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Soft SUSY Breaking, Scalar Top-Charm Mixing and Higgs Signatures

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Outline

★ **Motivation**

★ **Soft SUSY-Breaking & Minimal FCNC Scheme**

- **Type-A: Non-Diagonal A-term**
- **Type-B: Horizontal $U(1)_H$**

★ **SUSY Radiative Corrections to $cbH^{\pm}$ & tch^0**

- **Correction to $cbH^{\pm}$ Vertex**
- **Correction to tch^0 Vertex**

★ **Collider Phenomenology**

- **Charm-Bottom Fusion: $cb \to H^{\pm}$**
- **Flavor-Changing Top Decay: $t \to ch^0$**

Two Main Issues for Weak Scale SUSY:

EWSB & Flavor Sector $\Rightarrow$ **un-separable!**

Recall SM:

e	u	d	μ s	c τ	b	W, Z	t
	.001	.01	.1	1	10	100 GeV	

Radiative EWSB in SUSY:

$\Rightarrow$ **A Natural/Real "Topflavor" Model!**

$$\frac{dm^2_{H_u}}{dt} = \frac{3}{8\pi^2}\left[\Delta_t - g_2^2 M_2^2 - \frac{g_1^2}{5}M_1^2\right]$$
$$\frac{dm^2_{H_d}}{dt} = \frac{3}{8\pi^2}\left[\Delta_b + \frac{1}{3}\Delta_\tau - g_2^2 M_2^2 - \frac{g_1^2}{5}M_1^2\right]$$
$$\Delta_t = y_t^2\left(m^2_{H_u} + m^2_{Q_3} + m^2_{\bar{t}}\right) + A_t^2$$
$$\Delta_b = y_b^2\left(m^2_{H_d} + m^2_{Q_3} + m^2_{\bar{b}}\right) + A_b^2$$
$$\Delta_\tau = y_\tau^2\left(m^2_{H_d} + m^2_{L_3} + m^2_{\bar{\tau}}\right) + A_\tau^2$$

Generic Higgs Upper Bound in MSSM:

$$m^2_{h^0} \lesssim m_z^2 + \frac{N_c}{2\pi^2}\frac{m_t^4}{v^2}\ln\frac{m_{\tilde{t}_1}m_{\tilde{t}_2}}{m_t^2} \lesssim (135\,\text{GeV})^2$$

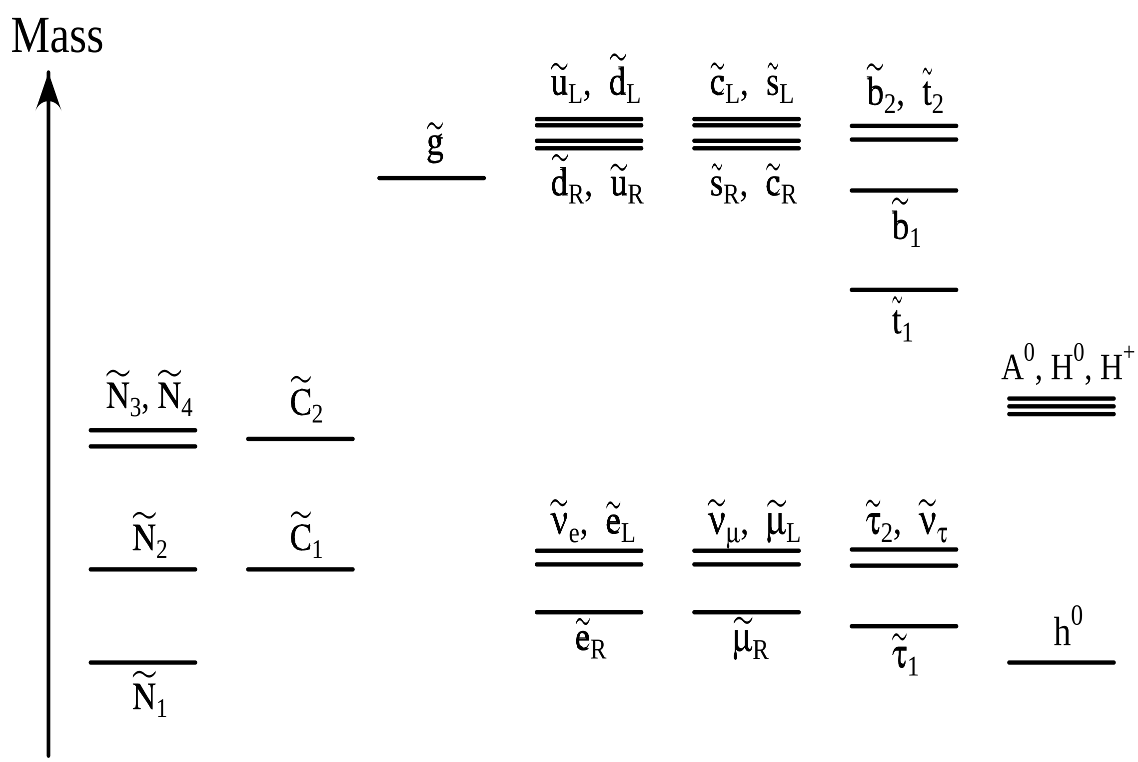
$\Rightarrow$ e.g., $t \to ch^0$ is always kinematically allowed.

