A glimpse at $W W \gamma$ and $W Z \gamma$ with ATLAS

On arXiv soon!

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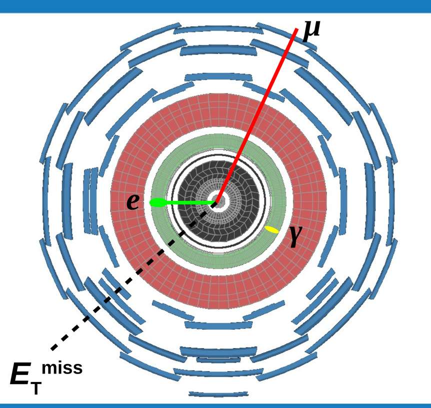
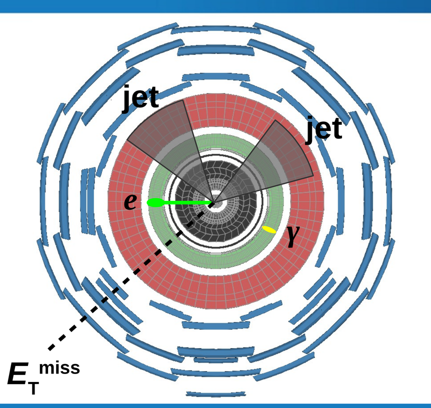
3 final states:

- $e\nu\mu\nu\gamma$
- $e\nu jj\gamma$
- $\mu\nu jj\gamma$



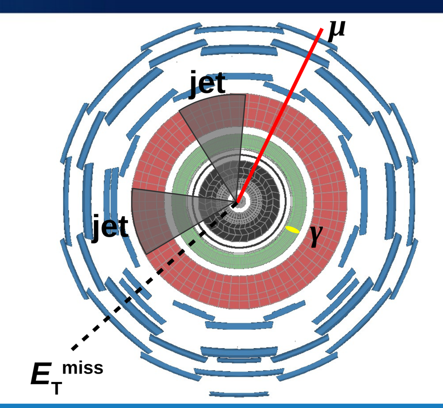
$e\nu\mu\nu\gamma$:

- 1 e and 1 μ, p_T > 20 GeV
- ≥ 1 γ, E_T > 15 GeV
- No jets, p_T > 25 GeV
- $E_T^{miss,rel}$ > 15 GeV
- m_{ll} > 50 GeV



$e\nu jj\gamma$ and $\mu\nu jj\gamma$:

- 1 e or 1 μ, p_T > 25 GeV
- ≥ 1 γ, E_T > 15 GeV
- ≥ 2 jets, no b-jets, p_T > 25 GeV,
- E_T^{miss} > 30 GeV, m_T > 50 GeV
- 70 GeV < m_{jj} < 100 GeV



