Sensitivity studies for 3^{rd} generation LQ and RPV SUSY search

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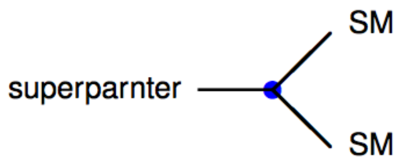
Outlook

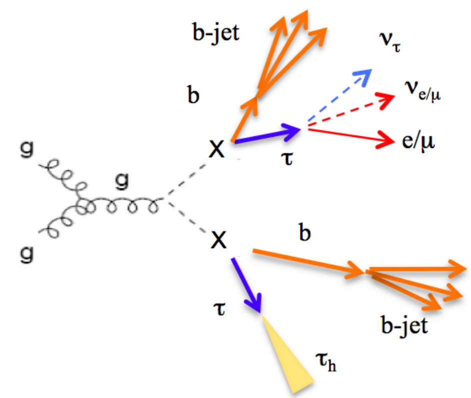
- Motivation: search for new physics in final state with tau leptons and b jets
  - Single/Vector LQ
  - RPV Stop
- Review of the previously published analysis and results
- Current sensitivity studies and results
- Conclusion

Motivation

- Symmetries between leptons and quarks motivate existence of boson fields mediating lepton-quark interaction
  - GUT, Composite models – Leptoquarks
  - R-parity violating SUSY – squarks or sleptons



$$W = \frac{1}{2}\lambda_{ijk} L_i L_j E^c_k + \lambda'_{ijk} L_i Q_j D^c_k + \frac{1}{2}\lambda''_{ijk} U^c_i D^c_j D^c_k$$



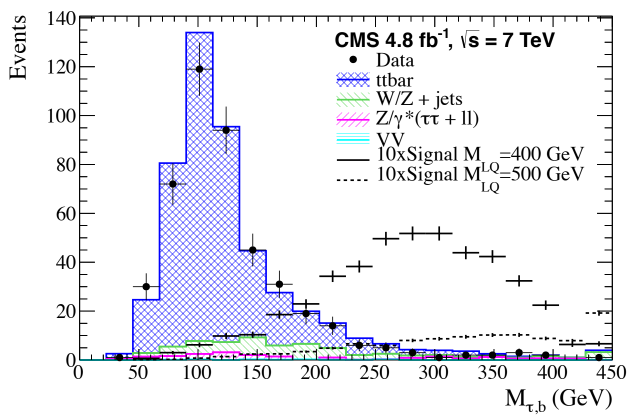
- Dominant production of pair of heavy particles is via QCD interactions
  - Cross section depends only on mass of a particle

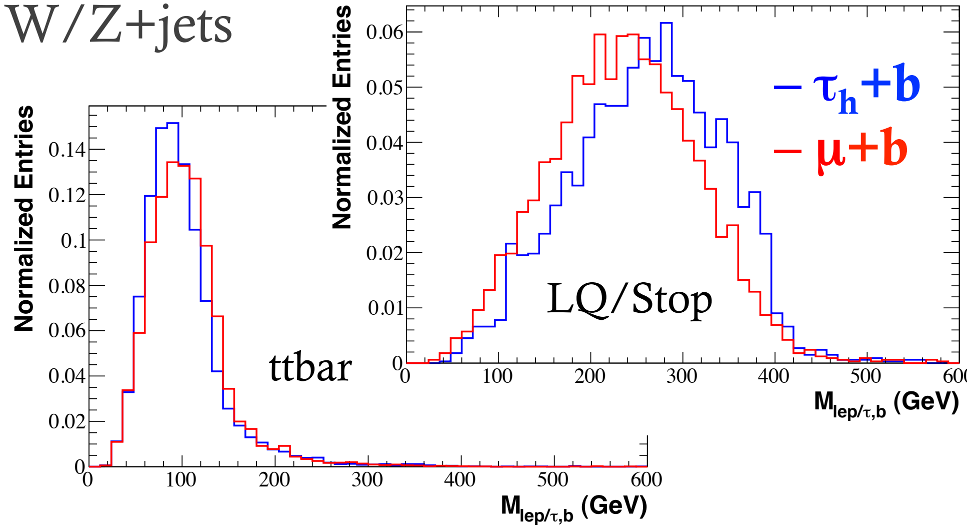
- Pair production of third generation LQ or Stops are studied
  - Signature with two τ leptons and two b jets: $e\tau_h$+2b-jets and $\mu\tau_h$+2b-jets

