Checklist for the next 3σ excess

Is it a local significance?

- With O(100) searches/year a global significance of 2σ is expected to happen regularly

Is it in the region dominated by systematics?

- Read the systematics section critically

Is it dominated by a single bin with few events?

- Experimental resolution may already disfavour a BSM interpretation (i.e. ATLAS VH excess)

Is it excluded by a more sensitive search?

- In many cases multiple searches are sensitive to the same BSM scenario (i.e. ATLAS di-boson)

Is it a single search in a single experiment?

- Typically, ATLAS and CMS have similar sensitivity. Real signals will be confirmed.

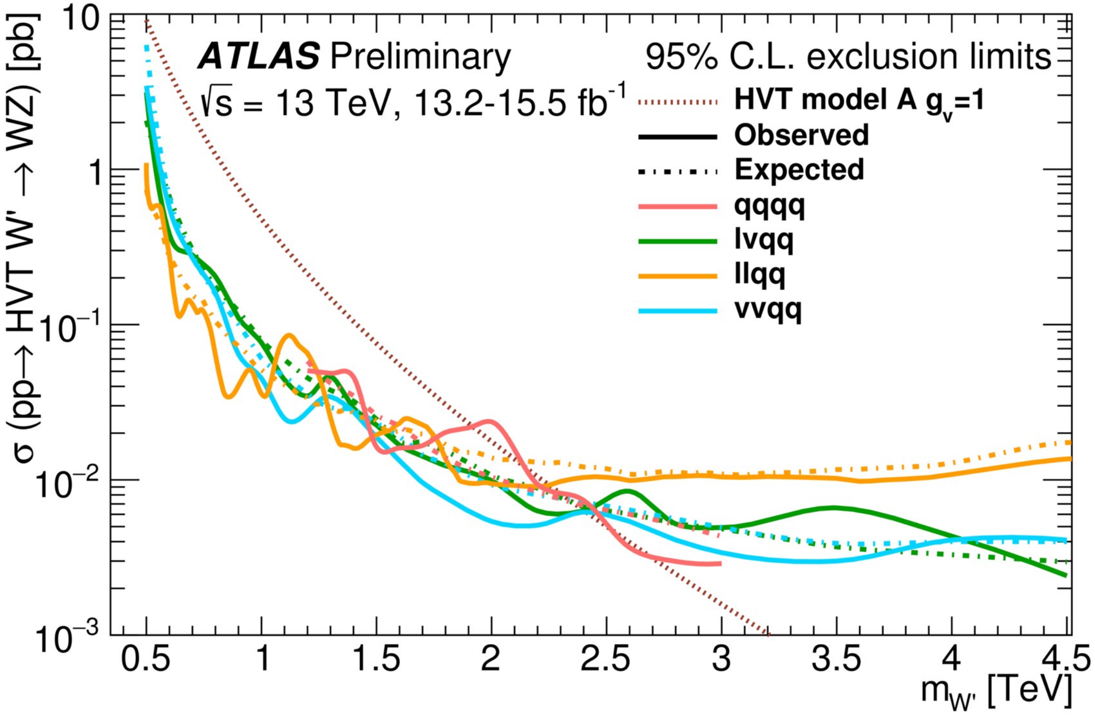
If the answer to any of the above questions is YES, stay tuned, but do not get too excited!!!

ATLAS di-boson resonance search

Slight excess observed around 2 TeV in qqqq channel generated some enthousiasm

The vvqq and lvqq channels are equally sensitive in that region, but generated less interest

It's great to see hadronic analyses with competitive sensitivity. Possibly boosted object tagging has some potential to shape distributions.



