

Dark matter at LHC: jets+met searches

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Why missing energy?



Monojet EFT



Simplified models



Suggestions and wish list



Outline

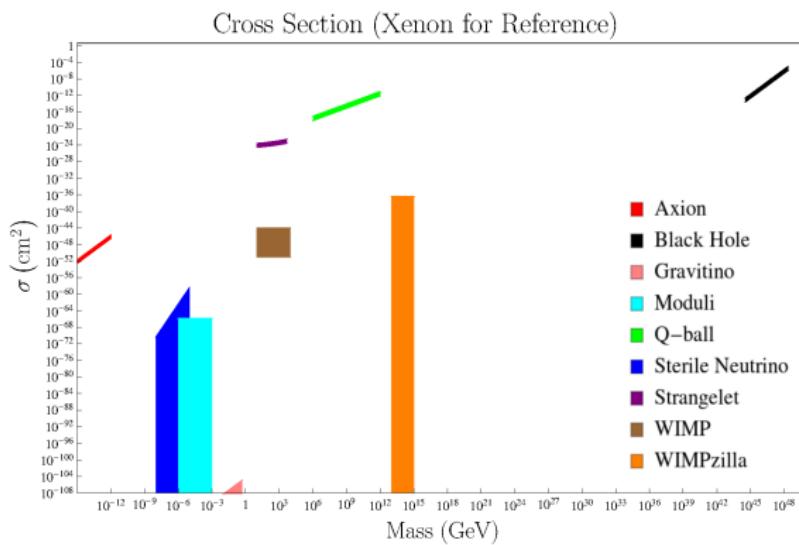
1 Why missing energy?

2 Monojet EFT

3 Simplified models

4 Suggestions and wish list

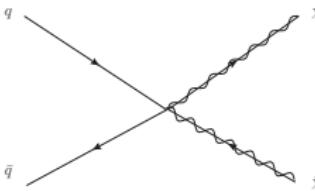
Which, Where?



- ▶ Stable particles are a common feature of many BSM scenarios
- ▶ LHC is questioning naturalness more and more
- ▶ We know DM is there.. worth exploring at colliders

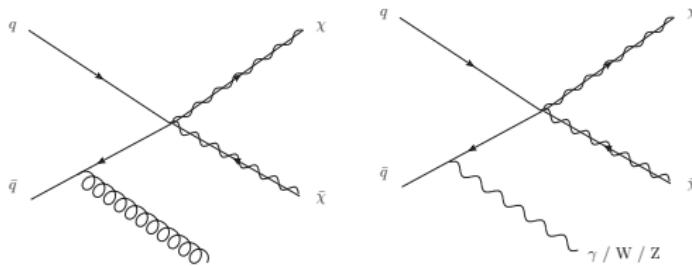
Dark Matter EFT?

- ▶ Common approach until recently: let's be agnostic
- ▶ Parametrize our ignorance with an EFT description of SM-DM interactions



Dark Matter EFT?

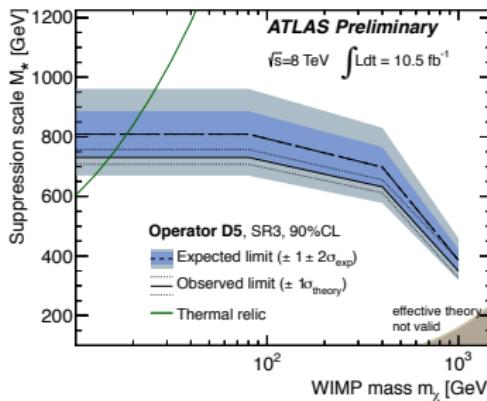
- ▶ Common approach until recently: let's be agnostic
- ▶ Parametrize our ignorance with an EFT description of SM-DM interactions



- ▶ Dress EFT interaction with SM gauge bosons
- ▶ Look for mono-jet, mono-photon, mono-W/Z

EFT validity

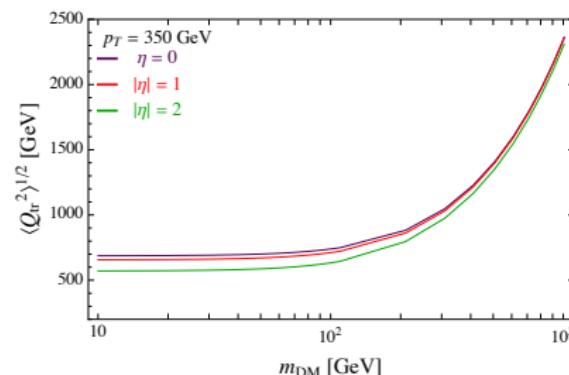
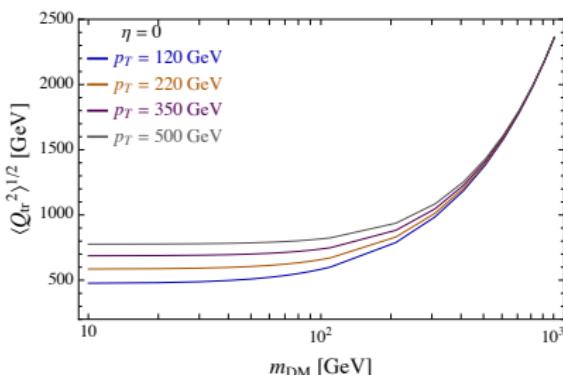
- ▶ ATLAS results from ATLAS-CONF-2012-147



