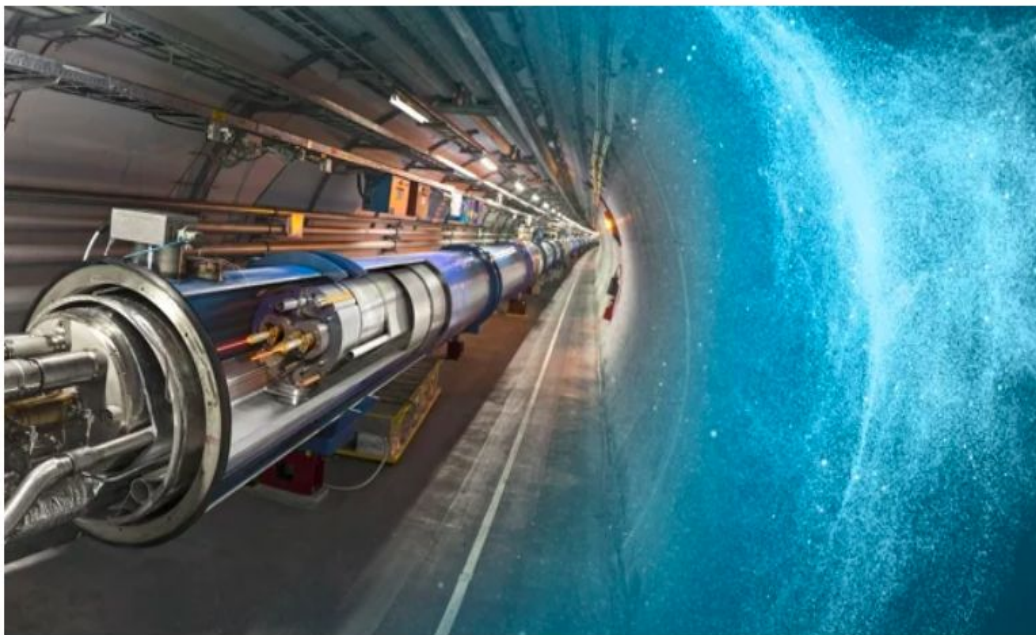


Overview of DM + heavy flavour searches at DESY-Zeuthen group



Alvaro Lopez Solis
on behalf of ATLAS DESY-Z group

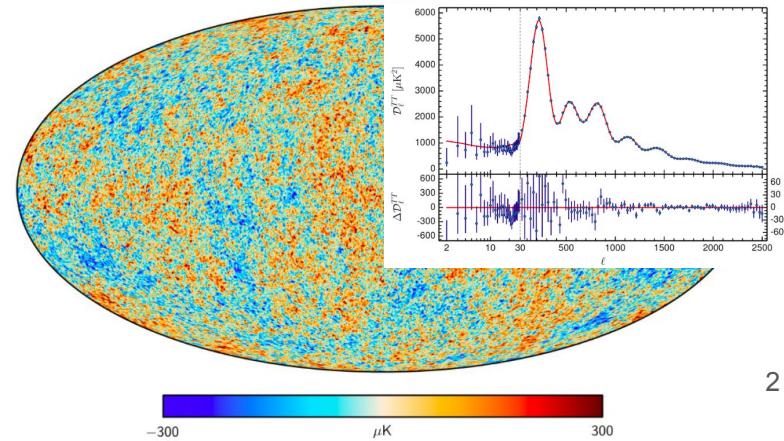
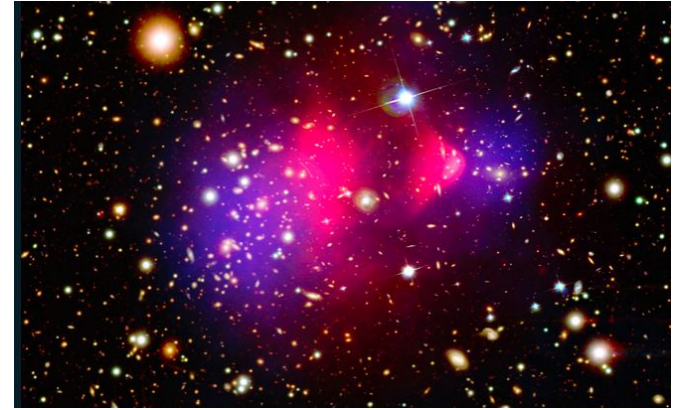
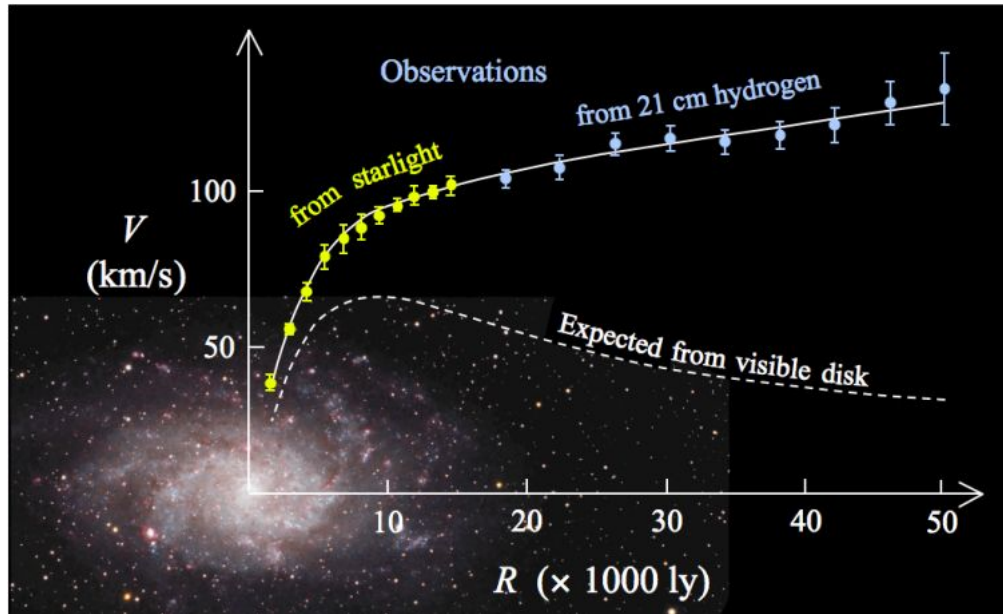
DESY Mini-Retreat 2023
Humboldt University, Adlershof



HELMHOLTZ
RESEARCH FOR GRAND CHALLENGE



Why dark matter ?



