Università di Roma Tor Vergata

INFN Sezione di Roma Tor Vergata

Dark Matter searches with the ATLAS experiment at the LHC

Marco Vanadia
Tor Vergata University of Rome and INFN

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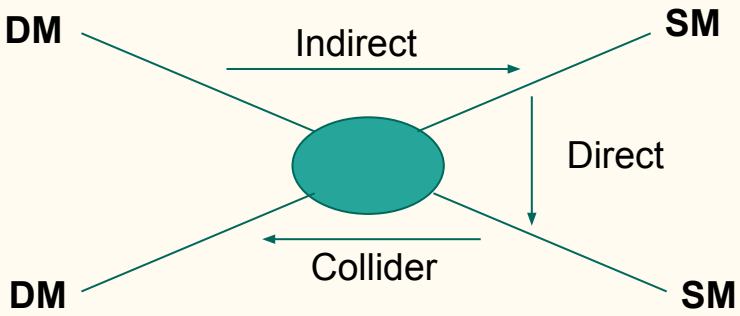
ATLAS EXPERIMENT

Introduction

- Overwhelming astrophysical evidence for **Dark Matter** (DM) in our Universe
  - DM accounts for **~26% of the Universe content**
- Ok, so what is DM?
  - **gravitationally interacting** matter
  - huge number of candidates
- I'll focus on the **WIMP** paradigm (weakly interacting massive particles)
  - several nice features, weak cross section -> correct relic abundance, stable, cold
  - excellent interplay between **indirect**, **direct** and **collider** searches

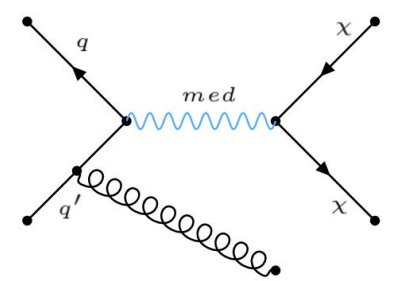


Overview on DM searches in ATLAS

DM benchmarks for run-2: EFT -> Simplified Models (see arxiv:1507.00966, 1603.04156)

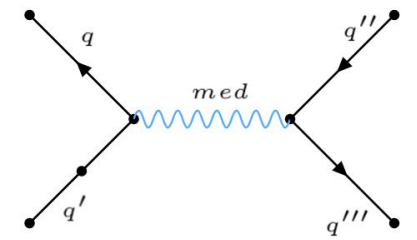
Mono-x searches

- Jet+X
- Photon+X
- H+X
- W+X
- Z+X
- ℓℓ+X
- tt+X
- bb+X
- ...



Di-x searches

- Di-jet
- Di-jet @ trigger level
- Di-jet + ISR
- Di-b-jet
- ...



Other DM-related searches

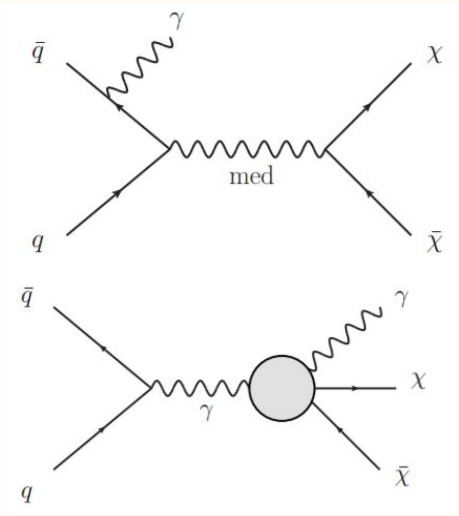
- Long-lived particles...
- BSM Higgs, Higgs->invisible...
- More exotics results...

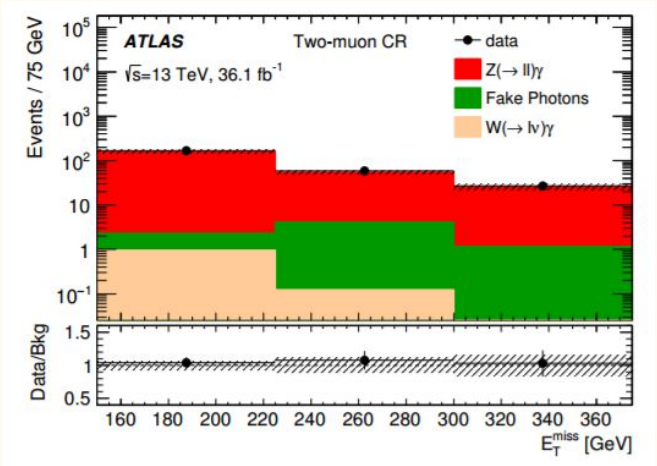
In this talk I'll focus on very recent ATLAS results on full 2015+2016 dataset:

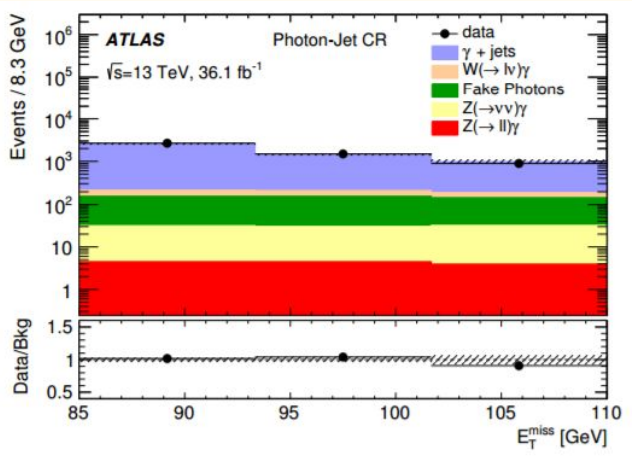
- Photon+X arXiv: arXiv:1703.09127
- Di-jet arXiv:1703.09127
- H(->bb)+X conf-note ATLAS-CONF-2017-028 and H(->γγ)+X ATLAS-CONF-2017-024

$\gamma + X$ **NEW**, 36/fb arXiv:1703.09127

- **>=1 isolated photon** and $\mathbf{E_T^{miss}}$
- **3** $\mathbf{E_T^{miss}}$ **regions**: 150-225, 225-300, >300 GeV
- **Z** and **W** bkg from control regions (**CRs**) with **leptons**
- **Fake photons from electrons** from Z->eγ/Z->ee
- **Fake photons from jets** with ABCD method, CRs with inverted isolation/inverted quality cuts
- **γ+jet** with a **wrong jet reconstruction:** low E_T^{miss} **CR**



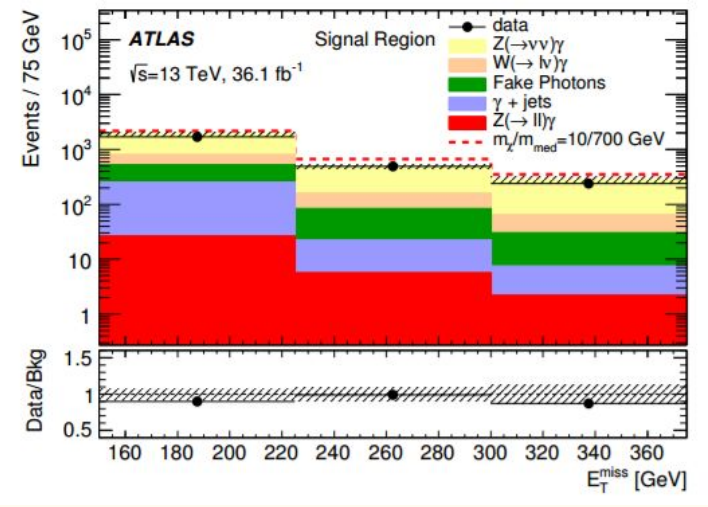


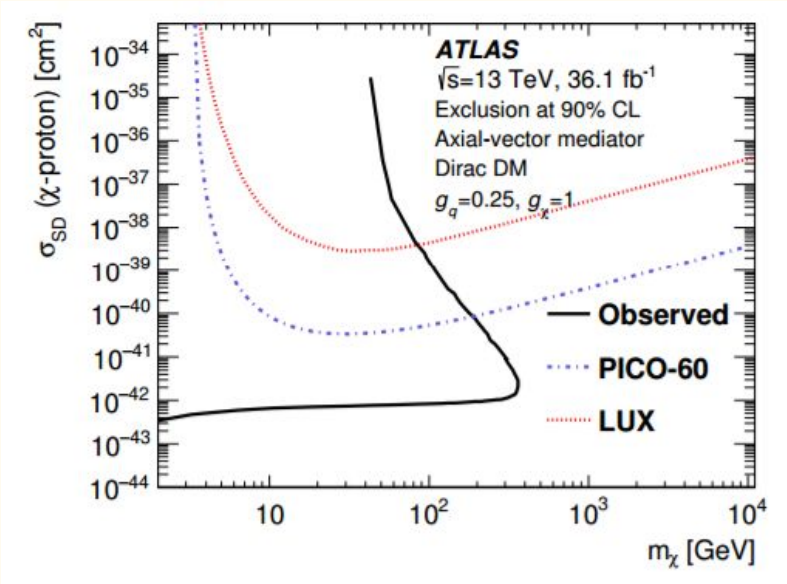


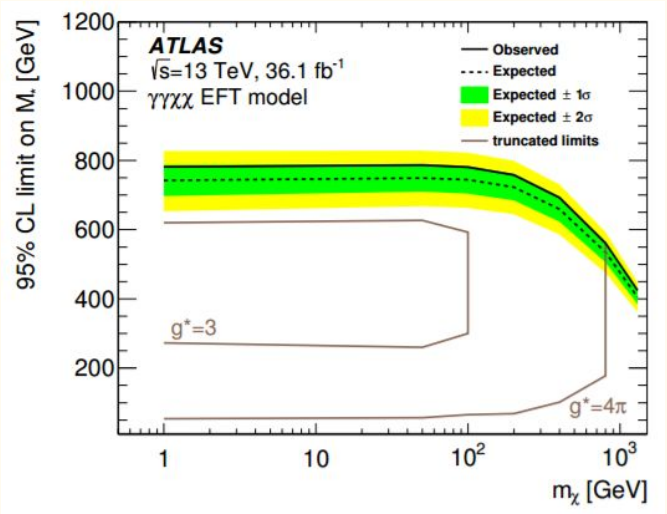
$\gamma + X$ **NEW**, 36/fb arXiv:1703.09127

simultaneous fit to all **CRs** and **SR**, no bkg shape fit

- **Statistically limited** measurement
- Limits on **DM production** via **vector/axial-vector**
  - **X+MET @ collider important for low DM mass, and particularly for spin-dep. int.**





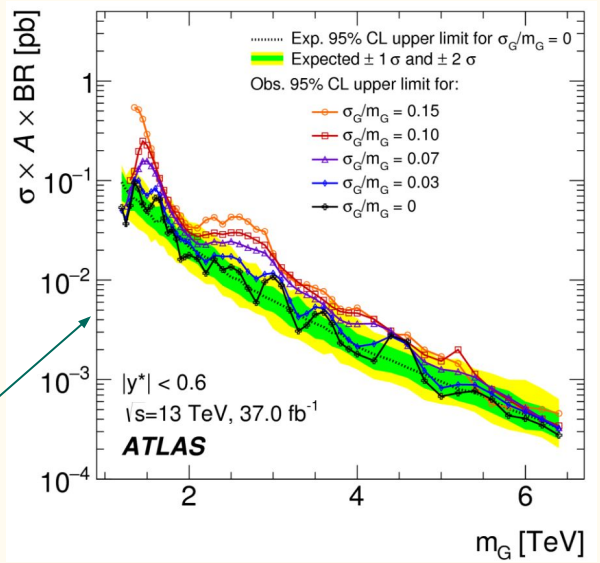


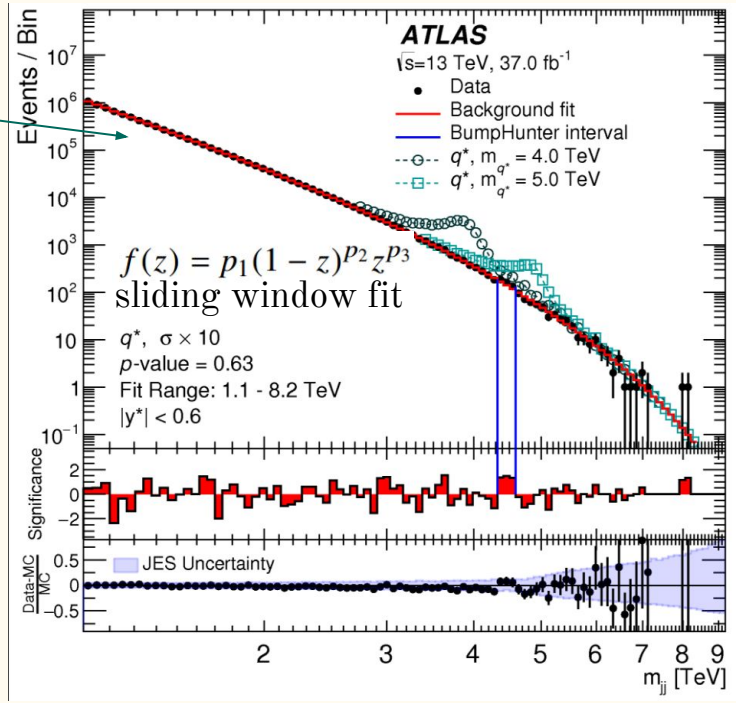
Limits on $\gamma\gamma\chi\chi$ via dimension-7 **EFT** operator

Di-jet analysis **NEW**, 37/fb, arXiv:1703.09127

- Search for **resonances** on **m_{jj} spectrum**
- Completely data-driven: **functional fit**
- **New sliding window fit**, robust for high stat

- No significant excess: **limits** on q^*, quantum black holes, W', **Z'**, W^*
- **New folding** with transfer-matrix: limits on generic gaussian with a **truth-level** width
- Also: angular analysis (see backup)





$y^* = (y_1 - y_2)/2 < 0.6$ explored (1.2 for W^*)
leading jet $p_T > 440$ GeV (due to trigger)
$m_{jj} > 1.1$ TeV (due to trigger)

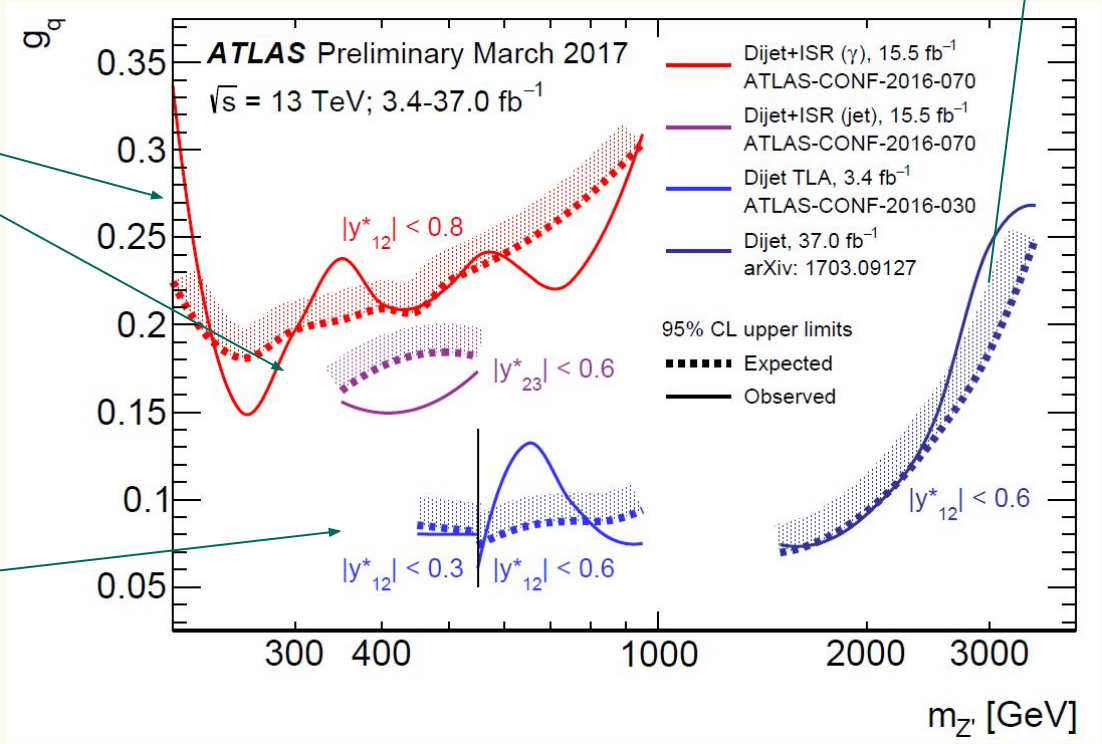
Di-jet @ low mass link

High-mass di-jet

Di-jet + ISR

ISR γ/jet -> **trigger**

search in m_{jj} of dijet



Trigger Level Analysis

- **partial info** stored
- ad-hoc calibration
- huge statistics

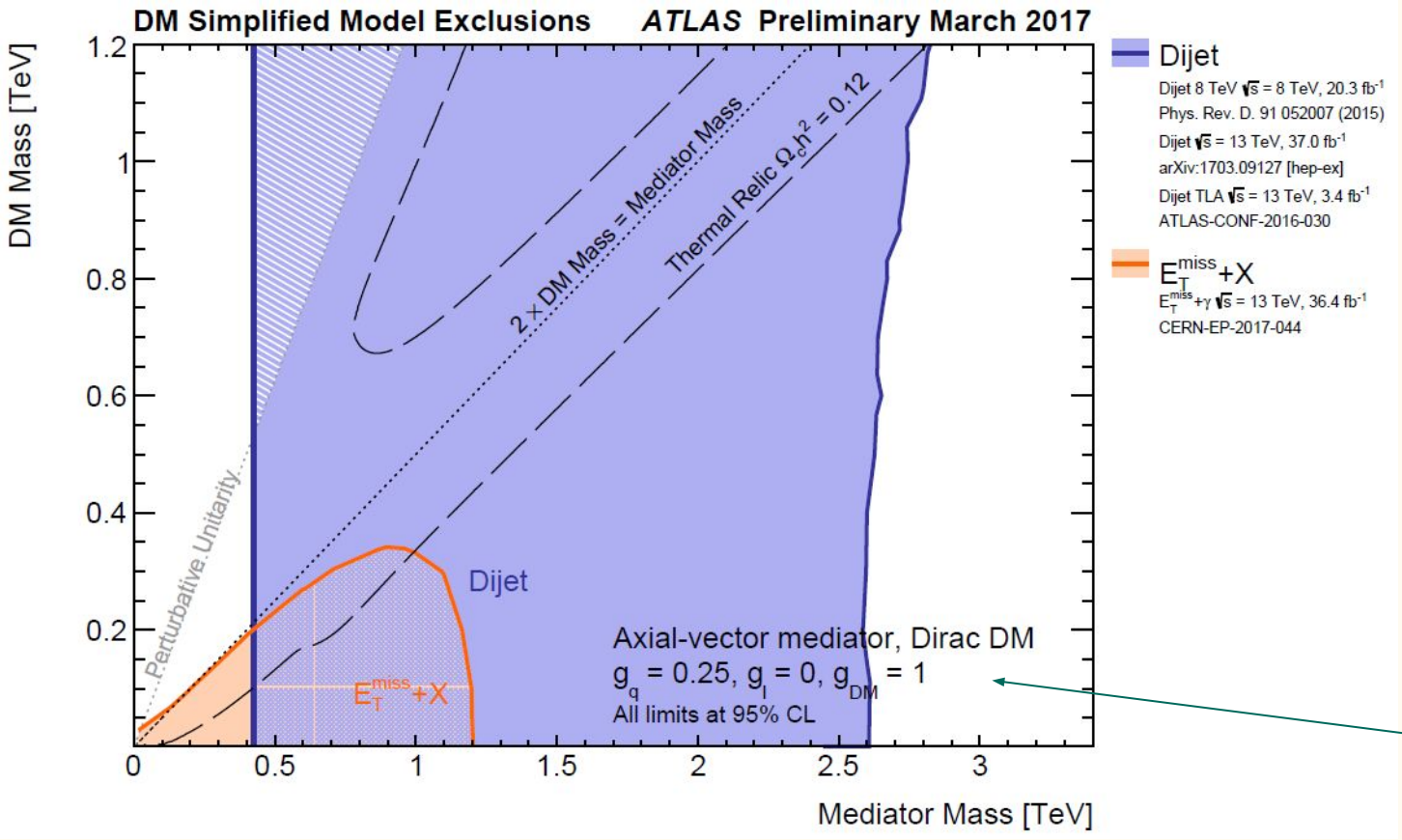
  ↓

  fit technique more complicated

di-bjet on 13.3/fb @ 13 TeV ATLAS-CONF-2016-060

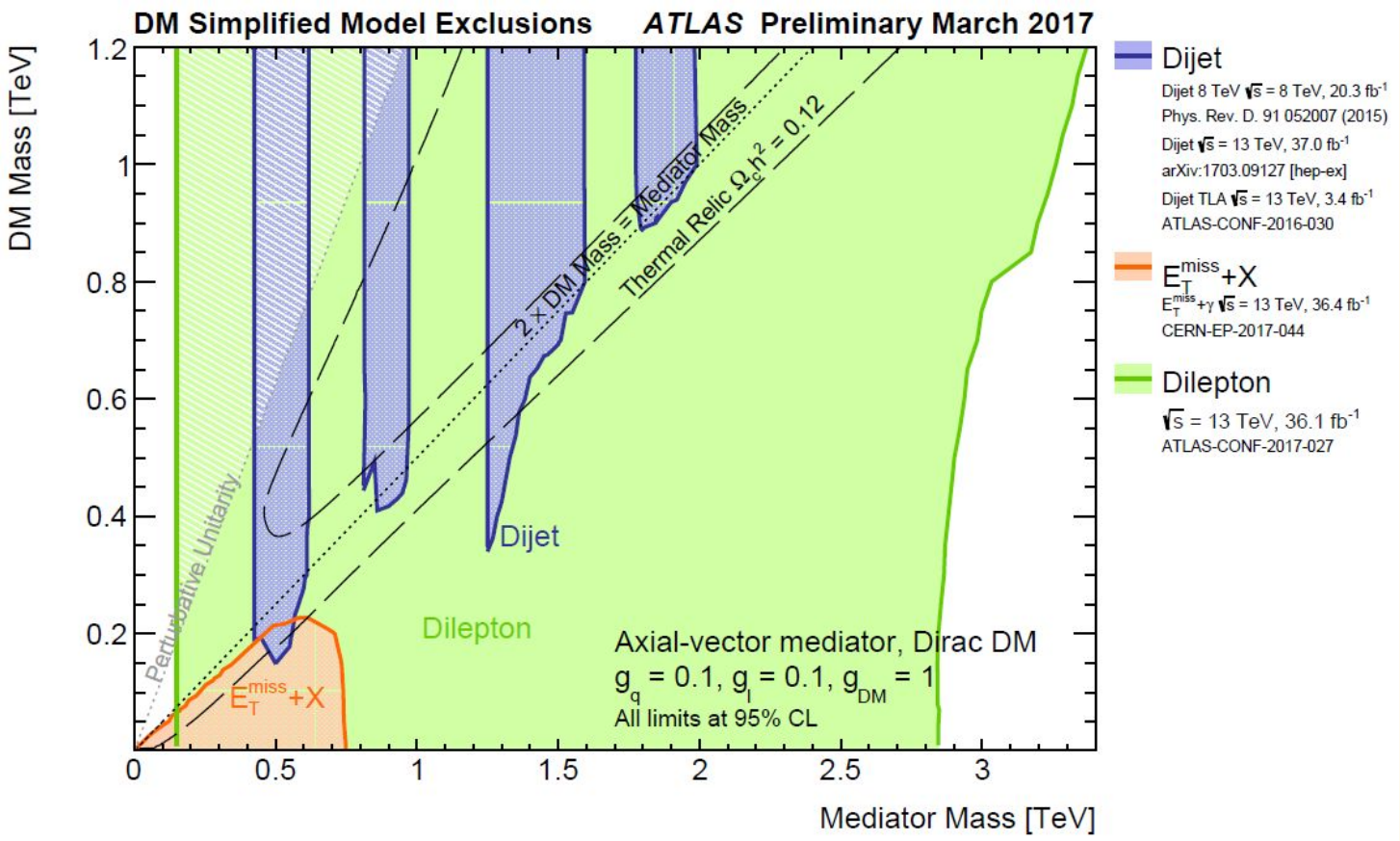
γ+jet on 3.2/fb @ 13 TeV JHEP 03 (2016) 041

Photon+X and di-jet: filling the empty space link



coupling to quarks $\mathbf{g_q}$ critical for the interplay between mono-x and di-jet

Adding leptons in the big picture link



Mono-h(bb) 36/fb ATLAS-CONF-2017-028

Mono-h(γγ) 36/fb ATLAS-CONF-2017-024

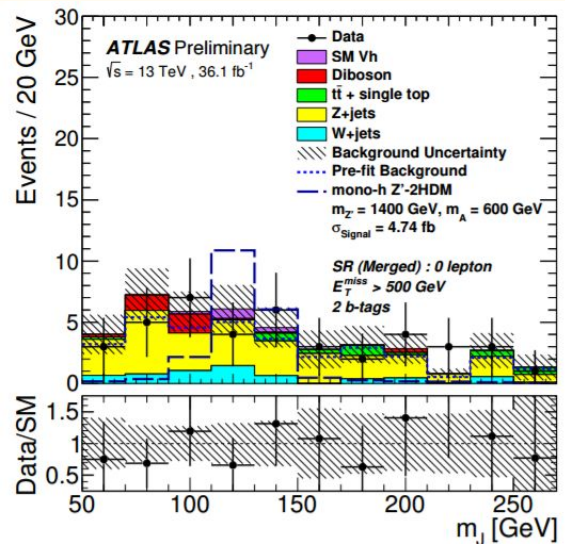
h-ISR suppressed: higgs involved in DM mechanism!

