Search for R-parity violating supersymmetric signals with the ATLAS detector

Russell Smith,
on behalf of the ATLAS Collaboration

3 July 2016

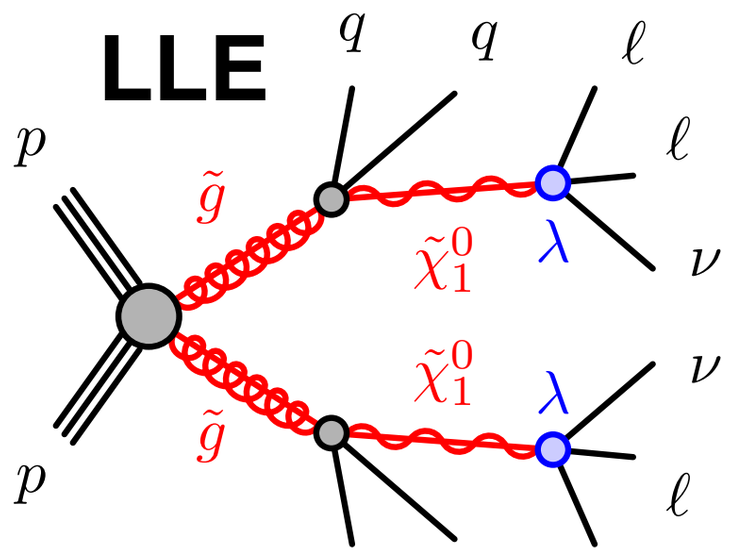
COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

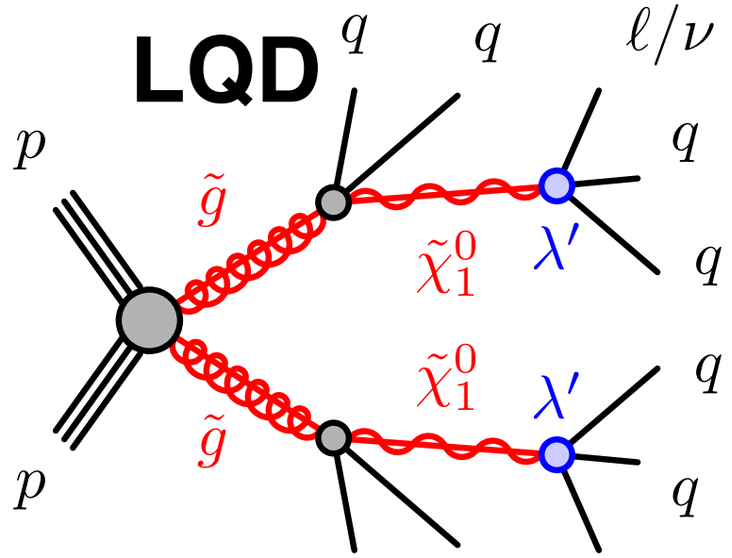
Introduction

$$W_{\not L\mathrm{RPV}} = \frac{1}{2}\lambda_{ijk} L_i L_j \bar{E}_k + \lambda'_{ijk} L_i Q_j \bar{D}_k + \epsilon_i L_i H_2$$

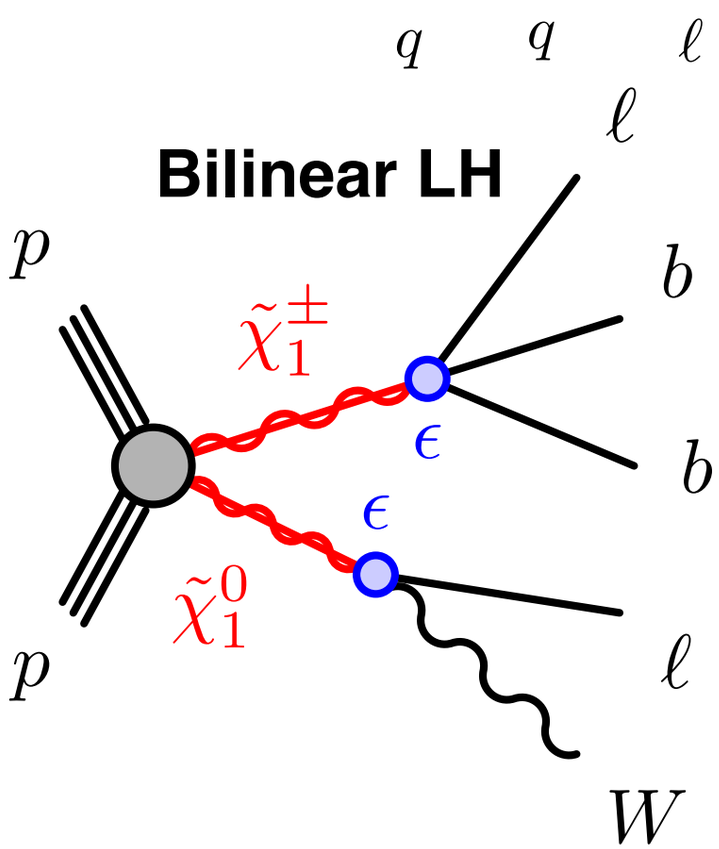
$$W_{\not B\mathrm{RPV}} = \frac{1}{2}\lambda''_{ijk} \bar{U}_i \bar{D}_j \bar{D}_k$$

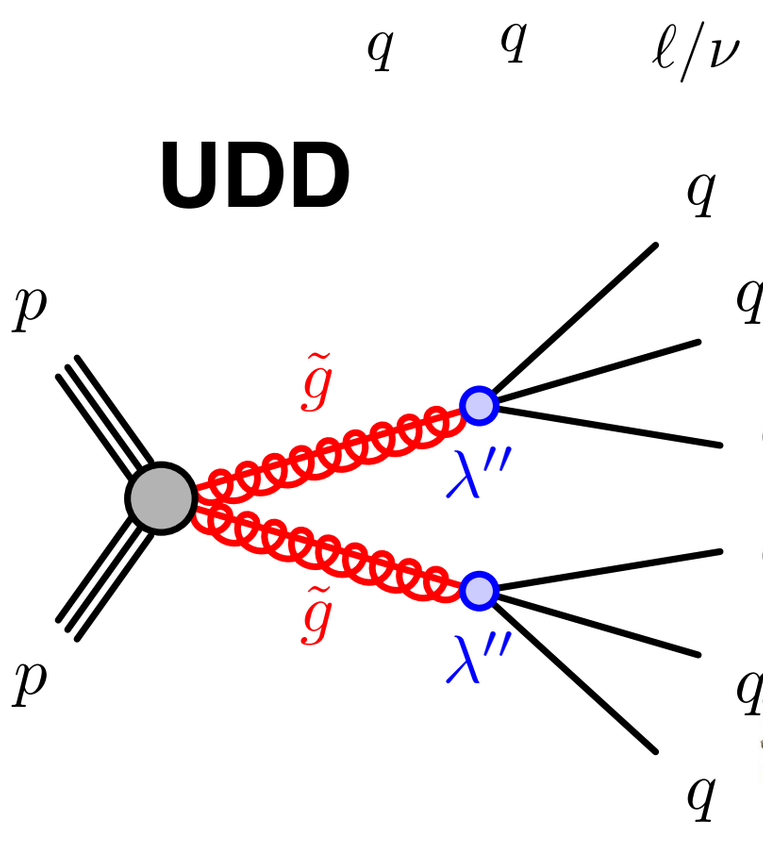
- RPV models include terms which violate lepton and baryon number
- Decaying LSP -> lower missing transverse energy
  - QCD backgrounds very challenging in this regime





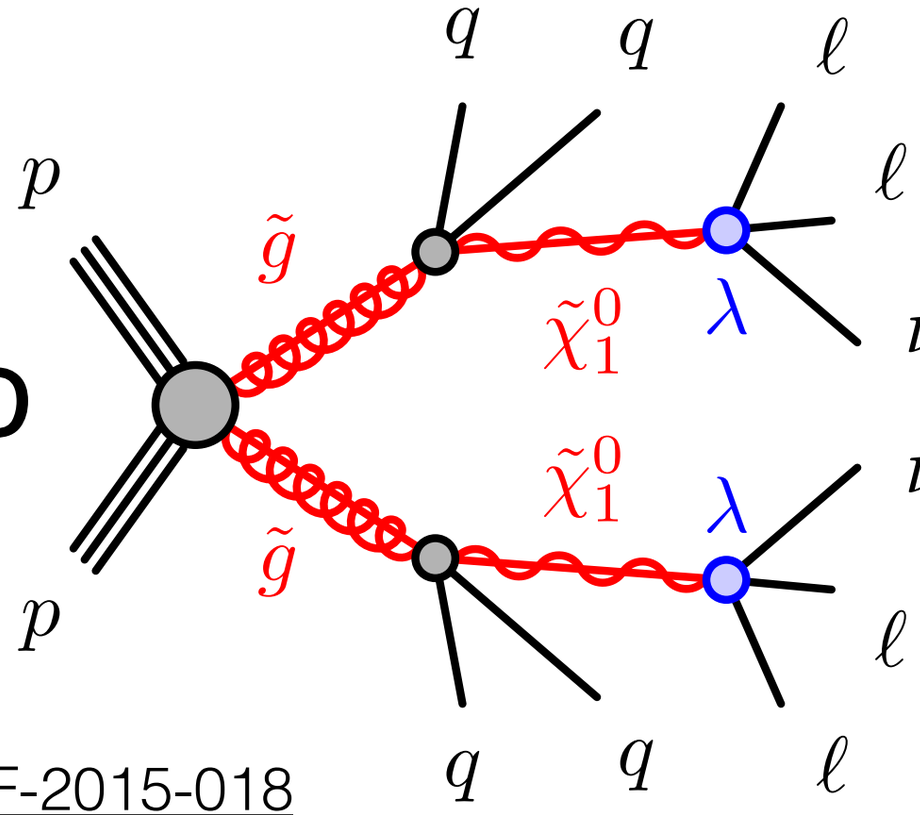
- RPV couplings names from terms in superpotential
  - LLE term
  - LQD term
  - Bilinear LH term
  - UDD term





COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

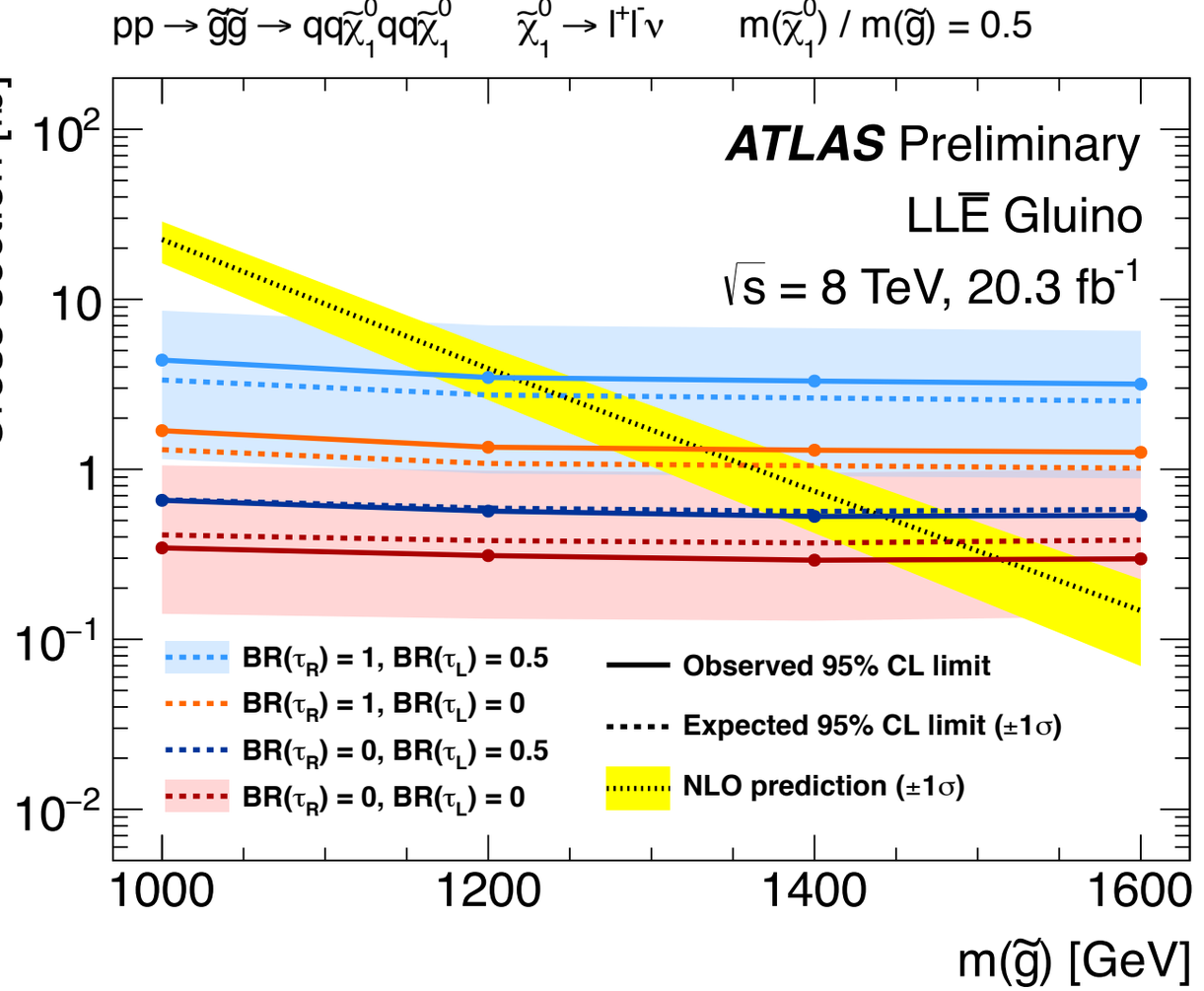
LLE Gluino

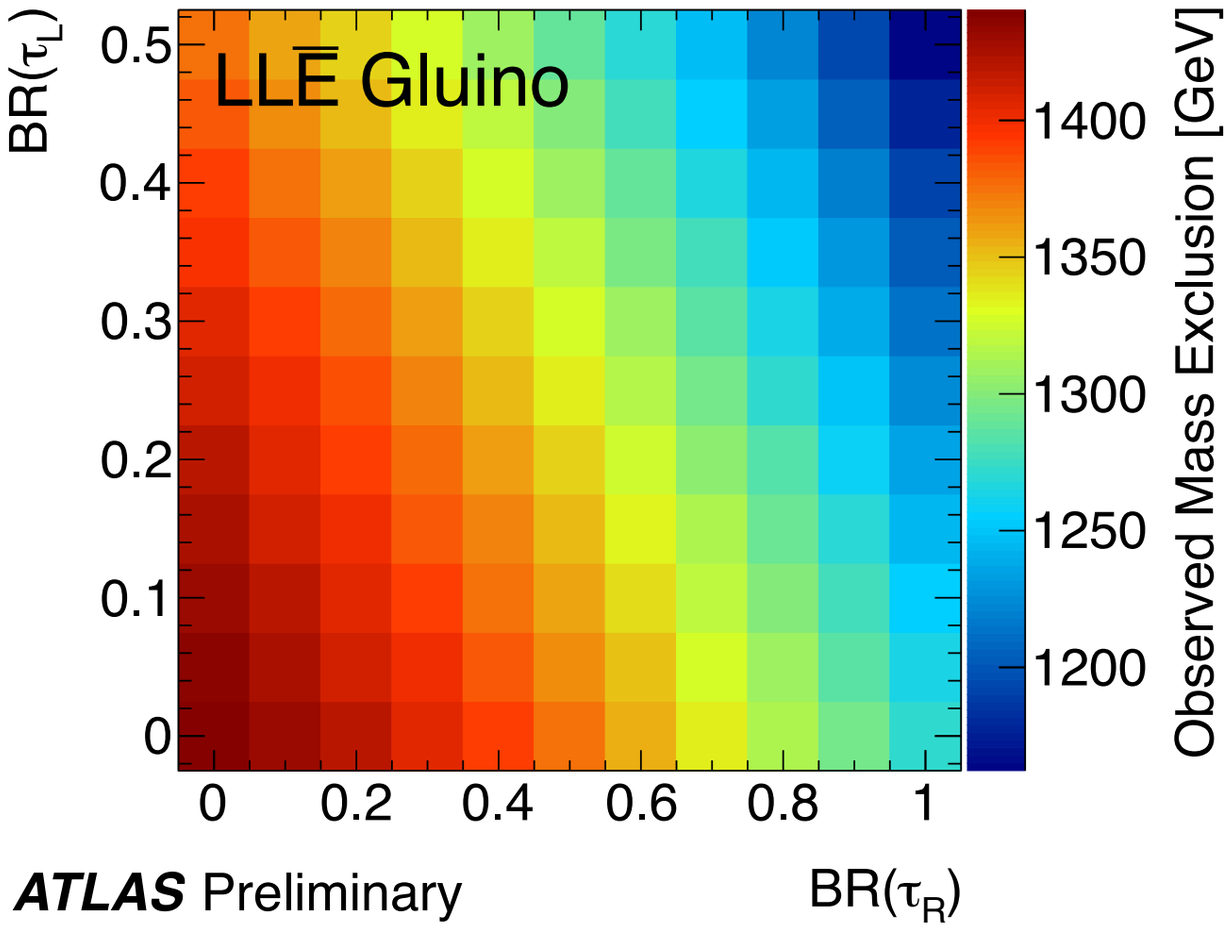


ATLAS-CONF-2015-018

$pp \to \tilde{g}\tilde{g} \to qq\tilde{\chi}_1^0 qq\tilde{\chi}_1^0 \quad \tilde{\chi}_1^0 \to l^+l^-\nu \quad \sqrt{s} = 8$ TeV, 20.3 fb^{-1}

All limits at 95% CL $\quad m(\tilde{\chi}_1^0) / m(\tilde{g}) = 0.5$

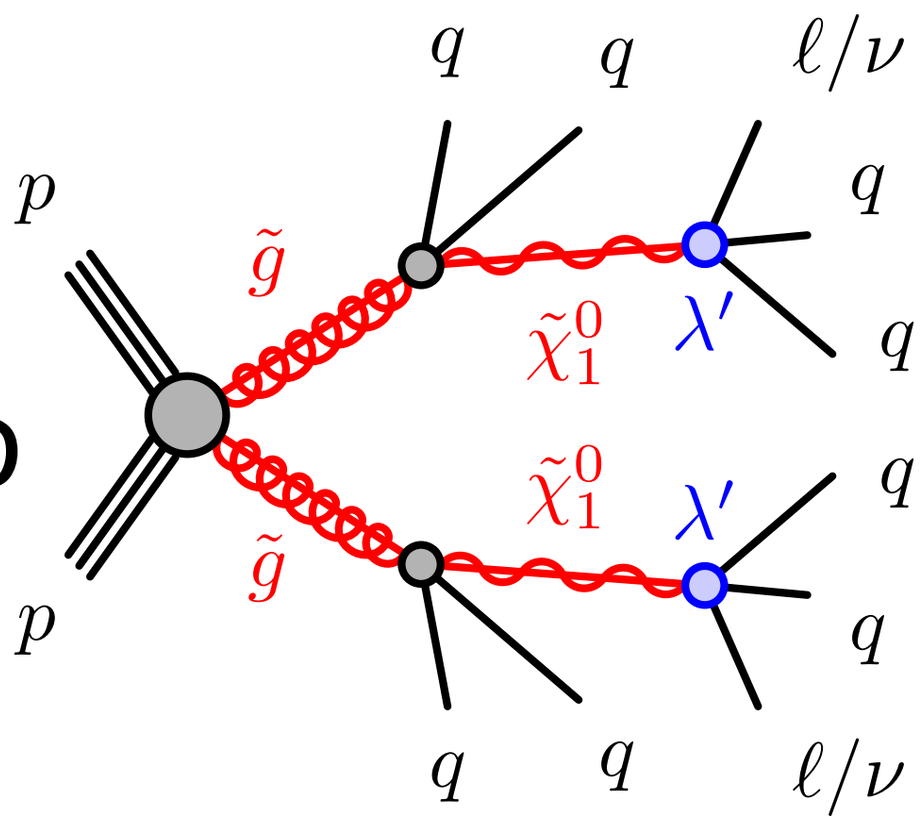




- LSP decays to two leptons and neutrino via LLE coupling
- Signal regions defined by light lepton multiplicity
  - Two same-sign leptons, three leptons, four leptons
  - Regions contribute to different parts of τ BR plane

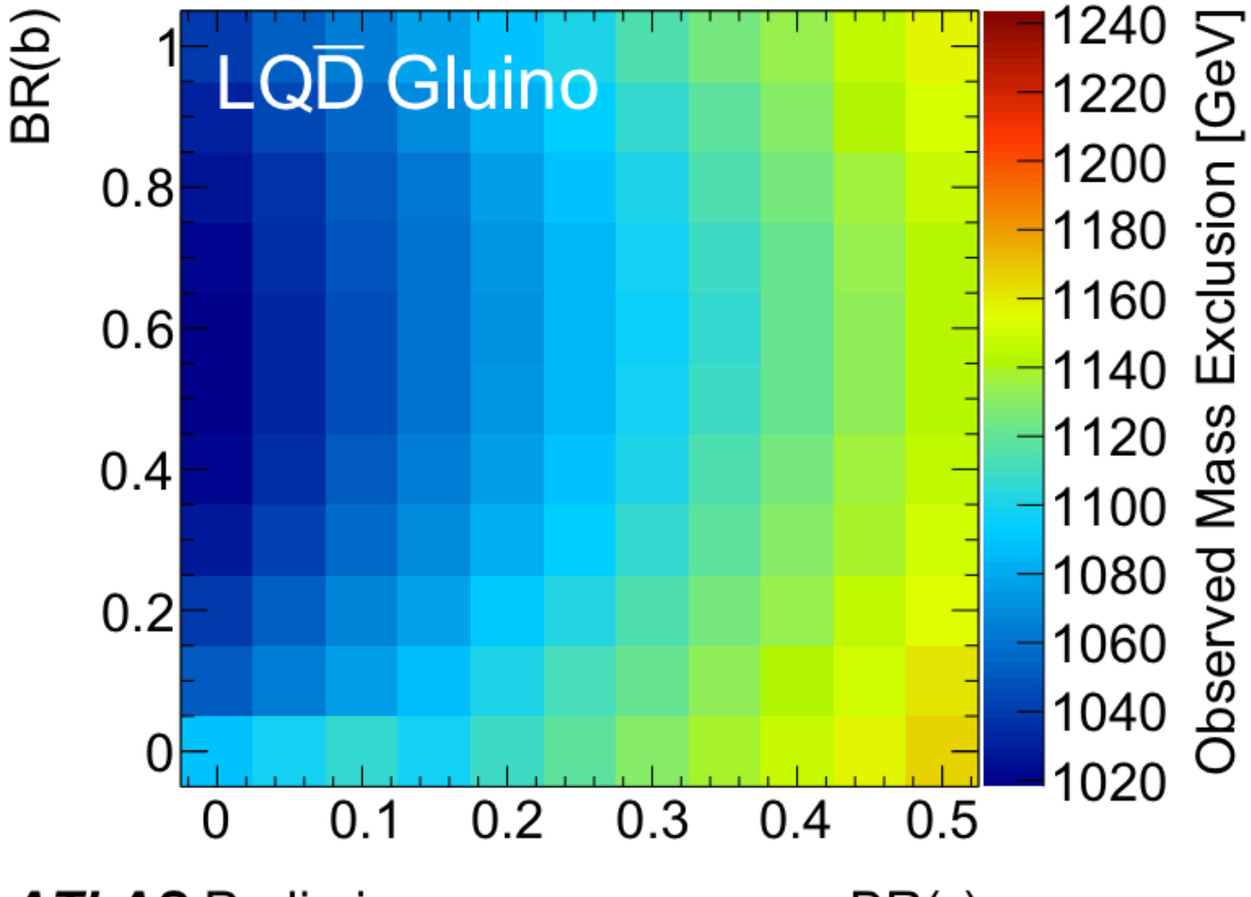
ATLAS Preliminary

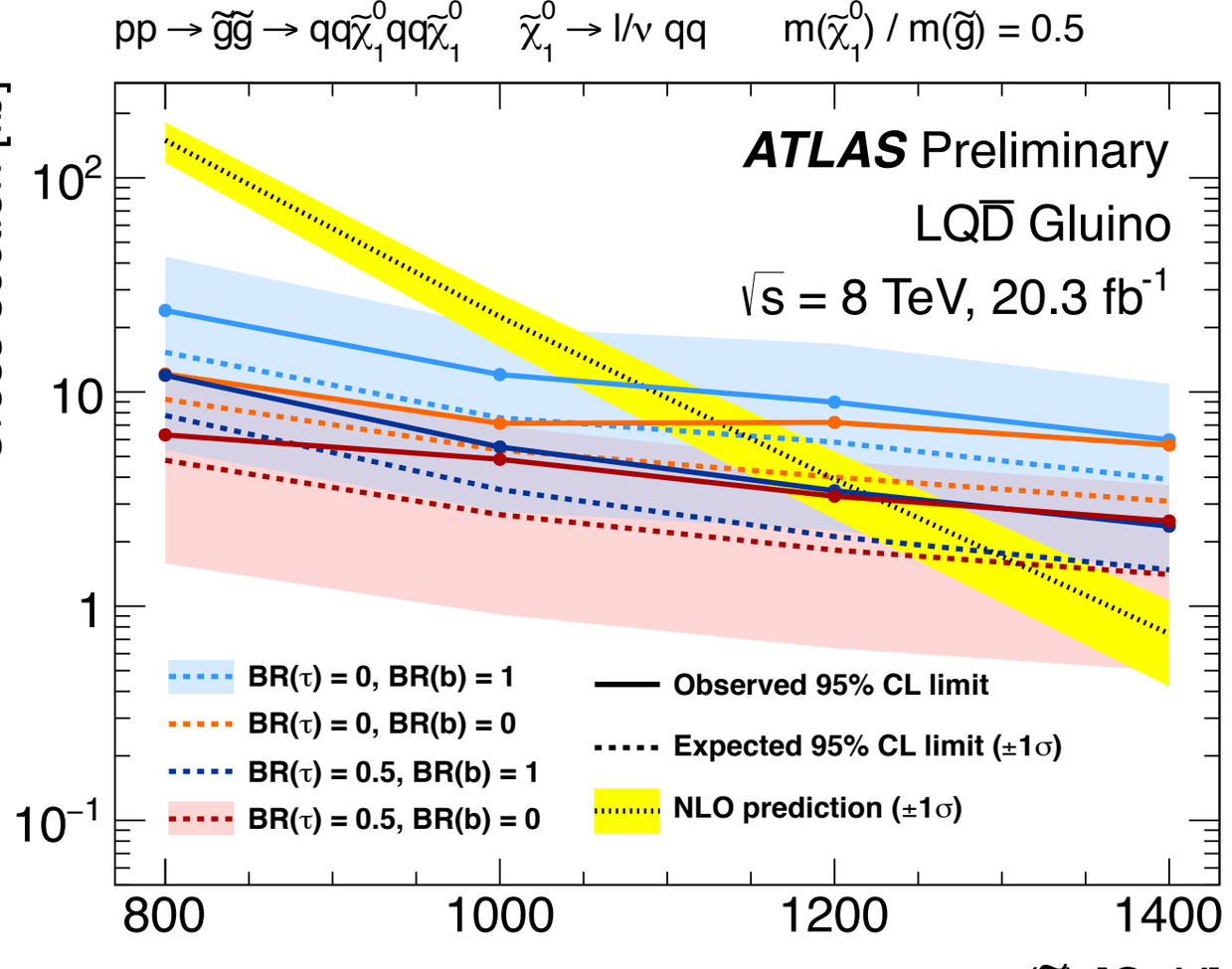
LQD Gluino



$pp \to \tilde{g}\tilde{g} \to qq\tilde{\chi}_1^0 qq\tilde{\chi}_1^0$ $\quad \tilde{\chi}_1^0 \to l/\nu\ qq$ $\quad \sqrt{s} = 8$ TeV, 20.3 fb^{-1}

