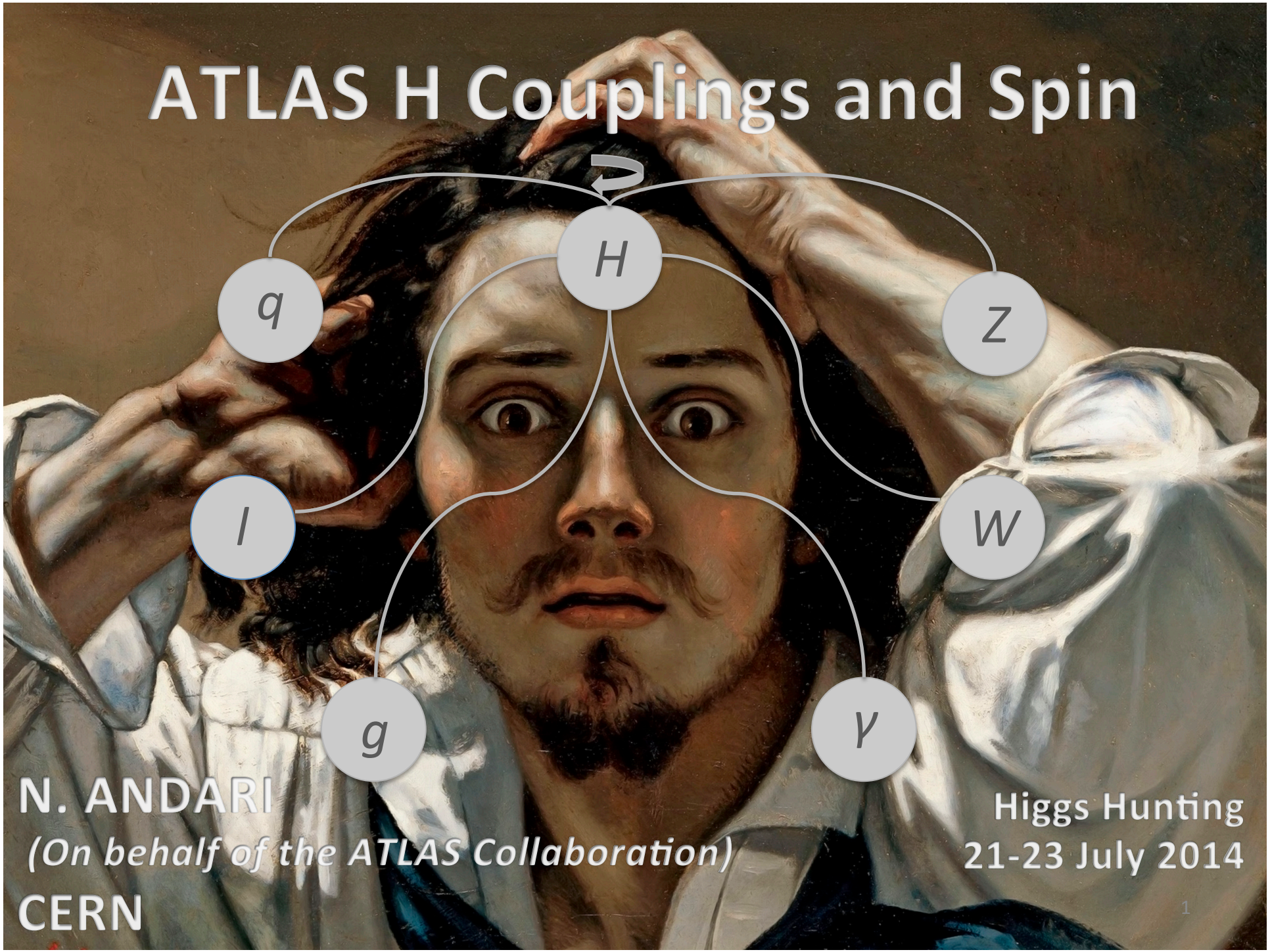
ATLAS H Couplings and Spin



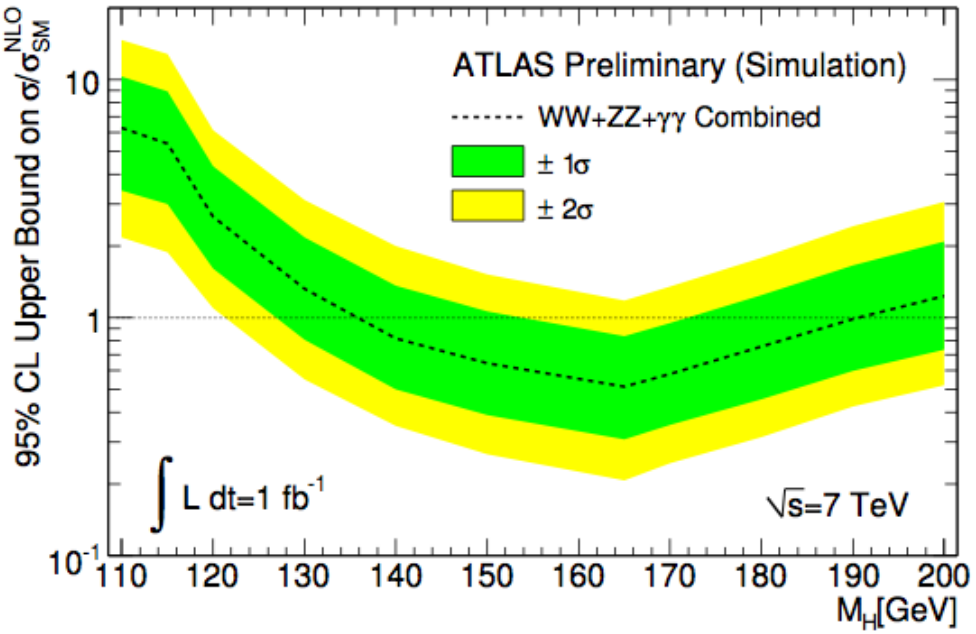
N. ANDARI
(On behalf of the ATLAS Collaboration)
CERN

Higgs Hunting
21-23 July 2014

Outline

- Introduction
- Brief review of bosonic channels (for more details see Marianna's talk)
- Spin/Parity Combination Results
- Brief review of fermionic channels (for more details see Geng-Yuan's talk)
- Combination of Higgs coupling measurements
- Constraints on New Phenomena from coupling measurements
- Conclusions and Perspectives

2010 LHC data taking (7 TeV,
$L \approx 340\ nb^{-1}$)
Performance studies and setting first exclusion limits with a projection to $1fb^{-1}$

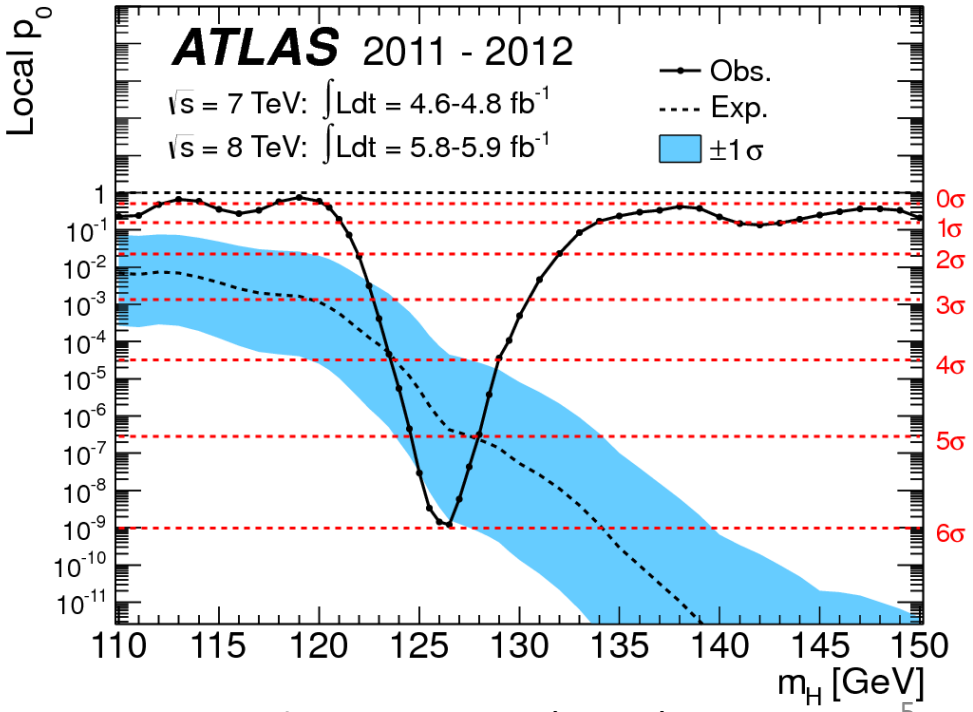


ATL-PHYS-PUB-2010-009

2010 LHC data taking (7 TeV,
$L \approx 340\ nb^{-1}$)
Performance studies and setting first exclusion limits

2011 data (7 TeV, $L = 1fb^{-1}$)
Hunting and setting exclusion limits
$155 < M_H < 190$ GeV and $295 < M_H < 450$ GeV

Unveil the scalar boson, Discovery by the ATLAS and CMS experiments using 2011 and 2012 data (5fb^{-1} 7 TeV and 6fb^{-1} of 8 TeV)



Phys.Lett.B716(2012) 1-29

Unveil the scalar boson, Discovery by the ATLAS and CMS experiments using 2011 and 2012 data (5 fb^{-1} 7 TeV and 6 fb^{-1} of 8 TeV)

Measurement of the first properties of the scalar boson using data (5 fb^{-1} 7 TeV and 20 fb^{-1} of 8 TeV)

Final LHC Run-I data analyses. Precision measurements of the properties of the scalar boson: mass, couplings, spin, differential cross section… with an improved calibration/ analysis

Many Results to be updated soon. The combination result is based on results of the old analysis published in *Phys.Lett.B726(2013), pp. 88-119, Phys.Lett.B726(2013), pp. 120-144, ATLAS-CONF-2014-009 and ATLAS-CONF-2014-010*

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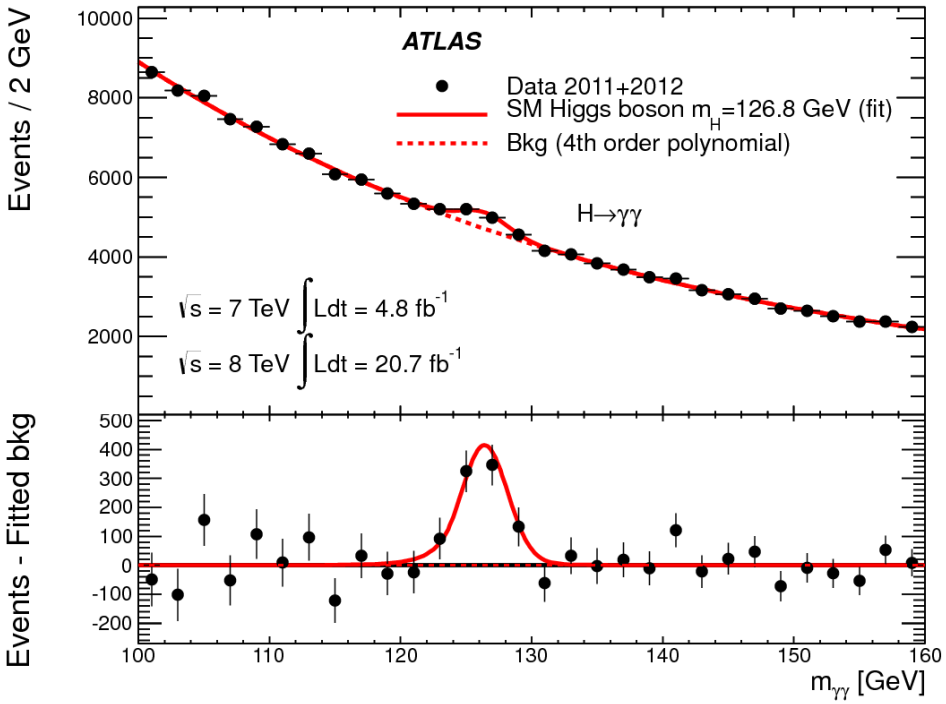
H--> γ γ analysis

Phys.Lett.B726(2013), pp. 88-119



Local significance: observed 7.4σ (expected 4.1σ)

Best fit mass= 126.8 ± 0.2 (stat) ± 0.7 (syst) GeV

H-->γ γ analysis

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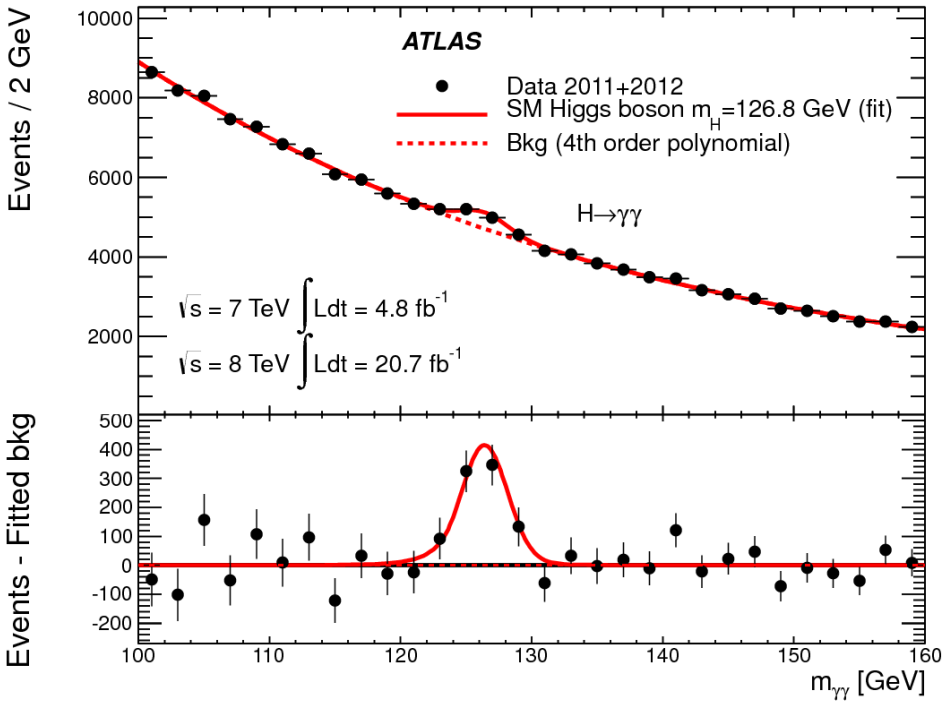
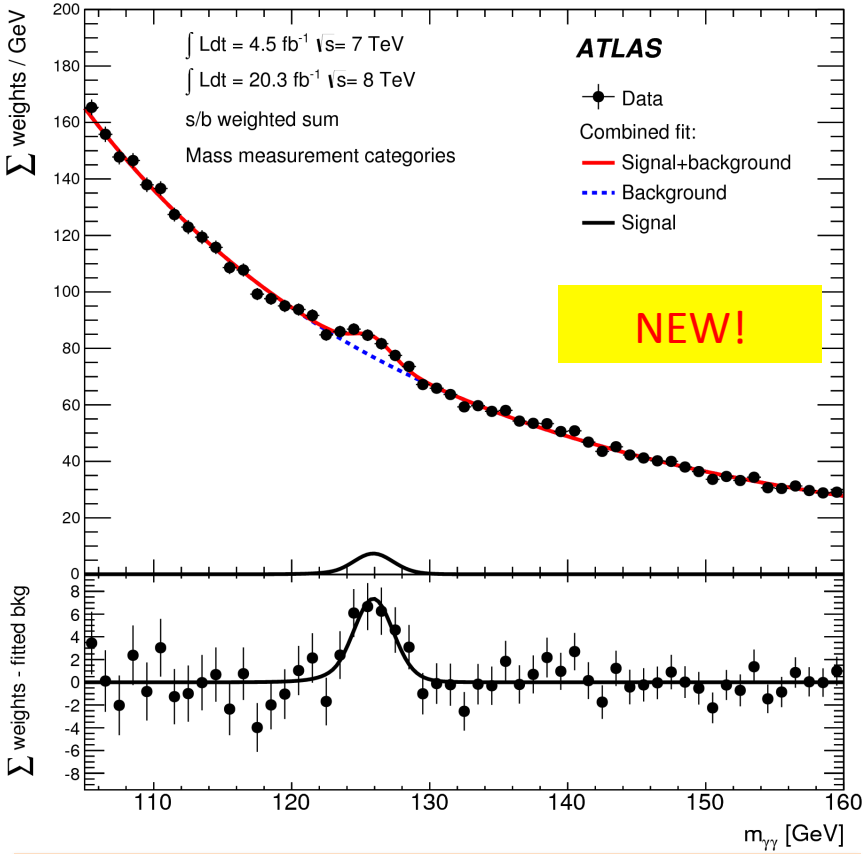


arXiv:1406.3827[hep-ex] submitted to PRD



Local significance: observed 7.4σ (expected 4.1σ)

Best fit mass= 126.8 ± 0.2 (stat) ± 0.7 (syst) GeV

New Mass Fit Result:
125.98±0.42(stat)±0.28(syst) GeV

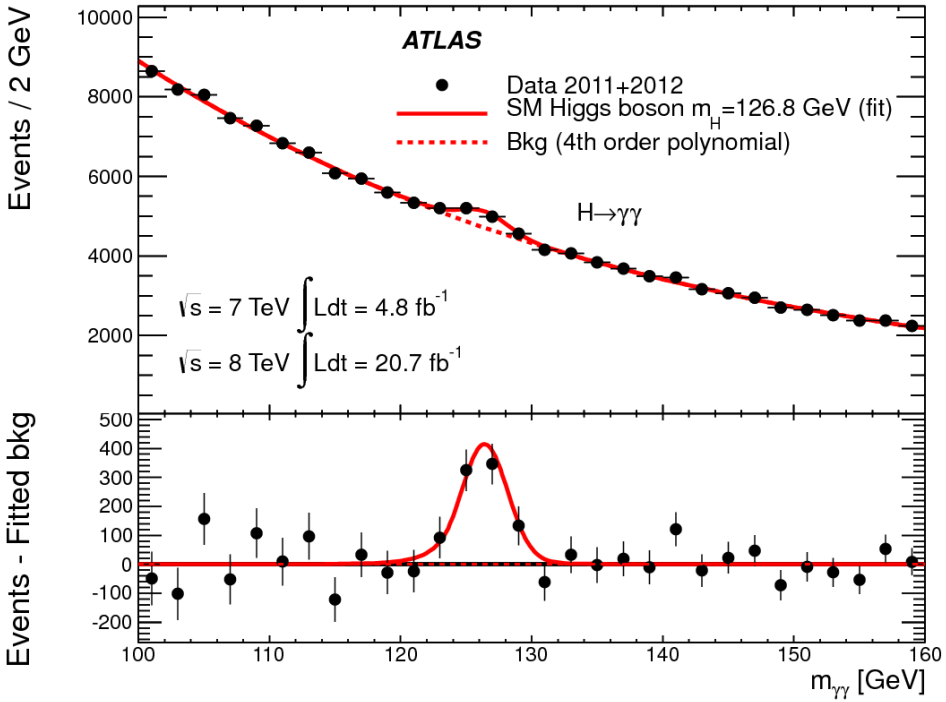
Improved calibration, detector material description and analysis

For more details on the new mass measurement see Sarah's talk

The old mass measurement is used for the combination presented in this talk

H-->γ γ analysis

Phys.Lett.B726(2013), pp. 88-119

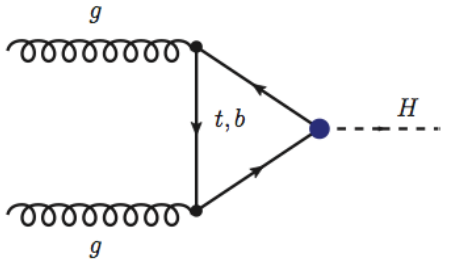


Local significance: observed 7.4σ (expected 4.1σ)
Best fit mass= 126.8 ± 0.2 (stat) ± 0.7 (syst) GeV

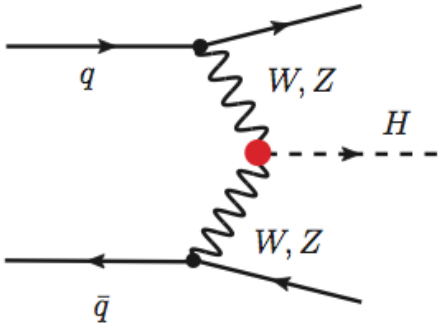
Classification into 14 categories with different S/B (1-60%) and different resolutions (1.4-2.5 GeV)
--> optimised for coupling measurements to fermions/bosons

