Search for the Higgs boson in VH, $H \to b\bar{b}$ using the ATLAS detector

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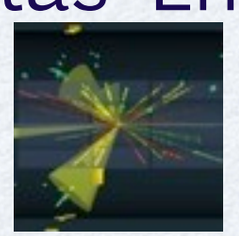

Introduction

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- *Event selection*
- *Search strategy*
- *Background modeling*
- *Systematic uncertainties*
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- *Results*
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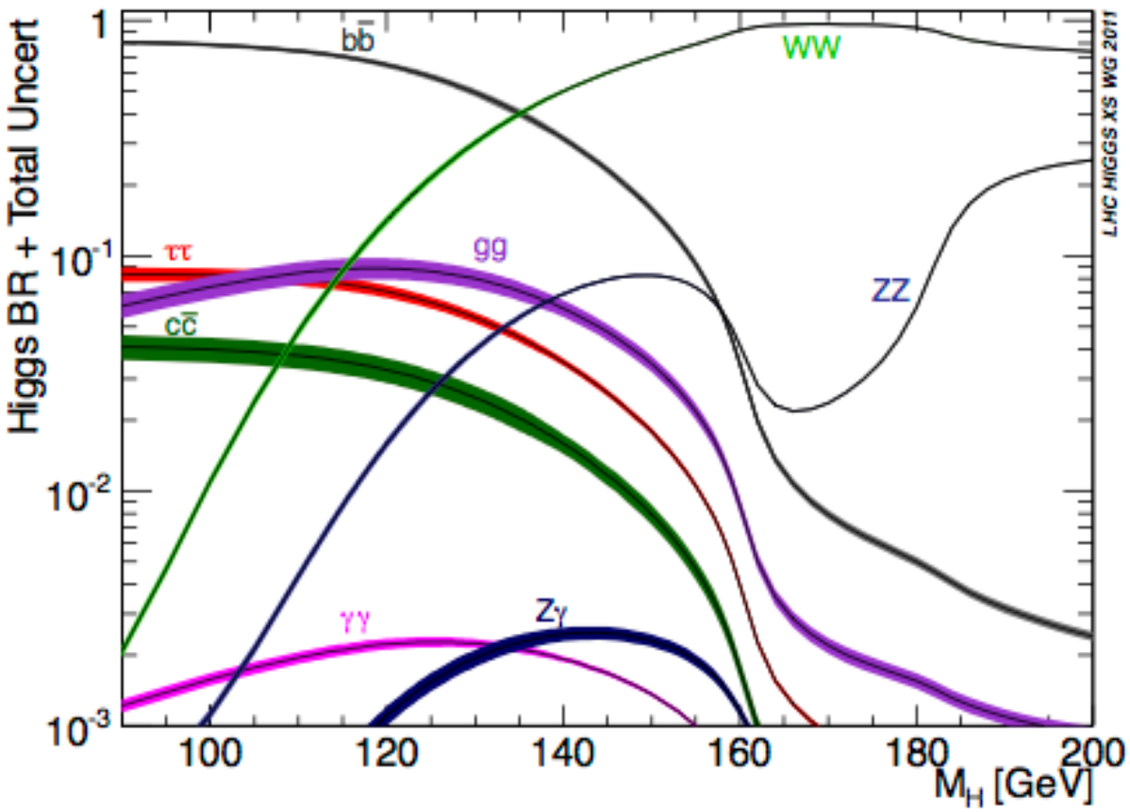
Analysis overview

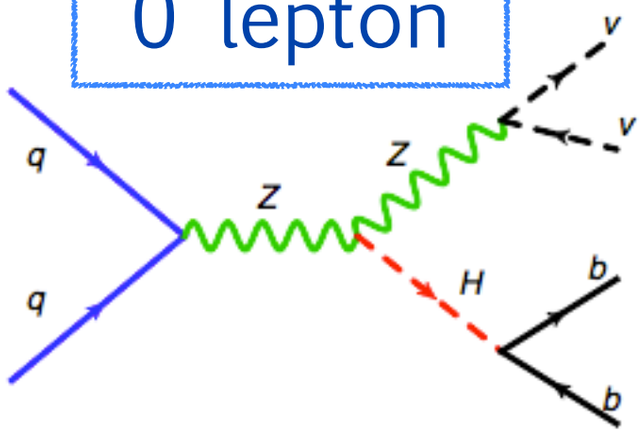
7TeV pp collisions: 4.7 fb^{-1}
8TeV pp collisions: 20.3 fb^{-1}

- **Highest B.R. in the low mass region**
- **Investigating fermionic couplings**
- **Associated production VH (H->bb)**
  - Necessary to cope with the overwhelming multijet background at the LHC
- **Combination of three channels in order to increase the sensitivity**

