SUSY HIGGS DECAYS: TRILINEAR A COUPLINGS

S.Y.Choi, H.-U.Martyn, P.M.Zerwas

Soft SUSY breaking: gaugino / higgsino / scalar mass terms

trilinear couplings A : Yukawa $g_{ij} \to A_{ij} g_{ij}$ [3rd gen]

A's affect: L/R mixing in sfermion mass matrices

Higgs H, A decays to LR sfermions

up sparticles : $M^2_{LR} = m_u[A_u - \mu \cot\beta]$ mixing sensitive

$A\tilde{u}_L\tilde{u}_R = m_u[A_u \cot\beta + \mu]$ decays insensitive

down sparticles: $M^2_{LR} = m_d[A_d - \mu \tan\beta]$ mixing screened

$A\tilde{d}_L\tilde{d}_R = m_d[A_d \tan\beta + \mu]$ decays sensitive for large $\tan\beta$

large $\tan\beta \Rightarrow$ significant branching ratio to stau pairs $\sim\ m_\tau^2\ \tan^2\beta$:

A decays : $\Gamma(A \to \tilde{\tau}_L \tilde{\tau}_R) = \frac{G_F m_\tau^2}{4\sqrt{2}\pi}\,\lambda^{1/2}\,\frac{(A_\tau \tan\beta + \mu)^2}{m_A}$

A : no diagonal stau decays by CP invariance

H decays : $\Gamma(H \to \tilde{\tau}_L \tilde{\tau}_R) = \frac{G_F m_\tau^2}{4\sqrt{2}\pi}\,\lambda^{1/2}\,\frac{(A_\tau \tan\beta + \mu)^2}{m_A}$ for large $\tan\beta$

H : diagonal stau decays not enhanced

EXAMPLE SPS1a′ : $M_0 = 70$ GeV, $M_{1/2} = 250$ GeV, $A_0 = -300$ GeV,

$\tan\beta = 10$ and sign $\mu = +$

1.) A and H decay modes : b leading ; $\tilde{\tau}$ at per-cent level

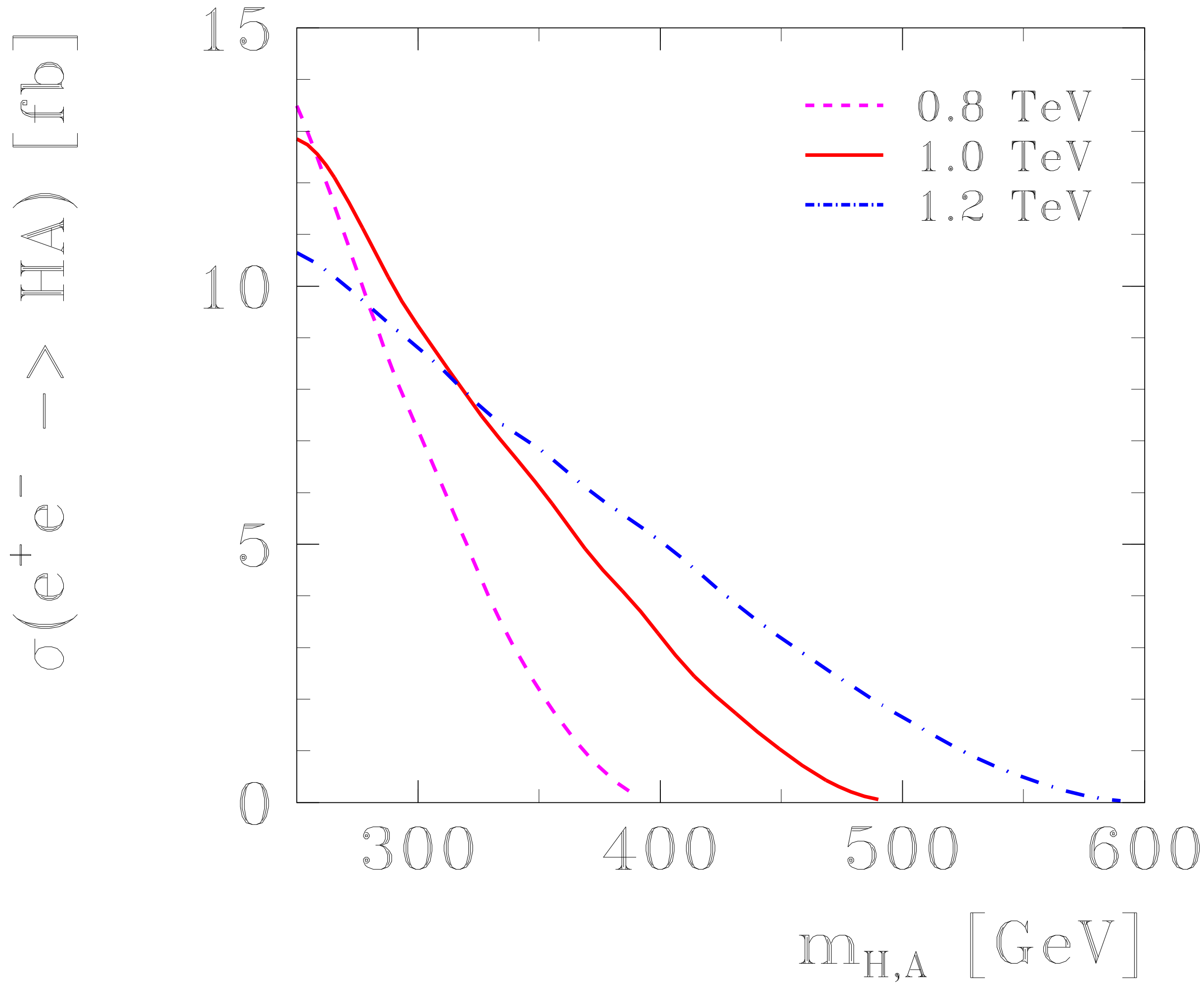
bkgd χ's [per-cent level]: dominating $\tau, \tilde{\tau}$ decays

