Search for scalar γγ resonances at √s = 13 TeV with the ATLAS detector

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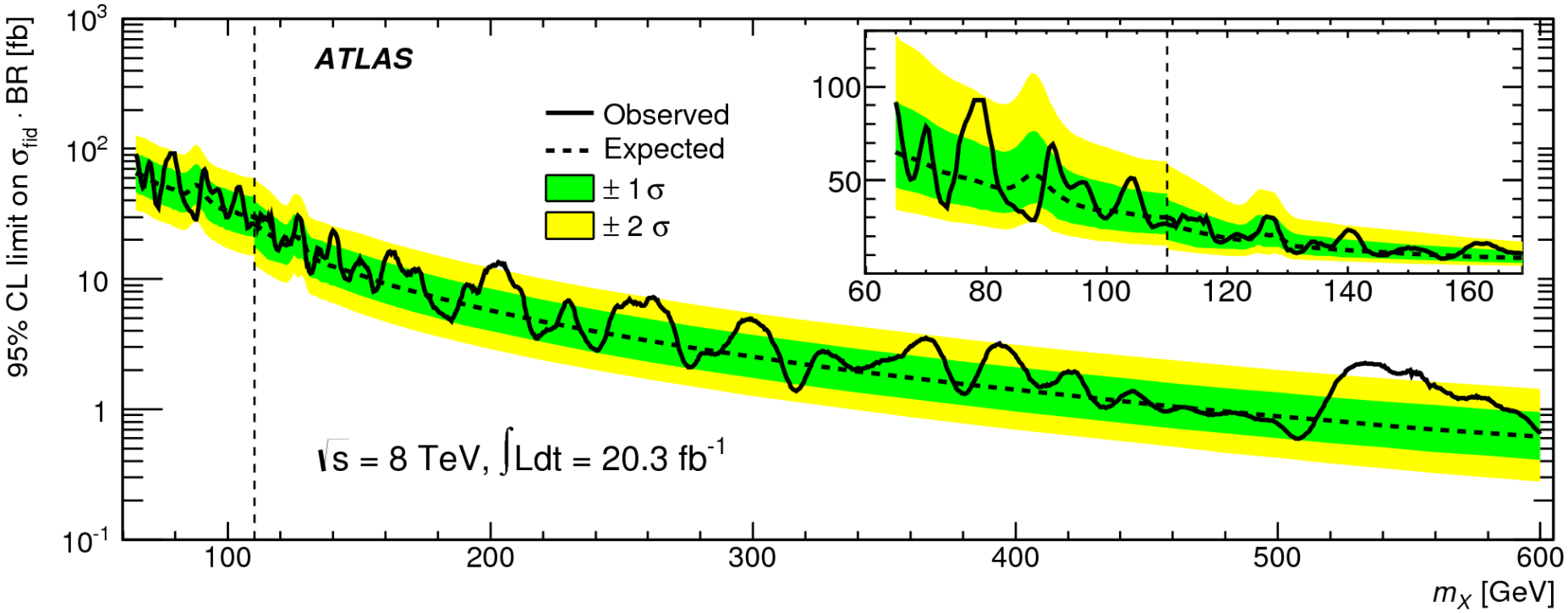
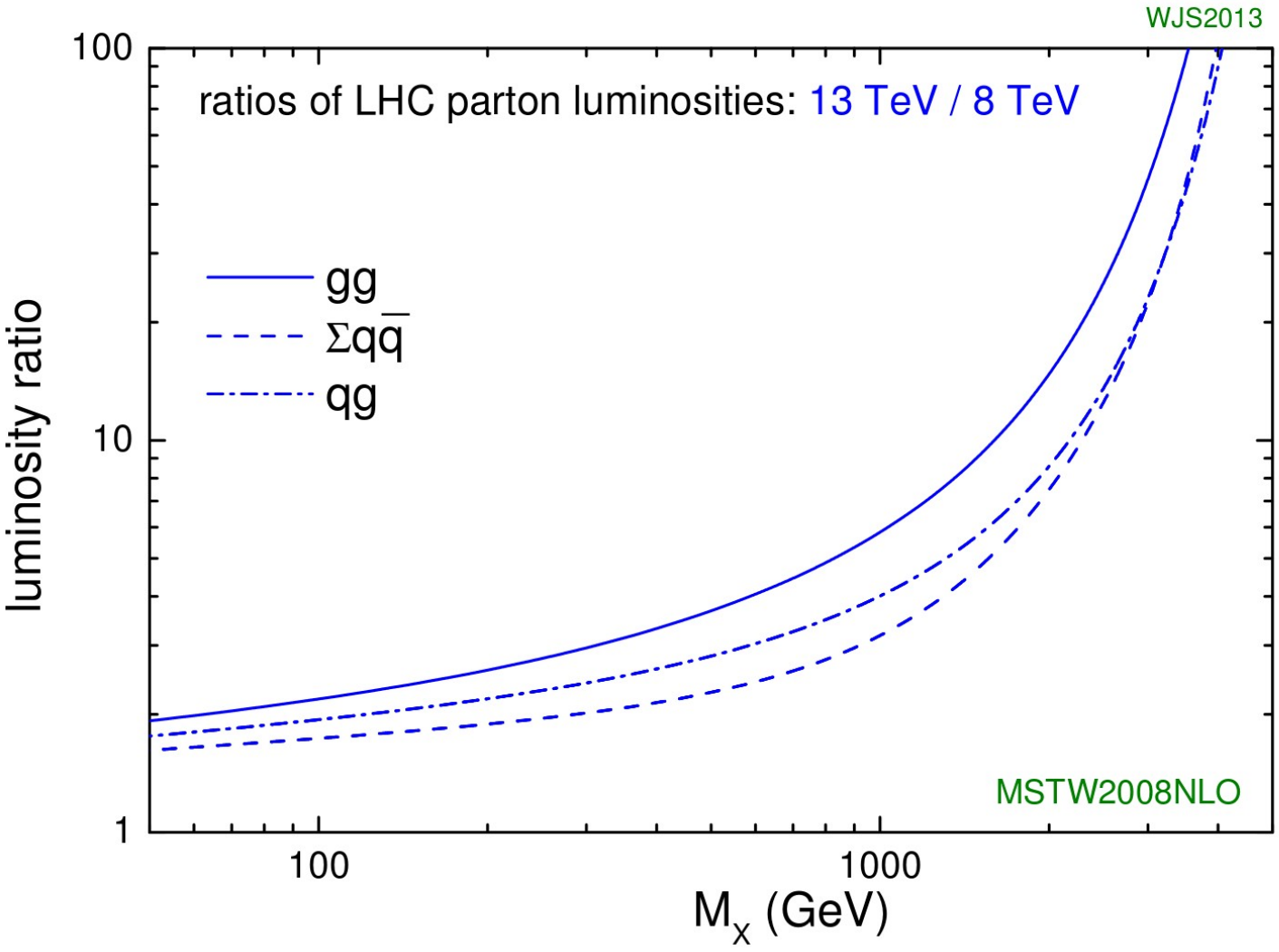
Introduction

