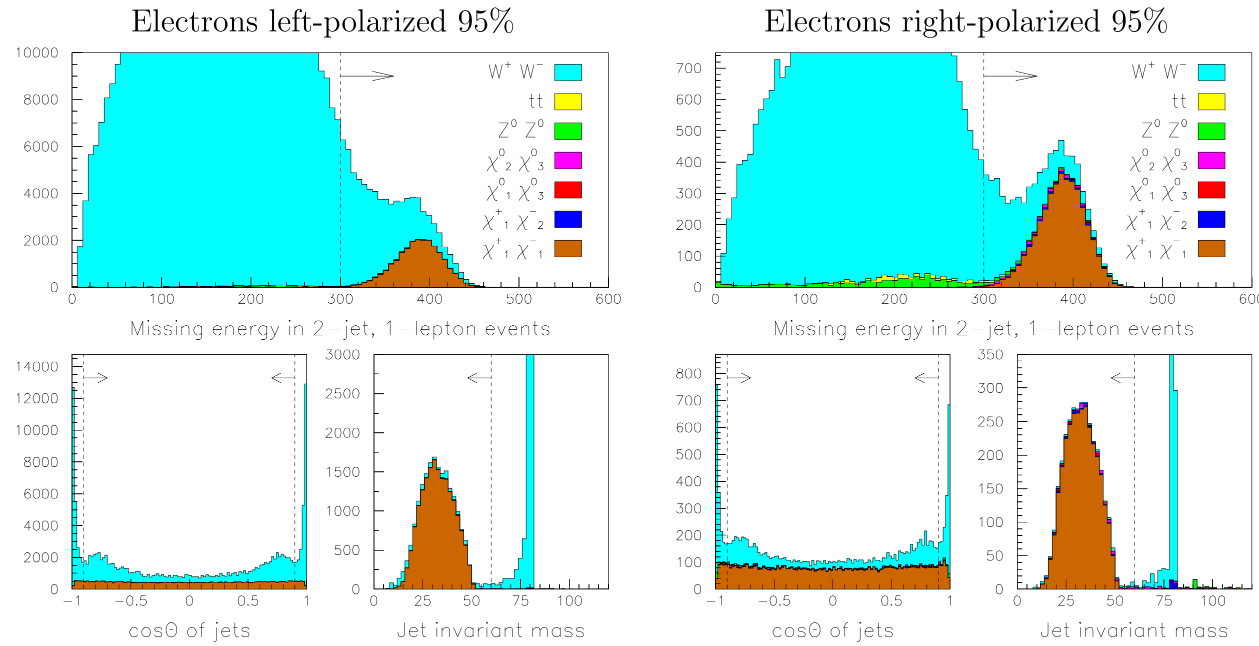

Figure 1: Event selection for light charginos from 250 fb^{-1} of e^+e^- collisions: the left set of plots have electrons 95% left-polarized and the right set have electrons 95% right polarized; positrons are unpolarized in both. Within each set, the top plot is the missing energy for events with two jets and one lepton. Bottom-left: $\cos\theta$ distribution of each jet where θ is the polar angle, with $>$ 300 GeV missing energy. Bottom-right: Invariant mass of the two jets with missing energy and $|\cos\theta| > 0.9$. SUSY charginos are distinguished from Standard Model W-pairs by requiring the invariant mass to be $<$ 60 GeV.

1 Light Charginos to Two Jets, One Lepton

$$
\begin{array}{llllllll}
e^+e^- \rightarrow & \tilde{\chi}_1^+ & & & \tilde{\chi}_1^- & & & \\
& \tilde{\chi}_1^+ & \rightarrow \tilde{\chi}_1^0 & W^+ & \tilde{\chi}_1^- & \rightarrow \tilde{\chi}_1^0 & W^- & \\
& & & W^+ \rightarrow jj & & & W^- \rightarrow \ell^-\bar{\nu} &
\end{array}
$$

