

Experimental Limits on SUSY and Other New Phenomena

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ABSTRACT

This review summarizes searches for supersymmetric particles based mainly upon recent data from H1 and ZEUS at HERA; ALEPH, DELPHI, L3, and OPAL at LEP 1.5; and CDF and D0 at the Tevatron Collider. LEP 1.5 refers to runs at the center-of-mass energies of 130 GeV and 136 GeV, intermediate energies between that of LEP 1 at energies around the Z peak and the eventual LEP 2 energy of about 192 GeV. Data from LEP 2 are not included in this review as none are yet available at the time of this conference.

A summary of some interesting candidate events from HERA, LEP 1.5, and the Tevatron Collider is also presented. These candidates have low probabilities of being from Standard Model processes.

I. INTRODUCTION

In the spirit of this workshop which addresses new accelerators with discovery potential, this review gives the latest result on searches for SUSY particles and other new phenomena. These results are due to the devoted work of many physicists at HERA, LEP, the Tevatron, and Tristan.

In November 1995, LEP raised its center-of-mass energy to 130 GeV and 136 GeV and achieved an integrated luminosity of about 6 pb^{-1} for each of the four experiments: ALEPH, DELPHI, L3 and OPAL. These data are referred to as LEP 1.5. LEP has now begun to run at the higher energy of 161 GeV, just above the threshold for the production of W pairs. From runs 1A, 1B, and 1C, the Tevatron has accumulated a total luminosity of about 120 pb^{-1} each for CDF and D0.

The results of searches for sleptons, charginos, neutralinos, squarks (including stop), and gluinos are summarized in the following sections. Most of the discussion is in context of the Minimal Supersymmetric Standard Model (MSSM). It should be noted that all of the searches summarized in this paper give only limits. However, several candidates for new phenomena from HERA, the Tevatron, and LEP are discussed in Section VIII.

II. THE MINIMAL SUPERSYMMETRIC STANDARD MODEL(MSSM)

This refers to the minimal supersymmetric extension of the Standard Model. The MSSM requires two Higgs doublets instead of only one as in the Standard Model. This two doublet structure of the MSSM yields five Higgs bosons: H_1^0 , H_2^0 , A, H^+ , and H^- . The MSSM also predicts SUSY partners for the other particles in the Standard Model. These SUSY particles to be searched for include:

sleptons $\tilde{e}, \tilde{\mu}, \tilde{\tau}, \tilde{\nu}$

charginos $\tilde{\chi}_i^\pm \quad i = 1, 2$
neutralinos $\tilde{\chi}_i^0 \quad i = 1, 2, 3, 4$
squarks $\tilde{q}$
gluinos $\tilde{g}$

Sleptons are the SUSY partners of the Standard Model charged and neutral leptons. The charginos are the mass eigenstates from $H^\pm$ and the SUSY partners of $W^\pm$. The neutralinos are the mass eigenstates from H_1^0, H_2^0 , and the SUSY partners of γ and Z. Squarks include the supersymmetric partner of the top quark, called the stop or $\tilde{t}$. Finally, gluinos are the SUSY partners of the gluons.

In the MSSM, it is convenient to define R-parity which is equal to -1 for SUSY particles, and $+1$ for Standard Model particles. If R-parity is conserved, all SUSY particles must be produced in pairs; hence, the lightest SUSY particle (LSP) is stable and cannot decay. If the LSP is neutral, then it carries away energy without being detected. Therefore, an important signature for supersymmetry is sizable missing energy in a detector. With the exception of results from HERA (discussed in Section VII) R-parity is assumed to be conserved.

Some of the parameters of the MSSM are:

μ : the supersymmetric Higgs mass term;
 M_1 : the supersymmetric breaking mass term associated with the U(1) group;
 M_2 : the supersymmetric breaking mass term associated with the $SU(2)_L$ group;
 $\tan\beta$: the ratio of the vacuum expectation values of the two Higgs doublet;
 m_0 : the universal scalar mass term.

Theoretically motivated assumptions are used to interpret search results in the context of the MSSM. For example, the gauge unification condition

$$M_1 = \frac{5}{2} \tan^2 \theta_W M_2$$

is generally assumed in the searches reported in this review.

Charginos and neutralinos are said to be *higgsino-like* if $|\mu| \ll M_2$, and *gaugino-like* if $|\mu| \gg M_2$.

III. SEARCHES FOR SLEPTONS AT ALEPH, L3, OPAL, AND TRISTAN

Figure 1 shows diagrams for the production and decay of charged sleptons from electron-positron annihilation. Figure 1(a) shows pair production of sleptons; Figure 1(b) presents an additional diagram for the pair production of selectrons, not available for other sleptons; and Figure 1(c) shows the decay of sleptons, where $\tilde{\chi}_1^0$ is the lightest neutralino. If the $\tilde{\chi}_1^0$ is the LSP, then, as seen from Figure 1(c), it will carry away energy without being detected. Therefore, a signature for the production of

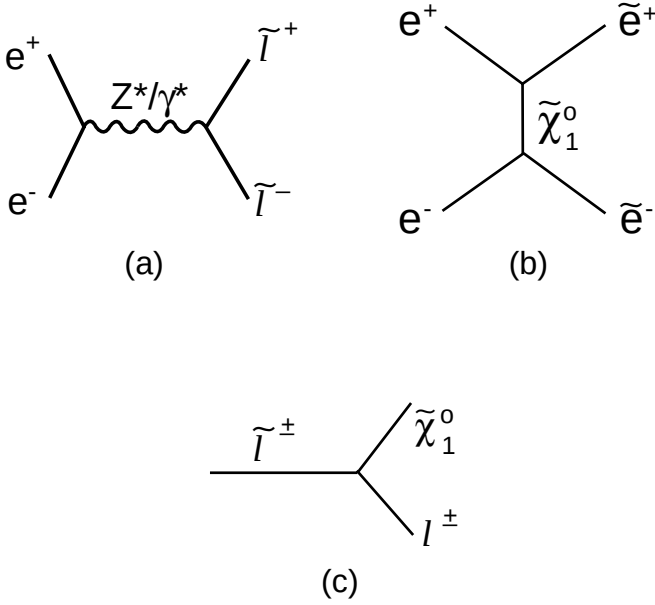


Figure 1: Feynman diagrams for the production, (a) and (b), and decay, (c), of charged sleptons in electron-positron annihilation. Here $\tilde{\chi}_1^0$ is assumed to be the lightest neutralino.

sleptons at electron-positron colliders is a pair of acoplanar leptons accompanied by missing energy. Thus far, no slepton candidate events have been observed. In the case of a right selectron, the excluded regions, based upon recent LEP data at the center-of-mass energies of 130 GeV and 136 GeV, are shown in Figures 2(a), 2(b) and 2(c) from ALEPH[1], L3[2], and OPAL[3] respectively. For the cases of scalar muons and taus, the LEP 1.5 data do not give any improvement over the previous LEP 1 data due to low production cross sections.

As shown in Figure 3(a), a different process has been used to search for evidence of selectrons at Tristram, where the center-of-mass energy is 57.8 GeV. Production of a pair of $\tilde{\gamma}$ ($\tilde{\chi}_1^0$ in Figure 1) through t-channel selectron exchange, is excluded by an analysis of single photon events. The excluded regions[4] are presented in Figure 3(b).

IV. SEARCHES FOR CHARGINOS AND NEUTRALINOS AT ALEPH, CDF, DELPHI, D0, L3, AND OPAL

A. Searches at LEP (ALEPH, DELPHI, L3, OPAL)

Feynman diagrams for the production of charginos and neutralinos in electron-positron annihilation are shown in Figures 4(a) and 5(a). In Figure 5(a), $\tilde{\chi}_1^0$ is the lightest neutralino, assumed to be the LSP, and $\tilde{\chi}_2^0$ is the next lightest neutralino, which decays into $\tilde{\chi}_1^0$.

