Higgs to AA Decays at the LHC

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Early Phase of LHC for ILC

in collaboration with
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LEP Results

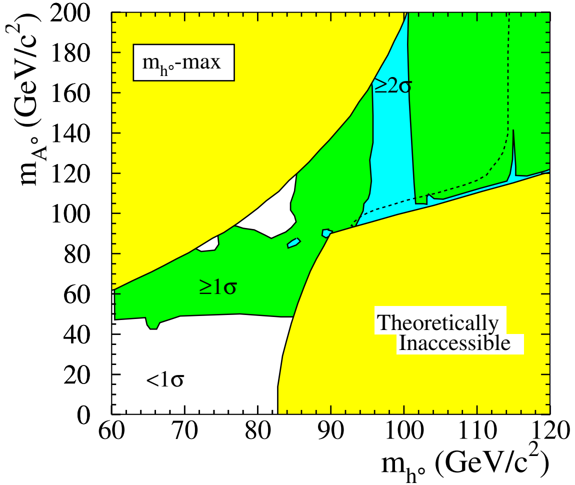
m_{Higgs} Lower Limit

- Standard Model: 114 GeV
- MSSM: 114 GeV, 90 GeV
- . . .

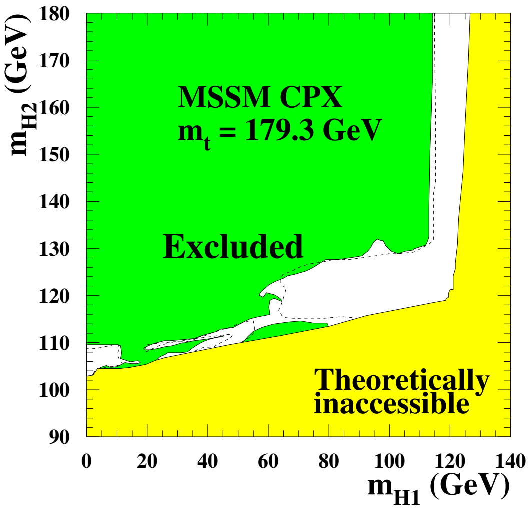
  Most searches focus on 'Standard Channels'

  channel blind search (recoil mass method):
- 82 GeV with full SM coupling
- 20 GeV with $1/10$ SM coupling

No Light Higgs Bosons



Maybe Light Higgs Bosons



H to AA

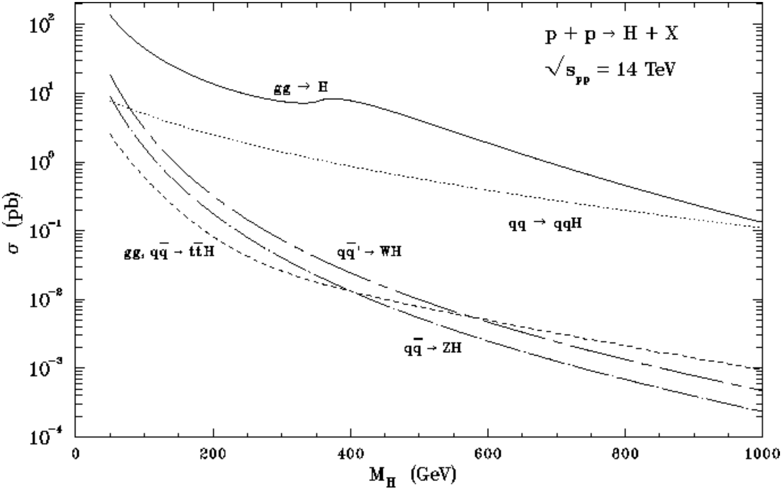
Allows existence of relatively light Higgs $(80 - 150\text{GeV})$ to decay to even lighter Higgs pairs.

Lightest Higgs (A) dominantly decays into $b\bar{b}$, $\tau\bar{\tau}$, light jets, $\gamma\gamma$ ...