2.) AH production cross section : $\sqrt{s} = 1$ TeV and $L = 1$ ab^{-1}

$\Rightarrow$ 2,000 events $\uparrow$ energy

$\text{BR}_{12} \simeq 3\%$ $\Rightarrow$ 120 events

Particle	Mass [GeV]	Decay	$\mathcal{B}$	Decay	$\mathcal{B}$
H^0	431.1	$\tau^-\tau^+$	0.075	$\tilde{\chi}_1^0\tilde{\chi}_1^0$	0.011
		$b\bar{b}$	0.683	$\tilde{\chi}_1^0\tilde{\chi}_2^0$	0.040
		$\tilde{\tau}_1^-\tilde{\tau}_1^+$	0.014	$\tilde{\chi}_2^0\tilde{\chi}_2^0$	0.023
		$\tilde{\tau}_1^\mp\tilde{\tau}_2^\pm$	0.031	$\tilde{\chi}_1^+\tilde{\chi}_1^-$	0.056
		$\tilde{\tau}_2^-\tilde{\tau}_2^+$	0.003		
A^0	431.0	$\tau^-\tau^+$	0.055	$\tilde{\chi}_1^0\tilde{\chi}_1^0$	0.011
		$b\bar{b}$	0.505	$\tilde{\chi}_1^0\tilde{\chi}_2^0$	0.055
		$\tilde{\tau}_1^\mp\tilde{\tau}_2^\pm$	0.035	$\tilde{\chi}_2^0\tilde{\chi}_2^0$	0.063
				$\tilde{\chi}_1^+\tilde{\chi}_1^-$	0.170
$\tilde{\chi}_2^0$	184.4	$\tilde{\tau}_1^\pm\tau^\mp$	0.564	$\tilde{\nu}_\tau\nu_\tau$	0.155
$\tilde{\chi}_1^+$	184.2	$\tilde{\tau}_1^+\nu_\tau$	0.519	$\tilde{\nu}_\tau\tau^+$	0.189
$\tilde{\tau}_1$	107.4	$\tilde{\chi}_1^0\tau^-$	1.000		
$\tilde{\tau}_2$	195.3	$\tilde{\chi}_1^0\tau^-$	0.869	$\tilde{\chi}_1^-\nu_\tau$	0.086
$\tilde{\nu}_\tau$	170.7	$\tilde{\chi}_1^0\nu_\tau$	1.000		