In the case of the production of chargino pairs as shown in Figure 4(a), these two contributions interfere destructively, an ef-

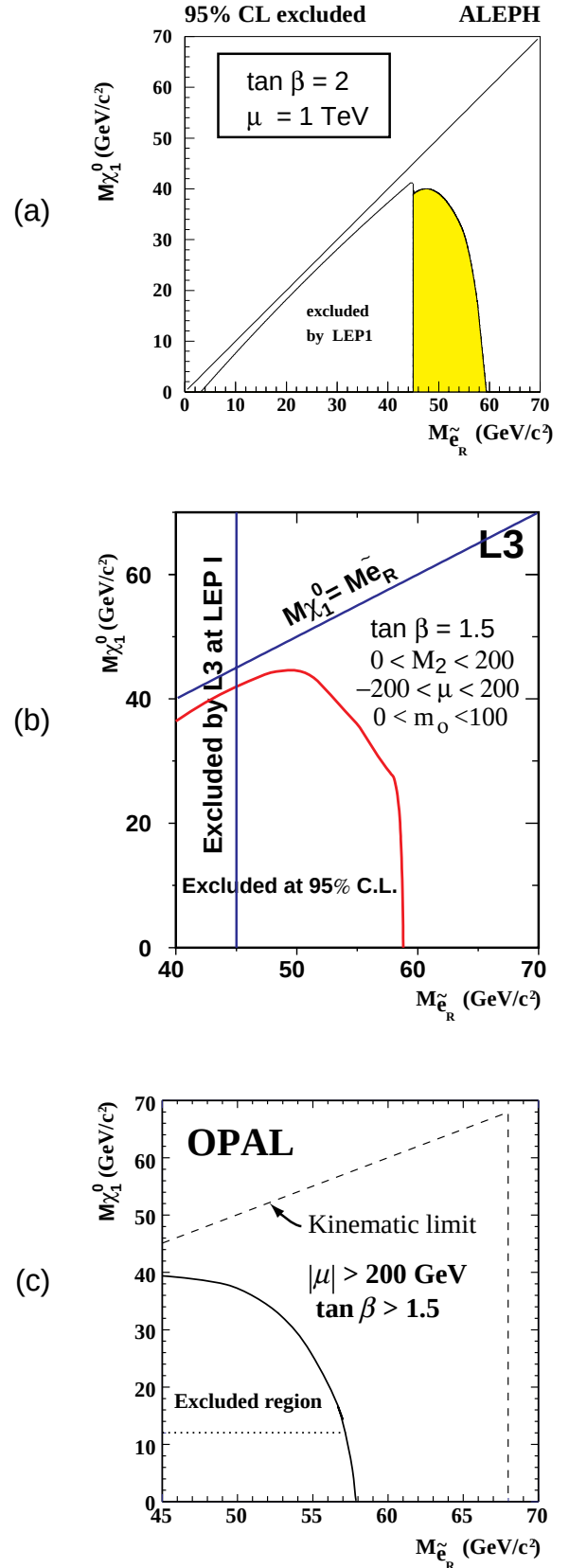


Figure 2: Excluded regions in the plane of the $\tilde{\chi}_1^0$ mass versus the right selectron mass based on LEP data at 130 GeV and 136 GeV: (a) ALEPH, (b) L3, and (c) OPAL.

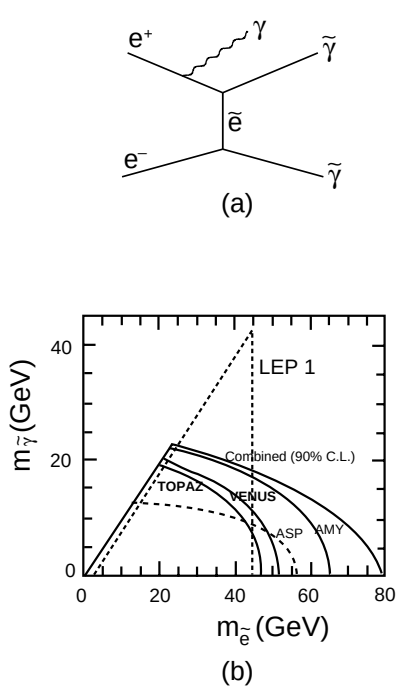


Figure 3: (a) The Feynman diagram for the process $e^+e^- \rightarrow \gamma\tilde{\gamma}\tilde{\gamma}$. (b) The 90% C.L. excluded region in the $\tilde{\gamma}$ mass versus selectron mass plane. The 95% C.L. excluded region from LEP1 is also shown.

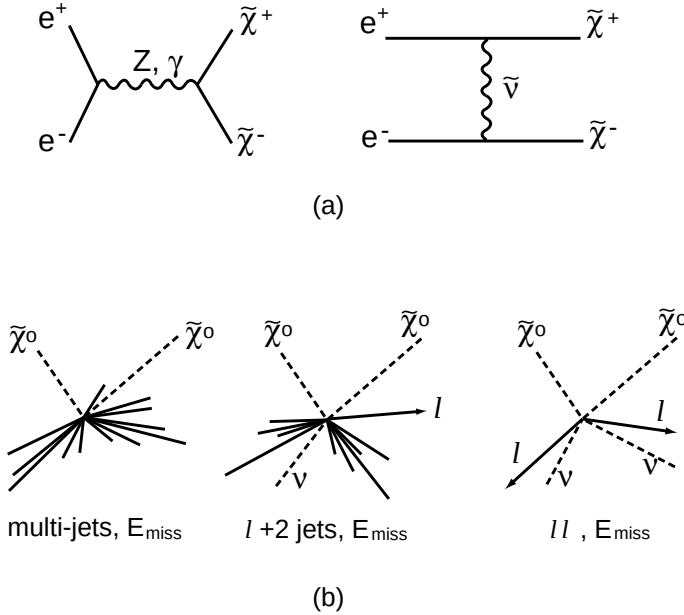


Figure 4: (a) Feynman diagrams for the production of a pair of charginos, and (b) the expected topologies for these processes.

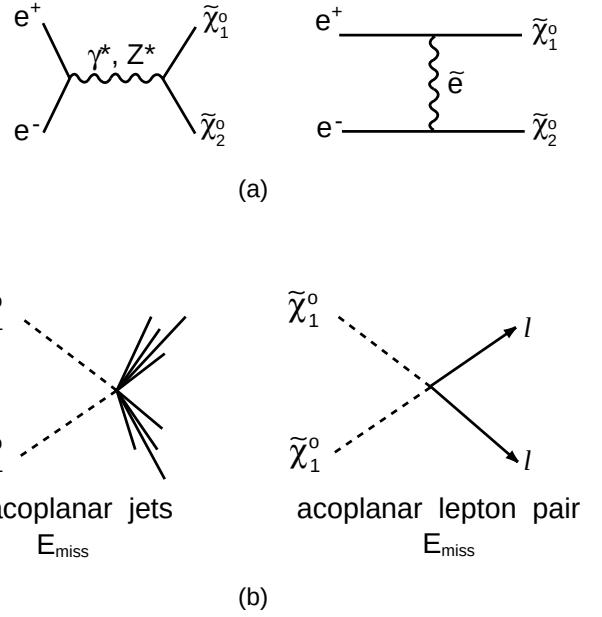


Figure 5: (a) Feynman diagrams for the production of a pair of neutralinos, and (b) the expected topologies for these processes.

fect which is most pronounced when the sneutrino $\tilde{\nu}$ is light and when $\tilde{\chi}^\pm$ is gaugino-like. When $\tilde{\nu}$ exchange can be neglected (i.e., if $\tilde{\nu}$ is very massive or if $\tilde{\chi}^\pm$ is higgsino-like) the production cross section at 136 GeV ranges from 5.5 to 18 pb when the mass of the $\tilde{\chi}^\pm$ is 60 GeV/ c^2 . This usually decays via a virtual W :

$$\tilde{\chi}^\pm \rightarrow W^\pm \tilde{\chi}_1^0 \rightarrow \begin{cases} q\bar{q}\tilde{\chi}_1^0 & 67\% \\ \ell\nu\tilde{\chi}_1^0 & 33\% \end{cases}$$

This leads to the topologies shown in Figure 4(b).

In the case of the production of neutralinos as shown in Figure 5(a), the couplings involved are more strongly model-dependent. The subsequent decay of $\tilde{\chi}_2^0$ usually proceeds via a virtual Z :

$$\tilde{\chi}_2^0 \rightarrow Z\tilde{\chi}_1^0 \rightarrow \begin{cases} q\bar{q}\tilde{\chi}_1^0 & 70\% \\ \ell\bar{\ell}\tilde{\chi}_1^0 & 10\% \\ \nu\bar{\nu}\tilde{\chi}_1^0 & 20\% \end{cases}$$

This leads to the topologies shown in Figure 5(b).

