Measurement of the Higgs-Boson cross sections in the diphoton channel using 80 fb^{-1} of 13 TeV of pp collisions with ATLAS

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on behalf of the ATLAS collaboration

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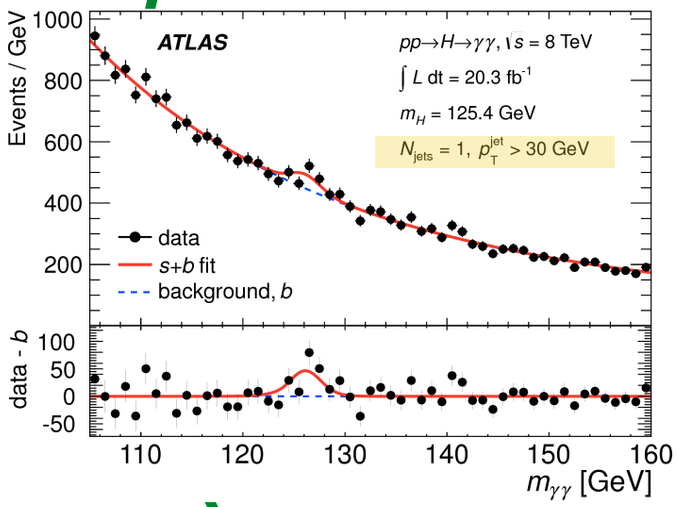
Introduction

- **Differential and fiducial cross section measurement using the 13 TeV data is a key measurement to probe the properties of the Higgs boson**
- Performed with 80 fb^{-1} of pp collision data collected between 2015-2017
  - **43.6 fb^{-1} of new data collected in 2017 compared to the <u>previous</u> ATLAS publication (36 fb^{-1})**
- **A measurement with minimal SM assumption**
  - Similar particle and detector level event selection to avoid extrapolation across the phase space
  - Allows reinterpretations using different theory models (Effective field theory)
- **Measurement in the $\gamma\gamma$ channel has low BR (0.2%) but have excellent resolution and high photon reconstruction and identification efficiencies**

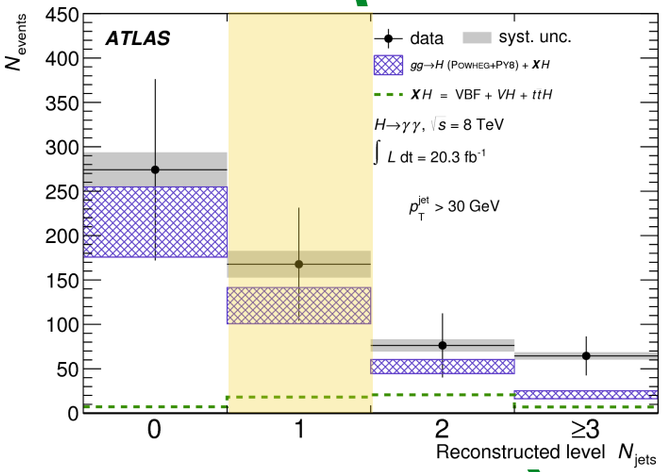
Analysis strategy

Detector



Event selection and categorisation
e.g. 1 jet

Signal yield (detector phase space)

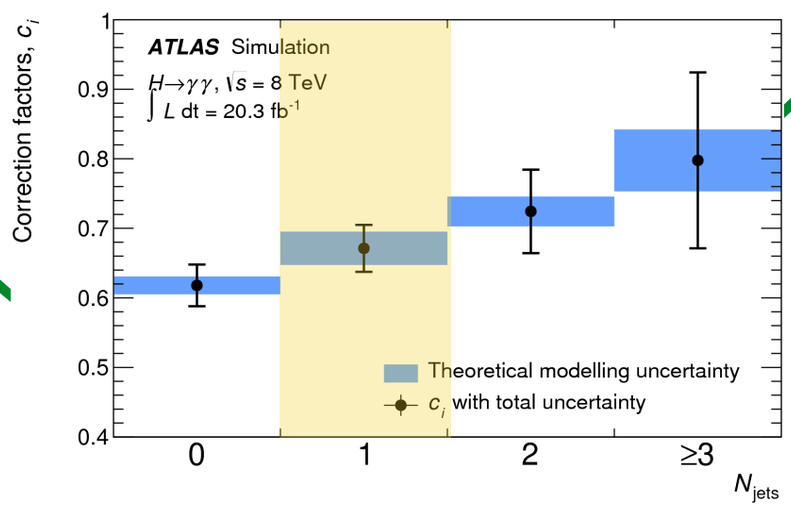


Signal + BG fits

$$\sigma_i = \frac{\nu_i^{sig}}{C_i \cdot \mathcal{L}_{int}}$$

Correction for detector effects (unfolding)

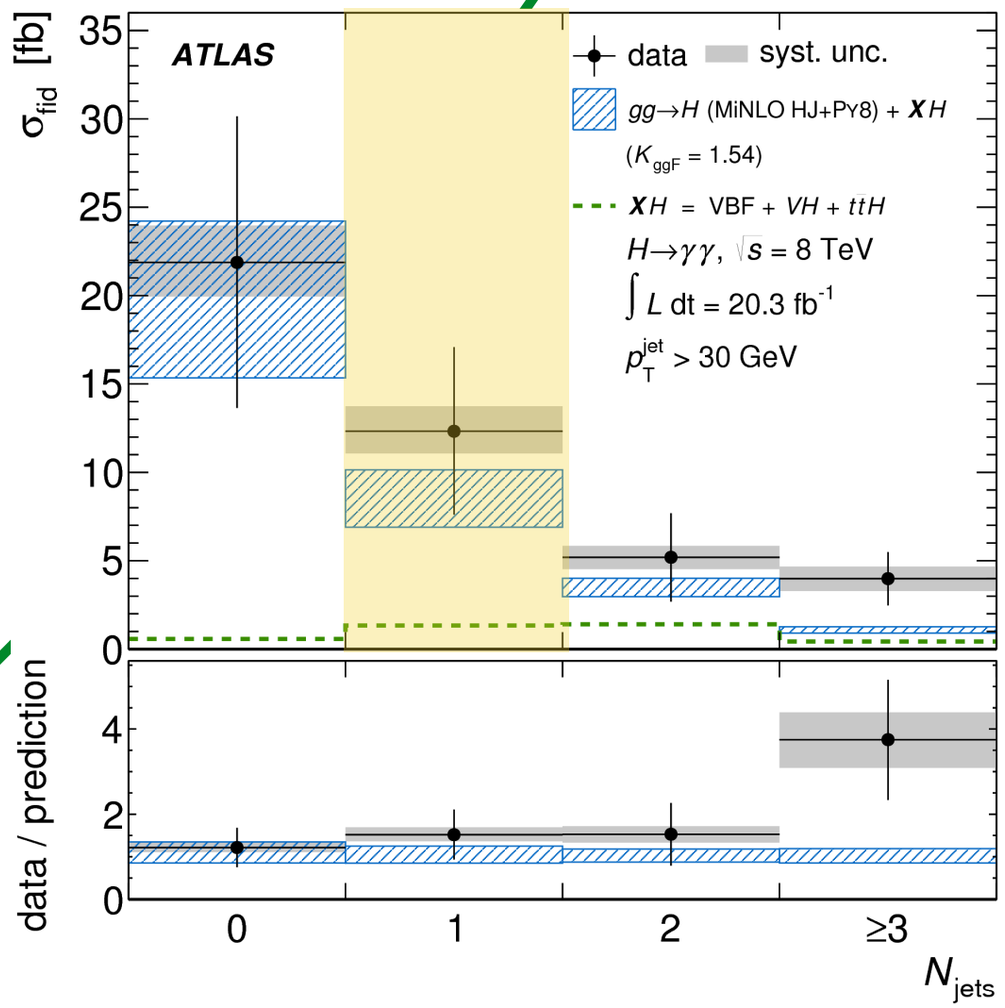
$$C_i = \frac{N_{reco}^i}{N_{true}^i}$$



Theory

Parton level (full phase space)

