

Search for Second Generation Leptoquarks

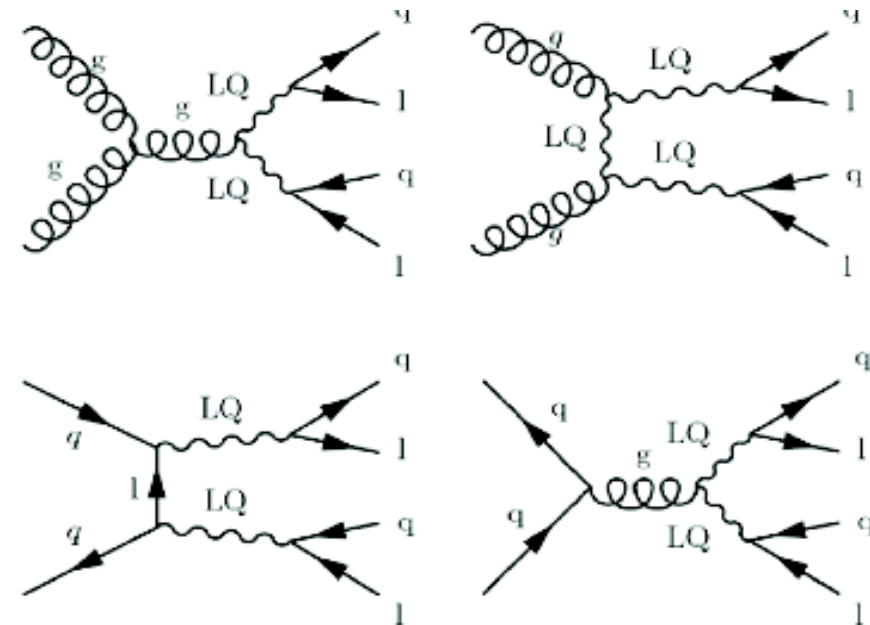
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Leptoquarks (LQ's) - Introduction

- LQ's are hypothetical particles predicted by many theories beyond the SM – GUTs, technicolor and composite models.
 - carry both baryon and lepton numbers, thus couple to leptons and quarks of a single generation.
 - characterized by their mass, BR to lq and LQ-l-q coupling.
- At LHC, LQs are produced in pairs mostly through gg fusion and $q\bar{q}$ annihilation

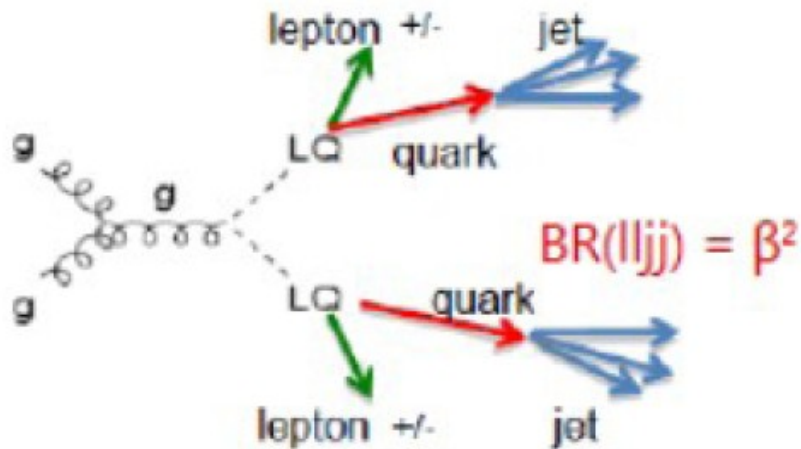
Model parameters	
M_{LQ}	LQ mass
β	$BR(LQ \rightarrow l^{+/-} + q)$
λ_{l-q-LQ}	l-q-LQ coupling



