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Radiative Corrections to Chargino Production with Polarized Beams

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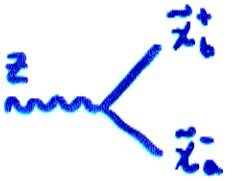
Tree Level:

$$e^+(p_2) + e^-(p_1) \longrightarrow \tilde{\chi}_a^-(k_1) + \tilde{\chi}_b^+(k_2)$$

$\mathcal{M}^{(0)} =$



$\sim O'^L_{ab}\,\gamma^\mu P_L + O'^R_{ab}\,\gamma^\mu P_R$

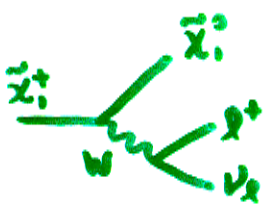
$\sim V_{b1}$

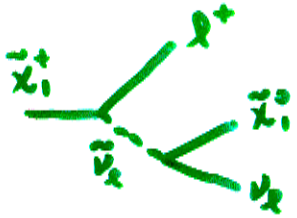
$$O'^L_{ab} = -V_{a1}V_{b1} - \tfrac{1}{2}V_{a2}V_{b2} + \delta_{ab}s_W^2$$
$$O'^R_{ab} = -U_{a1}U_{b1} - \tfrac{1}{2}U_{a2}U_{b2} + \delta_{ab}s_W^2$$

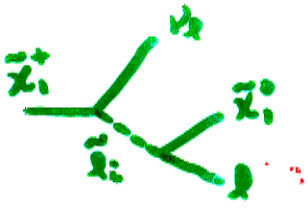
Matrices U and V diagonalizes the chargino mass matrix:

$$U \begin{pmatrix} M & \sqrt{2}\,m_W s_\beta \\ \sqrt{2}\,m_W c_\beta & \mu \end{pmatrix} V^{-1} = \begin{pmatrix} m_{\chi_1} & 0 \\ 0 & m_{\chi_2} \end{pmatrix}$$

Decay:







We do not consider the decay of the chargino, i.e., neglect spin correlations:

see G. Moortgat-Pick's talk.

Determination of SUSY parameters:

Connection with Choi, Djouadi, Kalinowski, Zerwas, ... notation:

$$U = \begin{pmatrix} \cos\phi_L & \sin\phi_L \\ -\sin\phi_L & \cos\phi_L \end{pmatrix} \qquad V = \begin{pmatrix} \cos\phi_R & \sin\phi_R \\ -\sin\phi_R & \cos\phi_R \end{pmatrix}$$

chargino masses at tree level:

$$m^{(0)\,2}_{\tilde{\chi}^+_{1,2}} = \frac{1}{2}\left(M^2 + \mu^2 + 2m_W^2\right) \mp \frac{1}{2}\sqrt{(M^2-\mu^2)^2 + 4m_W^2\left(M^2+\mu^2+m_W^2\cos^2 2\beta\right)}$$

at one loop:

$$m^{(1)\,2}_{\tilde{\chi}^+_{1,2}} = m^{(0)\,2}_{\tilde{\chi}^+_{1,2}} + \Delta m^2_{\tilde{\chi}^+_{1,2}}$$

[Pierce, Papadopoulos, 9...

same with cross section:

$$\sigma^{ij\,(1)}_{L,R} = \sigma^{i,j\,(0)}_{L,R} + \Delta\sigma^{i,j}_{L,R}$$

[Diaz, King, Ross, 98; Kiyoura, et.al., 98]

Bookkeeping 1: $\mu, M, t_\beta \longrightarrow$ $m^{(0)}_{\tilde{\chi}^+_i}$ tree level; $m^{(1)}_{\tilde{\chi}^+_i}$ one loop

Bookkeeping 2: $m_{\tilde{\chi}^+_1}, m_{\tilde{\chi}^+_2}, t_\beta \longrightarrow$ $\mu^{(0)}, M^{(0)}$ tree level; $\mu^{(1)}, M^{(1)}$ one loop

Approximation: 3 generations of quarks and squarks in the loops.
enhanced by $N_c = 3$ and Yukawa (3rd gen.)

