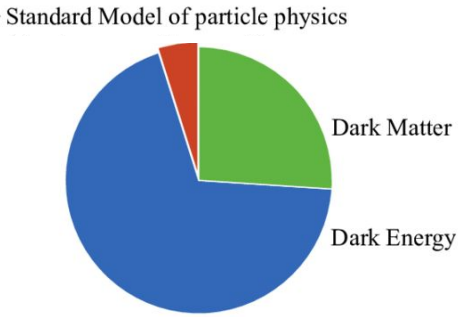
Searches for dark matter with the ATLAS detector

Jona Bossio (CERN)

on behalf of the ATLAS Collaboration

EPS-HEP2021 | 26-30 July 2021



CERN

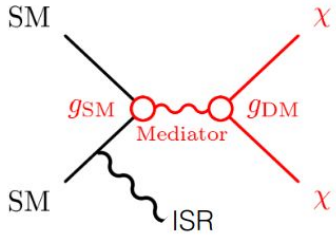
ATLAS EXPERIMENT

Overview of Dark Matter models

Simplified models

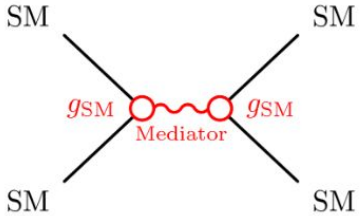
Possible mediators: (axial-)vector, (pseudo-)scalar
Possible DM: Dirac/Majorana fermion, real/complex scalar

X + MET searches



- Use ISR or associated production to tag the events
- Look for deviation from SM background

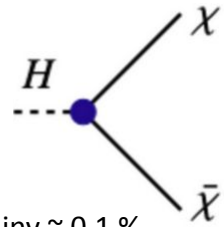
Mediator (resonance) searches



- Visible final states
- Look for mass peak above background continuum

Higgs-portal models

Higgs as mediator

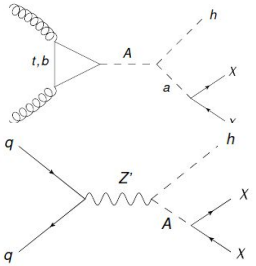


In SM, H→inv ~ 0.1 %
(H→ZZ*→4ν)
Look for enhancement of higgs decay to invisible

Dark/hidden sector

2HDM

- Two-Higgs doublet extensions with a vector Z' or pseudo-scalar a
- Couplings prioritize third generation and signatures with vector and Higgs bosons



Z'

E.g. the baryonic Z' model predicts a new massive vector mediator (Z') that emits a Higgs boson and then decays to a pair of Dirac fermionic DM particles

SUSY

Lightest supersymmetric particle is stable, neutral and interacts weakly with SM particles → DM candidate

Outline of the talk

- X + MET searches
  - Jet + MET
  - H($b\bar{b}$) + MET
- DM + Heavy Flavour
  - DM + t
  - DM + $t\bar{t}$
- Brand new results:
  - Z($\ell\ell$)+MET NEW
  - Combination of 2HDM+a results NEW
- Z($\ell\ell$)+H($b\bar{b}$)+MET within NMSSM

Jet + MET

Phys. Rev. D 103 (2021) 112006
arXiv:2102.10874

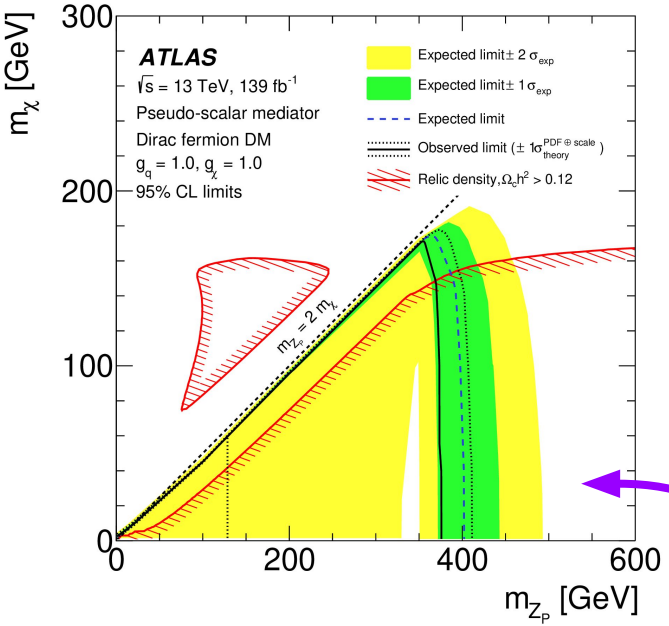
Background estimations: V+jets, $t\bar{t}$ and single-t: dedicated Control Regions (CRs). Multijets: jet smearing method in data

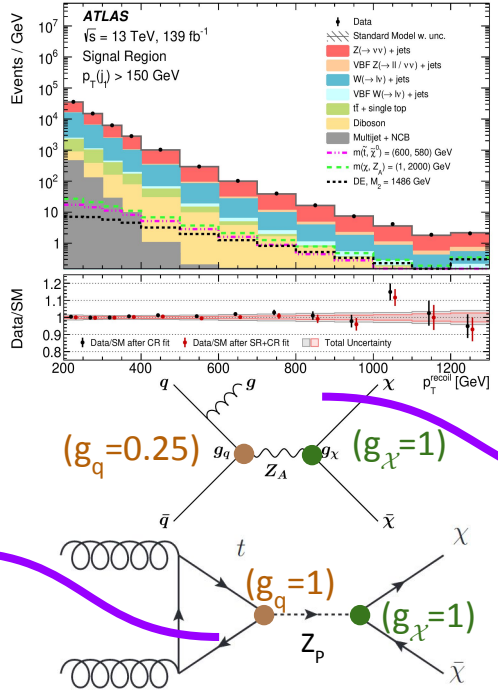
Event selection: MET> 200 GeV, p_T^{jet}>30 GeV & $|\eta|$<2.8 ($p_T^{lead\ jet}$>150 GeV & $|\eta^{lead\ jet}|$<2.4), $\Delta\phi$(jet,p_T^{miss}) cut to reduce multijet contribution

Results: Simultaneous and binned profile likelihood fit to the p_T^{recoil} distribution (SR + 5 CRs)

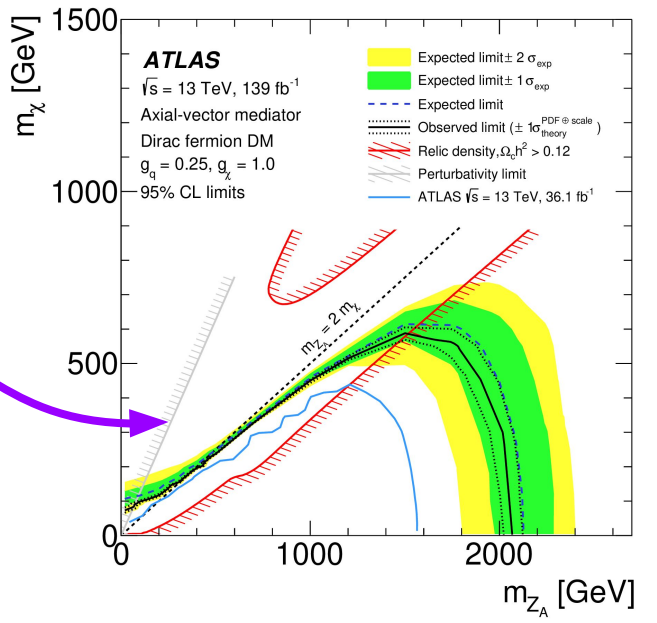
Interpretation in terms of DM model with Dirac DM: upper limits at 95% CL

Simplified pseudo-scalar model





Simplified axial-vector model



H($b\bar{b}$) + MET

ATLAS-CONF-2021-006

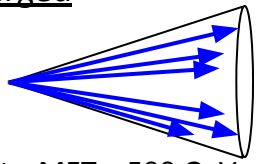
Main backgrounds: V + HF (Heavy Flavour) jets and $t\bar{t}$ (normalizations estimated with CRs)

Results: Binned profile likelihood fit to Higgs mass distribution (SR + CRs)

Event selection based on the Higgs boson boost

Merged

Higgs

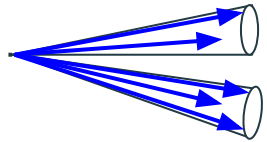


★ ≥ 1 large-*R* jets, MET > 500 GeV

★ Boosted Higgs identified w/ Variable Radius (VR) track jets

Resolved

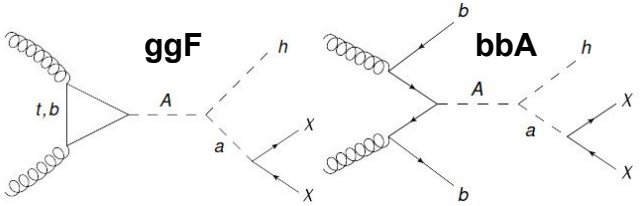
Higgs



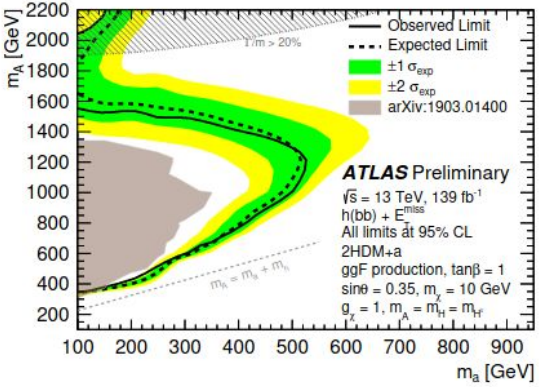
★ ≥ 2 small-*R* jets (≥ 2 b-tagged jets)

★ 3 MET regions in range [150,500] GeV

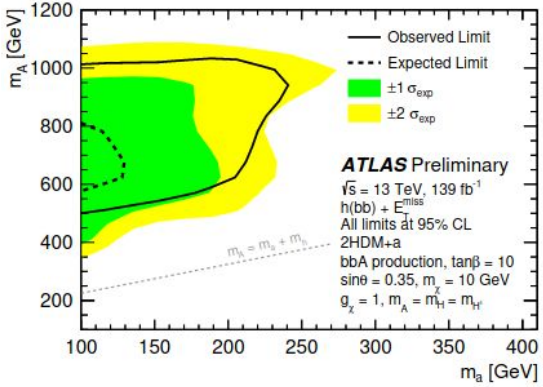
2HDM+a (2HDM + light pseudo-scalar a)



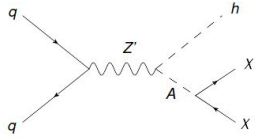
tanβ=1 (dominated by ggF)

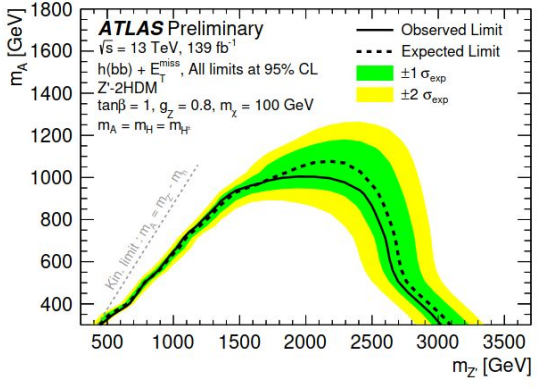


tanβ=10 (dominated by bbA)



Z'-2HDM model (2HDM + Z'→hA, A: heavy pseudo-scalar)



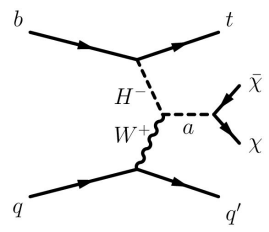


DM + t

Search for dark matter in the context of 2HDM+a

arXiv:2011.09308
submitted to Eur. Phys. J. C.

