hadbig(i,j)
      hcal(jdx,idx) = hcal(jdx,idx) + eb + es
c     print 37,idx,jdx,eb,es
37    format(' Hfill:',2i4,3x,2f12.3)
      enddo
      endif
      enddo
c
      return
      end
+deck,testhad.
      subroutine testhad
c     test out hadron model
c
+seq,epara.
+seq,image.
+seq,hadprm.
c
      call clrcal
      re = 0.
      rp = 0.   ! Dead center...
c     e = 20.
      e = 8.
c
      do nn=1,1000
c     re = 1. - ranf()*2
c     rp = (0.5 - ranf()) * 3.1415 * 2
c     e = ranf() * 25.
      call dohadron(re,rp,e,0)
```

```
      call hfill(201,edephd,0,1.)
      enddo
c
      nzz = nzd/2 - 15
      npp = ncb/2 - 15
      do i = 1,30
      do j = 1,30
      call hijxy(202,i,j,xx,yy)
      xx = xx + .1
      yy = yy + .1
      call hfill(202,xx,yy,ecal(npp+i,nzz+j))
      enddo
      enddo
c
      print *,'*** Hadron test finished!!!! ****'
c     call hprint(201)
c     call hprint(202)
c     stop 'hadron test done!!'
c
      end
+deck,getcrd.
      subroutine getcrd(ne,np,etk,phk)    ! Gets coordinates into ecal
array
+seq,epara.
      ne = 1 + (etk + eta00)/xtblwn
      np = 1 + (pi + phk)/xtblwpr
      if (ne.gt.nzd) ne = nzd
      if (np.gt.ncb) np = ncb
      if (ne.le.0) ne = 1
      if (np.le.0) np = 1
      return
      end
+deck,clrcal.
      subroutine clrcal   ! Clears out the calorimeter array
+seq,epara.
+seq,image.
c
c     This is where one would put noise into the system if it is
desired to
c     be added in....
c
      do n1 = 1,nzd
      call vzero(ecal(1,n1),ncb)
      call vzero(rchrg(1,n1),ncb)
      enddo
      do n1 = 1,nhe
      call vzero(hcal(1,n1),nhp)
      enddo
      return
      end
+deck,cmpres
      subroutine cmpres(ncnt,calout,nlim,cal,iovf,iff)
c     compress calorimeter pixel arrays
+seq,epara.
+seq,image.
      dimension calout(1000),cal(iet,iph)
c
      nzq = nzd
      ncq = ncb
      if (iff.eq.1) then   ! Hadron array (1) or electron (0)
      nzq = nhp
      ncq = nhe
      endif
c
      iovf = 0
      ictr = 0
      iL1 = 0
      il2 = 0
      do n1 = 1,nzd
      iflp = 1
      do n2 = 1,ncb
      if (cal(n1,n2).ne.0) then
      if (iflp.ne.0) then
      if (n1.ne.iL1) then
      iL1 = n1
      ictr = ictr + 1
      if (ictr.gt.nlim) goto 100
      calout(ictr) = -n1
      endif
      if (n2.ne.il2) then
      il2 = n2
      ictr = ictr + 1
      if (ictr.gt.nlim) goto 100
      calout(ictr) = -(n2 + 1000)
      endif
      endif
      ictr = ictr + 1
      calout(ictr) = cal(n1,n2)
      iflp = 0
      else
      iflp = 1
      endif
      enddo
      enddo
      ncnt = ictr
      return
100   iovf = 1
      ncnt = nlim
      return
      end
+deck,cmpres
      subroutine impres(ncnt,calout,nlim,cal,iovf)
+seq,epara.
+seq,image.
      dimension cal(iet,iph),calout(1000)
      integer calout,cal
c
      iovf = 0
      ictr = 0
      iL1 = 0
      il2 = 0
      do n1 = 1,nzd
      iflp = 1
      do n2 = 1,ncb
      if (cal(n1,n2).ne.0) then
      if (iflp.ne.0) then
      if (n1.ne.iL1) then
      iL1 = n1
      ictr = ictr + 1
      if (ictr.gt.nlim) goto 100
      calout(ictr) = -n1
      endif
      if (n2.ne.il2) then
      il2 = n2
      ictr = ictr + 1
      if (ictr.gt.nlim) goto 100
      calout(ictr) = -(n2 + 1000)
      endif
      endif
      ictr = ictr + 1
      calout(ictr) = cal(n1,n2)
      iflp = 0
      else
      iflp = 1
      endif
      enddo
      enddo
      ncnt = ictr
      return
100   iovf = 1
      ncnt = nlim
      return
      end
+deck,mhini.
      subroutine mhini
+seq,epara.
+seq,image.
+seq,trgstf.
c
      call hbook1(201,'Hadron Energy in Ecal',45,0.,15.,0)
      call hbook2(202,'Hadron Spatial distribution in Ecal',30,
     .-15.,15.,30,-15.,15.,0)
c
      call hbook1(4,'Occupancy; > 0',50,0.,10000.,0)
      call hbook1(5,'Occupancy; > 1 MIP',50,0.,500.,0)
c
      call hbook2(15,'Isolation energy; .1-.05',50,0.,15.,50,0.,100.)
      call hbook2(6,'Isolation cone energy',50,0.,25.,50,0.,100.,0)
      call hbook2(7,'Isolation energy; .2-.05',50,0.,15.,50,0.,100.,0)
      call hbook2(8,'Isolation energy; .2-.1',50,0.,15.,50,0.,100.,0)
      call hbook2(17,'Isolation energy; .2-.05 Fixed',50,0.,15.,
     .50,0.,100.,0)
      call hbook2(9,'Hadron cal. energy',40,0.,20.,50,0.,100.,0)
      call hbook2(16,'Centered Hadron energy',50,0.,25.,50,0.,100.,0)
      call hbook1(10,'Charged Energy',40,0.,40.,0.)
      call hbprox(15,0.)
      call hbprox(6,0.)
      call hbprox(7,0.)
      call hbprox(8,0.)
      call hbprox(9,0.)
      call hbprox(16,0.)
      call hbprox(17,0.)
C
      call hbook2(11,'Max. vs. 2nd max. Energy; .05 x .05',
     .50,0.,100.,50,0.,100.,0)
      call hbook2(12,'Max. vs. 2nd max. Energy; .10 x .10',
     .50,0.,100.,50,0.,100.,0)
c     call hbook2(13,'Max. vs. 2nd max. Energy; .15 x .15',
c    .50,0.,100.,50,0.,100.,0)
      call hbook2(13,'Max. vs. 2nd max. Energy; .20 x .20',
     .50,0.,100.,50,0.,100.,0)