Overview of 7 TeV analysis

- Major backgrounds -- ttbar and W/Z+jets processes
  - Invariant mass of τ_h and b-jet

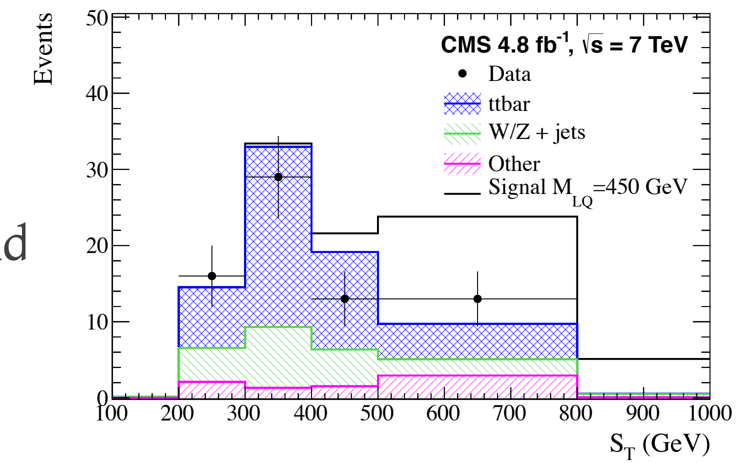
$$M(\tau_h, b) = \sqrt{(E_{\tau_h} + E_b)^2 - (\vec{p}_{\tau_h} + \vec{p}_b)^2}$$





- Search for excess over the SM background in S_T distribution

$$ST = p_T(\tau_h) + p_T(\mu) + p_T(bjet_1) + p_T(bjet_2)$$



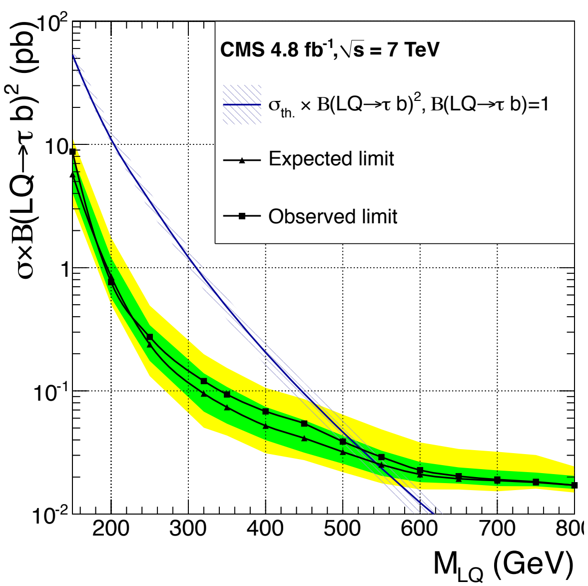
Results on LQ3/RPV Stop

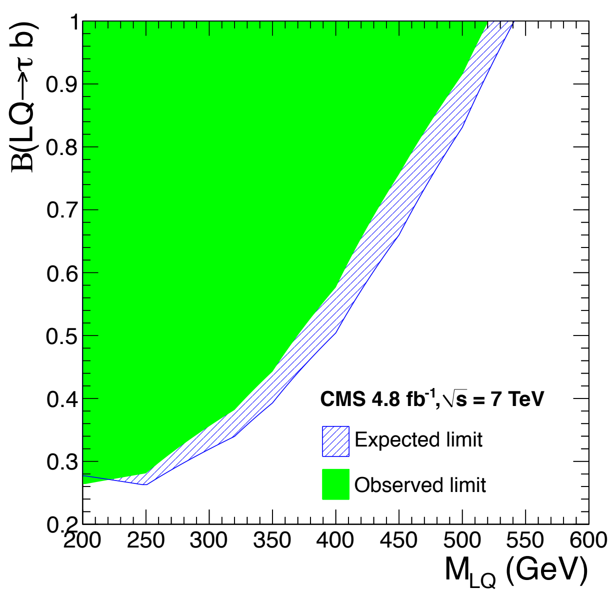
- Scalar LQ/Stops with RPV decay with masses below 525 GeV are excluded at 95% C.L.

