

# *Contur* *Constraints On New Theories Using Rivet*



*a tool for reinterpreting  
particle-level measurements.*



12/6/2024

MCnet School, CERN

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# The problem



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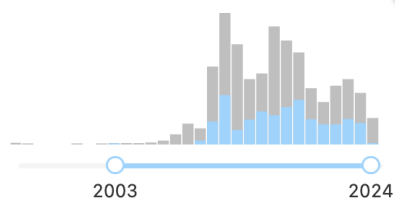
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Number of authors

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Document Type

- published 1,158
- article 1,157
- note 2
- conference paper 1

A search for R-parity-violating supersymmetry in final states containing many jets in pp collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector #1

ATLAS Collaboration · Georges Aad (Marseille, CPPM) et al. (Jan 29, 2024)  
Published in: *JHEP* 05 (2024) 003 · e-Print: 2401.16333 [hep-ex]

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Search for new phenomena with top-quark pairs and large missing transverse momentum using  $140 \text{ fb}^{-1}$  of pp collision data at  $\sqrt{s} = 13$  TeV with the ATLAS detector #2

ATLAS Collaboration · Georges Aad (Marseille, CPPM) et al. (Jan 24, 2024)  
Published in: *JHEP* 03 (2024) 139 · e-Print: 2401.13430 [hep-ex]

pdf DOI cite claim reference search 2 citations

Search for Long-Lived Heavy Neutral Leptons with Lepton Flavour Conserving or Violating Decays to a Jet and a Charged Lepton #3

CMS Collaboration · Aram Hayrapetyan (Yerevan Phys. Inst.) et al. (Dec 12, 2023)  
Published in: *JHEP* 03 (2024) 105 · e-Print: 2312.07484 [hep-ex]

pdf DOI cite datasets claim reference search 6 citations

Search for flavor changing neutral current interactions of the top quark in final states with a photon and additional jets in proton-proton collisions at  $\sqrt{s} = 13$  TeV #4

CMS Collaboration · Aram Hayrapetyan (Yerevan Phys. Inst.) et al. (Dec 11, 2023)  
Published in: *Phys Rev D* 109 (2024) 7 · e-Print: 2312.08229 [hep-ex]

# (Part of) The Solution



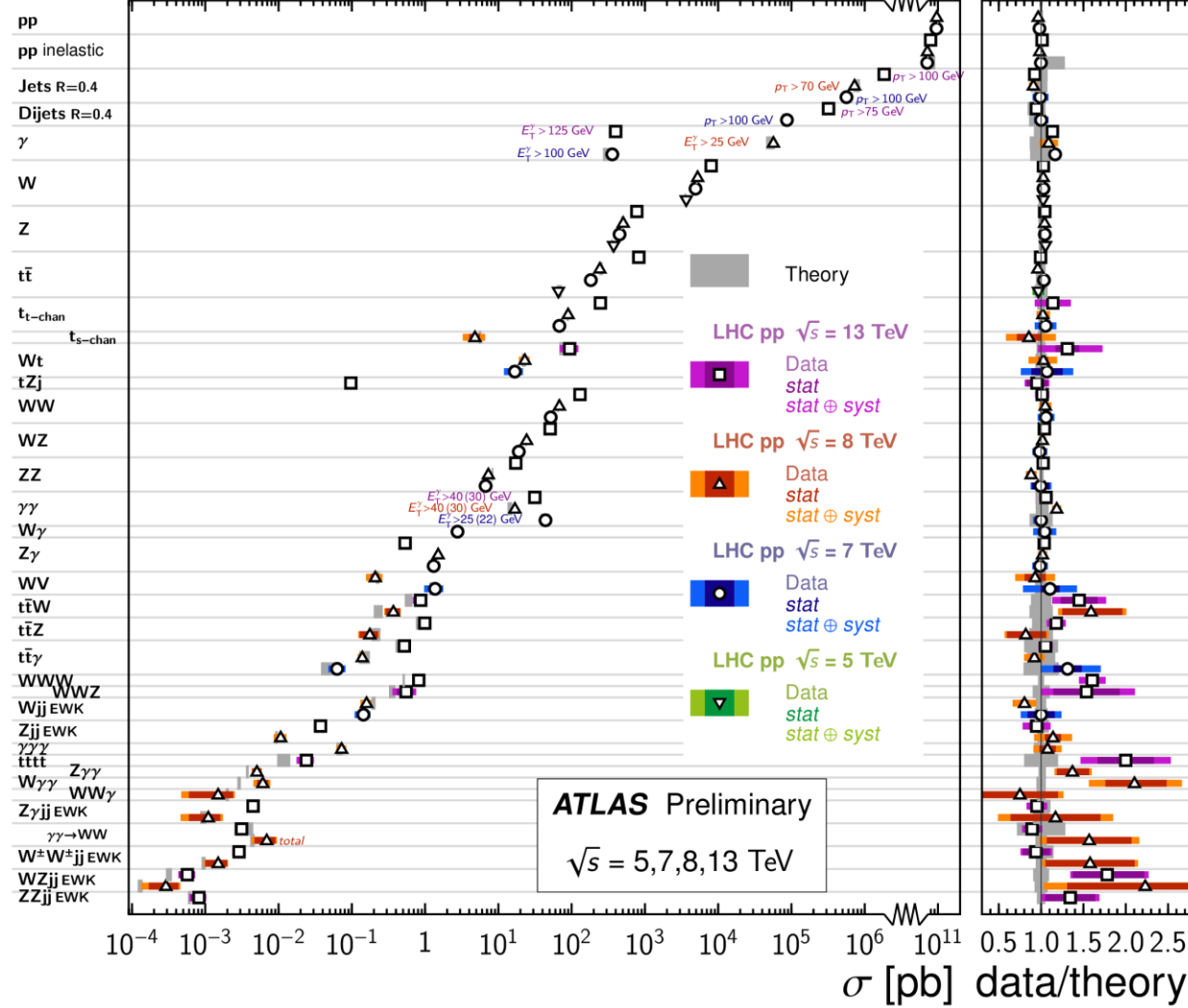
The LHC measurement “library”