No evidence in the LEP 1.5 data has been seen for either chargino or neutralino production. DELPHI has selected one candidate (the same event for chargino and neutralino) compared with an expected background of 0.95 events. The excluded regions from L3[2] and ALEPH[1] are shown in Figures 6(a) and 6(b) respectively. DELPHI[5, 6] and OPAL[7] have obtained similar results.

B. Searches at the Tevatron (CDF, D0)

Both CDF and D0 have searched for charginos and neutralinos by looking for trilepton events, an exceptionally clean signature. Some of the production and decay diagrams that lead to

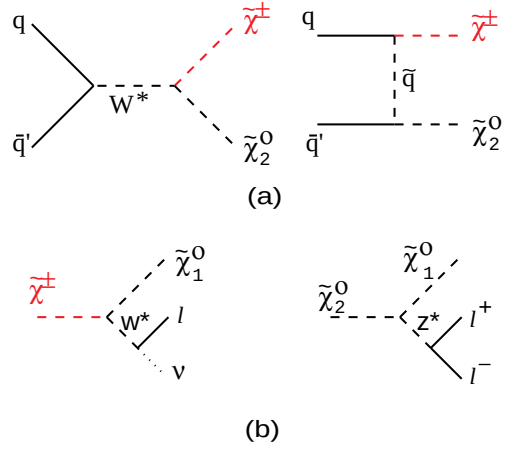
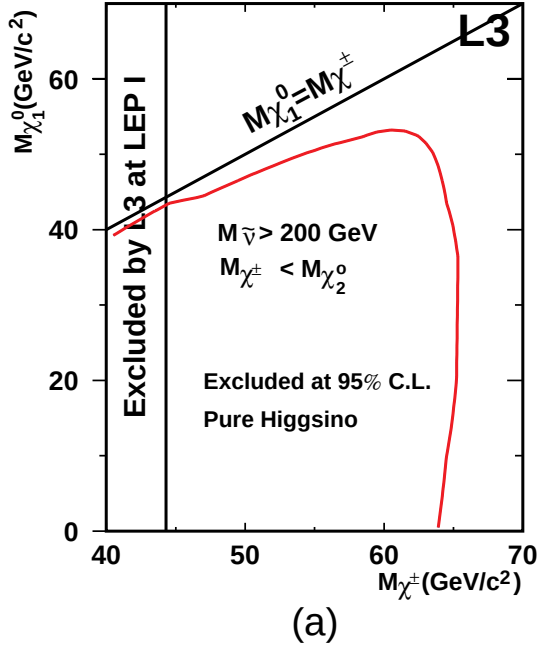


Figure 7: (a) Production and (b) decay of charginos and neutralinos at the Tevatron which lead to trilepton final states.

the trilepton final states are shown in Figure 7; other diagrams exist that give the same final states.

The results from this search are shown in Figures 8(a) and 8(b) for CDF[8] and D0[9] respectively.

C. Mass Limit for the Lightest Neutralino from ALEPH

The Lightest Supersymmetric Particle (LSP) is a good candidate for dark matter. Therefore, a limit on the LSP mass is relevant. Cosmological considerations preclude an LSP with charge or color. This leaves the neutralino and the sneutrino as likely candidates. Search results from LEP 1 and LEP 1.5 taken separately do not rule out a massless neutralino; however, ALEPH has done an analysis which combines these results, setting a lower limit on the mass of the lightest neutralino.

The result of this analysis[10] is shown in Figure 9. As seen in this figure, for $M_{\tilde{\nu}} > 200 \text{ GeV}/c^2$, the mass of the lightest neutralino must be at least $12.8 \text{ GeV}/c^2$ for $\tan\beta > 1$, and at least $34.1 \text{ GeV}/c^2$ for $\tan\beta > 10$, at 95% C.L.

V. SEARCHES FOR STOP AT DELPHI, D0, L3, AND OPAL

The search for stop – the supersymmetric partner of the top quark – has been carried out at both LEP and the Tevatron. An interesting property of the stop is that it may be the lightest squarks since due to the large mass of the top quark, the right and left stops are expected to mix significantly. Thus, the lighter stop is given by

$$\tilde{t}_1 = \tilde{t}_L \cos\theta + \tilde{t}_R \sin\theta$$

where θ is the mixing angle.

The Feynman diagrams for the production of stop pairs are shown in Figure 10(a) for LEP and 10(b) for the Tevatron. The production cross section of the process shown in Figure 10(a) for

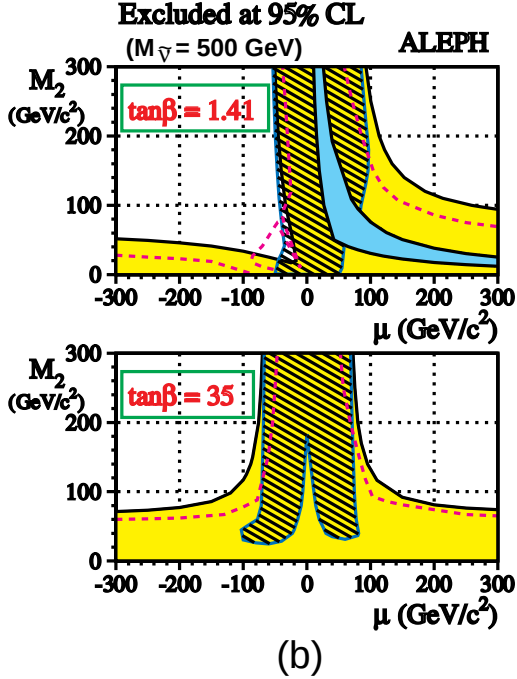


Figure 6: (a) the excluded region in the chargino versus neutralino mass plane, from L3, (b) the MSSM exclusion, from ALEPH. The shaded regions are from the chargino search, and the hatched region is from the neutralino search.

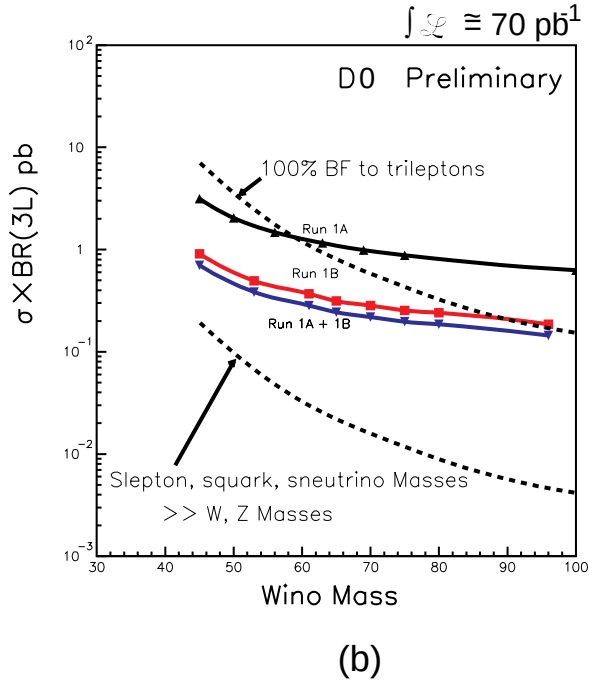
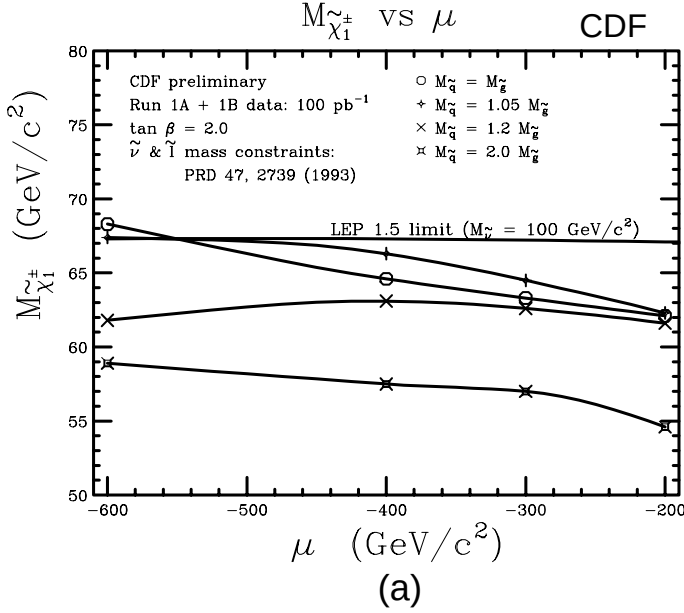


Figure 8: Results of the trilepton searches for charginos and neutralinos at the Tevatron: (a) CDF and (b) D0.