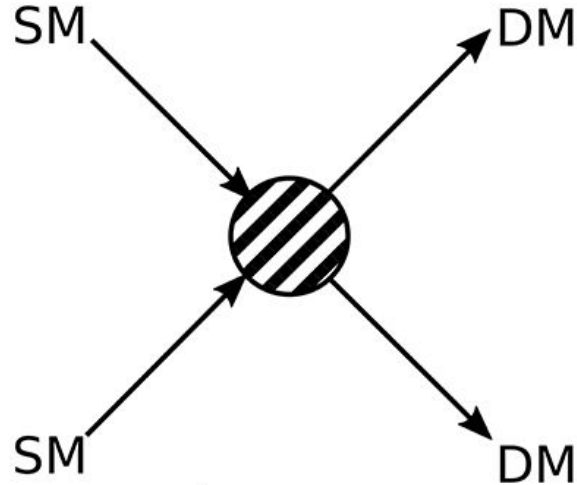
Powerful evidence indicating the **existence of weakly interacting non-luminous particles** in the Universe

WIMPs and its couplings to Standard Model

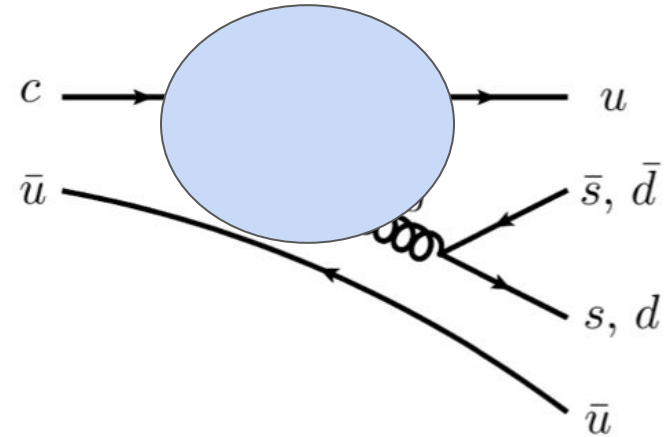
WIMPs: **thermal equilibrium and freeze-out only if DM-SM interaction.** But how?

- New interactions might introduce additional flavour violation or FCNC.

[Ann.Rev.Nucl.Part.Sci.60](#)



Generic flavour violating
couplings ?

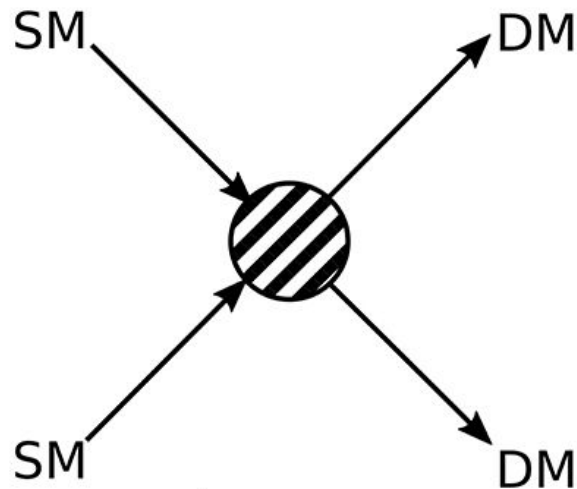


WIMPs and its couplings to Standard Model

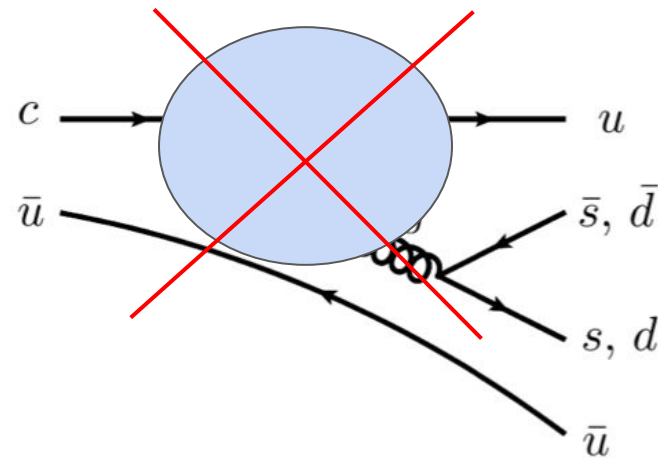
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Generic flavour violating
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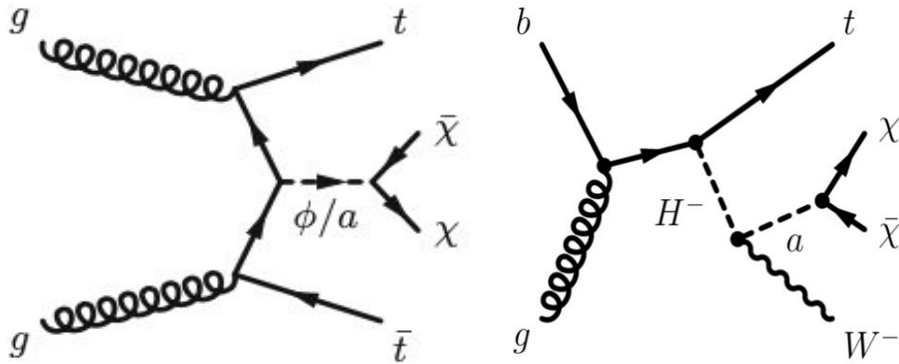
Highly constrained by flavour measurements !

