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New results on Higgs properties

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ABSTRACT

We present the latest ATLAS and CMS measurements of several Higgs properties, such as signal-strength modifiers for the main production modes, fiducial and differential cross sections, and the Higgs mass. We have analyzed the 13 TeV proton-proton LHC collision data recorded in 2016, corresponding to integrated luminosities up to 36.1 fb^{-1}. Results for the $\text{H} \to \text{ZZ} \to 4\ell$ ($\ell = \text{e}\mu$), $\text{H} \to \gamma\gamma$, and $\text{H} \to \tau\tau$ decay channels are presented. In addition, searches for new phenomena in the $\text{H} \to \gamma\gamma + E_{\text{T}}^{\text{miss}}$ and $\text{H} \to \text{b}\overline{\text{b}} + E_{\text{T}}^{\text{miss}}$ decay channels are presented.

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1 Introduction

The discovery of the Higgs boson was announced in 2012 by the ATLAS and CMS collaborations [1, 2] based on proton-proton collisions collected at the CERN LHC at the centre of mass energies of 7 and 8 TeV. Since then a huge effort has been made in the determination of the properties of this newly found particle. The dataset already collected at 13 TeV allows inclusive Higgs boson measurements to be repeated. Furthermore, the increased centre-of-mass energy results in much larger cross sections for events at high partonic centre-of-mass energy. This implies improved sensitivity to a variety of interesting physics processes, such as Higgs bosons produced at high transverse momentum.

In this document we present the latest ATLAS and CMS measurements of several Higgs properties in different decay channels, such as $\mathrm{H} \to \mathrm{ZZ}$, $\mathrm{H} \to \gamma\gamma$ and $\mathrm{H} \to \tau\tau$. In addition, we also present results on searches for phenomena beyond the Standard Model, in Higgs decays to $\gamma\gamma$ or $\mathrm{b\bar{b}}$, with $E_{\mathrm{T}}^{\mathrm{miss}}$ in the final state.

2 $\mathrm{H} \to \mathrm{ZZ}$

The $\mathrm{H} \to \mathrm{ZZ} \to 4\ell$ decay channel ($\ell = \mathrm{e}, \mu$) has a large signal-to-background ratio due to the complete reconstruction of the final state decay products and excellent lepton momentum resolution, making it one of the most important channels for studies of the Higgs boson's properties. Here we present measurements of properties of the Higgs boson in this channel at 13 TeV, for both the ATLAS and CMS collaborations [3, 4].

See Figure 1.

3 $\mathrm{H} \to \gamma\gamma$

See Figure 2.

4 $\mathrm{H} \to \tau\tau$

To establish the mass generation mechanism for fermions, it is necessary to demonstrate the direct coupling of the scalar boson to fermions, and the proportionality of its strength to the fermion mass. The most promising decay channel is $\tau\tau$, because of the large event rate expected in the SM compared to the other leptonic decay modes, and of the smaller contribution from background events with respect to the $\mathrm{b\bar{b}}$ channel. Here we report the results of a search for the SM scalar boson using 35.9 fb^{-1} at 13 TeV, when it decays to a pair of τ leptons [5]. The four τ-pair final states with the largest branching fractions, $\mu\tau_{\mathrm{h}}$, $\mathrm{e}\tau_{\mathrm{h}}$, $\tau_{\mathrm{h}}\tau_{\mathrm{h}}$, and $\mathrm{e}\mu$, are studied.

The search for an excess of SM scalar boson events over the expected background involves a global maximum likelihood fit based on two-dimensional distributions in all channels, together with control regions for the $\mathrm{t\bar{t}}$, QCD multijet and W+jets backgrounds. Figure 3 shows the distribution observed, together with the expected background and signal distributions, in the $\tau_{\mathrm{h}}\tau_{\mathrm{h}}$ channel and VBF category. The signal prediction for a scalar boson with $m_{\mathrm{H}} = 125$ GeV is normalized to its best-fit cross section times branching fraction. The background distributions are adjusted to the results of the global maximum likelihood fit.

5 Searches for new phenomena

Many searches for dark matter (DM) at the LHC involve missing transverse momentum produced in association to detectable particles. Here we present an updated search by the ATLAS experiment [6] for DM associated with the SM Higgs boson decaying to a pair of photons using 36.1 fb^{-1} of pp collision data collected at 13 TeV. Three theoretical benchmark models are considered in this analysis. In the Z'_{B} model a massive vector mediator Z' emits a Higgs boson and subsequently decays to a pair of Dirac fermionic DM candidates. The Z'-2HDM model involves the Z' boson decaying to the Higgs boson and an intermediate

