A Sneaky Light Stop

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arXiv:1410.7025

Motivation

A minimal SUSY solution to the hierarchy problem requires light stops

Gospel Church Choir Cats Cat Art By Tarafly

There is no (approximate) symmetry to protect the Higgs mass from Quantum Corrections

Naively, the mass receives quadratic corrections to highest mass scale

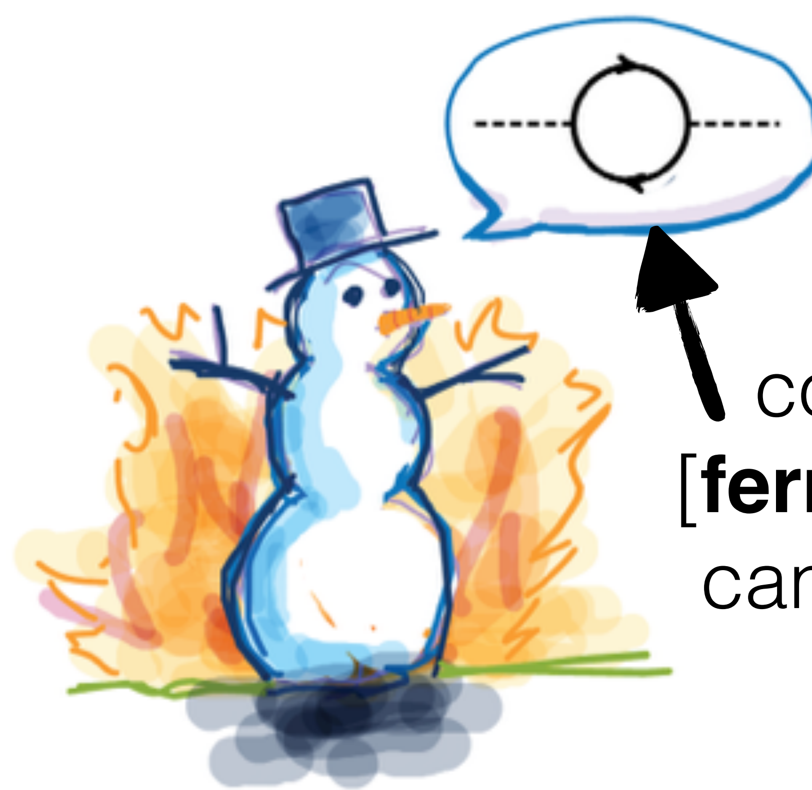
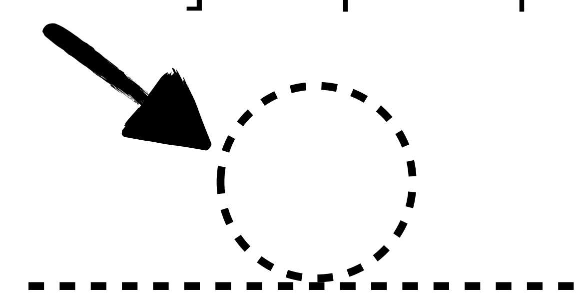


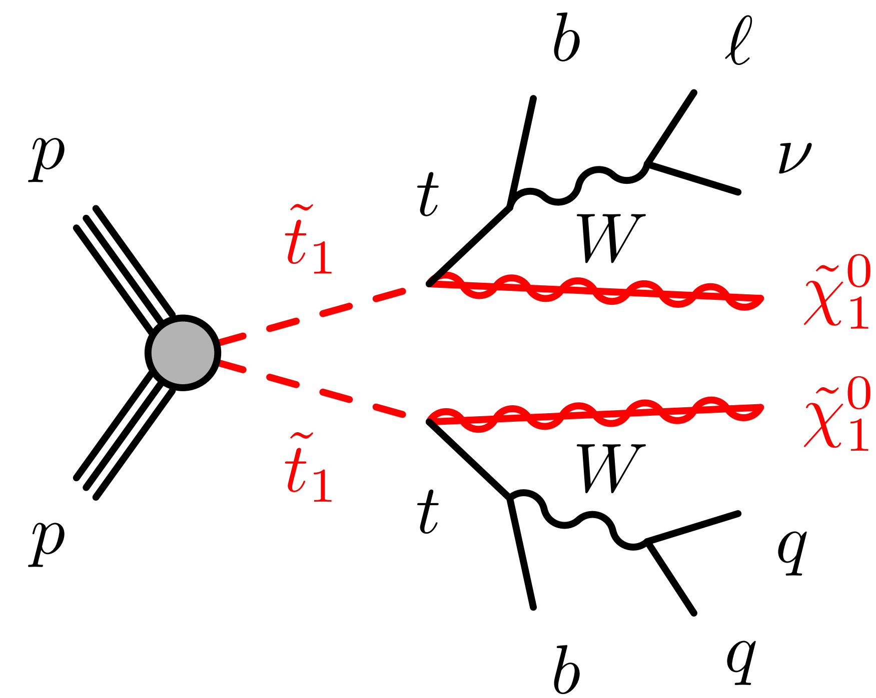
Image from Flip Tanedo (Quantum Diaries)

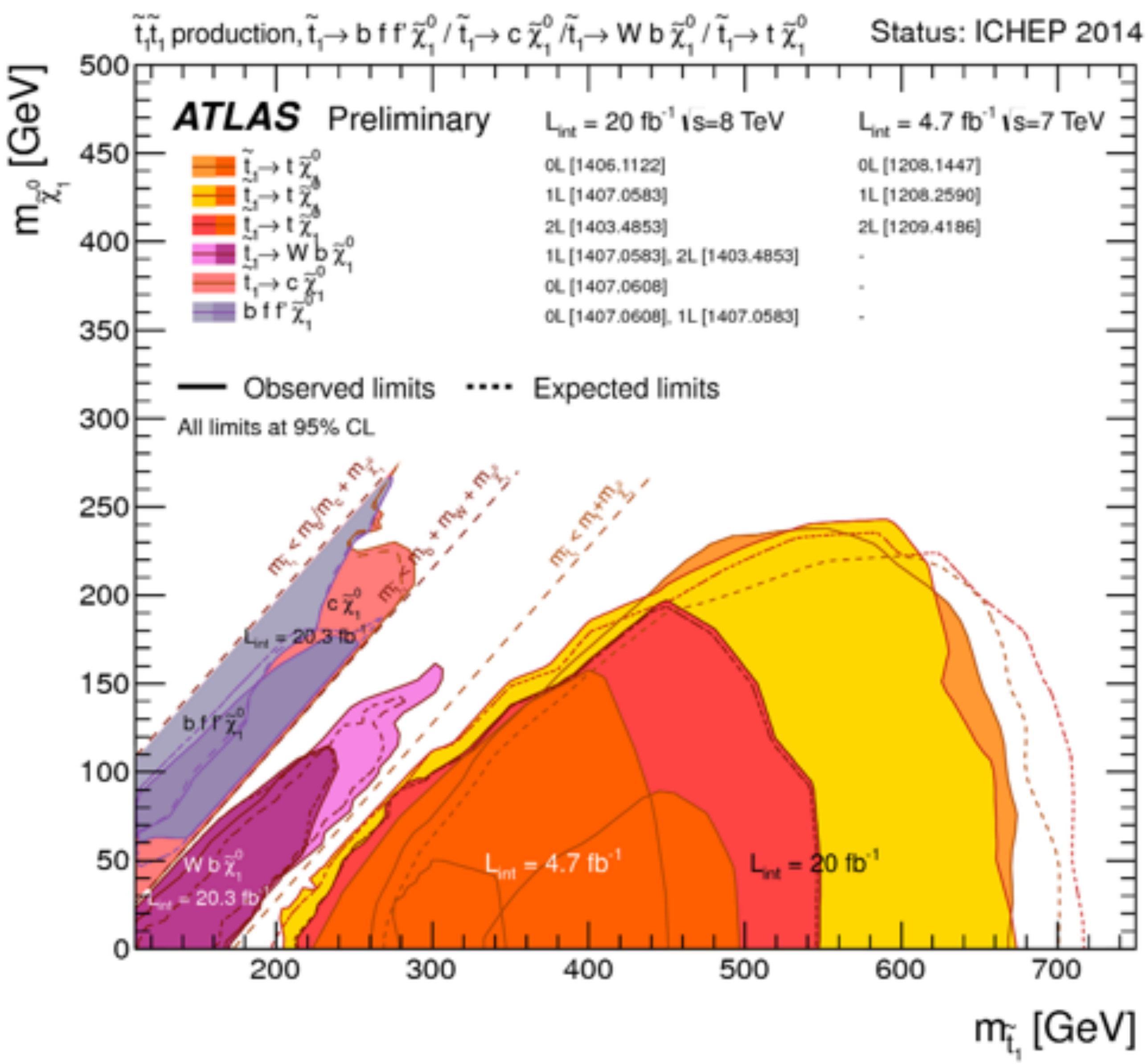
The largest (quantum) contribution comes from the [**fermionic**] top quark loop - can cancel with [**scaler**] stop loops

