Searches for Leptoquarks and heavy quarks with CMS

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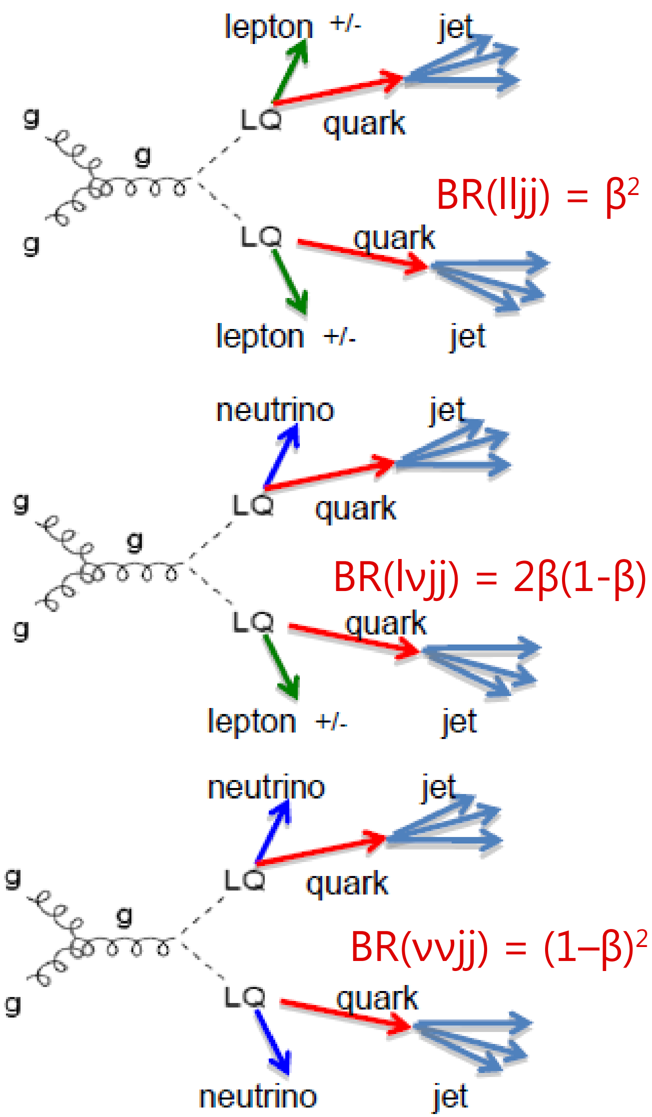
Introduction

- Leptoquarks and heavy quarks: a nice way to look for new physics
  - High discovery potential: LQs and q' could be amond the first LHC discoveries
  - several final states: isolated leptons, high transverse energy
  - intermediate energy range, detached from the main SM backgrounds
- Status of searches for leptoquarks and heavy quarks at CMS
  - submitted or accepted for publication
  - 2010 p-p collisions at $\sqrt{s}$ = 7 TeV: 33-36 pb^{-1} analyzed

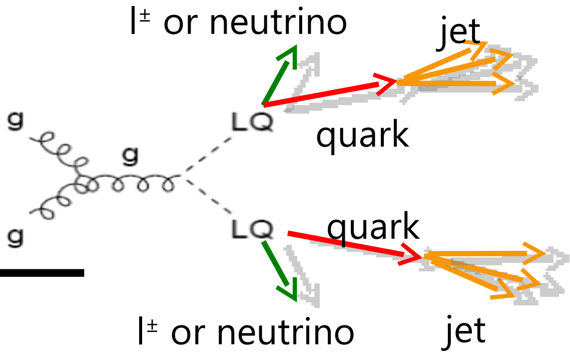
Please refer to: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO for more details

Searching for Leptoquarks

- Predicted by many extensions of the Standard Model: GUTs, RPV SUSY, technicolor,…
- Couple directly to quarks and leptons via unknown λ(LQ-l-q) Color triplet, carrying L, B, fractional Q_{em}, J (0, 1)
- Benchmark model:
  - 3 generations of family-diagonal leptoquarks (no FCNC)
  - Quantum numbers conservation (no proton decay)
  - Total coupling to the gluon normalized to EM scale α_{EM}
  - Focus on pair production, λ-independent
  - Narrow resonances (LQ→lq)
- Decay channels
  - Lepton = $l^{\pm}$ or ν , pair production leads to 3 final states
  - β = BR(LQ→$l^{\pm}$q)
  - Combination of channels to extend β range



LQ analysis plan



Cut-based, event counting analysis

Heavy LQ: excess in S_T and M(ll) or $M_T(l\nu)$ spectra

Signature and base selection

- Single lepton trigger
- Isolated lepton(s) with high p_T
- 2 or more jets with high E_T
- *High MET*

Standard backgrounds

- Z(ll) and $W^{\pm}(l\nu)$ + jets
- Top quark pair and single productions
- Multijet (instrumental)
- Dibosons (ZZ, WZ, WW)

Shapes from simulation
Normalization from data

Background reduction

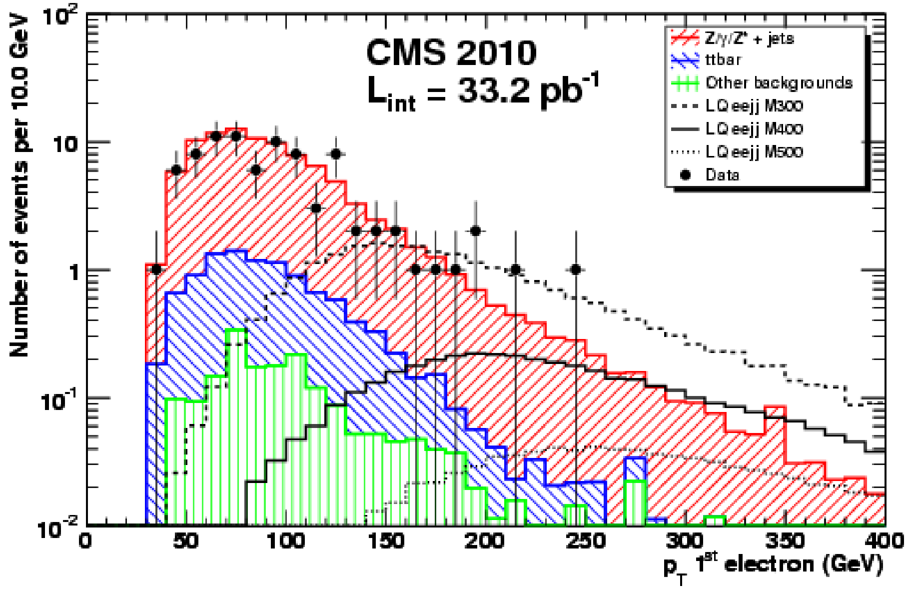
- **M(ll) or $M_T(l\nu)$**
- Lepton multiplicity
- $\mathbf{S_T} = \Sigma p_T(l) + E_t^{miss} + E_T(j1) + E_T(j2)$

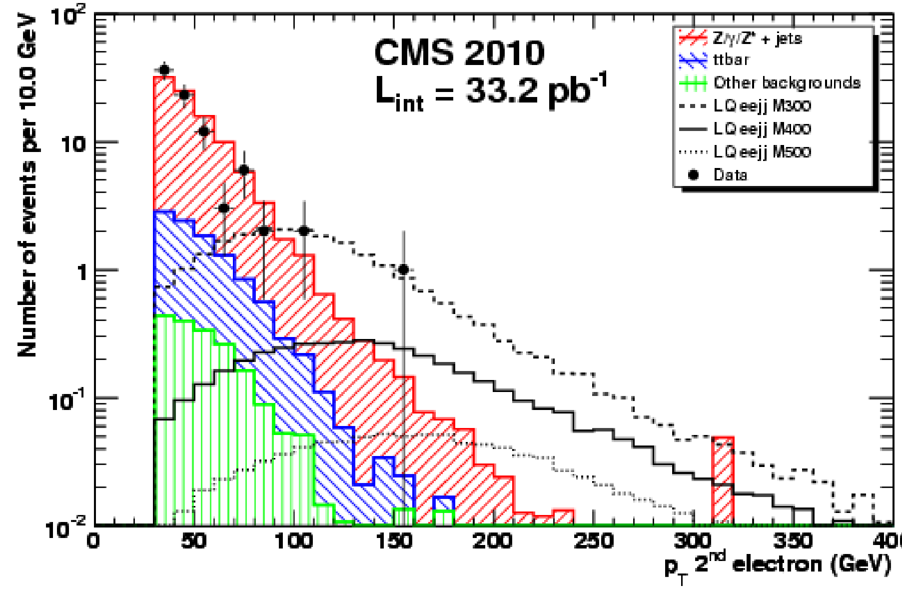
Optimization
maximize back. rejection and signal efficiency

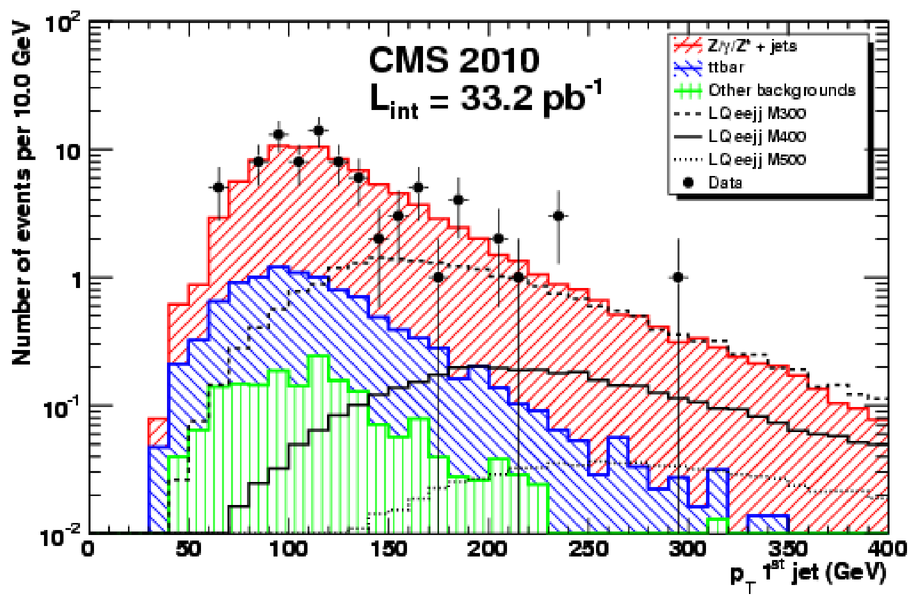
Bayesian approach

Upper limit on the expected and observed production cross sections
Lower limit on a scalar LQ mass M_{LQ}

Data-MC comparison (eejj selection)







Single or double EM trigger (100%)

≥ 2 isolated electrons p_T>30 GeV, |η|<2.5

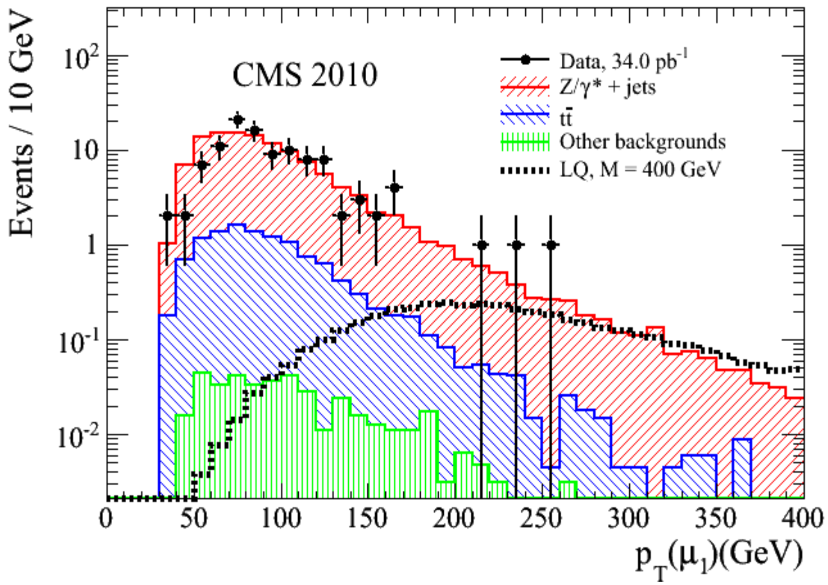
≥ 2 jets E_T>30 GeV, |η|<3.0

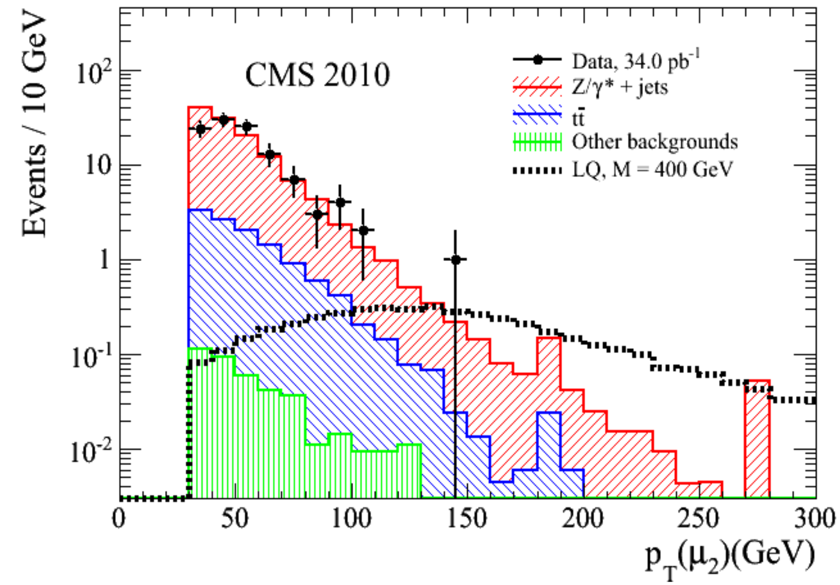
ΔR(e, j)>0.7

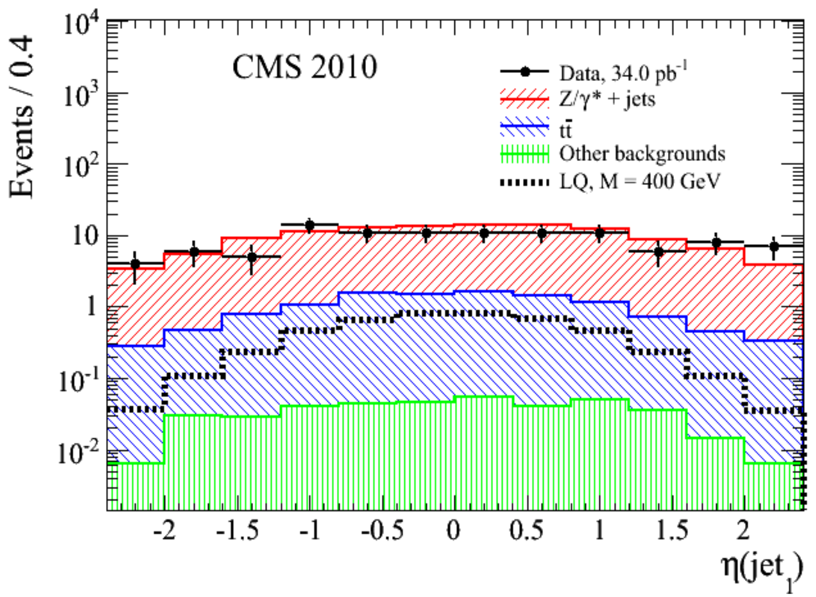
M(ee)>50 GeV

$S_T = p_T(e1)+p_T(e2)+E_T(j1)+E_T(j2) > 250$ GeV

Data-MC comparison (μμjj selection)