All limits at 95% CL $\quad m(\tilde{\chi}_1^0) / m(\tilde{g}) = 0.5$

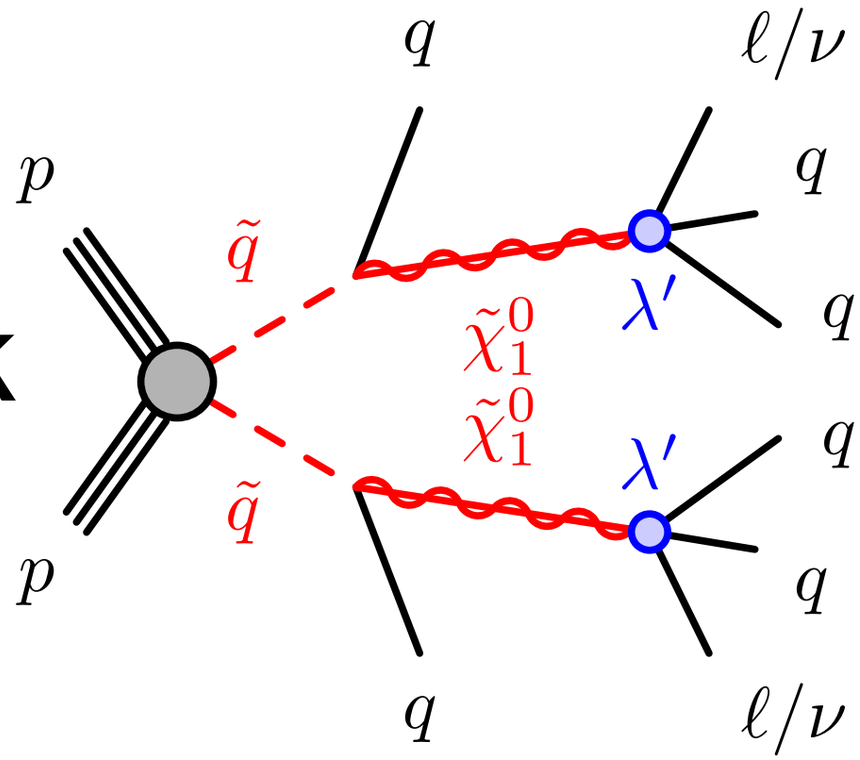




- LSP from gluino decays to lepton and two quarks via LQD coupling
- Signal regions binned by light lepton and jet multiplicity
  - 0 or 1 lepton
  - 2 - 10 jets

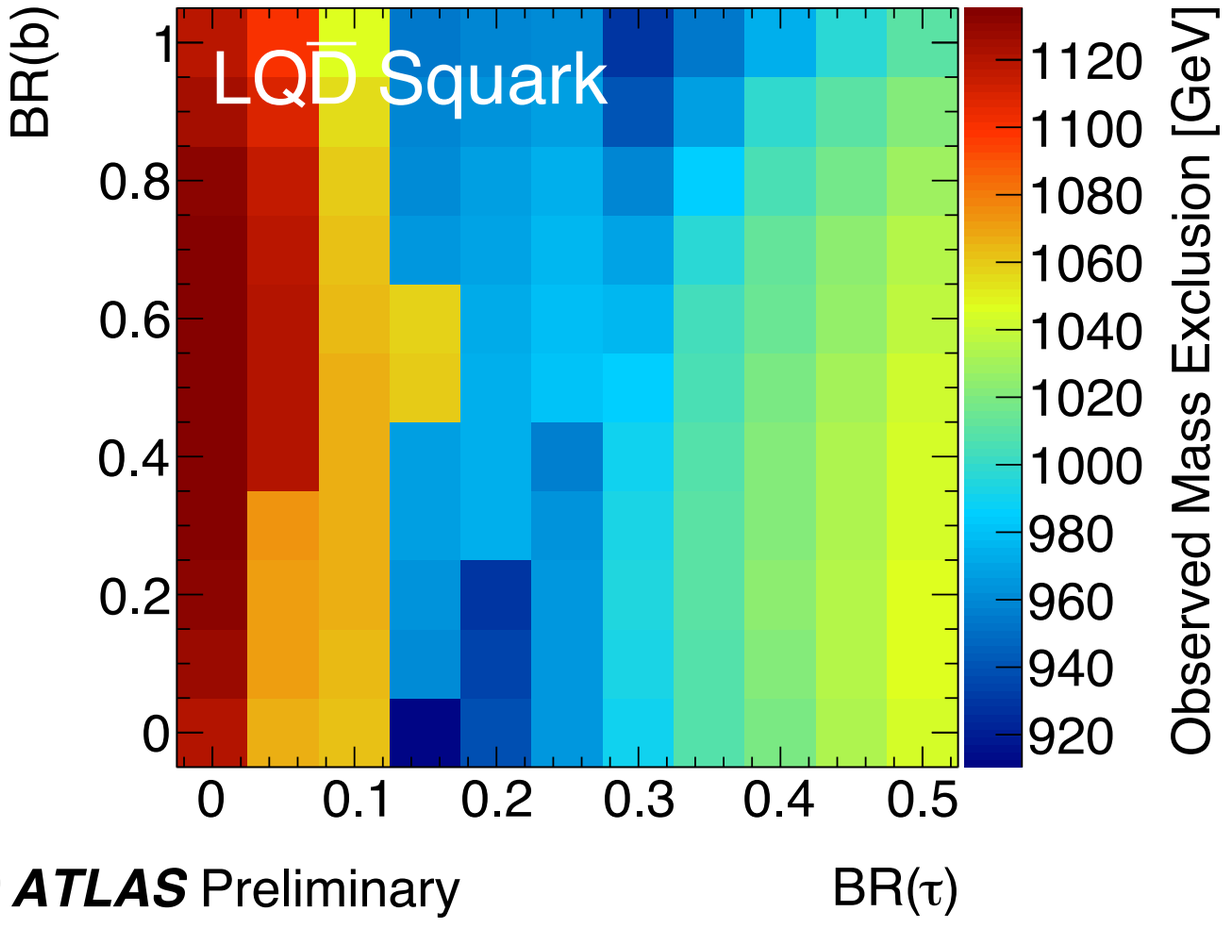
ATLAS-CONF-2015-018

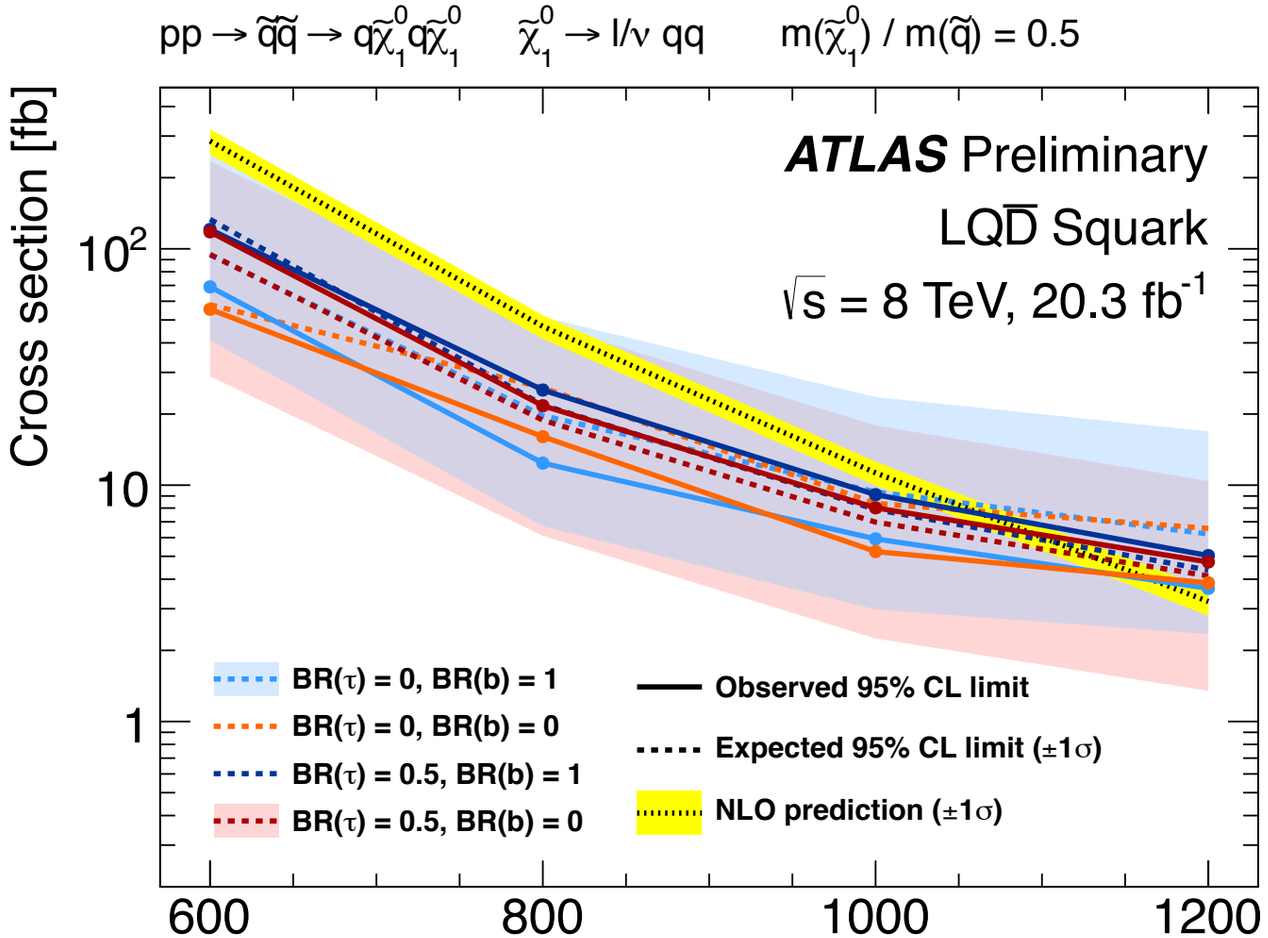
LQD Squark



$pp \to \tilde{q}\tilde{q} \to q\tilde{\chi}_1^0 q\tilde{\chi}_1^0$ $\tilde{\chi}_1^0 \to l/\nu\ qq$ $\sqrt{s}$ = 8 TeV, 20.3 fb^{-1}