Minimal flavour violation

Minimal flavour violation

No additional flavour violation source in DM sector

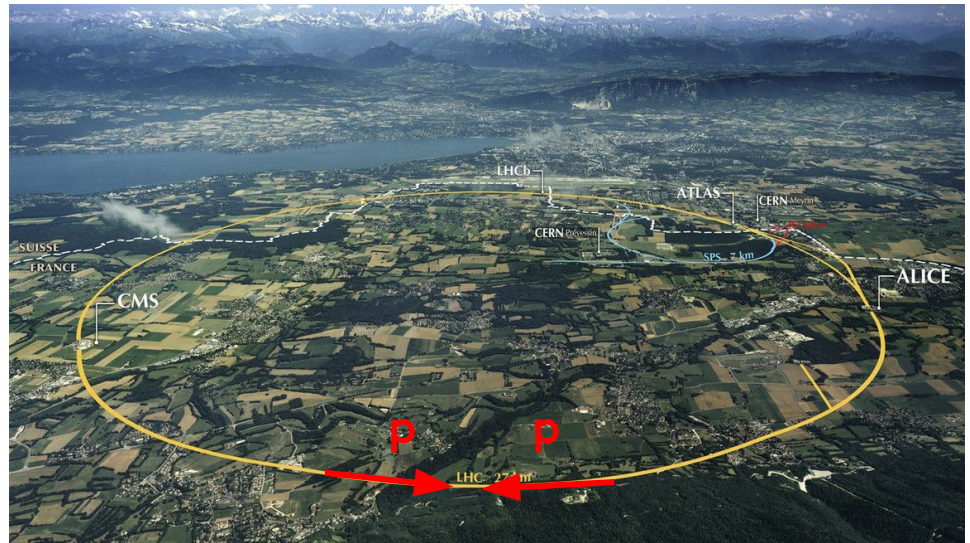
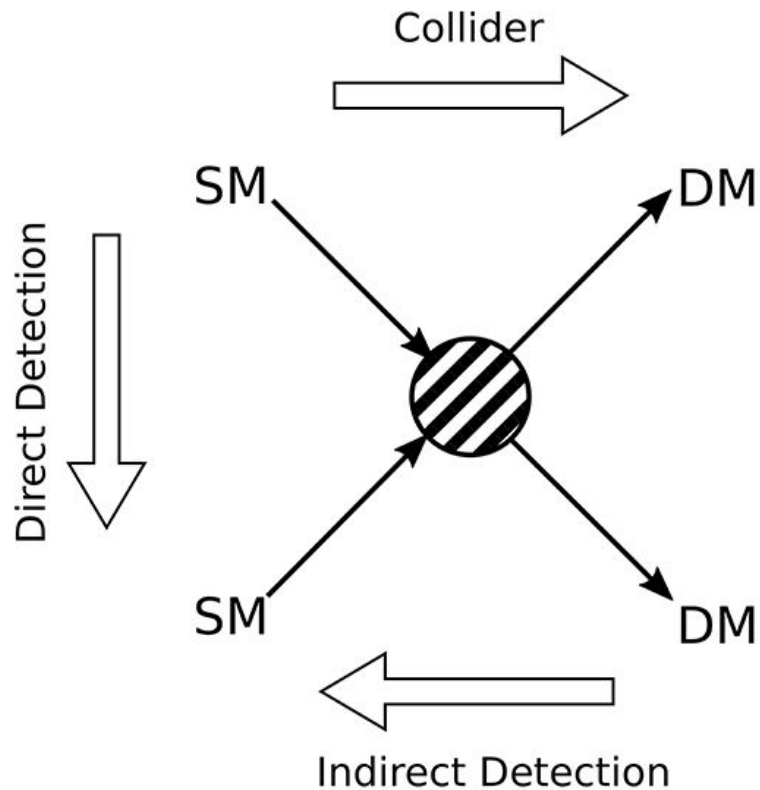
Restrict couplings of DM to SM must be proportional to SM Yukawa couplings → **predominant couplings to heavy flavours**



Models with 2-Higgs-Double sector + mediator+DM
2HDM+a model



How to search for Dark Matter

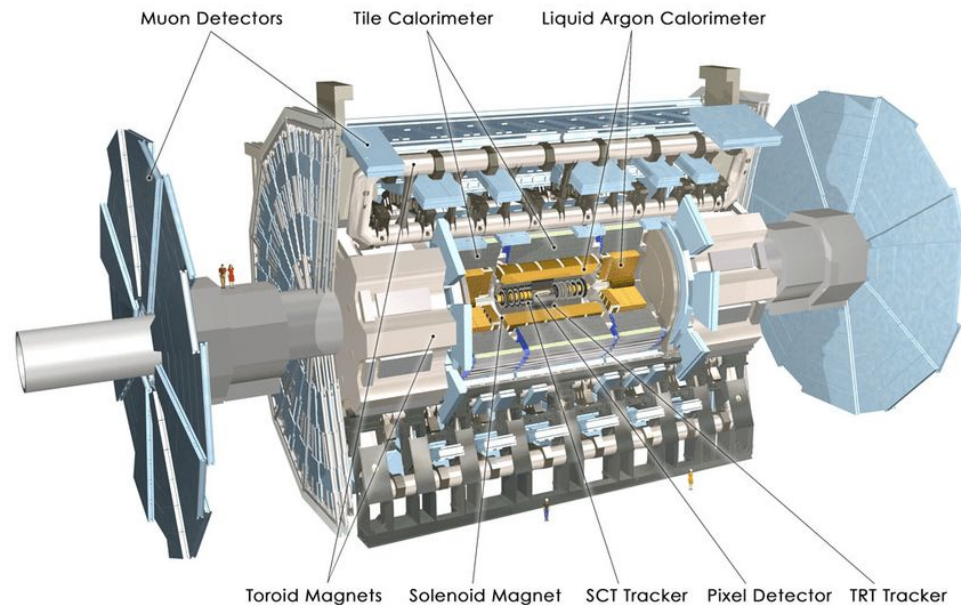
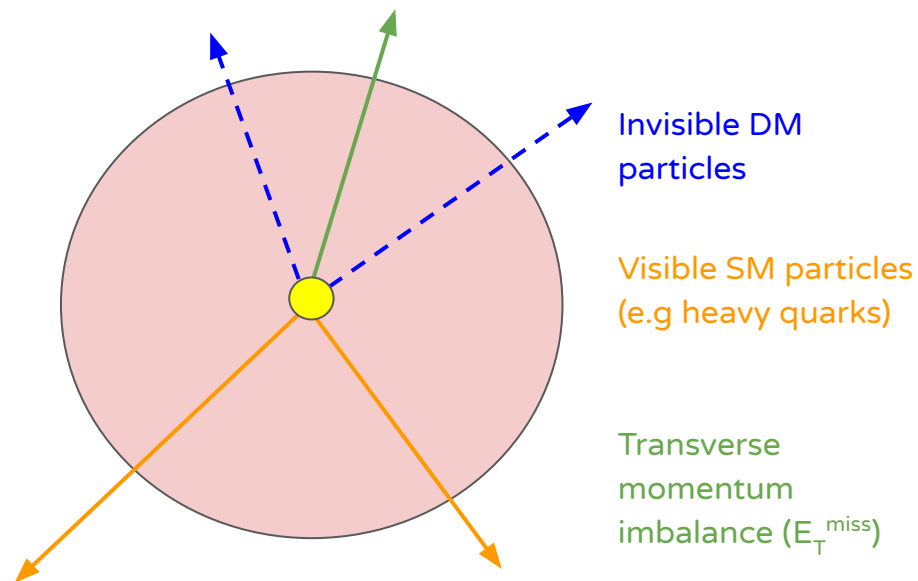