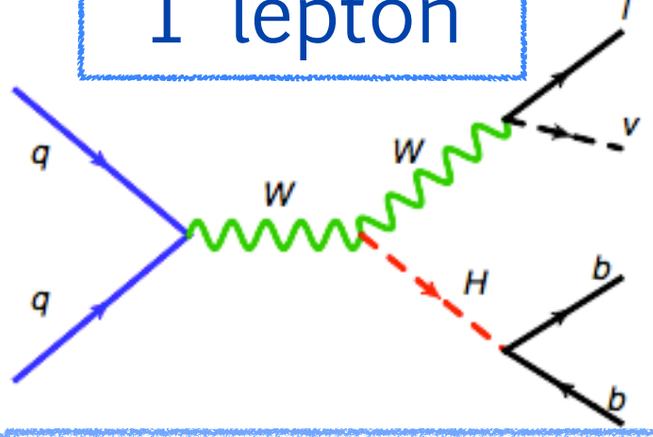


- $ZH \longrightarrow \nu\nu\ b\bar{b}$ (0 lepton)
- $WH \longrightarrow l\nu\ b\bar{b}$ (1 lepton)
- $ZH \longrightarrow ll\ b\bar{b}$ (2 lepton)

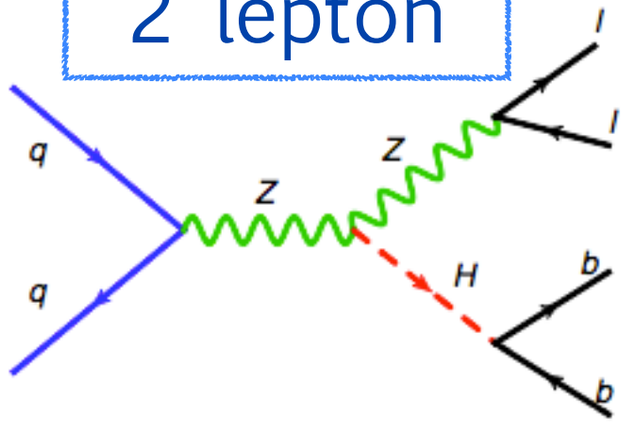
0 lepton



1 lepton



2 lepton



N.B. lepton = (e,μ)

Event selection

COMMON SELECTION:

- Two jets (p_T > 20 GeV and central region), both b-tagged with MV1 (70% b-tagging efficiency)
- Leading jet p_T > 45 GeV
- ΔR cuts bewteen the two leading jets depending on p_T^V to exploit the different signal/background kinematics

PLUS CHANNEL SPECIFIC KINEMATICS CUTS:

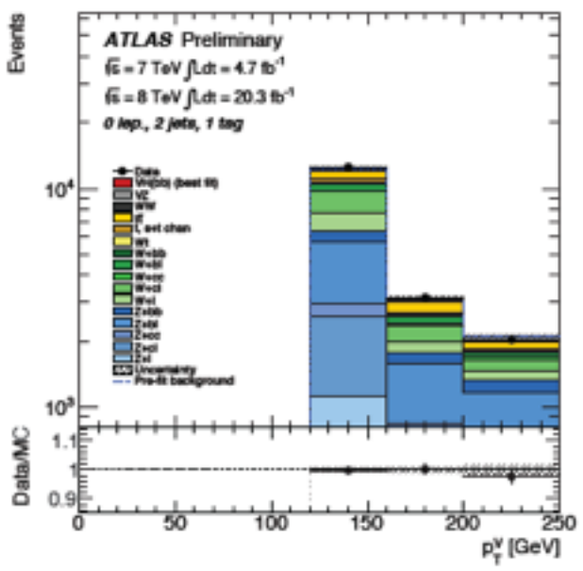
- lepton selection for reconstructing the vector boson candidate
- specific cuts to suppress QCD and other backgrounds (more in the backup)

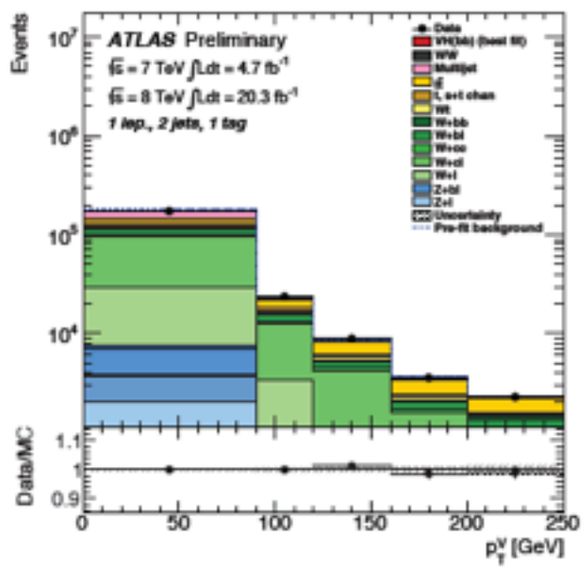
p_T^V defined as:
1-lepton: p_T(l+missing transverse energy)
2-lepton: p_T(ll)
0-lepton: missing transverse energy

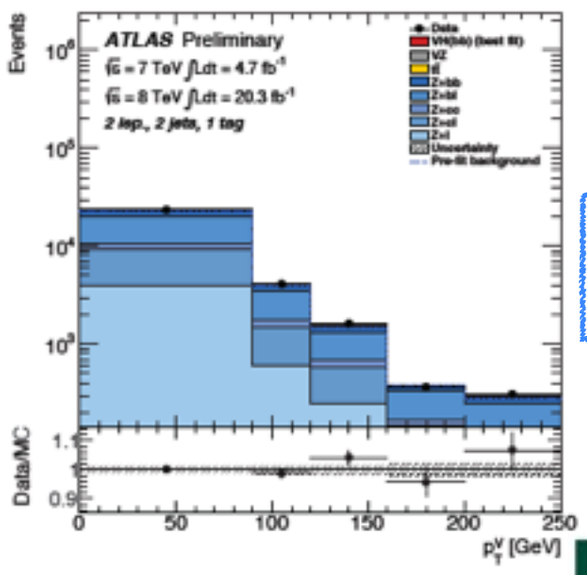
Search strategy

- Definition of different **event categories** by discriminating on:
  - **number of jets** (2, 3 jets regions)
  - **number of b-tags** (0, 1-tag control regions, **2-tag signal regions**)
  - Each category divided in **bins of p_T^V**:
    - 0-90, 90-120, 120-160, 160-200, >200 GeV
- Different categories dominated by different backgrounds:

	2jets, 1tag	3jets, 1tag	2jets, 2tags	3jets, 2tags	top eμ CR	x3 p_T^V bins
0-lepton	W+jets/Z+jets	W+j/Z+j/top	top/Z+b	top/Z+b	-	x5 p_T^V bins
1-lepton	W+c	W+c / top	W+b / top	top	-	x5 p_T^V bins
2-lepton	Z+c	Z+c	Z+b	Z+b	top	x5 p_T^V bins

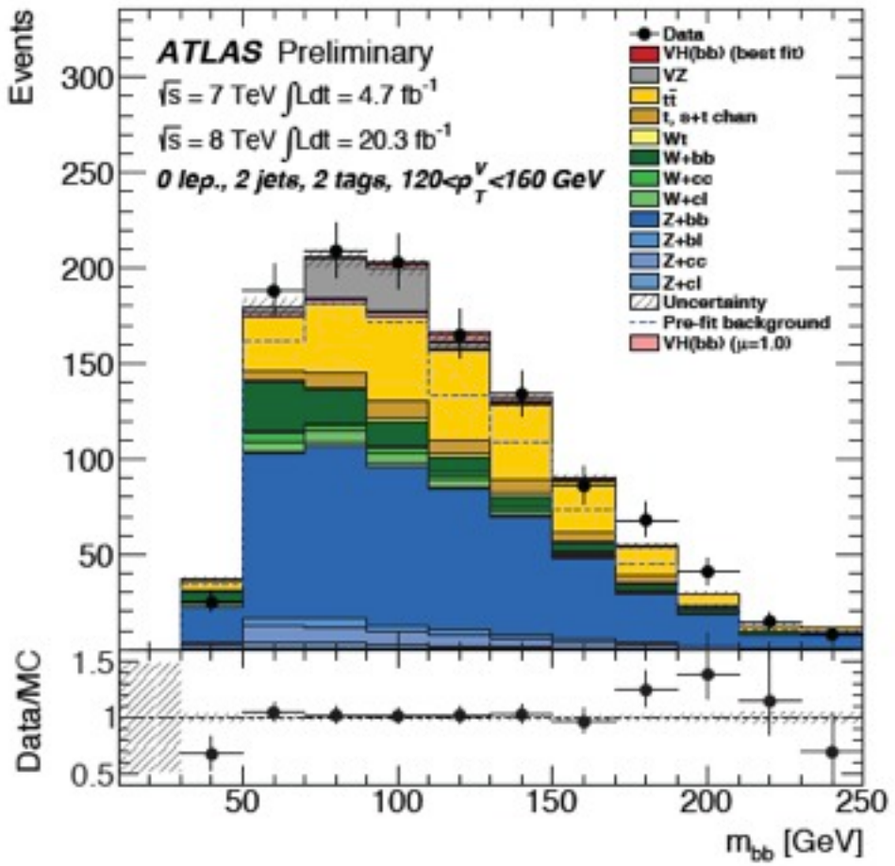






2jet 1tag p_T^V distribution

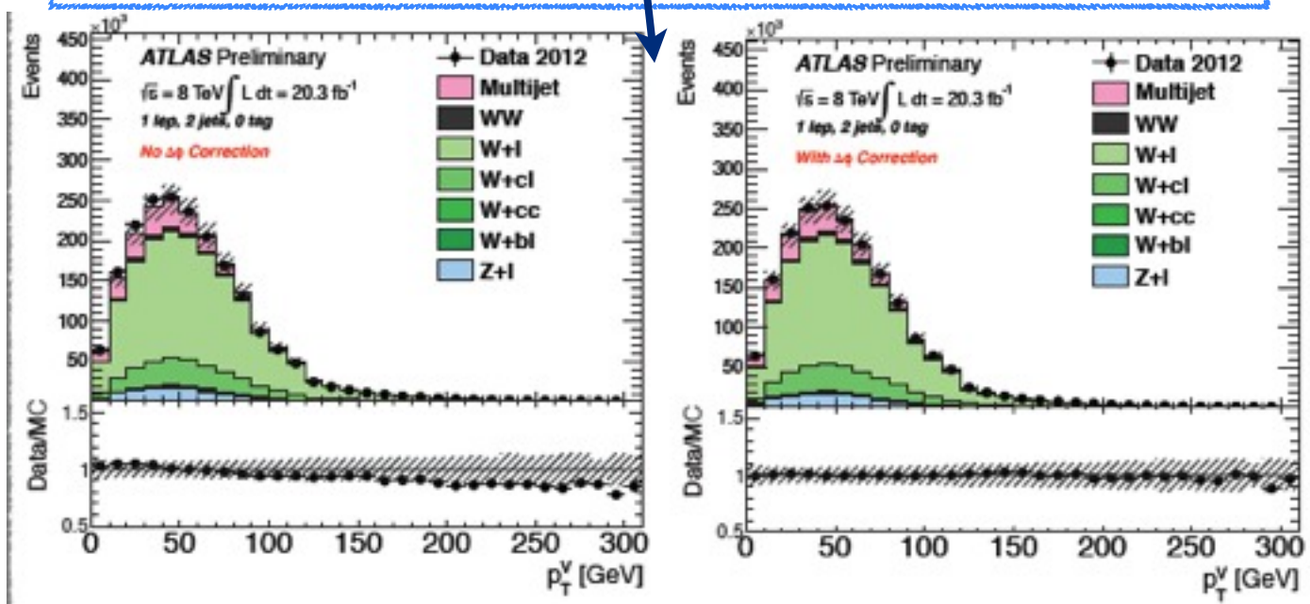
Background modeling



- Mbb shape
- 3 to 2 jets normalization
- p_T^V shape
- flavor composition in V+jets
- normalization (diboson, single top)

MC mismodeling of data:

- truth top p_T correction derived from dedicated study
- $\Delta\phi$ correction for V+jets Sherpa, improving modeling of other distributions



Backgrounds and generators:

- ttbar - POWHEG+PYTHIA
