Polarization Issues in Stop Searches

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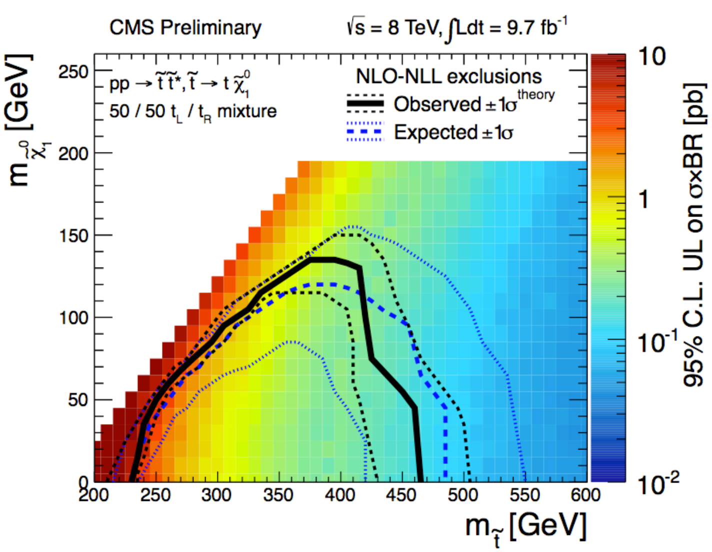
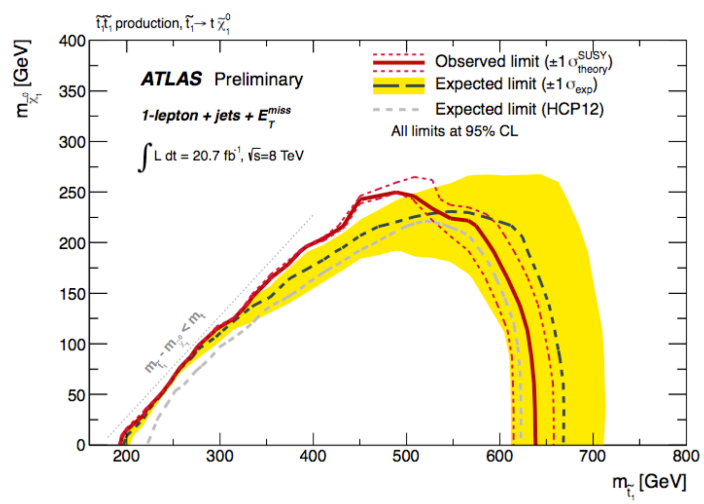
April 25, 2013 @ Davis Higgs Workshop

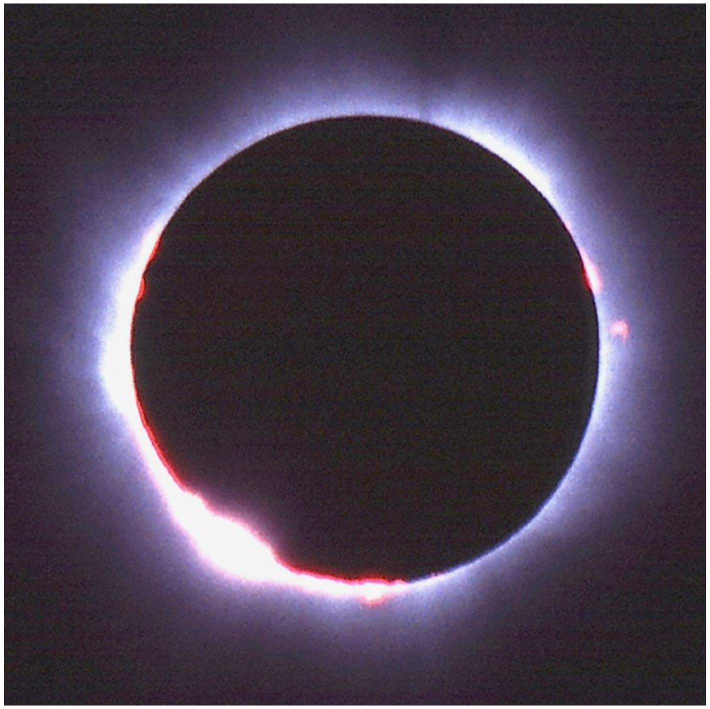
Based on discussions with Claudio Campagnari and 1304.0491





Stop searches is the litmus test for naturalness in supersymmetry:

Natural??



Fine-tuned??

I will focus on direct stop searches, although most of what I will say applies to stops produced in gluino decays.

If kinematically allowed, stops naturally decay to third generation quarks:

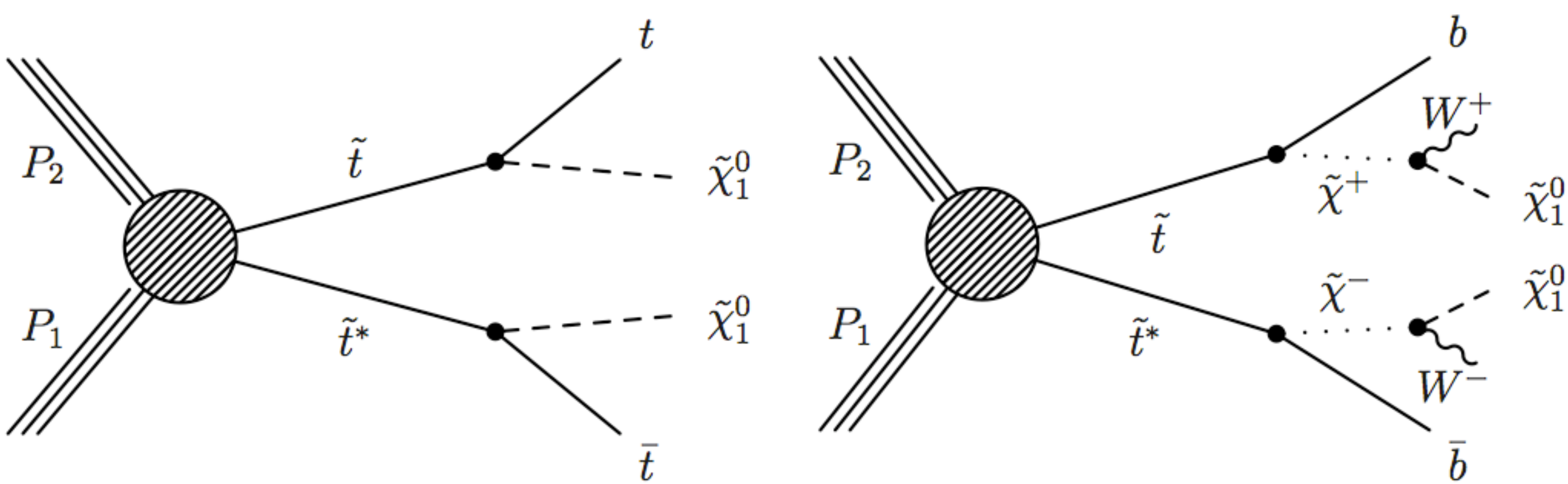


Figure 1: Diagram for top squark pair production for the $\tilde{t} \to t\tilde{\chi}_1^0 \to bW\tilde{\chi}_1^0$ decay mode (left) and the $\tilde{t} \to b\tilde{\chi}_1^+ \to bW\tilde{\chi}_1^0$ decay mode (right).