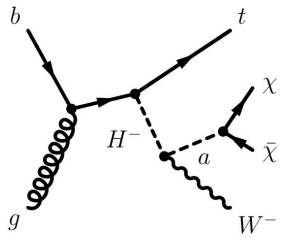
t-channel



tj_{1L}

- 1 isolated lepton
- N_{jets} ϵ [1,4]
- $N^{b\text{-}jets}$ ϵ [1,2]
- MET > 200 GeV
- BDT trained to improve sensitivity

tW-channel

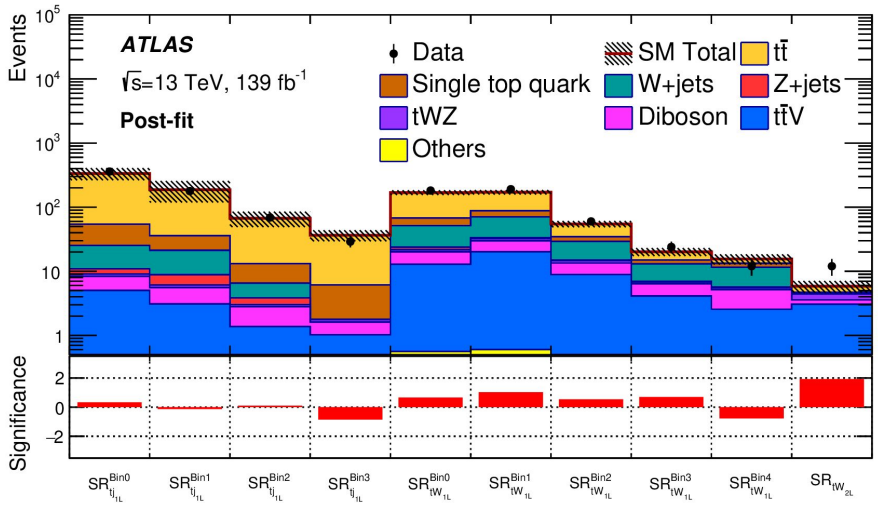


tW_{1L} (1 W decays leptonically)

- 1 isolated lepton
- $N_{jets} \geq 3$
- $N_{b\text{-}jets} \geq 1$
- MET > 250 GeV

tW_{2L} (2 Ws decay leptonically)

- 2 OS isolated leptons
- $N_{jets} \geq 1$
- $N_{b\text{-}jets} \geq 1$
- MET > 200 GeV



Targetting DM+t processes, but also sensitive to DM+t$\bar{t}$:

- Low $m_{H^\pm}$: dominated by DM+t
- High $m_{H^\pm}$: dominated by DM+tt

Main backgrounds

tj_{1L}: $t\bar{t}$ and W+jets
tW_{1L}: $t\bar{t}$ and W+jets
tW_{2L}: $t\bar{t}$, $t\bar{t}Z$ and tWZ

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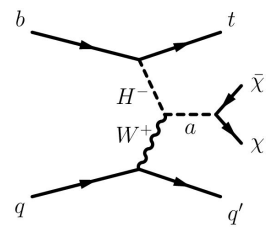

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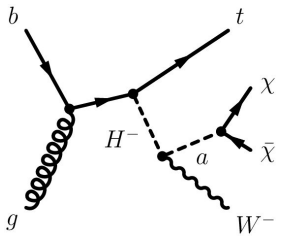

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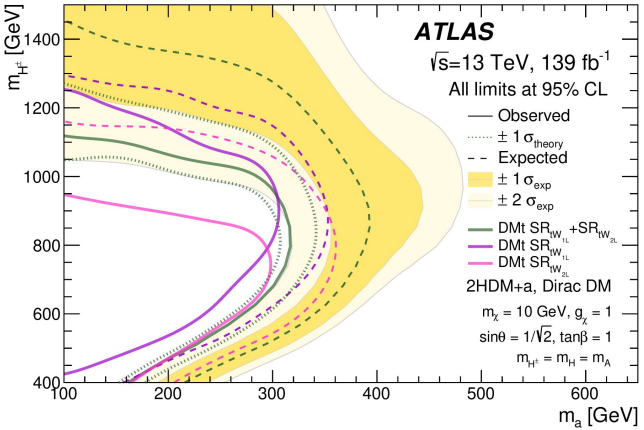
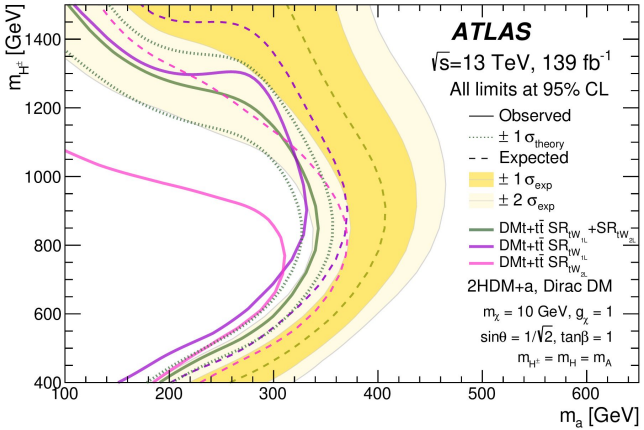
tW_{2L} (2 Ws decay leptonically)

- 2 OS isolated leptons
- $N_{jets} \geq 1$
- $N_{b\text{-jets}} \geq 1$
- MET > 200 GeV

Assuming only DM+t contributions (tW channel only)



Assuming DM+t$\bar{t}$ and DM+t contributions



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Main backgrounds

tj_{1L}: $t\bar{t}$ and W+jets
tW_{1L}: $t\bar{t}$ and W+jets
tW_{2L}: $t\bar{t}$, $t\bar{t}Z$ and tWZ

DM+$t\bar{t}$

JHEP 04 (2021) 165 arXiv:2102.01444 JHEP 04 (2021) 174 arXiv:2012.03799

$$m_{T2}(\mathbf{p}_{T,1}, \mathbf{p}_{T,2}, \mathbf{p}_T^{miss}) = \min_{\mathbf{q}_{T,1}+\mathbf{q}_{T,2}=\mathbf{p}_T^{miss}} \{\max[\, m_T(\mathbf{p}_{T,1}, \mathbf{q}_{T,1}), m_T(\mathbf{p}_{T,2}, \mathbf{q}_{T,2})\,]\}$$

$$m_{T2}^{\ell\ell} = m_{T2}(\mathbf{p}_T(\ell_1), \mathbf{p}_T(\ell_2), \mathbf{p}_T^{miss})$$

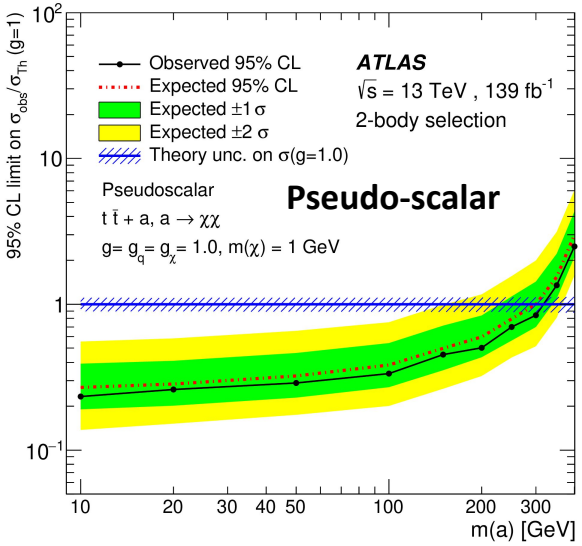
Final states: One or two leptons, multiple jets and large MET

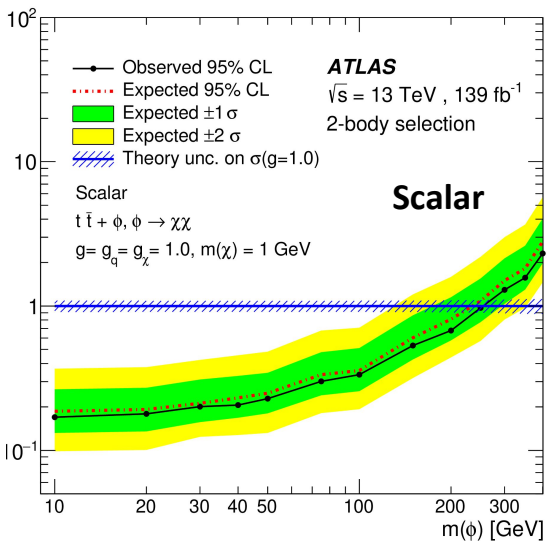
- Dedicated selection/analysis for each decay mode

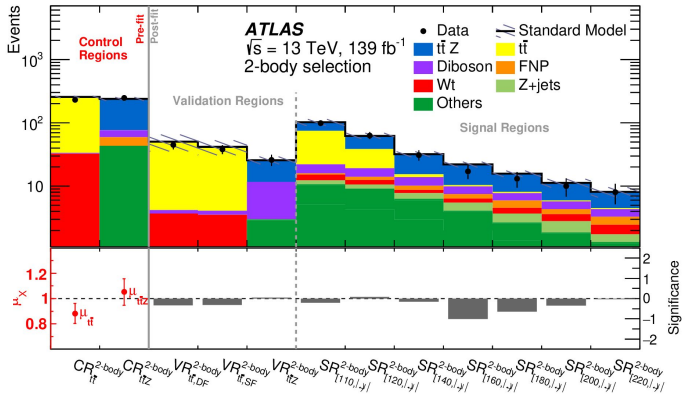
Spin-0 mediator DM model: Mediator (scalar ϕ or pseudoscalar a) is produced in association with a top-quark pair and decays to a pair of DM particles

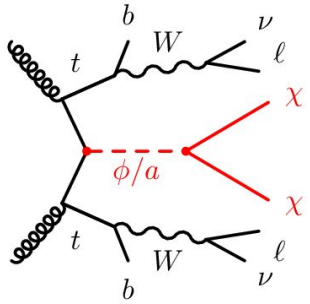
↓ All plots are for the analysis with 2 leptons →

Upper limits are calculated at 95% CL on the ratio of the production cross-section for the spin-0 mediator model to the theoretical cross-section









$$SR^{2\text{-body}}_{[x,\infty)}$$

with x being the lower bound placed on $m_{T2}^{\ell\ell}$

DM+bb available too: JHEP 05 (2021) 093

Z(ℓℓ)+MET | Higgs portal

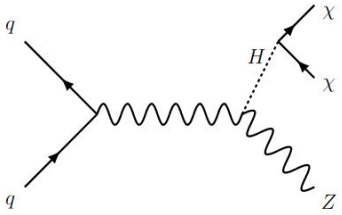
ATLAS-CONF-2021-029

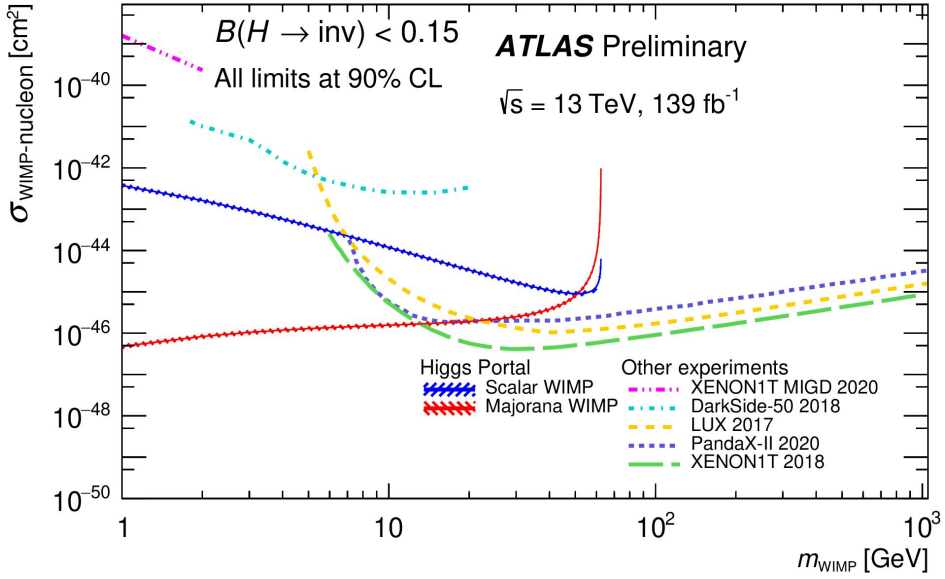
NEW

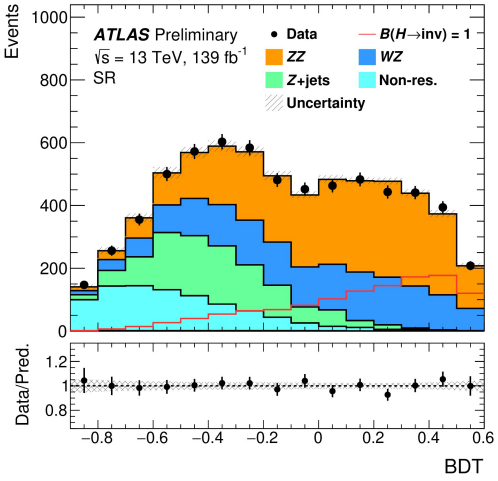
DM-SM interactions mediated by Higgs boson: coupling to DM enhances H⟶invisible decays