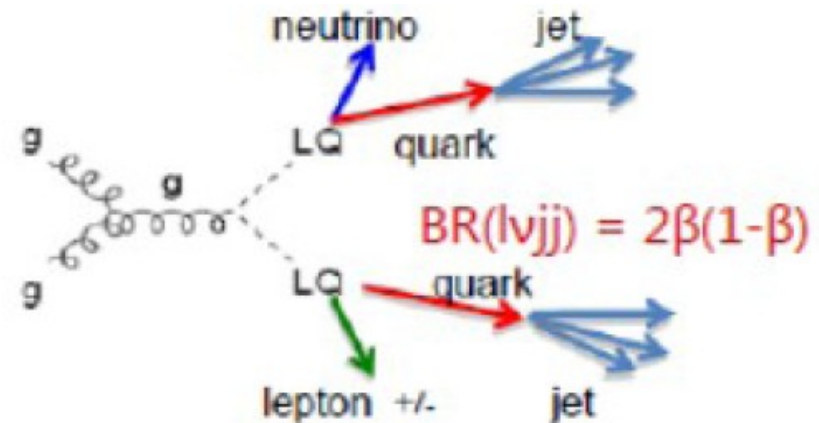
This talk focus on “Search for pair production of 2nd generation scalar LQ's (denoted as LQ2's) in pp collisions at $\sqrt{s} = 8$ TeV with the CMS detector”.

Event Signature

- Di-muon + jets ($\mu\mu jj$)



- Muon + missing transverse energy + jets ($\mu\nu jj$)



- Major backgrounds:

- Z +jets, $t\bar{t}$

- Major backgrounds:

- W +jets, $t\bar{t}$

Other backgrounds like QCD multijets, diboson, and single top production, are found to have negligible contribution.

Event Selection

LQ2 $\rightarrow \mu\mu jj$

- At least two muons
 - $P_T > 45 \text{ GeV}$, $|\eta| < 2.1$

LQ2 $\rightarrow \mu\nu jj$

- Exactly one muon
 - $P_T > 45 \text{ GeV}$, $|\eta| < 2.1$
 - Missing transverse energy $> 55 \text{ GeV}$
 - Veto event with 2nd μ or electron

At least two jets with $P_T(\text{jet}_1) > 145 \text{ GeV}$, $P_T(\text{jet}_2) > 45 \text{ GeV}$, $|\eta| < 2.4$

- $S_T = \sum(P_T \text{ of final state objects in event})$
- $M_{\min}(\mu, \text{jet}) = \text{smallest reconstructed muon-jet invariant mass}$
- $M_{\mu\mu}$ or $M_{\mu\nu}^T$

Cuts on these variables optimized by maximizing $S/\sqrt{(S+B)}$

Background Studies

$$LQ \rightarrow \mu\mu jj$$

- $Z/\gamma^* + \text{jets}$

- Rescale MC to data in Z-enriched region
 - i.e. $80 < M_{\mu\mu} < 100$ GeV
- $R_Z = 0.92 \pm 0.01$ (stat.)

- $t\bar{t}$

- Estimated with $t\bar{t}$ -enriched data sample of $e\mu$ events
- Sample is reweighted to account for different BR of $e\mu$ and $\mu\mu$ final states
- Use the rescaled $e\mu$ data sample to estimate $t\bar{t}$ background