Single muon trigger (99%)

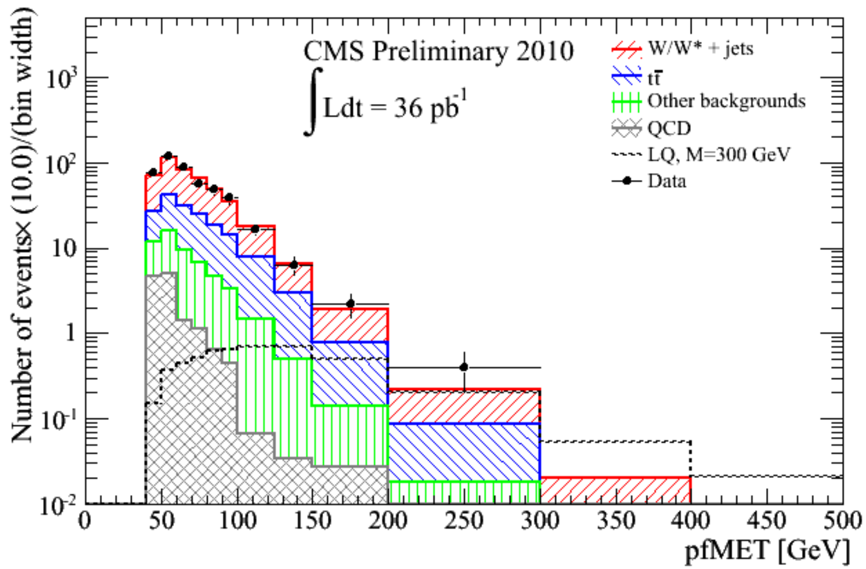
≥ 2 isolated muons $p_T > 30$ GeV,

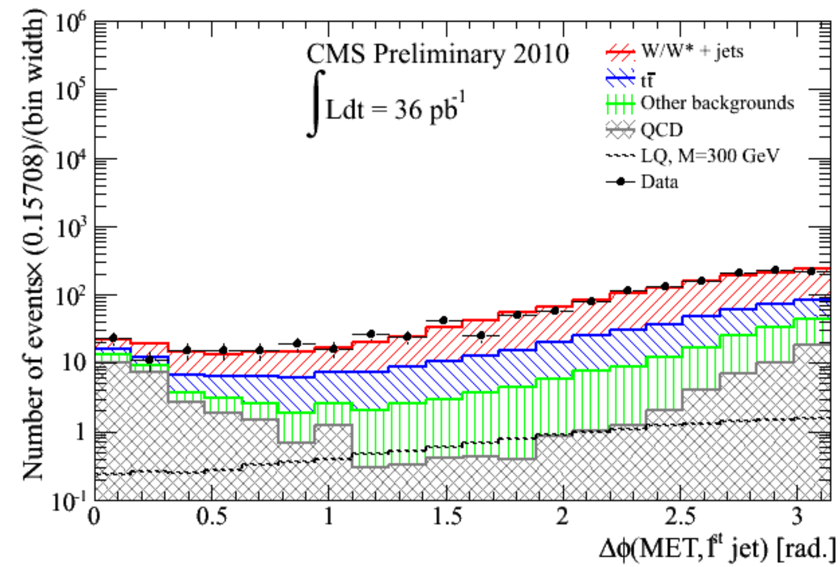
$|\eta| < 2.4$, $d0 < 2mm$, $\Delta R(\mu,\mu) > 0.3$

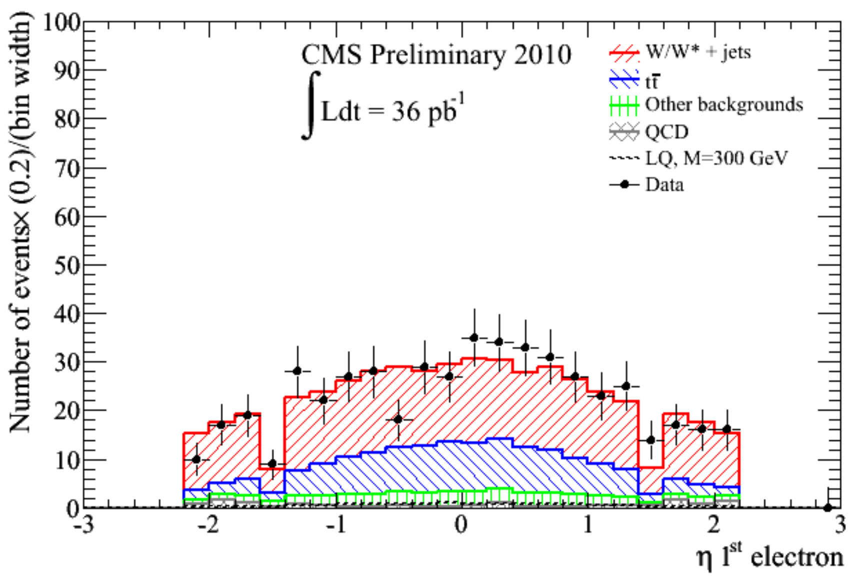
≥ 2 jets $E_T > 30$ GeV, $|\eta| < 3.0$

$S_T = p_T(\mu1) + p_T(\mu2) + E_T(j1) + E_T(j2) > 250$ GeV

Data-MC comparison (evjj selection)







Single EM trigger

1 isolated electron p_T>35 GeV, |η|<2.2

≥ 2 jets E_T>30 GeV, |η|<3.0

MET> 45 GeV, No muon with p_T>10 GeV

ΔR(e, j)>0.7, Δφ(MET, e)>0.8, Δφ(MET, j1)>0.5

S_T=p_T(e1)+MET+E_T(j1)+E_T(j2)>250 GeV

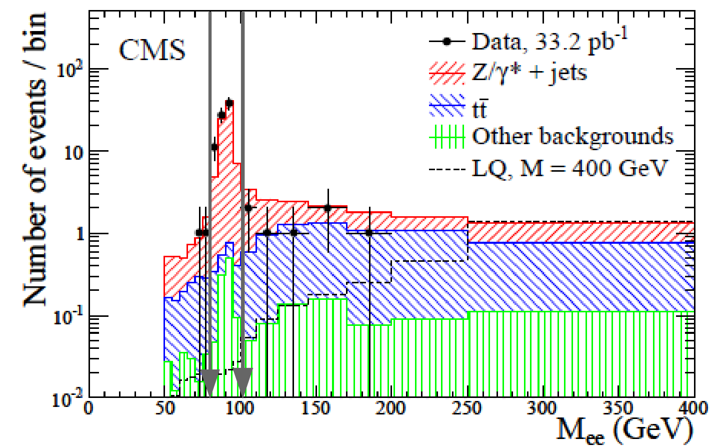
Normalization of the backgrounds

- ttbar+jets normalization based on a CMS measurement

- Normalization factor of the Z+jets background:

$$R_Z = \frac{N_{data} - (N_{t\bar{t}} + N_{others})}{N_Z}$$

Number of events measured in **80<M(ll)<100 GeV**

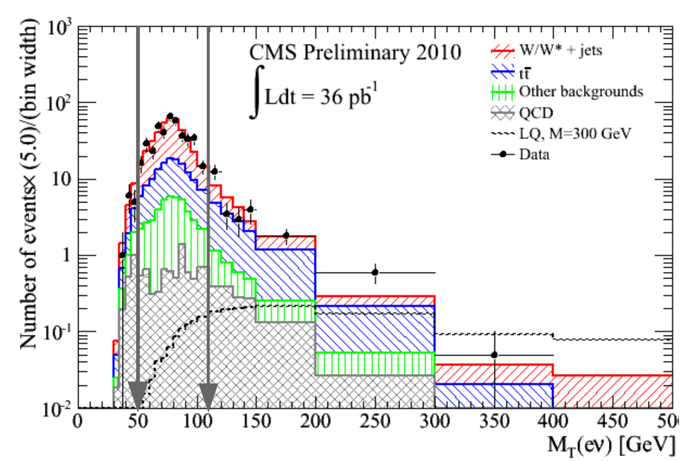


- Normalization factor of the W+jets background:

$$R_W = \frac{N_{\mathrm{data}} - (N_{t\bar{t}} + N_Z + N_{\mathrm{others}})}{N_W}$$

N_{tt}, N_Z, N_{others} and N_W: numbers of MC events in tt, Z+jets, sum of other backgrounds (QCD, VV, single top) and W+jets, normalized to the data luminosity, measured in **50<M_T(lν)<110**

  - Error on R_W: stat. uncertainty on data and MC summed in quadrature, plus syst. uncertainties on non-W backgrounds



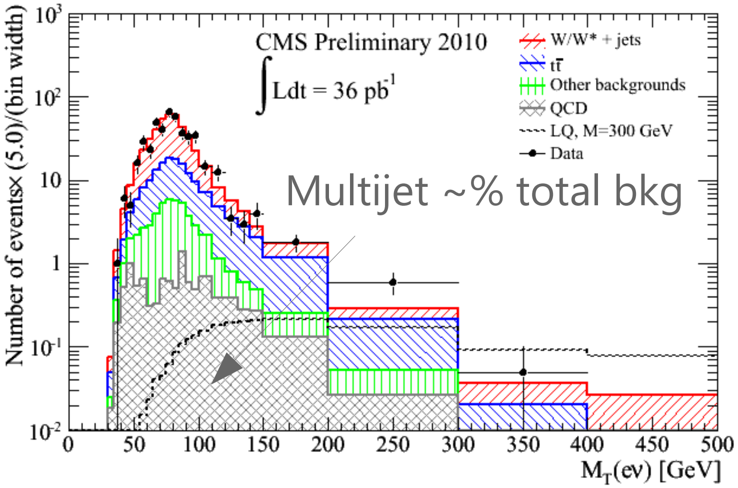
Instrumental background estimation

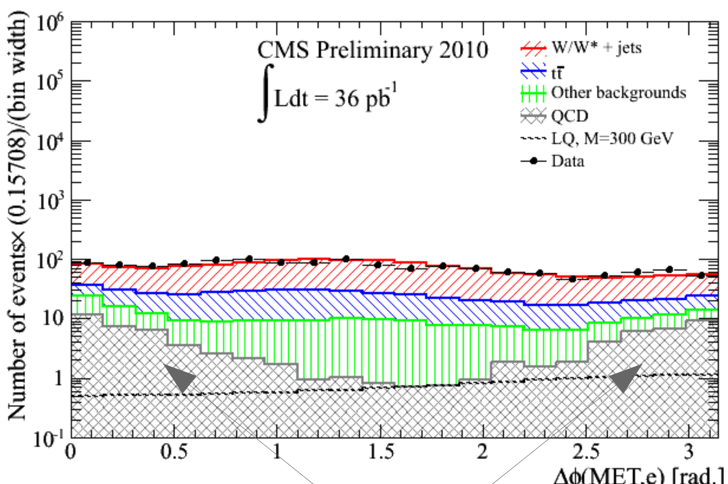
- Instrumental background: multijet events in which some jets are reconstructed as electrons, jet mismeasurement creating fake MET. MC generally not satisfactory: extracted from data
- Multijet-like sample, ccjj or cνjj selection: 1 or 2 EM energy clusters, loose isolation, 2 jets
- **Estimation of the number of multijet events in the signal eejj or eνjj selection:**

$$N_{eejj}^{QCD} = \sum_{ccjj \text{ events in data}} P(e|c_1) \times P(e|c_2)$$

$$N_{e\nu jj}^{QCD} = \sum_{c\nu jj \text{ events in data}} P(e|c : p_T, \eta)$$

P(e|c): probability for a cluster to be reconstructed as an electron i.e. matched to a track, tight isolation





Multijet=MET aligned
or opposed to EM direction

Systematic uncertainties

- **Maximum uncertainty:**
  26-28% on background, 15% (8%) on signal for dilepton channels (eνjj channel)

lljj	eνjj
- Background uncertainty dominated by the normalization and JES - Signal uncertainty dominated by the lepton reco/ID/iso	- Background dominated by W+jets shape and normalization - Signal dominated by JES and EM trigger/reco/ID/iso

- **Data-driven background normalization:** See slide 8
- **V+jets background shape:** compare MC MadGraph samples with different renormalization and factorization scales and matching thresholds
- **Jet/MET energy scale:** A conservative 5% uncertainty is considered on jet energy scale (independent of jet p_T and η). The event-by-event variation of the JES and propagation to the MET scale, leads to a total uncertainty of ~10% on the background prediction

Bayesian approach for an exclusion

- In absence of LQ signal, upper limit on the scalar LQ production cross section. Probability density for a cross section σ, with n observed events, a signal acceptance A, a luminosity $\mathcal{L}$, b the number of background events and π(σ) a flat prior for the signal cross section :

$$p(\sigma|n, A, \mathcal{L}, b) = \frac{L(n|\sigma, A, \mathcal{L}, b)\pi(\sigma)}{\int_{-\infty}^{+\infty} L(n|\sigma, A, \mathcal{L}, b)\pi(\sigma)d\sigma} \qquad \pi(\sigma) = \begin{cases} 0 & \text{if } \sigma < 0 \\ 1 & \text{if } \sigma \geq 0 \end{cases}$$

- $L(n|\sigma, A, \mathcal{L}, b)$ is a Poisson distribution: $L(n|\sigma, A, \mathcal{L}, b) = \frac{(\sigma A\mathcal{L} + b)^n}{n!} e^{-(\sigma A\mathcal{L}+b))}$