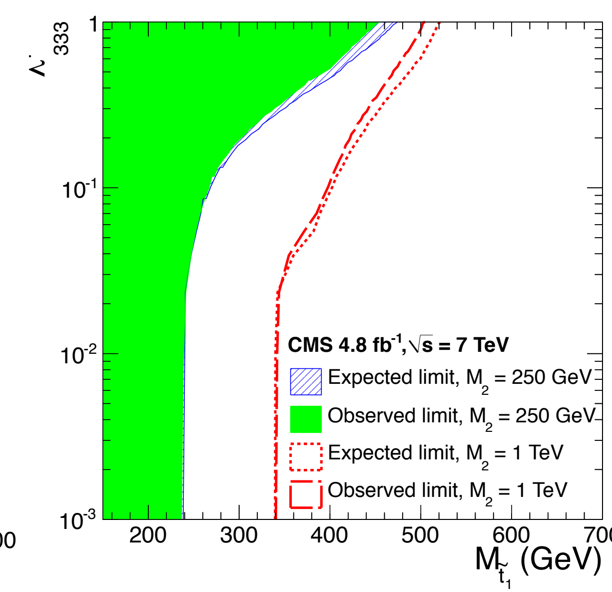
PRL 110, 081801 (2013)
arXiv: 1210.5629v1

- Limits are set on RPV coupling λ'_{333} for a given benchmark scenario

Benchmark:
- heavy or light M_2
- Higgsino mixing μ = 380 GeV
- tan β ~ 40 and mixing angle ~0







Sensitivity Studies

- What higher center of mass (CM) machine can offer
  - Higher cross sections and thus a higher mass reach
  - Much higher pileup (PU)
    - Effects on the efficiency might be noticeable, but at high-p_T we expect them to be less drastic

- Outline of the work presented today
  - Use signal and background MC samples: Delphes3.0.9, √s=14 TeV
  - NLO cross sections
    - Officially provided by fast-simulation team, summarized at http://home.fnal.gov/~jhirsch/snowmass/pythia_cross_sections_14tev.txt
    - LQ Signal sample was generated for 14 TeV with old PU scenario *arXiv: 0411038, Phys.Rev.D71:057503,2005*

The first studies were done for BNL EF meeting
https://indico.bnl.gov/getFile.py/access?contribId=129&sessionId=12&resId=0&materialId=slides&confId=571

Analysis strategy

- Select events with and $\mu\tau_h$+2b-jets
  - Kinematic selection
  - All objects are separated by at least ΔR=0.5
  - μ and τ_h must have opposite charges

	pT >	|η|<
μ	30 GeV	2.1
τ_h	50 GeV	2.3
bjets	30 GeV	2.4

- Topological cuts to reject ttbar and V+jets backgrounds
  - $M(\tau_h b)$ > X GeV and ST > Y GeV
    - Thresholds are obtained for each signal mass (M) hypothesis based on optimization: X=0.5M; Y=1.25M

$$M(\tau_h, b) = \sqrt{(E_{\tau_h} + E_b)^2 - (\vec{p}_{\tau_h} + \vec{p}_b)^2}$$

$$ST = p_T(\tau_h) + p_T(\mu) + p_T(bjet_1) + p_T(bjet_2)$$

- Count signal and background events after the final selection

Systematic Uncertainties

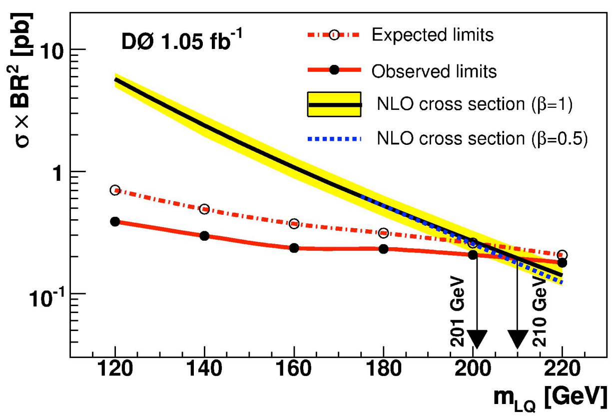
- Analysis is statistics dominated, thus systematic uncertainties do not affect on final result much. In anyways,
  - considered following for 50 PU-300 fb^{-1} scenario
  - Uncertainties due to object ID and mis-isdentification rate are inflated by 50% for 140 PU-3000 fb^{-1} scenario

