BACKGROUND STUDY FOR THE PROCESS $H^0 \rightarrow \tilde{h} + \tilde{z}$

Y.Morita
University of Tsukuba, Ibaraki, 305, JAPAN

ABSTRACT

A hard photon and a pair of electrons together with large missing Et is one of the interest signature of the supersymmetric process. A study has been made to estimate the contribution of the background which comes from the fluctuation of QCD jet fragmentation.

INTRODUCTION

Under some assumptions of the mass relation between Higgs and the supersymmetric particles, Higgs can decay into a pair of Higgsino and Zino.[1] If Higgsino is heavier than photino, Higgsino decays into a photon and a photino at a relatively high branching ratio (~ 0.25). In this scenario, the signature of the above process will be a hard photon, a pair of electrons and a large amount of missing Et.

$$H^0 \rightarrow \tilde{h} + \tilde{z} \tag{1}$$

where,

$$\tilde{h} \rightarrow \tilde{\gamma} + \gamma \tag{2}$$

$$\tilde{z} \rightarrow e^+ + e^- + \tilde{\gamma} \tag{3}$$

Though this is very clean signature, estimated cross section of this process is very small. ($\sigma(H^0) \approx 2pb$, assuming the top quark mass to be 40 GeV. Using the branching ratio of the process (3) to be 0.06, we can obtain 300 events at the integrated luminosity $10^{40} cm^{-2}$.) Therefore, several sources of backgrounds have been considered[1] to estimate their contribution to this signature. They can be classified into two categories, namely a physical background such as WWγ, and a detector oriented background such as mismeasurement and/or misidentification of the particles. The cross section of the QCD jets were estimated at an order of $10\mu b$ for $Pt > 100$ GeV jets at the SSC energy. So we have to have an order of 10^{-9} rejection power against the QCD backqround. In this paper, the effort was concentrated on the calculation of the probability that a QCD jet fakes single photon.

Event Generation & Simulation

In this study, ISAJET (version 5.20) adopted to the CDF package (version 4.0) was used for the QCD twojet event generation. Kinematic points used are $Pt = 100 \sim 500$ GeV and $200 \sim 600$ GeV. A simple detector simulation was performed by using a segmentation $\Delta\eta = 0.1$, $\Delta\phi = 5^o$. Particle energies were smeared by $\Delta E/E = 15\%/\sqrt{E}$ for electromagnetic component and $35\%/\sqrt{E}$ for hadronic component. The coverage of the calorimeter in η was set to ± 5. The effect of the difference in electromagnetic/hadronic energy response which affects the resolution of the jet energy was omitted here. The effect of the beam-pipe conversion and of the magnetic field were also omitted. Tracking information was also not used. To avoid the contribution from the beam jets, the events which the initial parton went out to $|\eta| > 2$ were discarded.

Identification of the electromagnetic cluster

First, a simple window algorithm with window radius D $(= \sqrt{\Delta\eta^2 + \Delta\phi^2}) \leq 1$ was applyed to measure the jet energy. The resolution of the jet energy was $14 \sim 19\%$ for the $Pt >$ 100 GeV event sample. An electromagnetic cluster (em cluster) which would be the candidate of a photon or an electron was searched inside this jet cone. The most energetic electromagnetic tower was searched and defined as the 'seed' of the em cluster. An em cluster finding algorithm CLUSTE[2] was performed onto this 'seed'. An isolation cut which requires no hadronic activity within the $D \leq 1$ cone were applyed to select photon/electron candidates.

Hadronic activity inside the cone

To establish the criteria for the isolation cut of the em cluster, underlying hadronic energy flow at the SSC energy was studied by generating $W \rightarrow e + \nu$ events with ISAJET. The jet cone was selected so that the window center has the same η as the electron from W, and 90° apart in ϕ-angle. Thus the hadronic Et sum within the cone represents the underlying hadronic activity came from beam jets and initial state bremsstrahlung. Fig.1 shows this 'off-axis' hadronic Et distribution for $W \rightarrow e+\nu$ events. The number of events generated were 1300 and 98 events were left after $Et \geq 20$ GeV cut for the em cluster. From the Fig.1, the criteria for the isolation cut of photon/electron candidate cannot go lower than 10 GeV to keep photon/electron detection efficiency high.

