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A discussion of $H \to ZZ \to 4\ell$ results and analysis strategies for 13 TeV

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Summary. — Studies of Higgs boson production are presented using the $H \to ZZ \to 4\ell$ ($\ell = e, \mu$) decay. These studies are performed using a data sample corresponding to an integrated luminosity of $2.8\,fb^{-1}$ of pp collisions at a center-of-mass energy of 13 TeV collected by the CMS experiment at the LHC during 2015. The observed significance for the standard model Higgs boson with $m_H = 125.09\,GeV$ is 2.5σ, where the expected significance is 3.4σ. The model-independent fiducial cross section is measured to be $\sigma_{fid} = 2.48^{+1.48}_{-1.14}(\text{stat} \oplus \text{sys})^{+0.01}_{-0.04}(\text{model dep.})$ fb.

1. – Description

The studies in various Higgs decay channels and production modes with the full LHC Run 1 [1] data set and combined measurements from ATLAS and CMS showed that the properties of the new boson are so far consistent with expectations for the SM Higgs.

The start of the LHC Run 2 in 2015, at an increased center-of-mass energy of $\sqrt{s} = 13\,TeV$, aimed to rediscover the Higgs boson which opens the way for an era of new precision measurements of the Higgs boson, which will involve the observation and study of its rare production modes such as vector boson fusion (VBF) and associated production with a vector boson (WH, ZH) and top pair production ttH.

2. – Results

The $H \to ZZ \to 4\ell$ analysis is based on the reconstruction, identification and isolation of leptons. The event selection is designed to extract signal candidates from events containing at least four well-identified and isolated leptons, each originating from the primary vertex. First, Z candidates are formed with pairs of leptons of the same flavor and opposite-charge and required to pass $12 < m_{l^+l^-} < 120\,GeV$. They are then combined into ZZ candidates, wherein we denote as Z1 the Z candidate with an invariant mass closest to the nominal Z boson mass, and as Z2 the other one. The details of the event

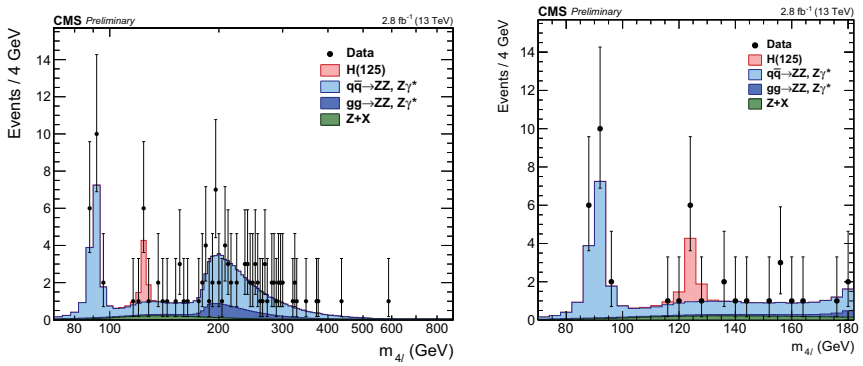

Fig. 1. – Left: Distribution of the four-lepton invariant mass m_{4l} in the full mass range and in the low-mass region. Right: Points with error bars represent the data and stacked histograms represent expected distributions.

selection can be found in [2]. Figure 1 shows the distributions obtained from this selection.

To extract the signal significance for the excess of events observed in the Higgs peak region and estimate its signal strength, a multi-dimensional fit is performed that relies on two variables: the four-lepton invariant mass m_{4l} and the D_{kin}^{bkg} discriminant (which separates the gluon fusion from other production modes). The results for the significance of excess and the signal strength modifiers are shown in fig. 2.

The fiducial volume is defined in [3]. Integrated fiducial cross section for pp $\rightarrow$ H $\rightarrow$ 4ℓ is obtained by performing a maximum likelihood fit of the signal and background parameterizations to the observed 4ℓ mass distribution. The results are shown in fig. 3.

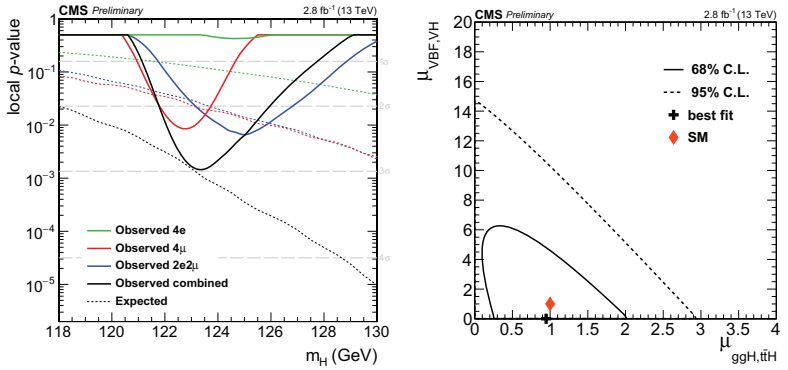

Fig. 2. – Left: Significance of the local fluctuation with respect to the SM expectation as a function of the Higgs boson mass. Dashed lines show the mean expected significance of the SM Higgs boson for a given mass hypothesis. Right: Result of the 2D likelihood scan for the μ_F and μ_V signal-strength modifiers. The solid and dashed contours show the 68% and 95% CL regions, respectively. The cross indicates the best-fit values, and the diamond represents the expected values for the SM Higgs boson.

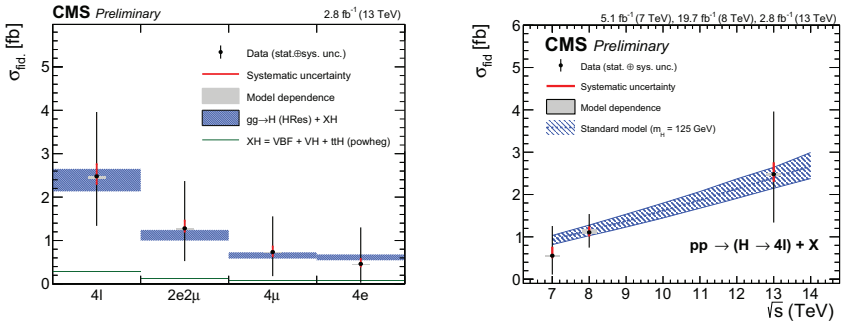

Fig. 3. – Left: Result of measured fiducial cross section in each final state. Right: The measured fiducial cross section as a function center-of-mass energy $\sqrt{s}$.

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