CMS-PAS-SUS-12-023

It has been noted previously that the top quark in stop decays is polarized:

$$g_{\rm eff}^{(t)}\ \bar{t}\left(\sin\theta_{\rm eff}^{(t)}\,P_L+\cos\theta_{\rm eff}^{(t)}\,P_R\right)\tilde{\chi}_1^0\,\tilde{t}_1$$

$$\begin{pmatrix}\tilde{t}_1\\ \tilde{t}_2\end{pmatrix}=\begin{pmatrix}\cos\theta_t & \sin\theta_t\\ -\sin\theta_t & \cos\theta_t\end{pmatrix}\begin{pmatrix}\tilde{t}_L\\ \tilde{t}_R\end{pmatrix}\qquad \tan\theta_{\rm eff}^{(t)}=\frac{y_tN_{j4}\cos\theta_t-\frac{2\sqrt{2}}{3}g'N_{j1}\sin\theta_t}{\sqrt{2}\left(\frac{g}{2}N_{j2}+\frac{g'}{6}N_{j1}\right)\cos\theta_t+y_tN_{j4}\sin\theta_t}$$

$$\tilde{N}_i=(-i\tilde{B},-i\tilde{W},\tilde{H}_d,\tilde{H}_u),\qquad \tilde{\chi}_i^0=N_{ij}\tilde{N}_k$$

Gunion and Haber, NPB 1984;
Perelstein and Weiler: 0811.1042

from Claudio Campagnari

The top polarization in stop_1 decay depends on stop mixing **and** the neutralino mixing. It is easy to see why:

LSP	Allowed stop decays	Why
$\tilde{\chi}_1^0=\tilde{B}_3$	$\tilde{t}_L\to t_L\tilde{\chi}_1^0\quad \tilde{t}_R\to t_R\tilde{\chi}_1^0$	U(1) couples L to L and R to R
$\tilde{\chi}_1^0=\tilde{W}_3$	$\tilde{t}_L\to t_L\tilde{\chi}_1^0$	SU(2) only acts on L
$\tilde{\chi}_1^0=\tilde{H}_d^0$	none	Only couples to down-type
$\tilde{\chi}_1^0=\tilde{H}_u^0$	$\tilde{t}_L\to t_R\tilde{\chi}_1^0\quad \tilde{t}_R\to t_L\tilde{\chi}_1^0$	Higgs couple L to R (mass term)

Study on top polarization has a long history:

Jezabek and Kuhn, NPB (1989) + many more…

The polarization is manifested in the decay angular distributions in the top rest frame:

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_f} = \frac{1}{2}(1 + P_f\,\alpha\,\cos\theta_f)$$

- θ_f : angle between the daughter fermion and the polarization axis.
- α = 0 for unpolarized tops, ±1 for fully polarized tops.
- P_f : the "spin-analyzing" power,

  = 1 for the anti-fermion from W decays (ie the charged lepton)

  ≈ -0.4 for the b-quark

Therefore, the polarization of top in stop decays would affect

- P_T spectra of decay products, such as the b-jet and the charged lepton.

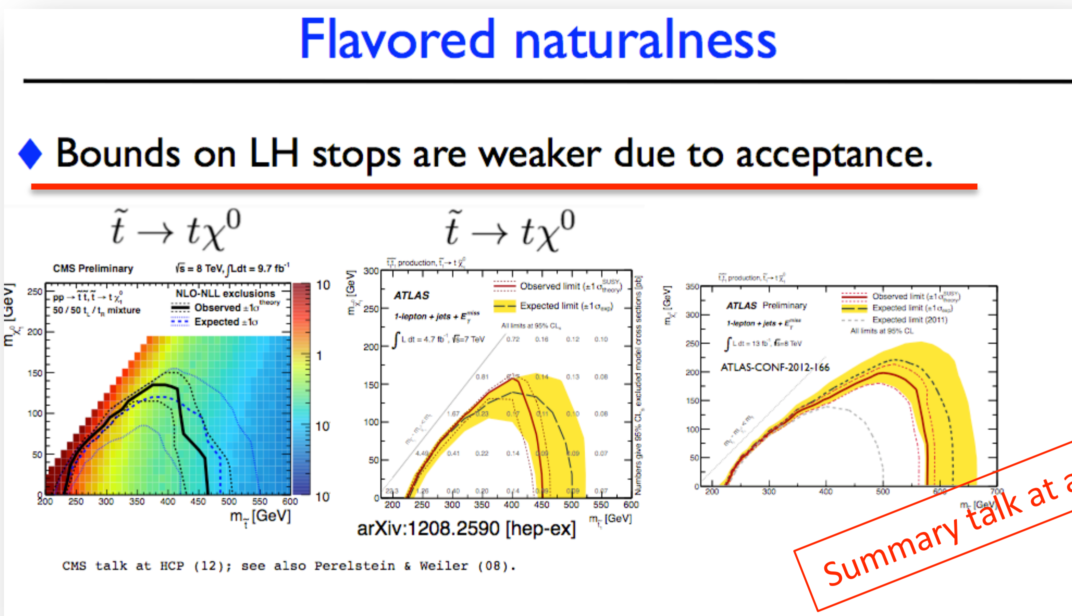
- the selection efficiencies, which have direct impacts on the search limits of stops!

What is important here is the polarization of the top, but NOT the left/right-mixing of the "stop"!

The top polarization is controlled by

$$\tan\theta_{\rm eff}^{(t)} = \frac{y_t N_{j4}\cos\theta_t - \frac{2\sqrt{2}}{3} g' N_{j1}\sin\theta_t}{\sqrt{2}\left(\frac{g}{2}N_{j2} + \frac{g'}{6}N_{j1}\right)\cos\theta_t + y_t N_{j4}\sin\theta_t}$$

People (theorists and experimentalists alike) often confuse top polarization with the left/right stop mixing:



Summary talk at a recent workshop

The top polarization is controlled by

$$\tan\theta_{\rm eff}^{(t)} = \frac{y_t N_{j4}\cos\theta_t - \frac{2\sqrt{2}}{3} g' N_{j1}\sin\theta_t}{\sqrt{2}\left(\frac{g}{2}N_{j2} + \frac{g'}{6}N_{j1}\right)\cos\theta_t + y_t N_{j4}\sin\theta_t}$$

People (theorists and experimentalists alike) often confuse top polarization with the left/right stop mixing:

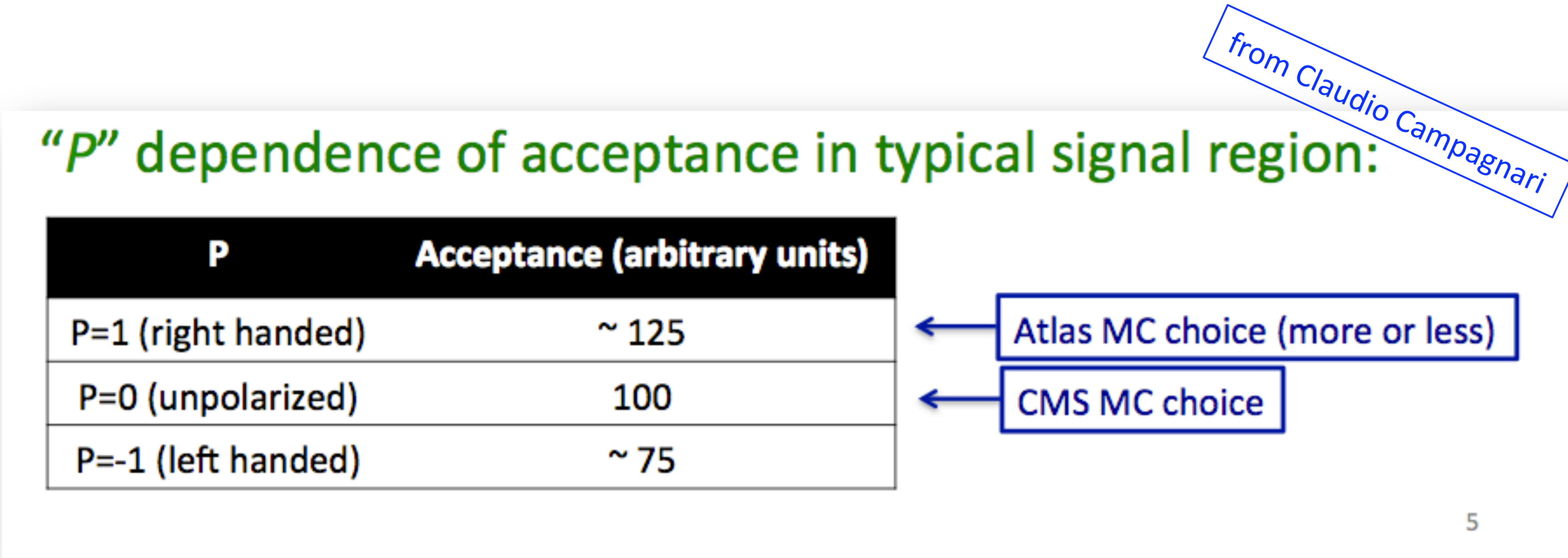
Search for direct top squark pair production in final states with one isolated lepton, jets, and missing transverse momentum in $\sqrt{s}$ = 8 TeV pp collisions using 21 fb^{-1} of ATLAS data

