# Running bumps

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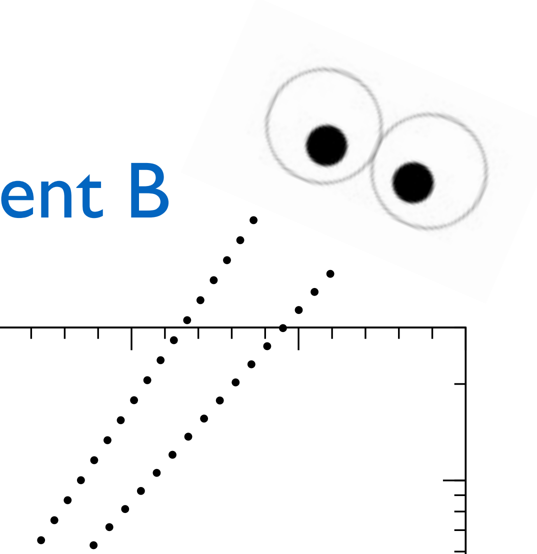
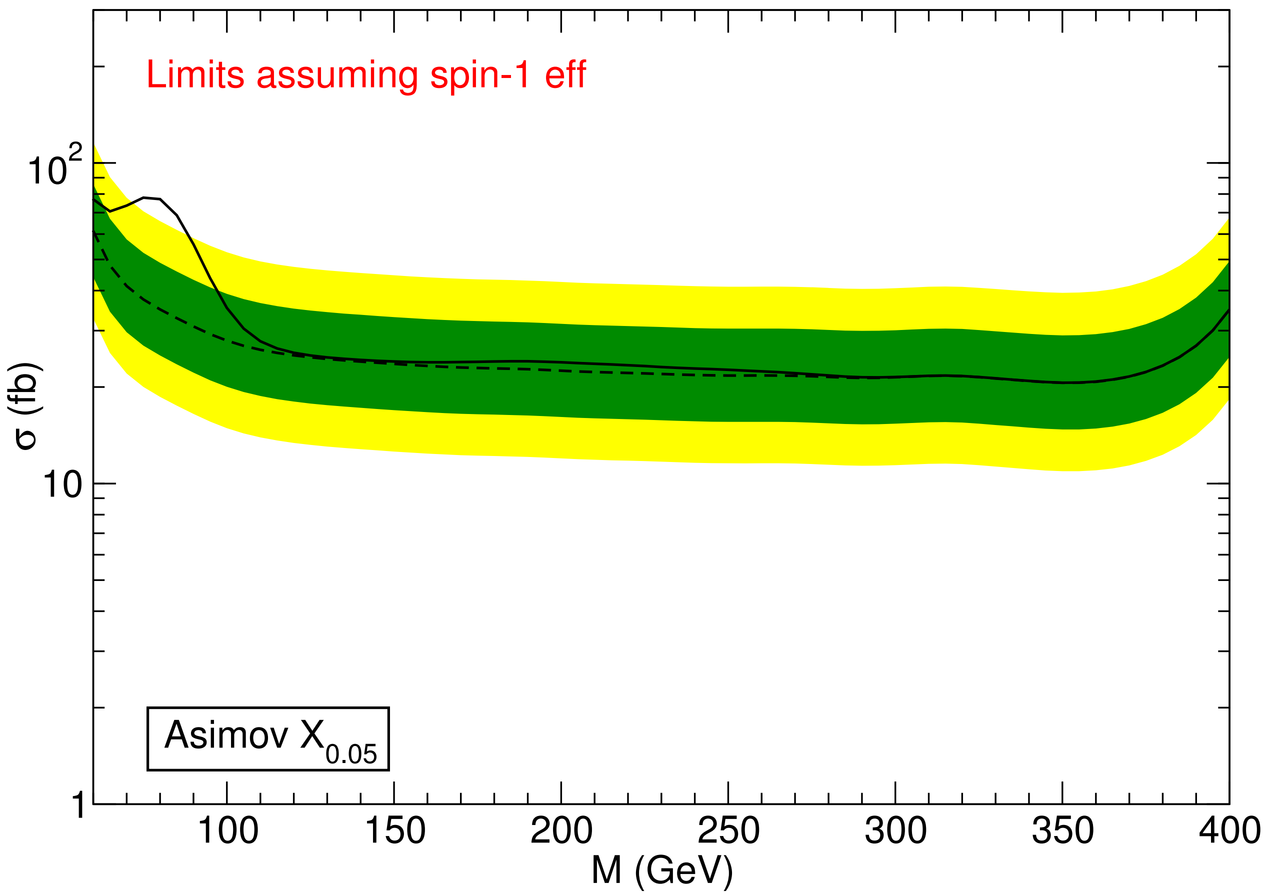
Red LHC 2nd workshop, CIEMAT, May 10th 2018

