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INVESTIGATION OF HIGGS BOSONS IN THE LOW MASS REGION WITH ATLAS

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The present constraints from electroweak radiative corrections suggest that the low mass region will be particularly interesting in future Higgs boson searches. In this paper, the discovery potential for a search of a low mass Standard Model Higgs boson, as well as the sensitivity to the lightest Higgs boson of the MSSM (h) are presented as a function of the collected luminosity, for the ATLAS experiment at the LHC.

Keywords: Higgs; ATLAS; MSSM

1. Introduction

The search for the Higgs boson(s) is one of the major goals of experiments at the LHC (Large Hadron Collider). The LHC, which is built in the LEP tunnel, will collide protons at a center of mass energy of 14 TeV, with an instantaneous luminosity of 10^{33} cm^{-2}s^{-1} the first three years (30 fb^{-1} integrated luminosity), and 10^{34} cm^{-2}s^{-1} the next three years (300 fb^{-1} integrated luminosity). ATLAS (A Toroidal LHC Apparatus) will be a 40 meters long, 20 meters high cylinder detector. It will have inner tracking detectors inside a two Tesla solenoid magnetic field, electromagnetic and hadronic calorimeters and a muon spectrometer. The ATLAS detector has been designed to have excellent photon and lepton identification performances, and a 4π coverage around the interaction point. [1]

Investigations of the Higgs boson at LEP provided a low mass limit of 114.4 GeV/c^2 (95% CL), obtained from direct searches, and an upper mass limit of 260 GeV/c^2 (95% CL), obtained from electroweak fits. These results suggest that the low mass Higgs region is particularly interesting to consider for the Higgs search.

2. Standard Model Higgs: Overall Sensitivity

At the LHC, the Higgs production cross section is dominated by gluon-gluon fusion. The second dominant mechanism is the vector boson fusion (VBF) production, at the level of 10-20% of total cross section at low mass, this fraction increasing with the Higgs mass. Associated productions with $t\bar{t}$, $b\bar{b}$, W or Z are about a few % of the total cross section. The huge QCD background in hadron collisions leads to the choice of channels with leptons or photons for the Higgs search.

The main discovery channels are H→ $\gamma\gamma$, ZZ*, WW* or $\tau^+\tau^-$, the latest only with VBF production. VBF channels have a specific signature with two very forward high P_T jets coming from the initial quarks emitting the bosons, and no central jet activity due to the lack of colour exchange between these quarks.

Figure 1 illustrates the overall sensitivity for the SM Higgs discovery using ATLAS experiment [2] with an integrated luminosity of 10 fb^{-1} (one year at low luminosity) and 30 fb^{-1}. The discovery, defined as a significance $S = Signal/\sqrt{Background}$ greater than five, is achievable for a Higgs mass above 120 GeV/c^2 with 10 fb^{-1}, and over the full Higgs mass range with 30 fb^{-1}. As can be seen on this figure, the VBF studies significantly improve the low mass range Higgs sensitivity.

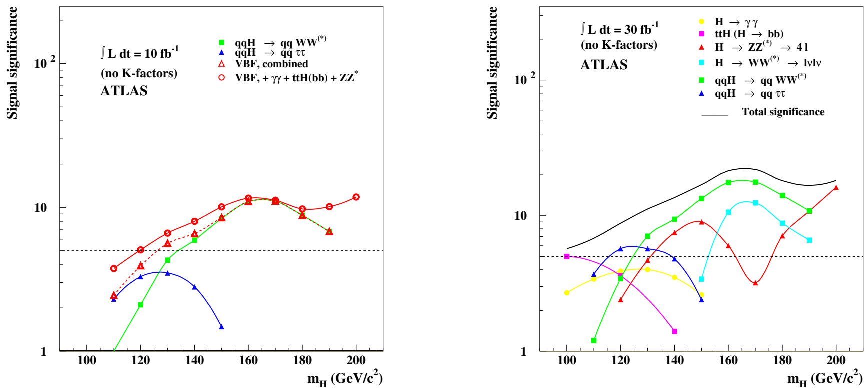

Fig. 1. ATLAS sensitivity for the discovery of SM Higgs as a function of the Higgs mass for an integrated luminosity of 10 fb^{-1} (left) and 30 fb^{-1} (right). The channels qqH $\rightarrow$ qq WW$^{(*)}$, qq $\tau\tau$ are VBF channels.

3. MSSM Higgs discovery potential

Another major goal for LHC experiments is the search for new physics, and especially SuperSymmetry. SUSY Higgs discovery potential has been investigated in the Minimal Supersymmetric Standard Model (MSSM), in the case of heavy SUSY particles where the Higgs bosons cannot decay in SUSY particle modes. This model provides 5 Higgs bosons, 3 of which are neutral and 2 charged. The lighest one, h, is theoretically upper bounded by a maximum value of 152 GeV/c^2, and is in most cases SM-like. [3] It is thus searched with the same decay modes as for the SM Higgs search, the rates depending on the parameters choice. Dedicated channels are also used for A, H and $H^{\pm}$ searches.

Figure 2 illustrates the discovery potential in the m_A (pseudosacalar Higgs mass), $\tan\beta$ (ratio of the vacuum expectation values of the two-Higgs doublets) plane, with 10 fb^{-1} and 300 fb^{-1}. This figure shows that almost all the parameter space is covered with only 10 fb^{-1}, a large part being covered by the lightest Higgs search. With 300 fb^{-1}, at least two Higgs bosons can be discovered over a large part of the parameter space, which will be powerfull to discriminate between SM and SUSY.

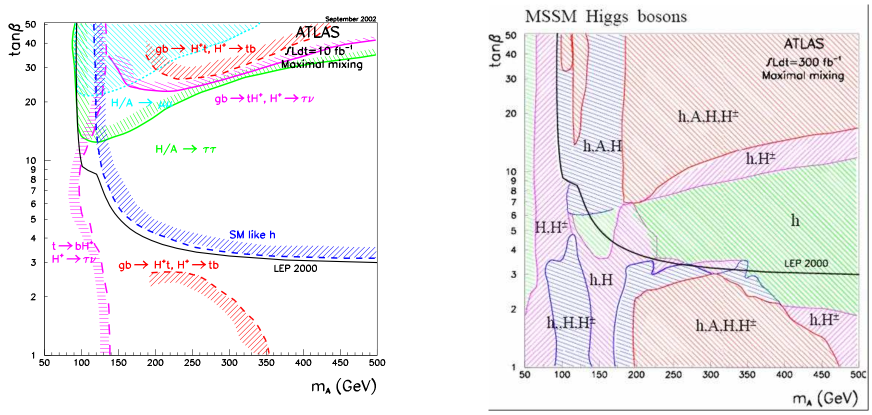

Fig. 2. MSSM Higgs bosons discovery potential in the m_A, $\tan\beta$ plane, with 10 fb^{-1} (left) and 300 fb^{-1} (right).

4. Conclusions

Low mass Higgs sensitivity is significantly increased by VBF channels. Combination with all other channels provides SM Higgs coverage over the full mass range with 30 fb^{-1}. A large part of the MSSM parameter space is covered by one year of data taking at LHC. In a large fraction of this space, more than one Higgs can be discovered. All these predictions are based on full simulation and need excellent detector performances to be achieved.

References

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