LHC probe of SUSY $0\nu\beta\beta$ mechanism

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Outline

- $0\nu\beta\beta$ in SUSY with R-parity violation.
- Single slepton production at the LHC.
- Inferring $0\nu\beta\beta$ rate from the LHC.
- Summary.

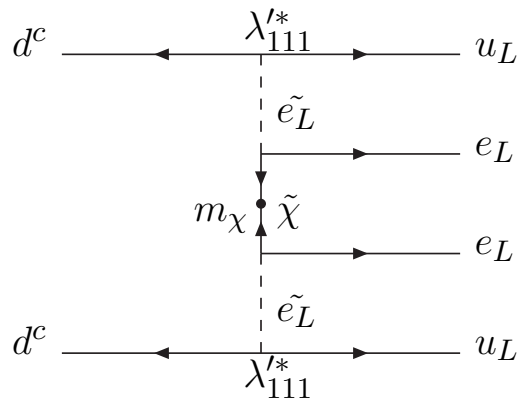
Mechanisms of $0\nu\beta\beta$

- Majorana mass, right handed currents, KK neutrino exchange ...
- Need to find out the underlying $0\nu\beta\beta$ mechanism.
- We shall focus on $0\nu\beta\beta$ in SUSY with R-parity violation (RPV SUSY) and signals from the LHC

  Allanach, CHK, Päs arXiv:0902.4697,0903.0347

$0\nu\beta\beta$ in RPV SUSY

- RPV SUSY contains Lepton no. violating operators, e.g. $\lambda'_{111} L_1 Q_1 D_1^c$.
- *Direct* $0\nu\beta\beta$ mediation without neutrino mass insertion possible !

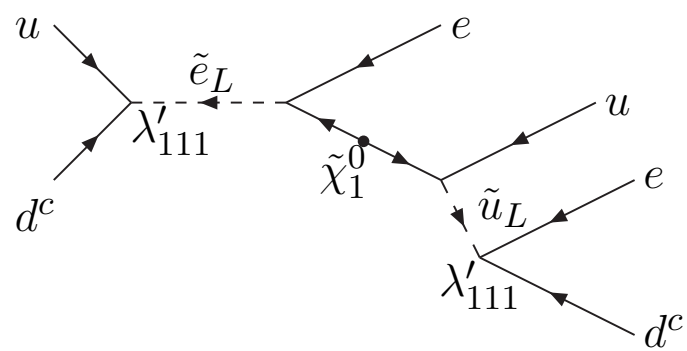


(a)

- Dimension 9 operators:
  very stringent λ'_{111} bound for low SUSY scale,
  but relaxes rapidly when SUSY scale increases.

Single slepton production at the LHC

- Can we infer the existence of λ'_{111} at the LHC ?
  Possible: single selectron production at the LHC.



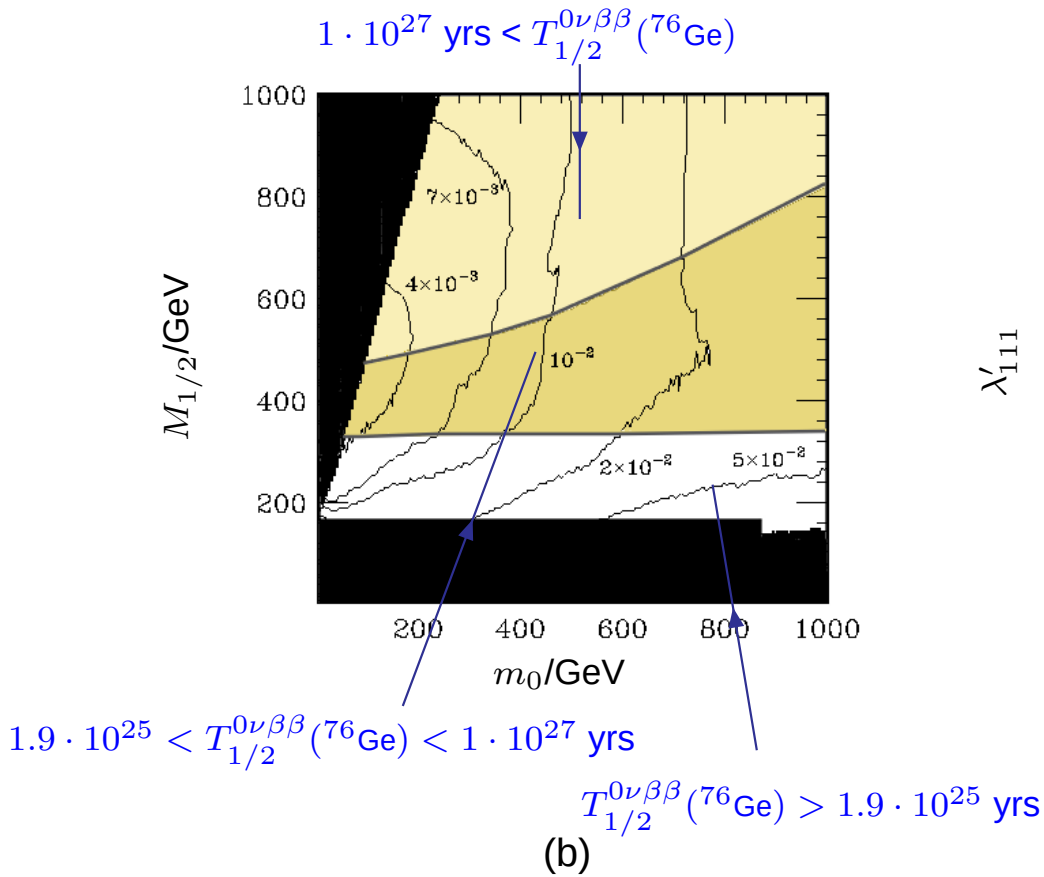
- Signal: *Same* sign (SS) di-electron with small $\not{p}_T$.
- Previous analysis on SS di-muon signals for λ'_{211}
  Dreiner,Richardson,Seymour 99 .
- SS di-electron signal for λ'_{111} believed to be tiny, due to strong $0\nu\beta\beta$ constraint !!

