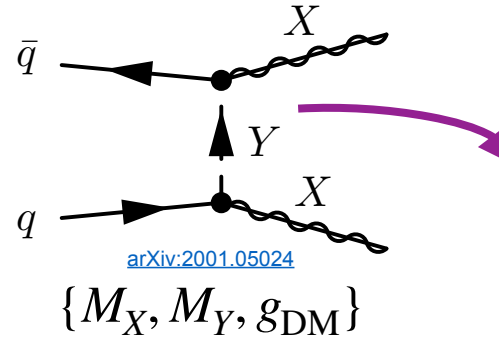


CONTUR: new results and technical developments

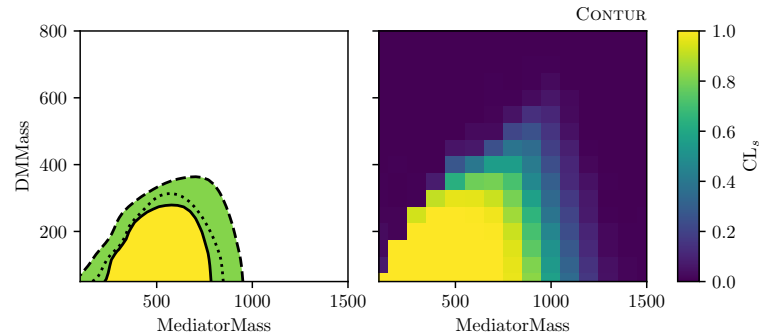
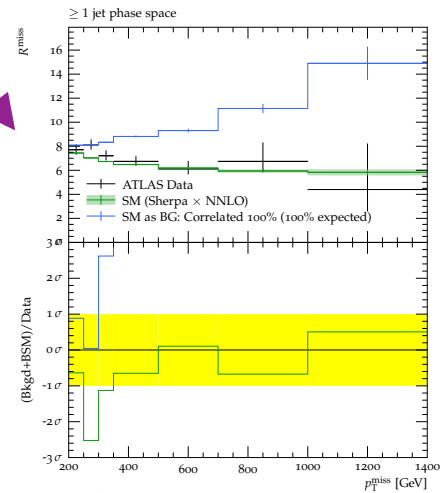
MCnet Meeting 2022, Universität Graz
Yoran Yeh on behalf of the CONTUR team
23 September 2022



- Constraints on new theories using Rivet ([SciPost Phys.Core 4 \(2021\) 013](https://arxiv.org/abs/2001.05024))
- Aims to answer: “How excluded is a new beyond the SM (BSM) theory already by published LHC measurements?”
- Very quick and computationally light because only particle-level measurements are considered
- Rivet analyses divided into orthogonal pools (experiment, beam energy, final state)
- Results webpage: <https://hepcedar.gitlab.io/contur-webpage/index.html>