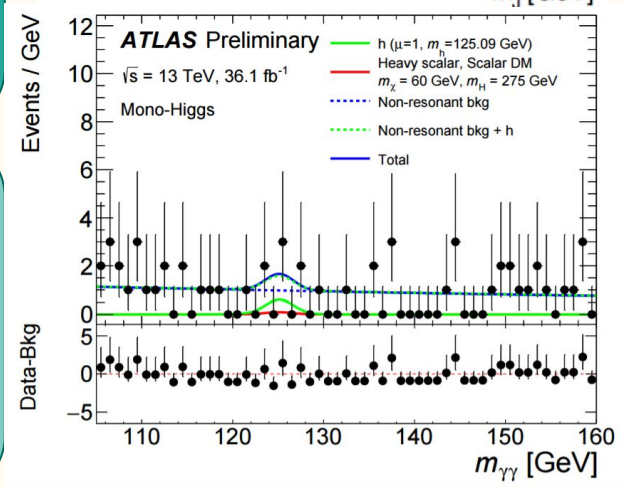
h->bb

- resolved category: 2 small-R b-jets
- merged category (high E_T^{miss}): 1 large-R jet, track-jets used for b-tagging
- Fit in m_h^{reco} to CRs and SR in 4 E_T^{miss} regions

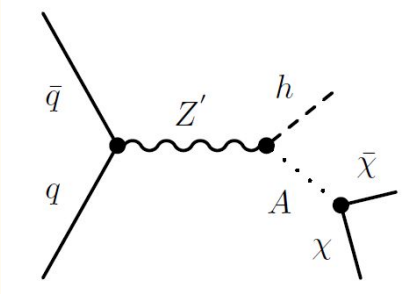
h->γγ

- Several categories mainly based on E_T^{miss} significance and $p_T^{\gamma\gamma}$
- Fit to $m_{\gamma\gamma}$ in the different categories searching for signal contributions

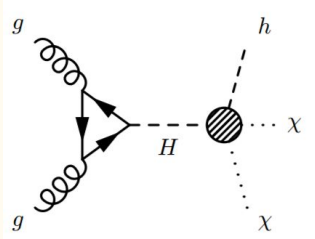


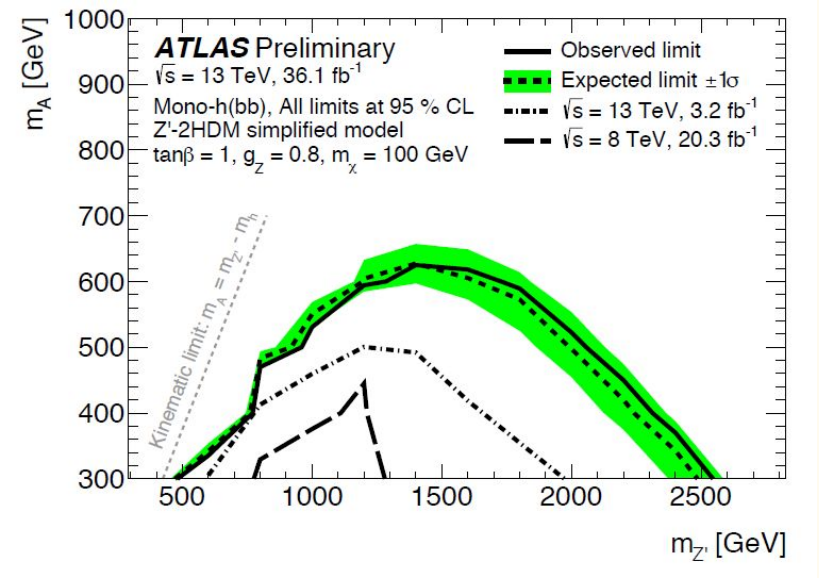


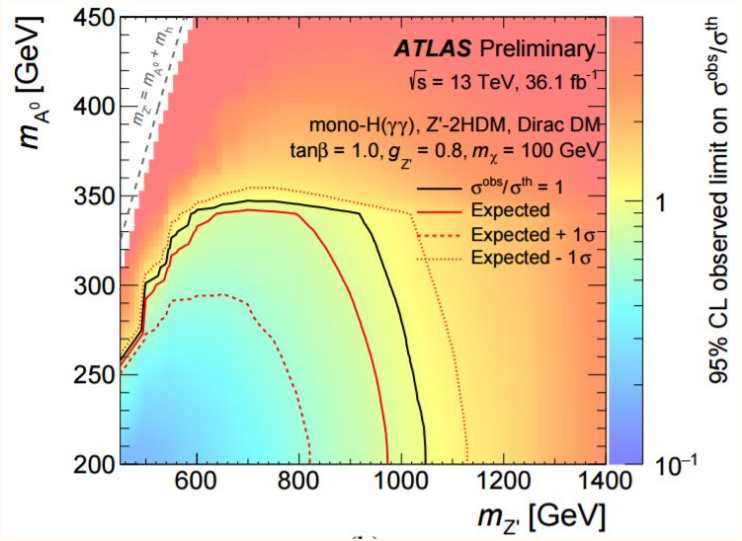
Mono-h results



- Results interpreted in a Z'-2HDM model
- h->bb dominates the sensitivity
- h->γγ presents limits also for a heavy H-EFT model and for a Z'_B model
- h->bb presents generic limits on h+DM visible cross section

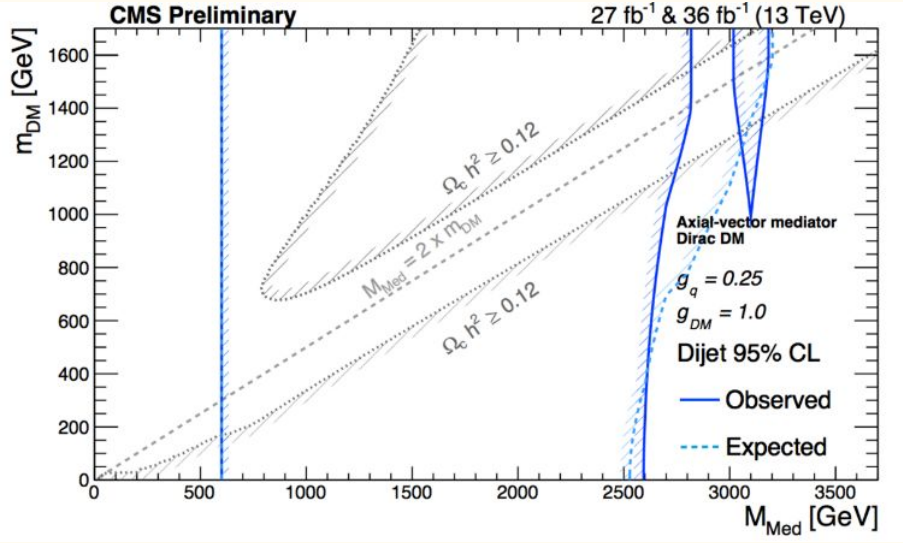




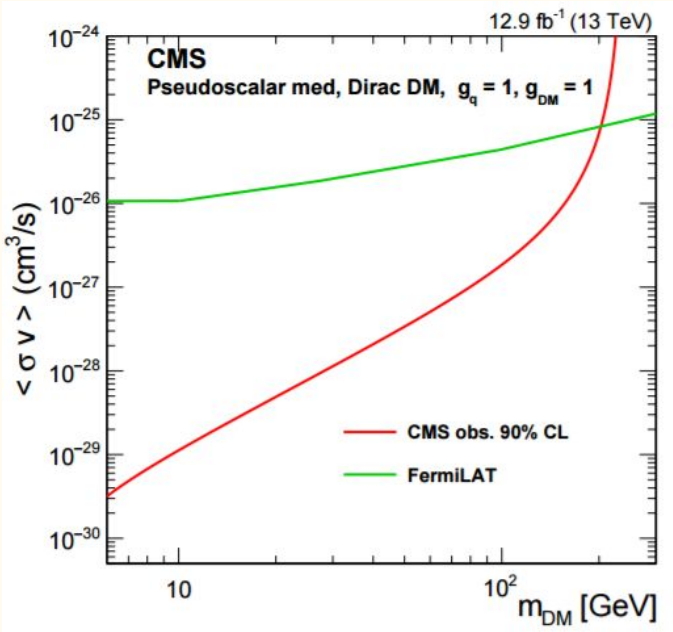


DM @ CMS

Di-jet preliminary results PAS-EXO-16-056



- high-mass and low-mass (data scouting)
- used wide-jets, less sensitive to FSR
- limits for qq, qg, gg resonances



Jet+X publication on 13/fb arXiv:1703.01651

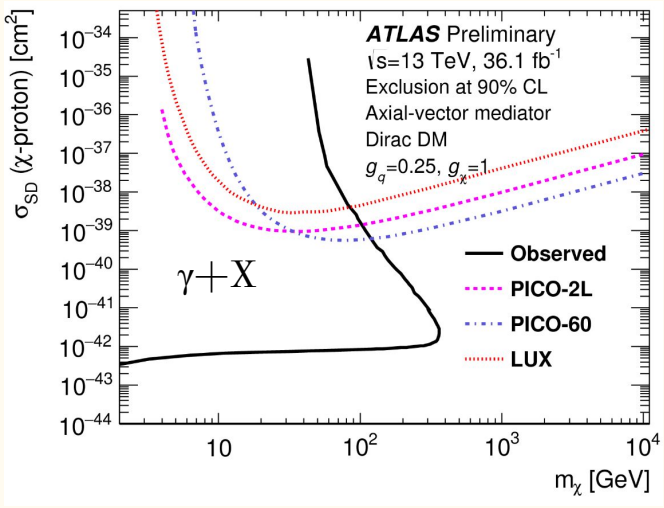
- challenging, limited by syst in significant region
- W+X and Z+X considered and combined
- γ+jet CR used in addition to leptonic ones

Also: **h->(bb,γγ)+X** 2015 dataset arXiv:1703.05236

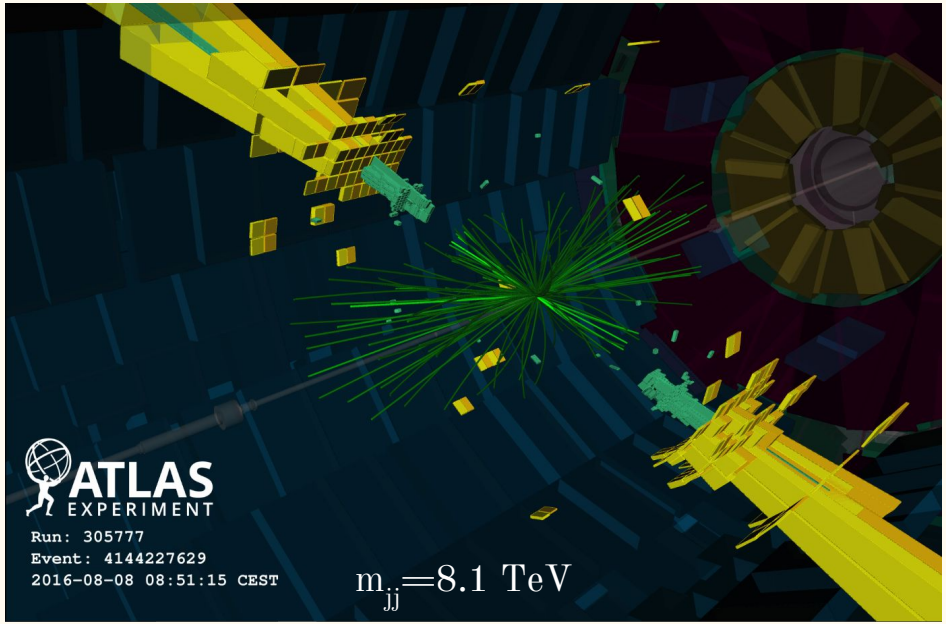
Conclusion

Searches for **Dark Matter at colliders:**

Complementary with other DM searches



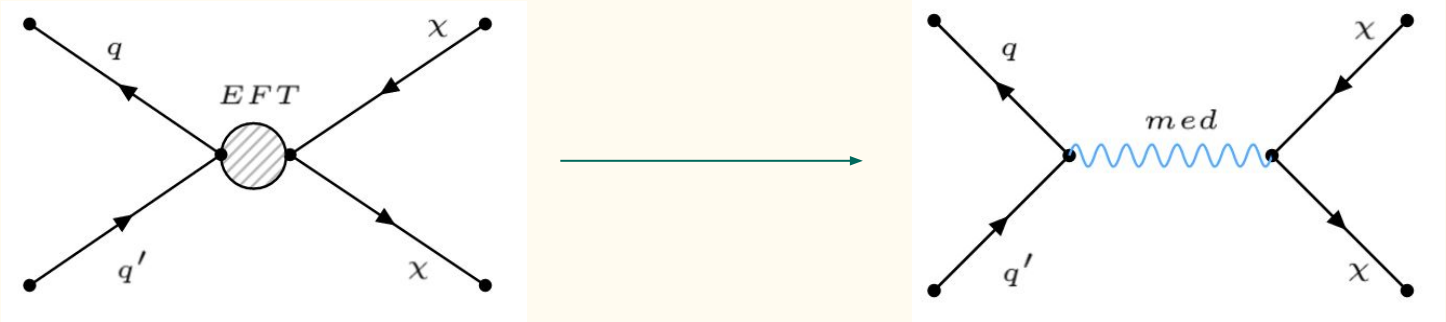
Challenging! Invisible particles, control of detector performance in extreme regimes, control of backgrounds...



- **2015+2016 dataset > Run 1**
- **Many results on their way**
- CMS recent results:
  - **di-jet** full 2015+2016 dataset PAS-EXO-16-056
  - **Jet+X** partial 2015+2016 dataset arXiv:1703.01651
  - **h->(bb,γγ)+X** 2015 dataset arXiv:1703.05236
- **ATLAS+CMS+theorists** working together Dark Matter Working Group

BACKUP

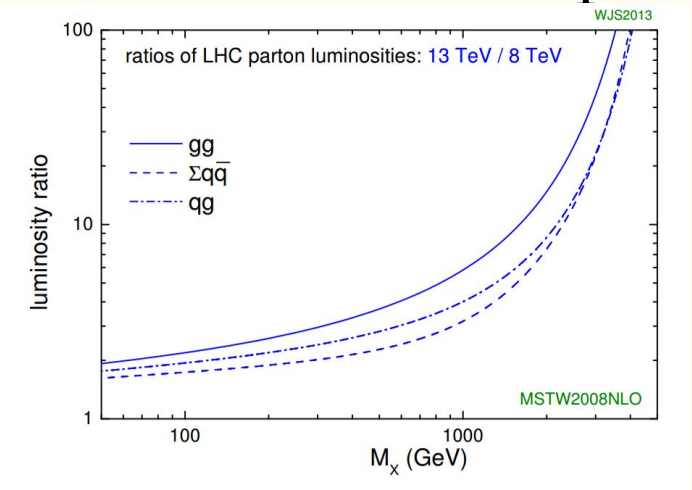
From EFTs to Simplified Models

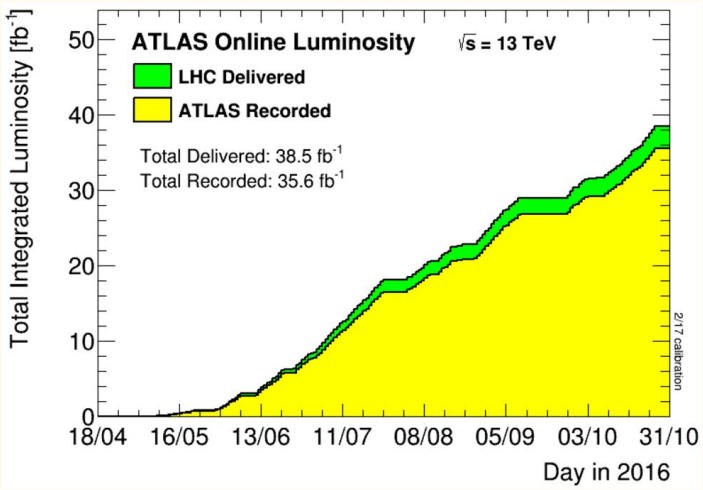


- Effective Field Theories (EFTs) used in the past to model in a general way DM production
- Recent collider DM papers moving to simplified model approach (see arxiv:1507.00966, 1603.04156)
  - a mediator (scalar, pseudo-s., vector, axial-vector,...) is assumed
  - less general, richer phenomenology, better defined comparison with direct searches
- Mediatior with mass > 10 TeV $\rightarrow$ EFT

The Large Hadron Collider and the ATLAS exp.

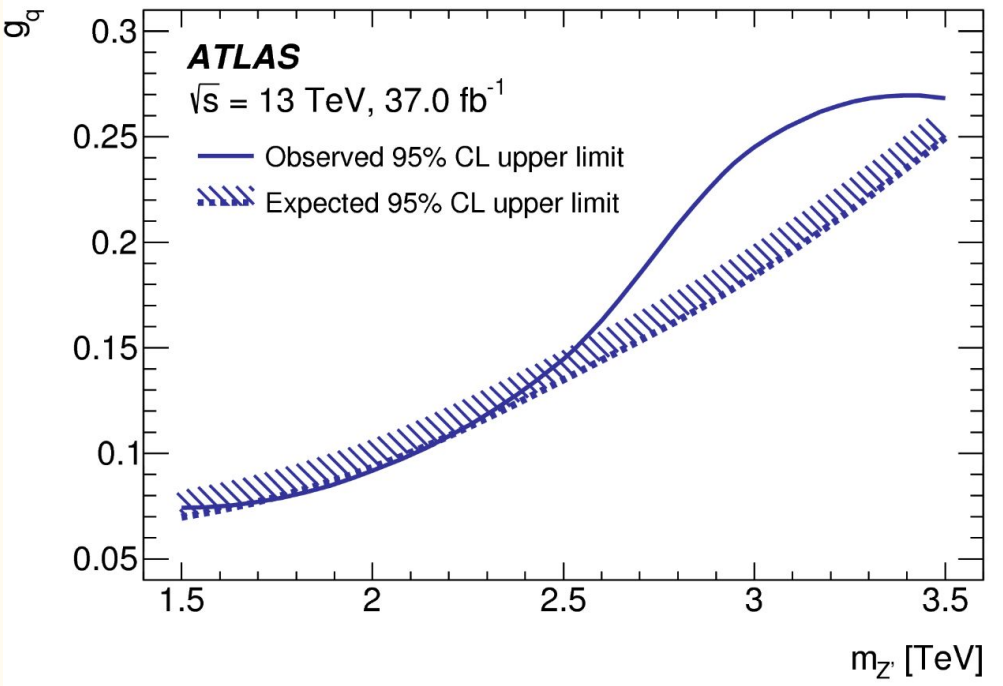
- LHC started **run-2** in 2015, proton vs proton @ **$\sqrt{s}$=13 TeV**
- **Parton luminosity** for producing **massive states** is greatly **enhanced** -> great opportunity for **searches!**





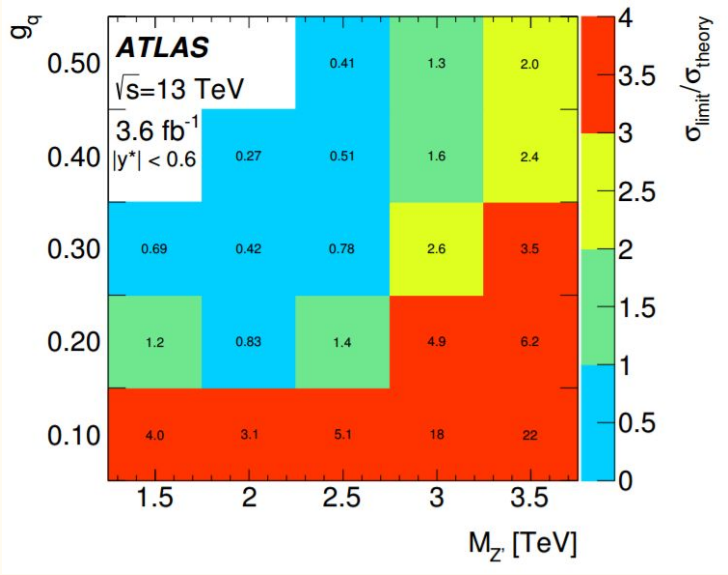
- Almost **40/fb of data collected** by the ATLAS experiment with excellent performance
  - already more than run-1!

Di-jet analysis **NEW**, 37/fb, arXiv:1703.09127



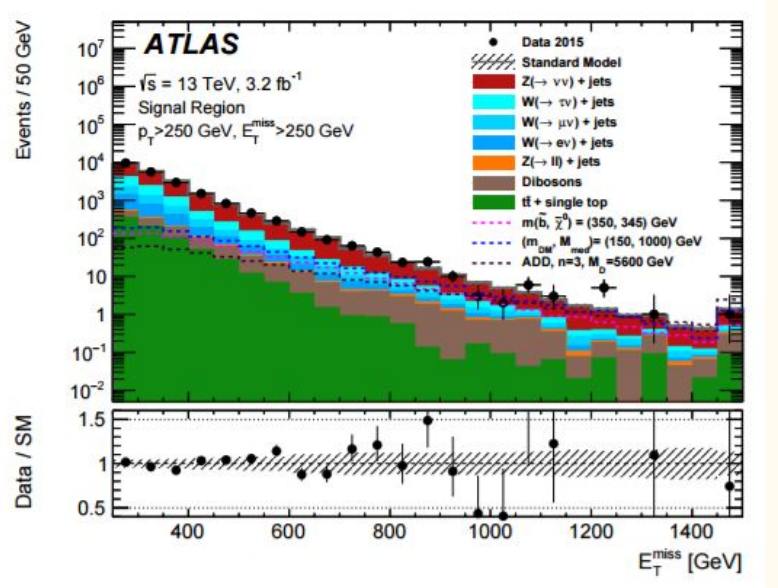
NEW Limits on Z'

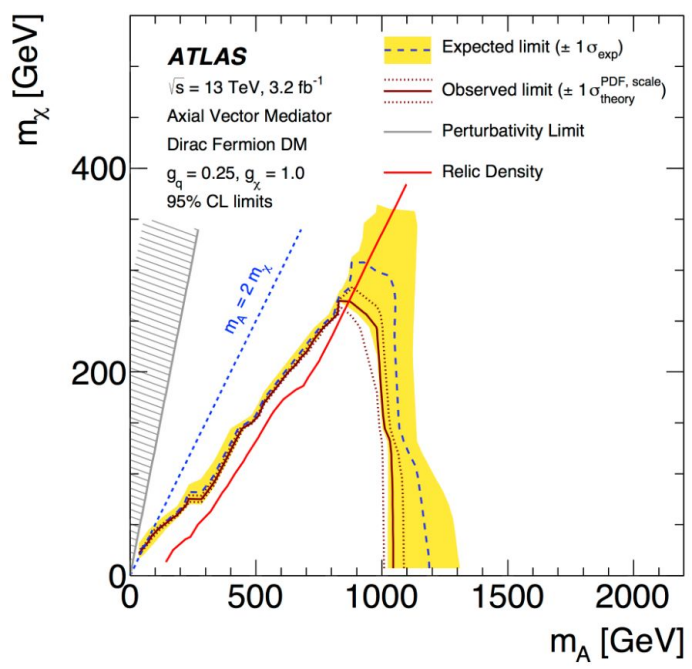
Limits from previous publication
PLB 754 (2016) 302



Jet + X 3.2/fb @ 13 TeV, PRD 94 (2016) 032005

- Select events with **high p_T jet(s)** and **E_T^{miss}**
- Trigger fully efficient for E_T^{miss}>250 GeV
- Dominant bkg **Z(->νν)+jets**, **W(->ℓν)+jets**
  - constrained in **control regions (CRs)** with leptons

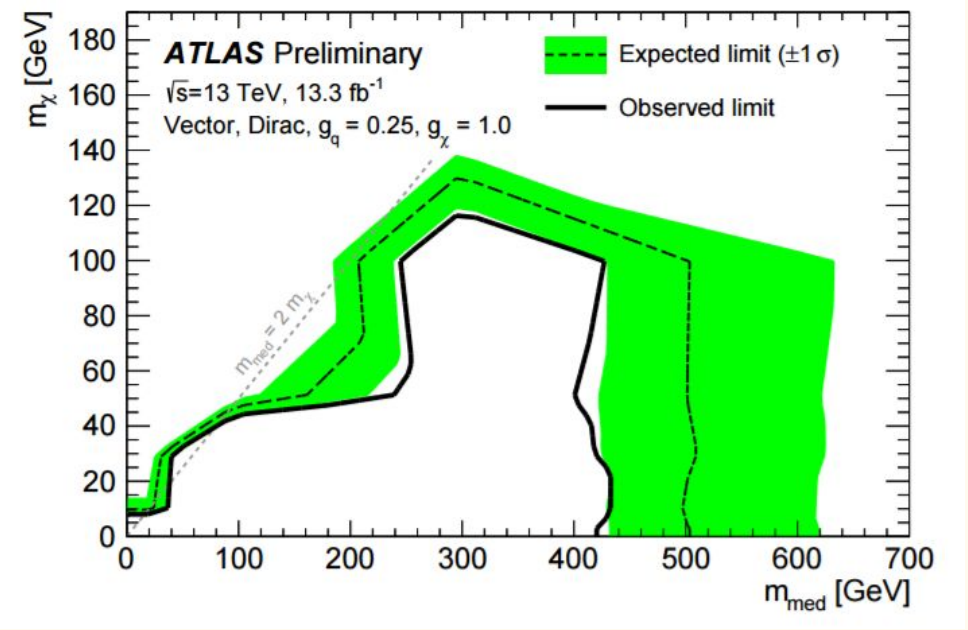


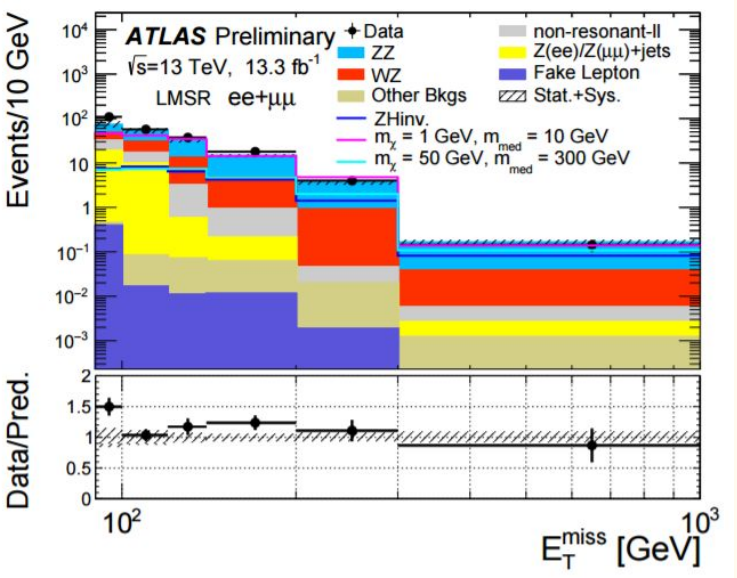


- **Simultaneous fit** to **CRs** and **signal region (SR)**
- No excess -> **limits** on several models
- ADD for Large Extra-Dimensions, squark pairs production, **WIMPs** produced by axial-vector mediator

X+ℓℓ 13/fb @13 TeV ATLAS-CONF-2016-056

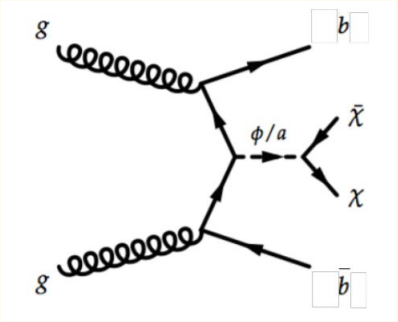
- **ee/μμ + E_T^{miss}**
- **ZZ from MC, WZ 25% from 3ℓ CR**
- **Z+jets (small)** with **data-driven method**



