Search for the Standard Model Higgs Boson in the H → Zγ Decay Mode

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1 Objectives

•Search for H → Z γ using event selection cuts identical to those used by the SM Z γ group.

•Use this analysis to study the kinematic distributions relevant for H → Z γ and develop techniques for suppressing the SM Z γ background.

•Using the standard ATLAS limit setting techniques, exercise the tools required for setting limits on a Z γ signal with this data set.

Analysis Philosophy

• Two step approach

(1) *Blinded Analysis:* Reconstruct the leptons and photons using the EGamma approved selection criteria, as well as the selection used for the SM Z γ cross-section measurement.

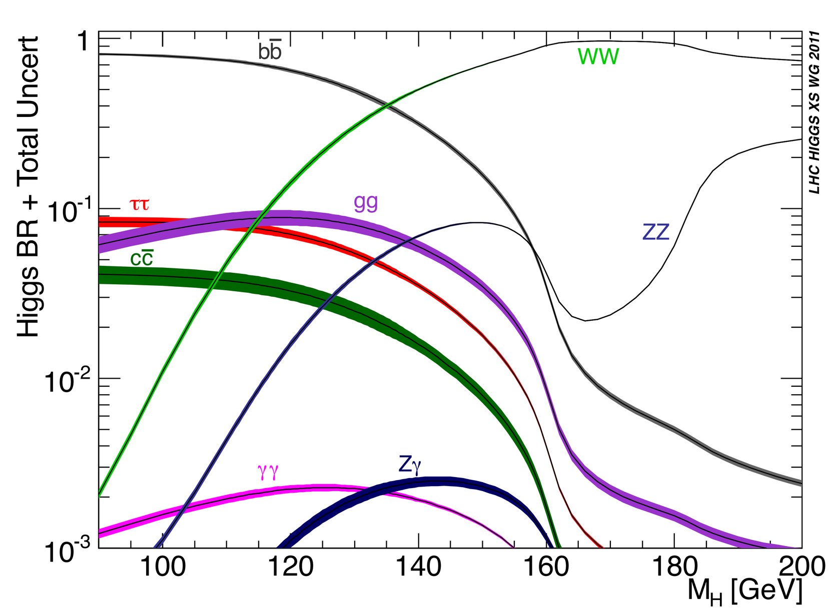
(2) *Tuned Analysis:* Develop cuts motivated by the decay properties of the Higgs.

2 Introduction

Expectations

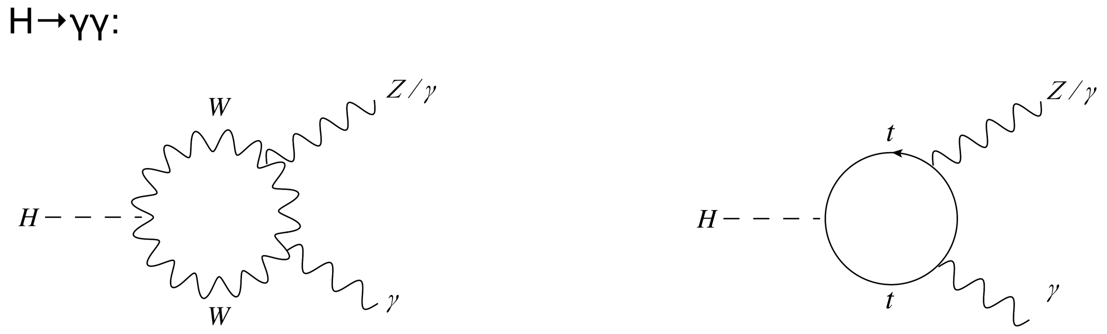
•Branching fraction Γ(H→Zγ) is comparable to Γ(H→γγ) at 1.553 × 10^{-3} GeV.

•The total final state cross-section, σ(H→ llγ), is comparable to the golden channel,σ(H→ llll):
- ~15 events using both muon and electron channels at 10 fb^{-1} assuming 100% efficiency and acceptance.



Motivation

•The H→Zγ is produced via a loop of destructively interfering W/top pairs, which is the same process as H→γγ:



•There is a hint of a high branching fraction for H→γγ, so a measurement / limit of Γ(H→Zγ) would confirm or refute this observation.

•In addition
(1) All final state particles can be measured well with the ATLAS detector.
(2) The Higgs mass can be measured from the total invariant mass spectrum.
(3) The spin of the Higgs can be studied by analyzing the angular distributions of the decay products.
(4) This channel can be used for setting limits on the Higgs coupling constants.

3 Methods

Object Selection

• Lepton: A pair of oppositely charged leptons each with a $p_T > 25$ GeV of the same flavor.
 -Muon: Isolated Combined and lies in the range |η| < 2.4.
 -Electron: Isolated Medium++ and is contained in the fiducial region 1.52 < |η| < 2.47.