$\boxed{\text{SUSY Flavor Sector:}}$ **3-Family Squarks/Sleptons**

$\Rightarrow$ **Large Portion of SUSY Spectrum/Param.Space**

$\Rightarrow$ **Adds Complexity & Challenge!**

$\Rightarrow$ **We Explore FCNC with 3rd+2nd Family-Squarks.**



A schematic (**arbitrary**) sample Spectrum.

$\boxed{\text{MSSM Soft Breaking: Squark sector}}$

$$\mathcal{L}_{\text{soft}} \supset -\widetilde{Q}_i^\dagger (M^2_{\widetilde{Q}})_{ij}\widetilde{Q}_j - \widetilde{U}_i^\dagger (M^2_{\widetilde{U}})_{ij}\widetilde{U}_j - \widetilde{D}_i^\dagger (M^2_{\widetilde{D}})_{ij}\widetilde{D}_j$$
$$+(A_u{}^{ij}\widetilde{Q}_i H_u \widetilde{U}_j - A_d{}^{ij}\widetilde{Q}_i H_d \widetilde{D}_j + \text{c.c.})$$

$M^2_{\widetilde{Q},\widetilde{U},\widetilde{D}}$ & $A_{u,d}$ are 3×3 matrices in squark flavor-space.

Soft SUSY Breaking and $\tilde{t}-\tilde{c}$ Mixings

MSSM Squark Mass-terms and Trilinear A-terms:

$$\begin{aligned}\mathcal{L}_{\text{soft}}^{\tilde{q}} = & -\widetilde{Q}_i^{\dagger}(M_{\widetilde{Q}}^2)_{ij}\widetilde{Q}_j - \widetilde{U}_i^{\dagger}(M_{\widetilde{U}}^2)_{ij}\widetilde{U}_j - \widetilde{D}_i^{\dagger}(M_{\widetilde{D}}^2)_{ij}\widetilde{D}_j \\ & +({A_u}^{ij}\widetilde{Q}_i H_u \widetilde{U}_j - {A_d}^{ij}\widetilde{Q}_i H_d \widetilde{D}_j + \text{c.c.})\end{aligned}$$

Generic 6×6 mass matrix,

$$\widetilde{\mathcal{M}}_u^2 = \begin{pmatrix} M_{LL}^2 & M_{LR}^2 \\ M_{LR}^{2\,\dagger} & M_{RR}^2 \end{pmatrix},$$

$$\begin{aligned} M_{LL}^2 &= M_{\widetilde{Q}}^2 + M_u^2 + \tfrac{1}{6}\cos 2\beta\,(4m_w^2 - m_z^2)\,, \\ M_{RR}^2 &= M_{\widetilde{U}}^2 + M_u^2 + \tfrac{2}{3}\cos 2\beta \sin^2\theta_w\, m_z^2\,, \\ M_{LR}^2 &= A_u v \sin\beta/\sqrt{2} - M_u\,\mu\cot\beta\,. \end{aligned}$$

Some Comments:

- $\widetilde{\mathcal{M}}_u^2$ is generally non-diagonal & very complicated

- In literature, use crude "Mass Insertion" Approximation, not good for large mixings of $O(1)$.