New Couplings analysis will be updated soon

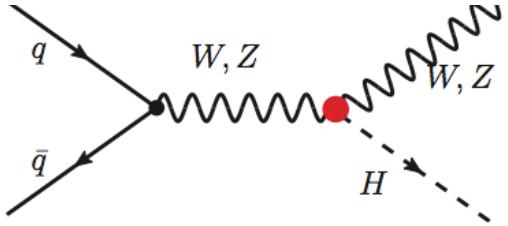
ggH



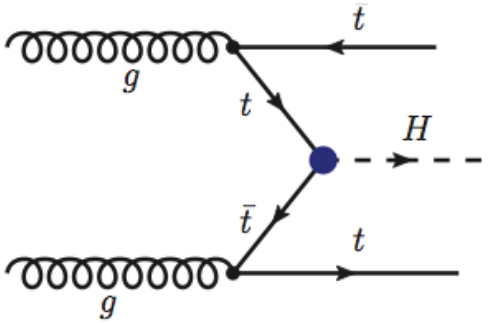
VBF



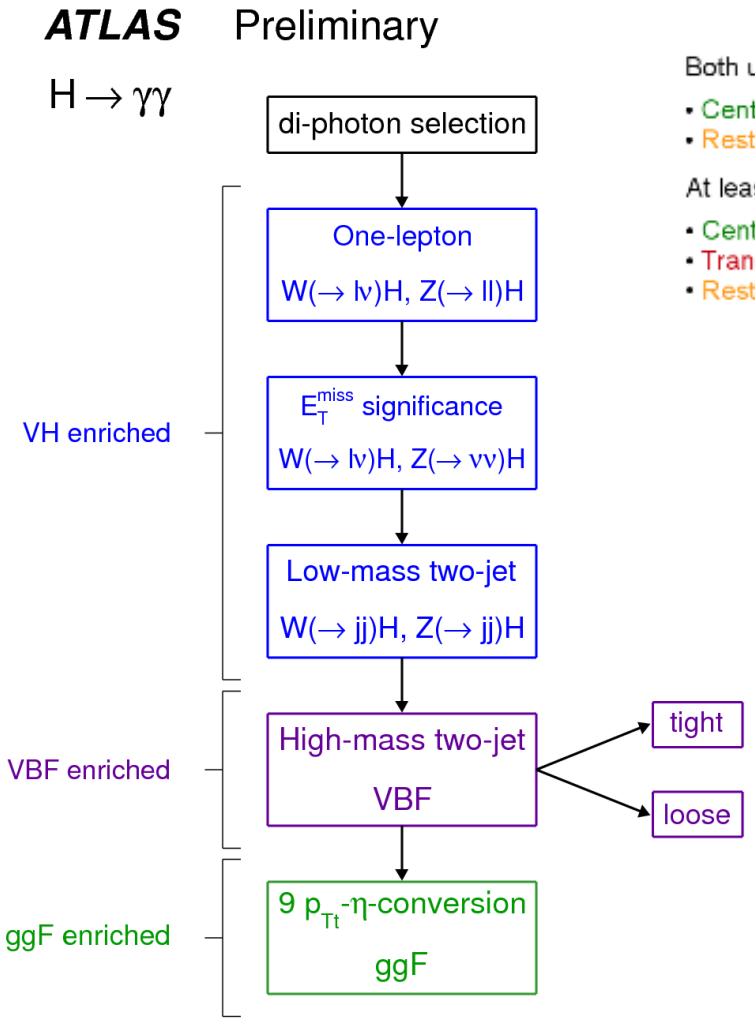
VH

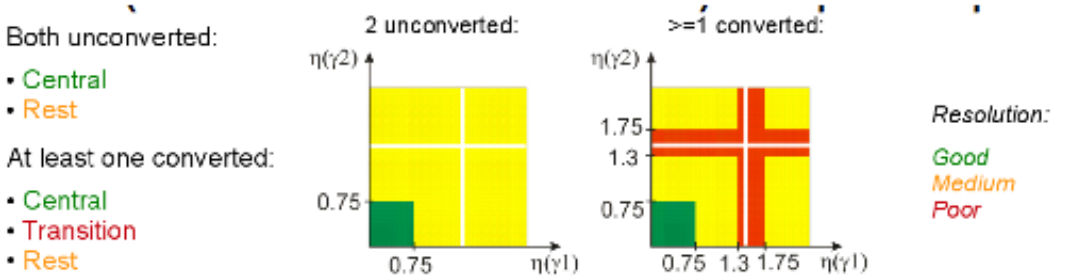


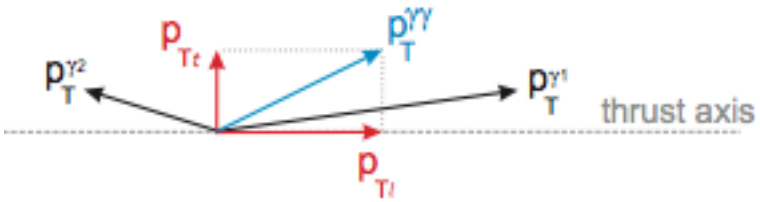
ttH

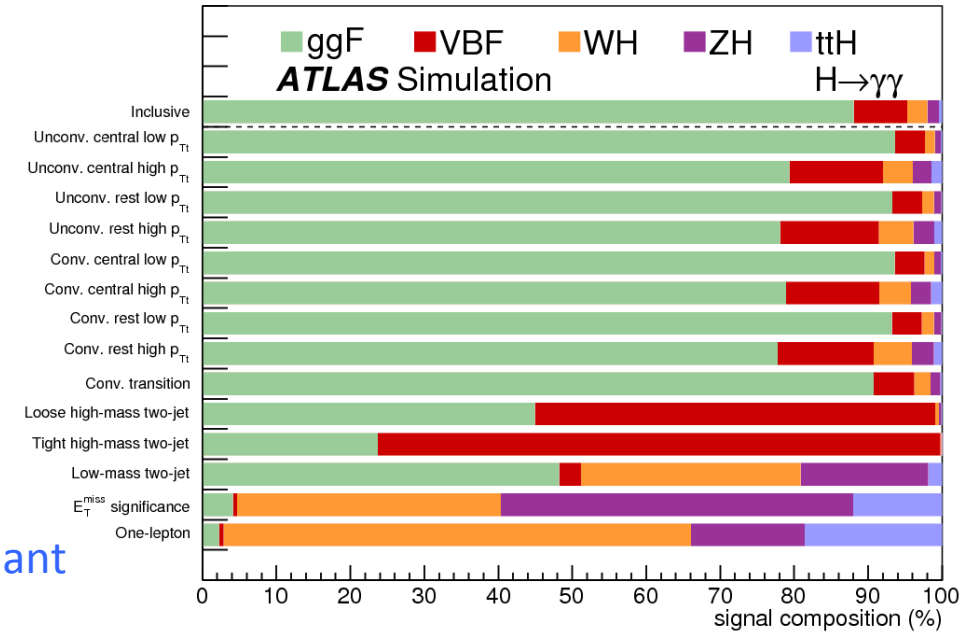


H-->γ γ analysis







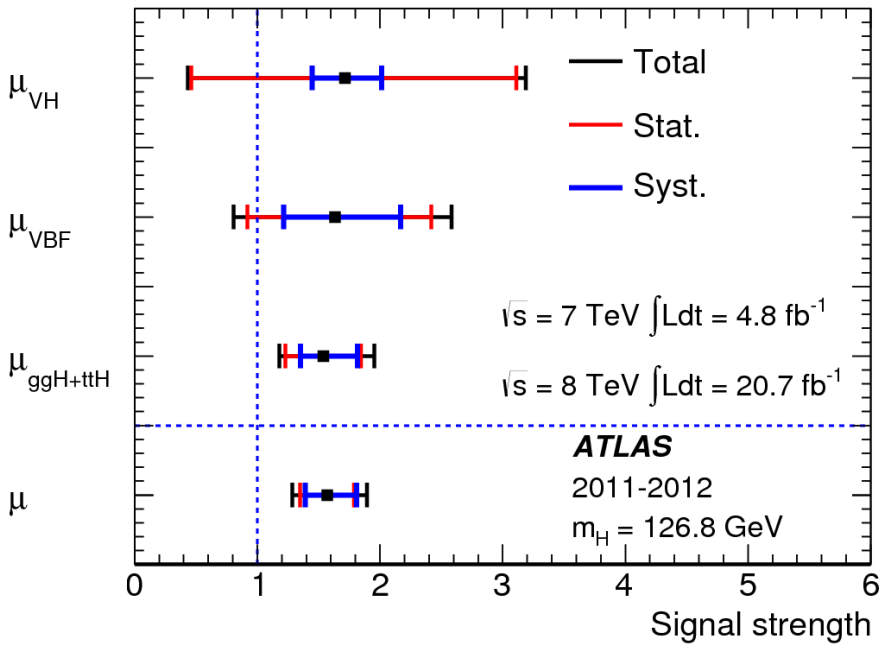


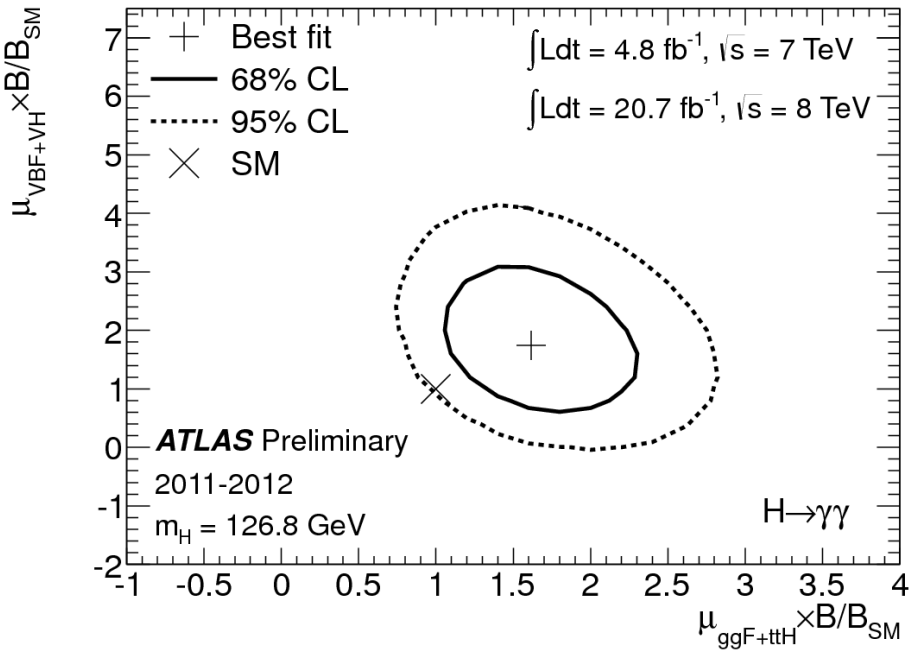
VBF-like category is built on a MVA discriminant

VBF purity~75%, ~8 signal events expected

**For 7 TeV analysis, only 10 categories are used: 9 depending on η and pTt and one VBF-like*

H--> γ γ couplings measurement





Best fit of signal strength @125.5 GeV:

Phys.Lett.B726(2013), pp. 88-119

$$\mu = \sigma / \sigma_{SM} = 1.55 \pm 0.23(stat) \pm 0.15(syst) \pm 0.15(th)$$

Compatibility with the SM at the level of 2σ (consistency checked in all categories)

$$\mu_{ggF+ttH} = 1.5 \pm 0.3(stat)^{+0.3}_{-0.2}(sys), \mu_{VBF} = 1.6 \pm 0.8(stat)^{+0.5}_{-0.4}(syst),$$

$$\mu_{VH} = 1.7^{+1.5}_{-1.3}(stat) \pm 0.3(sys)$$

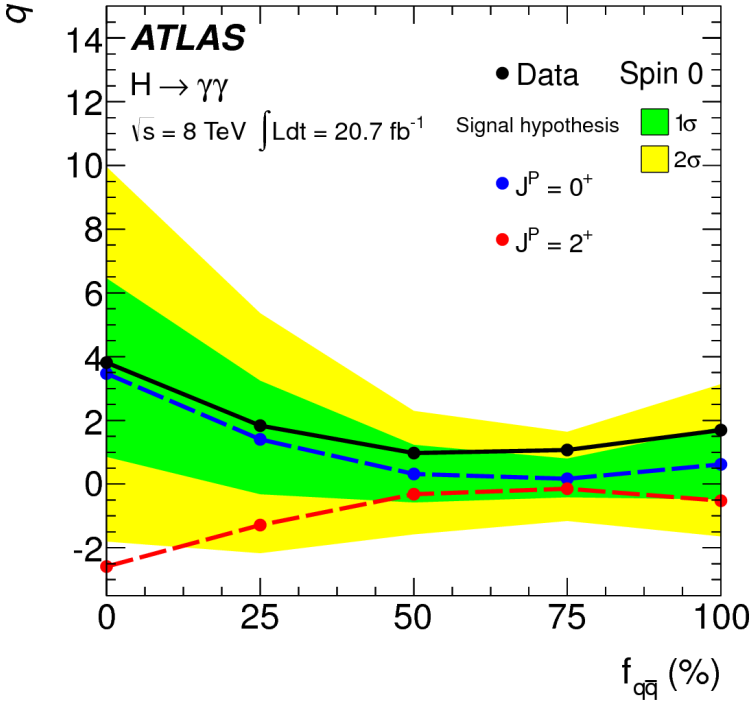
H--> γ γ spin measurement

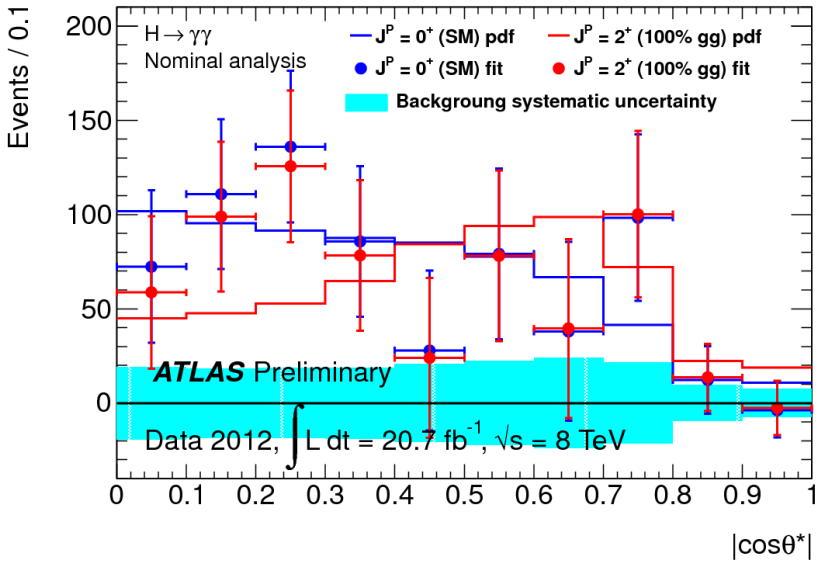
Landau-Yang theorem forbids a direct decay of an on-shell spin 1 particle to γγ->look@spin2

Discriminant: polar angle distribution of the photons in the resonance (Collins-Soper) rest frame θ*

2^+_m (graviton-like tensor with minimal couplings) hypothesis considered

2^+: different fractions of qq (f_{qq}) are considered, from 0% to 100% in steps of 25%



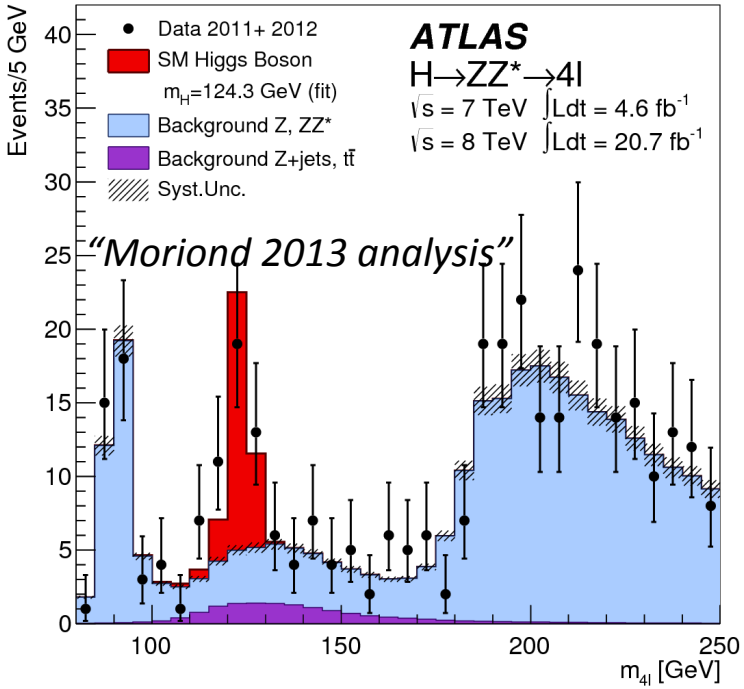


The minimal spin 2^+ hypothesis is excluded at the level of **99.3% CL** (2.46 σ) for 100% gg production mode

Phys.Lett.B726(2013), pp. 120-144

H-->ZZ-->4l analysis

Phys.Lett.B726(2013), pp. 88-119



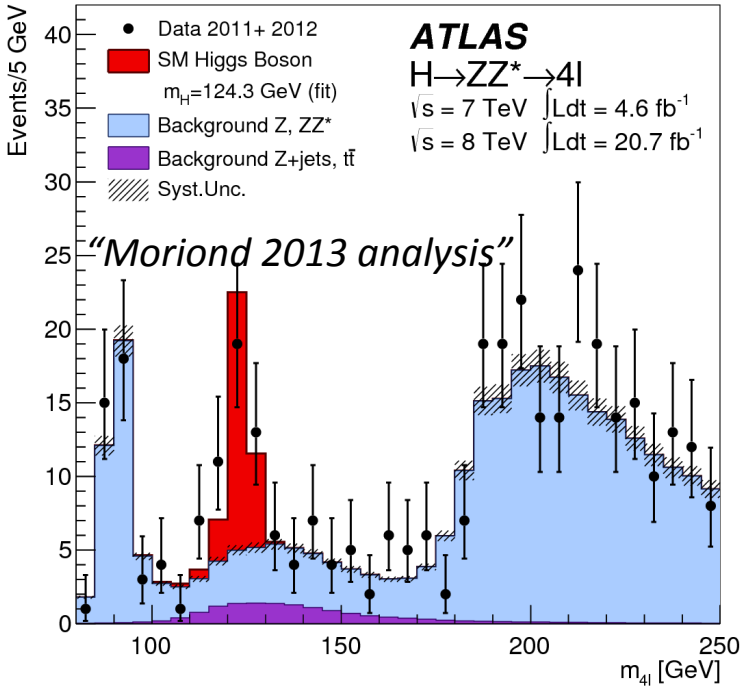
Local significance 6.6σ (expected 4.4σ)

at best fit mass:

$$124.3^{+0.6}_{-0.5}(stat)^{+0.5}_{-0.3}(syst)GeV$$

H-->ZZ-->4l analysis

Phys.Lett.B726(2013), pp. 88-119

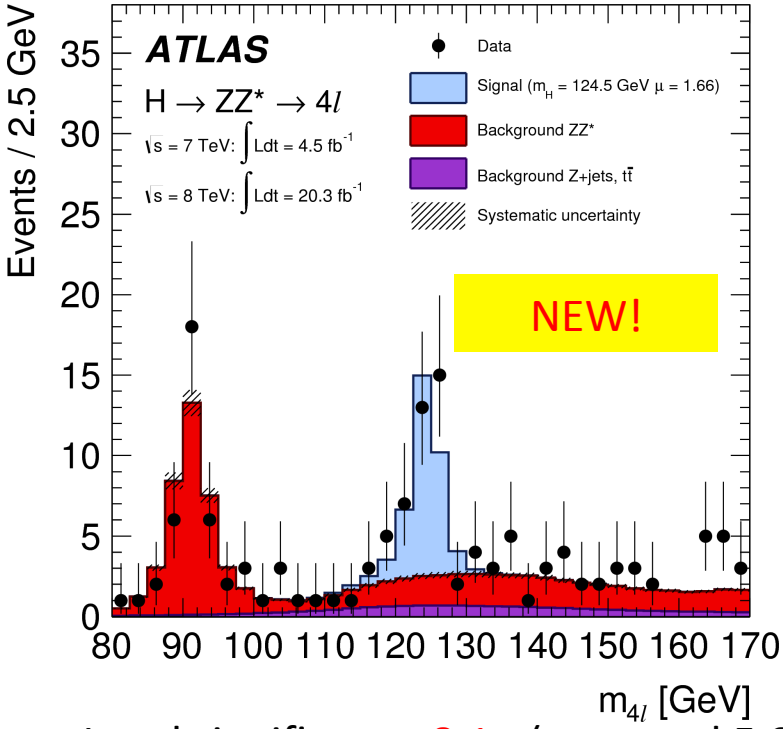


Local significance 6.6σ (expected 4.4σ)

at best fit mass:

$124.3^{+0.6}_{-0.5}(stat)^{+0.5}_{-0.3}(syst)GeV$

(To be submitted to PRD)



Local significance 8.1σ (expected 5.8σ)

at best fit mass:

$124.51 \pm 0.52(stat) \pm 0.06(syst)GeV$

No big change in the mass

New in the inclusive analysis (used also for the new mass measurement) since Moriond 2013:

-new electron ID (loose likelihood for 2012 only)

-new electron and muon energy calibration

-E/p combination for the electrons

-far FSR recovery for electrons and muons

-BDT for ZZ* background…

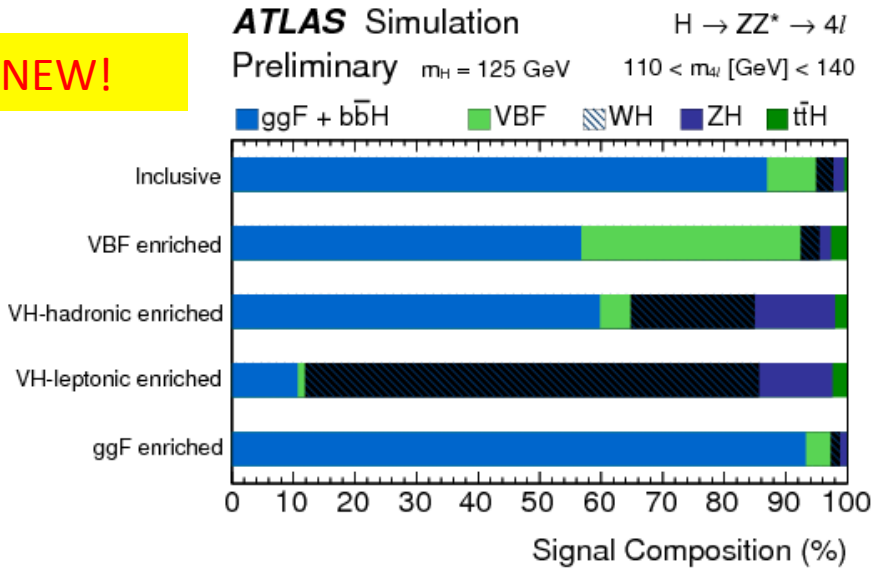
H-->ZZ-->4l coupling analysis

(To be submitted to PRD)