Results translated into a spin-independent DM-nucleon elastic scattering cross-section limit and are compared to direct searches

Assuming Higgs portal scenarios where the 125 GeV Higgs boson decays to a pair of DM particles that are either scalars or Majorana fermions







Observed upper limit on the branching ratio of a SM-like Higgs boson to invisible particles

BR(H⟶inv) < 18% at a 95% CL

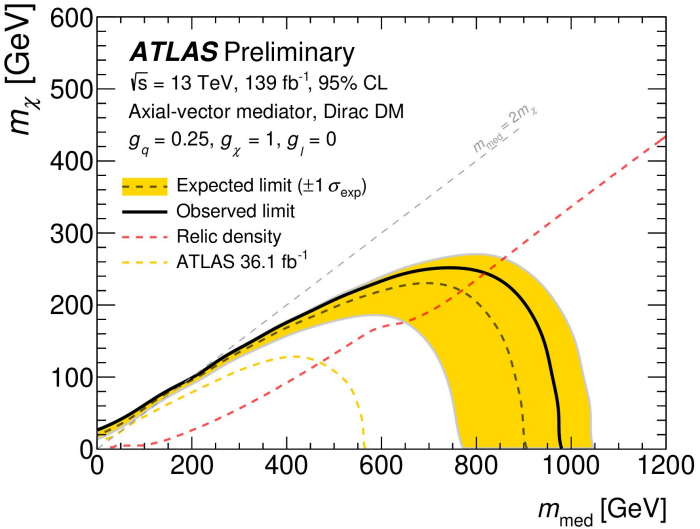
Z(ℓℓ)+MET | Simplified model + 2HDM+a

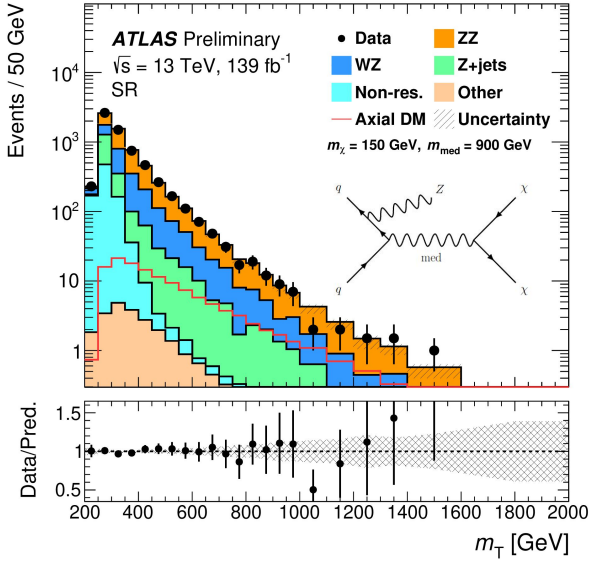
ATLAS-CONF-2021-029

$$m_{\mathrm{T}} = \sqrt{\sqrt{m_Z^2 + (p_{\mathrm{T}}^{\ell\ell})^2} + \sqrt{m_Z^2 + (E_{\mathrm{T}}^{\mathrm{miss}})^2} - (\vec{p}_{\mathrm{T}}^{\,\ell\ell} + \vec{E}_{\mathrm{T}}^{\mathrm{miss}})^2}$$

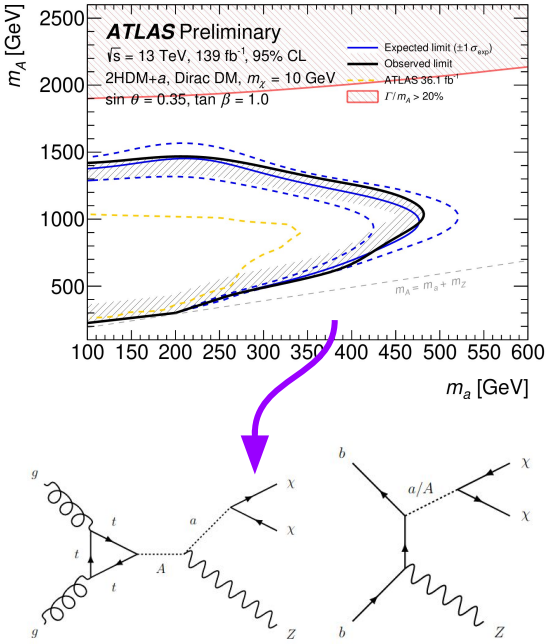
Simplified DM model

Axial-vector mediator





2HDM+a



Combination of 2HDM+a results

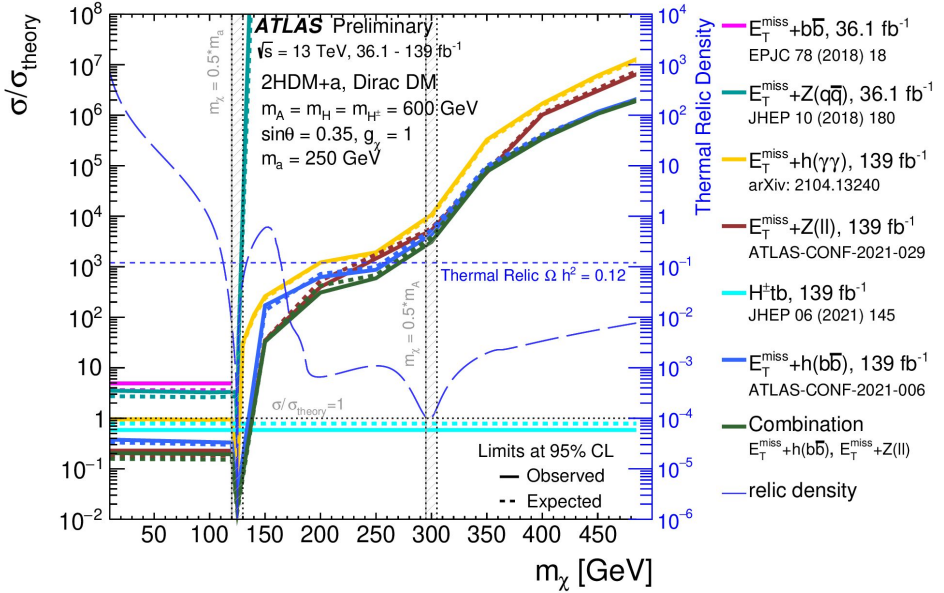
ATLAS-CONF-2021-041

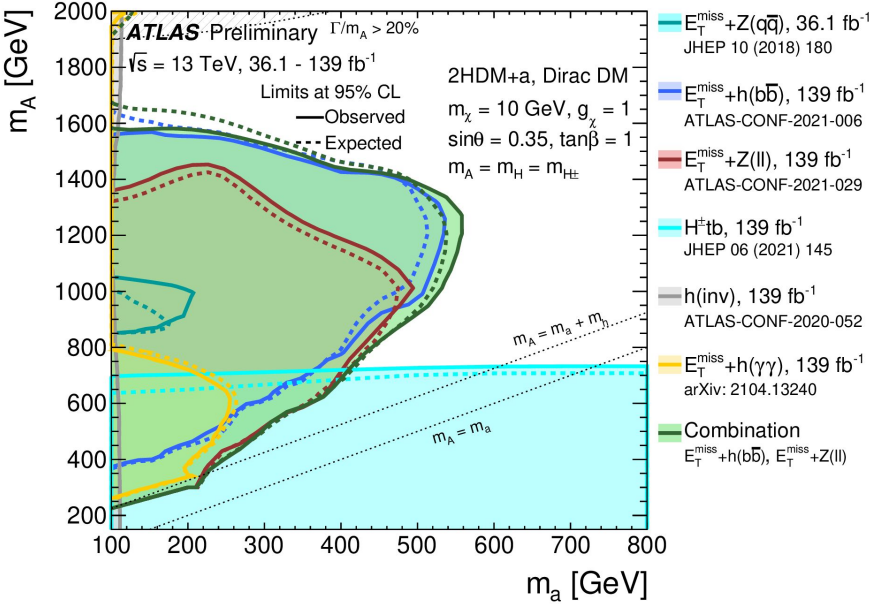
Summary of searches for DM produced in extended Higgs sectors

NEW

New w.r.t previous DM summary results [JHEP05(2019) 142]:

- Reinterpretation of $H^{\pm}tb$ search in the context of DM models
- Statistical combination of MET+h($b\bar{b}$) and MET+Z($\ell\ell$) (which are complementarity and share comparable sensitivity)
- Most sensitive searches updated to full Run 2 luminosity





$Z(\ell\ell)+H\rightarrow b\bar{b}+MET$

HDBS-2018-07

Search targets events from ZH production in an Next-to-MSSM scenario where $H \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^0$ with $\tilde{\chi}_2^0 \rightarrow a\tilde{\chi}_1^0$

$\tilde{\chi}_1^0$ and $\tilde{\chi}_2^0$ are the lightest neutralinos, a is an additional pseudo-scalar Higgs boson (where $a\rightarrow b\bar{b}$ dominates)

Event selections:

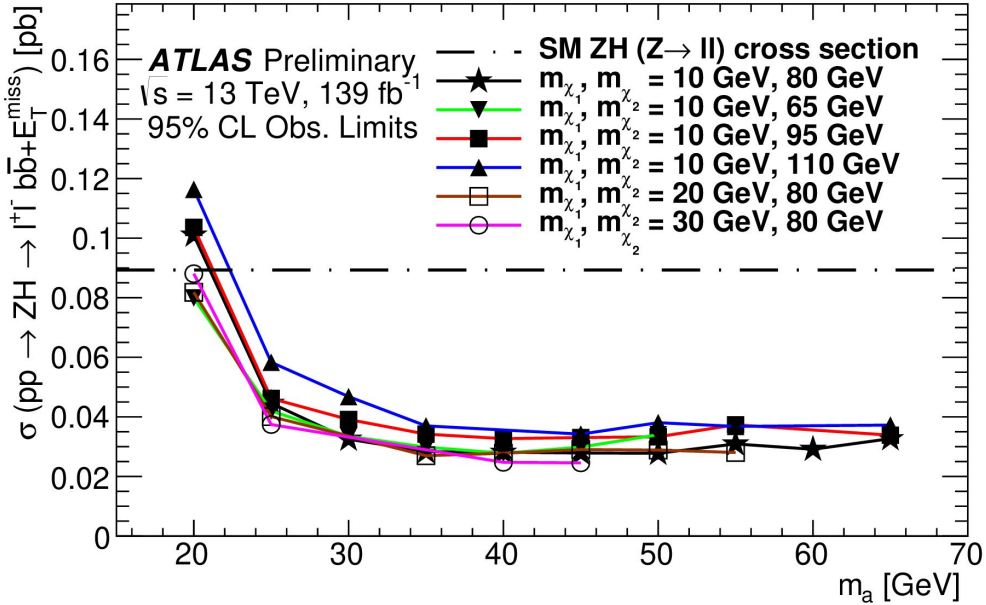
- Jets ≥ 2 (1 of the 2 leading p_T jets must be b-tagged)
  - Requiring only 1 b-tagged jet is a trade-off b/w signal acceptance and background rejection
- MET > 100 GeV
- 20 < m_{jj} [GeV] < 120 (using the two leading p_T jets)
- 0.8 < (p^{jj}_T + MET) / $p^{\ell\ell}_T$ < 1.2 (reduces $t\bar{t}$ background)