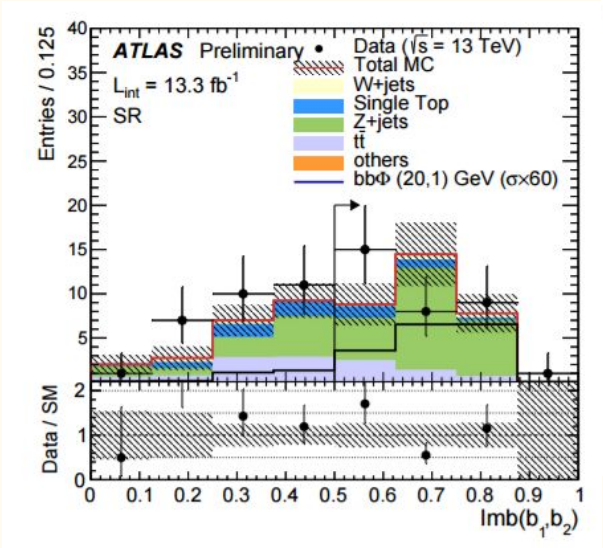


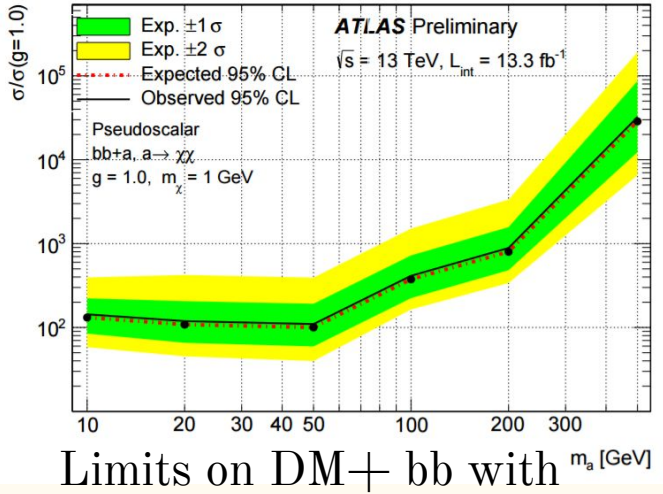
- **Non-resonant** (WW, tt, Wt, Z->ττ) **from eμ** CR
- Bkg **uncertainty dominated by Z+jets**
- **Limits** produced for heavy Higgs, RS graviton, Zh with h->invisibile, **DM with vector mediator**

DM+bb 13/fb @ 13 TeV ATLAS-CONF-2016-086



- Events with **exactly 2 b-jets** and $\mathbf{E_T^{miss}}$, 3rd jet veto
- **b-tagging** based on **multivariate** algorithm with ε=60%
- Dominant bkg from **Z+bb**, reduced with cut on ΔR_{jj} (separation)
- Cut on **momentum imbalance between jets** $\mathrm{Imb}(b_1,b_2)$
- CRs defined for **2ℓ+1b** (->Z+bb), **1ℓ+2b** (->ttbar), **1ℓ+1b**(->W+hf, single-t)
- **Validation regions** used to validate bkg
- **Combined fit** to all CRs + SR
- **Dominant syst** from jet energy scale, b-tagging, V+jets modelling

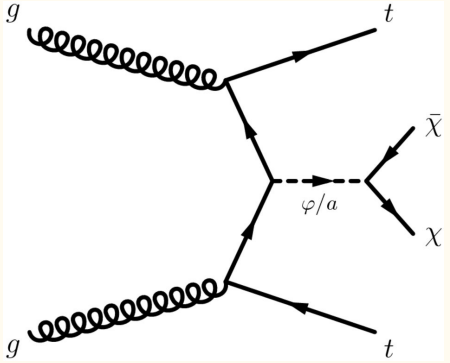




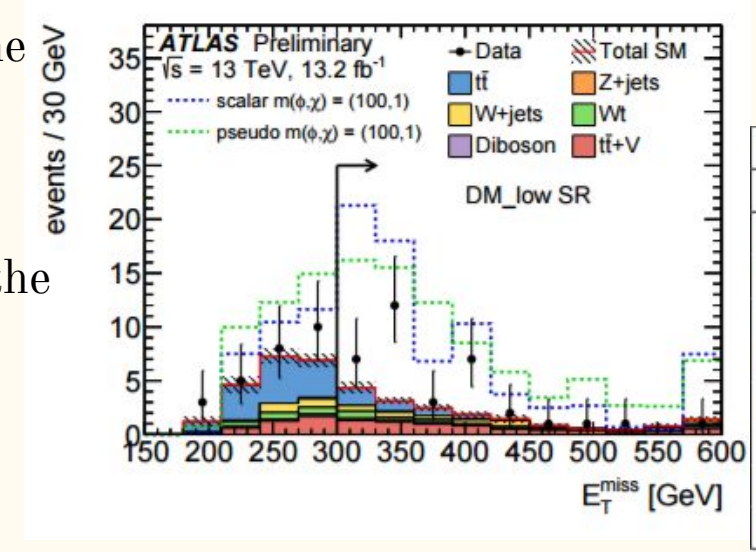
Limits on DM+ bb with pseudoscalar mediator

DM+tt 13/fb @ 13 TeV, ATLAS-CONF-2016-077, 2016-050, 2016-076

- In **searches for stops** with 0, 1 or 2 charged leptons, **produced limits also on DM** via **scalar/pseudoscalar med.**
- **Many SRs**, based on kinematics/topological **discriminating variables**, and have **regions dedicated to DM searches**

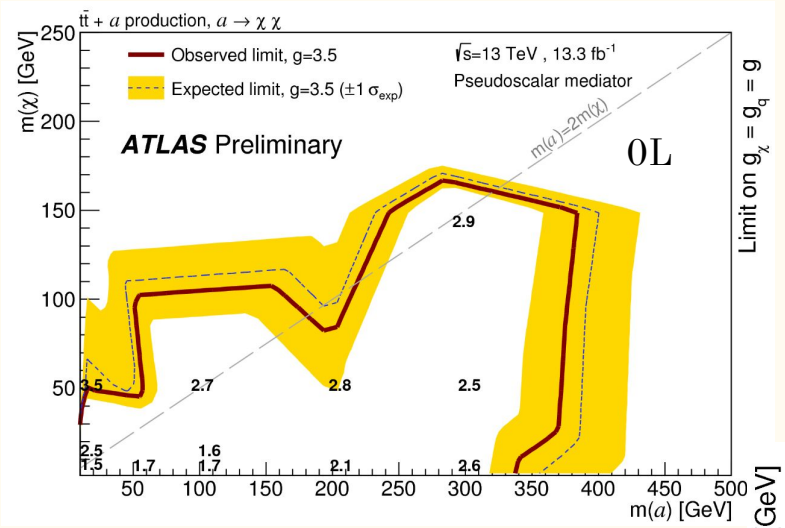


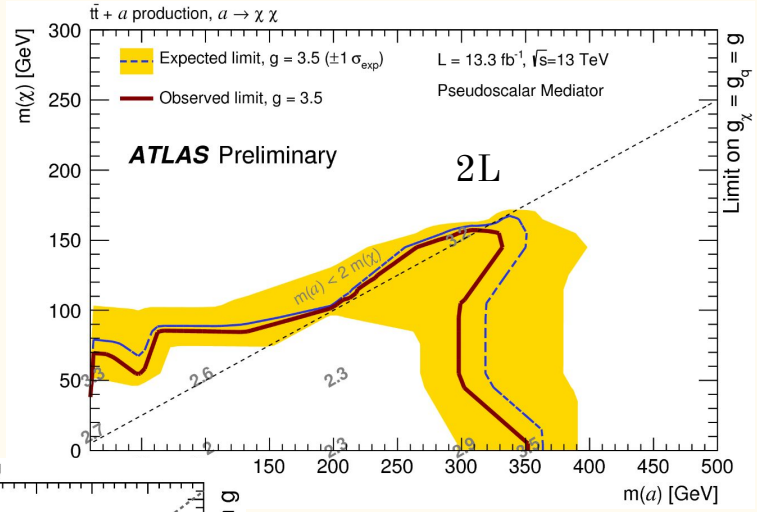
- **Slight excess** in one SR in 1-lepton analysis (3.3 σ)
- **Not unexpected**, when considering the **huge number of regions explored**

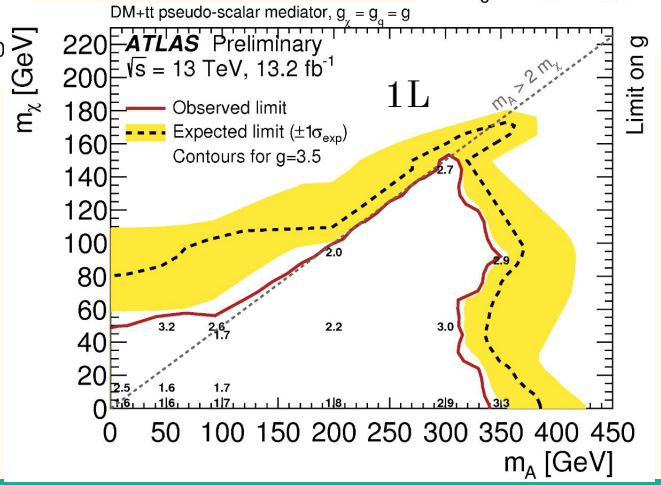


Variable	DM_low
≥4 jets with p_T > [GeV]	(60 60 40 25)
E_T^{miss} [GeV]	> 300
$H_{T,sig}^{miss}$	> 14
m_T [GeV]	> 120
am_{T2} [GeV]	> 140
$\min(\Delta\phi(\vec{p}_T^{miss}, \text{jet}_i))(i \in \{1-4\})$	> 1.4
$\Delta\phi(\vec{p}_T^{miss}, \ell)$	> 0.8
$\Delta R(b_1, b_2)$	–
Number of b-tags	≥ 1

DM+tt 13.2/fb @ 13 TeV, ATLAS-CONF-2016-077, 2016-050, 2016-076



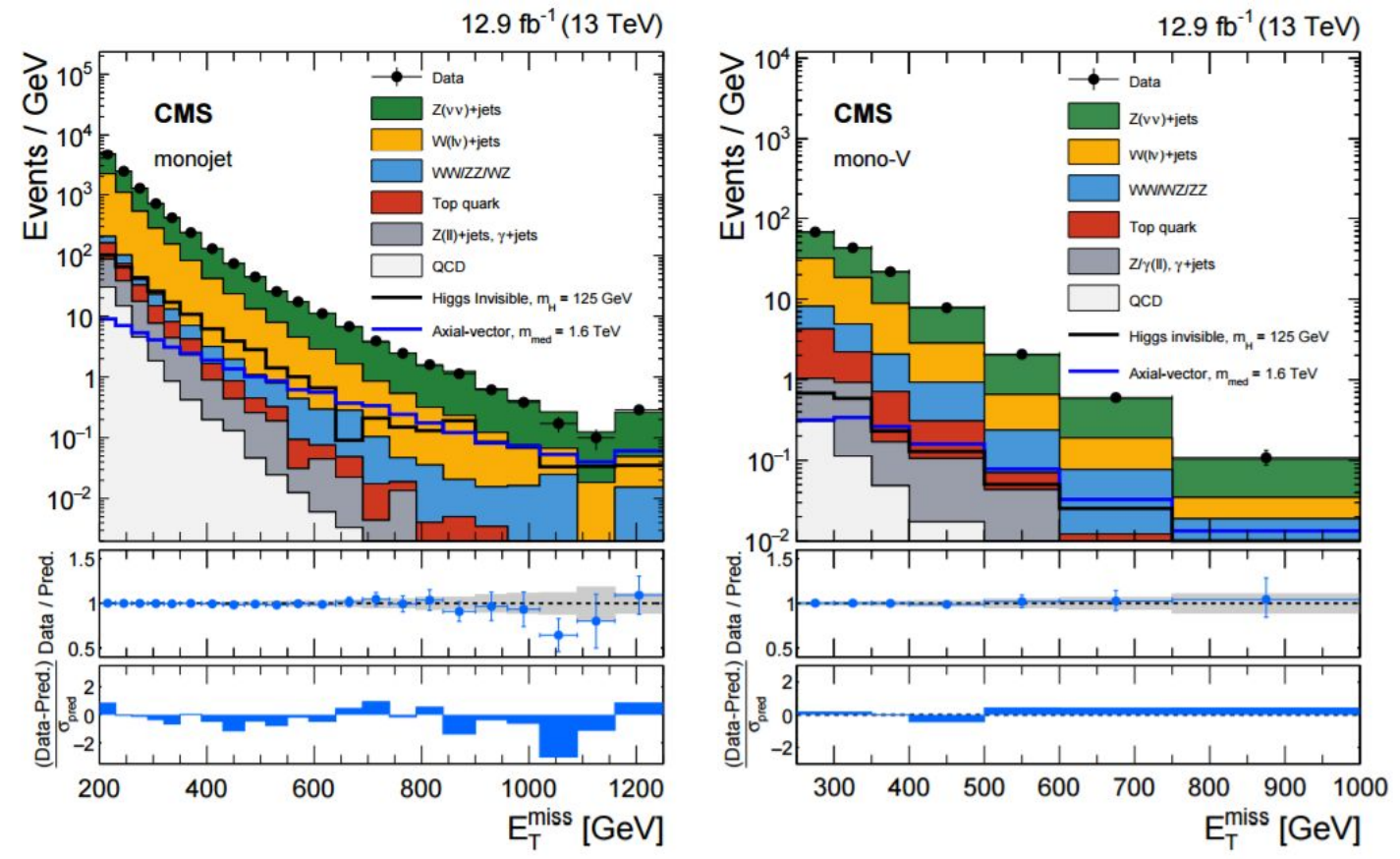




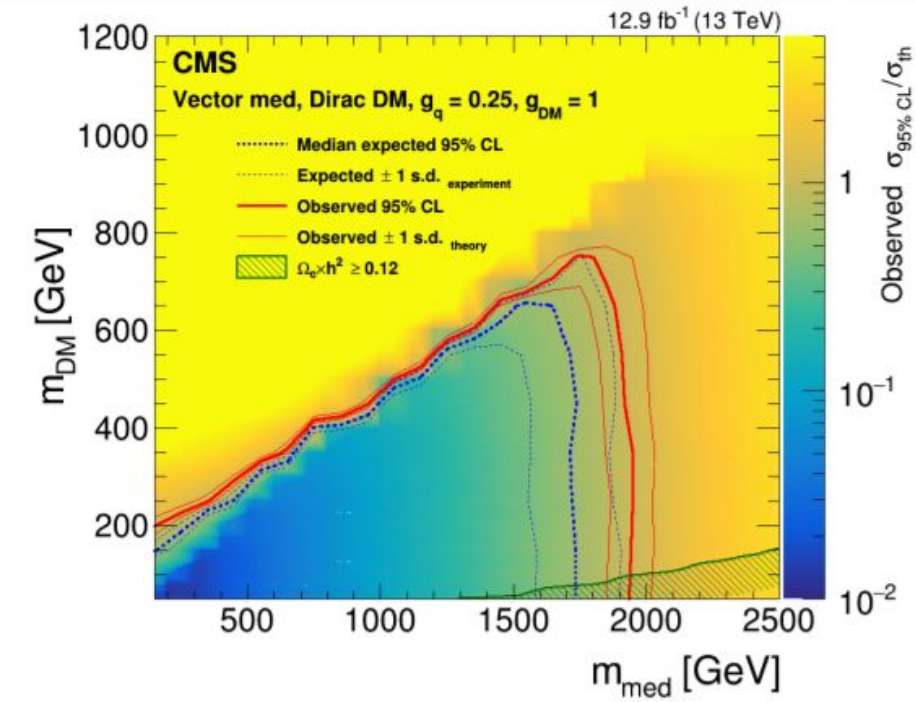
Comparable sensitivity
for the different searches

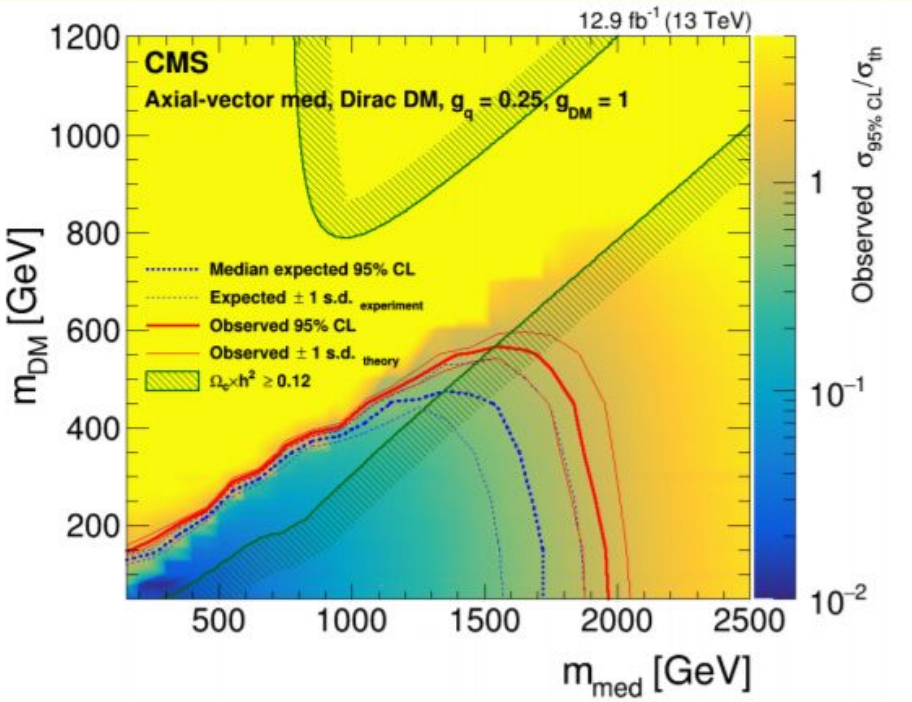
CMS Jet+X

CMS Jet+X arXiv:1703.09127

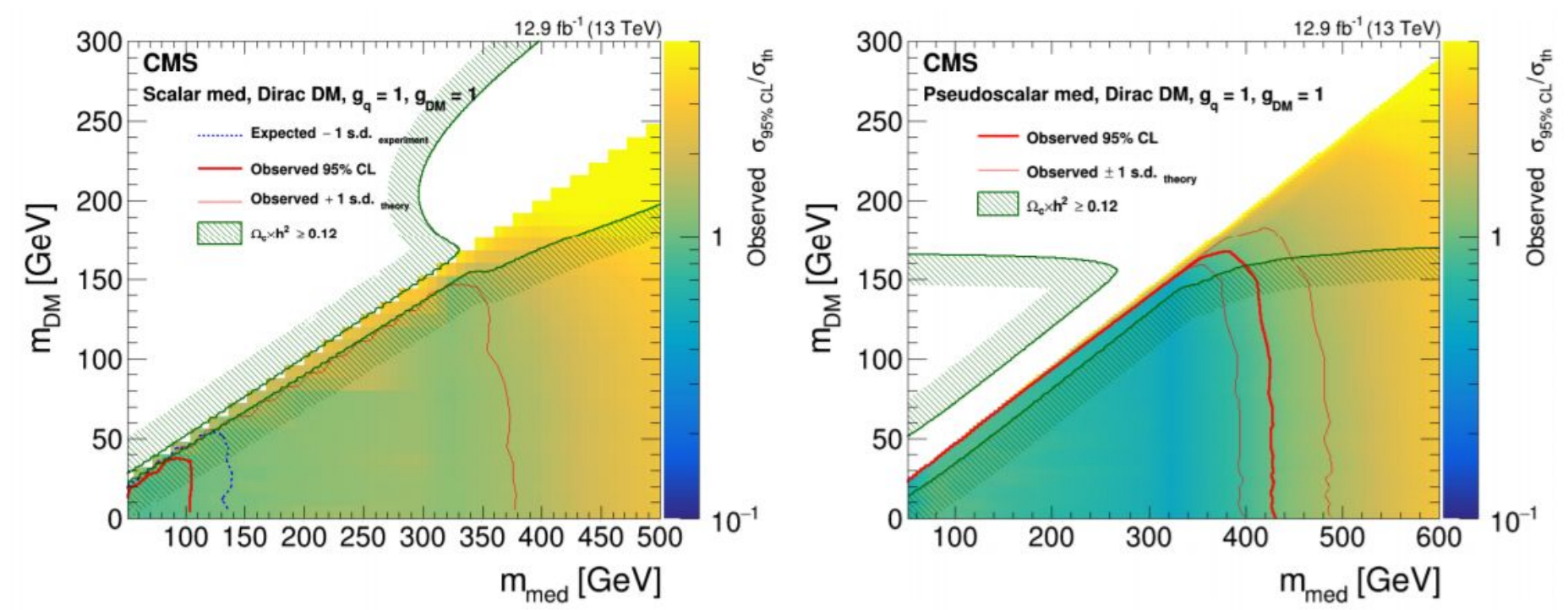


CMS Jet+X [arXiv:1703.09127]





CMS Jet+X arXiv:1703.09127



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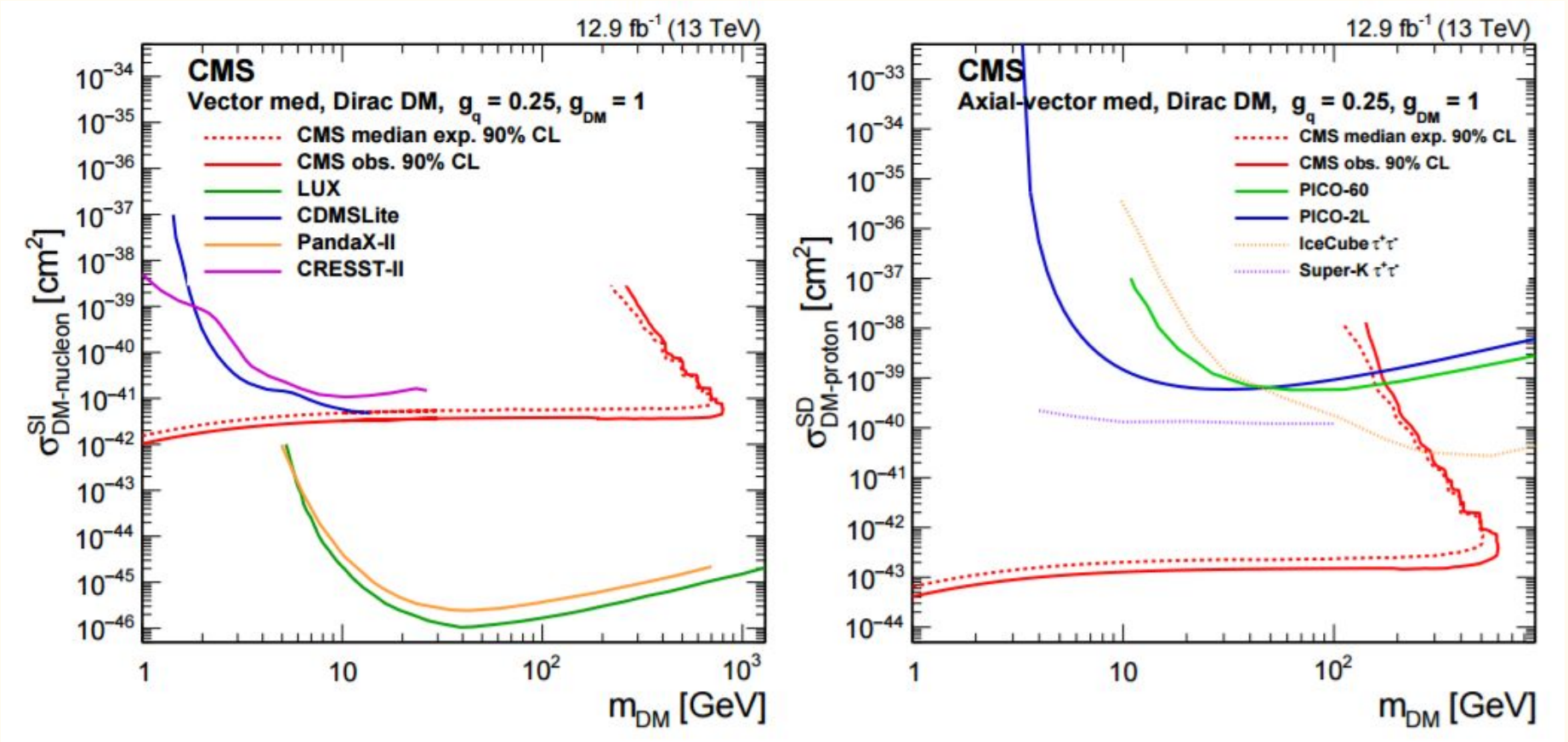
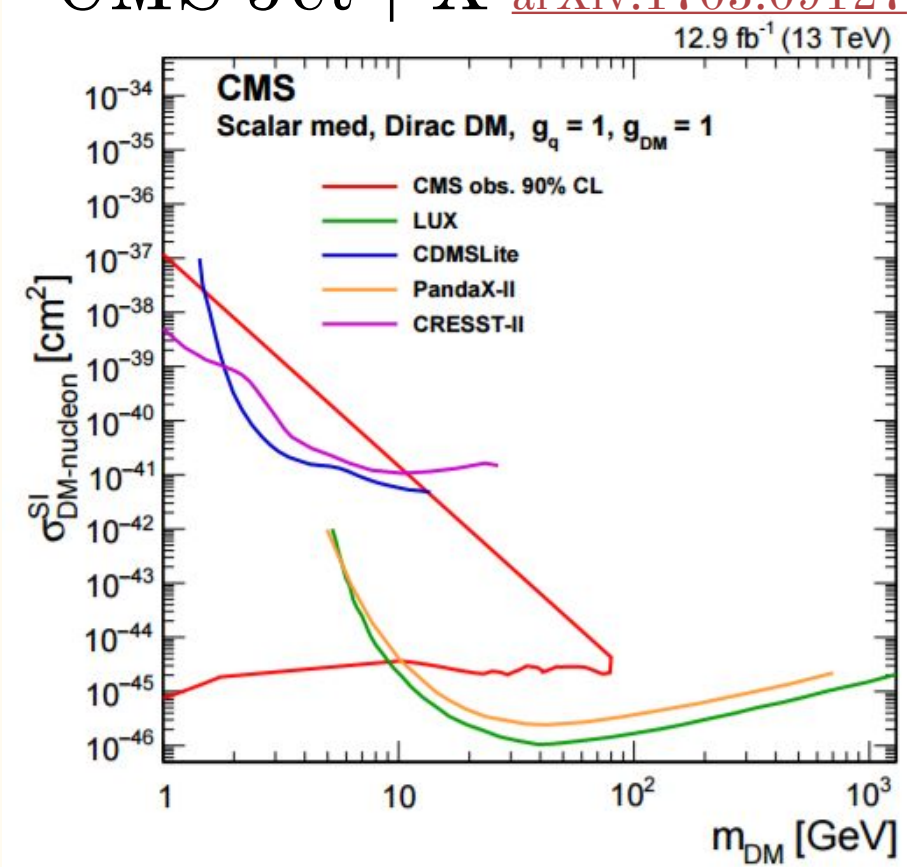
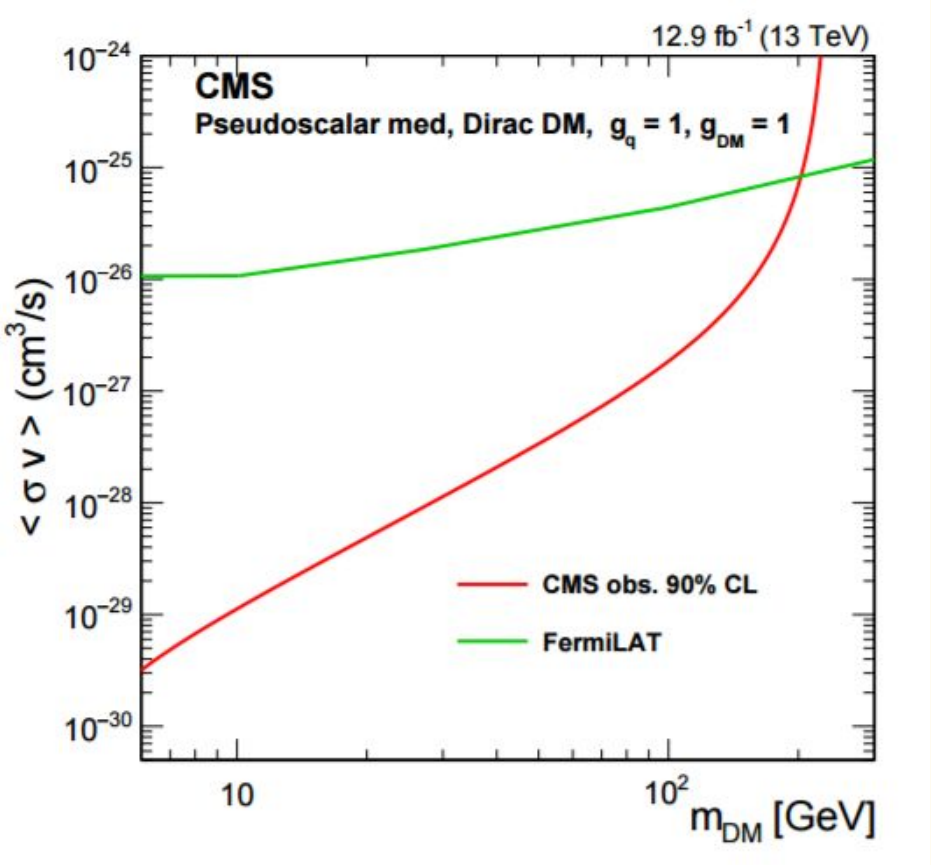