All limits at 95% CL $m(\tilde{\chi}_1^0) / m(\tilde{q}) = 0.5$





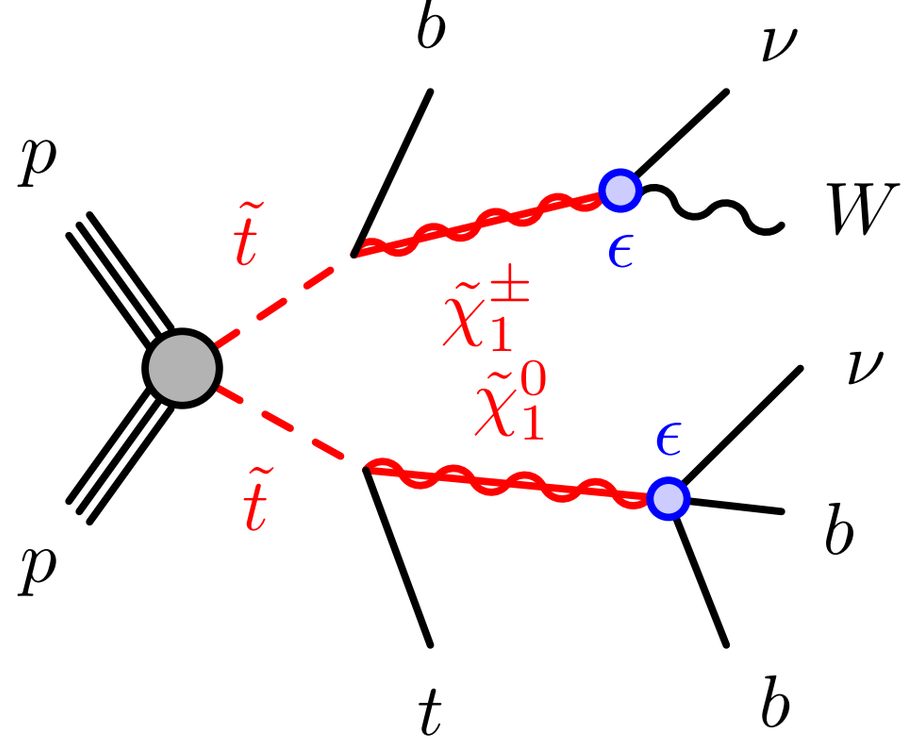
- LSP from squark decays to lepton and two quarks via LQD coupling
- Signal regions binned by light lepton and jet multiplicity
  - 0 or 1 lepton
  - 2 - 6 jets

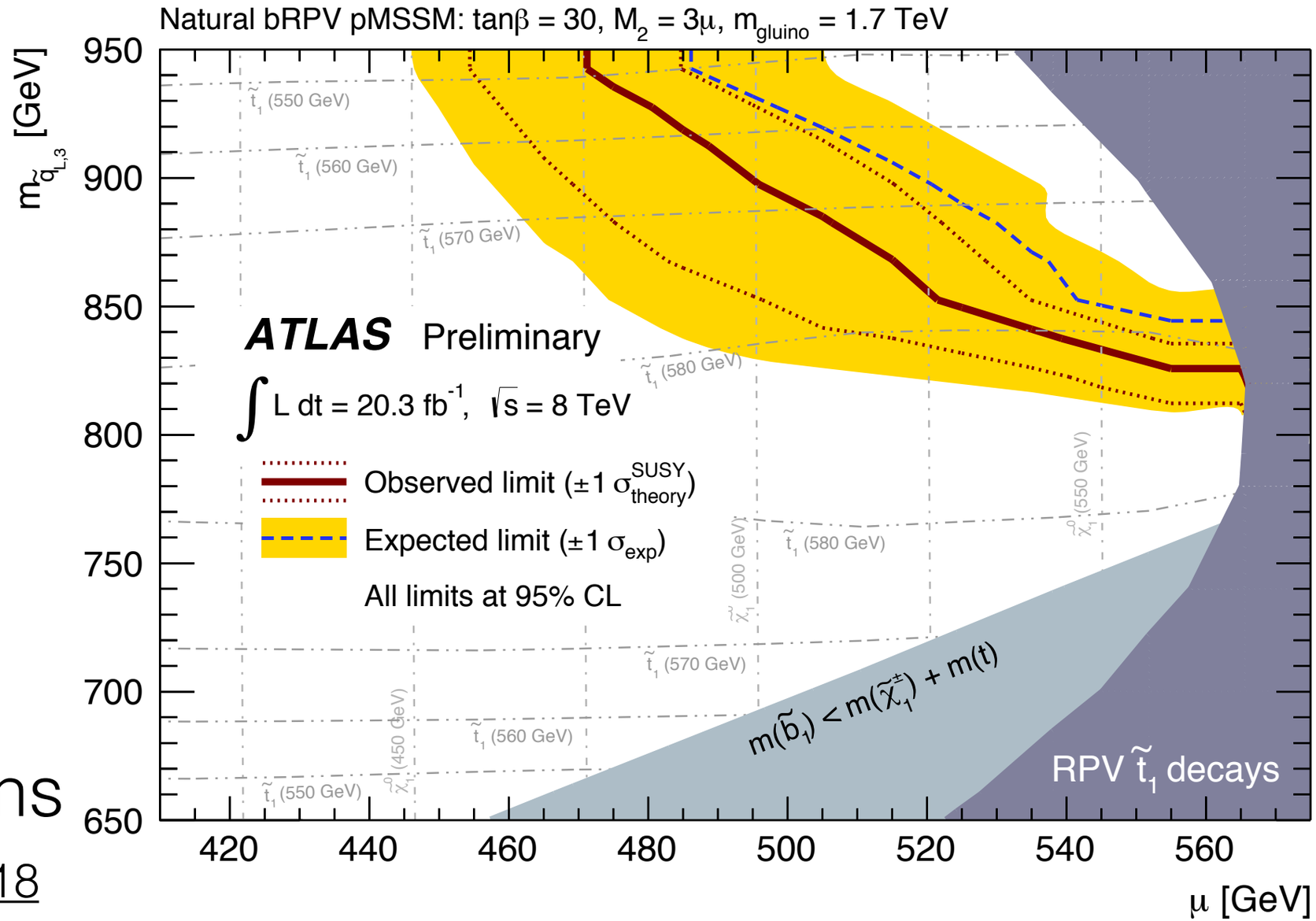
ATLAS-CONF-2015-018

ATLAS Preliminary

Bilinear LH

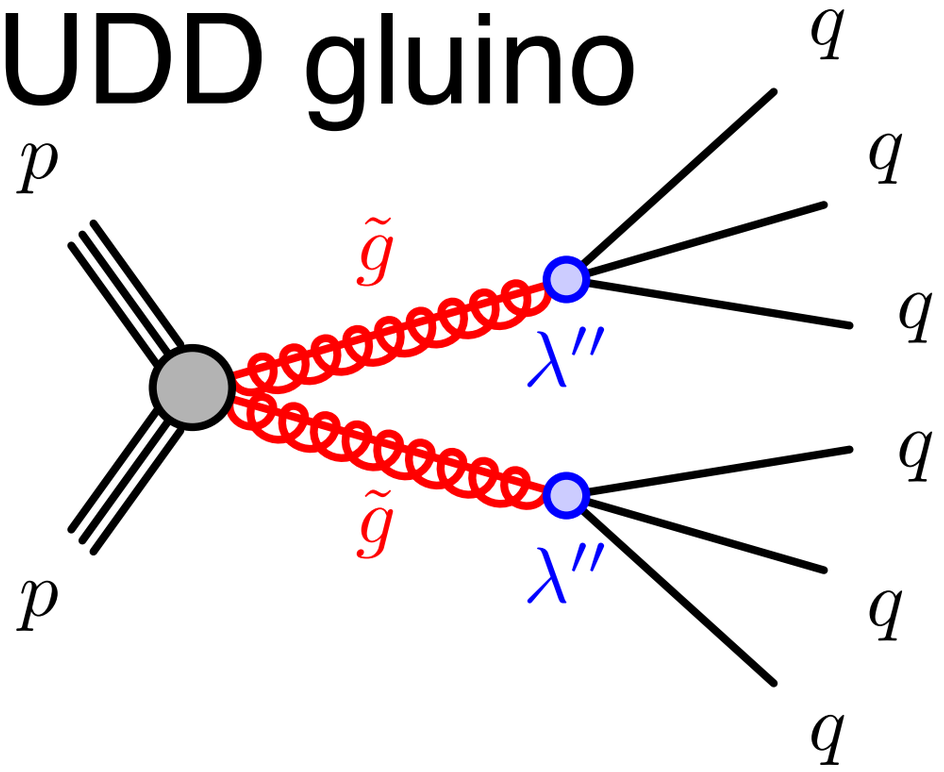
- Consider natural SUSY scenario with bilinear RPV coupling
  - Only third generation squarks considered
- Limits set using combination of same-sign two lepton and three lepton signal regions