Direct detection and indirect detection to register signatures of the DM - SM or DM annihilation into SM
Collider searches focused on producing dark matter from SM collisions

How to search for Dark Matter

Proton-proton collisions at LHC might produce dark matter particles

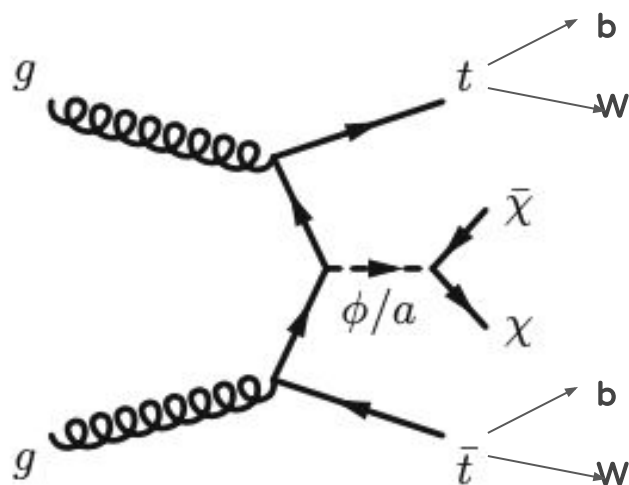
Weakly interacting particles with SM \rightarrow undetected



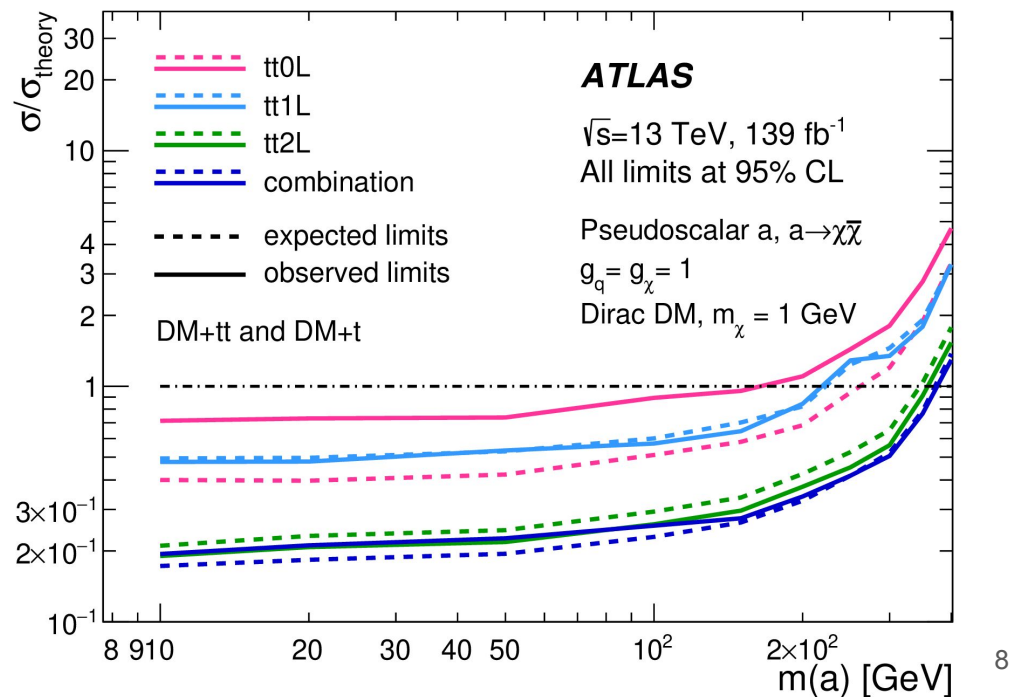
Detect SM particles and large E_T^{miss} (missing transverse momentum)

Searches for $t\bar{t}$ +DM signatures in ATLAS

Searches for dark matter in association to heavy-quarks \rightarrow ATLAS searches for $t\bar{t} + E_T^{\text{miss}}$.



Extending sensitivity for mediator masses up to 50 GeV w.r.t individual channels

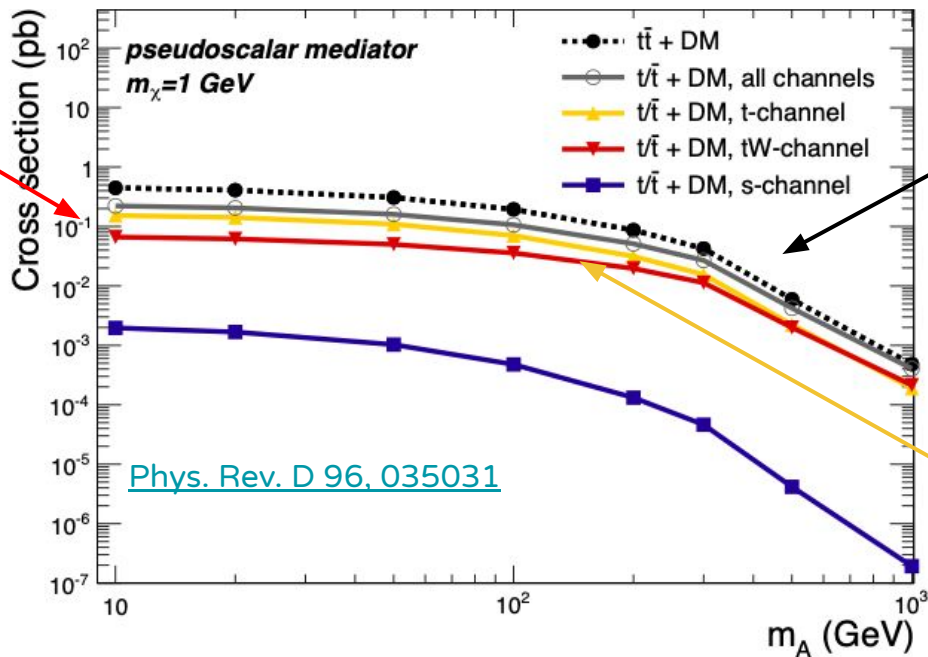
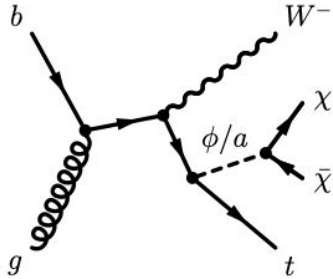