      do i = 1,ntry
      i0 = (i-1)*30 + 1000
c
      call hbook1(i0+1,'# Towers > 10 GeV; .05 x .05',30,0.,30)
      call hbook1(i0+2,'# Towers > 15 GeV; .05 x .05',30,0.,30)
      call hbook1(i0+3,'# Towers > 20 GeV; .05 x .05',30,0.,30)
      call hbook1(i0+4,'# Towers > 30 GeV; .05 x .05',30,0.,30)
      call hbook1(i0+5,'# Towers > 40 GeV; .05 x .05',30,0.,30)
      call hbook1(i0+6,'# Towers > 50 GeV; .05 x .05',30,0.,30)
c
      call hbook1(i0+11,'# Towers > 10 GeV; .10 x .10',30,0.,30)
      call hbook1(i0+12,'# Towers > 15 GeV; .10 x .10',30,0.,30)
      call hbook1(i0+13,'# Towers > 20 GeV; .10 x .10',30,0.,30)
      call hbook1(i0+14,'# Towers > 30 GeV; .10 x .10',30,0.,30)
      call hbook1(i0+15,'# Towers > 40 GeV; .10 x .10',30,0.,30)
      call hbook1(i0+16,'# Towers > 50 GeV; .10 x .10',30,0.,30)
c
      call hbook1(i0+21,'# Towers > 10 GeV; .20 x .20',30,0.,30)
      call hbook1(i0+22,'# Towers > 15 GeV; .20 x .20',30,0.,30)
      call hbook1(i0+23,'# Towers > 20 GeV; .20 x .20',30,0.,30)
      call hbook1(i0+24,'# Towers > 30 GeV; .20 x .20',30,0.,30)
      call hbook1(i0+25,'# Towers > 40 GeV; .20 x .20',30,0.,30)
      call hbook1(i0+26,'# Towers > 50 GeV; .20 x .20',30,0.,30)
c
      enddo

      return
      end

+deck,tstshr
      subroutine tstshr
+seq,epara.
      dimension xprt(3)
      data xprt/0.9,0,-0.9/
c
c     set parametere
c
      phifac = xtblwn/xtblwpr
      xtalw2 = xtblwn/2
      etabrk = xtalw2 * 0.7      ! Break in eta for shower sharing
      etabr0 = xtalw2 * 0.5      ! Small shower sharing
      debk = etabrk - etabr0
      xtlwbk = xtalw2 - etabrk
C
      do i3 = 1,2
      if (i3.eq.2) then
      xprt(1) = xprt(1)*.4
      xprt(2) = xprt(2)*.4
      xprt(3) = xprt(3)*.4
      endif
c     print *,'Shower Spreading Test; cycle:',i3
      DO I = 1,3
      DO J = 1,3
      xoff = xprt(i)*xtalw2
      yoff = xprt(j)*xtalw2
      call spread(xoff,yoff)
c     print *,'!!!!!!!!! ',xoff,yoff,' !!!!!!!!!!'
      rrtot = 0
      do k = 1,3
c     print *,xtlshr(k,1),xtlshr(k,2),xtlshr(k,3)
      rrtot = rrtot + xtlshr(k,1)+xtlshr(k,2)+xtlshr(k,3)
      enddo
c     print *,'---- normalization is:',rrtot
      enddo
      enddo
      enddo
c
      return
      end
+deck,spread
      subroutine spread(xoff,yoff)
+seq,epara.
      dimension xtlsh0(3,3),xtlclx(3),ishcp(3,2)
      data xtlsh0/.01,.05,.01,.05,.76,.05,.01,.05,.01/
      data xtlclx/.06,.81,.06/
      data ishcp/1,2,3,3,2,1/
```

```
c
      xab = abs(xoff)
      if (xab.le.etabr0) then
      rsclx = 0.
      else
      if (xab.le.etabrk) then
      rsclx = 0.07 * (xab-etabr0)/debk
      else
      rsclx = 0.07 + 0.43 * (xab - etabrk)/xtlwbk
      endif
      endif
      yab = abs(yoff)
      if (yab.le.etabr0) then
      rscly = 0.
      else
      if (yab.le.etabrk) then
      rscly = 0.07 * (yab-etabr0)/debk
      else
      rscly = 0.07 + 0.43 * (yab - etabrk)/xtlwbk
      endif
      endif
      rdxx = 1 - rsclx
      rdxy = 1 - rscly
c  smudge along x
      isf = 2
      if (xoff.gt.0) isf = 1
      do n = 1,2
      do m = 1,3
      xtlshr(m,ishcp(n,isf)) = xtlsh0(m,ishcp(n,isf))*rdxx
      enddo
      enddo
      do m = 1,3
      xtlshr(m,ishcp(3,isf)) = xtlsh0(m,3) + xtlclx(m) * rsclx
      enddo
c  smudge along y
      isf = 2
      if (yoff.gt.0) isf = 1
      do n = 1,2
      do m = 1,3
      xtlshr(ishcp(n,isf),m) = xtlshr(ishcp(n,isf),m)*rdxy
      enddo
      enddo
      do m = 1,3
      xtlshr(ishcp(3,isf),m)= xtlshr(ishcp(3,isf),m) +
     .(xtlshr(ishcp(1,isf),m) + xtlshr(ishcp(2,isf),m))*rscly/rdxy
      enddo
c
      return
      end
+deck,ugeom.
      subroutine ugeom
      double precision dsc
+seq,epara.
+seq,image.
+seq,field.
+seq,trgstf.

