ICHEP results from ATLAS on

Dark Matter + HF

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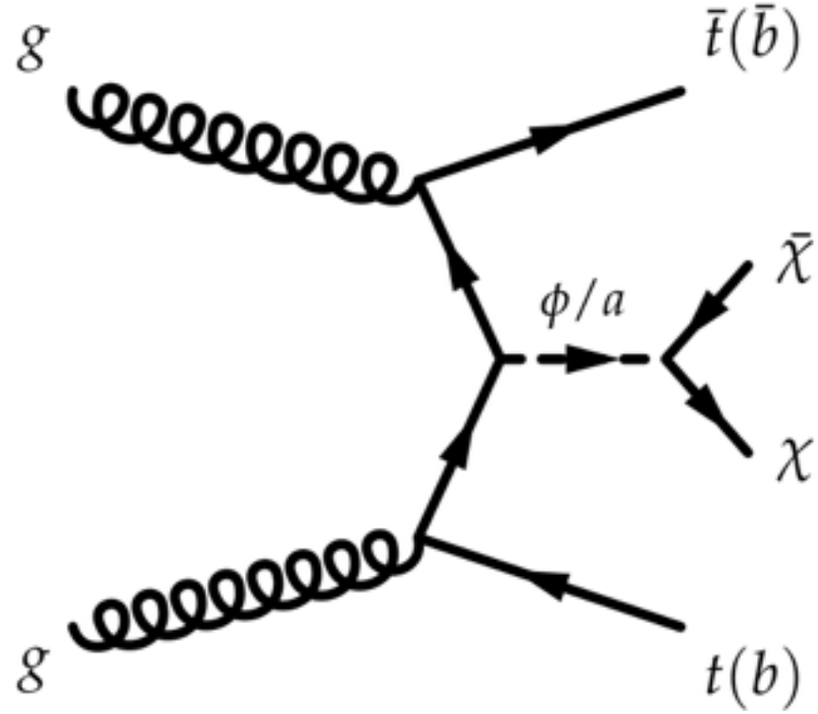
UNIVERSITÉ DE GENÈVE

Introduction

- DM+HF presents unique experimental signature
  - Final states: tt + E_T^{miss}, b(b) + E_T^{miss}
- Theoretical motivation: Yukawa-like couplings between mediator and SM quarks
  - Expect stronger couplings for tops, b's interesting in case coupling is only present to down-type quarks



- Both collaborations presented results on these searches recently
  - CMS: dataset of 2.2\fb was analysed for DM + tt (0L, 1L) and DM + b(b)
    → Presented by Kevin Kai Hong Sung
  - ATLAS: full ICHEP dataset of 13.2/fb was analysed for DM + tt (0L, 1L, 2L) and DM + b(b)
    → **Presented in this talk**

DM + tt

Analysis strategy

- Analyses share final state (tt + E_T^{miss}) with searches for SUSY stops
  - Performed in same analysis group with similar strategy for triggers, variables, cuts, …
  - Dedicated DM SRs
    - Observed significant overlap: DM SRs sometimes perform well for stop signals and vice versa
  - Share background estimation strategy: define background-enriched CRs to normalise MCs in combined fit
- Optimised for discovery: cut and count in few number of bins
  - Optimised for mediator masses of 350 GeV, 100 GeV (only 1L) and 10 GeV (only 2L)

Event selection

0L	1L	2L
0ℓ (e, μ)	1ℓ (e, μ, 25 GeV)	2ℓ (e, μ, OC, 25/20 GeV)
E_T^{miss} trigger (calo-based, 80 GeV (2015) / 100 GeV (2016))		2ℓ trigger
against QCD: $\Delta\phi$(jet,E_T^{miss}) > 0.4		against resonances: $m_{\ell\ell}$ > 20 GeV
hadronic tau veto		

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against QCD: $\Delta\phi$(jet,E_T^{miss}) > 0.4		against resonances: $m_{\ell\ell}$ > 20 GeV
hadronic tau veto		

# jets/b's	**≥ 6 / 2**
E_T^{miss} [GeV]	**≥ 300**
E_T^{miss} /√(H_T) [√GeV]	**>14**
$m_T^{b,min}$ [GeV]	**> 200**
$m_{j,R=1.2}$ [GeV]	**> 140/60**
ΔR(b,b)	**> 1.5**

transverse mass with b closest to E_T^{miss} rejects tt (1L)

mass of reclustered jets: top 'reconstruction' rejects non-top backgrounds

rejects Z+jets

Event selection

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0ℓ (e, μ)	1ℓ (e, μ, 25 GeV)	2ℓ (e, μ, OC, 25/20 GeV)
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$m_T^{b,min}$ [GeV]	**> 200**
$m_{j,R=1.2}$ [GeV]	**> 140/60**
ΔR(b,b)	**> 1.5**

	low M_{med}	**high M_{med}**
# jets/b's	**≥ 4 / 1**	
E_T^{miss} [GeV]	**≥ 300**	**≥ 330**
$H_T^{miss,sig}$ [√GeV]	**> 14**	**> 9.5**
m_T [GeV]	**> 120**	**> 220**
am_{T2} [GeV]	**> 140**	**> 170**
min(Δϕ(E_T^{miss},j)	**> 1.4**	**> 0.8**
Δϕ(E_T^{miss},ℓ)	**> 0.8**	

reconstruct decay branches, accounting for lost particles rejects tt (2L)

favours DM-like event topology

Event selection

0L	1L	2L
0ℓ (e, μ)	1ℓ (e, μ, 25 GeV)	2ℓ (e, μ, OC, 25/20 GeV)
E_T^{miss} trigger (calo-based, 80 GeV (2015) / 100 GeV (2016))		2ℓ trigger
against QCD: $\Delta\phi$(jet,E_T^{miss}) > 0.4		against resonances: $m_{\ell\ell}$ > 20 GeV
hadronic tau veto		

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E_T^{miss} [GeV]	≥ 300
$E_T^{miss}/\sqrt{(H_T)}$ [√GeV]	>14
$m_T^{b,min}$ [GeV]	> 200
$m_{j,R=1.2}$ [GeV]	> 140/60
ΔR(b,b)	> 1.5

	low M_{med}	high M_{med}
# jets/b's	≥ 4 / 1	
E_T^{miss} [GeV]	≥ 300	≥ 330
$H_T^{miss,s}$	exclude Z peak	> 5
m_T [GeV]	> 120	> 220
am_{T2} [GeV]	> 140	> 170
min($\Delta\phi(E_T^{miss},j)$	> 1.4	> 0.8
$\Delta\phi(E_T^{miss},\ell)$	> 0.8	

	low M_{med}	high M_{med}
# jets/b's	≥ 1 / 1	
E_T^{miss} [GeV]	≥ 180	≥ 260
$\lvert m_{\ell\ell} - m_Z \rvert$ (SF)	> 20 GeV	
$m_{T2}^{\ell\ell}$ [GeV]	> 120	
$\Delta\phi^{boost}$	< 1.0	

angular difference between p_T^{miss} and $p_T^{miss} + p_{T\ell 1} + p_{T\ell 2}$

