

Search for leptoquarks in top quark final states at 13 TeV with CMS

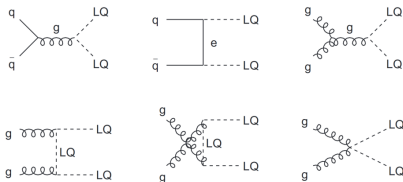
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28.11.2017



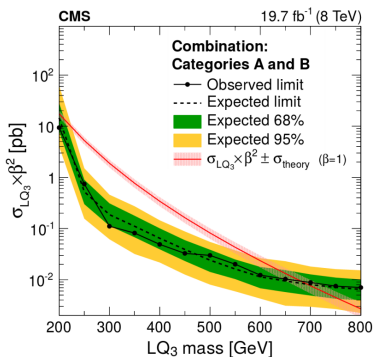
Leptoquarks - $LQ \rightarrow t + l$ decay channels

- Hypothetical new particles
- Predicted by many BSM theories
- Coupling to a lepton and a quark
- Fractional EM charge, Spin 0 or 1
- 13 TeV LHC: Pair-production dominating in $LQ \rightarrow t + l$ decay channel



Existing search (8 TeV)

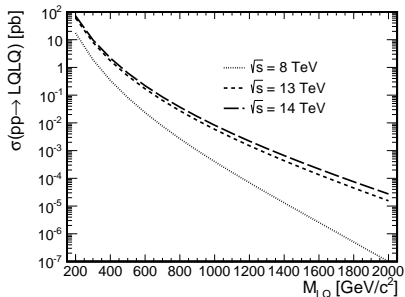
- $LQ \rightarrow t + \tau_{\text{had}}$ channel
exclusion limit: $M_{LQ} > 685 \text{ GeV}$
[JHEP 07 (2015) 042]



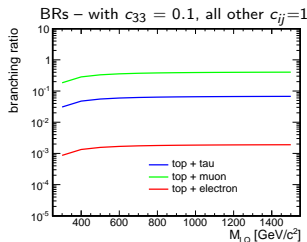
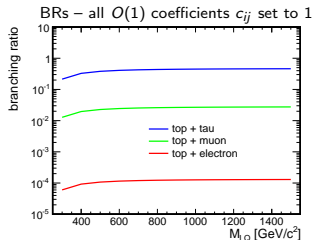
Motivation

Search for third generation LQ pairs in decay channels $LQ \rightarrow t\tau$ & $LQ \rightarrow t\mu$ at $\sqrt{s} = 13$ TeV

- Flavor anomalies in b sector e.g. [Phys. Rev. D 88 (2013) 094012]
- increasing cross section
- current limit for $t\tau$ channel: 685 GeV [JHEP 07 (2015) 042]
- $t\mu$ channel never investigated before

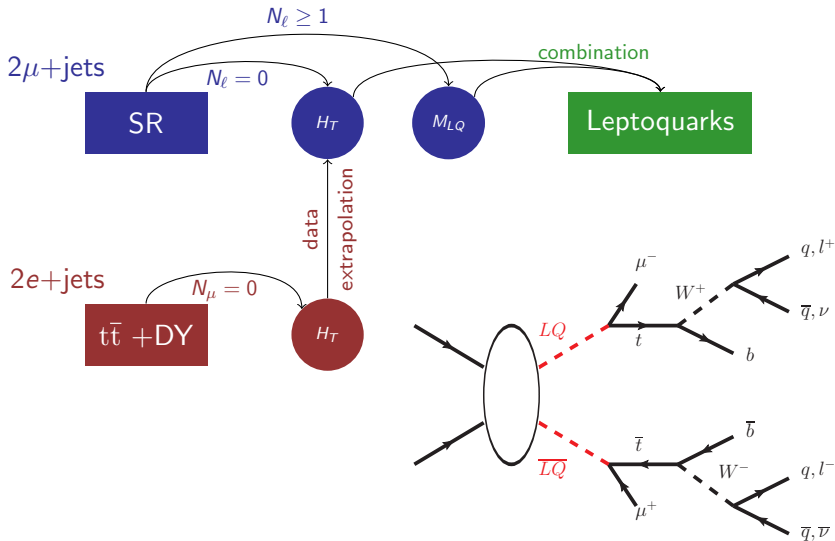


Example compositeness model:



based on JHEP 05 (2015) 006
[arXiv:1412.1791]