Particle level (fiducial phase space)

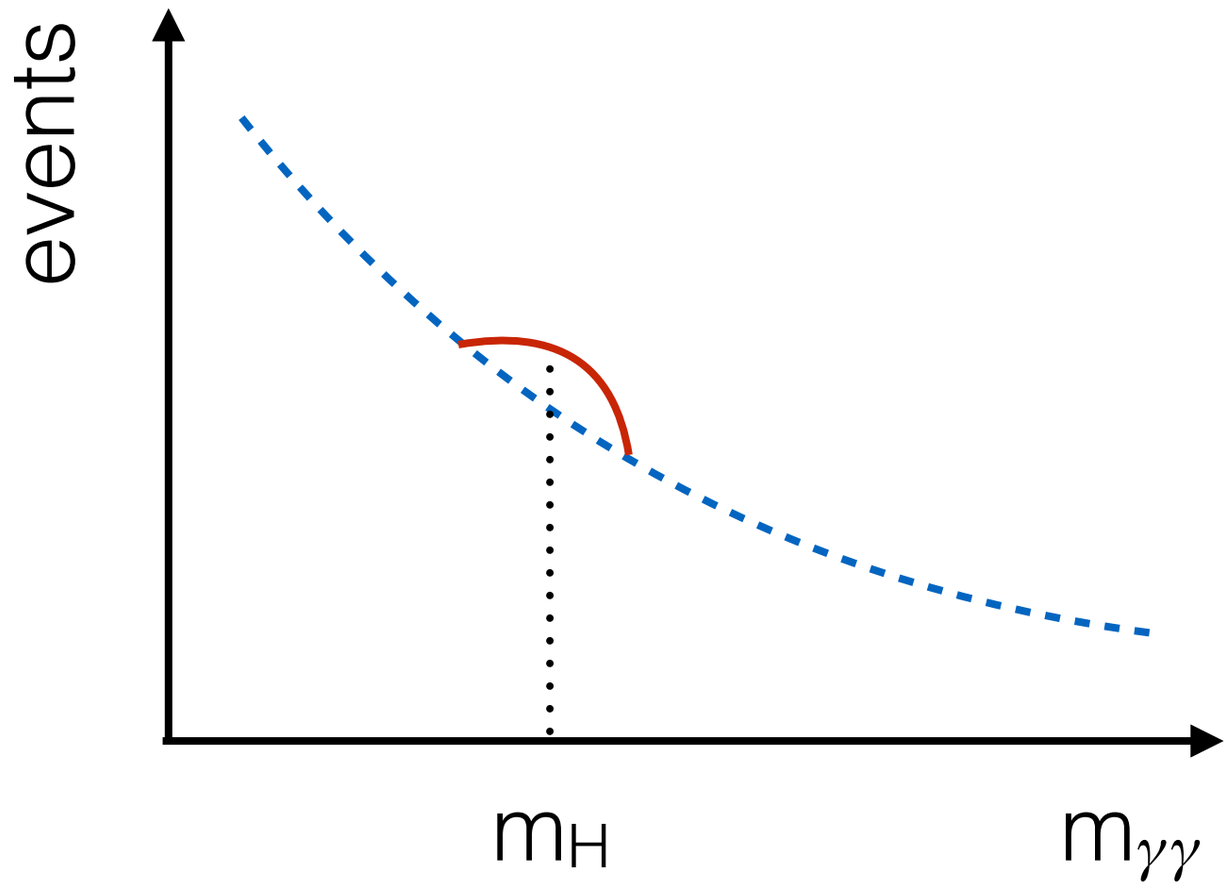


Event selection and categorisation

simplified ***Event Selection***

- Two photons with $p_T/m_{\gamma\gamma}$ > 0.35(0.25) for leading(sub-leading)
- within $|\eta|<2.37$
- Pass photon identification criteria
- Low hadronic activity around the photons (Isolated)
- invariant mass within Higgs mass window [105-160] GeV

➡ **Signal** appears as a narrow peak on top of a uniformly decreasing **background** of irreducible $\gamma\gamma$ (+fakes) in the m_{yy} spectrum