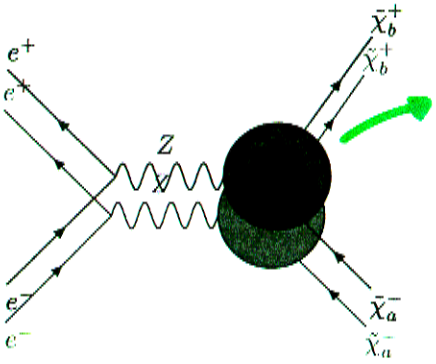
Tree level:

$$F^+_{z\alpha} = \frac{g}{2c_w} O'^L_{ab}$$

$$F^-_{z\alpha} = \frac{g}{2c_w} O'^R_{ab}$$

$$F^+_{zi} = F^-_{zi} = 0 \qquad i = 1,2$$

$\mathcal{M}_Z$ =

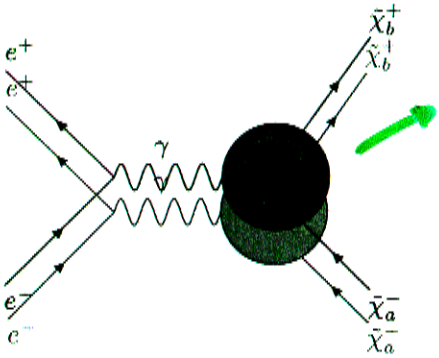


$\mathcal{M}_Z$ = $(1+\gamma_5)[F^+_{z\alpha}\gamma^\mu + F^+_{zi} k^\mu_i]$
$+(1-\gamma_5)[F^-_{z\alpha}\gamma^\mu + F^-_{zi} k^\mu_i]$

$$F^+_{\gamma\alpha} = F^-_{\gamma\alpha} = -e\,\delta_{ab}$$

$$F^+_{\gamma i} = F^-_{\gamma i} = 0$$

$\mathcal{M}_\gamma$ =

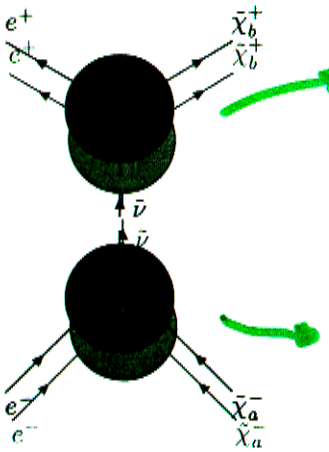


$\mathcal{M}_\gamma$ = $(1+\gamma_5)[F^+_{\gamma\alpha}\gamma^\mu + F^+_{\gamma i} k^\mu_i]$
$+(1-\gamma_5)[F^-_{\gamma\alpha}\gamma^\mu + F^-_{\gamma i} k^\mu_i]$