Source	uncertainty
Luminosity	4%
Tau ID	10%
b ID	5%
Mistag rate	10%
tt normalization	15%
jet faking tau	30%

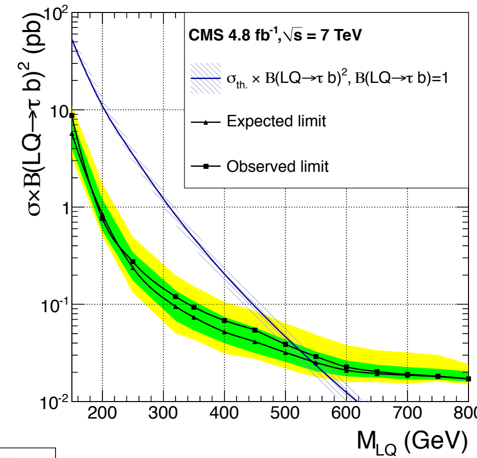
Results

- Previous results:
  - D0 with 1 fb^{-1} excludes ~200 GeV masses
  - CMS with 5 fb^{-1} at 7 TeV excludes ~500 GeV

D0 – $\sqrt{s}$=1.96 TeV, 1.1 fb^{-1}

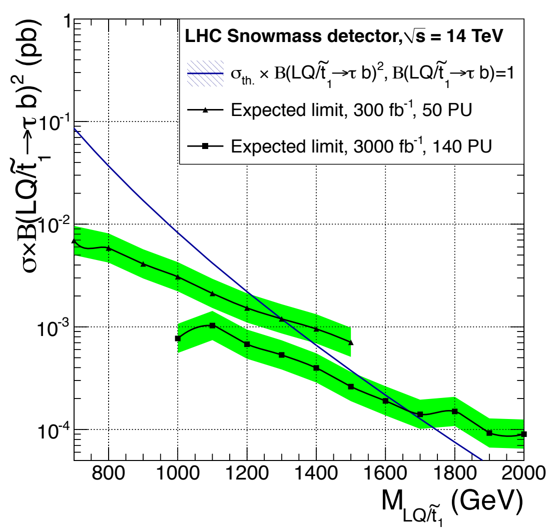


CMS – $\sqrt{s}$=7 TeV, 4.8 fb^{-1}



- Expected exclusion at
  - 1.3 TeV with 300 fb^{-1}
  - 1.7 TeV with 3000 fb^{-1}

Note: These results are obtained from only $\mu\tau_h$+2b-jets channel. Factor of two improvement in σXB limit is expected by adding $e\tau_h$+2b-jets channel



LHC Snowmass detector – $\sqrt{s}$=14 TeV,
*** 300 fb^{-1}**
*** 3000 fb^{-1}**

Summary

- The sensitivity studies for pair-production of RPV Stop/LQ3→tau+b were presented
  - The Delphes3.0.9 parameterized simulation of background and signal samples where used
  - The selection criteria was optimized for each signal hypothesis
  - Systematic uncertainties were taken into account

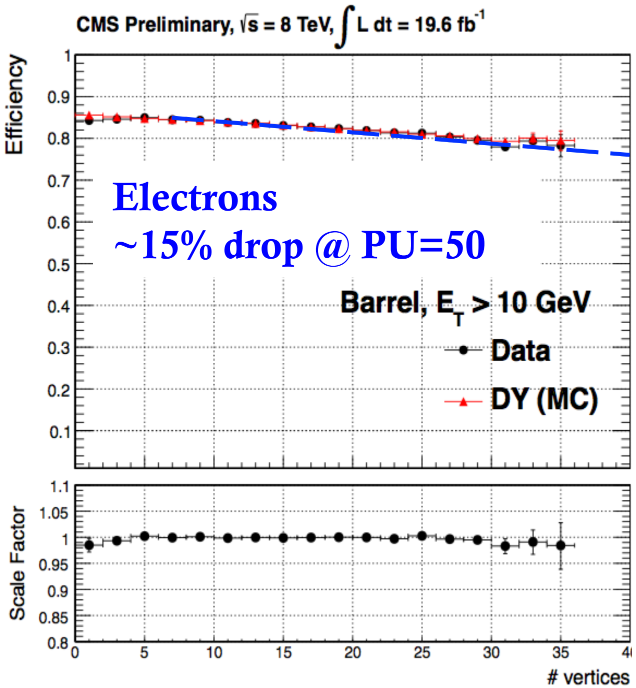
- Expected exclusion of these particles are at 1.3 TeV and 1.7 TeV for 300 fb^{-1} (50PU) and 3000 fb^{-1} (140PU) scenario, respectively, at $\sqrt{s}$=14 TeV

