Search for new phenomena in high-mass diphoton final states with the ATLAS detector

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2017 Division of Particles and Fields Meeting
August 1, 2017

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ATLAS
EXPERIMENT

Introduction

- Search for phenomena in the diphoton final state are presented
  - Observable is diphoton invariant mass

- Using 37fb^{-1} data collected in 2015+2016
  - result updated from 15fb^{-1} (ATLAS-CONF-2016-059)

- Three benchmark models are studied:
  - Extended Higgs sector, spin-0 resonance
  - Randall-Sundrum graviton, spin-2 resonance
  - ADD scenario, spin-2 non-resonant

Event Selection

- Preselection:
- $E_T^{\gamma,1} > 40$ GeV, $E_T^{\gamma,2} > 30$ GeV
- $|\eta^{\gamma}| < 2.37$ excluding $1.37 < |\eta^{\gamma}| < 1.52$

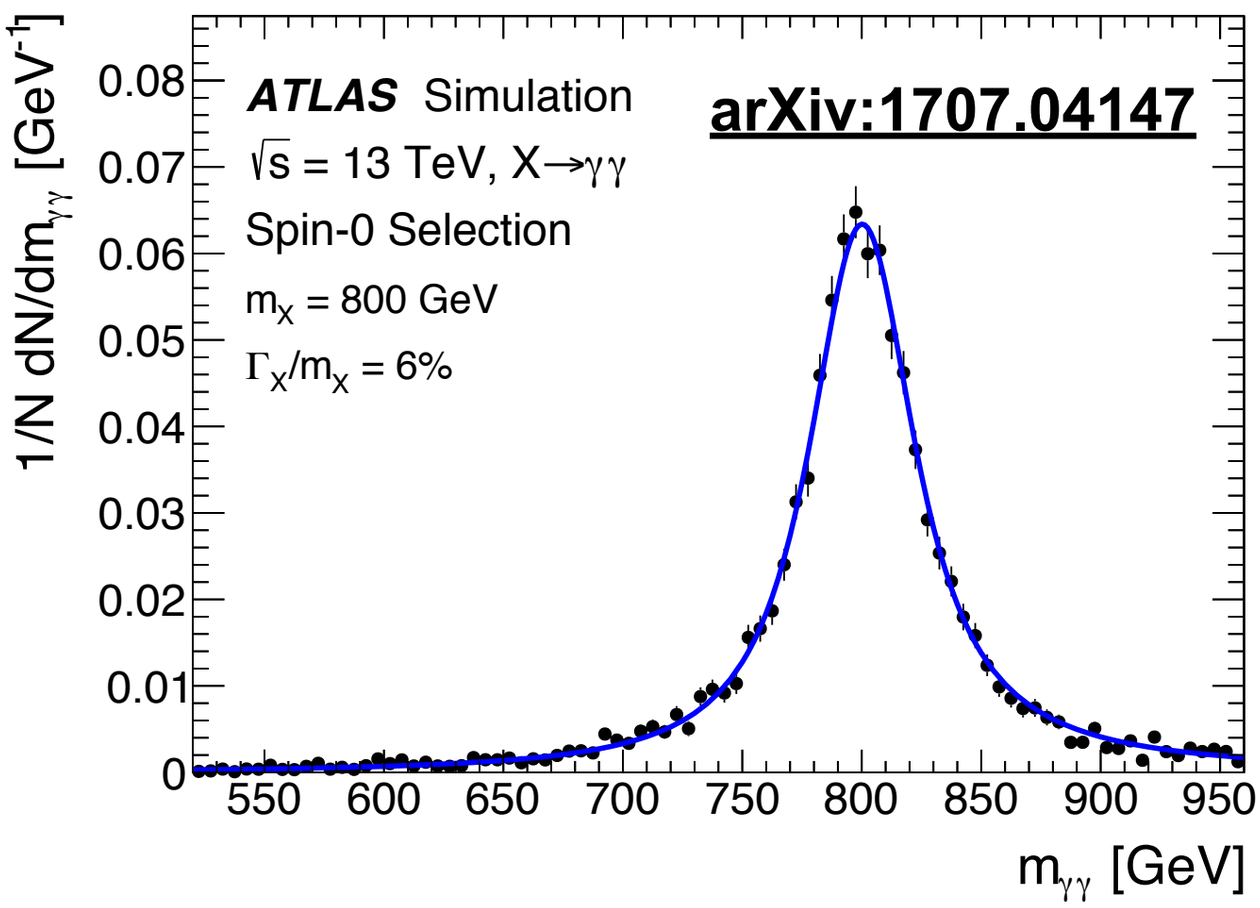
- Tight photon identification
  - using EM calorimeter shower shapes
- Photon isolation (track and calorimeter based)

