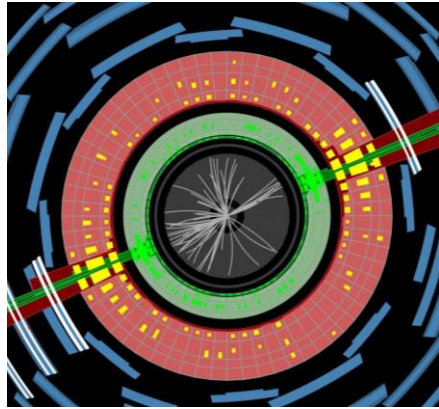


# *Contur Update*

*Constraints On New Theories Using Rivet*



*a tool for  
reinterpreting  
particle-level  
measurements.*



18/6/2024

OpenMAPP/RIF Grenoble

Jon Butterworth



# Rivet



“Robust Independent Validation of Experiment and Theory”

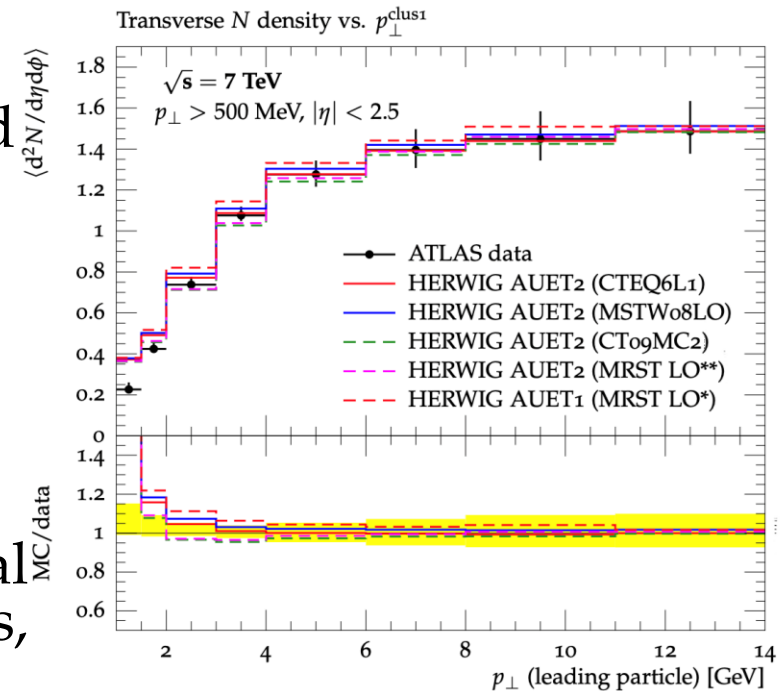
HERA legacy (1990s, HZTOOL)

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

# Rivet



NEW! Rivet 4.0 (Yoda 2.0)

[arXiv:2404.15984](https://arxiv.org/abs/2404.15984)

- Major generalisation and more semantically coherent model for histograms and related data objects
- Thorough clean-up of inelegant and legacy observable-computation tools
- New systems for extended analysis-data, incorporation of preserved machine-learning models, and serialization for high-performance computing applications (thread safety)

