UNIVERSITY OF BIRMINGHAM | SCHOOL OF PHYSICS AND ASTRONOMY

Searches for Dark Matter and Dark Energy in jet+E_T^{miss} Final States Using the ATLAS Detector

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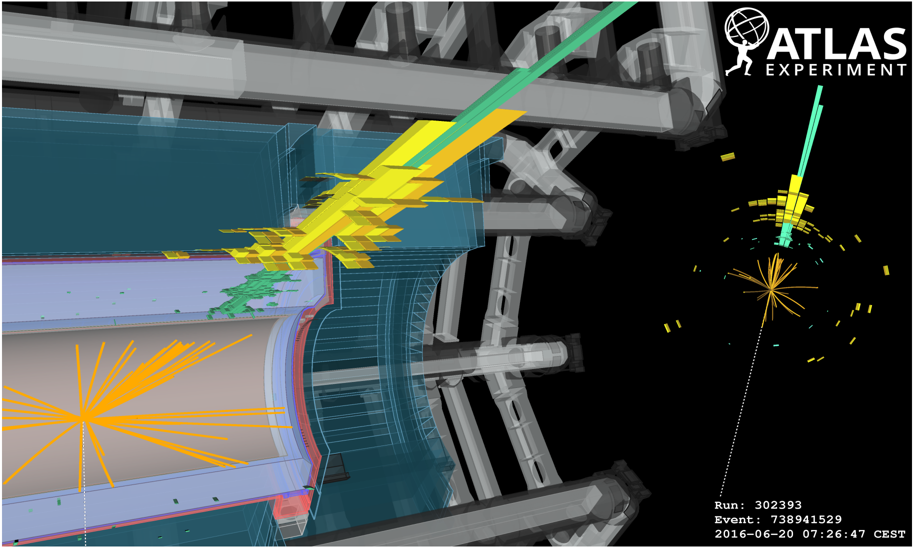
On Behalf of the ATLAS Collaboration

Dark Matter @ LHC 2019, University of Washington, Seattle

August 13th, 2019

Monojet


ATLAS
EXPERIMENT
Run: 302393
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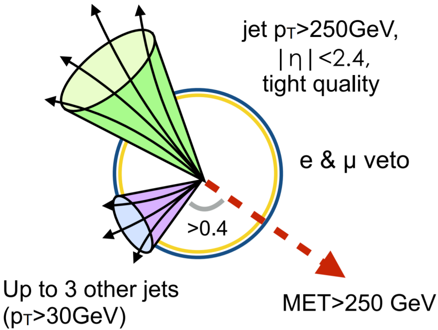
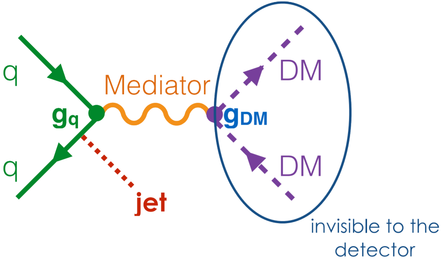
2016-06-20 07:26:47 CEST

Introduction - Monojet Overview

Final state with at least 1 energetic jet & high E_T^{miss}. Can arise from Initial State Radiation (ISR) which doesn't require a jet to interact directly with BSM, hence a large range of BSM is probed.

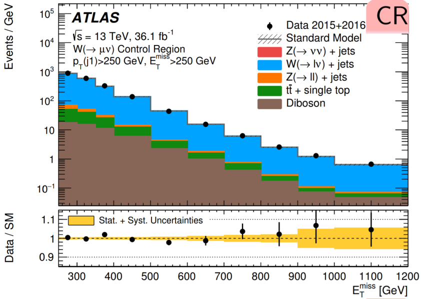


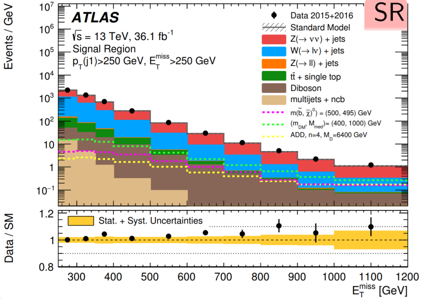


- Larger ISR statistics than other mono-X searches ($\alpha_s \gg \alpha_{EW}$).
- Main background Z($\nu\nu$) + jets, 56%.