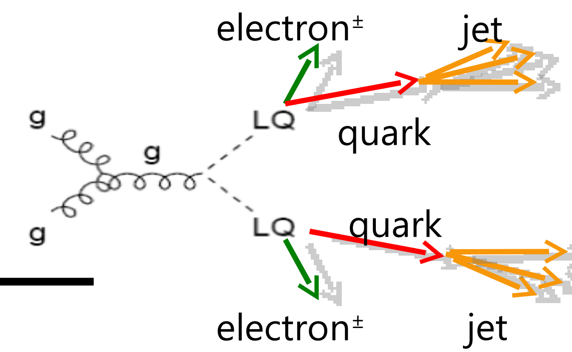
$$\int_{-\infty}^{\sigma_{up}(n)} p(\sigma|n, A, \mathcal{L}, b)d\sigma = \frac{\int_{-\infty}^{\sigma_{up}(n)} L(n|\sigma, A, \mathcal{L}, b)\pi(\sigma)d\sigma}{\int_{-\infty}^{+\infty} L(n|\sigma, A, \mathcal{L}, b)\pi(\sigma)d\sigma} = 0.95$$

- Upper expected limit calculated with a background-only hypothesis $< \sigma_{up} >= \sum_{n=0}^{+\infty} \sigma_{up} L(n|0, A, \mathcal{L}, b)$
- Systematic uncertainties are treated as nuisance parameters: here, g, h and f are Gaussians

$$L'(n|\sigma, A, \mathcal{L}, b) = \int_0^{+\infty}\int_0^{+\infty}\int_0^{+\infty} L(n|\sigma, A', \mathcal{L}', b')g(A')h(\mathcal{L}')f(b')(\mathcal{L})dA'd\mathcal{L}'db'$$

- Combination: product of likelihoods; fully correlated uncertainties. Use largest uncertainty

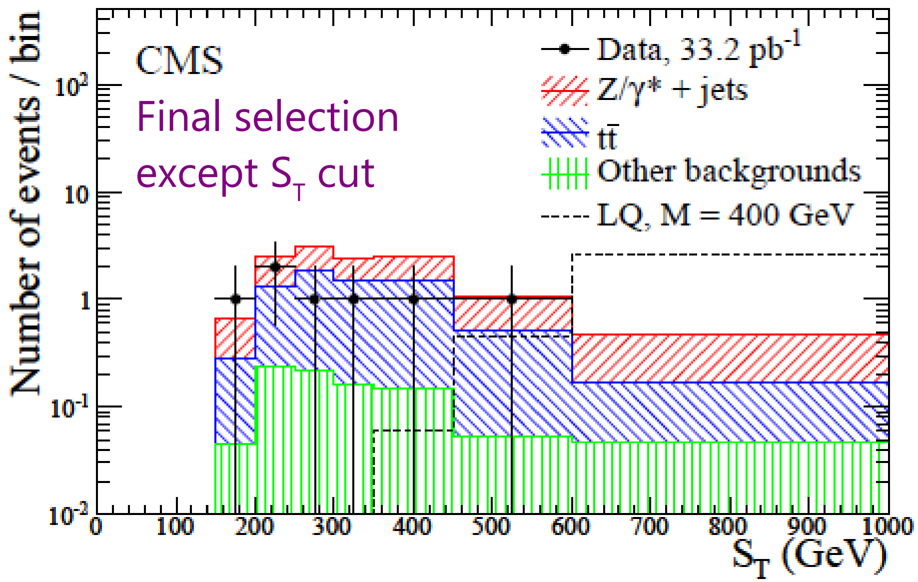
Search for LQ1 LQ1 → eejj

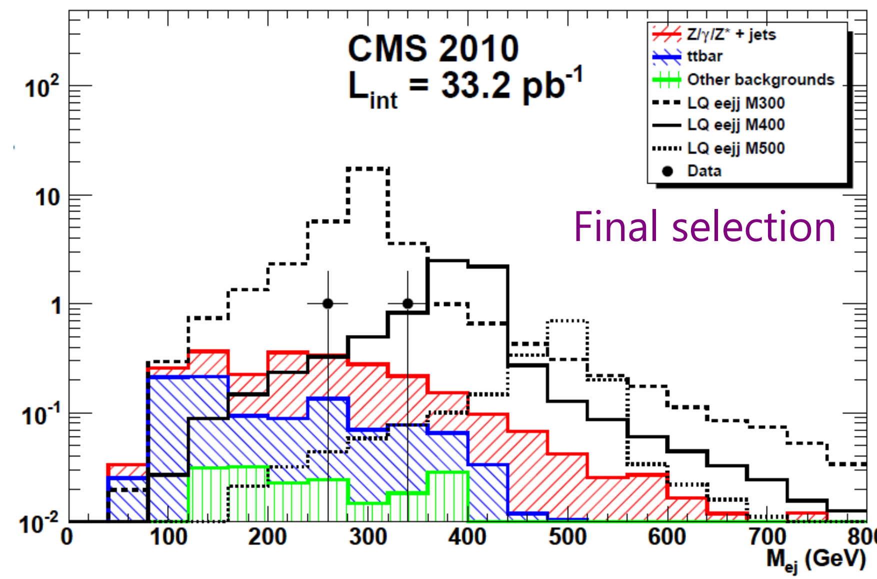


- **Preselection :** M(ee)>50 GeV, S_T>250 GeV
- **Final selection :** M(ee)>125 GeV to reduce Z/γ*→ ee, S_T optimized f(MLQ)

For MLQ=300 GeV:

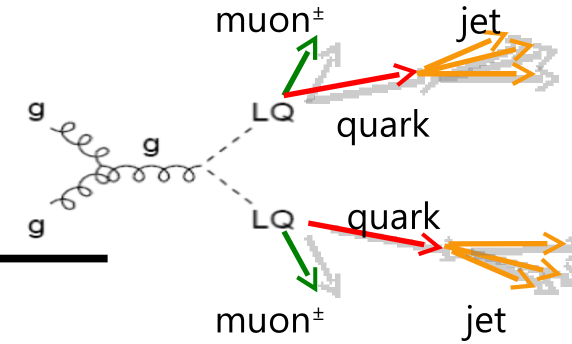
ST cut (GeV)	Data	Total background	Z+jets	Ttbar	Signal	Efficiency	Exp.	Obs.
470	1	1.4 +/- 0.1	0.75 +/-0.07	0.52 +/- 0.05	17.3 +/- 0.1	0.43	0.33	0.29



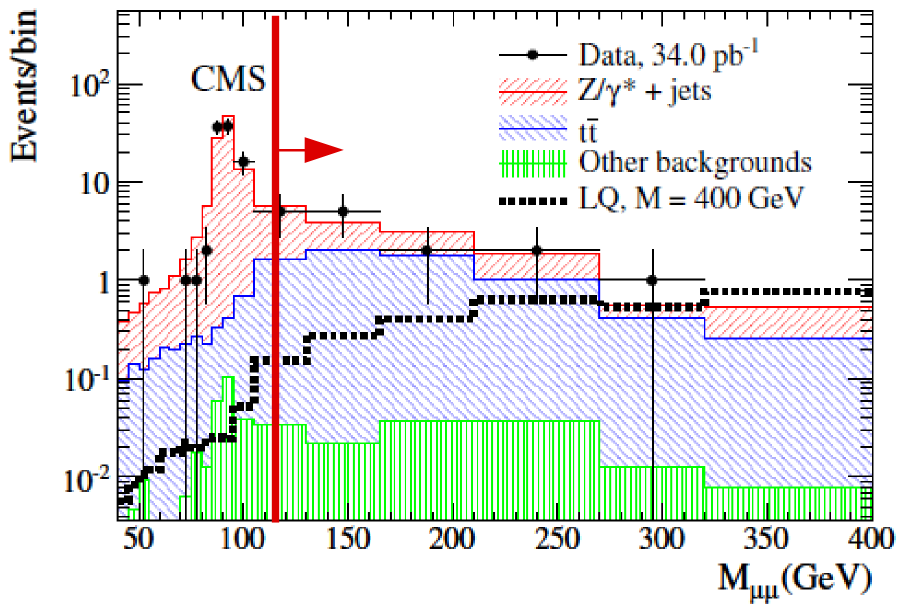


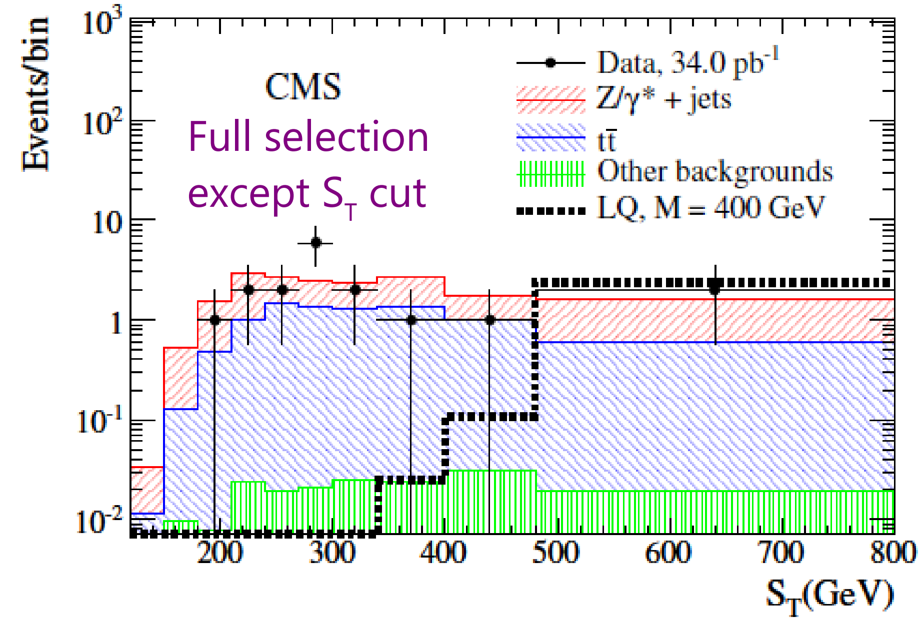
- Good data-simulation agreement observed at each step of the analysis.
  In absence of excess of data with respect to predictions, we set an upper limit on the production cross section of a first-generation scalar Leptoquark

Search for LQ2 LQ2 → μμjj



- Integrated luminosity: 34 pb^{-1}
- Discriminant variables: M(Z→μμ) and $S_T = p_T(\mu 1) + p_T(\mu 2) + E_T(j1) + E_T(j2)$



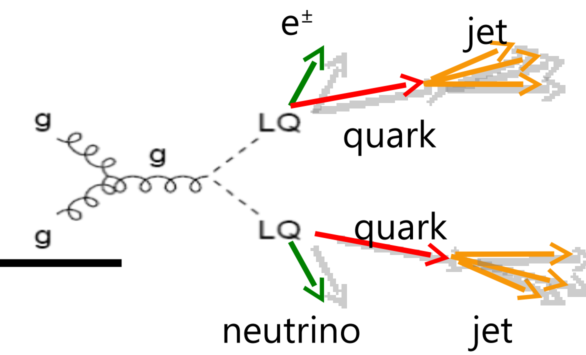


- **Preselection :** S_T>250 GeV. The multijet background (like-sign muons) is negligible
- **Final selection:** M(μμ)>115 GeV, S_T optimized as a function of M_{LQ}. For M_{LQ}=300 GeV:

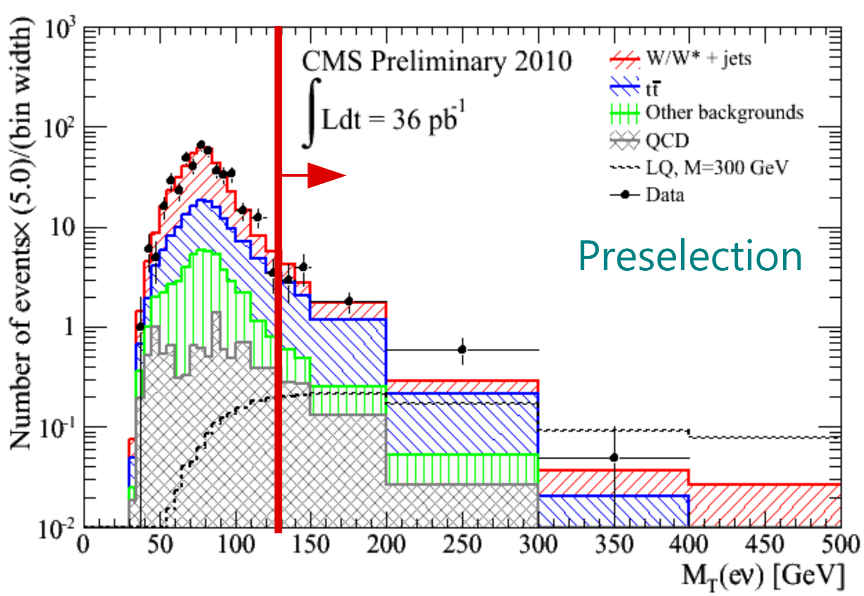
ST cut (GeV)	Data	Total background	Z+jets	Ttbar	Signal	Efficiency	Exp.	Obs.
440	3	2.72 +/- 0.08	1.53 +/-0.03	1.15 +/- 0.07	21 +/- 2	0.52	0.33	0.33

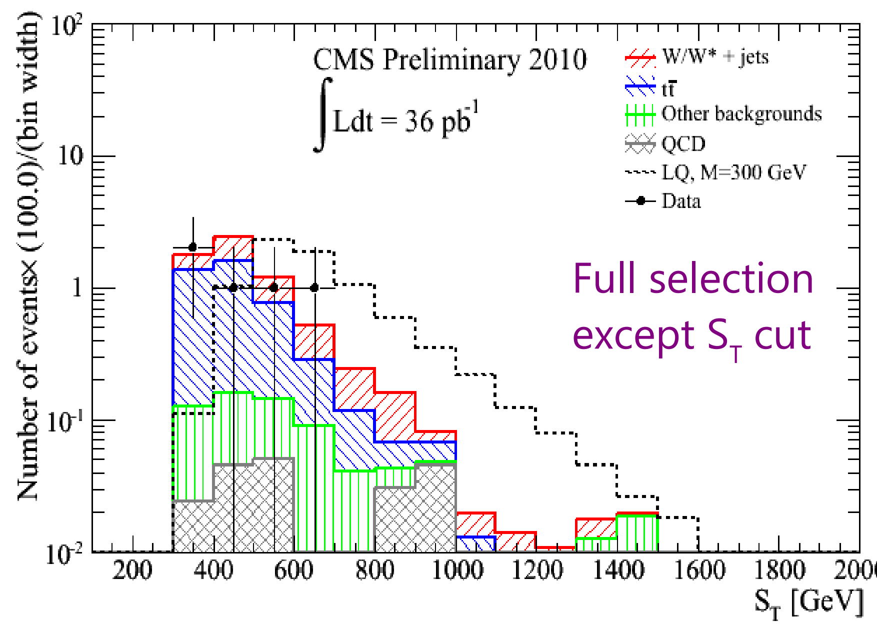
- In absence of signal, we set an upper limit on the production σ of a scalar LQ2