- Based on compelling Exp/Theor bounds, we construct Minimal FCNC Schemes with $O(1)$ $\tilde{t}-\tilde{c}$ Mixings. $\Rightarrow$ Consistent with all existing bounds & Exact Diagonalization of $\widetilde{\mathcal{M}}_u^2$, no "mass-insertion" & give New Higgs Signatures in production/decay, etc.

$\bigstar$ **Minimal FCNC Scheme-A: Non-diagonal A_u**

By strong CCB and VS bounds together with Exp FCNC bounds, we define, at the weak scale, A_u as the main source of FCNC,

$$\textbf{Type}-\textbf{A}: \qquad A'_u = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & x \\ 0 & y & 1 \end{pmatrix} A$$

$(x,\, y) = O(1)$, $\Rightarrow$ Large flavor-mixings in $\tilde{t} - \tilde{c}$ sector, consistent with all low energy EXP-data & theoretical CCB/VS bounds.

For convenience of numericaly analysis, define:

▶ **Type-A1**: $x \neq 0,\ y = 0$.

▶ **Type-A2**: $x = 0,\ y \neq 0$.

Also, consider, for simplicity,

$$M_{LL}^2 \simeq M_{RR}^2 \simeq \widetilde{m}_0^2 \mathbf{I}_{3\times 3}$$

Charge-Color-Breaking Bounds (CCB)

$$|A_u^{ij}|^2 \le y_{u_k}^2 \left(M_{\tilde{u}_{Li}}^2 + M_{\tilde{u}_{Rj}}^2 + M_2^2 \right), \quad k = \text{max}(i,j)$$
$$|A_d^{ij}|^2 \le y_{d_k}^2 \left(M_{\tilde{d}_{Li}}^2 + M_{\tilde{u}_{Rj}}^2 + M_1^2 \right), \quad k = \text{max}(i,j)$$
$$|A_\ell^{ij}|^2 \le y_{\ell_k}^2 \left(M_{\tilde{\ell}_{Li}}^2 + M_{\tilde{\ell}_{Rj}}^2 + M_1^2 \right), \quad k = \text{max}(i,j)$$

Vacuum Stability Bounds (VS)

$$|A_u^{ij}|^2 \le y_{u_k}^2 \left(M_{\tilde{u}_{Li}}^2 + M_{\tilde{u}_{Rj}}^2 + M_{\tilde{\ell}_{Li'}}^2 + M_{\tilde{\ell}_{Rj'}} \right),$$
$$|A_d^{ij}|^2 \le y_{d_k}^2 \left(M_{\tilde{d}_{Li}}^2 + M_{\tilde{u}_{Rj}}^2 + M_{\tilde{\nu}_p}^2 \right),$$
$$|A_\ell^{ij}|^2 \le y_{\ell_k}^2 \left(M_{\tilde{\ell}_{Li}}^2 + M_{\tilde{\ell}_{Rj}}^2 + M_{\tilde{\nu}_p}^2 \right),$$

where $k = \text{max}(i,j), \quad i' \neq j', \quad p \neq (i,j)$.

$$\text{Note :} \qquad y_t = \frac{y_t^{\text{sm}}}{\sin\beta} \simeq 1, \quad y_{f'} \simeq \frac{m_{f'}}{m_t} \ll 1$$

$\Rightarrow A_{u,d,\ell}^{ij} \ll M_{\text{SUSY}}$, except that, remarkably,

$$\left(A_u^{23},\, A_u^{32},\, A_u^{33} \right) \lesssim M_{\text{SUSY}}$$

$A_u^{13,31}$ may be also large, but receive stronger bounds from low energy experimental data; we'll not consider large $A_u^{13,31}$.

See: Misiak,Pokorski,Rosiek, hep-ph/9703442,....

