Search for R-Parity Violating SUSY and Long Lived Particles with the ATLAS Detector

Michael Mazur
Universität Bonn

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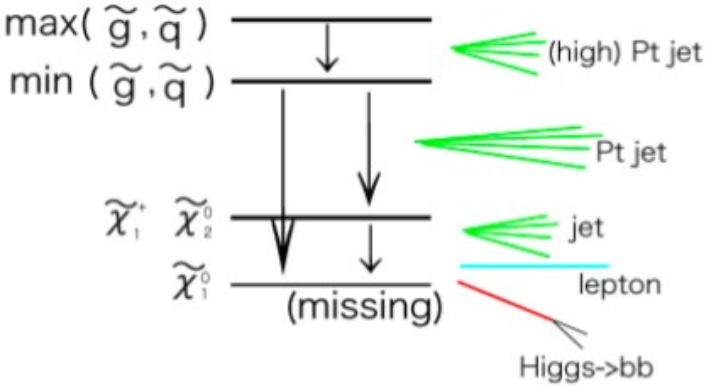
Rheinische
Friedrich-Wilhelms-
Universität Bonn

Outline

- Motivation
- Search for displaced vertices — Based on 33 pb^{-1} of data
- Updated search for $e\mu$ resonance — Based on 0.87 fb^{-1}
- Outlook

SUSY and R-Parity Violation



- R-parity violating terms like

$$W_{\not R_p} = \mu_i H_u L_i + \frac{1}{2}\lambda_{ijk} L_i L_j E_k^c + \lambda'_{ijk} L_i Q_j D_k^c + \frac{1}{2}\lambda''_{ijk} U_i^c D_j^c D_k^c$$

  invariant under MSSM gauge transformations: not a priori forbidden

  - Induce B and L number violating processes
  - Lightest SUSY particle no longer stable, can decay to SM particles
  - Constraints from low-energy (proton decay, cosmology, etc.) require couplings to be small
  - Small Λ also imply small decay widths for LSP $\Rightarrow$ long-lived particles
    - Lifetime depends on Λ, LSP identity and mass; can be very short or very long
    - Displaced vertex analysis sensitive to lifetimes $c\tau \sim$ 1-100 mm

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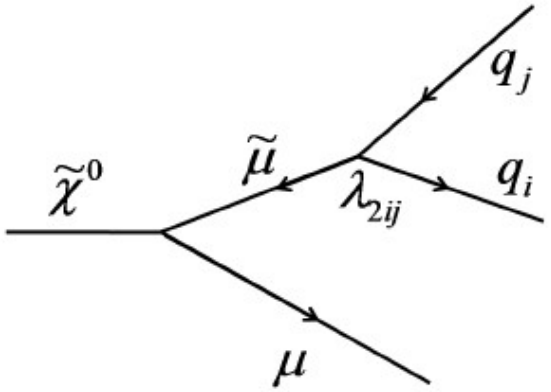
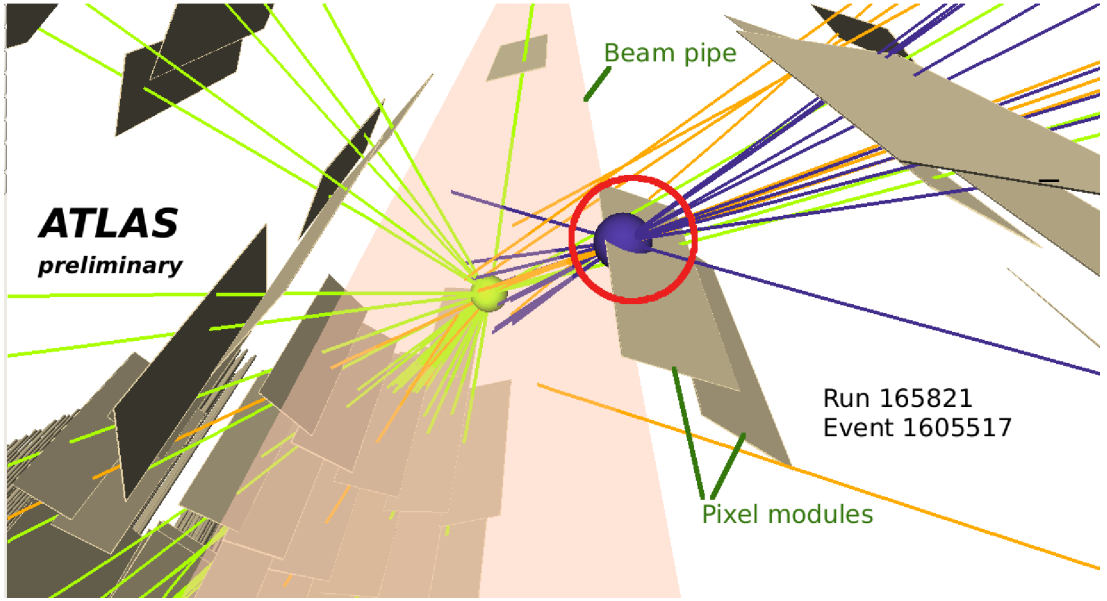
Displaced Vertex Search