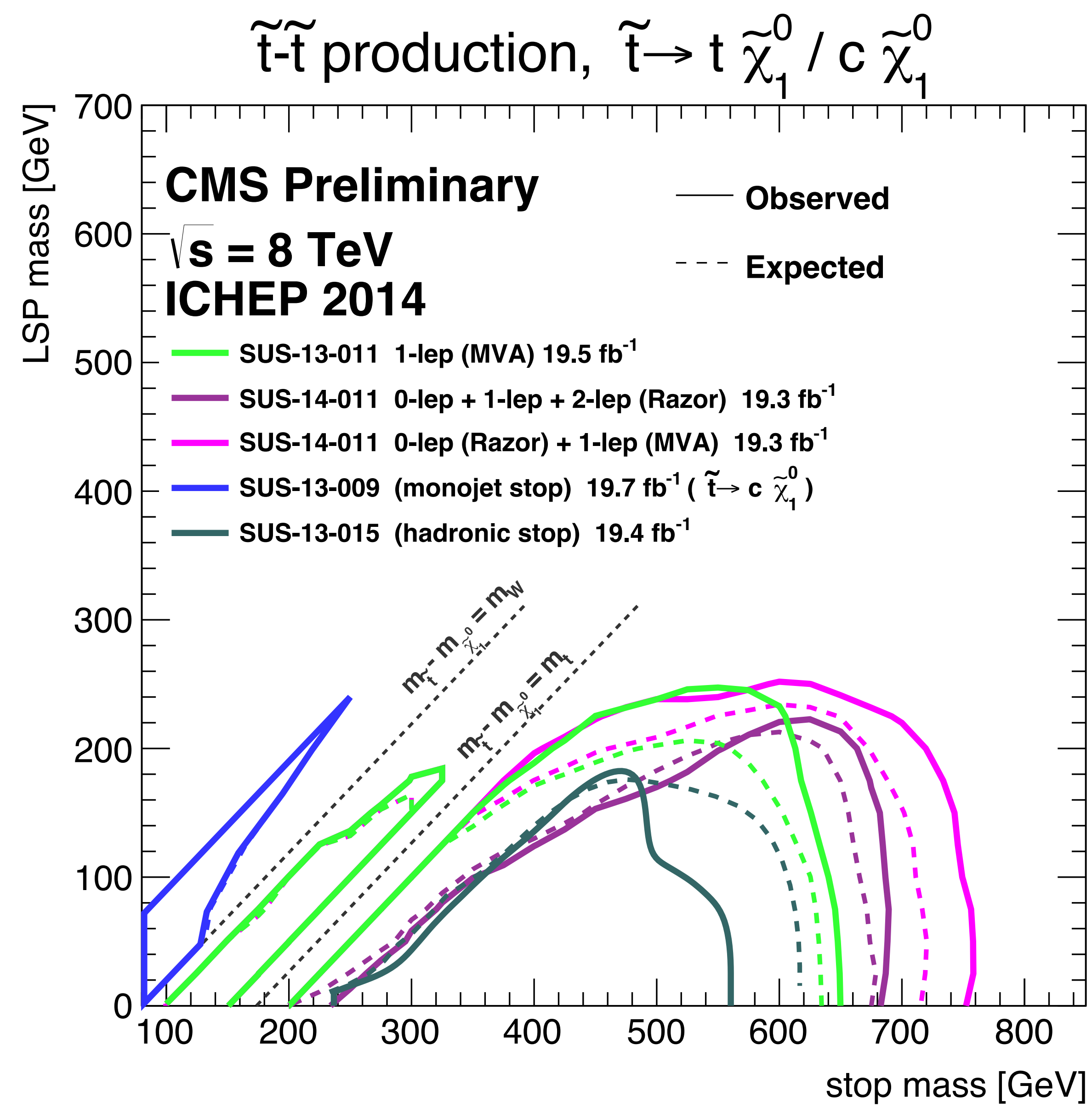


S for ***SU****per****SY****mmetry*

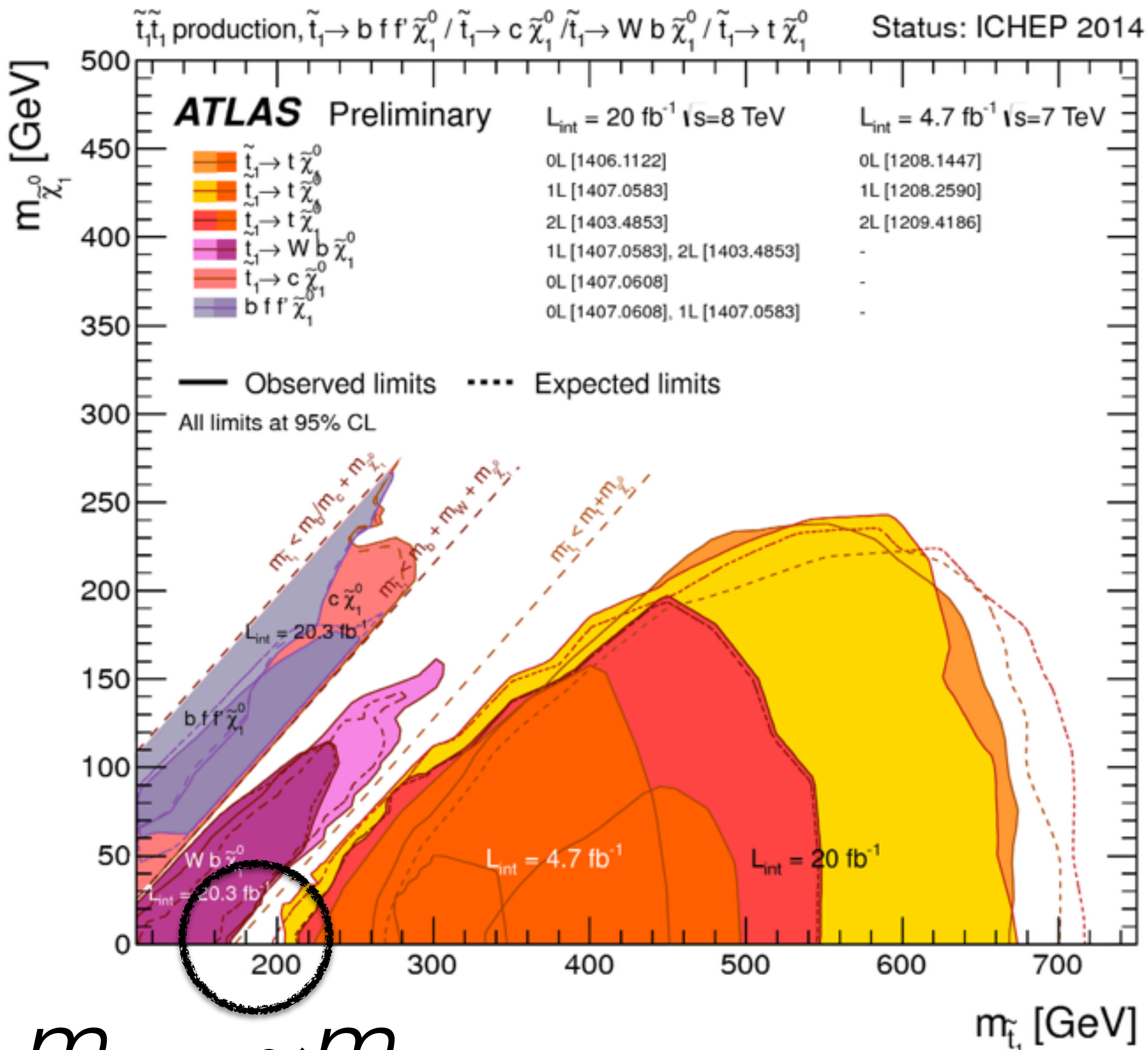
ATLAS *and* ***CMS*** *have a comprehensive program in direct stop searches*







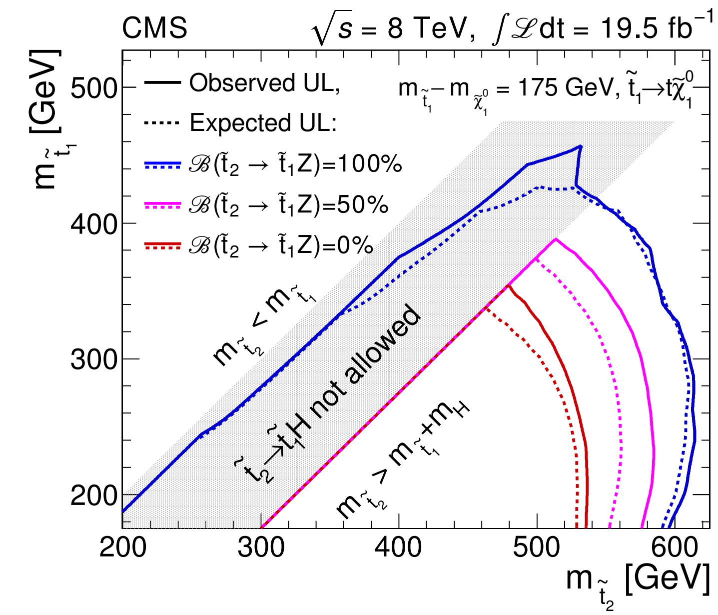
The stealth stop is difficult: looks like the SM!



$m_{stop} \sim m_{top}$

-Three Strategies-

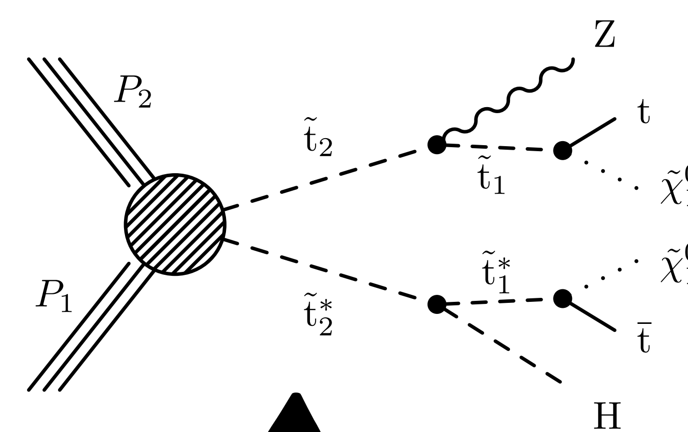
1405.3886

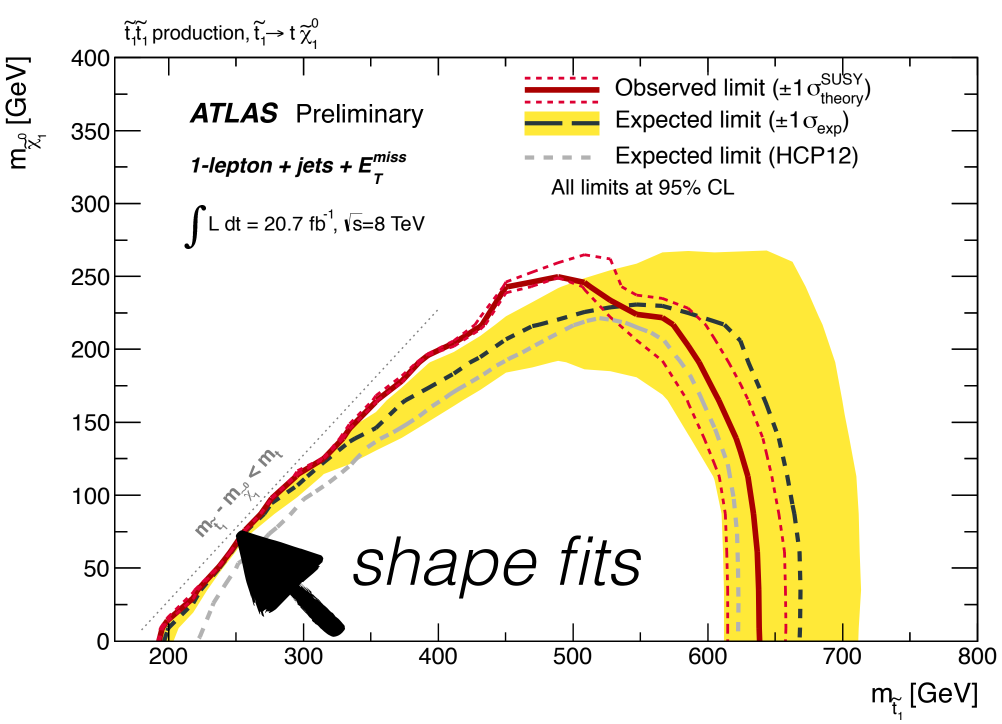


Direct Search

Precision Top Properties

(this talk)



