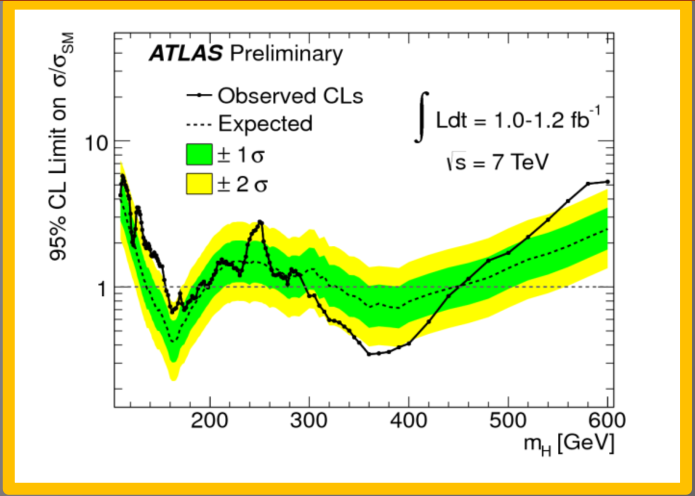
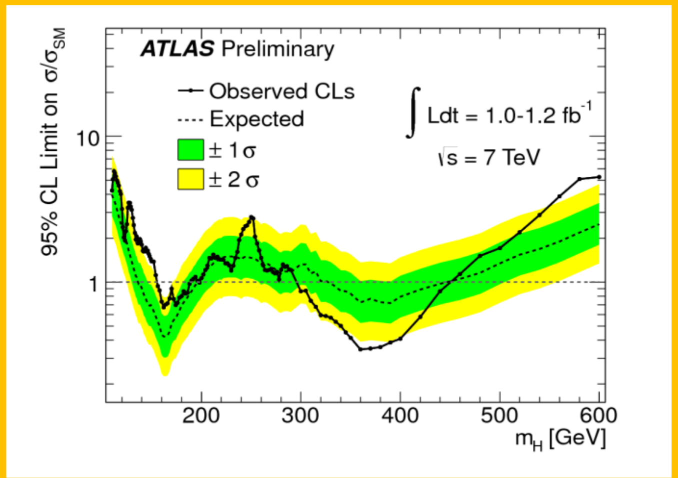
Results on the Brout-Englert-Higgs boson search with the ATLAS experiment

Lydia Iconomidou-Fayard
LAL-In2p3-CNRS-Paris XI

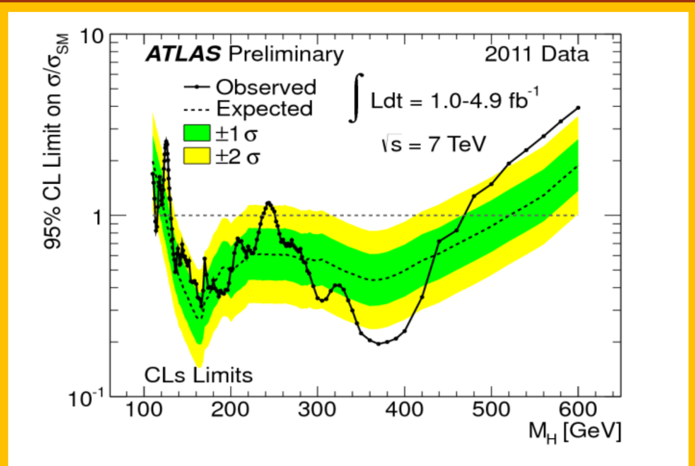
From EPS (07/2011)…



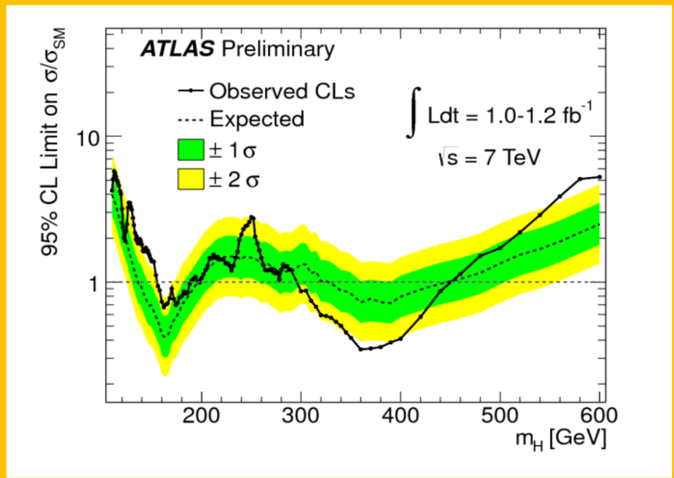
From EPS (07/2011)…



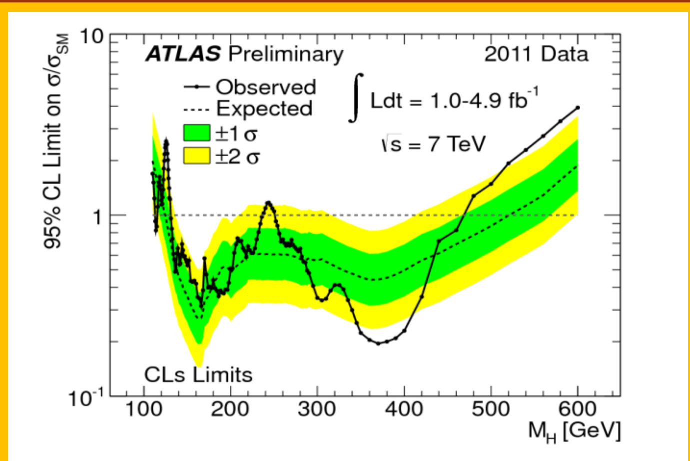
..to CERN seminar (12/2011)



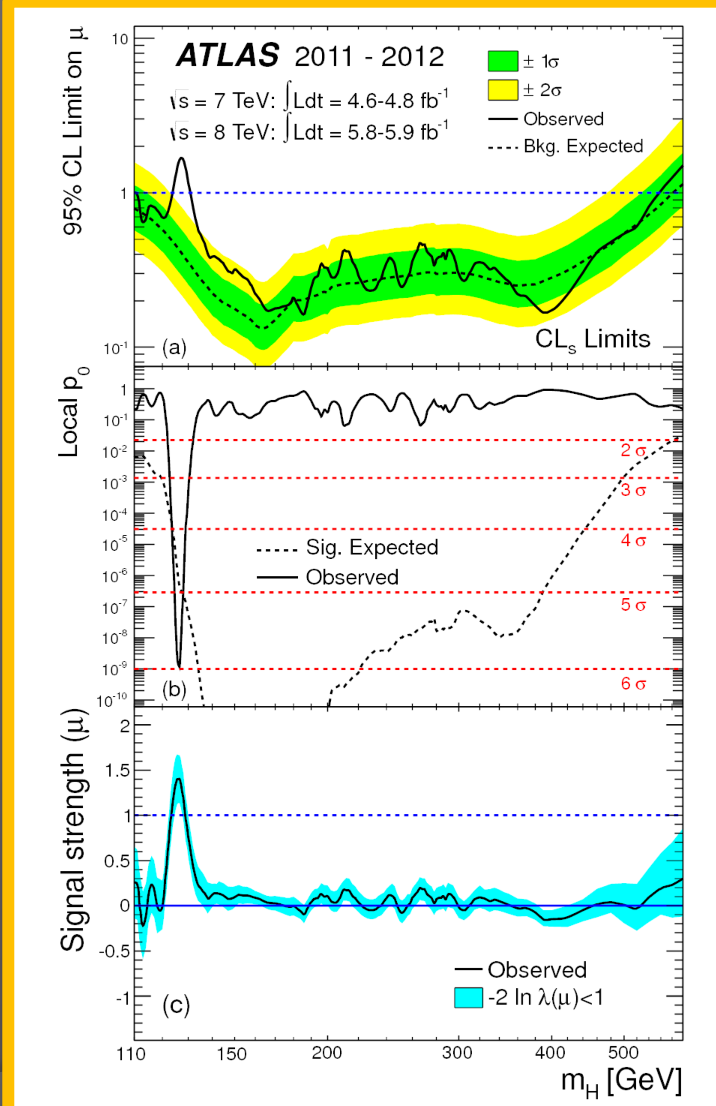
From EPS (07/2011)…



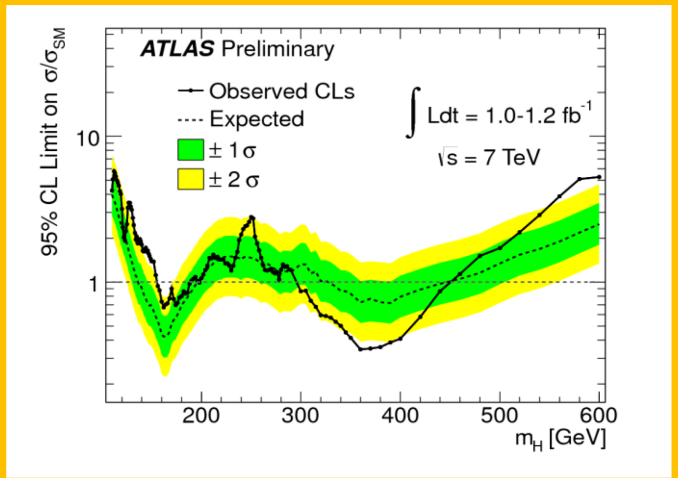
..to CERN seminar (12/2011)



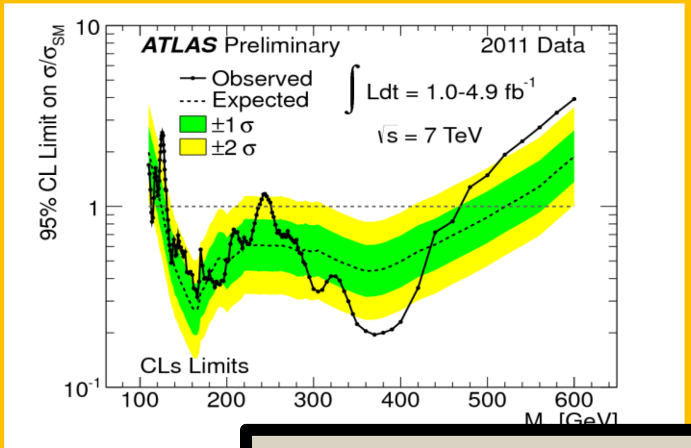
.. To July 2012



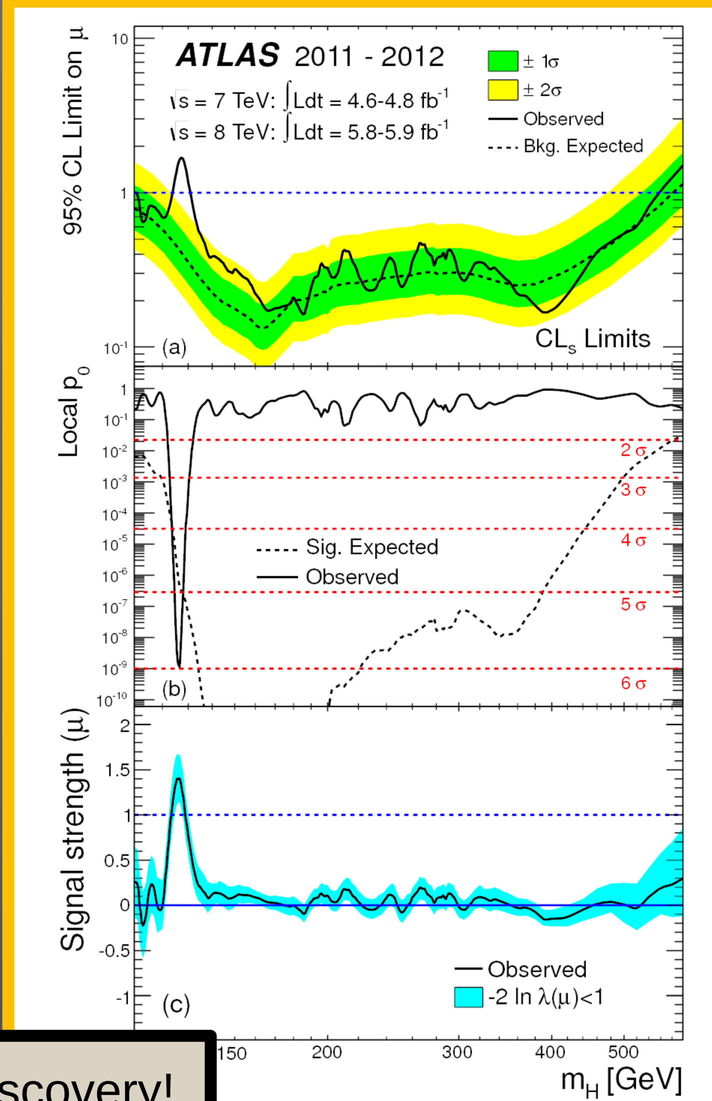
From EPS (07/2011)…



..to CERN seminar (12/2011)



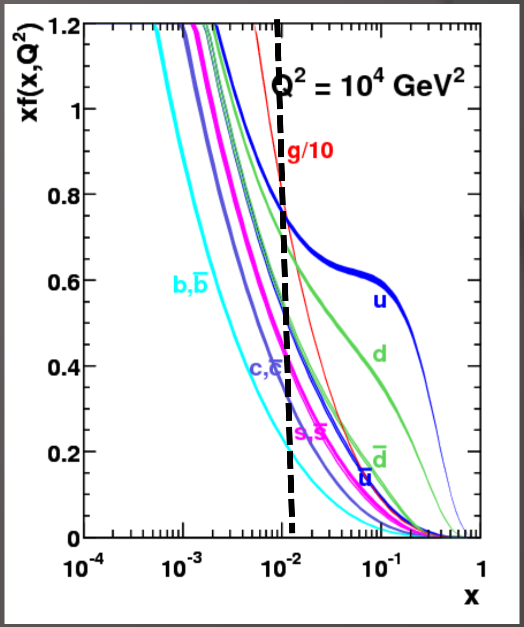
.. To July 2012



One year running time : Fast discovery!

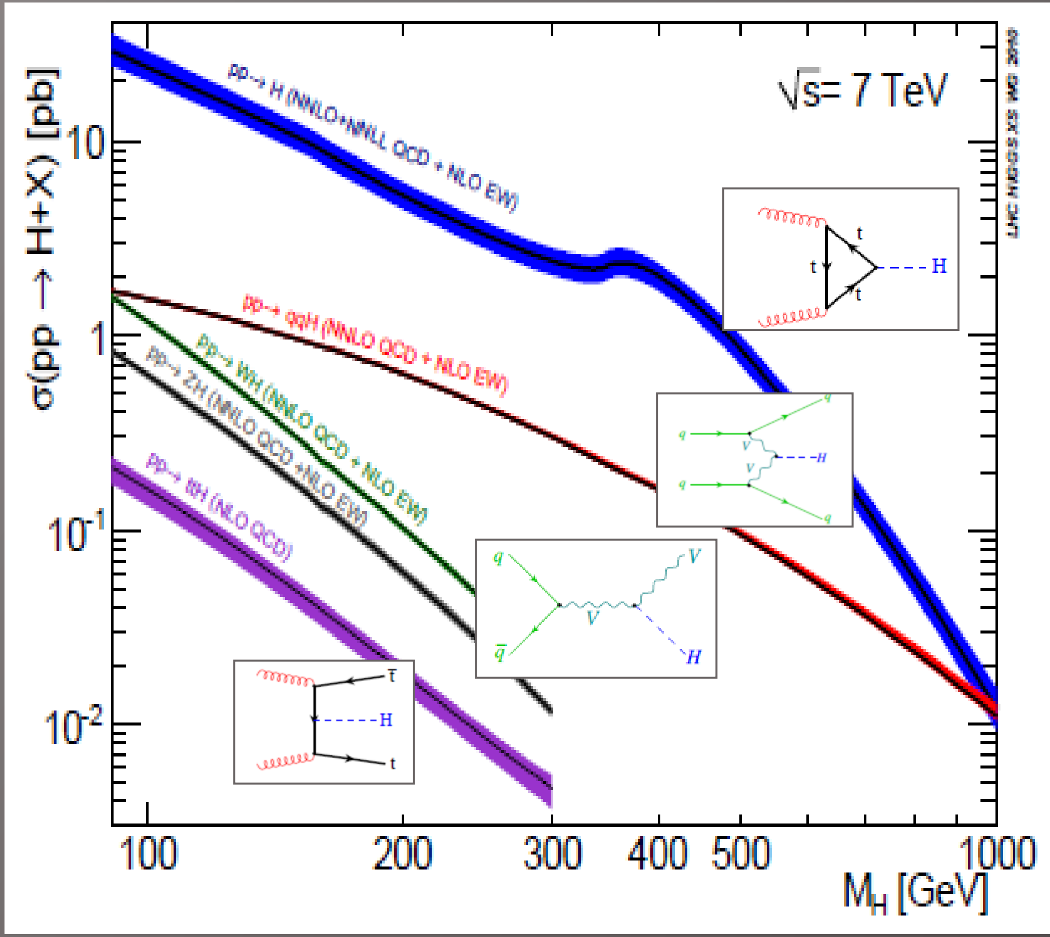
Thanks to the LHC team for the amazing machine performance !

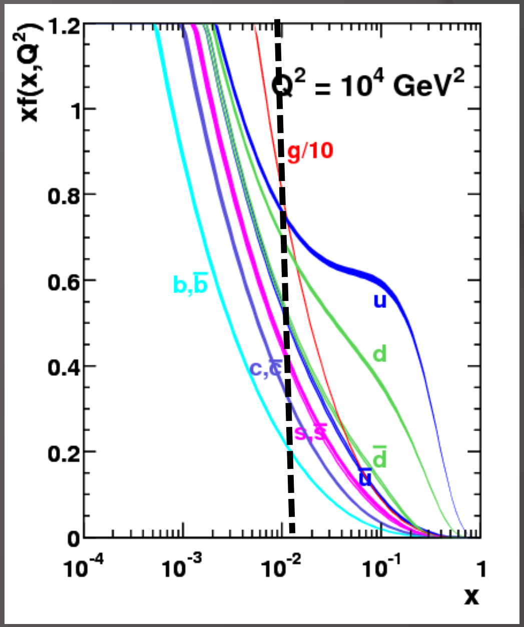
BEH production in LHC…



At LHC $\sqrt{S}$=7TeV
For M~100GeV
X ≈ M/$\sqrt{S}$ = 0.01

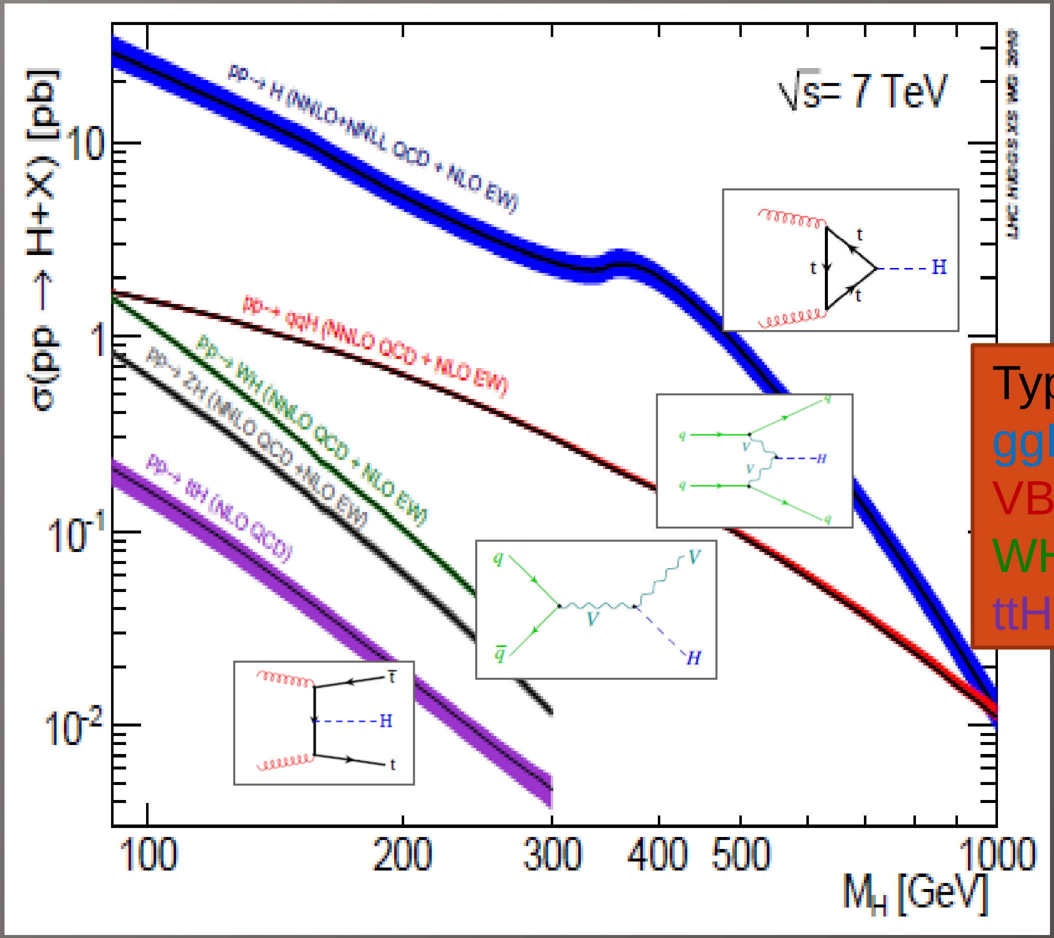
BEH production in LHC…





At LHC √S=7TeV
For M~100GeV
X ≈ M/√S = 0.01

BEH production in LHC…

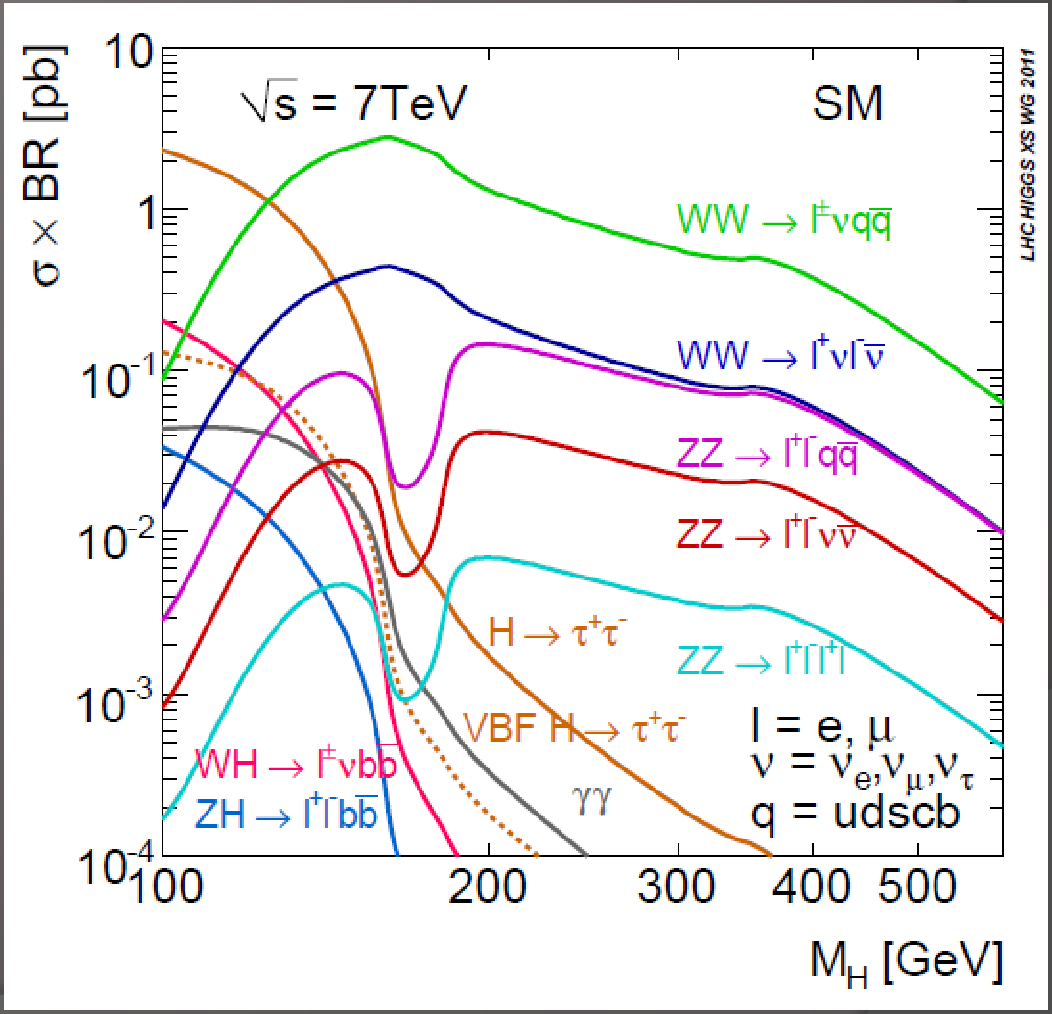


Typical uncertainties on XS
ggF: 15-20% (NNLO)
VBF: 5% (NLO)
WH, ZH : 5% (NNLO)
ttH : 15% (NNLO)

LHC Higgs Cross-Section Working Group arXiv:1101.0593 [hep-ph], 1201.3084 [hep-ph]

… and its Decay

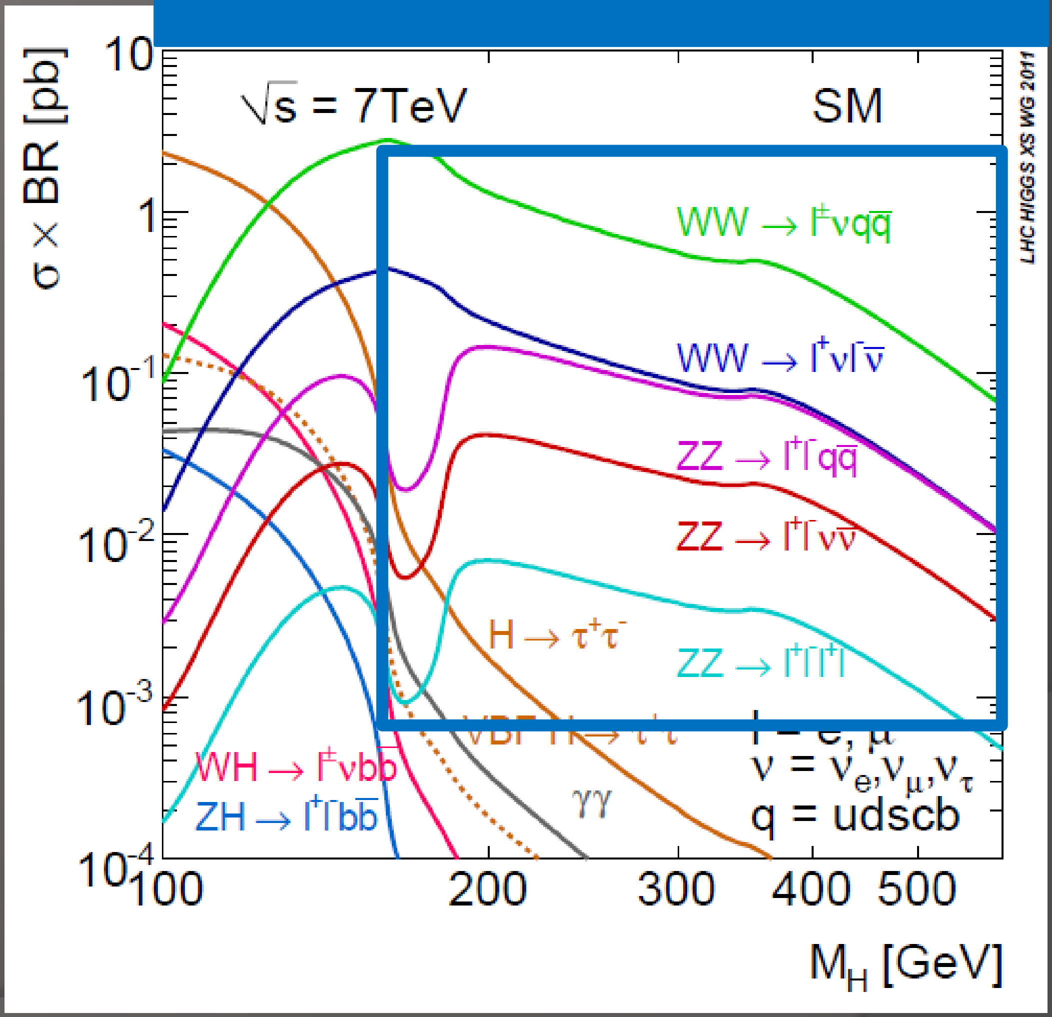
Depending on its mass, BEH decays preferentially to the heavier particles



… and its Decay

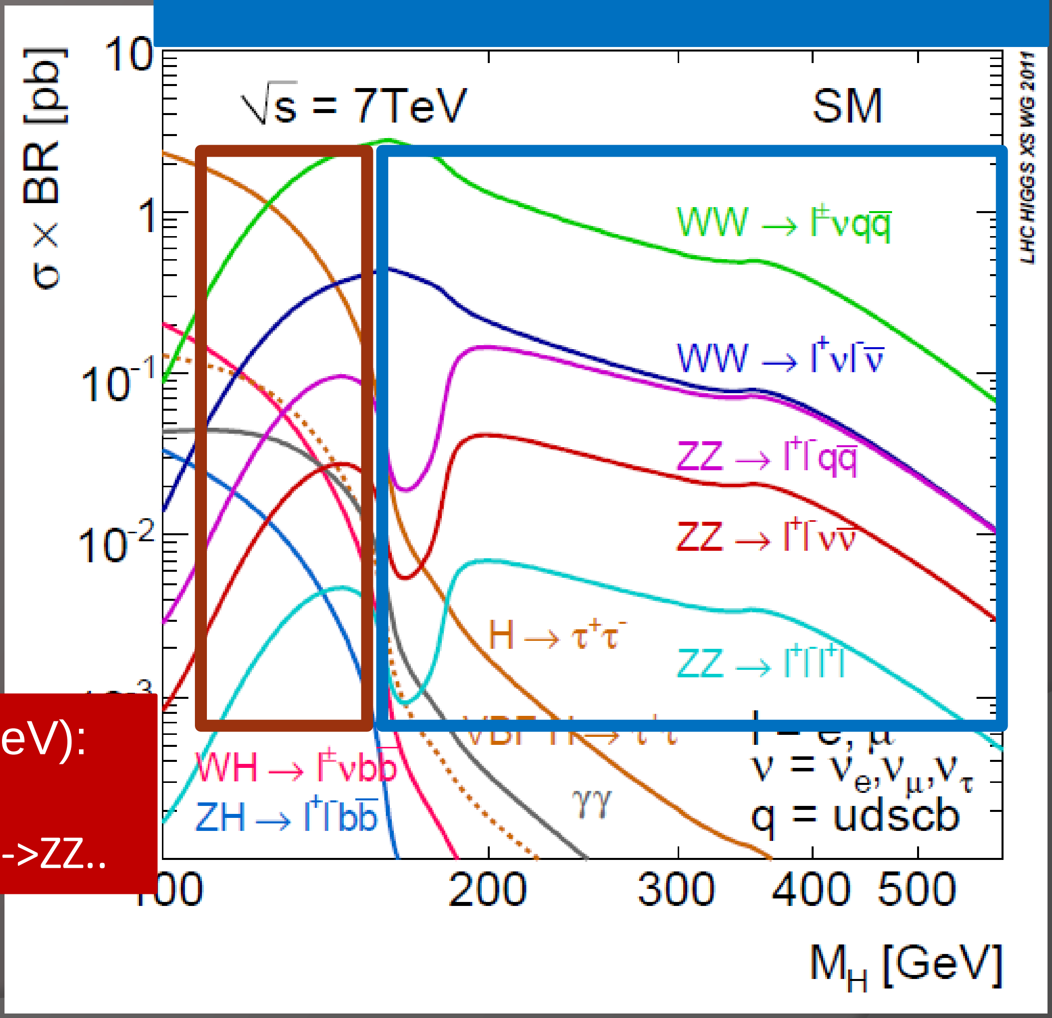
High mass searches (M≥180GeV) : first exclusions using the diboson channels

Depending on its mass, BEH decays preferentially to the heavier particles



… and its Decay

.
High mass searches (M≥180GeV) : first exclusions using the diboson channels



Depending on its mass, BEH decays preferentially to the heavier particles

Low mass searches (M<160GeV): Several channels
H->bb, H->ττ, H->γγ, H->WW, H->ZZ..

