



Reinterpreting ML searches in Rivet: One example

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Overview

- ATLAS SUSY-2018-30 review
- Non-ML problems
 - B tagging
 - (reminder: these are often significant!)
- C&C analysis (for comparison)
- NN analysis

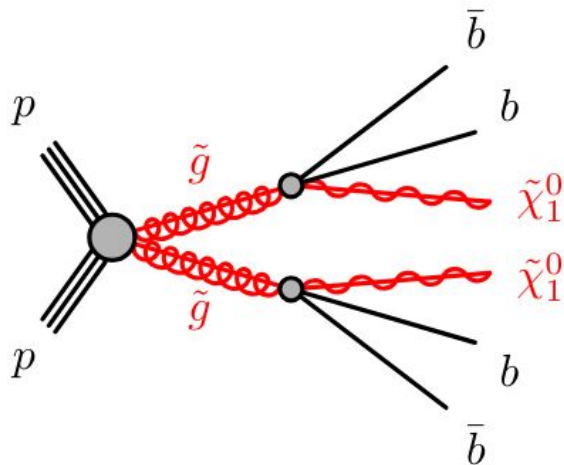
Reinterpreting ML with Rivet

- RivetONNXrt.h, RivetLWTNN.h headers provide classes for easy loading of NN files.
 - As easy as:

```
nn = getONNX(name());
```
 - ```
nn->compute(nn_input);
```
  - (though e.g. normalisation needs to be looked at per-analysis)
- **New! (from Rivet 4):** pluginONNX directory of ONNX dependent analyses
  - Not built by default.
  - Switched on at compile time with
  - Configure-time metadata retrieval (i.e. ONNX files are too big for our tarball)
  - So we can accept your ONNX dependent analyses from now!
- Also easy to add your own new networks to analyses for other games (c.f. e.g. my [talk](#) at IOP)

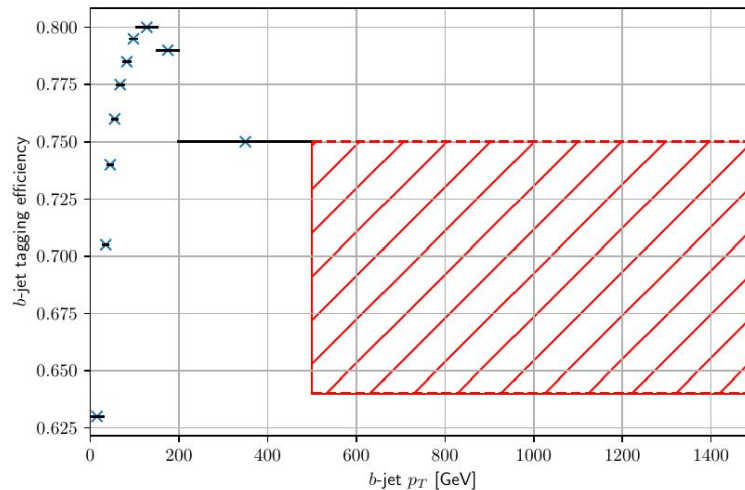
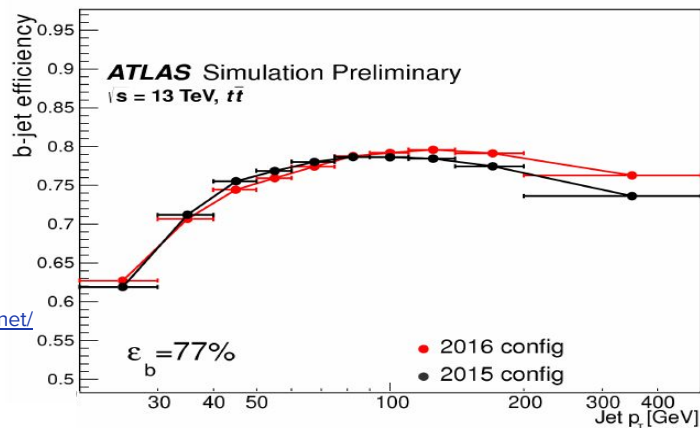
# ATLAS SUSY 2018 30 [\(2211.08028\)](#)

- ATLAS search for gluino pair production in multi- $b$  final states.
- A huge thanks to the analysis team for analysis team for all the available material:
  - Slha files
  - Cutflows
  - simpleAnalysis code
  - ONNX files (via simpleAnalysis)
- For the purposes of this talk, will focus on Gbb model
  - 4 NN SRs (based on parameterized mass points), 3 C&C SRs
  - Gtt performance very similar; Gtb (C&C only!) ~slightly less so.
  - Unless stated otherwise, all MC is Pythia 8.310  
(for easy comparison to Gambit)
- NN takes 87 parameters, primarily event kinematics
  - All quite easy to model.