Search for LQ1 LQ1 → eνjj



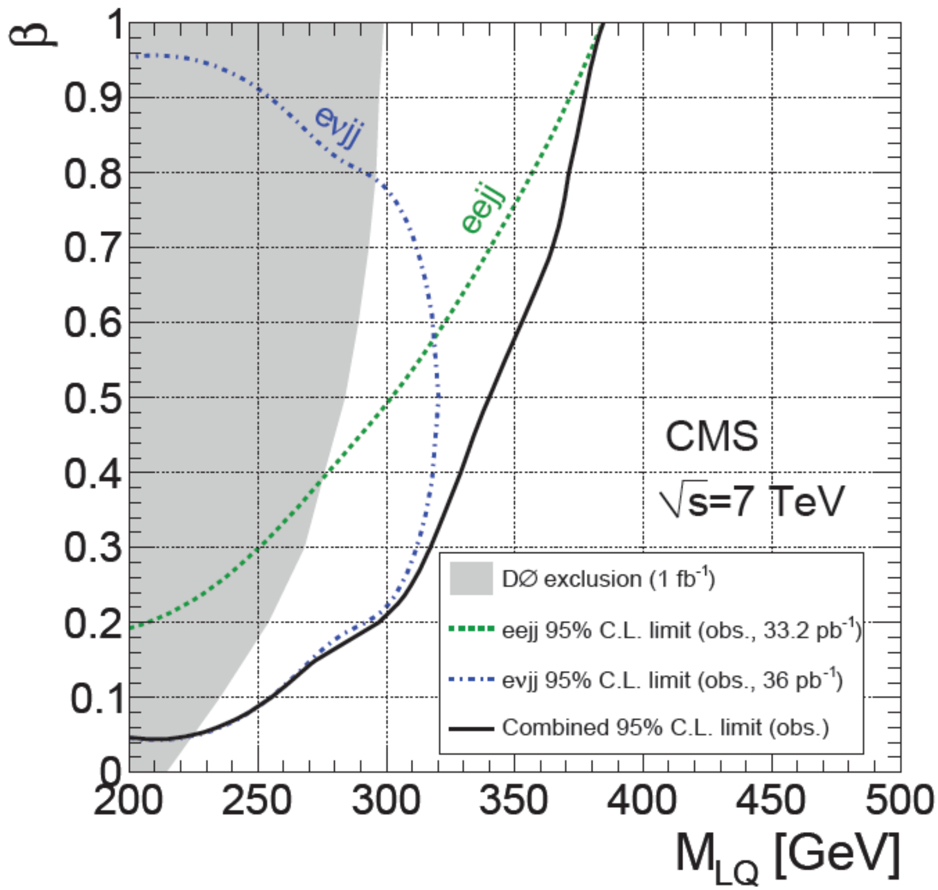
- Integrated luminosity: 36 pb^{-1}
- Discriminant variables: $M_T(W \rightarrow e\nu)$ and $S_T = p_T(e) + E_T^{miss} + E_T(j1) + E_T(j2)$

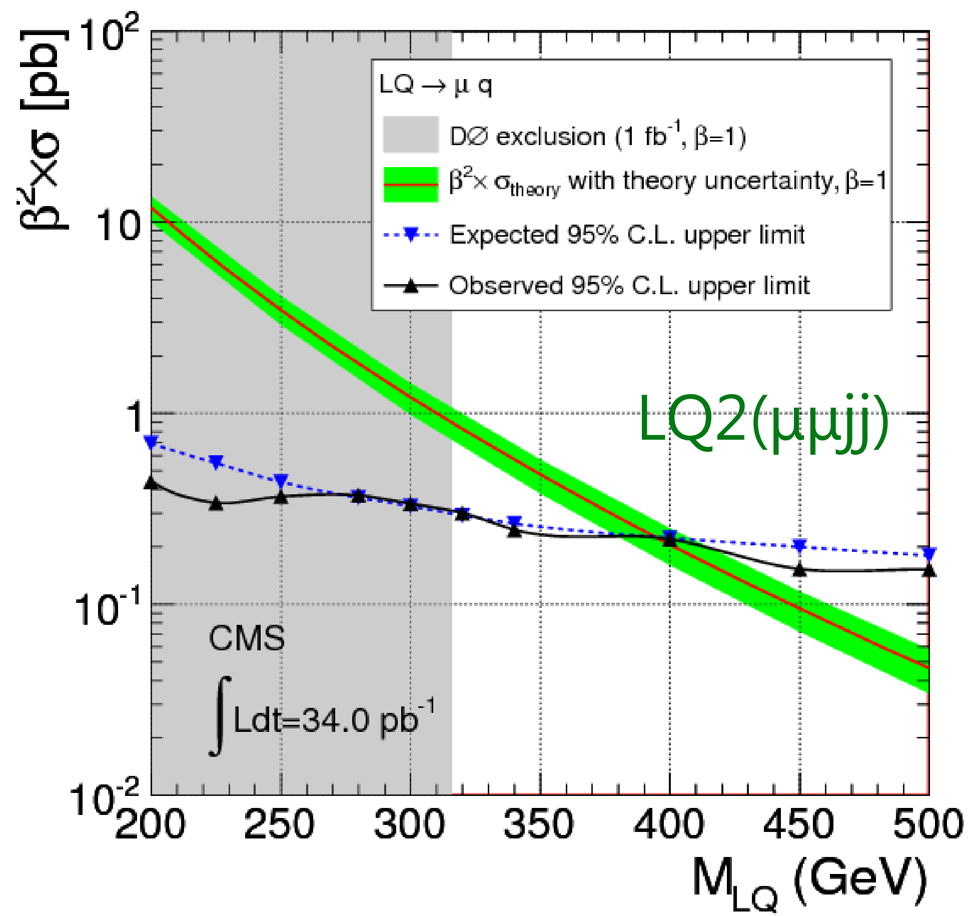




- **Preselection :** $S_T > 250$ GeV.
- **Final selection:** min(MET, p_T^e)>85 GeV, $M_T(e\nu)$>125 GeV, S_T optimized as a function of M_{LQ}
- In absence of excess of data with respect to predictions, we set an upper limit on the cross section production of a scalar first-generation LQ

Results: searches for scalar Leptoquarks





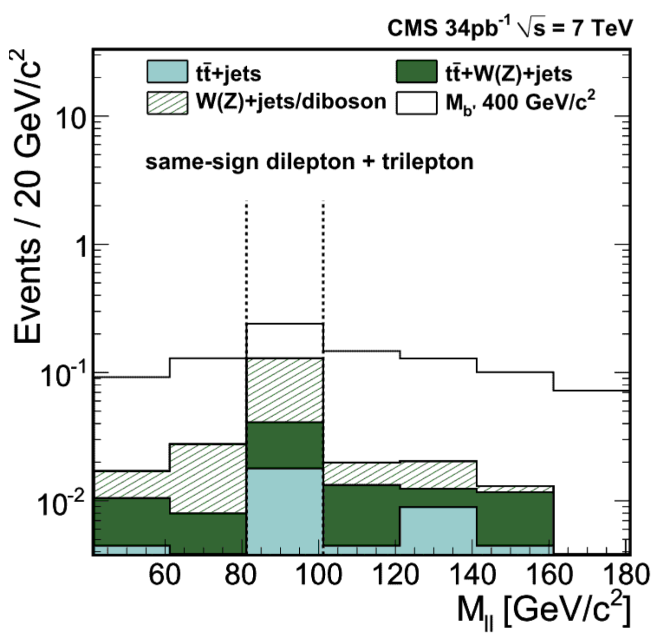
New combined limit on the mass of a scalar LQ1 : M_{LQ1}>384,340 GeV/c^2, β = 1, 0.5

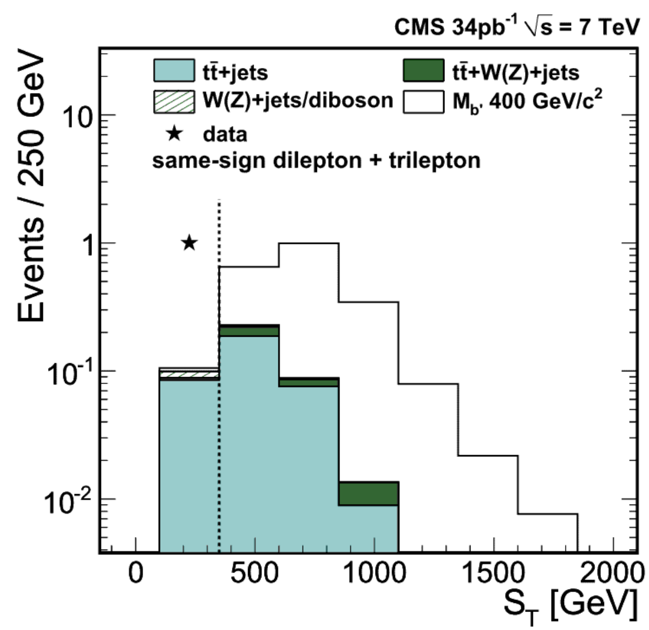
New limit on the mass of a scalar LQ2 : M_{LQ2} > 394 (394 exp.) GeV/c^2, β = 1

Significant extension of the parameter space excluded by the Tevatron experiments

Search for the 4th generation: b'

- Heavy, pair-produced b', each b' decays: $b' \to tW \to bWW$
  Each W can decay leptonically ($W \to l\nu$) or hadronically ($W \to jj$)
- Like-sign dileptons (e, μ) and trileptons (2 OS + 1) + jets
- Selection:
  - lepton (e/μ) $p_T > 20$ GeV
  - at least 2 (4) jets $p_T > 25$ GeV for tri-lepton (like-sign dilepton)
  - Z veto: |M(ll) – M(Z) |<10 GeV
  - S_T = Sum p_T(jets)+p_T(leptons)+MET >350 GeV

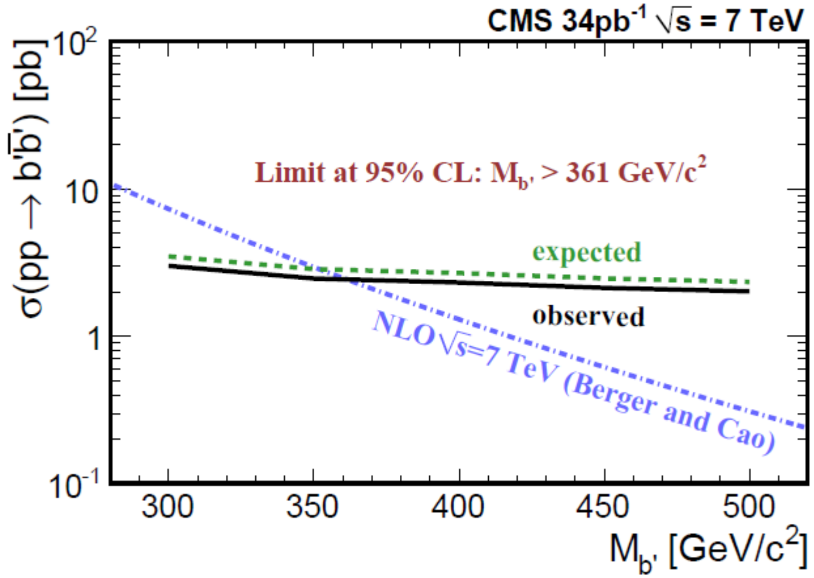




- Signal efficiency: for M=350 GeV, ε = 3.75%
- N background = 0.3 ±0.2 (tt+jets)

Search for the 4th generation: b'

- **Background measurement:**
  - tt+jets, V+jets normalized to the CMS measured cross sections. Dibosons from NLO MCFM
  - For SS dilepton channel, tt background = single-lepton tt +1 mis-ID or non-iso lepton, or dilepton tt with a charge mis-ID electron. Backgrounds are estimated from data
  - trilepton channel: control region with the same criteria as for signal, but only two OS leptons. Normalization between B in the signal region/B in control region: from M
- **Systematic uncertainties**
  - Dominant on B: bias of control-to-signal ratio methods = 56%. Total = 65%
  - Dominant on S : lepton selecton (13%). Total = 13%
- **Limit on $M_{b'}$ at 95%C.L.**
  - Bayesian method with log-normal prior for nuisance parameters
  - **$M_{b'}$>361 GeV**
    (CDF limit ~5 fb^{-1}: 371 GeV)



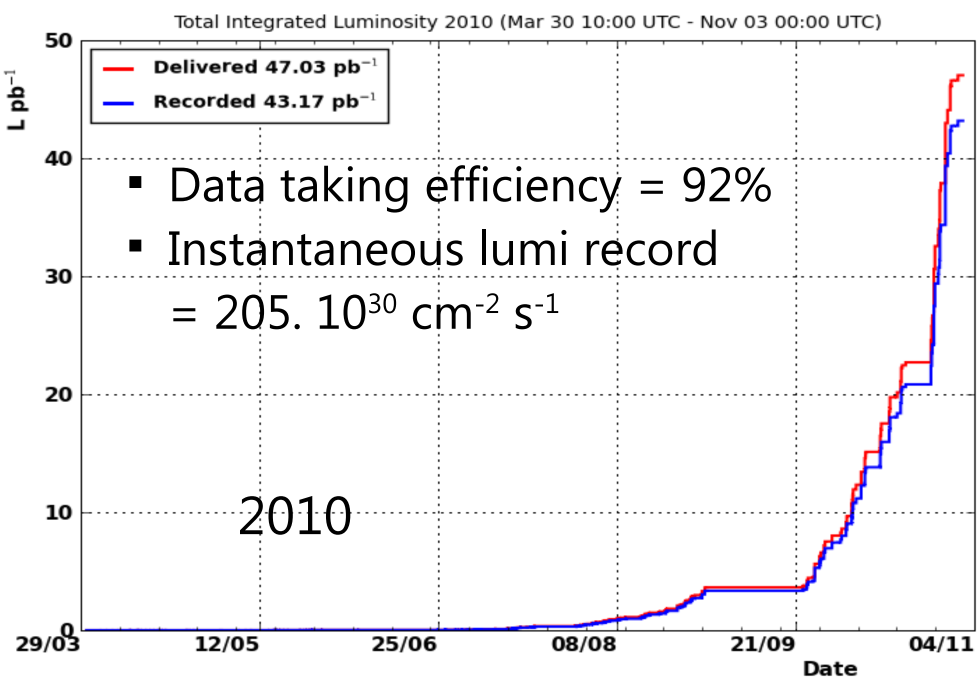
Conclusion

- Searches for leptoquarks and heavy quarks at CMS have been presented, 35 pb^{-1}
  - No excess found in 2010 data
- Leptoquark searches:
  - Many channels analyzed at CMS, new limits exceed Tevatron limits in a wide β range
  - These results are among the first CMS publications
  - Final-state driven searches, high reach to new phenomena
  - Data-driven techniques to estimate some of the major background contributions
- These analyses demonstrate a good understanding of the standard backgrounds
- With 2011 data:
  - Deploy all data-driven techniques after adapting them to new conditions (pileup)
  - Even more discovery potential!