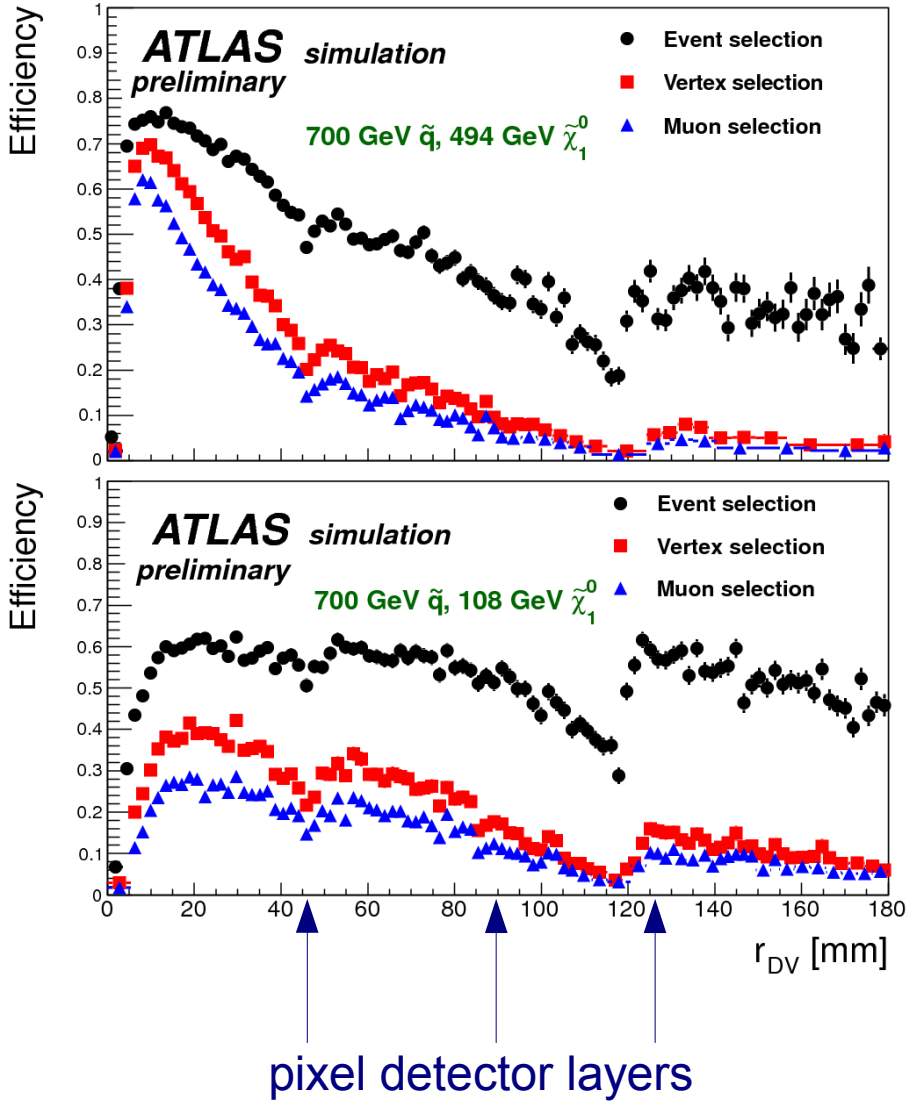
- Select events with a high p_T (trigger) muon and a secondary vertex within the central pixel detector volume
- Dominant backgrounds: combinatorial vertices, material interactions
- Generic search for long-lived particle decaying to muon+hadron(s)