High masses : the first reached

Sensitive modes at high M_H
H->dibosons

WW->lνqq	300-600 GeV
WW->lνlν	110-600 GeV
ZZ-> llqq	200-600 GeV
ZZ -> llνν	200-600 GeV
ZZ -> 4l	110-600 GeV

High masses : the first reached

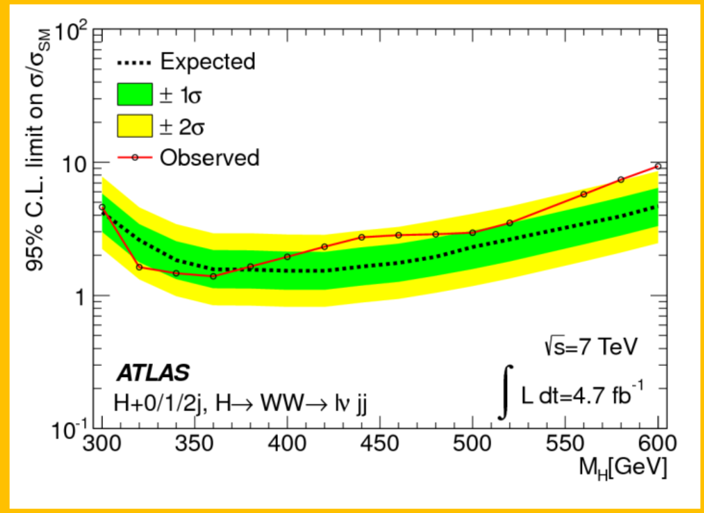
Sensitive modes at high M_H
H->dibosons

WW->lνqq	300-600 GeV
WW->lνlν	110-600 GeV
ZZ-> llqq	200-600 GeV
ZZ -> llνν	200-600 GeV
ZZ -> 4l	110-600 GeV

WW->lνqq with 4.7fb^{-1} data at $\sqrt{s}$=7TeV
Search range : 300-600GeV

Signature: one high P_T electron, two jets and missing momentum

Best senstitivity: ~1.5SM at 350GeV

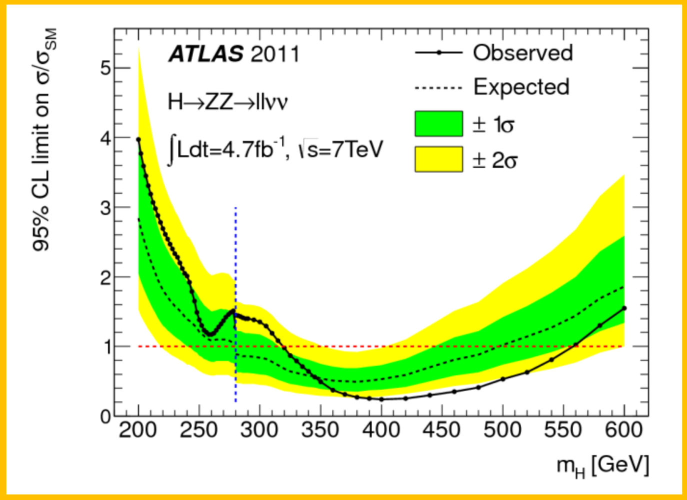


High masses : the first reached

ZZ->llνν with 4.7fb^{-1} data at $\sqrt{s}$=7TeV
Search range : 200-600GeV

Signature : resonant di-lepton pair, missing momentum, high di-lepton P_T

No excess observed
Excluded region : 319-558 GeV

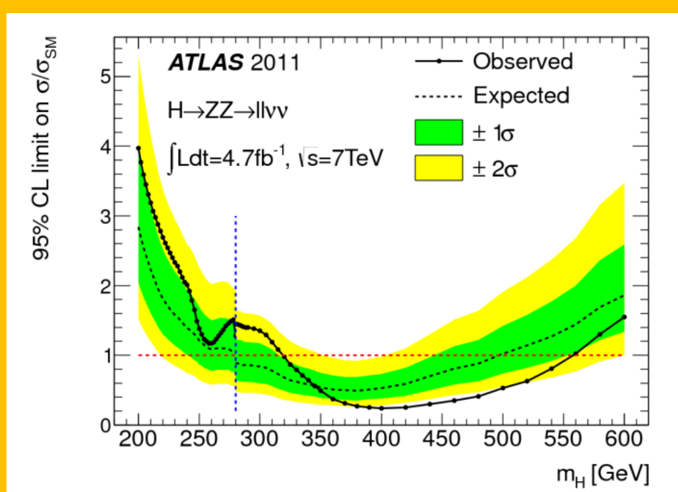


High masses : the first reached

ZZ->llvv with 4.7fb^{-1} data at $\sqrt{s}$=7TeV
Search range : 200-600GeV

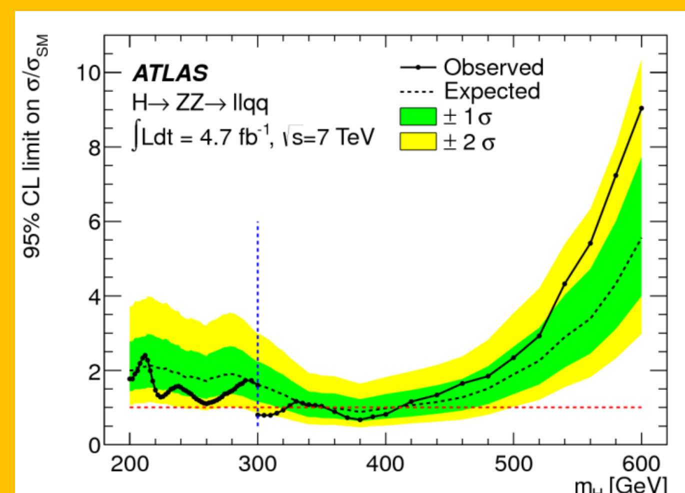
Signature : resonant di-lepton pair, missing momentum, high di-lepton P_T

No excess observed
Excluded region : 319-558 GeV



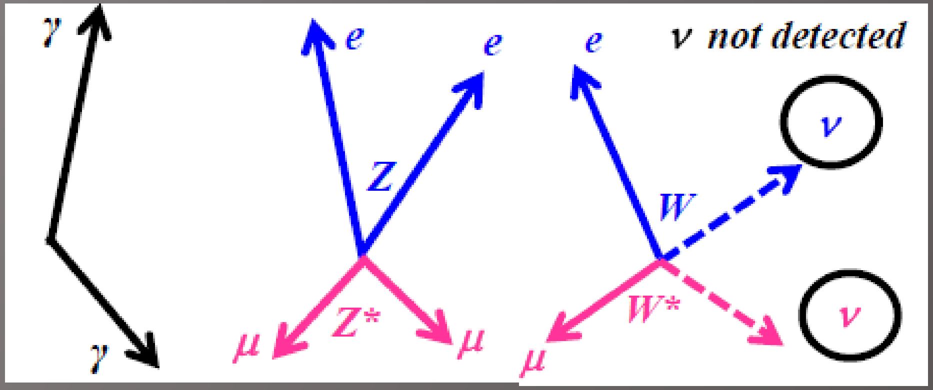
ZZ->llqq with 4.7fb^{-1} data at $\sqrt{s}$=7TeV
Search range : 200-600GeV

Signature: two on-shelll Zs, two isolated high P_T leptons. two jets , small $E_T$miss, b-tagging
No excess observed
Excluded region: 300-322, 353-410 GeV



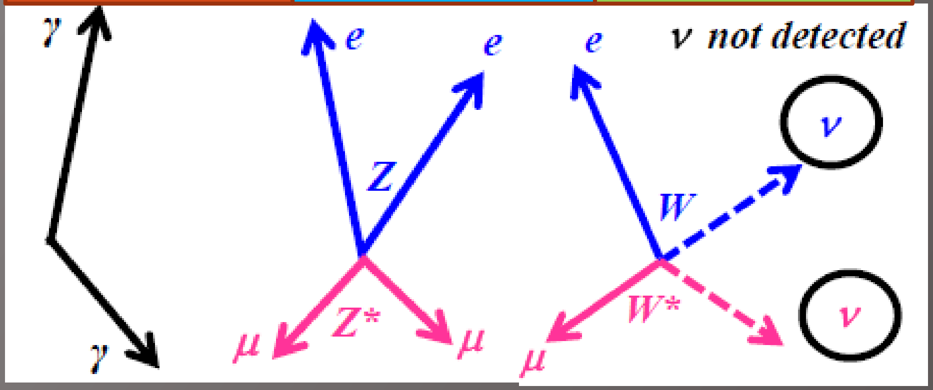
Low mass BEH boson

Main sensitive H decay modes at M_H~125GeV
Produced/Detected per 5fb-1



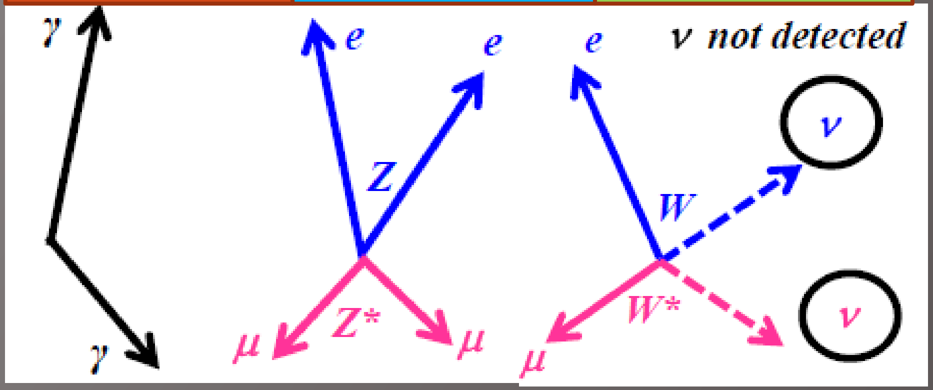
Low mass BEH boson

Main sensitive H decay modes at M_H~125GeV Produced/Detected events per 5fb-1		
H-> ɣɣ 200/70 S/B~0.02	H->ZZ->4l 10 /3 S/B ~1.5	H->WW 770/50 S/B ~0.3



Low mass BEH boson

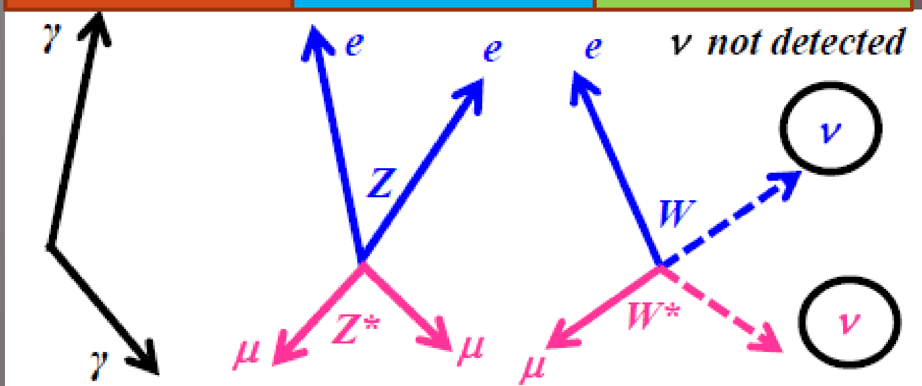
Main sensitive H decay modes at M_H~125GeV Produced/Detected events per 5fb-1		
H-> ɣɣ 200/70 S/B~0.02	H->ZZ->4l 10 /3 S/B ~1.5	H->WW 770/50 S/B ~0.3



Fully detected final state
➔Mass measurement

Low mass BEH boson

Main sensitive H decay modes at M_H~125GeV Produced/Detected events per 5fb-1		
H-> ɣɣ 200/70 S/B~0.02	H->ZZ->4l 10 /3 S/B ~1.5	H->WW 770/50 S/B ~0.3



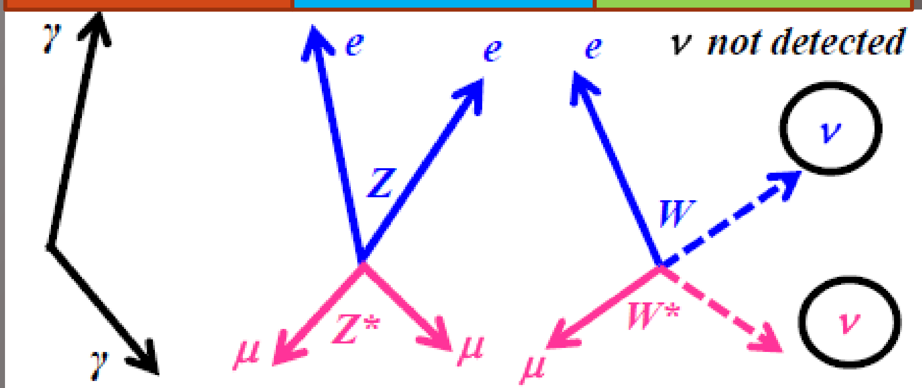
For M_H ~125GeV,
natural width~4MeV
(T~10-22s, Lflight~100fm)

Fully detected final state
➔Mass measurement

Low mass BEH boson

Main sensitive H decay modes at M_H~125GeV
Produced/Detected events per 5fb-1

H-> ɣɣ	H->ZZ->4l	H->WW
200/70	10 /3	770/50
S/B~0.02	S/B ~1.5	S/B ~0.3



Fully detected final state
➔Mass measurement

For M_H ~125GeV,
natural width~4MeV
(T~10-22s, Lflight~100fm)

Detector resolution crucial for detection!!

H->ɣɣ and H->ZZ*->4l performances
Guided the conception of ATLAS
(Liquid argon calorimetry, Muon Spectrometer)

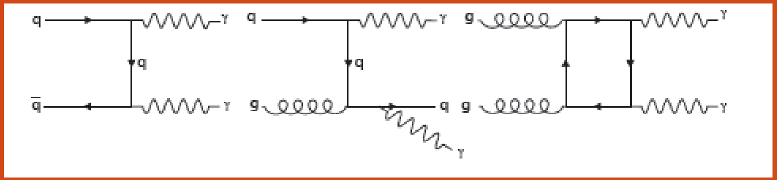
$H \to \gamma\gamma$: the historical channel

- ➔ Clean signature: 2 isolated high P_T photons.
- ➔ P_{T1}>40GeV P_{T2}>30GeV
- ➔ **Look for a bump in the diphoton mass spectrum**
- ➔ Requires excellent mass resolution to distinguish a bump on top of a continuum

H->γγ : the historical channel

- ➔Clean signature: 2 isolated high P_T photons.
- ➔ P_{T1}>40GeV P_{T2}>30GeV
- ➔ **Look for a bump in the diphoton mass spectrum**
- ➔ Requires excellent mass resolution to distinguish a bump on top of a continuum

➔Irreducible background:

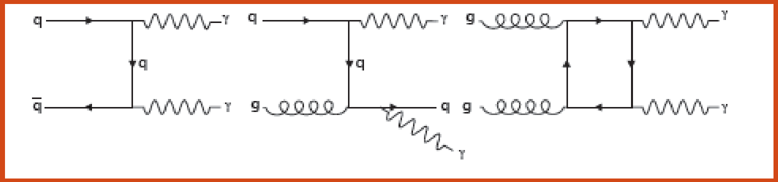


Non resonant in Mγγ

H->γγ : the historical channel

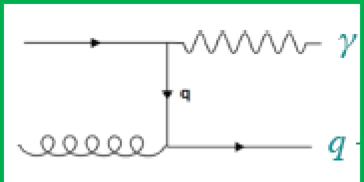
- ➔Clean signature: 2 isolated high P_T photons.
- ➔ P_{T1}>40GeV P_{T2}>30GeV
- ➔ **Look for a bump in the diphoton mass spectrum**
- ➔ Requires excellent mass resolution to distinguish a bump on top of a continuum

➔Irreducible background:



Non resonant in Mγγ

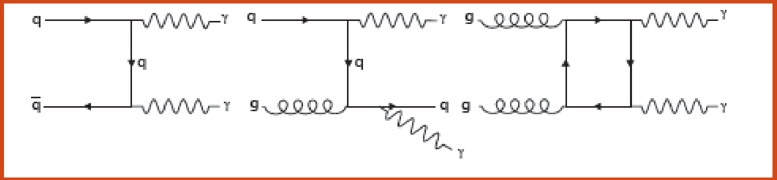
➔Reducible:
γ+Jet (π0),
Jet(π0)+Jet(π0)



H->γγ : the historical channel

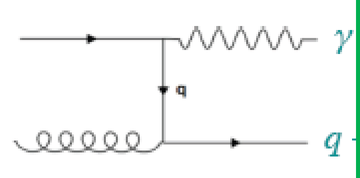
- ➔Clean signature: 2 isolated high P_T photons.
- ➔ P_{T1}>40GeV P_{T2}>30GeV
- ➔ **Look for a bump in the diphoton mass spectrum**
- ➔ Requires excellent mass resolution to distinguish a bump on top of a continuum

➔Irreducible background:



Non resonant in Mγγ

➔Reducible:
γ+Jet (π0),
Jet(π0)+Jet(π0)

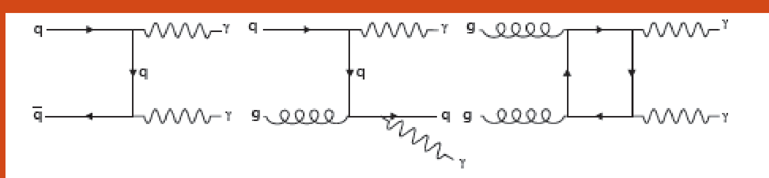


Electromagnetic Calorimetry
- Liquid Argon+Lead
- Stable response
- Hermetic in phi
- Longitudinaly segmented in 3 layers
- Preshower in front to collect lost energy

H->γγ : the historical channel

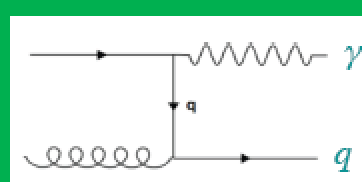
- ➔Clean signature: 2 isolated high P_T photons.
- ➔ P_{T1}>40GeV P_{T2}>30GeV
- ➔ **Look for a bump in the diphoton mass spectrum**
- ➔ Requires excellent mass resolution to distinguish a bump on top of a continuum

➔Irreducible background:



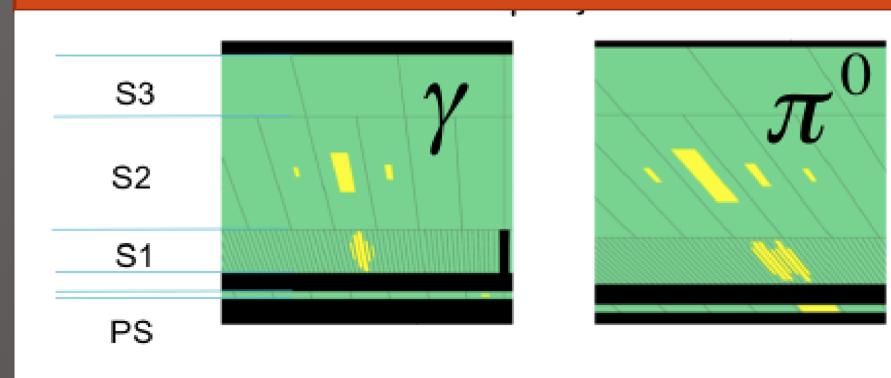
Non resonant in Mγγ

➔Reducible:
γ+Jet (π0),
Jet(π0)+Jet(π0)



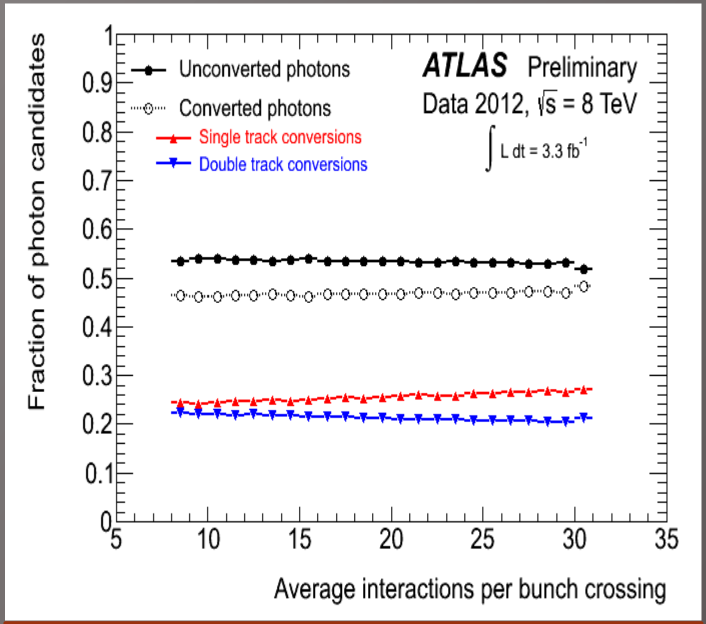
Electromagnetic Calorimetry
- Liquid Argon+Lead
- Stable response
- Hermetic in phi
- Longitudinaly segmented in 3 layers

Make use of the fine granularity of the first calorimetric layer.



Opening angle of the two photons of a π^0 of P_T=40GeV is ≥0.007, to be compared with strip size=0.003

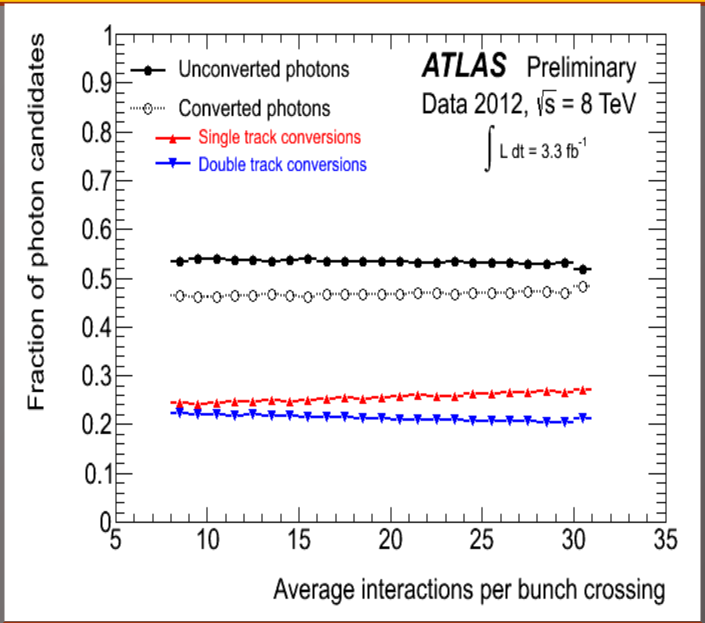
H->γγ : photon performances



~55% converted photons

H->γγ : photon performances

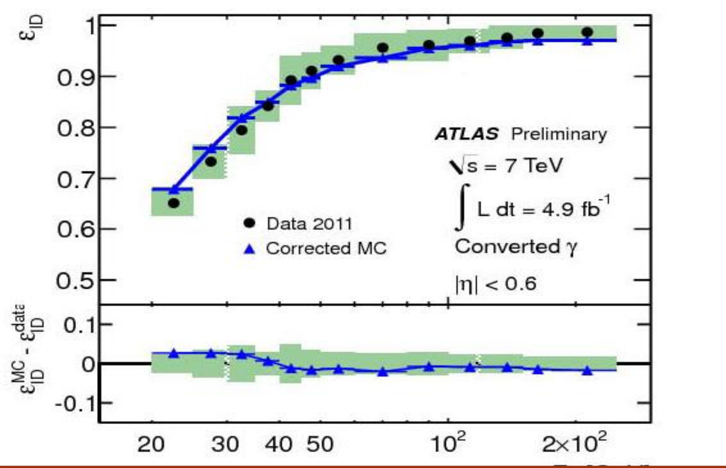
➔*Improved (wrt 2011) photon reconstruction robust against pileup, for both unconverted and converted (~45% of photons)*



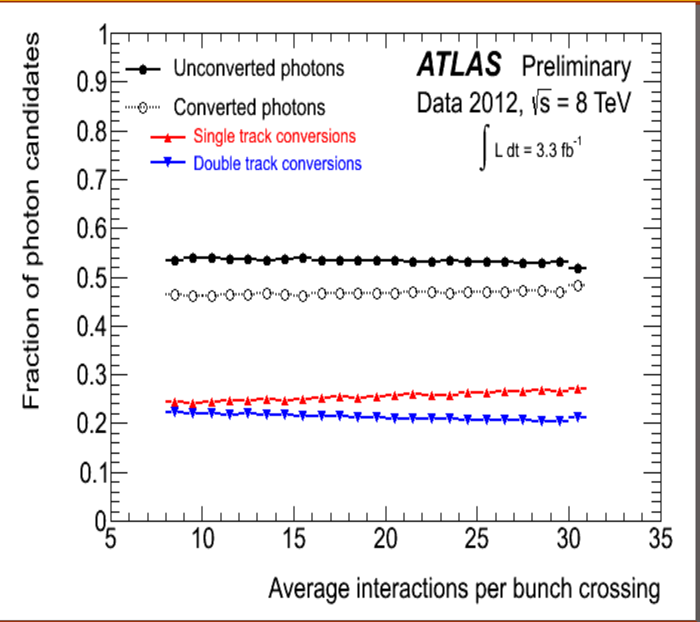
~55% converted photons

H->γγ : photon performances

➔*Improved (wrt 2011) photon reconstruction robust against pileup, for both unconverted and converted (~45% of photons)*



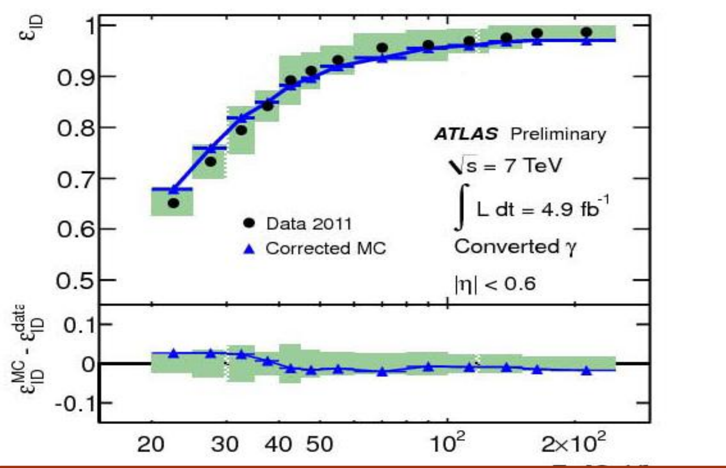
Photon Id efficiency vs E_T
(known to 5%- dominant uncertainty 10% on signal yield)



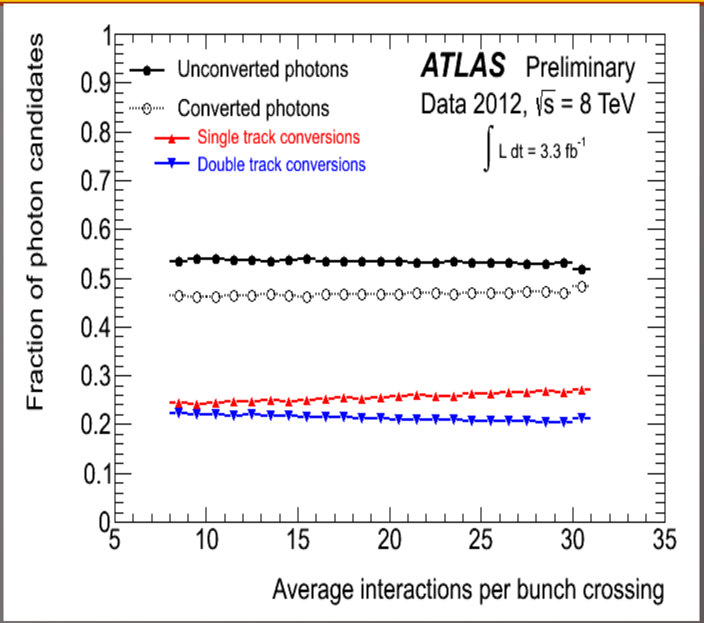
~55% converted photons

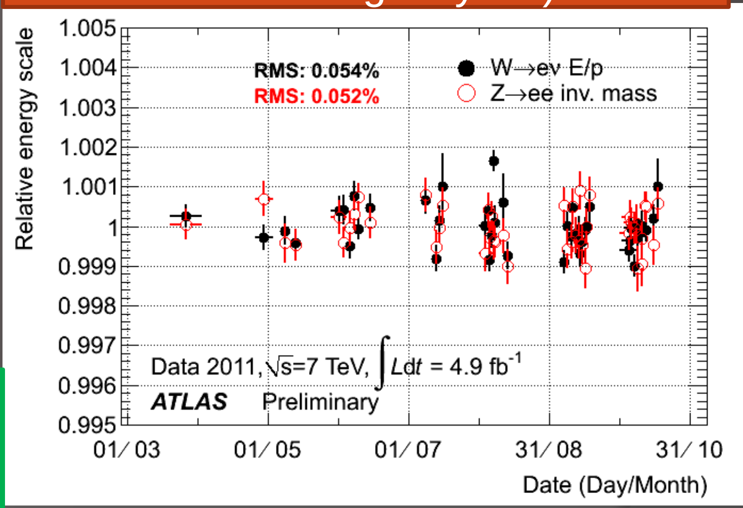
H->γγ : photon performances

➔*Improved (wrt 2011) photon reconstruction robust against pileup, for both unconverted and converted (~45% of photons)*



Photon Id efficiency vs E_T
(known to 5%- dominant uncertainty 10% on signal yield)



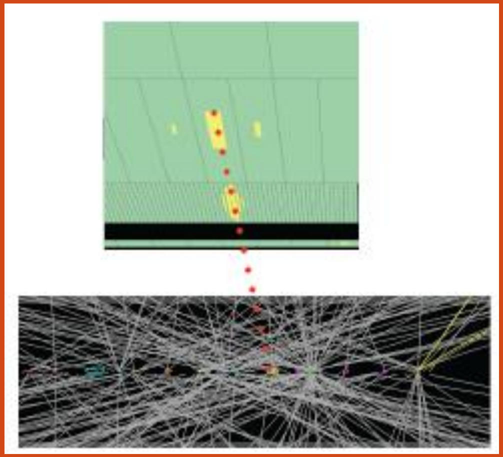


Energy scale known to 0.3%
Energy stability/time better than 0.1%

Diphoton mass spectra

$M^2_{\gamma\gamma} = 2\ E1E2\ (1\text{-}\cos\theta)$

→Energies from Calo
→Photon direction from Calo (thanks to the 3-layer segmentation)

