Standard Model Higgs Boson results from 2010 ATLAS data

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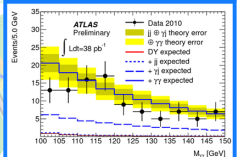
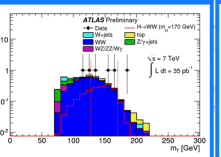
H→γγ



Plotted above is the diphoton invariant mass for the 99 events composing the data sample. The overlaid histograms represent cumulative Drell-Yan (red solid), dijet (blue dotted), photon-jet (blue dashed) and diphoton (blue solid) components of the background, according to the predictions from theoretical models and simulation. The dark yellow band is the uncertainty for the reducible background components, and the yellow band is the total uncertainty on the reducible plus irreducible backgrounds.

Results in this channel using an additional 94 pb-1 of 2011 data have also been released, where the γγ background distribution has been studied further.

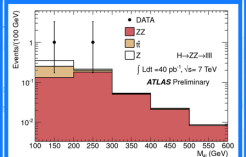
H→WW→lνlν



Owing to the large H→WW branching ratio near the 2M_W threshold and the clean lepton + missing energy signature, H→WW→lνlν near 160 GeV is the most powerful search channel throughout the mass spectrum. At 160 GeV, ATLAS is able to set an expected limit on the Higgs production cross section at 2.3 times that expected by the Standard Model.

Shown above is the transverse mass distribution in the H+0j analysis after all selections, except for the cut on the transverse mass itself. The signal is shown for m_H = 170 GeV. The signal region lies between the two dotted lines.

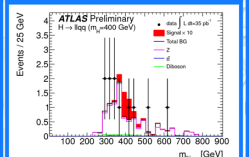
H→ZZ→llll



Although the H→ZZ→4l decay mode is limited in at low luminosities by the small four lepton branching ratio, the invariant mass spectrum is still an ongoing area of study. Early data provides an opportunity to study and understand the ttbar and Z+jets background.

The most sensitive region of the mass spectrum is near 220 GeV, where this channel matches the the sensitivity of other decay modes. Because of the high signal to background ratio, H→ZZ→4l will quickly become an important channel throughout the full mass spectrum as the LHC achieves a higher integrated luminosity.

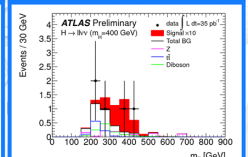
H→ZZ→llqq



The H→ZZ→llqq channel provides a boost to the Higgs search in the high mass regime. The large Z→qq branching ratio allows for a higher expected event rate compared to H→ZZ→4l, while the second Z provides a clean dilepton signature.

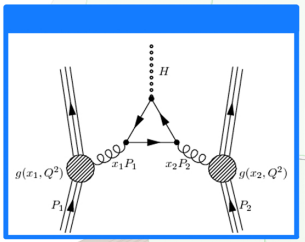
Shown in this plot is the invariant mass distribution of the llj system in the H→ZZ→llqq channel after all selection cuts for m_H = 400 GeV. The electron and muon channels are combined.

H→ZZ→llνν



In addition to H→ZZ→llqq, the H→ZZ→llνν decay mode leads to a dilepton + missing energy signature. At masses well above the 2M_Z threshold, the Z bosons are boosted, allowing for the Z decaying to neutrinos to leave large missing energy in the calorimeter.

The distribution above is the dilepton transverse mass of the llnunu system after all selection cuts for m_H = 400 GeV. The electron and muon channels are combined.

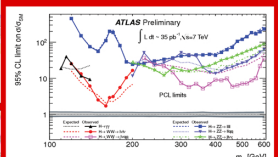


2010 Proved to be an interesting year for Higgs analyses in ATLAS. With approximately 35 pb^{-1} of data provided by the LHC, ATLAS was able to excersise for the first time the full Higgs analysis chain. With this dataset, which is relatively modest for Higgs searches, ATLAS was able to provide sensetivities approaching the expected Standard Model rate for part of the search region.

In addition to the Standard Model analysis, fourth generation fermion models were considered. Additional quark loops in the gg→H production mechanism are expected to enhance the Higgs production cross section. Aided by this, the exclusion of Higgs masses in this model were possible. High mass Higgs analyses in this model are also approaching the luminosity needed for exclusion.