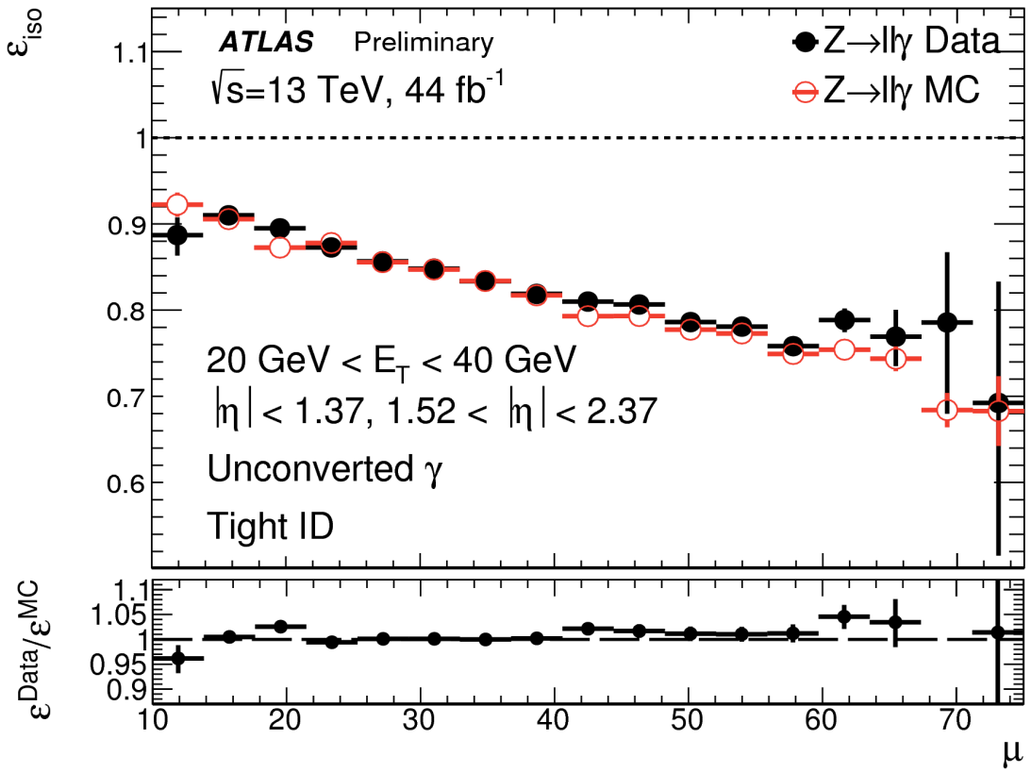


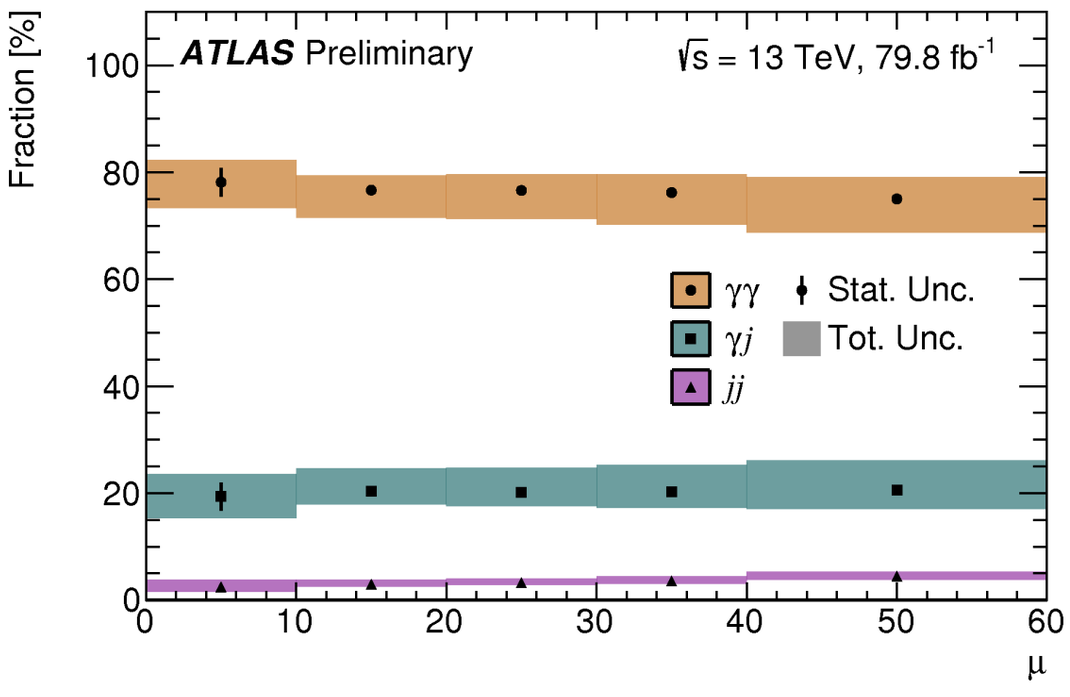
Measurement performed in the following fiducial and different regions

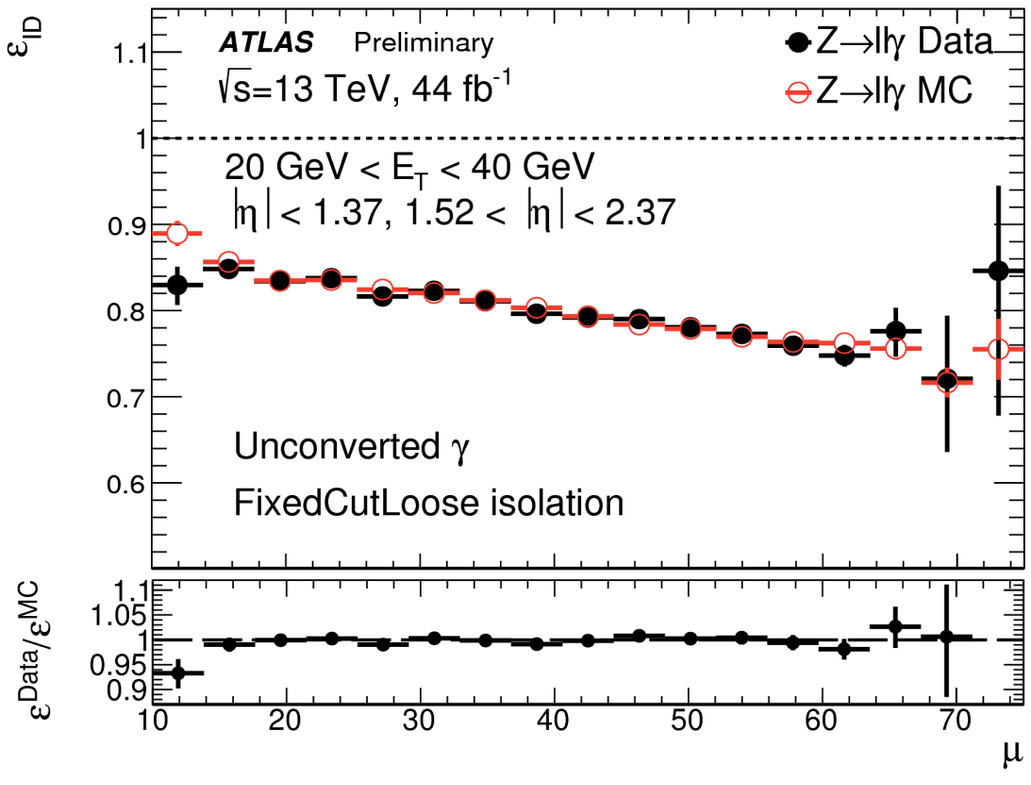
- **The inclusive fiducial region** : matching the detector acceptance
- **Transverse momentum of the diphoton system** $p_T^{\gamma\gamma}$
- **Absolute rapidity separation of the diphoton system** $|y_{\gamma\gamma}|$
- **Transverse momentum of the leading jet** $p_{T,j1}$
- **New Measurement Number of b-jets** $N_{\text{b-jets}}$

2017 Run Conditions

- **In 2017 pileup has increased <μ>~38 compared to <μ>~24 in 2015+2016**
  - Photon identification and isolation performs well at high pileup **EGAM-2018-007**
  - Sample composition was found stable with the high pileup

