Radiative Corrections to Chargino Production with Polarized Beams

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Abstract.
We show that radiative corrections to chargino production in electron–positron annihilation with polarized beams can be large especially in the case of right handed electrons. In addition, there is some dependency on the squark masses that allows us to extract information about the squark spectrum from the chargino production.

If supersymmetry is realized in nature, charginos[1] should be discovered at the LHC (or at the Tevatron if they are light enough). Nevertheless, it is at a future electron-positron collider where the necessary precision [2] on the measurements of masses and cross-sections can be achieved in order to extract the fundamental SUSY parameters of the theory [3]. Furthermore, knowing the SUSY parameters at the weak scale, allow us to infer information on physical principles at very high energy scales [4]. In this way, it is clear the importance of including one-loop radiative corrections to the masses [5] and cross sections [6,7].

The importance of beam polarization and chargino helicities [8] has also been stressed, and radiative corrections to chargino production with polarized electron and positron beams have been calculated recently [9,10]. Here we report on this calculation [9], and show that most of the time the corrections are non-negligible, and some times they are very large, especially when the electrons are right-handed polarized. The calculation is done in the $\overline{MS}$ scheme and we include quarks and squarks in the loops, gaining a color factor $N_c = 3$ over the rest of the loops and an additional factor of $N_g = 3$ over loops involving gauge and Higgs bosons. Charginos can be produced in electron-positron annihilation via intermediate Z and photons in the s-channel and via electron-sneutrinos in the t-channel. The corrections reported here can be organize into $Z\tilde{\chi}^+\tilde{\chi}^-$, $\gamma\tilde{\chi}^+\tilde{\chi}^-$, and $e^\pm\tilde{\nu}_e\tilde{\chi}^\mp$ corrected vertices [9].

Fig. 1 shows the cross-section for a beam of left-handed electrons for the produc-

[1)] See [1] for latest experimental (negative) results on chargino searches.

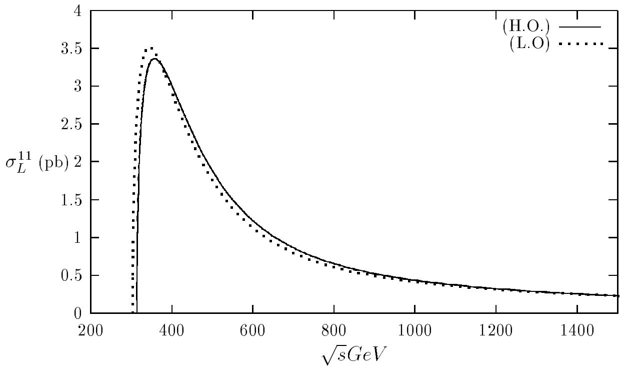

FIGURE 1. Lowest order (L.O.) and higher order (H.O.) cross-section for lightest chargino pair production for left-polarized electrons with $\tan\beta = 5$ and the other parameters as given in the text.

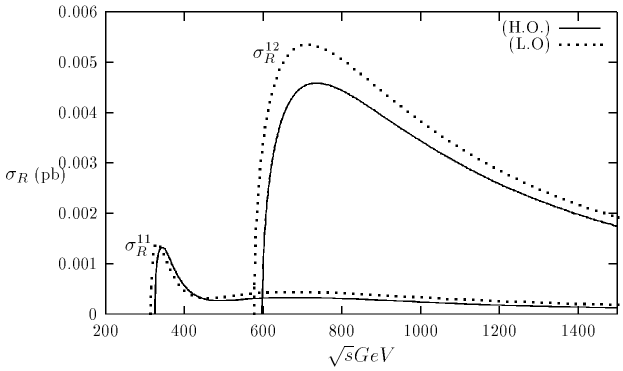

FIGURE 2. Lowest order (L.O.) and higher order (H.O.) cross-sections for lightest and unequal mass chargino pair production for right-polarized electrons with $\tan\beta = 50$ and the other parameters as given in the text.

tion of two lightest charginos. We consider running parameters $M_2 = 165$ GeV, $\mu = 400$ GeV, and $\tan\beta = 5$ at the scale $Q = m_z$. For the squark soft parameters we take, for simplicity, degenerate values $M_Q = M_U = M_D = 500$ GeV and $A \equiv A_U = A_D = 500$ GeV. For definiteness, we take the sneutrino mass to be degenerate with the squark mass parameters. We observe that the peak of the cross section is reduced due to one-loop radiative corrections by 4%. The values of the chargino masses in this case are: 151 and 421 GeV for the running masses and 157 and 431 GeV for the pole masses. Therefore, the shift in the threshold in Fig. 1 corresponds to an increase of 4% in the lightest chargino mass.

