Search for Higgs boson pair production in the $\gamma\gamma WW^*$ channel using *pp* collision data recorded at 13 TeV with the ATLAS detector

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on behalf of the ATLAS collaboration

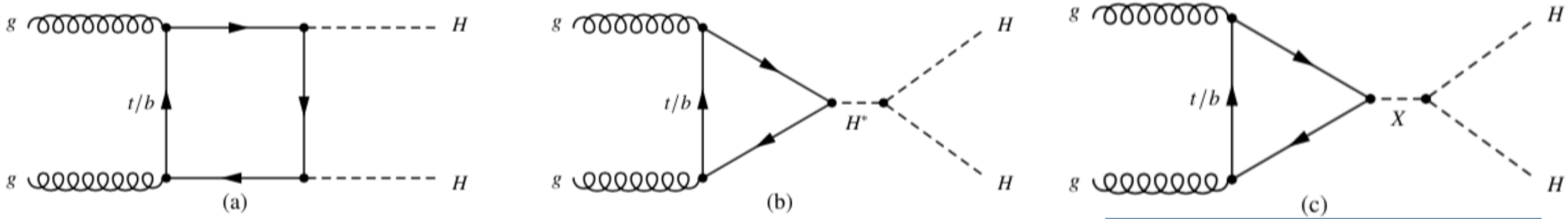
23/07/2018, Higgs Hunting 2018, Orsay-Paris, France

ATLAS EXPERIMENT

IHEP

Motivations

- SM di-Higgs production can probe trilinear Higgs self-coupling.
- BSM models with extended Higgs sectors predict a heavy Higgs boson, which can decay into a pair of SM Higgs bosons.

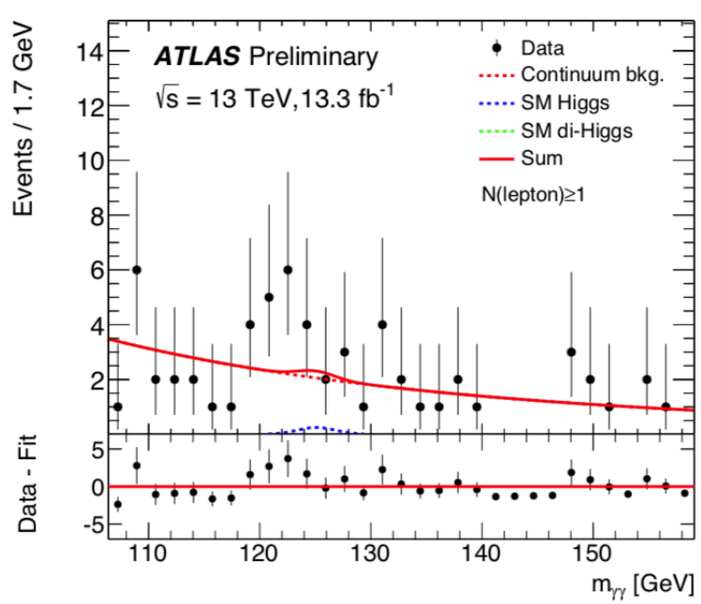


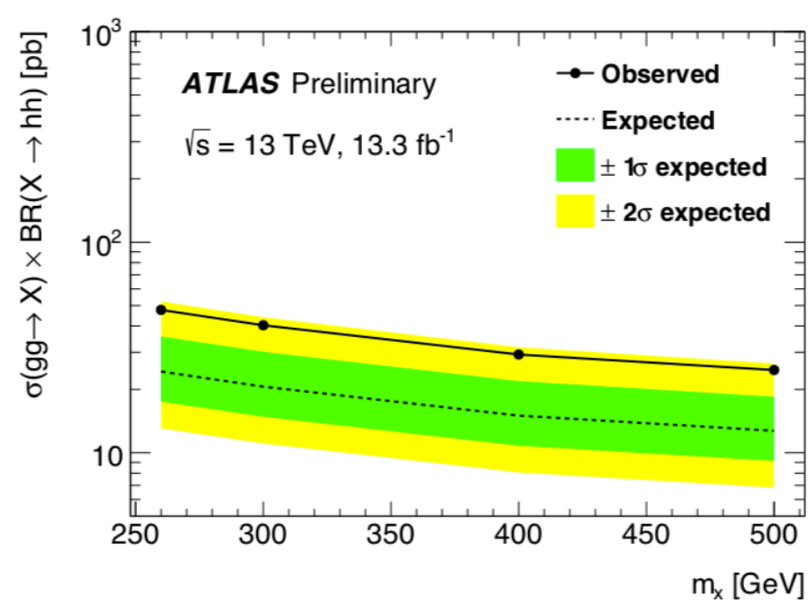
- h→WW*: second largest branching ratio after h→b$\bar{b}$.
- h→γγ: excellent diphoton mass resolution distinguishes signal and backgrounds.