Event selection

0L	1L	2L
0ℓ (e, μ)	1ℓ (e, μ, 25 GeV)	2ℓ (e, μ, OC, 25/20 GeV)
E_T^{miss} trigger (calo-based, 80 GeV (2015) / 100 GeV (2016))		2ℓ trigger
against QCD: $\Delta\phi$(jet,E_T^{miss}) > 0.4		against resonances: $m_{\ell\ell}$ > 20 GeV
hadronic tau veto		

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E_T^{miss} [GeV]	**≥ 300**
E_T^{miss} /√(H_T) [√GeV]	**>14**
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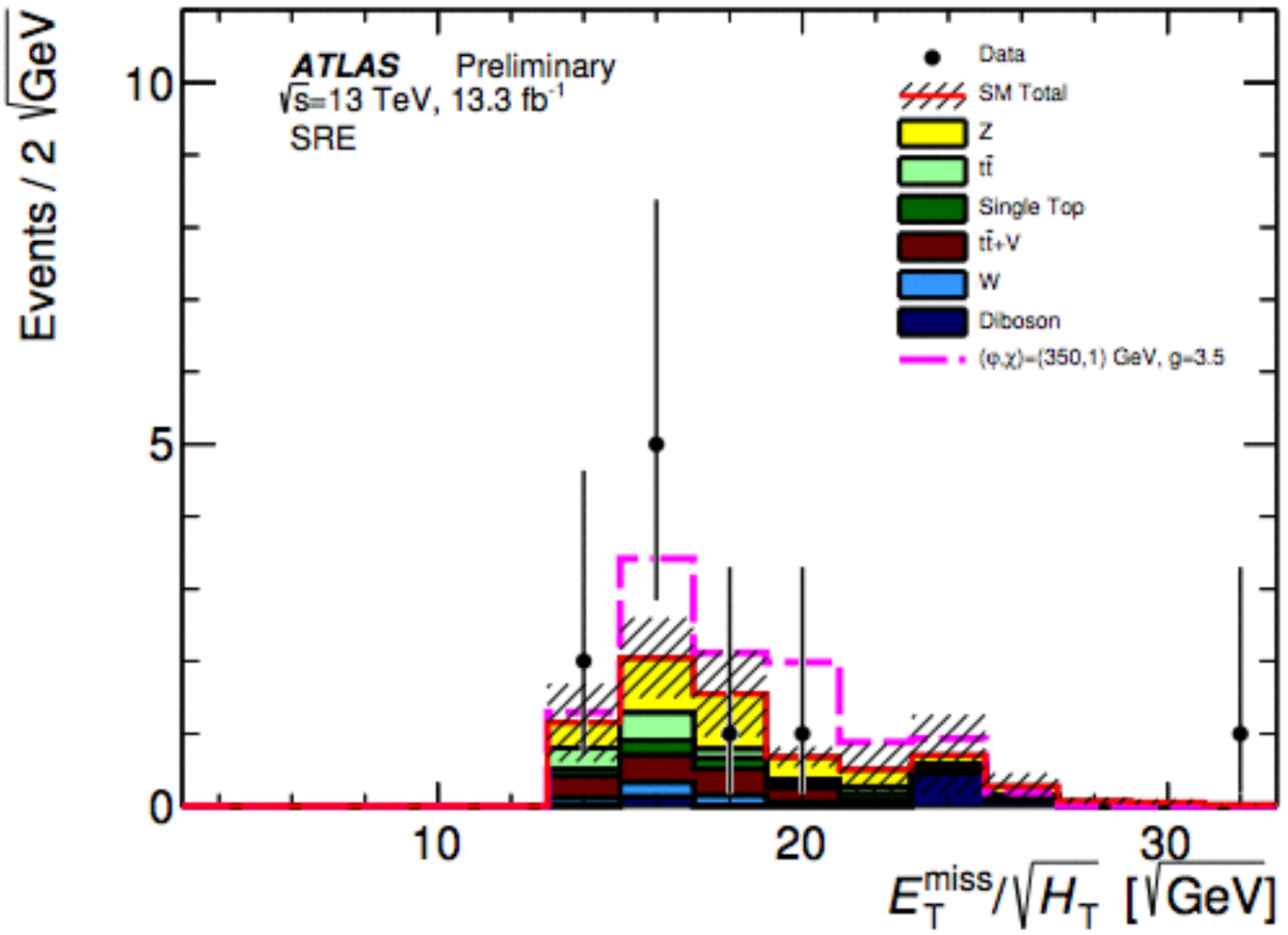
min(Δϕ(E_T^{miss},j)	**> 1.4**	**> 0.8**
Δϕ(E_T^{miss},ℓ)	**> 0.8**	

	low M_{med}	high M_{med}
# jets/b's	**≥ 1 / 1**	
E_T^{miss} [GeV]	**≥ 180**	**≥ 260**
Im$_{\ell\ell}$ - mZl (SF)	**> 20 GeV**	
$m_{T2}^{\ell\ell}$ [GeV]	**> 120**	
Δϕ^{boost}	**< 1.0**	

Results - 0L

- SR was optimised for high mediator masses
- No significant excess of events was observed in the DM+tt SR (SRE)
  - Good agreement between predicted distributions and data (e.g for $E_T^{miss}/\sqrt{(H_T)}$)

