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Search for MSSM Higgs Boson Production in Di-tau Final States with $\mathcal{L}$=2.2 fb^{-1} at the DØ Detector

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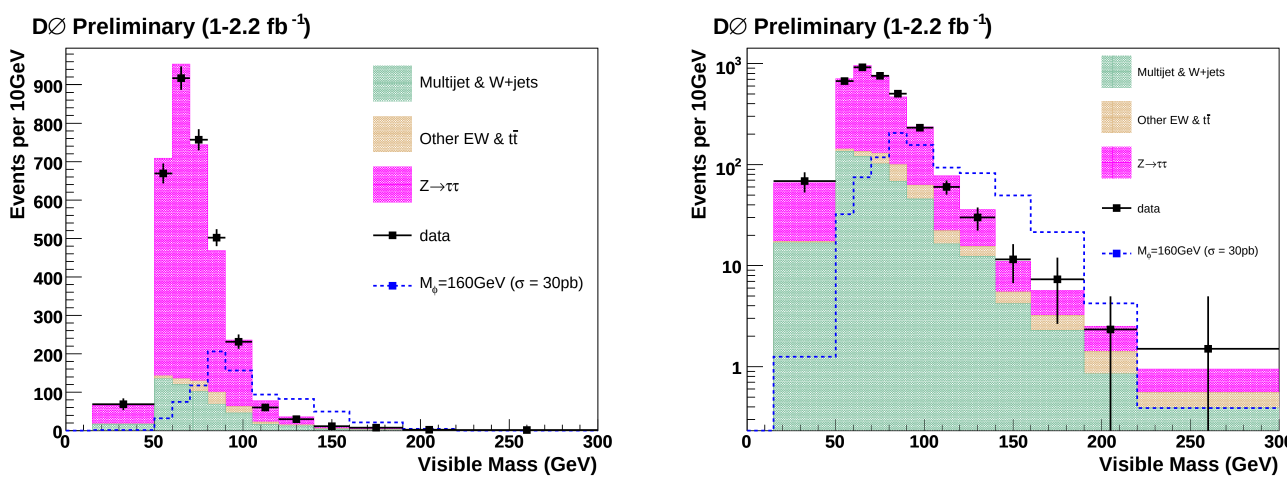
Upper limits on the production cross section for neutral Higgs bosons decaying into $\tau^+\tau^-$ final states are presented from $p\bar{p}$ collisions at a center-of-mass energy of 1.96 TeV. The integrated luminosity for the study is about 2.2 fb^{-1}, collected by the DØ Experiment at the Fermilab Tevatron Collider during Run IIa and Run IIb. The results are interpreted in the Minimal Supersymmetric Standard Model (MSSM), and regions in the (m_A, tanβ) parameter space for two MSSM benchmark scenarios are excluded.

Preliminary Results for Summer 2008 Conferences

I. COMBINED LIMITS ON CROSS-SECTION

Searches for neutral Higgs boson decaying into tau lepton pairs, ϕ $(= H, h, A) \rightarrow \tau\tau$, have been performed by the DØ Collaboration with integrated luminosities of $\mathcal{L} = 1.0$ fb^{-1} in Run IIa [1] and $\mathcal{L} = 1.2$ fb^{-1} in Run IIb [2]. The Run IIa search requires the tau pairs to decay into $\tau_e\tau_{had}$, $\tau_\mu\tau_{had}$, or $\tau_e\tau_\mu$, and the Run IIb search requires the tau pairs to decay into $\tau_\mu\tau_{had}$, where τ_e and τ_μ are the leptonic decays of the tau and τ_{had} is the hadronic decay mode. In these studies, which together represent a dataset of $\mathcal{L} = 2.2$ fb^{-1}, no significant excess in signal over background has been observed and thus limits on the production cross section for neutral Higgs boson times the branching fraction into tau leptons are determined for Higgs masses within the range of 90 to 300 GeV. The visible mass spectrum, shown in Fig. 1 and defined in [1, 2], is used in the limit calculation. These limits are shown in Fig. 2 in comparison to rates for a Higgs boson with Standard Model (SM) width. Correlations in systematic uncertainties between the different tau decay channels that have been studied are taken into account. The combination of the 2.2 fb^{-1} dataset analyzed at DØ in Run II provides a 10-20% improvement in the cross section across the range of Higgs boson masses studied.



