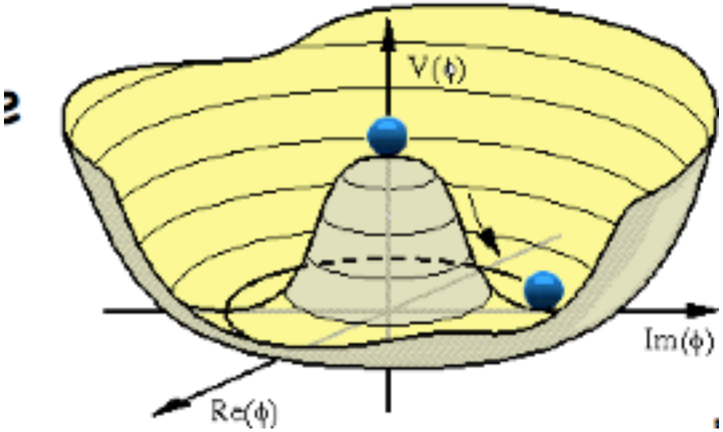
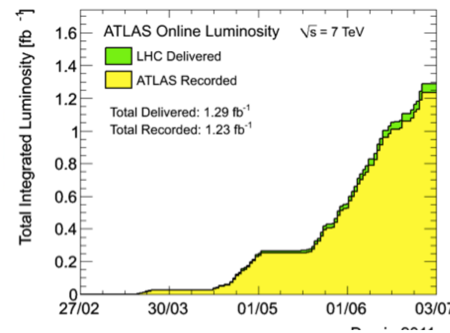
Summary of ATLAS SM Higgs Searches with 1 fb^-1 at 7TeV (EPS 2011 results)

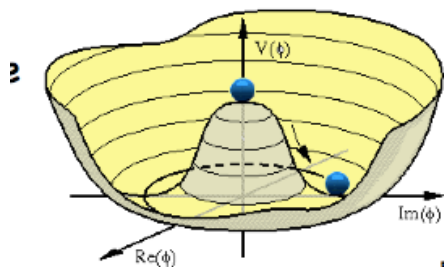
Marcos Jimenez



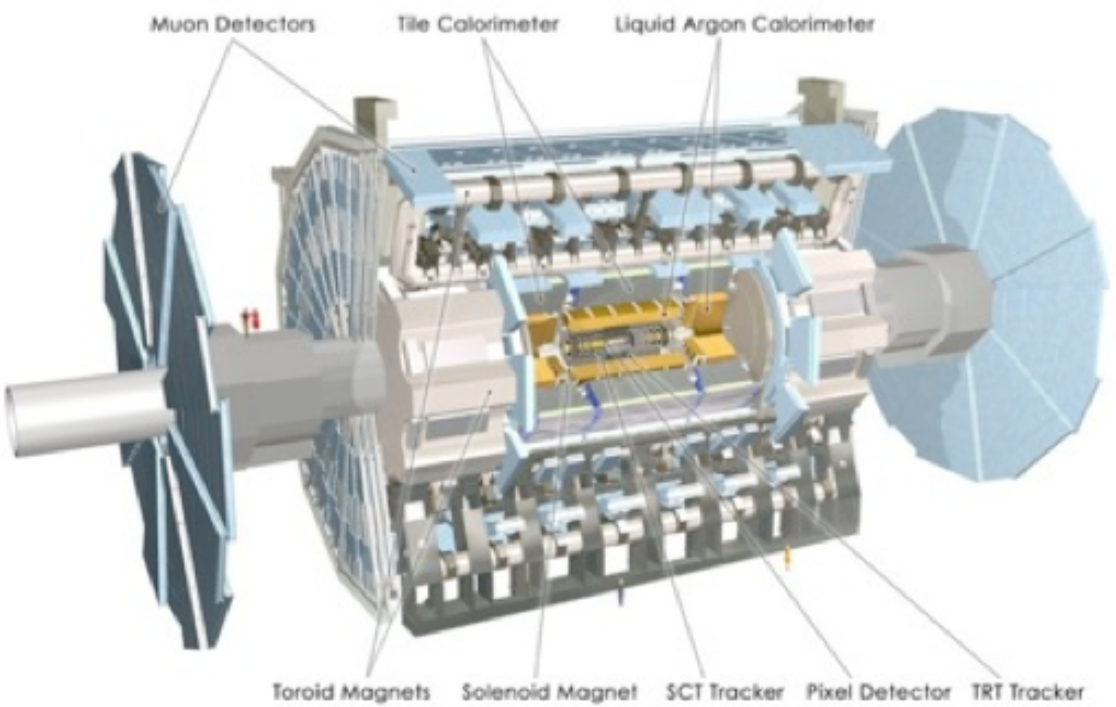
Introduction

→ ***The LHC has been running exceptionally well this year and has already delivered more than 1fb^-1 of data***





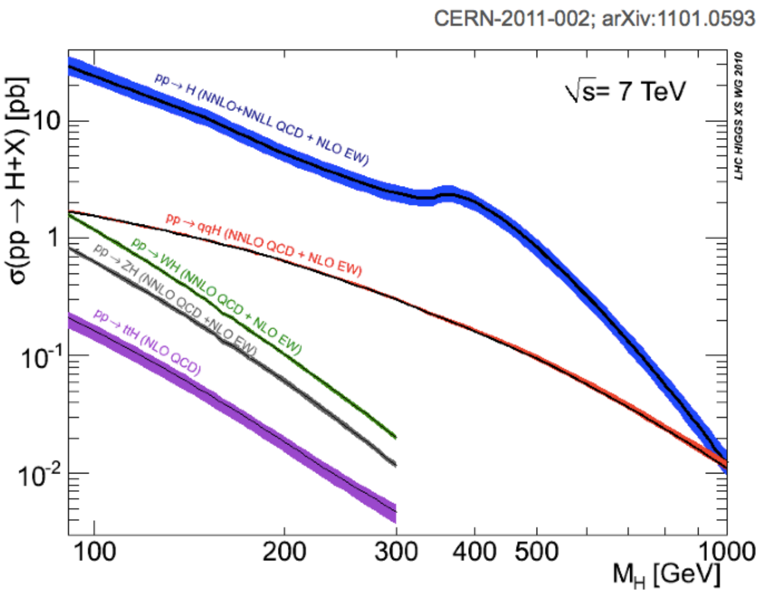
→ *Higgs mechanism is still an unverified yet fundamental piece of the SM*



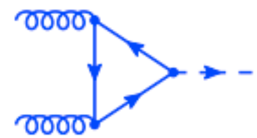
→ ***The design of ATLAS was partially driven to provide high sensitivity to Higgs production***

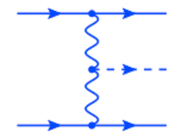
→ ***The ATLAS collaboration has carried out SM Higgs seaches in several channels using ~1fb^-1 of data***

