



Recent Results from ATLAS

Chris Meyer on behalf of the ATLAS Collaboration



- Wide range of open questions in high-energy physics:
 - What is the origin of dark matter / dark energy?
 - Why is the Higgs boson mass 125 GeV?
 - Is there a quantum theory of gravity?
- Many solutions that answer some or all of these questions:
 - Supersymmetry
 - Leptoquarks
 - Etc.
- How can we go about investigating the various choices?

Large Hadron Collider @ CERN



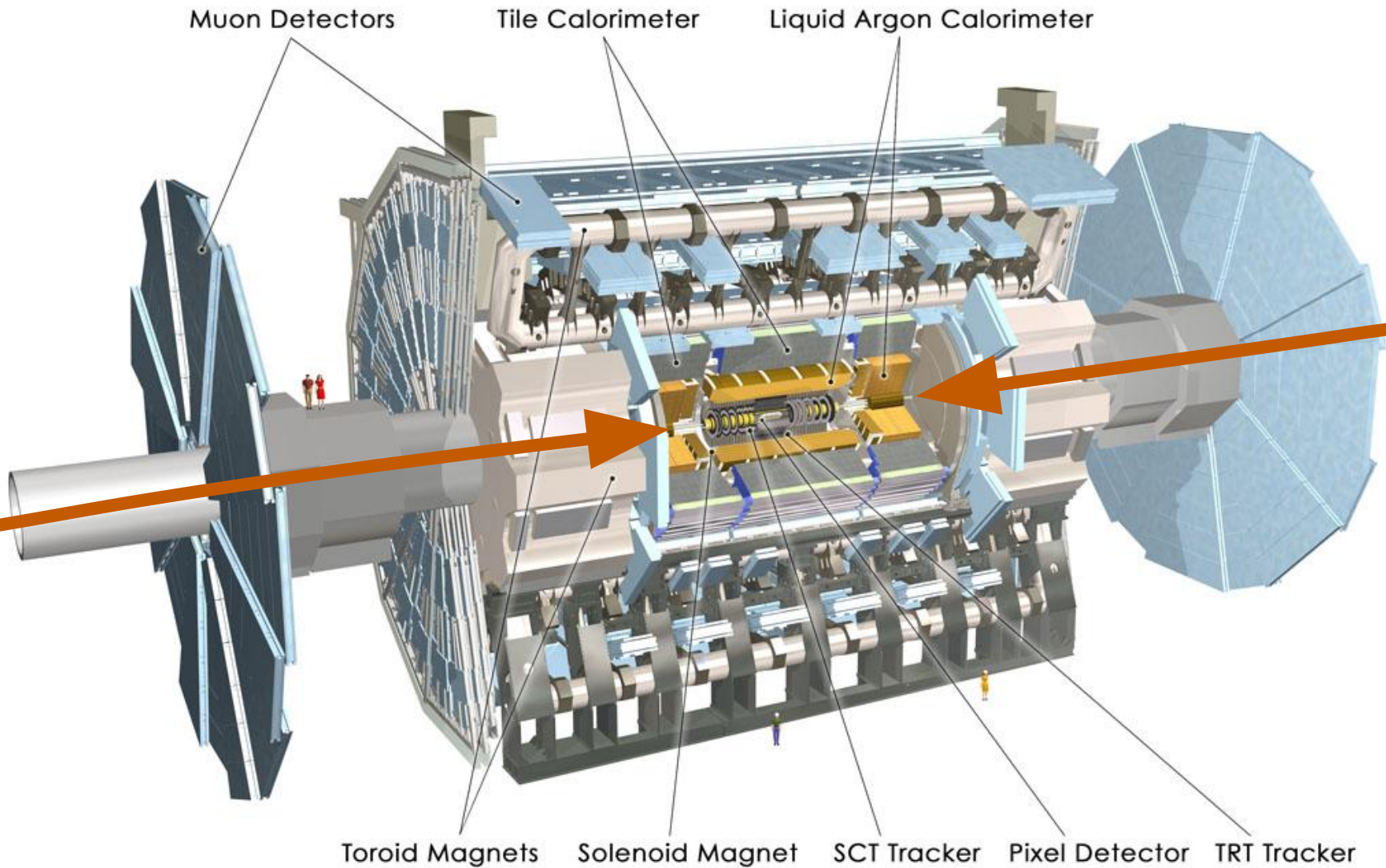
27 km in diameter

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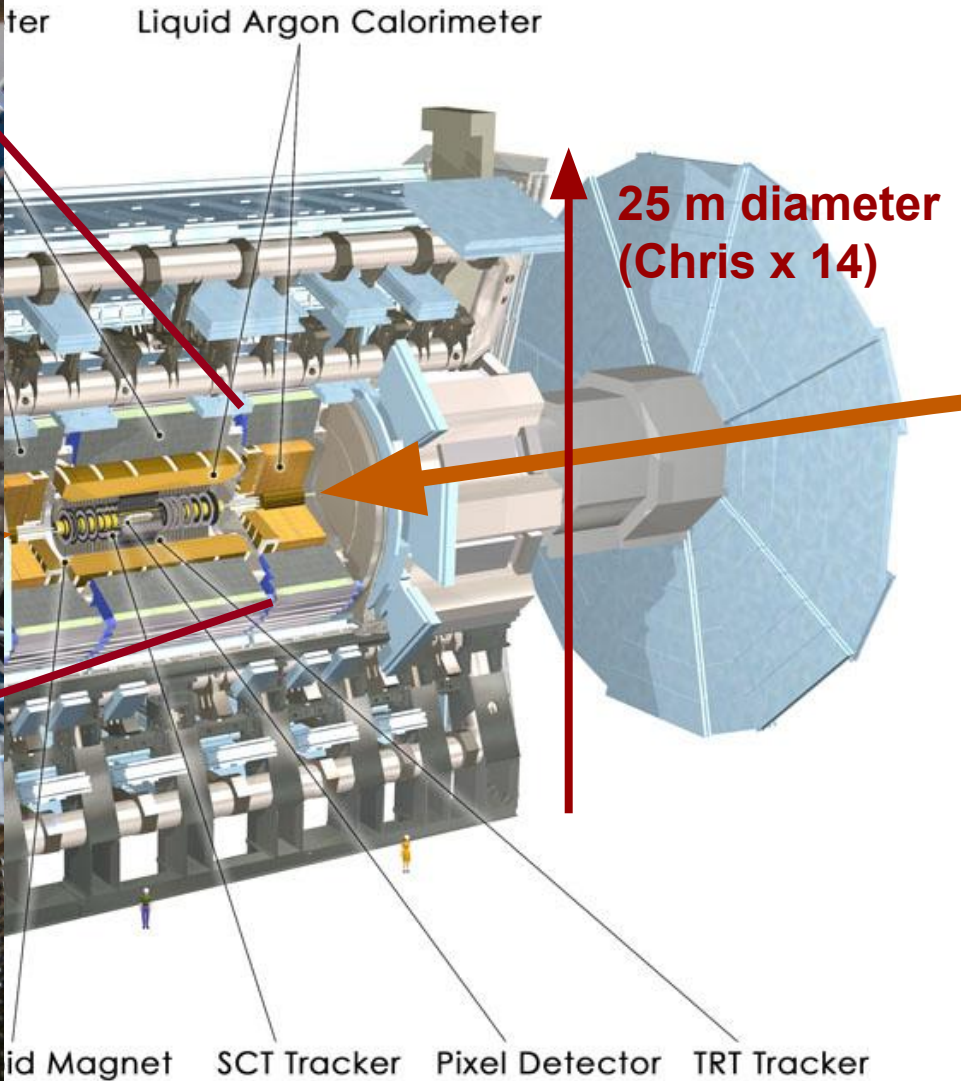
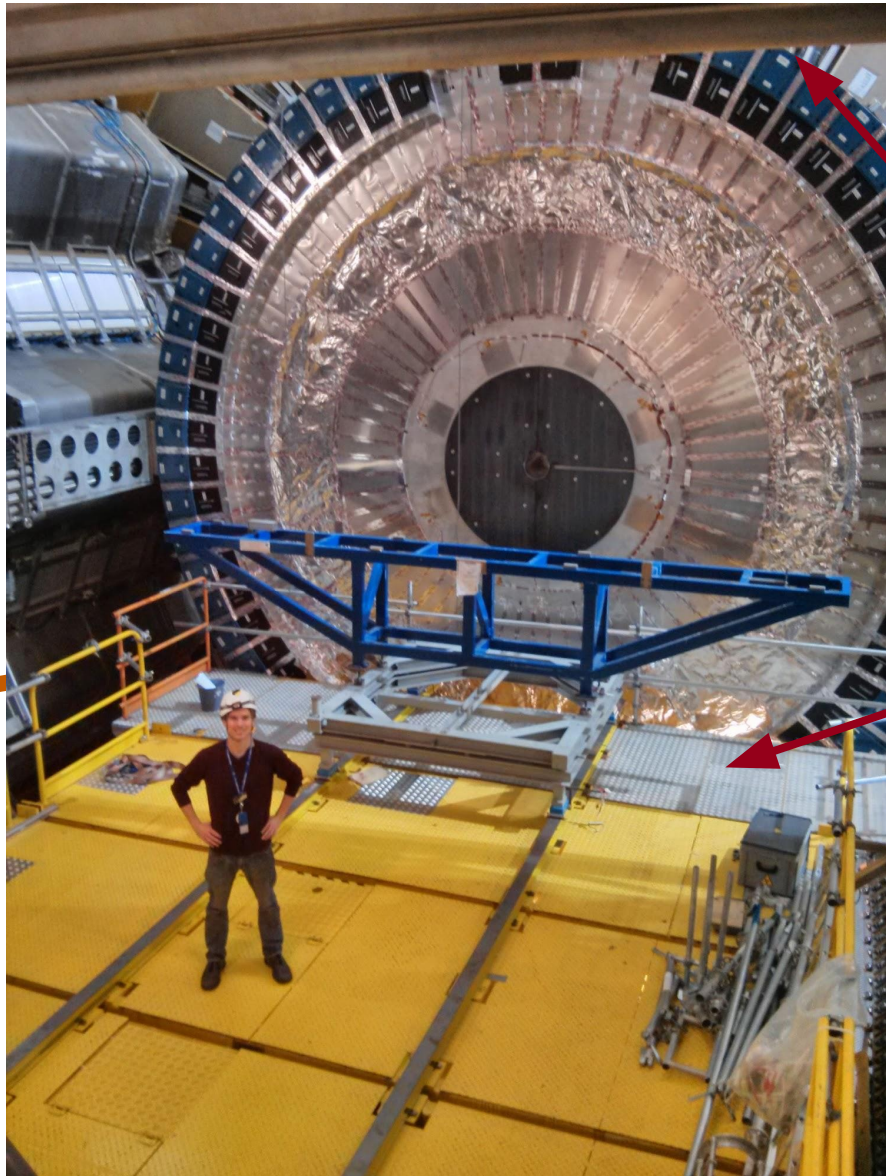


ATLAS Detector





ATLAS Detector



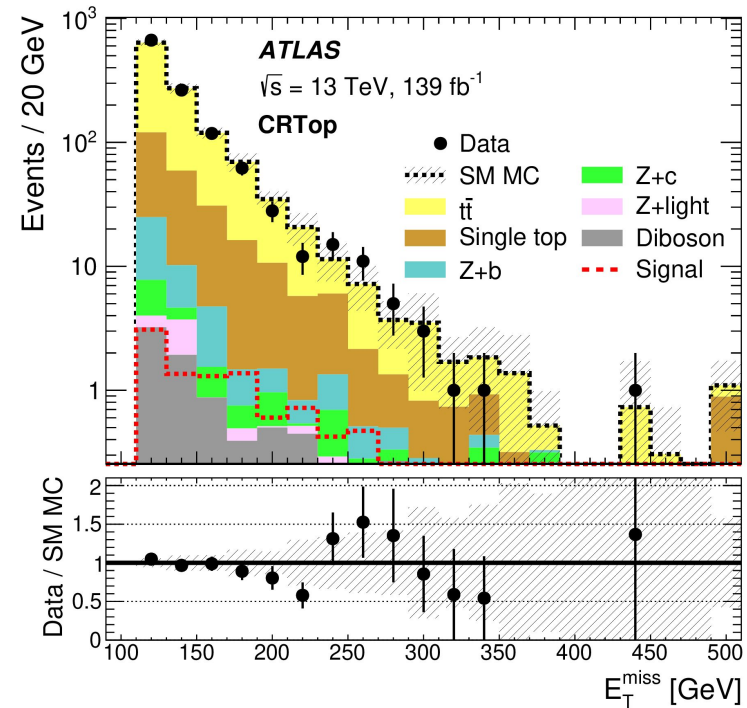
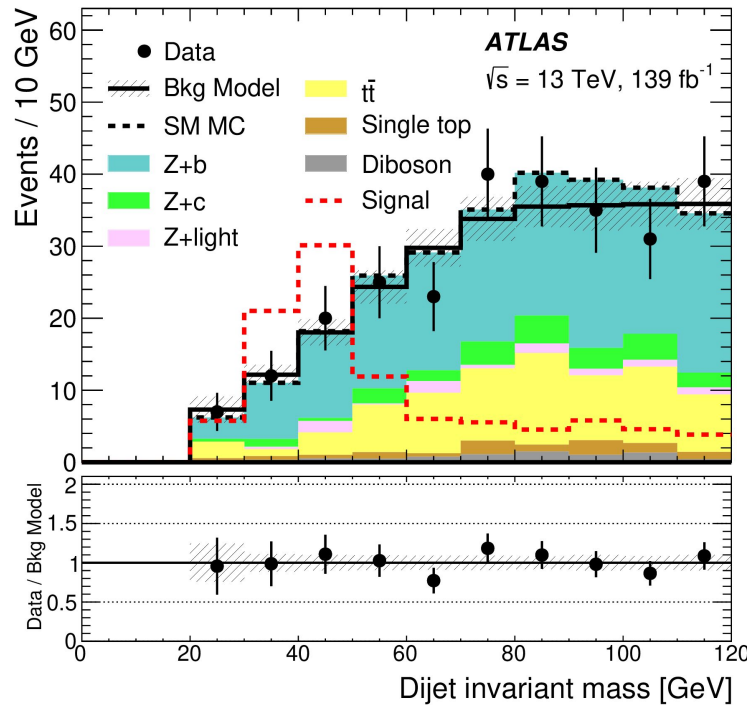
Higgs Boson Techniques

We developed all these cool techniques to find it, seems a waste not to use them...



