Re-interpretable Results: ATLAS perspective

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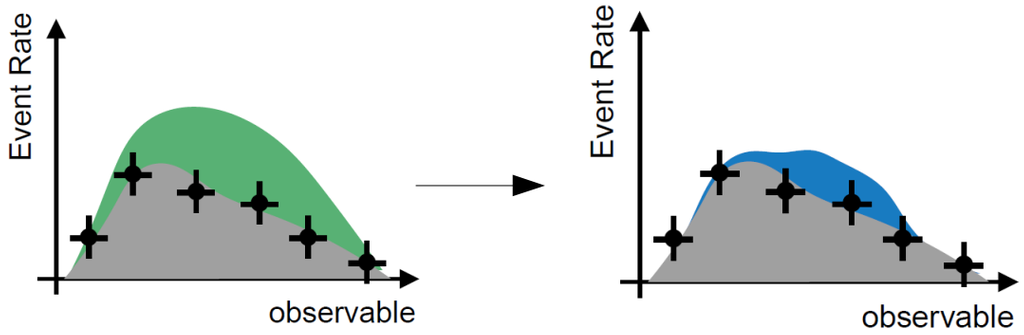
Analysis Preservation & RECAST

Each ATLAS analysis entails a tremendous effort, often developed over many years with significant person power and computational resources invested.
ATLAS results have a high and long-lasting scientific value!
→ It's important to preserve not only the data but the analysis itself (setup, software, selections, fits, …) and by that the ability to repeat the entire analysis
→ This is relevant not only to ATLAS, but to CERN experiments in general (→ CERN analysis preservation service)



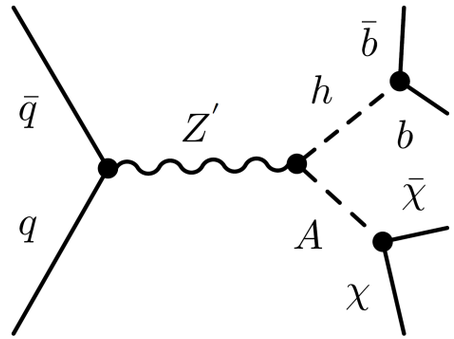
RECAST (*Request Efficiency Computation for Alternative Signal Theories*) is a tool that enables an analysis to recompute efficiencies and limits for the same dataset and the same background but new signal hypotheses. https://arxiv.org/abs/1010.2506

→ Simplification compared to a full analysis, but allows to test new models relatively easily and quickly by re-using an existing analysis (re-interpretation with a streamlined workflow)

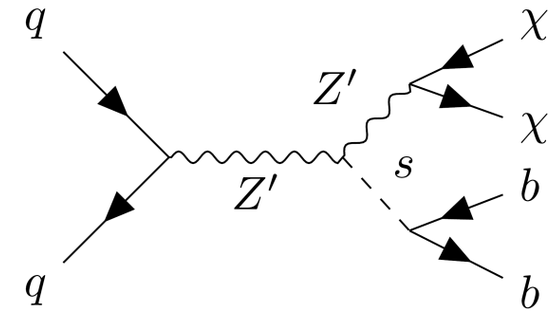
Has been used successfully for some Exotics and SUSY searches

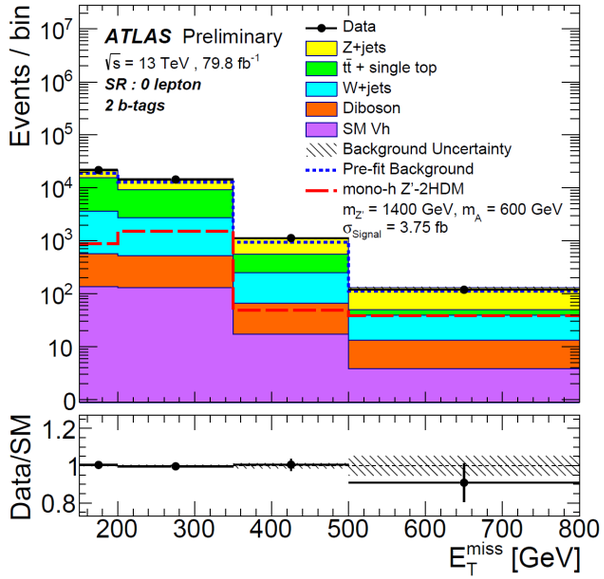
Example: H → bb + MET recasted to Dark Higgs search