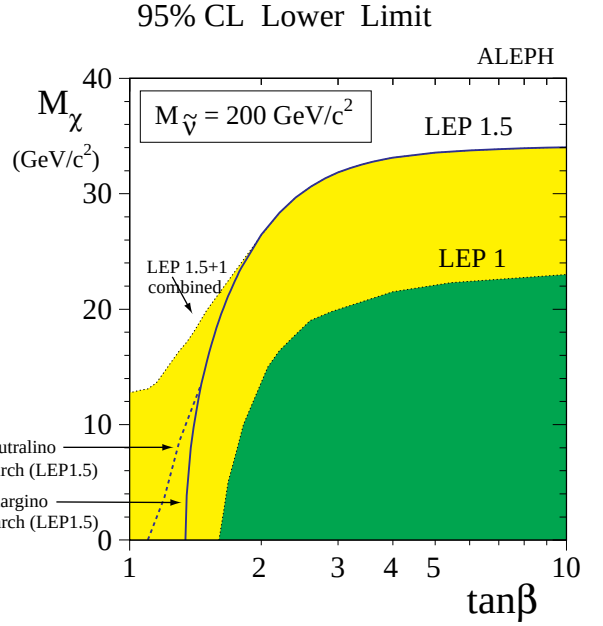


Figure 9: The lower limit on the mass of the lightest neutralino as a function of $\tan\beta$, for $M_{\tilde{\nu}} = 200 \text{ GeV}/c^2$

electron-positron annihilation varies appreciably with the value of the mixing angle θ . For example, at the center-of-mass energy of 136 GeV and for a stop mass of $60 \text{ GeV}/c^2$, the cross section is about 0.22 pb when $\theta = 0.98$ rad (when the production is entirely through the virtual photon) to about 0.65 pb when $\cos\theta = 1$.

When the mass of $\tilde{t}_1$ is sufficiently low such that it can be seen and it is the next-to-lightest Supersymmetric particle, the dominant decay mode is expected to be

$$\tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$$

This branching ratio is assumed to be 100%. Therefore the signature for the production of a stop pair is the presence of two acoplanar jets and missing energy. The result of the search for stop is shown in Figure 11 for D0[9] at the Tevatron, and respectively in Figures 12(a), 12(b), and 12(c) for DELPHI[11], L3[2], and OPAL[3] at LEP.

VI. SEARCHES FOR SQUARKS AND GLUINOS AT THE TEVATRON (CDF, D0)

Squarks and gluinos are pair produced by either quark-antiquark annihilation or gluon fusion, the former is shown in Figure 13(a). One of the many possible decay modes is shown in Figure 13(b). Note that this decay can yield a same-sign lepton pair. The topology for such a process can be either multiple jets and missing energy, as shown in Figure 13(c), or jets with lepton(s) and missing energy, as in the case for that of Figure 13(b). The resulting excluded region in the plane of the squark and the gluino masses from CDF[8] and D0[9] is shown in Figure 14.

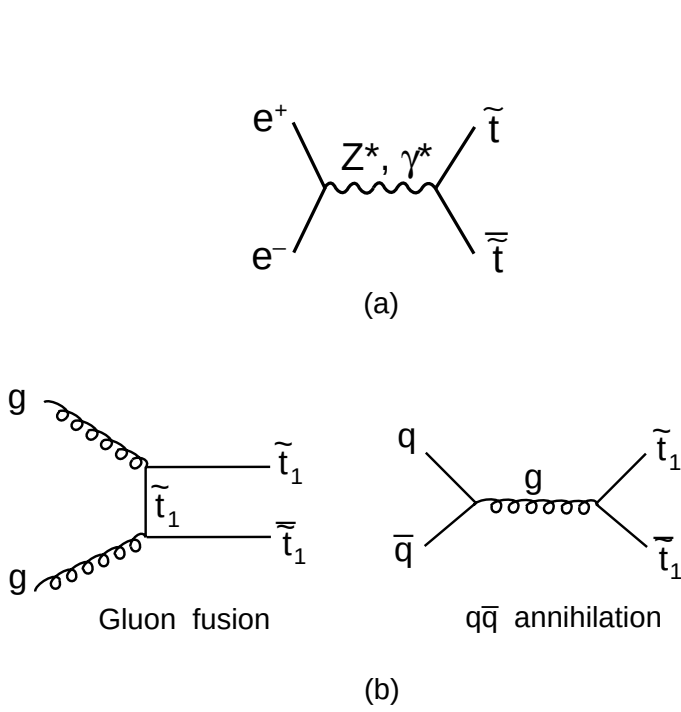


Figure 10: Feynman diagrams for the production of stop pairs at (a) LEP and (b) the Tevatron.

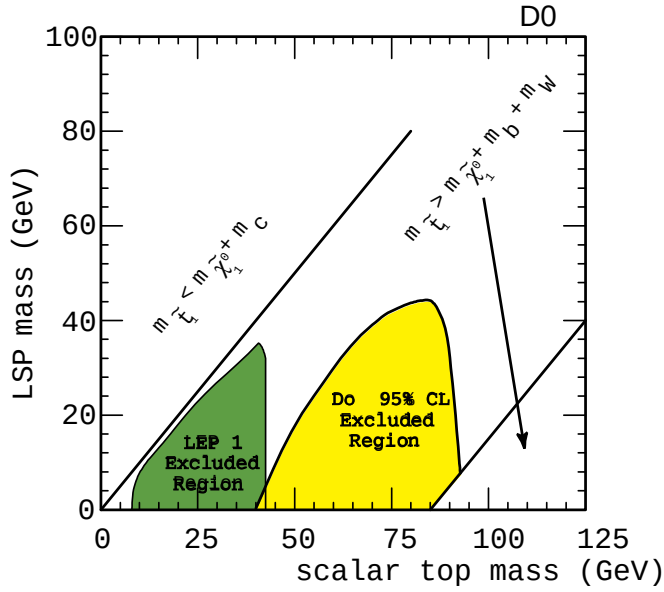


Figure 11: Excluded region in the $M_{\tilde{t}} - M_{\chi_1^0}$ plane from D0.