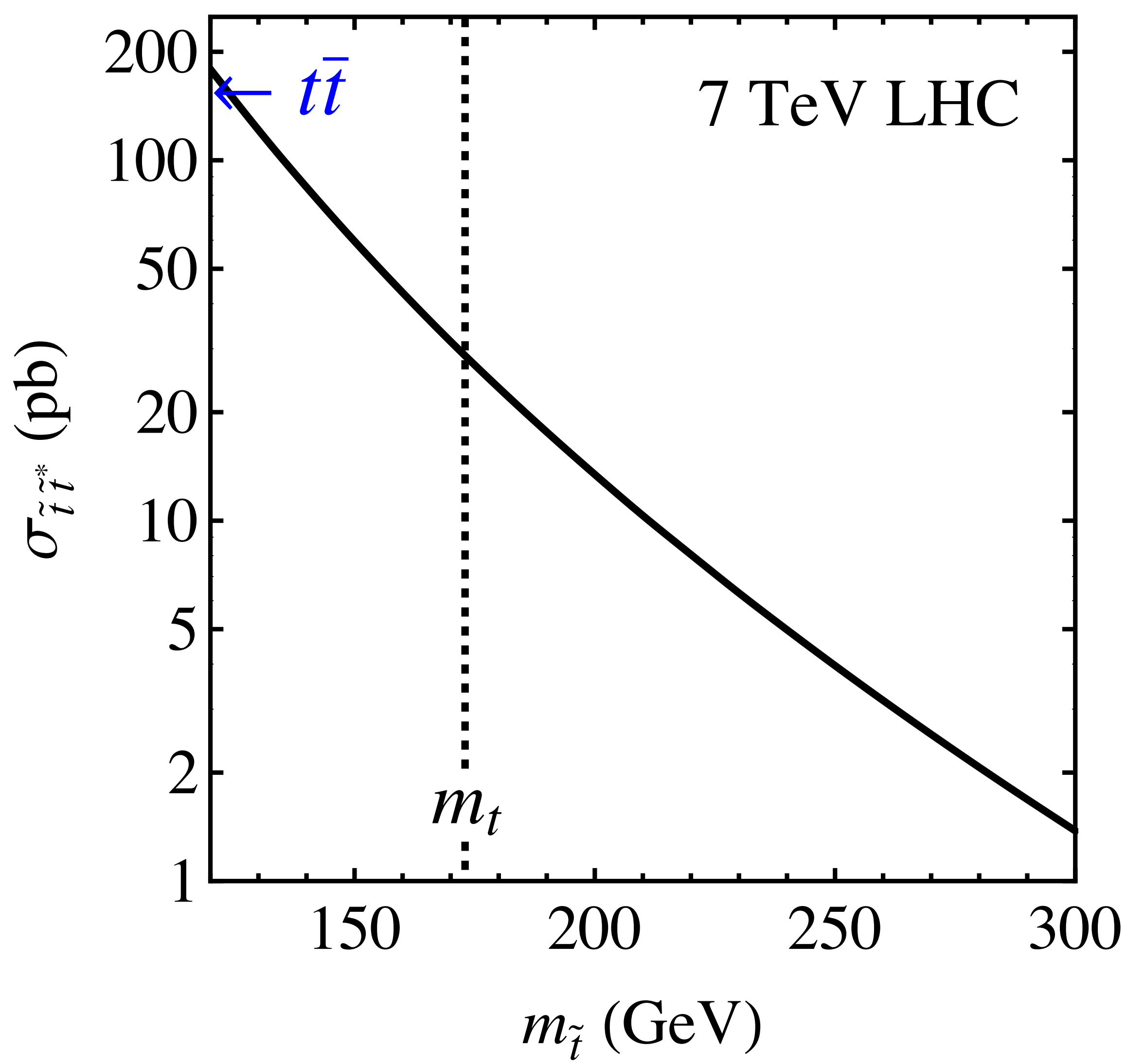


Cascade Decays

The stealth stop is difficult: looks like the SM!

One way forward: Precision top quark properties to complement direct searches

1106.0030



SUSY σ set by the stop mass

Cross Section

$\sigma_{\mathrm{SUSY}} \sim 10\% \times \sigma_{\mathrm{SM}}$

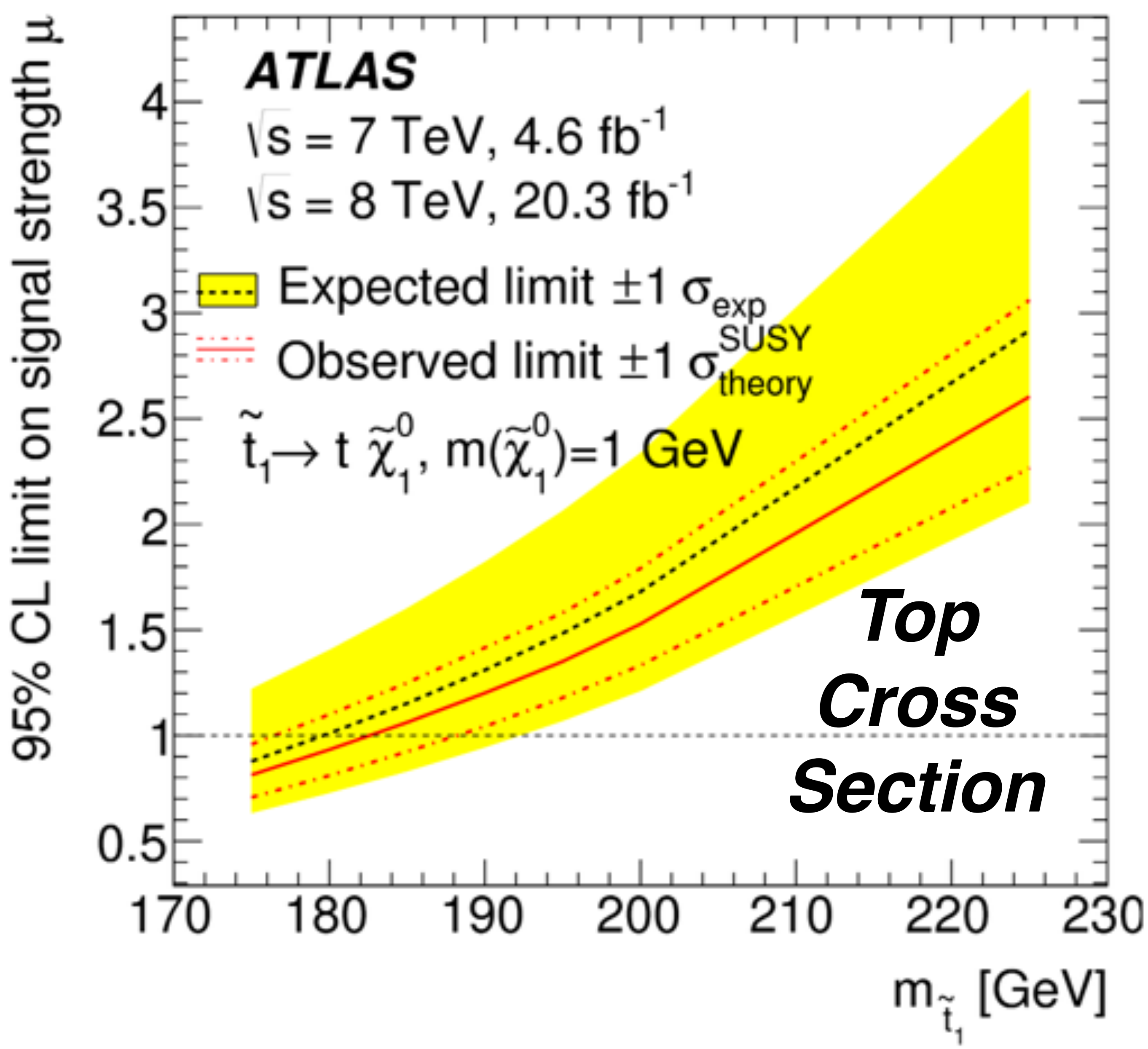
Current experimental precision ~ 4%

Angular Distributions

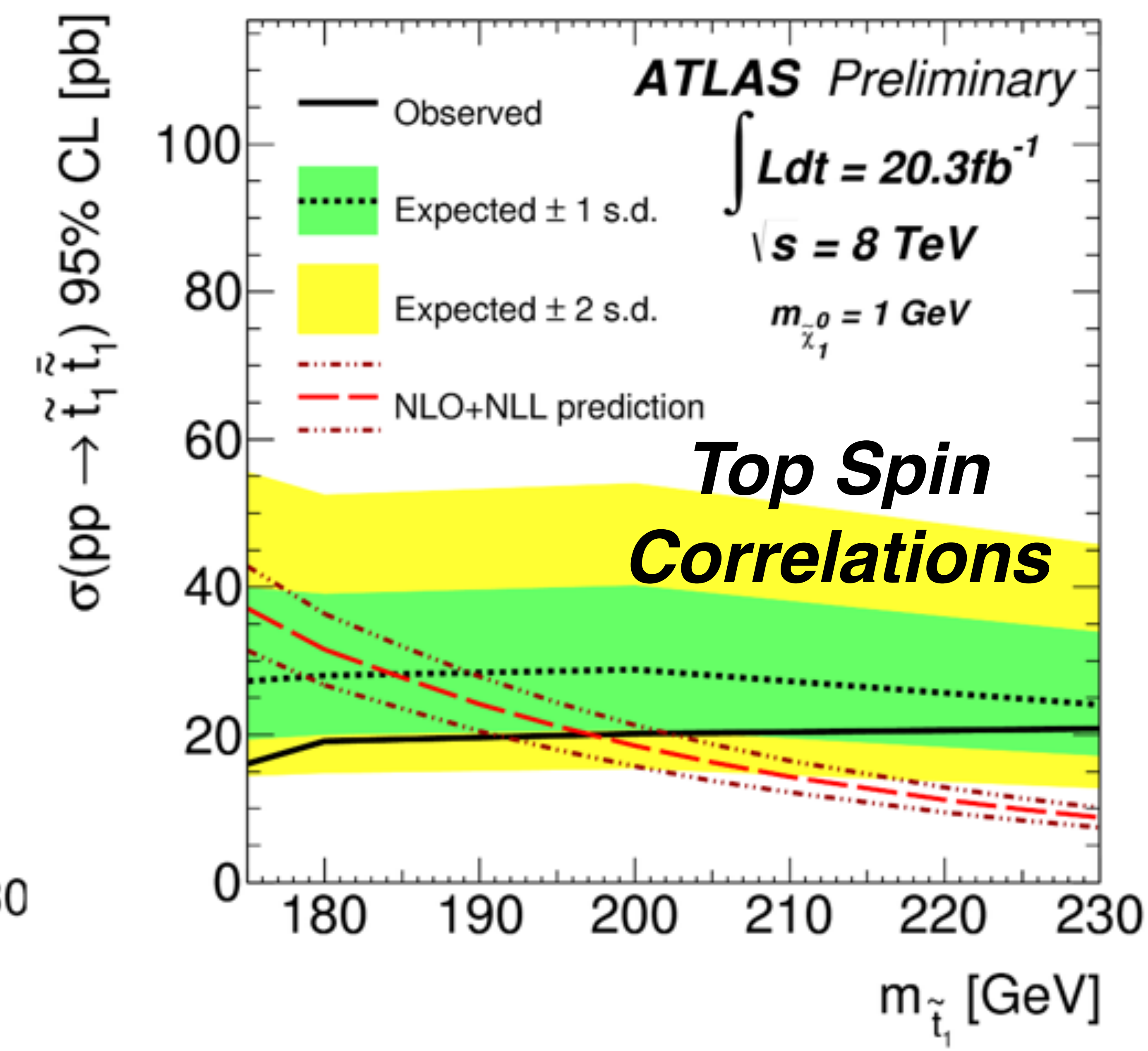
Stop is a scalar; top can be polarized

ATLAS is leading the community on this front: measurements in both cases are used to constrain light stops

1406.5375



ATLAS-CONF-2014-056



$m_{stop} \sim m_{top}$ excluded

Important Assumption: *m_{top} is known*

If there are light stops, they could bias the top mass measurement

The top mass is a parameter of the SM Lagrangian, so we can't use this to find stops