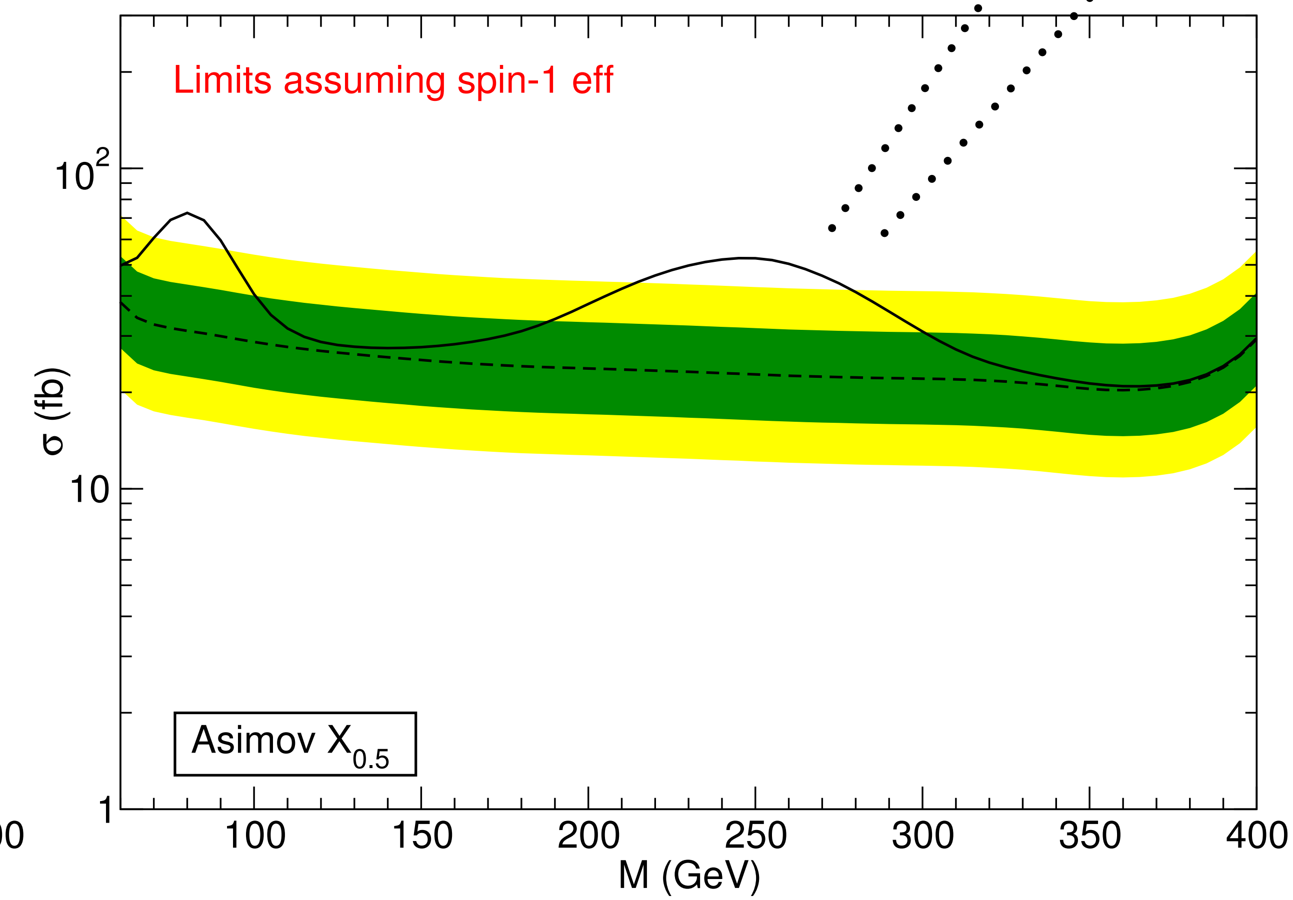
What would be your reaction if you saw experimental results like these?



Experiment A




Experiment B




(1) the bump in experiment B is a fluctuation

(2) experiment A is missing something at 250 GeV

(3) I don't want to hear you talk about bumps anymore, I'm pro-SM

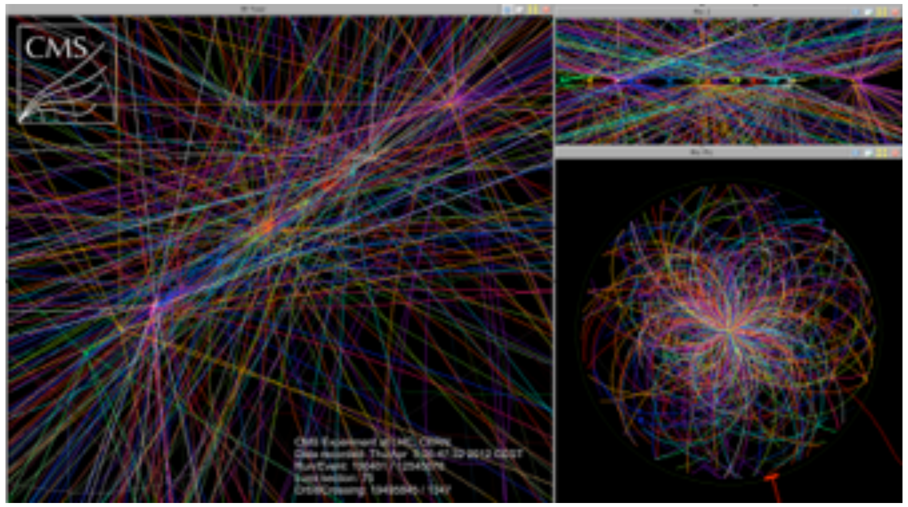
It is not a fluctuation.

It is just one example of the consequences of the `bump running effect´ described in 1705.07885 and 1801.08129.

This shocking effect may happen in analyses involving complex objects such as boosted jets in case an experiment finds something which is not what they look for.

Which is a possibility that definitely must be considered, because for many years the experiments have not found what they look for.