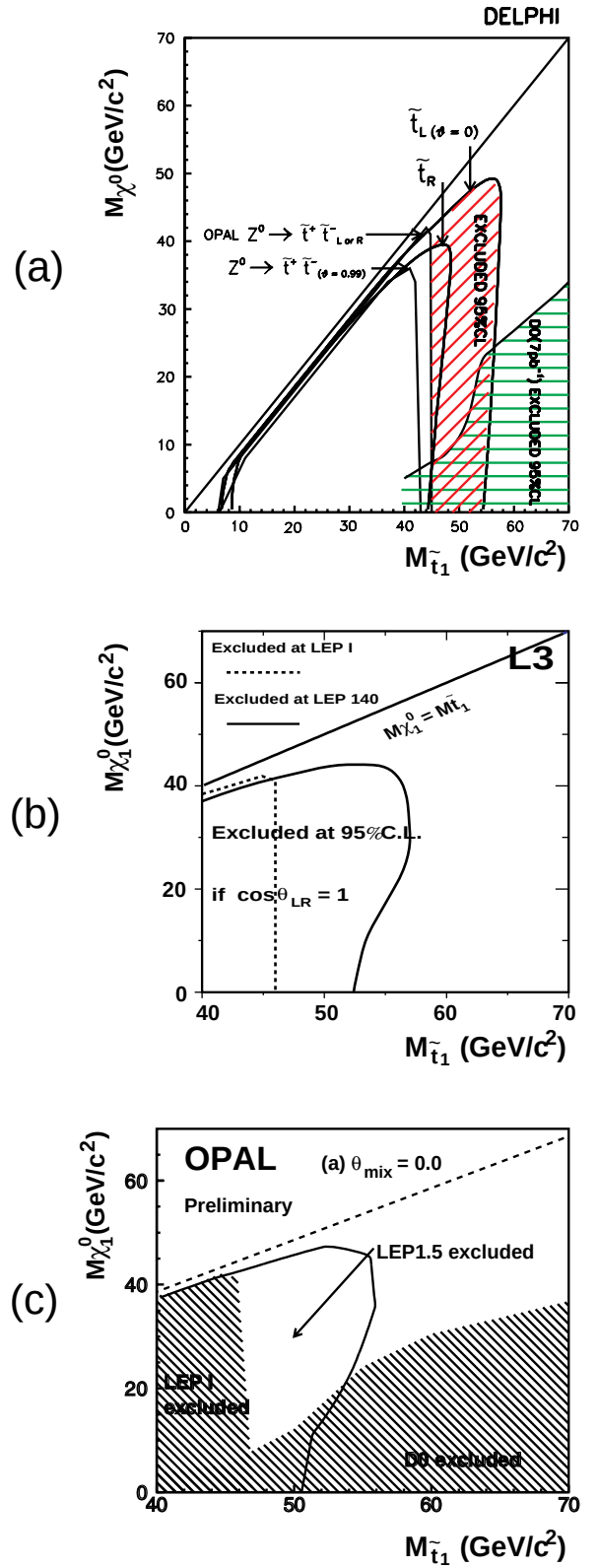


Figure 12: Excluded regions in the $M_{\tilde{t}} - M_{\chi_1^0}$ planes: (a) DELPHI, (b) L3, and (c) OPAL. In (b) and (c), the mixing angle θ is assumed to be zero.

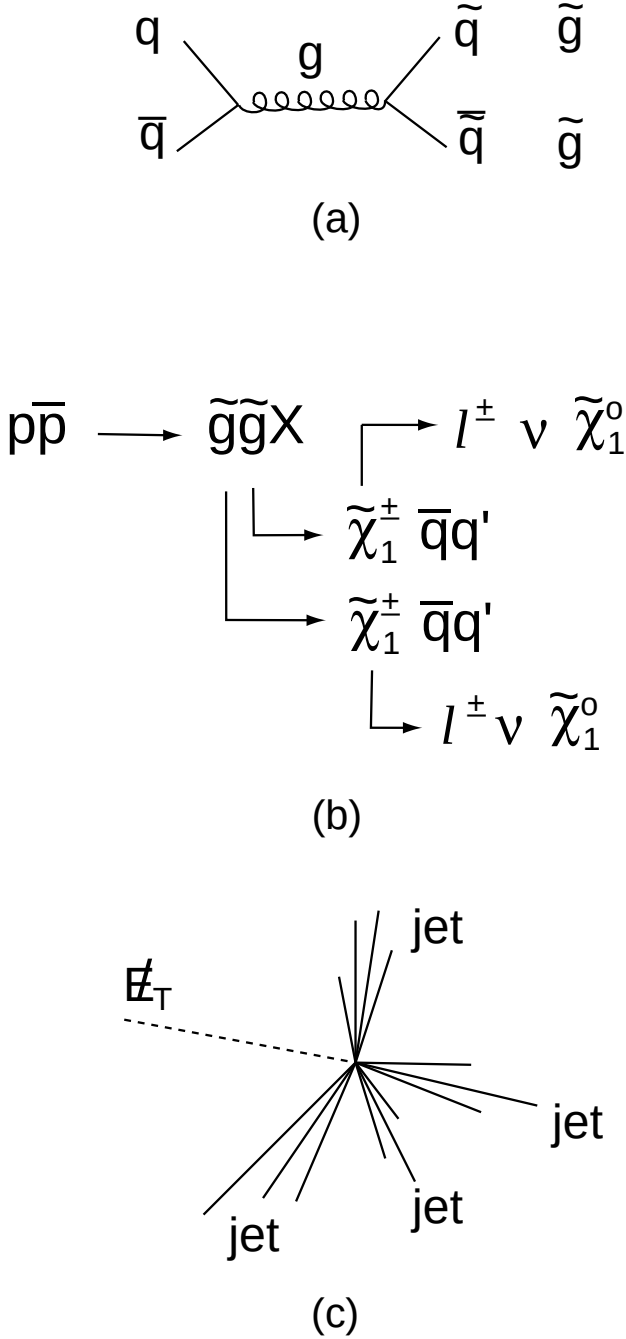


Figure 13: Examples of (a) a diagram for the production, (b) the decay, and (c) the event topology of squarks and gluinos at the Tevatron.

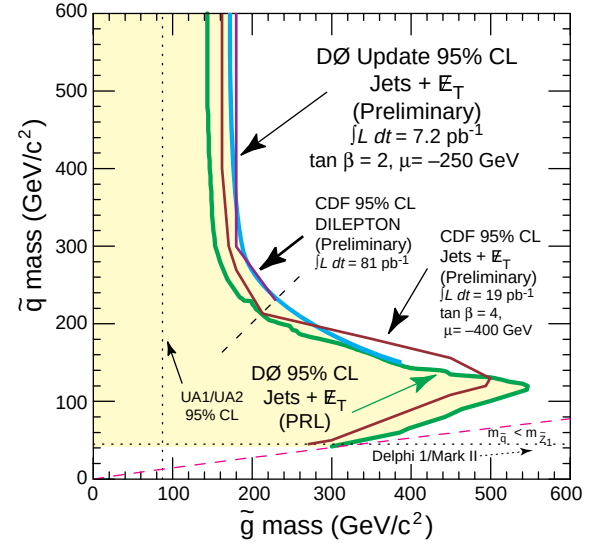


Figure 14: Excluded regions in the plane of the squark and gluino masses from CDF and DØ, (compiled by Adam Lyon of the DØ Collaboration).

VII. SEARCHES FOR SLEPTONS AND SQUARKS AT HERA (H1 AND ZEUS)

HERA has the distinction of being the only high-energy electron-proton collider in the world. In a reaction initiated by a quark and a lepton, a squark and a slepton may be pair-produced through the exchange of a neutralino. A diagram for such a process is shown in Figure 15(a). By searching for such processes, analyses conducted by H1 at HERA[12] have excluded regions in the plane of the masses of the selectron and the squark. This is shown in Figure 15(b) for three different values of M_2 , namely 50, 60 and 65 GeV/c^2 .

So far in this review, R-parity has been assumed to be conserved for the supersymmetric theory under consideration. However, since there is no convincing reason why R-parity should be conserved, a search for squarks has been carried out at HERA where R-parity could be violated. More precisely, the R-parity-violating coupling studied at HERA is of the form

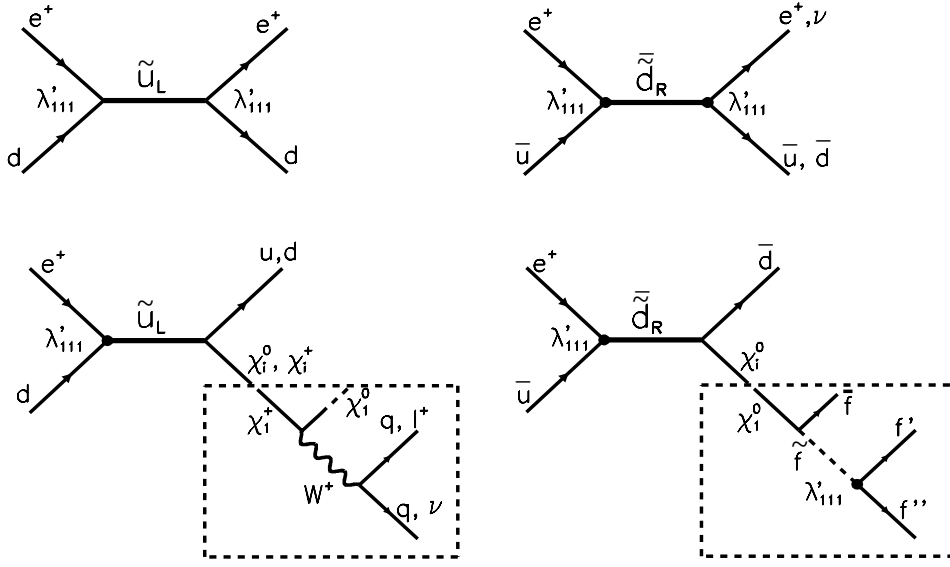
$$\lambda'_{ijk} L_i Q_j D_k$$

where L , Q and D stand for lepton, quark, and squark respectively. For example, λ'_{111} leads to the production processes