- Search for new physics in the diphoton final state
- Analysis similar to the SM 125 GeV Higgs boson
- Run1: limit from 60 to 600 GeV
- Tried to be as process-independent as possible



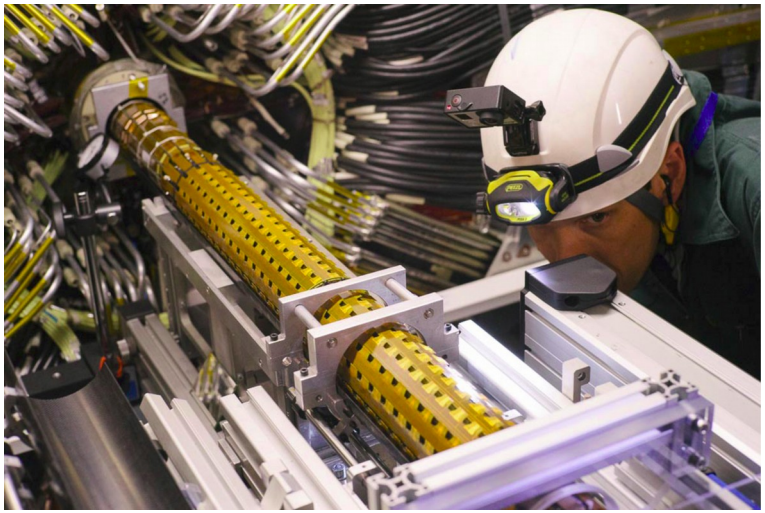
LHC Run 2

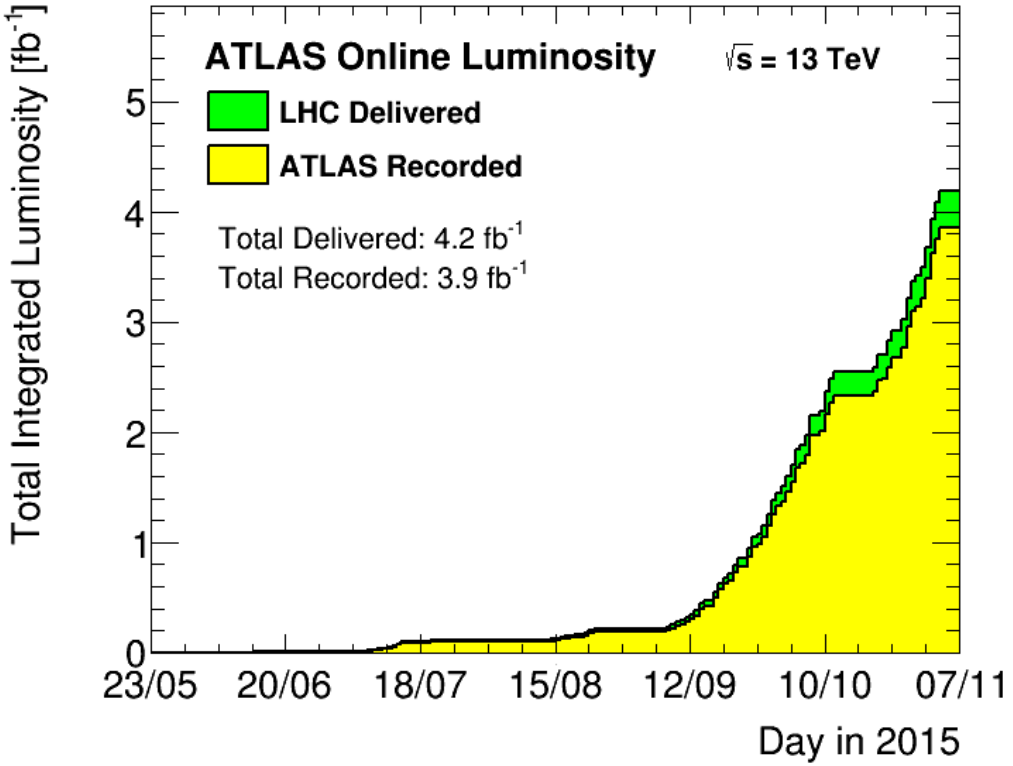
- Increase of centre-of-mass energy: 8 → 13 TeV



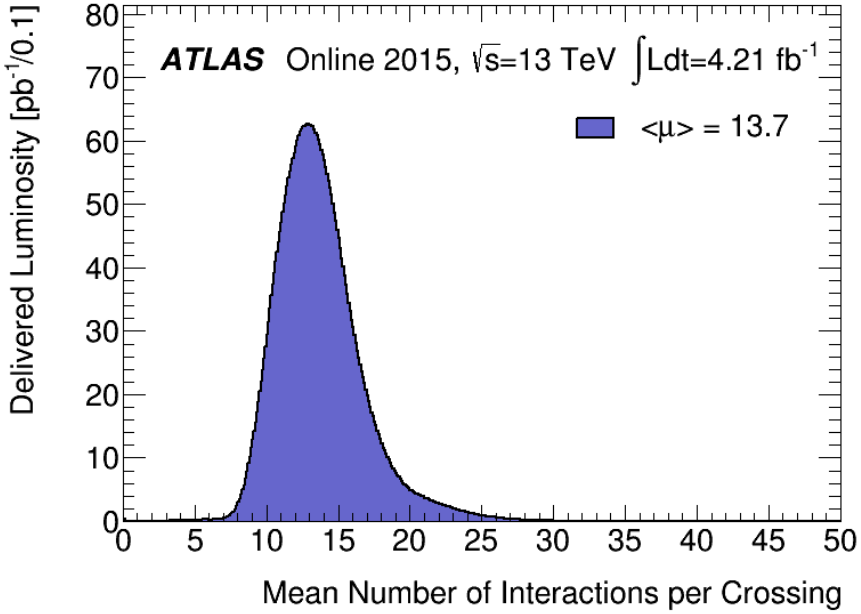
ATLAS detector in 2015

- New pixel layer (IBL)