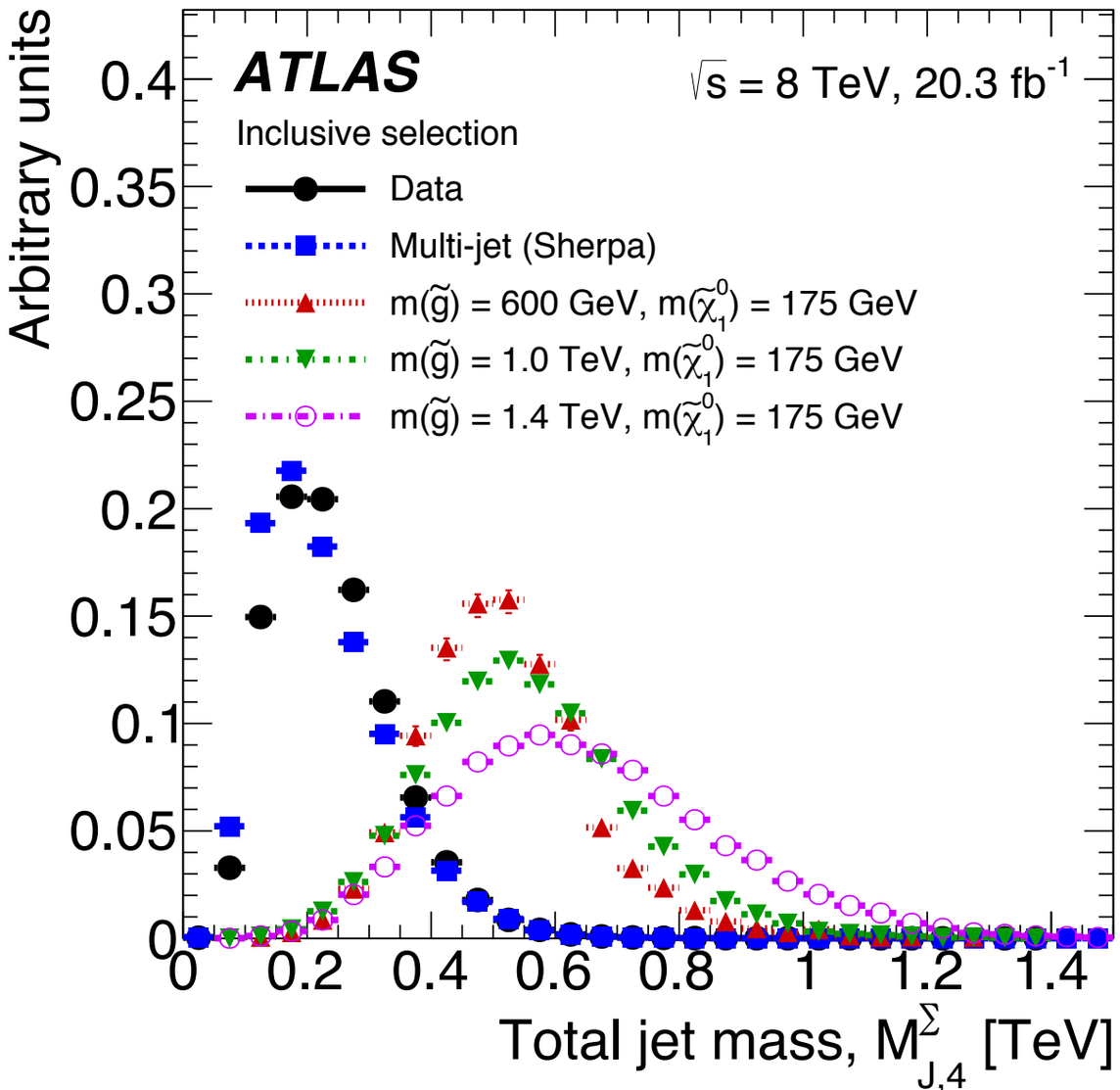


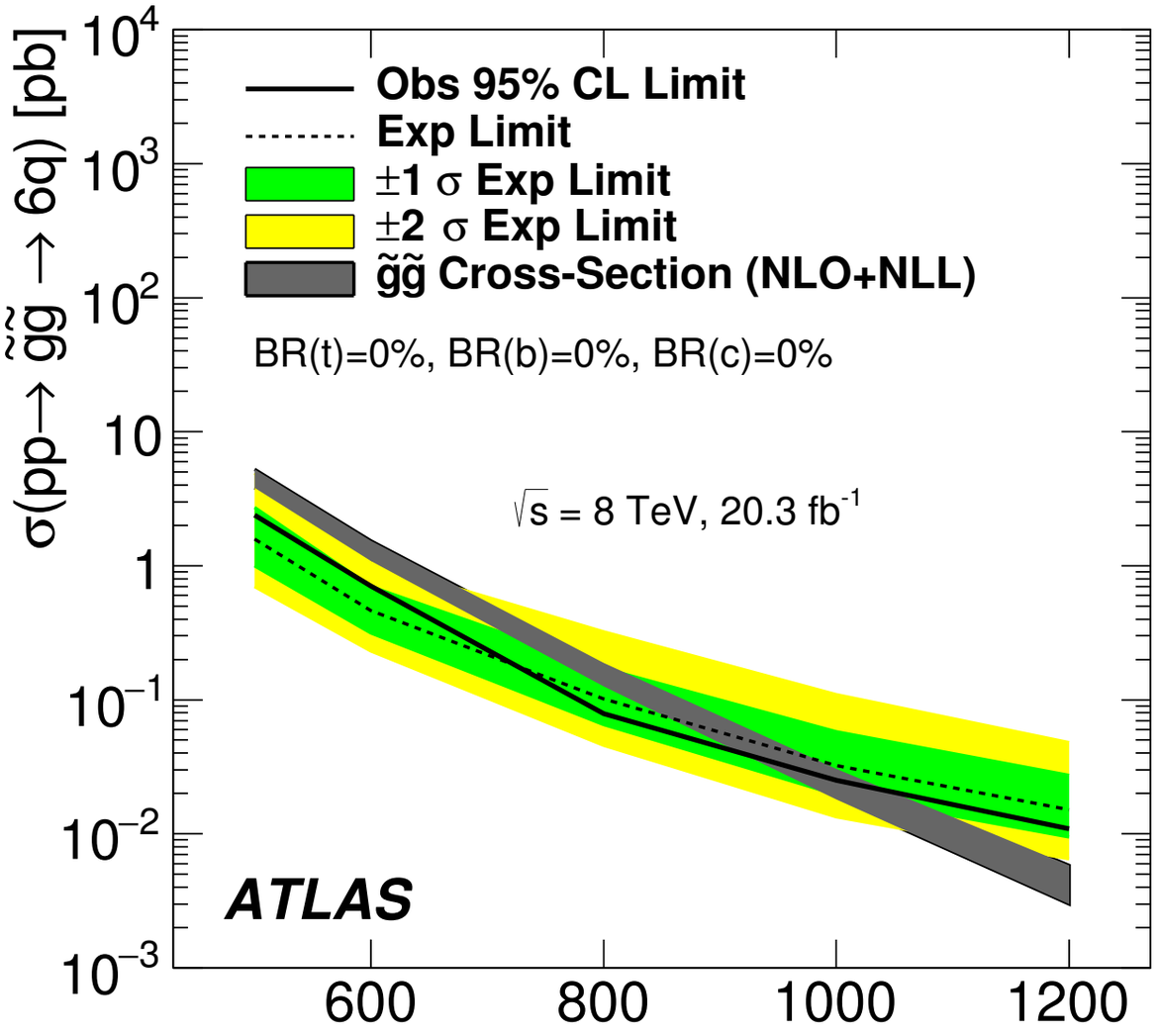
ATLAS-CONF-2015-018

UDD gluino



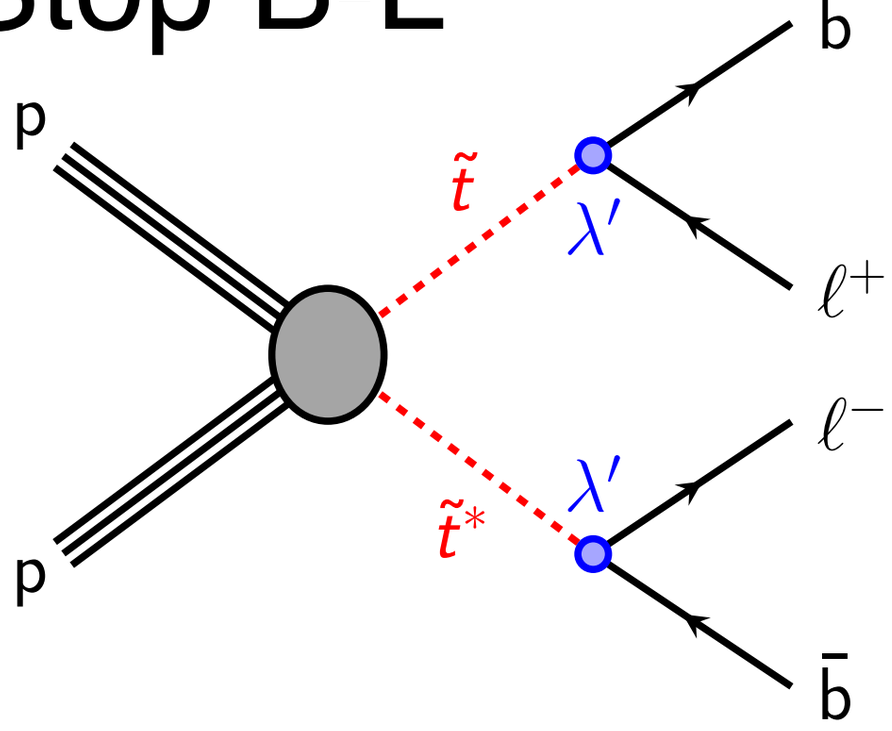
- Gluino decays via RPV coupling to three quarks
- Dual analysis technique
  - Jet counting in events with >= 6,7 jets
  - Template method using total jet mass of large-R jets
    - Predictive scaling of total jet-mass differs between signal and SM background





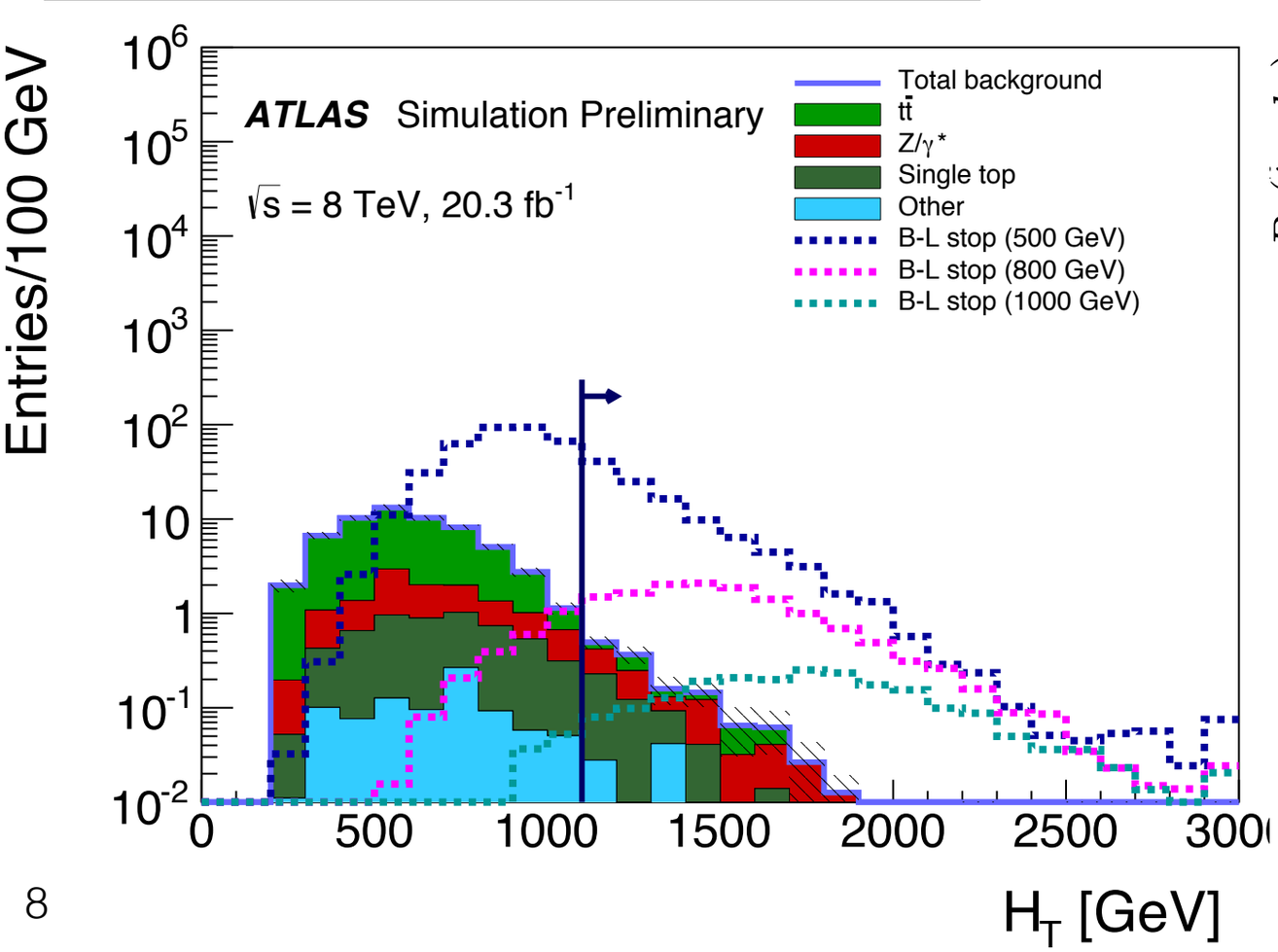
Phys. Rev. D 91, 112016

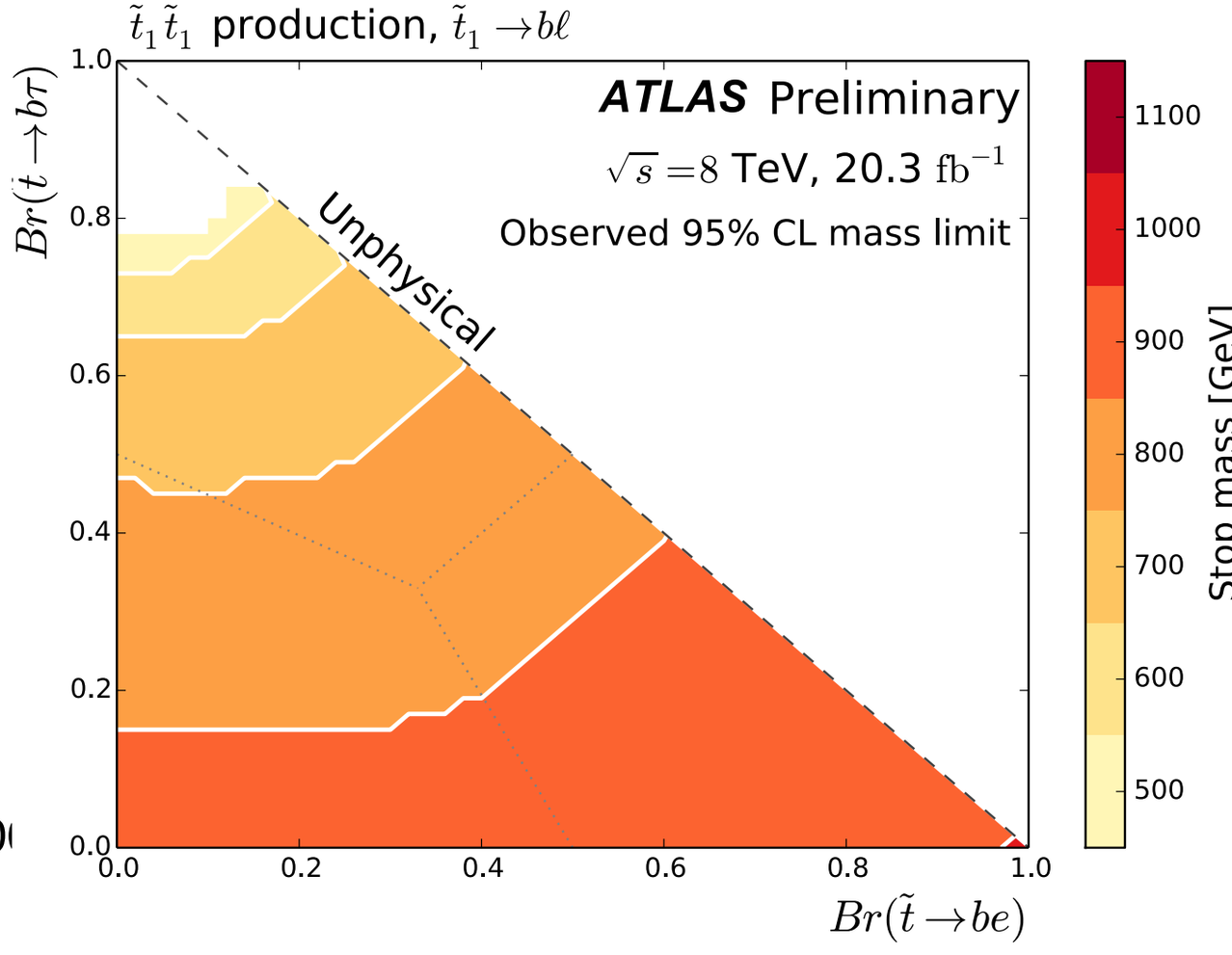
Stop B-L



- Instead of imposing RPC, add $U(1)_{B-L}$ symmetry
  - Stop decays via RPV interaction to lepton and bottom quark
- Search strategy requires two leptons and two b-tagged jets
  - Signal regions defined based on H_T, m_{bl}^0, and m_{bl} asymmetry