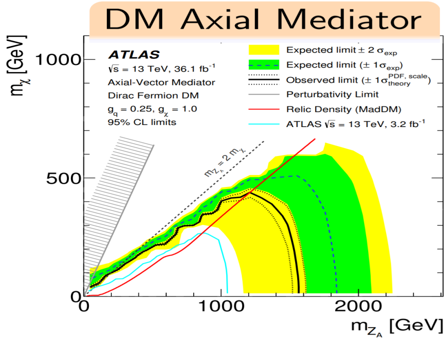
Strategy

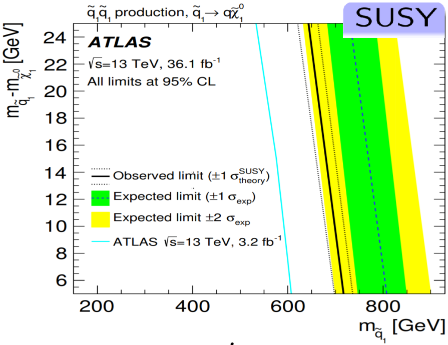
- Control Regions (CR) measure backgrounds to model them in Signal Region (SR).
- MC is normalized by data in the CR, using a global fit that includes systematics.
- 2.4% background uncertainty on total events in SR (lower at low E_T^{miss}).
- Published model dependent & independent limits (WIMPs, squark pair production, extra dimensions, scalar dark energy).

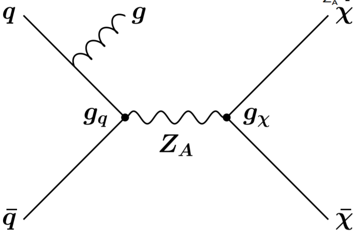


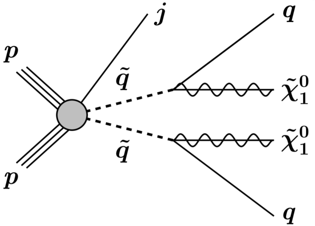


Limits [JHEP (2018): 126.]









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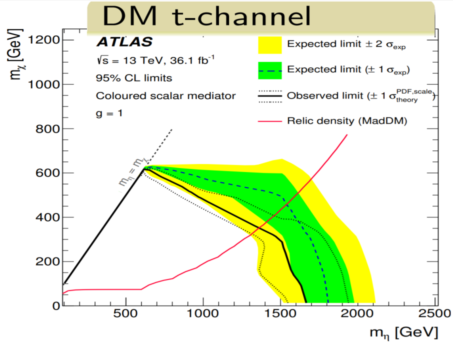
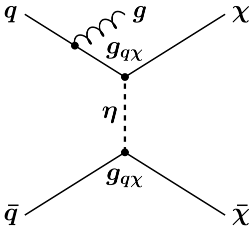
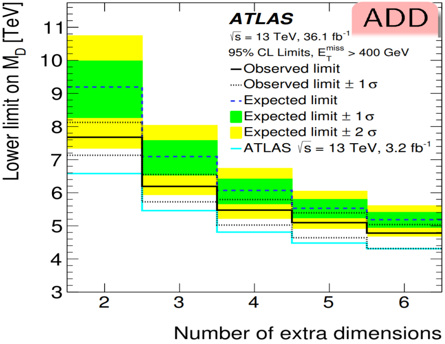




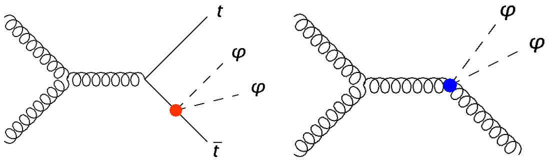


- ADD has massive graviton modes escaping into extra dimensions.
- T-channel model has no resonances and monojet limits are dominant.

New Dark Energy (DE) Model [JHEP (2019): 142]

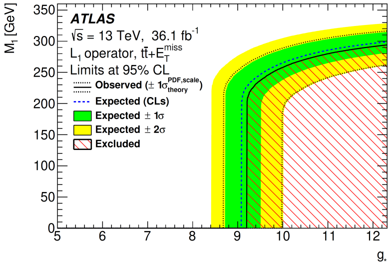
- First collider probe of DE [PhysRevD.94.084054] along with $t\bar{t} + E_T^{miss}$
- Scalar field (ϕ) couples to gravitation & matter, producing small Λ.
- Two classes of operators: invariant & not-invariant under $\phi \to \phi + c$.
  - Shift symmetric operators (SSO) produce stable scalar particles.
  - 9 SSO, the 2 leading order of which have been considered.