From $t\bar{t}$ +DM to single-top+DM

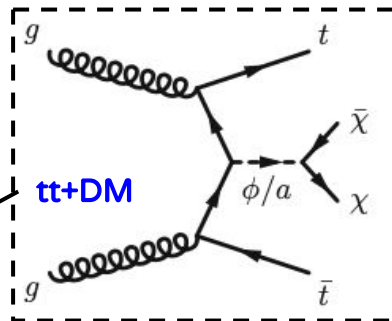
Single-top topology neglected by previous searches in ATLAS (basic simplified models). Subdominant against $t\bar{t}$ +DM \rightarrow $t\bar{t}$ +DM only searches

Simplified model with pseudo-scalar + DM

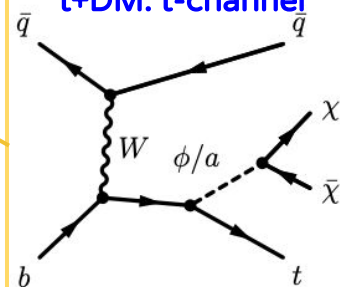
t +DM: tW-channel



$t\bar{t}$ +DM



t +DM: t-channel



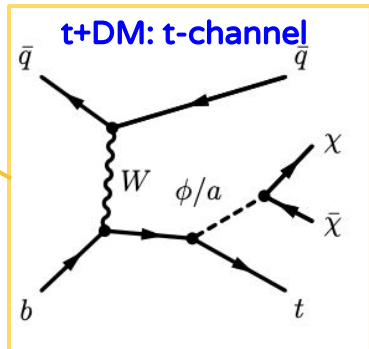
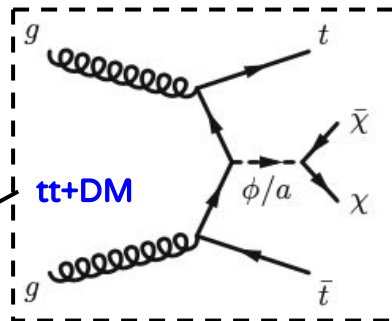
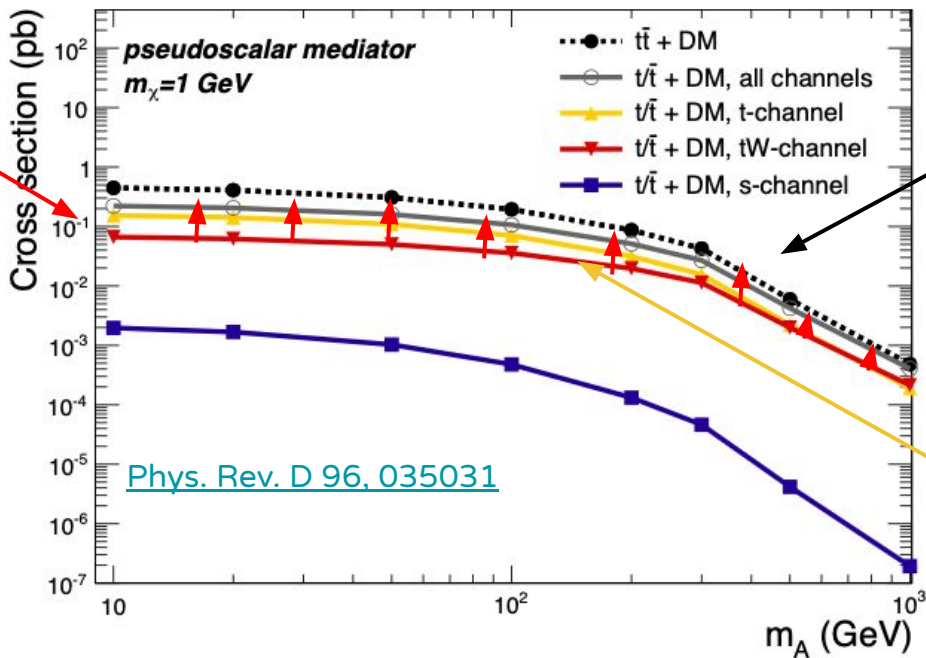
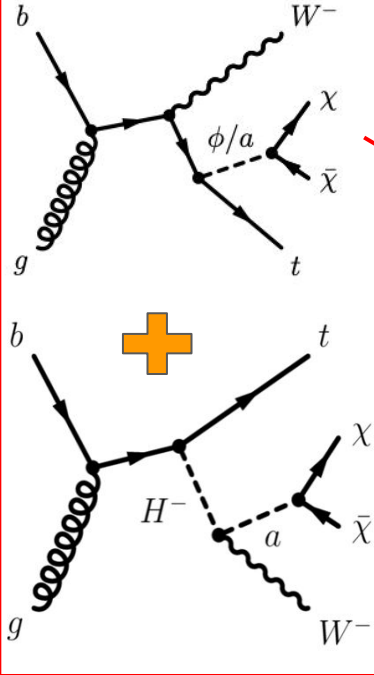
From $t\bar{t}$ +DM to single-top+DM

2HDM+a model adds a resonant diagram to the tW +DM final state \rightarrow DM in $tW+E_T^{\text{miss}}$ signatures