•Photon: Tight, $p_T > 15$ GeV, |η| < 2.37 excluding the crack region, isolated (E_TCone30 > 6 GeV) and ΔR(lepton,photon) > 0.7.

Backgrounds
Direct Zγ production
Zγ production due to fragmentation
Z+jets
t-tbar
Z →tau tau
Other electroweak backgrounds

Event Selection

•GRLs / LarError (2011)
•Primary vertex has ≥ 3 associated tracks
•Di-lepton triggers

•Two oppositely charged leptons
•One good and isolated photon
•ΔR(lepton,photon) > 0.7

Limit Setting Strategy

•Set the limit using SM Zγ Monte Carlo:
(1)Gaussian H→Zγ signal:
 -Width determined from the mass resolution
 -Expected signal determined from NNLO predictions with known branching ratios scaled by our selection's efficiency

(2) Polynomial Background
 -Remove the signal region from data and fit a second degree polynomial to the remaining data points.

P-Value Calculation

Test Statistic: Profile Likelihood Ratio

$$\lambda(\mu) = \frac{L(\mu, \hat{\hat{\theta}})}{L(\hat{\mu}, \hat{\theta})}$$

→ Fix μ, fit θ (numerator)
→ Fit both μ and θ (denominator)

where

$$L(\mu, \theta) = \prod_{i=1}^{m} \frac{(\mu s_i + b_i)^{n_i^{obs}}}{n_i^{obs}!} e^{-(\mu s_i + b_i)}$$

4 Results

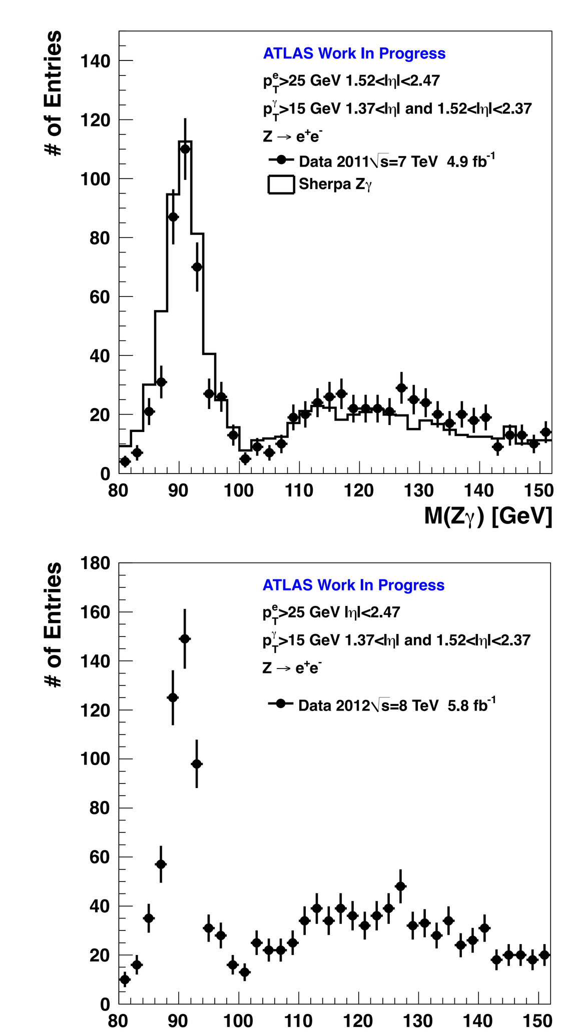
Zγ Mass Distributions

•Distributions of the invariant mass of the Zγ system for 2011 (top) and 2012 (bottom) in the electron channel.

•A Sherpa Zγ + 0-3 jets Monte Carlo sample (white histogram) is compared with the 2011 data. The Monte Carlo is normalized to the 4.9 fb^{-1} of luminosity delivered by the ATLAS detector in 2011.

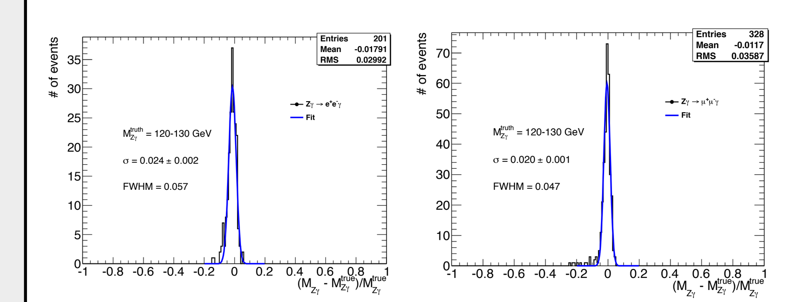
•Good agreement between theory and data is seen in the electron channel. The large agreement between the signal Monte Carlo and the data indicates a low background rate for the Zγ signal.

•However, no clear signal for a SM Higgs boson is seen.