- W+jets (ll, cl, cc, bl, bb) - SHERPA
- Z+jets (ll, cl, cc, bl, bb) - SHERPA
- WH/ZH - PYTHIA8
- single top - ACER/POWHEG
- diboson - Herwig
- multijet - data driven

Systematic uncertainties

- **Three categories:**
  - experimental uncertainties
  - uncertainties on the modeling of the background processes
  - theoretical uncertainties on the signal processes

Experimental

- luminosity and pileup
- trigger
- lepton ID and reconstruction
- MET
- jet energy scale and resolution
- jet vertex fraction
- b-tagging

Theoretical

- NLO EW corrections
- renormalization and factorization scale
- PDFs
- signal acceptance

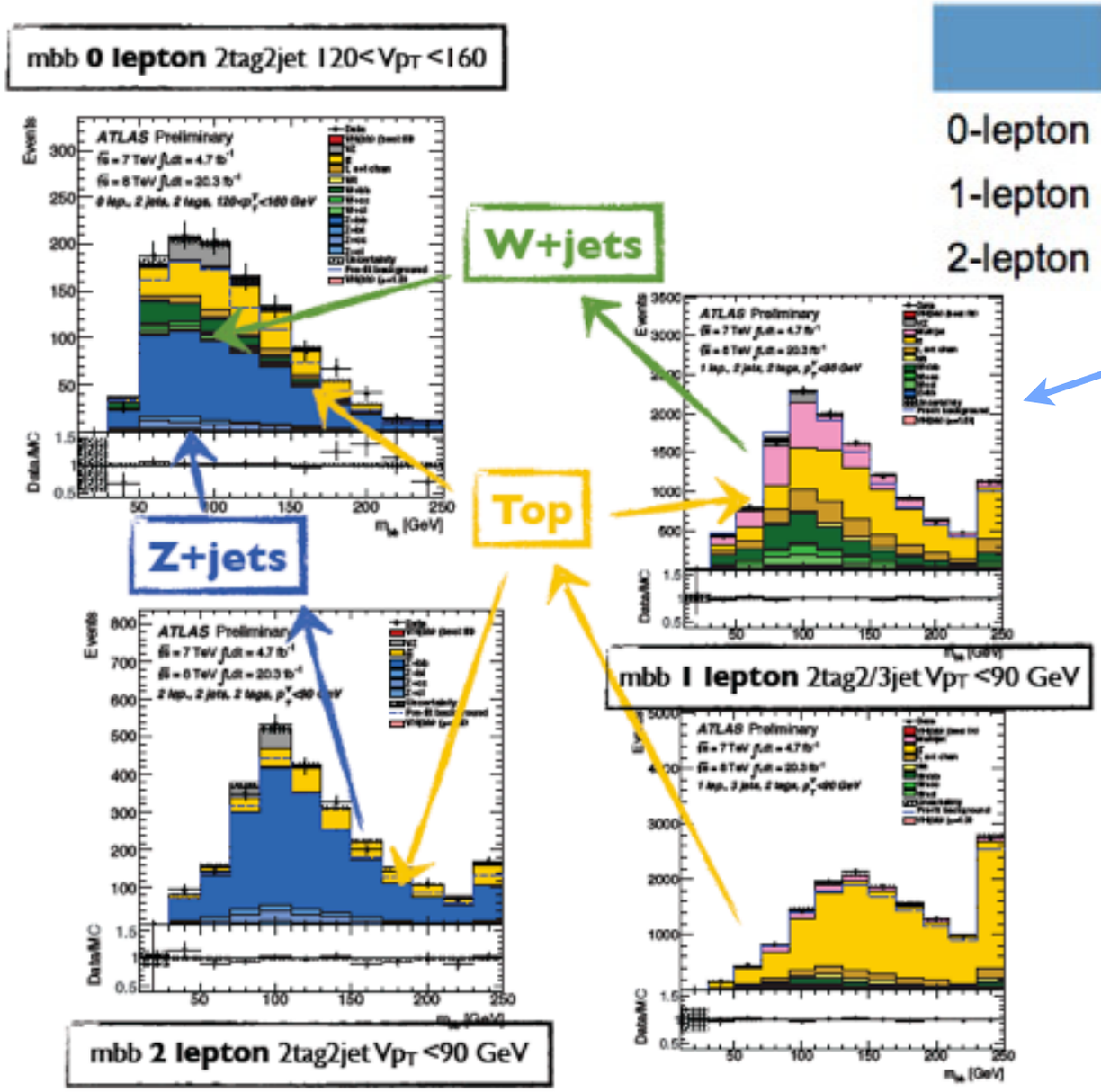
+ uncertainties on flavor composition, cross sections