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



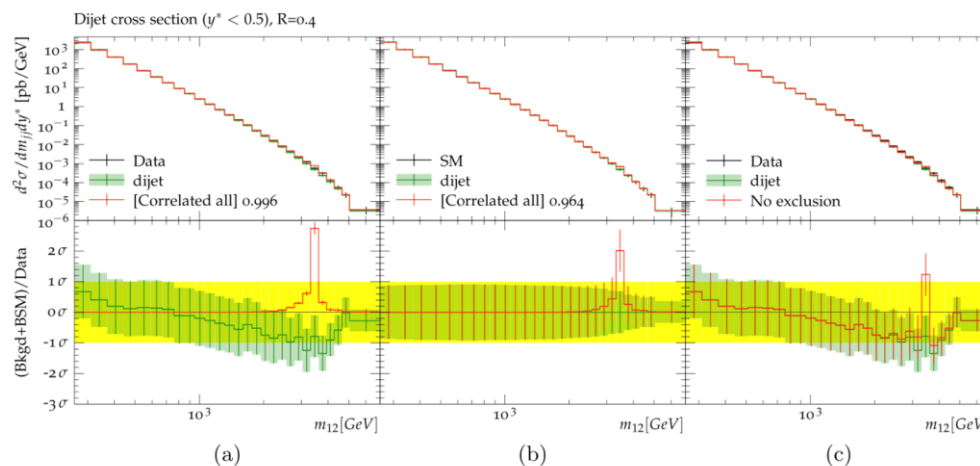
# Contur

## “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



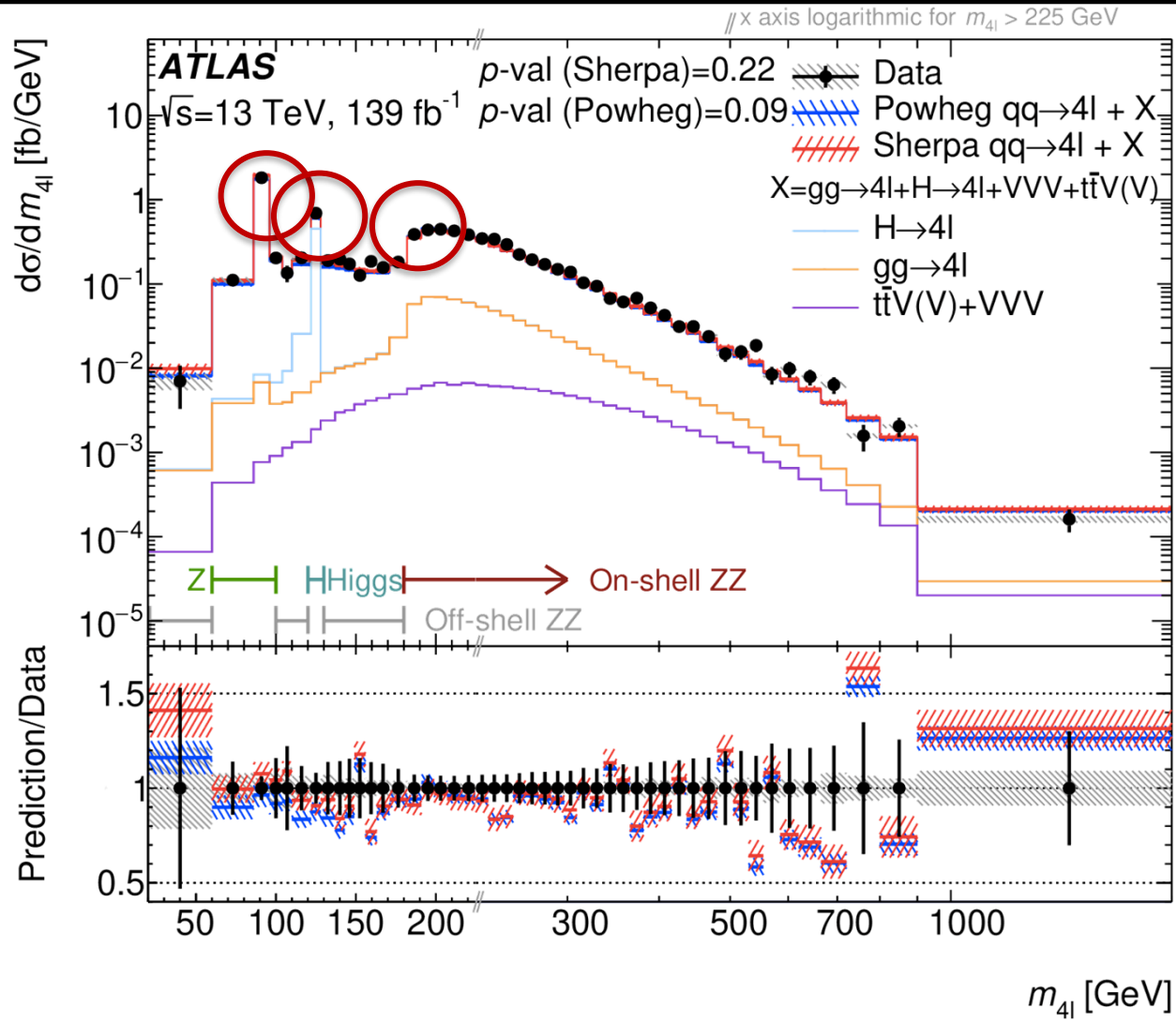
From Altakach, JMB, Ježo, Klasen, Schienbein  
*arXiv:2111.15406 (SciPost Core)*

