Triple-Top Signal of New Physics at the LHC

Brian Yencho

UW - Madison

with

Vernon Barger

Wai-Yee Keung

Pheno 2010

Outline

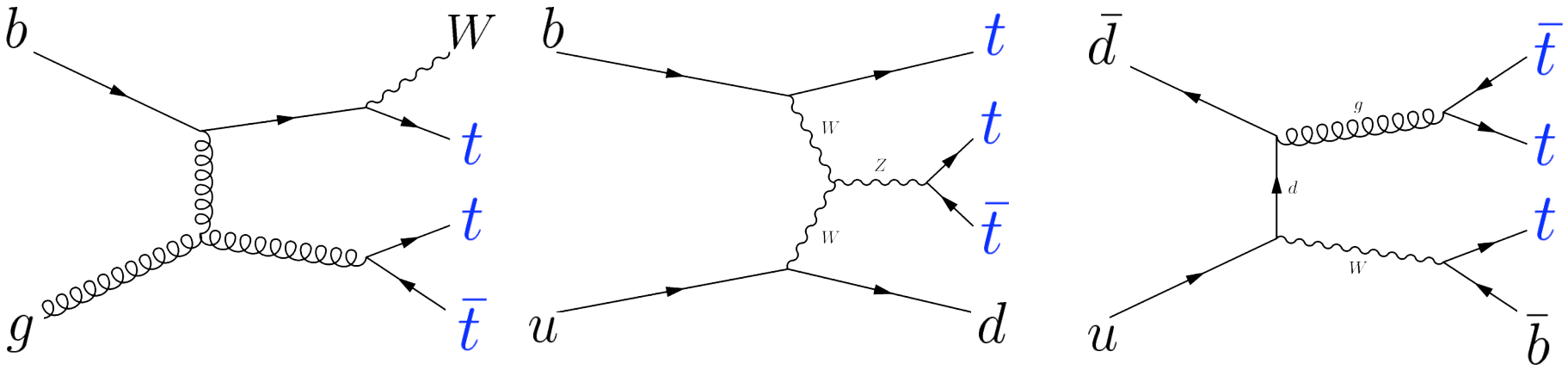
- Standard Model top production at LHC
- New physics models
  - MSSM (Focus Point region)
  - U(1)'
- Triple-Top Results
- Possible Applications

Motivation

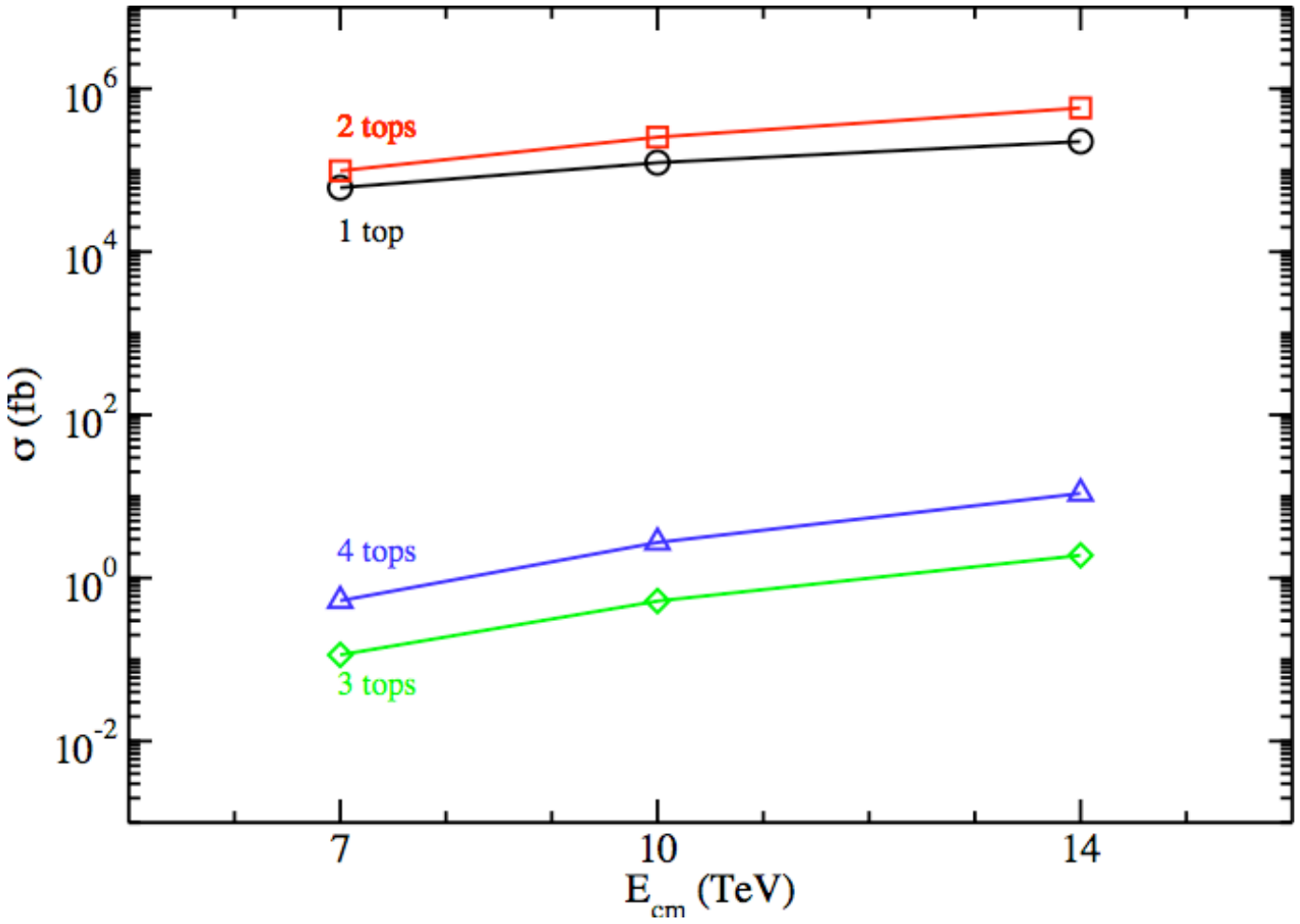
- LHC: *top factory*
- Tops <-> New Physics
- One-, two-, and four-top signals all investigated

Triple-Top: SM

- SM production associated with W, b, or single jet (at LO)
- Weak process + initial state b-quark
  - Low rates



Top Production: SM



Models: MSSM

- $pp \rightarrow \tilde{g}\tilde{g}$ is typically dominant SUSY process at LHC
- "Focus Point" region: (ex: SPS 2)

$$m_{\tilde{g}} < m_{\tilde{q}_i}$$

  - therefore

$$\tilde{g} \rightarrow q\bar{\tilde{q}}_{L,R},\ \bar{q}\tilde{q}_{L,R}$$ kinematically forbidden

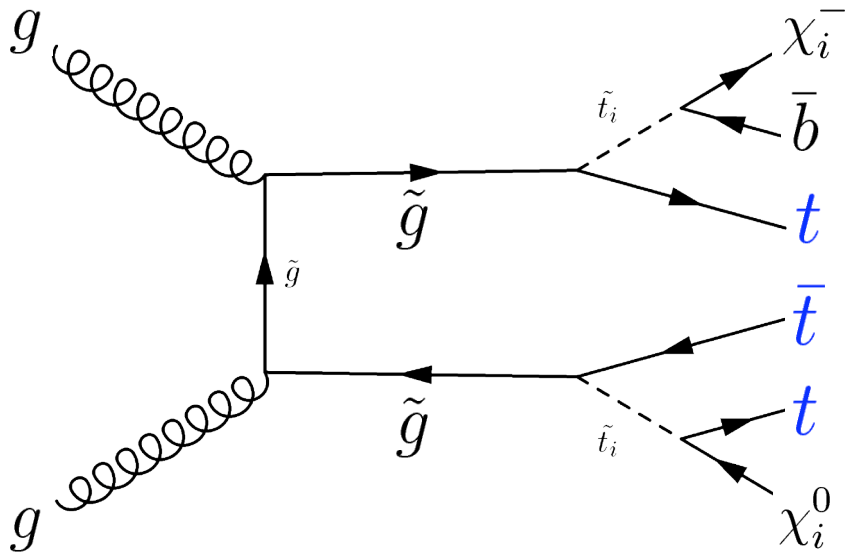
- Can have large BR to tops

$$\tilde{g} \rightarrow \chi_i^0 t\bar{t}$$

$$\tilde{g} \rightarrow \chi_i^{\pm} t\bar{b}\ (\chi_i^{\pm} b\bar{t})$$

Models: MSSM

Gluino Branching Fractions	
$\tilde{g} \to 1t + \ldots$	0.21
$\tilde{g} \to t\bar{b}\chi_1^-$	0.080
$\tilde{g} \to \bar{t}b\chi_1^+$	0.080
$\tilde{g} \to t\bar{b}\chi_2^-$	0.024
$\tilde{g} \to \bar{t}b\chi_2^+$	0.024
$\tilde{g} \to 2t + \ldots$	0.11
$\tilde{g} \to t\bar{t}\chi_1^0$	0.099
$\tilde{g} \to t\bar{t}\chi_2^0$	0.012
$\tilde{g} \to t\bar{t}\chi_3^0$	0
$\tilde{g} \to t\bar{t}\chi_4^0$	0



- At SPS 2 (mSUGRA benchmark):

$$m_0 = 1450, \quad m_{1/2} = 300, \quad A_0 = 0, \quad \tan\beta = 10, \quad \mu > 0$$

Models: Z'

- Additional U(1) with interaction term:

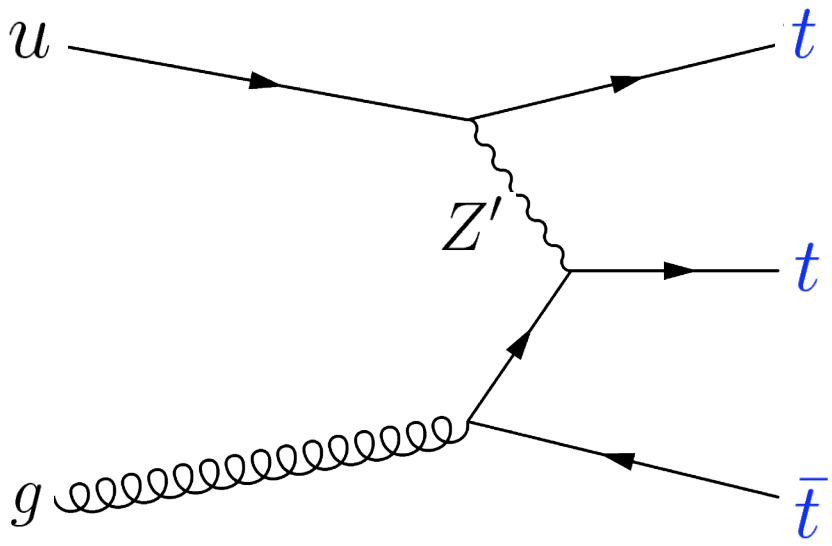
$$\mathscr{L} \supset (g_X Z'_\mu \bar{u} \gamma^\mu P_R t + h.c.) + \epsilon_U g_X Z'_\mu \bar{u}_i \gamma^\mu P_R u_i$$

- Introduced to explain top-pair FB asymmetry

S. Jung, H. Murayama, A. Pierce, and J.D. Wells, arXiv:0907.4112 [hep-ph]

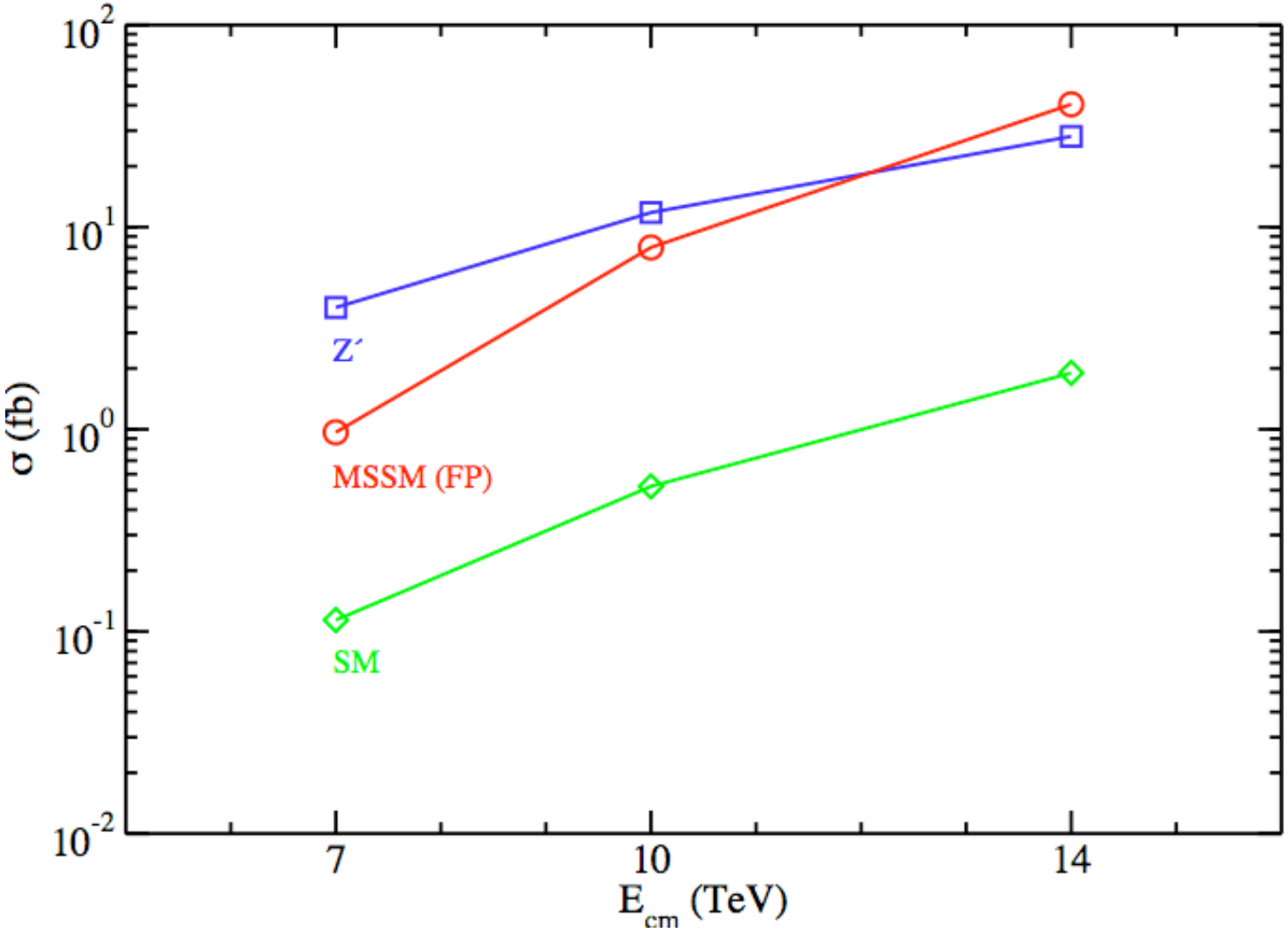
- ϵ_U : forces decay $Z' \to u\bar{u}$
- Best-fit: $M_{z'} = 160\ \mathrm{GeV},\ \alpha_x = 0.024,\ \epsilon_U < 1$
- We take: $\epsilon_U = 0.1$

Models: Z'