Exp FCNC Bounds on $\tilde{t}/\tilde{\ell}$ Sector

Define : $$(\delta_x)^{ij}_{IJ} \equiv \frac{(\widetilde{\mathcal{M}^2_x})^{ij}_{IJ}}{[(\widetilde{\mathcal{M}^2_x})^{ii}_{II}(\widetilde{\mathcal{M}^2_x})^{jj}_{JJ}]^{1/2}} \approx \frac{(\widetilde{\mathcal{M}^2_x})^{ij}_{IJ}}{\widetilde{m}^2_0}$$

where $x \in (U, D)$, $(I, J) \in (L, R)$, $(i, j) \in (1, 2, 3)$ and $R \equiv \dfrac{\widetilde{m}_{\mathrm{max}}}{1\ \mathrm{TeV}}$.

$$\delta^U_{LL} \lesssim \begin{pmatrix} & 0.2R & 0.2R \\ 0.2R & & 30R^2 \\ 0.2R & 30R^2 & \end{pmatrix}, \quad \delta^U_{RR} \lesssim \begin{pmatrix} & 0.2R & ? \\ 0.2R & & ? \\ ? & ? & \end{pmatrix},$$

$$\delta^U_{LR} \lesssim \begin{pmatrix} & 0.2R & 12R^2 \\ 0.2R & & 12R^2 \\ ? & ? & \end{pmatrix},$$

$$\delta^D_{LL,RR} \lesssim \begin{pmatrix} & .08R & .2R \\ .08R & & 30R^2 \\ .2R & 30R^2 & \end{pmatrix},$$

$$\delta^D_{LR} \lesssim \begin{pmatrix} & .009R & .07R \\ .009R & & .03R \\ .07R & .03R & \end{pmatrix},$$

★ First family squarks $\tilde{u}_{L,R}$ decouple $\Rightarrow$ 6×6 mass-matrix reduces to 4×4,

$$\widetilde{\mathcal{M}}^2_{ct} = \begin{pmatrix} \widetilde{m}_0^2 & 0 & 0 & A_x \\ 0 & \widetilde{m}_0^2 & A_y & 0 \\ 0 & A_y & \widetilde{m}_0^2 & X_t \\ A_x & 0 & X_t & \widetilde{m}_0^2 \end{pmatrix}$$

for squarks $(\tilde{c}_L, \tilde{c}_R, \tilde{t}_L, \tilde{t}_R)$, where

$$\begin{aligned} & A_x = x\widehat{A}, \quad A_y = y\widehat{A}, \quad \widehat{A} = Av\sin\beta/\sqrt{2}\,, \\ & X_t = \widehat{A} - \mu\, m_t \cot\beta\,. \end{aligned}$$

★ Stop/Scharm Mass Eigenvalues:

$$\begin{aligned} M^2_{\tilde{c}1,2} &= \widetilde{m}_0^2 \mp \tfrac{1}{2}\left|\sqrt{\omega_+} - \sqrt{\omega_-}\right|, \\ M^2_{\tilde{t}1,2} &= \widetilde{m}_0^2 \mp \tfrac{1}{2}\left|\sqrt{\omega_+} + \sqrt{\omega_-}\right|, \end{aligned}$$

where $\omega_\pm = X_t^2 + (A_x \pm A_y)^2\,.$

$$\mathrm{Mass\,Spectrum:} \qquad M_{\tilde{t}1} < M_{\tilde{c}1} < M_{\tilde{c}2} < M_{\tilde{t}2}$$

$M_{\tilde{t}_1}$ can be as light as 120-300GeV for $\widetilde{m}_0 \gtrsim$ 0.5-1TeV