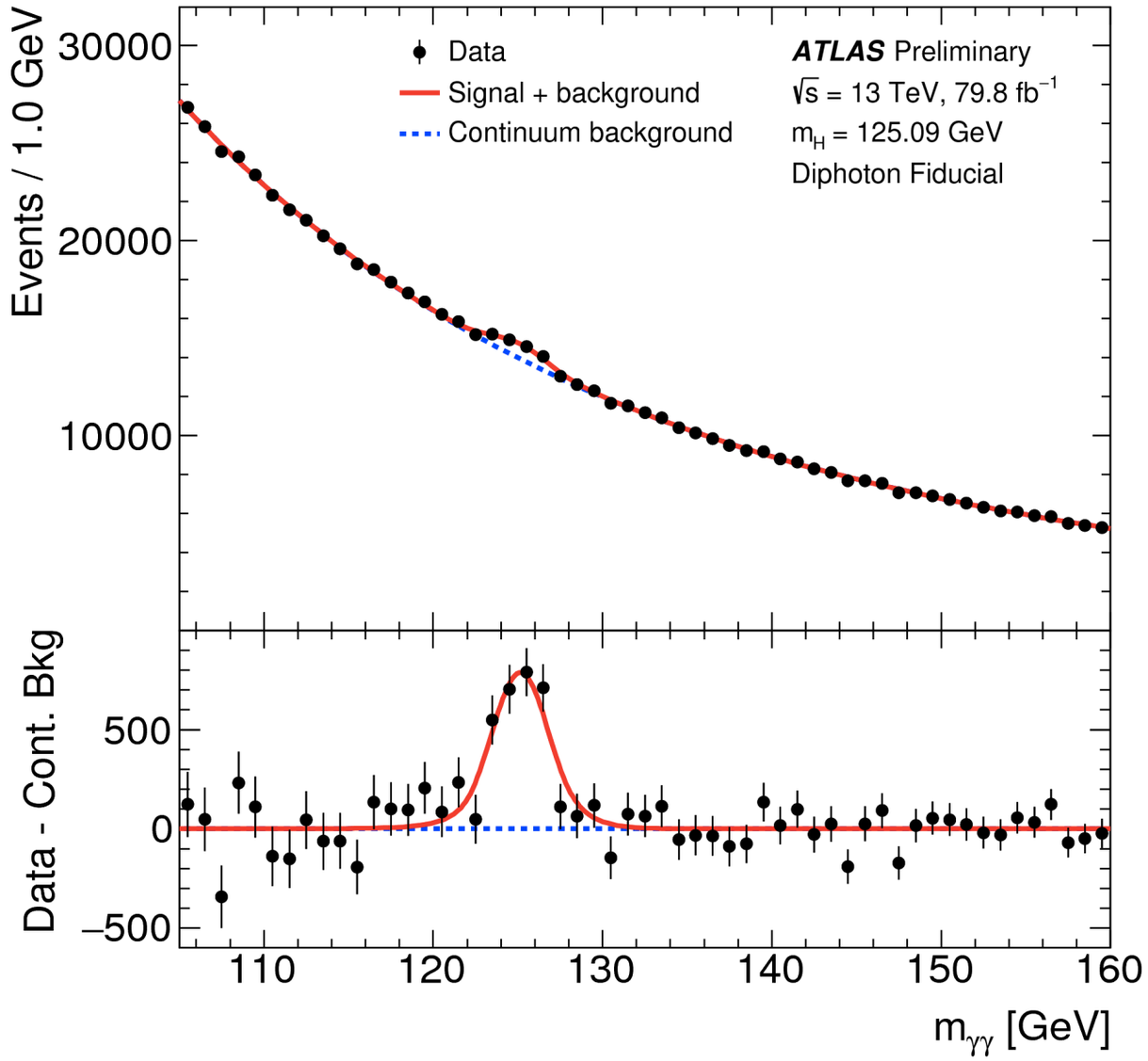






Inclusive fiducial region

- Signal yield is extracted from a signal + background fit on data
- The fitted signal yields are corrected for detector effects (unfolded to particle level) using a **bin-by-bin correction factor** $C_i = \frac{N^i_{reco}}{N^i_{true}}$



Measured cross section : 60.4 ± 6.1 (stat.) ± 6.0 (exp.) ± 0.3 (theo.) fb

Standard Model prediction : 63.5 ± 3.3 fb

ggF : POWHEG NNLOPS with N3LO(QCD)+NLO(EW) normalisation

Breakdown of uncertainties

Experimental uncertainties on signal and background modelling

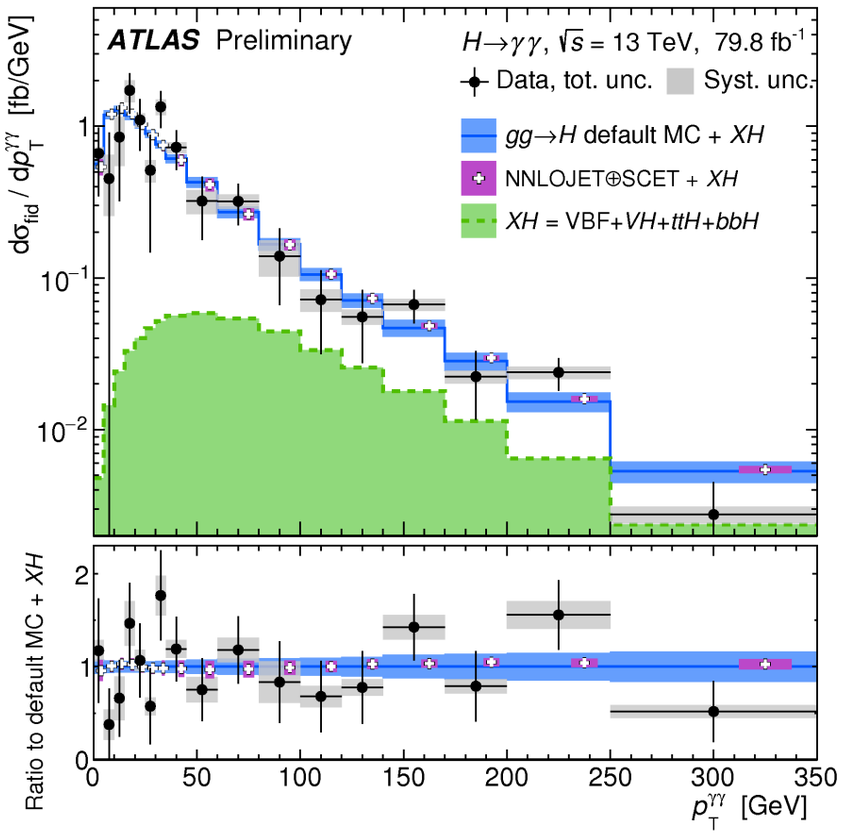
Experimental uncertainties on the correction factor