$$F^+_{\nu_e} = -\frac{g}{2} V_{b1}$$

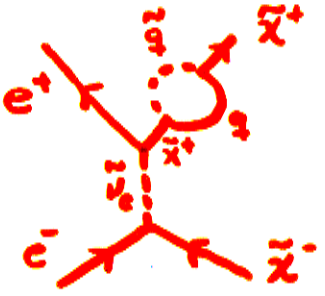
$$F^-_{\nu_e} = \frac{g}{2} V^*_{a1}$$

$\mathcal{M}_{\tilde{\nu}}$ =

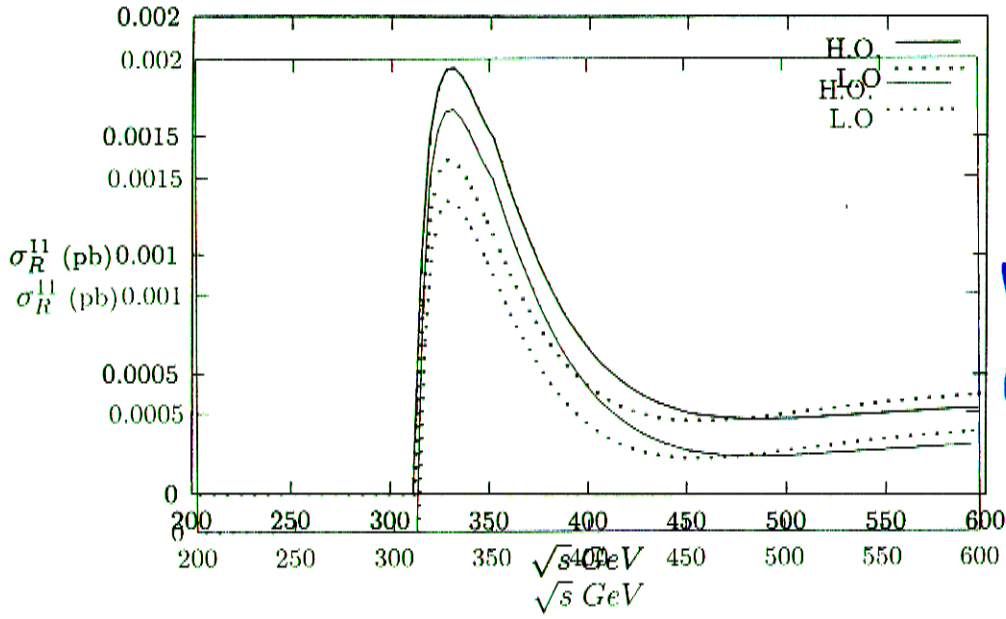


$\mathcal{M}_{\tilde{\nu}}$ = $(1+\gamma_5)\, C\, F^+_{\tilde{\nu}_e}$
$+\, C^{-1}(1-\gamma_5)\, F^-_{\tilde{\nu}_e}$

Typical graphs:



$\sigma_R^{11} = (e_R^- e_L^+ \longrightarrow \tilde{\chi}_1^+ \tilde{\chi}_1^-)$ vs $\sqrt{s}$



$t_\beta = 50$

$M_Q = A = 500$ G

(3 generations)

-) 26% correction at $\sqrt{s} = 400$ GeV

-) 20% correction to the peak cross section.

