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Search for a Standard Model $H \to \tau\tau \to \ell\tau_{\mathrm{h}}$ with the ATLAS detector in pp collisions at 7 TeV

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Summary. — The results for a search of a SM Higgs that decays to two taus, where one tau decays leptonically and the other hadronically in ATLAS data at 7 TeV, corresponding to a luminosity of $4.7\,\mathrm{fb}^{-1}$, are presented. The number of observed events is consistent with the background estimation. Exclusion limits on the production cross section multiplied by the branching ratio are derived as a function of the Higgs mass.

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1. – Introduction

The $H \to \tau\tau$ channel is important in the Standard Model (SM) Higgs search, especially at low masses. The channel where one tau decays leptonically and the other hadronically is favoured by the large branching ratio ($\sim 45\%$) and by the clean experimental signature. The search for $H \to \tau\tau$ in the lepton-hadron channel at the ATLAS detector [1], operating at the LHC is presented [2].

2. – Event selection

Events are first of all selected by single-lepton triggers. Then the presence of an electron or muon and a tau candidate, all satisfying reconstruction and identification quality criteria, passing a moderate p_T cut is required. Isolation requirements are imposed as well on electrons and muons.

Jets in the event are reconstructed by the anti-k_t algorithm with distance parameter $R = 0.4$ starting from calibrated calorimeter clusters while the measurement of the missing transverse momentum (E_T^{miss}) in the event is based on the energy deposited in the calorimeter cells and on muons reconstructed in the muon spectrometer.

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Events with more than one electron or muon are discarded, and exactly one tau candidate is required. Finally the charge of the lepton and of the tau candidate are required to have opposite signs and a cut on the transverse mass of the lepton and E_T^{miss} $m_T > 30 \, \text{GeV}$ is imposed.

Events are divided into categories in order to enhance the analysis sensitivity. As an example, the VBF category is defined by requiring the presence of at least two jets that display the typical kinematics of jets in the Higgs Vector Boson Fusion production process.

The invariant mass of the system cannot be trivially reconstructed, since neutrinos from tau decays are not detected. Nevertheless, the mass can be reconstructed by assuming the collinearity of visible and invisible tau decay products. The reconstruction however fails if the two taus are back to back or if E_T^{miss} is not well measured. The knowledge of the tau decay kinematics is therefore used to build an estimator of the mass (MMC). This allows as well to partially compensate for the effects of the resolution in the E_T^{miss} measurement.

3. – Background estimation and systematics

The main background in this search channel is the irreducible $Z \to \tau\tau$ background, which is modeled starting from $Z \to \mu\mu$ real events, where the muons are replaced by simulated taus (embedding). Other backgrounds, namely $W \to l\nu$, $Z \to ll$, multi-jet production and di-boson production are estimated thanks to a mixed data-driven and Monte Carlo technique. The strategy is based on the assumption that the mass spectrum does not depend on the charge correlation between the lepton and tau candidate and that the ratio between events with opposite charge of the lepton and tau candidate (OS) and those with same charge (SS) is unity for multi-jet events.

Systematic uncertainties in this search are related to the detector, background normalization and theory. Detector uncertainties include luminosity, detector pile-up conditions, jet energy scale and resolution uncertainties. Furthermore differences between data and Monte Carlo in the identification efficiencies, energy and momentum scale of electrons, muons and taus are considered. Uncertainties in the normalisation of backgrounds are kept under control by considering possible uncertainties in the embedding procedure and by checking the assumptions on which the background estimation is based in dedicated control regions.

4. – Results and conclusion

The pp collision sample at a centre of mass energy of $7 \, \text{TeV}$ collected by ATLAS was used for a search of the SM Higgs boson in the $H \to \tau\tau \to l\tau_{\text{had}}$ channel. A statistical analysis was performed using the profile-likelihood formalism. No significant excess with respect to the background prediction was observed in the 100–150 GeV mass range. Exclusion limits at the 95% confidence level, using the modified frequentist method CLs, were set for cross sections between 4 and 17 times larger than the ones predicted by the SM.

REFERENCES

[1] THE ATLAS COLLABORATION, *JINST*, **3** (2008) S08003.
[2] THE ATLAS COLLABORATION, ATLAS-CONF-2012-014.