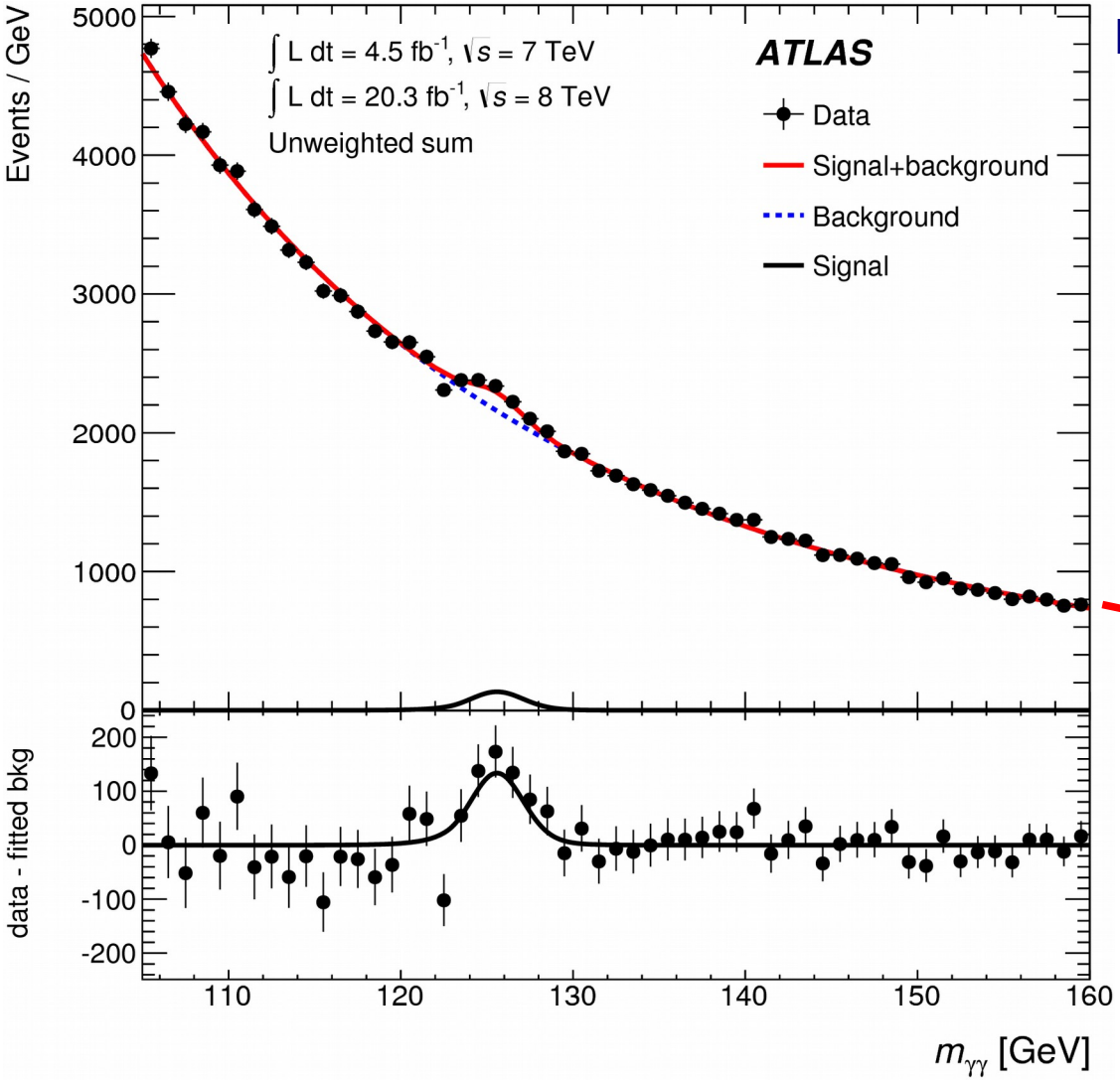


- ~4 fb^{-1} recorded data
  - 87% good for physics
- Used in this analysis: **3.2 fb^{-1}**



Method in a nut-shell

- Signal + background fit on the diphoton invariant mass
  - signal modelling from MC
  - background function chosen from MC, fitted on data
  - normalisation from data



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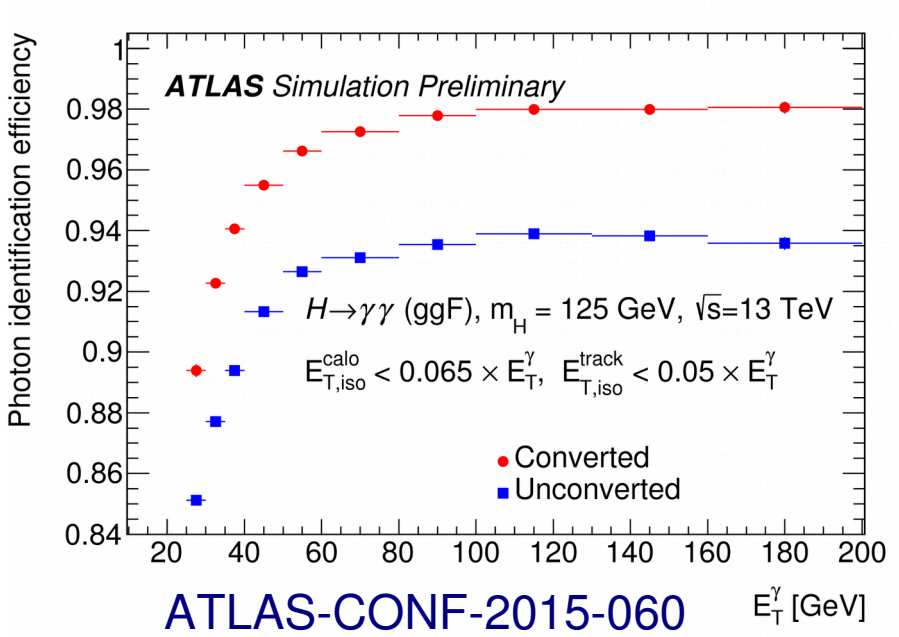
Diphoton selection