Cross-sections for a beam with right-handed electrons are smaller than for the left-handed electron case. For this reason, the effect of radiative corrections tends to be more important. In addition, at large values of $\tan\beta$ radiative corrections are also larger due to the increase on the top and bottom yukawa couplings. This can be seen in Fig. 2 where we have taken $\tan\beta = 50$ [2], with the rest of the parameters

[2] This high value of $\tan\beta$ is favored by $SO(10)$ inspired models with top-bottom-tau Yukawa

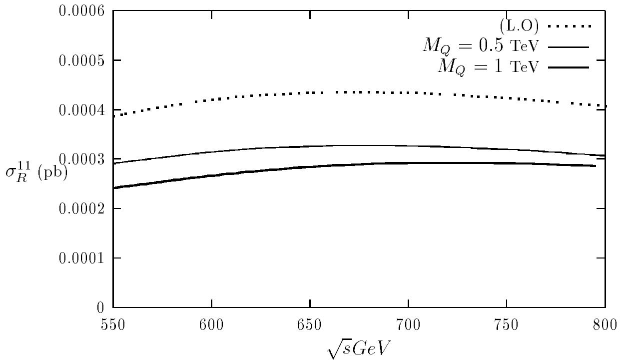

FIGURE 3. Detailed blow-up of cross-sections for right-polarized electrons for the lightest chargino pair with $\tan\beta = 50$. The H.O. cross-sections are for degenerate squark soft mass parameters of 0.5 TeV and 1 TeV.

as in the previous figure. Corrections to the peak cross section are -14% for the case of mixed production of $\tilde{\chi}_1^+\tilde{\chi}_2^-$ (a factor of two should be added if we include the case $\tilde{\chi}_2^+\tilde{\chi}_1^-$), and -6% for the production of a pair of the lightest charginos. Despite the smallness of the cross-section, with luminosities of the order of $1\,ab^{-1}$ these signals will be measurable. Note that right-handed electrons do not couple to charginos and, therefore, the sneutrino contribution to the cross section σ_R is not present.

Corrections to σ_R^{11} away from the peak of the cross-section are larger. In Fig. 3 we show a blow-up of the region with intermediate values of the center of mass energy. For example, for $\sqrt{s} = 650$ GeV the one-loop corrected cross-section is 25% smaller than the tree level cross section. In addition, we show the case where the squark mass parameters are degenerate and equal to 1 TeV. In this case, for $\sqrt{s} = 650$ GeV the correction is -35%. This squark mass scale dependency permits the extraction of information on the squark sector from chargino observables.

The large radiative corrections to the chargino production cross section observed in the previous figures cannot be explained simply by a shift in the chargino masses [9]. This can be seen in Fig. 4 where we compare the corrected cross-section with a "modified tree-level" cross-section calculated with running masses whose numerical value are the same as the renormalized masses (therefore, calculated with a different set of values for M_2 and μ). In this way, in Fig. 4 we see the genuine corrections to the cross section, which corresponds to a 31% increase of the peak of the cross-section for 1 TeV squark mass parameters (20% if the squark mass parameters are equal to 500 GeV).

In summary, we have shown that it is crucial to include the one-loop radiative corrections to the chargino masses and cross sections in order to correctly extract the fundamental SUSY parameters from the experimental observables. Especially large corrections are obtained at large values of $\tan\beta$ and for right handed polarized

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unification and consistent radiative electroweak symmetry breaking, obtained after the inclusion of D-terms [11,4].

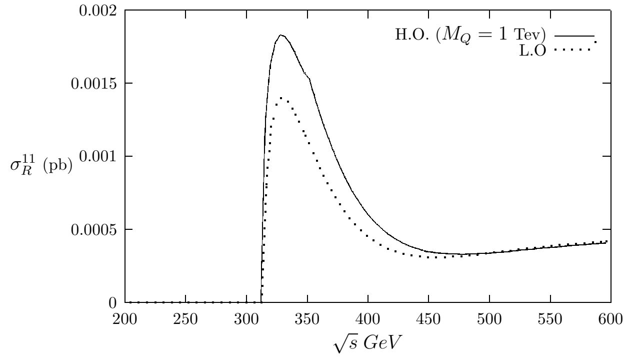

FIGURE 4. L.O. and H.O. cross sections for $\tan\beta = 50$ and degenerate squark soft mass parameters of 1 TeV, for the case where μ and M_2 are modified such that the chargino pole masses remain the same.

electrons. Since dependence exist on the squark masses, information on the squak spectrum can be inferred from the chargino observables.

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