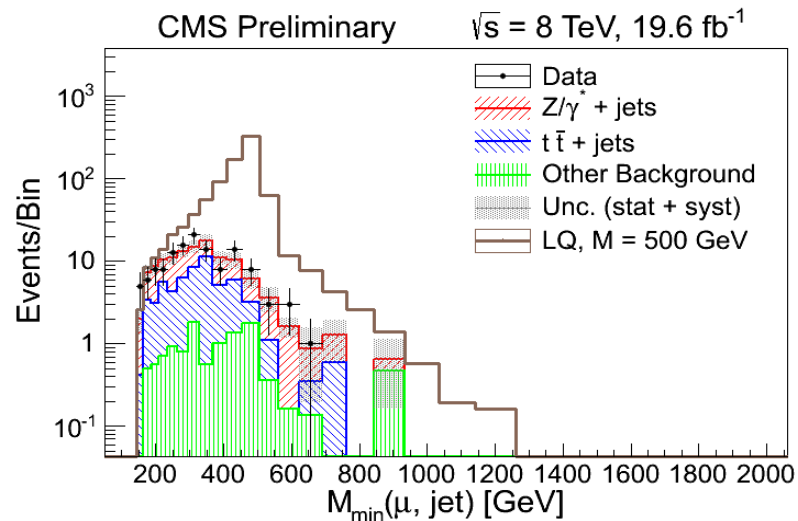
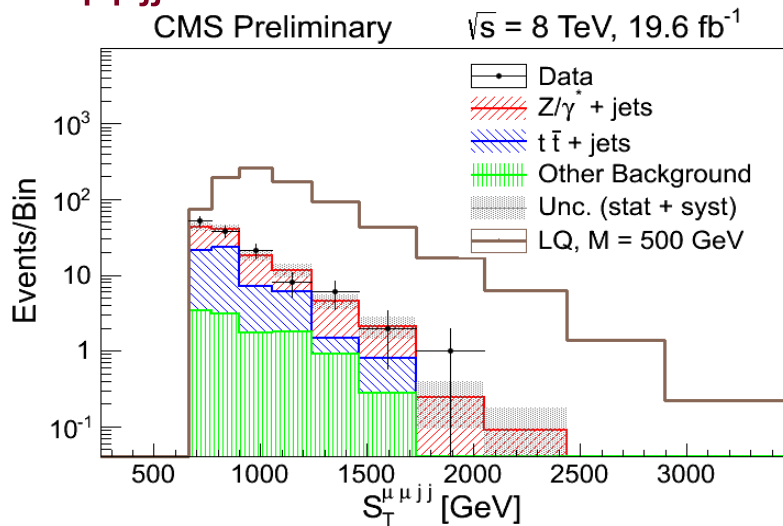
Background studies

$$LQ \rightarrow \mu\nu jj$$

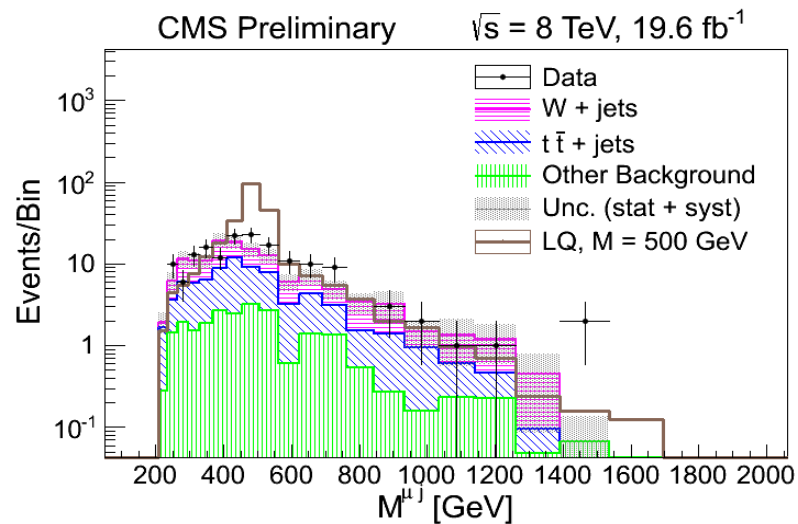
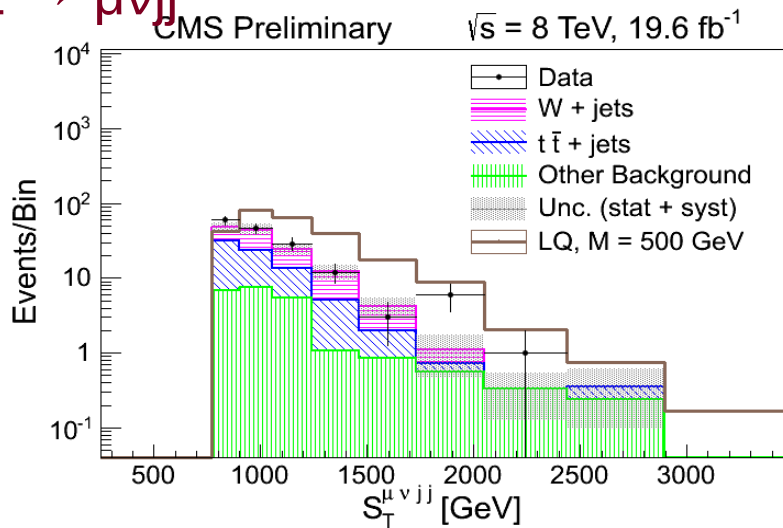
- **W+jets and $t\bar{t}$**
 - Rescale MC to data in W control region i.e. $70 < M_{\mu\nu}^T < 110$ GeV
 - Determine W+jets and $t\bar{t}$ normalization factors by using two mutually exclusive selections based on jet multiplicity
 - W+jets enriched for $N_{\text{jets}} < 4$
 - $t\bar{t}$ enriched for $N_{\text{jets}} \geq 4$
 - Solve a system of two equations:
 - $N_1 = R_{t\bar{t}} N_{1,t\bar{t}} + R_W N_{1,W} + N_{1,\text{other}}$
 - $N_2 = R_{t\bar{t}} N_{2,t\bar{t}} + R_W N_{2,W} + N_{2,\text{other}}$
 - $R_W = 0.95 \pm 0.01$ (stat.)
 - $R_{t\bar{t}} = 0.99 \pm 0.02$ (stat.)