BR	b$\bar{b}$	WW*	ττ	ZZ	γγ
b$\bar{b}$	33%				
WW*	25%	4.6%			
ττ	7.4%	2.5%	0.4%		
ZZ	3.1%	1.2%	0.3%	0.08%	
γγ	0.26%	0.1%	0.029%	0.013%	0.005%

Review

- ATLAS Run 1 (20.3 fb^{-1}): Phys. Rev. D92, 092004, 2015
  - Observed (expected) upper limit for non-resonant production is 1150 (680) × SM (10.15 fb).
- ATLAS Run 2 (13.3 fb^{-1}): ATLAS-CONF-2016-071
  - Observed (expected) upper limit for non-resonant production is 748 (386) × SM (33.41 fb).

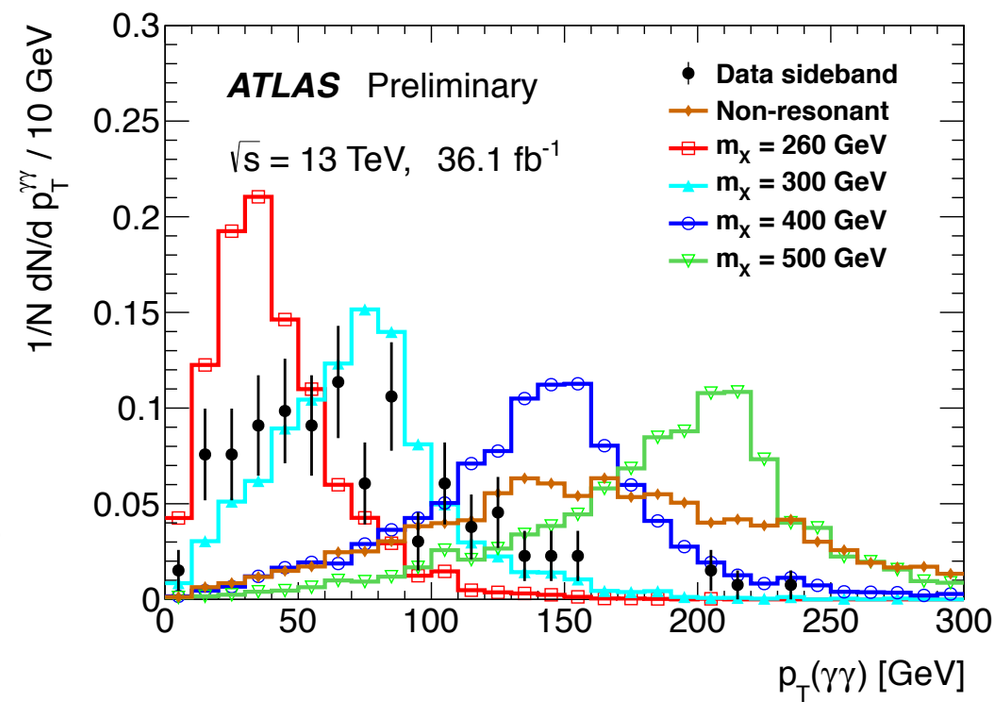




Event counting experiment

Run 2 analysis with 36.1 fb^{-1}

- Focus on semi-leptonic WW decay ($HH \rightarrow \gamma\gamma l\nu jj$).
- Trigger & Event selections:
  - Di-photon trigger.
  - two tight photons with p_T>25 GeV;
  - $p_T / m_{\gamma\gamma}$>0.35 (0.25) for leading (subleading) photon.
  - At least one lepton;
  - At least two jets, b-veto.
  - $p_T(\gamma\gamma)$ >100 GeV for $m_X \geq 400$ GeV and non-resonant production.