# Standard Model Production Cross Section Measurements

Status:  
February 2022



$\int \mathcal{L} dt$   
[fb<sup>-1</sup>]

**Reference**

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- Nucl. Phys. B, 486-548 (2014)
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- PLB 761 (2016) 158
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- EPJC 79 (2019) 760
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- JHEP 01, 064 (2016)
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- JHEP 07 (2020) 124
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- PLB 798 (2019) 134913
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- EPJC 81 (2021) 163
- JHEP 04, 031 (2014)
- PLB 761 (2016) 55
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- PRL 115, 031802 (2015)
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- PRD 94 (2016) 032011
- PRL 123, 161801 (2019)
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- PLB 793 (2019) 469
- PRD 93, 092004 (2016)
- arXiv:2004.10612



HIGGS

# Introducing Rivet

“Robust Independent Validation of Experiment and Theory”



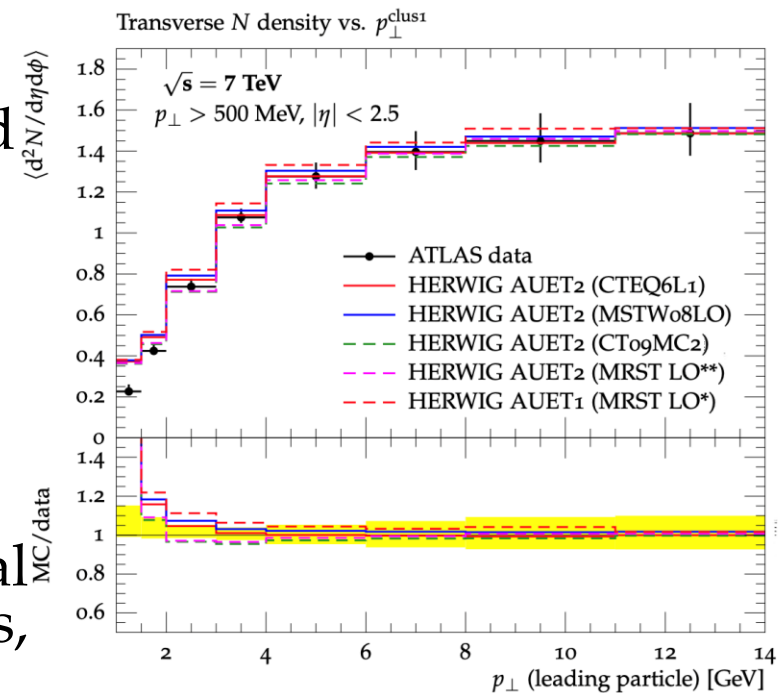
HERA legacy (1990s, HZTOOL)

Developed by MCnet for tuning and validation of new MC event generators

- e.g. What does the underlying event look like in 7 TeV pp collisions?

