Tevatron High Luminosity Projections for MSSM Higgs Search in the $\tau\tau$ Channel.

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We present projections for the sensitivity for the MSSM Higgs decaying to τ for high luminosity running at the Tevatron. We use the sensitivity achieved in this search mode at CDF, and assume similar performance by D0 in this mode.

The MSSM has two Higgs doublets and the corresponding fields couple to up-type and down-type fermions. The ratio of the vacuum expectation values of the two Higgs fields is defined as $\tan\beta$. The MSSM has five physical Higgs bosons, three neutral and two charged. We search for the neutral Higgs bosons decaying to τ pairs.

The neutral Higgs bosons of the MSSM have an interesting mass spectrum. A CP-odd (pseudoscalar) – the A, and two CP-even (scalars) – h, and H, can range from M_Z at the low end to large masses. The A and either the h or H are nearly degenerate in mass and production cross-section. The crossover mass (where the h and H switch to being degenerate with the A) depends on the particulars of the MSSM scenario.

Higgs bosons in the MSSM are produced via $gg \to \phi$ and $b\bar{b} \to \phi$, where ϕ is A or h/H. The production cross section for both modes increases as $\tan^2\beta$. We do not require any additional leptons or jets (b-tagged or not) in the event, nor do we directly veto the presence of extra objects in the event. Therefore we are sensitive to both $gg \to \phi$ and $b\bar{b} \to \phi$. We use HIGLU from M. Spira to calculate the former cross-section, and for the latter we multiply the $b\bar{b} \to h$ in the Standard Model by W. Kilgore to the MSSM/SM ratio given by the FeynHiggs program of Sven Heinemeyer et. al.

Values of $\tan\beta$ near 40 are interesting ($m_{\mathrm{top}}/m_{\mathrm{bottom}} \approx 40$), and we evaluate the production cross sections for a M=120, 140 GeV/c^2 at $\tan\beta = 40$

Mass GeV/c^2	$gg \to A$ (pb)	$gg \to H$ (pb)	$bb \to A$ (pb)	$bb \to H$ (pb)	Total MSSM (pb)	SM (pb)
120	11.4	8.6	16.7	16.7	53.4	0.01
140	4.3	4.1	8.2	8.2	24.8	0.005

Table 1: **Production cross-sections for the neutral MSSM Higgs bosons for $\tan\beta = 40$. The cross-sections are considerably higher than those predicted for the Standard Model (SM) in the final column.**

We use decay modes of the τ pairs in which one τ decays to either an electron on muon, and the other τ decays hadronically. We reconstruct the $\tau\tau$ invariant mass as best we can given the missing neutrinos. We then fit this "mass-like variable" with background and Higgs signal templates and extract a limit for cross-section times branching ratio to taus, for various Higgs masses.

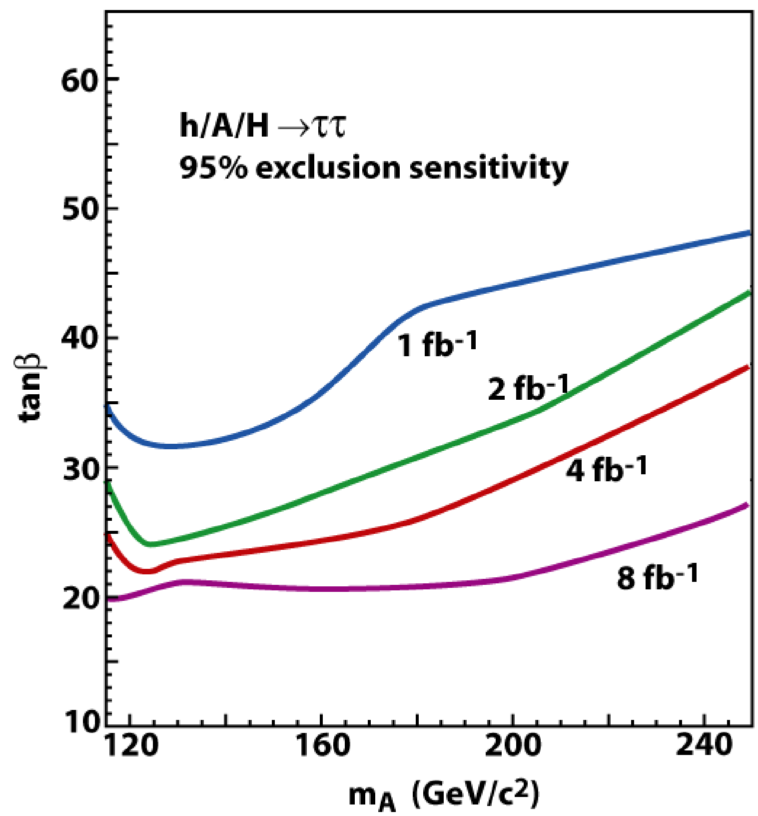

Figure 1: **Exclusion at 95% C.L.**

For the high luminosity projections shown here, we have used the background and signal templates obtained for the current analysis, and calculated the expected limits at 95% confidence level for various luminosity projections. We then convert these cross-section limits to $\tan\beta$ exclusions using the predicted cross sections described above.

We have made certain assumptions in these projections. We have added 30% to the sensitivity for improvements to the analysis. We will include other tau decay channels in which one tau decays to an electron and the other to a muon, as well as ones where both taus decay to hadrons. We will also improve our fitting procedure, taking advantage of kinematic differences between Higgs decays and background (largely $Z \to \tau\tau$). We also assume that the τ energy determination will improve as we continue to understand our detectors better, and that the Parton Density Function (PDF) uncertainty on the gluon and b content of the proton will be reduced.