The light chargino mode ($\tilde{\chi}_1^+\tilde{\chi}_1^-$) is the most copious of the four SUSY decays studied, and can be very cleanly separated from all backgrounds by requiring two jets, exactly one isolated track, and missing energy. Each $\tilde{\chi}_1^\pm$ decays into a $\tilde{\chi}_1^0$ and a virtual $W^\pm$, one $W^\pm$ decays into two jets and the other into an electron or muon, and a neutrino. The two ground-state neutralinos disappear as missing energy (along with the neutrino), and the single lepton tags the event as the decay of a pair of charged particles through $W^\pm$. The invariant mass of the two jets may then be used to veto Standard Model on-shell W bosons, and then measure the $\tilde{\chi}_1^\pm$, $\tilde{\chi}_1^0$ mass difference by identifying the upper threshold. Since the initial state energy is known and the charginos can be cleanly separated from all backgrounds, the absolute mass of the LSP $\tilde{\chi}_1^0$ can be estimated from the kinematic envelope of the two jets.

Two polarization states were studied: one in which the electrons are 95% left-polarized and another in which the electrons are 95% right-polarized, with unpolarized positrons in either case. After requiring two distinguishable jets and an isolated track, identified as a lepton, we require events to have more than 300 GeV of missing energy. At this point, the only significant background is Standard Model W-pairs. We further reject events in which either jet points within 25 degrees of the beamline ($|\cos\theta| > 0.9$ for polar angle θ), so that all of the energy and momentum of each jet is accounted for. Then we plot the invariant mass of the two jets, and reject the peak from on-shell W-pairs by requiring the invariant mass to be less than 60 GeV. All of these selection criteria are presented in Figure 1.

With these cuts, the sum of all physics backgrounds constitutes about 5–8% of the measured events, so even after background subtraction, the uncertainty in the number of chargino events seen can be taken to be approximately the square root of this number. With σ, $\mathcal{L}$, $\mathcal{B}$, and ε as the light chargino cross-section, integrated luminosity, branching fraction to our final state, and the efficiency of the cuts, respectively, the number of events after cuts ($\sigma\mathcal{L}\mathcal{B}\varepsilon$) has uncertainty $\sqrt{\sigma\mathcal{L}\mathcal{B}\varepsilon}$. Therefore, the cross-section has uncertainty

$$\sigma \pm \sqrt{\frac{\sigma}{\mathcal{L}\mathcal{B}\varepsilon}}. \tag{1}$$

The product $\mathcal{B}\varepsilon$ is 7.7% for charginos produced with left-handed electrons and 10.5% for charginos produced with right-handed electrons, so the uncertainty in these cross-section measurements scale as

$$\sigma_L = 940 \text{ fb} \pm \sqrt{\frac{940 \text{ fb}}{0.077\,\mathcal{L}}} \qquad \text{and} \qquad \sigma_R = 119 \text{ fb} \pm \sqrt{\frac{119 \text{ fb}}{0.105\,\mathcal{L}}}. \tag{2}$$

With 250 fb^{-1}, σ_L can be measured to ± 7.0 fb and σ_R can be measured to ± 2 fb.

The upper threshold in the two jet invariant mass can be used to measure the mass difference between $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_1^0$. We proceed by fitting the left-polarized jet invariant mass to the function described in section **??**, which, for our purposes, has two free parameters: the desired mass difference and $\zeta = (|C_V|^2 - |C_A|^2)/(|C_V|^2 + |C_A|^2)$. Anticipating a sensitivity to bin spacing, we perform an unbinned maximum liklihood fit to this function, with Gaussian smearing to adequately represent mismeasured jets that lie above threshold. A Gaussian smearing width of 1.2 GeV is taken from the width of the real $W^\pm$ peak. (Noting the asymmetry in the $W^\pm$ peak from Figure 1, this convolution would be improved with a low-invariant mass tail.) Invariant masses below 25 GeV are dropped from the fit, since pairs of jets with low invariant masses are likely to overlap, leading to low jet-finding efficiency. From this fit, we obtain an uncertainty in mass difference of ± 0.3 GeV and an ζ of 0.95 ± 0.02. (See the left of Figure 2.)