The ATLAS Collaboration

ATLAS-CONF-2013-037

for the stop and LSP mass values. The $\tilde{t}_1$ is chosen to be mostly the partner of the right-handed top quark (the $\tilde{t}_R$ component is about 70%)[2], and the $\tilde{\chi}_1^0$ to be almost a pure bino. Different hypotheses on the nature of the left/right mixing in the stop sector and the bino-like neutralino might lead to different acceptance values. A subset of purely $\tilde{t}_L$ models is generated, varying the stop mass, while fixing the $\tilde{\chi}_1^0$ mass to assess the variation in acceptance and hence sensitivity. In addition, a selection of signal models

In addition, ATLAS and CMS made different assumptions for the polarization, leading to different acceptance rates:


“*P*” dependence of acceptance in typical signal region:

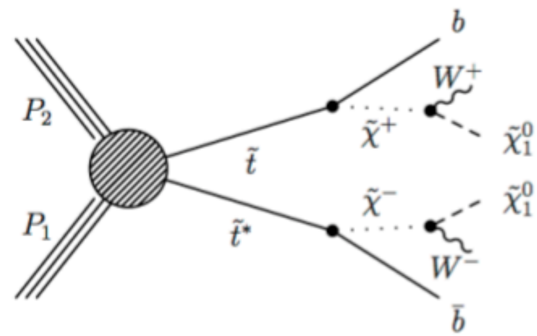
P	Acceptance (arbitrary units)
P=1 (right handed)	~ 125
P=0 (unpolarized)	100
P=-1 (left handed)	~ 75

This is one of the reasons CMS has a weaker limit than the ATLAS back in November of 2012.

Moreover, Claudio Campagnari posed the following questions to theorists:

What about the other decay mode?

- Chances are that there are similar issues in this mode
- We should also be prepared to present results in limiting cases



- What are these limiting cases?
- How do we reweight the MC samples?

It seems Claudio is right that the corresponding polarization issue in the chargino channel has received very little attention!

I consider the following stop -> chargino channel

$$\tilde{t}_1 \to b\tilde{\chi}_1^+ \to b(W^+\tilde{\chi}_1^0)$$

The stop-bottom-chargino vertex is

Gunion and Haber, NPB 1984

$$\mathcal{L}_{b\tilde{t}\tilde{\chi}^\pm} = \left[-gV_{i1}\,\tilde{t}_L + y_t V_{i2}\,\tilde{t}_R\right]\left(\bar{b}\,P_R\,\tilde{\chi}_i^{+\,c}\right) + y_b\,U_{i2}^*\,\tilde{t}_L\left(\bar{b}\,P_L\,\tilde{\chi}_i^{+\,c}\right)$$

- In the limit the bottom Yukawa y_b<< 1, the bottom quark is always left-handed and the chargino 100% polarized!

- But since

$$y_b = \frac{\sqrt{2}\,m_b}{v\cos\beta} = \frac{\sqrt{2}\,m_b}{v\sin\beta}\tan\beta \approx \frac{\sqrt{2}\,m_b}{v}\tan\beta$$

The chargino polarization is dependent on the stop mixing only in the large tan(beta) region!

One can define the relevant effective vertices for stop decays and chargino decays, respectively:

$$\boxed{\tilde{t}_1 \to b\tilde{\chi}_1^+} \to b(W^+\tilde{\chi}_1^0) \quad \Longrightarrow \quad g_{\rm eff}^{(\chi)}\, \bar{b} \left(\sin\theta_{\rm eff}^{(\chi)}\, P_L + \cos\theta_{\rm eff}^{(\chi)}\, P_R\right) \tilde{\chi}_1^{+\,c}\, \tilde{t}_1$$

$$\tilde{t}_1 \to \boxed{b\tilde{\chi}_1^+ \to b(W^+\tilde{\chi}_1^0)} \quad \Longrightarrow \quad g_{\rm eff}^{(W)}\, W_\mu^- \bar{\tilde{\chi}}_1^0 \gamma^\mu \left(\sin\theta_{\rm eff}^{(W)}\, P_L + \cos\theta_{\rm eff}^{(W)}\, P_R\right) \tilde{\chi}_1^+$$

$$\tan\theta_{\rm eff}^{(\chi)} = \frac{y_b U_{12}^* \sin\theta_t}{-gV_{11}\cos\theta_t + y_t V_{12}\sin\theta_t}$$

$$\tan\theta_{\rm eff}^{(W)} = \frac{-N_{14}V_{12}^* + \sqrt{2}N_{12}V_{11}^*}{N_{13}^* U_{12} + \sqrt{2}N_{12}^* U_{11}}$$

The computation of lepton energy and angular spectra is straightforward.

Top Channel:

(top rest frame)

Perelstein and Weiler: 0811.1042

$$\frac{d\sigma}{d\cos\hat{\theta}_l} \propto E_\chi + \sin 2\theta_{\rm eff} m_\chi + p_\chi \cos 2\theta_{\rm eff} \ \cos\hat{\theta}_l$$

Chargino Channel:

(chargino rest frame)

Low: 1304.0491

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_l} = \frac{1}{2}\left(1 + \frac{S_2(m_{\tilde{\chi}^+}, m_{\tilde{\chi}^0}, m_W)}{S_1(m_{\tilde{\chi}^+}, m_{\tilde{\chi}^0}, m_W)}\,|\vec{s}|\cos\theta_l\right) , \qquad (35)$$

where

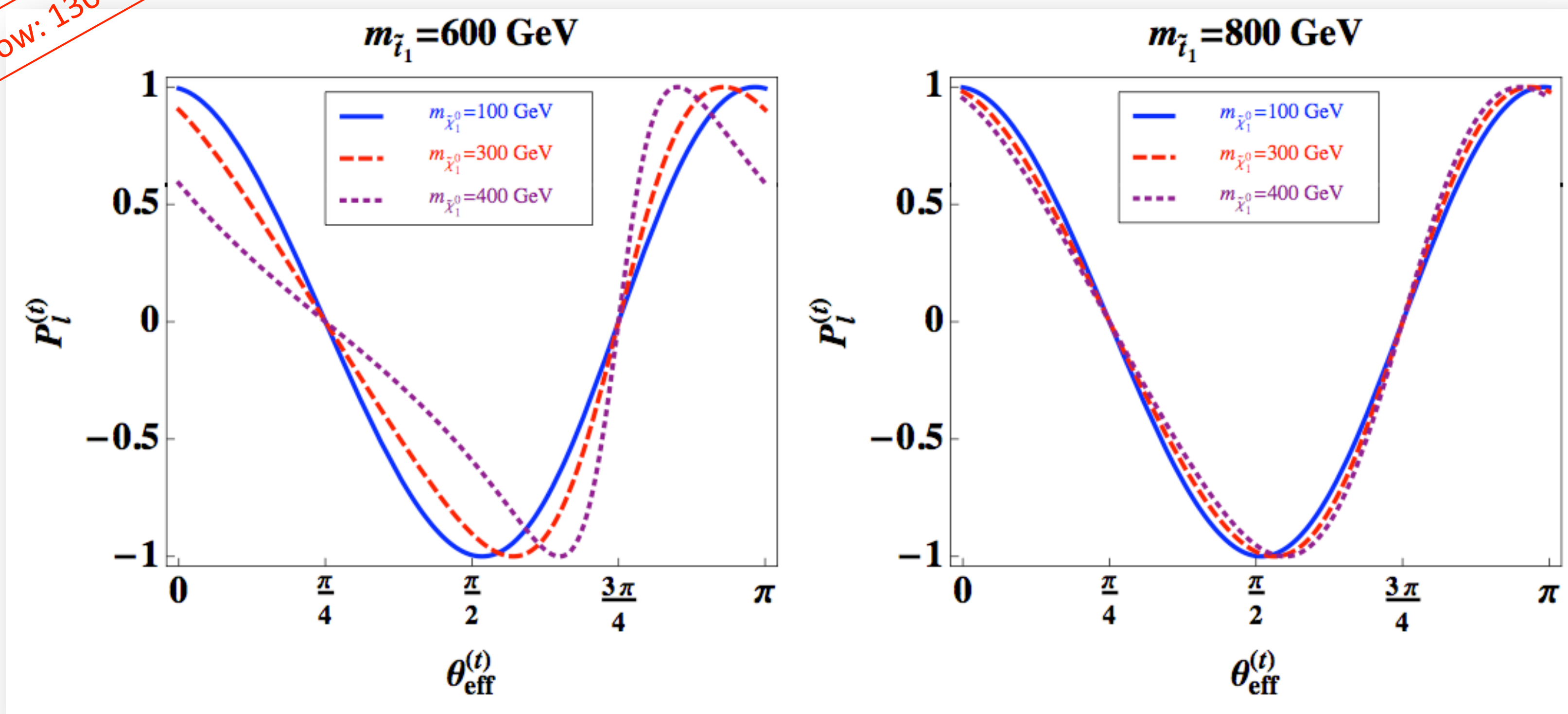
$$S_1(m_{\tilde{\chi}^+}, m_{\tilde{\chi}^0}, m_W) = \frac{\lambda^{1/2}(m^2_{\tilde{\chi}^+}, m^2_{\tilde{\chi}^0}, m^2_W)}{2m_{\tilde{\chi}^+}}\left\{-2m_{\tilde{\chi}^+}m_{\tilde{\chi}^0}m^2_W \ \sin 2\theta^{(W)}_{\rm eff} + \frac{1}{3}\left[(m^2_{\tilde{\chi}^+} - m^2_{\tilde{\chi}^0})^2 + (m^2_{\tilde{\chi}^+} + m^2_{\tilde{\chi}^0})m^2_W - 2m^4_W\right]\right\} , \qquad (36)$$