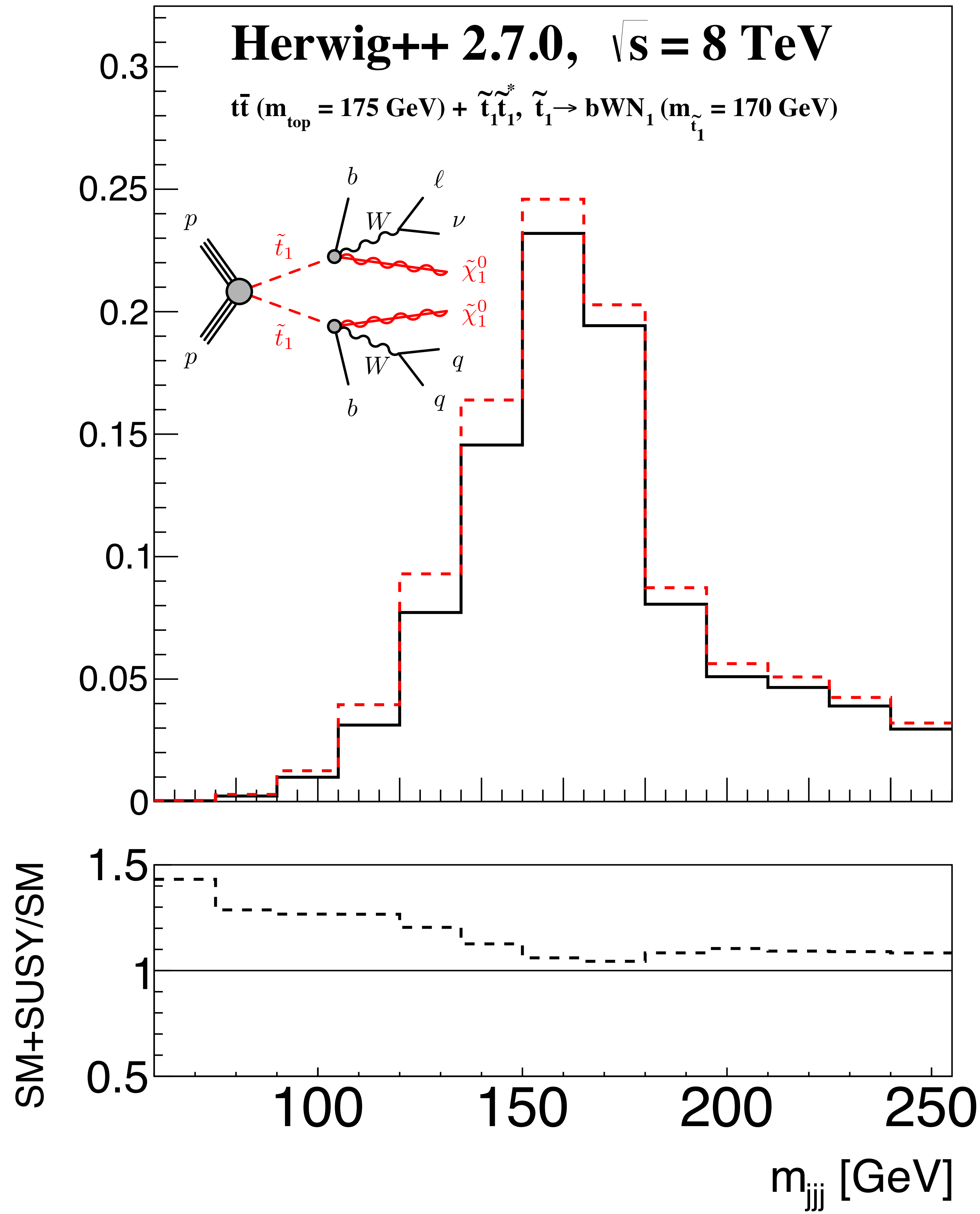
But the cross section prediction depends strongly on the mass!

Light stops can bias the top mass measurements in such a way as to be ***sneaky****:*

1) $m_{top}^{measured} < m_{top}^{truth}$

2) $\sigma_{top}^{measured} > \sigma_{top}^{truth}$

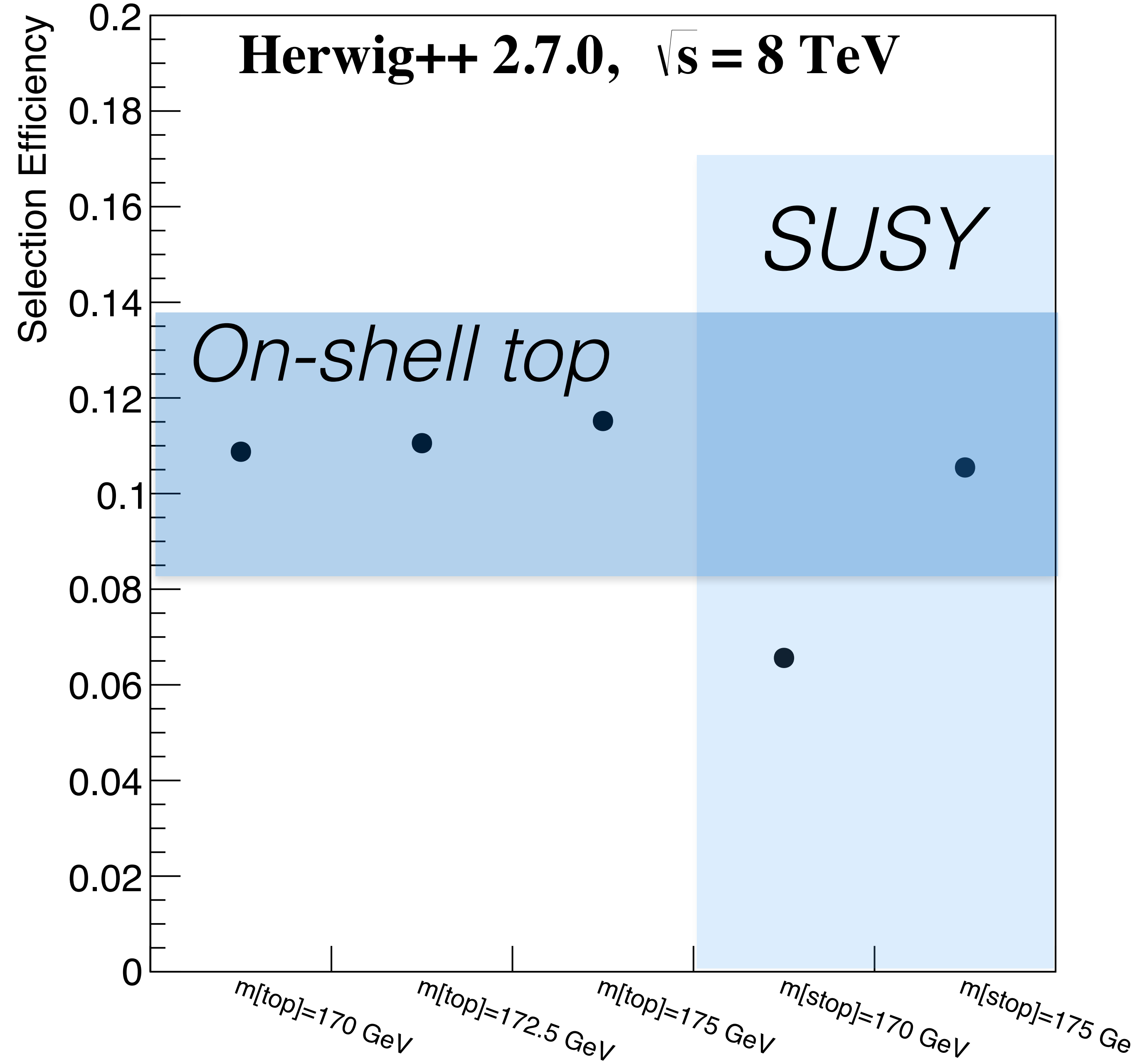
3) $\sigma_{top}^{measured} \sim \sigma_{top}^{truth} + \sigma_{SUSY}$



