Collider phenomenology of the minimal models

towards a t-channel DM whitepaper

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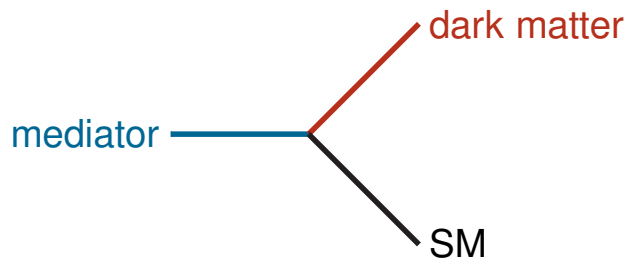
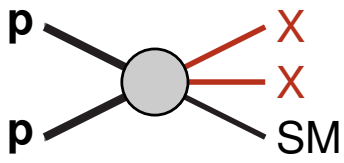
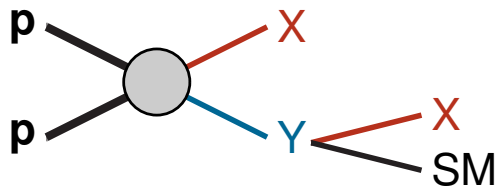
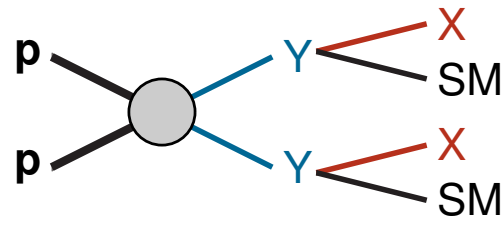


Which signatures





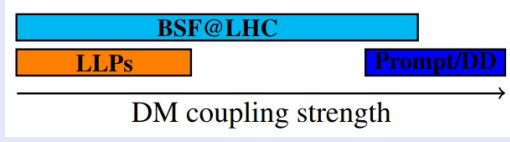


Not all processes might be possible at tree-level

depending on coupling or mass splitting

Long-lived mediators

Bound states
Displaced vertices
Delayed jets/photons



Mediators with prompt decay

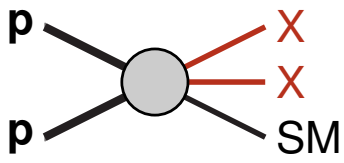
MET+SM

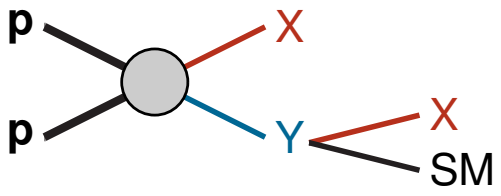
depending on which SM particle

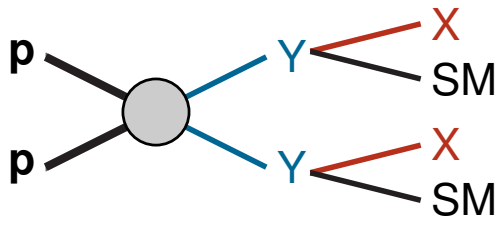
quark-philic { 1st generation / 2st generation / 3st generation / universal / ... } **lepto-philic**

Interacting with SM gauge bosons (Z/W) or the Higgs boson

Which signatures







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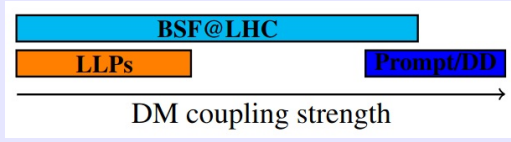

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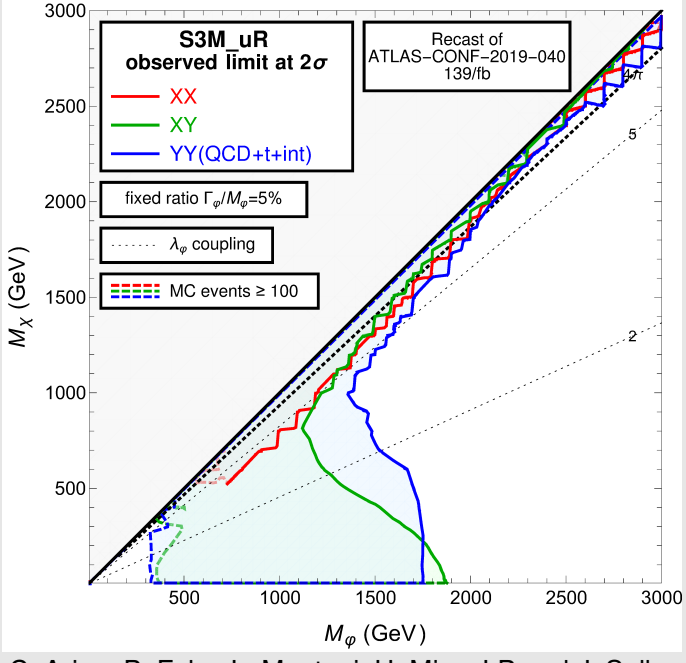
Interacting with SM gauge bosons (Z/W) or the Higgs boson