$$S_2(m_{\tilde{\chi}^+}, m_{\tilde{\chi}^0}, m_W) = \frac{\lambda^{1/2}(m^2_{\tilde{\chi}^+}, m^2_{\tilde{\chi}^0}, m^2_W)}{2m_{\tilde{\chi}^+}}\left\{4m^2_{\tilde{\chi}^+}m^2_W \ \cos^2\theta^{(W)}_{\rm eff} - 2m_{\tilde{\chi}^+}m_{\tilde{\chi}^0}m^2_W \ \sin 2\theta^{(W)}_{\rm eff} - \frac{1}{3}\left[(m^2_{\tilde{\chi}^+} - m^2_{\tilde{\chi}^0})^2 + (m^2_{\tilde{\chi}^+} + m^2_{\tilde{\chi}^0})m^2_W - 2m^4_W\right]\cos 2\theta^{(W)}_{\rm eff}\right\} - 2m_{\tilde{\chi}^+}\cos^2\theta^{(W)}_{\rm eff} m^4_W \log\left[\frac{m^2_{\tilde{\chi}^+} + m^2_W - m^2_{\tilde{\chi}^0} + \lambda^{1/2}(m^2_{\tilde{\chi}^+}, m^2_{\tilde{\chi}^0}, m^2_W)}{m^2_{\tilde{\chi}^+} + m^2_W - m^2_{\tilde{\chi}^0} - \lambda^{1/2}(m^2_{\tilde{\chi}^+}, m^2_{\tilde{\chi}^0}, m^2_W)}\right] . \qquad (37)$$

It is well-known that the charged lepton is an excellent spin-analyzer for the top polarization in stop decays:

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_l} = \frac{1}{2}\left(1 + \mathcal{P}_l \cos\theta_l\right)$$

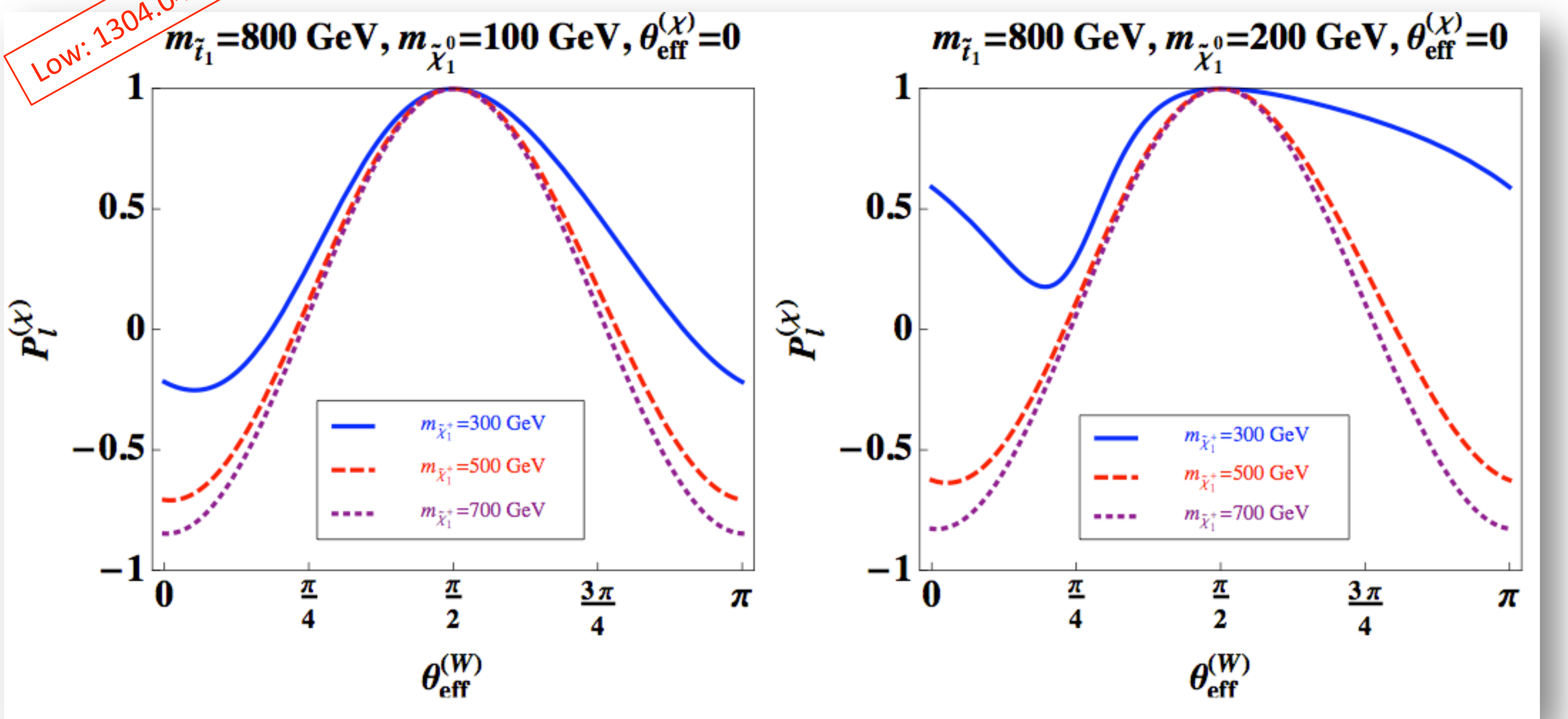
Low: 1304.0491



In the chargino channel it is not as good a spin-analyzer as in the top channel, but still OK.

Since there are three mass scales, the analyzing power is more dependent on masses of the particles in the decay chain.

Low: 1304.0491



In the case of discovery, the angular distributions could be used to extract the "effective" mixing angles.

But in the case of exclusion limits, two questions I'd like to study:

- Does the top/chargino polarization affect the kinematic distributions, and hence the selection efficiencies?

- Can one exploit the kinematic differences to optimize the searches in the top channel v.s. the chargino channel?

The first observable to look at is the lepton energy and P_T. The main physics can be understood using just angular momentum conservation.