  - 105 GeV< $m_{\gamma\gamma}$ <160 GeV.
  - $|m_{\gamma\gamma}$ -125.09 GeV$|$<2σ (σ=1.7 GeV).
    (in and out of the window are used in final fit)



Analysis strategy:
→ Continuum background ($\gamma\gamma l\nu jj$) estimated with side-band data (~90%);
→ Single Higgs backgrounds by MC.

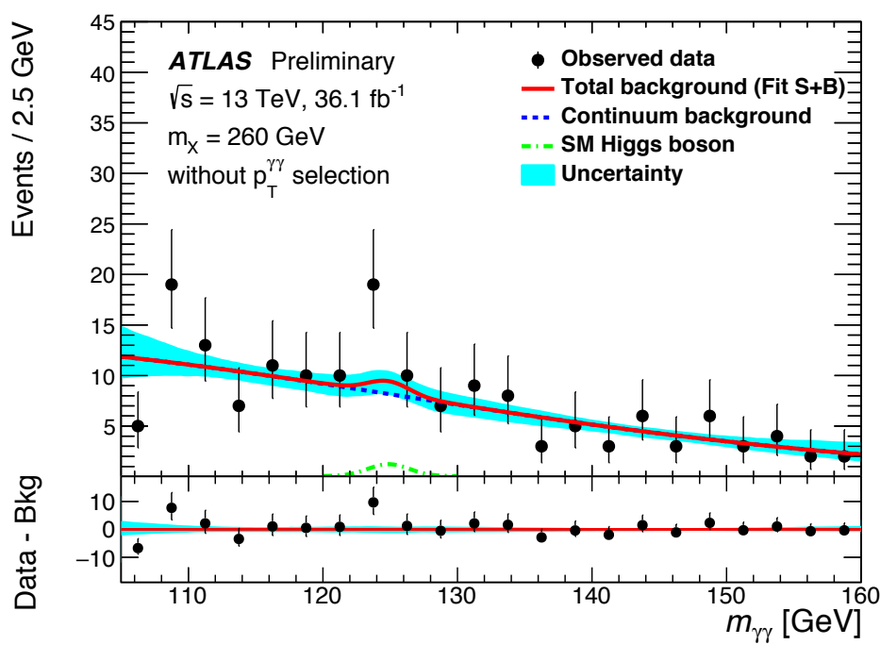
Systematics

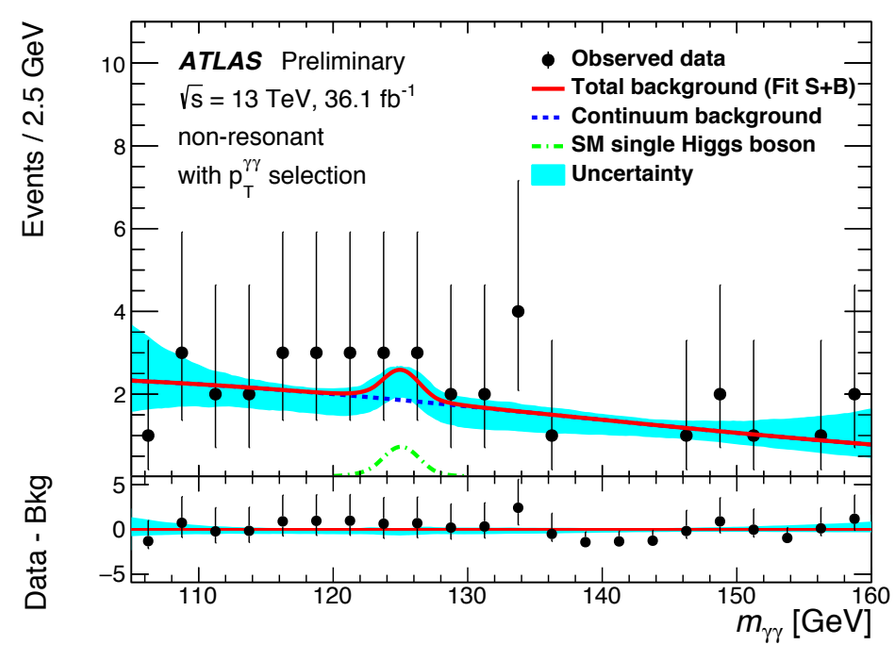
- The dominant uncertainties come from continuum background modelling (spurious signal).
  - Fit a signal-plus-background model to a large-size simulated background-only sample, which consists of irreducible ($\gamma\gamma$lvjj) and reducible processes (where one or two hadronic jets are misidentified as photons).
  - The maximum fitted signal yields reach 0.46 (0.26) when (not) applying the $p_T(\gamma\gamma)$ cut among non-resonant and resonant signal models (~0.04 for predicted SM Higgs yield).