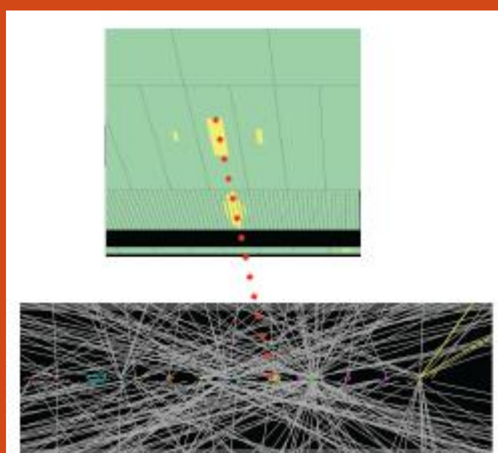


Vertex resolution ~ 1.5cm

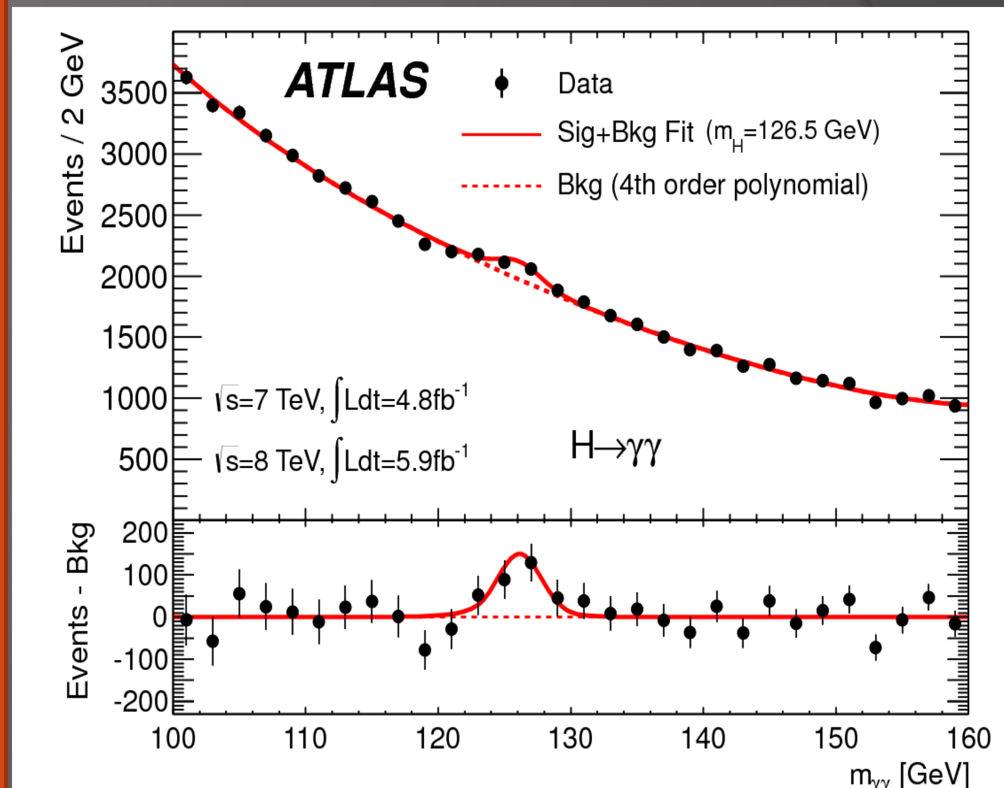
Diphoton mass spectra

$M^2_{\gamma\gamma} = 2\ E1E2\ (1\text{-}\cos\theta)$

→Energies from Calo
→Photon direction from Calo (thanks to the 3-layer segmentation)



Vertex resolution ~ 1.5cm

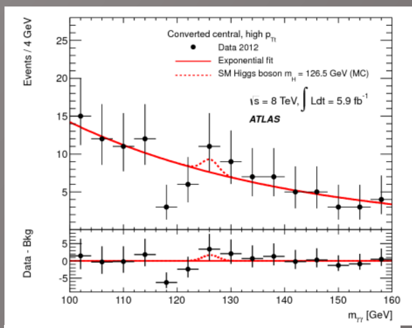


All diphotons, inclusive background Fit +signal

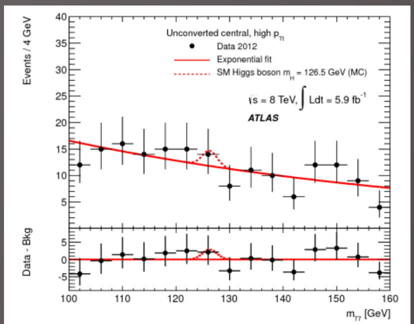
Diphoton mass spectra

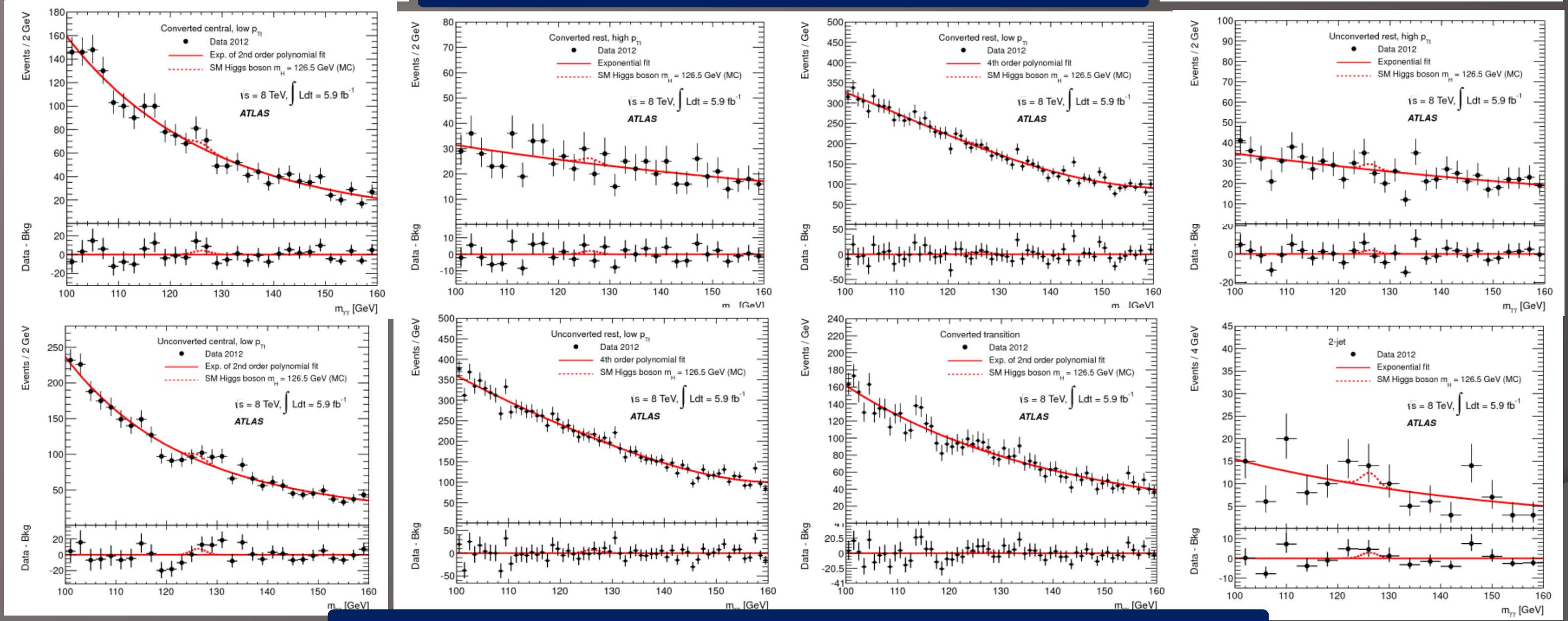
To enhance sensitivity
Divide data in 10 categories
following the S/B, resolution,
$P_T(\gamma\gamma)$, Converted/Uncoverted,
pseudorapity, and VBF

Diphoton mass spectra



To enhance sensitivity
Divide data in 10 categories
following the S/B, resolution,
$P_T(\gamma\gamma)$, Converted/Uncoverted,
pseudorapity, and VBF

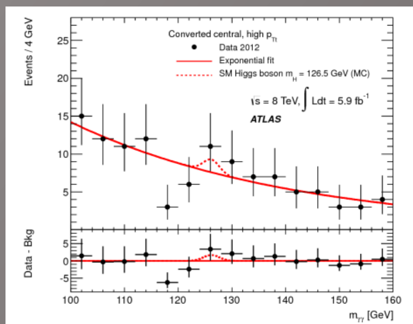


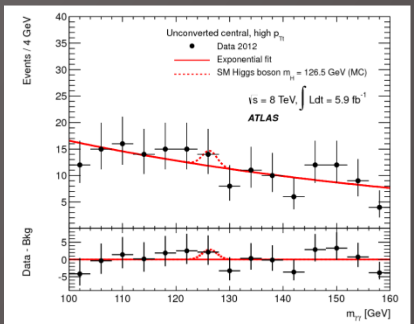


10 categories, data at $\sqrt{s}$ = 8 TeV

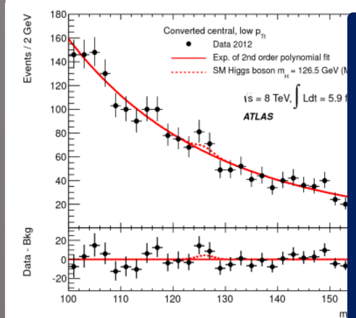
Diphoton mass spectra

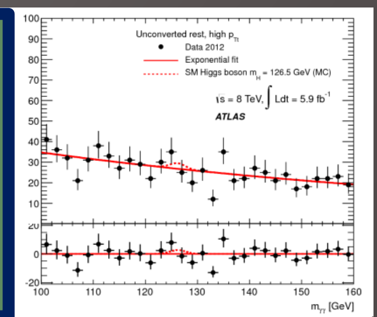
To enhance sensitivity
Divide data in 10 categories
following the S/B, resolution,
$P_T(\gamma\gamma)$, Converted/Uncoverted,
pseudorapity, and VBF

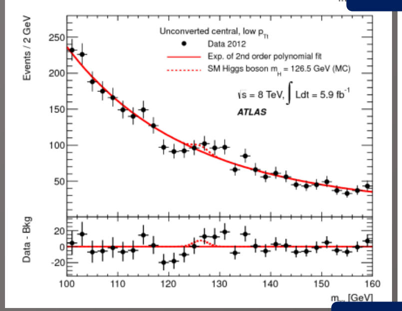


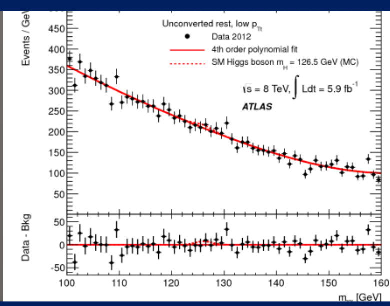


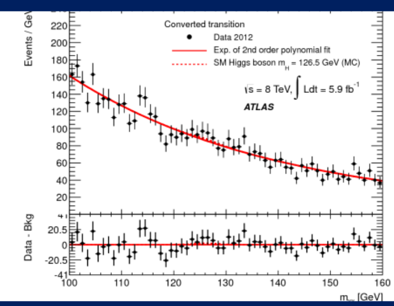
In each category : Fit the M(γγ) by a
background model chosen to ensure
minimal bias and a Crystal-Ball
+Gaussian for the signal

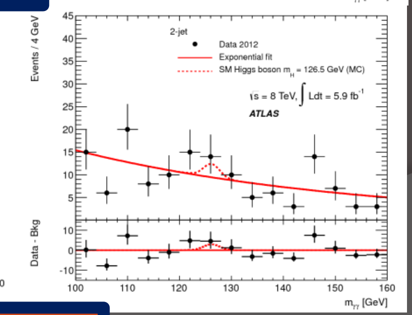






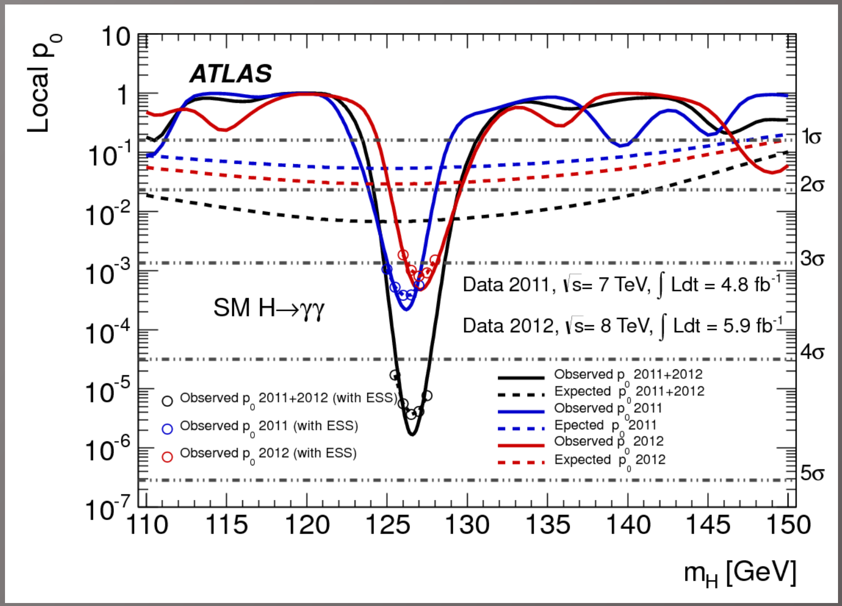






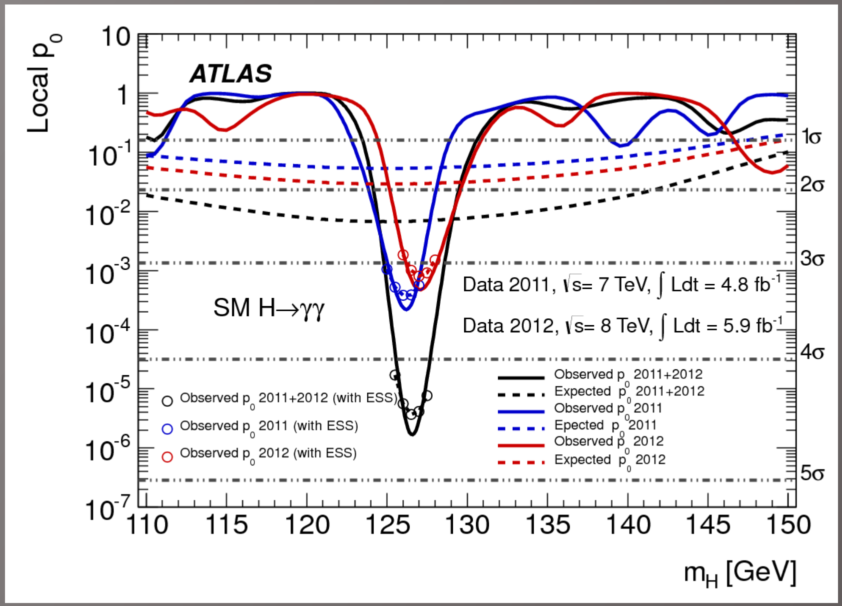
10 categories, data at $\sqrt{s}$ = 8 TeV

H-> γγ : Results



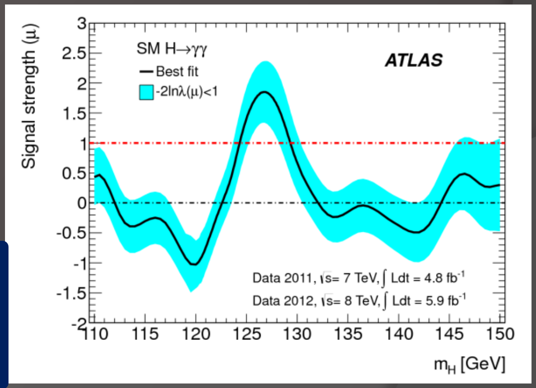
Maximum deviation at 126.5GeV
Local significance 4.5σ

H-> γγ : Results

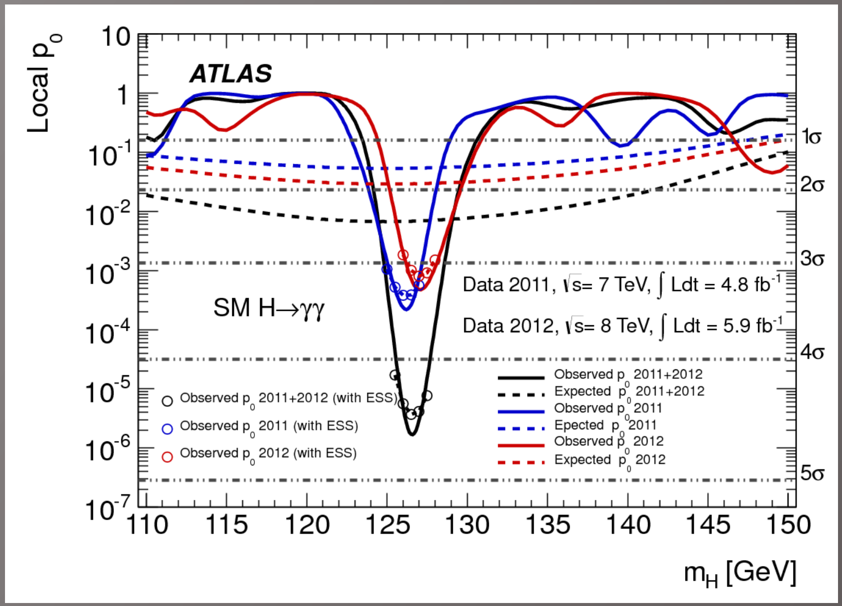


Maximum deviation at 126.5GeV
Local significance 4.5σ

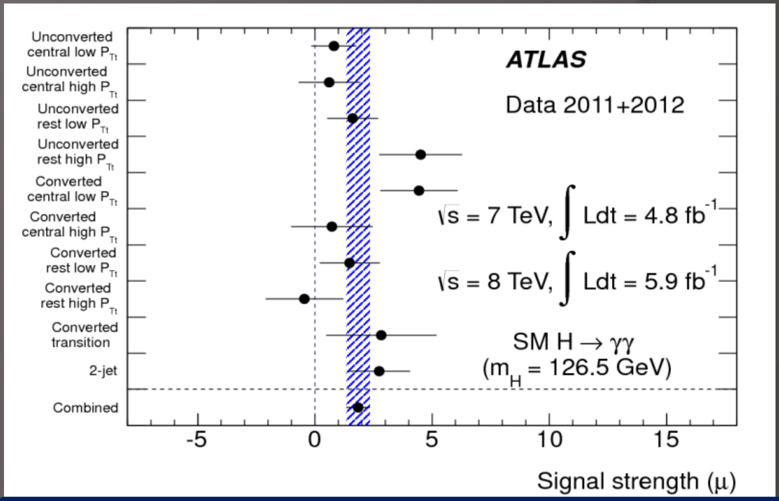
$\mu = 1.8 \pm 0.5$



H-> γγ : Results

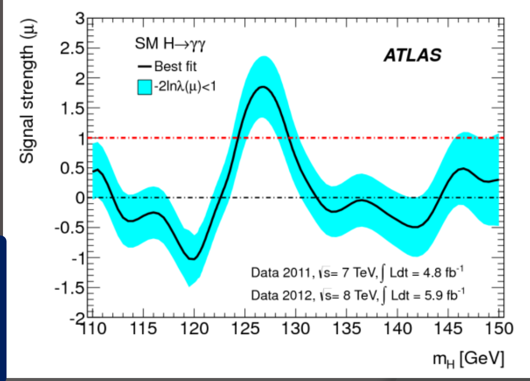


Maximum deviation at 126.5GeV
Local significance 4.5σ



Excess consistent in all categories

μ = 1.8±0.5



H->ZZ*->4l : the golden channel

→Small background

→Clean signature

H->ZZ*->4l : the golden channel

→Small background
→Clean signature

Cut based lepton selection
Require two same flavour and opposite sign lepton pairs.

The closest to M_Z mass pair =>M_{12}
The second mass pair => M_{34}

H->ZZ*->4l : the golden channel

→Small background
→Clean signature

For low M_H mass, both Z^0s may be often virtual

After 2011, optimize the kinematic selection to increase acceptance for low M_H

P_T>20,15,10,7(6) GeV
50< M_{12}<106 GeV

Cut based lepton selection
Require two same flavour and opposite sign lepton pairs.

The closest to M_Z mass pair =>M_{12}
The second mass pair => M_{34}

H->ZZ*->4l : the golden channel

→Small background
→Clean signature

For low M_H mass, both Z^0s may be often virtual

After 2011, optimize the kinematic selection to increase acceptance for low M_H

P_T>20,15,10,7(6) GeV
50< M_{12}<106 GeV

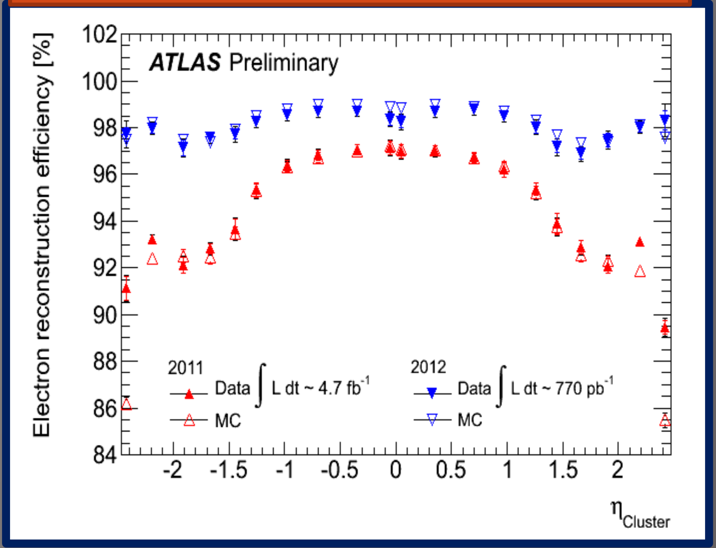
Cut based lepton selection
Require two same flavour and opposite sign lepton pairs.

The closest to M_Z mass pair =>M_{12}
The second mass pair => M_{34}

Small rate
σBr ~4pb at √s=7 TeV
Requires high lepton acceptance , in particular at low E_T

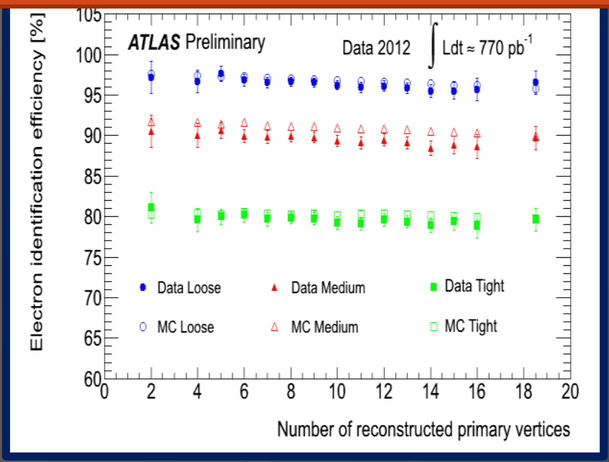
H->4l : Improvements in 2012

New electron reconstruction with brem recovery



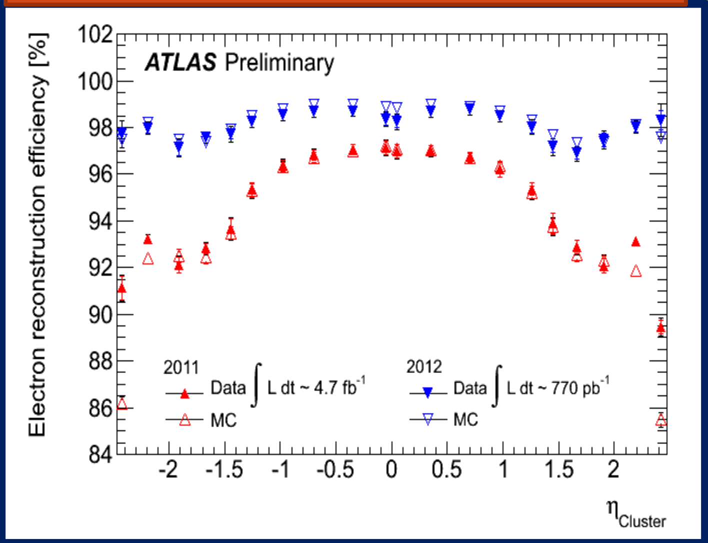
electrons

New pileup-robust identification

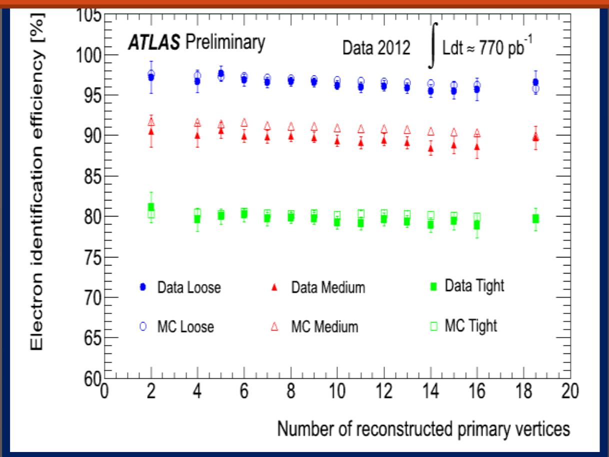


H->4l : Improvements in 2012

New electron reconstruction with brem recovery



New pileup-robust identification

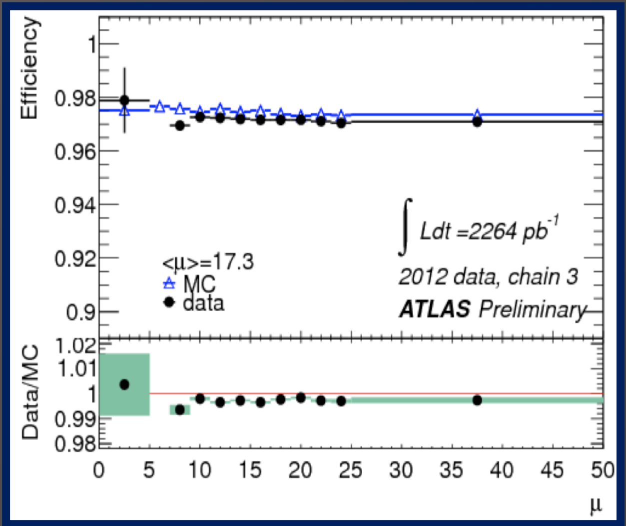


electrons

Extended coverage in muon reconstruction

➔2.5<η<2.7 Muon standalone
➔|η|<0.1 Track+Calo

muons



Constraint on Invariant Mass

Higgs natural width ~3MeV (MH=125GeV)
M4l : final discriminant variable→ resolution crucial for sensitivity

Constraint on Invariant Mass

Higgs natural width ~3MeV (MH=125GeV)
M4l : final discriminant variable→ resolution crucial for sensitivity

Correct M_{12} applying Z-mass constraint using the event uncertainties .

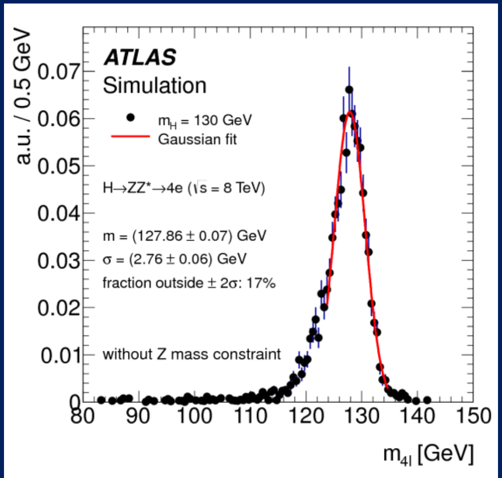
Constraint on Invariant Mass

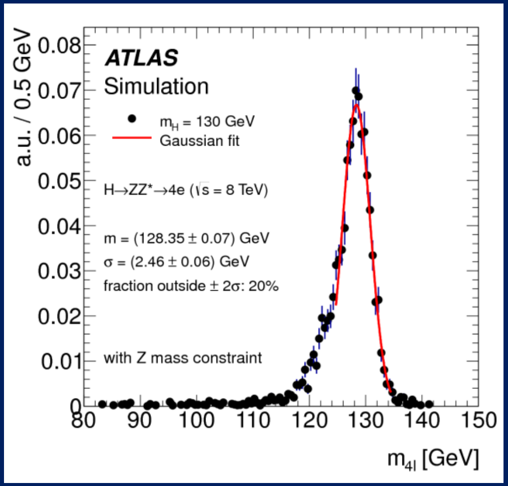
Higgs natural width ~3MeV (MH=125GeV)
M4l : final discriminant variable➔ resolution crucial for sensitivity

Correct M_{12} applying Z-mass constraint using the event uncertainties .

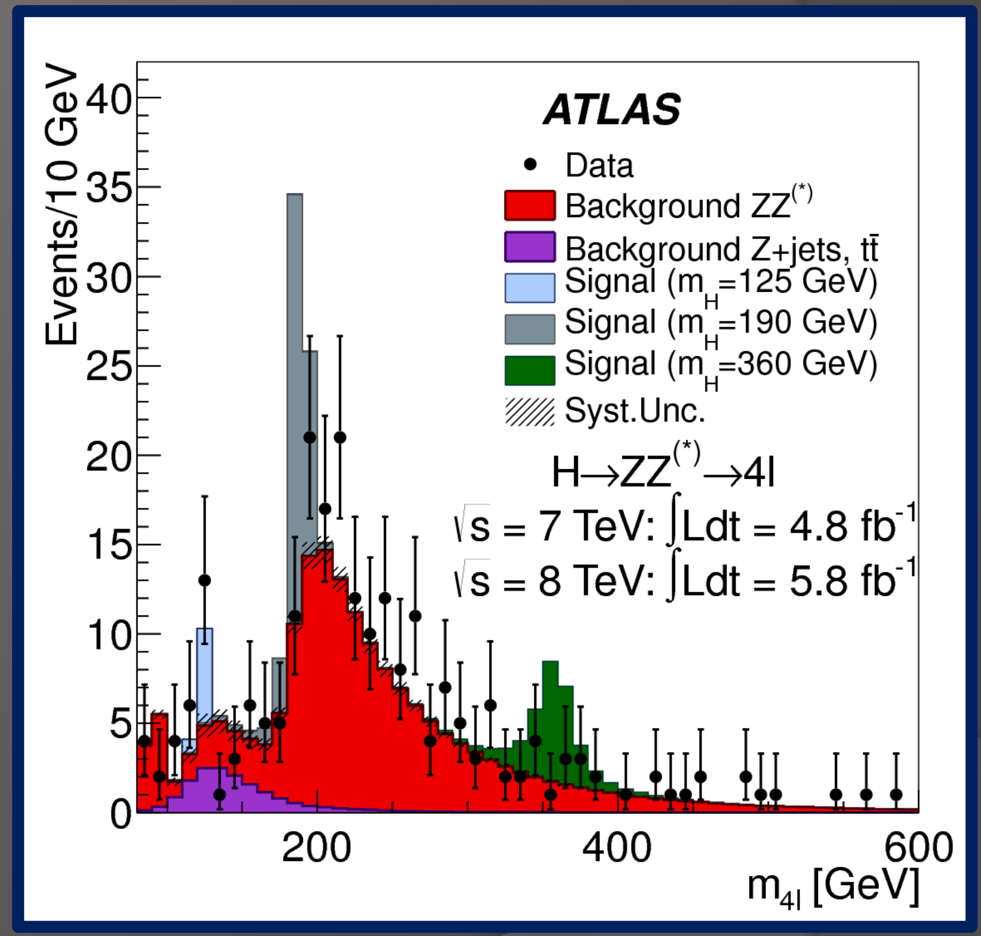
Recover some energy losses from radiation.

