LEPTOQUARK SEARCHES AT THE LHC

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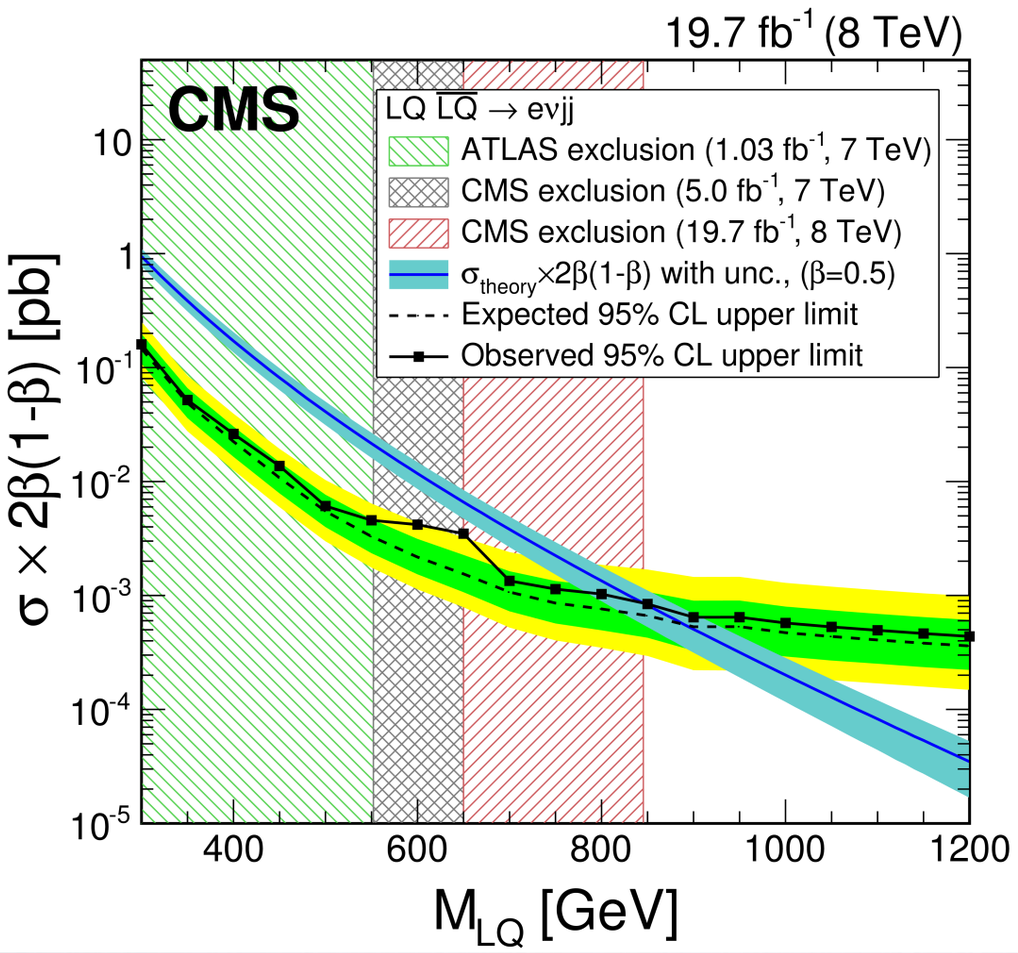
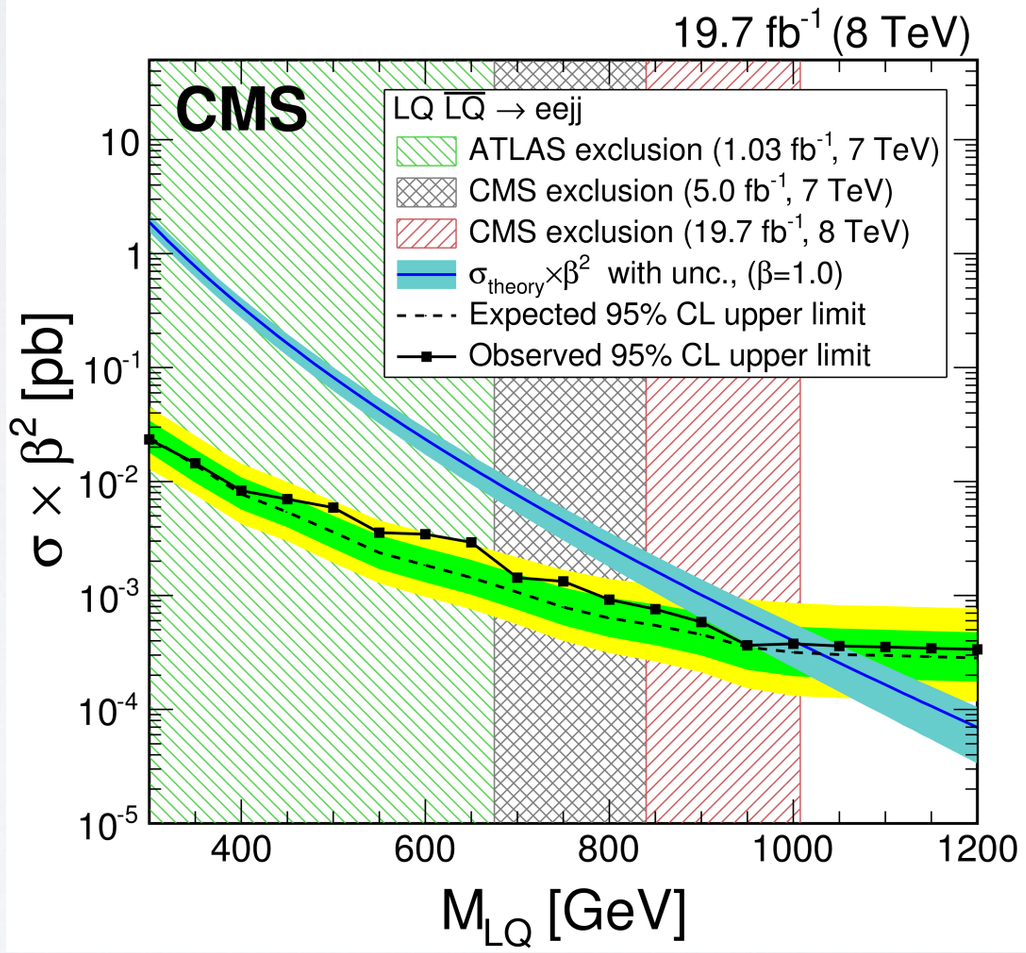
WHY LEPTOQUARKS?