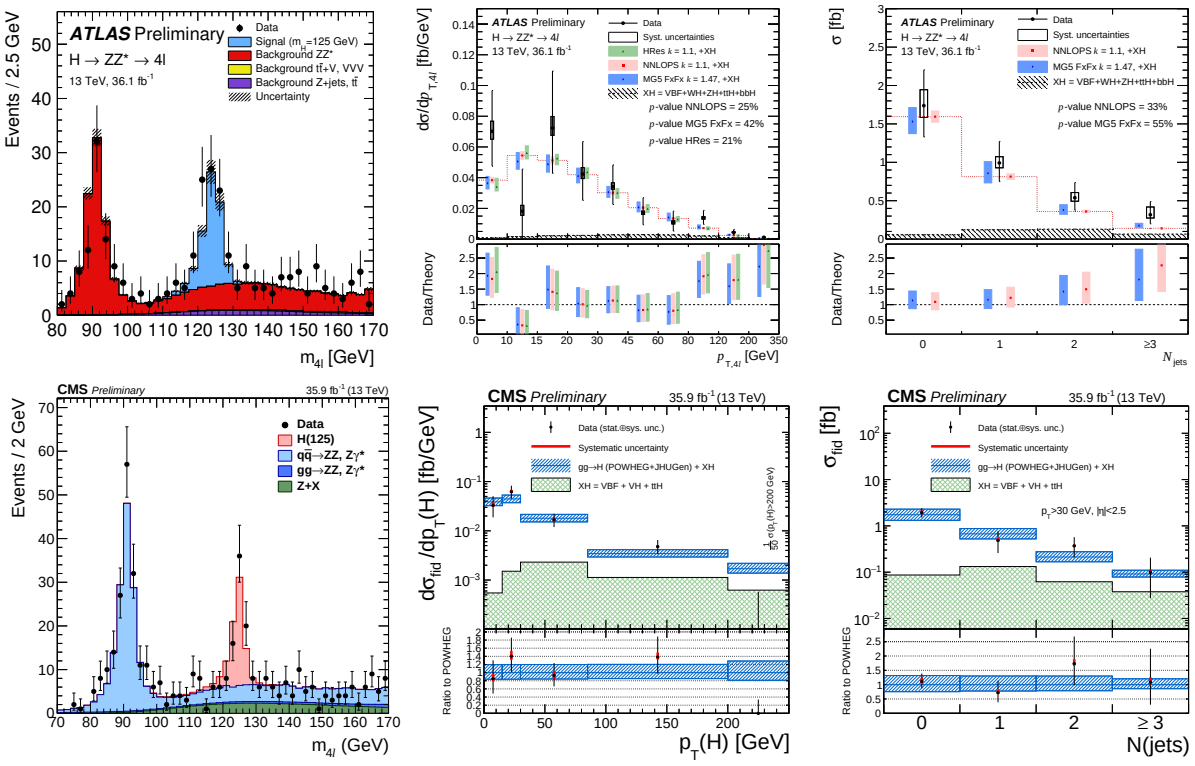

Figure 1: (Top left) ATLAS four-lepton invariant mass distribution of the selected events. The systematic uncertainty on the prediction is shown by the dashed band. (Top center and right) ATLAS differential fiducial cross sections, for the transverse momentum of the Higgs boson (center) and the number of jets (right). The measured cross sections are compared to different ggH predictions, and predictions for all other Higgs production modes XH are added. (Bottom left) CMS four-lepton invariant mass distribution of the selected events. (Bottom center and right) CMS differential fiducial cross sections, for the transverse momentum of the Higgs boson (center) and the number of jets (right). The sub-dominant component of the signal (VBF + VH + ttH) is denoted as XH.

heavy pseudoscalar boson A^0, which then decays to a pair of Dirac fermionic DM particles. The third model, referred to as the heavy scalar model, introduces a heavy scalar boson H produced primarily via gluon-gluon fusion. Here an effective quartic coupling between the SM Higgs h, H and two DM particles is considered, with the DM particle assumed to be scalar. The events that pass a common selection requiring at least two photon candidates are divided into five categories based on the event kinematics. These categories have been optimized based either on the Z'_B and Z′-2HDM signal samples, or using simulated heavy scalar boson samples, to cover the different kinematic regimes of the heavy scalar model. The results of the analysis are derived from a likelihood fit of the $m_{\gamma\gamma}$ distribution in the range of 105 GeV $< m_{\gamma\gamma} <$ 160 GeV. No significant excess over the background expectation is observed and 95% confidence level limits are set on the production cross section times branching fraction of the SM Higgs boson decaying into two photons in association with missing transverse energy in the three different theoretical benchmark models. 95% confidence level limits are also set on the observed signal strength in a two-dimensional m_χ-$m_{Z'_B}$ plane for the Z'_B model, and the m_{A^0}-$m_{Z'}$ plane for the Z′-2HDM model. In the model involving heavy scalar production, 95% confidence level upper limits are set on the production cross section times the branching fraction of $H \to h\chi\chi$, for a dark matter particle with mass of 60 GeV. The heavy scalar model is excluded for all the benchmark points investigated.