      XTALW0 = 3.

c      ifield   = 0
c      bfield   = 0.
c      rscale   = 1.

c      ifield   = 1
c      bfield   = 7.
c      rscale   = 1.

c      ifield   = 1
c      bfield   = 40.
c      rscale   = 1.

c      ifield   = 0
c      bfield   = 0.
c      rscale   = 0.5

c      default configuration below (now set via input file)
c     ifield   = 1
c     bfield   = 7.
c     rscale   = 1.0

c      ifield   = 1
c      bfield   = 40.
c      rscale   = 0.5

c     r00      = 300.       ! Set in file
c     eta00    = 1.         ! Set in file
      d00      = r00/tan( 2.*atan(exp(-eta00)) )
      rp0      = 150.
      zp0      = 550.

      r0       = r00 * rscale
      d0       = d00 * rscale
      rp       = rp0 * rscale
      zp       = zp0 * rscale
      r02 = r0/2
      totx0 = 25.     ! # of radiation lengths

      ecutb = 0.0003 * bfield * r02   ! Cutoff due to field
      print *,'Transverse momentum cut from B (GeV):',ecutb
c
* for LXe
c     x0       = 2.77
c     rm       = 4.05
* for CeF3
      x0       = 1.63    ! Radiation length
      rm       = 2.6
      rint = 26.2    ! Interaction length (cm)
      x0int = x0/rint
      totint = totx0 * x0int
c     totint = 0.93  ! BGO for test...
      emip = 0.35              ! Energy of MIP (GeV)
      rmipn = emip/3.5   ! Landau normalization
      print *,'# of interaction lengths:',totint
      print *,'MIP Energy (peak of Landau):',emip
c
      ETAMAX   = 2.
      tetamin  = 2.*atan( exp( -etamax) )
      tetamind = 2.*atan( exp( -etamax) )/pi*180.
      talfa    = (r0-rp)/(zp-d0)
      alfa     = atan(talfa)
      alfad    = atan(talfa)/pi*180.
      tetakrit = atan(r0/d0)
      tetakrid = atan(r0/d0)/pi*180.
      zmin     = (r0+d0*talfa)/(talfa+tan(tetamin))
      rmin     = zmin*tan(tetamin)
      wl       = 25.*x0/sin(alfa+tetamin)

      z3       = zmin+wl*cos(tetamin)
      r3a      = rmin-talfa*wl*cos(tetamin)
```

```
      r3b      = rmin+wl*sin(tetamin)

      z2       = d0+25.*x0*cos(pi/2.-alfa)
      r2a      = r0-25.*x0*cos(pi/2.-alfa)*talfa
      r2b      = r0+25.*x0

      z1       = d0
      r1a      = r0
      r1b      = r0+25.*x0

      if(r3a.lt.0.) then
         dva=abs(r3a)+1.
         dh=dva/talfa

         tb=(r2b-r3b)/(z3-z2)
         dvb=tb*dh

         z3=z3-dh
         r3a=r3a+dva
         r3b=r3b+dvb

         tm=r3b/z3
         em=-log(tan(0.5*atan(tm)))
         print *,' New lower eta limit=',em
      endif

      print *,' s/r ugeom:tetamin,tetakrit,alfa,talfa=',
     >tetamind,tetakrid,alfad,talfa
      print *,'           zmin,rmin=',zmin,rmin
      print *,'    z1,z2,z3=',z1,z2,z3
      print *,'    r1a,b,r2ab,r3ab=',r1a,r1b,r2a,r2b,r3a,r3b
      print *,'    r00,d00,rscale=',r00,d00,rscale
      print *,'    ifield,bfield(KGauss)=',ifield,bfield
C
C   MODIFICATIONS FOR DISCRETE XTAL INSERTION -- JAP 18-NOV-91
C
      CTHC = COS(TETAKRIT)
C
C     PROJECTIVE GEOMETRY IN BARREL
C
c       Lots of old junk below (geometry was changing)
c       Relevant stuff is at bottom for constant eta in barrel
c       Sorry...........            -- Joe --
c
      PRINT *,'********* BARREL ***********'
      DSC = XTALW0/R0
      DSC = DSC**2
      DSC = 1.D0 - DSC
      DSC = DSQRT(DSC)
      DSC = 1.D0 - DSC
      STH0 = DSC*R0/XTALW0
      TH0 = ASIN(STH0)
      THP = PI2
      THT = TH0
      ZTEXT = 0
      NZD = 0
      DTHT02 = ATAN(XTALW0*COS(TH0)/(2*R0))
      PRINT *,'TH0:',TH0,'    DELTA THT0/2:',DTHT02
136   CONTINUE
      DTHT = 2*ATAN(XTALW0*COS(THT)/(2*R0))
      THP = THP - DTHT
      NZD = NZD + 1
      XTBLWT(NZD) = THP
      ZTEXT = ZTEXT + XTALW0*COS(THT)
      XTBLWZ(NZD) = ZTEXT
      THT = THT + DTHT
      IF (THP.GT.TETAKRIT) GOTO 136
C     RZD = D0/XTALW0
C     NZD = RZD
C     XTALWZ = D0/NZD
      CIRB = 2. * PI * R0
      RCB = CIRB/XTALW0
      NCB = RCB     ! number of xtals in phi
      xtt = ncb
      xtt = xtt/itrnp
      ntt = xtt
      r = xtt - ntt
      if (r.gt.0.5) ntt = ntt + 1  ! Round # xtls to multiple of tower
dim
      ncb = ntt * itrnp
c
      XTBLWPC = CIRB/NCB
      XTBLWPR = XTBLWPC/R0
      XTBLWP2 = XTBLWPR/2.
      PRINT *,'BARREL HALF-LENGTH (z-cm):',ZTEXT
      PRINT *,'XTAL DIMENSIONS (phi-cm):',XTBLWPC
      PRINT *,'XTAL DIMENSIONS (phi-rad):',XTBLWPR
C
      ETANML = PI2 - XTALWZ/R0
      ETANML = -ALOG(TAN(ETANML/2))
      ETAEND = R00/(D0 - XTALWZ)
      ETAEND = -ALOG(TAN(ATAN(ETAEND)/2))
      ETAEND = 1. - ETAEND
C
      PRINT *,'Raw XTALS IN BARREL ARRAY (z,phi):',2*NZD,NCB
C     PRINT *,'BARREL DELTA ETA; MIDDLE:',ETANML,'  END:',ETAEND
C
       ZQQ = 0
       ETAL = 0
       DO N = 1,NZD
       ETAHI = -ALOG(TAN(XTBLWT(N)/2))
       DETA = ETAHI - ETAL
       DZ = XTBLWZ(N) - Z0Q
       Z0Q = XTBLWZ(N)
       ETAL = ETAHI
c      PRINT 33,N,XTBLWT(N)*180./PI,ETAHI,NCB,DETA,XTBLWPR,DZ
       ENDDO
C
C     CONSTANT ETA APPROXIMATION (Relevant stuff...)
C
      XTBLWN = -ALOG(TAN((PI2/2) - DTHT02))
      RNZD = ETA00/XTBLWN
      NZD = RNZD
      IF (RNZD - NZD.GE.0.5) NZD = NZD + 1
c
      xtt = nzd * 2
      xtt = xtt/itrnp
      ntt = xtt
      r = xtt - ntt
      if (r.gt.0.5) ntt = ntt + 1  ! Round # xtls to multiple of tower
dim
      nzd = ntt * itrnp/2
      xtblwn = eta00/nzd   ! Re-define the xtal width
      ETMAX = XTBLWN*NZD
      PRINT *,'CONSTANT ETA WIDTH:',XTBLWN,'  NO. XTALS:',NZD
      PRINT *,'TOTAL ETA WIDTH OF ALL TRUNCATED CRYSTALS:',ETMAX
C
      EL00 = SQRT((ZP0 - D0)**2 + R0**2)
      EL01 = SQRT((ZP0 - D0)**2 + (R0 - rp0)**2)
```