MSSM model

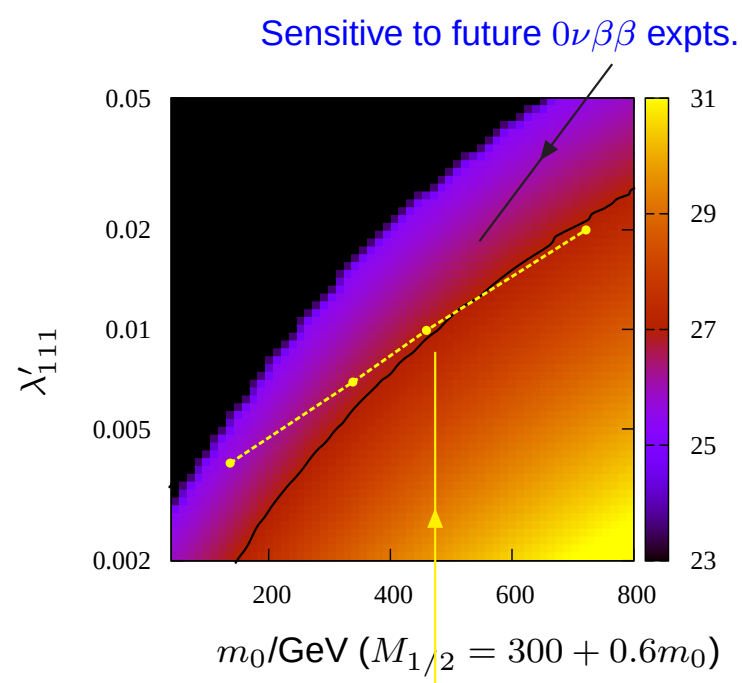
- MSSM models with λ'_{111} defined at *SUSY* scale, masses defined by mSUGRA parameters.
- Consider only regions with neutralino LSP.
- Lower $T^{0\nu\beta\beta}_{1/2}(^{76}\text{Ge})$ limit: $\lambda'_{111} \lesssim 5 \cdot 10^{-4}(\frac{\Lambda_{SUSY}}{100GeV})^{2.5}$
  Single slepton production: $\sigma(pp \to \tilde{l}) \propto |\lambda'_{111}|^2/m^3_{\tilde{l}}$
  $\to$ *production upper limit increases with* Λ_{SUSY}

Results

- Infer $T_{1/2}^{0\nu\beta\beta}(^{76}\text{Ge})$ from SS di-election 5-σ discovery reach at 10 fb^{-1}:



(b)



(c)

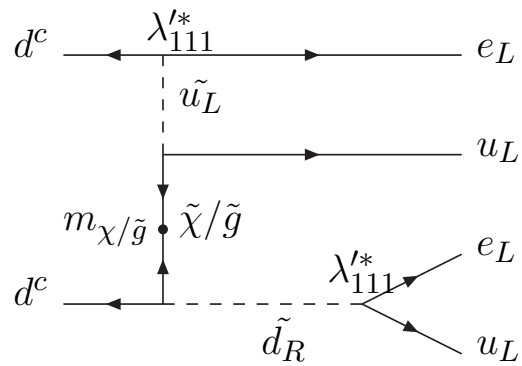
Comments and summary

- Discussed interplay between $0\nu\beta\beta$ and single slepton production at the LHC in RPV SUSY.
- Observation of single slepton at 5 σ implies that $0\nu\beta\beta$ is within reach of the next generation of experiments.
- Conversely, if $0\nu\beta\beta$ is discovered, expect single slepton production to be able to test the λ'_{111} hypothesis.
- This is with only 10 fb^{-1} of data at the LHC.
- Next : reconstructing mass spectrum and predict $0\nu\beta\beta$ rate including uncertainties...

