Toptet

w/ Thomas Gregoire (Carleton) and Ami Katz (Boston University)

arXiv:1101.1294 [hep-ph]

York Université University

Top talks EWSB physics
EWSB needs new physics
Tops talk to new physics

Models addressing fermion mass generation
special relation to tops

COLORFUL EVENTS

Examples

Light stop SUSY

Little Higgs

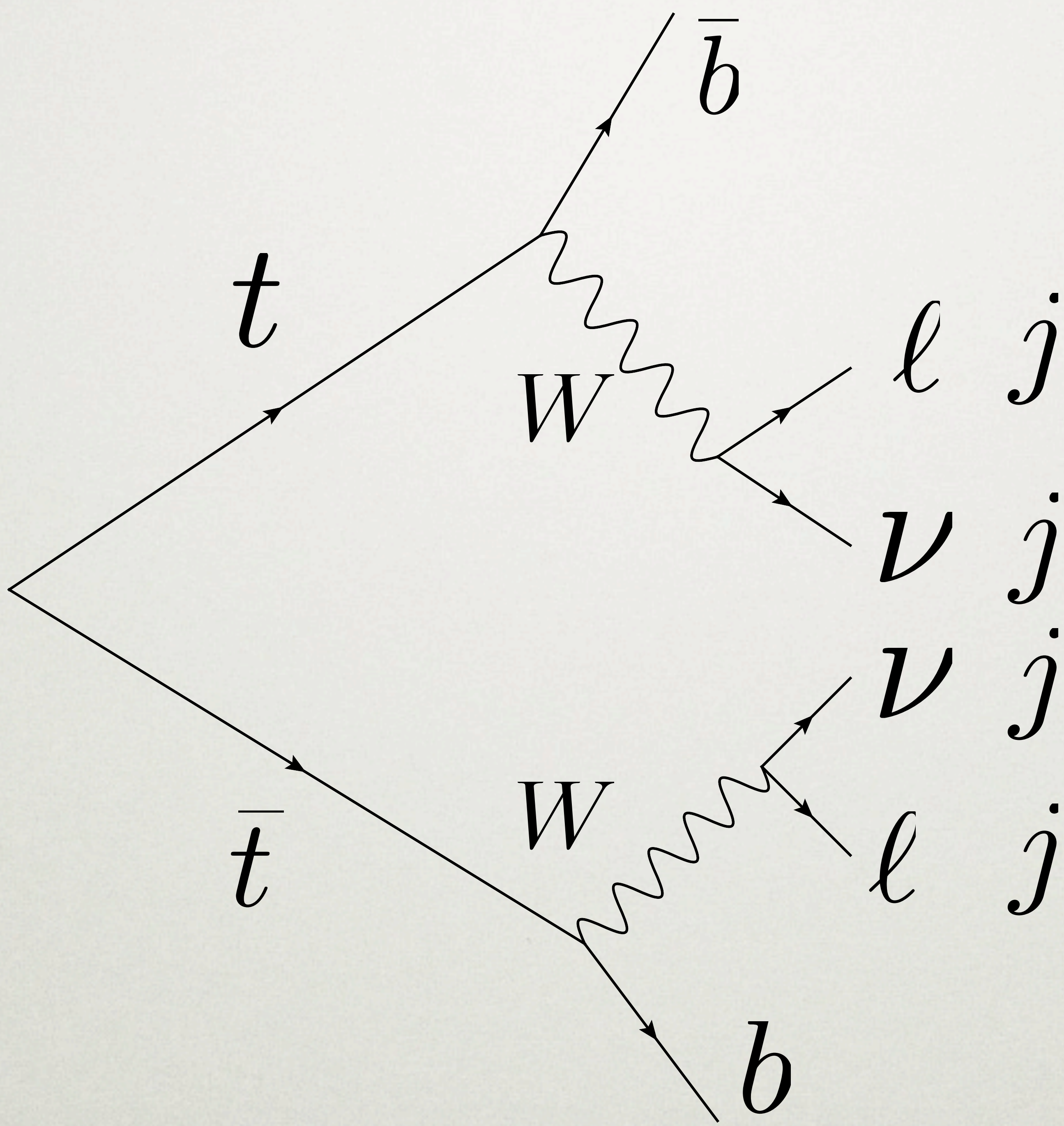
Randall-Sundrum models

Higgsless

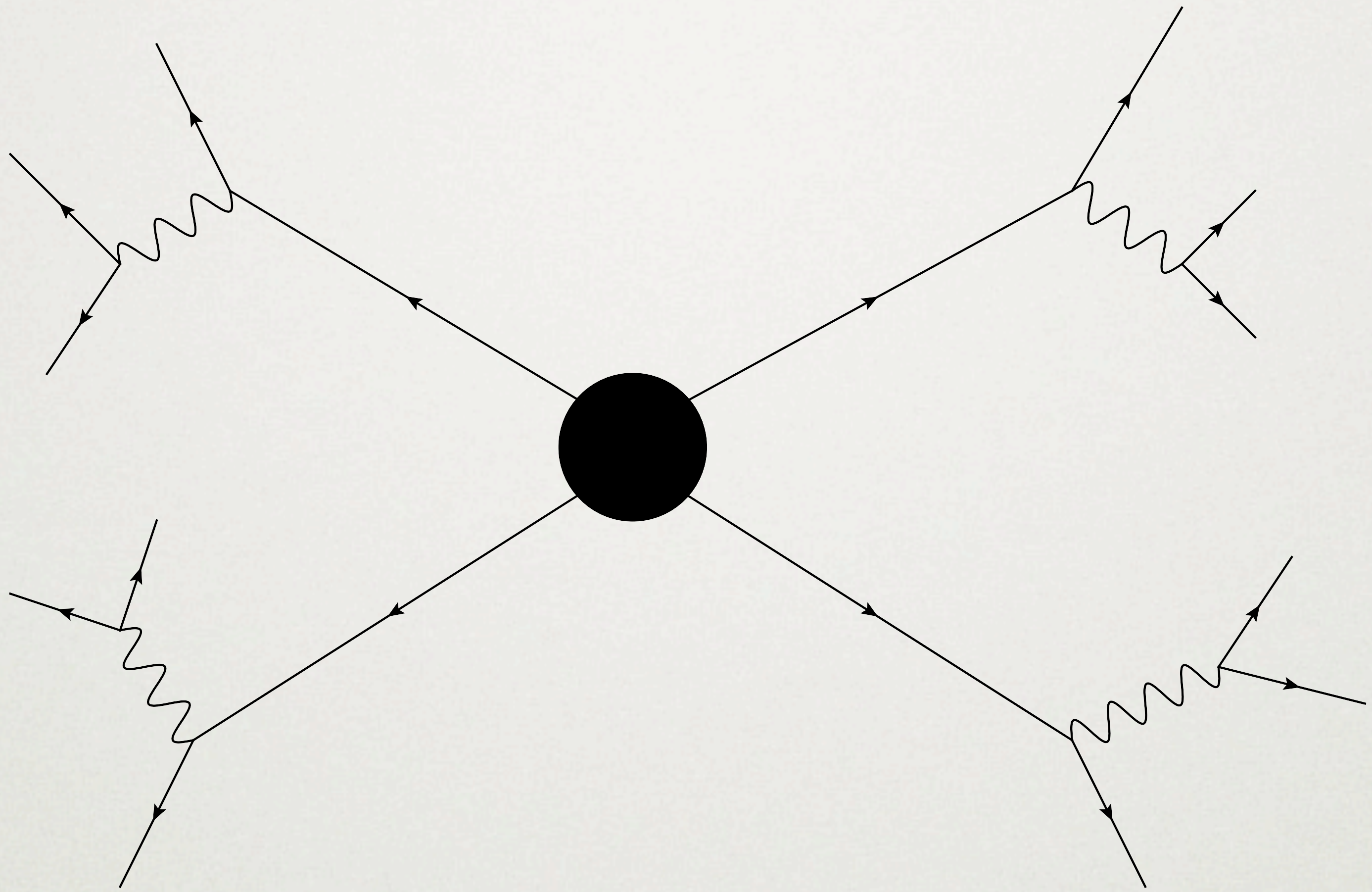
Colorons...

...and the LHC is a top factory

but tops are complicated objects



And many tops are even more challenging



combinatorics, multiple b-tagging

That doesn't mean we can't see new physics

$$2SSL,\ n_b,\ H_T$$

Tait et al
HEP 0804:087,2008.
Pierce et al
Phys.Rev.D77:095003,2008.
Servant et al
Les Houches 2009
Serra et al
Phys. Rev. D78 (2008) 074026
...

can beat SM backgrounds
mostly from fakes, e.g.