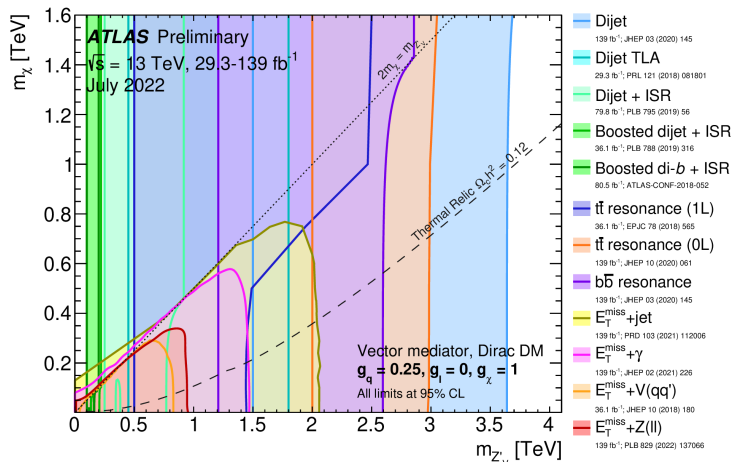
Vary model parameters



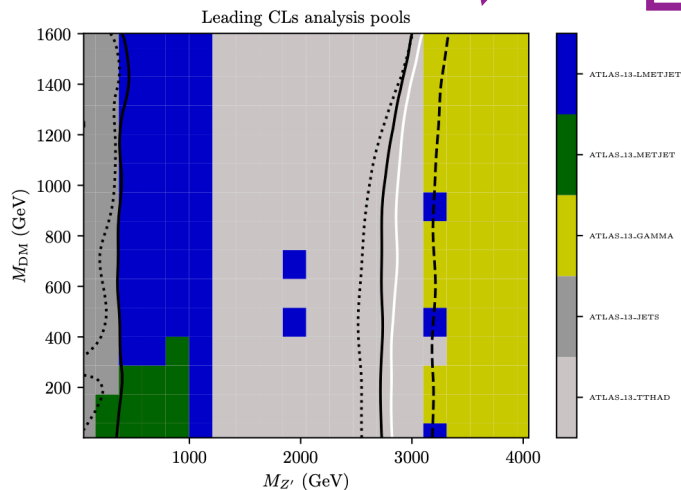
Dirac DM, vector (V) mediator

- DM model mediated in s-channel diagrams, benchmarked to [ATLAS search summary plots](#)
- Right plot: coloured squares indicate measurement pool with largest exclusion
- $t\bar{t}$ production at $M_{Z'} > 350$ GeV
- Slightly lower sensitivity in CONTUR at high $M_{Z'}$

Dijet and missing energy+jets at 3.2 fb⁻¹
 $t\bar{t}$ production at 36.1 fb⁻¹



[ATL-PHYS-PUB-2022-036](#)

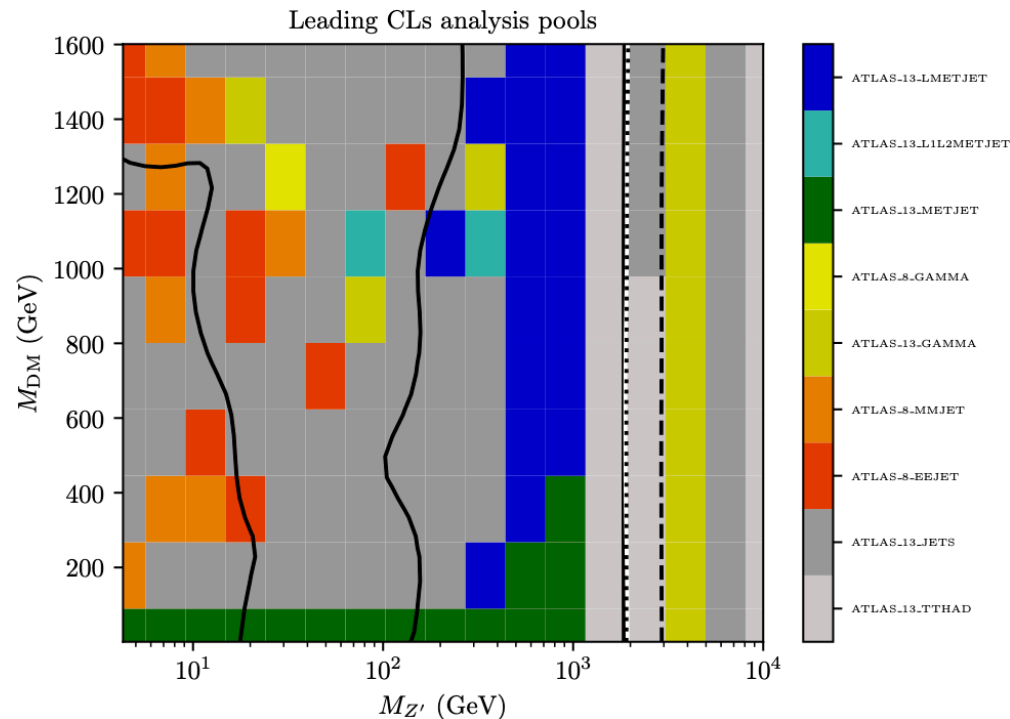


C. Velasquez, J. Butterworth

Solid: 95% (obs.)
 Dashed: 68% (obs.)
 Dotted: 95% (exp.)
 White: 95% (obs., data as bkg.)

