Probing new physics in states with top missing energy

(Part I)

Rakhi Mahbubani

Work done in collaboration with Tao Han, Devin Walker and

What might we see at the LHC?

- SUSY?
- Technicolor?
- Little Higgs?
- UED?
- Higgsless Theory?
- Something else?
- Nothing?

Why Top Partners?

- Large cross-section for colored particles at hadron colliders
- Standard Model top gives rise to large higgs quadratic diverg
  to make theory natural

Top partner can be a scalar (e.g stop in SUSY), or fermionic (e.g
models, UED)

We need to be able to tell these apart

Hard at the LHC, lab frame $\neq$ rest frame of colliding particles

The Story So Far

A number of groups have begun to a more model-independent ap
problem:

- Barr, Lester and Stephens

  Proposed new transverse mass parameter (m_{T2}) for decays
  invisible particles.

- Meade and Reece: Studied pure hadronic decay of tops, sign
  - Good: can reconstruct tops completely
  - Not so good: large QCD background

  Proposed beam-line asymmetry (BLA) to determine spin of to

- Matsumoto, Nojiri and Nomura: mainly pure hadronic channe

  Observed correlation between m_{eff} and $\not{E}_T$ for large mass

Our signal

We assume that the top partner (T) is pair-produced and decays
plus a new stable particle (A_H) which escapes the detector

We analyse the semileptonic channel $pp \to T\overline{T}X \to b\bar{b}jjl\nu A$
signature $l + 4j + \not{E}_T$

- Even though suppressed compared to hadronic channel, sup
  substantial
- Presence of isolated lepton makes QCD background constra
- Kinematics is dependent on $\Delta M_{TA} = m_T - m_A$, and eve
  reconstructable
- Will present results for $m_T = 1$ TeV; $m_A = 200{,}800$ GeV

Outline

- Basic cuts
- Background Suppression
  - Missing energy distributions
  - Transverse Mass Parameters
  - Correlation between m_{eff} and $\not{E}_T$
  - Mass reconstruction
  - Angular distribution in transverse plane