# Problems other than ML: *b*-tagging

- SR's have minimum 3/4 b-tags
  - Combinatorics alone is going to make us sensitive.
- Improvements seen going to pT dependent efficiencies
- But... extrapolation values?!

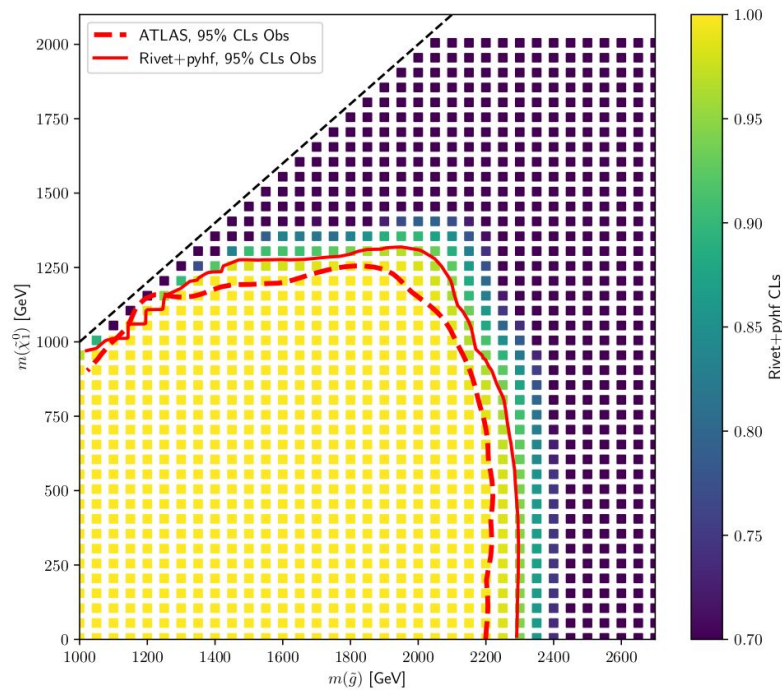


- Would be good to fix this for Run 3/GN2 etc!
  - (whether through surrogate taggers or better more parametrised efficiencies)

# CC-defined Regions

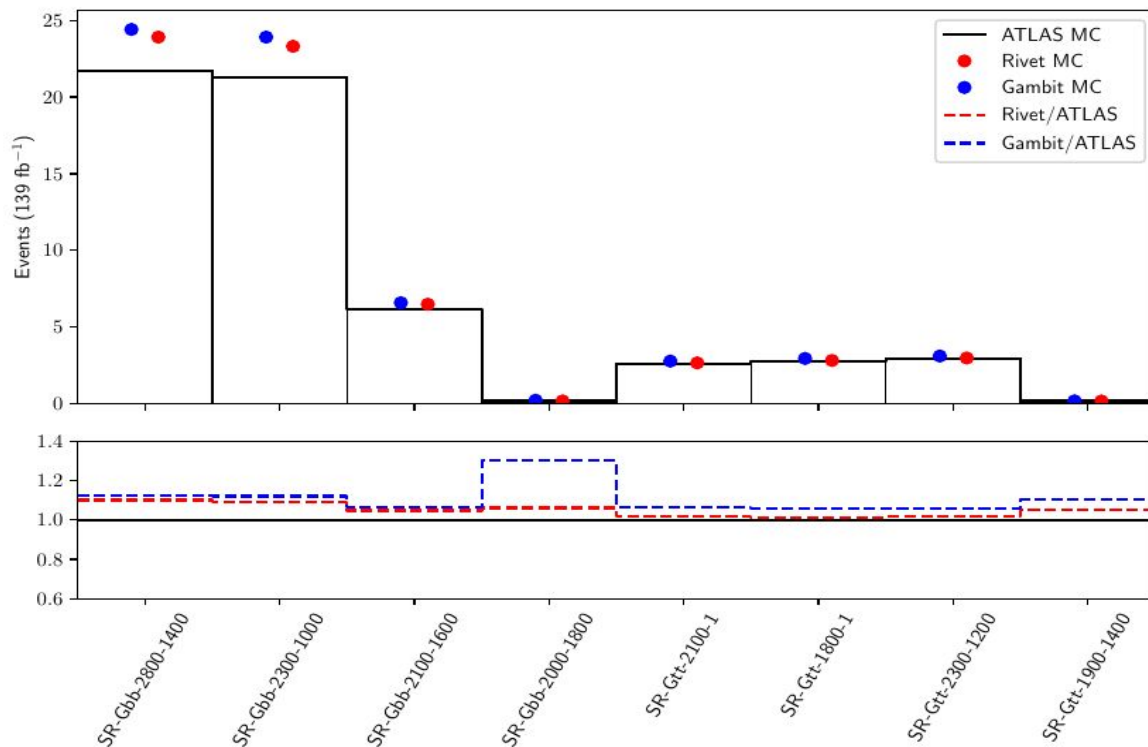
- Great cross-check
  - is ML to blame?
- Cutflow looks great
- Reinterpretation never deviates by  $> \sim 100\text{GeV}$ , less exclusionary in compressed region.