★ 4×4 Rotation Matrix of Squark Diagonalization:

$$\begin{pmatrix} \tilde{c}_L \\ \tilde{c}_R \\ \tilde{t}_L \\ \tilde{t}_R \end{pmatrix} = \begin{pmatrix} c_1 c_3 & c_1 s_3 & s_1 s_4 & s_1 c_4 \\ -c_2 s_3 & c_2 c_3 & s_2 c_4 & -s_2 s_4 \\ -s_1 c_3 & -s_1 s_3 & c_1 s_4 & c_1 c_4 \\ s_2 s_3 & -s_2 c_3 & c_2 c_4 & -c_2 s_4 \end{pmatrix} \begin{pmatrix} \tilde{c}_1 \\ \tilde{c}_2 \\ \tilde{t}_1 \\ \tilde{t}_2 \end{pmatrix}$$

$$s_{1,2} = \frac{1}{\sqrt{2}} \left[1 - \frac{X_t^2 \mp A_x^2 \pm A_y^2}{\sqrt{\omega_+ \omega_-}} \right]^{1/2}, \quad s_4 = \frac{1}{\sqrt{2}},$$

$$s_3 = 0 \, (1/\sqrt{2}) \;\; (\text{if } xy = 0 \, (\neq 0)), \quad s_j^2 + c_j^2 = 1 \, .$$

Type-B Scheme:
Quark Masses and Mixings &
Horizontal $U(1)_H$ Symmetry

Table 1. General definition of **Type-B** with $U(1)_H$.

Q_1	Q_2	Q_3	$\overline{u}_1$	$\overline{u}_2$	$\overline{u}_3$	$\overline{d}_1$	$\overline{d}_2$	$\overline{d}_3$	H_u	H_d	S
h_1	h_2	h_3	α_1	α_2	α_3	β_1	β_2	β_3	ξ	ξ'	-1

Below $U(1)_H$ breaking scale and with S^0 integrated out, effective operator $\mathcal{O}_j$ with charge q:

$$\mathcal{O}_j = c_j \mathcal{F}(f, \bar{f}, H_u, H_d) \quad \Rightarrow \quad c_j \sim \lambda^{|q|}, \quad \lambda \equiv \frac{\langle S^0 \rangle}{\Lambda} \simeq 0.22$$

★ **Solving μ-Problem**:

$$\frac{\kappa}{\Lambda^{n-1}} S^n H_u H_d \Rightarrow \mu H_u H_d$$

$$\mu = \kappa \lambda^{n-1} \langle S^0 \rangle \ll \Lambda_{\text{Planck}}, \quad (n = \xi + \xi')$$

★ **Quark Mass Hierarchy Structures**:

$$M_u^{ij} \sim \frac{v_u}{\sqrt{2}} \lambda^{\alpha_i + h_j + \xi}, \quad M_d^{ij} \sim \frac{v_u}{\sqrt{2}} \frac{1}{\tan\beta} \lambda^{\beta_i + h_j + \xi'},$$

★ **The CKM Matrix:**

$$(V_{us}, V_{cb}, V_{ub}) \sim \left(\lambda^{h_1 - h_2}, \lambda^{h_2 - h_3}, \lambda^{h_1 - h_3}\right)$$

★ **KEY ingredient of our Model Constructions**:

$$\boxed{\textbf{New Condition:} \quad \alpha_2 = \alpha_3}$$

The Minimal Type-B Models:

Q_1	Q_2	Q_3	$\overline{u}_1$	$\overline{u}_2$	$\overline{u}_3$	$\overline{d}_1$	$\overline{d}_2$	$\overline{d}_3$	H_u	H_d	S
4	3	0	$3-\xi$	$-\xi$	$-\xi$	$4-\xi'$	$3-\xi'$	$3-\xi'$	ξ	ξ'	-1

Quark mass-matrices takes forms of:

$$M_u \sim \frac{v_u}{\sqrt{2}} \begin{pmatrix} \lambda^7 & \lambda^4 & \lambda^4 \\ \lambda^6 & \lambda^3 & \lambda^3 \\ \lambda^3 & 1 & 1 \end{pmatrix}, \qquad M_d \sim \frac{v_d}{\sqrt{2}} \begin{pmatrix} \lambda^8 & \lambda^7 & \lambda^7 \\ \lambda^7 & \lambda^6 & \lambda^6 \\ \lambda^4 & \lambda^3 & \lambda^3 \end{pmatrix}$$