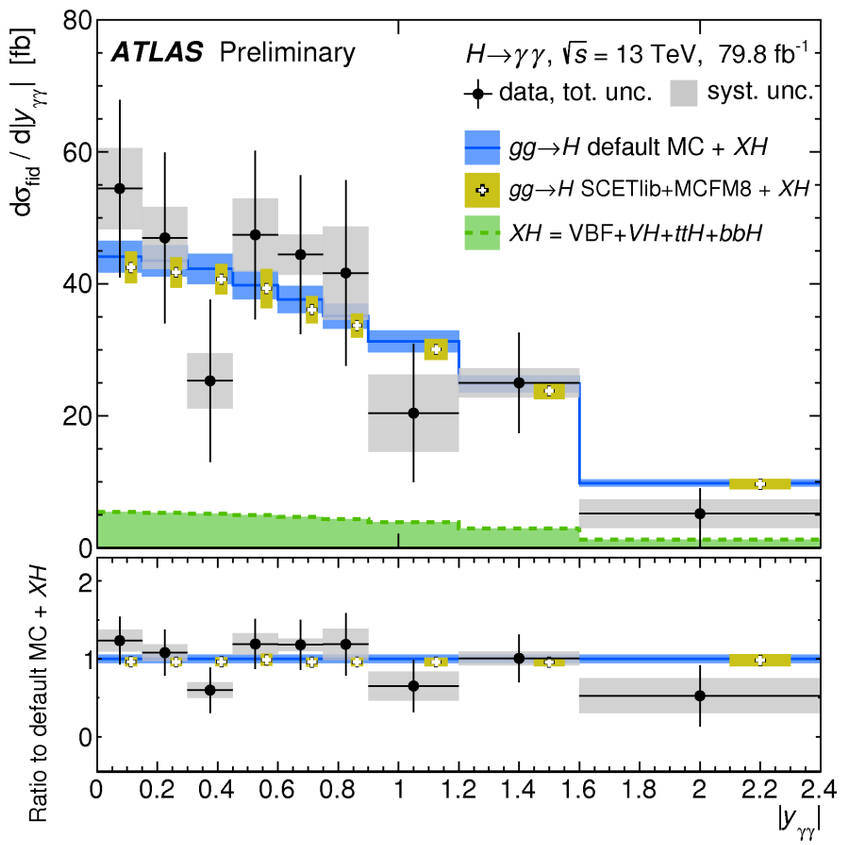
Theoretical uncertainties

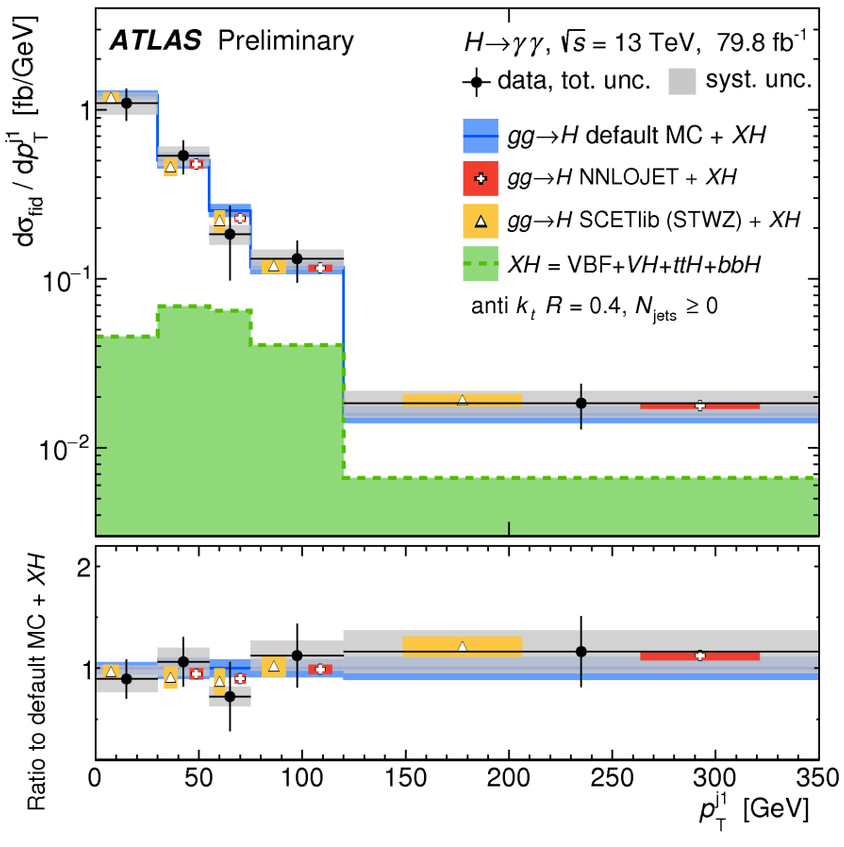
Experimental uncertainties on the correction factor

Source	Uncertainty (%)
Fit (stat.)	10
Fit (syst.)	8.3
Photon energy scale & resolution	4.0
Background modeling (spurious signal)	7.3
Correction factor	5.2
Photon isolation efficiency	4.6
Pileup	1.9
Photon ID efficiency	1.3
Trigger efficiency	0.7
Dalitz Decays	0.4
Theoretical modeling	$^{+0.3}_{-0.4}$
Diphoton vertex selection	0.1
Photon energy scale & resolution	0.1
Luminosity	2.0
Total	14

$p_T^{\gamma\gamma}$, $|y_{\gamma\gamma}|$ and $p_{T,j1}$







➡ **Uncertainty dominated by the statistical component for all the differential cross-sections**

Agreement with the default Standard Model prediction $p(\chi^2)$

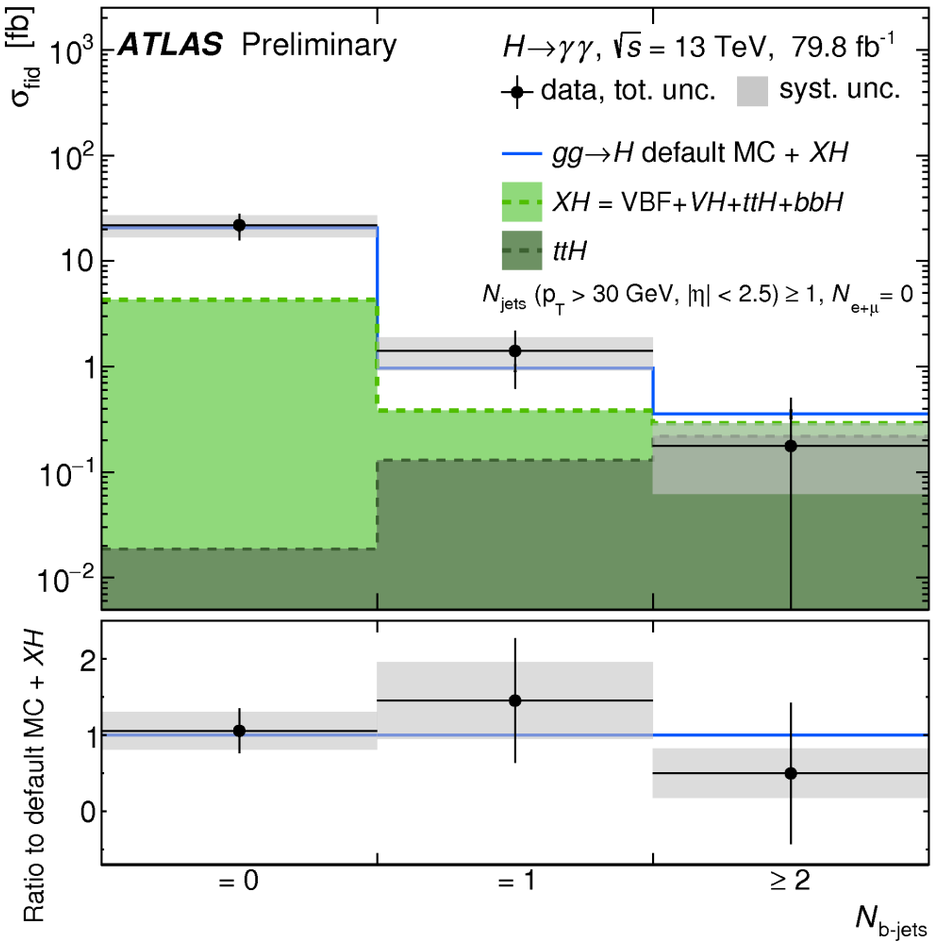
$p^T{}_{\gamma\gamma}$	32%
$\lvert y_{\gamma\gamma}\rvert$	56%
p_{Tj1}	88%