Feynman Diagrams from 1407.0583

To quantify the existence of ***sneaky*** stops, we simulate SM and SUSY events

Herwig++ nominal
Madgraph+Herwig as a cross-check

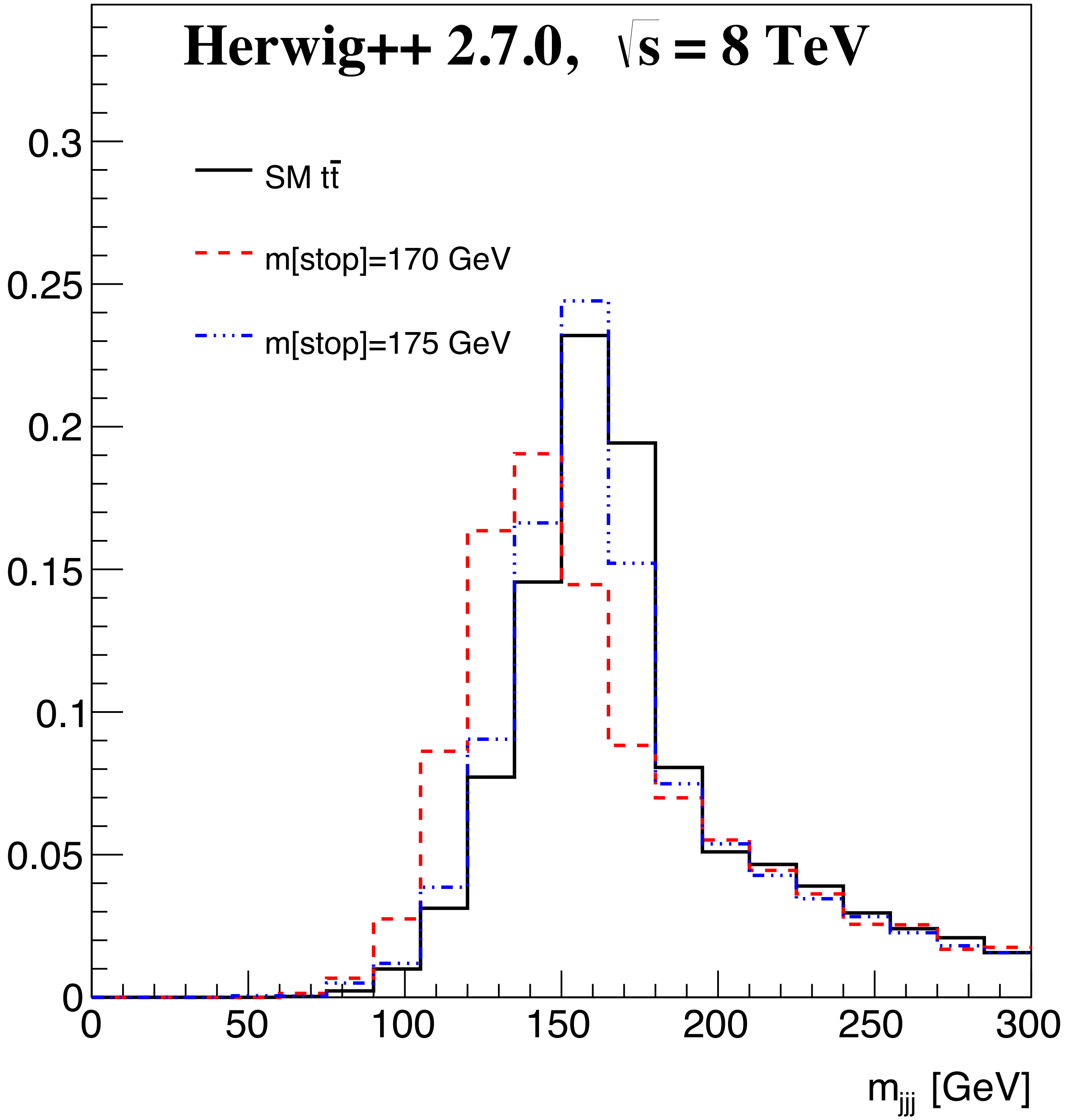


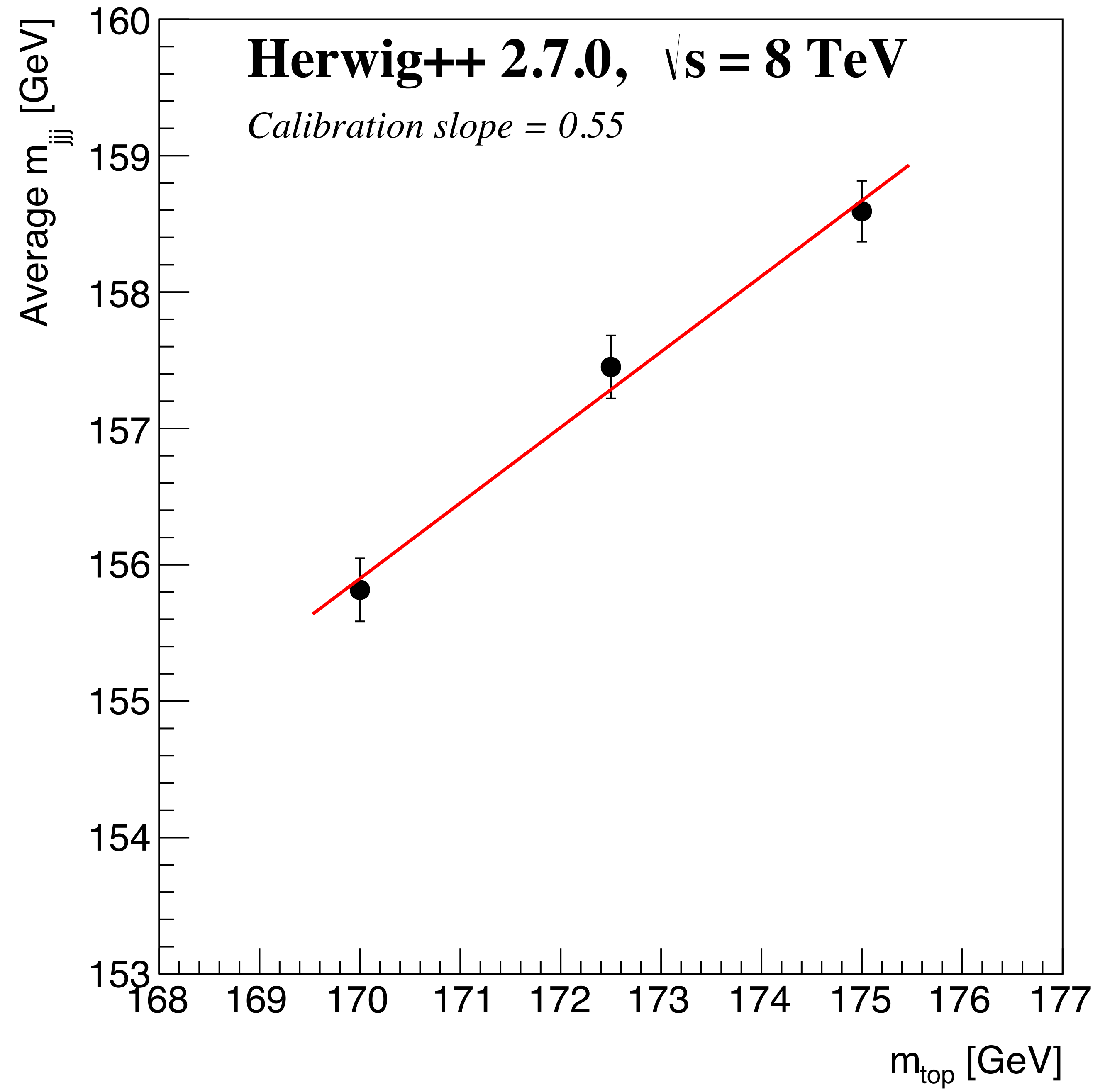
We perform a simple mass measurement, using a χ^2 to create a m_{jjj} observable

$$\chi^2 = \frac{(m_{j_1 j_2 b_1} - m_{b_2 l \nu})^2}{(20\ \mathrm{GeV})^2} + \frac{(m_{j_1 j_2} - m_W)^2}{(10\ \mathrm{GeV})^2},$$

Choose semileptonic events with jets/leptons above a p_T threshold

Mass sensitive observable: $\langle m_{jjj} \rangle = f(m_{top})$

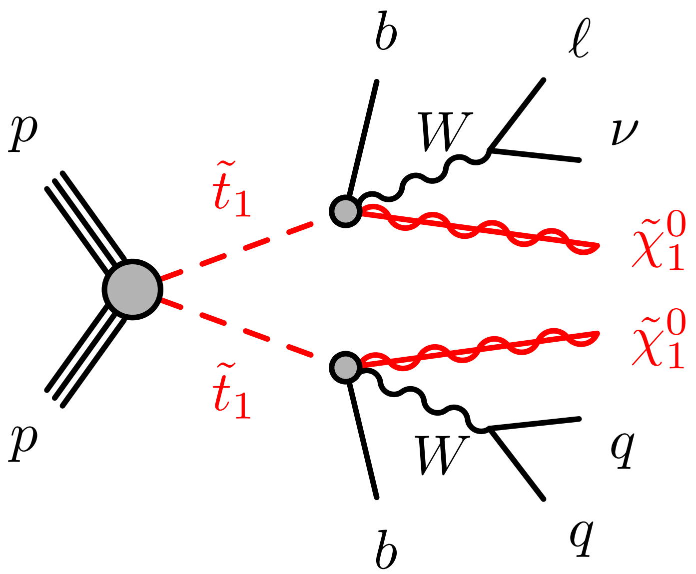




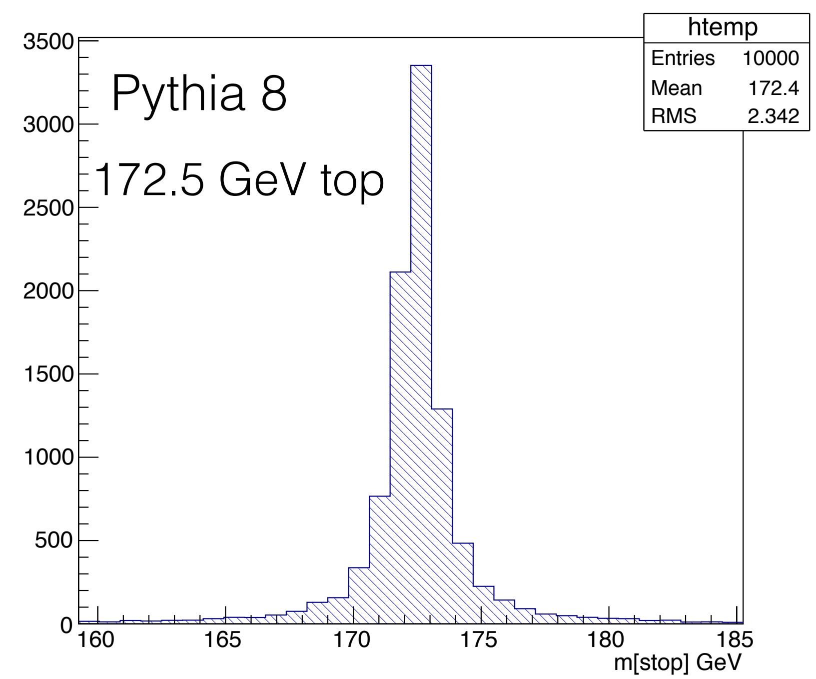
‘Measure’ $\langle m_{jjj} \rangle$ and then invert f to infer m_{top}

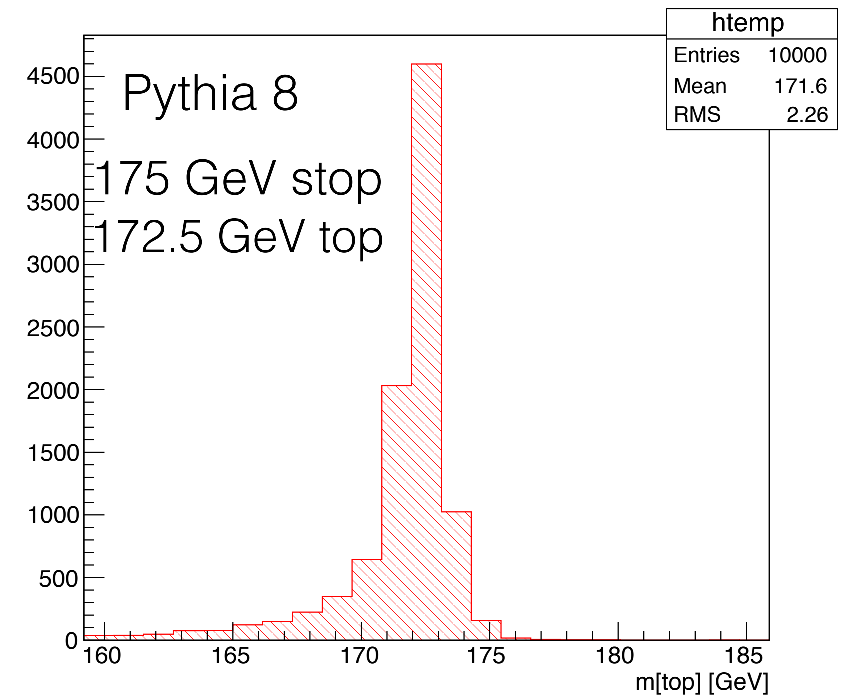
cross-checked with a simple template fit

Origin of (Negative) Biases



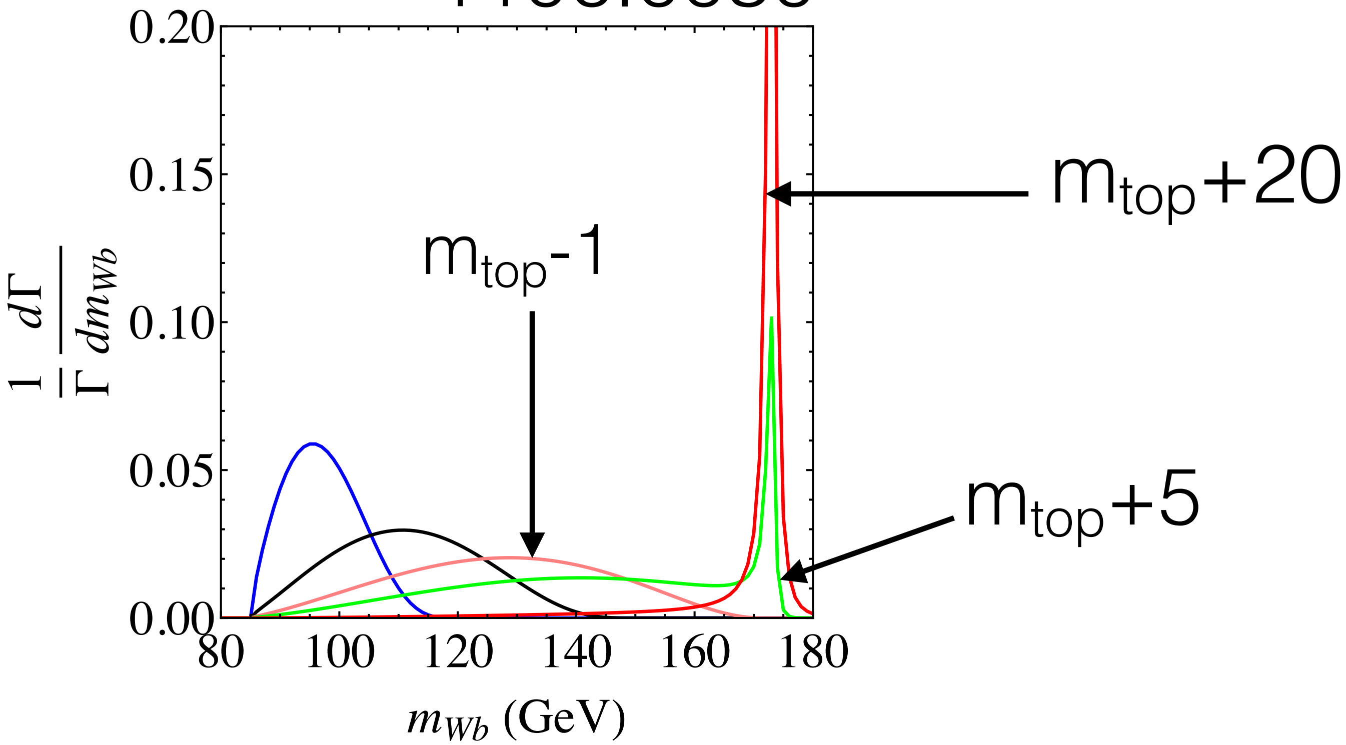
For resonant tops, the BW is sculpted from the finite top/stop widths

