Constraining New Physics with Standard Model measurements

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ALPS2017, Obergurgl

Introduction

- Goal: Set limits on BSM models using precision LHC measurement data.
  - Different data source from typical recasting efforts.

- Build on success of Rivet and HepData as a route to market for data.

- Match desire from experimental collaborations to publish more data.
  - Closing the loop

- Original proof of principle paper now published arXiv:1606.05296
  - J. Butterworth, D. Yallup [UCL], D. Grellscheid [IPPP], M. Krämer, B. Sarrazin [Aachen]

- Constraints On New Theories Using Rivet - **Contur**
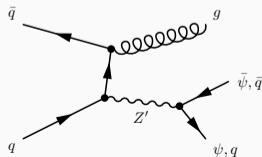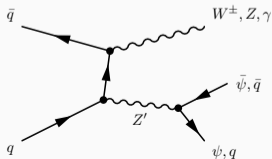
BSM - a simple test case
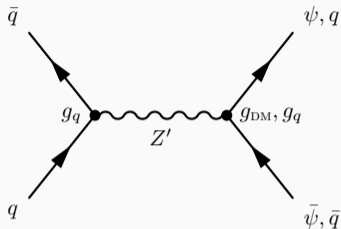
Examples showing a simplified Dark Matter model coupling to quarks

$$\mathcal{L} \supset g_{\mathrm{DM}}\overline{\psi}\gamma_\mu\gamma_5\psi Z'^{\mu} + g_q \sum_q \bar{q}\gamma_\mu q Z'^{\mu}$$

Study here taken from, arXiv:1606.05296

Nature of available routines, currently majority based of SM expected final states. Limited sensitivity to production of DM candidate. Never the less, can see what the Standard Model will be in tension with.

Core concept

- Take a particle level measurement (implemented in Rivet)
- Generate BSM events
- Form exclusion test out of induced perturbation to the measurements from BSM, assuming measured data contains only SM
- Example below, ATLAS 7TeV Dijet double differential cross section

ATLAS Dijet double-differential cross sections ($y^* < 0.5$)
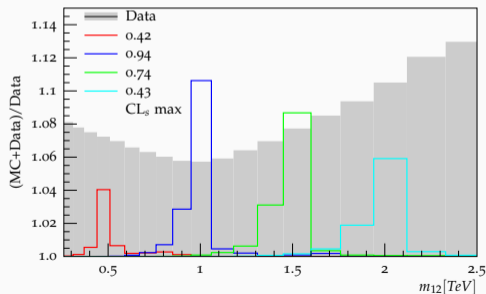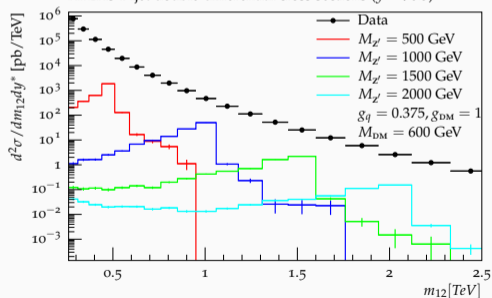
- Strength in depth of Rivet analyses already available
- Using particle level unfolded measurements removes need for detector simulation, efficiencies etc.
  - Minimizes ambiguities in BSM interpretation of data.
- Another example below, ATLAS 7TeV W+jets differential cross section