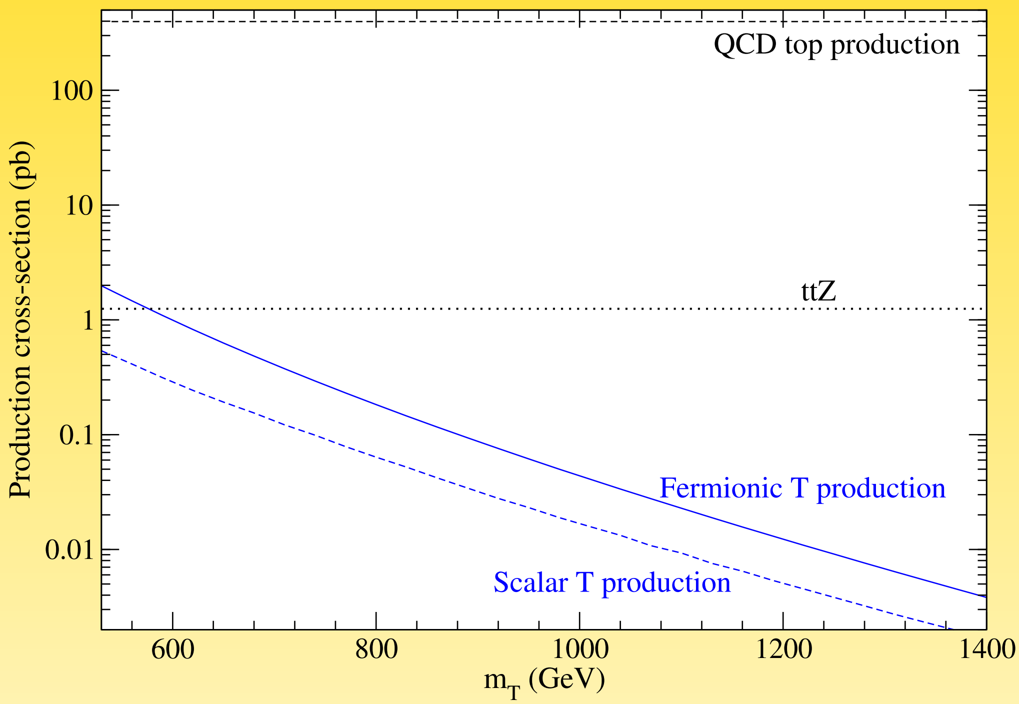
Basic cuts

To simulate detector acceptance we use the following basic cuts:

- $\not{E}_T$ cut of 20 GeV on lepton and light jets, 30 GeV for bs
- η cut of 2.5
- Isolation cut ΔR of 0.4 for light jets and bs, 0.3 for leptons

We also smear particle energies to simulate calorimetry respons

T production



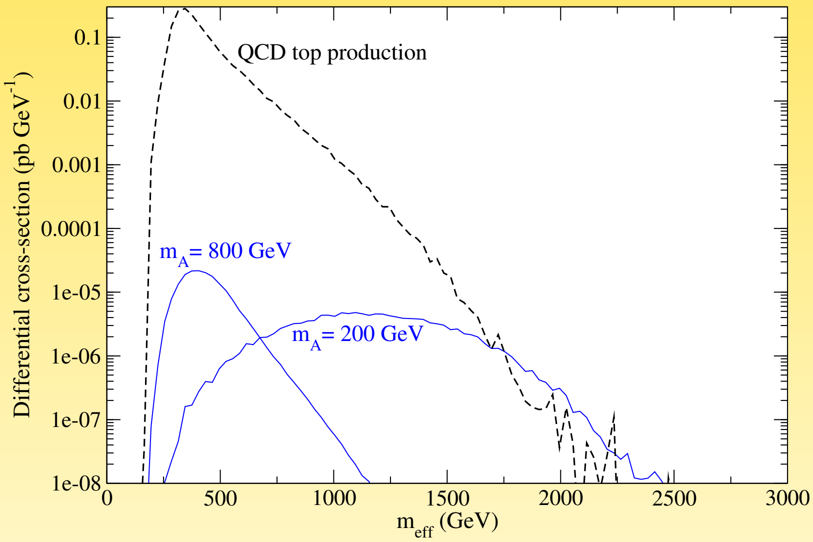
Signal is overwhelmed by QCD $t\bar{t}$ production, need a smart way
from background

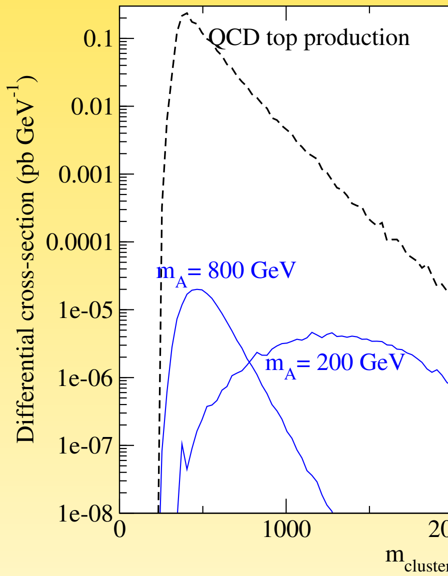
Transverse mass parameters

It is sometimes possible to obtain information about particle mass

mass parameters, m_{eff} and $m_{cluster}$.

Definitions tailored to kinematics of particular event under consid

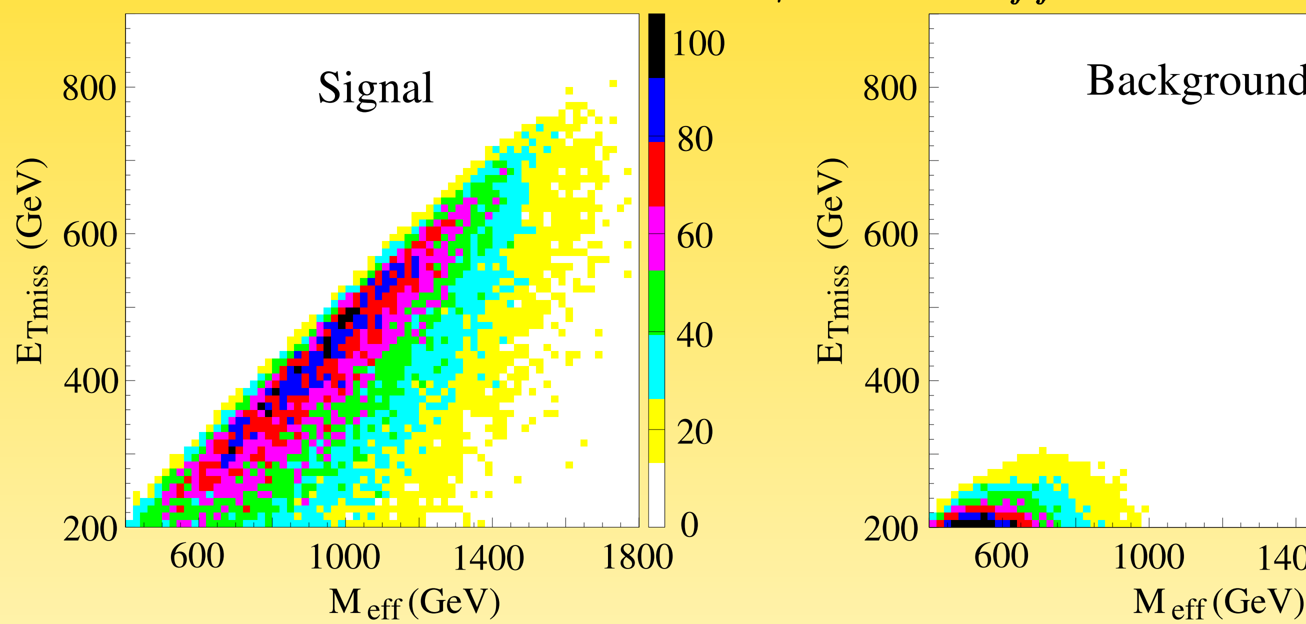




Not obviously helpful!

Correlation between transverse mass and miss

Interesting correlation between these $\not{E}_T$ and m_{eff} for small ma

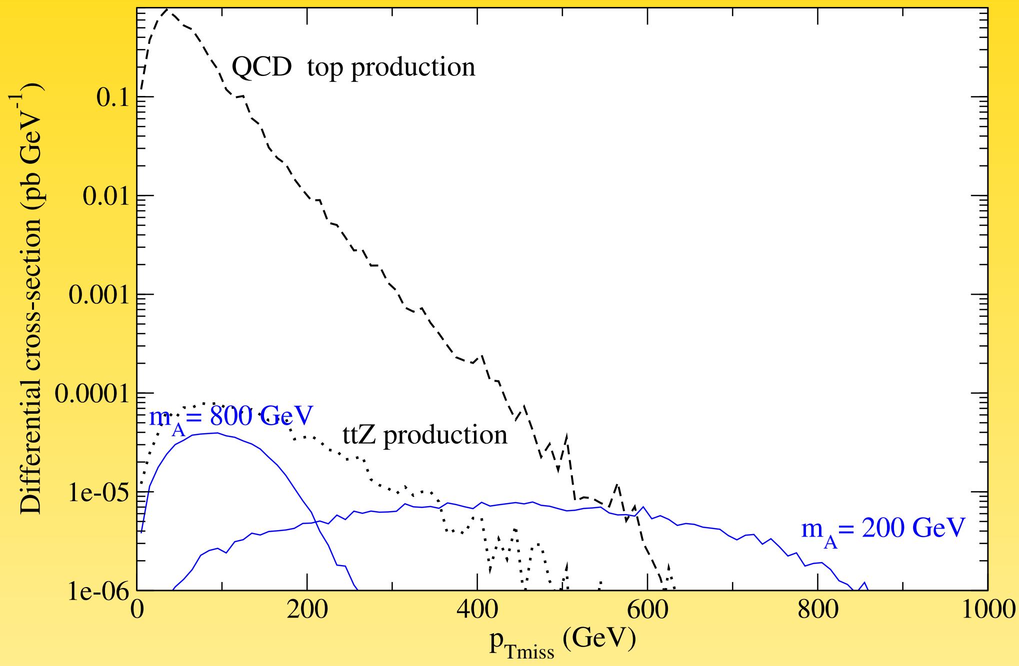


(Matsumoto et al)

Correlation not present for small ΔM_{TA}, has very similar kinematics to

Cannot be used for signal selection because of overwhelmingly large rat

Missing energy distribution



Provides a clear distinction between signal and background for la

With a strong cut $\not{E}_T > 600 GeV$, for a luminosity 100 fb^{-1}

$S:\ m_A$ =200 GeV			m_A =800 GeV			B
σ (fb)	S/B	$S/\sqrt{B}$	σ (fb)	S/B	$S/\sqrt{B}$	σ
0.8	7.9	26	0	0	0	0

But is there any hope for small ΔM_{TA} signal?

Mass reconstruction

If missing energy only from ν, can easily solve for p_ν by imposin

conditions for ν and leptonically-decaying W.

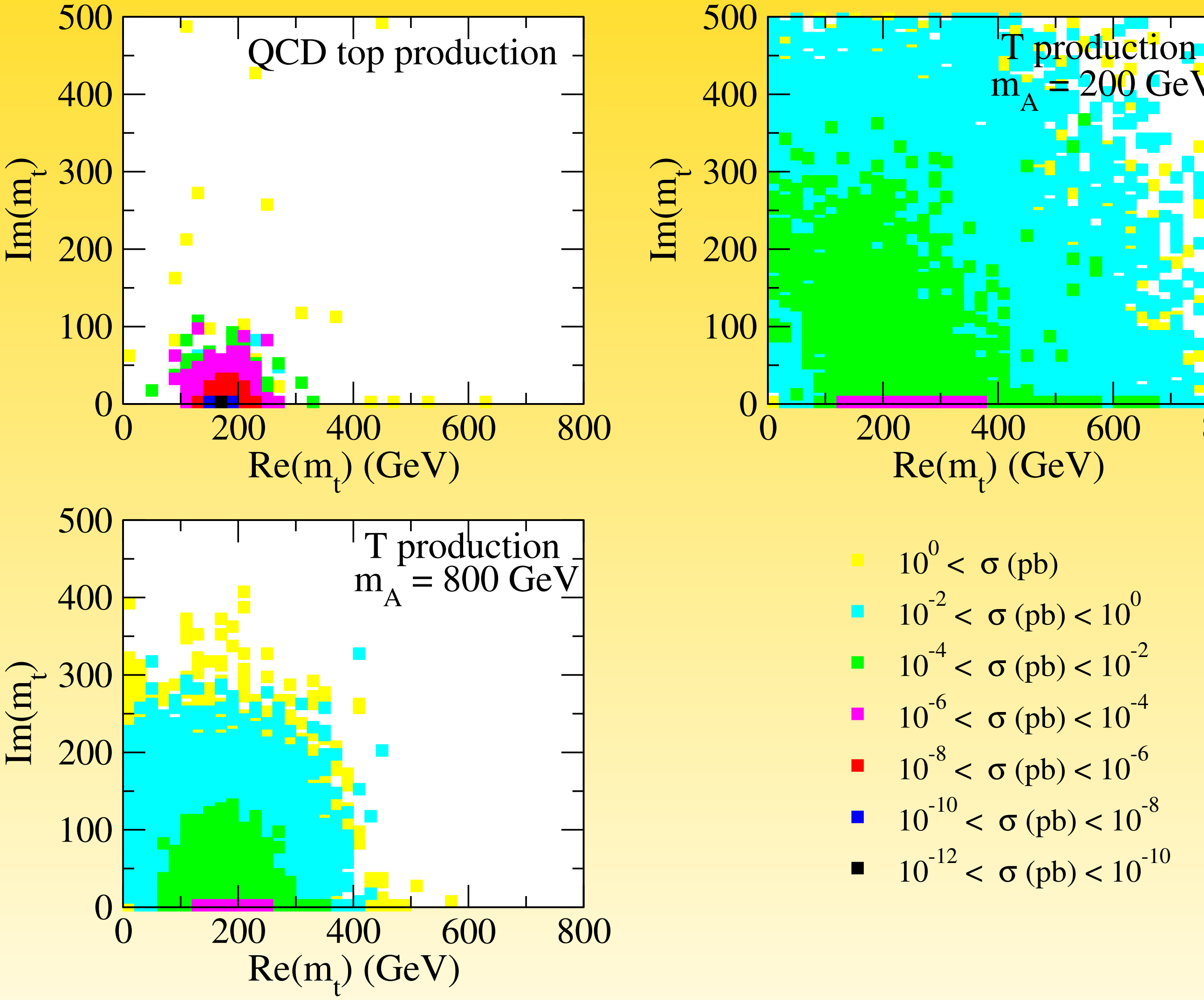
We apply the same reconstruction method to signal.

In general solutions for p_ν not physical because of additional invi

We allow the reconstructed m_t to contain an imaginary part, anc

away background.

Imaginary mass?



Reconstructed t mass cut

Imposing $|m_{tR} - m_t| >$ 100 GeV gives

$S:\ m_A =$200 GeV			$m_A =$800 GeV			B
σ (fb)	S/B	$S/\sqrt{B}$	σ (fb)	S/B	$S/\sqrt{B}$	σ
3.0	1	17	0.3	0.1	1.9	

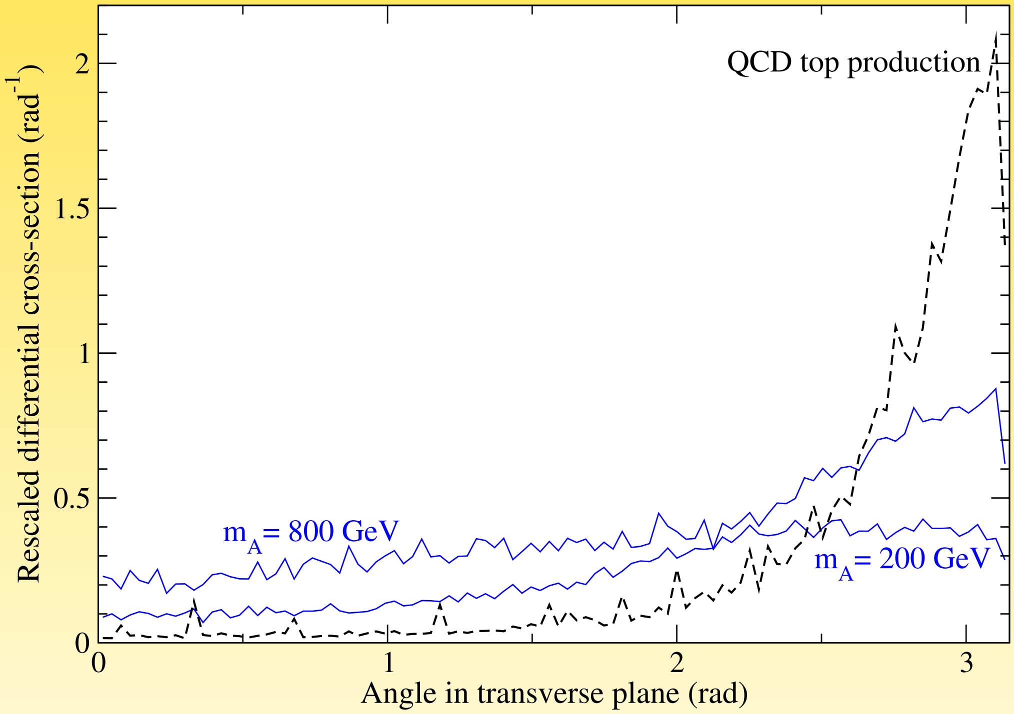
This cut is extremely effective for $t\bar{t}$ background, but not for ttZ