CMS Jet+X arXiv:1703.09127





Jet+X

Jet+X selection

PRD 94 (2016) 032005

Selection criteria							
Primary vertex							
$E_{\mathrm{T}}^{\mathrm{miss}} > 250$ GeV							
Leading jet with $p_{\mathrm{T}} > 250$ GeV and $\lvert\eta\rvert < 2.4$							
At most four jets with $p_{\mathrm{T}} > 30$ GeV and $\lvert\eta\rvert < 2.8$							
$\Delta\phi(\mathrm{jet}, \vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}) > 0.4$							
Jet quality requirements							
No identified muons with $p_{\mathrm{T}} > 10$ GeV or electrons with $p_{\mathrm{T}} > 20$ GeV							
Inclusive signal region	IM1	IM2	IM3	IM4	IM5	IM6	IM7
$E_{\mathrm{T}}^{\mathrm{miss}}$ (GeV)	> 250	> 300	> 350	> 400	> 500	> 600	> 700
Exclusive signal region	EM1	EM2	EM3	EM4	EM5	EM6	
$E_{\mathrm{T}}^{\mathrm{miss}}$ (GeV)	[250–300]	[300–350]	[350–400]	[400–500]	[500–600]	[600–700]	

- Inclusive regions used for model-independent limits
- Exclusive regions for benchmark models

Jet+X background estimation

PRD 94 (2016) 032005

Background process	Method	Control sample
$Z(\to \nu\bar{\nu})$+jets	MC and control samples in data	$W(\to \mu\nu)$
$W(\to e\nu)$+jets	MC and control samples in data	$W(\to e\nu)$
$W(\to \tau\nu)$+jets	MC and control samples in data	$W(\to e\nu)$
$W(\to \mu\nu)$+jets	MC and control samples in data	$W(\to \mu\nu)$
$Z/\gamma^*(\to \mu^+\mu^-)$+jets	MC and control samples in data	$Z/\gamma^*(\to \mu^+\mu^-)$
$Z/\gamma^*(\to \tau^+\tau^-)$+jets	MC and control samples in data	$W(\to e\nu)$
$Z/\gamma^*(\to e^+e^-)$+jets	MC only	
$t\bar{t}$, single top	MC only	
Diboson	MC only	
Multijets	data-driven	
Non-collision	data-driven	

- Multijet (very small, 0.5% in first region, negligible in other) with jet smearing method, which uses well measured low-MET multijet events convoluted with a MC-based data-constained response function to generate a sample of pseudodata events
- Non-collision background is impportant at online level, and significantly reduced by jet quality. Main remaining bkg due to beam-induced events, estimated in data identifing calorimeter clusters associated with muons parallel to beam pipe. The efficiency of the method is evaluated in a CR with inverted jet quality. The final bkg is very small, similar to MJ

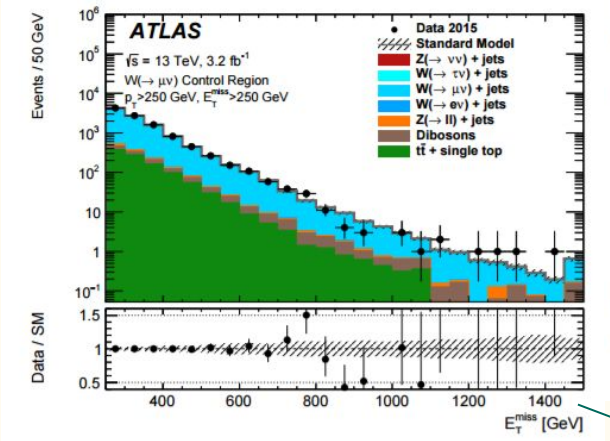
Jet+X background estimation PRD 94 (2016) 032005

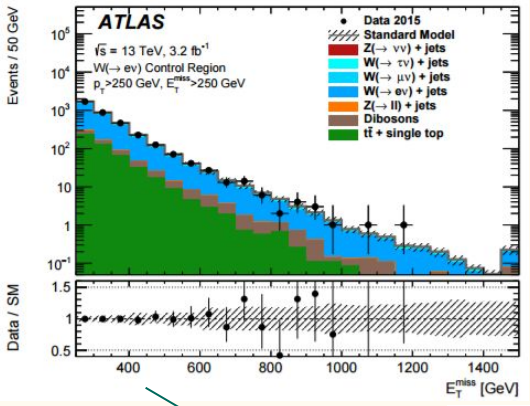
Table 5: Data and SM background prediction, before and after the fit, in the $W(\rightarrow \mu\nu)$ control region for the different selections. For the SM predictions both the statistical and systematic uncertainties are included.

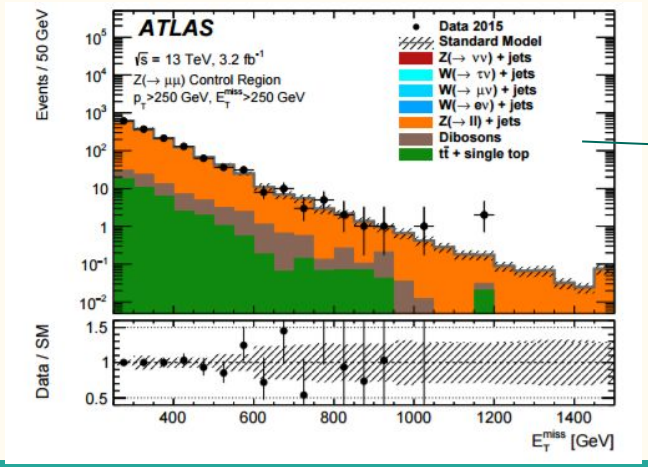
Inclusive Selection	IM1	IM2	IM3	IM4	IM5	IM6	IM7
Observed events (3.2 fb^{-1})	10481	6279	3538	1939	677	261	95
SM prediction (post-fit)	10480 ± 100	6279 ± 79	3538 ± 60	1939 ± 44	677 ± 26	261 ± 16	95 ± 10
SM prediction (pre-fit)	10500 ± 710	6350 ± 460	3560 ± 280	2010 ± 160	700 ± 57	256 ± 23	106 ± 9
Exclusive Selection	EM1	EM2	EM3	EM4	EM5	EM6	
Observed events (3.2 fb^{-1})	4202	2741	1599	1262	416	166	
SM prediction (post-fit)	4202 ± 65	2741 ± 52	1599 ± 40	1262 ± 36	416 ± 20	166 ± 13	
SM prediction (pre-fit)	4140 ± 260	2800 ± 190	1540 ± 120	1310 ± 100	444 ± 35	150 ± 14	

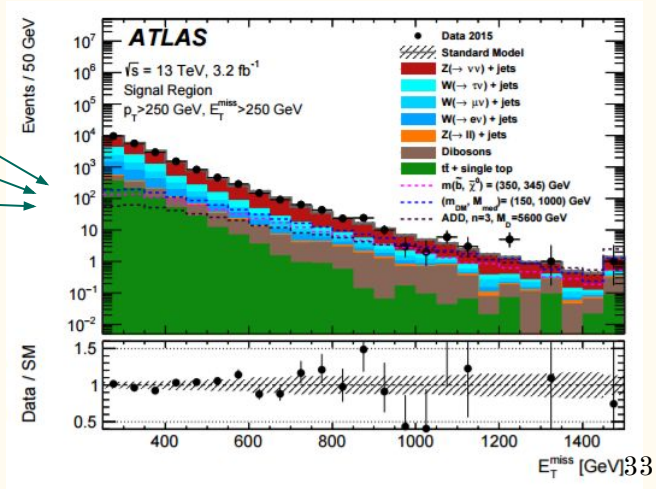
$$N_{\text{signal}}^{Z(\rightarrow\nu\bar{\nu})} = (N_{W(\rightarrow\mu\nu),\text{control}}^{\text{data}} - N_{W(\rightarrow\mu\nu),\text{control}}^{\text{non}-W}) \times \frac{N_{\text{signal}}^{\text{MC}(Z(\rightarrow\nu\bar{\nu}))}}{N_{W(\rightarrow\mu\nu),\text{control}}^{\text{MC}}}$$

Jet + X 3.2/fb @ 13 TeV, PRD 94 (2016) 032005









Jet+X background uncertainties PRD 94 (2016) 032005

Impact on total background:

- JES, MET scale: 0.5% (IM1) - 1.6% (IM7)
- Jet quality, pileup, correction to jet-pt and MET: 0.2% - 0.9%
- Lepton id/reco/scale: (in the relevant CR) 1.4%- 2.6%
- Scale, PDF, matching: 1.1% - 1.3%
- Modelling and theoretical unc on W->Z: 2.0% - 3.9%
- Theoretical unc on top bkg: 2.7%-3.3%
- Other bkg: very small impact
- Stat: 2.5% - 10%
- Luminosity: negligible

Jet+X results

PRD 94 (2016) 032005

Signal Region	IM1	IM2	IM3	IM4	IM5	IM6	IM7
Observed events (3.2 fb^{-1})	21447	11975	6433	3494	1170	423	185
SM prediction	21730 ± 940	12340 ± 570	6570 ± 340	3390 ± 200	1125 ± 77	441 ± 39	167 ± 20
Signal Region	EM1	EM2	EM3	EM4	EM5	EM6	
Observed events (3.2 fb^{-1})	9472	5542	2939	2324	747	238	
SM prediction	9400 ± 410	5770 ± 260	3210 ± 170	2260 ± 140	686 ± 50	271 ± 28	

Table 9: Observed and expected 95% CL upper limits on the number of signal events, S^{95}_{obs} and S^{95}_{exp}, and on the visible cross section, defined as the product of cross section, acceptance and efficiency, $\langle\sigma\rangle^{95}_{obs}$, for the IM1–IM7 selections.

Signal channel	$\langle\sigma\rangle^{95}_{obs}$ [fb]	S^{95}_{obs}	S^{95}_{exp}
IM1	553	1773	1864^{+829}_{-548}
IM2	308	988	1178^{+541}_{-348}
IM3	196	630	694^{+308}_{-204}
IM4	153	491	401^{+168}_{-113}
IM5	61	196	164^{+63}_{-45}
IM6	23	75	84^{+32}_{-23}
IM7	19	61	48^{+18}_{-13}

Jet+X results

PRD 94 (2016) 032005

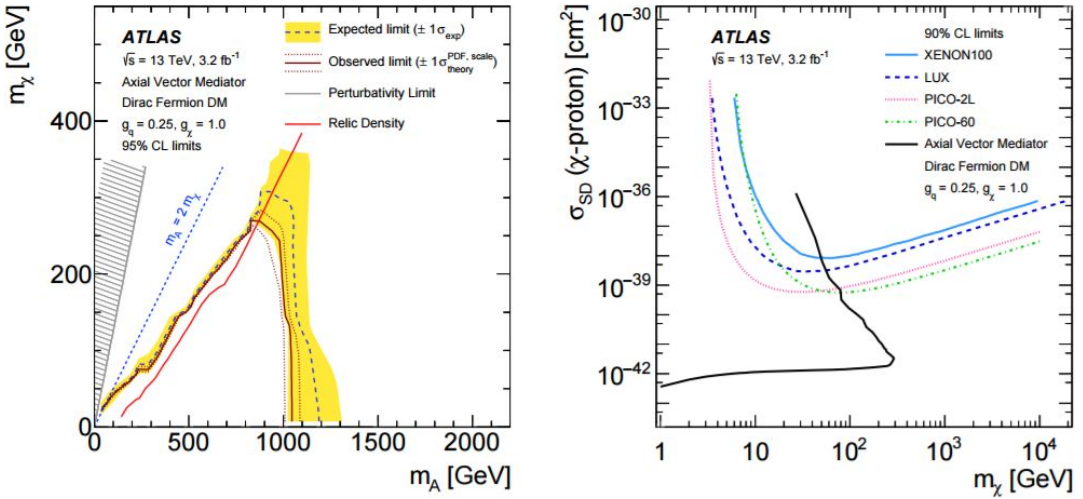
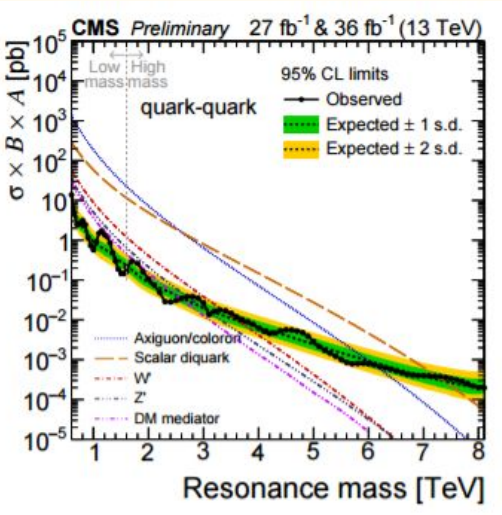
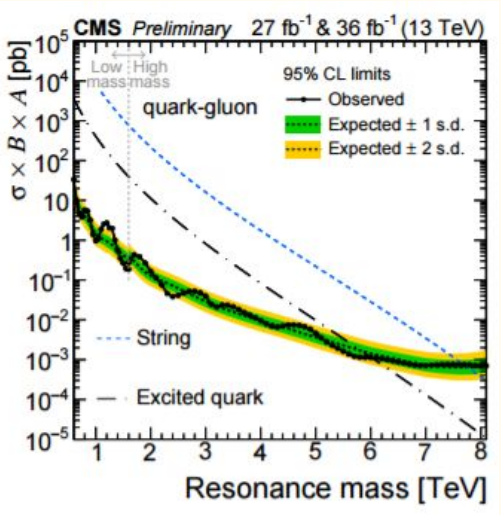
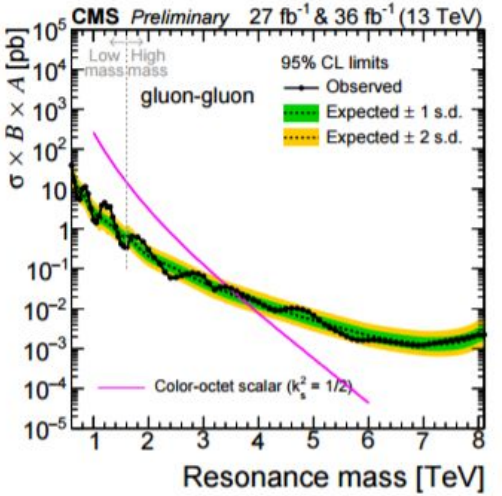


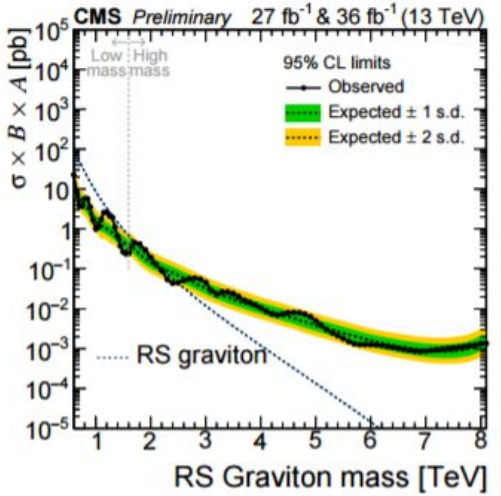
Figure 7: Left: 95% CL exclusion contours in the m_χ–m_A parameter plane. The solid (dashed) curve shows the median of the observed (expected) limit, while the bands indicate the $\pm 1\sigma$ theory uncertainties in the observed limit and $\pm 1\sigma$ range of the expected limit in the absence of a signal. The red curve corresponds to the expected relic density. The region excluded due to perturbativity, defined by $m_\chi > \sqrt{\pi/2}\, m_A$, is indicated by the hatched area. Right: A comparison of the inferred limits to the constraints from direct detection experiments on the spin-dependent WIMP–proton scattering cross section in the context of the Z'-like simplified model with axial-vector couplings. Unlike in the m_χ–m_A parameter plane, the limits are shown at 90% CL. The results from this analysis, excluding the region to the left of the contour, are compared with limits from the XENON100 [96], LUX [97], and PICO [98, 99] experiments. The comparison is model-dependent and solely valid in the context of this model, assuming minimal mediator width and the coupling values $g_q = 1/4$ and $g_\chi = 1$.

CMS di-jet



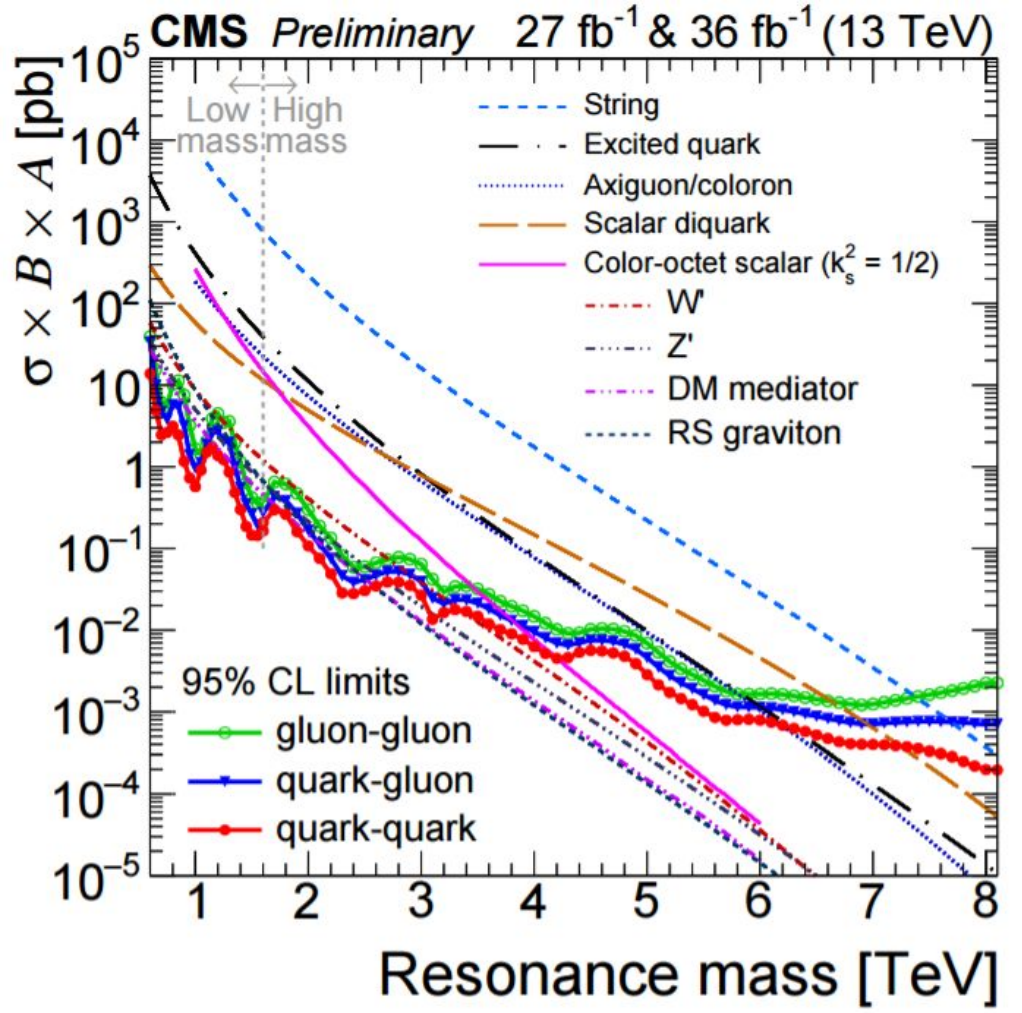






CMS di-jet

[EXO-16-056]



CMS di-jet

EXO-16-056

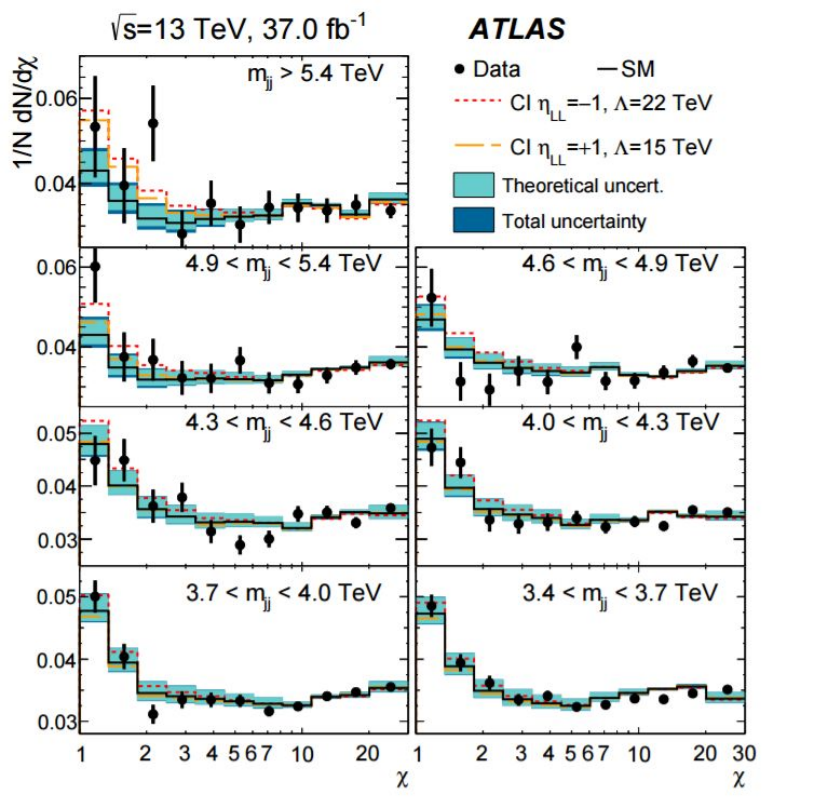
Table 1: Observed and expected mass limits at 95% CL from this analysis with 36 fb^{-1} at $\sqrt{s}$ = 13 TeV compared to previously published limits on narrow resonances from CMS with 12.9 fb^{-1} and 2.4 fb^{-1} at $\sqrt{s}$ = 13 TeV [3, 6] and with 20 fb^{-1} at $\sqrt{s}$ = 8 TeV [8]. The listed models are excluded between 0.6 TeV and the indicated mass limit by this analysis. In addition to the observed mass limits listed below, this analysis also excludes the RS Graviton model within the mass interval between 2.1 and 2.5 TeV and the Z′ model within roughly a 50 GeV window around 3.1 TeV.

Model	Final State	Observed (expected) mass limit [TeV] 36 fb^{-1} 13 TeV	12.9 fb^{-1} 13 TeV	2.4 fb^{-1} 13 TeV	20 fb^{-1} 8 TeV
String	qg	7.7 (7.7)	7.4 (7.4)	7.0 (6.9)	5.0 (4.9)
Scalar diquark	qq	7.2 (7.4)	6.9 (6.8)	6.0 (6.1)	4.7 (4.4)
Axigluon/coloron	$q\bar{q}$	6.1 (6.0)	5.5 (5.6)	5.1 (5.1)	3.7 (3.9)
Excited quark	qg	6.0 (5.8)	5.4 (5.4)	5.0 (4.8)	3.5 (3.7)
Color-octet scalar ($k_s^2 = 1/2$)	gg	3.4 (3.6)	3.0 (3.3)	—	—
W′	$q\bar{q}$	3.3 (3.6)	2.7 (3.1)	2.6 (2.3)	2.2 (2.2)
Z′	$q\bar{q}$	2.7 (2.9)	2.1 (2.3)	—	1.7 (1.8)
RS Graviton ($k/M_{PL} = 0.1$)	$q\bar{q}$, gg	1.7 (2.1)	1.9 (1.8)	—	1.6 (1.3)
DM Mediator (m_{DM} = 1 GeV)	$q\bar{q}$	2.6 (2.5)	2.0 (2.0)	—	—

CMS di-jet EXO-16-056

Di-jet

Di-jet analysis **NEW**, 37/fb arXiv:1703.09127

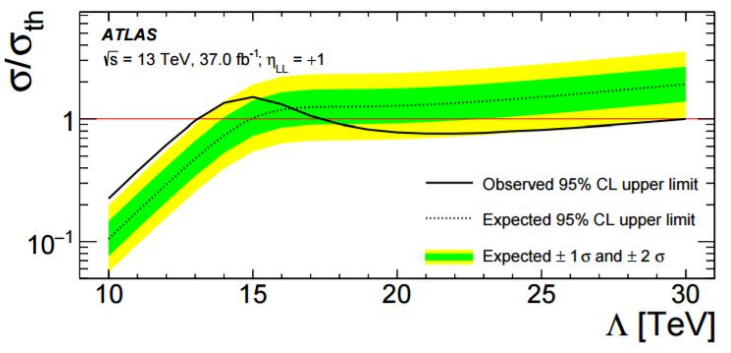


Simultaneous fit in 7 m_{jj} regions

- Non-resonant signals: look at **angular distribution** of jets

$$\chi = e^{2|y^*|} \sim \frac{1+\cos\theta^*}{1-\cos\theta^*}$$

- QCD dominated by **t-channel -> flat χ**
- s-channel, NLO QCD, LO EW corrections **-> χ dependence**
- **BSM more at low χ than QCD**
- QCD from Pythia LO + corrections
- μ_R/μ_F scale, jet energy scale: dominant unc.