Higgs \rightarrow Neutralinos \rightarrow bb + missing energy

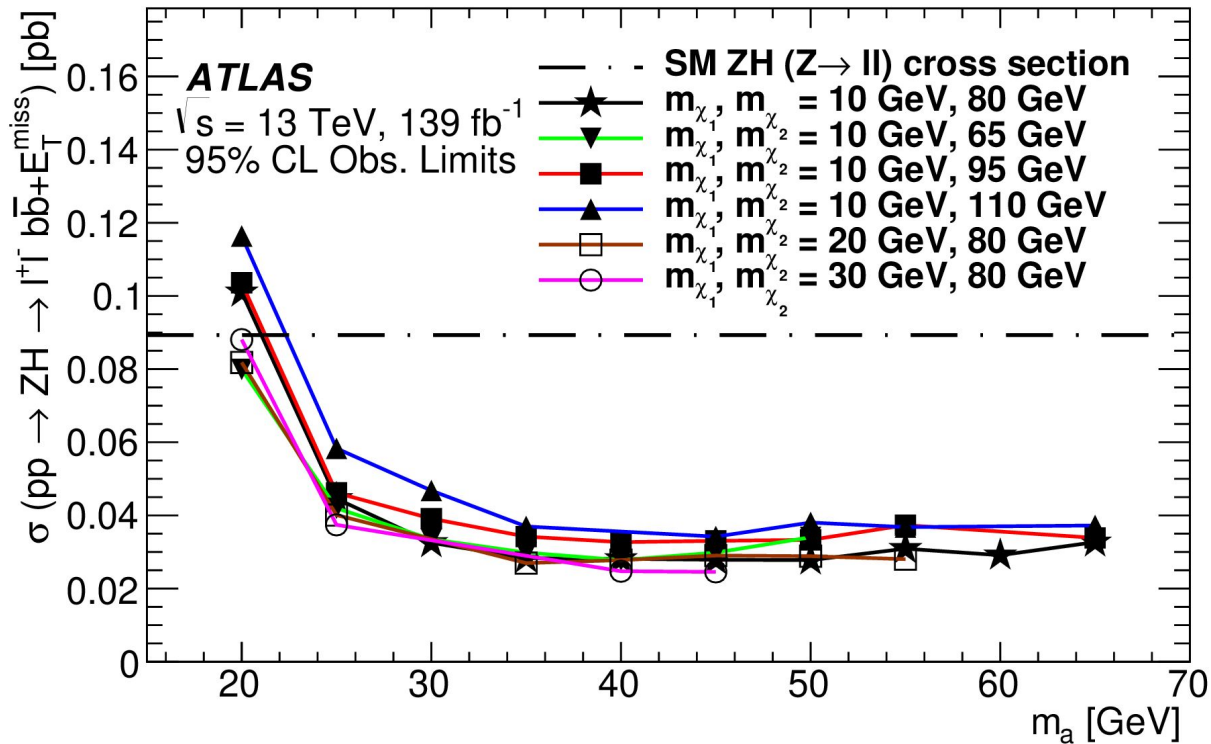
- Use ZH events to probe: $H \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^0 \rightarrow a \tilde{\chi}_1^0 \tilde{\chi}_1^0 \rightarrow b\bar{b} \tilde{\chi}_1^0 \tilde{\chi}_1^0$
 - a is a light pseudoscalar Higgs boson
 - $\tilde{\chi}_{1,2}^0$ are the two lightest neutralinos





Higgs \rightarrow Neutralinos \rightarrow $bb +$ missing energy

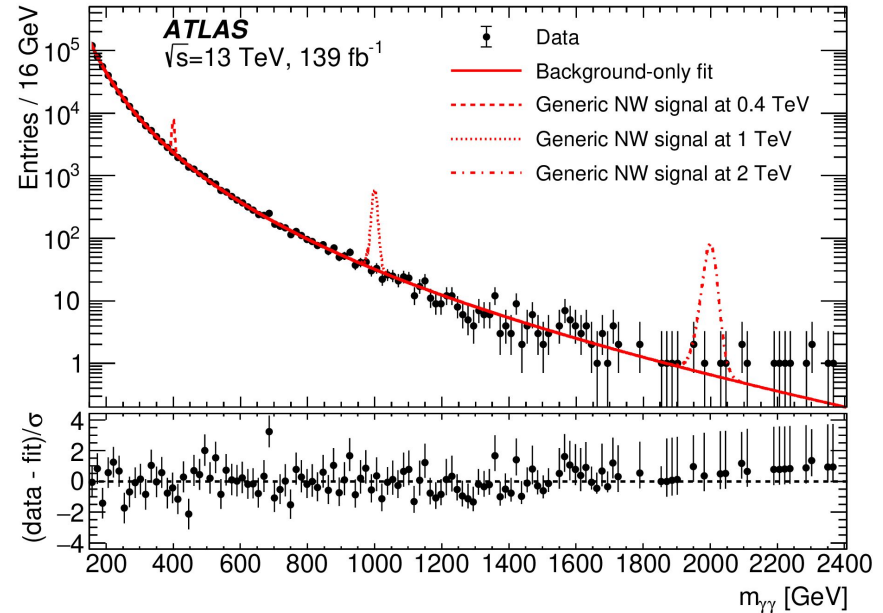
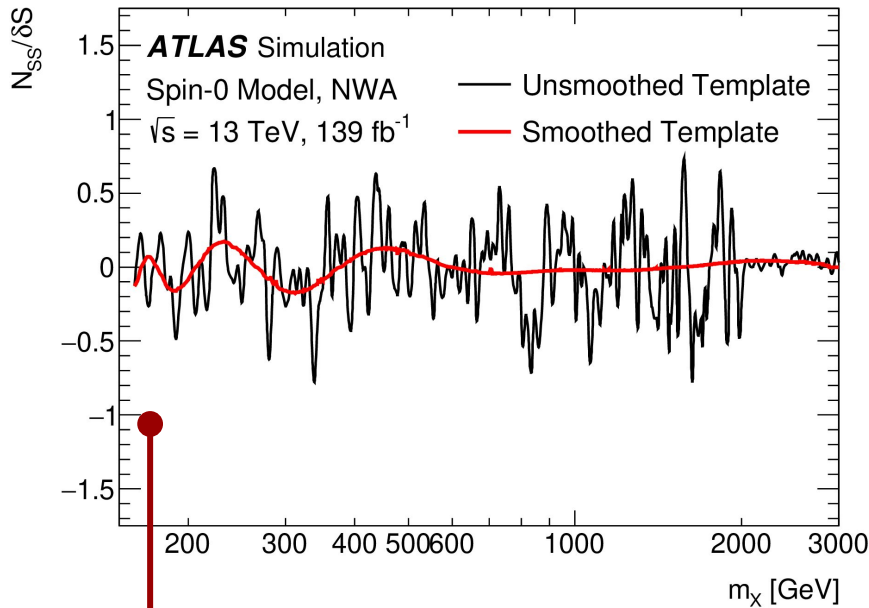
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“Higgs-like boson” $\rightarrow \gamma\gamma$

- Bump hunt for new spin-0 / spin-2 particle \rightarrow two photons
- No Higgs Boson; uses techniques pioneered by 125 GeV analysis

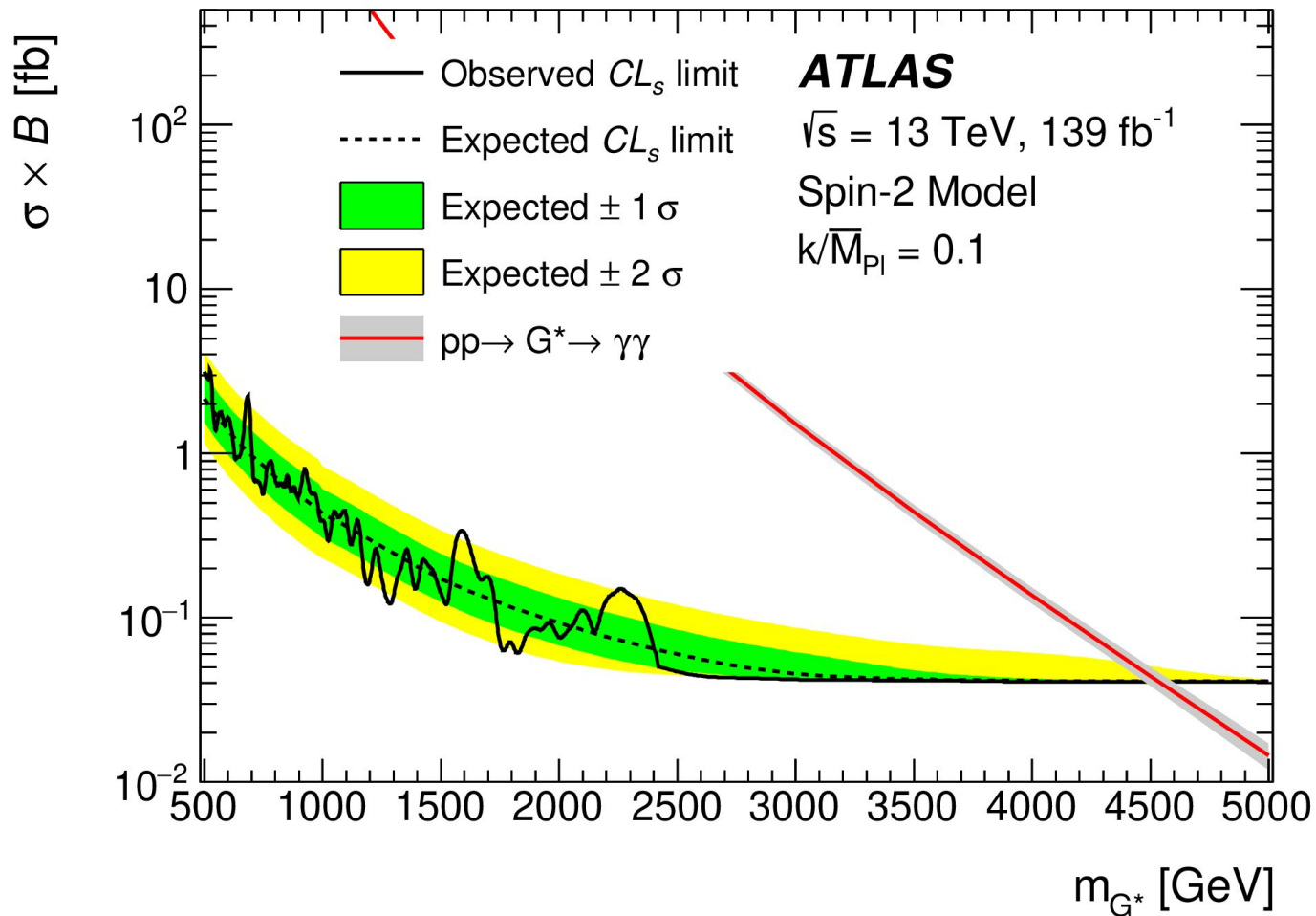


- Fake signal due to using analytic function for background
- Gaussian Process smoothing greatly reduces uncertainty



“Higgs-like boson” $\rightarrow \gamma\gamma$

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Englert and Higgs discussing the merits of their favorite boson decaying to **two b-quarks** vs. **two photons**



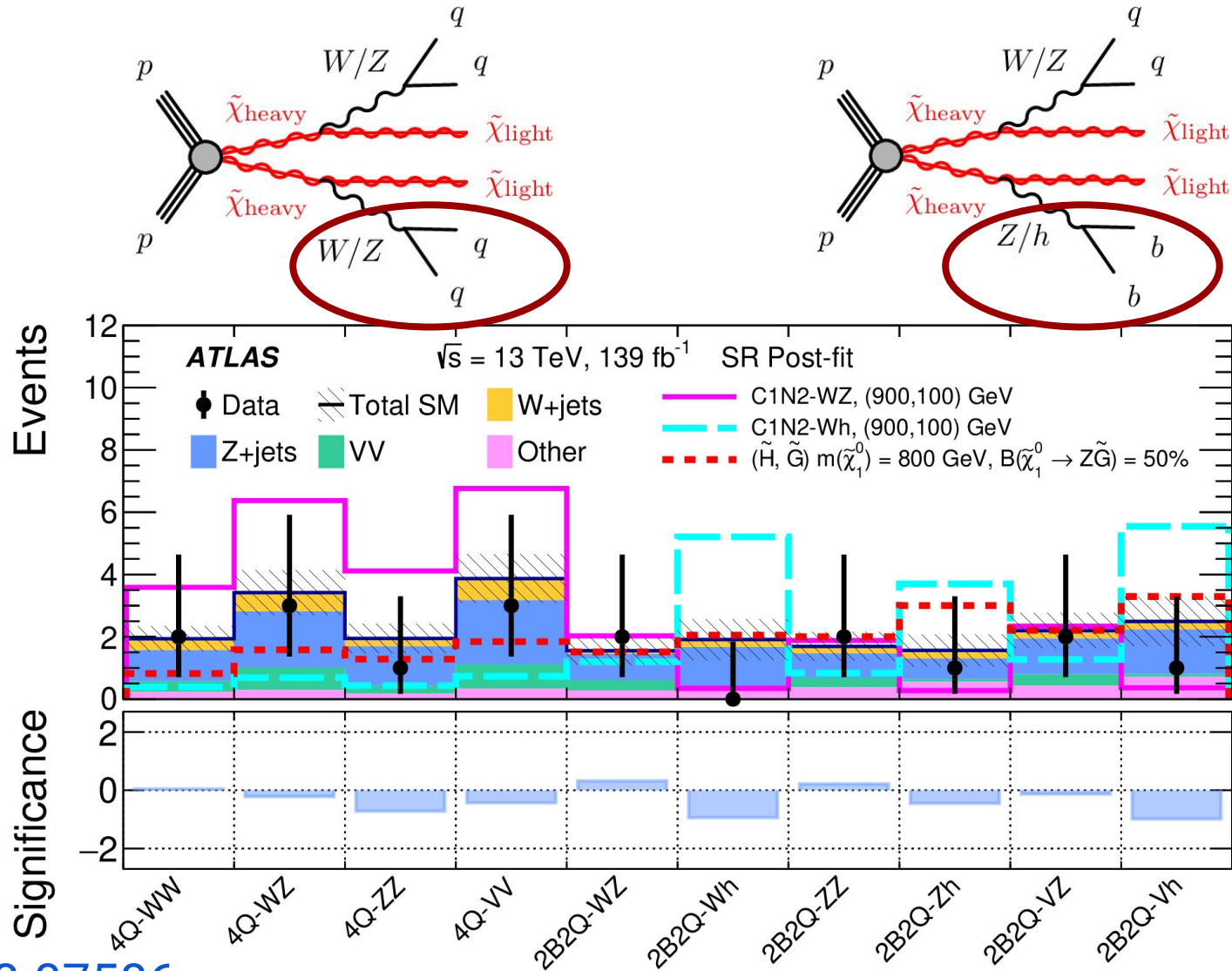
Supersymmetry

What is physics without symmetry? And for good measure, let's keep using the Higgs boson as a probe...



Charginos and neutralinos in diboson events

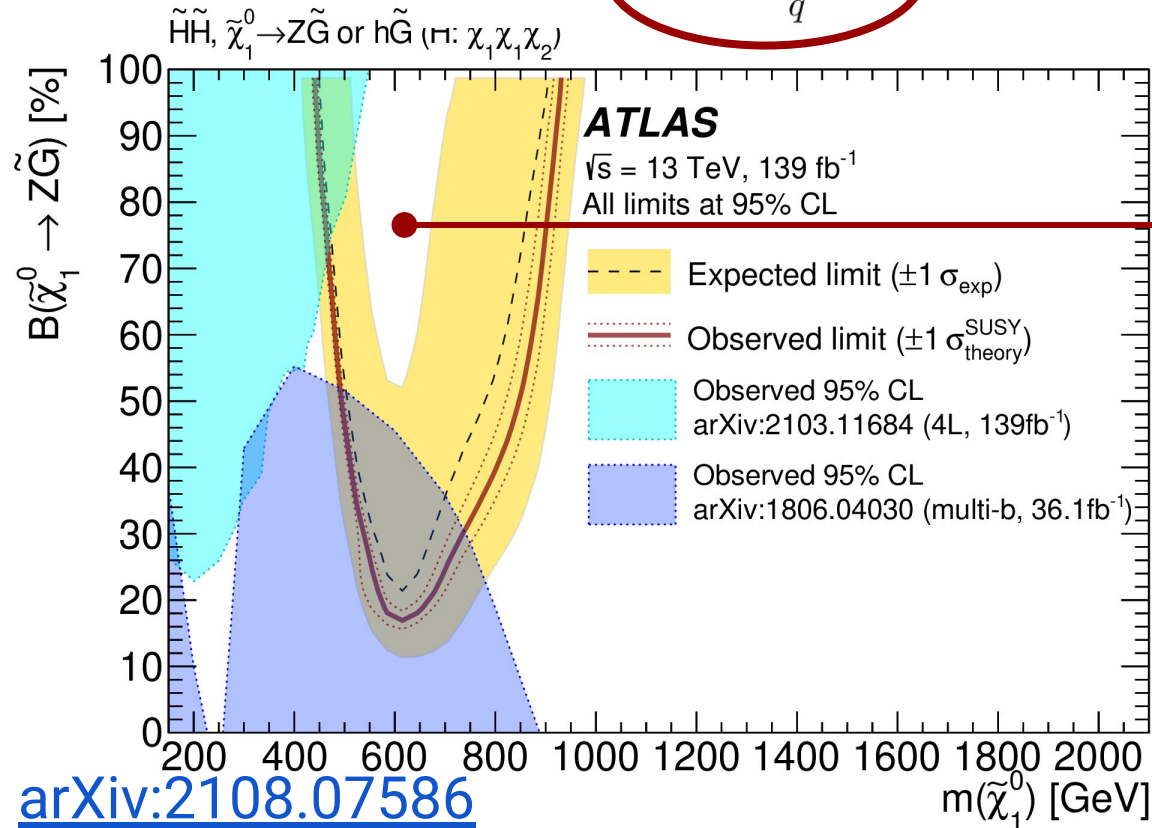
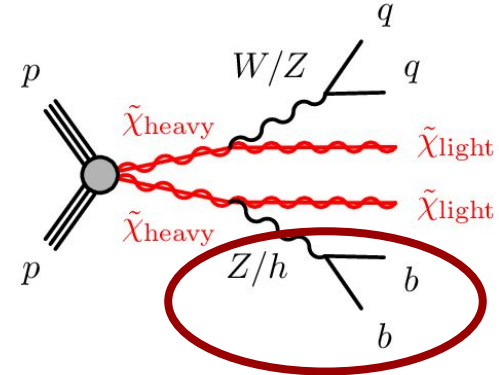
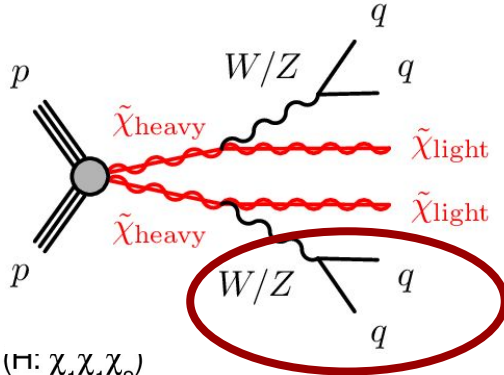
- Searching 4-quark (from two bosons) events





