

Search for neutral and charged MSSM Higgs bosons in ATLAS

Martin FLECHL*[†]

Universität Freiburg

E-mail: martin.flechl@cern.ch

The results of Higgs boson searches in the context of the Minimal Supersymmetric extension of the Standard Model (MSSM) in proton-proton collisions with the ATLAS detector based on collected data corresponding to up to 36 pb^{-1} are presented. Searches in the channels $H^+ \rightarrow c\bar{s}$, $H^+ \rightarrow \tau\nu$, and $H \rightarrow \tau\tau$ are discussed. All observations agree with the expectation of the Standard Model (SM)-only hypothesis and thus exclusion limits are derived.

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*Speaker.

[†]on behalf of the ATLAS Collaboration.

1. Introduction

The Higgs sector of the MSSM consists of two complex scalar fields leading to the existence of five physical Higgs bosons, three of them neutral (h, H, A), and a charged pair (H^\pm). Searches for these particles have been performed in the $H^+ \rightarrow c\bar{s}$, $H^+ \rightarrow \tau\nu$ and $h/H/A \rightarrow \tau\tau$ channels with the ATLAS detector [1]. The recommendations of the LHC Higgs cross section working group [2] have been used for signal rates.

2. Charged Higgs boson decays to $c\bar{s}$

The channel $H^+ \rightarrow c\bar{s}$ is important for light charged Higgs bosons and $\tan\beta < 3$. The ATLAS search focuses on production in $t\bar{t}$ events in the decay mode $b\ell\nu bH^+$ [3]. The signal topology is the same as for SM $t\bar{t}$ events in the lepton+jets mode but the invariant mass of the light-flavour jet pair corresponds to the H^+ instead of the W mass. The analysis strategy is to select lepton+jets events by requiring an isolated lepton, significant missing transverse energy (E_T^{miss}), at least 4 jets of which at least one is b -tagged, and a transverse mass $m_T(\text{lepton}, E_T^{\text{miss}})$ compatible with a W boson, and to look for a second peak in the resulting dijet mass distribution shown in Fig. 1. A

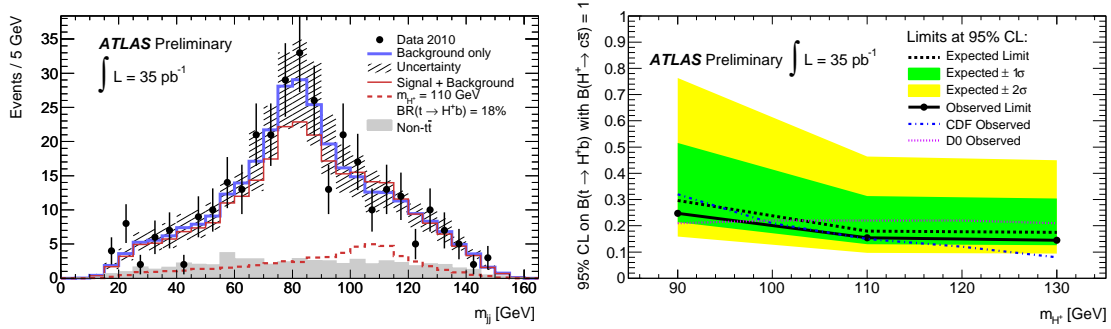


Figure 1: Left: The dijet mass distribution after lepton+jets event selection for data is compared to the SM-only and the signal expectation with $\text{BR}(t \rightarrow bH^+) = 0.18$ and $\text{BR}(H^+ \rightarrow c\bar{s}) = 1$. Right: 95% C.L. limit on $\text{BR}(t \rightarrow bH^+)$ using the CLs [4] method.

kinematic χ^2 fitter is applied to the whole event, and the multi-jet background is estimated from data. As the event yield and shape agrees with the SM expectation, limits at the 95% C.L. are set (see Fig. 1). A branching ratio $\text{BR}(t \rightarrow bH^+)$ of 0.25-0.14 is excluded in the mass range 90-130 GeV, assuming $\text{BR}(H^+ \rightarrow c\bar{s}) = 1$.