Limits on contact interaction with destructive interrference with SM

Di-jet analysis **NEW**, 37/fb arXiv:1703.09127

Table 2: The 95% CL lower limits on the masses of ADD quantum black holes (BlackMax event generator), W' and W^* bosons, excited quarks, and Z' bosons for selected coupling values from the resonance search, as well as on the scale of contact interactions for constructive ($\eta_{LL} = -1$) and destructive ($\eta_{LL} = +1$) interference from the angular analysis. Where an additional range is listed, masses within the range are also excluded. Full limits on the Z' model are provided in Figure 4.

Model	95% CL exclusion limit	
	Observed	Expected
Quantum black hole	8.9 TeV	8.9 TeV
W'	3.6 TeV	3.7 TeV
W^*	3.4 TeV 3.77 TeV – 3.85 TeV	3.6 TeV
Excited quark	6.0 TeV	5.8 TeV
$Z'(g_q = 0.1)$	2.1 TeV	2.1 TeV
$Z'(g_q = 0.2)$	2.9 TeV	3.3 TeV
Contact interaction ($\eta_{LL} = -1$)	21.8 TeV	28.3 TeV
Contact interaction ($\eta_{LL} = +1$)	13.1 TeV 17.4 TeV – 29.5 TeV	15.0 TeV

Photon+x

Photon+X simulations

arXiv:1704.03848

Process	Generators used	PDF sets	Order	Requirements
DMsimp model	MG5_aMC@NLO v2.4.3 + PYTHIA 8.212	NNPDF30_nlo_as_0118	NLO	$E_{\mathrm{T}}^{\gamma} > 130$ GeV
EFT model	MG5_aMC@NLO v2.2.3 + PYTHIA 8.186	NNPDF30_lo_as_0130	LO	$E_{\mathrm{T}}^{\gamma} > 130$ GeV
BSM resonance	POWHEG-BOX + PYTHIA 8.210	CT10	NLO	--
$W/Z\gamma$	SHERPA 2.1.1	CT10	LO	for γ^*/Z:$m_{\ell\ell} > 10$ GeV
γ-jets	SHERPA 2.1.1	CT10	LO	--
W/Z+jets	SHERPA 2.2.0	NNPDF3.0 at NNLO	LO/NLO	--

Photon+X selection

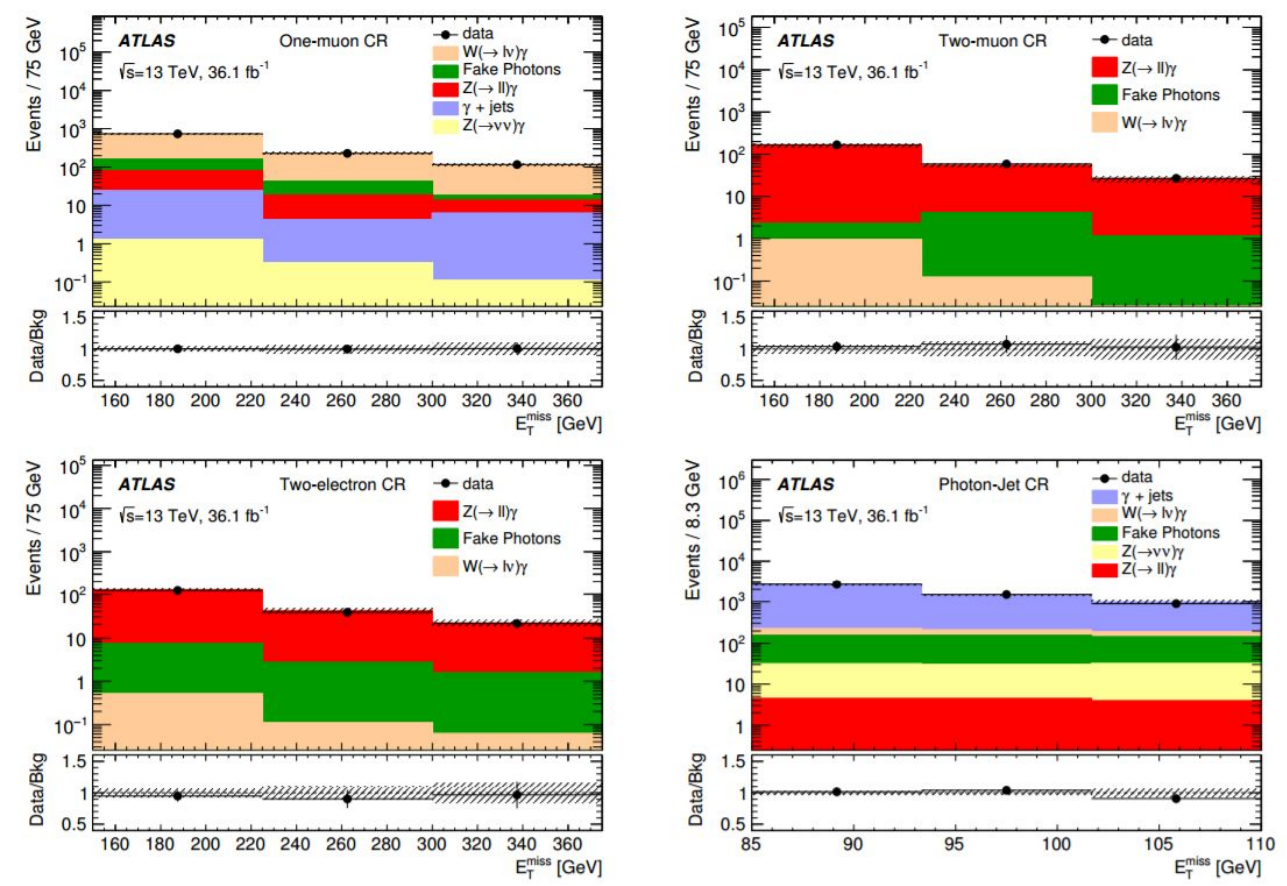
arXiv:1704.03848

Table 2: Criteria for selecting events in the SRs and the numbers of events selected in data.

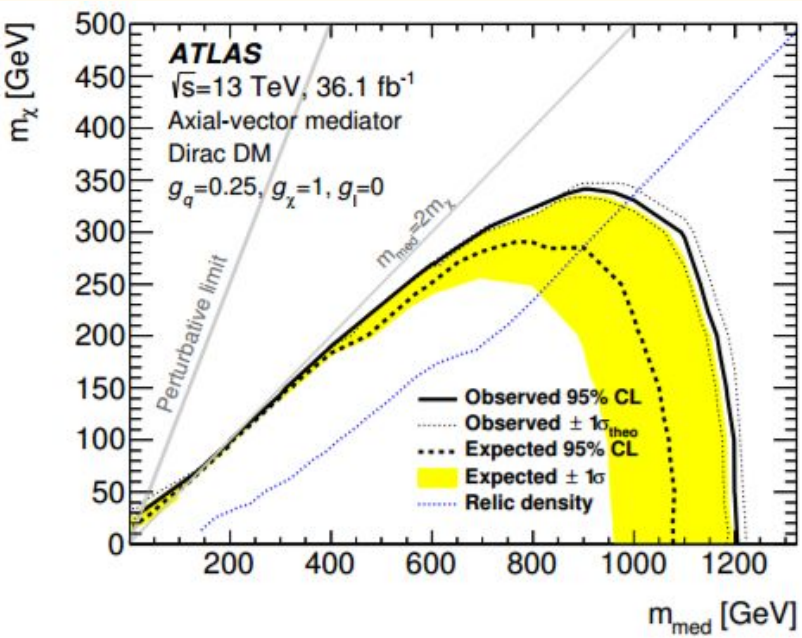
Event cleaning	Quality and Primary vertex				
Leading γ	$E_{\mathrm{T}}^{\gamma} > 150$ GeV, $\lvert\eta\rvert < 1.37$ or $1.52 < \lvert\eta\rvert < 2.37$, tight, isolated, $\lvert z\rvert < 0.25$ m, $\Delta\phi(\gamma, \boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}}) > 0.4$				
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{\Sigma E_T}$	$> 8.5\ \mathrm{GeV}^{1/2}$				
Jets	0 or 1 with $p_{\mathrm{T}} > 30$ GeV, $\lvert\eta\rvert < 4.5$ and $\Delta\phi(\mathrm{jet}, \boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}}) > 0.4$				
Lepton	veto on e and μ				
	SRI1	SRI2	SRI3	SRE1	SRE2
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 150	> 225	> 300	150–225	225–300
Selected events in data	2400	729	236	1671	493
Events with 0 jets	1559	379	116	1180	263

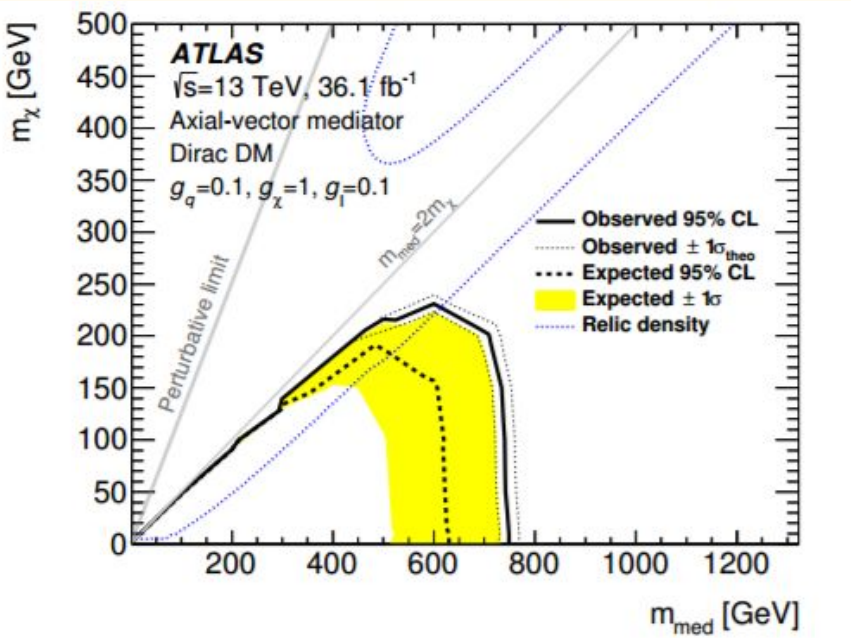
Photon+X CRs

arXiv:1704.03848



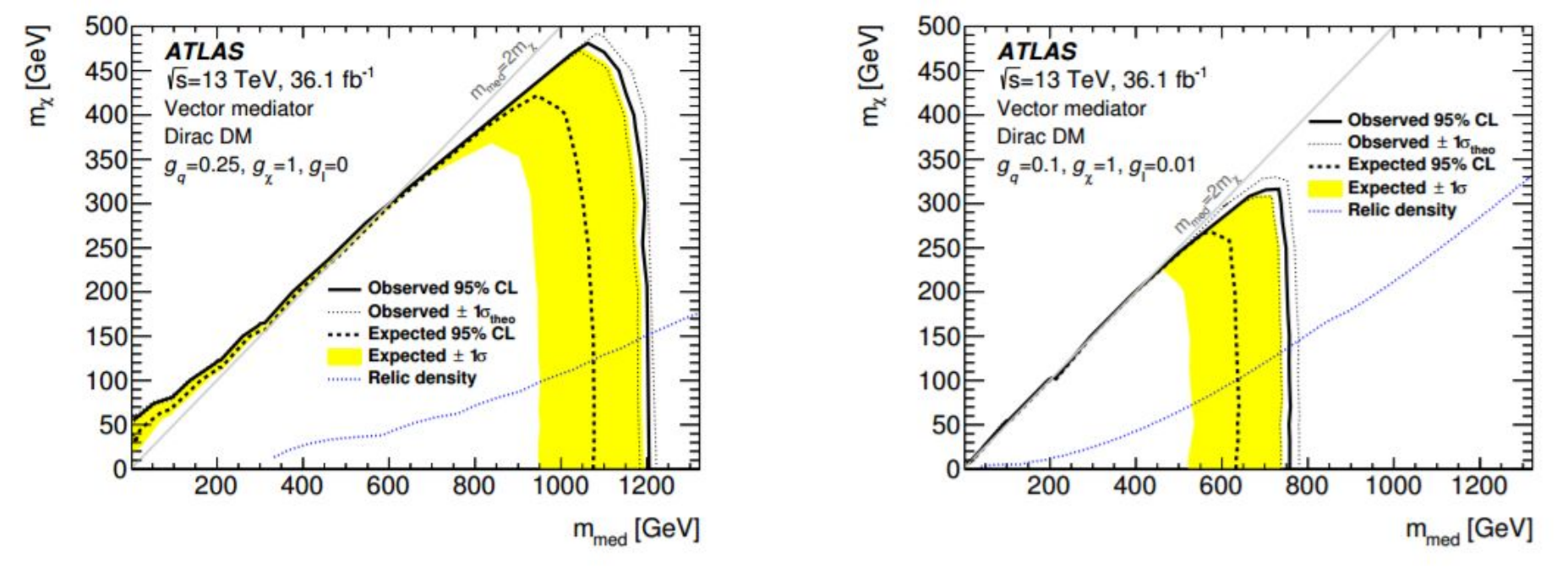
Photon+X results: AV mediator [arXiv:1704.03848]





Photon+X results: V mediator

arXiv:1704.03848

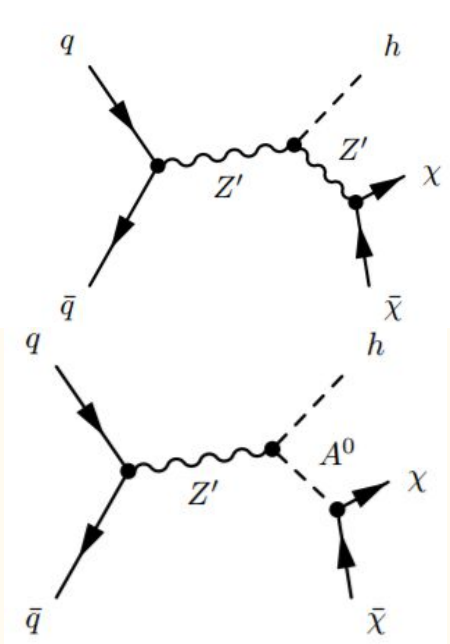


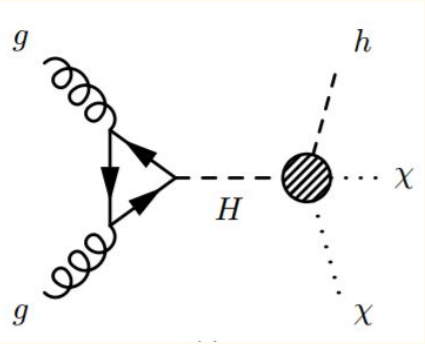
X+h->γγ

X+h->γγ signal models

- Z'_B model, vector mediator for a $U(1)_B$ symmetry, with mass given by an additional scalar Higgs (mixing with the SM higgs with a given angle)
  - Parameters: g_q, g_{DM}, $g_{hZ'Z'}$ (dimensional parameter, dimension of a mass), mixing angle, $m_{Z'}$, m_{DM}
- Z'-2HDM model
  - different kinematics, due to on-shell Z' production -> harder MET spectrum
  - Parameters: m_A, m_{DM}, $m_{Z'}$, ratio VEV 2HDM, $g_{Z'}$
- Heavy scalar model
  - $2m_h < m_H < 2m_t$
  - DM is with spin-0 here

ATLAS-CONF-2017-024

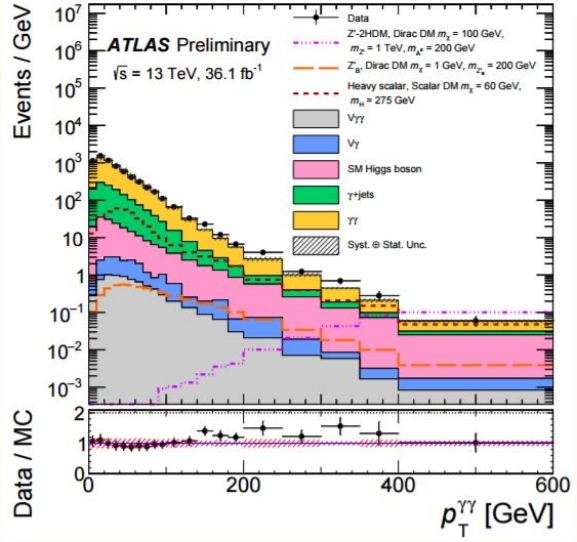


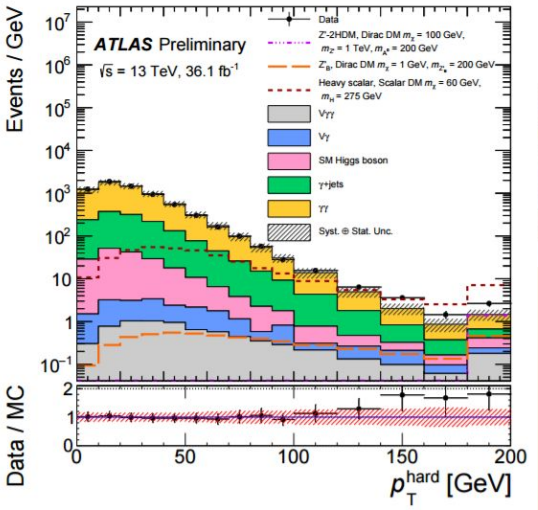


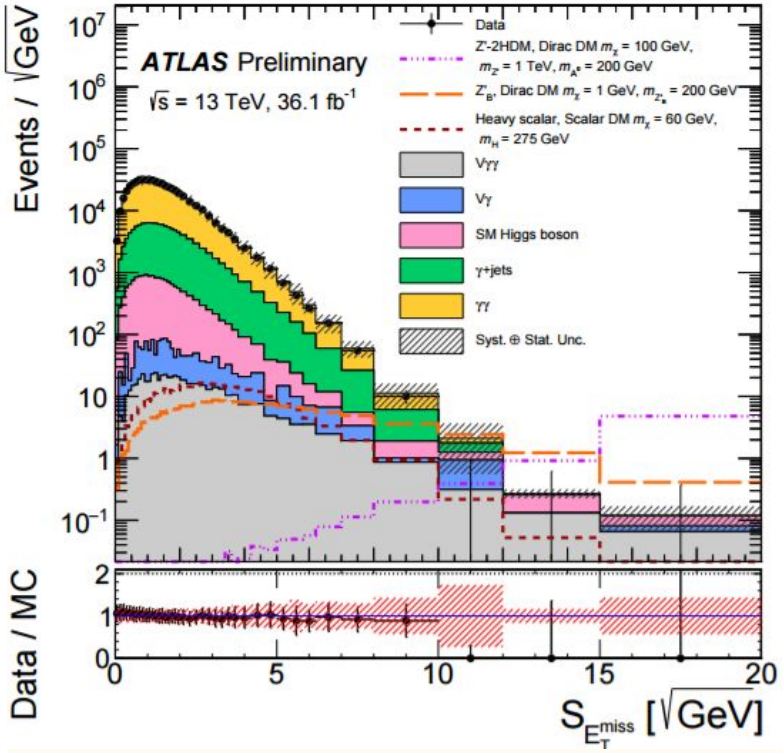
X+h->γγ ATLAS-CONF-2017-024

Table 1: Optimized criteria used in the categorization. Each category excludes events that are in the upper categories.

Category	Requirements
Mono-Higgs	$S_{E_{\mathrm{T}}^{\mathrm{miss}}} > 7\ \sqrt{\mathrm{GeV}}$, $p_{\mathrm{T}}^{\gamma\gamma} > 90$ GeV, lepton veto
High-$E_{\mathrm{T}}^{\mathrm{miss}}$	$S_{E_{\mathrm{T}}^{\mathrm{miss}}} > 5.5\ \sqrt{\mathrm{GeV}}$, $\lvert z_{PV}^{\mathrm{hard}} - z_{PV}^{\gamma\gamma}\rvert < 0.1$ mm
Intermediate-$E_{\mathrm{T}}^{\mathrm{miss}}$	$S_{E_{\mathrm{T}}^{\mathrm{miss}}} > 4\ \sqrt{\mathrm{GeV}}$, $p_{\mathrm{T}}^{\mathrm{hard}} > 40$ GeV, $\lvert z_{PV}^{\mathrm{hard}} - z_{PV}^{\gamma\gamma}\rvert < 0.1$ mm
Different-Vertex	$S_{E_{\mathrm{T}}^{\mathrm{miss}}} > 4\ \sqrt{\mathrm{GeV}}$, $p_{\mathrm{T}}^{\mathrm{hard}} > 40$ GeV, $\lvert z_{PV}^{\mathrm{hard}} - z_{PV}^{\gamma\gamma}\rvert > 0.1$ mm
Rest	$p_{\mathrm{T}}^{\gamma\gamma} > 15$ GeV







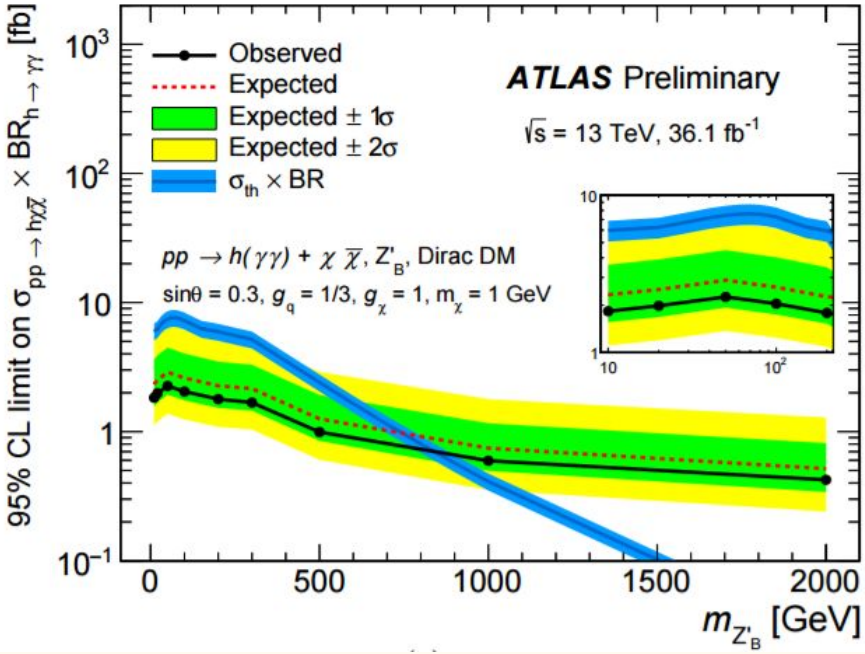
X+h->γγ ATLAS-CONF-2017-024

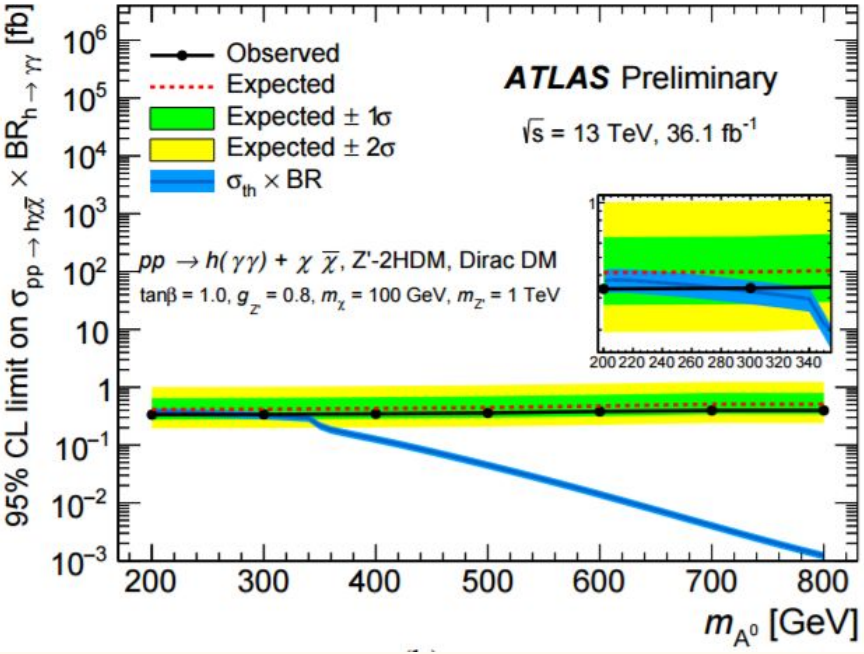
Source	Signals (%)	Backgrounds (%)	
		SM Higgs boson	Non-resonant background
Experimental			
Luminosity		3.2	-
Trigger efficiency		0.4	-
Vertex selection		< 0.01	-
Photon energy scale	0.1 – 2	0.1 – 1.4	-
Photon energy resolution	0.1 – 0.2	0.1 – 1.1	-
Photon identification efficiency	2.9 – 4.3	1.9 – 3.8	-
Photon isolation efficiency	1.2	0.8 – 1.6	-
$E_{\mathrm{T}}^{\mathrm{miss}}$ reconstruction (diphoton vertex)	< 0.01	0.5 – 1.9	-
$E_{\mathrm{T}}^{\mathrm{miss}}$ reconstruction (jets, soft term)	1.0 – 1.4	0.8 – 22.5	-
Diphoton vertex = hardest vertex	0.0 –1.9	0.0 – 6.0	-
Pileup reweighting	0.2 – 5.6	0.7 – 11.0	-
Non-resonant background modeling	-	-	0.01 – 9.8
Theoretical			
Factorisation and renormalisation scale	0.6 – 11	2.5 – 6.0	-
PDF+α_S	10.5 – 25	1.2 – 2.9	-
Multi-parton interactions	< 1	0.4 – 5.8	-
BR($H \to \gamma\gamma$)		1.73	-

