

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

ATLAS-CONF-2020-037

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ICHEP 2020



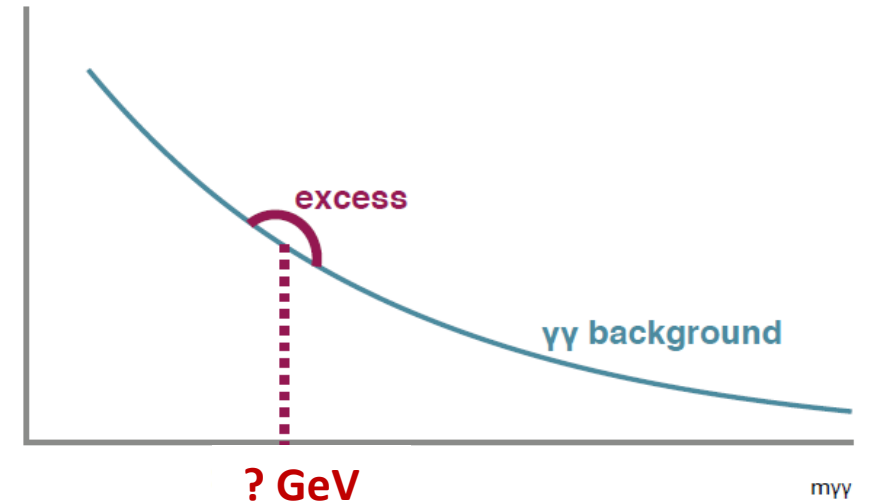
Motivation & introduction

- Search for a diphoton resonance in the high-mass spectrum ($m_{\gamma\gamma} > 160$ GeV).
 - **spin-0**: search for a narrow or large width resonance, up to $\Gamma_X/m_X = 10\%$.
 - **spin-2**: search for the RS graviton for $0.01 < k/M_{pl} < 0.1$.
- In the absence of a significant excess, set limits on fiducial/total cross-section.

Diphoton final state provides **excellent invariant mass resolution** and **smoothly falling background**.

Analysis strategy:

- fit data with **analytical functions** that model the background and signal shape.



Event selection harmonized 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.

Analysis overview

Signal:

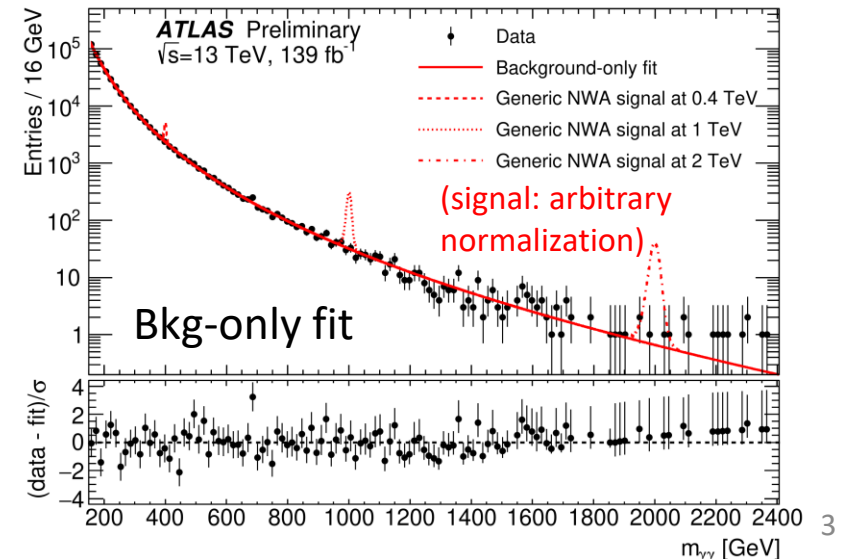
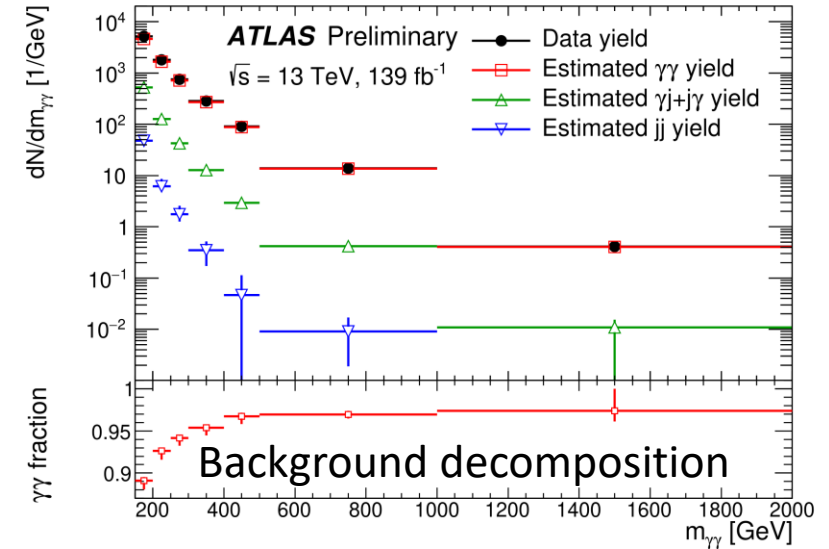
- **Narrow width approximation (NWA):**
(Signal shape dominated by detector resolution)
 - Modeled by a double-sided Crystal Ball function (DSCB)
 - Parameters of DSCB functions expressed as function of m_X
- **Large width (LW, $0.5\% \leq \Gamma_X/m_X \leq 10\%$):**
 - DSCB \otimes relativistic Breit-Wigner function for spin-0
 - DSCB \otimes graviton lineshape for spin-2

Background:

Background template used to validate the analytical functions.

- **Irreducible:** real $\gamma\gamma$ events (shape from Sherpa NLO)
- **Reducible:** γ +jet, multi-jet (shape from data-driven control regions)

Total background template built by adding $\gamma\gamma$ and γ +jet according to their **respective fraction** (0.92/0.08) measured in data.



Results

Highest $m_{\gamma\gamma}$ in data: 2.36 TeV.

No significant excess from the SM expectation observed.

Largest deviation at $m_\chi = 684$ GeV:

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

(Above 2.4 TeV, pseudo-experiments used to obtain observed and expected limits as a cross-check.)

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.