3. Charged Higgs boson decays to $\tau\nu$

In the MSSM, the decay $H^+ \rightarrow \tau\nu$ has a branching ratio close to 1 for $\tan\beta > 3$ and $m_{H^+} < m_t$. Four channels have been studied in the context $t\bar{t} \rightarrow bWbH^+$, $H^+ \rightarrow \tau\nu$: $W \rightarrow qq$, hadronic τ decays (“ τ +jets”), $W \rightarrow \ell\nu$, hadronic τ decays (“ τ +lepton”) [5]; $W \rightarrow qq$, leptonic τ decays (“lepton+jets”), $W \rightarrow \ell\nu$, leptonic τ decays (“dilepton”) [6]. For all searches, the main background are SM $t\bar{t}$ decays. Other backgrounds considered are W/Z +jets, single-top, and multi-jets.

The τ +jets event selection requires one τ jet, no electrons or muons in the event, significant E_T^{miss} , at least four jets of which at least one is b -tagged, and a top quark candidate reconstructed;

and the τ +lepton one τ jet, one electron or muon with opposite charge with respect to the τ jet, at least two jets of which at least one is b -tagged, and the transverse energy sum to be larger than 200 GeV. The final discriminants for the analyses involving τ jets are shown in Fig. 2. For the lepton+jets searches, one isolated electron or muon is required, at least four jets of which two are b -tagged, significant E_T^{miss} , and a top quark candidate. The dilepton analysis requires two oppositely-charged isolated leptons, at least two jets. For same-flavor events, $|m_{ll} - m_Z| > 10$ GeV and significant E_T^{miss} is required; otherwise a transverse energy sum larger than 150 GeV. The final generalized transverse mass distributions [7] are shown in Fig. 3. Within statistics, a good agreement with the SM expectation is observed for all channels.

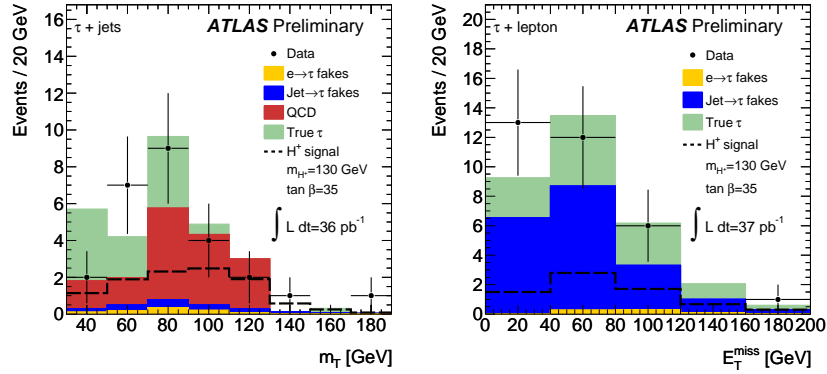


Figure 2: Left: The m_T distribution after event selection for the τ +jets channel. Right: The E_T^{miss} distribution after event selection for the τ +lepton channel. The distribution of the H^+ signal is given for a reference point in parameter space corresponding to $\text{BR}(t \rightarrow bH^+) \approx 6\%$. Backgrounds in which electron and jets are misidentified as τ jets, τ jets are identified correctly, and QCD multi-jet are shown separately.