Charginos and neutralinos in diboson events

- Searching 4-quark (from two bosons) events

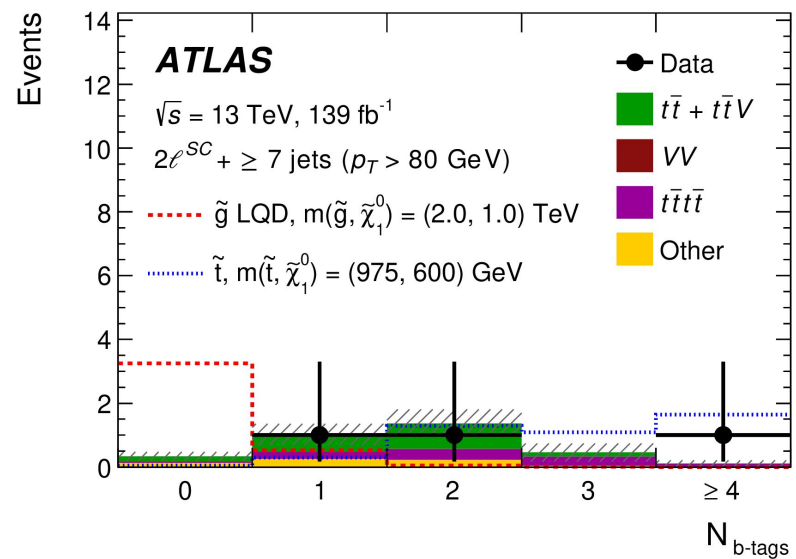
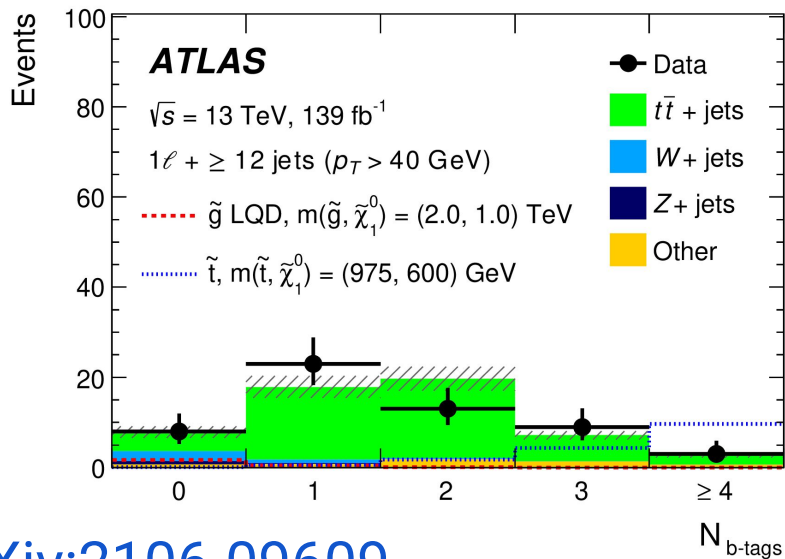
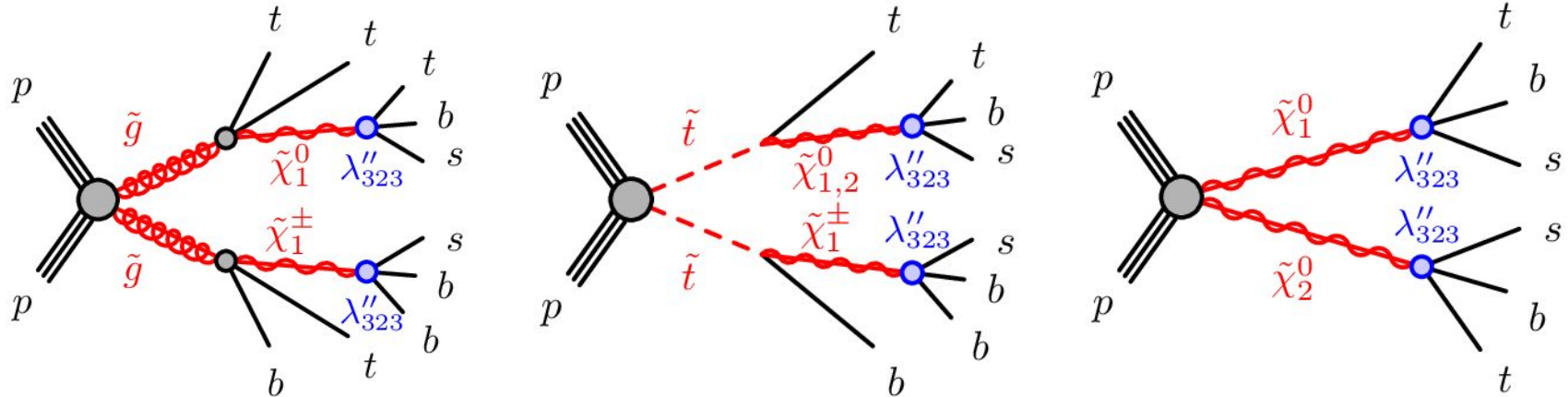


Excludes orthogonal phase space



R-parity violating supersymmetry

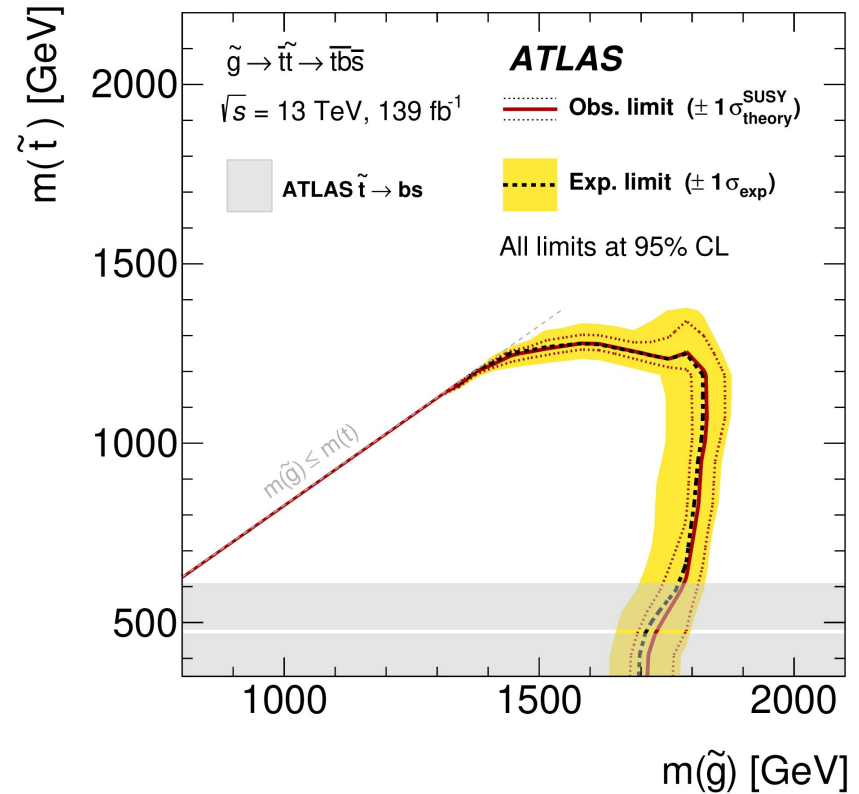
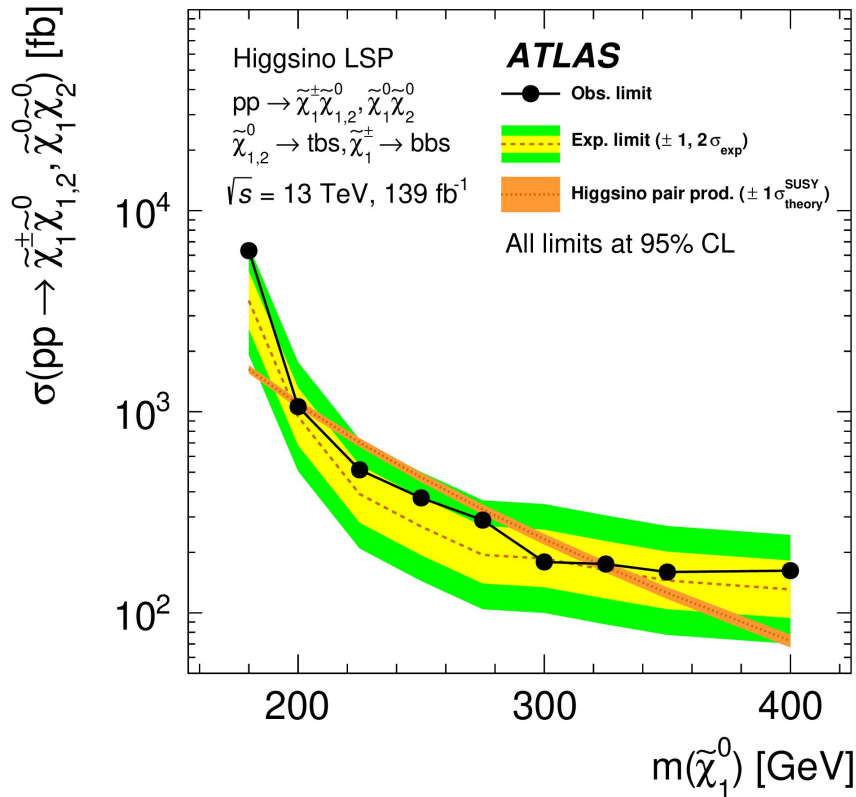
- Exploit events with high multiplicity of jets





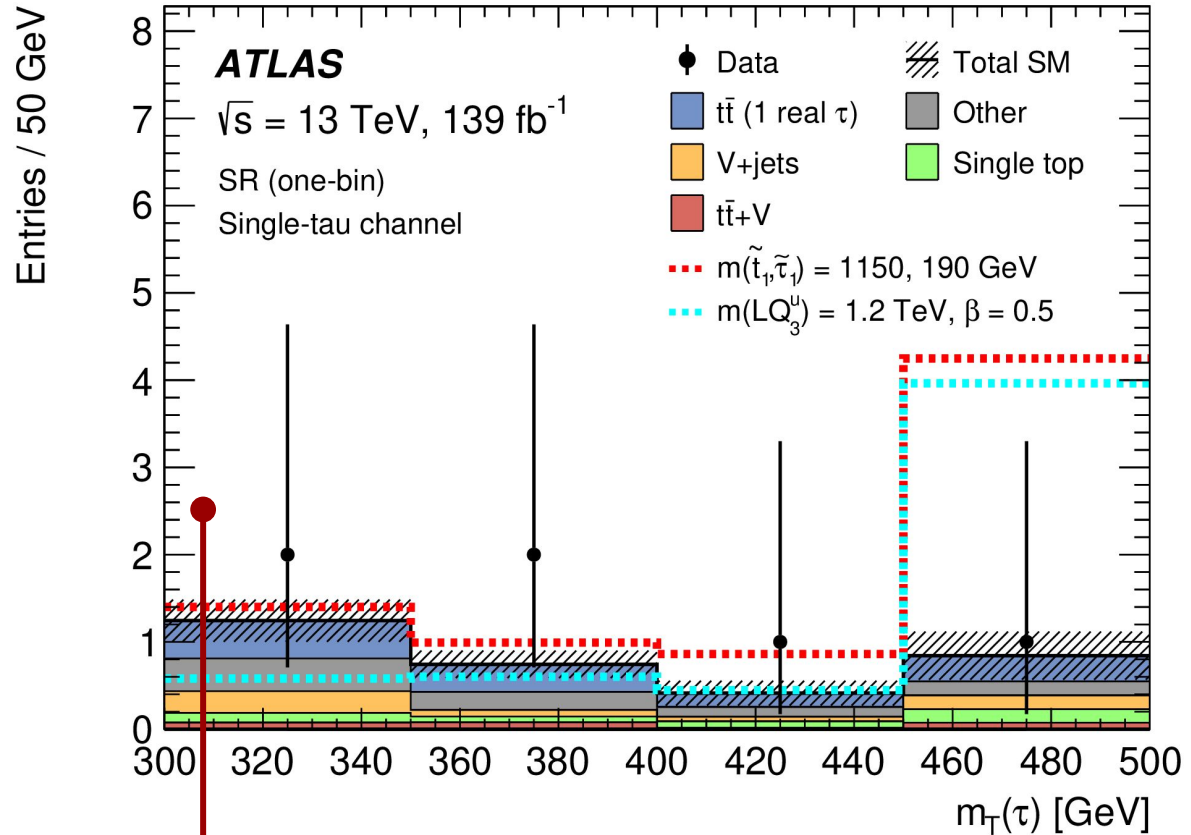
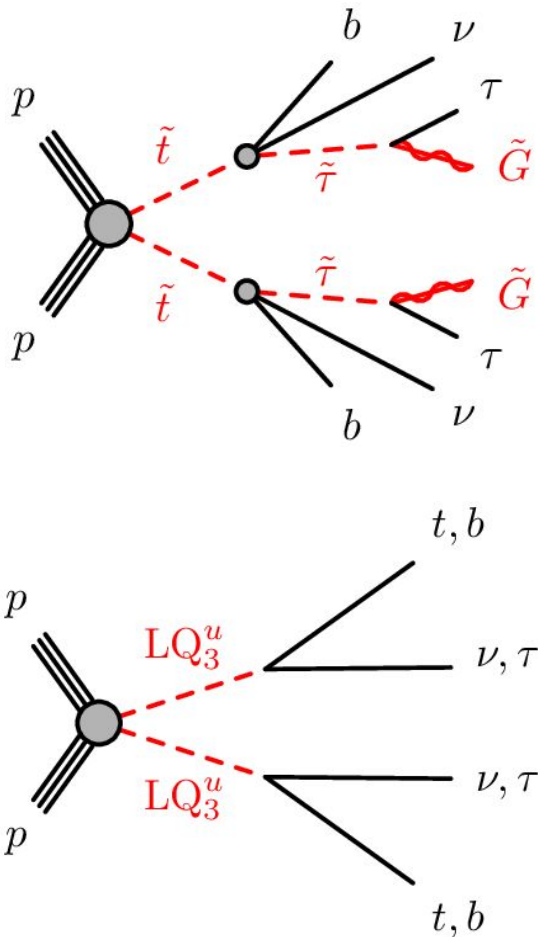
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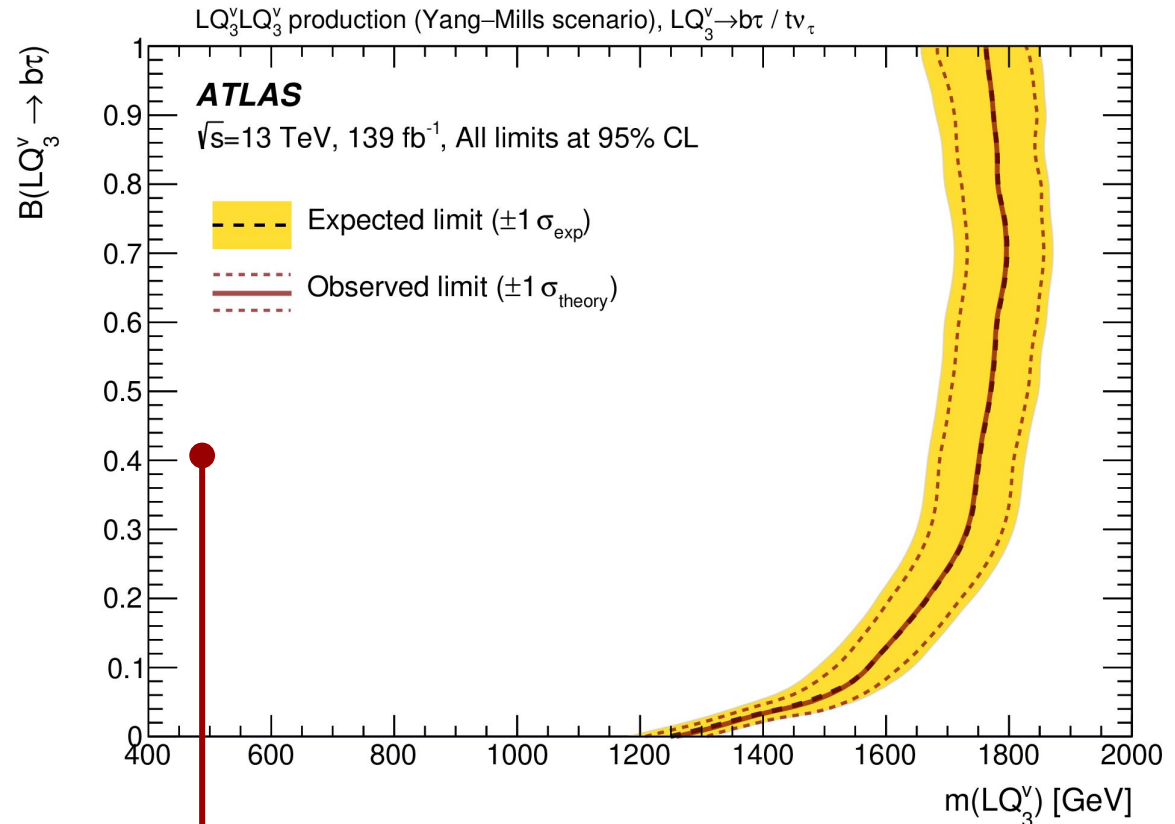
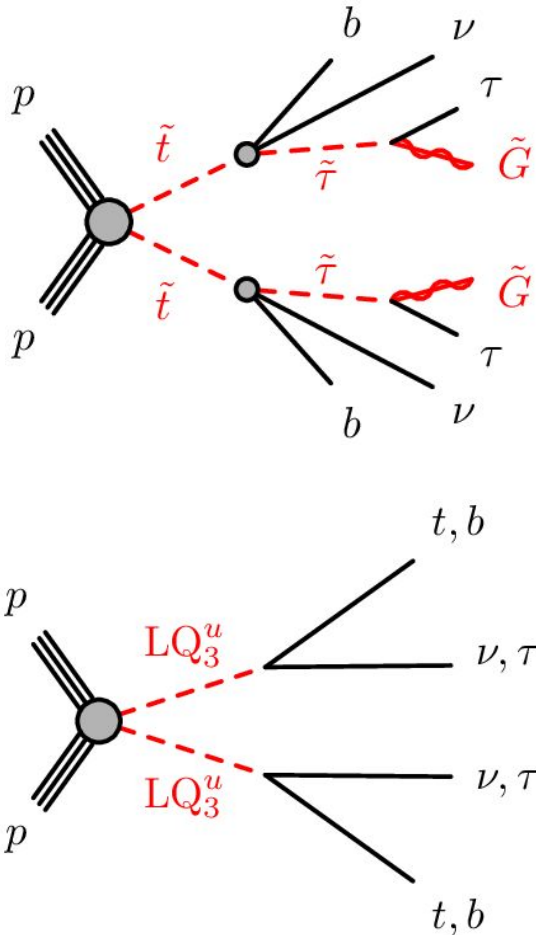
- First time since LEP that we've reached this level of sensitivity for EWKino production in models with RPV fully-hadronic couplings