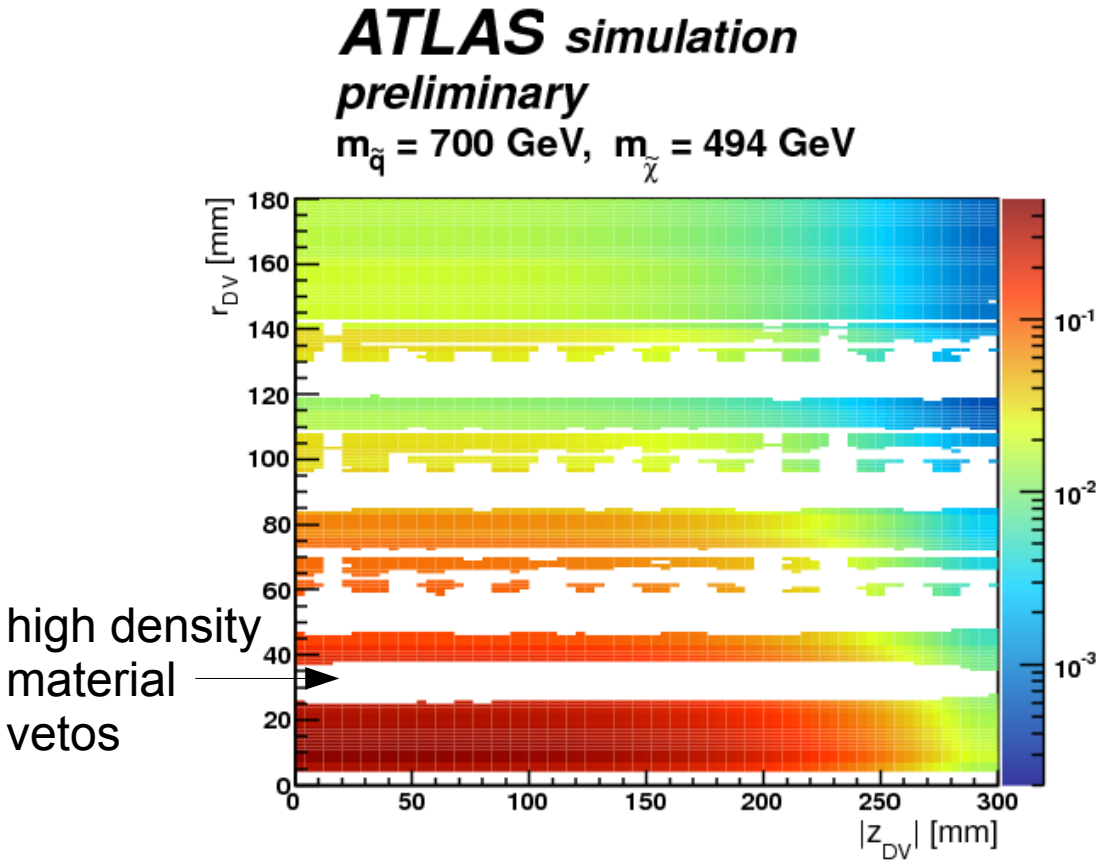
Signal vertex selecton:

- $N_{track} \geq 4$
- Vertex mass > 10 GeV
- Veto areas of high material density