- Uncertainties related to **b-tagging** and **jet energy scale** are dominant

- Each systematic uncertainty is treated as a nuisance parameter in the statistical fit

Statistical treatment

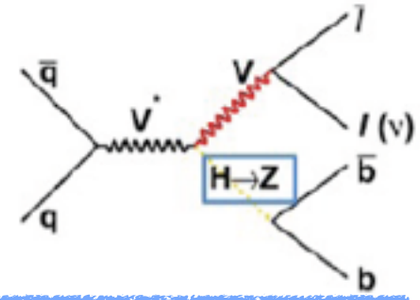
- Combined profile likelihood fit
- Each systematic uncertainty is treated as a nuisance parameter
- Fit performed in signal regions and 1-tag, top control regions



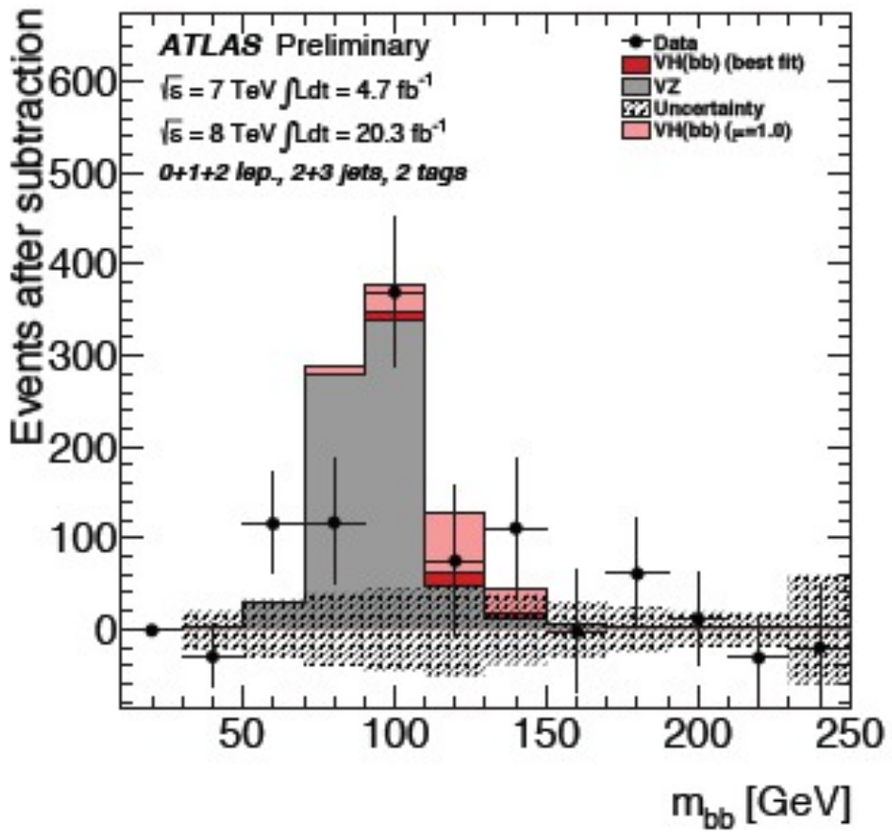
	2jets, 1-tags	3jets, 1-tags	2jets, 2-tags	3jets, 2-tags	Top emu CR
0-lepton	Norm	Norm	**Shape**	Shape	-
1-lepton	Norm	Norm	**Shape**	Shape	-
2-lepton	Norm	Norm	**Shape**	Shape	**Norm**

- **Fit performed simultaneously on the 3 channels and all the regions**
- **Coherent normalization among the channels and region**
  - Normalization floated for main backgrounds: V+cl, V+bl, V+bb/cc, ttbar
  - Normalization fixed to MC for diboson, single top, V+light jets

Validation: diboson fit



- The VZ, Z->bb process has a similar signature with 5 times larger cross section with respect to VH, H->bb
- Use this process to validate the fit model with identical procedure used for the Higgs boson search