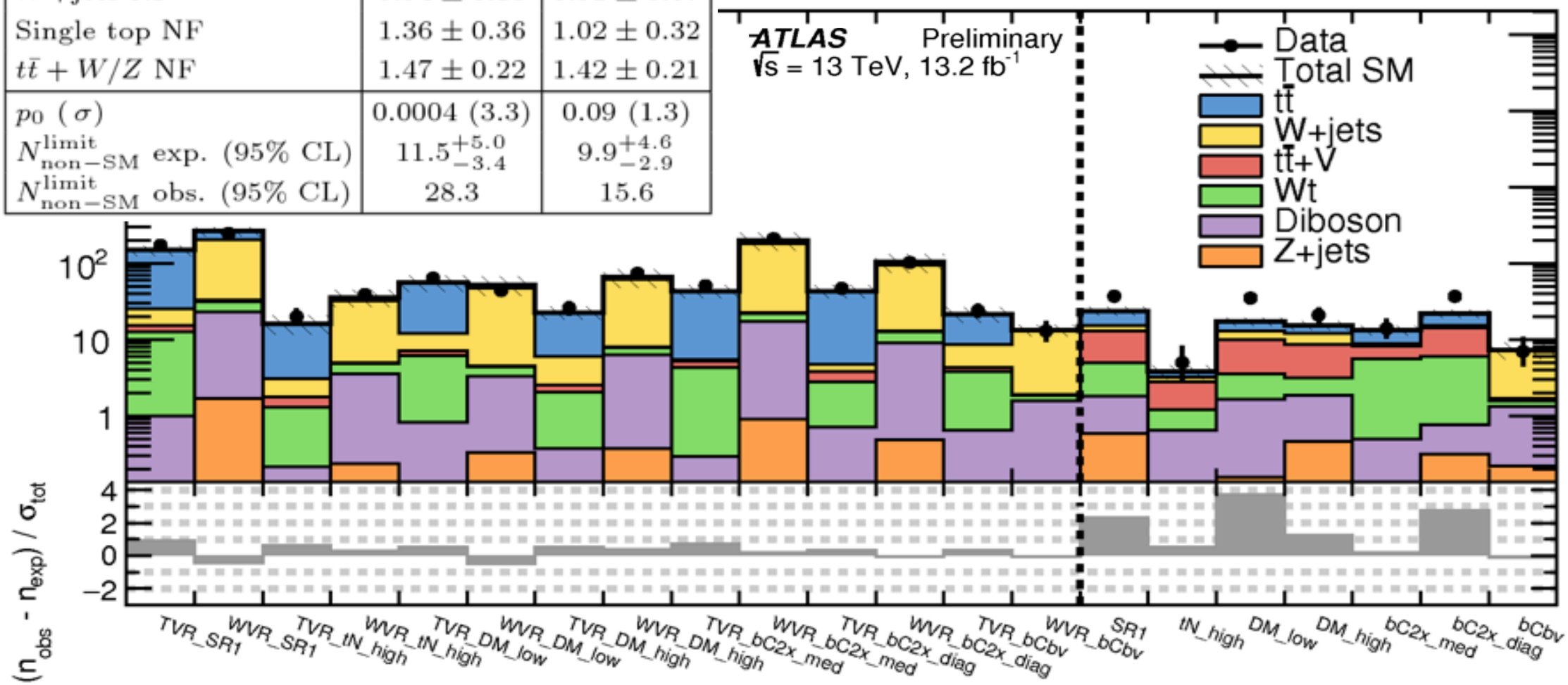
	SRE
Observed	9
Total SM	7.1 ± 1.8
$t\bar{t}$	0.92 ± 0.48
W + jets	0.56 ± 0.17
Z + jets	2.78 ± 0.98
$t\bar{t}$+W/Z	1.46 ± 0.55
Single top	$0.70\ ^{+0.80}_{-0.70}$
Dibosons	0.63 ± 0.48
Multijets	$0.01\ ^{+0.02}_{-0.01}$



Results - 1L

Signal region	DM_low	DM_high
Observed	35	21
Total background	17 ± 2	15 ± 2
$t\bar{t}$	4.2 ± 1.3	3.3 ± 0.8
W+jets	3.1 ± 1.5	3.4 ± 1.4
Single top	1.9 ± 0.9	1.3 ± 0.8
$t\bar{t} + V$	6.4 ± 1.4	5.5 ± 1.1
Diboson	1.5 ± 0.6	1.4 ± 0.5
Z+jets	0.16 ± 0.14	0.47 ± 0.44
$t\bar{t}$ NF	0.90 ± 0.17	1.01 ± 0.13
W+jets NF	0.94 ± 0.13	0.91 ± 0.07
Single top NF	1.36 ± 0.36	1.02 ± 0.32
$t\bar{t} + W/Z$ NF	1.47 ± 0.22	1.42 ± 0.21
p_0 (σ)	0.0004 (3.3)	0.09 (1.3)
$N^{\text{limit}}_{\text{non-SM}}$ exp. (95% CL)	$11.5^{+5.0}_{-3.4}$	$9.9^{+4.6}_{-2.9}$
$N^{\text{limit}}_{\text{non-SM}}$ obs. (95% CL)	28.3	15.6

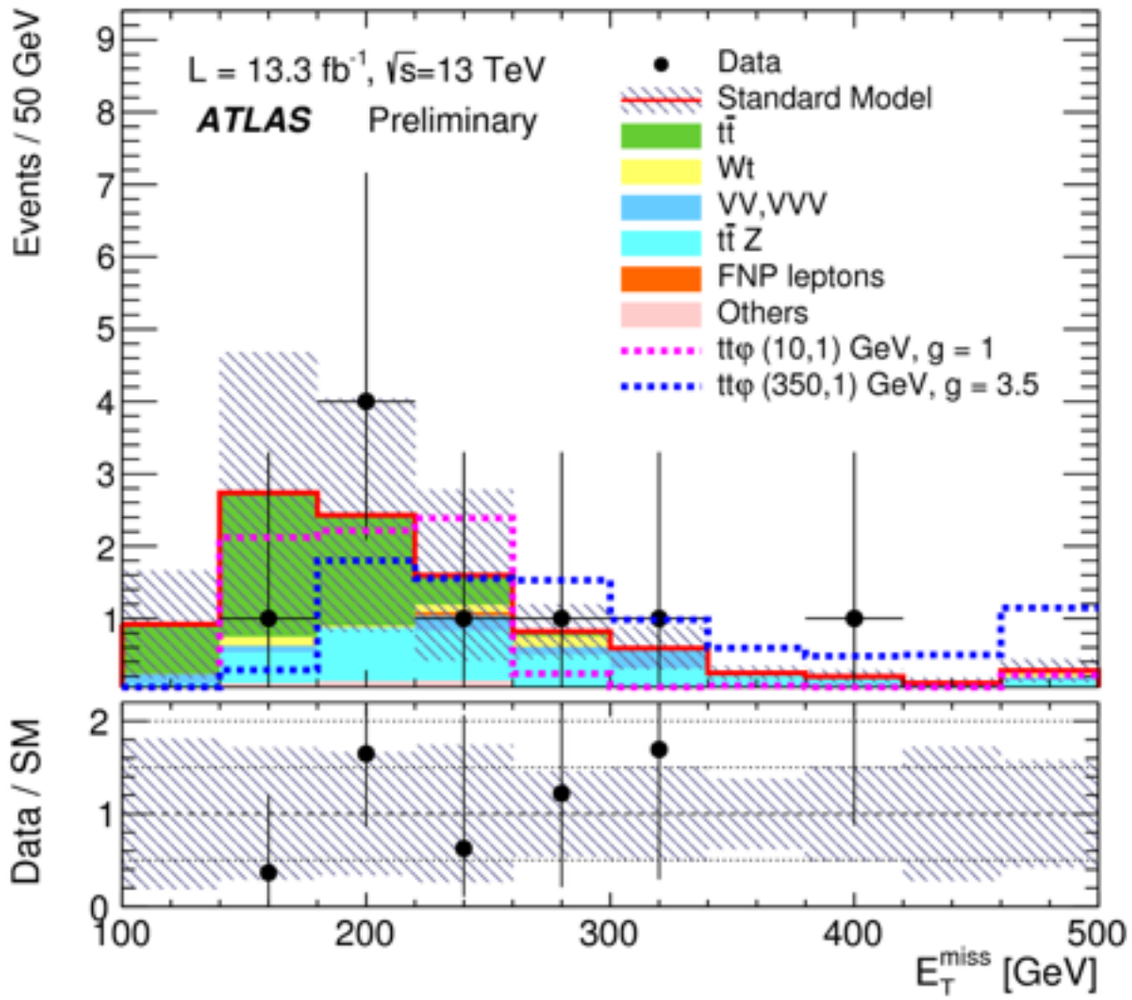
- Reasonable data - MC agreement in validation regions
- Excess seen in three SRs
  → SRs are NOT orthogonal!
  - Largest deviation: 3.3 sigma in DM_low (region optimised for M_{med} = 100 GeV)