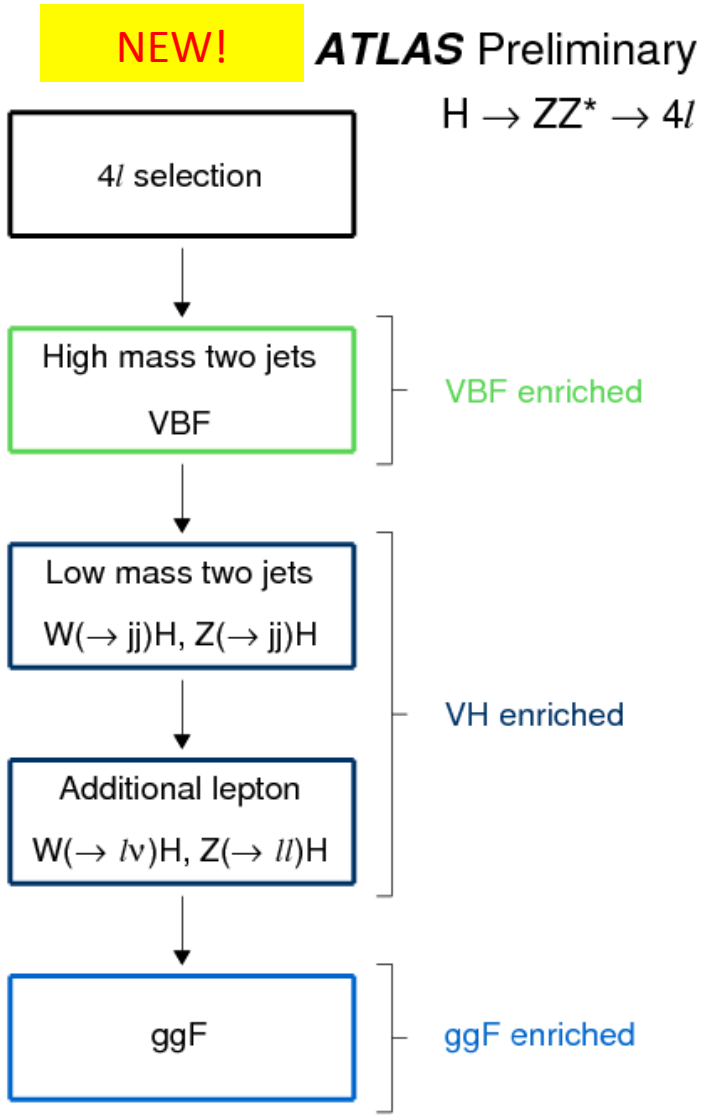
3 categories were considered in the Moriond 2013 analysis:
-VBF-like (accompanied with 2 high pT jets widely separated in rapidity),
-VH-like (accompanied with an additional lepton)
-ggF-like (all the others)

New in the specific couplings analysis:
-Add a VH hadronic category
-Looser cuts on the VBF category
-BDT for both VBF and VH categories

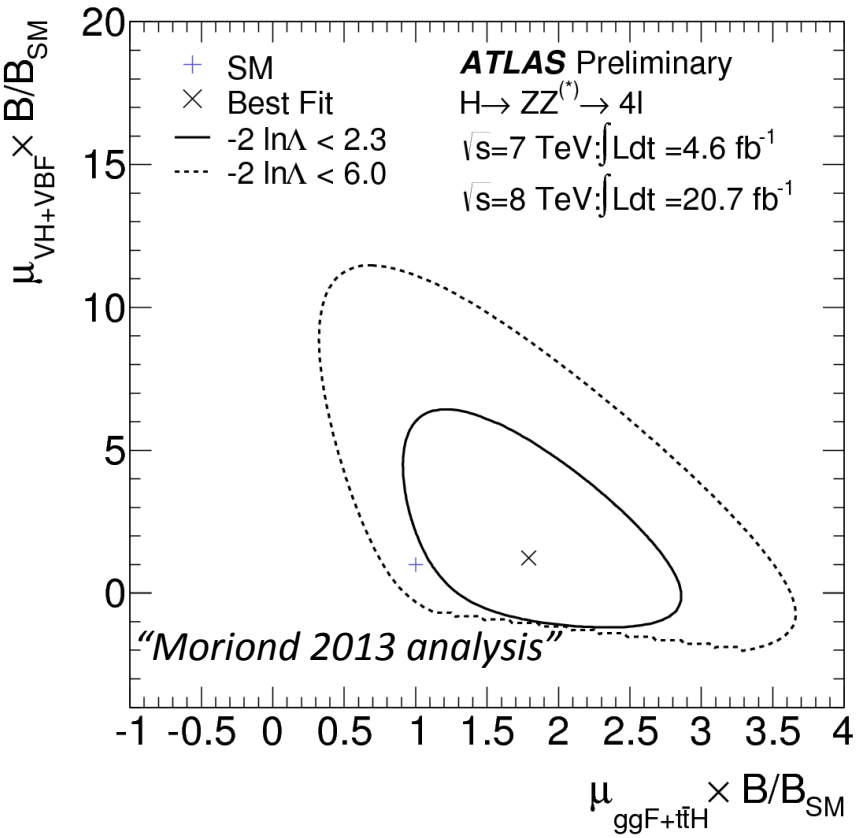
NEW!



NEW!



H-->ZZ-->4l coupling measurement



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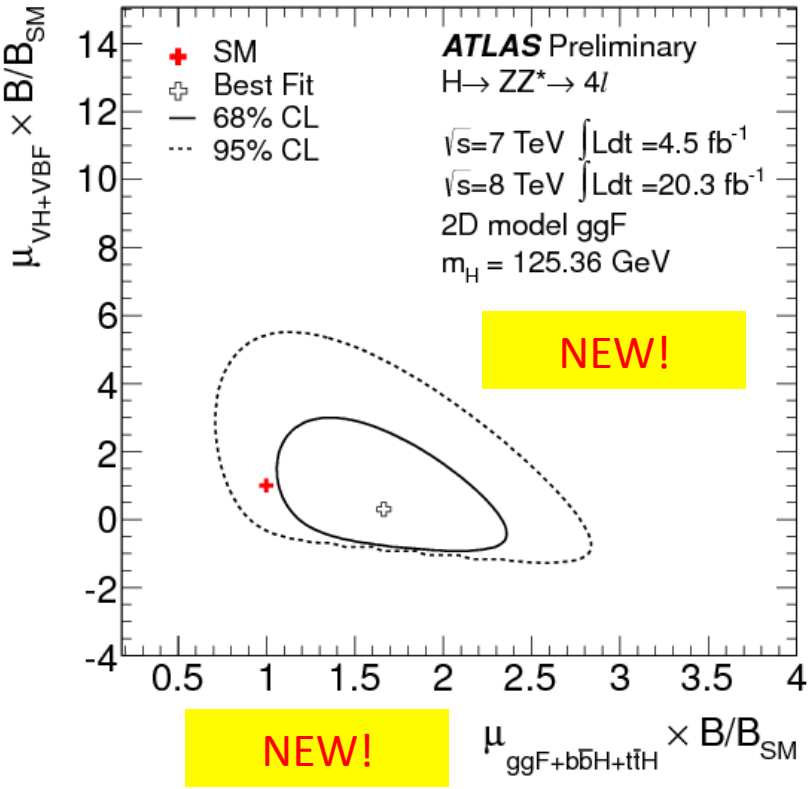


@mass (4l) = 124.3 GeV

$\mu = 1.7^{+0.5}_{-0.4}$

$\mu_{ggF+bbH+ttH} * B / B_{SM} = 1.8^{+0.8}_{-0.5}$

$\mu_{VBF+VH} * B / B_{SM} = 1.2^{+3.8}_{-1.4}$

@mass (4l+γγ) = 125.5 GeV

$\mu = 1.44^{+0.40}_{-0.35}$

No change in mu
as next combination input

@mass (4l+γγ) = 125.36 GeV

$\mu = 1.44^{+0.34}_{-0.31}(stat)^{+0.21}_{-0.11}(syst)$

$\mu_{ggF+bbH+ttH} * B / B_{SM} = 1.66^{+0.45}_{-0.41}(stat)^{+0.25}_{-0.15}(syst)$

$\mu_{VBF+VH} * B / B_{SM} = 0.26^{+1.60}_{-0.91}(stat)^{+0.36}_{-0.23}(syst)$

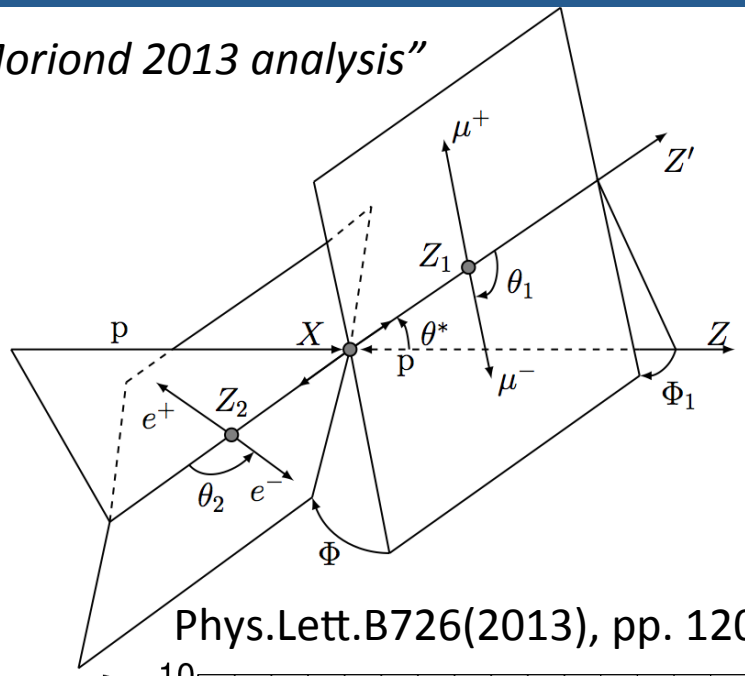
Old ZZ result is used in the current combination but no big change expected with the new result

H-->ZZ-->4l spin/CP measurement

Spin 0^-, 1^+, 1^- and 2^+_m hypotheses are considered using kinematic properties: 5 production and decay angles, m_{12}, m_{34}
→BDT

The production and decay of non-SM resonances are produced using JHU LO generator, interfaced to Pythia8 for PS and hadronisation.

"Moriond 2013 analysis"



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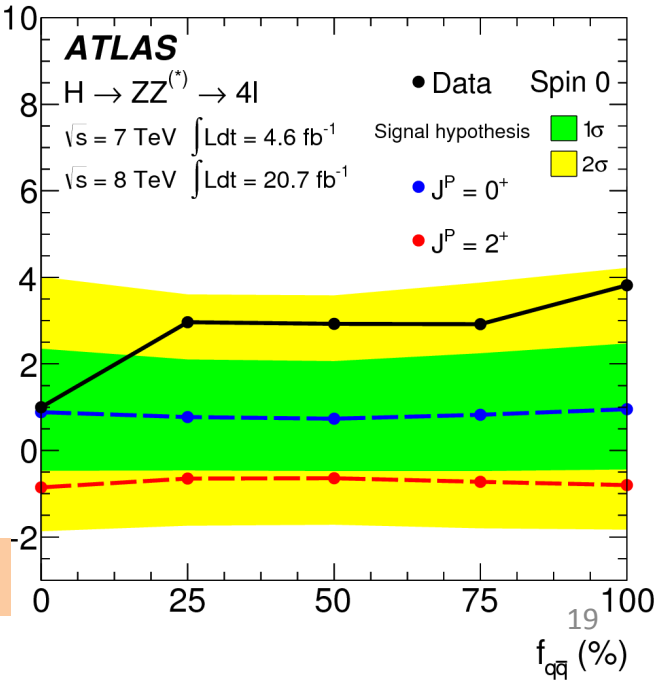
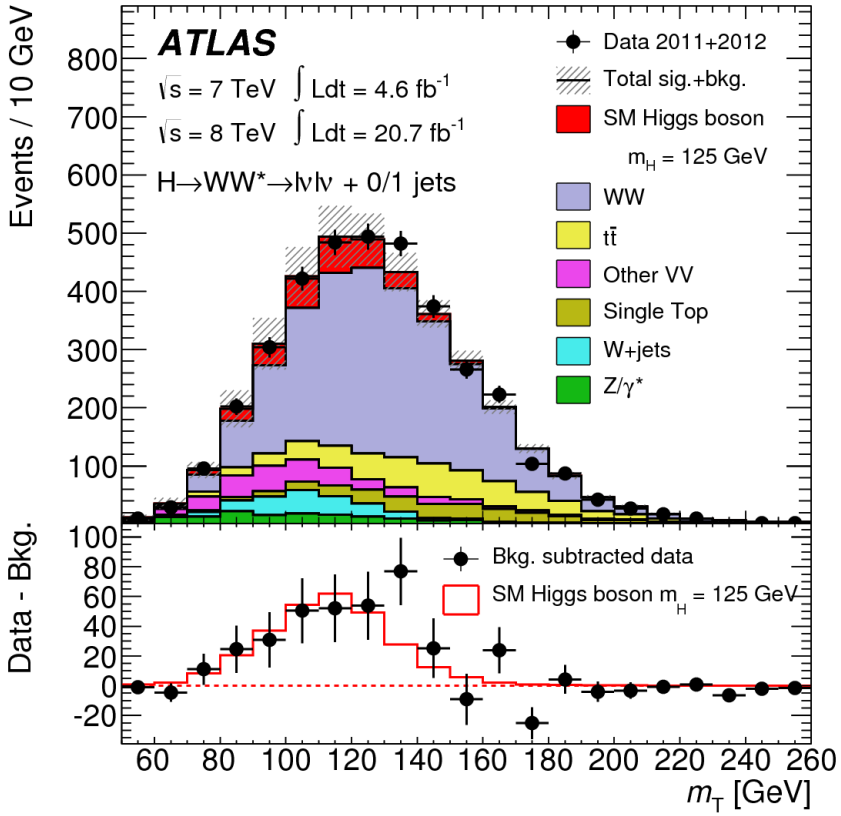
Spin	Observed exclusion CLs
0^-	97.8%
1^+	99.8%
1^-	94.0%
2^+_m	83.0%



The spin 0^- and 1^- are excluded > 97%CL in favour of 0^+

H-->WW-->lν lν couplings



Observed significance@125 GeV:
3.8σ (expected 3.7σ)

$$\mu = 1.01 \pm 0.31 (@125 GeV)$$

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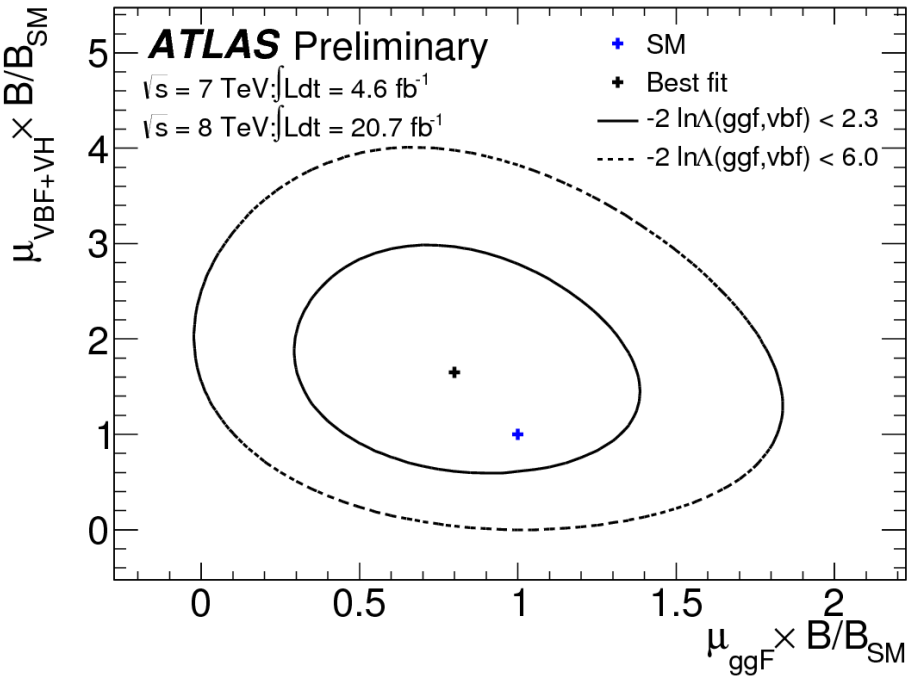


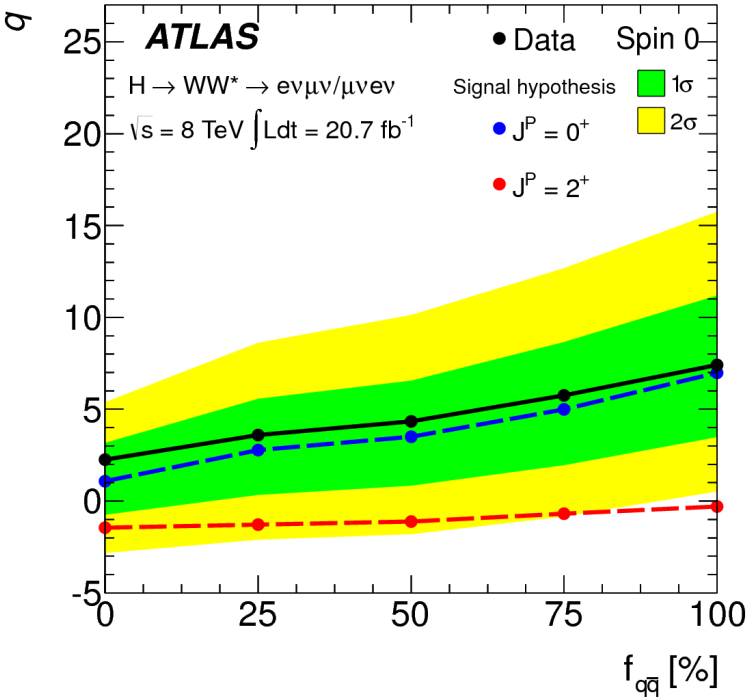
Consistency with SM <1σ level

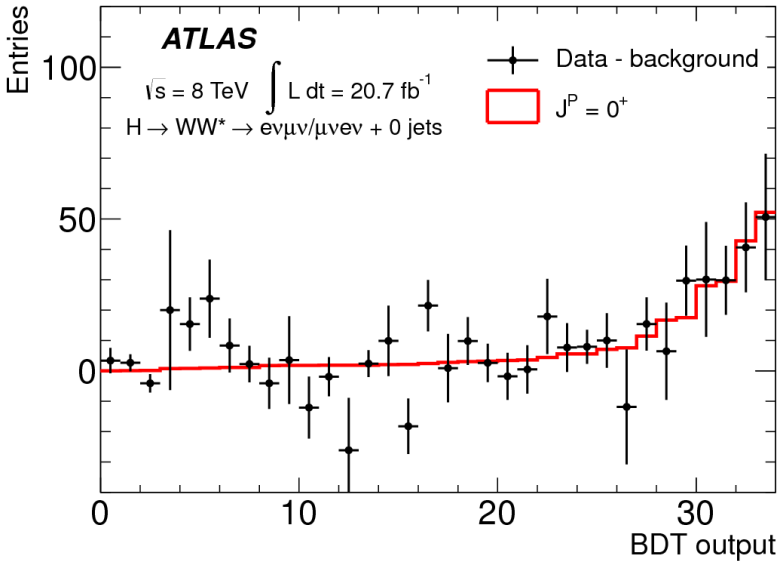
VBF: Observed significance@125 GeV:
2.5σ (expected 1.8σ)

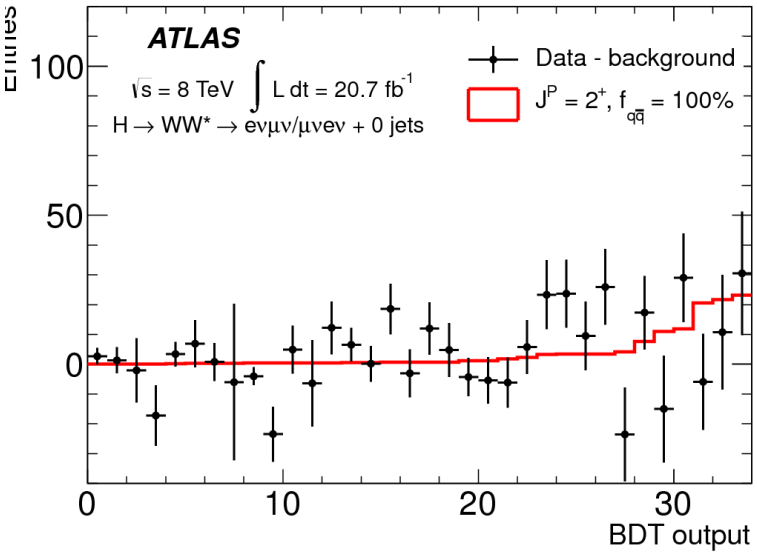
H-->WW-->lν lν spin

Compare SM spin 0^+ to 2^+ (both qq and gg production considered)

Discriminant variables: m_{ll}, $\Delta\phi_{ll}$, p_T^{ll}, $E_{T,rel}^{miss}$
--> Boost Decision Tree (BDT)







The spin 2^+ is excluded in favour of a 0^+ hypothesis at a CL varying between 99% for f_{qq}=100% and 95% for f_{qq}=0%