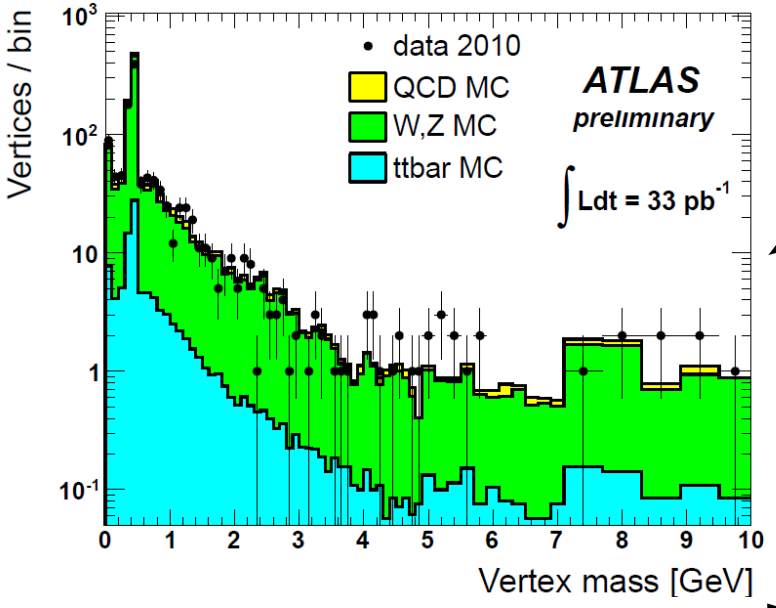
Signal Efficiencies



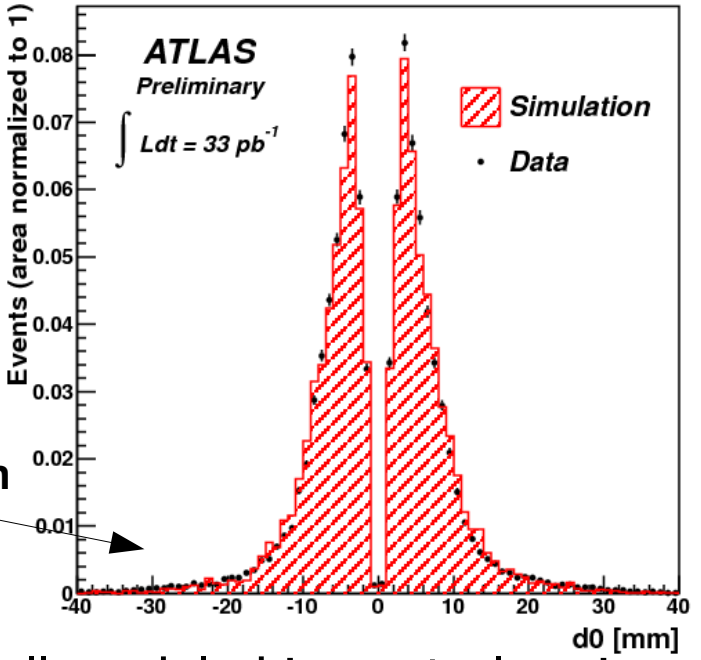
- ε depends on neutralino mass, lifetime, and boost, and on decay position relative to pixel layers
  - Final ε including material vetos:



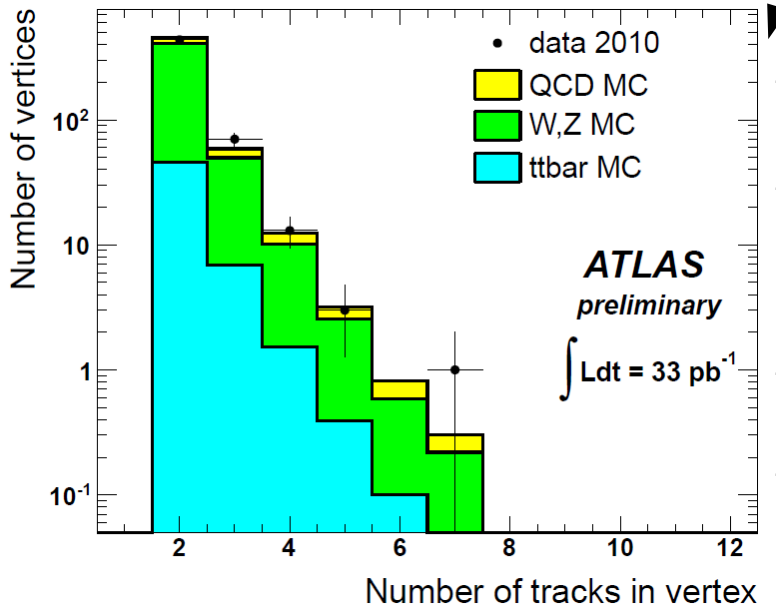
Background Studies



Inverted N_{track} and vertex mass cuts

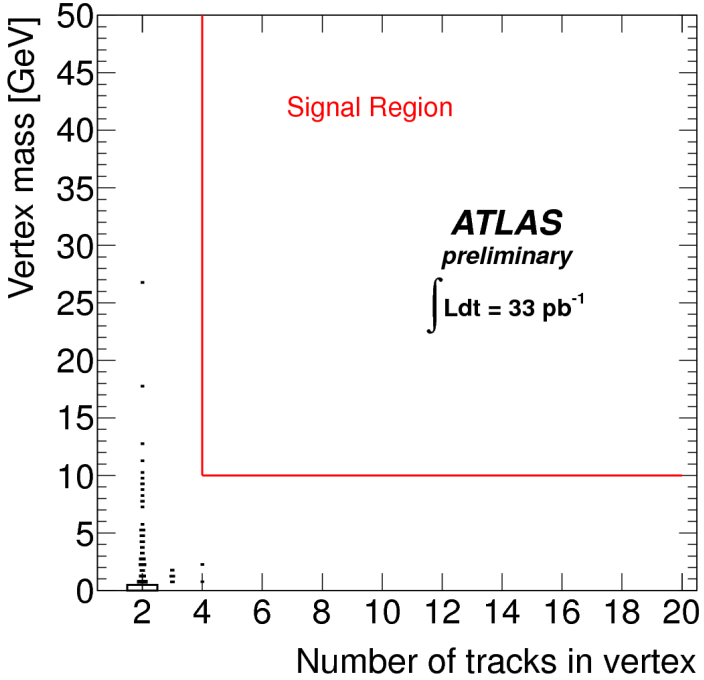


K_s control region



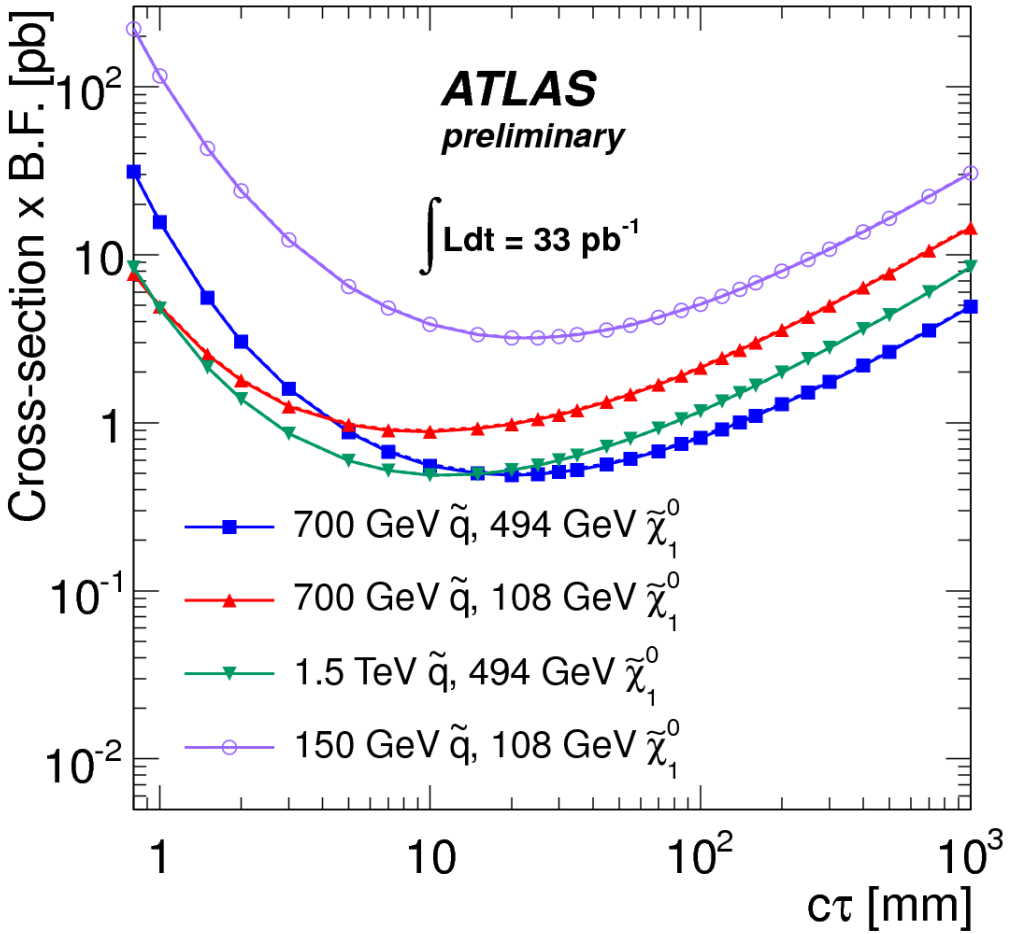
- N_{track} and mass well modeled in control region
- K_S, Λ, and γ conversion control samples used to study track efficiency vs d_0
- Cosmics used to study muon efficiency vs d_0
- Independent jet-triggered events used to crosscheck vertex mass distributions

Displaced vertex: Results



- Zero events observed in 33 pb^{-1} of data
  - Expected BG < 0.03 events @ 90% CL

- Set limits as a function of squark/neutralino mass and cτ
  - For 150 GeV squark, limit below expected 95 pb for large ct range
  - Generic limit (σ x BF x acceptance) < 0.09 pb at 95% CL



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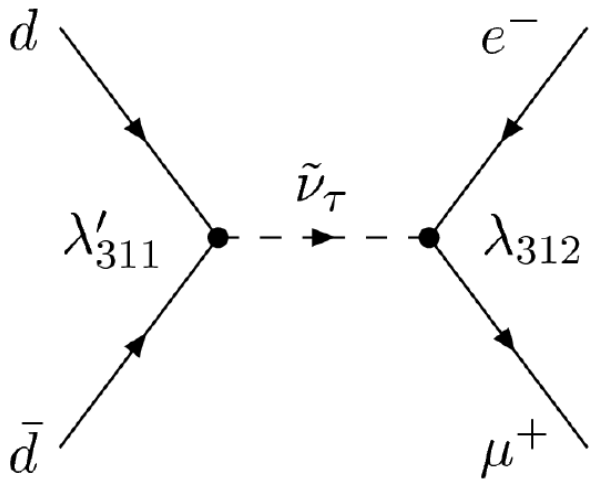
eμ Resonance Search

- Trigger on either electron or muon
- Require exactly one opposite-charge eμ pair, with both e and μ well isolated
- Can also be interpreted as Z'→eμ