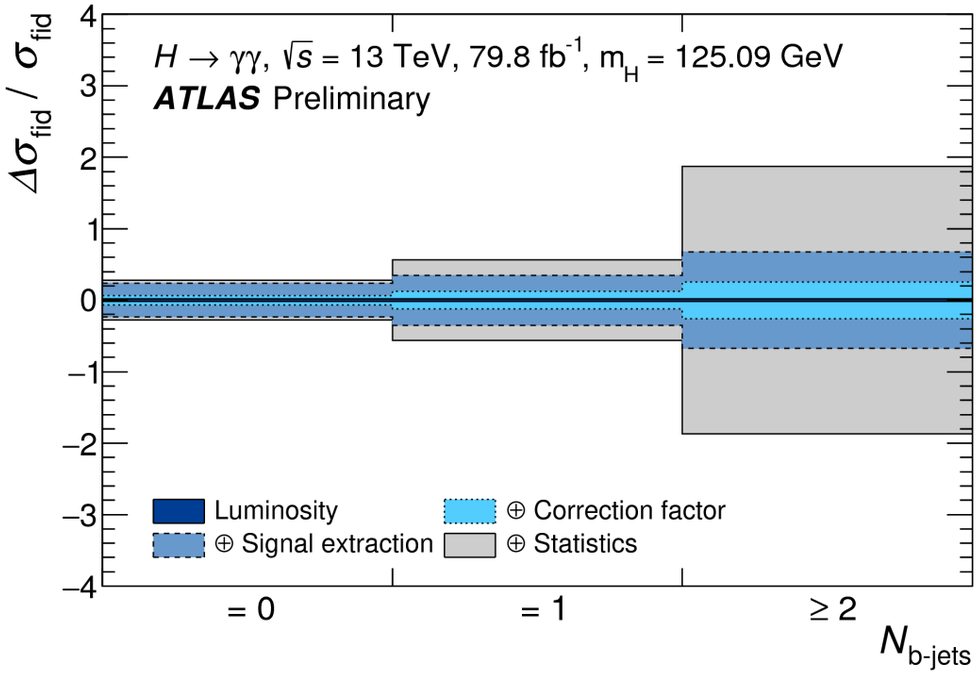
very good agreement with the SM !

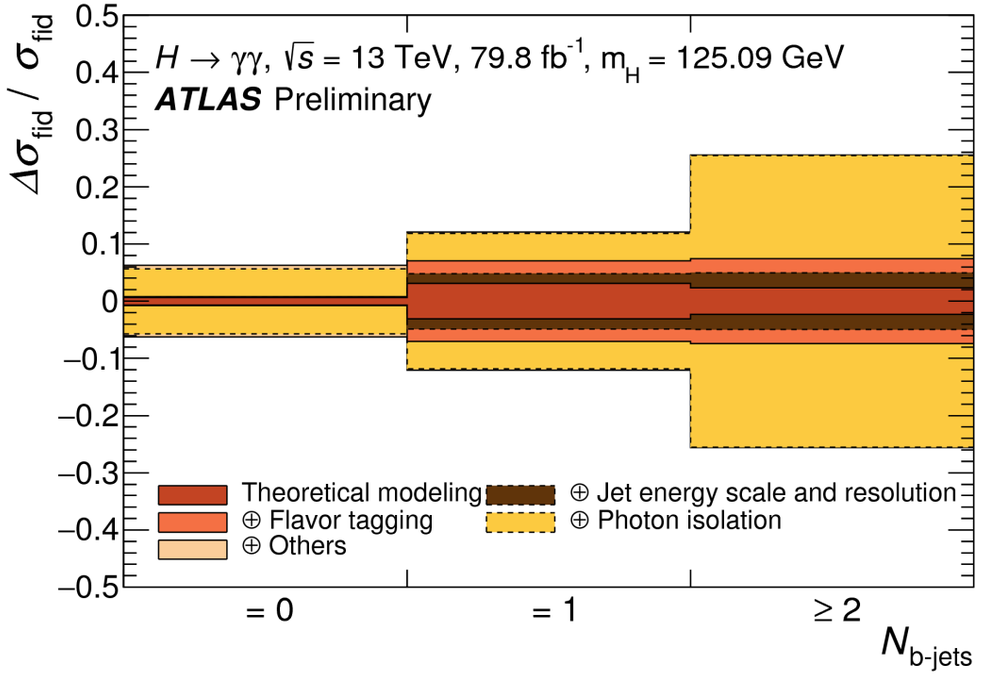
Number of b-jets $N_{\text{b-jets}}$

- **New measurement aiming at measuring Higgs with associated heavy flavour**
  - poorly constrained theoretically for ttH and HH

  Fiducial region for this measurement
  - Requires at least one central jet with p_T>30 GeV
  - A veto on electrons and muons to reduce ttH
  - Probed with $N_{bjet} = 1$
- Compatibility with SM p(χ^2) = 84%







Conclusion

ATLAS-CONF-2018-028

- **Measurement of the fiducial and differential cross sections in the $H \to \gamma\gamma$ channel using 80 fb^{-1} of data**
  - **Better statistical precision with respect to previous publication (16% → 10% for the inclusive cross-section)**
    - Systematic error is of the same order as statistical error for the inclusive cross-section
    - Statistical error remains larger than the systematic error for the differential distributions
- **Excellent agreement with standard model predictions**

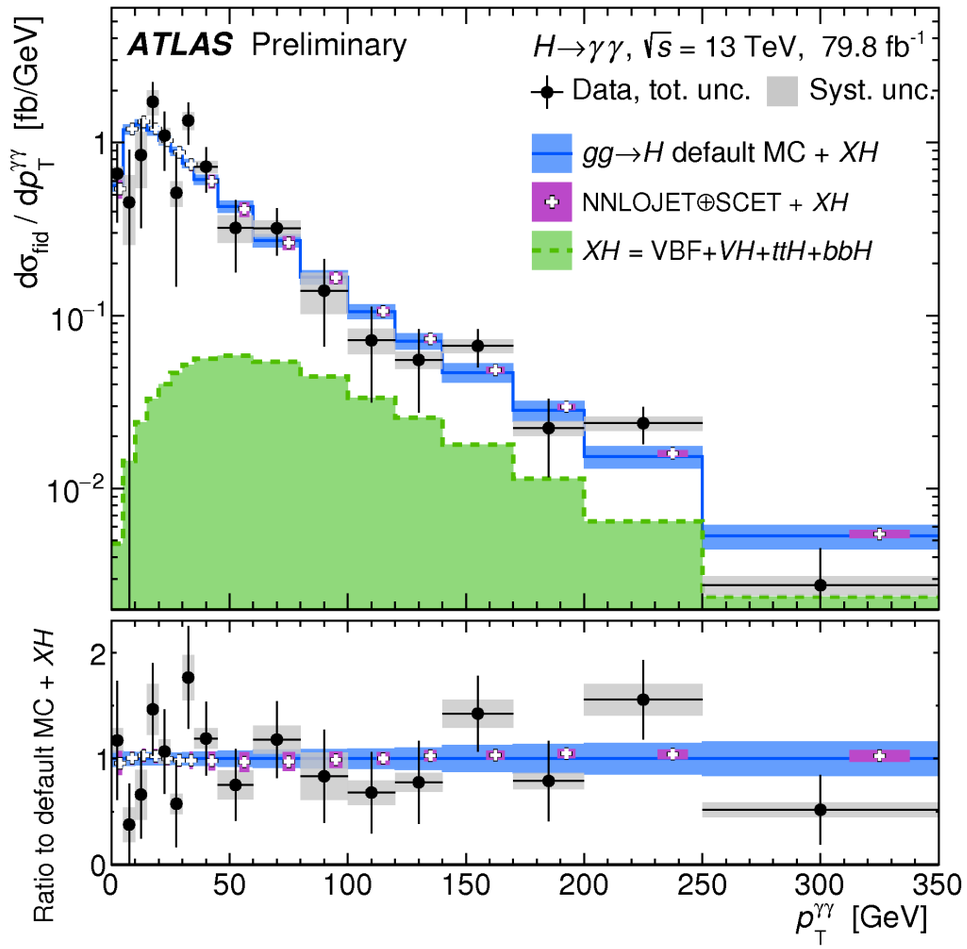
  Outlook : Performing the measurements using the full run-2 data