Data Comparison

LQ2 $\rightarrow \mu\mu jj$



LQ2 $\rightarrow \mu\nu jj$

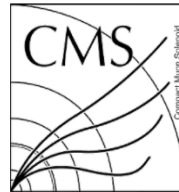
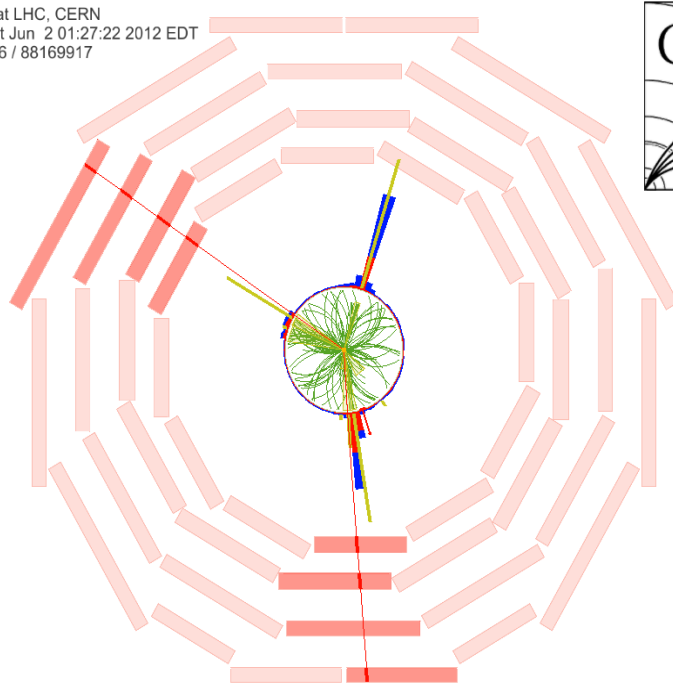