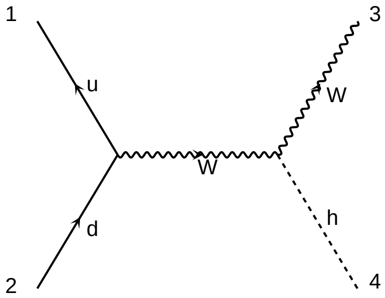
Search channels studied: $bb\bar{b}\bar{b}$,$b\bar{b}\tau\bar{\tau}$, $\tau\tau\bar{\tau}\bar{\tau}$, $\tau\bar{\tau}jj$, 4γ ...

Most studies make use of the leading Higgs production mechanisms: gluon fusion and weak boson fusion.

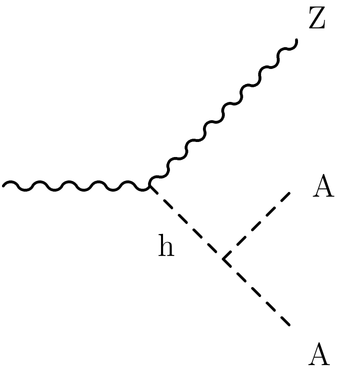
Higgs Production



W/Z associated Higgs production



Decay Chain



- $W/Z \rightarrow l\nu_l/l + l-$
- $H \rightarrow AA$
- $A, A \rightarrow b\bar{b}, \tau\bar{\tau}$

- Signal compromised by smaller σ and W, Z leptonic BR.
- Background suppressed by 2 or more orders of magnitude.

Factorization of the Cross Section

$$\sigma = \sigma(Wh)\ \mathcal{B}(W)\ \kappa_{hWW}^2 \mathcal{B}(h \to aa)\mathcal{B}(a \to b\bar{b})\mathcal{B}(a \to \tau\bar{\tau}) \cdot 2$$

$$\sigma = \sigma(Wh)\ \mathcal{B}(W)\ \kappa_{hWW}^2 \mathcal{B}(h \to aa)\mathcal{B}(a \to b\bar{b})^2$$

$$C_{bb\tau\tau}^2 \equiv \kappa_{hWW}^2 \mathcal{B}(h \to aa)\mathcal{B}(a \to b\bar{b})\mathcal{B}(a \to \tau\bar{\tau}) \cdot 2$$

$$C_{bbbb}^2 \equiv \kappa_{hWW}^2 \mathcal{B}(h \to aa)\mathcal{B}(a \to b\bar{b})^2$$

Parameters

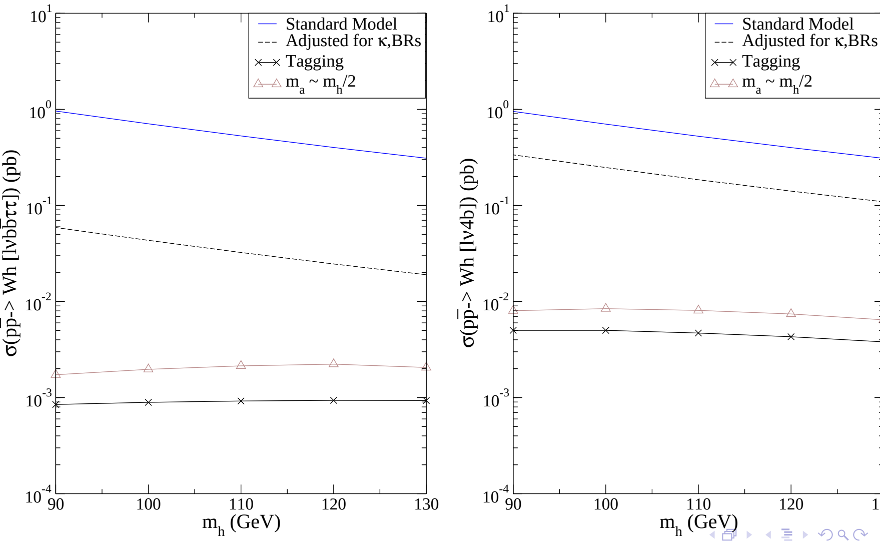
	parameters	representative value	considered range
masses	m_h	120	90–130
	m_a	30	20–60
coupling	κ_{hVV}	0.7	0.5–1.0
branching fractions	$\mathcal{B}(h \to aa)$	0.85	0.8–1.0
	$\mathcal{B}(a \to b\bar{b})$	0.92	0.95–0.70
	$\mathcal{B}(a \to \tau\bar{\tau})$	0.08	0.05–0.30
$2b2\tau$ channel	$C^2_{2b2\tau}$	0.061	0.019–0.42
$4b$ channel	C^2_{4b}	0.35	0.13–0.90