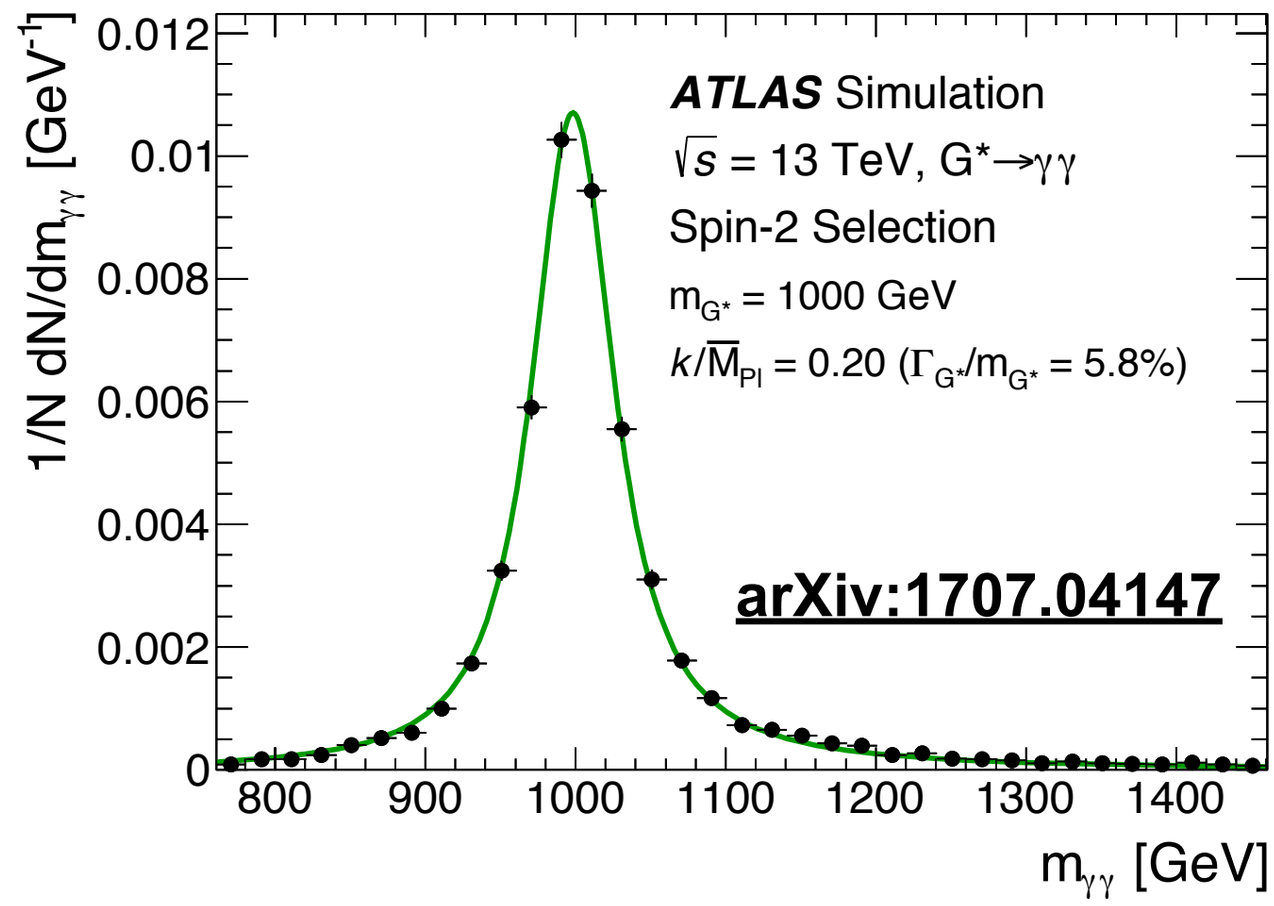
Spin-0 Selection
$E_T^{\gamma,1}/m_{\gamma\gamma} > 0.4$, $E_T^{\gamma,2}/m_{\gamma\gamma} > 0.3$
$m_{\gamma\gamma}$ = 200-2700 GeV

Spin-2 Selection
$E_T^{\gamma,1} > 55$ GeV, $E_T^{\gamma,2} > 55$ GeV
$m_{\gamma\gamma}$ = 500-2700 GeV

Signal Modeling

- Double-sided crystal ball for spin-0 and spin-2 resonance model
  - Parametrized as function of $m_{\gamma\gamma}$ and width





Signal Modeling

- Primary sources of uncertainty on signal yield
  - Mass resolution is 17-38% (28-36%) for spin 0 (spin 2) resonance
  - The combined uncertainty (minus resolution) is less than 6% on signal yield

Uncertainty source	Spin-0 resonance [%]	Spin-2 resonance [%]
Signal mass resolution	17–38	28–36
Signal photon identification efficiency	1.3–3.0	2.6–3.1
Signal photon isolation efficiency	1.1–1.3	1.2–1.4
Signal width dependence	2.8	2.9
Trigger efficiency		0.4
Luminosity		2.1 (2015), 3.4 (2016)
Total uncertainty in signal yield	4.6–5.4	5.3–5.5

arXiv:1707.04147

Background Model - spin 0

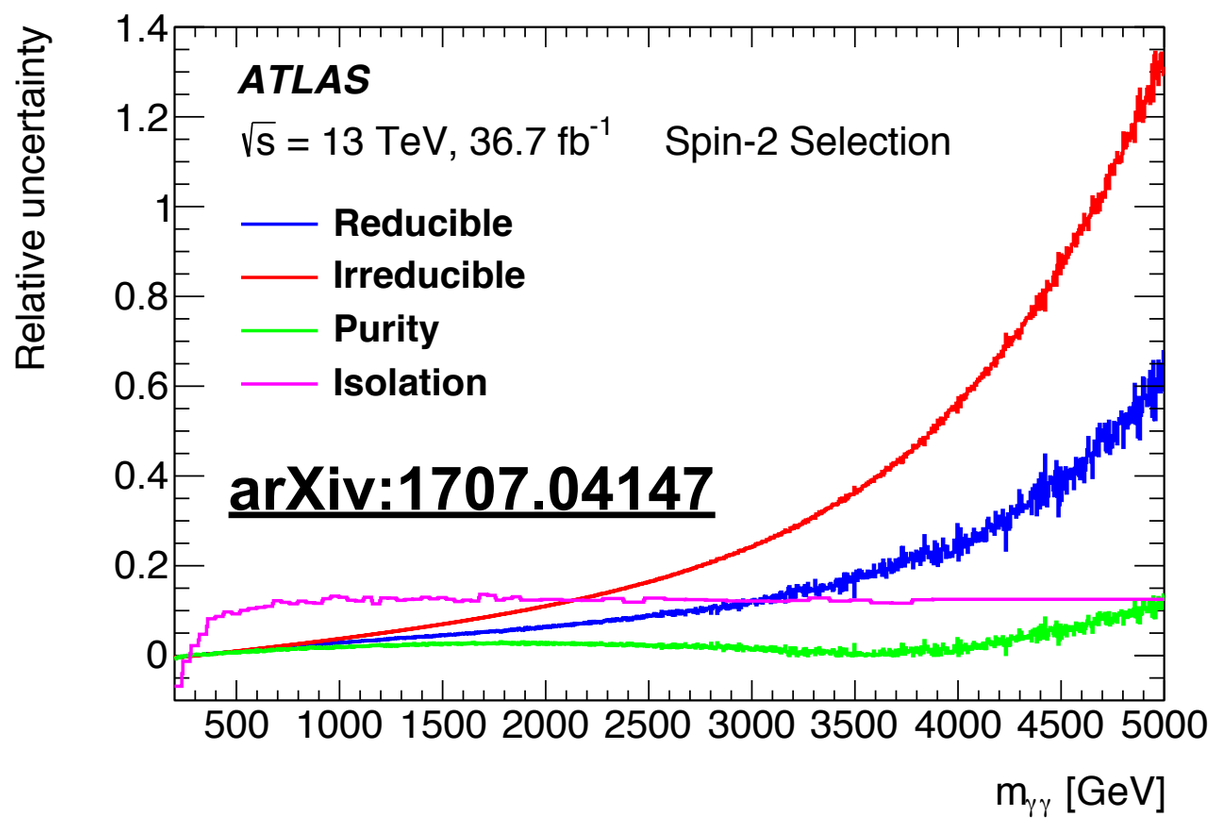
- Fit to smooth function for $m_{\gamma\gamma} > 180$ GeV
  - $m_{\gamma\gamma} > 150$ GeV when fitting to 2015 data alone