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

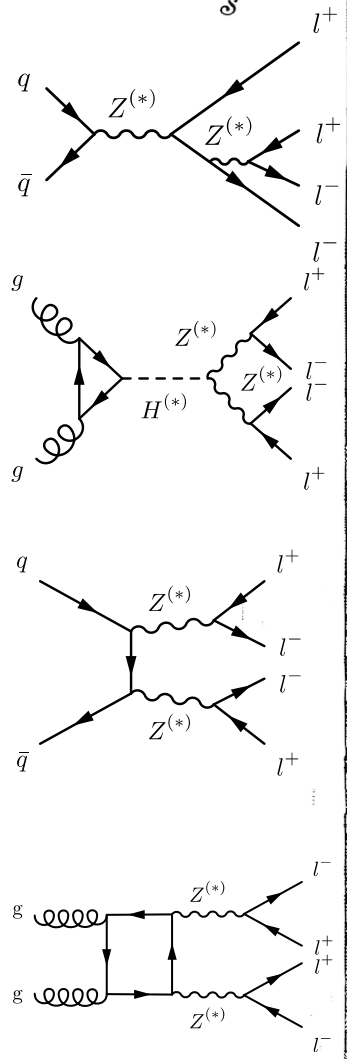
# *A Contur-friendly measurement*

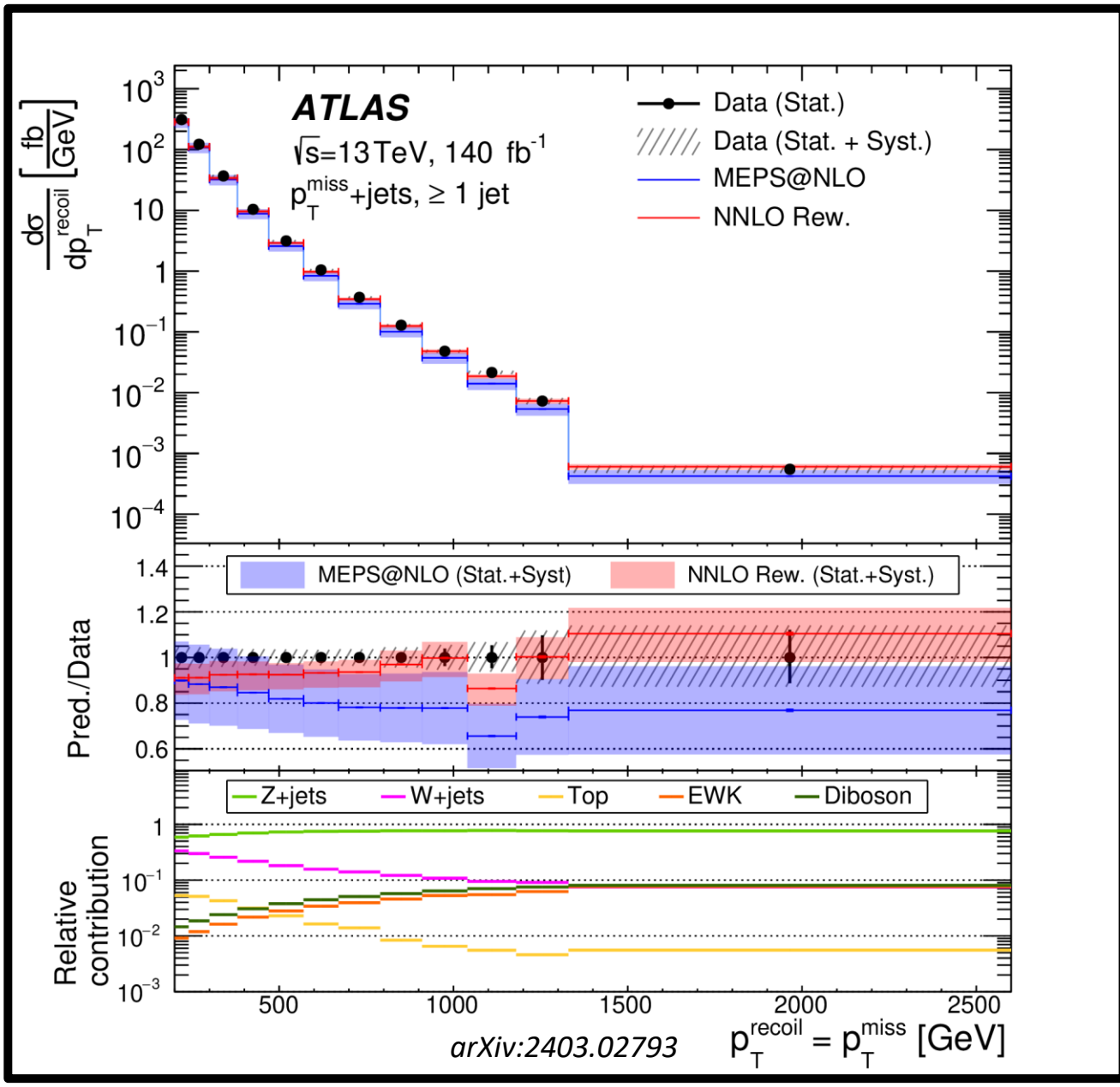


- Is unfolded to particle-level
- Is defined in terms of the final state, not production process
- Has a fiducial phase space which is as inclusive as possible and reflects the actual selection
  - No hidden vetos
  - Minimal extrapolations
- For example:



arXiv:2103.01918 (JHEP)

