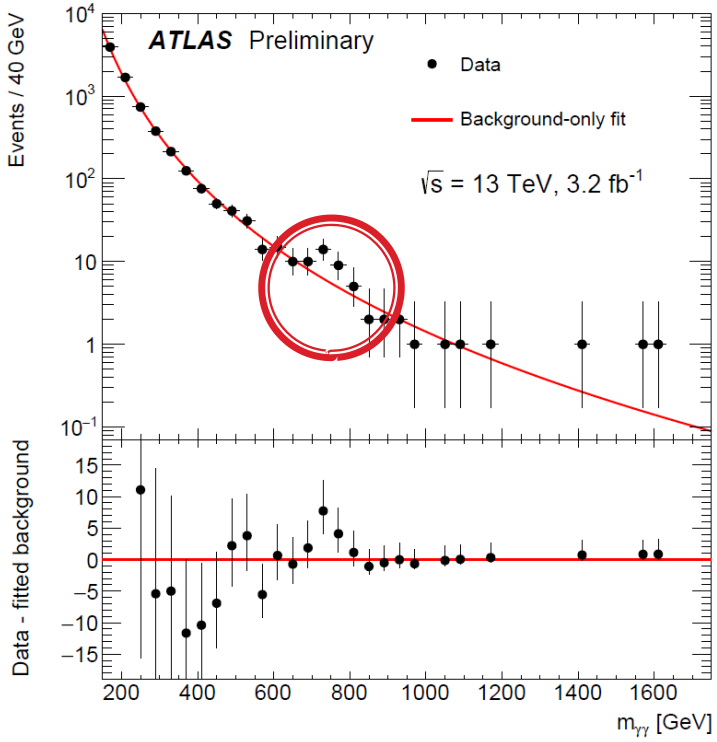
The 750 GeV excess

It's definitely real

On behalf of the WOOOOAHSAAAA collaboration
WOrkgrOup On emplOying tOrOidal and Other Apparati
for diHiggs SeArches And AlternAtives

The 750 excess

- 750 GeV $\gamma\gamma$ bump
- What if it's a heavy Higgs?
- Decay into dihiggs



DiHiggs searches: theoretical models

Randall-Sundrum Radions

Gravitons "alien visitors" from other brane

Golberger-Wise mechanism gives mass to brane oscillation in new dimension: radion

Kaluza-klein graviton

Add fifth dimension to unify EM & GR

$$\widetilde{g}_{ab} \equiv \begin{bmatrix} g_{\mu\nu} + \phi^2 A_\mu A_\nu & \phi^2 A_\mu \\ \phi^2 A_\nu & \phi^2 \end{bmatrix}.$$

Nonresonant production: new colored particles

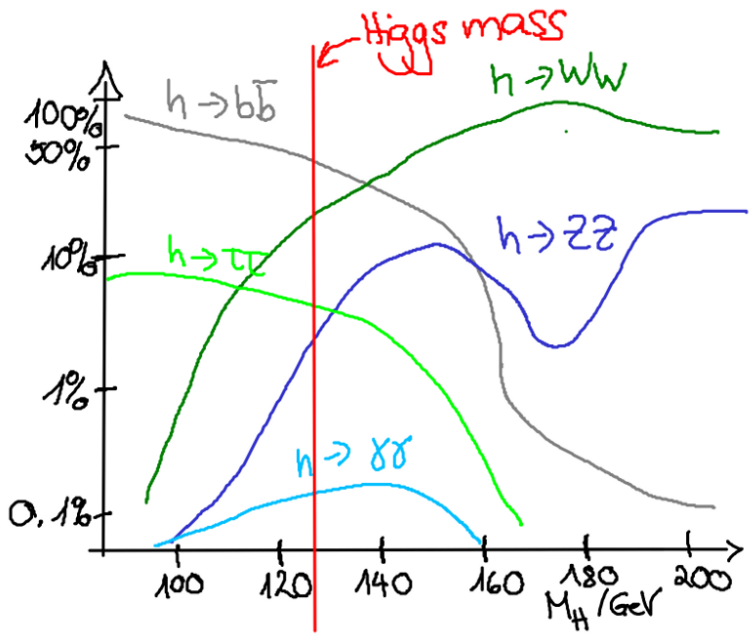
e.g. stop, can spoil cancellation between trilinear and fermion box diHiggd production diagrams