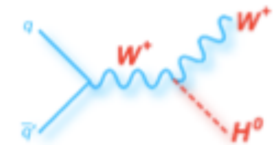
Higgs Production at the LHC



Gluon Fusion | *VBF* | *Higgs Strahlung*



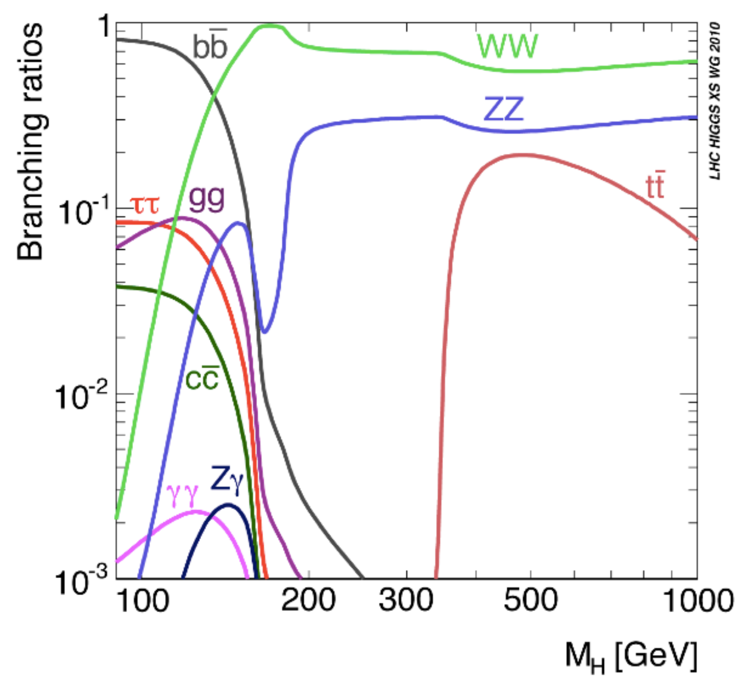




Theo. Unc O(15%) | **Theo unc O(7%)** | **Theo unc. O(5%)**

→ The Higgs decay branching ratios depend on the Higgs mass.

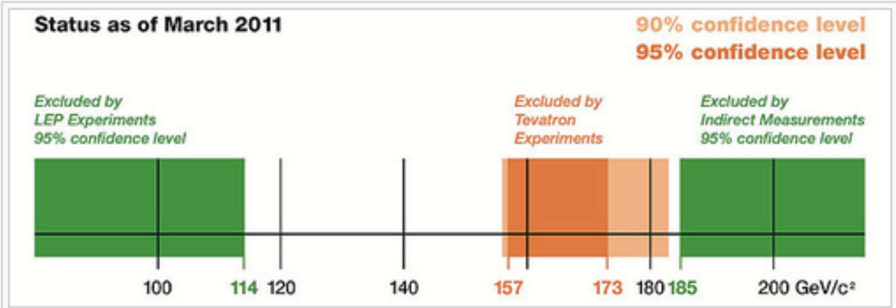
→ Higgs searches through various channels thus explore different ranges of potential Higgs masses



SM Higgs decay channels investigated at ATLAS and combined in a single mass exclusion fit

Channel		btag (veto)	Jets	MET (GeV)	Shape	Mass Range (GeV/c²)	Main backgrounds
γγ					M_{gg}	110-150	γγ (from sidebands)
WH		✓	2		M_{bb}	110-130	Top (3j - high M_{bb}) and W+jets (low M_{bb})
ZH		✓	2		M_{bb}	110-130	Z+jets (low M_{bb})
WW (lνlν)	0-jet		0	>30		110-240	WW (control region M_{ll})
	1-jet	veto	1	>30		110-240	Top (from reverse btag) and WW (M_{ll} CR)
WW (lνqq)	0-jet		0	>30	M_{WW}	200-600	W+jets (sidebands)
	1-jet	veto	1	>30	M_{WW}	200-600	W+jets (sidebands)
ZZ (llνν)		✓		>30	M_T	200-600	VV(from MC) and top (MC and checks)
ZZ (llqq)		✓	2	<50	M_{llqq}	200-600	Z+jets (from MC) and top (from MC)
ZZ (4l)		IP			M_{4l}	110-600	ZZ (from MC), Z+jets (MC) and top (CR)

Life before the 2011 EPS…

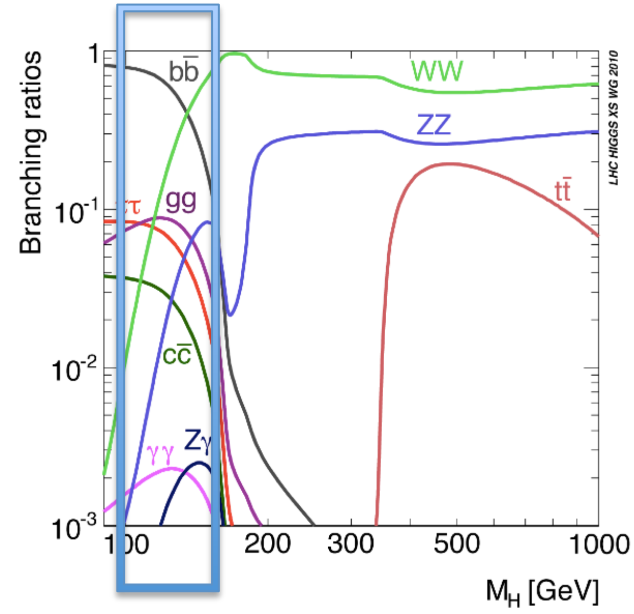


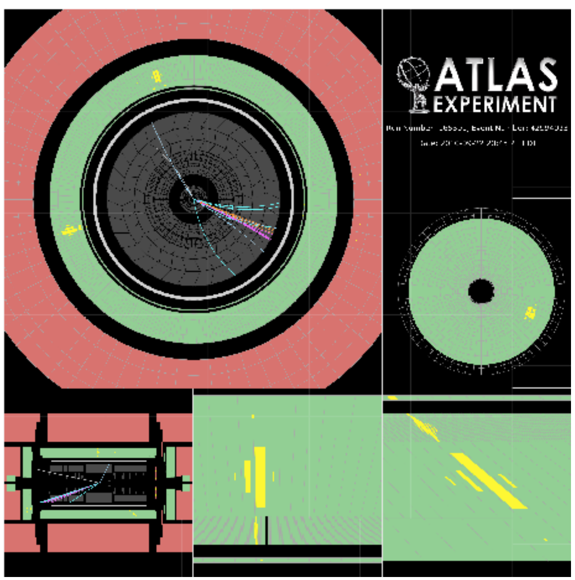
Higgs to γγ – low mass channel

→ Although branching fraction is relatively low, this channel has a ***good signal to background*** yield. ***A narrow peak is expected over a smooth background***

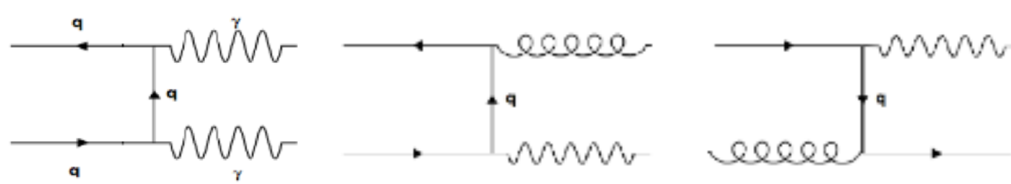
→ This channel is sensitive to Higgs production in the 100 < M_h < 150 GeV range