# LHC needs cleaning!

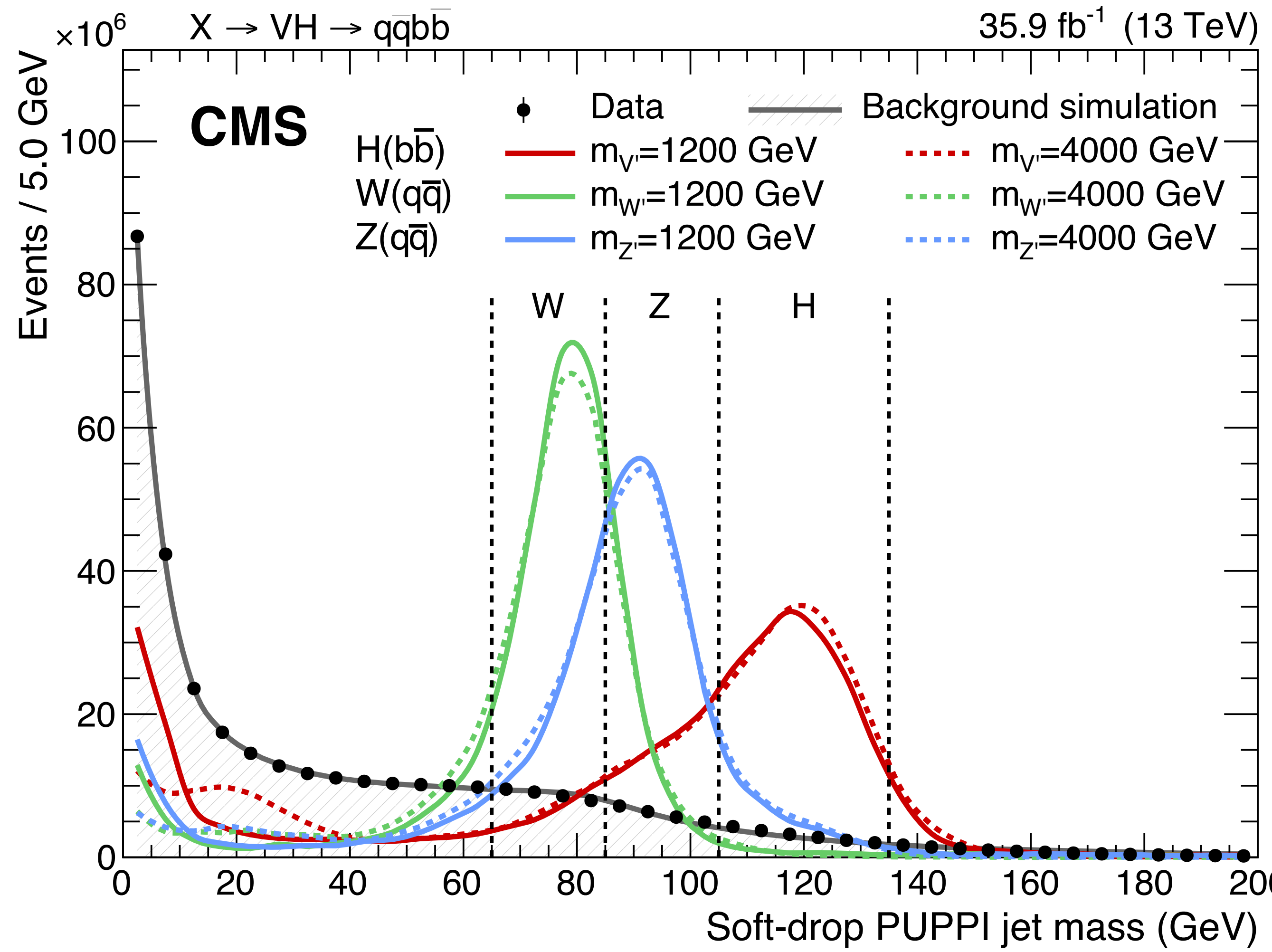


Before computing the jet mass, some *grooming* is performed to eliminate extraneous stuff

[ISR, multiple interactions and pile-up]

Several grooming algorithms in the market, which work well for *W*, *Z* bosons.

Butterworth et al 0802.2470
Krohn, Thaler, Wang 0912.1342
Ellis, Vermilion, Walsh 0912.0033
Larkoski et al. 1402.2657

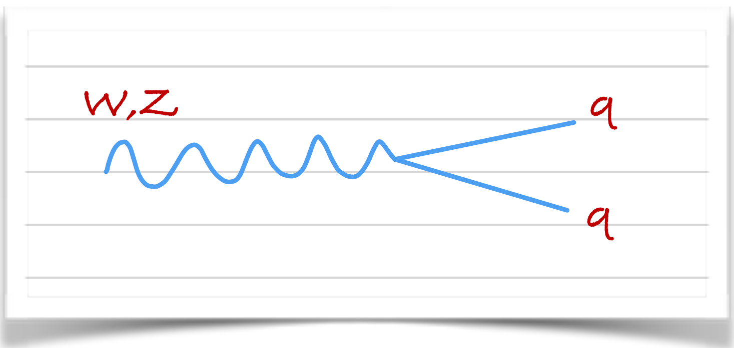


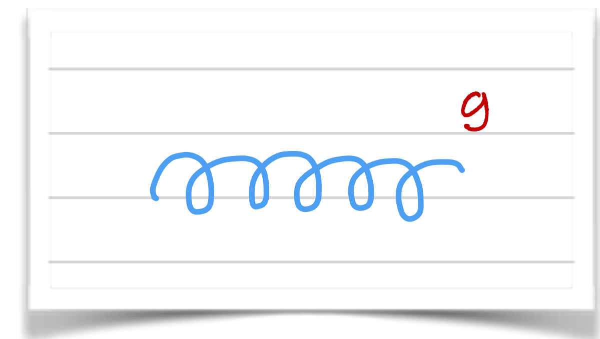

Jets are tagged as *W*, *Z* or *H* depending on their mass, in a somewhat abritrary way