Resolution improves from 1.6-2.1% to 1.3-1.9%



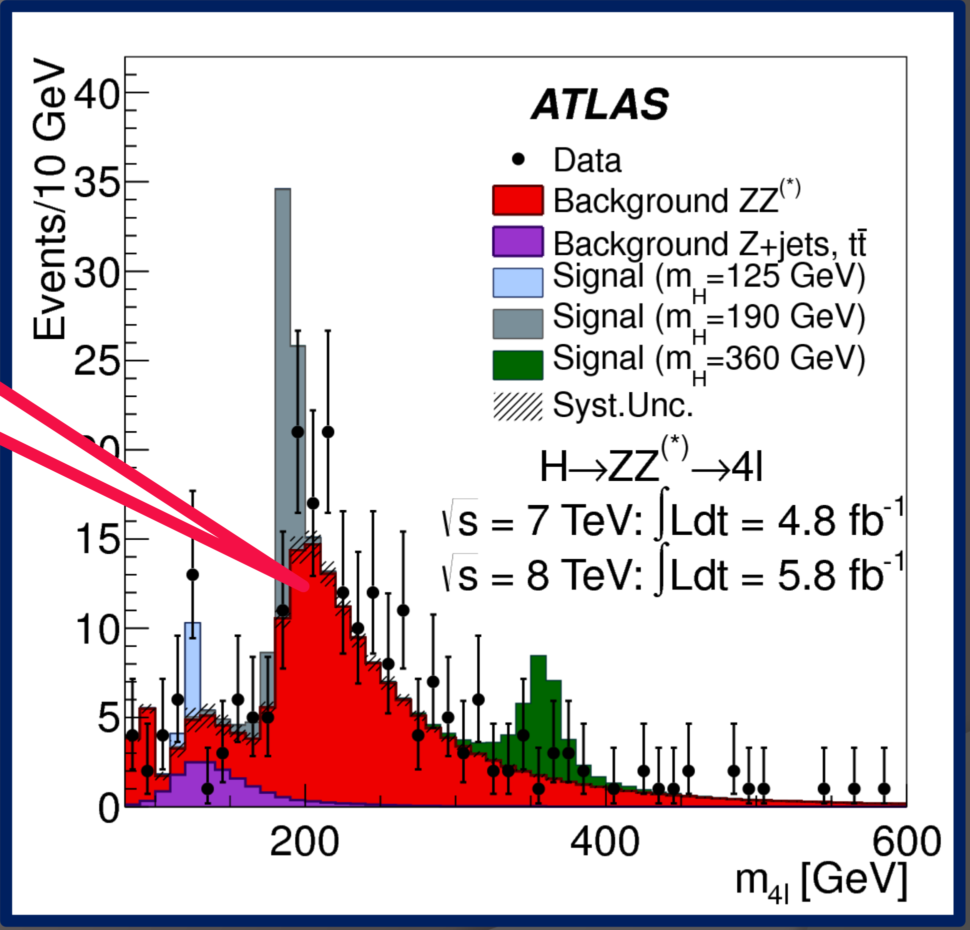


Background processes



Background processes

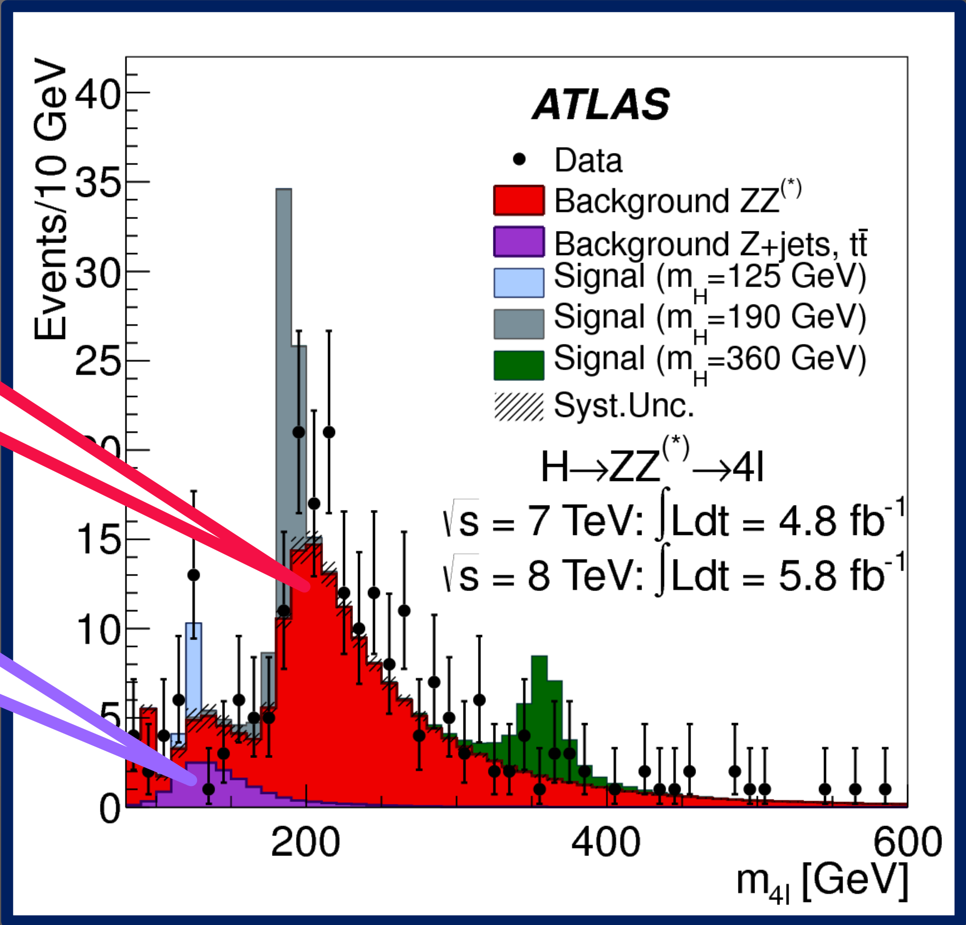
Irreducible : pp->ZZ*
Shape from MC simulation
Scaled to luminosity
Non resonant spectrum



Background processes

Irreducible : pp->ZZ*
Shape from MC simulation
Scaled to luminosity
Non resonnant spectrum

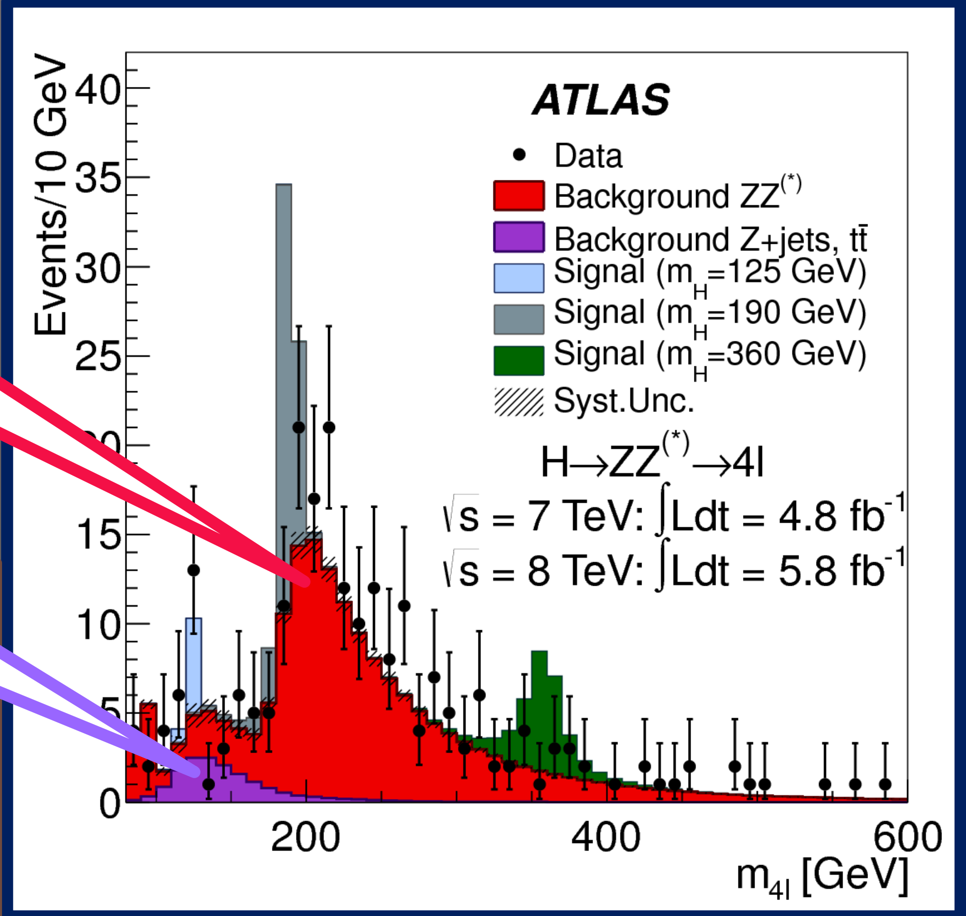
Reducible : Z+jets, ttbar→4l
Sizeable at low 4l invariant mass
Reduced by isolation and impact parameter criteria



Background processes

Irreducible : pp->ZZ*
Shape from MC simulation
Scaled to luminosity
Non resonnant spectrum

Reducible : Z+jets, ttbar→4l
Sizeable at low 4l invariant mass
Reduced by isolation and impact parameter criteria



➔Reducible background depends the flavour of the subleading pair leptons

➔From data driven methods:
Study in enriched samples and then extrapolate to the signal region

➔Several methods allowing cross-checks

Study of Z+ee (4e ,2μ2e) bacgkround

Z+XX control region → No isolation, no impact parameter

Study of Z+ee (4e ,2μ2e) bacgkround

Z+XX control region ➔No isolation, no impact parameter

X = misId jets « F»
X = electron from conversions « C »
X = electron from heavy flavors « E »

Study of Z+ee (4e ,2μ2e) bacgkround

Z+XX control region → No isolation, no impact parameter

X = misId jets « F»
X = electron from conversions « C »
X = electron from heavy flavors « E »

Classify as E,C or F based on
→ E(S1)/E,
→ S2 containtement in ϕ.
→ TRThits
→ intermost pixel hits

Study of Z+ee (4e ,2μ2e) bacgkround

Z+XX control region → No isolation, no impact parameter

X = misId jets « F»
X = electron from conversions « C »
X = electron from heavy flavors « E »

Classify as E,C or F based on
→ E(S1)/E,
→ S2 containtement in ϕ.
→ TRThits
→ intermost pixel hits

9 categories for subleading electron candidates

CC, CF, CE, EF, EE,FF,EC, FC ,FE (pt ordered)

Study of Z+ee (4e ,2μ2e) bacgkround

Z+XX control region → No isolation, no impact parameter

X = misId jets « F»
X = electron from conversions « C »
X = electron from heavy flavors « E »

Classify as E,C or F based on
→E(S1)/E,
→S2 containtement in ϕ.
→TRThits
→intermost pixel hits

9 categories for subleading electron candidates

CC, CF, CE, EF, EE,FF,EC, FC ,FE (pt ordered)

- Data composition from MC

TRUTH/ RECO	EE	EF	EC	....
EE				
EF				
EC				
….				

Study of Z+ee (4e ,2μ2e) bacgkround

Z+XX control region →No isolation, no impact parameter

X = misId jets « F»
X = electron from conversions « C »
X = electron from heavy flavors « E »

- Data composition from MC

TRUTH/ RECO	EE	EF	EC	….
EE				
EF				
EC				
….				

Classify as E,C or F based on
→E(S1)/E,
→S2 containtement in ϕ.
→TRThits
→intermost pixel hits

9 categories for subleading electron candidates

CC, CF, CE, EF, EE,FF,EC, FC ,FE (pt ordered)

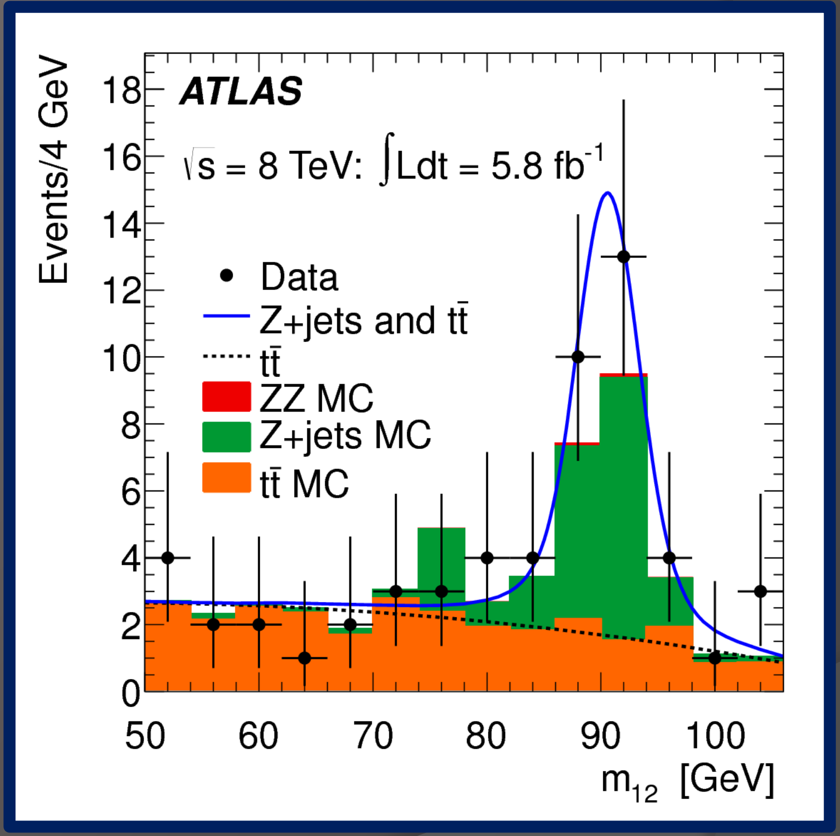
Extrapolate from control to signal region using MC

Study of Z+μμ (4μ, 2e2μ) background

Dominant background: b decays .
Control region:
→No isolation on subleading muons
→At least one fails the impact parameter
➔This removes ZZ*
➔This enhances Z+jets and ttbar

Study of Z+μμ (4μ, 2e2μ) background

Dominant background: b decays .
Control region:
→No isolation on subleading muons
→At least one fails the impact parameter
➔This removes ZZ*
➔This enhances Z+jets and ttbar



Estimation of the background yields in control region:

→Fitting the M_{12} spectrum
Crystal-Ball x Breit-Wigner + Chebychev
➔ Extrapolate to the signal region using MC-based efficiency

Summary of background estimates

$\sqrt{s}$ = 7 TeV

Method	Estimated number of events
4μ	
m_{12} fit: Z + jets contribution	$0.25\pm 0.10 \pm 0.08^{\dagger}$
m_{12} fit: $t\bar{t}$ contribution	$0.022\pm 0.010\pm 0.011^{\dagger}$
$t\bar{t}$ from $e^{\pm}\mu^{\mp} + \mu^{\pm}\mu^{\mp}$	$0.025\pm 0.009\pm 0.014$
$2e2\mu$	
m_{12} fit: Z + jets contribution	$0.20\pm 0.08 \pm 0.06^{\dagger}$
m_{12} fit: $t\bar{t}$ contribution	$0.020\pm 0.009\pm 0.011^{\dagger}$
$t\bar{t}$ from $e^{\pm}\mu^{\mp} + \mu^{\pm}\mu^{\mp}$	$0.024\pm 0.009\pm 0.014$
$2\mu 2e$	
$\ell\ell + e^{\pm}e^{\mp}$	$2.6\pm 0.4 \pm 0.4^{\dagger}$
$\ell\ell + e^{\pm}e^{\pm}$	$3.7\pm 0.9 \pm 0.6$
$3\ell + \ell$ (same-sign)	$2.0\pm 0.5 \pm 0.3$
$4e$	
$\ell\ell + e^{\pm}e^{\mp}$	$3.1\pm 0.6 \pm 0.5^{\dagger}$
$\ell\ell + e^{\pm}e^{\pm}$	$3.2\pm 0.6 \pm 0.5$
$3\ell + \ell$ (same-sign)	$2.2\pm 0.5 \pm 0.3$

$\sqrt{s}$ = 8 TeV

Method	Estimated number of events
4μ	
m_{12} fit: Z + jets contribution	$0.51\pm 0.13 \pm 0.16^{\dagger}$
m_{12} fit: $t\bar{t}$ contribution	$0.044\pm 0.015\pm 0.015^{\dagger}$
$t\bar{t}$ from $e^{\pm}\mu^{\mp} + \mu^{\pm}\mu^{\mp}$	$0.058\pm 0.015\pm 0.019$
$2e2\mu$	
m_{12} fit: Z + jets contribution	$0.41\pm 0.10 \pm 0.13^{\dagger}$
m_{12} fit: $t\bar{t}$ contribution	$0.040\pm 0.013\pm 0.013^{\dagger}$
$t\bar{t}$ from $e^{\pm}\mu^{\mp} + \mu^{\pm}\mu^{\mp}$	$0.051\pm 0.013\pm 0.017$
$2\mu 2e$	
$\ell\ell + e^{\pm}e^{\mp}$	$4.9\pm 0.8 \pm 0.7^{\dagger}$
$\ell\ell + e^{\pm}e^{\pm}$	$4.1\pm 0.6 \pm 0.8$
$3\ell + \ell$ (same-sign)	$3.5\pm 0.5 \pm 0.5$
$4e$	
$\ell\ell + e^{\pm}e^{\mp}$	$3.9\pm 0.7 \pm 0.8^{\dagger}$
$\ell\ell + e^{\pm}e^{\pm}$	$3.1\pm 0.5 \pm 0.6$
$3\ell + \ell$ (same-sign)	$3.0\pm 0.4 \pm 0.4$

→Good agreement between methods
→Uncertainties ~20%-70%
→More background in electron sub-leading lepton channels

Summary of background estimates

$\sqrt{s}$ = 7 TeV

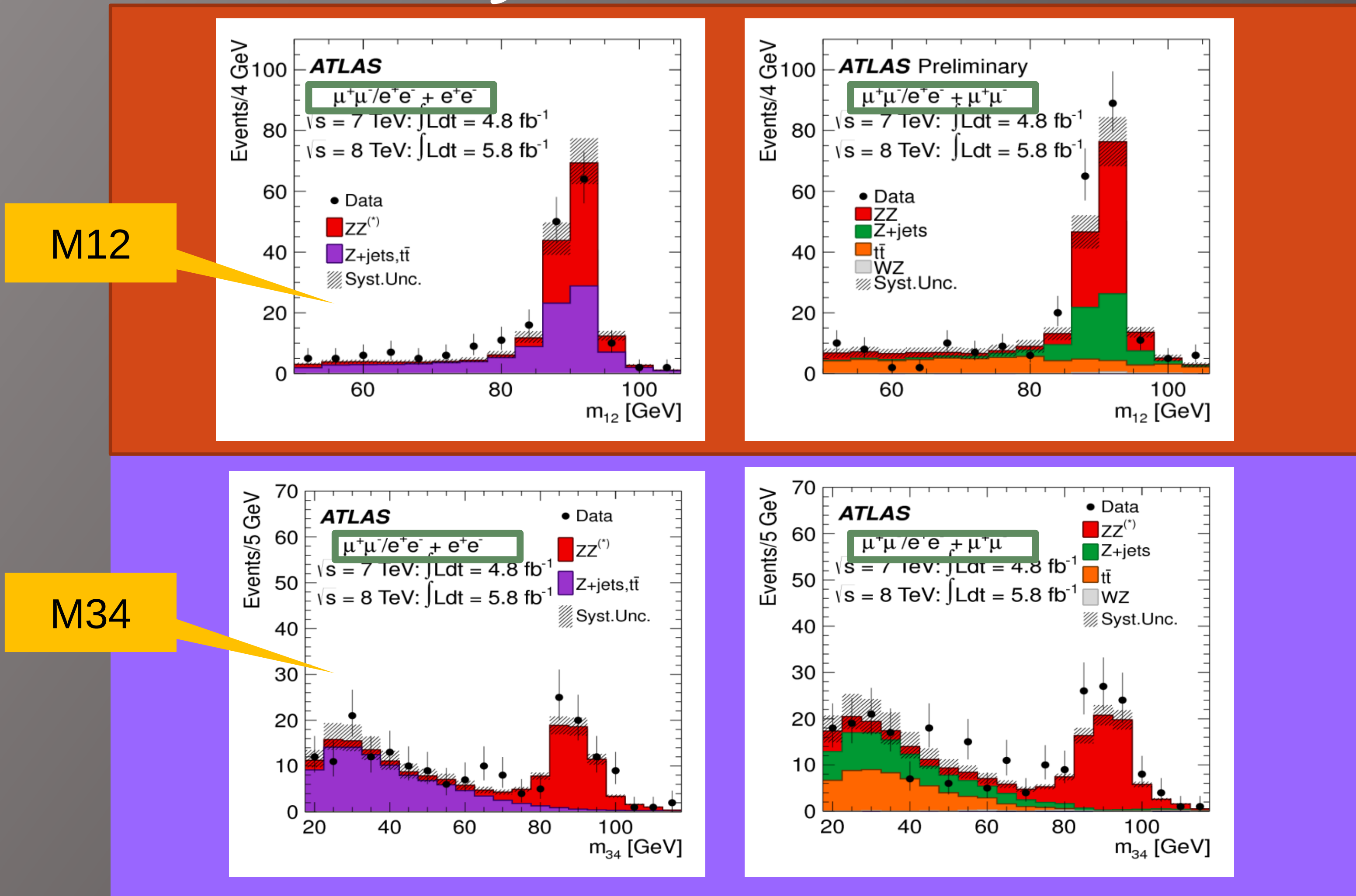
Method	Estimated number of events
4μ	
m_{12} fit: Z + jets contribution	$0.25\pm 0.10 \pm 0.08^{\dagger}$
m_{12} fit: $t\bar{t}$ contribution	$0.022\pm 0.010\pm 0.011^{\dagger}$
$t\bar{t}$ from $e^{\pm}\mu^{\mp} + \mu^{\pm}\mu^{\mp}$	$0.025\pm 0.009\pm 0.014$
$2e2\mu$	
m_{12} fit: Z + jets contribution	$0.20\pm 0.08 \pm 0.06^{\dagger}$
m_{12} fit: $t\bar{t}$ contribution	$0.020\pm 0.009\pm 0.011^{\dagger}$
$t\bar{t}$ from $e^{\pm}\mu^{\mp} + \mu^{\pm}\mu^{\mp}$	$0.024\pm 0.009\pm 0.014$
$2\mu 2e$	
$\ell\ell + e^{\pm}e^{\mp}$	$2.6\pm 0.4 \pm 0.4^{\dagger}$
$\ell\ell + e^{\pm}e^{\pm}$	$3.7\pm 0.9 \pm 0.6$
$3\ell + \ell$ (same-sign)	$2.0\pm 0.5 \pm 0.3$
$4e$	
$\ell\ell + e^{\pm}e^{\mp}$	$3.1\pm 0.6 \pm 0.5^{\dagger}$
$\ell\ell + e^{\pm}e^{\pm}$	$3.2\pm 0.6 \pm 0.5$
$3\ell + \ell$ (same-sign)	$2.2\pm 0.5 \pm 0.3$

$\sqrt{s}$ = 8 TeV

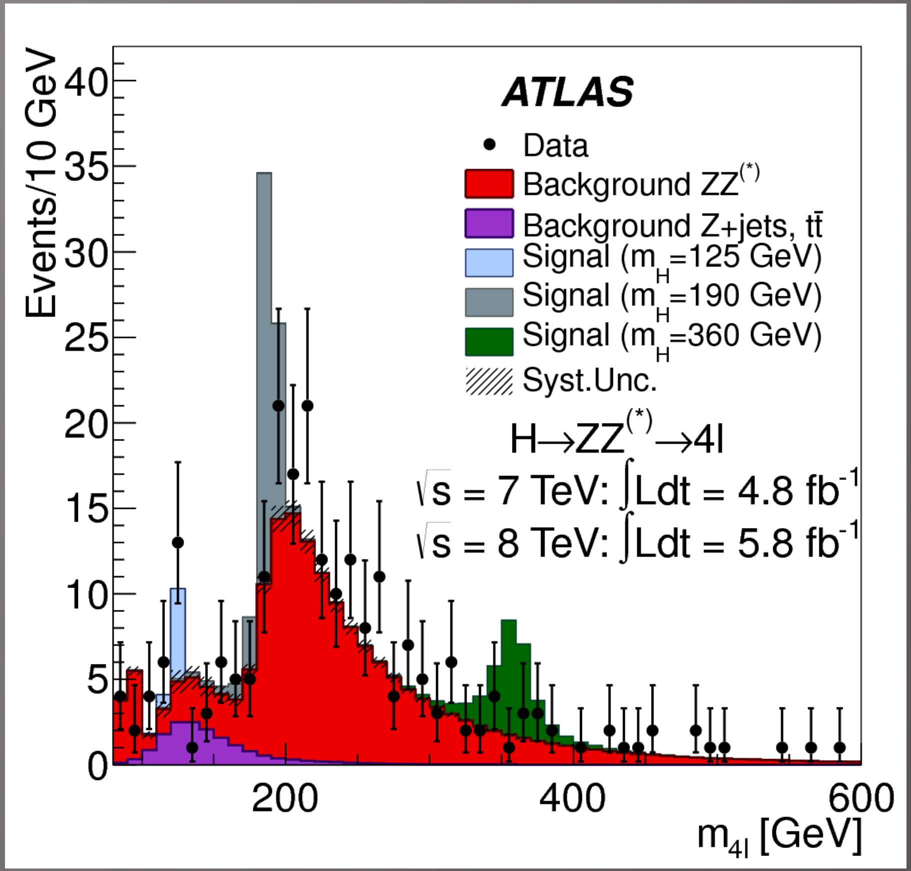
Method	Estimated number of events
4μ	
m_{12} fit: Z + jets contribution	$0.51\pm 0.13 \pm 0.16^{\dagger}$
m_{12} fit: $t\bar{t}$ contribution	$0.044\pm 0.015\pm 0.015^{\dagger}$
$t\bar{t}$ from $e^{\pm}\mu^{\mp} + \mu^{\pm}\mu^{\mp}$	$0.058\pm 0.015\pm 0.019$
$2e2\mu$	
m_{12} fit: Z + jets contribution	$0.41\pm 0.10 \pm 0.13^{\dagger}$
m_{12} fit: $t\bar{t}$ contribution	$0.040\pm 0.013\pm 0.013^{\dagger}$
$t\bar{t}$ from $e^{\pm}\mu^{\mp} + \mu^{\pm}\mu^{\mp}$	$0.051\pm 0.013\pm 0.017$
$2\mu 2e$	
$\ell\ell + e^{\pm}e^{\mp}$	$4.9\pm 0.8 \pm 0.7^{\dagger}$
$\ell\ell + e^{\pm}e^{\pm}$	$4.1\pm 0.6 \pm 0.8$
$3\ell + \ell$ (same-sign)	$3.5\pm 0.5 \pm 0.5$
$4e$	
$\ell\ell + e^{\pm}e^{\mp}$	$3.9\pm 0.7 \pm 0.8^{\dagger}$
$\ell\ell + e^{\pm}e^{\pm}$	$3.1\pm 0.5 \pm 0.6$
$3\ell + \ell$ (same-sign)	$3.0\pm 0.4 \pm 0.4$

→Good agreement between methods
→Uncertainties ~20%-70%
→More background in electron sub-leading lepton channels

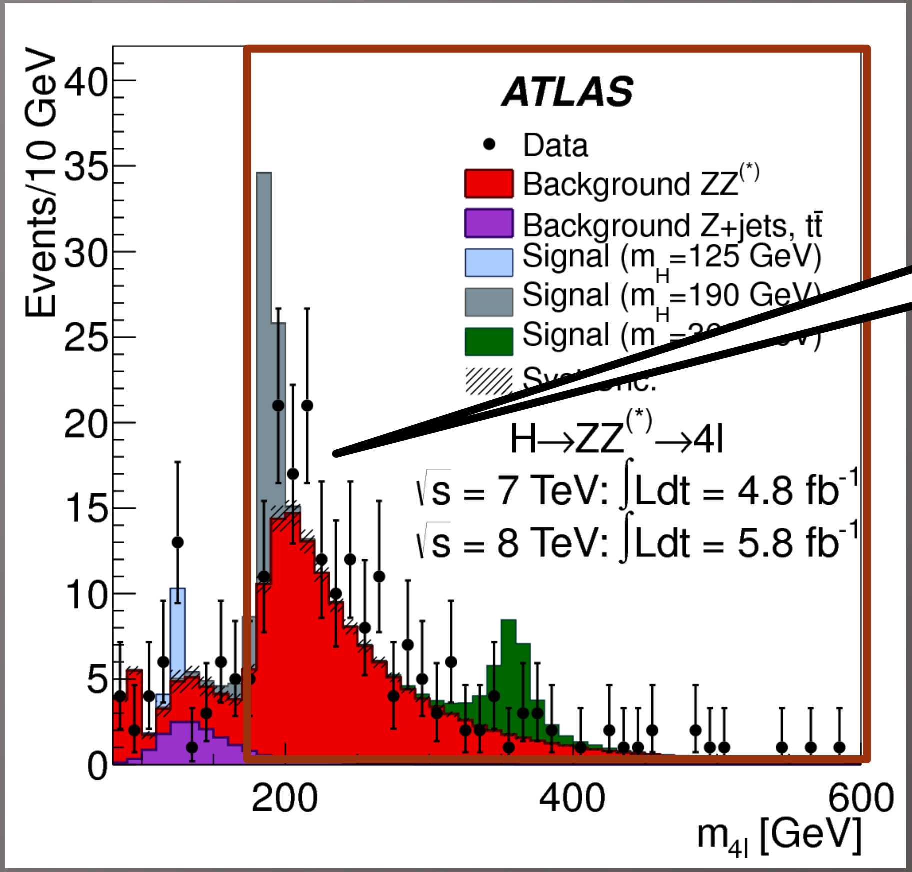
Data-MC agreement in control regions



The M4l distribution

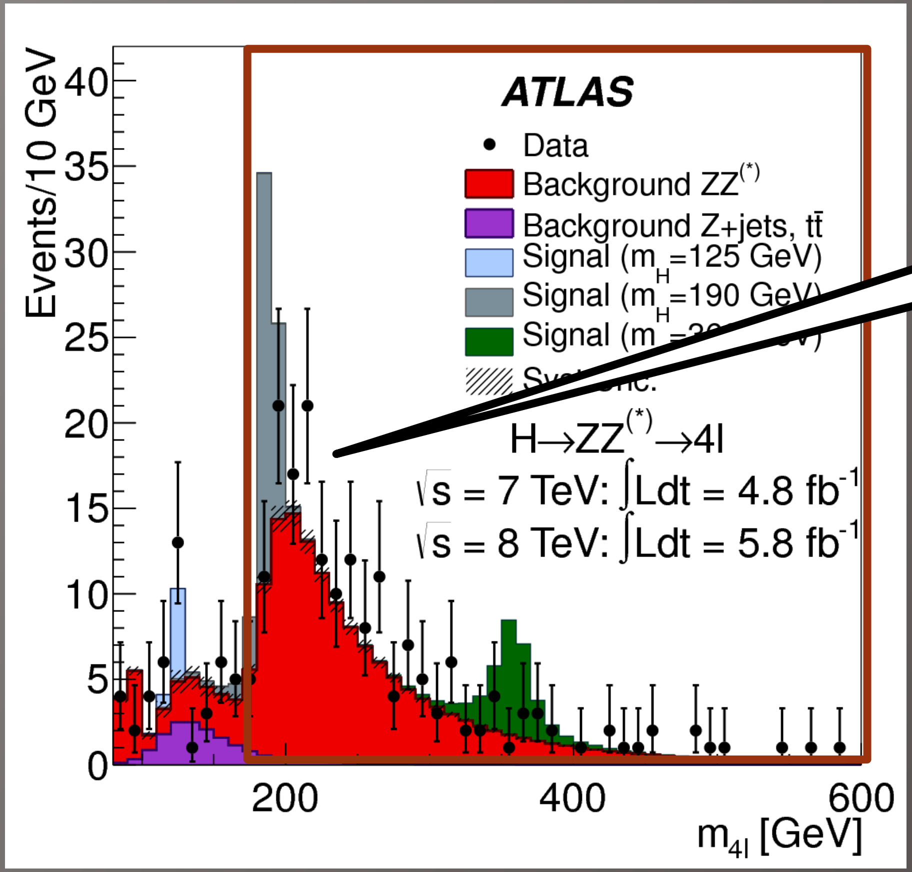


The M4l distribution



For M4l>160 GeV
147± 11 events
expected 191 (from pp->ZZ)

