Search for SUSY photonic signatures in 13 TeV pp collisions with the ATLAS detector

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A search for photonic signatures of various generalised models of gauge-mediated supersymmetry breaking is presented at proton–proton collisions at a centre-of-mass energy of 13 TeV. The results are based on 2015-2016 data recorded by the ATLAS detector at the LHC. Different experimental signatures incorporating one or more isolated photon and significant missing transverse momentum are explored.

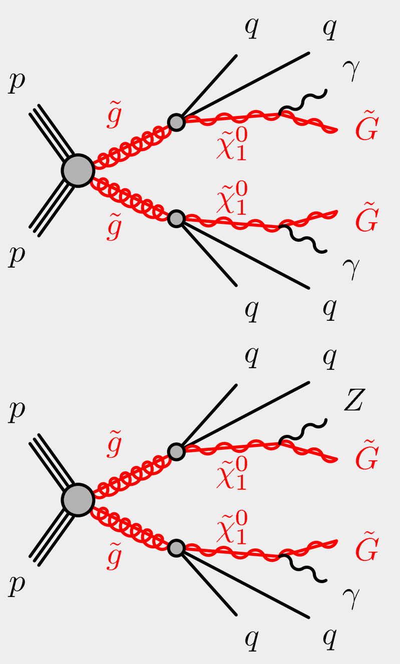
Phenomenology

The results are interpreted in the context of general gauge mediation (GGM) models.

- Lightest supersymmetric particle (LSP) $\Rightarrow$ ultra-light gravitino $\tilde{G}$.
- Next-to-lightest supersymmetric particle (NLSP) $\Rightarrow \tilde{\chi}_1^0$.

Scenarios:

- Diphoton + E_T^{miss}: Bino-like $\tilde{\chi}_1^0$ NLSP. Gluino and $\tilde{\chi}_1^0$ masses are free parameters.
- Photon + jets + E_T^{miss}: NLSP is bino-higgsino $\tilde{\chi}_1^0$ with 50/50 branching to $\gamma + \tilde{G}$ and $Z^0 + \tilde{G}$. Gluino and combined bino/higgsino mass parameters are free.



Event selection

	$\mathrm{SR}^{\gamma\gamma}$ (3.2fb^{-1})	$\mathrm{SR}_L^{\gamma j}$ (13.3fb^{-1})	$\mathrm{SR}_H^{\gamma j}$ (13.3fb^{-1})
N_{photons}	$= 2$	≥ 1	≥ 1
p_{T}^{γ}	> 75 GeV	> 145 GeV	> 400 GeV
N_{leptons}	—	0	0
N_{jets}	—	≥ 5	≥ 3
$\Delta\phi(\mathrm{jet}, E_T^{miss})$	> 0.5	> 0.4	> 0.4
$\Delta\phi(\gamma, E_T^{miss})$	—	> 0.4	> 0.4
E_T^{miss}	> 175 GeV	> 200 GeV	> 400 GeV
m_{eff}	> 1500 GeV	> 2000 GeV	> 2000 GeV
R_{T}^4	—	< 0.90	—

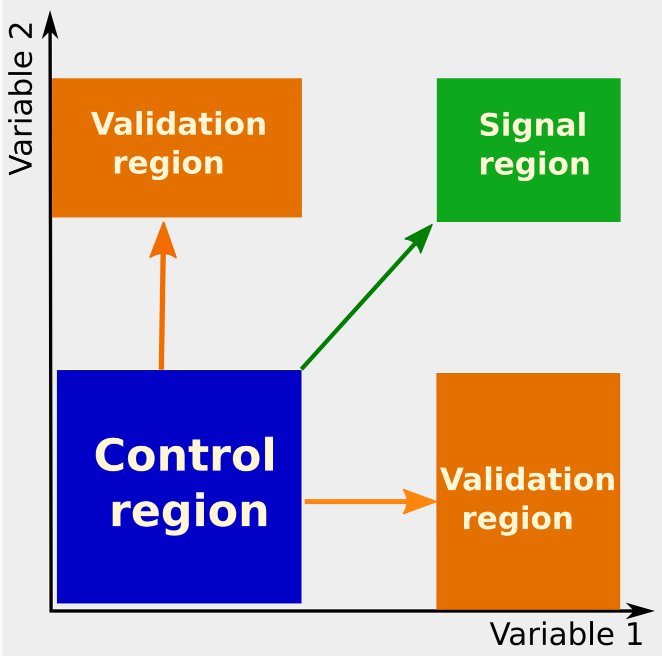
Diphoton+E_T^{miss} analysis optimized for the expected reach in $m_{\tilde{g}}$.
Two signal regions for γ + jets + E_T^{miss}:

- $\mathrm{SR_L}$ $m_{\tilde{g}} > m_{\tilde{\chi}_1^0} \Rightarrow$ large jet multiplicity and hadronic activity, but moderate E_T^{miss}.
- $\mathrm{SR_H}$ $m_{\tilde{g}} \gtrsim m_{\tilde{\chi}_1^0} \Rightarrow$ lower jet multiplicity and hadronic activity, while producing hard photons and high E_T^{miss} in final state.

Background estimation

Photon Category	Real E_T^{miss}	Instrumental E_T^{miss}
Real photon	$Z(\rightarrow \nu\nu)\gamma\gamma$, $W\gamma\gamma$	$\gamma\gamma$
Real photon for $\gamma + j + E_T^{miss}$ e/jet fakes for $\gamma\gamma + E_T^{miss}$	$Z(\rightarrow \nu\nu)\gamma$, $W\gamma$, $t\bar{t}\gamma$	γ+jets
e/jet fakes	W+jets, $Z(\rightarrow \nu\nu)$+jets $t\bar{t}$, dibosons	Multijet, $Z(\rightarrow ll)$+jets

Main contributions



Not perfect modeling in MC $\Rightarrow$ extract normalization from data in signal-free region.
For $W\gamma\gamma$, $W\gamma$, $t\bar{t}\gamma$ and γ+jets:

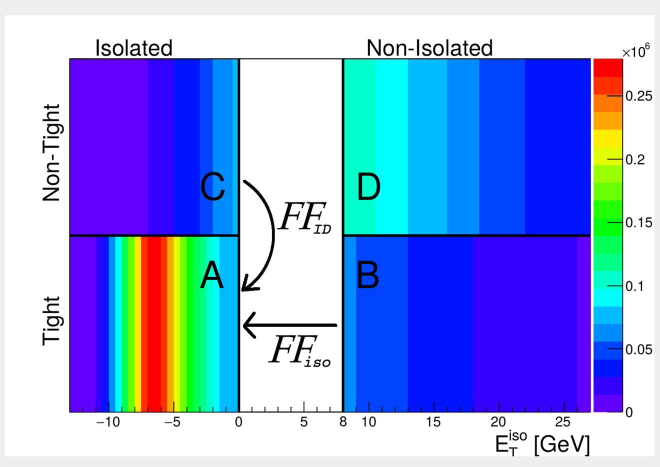
- High-purity control region (CRs).
  - simultaneous fit of MC to data $\Rightarrow$ normalization factors.
- Test extrapolation using validation regions (VRs).
- Predict yields in blinded signal regions (SRs).

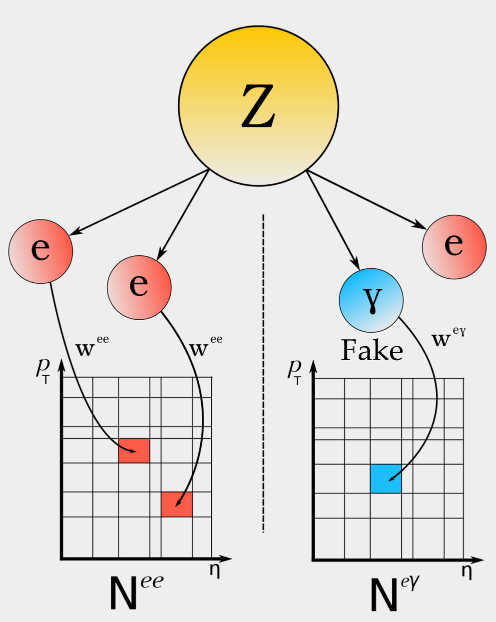
Fake-photon backgrounds were estimated using data-driven methods:

Number of jets faking photons in region A:

$$N_A^{j\rightarrow\gamma} = \frac{(N_C - N_C^{leak})}{(N_D - N_D^{leak})} \times (N_B - N_B^{leak})$$

Signal leakage in the control regions obtained from MC .





Number of electron faking photons based on a sample of $Z \rightarrow ee/e\gamma_{fake}$.

- Electron-to-photon misidentification rate:

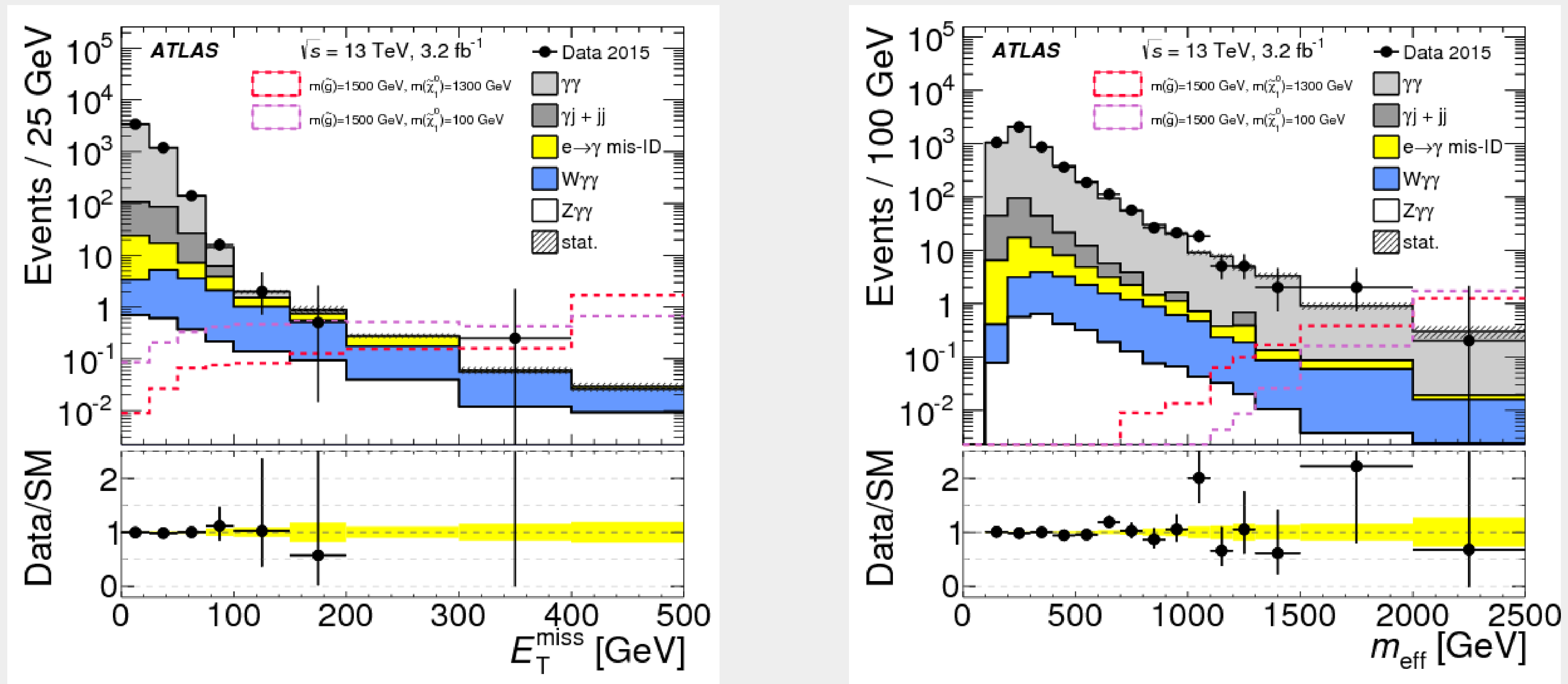
$$F_{e\rightarrow\gamma}(p_T, \eta) = \frac{N^{e\gamma}(p_T, \eta)}{N^{ee}(p_T, \eta)}$$