Results - 2L

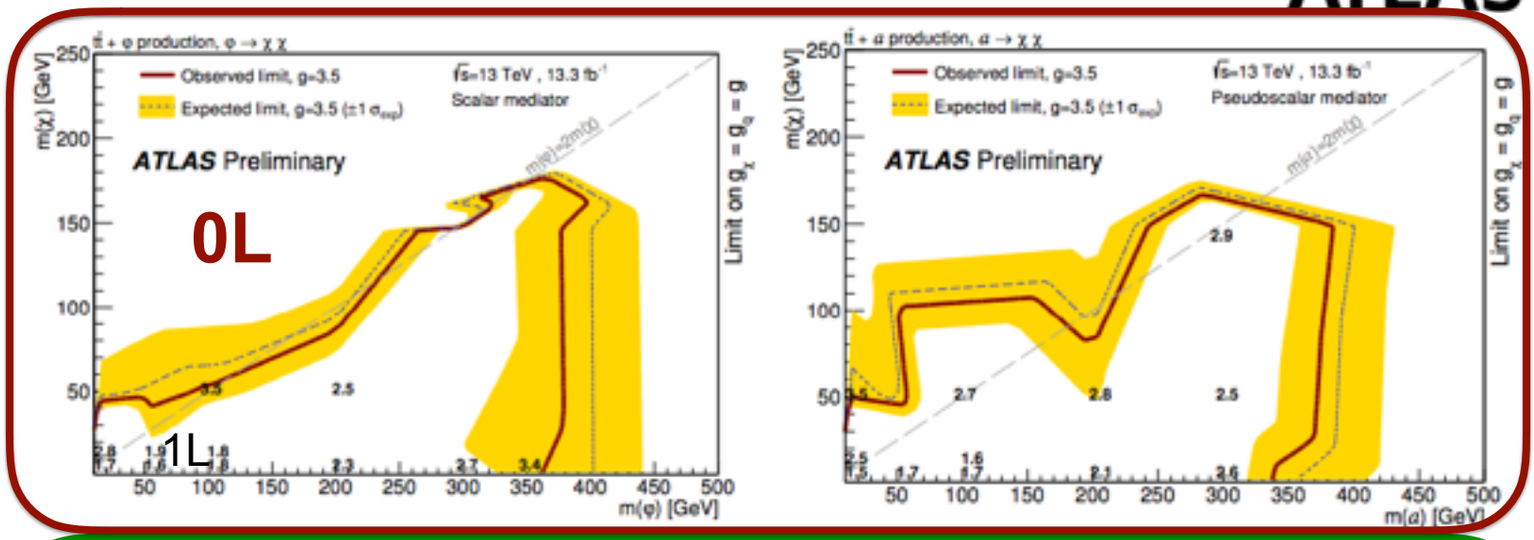
- Data agrees well with prediction
  - No excess observed in low- or high-M_{med} SRs