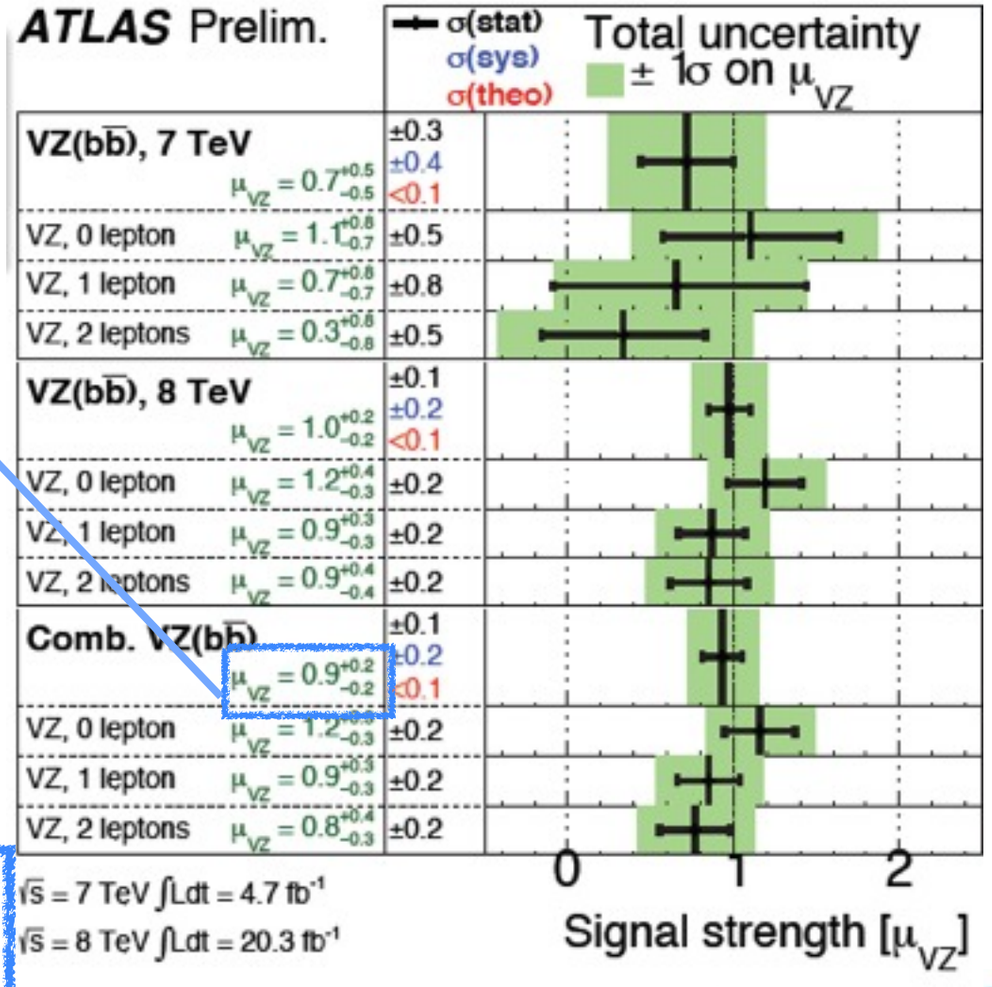


Light red: SM Higgs peak with μ = 1
Dark red: Higgs peak with fit μ result

$$\mu = \frac{\sigma_{\mathrm{meas}}}{\sigma_{\mathrm{SM}}}$$

$$\mu_{VZ} = 0.9^{+0.2}_{-0.2}$$

compatible with SM expectation μ=1

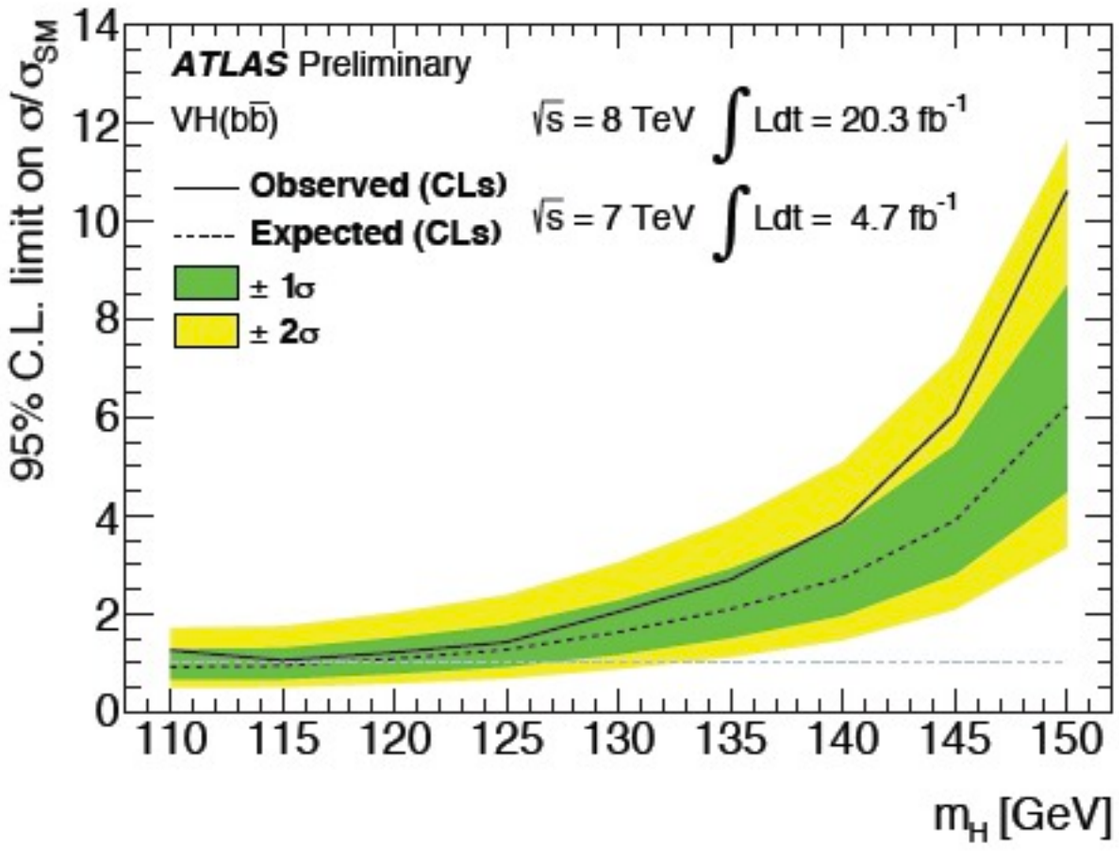


Obs. (exp.) significance 4.8 (5.1)