100% polarization for e^+ and e^-

Unpolarized charginos

Leading order : $M^{(0)} = 165$ $\mu^{(0)} = 400$

Higher order : $M^{(1)} = 159$ $\mu^{(1)} = 383$

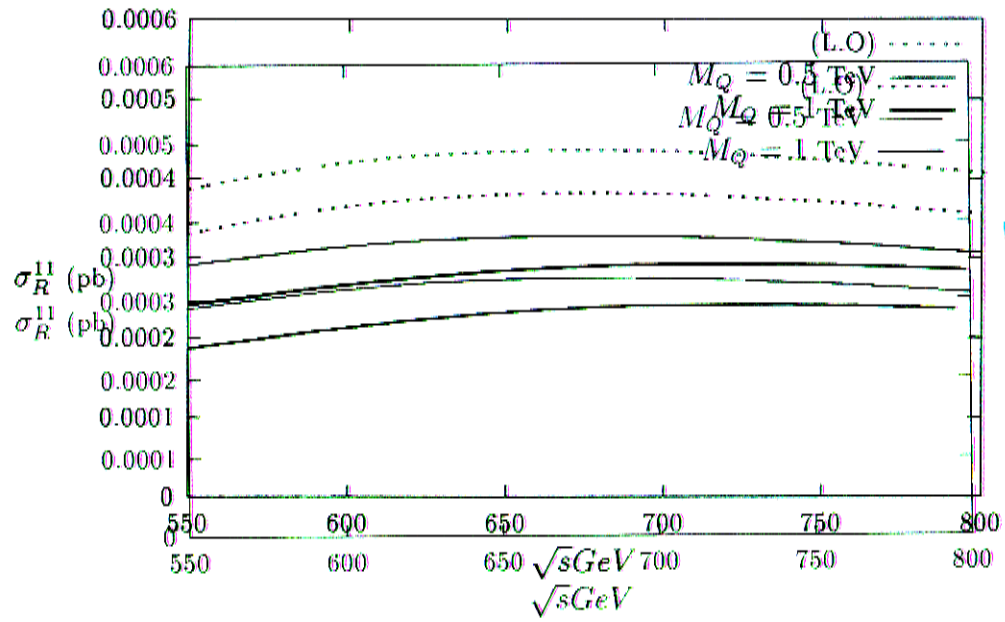
⇓

$m_{\chi_1^\pm} = 156$ GeV

$m_{\chi_2^\pm} = 419$ GeV

(Bookkeeping 2)

$\sigma_R^{11}(e_R^- e_L^+ \to \tilde{\chi}_1^+ \tilde{\chi}_1^-)$ vs $\sqrt{s}$



$t_\beta = 50$

$M_Q = A = \begin{cases} 1 \\ 0.5 \end{cases}$ T

(3 gen.)

-) -25% correction at $\sqrt{s} = 700$ GeV, for $M_Q = 0.5$ T

-) -32% correction at $\sqrt{s} = 700$ GeV, for $M_Q = 1$ T

100% polarisation for e^+ and e^-

Unpolarised charginos

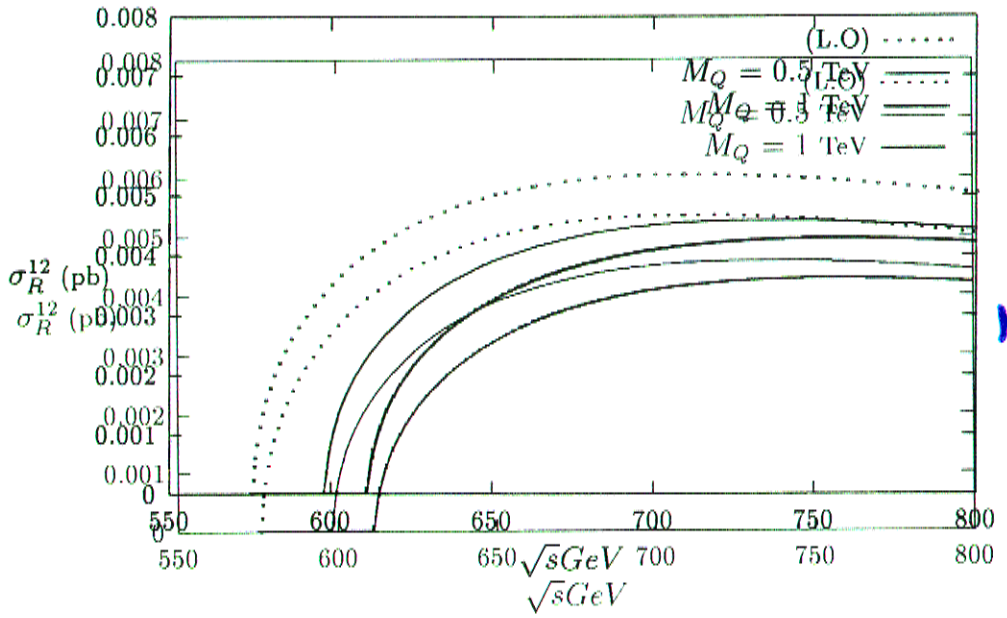
$M = 165$ GeV $\quad \mu = 400$ GeV

$\Rightarrow$ L.O.: $m_{\chi_1} = 157$ $m_{\chi_2} = 419$

H.O.: $m_{\chi_1} = 163$ $m_{\chi_2} = 435$ $(M_Q = 0.5)$

(Bookkeeping !) $m_{\chi_1} = 166$ $m_{\chi_2} = 446$ $(M_Q = 1)$

$\sigma_R^{12}(e_R^- e_L^+ \to \tilde{\chi}_1^+ \tilde{\chi}_2^-)$ vs $\sqrt{s}$



$t_\beta = 50$

$M_Q = A = \begin{cases} 1 \text{ Tel} \\ 0.5 \text{ Te} \end{cases}$

(3 gen.)

-) -16% correction at $\sqrt{s} = 700$ GeV for $M_Q = 0.5$ T

-) -24% correction at $\sqrt{s} = 700$ GeV for $M_Q = 1$ TeV

100% polarization for e^+ and e^-

Unpolarized charginos

$M = 165$ GeV $\quad \mu = 400$ GeV

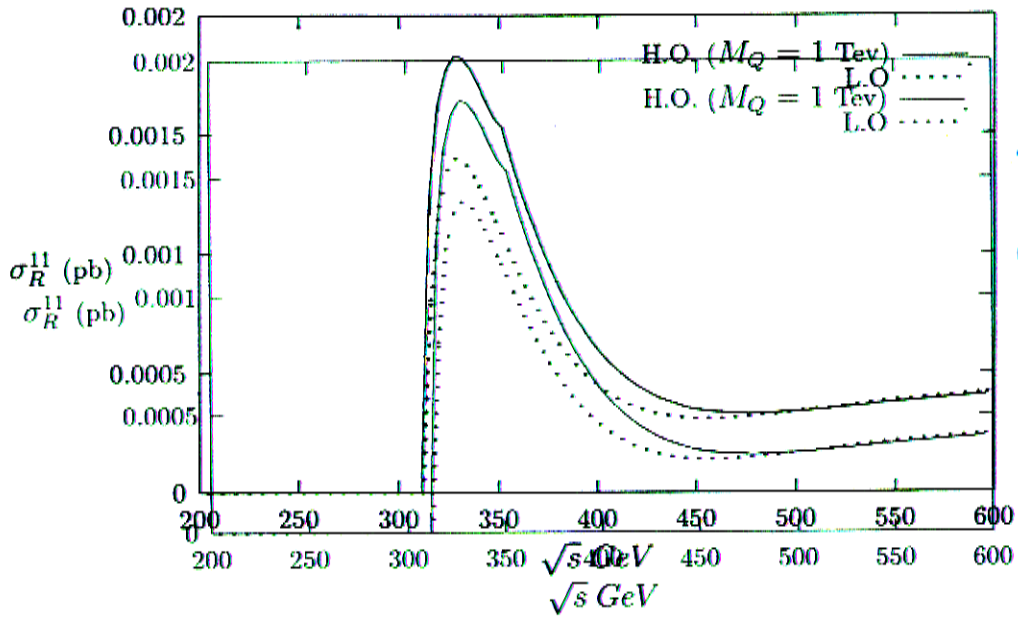
$\Rightarrow$ L.O: $m_{\chi_1^+} = 157$ $\quad m_{\chi_2^+} = 419$

H.O: $m_{\chi_1^+} = 163$ $\quad m_{\chi_2^+} = 435$ $\quad (M_Q = 0.5$

$m_{\chi_1^+} = 166$ $\quad m_{\chi_2^+} = 446$ $\quad (M_Q = 1$

(Bookkeeping 1)

$\sigma_R^{11} = \sigma(e_R^- e_L^+ \to \tilde{\chi}_1^+ \tilde{\chi}_1^-)$ vs $\sqrt{s}$



$t_\beta = 50$

$M_Q = A = 1$ Te

(3 generations

- 34% correction at $\sqrt{s} = 400$ GeV
- 31% correction to the peak cross section.

100% polarization for e^+ and e^-.

Unpolarized charginos.

Leading Order : $M^{(1)} = 165$ GeV $\quad \mu^{(1)} = 400$ GeV

Higher Order : $M^{(1)} = 156$ GeV $\quad \mu^{(1)} = 374$ GeV

$\Downarrow$

$m_{\chi_1^+} = 156$ GeV

$m_{\chi_2^+} = 419$ GeV

(Bookkeeping 2)

Conclusions:

-) Radiative corrections to chargino pair production cross sections can be large, for example, for right handed electrons and large $\tan\beta$, where we find corrections of the order of 30%, with sensitivity to squark masses.

-) These corrections cannot be absorbed into a redefinition of the chargino masses.