On top of Dark Matter at the LHC.

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The Dark Matter mystery





- Electrically neutral
- Observed via gravity, massive

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The Dark Matter mystery



Electrically neutral

- Observed via gravity, massive
- Weakly interacting
- Elementary particles created in the early universe





The collider ansatz



Particles
 detection and
 identification

2. Production mechanism / theoretical framework

7

DM Collider experiments





century. In the high energy proton-proton collisions Hadron Collider at CERN, particles that were present universe can be recreated and studied in detail.

SM \

SM

 ${}_{SM}^{g_{SM}}$

SM

φ

lesseng

Γø

gdm

×χ

DM

Jet

DM

DM

classified based on their spin
and CP
car* statuerichtphonomeconlagter;
ihilate somewhere in the universe;
produced in the LHC collisions.

atd

verse budget one with DM +

gSM, gDM, Γφ

mediator

★ Reduce a complex model to a

\star Few free parameters: m ϕ , m χ ,

★ Nature of mediator and DM can

(also) be systematically

DARK SECTOR

3%

Dark Energy



Not Visible

E_Tmis





The strange case of spin-0 mediators

When the mediator behaves like the Higgs



Figure 17: Diagram 17

(*) will show later that there are more channels with top quarks that matter **DESY.** | P. Pani Representer @Colliders - SIF 2021

3. Highlights for simplified models



Spin-1 mediators - masses



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Spin-1 mediators - masses







h/+

Considerations on the results

- Simplified models are good
 phenomenology proxies.
- ★ Simplified models are simplified models.
- ★ All exclusions need to be taken with a grain of salt.
- ★ Simplified models are not full and complete theories, which might have more complex topologies.



4. highlights for less simplified models: 2HDMs



2HDM-based models



2HDM DM models



★ Richer phenomenology: Higgs bosons productions and decays, mixing, many final states.



2HDM-based mocket Ment



nant production/ in alisophifics interdelmplified model Resonant production/ new in 2HDM! oduction/ IDM!















- Benchmarks set
 m(H) = m(A) = m(H[±])
- Nature might differ, need to investigate all three signatures!

Results (I)

Combination h(bb)+E_T^{miss} and Z+E_T^{miss}

600



Further considerations where to from here?

★ Many results with the full Run-2 datasets still in preparation but we can already plan ahead: *leave no stone unturned!*

★ <u>HL-LHC Yellow Report</u> shows many projection on searches evolution in the next data-taking periods, reaching higher higher DM & mediator masses

★ LPCC DMWG working on establishing additional "less simplified" frameworks

Conclusions

 Understanding the nature of dark matter is one of the greatest challenges in understanding our Universe

 Colliders have the potential to provide a unique tool to constrain and eventually measure dark matter properties and interactions

> 2012 The Higgs Boson discovery 2016 The Gravitational Waves discovery <2024 ... ?

Thanks for your attention!

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