X+h->γγ ATLAS-CONF-2017-024

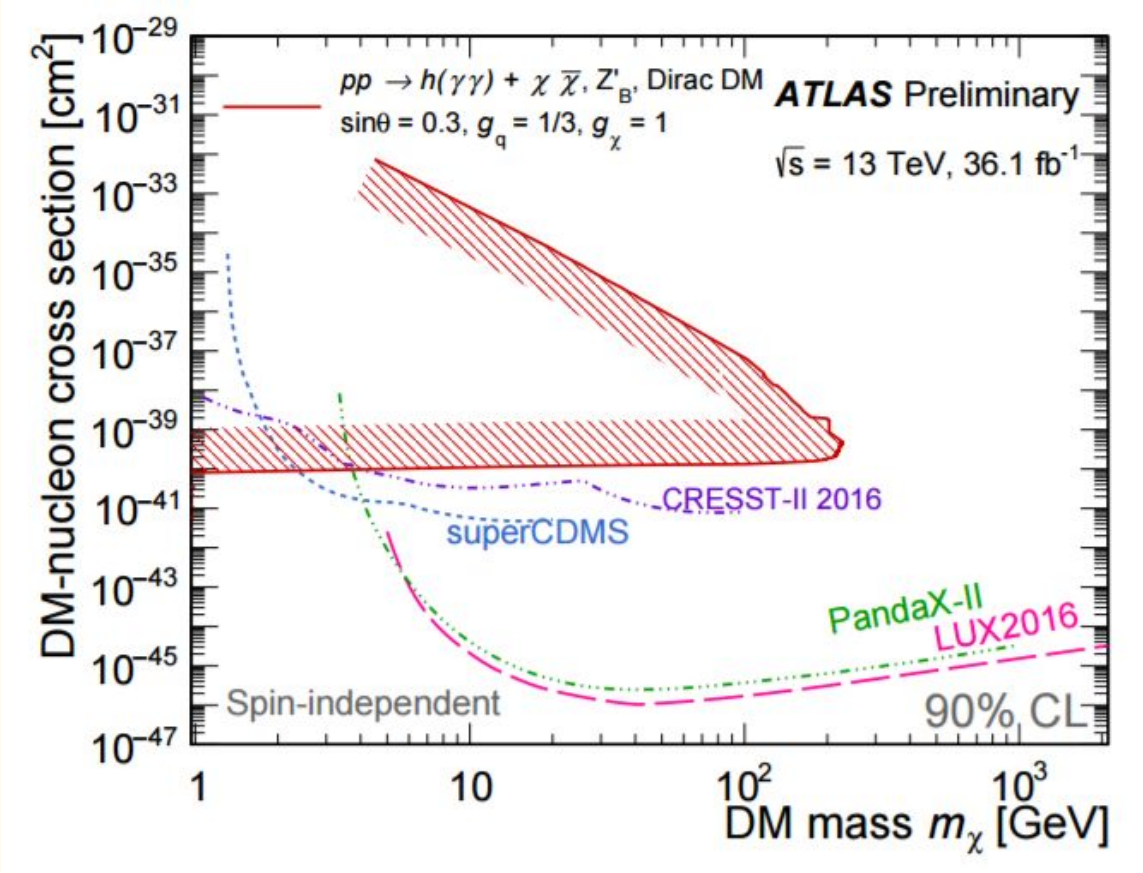
Category	Mono-Higgs	High-E_T^{miss}	Intermediate-E_T^{miss}	Different-Vertex	Rest
Data	9	72	464	1511	46804
Backgrounds					
SM Higgs boson	2.43 ± 0.22	4.2 ± 0.6	11.9 ± 2.7	44 ± 10	1360 ± 110
Non-resonant	9.9 ± 1.9	62 ± 5	418 ± 10	1490 ± 18	45570 ± 110
Total background	12.3 ± 1.9	67 ± 5	430 ± 10	1535 ± 21	46930 ± 170
Heavy scalar, m_H = 275 GeV, m_χ = 60 GeV					
Expected yields	10.9 ± 1.4	23.8 ± 3.2	43 ± 5	33 ± 5	222 ± 20
$A \times \epsilon$ (%)	1.22 ± 0.07	2.67 ± 0.10	4.82 ± 0.14	3.65 ± 0.13	24.9 ± 0.4
Z'_B model, $m_{Z'_B}$ = 200 GeV, m_χ = 1 GeV					
Expected yields	20.0 ± 4.5	–	–	–	–
$A \times \epsilon$ (%)	17.4 ± 0.2	–	–	–	–
Z'-2HDM model, $m_{Z'}$ = 1000 GeV, m_{A^0} = 200 GeV, and m_χ = 100 GeV					
Expected yields	28.0 ± 5.3	–	–	–	–
$A \times \epsilon$ (%)	70.7 ± 0.2	–	–	–	–

X+h->γγ ATLAS-CONF-2017-024





X+h->γγ ATLAS-CONF-2017-024

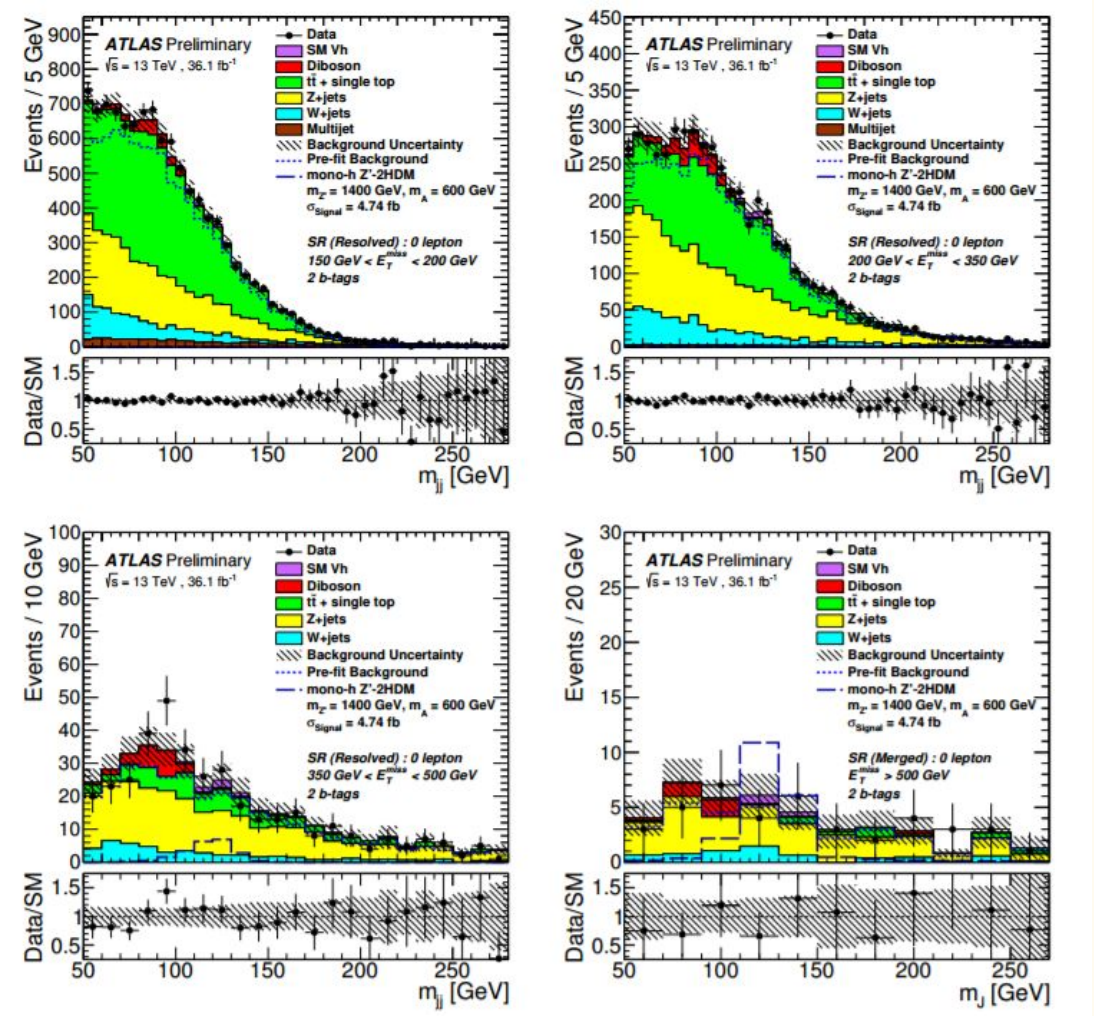


X+h->bb

X+h->bb ATLAS-CONF-2017-028

Table 1: Dominant sources of uncertainty for three representative scenarios: (a) with $(m_{Z'}, m_A) = (0.6\,\text{TeV}, 0.3\,\text{TeV})$ described by low $E_{\text{T}}^{\text{miss}}$, (b) with $(m_{Z'}, m_A) = (1.4\,\text{TeV}, 0.6\,\text{TeV})$ characterized by medium $E_{\text{T}}^{\text{miss}}$, and (c) with $(m_{Z'}, m_A) = (2.6\,\text{TeV}, 0.3\,\text{TeV})$ featuring high $E_{\text{T}}^{\text{miss}}$. The effect is expressed as the fractional uncertainty on the signal yield, assuming total cross-sections of (a) 425 fb, (b) 4.74 fb, and (c) 1.91 fb. Total is the quadrature sum of statistical and total systematic uncertainties.

Source of uncert.	Impact [%]		
	(a)	(b)	(c)
V+jets modeling	5.0	5.7	8.2
$t\bar{t}$, single-t modeling	3.2	3.0	3.9
SM $Vh(b\bar{b})$ norm.	2.2	6.9	6.9
Signal modeling	3.9	2.9	2.1
MC statistics	4.9	11	22
Luminosity	3.2	4.5	5.4
b-tagging, track jets	1.4	11	17
b-tagging, calo jets	5.0	3.4	4.7
Jets with $R = 0.4$	1.7	3.8	2.1
Jets with $R = 1.0$	<0.1	1.2	4.7
Total systematic	10	21	36
Statistical	6	38	62
Total	12	43	71



X+h->bb

ATLAS-CONF-2017-028

X+h->bb ATLAS-CONF-2017-028

Table 2: Upper limits at 95% confidence level on the visible cross-section $\sigma_{\text{vis},h+\text{DM}}$ of h+DM events. The observed $\sigma^{\text{obs}}_{\text{vis},h+\text{DM}}$ is consistent with the expectation $\sigma^{\text{exp}}_{\text{vis},h+\text{DM}}$ within uncertainties. Also shown are the $\mathcal{A} \times \varepsilon$ values to reconstruct and select an event in the same $E_{\text{T}}^{\text{miss}}$ bin as generated.

Range in $E_{\text{T}}^{\text{miss}}$/GeV	$\sigma^{\text{obs}}_{\text{vis},h+\text{DM}}$ [fb]	$\sigma^{\text{exp}}_{\text{vis},h+\text{DM}}$ [fb]	$\mathcal{A} \times \varepsilon$ %
[150, 200)	19.1	$18.3^{+7.2}_{-5.1}$	15
[200, 350)	13.1	$10.5^{+4.1}_{-2.9}$	35
[350, 500)	2.4	$1.7^{+0.7}_{-0.5}$	40
[500, ∞)	1.7	$1.8^{+0.7}_{-0.5}$	55

X+V->hadronic

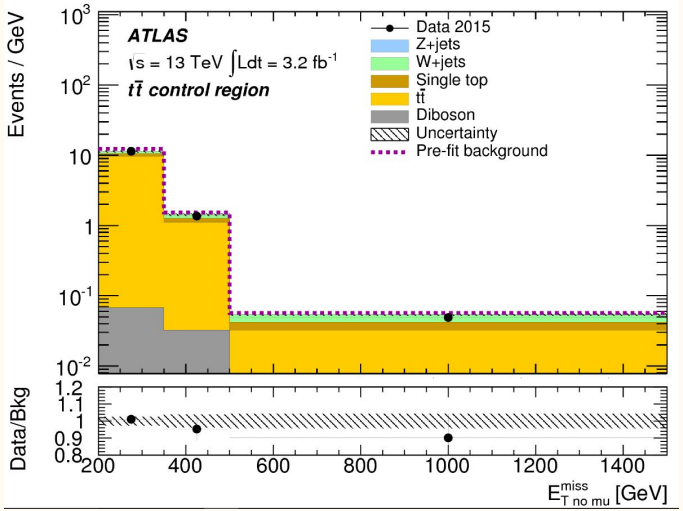
X+V->hadronic: selection and background

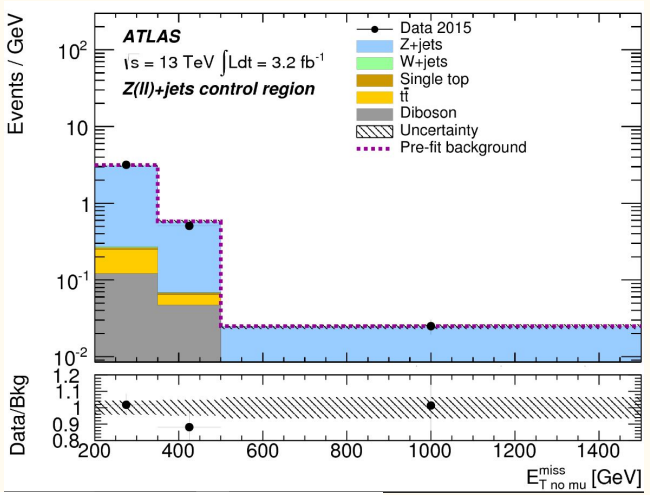
- Trigger MET>70 GeV
- MET>250 GeV, p_T^{miss}>30 GeV
- >=1 large-R jet with p_T>200 GeV, m_J consistent with W/Z, D_2 cut
- ΔΦ(MET,jets)>0.6 rad
- ΔΦ(MET,p_T^{miss})<90°

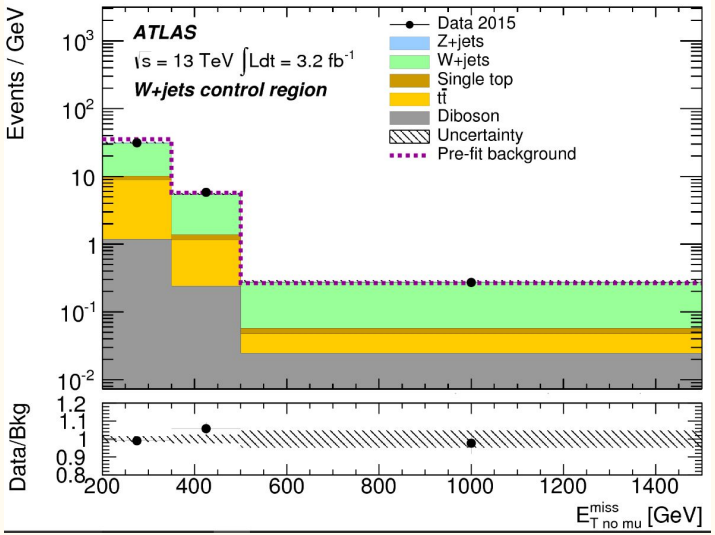
Bkg CRs all require one large-R jet with D_2 cut, MET>200 GeV, p_T^{miss}>30 GeV

- Z+jets in 2mu CR, mass compatible with Z
- W boson in 1mu CR, no-btag
- top in 1mu CR, >=1 b-tagged track jet

X+V->hadronic: CRs

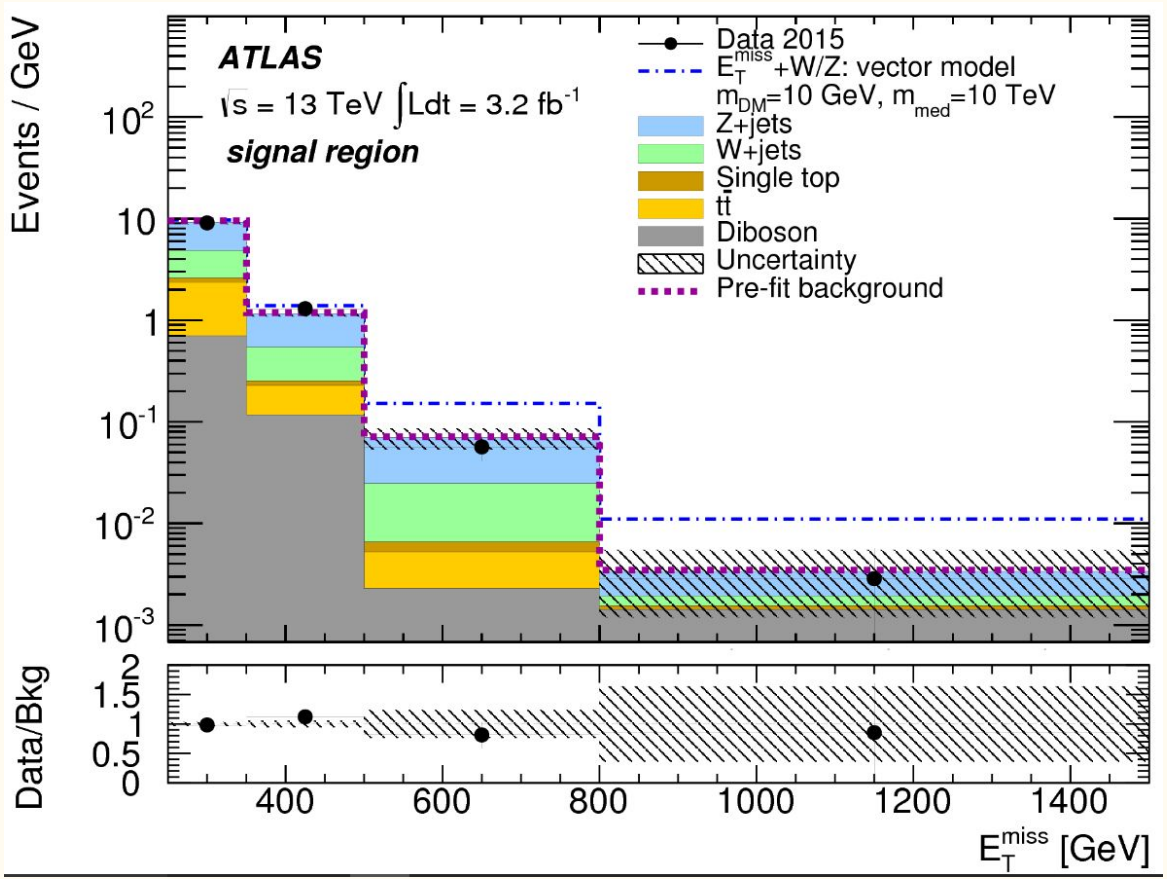






PLB 763 (2016) 251

X+V->hadronic: SR

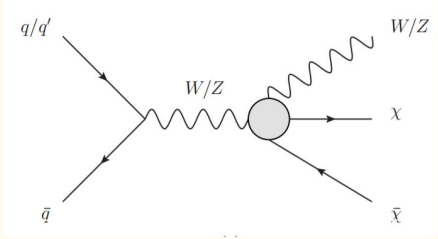


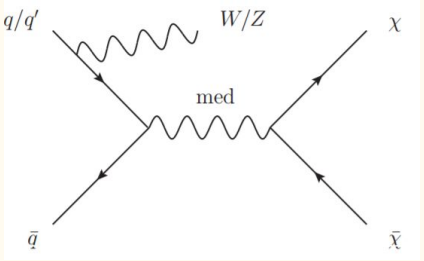
Process	Events
Z+jets	544 ± 33
W+jets	275 ± 24
$t\bar{t}$ and single-top	211 ± 19
Diboson	89 ± 12
Total Background	1120 ± 47
Data	1121

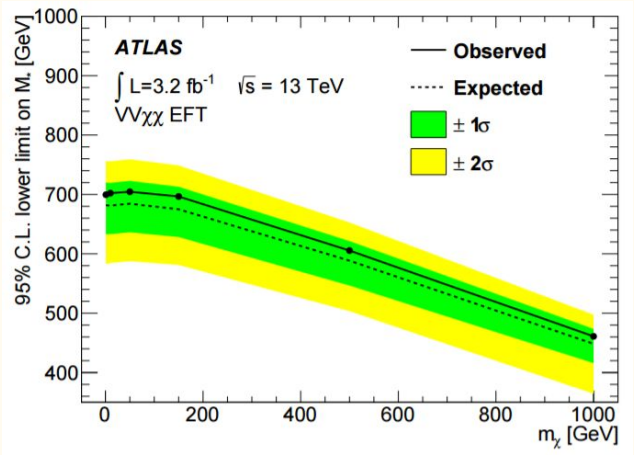
Process	Normalization Factor
Z+jets	1.01 ± 0.16
W+jets	0.90 ± 0.16
$t\bar{t}$	0.91 ± 0.18

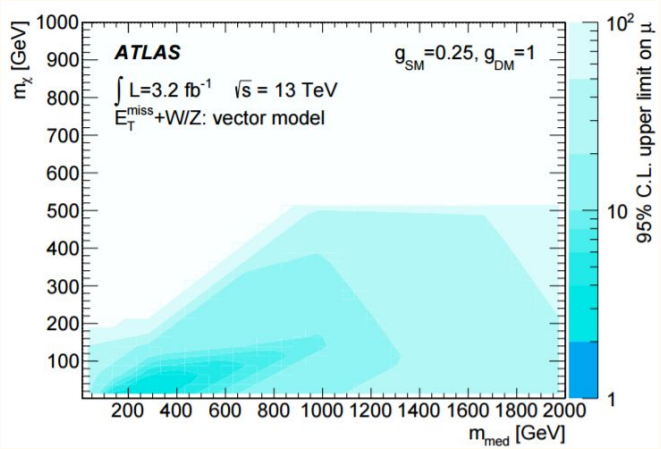
PLB 763 (2016) 251

V+X with V->hadron limits on VV$\chi\chi$ EFT model and on a simplified model









PLB 763 (2016) 251

X+ll

X+ll: signal models

ATLAS-CONF-2016-056

- High mass analysis
  - heavy H -> ZZ -> llnunu in 300-1000 GeV region, narrow width
    - particularly relevant above 500 GeV in the ZZ combination
  - llnunu final state used also for spin-2 KK graviton in the Randall-Sundrum framework with warped extra dimension (RS1)
- Low mass analysis
  - Mono-Z(->ll), vector interaction
  - Zh with Z->ll, h->invisible (prediction, 0.1% due to ZZ->nununu)

X+ll: event selection

ATLAS-CONF-2016-056

Event Selection		
Exactly one ee or $\mu\mu$ pair		
$p_T(e/\mu) > 30(20)$ GeV for leading (sub-leading) lepton		
Selection	**High Mass**	**Low Mass**
$\lvert m_{ll} - m_Z \rvert$	< 15 GeV	
E_T^{miss}	> 120 GeV	> 90 GeV
$\Delta R_{\ell\ell}$	< 1.8	
$\lvert \Delta\phi(\vec{p}_T^{\ell\ell}, \vec{E}_T^{miss}) \rvert$	> 2.7	
$\lvert p_T^{miss,jet} - p_T^{\ell\ell} \rvert / p_T^{\ell\ell}$	< 0.2	
$\lvert \Delta\phi(\vec{E}_T^{miss}, jets) \rvert$	> 0.4 $p_T(jet) > 100$ GeV	> 0.7 $p_T(jet) > 25$ GeV
$p_T^{\ell\ell}/m_T$	< 0.7	< 0.9
Number of b-jets	$= 0$	

High Mass SR	ggF	
m_H [GeV]	600	1000
Acc. × Eff.	47% (ee) 47% ($\mu\mu$)	54% (ee) 48% ($\mu\mu$)

Low Mass SR	ZH	Mono-Z	
Signal Model	$qqZH$	$(m_\chi, m_{med}) = (1, 10)$ GeV	$(m_\chi, m_{med}) = (50, 300)$ GeV
Acc. × Eff.	18% (ee) 19% ($\mu\mu$)	2% (ee) 2% ($\mu\mu$)	13% (ee) 14% ($\mu\mu$)

X+ll: background estimation

ATLAS-CONF-2016-056

- ZZ from MC
- WZ in the 3l CR, ll pair compatible with Z + 1 e/mu
  - m_T^W>60 GeV to reduce contamination from Z+jets and tt
  - no b-jets

$$N_{WZ}^{\mathrm{SR}} = N_{WZ,\,\mathrm{MC}}^{\mathrm{SR}} \times \frac{N_{\mathrm{data}}^{3\ell} - N_{\text{non-}WZ,\,\mathrm{MC}}^{3\ell}}{N_{WZ,\,\mathrm{MC}}^{3\ell}} = N_{WZ,\,\mathrm{MC}}^{\mathrm{SR}} \times f_{WZ}$$

  - the corection factor f_{WZ} results = 1.25+-0.04+-0.05
- Z+jets from ABCD method, cuts on fractional p_T <0.2 and $\Delta\Phi(\mathrm{MET}, p_T^{ll})$>2.7, then

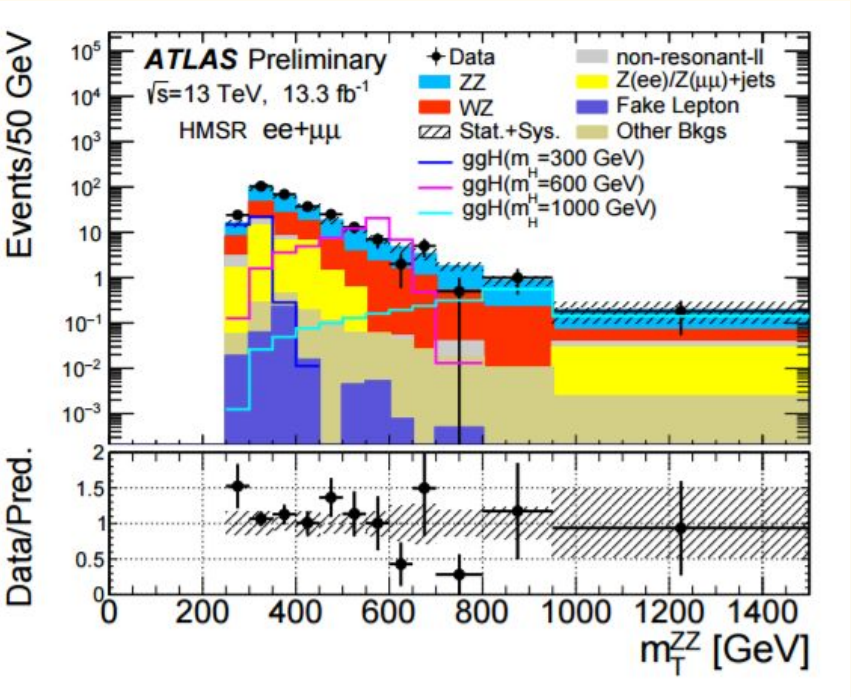
$$N_{Z+\mathrm{jets}}^{\mathrm{SR}} = N_{\mathrm{data\text{-}nonZ}}^{C} \times \frac{N_{\mathrm{data\text{-}nonZ}}^{B}}{N_{\mathrm{data\text{-}nonZ}}^{D}}$$