- 2 well identified, isolated photons
  - identification eff > 90%
  - isolation eff > 80-90%
- $E_T^{\gamma 1}/m_{\gamma\gamma} > 0.4$ and $E_T^{\gamma 2}/m_{\gamma\gamma} > 0.3$
  - 60/45 GeV for $m_{\gamma\gamma}$ = 150 GeV
  - 640/480 GeV for $m_{\gamma\gamma}$ = 1600 GeV
- Total selection efficiency: 30-40%
- γγ purity > 90% above 200 GeV



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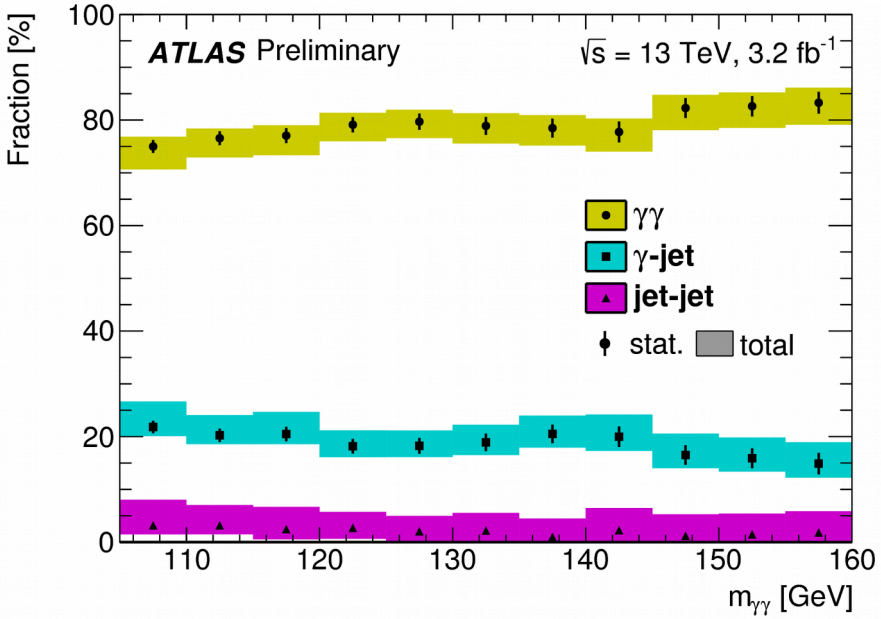
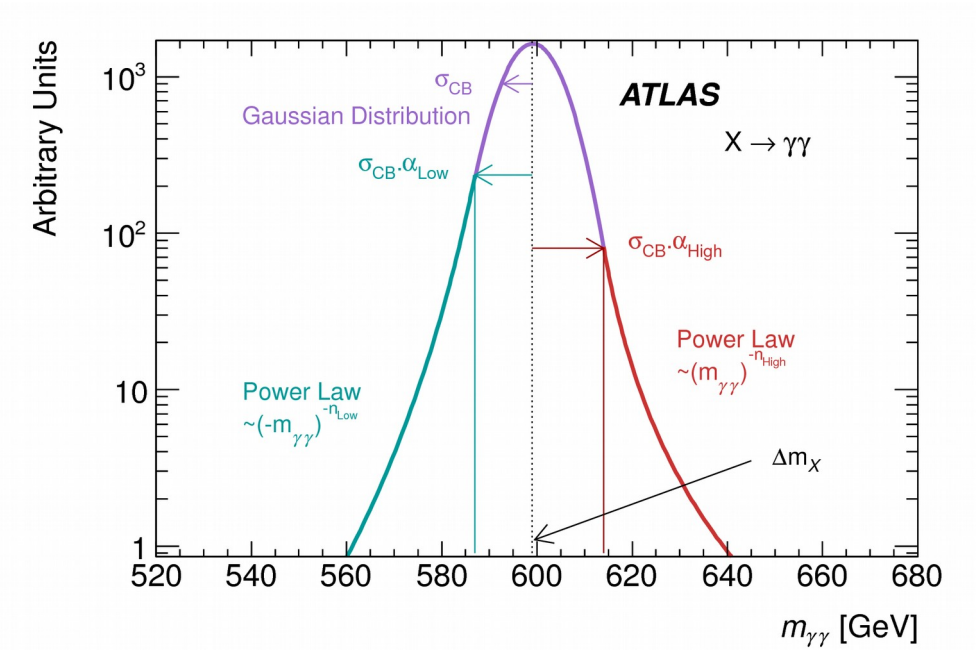
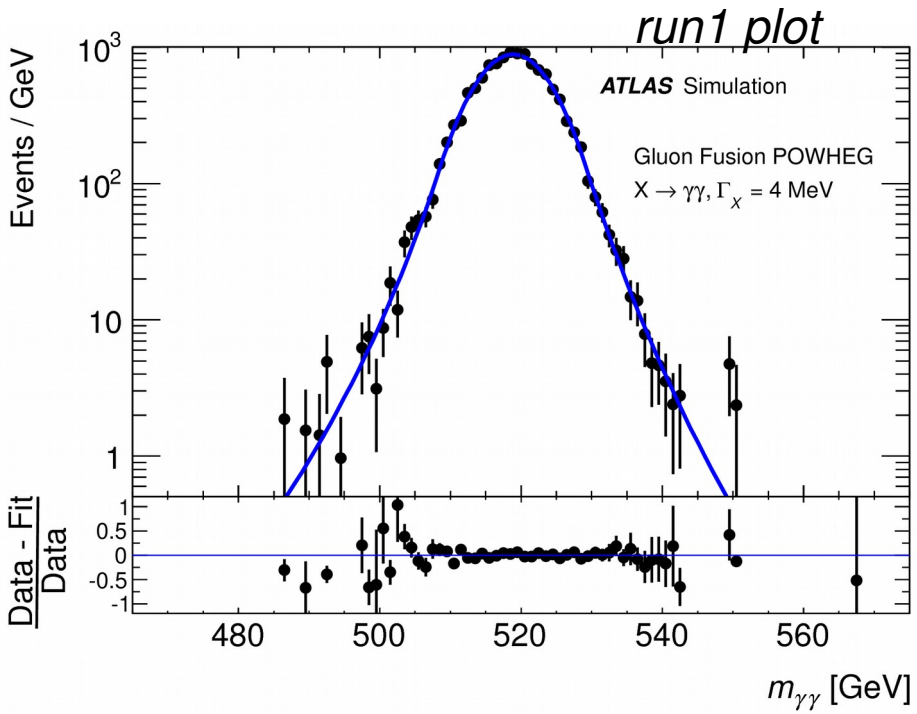


Signal modelling (1)