Triboson production at ATLAS

Includes quartic gauge vertices
→ Measurement tests non-Abelian structure

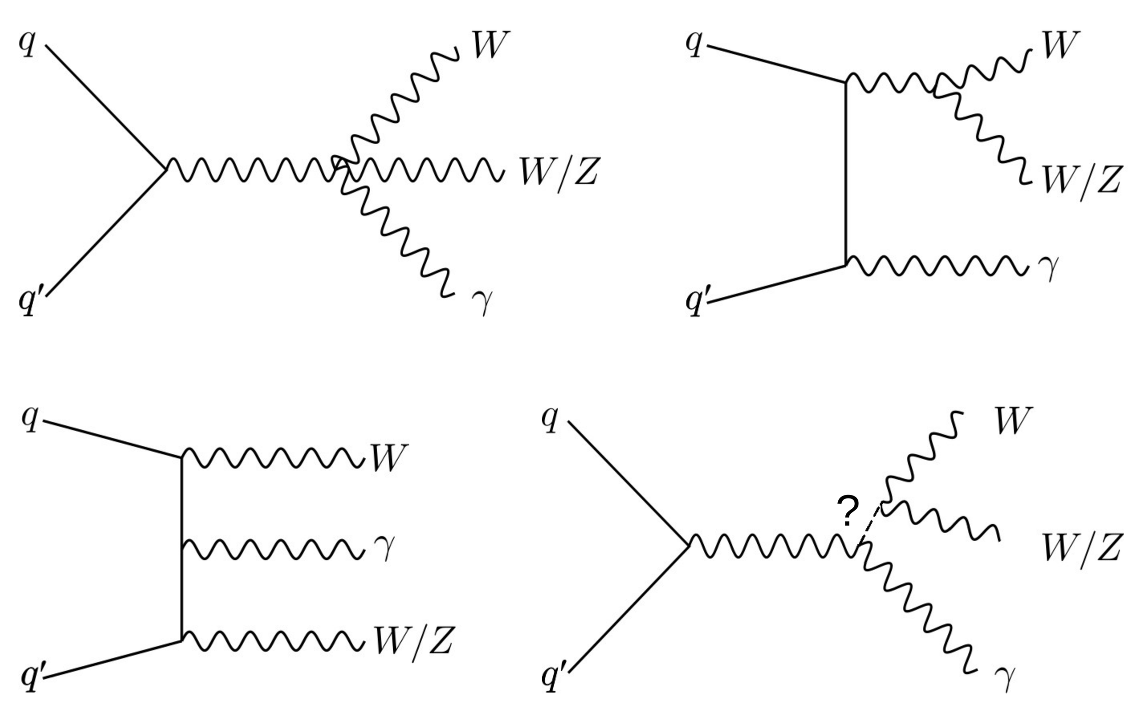
Determined by the Standard Model
→ Sensitive to new physical phenomena

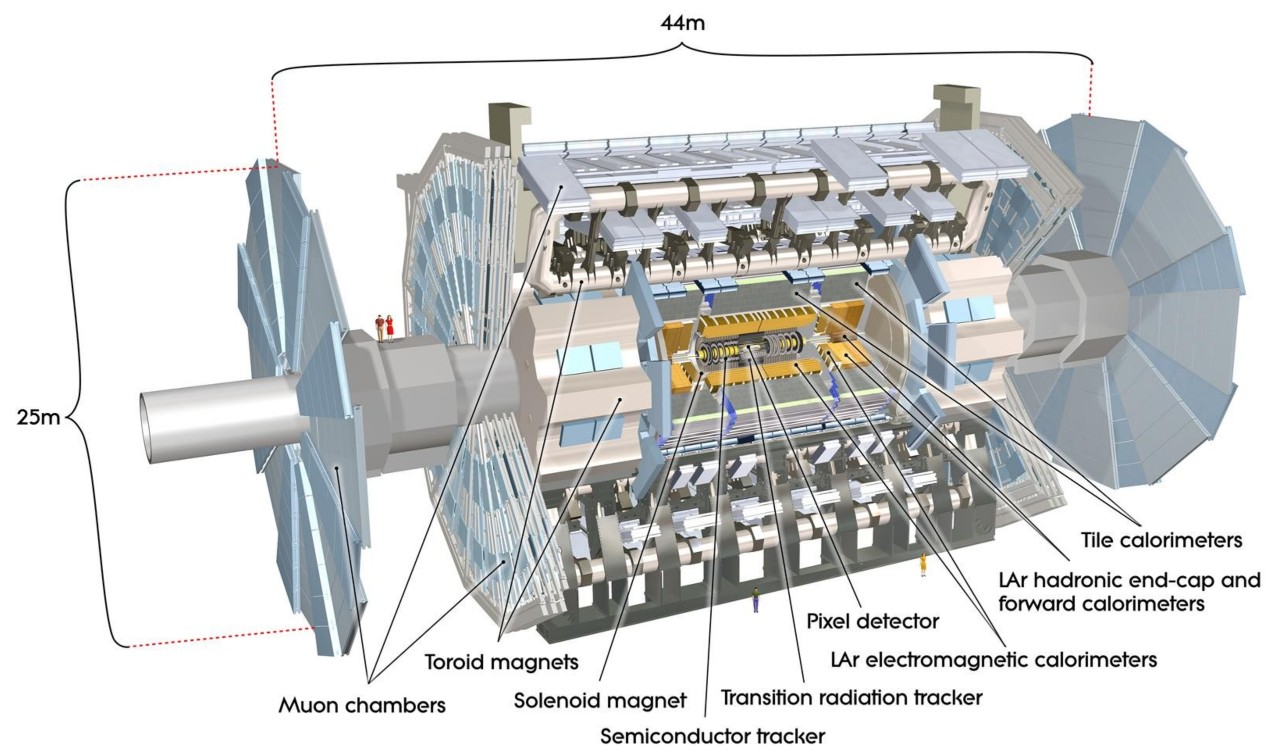
Low production cross-section
→ Need efficient selection criteria to isolate signal