ATLAS $W+ \geq 2$ jet differential cross section
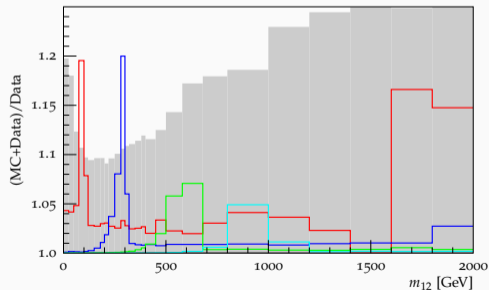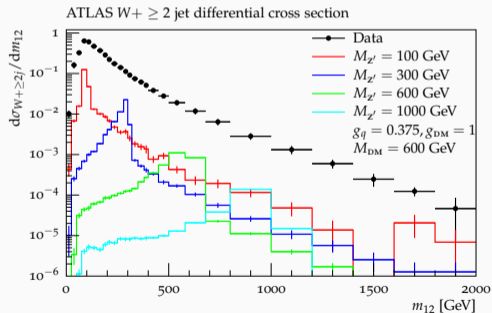
Heatmaps

- Translate previous Rivet outputs to conventional 2D scans in parameter space plane
- Here set $g_q = 0.25$, $g_{DM} = 1.0$, scan in Mediator/DM mass plane
- Coverage of majority of plane from dijet measurements, some residual low mass exclusion from associated EW production
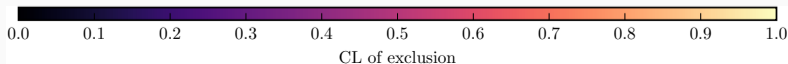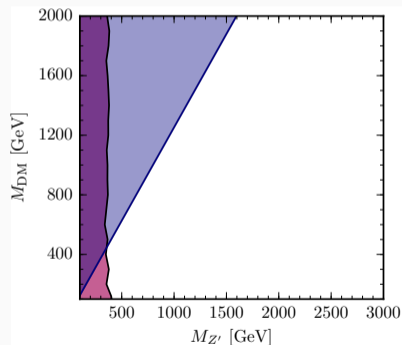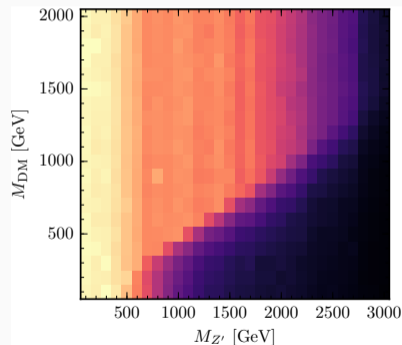
Heatmaps

- Illustrate behavior by turning the coupling up
- Here set $g_q = 0.5$, $g_{DM} = 1.0$, scan in Mediator/DM mass plane

Conclusion
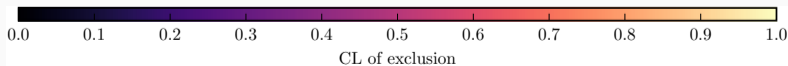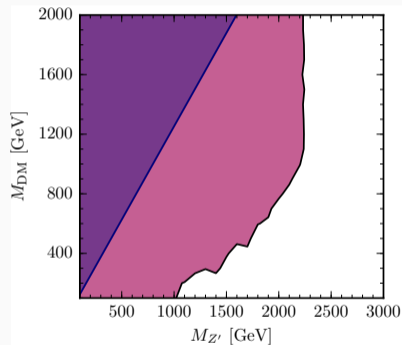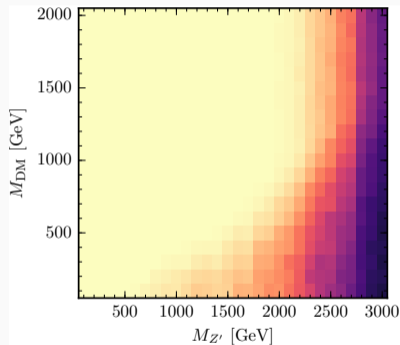
- Contur looks to build unfolded particle level measurements into a test of new physics.

- Main aims going forward:
    - Continue to integrate additional data/models
    - Utilize additional supplementary data beyond the cross section, in particular correlations
        - Feeds back to HepData and the Experimental collaborations.
    - Incorporate theoretical uncertainty/prediction of the SM, current method of limit setting builds some assumptions in.