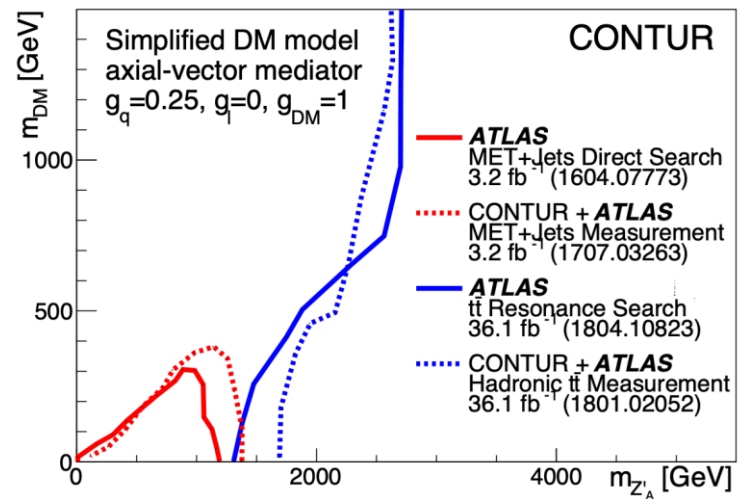




# Unleashing the power of LHC cross section measurements



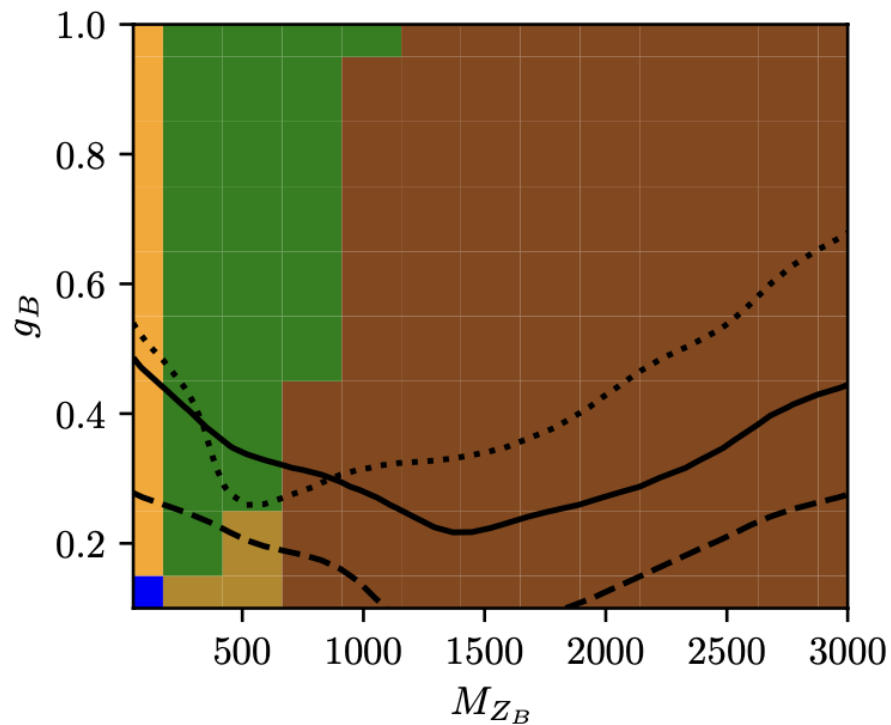
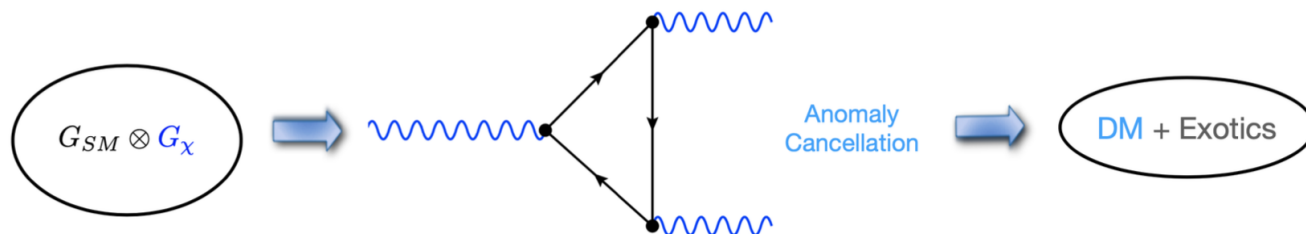
- **Dark Matter from Anomaly Cancellation at the LHC**
  - [J Butterworth, H Debnath, P Fileviez Perez, Y Yeh 2405.03749](#) [hep-ph]
- **Custodial symmetry breaking and Higgs boson signatures at the LHC**
  - [J Butterworth, H Debnath, P Fileviez Perez, F Mitchell Phys.Rev.D 109 \(2024\) 9, 095014 2309.10027](#) [hep-ph]
- **Measuring hadronic Higgs boson branching ratios at future lepton colliders**
  - [M Knobbe, F Krauss, D Reichelt, S Schumann Eur.Phys.J.C 84 \(2024\) 1, 83 2306.03682](#) [hep-ph]
- **Hunting scalar partners of the Higgs boson at the LHC**
  - [W Porod, PoS CORFU2022 \(2023\) 126, 2304.10753](#) [hep-ph]
- **Collider constraints on electroweakinos in the presence of a light gravitino**
  - [GAMBIT Collaboration Eur.Phys.J.C 83 \(2023\) 6, 493, 2303.09082](#) [hep-ph]
- **Combined constraints on dark photons and discovery prospects at the LHC and the Forward Physics Facility**
  - [A Aboubrahim, M Altakach, M Klasen, P Nath, Z-Y Wang JHEP 03 \(2023\) 182 2212.01268](#) [hep-ph]
- **Testing the scalar triplet solution to CDF's heavy W problem at the LHC**
  - [J Butterworth, J Heeck, S H Jeon, O Mattelaer, R Ruiz Phys.Rev.D 107 \(2023\) 7, 075020 2210.13496](#) [hep-ph]