Main backgrounds:

Z + heavy-flavour (bottom and charm) jets and $t\bar{t}$

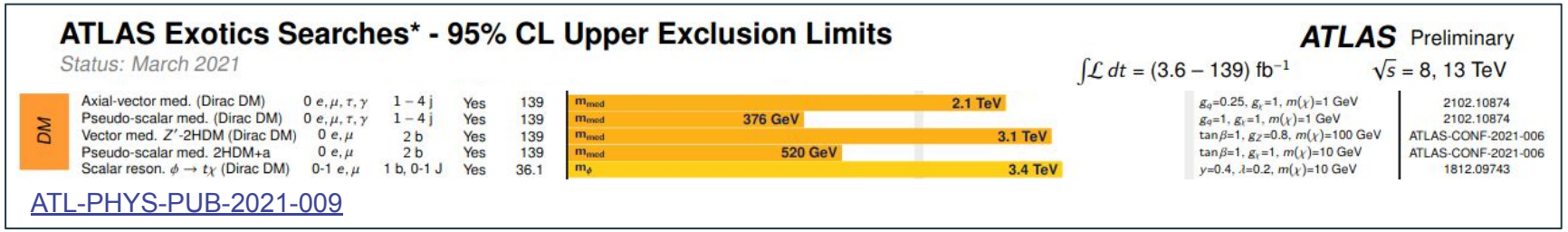
➔ their contributions are estimated from data in CRs

m_{jj} is used as the final discriminant in a binned likelihood fit



Conclusions

- A large number of searches for DM candidates has been performed by ATLAS with no significant excess found
  - Various models from several signatures investigated:
    - mono-X, resonances, H⟶inv, SUSY, 2HDM, etc
- These analyses are complementary with non-collider/direct searches
- More searches are in progress with full Run 2 data (stay tuned!)
- Huge prospects for DM searches in HL-LHC:
  - ATL-PHYS-PUB-2018-038, ATL-PHYS-PUB-2018-043, ATL-PHYS-PUB-2018-036, ATL-PHYS-PUB-2018-048, etc

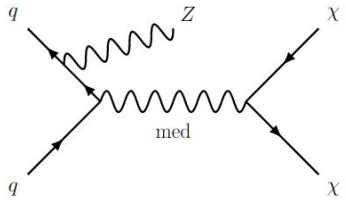



ARCHIVE
BACKUP

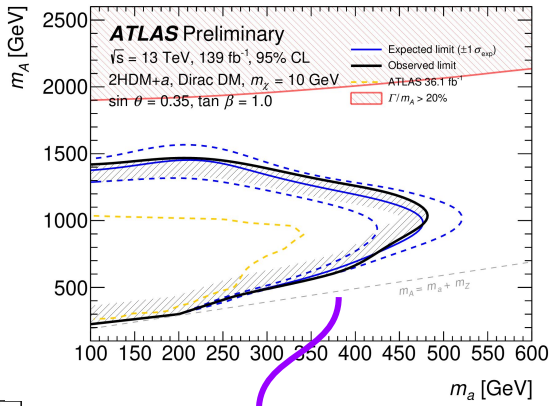
Z(ℓℓ)+MET | Simplified model + 2HDM+a

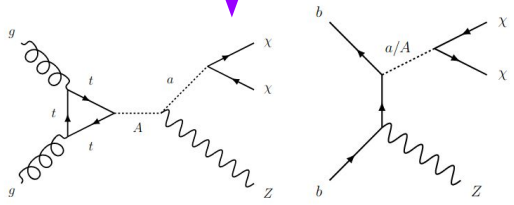
ATLAS-CONF-2021-029

Simplified DM models

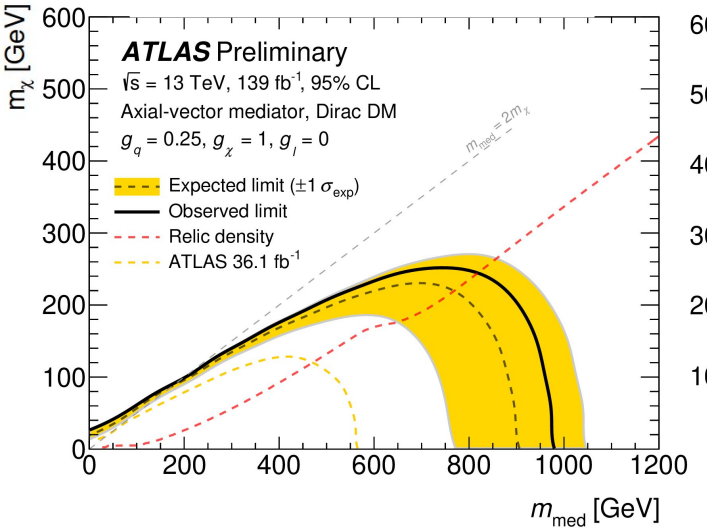


2HDM+a

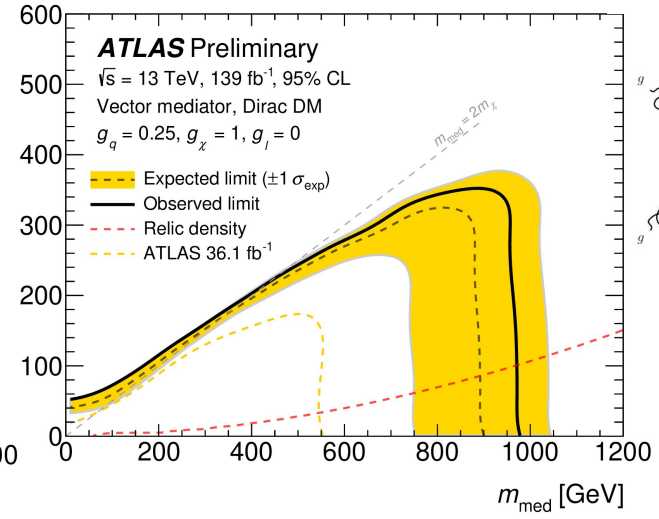




Axial-vector mediator



Vector mediator



$Z(\ell\ell)+H\rightarrow b\bar{b}+MET$

HDBS-2018-07

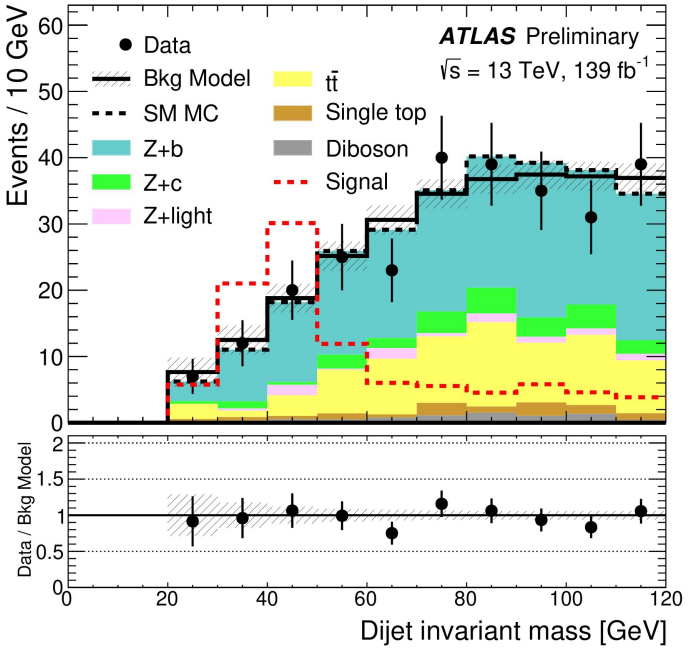
	SR	CRZ	CRTop	VRMET
Number of leptons			2	
Number of jets			≥ 2	
Number of b-tagged jets			≥ 1	
Dilepton p_{T} [GeV]			> 40	
p_{T} fraction			[0.8, 1.2]	
Dilepton mass [GeV]	[81, 101]	[81, 101]	[50, 81] or > 101	[81, 101]
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 100	[60, 100]	> 100	> 50
Dijet mass [GeV]	[20, 120]	[20, 120]	[20, 120]	> 150

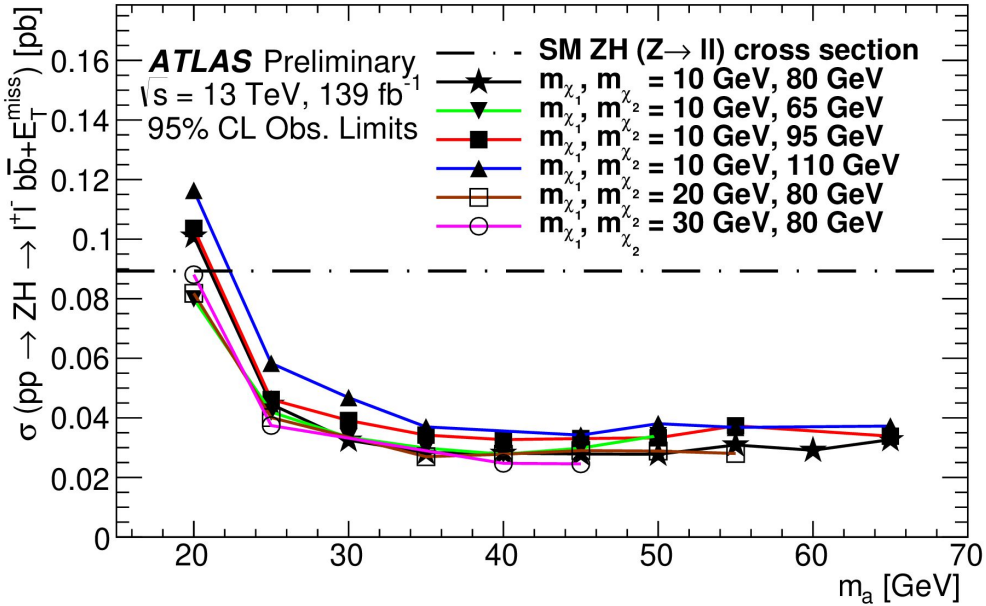
$Z(\ell\ell)+H\rightarrow b\bar{b}+MET$

HDBS-2018-07

Search targets events from ZH production in an Next-to-MSSM scenario where $H \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^0$ with $\tilde{\chi}_2^0 \rightarrow a\tilde{\chi}_1^0$

$\tilde{\chi}_1^0$ and $\tilde{\chi}_2^0$ are the lightest neutralinos, a is an additional pseudo-scalar Higgs boson (where $a\rightarrow b\bar{b}$ dominates)