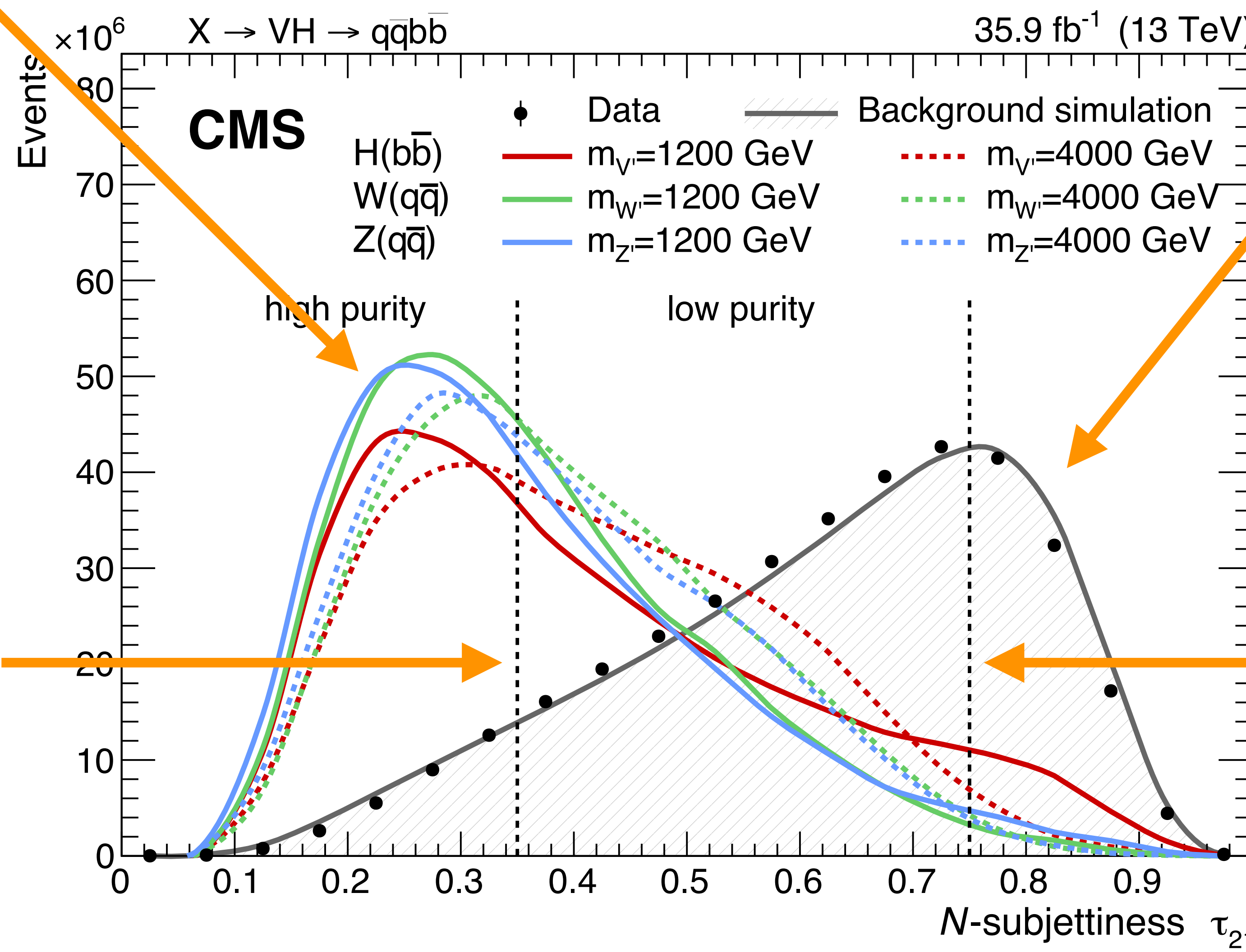
# Jet substructure

It is required that jets <u>look like they have two prongs</u> by using some jet substructure variable, e.g. $\tau_{21}$ (CMS), $D_2$ (ATLAS), …

Thaler, van Tilburg 1108.2701
Larkoski, Salam, Thaler, 1305.0007



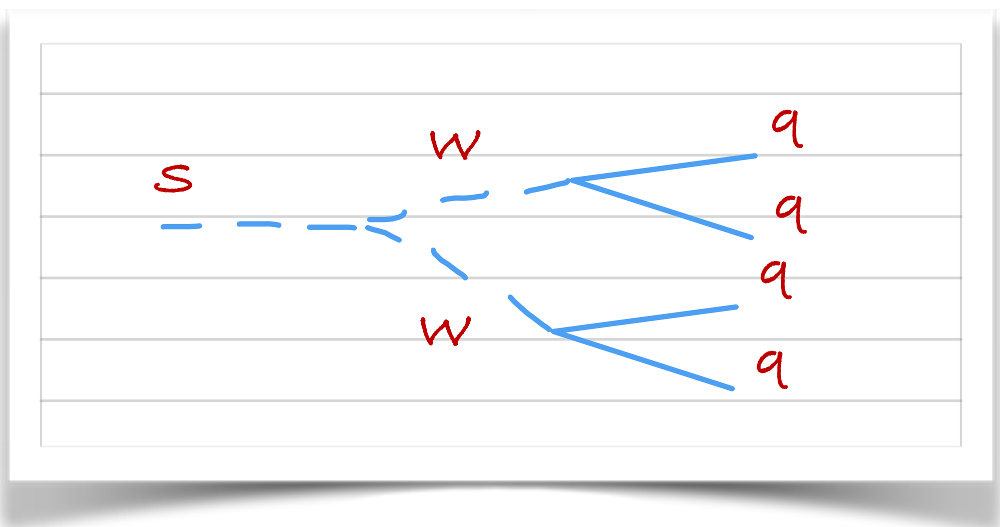

Jets with $\tau_{21}$ below this cut are \`HP tagged´

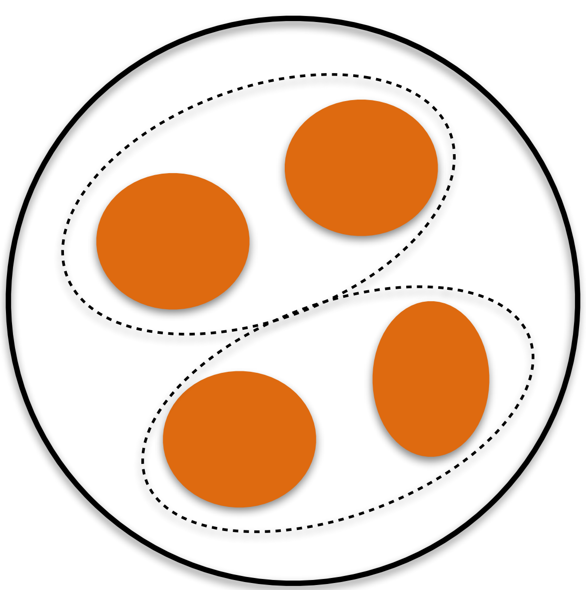
Jets with $\tau_{21}$ below this cut are \`LP tagged´

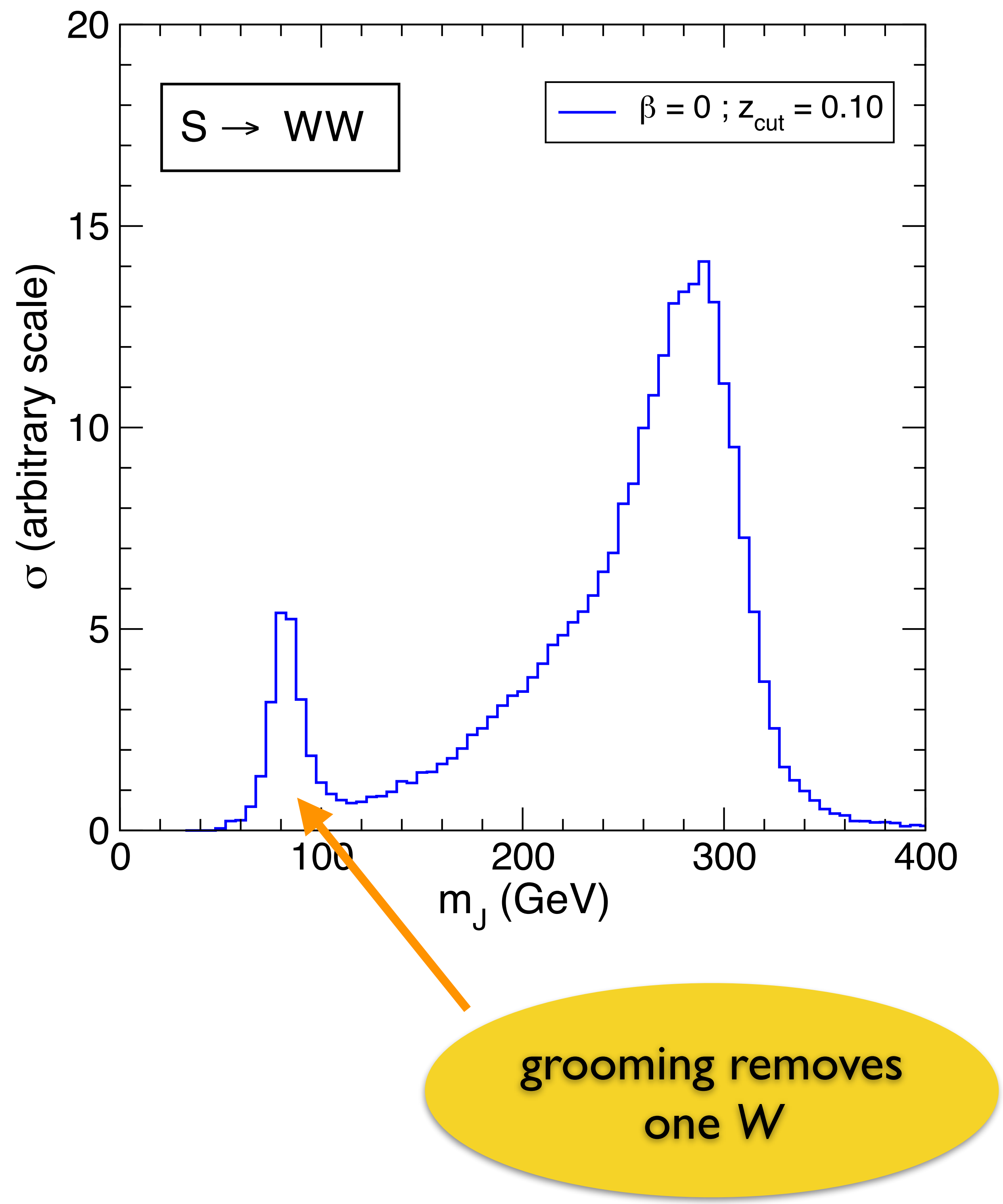
What happens when these tools are applied to four-pronged jets?

