Boosted Tops from Gluino Decays

Michael Saelim

Cornell University

Pheno 2012

Joshua Berger, Maxim Perelstein, M.S., Andrew Spray

arXiv:1111.6594

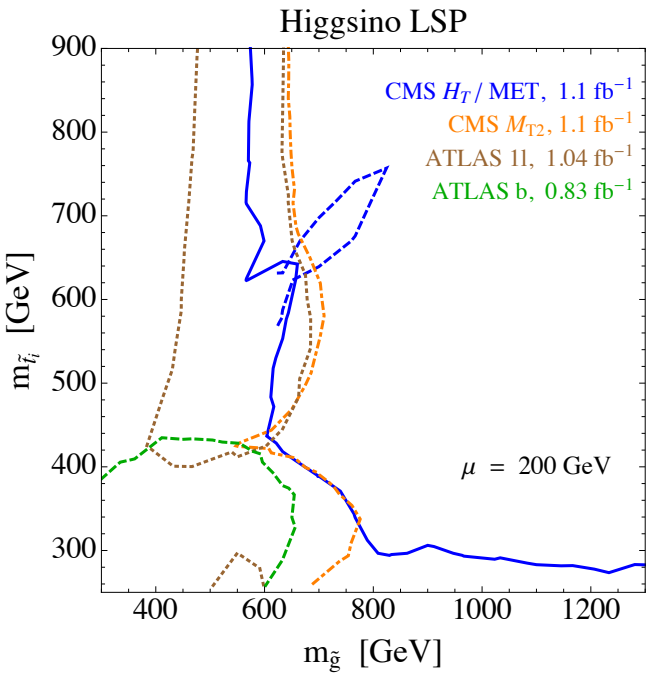
One-slide overview

- LHC + naturalness $\Longrightarrow$ SUSY w/ light 3rd gen.
- Gluino pair-production signatures:

  4 boosted tops + MET

- Tagging boosted tops gives us low SM background
- Probe gluino masses up to 1 TeV at the 7 TeV LHC with $\int \mathcal{L} = 30$ fb^{-1}

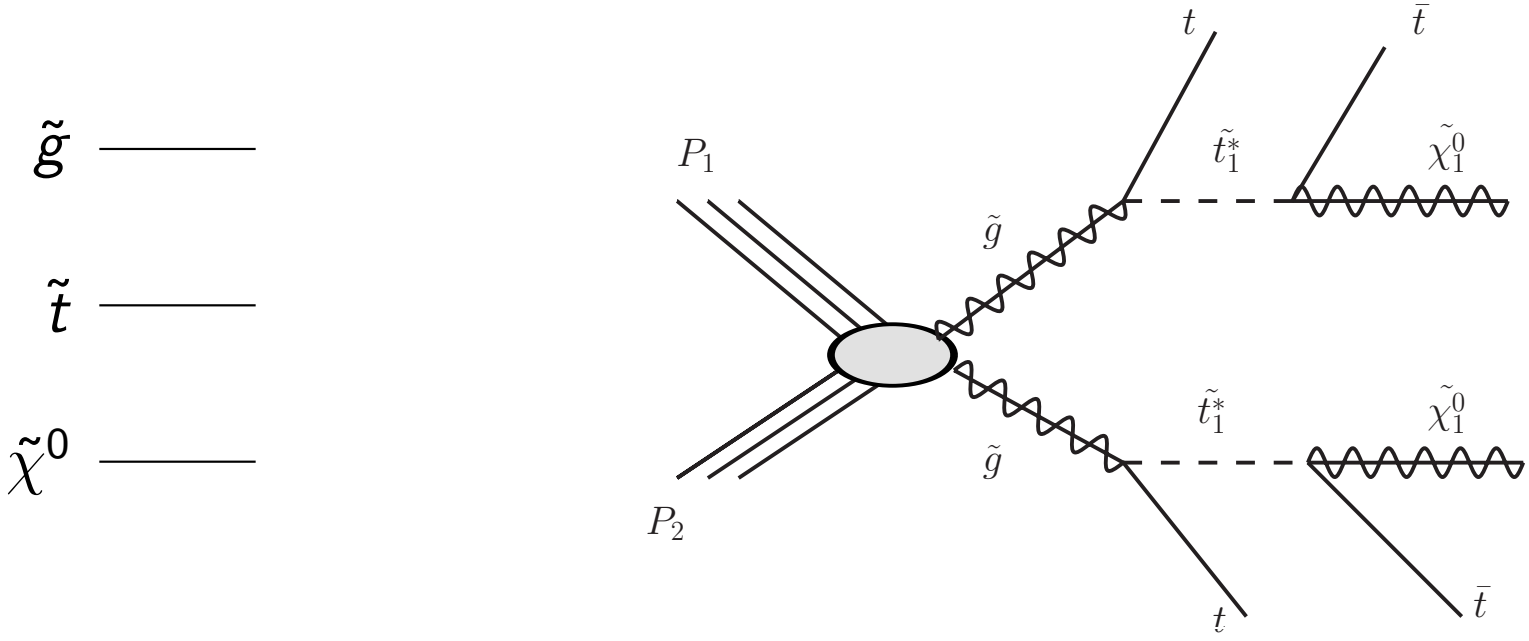
SUSY with light 3rd generation



(arXiv:1110.6926)

- MSSM w/ degenerate squarks: squarks and gluinos > 1 TeV
- MSSM w/ light 3rd gen.: stops $>$ 2-300 GeV, gluinos $>$ 600 GeV

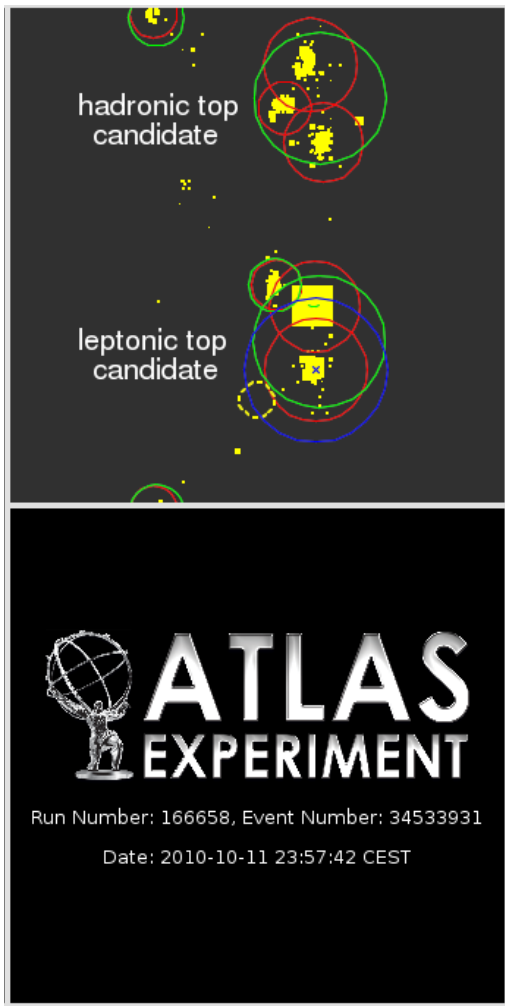
Simplified model



- Require $m(\tilde{g}) - m(\tilde{t})$ and $m(\tilde{t}) - m(\tilde{\chi}^0) > m(t)$ to get on-shell tops, and fix $m(\tilde{\chi}^0) = 60$ GeV
- 4 top + MET signal

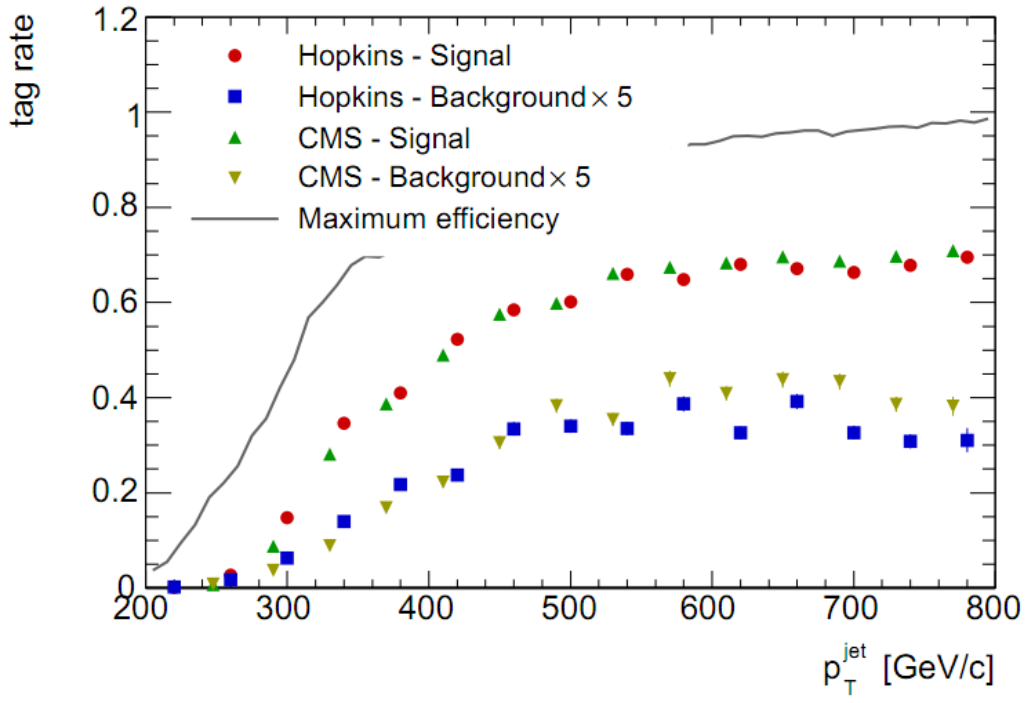
(figure credit: CMS PAS SUS-11-020)

Tagging boosted tops



- First done at Johns Hopkins (arXiv: 0806.0848)
- Cluster "fat jets" with R $\sim$ 1.0
- Examine substructure and invariant mass of hadronic tops
- (figure credit: ATLAS-CONF-2011-073)

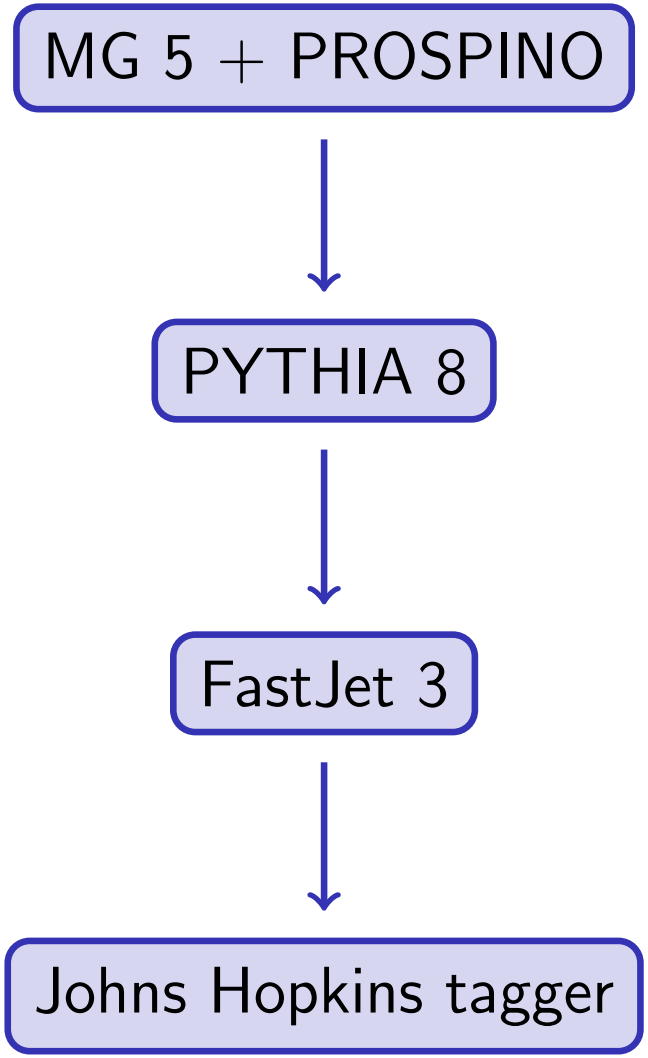
Johns Hopkins Top Tagger



(BOOST 2010 workshop, arXiv:1012.5412)

- 50% tag rate, with only a few % mistag rate
- Used in search for $Z' \to t\bar{t}$ (CMS-EXO-11-006)

Signal simulation



- Gluino pair-production
- We require
  - ≥ 4 jets with $p_T > 100$ GeV,
  - some jets top-tagged,
  - and significant $\not{E}_T$

Background simulation

- Backgrounds:
  - n tops + $(4 - n)$ jets
  - n tops + $(4 - n)$ jets + leptonic W
  - n tops + $(4 - n)$ jets + invisible Z
- LO cross sections used; known K-factors are < 1
- p_T and $\not{E}_T$ cut efficiencies computed at parton level
- p_T-dependent tagging efficiencies and mistag rates from the BOOST2010 workshop used (arXiv:1012.5412)

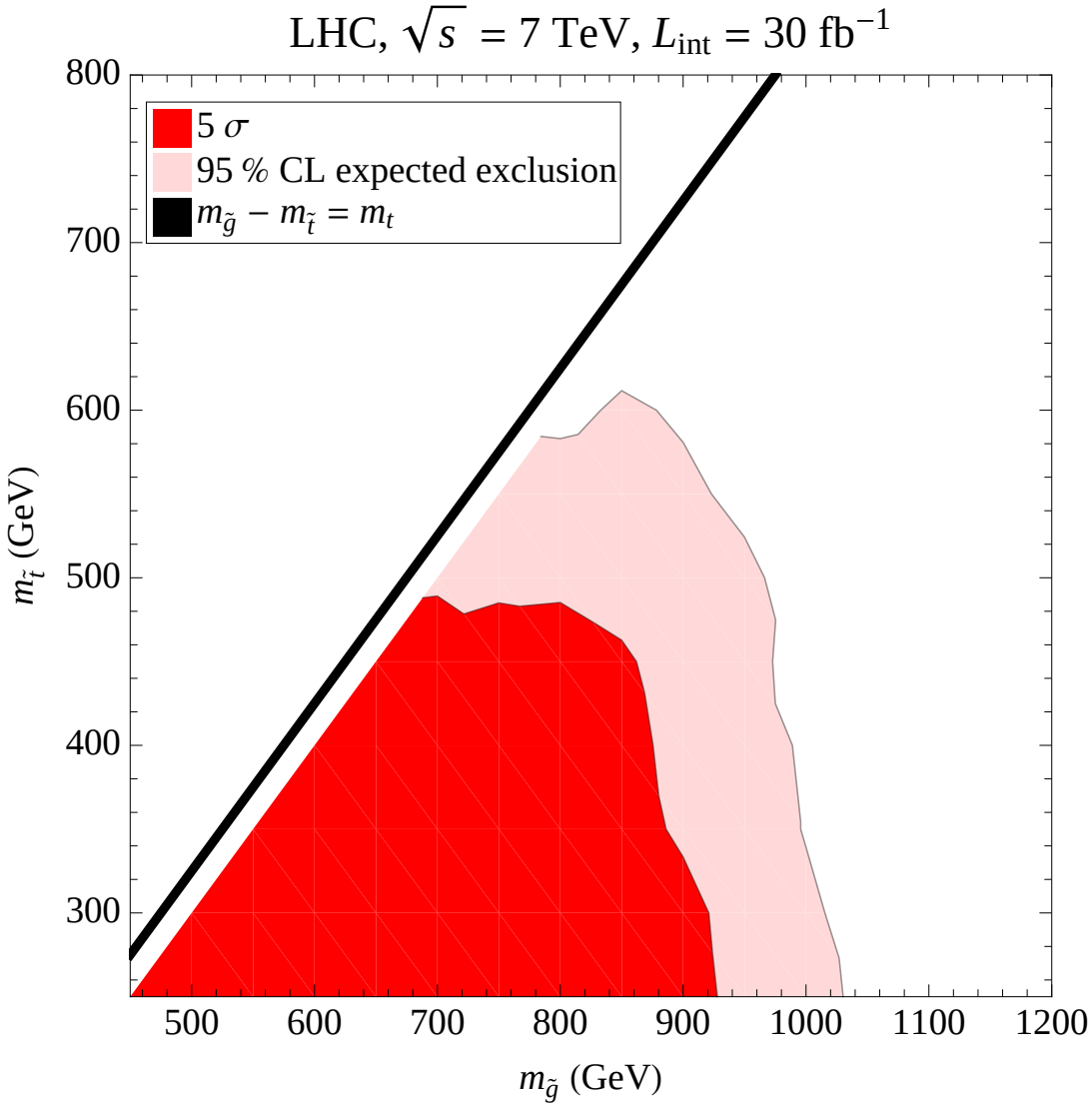
Cuts at 7 TeV and 30 fb^{-1}

- Optimized for $(m(\tilde{g}), m(\tilde{t})) = (800, 400)$ GeV
  - ≥ 4 jets with $p_T > 100$ GeV
  - ≥ 2 of those have top tags
  - $\not{E}_T > 100$ GeV
- 32 signal events, S/B $= 2.4$, stat. sig. 6.8

Benchmark efficiencies at 7 TeV

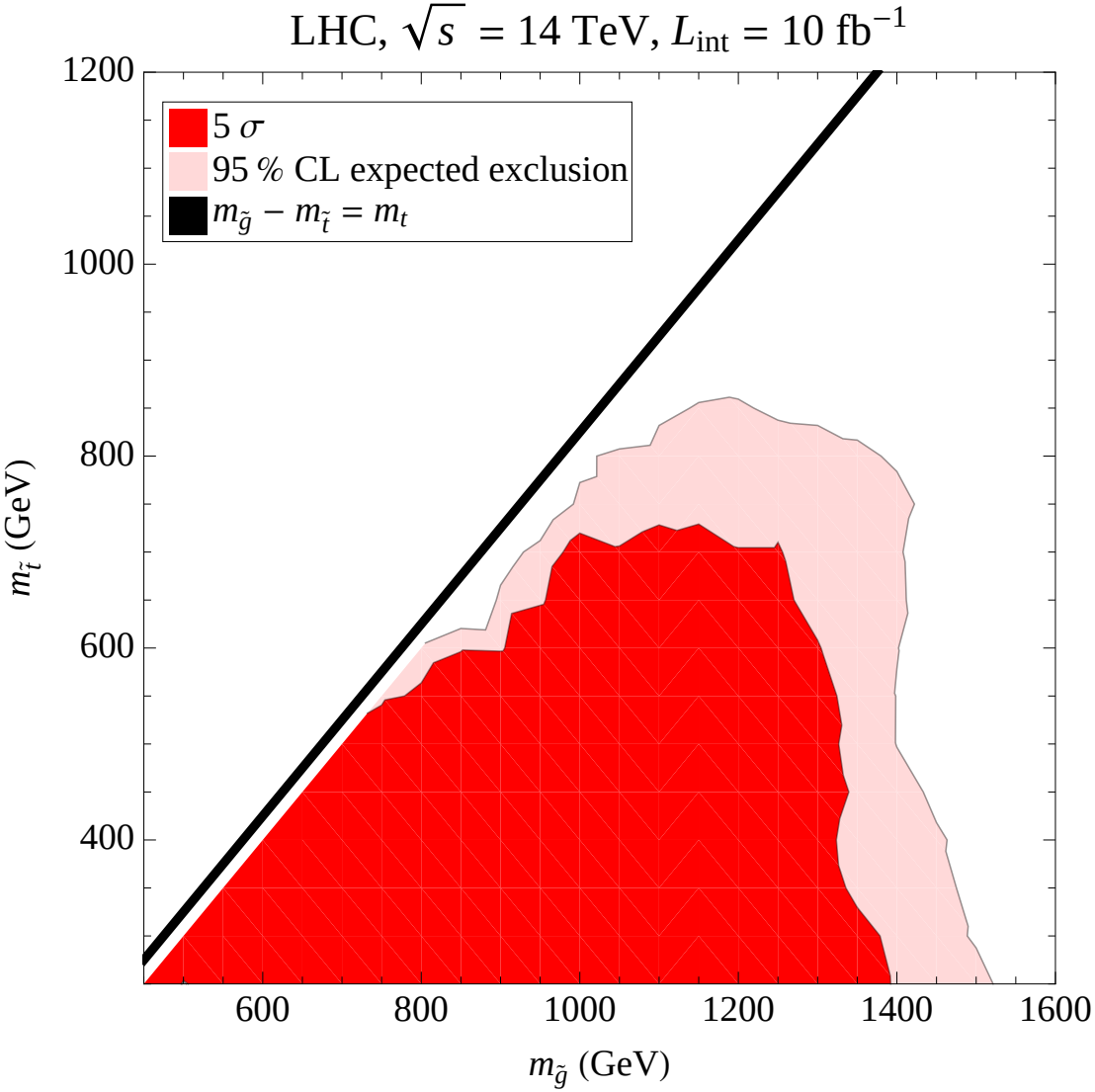
Process	$\sigma_{\rm tot}(fb)$	Eff(p_T) (%)	Eff(tag)	$\sigma_{\rm tag}$	Eff($\not{E}_T$)	$\sigma_{\rm all\ cuts}$
signal	61.5	37	6	1.31	81	1.06
$Z + 4j$	2×10^5	0.2	0.1	0.44	66	0.29
$2t + 2j$	5×10^4	3	0.3	5.7	2	0.10
$W + 4j$	2×10^5	0.2	0.03	0.12	29	0.04
$Z + 2t + 2j$	50	4	1	0.02	72	0.02

Reach at 7 TeV and 30 fb^{-1}



- Probe $\tilde{g}$ mass up to 1 TeV
- 5σ up to $m(\tilde{g}) \sim 900$ GeV
- S/B > 1 throughout the probed region

Going to 14 TeV and 10 fb^{-1}



- Optimized for (1200, 600)
- $\geq$ 4 jets with $p_T > 100$ GeV
- $\geq$ 3 top tags
- $\not{E}_T > 175$ GeV
- $S/B > 10$

However...

- Detector effects/systematics not included
- Larger background samples needed
- QCD $4j$ $\not{E}_T$ tail needs studying

- But, the reach may be underestimated

Conclusion

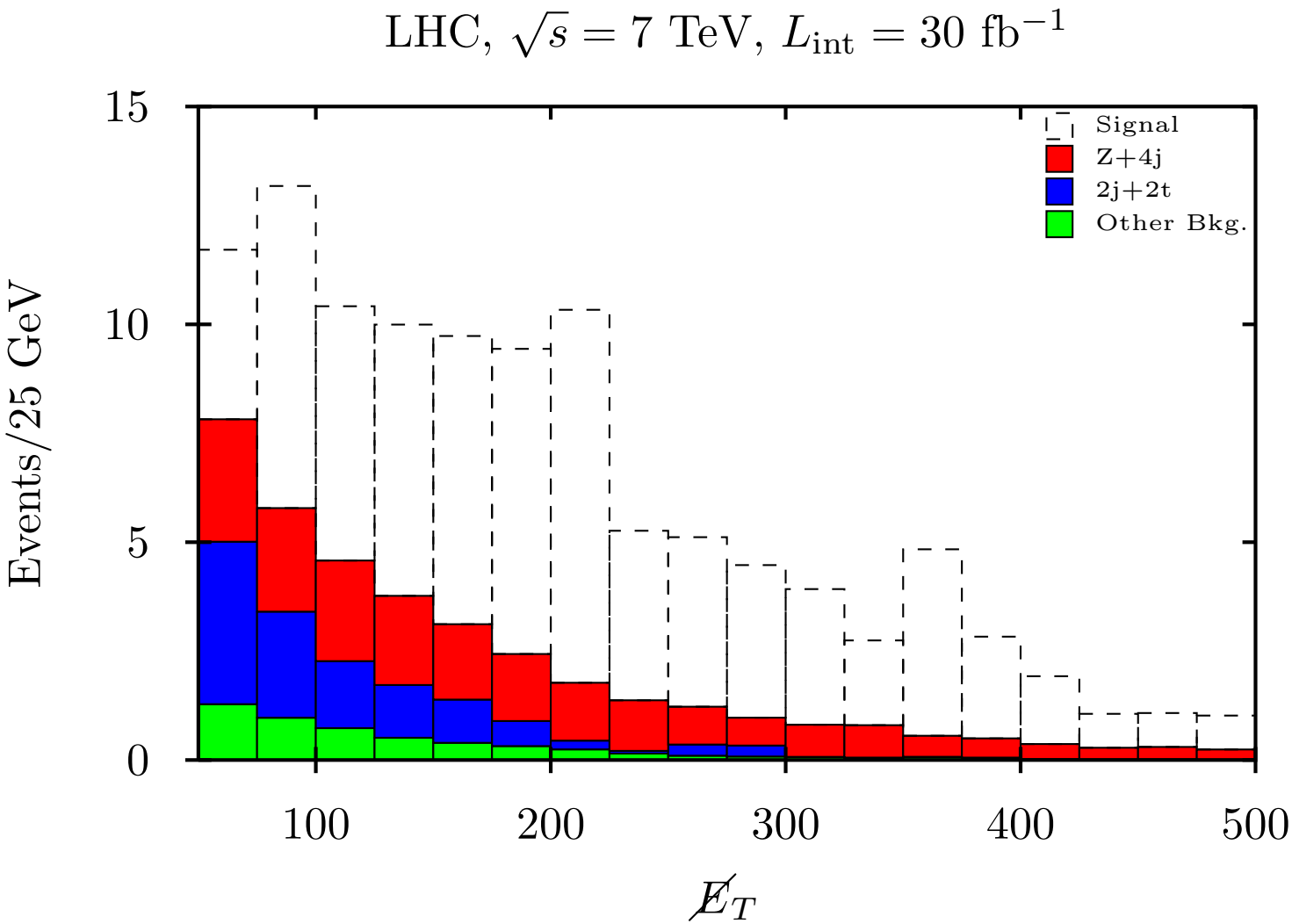
- SUSY could be hiding if lightest colored super partner is stop
- Boosted top tagging provides excellent coverage of this scenario, including at 7 and 8 TeV
- Let's get an experimental analysis going!

Extra Slides

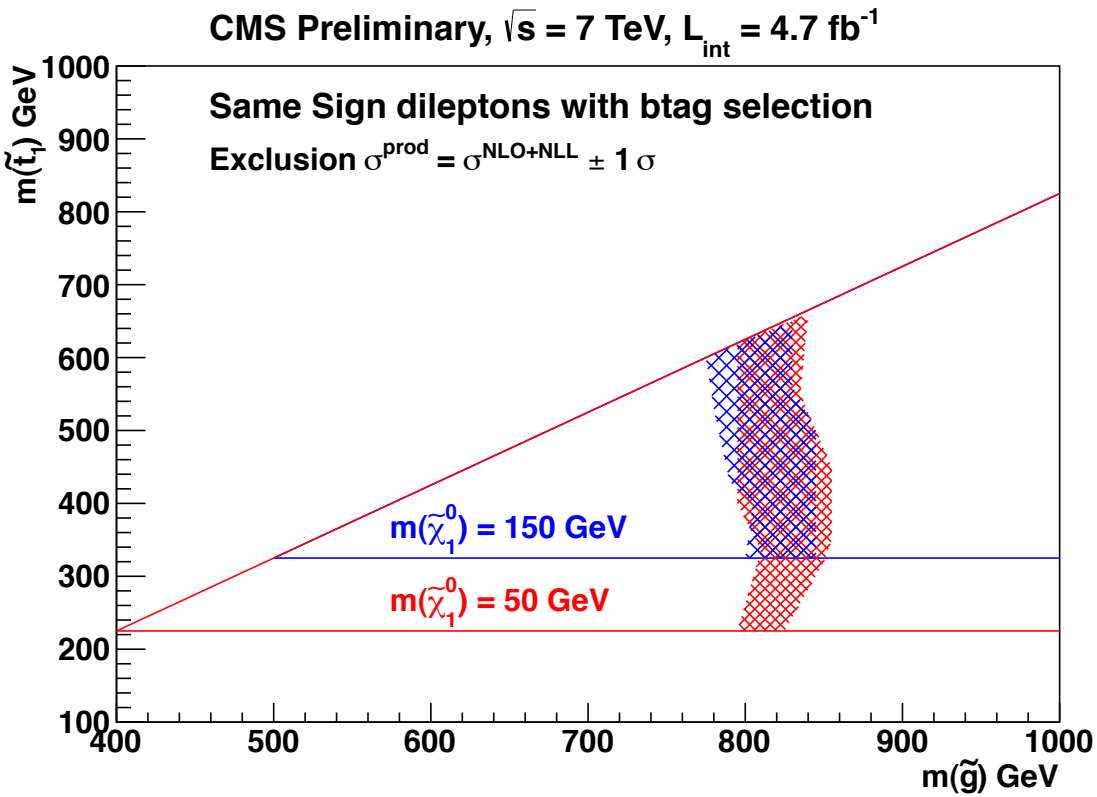
Johns Hopkins top tagger settings

- $\delta_p = 0.04$
- $\delta_r = 0.19$
- $160 < m_t < 265$ GeV
- $\cos\theta_h < 0.95$
- $60 < m_W < 120$ GeV

$\not{E}_T$ after top tag cuts at benchmark



Update: CMS PAS SUS-11-020 (March 2012)



- Preliminary update after 4.7 fb^{-1}:
- gluinos > 800 GeV