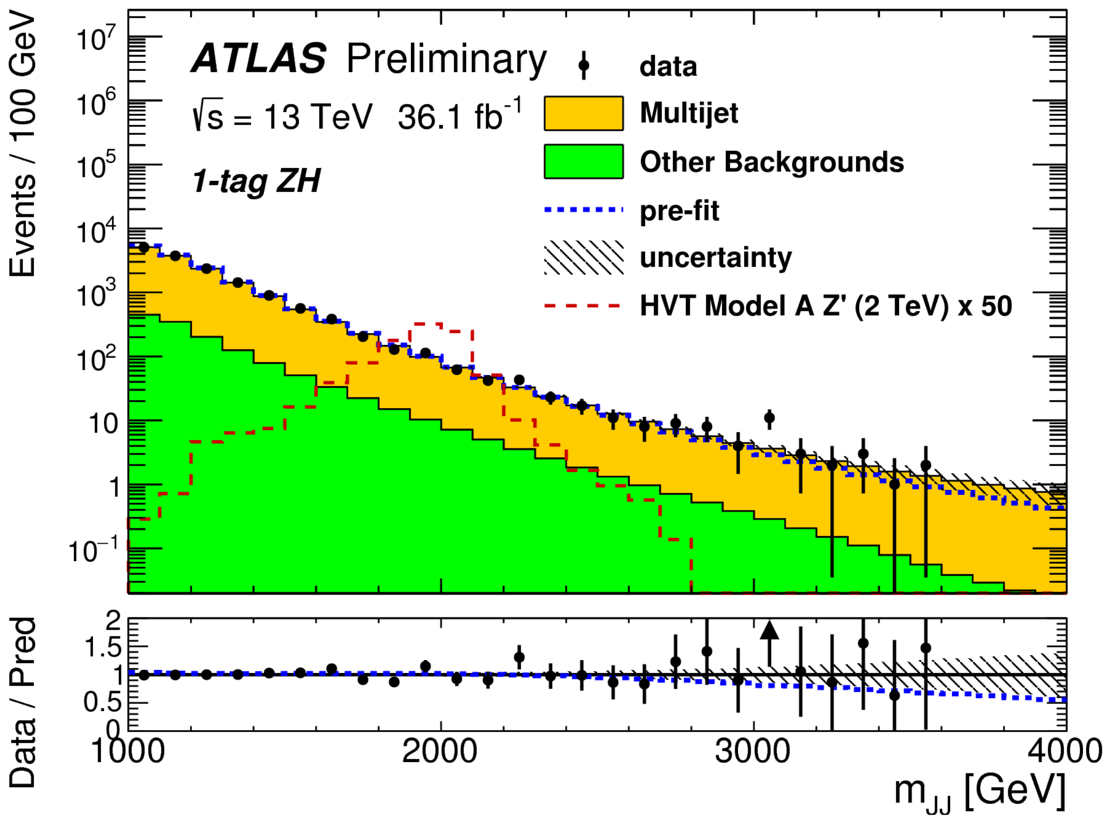
ATLAS X → VH search

Two large-R jets tagged as W/Z → jj and H → bb

Mass resolution > 10%

3σ excess driven by single bin

ATLAS-CONF-2017-018



Ultimate sensitivity to BSM physics

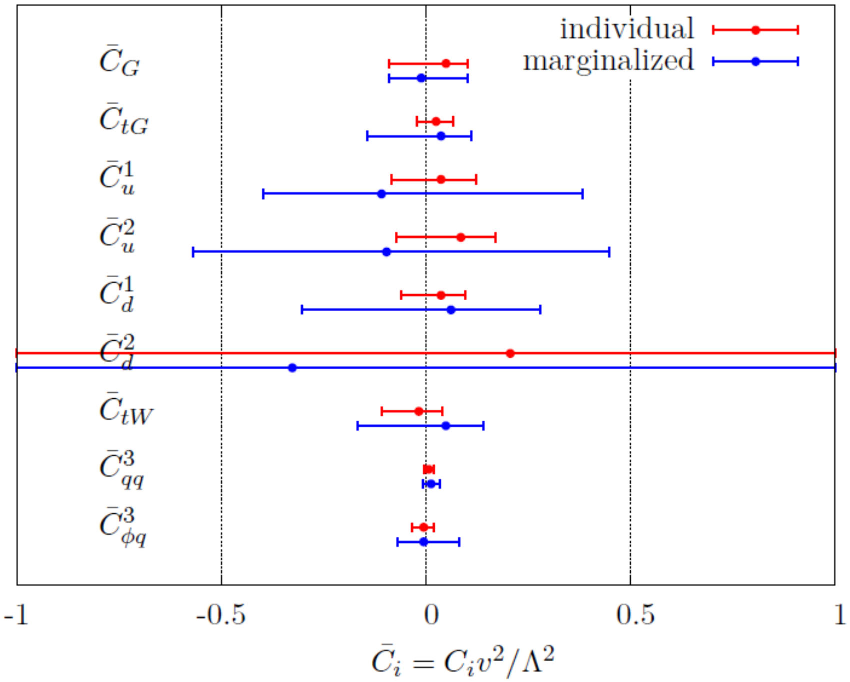
Assume for a second that all your favourite 3 and 4 sigma excesses in searches evaporate, and none of the new ones become solid.

Consider the LHC a low-energy machine. Use precise measurements to constrain higher-scale new physics.

Obvious example: Higgs boson couplings
Top physics following closely

Write "general" Lagrangian

$$\mathcal{L}_{eff} = \mathcal{L}_{SM} + \frac{1}{\Lambda^2} \sum_i C_i O_i + \mathcal{O}\left(\Lambda^{-4}\right)$$



Simultaneous fit of coefficients to all existing top physics data from LHC and Tevatron
arXiv:1506.08845, arXiv:1512.03360

Ultimate limits on BSM physics

With the complete sample from HL-LHC, the theory uncertainty often limits the precision of the comparison

Move towards relative cross sections or ratios of processes

FCC study by Mangano et al.