While the invariant mass distribution is insensitive to the absolute mass of $\tilde{\chi}_1^0$, this value can be obtained from the sum of the jet energies. The right of Figure 2 shows this distribution fitted to a curve derived from the invariant mass distribution (keeping the mass difference fixed). The jet energies distribution needs to be corrected for initial state radiation, which shifts the peak down 10 GeV, and it needs to be efficiency corrected, as the jet efficiency is noticibly poor even above the peak. The high-energy edge of this plot (which is corrected for initial state radiation and efficiency the least) is a function of $\tilde{\chi}_1^0$ mass, the $\tilde{\chi}_1^\pm$-$\tilde{\chi}_1^0$ mass difference, and the lowest invariant mass events. Since the jet-finding efficiency is low for low invariant mass events, we again restrict ourselves to events with invariant masses above

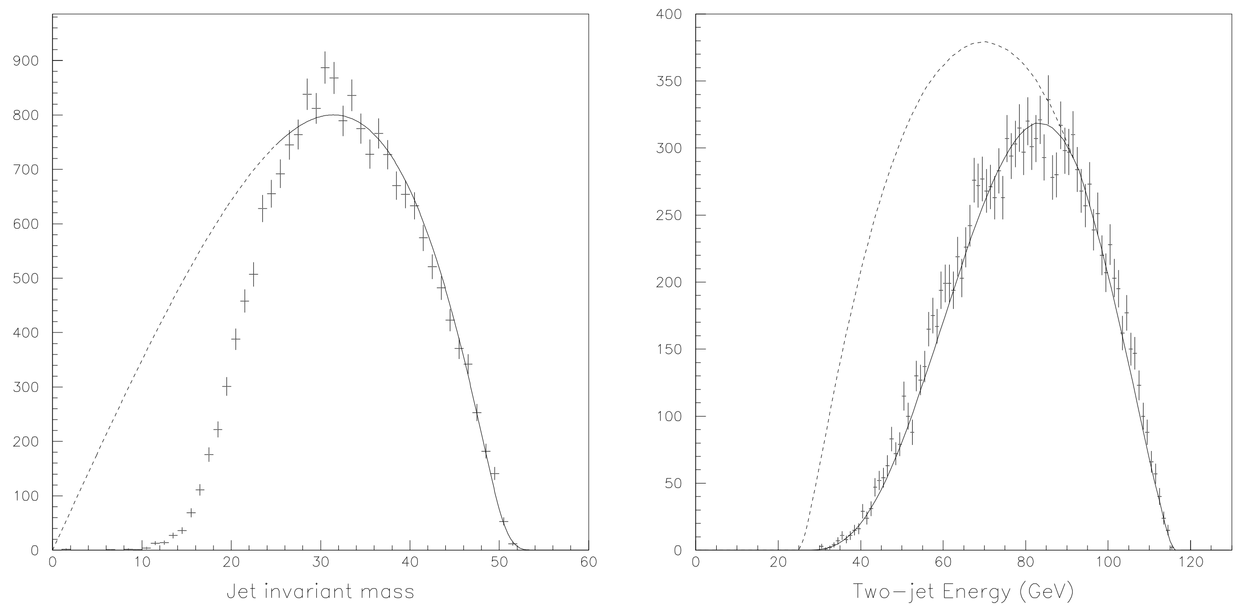

Figure 2: Light charginos from 250 fb^{-1} of e^+e^- collisions with electrons 95% left-polarized and positrons unpolarized. Left: Maximum liklihood fit to two-jet invariant mass above 25 GeV (not efficiency corrected). Right: Maximum liklihood fit to two-jet total energy (with invariant mass above 25 GeV). The dotted line is the raw spectrum, and the solid line is efficiency corrected.

25 GeV, and we fix the mass difference using the previous fit result. An unbinned maximum liklihood fit to the jet energies distribution yields a ± 0.4 GeV statistical error in the $\tilde{\chi}^0_1$ mass, with ± 0.5 GeV systematic error from uncertainty in the mass difference and ± 0.2 GeV from uncertainty in ζ. This sets the mass scale for the entire SUSY spectrum.