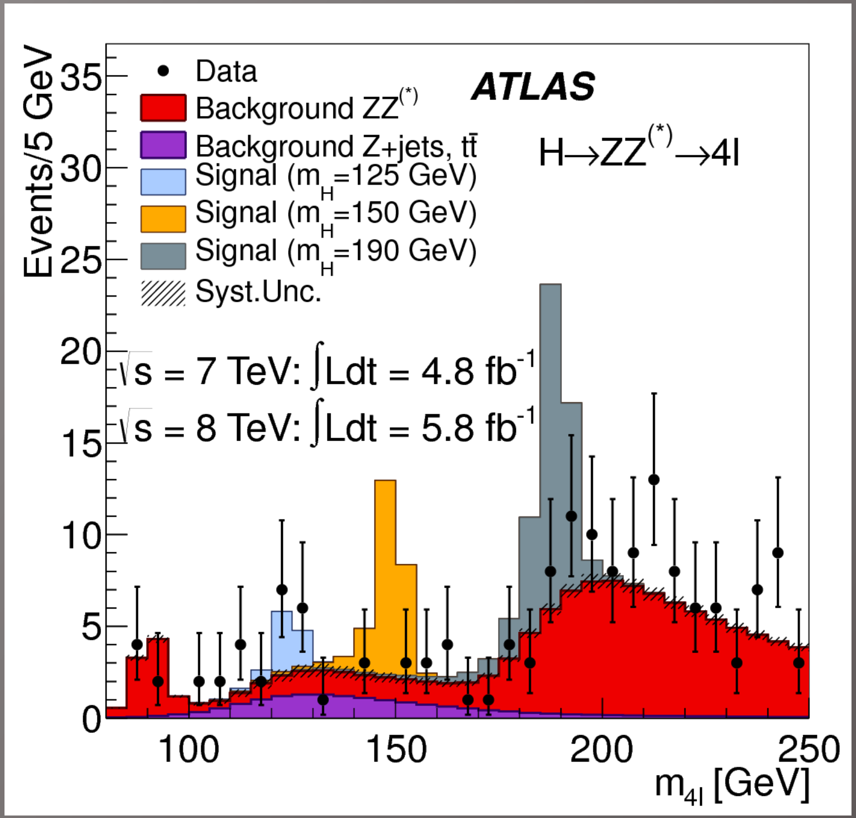
The M4l distribution



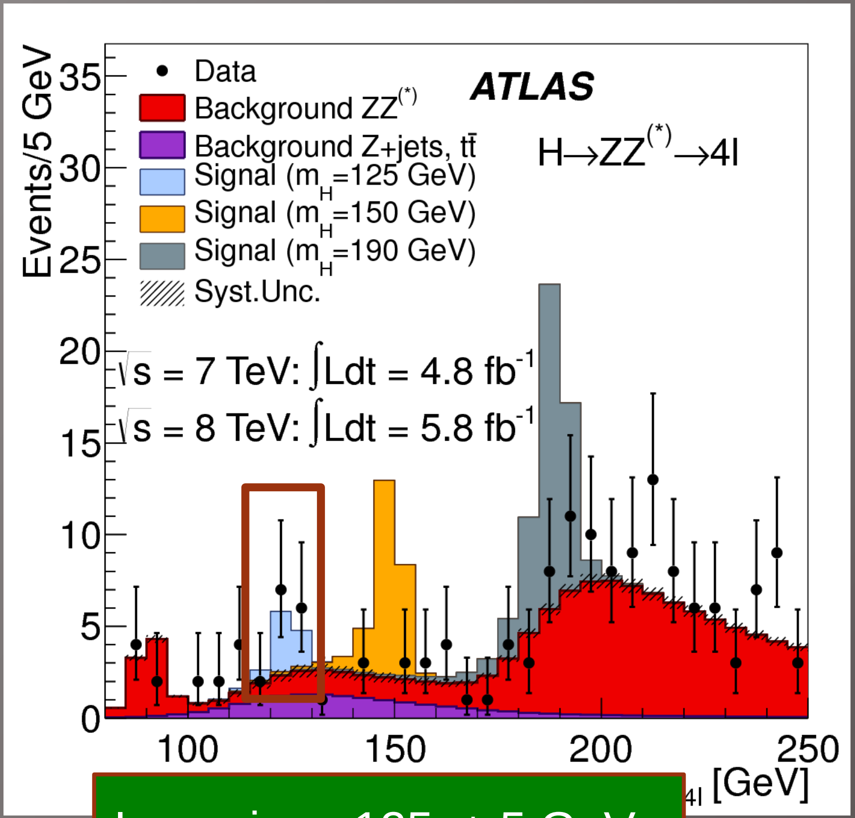
For M4l>160 GeV
Expected 147± 11 events
observed 191

In agreement with ZZ cross-section measurement
Measured = 9.3 ± 1.2 pb
SM (NLO) = 7.4 ± 0.4pb

The low M4l region



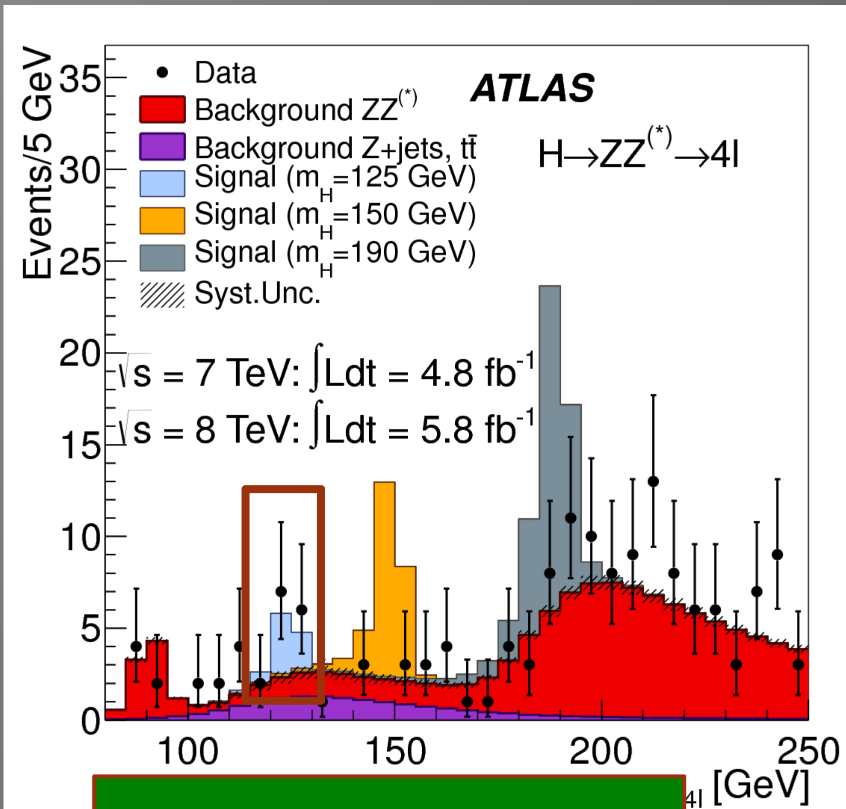
The low M4l region

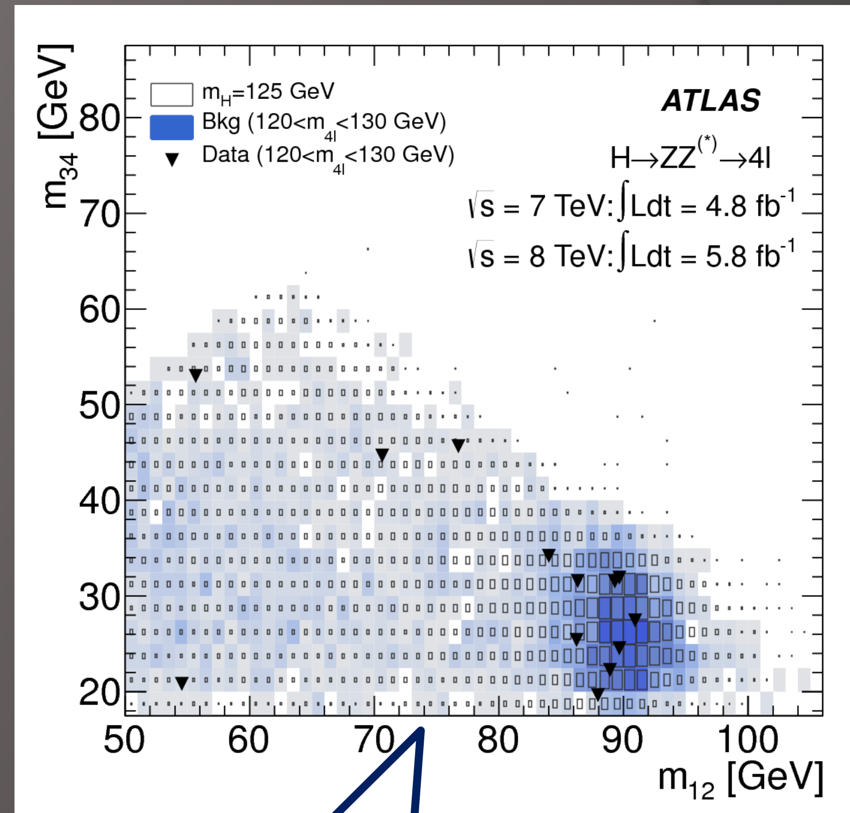


In region 125 ± 5 GeV

Observed	**13 events**
Background	5.1 ± 0.8 events
Signal M_H=125	5.3 ± 0.8 evemts

The low M4l region



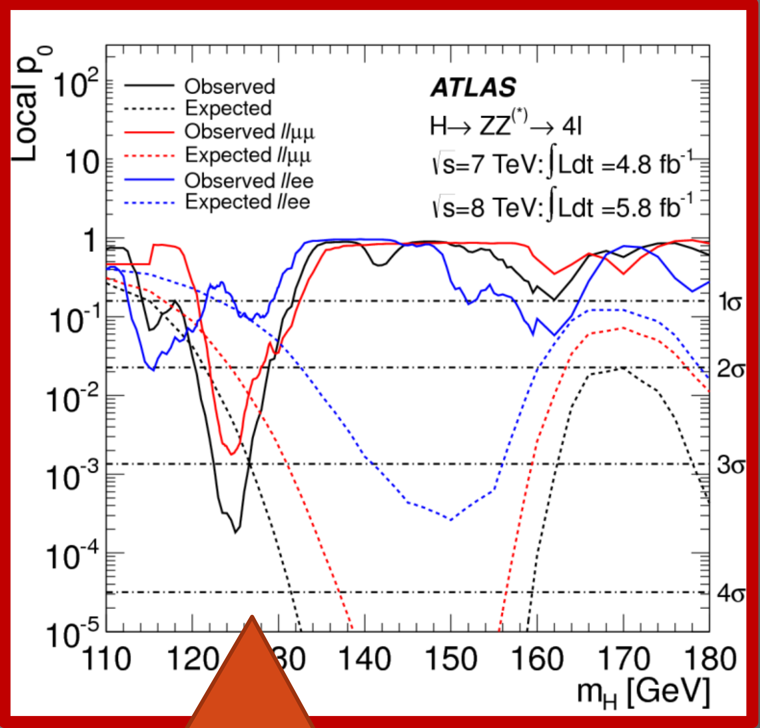


In region 125 ± 5 GeV

Observed	**13 events**
Background	5.1 ± 0.8 events
Signal M_H=125	5.3 ± 0.8 evemts

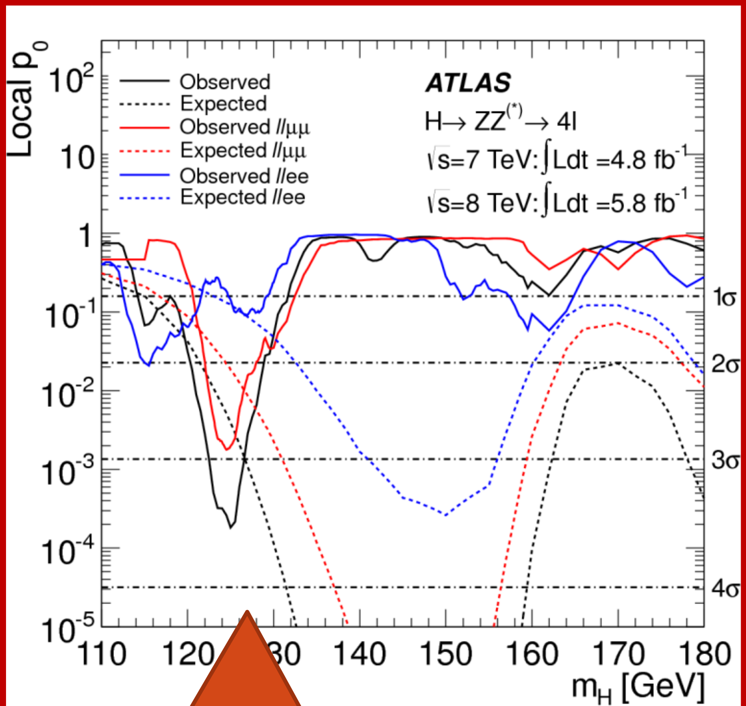
M_{12} vs M_{34}
For data, signal and background MC

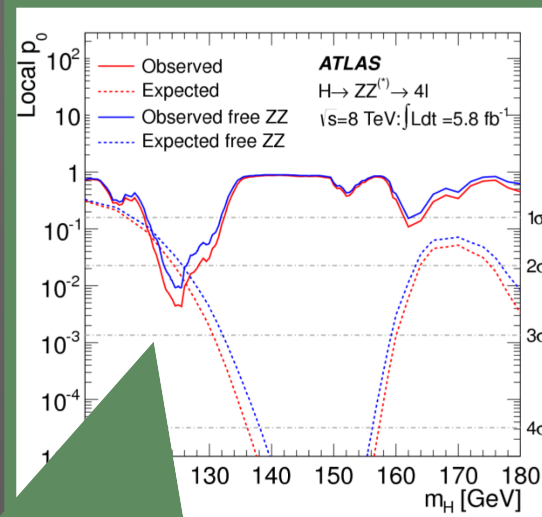
Some p0 plots for H->4l



Local p0 =0.0004➔ 3.4σ for M_H=125

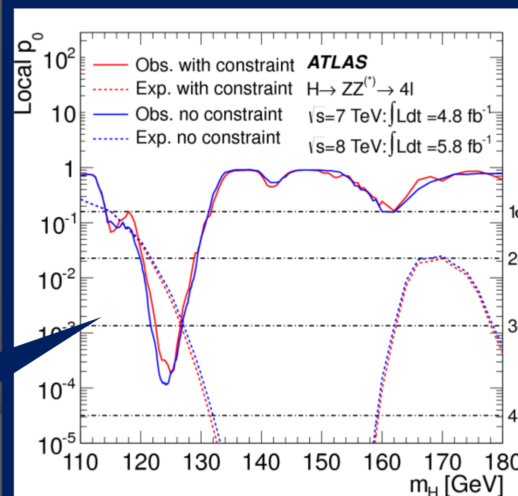
Some p0 plots for H->4l





Effect on p0 of ZZ* normalisation

Local p0 =0.0004➔ 3.4σ for M_H=125



Effect on p0 of M_{12} mass constraint

H->WW : the abundant

➔High production rate but poor mass resolution

H->WW : the abundant

➔High production rate but poor mass resolution

➔Signature: two opposite sign isolated leptons and missing Et

H->WW : the abundant

➔High production rate but poor mass resolution

➔Signature: two opposite sign isolated leptons and missing Et

➔2011 analysis: e+e-, eμ, μe, μμ

➔2012 analysis : result using only eμ+μe channels

Selection : Two OS isolated leptons

➔ Pt>20,15GeV, Etmis>25GeV

➔ Count jets with Et>25(30)GeV

H->WW : the abundant

➔High production rate but poor mass resolution

➔Signature: two opposite sign isolated leptons and missing Et

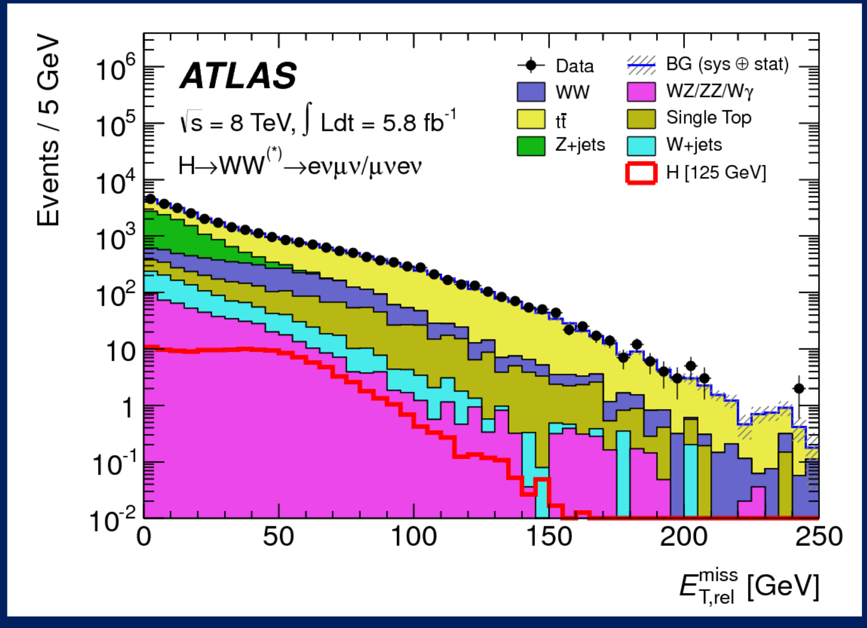
➔2011 analysis: e+e-, eμ, μe, μμ

➔2012 analysis : result using only eμ+μe channels

Selection : Two OS isolated leptons

➔ Pt>20,15GeV, Etmis>25GeV

➔ Count jets with Et>25(30)GeV



H->WW : the abundant

➔High production rate but poor mass resolution

➔Signature: two opposite sign isolated leptons and missing Et

➔2011 analysis: e+e-, eμ, μe, μμ

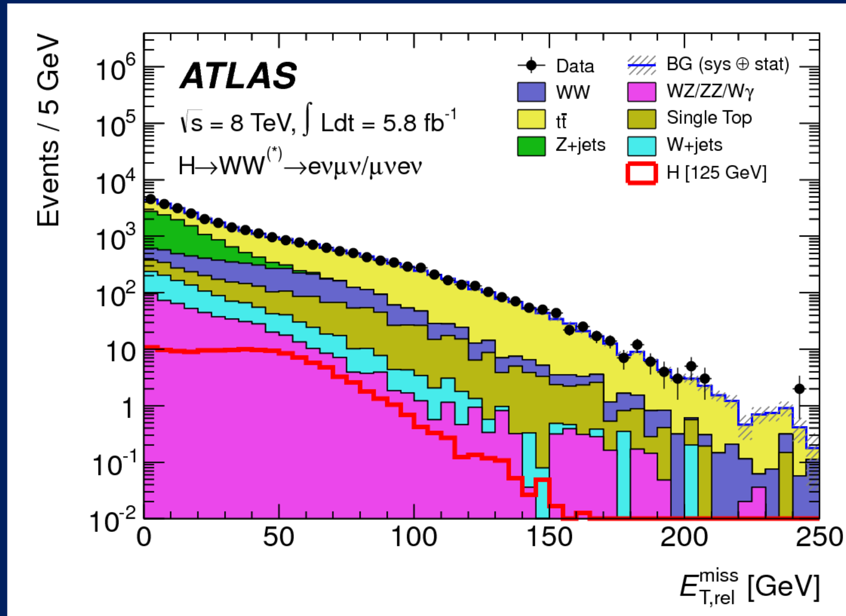
➔2012 analysis : result using only eμ+μe channels

Selection : Two OS isolated leptons

➔ Pt>20,15GeV, Etmis>25GeV

➔ Count jets with Et>25(30)GeV

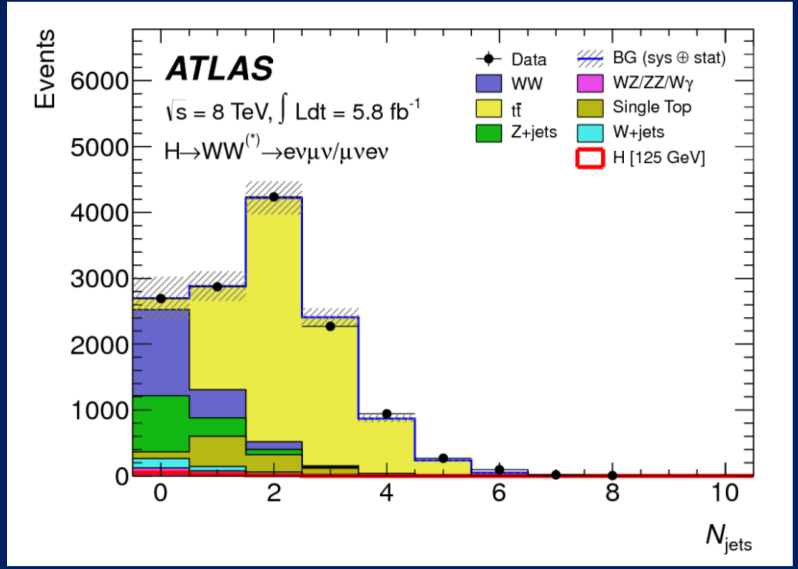
Backgrounds: pp->WW, Top, W+jets, Wɣ*/WZ*, Z*Z*



Study the background in Control Regions= enhance the background by inverting or relaxing relevant cuts

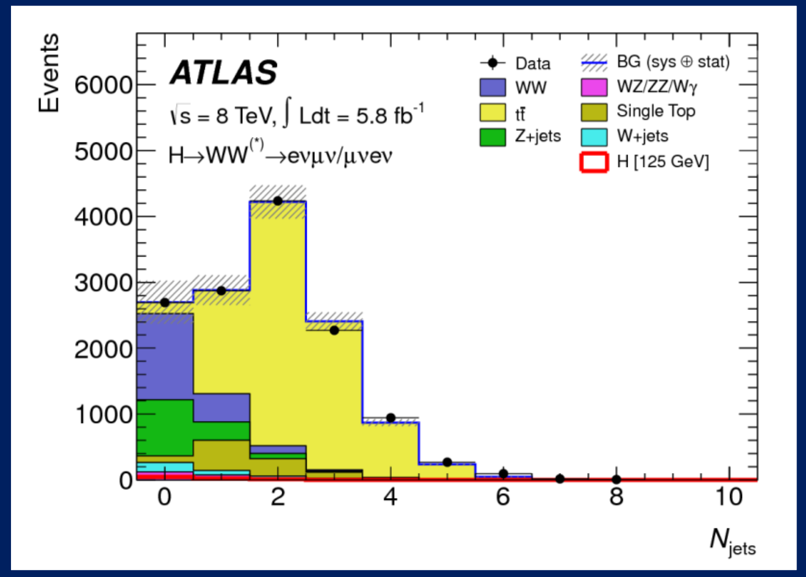
H->WW : kinematic cuts

Analysis done separately in
- ➔+0 jet (ggF, background pp->WW)
- ➔+1 jets (ggF, background pp->WW + pp->ttbar)
- ➔+ >=2 Jets (+VBF, background pp->ttbar)

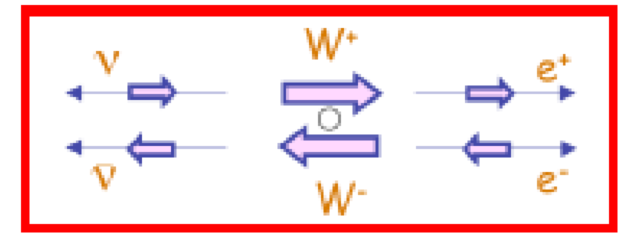


H->WW : kinematic cuts

Analysis done separately in
- ➔+0 jet (ggF, background pp->WW)
- ➔+1 jets (ggF, background pp->WW + pp->ttbar)
- ➔+ >=2 Jets (+VBF, background pp->ttbar)

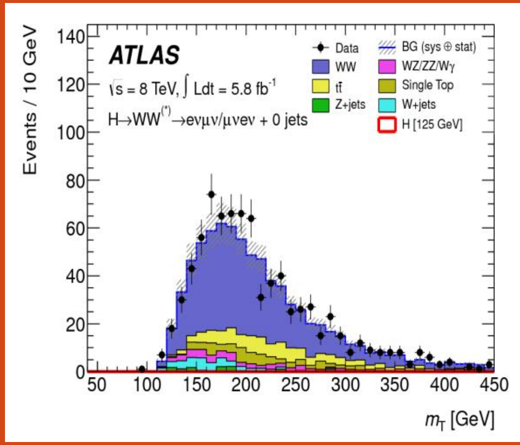


Predicted spin(H)=0 and V-A coupling for the W bosons => Leptons emerge in the same direction
➔distinguishing H->WW from pp->WW using |ΔΦll| < 1.8 and mll cuts

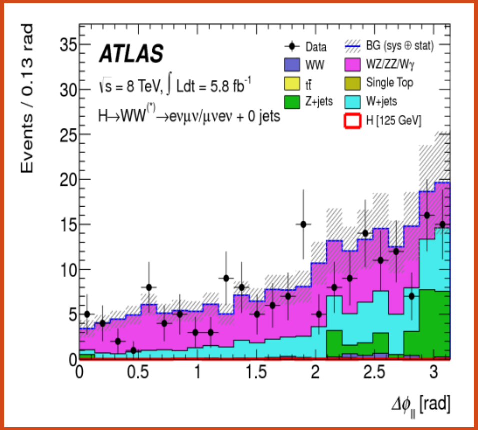


Background control regions

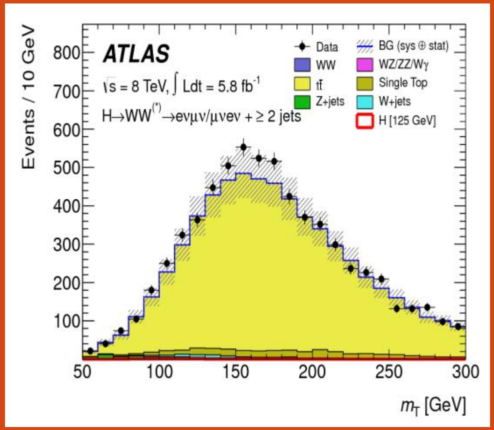
WW control sample:
(H+0,H+1 jets)
All cuts except ΔΦ and mT
Require Mll>80GeV



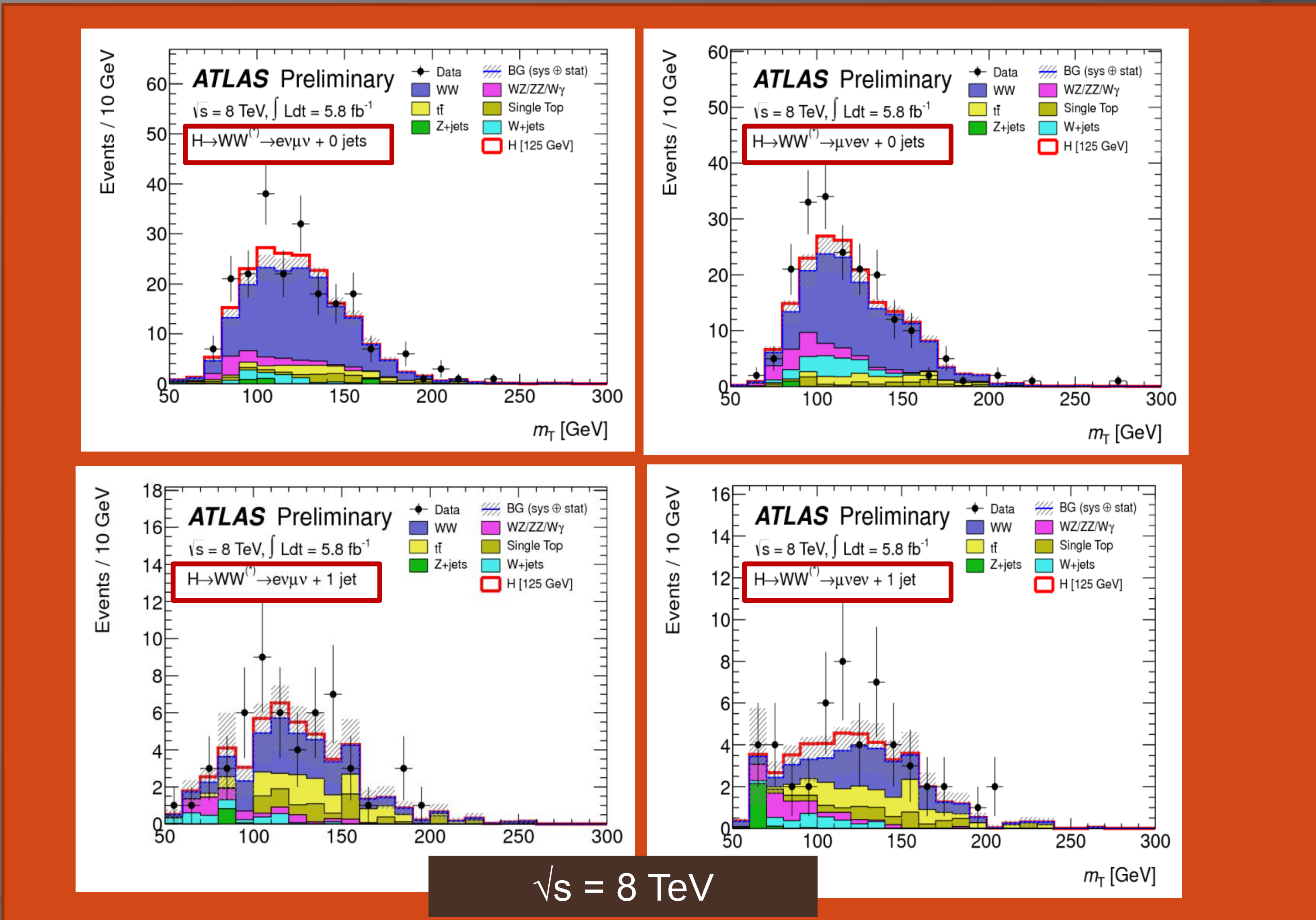
W+jet control sample
All requirements to one lepton and only loosen Id to the second



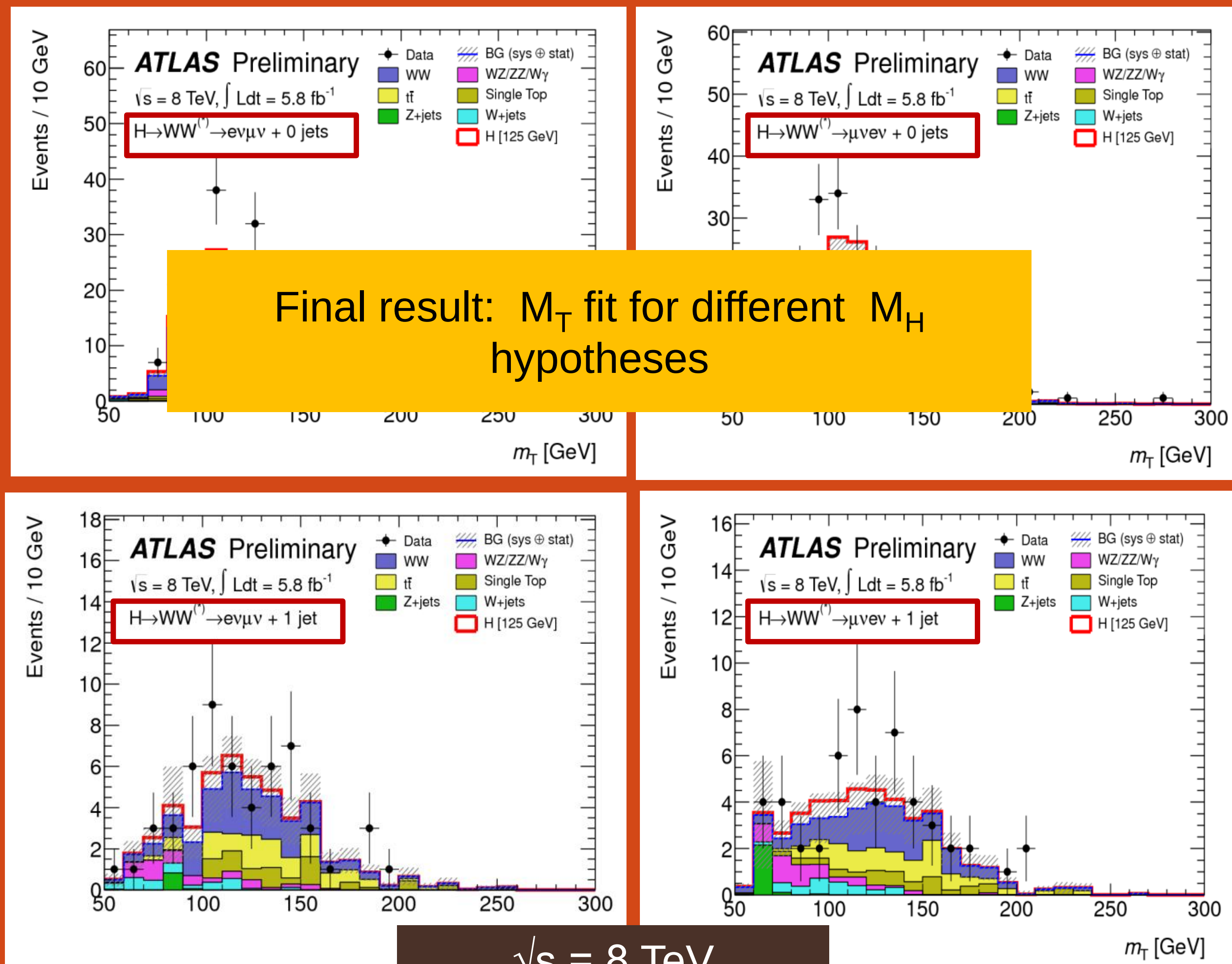
Top control sample:
B-jet enriched sample