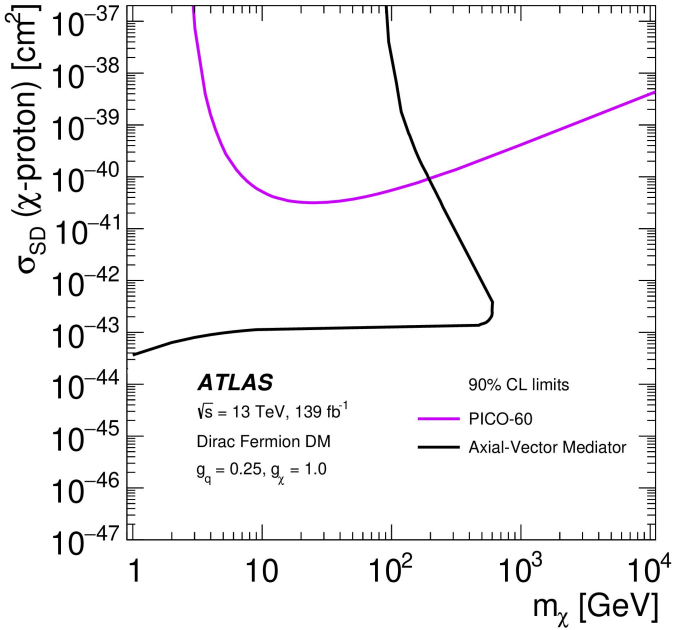


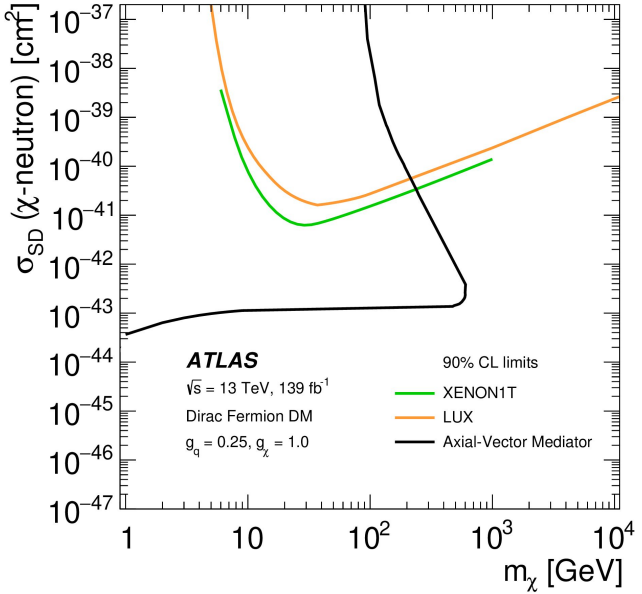
Jet + MET

Comparing with direct searches

Phys. Rev. D 103 (2021) 112006
arXiv:102.10874

Comparison of ATLAS limits (black line) on the spin-dependent WIMP--proton scattering cross section (left) and on the spin-dependent WIMP--neutron scattering cross section (right) as a function of the WIMP mass, in the context of the simplified model with axial-vector couplings





Jet + MET

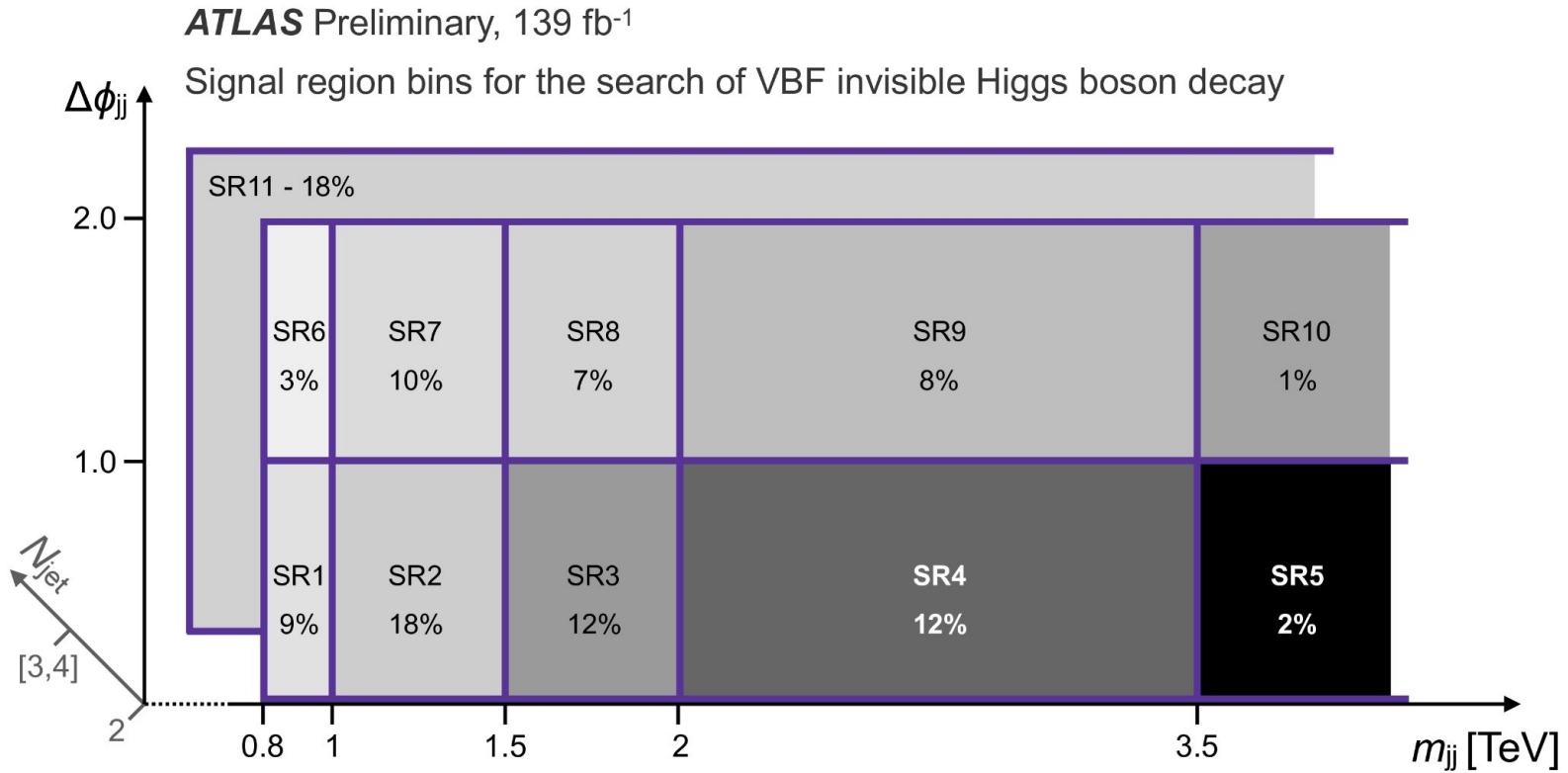
Phys. Rev. D 103 (2021) 112006
arXiv:102.10874

Requirement	SR	$W \to \mu\nu$	$Z \to \mu\mu$	$W \to e\nu$	$Z \to ee$	Top
Primary vertex	at least one with ≥ 2 associated tracks with $p_T > 500$ MeV					
Trigger	E_T^{miss}			single-electron		E_T^{miss}, single-electron
p_T^{recoil} cut	$E_T^{miss} > 200$ GeV	$\lvert\mathbf{p}_T^{miss} + \mathbf{p}_T(\mu)\rvert > 200$ GeV	$\lvert\mathbf{p}_T^{miss} + \mathbf{p}_T(\mu\mu)\rvert > 200$ GeV	$\lvert\mathbf{p}_T^{miss} + \mathbf{p}_T(e)\rvert > 200$ GeV	$\lvert\mathbf{p}_T^{miss} + \mathbf{p}_T(ee)\rvert > 200$ GeV	$\lvert\mathbf{p}_T^{miss} + \mathbf{p}_T(\mu)\rvert > 200$ GeV or $\lvert\mathbf{p}_T^{miss} + \mathbf{p}_T(e)\rvert > 200$ GeV
Jets	up to 4 with $p_T > 30$ GeV, $\lvert\eta\rvert < 2.8$					
$\lvert\Delta\phi(\text{jets}, \mathbf{p}_T^{recoil})\rvert$	> 0.4 (> 0.6 if 200 GeV $< E_T^{miss} \leq 250$ GeV)					
Leading jet	$p_T > 150$ GeV, $\lvert\eta\rvert < 2.4$, $f_{ch}/f_{max} > 0.1$					
b-jets	any	none	any	none	any	at least one
Electrons or muons	none	exactly one muon, with $p_T > 10$ GeV, $30 < m_T < 100$ GeV; no electron	exactly two muons, with $p_T > 10$ GeV, $66 < m_{\mu\mu} < 116$ GeV; no electron	exactly one electron, tight, with $p_T > 30$ GeV, $\lvert\eta\rvert \notin (1.37, 1.52)$, tight isolation, $30 < m_T < 100$ GeV; no muon	exactly two electrons, with $p_T > 30$ GeV, $66 < m_{ee} < 116$ GeV; no muon	same as for $W \to \mu\nu$ or same as for $W \to e\nu$
τ-leptons	none					
Photons	none					

H($b\bar{b}$) + MET

ATLAS-CONF-2021-006

Schematic view of the eleven bins in the signal region. The shading indicates the signal to background ratio and a darker grey corresponds to a higher value. The percentage gives the distribution of signal from invisibly decaying Higgs bosons to each of the bins.



Search for dark matter in the context of 2HDM+a

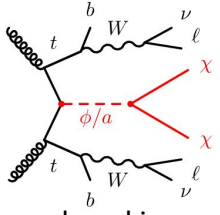
arXiv:2011.09308
submitted to Eur. Phys. J. C.

Variable	tW_{1L}	tW_{2L}	tj_{1L}
Trigger	E_T^{miss}	dilepton	E_T^{miss} OR one-lepton
N_ℓ^{signal}	$= 1$	$= 2$ (OS)	$= 1$
$p_T(\ell_1)$ [GeV]	> 30	> 25	> 30
$p_T(\ell_2)$ [GeV]	-	> 20	-
N_{jet}	≥ 3	≥ 1	$\in [1, 4]$
p_T(jet) [GeV]	> 30	> 30	> 30
$N_{b\text{-jet}}$	≥ 1	≥ 1	$\in [1, 2]$
$p_T(b_1)$ [GeV]	> 50	> 50	> 50
E_T^{miss} [GeV]	> 250	> 200	> 200
m_T^{lep} [GeV]	> 30	-	> 60
$m_{\ell\ell}$ [GeV]	-	$\geq 40, \notin [71, 111]$ $(ee/\mu\mu)$	-
$\Delta\phi_{min}$ [rad]	> 0.5	-	> 0.5

DM+$t\bar{t}$

JHEP 04 (2021) 165 arXiv:2102.01444

JHEP 04 (2021) 174 arXiv:2012.03799



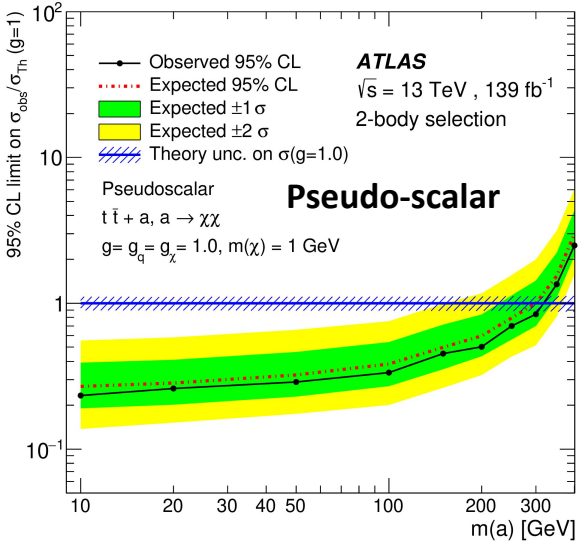
Final states: One or two leptons, multiple jets and large MET