Event displays

- For events passing final selection for an LQ mass of 850 GeV

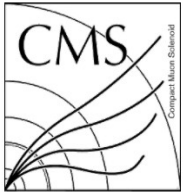
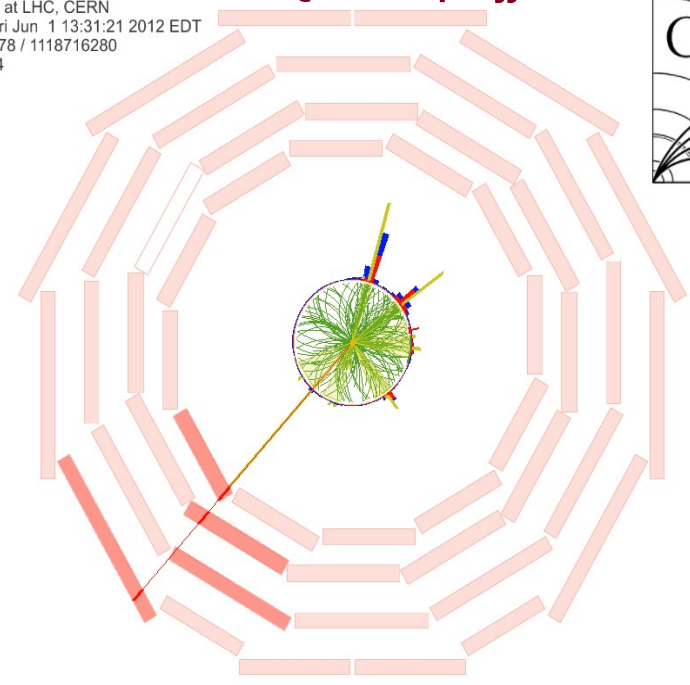
CMS Experiment at LHC, CERN
Data recorded: Sat Jun 2 01:27:22 2012 EDT
Run/Event: 195396 / 88169917
Lumi section: 89