Dirac DM, V (low-mass)

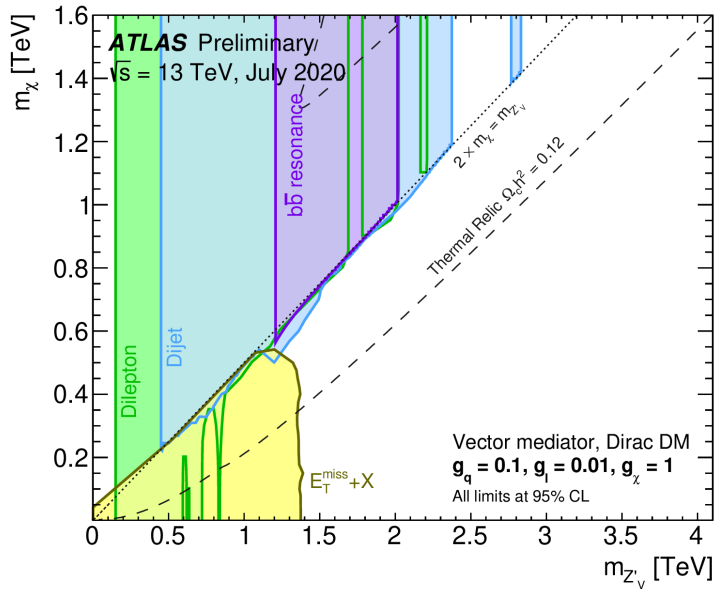
- Extend plot down to $M_{Z'} = 4$ GeV on a logarithmic axis
- Sensitive for data as bkg. (white line), from $\gamma +$ jets and $W, Z +$ jets measurements
- SM predictions for some analyses not yet available in CONTUR, hence sensitivity of solid black line is not as stringent



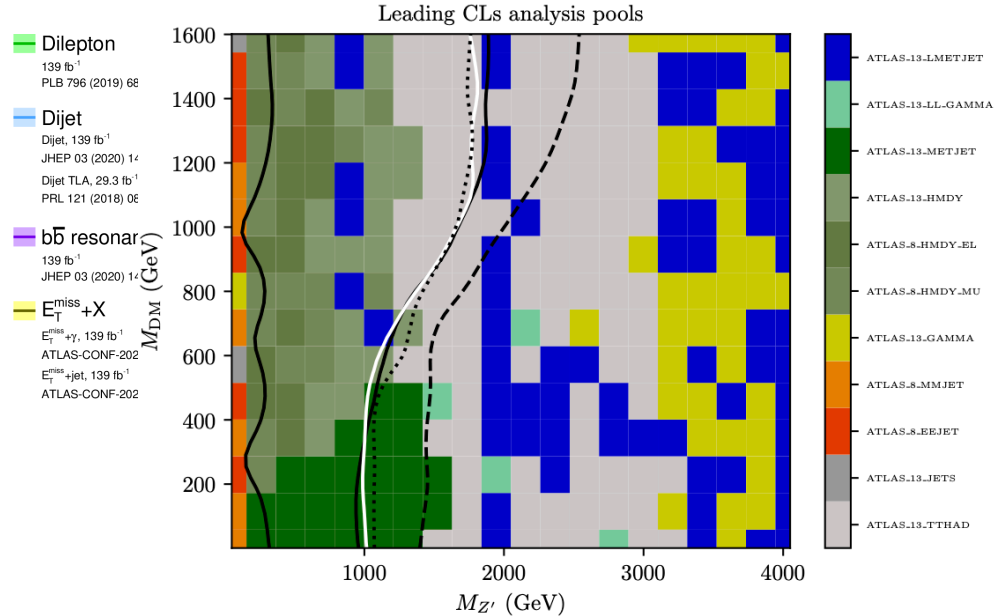
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Dirac DM, V , non-zero lepton coupling

- Shape of excluded region similar, ATLAS searches with 139 fb^{-1} of data benefit from better statistics (vs. 3.2 fb^{-1} for the analyses used in CONTUR)