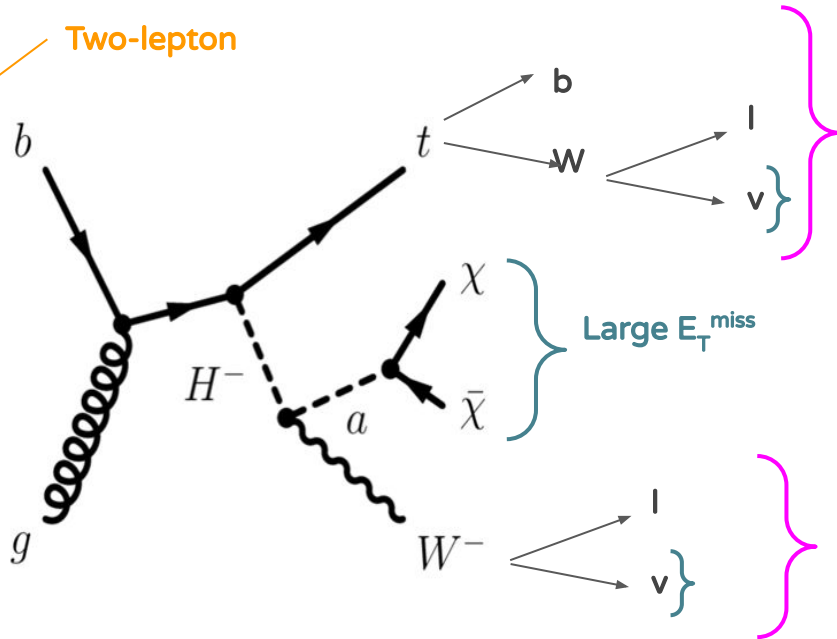
Searches relatively unexplored in ATLAS.

2HDM+a model

t +DM: tW -channel



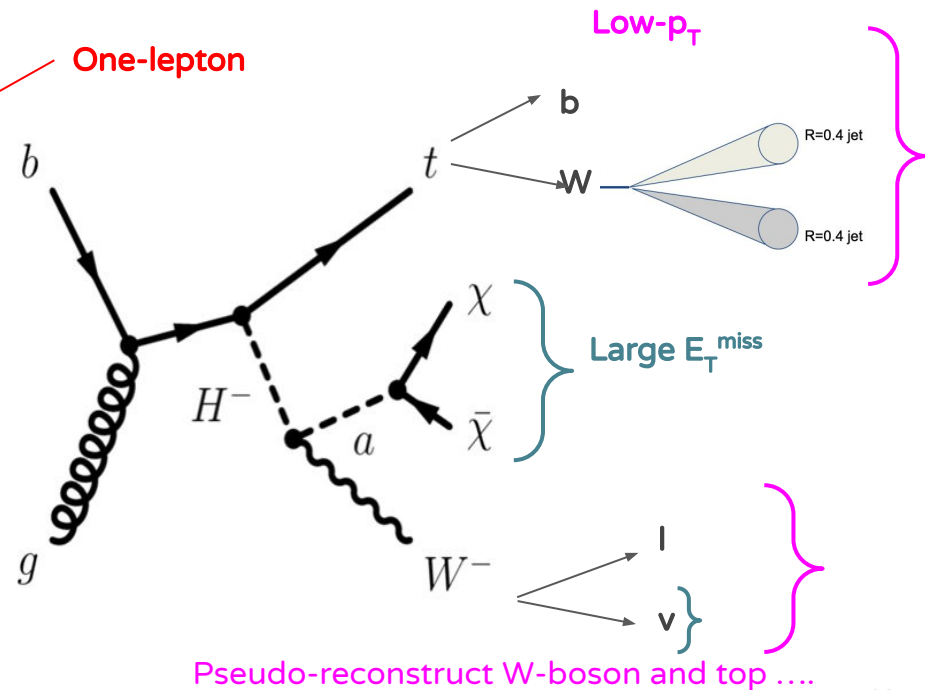
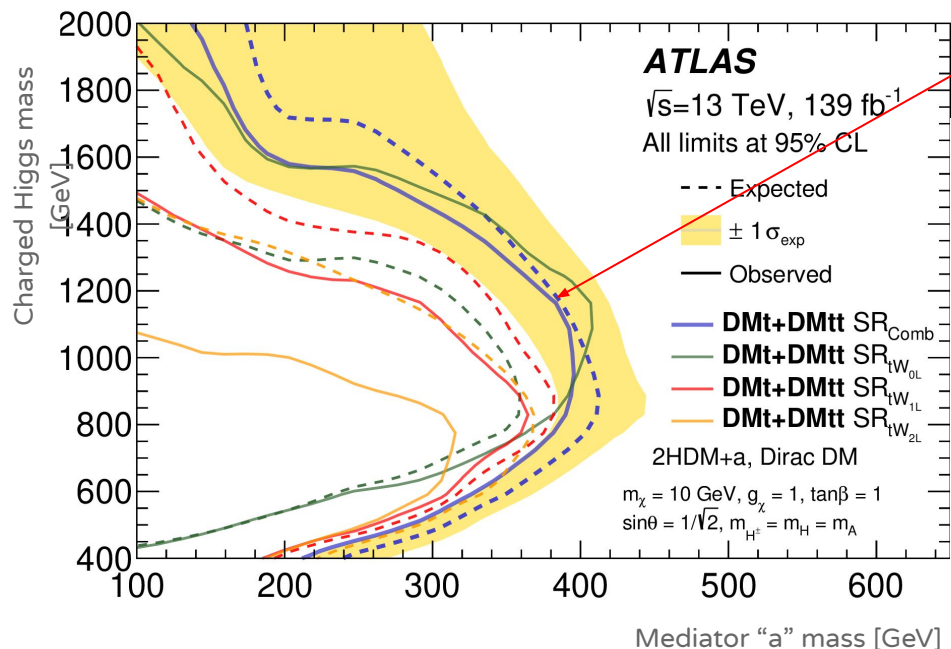
Possibility to search in 3 different final states depending on W-boson decays and covering distinct areas of the parameter space