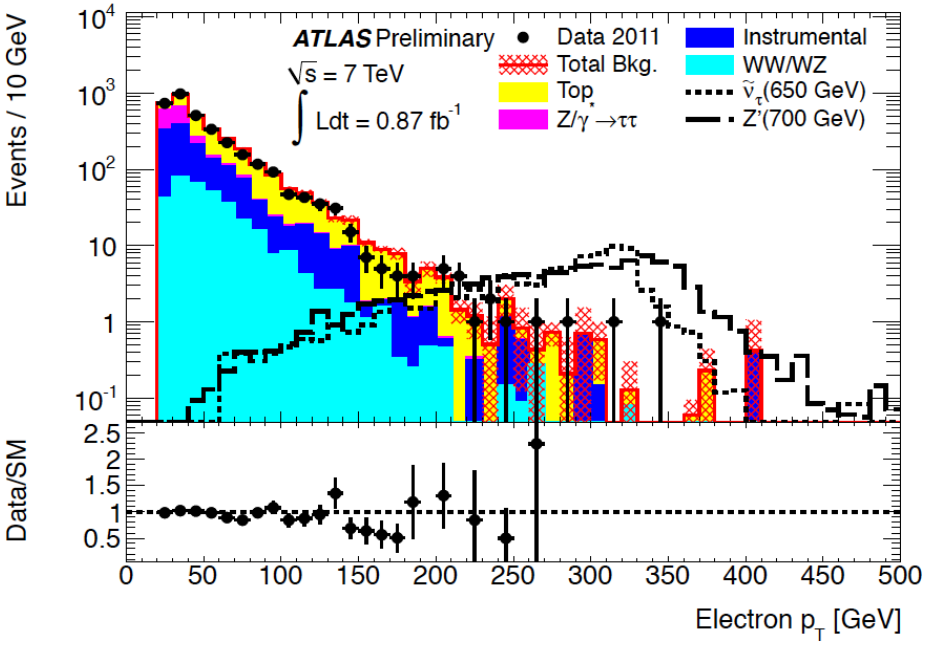
- Previous ATLAS search PRL**106** 251801 (2011). Changes since then:
  - x25 more luminosity (0.87 fb^{-1} vs 35 pb^{-1})
  - Higher e/μ pT thresholds, slightly improved isolation requirements
  - More sophisticated data-driven instrumental background estimation
  - New signal region definitions for limit setting