Backup slides

LHC available datasets

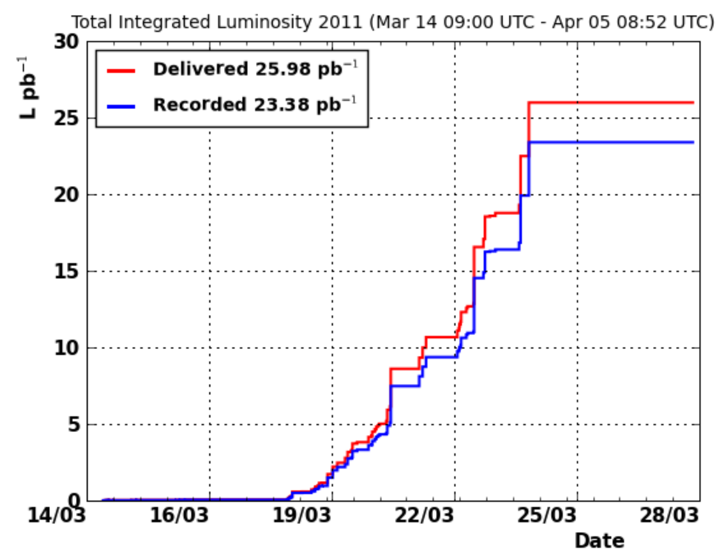
- The LHC runs at sqrt(s)=7 TeV since mars 2010: excellent performances
- In 2010, CMS accumulated more than 40 pb^{-1} of proton-proton collisions



- Data taking efficiency = 92%
- Instantaneous lumi record = $205.\ 10^{30}\ cm^{-2}\ s^{-1}$

2010

2011



- All results presented here based on 2010 data
- Few fb^{-1} at 7 and 8 TeV expected in the next years

LQ signal samples

- We have generated 9 signal samples
  - **PYTHIA**, Tune **D6T**, in CMSSW_3_5_6 (Spring10):
  - for mass points from 200 to 500 GeV

LQ mass (GeV)	Events Generated	σ_{NLO} (pb) $\mu = M_{LQ}$	$\mu = M_{LQ}/2$	$\mu = 2M_{LQ}$	δ_σ (pb) from PDF Uncertainty
200	108928	11.9	13.5	10.2	.972
250	111609	3.47	3.93	2.99	.370
280	105830	1.82	2.05	1.56	.218
300	108351	1.21	1.37	1.04	.157
320	105720	0.824	.930	.708	.114
340	106315	0.570	.644	.489	.0841
400	101985	0.205	.232	.176	.0356
450	104333	0.0949	.107	.0811	.0185
500	108442	0.0463	.0523	.0395	.0100

Thanks to M. Krämer for providing NLO cross sections

More about background MC samples

- The following Spring10 SM background samples (Tune D6T) were used:
  - ttbar+jets → generated with MadGraph
  - W+jets → generated with Alpgen in bins of p_T and N_{jets}
  - Z/γ+jets → generated with Alpgen in bins of p_T and N_{jets}
  - VV (V=W, Z) → generated with PYTHIA
  - Single top → generated with MadGraph
- Additional Fall10 samples (Tune D6T):
  - b+jets → generated with MadGraph
  - γ+jets → generated with MadGraph
- Cross sections from the CMS Standard Model cross sections TWiki were used
  - Additional data-driven rescaling applied to V+jets background

Systematic uncertainties

eejj

Systematic Uncertainty	Magnitude [%]	Effect on N_{signal} [%]	Effect on $N_{All\,Bkg}$ [%]
Data-Driven Uncertainty	-	-	22
Z/γ^*+jets Background Shape	20	-	11
Jet Energy Scale	5	3	11
Elec. Energy Scale Barrel/Endcap	1/3	1	5
Electron Pair Reco/ID/Iso	10	10	-
MC Statistics	-	1	6
Integrated Luminosity	11	11	-
Total	-	15	28

$\mu\mu jj$

Systematic Uncertainty	Magnitude	Effect on Signal	Effect on Background
JES	5%	2%	–
JES & Data Backgr. Est.	–	–	26%
Muon Momentum Scale	1%	1%	$< 0.5\%$
Muon Pair Reco/ID/Iso	10%	10%	$< 0.05\%$
Integrated Luminosity	11%	11%	–
Total		15%	26%

$e\nu jj$

Systematic uncertainty	Magnitude [%]	Effect on signal eff [%]	Effect on bkg [%]
Background normalization	See text	-	13
W+jets shape	43	-	17
Jet energy scale	5	5	7
Électron momentum scale	1-4	1	3
MC Statistics		0,4	9
EM trigger/reco/ID/iso	3-10	6	-
Total		8	25

Optimization

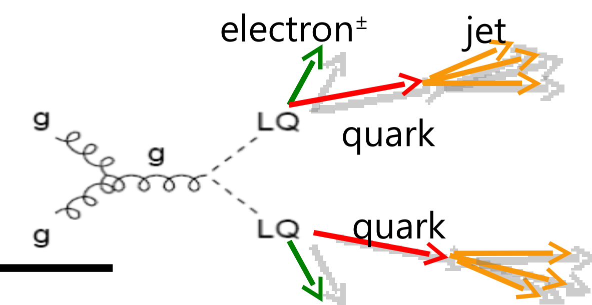
eejj:

M_{LQ} (S_T Cut) [GeV]	Signal Samples (MC) Selected Events	Acceptance $\times$Efficiency	Standard Model Background Samples (MC) Selected Events in $t\bar{t}$ + jets	Z/γ^*+ jets	Others	All	Events in Data	Obs./Exp. 95% C.L. u.l. on σ [pb]
200 (S_T >340)	117.5±0.8	0.297±0.002	2.6 ±0.1	2.0 ±0.2	0.27±0.05	4.9 ±0.2	2	0.441 / 0.720
250 (S_T >400)	43.8±0.2	0.380±0.002	1.3 ±0.1	1.3 ±0.1	0.14±0.02	2.7 ±0.1	1	0.309 / 0.454
280 (S_T >450)	24.4±0.1	0.403±0.002	0.69±0.05	0.87±0.07	0.10±0.02	1.7 ±0.1	1	0.305 / 0.373
300 (S_T >470)	17.3±0.09	0.430±0.002	0.52±0.05	0.75±0.07	0.10±0.02	1.4 ±0.1	1	0.292 / 0.332
320 (S_T >490)	12.3±0.06	0.451±0.002	0.43±0.04	0.65±0.07	0.08±0.02	1.2 ±0.1	1	0.283 / 0.305
340 (S_T >510)	8.88±0.04	0.469±0.002	0.32±0.04	0.56±0.06	0.08±0.02	0.96±0.08	1	0.278 / 0.279
370 (S_T >540)	5.55±0.02	0.496±0.002	0.26±0.03	0.47±0.06	0.07±0.02	0.80±0.07	1	0.267 / 0.254
400 (S_T >560)	3.55±0.02	0.522±0.002	0.20±0.03	0.41±0.05	0.06±0.02	0.67±0.07	1	0.257 / 0.234
450 (S_T >620)	1.70±0.01	0.539±0.002	0.12±0.02	0.28±0.05	0.02±0.01	0.42±0.06	0	0.174 / 0.210
500 (S_T >660)	0.868±0.003	0.565±0.002	0.08±0.02	0.23±0.05	0.02±0.01	0.33±0.05	0	0.166 / 0.194

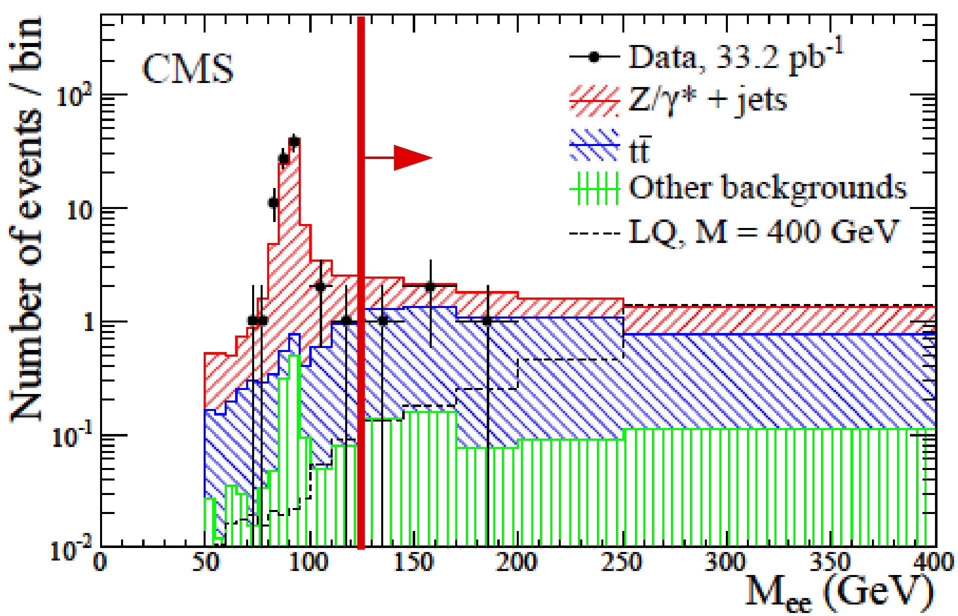
mumujj:

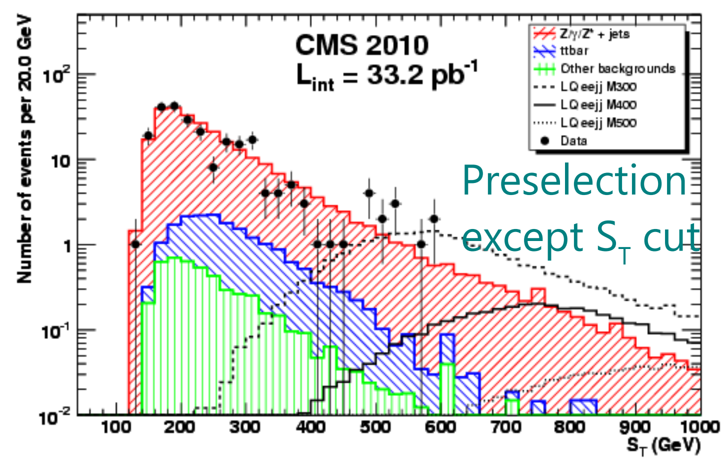
M_{LQ} (S_T Cut) [GeV]	MC Signal Samples Selected Events	Acceptance $\times$ Efficiency	Monte Carlo Background Samples Selected Events in $t\bar{t}$ + jets	Z/γ^* +jets	Others	All	Events in Data	Obs./Exp. 95% C.L. u.l. on σ [pb]
200 (S_T > 310)	160±20	0.388±0.003	4.6±0.1	4.08±0.07	0.1±0.01	8.8±0.2	5	0.438 / 0.695
225 (S_T > 350)	89±9	0.421±0.003	3.1±0.1	2.99±0.05	0.07±0.01	6.2±0.1	3	0.339 / 0.547
250 (S_T > 400)	51±5	0.437±0.003	1.88±0.09	1.92±0.04	0.051±0.009	3.9±0.1	3	0.366 / 0.436
280 (S_T > 440)	28±3	0.467±0.003	1.15±0.07	1.53±0.03	0.038±0.008	2.72±0.08	3	0.371 / 0.361
300 (S_T > 440)	21±2	0.518±0.004	1.15±0.07	1.53±0.03	0.038±0.008	2.72±0.08	3	0.335 / 0.326
320 (S_T > 490)	14±1	0.509±0.004	0.64±0.05	1.12±0.02	0.019±0.005	1.78±0.06	2	0.300 / 0.292
340 (S_T > 530)	9±1	0.508±0.003	0.4±0.04	0.79±0.01	0.01±0.004	1.20±0.04	1	0.245 /0.264
400 (S_T > 560)	4.0±0.4	0.578±0.004	0.31±0.04	0.67±0.01	0.01±0.004	0.99±0.04	1	0.219 / 0.222
450 (S_T > 620)	1.9±0.2	0.600±0.004	0.19±0.03	0.49±0.01	0.006±0.003	0.69±0.03	0	0.153 / 0.199
500 (S_T > 700)	0.9±0.1	0.602±0.004	0.09±0.02	0.277±0.006	0.003±0.002	0.37±0.02	0	0.152 / 0.180

Search for LQ1 LQ1 → eejj

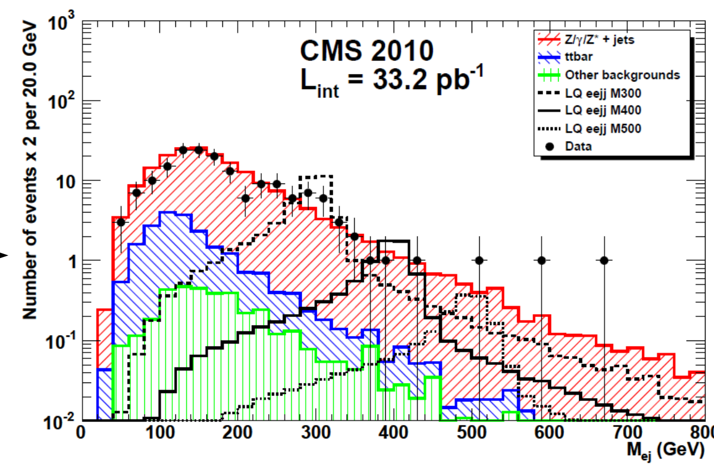


- Integrated luminosity : 33.2 pb^{-1}
- Discriminant variables : M(Z→ee) et $S_T = p_T(e1) + p_T(e2) + E_T(j1) + E_T(j2)$
- **Preselection :** M(ee)>50 GeV, S_T>250 GeV

