DETERMINATION OF THE SCALAR TOP MASS AT A LINEAR e^+e^- COLLIDER

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Four methods for the determination of the scalar top mass at an e^+e^- collider are compared.

1 Introduction

We compare four methods for measuring the scalar top mass at a future linear collider. Two of the methods rely on accurate cross section measurements, the other two use kinematic information from the observed jets. All studies have been performed for a benchmark parameter set named "SPS5 point", $m_{\tilde{t}_1} = 220.7$ GeV, $m_{\tilde{\chi}_1^0} = 120$ GeV, $\cos\theta_{\tilde{t}} = 0.5377$. The signal events contain two charm jets with large missing energy due to the unobserved $\tilde{\chi}_1^0$.

2 Mass Determination From Cross Section Measurements

Accurate cross section measurements can be combined with theoretical expectations to obtain precise determinations of the scalar top mass. This requires a high sensitivity, and we use an Iterative Discriminant Analysis (IDA) method [1] to obtain a signal to background ratio of 10 or better. The expected size of the signal is between one thousand and two thousand events in 500 fb^{-1} at a linear collider with $\sqrt{s} = 500$ GeV [2].

2.1 Use of beam polarization

A high degree of beam polarization is expected to be available at future e^+e^- colliders, and by making measurements of the production cross section in both left and right handed configurations both $m_{\tilde{t}_1}$ and $\cos\theta_{\tilde{t}}$ can be measured, as shown in Figure 1(a) and discussed in [2].

2.2 Threshold scan

Measuring the cross section for scalar top production close to threshold and fitting a theoretical curve allows the mass to be deduced. In this case the curve has a β^3 form. This is shown in Figure 1(b) for 6 points each equivalent to a luminosity of 50 fb^{-1}. In this study right hand beam polarization was assumed as this provides the best signal to background ratio.

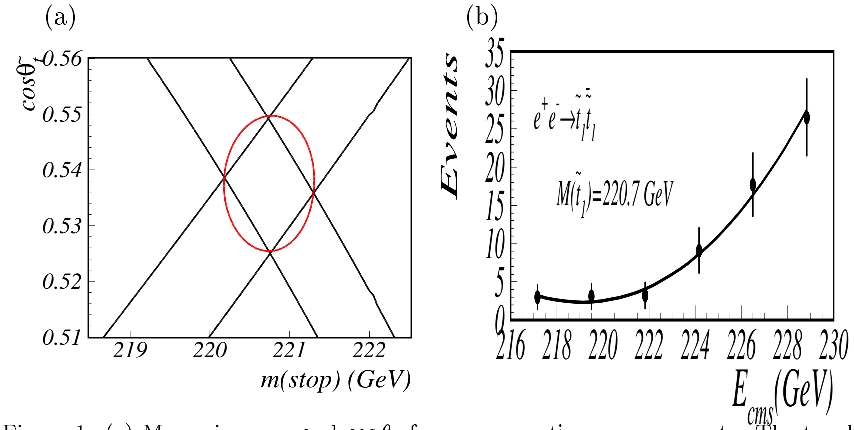

Figure 1: (a) Measuring $m_{\tilde{t}_1}$ and $\cos\theta_{\tilde{t}}$ from cross section measurements. The two bands correspond to different beam polarizations. The ellipse indicates the accuracy that could be obtained. (b) Fit of the scalar top mass from cross section determination near threshold.

3 Mass Determination From Jet Measurements

The following two methods rely on measuring the kinematics of the observed jets, and thus deriving information about the originating quarks. The quality of this measurement depends on the jet energy resolution which is expected to be several GeV in this case.

The IDA method provides an optimal signal to background ratio, but distorts the jet energy measurements, so for this part of the analysis we have used a simple cuts based method. This gives a signal to background ratio of just over 2.0 with an expected signal of 900 events.

3.1 End point method.

The energy spectrum of a particle from a two body decay is approximately a step function, whose end points contain information about the masses of both the particle that decayed, and the other particle produced in the decay, which in this case is not observed. In the case of jets, this ideal situation is distorted by detector resolution, hadronization, and jet finding, as shown in Figure 2(a).

3.2 Minimum mass method

In the case when $\mathrm{m}_{\tilde{\chi}_1^0}$ is known one can calculate the minimum allowed mass of the two jets in an event [3]. Figure 2(b) shows an example of the distribution of this variable. Fitting this with prediction from Monte Carlo allows a precise determination of $m_{\tilde{t}_1}$ to be performed.

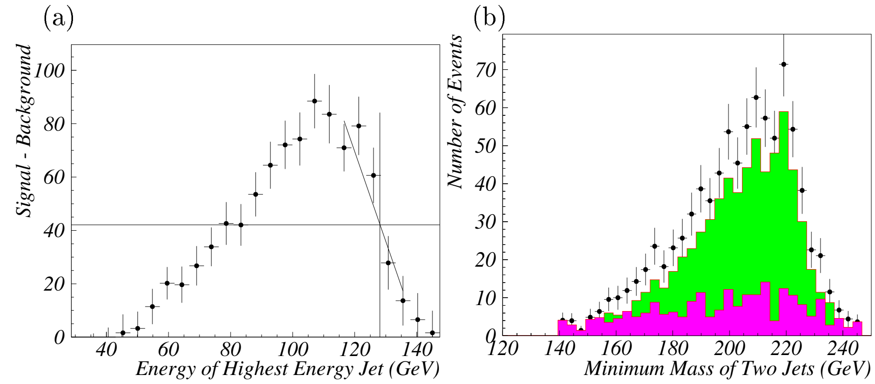

Figure 2: Examples of (a) measuring the maximum jet energy end point and (b) the minimum mass of two jets. The points with error bars are the simulated signal. The green histogram is the scalar top signal and the magenta histogram is the expected background.

4 Conclusions

The precision of the mass determination of the four methods described are summarized in the following table. Slightly higher precision is obtained from the polarization method, however the large theoretical uncertainties, which are up to now dominant are not included. Overall a high sensitivity on the mass determination can be achieved.

Method	Δ_m (GeV)	Luminosity	Comment
Polarization	0.57	$2 \times 500\,\mathrm{fb}^{-1}$	no theory errors included
Threshold scan	1.2	$300\,\mathrm{fb}^{-1}$	right hand polarization
End point	1.7	$500\,\mathrm{fb}^{-1}$	
Minimum mass	1.5	$500\,\mathrm{fb}^{-1}$	assumes $\mathrm{m}_{\tilde{\chi}_1^0}$ known

References

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3. J. Feng and D. Finnell, Phys.Rev. **D49** (1994) 2369.