Background obtained with:

$$N_{e\rightarrow\gamma}(p_T, \eta, ...) = F_{e\rightarrow\gamma}(p_T, \eta) \times N_e(p_T, \eta, ...)$$

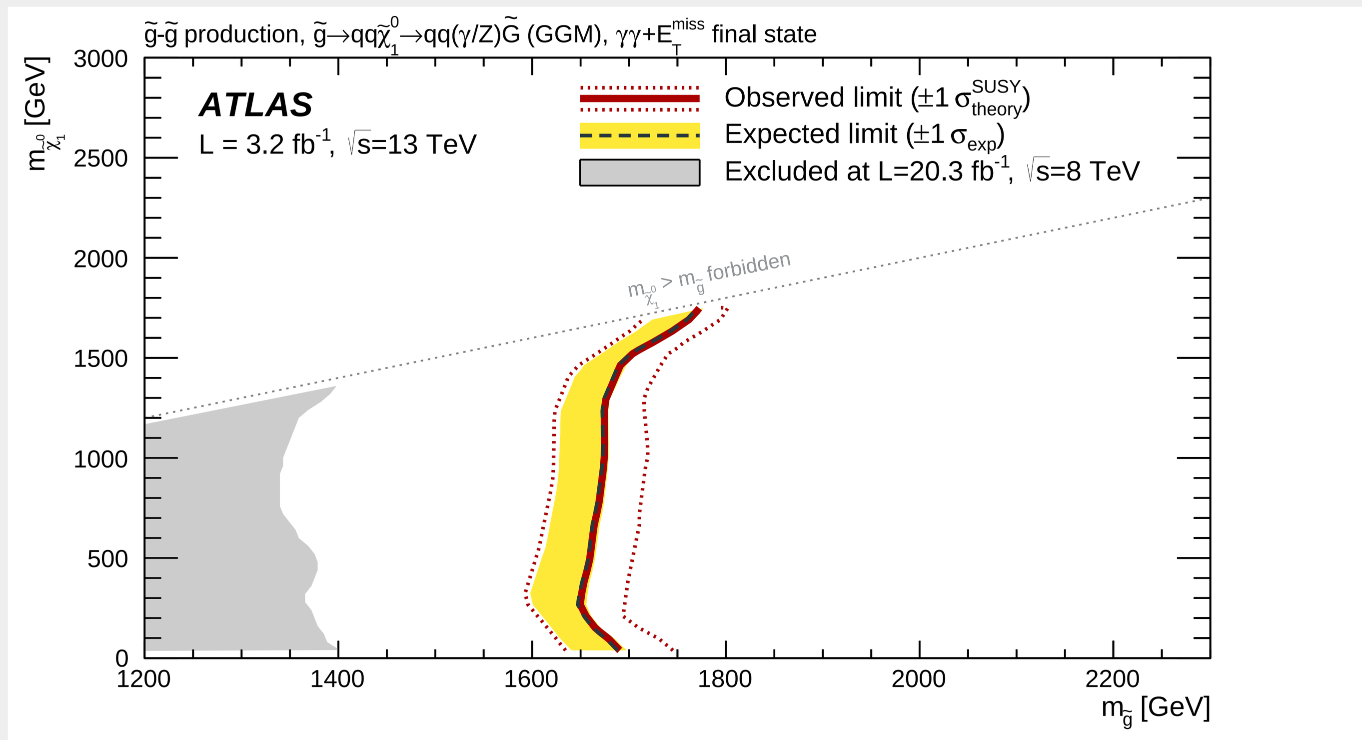
N^e: Number of events in a region with an electron instead of a photon.