2B

signature : $e^+e^- \rightarrow HA \rightarrow b\bar{b} + X$ $\Leftarrow$ Martyn

signal : $X_{\tilde{\tau}\tilde{\tau}} = \tilde{\tau}_1\tilde{\tau}_2 + \tilde{\tau}_1\tilde{\tau}_1 + \tilde{\tau}_2\tilde{\tau}_2 \rightarrow \tau^+\tau^- + \not{E}$

bkgd : $X_{nn} = \tilde{\chi}^0_1\tilde{\chi}^0_2 + \tilde{\chi}^0_2\tilde{\chi}^0_2 \rightarrow \tau^+\tau^- + \not{E}$

bkgd : $X_{cc} = \tilde{\chi}^+_1\tilde{\chi}^-_1 \rightarrow \tau^+\tau^- + \not{E}$

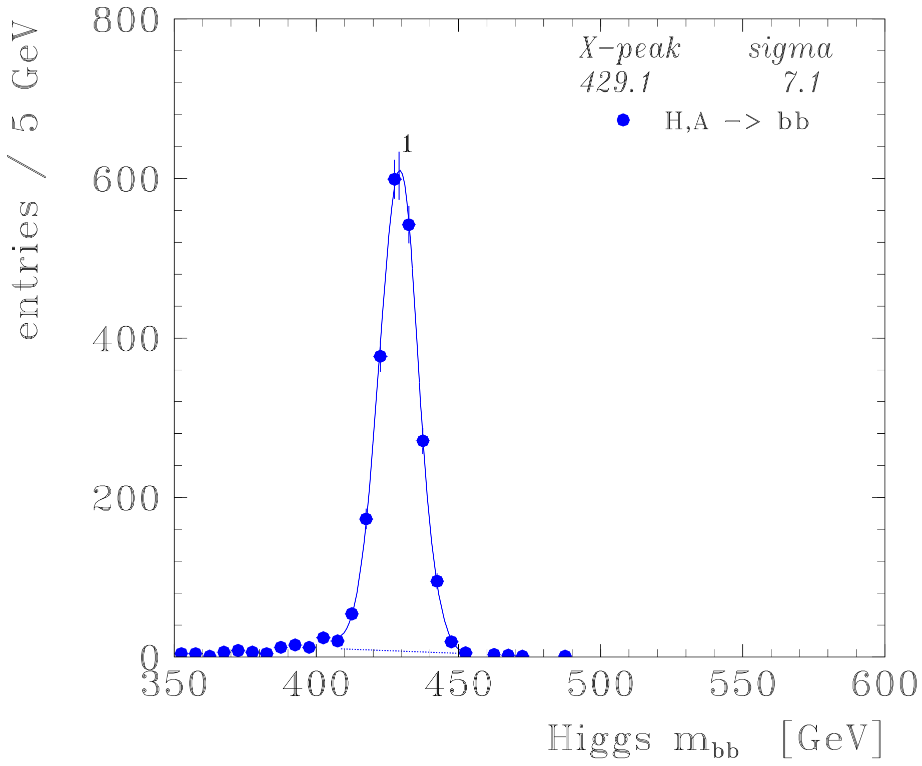
reference : $e^+e^- \rightarrow HA \rightarrow b\bar{b} + b\bar{b}$ and $b\bar{b} + \tau^+\tau^-$