Thank you.

Feynman diagrams for direct RPV $0\nu\beta\beta$

- λ'_{111}: squark-gluino, squark-neutralino and slepton-neutraino diagrams, e.g.



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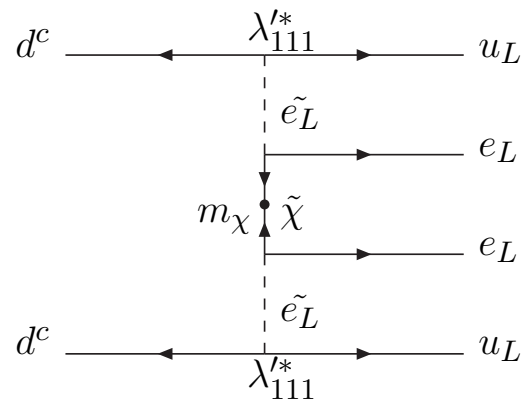
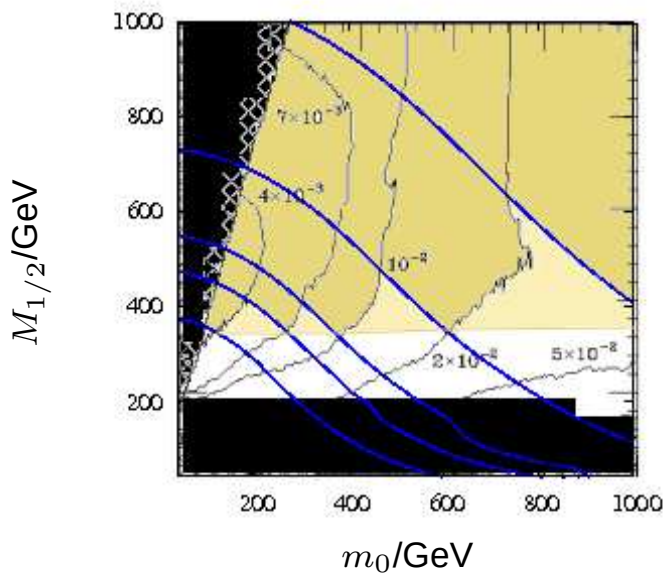


(e)

- Dimension 9 operators:
  very stringent λ'_{111} bound for low SUSY scale,
  but relaxes rapidly when SUSY scale increases.

Comparing λ'_{111} bounds

- Infer $T_{1/2}^{0\nu\beta\beta}(^{76}\text{Ge})$ from SS di-election 5-σ discovery reach at 10 fb^{-1}:



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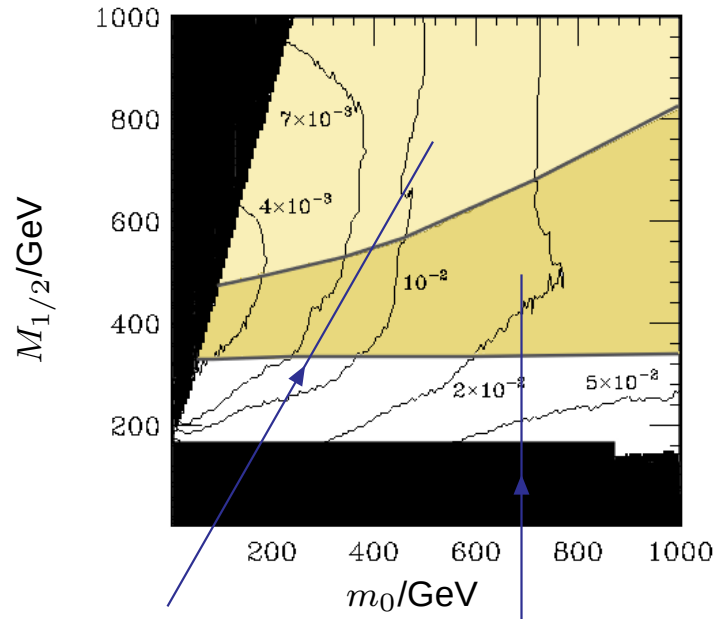

$1 \cdot 10^{27}$ yrs < $T_{1/2}^{0\nu\beta\beta}(^{76}\text{Ge})$

$1.9 \cdot 10^{25} < T_{1/2}^{0\nu\beta\beta}(^{76}\text{Ge}) < 1 \cdot 10^{27}$ yrs

(g)

LHC SS slepton cuts

From Dreiner,Richardson,Seymour 99

- Lepton $|\eta| < 2.0$.
- Lepton $p_T > 40$ GeV.
- Isolation cut: $E_T < 5$ GeV in cone R=0.4.
- Reject 65 < M_T < 80 GeV.
- $\not{p}_T$ < 20 GeV.
- OSSF lepton veto.
- No more than 2 jets, each with $p_T > 50$ GeV.