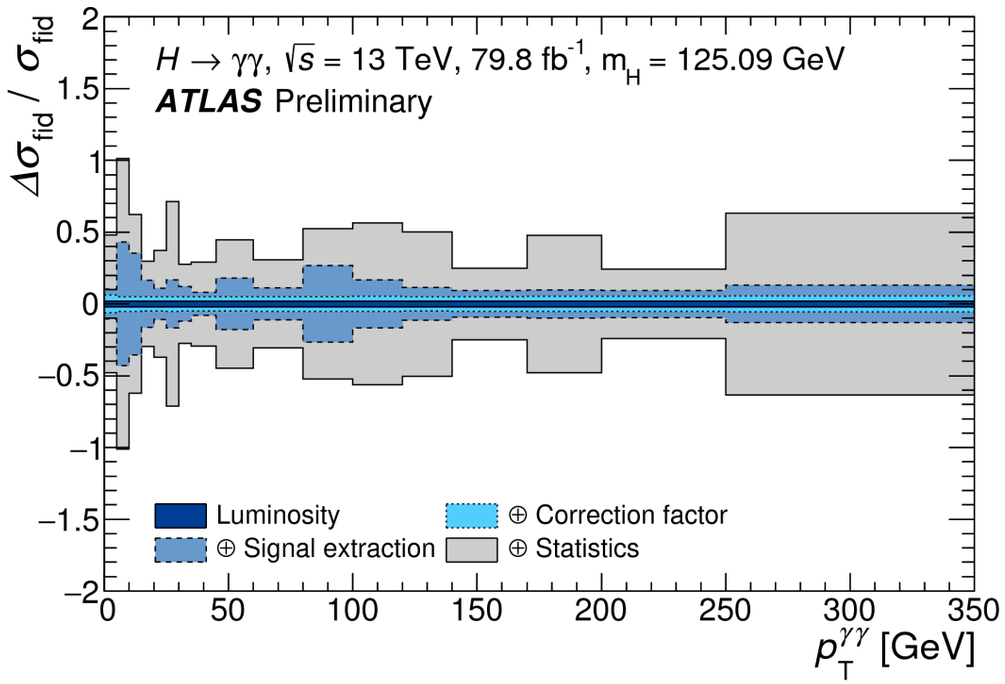
  + working on reducing systematic uncertainties

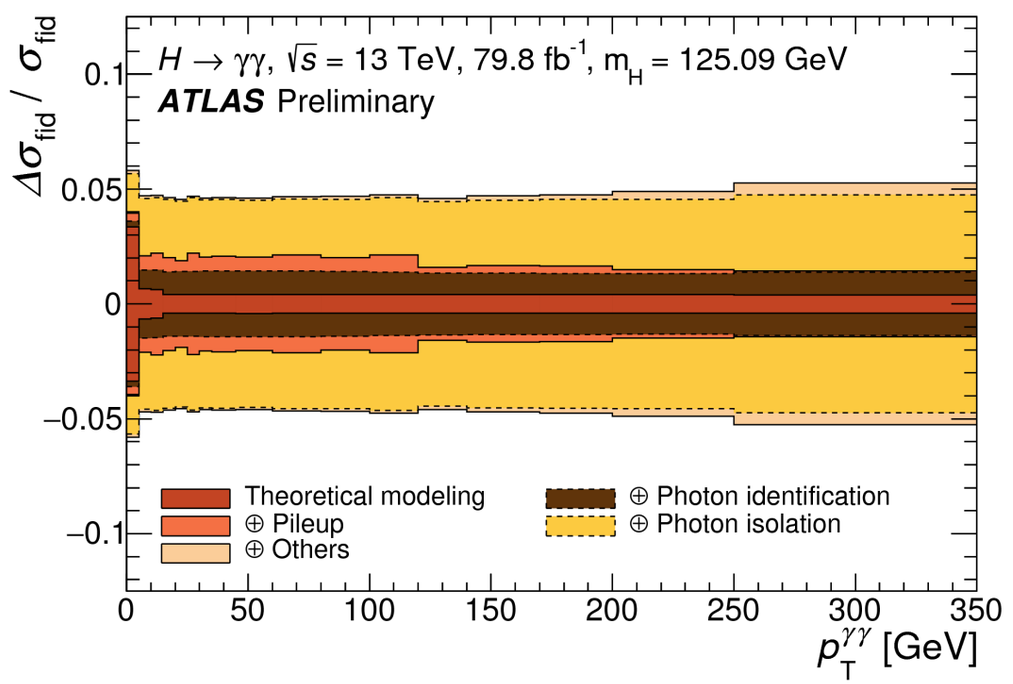
Backup

Diphoton system transverse moment

- **default MC:** PowHeg NNLOPS, normalisation: N3LO(QCD) and NLO(EW) + ***XH***
  - Compatibility with data $p(\chi^2) = 32\%$
- **NNLOjet⊕SCET :** NNLO+N3LL resummation + ***XH***