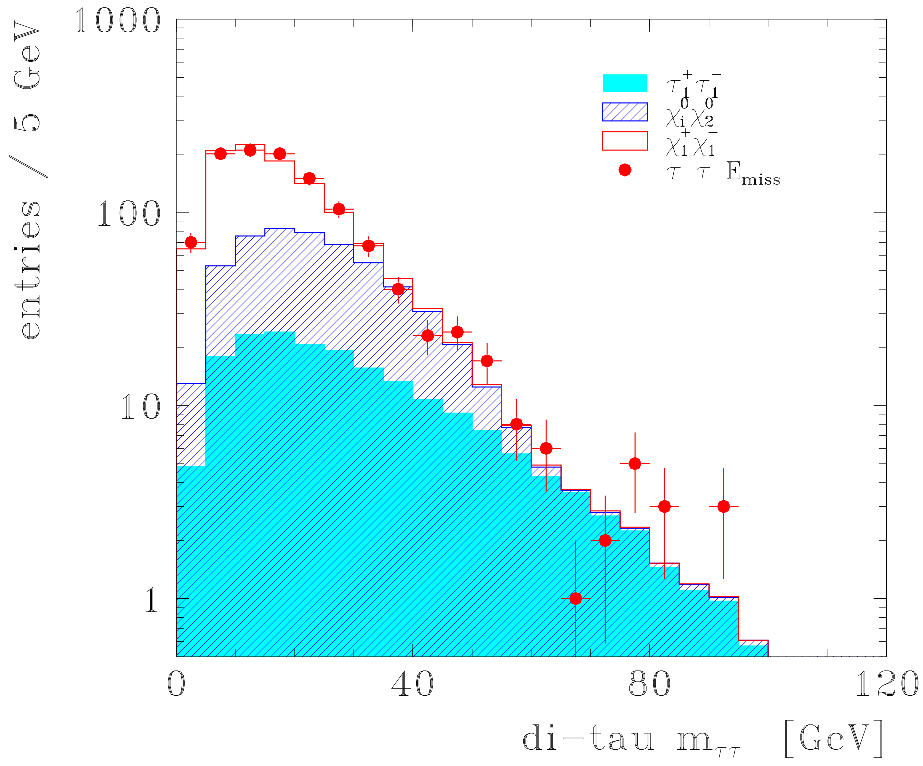
strategy : – reconstruct one Higgs boson as $b\bar{b}$ resonance

– study recoil system for $\tau\tau\not{E}$ and $bb/\tau\tau$ [overall eff $\sim$ 40%]

Selection criteria		Constraint
1	two identified b jets	
2	b jet energy	100 GeV $< E_b <$ 400 GeV
3	bb invariant mass	$m_{H,A} - 30$ GeV $< m_{bb} < m_{H,A} + 30$ GeV
	recoil mass against bb	$m_{H,A} - 30$ GeV $< m_{recoil} < m_{H,A} + 90$ GeV
4	two oppositely charged τ candidates	
5	visible τ energy	2.5 GeV $< E_\tau <$ 200 GeV
	visible $\tau\tau$ energy	$E_{\tau\tau} <$ 250 GeV
6	missing energy	250 GeV $< \not{E} <$ 550 GeV
7	acollinearity angle in Higgs rest frame	$\xi^*_{\tau\tau} > 10^\circ$