Search for $LQ \rightarrow t\mu$



M_{LQ} Reconstruction

Requirements/Assumptions

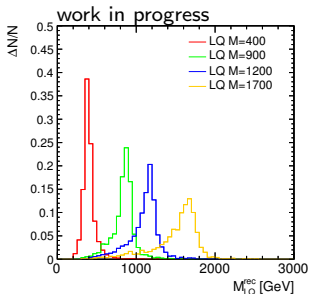
- LQ_{lep} : $W_{lep} \rightarrow e/\mu + \nu$
- LQ_{had} : $W_{had} \rightarrow q\bar{q}'$
- $N_{jets} \geq 2$
- $2\mu +$ at least 1 ℓ

top hypotheses

- 1 Reconstruct ν
- 2 Build hypotheses $t_{hyp}^{lep}(\nu, \ell, jets)$
- 3 Build hypotheses $t_{hyp}^{had}(jets)$

LQ hypotheses

- Build hypotheses $LQ_{hyp}^{lep}(t_{hyp}^{lep}, \mu^{os})$
- Build hypotheses $LQ_{hyp}^{had}(t_{hyp}^{had}, \mu^{ss})$
- Choose best set of hypotheses based on a χ^2
- Final $M_{LQ}^{rec} = (M_{LQ}^{had} + M_{LQ}^{lep})/2$

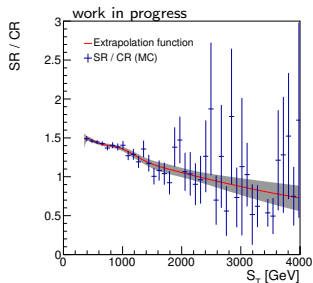
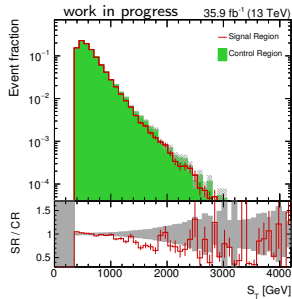


Background Estimation - $t\bar{t}$ + DY

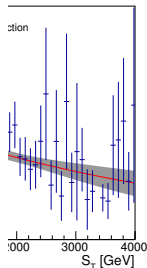
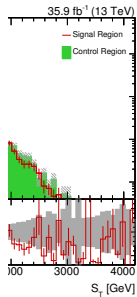
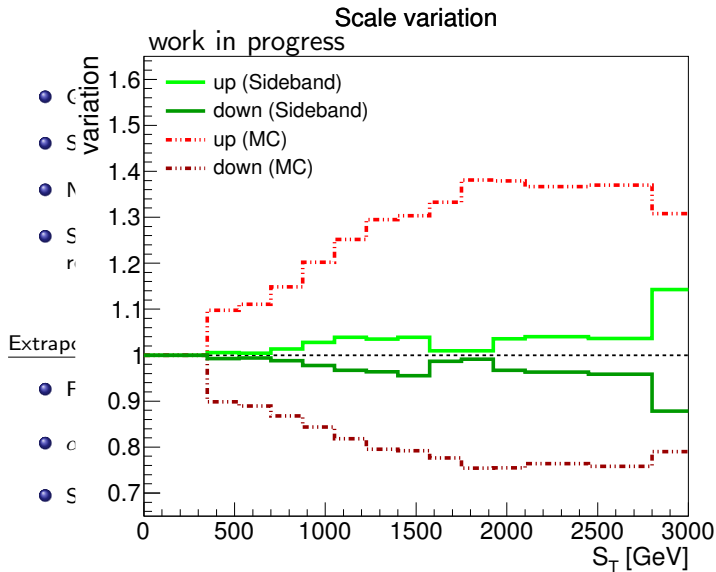
- Go from 2μ into $2e$ final state \rightarrow Very similar CR
- Shapes of CR and SR do not agree well enough
- Need sophisticated extrapolation procedure
- Shape and normalization taken from ratio of signal region and control region in MC

Extrapolation function α :

- Fit S_T in SR and CR with function F
- $$\alpha(S_T) = \frac{F^{SR}(S_T)}{F^{CR}(S_T)}$$
- Simultaneous correction of shape and normalization