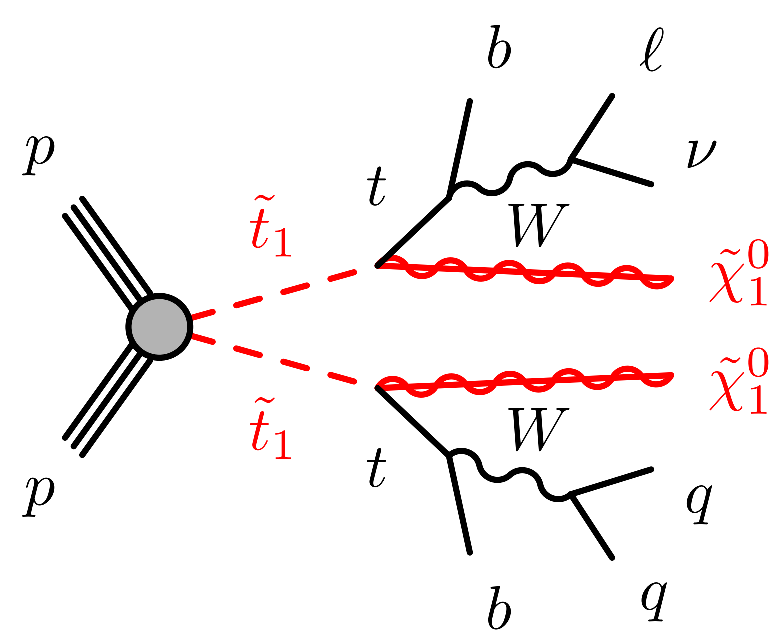




3-body phase space significantly different than for resonant tops

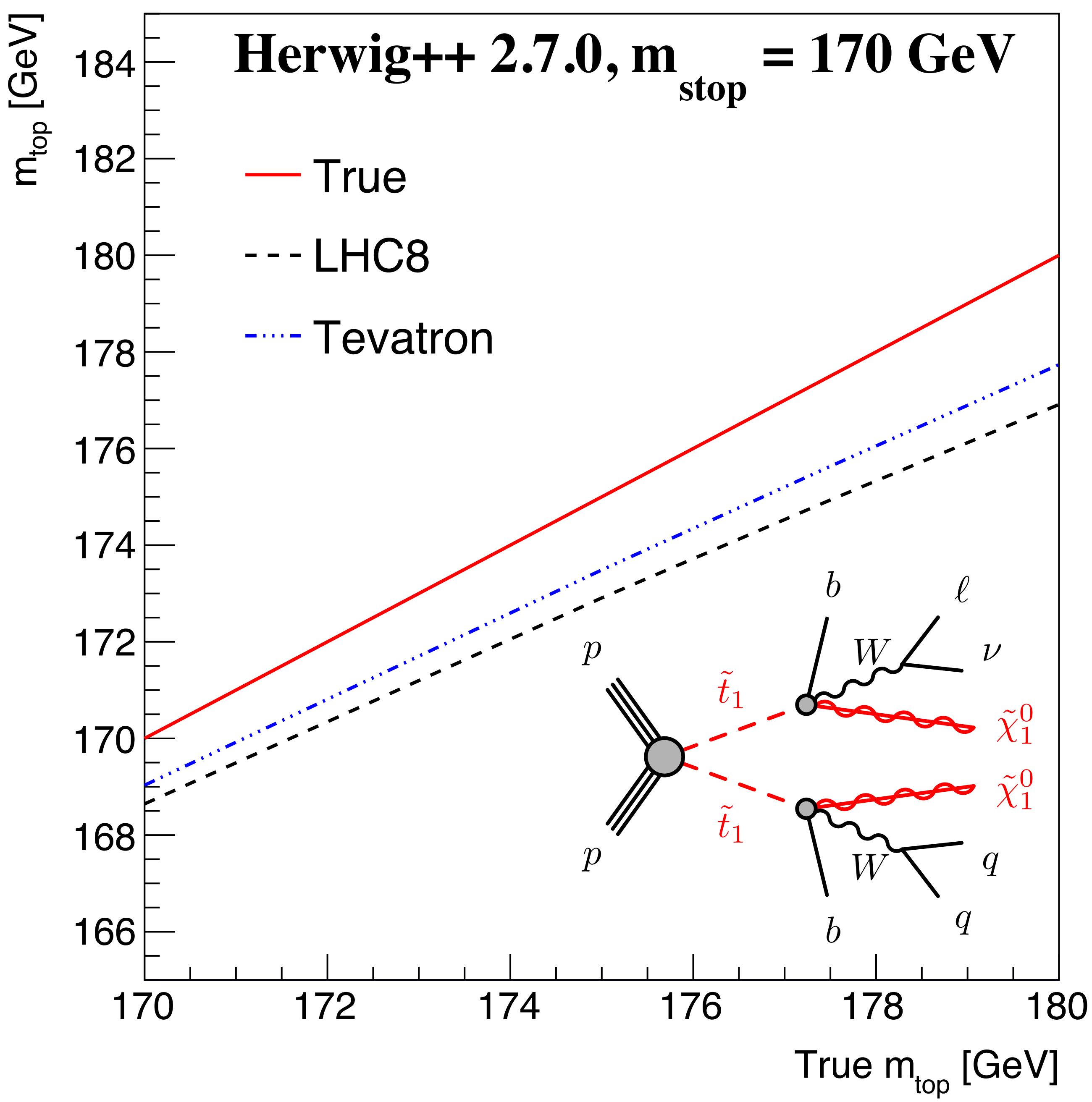
1106.0030

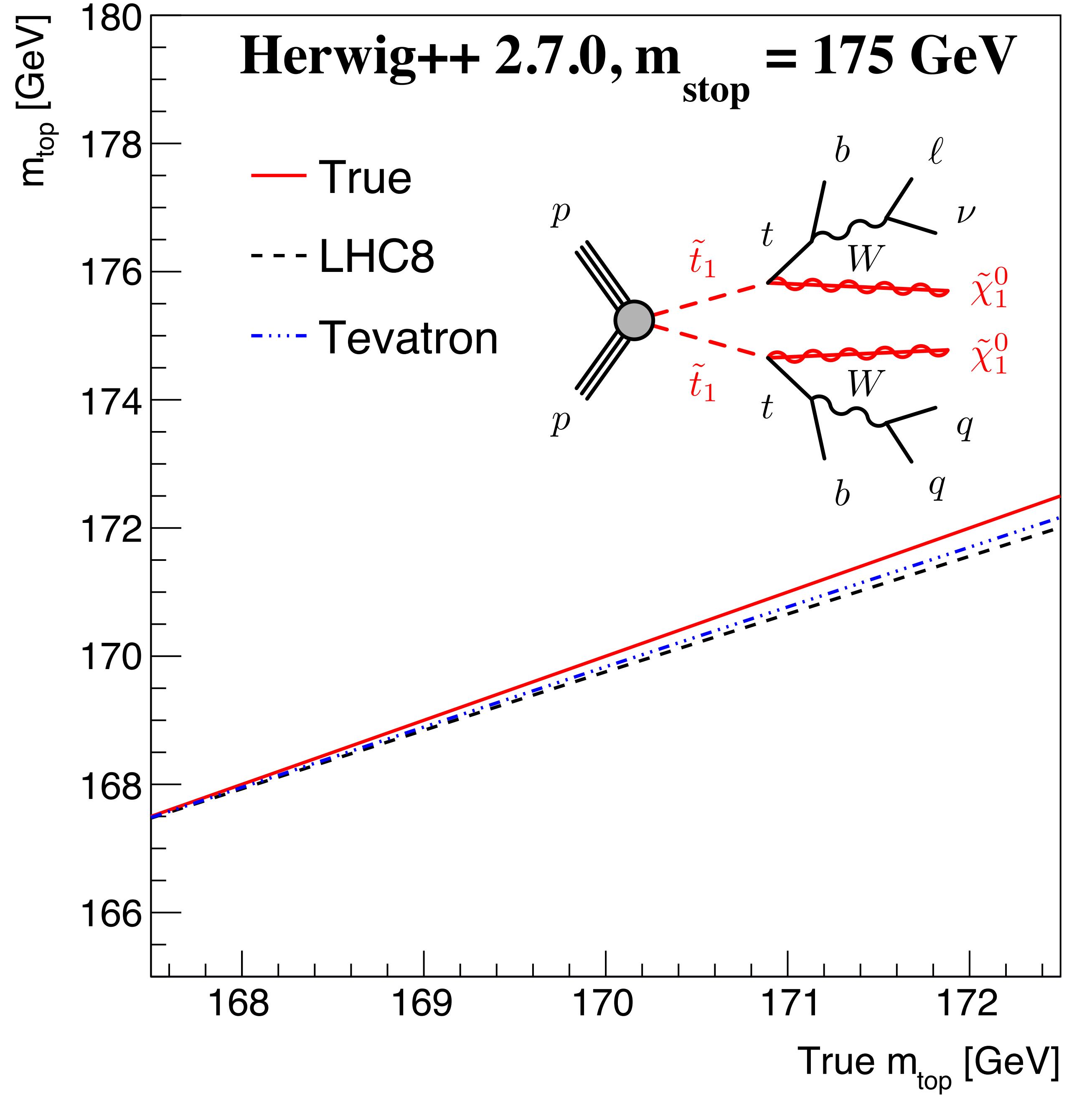




Measured Bias

For the 3-body decays, larger bias. When there is a resonant top, the bias is very small (so LHC results so far are robust).

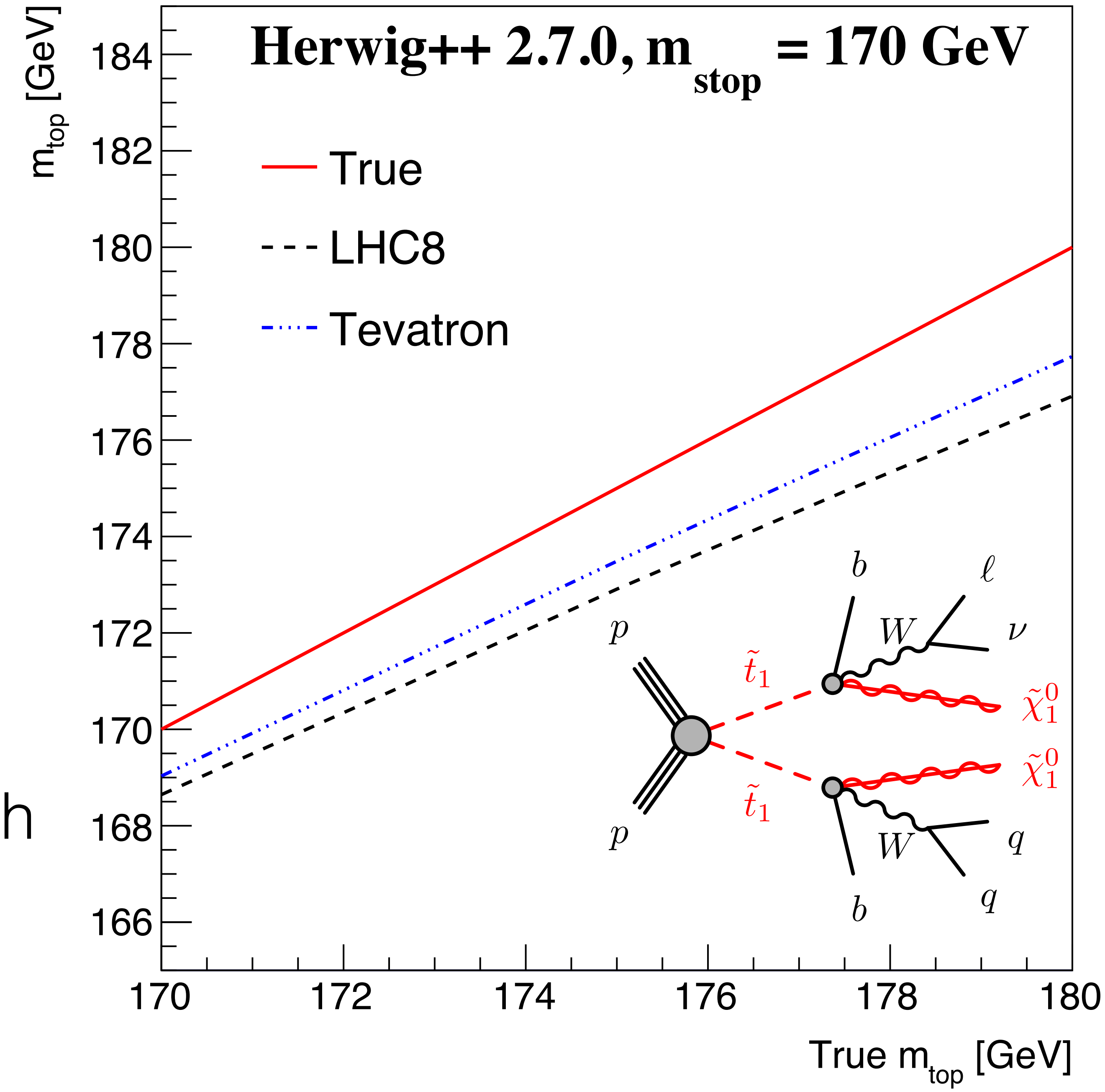




Measured Biases: 3-body

A 170 GeV stop can hide in within the current measurement uncertainty

The consistency with the measurement improves for slightly higher stop masses (not shown)