Diphoton+E_T^{miss} results (3.2 fb^{-1})



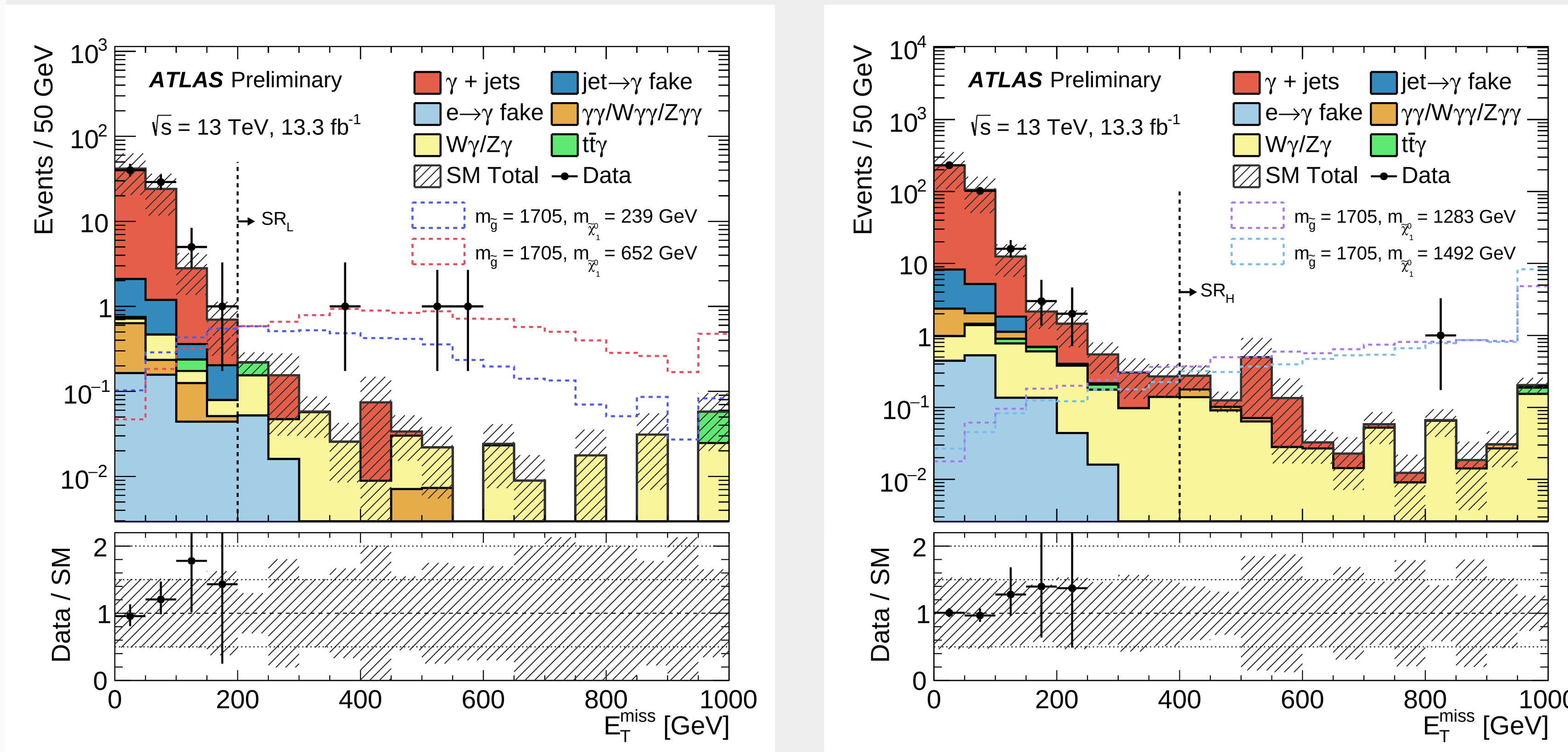
Source	Number of events
QCD ($\gamma\gamma$, γj, jj)	$0.05^{+0.20}_{-0.05}$
$e \rightarrow \gamma$ fakes	0.03 ± 0.02
$W\gamma\gamma$	0.17 ± 0.08
$Z\gamma\gamma$	0.02 ± 0.02
Sum	$0.27^{+0.22}_{-0.10}$
Observed events	0