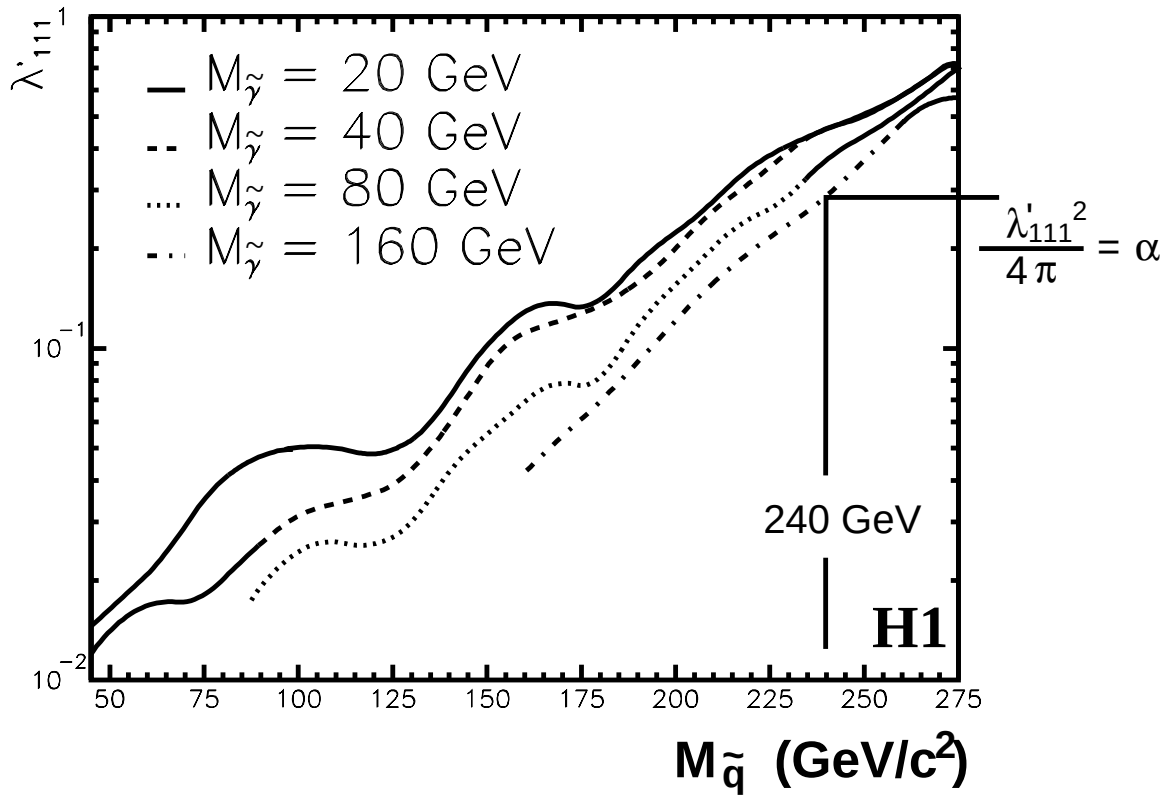
$$e^+ + \bar{u} \rightarrow \bar{d}_R \text{ and } e^+ + d \rightarrow \bar{u}_L$$

In other words, with this R-parity-violating coupling, the supersymmetric partners of quarks behave as lepto-quarks. For this reason, this search is especially suitable for HERA.

Some of the diagrams for the production and decays under consideration are given in Figure 16(a).



(a)



(b)

Figure 16: (a) Some diagrams for the production of squarks (lepto-quarks), when R-parity is not conserved, and subsequent decays. (b) Limit on the R-parity-violating coupling constant λ'_{111} as a function of the masses of $\tilde{q}$ and $\tilde{\gamma}$.

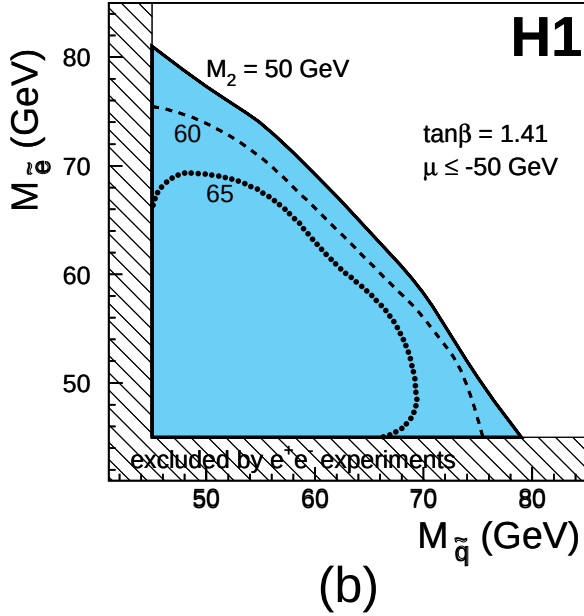
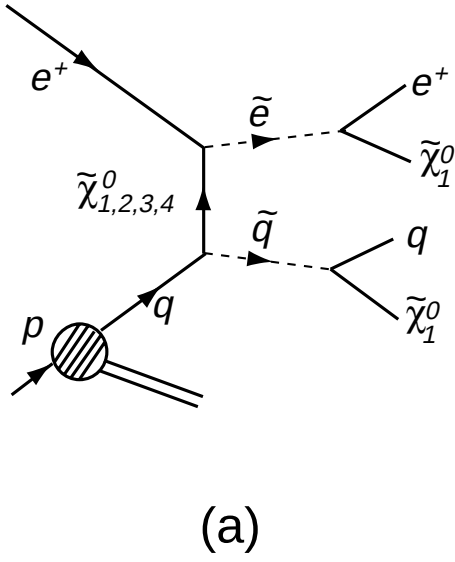


Figure 15: (a) The Feynman diagram for the pair production of a selectron and a squark at HERA; (b) the excluded region in the $M_{\tilde{e}} - M_{\tilde{q}}$ plane for different values of M_2 .

The result of this search from H1[13, 14] is shown in Figure 16(b). It is seen from this figure that the first generation squarks with R-parity-violating couplings are excluded at 95% C.L. up to a mass of $240 \text{ GeV}/c^2$ for $\lambda'_{111} \geq \sqrt{4\pi\alpha_{em}}$. A similar result has also been obtained by ZEUS[14]. With a slightly different assumption, their limit is $210 \text{ GeV}/c^2$ for $\lambda'_{111} \geq \sqrt{4\pi\alpha_{em}}$.

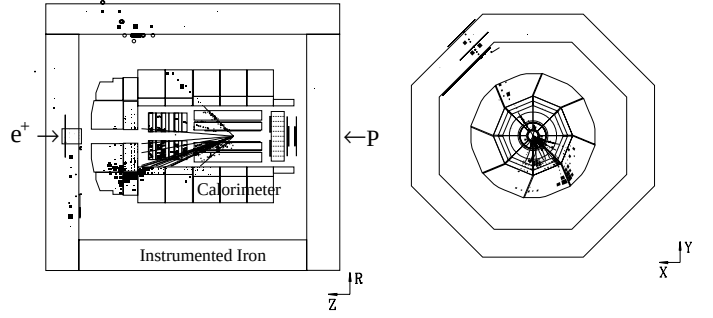


Figure 17: The H1 event of $e^+ p \rightarrow \mu^+ X$ with high transverse momentum: (a) $R - Z$ view and (b) $R - \phi$ view.

VIII. SOME INTERESTING EVENTS

All the searches summarized in the preceding sections have not led to any sign of supersymmetric particles, and hence give only excluded regions and limits. In this section, some interesting events are described.