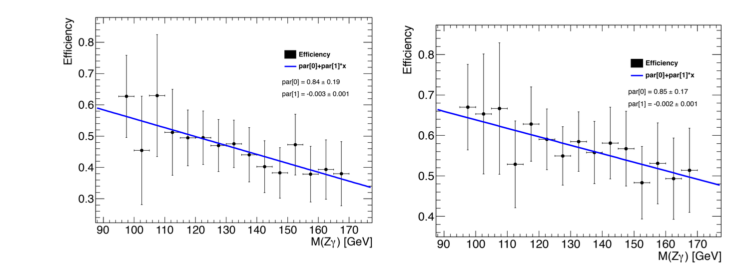
5 Results Cont.

Mass Resolution



•mass resolutions of ~ 6% and ~ 5% were measured for the electron and muon channels respectively.

Reco. and ID Efficiency

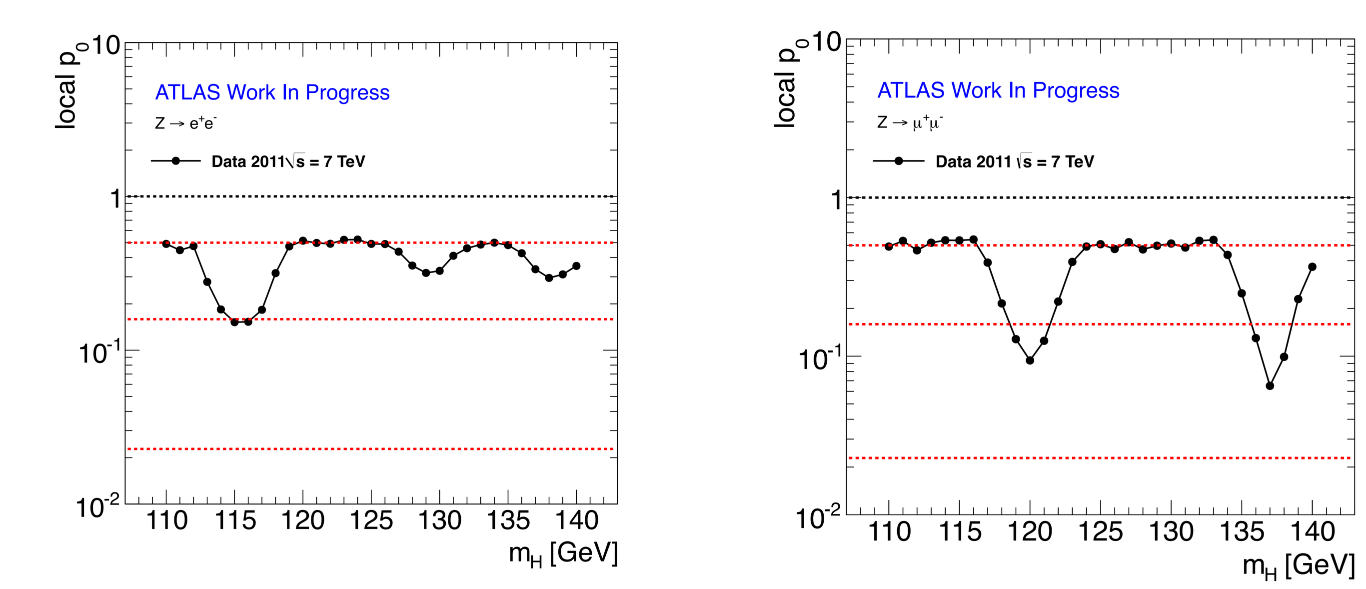


•A reconstruction and identification efficiency ranging from 60% - 40% was calculated for the electron channel, while the muon channel's efficiency ranged from 70% - 50%.

Statistical Significance

• A p-value scan as a function of the Higgs' mass was performed on the 2011 data. Only 1σ fluctuations were found, which does not rule out the background only hypothesis.

•The results are consistent with a SM Higgs boson and confirm our hypothesis of a lack of sensitivity to a SM Higgs boson at this time.



6 Conclusion

•No clear signal of a SM Higgs was observed in the data.

•The analysis has recently been adopted by HSG1 with various research groups contributing.

•This group plans to present an analysis using the standard Electroweak cuts at HCP-2012 in November.

•A long term goal is to present a full analysis with cuts optimized for Higgs decays using all the data collected in 2012 at Moriond 2013.

References

•LHC Higgs Cross Section Working Group Collaboration, S. Dittmaier et al., *Handbook of LHC Higgs Cross Sections: 1. Inclusive Observables,* arXiv:1101.0593 [hep-ph].

•James S. Gainer, Wai-Yee-keung, Ian Low, Pedro Schwaller, *Looking for the Light Higgs Boson in the Over Looked Channel,* arXiv:1112.1405v2 [hep-ph]