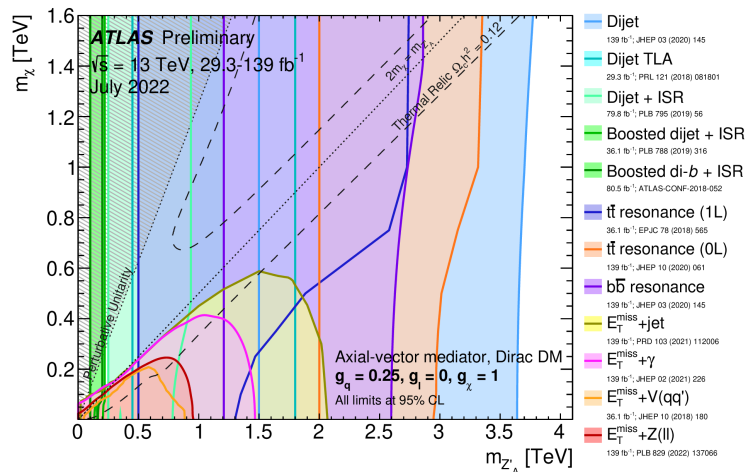
[ATL-PHYS-PUB-2022-036](#)



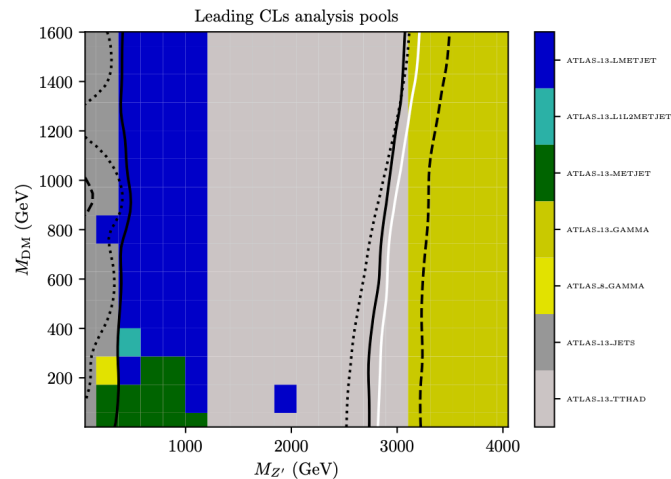
C. Velasquez, J. Butterworth

Dirac DM, axial-vector (A) mediator

- Similar to vector DM case: comparable shape but slightly different sensitivity
- Full Run-2 dijet measurement (and missing energy+jets measurement) expected to improve limits significantly



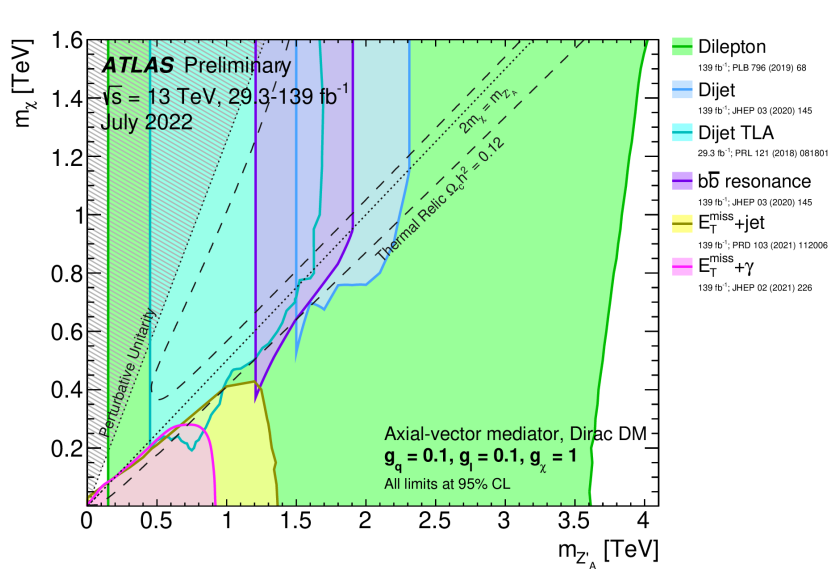
[ATL-PHYS-PUB-2022-036](#)