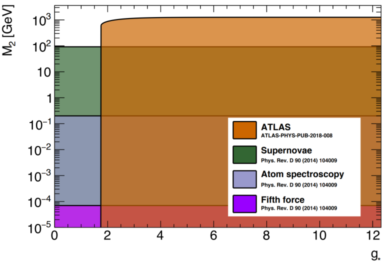
$$\mathcal{L}_1 = \frac{\partial_\mu \phi \partial^\mu \phi}{M_1^4} T_\nu^\nu \qquad \mathcal{L}_2 = \frac{\partial_\mu \phi \partial_\nu \phi}{M_2^4} T^{\mu\nu}$$



- Non SSO are also phenomenologically rich & produce long lived particle signatures which have not yet been considered.

New DE Model Limits [JHEP (2019): 142]





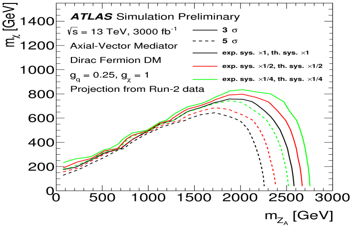
In addition to direct production in colliders, the model investigated is phenomenologically rich in other areas:

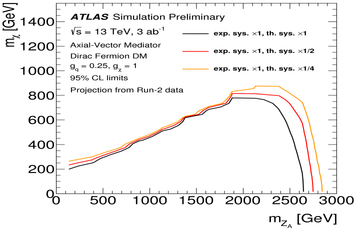
- Galileons/CMB, Grav.waves: $\mathcal{L}_7, \mathcal{L}_8$ [PhysRevLett.119.251303 (2017)]
- Chameleons/Atom interferometry: $\frac{1}{2}\mathcal{L}_{6,1} + \mathcal{L}_{10,1} + \mathcal{L}_{11,1}$ [JCAP (2015)]
- Symmetrons/Torsion pendulum: $-\frac{1}{2}\mathcal{L}_{6,1} - \frac{1}{2}\mathcal{L}_{10,2} + \frac{1}{2}\mathcal{L}_{11,2} - \frac{1}{4!}\mathcal{L}_{11,4}$ [PhysRevLett.110.031301 (2013)]

A close combination of many different fields can therefore help constrain the overall phase space of this model.

Future [ATL-PHYS-PUB-2018-043]

- With HL-LHC ATLAS is expected to collect 3000fb^{-1} of data by 2036, greatly enhancing the monojet discovery potential.
- Improvements to theoretical systematics also greatly enhance discovery potential.
- Further optimizing the monojet analysis strategy can enhance discovery potential.





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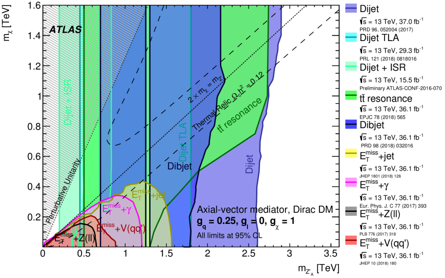
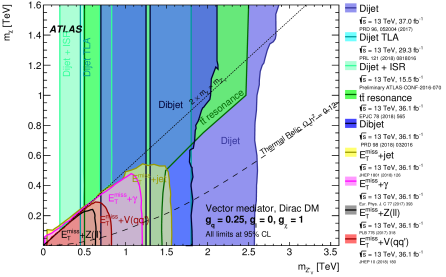
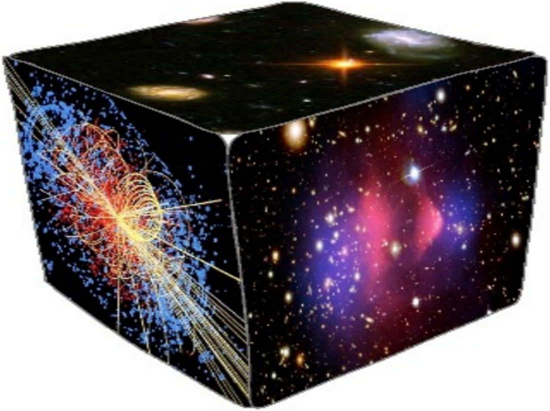




Conclusion

- New monojet analysis paper published with 2015+2016 data. [JHEP (2018): 126.]
- First collider probes of a dark energy model, with $t\bar{t} + E_T^{miss}$. [ATL-PHYS-PUB-2018-008] & [JHEP (2019): 142]
- Dark matter summary paper published alongside other search strategies. [JHEP (2019): 142]
- Further improvements to be made in the monojet analysis - Future looks bright. [ATL-PHYS-PUB-2018-043]
- Push hard to constrain phase space for DM using full Run 2 data.

Backups



Backup Slides