

Contur Status and Update

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April 6, 2017

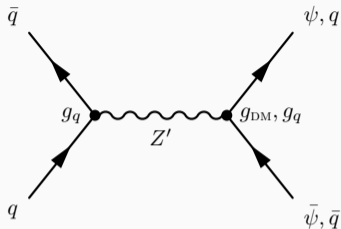
15th MCnet Network Meeting, CERN



- Goal: Set limits on BSM models using precision LHC measurement data.
- Build on success of Rivet and HepData
- Match desire from experimental collaborations to publish more data.
 - Closing the loop
- Original proof of principle paper now published [arXiv:1606.05296](https://arxiv.org/abs/1606.05296)

- MCnet Project (as of new network) under CEDAR
- People involved:
 - J. Butterworth, D. Yallup [UCL]
 - D. Grellscheid [IPPP]
 - M. Krämer, B. Sarrazin [Aachen]
- 4x MSci Students, 2x MSc [UCL]
- MCnet funded PhD student [Joint Glasgow(w. A. Buckley)/UCL, starting Sept 17]
- Integration with ATLAS experimental collaboration members

BSM - a simple test case

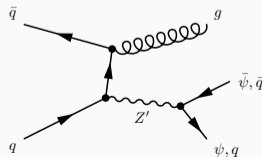
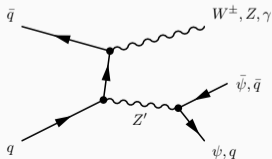


Examples showing a simplified Dark Matter model coupling to quarks

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

Study here taken from, [arXiv:1606.05296](https://arxiv.org/abs/1606.05296)

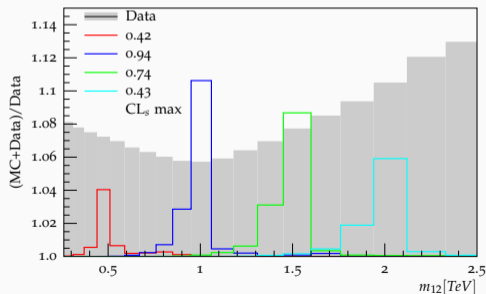
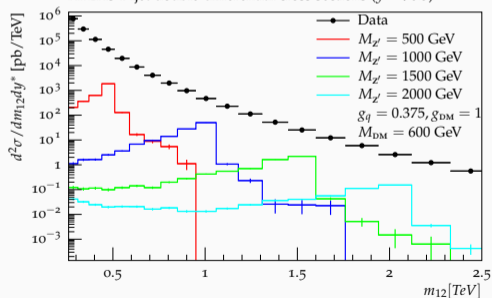
Nature of available routines, currently majority based of SM expected final states. Limited sensitivity to production of DM candidate. Never the less, can see what the Standard Model will be in tension with.



Core concept

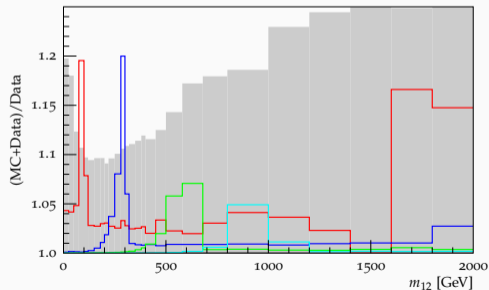
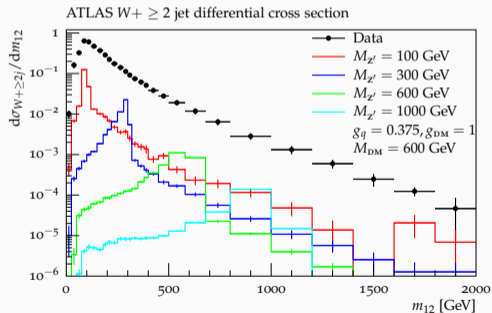
- Take a particle level measurement (implemented in Rivet)
- Generate BSM events
- Form exclusion test out of induced perturbation to the measurements from BSM, assuming measured data contains only SM
- Example below, ATLAS 7TeV Dijet double differential cross section

ATLAS Dijet double-differential cross sections ($y^* < 0.5$)



Core concept cont.

- Strength in depth of Rivet analyses already available
- Using particle level unfolded measurements removes need for detector simulation, Signal region efficiencies
 - Minimizes ambiguities in BSM interpretation of data.
- Another example below, ATLAS 7TeV $W+\geq 2$ jets differential cross section