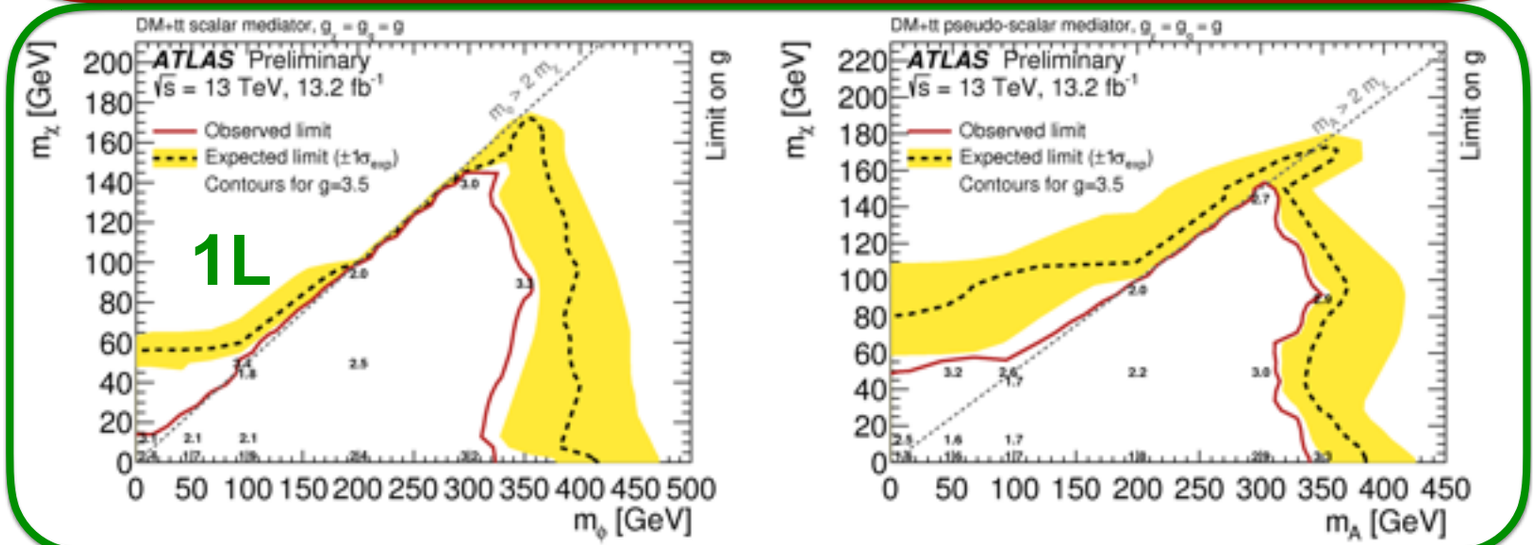
	DM-SRL	DM-SRH
Observed	8	3
Total Standard Model	6.4 ± 2.3	2.27 ± 0.59
Fitted $t\bar{t}$	2.1 ± 1.9	$0.15^{+0.40}_{-0.15}$
Fitted Wt	0.37 ± 0.36	$0.24^{+0.31}_{-0.24}$
Z/γ^*+jets	0.15 ± 0.08	0.03 ± 0.03
VV, VVV	0.64 ± 0.22	0.43 ± 0.18
Fitted $t\bar{t}$ Z	2.01 ± 0.86	1.00 ± 0.44
$t\bar{t}$ W	0.69 ± 0.07	0.27 ± 0.04
Fake and non prompt	$0.00^{+0.35}_{-0.00}$	$0.00^{+0.35}_{-0.00}$
Others	0.42 ± 0.08	0.14 ± 0.04
MC exp. Standard Model	6.7	2.5
MC exp. $t\bar{t}$	2.0	0.14
MC exp. Wt	2.6	1.28
$t\bar{t}\varphi$ (10, 1) GeV, $g = 3.5$	148 ± 57	16^{+19}_{-16}
$t\bar{t}\varphi$ (350, 1) GeV, $g = 3.5$	8.6 ± 1.0	5.23 ± 0.80

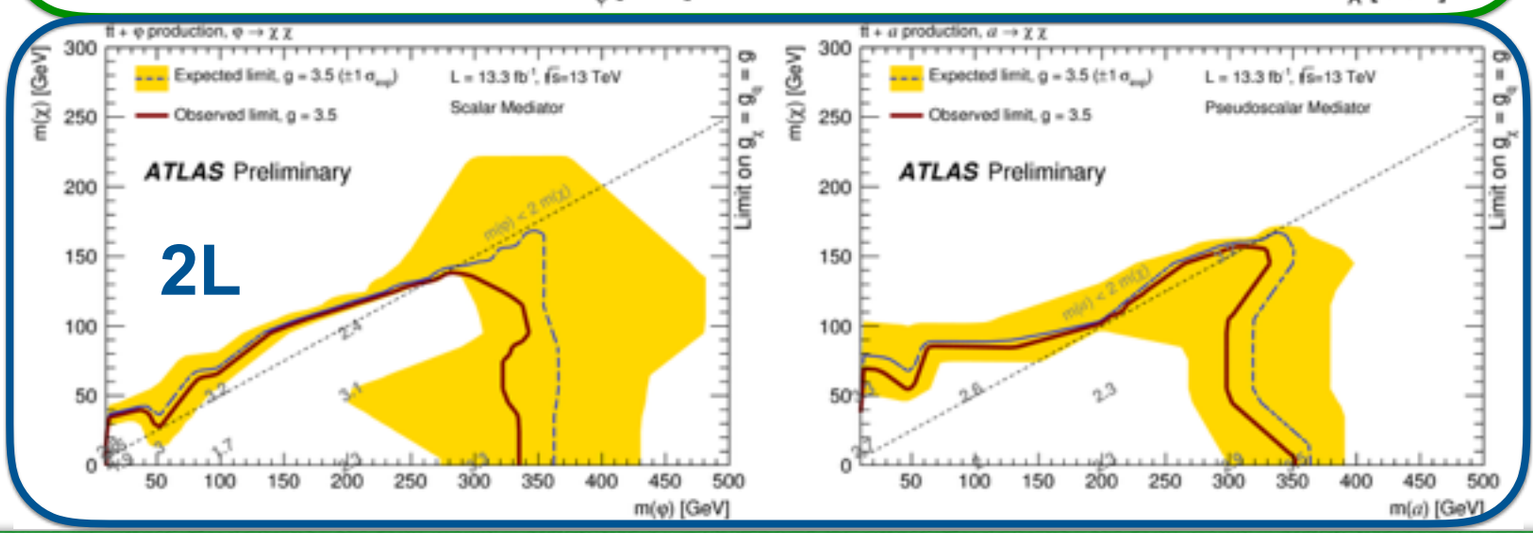


Interpretation

- As said, simple cut-and-count approach
- Exclusion reach up to 350 GeV in M_{med} for g = 3.5 (exp slightly higher)
- Excess in 1L visible as deviation of observed from expected limit
  - 2L slightly more sensitive to off-shell/low-M_{med}