(a) (b)

FIG. 1: Distribution of the visible mass after all selections applied on (a) a linear scale and (b) a log scale. The data, shown with error bars, is compared to the sum of the expected backgrounds. Also shown, in blue open histogram, is the signal for a Higgs mass of 160 GeV assuming a signal cross section times branching fraction of 30 pb.

II. INTERPRETATION OF RESULTS IN MSSM

From the cross section limits for neutral Higgs production regions of the (m_A, tanβ) parameter space can be excluded in the Minimal Supersymmetric Standard Model (MSSM). Through radiative corrections beyond tree level, the masses and couplings of the Higgs boson depend on additional SUSY parameters. Assuming a CP-conserving Higgs sector, limits on tanβ as a function of m_A can be derived in two benchmark scenarios given by:

- **m_h^{max} scenario:**
  - $X_t = 2$ TeV;
  - $\mu = \pm 0.2$ TeV;
  - $M_2 = 0.2$ TeV;
  - $m_{\tilde{g}} = 0.8$ TeV
  - $M_{SUSY} = 1$ TeV

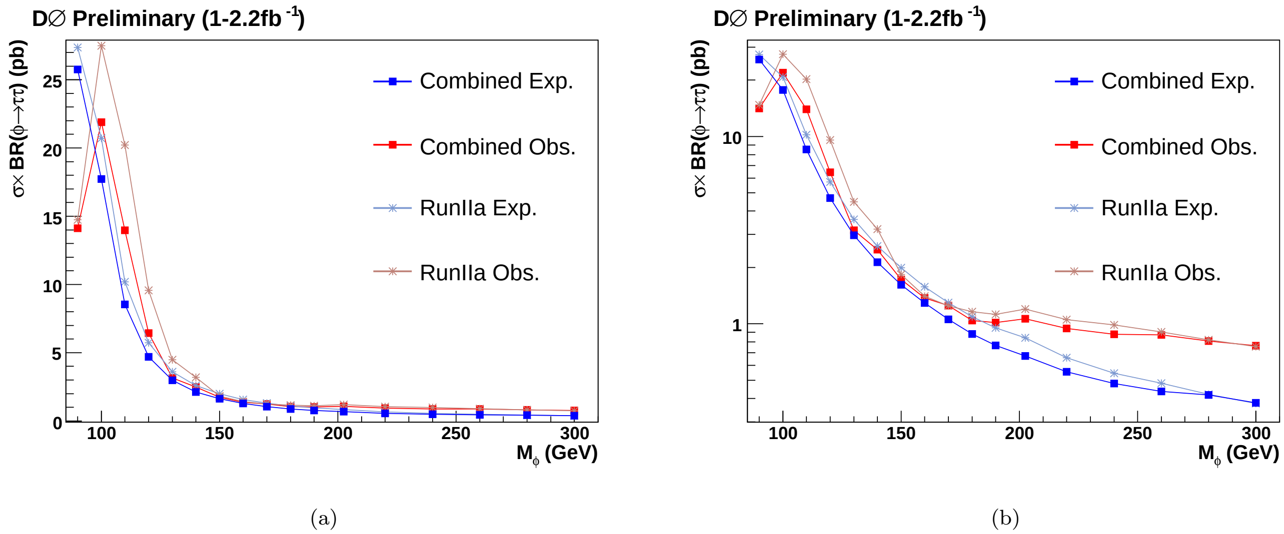


FIG. 2: Expected and observed upper limits on the production cross section times branching ratio for $\phi \to \tau\tau$ production as a function of m_ϕ assuming the SM width of the Higgs boson on (a) a linear scale and (b) a log scale. Results (square marker) correspond to an integrated luminosity of $\mathcal{L}$=2.2 fb^{-1} and are compared to the DØ Run IIa $\mathcal{L}$=1.0 fb^{-1} result (asterisk marker).

