Correction to "Mass Determination Method for $\widetilde{e}^{\mp}_{R/L}$ Above Production Threshold[1]"

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(July 31, 2002)

This paper describes a correction to the method for the determination of Supersymmetric particles with handedness dependent masses; presented in a paper by Mihai Dima, et. al.[1]. Dima's paper in turn is a modification of the end-point method[2, 3] for finding Supersymmetric particle masses.

The correction described here is to equation (8) in Dima[1]. In this paper are derived a set of four equations that are solved for the masses of the corresponding right and left handed selectrons, in terms of the boost and center of mass energy. The corrected equations are given here:

$$M_{\widetilde{e}_L} = \frac{1}{2}\sqrt{s}\frac{\gamma_{\widetilde{e}_R}\sqrt{s} - 2E^*_{e,R}}{\gamma_{\widetilde{e}_L}\gamma_{\widetilde{e}_R}\sqrt{s} - \gamma_{\widetilde{e}_L}E^*_{e,R} - \gamma_{\widetilde{e}_R}E^*_{e,L}} \tag{1}$$

$$M_{\widetilde{e}_R} = \frac{1}{2}\sqrt{s}\frac{\gamma_{\widetilde{e}_L}\sqrt{s} - 2E^*_{e,L}}{\gamma_{\widetilde{e}_L}\gamma_{\widetilde{e}_R}\sqrt{s} - \gamma_{\widetilde{e}_R}E^*_{e,L} - \gamma_{\widetilde{e}_L}E^*_{e,R}} \tag{2}$$

where
($\widetilde{e}_L$ and $\widetilde{e}_R$) denotes the Left and Right handed Selectrons.
($\widetilde{\chi}^0_1$) denotes the Chi(1,0) particle.
($E^*_{e,R/L}$) denotes the center of mass energy of the left or right handed electron.
($\gamma_{\widetilde{e}_{R/L}}$) denotes the boost of the left or right handed Selectron.
Below we show the derivation of equation 1 which is equation 8 in Dima et. al. paper. Calculating the boost of the right and left handed selectron:

$$\sqrt{s} = E_{\widetilde{e}_R} + E_{\widetilde{e}_L} = E_{\widetilde{e}_R} + \sqrt{M^2_{\widetilde{e}_L} + P^2_{\widetilde{e}_L}} \tag{3}$$

Substituting: $P^2_{\widetilde{e}_L} = P^2_{\widetilde{e}_R} = E^2_{\widetilde{e}_R} - M^2_{\widetilde{e}_R}$

$$\sqrt{s} = E_{\widetilde{e}_R} + \sqrt{M^2_{\widetilde{e}_L} + E^2_{\widetilde{e}_R} - M^2_{\widetilde{e}_R}} \tag{4}$$

Squaring both sides, and solving for $E_{\widetilde{e}_R}$ gives:

$$E_{\widetilde{e}_R} = \frac{M^2_{\widetilde{e}_R} - M^2_{\widetilde{e}_L} + s}{2\sqrt{s}} \tag{5}$$

A similar equation can be obtained for $E_{\widetilde{e}_L}$ namely:

$$E_{\widetilde{e}_L} = \frac{M^2_{\widetilde{e}_L} - M^2_{\widetilde{e}_R} + s}{2\sqrt{s}} \tag{6}$$

The boost is defined as:

$$\gamma_{\widetilde{e}_{R/L}} = \frac{E_{\widetilde{e}_{R/L}}}{M_{\widetilde{e}_{R/L}}}$$

Which leads us to the following four equations from Dima et. al. paper[1] shown below.

$$2\gamma_{\tilde{e}_R} M_{\tilde{e}_R} \sqrt{s} = s + (M^2_{\tilde{e}_R} - M^2_{\tilde{e}_L}) \quad (7)$$

$$2\gamma_{\tilde{e}_L} M_{\tilde{e}_L} \sqrt{s} = s + (M^2_{\tilde{e}_L} - M^2_{\tilde{e}_R}) \quad (8)$$

Assuming the mass of the electron is zero and writing the conservation of energy equations in the Selectron rest frame gives:

$$2E^*_{e,R} M_{\tilde{e}_R} = M^2_{\tilde{e}_R} - M^2_{\tilde{\chi}^0_1} \quad (9)$$

$$2E^*_{e,L} M_{\tilde{e}_L} = M^2_{\tilde{e}_L} - M^2_{\tilde{\chi}^0_1} \quad (10)$$

Subtracting equation (9) from (10) gives:

$$2E^*_{e,L} M_{\tilde{e}_L} - 2E^*_{e,R} M_{\tilde{e}_R} = (M^2_{\tilde{e}_L} - M^2_{\tilde{e}_R}) \quad (11)$$

$$2E^*_{e,R} M_{\tilde{e}_R} - 2E^*_{e,L} M_{\tilde{e}_L} = (M^2_{\tilde{e}_R} - M^2_{\tilde{e}_L}) \quad (12)$$

Substituting the result into equations (7) and (8)

$$2\gamma_{\tilde{e}_R} M_{\tilde{e}_R} \sqrt{s} = s + 2E^*_{e,R} M_{\tilde{e}_R} - 2E^*_{e,L} M_{\tilde{e}_L} \quad (13)$$

$$2\gamma_{\tilde{e}_L} M_{\tilde{e}_L} \sqrt{s} = s + 2E^*_{e,L} M_{\tilde{e}_L} - 2E^*_{e,R} M_{\tilde{e}_R} \quad (14)$$

Solving for $M_{\tilde{e}_R}$ or $M_{\tilde{e}_L}$ by adding equations (13) and (14):

$$M_{\tilde{e}_R} = \frac{\sqrt{s}}{\gamma_{\tilde{e}_R}} - \frac{\gamma_{\tilde{e}_L}}{\gamma_{\tilde{e}_R}} M_{\tilde{e}_L} \quad (15)$$

Substituting $M_{\tilde{e}_R}$ into equation (13) or (14) and solving for $M_{\tilde{e}_L}$ gives us the correct equations. See equation (8) in Dima[1]

$$M_{\tilde{e}_L} = \frac{1}{2}\sqrt{s} \frac{\gamma_{\tilde{e}_R}\sqrt{s} - 2E^*_{e,R}}{\gamma_{\tilde{e}_L}\gamma_{\tilde{e}_R}\sqrt{s} - \gamma_{\tilde{e}_L} E^*_{e,R} - \gamma_{\tilde{e}_R} E^*_{e,L}} \quad (16)$$

$$M_{\tilde{e}_R} = \frac{1}{2}\sqrt{s} \frac{\gamma_{\tilde{e}_L}\sqrt{s} - 2E^*_{e,L}}{\gamma_{\tilde{e}_L}\gamma_{\tilde{e}_R}\sqrt{s} - \gamma_{\tilde{e}_R} E^*_{e,L} - \gamma_{\tilde{e}_L} E^*_{e,R}} \quad (17)$$

References

Note: All the papers with CU-HEP numbers can be found on the web at:
http://hep-www.colorado.edu/SUSY/.

[1] Dima, Mihai et al. *Mass Determination Method for $\tilde{e}^{\pm}_{R,L}$ Above Production Threshold.* December, 2001. COLO-HEP 478.

[2] Goodman, Elizabeth. *The Search for the Supersymmetric Selectron.* April, 1998. COLO-HEP 398.

[3] Williams, Brook *Study of the Production of Supersymmetric Particles.* April, 1998. COLO-HEP 402.