- General search using hadronically decaying tau leptons



- One of many search regions
- Unfortunately without excess

- General search using hadronically decaying tau leptons



Limits on $LQ^V \rightarrow b\tau$, a possible explanation for B-physics anomalies

More Exotic Ideas

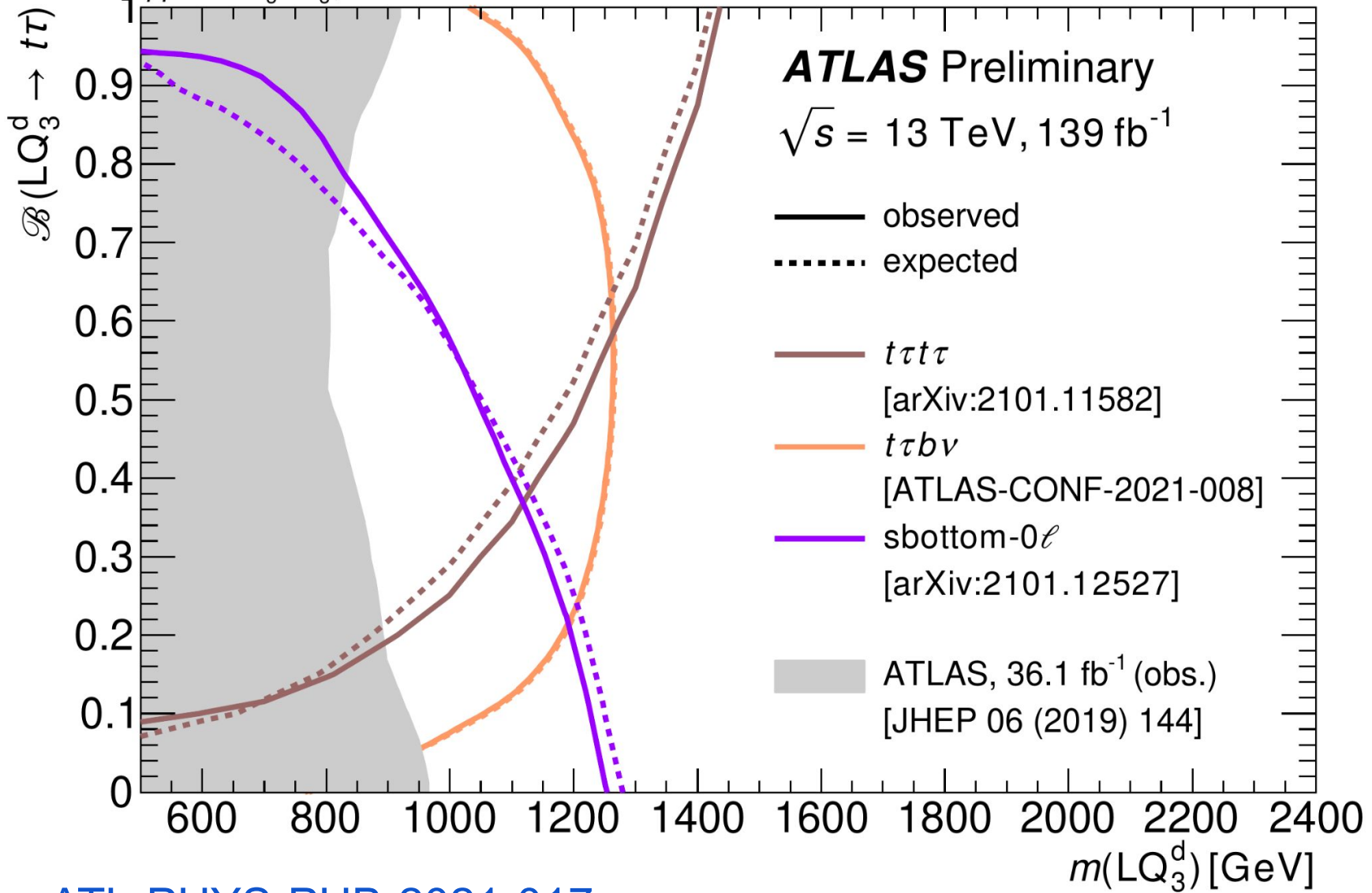
Add some spice to your searches



Combined limits on leptoquarks

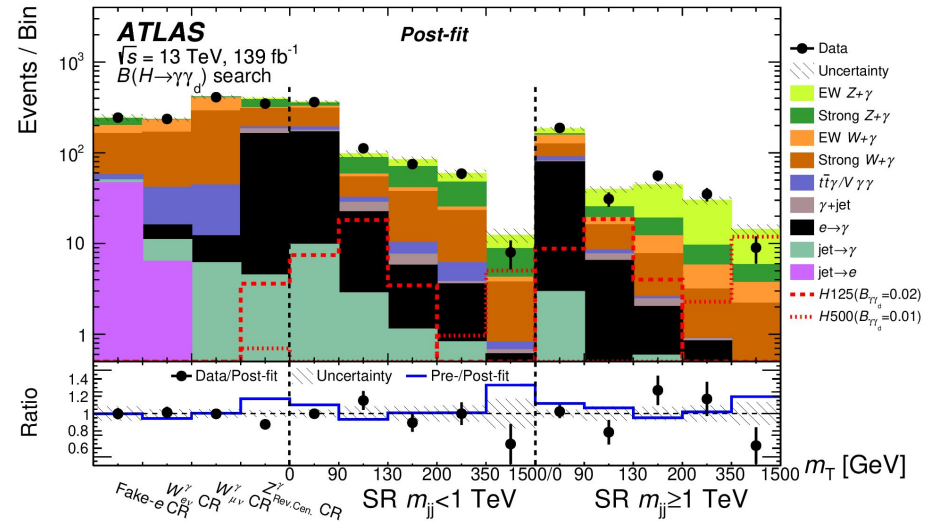
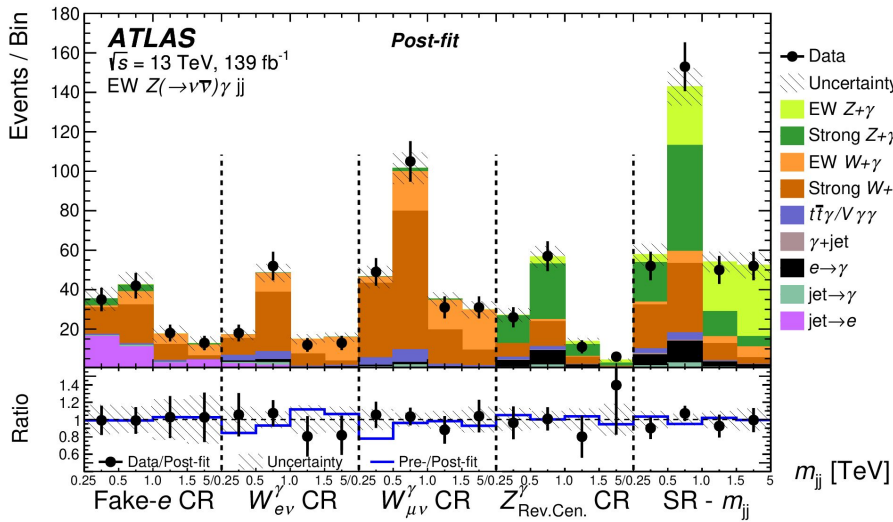
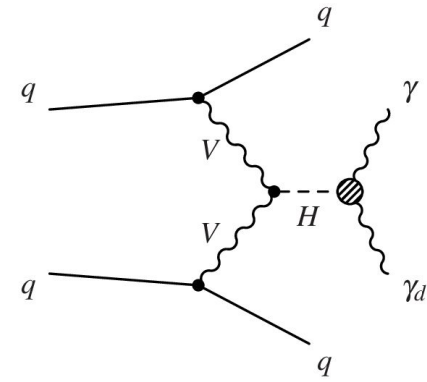
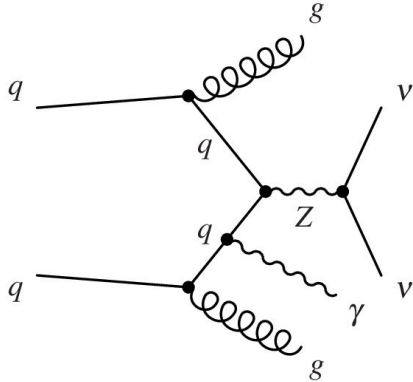
$pp \rightarrow LQ_3^d LQ_3^d$, all contours at 95 % confidence level

June 2021



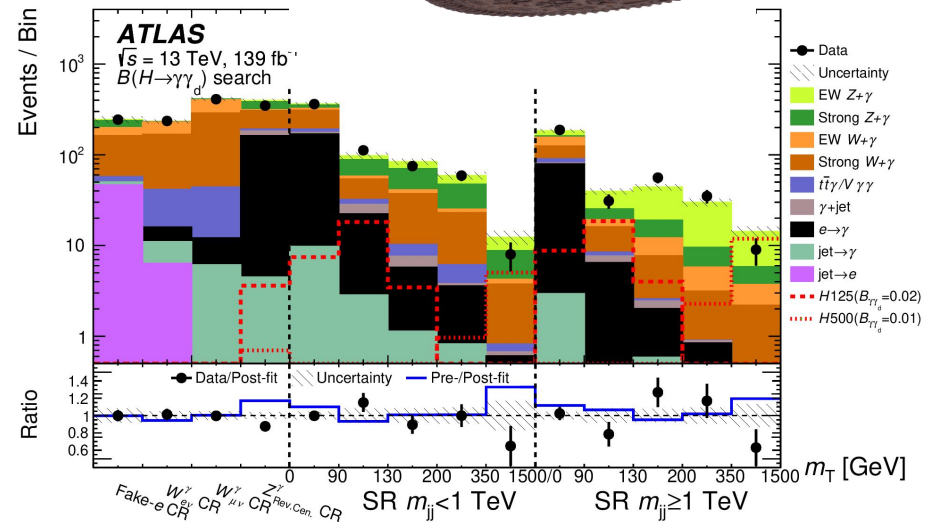
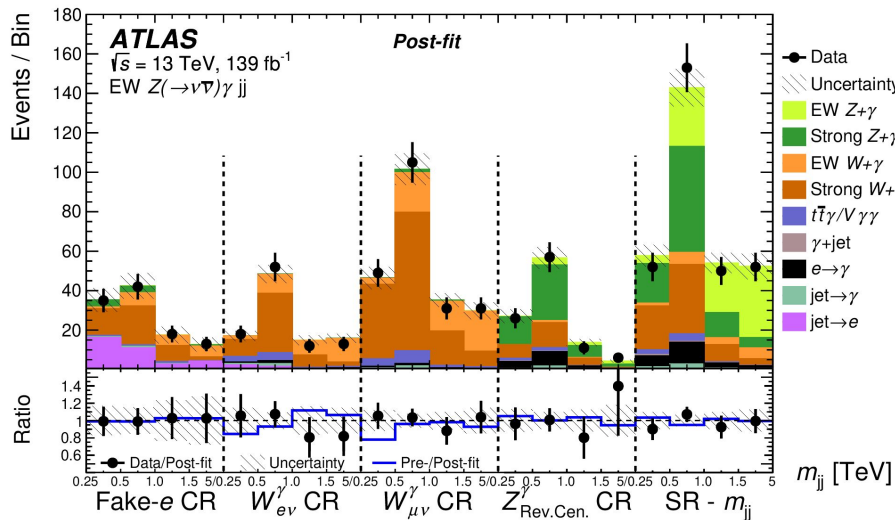
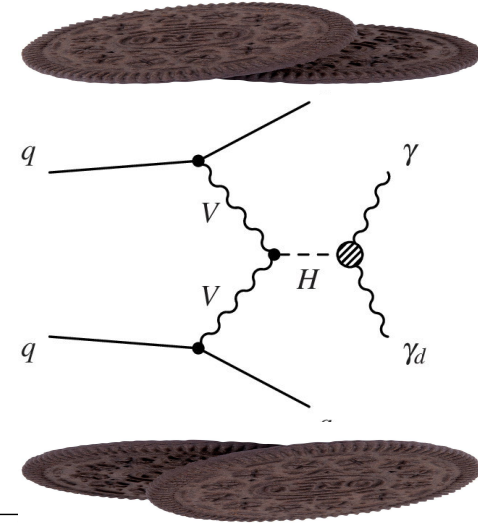
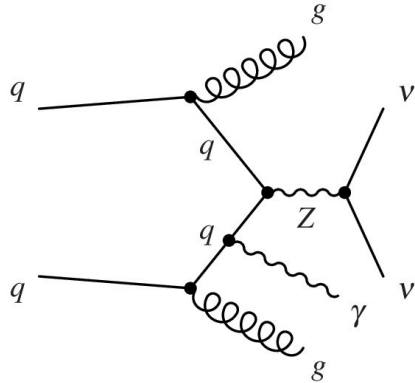
VBF-like signature with photons + missing energy