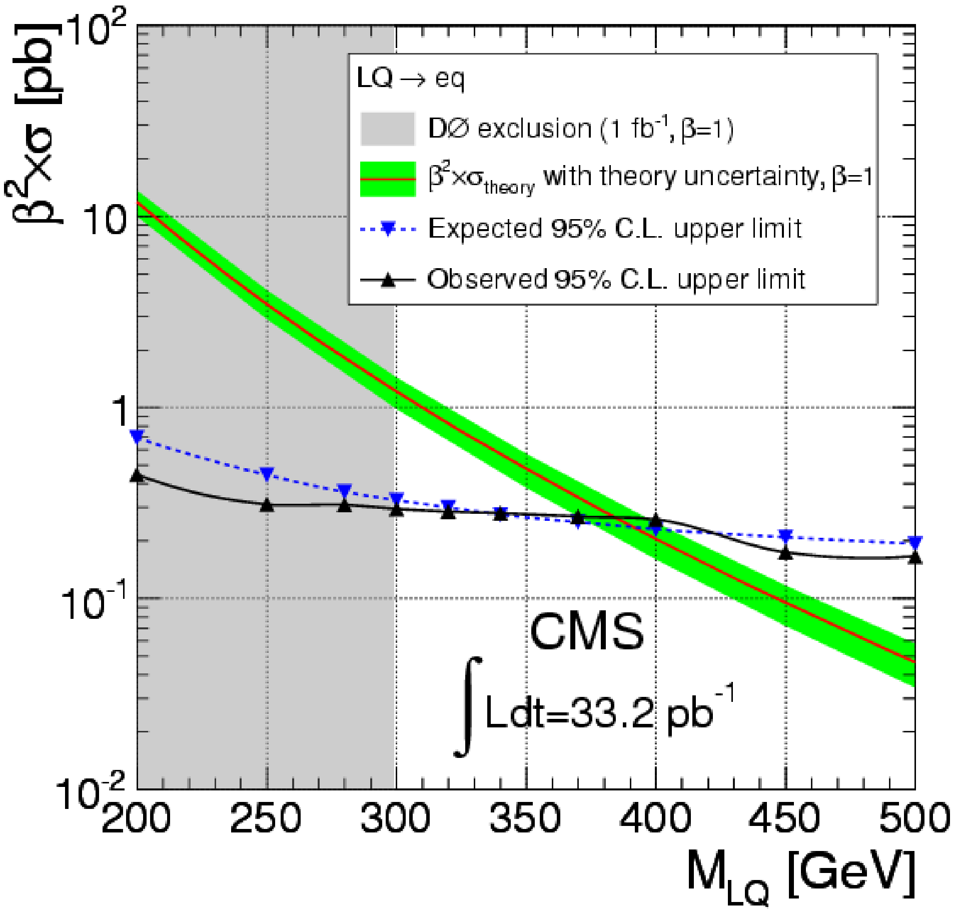


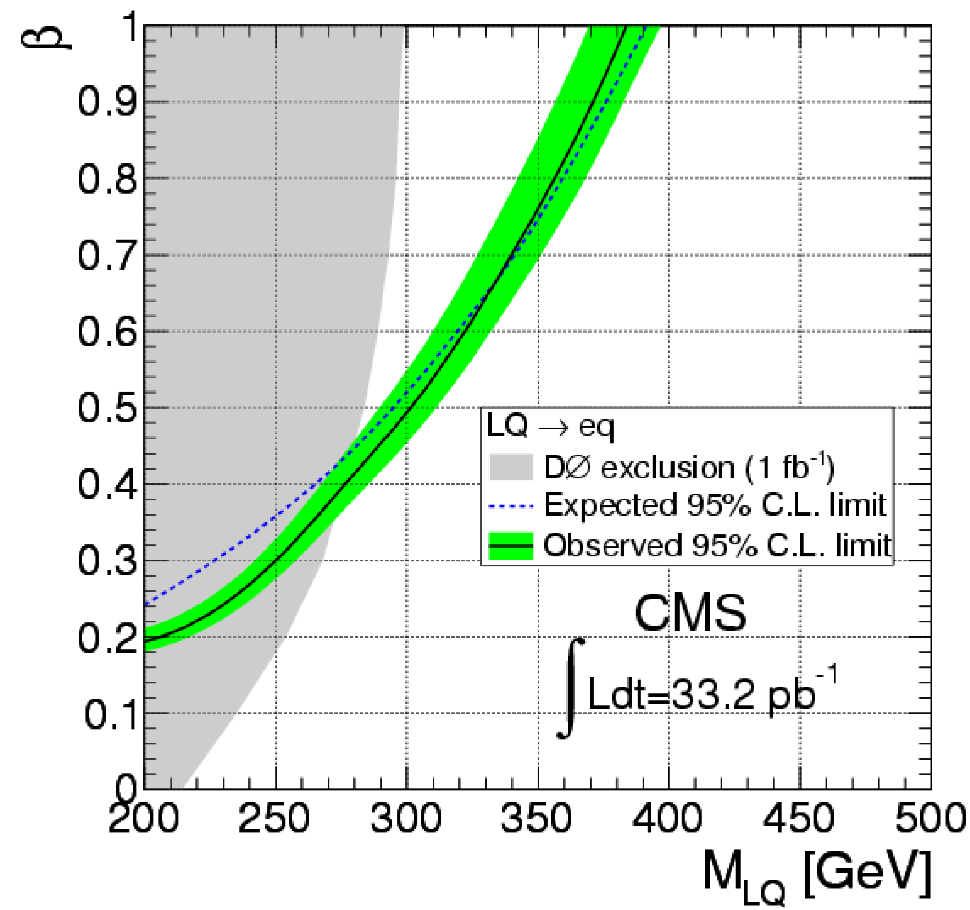


Leptoquark invariant mass: →
(less powerful than S_T because of ISR/FSR)



Search for LQ1 LQ1 → eejj

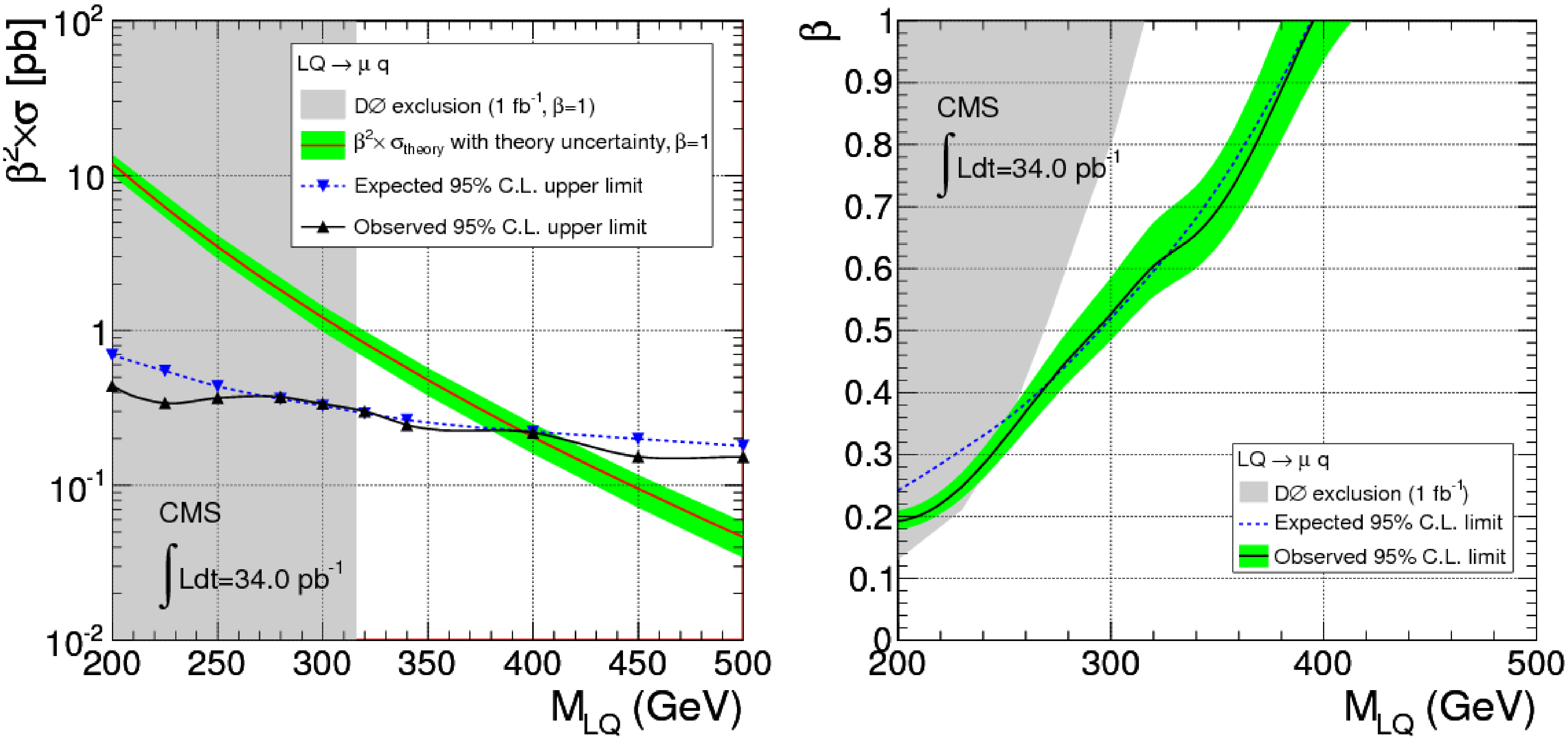




New limit on the mass of a scalar LQ1 : M_{LQ1} > 384 (391 exp.) GeV/c^2, β = 1

Significant extension of the excluded parameter space by the Tevatron experiments (299)

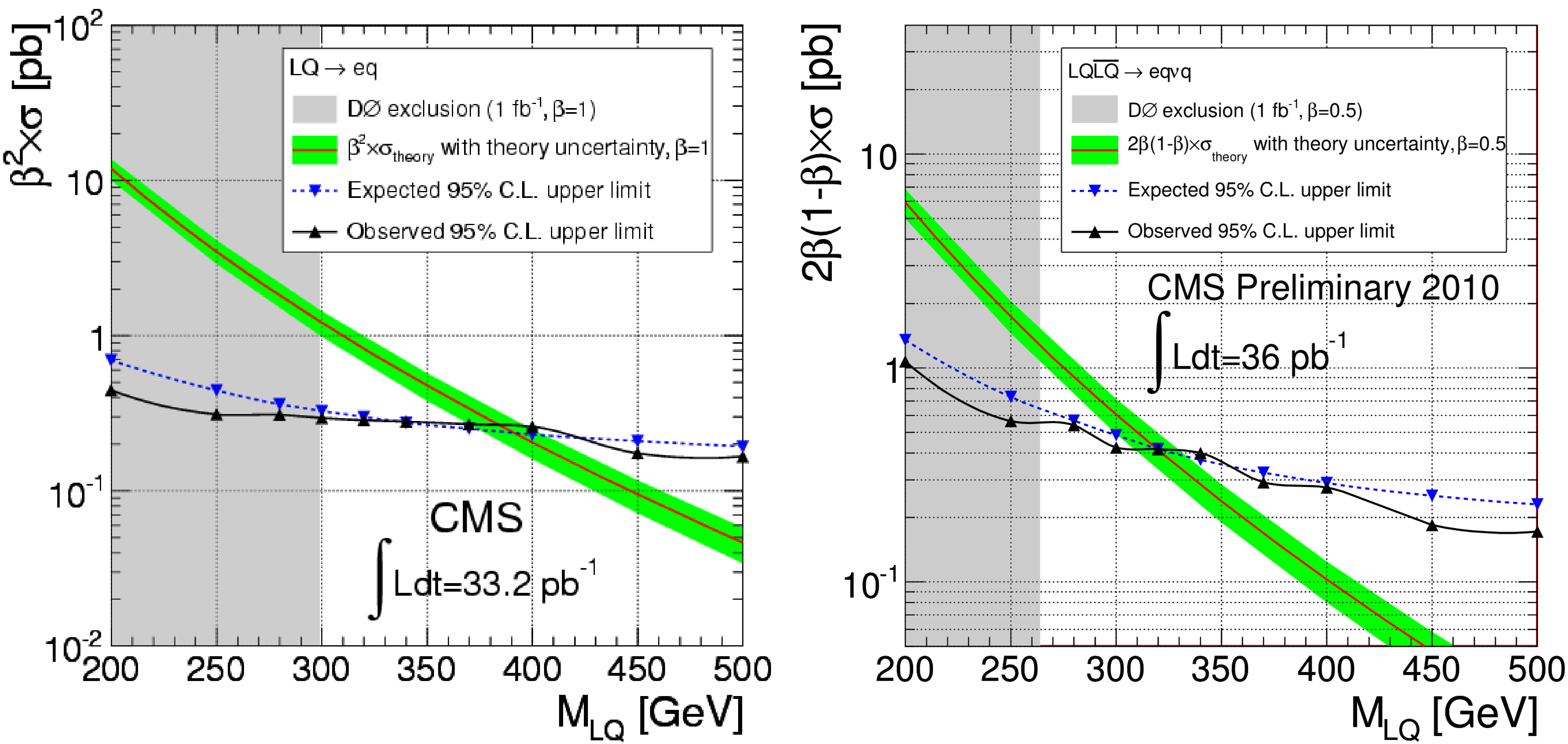
Search for LQ2 LQ2 → μμjj



New limit on the mass of a scalar LQ2 : M_{LQ2} > 394 (394 exp.) GeV/c^2, β = 1

Significant extension of the parameter space excluded by the Tevatron experiments (316)