Squark mass-matrices (M_{LL}^2, M_{RR}^2):

$$M_{LL}^2 \sim \widetilde{m}_0^2 \begin{pmatrix} 1 & \lambda & \lambda^4 \\ \lambda & 1 & \lambda^3 \\ \lambda^4 & \lambda^3 & 1 \end{pmatrix}, \qquad M_{RR}^2 \sim \widetilde{m}_0^2 \begin{pmatrix} 1 & \lambda^3 & \lambda^3 \\ \lambda^3 & 1 & 1 \\ \lambda^3 & 1 & 1 \end{pmatrix}$$

A_u Term takes the form of:

$$A_u \sim A \begin{pmatrix} \lambda^7 & \lambda^4 & \lambda^4 \\ \lambda^6 & \lambda^3 & \lambda^3 \\ \lambda^3 & 1 & 1 \end{pmatrix}$$

★ Define Minimal Type-B A-Term: $[y = O(1)]$

$$A'_u = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & y & 1 \end{pmatrix} A$$

Squarks $(\tilde{u}_L, \tilde{u}_R, \tilde{c}_L)$ decouple from the rest.

★ 3×3 matrix, under the basis $(\tilde{c}_R, \tilde{t}_L, \tilde{t}_R)$,

$$\widetilde{M}^2_{ct}[B] = \begin{pmatrix} \widetilde{m}^2_0 & A_y & x\widetilde{m}^2_0 \\ A_y & \widetilde{m}^2_0 & -X_t \\ x\widetilde{m}^2_0 & -X_t & \widetilde{m}^2_0 \end{pmatrix},$$

▶ **Type-B1**: $x \neq 0,\ y = 0.$

⇒ similar to **Type-A1**, but due to non-diagonal M^2_{RR}

▶ **Type-B2**: $x = 0,\ y \neq 0.$

⇒ identical to **Type-A2** (Non-diagonal A-Term)

Type-B1 squark mass spectrum:

$$M^2_{\tilde{c}_1} = M^2_{\tilde{c}_2} = \widetilde{m}^2_0, \quad M^2_{\tilde{t}_1} = \widetilde{m}^2_0 - \sqrt{\omega}, \quad M^2_{\tilde{t}_2} = \widetilde{m}^2_0 + \sqrt{\omega},$$
$$M_{\tilde{t}_1} < M_{\tilde{c}_1} = M_{\tilde{c}_2} < M_{\tilde{t}_2}$$

Squark rotation from basis $(\tilde{c}_R, \tilde{t}_L, \tilde{t}_R)$ into $(\tilde{c}_2, \tilde{t}_1, \tilde{t}_2)$:

$$R[B1] = \begin{pmatrix} c_1 & -s_1/\sqrt{2} & -s_1/\sqrt{2} \\ s_1 & c_1/\sqrt{2} & c_1/\sqrt{2} \\ 0 & -1/\sqrt{2} & 1/\sqrt{2} \end{pmatrix}$$

$$(s_1,\, c_1) = \left(x\widetilde{m}^2_0,\, X_t\right)/\sqrt{\omega}, \qquad \omega \equiv (x\widetilde{m}^2_0)^2 + X_t^2$$

SUSY Radiative $bcH^{\pm}$ & tch^0 Vertices

Comments: No mass-insertion needed; Exact Feynman Rules, about $O(10)$ Loop-diagrams summed up in each process

★ **Corrections to $bcH^{\pm}$: Squark-Gluino Loops**

$$\begin{aligned}\Gamma_{H^+b\bar{c}} &= i\,\overline{u}_c(k_2)\,(F_L P_L + F_R P_R)\,u_b(k_1)\,,\\ F_{L,R} &= F^0_{L,R} + F^V_{L,R} + F^S_{L,R}\,,\end{aligned}$$

$$(F^0_L,\, F^0_R) = \frac{gV_{cb}}{\sqrt{2}m_w}\,(m_c\cot\beta,\, m_b\tan\beta)$$

One-loop Vertex Corrections in Type-A1:

$$F^V_L = 0$$

$$F^V_R = \frac{\alpha_s}{3\pi} m_{\tilde{g}} \sum_{j,k} \kappa^R_{jk} C_0(m^2_H, 0, 0; m_{\tilde{b}_j}, m_{\tilde{g}}, m_{\tilde{u}_k}),$$

where $\tilde{u}_k \in (\tilde{c}_2, \tilde{t}_1, \tilde{t}_2)$, $\tilde{b}_j \in (\tilde{b}_1, \tilde{b}_2)$.