- Two forward-backward jets with new physics in the middle



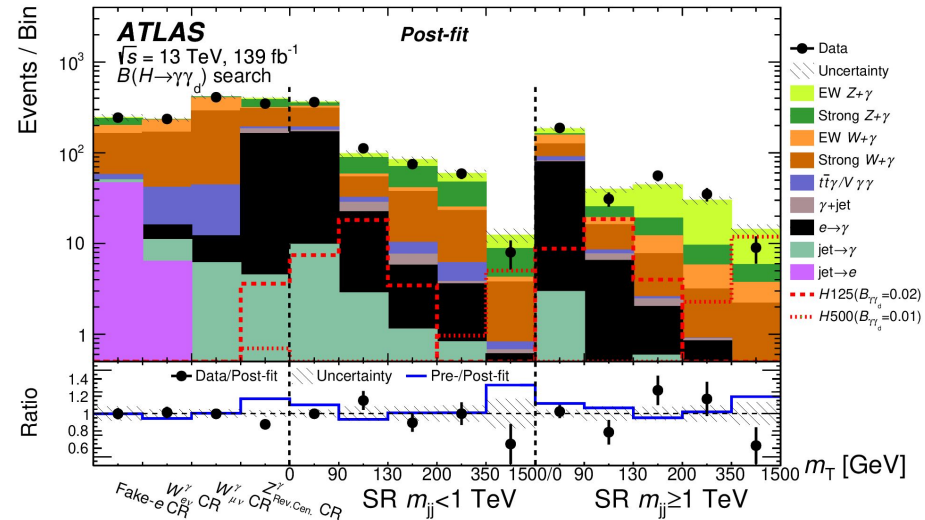
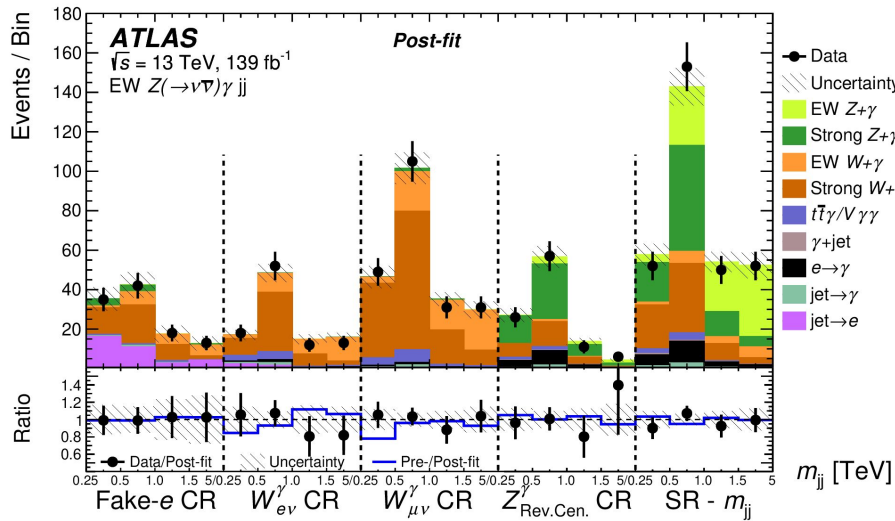
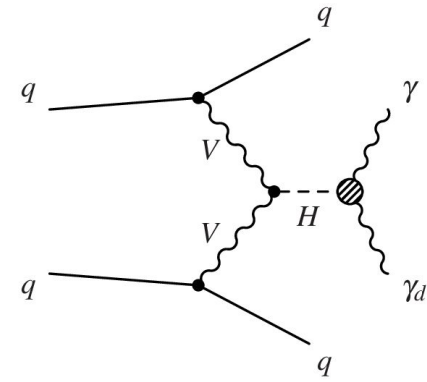
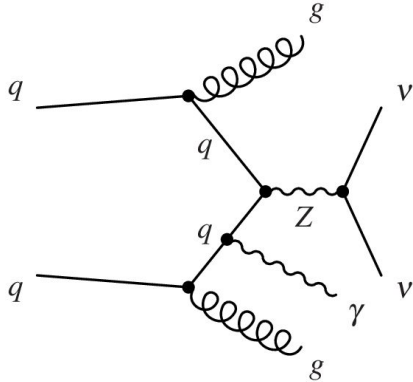
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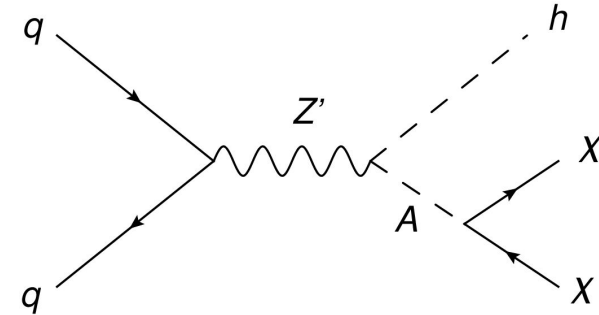
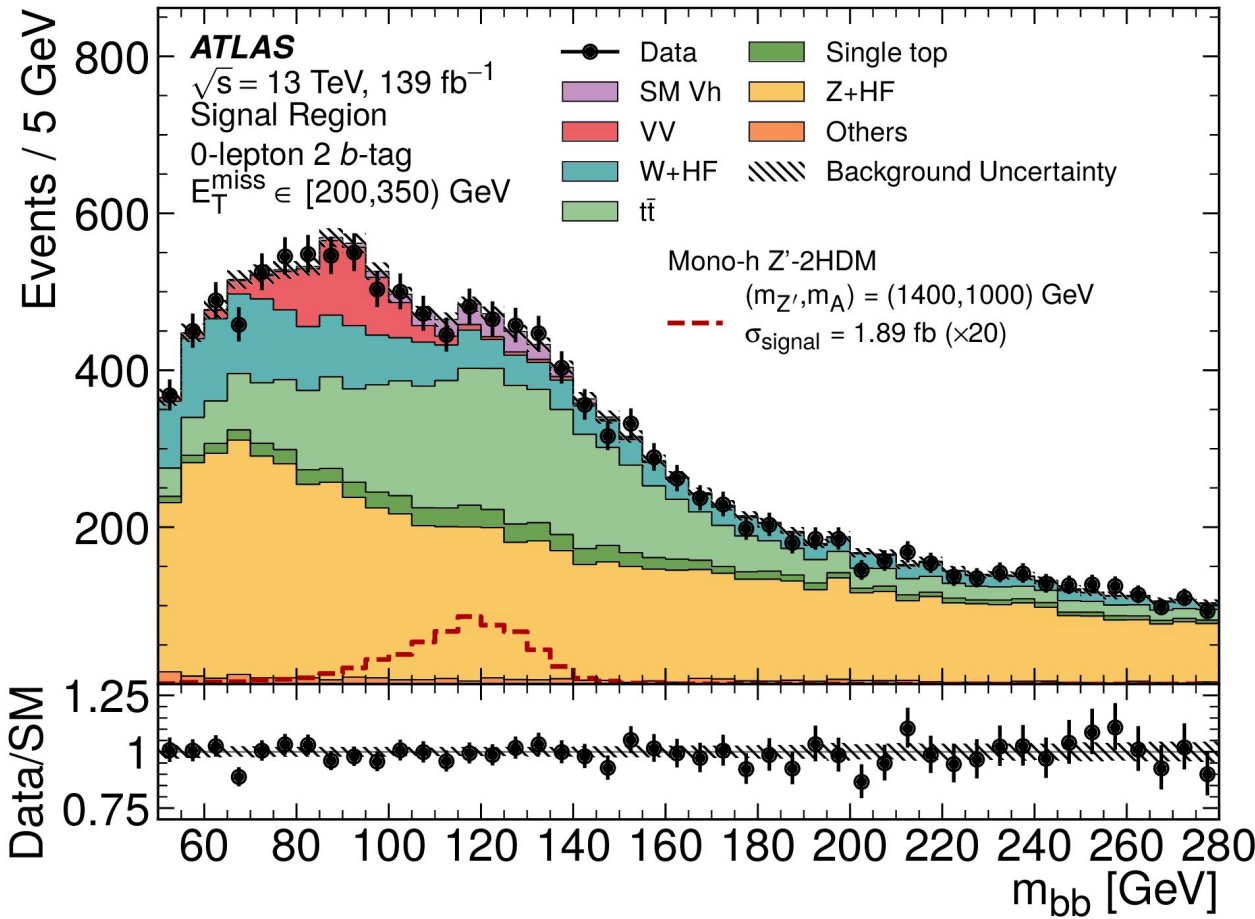


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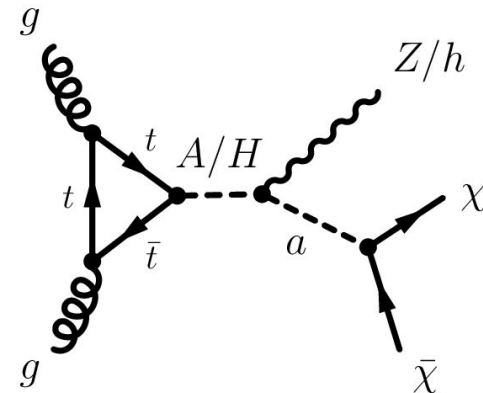
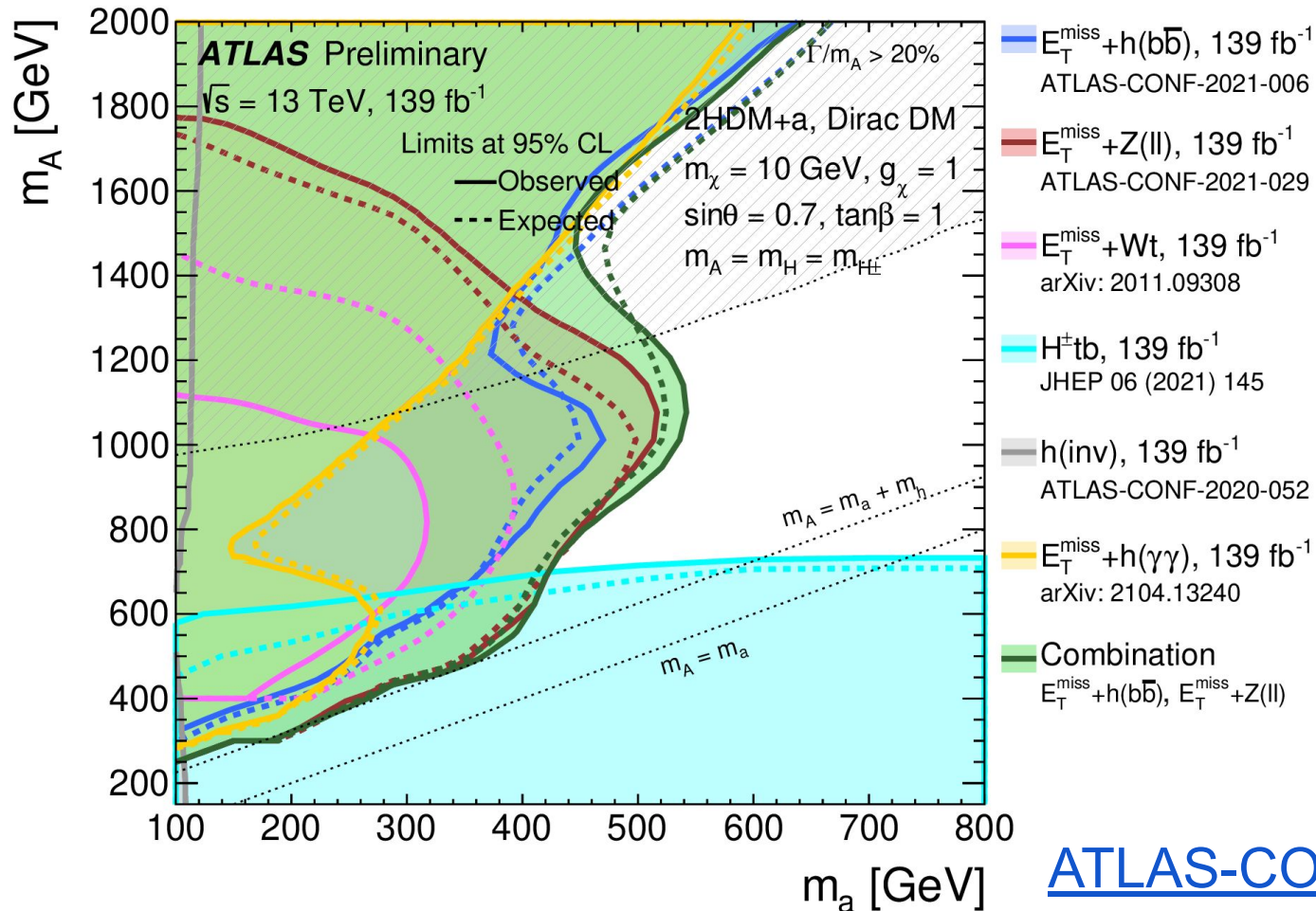
- Impressive description of bb background





mono-Higgs, mono-Z plus others

- Exploit multiple missing energy searches
- Limits on 2HDM+a \rightarrow UV complete DM model

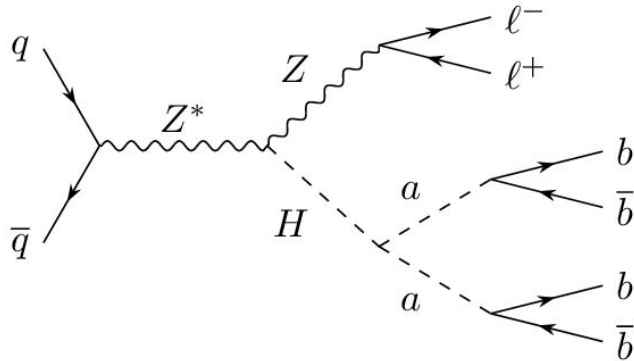


[ATLAS-CONF-2021-036](#)

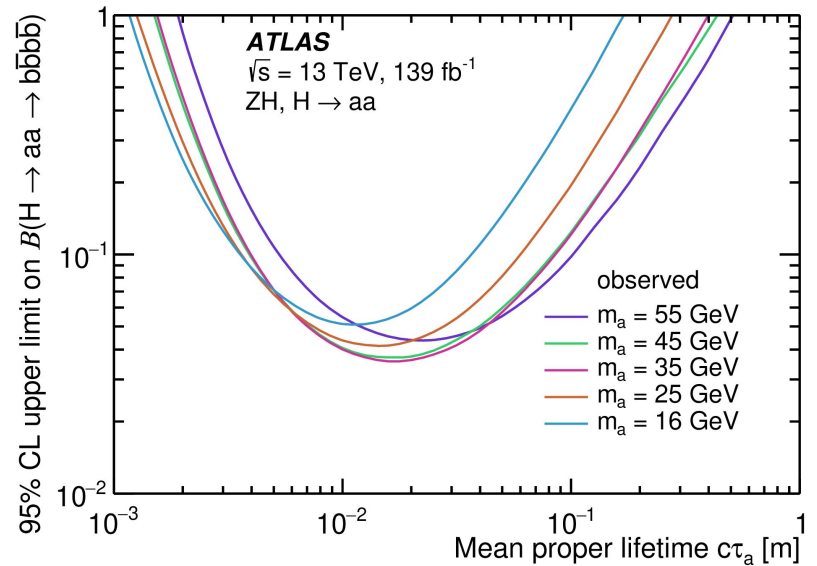
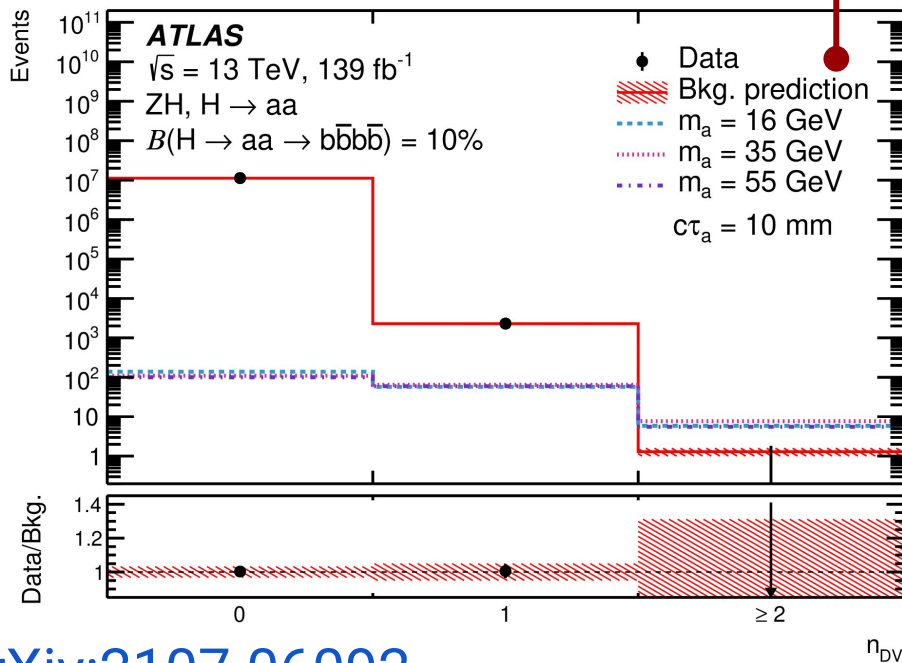