- Suppose we set

$$\sin\theta^{(\chi)}_{\text{eff}} = 0 : \qquad g^{(\chi)}_{\text{eff}}\, \bar{b}\left(\sin\theta^{(\chi)}_{\text{eff}}\, P_L + \cos\theta^{(\chi)}_{\text{eff}}\, P_R\right) \tilde{\chi}_1^{+\,c}\, \tilde{t}_1$$

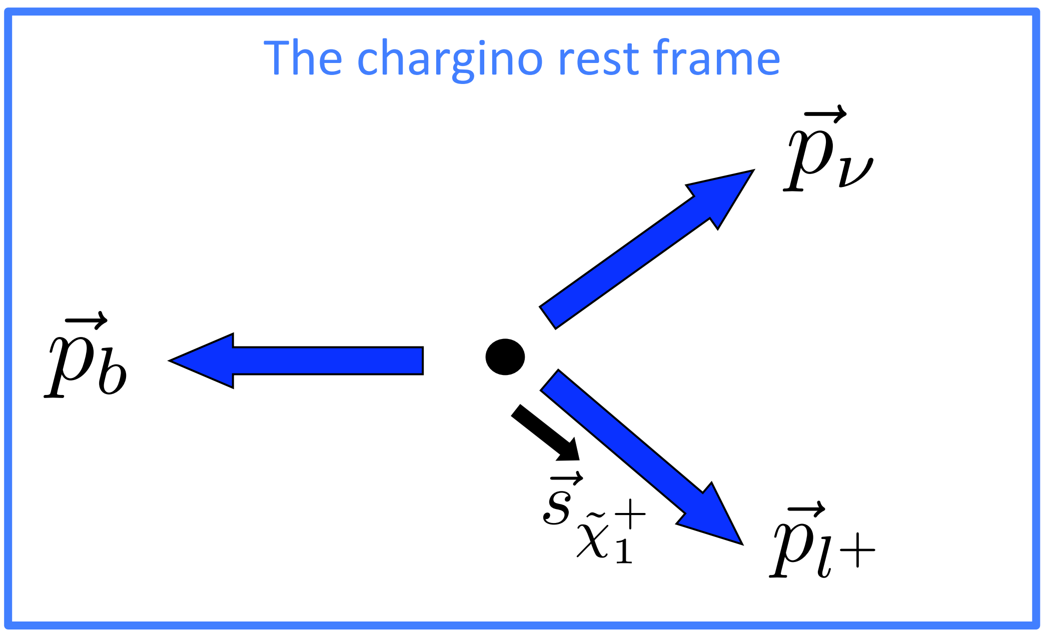
Helicity eigenstates in the stop rest frame

So the motion of the b quark is aligned with the polarization of the charigno.

- Next we set

$$\cos\theta_{\text{eff}}^{(W)} = 0 : \qquad g_{\text{eff}}^{(W)} W_\mu^- \bar{\tilde{\chi}}_1^0 \gamma^\mu \left(\sin\theta_{\text{eff}}^{(W)} P_L + \cos \times P_R \right) \tilde{\chi}_1^+$$

Same as the Top quark decay, the charged lepton from W decays tends to align with the polarization of the chargino in the chargino rest frame.

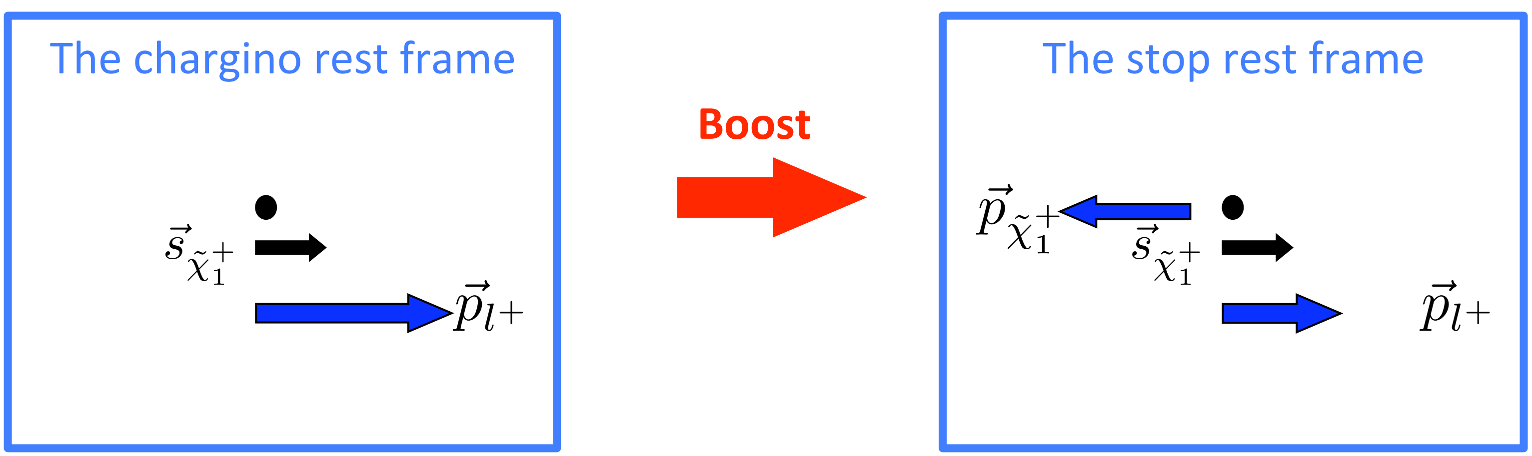


- Next we set

$$\cos\theta_{\rm eff}^{(W)} = 0 : \qquad g_{\rm eff}^{(W)}\, W_\mu^- \bar{\tilde{\chi}}_1^0 \gamma^\mu \left(\sin\theta_{\rm eff}^{(W)}\, P_L + \cos \; P_R\right) \tilde{\chi}_1^+$$

Same as the Top quark decay, the charged lepton from W decays tends to align with the polarization of the chargino in the chargino rest frame.

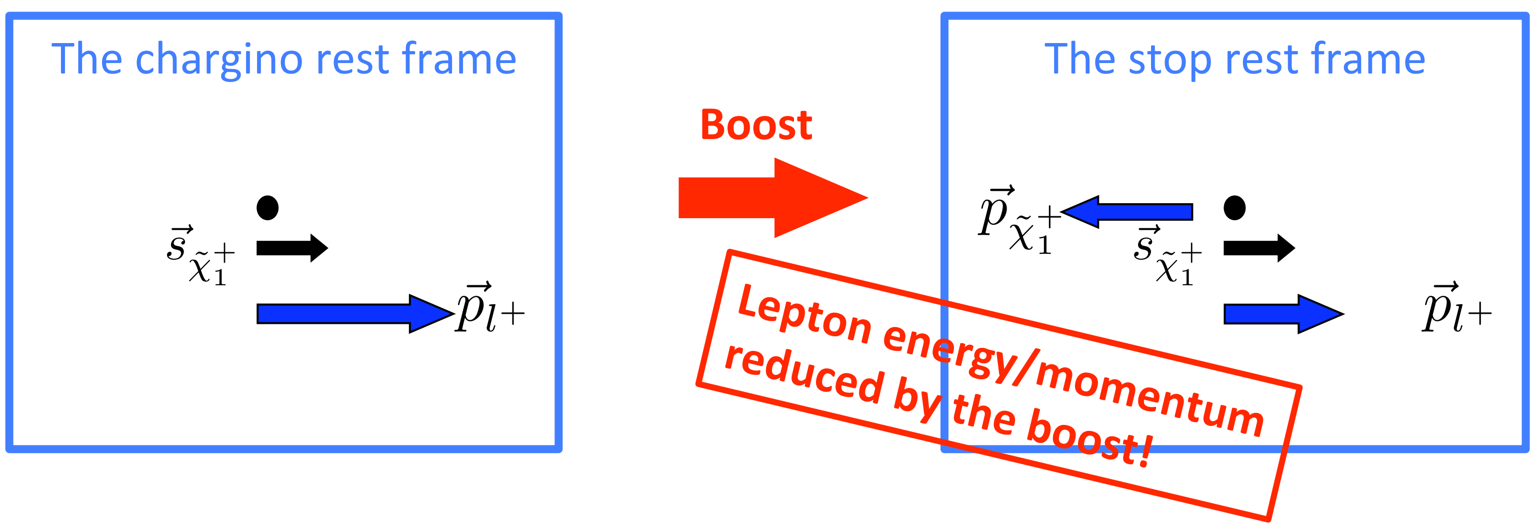
The boost to the stop rest frame must be in the same direction as the chargino polarization:



As a result, the energy and momentum of the charged lepton tend to be reduced in going to the stop rest frame.