```
      REL0 = EL01/XTALW0
      NEL0 = REL0
      XTALHE = EL01/NEL0
      SA = R0/EL00
      NZD = 2 * NZD      ! BARREL ETA!!
c
      nhp = ncb/ietoh
      nhe = nzd/ietoh
      PRINT *,'ROUNDED # CRYSTALS IN ETA:',NZD
      PRINT *,'# HADRON CELLS:',NHE,NHP
C
      PRINT *,'******** ENDCAP ***********'
C
      PRINT *,'RO:',R0,'SA:',SA,'EL00:',EL00
      NCEND = 0
      DO N = 1,NEL0
      YB = R0 - (N * SA * XTALHE)
      XTEWT(N) = ATAN(YB/D0)
      YM = YB + 0.5 * SA * XTALHE
      RLOC = 2. * PI * YM
      RPL0 = RLOC/XTALW0
      NPL0 = RPL0
      NOXTE(N) = NPL0
      XTEWPC(N) = RLOC/NPL0
      XTEWP(N) = XTEWPC(N)/YM
      NCEND = NCEND + NOXTE(N)
      ENDDO
C
      THTOP = tetakrit
      PRINT *,'NO. XTALS IN ENDCAP THETA:',NEL0,'  SIZE (cm):',XTALHE
      PRINT *,'NO. XTALS (TOT) IN ENDCAP:',NCEND
      PRINT *,'THETA CRITICAL (AT ETA BREAK):',THTOP*180./pi
      THTSTP = THTOP
      DO N = 1,NEL0
      ETALOW = -ALOG(TAN(THTOP/2))
      THTOP = XTEWT(N)
      ETAHI = -ALOG(TAN(THTOP/2))
      DETA = ETAHI - ETALOW
      ETAMID = (ETAHI + ETALOW)/2.
      THMN = (THSTP + THTOP)/2.
      THSTP = THTOP
c     PRINT 33,N,THMN*180./PI,ETAMID,NOXTE(N),DETA,XTEWP(N),XTEWPC(N)
33    FORMAT(1X,I3,'  THETA:',F7.4,'  ETA:',F7.4,'  #XTALS:',I3,
     .'  D_ETA:',F7.4,'  D_PHI:',F7.4,'  XTL SIZE(cm):',F7.4)
      ENDDO
C
C     BARREL COORDINATES
C
      DO K = 1,NZD
      ETACRD(K) = -ETA00 + (K-0.5)*XTBLWN
      ENDDO
      DO K = 1,NCB
      PHICRD(K) = XTBLWPR* (K-0.5) - pi
      ENDDO
C
      end

      Subroutine trgint
c    Initialize trigger processes
c
+seq,param.
+seq,epara.
+seq,image.
+seq,trgstf.
c
      do i = 1,nlevs     ! Tower Energies
      etwr(i) = (i-1) * 10
      etwr2(i) = etwr(i)/2.
      enddo
      etwr(2) = 15.
      etwr2(2) = 7.5
      etwr(1) = 10.
      etwr2(1) = 5.
c
      itrz(1,1) = ncb
      itrz(2,1) = nzd
      itrz(1,2) = iphh
      itrz(2,2) = iehh
      itrz(1,3) = ip10
      itrz(2,3) = ie10
c     itrz(1,4) = ip15
c     itrz(2,4) = ie15
      itrz(1,4) = ip20
      itrz(2,4) = ie20

      do i = 1,nlevs
      do j = 1,ntwr
      do k = 1,ntry
      ntegy(k,i,j) = 0
      ntegp(k,i,j) = 0
      enddo
      nprox(i,j) = 0
      enddo
      enddo

      print *,'+-+-+- Trigger Initialization; tower widths
(n,eta,phi)'
      do i = 1,ntwr
      imrr = 5 * i
      weta = xtblwn *  imrr
      wphi = xtblwpr * imrr
      print *,weta,wphi
      do k = 1,ntry
      nseez(k,i) = 0
      enddo
      enddo

      etrad = 0.3        ! Radius for cone isolation cuts
      ncircle = 0
      do j = -30,30
      nk = 0
      ij = 31 + j
      do k = -30,30
      ik = 31 + k
      r = j**2 + k**2
      r = sqrt(r) * xtblwn
      if (r.le.etrad) then
      nk = nk + 1
      icrdr(nk,ij) = k
      ncircle = ncircle + 1
      endif
      enddo
      nkcr(ij) = nk
      enddo

      iadadj = 0   ! 0 = don't add adjacent hits, 1 = add them in
      print 454,iadadj
454   format(' Code to add adjacent hits (1 means add them):',i2)

      ipsz(1) = 4
      ipsz(2) = 3

      e1sz = etwr(ipsz(1))      ! Seez cuts (GeV)
      e2sz = etwr(ipsz(2))
      print *,'Seez Cuts:',e1sz,e2sz

      iseq(1,1) = 4   ! Best cut sequence
      iseq(2,1) = 6
      iseq(3,1) = 9
      iseq(4,1) = 10
      iseq(5,1) = 8
      iseq(1,2) = 5   ! Realistic cut sequence
      iseq(2,2) = 7
      iseq(3,2) = 9
      iseq(4,2) = 11
      iseq(5,2) = 8