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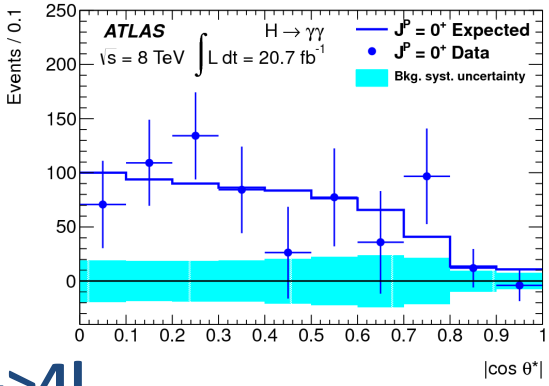
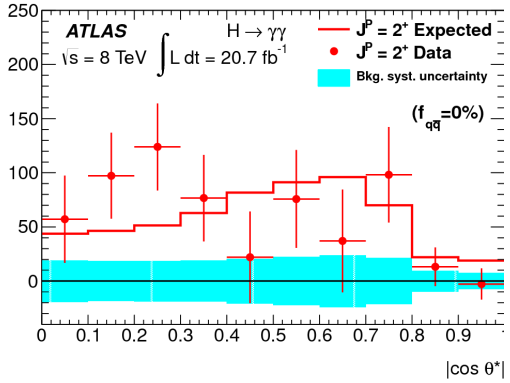
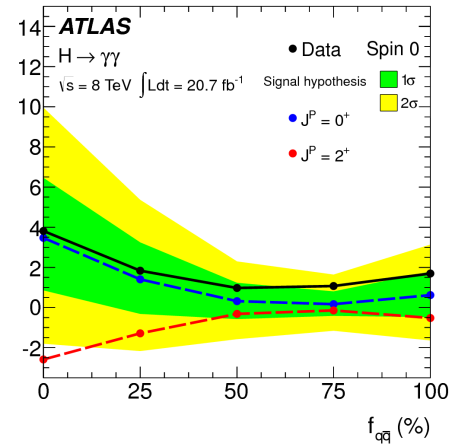
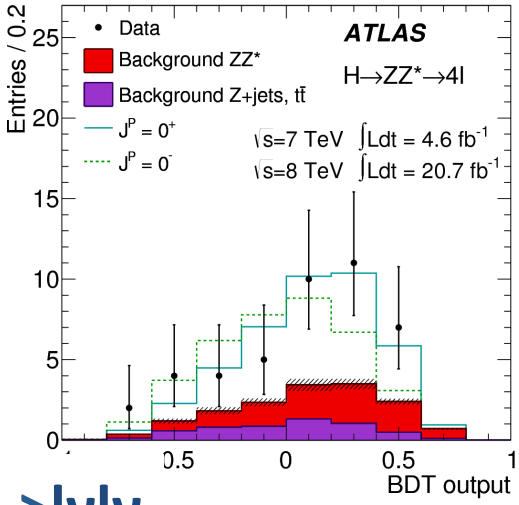
H-->γγ

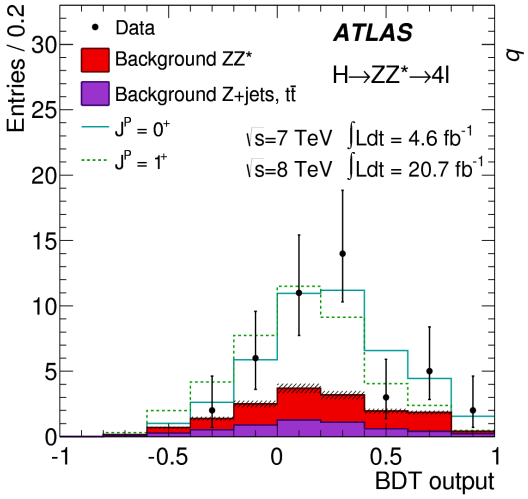


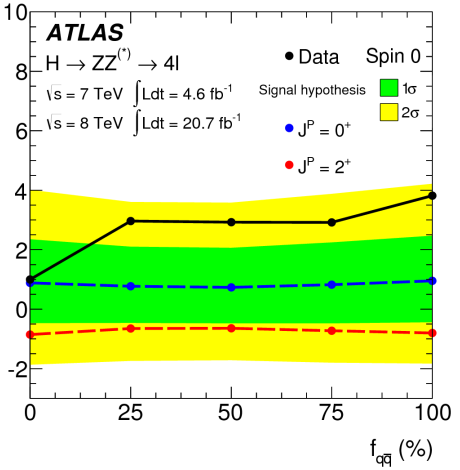




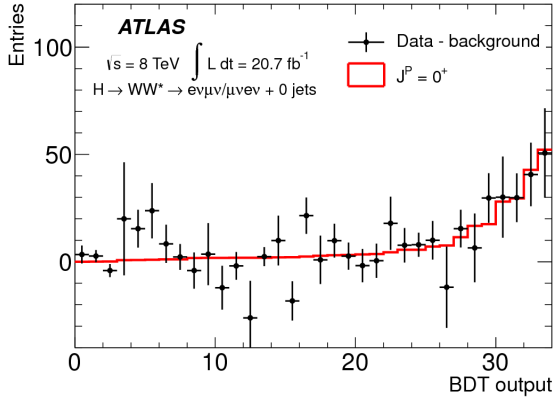
H-->ZZ-->4l

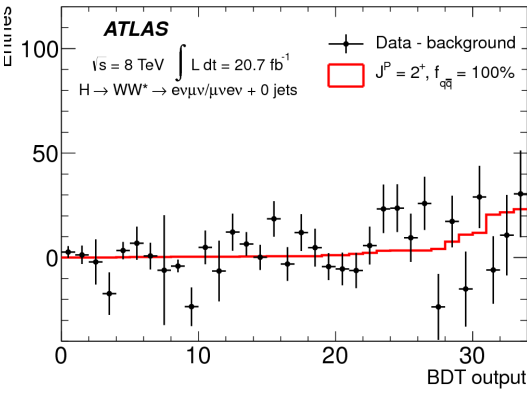


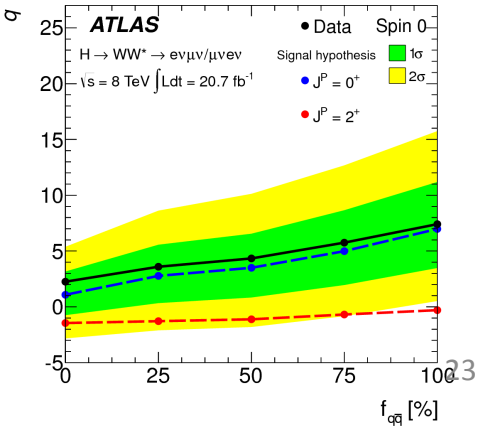




H→WW-->lvlv

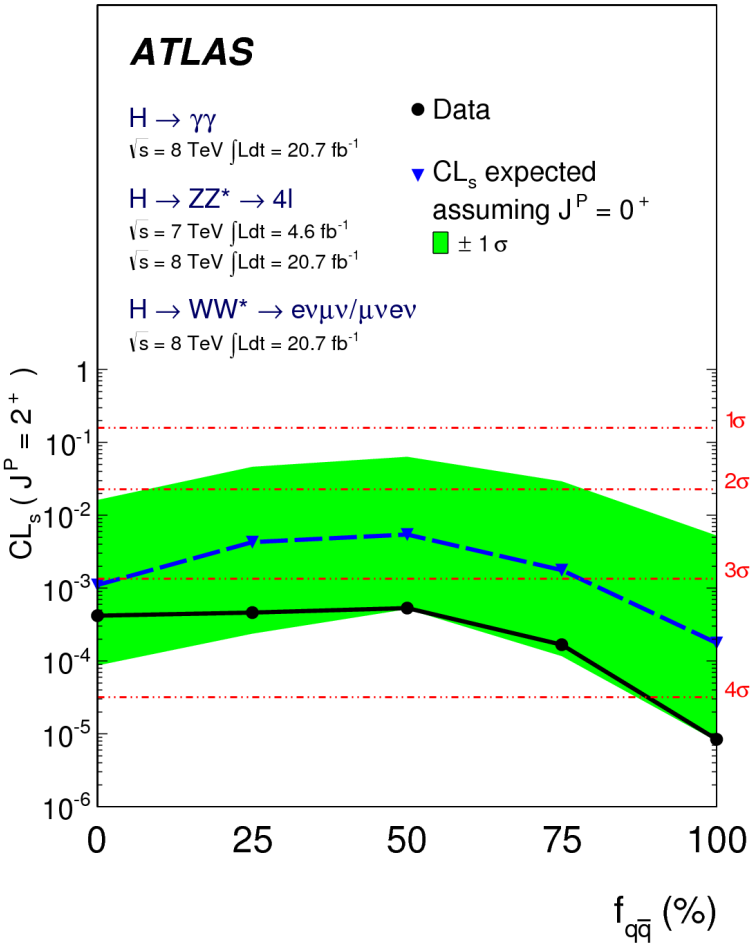


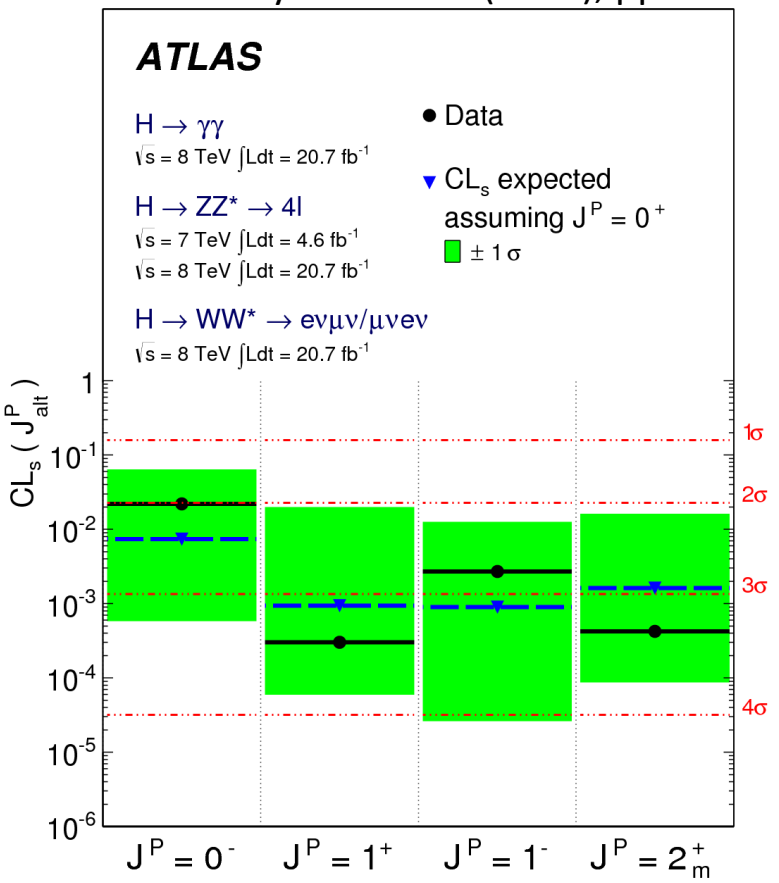




Combined Spin/CP measurement

Phys.Lett.B726(2013), pp. 120-144





Exclusion >99.9% CL for all f_{qq}

Evidence for the spin-0 nature of the discovered particle

$0^+/0^-$	only ZZ	97.8% CL
$0^+/1^+$	ZZ+WW	99.97%CL
$0^+/1^-$	ZZ+WW	99.7%CL
$0^+/2^+$	γγ+ZZ+WW	>99.9%CL

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H-->bb analysis

Channel with the highest branching ratio (58% for 125 GeV) but suffers from large QCD bkg

3 final states: ZH->ll+bb, ZH->νν+bb, WH->lν+bb in the VH production mode

Categories: split according to the vector boson pT, number of jets, number of b-tags

26 2-b tags signal regions, 26 1-b tag control regions and 5 top control regions

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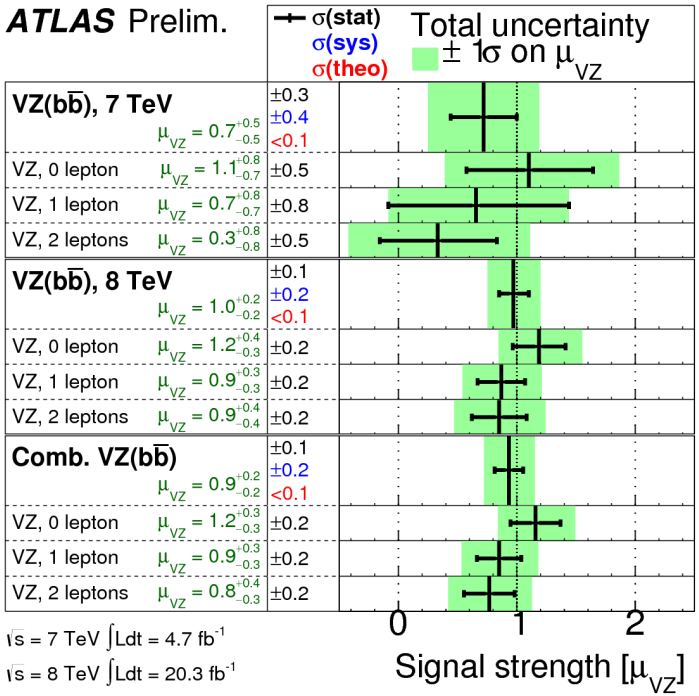

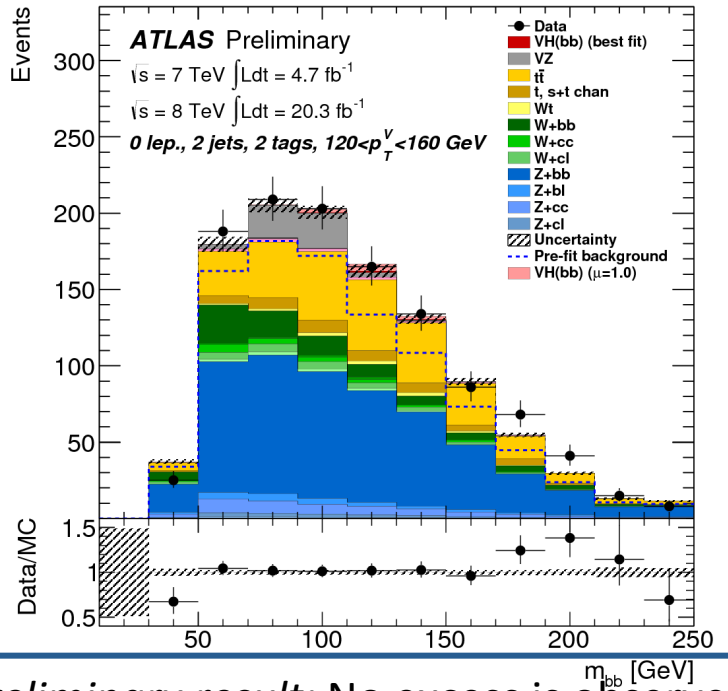

Check with VZ(-->bb): μ_{VZ}= 0.9±0.2 agrees with SM, observed significance of 4.8σ (5.1σ)

Preliminary result: No excess is observed.
For mH=125 GeV: μ= 0.2±0.5(stat)±0.4(sys)
95%CL observed upper limit: 1.4 SM (1.3)

An excess is however observed for m_H=125 GeV at TeVatron at the level of 2.8σ and 2.1σ in CMS

H--> τ τ analysis

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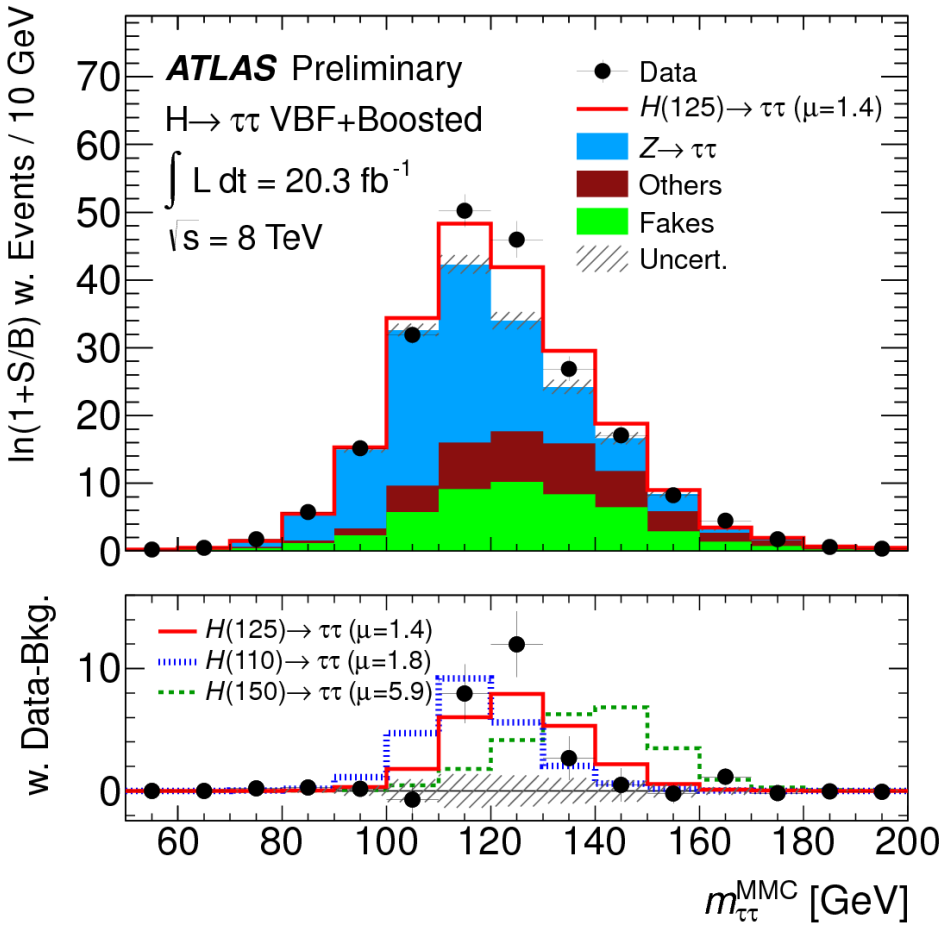
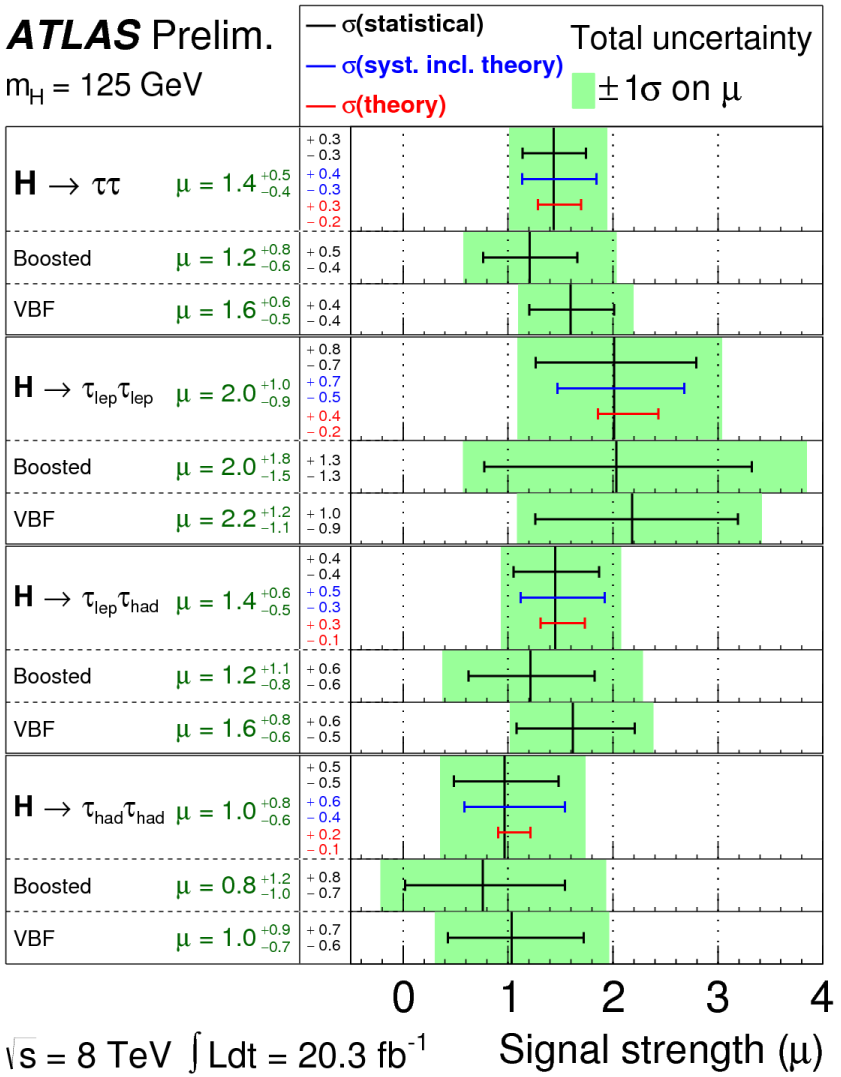


For m_H=125 GeV:

Observed local significance 4.1σ (expected 3.2σ)