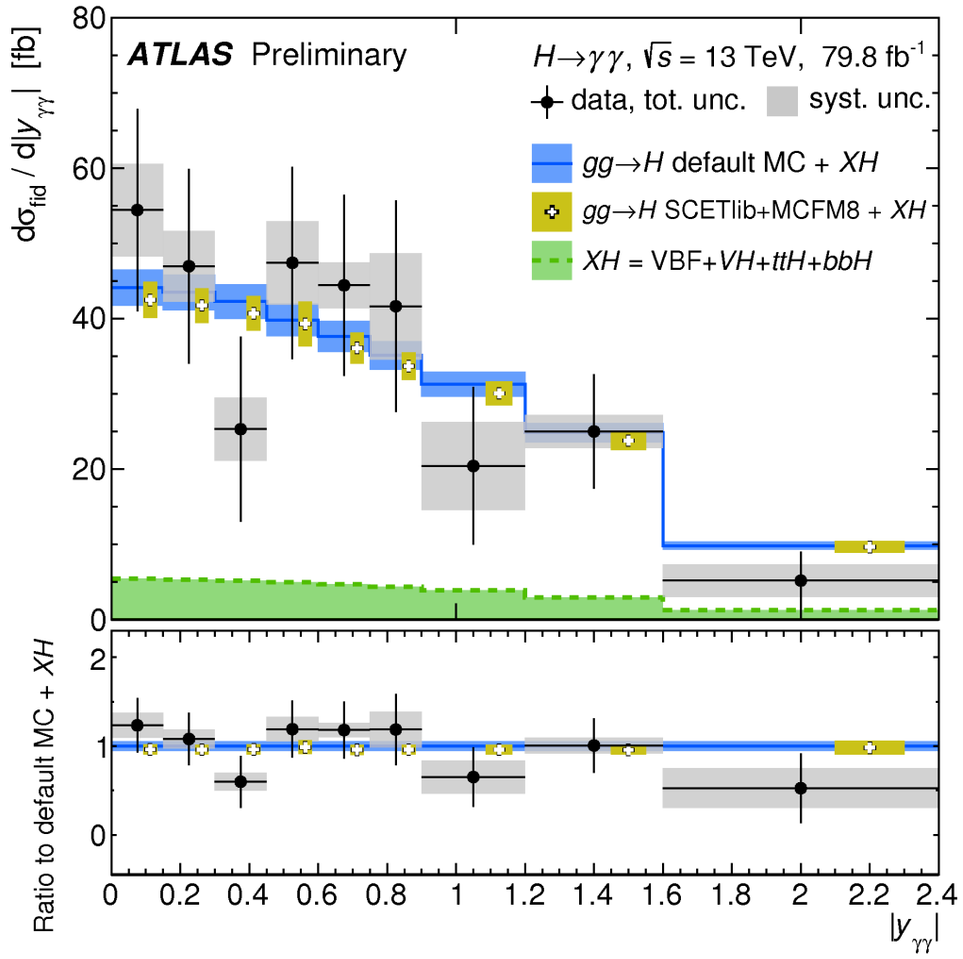


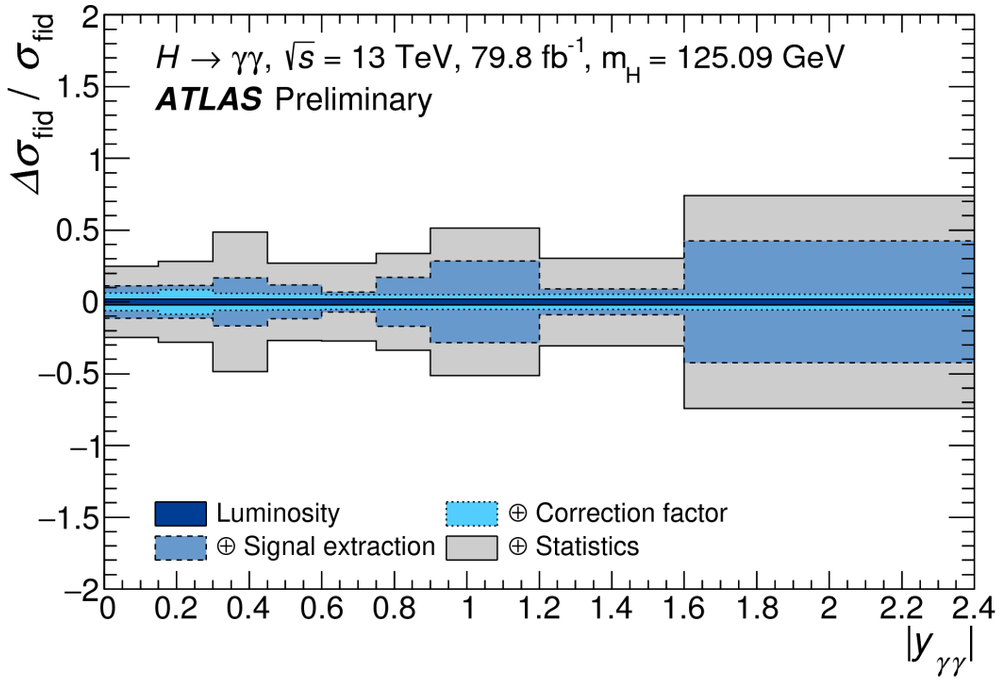


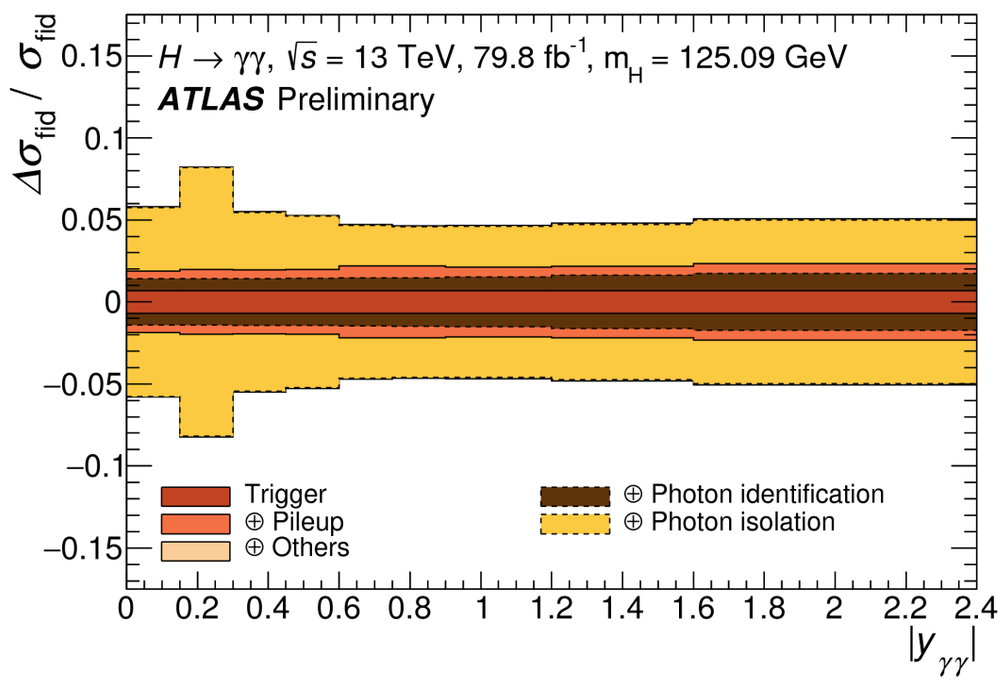


Diphoton system absolute rapidity

- **$SCET_{LIB}$+MCFM8 :** NNLO+NNLL'$_{\phi}$ accuracy
- Compatibility with data $p(\chi^2) = 56\%$







Transverse moment of leading jet

- **$NNLO_{JET}$:** a parton level fixed-order NNLO prediction in QCD for inclusive H +1-jet production
- **$SCET_{LIB}(STWZ)$:** NNLL' +$NNLO_0$ accuracy
- Compatibility with data $p(\chi^2) = 88\%$