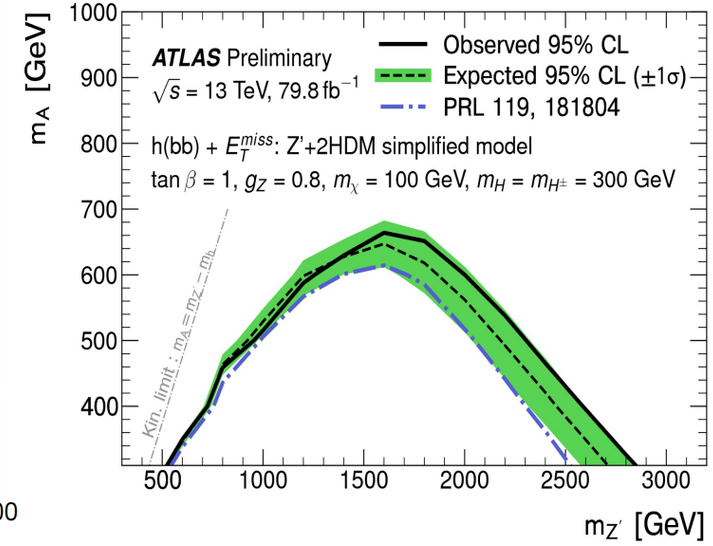
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2019-032/