- Consequence of many well-motivated SM extensions: Grand Unification, R-parity violation
- Some varieties can alleviate fine-tuning @ LHC
- Interesting and unique phenomenology to set as a benchmark for future searches

LEPTOQUARK EXCITEMENT!





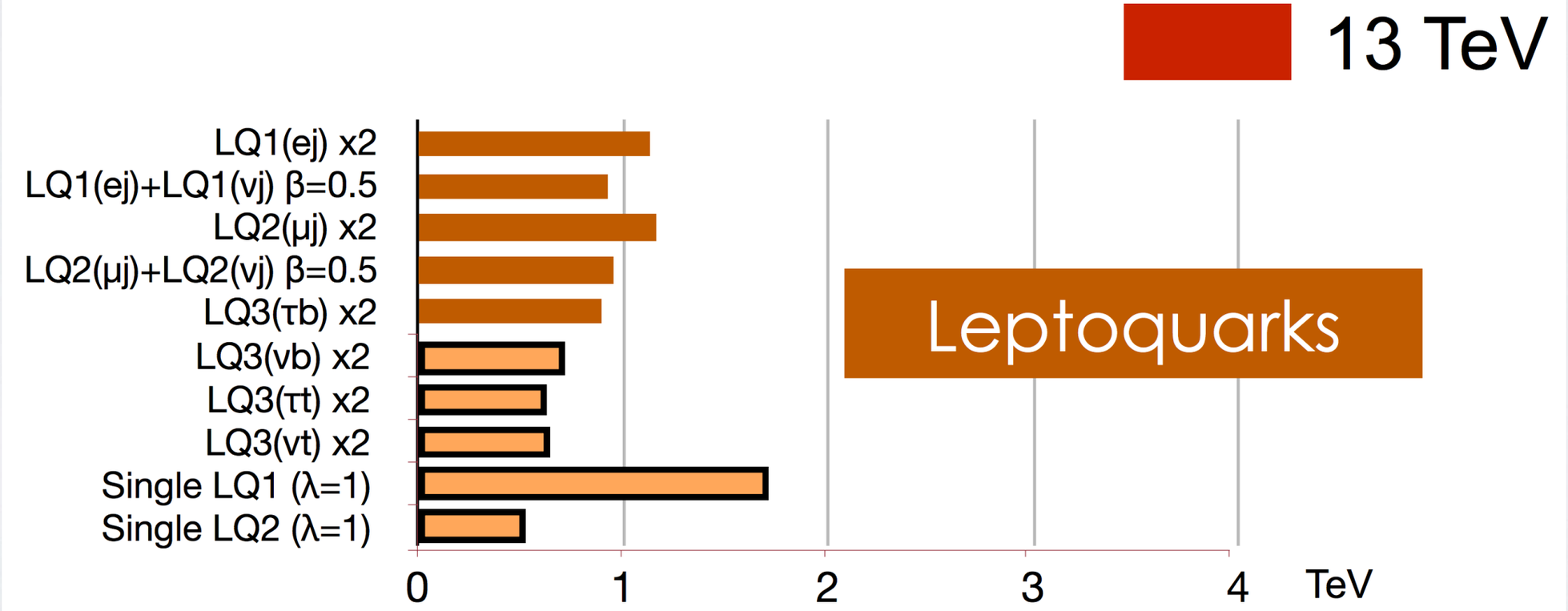
CMS-PAS-EXO-12-041

CURRENT STATUS

Based on 2015 data!

LQ	Scalar LQ 1st gen	2 e	≥ 2 j	–	3.2	LQ mass	1.1 TeV	$\beta = 1$	1605.06035
	Scalar LQ 2nd gen	2 μ	≥ 2 j	–	3.2	LQ mass	1.05 TeV	$\beta = 1$	1605.06035
	Scalar LQ 3rd gen	1 e, μ	≥1 b, ≥3 j	Yes	20.3	LQ mass	640 GeV	$\beta = 0$	1508.04735

ATLAS Exotics



CMS Exotica

NON-SUSY MODELS

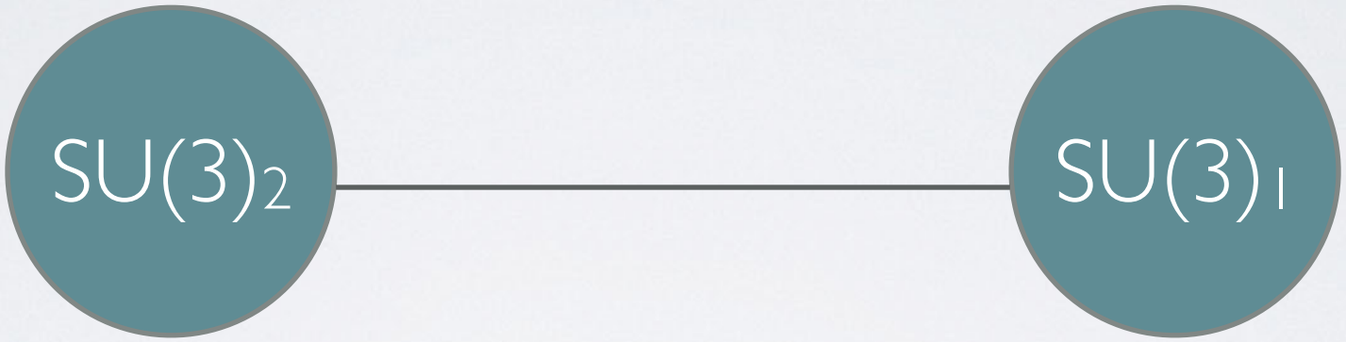
- Leptoquarks must be charged under QCD: minimal production mechanism