Final $M_T = \sqrt{(E_T^{ll}+E_T^{miss})^2-|p_T^{ll}+E_T^{miss}|^2}$



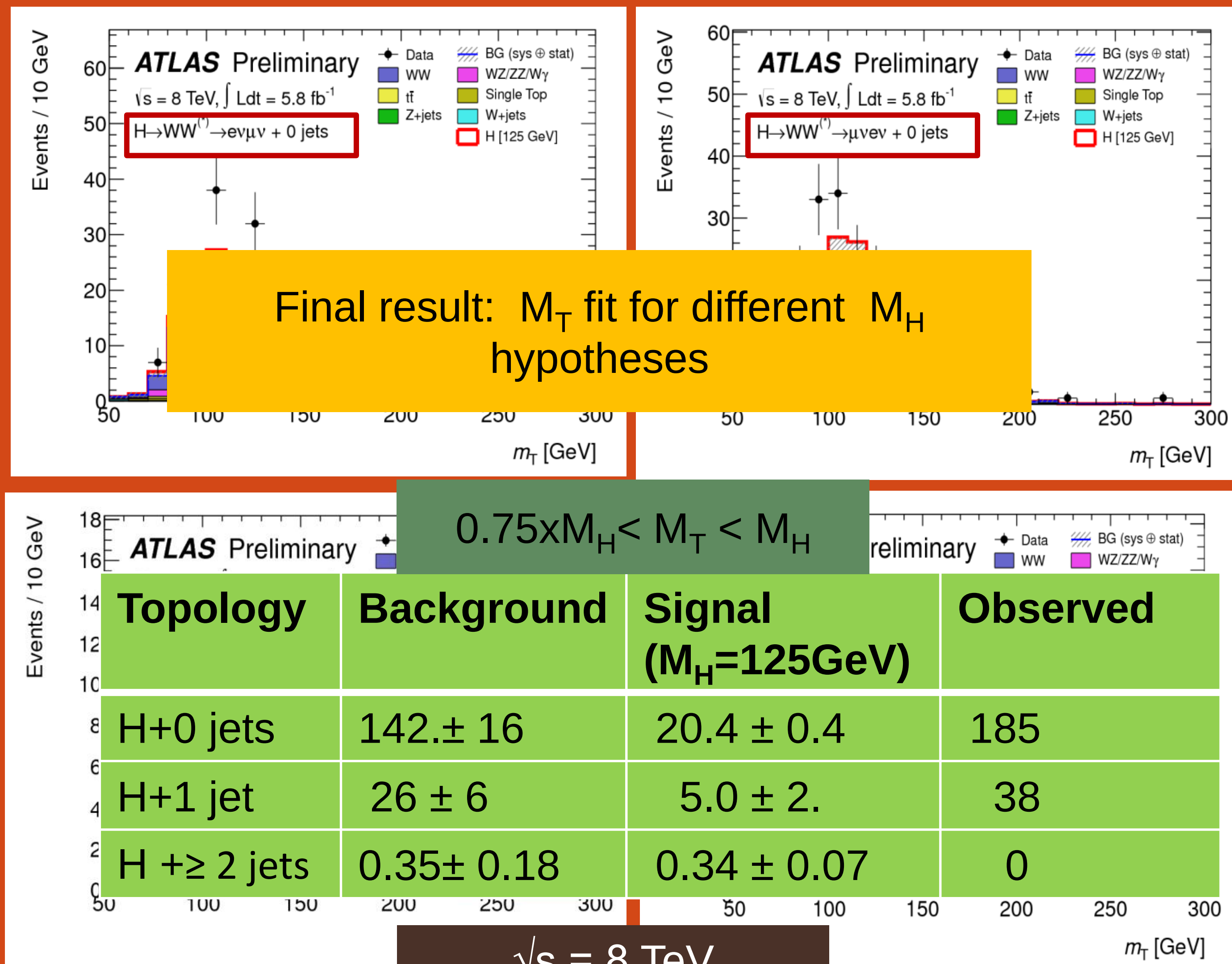
Final $M_T = \sqrt{(E_T^{ll}+E_T^{miss})^2 - |p_T^{ll}+E_T^{miss}|^2}$



Final result: M_T fit for different M_H hypotheses

$\sqrt{s}$ = 8 TeV

Final $M_T = \sqrt{(E_T^{ll}+E_T^{miss})^2 - |p_T^{ll}+E_T^{miss}|^2}$



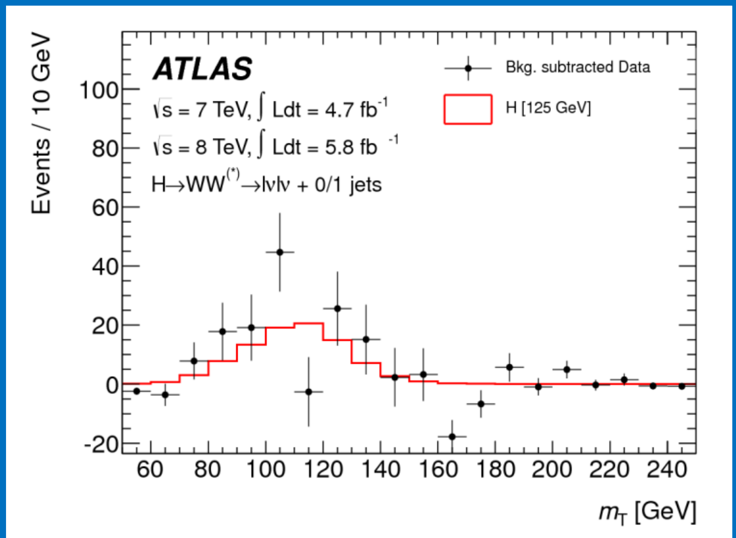
Final result: M_T fit for different M_H hypotheses

$0.75 \times M_H < M_T < M_H$

Topology	Background	Signal (M_H=125GeV)	Observed
H+0 jets	142.± 16	20.4 ± 0.4	185
H+1 jet	26 ± 6	5.0 ± 2.	38
H +≥ 2 jets	0.35± 0.18	0.34 ± 0.07	0

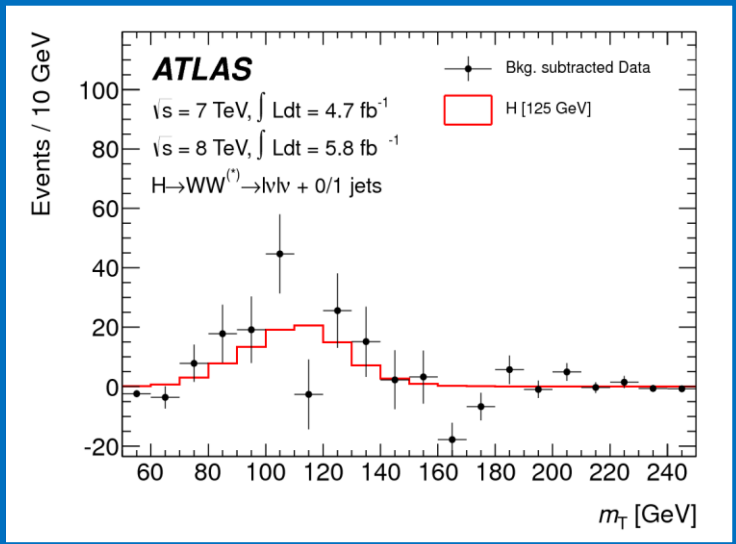
$\sqrt{s}$ = 8 TeV

H->WW results (2011+2012)



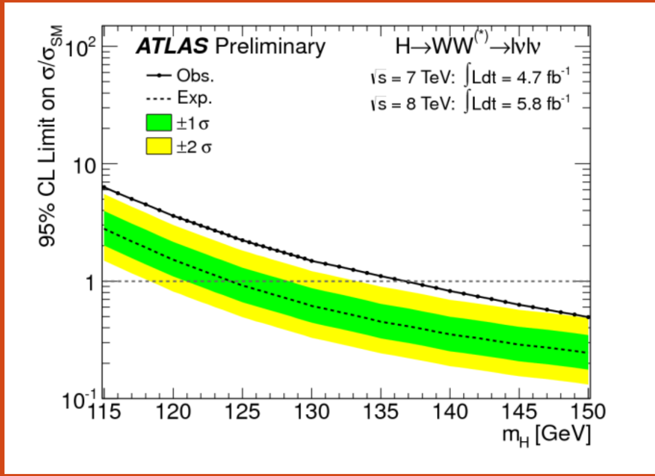
Broad excess of events in background subtracted M_T distribution

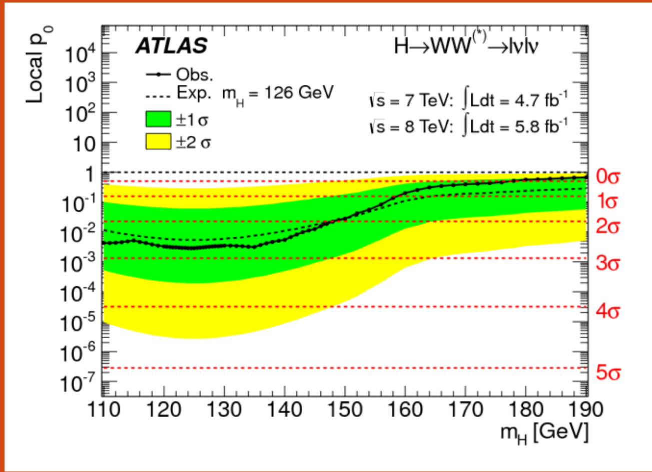
H->WW results (2011+2012)



Broad excess of events in background subtracted M_T distribution

➔Excluded region
137-261 GeV
(exp 124-233 GeV)
➔Local p0 = 0.003➔2.8σ





All modes : combined results and properties

Higgs Boson Decay	Subsequent Decay	Sub-Channels	m_H Range [GeV]	$\int L\,dt$ [fb^{-1}]
		2011 $\sqrt{s}$ =7 TeV		
$H \rightarrow ZZ^{(*)}$	4ℓ	$\{4e, 2e2\mu, 2\mu 2e, 4\mu\}$	110–600	4.8
	$\ell\ell\nu\bar{\nu}$	$\{ee, \mu\mu\} \otimes$ {low, high pile-up}	200–280–600	4.7
	$\ell\ell q\bar{q}$	{b-tagged, untagged}	200–300–600	4.7
$H \rightarrow \gamma\gamma$	–	10 categories $\{p_{Tt} \otimes \eta_\gamma \otimes$ conversion$\} \oplus$ {2-jet}	110–150	4.8
$H \rightarrow WW^{(*)}$	$\ell\nu\ell\nu$	$\{ee, e\mu/\mu e, \mu\mu\} \otimes$ {0-jet, 1-jet, 2-jet} $\otimes$ {low, high pile-up}	110–200–300–600	4.7
	$\ell\nu qq'$	$\{e, \mu\} \otimes$ {0-jet, 1-jet, 2-jet}	300–600	4.7
$H \rightarrow \tau\tau$	$\tau_{lep}\tau_{lep}$	$\{e\mu\} \otimes$ {0-jet} $\oplus$ $\{\ell\ell\} \otimes$ {1-jet, 2-jet, VH}	110–150	4.7
	$\tau_{lep}\tau_{had}$	$\{e, \mu\} \otimes$ {0-jet} $\otimes$ $\{E_T^{miss} < 20$ GeV, $E_T^{miss} \geq 20$ GeV$\}$ $\oplus$ $\{e, \mu\} \otimes$ {1-jet} $\oplus$ $\{\ell\} \otimes$ {2-jet}	110–150	4.7
	$\tau_{had}\tau_{had}$	{1-jet}	110–150	4.7
$VH \rightarrow Vbb$	$Z \rightarrow \nu\nu$	$E_T^{miss} \in \{120-160, 160-200, \geq 200$ GeV$\}$	110–130	4.6
	$W \rightarrow \ell\nu$	$p_T^W \in \{< 50, 50-100, 100-200, \geq 200$ GeV$\}$	110–130	4.7
	$Z \rightarrow \ell\ell$	$p_T^Z \in \{< 50, 50-100, 100-200, \geq 200$ GeV$\}$	110–130	4.7
		2012 $\sqrt{s}$ =8 TeV		
$H \rightarrow ZZ^{(*)}$	4ℓ	$\{4e, 2e2\mu, 2\mu 2e, 4\mu\}$	110–600	5.8
$H \rightarrow \gamma\gamma$	–	10 categories $\{p_{Tt} \otimes \eta_\gamma \otimes$ conversion$\} \oplus$ {2-jet}	110–150	5.9
$H \rightarrow WW^{(*)}$	$e\nu\mu\nu$	$\{e\mu, \mu e\} \otimes$ {0-jet, 1-jet, 2-jet}	110–200	5.8

Main systematic uncertainties

H->4l

H->4l	**Uncertainty**
Reconstruction	~1% - 8% (M_H=115GeV)
Energy Scale	0.2-0.7%
ZZ* modeling	5%(scale),4%(PDF q),8%(PDF g)
Background	10%-70% on background yields

	7 TeV	8 TeV
Photon id efficiency	8.4%	10.8%
Theory	up to 25% ($gg \to H + 2$ jets)	
Jet E-scale (2-jets)	9-18%	
Underl. evt. (2-jets)	6-30%	
Higgs p_T	up to 12.5%	
Bkgd Param (evts)	0.2-4.6	0.3-6.8
$m_{\gamma\gamma}$ resolution	14%	
γ energy scale	0.6%	

H->γγ

Source (0-jet)	Signal (%)	Bkg. (%)
Inclusive ggF signal ren./fact. scale	13	-
1-jet incl. ggF signal ren./fact. scale	10	-
Parton distribution functions	8	2
Jet energy scale	7	4
WW modelling and shape	-	5
QCD scale acceptance	4	2
WW normalisation	-	4
W+jets fake factor	-	4
Lepton isolation	3	3
Source (1-jet)	**Signal (%)**	**Bkg. (%)**
1-jet incl. ggF signal ren./fact. scale	28	-
2-jet incl. ggF signal ren./fact. scale	16	-
WW normalisation	0	14
b-tagging efficiency	-	8
Top normalisation	-	6
Pile-up	5	5

H->WW

Main systematic uncertainties

H->4l

H->4l	Uncertainty
Reconstruction	~1% - 8% (M_H=115GeV)
Energy Scale	0.2-0.7%
ZZ* modeling	5%(scale),4%(PDF q),8%(PDF g)

Some uncertainties affect the event yields
Some uncertainties affect the mass measurement
Some uncertainties affect both

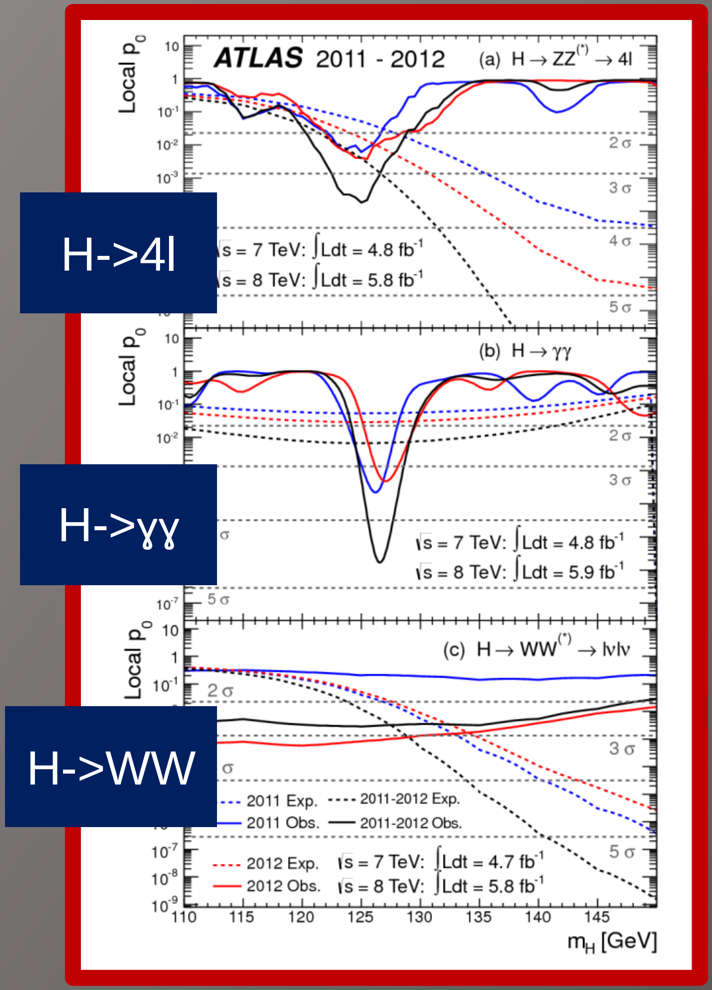
Photon id efficiency		
Theory		
Jet E-scale (2-jets)	9-18%	
Underl. evt. (2-jets)	6-30%	
Higgs p_T	up to 12.5%	
Bkgd Param (evts)	0.2-4.6	0.3-6.8
$m_{\gamma\gamma}$ resolution	14%	
γ energy scale	0.6%	

H->γγ

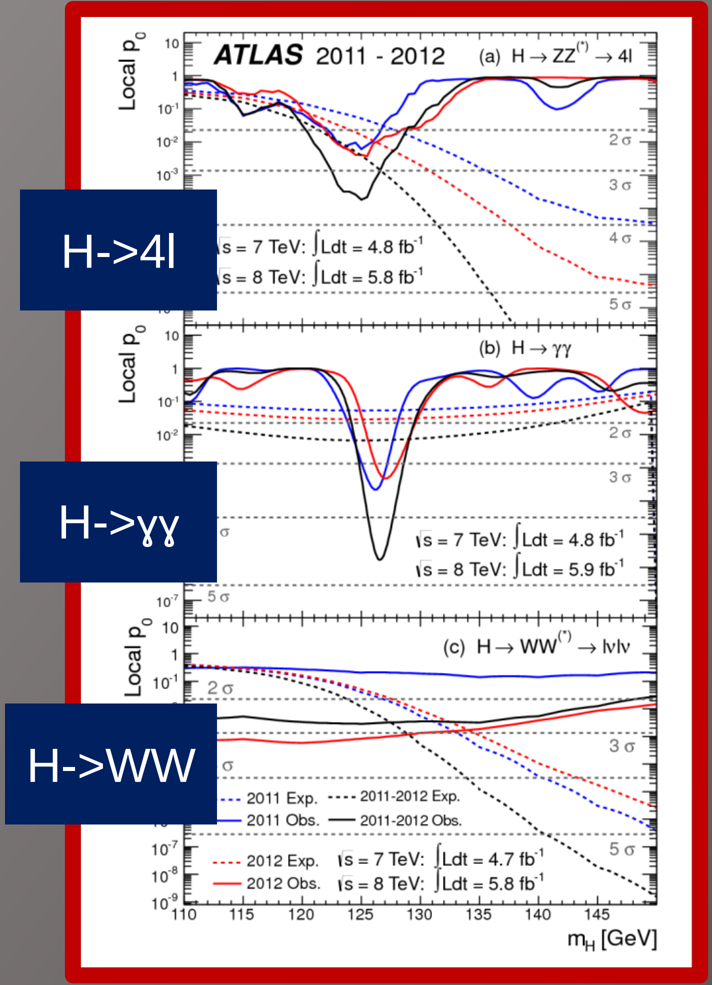
		(%)
		-
		-
		2
Jet energy scale	7	4
WW modelling and shape	-	5
QCD scale acceptance	4	2
WW normalisation	-	4
W+jets fake factor	-	4
Lepton isolation	3	3
Source (1-jet)	Signal (%)	Bkg. (%)
1-jet incl. ggF signal ren./fact. scale	28	-
2-jet incl. ggF signal ren./fact. scale	16	-
WW normalisation	0	14
b-tagging efficiency	-	8
Top normalisation	-	6
Pile-up	5	5

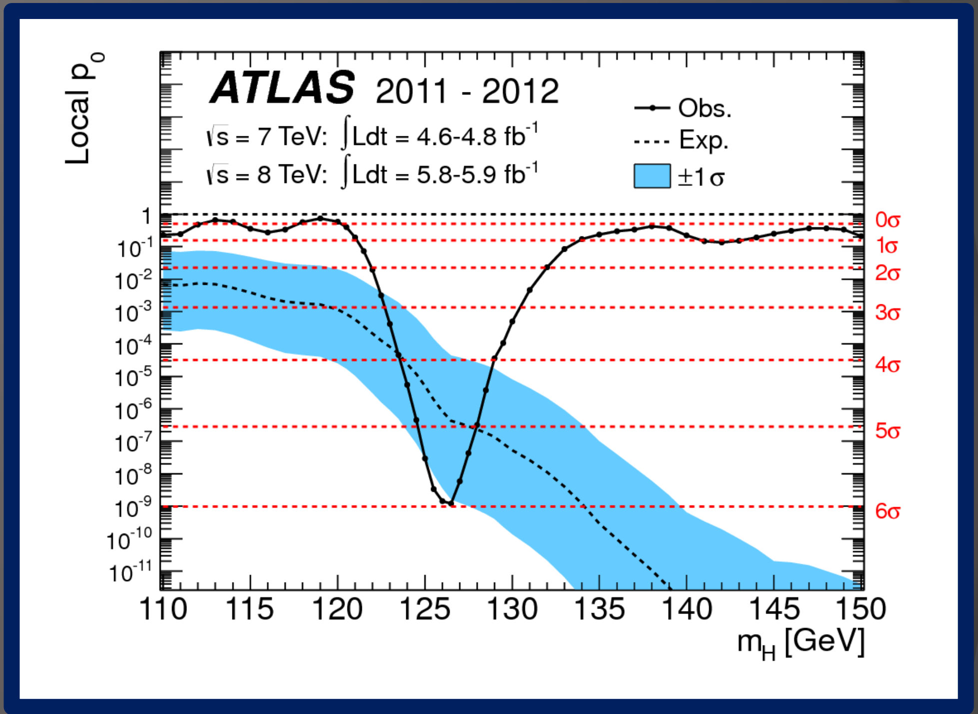
H->WW

All modes : combined results and properties



All modes : combined results and properties





Combined:

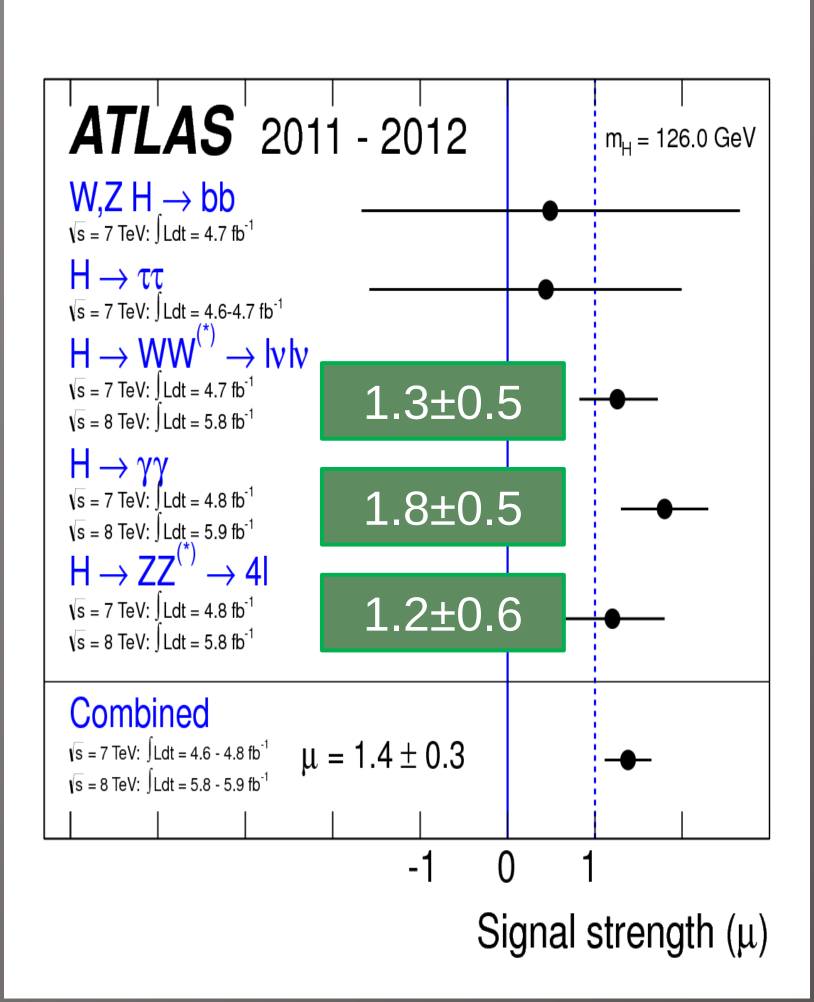
A 6σ excess at M_H=126.5 GeV (exp 4.9)

With LEE in 110-150(600)->5.3(5.1)

All modes : combined results and properties

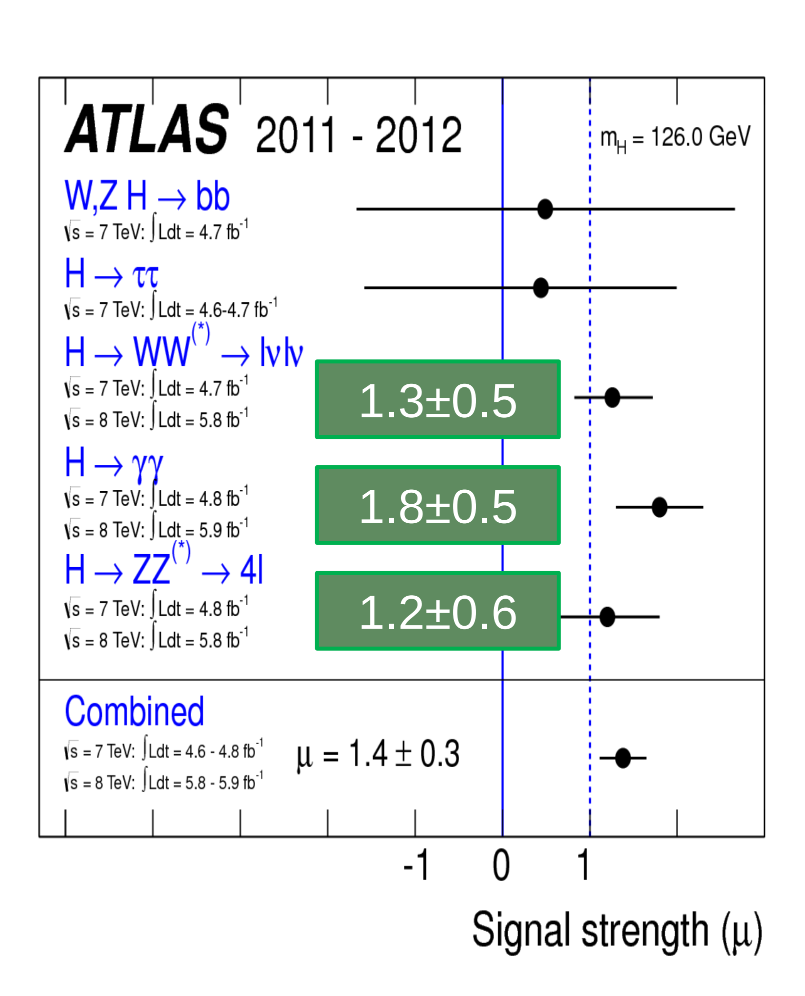
Excesses observed in 3 channels
ɣɣ, ZZ*, WW*
Characterized by the signal strength μ
(μ = 0 if background, μ =1 for SM, μ <0 if lack of events)

All modes : combined results and properties



Excesses observed in 3 channels
ɣɣ, ZZ*, WW*
Characterized by the signal strength μ
(μ = 0 if background, μ =1 for SM, μ <0 if lack of events)

All modes : combined results and properties



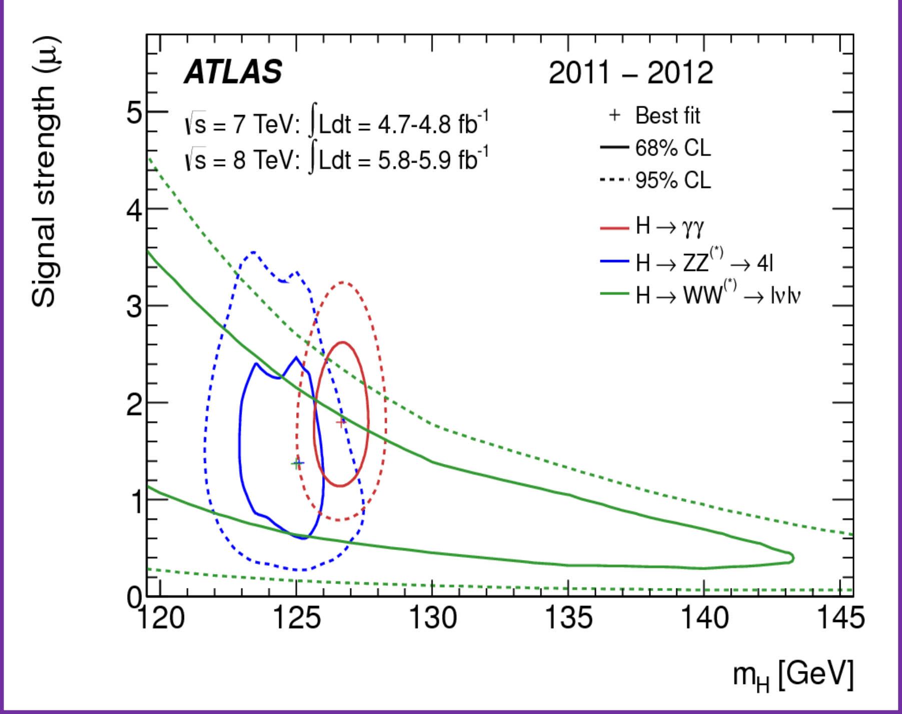
Excesses observed in 3 channels
ɣɣ, ZZ*, WW*
Characterized by the signal strength μ
(μ = 0 if background, μ =1 for SM, μ <0 if lack of events)

Current questions on the new particle

- →What is the observed particle?
- →What is its mass?
- →Its quantum numbers ?
- →Its couplings to fermions and bosons?
- →Is it the SM Higgs?
- →Is it elementary?

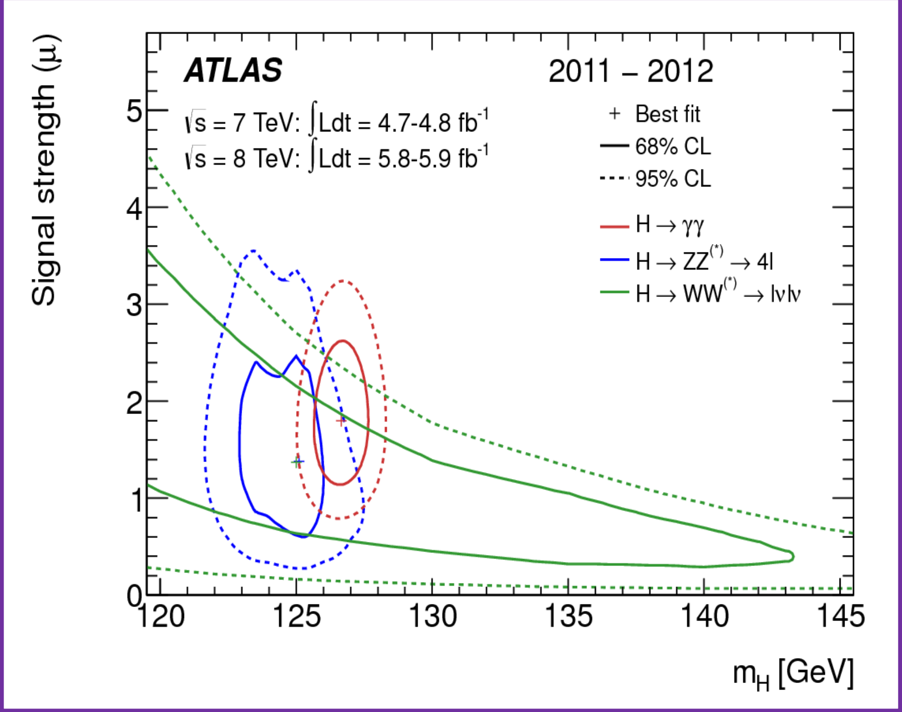
What is its mass?

➔Profile likelihood ratio λ (μ, Mh) to scan strength-mass consistency regions



What is its mass?

➔Profile likelihood ratio λ (μ, Mh) to scan strength-mass consistency regions



The mass : extracted from the two channels with the highest resolution ($H\rightarrow ZZ^*\rightarrow 4l$ and $H\rightarrow\gamma\gamma$)
Profile likelihood ratio $\lambda(M_H)$.

M_H=126.0 ± 0.4(stat) ± 0.4(syst)

➔Non-sensitive to μ hypothesis
➔Leading systematics: energy scale and resolution for photons and electrons
➔Compatibility of mass peaks in $Z\rightarrow 4l$ and $Z\rightarrow\gamma\gamma$ = 8%

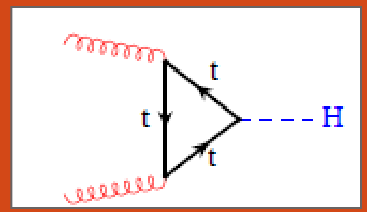
Couplings of the new particle to fermions and bosons

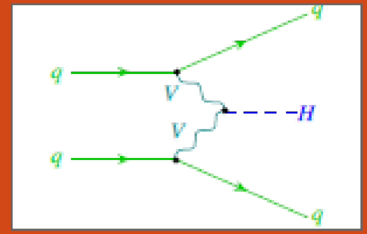
The SM BEH is produced and decays through vector bosons and fermions.

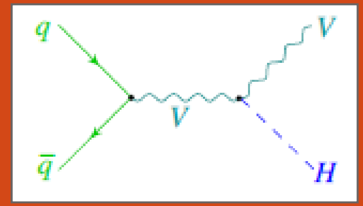
Couplings of the new particle to fermions and bosons

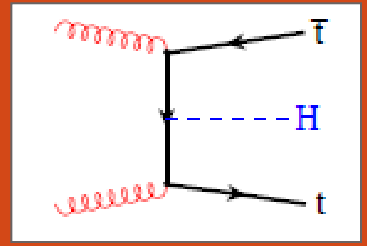
The SM BEH is produced and decays through vector bosons and fermions.

Production





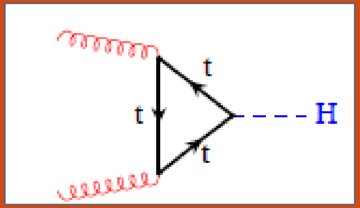


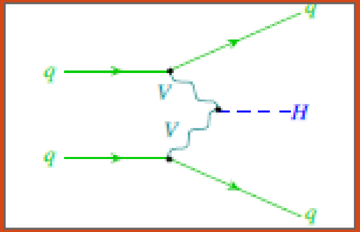


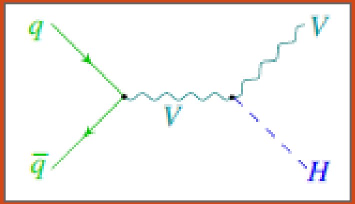
Couplings of the new particle to fermions and bosons

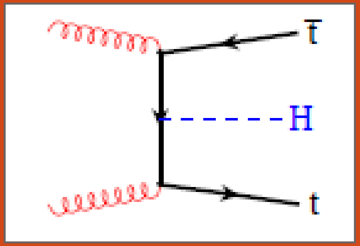
The SM BEH is produced and decays through vector bosons and fermions.

Production

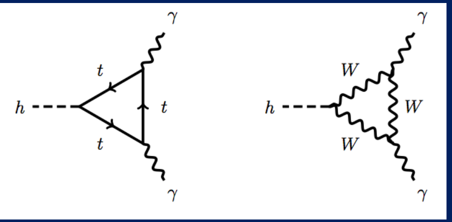


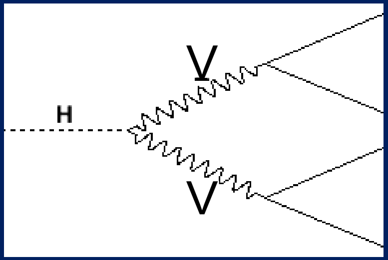


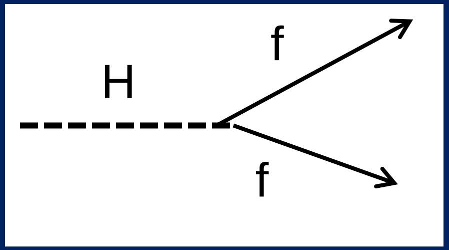




Decay







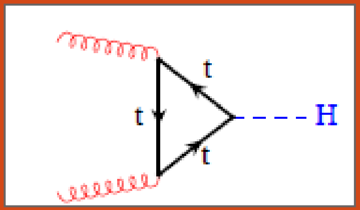
Couplings of the new particle to fermions and bosons

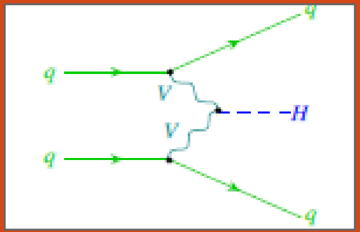
The SM BEH is produced and decays through vector bosons and fermions.

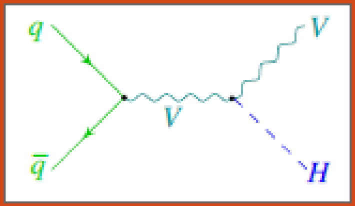
Combining observations in different decay channels gives access to the couplings

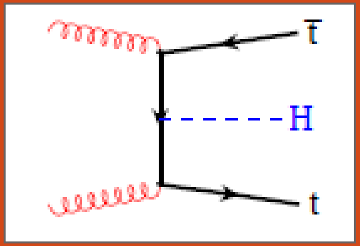
For the time being, analysis is less sensitive to pure fermionic modes (H->bb, H->ττ) to direct constrain that coupling

Production

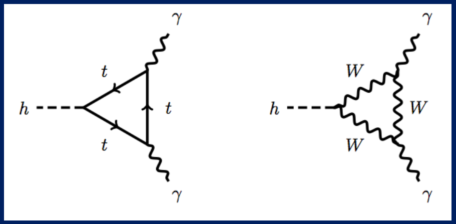


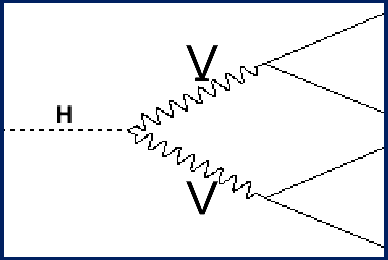


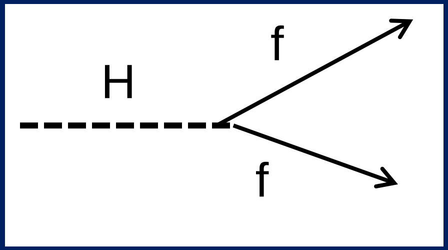




Decay







Couplings of the new particle to fermions and bosons

Principle : Allow a scale for the SM production cross section and another scale for the partial decays

Couplings of the new particle to fermions and bosons

Principle : Allow a scale for the SM production cross section and another scale for the partial decays

Production modes

$$\frac{\sigma_{\mathrm{ggH}}}{\sigma^{\mathrm{SM}}_{\mathrm{ggH}}} = \begin{cases} \kappa_g^2(\kappa_b, \kappa_t, m_H) \\ \kappa_g^2 \end{cases}$$

$$\frac{\sigma_{\mathrm{VBF}}}{\sigma^{\mathrm{SM}}_{\mathrm{VBF}}} = \kappa_{\mathrm{VBF}}^2(\kappa_W, \kappa_Z, m_H)$$

$$\frac{\sigma_{\mathrm{WH}}}{\sigma^{\mathrm{SM}}_{\mathrm{WH}}} = \kappa_W^2$$

$$\frac{\sigma_{\mathrm{ZH}}}{\sigma^{\mathrm{SM}}_{\mathrm{ZH}}} = \kappa_Z^2$$

$$\frac{\sigma_{t\bar{t}H}}{\sigma^{\mathrm{SM}}_{t\bar{t}H}} = \kappa_t^2$$

Couplings of the new particle to fermions and bosons

Principle : Allow a scale for the SM production cross section and another scale for the partial decays

Production modes

$$\frac{\sigma_{ggH}}{\sigma_{ggH}^{SM}} = \begin{cases} \kappa_g^2(\kappa_b, \kappa_t, m_H) \\ \kappa_g^2 \end{cases}$$

$$\frac{\sigma_{VBF}}{\sigma_{VBF}^{SM}} = \kappa_{VBF}^2(\kappa_W, \kappa_Z, m_H)$$

$$\frac{\sigma_{WH}}{\sigma_{WH}^{SM}} = \kappa_W^2$$

$$\frac{\sigma_{ZH}}{\sigma_{ZH}^{SM}} = \kappa_Z^2$$

$$\frac{\sigma_{t\bar{t}H}}{\sigma_{t\bar{t}H}^{SM}} = \kappa_t^2$$

Decay modes

$$\frac{\Gamma_{WW^{(*)}}}{\Gamma_{WW^{(*)}}^{SM}} = \kappa_W^2$$

$$\frac{\Gamma_{ZZ^{(*)}}}{\Gamma_{ZZ^{(*)}}^{SM}} = \kappa_Z^2$$

$$\frac{\Gamma_{b\bar{b}}}{\Gamma_{b\bar{b}}^{SM}} = \kappa_b^2$$

$$\frac{\Gamma_{\tau^-\tau^+}}{\Gamma_{\tau^-\tau^+}^{SM}} = \kappa_\tau^2$$

$$\frac{\Gamma_{\gamma\gamma}}{\Gamma_{\gamma\gamma}^{SM}} = \begin{cases} \kappa_\gamma^2(\kappa_b, \kappa_t, \kappa_\tau, \kappa_W, m_H) \\ \kappa_\gamma^2 \end{cases}$$

Couplings of the new particle to fermions and bosons

Principle : Allow a scale for the SM production cross section and another scale for the partial decays

Production modes

$$\frac{\sigma_{ggH}}{\sigma^{SM}_{ggH}} = \begin{cases} \kappa_g^2(\kappa_b, \kappa_t, m_H) \\ \kappa_g^2 \end{cases}$$

$$\frac{\sigma_{VBF}}{\sigma^{SM}_{VBF}} = \kappa_{VBF}^2(\kappa_W, \kappa_Z, m_H)$$

ZH

$$\frac{\sigma_{t\bar{t}H}}{\sigma^{SM}_{t\bar{t}H}} = \kappa_t^2$$

Decay modes

$$\frac{\Gamma_{WW^{(*)}}}{\Gamma^{SM}_{WW^{(*)}}} = \kappa_W^2$$

$$\frac{\Gamma_{ZZ^{(*)}}}{\Gamma^{SM}_{ZZ^{(*)}}} = \kappa_Z^2$$

$\tau^-\tau^+$

$$\frac{\Gamma_{\gamma\gamma}}{\Gamma^{SM}_{\gamma\gamma}} = \begin{cases} \kappa_\gamma^2(\kappa_b, \kappa_t, \kappa_\tau, \kappa_W, m_H) \\ \kappa_\gamma^2 \end{cases}$$

Example

$$(\sigma \cdot BR)(gg \to H \to \gamma\gamma) = \sigma_{SM}(gg \to H) \cdot BR_{SM}(H \to \gamma\gamma) \cdot \frac{\kappa_g^2 \cdot \kappa_\gamma^2}{\kappa_H^2}$$

Couplings of the new particle to fermions and bosons

Principle : Allow a scale for the SM production cross section and another scale for the partial decays

Production modes

$$\frac{\sigma_{ggH}}{\sigma^{SM}_{ggH}} = \begin{cases} \kappa_g^2(\kappa_b, \kappa_t, m_H) \\ \kappa_g^2 \end{cases}$$

$$\frac{\sigma_{VBF}}{\sigma^{SM}_{VBF}} = \kappa_{VBF}^2(\kappa_W, \kappa_Z, m_H)$$

ZH

$$\frac{\sigma_{t\bar{t}H}}{\sigma^{SM}_{t\bar{t}H}} = \kappa_t^2$$

Decay modes

$$\frac{\Gamma_{WW^{(*)}}}{\Gamma^{SM}_{WW^{(*)}}} = \kappa_W^2$$

$$\frac{\Gamma_{ZZ^{(*)}}}{\Gamma^{SM}_{ZZ^{(*)}}} = \kappa_Z^2$$

$\tau^-\tau^+$

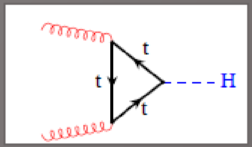
$$\frac{\Gamma_{\gamma\gamma}}{\Gamma^{SM}_{\gamma\gamma}} = \begin{cases} \kappa_\gamma^2(\kappa_b, \kappa_t, \kappa_\tau, \kappa_W, m_H) \\ \kappa_\gamma^2 \end{cases}$$

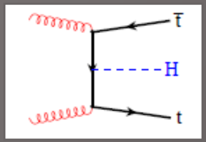
Example

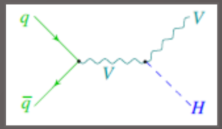
$$(\sigma \cdot BR)(gg \to H \to \gamma\gamma) = \sigma_{SM}(gg \to H) \cdot BR_{SM}(H \to \gamma\gamma) \cdot \frac{\kappa_g^2 \cdot \kappa_\gamma^2}{\kappa_H^2}$$

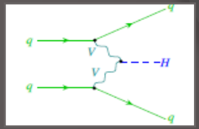
NEW : ATLAS-CONF-2012-127

Comparison ggH+ttH vs VBF+VH

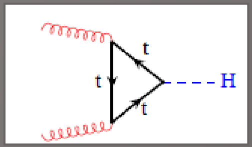


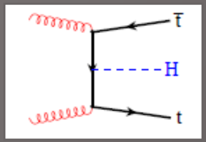


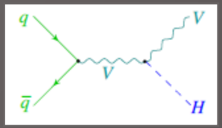


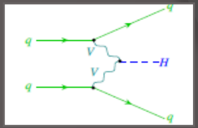


Comparison ggH+ttH vs VBF+VH

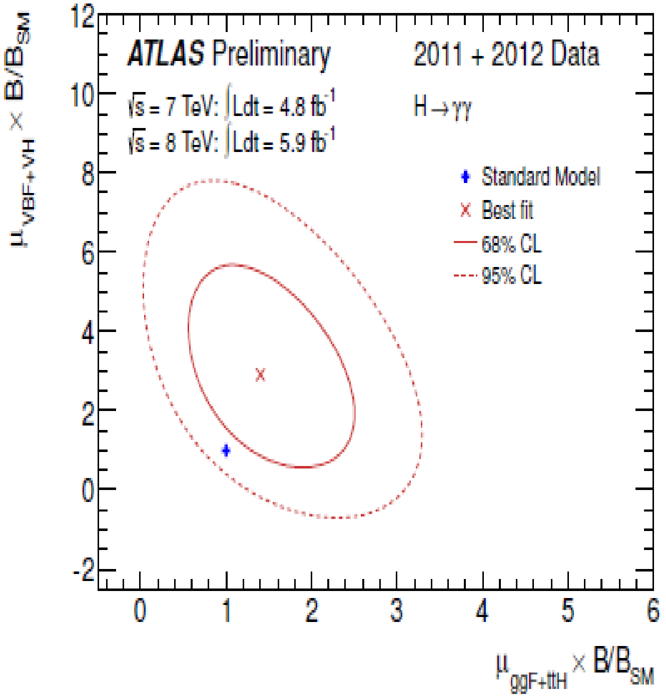




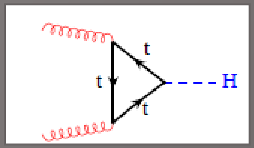


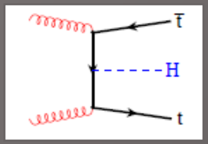


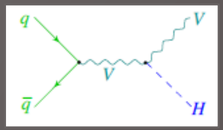
H->γγ

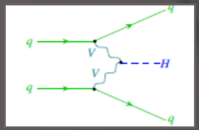


Comparison ggH+ttH vs VBF+VH

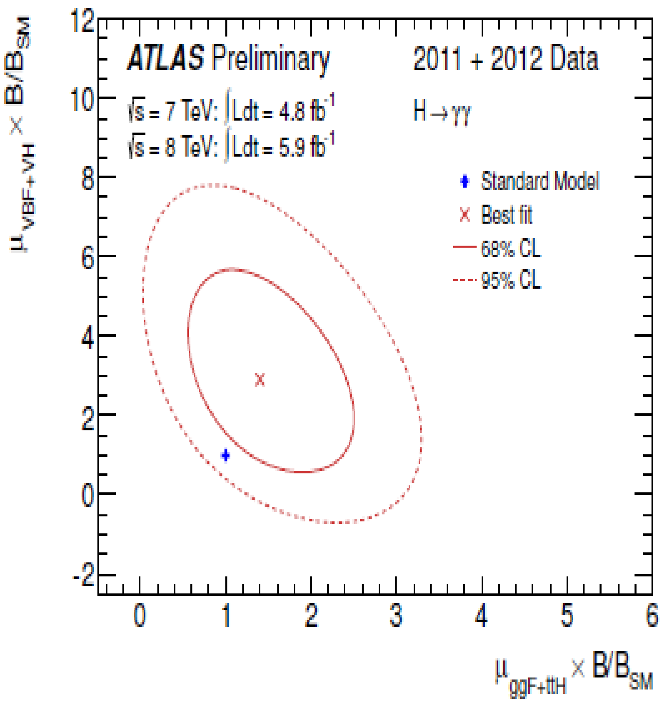




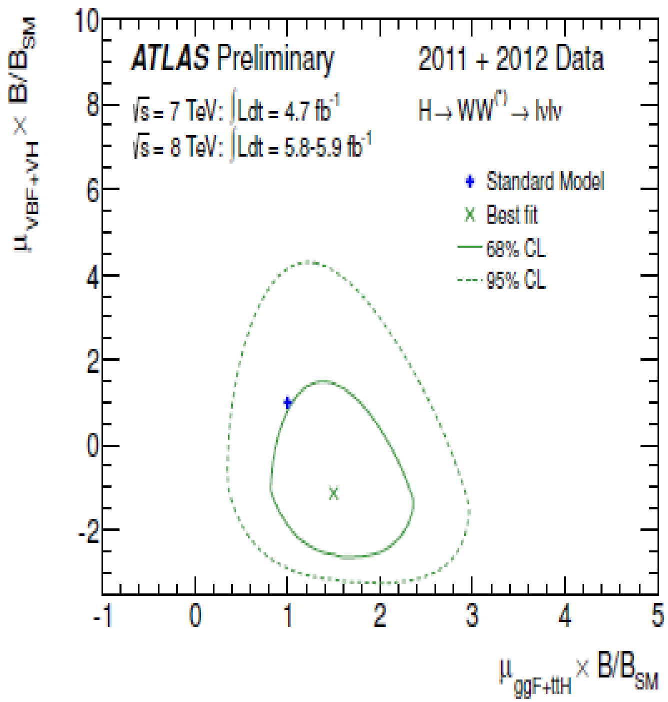




H->γγ



H->WW



Couplings of the new particle to fermions and bosons

Scan couplings space under assumptions

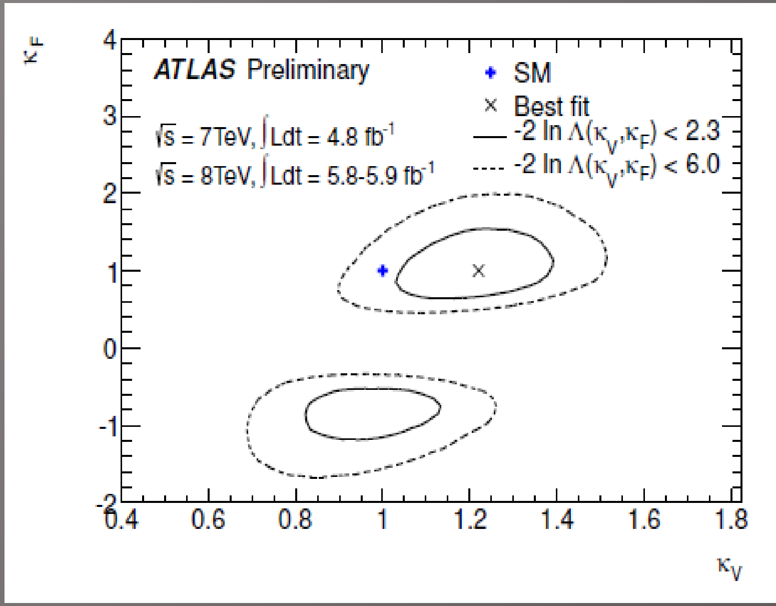
Test κ_V vs κ_F assuming single coupling to all bosons and single coupling to fermions. No BSM.

$$\kappa_V = \kappa_W = \kappa_Z$$

$$\kappa_F = \kappa_t = \kappa_b = \kappa_\tau$$

Couplings of the new particle to fermions and bosons

Scan couplings space under assumptions



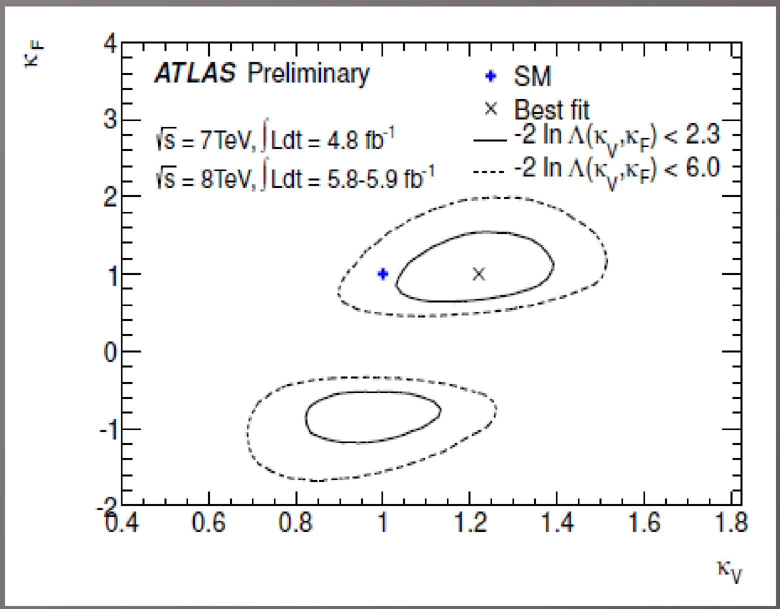
Test κ_V vs κ_F assuming single coupling to all bosons and single coupling to fermions. No BSM.

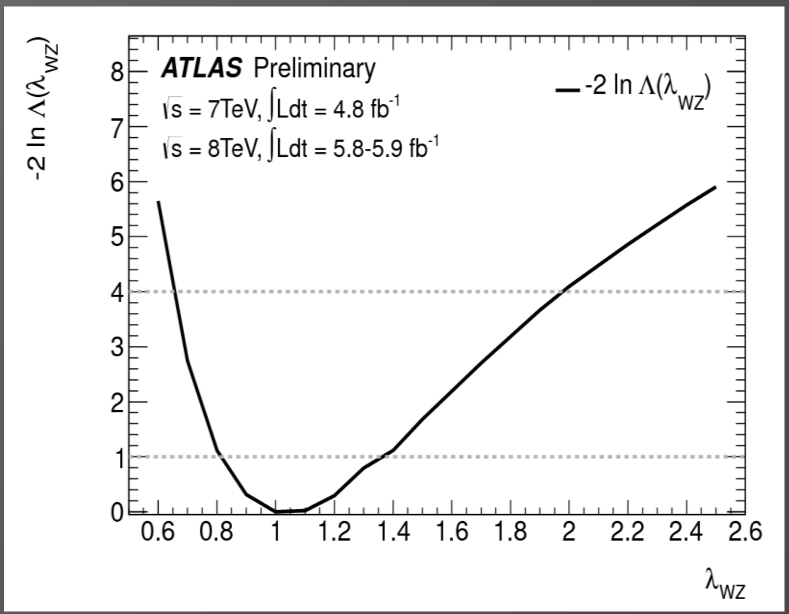
$$\kappa_V = \kappa_W = \kappa_Z$$

$$\kappa_F = \kappa_t = \kappa_b = \kappa_\tau$$

Couplings of the new particle to fermions and bosons

Scan couplings space under assumptions





Test κ_V vs κ_F assuming single coupling to all bosons and single coupling to fermions. No BSM.

$$\kappa_V = \kappa_W = \kappa_Z$$

$$\kappa_F = \kappa_t = \kappa_b = \kappa_\tau$$

Test custodial symmetry

$$\lambda_{WZ} = \kappa_W / \kappa_Z$$

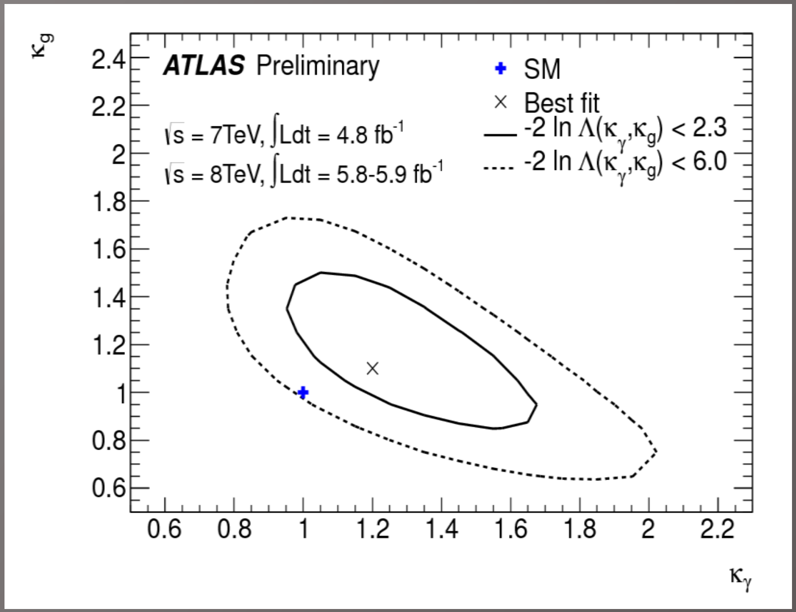
$$\lambda_{WZ} = 1.07^{+0.35}_{-0.27}$$

Couplings of the new particle to fermions and bosons

Test for new particles . Keep all ki=1

Couplings of the new particle to fermions and bosons

Test for new particles . Keep all ki=1

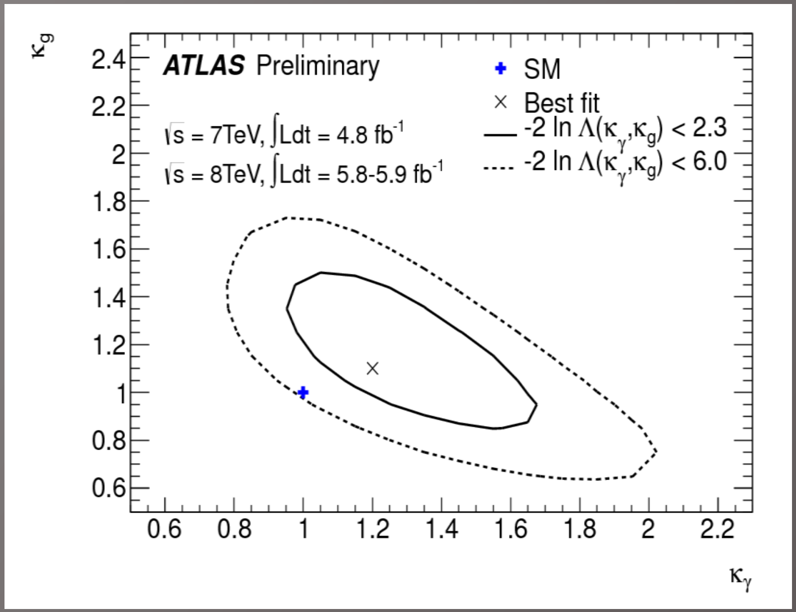


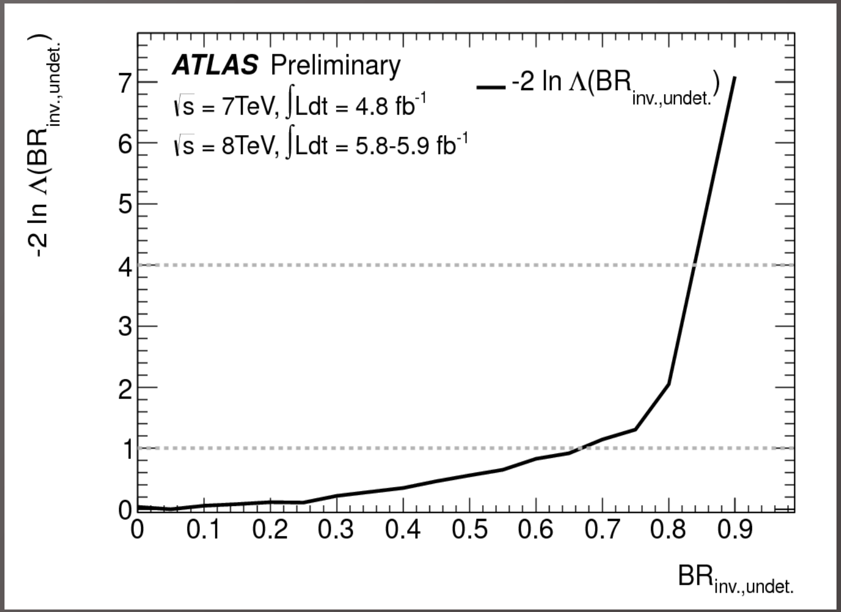
Allow extra contributions into the loops in H->ɣɣ and gg->H

$\kappa_g = 1.1^{+0.2}_{-0.3}$ $\kappa_\gamma = 1.2^{+0.3}_{-0.2}$

Couplings of the new particle to fermions and bosons

Test for new particles . Keep all ki=1





Allow extra contributions into the loops in H->γγ and gg->H

$\kappa_g = 1.1^{+0.2}_{-0.3}$ $\kappa_\gamma = 1.2^{+0.3}_{-0.2}$

Let BR free

BR(inv. or undet) < 0.84 at 95%CL

$\kappa_g = 1.1^{+1.4}_{-0.2}$ $\kappa_\gamma = 1.2^{+0.3}_{-0.2}$

Conclusions



ATLAS observes a 6σ excess at a mass=126.0±0.6 GeV

Conclusions

ATLAS observes a 6σ excess at a mass=126.0±0.6 GeV

In July 2012 closed the Higgs Hunting era, after ~30years of world-wide efforts.

