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Z' explorer 2.0

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Abstract: Write abstract

1 Introduction

Z' models are widely used in a variety of context, as they are theoretically motivated (portal model $F_{\mu\nu}F'^{,\mu\nu}$). Come from string theory. Model used for flavour physics, for low resonance searches (dark photon), can explain LFU anomalies ($U(1)_{B-L}$, for instance, or $U(1)_{\tau\mu}$) and also used as mediators to the dark sector [cite s-channel review].

In particular, these models are also of interest in the context of dark matter, due to the process $pp \to Z' \to \chi\chi$ via a Z' in the s-channel. The presence of this process guarantees that Z' couples to both the Standard Model and the dark sector, thus given a robust foundation to a mediator search program at the LHC, based in both visible and "invisible" final states. [cite s-channel models, cite some ATLAS and CMS papers]

Given the ubiquitious nature of Z' models in a plethora of BSM context, it is relevant to have at hand a fast and flexible tool for the fast reinterpretation of the broad palette of experimental searches. A first step in that direction was done in Z' 1.0, where the whole suite of visible final states was introduce. In comparison with its main rivals, like ZPEED (cuál otro?) or recasting software like CheckMATE (where events are needed), the philosophy of Z' explorer is to **[JZ: here for Rosa]**. Based on a simple, yet generic parametrization of Z' couplings and widths, it allows the user to go beyond the default benchmark models and explorer a richer landscape of Z' models (here mention that ATLAS uses only vector or axial-vector), allowing to test arbitrary coupling structures. [discuss more details of Z' 1.0, and the competitors]

In this article we extend the capabilities of Z' explorer to further include searches with missing energy. To that effect, we perform the first reintepretation of the ATLAS missing-energy + jets study [CITE], which would give the strongest constraints in the invisible channels via the mono-jet process, $pp \to Z'j, Z' \to \chi\chi$. Our code goes beyond the two studied ATLAS scenarios, including the possibility of an arbitrary coupling structure for the dark sector to the Z' boson, going beyond the axial-vector and axial scenarios used in the ATLAS study. Our results are implemented in the Z' 2.0, which is publicly available in [CITE link]. As a by-product of our analysis, we have derived for the first time (to the best of our knowledge) the complete analytical expression for exclusion in the case of unknown background, irrespectively of being in a Poissonian or Gaussian case;

The current article is structure as follows. In section 2 we review the fundamentals of Z' models, presenting the parametrization used within Z' explorer, which is in correspondence with the Z' s-channel

2 Z' models: theoretical framework

Z' models: Lagrangian, parametrization, visible searches (in Z' explorer 1.0), competitor codes.

Explain dependencies on g_q, $g_{V,A}$, etc of cross section and distributions (our expectations).

Compute branching ratios and width as function of our observables.

3 ATLAS search for Z' mediators to the dark sector

List existing ATLAS and CMS searches for Z' with missing energy. Explain why ATLAS mono-jet should give leading bounds. 1: strong coupling points to monojet, cite [1]. 2: Some subtleties in CMS study **[JZ: Clarify!]**

Summarize the ATLAS search and its validation. Explain with care rescaling factors.

Explain we have verified the expected beahviour of the shape and cross section with the couplings, which allows to make reinterpretations with arbitrary parameters.

Put forward which parameters alter the shape, and which ones do not.

Complain about lack of reinterpretation data in ATLAS paper (exclusive vs inclusive). As it stands, it does not allow for full reinterpretation, even within Z' model.

4 Numerical results

Present numerical results for a few examples. Current proposals

- reproduce Boyu Gao plot.
- Model Victor.
- top-philic DM.
- lepto-philic DM.
- exclusion for arbitrary coupling structure $g_{A,V}$.

5 Conclusions

In this work we have presented the expansion of the code Z' explorer to further include missing energy searches, where Z' plays the role of a mediator between the dark and visible sectors.

A Derivation of exclusion significance in the presence of unknown backgrounds

For exclusive use of Victor

B Z' explorer 2.0: implementation details

For exclusive use of Rosa

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References

[1] E. Bernreuther, J. Horak, T. Plehn, and A. Butter, *Actual Physics behind Mono-X*, SciPost Phys. **5** (2018), no. 4 034, [arXiv:1805.11637].