- Single leptoquark production possible, but constrained by other BLV tests

- More states means other production modes: coloron + leptoquark model

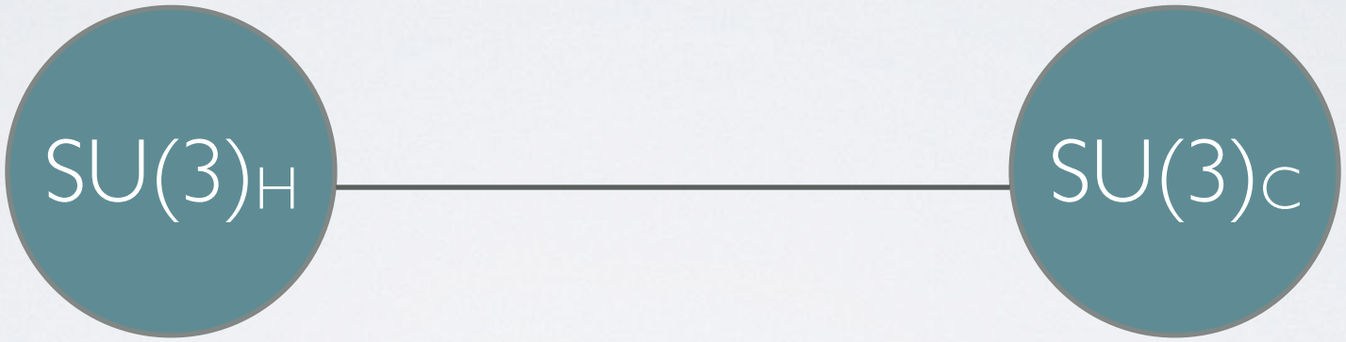
Bai, JB: 1407.4466

HIGH ENERGY STRUCTURE



G_2	G_1
h_2	h_1
S_1	q_i

LOW ENERGY STRUCTURE



$G' = -s_\theta G_1 + c_\theta G_2$

$g_s\ t_\theta\ (1),\ g_s/t_\theta\ (2)$

$g_s'(q_i)/g_s'(S_1) \sim t_\theta$

$G = c_\theta G_1 + s_\theta G_2$

g_s

No GGG'