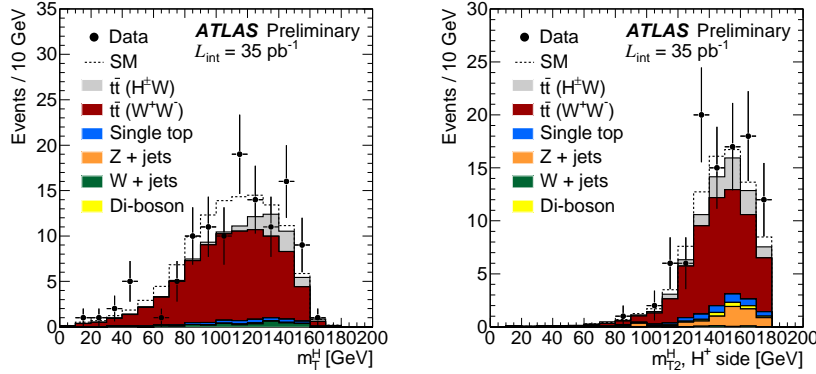


Figure 3: Left: The m_H^H distribution after event selection for the lepton+jets channel. Right: The m_{T2}^H distribution after event selection for the dilepton channel. The dashed line shows the SM expectation, and the stacked histograms the signal+background expectation for $\text{BR}(t \rightarrow bH^+) = 0.15$.

4. Neutral MSSM Higgs boson decays to $\tau\tau$

The most promising channel for the observation of neutral Higgs bosons in the context of the MSSM is the decay to two τ leptons. The gluon fusion and b -associated production modes are

considered, and ATLAS searches focus on the channels where one τ lepton decays hadronically, and the other leptonically (“lepton-hadron”) or where both τ leptons decay leptonically (“lepton-lepton”) [8]. The dominant background is $Z/\gamma^* \rightarrow \tau\tau$; W +jets, $t\bar{t}$, diboson, and multi-jet backgrounds have been considered as well.

The lepton-hadron event selection requires exactly one electron or muon and one oppositely-charged τ jet, significant E_T^{miss} , and a transverse mass of the $\ell - E_T^{\text{miss}}$ system below 30 GeV. The final discriminant after event selection, the visible mass (invariant mass of electron or muon and the τ jet), is shown in Fig. 4. In the lepton-lepton analysis, an isolated electron and an isolated muon with opposite charge and an opening angle larger than 2.0 rad are required. Additionally, the scalar sum of the transverse momenta of the leptons and of the missing transverse momentum must be smaller than 120 GeV. The final discriminant after event selection, the effective mass $m_{\tau\tau}^{\text{effective}} = \sqrt{(p_e + p_\mu + p_{\text{miss}})^2}$, is shown in Fig. 4. The observation is compatible with the data, thus exclusion limits are set (see Fig. 4), extending existing Tevatron limits for $m_A > 180$ GeV.

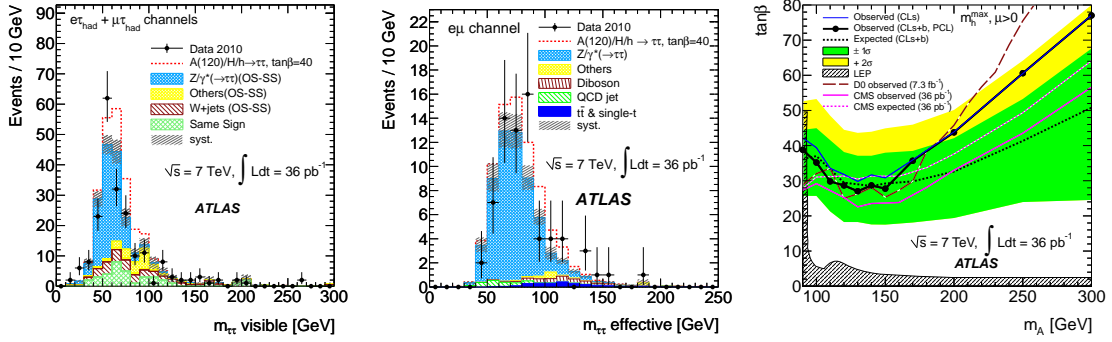


Figure 4: Final mass discriminants after the lepton-hadron (left) and lepton-lepton event selections (center). The figure to the right shows the resulting 95% C.L. limits.

5. Conclusions

Results from all ATLAS searches for MSSM Higgs bosons with up to 36 fb^{-1} are compatible with the SM expectation. Hence exclusion limits have been set in the $H^+ \rightarrow cs$ and $h/H/A \rightarrow \tau\tau$ channels, confirming and extending (for $m_A > 180$ GeV) existing Tevatron limits.

References

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