GOING OVER THE TOP

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

WORK IN PROGRESS

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

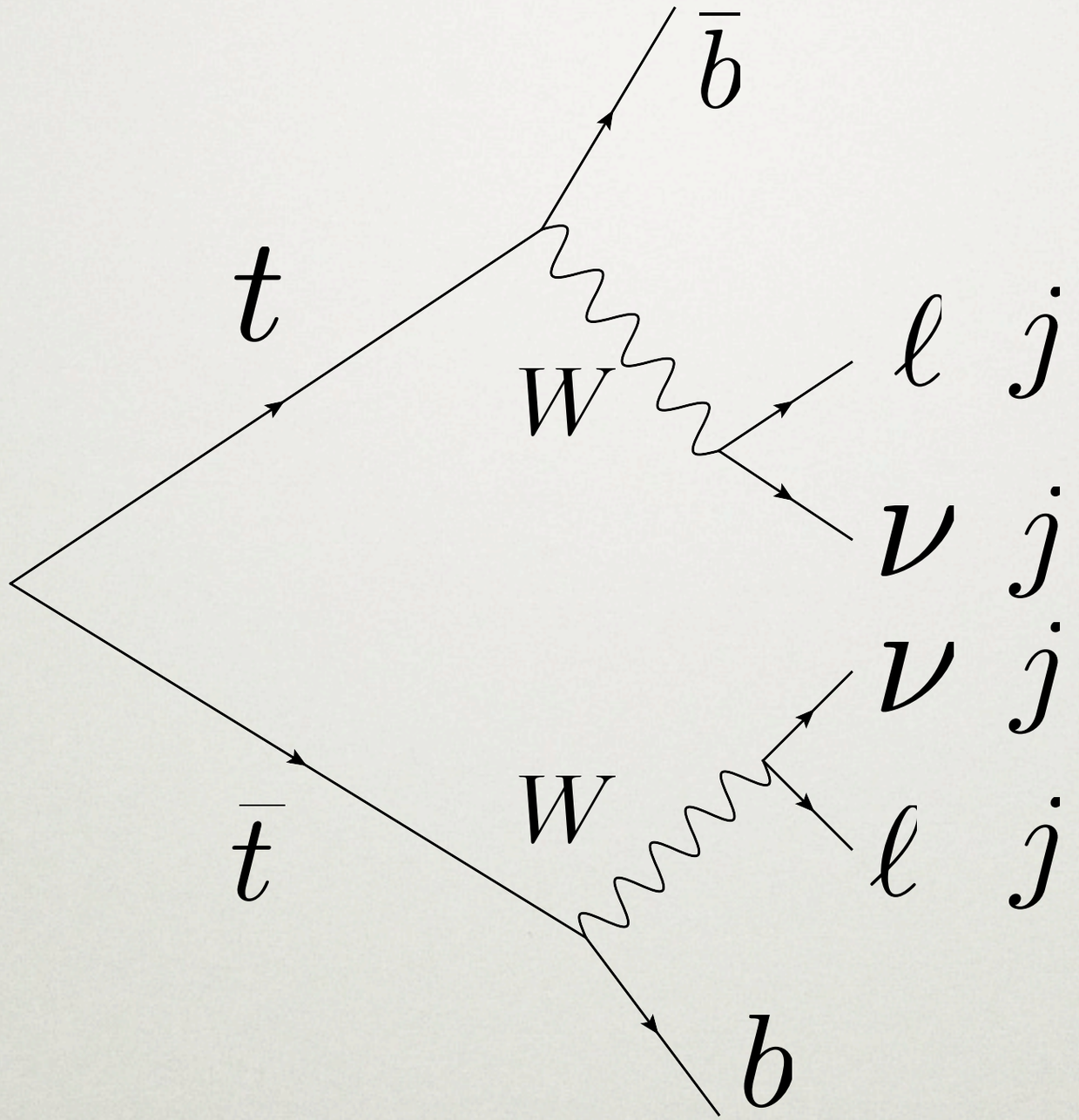
Randall-Sundrum models

Higgsless

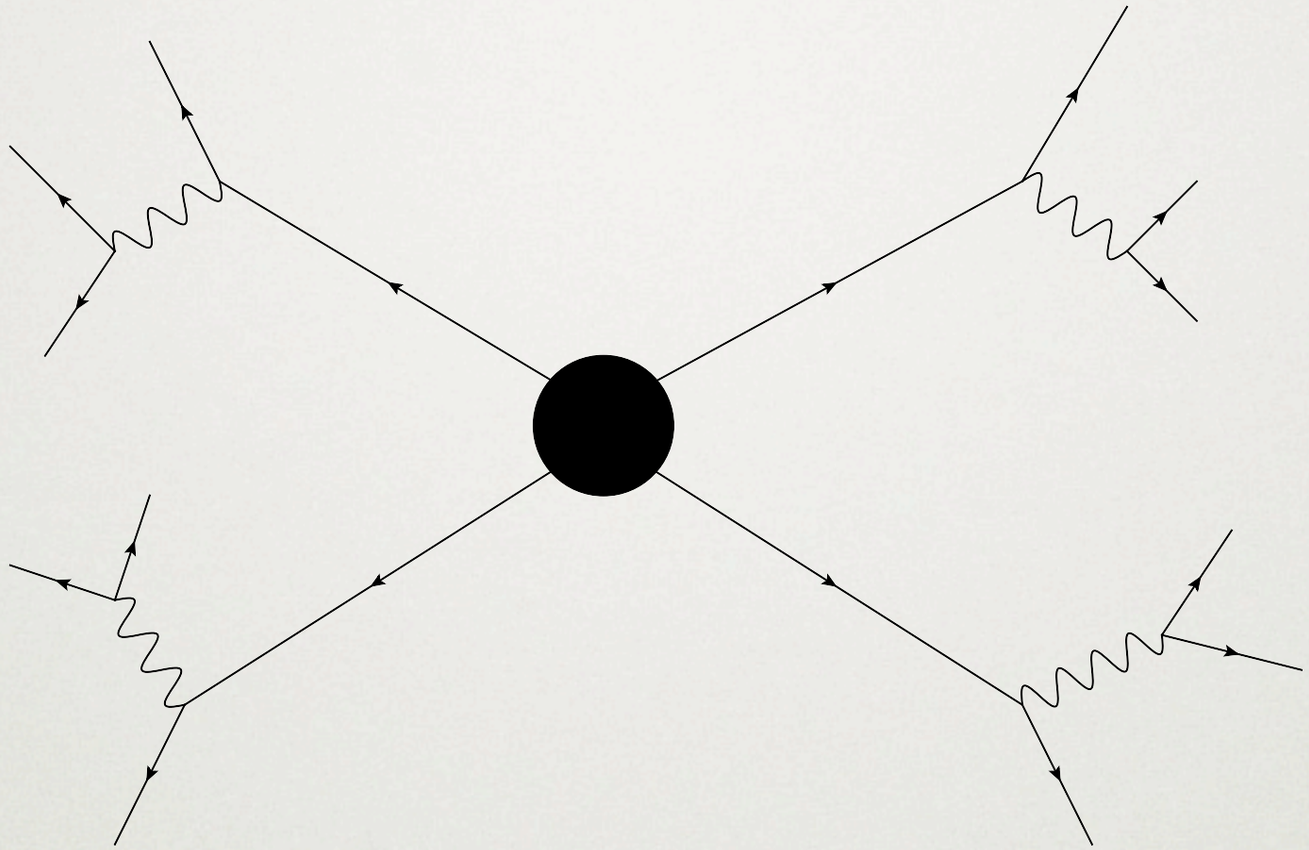
Colorons...

...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

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

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

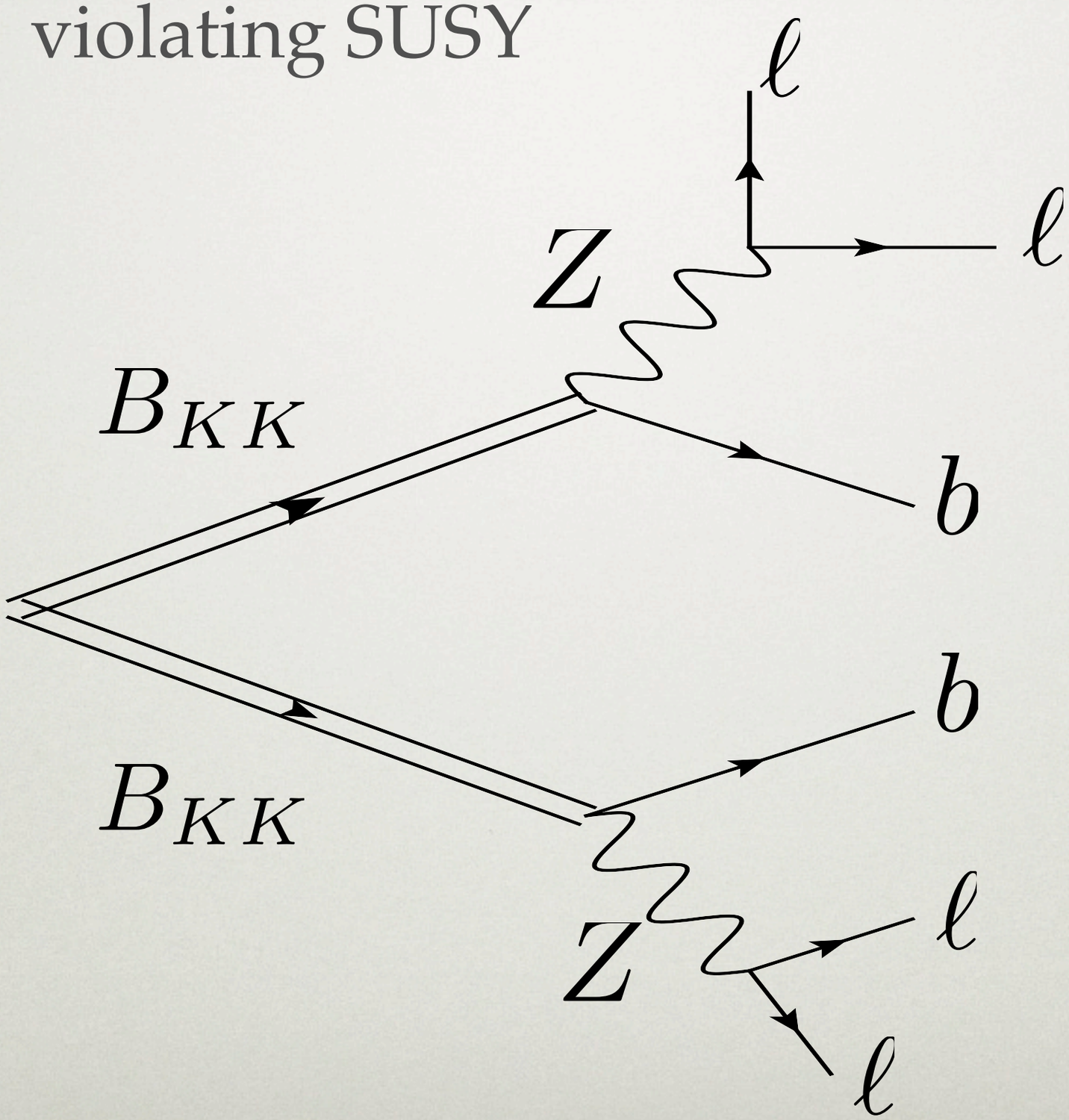
$$W^+W^- + \text{jets}$$

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
...

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

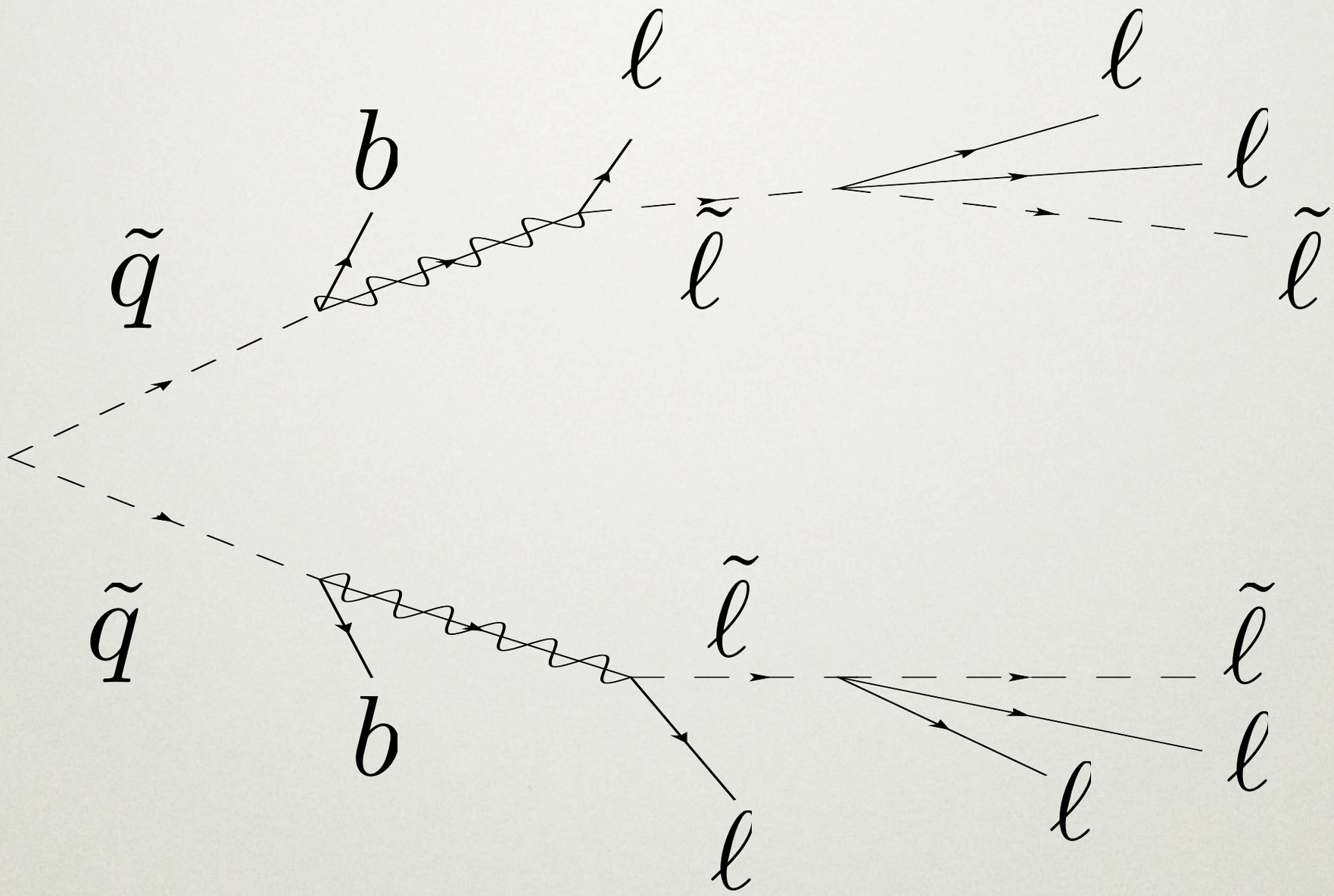
Heavy colored particles: Higgsless, Little Higgs, R-violating SUSY

Martin, VS
JHEP 2010:1-28,2010



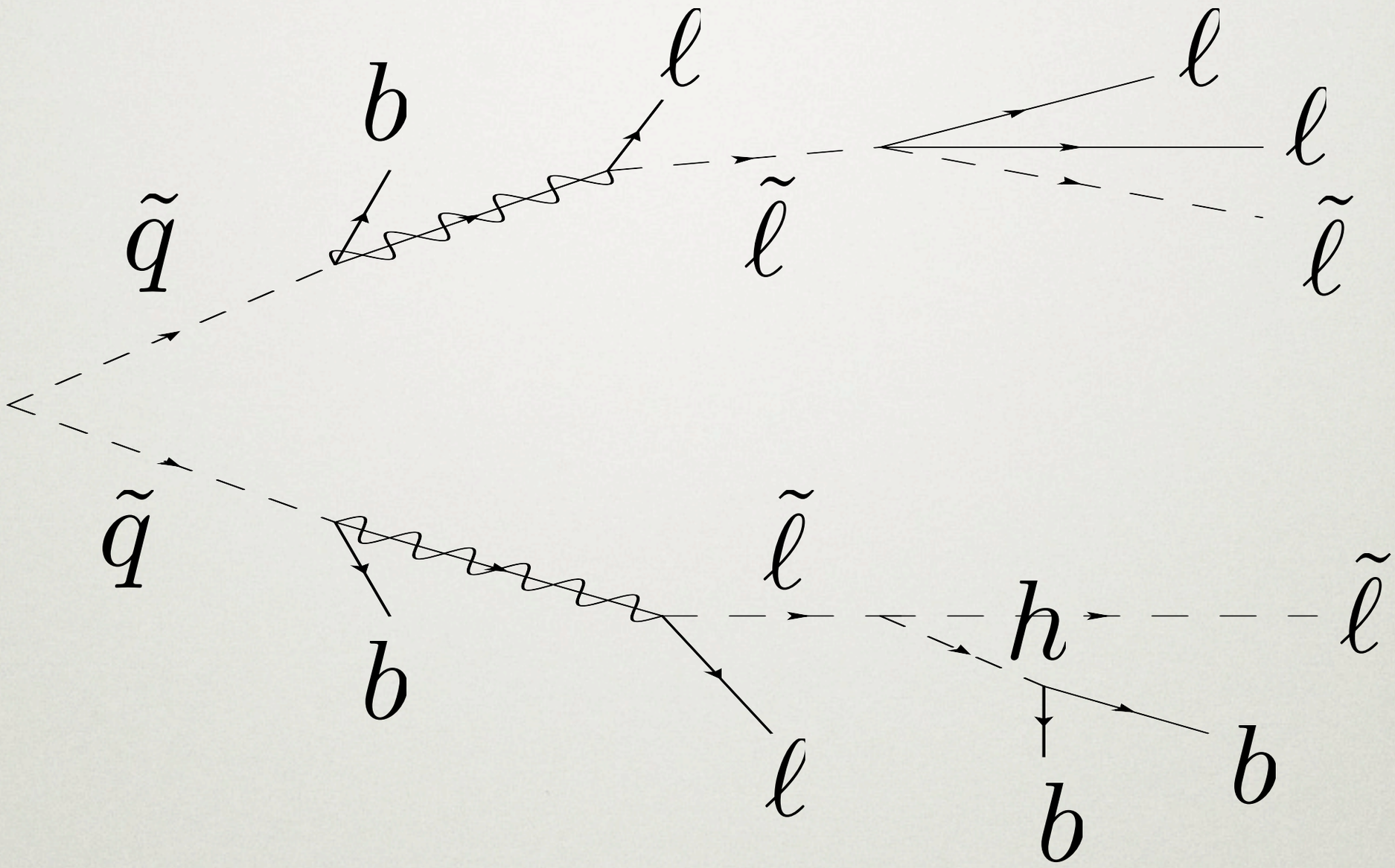
SUSY cascade decays as in lepto-SUSY

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



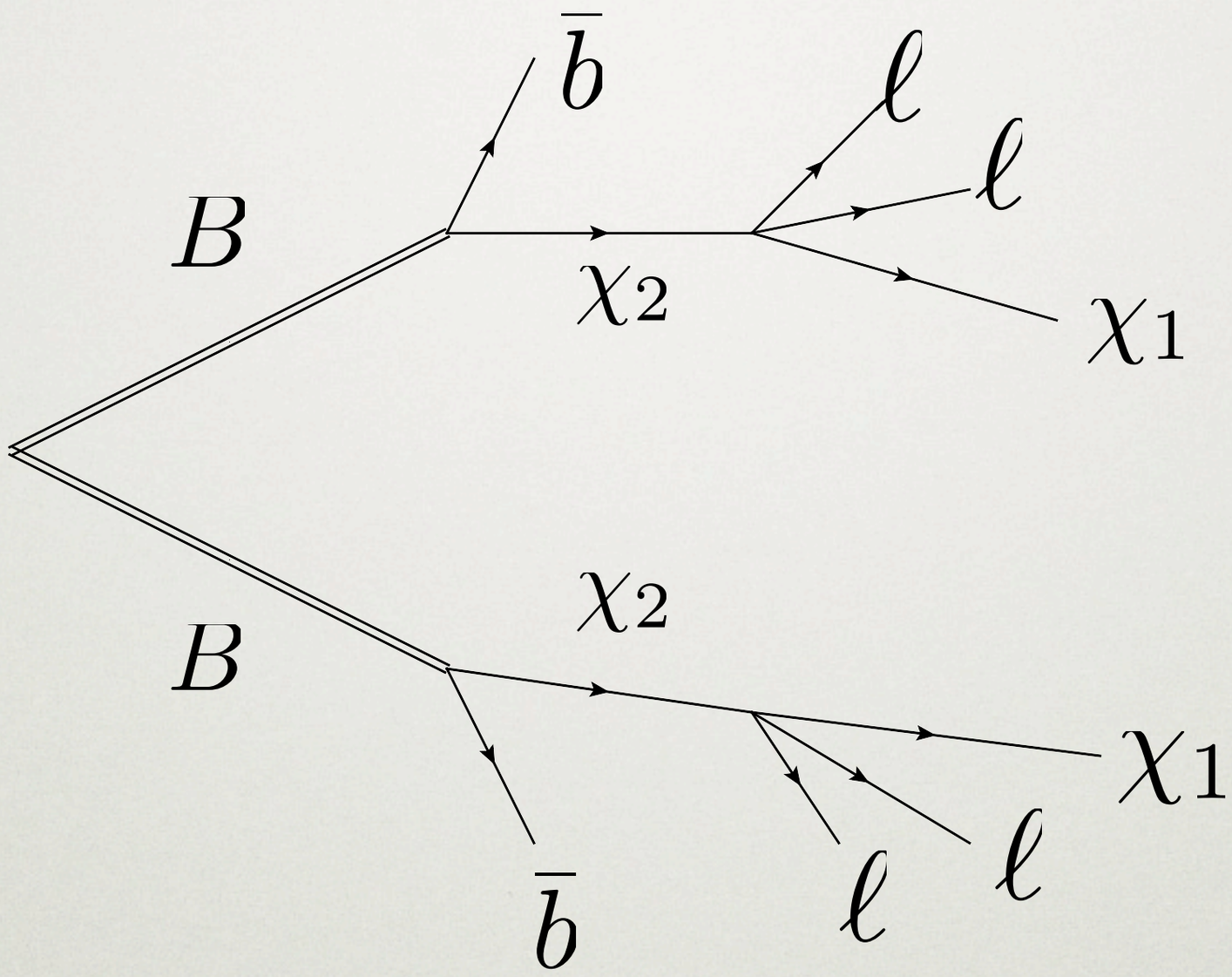
SUSY cascade decays as in lepto-SUSY

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



Or in pseudo-Dirac Dark Matter models

de Simone, VS, Sato
arXiv:1004.1567 [hep-ph]
submitted PRL



How do we know that the new physics with

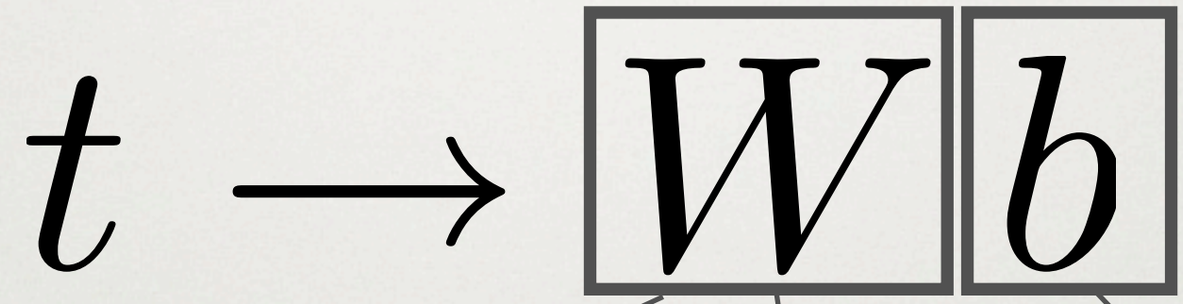
$$2SSL,\ n_b,\ H_T$$

involves tops?

The challenge is to find a measure of

TOP-NESS

Reconstruct tops



Leptonic
BR
missing energy

Hadronic
combinatorial

tagging

Reconstruction j-j-b

Combinatorics!

Cuts or smart strategies to select right combinations

Separation+jj invariant mass cuts

Very hard

Lillie et al
HEP 0804:087,2008.
Gerbush et al
Phys.Rev.D77:095003,2008.

This talk, new strategy

Backgrounds

$t\bar{t}+$ jets, $W+$ jets, $Z+$ jets, $b\bar{b}+$ 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 b jet and form all possible combinations jjb
2. Apply cuts
3. If more than one jjb passes cuts, select the combination with mass closer to the top

Basic cuts

At least one lepton (electron, muon) with pT>20 GeV
Three or more jets with pT>20 GeV, where at least one is a b-jet

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}.

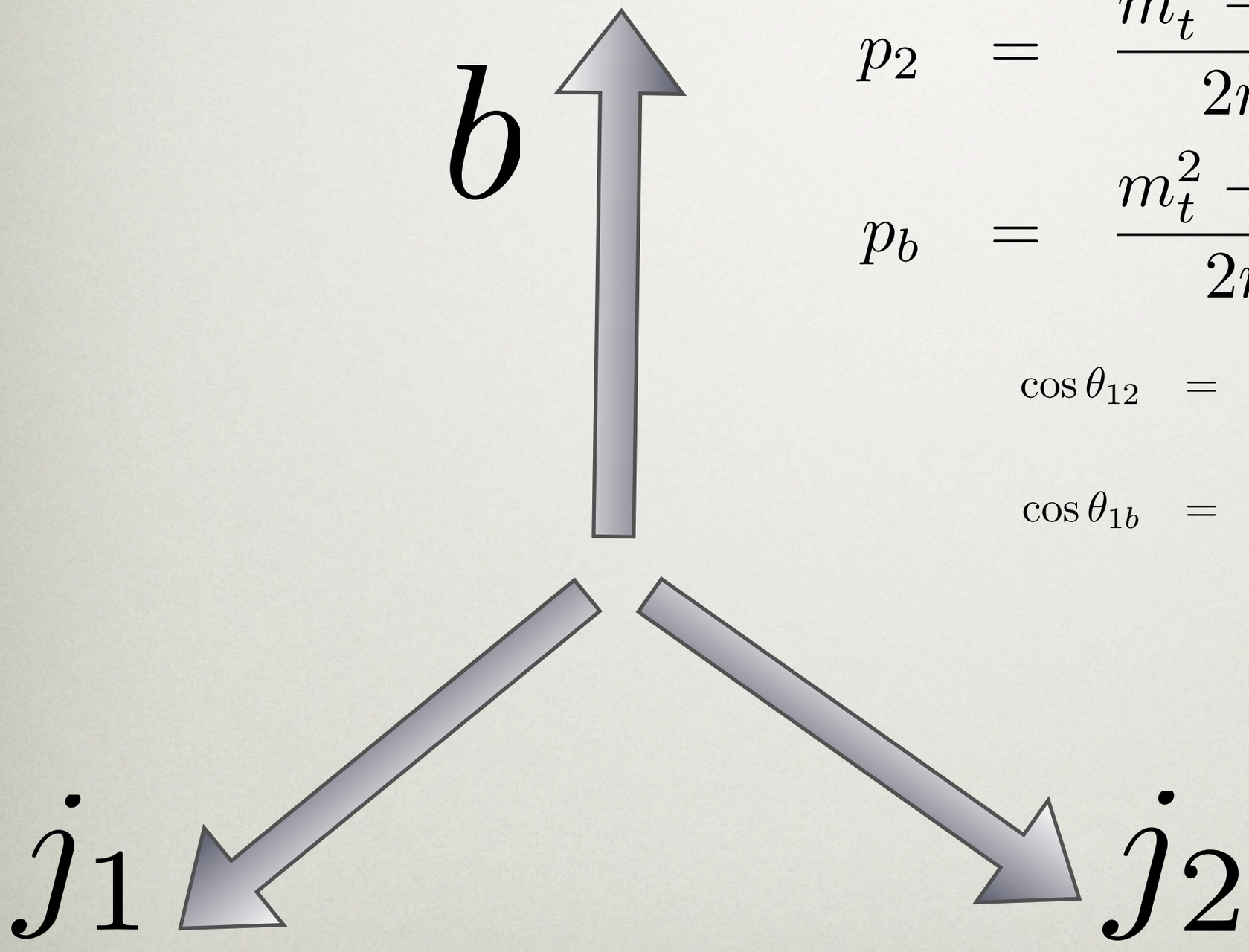
Electron analysis						
Sample	default	W const.	m_t win	W const. + $\|\eta\| < 1$	W const. + 1 b-tag	W const. + 2 b-tag
$t\bar{t}$	2555	1262	561	303	329	208
hadronic $t\bar{t}$	11	4	0.0	0.8	0.6	0.0
W+jets	761	241	60	38	7	1
single top	183	67	23	12	18	7
$Z \rightarrow ll$ +jets	115	35	8	5	2	0.4
$W\ b\bar{b}$	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 a different cut

In the top CM

$$
\begin{aligned}
p_1 &= \frac{m_{1b}^2 + m_W^2}{2m_t} \\
p_2 &= \frac{m_t^2 - m_{1b}^2}{2m_t} \\
p_b &= \frac{m_t^2 - m_W^2}{2m_t}
\end{aligned}
$$

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



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

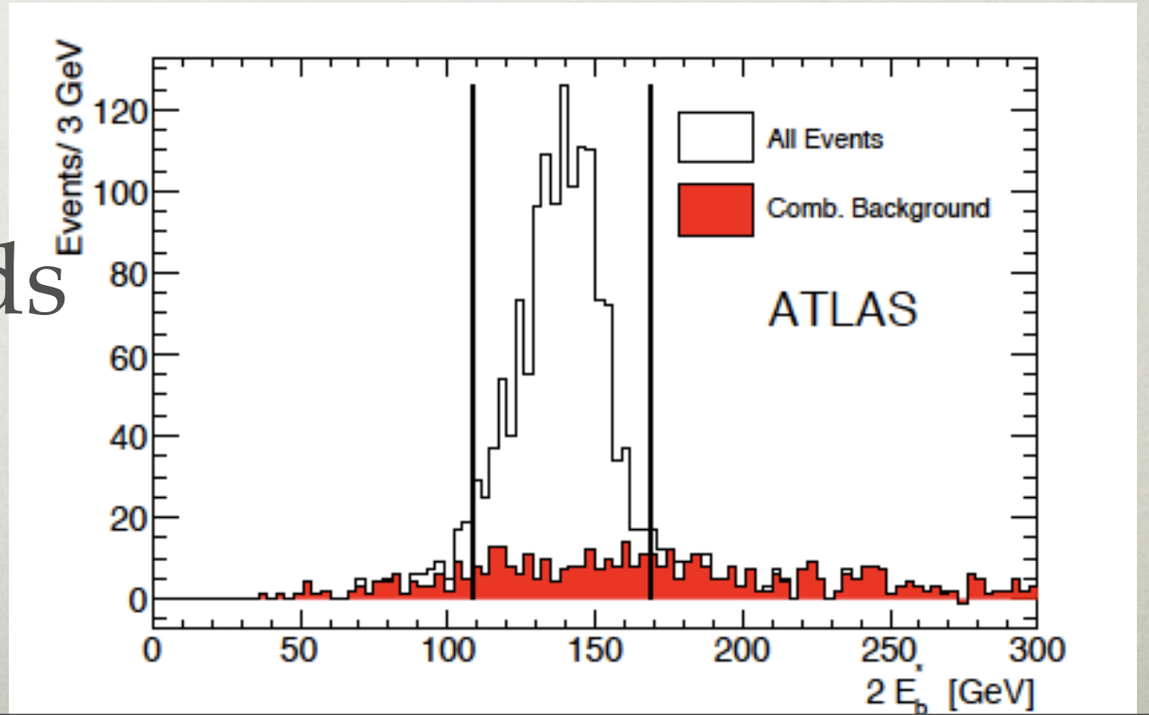
ATLAS TDR

$$X_1 = E_{\text{W}}^* - E_{\text{b}}^*$$

$$X_2 = 2E_{\text{b}}^*$$

Cuts on the top CM ref frame

Estimate errors needs MC



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

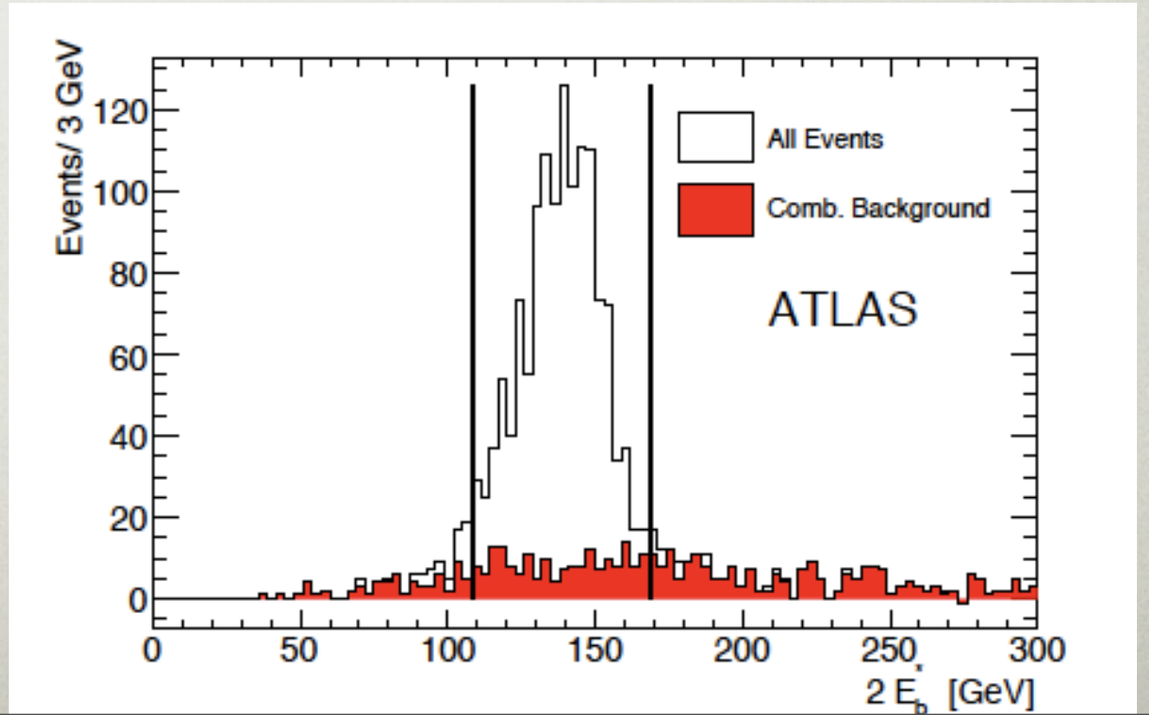
ATLAS TDR

$$X_1 = E_{\text{W}}^* - E_{\text{b}}^*$$

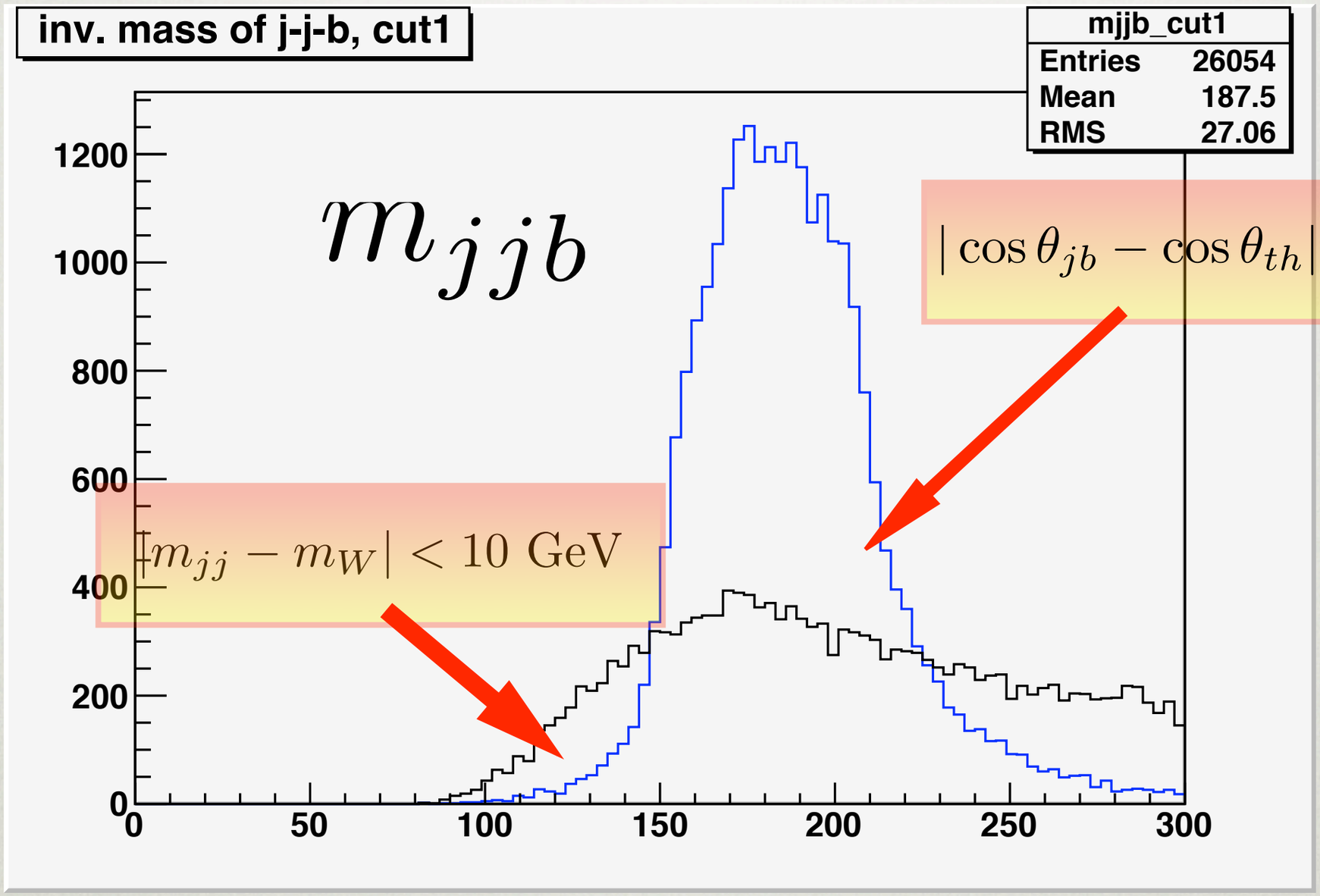
$$X_2 = 2E_{\text{b}}^*$$

Cuts on the top CM ref frame

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

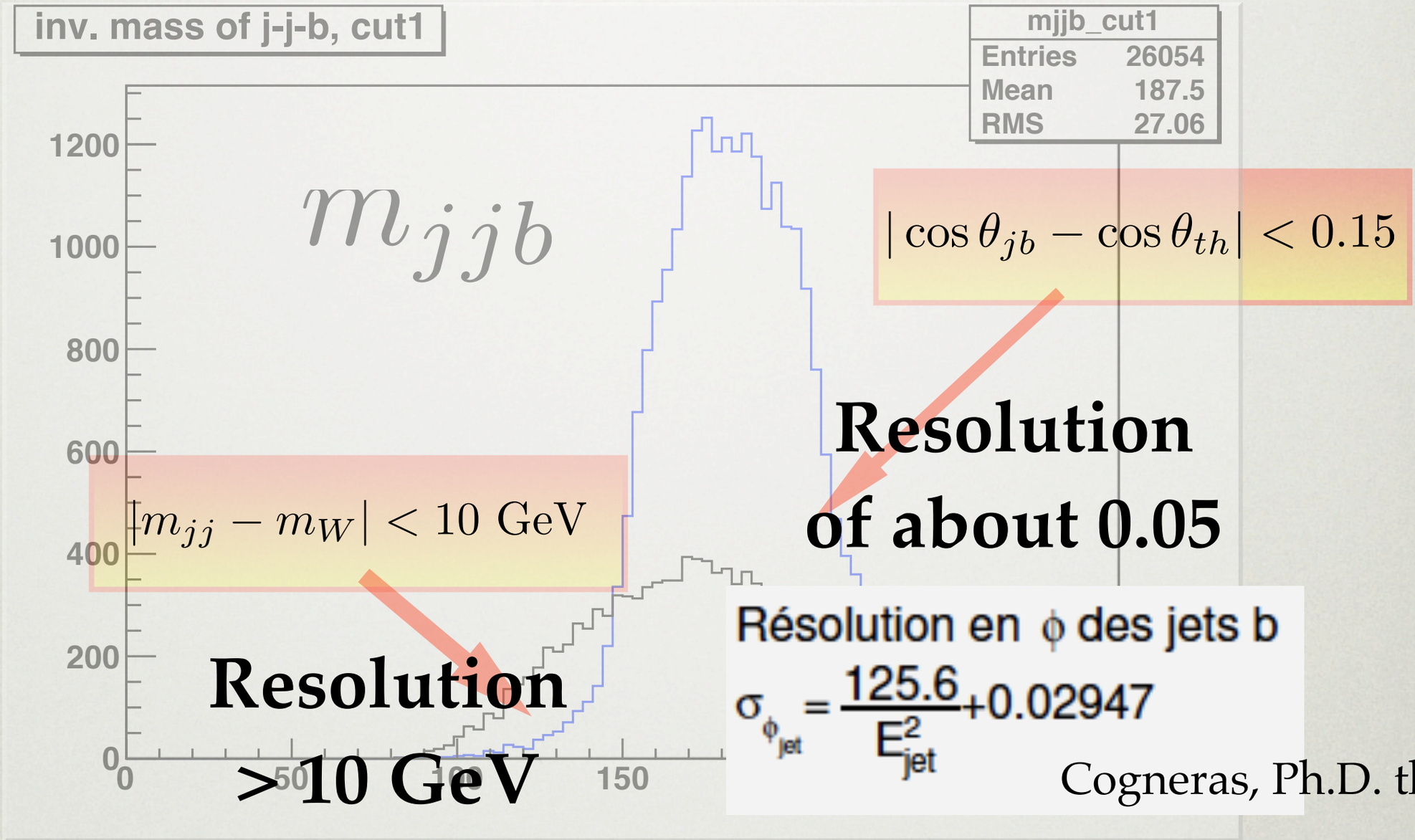


m_W vs $\cos\theta_{1b}$



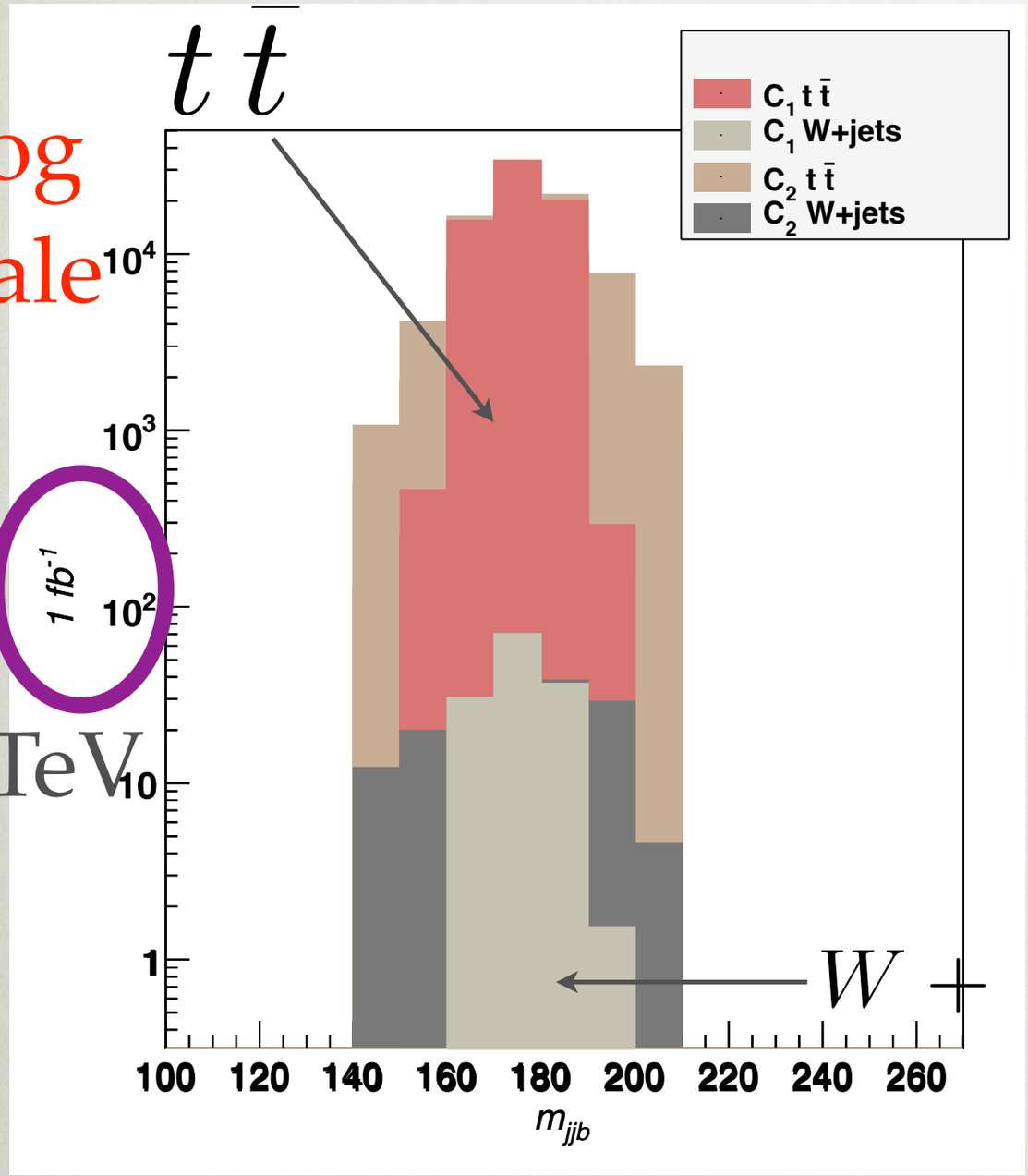
Normalized to the same number of top candidates

m_W vs $\cos\theta_{1b}$



The angular cut is better

And we use this cut to study SM ttbar vs other SM bgs

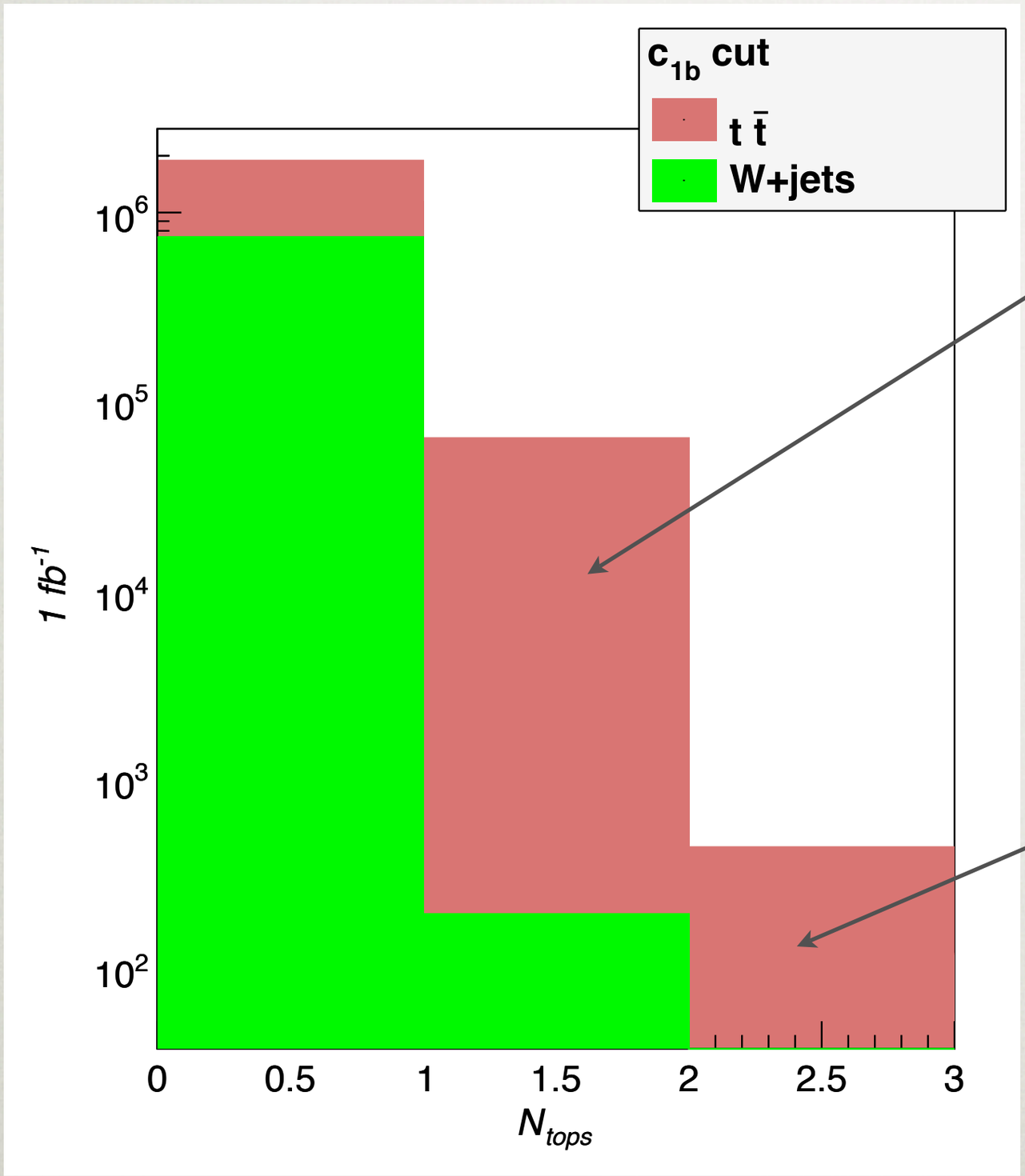


Combination angular and top mass cuts

$$|m_{jjb} - m_t| < 30 \text{ GeV}$$

$$|c_{jb} - c_{1b}| < 0.05$$

Counting ttbar tops



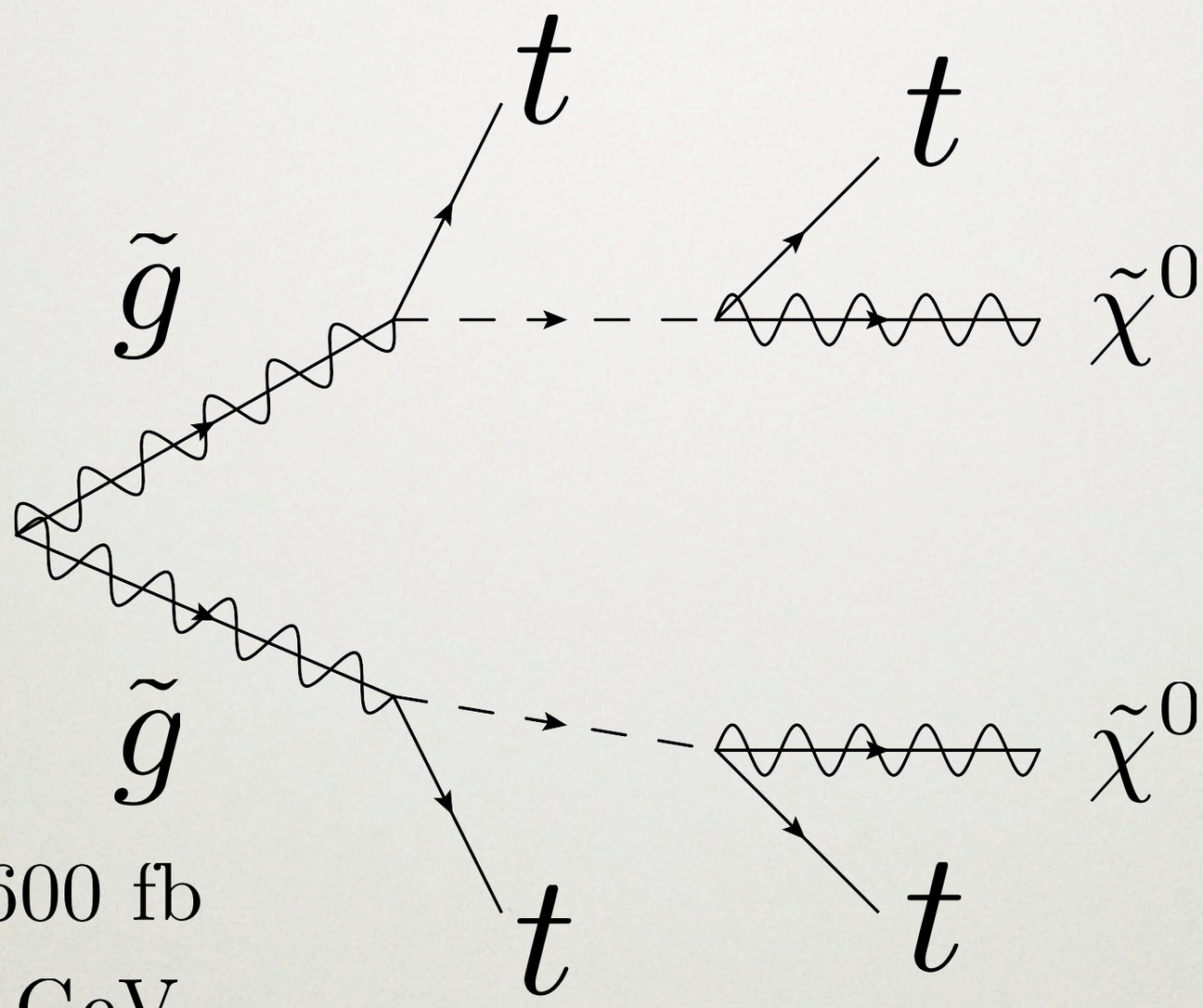
Efficiency 0.04
loosen c1b cut?

$$|m_{jjb} - m_t| < 30 \text{ GeV}$$

$$|c_{jb} - c_{1b}| < 0.05$$

Fakes (we're asking for a lepton)
increase pT cut?

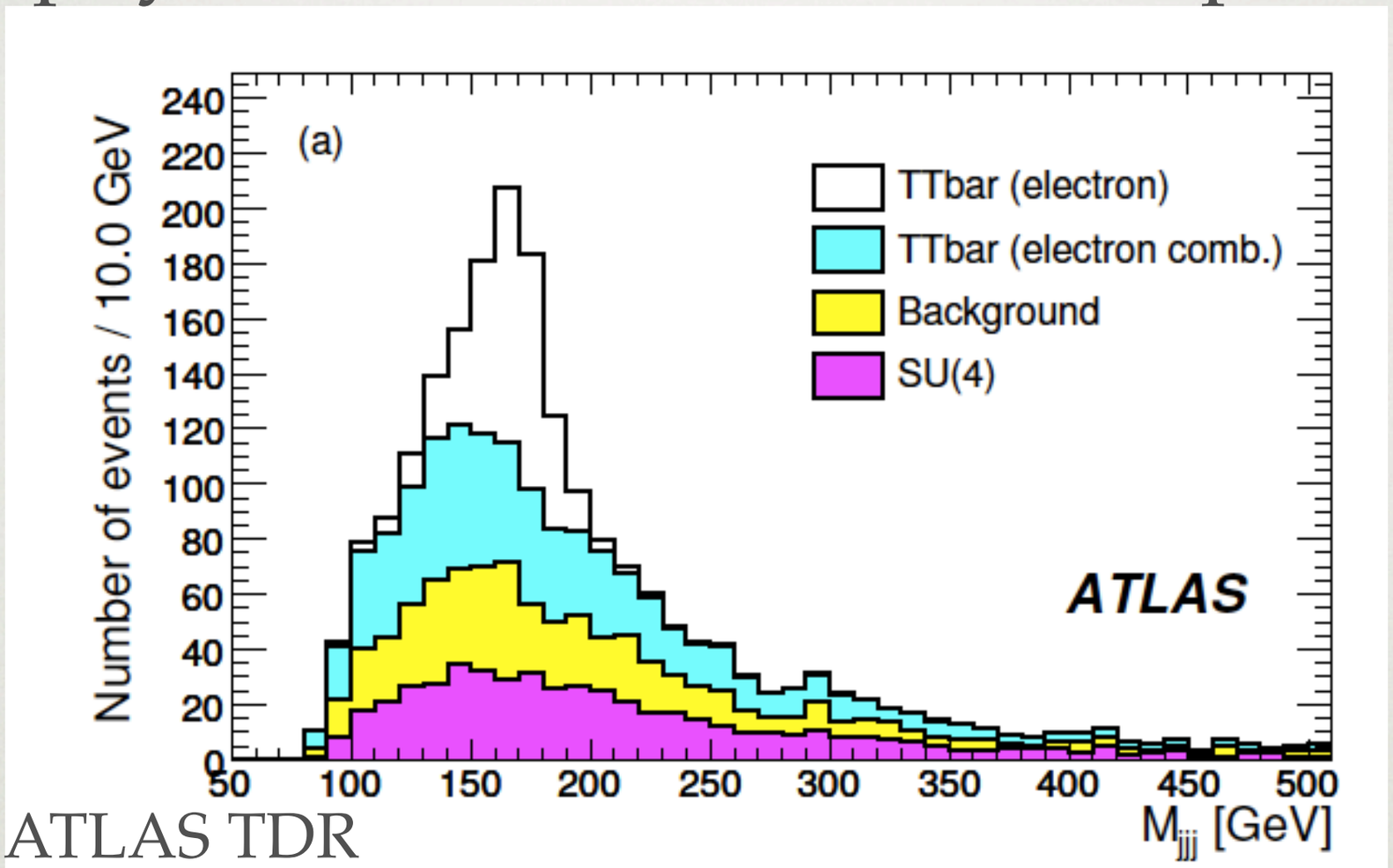
Now new physics
MC simulation, need to specify model
SUSY decay chain light stops



$\sigma_{prod} \simeq 600$ fb

$p_T > 20$ GeV

New physics is subdominant in 2tops events



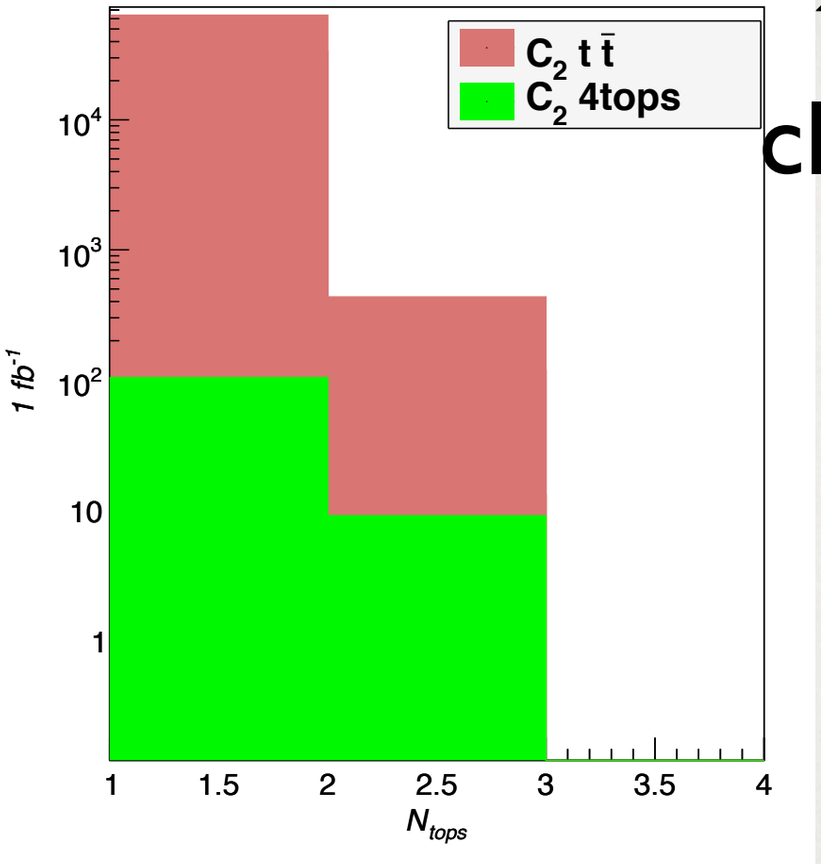
ATLAS TDR

Need reconstructing more tops to beat SM ttbar

First we need to reduce the ttbar fakes in Nt=2 bin

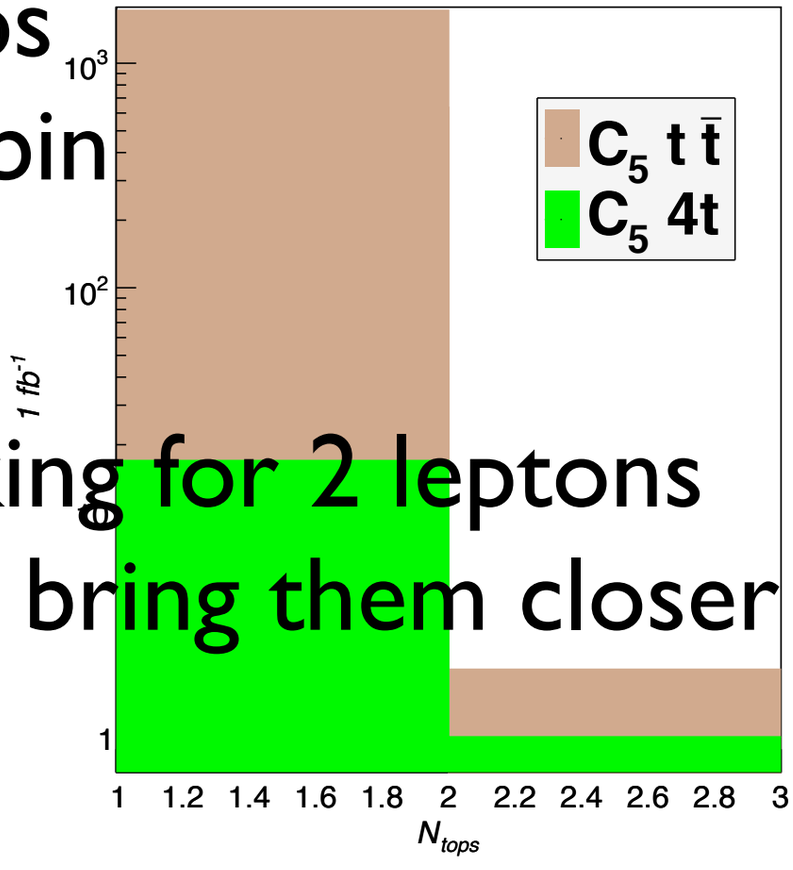
ttbar versus 4tops

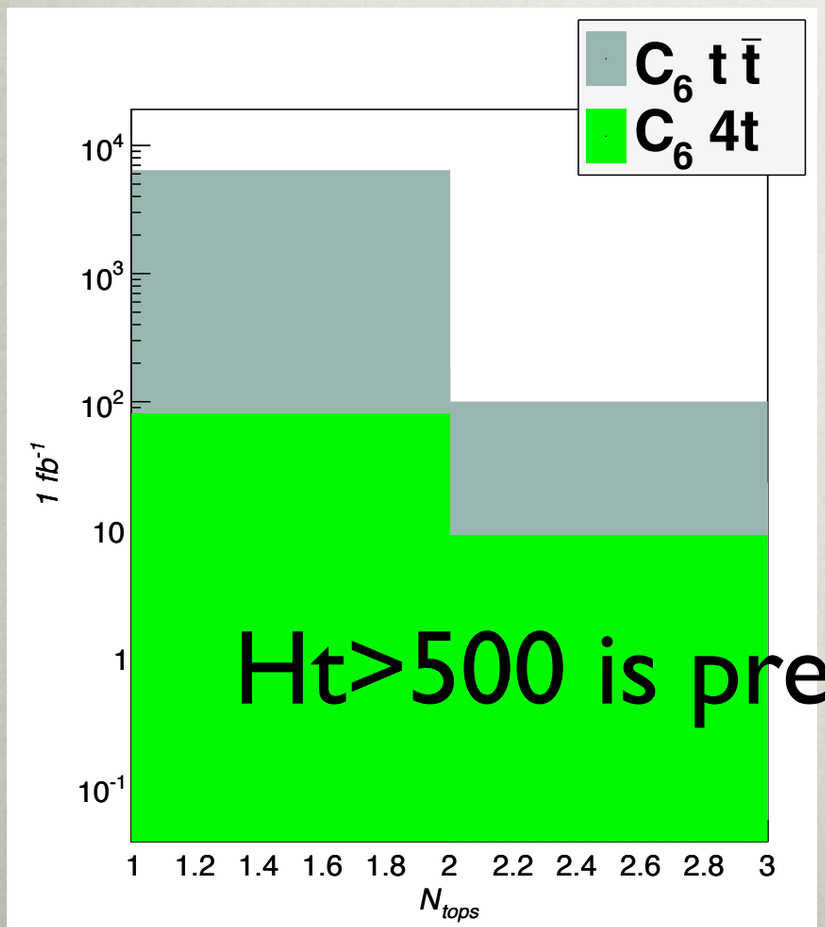
cleaning the 2top bin



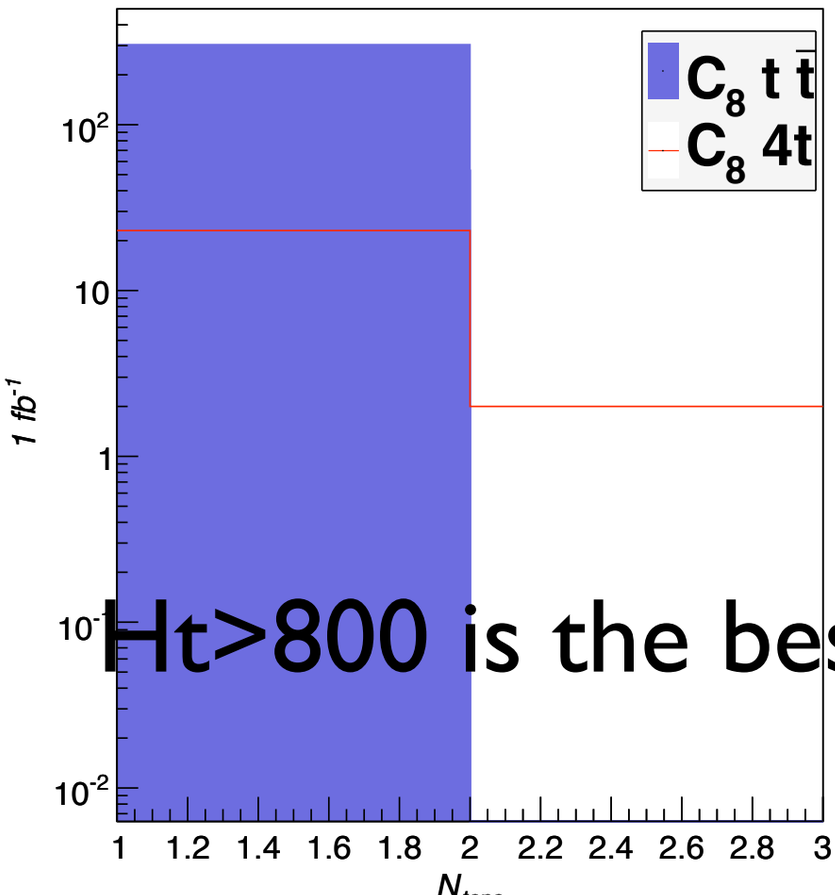
asking for 2 leptons

does bring them closer





Ht>500 is pretty good but

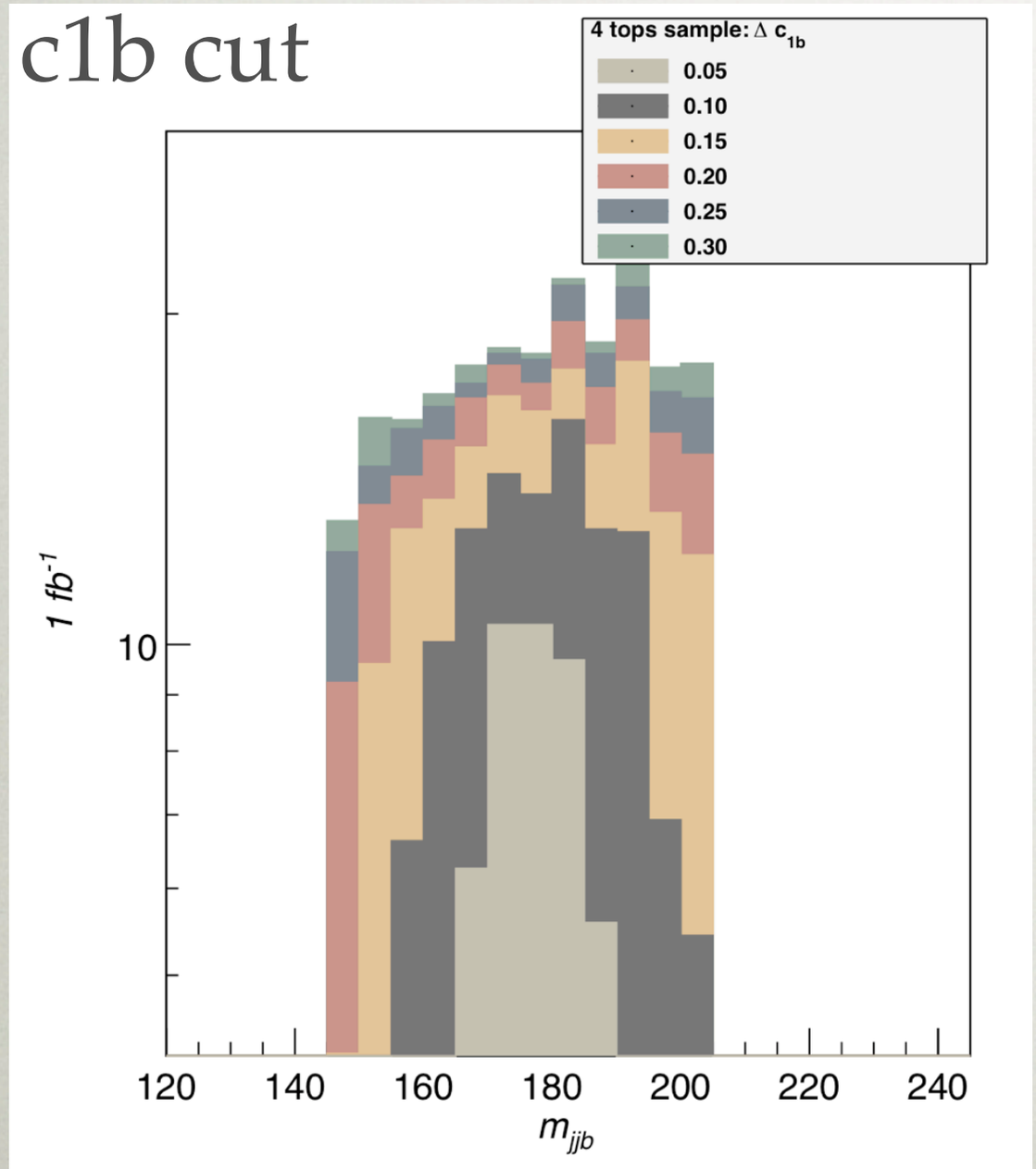


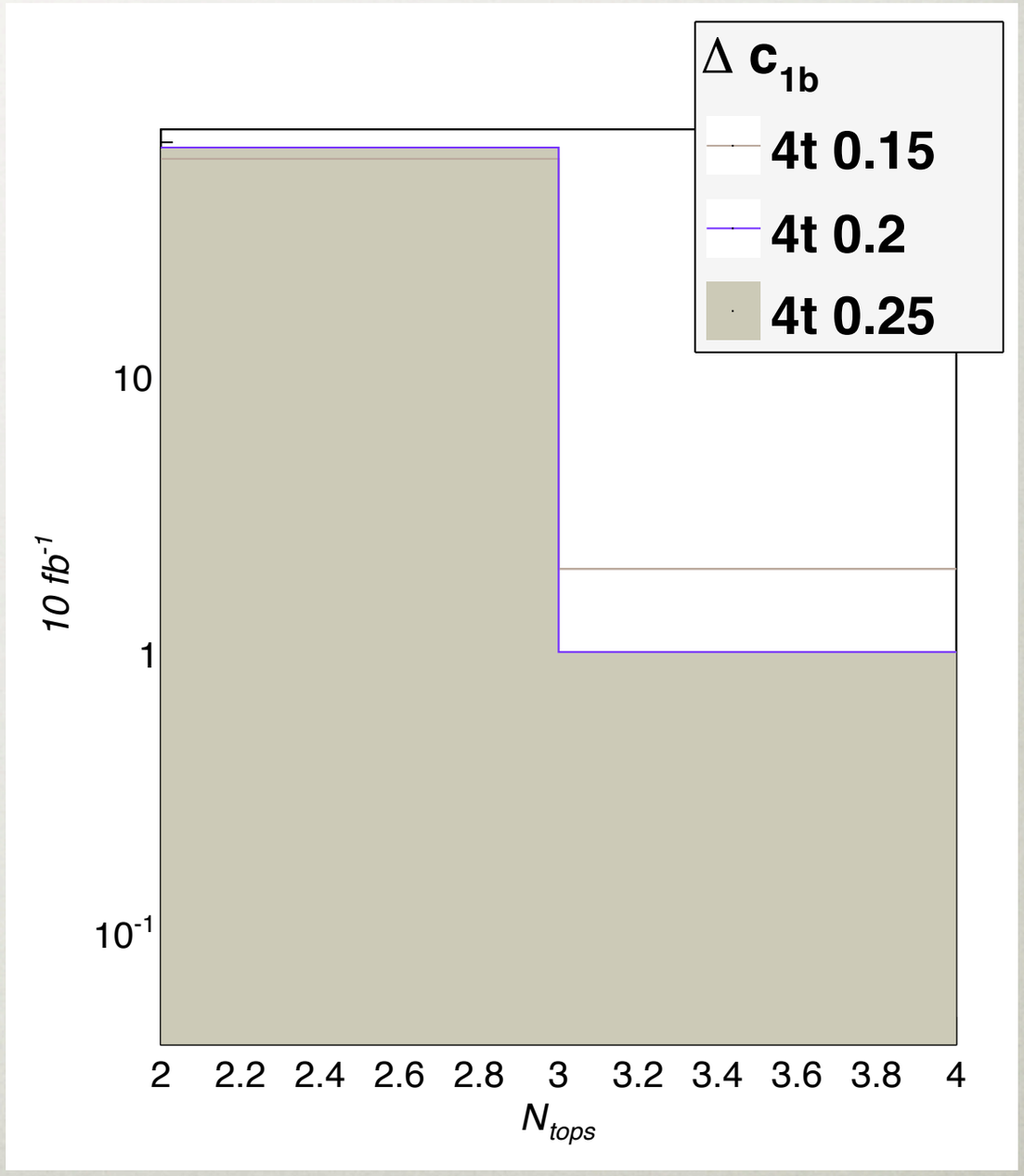
Ht>800 is the best

So we need an Ht cut to get rid of ttbar fakes now loosen c1b cut

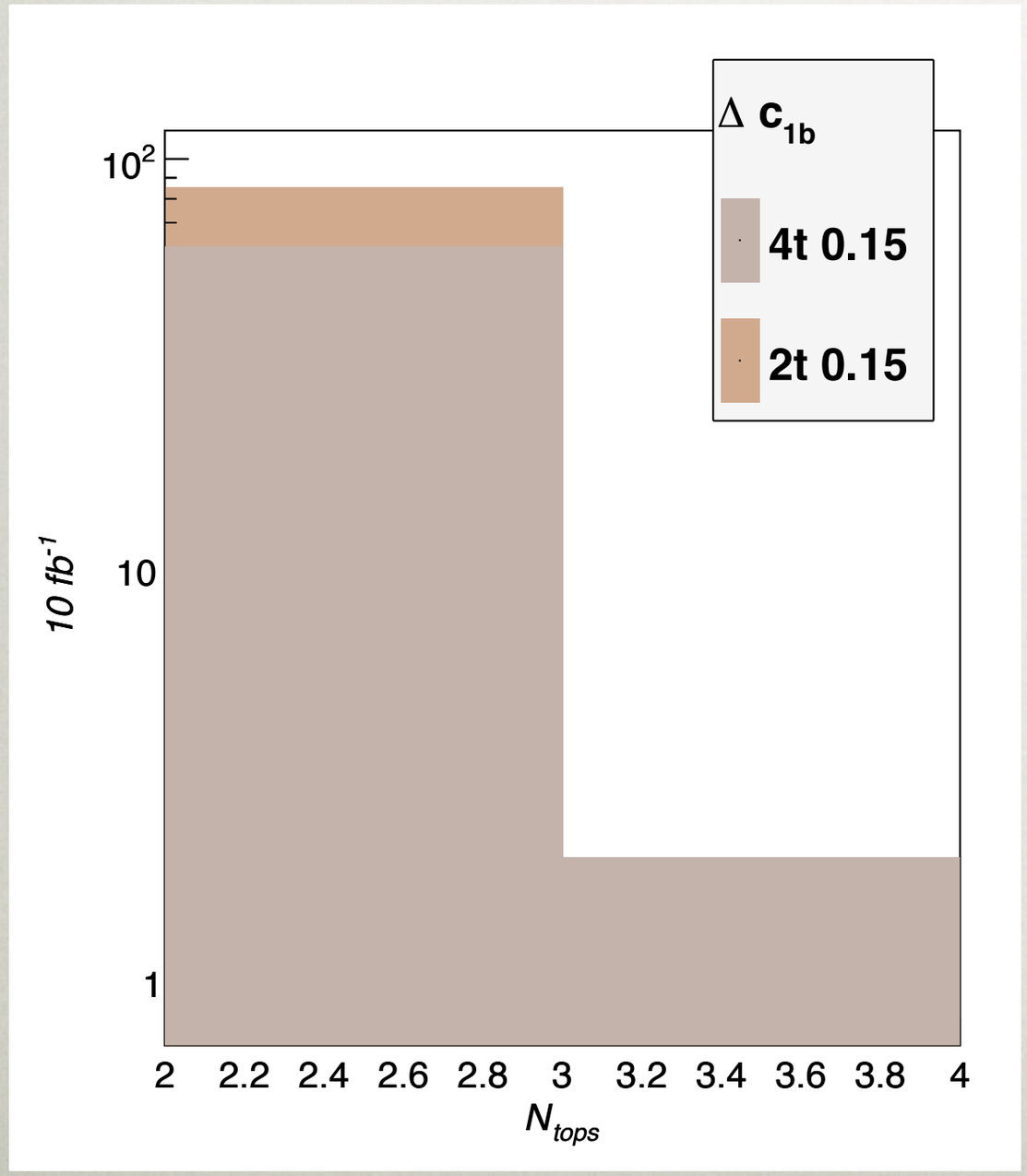
4 tops

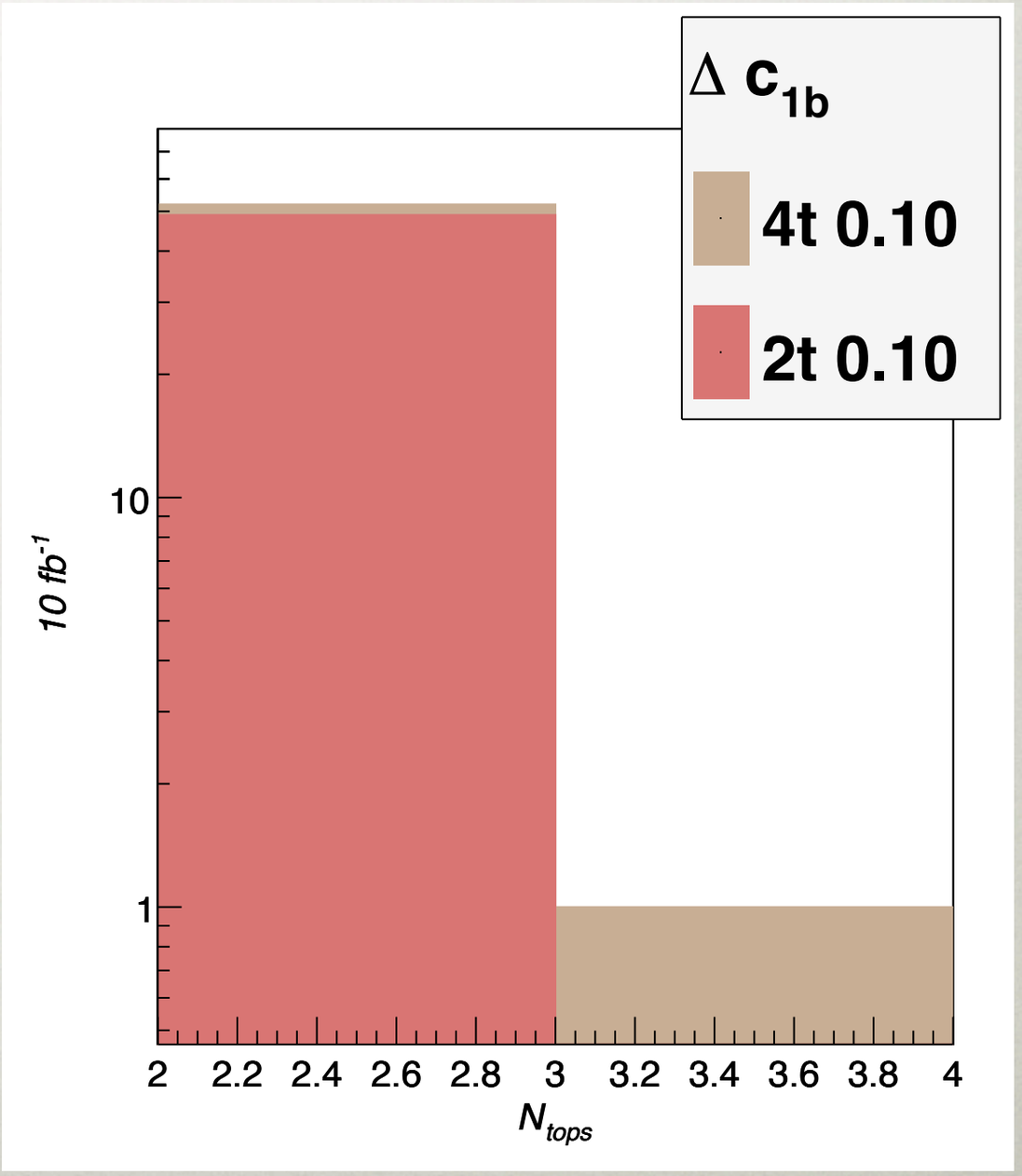
c1b cut





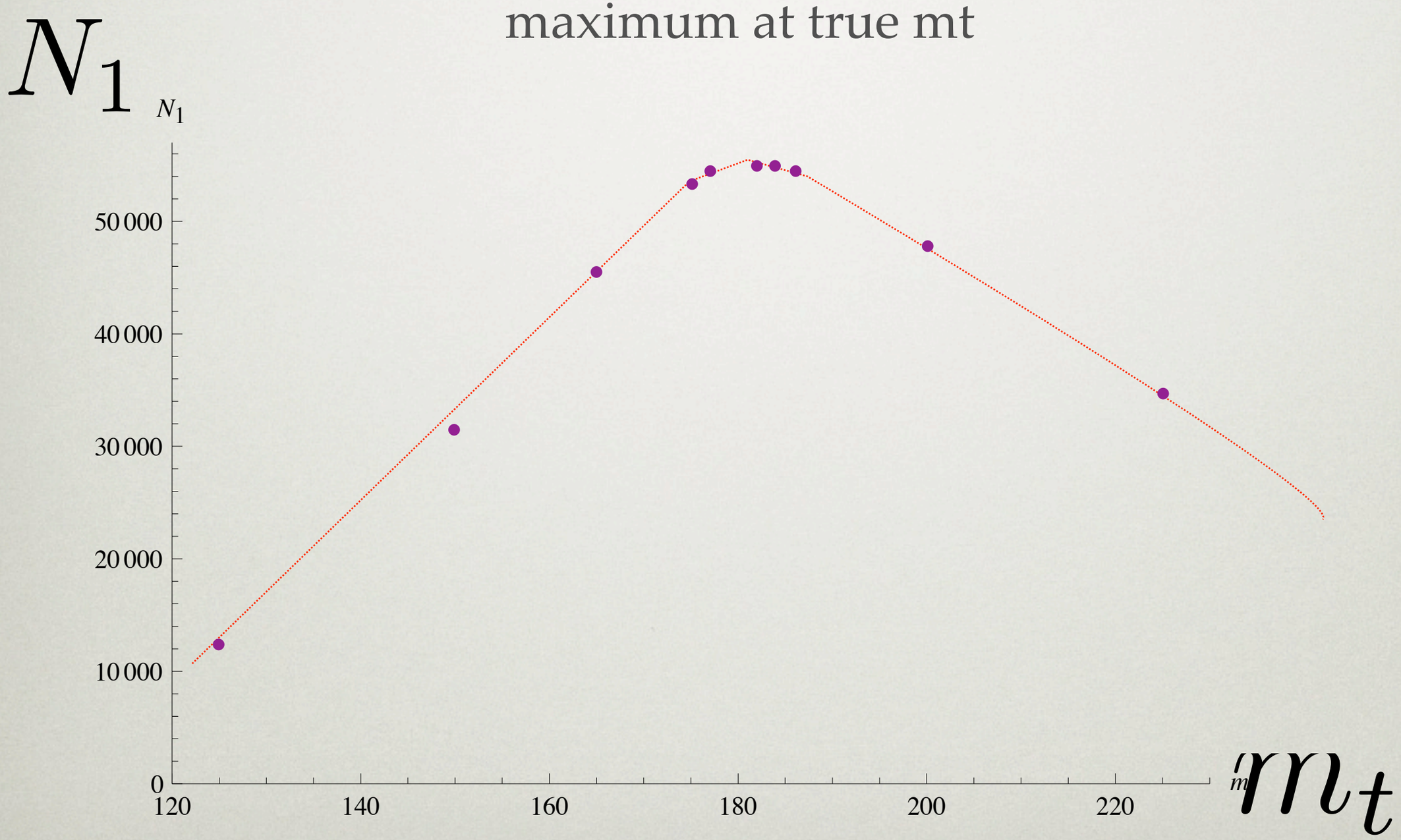
by varying the c1b cut
we can beat ttbar in both Nt=1 and 2 bins





Top mass measurement?

Vary the value of mt in the cuts
count how many top candidates
maximum at true mt



CONCLUSIONS

TOPS: window EWSB, strong production

many tops interesting, early physics

here a strategy to measure topness and the top mass

4 tops: no 2SSL but Ht and angular

We need you, experimentalists

TDRs SM searches

Error in angle when CM->LAB

mt determination

cross section measurement

other interesting ratios N1/N2...

lepton information mT2

no b-tagging