Many thanks to
** The team of experts for producing the background samples and providing guidance on how to use those*
** Jared Evans for producing signal samples for my analysis*

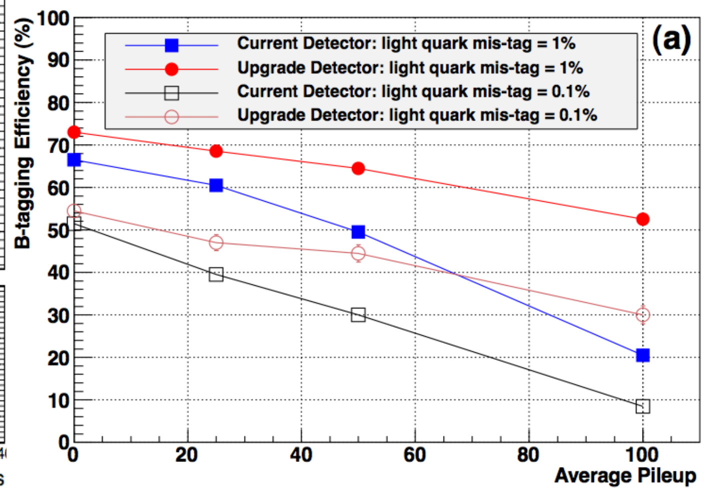
BACKUP

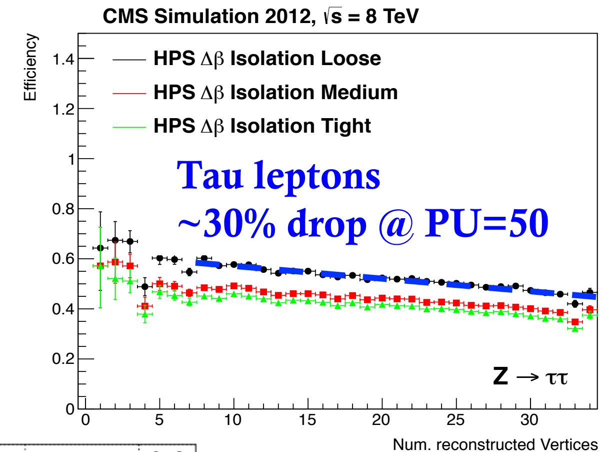
Object ID performance

- High PU is expected to degrade capabilities to identify physics objects: leptons, hadronic tau leptons, and b-jets



b-jets
~15% drop @ PU=50

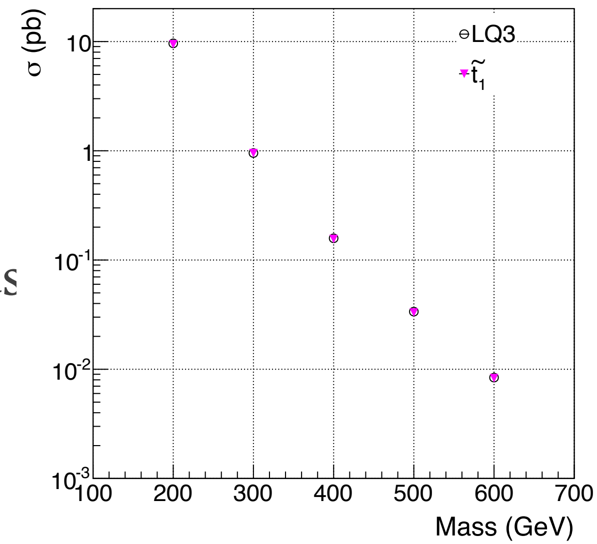




These performances are averaged over p_T → gives conservative estimate of efficiencies at high PU for heavy resonance searches

Stop vs LQ

- Cross sections agree within a couple of percent for heavy gluino scenario
  - Dependence on tan β and stop mixing angle is small



- Branching fraction is strongly dependent on various parameters: SU(2) gaugino mass M_2, Higgsino mixing parameter μ, stop mixing angle, etc.