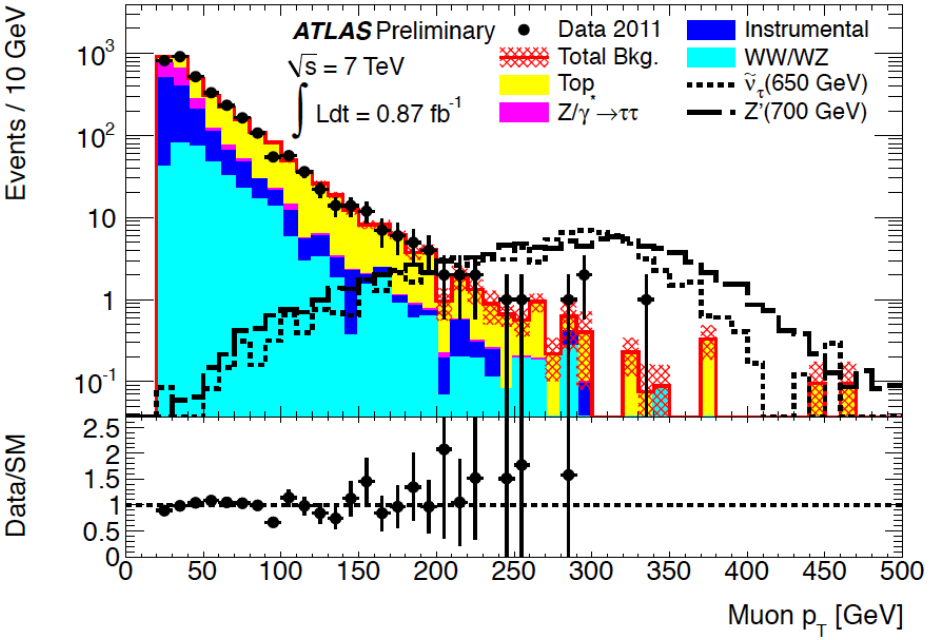
eμ Resonance: Backgrounds

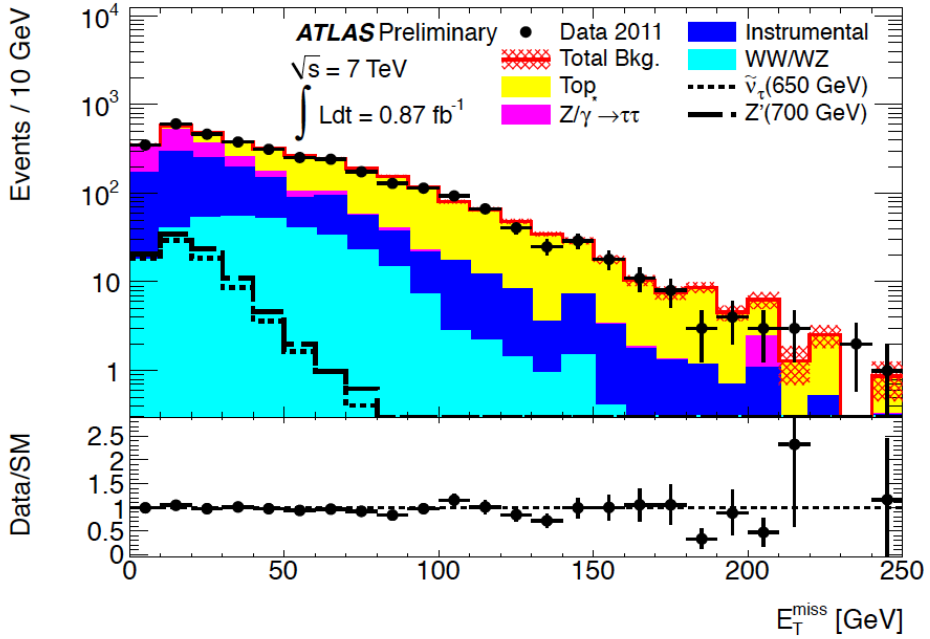
- Events with two prompt leptons
  - ttbar, Z→ττ, WW, WZ, ZZ
  - estimated from Monte Carlo samples
- Instrumental backgrounds
  - γ conversions, secondary leptons within jets estimated from MC
  - Fake leptons estimated from data using a matrix method
    - Use both "loose" and "tight" e and μ selection criteria
    - Efficiencies for real leptons measured in Z→ee/μμ in data
    - Fake rates measured in QCD dijet control sample in data
    - Use efficiencies, fake rates, and loose lepton yields to measure BG

Process	Num. of events
$Z/\gamma^* \to \tau\tau$	614±53
$t\bar{t}$	1281 ± 168
WW	318 ± 24
Single top	125 ± 17
WZ	18.2 ± 1.9
$W/Z + \gamma$	67 ± 11
Jet instrumental background	984 ± 105
Total background	3408 ± 230
Data	3338