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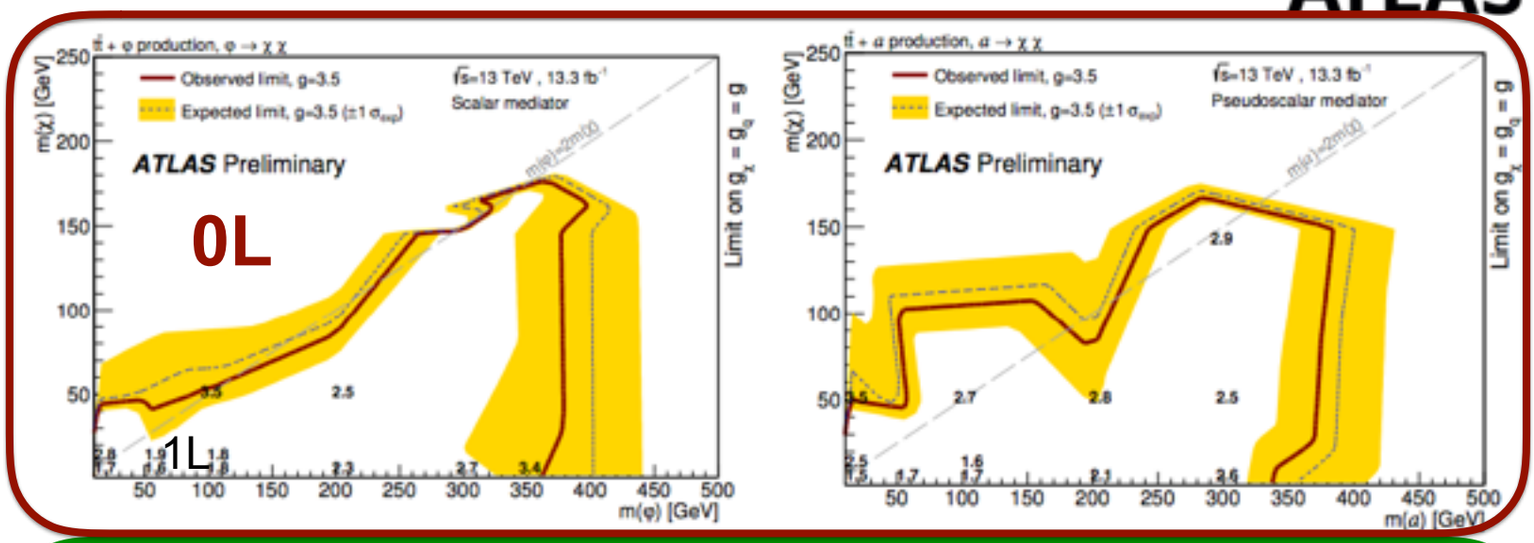
Side remark:
ATLAS plots are 2D, but for g=3.5 (no meaningful exclusions for g=1)
CMS plots are for g=1 but lose 2D information (no m_{DM} axis)
→ ideally both?



DM + bb

Selection and Results

Quantity	SR
$\mathcal{N}_{lepton}$ (baseline)	0
$\mathcal{N}_{lepton}$ (high-purity)	0
$\Delta\phi^{j}_{\mathrm{min}}$	> 0.4
$\mathcal{N}_{jets}$	$2-3$
$\mathcal{N}_{\mathrm{b}jets}$	$= 2$
jet 1 p_{T} [GeV]	> 100
jet 2 p_{T} [GeV]	> 20
jet 3 p_{T} [GeV]	< 60
$p_{\mathrm{T}}^{\text{b-jet1}}$ [GeV]	> 50
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 150
$E_{\mathrm{T}}^{\mathrm{miss,cor}}$ [GeV]	-
ΔR_{min}	> 2.8
$\Delta\eta(b_1, b_2)$	> 0.5
$Imb(b_1, b_2)$	> 0.5
m_{T}^{lep}	-
$m_{\ell\ell}$	-
lepton 1 p_{T} [GeV]	-
lepton 2 p_{T} [GeV]	-
$\Delta\phi(b_1, b_2)$	> 2.2