- ▶ Note that ATLAS-CONF-2013-068 is more constraining but no plots are provided ("susy-search")

EFT validity

- ▶ Can we trust EFT in this regime?
- ▶ Expansion in \hat{s}/Λ^2 or Q^2/Λ^2
- ▶ Q^2 distribution at LHC8:



[Busoni, De Simone, Morgante, Riotto](#)

- ▶ In the regime accessible at LHC corrections to EFT are $\sim O(1)$.
- ▶ Need to go beyond...

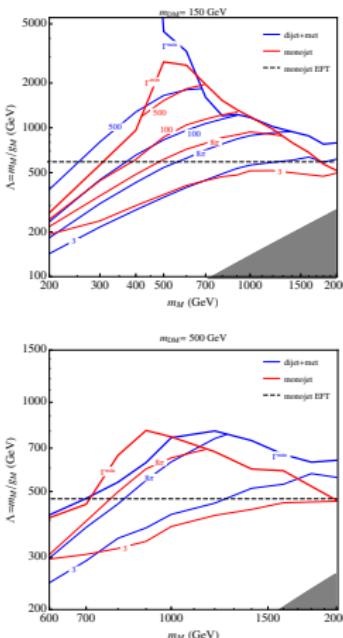
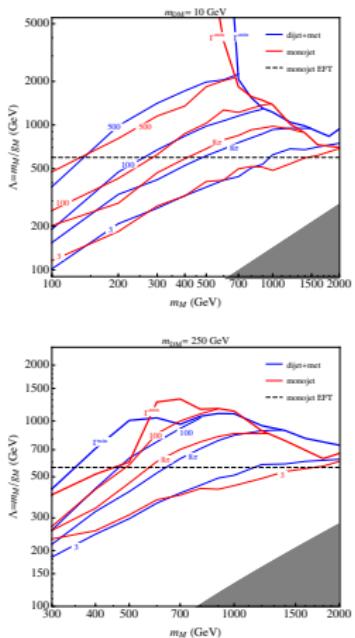
- ▶ Consider simplified models: stable particle(s) + mediator(s)
- ▶ EX: squarks + a fermion

$$\mathcal{L} = \mathcal{L}_{SM} + g_M \sum_{i=1,2} \left(\tilde{Q}_L^i \bar{Q}_L^i + \tilde{u}_R^i \bar{u}_R^i + \tilde{d}_R^i \bar{d}_R^i \right) \chi + \text{mass terms} + c.c.$$

Why consider only monojet searches? List all possible allowed final states:

- ▶ Monojet, monophoton,....
- ▶ jets+ missing energy
- ▶ Dijets (in the case of a Z' or a higgs like mediator)
- ▶

Searches comparison



Dijets+met:

- ▶ ATLAS-CONF-2013-047
- ▶ ATLAS-CONF-2012-109
- ▶ CMS-PAS-SUS-13-012
- ▶ CMS-PAS-SUS-12-028
- ▶ ATLAS-CONF-2012-033
- ▶ CMS-PAS-SUS-11-022
- ▶ CMS-PAS-SUS-12-011

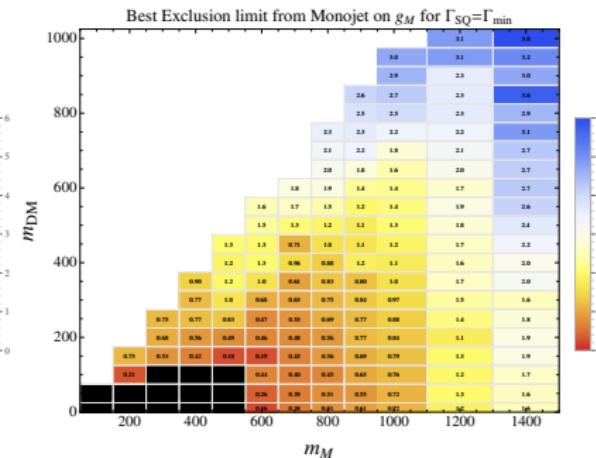
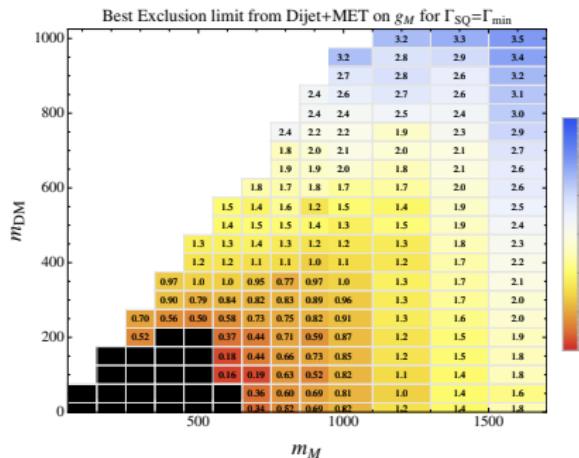
Monojet:

- ▶ ATLAS-CONF-2013-068
- ▶ CMS-PAS-SUS-12-048
- ▶ ATLAS-CONF-2012-147
- ▶ ATLAS-CONF-2011-096
- ▶ CMS-PAS-SUS-11-059



Results presentation

Present results in terms of excluded couplings:



- ▶ Easy to compare different searches
- ▶ Immediate use (no simulation needed)

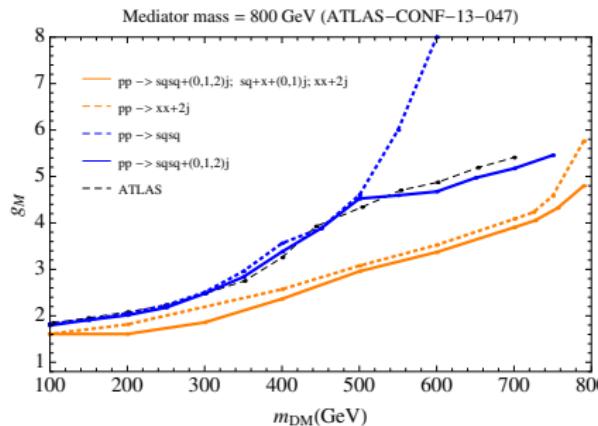
Susy exclusion limits

How is currently done:

- ▶ simulate on shell states: $pp \rightarrow \tilde{q}\tilde{q}$ (plus ISR)
- ▶ decay final states (phythia?): $\tilde{q} \rightarrow q\chi$

What is missing

- ▶ finite width effects
- ▶ diagrams with no \tilde{q} in the s -channel.



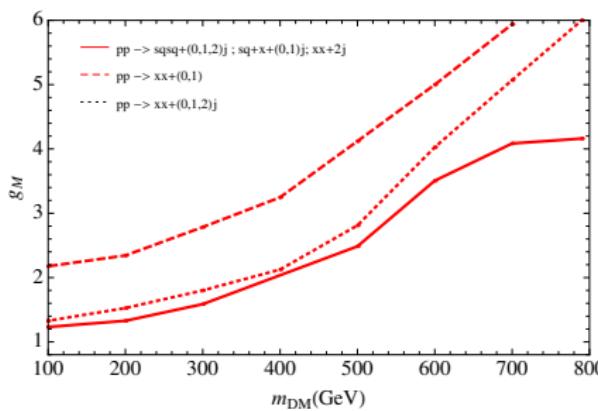
Both effects change considerably the exclusion limits.

Monojet cuts

Differences between 7TeV and 8TeV searches

- ▶ 7TeV: cut on p_T of the second jet
- ▶ 8TeV: NO cut on p_T of the second leading jet
- ▶ Limits got stronger (if the second jet is included in the simulation)

ATLAS-CONF-2013-047



ATLAS vs CMS

	ATLAS	CMS
▶ Monojet:	✓	✓
▶ Jets+met: constraining power:	X	✓
▶ Jets+met: reproducibility:	✓	X

▶ Monojet:

- ▶ standard cuts on MET, p_T , η , $\Delta\phi$
- ▶ events per bin and exclusion limits per bin
- ▶ independent bins

▶ Jets+met: constraining power:

- ▶ ATLAS standard cuts on MET, p_T , η , $\Delta\phi$
- ▶ CMS cuts on α_T and H_T also.

▶ Jets+met: reproducibility:

- ▶ ATLAS: independent bins
- ▶ ATLAS: exclusion limits provided
- ▶ CMS: not independent bins
- ▶ CMS: statistical analysis must be redone

Conclusions

- ▶ Jet+met searches represent an important tool to explore Dark Matter at LHC
- ▶ Need to use simplified models and not EFT
- ▶ Best exclusion limits not always come from Monojet searches
- ▶ A summary of the searches for each simplified model would be extremely useful: something like...

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