Cross Section Prediction Too High

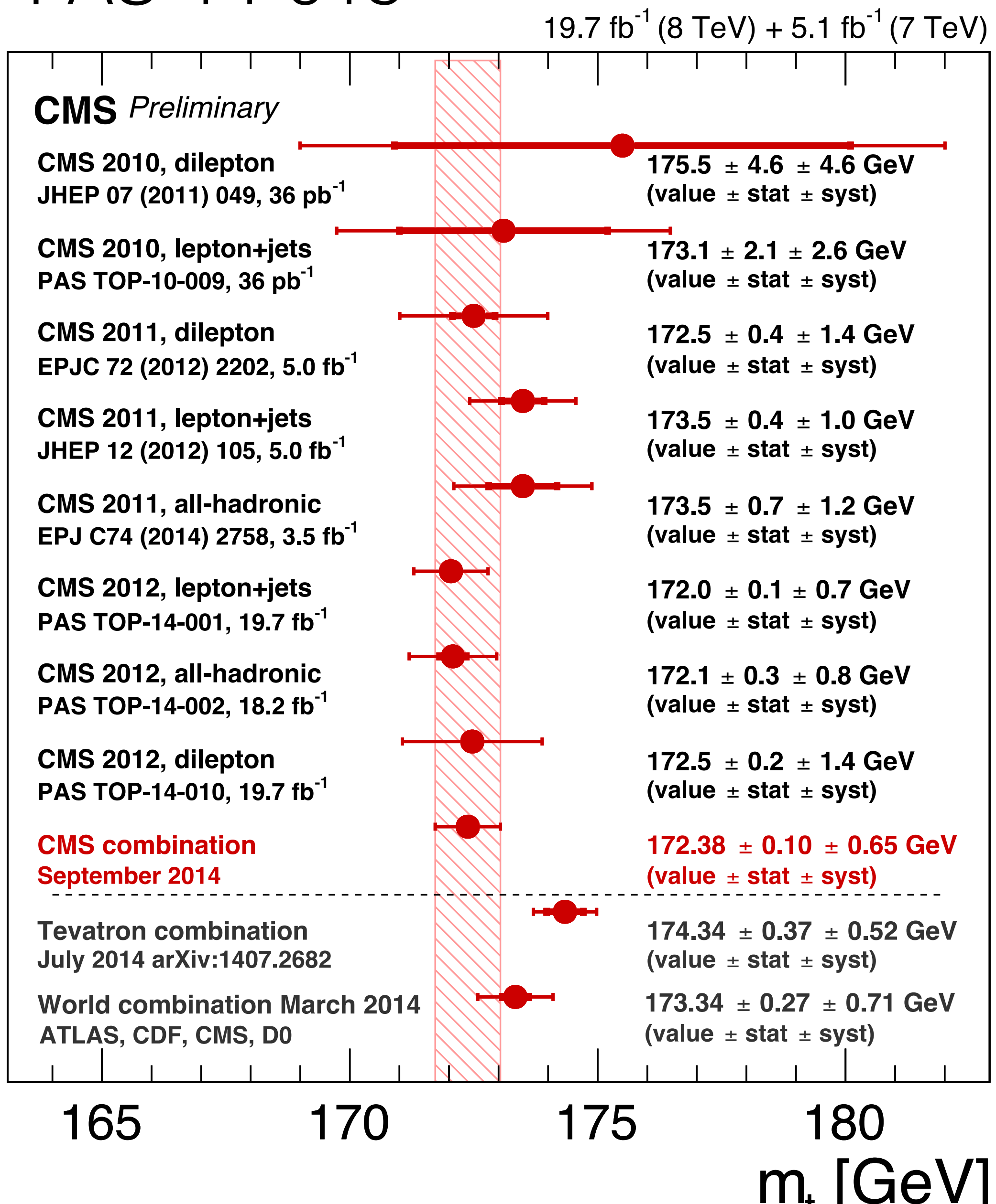
$m_{\rm top}^{\rm true}$	$m_{\rm top}^{\rm measured}$		True $\sigma_{t\bar t}(m_{\rm top}^{\rm true})$		True $\sigma_{t\bar t}(m_{\rm top}^{\rm measured})$		True $\sigma_{\tilde t\tilde t^*}$		Measured $\sigma_{t\bar t}$	
	LHC8	Tevatron	LHC8	Tevatron	LHC8	Tevatron	LHC8	Tevatron	LHC8	Tevatron
170	168.6	169.0	271.1	8.0	279.0	8.1	42.6	0.87	295.4	8.5
172.5	170.8	171.3	251.7	7.3	264.4	7.6	42.6	0.87	276.0	7.8
175	172.9	173.5	233.8	6.8	249.7	7.2	42.6	0.87	258.1	7.3

