Search for neutral SUSY Higgs bosons in $\tau\tau$ and $b+\tau\tau$ final states in $p\bar{p}$ collisions at 1.96 TeV

Subhendu Chakrabarti
For DO and CDF collaboration

SUNY @Stony Brook 08-12-2011

DPF 2011
Outline

- Introduction
- MSSM Higgs Searches $L=1.8-7.3$ fb$^{-1}$
  - Inclusive production $h \rightarrow \tau\tau$ final state
  - Associated production $hb \rightarrow \tau\tau b$ final state
MSSM Higgs production in $\tau\tau$ channels

- MSSM: 2 Higgs doublets coupling to down-type (vev $v^d$) and up-type quarks (vev $v^u$)
- Production cross section is enhanced by $\tan^2\beta$, $\tan\beta$ defined as $v^u/v^d$.
- Since one expects $\tan\beta \sim m_{\text{top}}/m_{\text{bottom}}$, high $\tan\beta$ region $\sim 35$ is interesting.
- After EW breaking 3 neutral Higgs ($h/H/A \sim \Phi$) and 2 charged Higgs physical states
  ✴ Parameter space controlled by $M_A$ and $\tan\beta$ at tree level
  ✴ $\tau\tau$ modes are much less sensitive to radiative corrections
- For $\tau\tau$ modes, $BR_{\tau\tau} \approx 10\%$. For $b\bar{b}$ modes, $BR_{b\bar{b}} \approx 90\%$ (Results at Tevatron in Craig Group’s talk this morning)
Hadronic $\tau$ decay is important for the channels

Identification challenging due to soft decay products, one or three prong decay and multijet background

$\tau$ Identification

- NN based on isolation, shower shape, trk-cal consistency variables
- Narrow isolated cone around seed track
Inclusive $h \to T_e T_h, T_\mu T_h$ @D0 (5.4 fb$^{-1}$)

- $\mu T$ channel, one isolated muon and an isolated hadronic tau
- Additional preselection cut $\Delta \phi > 0.5$ to suppress $Z_{\mu\mu}$ and $M_T < 50$ to suppress $w+jets$
- $e\mu$ channel, events with at least one muon and an OS electron
- Additional cuts $\Sigma p_T > 70$, $M_{T\text{min}} < 10$ and $\Delta \phi(l, P_T) < 0.3$ to reject $t\bar{t}$, $w+jets$, $WW$

$M_{\text{vis}} = \sqrt{(P_{T1} + P_{T2} + P_T)^2}$
$h \rightarrow \tau_\mu \tau_h, \tau_e \tau_h, \tau_\mu \tau_e$ @ CDF (1.8 fb$^{-1}$)

- $e\tau/\mu\tau$ channel, one isolated electron/muon and an OS hadronic tau
- $e\mu$ channel, events with one central muon and one central OS electron
- partially reconstructed di-tau mass fitted with data for signal exclusion

![Diagrams showing mass distributions and signal exclusion for di-tau searches in CDF Run II with 1.8 fb$^{-1}$ data.](image)
Model independent limit on $h \rightarrow \tau\tau$ production

- In DØ, data are found to be consistent with SM expectations.
- A modified frequentist approach used to set upper limits on the cross section times branching ratio in the Higgs boson mass ranging from 90 to 300 GeV.
- Similarly, CDF observed no signal evidence for mass range of 90 to 250 GeV.
Results in MSSM scenarios $h \rightarrow \tau \tau$ searches

- In the MSSM parameter space, excluding $\tan \beta$ values expected limit down to 30 for Higgs boson masses below 170 GeV for D0
- Similarly CDF excluded $\tan \beta$ values down to 45
- MSSM benchmark scenarios with mixing and no mixing shown for D0 and CDF
- Nearly as good as with first CMS result
Exactly one isolated electron, exactly one reconstructed hadronic tau and at least one jet

NN_b cut on b tagged sample

Final Discriminant=NN_{top}^*(L_{MJ}+10)/20

Complimentary to inclusive $\tau\tau$ production, associated production with $b$ quark searches exist

$b$ tagging reduces $Z+\text{jets}$ irreducible background

- Exactly one isolated electron, exactly one reconstructed hadronic tau and at least one jet
- $NN_b$ cut on $b$ tagged sample
- Final Discriminant=$NN_{top}^*(L_{MJ}+10)/20$
$\text{hb} \rightarrow b\tau_\mu\tau_h \ (7.3 \ \text{fb}^{-1}) \ @\text{D0}$

- Exactly one isolated muon, exactly one reconstructed hadronic tau, and at least one jet
- $b$ tagged sample at least one jet to have $\text{NN}_b > 0.25$
- Final likelihood discriminant formed by $D_{mj}$, $D_{tt}$, $\text{NN}_b$ and $M_{\hat{0}}$

![Graphs showing event distributions for different $\tau_h$ types and masses](image)
• DO data are found to be consistent with SM expectations

• DO sets upper limits on the cross section times branching ratio in the Higgs boson mass range from 90 to 320 GeV using a modified frequentist approach.

Limits on $h b \rightarrow b T \mu T h, b T e T h$ @ DO
MSSM parameter exclusion for $h b \rightarrow b \tau \tau$

In the MSSM two benchmark scenarios are shown excluding tan $\beta$ values down to 40 in $b \tau_e \tau_h$ ($25$ in $b \tau_\mu \tau_h$) for Higgs boson masses below 170 GeV in $+\mu$ parameter space.
In the MSSM two benchmark scenarios, excluding tan $\beta$ values down to 40 in $b\tau_e\tau_h$ (25 in $b\tau_\mu\tau_h$) for Higgs boson masses below 170 GeV in $-\mu$ parameter space.
Conclusions

MSSM Higgs Searches in complimentary $\tau\tau$ and $\tau\tau b$ channels exclude interesting regions of the SUSY parameter space.

These limits are the most stringent limits at Tevatron. Combination of Tevatron MSSM channels will be presented in Louise Suter’s talk this morning.

Tevatron sensitivity comparable to first LHC results. In EPS 2011, CMS updated results excluding $\tan \beta$ values down to 15.
Thanks !