Higgs decaying to long lived particles

- ZH production to select Higgs decaying to new



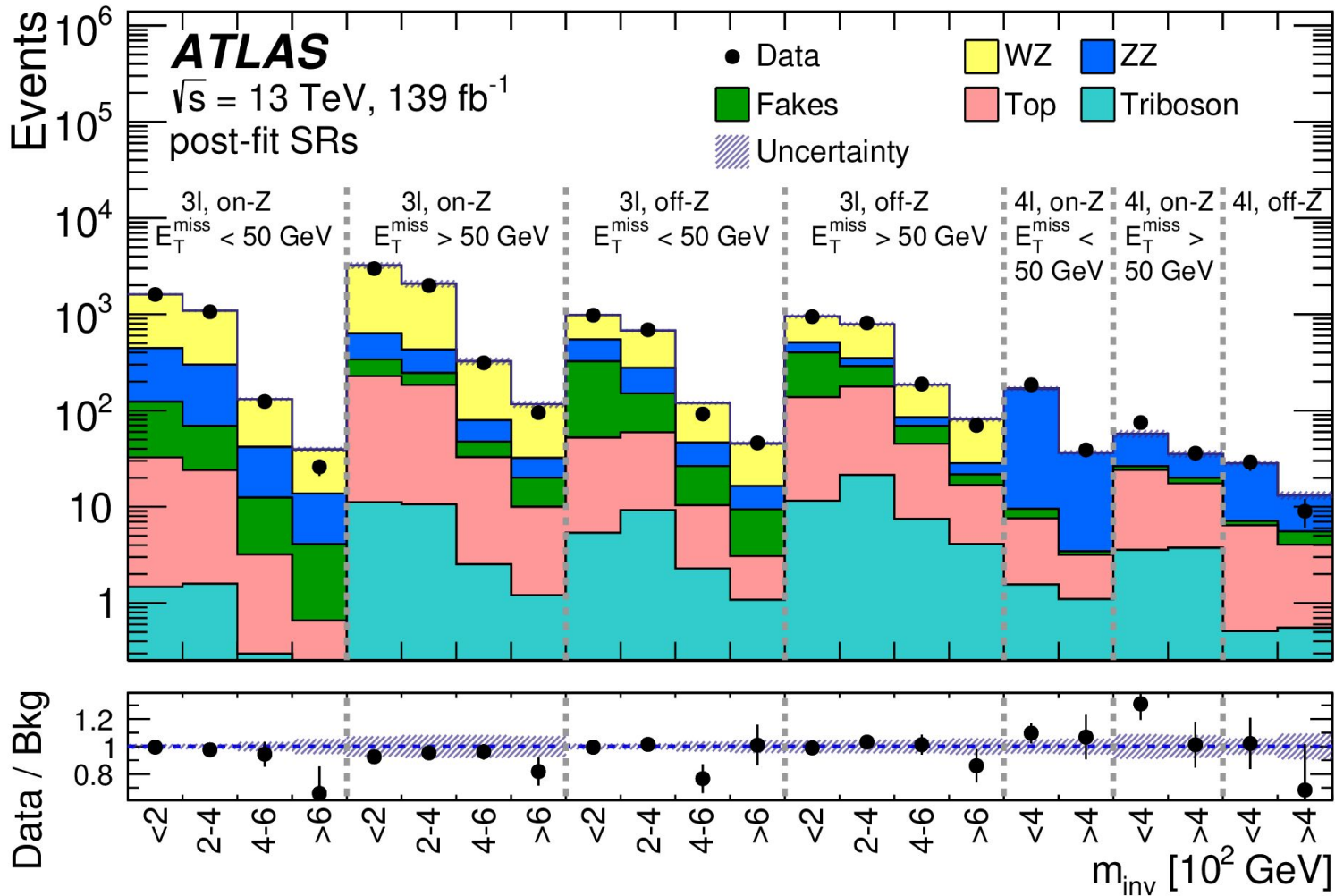
- Exploit # of displaced vertices
- 2+ effectively removes SM





3 or 4 lepton search

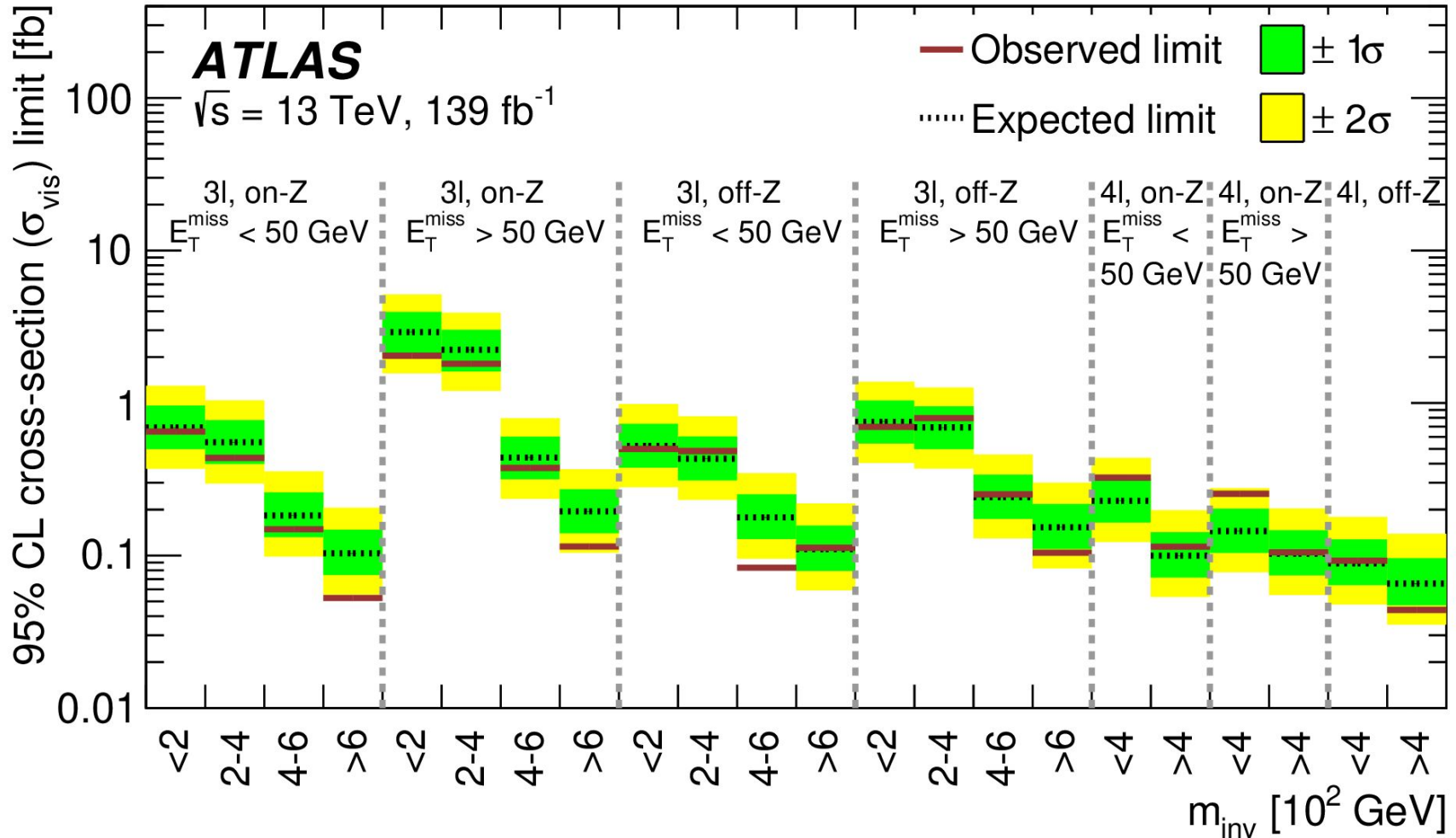
- General search using invariant mass of multi-lepton system





3 or 4 lepton search

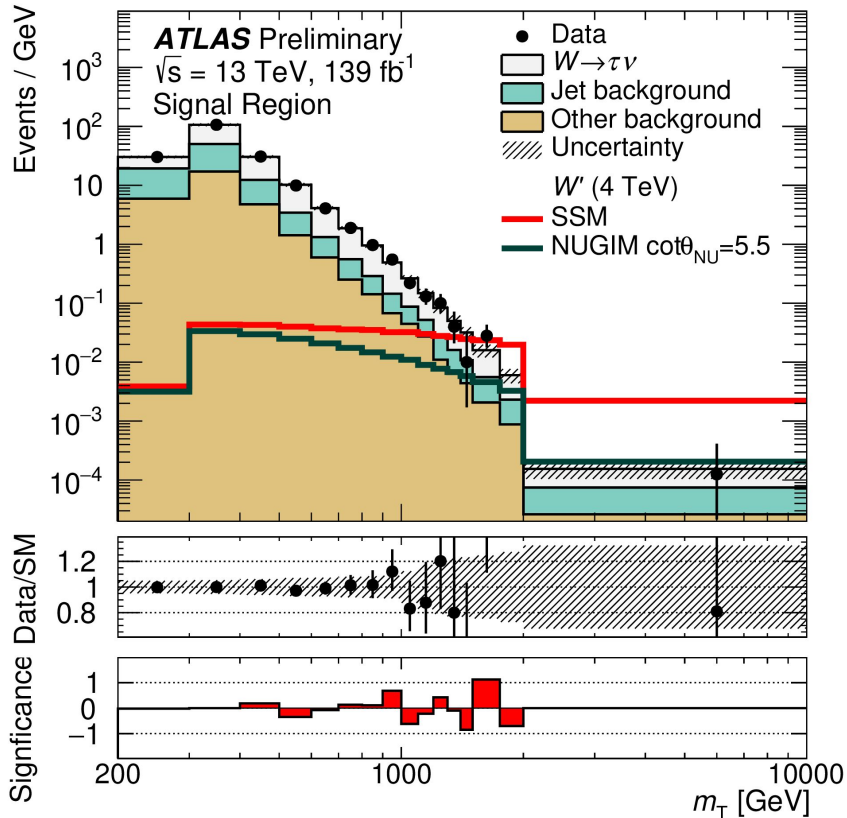
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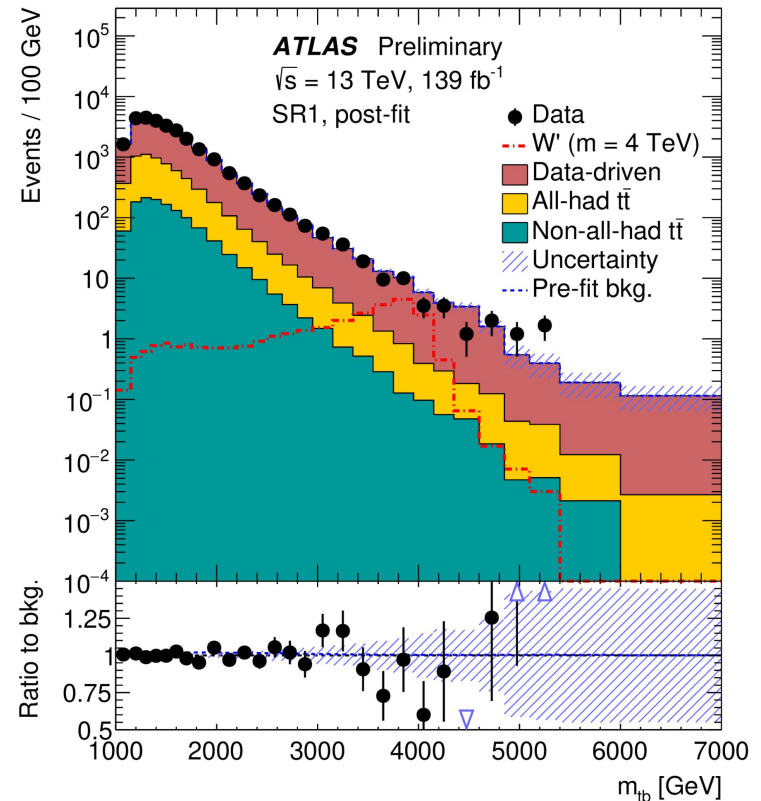


$W' \rightarrow \tau + \text{missing energy}, W' \rightarrow tb$

- Bump hunts aren't just for Higgs boson!
- Well reconstructed jets allow for powerful probe of W'



[ATLAS-CONF-2021-025](#)

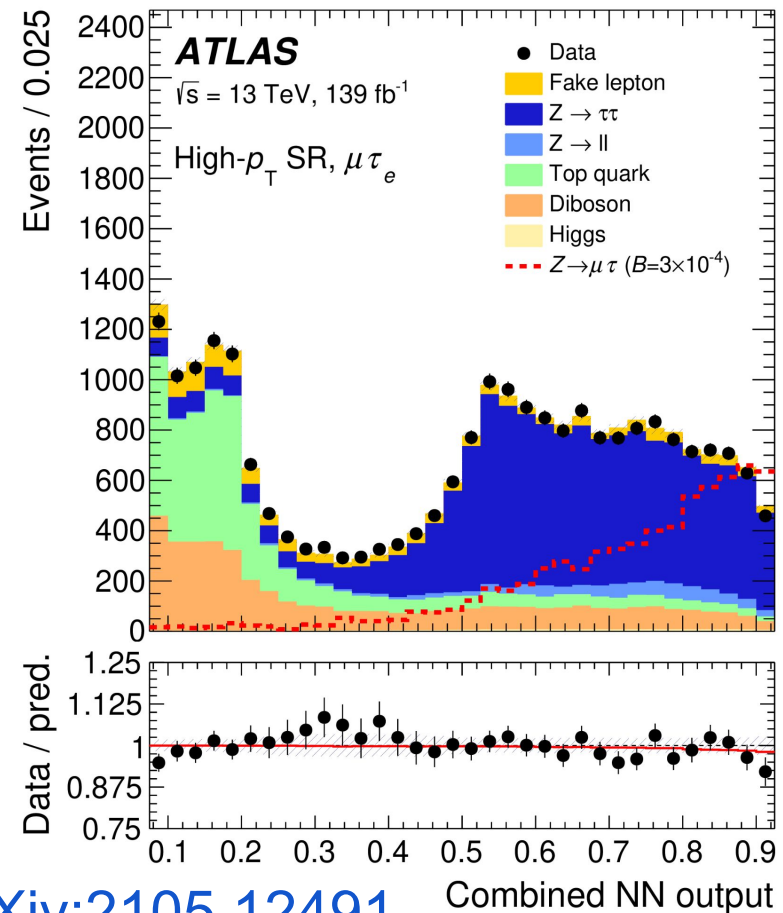
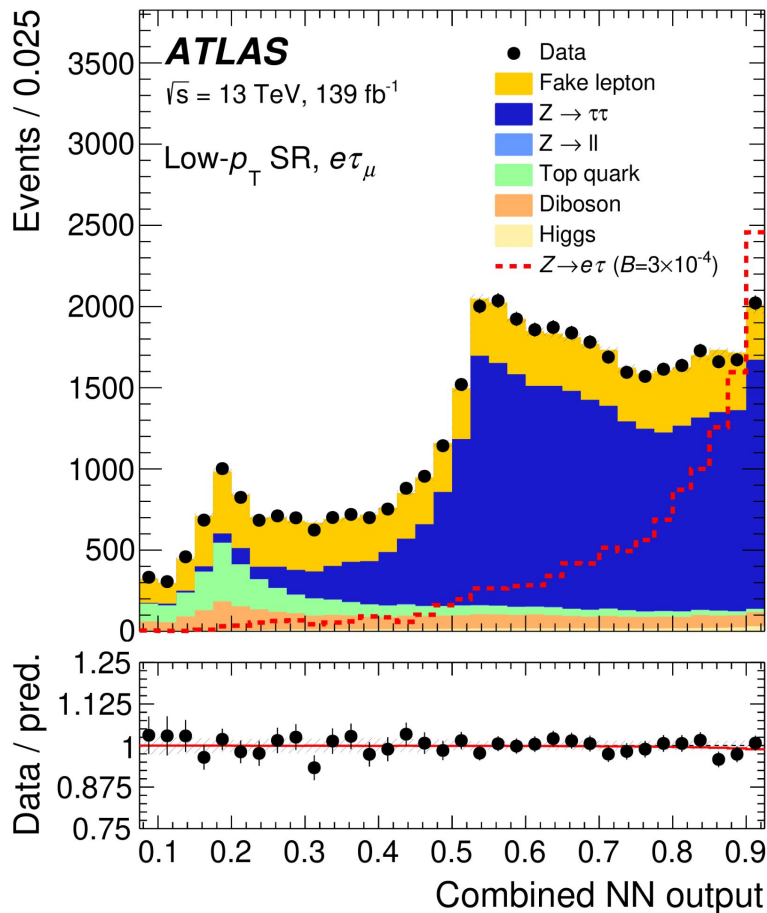


[ATLAS-CONF-2021-043](#)



Lepton-flavor-violation using Z boson decays

- Possible through neutrino oscillation, but VERY rarey
- An excess of $Z \rightarrow \ell\tau$ would be strong sign of new physics



[arXiv:2105.12491](https://arxiv.org/abs/2105.12491)