Searches for LQ1 LQ1 → eejj or eνjj

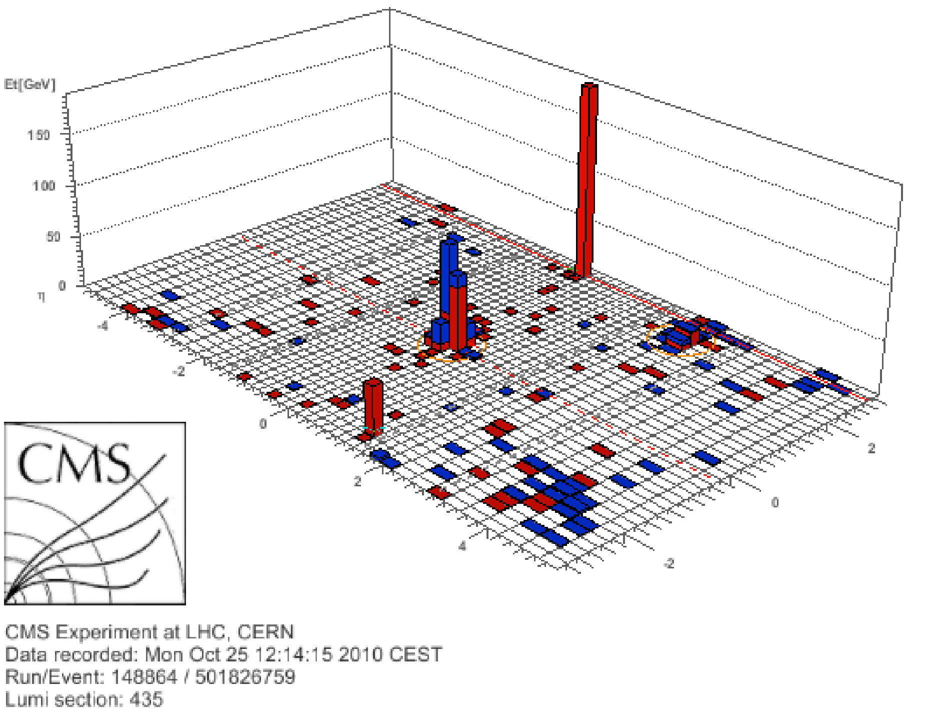


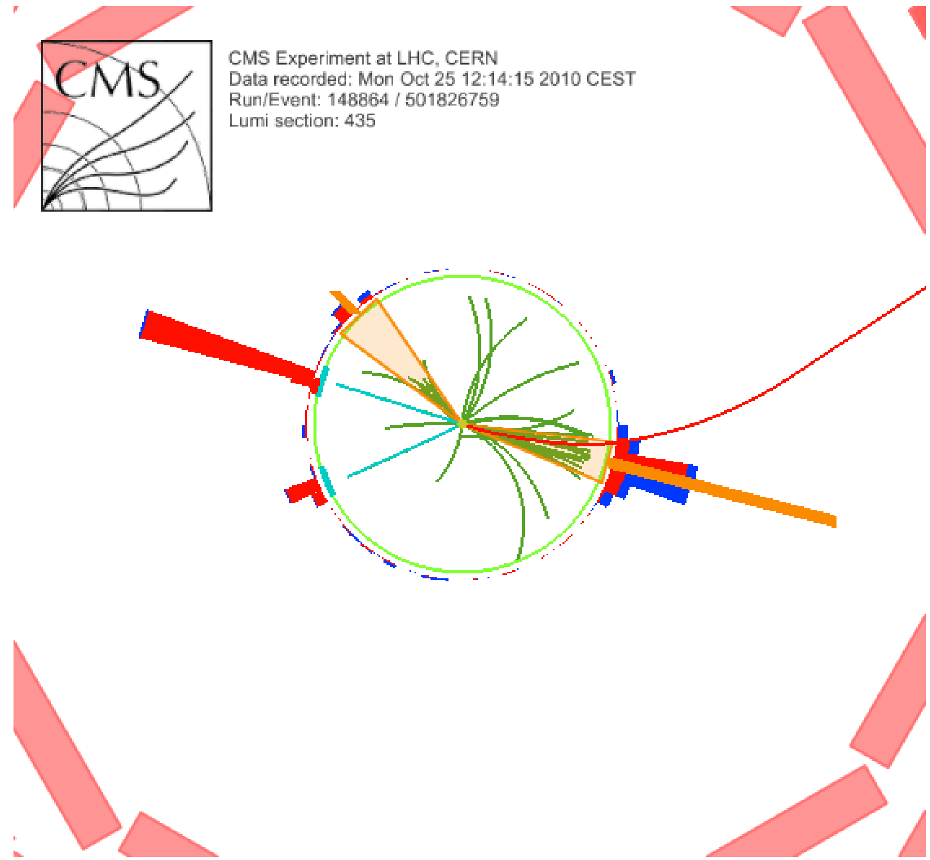
New limit on the mass of a scalar LQ1 : M_{LQ1} > 384 (391 exp.) GeV/c², β = 1

M_{LQ1} > 320 (320 exp.) GeV/c², β = 0.5

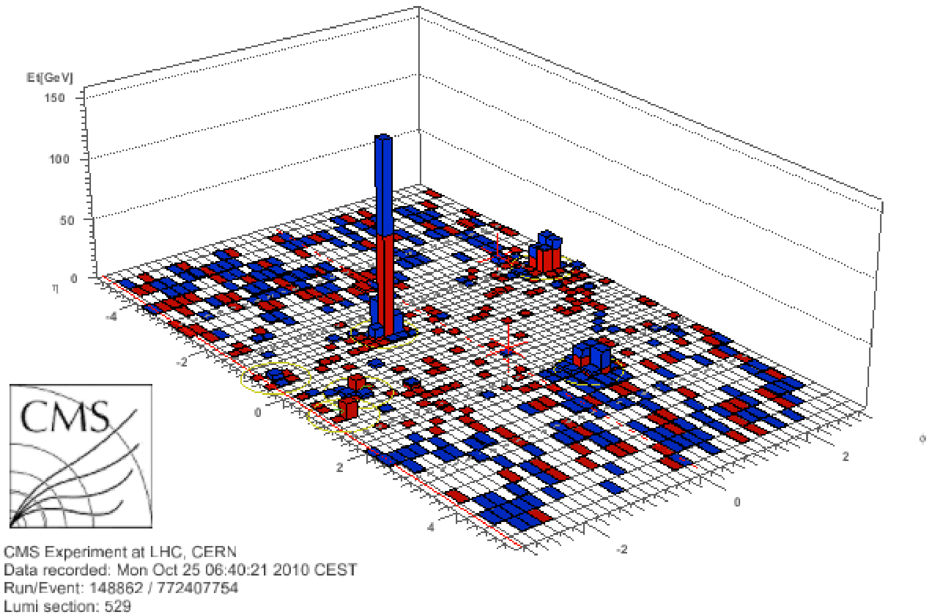
Significant extension of the excluded parameter space by the Tevatron experiments (299)

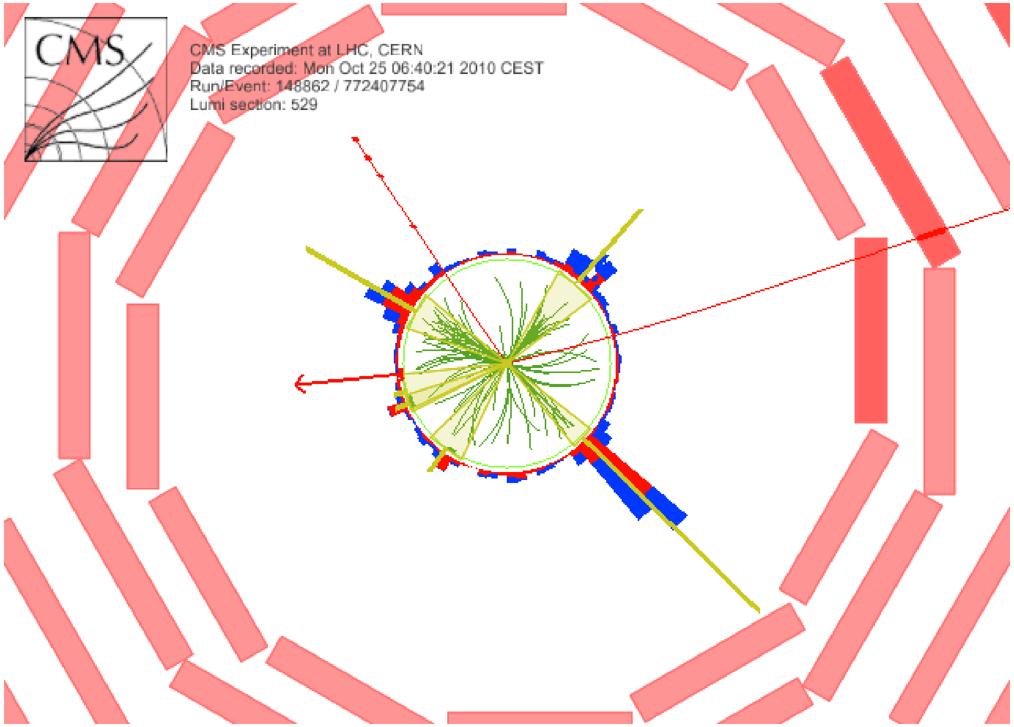
Event display (eejj)



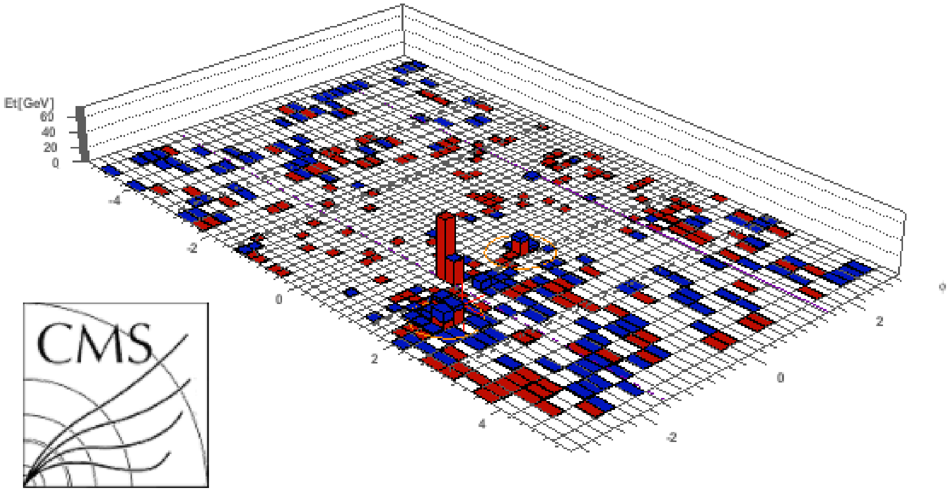


Event display (μμjj)

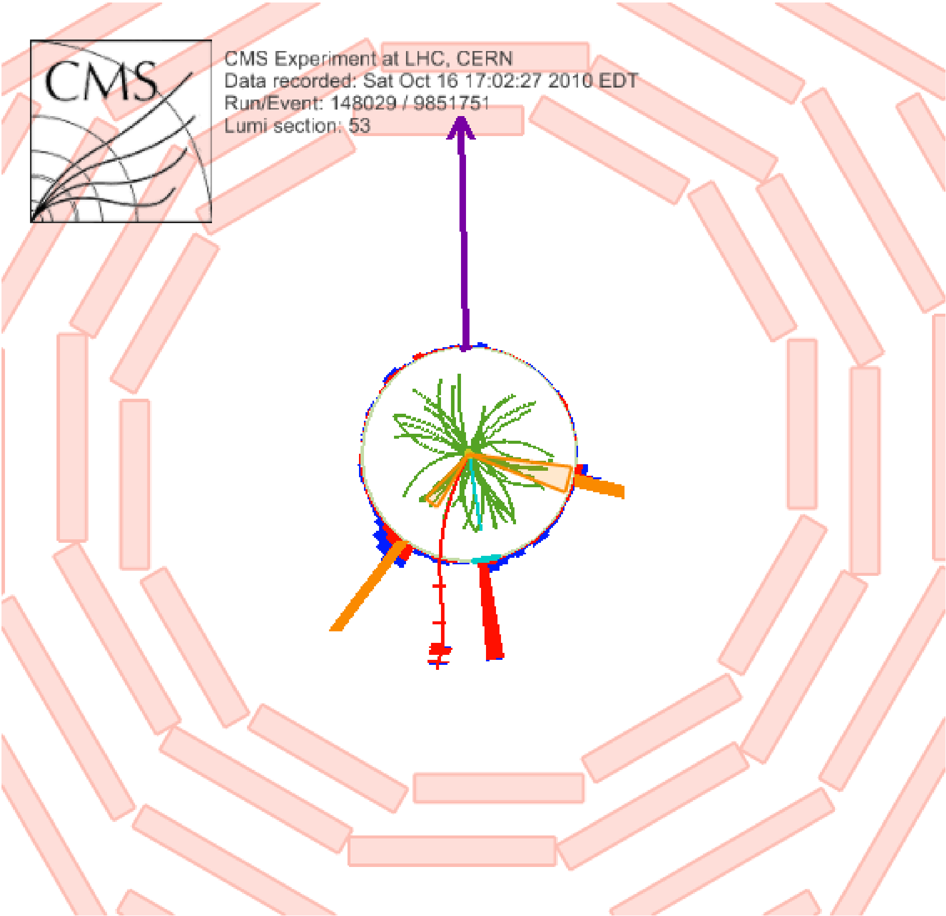




Event display (evjj)



CMS Experiment at LHC, CERN
Data recorded: Sat Oct 16 17:02:27 2010 EDT
Run/Event: 148029 / 9851751
Lumi section: 53



S_{cP} method

S_{cP} method for discovery

To quantify the significance of the leptoquark signal, S_{cP} significance estimator [19] is used. S_{cP} assumes a Poisson distribution with mean b and gives the probability to observe $n = s + b$ events or greater

$$P = p(n \geq s + b|b) = \sum_{n=s+b}^{+\infty} \frac{b^n}{n!} e^{-b}, \tag{4}$$

where s and b are the expected numbers of signal and background events, respectively. This probability is converted into an equivalent number of standard deviations using the one-sided Gaussian probability

$$P = \frac{1}{\sqrt{2\pi}} \int_{S_{cP}}^{+\infty} e^{-\frac{x^2}{2}} \mathrm{d}x, \tag{5}$$

which gives the numerical value of the S_{cP} significance. If the background has uncertainties, which we can express in terms of a probability density function $f(b)$, the probability to observe $n = s + b$ events or greater becomes

$$P = \int_0^{+\infty} p(n \geq s + b|b') f(b') \mathrm{d}b', \tag{6}$$

and the final S_{cP} significance is again obtained using Eq. 5. For $f(b')$, a Gaussian probability density function centered at b with a standard deviation σ_b given by the uncertainty on b was used. Figure 13 shows the required

Types de leptoquarks et couplages

- Modèle de Buchmüller-Rückl-Wyler
  - Couplage total λ_{eff} = combinaison linéaire des couplages $\lambda_{L,R}(lq)$ et $\lambda_L(\nu q)$
    e.g.: type $V_{2\mu}$ (Q=+4/3)
    $\lambda^2_{eff} = g_{2L}{}^2 + g_{2R}{}^2$
  - λ_{eff} choisi pour la génération du signal…
  - choix de λ_{eff} détermine la largeur de désintégration du LQ :