→ ***Simple signature -- 2 isolated photons*** with pT1 > 40 and pT2 > 25 GeV





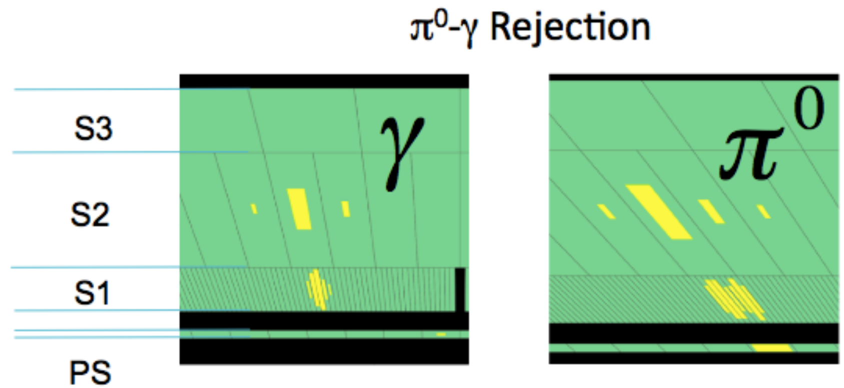
Main background comes from ***SM diphoton, dijet or gamma- Jet events*** *where a large fraction of the jet energy is carried by a neutral pion which fakes a photon..*



-- DESY-ATLAS is actively involved in this analysis

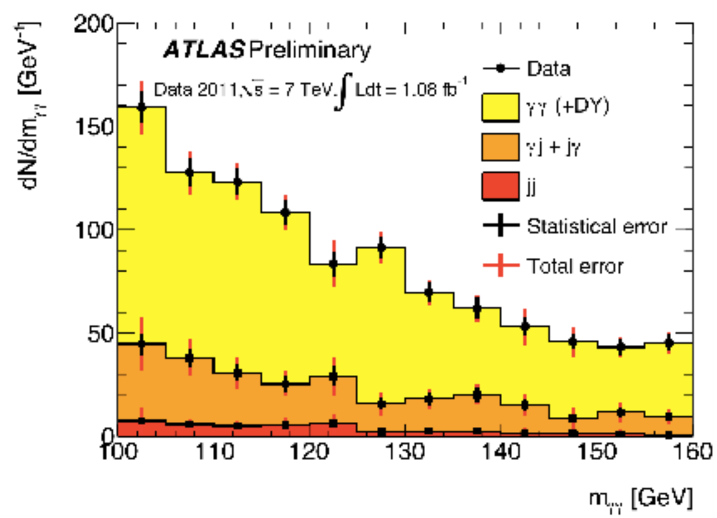
A few words on photon ID…

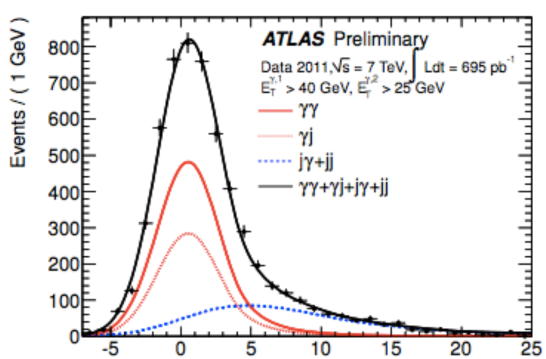
→ ***Both photons are required to pass tight cut-based shower selection*** *designed to reject background*
Shower cut ID efficiency goes from ~70% at 20 GeV and plateaus at ~90% at ~70 GeV



→ Converted photons have different showers from unconverted photons

→ ***2 Photons required to have calorimeter isolation***
- ambient energy, leakage corrected
- Isolation distribution also used for data-driven background estimates → ~70% purity achieved





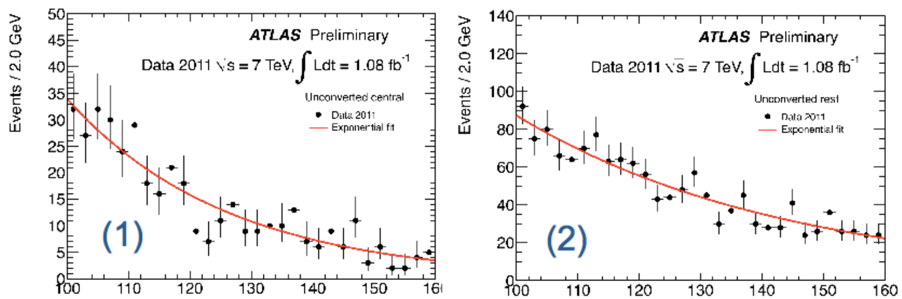
(a)

Higgs to γγ -- results

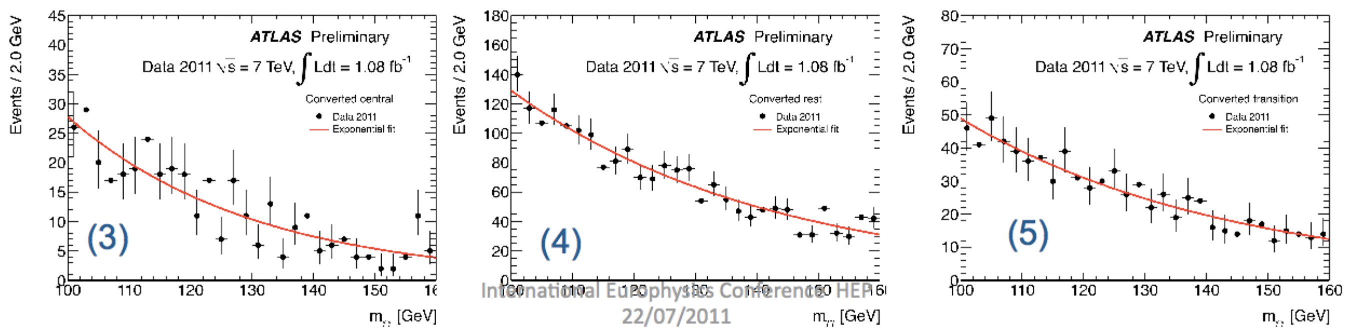
-Separate caegories in terms of resolution

- Also in terms of s/b

~15% Improvement



~5000 events selected in data..



1.- Unconverted-central: 2 UC In the central barrel calorimeter (|η|<0.75)

2.- Unconverted-rest: 2 UC , at least one not central

3.- Converted-central: at least 1 Conv., 2 central

4.- Converted-transition: at least 1Conv. And 1 near the transition barrel/end-cap(1.3< |η|<1.75)

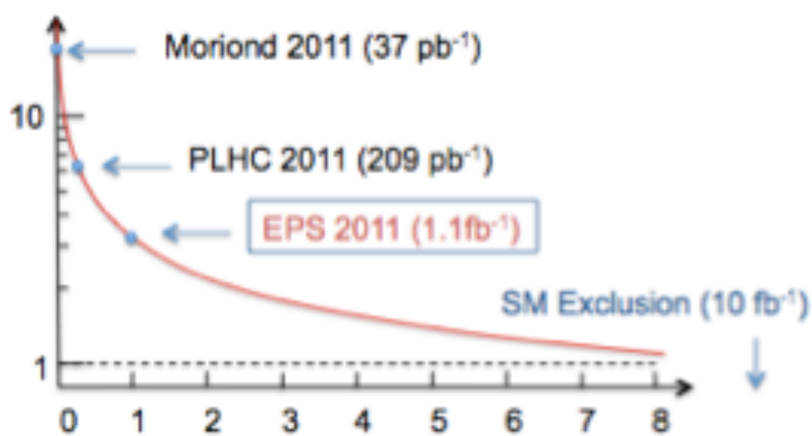
5.- Converted-rest: all other events with at least 1 Conv.