- Higgs-like signal simulation
  - Narrow Width Approximation (NWA): Γ = 4 MeV
  - dominated by detector resolution

- Use of double-sided Crystal-Ball function

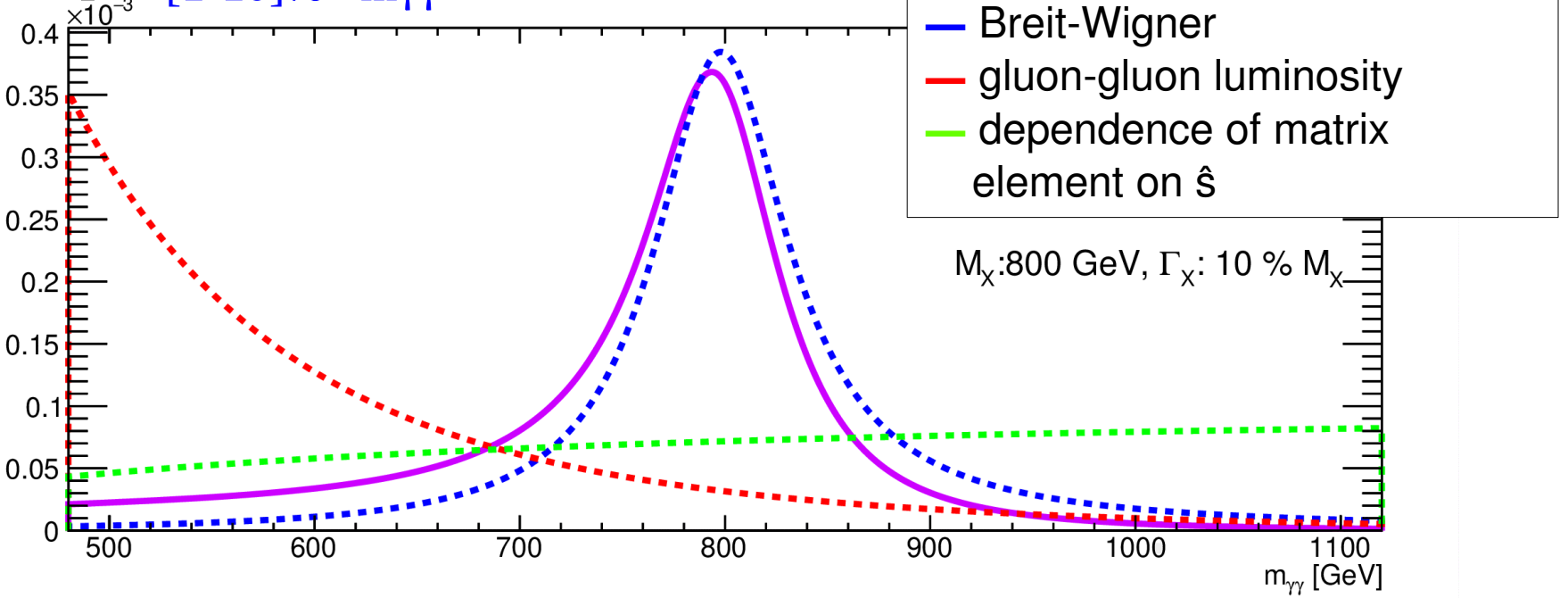




- Width: : ~2 GeV at 200 GeV, 13 GeV at 2 TeV

Signal modelling (2)

- Larger widths: convolute resolution with Breit-Wigner
  - taking into account dependence on gluon-gluon parton lumi and on ŝ
  - $\Gamma \in$ [1-10]% *mγγ



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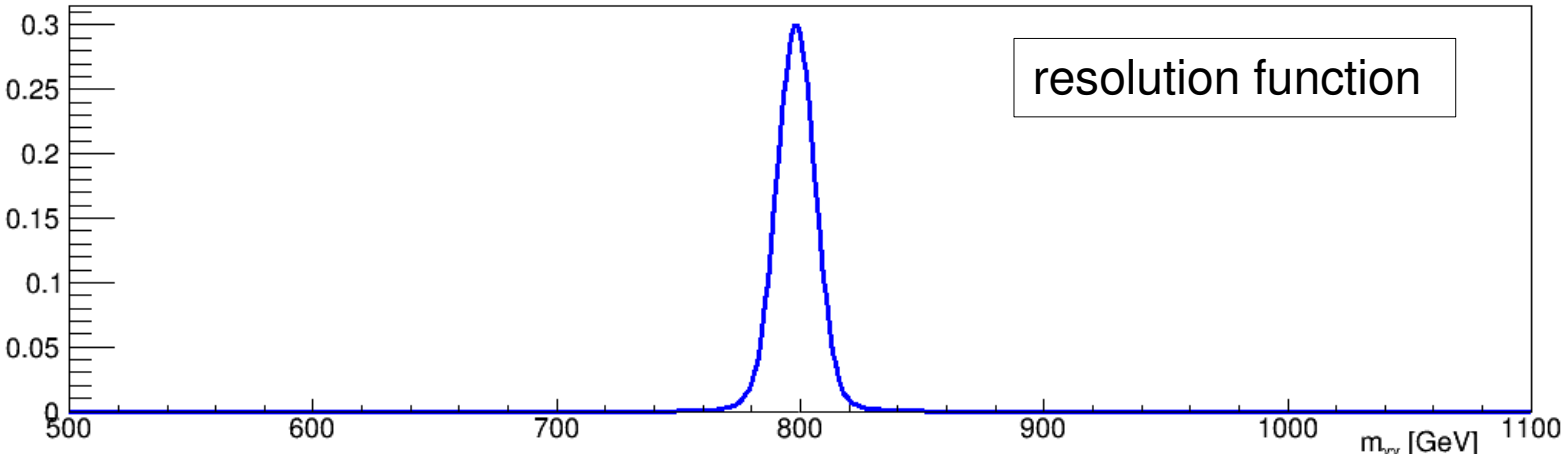
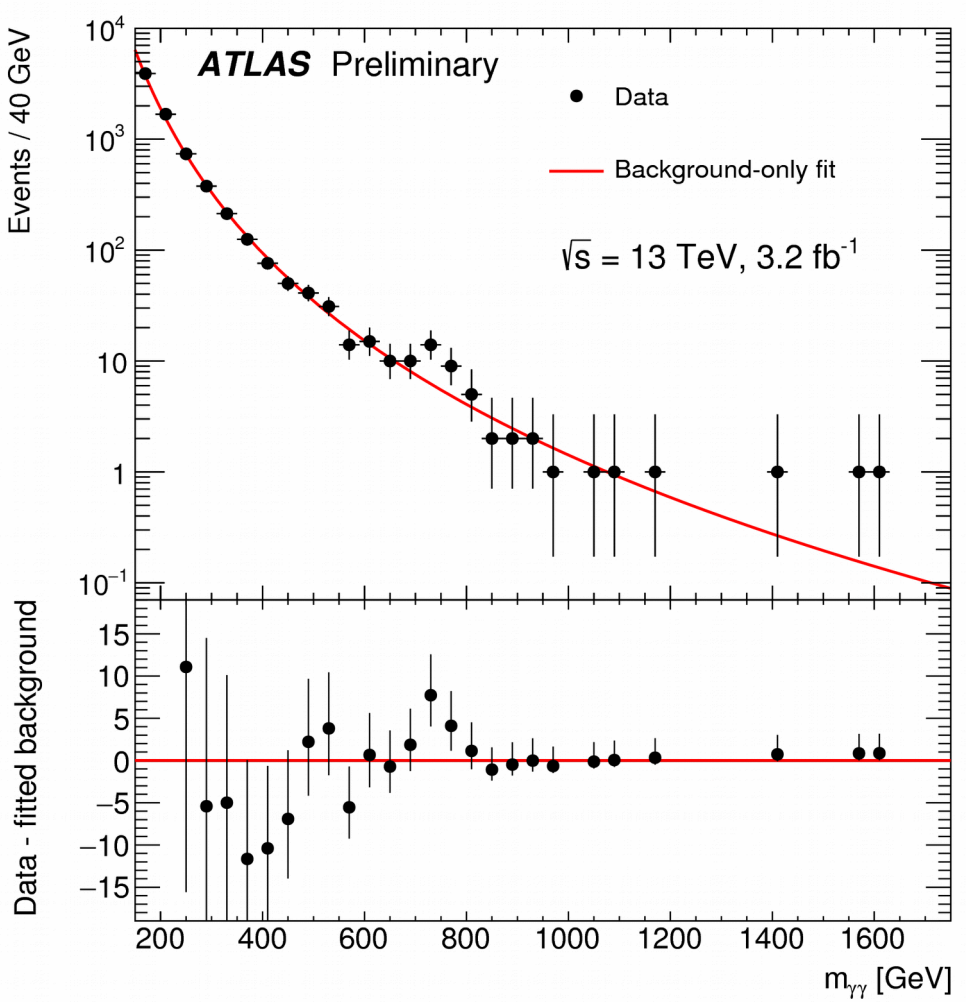