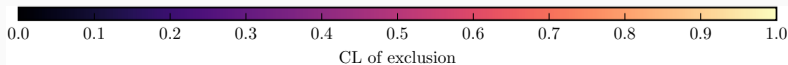
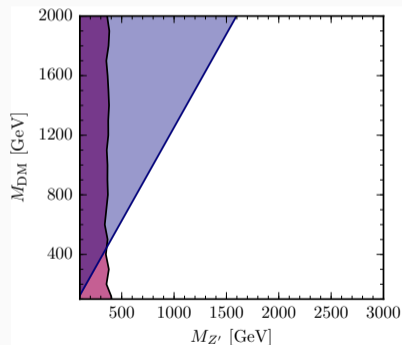
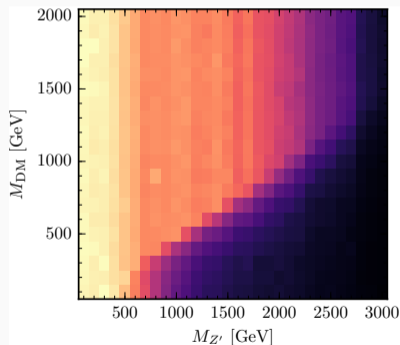
| CONTUR Category | Rivet/ Inspire ID | Rivet description |
|--------------------|--------------------------|--|
| ATLAS 7 Jets | ATLAS.2014.I1325553 [28] | Measurement of the inclusive jet cross-section |
| | ATLAS.2014.I1268975 [30] | High-mass dijet cross section |
| | ATLAS.2014.I1326641 [32] | 3-jet 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

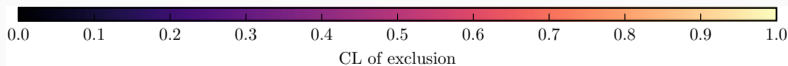
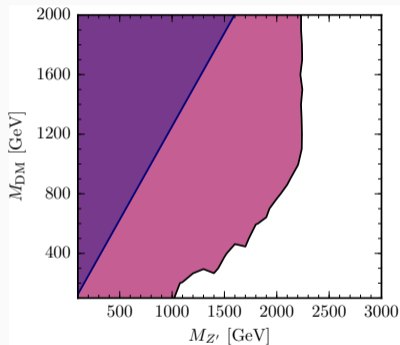
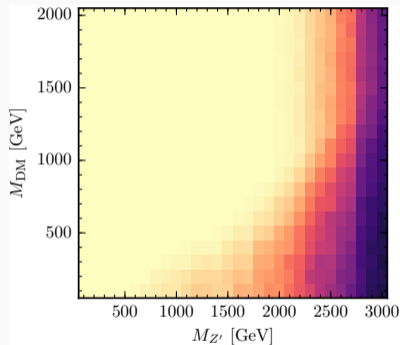
Heatmaps

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

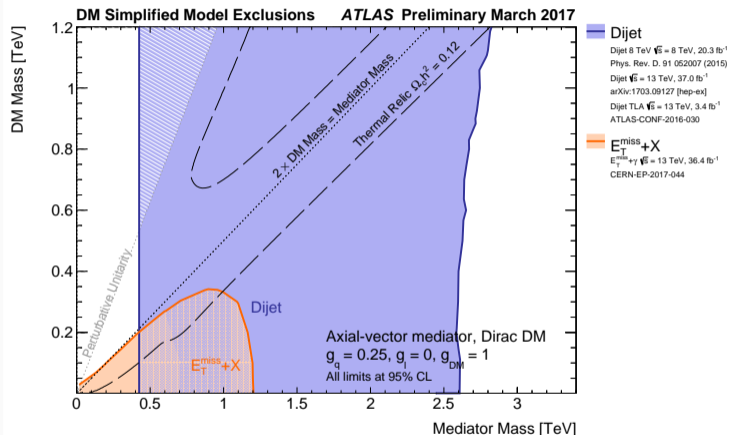


Heatmaps

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



Comparison to searches



- ATLAS Public results summary, similar (not identical) model.
- 7TeV Data not even included \rightarrow greater reach in Mediator mass

- 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.

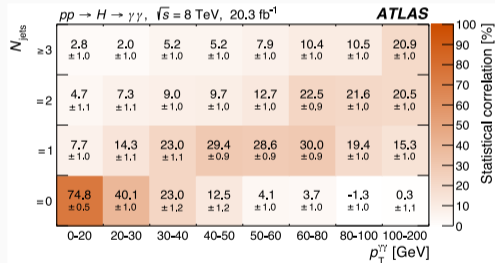
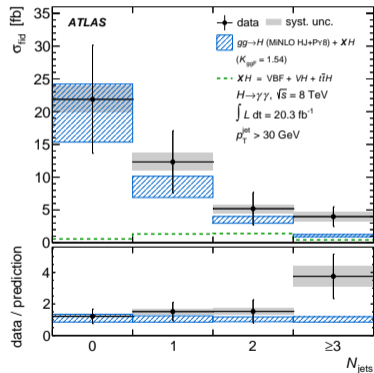
- Contur looks to build unfolded particle level measurements into a test of new physics, an alternative to existing recasting methods
- Main aims going forward:
 - Continue to integrate additional data/models
 - Utilize additional supplementary data beyond the cross section, in particular correlations
 - Feeds back to HepData and the Experimental collaborations.
 - Incorporate theoretical uncertainty/prediction of the SM
 - Develop user friendly interface, mostly likely as an afterburner to Yoda (Rivet) files.

Thanks for listening

Backup

Extending Data use example - ATLAS 8TeV Diphoton Higgs

- Original publication of differential x's, follow up paper to also publish statistical correlations between bins \rightarrow enables combination data in different kinematic distributions. [Close the loop!](#) n.b: Not yet implemented in Contur...



- Original differential x's paper
[arXiv:1407.4222](#)

- Statistical correlation supplement
[arXiv:1508.02507](#)