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Search for the SM Higgs boson in the diphoton decay channel with ATLAS

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Summary. — A search for the Standard Model Higgs boson is presented in the diphoton decay channel. The data used corresponds to an integrated luminosity of $4.9\,\text{fb}^{-1}$ collected with the ATLAS detector at the Large Hadron Collider in proton-proton collisions at a center-of-mass energy of $\sqrt{s} = 7\,\text{TeV}$.

PACS 14.80.Bn – Standard-model Higgs bosons.

The Higgs mechanism is one of the best-motivated processes to explain electroweak symmetry breaking. The diphoton decay mode is one of the most important channels in the search for the Higgs boson in the low-mass region. In this analysis [1] all the 2011 data from the ATLAS detector are used. The signal is expected to be very small $(\sigma \times \text{Br}(H \to \gamma\gamma) \simeq 40\,\text{fb}$ at $125\,\text{GeV})$ compared to the huge background from the direct (di)photon production and from jets misidentified as photons.

The candidates are required to pass: a trigger with two photons with transverse momentum $p_T > 20\,\text{GeV}$. There must be at least one vertex with three associated tracks. The pseudorapidity η of the photons must be inside a fiducial region of the calorimeter and the p_T must be greater than $40\,\text{GeV}$ ($25\,\text{GeV}$). Both photons candidates must pass several identification criteria based on the calorimetric shower shapes, and an isolation requirement based on the calorimetric energy. In the mass window 110–160 GeV 22489 events are selected, with a global efficiency of 35%.

To improve the sensitivity the candidates are divided into 9 categories with different purities and mass shapes according to their pseudorapidity, conversion status and p_{Tt}, defined as the transverse momentum with respect to the $(\vec{p}_1 - \vec{p}_2)$ axis. The last observable is sensitive to vector boson fusion and associated production.

As a cross check the background is decomposed in the $\gamma\gamma$, γj and jj categories using four different data-driven techniques, which give results compatible among each other and with Monte Carlo prediction: the reducible component of the background is about 1/3 of the total.

The angle between the two photons is determined from the interaction vertex position and the photon impact points in the calorimeter. For converted photons the vertex

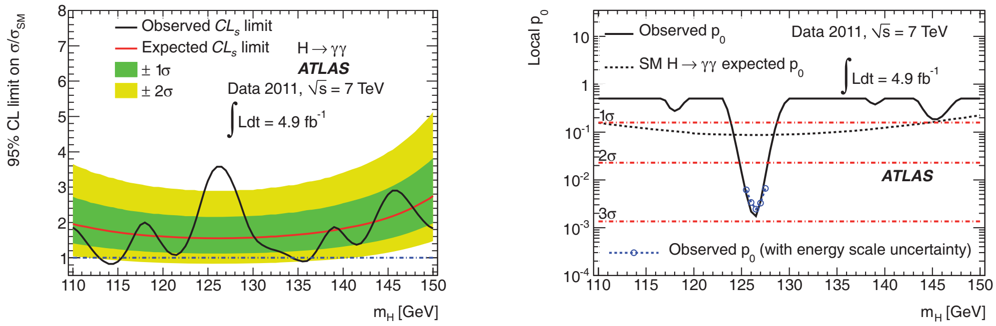

Fig. 1. – Results. Left: The observed and expected 95% confidence level limits, normalized to the SM Higgs boson cross sections, as a function of the hypothesized Higgs boson mass. Right: The observed local p_0 (solid line). The open points indicate the observed local p_0 value when energy scale uncertainties are taken into account. The dotted line shows the expected median local p_0 for the signal hypothesis when tested at m_H.

position is estimated from the intercept of the line joining the reconstructed conversion position and the calorimeter impact point with the beam line. For all other photons, the vertex position is estimated from the shower position measurements in the first and second layers of the calorimeter. Finally, the independent vertex position measurements from both photons are combined also taking into account the average beam spot position in z. Combining the two vertex position measurement gives an improvement on the mass resolution of 5–20% (depending on the pile-up condition) with respect to taking as primary vertex the one with highest $\sum p_T^2$.

The signal model is parametrized as a sum of a Crystal Ball function and a wide Gaussian describing the outliers. The expected width of the observed signal is dominated by the mass resolution, the full width at half maximum at 120 GeV is 4.1 GeV.

The background parametrization is from data by fitting the diphoton mass spectrum in the whole range with an exponential function with free slope and normalization parameters.

Exclusion limits are computed for each mass hypothesis with a modified frequentist approach ($\mathrm{CL_s}$). A frequentist approach is used to calculate the probability, p_0, for the background to fluctuate to the observed number of events or higher. Systematic uncertainties are incorporated by introducing 31 nuisance parameters with Gaussian constraints. The main systematics arise from the theoretical Higgs cross section $\binom{+15\%}{-11\%}$, the calorimeter resolution (12%), the photon reconstruction and identification efficiencies (±11%).

The results are summarized in fig. 1. The Standard Model Higgs boson is excluded at 95% confidence level in the mass ranges of 113–115 GeV and 134.5–136 GeV. In the diphoton mass range 110–150 GeV, the largest excess with respect to the background-only hypothesis is observed at 126.5 GeV, with a local significance of 2.8 standard deviations. Taking the look-elsewhere effect into account in the range 110–150 GeV, this significance becomes 1.5 standard deviations.

REFERENCES

[1] ATLAS Collaboration, *Phys. Rev. Lett.*, **108** (2012) 11.