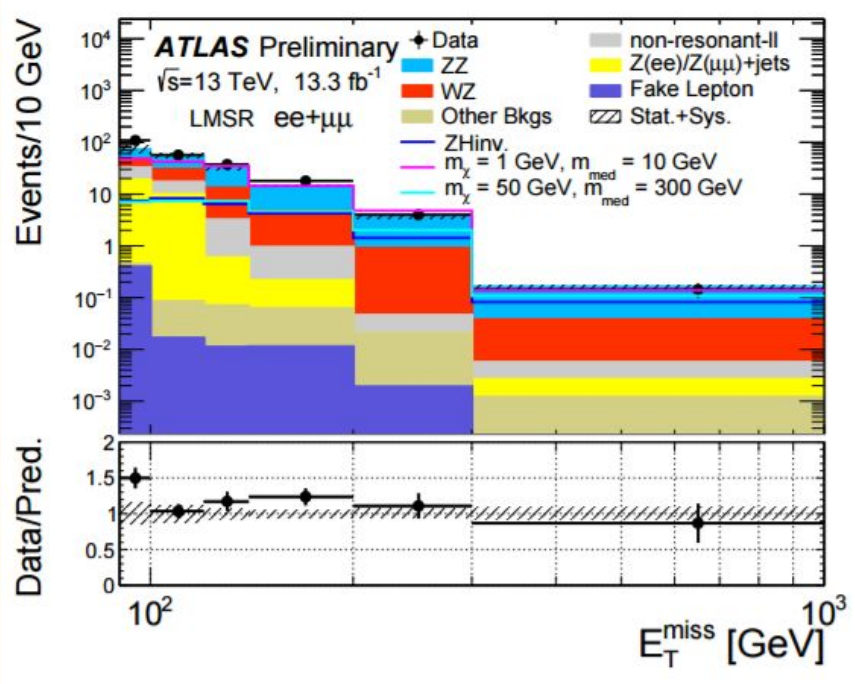
$$N_{\text{non-resonant-}\ell\ell}^{\mathrm{SR}} = \frac{1}{2} \times \epsilon_{\mathrm{corr}} \times N_{\mathrm{data\text{-}other}}^{e\mu}$$

- Non-resonant (WW, tt, Wt, Z->tautau) in emu CR
- Fake-lepton (small) from data CR with one loose but non tight lepton, multiplied by a fake factor measured in Z+jets events as #jets passing quality/#jets passing loose quality

X+ll results

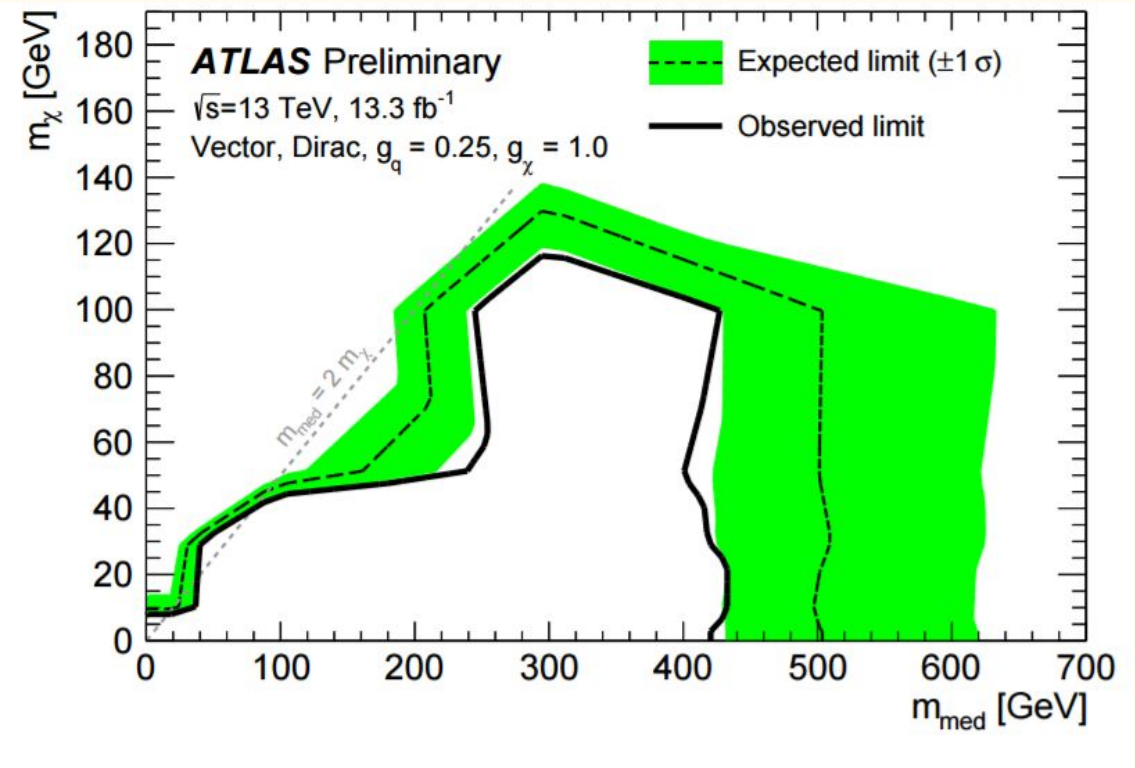
ATLAS-CONF-2016-056





X+ll results

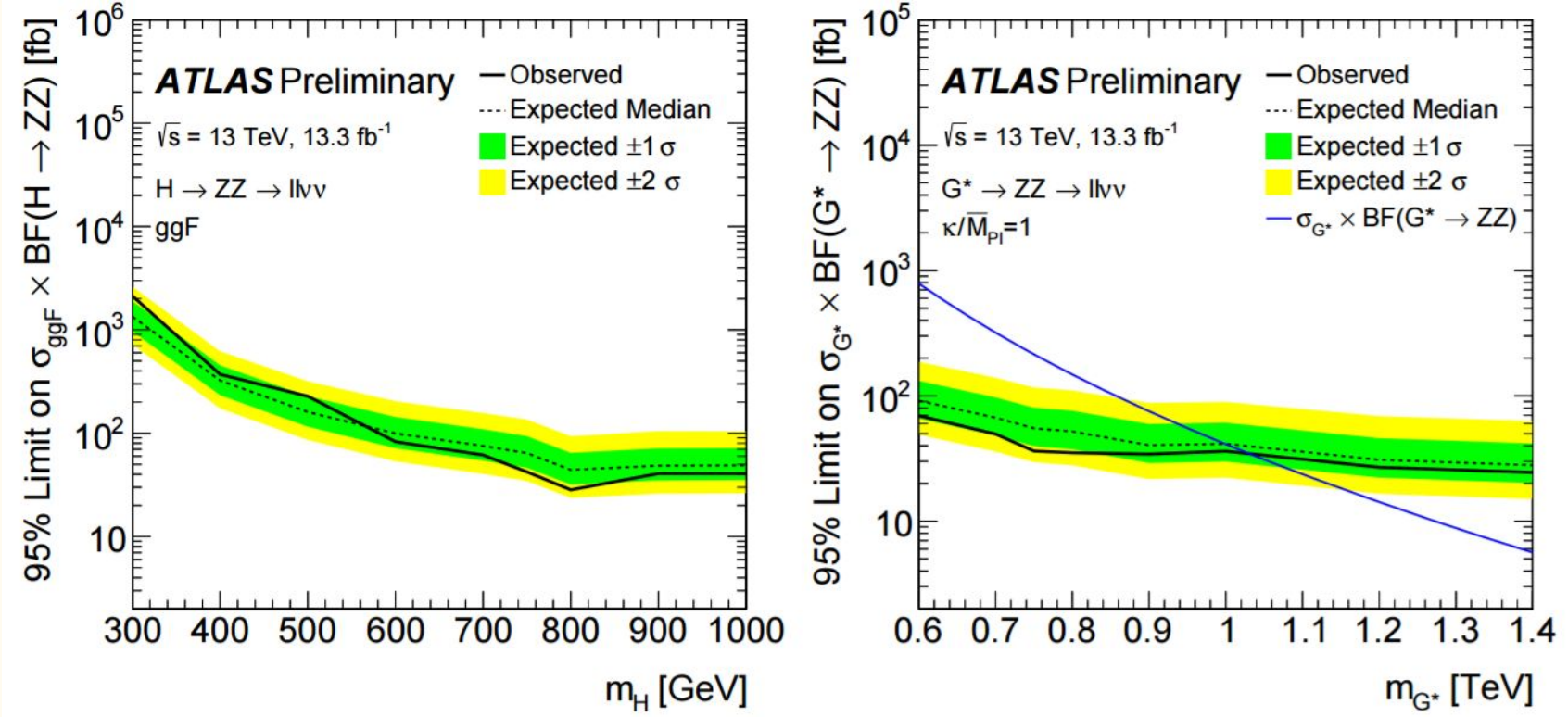
[ATLAS-CONF-2016-056]



	Limits on $\sigma(Z(\to \ell\ell)H(\to$ invisible)) [fb]		Limits on BF($H \to$ invisible)	
	Expected	Observed	Expected	Observed
Central Value	58	88	65%	98%
$(-1\sigma, +1\sigma)$	(41, 83)		(46%, 93%)	
$(-2\sigma, +2\sigma)$	(30, 115)		(34%, 100%)	

X+ll results

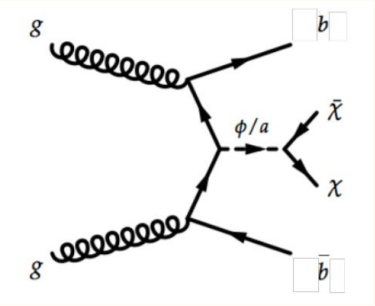
ATLAS-CONF-2016-056



DM+bb

DM+bb selection

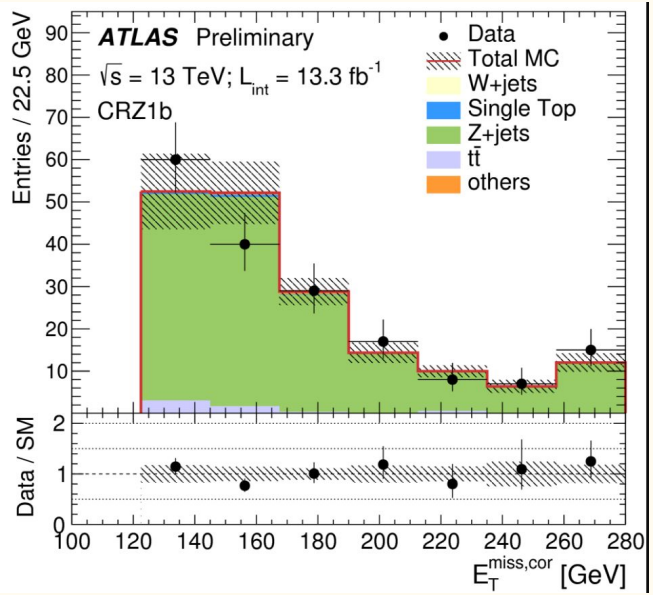
ATLAS-CONF-2016-086

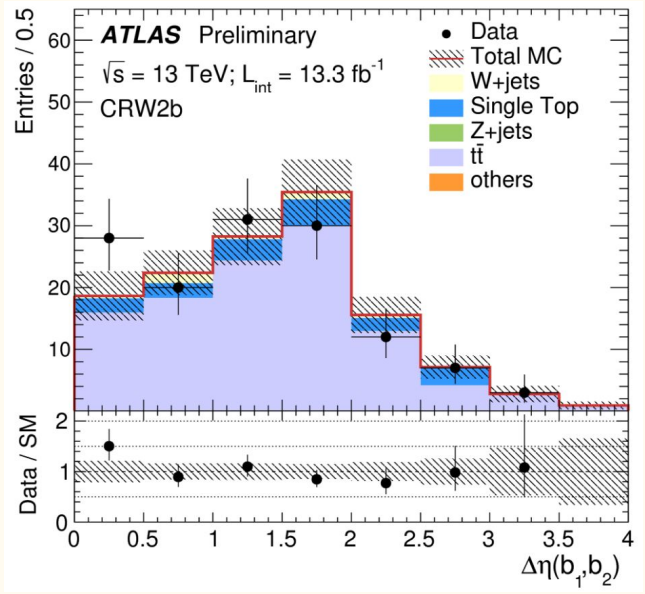


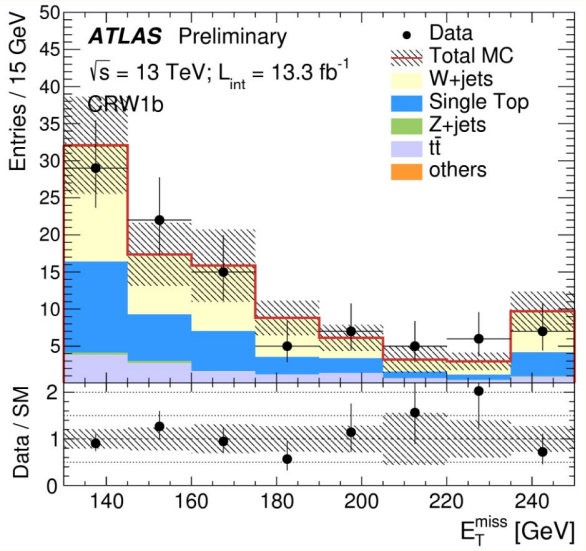
Quantity	SR	CRZ1b	VRZ2b	CRW1b	VRW1b	CRW2b	VRLR
$\mathcal{N}_{lepton}$ (baseline)	0	2 (SFOS)	2 (SFOS)	1	1	1	0
$\mathcal{N}_{lepton}$ (high-purity)	0	2 (SFOS)	2 (SFOS)	1	1	1	0
$\Delta\phi^{j}_{\min}$	> 0.4	> 0.4	> 0.4	> 0.4	> 0.4	> 0.4	> 0.4
$\mathcal{N}_{jets}$	$2-3$	$2-3$	$2-3$	$2-3$	$2-3$	$2-3$	$2-3$
$\mathcal{N}_{bjets}$	$= 2$	$= 1$	$= 2$	$= 1$	$= 1$	$= 2$	$= 2$
jet 1 p_{T} [GeV]	> 100	> 100	> 85	> 100	> 100	> 100	> 100
jet 2 p_{T} [GeV]	> 20	> 20	> 20	> 30	> 30	> 20	> 20
jet 3 p_{T} [GeV]	< 60	< 60	< 60	< 60	< 60	< 60	< 60
$p_{\mathrm{T}}^{\text{b-jet1}}$ [GeV]	> 50	> 50	> 50	> 50	> 50	> 50	> 50
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 150	< 100	< 80	> 130	> 150	> 120	> 150
$E_{\mathrm{T}}^{\mathrm{miss,cor}}$ [GeV]	-	> 120	> 100	-	-	-	-
ΔR_{min}	> 2.8	> 2.8	> 2.8	> 2.5	> 2.8	> 2.8	< 2.5
$\Delta\eta(b_1, b_2)$	> 0.5	-	-	-	> 0.5	-	> 0.5
$Imb(b_1, b_2)$	> 0.5	-	-	-	-	-	> 0.5
m_{T}^{lep}	-	-	-	$[30, 100]$	$[30, 100]$	> 30	-
$m_{\ell\ell}$	-	$[75, 105]$	$[80, 100]$	-	-	-	-
lepton 1 p_{T} [GeV]	-	> 30	> 30	> 30	> 30	> 30	-
lepton 2 p_{T} [GeV]	-	> 25	> 25	-	-	-	-
$\Delta\phi(b_1, b_2)$	> 2.2	> 2.2	-	$[1, 2.2]$	> 2.2	> 2.2	> 2.2

DM+bb background [ATLAS-CONF-2016-086]

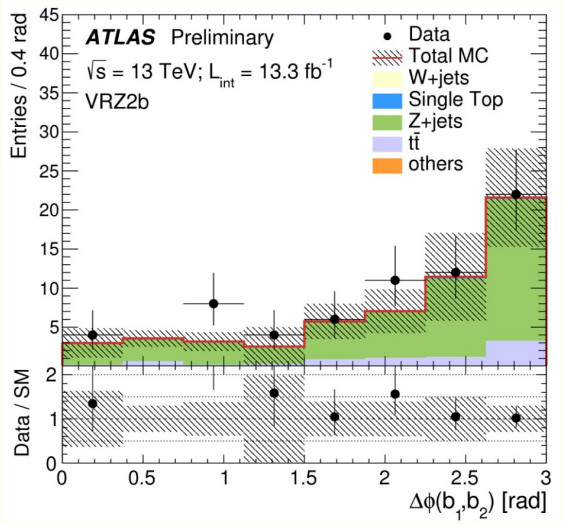
- Same flavour, opposite sign 2l CR for Z+jets
- 1 lepton, 2 b-jets: CRW2b for tt
- 1 lepton, 1 b-jet: CRW1b for W+jets and single-top

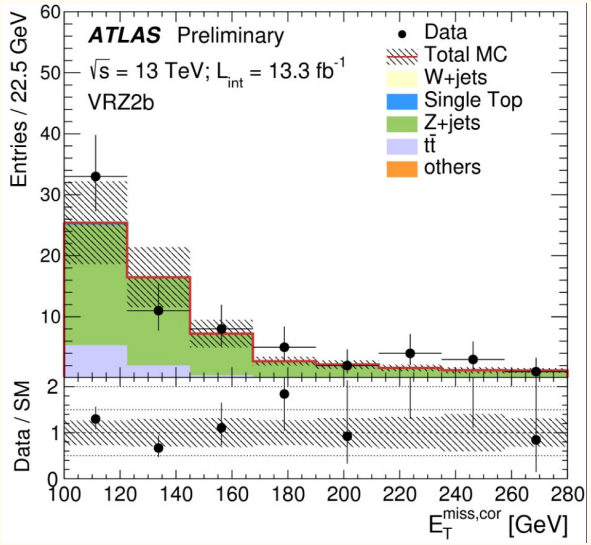


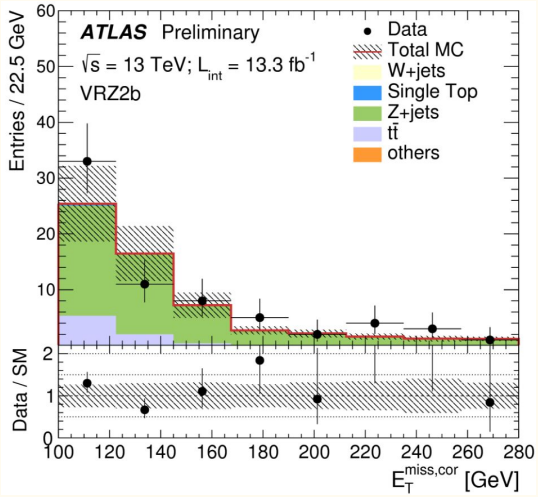


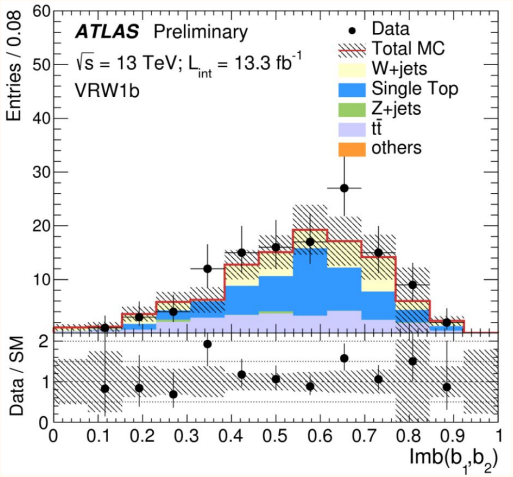


DM+bb validation regions









ATLAS-CONF-2016-086

DM + bb results

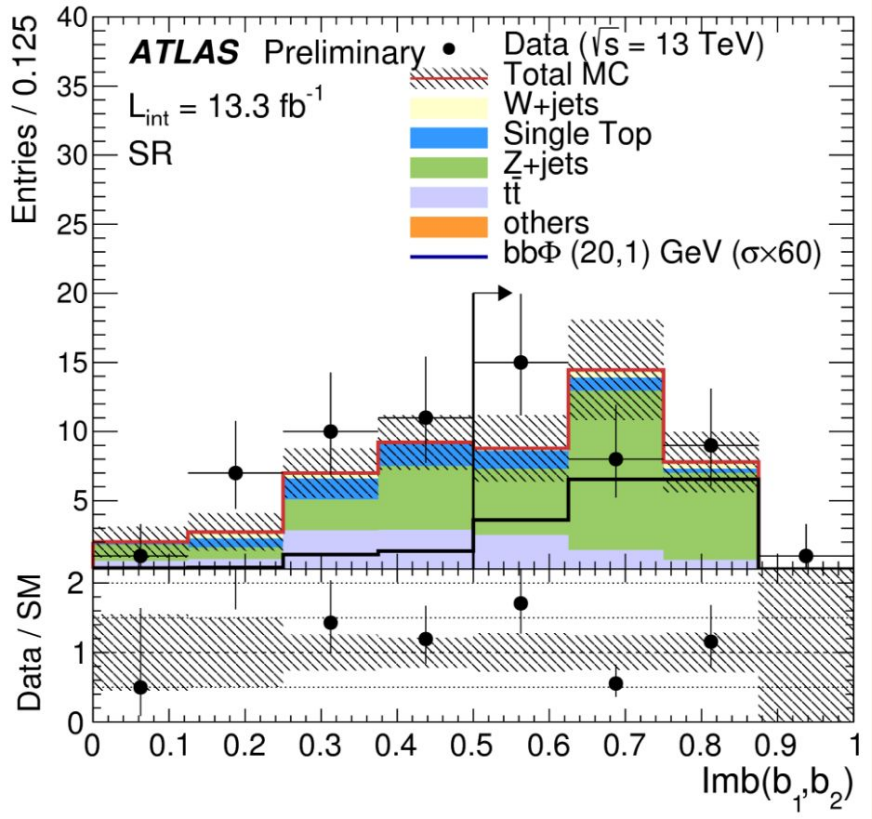
ATLAS-CONF-2016-086

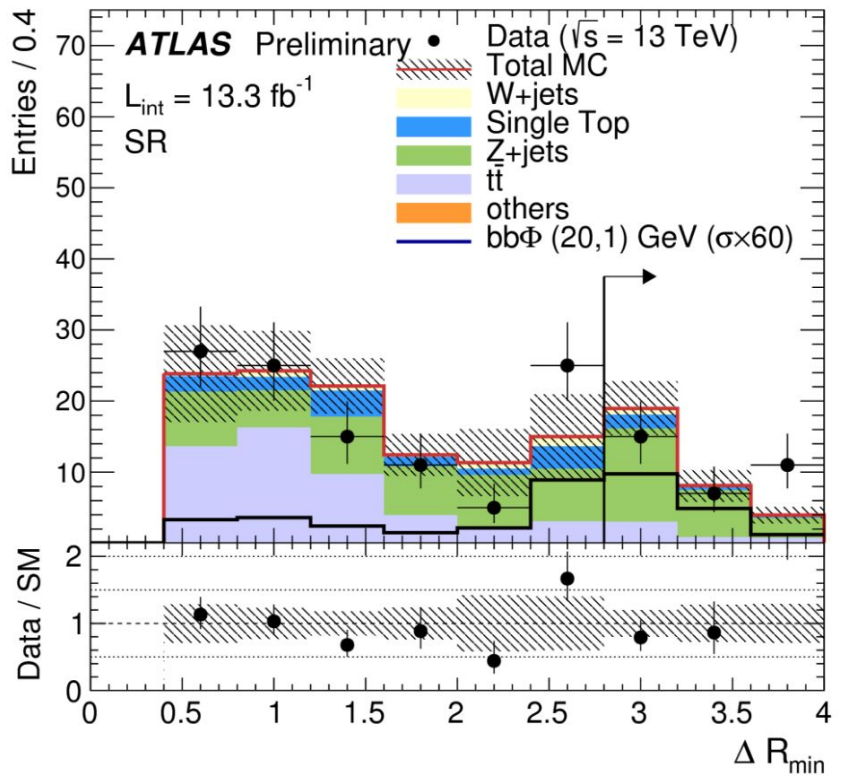
	SR
Observed	33
Total background	31.0 ± 6.2
W+jets	1.2 ± 0.8
Z+jets	22.6 ± 5.7
$t\bar{t}$	4.7 ± 1.4
single top	2.6 ± 1.1
others	-
pre-fit W+jets	1.2 ± 0.8
pre-fit Z+jets	20.1 ± 6.0
pre-fit $t\bar{t}$	5.8 ± 1.5
pre-fit single top	2.7 ± 1.1
pre-fit others	-

Signal channel	$\langle \epsilon\sigma \rangle^{95}_{\text{obs}}$[fb]	S^{95}_{obs}	S^{95}_{exp}	CL_B	$p(s=0)$
SR	1.38	18.3	$16.8^{+5.7}_{-4.3}$	0.62	0.37