Included in the analyses are the H→γγ and H→WW→lνlν decay modes at low masses. H→WW→lνqq, H→ZZ→llνν, and H→ZZ→llqq at high masses. H→ZZ→4l also contributes across the mass spectrum. The highest sensitivity was achieved in the H→WW→lνlν mode, where a 95% confidence limit of 2.3 times the Standard Model rate is expected at 160 GeV. In the fourth generation model, Higgs masses between 140 and 185 GeV were excluded.

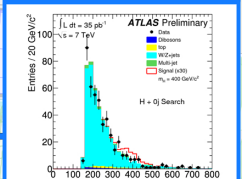
Higgs Limits



Many Higgs decay modes can be combined using statistical tools to tell us the overall picture of the Standard Model Higgs search. By generating an ensemble of background only pseudo-experiments and extracting the distribution of upper limits, we can compute the median expected upper limit on the production cross section divided by that expected from the Standard Model.

The expected and observed limits in the individual channels used for the combination are shown above. These results use the profile likelihood method with a power constraint (PCL). The limits are calculated at the masses marked with symbols. The lines between the points are to guide the eye. The grey horizontal bands show the uncertainty on the cross section prediction, with the inner region highlighting the contribution of QCD scale uncertainties.

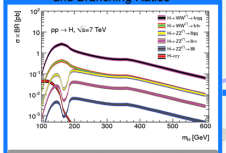
H→WW→lνqq



The H→WW→lνqq decay mode is the most sensitive channel for high mass searches above 200 GeV. The missing energy spectrum along with W mass constraints on the hadronic W provide powerful rejection against QCD background.

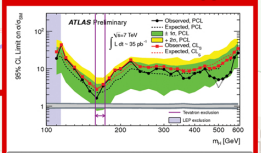
Shown above is the distribution of the reconstructed invariant mass of Higgs candidates (M_{WW}) for the H+0j analysis. The plot is summed over lepton flavour. The WZ+jets and Multi-jet backgrounds are normalized using the fit to the missing energy distribution.

Higgs Cross Section and Branching Ratios



The production cross section multiplied by decay branching ratios for Standard Model Higgs boson production in pp collisions at a 7 TeV centre-of-mass energy, as calculated by the LHC Higgs cross section group. All production modes are summed, and only final states which are studied in this paper are shown. Two bands are shown for each curve, the inner represents the QCD scale uncertainty and the outer also includes the PDF uncertainty.

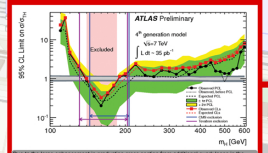
Standard Model Higgs



Shown is the limit on the total cross section divided by the expected Standard Model Higgs boson cross section. The green and yellow bands indicate the range in which the limit is expected to lie in the absence of a signal. The fine dotted line marks the results obtained from CLs, and the application of the power constraint gives the solid line.

The CLs procedure is added for comparison. As expected, when the results fluctuate up they converge, but downward fluctuations are less pronounced due to the larger over-coverage in CLs . The regions excluded by LEP and the Tevatron are indicated.

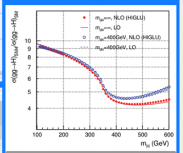
Higgs + 4th Generation



Due to the large enhancement in production cross section from additional quark loops in the gg→H production mode, much can already be said about the Higgs boson assuming fourth generation fermions.

The excluded cross section to the expected one when a fourth generation of high mass quarks and leptons with Standard Model-like couplings to the Higgs boson are included in the cross section calculations in this figure. The arrows indicate the regions excluded by CMS and the Tevatron experiments. The point set at 500 GeV is at the limit allowed by the power constraint.

4th Generation Cross Section Enhancement



The addition of 4th generation quarks to the Standard Model enhance the Higgs production cross section in the gluon-gluon fusion process through additional quark loops. Shown above is the expected enhancement factor in the fourth generation model.

X. Ruan, Z. Zhang, arXiv:1105.1634 [hep-ph]