If we approximate the stop rest frame with the Laboratory frame in direct stop productions, the P_T and energy of the charged lepton is then softer.

We will see MC simulations bear out the intuition.



In simulations I will use the semileptonic channel as the primary example.

- Signal is one isolated lepton, 4 (1 b-tag) jets, and MET

- Dominant backgrounds are:

1. Semileptonic decays of QCD ttbar production
2. Leptonically decaying W+ jets

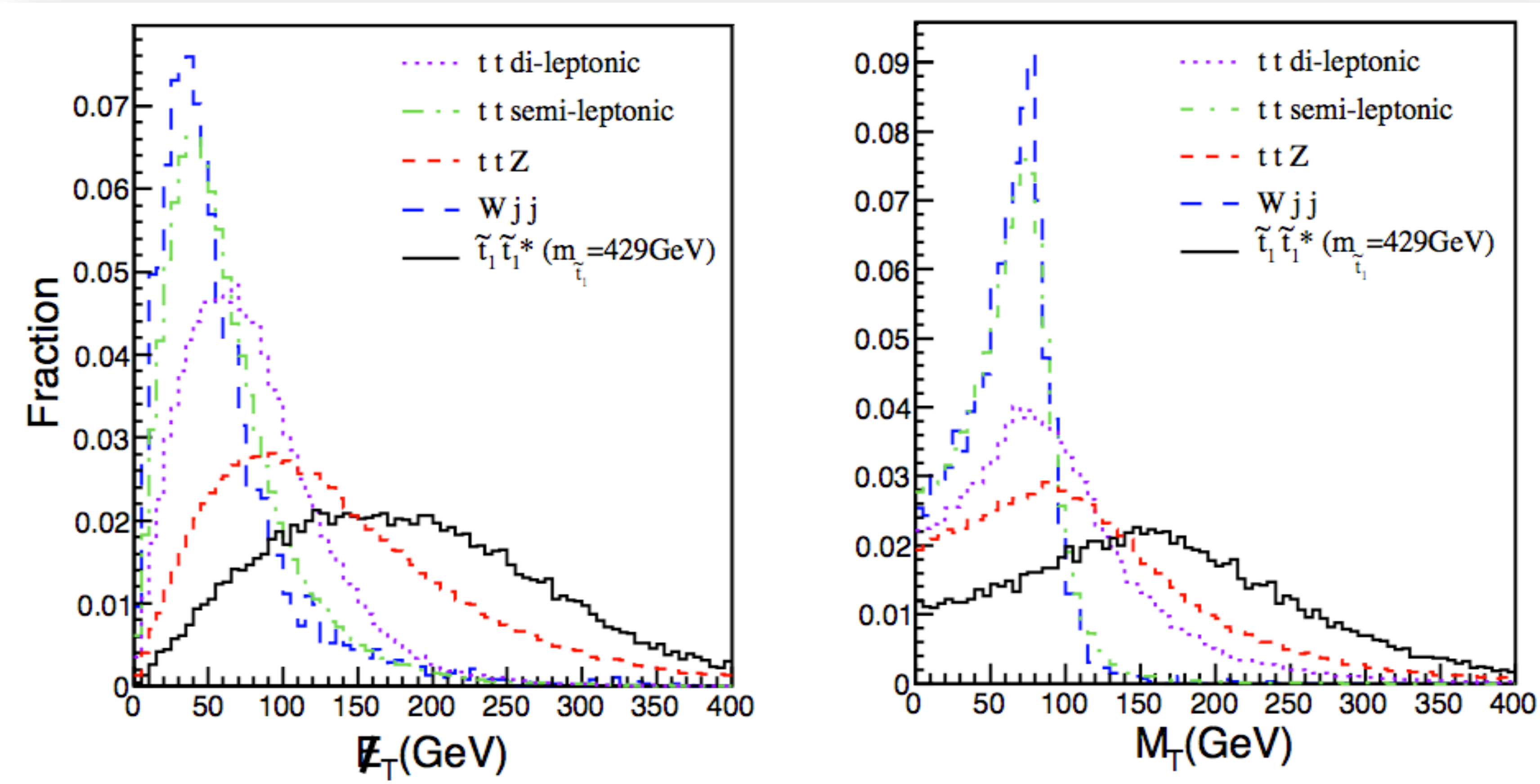
In these two cases the single lepton and the MET (single neutrino) come from the W boson

→ transverse mass peaked at M_W

MET should be smaller for the background

Here are the MET and M_T distributions for the backgrounds and signal:

$$m_{\tilde{t}_1} = 429 \text{ GeV and } m_{\tilde{\chi}_1^0} = 110 \text{ GeV}$$



Cao et al: 1206.3865

Disclaimers:

- ATLAS Moriond result in this channel uses additional (and more sophisticated) cuts involving M_{T2}, but I will try to keep things simple here.

  (Ask the local experts if you are interested.)

- I am mainly interested in the effect of polarization on kinematics, so in the MC simulations I will not include effects of hadronization and detector resolutions. Nor would I simulate the background.

  (The collaborations are in a much superior position to do these jobs than I am.)

The benchmarks in the top channel are

$$g_{\text{eff}}^{(t)}\, \bar{t}\left(\sin\theta_{\text{eff}}^{(t)}\, P_L + \cos\theta_{\text{eff}}^{(t)}\, P_R\right)\tilde{\chi}_1^0\,\tilde{t}_1$$

- TopL1: $m_{\tilde{t}_1} = 600$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, and $\theta_{\text{eff}}^{(t)} = \pi/2$.

  TopL2: $m_{\tilde{t}_1} = 800$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, and $\theta_{\text{eff}}^{(t)} = \pi/2$.

  Top is produced in a RH helicity state in the stop rest frame.

$$g_{\text{eff}}^{(t)}\, \bar{t}\left(\sin\theta_{\text{eff}}^{(t)}\, P_L + \cos\theta_{\text{eff}}^{(t)}\, P_R\right)\tilde{\chi}_1^0\,\tilde{t}_1$$

- TopR1: $m_{\tilde{t}_1} = 600$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, and $\theta_{\text{eff}}^{(t)} = 0$.

  TopR2: $m_{\tilde{t}_1} = 800$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, and $\theta_{\text{eff}}^{(t)} = 0$.

  Top is produced in a LH helicity state in the stop rest frame.

The benchmarks in the chargino channel are

$$g_{\rm eff}^{(\chi)}\ \bar{b}\left(\cancel{\sin\theta_{\rm eff}^{(\chi)}}\ P_L + \cos\theta_{\rm eff}^{(\chi)}\ P_R\right)\tilde{\chi}_1^{+\,c}\,\tilde{t}_1 \qquad g_{\rm eff}^{(W)}\ W_\mu^- \bar{\tilde{\chi}}_1^0 \gamma^\mu \left(\sin\theta_{\rm eff}^{(W)}\ P_L + \cancel{\cos\theta_{\rm eff}^{(W)}}\ P_R\right)\tilde{\chi}_1^+$$

- ChaL1: $m_{\tilde{t}_1} = 600$ GeV, $m_{\tilde{\chi}_1^+} = 300$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, $\theta_{\rm eff}^{(\chi)} = 0$, and $\theta_{\rm eff}^{(W)} = \pi/2$.

  ChaL2: $m_{\tilde{t}_1} = 800$ GeV, $m_{\tilde{\chi}_1^+} = 700$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, $\theta_{\rm eff}^{(\chi)} = 0$, and $\theta_{\rm eff}^{(W)} = \pi/2$.

  Chargino is produced in a LH helicity state in the stop rest frame, and decays like a top quark.

