

Title: Coloron-assisted Leptoquarks at the LHC

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URL: <http://pirsa.org/14080042>

Abstract: Recent searches for a first-generation leptoquark by the CMS collaboration have shown around 2.5 sigma deviations from Standard Model predictions in both the $eejj$ and $e\nu jj$ channels. Furthermore, the $eejj$ invariant mass distribution has another 2.8 sigma excess from the CMS right-handed W plus heavy neutrino search. We point out that additional leptoquark production from a heavy coloron decay can provide a good explanation for all three excesses. The coloron has a mass around 2.1 TeV and the leptoquark mass can vary from 550 GeV to 650 GeV. A key prediction of this model is an edge in the total m_T distribution of $e\nu jj$ events at around 2.1 TeV.

Coloron-assisted Leptoquarks

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The Latest from CMS

CMS excesses in 3 searches:

1. Pair-produced leptoquarks to $(ej)(ej)$
2. Pair produced leptoquarks to $(ej)(\nu j)$
3. W_R resonance to $eejj$

$$m_{LQ} \sim 650 \text{ GeV} \quad m_{eejj} \sim 2.1 \text{ TeV}$$

Nothing in analogous μ or τ channels

The Leptoquark Search: Overall Structure

- ▶ Apply basic pre-selection:

FS selection, isolation, $S_T > 300$ GeV, μ **veto**

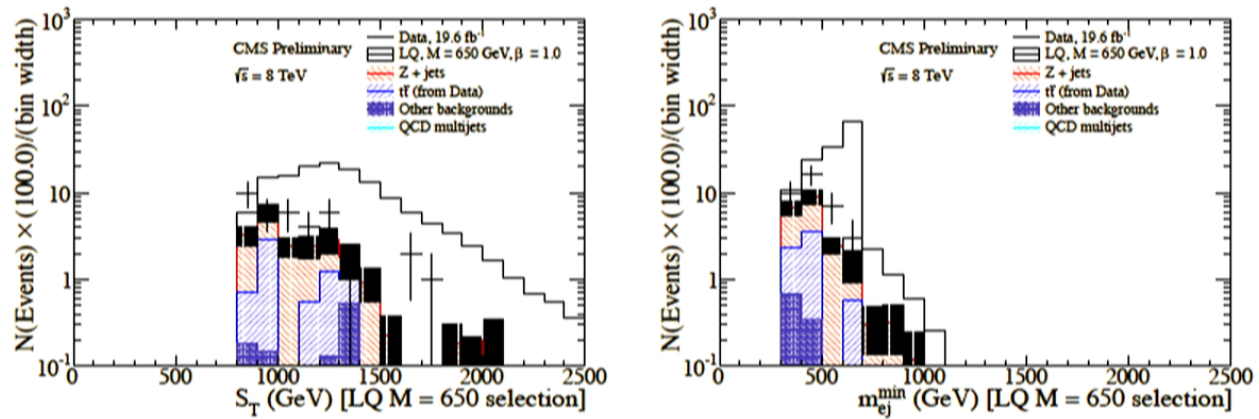
- ▶ Optimize cuts by LQ mass in 50 GeV steps

$eejj$	S_T	m_{ee}	m_{ej}^{\min}	
$e\nu jj$	S_T	E_T^{miss}	m_{ej}	$m_{T,e\nu}$

- ▶ Cut & Count
- ▶ Lower m_{LQ} bin contains all higher bins

$eejj$ Data: Bin Example

Optimized for $m_{LQ} = 650$ GeV



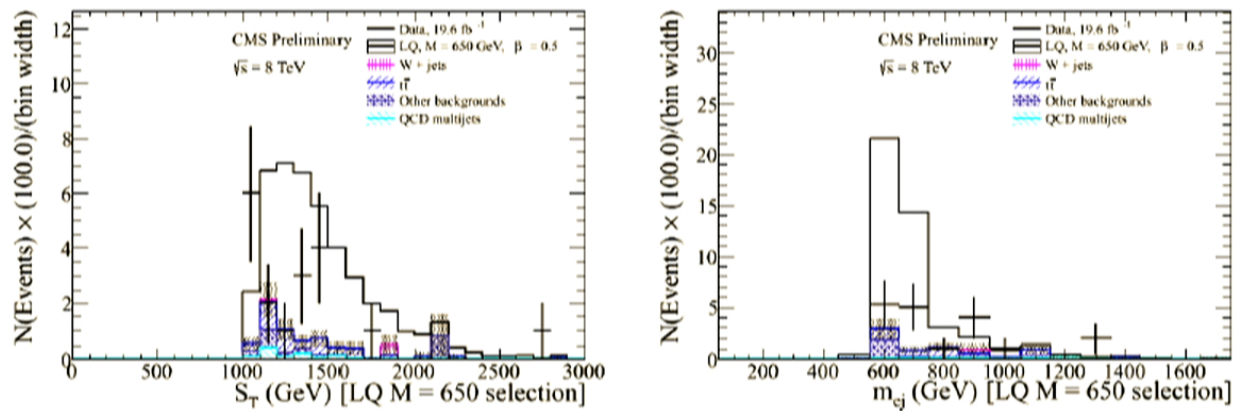
S_T	m_{ee}	m_{ej}
850 GeV	155 GeV	360 GeV