eμ Resonance: Kinematics

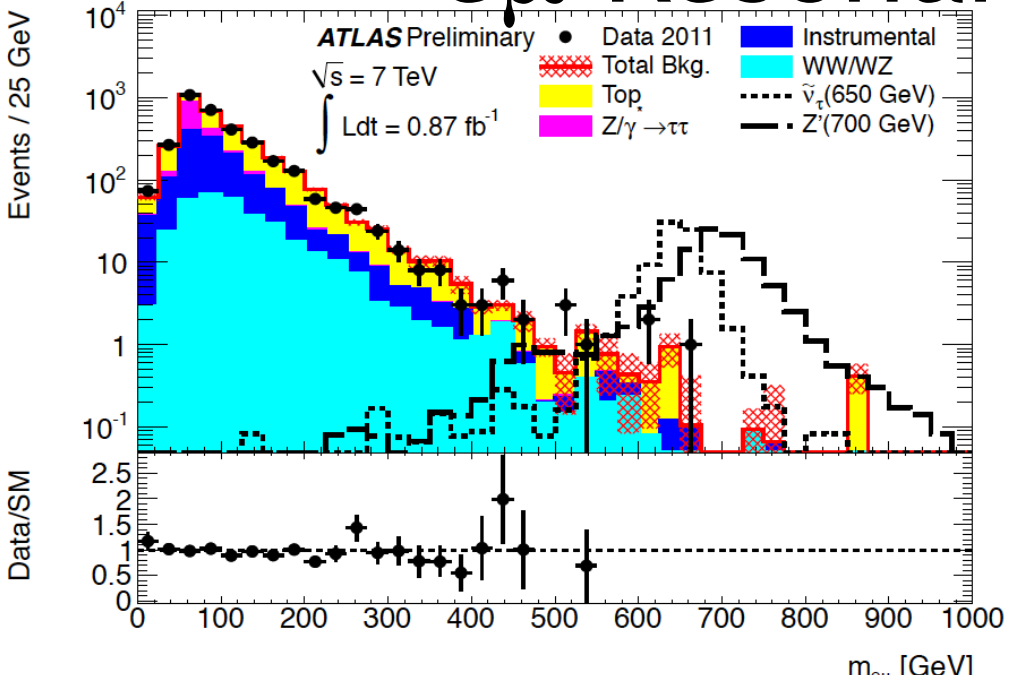




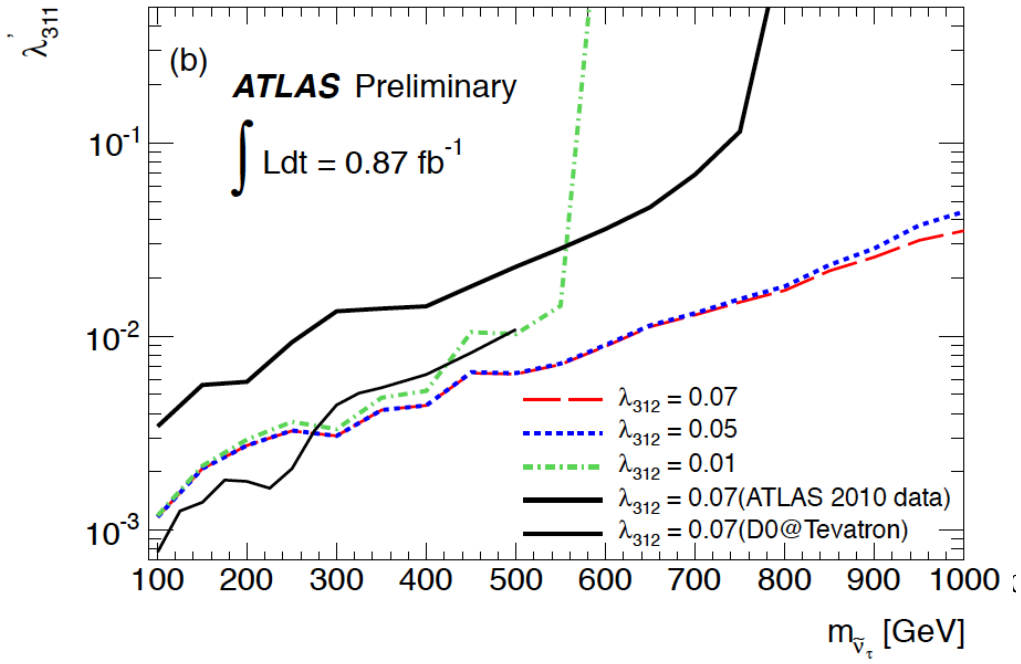


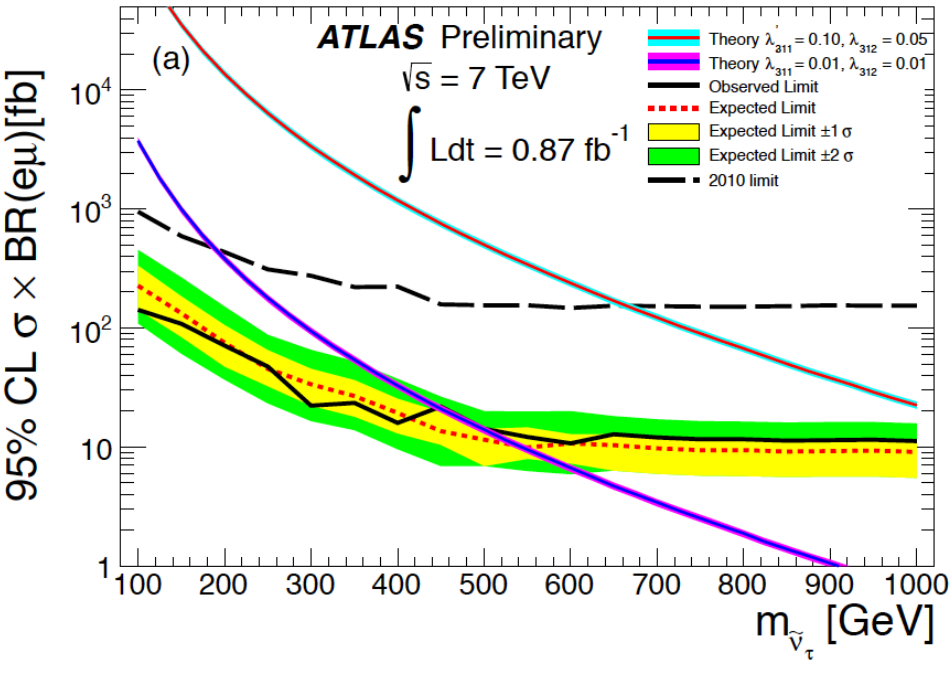
- Good agreement seen between data and MC in lepton kinematics and missing transverse energy
  - Missing energy not used in event selection

eμ Resonance: Results



- No significant excess seen
  - sneutrino ε ~35% (65%) for 100 (1000) GeV
  - Set limits as function of mass and RPV coupling constants:





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Conclusions

- R-parity violating SUSY is an active field of research at ATLAS

- Search for medium-lived neutralinos and displaced vertices
- Updated search for a sneutrino decaying to an eμ resonance
  - extend limits an order of magnitude beyond 2010 result
- No excess seen beyond the SM backgrounds... continue to push the limits and constrain the available RPV SUSY parameter space