      do i = 1,nzd
      tt = 2. * atan(exp(etacrd(i)))
      ceta(i) = sin(abs(tt))       ! factor to get Et from ecal array
      enddo

      do i = 1,iehh                ! factor to get Et from hadcal
array
      idq = (i - 1)*ietoh + 1
      sinhad(i) = ceta(idq)
      enddo

      return
      end

      subroutine trigger
c     Routine to emulate trigger processes
c
+seq,param.
+seq,epara.
+seq,image.
+seq,trgstf.
      save itrge
      data itrge/0/
      data ipm/3/  ! No. of events to dump out to printer file

      iocc0 = 0
      iocc1 = 0
c
c      Form Towers...
c
      call tower(1,ecal,twr05,itrz(1,1),itrz(1,2),1,2)
      call tower(2,twr05,twr10,itrz(1,2),itrz(1,3),2,3)
c     call tower(3,twr05,twr15,itrz(1,2),itrz(1,4),2,4)
      call tower(3,twr10,twr20,itrz(1,3),itrz(1,4),3,4)

c    Raw Energy cuts and analysis

      itrge = itrge + 1
      do i = 1,ntwr
      call hfill(10+i,epeak(1,i),epeak(2,i),1.)
      iseez(1,i) = 0
      if ((nclx(ipsz(1),i)-nuladj(ipsz(1),i).ge.1).and.
     .(nclx(ipsz(2),i)-nuladj(ipsz(2),i).ge.2)) iseez(1,i) = 1
      nseez(1,i) = nseez(1,i) + iseez(1,i)
      in1 = 1000 + (i - 1)*10
      if (itrge.le.ipm) print 10,i
10    format(' Testing Tower # ',i3,'  for threshold:')
      do j = 1,nlevs
      if (itrge.le.ipm) print 15,j,etwr(j),nclx(j,i)-nuladj(j,i),
     .nprox(j,i),nuladj(j,i)
15    format(' Lvl# ',i2,'  Egy:',f7.2,'  #Twrs Above:',i3,
     .'  +Prox:',i2,'  -Prox:',i2)
      ffx = nclx(j,i)-nuladj(j,i)
      call hfill(in1+j,ffx,0,1.)
      mmx = nclx(j,i)-nuladj(j,i)-nprox(j,i)
      if (mmx.ge.2) ntegy(1,j,i) = ntegy(1,j,i) + 1
      if (nprox(j,i)+mmx.ge.2) ntegp(1,j,i) = ntegp(1,j,i) + 1
      enddo
      if (itrge.le.ipm)
     .PRINT *,'SEEZ CUT TRIGGER',ISEEZ(1,I)
      enddo
      call hfill(4,float(iocc0),0.,1.)
      call hfill(5,float(iocc1),0.,1.)

*    Do isolation, hcal, and tracking veto here....

      nclist = 0        ! First find all distinct clusters & store
      do n = 1,ntwr
      igg = 2**(n-1)    ! Scale change
      do k = 1,nlevs
      knk = nclx(k,n)
      do j = 1,knk
      if (iptvto(j,k,n).eq.0) then
      do i = 1,nclist   ! Check to see if cluster was found before
      inp = 0
      do m = 1,2
      ixl = (ixcls(m,i)-1)/igg + 1
      if (ixl.eq.iptn(m,j,k,n)) inp = inp + 1
      enddo
      if (inp.ge.2) then       ! Cluster is old; ignore
      iptcls(j,k,n) = i        ! Point to old cluster
      goto 105                 ! Skip out
      endif
      enddo
      nclist = nclist + 1      ! Enter new cluster
cccccccc
c     print *,'c,#,E,T:',nclist,j,k,n
c     iw1 = iptn(1,j,k,n)
c     iw2 = iptn(2,j,k,n)
c     if (n.eq.1) then
c     ee = twr05(iw1,iw2)
c     else
c     if (n.eq.2) then
c     ee = twr10(iw1,iw2)
c     else
c     ee = twr20(iw1,iw2)
c     endif
c     endif
c     print *,'Entry:',iw1,iw2,ee
ccccccccc
      if (nclist.gt.mxc) then
      print *,'NC list too big!!!',nclist
      goto 333
      endif
      if (n.eq.1) then      ! Don't bother to chg. scale for small twr
      do m = 1,2
      ixcls(m,nclist) = iptn(m,j,k,n) ! Position in 5 x 5
      enddo
      else             ! Find peak 5 x 5 in bigger tower
      xm = -5.
      ixsc = (iptn(1,j,k,n)-1) * igg + 1
```

```
      iysc = (iptn(2,j,k,n)-1) * igg + 1
      ixmc = ixsc+igg-1
      iymc = iysc+igg-1
c     iqqp = 0
c     if ((nevread.eq.1).and.(nclist.eq.5)) then
c     iqqp = 1
c     print *,'Problem; lev,scl:',n,igg
c     print *,'Rg:',ixsc,ixmc,iysc,iymc
c     endif
      do ix = ixsc,ixmc
      do iy = iysc,iymc
      xtq = twr05(ix,iy)
c     if (iqqp.eq.1) print *,'E:',ix,iy,xtq,xm
      if (xtq.gt.xm) then
      xm = xtq
      ixlc = ix
      iylc = iy
      endif
      enddo
      enddo
      ixcls(1,nclist) = ixlc
      ixcls(2,nclist) = iylc
c     if (iqqp.eq.1) print *,'R:',ixlc,iylc,xm
      endif
      iptcls(j,k,n) = nclist
105   continue
      endif
      enddo
      enddo
      enddo

      if (itrge.le.ipm) then
      print *,'----------------------------'
      print *,'Net no. of separate clusters:',nclist
      do i = 1,nclist
      print *,ixcls(1,i),ixcls(2,i)
      enddo
      print *,'----------------------------'
      endif

      do i = 1,nclist       ! Cluster operations...