Analysed fully- and semi-leptonic final states
→ $e\nu\mu\nu\gamma$, $e\nu jj\gamma$, $\mu\nu jj\gamma$ using 20.2 fb^{-1} of 8 TeV pp data

Other ATLAS and CMS measurements:
→ $WV\gamma$ (V = hadronically decaying W or Z) [1], $W\gamma\gamma$ [2,3], $Z\gamma\gamma$ [3,4], WWW [5]

Production examples:





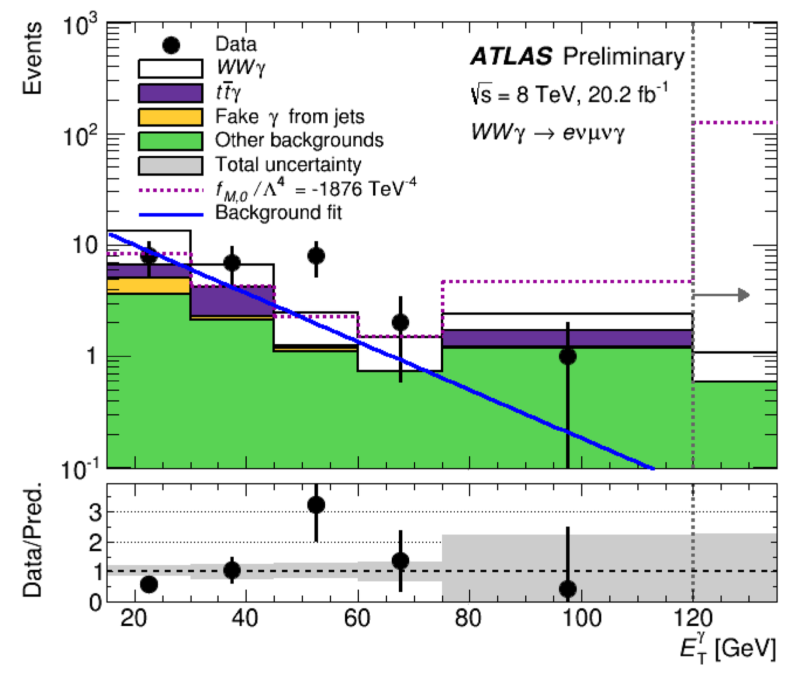
Results

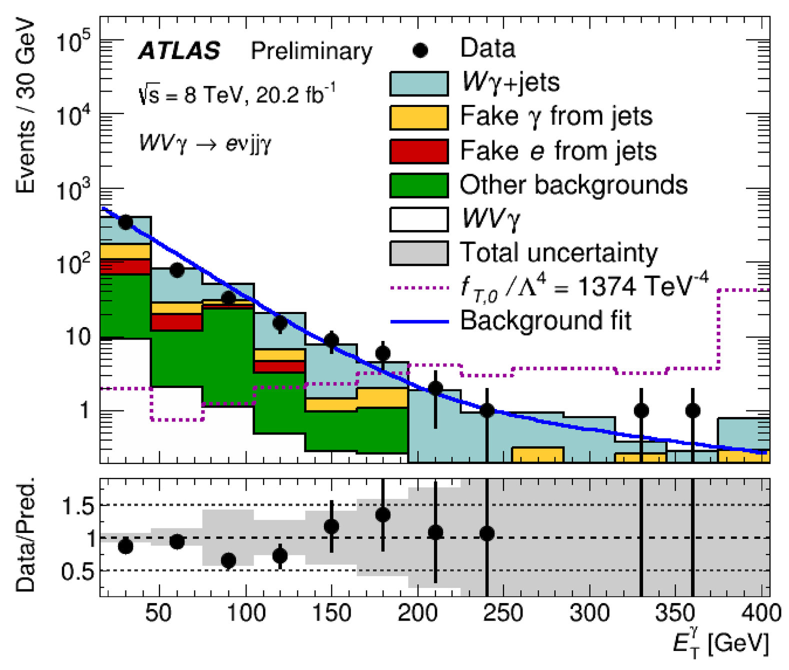
$e\nu\mu\nu\gamma$ production cross-section