Louie Corpe

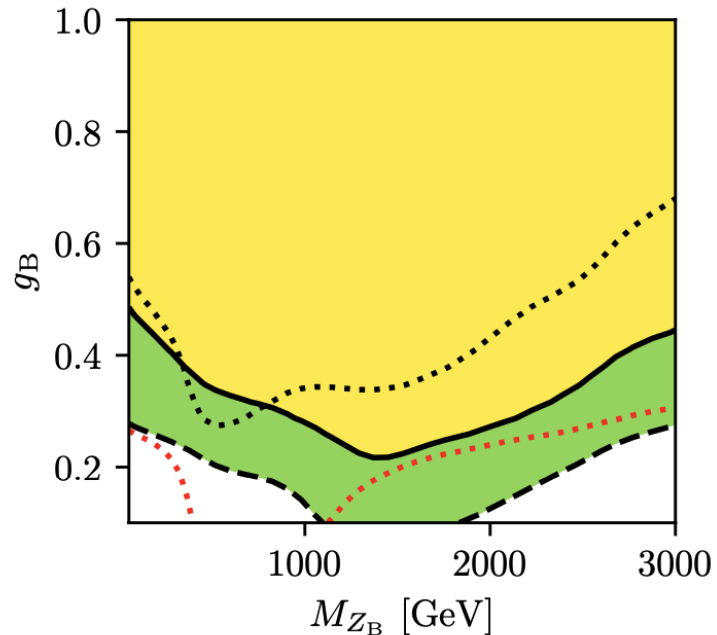
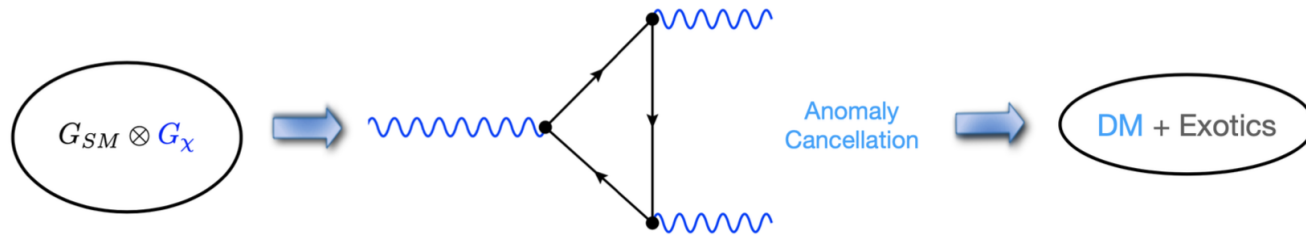


