Title: Coloron-assisted Leptoquarks at the LHC

Date: Aug 29, 2014 01:00 PM

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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August 29, 2014

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 $eejj$

$m_{LQ} \sim 650$ GeV $\qquad$ $m_{eejj} \sim 2.1$ 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**

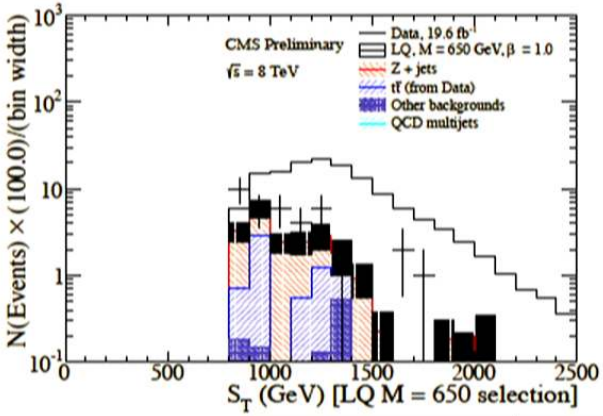
- Optimize cuts by LQ mass in 50 GeV steps

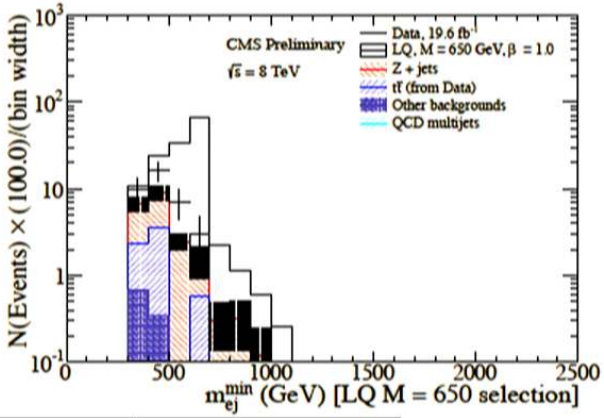
$eejj$	S_T	m_{ee}	$m_{ej}^{\min}$	
$e\nu jj$	S_T	E_T^{miss}	m_{ej}	$m_{T,e\nu}$