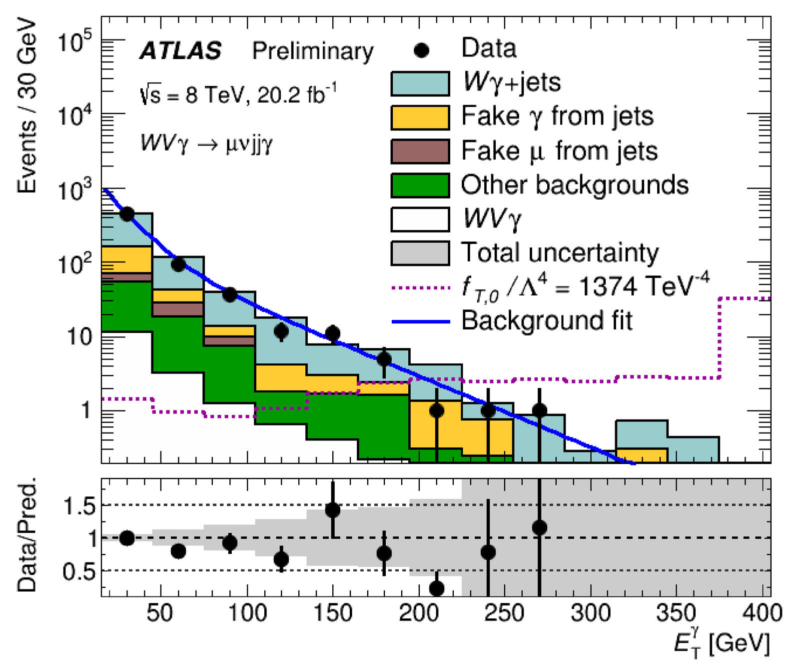
$$\sigma_{fid.}^{e\nu\mu\nu\gamma} = (1.5 \pm 0.9(\text{stat.}) \pm 0.5(\text{syst.}))\,\text{fb}$$

with 1.4σ significance (1.6σ expected)

→ Agreement with NLO prediction
VBFNLO: $\sigma_{theo.}^{e\nu\mu\nu\gamma} = (2.0 \pm 0.1)\,\text{fb}$







Upper exclusion limits on $e\nu jj\gamma$, $\mu\nu jj\gamma$ and $l\nu jj\gamma$ production cross-section

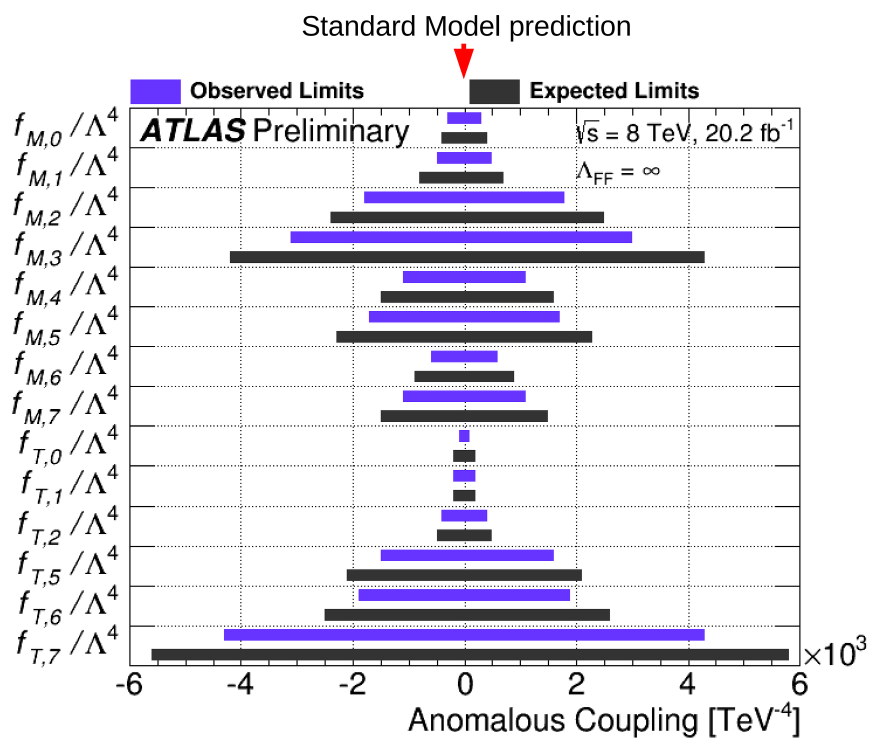
→ As low as 2.5 x Standard Model cross-section