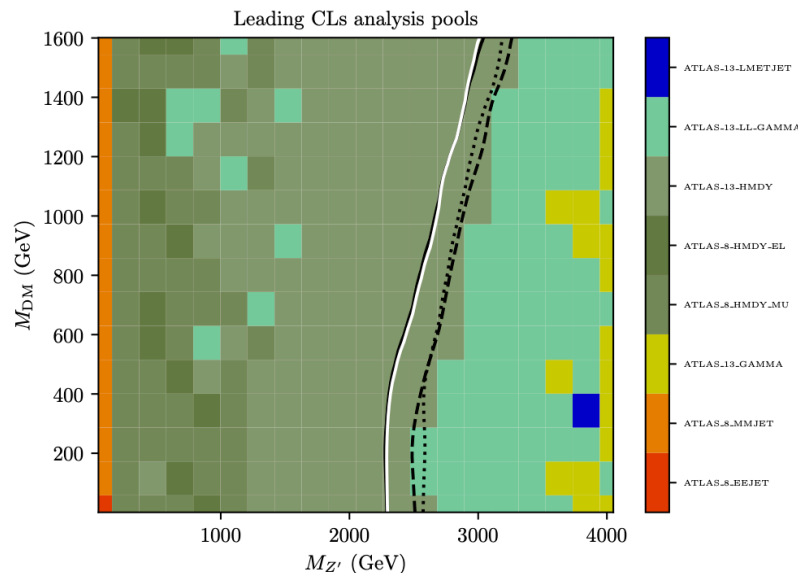
C. Velasquez, J. Butterworth

Dirac DM, A, non-zero lepton coupling

- Lepton signatures dominate the exclusion plot
- Eventual full Run-2 measurements of dileptons + ditau would increase CONTUR sensitivity
- Of course CONTUR is not limited to these common benchmark models!



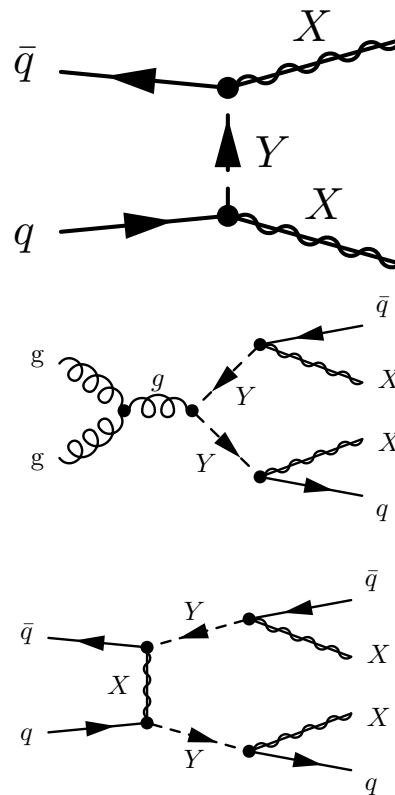
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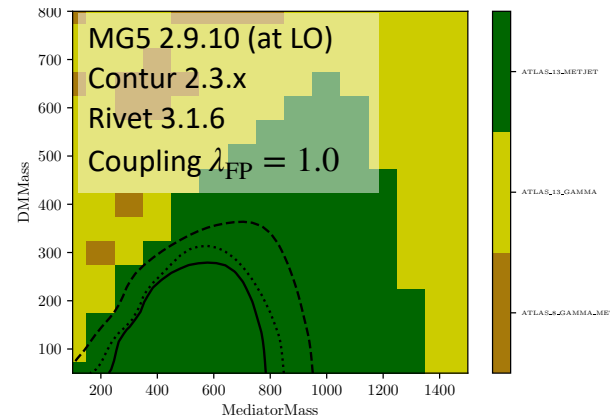
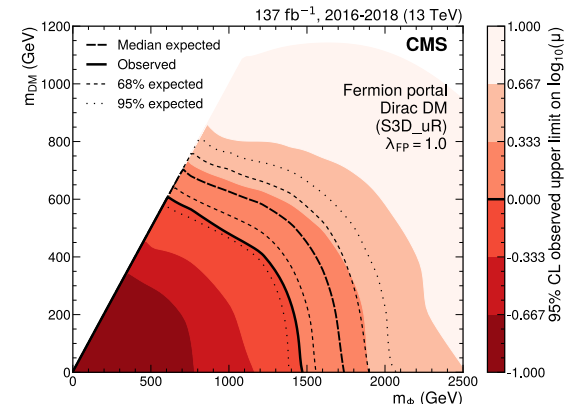
C. Velasquez, J. Butterworth