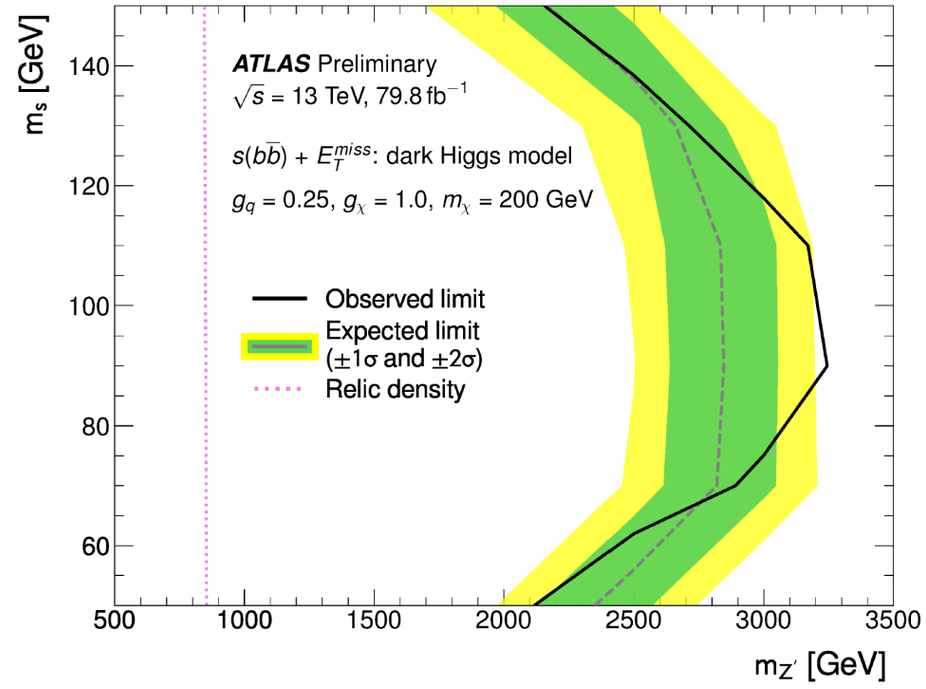


RECAST









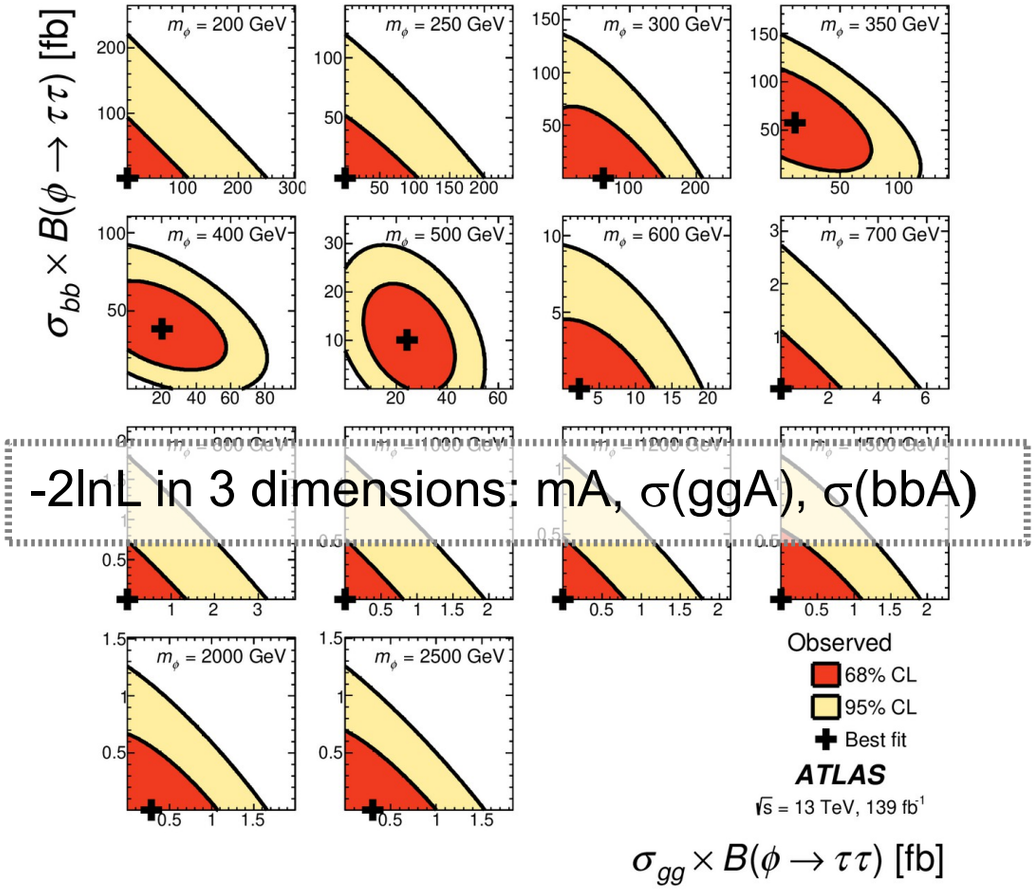
(from the authors)

- „all you are doing is to codify the sequence of steps to produce histograms for the statistics machinery, and running your event loop code over the signal (not data or background)"
- „its considerably easier, quite fast, and definitely the way of the future"

HEP Data

Numerical results of a published analysis are made available to scientists outside of ATLAS in a machine-readable form: https://www.hepdata.net/
These results typically are model-independent limits as a function of the mass hypothesis, measurements and their uncertainties (if applicable), correlation matrices, signal acceptances or cutflows, or likelihood scans

Example: A/H → ττ (HDBS-2018-46)



-2lnL in 3 dimensions: mA, σ(ggA), σ(bbA)

Theorists especially encourage we publish the likelihood values if we probe several production modes simultaneously.

Theorists would be happy to get the likelihood as a function of **all** parameters (masses, widths, σ, ...)