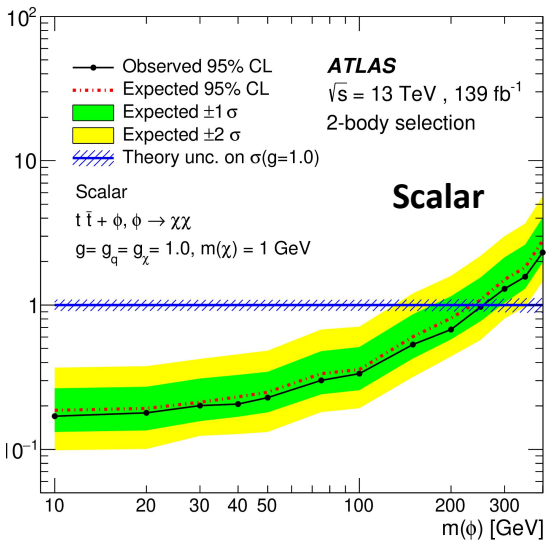
- Dedicated selection/analysis for each decay mode

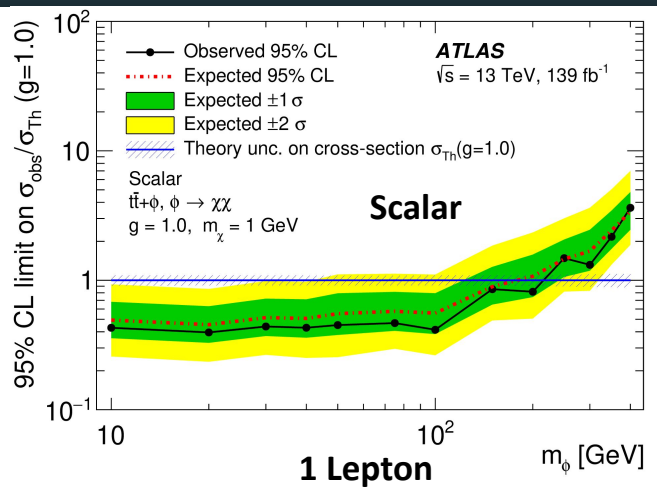
Spin-0 mediator DM model: Mediator (scalar ϕ or pseudoscalar a) is produced in association with a top-quark pair and decays to a pair of DM particles

Upper limits are calculated at 95% CL on the ratio of the production cross-section for the spin-0 mediator model to the theoretical cross-section

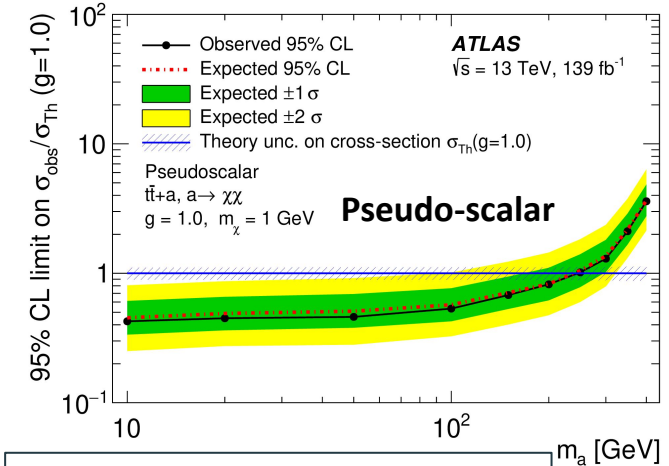
2 Leptons







1 Lepton



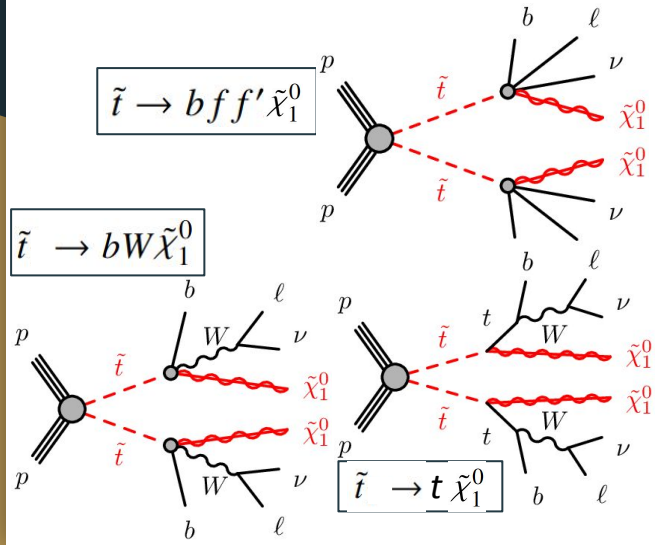
DM+bb available too: JHEP 05 (2021) 093

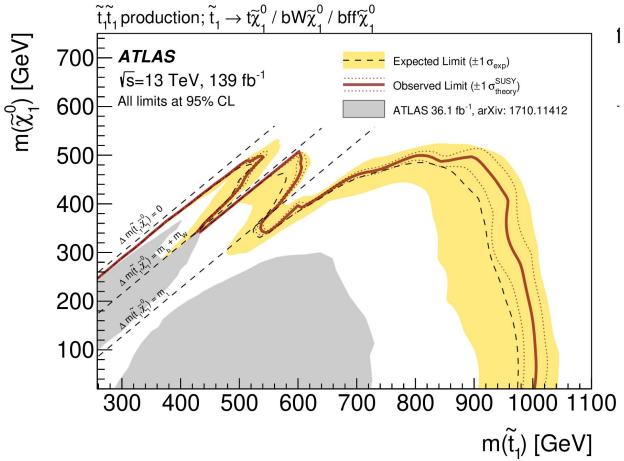
DM+$t\bar{t}$ | Interpretation within SUSY

JHEP 04 (2021) 165
arXiv:2102.01444
JHEP 04 (2021) 174
arXiv:2012.03799

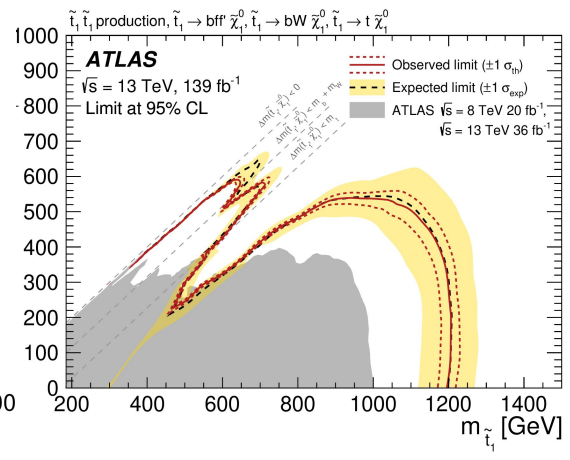
Final states: One or two leptons, multiple jets and large MET (dedicated selections for each decay mode)

- *R*-parity-conserving Minimal Supersymmetric Standard Model (MSSM):
  - Lightest supersymmetric particle (LSP) is stable and, if weakly interacting, a DM candidate
  - Considering models in which the DM candidate is the lightest neutralino $\tilde{\chi}_1^0$
  - Depending on the mass difference b/w the top squark and the neutralino, 3 decay modes are relevant





2 Leptons



1 Lepton

DM+$t\bar{t}$ | SR selections

JHEP 04 (2021) 165
arXiv:2102.01444
JHEP 04 (2021) 174
arXiv:2012.03799

	SR_W^{3-body}		SR_t^{3-body}	
Leptons flavour	DF	SF	DF	SF
$p_T(\ell_1)$ [GeV]	> 25		> 25	
$p_T(\ell_2)$ [GeV]	> 20		> 20	
$m_{\ell\ell}$ [GeV]	> 20		> 20	
$\lvert m_{\ell\ell} - m_Z \rvert$ [GeV]	–	> 20	–	> 20
$n_{b-\text{jets}}$	$= 0$		≥ 1	
$\Delta\phi_\beta^R$ [rad]	> 2.3		> 2.3	
E_T^{miss} significance	> 12		> 12	
$1/\gamma_{R+1}$	> 0.7		> 0.7	
R_{p_T}	> 0.78		> 0.70	
M_Δ^R [GeV]	> 105		> 120	

	SR^{2-body}	
Leptons flavour	DF	SF
$p_T(\ell_1)$ [GeV]	> 25	
$p_T(\ell_2)$ [GeV]	> 20	
$m_{\ell\ell}$ [GeV]	> 20	
$\lvert m_{\ell\ell} - m_Z \rvert$ [GeV]	–	> 20
$n_{b-\text{jets}}$	≥ 1	
$\Delta\phi_{\text{boost}}$ [rad]	< 1.5	
E_T^{miss} significance	> 12	
$m_{T2}^{\ell\ell}$ [GeV]	> 110	

DF = Different Flavour
SF = Same Flavour

	$SR^{4-body}_{\text{Small }\Delta m}$	$SR^{4-body}_{\text{Large }\Delta m}$
$p_T(\ell_1)$ [GeV]	< 25	< 100
$p_T(\ell_2)$ [GeV]	< 10	[10, 50]
$m_{\ell\ell}$ [GeV]	> 10	
$p_T(j_1)$ [GeV]	> 150	
$\min \Delta R_{\ell_2, j_i}$	> 1	
E_T^{miss} significance	> 10	
$p_{T,\text{boost}}^{\ell\ell}$ [GeV]	> 280	
E_T^{miss} [GeV]	> 400	
$R_{2\ell}$	> 25	> 13
$R_{2\ell 4j}$	> 0.44	> 0.38

VBF + γ | MET + 2 jets + γ

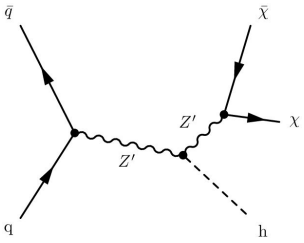
ATLAS-CONF-2021-004

Variable	SR	$W^{\gamma}_{\mu\nu}$ CR	$W^{\gamma}_{e\nu}$ CR	$Z^{\gamma}_{\text{Rev.Cen.}}$ CR	Fake$-e$ CR
(j_1) [GeV]			> 60		
(j_2) [GeV]			> 50		
			2,3		
$N_{\text{b-jet}}$			< 2		
$\Delta\phi_{\text{jj}}$			< 2.5 [2.0]		
$\lvert\Delta\eta_{\text{jj}}\rvert$			> 3.0		
$\eta(j_1) \times \eta(j_2)$			< 0		
C_3			< 0.7		
m_{jj} []			> 0.25		
[GeV]	> 150	–	> 80	> 150	< 80
$E_{\text{T}}^{\text{miss,lep-rm}}$ [GeV]	–	> 150	> 150	–	> 150
$E_{\text{T}}^{\text{jets,no-jvt}}$ [GeV]			> 130		
$\Delta\phi(j_i, E_{\text{T}}^{\text{miss,lep-rm}})$			> 1.0		
N_{γ}			1		
(γ) [GeV]		$> 15, < 110$ [> 15, $<\max(110, 0.733 \times m_{\text{T}})$]			
C_{γ}	> 0.4	> 0.4	> 0.4	< 0.4	> 0.4
$\Delta\phi(\gamma, E_{\text{T}}^{\text{miss,lep-rm}})$			> 1.8 [–]		
N_{ℓ}	0	1 μ	1 e	0	1 e
(ℓ) [GeV]			> 30		