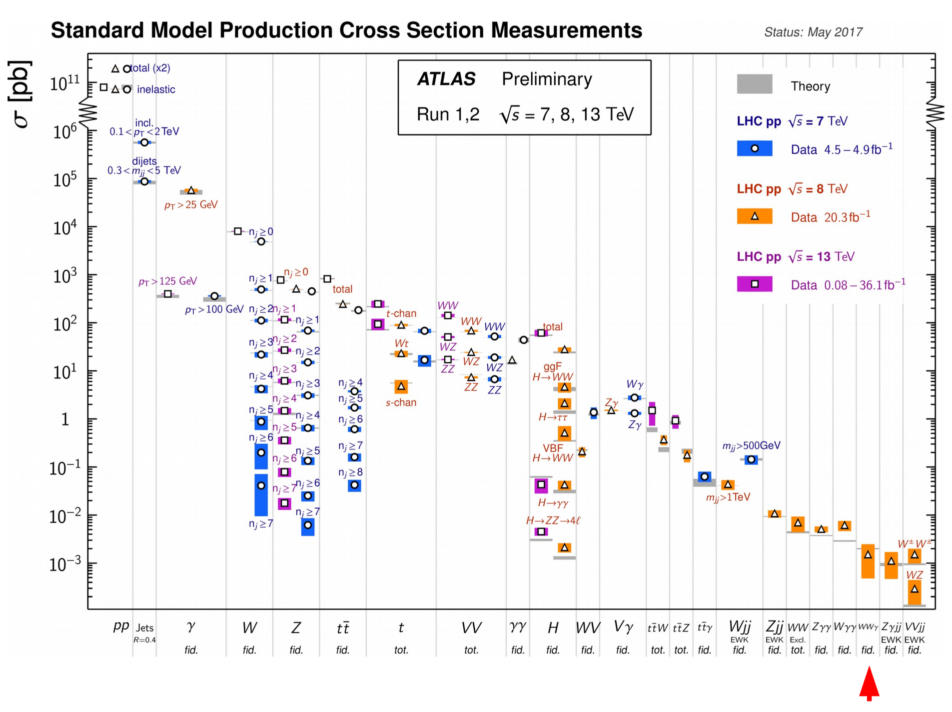
Interpretation using effective field theory:

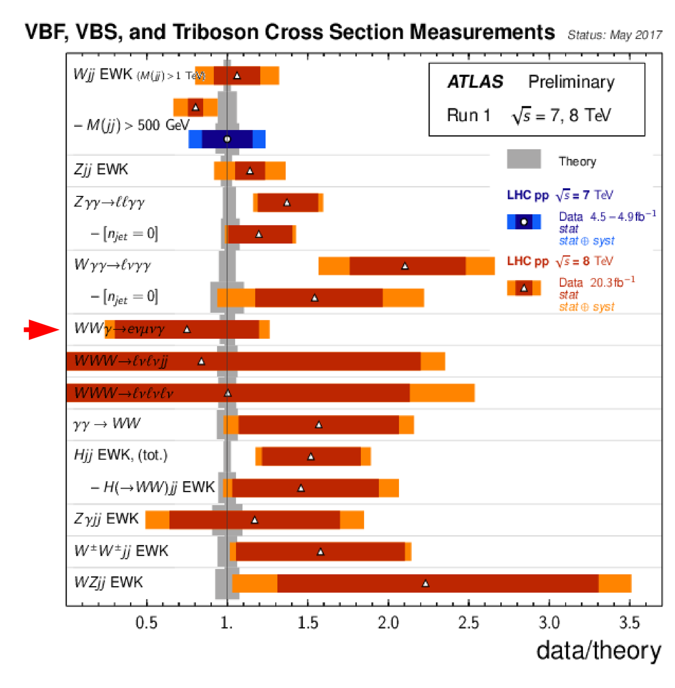
$$\mathcal{L}_{\text{eff}} = \mathcal{L}_{\text{SM}} + \sum_{j=0}^{7} \frac{f_{M,j}}{\Lambda^4} O_{M,j} + \sum_{j=0,1,2,5,6,7} \frac{f_{T,j}}{\Lambda^4} O_{T,j},$$