	$\sigma(t\bar{t}H)[\text{pb}]$	$\sigma(t\bar{t}Z)[\text{pb}]$	$\frac{\sigma(t\bar{t}H)}{\sigma(t\bar{t}Z)}$
13 TeV	$0.475^{+5.79\%+3.33\%}_{-9.04\%-3.08\%}$	$0.785^{+9.81\%+3.27\%}_{-11.2\%-3.12\%}$	$0.606^{+2.45\%+0.525\%}_{-3.66\%-0.319\%}$
100 TeV	$33.9^{+7.06\%+2.17\%}_{-8.29\%-2.18\%}$	$57.9^{+8.93\%+2.24\%}_{-9.46\%-2.43\%}$	$0.585^{+1.29\%+0.314\%}_{-2.02\%-0.147\%}$

Ratio turns O(10%) uncertainty into an O(1%) uncertainty

Even differential: cuts on p_T (Z/H, top, tt) lead to small increase only

Is this the key to precision physics in at hadron colliders?

it is important to verify the cancellation that occurs with synchronous scale variations and to establish robust uncertainties

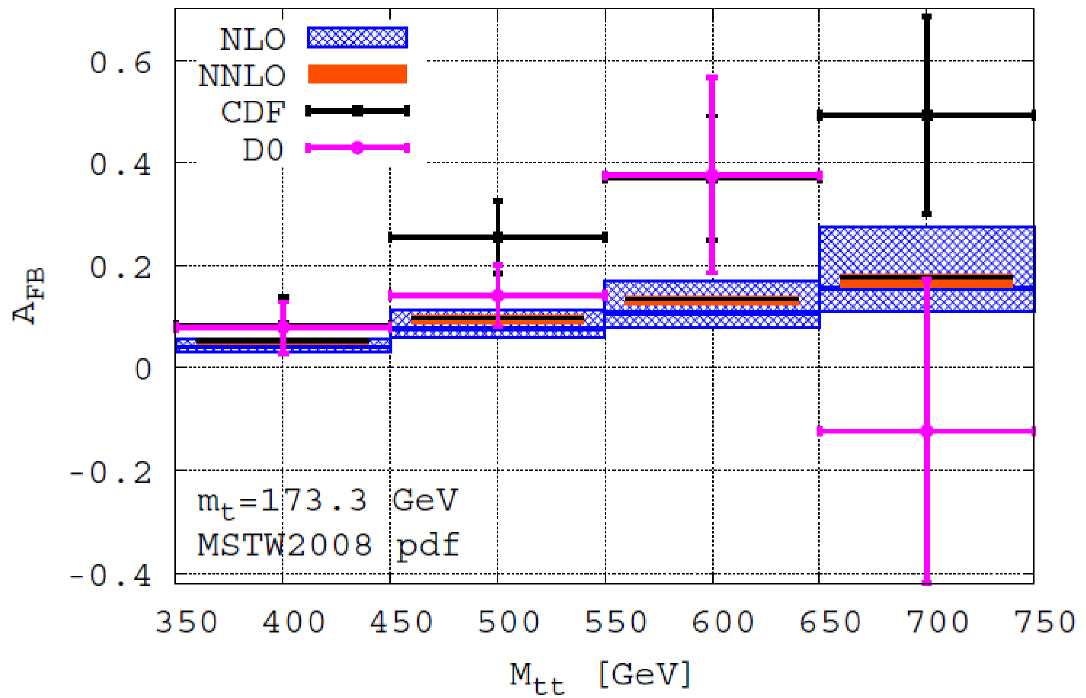
A notorious example: Tevatron A_{FB}

A classic example of how ratios help. The theoretical uncertainty is tiny!!

Tevatron (CDF) initially measured a 3σ deviation
Some tension with NNLO prediction remains