      do j = 1,mxcts       ! Reset all cuts....
      icuts(j,i) = 0
      enddo

      ixc = ixcls(1,i)
      iyc = ixcls(2,i)
      nx10 = (ixc-1)/2 + 1      ! Pointer to .1
      ny10 = (iyc-1)/2 + 1
      nx20 = (ixc-1)/4 + 1      ! Pointer to .2
      ny20 = (iyc-1)/4 + 1
      e05 = twr05(ixc,iyc)
      e10 = twr10(nx10,ny10)
      ed05 = e10 - e05
      ed10 = twr20(nx20,ny20) - e10 ! Isolation energies
      ed20 = twr20(nx20,ny20) - e05

      ym = -10.      ! Find peak xtal in cluster ctr.
      ixcq = (ixc - 1) * 5 + 1  ! Point to xtals
      iycq = (iyc - 1) * 5 + 1
      do i1 = ixcq,ixcq+4
      do i2 = iycq,iycq+4
c     if (iqqp.eq.1) then
c     print *,'C:',i1,i2,ecal(i1,i2),ym
c     endif
      if (ecal(i1,i2).gt.ym) then
      ixec(1,i) = i1
      ixec(2,i) = i2
      ym = ecal(i1,i2)
      endif
      enddo
      enddo
c     if (iqqp.eq.1) print *,'E:',ixec(1,i),ixec(2,i),ym
      if (itrge.le.ipm) then
      print *,'Xtal
#,E:',ixec(1,i),ixec(2,i),ecal(ixec(1,i),ixec(2,i))*
     .ceta(ixec(2,i))
      print *,'Twr .05; #,E:',ixc,iyc,twr05(ixc,iyc)
      print *,'Twr .10; #,E:',nx10,ny10,twr10(nx10,ny10)
      print *,'Twr .20; #,E:',nx20,ny20,twr20(nx20,ny20)
      endif
      twrm = 0.
      ixloff = ixec(1,i) - ixcq - 2  ! Get coords. of xtal relative to
.05 x .05
      iyloff = ixec(2,i) - iycq - 2
      ixsgn = isign(1,ixloff)
      iysgn = isign(1,iyloff)
c     print *,'SS:',ixloff,iyloff
      if (iabs(ixloff).le.1) ixsgn = 0
      if (iabs(iyloff).le.1) iysgn = 0
      if ((ixsgn.ne.0).and.(iysgn.ne.0)) then  ! Corner; sum all 3
      do ixa = 0,ixsgn,ixsgn
      do ixb = 0,iysgn,iysgn
      if ((ixa.ne.0).or.(ixb.ne.0)) then
      ixtra = ixc + ixa
      iytra = iyc + ixb
      if ((ixtra-1)/4+1.eq.nx20) then
      if ((iytra-1)/4+1.eq.ny20) then
      twrm = twrm + twr05(ixtra,iytra)
      endif
      endif
      endif
      enddo
      enddo
      else           ! Edge, sum only one
      if (ixsgn+iysgn.ne.0) then
      ixtra = ixc + ixsgn
      iytra = iyc + iysgn
      if ((ixtra-1)/4+1.eq.nx20) then
      if ((iytra-1)/4+1.eq.ny20) then
      twrm = twr05(ixtra,iytra)
      endif
      endif
      endif
      endif
      ed20f = ed20 - twrm    ! Subtract off the adjacent sum

      ect21 = e10/12.5         ! Isolation cut levels for tower blocks
      ect25 = e05/11.25
      ect15 = e05/11.25
      ect25f = 3.
      ect25g = 4.
      if (ect21.lt.4) ect21 = 4  ! Set lower limit @ 4 GeV
      if (ect25.lt.4) ect25 = 4  ! Set lower limit @ 4 GeV
      if (ect15.lt.4) ect15 = 4  ! Set lower limit @ 4 GeV
c     if (ect25f.lt.4) ect25f = 4  ! Set lower limit @ 4 GeV
      if (ed10.gt.ect21) icuts(1,i) = 1
      if (ed20.gt.ect25) icuts(2,i) = 1
      if (ed05.gt.ect15) icuts(3,i) = 1
      if (ed20f.gt.ect25f) icuts(4,i) = 1
      if (ed20f.gt.ect25g) icuts(5,i) = 1

      if (itrge.le.ipm) then
      print 1441,i,ed10,ed20,ed20f,ed05
1441  format(' #:',i3,'  Iso.(.2-.1):',f7.2,' (.2-.05):',f7.2,
     .'  (.2-F):',f7.2,'  (.1-.05):',f7.2)
      print *,'Adjacency signs:',ixsgn,iysgn
      endif

      call hfill(7,ed10,e10,1.)
      call hfill(8,ed20,e05,1.)
      call hfill(15,ed05,e05,1.)
      call hfill(17,ed20f,e05,1.)

      ehb = 0.              ! Get Hcal energy in rear .2 x .2
      ihxtr = (nx20 - 1) * 4 + 1
      ihxtp = ihxtr + 3
      ihytr = (ny20 - 1) * 4 + 1
      ihytp = ihytr + 3
      do iyy = ihytr,ihytp
      do ixx = ihxtr,ihxtp
      ehb = ehb + hcal(ixx,iyy) * sinhad(iyy)
      enddo
      enddo
      if (itrge.le.ipm) then
      print 1442,i,ehb
1442  format(' #:',i3,'   Hadron Egy:',f10.2)
      endif

      if (ehb.gt.2.) icuts(6,i) = 1     ! Cuts on Hadron backing
energy
      if (ehb.gt.4.) icuts(7,i) = 1     ! Cuts on Hadron backing
energy
      call hfill(9,ehb,e05,1.)

c     iqqp = 0
c     if (nevread.eq.1) then
c     if (i.eq.5) then
c     print *,'   Problem Cluster!!   '
c     print *,'xy05:',ixc,iyc,twr05(ixc,iyc)
c     print *,'xy10:',nx10,ny10,twr10(nx10,ny10)
c     print *,'xy20:',nx20,ny20,twr20(nx20,ny20)
c     iqqp = 1
c     endif
c     endif

      e99 = 0.     ! Get r=2 sum on ctr xtl. and charged e.
      chgtot = 0.
      ny1 = ixec(2,i)-2
      ny2 = ixec(2,i)+2
      nx1 = ixec(1,i)-2
      nx2 = ixec(1,i)+2
      do i2 = ny1,ny2
      if ((i2.gt.0).and.(i2.lt.nzd)) then
      do i1 = nx1,nx2
      nxx = i1 - ixec(1,i)
      nyy = i2 - ixec(2,i)
      iprp = i1
      if (iprp.gt.ncb) iprp = iprp - ncb
      if (iprp.le.0) iprp = ncb + iprp
      if (iabs(nxx)+iabs(nyy).le.2) then
      e99 = e99 + ecal(iprp,i2) * ceta(i2) ! E in circle inside 5x5
      endif
      if ((iabs(nxx).le.1).and.(iabs(nyy).le.1)) then  ! Charge in 3x3
      chgtot = chgtot + rchrg(iprp,i2)
      endif
      enddo
      endif
      enddo
      if (itrge.le.ipm) then
      print 1443,i,e99,chgtot
1443  format(' #:',i3,' E99:',f10.2,'  Chgtot:',f10.2)
      endif

      if (chgtot.gt.5) icuts(8,i) = 1      ! Cuts on total charge dep.
      call hfill(10,chgtot,0.,1.)