with operators of dimension eight and dipole form factor: $(1+\hat{s}/\Lambda_{FF}^2)^{-2}$ with form factors scale Λ_{FF}

→ Limits on 14 anomalous quartic coupling parameters unitarised (Λ_{FF} = 0.5 and 1 TeV) and non-unitarised (Λ_{FF} = ∞)







Background Estimation

Main challenge: Background from misidentified objects
→ Contribute due to low cross-section of signal process

$e\nu\mu\nu\gamma$ final state

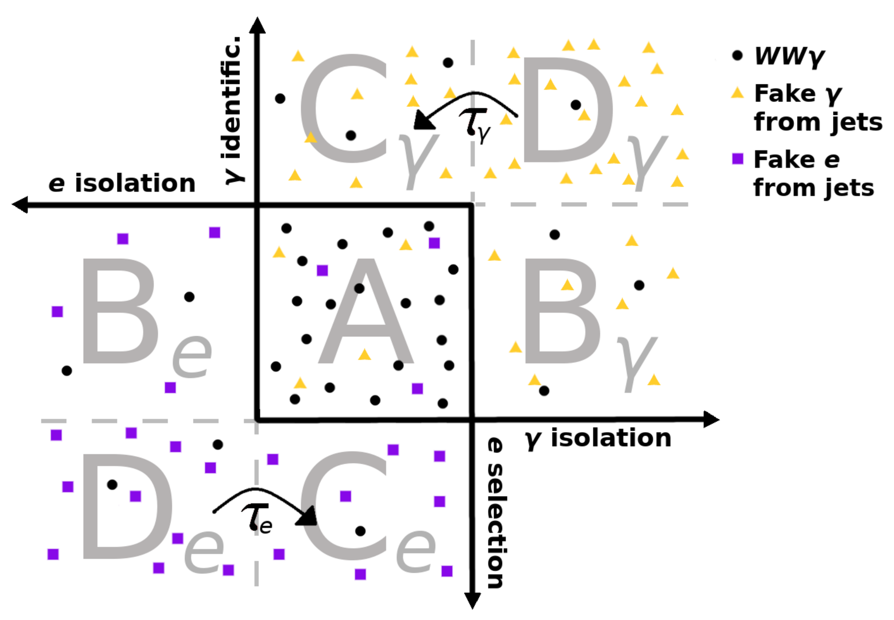
From data:

- Fake γ from e estimated using $Z \to ee$ decays
- Fake γ and fake e from jets estimated simultaneously using two 2D sideband methods:

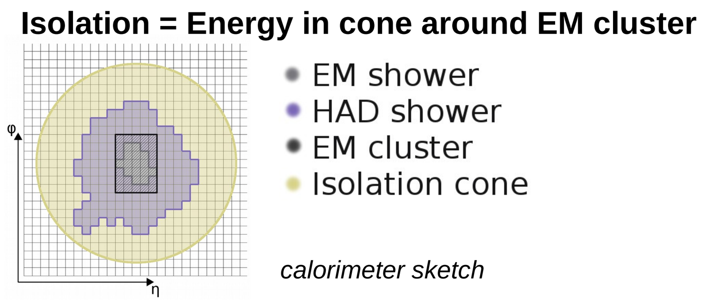
Sidebands defined by object isolation energy, photon identification criteria and electron-jet event selection. Background estimation combined using likelihood formulation.