LQ2 $\rightarrow \mu\mu jj$

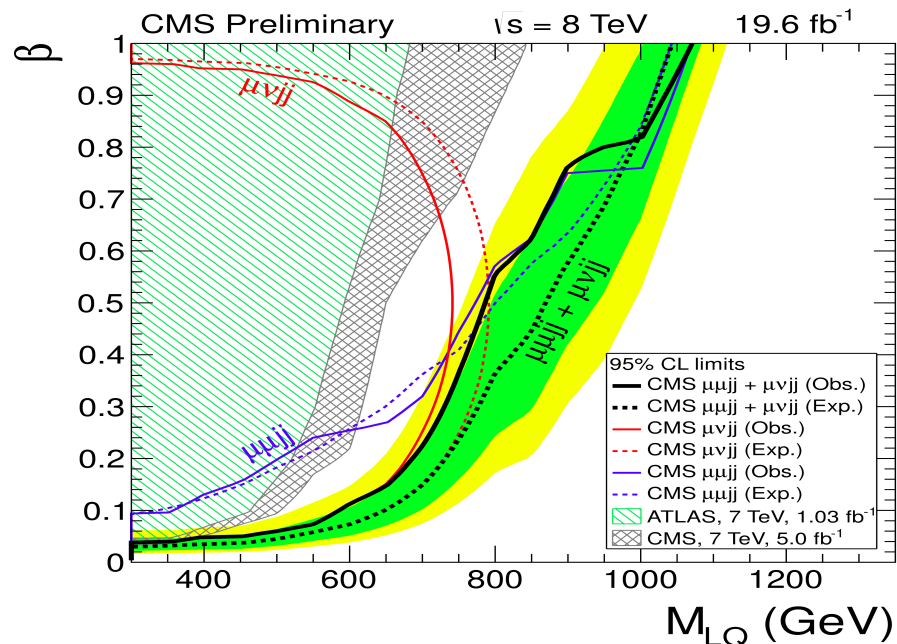
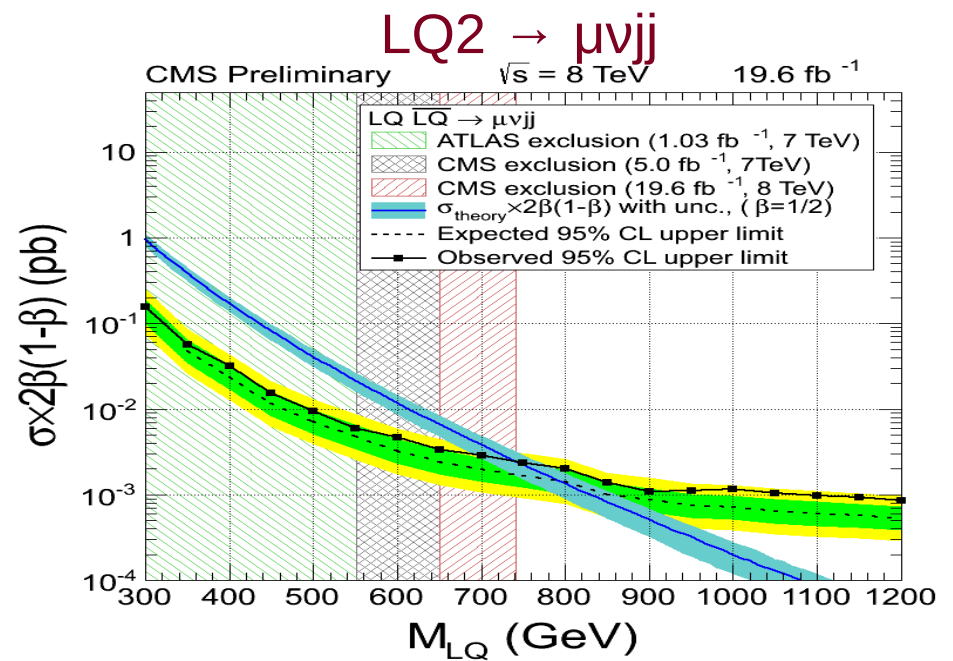
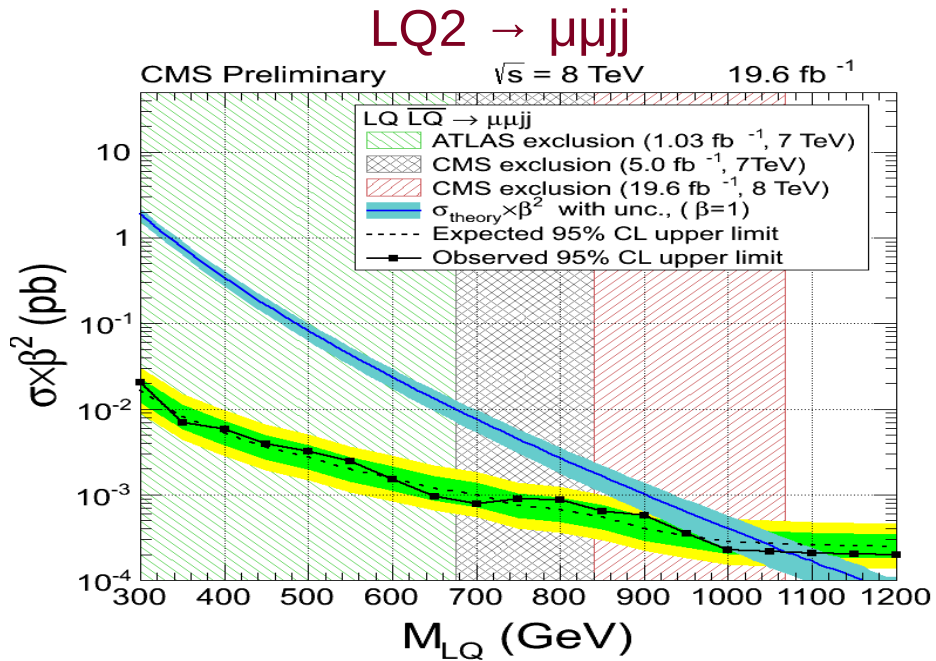


CMS Experiment at LHC, CERN
Data recorded: Fri Jun 1 13:31:21 2012 EDT
Run/Event: 195378 / 1118716280
Lumi section: 984

LQ2 $\rightarrow \mu\nu jj$



Results from 8 TeV LQ2 Searches



Summary

- Data found to be consistent with background expectations with no-signal hypothesis.
- Set an upper limit on the LQ2 production cross section:
 - 1070 (740) GeV for $\beta = 1$ (0.5)
- Combination of $\mu\mu jj$ and $\mu\nu jj$ channels, improve the mass exclusion values for $\beta < 1$:
 - Scalar LQ2's with masses < 785 GeV can be excluded for $\beta = 0.5$

<https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO12042>