Fig. 1 Underlying hadronic activity

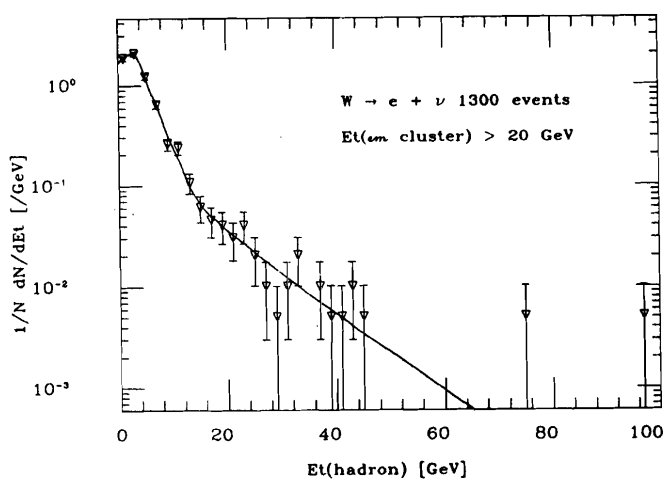

Fig.1 Underlying hadronic acitivity was measured by setting a cone of 90° apart from the electron from W decay. Events which $|\eta(\text{electron})| < 2$ and $Et(\text{electron}) > 20$ GeV were selected.

Fig. 2a Et(hadron) (Jet Pt 100 GeV)

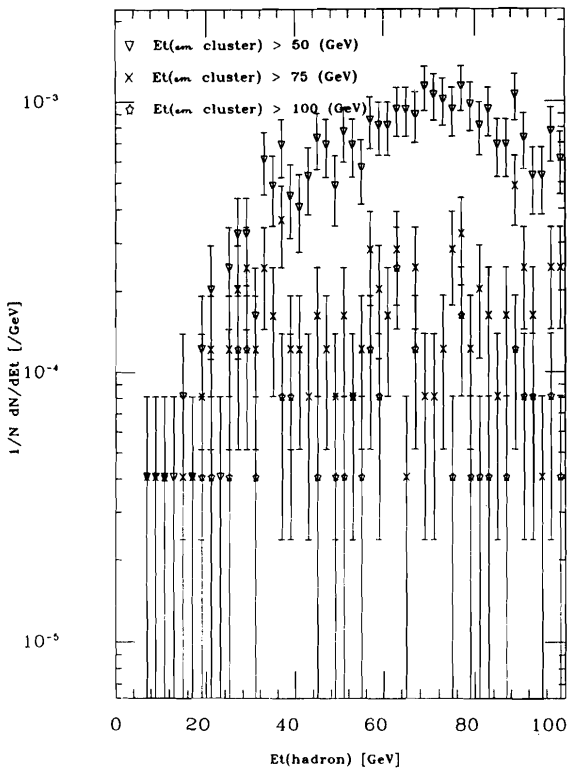

Fig. 2b Et(hadron) (Jet Pt 200 GeV)

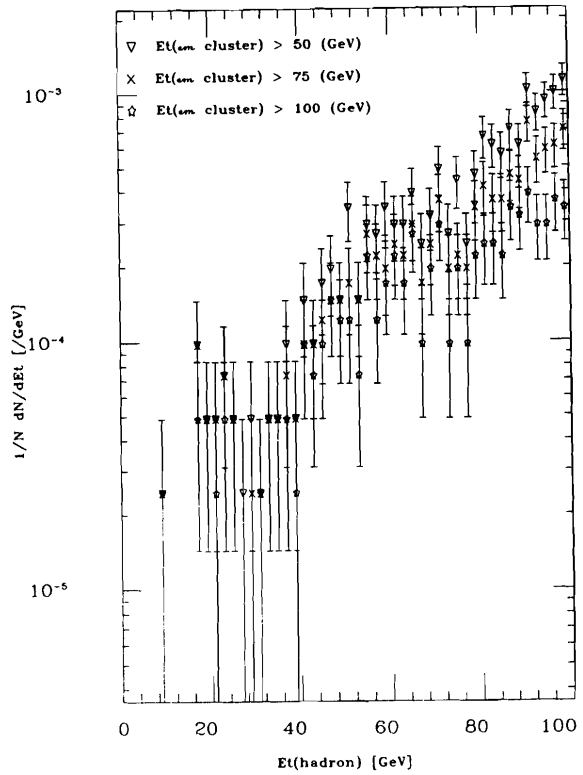

Fig.2 Hadronic activity inside the jet cone for various thresholds of *em* cluster *Et*. (a) *Pt* 100 GeV jet. (b) *Pt* 200 GeV jet.

Pt 100 GeV (12315 jets)			
Et(hadron)	*Et(em)* > 50 GeV	*Et(em)* > 75 GeV	*Et(em)* > 100 GeV
< 10 GeV	2	2	0
< 20 GeV	10	7	2
All	1175	333	109
Pt 200 GeV (20500 jets)			
Et(hadron)	*Et(em)* > 50 GeV	*Et(em)* > 75 GeV	*Et(em)* > 100 GeV
< 10 GeV	1	1	1
< 20 GeV	7	7	5
All	7077	3485	1653

Table I Number of jets passed through the isolation cuts

For $Pt > 100$ GeV jets, Fig.2a shows the hadronic activity inside the cone $D \leq 1$ around the *em* cluster at several thresholds of *em* cluster *Et*. Fig.2b is the same plot for $Pt > 200$ GeV jets. Table I also shows the number of jets remained after the isolation cut at various hadronic *Et* and *em* cluster *Et*. For the $Pt > 100$ GeV jets and the *em* cluster of which $Et \geq 50$ GeV, 2 jets were left after the cut of Et(hadron) < 10 GeV. This means 2×10^{-4} rejection power for the QCD jets faked photon/electron, even in this naive algorithm. There remains a possibility that the cut on number of towers employed in the *em* cluster and on the information from the tracking chambers will make things better. The essential point here is the requirement of the isolation of the *em* cluster. If we narrows the window size of the isolation cut, we will loose more information about the hadronic activity of the jets, and loose more rejection power against the background.