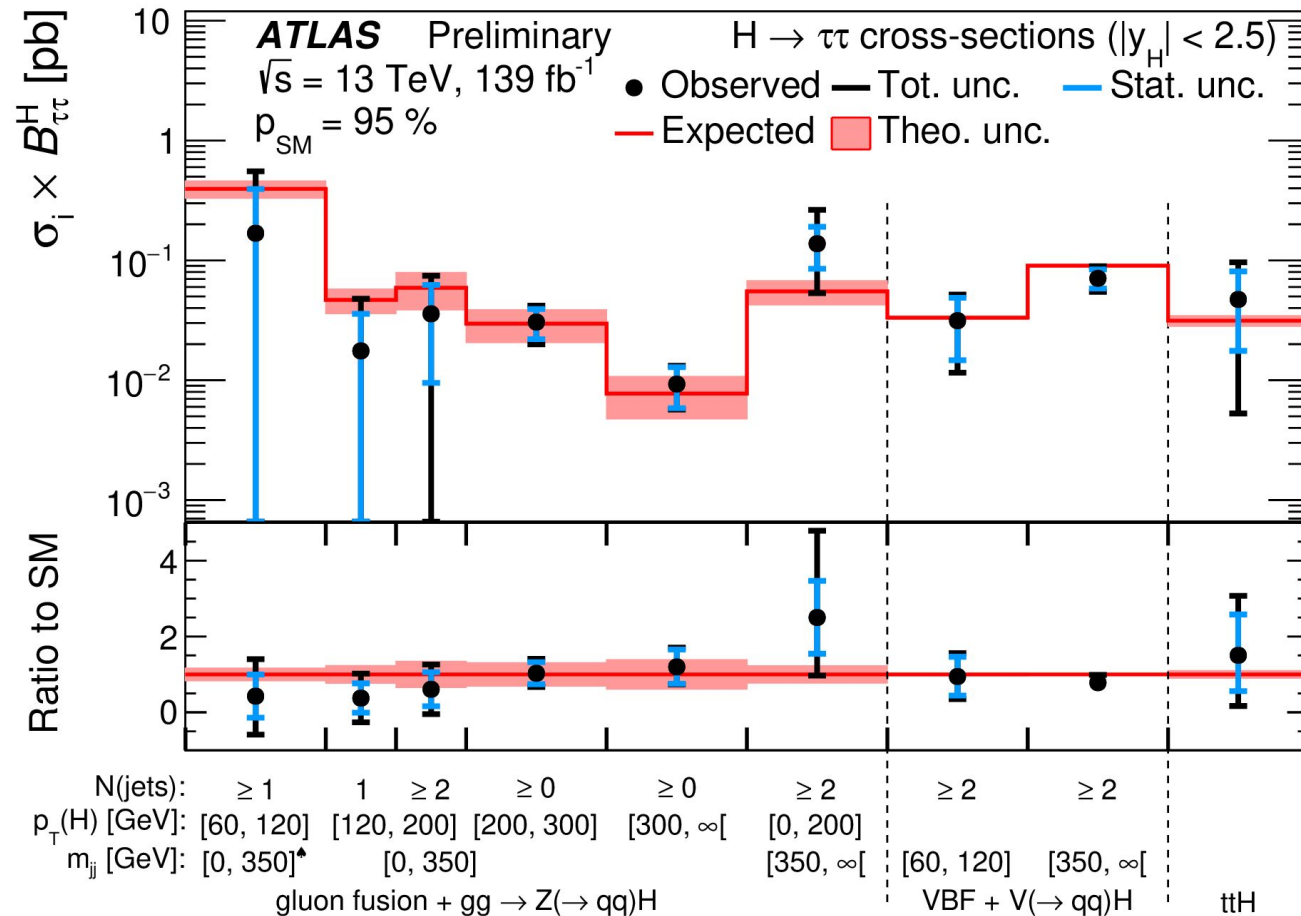
The Precision Approach

Because Standard Model doesn't sound as good on a grant



Higgs to $\tau\tau$ production cross-section

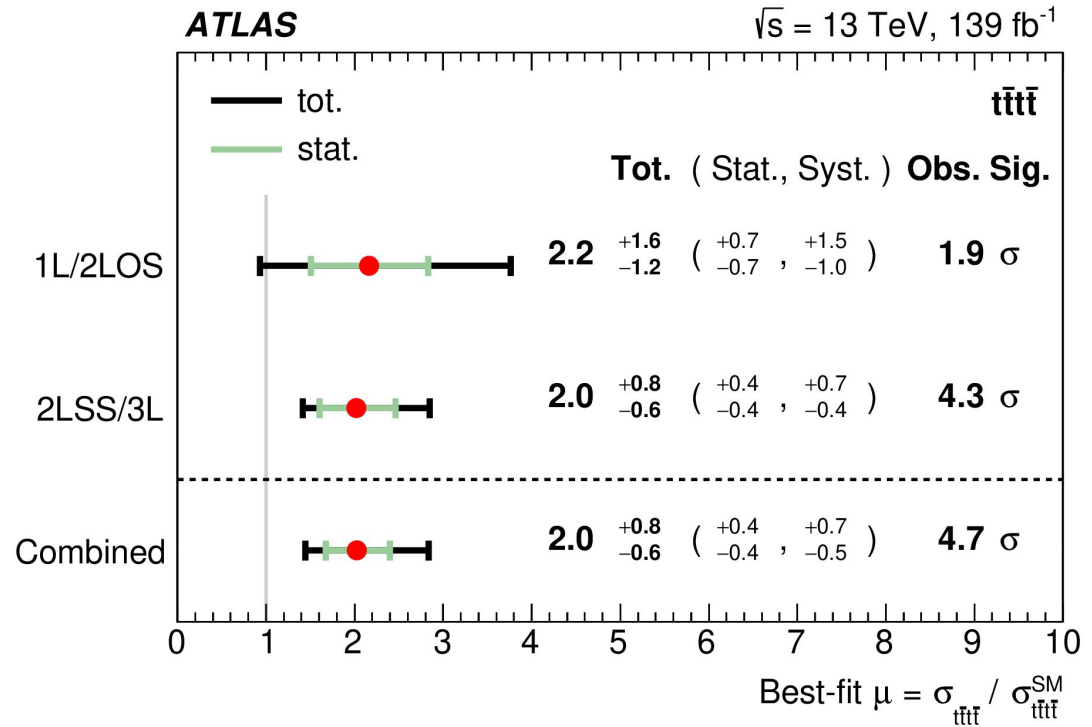
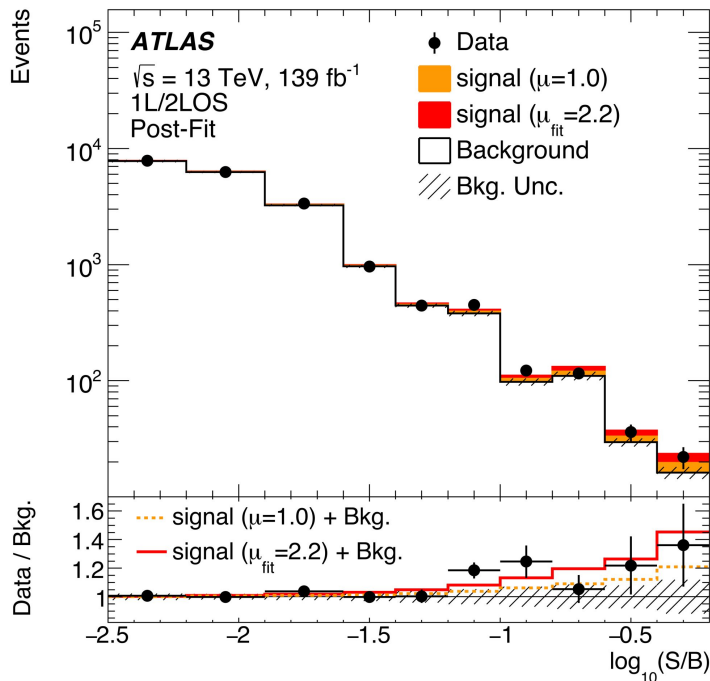
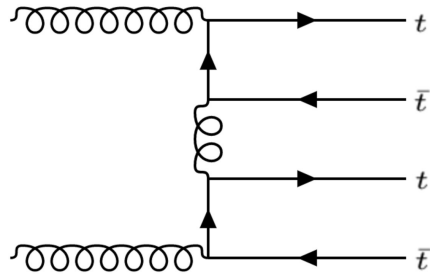
- Precision measurement of Higgs boson decaying to two τ
- Hope for deviations indicating new physics, e.g. EFTs





4 top cross section

- Searching for deviations from Standard Model

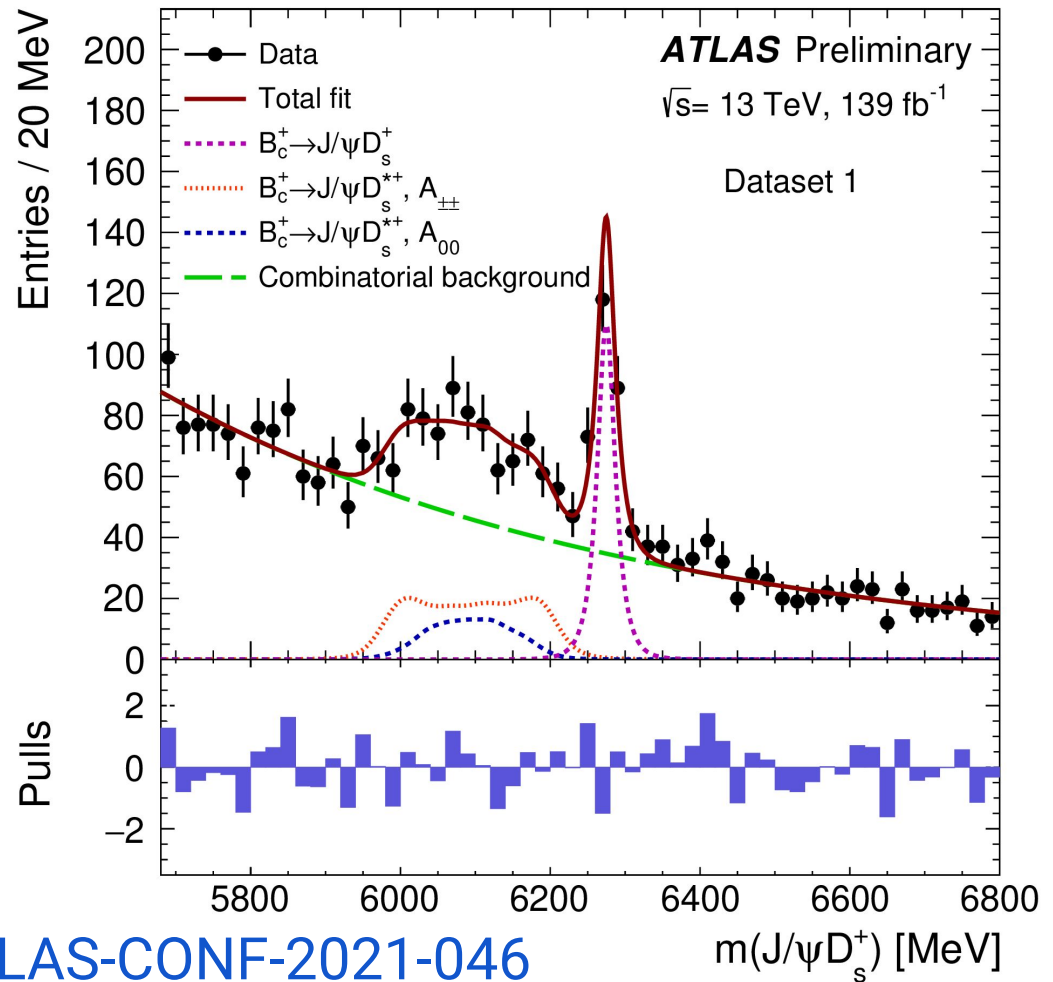
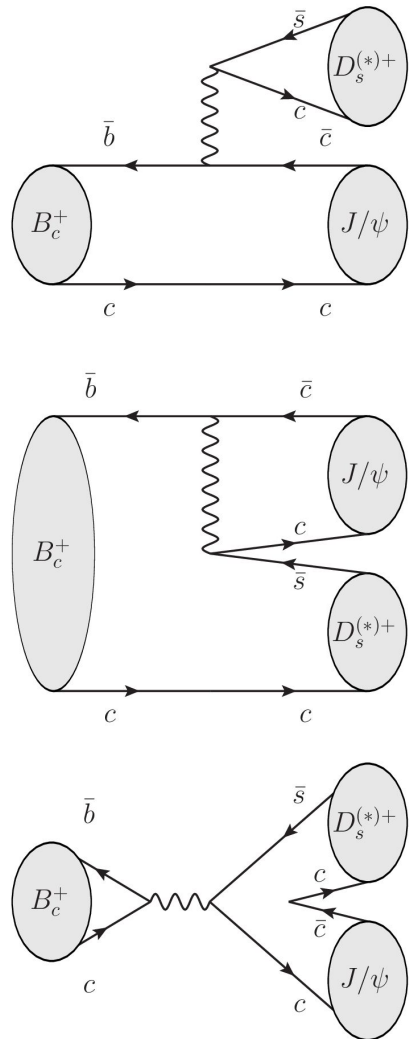


[arXiv:2106.11683](https://arxiv.org/abs/2106.11683)



Studies of B_c^+ decays

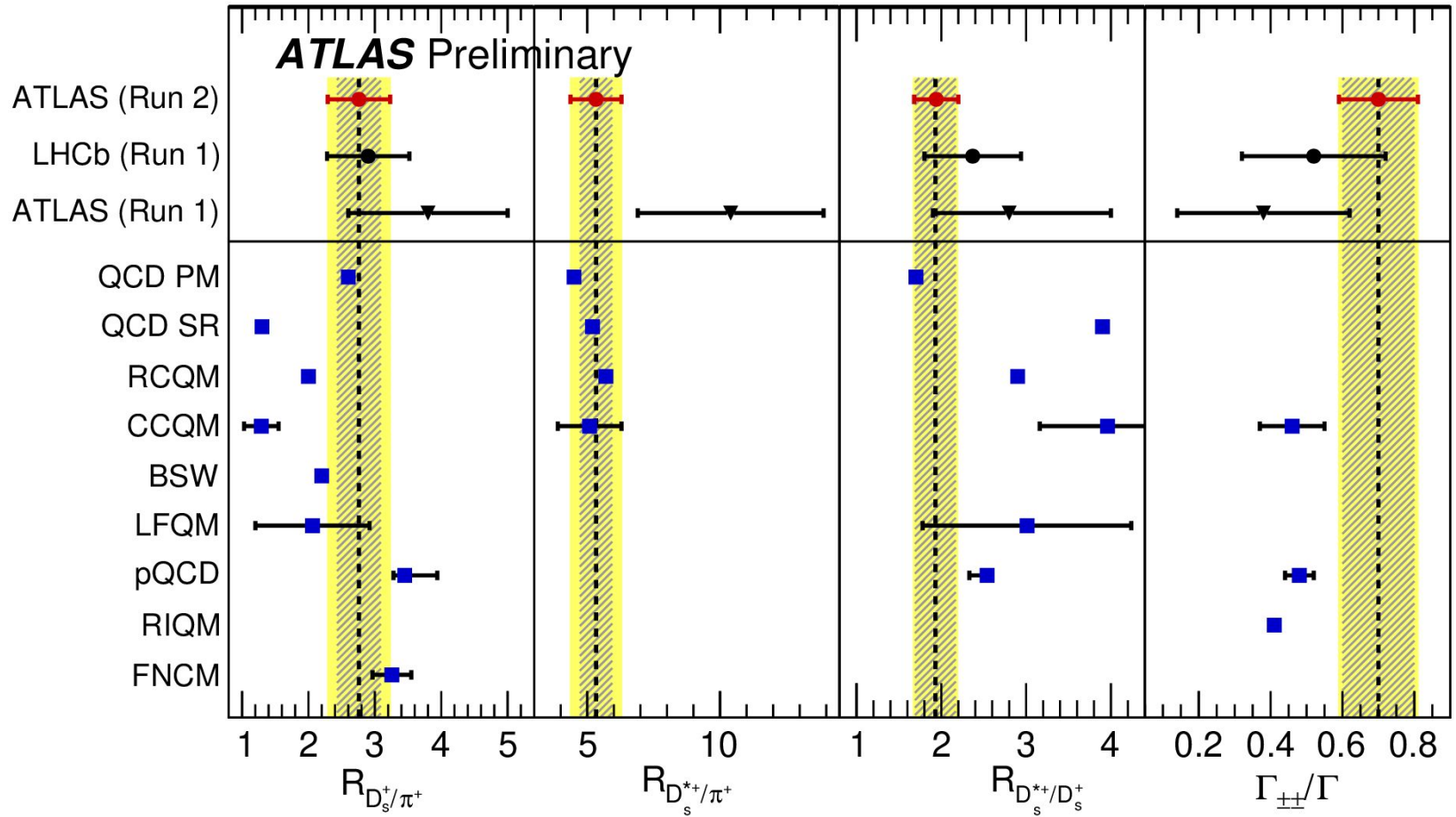
- Most precise measurements of B_c^+ production to date
- Nice separation of D_s^{*+} and D_s^+





Studies of B_c^+ decays

- Most precise measurements of B_c^+ production to date
- Varying levels of agreement with theory