From Monte Carlo:

- $tt\gamma$, $Z\gamma$, $WZ\gamma$, $WW\gamma$ (τ decays), Wt, ZZ, fake μ from jets using the MadGraph, SHERPA and POWHEG-BOX generators



Isolation = Energy in cone around EM cluster



$e\nu jj\gamma$ and $\mu\nu jj\gamma$ final states

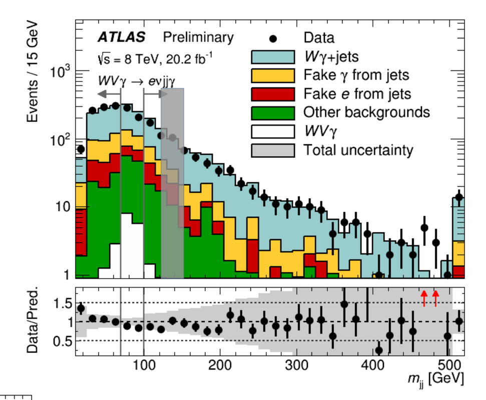
From data:

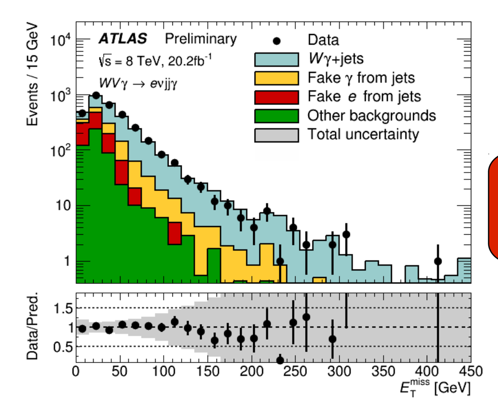
- Fake γ from e estimated using $Z \to ee$ decays
- $W\gamma$+jets, fake γ and fake leptons from jets estimated simultaneously by combining m_{jj} fit, E_T^{miss} fit and 2D sideband method with inverted m_{jj} requirement:

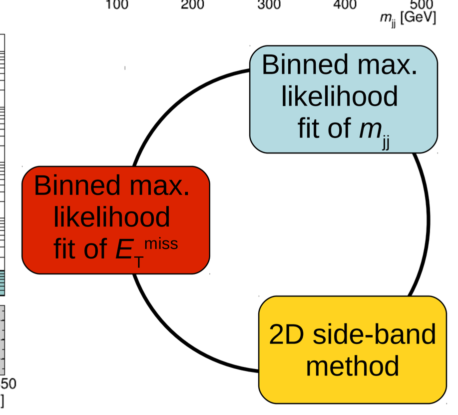
2D sideband method as done for $e\nu\mu\nu\gamma$ final state. Maximum likelihood fits use shape templates from simulation for all backgrounds apart from fake γ and fake leptons from jets shape templates that are obtained from data.

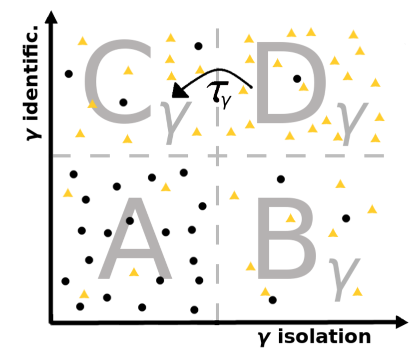
From Monte Carlo:

- $tt\gamma$, $Z\gamma$+jets, $WV\gamma$ (τ decays) using the MadGraph and SHERPA generators









References:
[1] CMS Collaboration, Phys. Rev. D 90 (2014) 032008.
[2] ATLAS Collaboration, Phys. Rev. Lett. 115 (2015) 031802.
[3] CMS Collaboration, arXiv: 1704.00366 [hep-ex], submitted to JHEP.
[4] ATLAS Collaboration, Phys. Rev. D 93 (2016) 112002.
[5] ATLAS Collaboration, Eur. Phys. J. C 77 (2016) 141.

ATLAS EXPERIMENT