In other words, how would a four-pronged signal look in standard analyses looking for two-pronged signals?

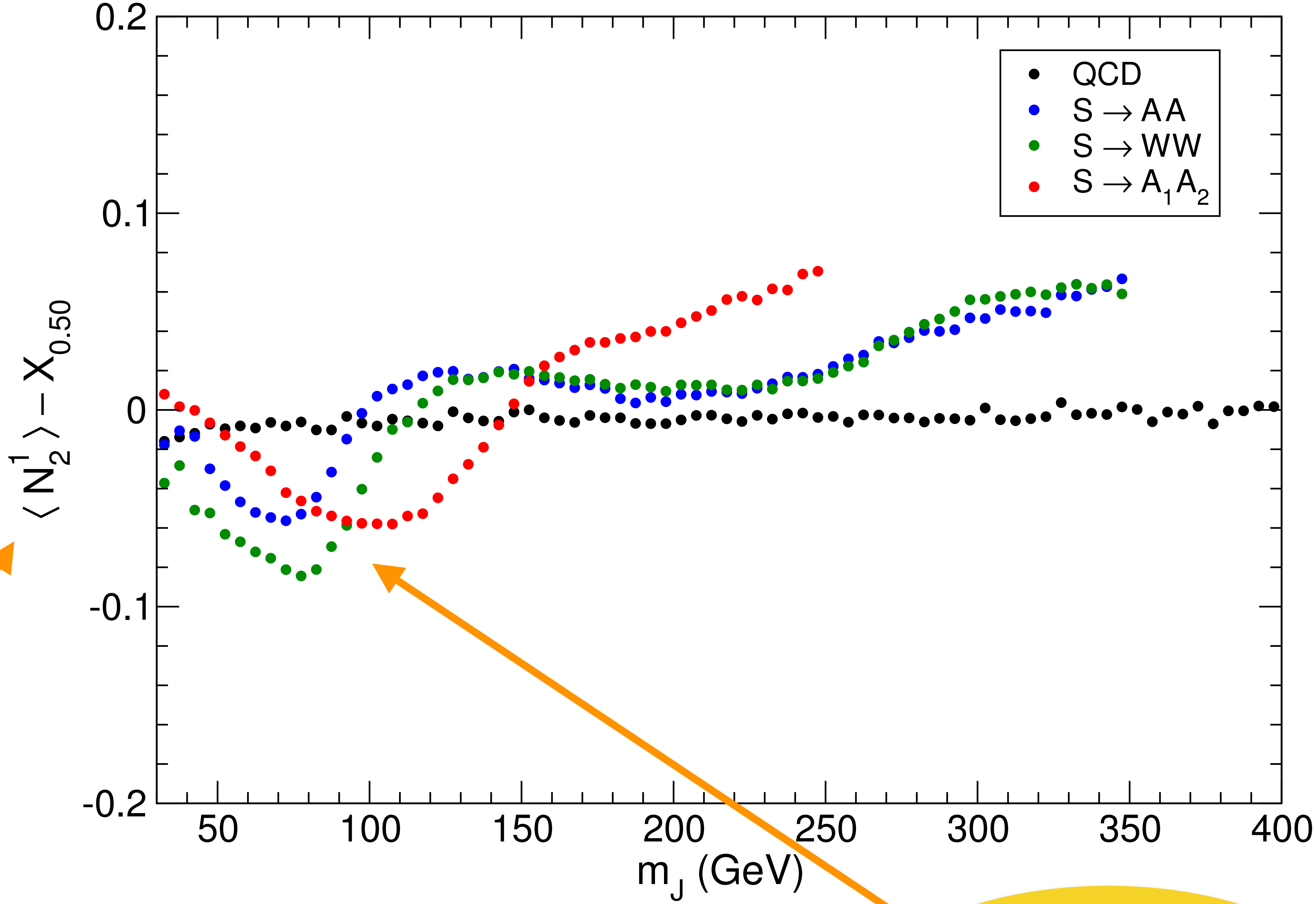
Example:





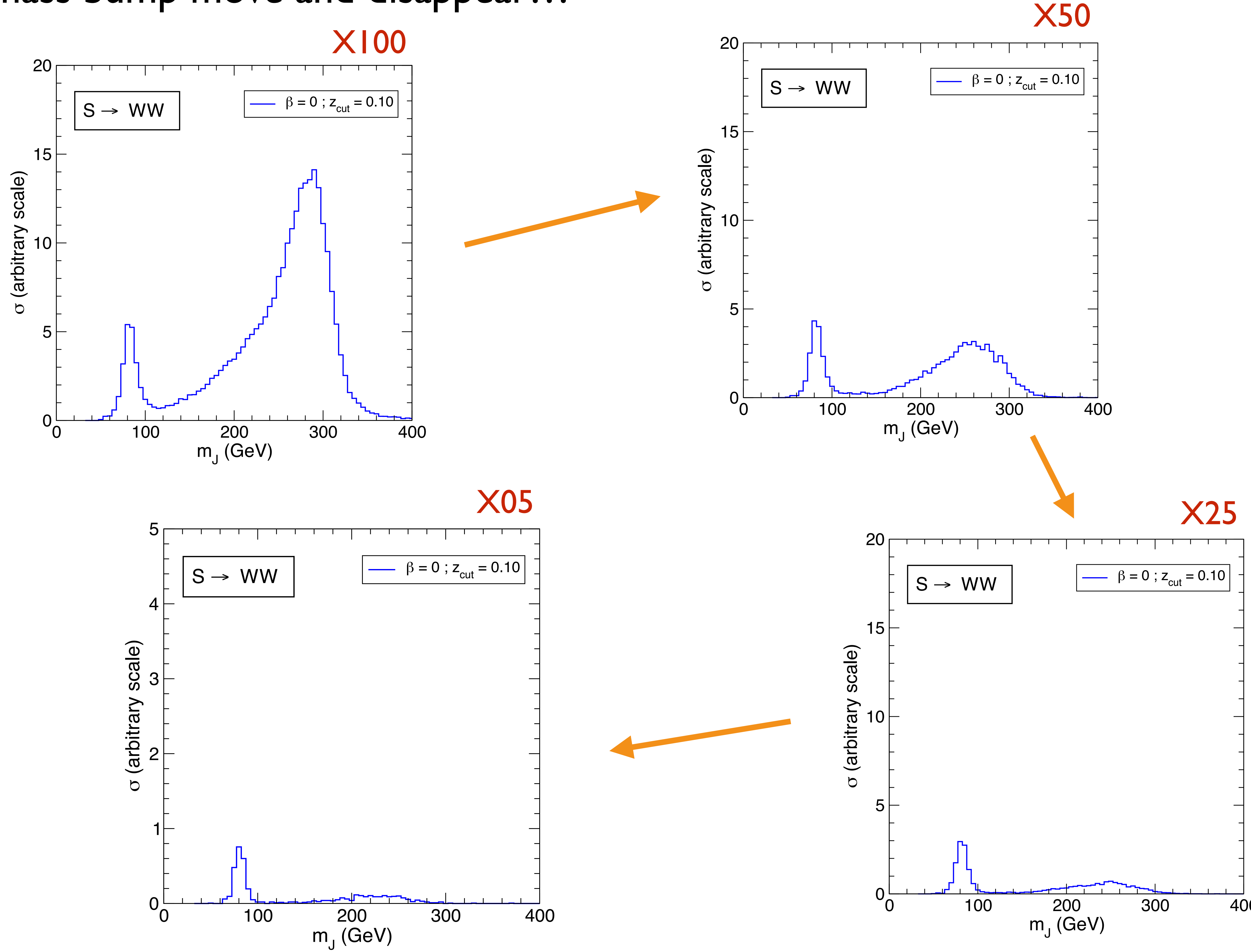
# And how is its groomed substructure?




Decorrelated subtructure variable,
you may ask if you want

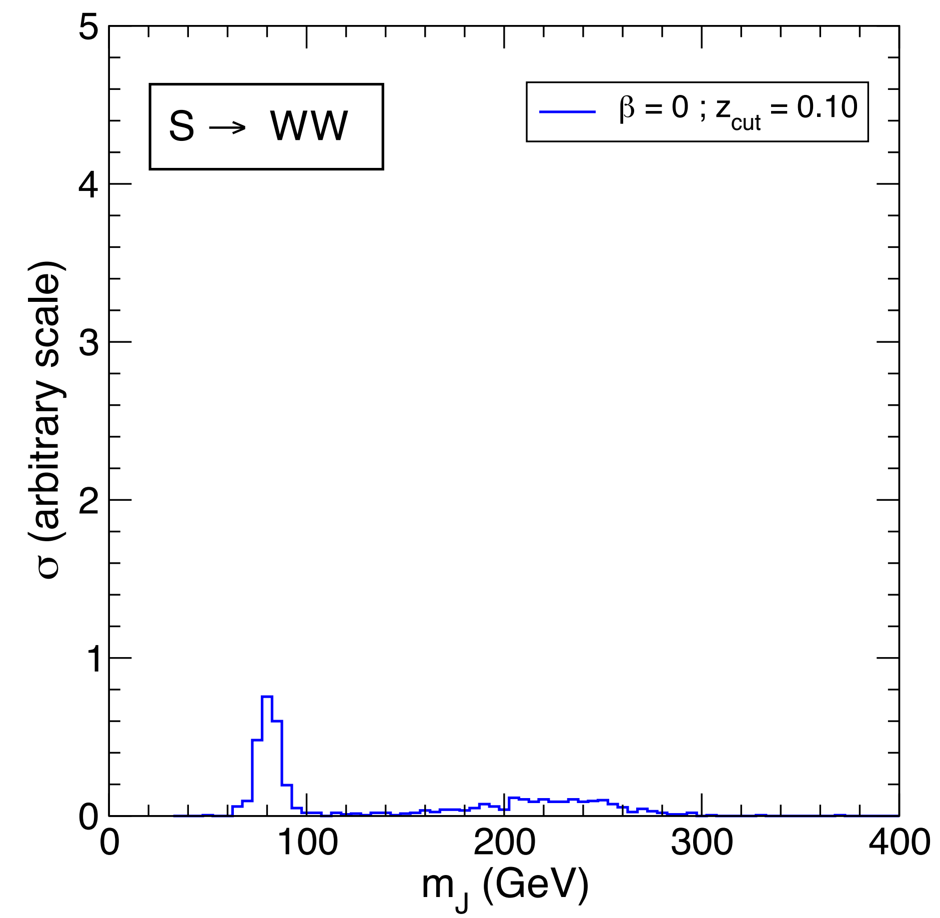
dip when grooming removes one decay product

Therefore, an increasingly harsher cut on groomed $N_2^1$ makes the high-mass bump move and disappear…