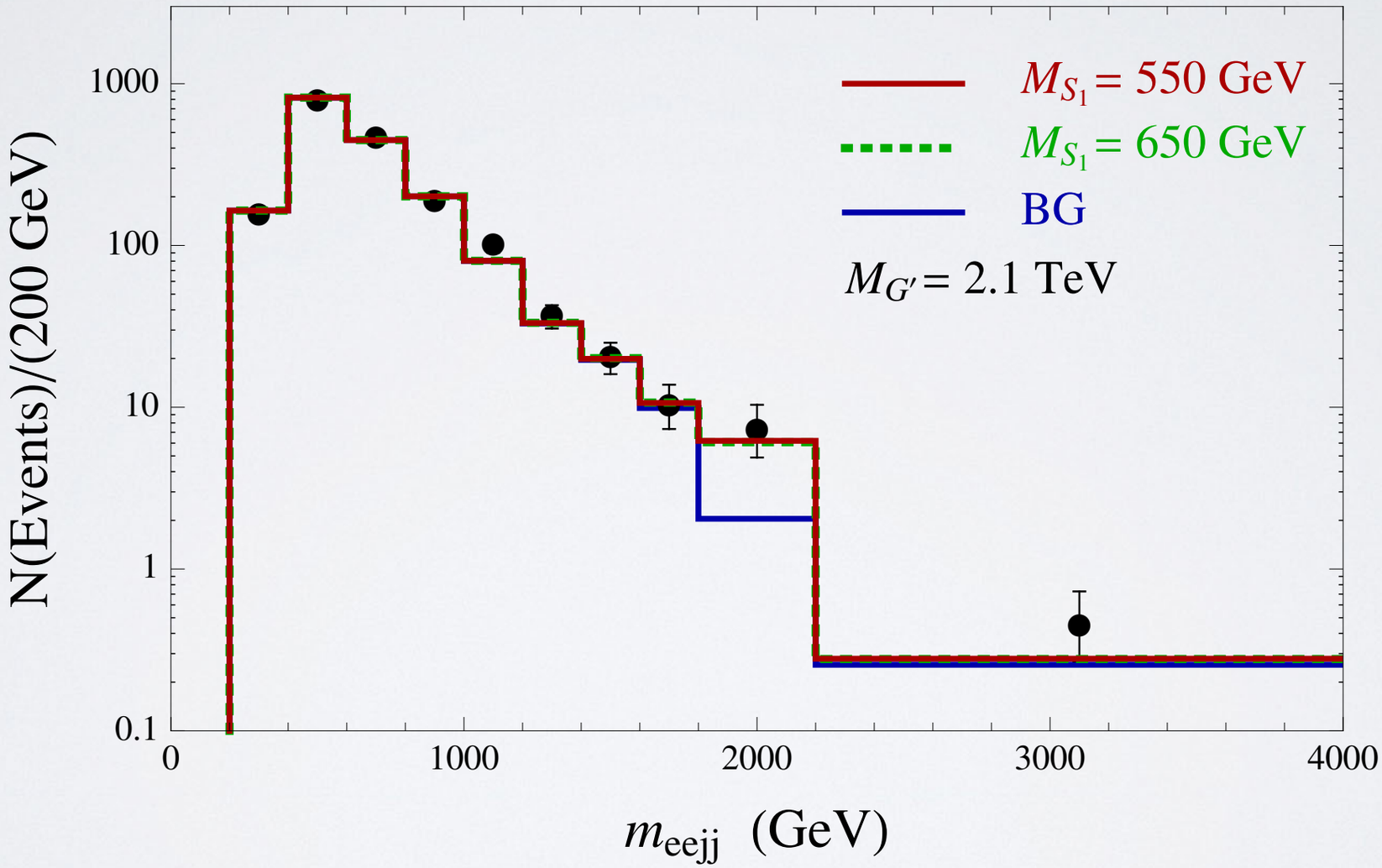
NEW PHENOMENOLOGY

- "Normal" leptoquark production at the LHC is still possible in this structure

- But color octet, spin 1 particle resonant production could be comparable or dominant

- Octet decaying to leptoquarks could yield a new type of signal with multibody final state

EXAMPLE SPECTRUM



LEPTONS + QUARKS IN SUSY

- Strong hints and constraints from data
- Suppress SSDL signals → Dirac gauginos?
- 125 GeV Higgs → non-MSSM Higgs sector?
- All this and more: Higgs as sneutrino