(a) Higgs m_{bb} in bbX **(b) di-tau $m_{\tau\tau}$ in $X = \tau\tau \not{E}$**

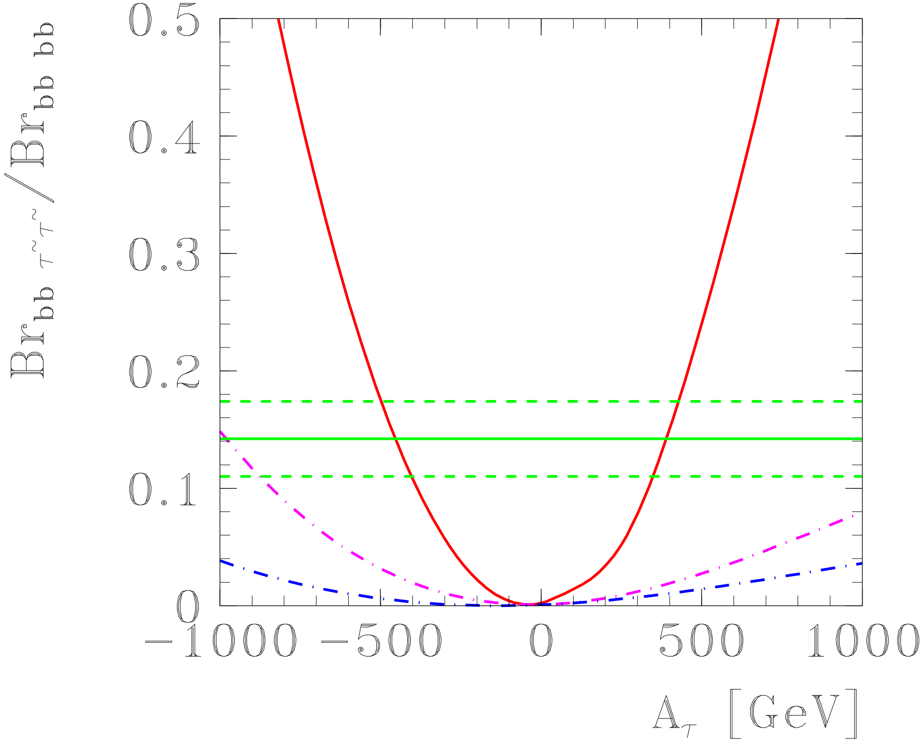


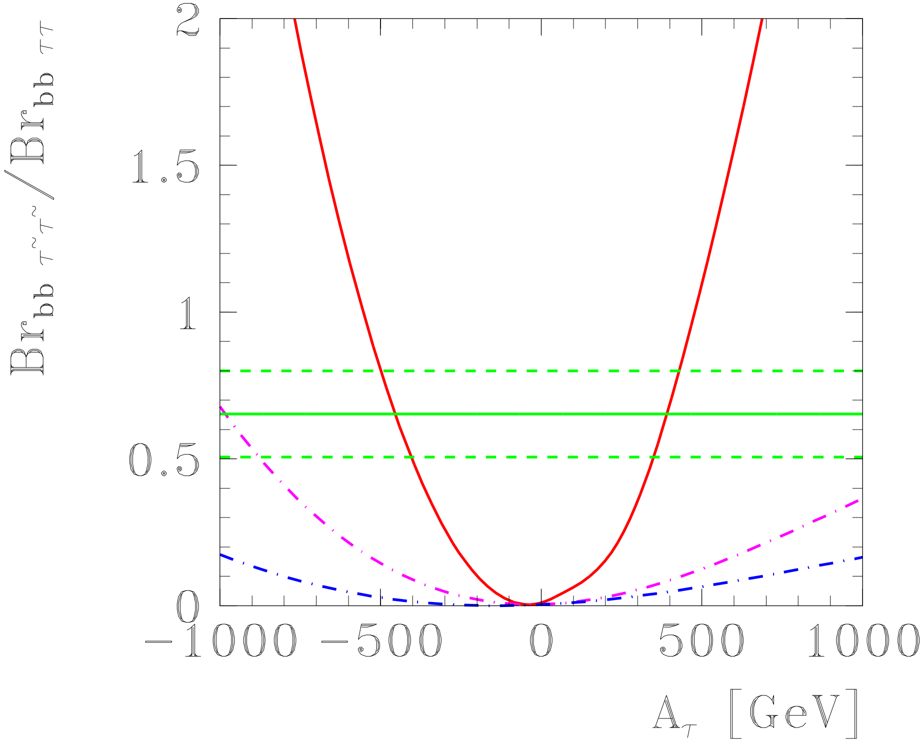


RESULTS

$$\frac{B(bb\,\tilde\tau\tilde\tau)}{B(bb\,bb)} = \frac{\Gamma(A\to\tilde\tau_1\tilde\tau_2)}{\Gamma(A\to bb)} + \frac{\Gamma(H\to\tilde\tau_i\tilde\tau_j)}{\Gamma(H\to bb)}$$

$$\frac{B(bb\,\tilde\tau\tilde\tau)}{B(bb\,\tau\tau)} = \frac{1}{2}\left\langle\frac{\Gamma(A\to\tilde\tau_1\tilde\tau_2)}{\Gamma(A\to\tau\tau)} + \frac{\Gamma(H\to\tilde\tau_i\tilde\tau_j)}{\Gamma(H\to\tau\tau)}\right\rangle$$





FINAL EVALUATION

– parabola slightly shifted due to $\mu \cot\beta$ term

and slightly distorted due to $H \to \tilde{\tau}_i \tilde{\tau}_i$

– 2 solutions : discriminate by measuring $\sin 2\theta_\tau$

accuracy a few % *vs* 20% difference

– ex/internal determination of $\tan\beta$; external μ

RESULT : $A_\tau = -450 \pm 50$ GeV

[equiv to indirect Fittino determination within MSSM