# Consequences I:

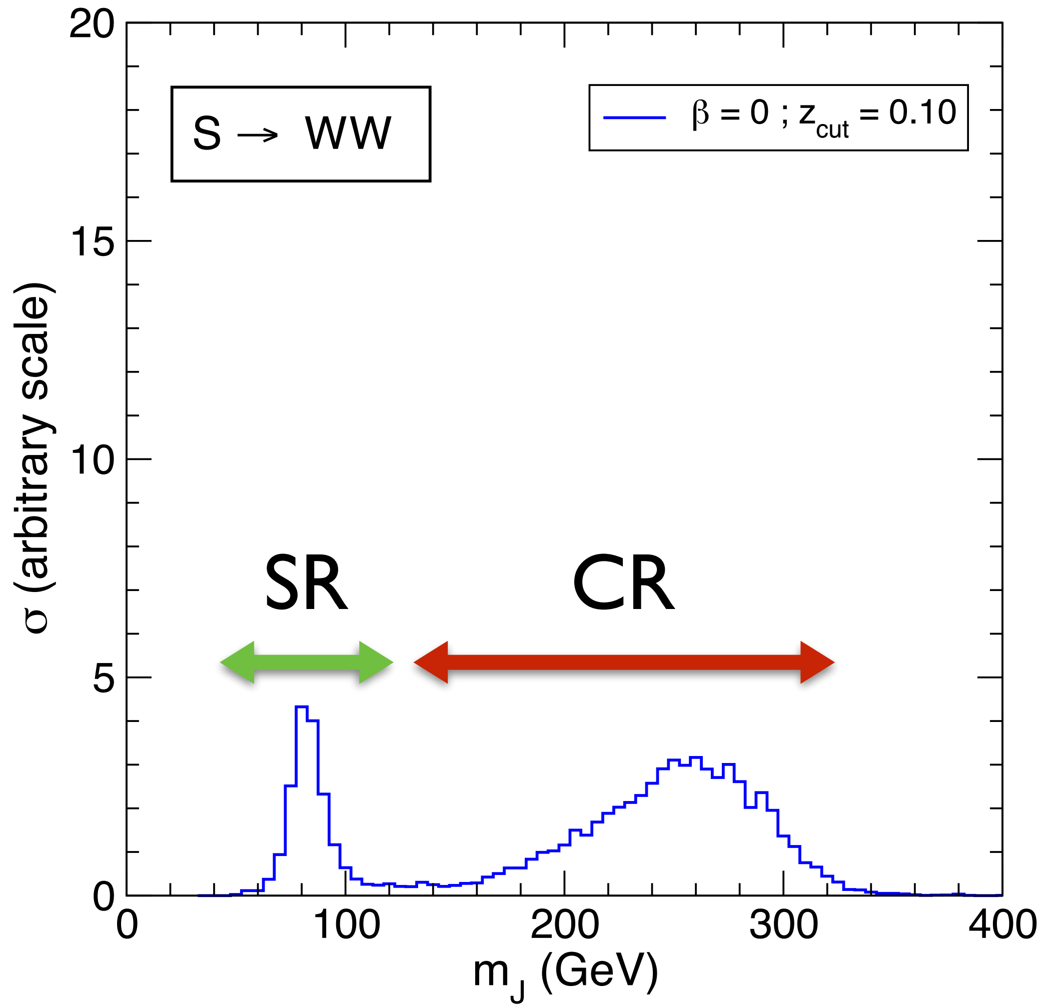
You may have a signal with a `*W*´ (or `*Z*´) that does not decay to leptons.

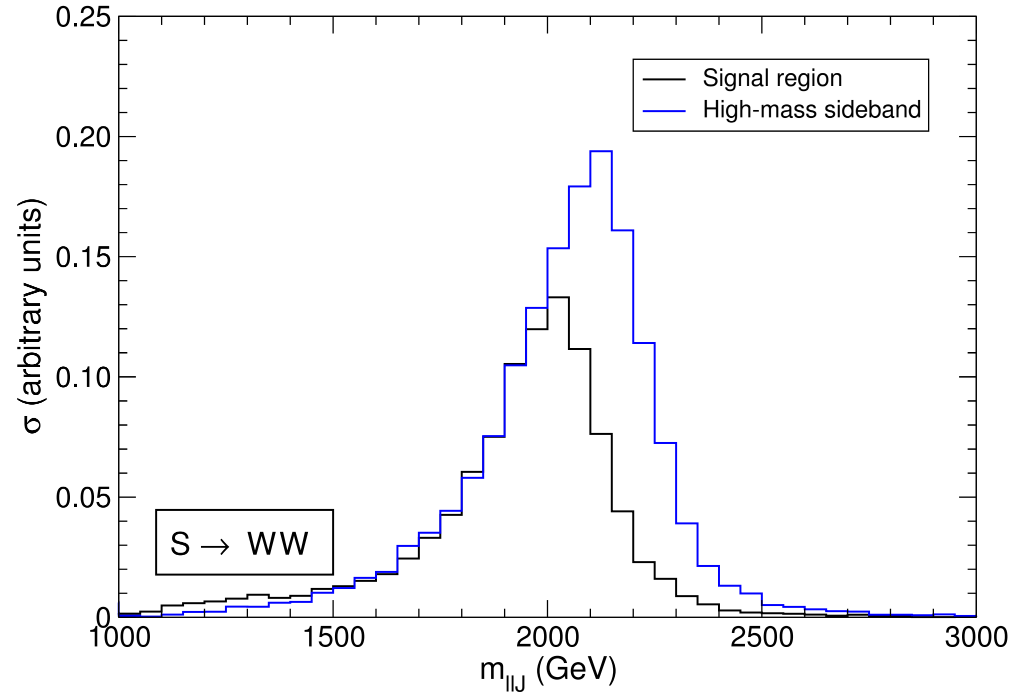



That is, if you look for the sister signal with leptonic decay of *W/Z* you don't find it: $S \to WW$ with one or two leptonic *W* decays doesn't look like $W \to e\nu, \mu\nu$ !

# Consequences II

For looser selections, a freaking signal like this also might seriously pollute the control regions where the background is normalised, yielding unaccountable results… maybe dips in the signal region!