Conclusions



ATLAS observes a 6σ excess at a mass=126.0±0.6 GeV

In July 2012 closed the Higgs Hunting era, after ~30years of world-wide efforts.

First studies of the new-born particle show fair agreement with expectations from the Standard Model BEH boson.

Conclusions



ATLAS observes a 6σ excess at a mass=126.0±0.6 GeV

In July 2012 closed the Higgs Hunting era, after ~30years of world-wide efforts.

First studies of the new-born particle show fair agreement with expectations from the Standard Model BEH boson.

Next ATLAS results foreseen for HCP.

Conclusions



ATLAS observes a 6σ excess at a mass=126.0±0.6 GeV

In July 2012 closed the Higgs Hunting era, after ~30years of world-wide efforts.

First studies of the new-born particle show fair agreement with expectations from the Standard Model BEH boson.

Next ATLAS results foreseen for HCP.

New data, new channels and optimized technics will soon allow to assess precise measurements of its properties. Shrinking of the systematics would be the next challenge

Conclusions



ATLAS observes a 6σ excess at a mass=126.0±0.6 GeV

In July 2012 closed the Higgs Hunting era, after ~30years of world-wide efforts.

First studies of the new-born particle show fair agreement with expectations from the Standard Model BEH boson.

Next ATLAS results foreseen for HCP.

New data, new channels and optimized technics will soon allow to assess precise measurements of its properties. Shrinking of the systematics would be the next challenge

The season of 95%CL limits and p0 plots maynot be over. Scrutinize plots at higher masses for testing existence of additional bosons

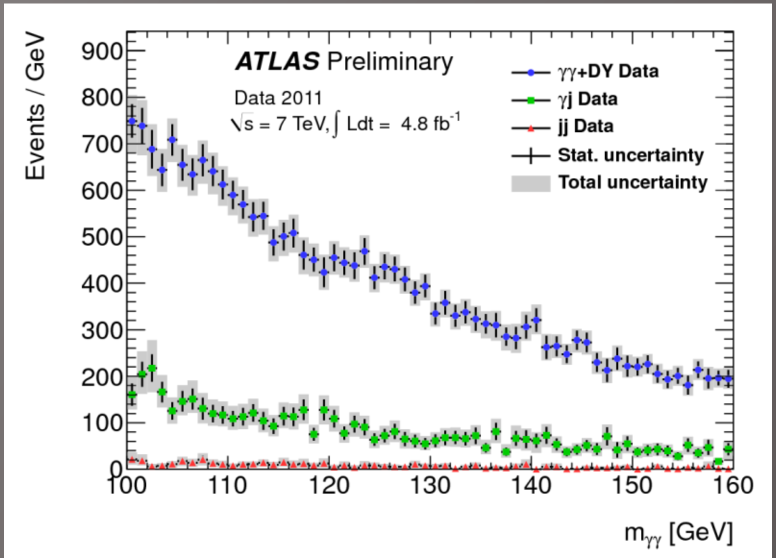
Backup

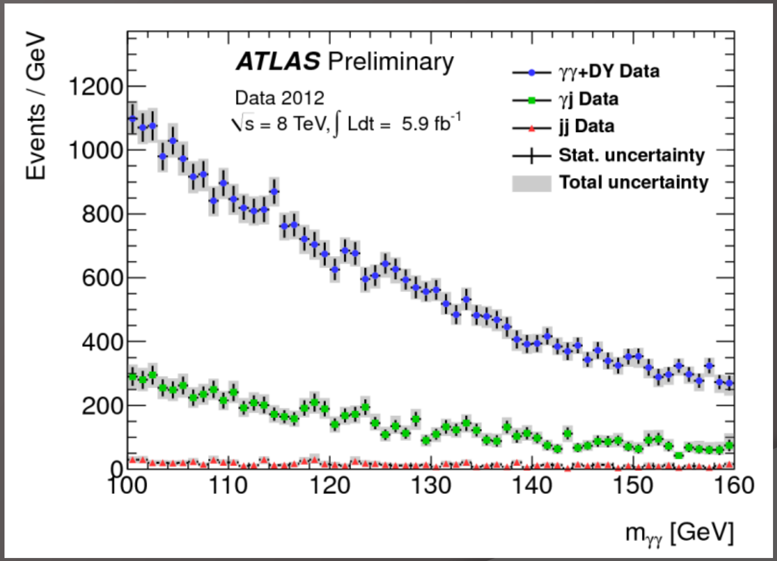
*Uncertainties on H->*γγ analysis

Systematic uncertainties	$\sqrt{s}$ = 7 TeV [%]	$\sqrt{s}$ = 8 TeV [%]
Signal event yield		
Photon identification	±8.4	±10.8
Effect of pileup on photon rec/ID	±4	
Photon energy scale	±0.3	
Photon Isolation	±0.4	±0.5
Trigger	±1	
Higgs boson cross section (perturbative)	$gg \to H$: $^{+12}_{-8}$, VBF: ±0.3, WH: $^{+0.2}_{-0.8}$, ZH: $^{+1.4}_{-1.6}$, ttH: $^{+3}_{-9}$	$gg \to H$: $^{+7}_{-8}$, VBF: ±0.2, WH: $^{+0.2}_{-0.6}$, ZH: $^{+1.6}_{-1.5}$, ttH: $^{+4}_{-9}$
	$gg \to H$ + 2 jets: ±25	
Higgs boson cross section (PDF+α_S)	$gg \to H$: $^{+8}_{-7}$, VBF: $^{+2.5}_{-2.1}$, VH: ±3.5, ttH: ±9	$gg \to H$: $^{+8}_{-7}$, VBF: $^{+2.6}_{-2.8}$, VH: ±3.5, ttH: ±8
Higgs boson branching ratio	±5	
Higgs boson p_T modeling	low p_{Tt}: ±1.1, high p_{Tt}: ∓12.5, 2-jets: ∓9	
Underlying Event (2-jets)	VBF: ±6, Others: ±30	
Luminosity	±1.8	±3.6
Signal category migration		
Material	Unconv: ±4, Conv: ∓3.5	
Effect of pileup on photon rec/ID	Unconv: ±3, Conv: ∓2, 2-jets: ±2	Unconv: ±2, Conv: ∓2, 2-jets: ±12
Jet energy scale	low p_{Tt}	
	$gg \to H$: ±0.1, VBF: ±2.6, Others: ±0.1	$gg \to H$: ±0.1, VBF: ±2.3, Others: ±0.1
	high p_{Tt}	
	$gg \to H$: ±0.1, VBF: ±4, Others: ±0.1	$gg \to H$: ±0.1, VBF: ±4, Others: ±0.1
	2-jets	
	$gg \to H$: ∓19, VBF: ∓8, Others: ∓15	$gg \to H$: ∓18, VBF: ∓9, Others: ∓13
Jet-vertex-fraction		2-jets: ±13, Others: ∓0.3
Primary vertex selection	negligible	
Signal mass resolution		
Calorimeter energy resolution	±12	
Electron to photon extrapolation	±6	
Effect of pileup on energy resolution	±4	
Primary vertex selection	negligible	
Signal mass position		
Photon energy scale	±0.6	
Background modeling	see Table 3	

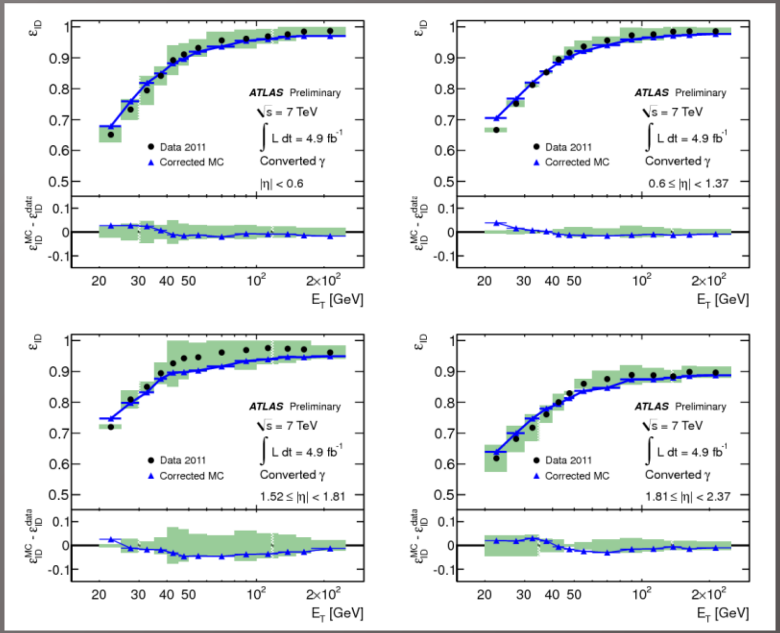
DiPhoton yields

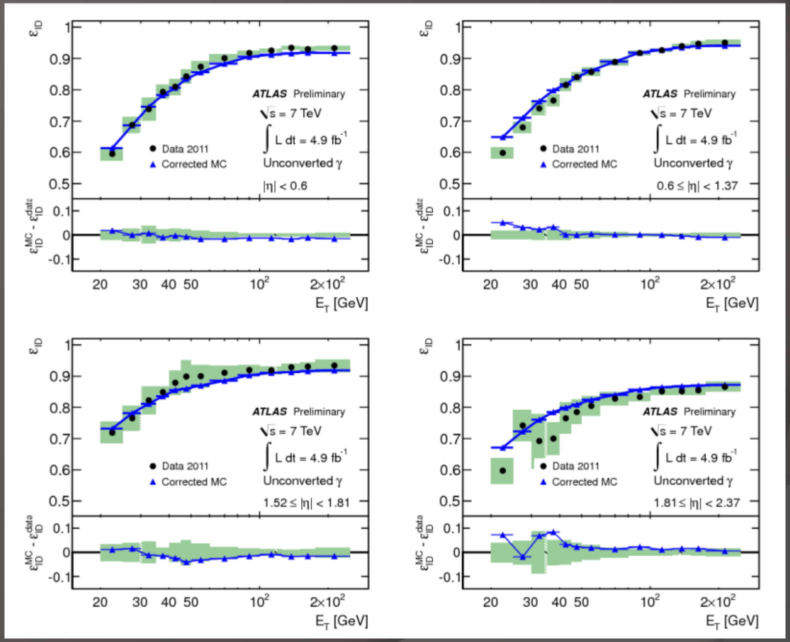
	$\gamma\gamma$+DY	γ-jet	jet-jet
7 TeV (NN ID)	$(80 \pm 4)\%$	$(19 \pm 3)\%$	$(1.8 \pm 0.5)\%$
8 TeV (Cut ID)	$(75 \pm 3)\%$	$(22 \pm 2)\%$	$(2.6 \pm 0.5)\%$





Photon efficiencies





Characteristics of categories

Category	σ_{CB} [GeV]	FWHM [GeV]	Observed [N_{evt}]	S [N_{evt}]	B [N_{evt}]
Inclusive	1.63	3.87	3693	100.4	3635
Unconverted central, low p_{Tt}	1.45	3.42	235	13.0	215
Unconverted central, high p_{Tt}	1.37	3.23	15	2.3	14
Unconverted rest, low p_{Tt}	1.57	3.72	1131	28.3	1133
Unconverted rest, high p_{Tt}	1.51	3.55	75	4.8	68
Converted central, low p_{Tt}	1.67	3.94	208	8.2	193
Converted central, high p_{Tt}	1.50	3.54	13	1.5	10
Converted rest, low p_{Tt}	1.93	4.54	1350	24.6	1346
Converted rest, high p_{Tt}	1.68	3.96	69	4.1	72
Converted transition	2.65	6.24	880	11.7	845
2-jets	1.57	3.70	18	2.6	12

Background fit functions

Category	Parametrization	Uncertainty [N_{evt}] $\sqrt{s}$ = 7 TeV	Uncertainty [N_{evt}] $\sqrt{s}$ = 8 TeV
Inclusive	4th order pol.	7.3	10.6
Unconverted central, low p_{Tt}	Exp. of 2nd order pol.	2.1	3.0
Unconverted central, high p_{Tt}	Exponential	0.2	0.3
Unconverted rest, low p_{Tt}	4th order pol.	2.2	3.3
Unconverted rest, high p_{Tt}	Exponential	0.5	0.8
Converted central, low p_{Tt}	Exp. of 2nd order pol.	1.6	2.3
Converted central, high p_{Tt}	Exponential	0.3	0.4
Converted rest, low p_{Tt}	4th order pol.	4.6	6.8
Converted rest, high p_{Tt}	Exponential	0.5	0.7
Converted transition	Exp. of 2nd order pol.	3.2	4.6
2-jets	Exponential	0.4	0.6

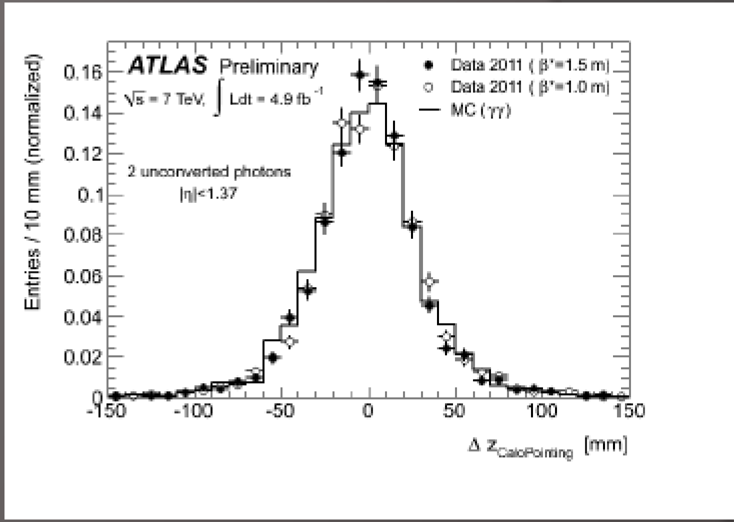
Pointing

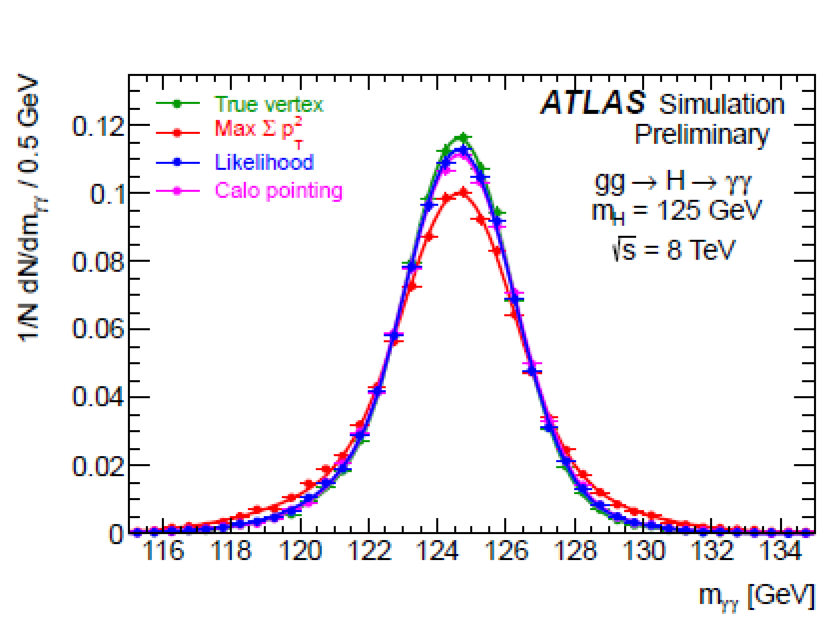
Improve photon angle measurement using likelihood based on

- Photon pointing
  - ⋆ Photon direction measured from calorimeter using longitudinal segmentation
  - ⋆ Position of conversion vertex for converted photons (with Si hits) — 7 TeV only
  - ⋆ Constraint to LHC beam spot
  - → Measure primary vertex position to $\sim 1.5\,\mathrm{cm}$
- Highest $\Sigma_{\mathrm{tracks}} p_T^2$ primary vertex from tracking

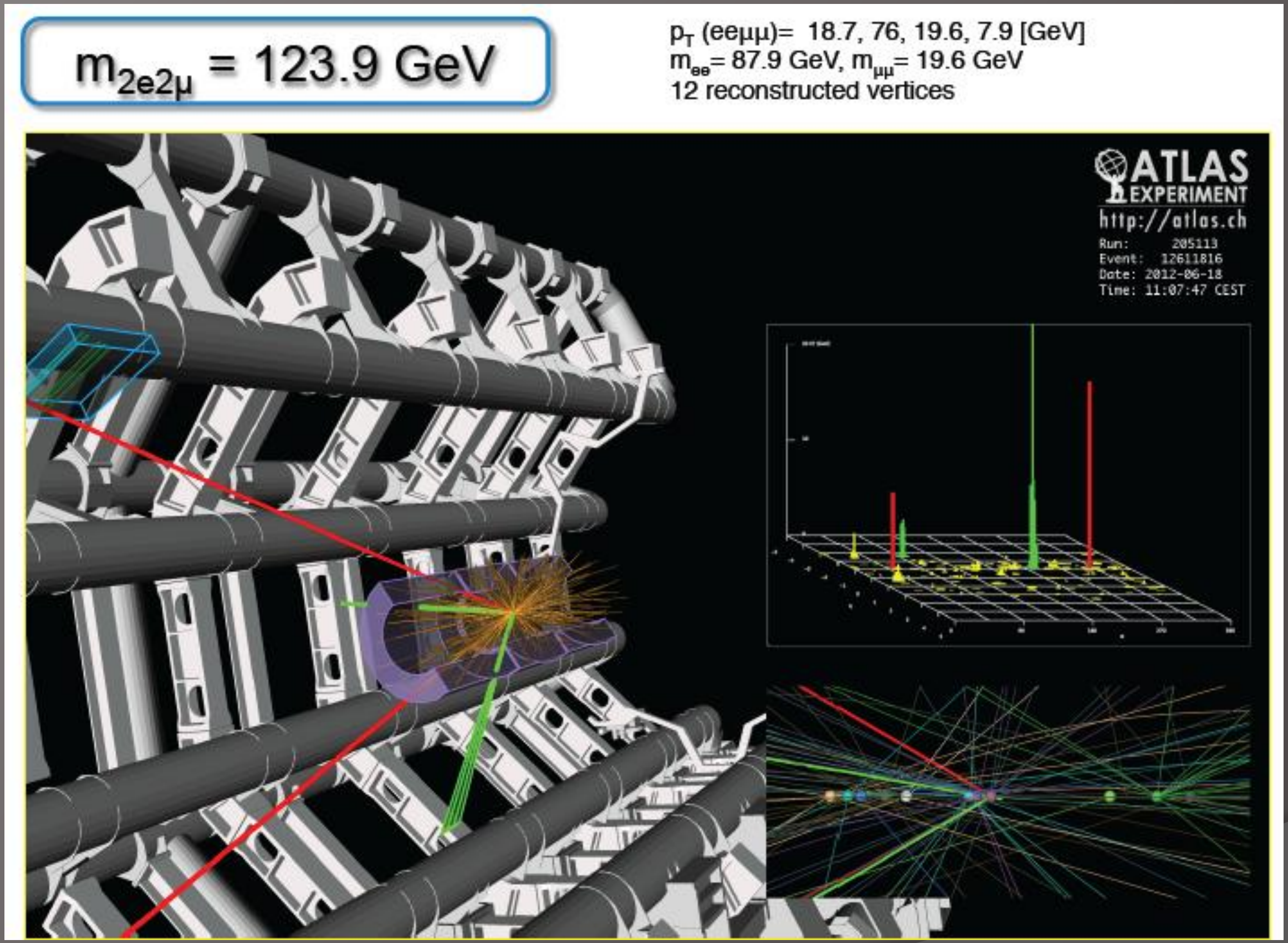
→ Contribution of angle measurement to mass resolution negligible already without primary vertex information

- ⋆ Robust with respect to pileup





H-> 2e 2μ candidate

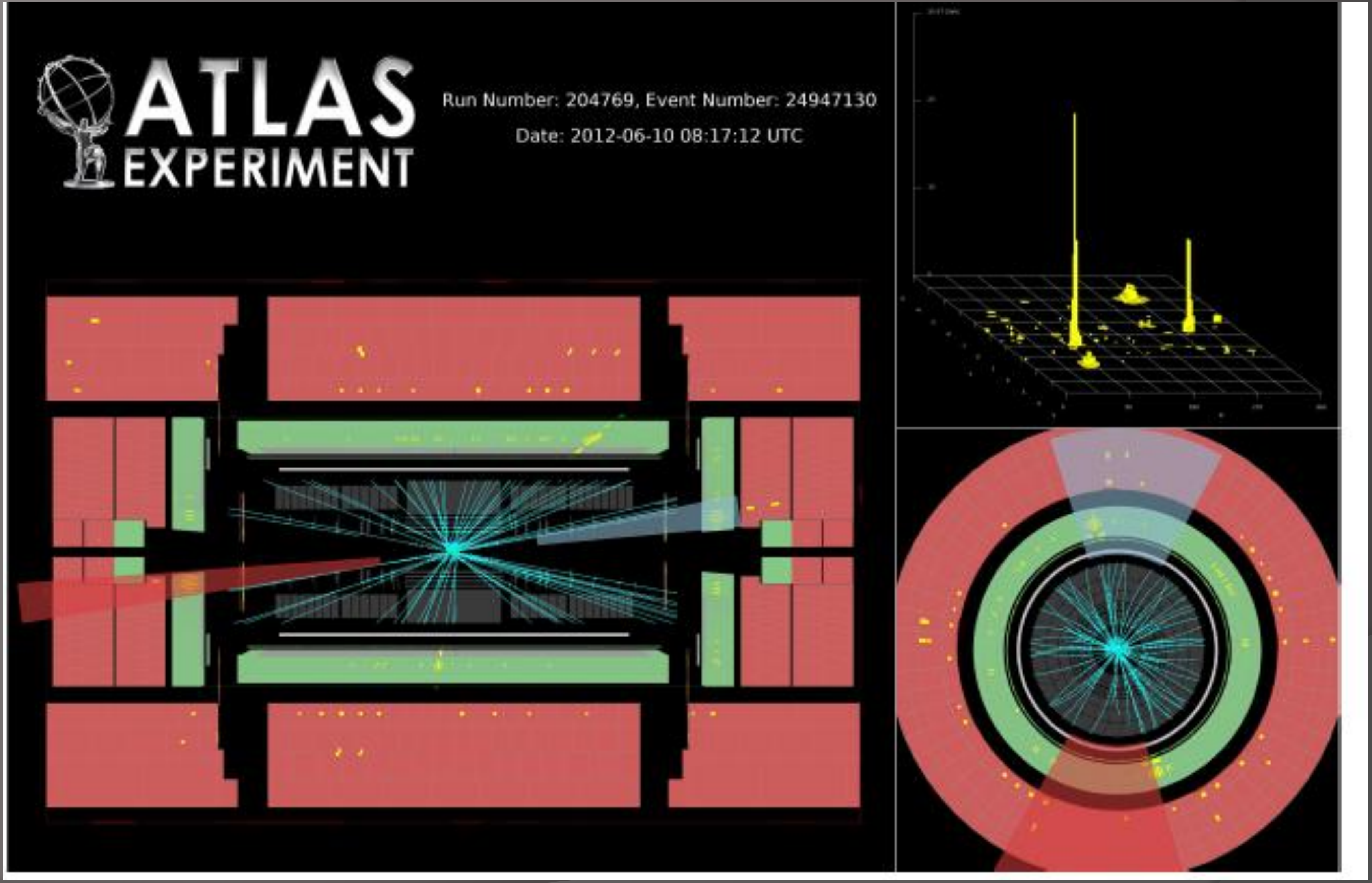


2011 H->γγ new analysis

15% expected improvement

Published analysis	Present 7 TeV analysis
$p_T^2 > 25\,\mathrm{GeV}$	$p_T^2 > 30\,\mathrm{GeV}$
Cut-based photon id	Neural neutwork photon id
Cell-based isolation	Cluster-based isolation
p_{Tt} categories: $40\,\mathrm{GeV}$	p_{Tt} categories: $60\,\mathrm{GeV}$
9 categories	10 categories (2-jets)
Pointing primary vertex	Likelihood primary vertex
Exponential background shape	New background parametrization

H->$\gamma\gamma$ VBF candidate (2jet category)



Strenghs and exclusions

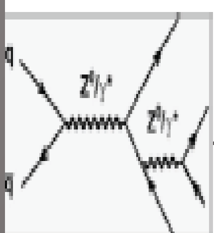
Search channel	Dataset	m_{max} [GeV]	Z_l [σ]	$E(Z_l)$ [σ]	$\hat{\mu}(m_H = 126$ GeV$)$	Expected exclusion [GeV]	Observed exclusion [GeV]
$H \rightarrow ZZ^{(*)} \rightarrow 4\ell$	7 TeV	125.0	2.5	1.6	1.4 ± 1.1		
	8 TeV	125.5	2.6	2.1	1.1 ± 0.8		
	7 & 8 TeV	125.0	3.6	2.7	1.2 ± 0.6	124–164, 176–500	131–162, 170–460
$H \rightarrow \gamma\gamma$	7 TeV	126.0	3.4	1.6	2.2 ± 0.7		
	8 TeV	127.0	3.2	1.9	1.5 ± 0.6		
	7 & 8 TeV	126.5	4.5	2.5	1.8 ± 0.5	110–140	112–123, 132–143
$H \rightarrow WW^{(*)} \rightarrow \ell\nu\ell\nu$	7 TeV	135.0	1.1	3.4	0.5 ± 0.6		
	8 TeV	120.0	3.3	1.0	1.9 ± 0.7		
	7 & 8 TeV	125.0	2.8	2.3	1.3 ± 0.5	124–233	137–261
Combined	7 TeV	126.5	3.6	3.2	1.2 ± 0.4		
	8 TeV	126.5	4.9	3.8	1.5 ± 0.4		
	7 & 8 TeV	126.5	6.0	4.9	1.4 ± 0.3	110–582 113–532 (*)	111–122, 131–559 113–114, 117–121, 132–527 (*)

pp->Z->4l

MZ±10 GeV
Obs : 57
Exp: 65± 5

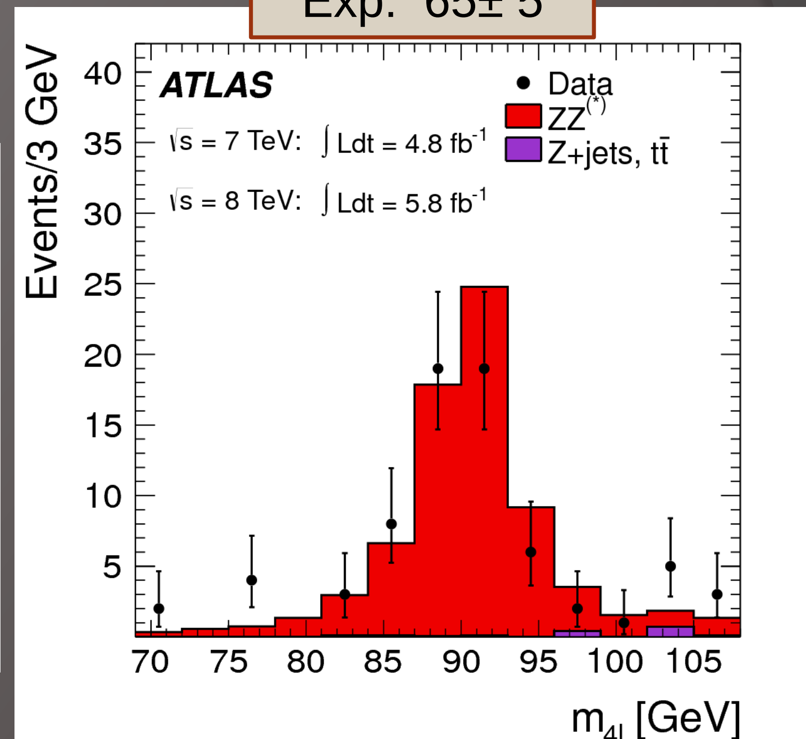
$pp \to Z \to 4l$

Relax analysis requirements: m_{12}>30 GeV, m_{34}>5 GeV and lower p_T for muons (>4 GeV)



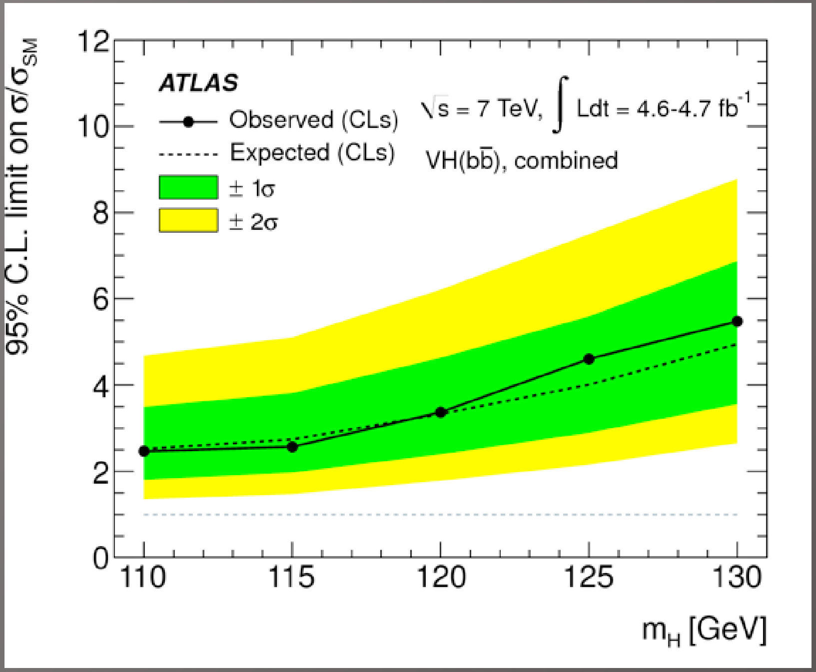
→ Cross-check of analysis configuration

→ Indicates (again) reasonable behavior of lepton reconstruction/identification



H->fermionPairs search (2011)

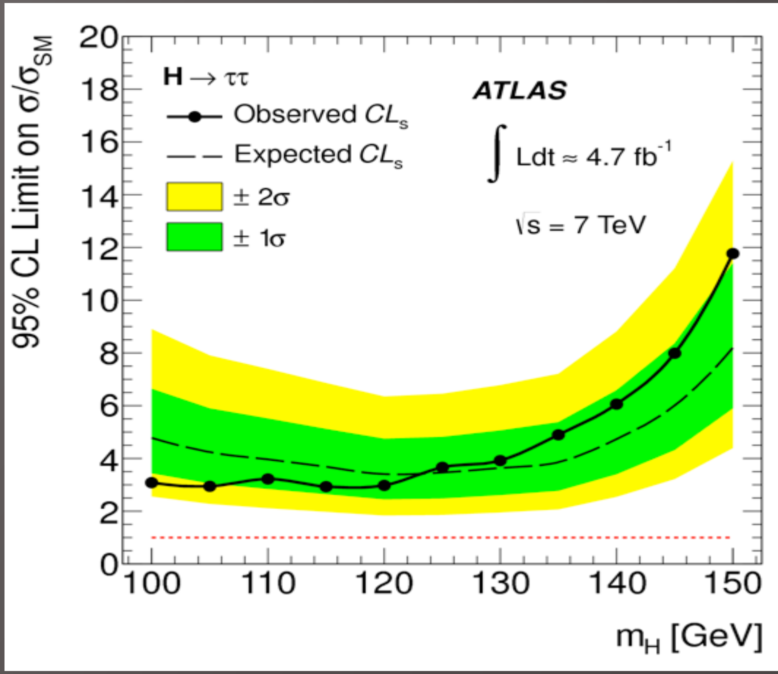
Categories : P_T(Z/W), ETmiss
Sensitivity : 3.5 x SM at M_H=125GeV



H->bb combined

ZH->llbb, ZH->ννbb, WH->lνbb

Categories: 0, 1, 2 jets
Sensitivity : 3.2 x SM at M_H=125GeV



H->ττ combined

ττ -> l-l, l-had, had-had