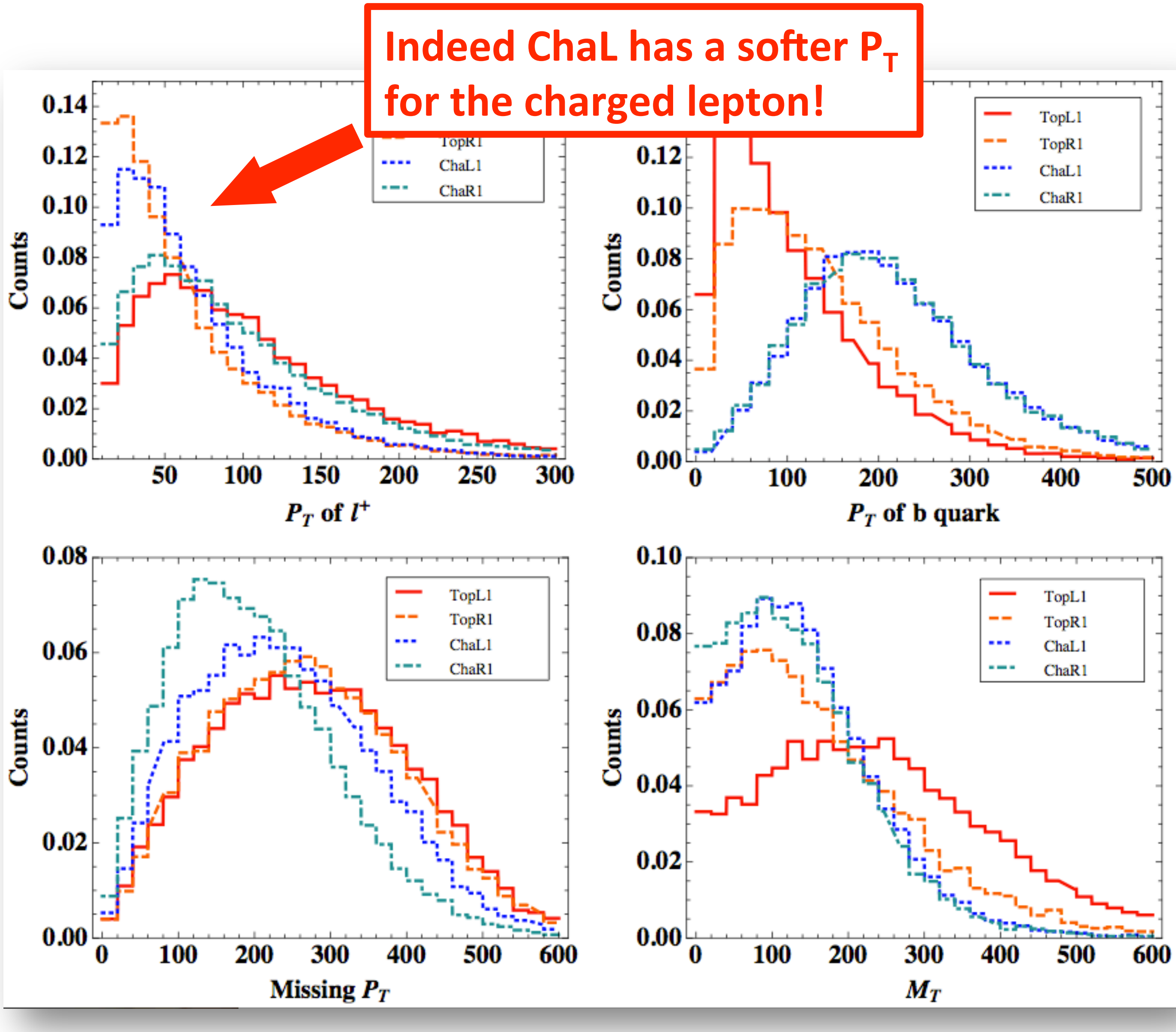
$$g_{\rm eff}^{(\chi)}\ \bar{b}\left(\cancel{\sin\theta_{\rm eff}^{(\chi)}}\ P_L + \cos\theta_{\rm eff}^{(\chi)}\ P_R\right)\tilde{\chi}_1^{+\,c}\,\tilde{t}_1 \qquad g_{\rm eff}^{(W)}\ W_\mu^- \bar{\tilde{\chi}}_1^0 \gamma^\mu \left(\cancel{\sin\theta_{\rm eff}^{(W)}}\ P_L + \cos\theta_{\rm eff}^{(W)}\ P_R\right)\tilde{\chi}_1^+$$

- ChaR1: $m_{\tilde{t}_1} = 600$ GeV, $m_{\tilde{\chi}_1^+} = 300$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, $\theta_{\rm eff}^{(\chi)} = 0$, and $\theta_{\rm eff}^{(W)} = 0$.

  ChaR2: $m_{\tilde{t}_1} = 800$ GeV, $m_{\tilde{\chi}_1^+} = 700$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, $\theta_{\rm eff}^{(\chi)} = 0$, and $\theta_{\rm eff}^{(W)} = 0$.

  Chargino has right-handed coupling to the W boson.

Parton level results, without selection cuts:



In the end, polarization has a significant impact in the top channel, but smaller effect in the chargino channel:

Cut 1	$p_T \geq 30$ GeV and $\|\eta\| \leq 2.4$ for both the charged lepton and the b quark
Cut 2	$\not{E}_T \geq 150$ GeV and $M_T \geq 120$ GeV

TABLE I: *Parton level cuts to study impacts of polarizations on kinematic variables.*

$\sqrt{s} = 8$ TeV	TopL1	TopR1	TopL2	TopR2	ChaL1	ChaR1	ChaL2	ChaR2
Events	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Cut 1	15,508	12,316	16,313	13,118	14,765	16,996	17,855	18,100
Cut 2	11,226	8,117	13,409	10,092	7,586	6,408	13,922	13,719
$\mathcal{P}_l$	-0.99	$+0.99$	-1.00	$+1.00$	$+1.00$	-0.22	$+1.00$	-0.85

TABLE II: *Cut flows and spin analyzing powers of the charged lepton for the benchmark scenarios.*

So the impact of polarization on selection efficiencies is significant in the top channel, and less so in the chargino channel in the benchmarks we considered.

In fact, a study using M_{T2} variable in dileptonic decays of the top channel made a similar observation (without pursuing further details):

> the opposite tendency for left-handed stops tends to *suppress* m_{T2} and m_T. For our own m_{T2} search, we therefore expect that searches for right-handed stops decaying to gravitinos will be more sensitive than for left-handed stops.

Kilic and Tweedie: 1211.6106

(Again, it's the top polarization, not LH stop vs RH stop…)

Therefore more detailed studies by the collaborations are fully warranted!

(But watch out for new CMS updates in the coming weeks…)

An important question to be addressed in the case of discovery:

How to measure chargino/top polarization in Lab frame?

On the flip side:

Are there kinematic variables which would optimize searches between the top channel and the chargino?

Again, I will not try to be fancy, but only use simple intuitions.

$$b \longleftarrow \tilde{t}_1 \longrightarrow \tilde{\chi}^+ \begin{array}{l} \longrightarrow W^+ \longrightarrow l^+\nu \\ \longrightarrow \tilde{\chi}^0 \end{array}$$

$$\begin{array}{r} l^+\nu \longleftarrow W^+ \longleftarrow \\ b \longleftarrow \end{array} t \longleftarrow \tilde{t}_1 \longrightarrow \tilde{\chi}^0$$

- In the stop rest frame, the chargino and b quark are back-to-back. So the chargino is naturally polarized in the direction of b-quark momentum:

- In the top channel, the axis of top polarization is the direction of neutralino, which cannot be measured!

The opening angle between b-quark and the charged lepton should provide sensitivity to the chargino polarization, even in the Lab frame!

Again, I will not try to be fancy, but only use simple intuitions.

$$b \longleftarrow \tilde{t}_1 \longrightarrow \tilde{\chi}^+ \begin{array}{l} \longrightarrow W^+ \longrightarrow l^+\nu \\ \longrightarrow \tilde{\chi}^0 \end{array}$$

$$\begin{array}{l} l^+\nu \longleftarrow W^+ \longleftarrow \\ b \longleftarrow \end{array} t \longleftarrow \tilde{t}_1 \longrightarrow \tilde{\chi}^0$$

Moreover, we see the b quark and the charged lepton come from top decays in the top channel, but from different mother particles in the chargino channel.

The opening angle between b and l^+ should be smaller in the top channel, due to the boost of the top quark, than in the chargino channel.

(The same comment applies to the SM ttbar background.)