Radial distance of b-jets

Momentum imbalance of b-jets

Selection and Results

Quantity	SR
$\mathcal{N}_{lepton}$ (baseline)	0
$\mathcal{N}_{lepton}$ (high-purity)	0
$\Delta\phi^{j}_{\mathrm{min}}$	> 0.4
$\mathcal{N}_{jets}$	$2-3$
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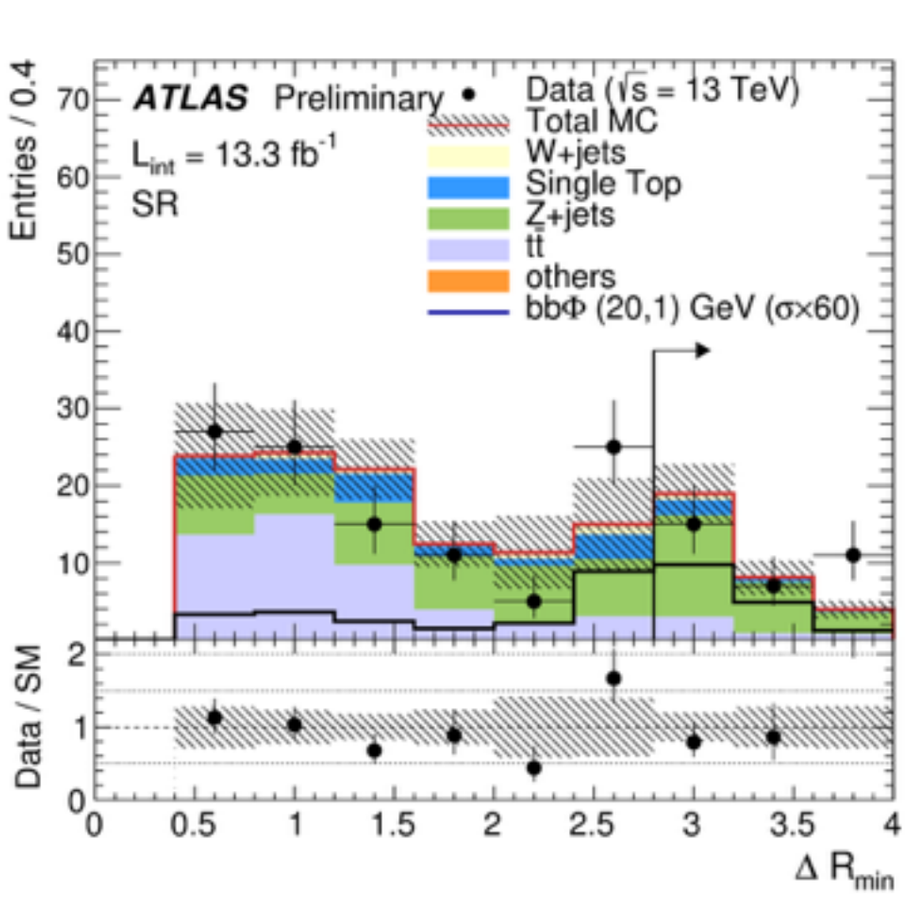
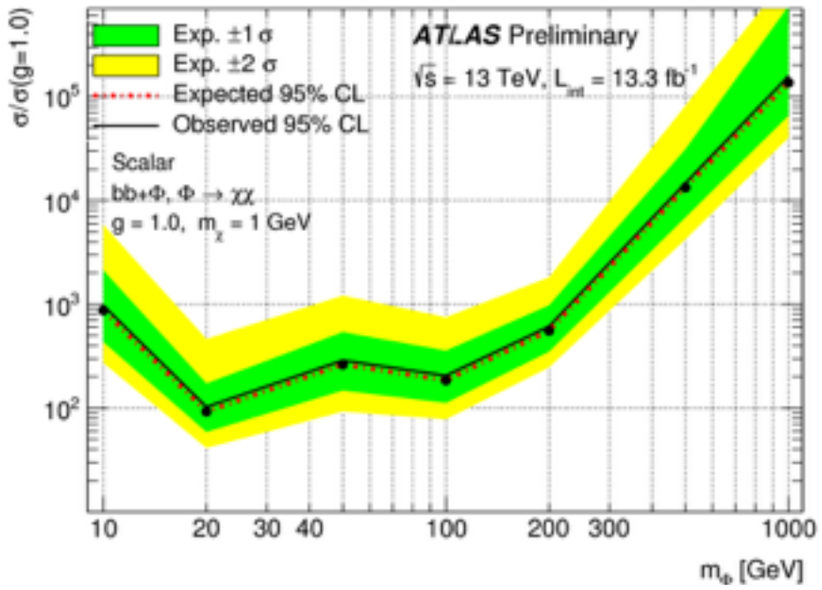
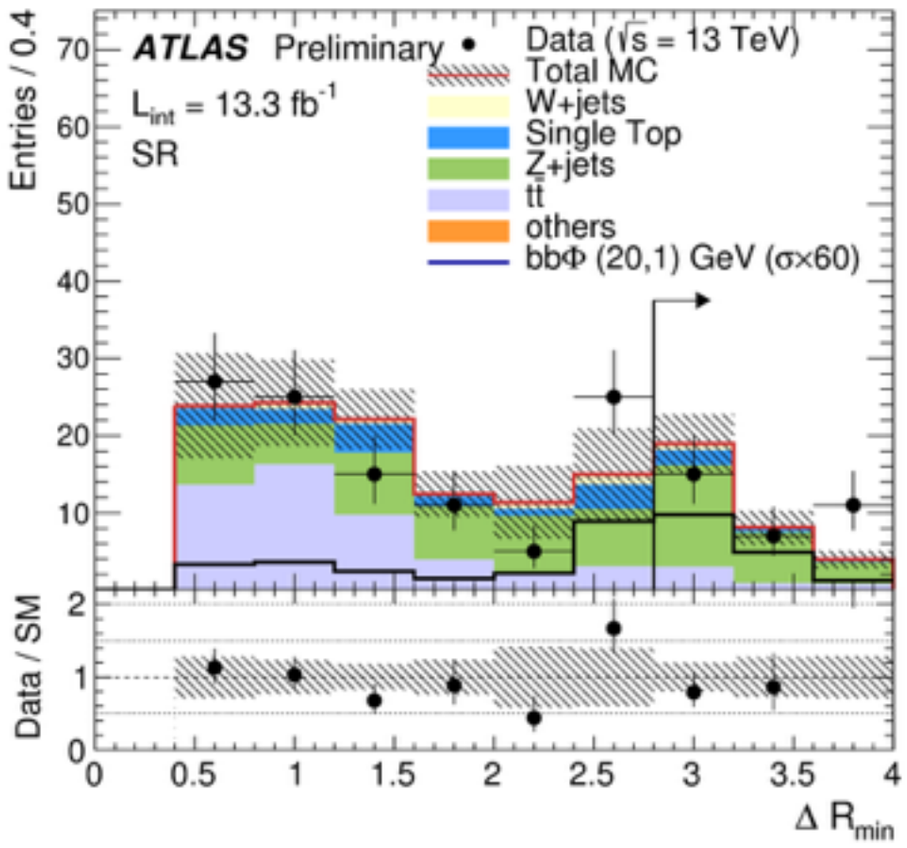
jet 1 p_{T} [GeV]	> 100
jet 2 p_{T} [GeV]	> 20
jet 3 p_{T} [GeV]	< 60
$p_{\mathrm{T}}^{\mathrm{b\text{-}jet1}}$ [GeV]	> 50
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 150
$E_{\mathrm{T}}^{\mathrm{miss,cor}}$ [GeV]	-
ΔR_{min}	> 2.8
$\Delta\eta(b_1, b_2)$	> 0.5
$Imb(b_1, b_2)$	> 0.5
m_{T}^{lep}	-
$m_{\ell\ell}$	-
lepton 1 p_{T} [GeV]	-
lepton 2 p_{T} [GeV]	-
$\Delta\phi(b_1, b_2)$	> 2.2



Selection and Results

- Data and prediction in good agreement
- Not yet able to exclude couplings of 1 or 3.5
  → present upper limits
  in σ/σ(g=1)





Quantity	SR
$\mathcal{N}_{lepton}$ (baseline)	0
$\mathcal{N}_{lepton}$ (high-purity)	0
$\Delta\phi^{j}_{\min}$	> 0.4
$\mathcal{N}_{jets}$	$2-3$
$\mathcal{N}_{\mathrm{b}jets}$	$= 2$
jet 1 p_{T} [GeV]	> 100
jet 2 p_{T} [GeV]	> 20
jet 3 p_{T} [GeV]	< 60
$p_{\mathrm{T}}^{\text{b-jet1}}$ [GeV]	> 50
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 150
$E_{\mathrm{T}}^{\mathrm{miss,cor}}$ [GeV]	-
ΔR_{min}	> 2.8
$\Delta\eta(b_1, b_2)$	> 0.5
$Imb(b_1, b_2)$	> 0.5
m_{T}^{lep}	-
$m_{\ell\ell}$	-
lepton 1 p_{T} [GeV]	-
lepton 2 p_{T} [GeV]	-
$\Delta\phi(b_1, b_2)$	> 2.2

Conclusions

Conclusions

- ATLAS presented results for 13.2/fb on DM + tt searches in 0L, 1L and 2L channels
- Analyses optimised for high(-ish) M_{med} → high(-ish) E_T^{miss} cuts
- Strategy optimised for discovery: few bins, cut-and-count
- 0L, 1L slightly stronger for higher M_{med}, 2L slightly better for off-shell/low M_{med}
  - Exclusions for g=3.5 presented in m_{DM} - M_{med} plane: reach up to 350 GeV in M_{med}
- Excess of 3.3 sigma observed in 1L low-M_{med} DM SR
  → to be seen with full 2016 dataset
- Interesting results also for DM + bb
  → sensitivity to be improved with more statistics

BACKUP

Selection DM+b(b)

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
$\Delta\phi^{j}_{\mathrm{min}}$	> 0.4	> 0.4	> 0.4	> 0.4	> 0.4	> 0.4	> 0.4
$\mathcal{N}_{jets}$	$2-3$	$2-3$	$2-3$	$2-3$	$2-3$	$2-3$	$2-3$
$\mathcal{N}_{\mathrm{b}jets}$	$= 2$	$= 1$	$= 2$	$= 1$	$= 1$	$= 2$	$= 2$
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