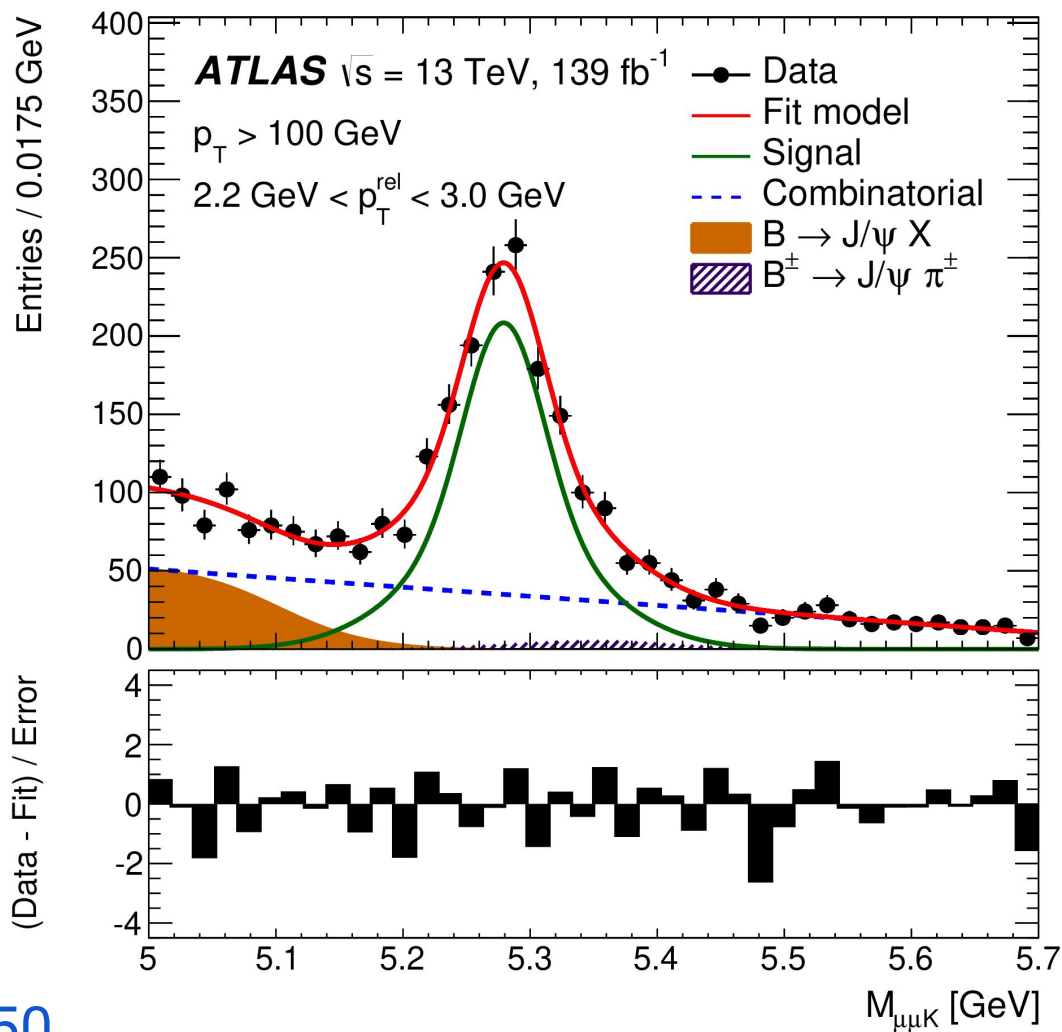
[ATLAS-CONF-2021-046](#)

→ Transverse polarization fraction



B-jet fragmentation

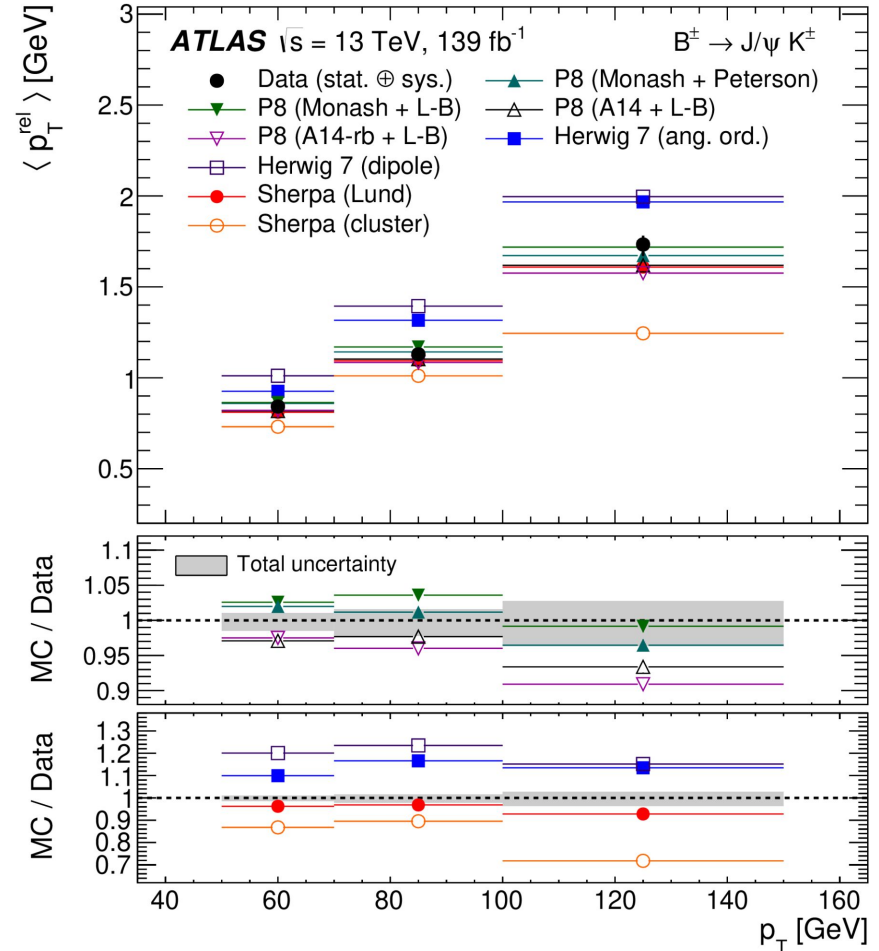
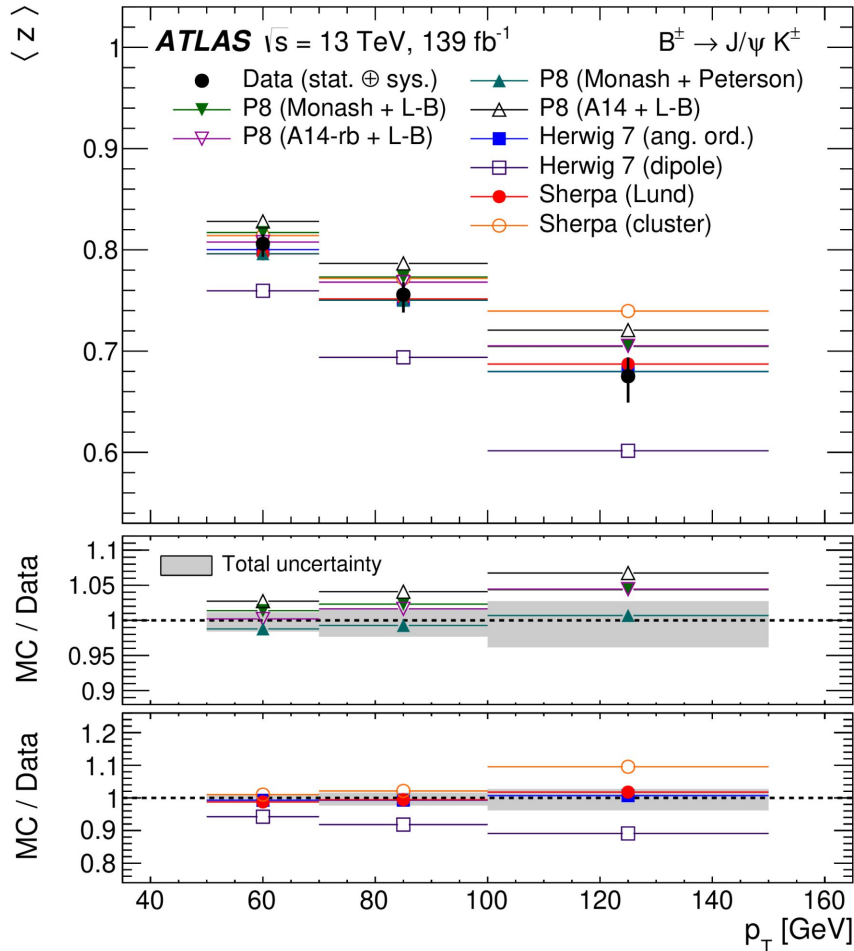
- B-hadrons often exploited in searches, how does MC perform?





B-jet fragmentation

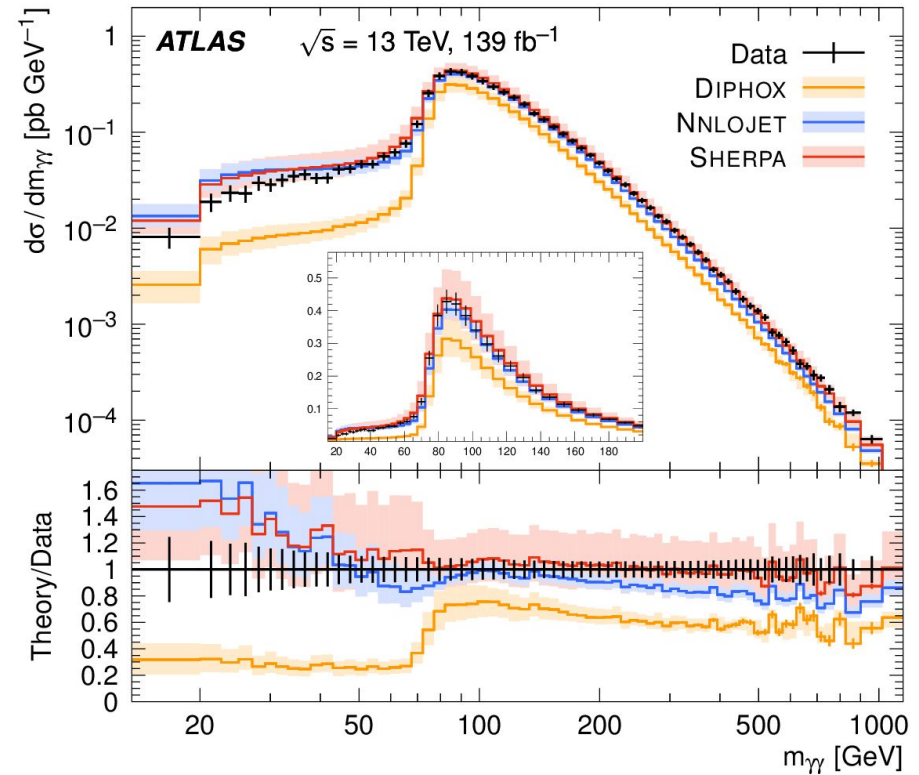
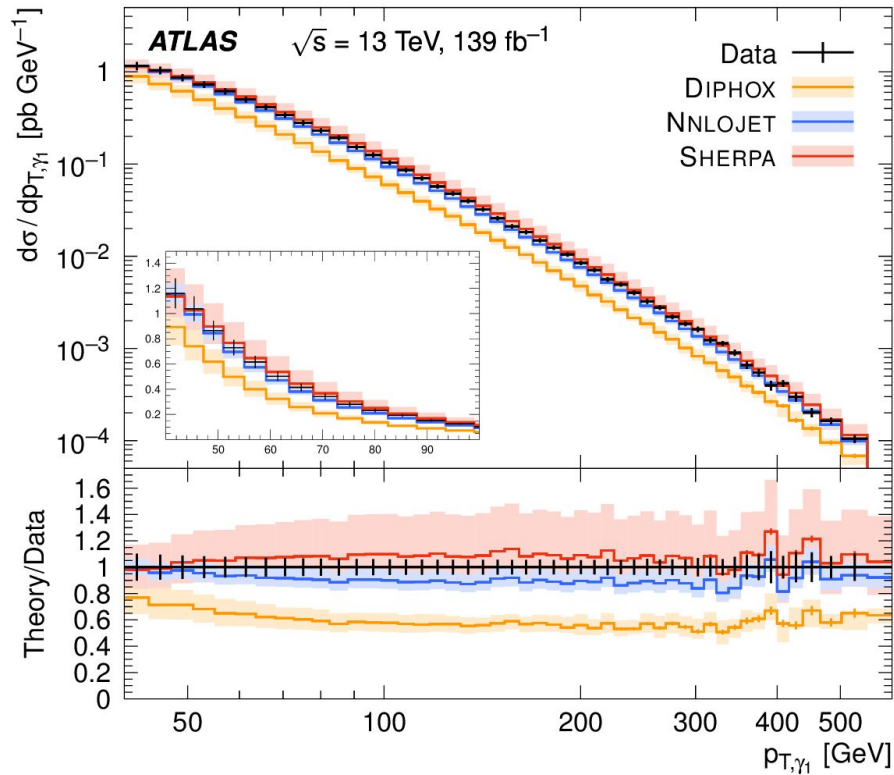
- B-hadrons often exploited in searches, how does MC perform?





Diphoton cross-section measurement

- Di-bosons a clean signature, how does MC perform?



Summary

If I had the conclusion, I'd also have a Nobel...



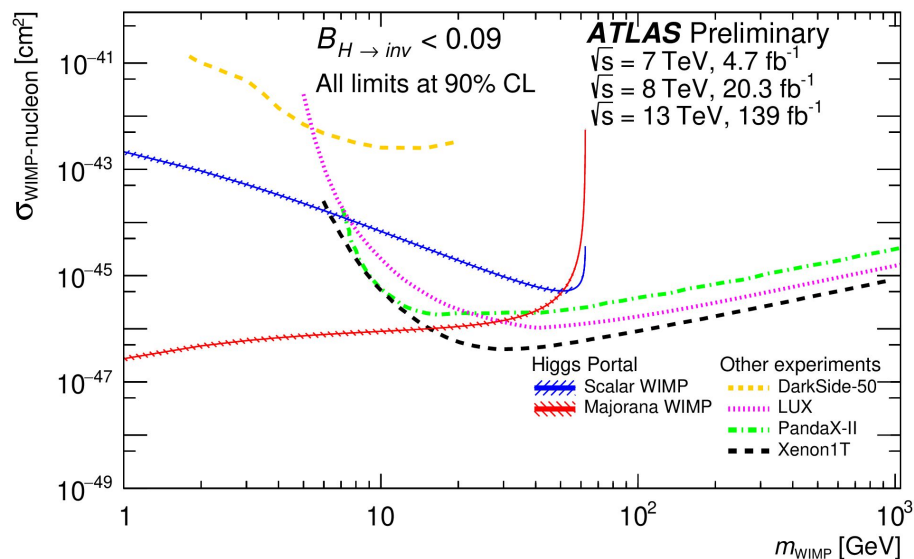
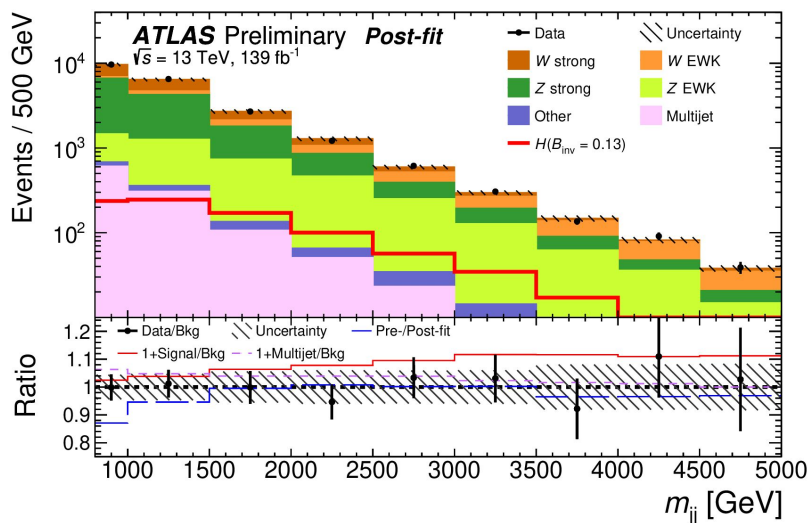
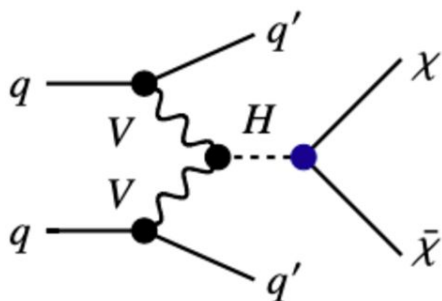
- Broad program targeting many BSM scenarios
 - Including potential answers to B-physics and $g-2$ anomalies...
- New analyses exploiting full Run-2 dataset are either:
 - Out now, many shown here!
 - Soon to be released, stay tuned...
- So far no obvious signs pointing at one theory or another
 - BUT severely limiting phase space where new physics can hide!
- In the meantime, preparing for:
 - Run-3 of LHC \rightarrow approximately double data collected during Run-2
 - High-Luminosity LHC \rightarrow 10x increase

BACKUP



VBF-like with only missing energy + Combination

- Use the Higgs boson as portal to Dark Matter
- Branching fraction into invisible particles $\rightarrow < 0.09$ at 90% CL



[ATLAS-CONF-2020-052](#)

[ATLAS-CONF-2020-008](#)