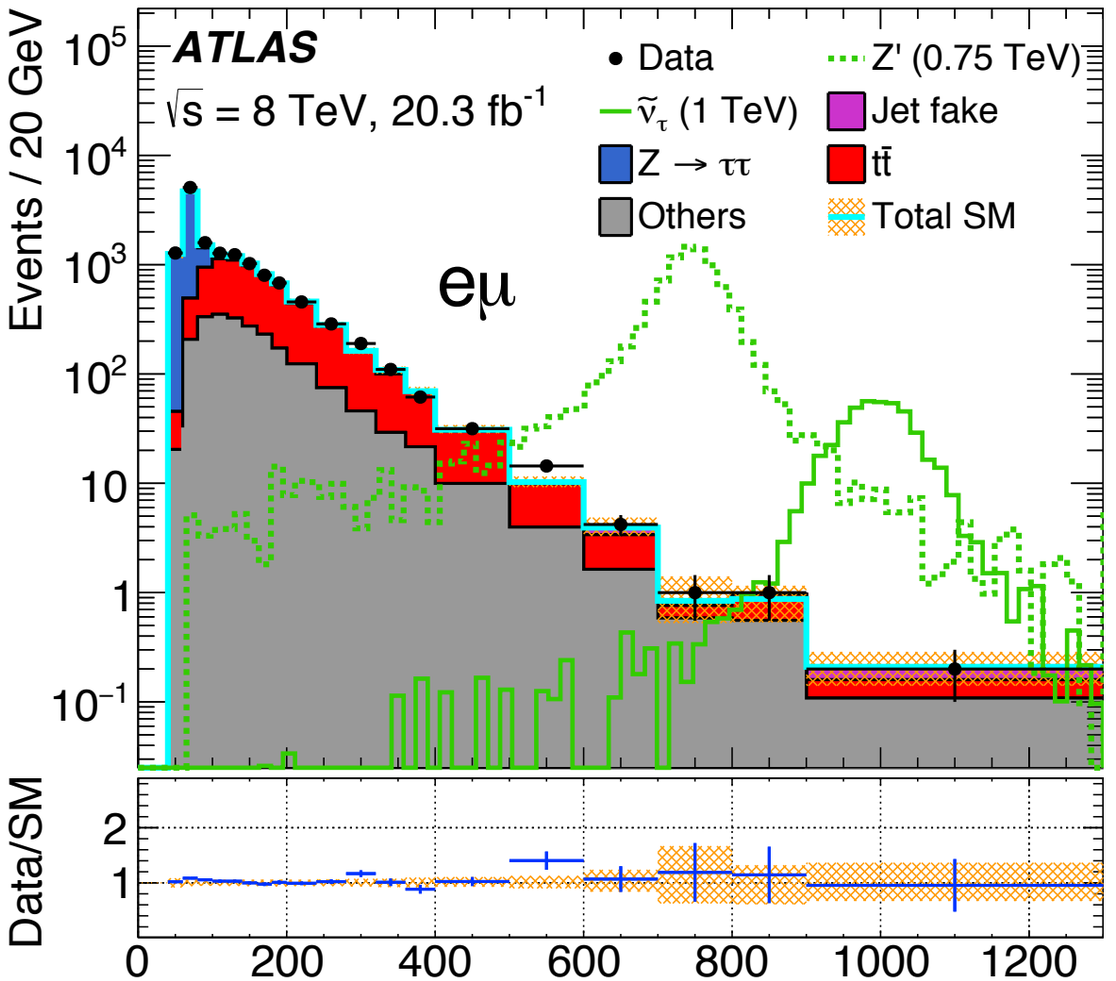
ATLAS-CONF-2015-015

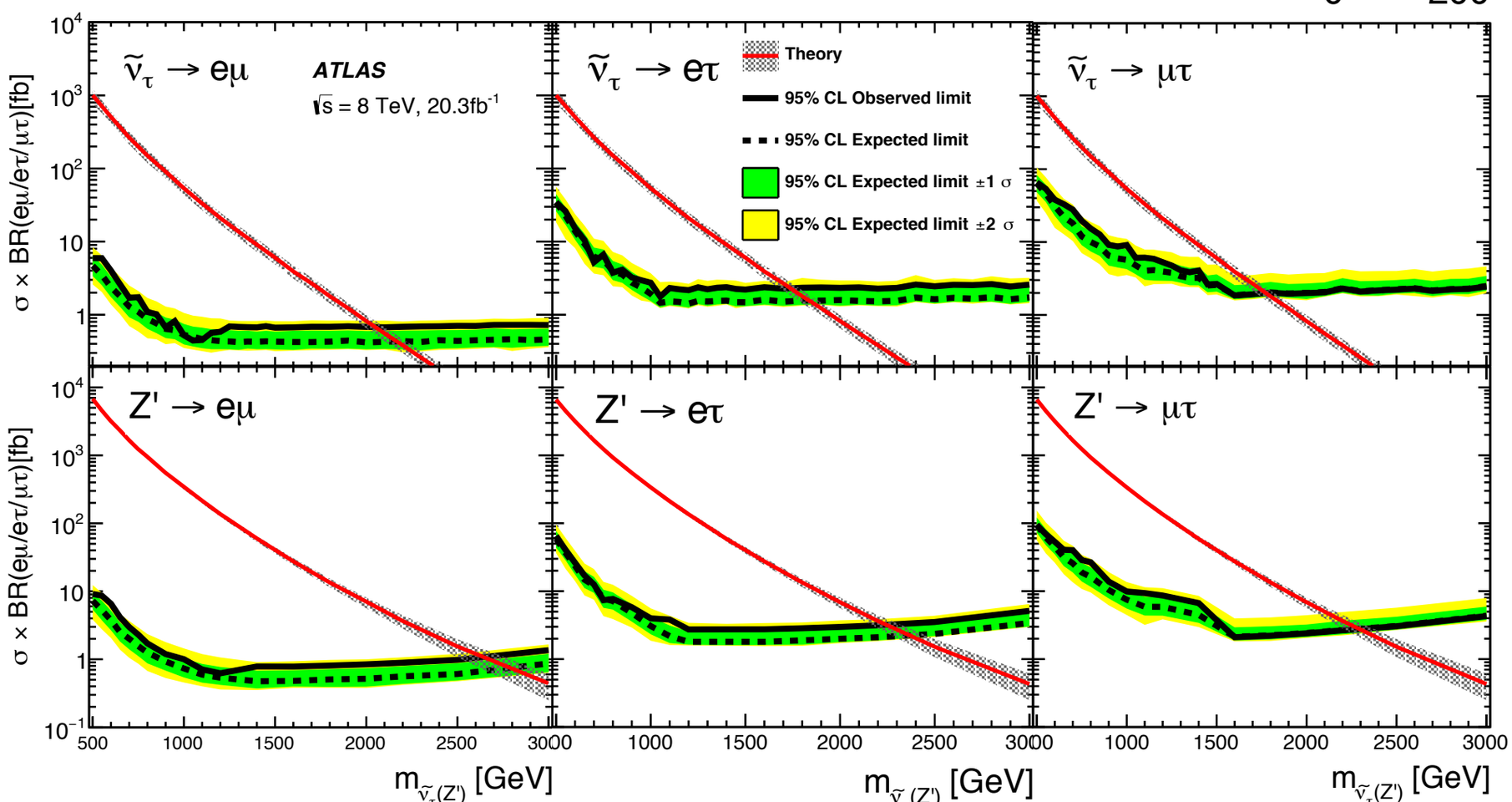


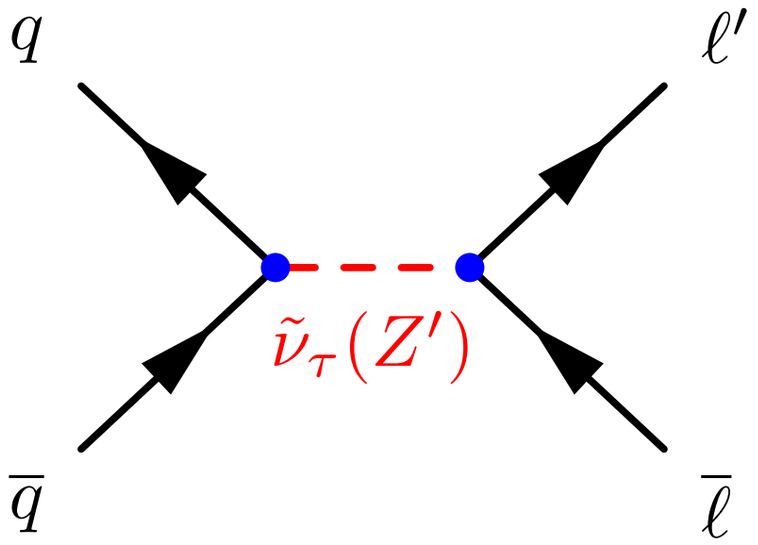


Lepton Flavor Violating Sneutrino Decay

- Search for decay of heavy neutral particle to $e^{\pm}\mu^{\mp}$,$e^{\pm}\tau^{\mp}$, or $\mu^{\pm}\tau^{\mp}$
  - RPV sneutrino decay
  - Search in dilepton mass spectrum
- Limits set in RPV SUSY models on RPV sneutrino cross section



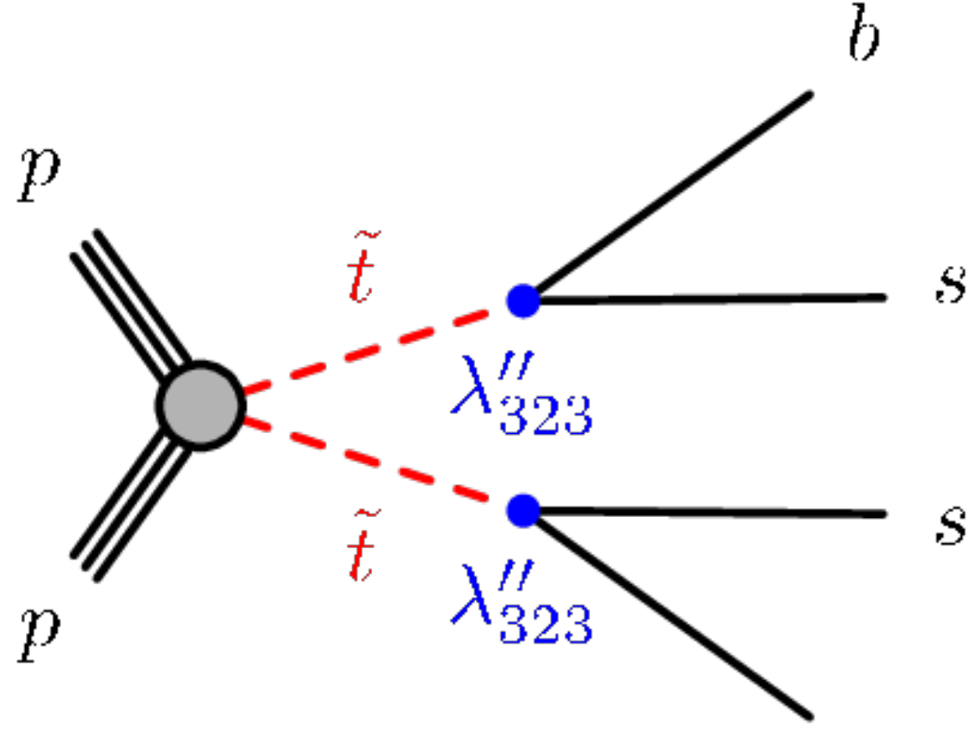


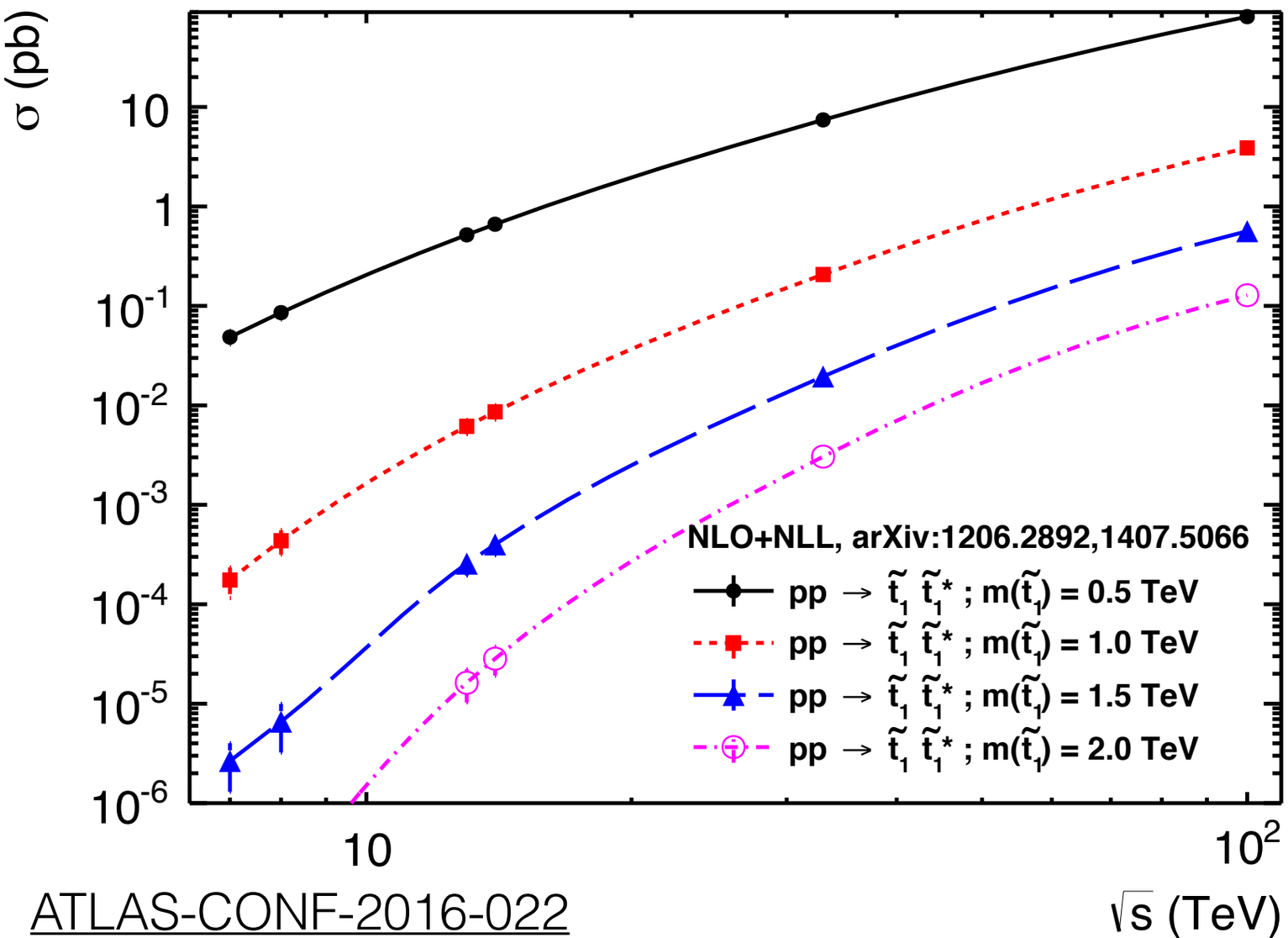


Phys. Rev. Lett. 115, 03180

UDD stop : introduction

- Stop decays via UDD coupling to bottom and strange quark
  - Search performed in Run1 and Run2
  - Increased stop cross-section wrt Run1 due to increased $\sqrt{s}$
- Search for excess in average of two large-R jet masses (m_{avg})