→Direct Evidence of H->ττ decays



$$\mu = 1.43^{+0.31}_{-0.29}(stat)^{+0.41}_{-0.30}(sys)$$

$\mu_{ggF}=1.1^{+1.3}_{-1.1}$, $\mu_{VH+VBF}=1.6^{+0.8}_{-0.7}$

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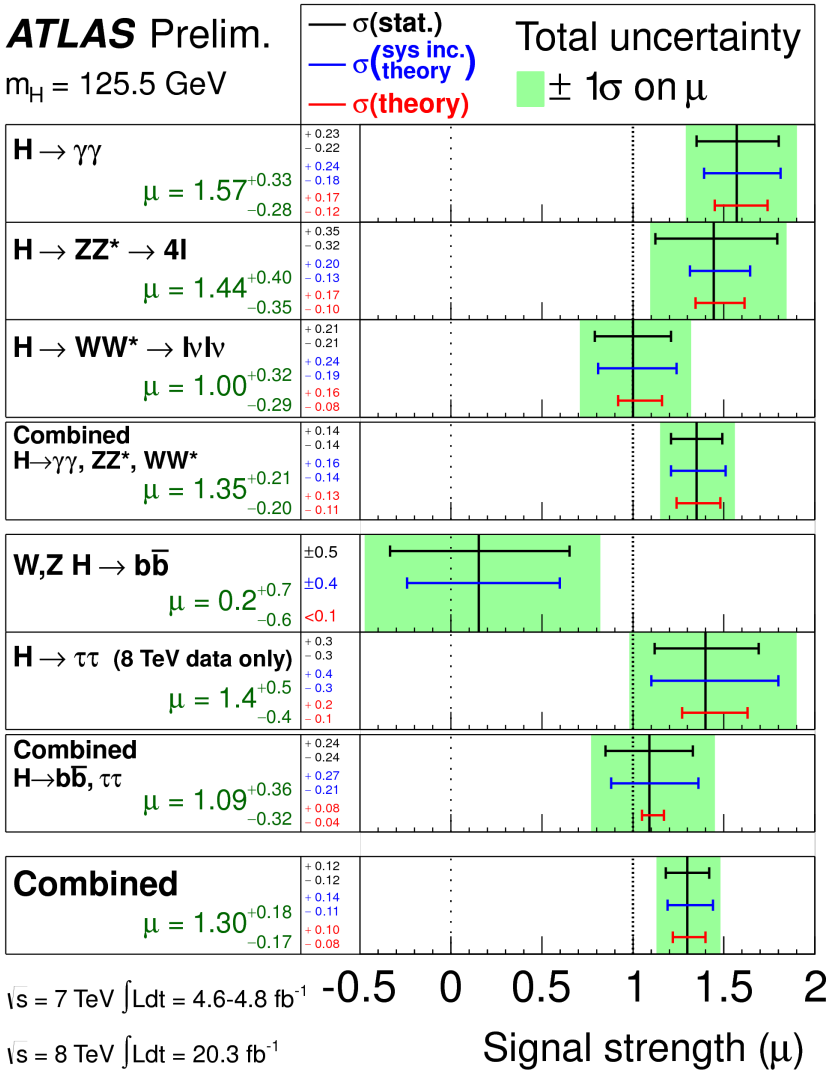
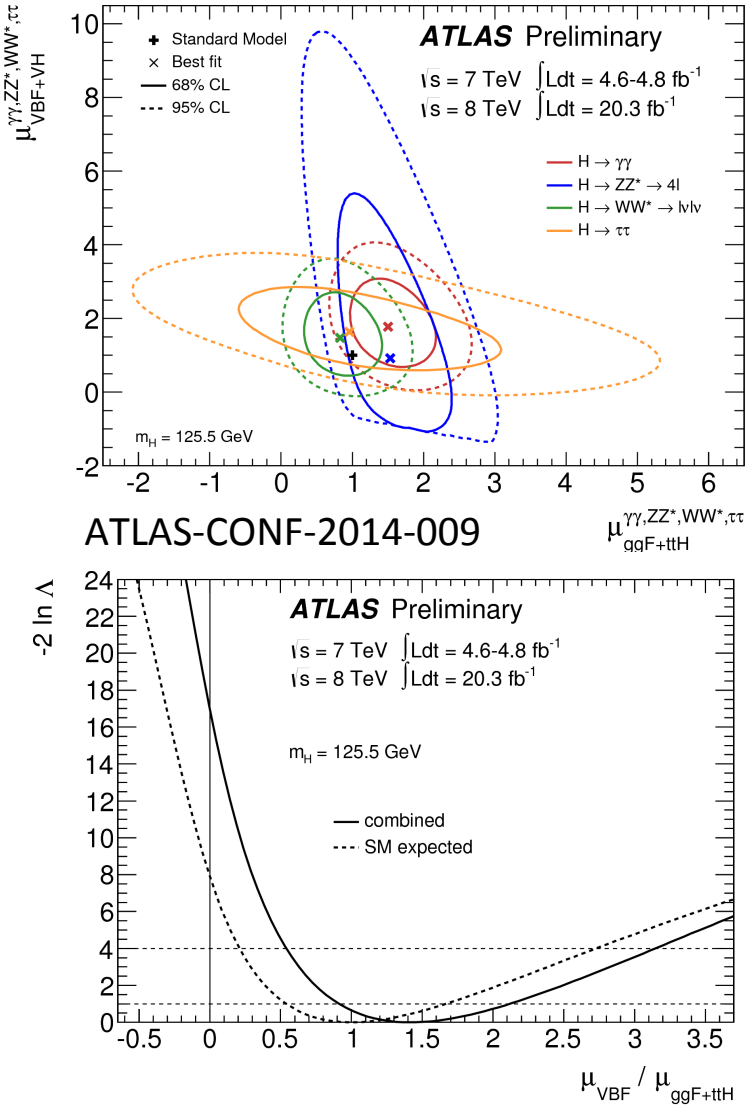
Combined signal strength & Evidence for VBF H



$$\mu = 1.30 \pm 0.12(stat)^{+0.14}_{-0.11}(sys)$$

Evidence at 3.7σ of direct fermionic decays



Evidence at 4.1σ for VBF production mode

$$\mu_{VBF} / \mu_{ggF+ttH} = 1.4^{+0.5}_{-0.4}(stat)^{+0.4}_{-0.3}(sys)$$

Coupling framework

Introducing the κ-formalism:

$$L = \kappa_3 \frac{m_H^2}{2v} H^3 + \kappa_Z \frac{m_Z^2}{v} Z_\mu Z^\mu H + \kappa_W \frac{2m_W^2}{v} W_\mu^+ W^{-\mu} H$$
$$+\kappa_g \frac{\alpha_s}{12\pi v} G^a_{\mu\nu} G^{a\mu\nu} H + \kappa_\gamma \frac{\alpha}{2\pi v} A_{\mu\nu} A^{\mu\nu} H + \kappa_{Z\gamma} \frac{\alpha}{\pi v} A_{\mu\nu} Z^{\mu\nu} H$$
$$-\left(\kappa_t \sum_{f=u,c,t} \frac{m_f}{v} f\bar{f} + \kappa_b \sum_{f=d,s,b} \frac{m_f}{v} f\bar{f} + \kappa_\tau \sum_{f=e,\mu,\tau} \frac{m_f}{v} f\bar{f} \right) H$$

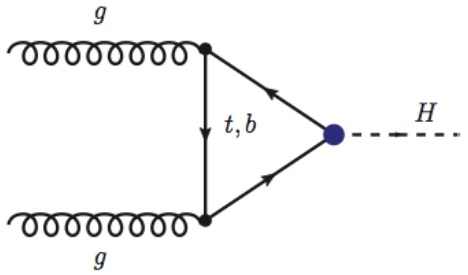
Assumptions:

-single resonance
-zero-width approximation
-modifications of the scale factors, tensor structure of the Lagrangian assume to be the same as in the SM

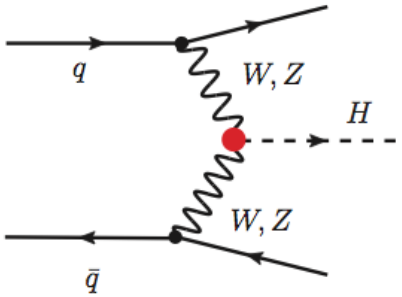
Production: $\kappa_i^2 = \frac{\sigma_i}{\sigma_i^{SM}}$ Decay: $\kappa_j^2 = \frac{\Gamma_j}{\Gamma_j^{SM}}$ Width: $\kappa_H^2 = \frac{\sum \kappa_j^2 \Gamma_j^{SM}}{\Gamma_H^{SM}}$

Coupling framework

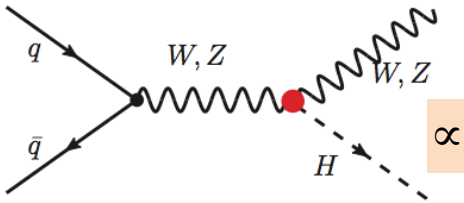
Production



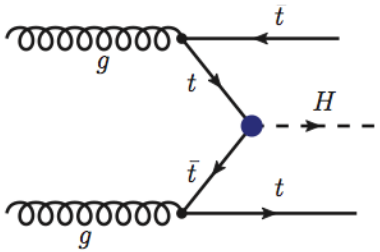
$\propto \kappa_g^2 = 1.06\kappa_t^2 - 0.07\kappa_t\kappa_b + 0.01\kappa_b^2$



$\propto \kappa_V^2$

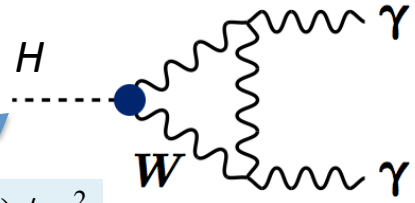


$\propto \kappa_V^2$

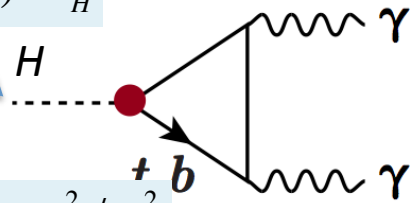


$\propto \kappa_t^2$

Decay



$\propto \kappa_\gamma^2 / \kappa_H^2 = (1.59\kappa_W^2 - 0.66\kappa_W\kappa_t + 0.07\kappa_t^2) / \kappa_H^2$



$\propto \kappa_V^2 / \kappa_H^2$

(κ_F, κ_V) formalism

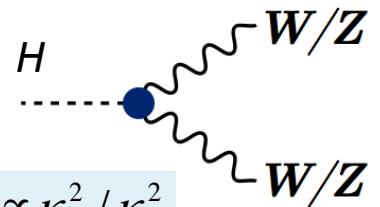
$$\sigma(ggF) \times BR(H \to \gamma\gamma) \sim \frac{\kappa_F^2 . \kappa_\gamma^2(\kappa_F, \kappa_F, \kappa_F, \kappa_V)}{0.75\kappa_F^2 + 0.25\kappa_V^2}$$

$$\sigma(VBF) \times BR(H \to \gamma\gamma) \sim \frac{\kappa_V^2 . \kappa_\gamma^2(\kappa_F, \kappa_F, \kappa_F, \kappa_V)}{0.75\kappa_F^2 + 0.25\kappa_V^2}$$

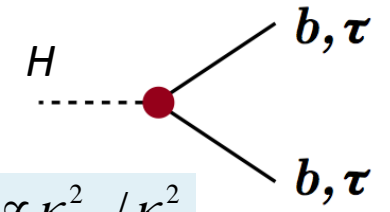
$$\sigma(ggF) \times BR(H \to WW, ZZ) \sim \frac{\kappa_F^2 . \kappa_V^2}{0.75\kappa_F^2 + 0.25\kappa_V^2}$$

$$\sigma(VBF) \times BR(H \to WW, ZZ) \sim \frac{\kappa_V^2 . \kappa_V^2}{0.75\kappa_F^2 + 0.25\kappa_V^2}$$

$$\sigma(VBF, VH) \times BR(H \to \tau\tau, bb) \sim \frac{\kappa_V^2 . \kappa_F^2}{0.75\kappa_F^2 + 0.25\kappa_V^2}$$



$\propto \kappa_V^2 / \kappa_H^2$



$\propto \kappa_{b,\tau}^2 / \kappa_H^2$

Fermion vs Vector couplings

Only SM contributions to the total width, assuming no new particles in loops or decays:

$$\kappa_F = \kappa_t = \kappa_b = \kappa_\tau \quad \text{and} \quad \kappa_V = \kappa_W = \kappa_Z$$

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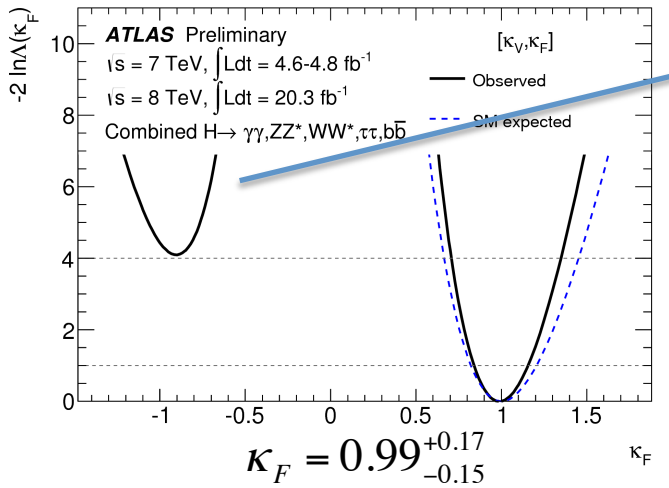
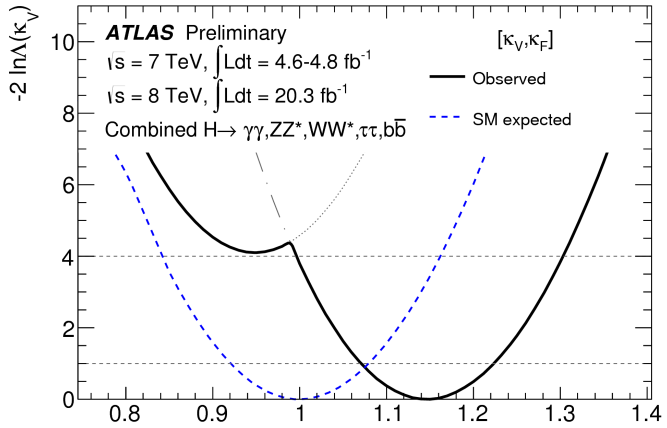
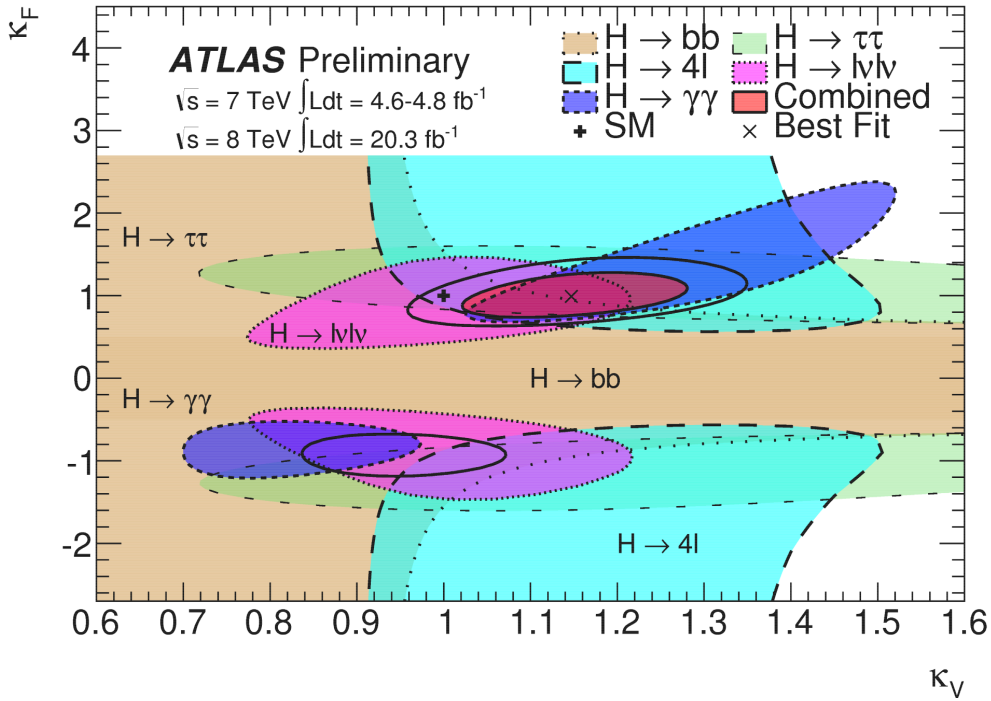


$$\kappa_F = 0.99^{+0.17}_{-0.15}$$



$$\kappa_V = 1.15 \pm 0.08$$

The γγ loop induces some sensitivity to the relative sign between κ_t and κ_W



2D compatibility with the SM = 10%

Negative κ_F disfavoured

Fermion vs Vector couplings

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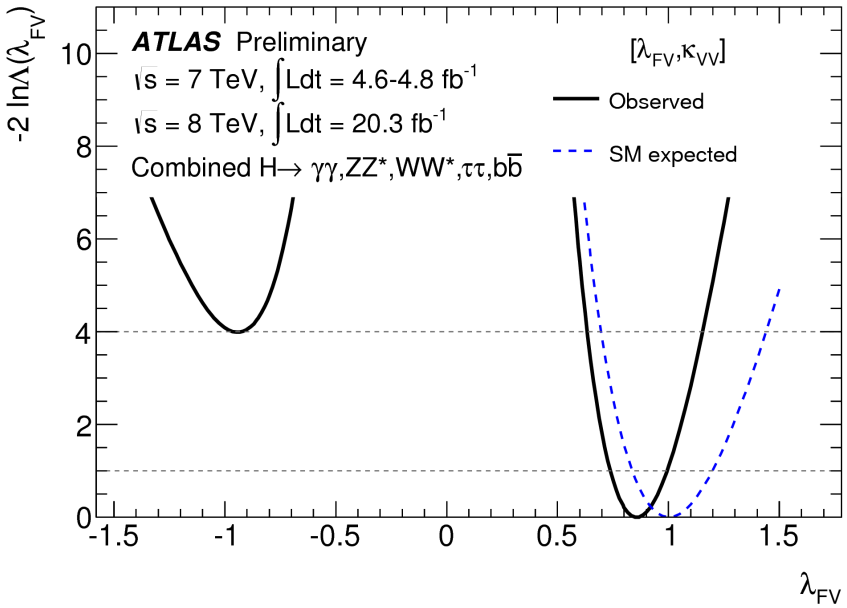
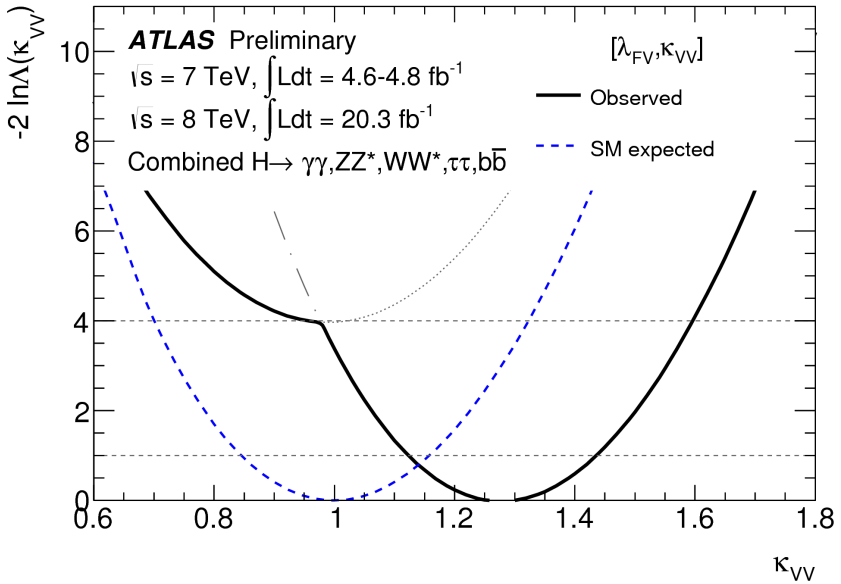
No assumption on the total width





$$\lambda_{FV} = \kappa_F / \kappa_V = 0.86^{+0.14}_{-0.12}$$

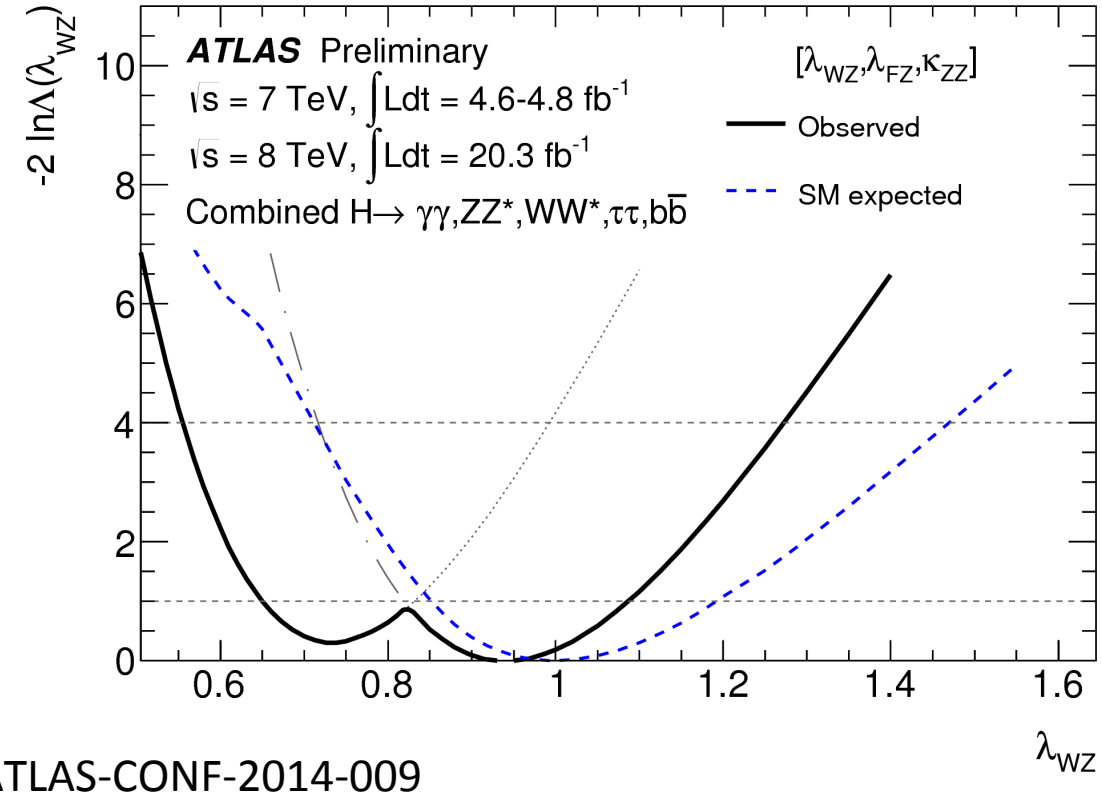
$$\kappa_{VV} = \kappa_V \kappa_V / \kappa_H = 1.28^{+0.16}_{-0.15}$$

Custodial Symmetry

Custodial symmetry imposes identical coupling scale factors for the W and Z boson

-->Probe the ratio $\lambda_{WZ} = \kappa_W / \kappa_Z$

Constraints from H-->WW-->lvlv and H-->ZZ-->4l decays, WH and ZH production modes and also indirectly from VBF production process (74% W, 26%Z) and H-->γγ for κ_W



$$\lambda_{WZ} = 0.94^{+0.14}_{-0.29}$$

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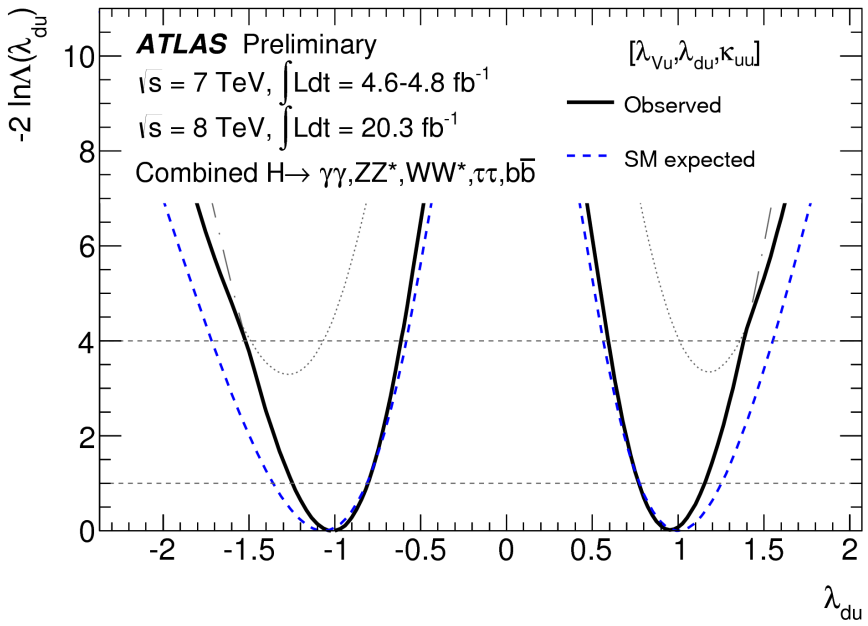
Relations in the fermion coupling sector

Many extensions of the SM predicts different coupling of the H to up- and down-type fermions.