Cuts, Tagging

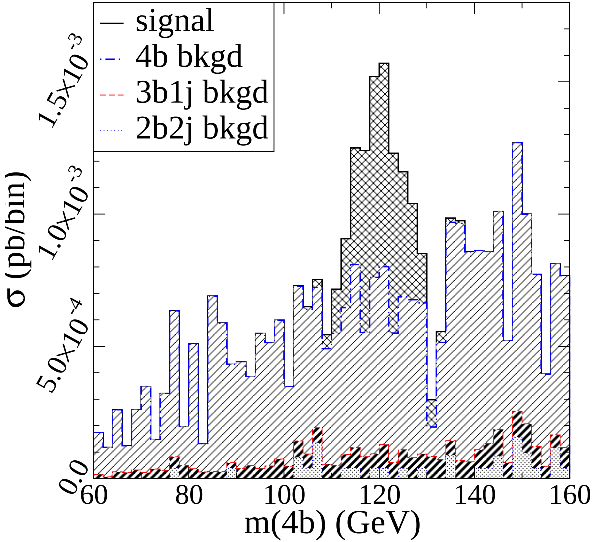
$$\begin{aligned} b - tagging: &\quad 50\% &\quad \text{for } E_T > 20 \text{ GeV}, \quad |\eta| < 1.0 \\ \tau - tagging: &\quad 40\% &\quad \text{for } E_{vis} > 20 \text{ GeV}, \quad |\eta| < 1.5 \\ jet\ \ rejection: &\quad 50 - 200 & \end{aligned}$$

$$\begin{aligned} \Delta R &> 0.4 \\ m_{inv} &> 20 \text{ GeV} \end{aligned}$$

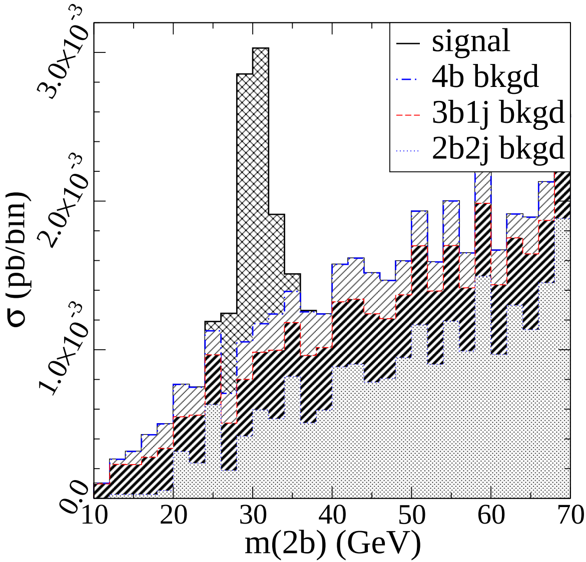
Signal (assuming $C^2_{2b2\tau} = 0.06, C^2_{4b} = 0.35$)



Signal vs. Background



Signal vs. Background



Signal Significance

Window Cuts

m(4b): $100 - 140$ GeV
m(2b): $20 - 40$ GeV

Statistics

$C_{4b}^2 = 0.35$	σ (fb)	S/B	$S/\sqrt{S+B}$ 10 fb^{-1}	100 fb^{-1}
m(4b)	4.5	0.35	3	9
m(2b)	4.5	0.32	3	9

With $\int Ldt = 10$ fb^{-1}, can achieve 5σ discovery for $C_{4b}^2 \gtrsim 0.5$
With $\int Ldt = 300$ fb^{-1}, can achieve 5σ discovery for $C_{4b}^2 \gtrsim 0.09$