Self-energy Corrections in Type-A1:

$$F^S_L = 0$$

$$F^S_R = \widehat{F}^0_R \frac{\alpha_s s_1}{3\pi} \frac{m_{\tilde{g}}}{m_t} \sum_{j=1,2} (-)^{j+1} B_0(0; m_{\tilde{g}}, m_{\tilde{t}_j}),$$

where $\widehat{F}^0_R = V_{tb}[\sqrt{2}m_b \tan\beta/v]$.

★ Corrections to tch^0: Squark-Gluino Loops

$$\begin{aligned} \Gamma_{\bar{c}th^0} &= i\,\overline{u}_c(k_2)\,(F_L P_L + F_R P_R)\,u_t(k_1) \\ F_{L,R} &= F^0_{L,R} + F^V_{L,R} + F^S_{L,R} \\ F^0_{L,R} &= 0 \end{aligned}$$

One-loop Vertex Corrections in Type-A1:

$$F_L^V = \frac{\alpha_s}{3\pi}\sum_j \kappa_{Lj} m_t\,(C_0 + C_{11})\left[m_h^2, m_t^2, 0; M_{\tilde{q}_{1j}}, M_{\tilde{g}}, M_{\tilde{q}_{2j}}\right]$$

$$F_R^V = \frac{\alpha_s}{3\pi}\sum_j \kappa_{Rj} M_{\tilde{g}} C_0\left[m_h^2, m_t^2, 0; M_{\tilde{q}_{1j}}, M_{\tilde{g}}, M_{\tilde{q}_{2j}}\right]$$

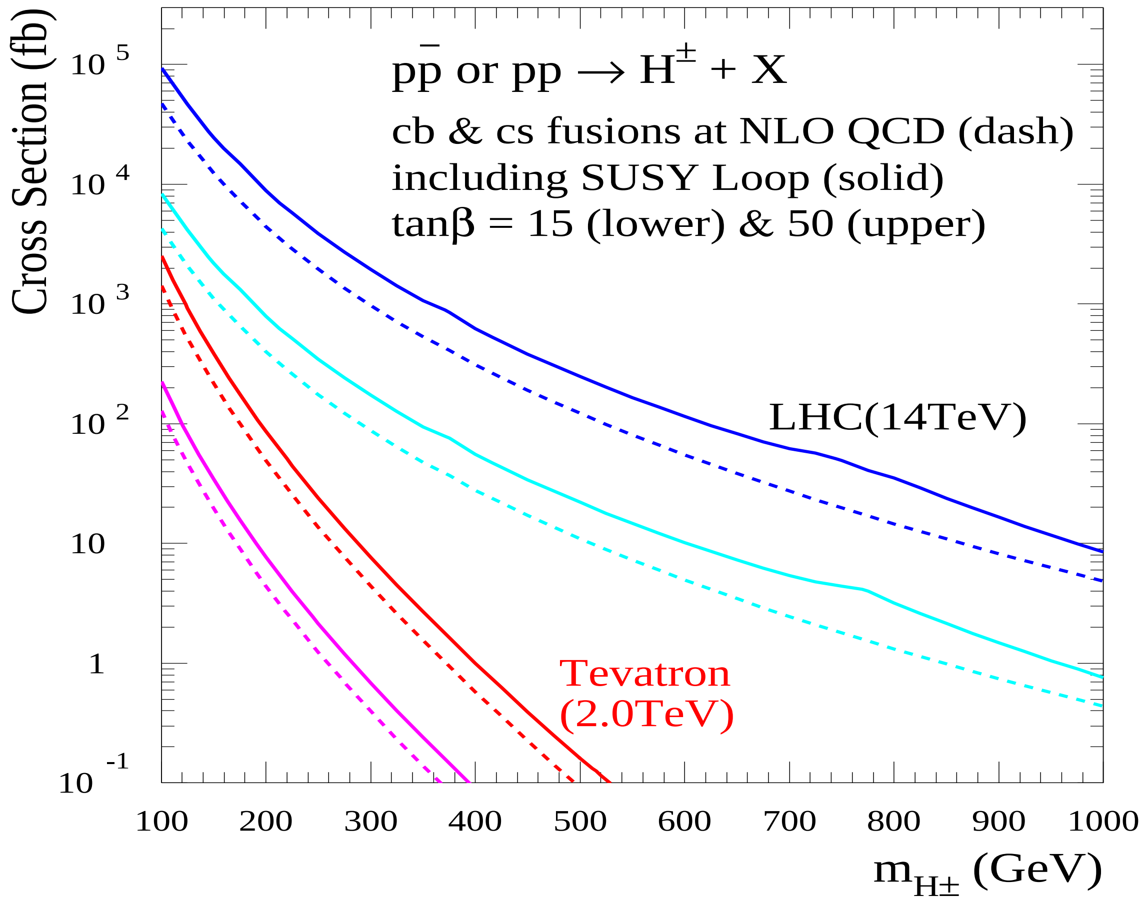
Self-energy Corrections in Type-A1:

$$F_L^S \simeq 0$$

$$F_R^S = \widehat{F}^0 \frac{\alpha_s s_\theta}{3\pi}\frac{M_{\tilde{g}}}{m_t}\sum_{j=1}^{2}(-)^j B_0(0; m_{\tilde{g}}, m_{\tilde{t}_j})$$

where $\widehat{F}^0 = (m_t/v)(\cos\alpha/\sin\beta)$.

Higgs Signatures at Colliders



▶ $H^{\pm}$ production via cb (and cs) fusions at colliders.
Type-A1: $(\mu,\, M_{\tilde{g}},\, \widetilde{m}_0) = (300,\, 300,\, 600)$ GeV, $(A,\, -A_b) = 1.5$ TeV.

▶ $\mathrm{Br}[t \to c\, h^0] \times 10^3$ is shown for Type-A1 inputs with $(\widetilde{m}_0, \mu, A) = (0.6, 0.3, 1.5)$ TeV and $M_{A^0} = 0.6$ TeV. In each entry, $x = (0.5,\, 0.75,\, 0.9)$.

$M_{\tilde{g}}$	$\tan\beta = 5$	20	50
100GeV	(.011, .10, .81)	(.015, .19, 4.6)	(.016, .21, 7.0)
500GeV	(.011, .09, .41)	(.015, .13, 1.0)	(.016, .14, 1.2)

Summary

★ **Supersymmtry:**

EWSB vs Flavor $\Rightarrow$ Un-separable !

Flavor sector needs to be fully explored.

★ **Constructions for**

Minimal SUSY FCNC Schemes in Soft Breaking

Type-A: Non-Diagonal A-Term

Type-B: Minimal Horizontal $U(1)_H$

$\Rightarrow$ **Natural $O(1)$ $\tilde{t}-\tilde{c}$ Mixings, but sufficiently suppressed FCNC with first two families.**

(Partial Alignment with quark sector)

$\Rightarrow$ **Natural Quark-mass Hierarchy/Mixings**

★ **SUSY Radiative Corrections to $cbH^{\pm}$ & tch^{0}**

- **Correction to $cbH^{\pm}$ Vertex**
- **Correction to tch^{0} Vertex**

★ **New Channels for SUSY Higgs Signatures**

- **Charm-Bottom Fusion: $cb \to H^{\pm}$**
- **Flavor-Changing Top Decay: $t \to ch^{0}$**

Question from audience:

Do you consider renormalization effect to CKM-matrix in the $cbH^{\pm}$ vertex calculation?

Answer:

No. The relevant CKM element is $V_{cb} \simeq 4\%$ for the tree-level $cbH^{\pm}$ vertex which is at most comparable to or smaller than the leading *SUSY-Loop* correction (enhanced by α_s). But the 1-loop correction to V_{cb} itself would be essentially of $O(V_{cb}/16\pi^2) \sim O(\text{2-loop})$, and thus fully negligible.