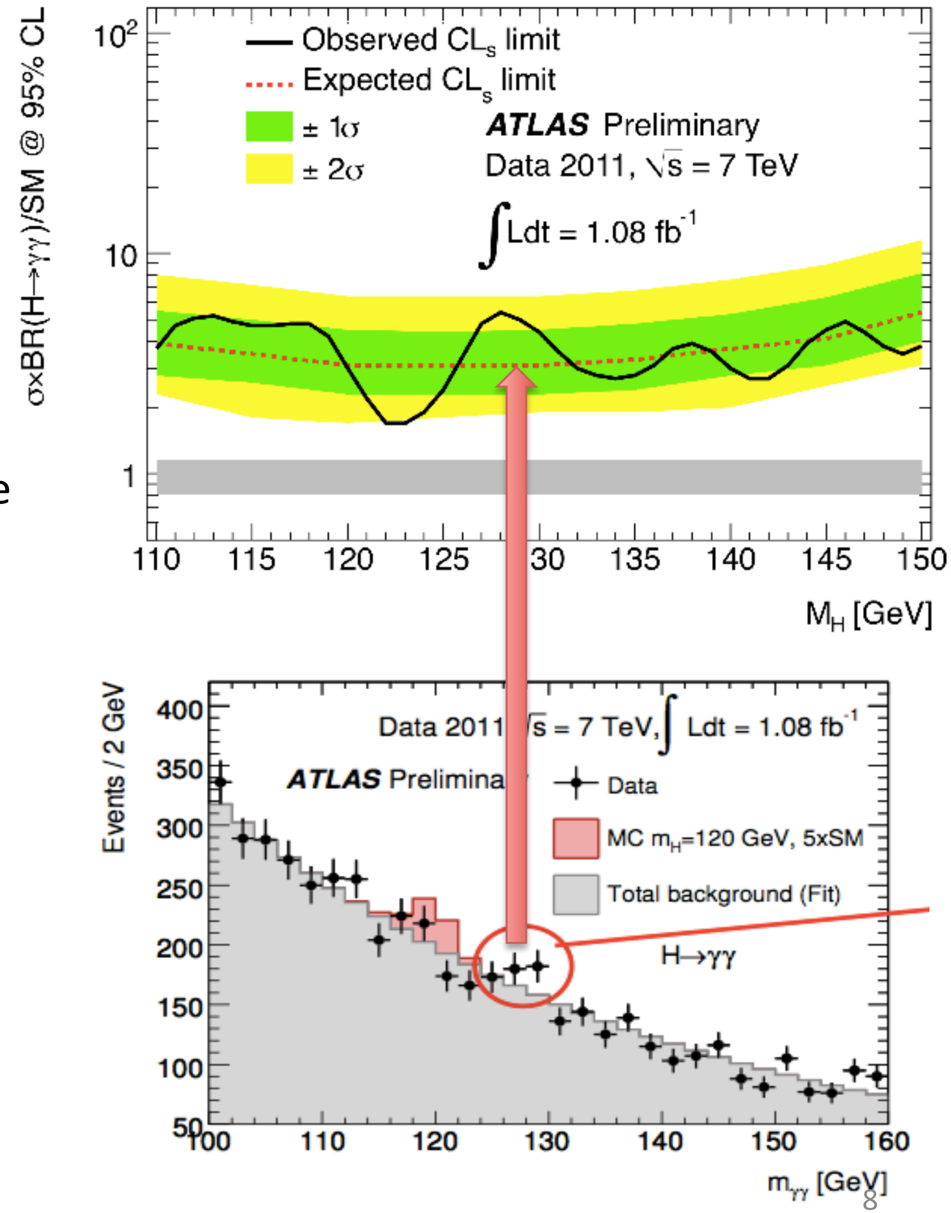
Higgs to γγ – results II

→Exclusion plots use a profile likelihood test (CL_s) to derive, given the current statistics, how many times the SM cross section for Higgs can be excluded at the 95% level

→ An excess in data results in less exclusion power than expected and thus goes in the direction of discovery

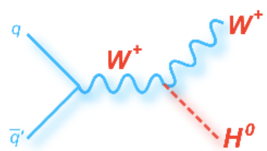
SM exclusion limit expected at around 10 fb^-1

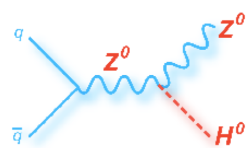


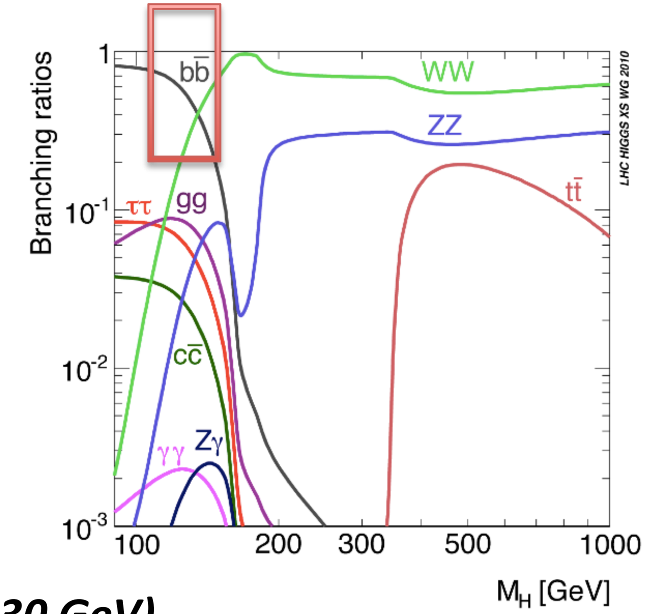


Higgs to bb through associated production

The WH and ZH channles decaying into H->bb







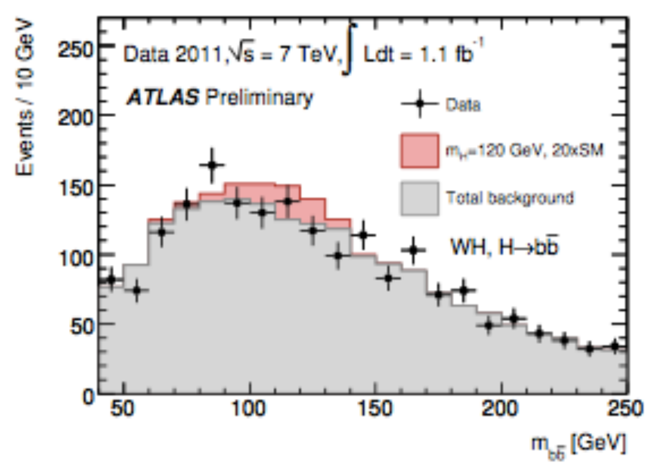
→ ***If the Higgs mass is less than twice the W mass branching fraction into bbar is large (110 < M_H < 130 GeV)***