| Region   | Selection                                   | Paper (ATLAS) | RIVET | Paper (ATLAS) % | RIVET % |
|----------|---------------------------------------------|---------------|-------|-----------------|---------|
| Common   | $N_{\text{lep,base}} = 0$                   | 80.0          | 83.7* | -               | -       |
|          | $\Delta\phi_{\text{min}}^{4j} \geq 4$       | 61.1          | 63.8  | 76%             | 76%*    |
|          | $m_{T,\text{min}}^{b\text{-jets}} \geq 130$ | 59.4          | 1.4   | 93%             | 93%     |
| SR-Gbb-B | $E_T^{\text{miss}} \geq 550$                | 35.69         | 37.5  | 63%             | 63%*    |
|          | $p_T^{\text{jet}} \geq 65$                  | 37.5          | 1.7   | 100%            | 100%*   |
|          | $m_{\text{eff}} \geq 2600$                  | 10.13         | 12.5  | 28%             | 33%     |
| SR-Gbb-M | $E_T^{\text{miss}} \geq 550$                | 35.69         | 37.5  | 63%             | 63%*    |
|          | $m_{\text{eff}} \geq 2000$                  | 28.30         | 30.2  | 79%             | 80%     |
| SR-Gbb-C | $E_T^{\text{miss}} \geq 550 \dagger$        | 35.69         | 37.5  | 63%             | 63%*    |
|          | $m_{\text{eff}} \geq 1600 \dagger$          | 34.71         | 36.6  | 97%             | 97%     |



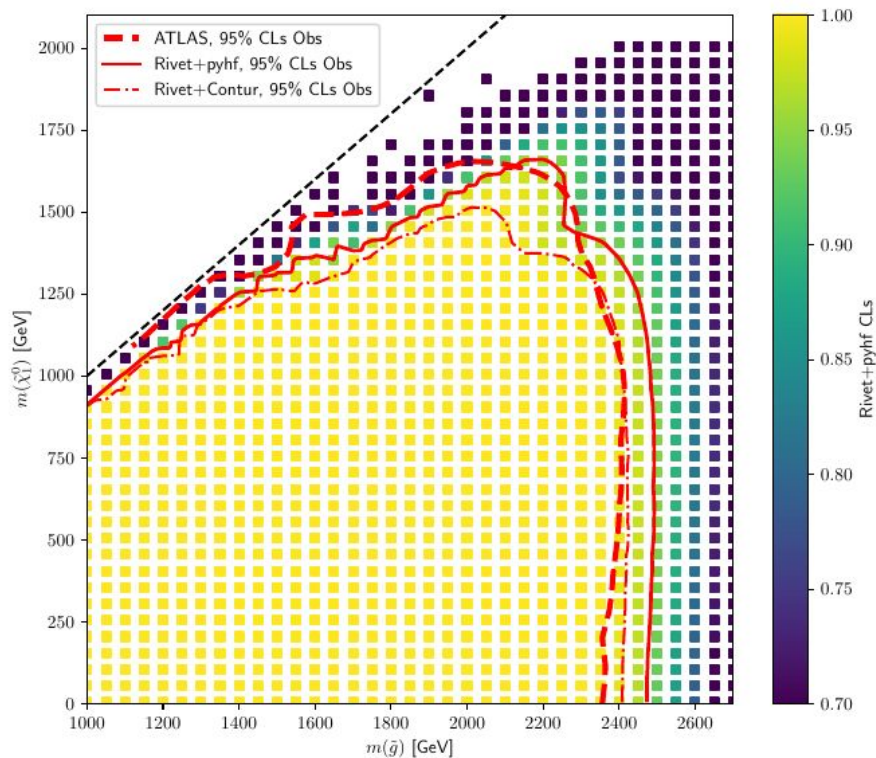
# ML-defined Regions - final counts:

ATLAS-SUSY-2018-30 Neural Net SRs: Atlas vs Rivet and Gambit



# ML-defined Regions - exclusion conto(u)rs

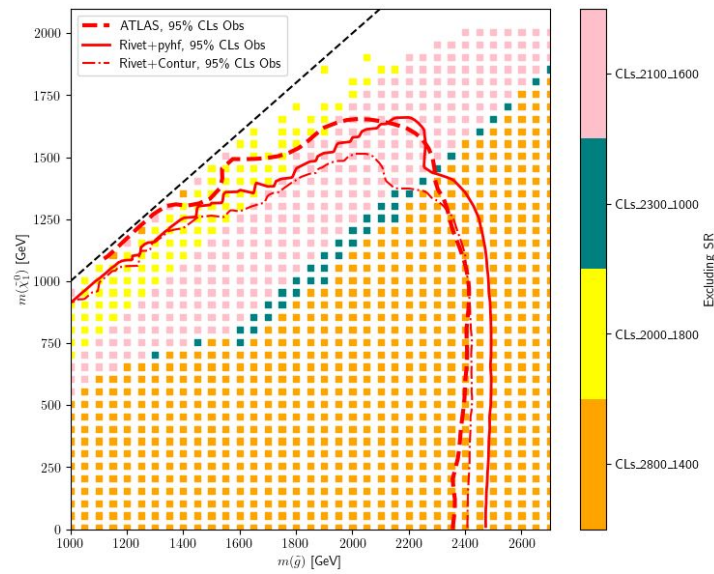
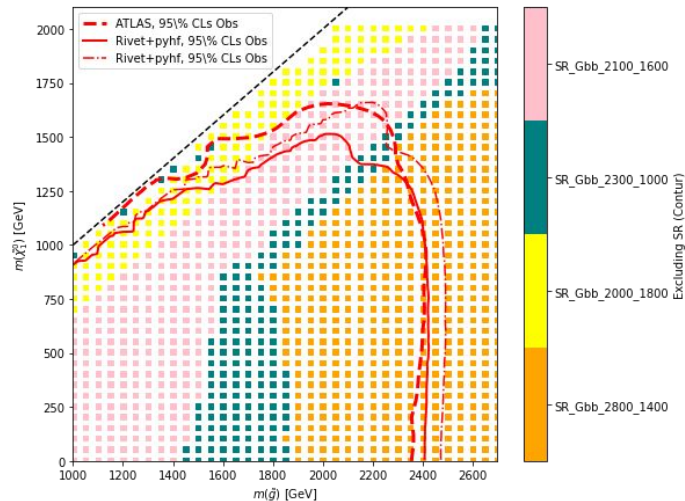
- Typically within 100 GeV.
- Under-exclusion in boosted region:
  - This was pythia internal SUSY with 2->2 only; ATLAS was mg5aMC including up to 2 extra partons.
  - Would like to do an mg5 test.
- Curious “dent” at  $\sim(2200,1300)$ 
  - See next slide
- Contur implementation slightly less exclusionary than pyhf
  - N.b. no regions combination in pyhf
  - Maybe likelihoods are just complex?
  - Different CLs definitions
  - Some errors were ambiguous?
  - I would like to try Spey, too...





# ML-defined Regions

- Curious “dent” at  $\sim(2200,1300)$ 
  -
- Less relative constraint from the 2100-1000 CR
- True using both pyhf and contour.
- Not seen in cutflows, but they’re only at one param point.



# Conclusion, next steps

- This can work!
- Added to both Rivet and Gambit - will be producing useful physics results!
- Let's keep getting analyses like this from the experiments.
  - Run 3 taggers implemented in our ONNX/lwttn interfaces?
- To re-echo the [LH guidelines](#)
  - Units and conventions!!!
  - Unified approach on where networks and metadata live - especially as they get more complex  
(Talks this afternoon about HEPData?)