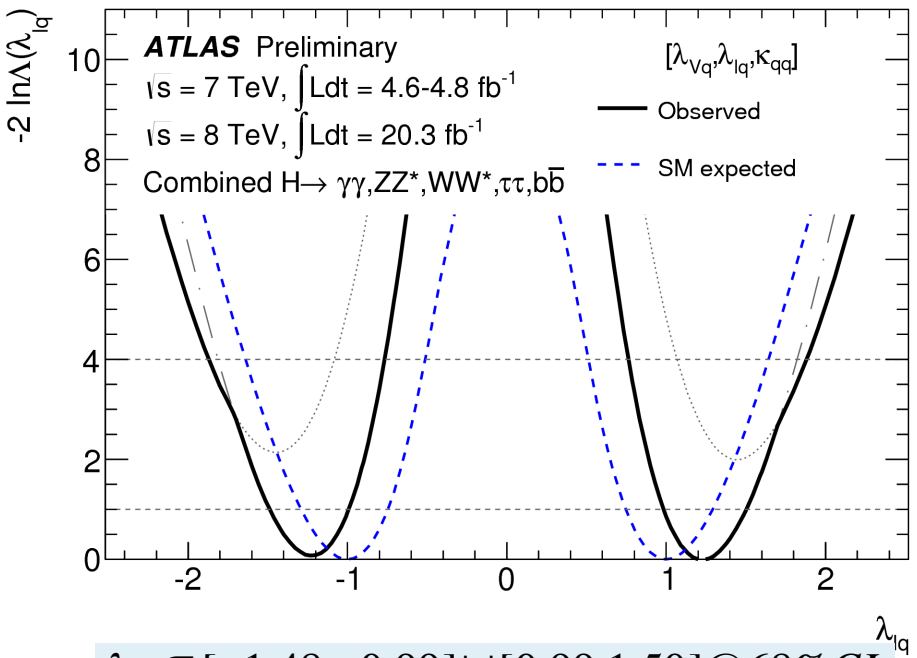
$$\kappa_u = \kappa_t \quad \kappa_d = \kappa_b = \kappa_\tau$$
$$\lambda_{du} = \kappa_d / \kappa_u$$



$$\lambda_{du} \in [-1.24,-0.81] \cup [0.78,1.15] @ 68\%CL$$

3.6 σ evidence of the couplings to down-type fermions

$$\kappa_l = \kappa_\tau \quad \kappa_q = \kappa_b = \kappa_t$$
$$\lambda_{lq} = \kappa_l / \kappa_q$$



$$\lambda_{lq} \in [-1.48,-0.99] \cup [0.99,1.50] @ 68\%CL$$

A vanishing coupling to leptons is excluded at the 4.0 σ level

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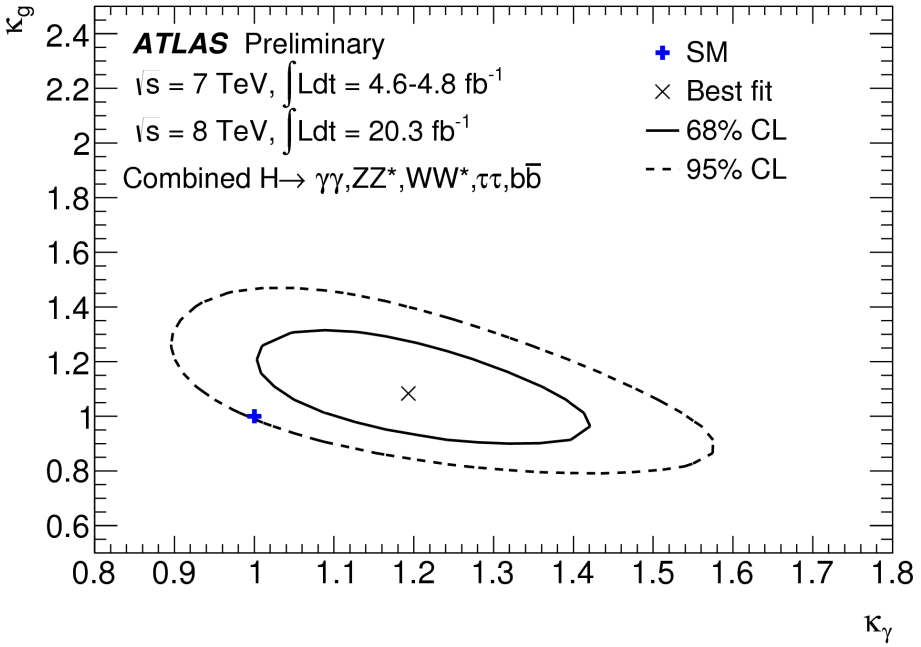
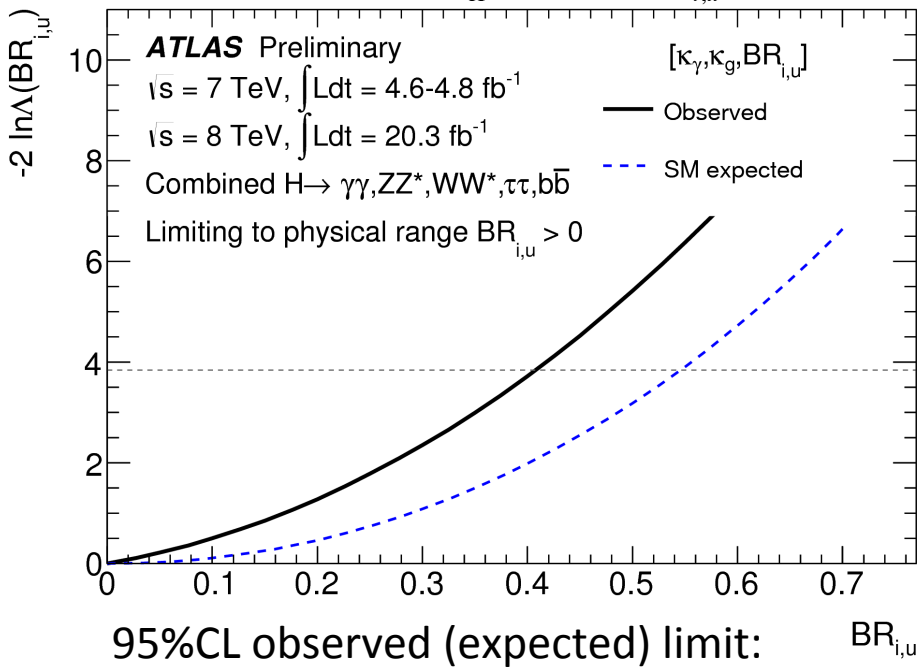
Beyond the SM contributions

Contributions from new particles either in loops or in new final states are considered
Two cases are considered: Only SM contributions to the total width or no assumption

$$\kappa_H^2 = \frac{\sum \kappa_j^2 \Gamma_j^{SM}}{\Gamma_H^{SM}} \times \frac{1}{1 - BR_{i,u}}$$





$$\kappa_g = 1.08^{+0.15}_{-0.13} \qquad \kappa_\gamma = 1.19^{+0.15}_{-0.12}$$

2D compatibility of the SM of 9% with the best fit point

95%CL observed (expected) limit:

$$BR_{i,u} < 0.41(0.55)$$

Releasing the physical boundary:

$$\kappa_g = 1.00^{+0.23}_{-0.16} \qquad \kappa_\gamma = 1.17^{+0.16}_{-0.13}$$

$$BR_{i,u} = -0.16^{+0.29}_{-0.30}$$

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Summary of combined coupling measurements

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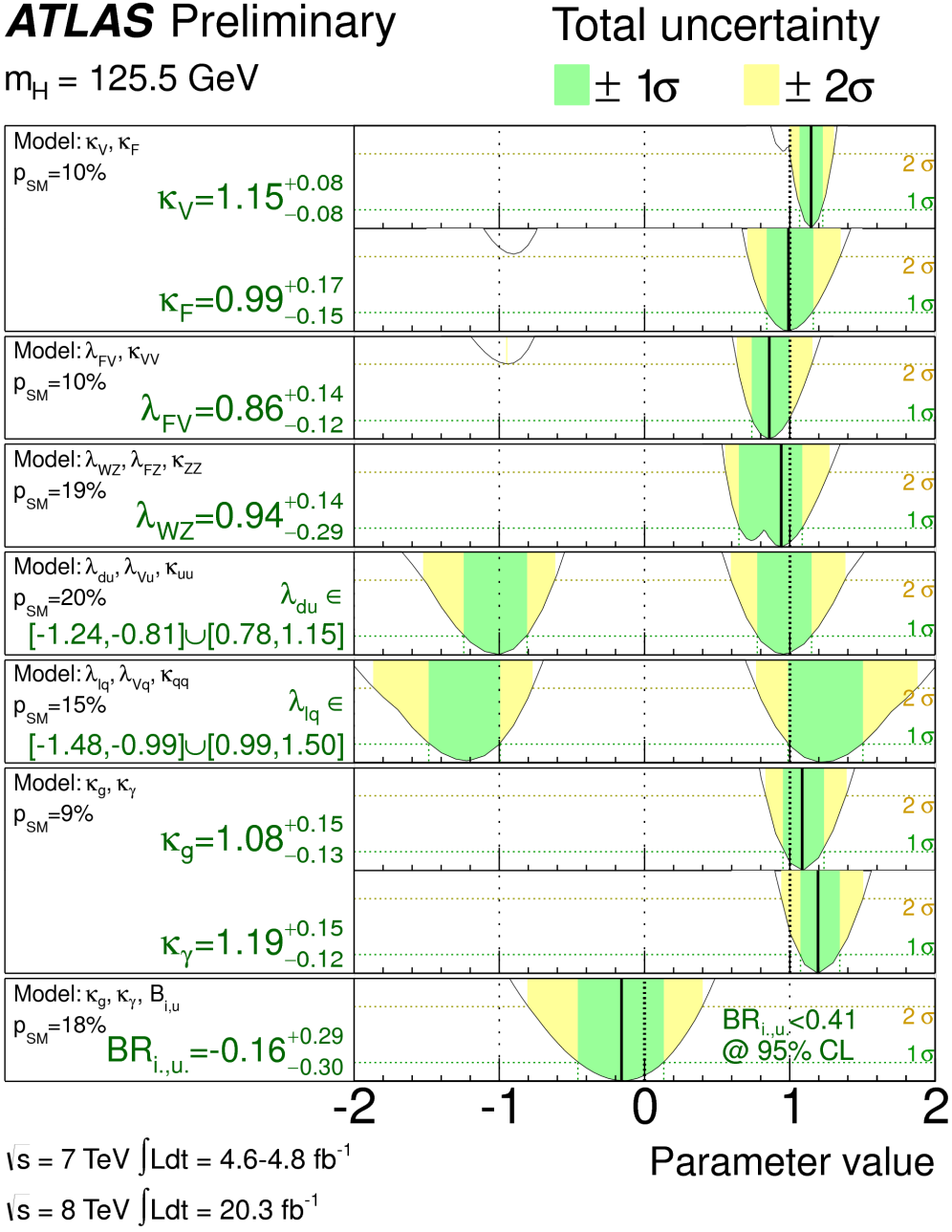

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Minimal Composite H Model

The H boson is composite: the H couplings to vector bosons and fermions are modified wrt SM as a function of the boson compositeness scale f

MCHM4: $\kappa = \kappa_V = \kappa_F = \sqrt{1-\xi}$

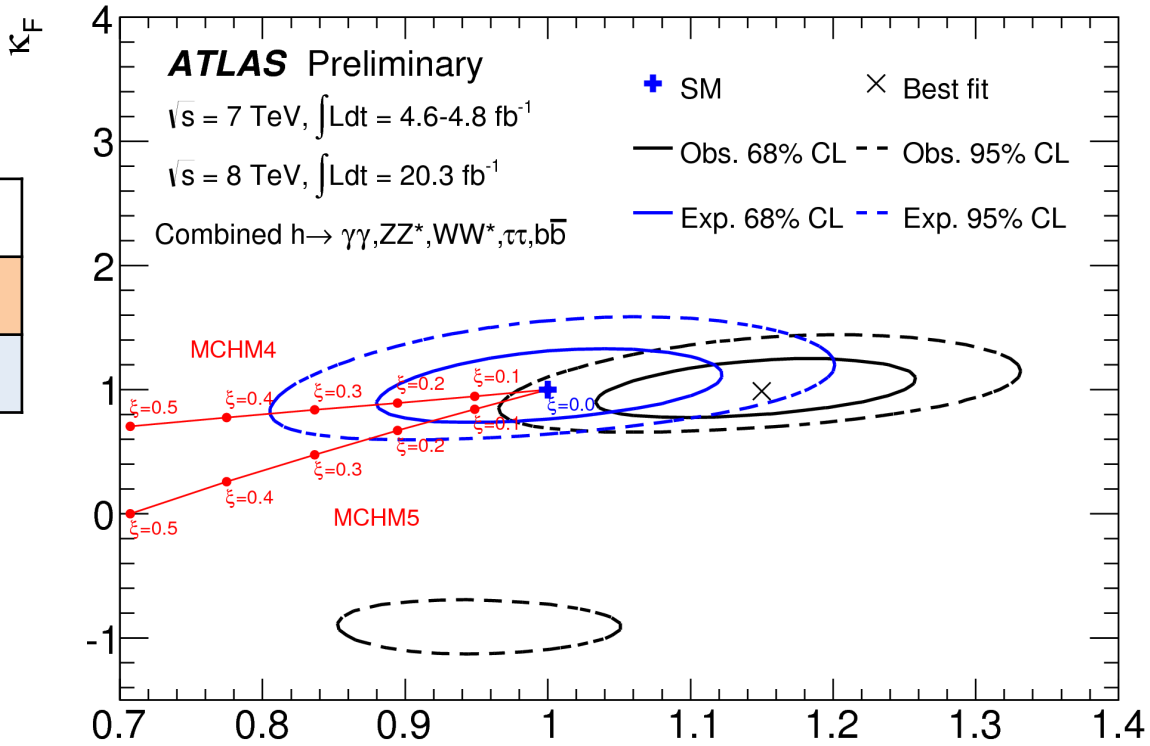
MCHM5: $\kappa_F = \frac{1-2\xi}{\sqrt{1-\xi}} \quad \kappa_V = \sqrt{1-\xi}$

$\xi = v^2/f^2$ a scaling parameter
SM recovered when $\xi \to 0$

With the physical boundary $\xi > 0$

95%CL	Expected	Observed
MCHM4	f>460 GeV	f>710 GeV
MCHM5	f>550 GeV	f>640 GeV

The observed limit is stronger than the expected one since $\mu_h > 1$



ATLAS-CONF-2014-010
Nucl. Phys. B 719 (2005) 165, Phys. Rev. D 75 (2007) 055014 , Phys. Rev. D76 (2007) 035006

Simple MSSM interpretation

In the simplified MSSM, couplings can be expressed as a function of mA, tanβ

$$\kappa_V = \frac{s_d(m_A,\tan\beta) + \tan\beta\, s_u(m_A,\tan\beta)}{\sqrt{1+\tan^2\beta}}$$

$$\kappa_u = s_u(m_A,\tan\beta)\frac{\sqrt{1+\tan^2\beta}}{\tan\beta}$$

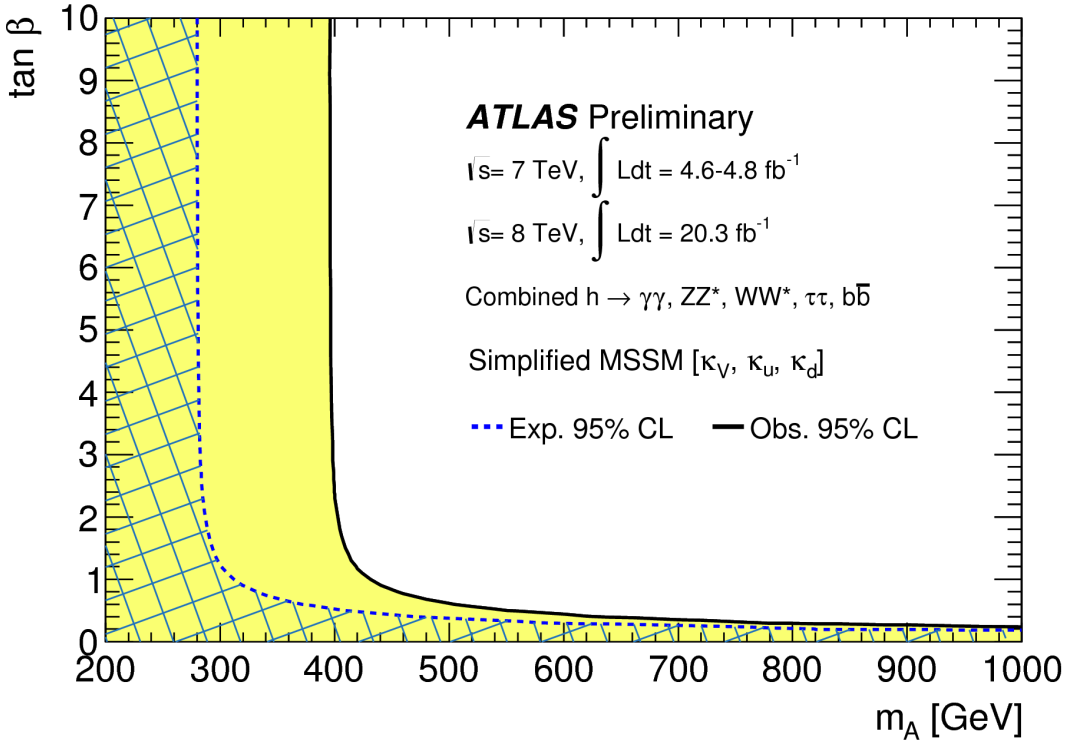
$$\kappa_d = s_d(m_A,\tan\beta)\sqrt{1+\tan^2\beta}$$

$$s_u = \frac{1}{\sqrt{1+\frac{(m_A^2+m_Z^2)^2\tan^2\beta}{(m_Z^2+m_A^2\tan^2\beta - m_h^2(1+\tan^2\beta))^2}}}$$

$$s_d = \frac{(m_A^2+m_Z^2)\tan\beta}{m_Z^2+m_A^2\tan^2\beta - m_h^2(1+\tan^2\beta)}\, s_u$$

Considering physical boundary mA>0 and tanβ>0:

The observed (expected) lower limit at 95%CL is mA>400 (280) GeV for 2<tanβ<10



ATLAS-CONF-2014-010
Phys. Lett. B 64 no. 2, (1976) 159,
Phys. Lett. B69 (1977) 489, Phys. Lett. B76 (1978) 575 , Nucl. Phys. B 193 (1981)150

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Conclusions and Perspectives

The measured properties (spin and couplings) of the H boson are compatible with SM

Couplings are already used to constrain BSM models

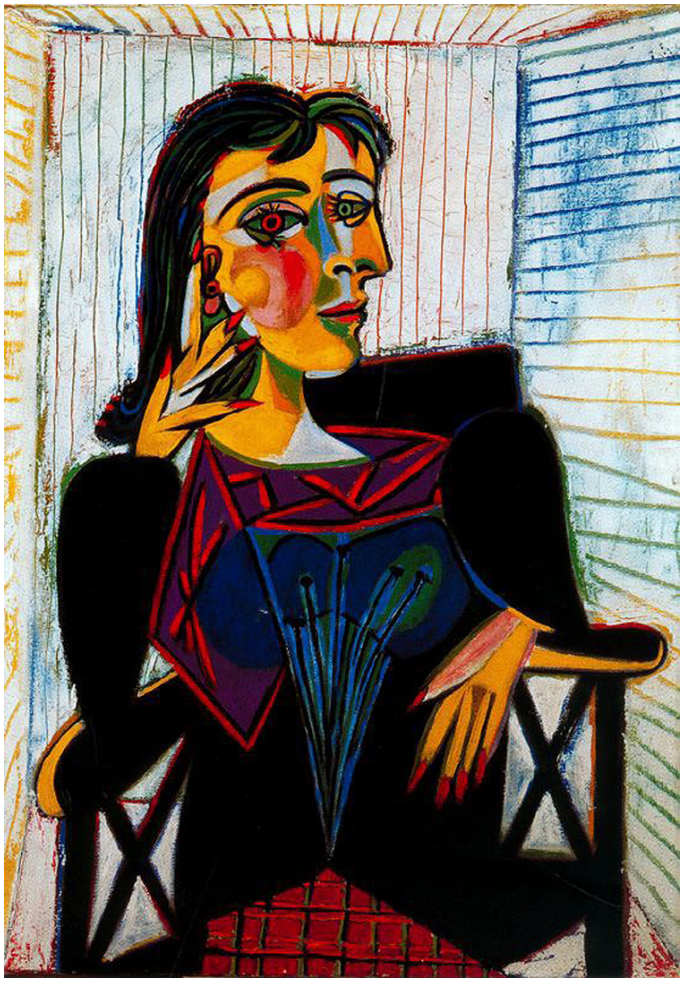
An evidence of VBF production and direct fermionic decay have been observed

More new results for the 5 main channels soon with LHC Run-I data, stay tuned ☺

In Run-II, more answers to come: what is precisely the H discovered? does it have another face of supersymmetrical type? New Physics?