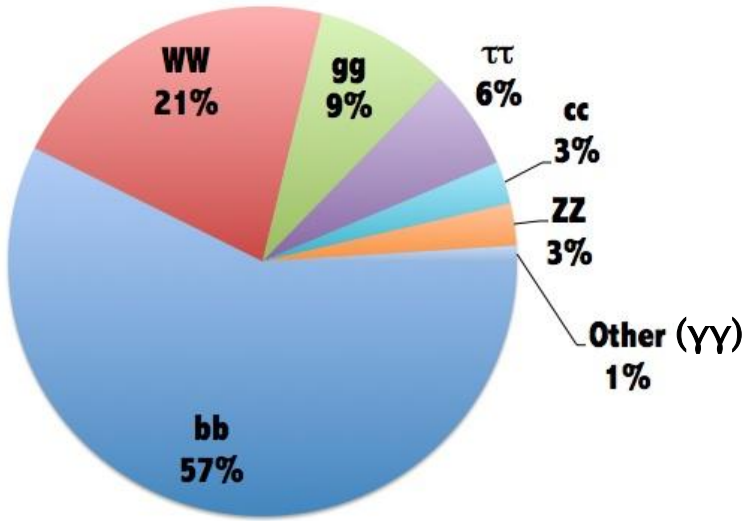
Constrained by [1508.01208v3]