- 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

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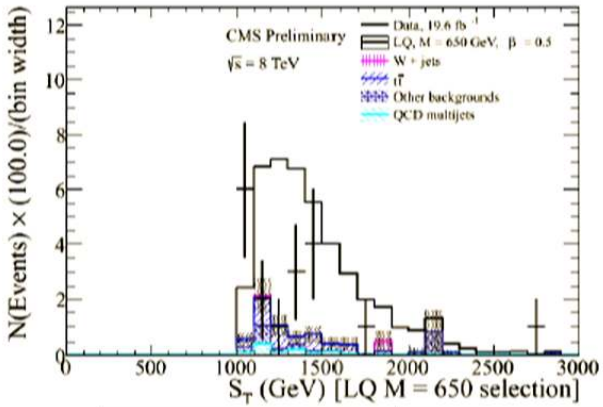
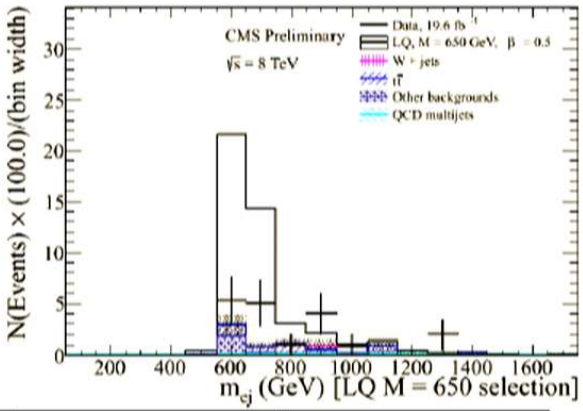
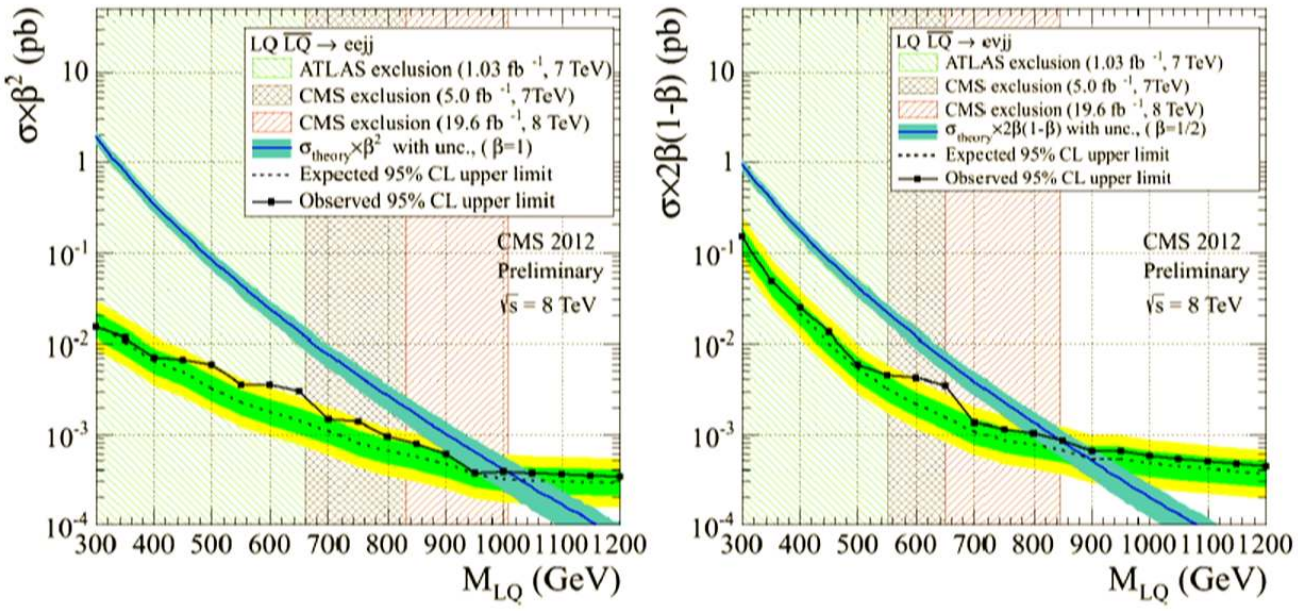