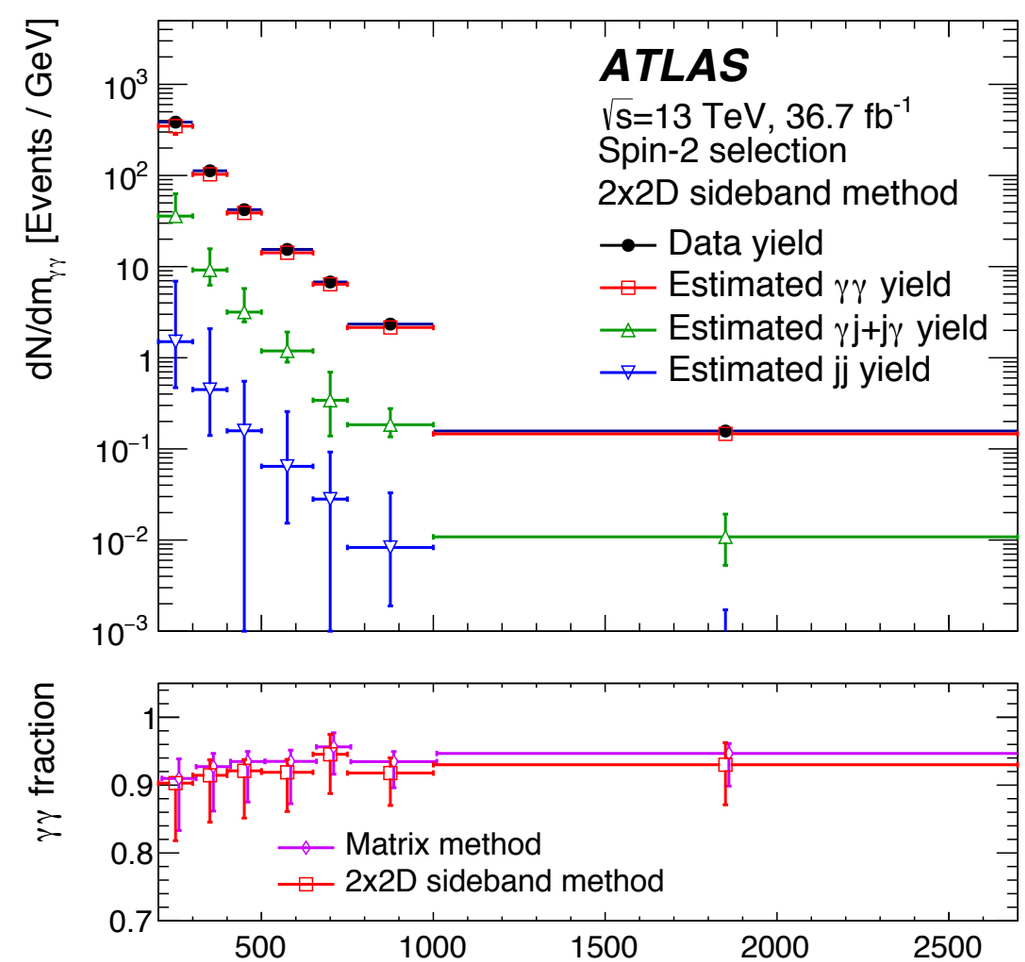
- Bias from choice of function shown in table below as “spurious signal” and used as systematic on background estimate
  - required to be < 30% of statistical uncertainty on fitted signal yield

	Narrow Width	10% width
Spurious signal	74-(6×10^{-3}) events	195-(4×10^{-2}) events

Background Model - spin 2

- Monte Carlo template (binned in 5 GeV)
  - γγ shape taken from Diphox NLO
    - parton level isolation requirement used as systematic
  - γj/jγ + jj shape taken from data driven techniques
  - relative normalization from data-driven technique