But often ATLAS does not publish the full likelihood, because the full model can have ~100+ parameters that require detailed documentation

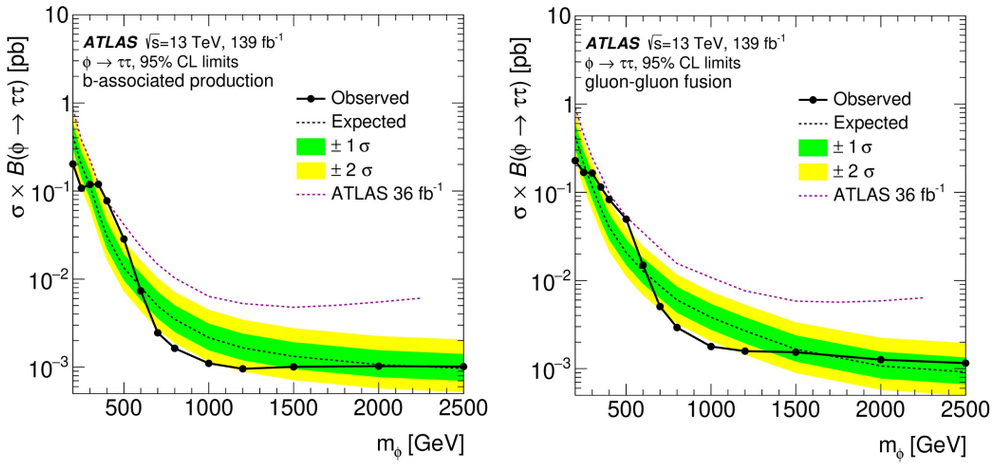
Some SUSY analyses however have done this! (Talk)

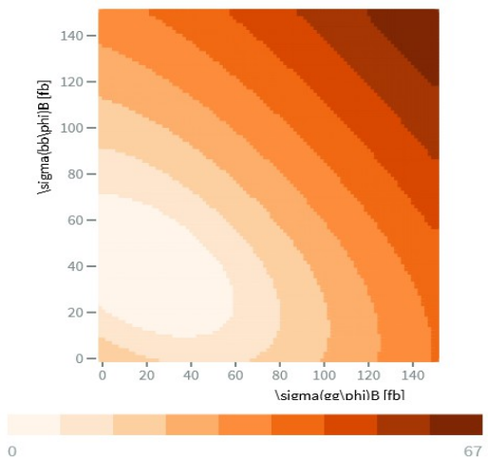
Lots of encouragement from the **LHC reinterpretation forum** to publish full likelihoods: arXiv:2109.04981

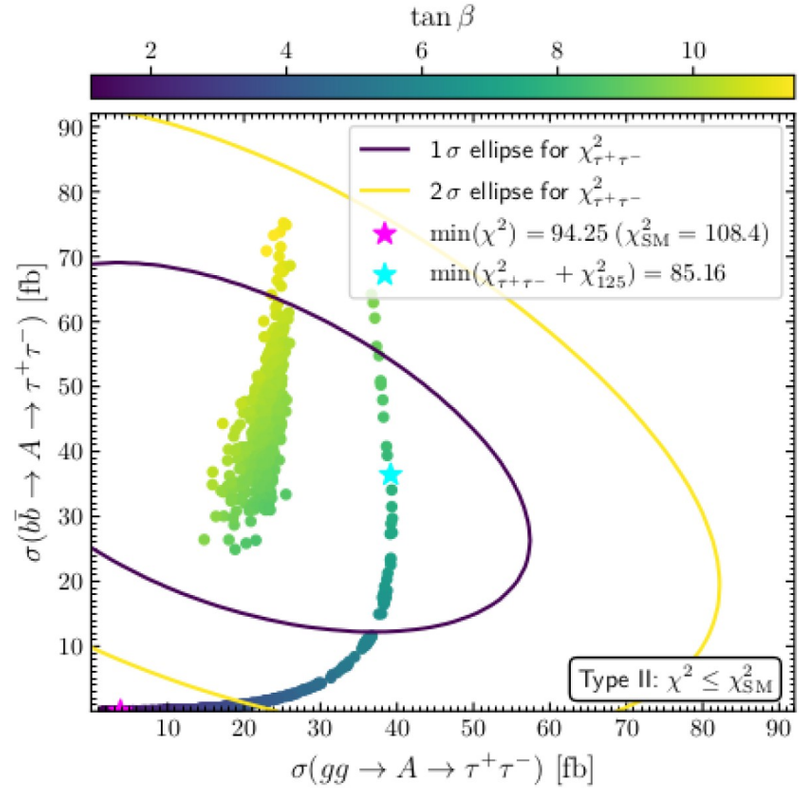
Recent Example how ATLAS Data has been Re-Interpreted by Theorists

https://arxiv.org/abs/2109.01128 (Biekötter, Grohsjean, Heinemeyer, Schwanenberger, Weiglein)