eejj Data: Final Results

m_{LQ}	Data	Bkg.	Stat.	Syt.	Sig.
500	148	121.61	5.96	6.03	1.8
600	57	39.66	3.35	2.42	2.1
650	36	20.49	2.14	2.45	2.4
750	12	6.53	1.13	1.09	1.6
800	7	4.06	0.90	0.89	1.1

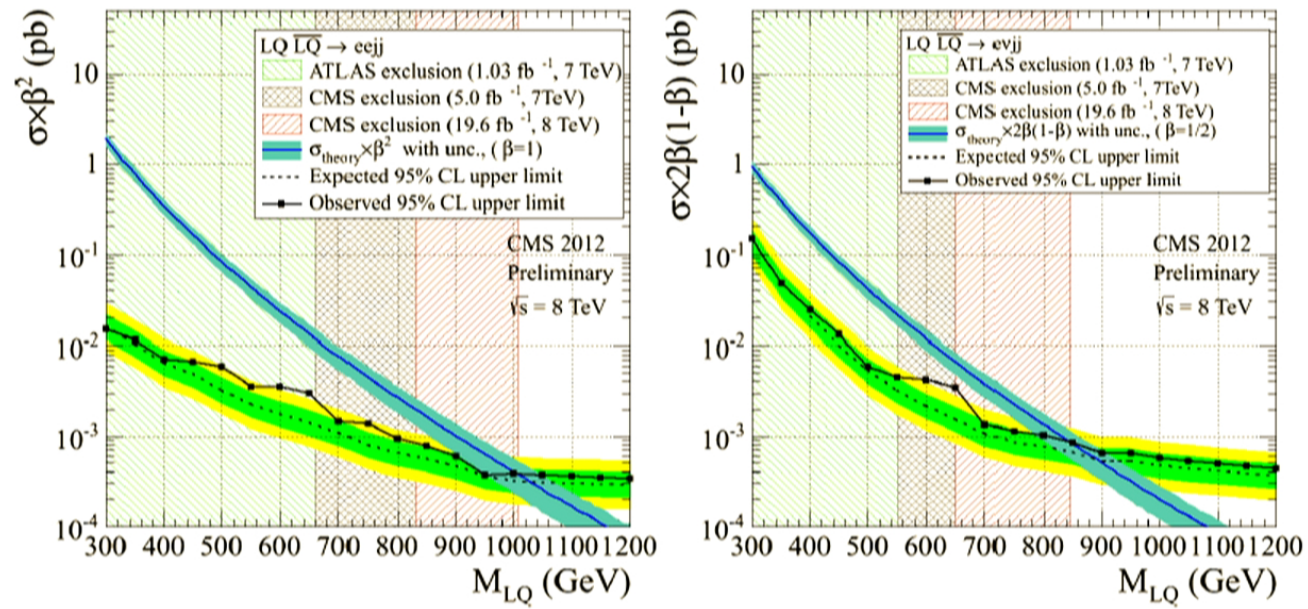
$e\nu jj$ Data: Bin Example

Optimized for $m_{LQ} = 650$ GeV



S_T	E_T^{miss}	m_{ej}	$m_{T,e\nu}$
1040 GeV	145 GeV	555 GeV	270 GeV

Leptoquark Comparison in Brazil Plots



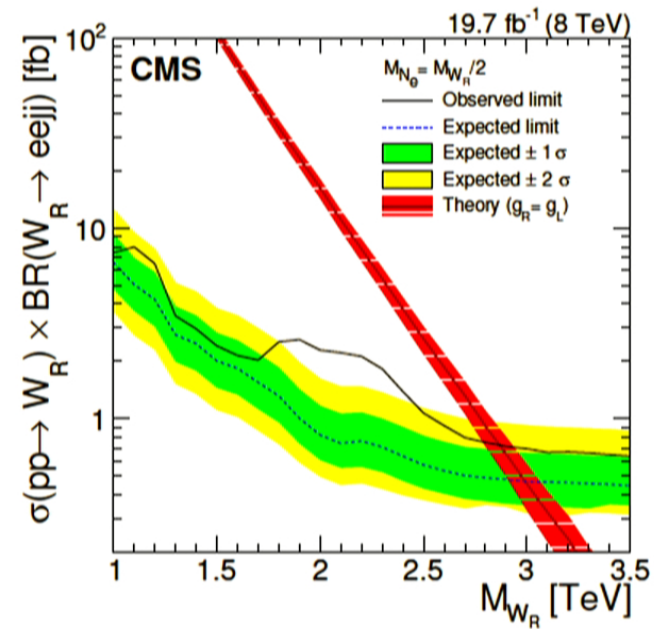
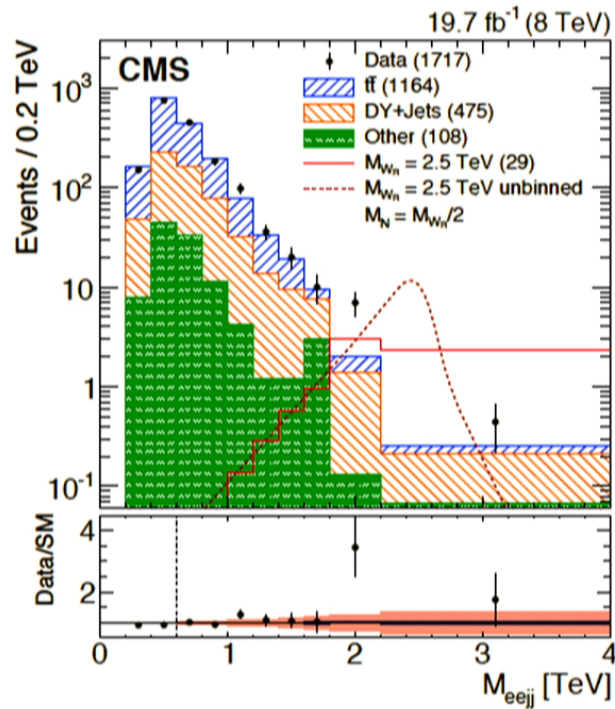
W_R Data: Overall Structure

- ▶ Apply basic pre-selection:
FS selection, isolation, $m_{ee} > 200$ GeV
- ▶ Use multibin CL_s on m_{eejj} distribution
- ▶ NOT Cut & Count
- ▶ (Slightly) different selection requirements

W_R Data: Overall Structure

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- ▶ Use multibin CL_s on m_{eejj} distribution