A. An $e^+ p \rightarrow \mu^+ X$ Event with High Transverse Momentum from H1

This event, with an incident positron energy of 27.5 GeV and proton energy of 820 GeV , was recorded by H1[15] about two years ago. The transverse momentum of the produced muon is approximately $23 \text{ GeV}/c$. This event is shown in Figure 17.

One of the proposed explanations for this event was the production of a W , which subsequently decayed leptonically. At the time when this event was registered, the integrated luminosity, summed over both electron runs and positron runs, was 4 pb^{-1} ; for this integrated luminosity, the expected number for events of this type was 0.03 . No similar event has been observed at HERA since this one was recorded.

B. An $ee\gamma\gamma$ Event with Large Missing Energy from CDF

About a year ago, CDF reported but did not publish the observation of an event with an electron, a positron, two photons, and large amount of missing energy. This event is shown in Figure 18(a)[8].

The invariant mass of the electron-positron pair is much larger than the Z mass. One possibility is the production of a WW pair followed by the leptonic decay of both W 's. However, the expected number of such events from the Standard Model is less than 0.001 . Another proposed explanation of this event is the production and decay of selectron pairs, as shown in Figure 18(b). Further data are needed in this case.

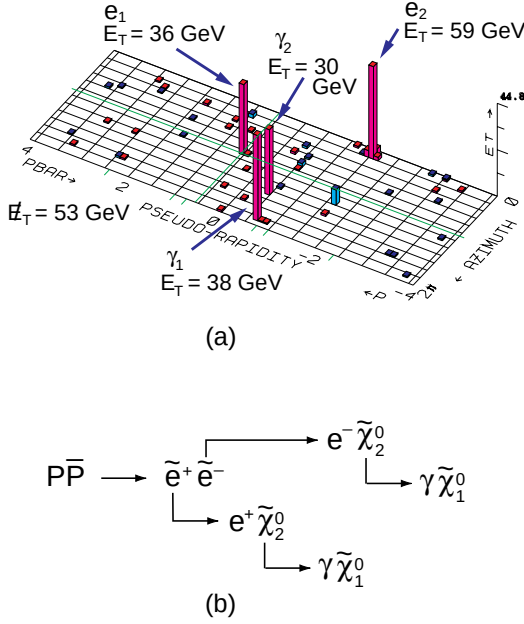


Figure 18: (a) Event display for the CDF event with $ee\gamma\gamma$ and large missing energy; (b) Production and decay of selectron pairs for proton-antiproton annihilation.

C. Four-Fermion Final States with High Multiplicity at LEP 1.5 from OPAL

An excess of $\ell^+ \ell^- q\bar{q}$ ($\ell = e, \mu$) four-fermion final states was observed by OPAL[16] at the center-of-mass energies of 130 GeV and 136 GeV. The schematic diagrams for these processes are shown in Figure 19. With an integrated luminosity of 5.3 pb^{-1} , 6 events were seen – one $e^+ e^- q\bar{q}$ and five $\mu^+ \mu^- q\bar{q}$. This number of events should be compared with $1.34_{-0.08}^{+0.10} \pm 0.17$ events expected from all known processes. The Poisson probability for the observation of six events is about 0.3%. No explanation for this excess was given.

The corresponding search at the Z peak yields no excess. An analysis performed by ALEPH, which considered $\ell^+ \ell^- q\bar{q}$ ($\ell = e, \mu$), $\ell^+ \ell^- \ell^+ \ell^-$ ($\ell = e, \mu, \tau$), and $\nu\bar{\nu} f f'$ ($f = q, e, \mu, \tau$) final states, yields five observed events for an integrated luminosity of 5.8 pb^{-1} , in agreement with the Standard Model predictions of 6.67 ± 0.38 events from four-fermion processes and $0.14_{-0.05}^{+0.19}$ events from background processes[17]. L3 also did an analysis which found no excess.

D. Four-Jet Final State at LEP 1.5 (ALEPH)

ALEPH[18] has performed an analysis of four-jet final states to search for hadronic decays of pair-produced heavy particles. At center-of-mass energies of 130 GeV and 136 GeV, an excess was observed which exhibits an enhancement in the sum of the two di-jet masses around $105 \text{ GeV}/c^2$. This is shown in Figure 20. This excess of nine events corresponds to a production cross section of $3.1 \pm 1.7 \text{ pb}^{-1}$. Furthermore, the branching ratio into

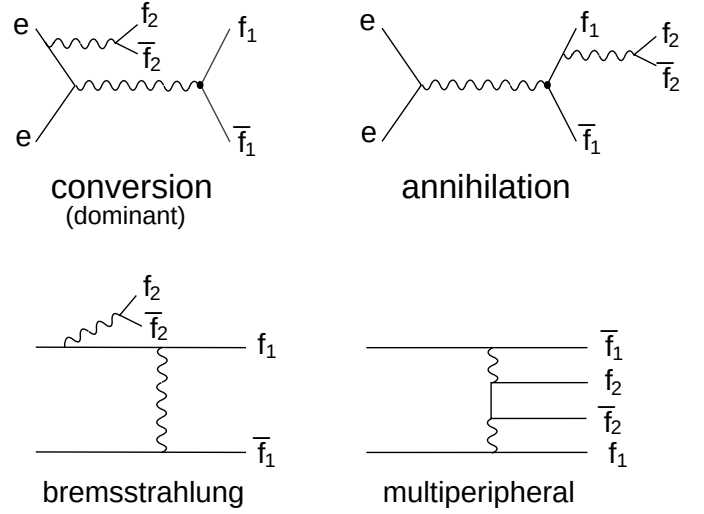


Figure 19: Schematic Feynman diagrams for four-fermion production processes.

final states with b quarks is not dominant, indicating that these events are not likely to be from the production of Higgs bosons. From the mass difference distribution, the production of equal-mass pairs is not favored. There is no clear indication of what these events are.

The other three collaborations at LEP – DELPHI[19], L3[20], and OPAL[3] – used their “ALEPH-like” analysis on their own data from LEP 1.5. Their results are shown in Figure 21. No enhancement of the significance of the ALEPH observation is seen by these experiments.

IX. CONCLUSION

New data from LEP 1.5 at the center-of-mass energies of 130 GeV and 136 GeV with an integrated luminosity of 6 pb^{-1} for each of the four experiments (ALEPH, DELPHI, L3, and OPAL) together with 120 pb^{-1} of data each from the Tevatron for CDF and D0, give no evidence of SUSY particles such as sleptons, charginos, neutralinos, squarks (including stop), and gluinos. However, improved limits have been obtained in extensive regions of SUSY parameter space.

As an example of special interest for cosmology, the 95% C.L. lower limit for the mass of the lightest supersymmetric particle (LSP), assumed to be a neutralino, is greater than $12.8 \text{ GeV}/c^2$ for $\tan\beta > 1$, and greater than $34.1 \text{ GeV}/c^2$ for $\tan\beta > 10$.

A few interesting candidate events have been seen. These events have low probabilities of being from standard processes:

- (A) One $e^+ p \rightarrow \mu^+ X$ event with high transverse momentum (H1 at Tevatron);
- (B) One event of $p\bar{p} \rightarrow ee\gamma\gamma X$ plus large missing energy (CDF at Tevatron);
- (C) Six $e^+ e^- \rightarrow \ell^+ \ell^- q\bar{q}$ events with $\ell = e, \mu$ while 1.3 events are expected (OPAL at LEP 1.5); and

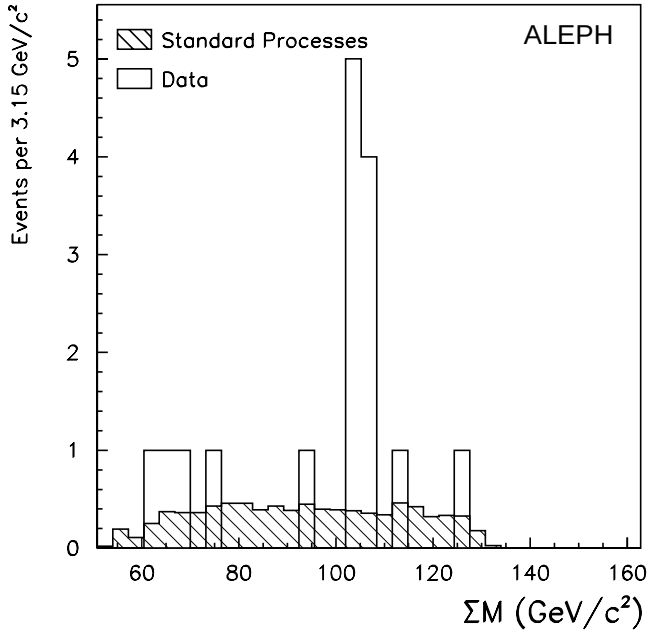


Figure 20: Distribution of the sum of the di-jet masses for the combination with the smallest mass difference for the data (histogram) at LEP1.5. The hatched histogram is the distribution expected from Monte Carlo simulations of standard processes.