      ncfill = 0    ! Look at isolation cone
      ecirc = 0.
      do i2 = 1,61
      ipe = ixec(2,i) - 31 + i2
      if ((ipe.gt.0).and.(ipe.le.nzd)) then
      ikk = nkcr(i2)
      do i1 = 1,ikk
      iaz = ixec(1,i) + icrdr(i1,i2)
      if (iaz.lt.0) iaz = ncb + iaz
      if (iaz.gt.ncb) iaz = iaz - ncb
      ncfill = ncfill + 1
      ecirc = ecirc + ecal(iaz,ipe) * ceta(ipe)
      enddo
      endif
      enddo

      ecirc = ecirc - e99
c     ecirc = ecirc * ncfill
c     ecirc = ecirc/ncircle
      if (itrge.le.ipm) then
      print 1444,i,ecirc,ncfill,ncircle
1444  format(' #:',i3,' Ecirc:',f10.2,'  Nfill,nc:',2i5)
      endif

      ekc = rpile + e99/5
      if (ecirc.gt.ekc) icuts(9,i) = 1       ! Cut on cone isolation
      call hfill(6,ecirc,e99,1.)

      hcone = 0.      ! Find E. in centered .2 x .2 hadron cal.
      nx1 = ixc - 2
      nx2 = ixc + 2
      ny1 = iyc - 2
      ny2 = iyc + 2
      do j = ny1,ny2
      if ((j.gt.0).and.(j.le.iehh)) then
      do k = nx1,nx2
      m = k
      if (m.gt.iphh) m = m - iphh
      if (m.le.0) m = m + iphh
      hcone = hcone + hcal(m,j) * sinhad(j)
      enddo
      endif
      enddo
      if (itrge.le.ipm) then
      print 466,i,hcone
466   format(1x,' #',i3,'   Centered Hadron Energy:',f10.3)
      endif

      if (hcone.gt.2.) icuts(10,i) = 1
      if (hcone.gt.4.) icuts(11,i) = 1
```

```
      call hfill(16,hcone,e99,1.)

      if (itrge.le.ipm) then
      print 48,(icuts(L,i),L=1,mxcts)
48    format(' Cut results:  ',11(i2,4x))
      print *,'--------------------------------------------'
      endif

      enddo         ! cluster loop (i)

c
c    A p p l y   T r i g g e r   C u t s
c
      do i = 1,ntwr    ! First apply each cut independently
      do k = 1,mxcts   ! Do over all cuts
      k2 = k + 1
      iseez(k2,i) = 0        ! First the assymetric (Seez) cuts
      is0 = ipsz(1)
      is1 = ltkvto(is0,i,k,k,0)
      if (is1.ge.1) then
      is0 = ipsz(2)
      is2 = ltkvto(is0,i,k,k,0)
      if (is2.ge.2) iseez(k2,i) = 1
      endif
      nseez(k2,i) = nseez(k2,i) + iseez(k2,i)
      ihq = 1000 + (i-1)*10 + k*30
      do j = 1,nlevs             ! Now look at the energy thresholds
      is1 = ltkvto(j,i,k,k,0)
      if (is1.ge.2) then
      ntegy(k2,j,i) = ntegy(k2,j,i) + 1    ! If 2 hits over threshold,
"Higgs"
      ntegp(k2,j,i) = ntegp(k2,j,i) + 1    ! Proximities are already
added in...
      endif
      call hfill(ihq+j,float(is1),0,1.)    ! Fill relevant histo w.
hit count
      enddo
      enddo

      do L = 1,2          ! Now apply the cuts in sequence (order
best/real)
      kb0 = mxcts + 1 + (L-1)*nctsq  !Offset into output arrays
      ih00 = 1000 + (i-1)*10 + kb0*30     ! Output Histo. Idx.
      do k = 1,nctsq
      k2 = kb0 + k
      iseez(k2,i) = 0        ! First the assymetric (Seez) cuts
      is1 = ltkvto(ipsz(1),i,1,k,L)
      if (is1.ge.1) then
      is2 = ltkvto(ipsz(2),i,1,k,L)
      if (is2.ge.2) iseez(k2,i) = 1
      endif
      nseez(k2,i) = nseez(k2,i) + iseez(k2,i)
      ih0 = ih00 + (k-1)*30  ! Point to histo
      do j = 1,nlevs             ! Now look at the energy thresholds
      is1 = ltkvto(j,i,1,k,L)    ! This time apply cuts in list from 1
to k
      if (is1.ge.2) then
      ntegy(k2,j,i) = ntegy(k2,j,i) + 1    ! If 2 hits over threshold,
"Higgs"
      ntegp(k2,j,i) = ntegp(k2,j,i) + 1    ! Proximities are already
added in...
      endif
      call hfill(ih0+j,float(is1),0,1.)    ! Fill relevant histo w.
hit count
      enddo
      enddo
      enddo

      enddo  ! Ntwr loop

333   continue
      return
      end

      subroutine tower(nx,tin,tout,id1x,id2x,ib1,ib2)
c
c     Forms and analyzes trigger towers
c
+seq,epara.
+seq,image.
+seq,trgstf.
      dimension tin(id1x,700),tout(id2x,700)
c
      ym1 = -100.
      ym2 = ym1

      id1y = itrz(2,ib1)
      id2y = itrz(2,ib2)
      ifac = id1y/id2y
c     print *,'In Tower!!;n:',nx
c     print *,'id1x,id2x:',id1x,id2x
c     print *,'id1y,id2y,ifac:',id1y,id2y,ifac