Thanks for listening

Backup

Analysis coverage

| CONTUR Category	Rivet/ Inspire ID	Rivet description
ATLAS 7 Jets	ATLAS_2014_I1325553 [28]	Measurement of the inclusive jet cross-section
	ATLAS_2014_I1268975 [30]	High-mass dijet cross section
	ATLAS_2014_I1326641 [32]	3-jet cross section
	ATLAS_2014_I1307243 [31]	Measurements of jet vetoes and azimuthal decorrelations in dijet events
CMS 7 Jets	CMS_2014_I1298810 [29]	Ratios of jet pT spectra, which relate to the ratios of inclusive, differential jet cross sections
ATLAS 8 Jets	ATLAS_2015_I1394679 [34]	Multijets at 8 TeV
ATLAS 7 Z Jets	ATLAS_2013_I1230812 [35]	Z + jets
CMS 7 Z Jets	CMS_2015_I1310737 [38]	Jet multiplicity and differential cross-sections of Z+jets events
CMS 7 W Jets	CMS_2014_I1303894 [37]	Differential cross-section of W bosons + jets
ATLAS 7 W jets	ATLAS_2014_I1319490 [36]	W + jets
ATLAS 7 Photon Jet	ATLAS_2013_I1263495 [42]	Inclusive isolated prompt photon analysis with 2011 LHC data
	ATLAS_2012_I1093738 [44]	Isolated prompt photon + jet cross-section
CMS 7 Photon Jet	CMS_2014_I1266056 [45]	Photon + jets triple differential cross-section
ATLAS 7 Diphoton	ATLAS_2012_I1199269 [43]	Inclusive diphoton $+X$ events
ATLAS 7 ZZ	ATLAS_2012_I1203852 [39]	Measurement of the $ZZ(*)$ production cross-section
ATLAS W/Z gamma	ATLAS_2013_I1217863 [40]	W/Z gamma production

Table 1: Table of all Rivet routines currently included in the limit-setting scan. With the one indicated exception, they are all based on 7 TeV data.

- Current selection of utilised routines
- Expanding as rapidly as the library of available Rivet routines

Comparison to searches
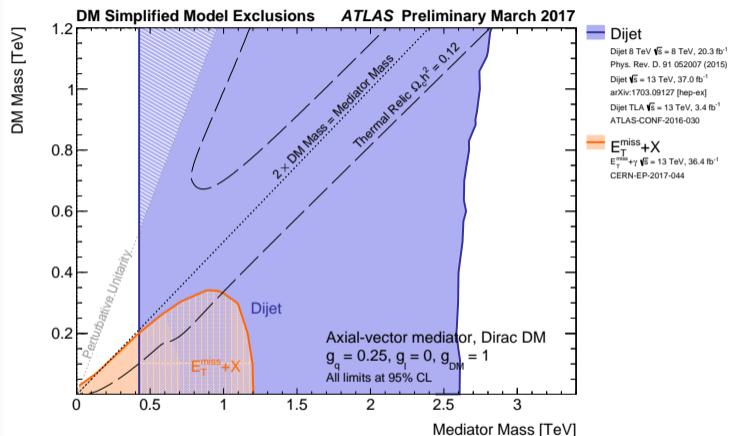
- ATLAS Public results summary, similar (not indentical) model.
- 7TeV Data not even included → greater reach in Mediator mass

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Evaluation

- Analysis coverage lags behind searches, a direct search for a specific model will be available faster
  - But can create a powerful repository of legacy data from LHC analyses

- Current method of statistical testing makes some assumptions that could be treated differently:
  - Most of the measurements currently utilized do not contain detailed correlation information, current statistical test just uses the least compatible (with the the SM) bin in a routine/dataset.
  - Some assumptions currently made on the Theory-Data agreement of the SM prediction

- Can apply a broad range of final state tests to a model, limitation on final states to include is on the experimental publications unfolded to particle level.