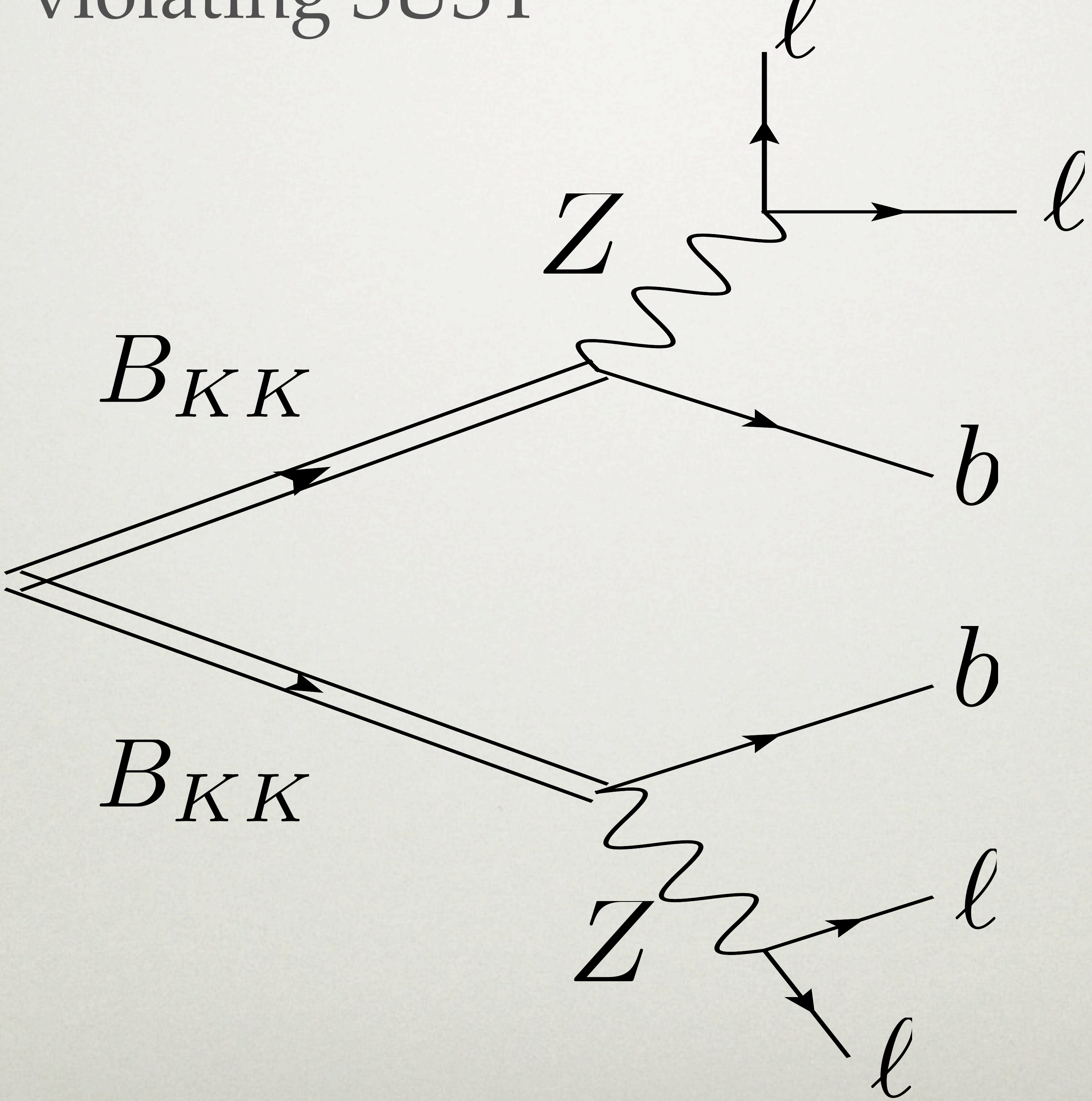
$$W^+W^- + \text{ jets}$$

But many other proposals for new physics have a similar final state...

Heavy colored particles:

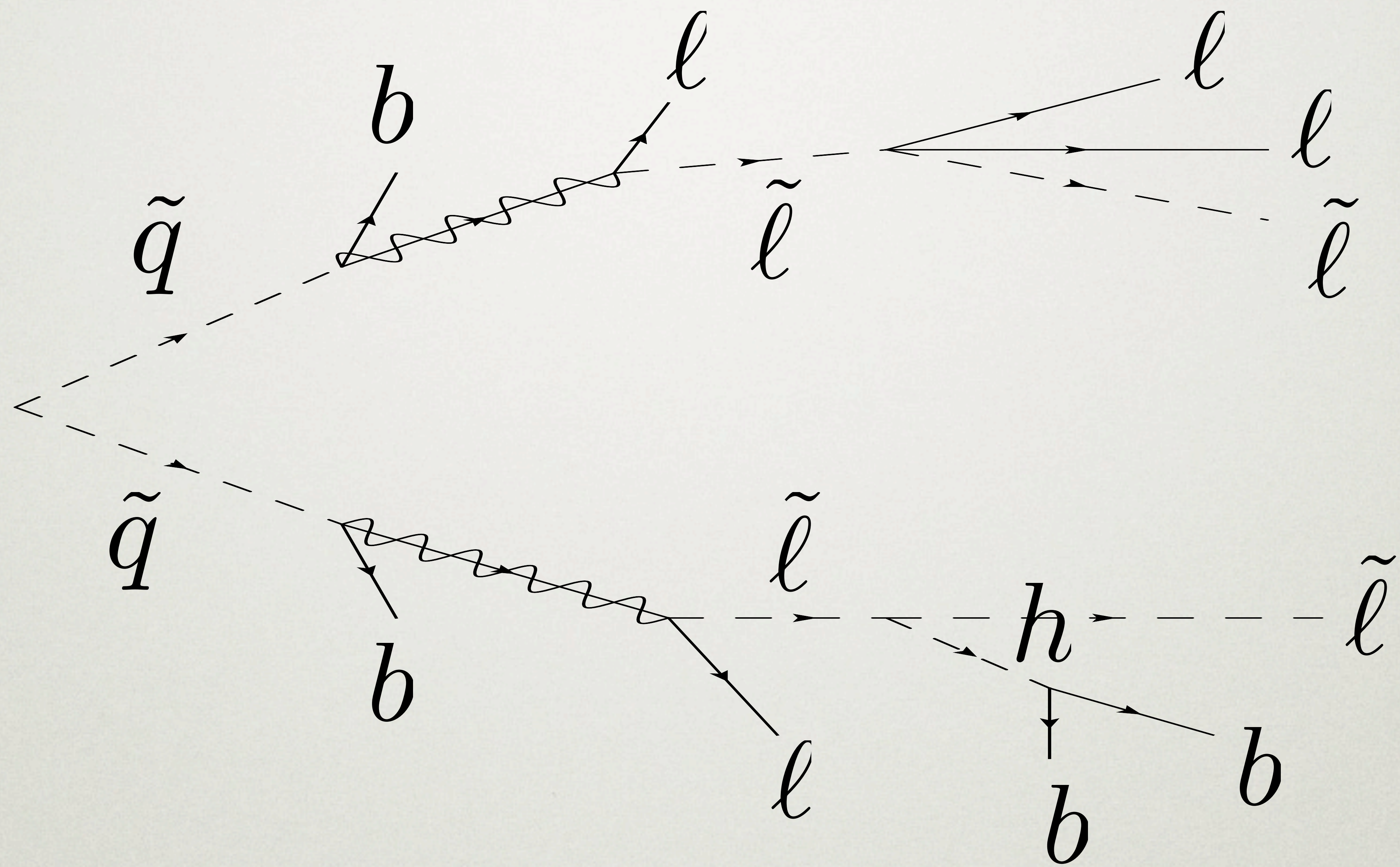
Higgsless, Little Higgs, R-violating SUSY

Martin, VS
JHEP 2010:1-28,2010



SUSY cascade decays
as in lepto-SUSY

de Simone, Fan, VS, Skiba
Phys.Rev.D80:035010,2009



So, the key question is...

How do we know that the new physics with

$$2SSL,\ n_b,\ H_T$$

involves tops?

The challenge is to find a measure of

TOP-NESS

Reconstruct tops

$$t \rightarrow \boxed{W}\,\boxed{b}$$

Leptonic
BR
missing energy

Hadronic
combinatorial

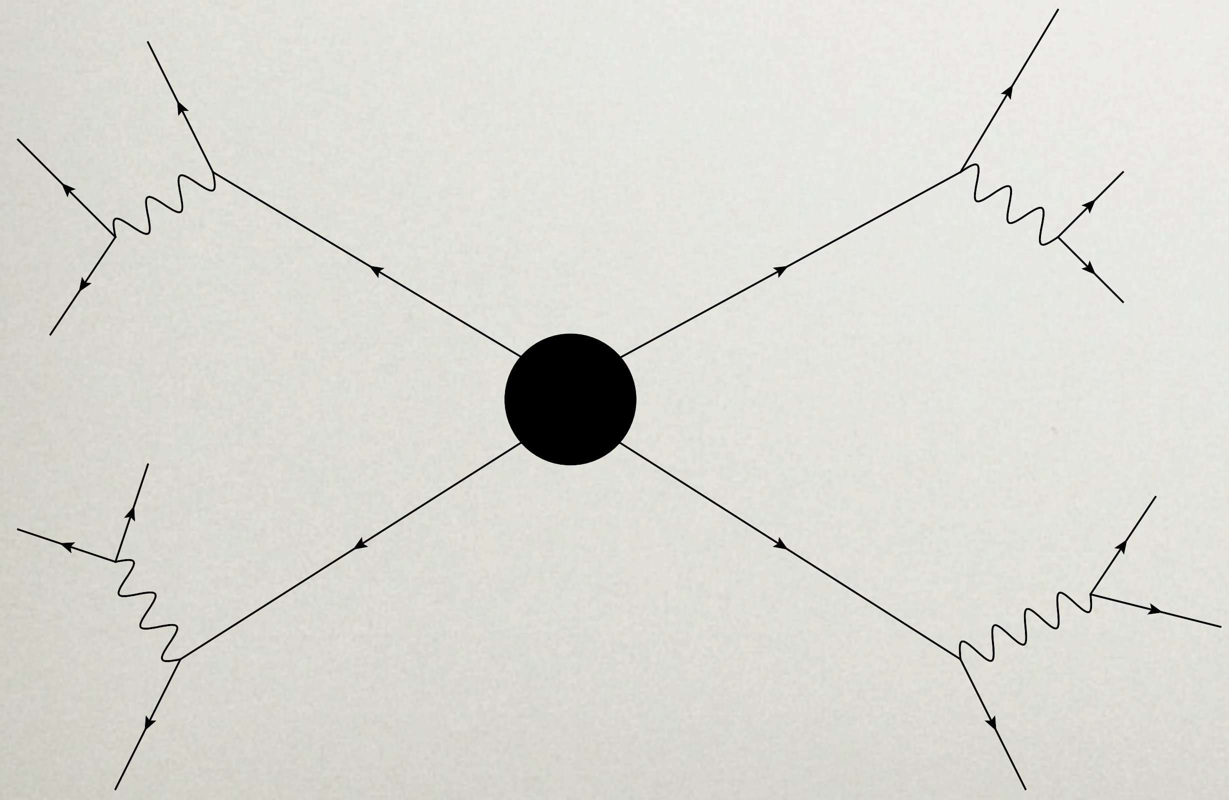
tagging

Reconstruction in hadronic channels

Combinatorics!

Cuts or smart strategies to select right combinations

example: boosted tops



Reconstruction in hadronic channels

Combinatorics!

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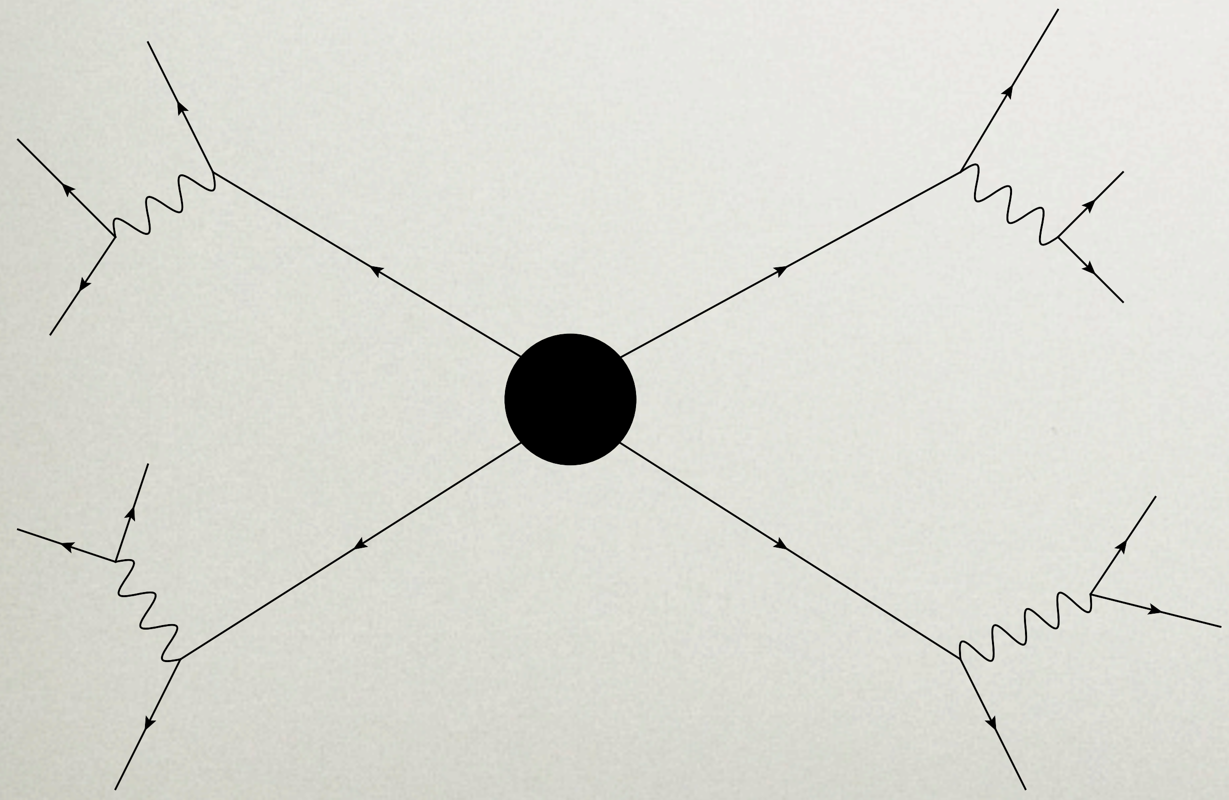
example: boosted tops

We don't want that



Reconstruction in hadronic channels

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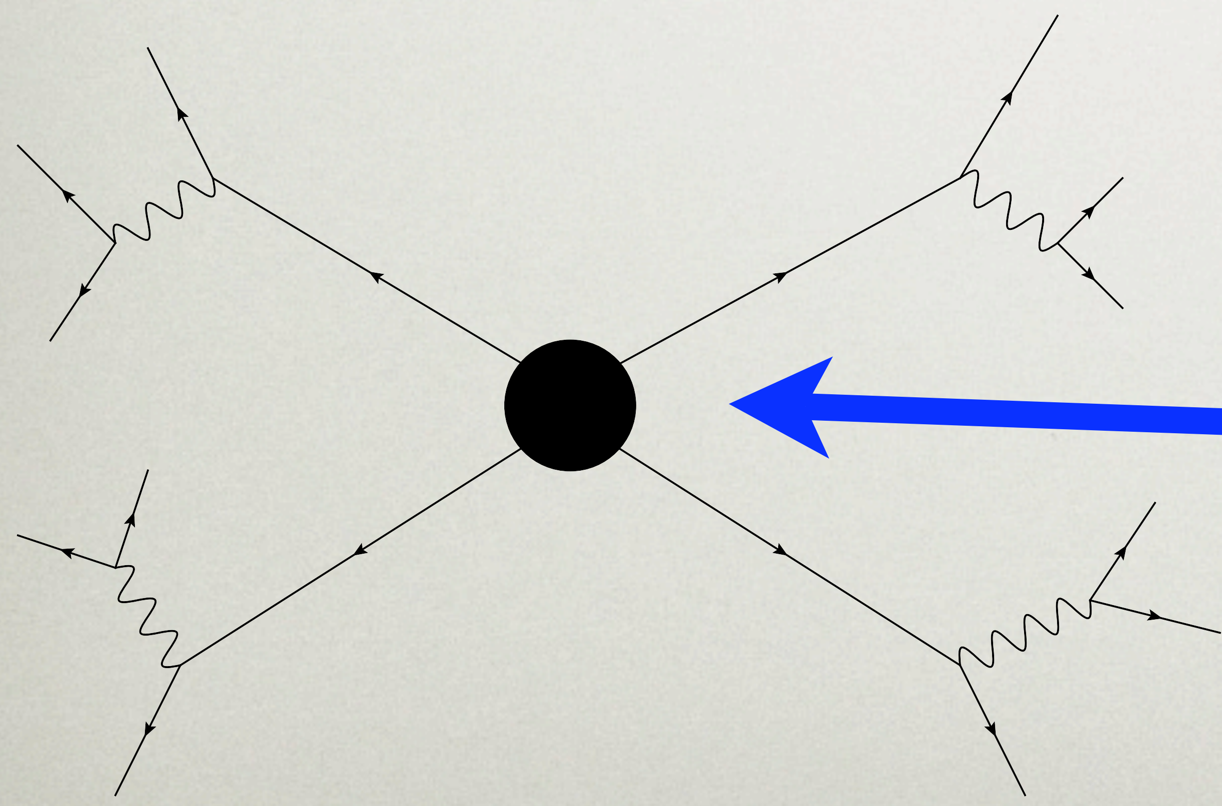


Early LHC

light resonances

decay products well separated

Backgrounds

$t\bar{t} + \text{ jets}, W + \text{ jets}, Z + \text{ jets}, b\bar{b} + \text{ jets}, \ldots$

ALPGENv213

with MLM matching

PYTHIAv6.4

PGS (Pretty Good Simulator)v4

Signals

MadGraph/MadEventv4.4.3

PYTHIAv6.4

PGSv4

Counting tops

1. Take one jet and call it b-jet (no b-tagging)
2. Form all possible combinations jjb
3. Apply cuts
4. If more than one jjb sharing a jet passes cuts, select the combination with mass closer to the top (ordering)

Basic cuts

At least one lepton (electron, muon) with pT>20 GeV,

missing energy > 20 GeV

pT jets> 30 GeV, separated 0.4

ATLAS TDR: QCD BG under control

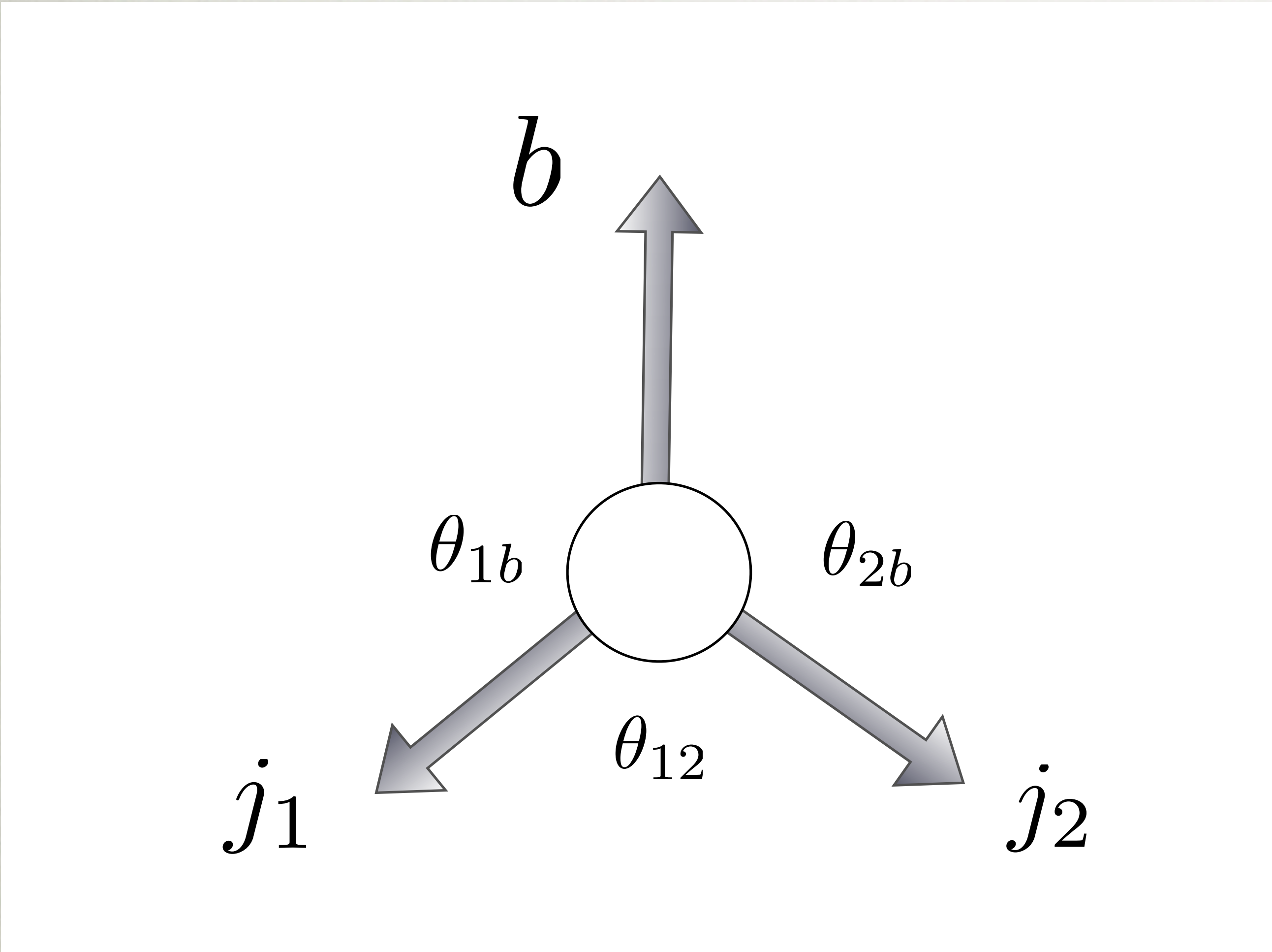
ATLAS TDR

Table 3: Number of events which pass the various electron selection criteria for the $t\bar{t}$ signal and for the most relevant backgrounds normalised to 100 pb^{-1}.

Electron analysis						
Sample	default	W const.	m_t win	W const. + $\|\eta\| < 1$	W const. + 1 b-tag	W const. + 2 b-tag
$t\bar{t}$	2555	1262	561	303	329	208
hadronic $t\bar{t}$	11	4	0.0	0.8	0.6	0.0
W+jets	761	241	60	38	7	1
single top	183	67	23	12	18	7
$Z\rightarrow ll$ +jets	115	35	8	5	2	0.4
$W\ b\bar{b}$	44	15	3	5	5	0.7
$W\ c\bar{c}$	19	6	1	1	0.4	0.0
WW	7	4	0.4	0.0	0.0	0.0
WZ	4	1	0.4	0.2	0.0	0.0
ZZ	0.5	0.2	0.1	0.0	0.0	0.0
Signal	2555	1262	561	303	329	208
Background	1144	374	96	63	33	10
S/B	2.2	3.4	5.8	4.8	10.0	20.8

We propose an alternative cut

In the top CM



$$p_1 = \frac{m_{1b}^2 + m_W^2}{2m_t}$$

$$p_2 = \frac{m_t^2 - m_{1b}^2}{2m_t}$$

$$p_b = \frac{m_t^2 - m_W^2}{2m_t}$$

$$\cos\theta_{12} = 1 - \frac{2m_W^2 m_t^2}{(m_{1b}^2 + m_W^2)(m_t^2 - m_{1b}^2)}$$

$$\cos\theta_{1b} = 1 - \frac{2m_{1b}^2 m_t^2}{(m_{1b}^2 + m_W^2)(m_t^2 - m_W^2)}$$

We played with all of them c1b and p2 are the most efficient

Top CM cuts not new

Table 4: Additional cuts applied, after the event selection, for both methods (X_i, μ_i and σ_i are defined in the text of this section).

Cut label	Description
Cut C0 (χ^2 minimization)	$\lvert M_W^{rec} - M_W^{PDG}\rvert < 2\Gamma_{M_W}^{PDG}$ (M_W^{rec} is the reconstructed hadronic W and $\Gamma_{M_W}^{PDG} = 2.1$ GeV)
Cut C1 (geometric method)	$\lvert M_W^{rec} - M_W^{peak}\rvert < 2\sigma_{M_W}$ ($\sigma_{M_W} = 10.4$ GeV)
Cut C2 (both methods)	$M(W_{had}, b_{lep}) > 200$ GeV
Cut C3 (both methods)	$M(\text{lepton}, b_{lep}) < 160$ GeV
Cut C4 (both methods)	$\lvert X_1 - \mu_1\rvert < 1.5\sigma_1$
Cut C5 (both methods)	$\lvert X_2 - \mu_2\rvert < 2\sigma_2$

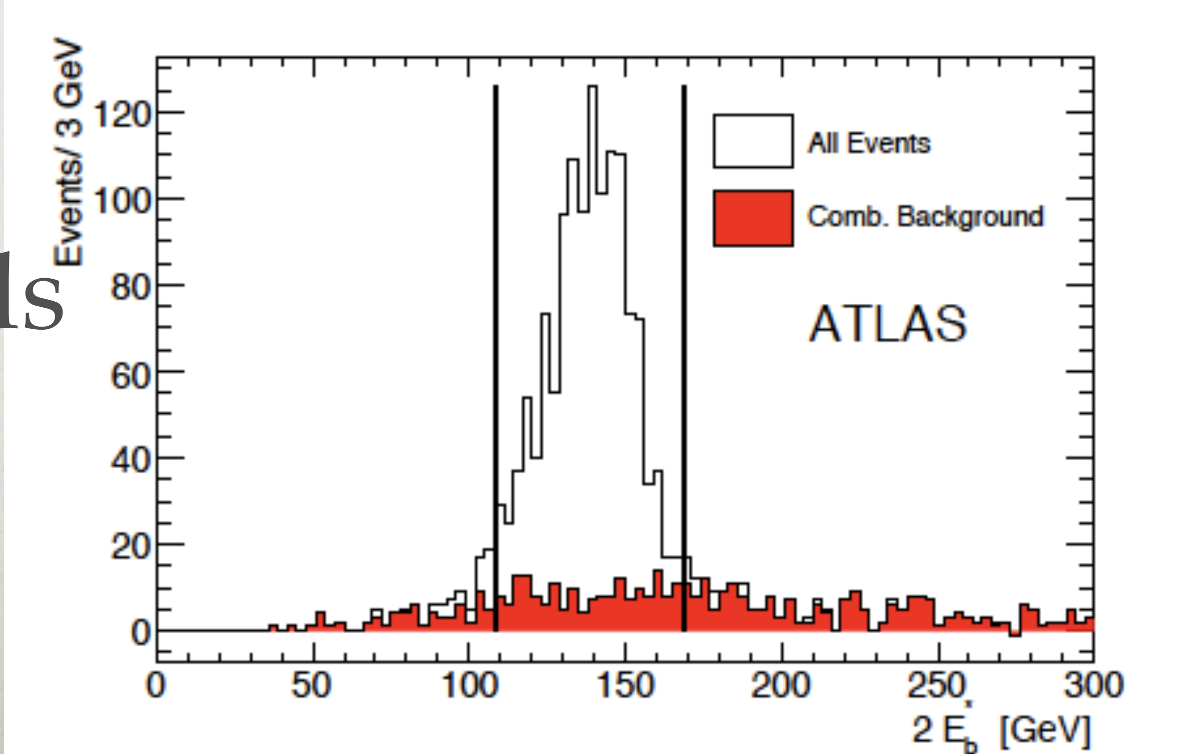
ATLAS TDR

$$X_1 = E_W^* - E_b^*$$

$$X_2 = 2E_b^*$$

Cuts on the top CM ref frame

Estimate errors needs MC



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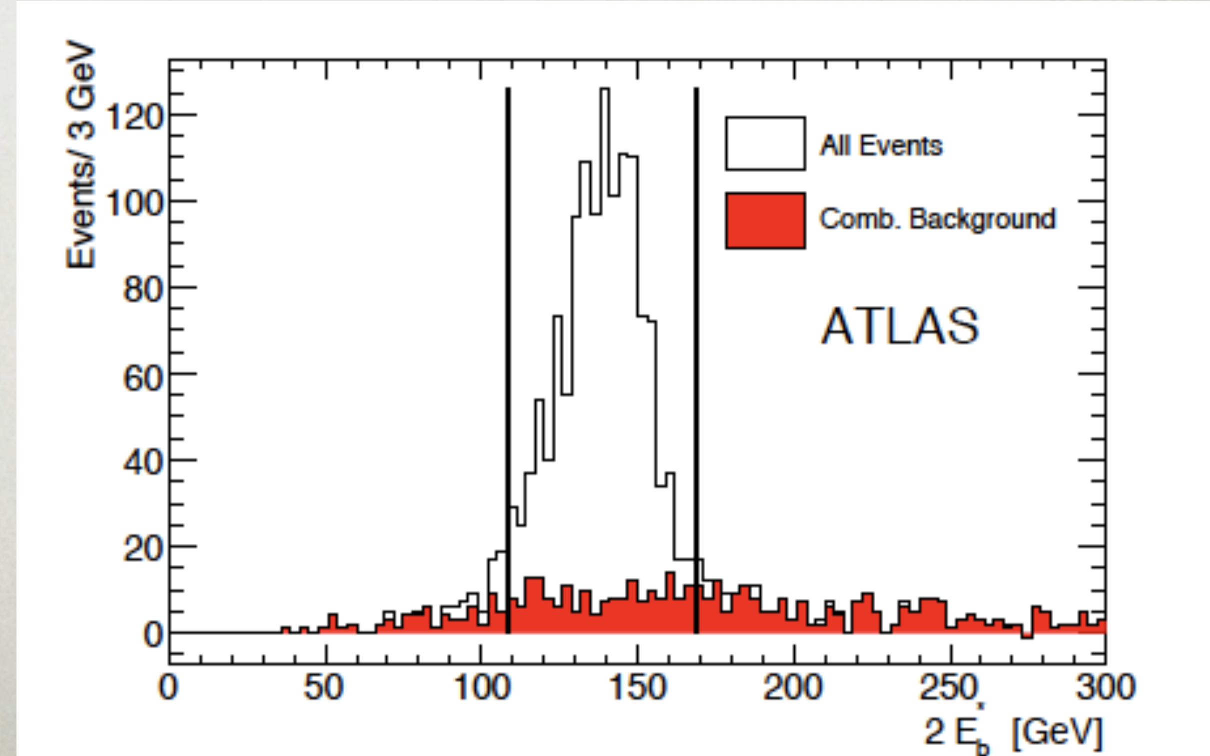
Cuts on the top CM ref frame

Instead
we cut on the angle
between the b and a
light jet



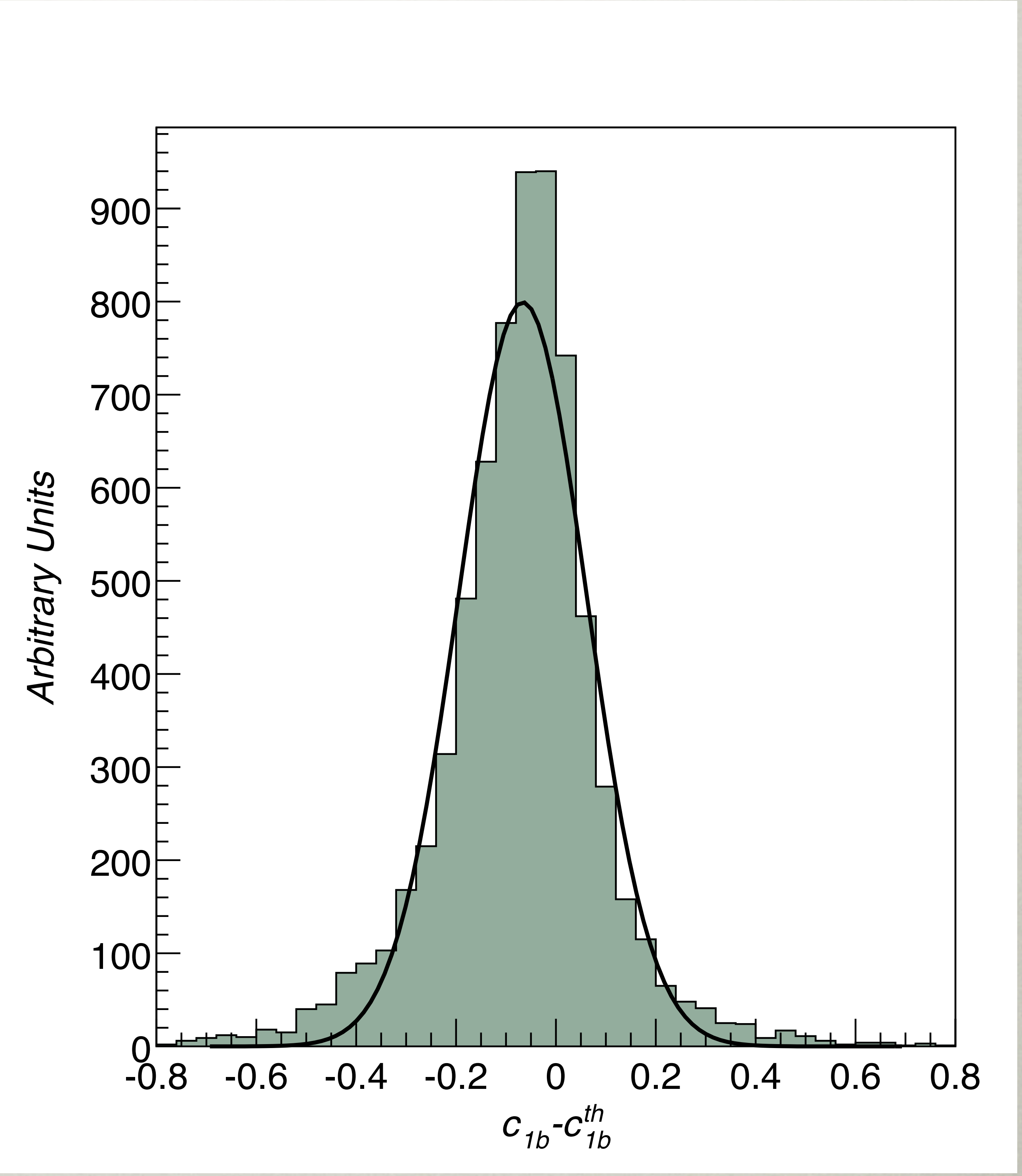
Resolution in c1b

matching parton and post-PGS

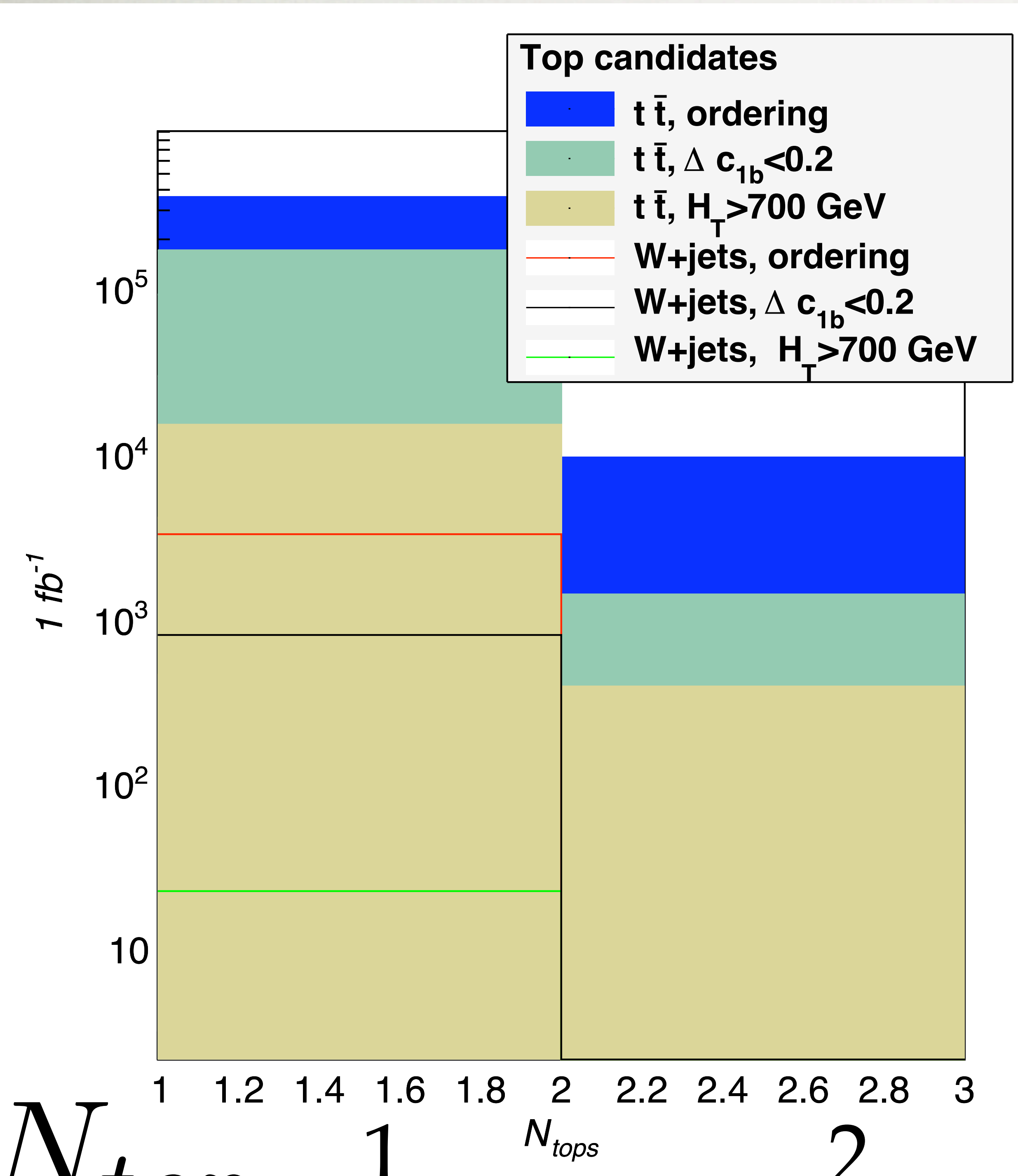
Fit: resolution order 0.1

Our strategy:

combination of CM-top, invariant mass, njets and Ht cuts



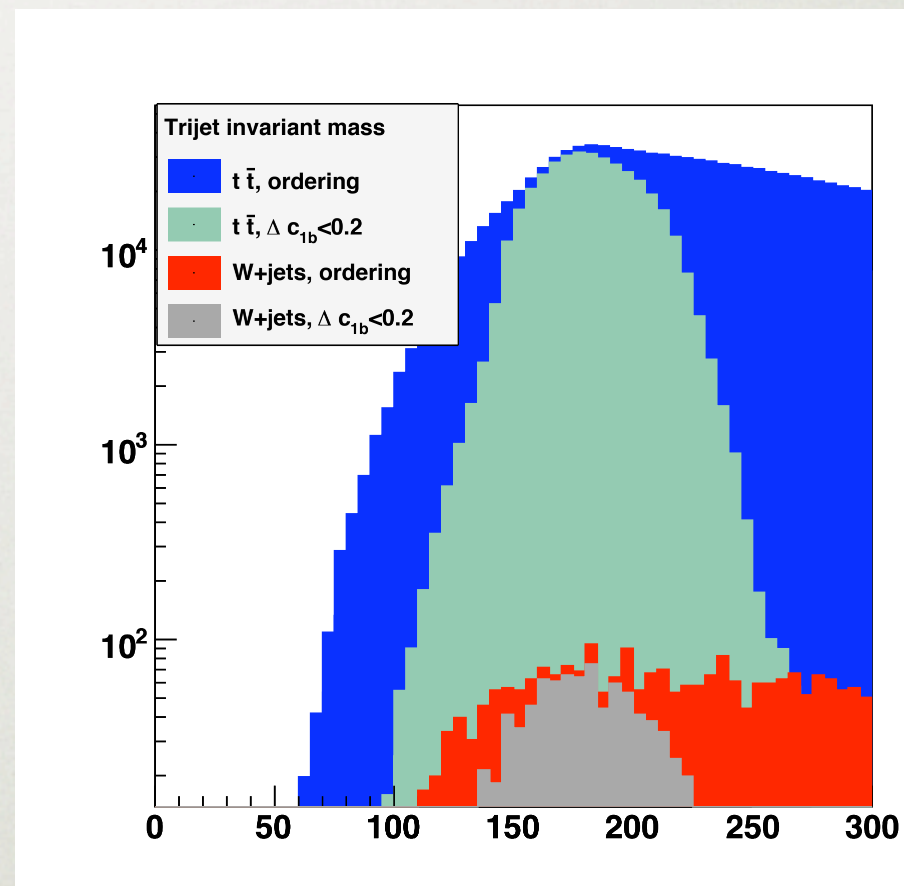
Test: Compare BGs with and without tops



N_{top} 1 2

One lepton, Ntop-1

Cuts sculpt BGs
But very low efficiency
for non-top BGs

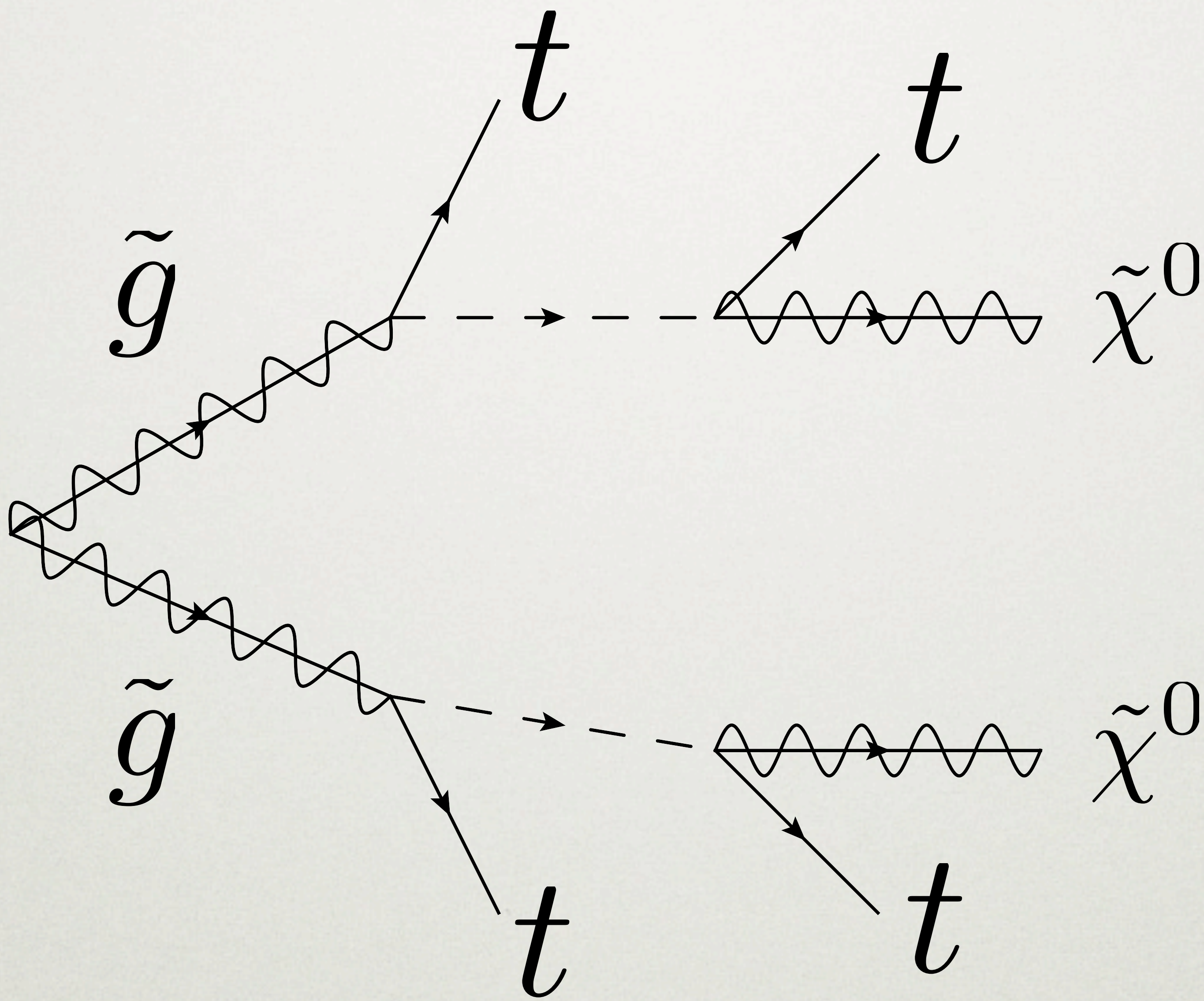


Good strategy to pick tops

Now new physics

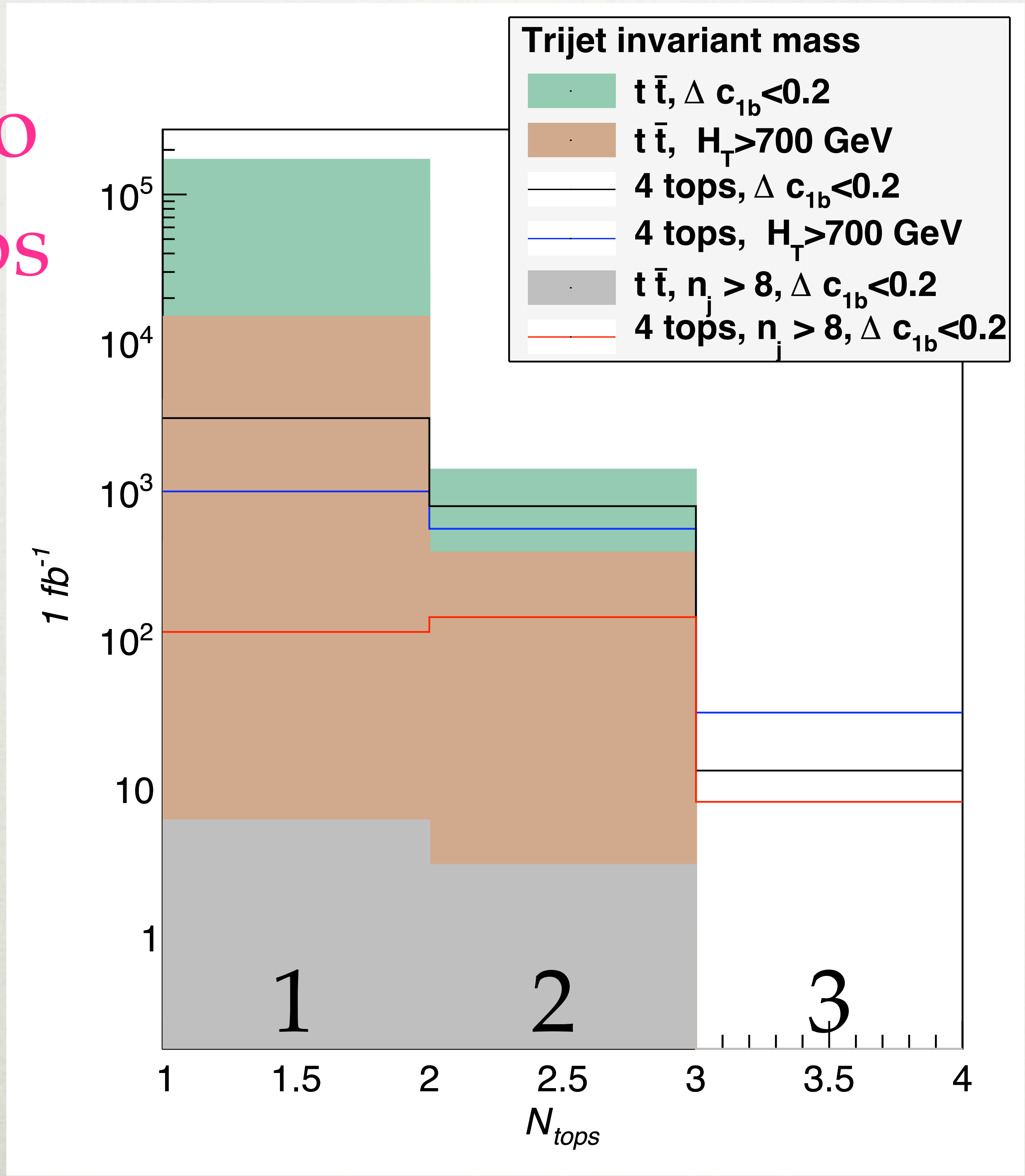
MC simulation, need to specify model

SUSY decay chain light stops



The real challenge: many tops versus SM ttbar

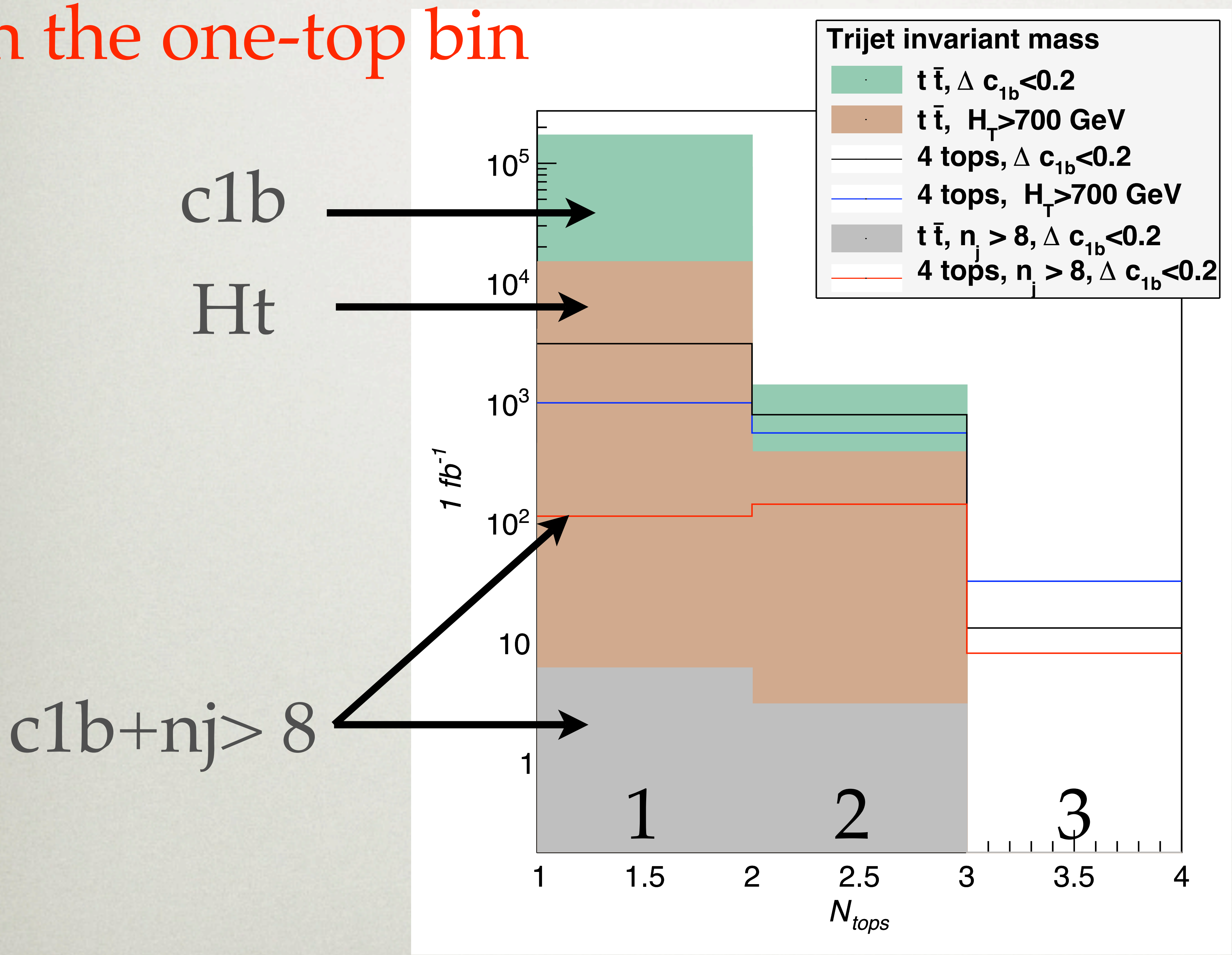
Simulation:
400 GeV gluino
pairs into 4 tops
@14 TeV



N_{top}

The real challenge: many tops versus SM ttbar

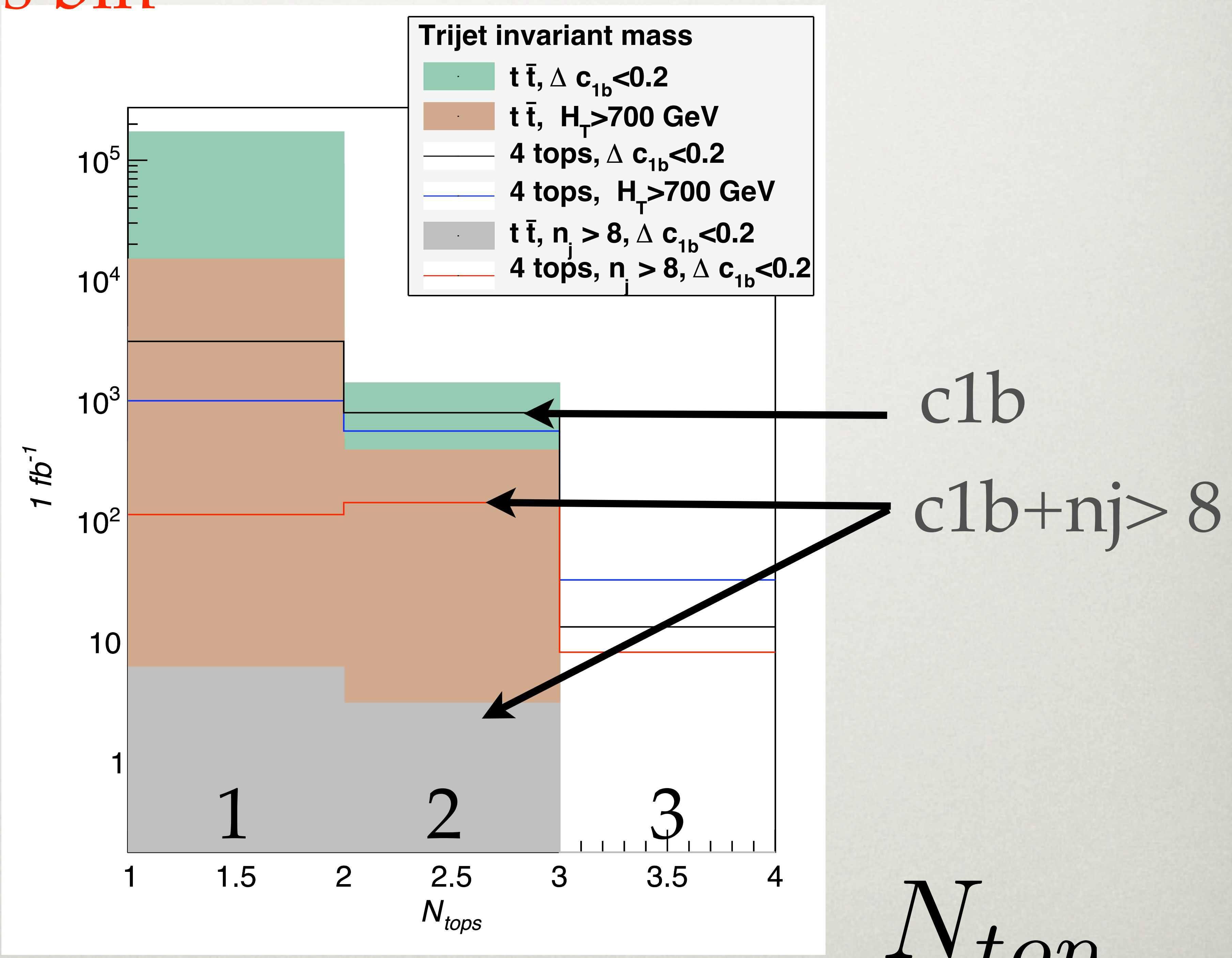
In the one-top bin



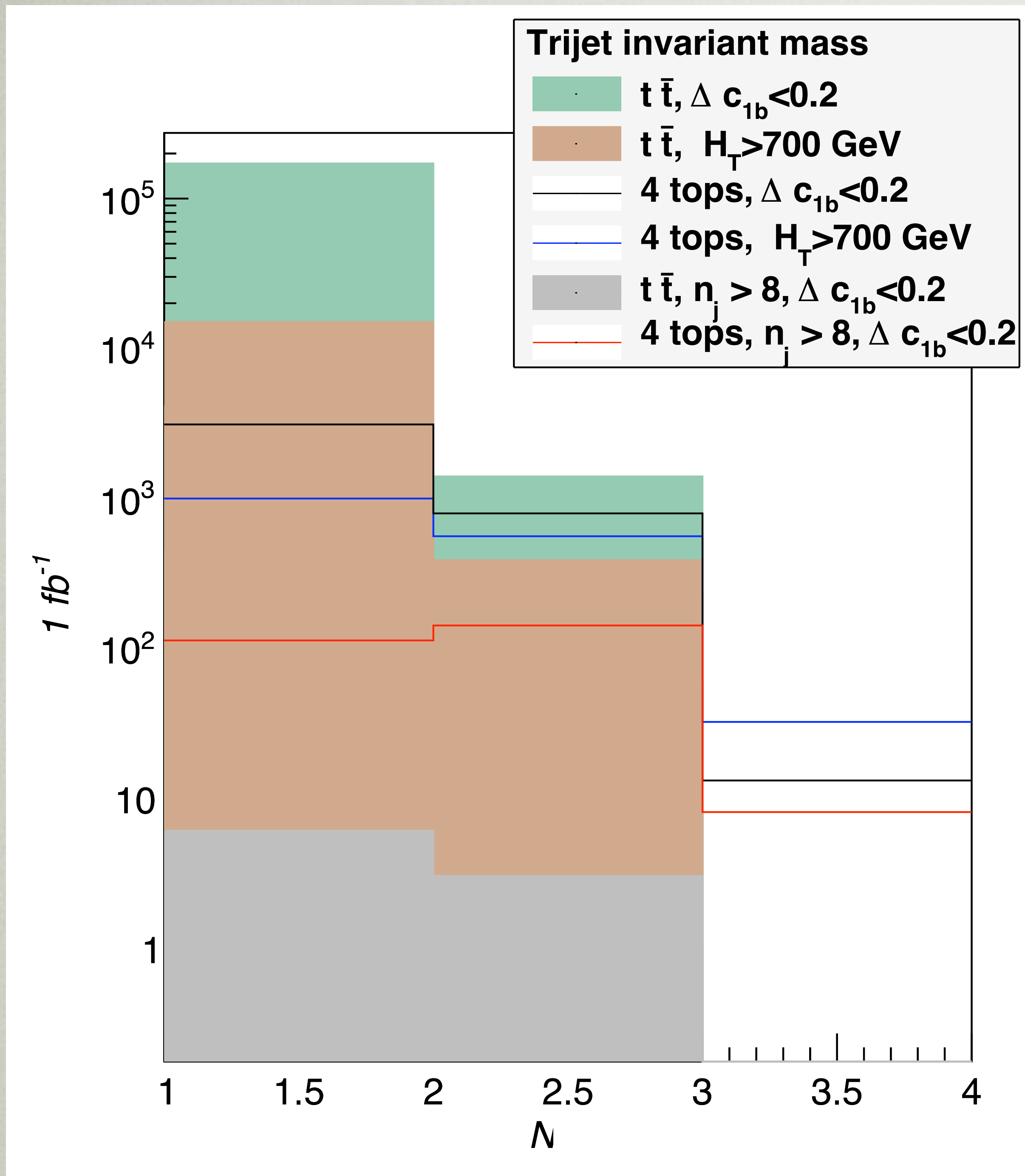
N_{top}

The real challenge: many tops versus SM ttbar

In the two-tops bin



N_{top}



Conclusion

4tops vs ttbar

combination of strategies for each bin

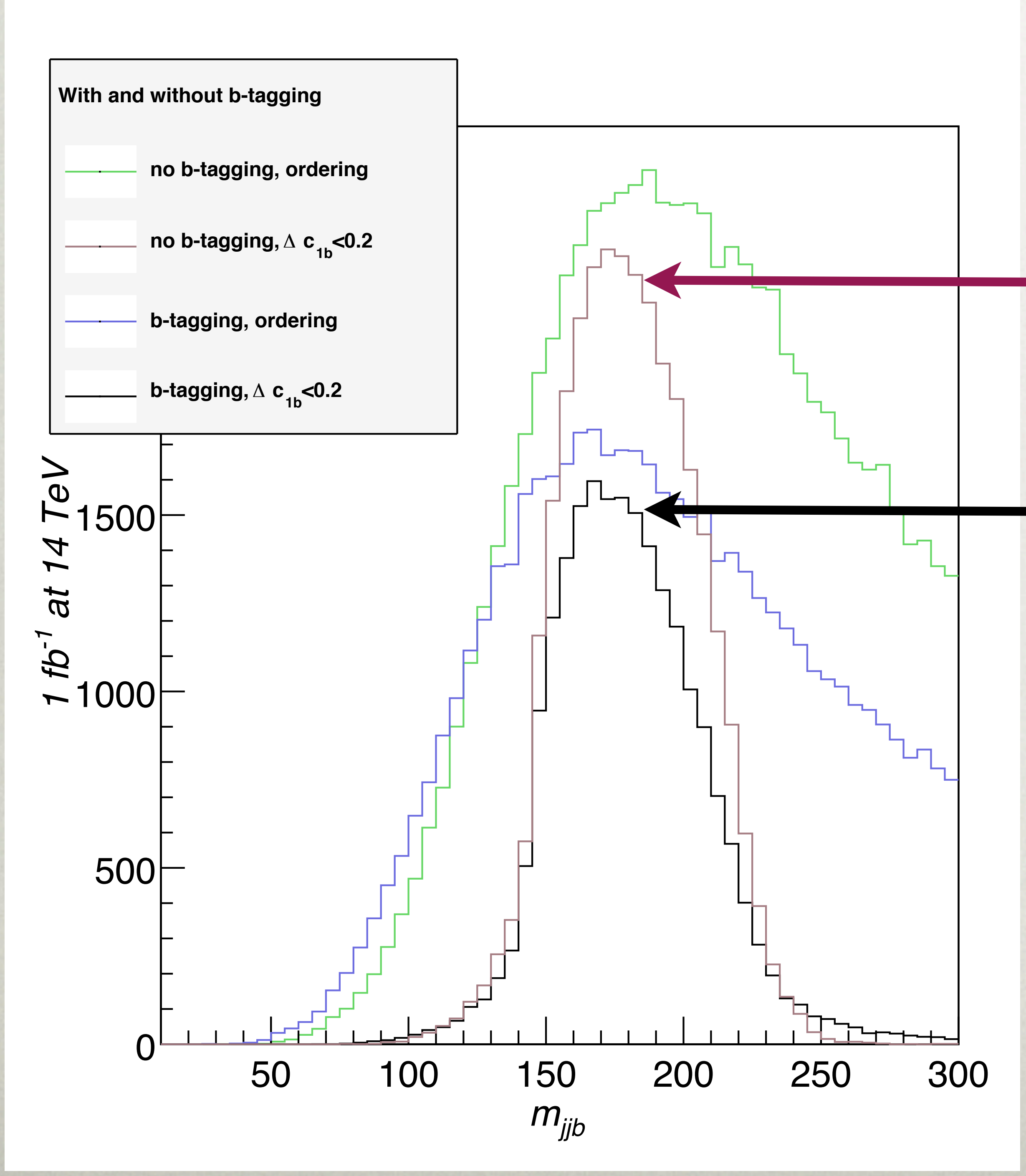
Example, in the Nt=2 bin

$N_2 = 2$	4 tops	$t\bar{t}+$ jets	$\frac{S}{B}$
$\Delta c_{1b} < 0.2$	800	1500	0.5
$\Delta c_{1b} < 0.2, n_j > 8$	150	3	50

Note: no b-tagging and no 2SSL cut?