11

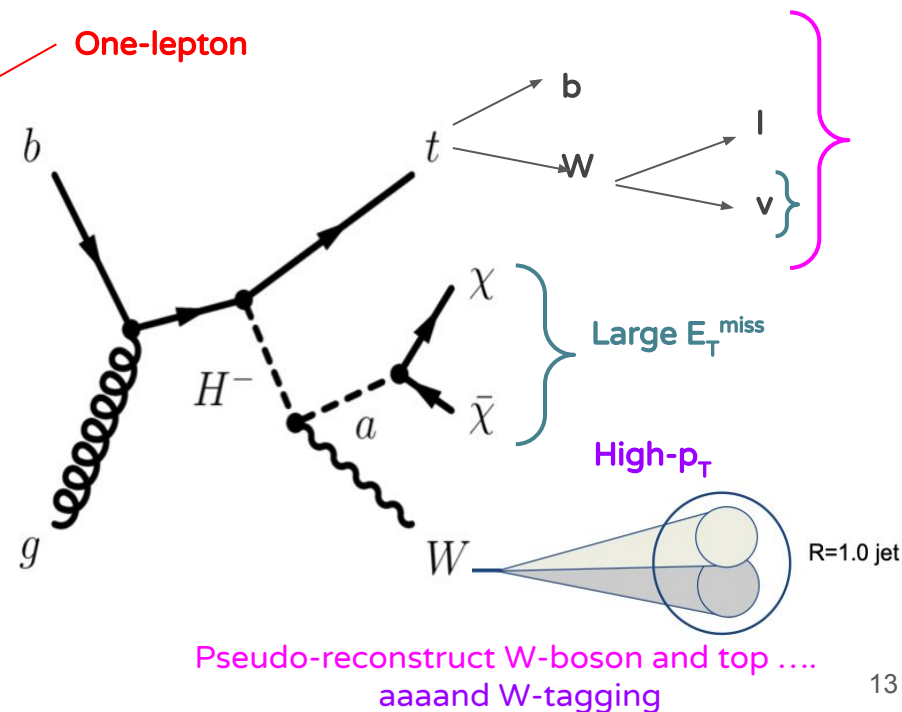
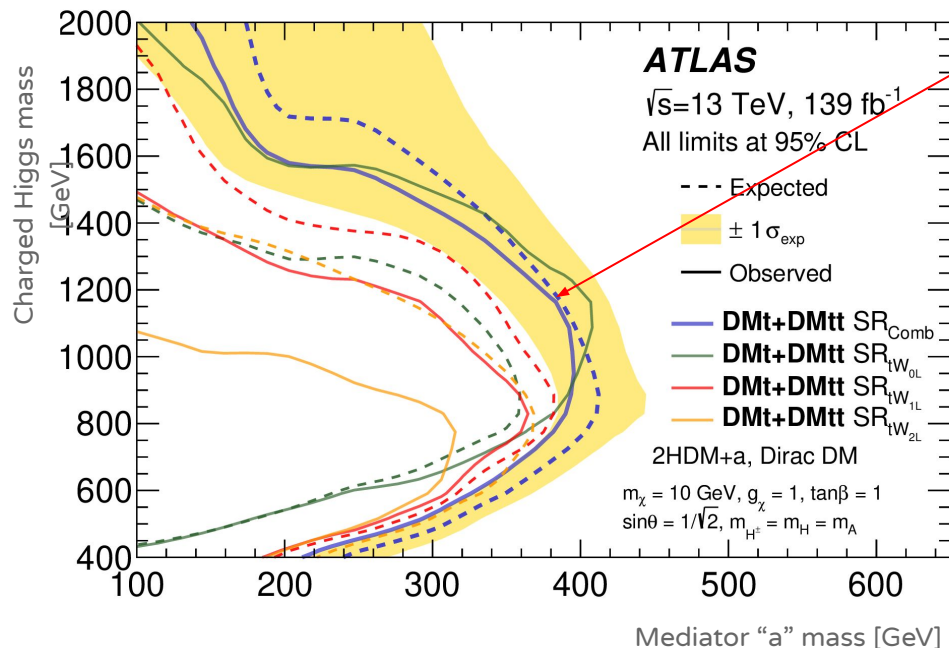
Search for tW +DM with ATLAS

Possibility to search in 3 different final states depending on W-boson decays and covering distinct areas of the parameter space

