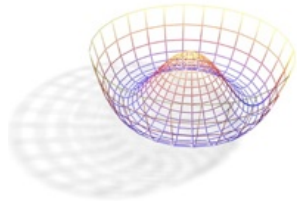
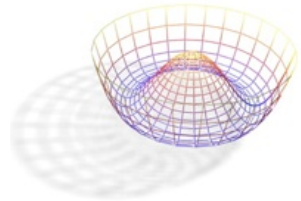


Latest Higgs Physics results from the ATLAS experiment

Nicolo de Groot

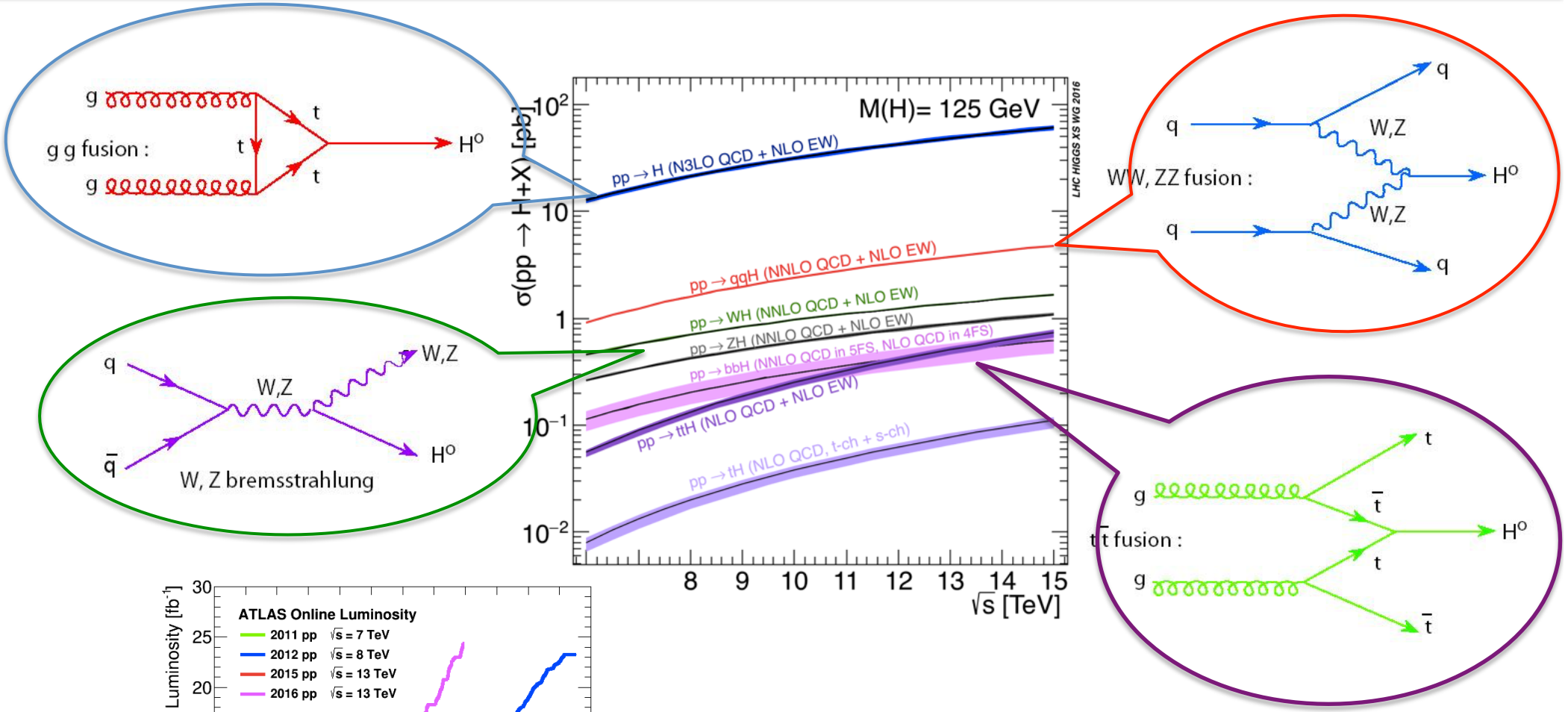
Radboud University and Nikhef

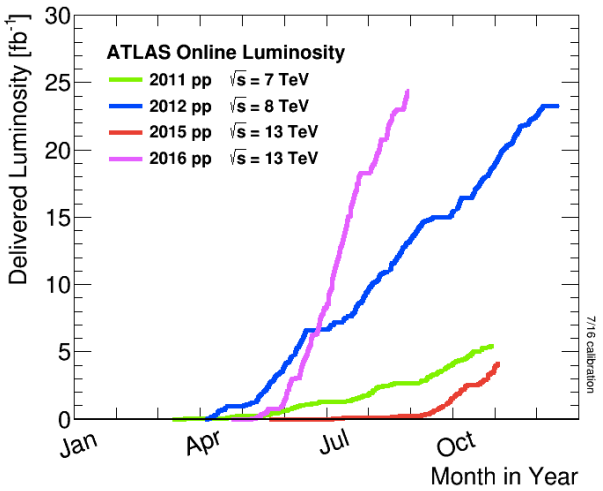
Overview



- Higgs at the LHC
- Run 1 highlights
- Higgs to bosons
- ttH
- Higgs to bb
- Rare decays
- Outlook and conclusions

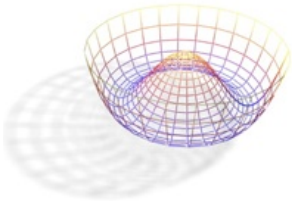
Higgs production at the LHC





From 8 TeV to 13 TeV: factor 2 in σ except ttH: factor 4

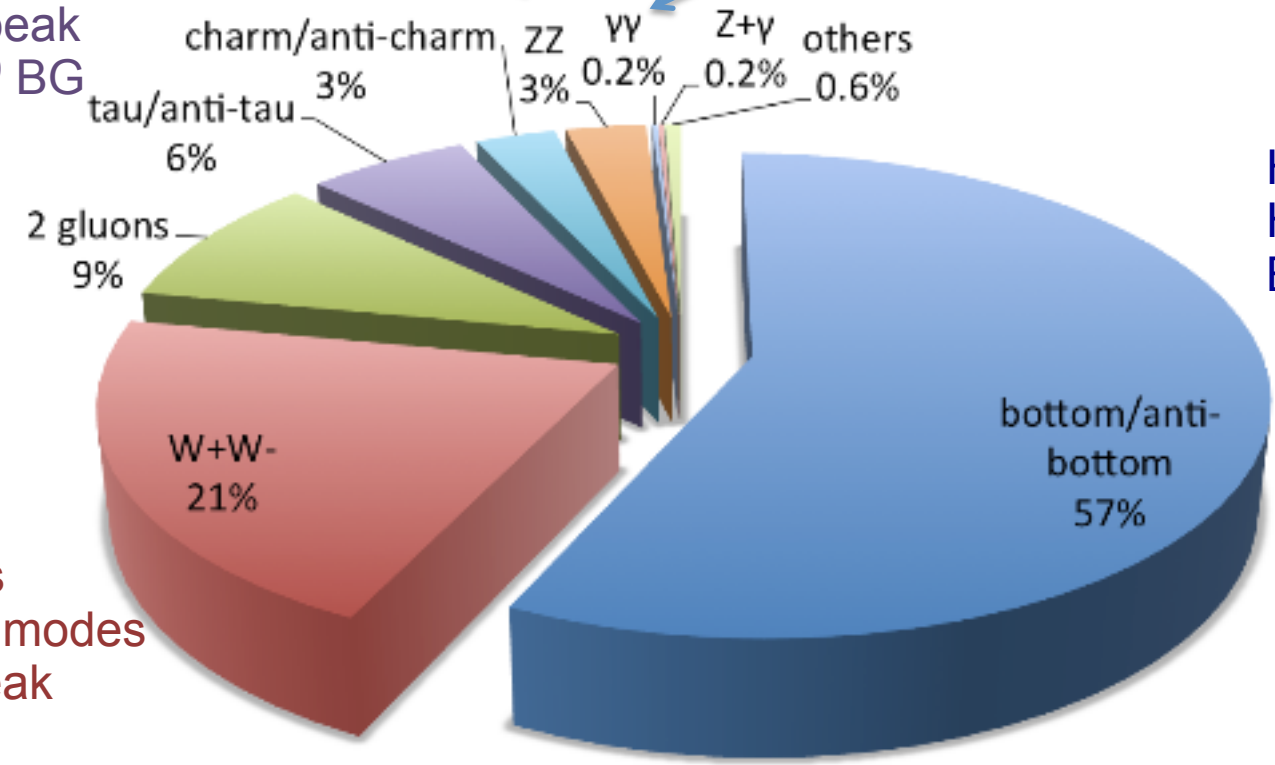
Higgs decays @ 125 GeV



Only 4l, low stat
No BG
Narrow peak

Ok stats
High BG
Narrow peak

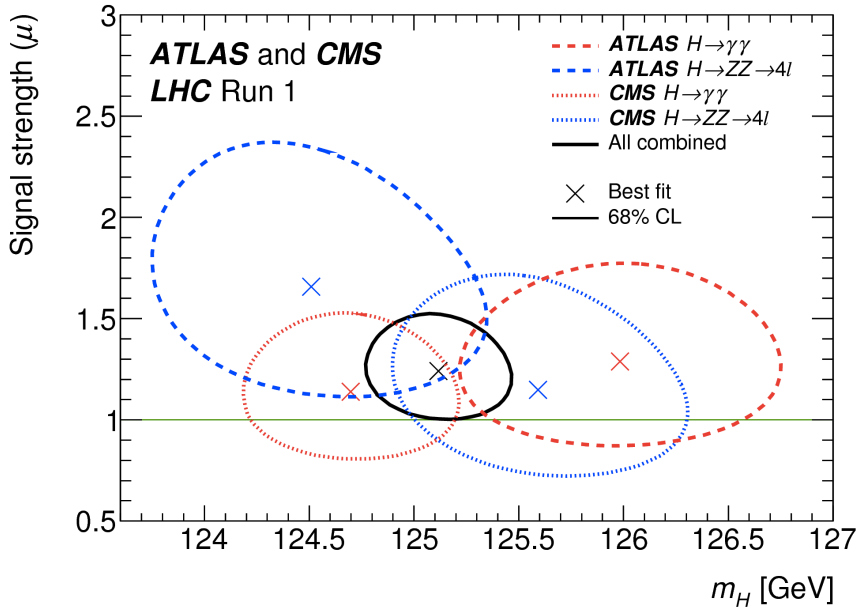
Lepton/had modes
Very broad peak
VBF best, Z^0 BG