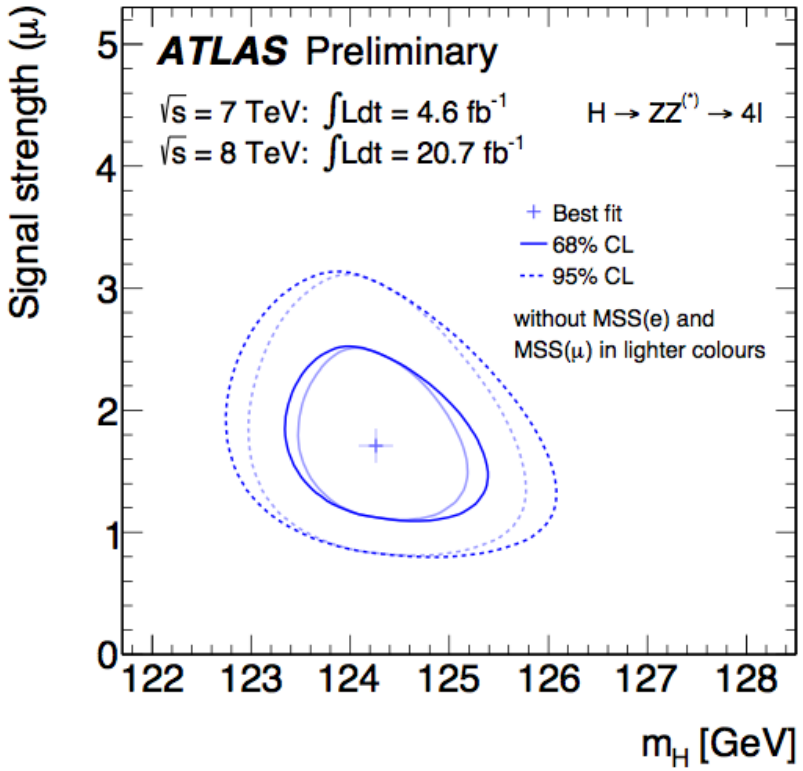
Looking forward for more precise measurements and searches for new particles…

Hopefully more answers in Higgs Hunting 2015

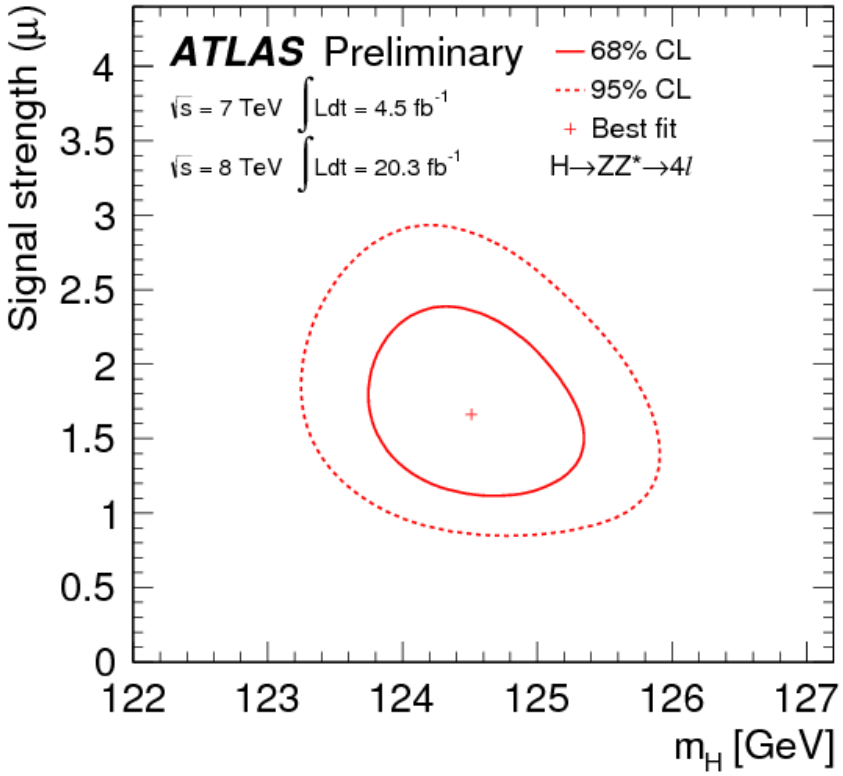


Backup Slides

"Moriond 2013 analysis"

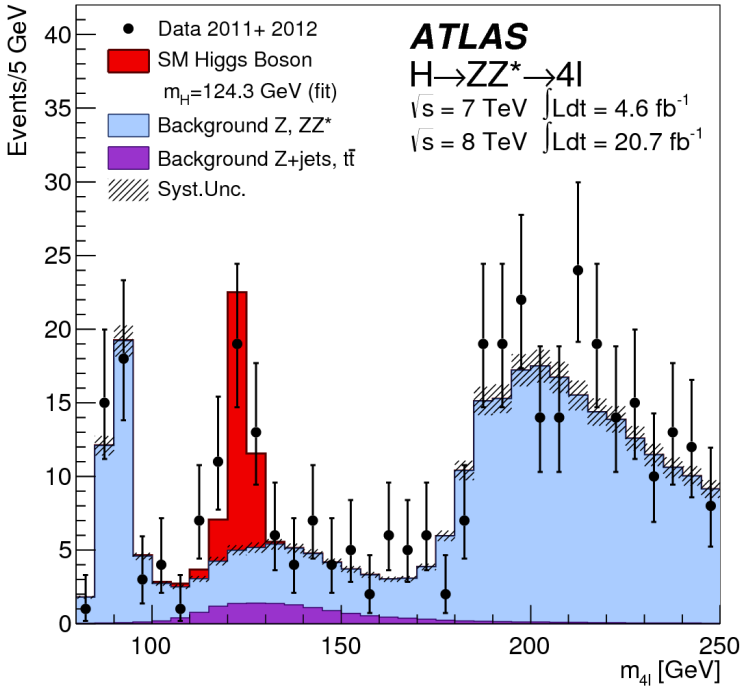


NEW!

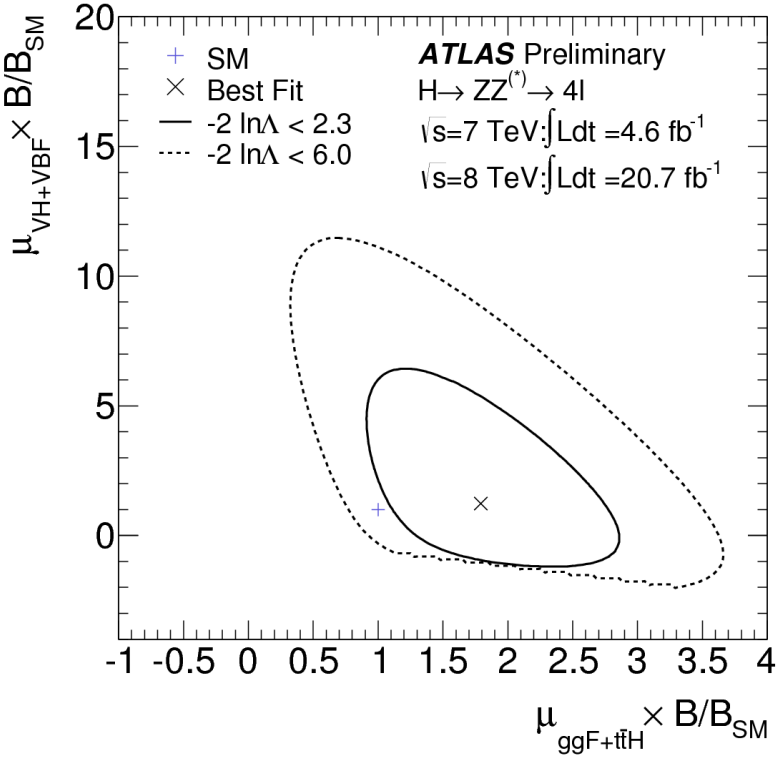


H-->ZZ-->4l coupling measurement

Phys.Lett.B726(2013), pp. 88-119



Local significance 6.6σ (expected 4.4σ) at 124.3 GeV.



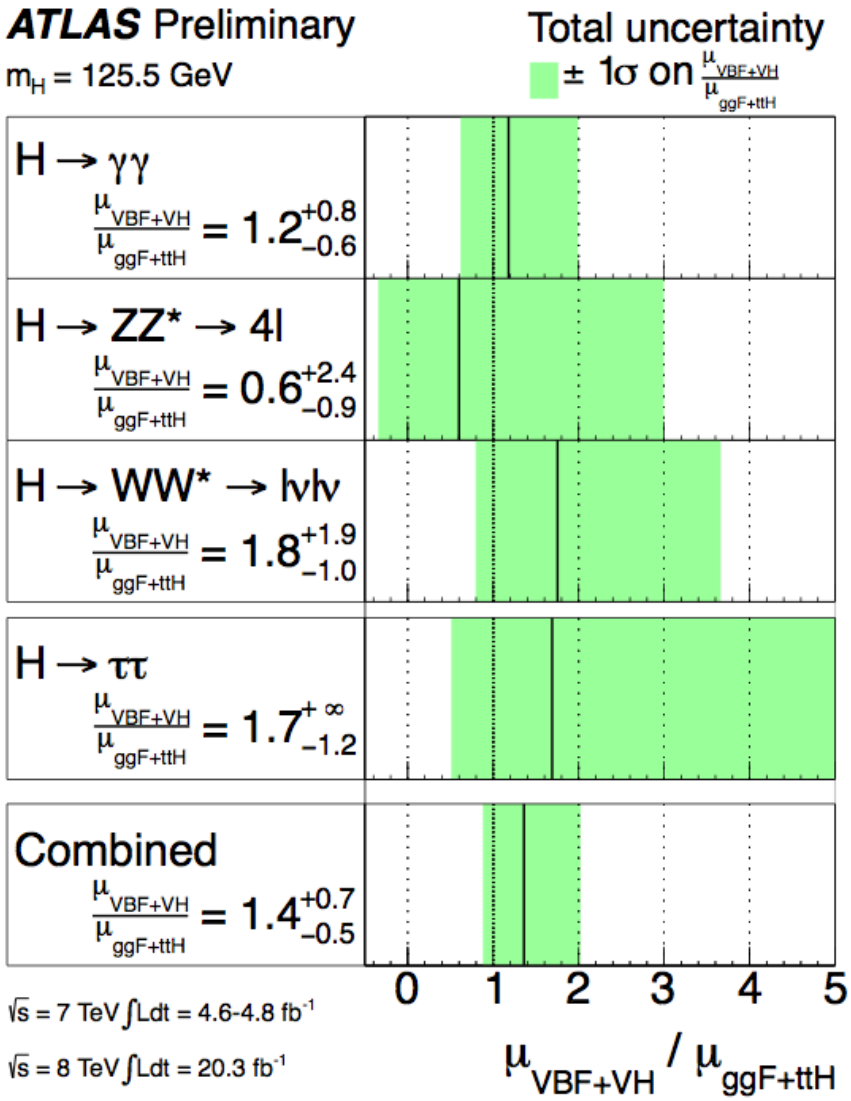
1 VBF-like event observed in 125±5 GeV (0.71±0.10 expected from SM with 60% VBF purity and S/B~5)

3 categories are considered in the Moriond 2013 analysis:
VBF-like (accompanied with 2 high pT jets widely separated in rapidity),
VH-like (accompanied with an additional lepton) and ggF-like (all the others)

The measured values @125.5 GeV:

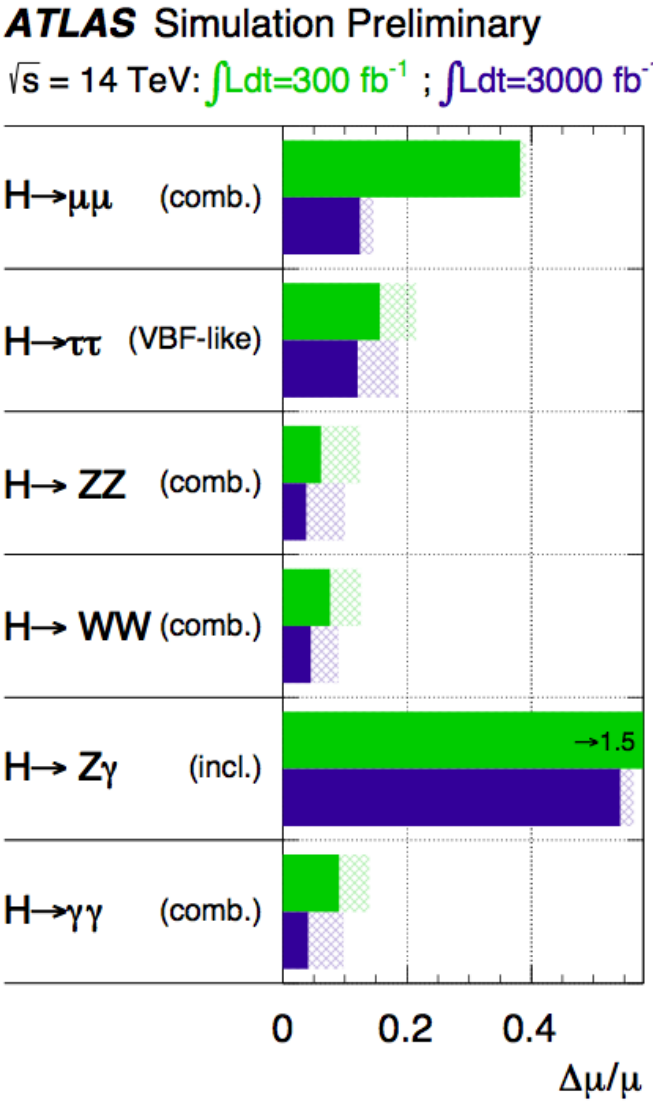
$$\mu = 1.43^{+0.40}_{-0.35}$$

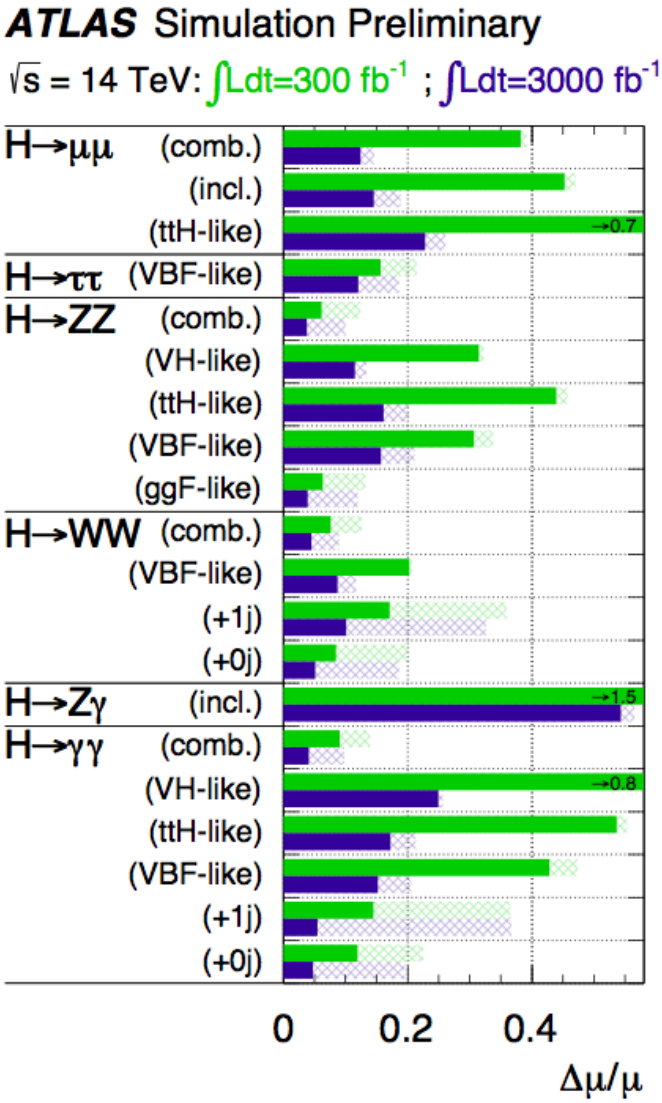
$$\mu_{ggF+ttH} = 1.45^{+0.43}_{-0.36}, \mu_{VBF+VH} = 1.2^{+1.6}_{-0.9}$$

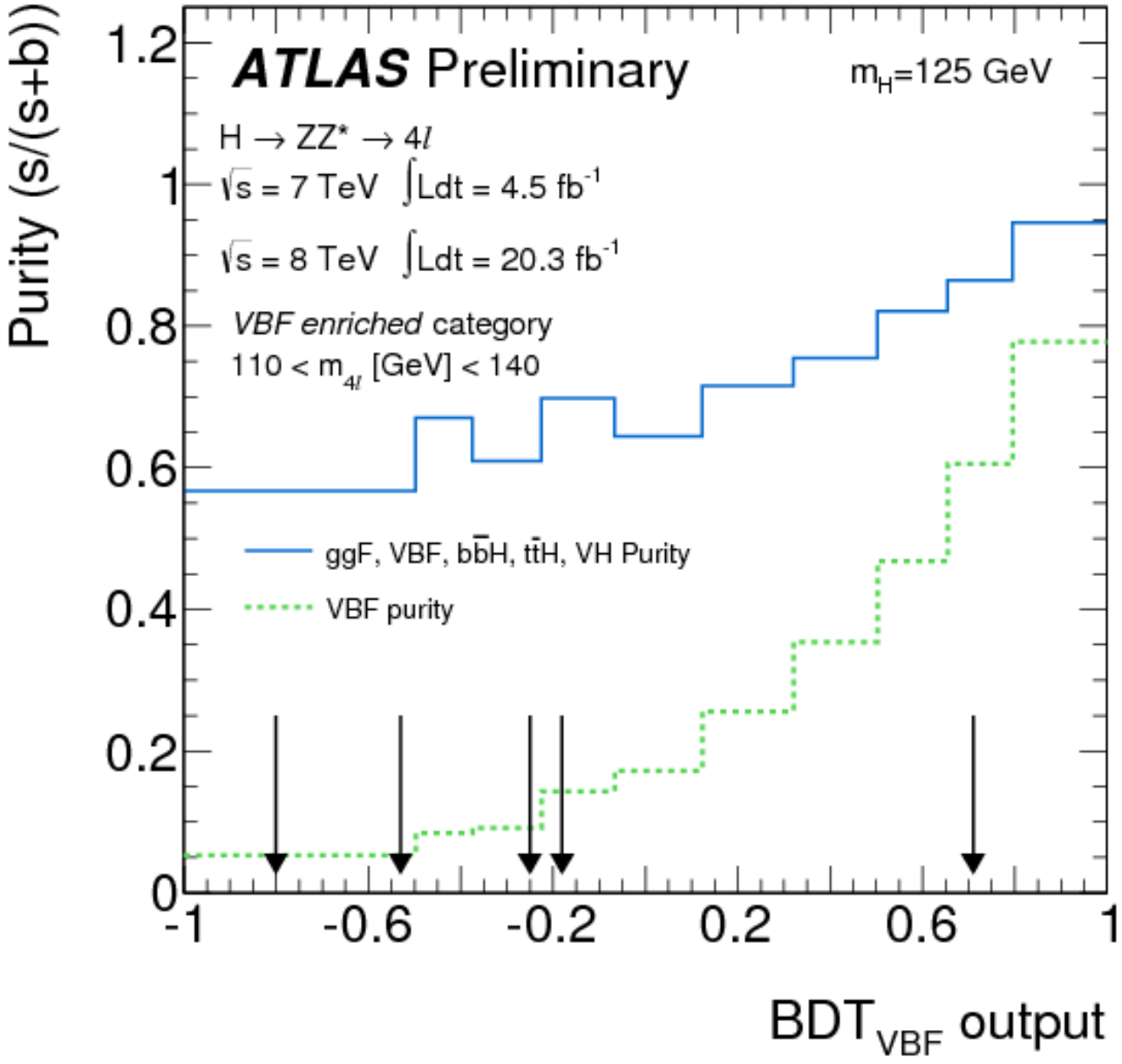


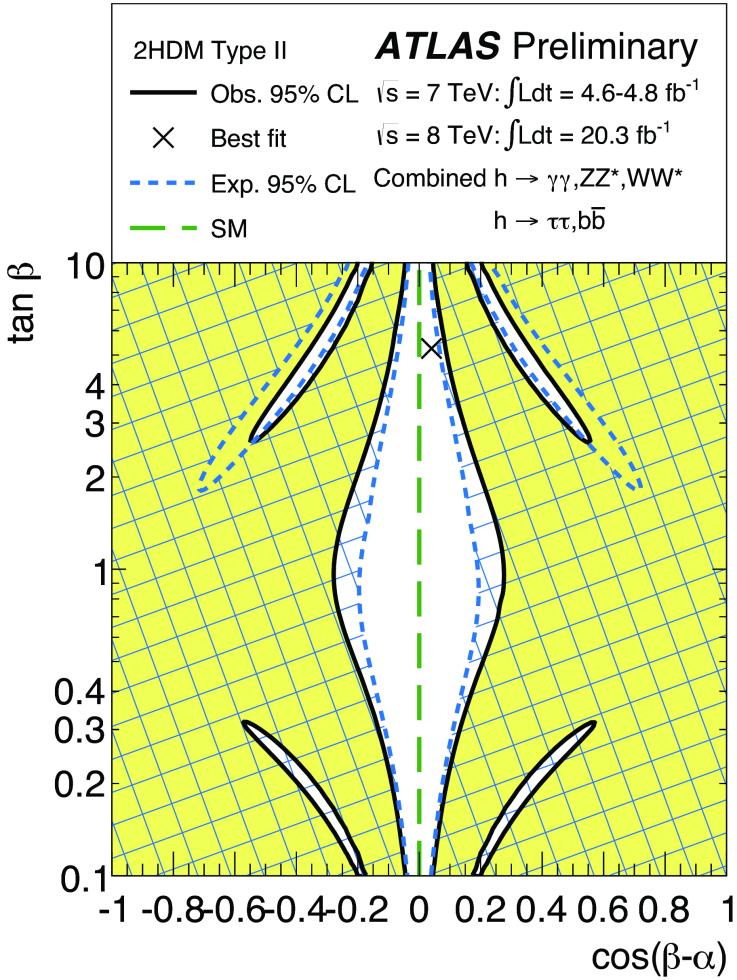
$$
\begin{aligned}
\sigma(gg \to H) * \mathrm{BR}(H \to \gamma\gamma) &\sim \frac{\kappa_g^2 \cdot \kappa_\gamma^2}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91} \\
\sigma(qq' \to qq'H) * \mathrm{BR}(H \to \gamma\gamma) &\sim \frac{\kappa_\gamma^2}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91} \\
\sigma(gg \to H) * \mathrm{BR}(H \to ZZ^*, H \to WW^*) &\sim \frac{\kappa_g^2}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91} \\
\sigma(qq' \to qq'H) * \mathrm{BR}(H \to ZZ^*, H \to WW^*) &\sim \frac{1}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91} \\
\sigma(qq' \to qq'H, VH) * \mathrm{BR}(H \to \tau\tau, H \to b\bar{b}) &\sim \frac{1}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91}.
\end{aligned}
$$

