EPS HEP 2013

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LHC Searches Examined via the RPV MSSM

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New High Energy Theory Center

Rutgers University

References

Higgsino production (w/Jared Evans)
to be released soon

Very interesting, but no time today

Stop production (w/Jared Evans)
arXiv:1209.0764 [JHEP 1304 (2013) 028]
now updated with 8 TeV searches ← **Today's talk**

Gluino production (w/Jared Evans, David Shih, Matt Strassler) – to be released soon

Motivation

THEORY

SUSY can stabilize the electroweak (EW) scale. Expect:

- Higgsinos near EW scale
- 3^{rd} generation squarks and gluinos not much heavier

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Unclear from theory how new physics will manifest itself.

Cover all classes of final states, regardless of theory motivation.

Which final states are not yet well-covered?

How can they be addressed?

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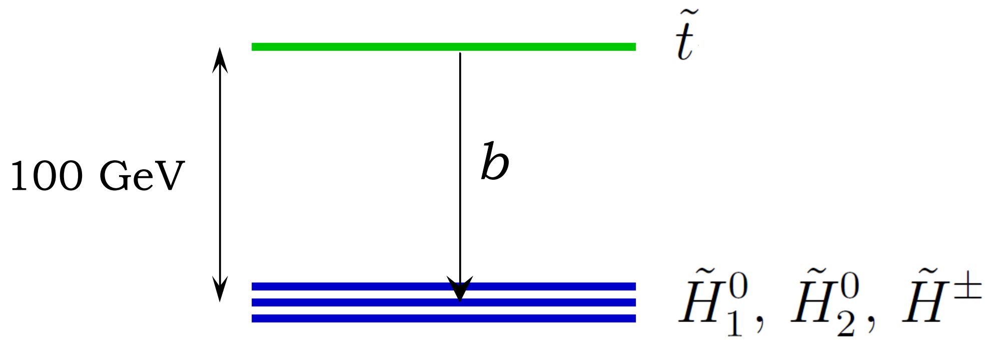
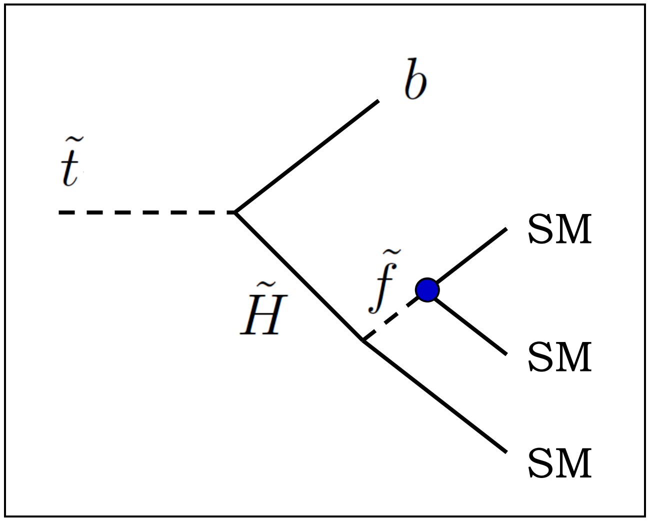
Why R-parity violation (RPV)?

- RPC SUSY already well-covered. RPV may still contain surprises!
- Freedom in RPV couplings $\rightarrow$ Many interesting benchmark models

Simplified models





Production $pp \to \tilde{t}\,\tilde{t}^*$

Stop decay $\tilde{t} \to b\,\tilde{H}^+$

Higgsino (chargino) decay

- Case 1: $\tilde{H}^+ \to W^{+*}\,\tilde{H}_1^0\,, \quad \tilde{H}_1^0 \to \text{RPV}$
  $W^{+*} \to$ soft particles (unobservable)

  } Stop and antistop can give same-sign leptons

- Case 2: $\tilde{H}^+ \to \text{RPV}$

For simplicity, the sfermion mediator $\tilde{f}$ assumed off-shell.

Simplified models

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq,\ \nu bbq$	$etbq,\ \nu tbq$
	321	$(\tilde{\nu}_\tau,\ \tilde{\tau})_L$	τbqq	τbqq
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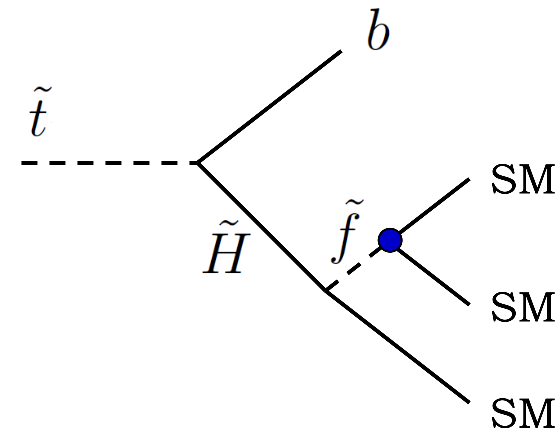
In each simplified model:

- Single RPV coupling is on
- Single mediator contributes

(see example in backup slides)



Case 1:

$$\tilde{H}^+ \rightarrow W^{+*}\, \tilde{H}_1^0$$

$$\tilde{H}_1^0 \rightarrow \mathrm{RPV}$$

Stop and antistop can give same-sign leptons

Case 2:

$$\tilde{H}^+ \rightarrow \mathrm{RPV}$$

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- **MET only from tops or τ** or essentially no MET
- Taus, but not e or μ or no leptons at all

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Simulated searches

ATLAS CMS

Final State	$\sqrt{s}$	$\mathcal{L}$	Reference
3ℓ+jets+MET	8	13.0	CONF-2012-151
3ℓ+MET (old)	8	13.0	CONF-2012-154
3ℓ+MET	8	20.7	CONF-2013-035
4ℓ (old)	8	13.0	CONF-2012-153
4ℓ+MET	8	20.7	CONF-2013-036
3-4ℓ	8	19.5	PAS-SUS-13-003
b' (3ℓ)	7	4.9	arXiv:1204.1088
3ℓ	7	1.02	CONF-2011-158
4ℓ	7	1.02	CONF-2011-144
3ℓ+MET	7	2.06	arXiv:1204.5638
3ℓ+MET	7	4.7	arXiv:1208.3144
4ℓ+MET	7	2.06	CONF-2012-001
3-4ℓ	7	4.98	arXiv:1204.5341
SS DIL+MET	8	5.8	CONF-2012-105
SS DIL w/b (SUSY)	8	20.7	CONF-2013-007
SS DIL w/b (Exo.)	8	14.3	CONF-2013-051
SS DIL w/b	8	10.5	arXiv:1212.6194
SS DIL	7	4.98	arXiv:1205.6615
SS DIL w/b	7	4.98	arXiv:1205.3933
SSSF DIL	7	4.98	arXiv:1207.6079
SSSF DIL	7	1.6	arXiv:1201.1091
SS DIL	7	4.7	arXiv:1210.4538
SS DIL+jets+MET	7	2.05	arXiv:1203.5763
SS DIL+MET	7	1.04	arXiv:1110.6189
b' (SS DIL)	7	4.7	CONF-2012-130
b' (SS DIL)	7	4.9	arXiv:1204.1088
OS DIL+MET	7	1.04	arXiv:1110.6189
OS DIL+jets+MET	7	4.7	arXiv:1208.4688
OS DIL+MET	7	4.98	arXiv:1206.3949
leptonic m_{T2}	7	4.7	arXiv:1209.4186
Z+jets+MET	7	4.98	arXiv:1204.3774
Z+jets+MET	7	2.05	arXiv:1204.6736

Final State	$\sqrt{s}$	$\mathcal{L}$	Reference
ℓ+jets+MET	8	5.8	CONF-2012-104
ℓ+b+$6j$+MET	8	19.4	PAS-SUS-13-007
$(\mu j)(\nu j)$	8	19.6	PAS-EXO-12-042
ℓ+$7j$+MET	7	4.7	CONF-2012-140
ℓ+jets+MET	7	4.7	PAS-SUS-12-010
ℓ+jets+MET	7	4.7	CONF-2012-041
ℓ+b+jets+MET	7	2.05	arXiv:1203.6193
ℓ+b+jets+MET	7	4.98	PAS-SUS-11-027
ℓ+b+jets+MET	7	4.98	PAS-SUS-11-028
$1/2\tau$+jets+MET	8	20.7	CONF-2013-026
4ℓ+MET w/τ	8	20.7	CONF-2013-036
3-4ℓ w/τ	8	19.5	PAS-SUS-13-003
$1/2\tau$+jets+MET	7	4.7	arXiv:1210.1314
τ+ℓ+jets+MET	7	4.7	arXiv:1210.1314
τ+jets+MET (old)	7	2.05	CONF-2012-005
2τ+jets+MET (old)	7	2.05	arXiv:1203.6580
OS DIL+MET w/τ	7	4.98	arXiv:1206.3949
SS DIL w/τ	7	4.98	arXiv:1205.6615
3-4ℓ w/1τ	7	4.98	arXiv:1204.5341
3-4ℓ w/2τ	7	4.98	arXiv:1204.5341
$t\bar{t}$ xsec (DIL)	8	2.4	PAS-TOP-12-007
$t\bar{t}$ xsec (DIL)	7	0.70	arXiv:1202.4892
$t\bar{t}$ xsec (DIL)	7	2.3	arXiv:1208.2671
$t\bar{t}$ xsec (DIL w/τ)	7	~ 2	arXiv:1203.6810
$t\bar{t}$+jet (LJ)	7	5.0	PAS-EXO-11-056
$t\bar{t}$+m_T (LJ)	7	1.04	arXiv:1109.4725

Final State	$\sqrt{s}$	$\mathcal{L}$	Reference
2-6 jets+MET	8	20.3	CONF-2013-047
2-6 jets+MET (old)	8	5.8	CONF-2012-109
7-10 jets+MET w/b	8	20.3	CONF-2013-054
8-10 jets+MET w/M_J^Σ	8	20.3	CONF-2013-054
6-9 jets+MET	8	5.8	CONF-2012-103
b+jets+MET	8	19.4	arXiv:1305.2390
$3b$+jets+MET	8	12.8	CONF-2012-145
jets w/α_T w/b	8	11.7	arXiv:1303.2985
monojet+MET	8	19.5	PAS-EXO-12-048
monojet+MET	8	10.5	CONF-2012-147
2-6 jets+MET	7	4.7	CONF-2012-033
6-9 jets+MET	7	4.7	CONF-2012-037
jets+MET	7	4.98	arXiv:1207.1898
jets+MET (old)	7	1.1	PAS-SUS-11-004
b+jets+MET	7	2.05	arXiv:1203.6193
b+jets+MET	7	4.98	arXiv:1208.4859
b+jets+MET (old)	7	1.1	PAS-SUS-11-006
$3b$+jets+MET	7	4.7	CONF-2012-058
jets w/α_T w/b	7	4.98	PAS-SUS-11-022
jets w/α_T (old)	7	1.14	arXiv:1109.2352
ℓ+b+jets (low MET)*	7	5.0	arXiv:1210.7471
ℓ+$3b$+jets (low MET)	8	14.3	CONF-2013-018
6 jets (no MET)	7	4.6	arXiv:1210.4813
up to 10 objects ("BH")	8	12.1	arXiv:1303.5338
$(\mu j)(\mu j)$	8	19.6	PAS-EXO-12-042
$(\tau b)(\tau b)$	7	4.8	PAS-EXO-12-002

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ℓ+jets+MET	7	4.7	CONF-2012-041
$\ell+b$+jets+MET	7	2.05	arXiv:1203.6193
$\ell+b$+jets+MET	7	4.98	PAS-SUS-11-027
$\ell+b$+jets+MET	7	4.98	PAS-SUS-11-028
$1/2\tau$+jets+MET	8	20.7	CONF-2013-026
4ℓ+MET w/τ	8	20.7	CONF-2013-036
3-4ℓ w/τ	8	19.5	PAS-SUS-13-003
$1/2\tau$+jets+MET	7	4.7	arXiv:1210.1314
$\tau+\ell$+jets+MET	7	4.7	arXiv:1210.1314
τ+jets+MET (old)	7	2.05	CONF-2012-005
2τ+jets+MET (old)	7	2.05	arXiv:1203.6580
OS DIL+MET w/τ	7	4.98	arXiv:1206.3949
SS DIL w/τ	7	4.98	arXiv:1205.6615
3-4ℓ w/1τ	7	4.98	arXiv:1204.5341
3-4ℓ w/2τ	7	4.98	arXiv:1204.5341
$t\bar{t}$ xsec (DIL)	8	2.4	PAS-TOP-12-007
$t\bar{t}$ xsec (DIL)	7	0.70	arXiv:1202.4892
$t\bar{t}$ xsec (DIL)	7	2.3	arXiv:1208.2671
$t\bar{t}$ xsec (DIL w/τ)	7	~ 2	arXiv:1203.6810
$t\bar{t}$+jet (LJ)	7	5.0	PAS-EXO-11-056
$t\bar{t}+m_T$ (LJ)	7	1.04	arXiv:1109.4725

Final State	$\sqrt{s}$	$\mathcal{L}$	Reference
2-6 jets+MET	8	20.3	CONF-2013-047
2-6 jets+MET (old)	8	5.8	CONF-2012-109
7-10 jets+MET w/b	8	20.3	CONF-2013-054
8-10 jets+MET w/M_J^Σ	8	20.3	CONF-2013-054
6-9 jets+MET	8	5.8	CONF-2012-103
b+jets+MET	8	19.4	arXiv:1305.2390
$3b$+jets+MET	8	12.8	CONF-2012-145
jets w/α_T w/b	8	11.7	arXiv:1303.2985
monojet+MET	8	19.5	PAS-EXO-12-048
monojet+MET	8	10.5	CONF-2012-147
2-6 jets+MET	7	4.7	CONF-2012-033
6-9 jets+MET	7	4.7	CONF-2012-037
jets+MET	7	4.98	arXiv:1207.1898
jets+MET (old)	7	1.1	PAS-SUS-11-004
b+jets+MET	7	2.05	arXiv:1203.6193
b+jets+MET	7	4.98	arXiv:1208.4859
b+jets+MET (old)	7	1.1	PAS-SUS-11-006
$3b$+jets+MET	7	4.7	CONF-2012-058
jets w/α_T w/b	7	4.98	PAS-SUS-11-022
jets w/α_T (old)	7	1.14	arXiv:1109.2352
$\ell+b$+jets (low MET)*	7	5.0	arXiv:1210.7471
$\ell+3b$+jets (low MET)	8	14.3	CONF-2013-018
6 jets (no MET)	7	4.6	arXiv:1210.4813
up to 10 objects ("BH")	8	12.1	arXiv:1303.5338
$(\mu j)(\mu j)$	8	19.6	PAS-EXO-12-042
$(\tau b)(\tau b)$	7	4.8	PAS-EXO-12-002

Several searches that will play a special role

$\ell + 3b$ + jets (low MET)

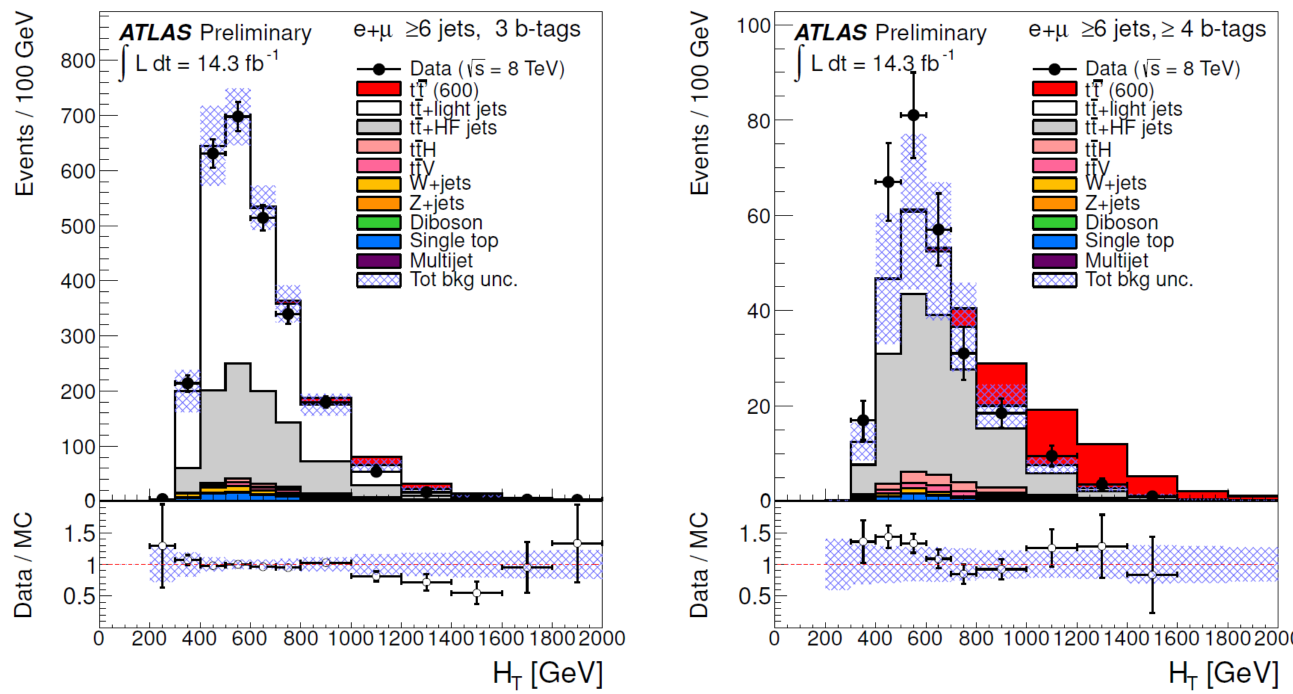
ATLAS-CONF-2013-018 (14.3/fb at 8 TeV)
Talk by Antonella Succurro yesterday

a.k.a.

Search for heavy top-like quarks decaying to a Higgs boson and a top quark in the lepton plus jets final state in pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector

Selection

- Exactly 1 lepton with $p_T > 25$ GeV
- 6+ jets with $p_T > 25$ GeV
- MET > 20 GeV
- MET + $m_T > 60$ GeV
- 3 or 4+ b-tags
- H_T distributions (incl. lepton, jets, MET)



We defined search regions as: $H_T > 800$, 1000, 1200, 1400, 1600, 1800 GeV

$\ell + b +$ jets (low MET)

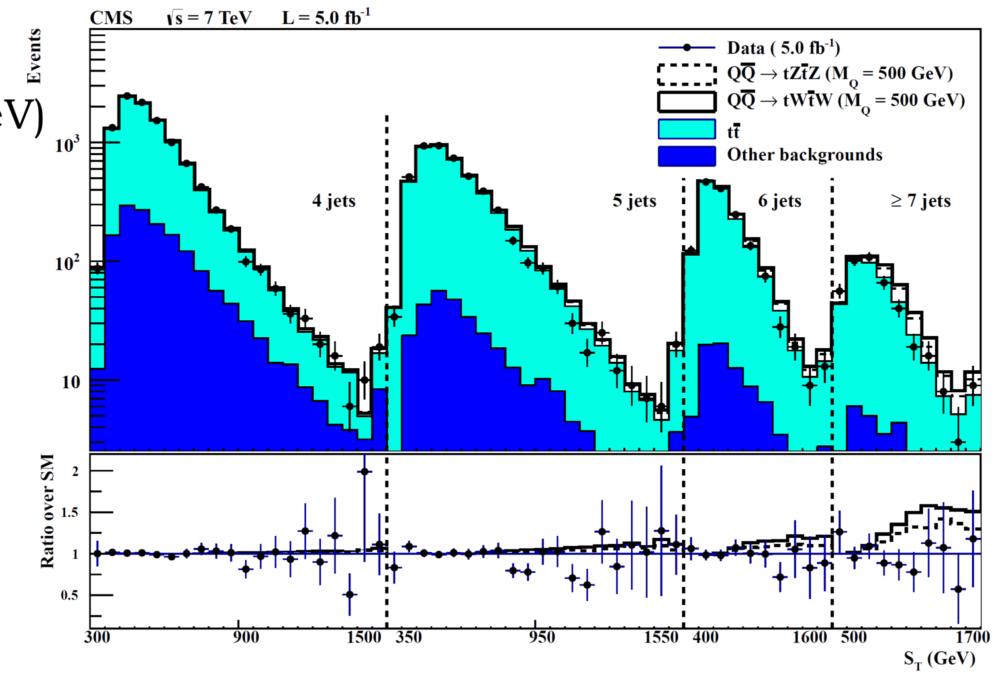
CMS-PAS-B2G-12-004, arXiv:1210.7471 (5/fb at 7 TeV)

a.k.a.

> Search for heavy quarks decaying into a top quark and a W or Z boson using lepton + jets events in pp collisions at $\sqrt{s} = 7$ TeV

Selection

- Exactly 1 lepton ($p_T{}^e > 35$ GeV, $p_T{}^\mu > 42$ GeV)
- Jets with $p_T > 100, 60, 50, 35$ GeV
- MET > 20 GeV
- 1+ b-tags
- $N_{\text{jets}} = 4, 5, 6, 7+$ (with $p_T > 35$ GeV)
- S_T distributions (incl. lepton, jets, MET)



Obstacles to reinterpretation

- Systematic uncertainties per S_T bin are not available
- 8 TeV search for a similar final state

> Inclusive search for a vector-like T quark by CMS

CMS-PAS-B2G-12-015 (20/fb at 8 TeV)
Talk by Devdatta Majumder yesterday

relies on BDT, so cannot be reinterpreted

ℓ + b + jets (low MET)
Our extension to 20/fb at 8 TeV

Selection

Same as in 7 TeV CMS search:

- Leptons, jets, MET, b-tagging

Different from CMS search:

- N_{jets} = 4+, 5+, 6+, 7+, 8+, 9+
- $S_T > S_T^{\max}$, with $S_T^{\max}$ = 400, 600, 800, …, 3000

Background estimation

$t\bar{t}$ + jets: ALPGEN + Pythia (matched up to 4 extra jets)

S_T distributions for 7 TeV agree with CMS if we normalize by 1.6. Same factor applied to 8 TeV distributions.

Systematic uncertainties

Tentatively assume 25% (similar to ATLAS search just mentioned)

$(\mu j)(\mu j)$

CMS-PAS-EXO-12-042 (19.6/fb at 8 TeV)
Talk by Edmund Berry yesterday

a.k.a. Search for pair production of second-generation scalar leptoquarks in pp collisions at $\sqrt{s} = 8$ TeV with the CMS Detector

Selection

- 2 muons
- Two leading jets p_T > 125, 45 GeV
- Cuts on S_T (2 muons + 2 jets), $M_{\mu\mu}$, $M_{\text{min}}(\mu, \text{jet})$ with different thresholds for each leptoquark (LQ) mass:

M_{LQ} (GeV)	300	350	400	450	500	550	600	650	700	750	800	850	900	950	≥1000
$S_T >$ (GeV)	380	460	540	615	685	755	820	880	935	990	1040	1090	1135	1175	1210
$M_{\mu\mu} >$ (GeV)	100	115	125	140	150	165	175	185	195	205	215	220	230	235	245
$M_{min}(\mu, \text{jet}) >$ (GeV)	115	115	120	135	155	180	210	250	295	345	400	465	535	610	690

In our context

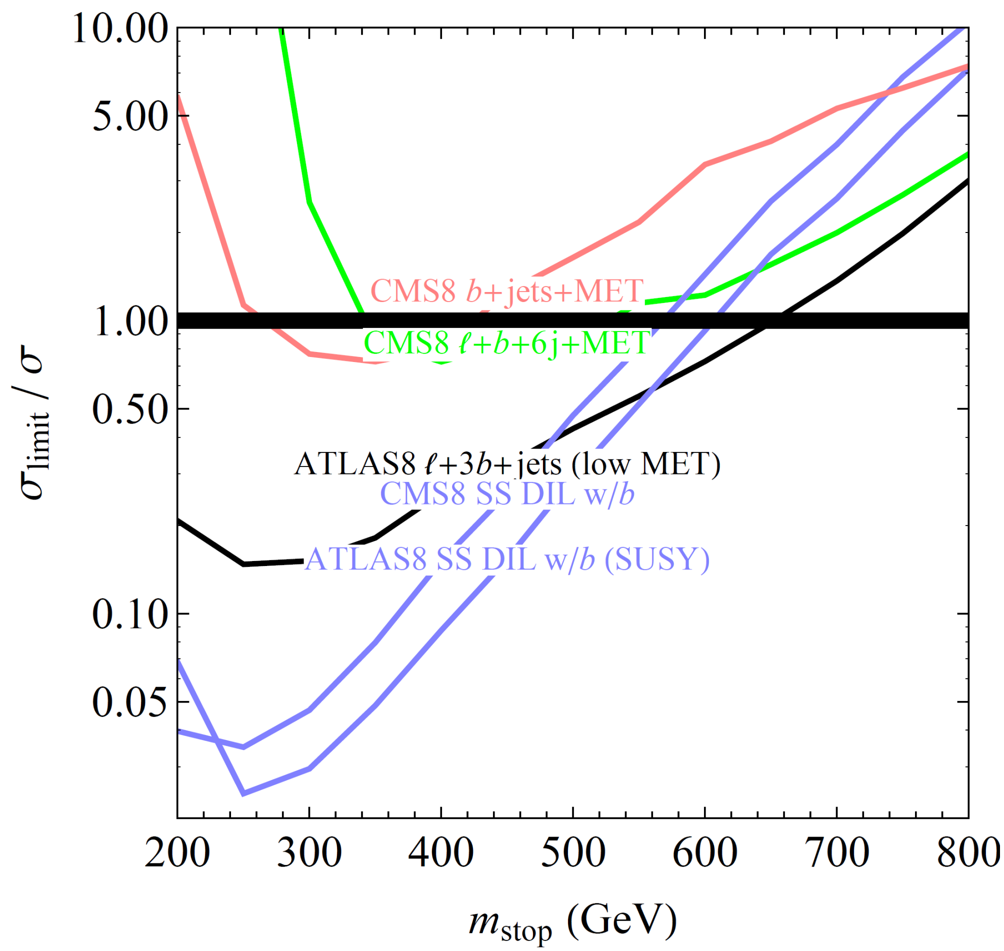
Relevant to 2 muons + *many* jets scenarios, e.g., $\tilde{t} \to \mu bbq$

We will use each LQ mass as a search region (for stops of any mass).

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq,\ \nu bbq$	$etbq,\ \nu tbq$
	321	$(\tilde{\nu}_\tau,\ \tilde{\tau})_L$	τbqq	τbqq
	323	$\tilde{b}_R$	$\tau bbq,\ \nu bbq$	$\tau tbq,\ \nu tbq$
		$(\tilde{\nu}_\tau,\ \tilde{\tau})_L$	τbbq	τbbq
	232	$\tilde{t}_L$	μtbq	μbbq
		$\tilde{b}_L$	νbbq	νtbq
	233	$\tilde{t}_L$	μtbb	μbbb
		$\tilde{b}_L$	νbbb	νtbb
	332	$\tilde{t}_L$	τtbq	τbbq
		$\tilde{b}_L$	νbbq	νtbq
	333	$\tilde{t}_L$	τtbb	τbbb
		$\tilde{b}_L$	νbbb	νtbb
UDD	213	$\tilde{b}_R$	$bbqq$	$tbqq$
	312	$\tilde{t}_R$	$tbqq$	$bbqq$
	323	$\tilde{t}_R$	$tbbq$	$bbbq$

Now let's look at some results!

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq$, νbbq	$etbq$, νtbq
	321	$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbqq	τbqq
	323	$\tilde{b}_R$	τbbq, νbbq	τtbq, νtbq
		$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbbq	τbbq
	232	$\tilde{t}_L$	μtbq	μbbq
		$\tilde{b}_L$	νbbq	νtbq
	233	$\tilde{t}_L$	μtbb	μbbb
		$\tilde{b}_L$	νbbb	νtbb
	332	$\tilde{t}_L$	τtbq	τbbq
		$\tilde{b}_L$	νbbq	νtbq
	333	$\tilde{t}_L$	τtbb	τbbb
		$\tilde{b}_L$	νbbb	νtbb
UDD	213	$\tilde{b}_R$	$bbqq$	$tbqq$
	312	$\tilde{t}_R$	$tbqq$	$bbqq$
	323	$\tilde{t}_R$	$tbbq$	$bbbq$



Even though MET and SS dileptons are available, the ATLAS lepton + many jets search (essentially without MET) sets the best limit at high masses.

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq$, νbbq	$etbq$, νtbq
	321	$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbqq	τbqq
	323	$\tilde{b}_R$	τbbq, νbbq	τtbq, νtbq
		$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbbq	τbbq
	232	$\tilde{t}_L$	μtbq	μbbq
		$\tilde{b}_L$	νbbq	νtbq
	233	$\tilde{t}_L$	μtbb	μbbb
		$\tilde{b}_L$	νbbb	νtbb
	332	$\tilde{t}_L$	τtbq	τbbq
		$\tilde{b}_L$	νbbq	νtbq
	333	$\tilde{t}_L$	τtbb	τbbb
		$\tilde{b}_L$	νbbb	νtbb
UDD	213	$\tilde{b}_R$	$bbqq$	$tbqq$
	312	$\tilde{t}_R$	$tbqq$	$bbqq$
	323	$\tilde{t}_R$	$tbbq$	$bbbq$

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq$, νbbq	$etbq$, νtbq
	321	$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbqq	τbqq
	323	$\tilde{b}_R$	τbbq, νbbq	τtbq, νtbq
		$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbbq	τbbq
	232	$\tilde{t}_L$	μtbq	μbbq
		$\tilde{b}_L$	νbbq	νtbq
	233	$\tilde{t}_L$	μtbb	μbbb
		$\tilde{b}_L$	νbbb	νtbb
	332	$\tilde{t}_L$	τtbq	τbbq
		$\tilde{b}_L$	νbbq	νtbq
	333	$\tilde{t}_L$	τtbb	τbbb
		$\tilde{b}_L$	νbbb	νtbb
UDD	213	$\tilde{b}_R$	$bbqq$	$tbqq$
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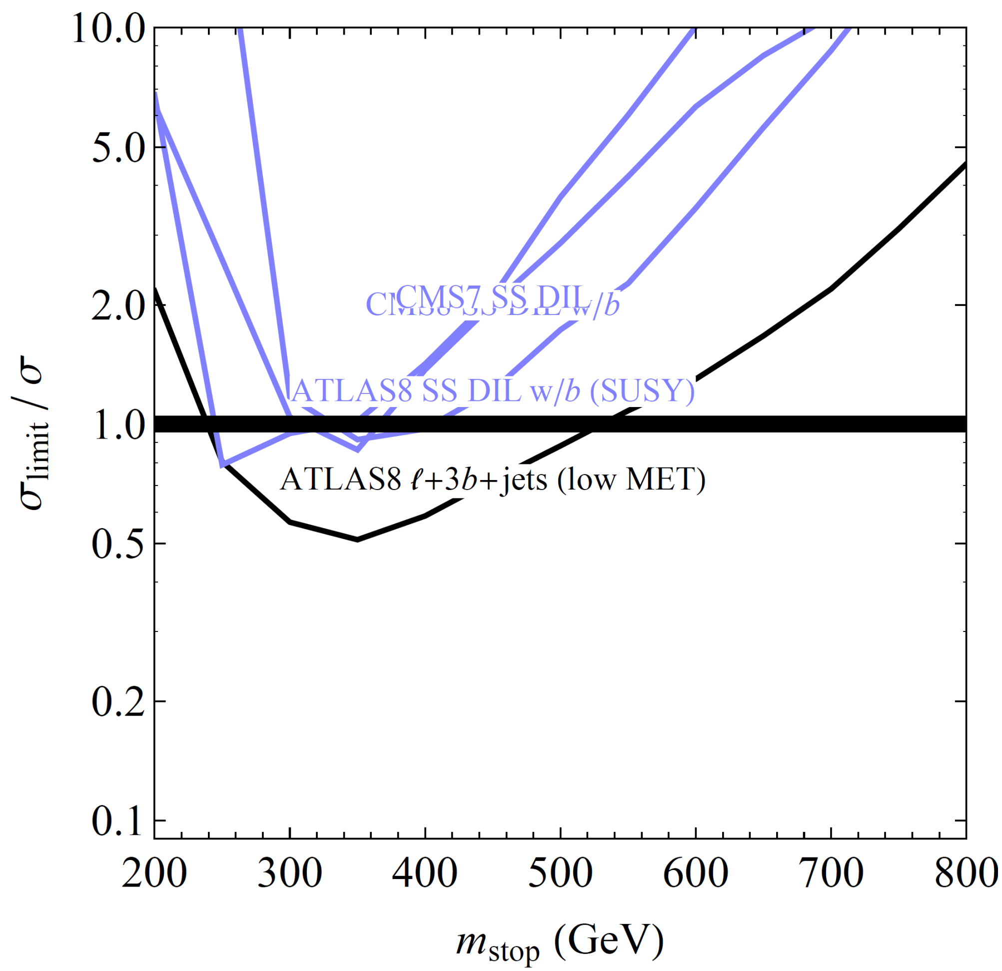

The lepton + many jets search is good also at utilizing leptons from tau decays.

Can it be optimized for lower masses?

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq$, νbbq	$etbq$, νtbq
	321	$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbqq	τbqq
	323	$\tilde{b}_R$	τbbq, νbbq	τtbq, νtbq
		$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbbq	τbbq
	232	$\tilde{t}_L$	μtbq	μbbq
		$\tilde{b}_L$	νbbq	νtbq
	233	$\tilde{t}_L$	μtbb	μbbb
		$\tilde{b}_L$	νbbb	νtbb
	332	$\tilde{t}_L$	τtbq	τbbq
		$\tilde{b}_L$	νbbq	νtbq
	333	$\tilde{t}_L$	τtbb	τbbb
		$\tilde{b}_L$	νbbb	νtbb
UDD	213	$\tilde{b}_R$	$bbqq$	$tbqq$
	312	$\tilde{t}_R$	$tbqq$	$bbqq$
	323	$\tilde{t}_R$	$tbbq$	$bbbq$

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq$, νbbq	$etbq$, νtbq
	321	$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbqq	τbqq
	323	$\tilde{b}_R$	τbbq, νbbq	τtbq, νtbq
		$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbbq	τbbq
	232	$\tilde{t}_L$	μtbq	μbbq
		$\tilde{b}_L$	νbbq	νtbq
	233	$\tilde{t}_L$	μtbb	μbbb
		$\tilde{b}_L$	νbbb	νtbb
	332	$\tilde{t}_L$	τtbq	τbbq
		$\tilde{b}_L$	νbbq	νtbq
	333	$\tilde{t}_L$	τtbb	τbbb
		$\tilde{b}_L$	νbbb	νtbb
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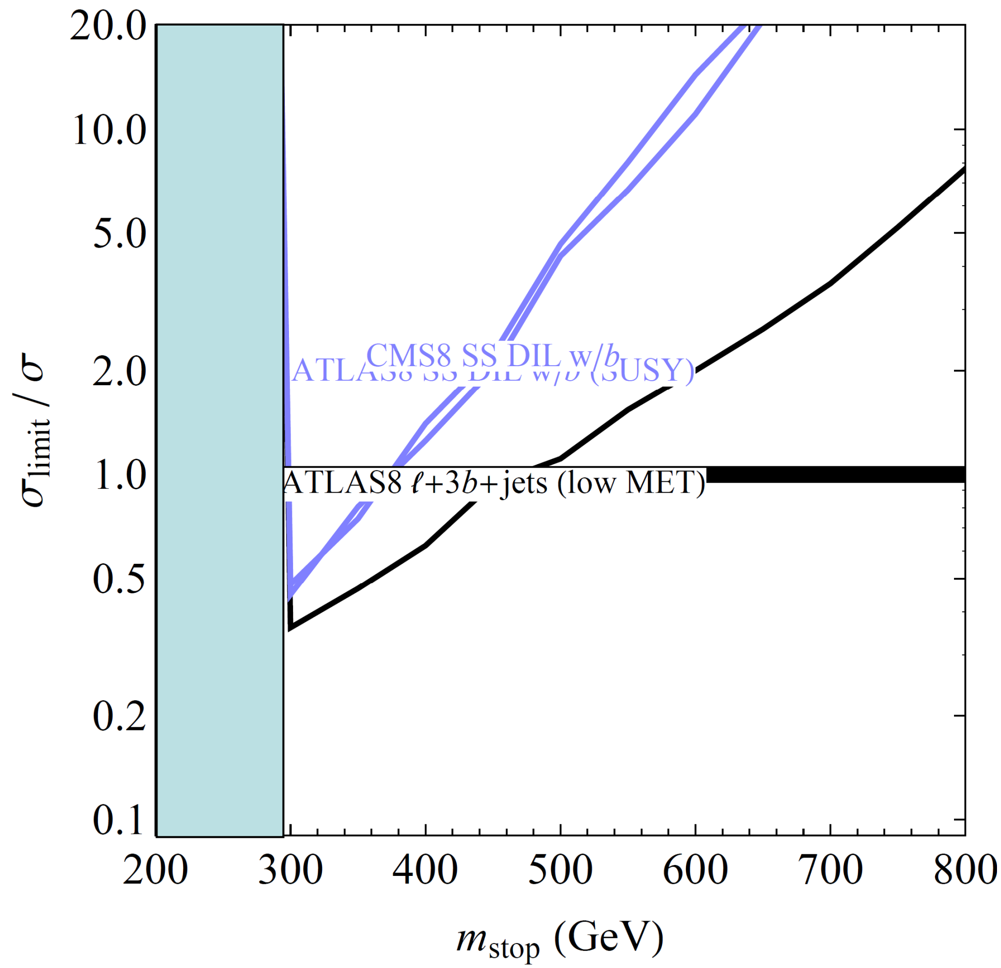
	323	$\tilde{t}_R$	$tbbq$	$bbbq$



Powerful also when leptons are coming from tops.

Could be strengthened by bins with more than 6 jets (since 10 parton-level jets are available).

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq$, νbbq	$etbq$, νtbq
	321	$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbqq	τbqq
	323	$\tilde{b}_R$	τbbq, νbbq	τtbq, νtbq
		$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbbq	τbbq
	232	$\tilde{t}_L$	μtbq	μbbq
		$\tilde{b}_L$	νbbq	νtbq
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Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq$, νbbq	$etbq$, νtbq
	321	$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbqq	τbqq
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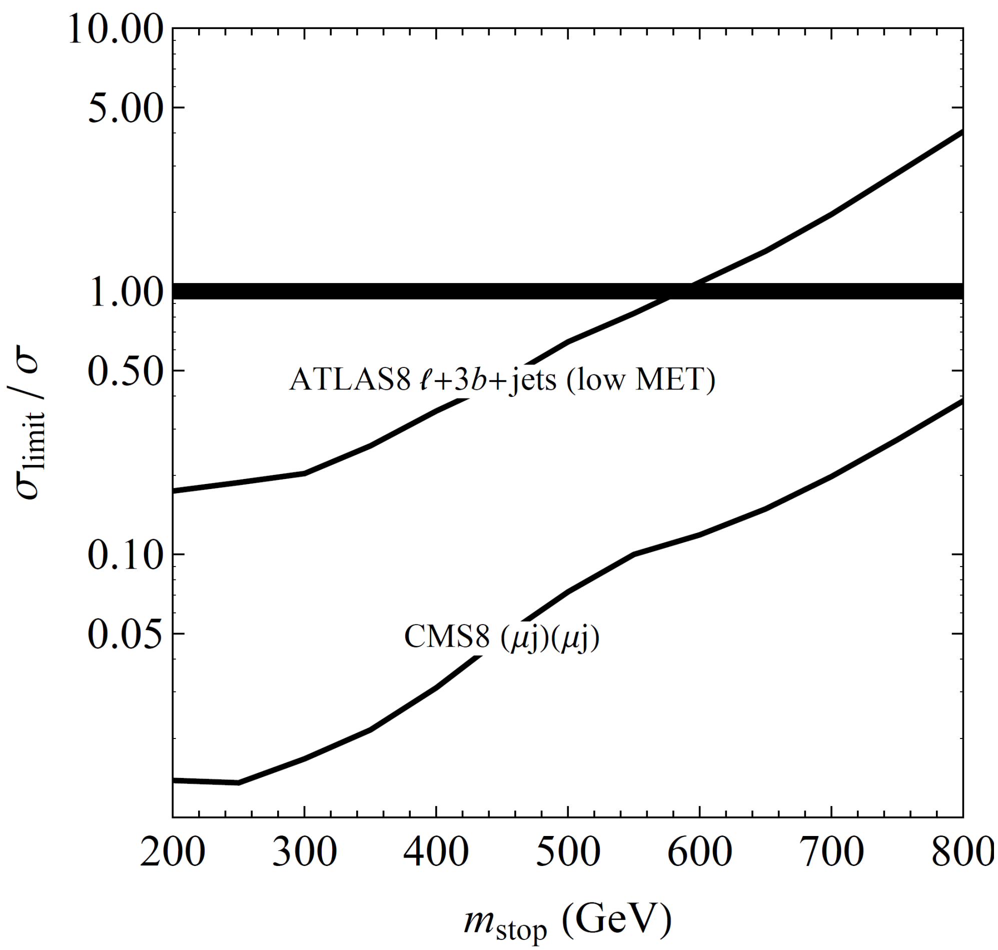

- Lepton + many jets search: effective despite needing to lose the 2nd muon
- Analogous “OS dilepton + many jets” search would be extremely powerful
- Even the LQ search sets very strong limits, despite its 2-body motivation and ignoring the *b* multiplicity

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
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		$\tilde{b}_L$	νbbb	νtbb
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	232	$\tilde{t}_L$ $\tilde{b}_L$	μtbq νbbq	μbbq νtbq
	233	$\tilde{t}_L$ $\tilde{b}_L$	μtbb νbbb	μbbb νtbb
	332	$\tilde{t}_L$ $\tilde{b}_L$	τtbq νbbq	τbbq νtbq
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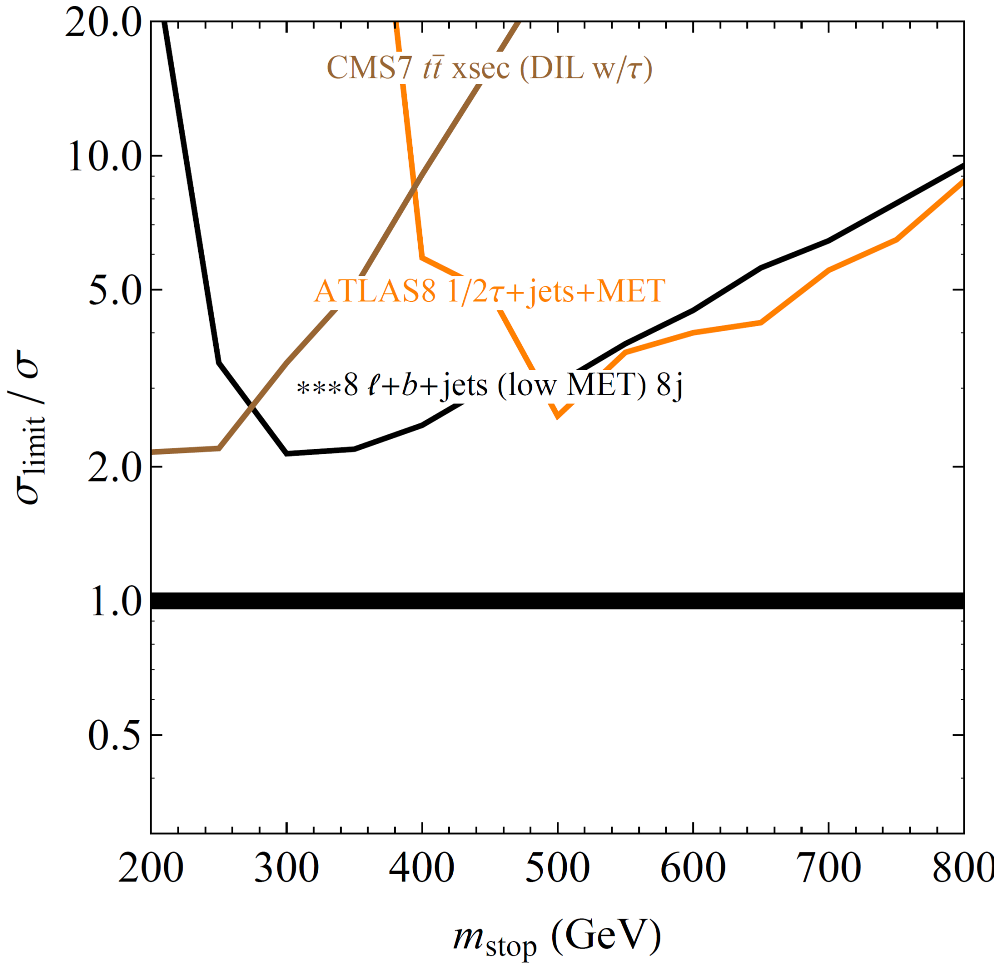

- Our 8 TeV extension of CMS lepton + many jets (single b) is almost sensitive.
  Ideas for a better search:
  - "lepton + τ_h + many jets" analogous to "lepton + many jets"
  - τ_h (+ τ_h/ℓ) + jets + MET, but with b-tagging, lower MET cuts than existing searches
  - Generalization of LQ3 search, $(\tau b)(\tau b)$
- Low masses: $t\bar{t}$ xsec w/ $\ell + \tau_h$ (with only 2/fb at 7 TeV) better than all searches!
  Construct search based on $t\bar{t}$ xsec measurement (use high jet multiplicity)

<table>
<tr><th colspan="3">Scenario</th><th colspan="2">Final state (for each stop)</th></tr>
<tr><th colspan="2">Coupling</th><th>Mediator $\tilde{f}$</th><th>Case 1</th><th>Case 2</th></tr>
<tr><td rowspan="12">LQD</td><td>123</td><td>$\tilde{b}_R$</td><td>$ebbq$, νbbq</td><td>$etbq$, νtbq</td></tr>
<tr><td>321</td><td>$(\tilde{\nu}_\tau, \tilde{\tau})_L$</td><td>$\tau bqq$</td><td>$\tau bqq$</td></tr>
<tr><td rowspan="2">323</td><td>$\tilde{b}_R$</td><td>τbbq, νbbq</td><td>τtbq, νtbq</td></tr>
<tr><td>$(\tilde{\nu}_\tau, \tilde{\tau})_L$</td><td>$\tau bbq$</td><td>$\tau bbq$</td></tr>
<tr><td rowspan="2">232</td><td>$\tilde{t}_L$</td><td>μtbq</td><td>μbbq</td></tr>
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<tr><td>$\tilde{b}_L$</td><td>νbbb</td><td>νtbb</td></tr>
<tr><td rowspan="3">UDD</td><td>213</td><td>$\tilde{b}_R$</td><td>$bbqq$</td><td>$tbqq$</td></tr>
<tr><td>312</td><td>$\tilde{t}_R$</td><td>$tbqq$</td><td>$bbqq$</td></tr>
<tr><td>323</td><td>$\tilde{t}_R$</td><td>$tbbq$</td><td>$bbbq$</td></tr>
</table>

Scenario			Final state (for each stop)	
Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq$, νbbq	$etbq$, νtbq
	321	$(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbqq	τbqq
	323	$\tilde{b}_R$ $(\tilde{\nu}_\tau, \tilde{\tau})_L$	τbbq, νbbq τbbq	τtbq, νtbq τbbq
	232	$\tilde{t}_L$ $\tilde{b}_L$	μtbq νbbq	μbbq νtbq
	233	$\tilde{t}_L$ $\tilde{b}_L$	μtbb νbbb	μbbb νtbb
	332	$\tilde{t}_L$ $\tilde{b}_L$	τtbq νbbq	τbbq νtbq
	333	$\tilde{t}_L$ $\tilde{b}_L$	τtbb νbbb	τbbb νtbb
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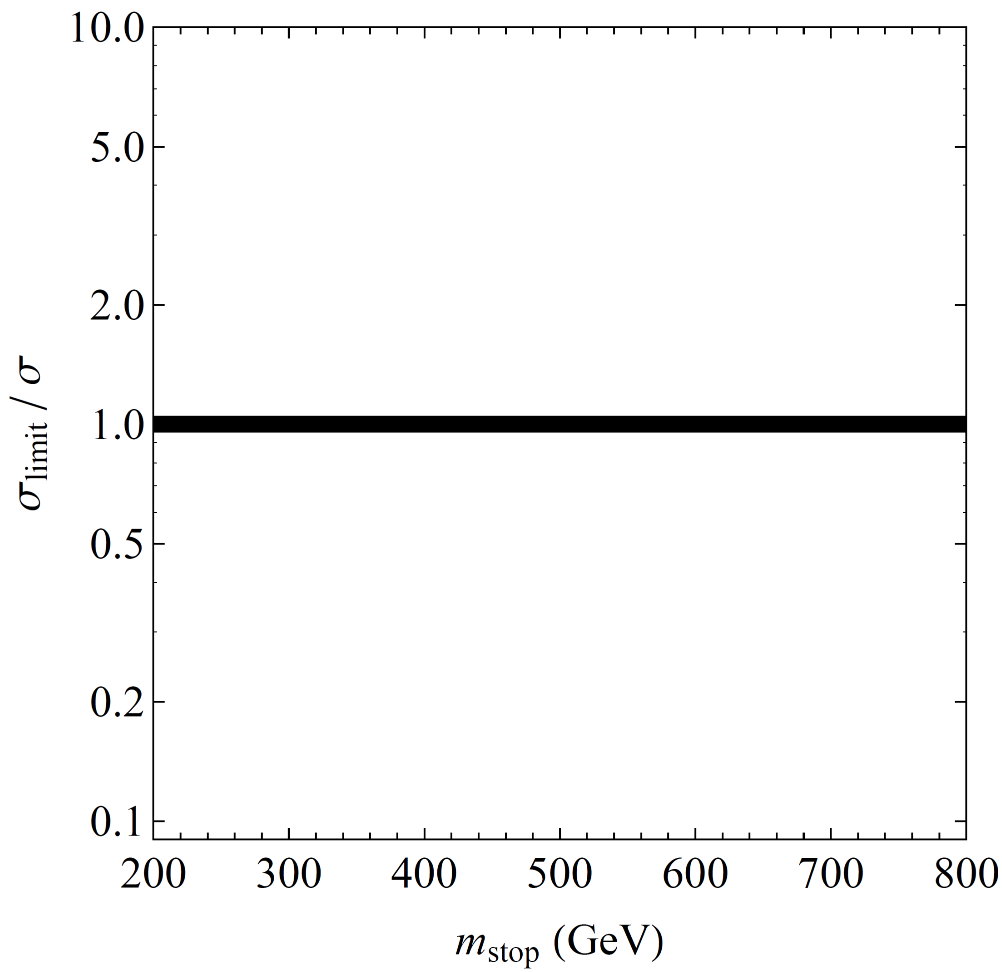
	312	$\tilde{t}_R$	$tbqq$	$bbqq$
	323	$\tilde{t}_R$	$tbbq$	$bbbq$



- No relevant searches exist
- At least the 6 b-jet case likely has low background
- Resonant structures are present

Conclusions

Lepton(s) + many jets (low MET) – relevant to a large, diverse set of scenarios

Promising searches: (also the gluino scenarios not included in this talk)

- Lepton + many jets
- OS dilepton + many jets
  (~ generalization of LQ searches)
- Lepton + hadronic tau + many jets

}{

- Jet multiplicities up to ~10
- Low and high *b*-jet multiplicities
- S_T: from as low as possible
  to as high as the data goes

See also *Lisanti, Schuster, Strassler, Toro:* arXiv:1107.5055 [JHEP 1211 (2012) 081]

Multijet

- Very few searches exist
- Can use high jet and *b*-jet multiplicities, resonant structures, ...
- Some of the scenarios addressed by lepton + many jets might get even stronger limits from appropriate multijet searches

New physics in the $t\bar{t}$ sample – relevant to several scenarios at low masses

Useful handles:
- Extra jets
- Extra *b*-jets
- Violation of lepton flavor universality (e.g., excess in taus only)

For reinterpretations by theorists

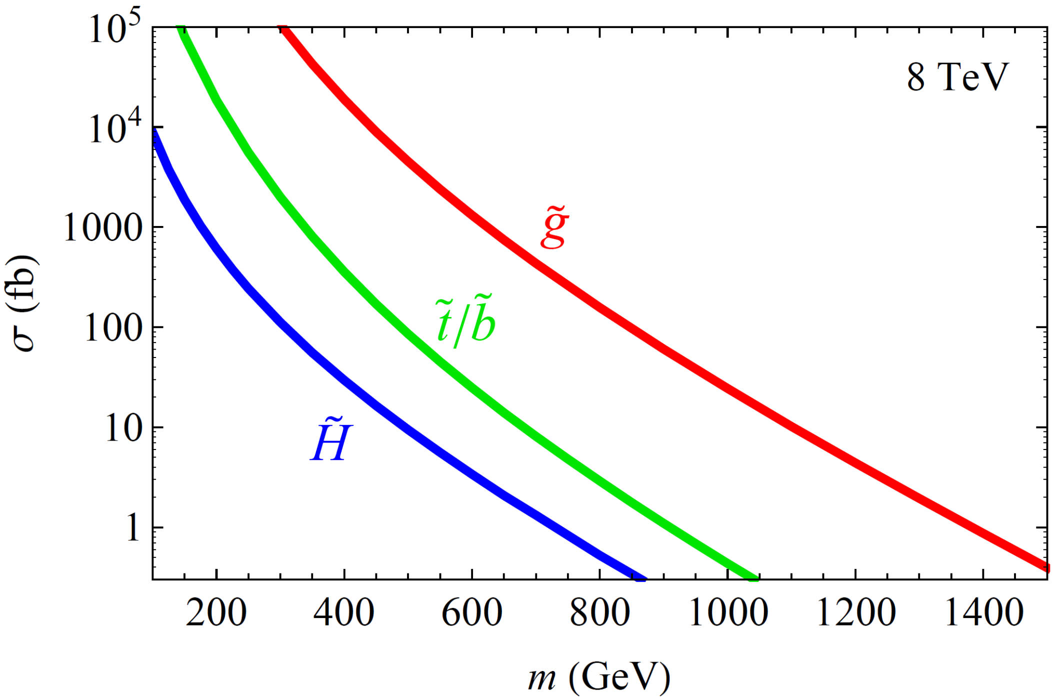
Include simple cut-and-count bins with measured event yields, expected background and systematic uncertainty.

Backup slides

Superpartner spectrum considerations

EW scale without fine tuning:

- Higgsinos: below ~ 200 GeV
- RH & LH stops, LH sbottom: below ~ 500 GeV
- Gluino: below ~ 1000 GeV (unless it's a Dirac gluino, beyond MSSM)



Dominant production process depends on the masses.

Other superpartners can also be around and mediate decays.

Higgsino production (w/Jared Evans)
to be released soon

Very interesting, but no time today

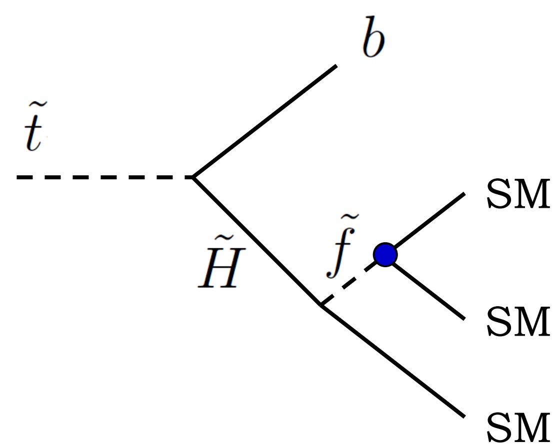
Stop production (w/Jared Evans)
arXiv:1209.0764 [JHEP 1304 (2013) 028]
now updated with 8 TeV searches ← **Today's talk**

Gluino production (w/Jared Evans, David Shih, Matt Strassler) – to be released soon

Simplified models

Scenario			Final state (for each stop)	
● Coupling		Mediator $\tilde{f}$	Case 1	Case 2
LQD	123	$\tilde{b}_R$	$ebbq,\ \nu bbq$	$etbq,\ \nu tbq$
	321	$(\tilde{\nu}_\tau,\ \tilde{\tau})_L$	τbqq	τbqq
	323	$\tilde{b}_R$	$\tau bbq,\ \nu bbq$	$\tau tbq,\ \nu tbq$
		$(\tilde{\nu}_\tau,\ \tilde{\tau})_L$	τbbq	τbbq
	232	$\tilde{t}_L$	μtbq	μbbq
		$\tilde{b}_L$	νbbq	νtbq
	233	$\tilde{t}_L$	μtbb	μbbb
		$\tilde{b}_L$	νbbb	νtbb
	332	$\tilde{t}_L$	τtbq	τbbq
		$\tilde{b}_L$	νbbq	νtbq
	333	$\tilde{t}_L$	τtbb	τbbb
		$\tilde{b}_L$	νbbb	νtbb
UDD	213	$\tilde{b}_R$	$bbqq$	$tbqq$
	312	$\tilde{t}_R$	$tbqq$	$bbqq$
	323	$\tilde{t}_R$	$tbbq$	$bbbq$

EXAMPLE



Case 1:

$$\tilde{H}^+ \rightarrow W^{+*}\,\tilde{H}_1^0$$

$$\tilde{H}_1^0 \rightarrow \text{RPV}$$

Stop and antistop can give same-sign leptons

Case 2:

$$\tilde{H}^+ \rightarrow \text{RPV}$$

Simulation and limit setting

- Detector simulation (incl. FastJet), with:
  - Lepton ID eff. (per search)
  - Lepton isolation (per search)
  - Jet energy resolution
  - *b*-tagging (per search)
  - and more…
- Cuts of ATLAS and CMS searches from the table
- Validation on examples from ATLAS and CMS papers: typically agree within ~30% (sometimes a factor of ~2)
- Efficiency threshold ~ 10^{-3} (instead of including systematic uncertainty for the signal tails)

  Typically has an effect for very low masses.
- Use backgrounds (and uncertainties) from the collaborations to derive limits. Search region with the best limit is used.