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Search for the Standard Model Higgs boson in decays in $H \to \tau^+\tau^-$ proton-proton collisions with the ATLAS detector

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Summary. — The status of the search for the Standard Model (SM) Higgs decaying into a τ pair is reported. The analysis is based on the proton-proton data collected with the ATLAS detector corresponding to integrated luminosities of 4.6 fb^{-1} and 13.0 fb^{-1} at centre-of-mass energies of $\sqrt{s} = 7$ TeV and 8 TeV, respectively. The observed (expected) upper limit at 95% CL on the $\sigma \times$ BR for SM $H \to \tau^+\tau^-$ is found to be 1.9 (1.2) $\times$ SM prediction for $m_H = 125$ GeV. For this Higgs mass the observed (expected) deviation for the background only hypothesis corresponds to a local significance of 1.1 (1.7) standard deviations.

PACS 14.80.Bn – Standard Model Higgs bosons.

1. – Introduction

The observation of a new particle with a mass of about 125 GeV by the ATLAS and CMS experiments in the search for the Standard Model (SM) Higgs boson [1,2] is a great success and the beginning of a new era in particle physics. For a Higgs-boson mass of 125 GeV, the $H \to \tau^+\tau^-$ channel is one of the leading decay modes with an expected branching ratio of 6.3%. Moreover, it may provide a measurements of the Higgs coupling to fermion, an important test of the SM.

2. – Analysis strategy

The $H \to \tau^+\tau^-$ analysis [3] exploits each of the final states resulting from the different decay modes of the τ pair: totally leptonic ($\tau_{lep}\tau_{lep}$), semileptonic ($\tau_{lep}\tau_{had}$) and totally hadronic ($\tau_{had}\tau_{had}$). The analysis is further divided into categories based on the jet multiplicity. In particular, the category with two jets with high p_{T} and large $\Delta\eta$ separation has the highest sensitivity thanks to its particular topology that provides good rejection against the background.

For all the subchannels the main background is given by $Z \to \tau\tau$ decays. This is an irreducible background and it is estimated with an *embedding procedure* [3]: starting from data $Z \to \mu\mu$ events, the μ pair is replaced with a simulated τ pair.

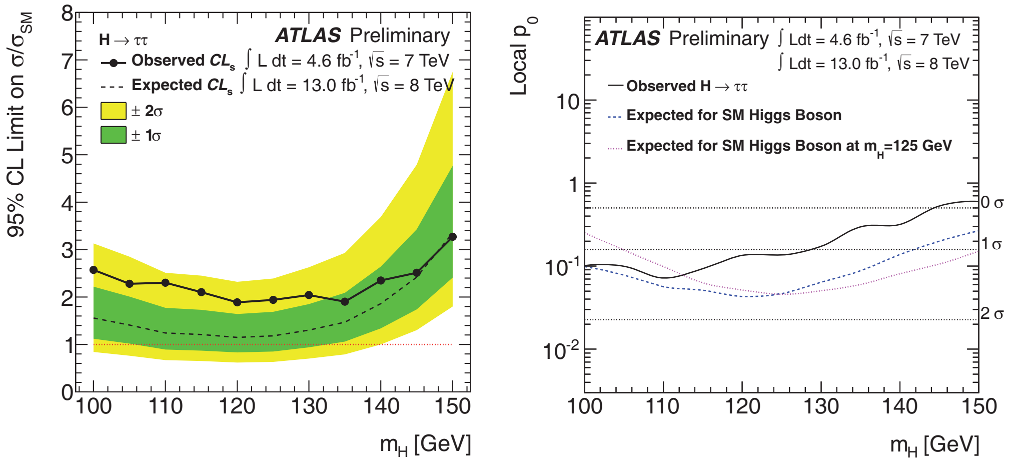

Fig. 1. – Limits and local p_0 for the $H \to \tau^+\tau^-$ channel combining 2011 and 2012 data.

The final discriminant is the reconstructed invariant mass of the $\tau\tau$ system, $m_{\tau\tau}$. Due to the presence of multiple neutrinos in the final state, the $m_{\tau\tau}$ cannot be directly computed. An estimate of this mass is obtained by scanning over the neutrino directions and $E_T^{\rm miss}$ values and picking the most likely value of $m_{\tau\tau}$ according to the probability density functions extracted from simulated τ decays [4]. No significant excess is observed in the data compared to the SM background-only expectation in any of the considered categories.

3. – Statistical analysis and results

The statistical analysis of the data employs a binned likelihood function constructed as a product of the likelihood terms for each category.

Figure 1 shows expected and observed cross-section limits for a combination of all the three channels for the full analyzed datasets as a function of the Higgs boson mass, m_H, at the 95% confidence level. For $m_H = 125\,\text{GeV}$, the expected limit is 1.2 and the observed 1.9.

The probability that a fluctuation in the background can mimic the presence of a SM Higgs boson signal is studied by calculating the local p_0 value with respect to the background hypothesis and it is also shown in fig. 1. The most significant deviation from the background-only hypothesis is observed for $m_H = 110\,\text{GeV}$ corresponding to a significance of 1.5 σ. For $m_H = 125\,\text{GeV}$, the probability to get a signal at least as large as the one observed in background-only experiments is 13.5%.

REFERENCES

[1] ATLAS Collaboration, *Phys. Lett. B*, **716** (2012) 1, arXiv:1207.7214 [hep-ex].
[2] CMS Collaboration, *Phys. Lett. B*, **716** (2012) 30, arXiv:1207.7235 [hep-ex].
[3] ATLAS Collaboration, ATLAS-CONF-2012-160, `http://cds.cern.ch/record/1493624`.
[4] Elagin A., Murat P., Pranko A. and Safonov A., arXiv:1012.4686.