Setting limits on simplified dark matter models using LHC monojet results

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Things I will discuss:

- Why mono-X (X $=$ jet, γ, Z, W) analyses are sensitive to particle dark matter models
- What simplified dark matter (DM) models are, and why they are needed for the interpretation of LHC results
- How to set limits on such models

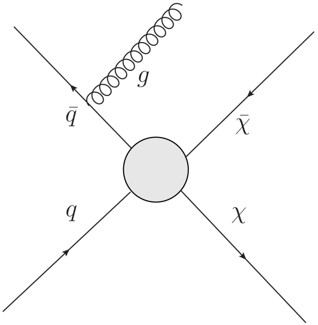

Figure : Diagram for DM pair production with a gluon radiated off the initial state.

- Question: how do we describe the interaction in a model-independent way?

Solution 1: Assume the mediator is heavy and integrate out – the Effective Field Theory (EFT) approach. Assuming a vector mediator and Dirac fermion DM with vector couplings, the operator is:

$$\bar{\chi}\gamma_\mu\chi\bar{q}\gamma^\mu q$$

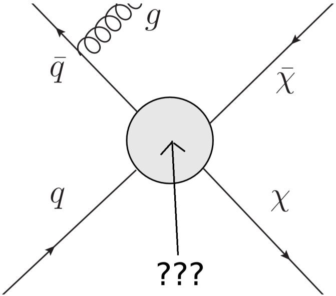

Figure : Diagram of the EFT approach.

Pros:

- The simplest way to add DM to the Standard Model, little model dependence
- Easy to compare limits to those set by (in)direct detection experiments

Cons:

- Depending on $M_{\rm med}$, might be probing events where $Q > \Lambda = M_{\rm med}/\sqrt{g_q g_\chi}$ at the LHC: 1402.1275 (Busoni et al.)
- Can over/underestimate limits depending on details of UV physics: 1308.6799 (Buchmueller et al.)

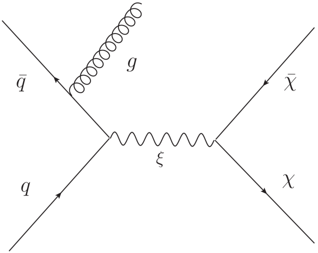

Figure : Same diagram as before, but with an explicit mediator.

Solution 2: Use a theory with a generic mediator ξ – the Simplified Model approach. Again assuming a vector mediator and Dirac fermion DM with vector couplings, we get the operator[1]:

$$g_q \bar{q} \gamma^\mu q \xi_\mu + g_\chi \bar{\chi} \gamma_\mu \chi \xi^\mu$$

Pros:

- Gives reliable results for all kinematically allowed configurations of M_{med}, M_{DM}, and Q

Cons:

- Is more complicated to set limits on, and the limits can not be easily compared to those of (in)direct detection experiments

[1]With thanks to Amelia Brennan!

1. Write down Lagrangian in FeynRules and output a model file
2. Plug model into MadGraph and generate parton level events
3. Shower the events in Pythia 8
4. Perform detector simulation and analysis in Atom/Rivet
5. Do statistics with numpy/RooStats

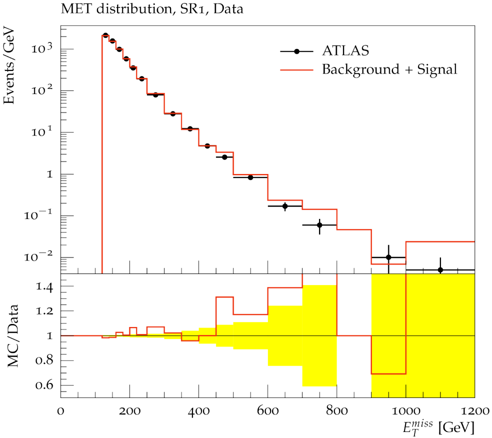

Figure : Example of background + signal versus data for missing E_T in one of the signal regions. In this case the signal is for $M_{\mathrm{med}} = 1$ TeV, $M_{\mathrm{DM}} = 400$ GeV at $\sqrt{s} = 8$ TeV.

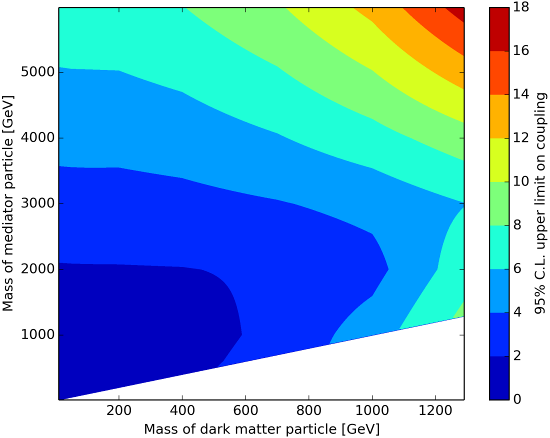

Figure : Example of output for $\sqrt{s} = 8$ TeV. This is for the operator defined earlier with $\Gamma_\xi = M_\xi/3$.

Thank you!