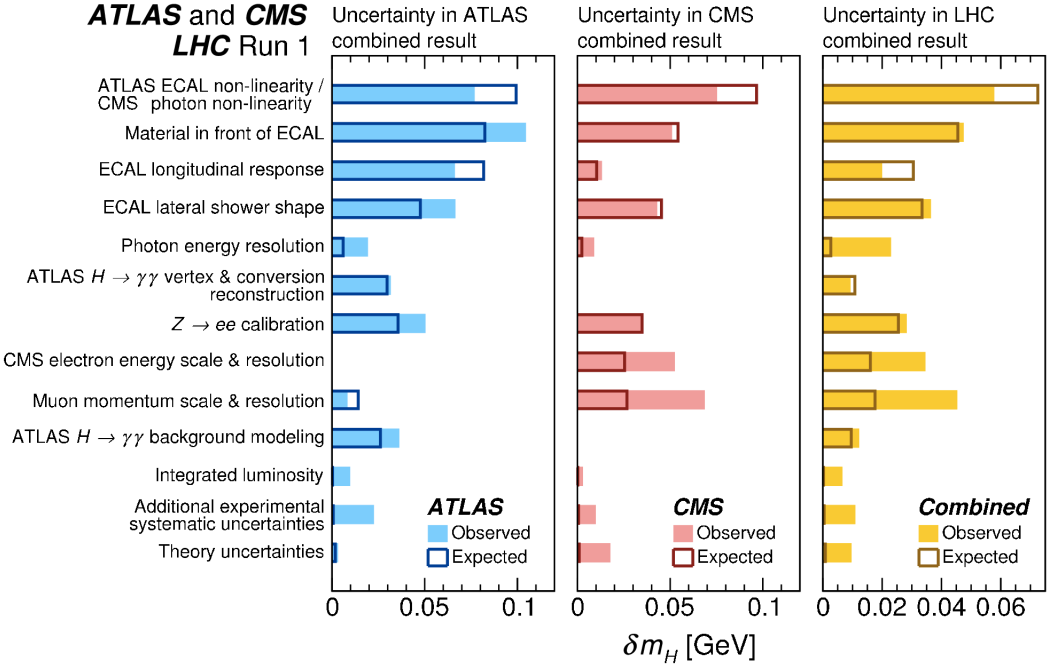


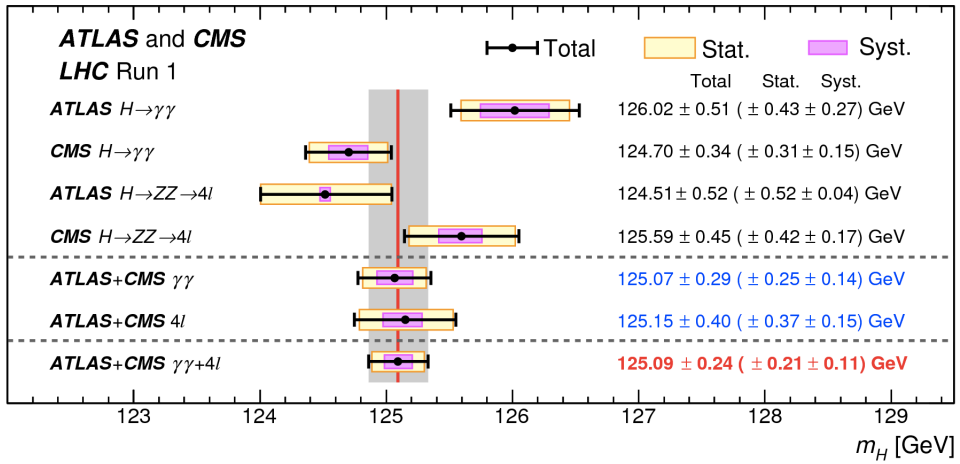
High statistics
High BG
Broad mass peak

Ok statistics
Only lepton modes
No mass peak

Run 1 - Higgs mass

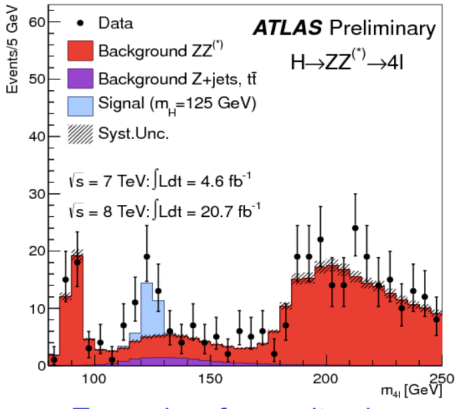


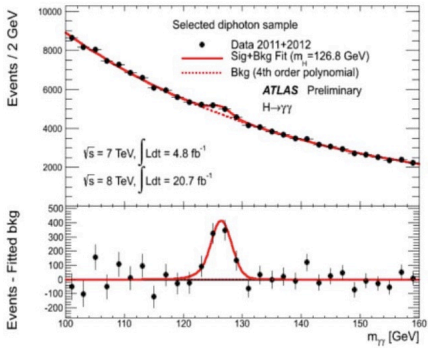


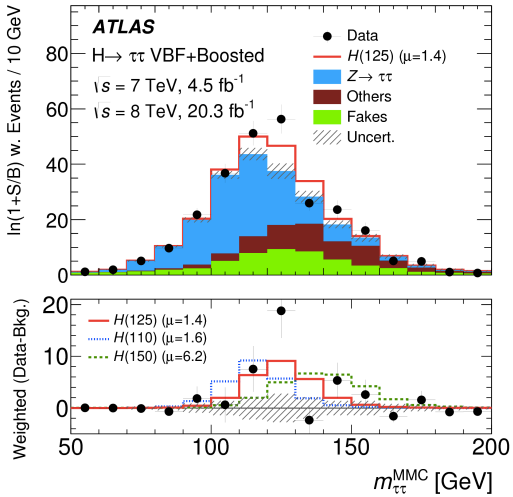


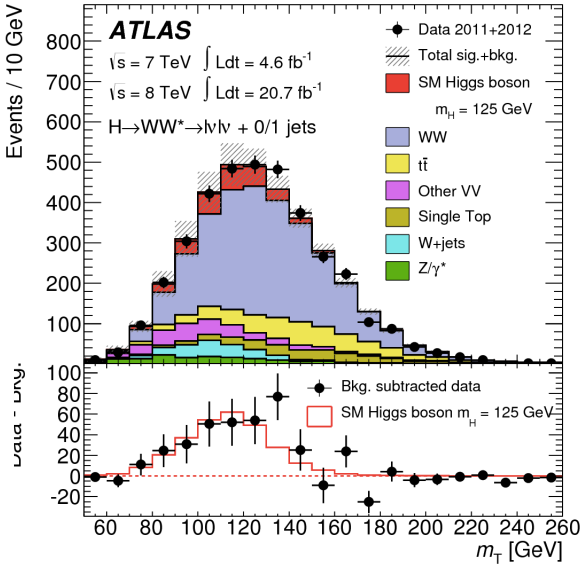
- Use μμ and γγ only
- M_H = 125.09 ± 0.24 GeV
- 0.2 % precision