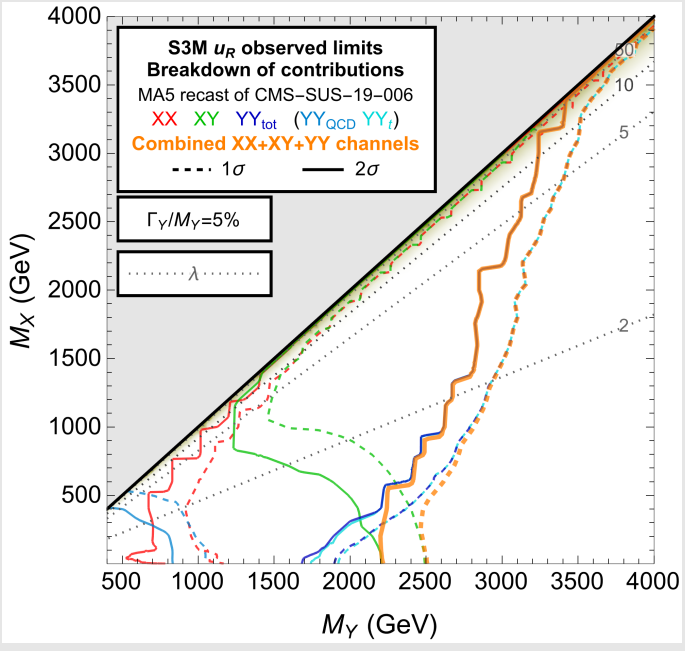
Interaction with the up quark

goals and status

- Go beyond existing results



C. Arina, B. Fuks, L. Mantani, H. Mies, LP and J. Salko,
Phys. Lett. B **813** (2021), 136038



C. Arina, B. Fuks, Jan Heisig, Michael Krämer, L. Mantani and LP, in preparation

Combination of all channels, relevance of NLO corrections and interference effects

Interaction with the up quark

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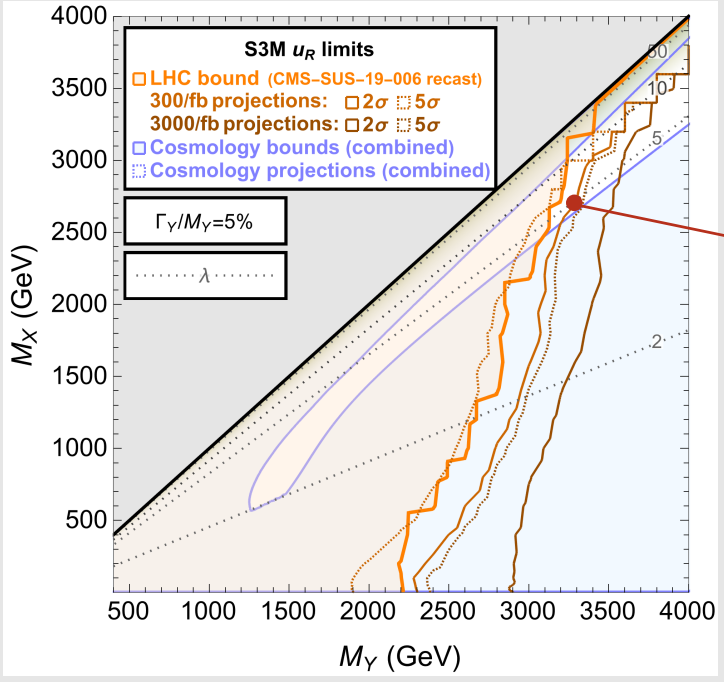
- Go beyond existing results
- Identify benchmarks allowed by LHC and cosmology observables



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	M_Y	M_X	λ
S3M_uR	3300	2700	4.79563
F3S_uR	3400	2500	4.88088
F3V_uR	3500	1500	1.0066