# Dark Matter from Anomaly Cancellation

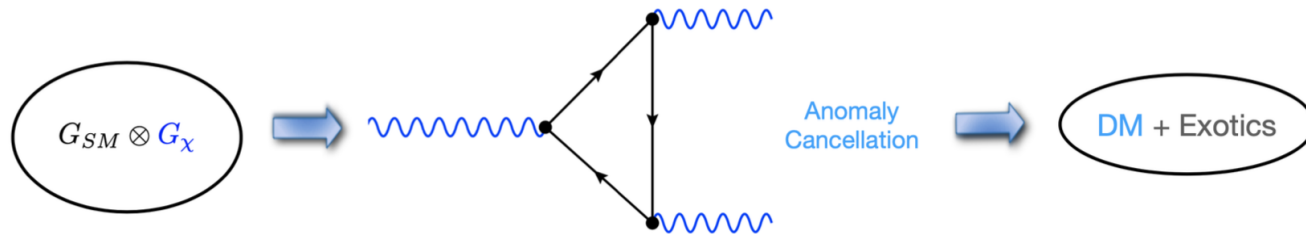


- $p_T^{\text{miss}} + \text{jet}$  [28, 29]
- $l^+ l^- + \text{jet}$  [30]
- hadronic  $t\bar{t}$  [31, 32]
- $l^+ l^- \gamma$  [33]
- $l + p_T^{\text{miss}} + \text{jet}$  [34–36]

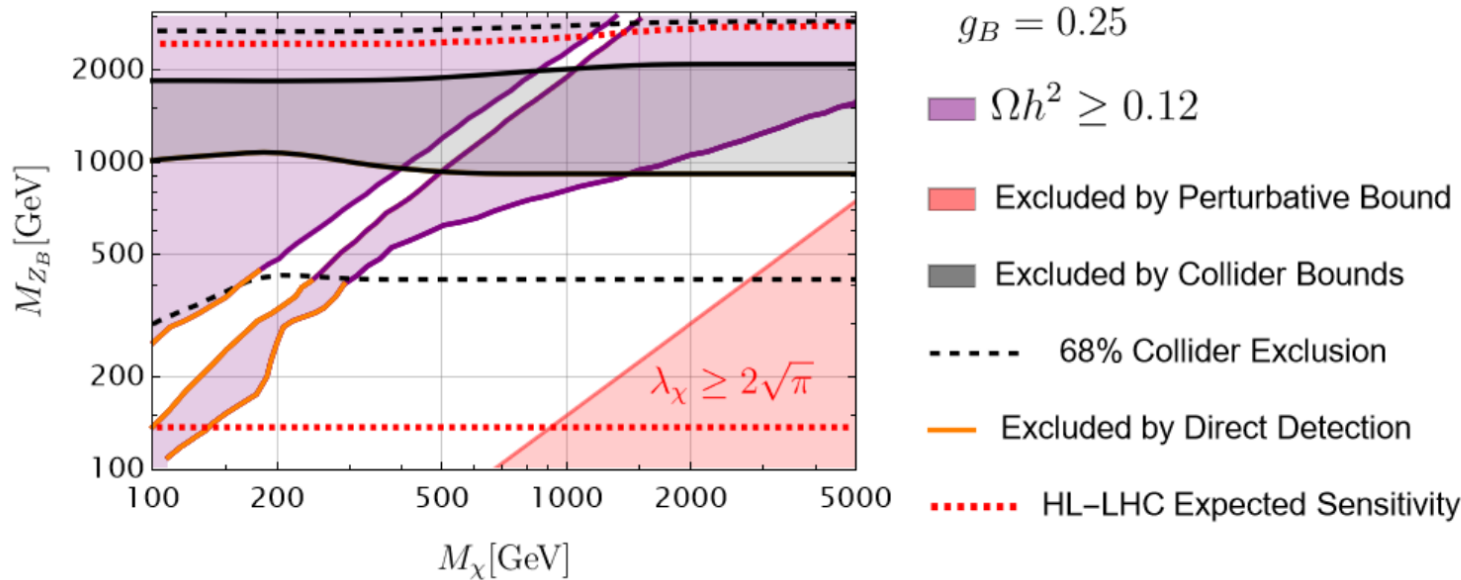
# Dark Matter from Anomaly Cancellation



# Dark Matter from Anomaly Cancellation



Majorana DM



# Contur Implementation



- 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)
- Nascent GUI and ML add-ons

# Contur Update



- 2.5.1
    - HL-LHC limits
    - Update for Rivet 3.1.10
  - 3.0.x
    - Better multi-dimensional scanning/slicing
    - Faster DB reading
    - Update for Rivet 4.0
- (new developers J. Egan, G. Gütschow)*