Nt=1 + 2SSL cut: eff below 0.005%

(our cuts: few percent)



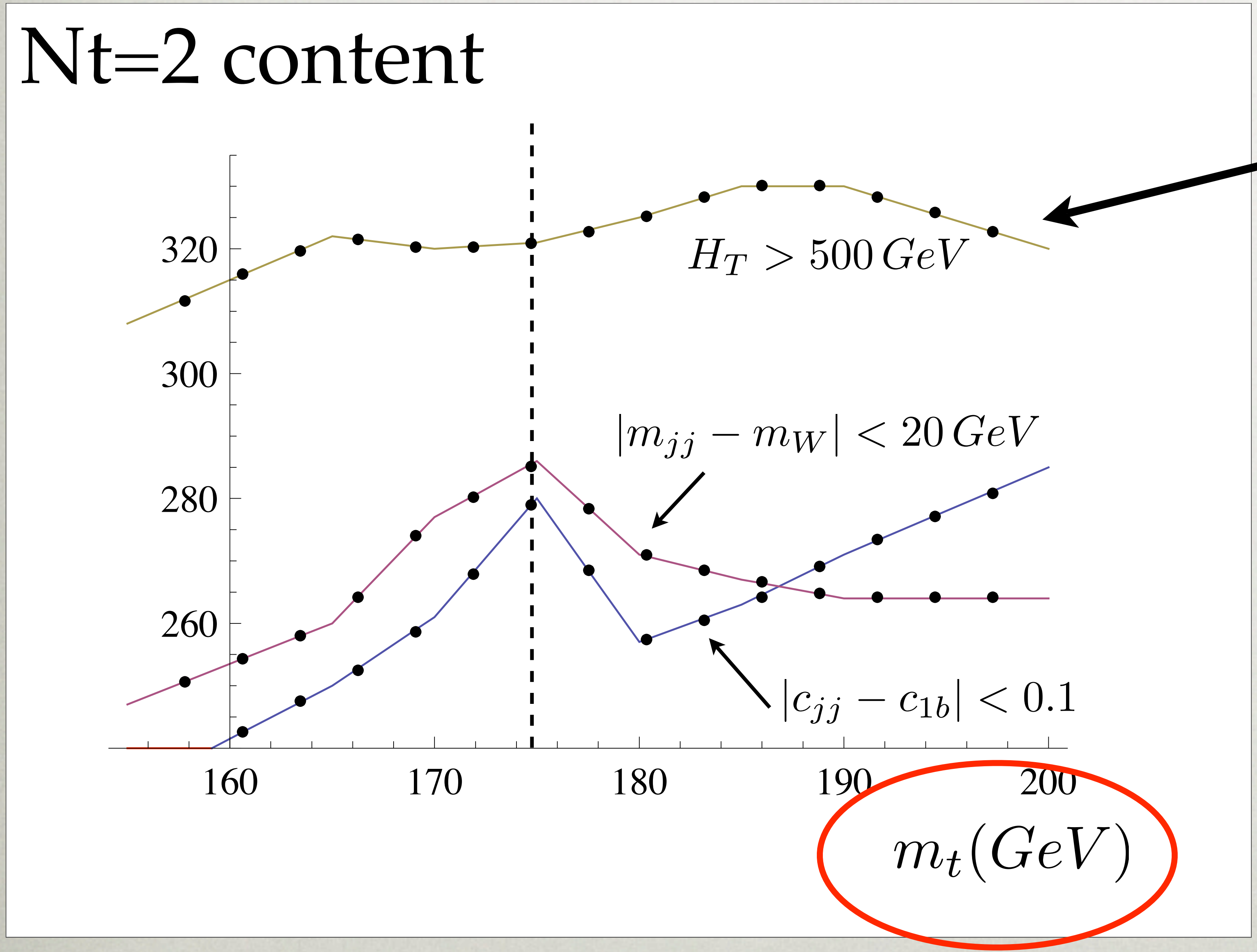
no b-tag, c1b cut

b-tag, c1b cut

b-tagging reduces the signal without payback

Finally, a litmus test

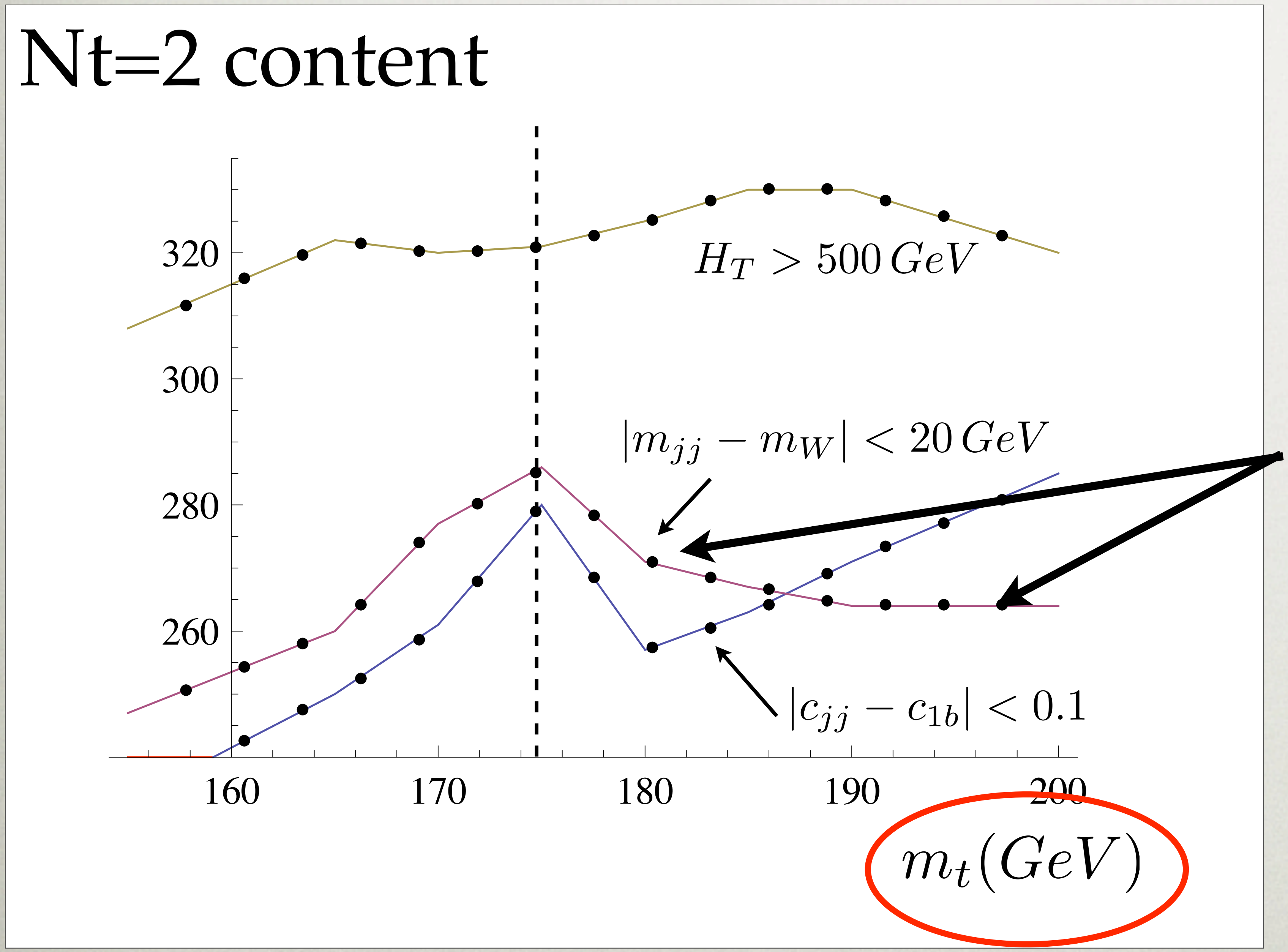
Take the two-top bin and re-do the analysis but with wrong top mass



Ht cut ~ insentitive

bigger mt, selecting higher pT combinations

Finally, a litmus test

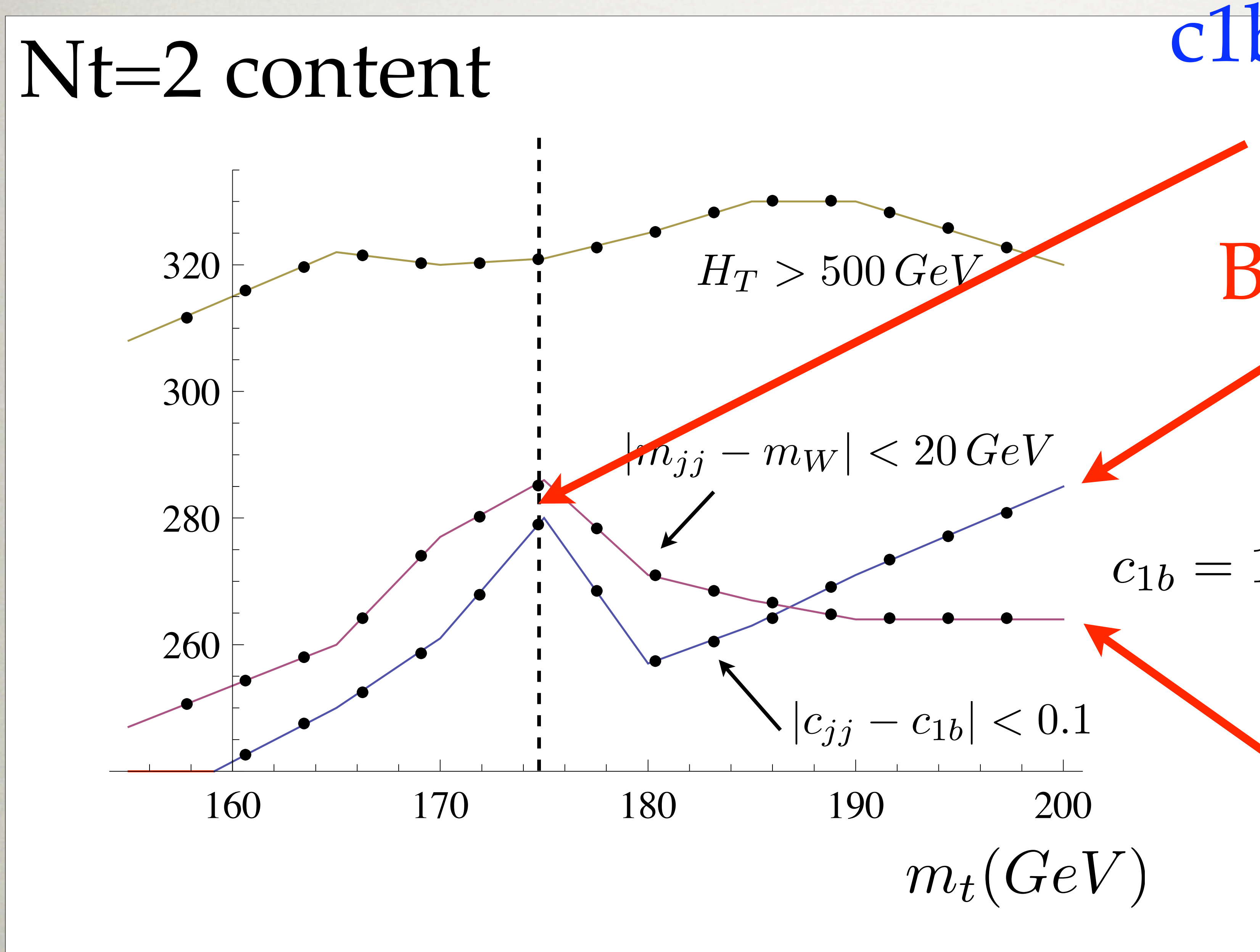


mjj and c1b cuts peak around right value of mt

Behavior is <u>complementary</u>

Finally, a litmus test

Behavior is complementary



c1b is more peaked around mt

But at large mt loses efficiency

$$c_{1b} = 1 - \frac{2m_{1b}^2 m_t^2}{(m_{1b}^2 + m_W^2)(m_t^2 - m_W^2)}$$

mW is more stable at large mt

CONCLUSIONS

TOPS: window EWSB, strong production

many tops interesting, early physics

here a strategy to measure topness and the top mass

no SSL, b-tagging or MET