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W_R Data: The Money Plots



Data Recap

Assuming all results hold \sim steady:

- ▶ Two new states:
 - ▶ $eejj$ resonance @ 2.1 TeV w/ $\sigma \times \text{Br} \sim 1$ fb
 - ▶ $ej/\nu j$ resonance @ 650 GeV w/ $\sigma \times \text{Br} \sim 1.5$ fb
- ▶ $\text{Br}(ej) : \text{Br}(\nu j) \approx 1 : 1$
- ▶ $\text{Br}(ej) + \text{Br}(\nu j) \sim 0.2 \ll 1$
- ▶ QCD-produced 650 GeV LQ has $\sigma = 13.2$ fb

Coloron + Leptoquark Model

- ▶ Coloron G' @ 2.1 TeV, LQ S_1 @ 550 – 650 GeV
- ▶ Both resonant coloron and QCD production contribute
- ▶ Pro: Handily fits the data
- ▶ Con?: LQ has other decay modes

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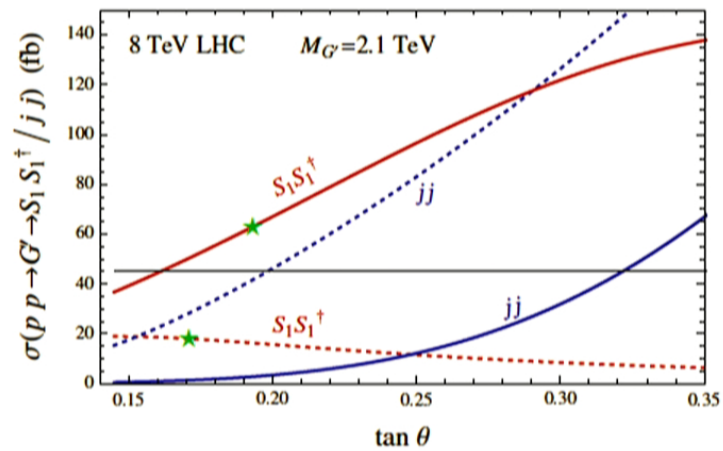
Coloron Production & Decay