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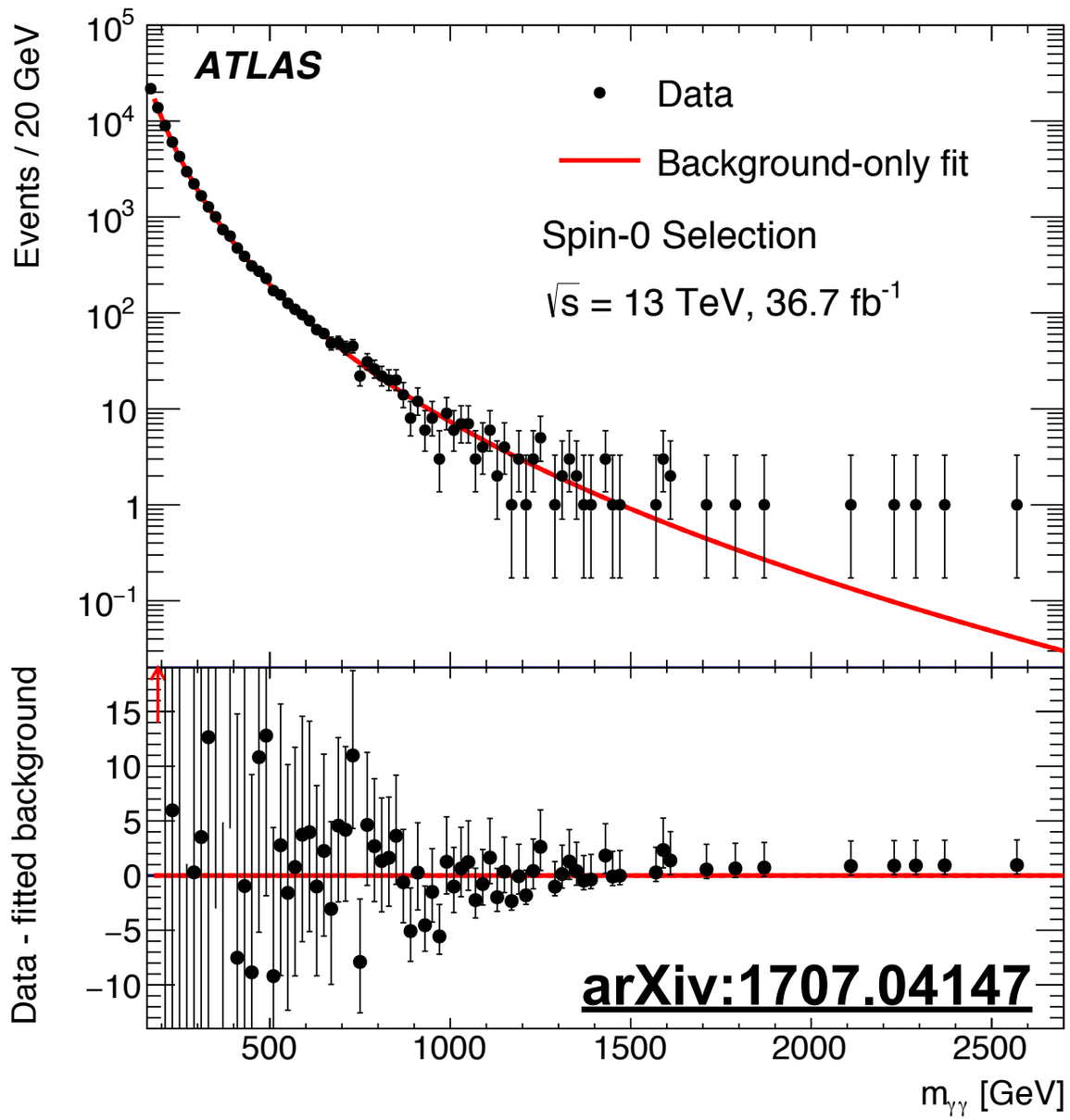
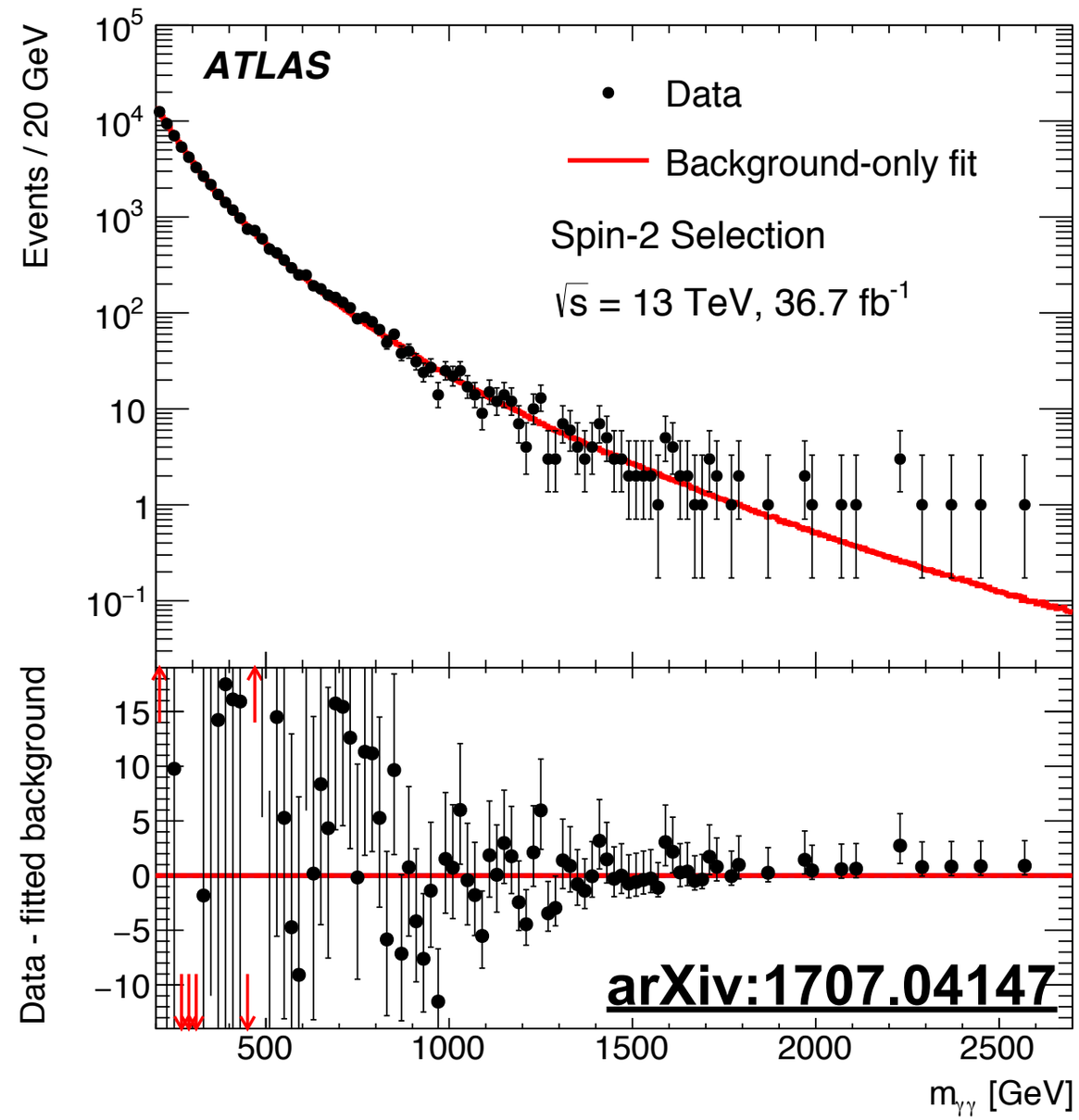
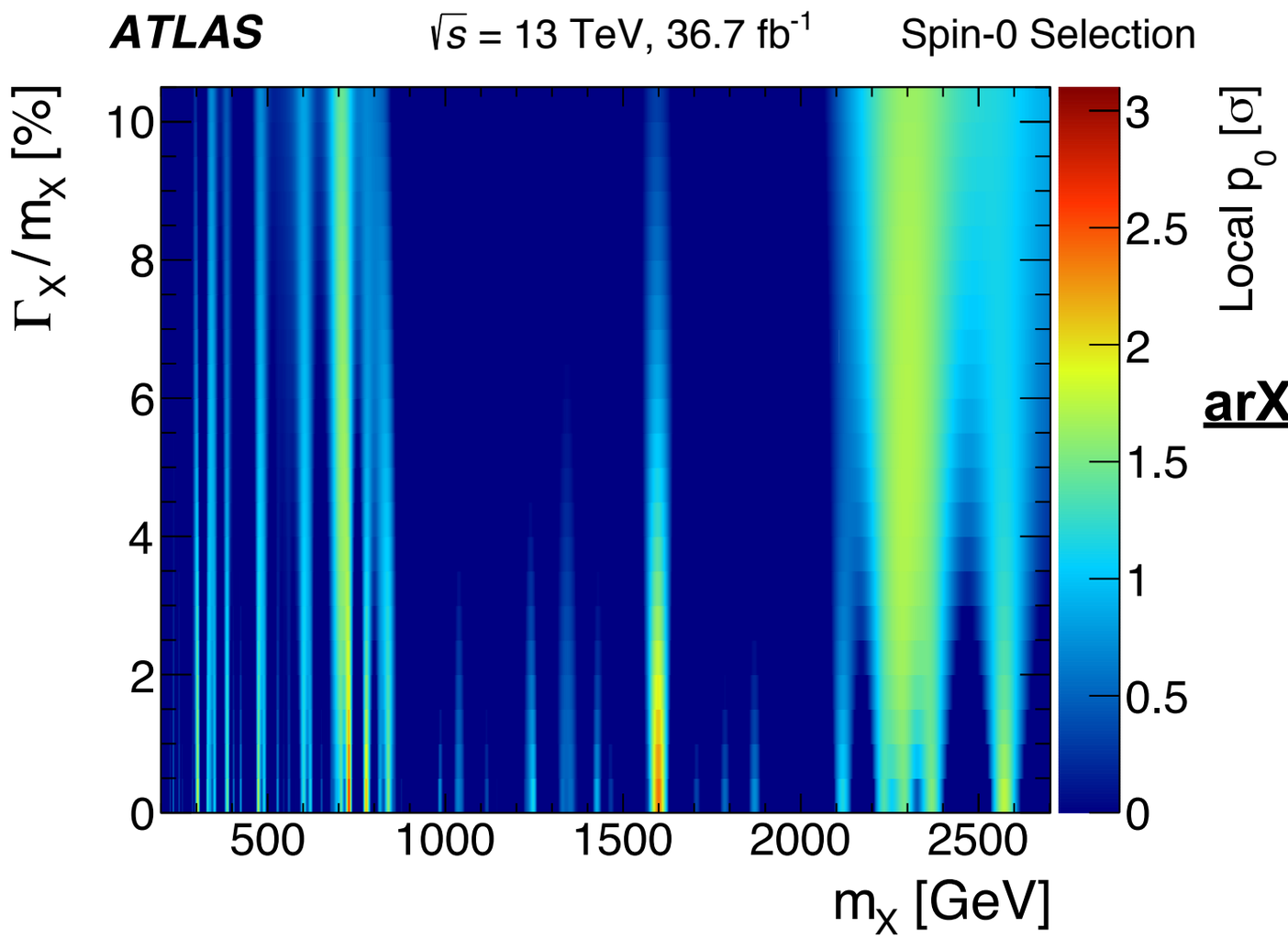
Fitted Invariant Mass