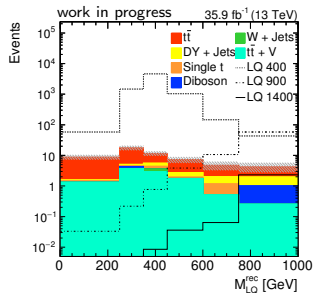
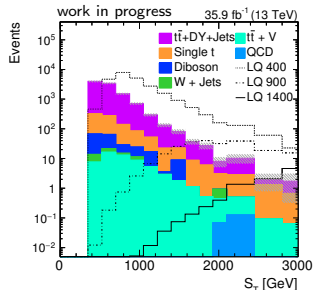
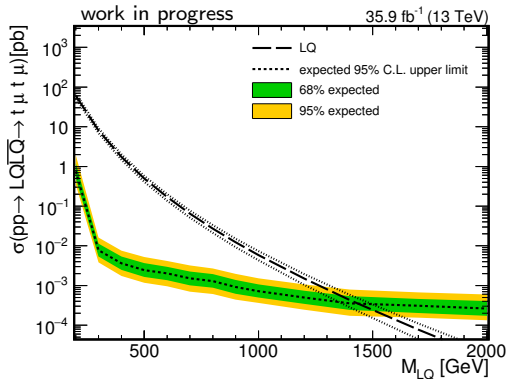


Background Estimation - $t\bar{t} + DY$



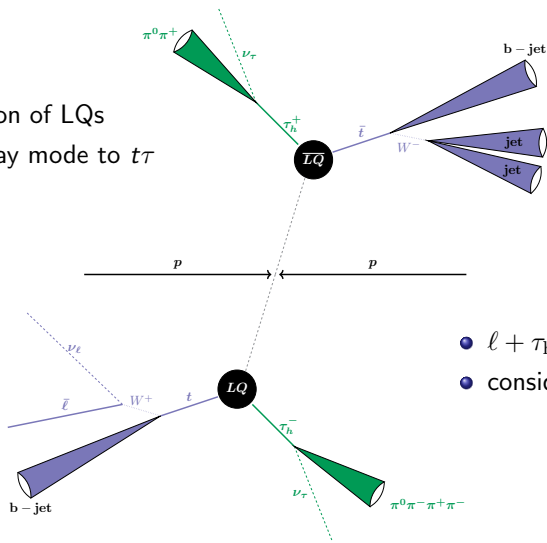
Expected sensitivity

- Combined binned likelihood template fit
- All uncertainties included



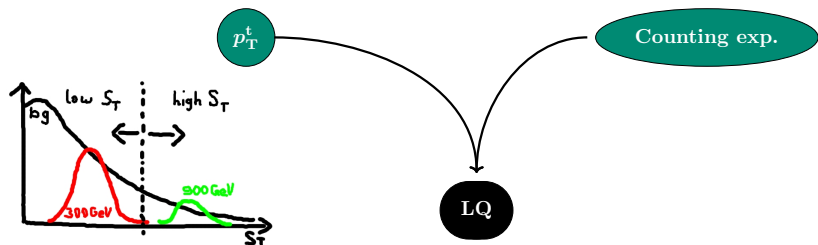
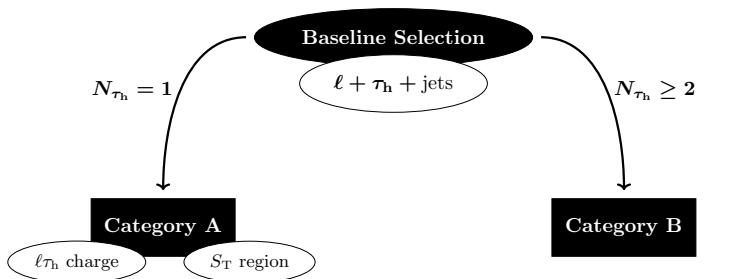
Search for $LQ \rightarrow t\tau$

- pair production of LQs
- exclusive decay mode to $t\tau$

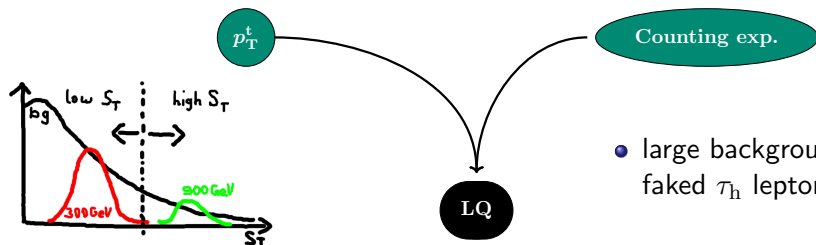
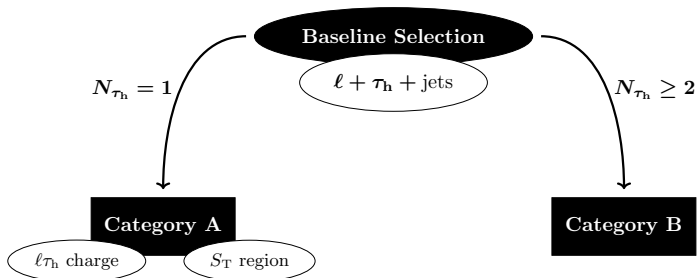