Background modelling

- Fit function chosen from high-statistics γγ MC
  - tested functions: $f_{(k)}(x;b,\{a_k\}) = (1-x^{1/3})^b \cdot x^{\sum_{j=0}^{k} a_j (\log x)^j}$ with $x = \frac{m_{\gamma\gamma}}{\sqrt{s}}$
  - F-test on data to decide if additional degrees of freedom are necessary → k=0

$f_{(0)}(x;b,a_0) = (1-x^{1/3})^b \cdot x^{a_0}$



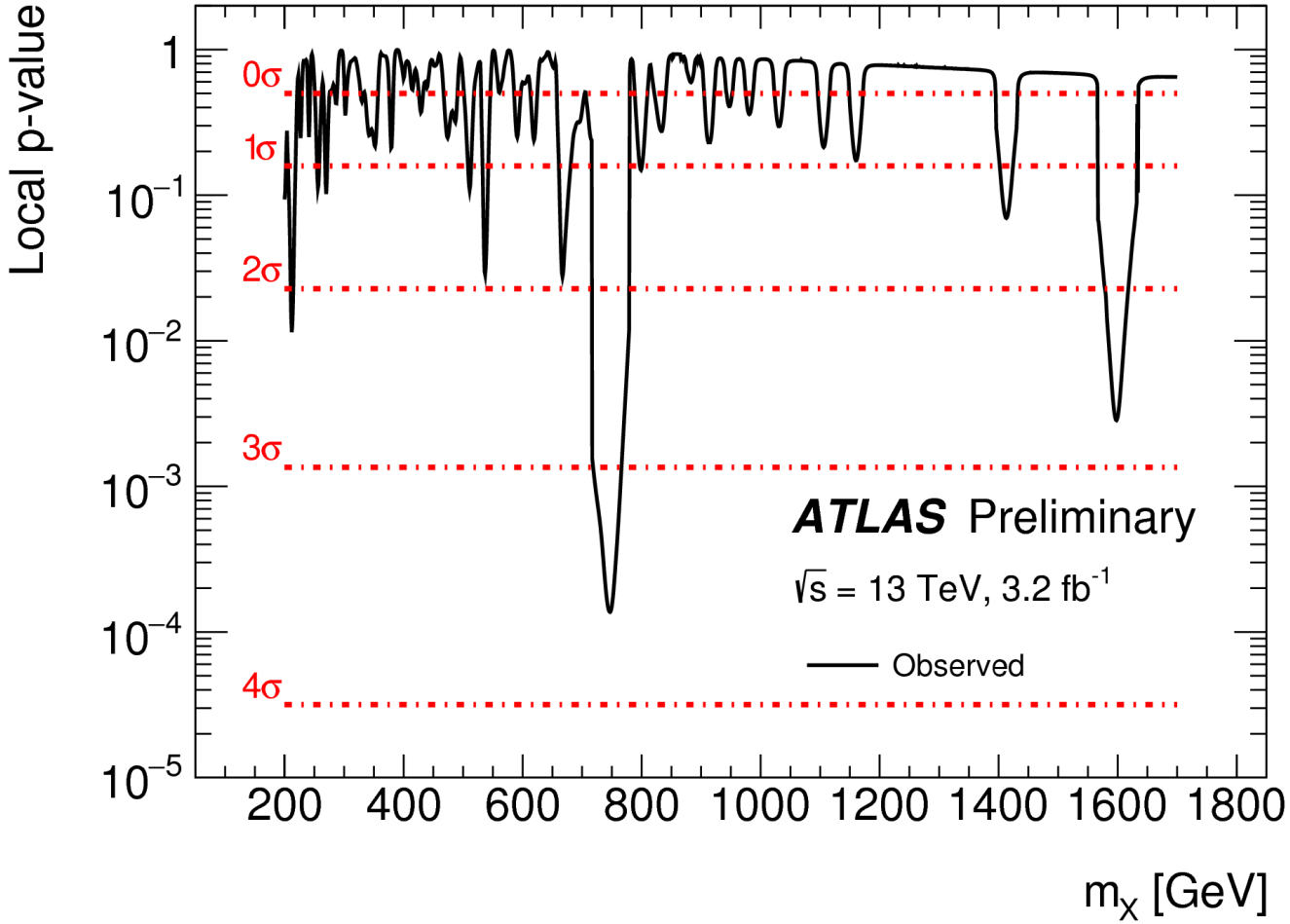
Uncertainties

- Main uncertainty: photon energy resolution
  - corrections from 2012 data-driven measurements
  - additional uncertainties: comparison of run1 and run2 setup