	$\langle\epsilon\sigma\rangle_{\mathrm{obs}}^{95}$[fb]	S_{obs}^{95}
$\mathrm{SR}^{\gamma\gamma}$	0.93	3.0



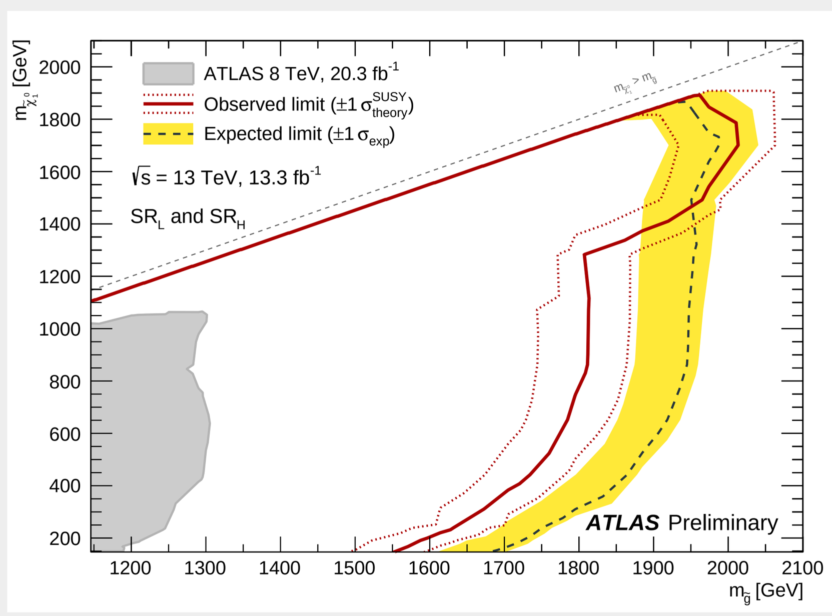
Gluino mass limits in the range of 1650-1750 GeV, roughly independent of neutralino mass.

Photon+jets+E_T^{miss} results (13.3 fb^{-1})



	$\langle\epsilon\sigma\rangle_{\mathrm{obs}}^{95}$[fb]	S_{obs}^{95}	S_{exp}^{95}	CL_B	$p(s=0)$ (Z)
$\mathrm{SR}_L^{\gamma j}$	0.48	6.4	$3.7^{+1.2}_{-0.2}$	0.97	0.02 (2.01)
$\mathrm{SR}_H^{\gamma j}$	0.28	3.7	$4.4^{+0.9}_{-0.9}$	0.34	0.65 (−0.39)

Signal Region	$\mathrm{SR}_L^{\gamma j}$	$\mathrm{SR}_H^{\gamma j}$
Observed events	3	1
Expected SM events	0.78 ± 0.18	1.49 ± 0.45
γ + jets	0.18 ± 0.11	0.70 ± 0.24
$W\gamma$	0.30 ± 0.07	0.37 ± 0.09
$Z\gamma$	0.08 ± 0.08	0.32 ± 0.32
$t\bar{t}\gamma$	0.10 ± 0.04	0.03 ± 0.01
$e \rightarrow \gamma$ fakes	0.07 ± 0.03	0.00 ± 0.00
jet $\rightarrow \gamma$ fakes	0.04 ± 0.01	0.00 ± 0.00
$\gamma\gamma$, $W\gamma\gamma$, $Z\gamma\gamma$	0.01 ± 0.00	0.07 ± 0.01



Lower limit set on the mass of gluino state of 1800 GeV for large range of neutralino masses, increasing to 2000 GeV in the case of high mass neutralino.

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