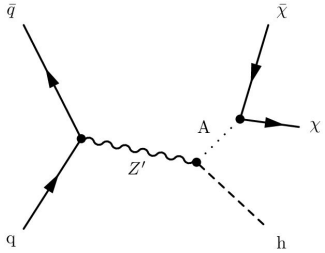
H(γγ) + MET

arXiv:2104.13240
submitted to JHEP

Z'_B model
Z' emits h and then decays to DM particles

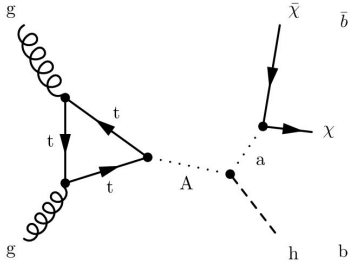


Z'-2HDM model
2HDM + Z'→hA
(A heavy pseudo-scalar)

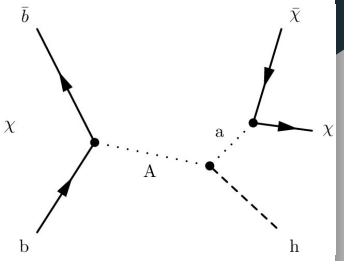


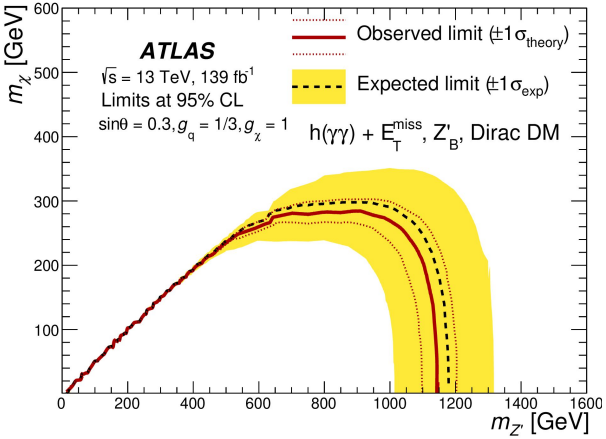
2HDM+a
2HDM + light pseudo-scalar a

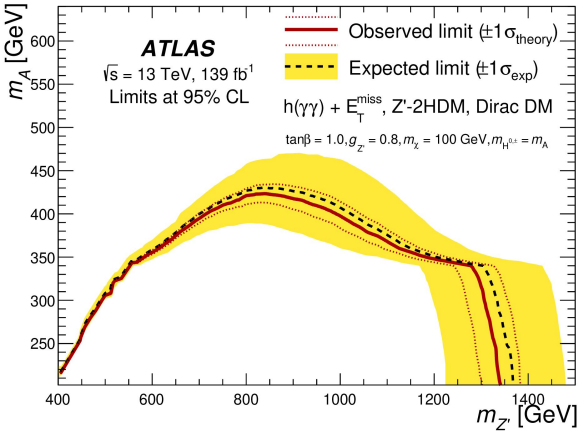
ggF (tanβ≲5)

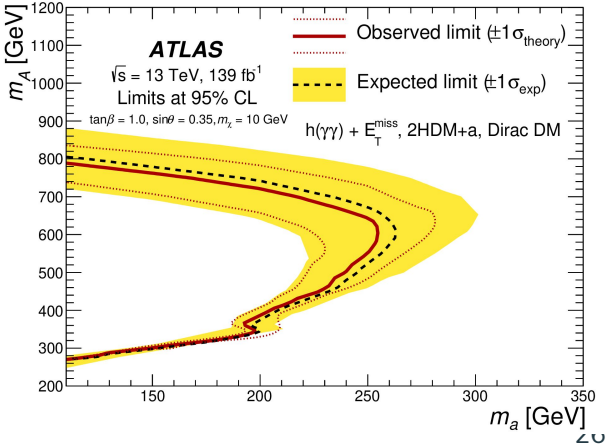


bbA (tanβ>5)







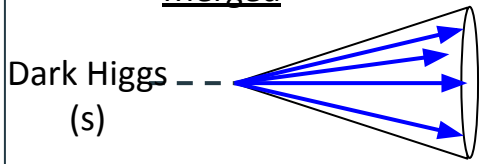


Mono-s→VV

Phys. Rev. Lett. 126, 121802 (2021)
arXiv:2010.06548

Event selection based on the Dark Higgs boson boost

Merged

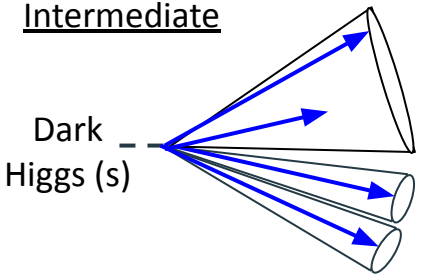


★ Improved sensitivity by using novel track-assisted reclustering (TAR) algorithm

★ Jet p_T> 300 GeV, MET>300 GeV

★ Most sensitive at low (high) m_s ($m_{Z'}$)

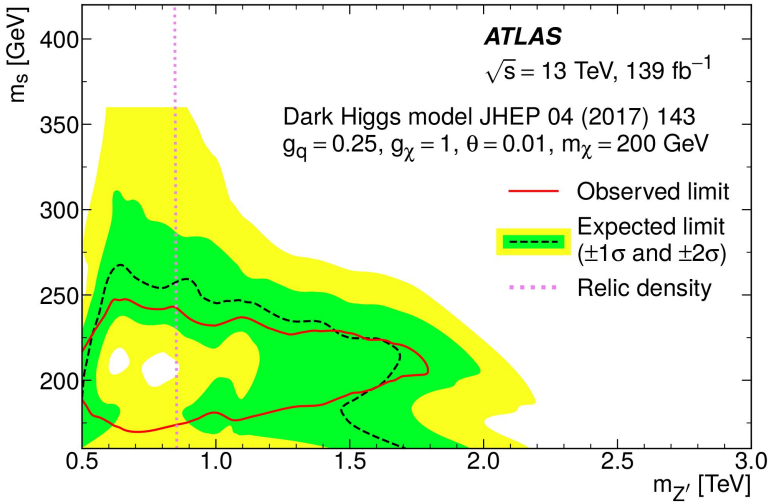
Intermediate



★ TAR jet is supplemented by up to two additional small-*R* jets within ΔR=2.□5 of the TAR jet. MET > 200 GeV

Main backgrounds: Z()+jets and W(lnu)+jets (normalizations estimated with CRs)

Interpretation in terms of dark Higgs model model with Majorana DM upper limits at 95% CL



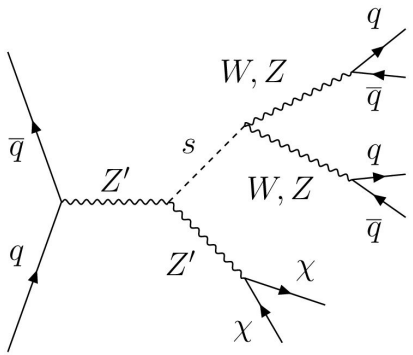
Dark Higgs model

Two mediators: Z', s

Z': massive spin-1 vector boson

s: dark Higgs (s→*VV*)

Majorana DM obtains mass via its Yukawa interactions with s

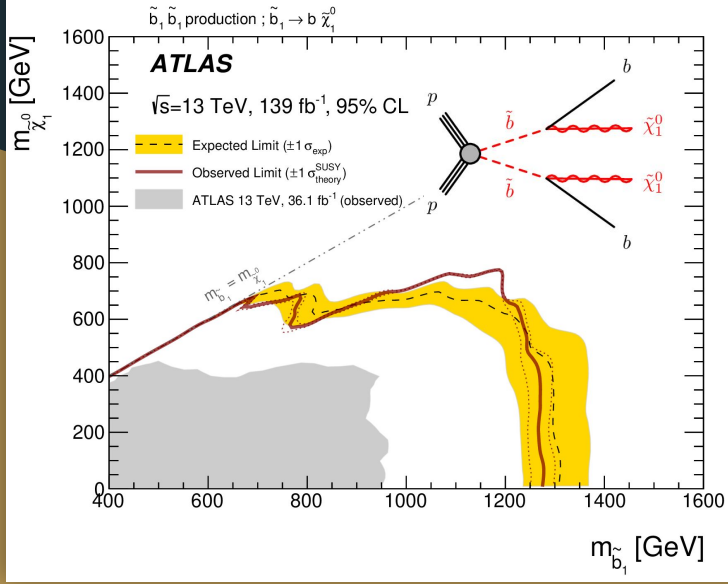


DM+$b\bar{b}$ |Spin-0 mediator and SUSY

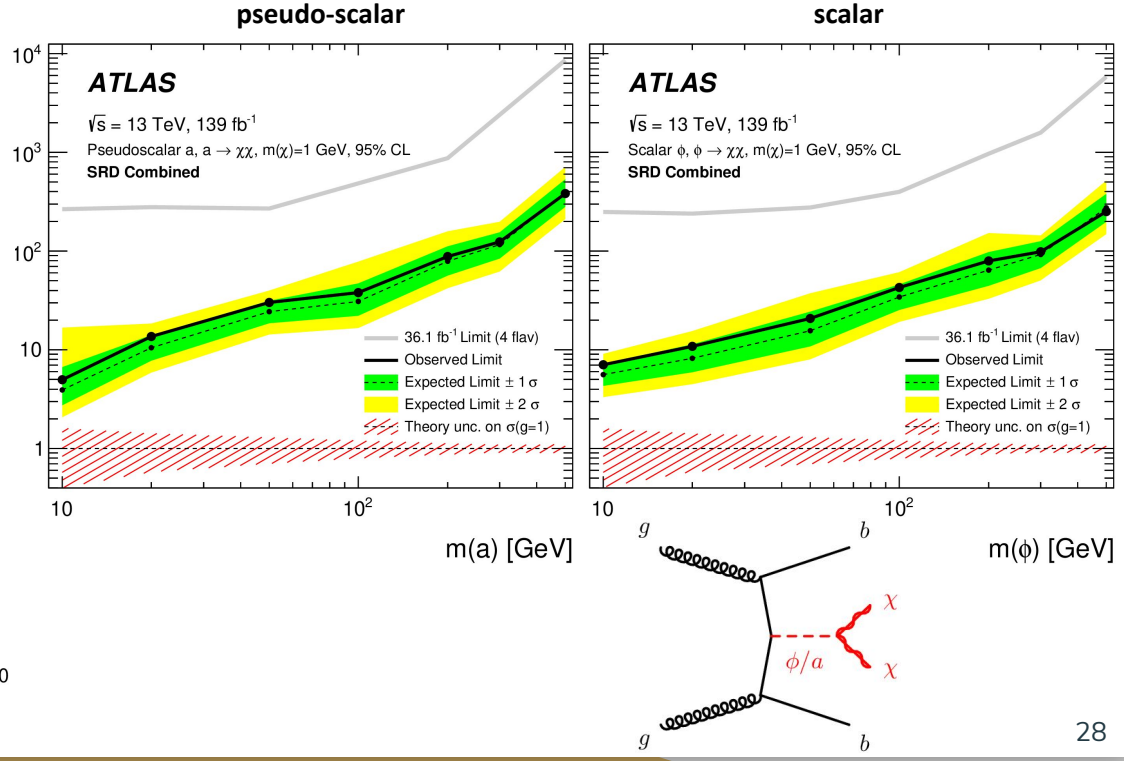
JHEP 05 (2021) 093
arXiv:2101.12527

DM search in final states with b-jets and MET

Exclusion limits at 95% CL on the masses of the $\tilde{b}_1$ and $\tilde{\chi}_1^0$



95% CL limits on the cross-section for models of DM production mediated by a scalar or pseudo-scalar mediator