Observed Significance - Spin 0



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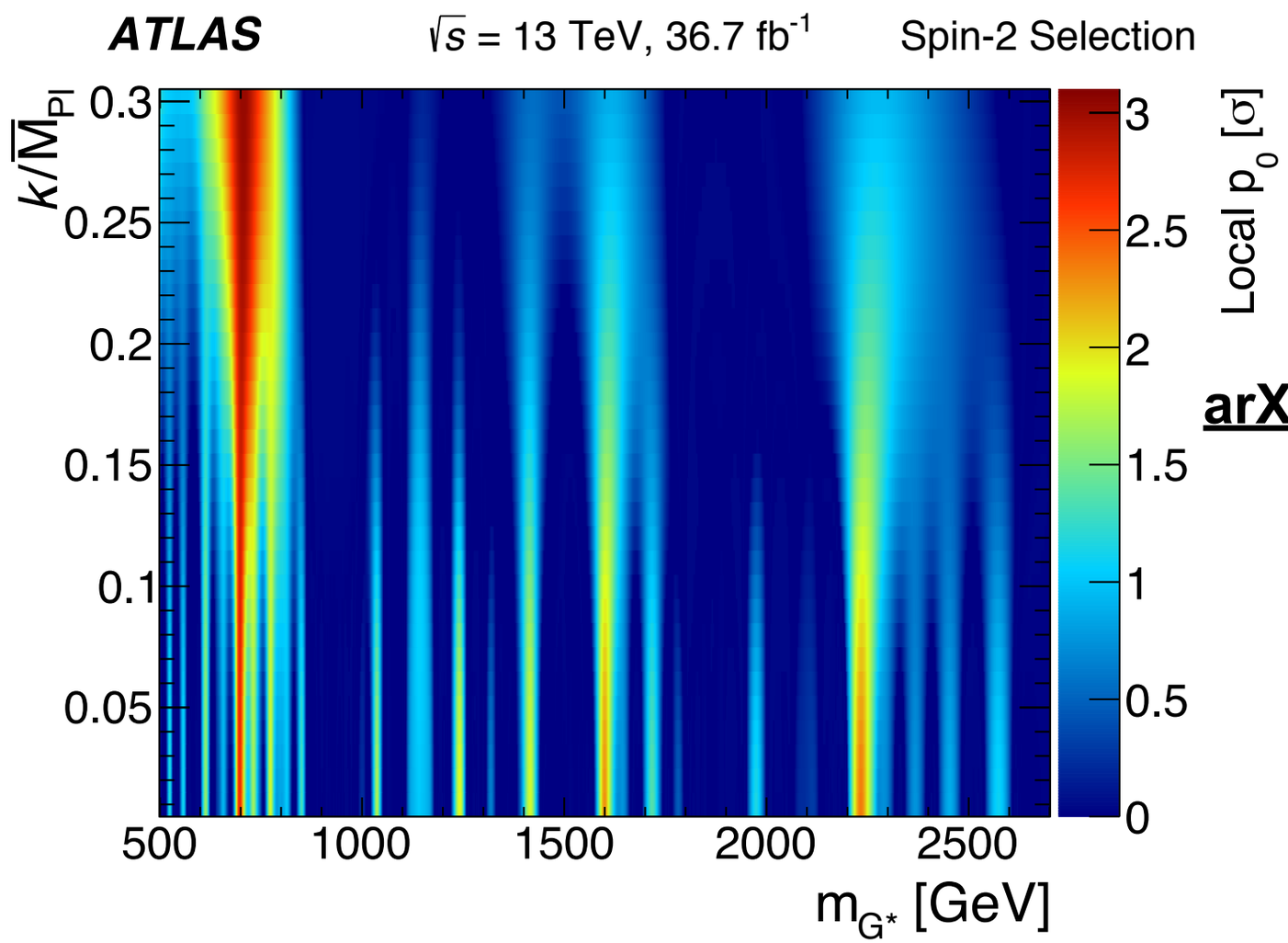
Largest Observed Significance $m_{\gamma\gamma}$ = [650,800 GeV]