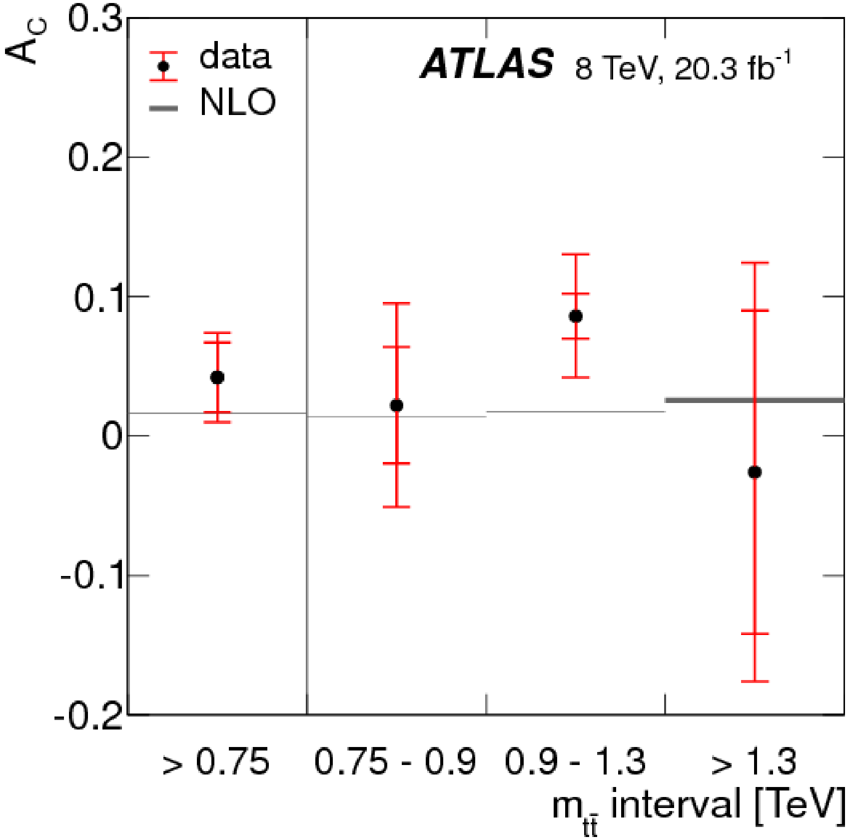
LHC charge asymmetry results are compatible with SM (and 0)
BSM explanations of Tevatron deviation are gradually being ruled out

Czakon, Fiedler, Mitov



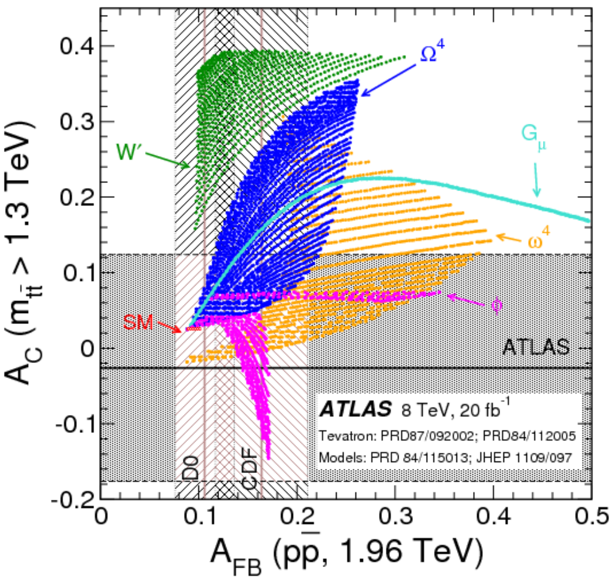
Massacre in model zoo

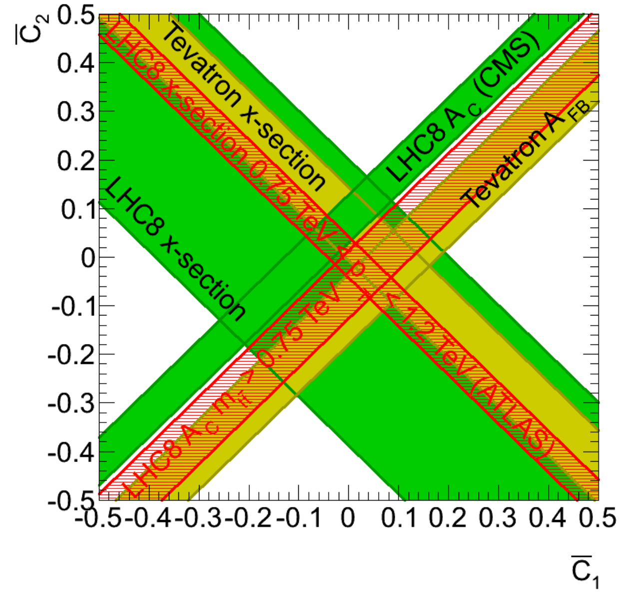
ATLAS ArXiv:1512.06092



M. Perello, M.V., arXiv:1512.07542

Competitive limits from boosted regime – require less precision





Constraining new physics with sensitivity & precision

Summary

Expect a few other false positives (including theorists' feeding frenzy) before the LHC is over + hopefully the real thing!!!

Critical scrutiny of the 3σ papers will save a lot of work.

Focus is shifting: searches will iterate less frequently; tight “legacy” limits from “BSM” measurements will become more important.

Prepare for LHC as a low-energy, precision machine.