Simplified t-channel DM model

- Characterised by quark/DM/mediator coupling
- Implemented in FeynRules ([Eur. Phys. J. C80 \(2020\) 409](#))
- Various configurations with different DM spins, Majorana/Dirac DM or quark contributions
- Benchmark against CMS missing energy + jets search ([arXiv:2107.13021](#))
- Great CONTUR candidate due to the number of different configurations and large parameter space



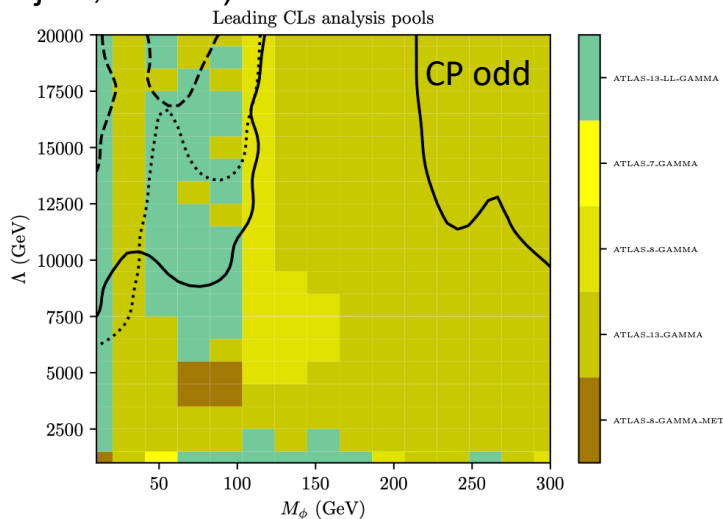
[arXiv:2001.05024](#)



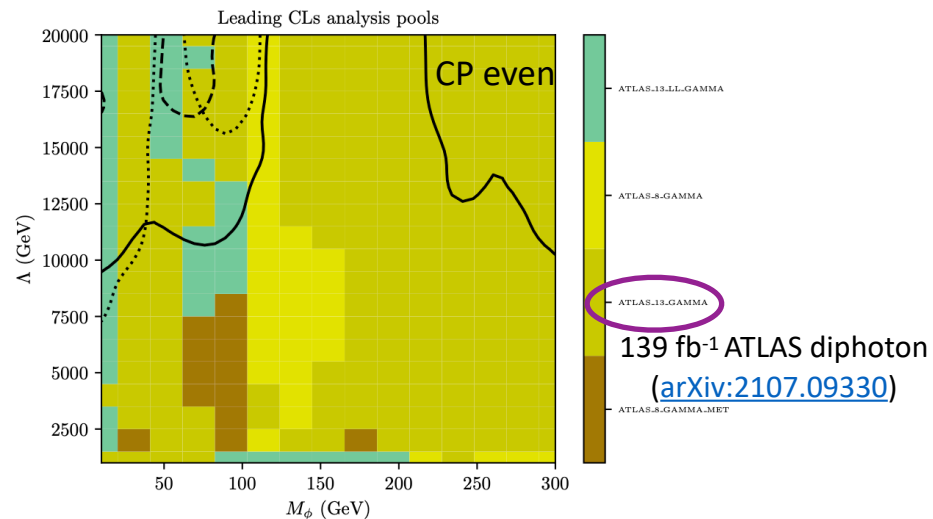
J. Butterworth, S. Jeon, C. Velasquez, YY

Light scalars with EFT couplings

- Light scalar particles (CP odd or even) ϕ coupling to electroweak gauge bosons
- Parameters: M_ϕ and coupling to SM particles, i.e. effective couplings governed by Λ_i for SM particle i
- CP-odd: set all scales very high, except W, B which are set equal CP. CP-even: include Higgs coupling
- Measurements of interest with an isolated photon or photon pairs in the final state (both inclusively and with jets, W or Z)