- **No-mixing scenario:**
  - ∗ $X_t = 0$ TeV;
  - ∗ $\mu = \pm 0.2$ TeV;
  - ∗ $M_2 = 0.2$ TeV;
  - ∗ $m_{\tilde{g}} = 1.6$ TeV;
  - ∗ $M_{SUSY} = 2$ TeV

where X_t, μ, M_2, $m_{\tilde{g}}$, and M_{SUSY} are the mixing parameter, Higgsino mass parameter, gaugino mass term, gluino mass, and the common scalar mass, respectively.

The cross section, width, and branching ratios for the Higgs boson have been calculated using the `FEYNHIGGS` program [3] version 2.6.4. The excluded region in the (m_A, tanβ) space in each scenario is given in Fig. 3, for the case of $\mu > 0$. The region excluded by the LEP experiments [5] is also shown. The $\mu < 0$ case, which is presently disfavored [4], is not considered. At large tanβ, the A boson is nearly degenerate in mass with either the h or H boson and thus, the production cross sections for $gg \to \phi$ and $b\bar{b} \to \phi$ are added at each (m_A, tanβ) point.

Acknowledgments

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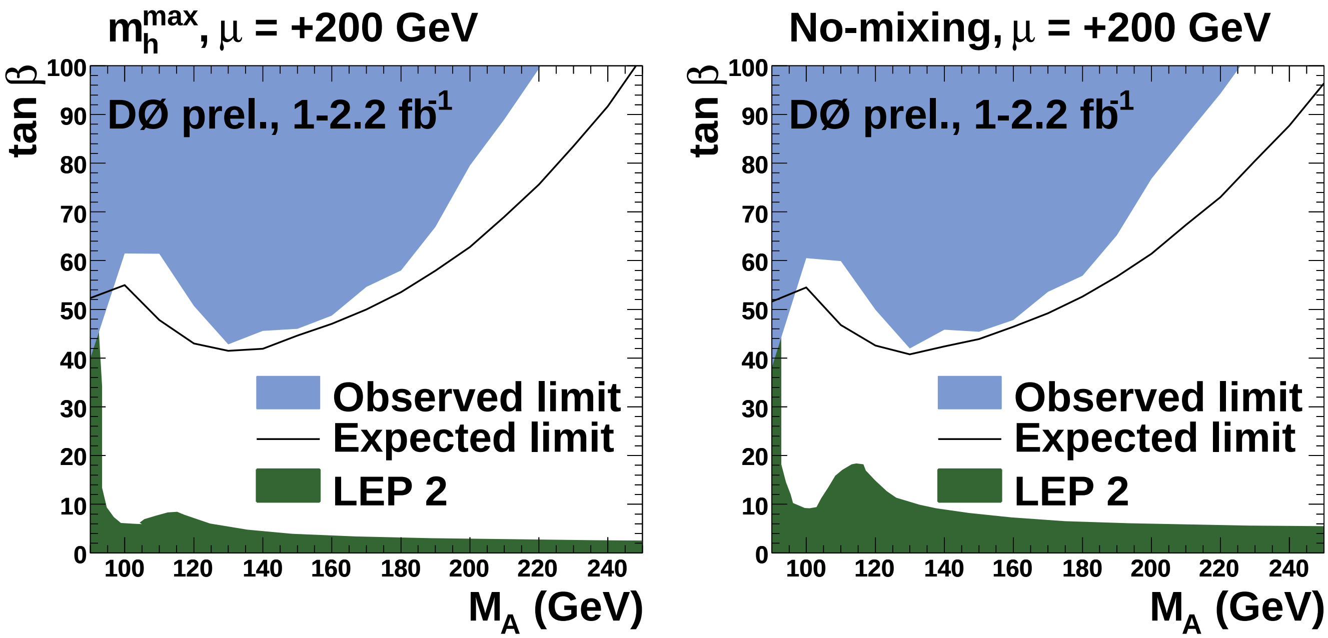

(a)

(b)

FIG. 3: Region in the (m_A, tanβ) parameter space that has been excluded at 95% CL for $\mu > 0$ in two MSSM benchmark scenarios: (a) m_h^{max} and (b) no-mixing. Shown also by the green shaded region is the excluded region by LEP [5].

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`FEYNHIGGS` program URL: `http://www.feynhiggs.de`

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