$$\Gamma(G' \rightarrow jj) = \frac{5\alpha_s}{6} t_\theta^2 M_{G'}$$

$$\Gamma(G' \rightarrow t\bar{t}) = \frac{\alpha_s}{6} t_\theta^2 M_{G'} \left[1 + \mathcal{O}\left(\frac{m_t^2}{M_{G'}}\right) \right]$$

$$\Gamma(G' \rightarrow S_1 S_1^\dagger) = \frac{g_{S_1}^2 \alpha_s}{24} M_{G'} \left(1 - \frac{4M_{S_1}^2}{M_{G'}^2} \right)^{3/2}$$

$$\sigma(pp \rightarrow G') \approx 1780 \times t_\theta^2 \text{ fb}$$



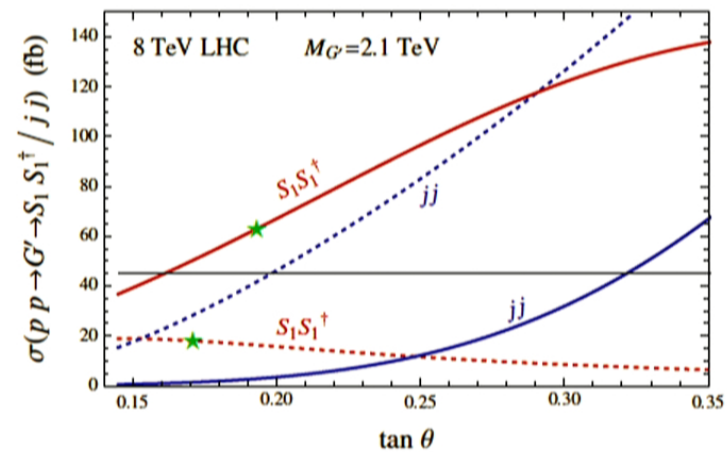
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Signal Acceptance from MC

$$m_{G'} = 2.1 \text{ TeV}$$

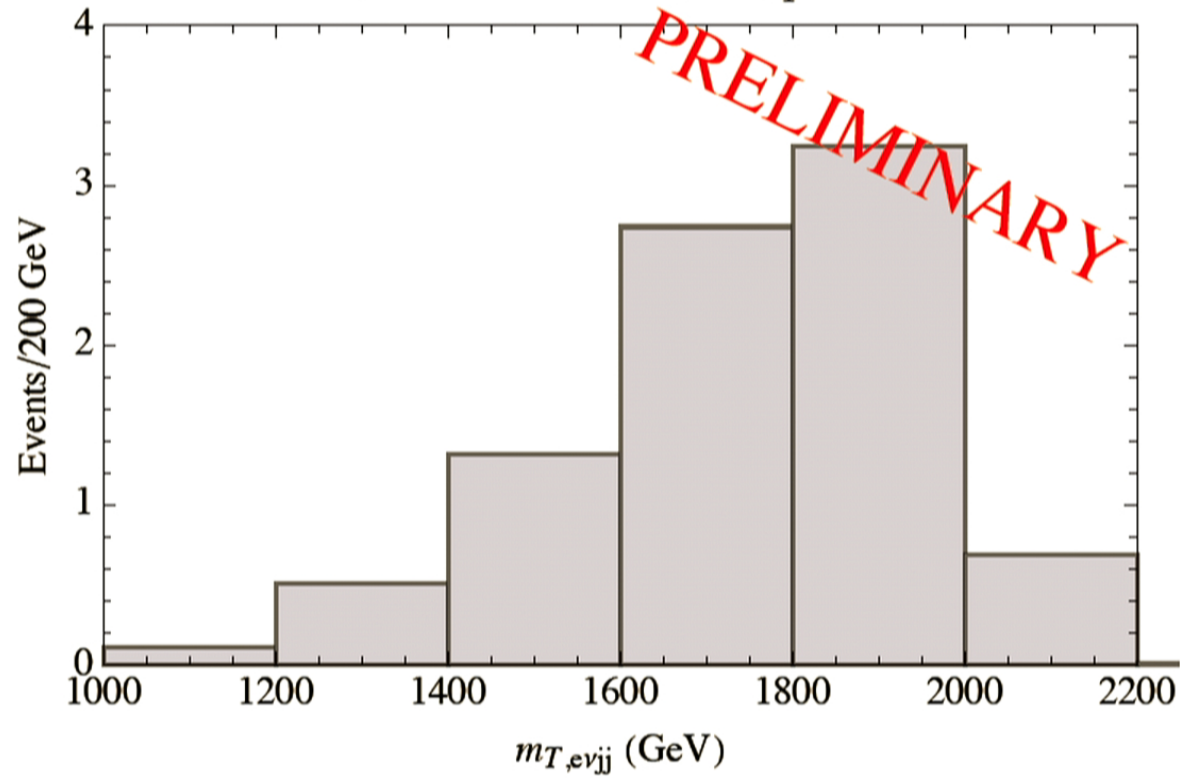
LQ Mass	Production	LQ $eejj$	LQ $\nu e jj$	$W_R + N_e$
550 GeV	QCD	0.45	0.08	0.04
	G'	0.60	0.18	0.55
650 GeV	QCD	0.49	0.29	0.08
	G'	0.64	0.45	0.58