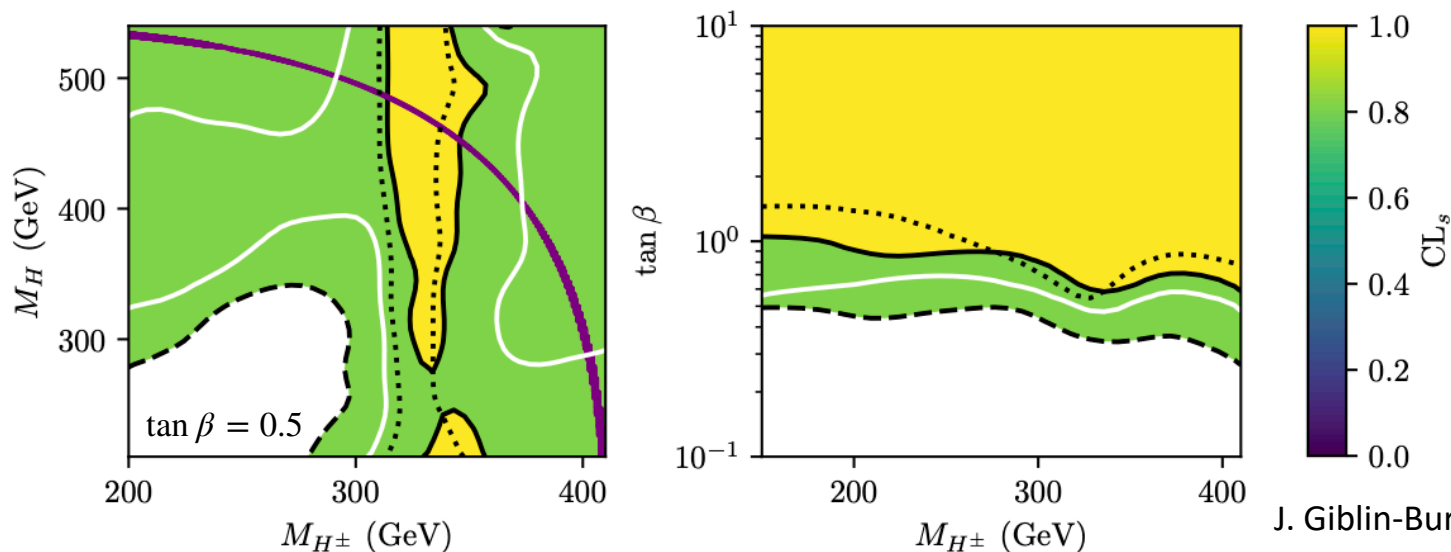
X. Wang, J. Butterworth



X. Wang, J. Butterworth

Gildner-Weinberg 2HDM

- Two-Higgs-doublet model with additional mass constraint $(\sum_{\mathcal{H}} M_{\mathcal{H}}^4)^{1/4} = 540$ GeV on extra Higgs-bosons
 $\mathcal{H} = \{H, H_A, H^\pm\}$ (see e.g. Les Houches 2019 New Physics Working Group report [arXiv:2002.12220](#))
- “Data as background” more stringent; not all measurements have SM predictions in CONTUR + SM uncertainties are included

