Search for resonances decaying to photon pairs in 139 fb^{-1} of pp collisions at $\sqrt{s}$= 13 TeV with the ATLAS detector

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Introduction

A search for new resonances decaying into two photons is performed, using 139 fb^{-1} of pp collision data at $\sqrt{s} = 13\ \mathrm{TeV}$ collected by the ATLAS detector from 2015 to 2018. Two kinds of signal models are searched for: spin-0 resonances that are predicted by theories with an extended Higgs sector, and spin-2 resonances using a warped extra-dimension benchmark model. Upper limits are set on the production cross-section times branching ratio as a function of the diphoton invariant mass above 160 GeV.

1. Analysis selection

Common for spin-0/spin-2:

- Diphoton triggers
- Tight photon isolation and identification
- $m_{\gamma\gamma}$ >150 GeV
- $E_T^{\gamma 1}/m_{\gamma\gamma} > 0.3$, $E_T^{\gamma 2}/m_{\gamma\gamma} > 0.25$

Fiducial selection:
Kinematic selections and truth isolation imitating the reconstruction-level selection.

2. Analysis strategy

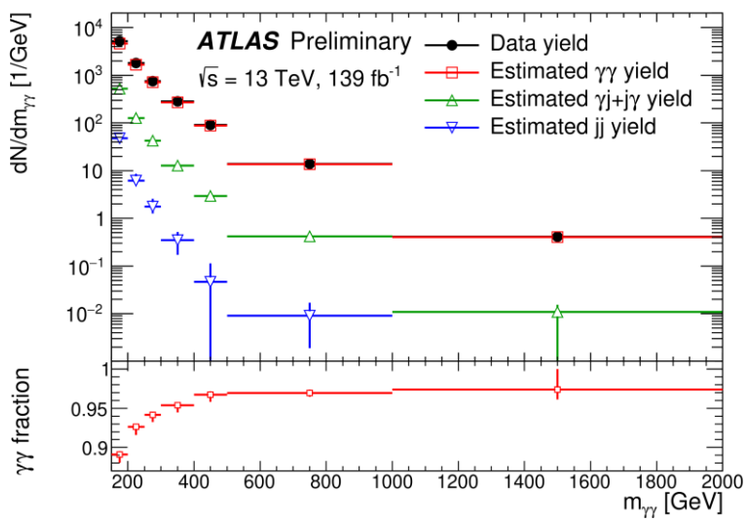
Spin−0: fiducial cross−section:

$$\sigma_{X,fid} \cdot \mathcal{B}(X \to \gamma\gamma) = \frac{N_{sig}^{reco}}{C_X \cdot L_{int}}$$

Spin−2: total cross−section:

$$\sigma_{X,total} \cdot \mathcal{B}(X \to \gamma\gamma) = \frac{N_{sig}^{reco}}{C_X \cdot A_X \cdot L_{int}}$$

- N_{sig}^{reco} is fitted in data with analytical functions that model the background and signal shape.
- fiducial correction factor C_X corrects for detector effects related to reconstruction efficiency and event migrations.
- Acceptance A_X is the fraction of generated events within the fiducial phase space.



3. Signal modeling

Parametric models are used to describe the resonant signals and parameterized as a function of m_X and signal width.

Narrow width approximation (NWA):

- Signal shape modeled by a double-sided Crystal Ball function (DSCB)
- Parameters of DSCB functions expressed as function of m_X

Large width (LW):

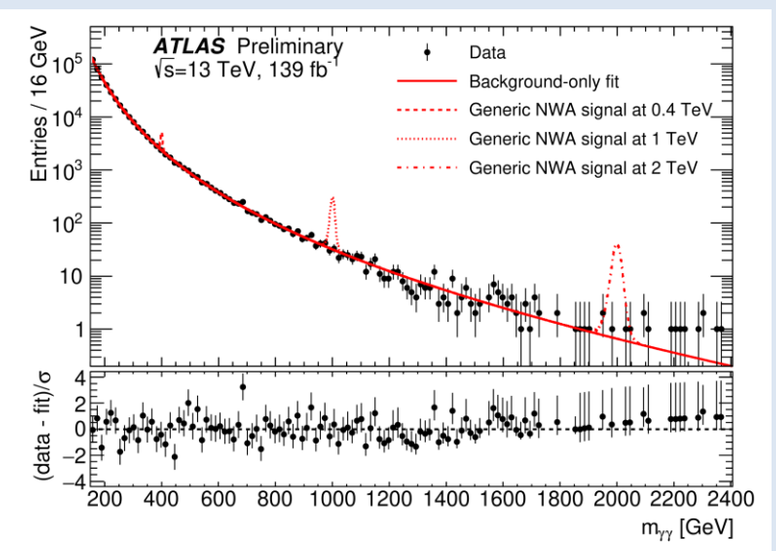
- DSCB ⊗ true lineshape (product of a relativistic Breit-Wigner form and mass and PDF dependent factors)

4. Background modeling

A background template is built from:

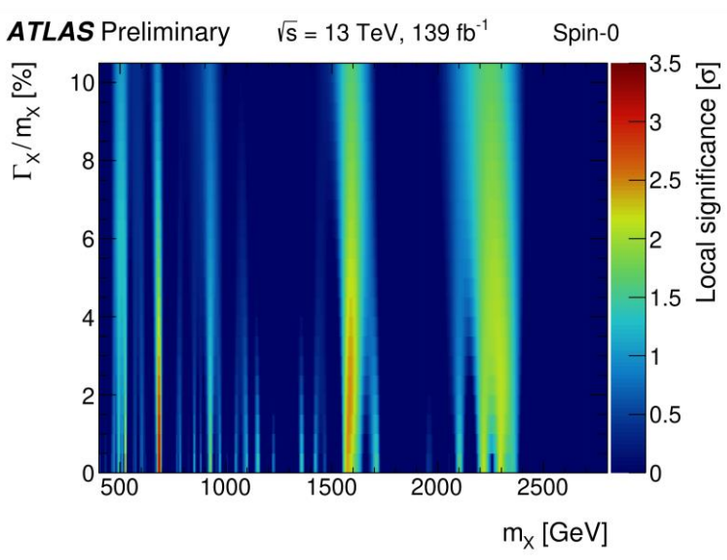
- real γγ events (irreducible), modeled from Sherpa NLO MC simulation
- γ+jet, multi-jet events (reducible), modeled from data