Around the exclusion reach at Run 3
and within the discovery reach for HL-LHC

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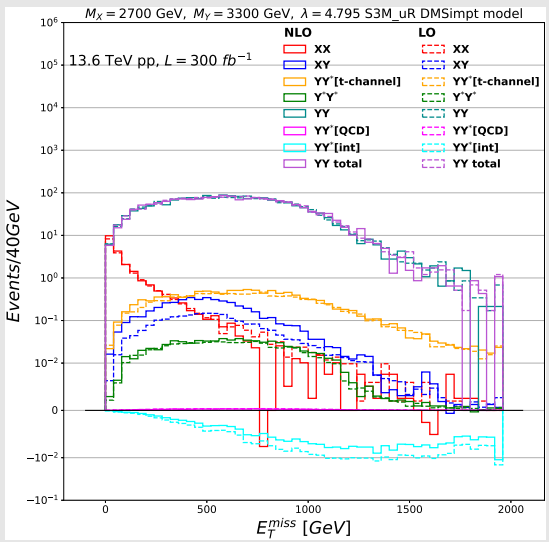
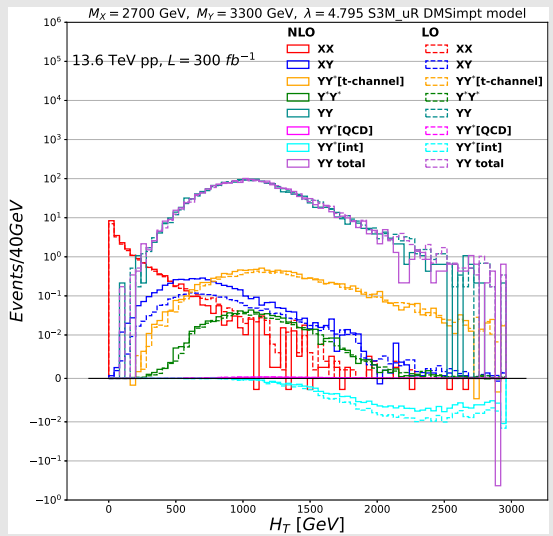
Around the exclusion reach at Run 3
and within the discovery reach for HL-LHC

- Store event samples and kinematical distributions for subsequent analyses





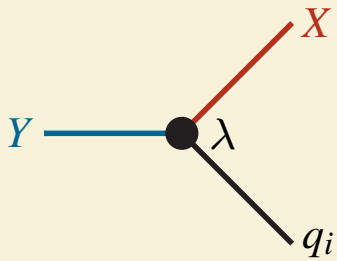
Plots by A. Desai
work in progress

Universal couplings

Identify and settle ambiguities:

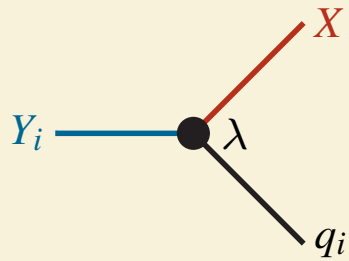
What does "universal" mean in the t-channel context?

Option 1



1 mediator interacting with 1 DM and any SM quark with the same coupling λ

Option 2



1 mediator for **each** SM quark interacting with the same DM with coupling λ

Assuming option 2 with degenerate Y's is not the same as option 1: different mediator widths

The public UFO model is constructed with option 2

C. Arina, B. Fuks and L. Mantani, Eur. Phys. J. C **80** (2020) no.5, 409, [arXiv:2001.05024 [hep-ph]].

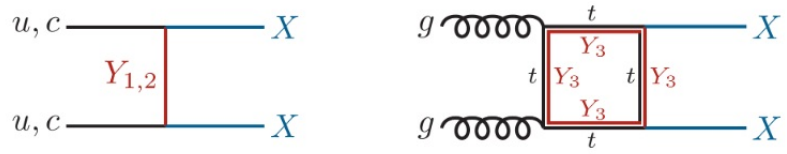
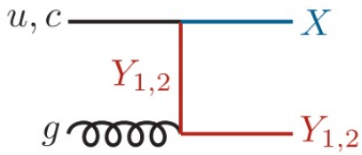
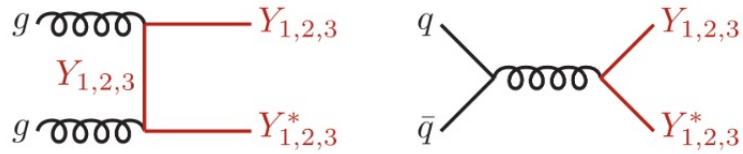
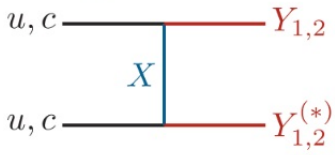
Possible arguments:

- Many theory models have mediator partners for each quark (*e.g. SUSY, UED...*), which justifies option 2
- If the DM is a gauge boson it would make sense to go with option 1, but if it is a composite vector option 2 is ok
- With option 1, if the DM is fermion or scalar, MFV would probably be more reasonable, so no universal couplings

Solution: we are going with option 2

Universal couplings

Analysis strategy

process	Representative topologies
XX	
XY	
YY (QCD)	
YY (t-channel)	

No interference between topologies involving different SM quarks

- Breaking the scan into all the signal elements to determine constraints for individual and universal couplings at the same time
- Combine collider results with cosmological bounds (already discussing with people in the cosmology section)
- Identify benchmark points not excluded yet and produce signal samples and kinematical distributions (same as for uR)

Conclusion

Possibility to cover an ample spectrum of possibilities
But simulations take time and resources

Person-power with cluster access would be useful
We are setting a common format for combining results from different simulations

Further directions and possible interplays

- So far only right-handed couplings: identify key differences with the left-handed case
- Top-philic models: identify points in common and differences to avoid doing the same work
- Lepto-philic models: are all possibilities covered? can we combine efforts?