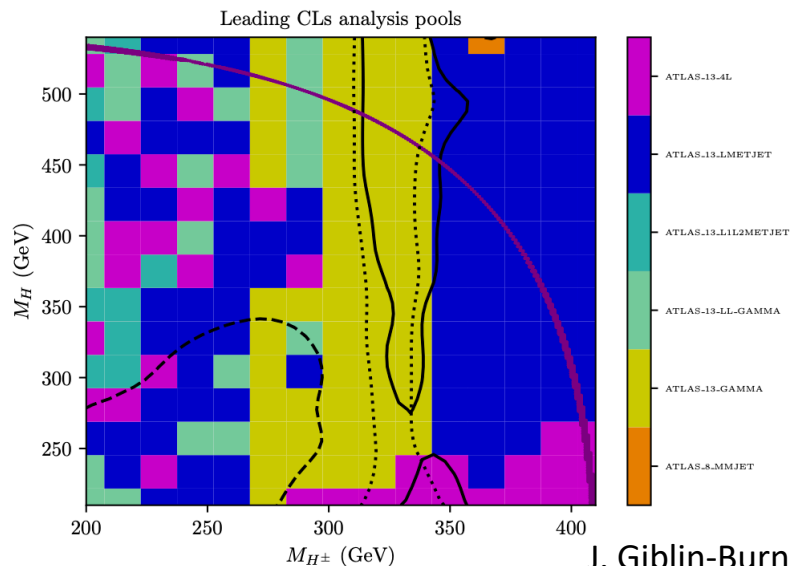


Sept. 2022
New data, use SM
predictions
(Rivet 3.1.6, Contur
2.4 candidate)

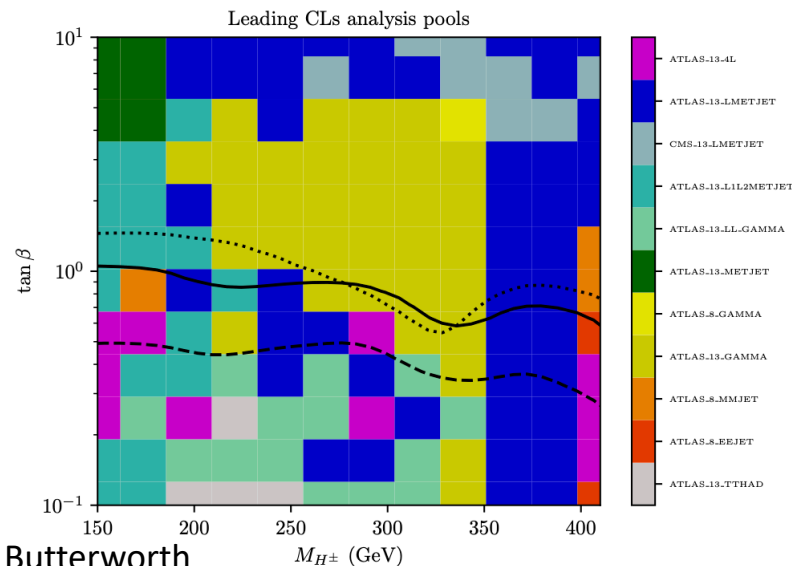
J. Giblin-Burnham, J. Butterworth

Gildner-Weinberg 2HDM

- New photon measurements (ATLAS_13_GAMMA) and four lepton (ATLAS_13_4L) analyses
- SM predictions for few dilepton+jets measurements not available in CONTUR



J. Giblin-Burnham, J. Butterworth



- [Contur 2.4.0 release notes](#) (aiming for release end of this month!)
 - Support pip/PyPI: `pip install contur` (M. Liu)
 - Emphasis on SM theory as background in `contur-plot` and uses YODA 1.9.6 with correlation bugfix (J. Butterworth)
 - Include covariance matrices from HEPData where possible (E. Butterworth)
 - Increase speed for plotting with results database (S. Mao)
 - Improved Madgraph5_aMC@NLO interface (S. Jeon)
 - Updated outputs to work with yodastream output for GAMBIT interface (T. Procter)

- CONTUR ORACLE: machine-learning assisted parameter scans (J. Rocamonde, L. Corpe, G. Zilgalvis, M. Avramidou & J. Butterworth)
 - Not viable to probe entire parameters space of BSM model in multidimensional scans
 - Most interested in the contour lines of 68% and 95% exclusion
 - Main idea: iterative training with partial CONTUR scans to predict exclusion status in parameter space, sample new points according to the outcome, repeat
 - >90% precision and <10% computing resources!
 - Details in [SciPost Phys. 13, 002 \(2022\)](#)
- To get started:
 - Local installation with `pip install` - instructions on the [Contur Gitlab page](#)
 - For CERN users; Rivet + CONTUR installation on LXPLUS
 - Docker container
 - [Mattermost channel](#)

- Updated and new limits on a wide range of BSM theories
 - Comparison with benchmark models from dedicated searches show added virtue of CONTUR!
- Ongoing technical developments to improve performance and user-friendliness
- There is always room for more!
 - Adding new measurements, SM predictions and correlations to library
 - Scrutinise new regions of parameter space