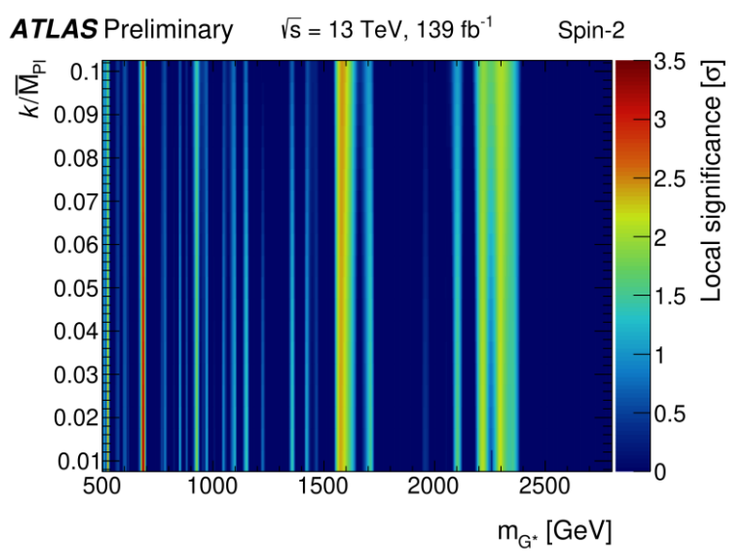
The respective fraction of γγ/γ+jet (0.92/0.08) measured in data is used to normalize the background components.

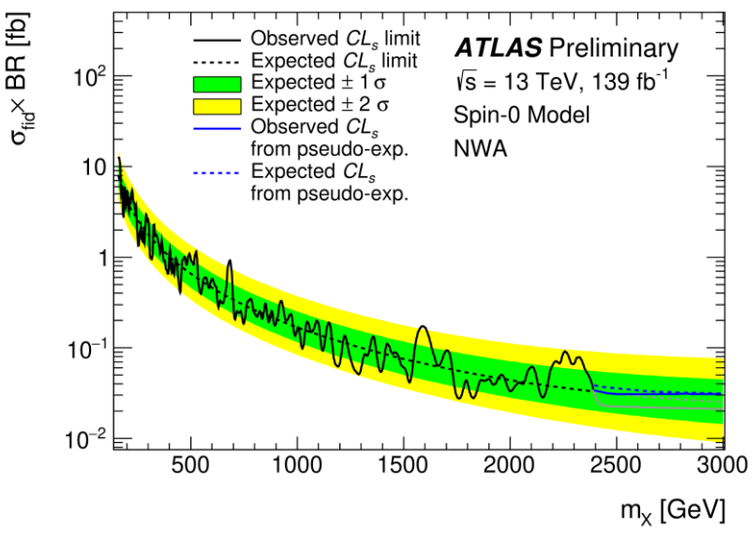


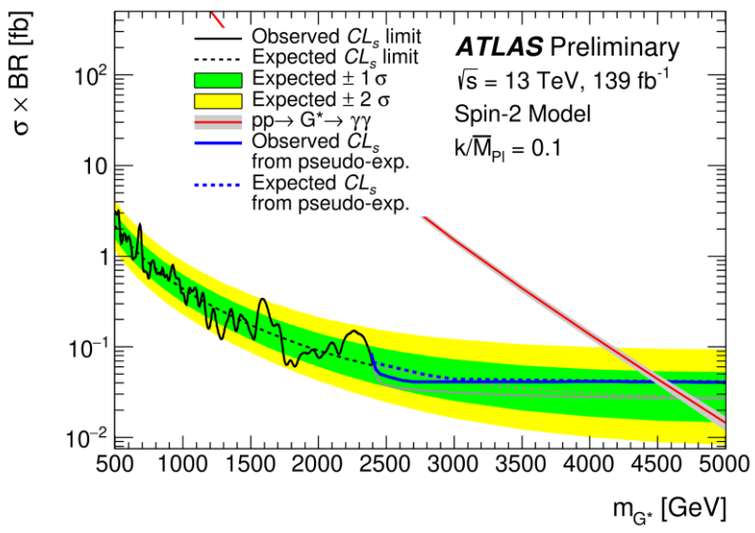
The best analytical function (in red) is chosen from spurious signal studies on the background template.

5. Results









The largest systematic uncertainties come from photon energy resolution (~20%) and spurious signal test (<5% on the observed limits).

Limits as function of of m_X and signal width are computed using asymptotic approximation.
No data observed above 2.36 TeV. Above 2.4 TeV, pseudo-experiments are used to obtain observed and expected limits as a cross-check.

No significant excess observed from the Standard Model expectation.

Largest deviation found at m_X = 684 GeV (narrow width signal):

- 3.29σ local, 1.3σ global significance considering look-elsewhere effect.

Observed limits on the spin-0 and spin-2 resonances:

- 12.5 fb (162 GeV) to 0.03 fb (3 TeV) for spin-0 narrow width signal.
- 3.2 fb (500 GeV) to 0.04 fb (~3 TeV) for k/M_{pl} = 0.1 graviton.

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