Selection DM + tt (1L)

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

Variable	DM_low	TCR / WCR	STCR
$\geq$4 jets with $p_{\mathrm{T}} >$ [GeV]	(60 60 40 25)	(60 60 40 25)	(60 60 40 25)
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 300	> 200 / > 230	> 200
$H_{\mathrm{T,sig}}^{\mathrm{miss}}$	> 14	> 8	> 8
m_{T} [GeV]	> 120	[30,90]	[30,120]
am_{T2} [GeV]	> 140	$[100, 200]$ / > 100	> 200
$\min(\Delta\phi(\vec{p}_{\mathrm{T}}^{\mathrm{miss}}, \mathrm{jet}_i))$ $(i \in \{1-4\})$	> 1.4	> 1.4	> 1.4
$\Delta\phi(\vec{p}_{\mathrm{T}}^{\mathrm{miss}}, \ell)$	> 0.8	> 0.8	–
$\Delta R(b_1, b_2)$	–	–	> 1.8
Number of b-tags	≥ 1	≥ 1 / $= 0$	≥ 2

Variable	DM_high	TCR / WCR	STCR
$\geq$4 jets with $p_{\mathrm{T}} >$ [GeV]	(50 50 50 25)	(50 50 50 25)	(50 50 50 25)
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 330	> 300 / > 330	> 250
$H_{\mathrm{T,sig}}^{\mathrm{miss}}$	> 9.5	> 9.5	> 5
m_{T} [GeV]	> 220	[30,90]	[30,120]
am_{T2} [GeV]	> 170	$[100, 200]$ / > 100	> 200
$\min(\Delta\phi(\vec{p}_{\mathrm{T}}^{\mathrm{miss}}, \mathrm{jet}_i))$ $(i \in \{1-4\})$	> 0.8	> 0.8	> 0.8
$\Delta R(b_1, b_2)$	–	–	> 1.2
Number of b-tags	≥ 1	≥ 1 / $= 0$	≥ 2

Results DM + tt (1L)

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

CRs - DM + tt (0L)

Selection	CRZ	CRT	CRT-ISR	CRST	CRW
Trigger	electron (muon)	$E_{\mathrm{T}}^{\mathrm{miss}}$			
N_ℓ	2	1			
p_{T}^{ℓ}	> 20 GeV				
$m_{\ell\ell}$	[86,96] GeV	-			
N_{jet}	≥ 4	≥ 4 (including leptons)			
jet p_{T}	$(40, 40, 20, 20)$ GeV	$(80, 80, 40, 40)$ GeV			$(80, 80, 20, 20)$ GeV
$E_{\mathrm{T}}^{\mathrm{miss}}$	< 50 GeV	> 250 GeV			
$E_{\mathrm{T}}^{\mathrm{miss}'}$	> 70 GeV	-			
b-tagged jets	≥ 2	≥ 2	≥ 1	≥ 2	$= 1$
$\lvert\Delta\phi\left(\mathrm{jet}^{0,1}, E_{\mathrm{T}}^{\mathrm{miss}}\right)\rvert$	-	> 0.4			
$\min m_{\mathrm{T}}(\ell, E_{\mathrm{T}}^{\mathrm{miss}})$	-	30 GeV	-	30 GeV	30 GeV
$\max m_{\mathrm{T}}(\ell, E_{\mathrm{T}}^{\mathrm{miss}})$	-	120 GeV	80 GeV	120 GeV	100 GeV
$m^{0}_{\mathrm{jet},R=1.2}$	-	> 70 GeV	-	> 70 GeV	< 60 GeV
$m_{\mathrm{T}}^{b,\mathrm{min}}$	-	> 100 GeV	-	> 175 GeV	-
$\Delta R\left(b, \ell\right)_{\mathrm{min}}$	-	< 1.5	< 2.0	> 1.5	> 2.0
m_{bb}	-	-	-	> 200 GeV	-
$N_{\mathrm{jet}}^{\mathrm{S}}$	-	-	≥ 5	-	-
$N_{b\text{-tag}}^{\mathrm{S}}$	-	-	≥ 1	-	-
$p_{\mathrm{T}}^{\mathrm{ISR}}$	-	-	≥ 400 GeV	-	-

Results - DM + tt (0L)

Signal channel	$\langle\epsilon\sigma\rangle^{95}_{\rm obs}$[fb]	$S^{95}_{\rm obs}$	$S^{95}_{\rm exp}$	$p(s=0)$	σ
SRA-TT	0.72	9.5	$6.9^{+3.3}_{-2.1}$	0.18	0.92
SRA-TW	0.46	6.1	$6.6^{+3.3}_{-2.0}$	0.50	0.00
SRA-T0	1.05	14.0	$10.1^{+4.4}_{-2.9}$	0.16	0.99
SRB-TT	1.17	15.5	$10.0^{+4.3}_{-2.9}$	0.08	1.41
SRB-TW	0.97	12.9	$12.1^{+4.8}_{-3.5}$	0.41	0.23
SRB-T0	3.91	52.1	$38.2^{+12.9}_{-10.0}$	0.10	1.28
SRC-low	2.19	29.1	$21.9^{+7.4}_{-5.7}$	0.13	1.13
SRC-med	1.10	14.6	$11.3^{+4.5}_{-3.2}$	0.19	0.88
SRC-high	0.66	8.8	$9.6^{+3.8}_{-2.6}$	0.50	0.00
SRD1	0.45	6.0	$6.1^{+3.1}_{-2.0}$	0.50	0.00
SRD2	0.47	6.2	$7.6^{+3.1}_{-2.1}$	0.50	0.00
SRD3	0.69	9.2	$9.0^{+3.7}_{-2.7}$	0.49	0.03
SRD4	0.67	8.9	$9.2^{+3.8}_{-2.7}$	0.50	0.00
SRD5	0.69	9.2	$9.6^{+4.1}_{-2.8}$	0.50	0.00
SRD6	0.50	6.6	$8.1^{+3.6}_{-2.2}$	0.50	0.00
SRD7	0.50	6.6	$6.8^{+3.2}_{-1.9}$	0.49	0.03
SRD8	0.28	3.7	$4.7^{+2.6}_{-1.2}$	0.50	0.00
SRE	0.72	9.5	$7.9^{+3.6}_{-2.3}$	0.29	0.55
SRF	0.42	5.6	$5.4^{+2.6}_{-1.6}$	0.47	0.08

Results DM + tt (2L)

	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