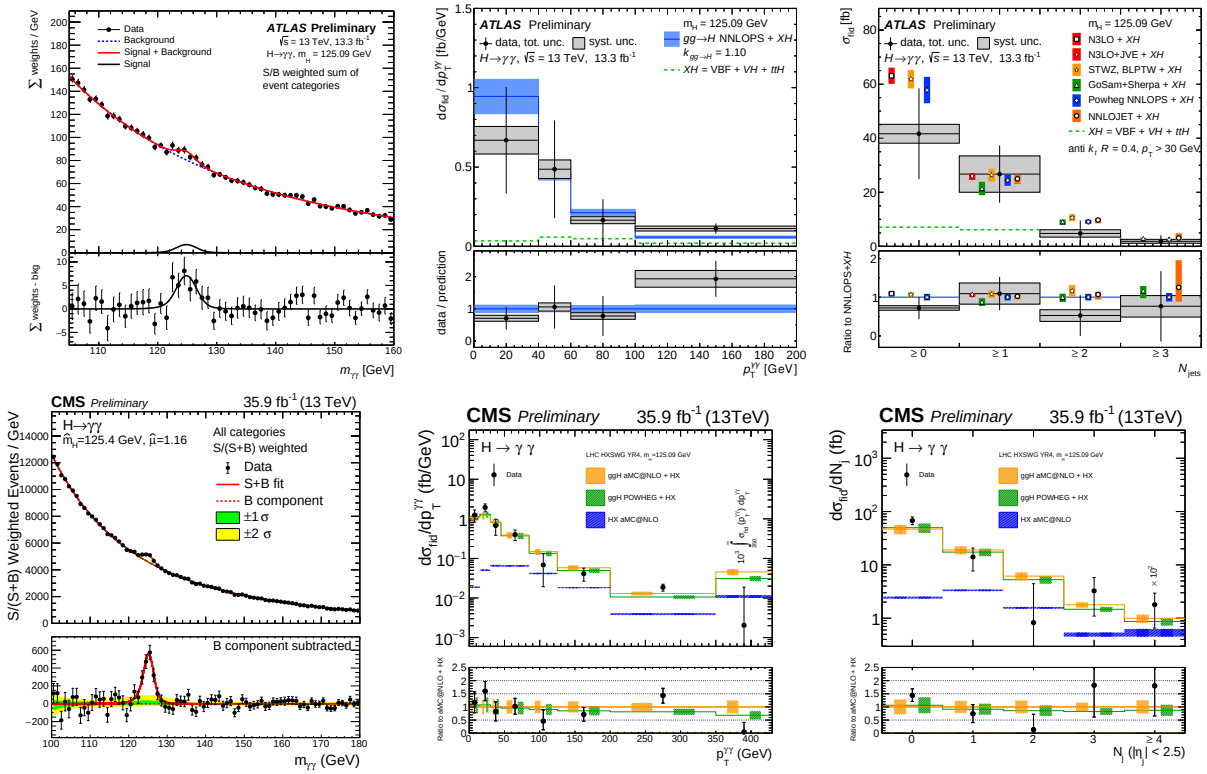

Figure 2: (Top left) ATLAS diphoton invariant mass spectrum. (Top center and right) ATLAS differential fiducial cross sections, for the transverse momentum of the Higgs boson (center) and the number of jets (right). (Bottom left) CMS diphoton invariant mass spectrum. (Bottom center and right) CMS differential fiducial cross sections, for the transverse momentum of the Higgs boson (center) and the number of jets (right).

6 Conclusions

References

[1] G. Aad *et al.* [ATLAS Collaboration], Phys. Lett. B **716**, 1 (2012) [arXiv:1207.7214 [hep-ex]].

[2] S. Chatrchyan *et al.* [CMS Collaboration], Phys. Lett. B **716**, 30 (2012) [arXiv:1207.7235 [hep-ex]].

[3] G. Aad *et al.* [ATLAS Collaboration], ATLAS-HIGG-2016-25.

[4] CMS Collaboration [CMS Collaboration], CMS-PAS-HIG-16-041.

[5] CMS Collaboration [CMS Collaboration], CMS-PAS-HIG-16-043.

[6] G. Aad *et al.* [ATLAS Collaboration], ATLAS-CONF-2017-024.

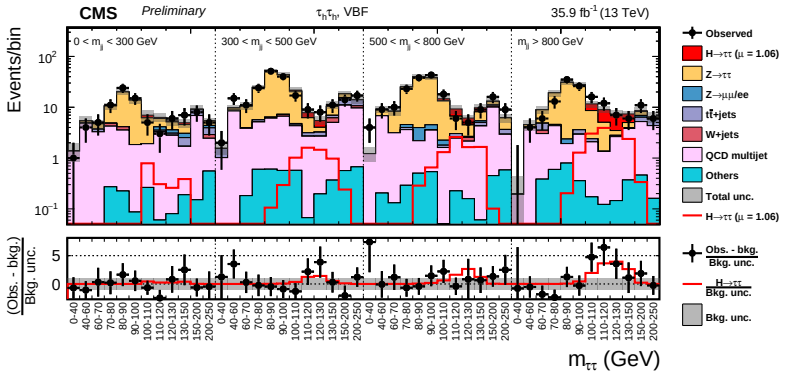

Figure 3: Observed and predicted 2D distributions in the VBF category of the $\tau_h\tau_h$ final state. The normalization of the predicted background distributions corresponds to the result of the global fit. The signal distribution is normalized to its best-fit signal strength.