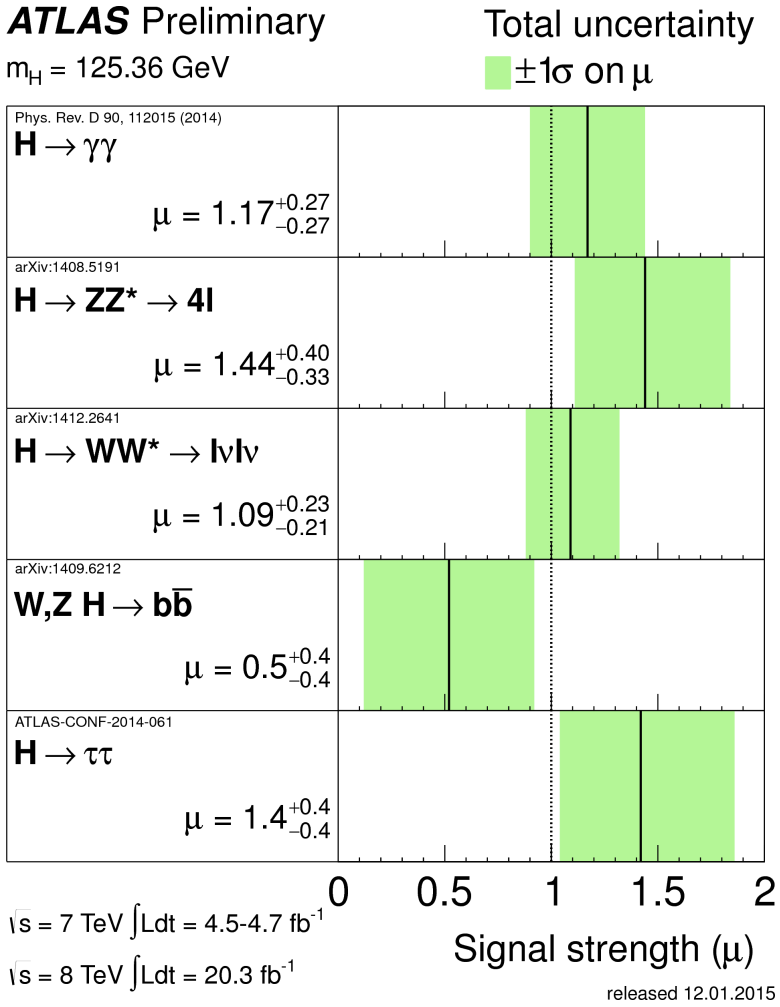
Run 1 - Higgs discovery and couplings





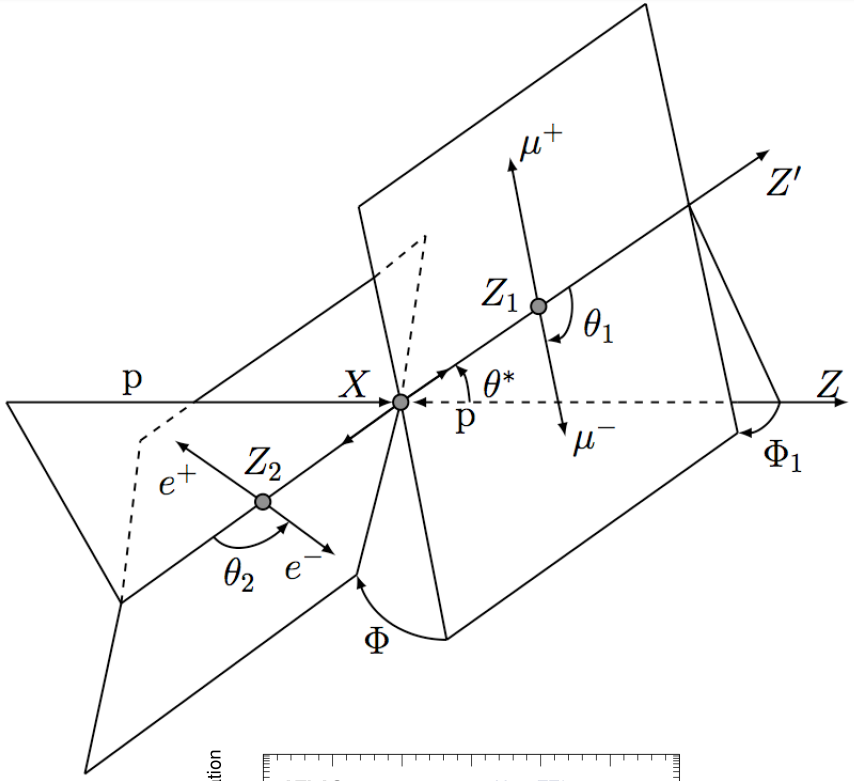


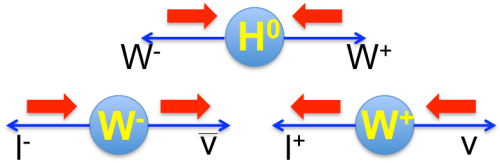


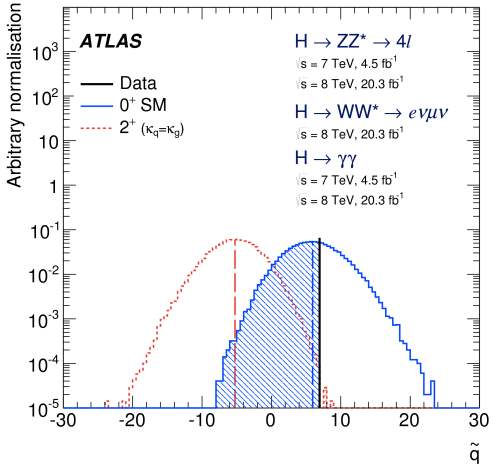


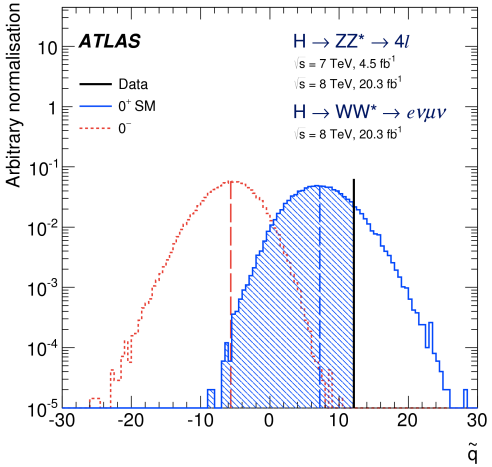
$\mu = \sigma / \sigma_{SM}$

Run 1 - Spin and parity measurement









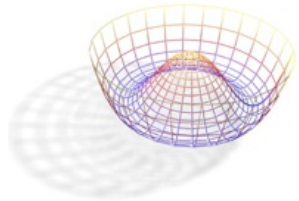
SM Higgs is spin 0 and positive parity

Decay angles are sensitive to the spin and parity of the Higgs boson

These are input to a multivariate analysis (BDT or NN)

Test SM hypothesis 0^+ against alternative

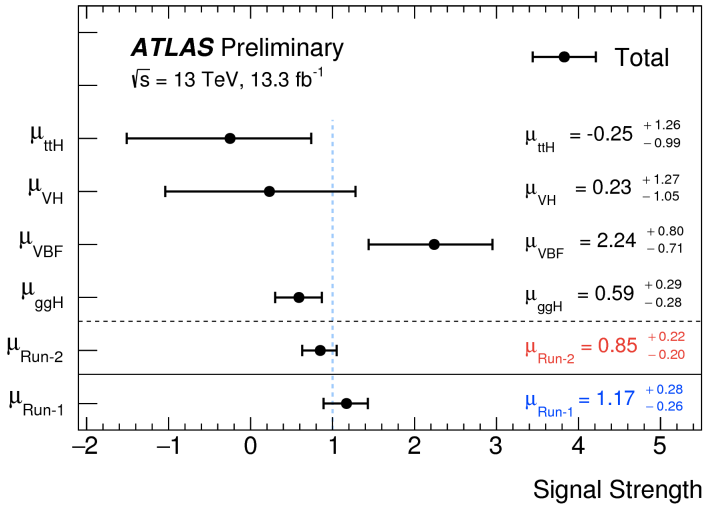
Clear preference for $0^+ \rightarrow$ It's a Higgs

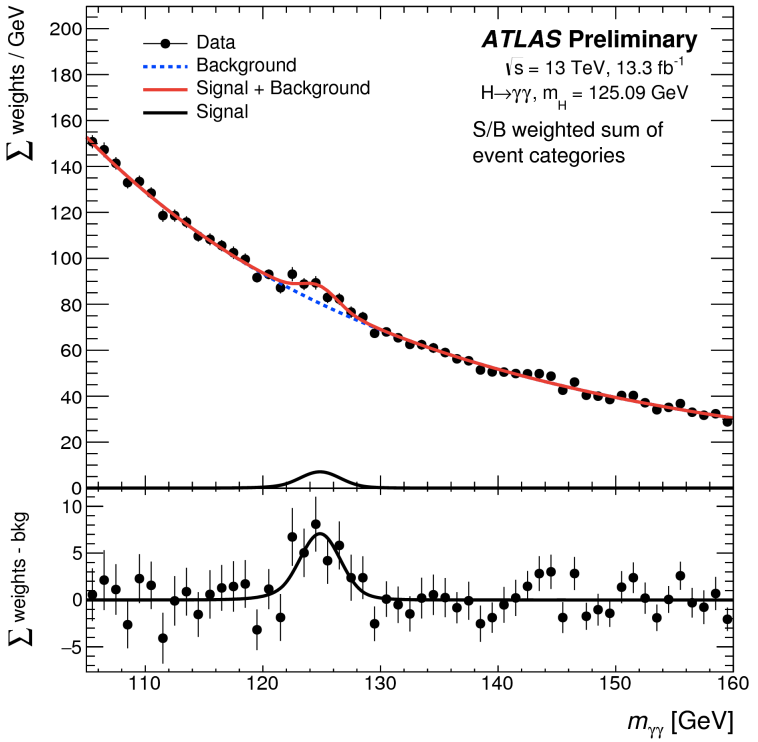


HIGGS TO BOSONS

H→γγ

- Signature: 2 isolated photons, narrow peak, falling background
- Main BG: γγ and γ-jet
- All production modes included
- Fit to mγγ spectrum
- Dominant systematic: γ energy scale/resolution bg model



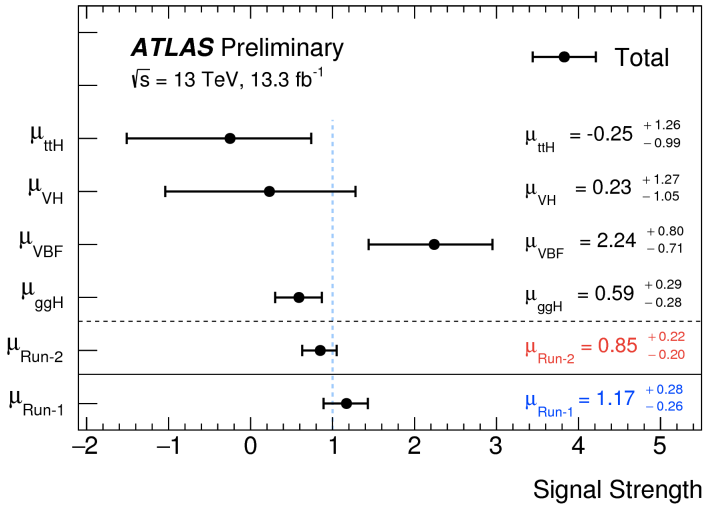


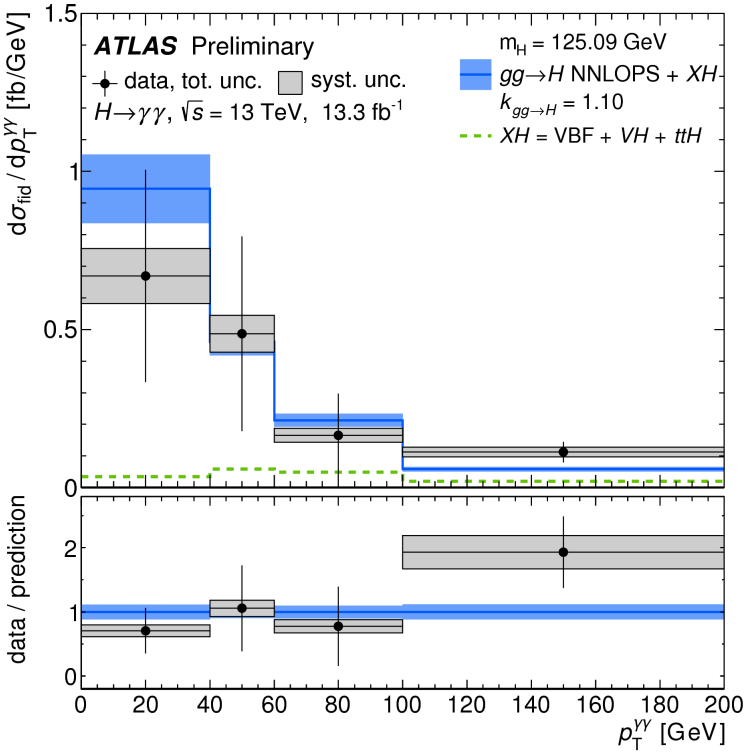
Precision run 2 already better than run 1
Fiducial Cross section:
σ = 43.2 ± 14.9 ± 4.9 fb

ATLAS-CONF-2016-067

H→γγ

- Signature: 2 isolated photons, narrow peak, falling background
- Main BG: γγ and γ-jet
- All production modes included
- Fit to mγγ spectrum
- Dominant systematic: γ energy scale/resolution bg model



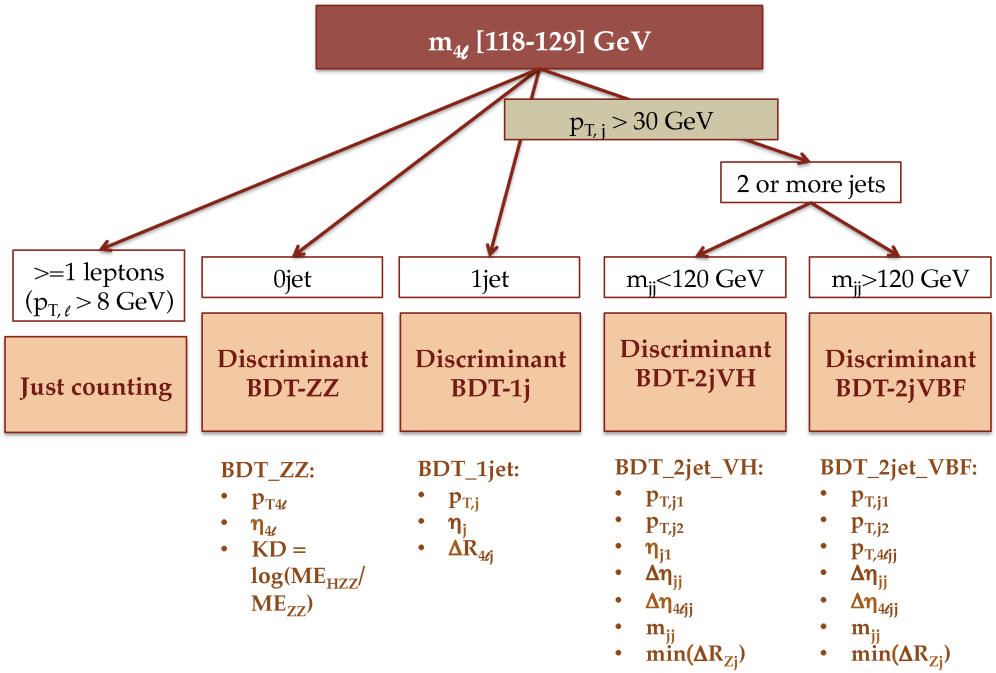


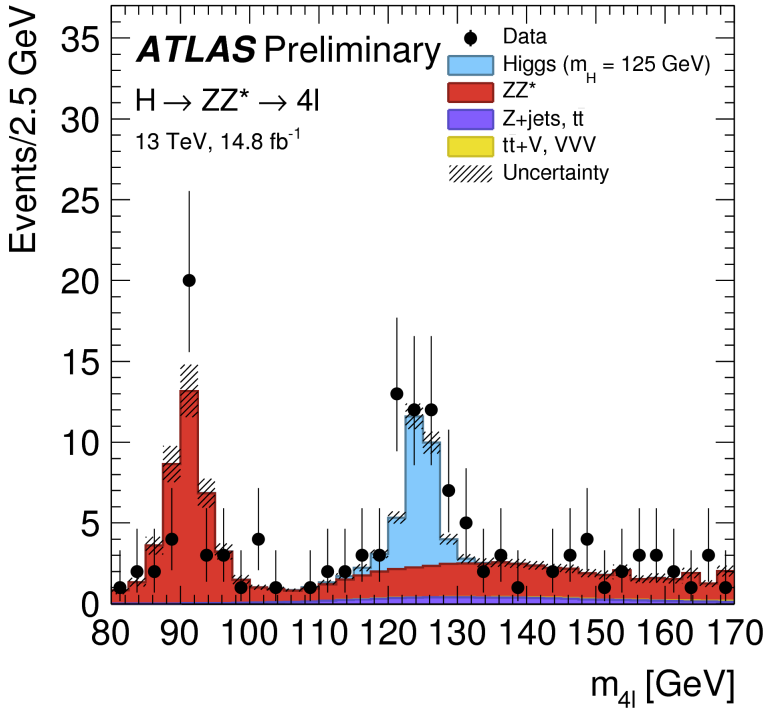
Differential distributions: p_t, η, #jets
Precision run 2 already better than run 1
Fiducial Cross section:
σ = 43.2 ± 14.9 ± 4.9 fb

ATLAS-CONF-2016-067

H→ZZ*

- Signature: 4 isolated leptons, narrow peak, flat background
- Main BG: ZZ
- All production modes included
- Fit to m_{4l} spectrum





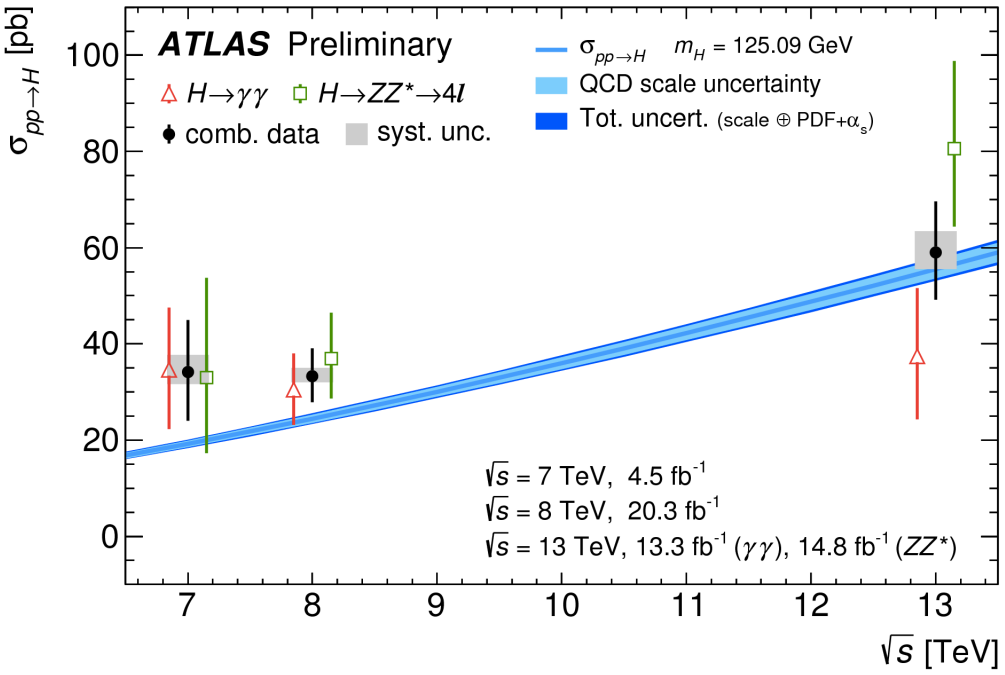
Fiducial Cross section:
$\sigma = 4.54^{+1.02}_{-0.90}$ fb

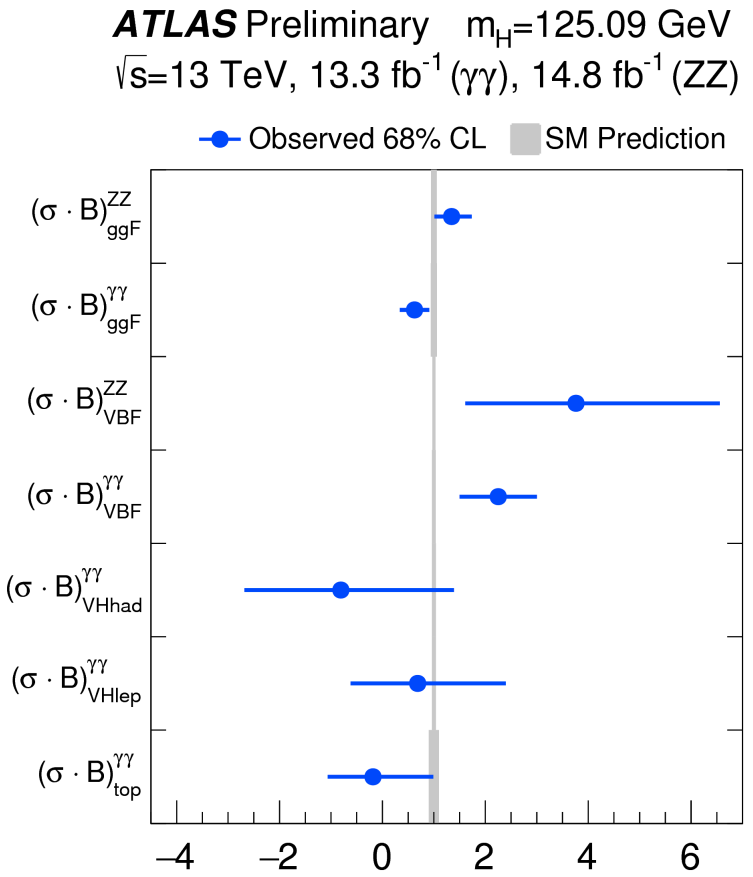
ATLAS-CONF-2016-079

H→γγ and ZZ* combination

- Combine the inclusive samples
- 10 σ observation (8.6 σ exp)
- $\mu = 1.13\ ^{+0.18}_{-0.17}$

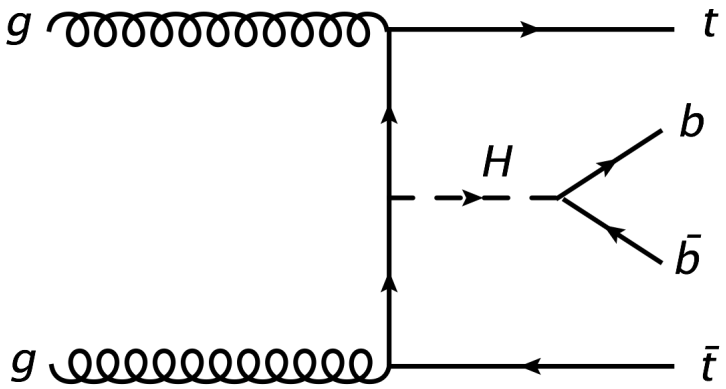
Similar precision as run 1



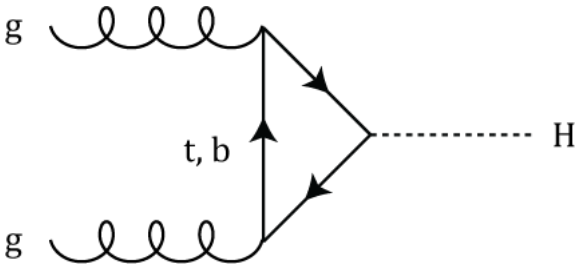


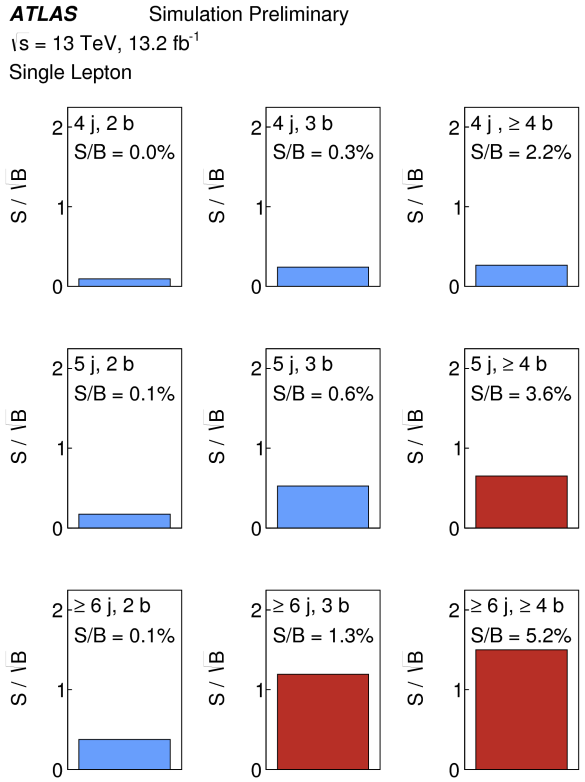
ATLAS-CONF-2016-081

ttH (H→ bb)



VS





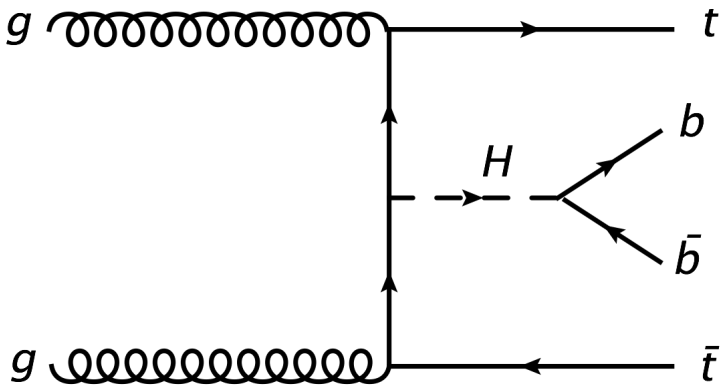
Motivation: direct probe of ttH Yukawa coupling

Strategy:

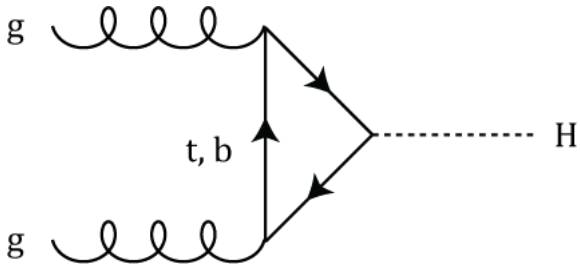
- Benefits from 13 TeV
- High BR H→ bb, 58%
- 4b jet final state, 1 lepton + 2 or 2 leptons
- Catagorize events in #jets, #b's #leptons
- Use multivariate techniques to boost S/B
- Dominant backgrounds tt + HF
- Dominant error tt+HF modeling

ATLAS-CONF-2016-080

ttH (H→ bb)



VS



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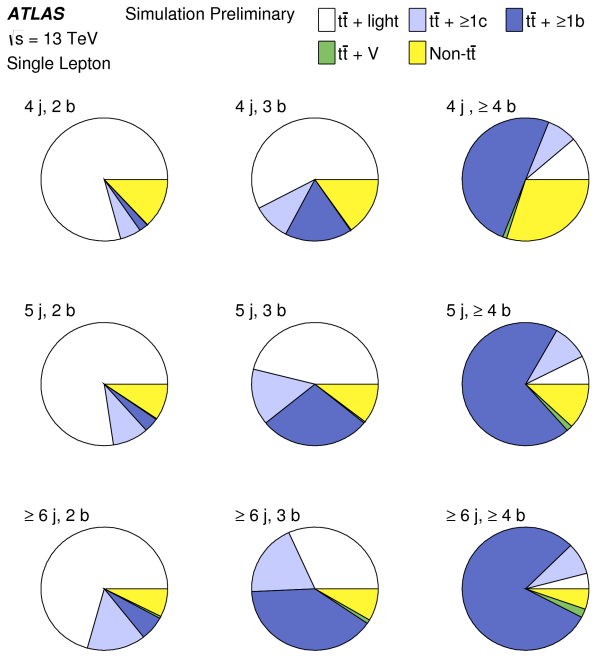
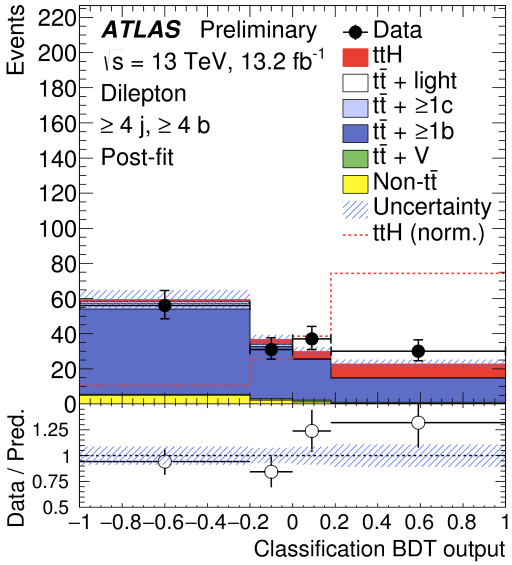
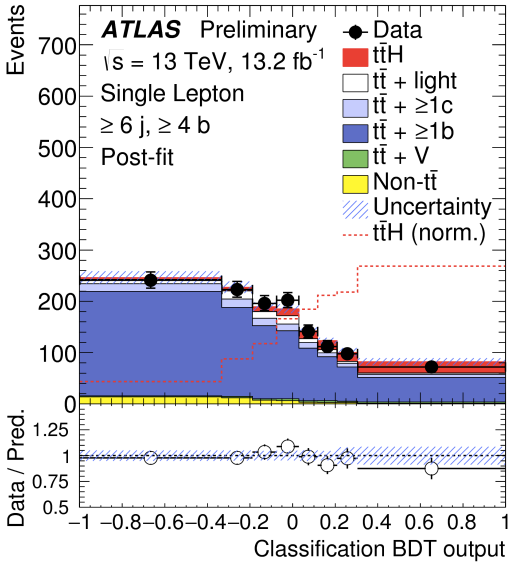
- Use multivariate techniques to boost S/B
- Dominant backgrounds tt + HF
- Dominant error tt+HF modeling

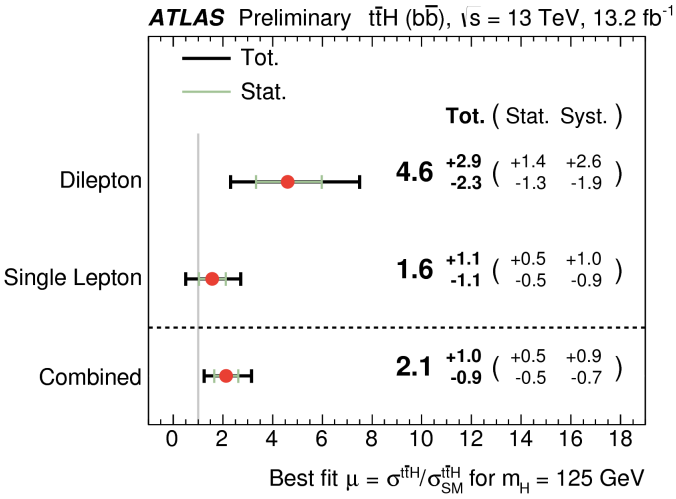


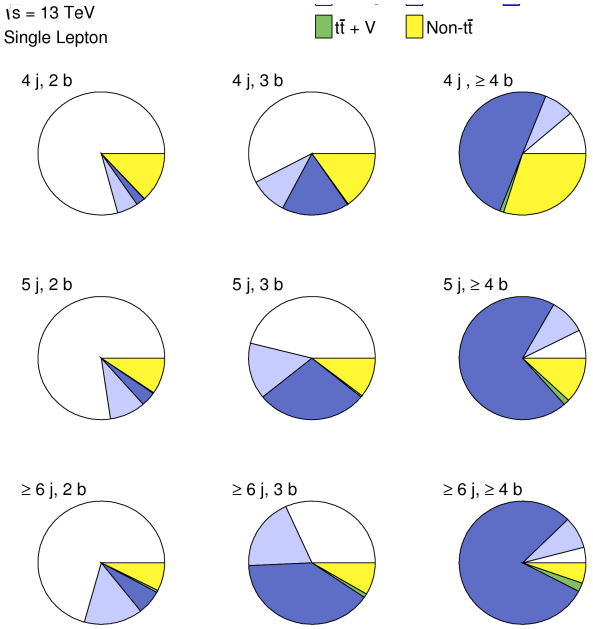
ATLAS-CONF-2016-080

ttH (H→ bb)









Motivation: direct probe of ttH Yukawa coupling

Strategy:

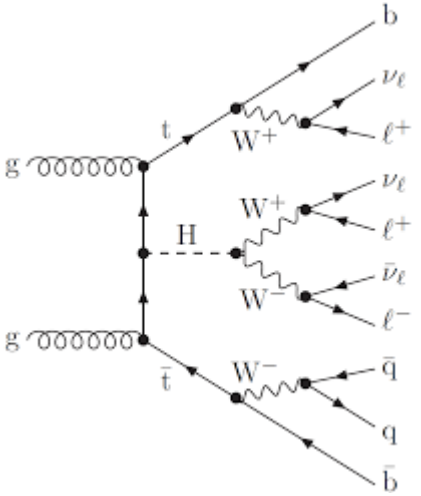
- Benefits from 13 TeV
- High BR H→ bb, 58%
- 4b jet final state, 1 lepton + 2 or 2 leptons
- Catagorize events in #jets, #b's #leptons
- Use multivariate techniques to boost S/B
- Dominant backgrounds tt + HF
- Dominant error tt+HF modeling

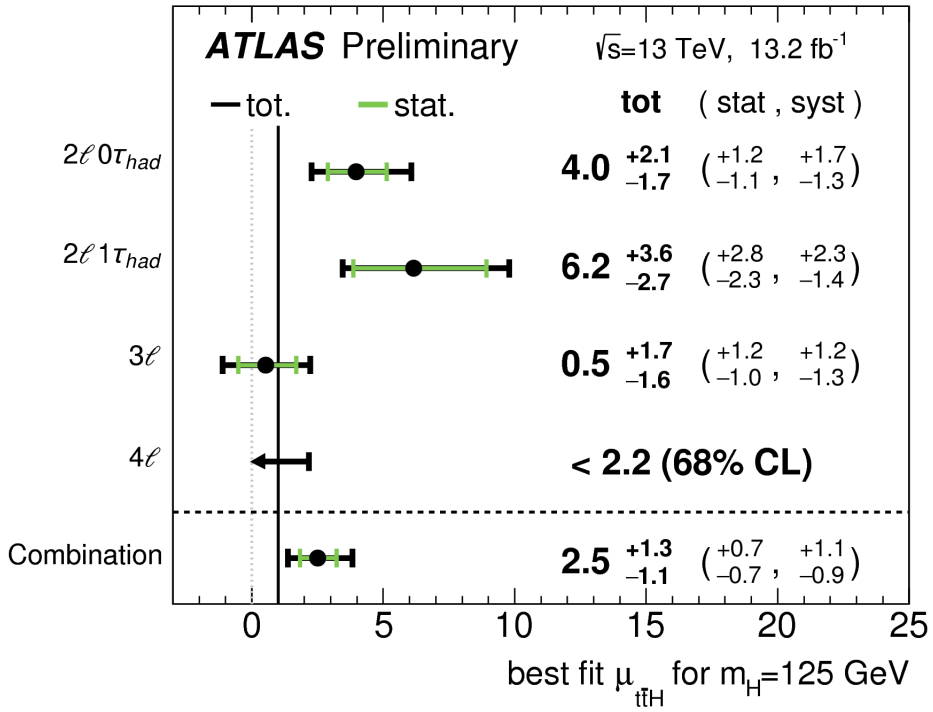
ATLAS-CONF-2016-080

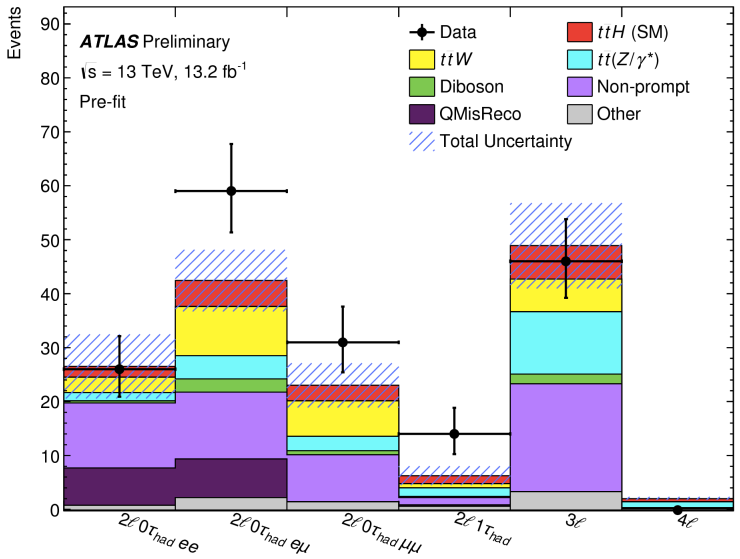
ttH multilepton

Strategy:

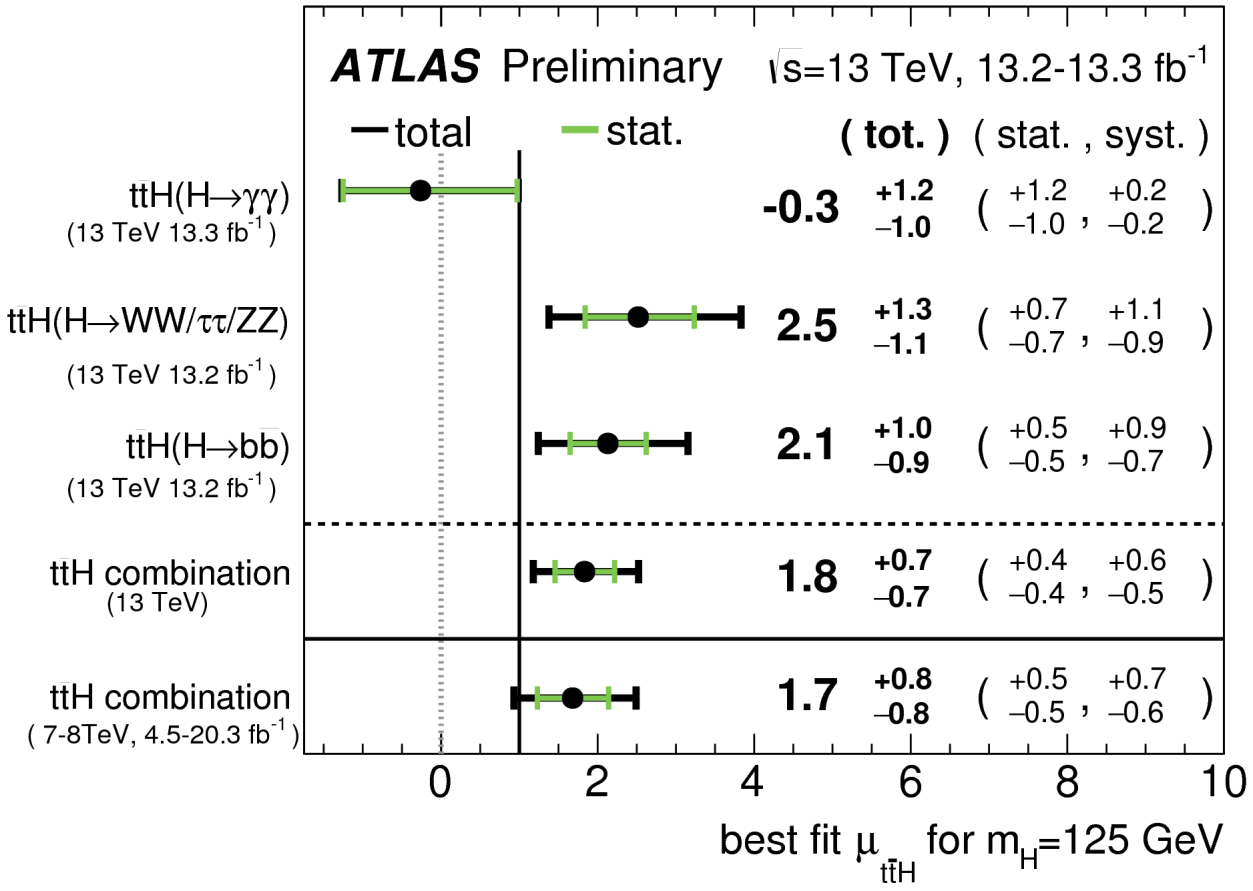
- Benefits from 13 TeV
- Clean signature, low BG
- 2 jet final state, 1-2b, 2-4 leptons, 0-1 τ
- Upper limit 95% C:L μ < 4.9 (2.3 exp)



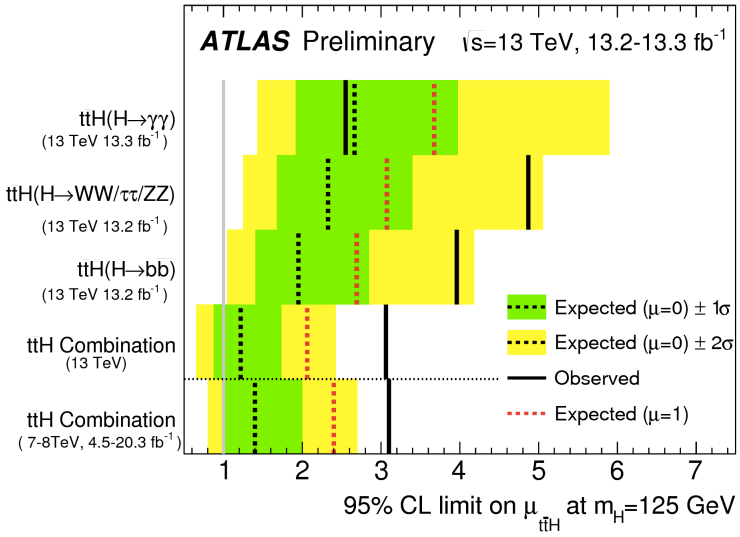


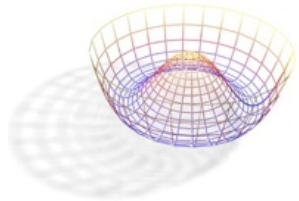


ttH combination



Significance:
Run 2: σ = 2.8 (1.8 exp)
Run 1: exp σ = 1.5
Already more sensitive



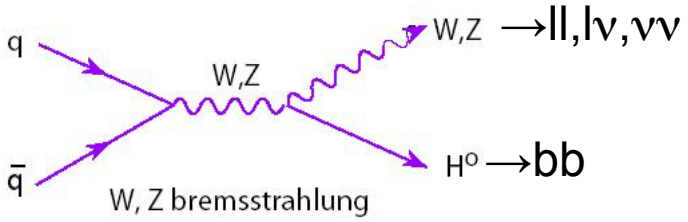


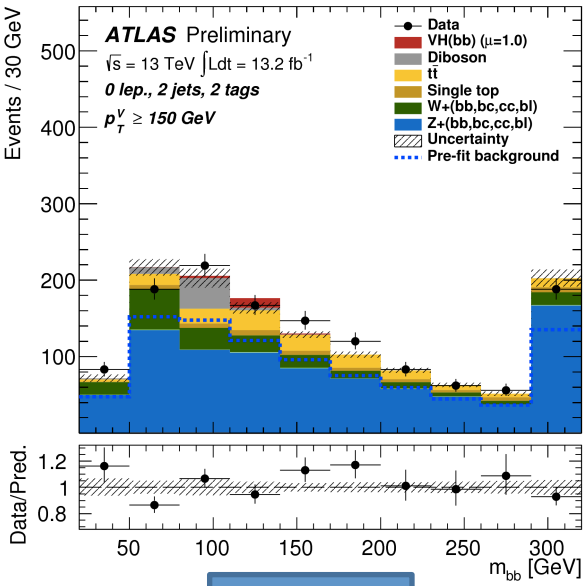
HIGGS TO BB

VH (H→ bb)

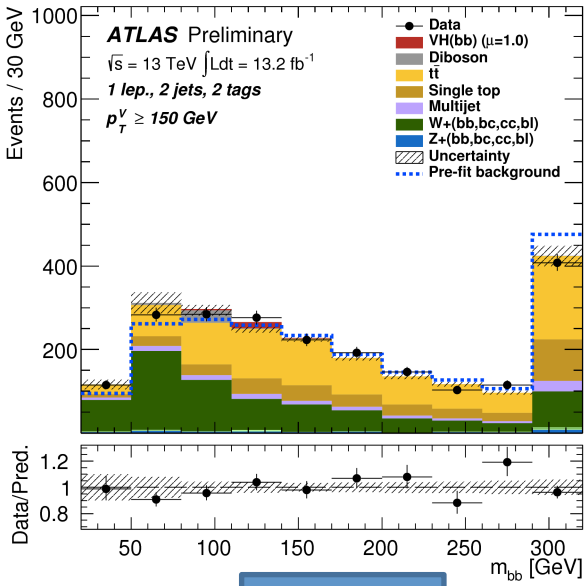
Strategy:

- High BR H→ bb
- Use lepton(s) from Z, W (or missing E_t for Z→ νν)
- Use multivariate techniques for good S/B
- Dominant backgrounds tt and Z+b
- Best discrimination from m_{bb} and ΔR_{bb}

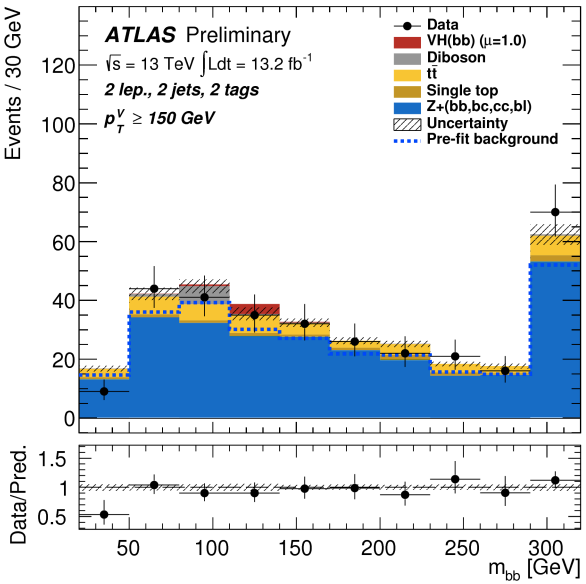




0 lepton



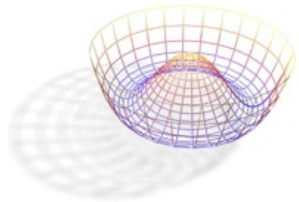
1 lepton



2 leptons

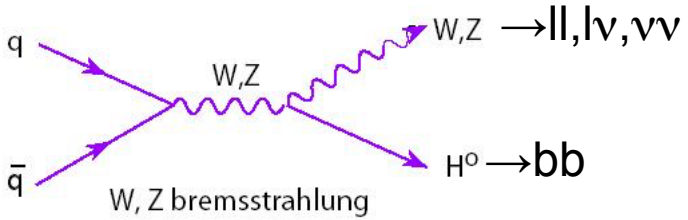
ATLAS-CONF-2016-091

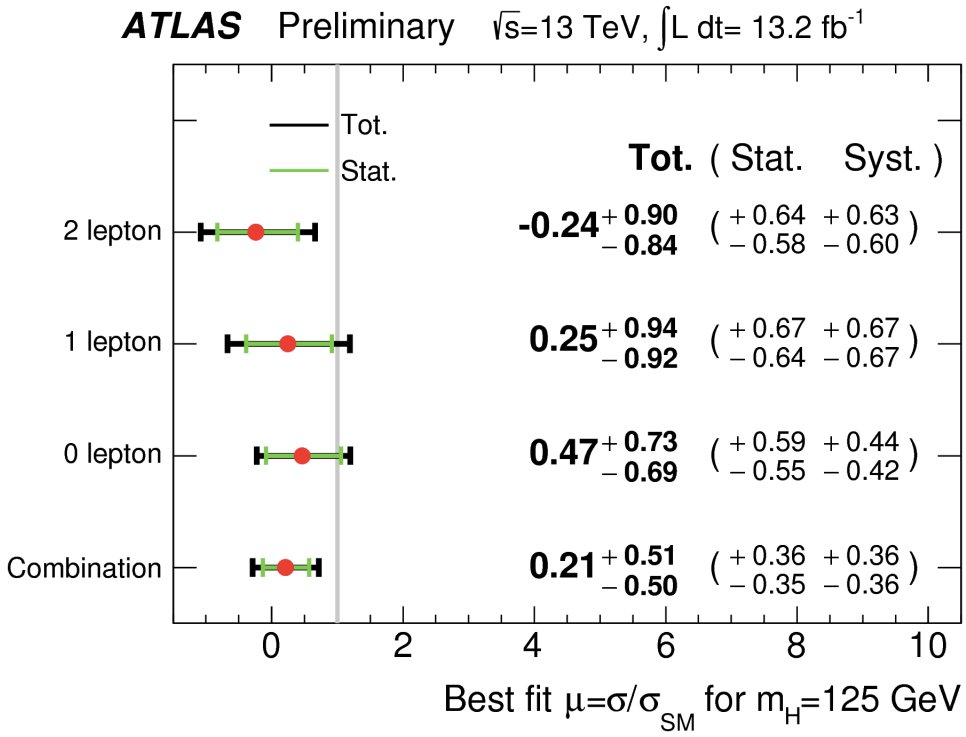
VH (H→ bb)

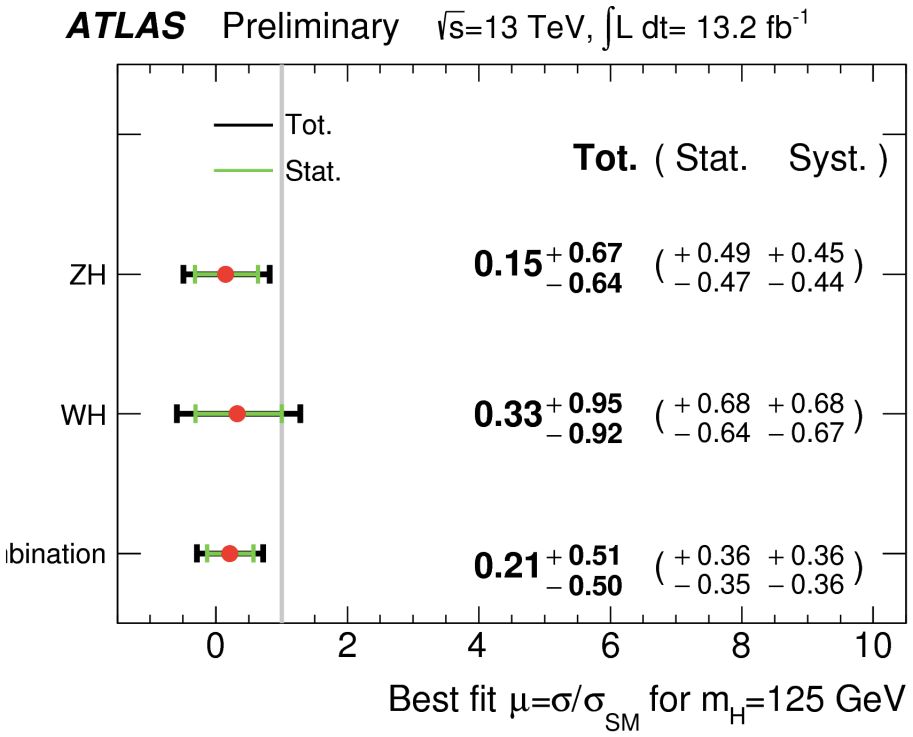


Strategy:

- High BR H→ bb
- Use lepton(s) from Z, W (or missing E_t for Z→ νν)
- Use multivariate techniques for good S/B
- Dominant backgrounds tt and Z+b
- Best discrimination from m_{bb} and ΔR_{bb}







ATLAS-CONF-2016-091

VBF (H→ bb)

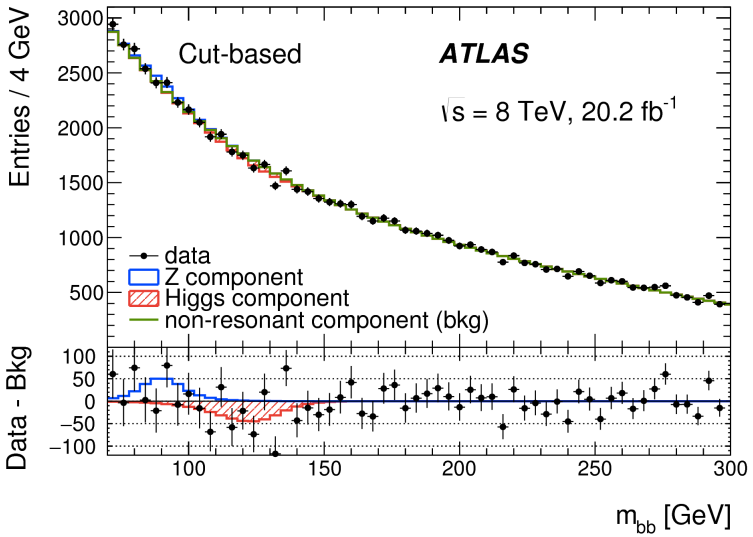
Strategy:

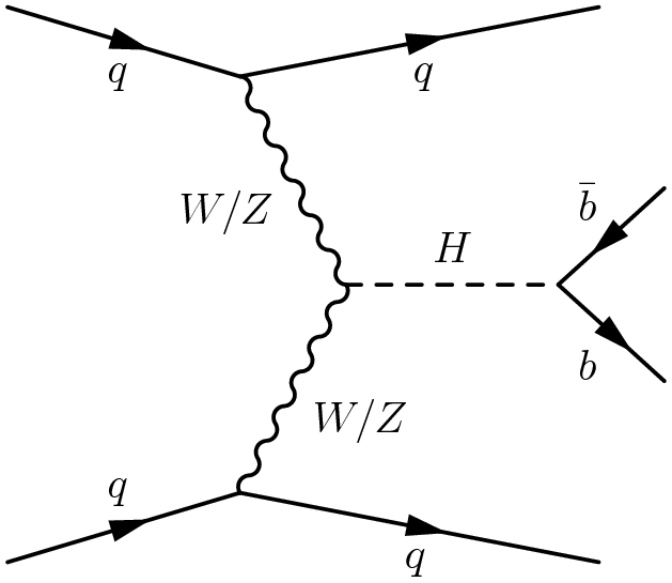
- High BR H→ bb
- Use forward tagging jets and rapidity gap
- Use BDT to improve S/B (still poor)
- Dominant backgrounds QCD, Z→ bb
- Fit to m_{bb}

Result:

$\mu = -0.8 \pm 1.3 \pm 1.8$

Limit: $\mu = 4.4$ @95%CL



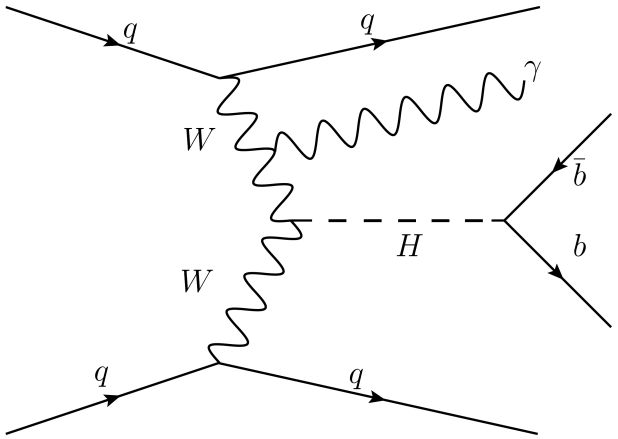


arXiv:1606.02181

VBF (H→ bb) + γ

Strategy:

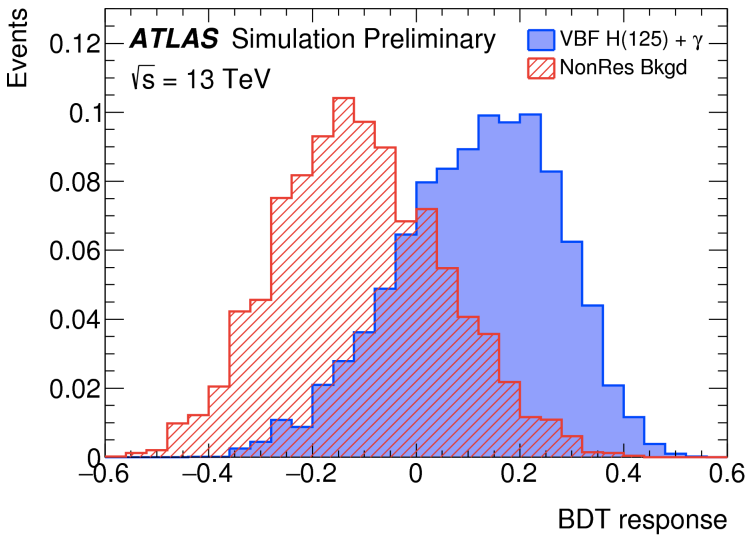
- High BR H→ bb,
- Use forward tagging jets and rapidity gap
- Clean-up with photon
- Use BDT to improve S/B
- Fit to m_{bb} in BDT bins

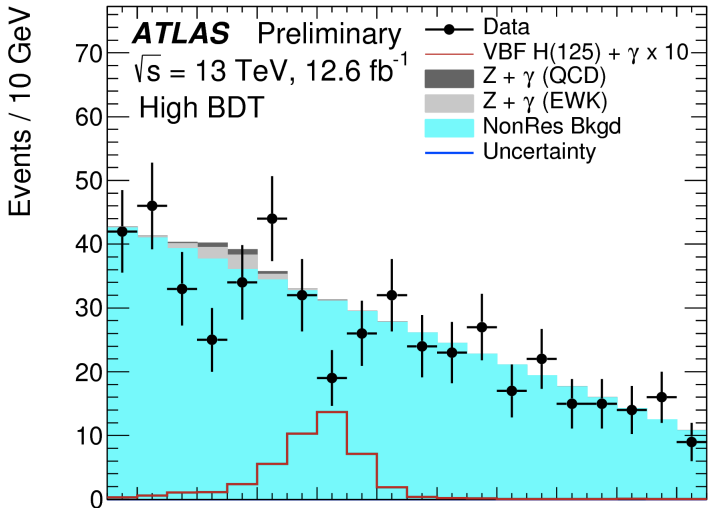


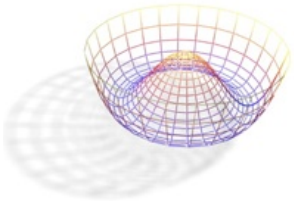
Result:

Limit: μ = 4.0 @95%CL (fit

Cross check with Z→ bb + γ

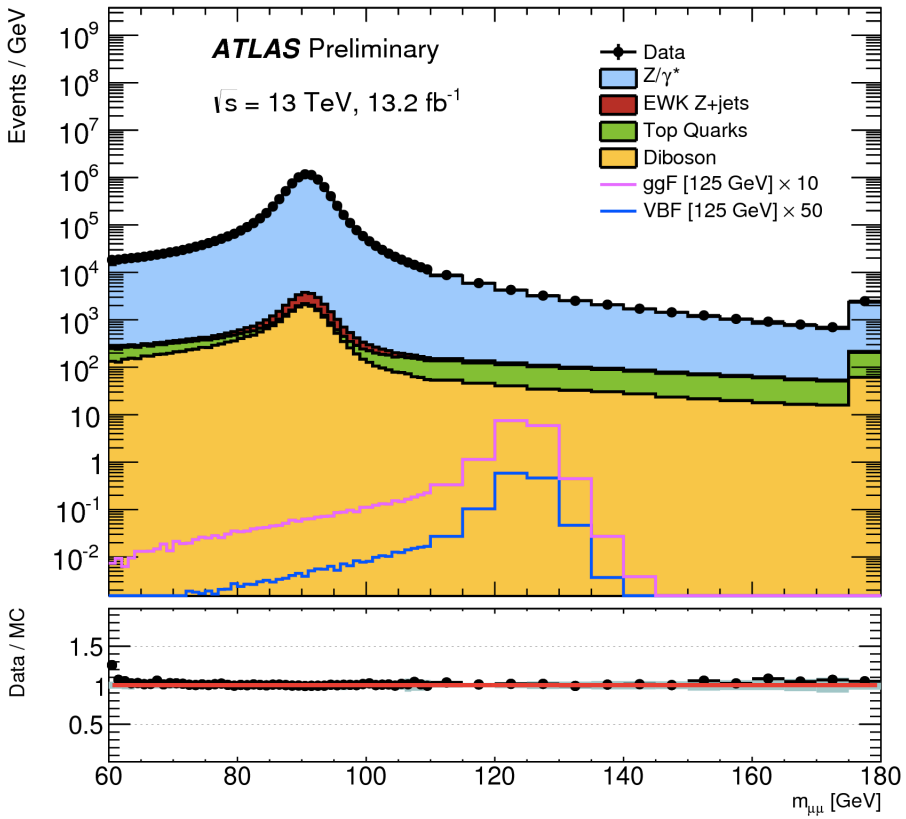






RARE AND FORBIDDEN DECAYS

Higgs→$\mu^+\mu^-$

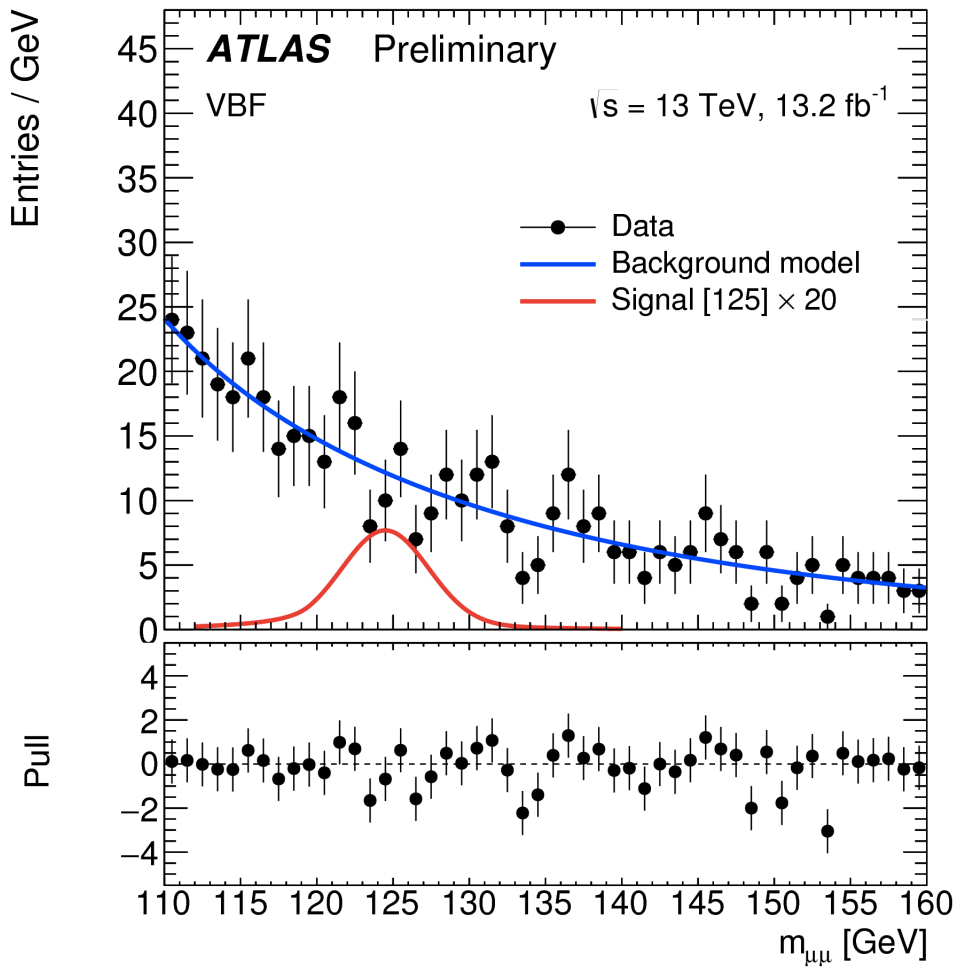


- Very rare decay in SM, BR ~ 2 x 10^{-4}
- First probe of Higgs coupling to 2nd generation fermions
- Very clean signature with 2 muons
- Large background from Z/γ*

- **Strategy:**
  - Separate VBF (S/√B ~ 0.28) from rest (S/√B 0.09-0.23)
  - Look for peak in $m_{\mu\mu}$ spectrum

ATLAS-CONF-2016-041

Higgs→$\mu^+\mu^-$



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- **Strategy:**
  - Separate VBF (S/√B ~ 0.28) from rest (S/√B 0.09-0.23)
  - Look for peak in $m_{\mu\mu}$ spectrum

Limits

	95% CL limit x SM (expected)
Run 1	7.1 (7.2)
Run 2	4.4 (5.5)
Combined	3.5 (4.5)

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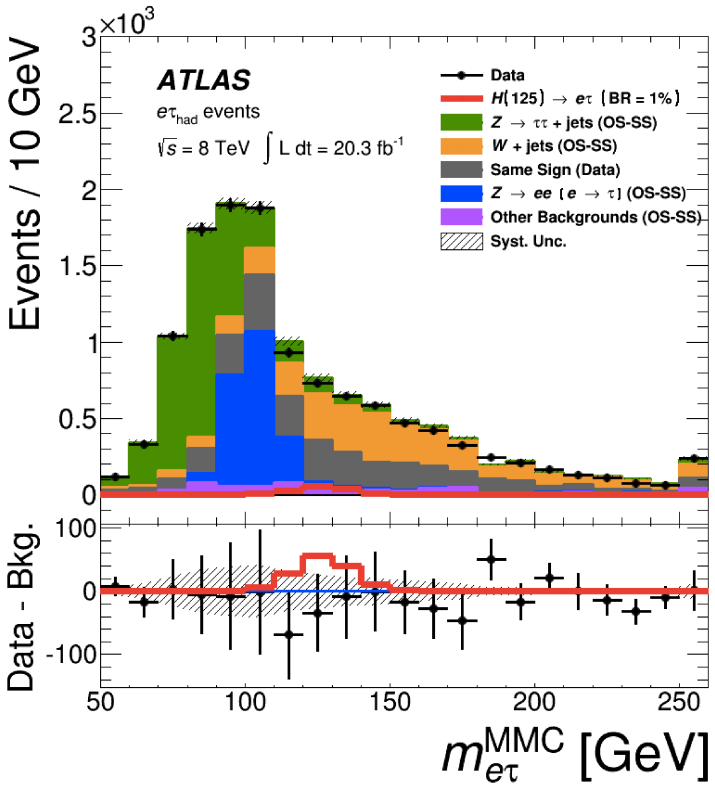
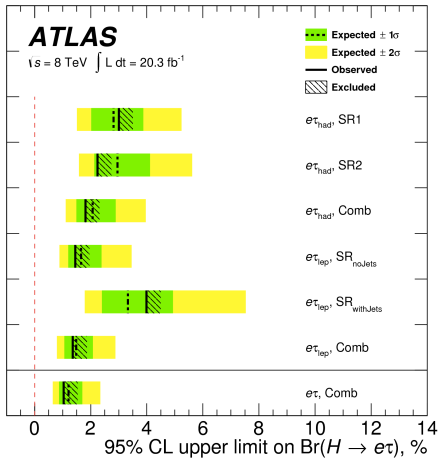
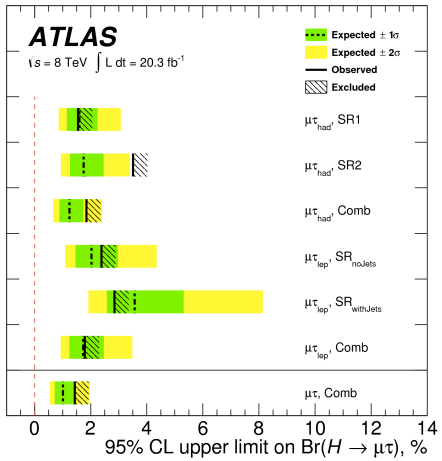
Lepton Flavor Violating Higgs



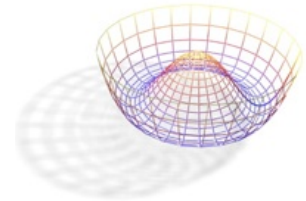
JHEP 1511 (2015)
arXiv:1604.07730

- Look for H→μτ and H→eτ
- Small excess seen by CMS in run 1
- Calculate invariant mass with MMC
- Main BG Z→ττ
- 95 % CL Limits:
  - H→eτ : 1%
  - H→μτ :1.4%





Outlook and conclusions



- Run 2 made an impressive start
- Higgs sample matching or exceeding run 1 already
- Many results, many more to come
  - Look for WW and $\tau\tau$ updates
  - Differential distributions
  - Higgs as a probe
  - CP studies
  - End 2016 2-6 x Run 1 Higgs sample, end 2018 8-20x

Higgs physics is becoming precision Standard Model physics