Dataset	Local Significance	Global
2015	3.3σ, 736 GeV, 8%	-
2016	1.8σ, 780 GeV, NWA	-
15+16	2.6σ, 730 GeV, NWA	0.0σ, 730 GeV, NWA

Observed Significance - Spin 2

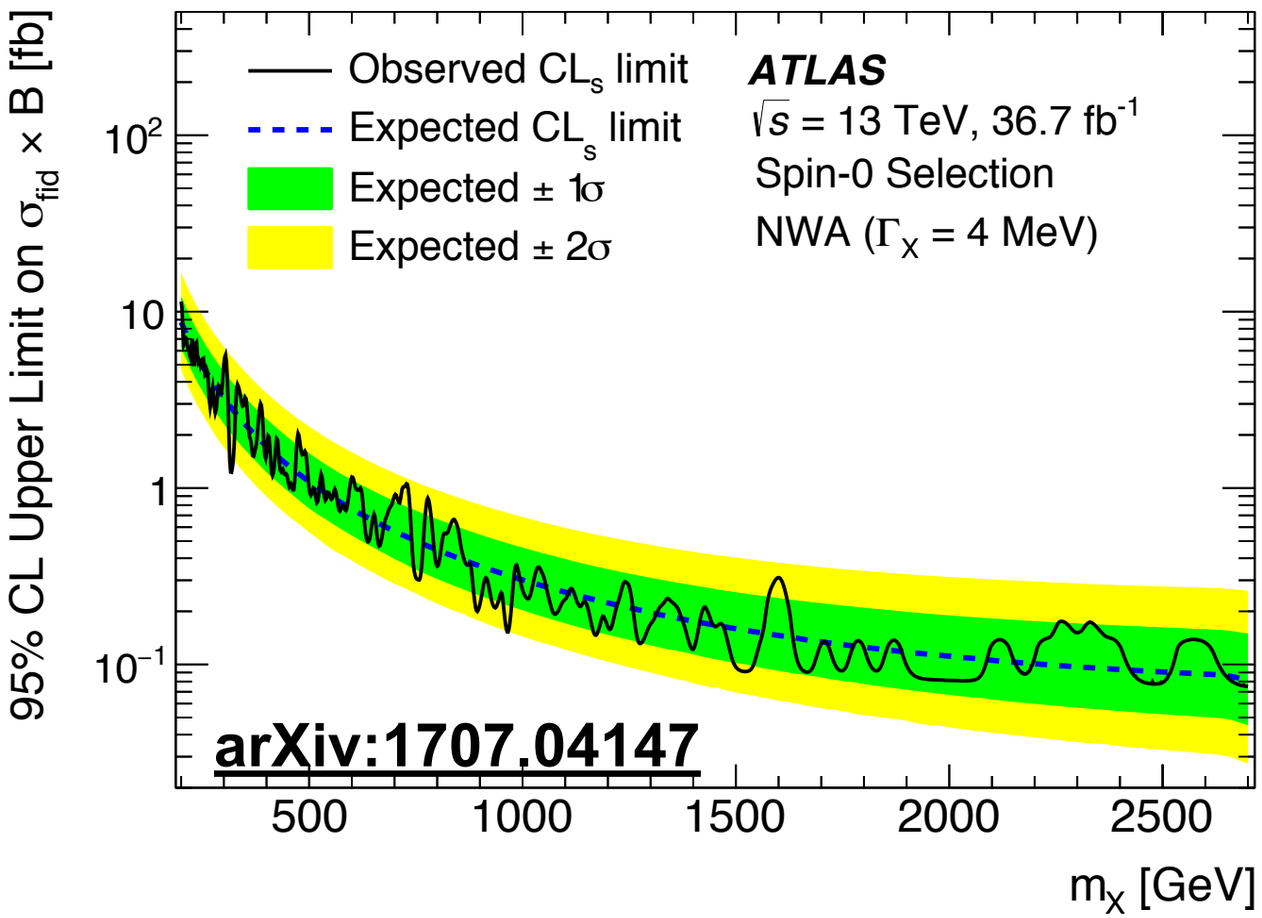


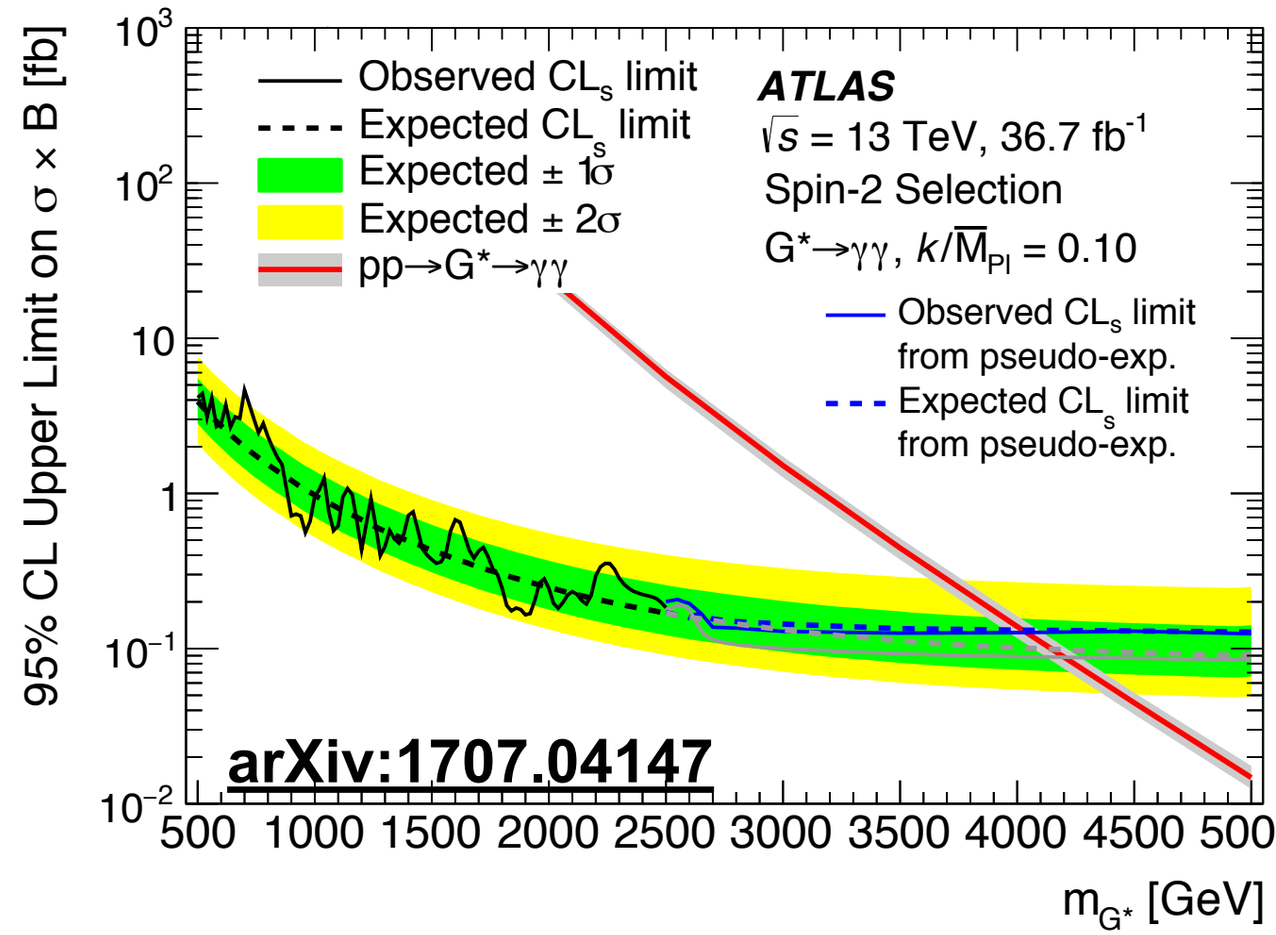
arXiv:1707.04147

Largest Observed Significance $m_{\gamma\gamma}$ = [650,800 GeV]

Dataset	Local Significance	Global
2015	3.2σ, 742 GeV, 0.28	-
2016	2.8σ, 698 GeV, 0.05	-
15+16	3.0σ, 708 GeV, 0.30	0.8σ, 708 GeV, 0.30

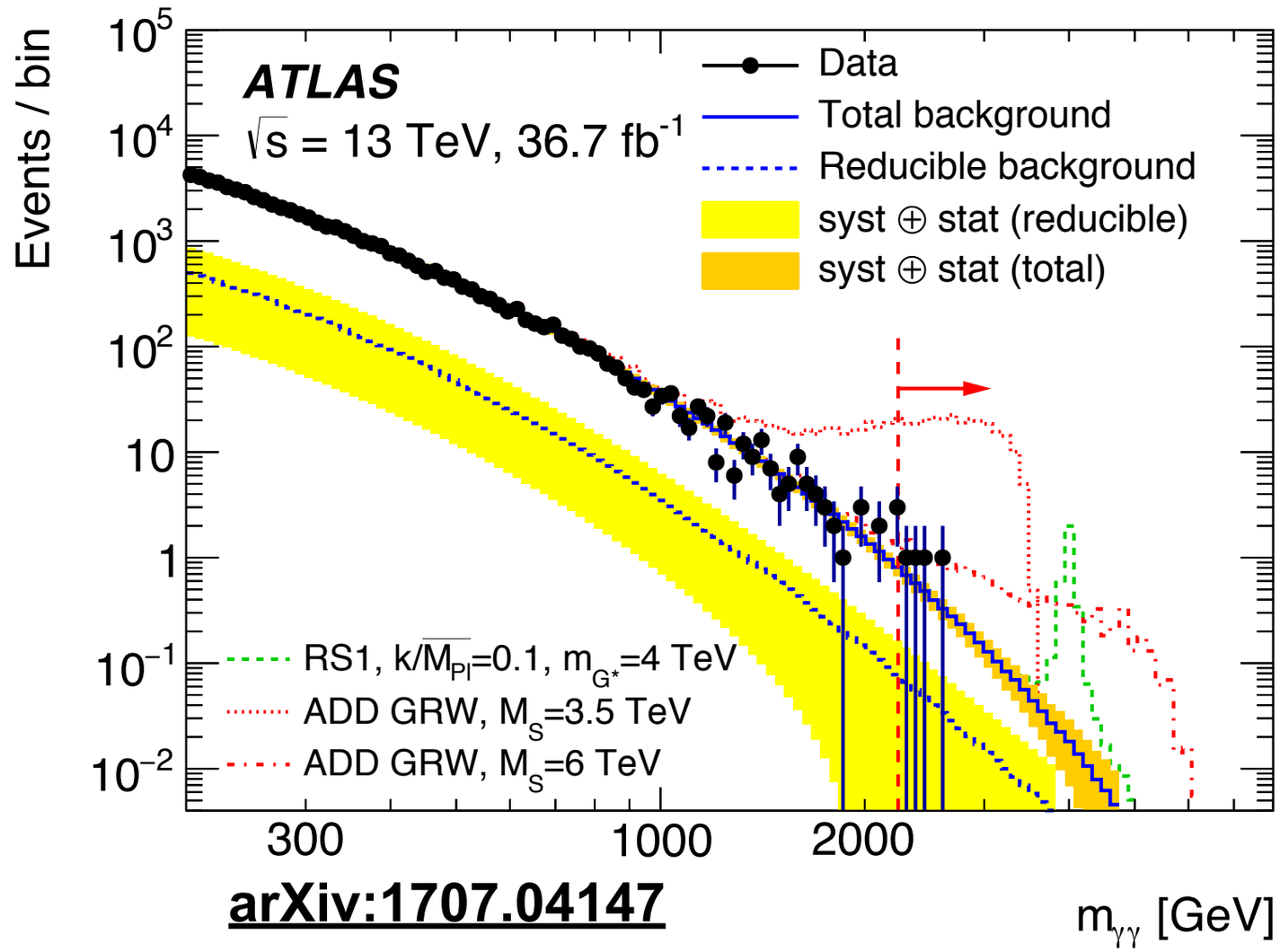
Results for resonances





- Spin-0 resonance limits
  - 11.4 fb at 200 GeV, 0.1 fb at 2700 GeV @ NWA
- Spin-2 resonance limits
  - 4.6 fb at 500 GeV, 0.1 fb at 500 GeV @ k/M_{Pl} = 0.1

Results for non-resonant search



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- Counting experiment implemented for $m_{\gamma\gamma} > 2.24$ TeV
- Observed: 4 events
- Expected: 4.3 ± 1.0
- Limits set on M_S from 5.7-8.1TeV

	ADD formalism Parameter	GRW	Hewett positive	HLZ $n=3$	HLZ $n=4$	HLZ $n=5$	HLZ $n=6$
Without K-factor	M_S observed limit [TeV]	6.8	6.1	8.1	6.8	6.1	5.7
With K-factor	M_S observed limit [TeV]	7.2	6.5	8.6	7.2	6.5	6.1