Jet fragmentation

To proceed further, I studied the fragmentation property of the jets at these SSC energies by looking into the z-distribution of the leading particle of the jet fragments, where,

$$z = \frac{dE(leading\ particle)}{dE(jet)} \tag{4}$$

The distributions are shown in Fig.3. I also plotted the energy spectrum of the 'next-leading' particle among the jet fragments in Fig.4. The meaning of this histogram is that the jets in each bin does not have the associated high energy particles above the value of the bin except for the leading particle. To interpret this distribution as a probability of a jet-faked photon/electron, one should multiply the probability of the leading particle to be an electromagnetic particle, like π^0 or η^0, which is 25%. By setting some criteria for finding photon/electron candidate, (e.g. $z > 0.9$, E(second leading) < 5 GeV), one can conclude from Fig.3 & 4 that we can again obtain an order of 10^{-4} rejection power.

CONCLUSION

The probability that a QCD jet behaves like a single *em* cluster is about $2 \sim 5 \times 10^{-4}$ for $Pt > 100$ GeV jets, by using reasonable photon/electron finding algorithm at the SSC energy. Using the tracking information will probably be able to reject these background further. To fake the signature of the process (1), an QCD process has to have all three jets to be faking photons/electrons. So the contribution of QCD background to this process is negligibly small.

Fig. 3 dN/dz of leading particle

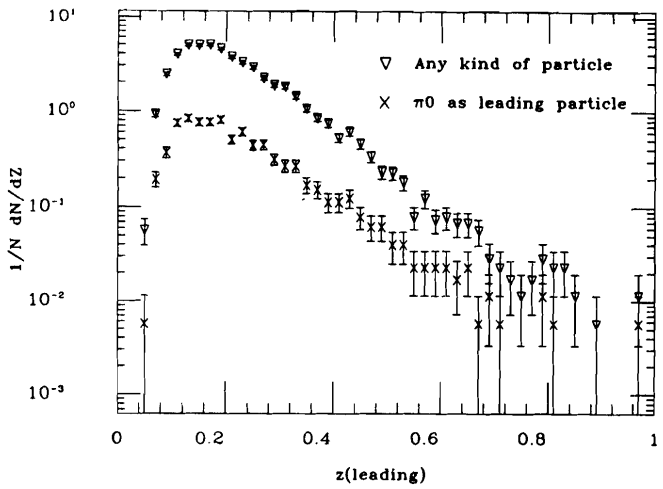

Fig.3 Energy fraction of leading particle within the jets. $Pt > 100$ GeV jets were used.

Fig. 4 Energy of second leading particle

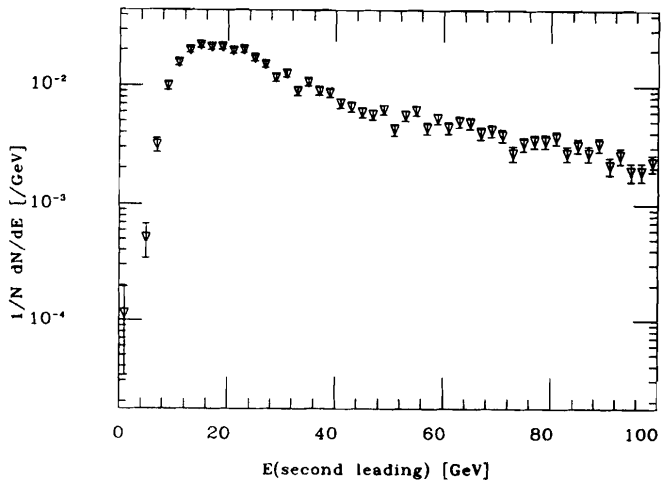

Fig.4 Energy distribution of secondary energetic particle within the jets. $Pt > 100$ GeV jets were used.

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REFERENCES

1. M.Barnett, et al, these proceedings.
2. Algorithm CLUSTE is now under developing at the CDF Data Reduction Group. This resembles to the jet finding algorithms used in UA1/UA2 except in one point that this algorithm does not use the informations from hadron calorimeters in clustering (but they are used at the filtering). The set of parameters used for this study were, seed threshold $Et \geq 3$ GeV, tower threshold $Et \geq 0.3$ GeV and parent-daughter ratio ≥ 1.