Fitting strategy

- A fit to the $m_{\gamma\gamma}$ distribution is performed to extract the signal yield.

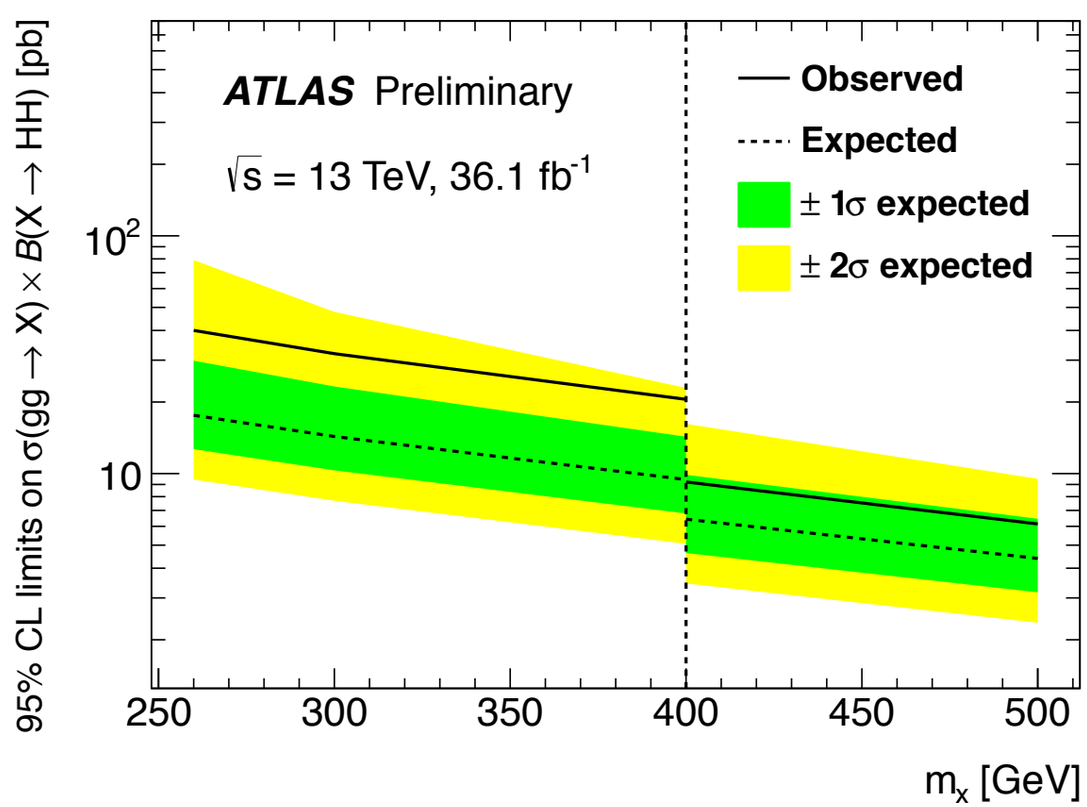
$$\mathcal{L}(\mu,\boldsymbol{\theta}) = \prod_i \Big((n_{\text{Signal}}(\mu,\boldsymbol{\theta}) + n_{\text{ss}}) \times f^1_{\text{DSCB}}(m^i_{\gamma\gamma},\boldsymbol{\theta}) + n_{\text{Cont}} \times f_{\text{Cont}}(m^i_{\gamma\gamma},\boldsymbol{\theta}) + n_{\text{SM-one-Higgs}}(\boldsymbol{\theta}) \times f^2_{\text{DSCB}}(m^i_{\gamma\gamma},\boldsymbol{\theta}) + n_{\text{SM-di-Higgs}} \times f^3_{\text{DSCB}}(m^i_{\gamma\gamma},\boldsymbol{\theta}) \Big) \prod G(0|\boldsymbol{\theta},1)$$