Fitting the ATLAS H/A → ττ excess at 400 GeV in the context of the N2HDM



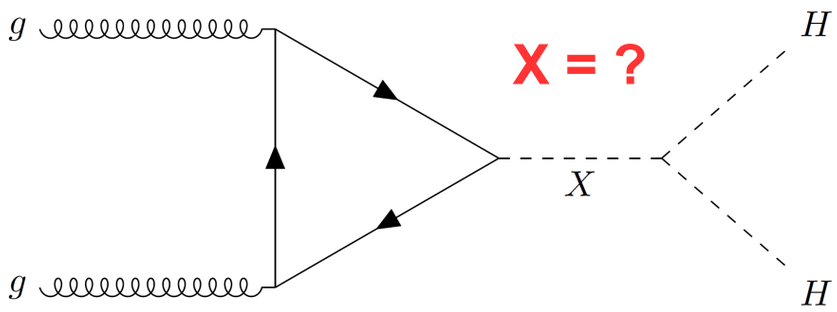




Colored points are allowed tanβ values in the N2HDM

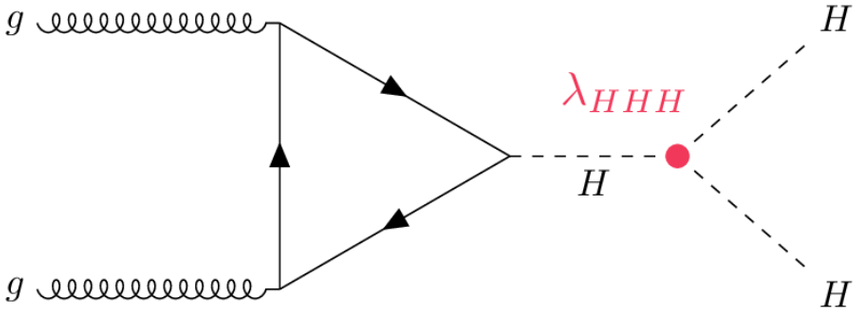
→ This is very nice and we should facilitate similar efforts in the context of HH
→ Great demand for published likelihood in case of an excess

How can we enable theorists to probe their favorite model using ATLAS HH results?



Imagine an excess of events in the reconstructed (resonant) HH mass spectrum → What is it?
Is it a new heavy Higgs? Which BSM Higgs model fits?
Is it a Graviton? Is it something else?
→ It's important that we test various width assumptions, and also spin0/2 signal models

Or, in case we observe a non-resonant HH excess:



In BSM models expect deviation of λ_{hhh} from 1

For (re-)interpretation, theorists need access to a large number of results:
HH searches, Heavy H searches, h_{125} measurements

For example arXiv:2005.10576 investigates allowed ranges of λ_{hhh} in the 2HDM using a plentitude of experimental results

HiggsBounds (arXiv:1102.1898) and **HiggsSignals** (arXiv:1305.1933) frameworks use ATLAS HEPData (and other) inputs, but treat them in a somewhat simplified way (neglecting some correlations, depending on which information was made available)

Summary

Data and analysis preservation and therefore the ability to reproduce a result are extremely important and „good science“

Re-utilization of existing analyses with new signal hypotheses is possible (RECAST), it's quick and easy but there are limitations

Re-interpretations by colleagues outside of ATLAS, who use the data published by ATLAS on HEPData, are encouraged („open access“).
Link to ATLAS policy document: https://cds.cern.ch/record/2002139/

Feedback regarding the information published on HEP Data is very welcome! Official channel are the ATLAS contacts in the LHC Higgs WG:
https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHWG

HH community needs to prepare for the case of an excess and its interpretation, also in combination with single H measurements