MC simulations confirm the intuition:

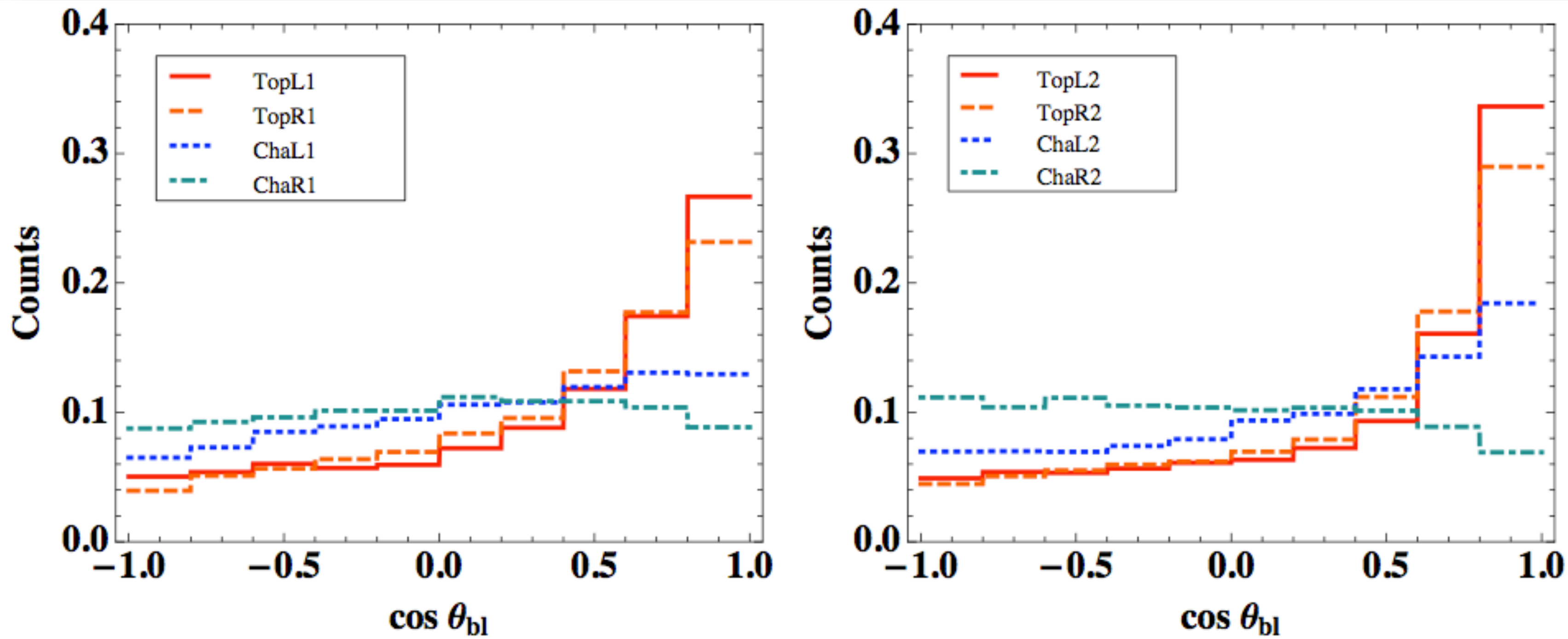


FIG. 4: *Cosine of θ_{bl}, the opening angle between the charged lepton and the b quark in the Lab frame. Results shown here are after the selection cuts in Table I and take into account the combinatorial factor of not being able to distinguish a b quark from a $\bar{b}$ quark.*

So the chargino polarization can be measured through the forward-backward asymmetry along the direction of b-quark, in case of a discovery:

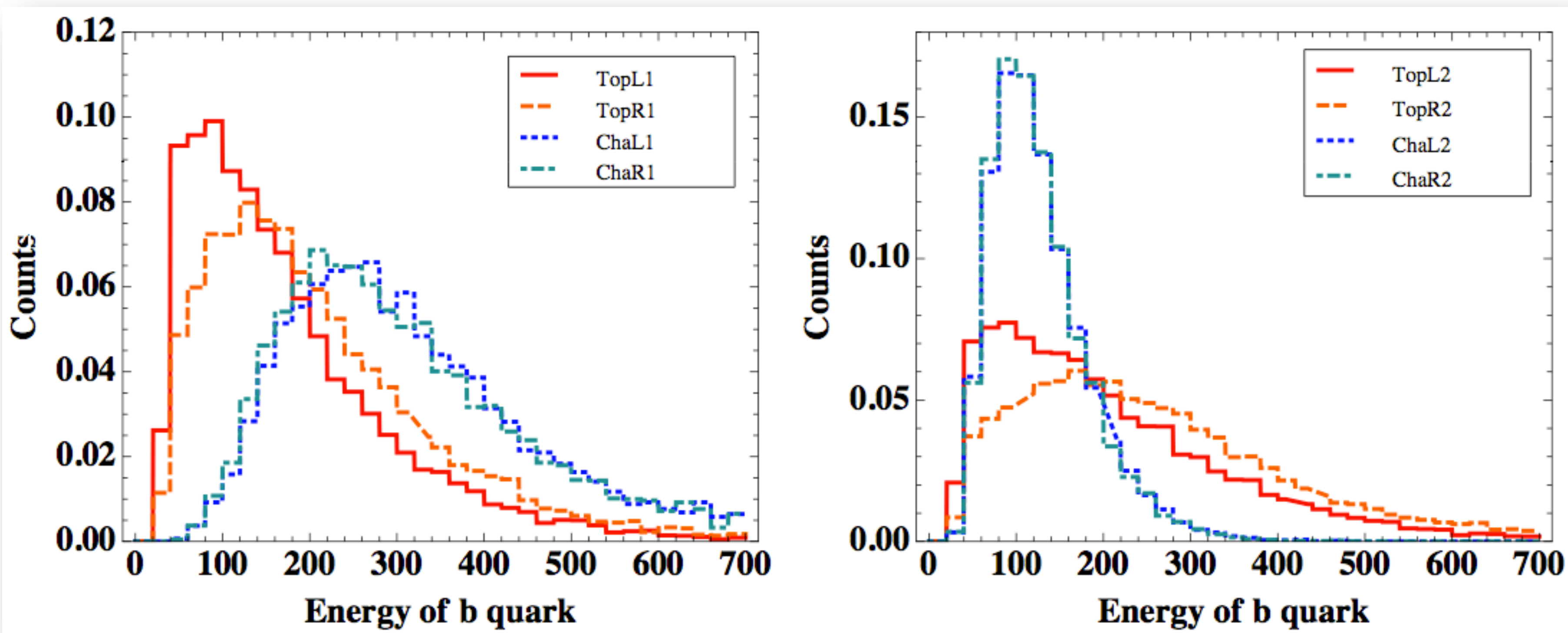
$$A_{FB}^{(bl)} = \frac{\left(\int_0^1 - \int_{-1}^0\right) d\cos\theta_{bl} \frac{d\sigma}{d\cos\theta_{bl}}}{\left(\int_{-1}^0 + \int_0^1\right) d\cos\theta_{bl} \frac{d\sigma}{d\cos\theta_{bl}}}$$

The same observation that b quark comes from stop decays in chargino channel and top decays in top channel also suggest the b quark energy distributions should be very different.

Indeed,

Peak in the top channel: $$\frac{m_t^2 - m_W^2 - m_b^2}{2m_t} \approx 70 \quad \text{GeV}$$

Peak in the chargino channel: $$\frac{m_{\tilde{t}_1}^2 - m_{\tilde{\chi}^+}^2 - m_b^2}{2m_{\tilde{t}_1}}$$



Moreover, the location of the peak in the chargino channel is invariant under boost of the chargino because the b quark is from a scalar decay.

(Agashe, Franceschini, and Kim:1209.0772)

The location of the peak could be shifted slightly due to the top polarization, but not by much.

So one could employ a "mass-dependent" cut on the energy of the b quark to optimize the search for the charginos.

Concluding Remarks

- Polarization of chargino and top in stop decays could have significant impacts on the outcome of experimental searches.
- Much room for improvement in the search strategies. (Now is a good time!)
- Most people, myself included, have been talking about kinematic features on special slices of phase space. In principle, one could catch 'em all with a MVA approach like the Matrix Element Method!