Results

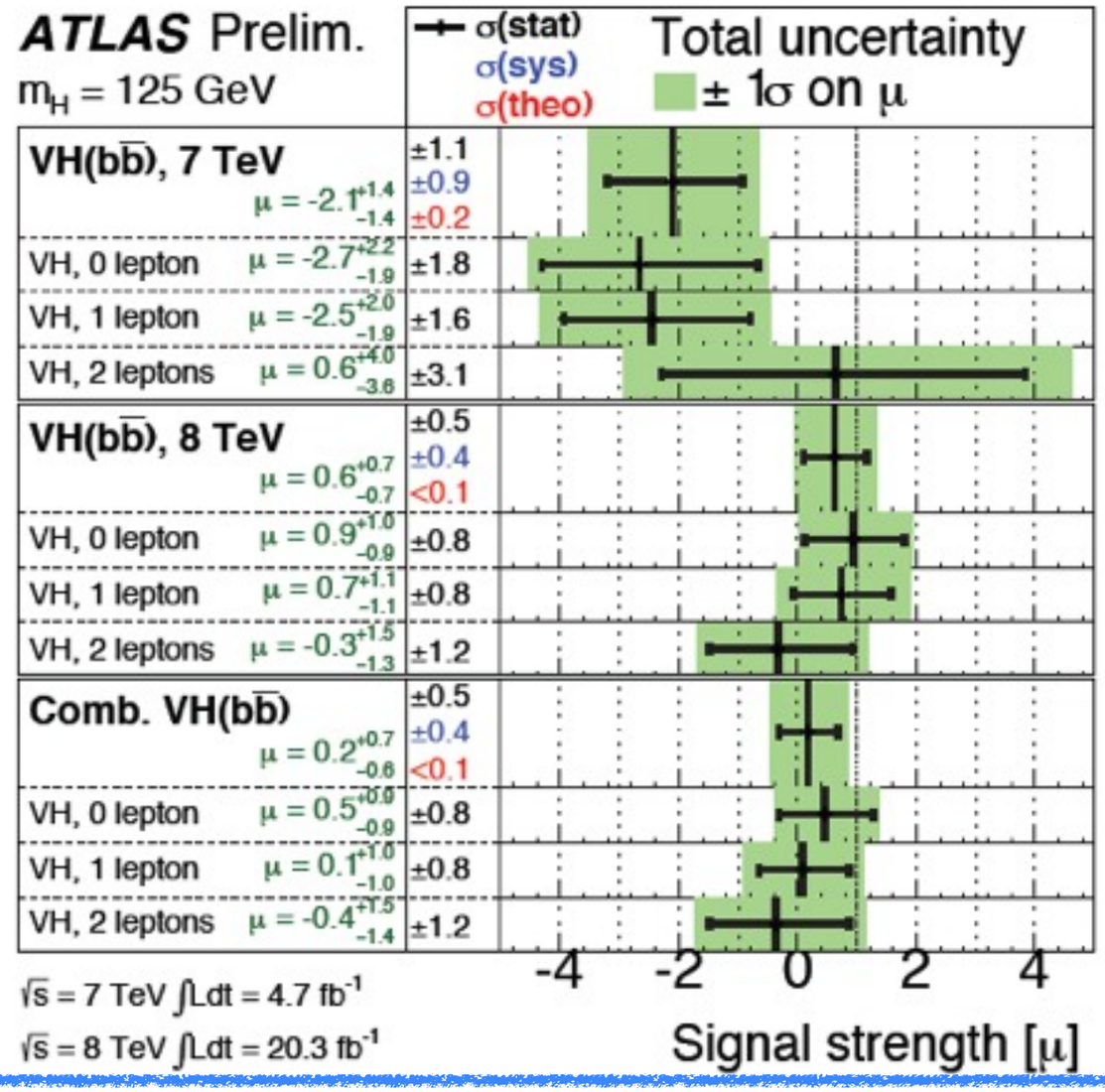
$$\mu = \frac{\sigma_{\text{meas}}}{\sigma_{\text{SM}}}$$

- Fit for the Higgs signal performed with the diboson contribution constrained to its SM value
- No significant excess observed



Observed (expected) 95% CL limit on σ/σ_{SM} at m_H=125 GeV:

1.4 (1.3)



The fitted value of the signal strength parameter (m_H=125 GeV) is:

μ = 0.2 ± 0.5 (stat.) ± 0.4 (syst.)