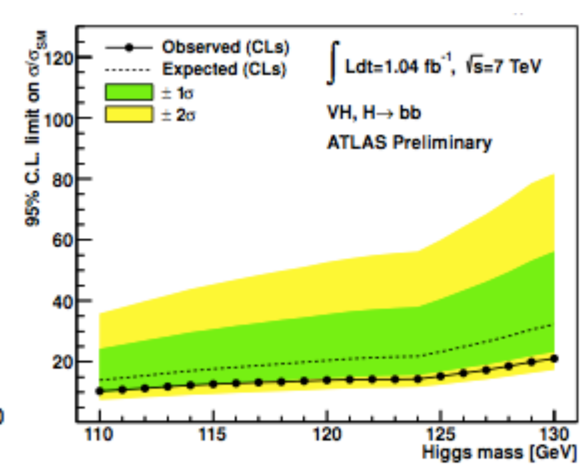
→ ***Association with Z or W helps reduce the otherwise prohibitely large SM background***

Signature

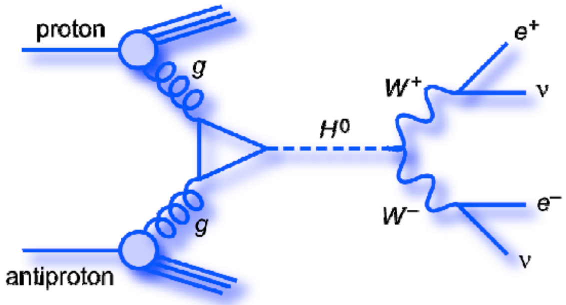
- **Isolated electron/muon with pT > 20**
- **MET (in case of W)**
- **|pTll – m_Z| < 15 (case of Z)**
- **Cut on transverse mass**
- **2 Jets (anti Kt with R=0.4) with b-tag**

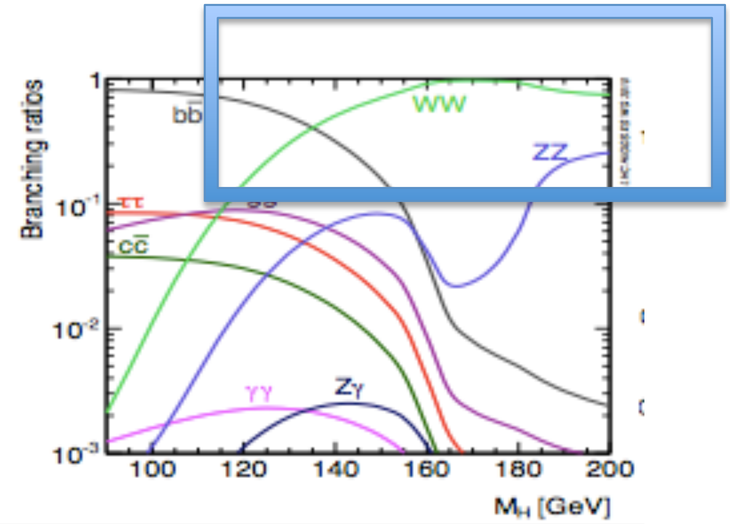
Broad signal results in less exclusion capacity





H→ WW → lνlν Channel





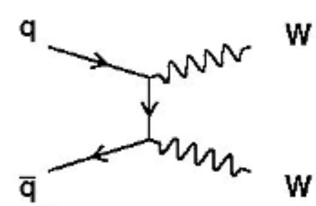
→ *This channel combines large branching fraction with clean final state*

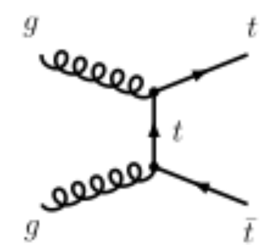
- ***Sensitive to Higgs production in range 120 < M_H < 240 GeV***
- ***has largest sensitivity of any SM channel for M_H ~ 160 GeV***

SIGNATURE

- *2 opposite sign leptons (e or mu) in final state*
- *Large MET*
- *2 categories defined (H+0 jet and H+1 jet) to tune selection according to specific backgrounds*

Dominant Backgrounds after selection are WW and tt:



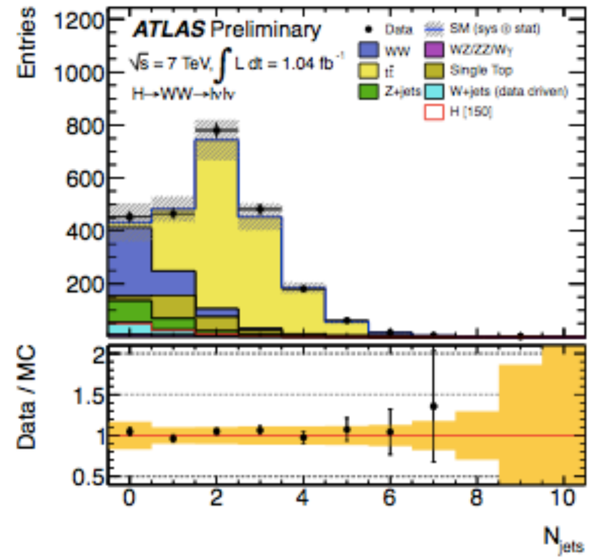


Selection and Background Estimates for H + 0 jet and H + 1 jet categories

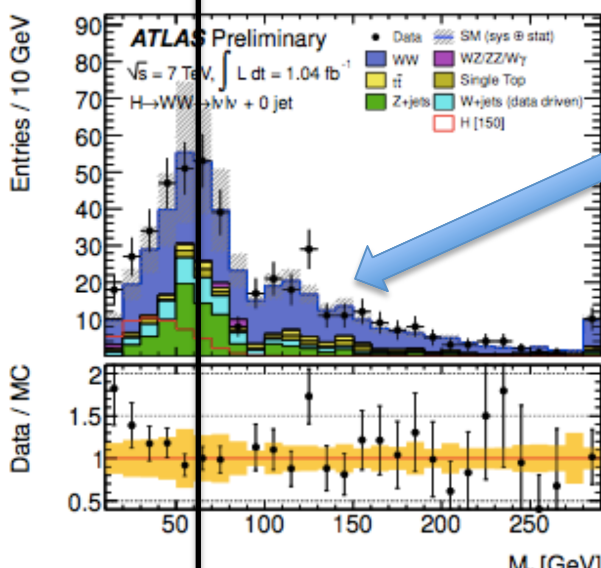
BOTH CATEGORIES (Topological cuts)

- *|Pt ll| < 30 GeV*
- *Dileption Mll < 60 GeV*
- *Dileption opening angle in Phi < 1.8 radians*
- *Transverse mass < ~150*

$$m_T = \sqrt{(E_T^{\ell\ell} + E_T^{\rm miss})^2 - (\mathbf{P}_T^{\ell\ell} + \mathbf{P}_T^{\rm miss})^2}$$