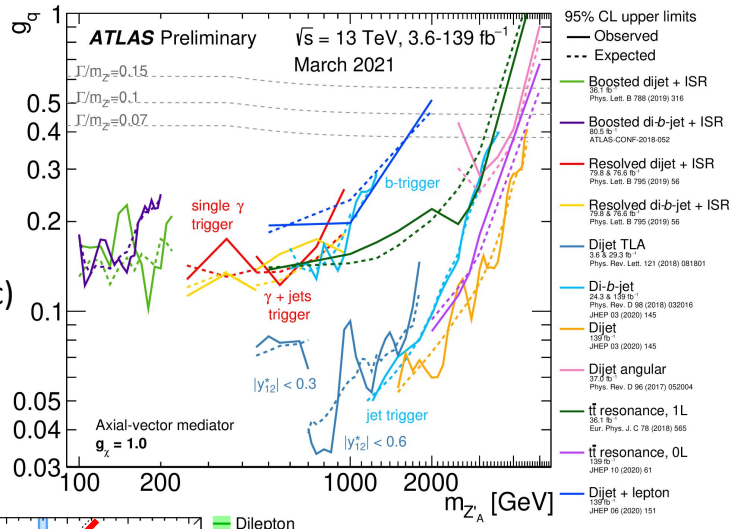


Interplay (X+MET & Resonance searches)

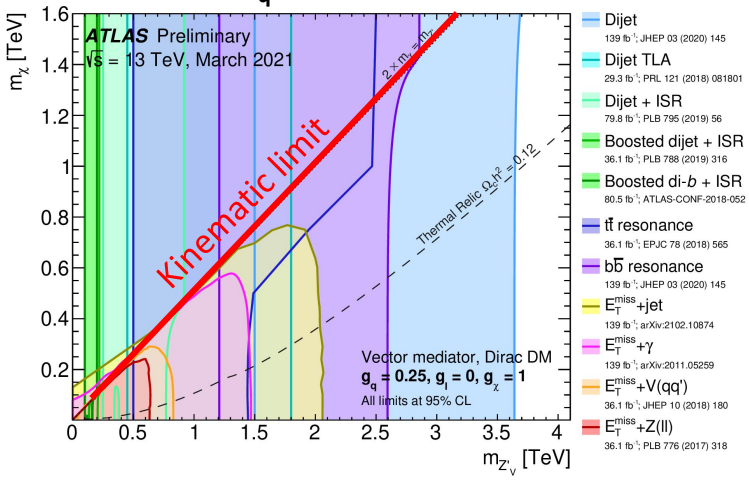
X + MET searches for spin-1 mediators have very low sensitivity in the off-shell region due to a strong reduction in the production cross section

➔ The sensitivity can be recovered using visible decays (dijets, dilepton, etc)

➔ Complementary to X+MET searches (depending on the model parameters)



g_q=0.25



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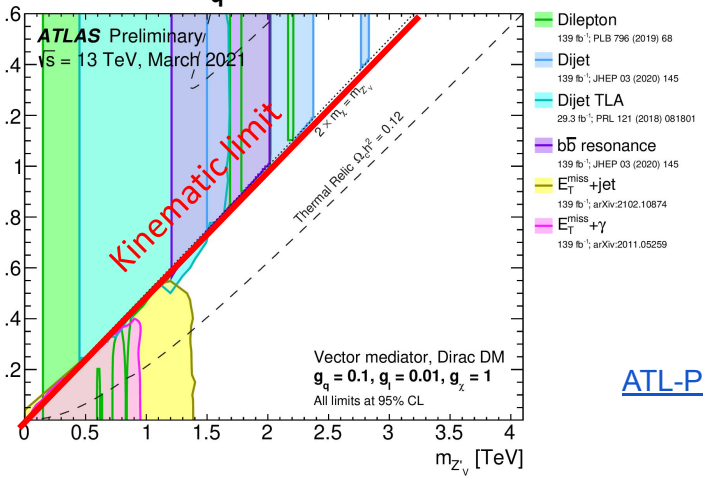
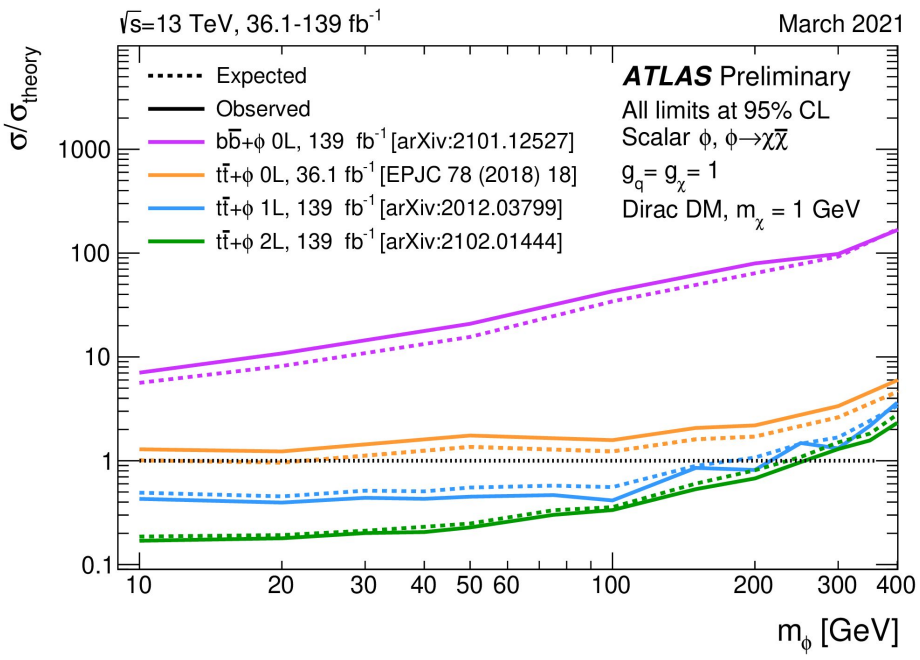


[ATL-PHYS-PUB-2021-006]

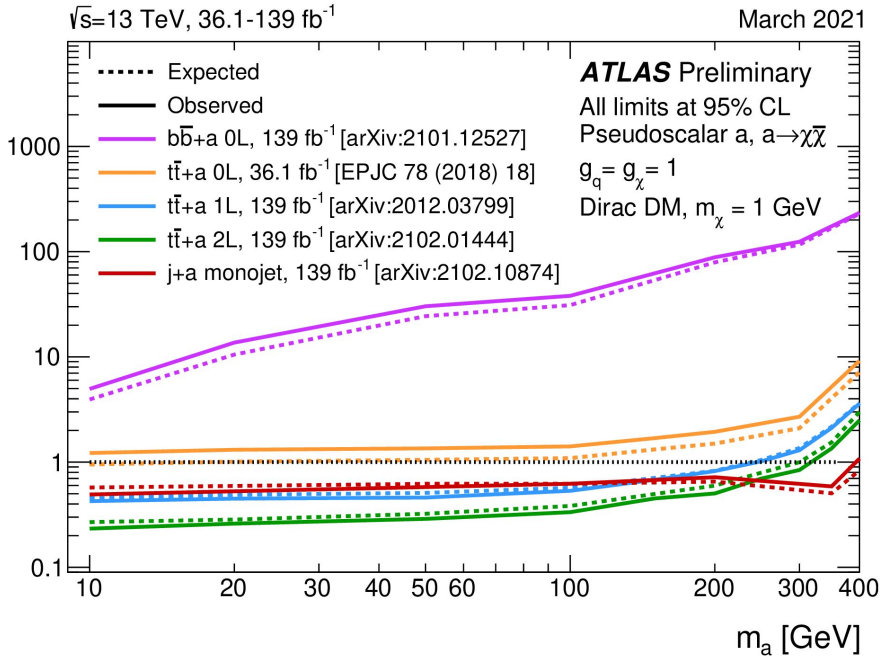
Summary searches for spin-0 mediators

ATL-PHYS-PUB-2021-006

Scalar mediator



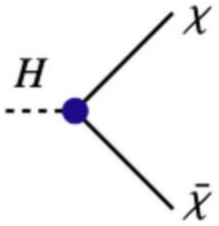
Pseudo-scalar mediator



Higgs as mediator | Combined results

ATLAS-CONF-2020-052

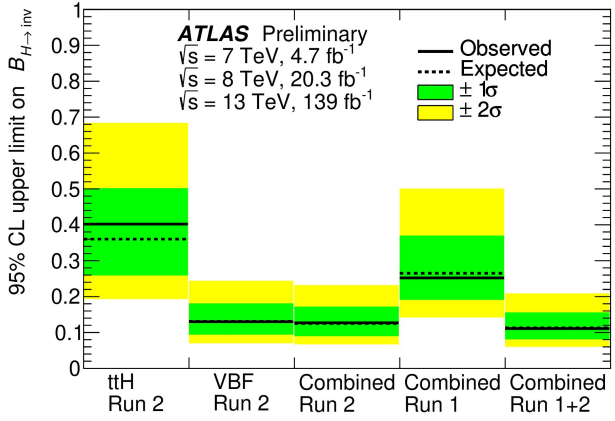
DM-SM interactions mediated by Higgs boson: coupling to DM enhances H→invisible decays (SM ~0.1%)



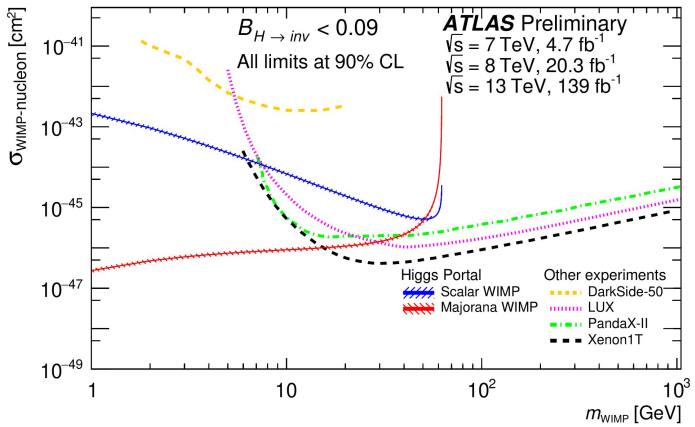
Combined results:

- $t\bar{t}H$ (MET+tt)
- VBF = Vector-Boson Fusion (MET + 2 jets) [Most sensitive]

ATLAS Run 1+2
BR(H→inv) < 0.11 (0.11) obs. (exp.) at 95% CL



Combined results translated into a spin-independent DM-nucleon elastic scattering cross-section limit and are compared to direct searches



Assuming Higgs portal scenarios where the 125 GeV Higgs boson decays to a pair of DM particles that are either scalars or Majorana fermions

VBF + γ | MET + 2 jets + γ

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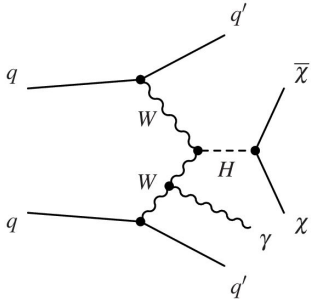
Search for the invisible or partially invisible decay of a Higgs boson produced through Vector Boson Fusion (VBF) with a photon in the final state

Extracted limits:

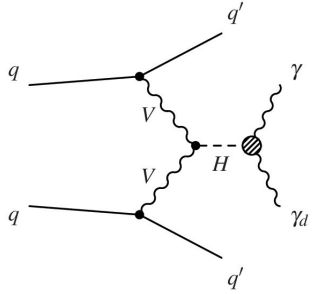
- Obs. (exp.) upper limit of 0.37 (0.34) at 95% CL on the branching ratio of a SM-like Higgs boson to invisible particles
- Obs. (exp.) 95% CL upper limit on the branching ratio for H→$\gamma\gamma_d$ at 0.014 (0.017) (m(H) = 125 GeV)

H→inv + emitted photon



Events are split into categories of different signal purities based on a multivariate analysis discriminant

H→photon + dark photon



Events are split into 5 bins of $m_T(\gamma,MET)$, and then split into 2 bins of m_{jj}

95% CL limit on the cross-section times SM-like Higgs boson branching ratio to $\gamma\gamma_d$ for different scalar-mediator-masses