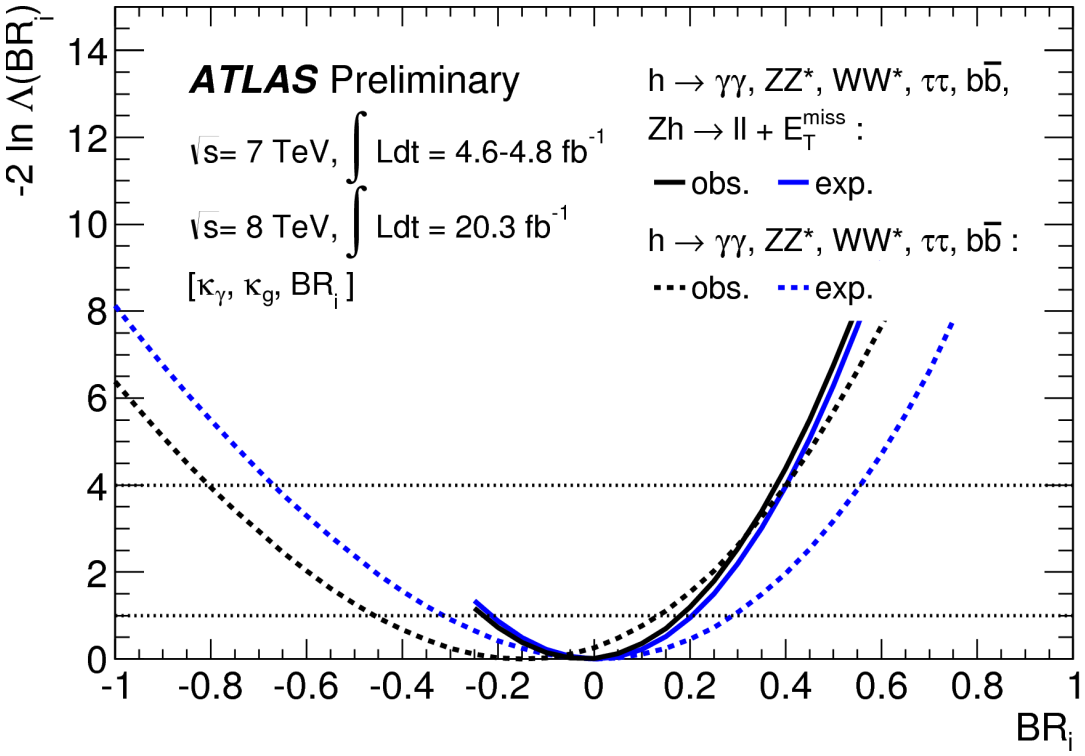
$$
\begin{aligned}
\sigma(gg \to H) * \mathrm{BR}(H \to \gamma\gamma) &\sim \frac{\kappa_g^2 \cdot \kappa_\gamma^2}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91} \cdot (1 - \mathrm{BR}_{i.,u.}) \\
\sigma(qq' \to qq'H) * \mathrm{BR}(H \to \gamma\gamma) &\sim \frac{\kappa_\gamma^2}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91} \cdot (1 - \mathrm{BR}_{i.,u.}) \\
\sigma(gg \to H) * \mathrm{BR}(H \to ZZ^*, H \to WW^*) &\sim \frac{\kappa_g^2}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91} \cdot (1 - \mathrm{BR}_{i.,u.}) \\
\sigma(qq' \to qq'H) * \mathrm{BR}(H \to ZZ^*, H \to WW^*) &\sim \frac{1}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91} \cdot (1 - \mathrm{BR}_{i.,u.}) \\
\sigma(qq' \to qq'H, VH) * \mathrm{BR}(H \to \tau\tau, H \to b\bar{b}) &\sim \frac{1}{0.085 \cdot \kappa_g^2 + 0.0023 \cdot \kappa_\gamma^2 + 0.91} \cdot (1 - \mathrm{BR}_{i.,u.}).
\end{aligned}
\tag{17}
$$


ATLAS Simulation Preliminary
√s = 14 TeV: ∫Ldt=300 fb-1 ; ∫Ldt=3000 fb-1
H→μμ (comb.)
H→ττ (VBF-like)
H→ ZZ (comb.)
H→ WW (comb.)
H→ Zγ (incl.)
H→γγ (comb.)
→1.5
0
0.2
0.4
Δμ/μ


ATLAS Simulation Preliminary
√s = 14 TeV: ∫Ldt=300 fb-1 ; ∫Ldt=3000 fb-1
H→μμ (comb.)
(incl.)
(ttH-like)
H→ττ (VBF-like)
H→ZZ (comb.)
(VH-like)
(ttH-like)
(VBF-like)
(ggF-like)
H→WW (comb.)
(VBF-like)
(+1j)
(+0j)
H→Zγ (incl.)
H→γγ (comb.)
(VH-like)
(ttH-like)
(VBF-like)
(+1j)
(+0j)
→0.7
→1.5
→0.8
0
0.2
0.4
Δμ/μ


ATLAS Preliminary
m_H=125 GeV
$H \rightarrow ZZ^* \rightarrow 4l$
$\sqrt{s}$ = 7 TeV $\int$Ldt = 4.5 fb^{-1}
$\sqrt{s}$ = 8 TeV $\int$Ldt = 20.3 fb^{-1}
VBF enriched category
110 < m_{4l} [GeV] < 140
ggF, VBF, $b\bar{b}H$, $t\bar{t}H$, VH Purity
VBF purity
Purity (s/(s+b))
BDT_{VBF} output
1.2
1
0.8
0.6
0.4
0.2
0
-1
-0.6
-0.2
0.2
0.6
1


2HDM Type II
ATLAS Preliminary
Obs. 95% CL
Best fit
Exp. 95% CL
SM
√s = 7 TeV: ∫Ldt = 4.6-4.8 fb-1
√s = 8 TeV: ∫Ldt = 20.3 fb-1
Combined h → γγ,ZZ*,WW*
h → ττ,bb̄
tan β
cos(β-α)


ATLAS Preliminary
√s= 7 TeV, ∫ Ldt = 4.6-4.8 fb-1
√s= 8 TeV, ∫ Ldt = 20.3 fb-1
[κγ, κg, BRi]
h → γγ, ZZ*, WW*, ττ, bb̄,
Zh → ll + ETmiss :
obs. exp.
h → γγ, ZZ*, WW*, ττ, bb̄ :
obs. exp.
-2 ln Λ(BRi)
BRi

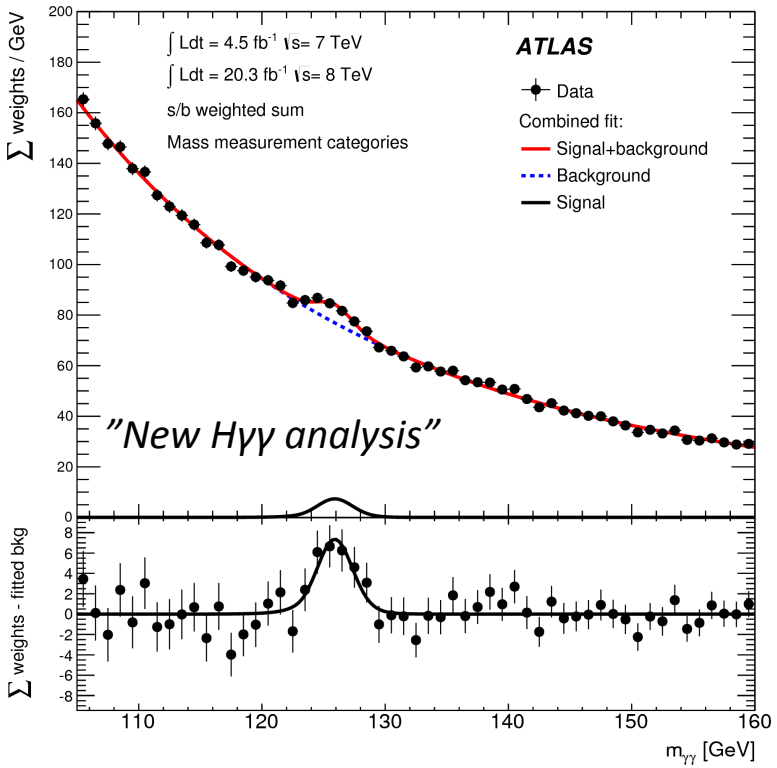
Coupling scale factor	Type I	Type II	Type III	Type IV
κ_V	$\sin(\beta-\alpha)$	$\sin(\beta-\alpha)$	$\sin(\beta-\alpha)$	$\sin(\beta-\alpha)$
κ_u	$\cos(\alpha)/\sin(\beta)$	$\cos(\alpha)/\sin(\beta)$	$\cos(\alpha)/\sin(\beta)$	$\cos(\alpha)/\sin(\beta)$
κ_d	$\cos(\alpha)/\sin(\beta)$	$-\sin(\alpha)/\cos(\beta)$	$\cos(\alpha)/\sin(\beta)$	$-\sin(\alpha)/\cos(\beta)$
κ_l	$\cos(\alpha)/\sin(\beta)$	$-\sin(\alpha)/\cos(\beta)$	$-\sin(\alpha)/\cos(\beta)$	$\cos(\alpha)/\sin(\beta)$

$$\mathcal{M}_S^2 = (m_Z^2+\delta_1)\begin{bmatrix}\cos^2(\beta) & -\cos(\beta)\sin(\beta)\\ -\cos(\beta)\sin(\beta) & \sin^2(\beta)\end{bmatrix} + m_A^2\begin{bmatrix}\sin^2(\beta) & -\cos(\beta)\sin(\beta)\\ -\cos(\beta)\sin(\beta) & \cos^2(\beta)\end{bmatrix} + \begin{bmatrix}0 & 0\\ 0 & \frac{\delta}{\sin^2(\beta)}\end{bmatrix} \quad (15)$$

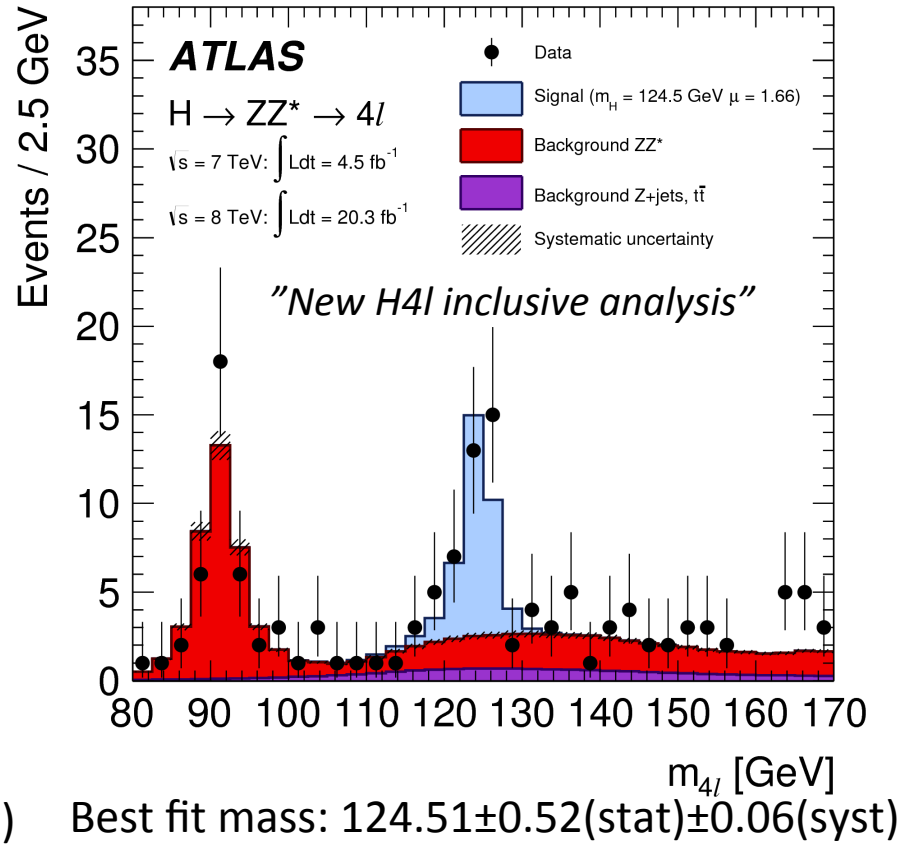
Updated New Mass Results

NEW!

Improved calibration, detector material description and analysis



Best fit mass: 125.98±0.42(stat)±0.28(syst)



Best fit mass: 124.51±0.52(stat)±0.06(syst)

Combined mass: 125.36±0.37(stat)±0.18(syst)

Reduction of the systematic uncertainty by about 60% wrt the old measurement

For more details see Sarah's talk

arXiv:1406.3827[hep-ex] submitted to PRD

H-->ZZ-->4l coupling analysis

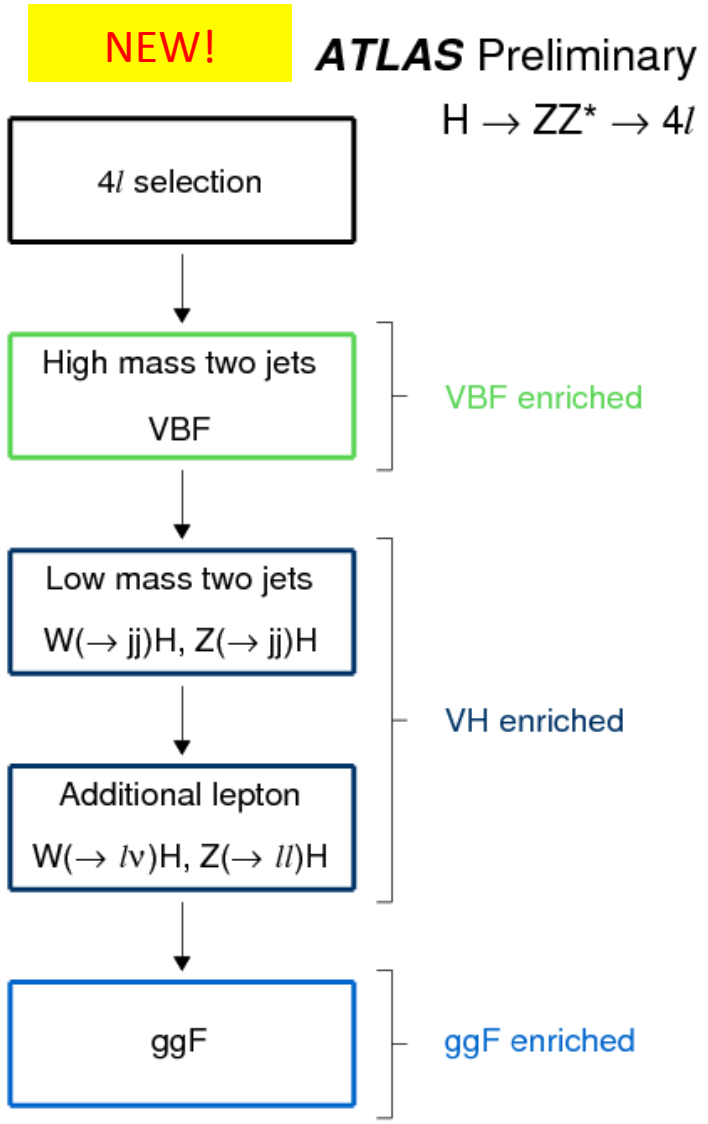
NEW!

Local significance 8.1σ (expected 5.8σ) at 124.51 GeV.

New in the inclusive analysis (used also for the new mass measurement) since Moriond 2013:
-new electron ID (loose likelihood for 2012 only)
-new electron and muon energy calibration
-E/p combination for the electrons
-far FSR recovery for electrons and muons
-BDT for ZZ* background

3 categories were considered in the Moriond 2013 analysis:
-VBF-like (accompanied with 2 high pT jets widely separated in rapidity)
-VH-like (accompanied with an additional lepton)
-ggF-like (all the others)

New in the specific couplings analysis:
-Add a VH hadronic category
-Looser cuts on the VBF category
-BDT for both VBF and VH categories



Updated New 4l Coupling Results

NEW!

H-->ZZ-->4l: NEW Coupling results!(To be submitted to PRD)

"New H4l coupling analysis"

(125.36 GeV combined mass)

NEW!

$$\mu = 1.44^{+0.34}_{-0.31}(stat)^{+0.21}_{-0.11}(syst)$$

$$\mu_{ggF+bbH+ttH} * B/B_{SM} = 1.66^{+0.45}_{-0.41}(stat)^{+0.25}_{-0.15}(syst)$$

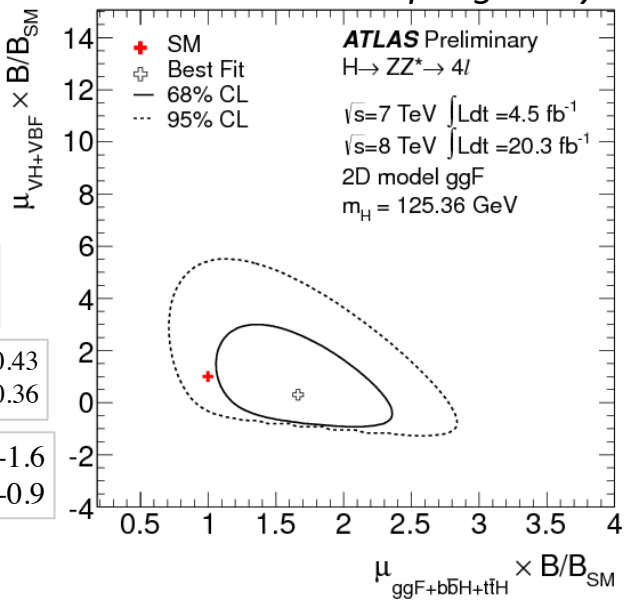
$$\mu_{VBF+VH} * B/B_{SM} = 0.26^{+1.60}_{-0.91}(stat)^{+0.36}_{-0.23}(syst)$$

OLD!

$$\mu = 1.43^{+0.40}_{-0.35}$$

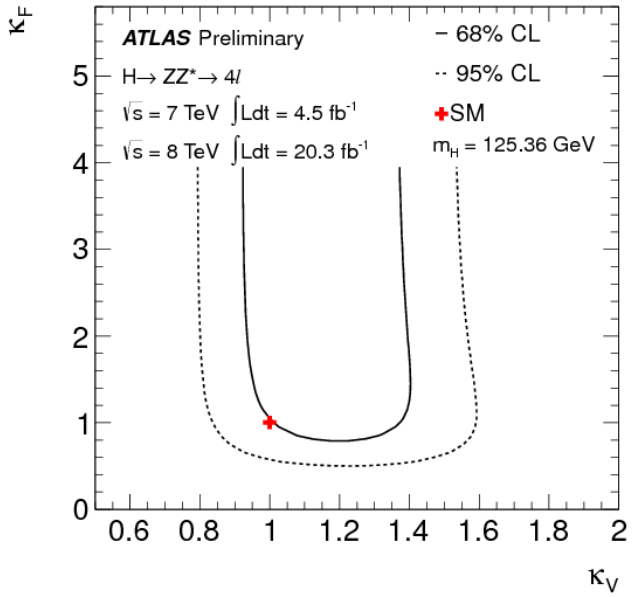
$$\mu_{ggF+ttH} = 1.45^{+0.43}_{-0.36}$$

$$\mu_{VBF+VH} = 1.2^{+1.6}_{-0.9}$$



κ_F is unbounded since cannot exclude μ_{VBF+VH}=0

2D compatibility with SM is 30%



λ_{FV}=0 is disfavoured at 4σ level