Vast library of measurements of final state particles produced in collisions, and variables derived from them

Buckley et al, Bierlich et al *arXiv:1003.0694* (CPC),  
*arXiv:1912.05451* (SciPost), *arXiv:2404.15984*



From ATL-PHYS-PUB-2011-008

# Introducing Contur



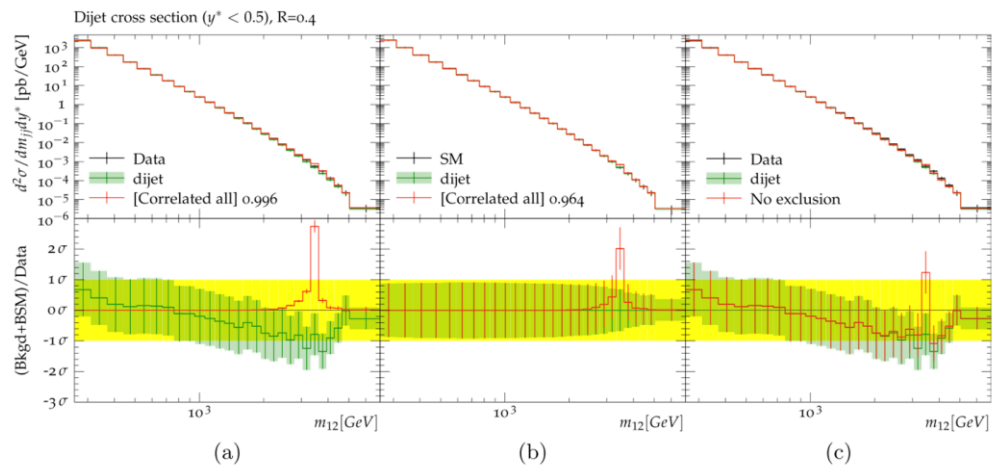
## “Constraints On New Theories Using Rivet”

Extend the power of Rivet beyond the Standard Model

Signal-injection of final-state particles from BSM physics events on to measured cross sections in Rivet

Increasingly precise measurements and SM calculations together extend the reach

JMB, Grellscheid, Krämer, Sarrazin, Yallup; Buckley et al  
arXiv:1606.05296 (JHEP), arXiv:2102.04377 (SciPost)

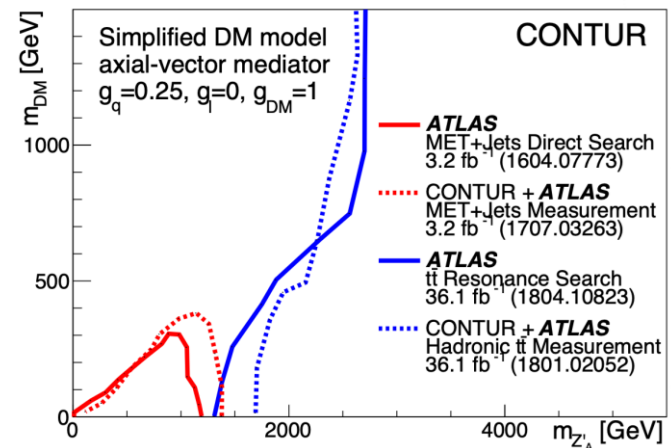


From Altakach, JMB, Ježo, Klasen, Schienbein  
arXiv:2111.15406 (SciPost Core)

# A Contur-friendly measurement



- Is unfolded to particle-level
- Is defined in terms of the final state, not production process
- Has a fiducial phase space which is as inclusive as possible and reflects the actual selection
  - No hidden vetos
  - Minimal extrapolations
- For example:



# Contur Software



- Written in Python:  
<https://gitlab.com/hepcedar/contur>
- Heavy use of python interface to Rivet, Yoda, and of matplotlib, scipy, numpy and more (including pylha)
- Rivet, Yoda mainly C++ (all on gitlab)
- Can steer event generators (currently Herwig, Madgraph, Pythia) but can also be run on any existing Rivet (Yoda) output (and Rivet can run on any HepMC events)
- Can also be invoked from inside the Madgraph command-line environment (along with Rivet) or via Gambit
- Nascent GUI and ML add-ons