Two-Higgs doublet model

Four more states: psuedoscalar, two charged higgs, new "normal" Higgs

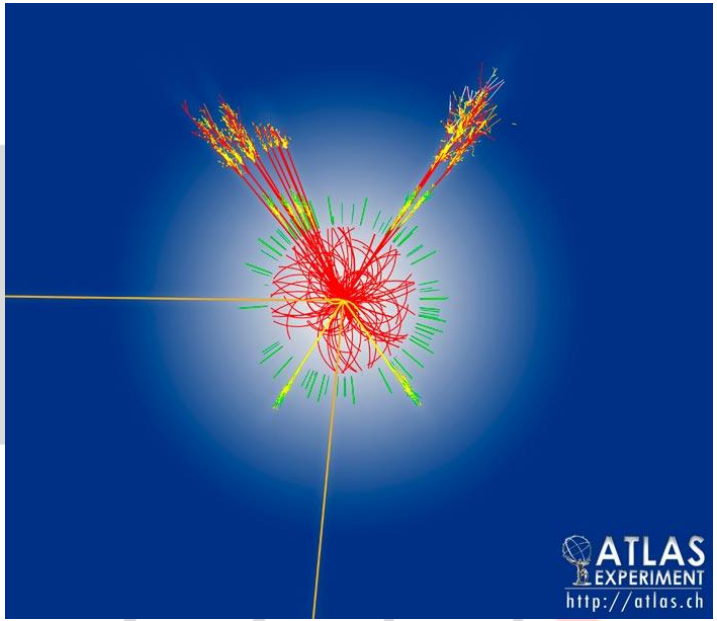
Higgs decay modes





The 4b channel

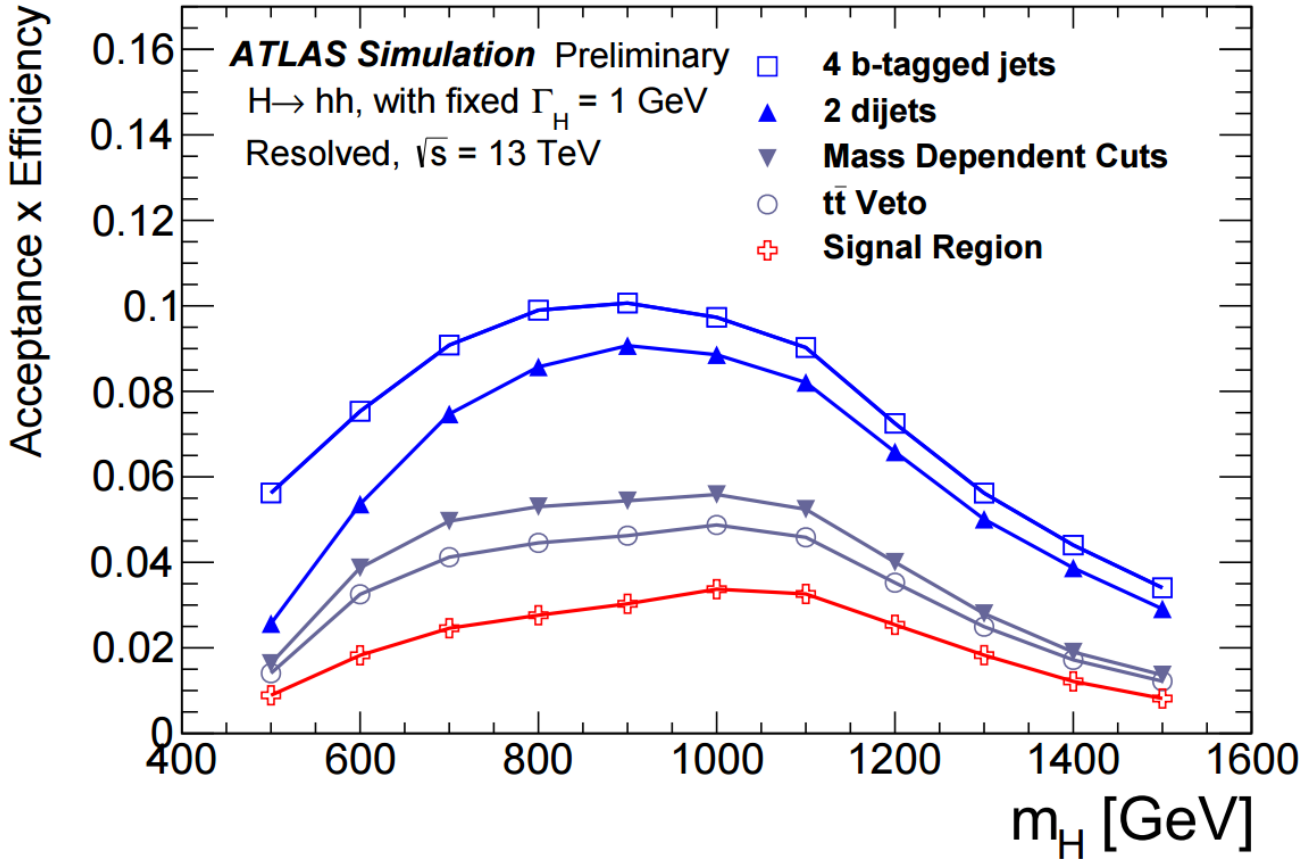
- $H \to hh \to b\bar{b}b\bar{b} \to 4$ b-jets
- Jets with b-tag
- Grouped into 2 dijets
- Invariant masses:
  - 750 GeV for all
  - 125 GeV for each dijet