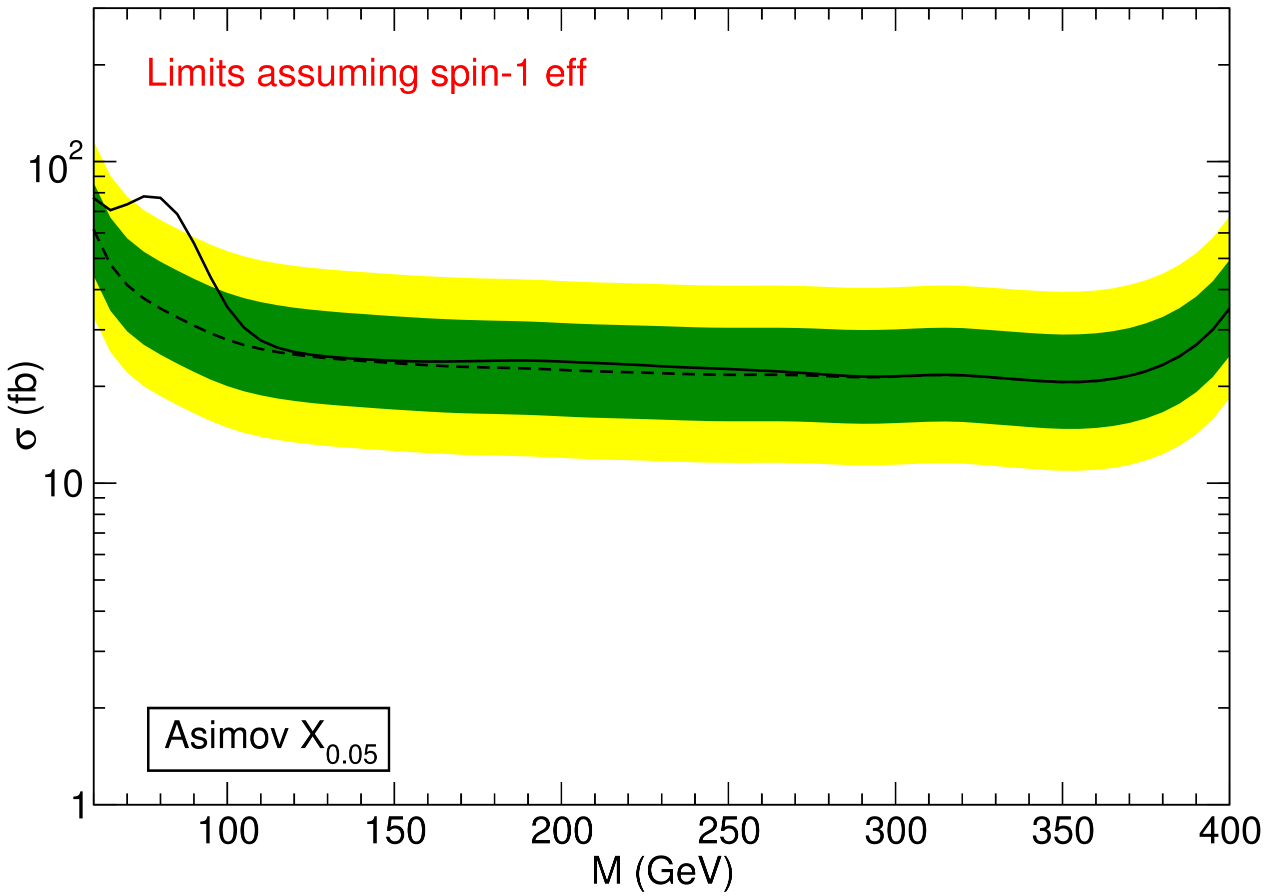


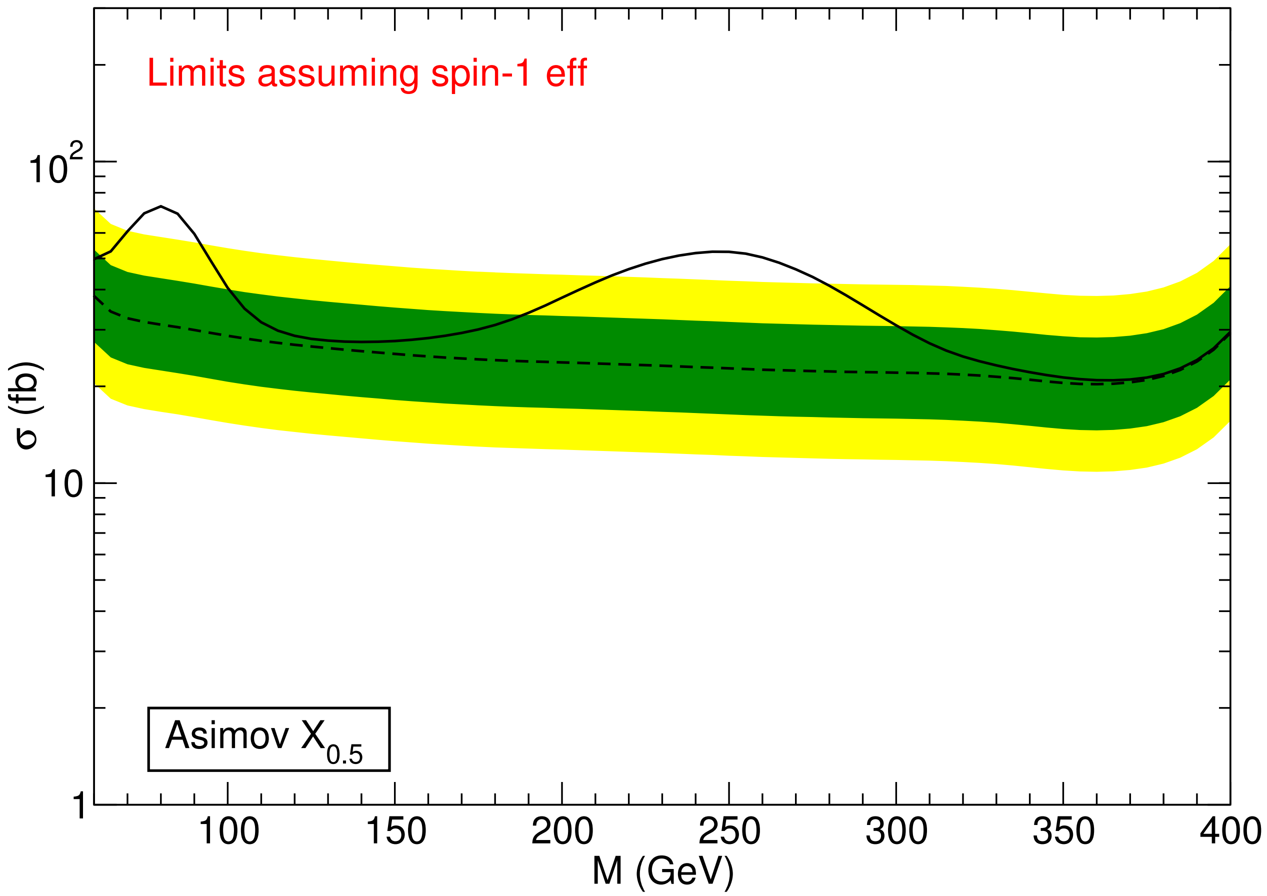




Remember the CDF *Wjj* excess in 2011!

# Consequences III

If you convert your observed limits on σ x eff to limits on σ by assuming the efficiency of some given signal, you can get these notorious differences between different event selections: seen in the first slide.



# Final consequence

There are many caveats in the searches, especially for complicated boosted objects.

New physics can be hiding there. The fact that ATLAS / CMS have not found what they looked for, does not mean that there isn't anything out there beyond the SM and at the reach of the LHC.