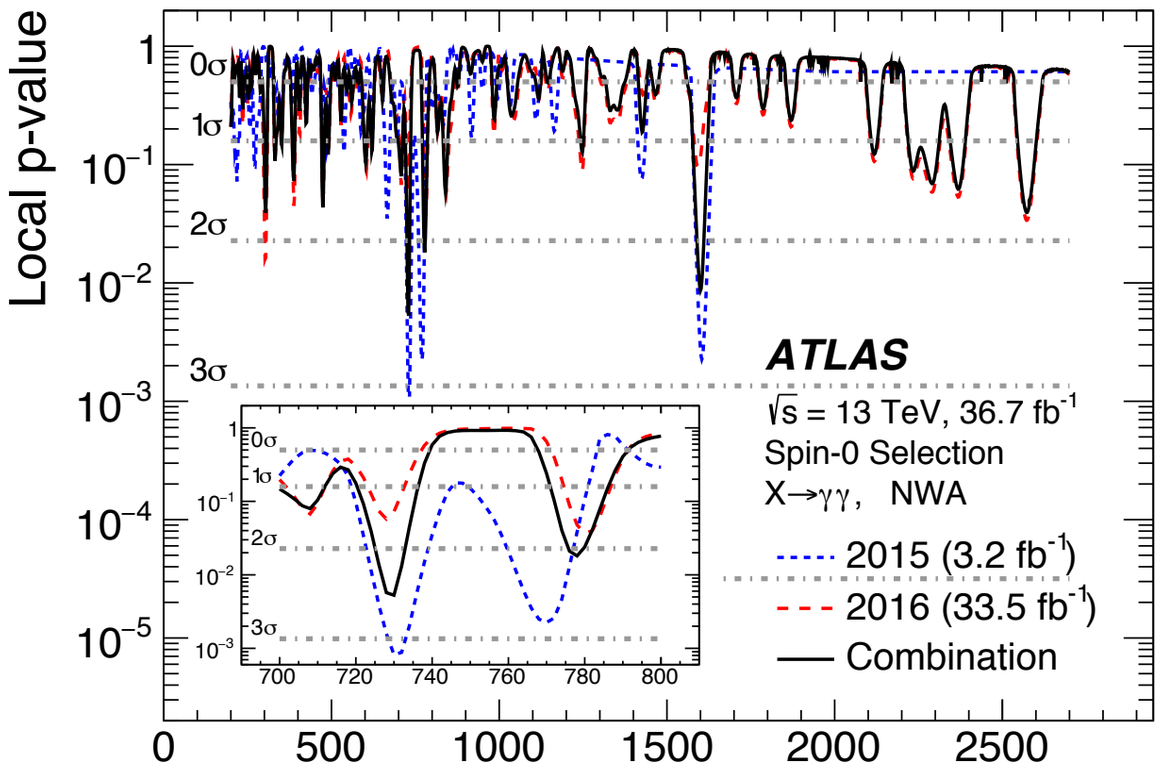
arXiv:1707.04147

Conclusion

- A search for high-mass phenomena in the diphoton channel was presented
- Observed significance is 2.6σ (3.0σ) for heavy Higgs (RS graviton) resonance search and globally found to be 0.0σ (0.8σ)
- Limits on ADD model are 5.7-8.6 TeV for ultraviolet cutoff scale M_S depending on the number of extra-dimensions
- Paper submitted to PLB (arXiv:1707.04147)

Thank you!

Observed Significance



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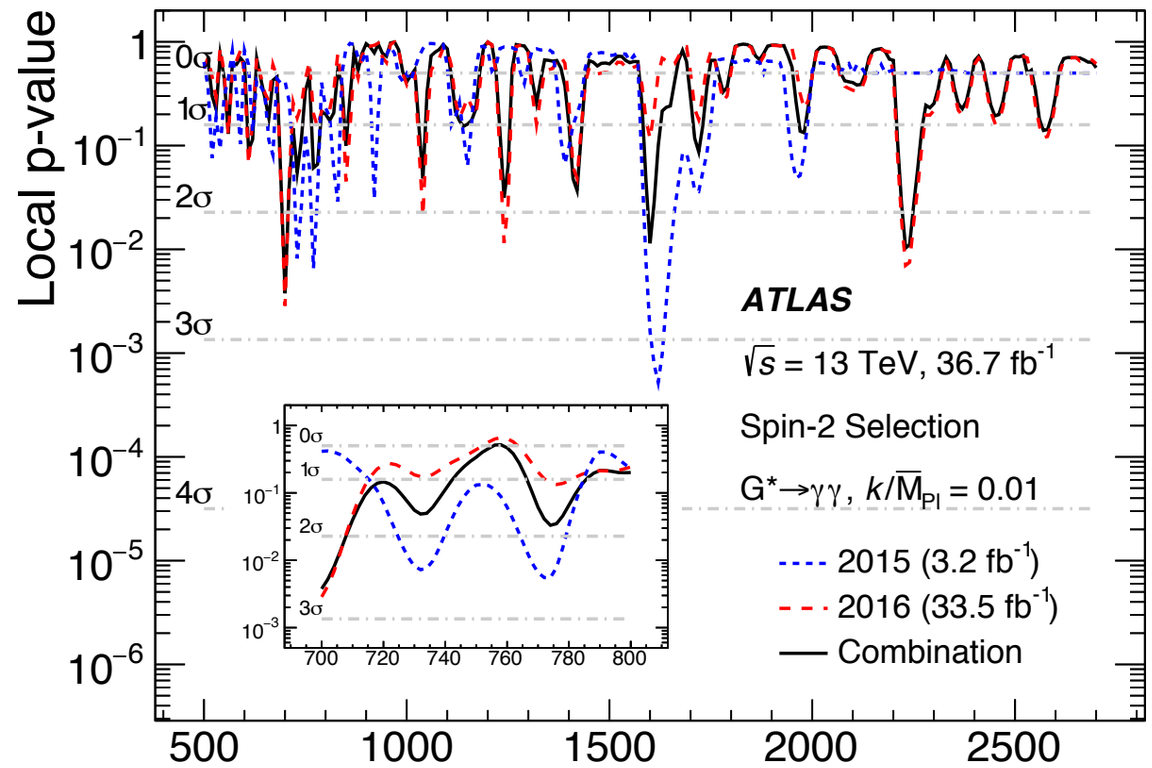

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- Observed significance for narrow width scenario in spin-0 and spin-2 resonance analysis
- Computed separately for 2015, 2016, and 15+16 datasets

Patron level isolation uncertainty

- Fit to low-mass sideband events in diphox
  - Uncertainty from fit used as systematic in background model for spin-2