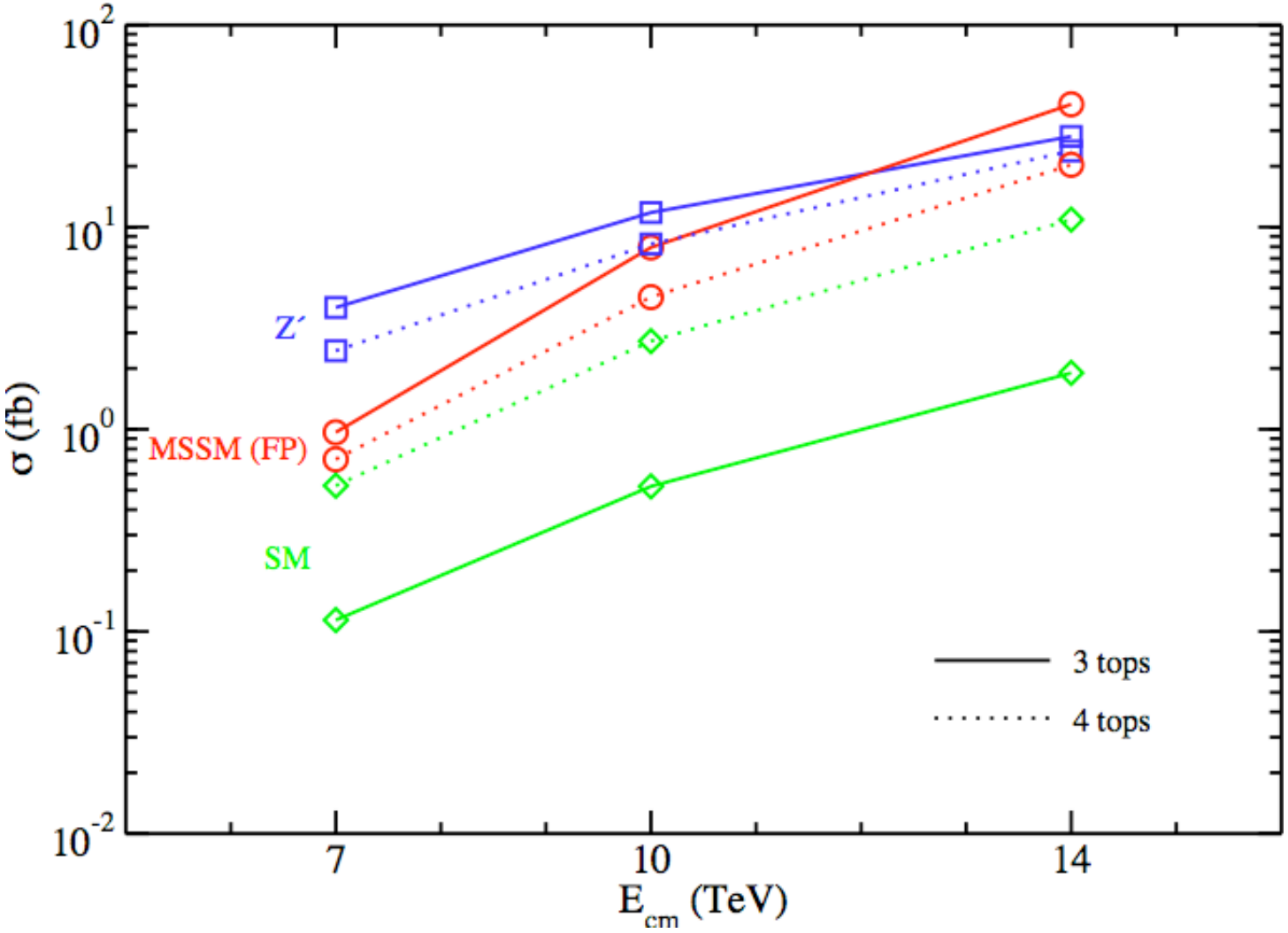


- Leading diagram from t-channel Z' exchange
- No associated jet, b, or W (at LO)
- Total contribution goes as ϵ_U^2

Triple-Top Cross-Sections



4-top misidentification?



Applications

- Discovery?
  - Initial run : 7 TeV, 1 fb^{-1} ***cx's too small!***
  - Later runs: MSSM > missing energy
    U(1)' > like-sign tops
- MSSM
  - Find relative branching ratios
  - Insight into squark mass parameters, neutralino composition, and gluino mass
  - B.S. Acharya, P. Grajek, G.L. Kane, E. Kuflik, K. Suruliz, and L.T. Wang, arXiv:0901.3367 [hep-ph]
- Z' model
  - Determine ϵ_U

Conclusions

- Small SM triple-top cross-section gets large enhancement in some new physics models
- Cross sections probably still too small to be discovery mode
- Triple-top signal can be used to learn certain model properties