→ **Jet multiplicity well described by MC**

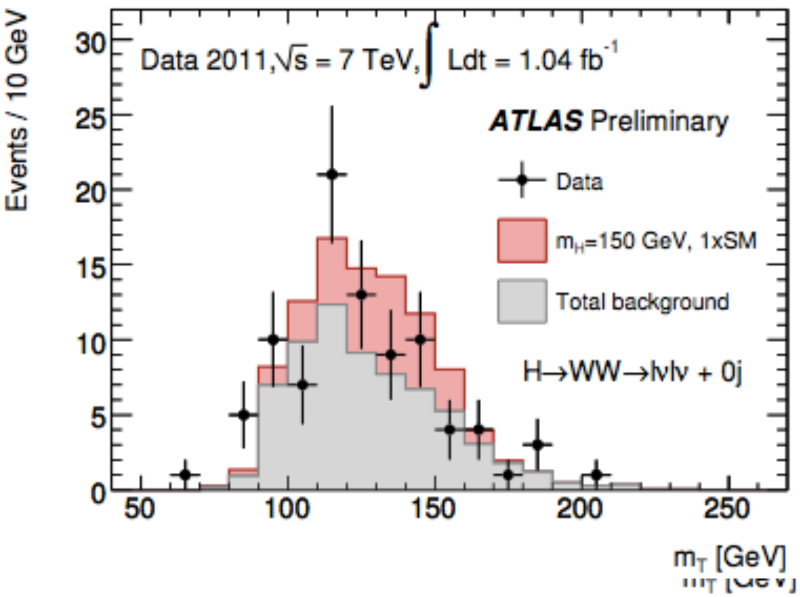


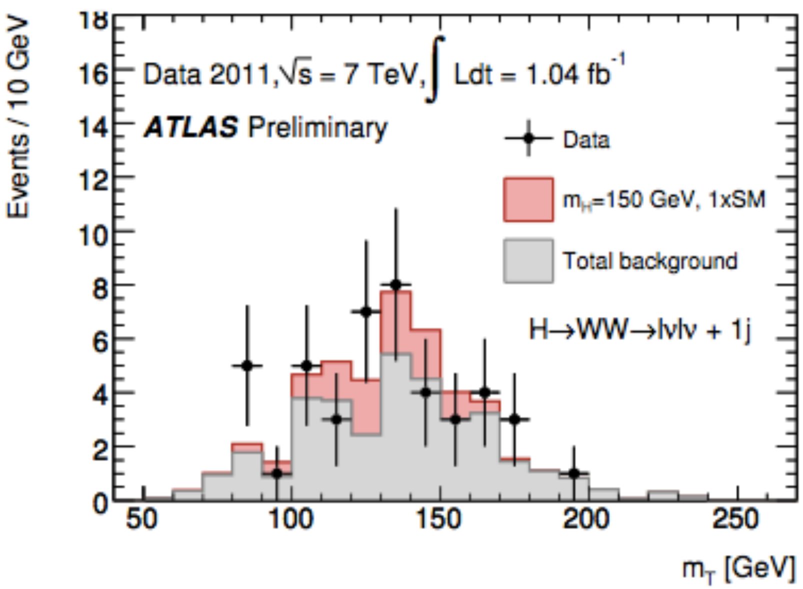
Background enriched region for SM WW

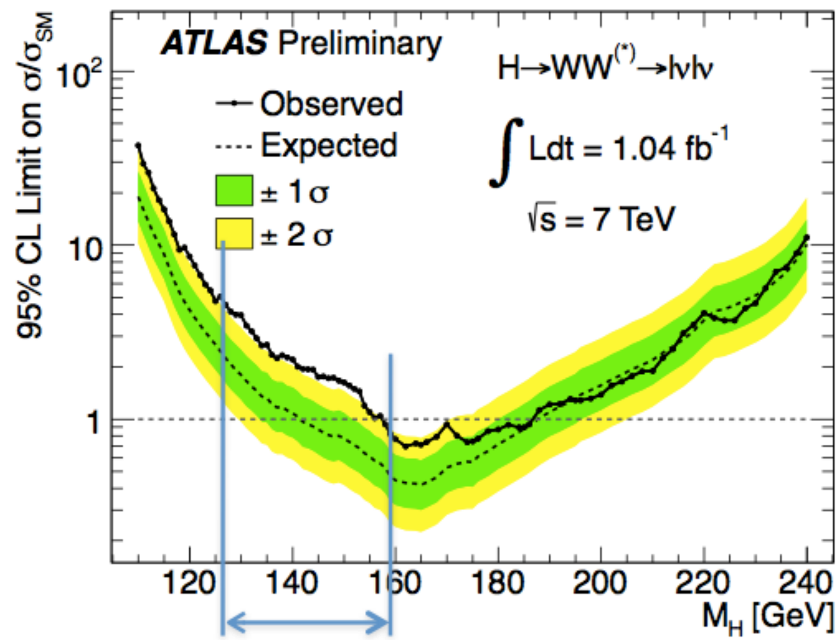
In addition, H+ 1 jet category

- *b-jet veto*
- *Cut on Pt of H + jet system*
- *Cut on |m_tt – m_z| < 25 GeV*

H→ WW → lvlv Channel -- Results





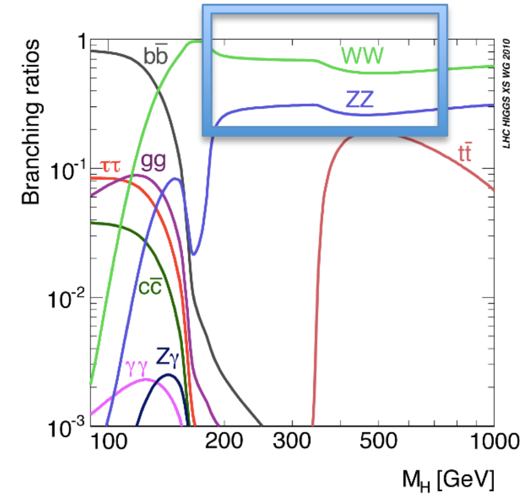


We can exclude 158 < M_h < 186 GeV !!

Broad excess observed in 126 < M_h < 158 such that this region cannot be excluded

- Fluctuation
- Background
- Discovery… who wants to bet.. ? ☺

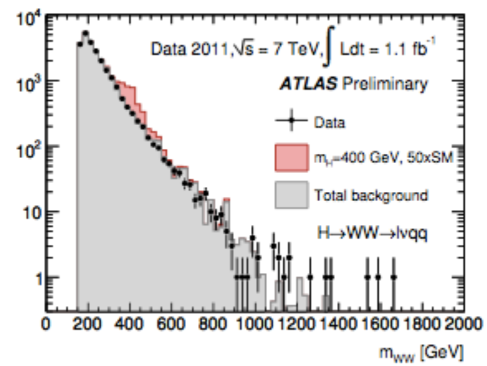
High mass channels H→ WW → lvqq
(200<M_h<600 GeV range)

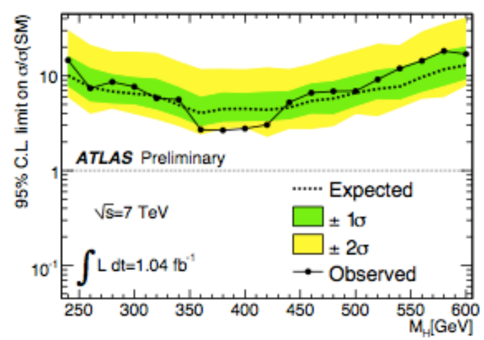


→*This channel suffers from* ***large ttbar and WW backgrounds at lower mass range*** *but provide high exclusion sensitivity at higher masses*

Signature

- **Isolated electron/muon with pT > 20**
- **MET**
- **Cut on transverse mass**
- **2 Jets (anti Kt with R=0.4)**
- ***B-tag veto imposed on jets to reduce bkg from ttbar***

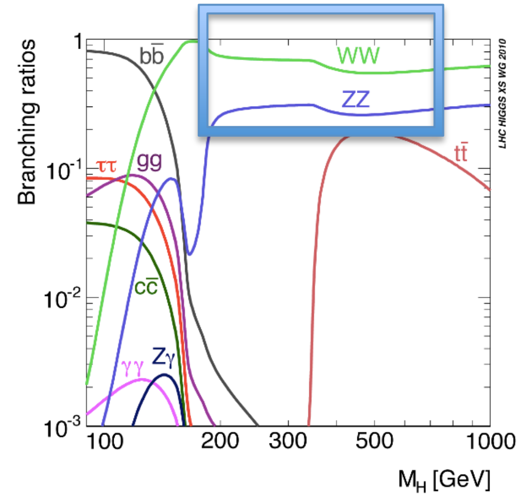




- ***The WW mass can be approximately reconstructed despite the missing neutrino pL component***

High mass channels H→ ZZ → llqq / ZZ -> llvv

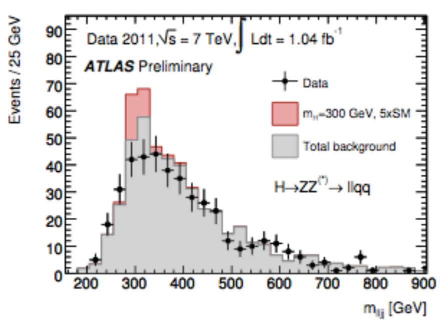
(200<M_h<600 GeV range)



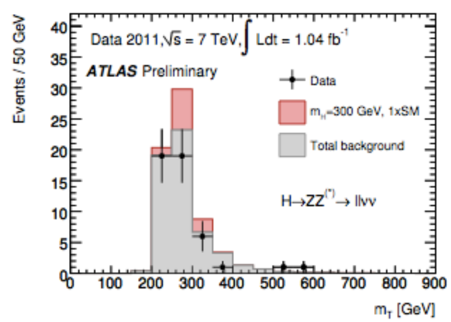
→ ***If Higgs mass is above ZZ mass limit, high branching ratio to ZZ***

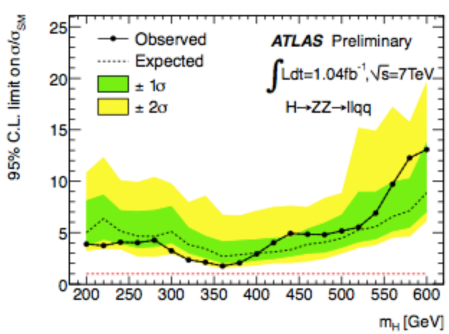
→ ***Cleaner ZZ->4l channel suffers from low stats due to low probability both Z decay into ll***

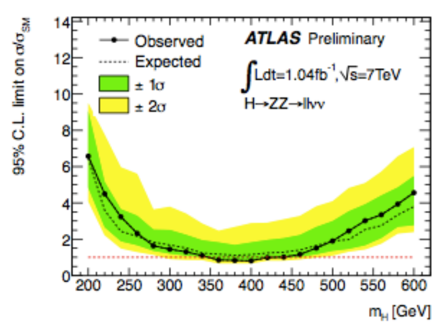
H→ ZZ → llqq



H→ ZZ → llνν





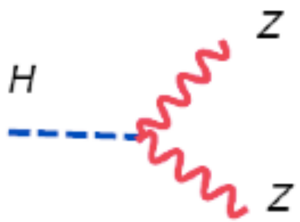


Signature

- **Two Isolated electron/ muon with high pT (close to Z mass)**
- **2 Jets (anti Kt with R=0.4) (in llqq case)**
- **MET > 60 GeV (in llvv case)**
- **High Higgs mass boosts leptons so cut on Phi_ll**

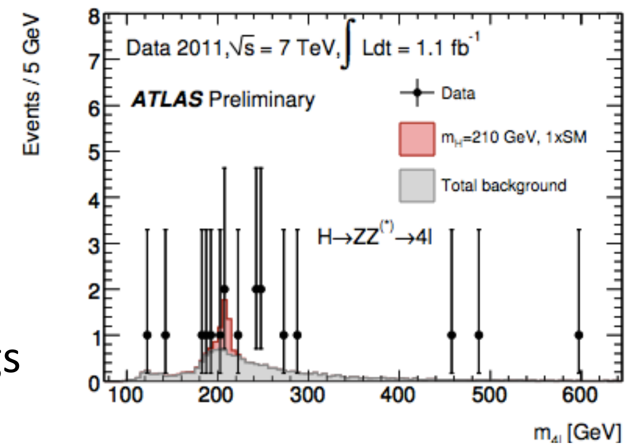
H->ZZ->llvv excludes range 295<m_H<450 !

H→ ZZ → 4l Channel (Golden Channel)

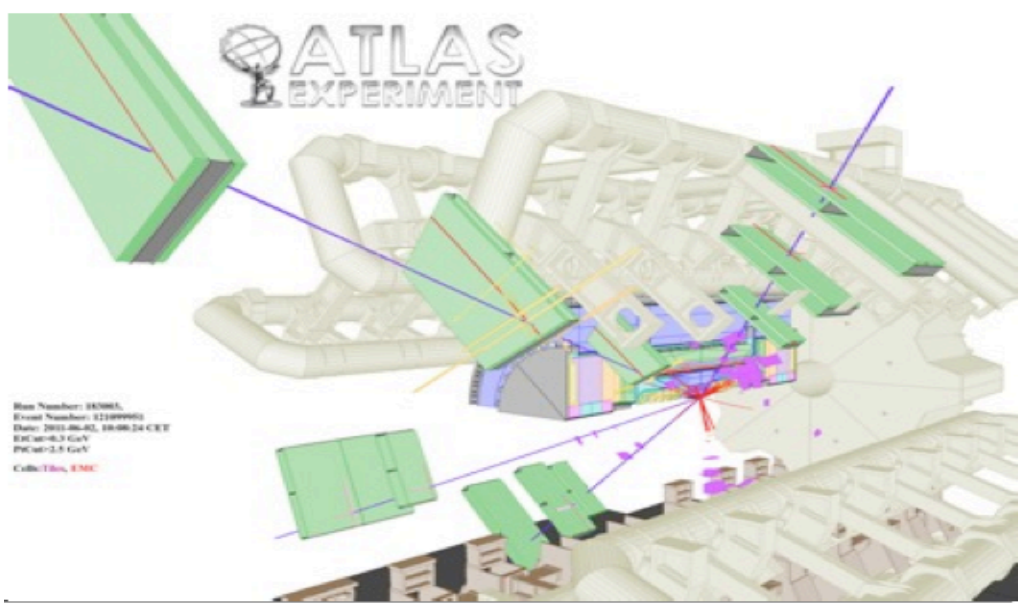


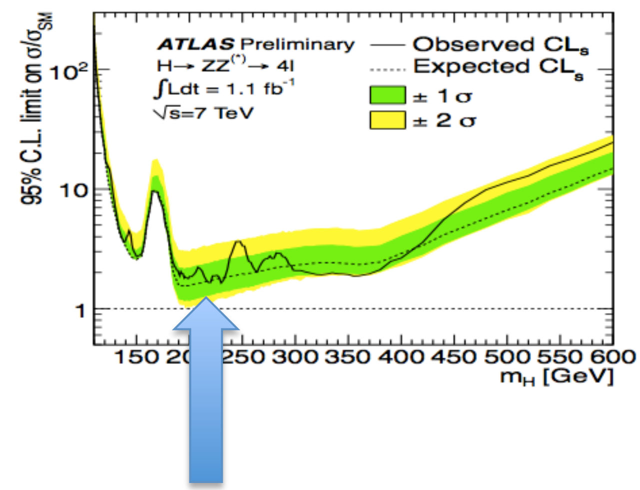
→ *Very clean final state and relatively high branching ratio in range 110 < M_h < 600 GeV*

→ Main background is SM ZZ production, where the higgs should appear as a narrow peak over background



Analysis carried out with 1.1fb^-1 of data but only 18 events recorded



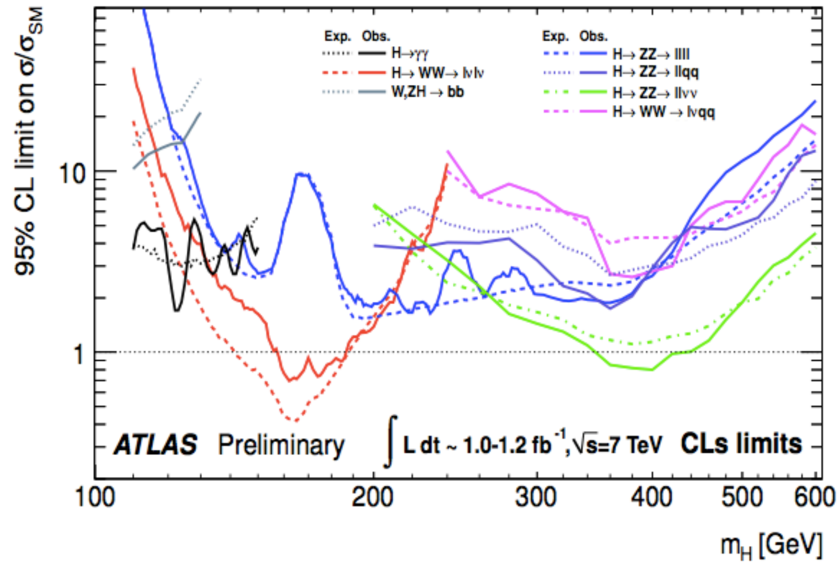


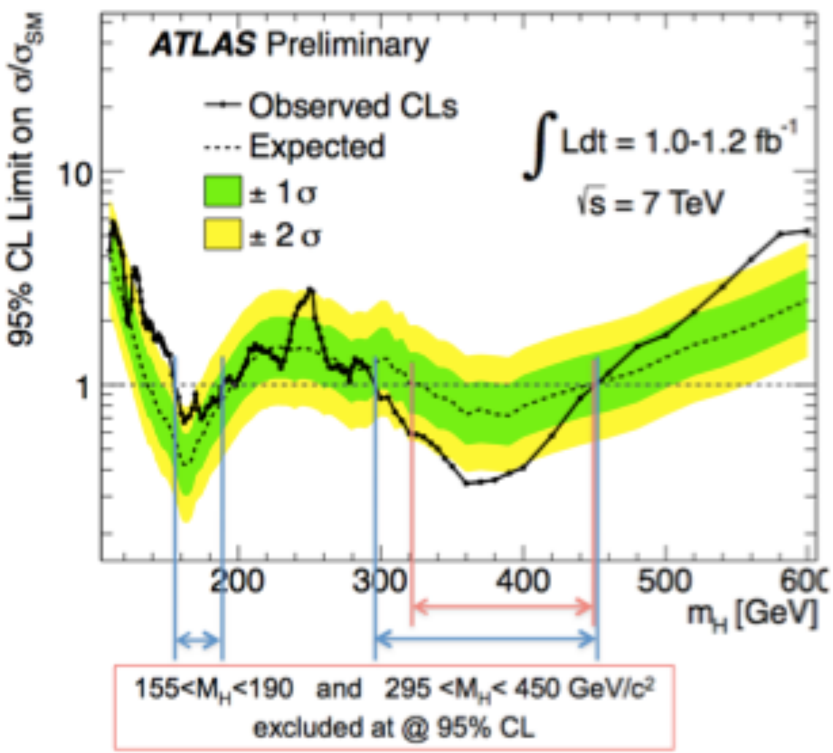
High sensitivity already despite low stats

Combination and Conclusions

→ Results for all the SM ATLAS searches have been shown

→ *Two channels already show SM exclusion power*





→ *ATLAS has also carried out a combined fit of all channels using the full luminosity available*

→ *Region of 155<M_H<190 and 295<M_H<450 excluded by combined fit !!*

→ *In low mass range, an excess of significance of 2.8 sigma is observed*

BACK-UP – Systematic uncertainties of jet and electron reco

Detector related uncertainties

Source of Uncertainty	Treatment in analysis
Jet Energy Scale (JES) [61]	2 – 7% as a function of p_T and η
Jet Pile-up Uncertainty	2 – 7% as a function of p_T and η
b-quark Energy Scale	2.5%
Jet Energy Resolution [62]	5 – 12%
Electron Selection Efficiency	0.7 – 3% as a function of p_T, 0.4 – 6% as a function of η
Electron Trigger Efficiency	0.4 – 1% as a function of η
Electron Reconstruction Efficiency	0.7 – 1.8% as a function of η
Electron Energy Scale	0.1 – 6% as a function of η, pileup, material effects etc.
Electron Energy Resolution	Sampling term 20%, a small constant term has a large variation with η
Muon Selection Efficiency	0.2 – 3% as a function of p_T
Muon Trigger Efficiency	$< 1\%$
Muon Momentum Scale	2 – 16% η-dependent systematic on scale
Muon Momentum Resolution	p_T and η-dependent resolution smearing functions, systematic $\leq 1\%$
b-tagging Efficiency	5 – 14% as a function of p_T
b-tagging Mis-tag Fraction	8 – 12% as a function of p_T and η
Missing Transverse Energy	Add/subtract object uncertainties in E_T^{miss}