DM + bb results

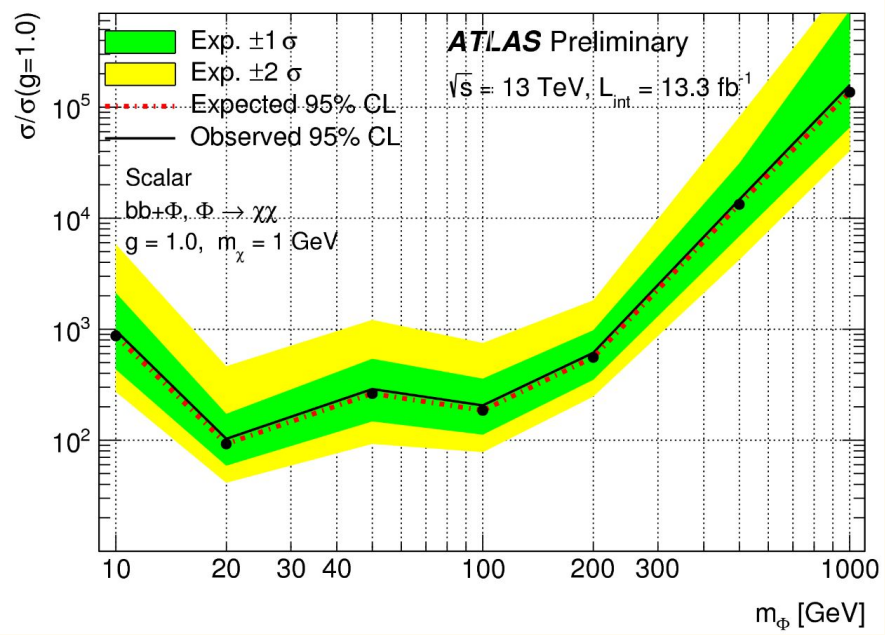
ATLAS-CONF-2016-086

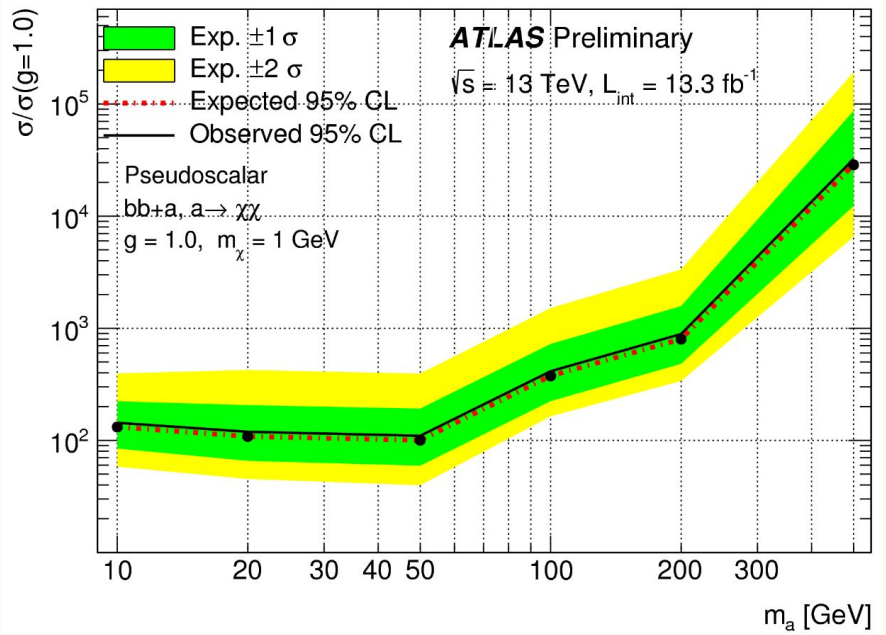




DM + bb results

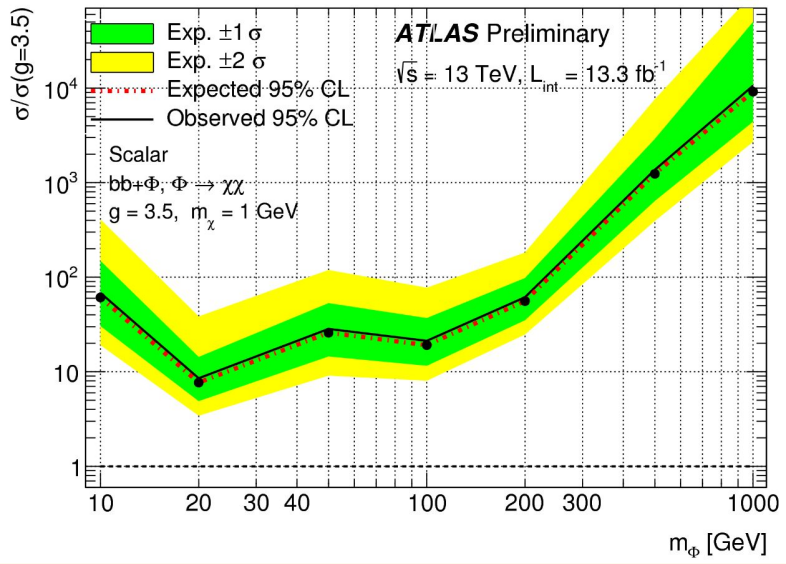
ATLAS-CONF-2016-086

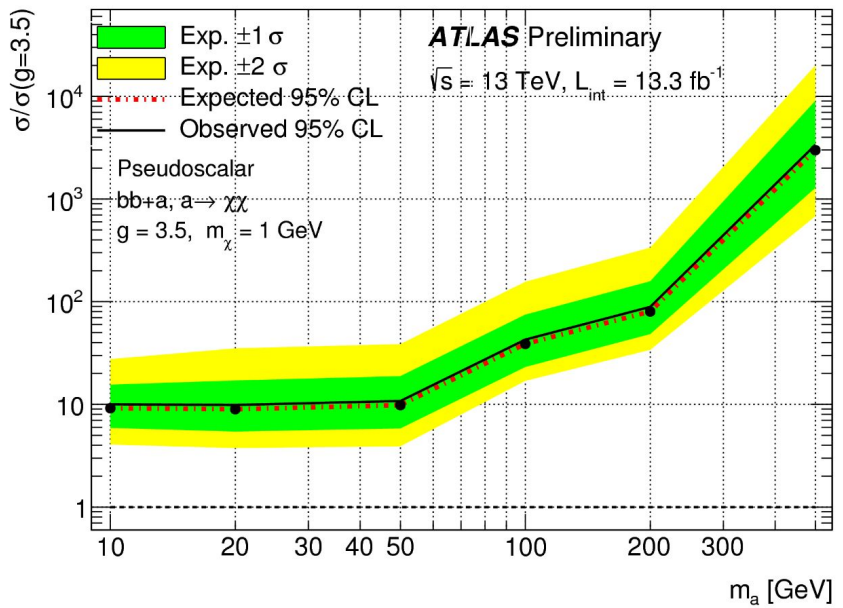




DM + bb results

ATLAS-CONF-2016-086





Stop searches

Selections

0L

Variable	SRE
b-tagged jets	≥ 2
$m^{0}_{\text{jet},R=1.2}$	> 140 GeV
$m^{1}_{\text{jet},R=1.2}$	> 60 GeV
$m^{0}_{\text{jet},R=0.8}$	-
$m^{1}_{\text{jet},R=0.8}$	-
$m_{\text{T}}^{b,\text{min}}$	> 200 GeV
$\tau-$veto	yes
$\Delta R(b,b)$	> 1.5
$E_{\text{T}}^{\text{miss}}$	> 300 GeV
H_{T}	-
$E_{\text{T}}^{\text{miss}}/\sqrt{H_{\text{T}}}$	$> 14\sqrt{GeV}$

1L

reclustered top candidates

Common event selection	
Trigger	$E_{\text{T}}^{\text{miss}}$ trigger
Lepton	exactly one signal lepton (e, μ), no additional baseline leptons
Jets	at least two signal jets, and $\lvert\Delta\phi(\text{jet}_i, \vec{p}_{\text{T}}^{\text{miss}})\rvert > 0.4$ for $i \in \{1,2\}$
Hadronic τ veto*	veto events with a hadronic τ decay and $m_{\text{T2}}^{\tau} < 80$ GeV

Variable	DM_low	DM_high
Number of (jets, b-tags)	(≥ 4, ≥ 1)	(≥ 4, ≥ 1)
Jet $p_{\text{T}}>$ [GeV]	(60 60 40 25)	(50 50 50 25)
$E_{\text{T}}^{\text{miss}}$ [GeV]	> 300	> 330
$H_{\text{T,sig}}^{\text{miss}}$	> 14	> 9.5
m_{T} [GeV]	> 120	> 220
am_{T2} [GeV]	> 140	> 170
$\min(\Delta\phi(\vec{p}_{\text{T}}^{\text{miss}}, \text{jet}_i))(i \in \{1-4\})$	> 1.4	> 0.8
$\Delta\phi(\vec{p}_{\text{T}}^{\text{miss}}, \ell)$	> 0.8	–

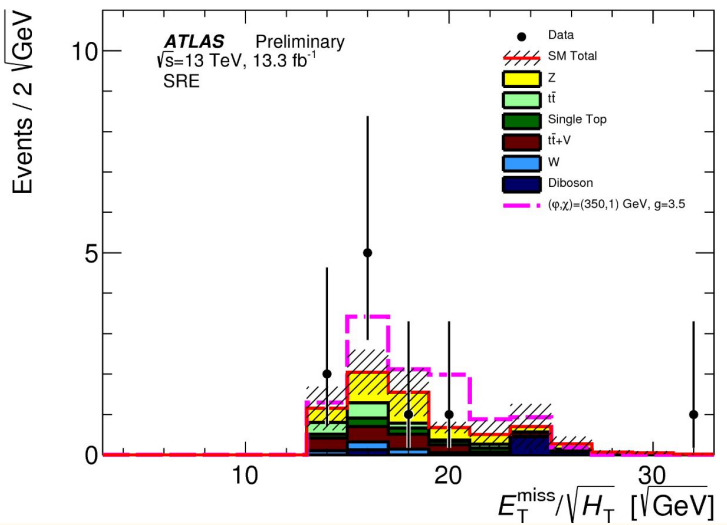
2L: dilepton trigger, $m_{ll} > 20$ GeV

Variable	DM-SRL	DM-SRH
$\lvert m_{\ell\ell} - m_Z\rvert$ [GeV] (SF only)	>20	>20
b-jet multiplicity	> 0	> 0
$\Delta\phi_{\text{boost}}$	< 1.0	< 1.0
m_{T2}^{ll} [GeV]	>120	>120
$E_{\text{T}}^{\text{miss}}$ [GeV]	> 180	> 260

ATLAS-CONF-2016-077, 2016-050, 2016-076

DM+tt 0L SR distribution

ATLAS-CONF-2016-077



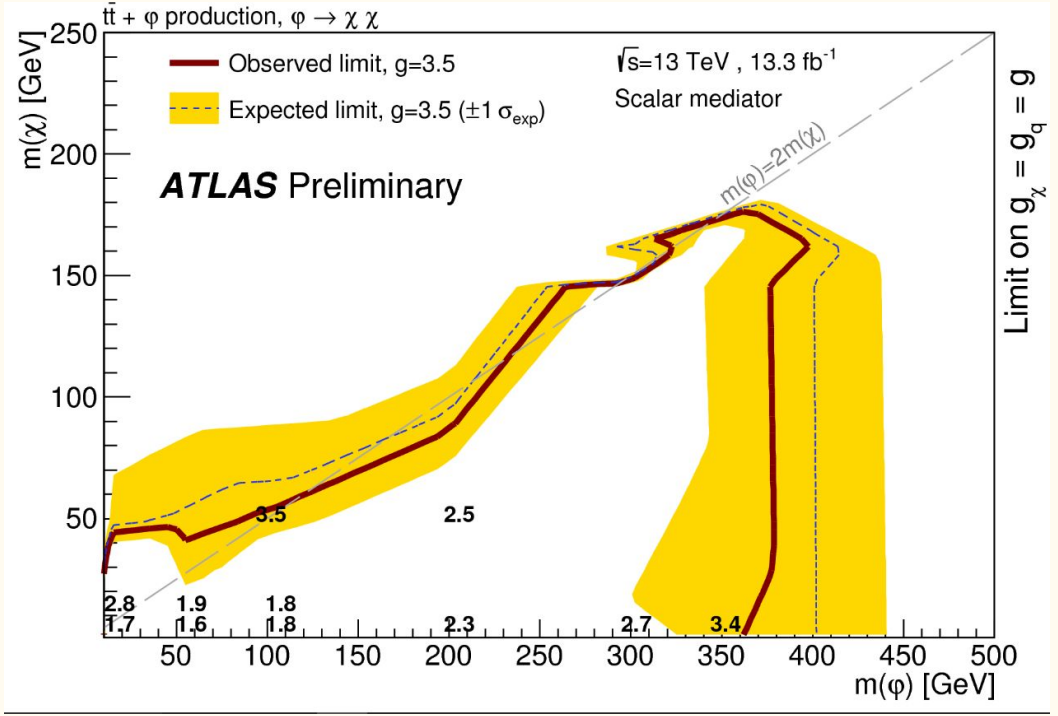
- CRs with reconstructed leptons are defined

	Z + jets	$t\bar{t}$		W + jets	single top
	CRZ	CRT	CRT-ISR	CRW	CRST
SF	1.20±0.26	0.91±0.18	0.78±0.19	1.21±0.21	0.86±0.33
SRA	34%-58%	9%-14%	-	10%-11%	6%-9%
SRB	22%-42%	22%-25%	-	9%-13%	10%
SRC	37%-39%	6%-17%	-	18%-25%	20%-26%
SRD1-4	0%	-	91%-92%	2%	1%-4%
SRD5-8	2%-10%	-	70%-84%	5%-9%	4%-8%
SRE	38%	12%	-	8%	10%
SRF	32%	10%	-	12%	17%

DM+tt 0L results

ATLAS-CONF-2016-077

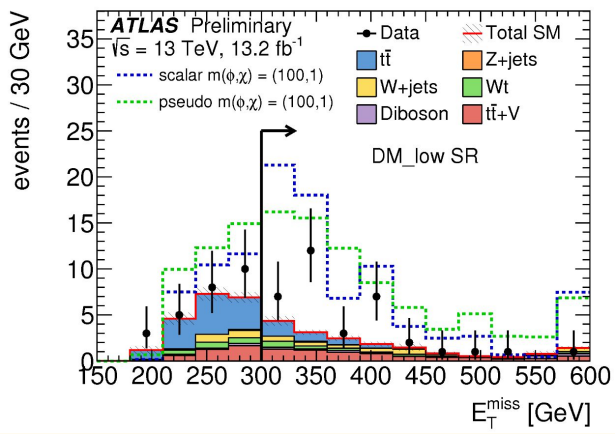
	SRE
Observed	9
Total SM	7.1 ± 1.8
$t\bar{t}$	0.92 ± 0.48
W + jets	0.56 ± 0.17
Z + jets	2.78 ± 0.98
$t\bar{t}+W/Z$	1.46 ± 0.55
Single top	$0.70 \, ^{+0.80}_{-0.70}$
Dibosons	0.63 ± 0.48
Multijets	$0.01 \, ^{+0.02}_{-0.01}$

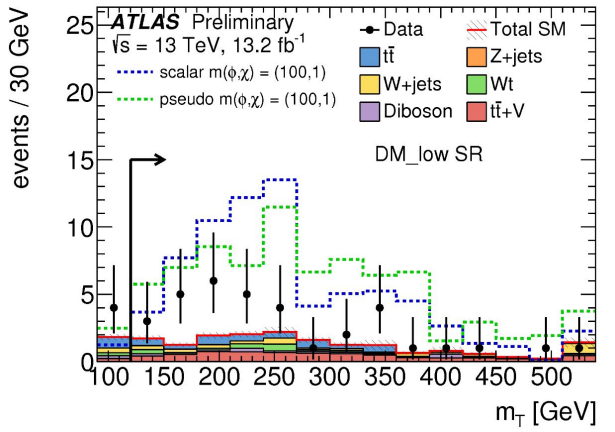


Pseudoscalar limits in the body of the presentation

DM+tt 1L SR distribution

ATLAS-CONF-2016-050





- ttbar (mostly from ll with one lost lepton) and W+jets in CR with lower m_T with/without b-jets
- single-top (from Wt) from CR with low m_T, high am_{T2}, 2 b-jets, high separation between the two b-jets
- tt+Z CR using tt+gamma (Z->ll has too low stat)
- multi-jet negligible
- Z+jets (small) from MC

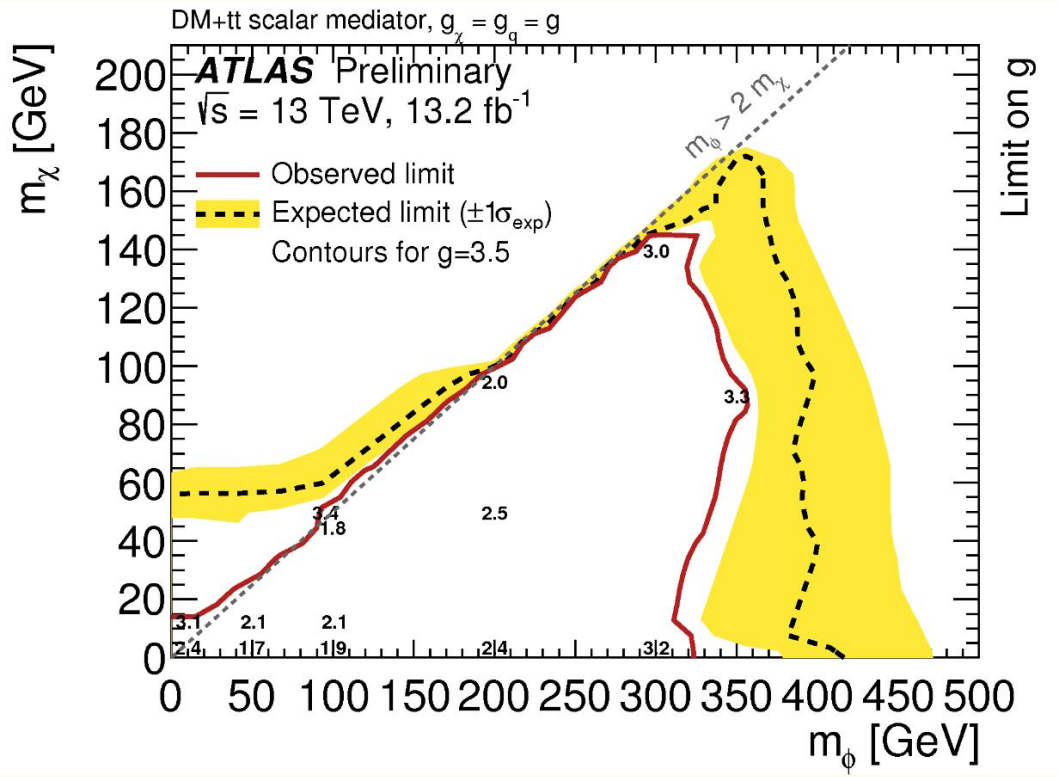
DM+tt 1L SR results

ATLAS-CONF-2016-050

Signal region	SR1	tN_high	bC2x_diag	bC2x_med	bCbv	DM_low	DM_high
Observed	37	5	37	14	7	35	21
Total background	24 ± 3	3.8 ± 0.8	22 ± 3	13 ± 2	7.4 ± 1.8	17 ± 2	15 ± 2
$t\bar{t}$	8.4 ± 1.9	0.60 ± 0.27	6.5 ± 1.5	4.3 ± 1.0	0.26 ± 0.18	4.2 ± 1.3	3.3 ± 0.8
W+jets	2.5 ± 1.1	0.15 ± 0.38	1.2 ± 0.5	0.63 ± 0.29	5.4 ± 1.8	3.1 ± 1.5	3.4 ± 1.4
Single top	3.1 ± 1.5	0.57 ± 0.44	5.3 ± 1.8	5.1 ± 1.6	0.24 ± 0.23	1.9 ± 0.9	1.3 ± 0.8
$t\bar{t} + V$	7.9 ± 1.6	1.6 ± 0.4	8.3 ± 1.7	2.7 ± 0.7	0.12 ± 0.03	6.4 ± 1.4	5.5 ± 1.1
Diboson	1.2 ± 0.4	0.61 ± 0.26	0.45 ± 0.17	0.42 ± 0.20	1.1 ± 0.4	1.5 ± 0.6	1.4 ± 0.5
Z+jets	0.59 ± 0.54	0.03 ± 0.03	0.32 ± 0.29	0.08 ± 0.08	0.22 ± 0.20	0.16 ± 0.14	0.47 ± 0.44
$t\bar{t}$ NF	1.03 ± 0.07	1.06 ± 0.15	0.89 ± 0.10	0.95 ± 0.12	0.73 ± 0.22	0.90 ± 0.17	1.01 ± 0.13
W+jets NF	0.76 ± 0.08	0.78 ± 0.08	0.87 ± 0.07	0.85 ± 0.06	0.97 ± 0.12	0.94 ± 0.13	0.91 ± 0.07
Single top NF	1.07 ± 0.30	1.30 ± 0.45	1.26 ± 0.31	0.97 ± 0.28	–	1.36 ± 0.36	1.02 ± 0.32
$t\bar{t} + W/Z$ NF	1.43 ± 0.21	1.39 ± 0.22	1.40 ± 0.21	1.30 ± 0.23	–	1.47 ± 0.22	1.42 ± 0.21
p_0 (σ)	0.012 (2.2)	0.26 (0.6)	0.004 (2.6)	0.40 (0.3)	0.50 (0)	0.0004 (3.3)	0.09 (1.3)
$N^{\text{limit}}_{\text{non-SM}}$ exp. (95% CL)	$12.9^{+5.5}_{-3.8}$	$5.5^{+2.8}_{-1.1}$	$12.4^{+5.4}_{-3.7}$	$9.0^{+4.2}_{-2.7}$	$7.3^{+3.5}_{-2.2}$	$11.5^{+5.0}_{-3.4}$	$9.9^{+4.6}_{-2.9}$
$N^{\text{limit}}_{\text{non-SM}}$ obs. (95% CL)	26.0	7.2	27.5	9.9	7.2	28.3	15.6

DM+tt 1L SR results

ATLAS-CONF-2016-050



Pseudoscalar limits in the body of the presentation

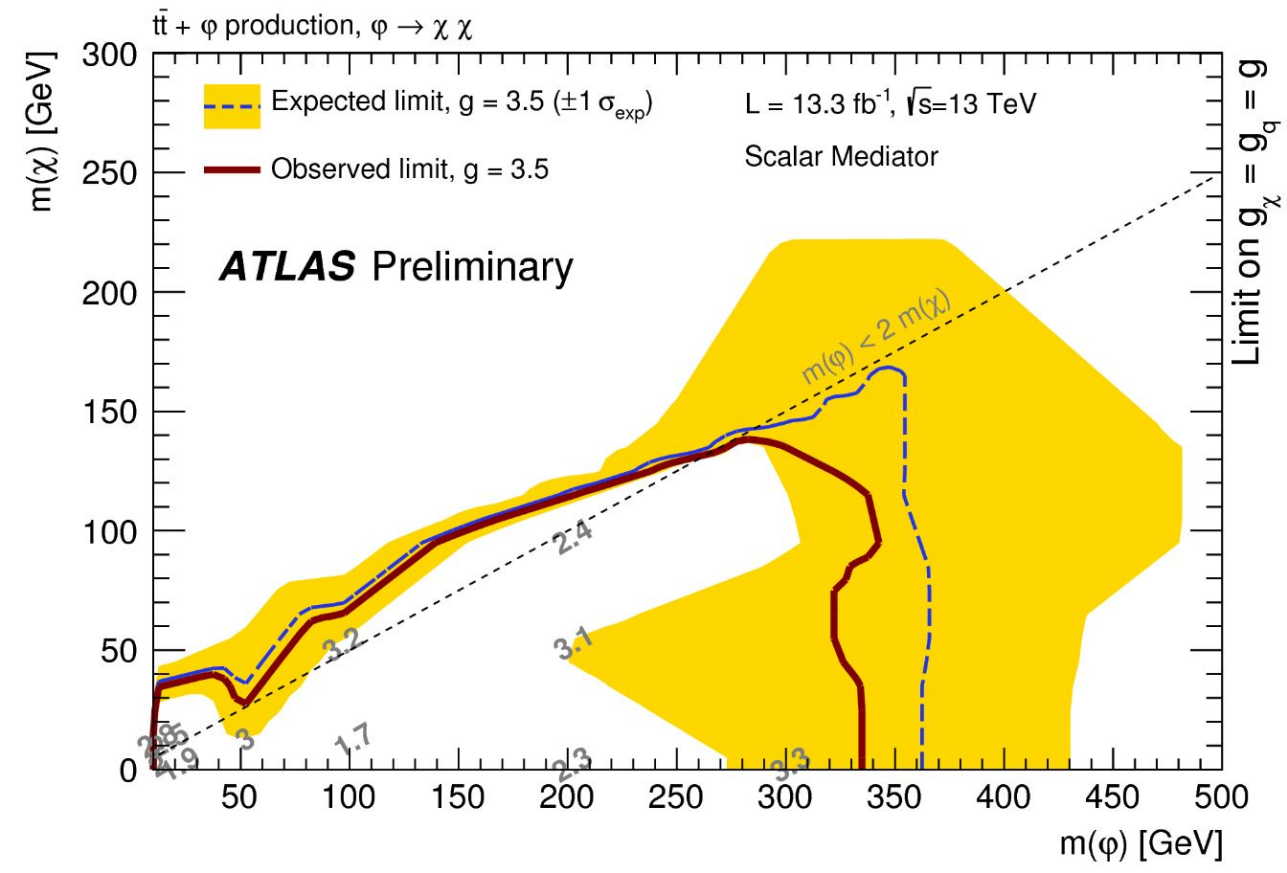
DM+tt 2L background estimation ATLAS-CONF-2016-076

Selection	CRT	CRTZ	VRVV	VRMET	VRMT2	VRINC
m_{T2}^{ll} [GeV]	60-100	>90	>100	–	>120	–
b-jet multiplicity	> 0	> 0	0	> 0	> 0	> 0
Jet multiplicity	> 1	> 1	> 1	> 1	> 1	–
Lepton multiplicity	2	> 2	2	2	2	2
$\Delta\phi_{\text{boost}}$	< 1	–	-	> 1	> 1	> 1
$E_{\text{T}}^{\text{miss}}$ [GeV]	–	–	–	> 180	–	–

	CRT	CRTZ	VRVV	VRMET	VRMT2	VRINC
Observed events	6758	26	100	30	71	10802
Total Standard Model	6758 ± 83	26.0 ± 5.1	90 ± 20	30.3 ± 3.8	53.3 ± 9.0	10600 ± 1000
Fitted $t\bar{t}$	6460 ± 89	–	39 ± 17	21.0 ± 4.6	20 ± 6.3	9700 ± 1000
Wt	264 ± 24	–	5.8 ± 1.8	4.9 ± 2.0	3.6 ± 1.5	847 ± 12
Z/γ^*+jets	$0.05^{+0.06}_{-0.05}$	–	$0.06^{+0.08}_{-0.06}$	1.26 ± 0.29	18.8 ± 3.4	47.7 ± 9.5
VV	12.4 ± 2.3	3.65 ± 0.92	40.9 ± 3.4	0.77 ± 0.31	6.2 ± 1.4	40.2 ± 5.6
Fitted $t\bar{t}$ Z	6.9 ± 2.9	14.5 ± 5.8	0.46 ± 0.21	0.63 ± 0.27	1.85 ± 0.79	11.0 ± 4.6
$t\bar{t}$ W	8.02 ± 0.28	2.44 ± 0.17	0.28 ± 0.06	0.34 ± 0.05	0.92 ± 0.10	10.88 ± 0.59
Fake and non prompt leptons	$1.7^{+1.7}_{-1.7}$	3.5 ± 2.5	$2.5^{+2.8}_{-2.5}$	1.3 ± 1.3	$1.1^{+1.5}_{-1.1}$	–
Other processes	5.59 ± 0.18	2.05 ± 0.17	0.14 ± 0.03	0.14 ± 0.02	0.93 ± 0.44	8.09 ± 0.61
MC exp. Standard Model	6500	30	88	28	34	10100
MC exp. $t\bar{t}$	6150	–	37	20	19	9200
MC exp. $t\bar{t}$ Z	8.76	18.4	0.58	0.80	2.0	14

DM+tt 2L results

Pseudoscalar limits in the body of the presentation [ATLAS-CONF-2016-076]



Other analyses

W’ and Z’ in leptonic channels ATLAS-CONF-2017-027, 2017-016

- Searches performed on 36/fb @ 13 TeV
- Key is the reconstruction performance for very energetic leptons
- Search performed on ℓν transvers mass (W’) and ℓℓ invariant mass (Z’)