Now I Look Into My Crystal Ball...



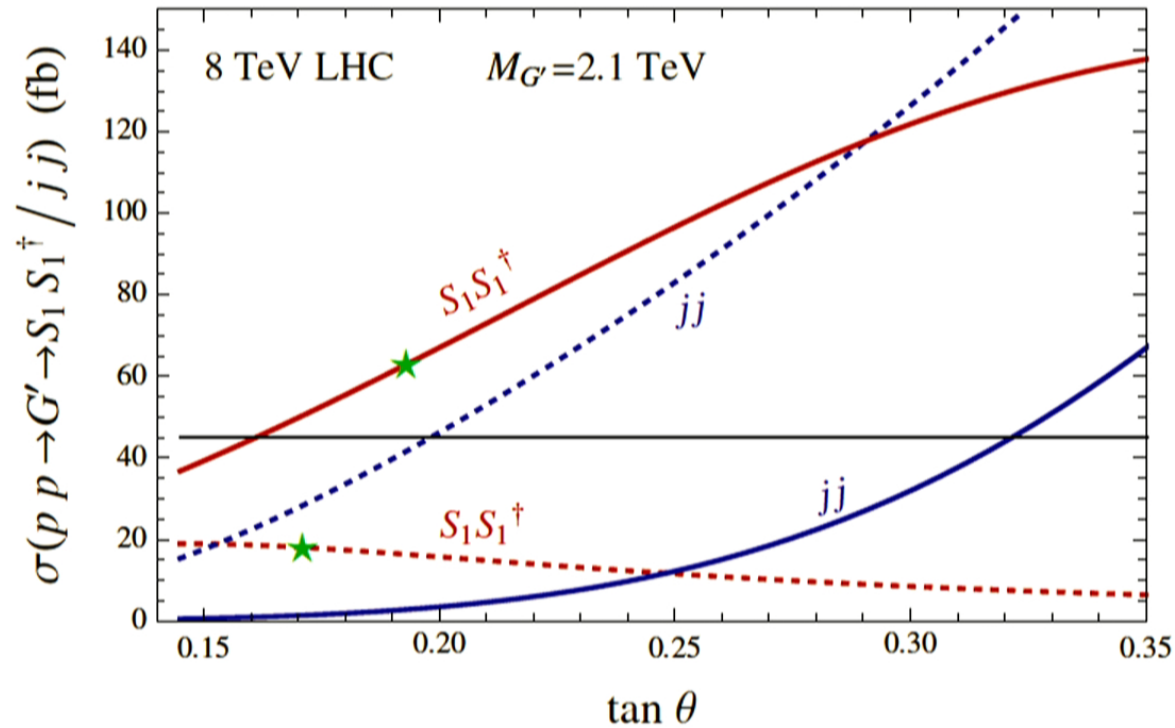
Prediction 1: Bump in m_{evjj} @ 2.1 TeV

Best fit $m_{G'}$ = 2.1 TeV, m_{S_1} = 650 GeV



Prediction 3: $jj/t\bar{t}$ Resonance @ 2.1 TeV

$$\sigma \times \text{Br} \approx 1 - 20 \text{ fb}$$



The Elephant in the Room



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- ▶ ~~μj~~ not observed
- ▶ τj ? – bizarre flavor structure, so... maybe
- ▶ ~~jj~~ proton decay \rightarrow displaced vertices
- ▶ $j\chi\chi$ – works if χ heavy-ish
- ▶ Any case: jets + ℓ and/or MET

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Future directions: Other Topologies

$m_{G'} = 2.1 \text{ TeV}$, $m_{S_1} = 550 \text{ GeV}$ vs. $m_{W_R} = 2.1 \text{ TeV}$, $m_{N_e} = 1.05 \text{ TeV}$