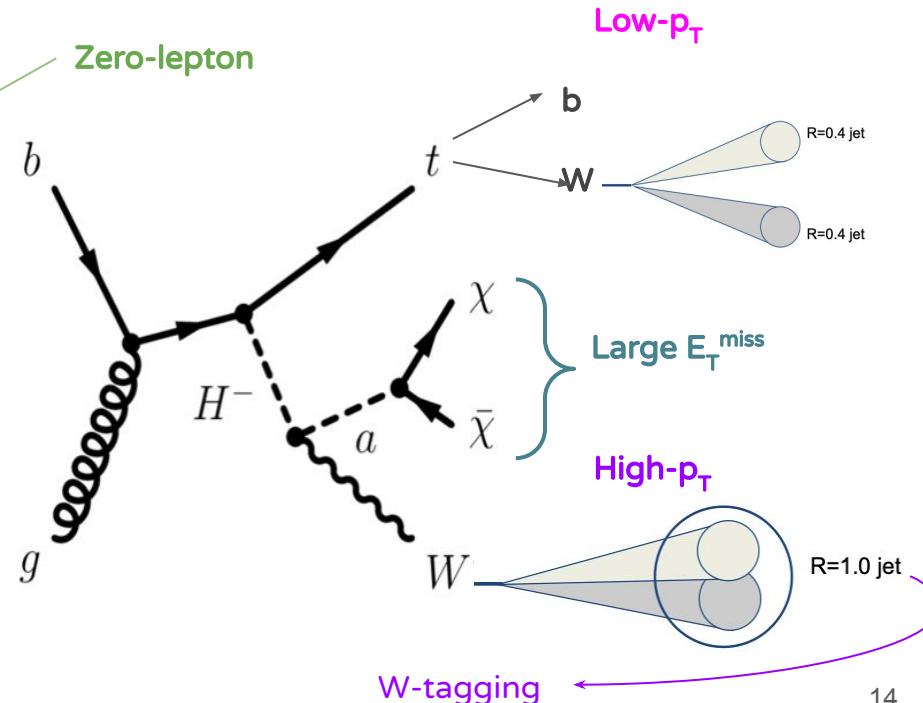


Search for tW +DM with ATLAS

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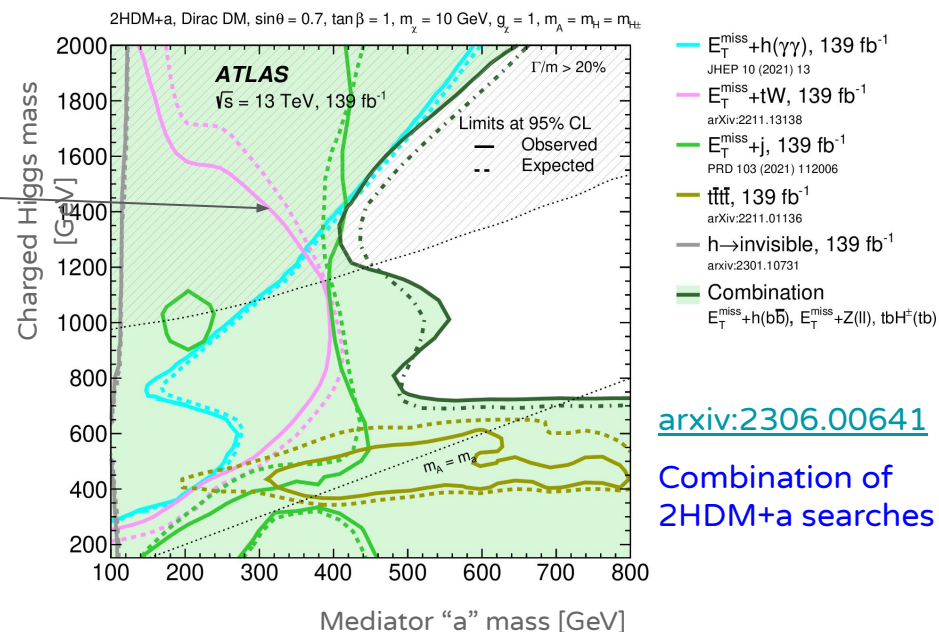
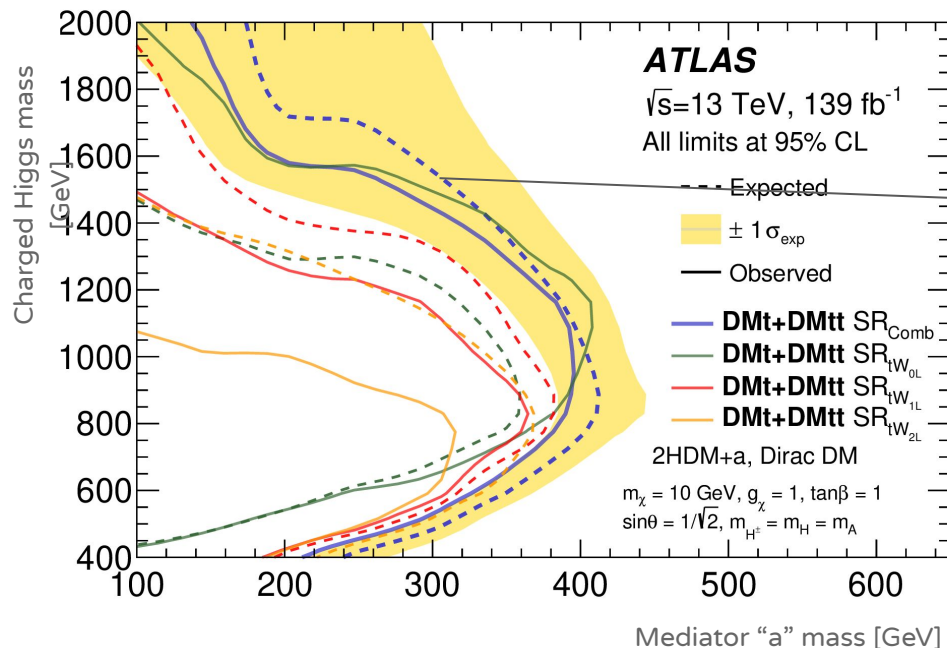


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Search for tW +DM with ATLAS

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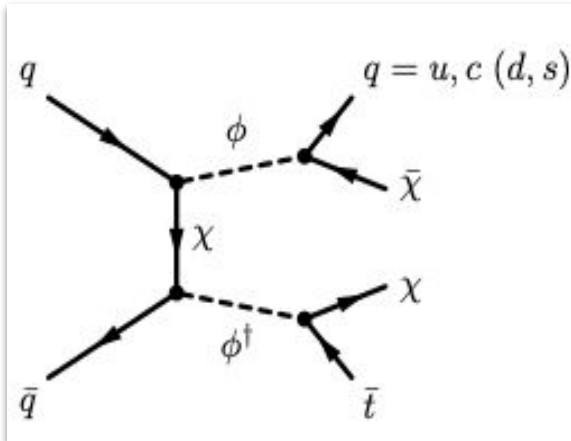
Most stringent limits in single-top DM to date for 2HDM+a model → Summary of all 2HDM+a searches

That was the past .. This is the present and future

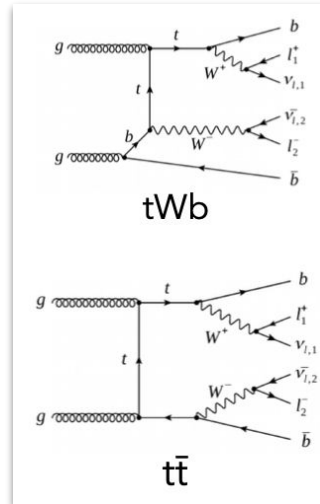
Minimal flavour violation not the only one consistent with flavour measurements → Non-minimal flavour violation!
t+DM searches affected by large uncertainty on SM $t\bar{t}+tW$ interference → We care about unknown and known!
As you have seen, the presence of b-jets is a common feature of the searches we do → **Flavour tagging** !

Non-MFV DM models

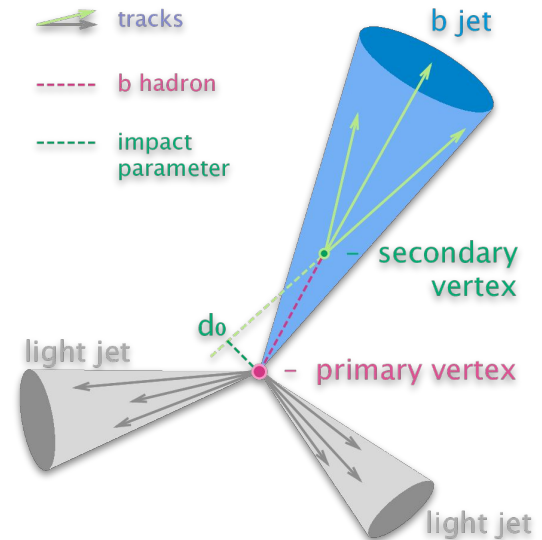
[JHEP 01 \(2021\) 194](#)



SM $t\bar{t}+tW$ interference



Flavour tagging → b-jets



Conclusion

Dark matter couplings to heavy flavours motivated by flavour measurements

Our ATLAS group searches for Dark Matter in final states with top-quarks

Fortes fortuna adiuvat! Started minimal, going to non-minimal.

Not only searches, but SM measurements as well

LHC Run-3 started . New and exciting results awaits us ahead. Stay tuned !



Backup