Source	Uncertainty
Background modeling °•	
Spurious signal	$2-10^{-3}$ events, mass-dependent
Background fit	$\leq 50\%$–$\leq 20\%$ of the total signal yield uncertainty, mass- and signal-dependent
Signal modeling °•	
Photon energy resolution	$^{+[55-110]\%}_{-[20-40]\%}$, mass-dependent

Narrow width result

- p-value vs mass:



- Most significant deviation: local significance of **3.6σ** around 750 GeV
  - global p0 of **2.0σ** (after look-elsewhere-effect in 200-2000 GeV)
  - 1.5σ pull on the nuisance parameter associated with photon energy resolution uncertainty ⇒ excess broader than experimental resolution

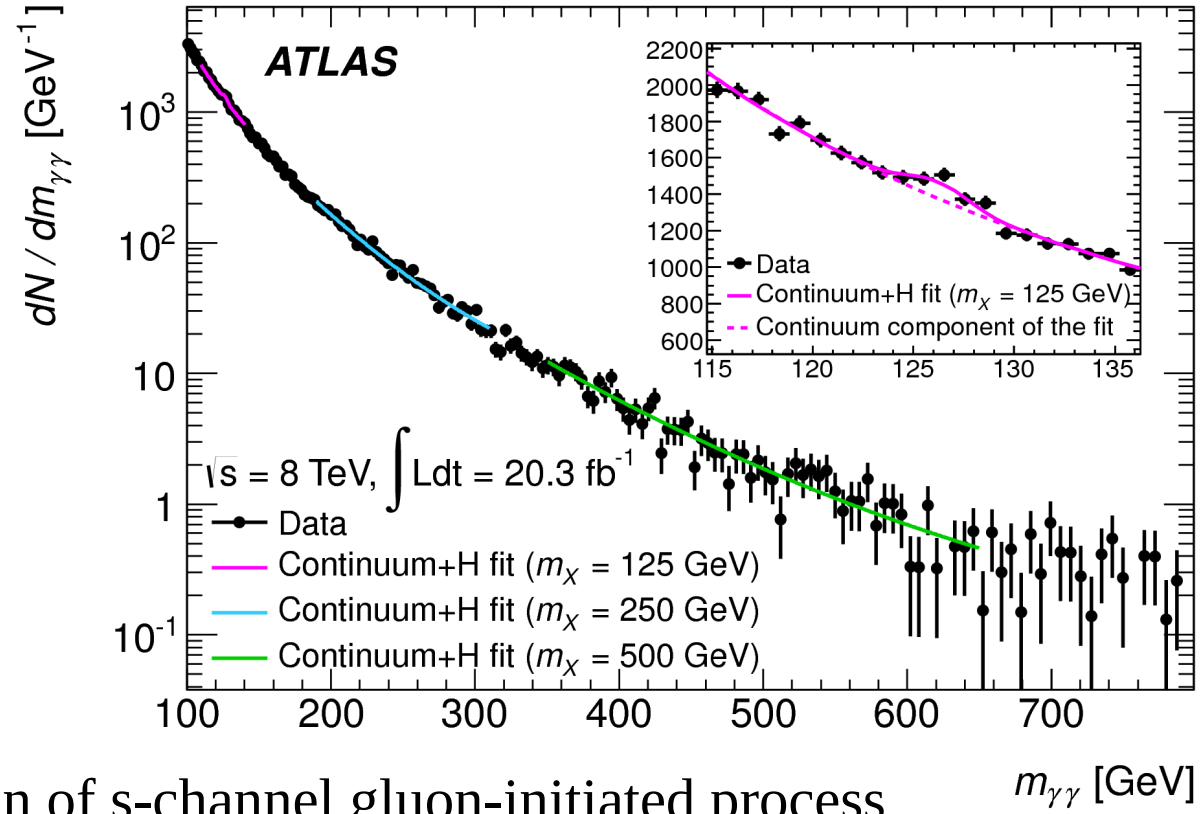
Large width result

- Fits redone while scanning mass and width ($\alpha = \Gamma/m$)
  - look-elsewhere-effect for $m_X \in [200\text{-}2000]$ GeV and $\alpha \in [1\text{-}10]\%$

- Largest deviation around 750 GeV and $\alpha \simeq 6\%$ (ie 45 GeV)
- Local significance: **3.9σ**
- Global significance: **2.3σ**

Compatibility with run 1 result

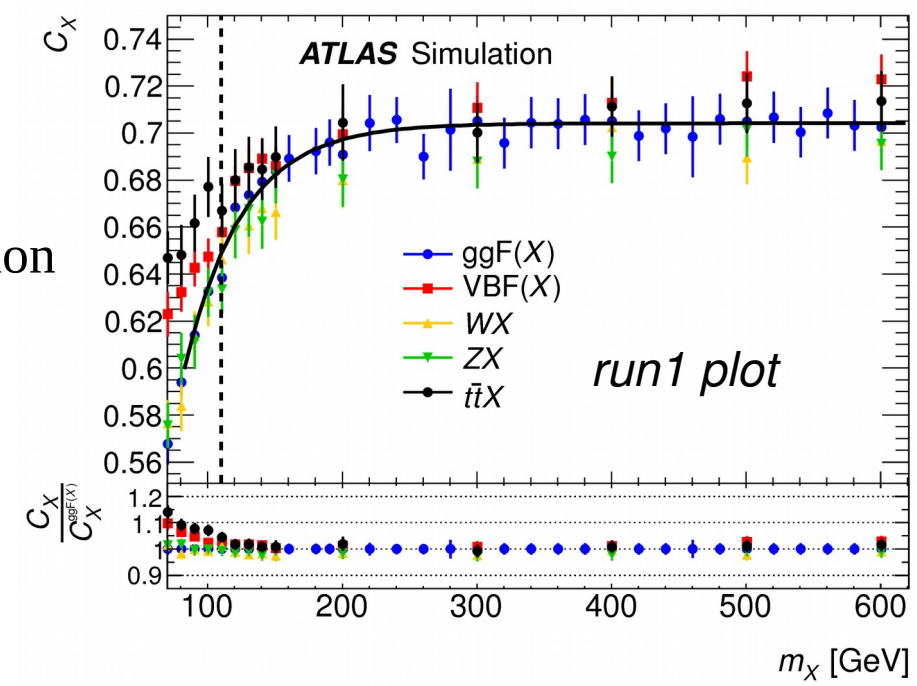
- Published result up to 600 GeV:
  - now extended with improved fit procedure



- Assumption of s-channel gluon-initiated process
  - σ(13 TeV)/σ(8 TeV) = 4.7
- Result
  - narrow-width: compatible within **2.2σ**
  - large width: compatible within **1.4σ**

Limit on fiducial cross section (1)

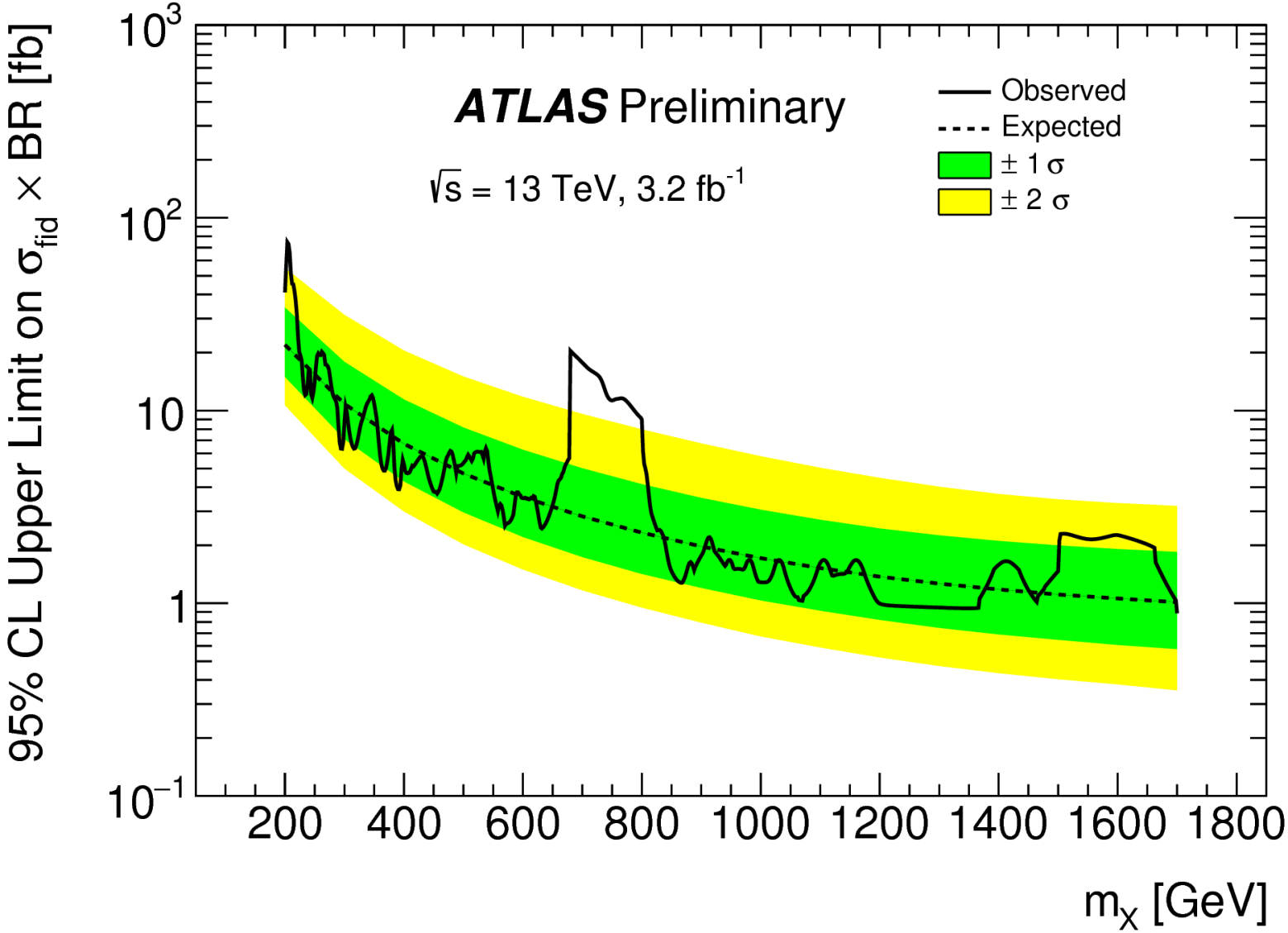
- Fiducial cross section: $\sigma_{fid} = \frac{N^{signal}}{C_X \cdot L}$
- C_X = correction factor in fiducial volume
  - computed for several Higgs-like production modes
  - difference as systematics
- Fiducial volume:
  - $E_T^{\gamma 1,truth} > 0.4 * m_{\gamma\gamma}$, $E_T^{\gamma 2,truth} > 0.3 * m_{\gamma\gamma}$
  - $|\eta^{truth}| < 2.37$
  - $E_T^{iso,truth} < 0.05 * E_T^{truth} + 6$ GeV
- Additional uncertainties:



Source	Uncertainty
Luminosity	±5%
Trigger	±0.63%
C_X factors •	
Photon identification	±(3–2)%, mass-dependent
Photon isolation	±(4.1–1)%, mass-dependent
Production process	±3.1%

Limit on fiducial cross section (2)

- Result only for narrow-width:



- More information in ATLAS-CONF-2015-081

Conclusion

- Look for scalar diphoton resonances in 3.2 fb^{-1} of 13 TeV data
  - from 200 to 2000 GeV

- Excess seen around 750 GeV:

	significance	local	global
width	narrow	3.6σ	2.0σ
	6%*mX	3.9σ	2.3σ

- No obvious detector nor reconstruction effect
- Kinematic properties in the excess region and on both sides are similar within statistical uncertainties

- LHC starting again next month!
- First stable beams in April
- Expected in 2016: ~30 fb^{-1}

Back-up

Large width signal parameterisation

- Example for m_X = 800 GeV