- $l + \tau_h + \text{jets}$ final state
- consider τ_h leptons

Analysis strategy



Analysis strategy



Background estimation - $t\bar{t} + W + \text{jets}$ (fake τ_h)

Low signal contamination

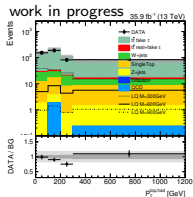
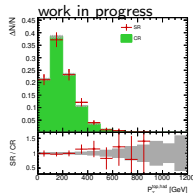
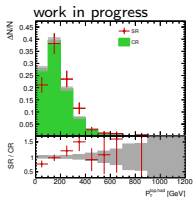
Large fraction of BG of interest

Define CR
(invert τ isolation)

Correction of kinematic differences between SR and CR

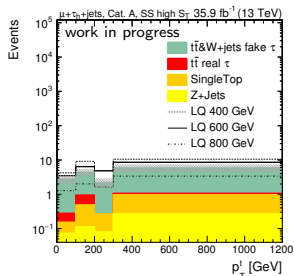
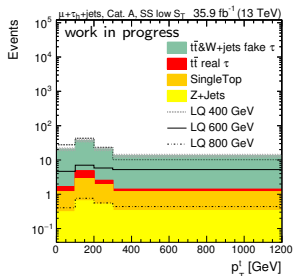
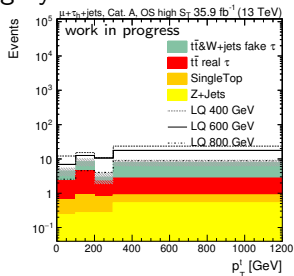
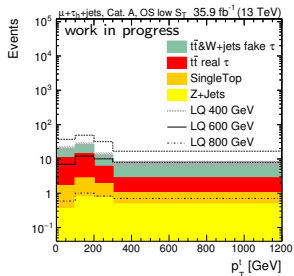
Subtraction of non relevant BGs from data in CR

Extrapolation of BG of interest in data to SR

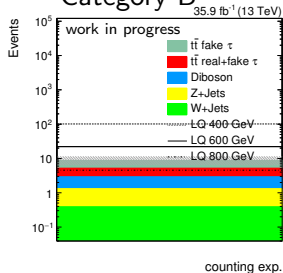


Final distributions ($\mu + \tau_h + \text{jets}$ channel)

Category A



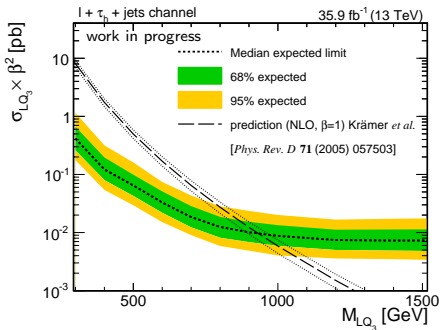
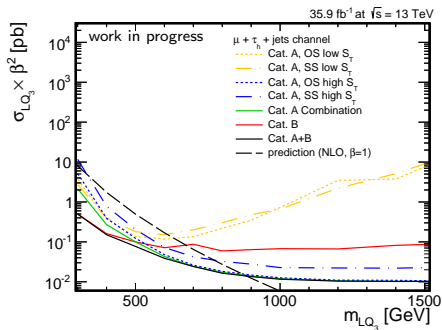
Category B



- different categories cover a wide range of LQ masses

Expected sensitivity

- binned maximum likelihood fit
- combination of all categories
- systematic uncertainties included



Conclusion & Outlook

Conclusion

- Searches for LQ pair production in $t\mu$ and $t\tau$ channels
- Expected sensitivities with 35.9 fb^{-1} at 13 TeV:
 - $t\mu$: $M_{LQ} \leq 1470 \text{ GeV}$ (first analysis)
 - $t\tau$: $M_{LQ} \leq 930 \text{ GeV}$ (8 TeV: 685 GeV)
- Data driven background methods

Outlook

- Analyses complete
- Combination planned