Riva, Biggio, Pomarol: 1211.4526
JB, Dror, Ng: 1506.08213

HIGGS AS SNEUTRINO

	SU(3)	U(1)
H	(1,2)	0
E	(1,1)	2
L	(1,2)	1-L
E	(1,1)	1+L
Q	(3,2)	1+B
U	(	1-B
D	(	1-B
W	(8,1)	1
Φ	(8,1)	0

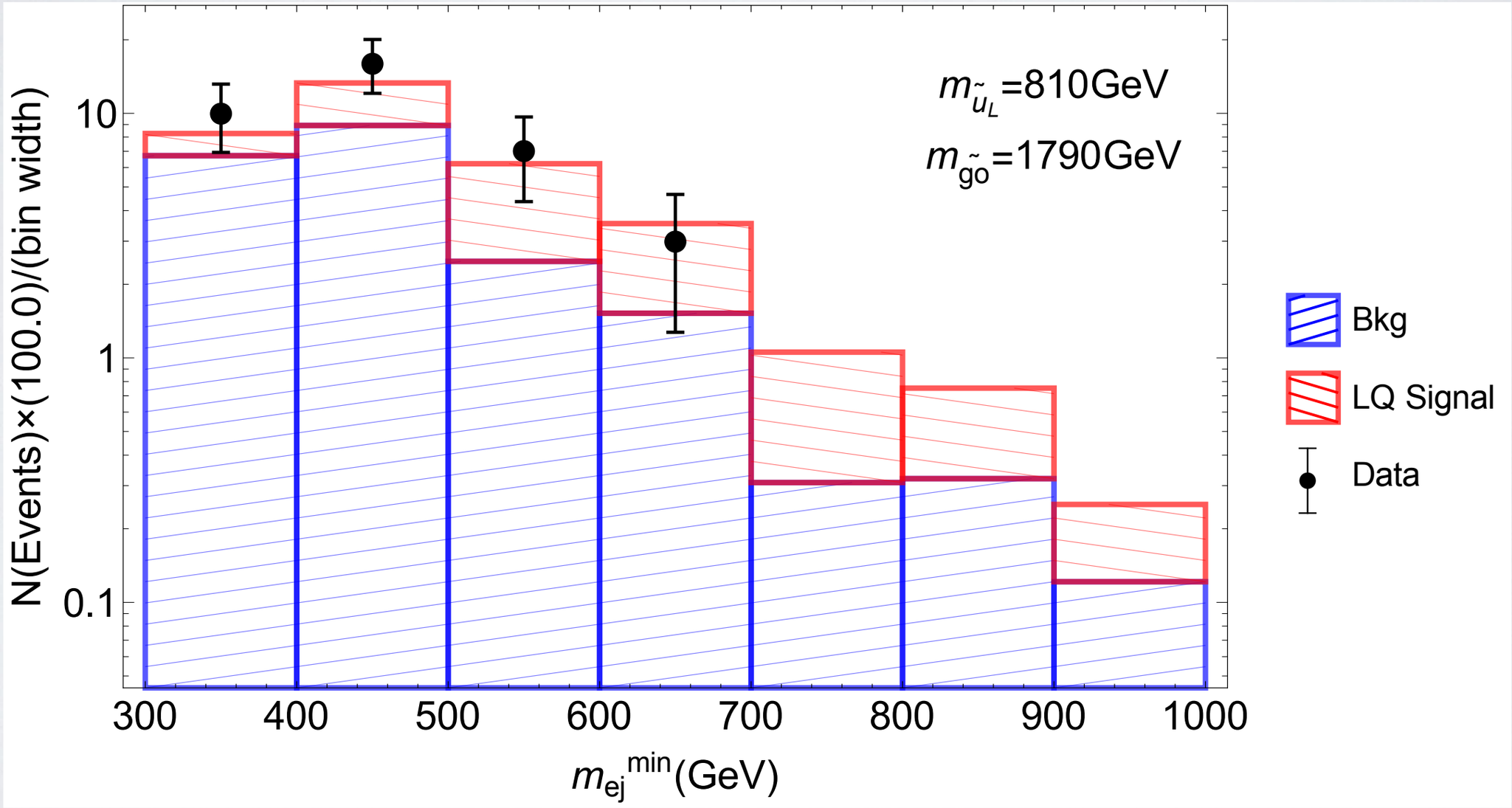
MODEL FEATURES

- R-parity conserved even after EWSB
- Neutrino is a neutralino, electron is a chargino
- Heavier neutralinos unstable due to mixing with neutrino: no MET and no DM candidate
- Squarks can decay via on- or off-shell $\tilde{B}$ & $\tilde{W}$

RICH PHENOMENOLOGY

- Production of $\tilde{q}\tilde{q}$, $\tilde{q}\tilde{g}$, $\tilde{g}\tilde{g}$
- Leptoquark-like decay for lightest squark:
  $\tilde{q} \rightarrow q \ell V/H$
- Final states with leptons, jets, not too much MET
- Kinematic features at multiple scales

BROAD BUMP SIGNAL



OTHER DECAY MODES?

- Can decay to diquark final state (qq or tb for e.g.): constrained by flavor and proton decay

- Can decay to quarks + dark matter (q**XX**): constrained by q + MET

- More complicated chain decay also possible and could be well hidden

LESSONS FROM OLD SIGNAL

- Additional production modes possible, can alter kinematics

- Additional decay modes possible, so don't just push up in energy, also push down in cross-section

- Non-trivial flavor structure difficult, but possible (and may have natural SUSY as a bonus)

WHAT'S LEFT?

- Push higher in mass, obviously: still waiting on 2016 data analysis for leptoquarks!

- But also push lower in branching fraction: leptoquark-like decay may not be dominant!

- Precision tests are also sensitive—could be related to the various flavor anomalies?