Summary

- Latest preliminary results on the ATLAS search for VH, H->bb production
  - Combination of full 7TeV (4.7 fb^{-1}) and 8TeV (20.3 fb^{-1}) datasets
- The diboson VZ cross-section measurement is consistent with SM prediction with an observed (expected) significance of 4.8 (5.1) standard deviations
- The search for VH production is performed and a combined observed (expected) 95% CL limit on σ/σ_{SM} at m_H=125 GeV of 1.4 (1.3) is obtained
- The observed signal strength is $\mu = 0.2 \pm 0.5\ (stat.) \pm 0.4\ (syst.)$
- Besides the gain from the increased integrated luminosity, the analysis has seen an improvement in sensitivity of ~35% with respect to the last released results
- Future improvements will come... Stay tuned!
- **For more information: ATLAS-CONF-2013-07**

BACKUP

Event selection

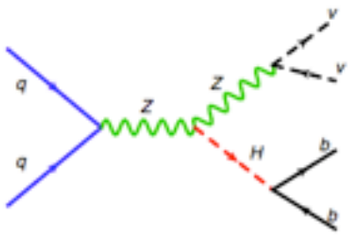
COMMON SELECTION:

- Two jets (p_T > 20 GeV and central region), both b-tagged with MV1 (70% b-tagging efficiency)
- Leading jet p_T > 45 GeV
- ΔR cuts bewteen the two leading jets depending on p_T^V to exploit the different signal/background kinematics

PLUS CHANNEL SPECIFIC KINEMATICS CUTS:

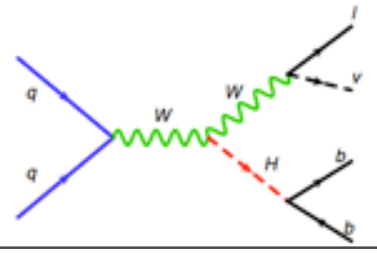
0-lepton cuts

- no loose leptons
- E_T^{miss} > 120 GeV
- QCD rejection cuts



1-lepton cuts

- 1 tight lepton
- no additional leptons
- QCD rejection cuts
- m_T^W>40 GeV (if p_T^W<160)
- E_T^{miss}>50 GeV (if p_T^W>200)



2-lepton cuts

- 1medium + 1loose lepton
- no additional leptons
- 83<m_{ll}<99 GeV
- E_T^{miss}<60 GeV

Fit model

Combined profile likelihood fit

- Likelihood function constructed as product of Poisson probability terms

$$L(\mu,\theta) = \prod_{j=1}^{N} \frac{(\mu s_j + b_j)^{n_j}}{n_j!} e^{-(\mu s_j + b_j)} \prod_{k=1}^{M} \frac{u_k^{m_k}}{m_k!} e^{-u_k}$$

- Signal and background parametrization:

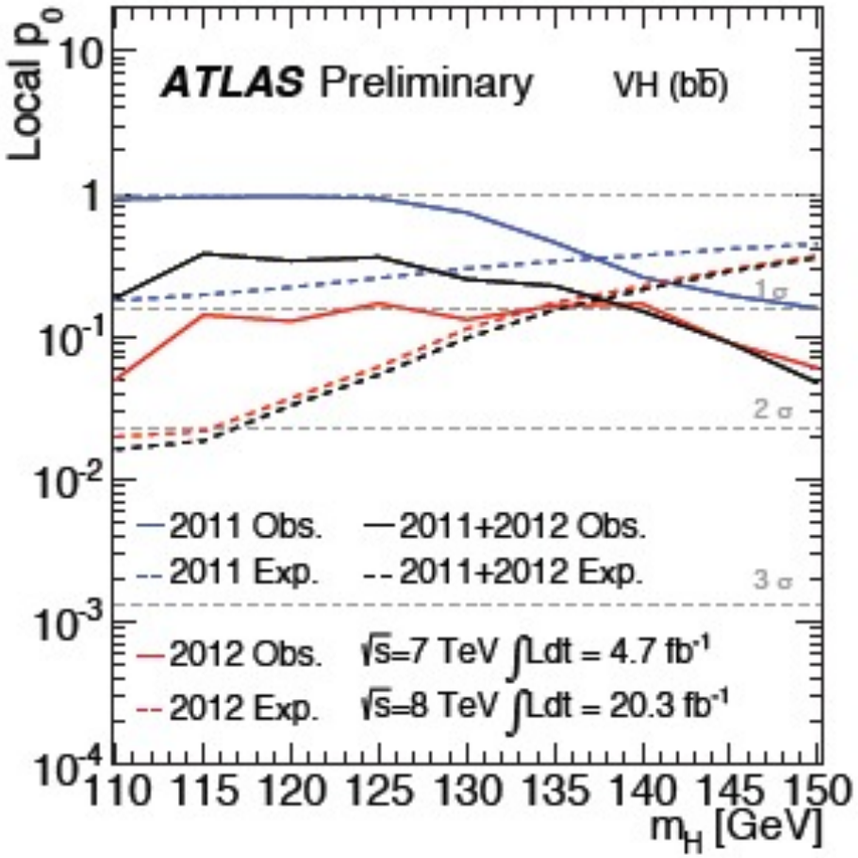
$$s_i = s_{tot} \int_{\text{bin } i} f_s(x;\theta_s)dx \qquad b_i = b_{tot} \int_{\text{bin } i} f_b(x;\theta_b)dx$$

- Test statistics constructed according to the profile likelihood ratio:

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

θ: nuisance parameters

More results



7 TeV data deficit drives a rather small excess compared with the SM p_0 expectation

Compatibility with μ=0 : 36 %
Compatibility with μ=1 : 11 %