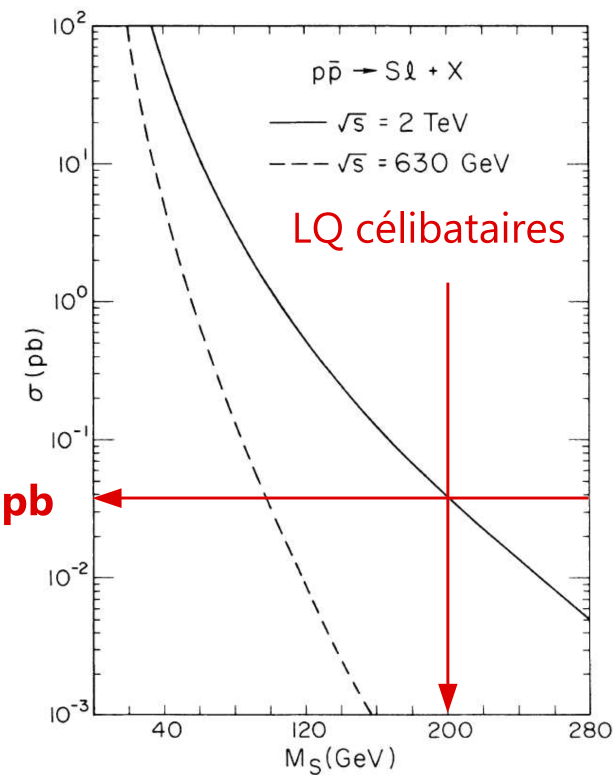
$$\Gamma = M_{LQ}\frac{\lambda^2_{eff}}{n\pi}$$

LQ	Spin	F	I_3	Q_{em}	$\lambda_L(lq)$	$\lambda_R(lq)$	$\lambda_L(\nu q)$	Couplages
S_1	0	-2	0	$+1/3$	g_{1L}	g_{1R}	$-g_{1L}$	$\bar{q}^c_L l_L$ ou $\bar{u}^c_R e_R$
$\tilde{S}_1$	0	-2	0	$+4/3$	0	$\tilde{g}_{1R}$	0	$\bar{d}^c_R e_R$
$\vec{S}_3$	0	-2	$+1$	$+4/3$	$-\sqrt{2}g_{3L}$	0	0	$\bar{q}^c_L l_L$
			0	$+1/3$	$-g_{3L}$	0	$-g_{3L}$	
			-1	$-2/3$	0	0	$\sqrt{2}g_{3L}$	
$V_{2\mu}$	1	-2	$+1/2$	$+4/3$	g_{2L}	g_{2R}	0	$\bar{d}^c_R\gamma^\mu l_L$ ou $\bar{q}^c_L\gamma^\mu e_R$
			$-1/2$	$+1/3$	0	g_{2R}	g_{2L}	
$\tilde{V}_{2\mu}$	1	-2	$+1/2$	$+1/3$	$\tilde{g}_{2L}$	0	0	$\bar{u}^c_R\gamma^\mu l_L$
			$-1/2$	$-2/3$	0	0	$\tilde{g}_{2L}$	
R_2	0	0	$+1/2$	$+5/3$	h_{2L}	h_{2R}	0	$\bar{u}_R l_L$ ou $\bar{q}_L e_R$
			$-1/2$	$+2/3$	0	$-h_{2R}$	h_{2L}	
$\tilde{R}_2$	0	0	$+1/2$	$+2/3$	$\tilde{h}_{2L}$	0	0	$\bar{d}_R l_L$
			$-1/2$	$-1/3$	0	0	$\tilde{h}_{2L}$	
$U_{1\mu}$	1	0	0	$+2/3$	h_{1L}	h_{1R}	h_{1L}	$\bar{q}_L\gamma^\mu l_L$ ou $\bar{d}_R\gamma^\mu e_R$
$\tilde{U}_{1\mu}$	1	0	0	$+5/3$	0	$\tilde{h}_{1R}$	0	$\bar{u}_R\gamma^\mu e_R$
$\vec{U}_{3\mu}$	1	0	$+1$	$+5/3$	$\sqrt{2}h_{3L}$	0	0	$\bar{q}_L\gamma^\mu l_L$
			0	$+2/3$	$-h_{3L}$	0	h_{3L}	
			-1	$-1/3$	0	0	$\sqrt{2}h_{3L}$	

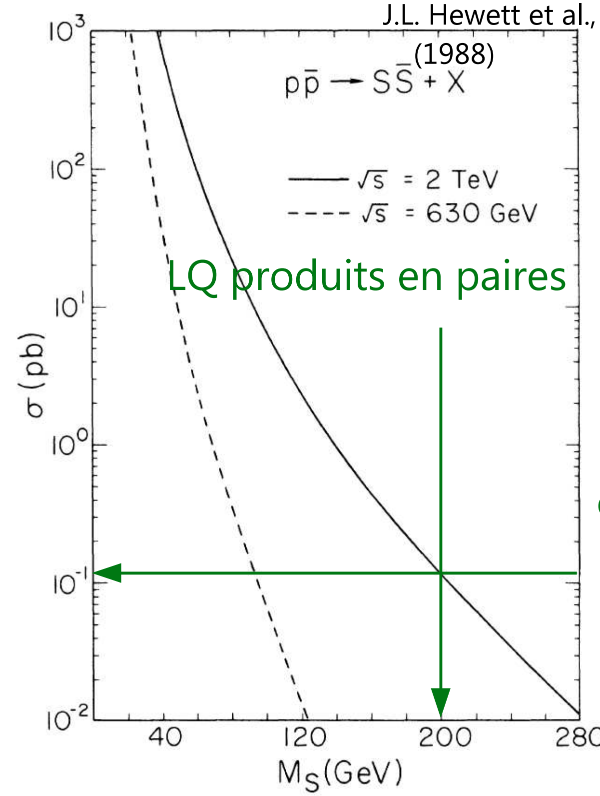
Des leptoquarks et des collisions

- Production (suite)
  - A √s = 2 TeV, la production de paires de LQ serait 2.5 fois plus importante que la production de LQ célibataire pour une masse M(LQ) de 200 GeV

J.L. Hewett et al., Phys. Rev. D 37 3165 (1988)



σ_s(200 GeV)~0.04 pb

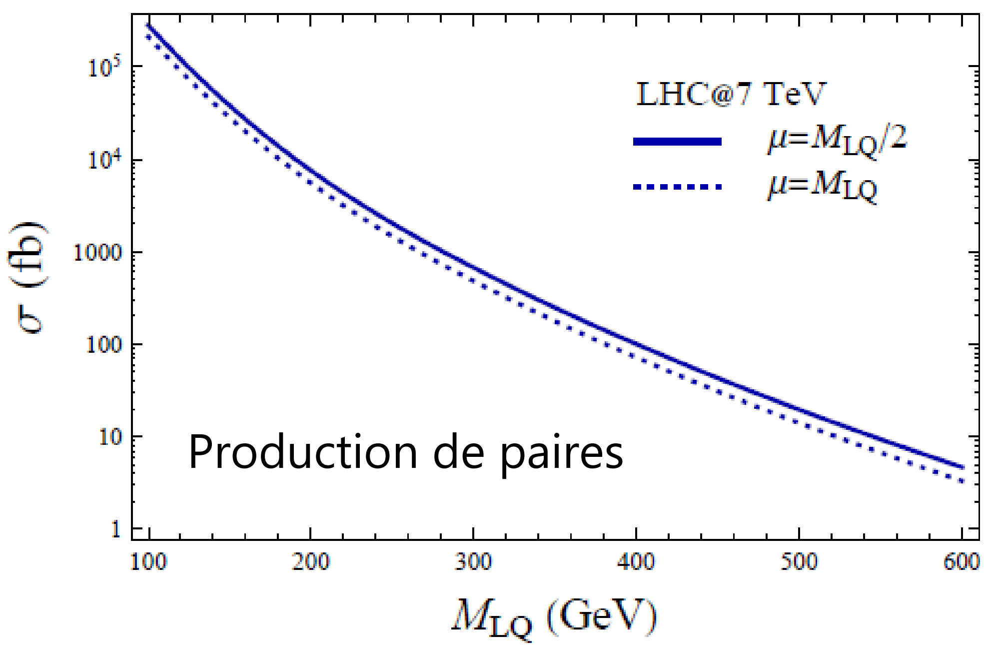


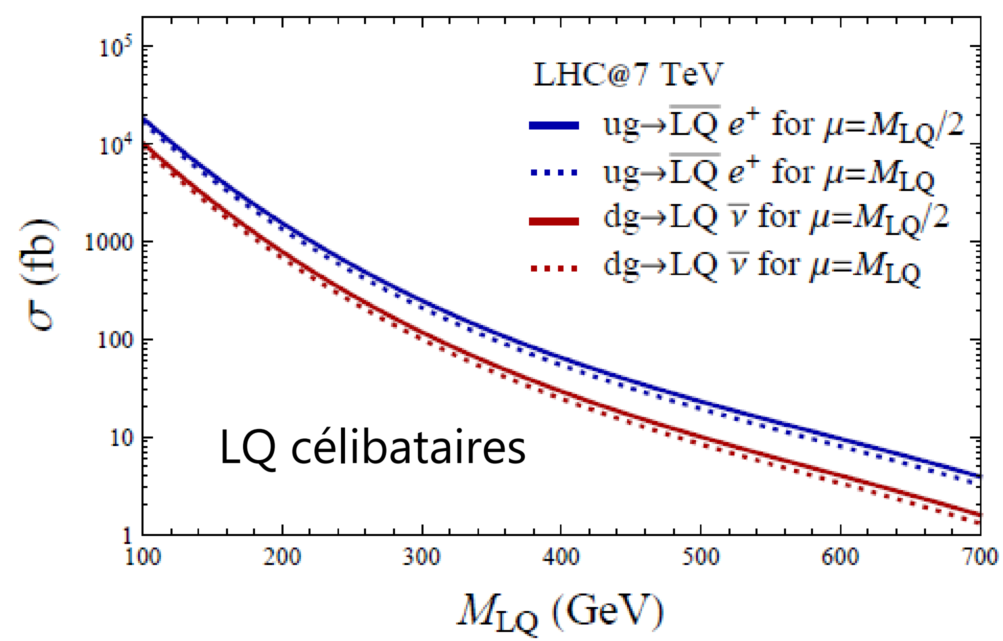
σ_p(200 GeV)~0.1 pb

Auprès des collisionneurs hadroniques, la production de paire domine pour M(LQ)<<1TeV

Des leptoquarks et des collisions

- Production (suite)
  - A $\sqrt{s}$ = 7 TeV, la production de LQ célibataire devient néanmoins comparable à la production de paires pour des masses de LQ élevées



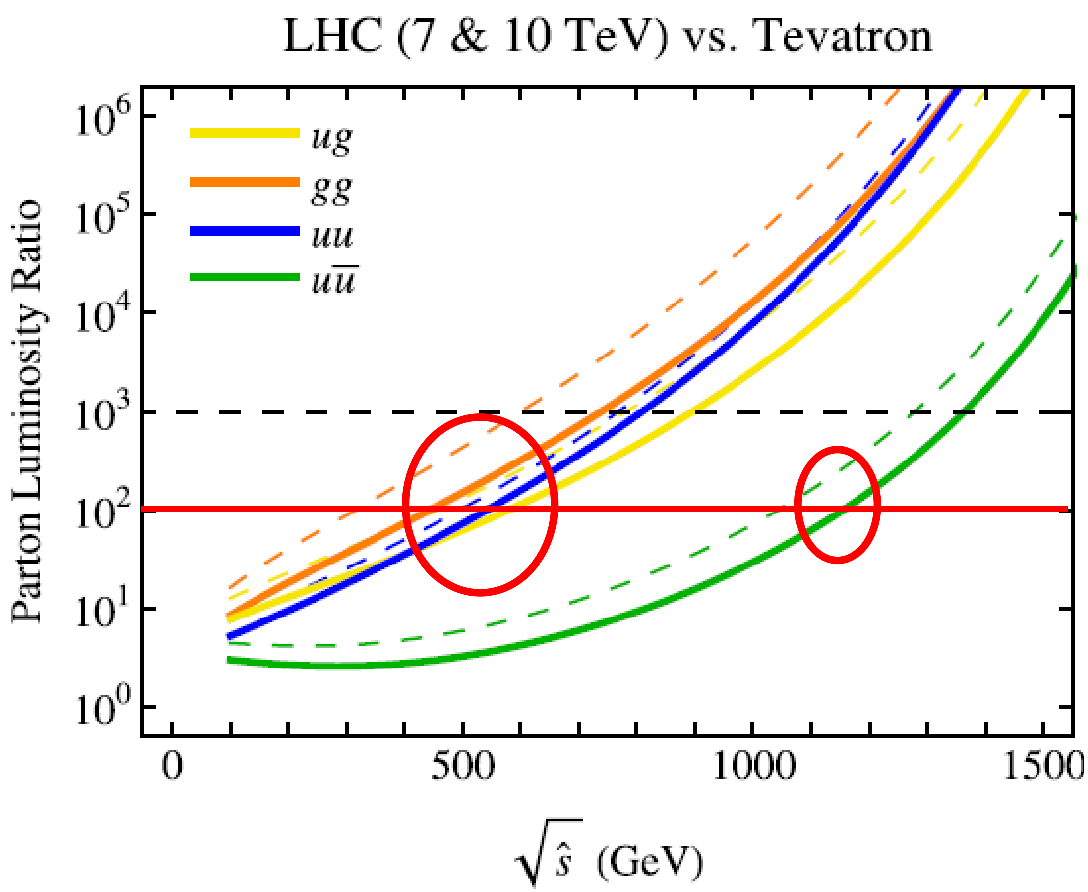


Recherche de LQ célibataires concurrente pour M_{LQ} > 500 GeV

Dans cette présentation, on se concentre sur la **production de paire** de LQ scalaires

Une machine de découvertes…

- Rapport des luminosités partoniques au LHC et au Tevatron > inverse du rapport des luminosités intégrées (100 ≈ 5 fb^{-1}/50 pb^{-1}) pour une énergie autour de 400-600 GeV (gg, qg, qq) et pour 1150 GeV ($q\bar{q}$)



- Intérêt particulier pour les objets de masses intermédiaires produits par fusion de gluons, interactions quark-gluon ou diquark

Bauer et al., Phys. Lett. B 690, 280 (2010)