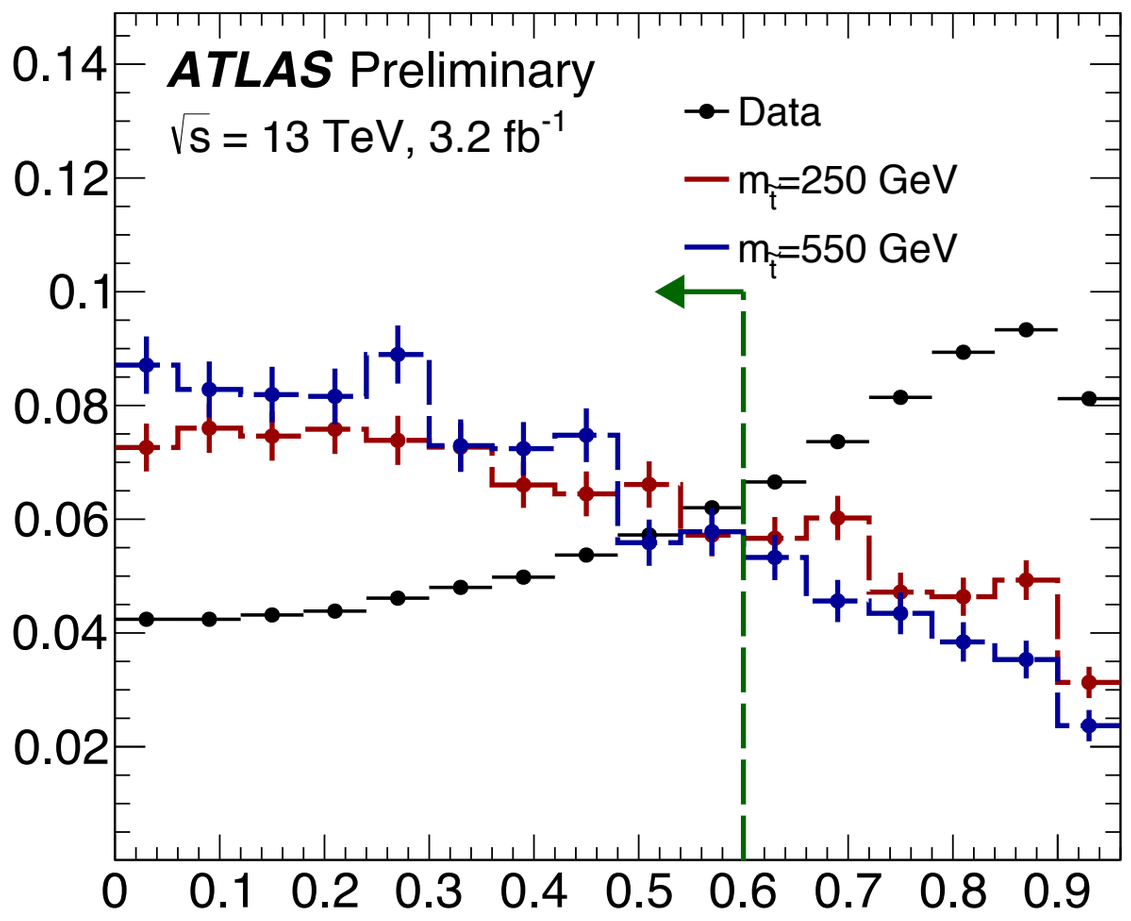
ATLAS-CONF-2016-022

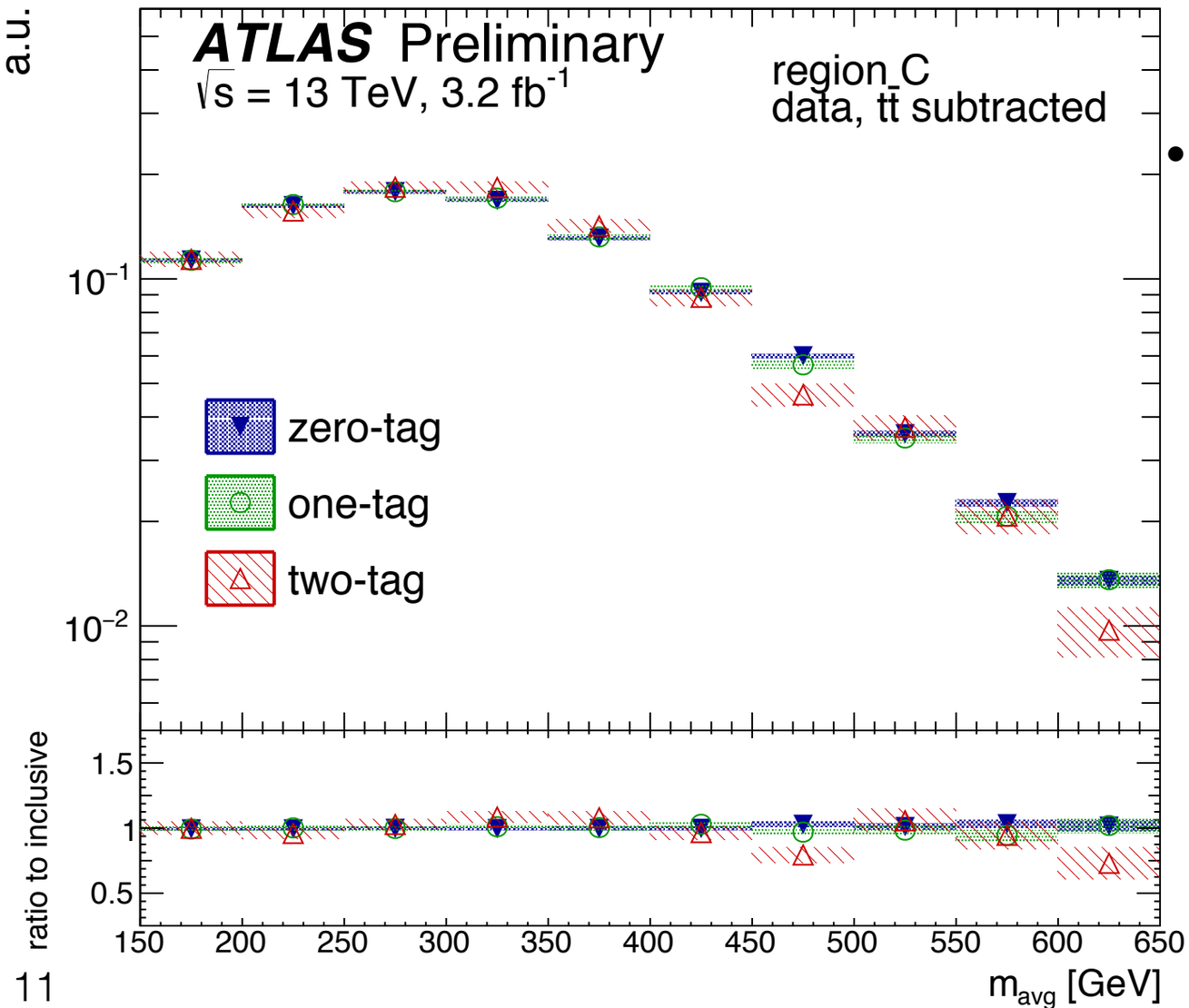
UDD stop : background

Dominated by multijet background

- Large-R jet mass asymmetry
- Jet centrality wrt beamline
- b-jet multiplicity

Region	$\mathcal{A}$	$\lvert\cos(\theta^*)\rvert$
A	< 0.075	≥ 0.6
B	≥ 0.075	≥ 0.6
C	≥ 0.075	< 0.6
D	< 0.075	< 0.6





- Two step background estimation
  - Data-driven prediction of zero b-tagged version of the SR, D
  - Projection factors : zero -> two b-tag regions derived

$$P_{AC} = \frac{1}{2}\left(\frac{N_{A2}}{N_{A0}} + \frac{N_{C2}}{N_{C0}}\right)$$

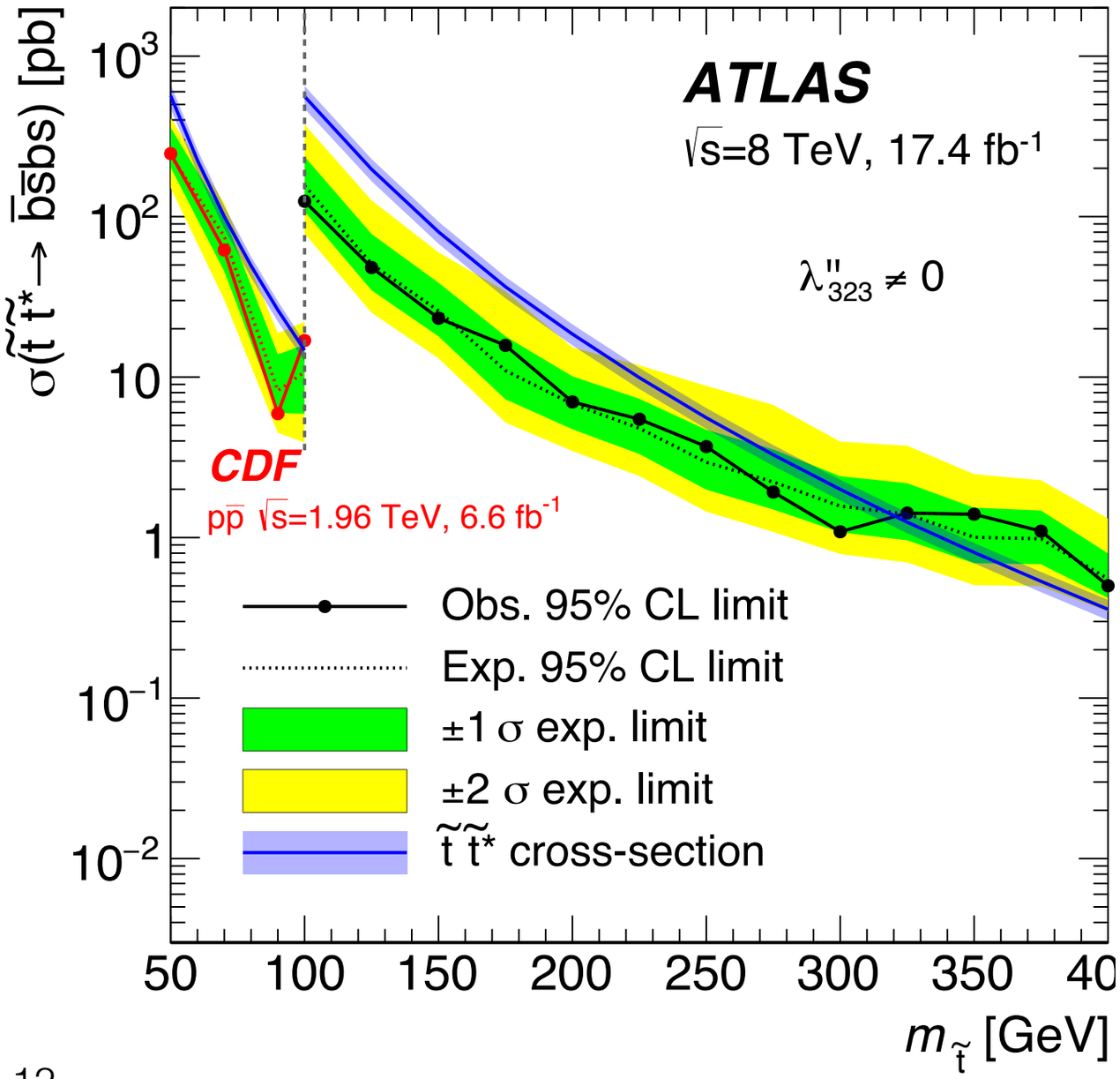
  - Validation of method
    - Prediction of one b-tagged region
    - Invariance of projection factors