S_T	E_T^{miss}	m_{ej}	$m_{T,e\nu}$
1040 GeV	145 GeV	555 GeV	270 GeV

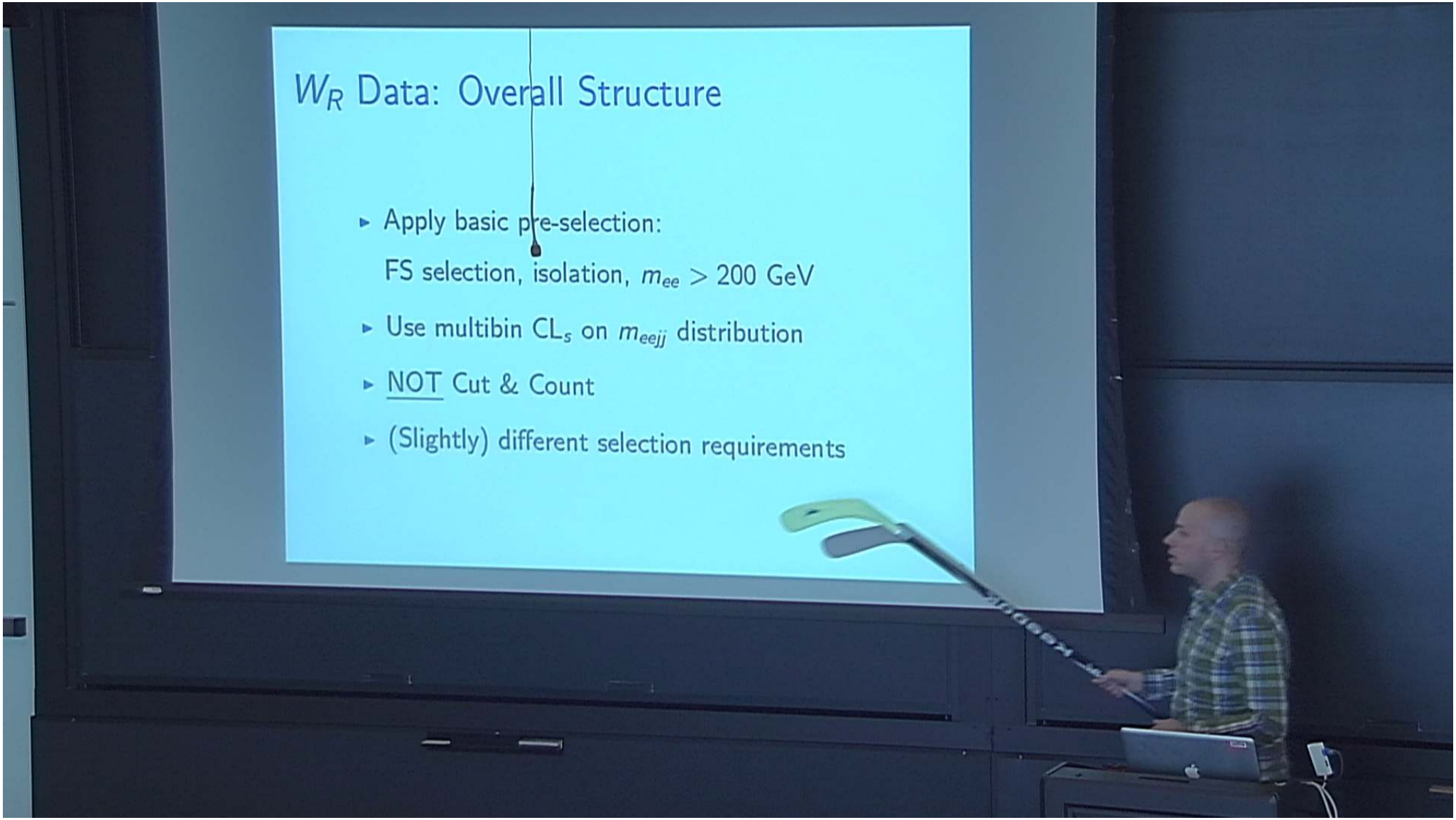
Leptoquark Comparison in Brazil Plots



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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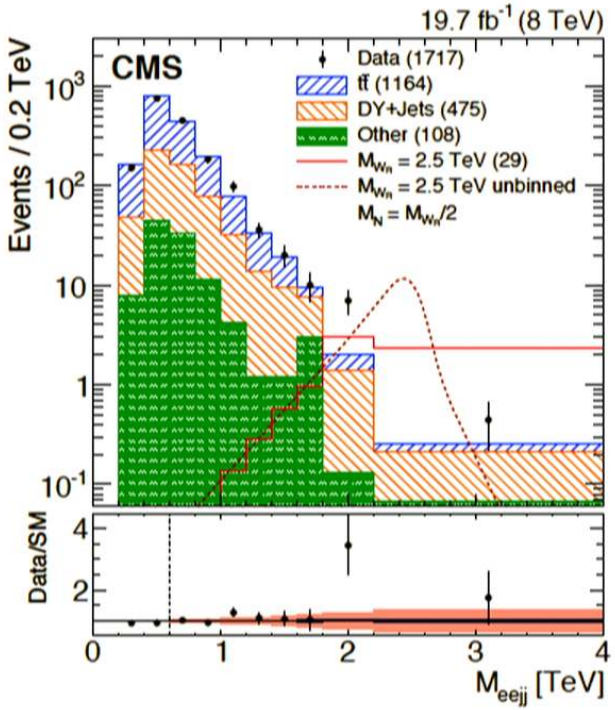
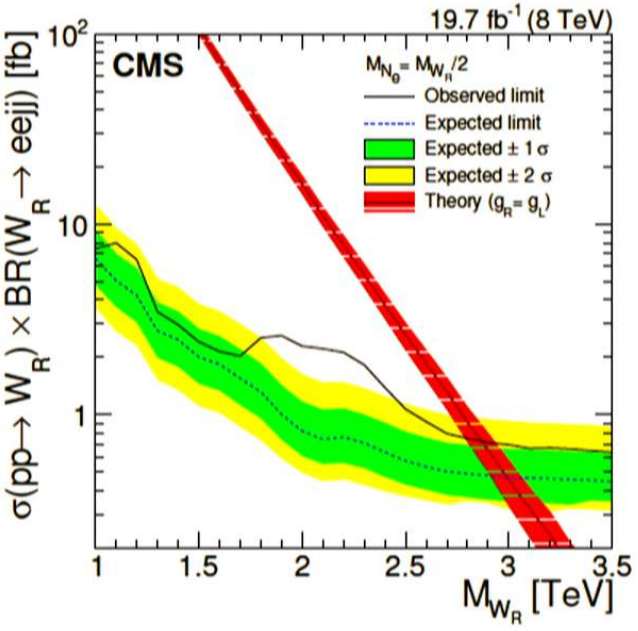
W_R Data: The Money Plots





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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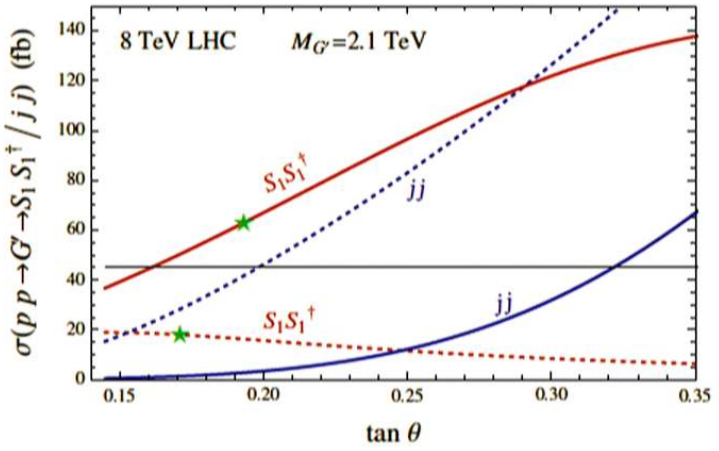
Coloron Production & Decay

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

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

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

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



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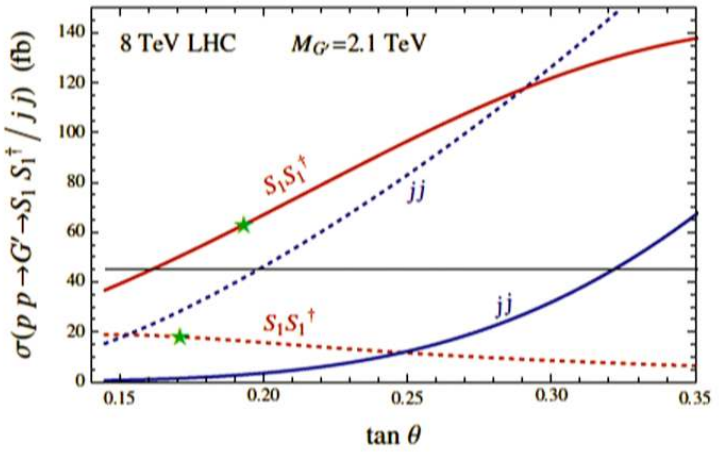


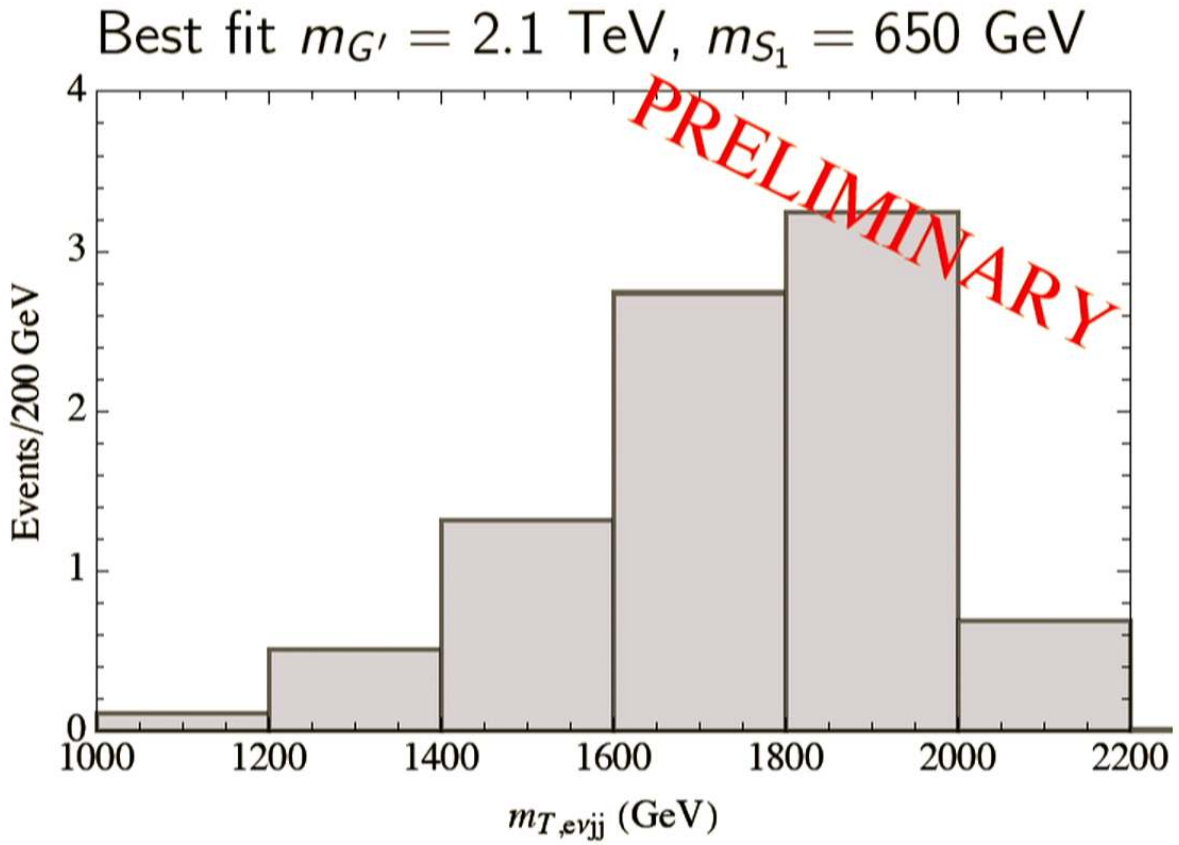
Signal Acceptance from MC

$m_{G'} = 2.1$ TeV

LQ Mass	Production	LQ $eejj$	LQ νejj	$W_R + N_e$
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

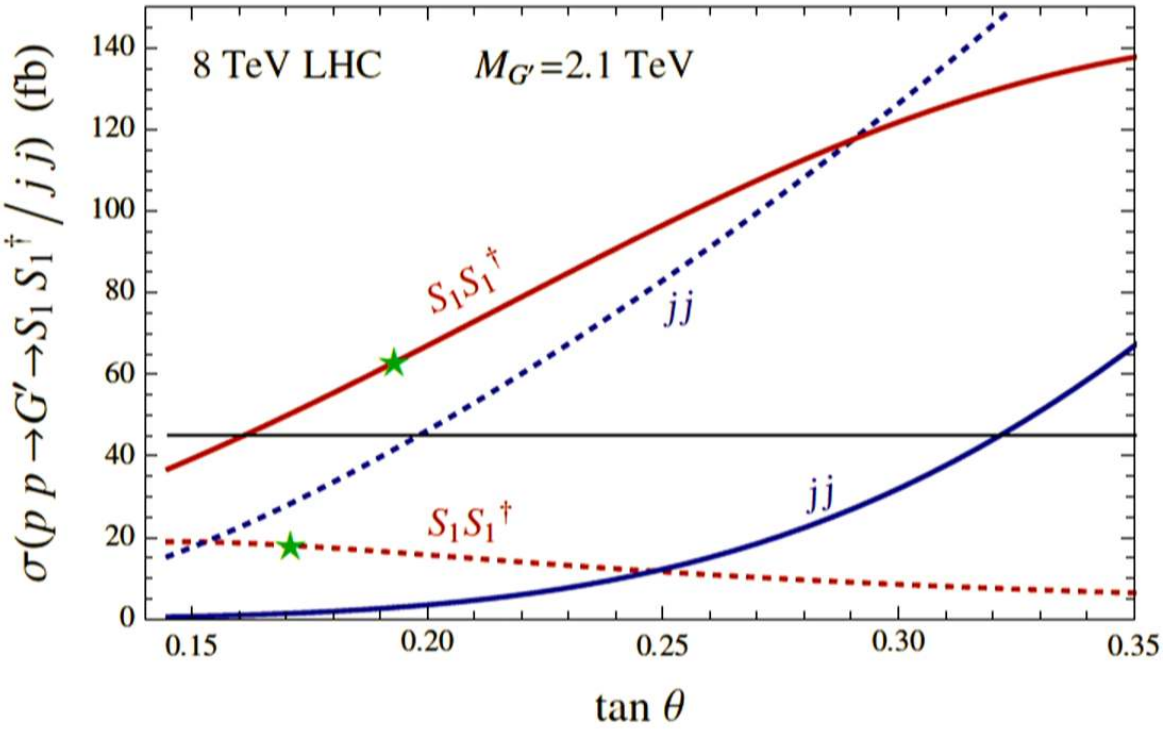
Now I Look Into My Crystal Ball...

Prediction 1: Bump in $m_{e\nu jj}$ @ 2.1 TeV

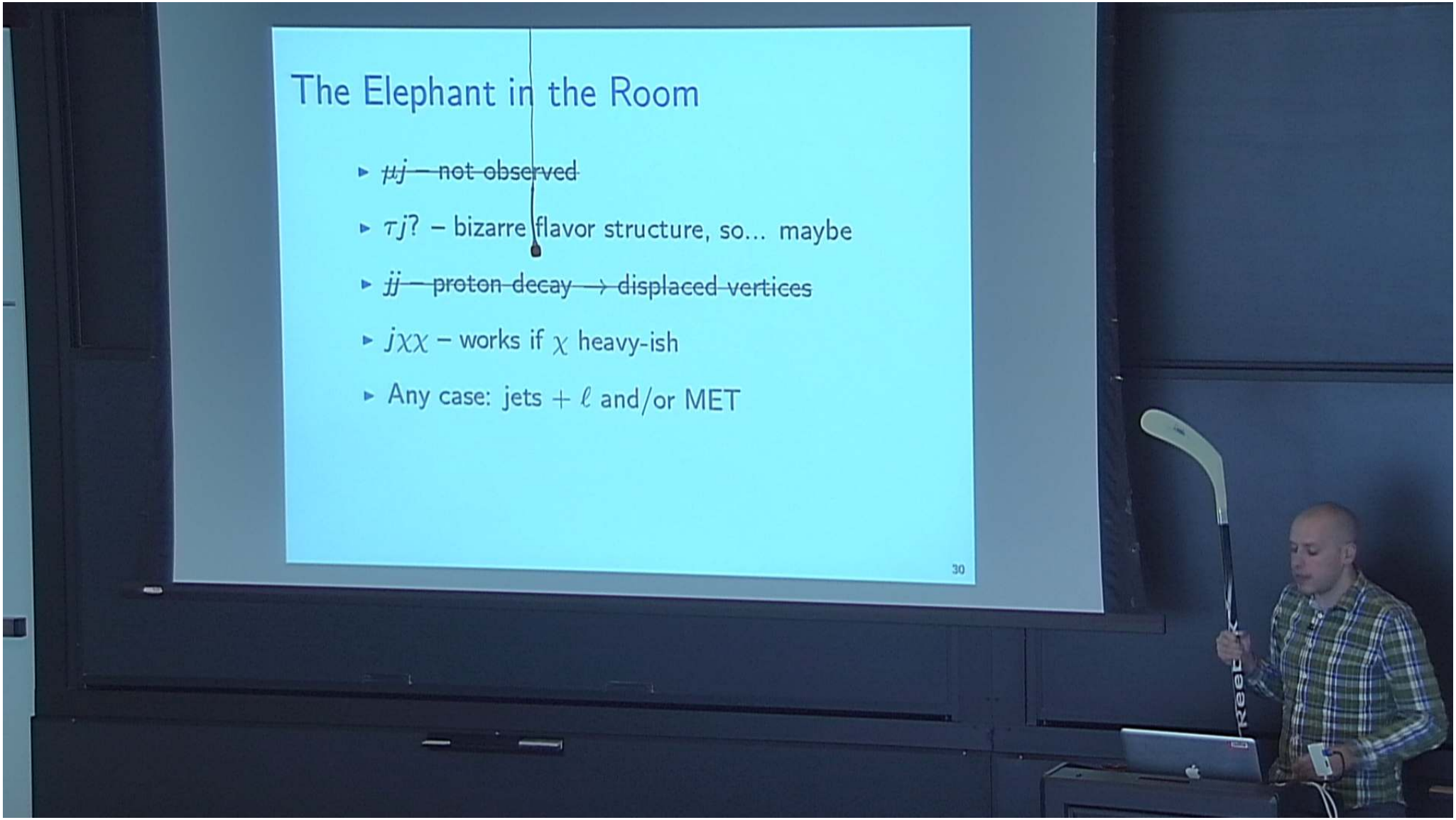


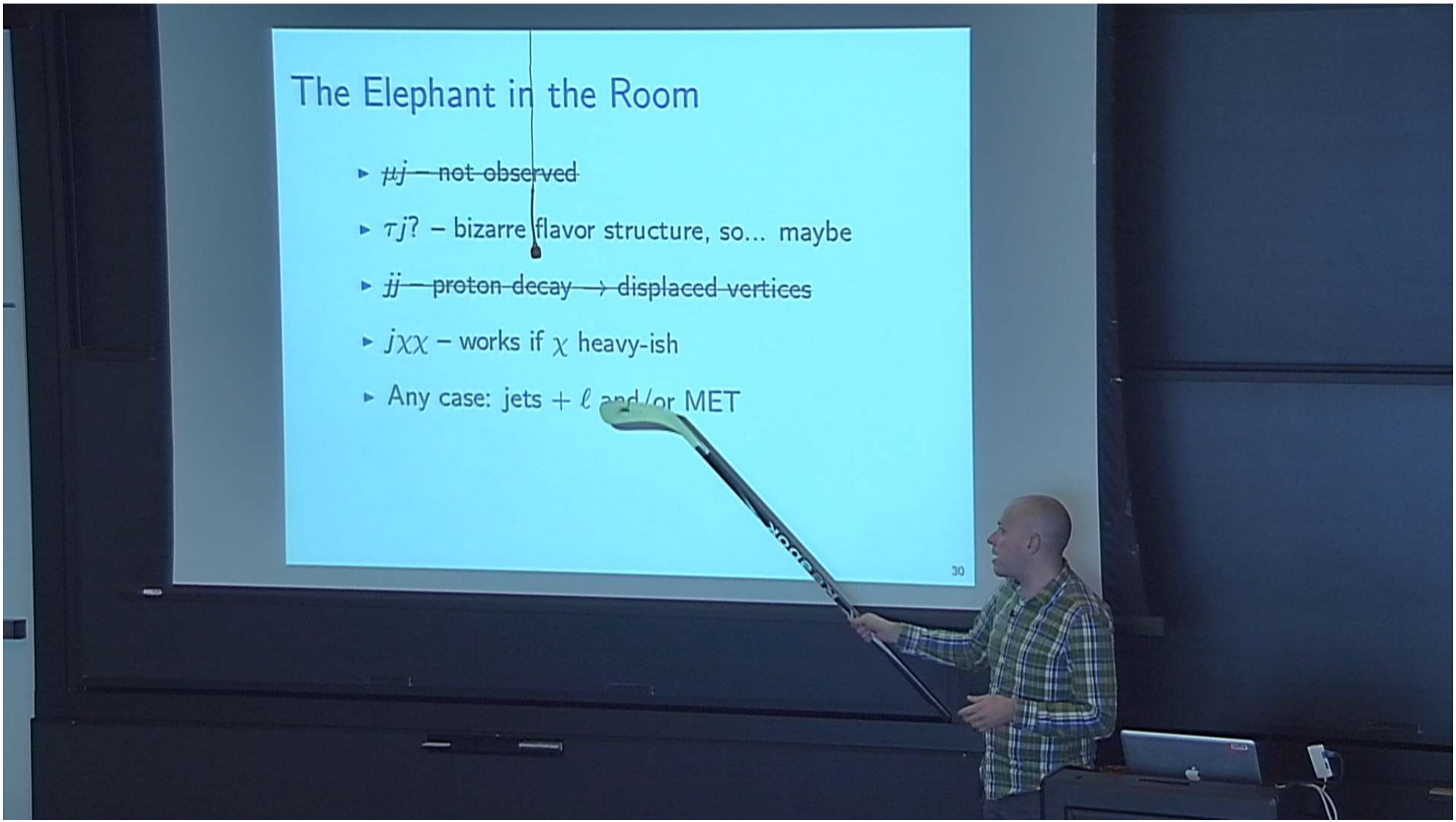
Prediction 3: $jj/t\bar{t}$ Resonance @ 2.1 TeV

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



The Elephant in the Room


The Elephant in the Room
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
30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Future directions: Other Topologies

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