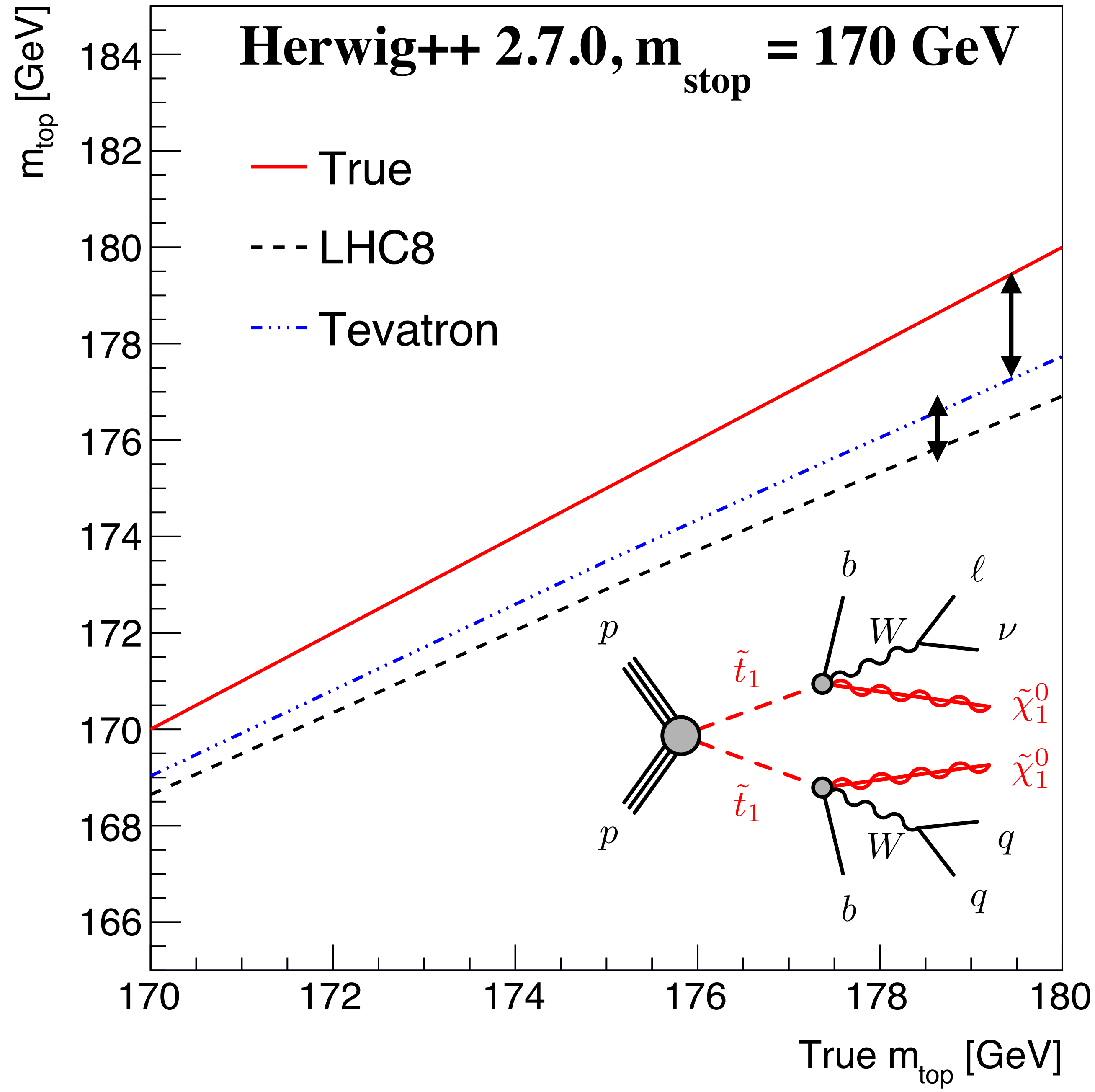
Measured Mass > True Mass

LHC vs Tevatron

Curiously, the measured Tevatron top mass is slightly higher than the LHC mass

CMS-PAS-14-015

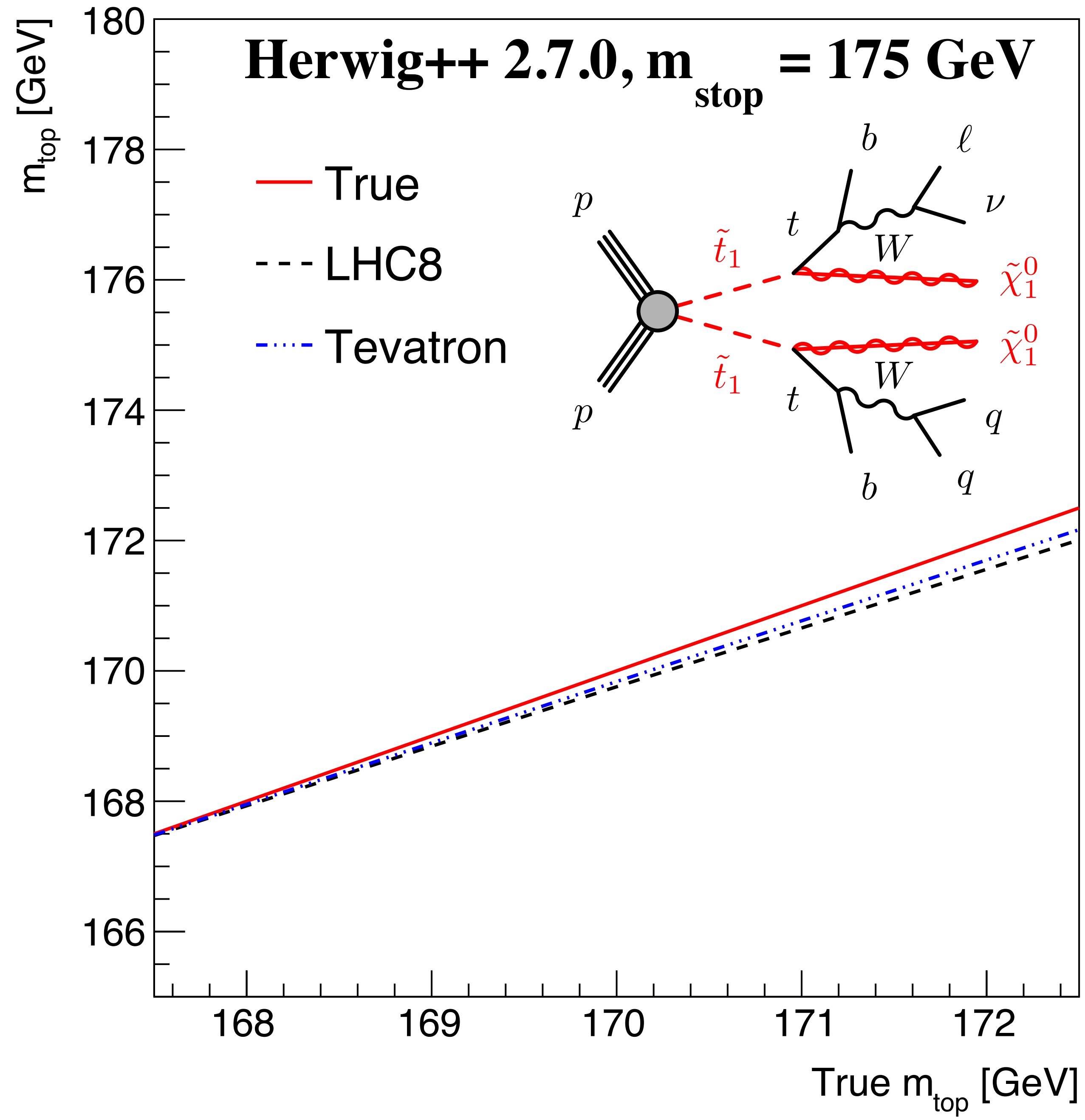




This could be explained by or provide a constraint on light stops.

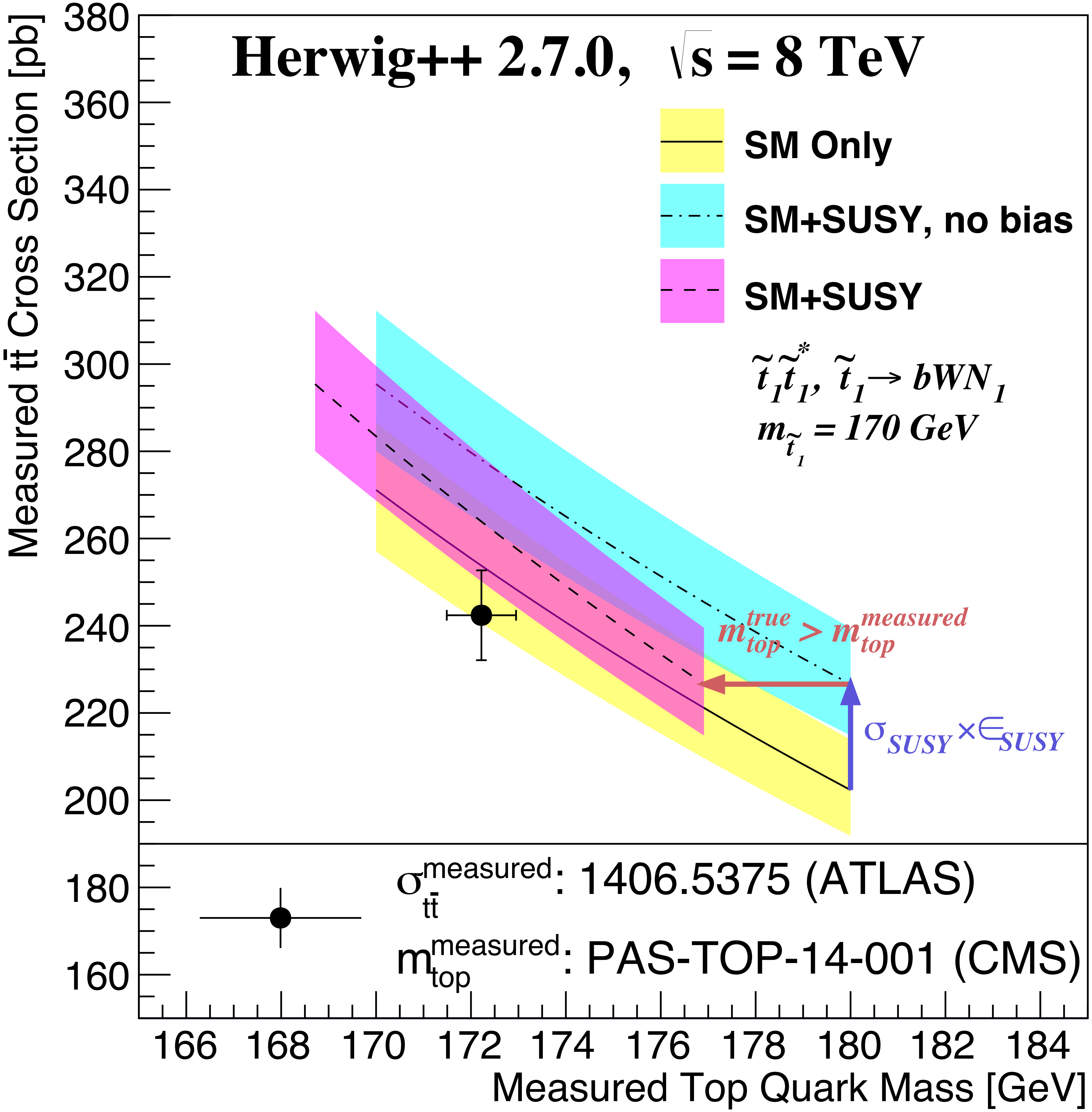
Many caveats: most importantly is the fact that different (nominal) generators are used!

Measured Biases: 2-body



Unlike for the 3-body decays, the measurement is nearly unbiased with resonant tops.

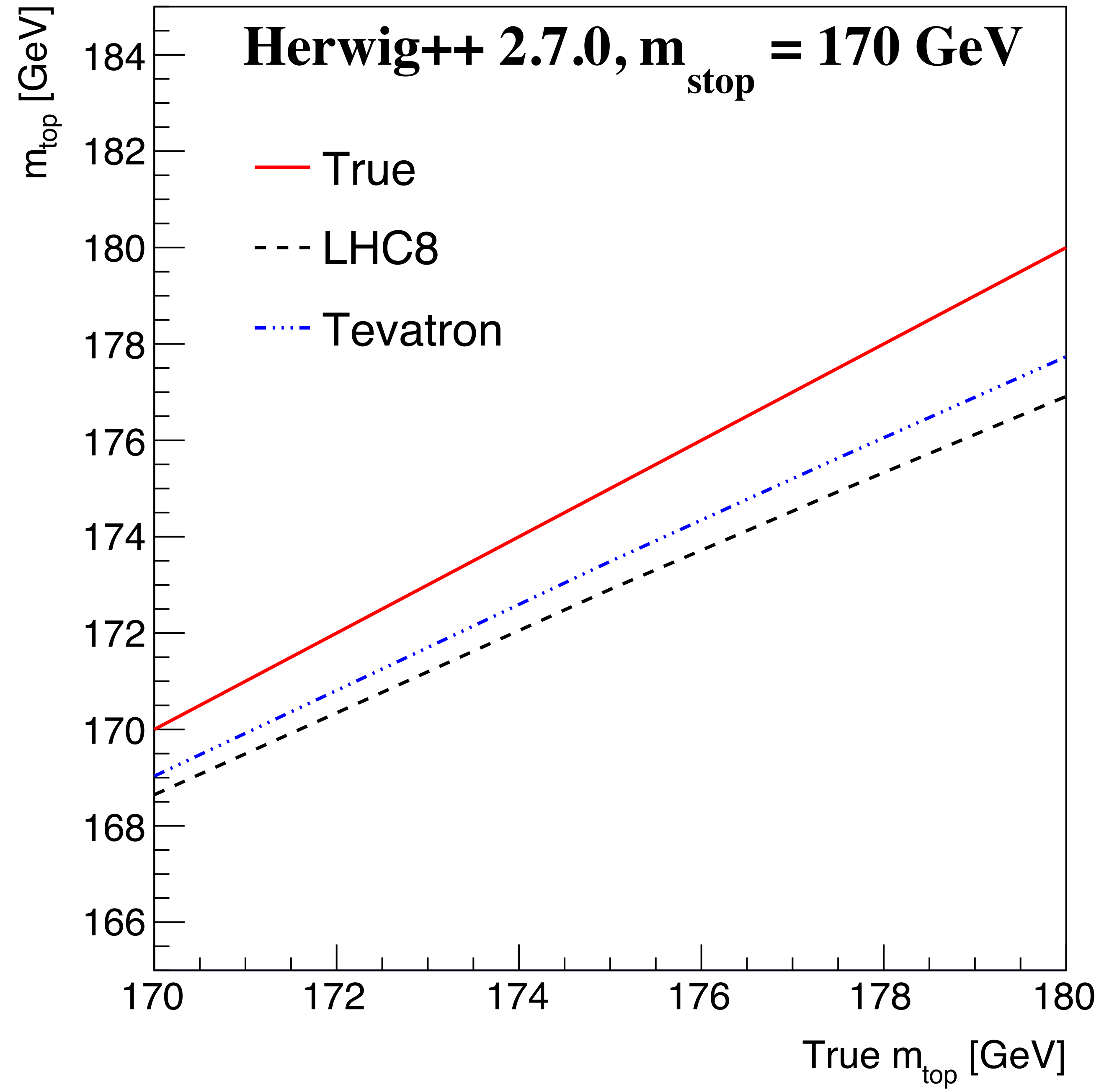
m_{top}^{true}	$m_{top}^{measured}$		True $\sigma_{t\bar{t}}(m_{top}^{true})$		True $\sigma_{t\bar{t}}(m_{top}^{measured})$		True $\sigma_{\tilde{t}\tilde{t}*}$		Measured $\sigma_{t\bar{t}}$	
	LHC8	Tevatron	LHC8	Tevatron	LHC8	Tevatron	LHC8	Tevatron	LHC8	Tevatron
170	169.8	169.8	271.1	8.0	273.7	8.0	36.8	0.70	304.8	8.6
172.5	172.0	172.2	251.7	7.3	255.4	7.4	36.8	0.70	285.4	8.0


Herwig++ 2.7.0, √s = 8 TeV
SM Only
SM+SUSY, no bias
SM+SUSY
t̃1t̃1*, t̃1 → bWN1
m t̃1 = 170 GeV
m top true > m top measured
σ SUSY × ∈ SUSY
σ tt̄ measured: 1406.5375 (ATLAS)
m top measured: PAS-TOP-14-001 (CMS)
Measured tt̄ Cross Section [pb]
Measured Top Quark Mass [GeV]
380
360
340
320
300
280
260
240
220
200
180
160
166
168
170
172
174
176
178
180
182
184

Conclusions

Searching for stealth stops will require precision top measurements

Such studies must consider the impact of biases in the top mass, in particular for 3-body decays



*Light, **sneaky**, stops may be hiding in the 8 TeV dataset!*