(D) Nine $e^+e^- \rightarrow$ four jets with the sum of the two di-jet masses around $105 \text{ GeV}/c^2$, while 0.8 events are expected (ALEPH at LEP 1.5).

Neither (C) nor (D) have been confirmed by the other experiments at LEP 1.5.

We look eagerly forward to more data from LEP 2, HERA, and the continuous extensive analysis of data from CDF and D0.

X. ACKNOWLEDGEMENTS

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XI. REFERENCES

- [1] “Search for supersymmetric particles in e^+e^- collisions of centre-of-mass energies of 130 and 136 GeV,” (The ALEPH Collaboration) D. Buskulic et al., CERN-PPE/96-010 and *Physics Letters B* **373** (1996) 246.

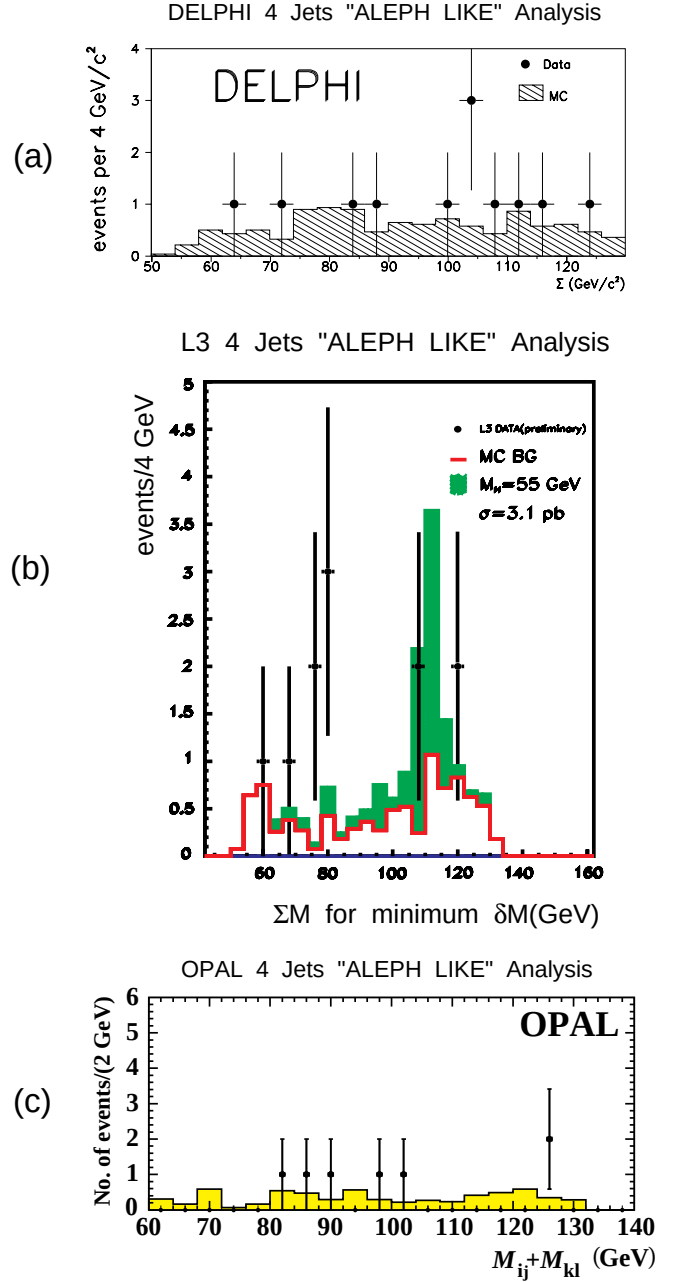


Figure 21: Results of four-jet “ALEPH-LIKE” analyses from (a) DELPHI, (b) L3, and (c) OPAL. The enhancement seen by ALEPH in the sum of the two di-jet masses around $105 \text{ GeV}/c^2$ is not confirmed.

- [2] “Search for Supersymmetric Particles at 130 GeV $\sqrt{s} < 140$ GeV at LEP,” (The L3 Collaboration) M. Acciarri et al., CERN-PPE/96-29 (Submitted to *Physics Letters B*).
- [3] “Searches for Supersymmetric Particles and Anomalous Four-Jet Production at $\sqrt{s} = 130$ and 136 GeV at LEP,” (The OPAL Collaboration) G. Alexander et al., CERN-PPE/96-09 (Submitted to *Zeitschrift für Physik*).
- [4] “New Limits on the masses of the selectron and photino,” (The AMY Collaboration) Y. Sugimoto et al., *Physics Letters* **B369** (1996) 86.
- [5] “Search for the lightest chargino at $\sqrt{s} = 130$ and 136 GeV in DELPHI,” (The DELPHI Collaboration) W. Adam et al., CERN PPE/96-75 and *Physics Letters* **B382** (1996) 323.
- [6] “Search for neutralinos, scalar leptons and scalar quarks in e^+e^- interactions at $\sqrt{s} = 130$ GeV and 136 GeV” (The DELPHI Collaboration) W. Adam et al., CERN PPE/96-110 (Submitted to *Physics Letters B*).
- [7] “Search for Chargino and Neutralino Production Using the OPAL Detector at $\sqrt{s}$ 130-136 GeV at LEP,” (The OPAL Collaboration) W. Adam et al., *Physics Letters* **B377** (1996) 181.
- [8] “Recent CDF Results,” by John Conway; talk given at SUSY 96, University of Maryland; 30 May 1996.
- [9] “SUSY Searches at D0,” by Wyatt Merritt; talk given at SUSY 96, University of Maryland; 30 May 1996.
- [10] “Mass Limit for the Lightest Neutralino,” (The ALEPH Collaboration) D. Buskulic et al., CERN-PPE/96-083 (Submitted to *Zeitschrift für Physik*).
- [11] Private communication; DELPHI Collaboration; 10 March 1996.
- [12] “A Search for Selectrons and Squarks at HERA,” (The H1 Collaboration) S. Aid et al., DESY 96-082.
- [13] “A Search for Squarks of Rp-Violating SUSY at HERA,” (The H1 Collaboration) S. Aid et al., DESY 96-056.
- [14] “Searches for SUSY Particles at HERA” by Yves Sirois; Talk given at SUSY 96, University of Maryland; 30 May 1996.
- [15] “Observation of an $e^+p \rightarrow \mu^+ X$ Event with High Transverse Momenta at HERA,” (The H1 Collaboration) S. Aid et al., DESY 94-248.
- [16] “A Study of Four-Fermion Final States with High Multiplicity at LEP,” (The OPAL Collaboration) G. Alexander et al., CERN-PPE/96-031 and *Physics Letters* **B376** (1996) 315.
- [17] “Four-fermion production in e^+e^- collisions at centre of mass energies of 130 and 136 GeV,” (The ALEPH Collaboration) D. Buskulic et al., CERN-PPE/96-088. (submitted to *Physics Letters B*).
- [18] “Four-jet final states production in e^+e^- collisions at centre-of-mass energies of 130 and 136 GeV,” (The ALEPH Collaboration) D. Buskulic et al., CERN PPE/96-052 and *Zeitschrift für Physik* **C71** (1996) 179.
- [19] “Search for Pair Production of Heavy Objects in 4-Jet Events at $\sqrt{s} = 130$ -136 GeV,” (The DELPHI Collaboration) W. Adam et al., CERN PPE/96-119 (Submitted to *Zeitschrift für Physik*).
- [20] “Four jet events from LEP,” by John Carr; talk given at SUSY 96, University of Maryland; 30 May 1996.