Still cannot distinguish small ΔM_{TA} signal

Transverse angle

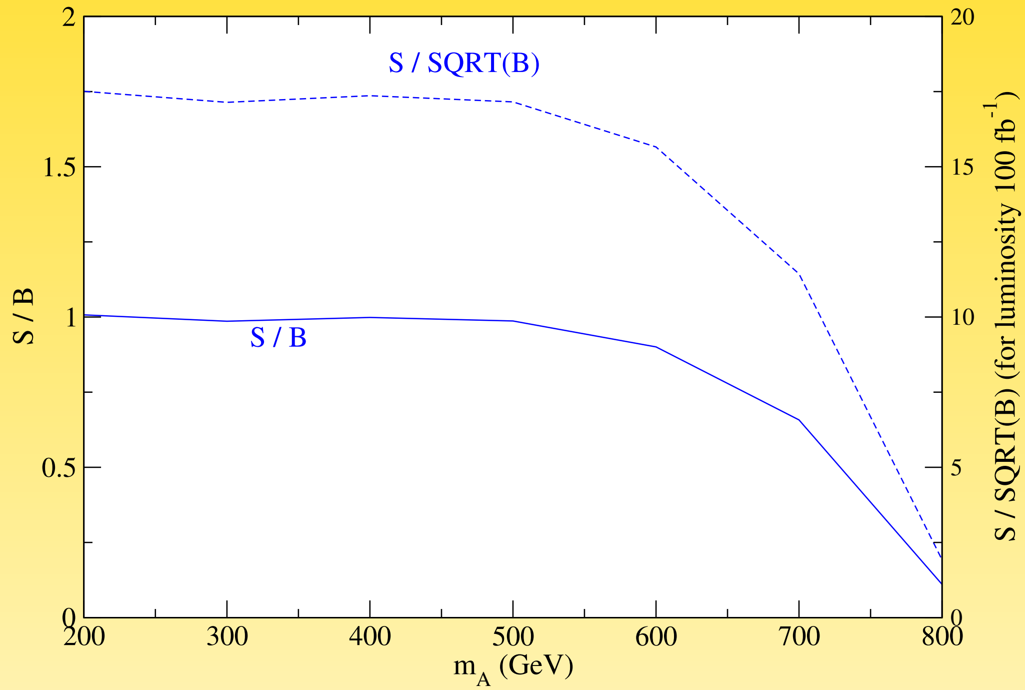
QCD $t\bar{t}$ should be produced back-to-back in a plane transverse t

Not true for tops in signal because of $\not{E}_T$ from As.



Reach

We can estimate our reach for ΔM_{TA} using only the m_{tR} cut:



If we ask for $S/B > 1$ then $\Delta M_{TA} < 500$ GeV

We might be able to improve on this using some combination of I

cuts

Conclusion

- More model-independent studies of top-partners at the LHC
- Most studies have focused on pure hadronic decay channel a
- We analysed the semi-leptonic channel, which has smaller ba
- Backgrounds can be culled using cuts on $\not{E}_T$, complex m_{tR} ts in transverse plane.
- Potential future directions:
  - Optimize cuts
  - Use generalization of Cambridge m_{T2} parameter to dete experimentally?
  - Analyse applicability of BLA to semileptonic mode
  - Other angular correlations for spin determination?