      ipy0 = 0
      do i = 1,id2y
      call vzero(tout(1,i),id2x)
      do j = 1,ifac
      ipx0 = 0
      iy = ipy0 + j
      do k = 1,id2x
      if (nx.eq.1) then    ! scale by transverse factors on first
pass...
      do L = 1,ifac
      tti = tin(ipx0+L,iy)
      tout(k,i) = tout(k,i) + tti * ceta(iy)
      if (tti.gt.0) iocc0 = iocc0 + 1
      if (tti.gt.emip) iocc1 = iocc1 + 1
      enddo
      else
      do L = 1,ifac
      tout(k,i) = tout(k,i) + tin(ipx0+L,iy)
      enddo
      endif
      ipx0 = ipx0 + ifac
      enddo
      enddo
      ipy0 = ipy0 + ifac

      do k = 1,id2x        !  Find 2 maximum towers
      yt = tout(k,i)
      if (yt.ge.ym1) then
      ym2 = ym1
      ym1 = yt
      else
      if (yt.gt.ym2) ym2 = yt
      endif
      enddo
C
      enddo

      epeak(1,nx) = ym1
      epeak(2,nx) = ym2

      do i = 1,nlevs     ! check trigger levels
      nclx(i,nx) = 0
      enddo
      do i = 1,id2x
      do j = 1,id2y
      cdd = tout(i,j)
      do k = 1,nlevs
      if (cdd.lt.etwr(k)) goto 10       ! Tower below threshold
      if (nclx(k,nx).lt.mxp) then
      nclx(k,nx) = nclx(k,nx) + 1
      ncpt = nclx(k,nx)
      iptvto(ncpt,k,nx) = 0    ! Clear veto flag
      iptn(1,ncpt,k,nx) = i
      iptn(2,ncpt,k,nx) = j
      endif
      enddo
10    continue
      enddo
      enddo

      do k = 3,nlevs      ! Adjacency coding (check to add hit from
lower
      nprox(k,nx) = 0     ! energy threshold).  2 neighboring hits not
      k1 = k - 2          ! included in the upper level are needed.
      ifnd = 0
      jfjf = nclx(k1,nx)-1
      do j = 1,jfjf
      do i1 = 1,nclx(k,nx)  ! Make sure it's not found higher up
      icm = 0
      do m = 1,2
      IF (IPTN(M,I1,K,NX).EQ.IPTN(M,J,K1,NX)) ICM = ICM + 1
      enddo
      if (icm.ge.2) goto 310  ! Found higher up; ignore
      enddo
      ix1 = iptn(1,j,k1,nx)
      iy1 = iptn(2,j,k1,nx)
      do i2 = j+1,nclx(k1,nx)   ! Look for adjacencies
      ix2 = iptn(1,i2,k1,nx)
      iy2 = iptn(2,i2,k1,nx)
      IF ((IABS(IX1-IX2).LE.1).AND.(IABS(IY1-IY2).LE.1)) THEN
      do i1 = 1,nclx(k,nx)  ! Again, not found higher up?
      icm = 0
      do m = 1,2
      if (iptn(m,i1,k,nx).eq.iptn(m,i2,k1,nx)) icm = icm + 1
      enddo
      if (icm.ge.2) goto 320
      enddo
      ifnd = ifnd + 1
      if (tout(ix1,iy1).gt.tout(ix2,iy2)) then  ! Point to biggest
      nxtptr(1,ifnd,k,nx) = ix1
      nxtptr(2,ifnd,k,nx) = iy1
      else
      nxtptr(1,ifnd,k,nx) = ix2
      nxtptr(2,ifnd,k,nx) = iy2
      endif
320   continue
      endif
      ENDDO
310   continue
      enddo
      nprox(k,nx) = nprox(k,nx) + ifnd
      enddo

      do k = 2,nlevs    ! Go through and add the new hits
      do j = 1,nprox(k,nx)
      if (nclx(k,nx).lt.mxp) then
      if (iadadj.EQ.1) then
      NCLX(K,NX) = NCLX(K,NX) + 1
      NCPT = NCLX(K,NX)
      IPTN(1,NCPT,K,NX) = NXTPTR(1,J,K,NX)
      IPTN(2,NCPT,K,NX) = NXTPTR(2,J,K,NX)
      endif
      endif
      enddo
      enddo

      do k = 1,nlevs    ! Now look for adjacent hits, and remove 'em!
      nuladj(k,nx) = 0
      jfjf = nclx(k,nx) - 1
      do j = 1,jfjf
      ix1 = iptn(1,j,k,nx)
      iy1 = iptn(2,j,k,nx)
      do i2 = j+1,nclx(k,nx)   ! Look for adjacencies
      ix2 = iptn(1,i2,k,nx)
      iy2 = iptn(2,i2,k,nx)
      IF ((IABS(IX1-IX2).LE.1).AND.(IABS(IY1-IY2).LE.1)) THEN
      nuladj(k,nx) = nuladj(k,nx) + 1
      if (tout(ix1,iy1).gt.tout(ix2,iy2)) then  ! Point to biggest
      iptvto(i2,k,nx) = 1
      else
      iptvto(j,k,nx) = 1
      endif
      endif
      enddo
      enddo
      enddo

      return
      end

      function ltkvto(i,j,ic1,ic2,ibf)
c
c     Routine to find out how many hits pass cuts
c     j=Tower#, i=Energy Threshold#, ic1,ic2=Range of cuts to apply
c     ibf = buffer flag (0 - apply cuts in direct order ic1-ic2,
c           1 or 2 means apply cuts from cut sequence list (iseq)
indexed
c           between ic1-ic2
c
+seq,image.
+seq,trgstf.
c
      ispj = 0
      nodo = nclx(i,j)
      do k = 1,nodo
      if (iptvto(k,i,j).eq.0) then  ! Don't bother if hit has
proximity veto flg
      ncl = iptcls(k,i,j)   ! Point to cluster associated w. hit
      icq = 0
      do m = ic1,ic2    ! go through range of cuts
      if (ibf.eq.0) then
      kqt = m      ! No indexing case
      else
      kqt = iseq(m,ibf)   ! Sequencing array
      endif
      icq = icq + icuts(kqt,ncl)  ! Add up cut flags
```

```
      enddo
      if (icq.eq.0) ispj = ispj + 1   ! Tally hit only if not rejected
      endif
      enddo
      ltkvto = ispj
      return
      end

+quit.
```