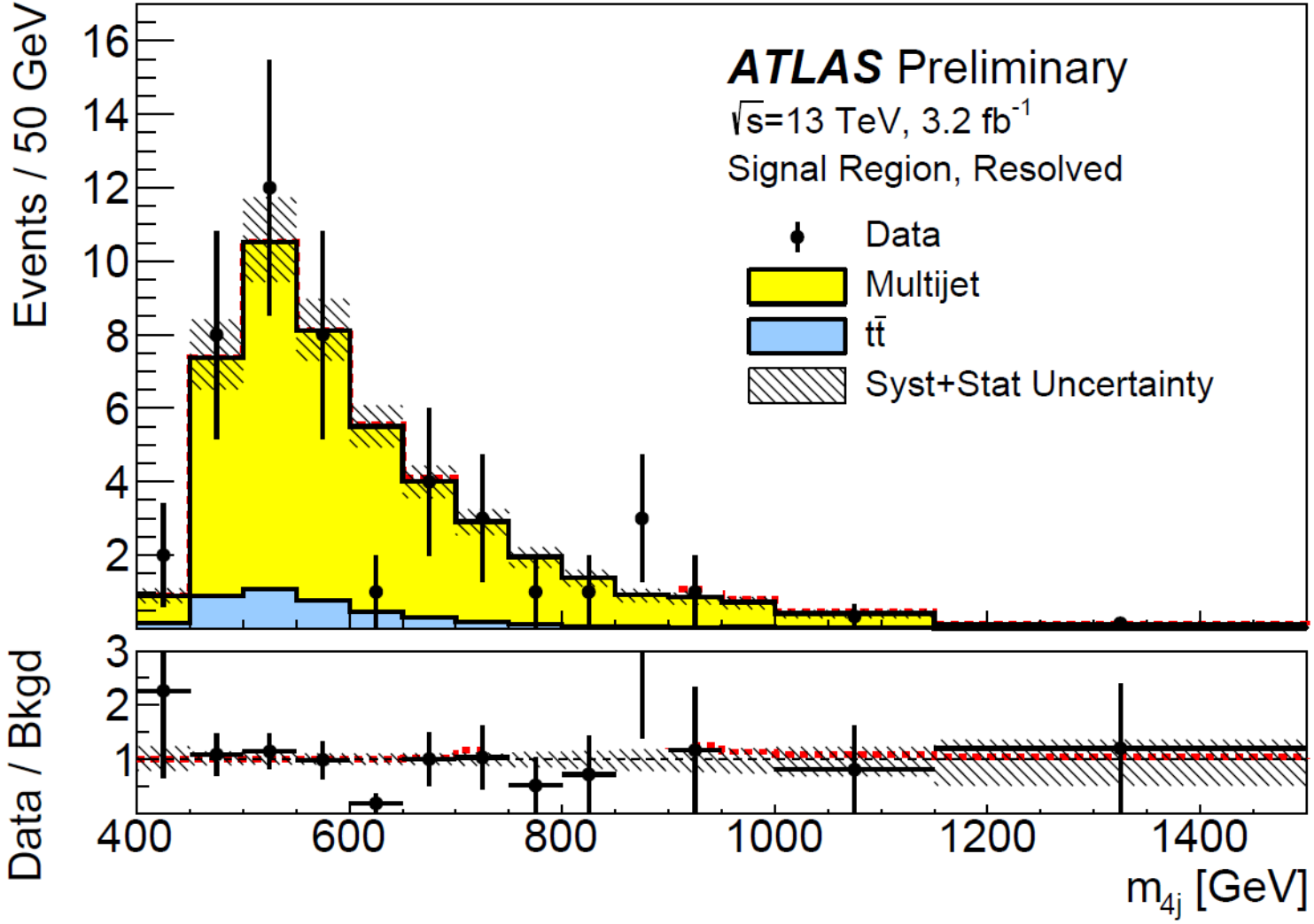


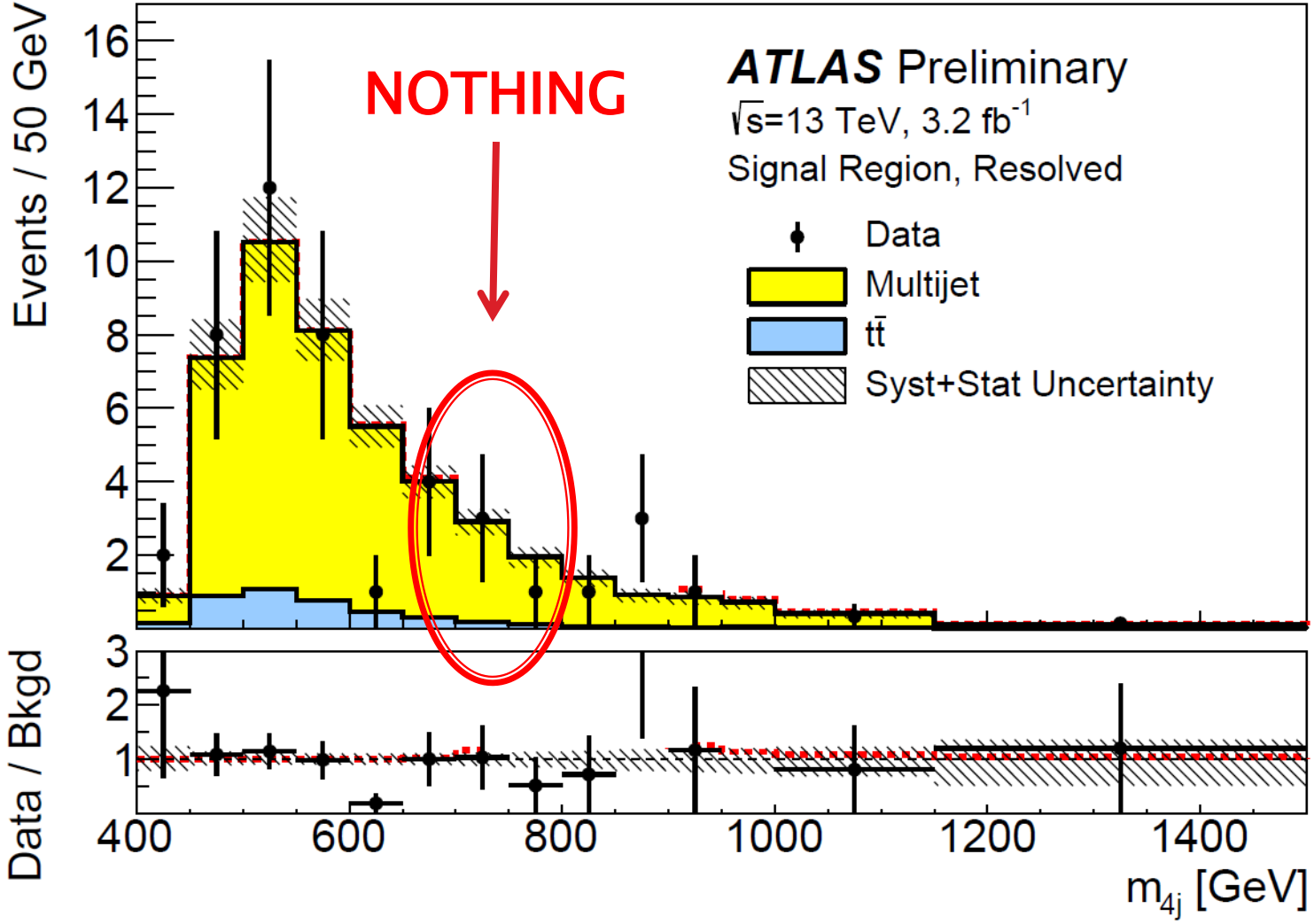
Backgrounds

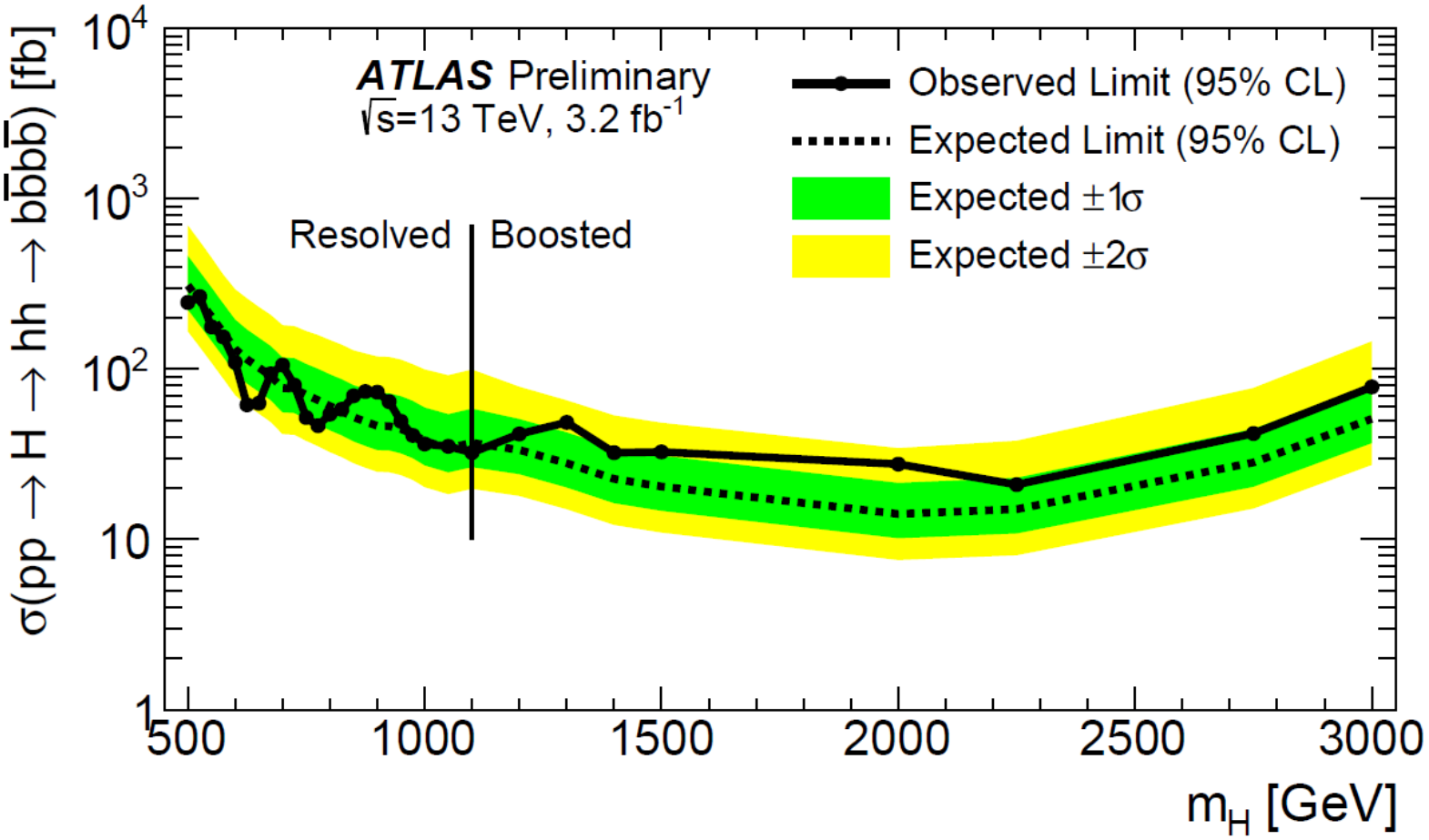
- 90%: multijets (QCD)
- Estimate background using control region
  - 2 b-tags, 2 other jets
- 10% ttbar ($t \rightarrow Wb \rightarrow jets$), mistagged
- Cut:
  - Combine b-jet with other jet, reconstruct *W* mass
  - W mass plus b-jet: *t* mass

Cuts


ATLAS Simulation Preliminary
H→ hh, with fixed Γ_H = 1 GeV
Resolved, √s = 13 TeV
4 b-tagged jets
2 dijets
Mass Dependent Cuts
tt̄ Veto
Signal Region
Acceptance x Efficiency
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
400
600
800
1000
1200
1400
1600
m_H [GeV]


ATLAS Preliminary
√s=13 TeV, 3.2 fb-1
Signal Region, Resolved
Data
Multijet
tt̄
Syst+Stat Uncertainty
Events / 50 GeV
Data / Bkgd
m4j [GeV]


NOTHING
ATLAS Preliminary
√s=13 TeV, 3.2 fb-1
Signal Region, Resolved
Data
Multijet
tt̄
Syst+Stat Uncertainty
Events / 50 GeV
Data / Bkgd
m4j [GeV]


ATLAS Preliminary
√s=13 TeV, 3.2 fb-1
Observed Limit (95% CL)
Expected Limit (95% CL)
Expected ±1σ
Expected ±2σ
Resolved
Boosted
σ(pp → H → hh → bb̄bb̄) [fb]
10^4
10^3
10^2
10
1
500
1000
1500
2000
2500
3000
m_H [GeV]

bbγγ channel

- H → hh → bbγγ
- γγ very clean and optimal trigger ($BR_{h\to\gamma\gamma}$ 0.4 %)
- bb high $BR_{h\to bb}$ (~60%)
-

Selection

- Di-photon trigger 100% efficiency in acceptance
- 0.4 cone for jets reconstruction
- 2-tagged b jets
- M_{bb} 95-135 GeV window
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Background

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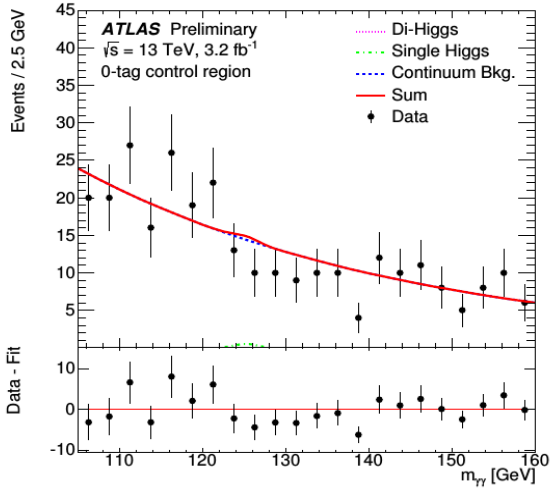
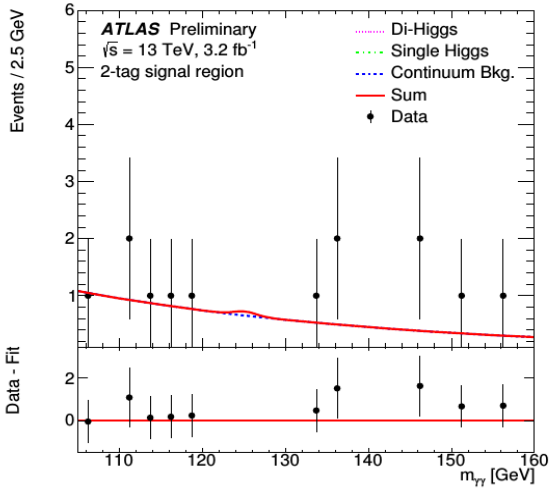
Exclusion limit

- Bkg estimate ~1evt/3.2fb^{-1}
- Uncertainties 36% for 3.2 fb^{-1} → 10-20% for 300 fb^{-1} (directly from sidebands)



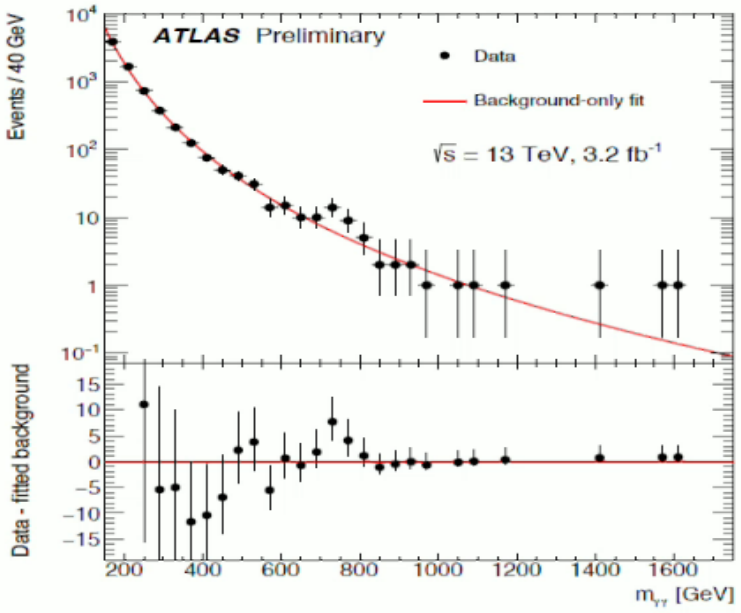


Exclusion limit

- Expect ~95 ± 16 events for bkg (eye-on-plot derivation)
- Exclude S=50 evts signal (3σ)
- $Hh \rightarrow bb\gamma\gamma$ BR = 2.7×10^{-3}
- $\sigma_H * BR_{Hhh}$ limit = **69 fb** at lm=300 fb^{-1}

Mass resolution

- $M_{\gamma\gamma}$ resolution 13%
- Normalize to m_h
- 5-10% mass resolution
- (conservative)



- Arxiv 1406.5053v4
- The ATLAS collaboration, ATLAS-conf-2016-017

Prospects

- More data coming in!
- 4b channel: background
  - Shape of ttbar
  - B-tagging efficiency
- bb$\gamma\gamma$: clean channel

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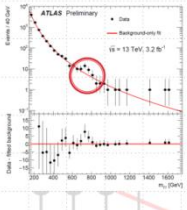

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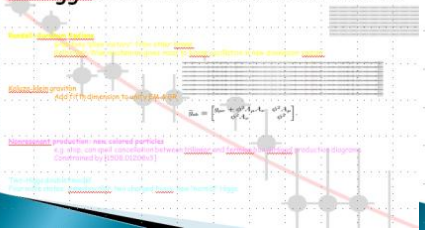

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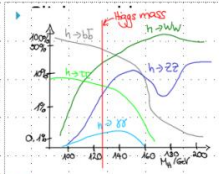

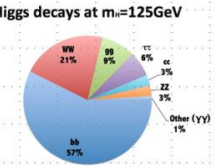

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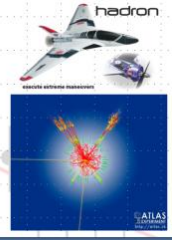

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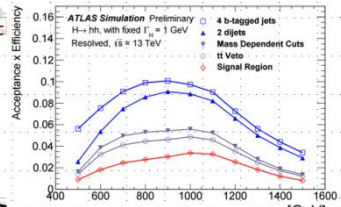

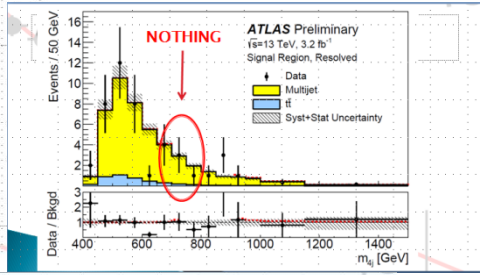

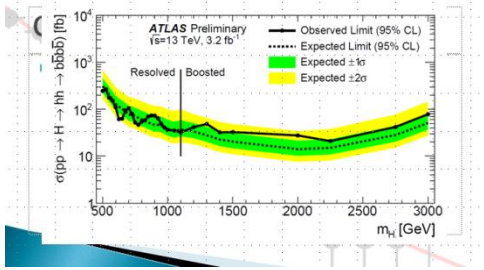

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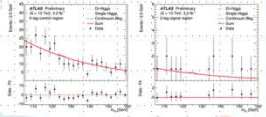

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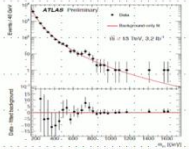

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