Results

- A modified CLs method is used to calculate the 95% CL exclusion limits with the asymptotic approximation.
- The observed (expected) limit for non-resonant production is 230 (160) × SM.
- The observed (expected) limit for resonant production ranges from 40 pb (17.6 pb) to 6.1 pb (4.4 pb).



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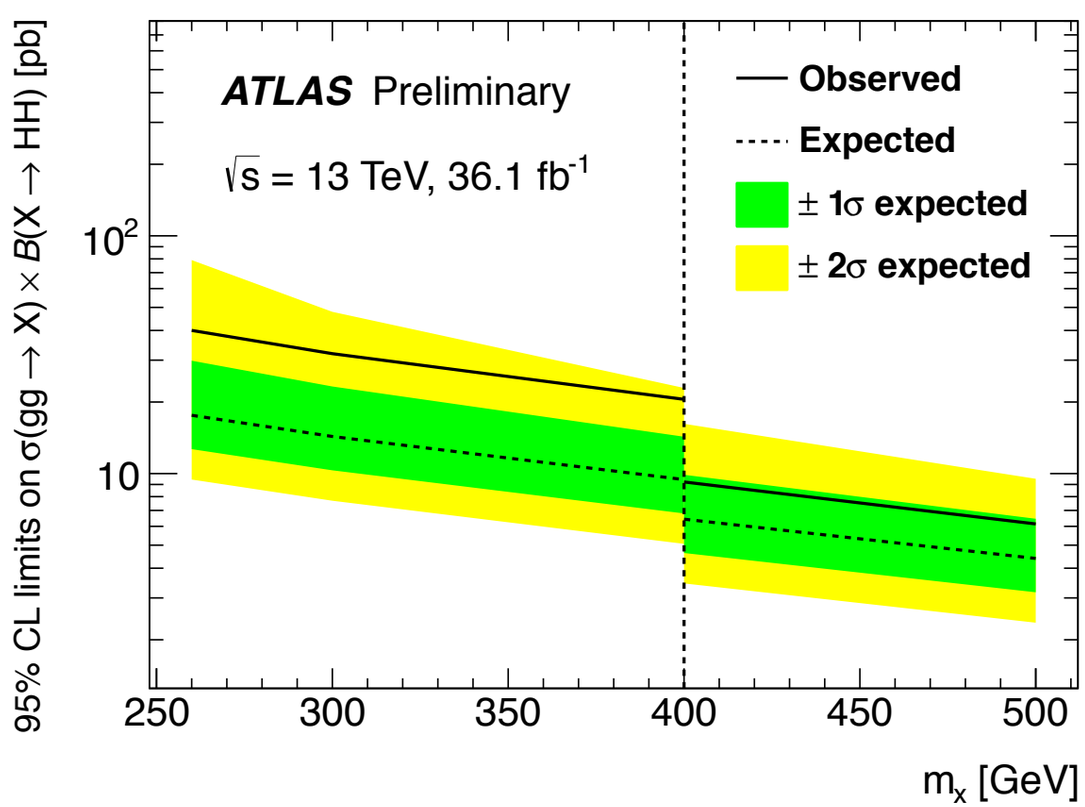
Stay tuned!



Thank you!

Back up

Limits with BRs