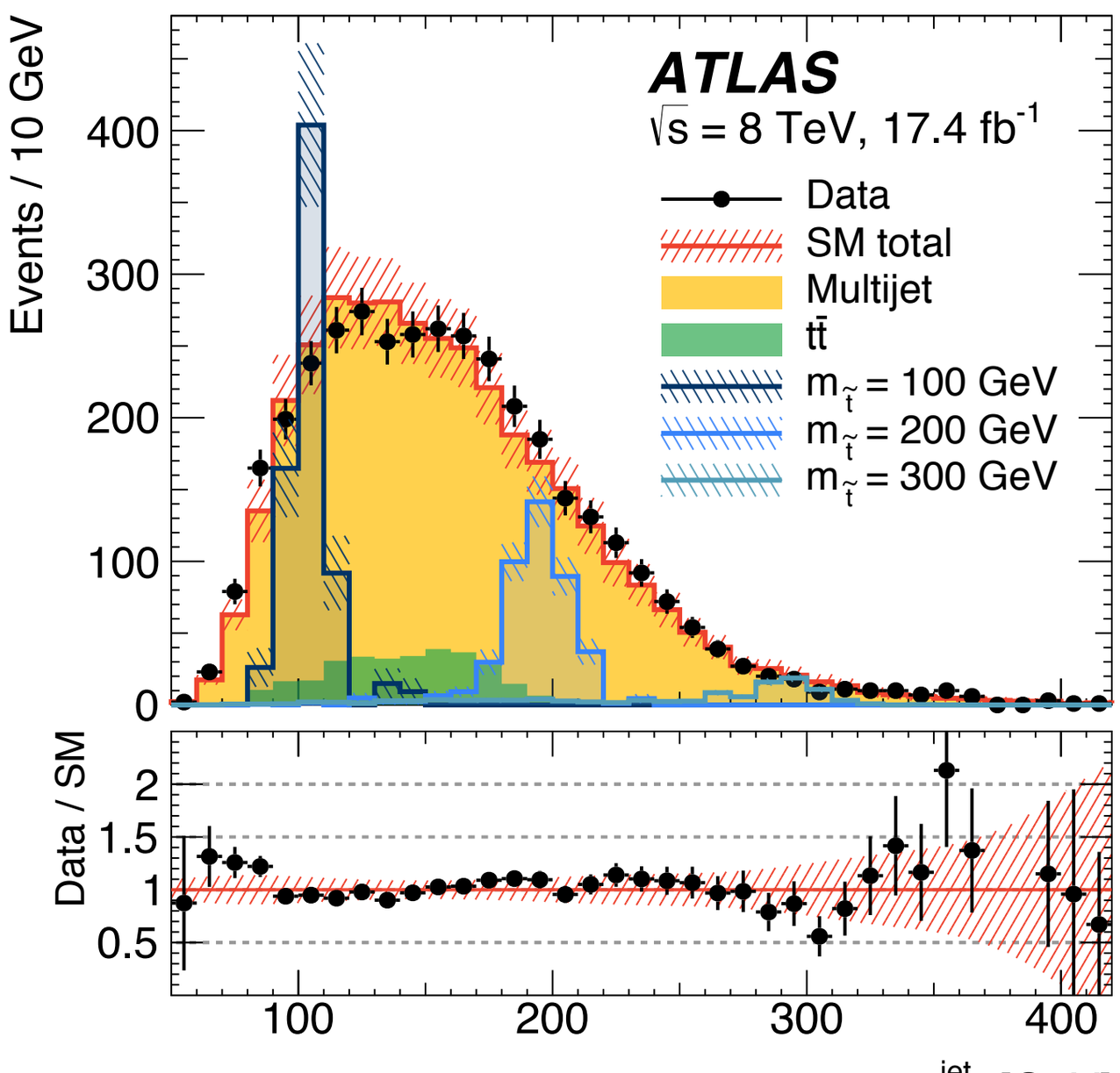
UDD stop : 8 TeV

JHEP 06 (2016) 067

- No excess seen over Standard Model background

- Limits extended to 315 GeV for stop decays into bottom and strange quark

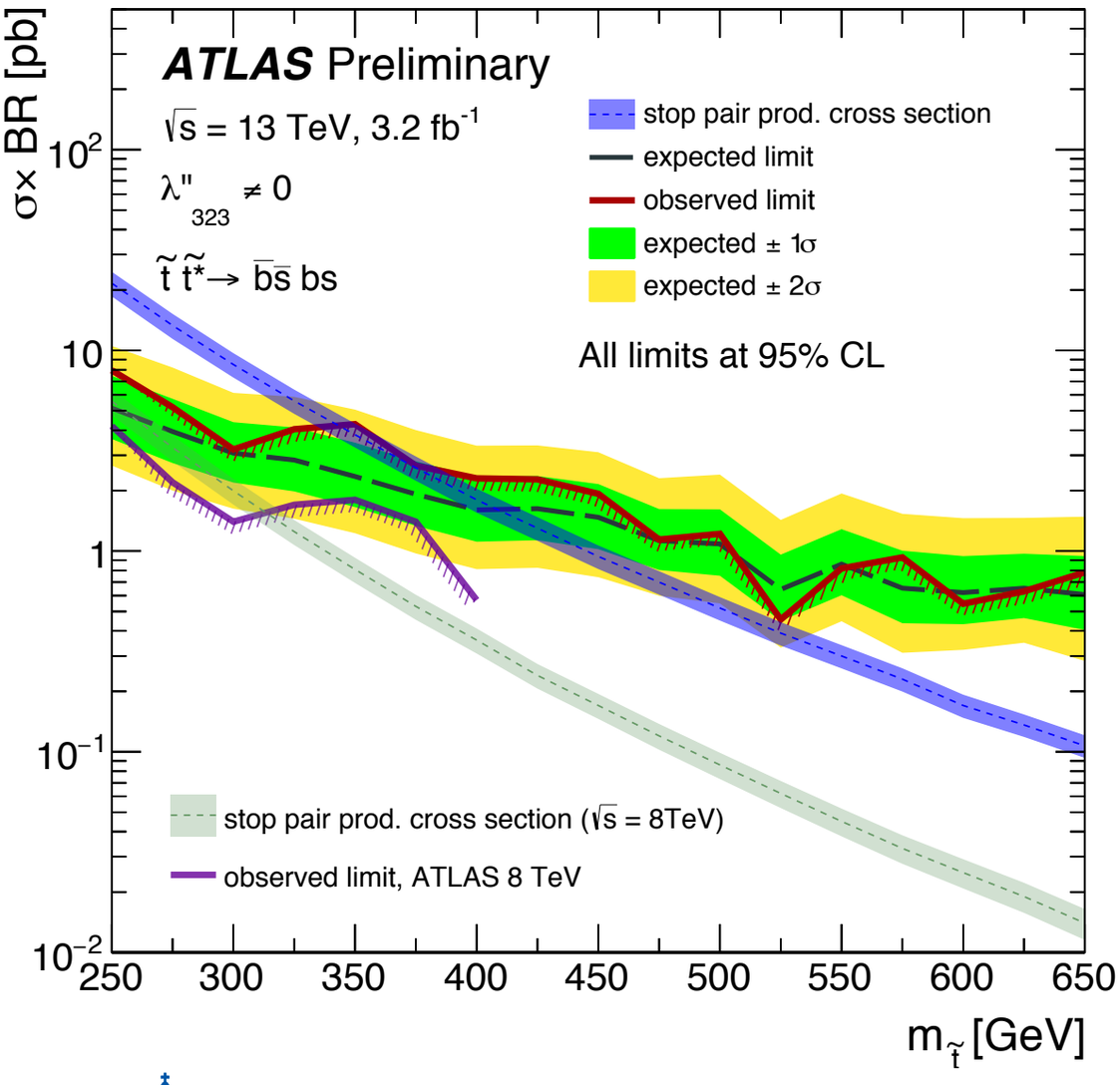


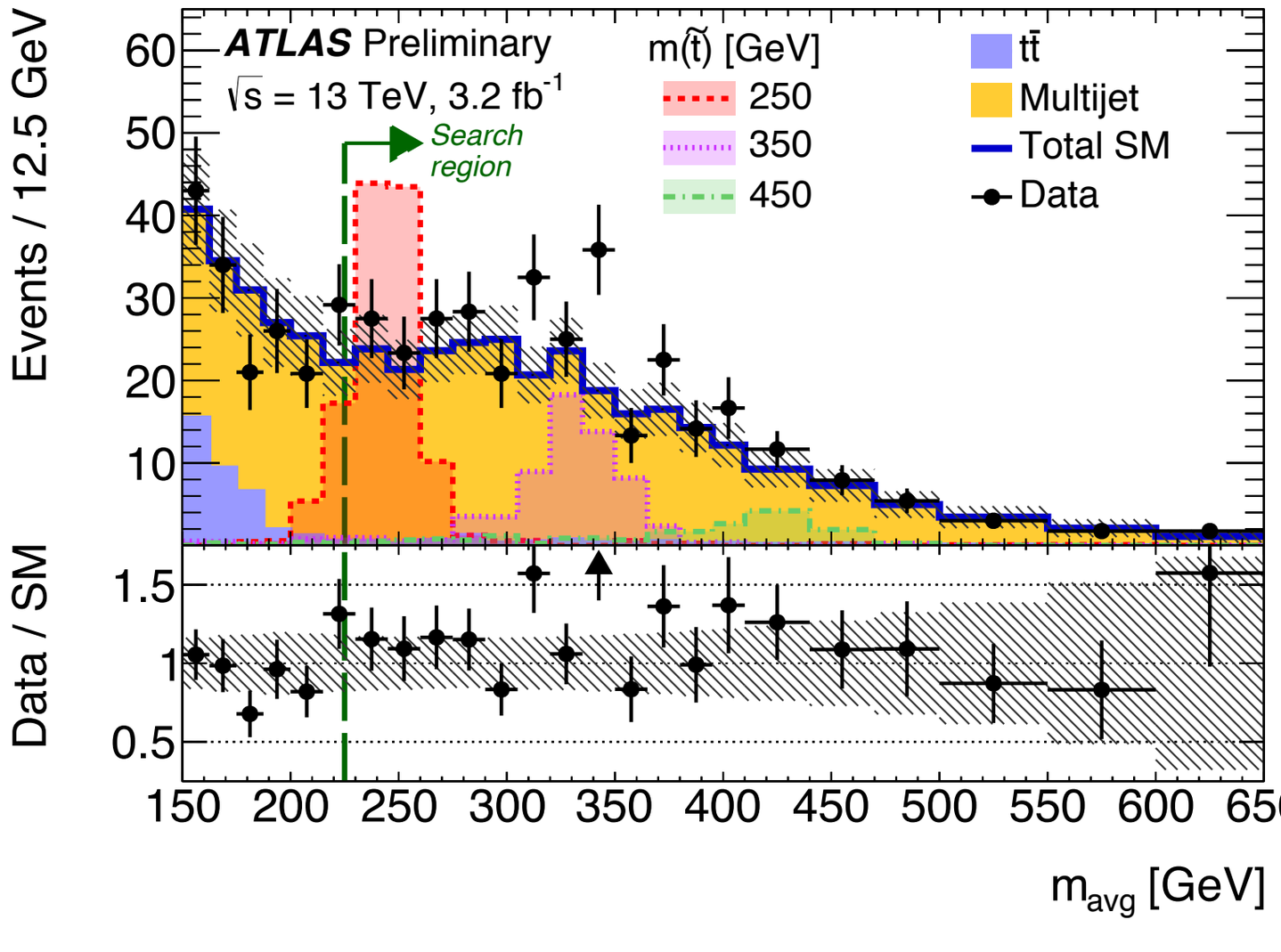


UDD stop : 13 TeV

ATLAS-CONF-2016-022

- No excess seen over Standard Model background
- Limits extended to 345 GeV for stop decays into bottom and strange quark





COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Conclusions

$$W_{\not L\mathrm{RPV}} = \frac{1}{2}\lambda_{ijk} L_i L_j \bar{E}_k + \lambda'_{ijk} L_i Q_j \bar{D}_k + \epsilon_i L_i H_2$$

$$W_{\not B\mathrm{RPV}} = \frac{1}{2}\lambda''_{ijk} \bar{U}_i \bar{D}_j \bar{D}_k$$

- R-parity violation leads to unique and interesting physics signatures
  - Decaying LSP -> lower missing transverse energy -> difficult background estimation
  - Despite challenges, many sensitive RPV searches
- ATLAS searches cover spectrum of possible RPV couplings
  - LLE - LSP decays to two leptons and neutrino
  - LQD - LSP decays to two quarks and lepton
  - Bilinear LH - lepton-gaugino mixing term
  - UDD
    - Gluino decays to three jets
    - Stop decays to bottom and strange quark

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK