Searches for direct supersymmetric gaugino production and R-parity violation in final states with leptons with the ATLAS detector

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Hideki Okawa (Brookhaven National Laboratory)
on behalf of the ATLAS Collaboration

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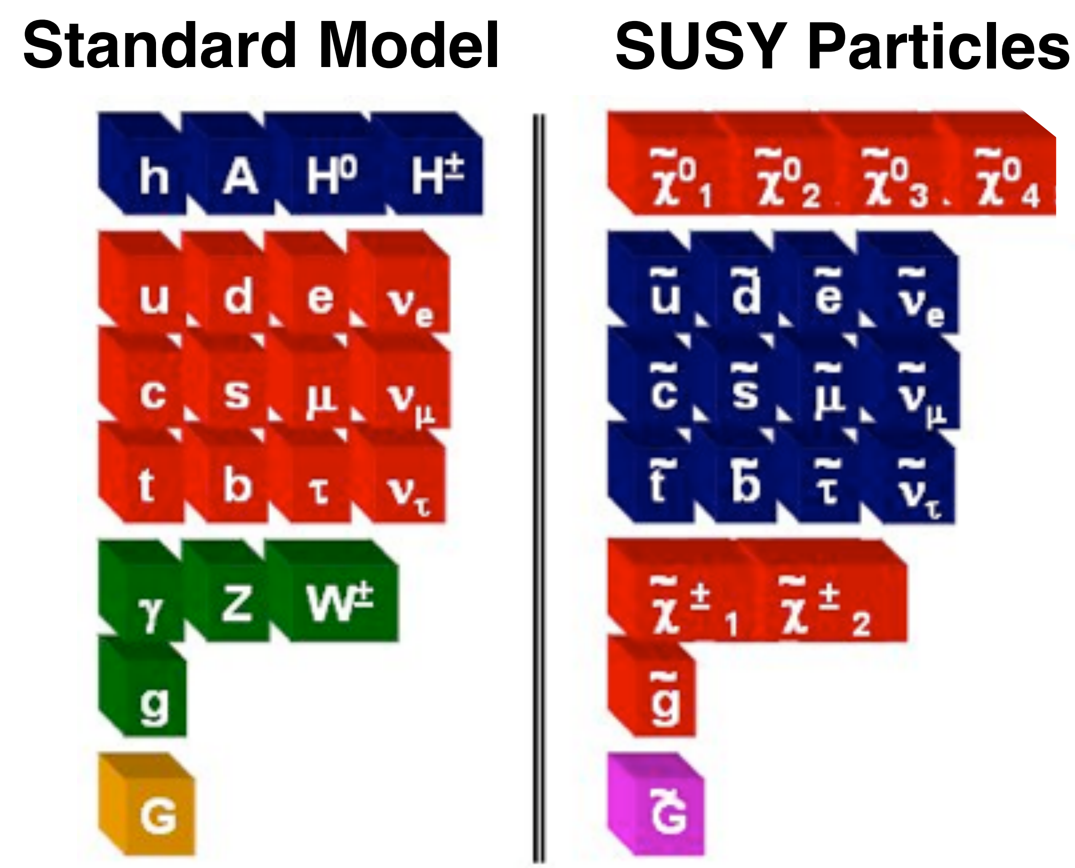
Why Supersymmetry?

- Mathematical beauty / Ingredients to the String Theory
- Grand Unification
- Solution to hierarchy problem / Stabilization of Higgs mass
- Provides a dark matter candidate ← if R-parity is conserved



In this talk

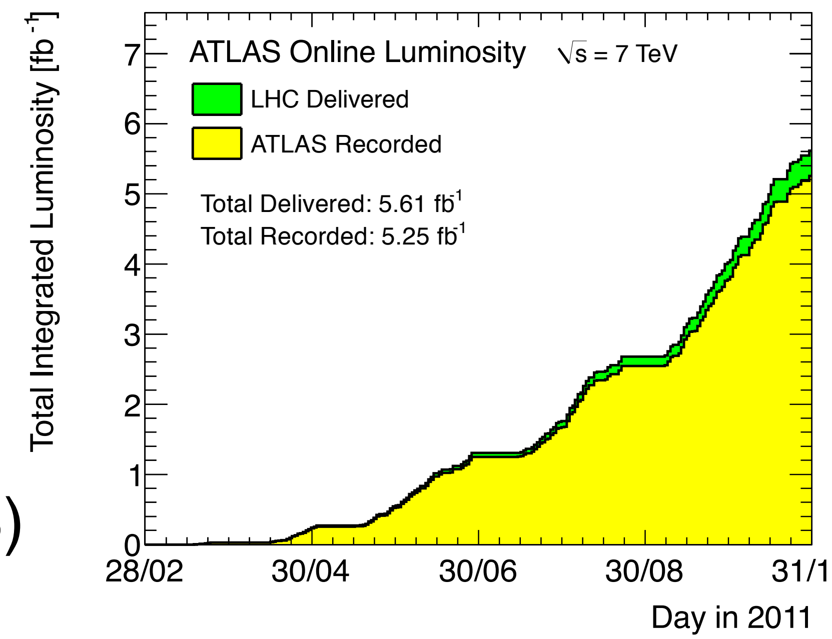
Will present results of supersymmetry **searches using events with leptons with the ATLAS detector at the LHC (2011 data)**

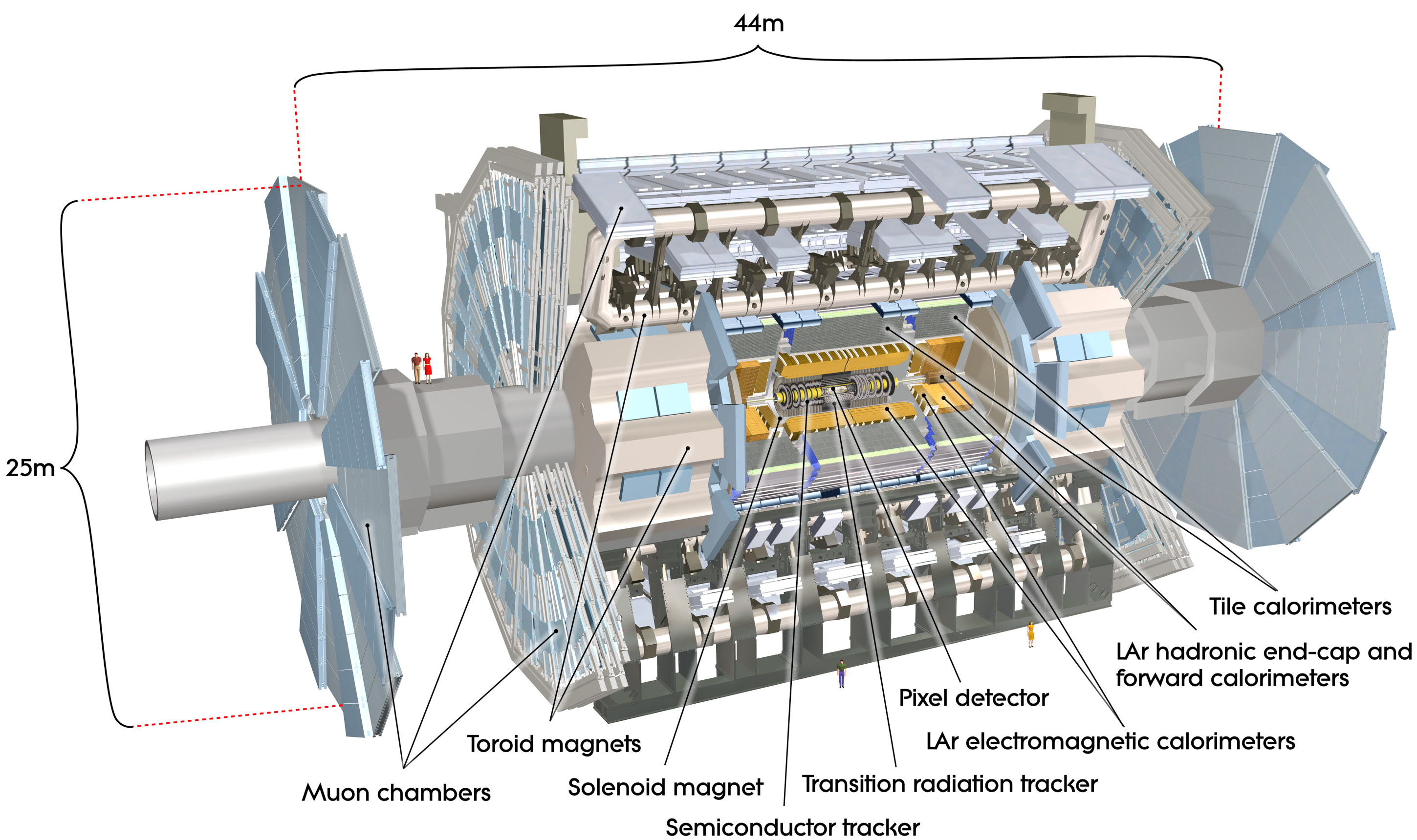
- **R-parity conserving cases:** ≥2-lepton searches for **direct gaugino processes**; interpreted with simplified models & pMSSM
- **R-parity violating (RPV) cases:** Stau-LSP, e-μ resonance/continuum from a tau sneutrino/stop, 1-lepton search for bilinear RPV in mSUGRA

LHC & ATLAS

Large Hadron Collider (LHC)

- pp collisions at $\sqrt{s}$=7 TeV in 2011
- Peak luminosity of 3.65×10^{33} $cm^{-2}s^{-1}$
- Total delivered lumi. 5.61 fb^{-1} (93.5% recorded in ATLAS)





ATLAS detector

- Precision tracking inner detectors (ID)
- Electromagnetic (EM) & hadronic calorimeters
- Muon spectrometer (MS) w/ toroidal magnetic field
- Trigger systems (Level-1,2 & Event Filter)
- Forward detectors for luminosity measurement

Leptons & Fake Estimation

- Electrons: Reconstructed from energy deposit in the EM calorimeter & an associated ID track. p_T cut at 10 GeV or higher. An isolation cut is further applied.

- Muons: Reconstructed by combining ID and MS tracks. p_T cut at 10 GeV or higher in the analyses shown in this talk. Isolation cuts are further applied.

- Fake leptons: e,μ's originating from heavy flavor jets or photon conversion

Data-driven Estimation of Fakes (Matrix Method)

$$\begin{bmatrix} N_{TT} \\ N_{TL} \\ N_{LT} \\ N_{LL} \end{bmatrix} = \begin{bmatrix} rr & rf & fr & ff \\ r(1-r) & r(1-f) & f(1-r) & f(1-f) \\ (1-r)r & (1-r)f & (1-f)r & (1-f)f \\ (1-r)(1-r) & (1-r)(1-f) & (1-f)(1-r) & (1-f)(1-f) \end{bmatrix} \begin{bmatrix} N_{RR} \\ N_{RF} \\ N_{FR} \\ N_{FF} \end{bmatrix}$$

From data **To be estimated**

r : 1-lepton real efficiency = "loose" real lepton passing "tight" selection

f : 1-lepton fake rate = "loose" fake lepton passing "tight" selection

N_{ij}: number of events w/ lepton i,j

T: "tight" selection
L: "loose" selection

R: real lepton
F: fake lepton

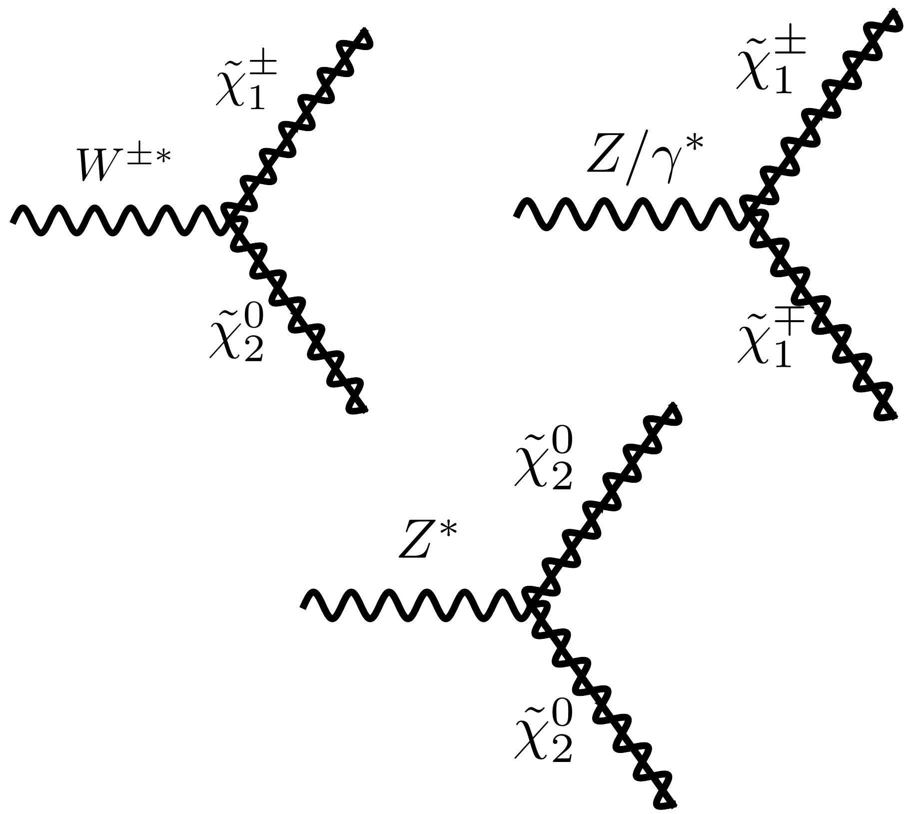
- Count events with "tight" leptons (dominated by real leptons) & "loose" leptons (dominated by fakes)

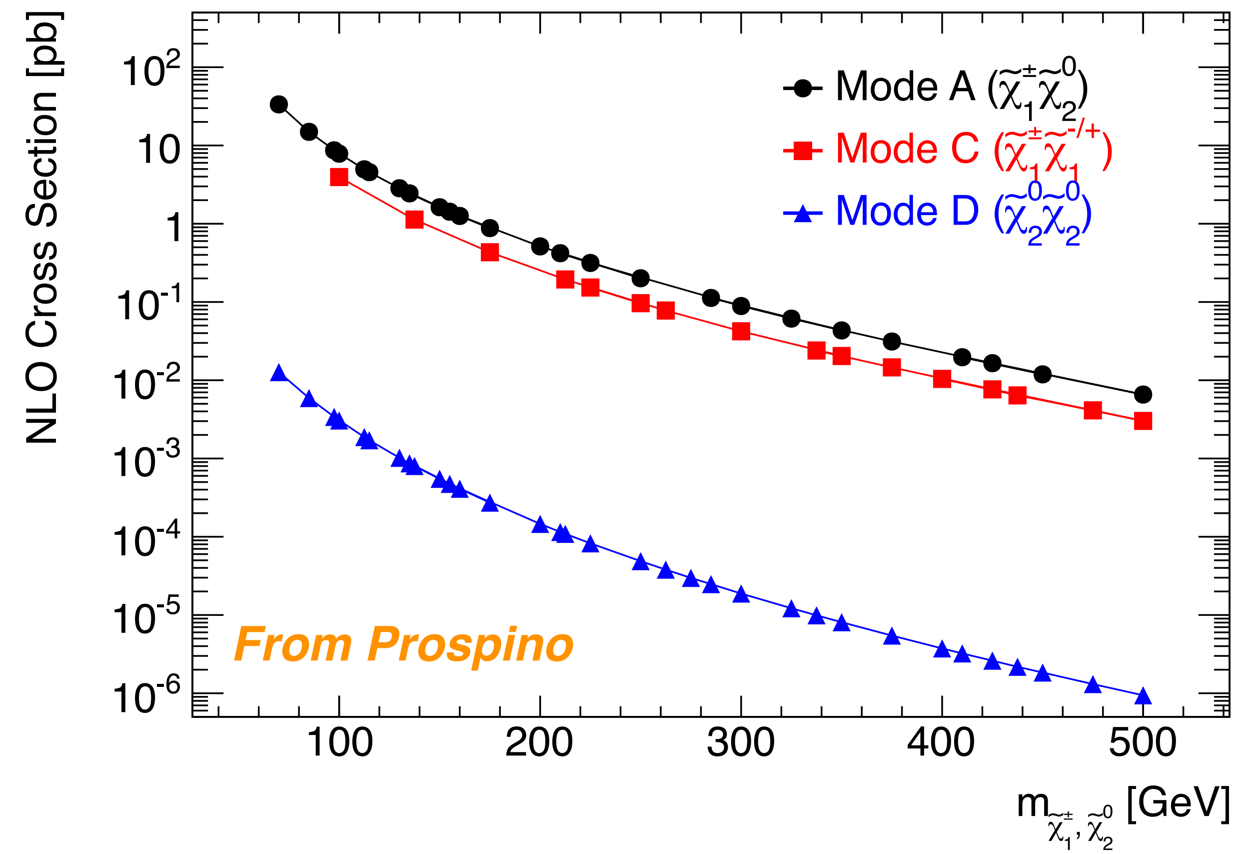
- Solve the linear equations for N_{RR}, N_{RF}, N_{FR}, N_{FF}

Direct Gaugino Searches

~ R-parity Conserved ~

Direct Gaugino Production





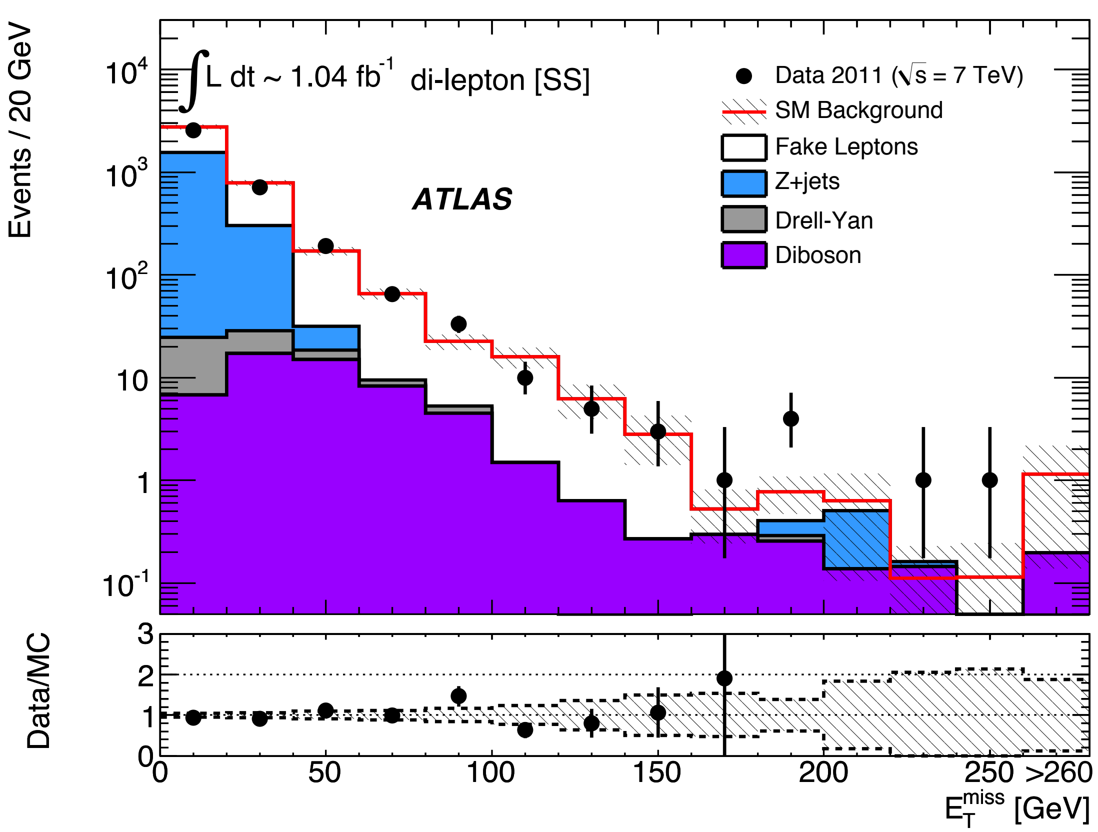
- Weak-gauginos could be accessible at the LHC due to naturalness
- Among wino-like gaugino pair-productions, $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ has the largest cross sections → sensitivity in same-sign 2 & 3-lepton channels
- Winos emit leptons when they decay to:
  - Slepton+lepton (when slepton is light): BR(→lep) would be close to 1
  - W/Z$^{(*)}$+LSP : BR(→lep) is small. Not promising for a few fb^{-1} of data

SS 2-Lepton Search (1 fb^{-1})

Signal region (SR): Same-sign 2-lepton (e,μ), m_{ll}>12 GeV, E_T^{miss}>100 GeV

Background (BG)

- Fake BG: One or two fake leptons from heavy-flavor & fake electrons from photon-conversions. Estimated using a data-driven method (Matrix Method)
- Charge flip: Electrons only ($e^-_{hard} \to e^-_{soft}\,\gamma_{hard} \to e^-_{soft}\,e^-_{soft}\,e^+_{hard}$). Mainly from $t\bar{t}$. MC-based estimation, but correction for charge flip ratio is extracted from data.
- Dibosons (WZ, W±W±+jets): MC-based. WW, WZ, ZZ cross sections are already measured at the LHC & consistent with the theoretical expectation.



Same Sign [SS-SR1]	$e^{\pm}e^{\pm}$	$e^{\pm}\mu^{\pm}$	$\mu^{\pm}\mu^{\pm}$
Fake	3.5 ± 1.6	14.4 ± 4.4	9.2 ± 3.3
Charge Flip	0.73 ± 0.08	1.1 ± 0.14	negligible
Dibosons	0.79 ± 0.27	1.7 ± 0.5	1.1 ± 0.22
Standard Model	5.0 ± 1.6	17.2 ± 4.4	10.3 ± 3.3
Cosmic Rays	$< 10^{-3}$	$< 10^{-3}$	$< 10^{-3}$
Observed	6	14	5

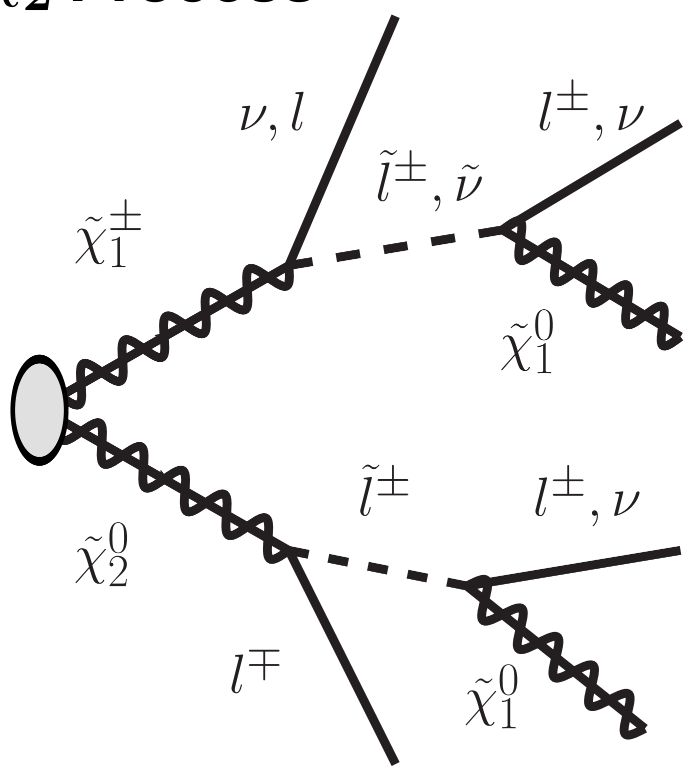
Main systematics: luminosity, cross section, jet energy scale/resolution, lepton energy scale/resolution

Observed no excess in each channel

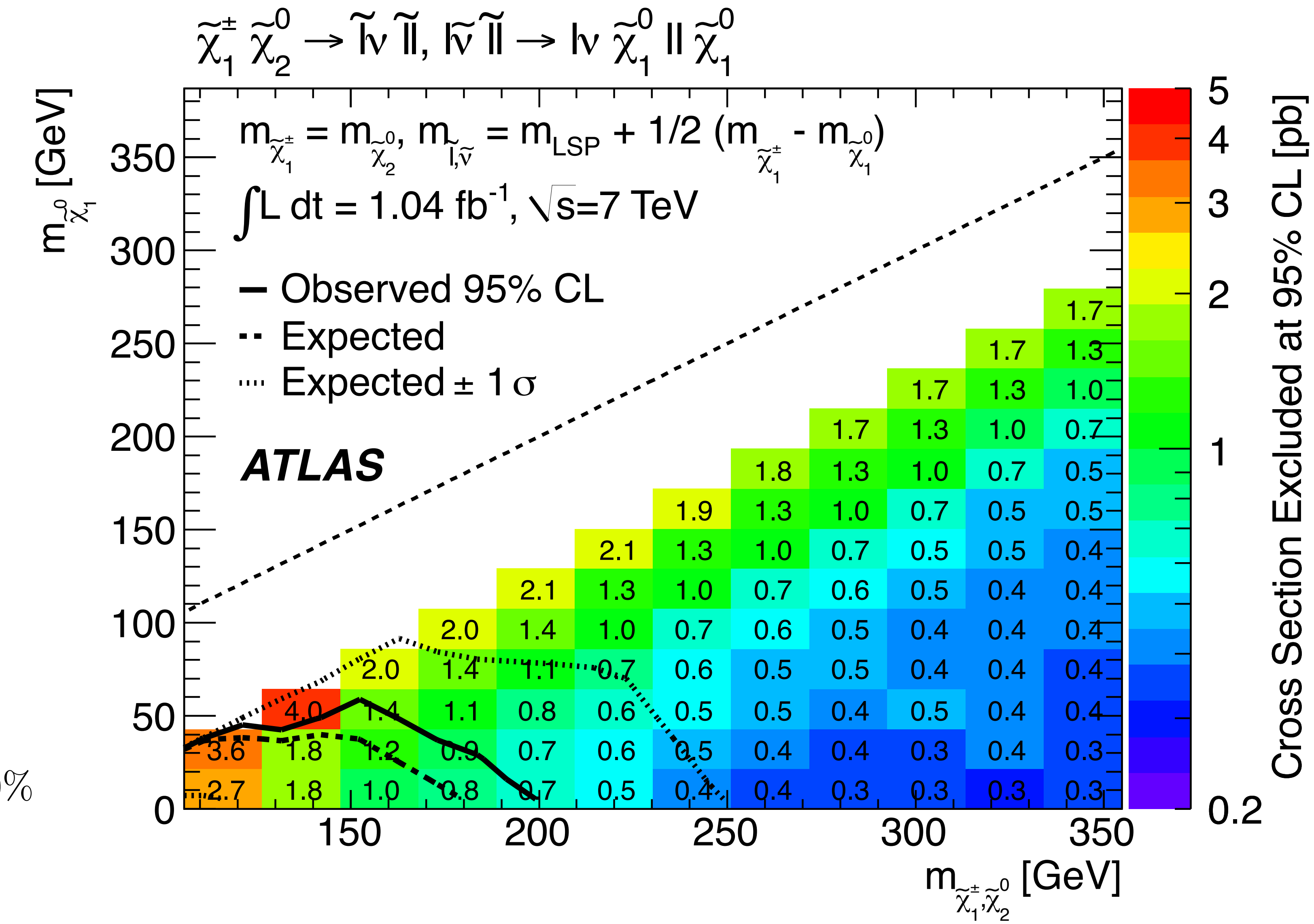
Phys. Lett. B 709 (2012) 137

Direct Gaugino Simplifed Models

$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^{0}$ Process



$$\mathbf{BR}(\tilde{\chi}_1^{\pm} \to \tilde{l}^{\pm}\nu) = \mathbf{BR}(\tilde{\chi}_1^{\pm} \to l^{\pm}\tilde{\nu}) = 50\%$$
$$\mathbf{BR}(\tilde{\chi}_2^{0} \to \tilde{l}^{\pm}l^{\mp}) = 100\%$$



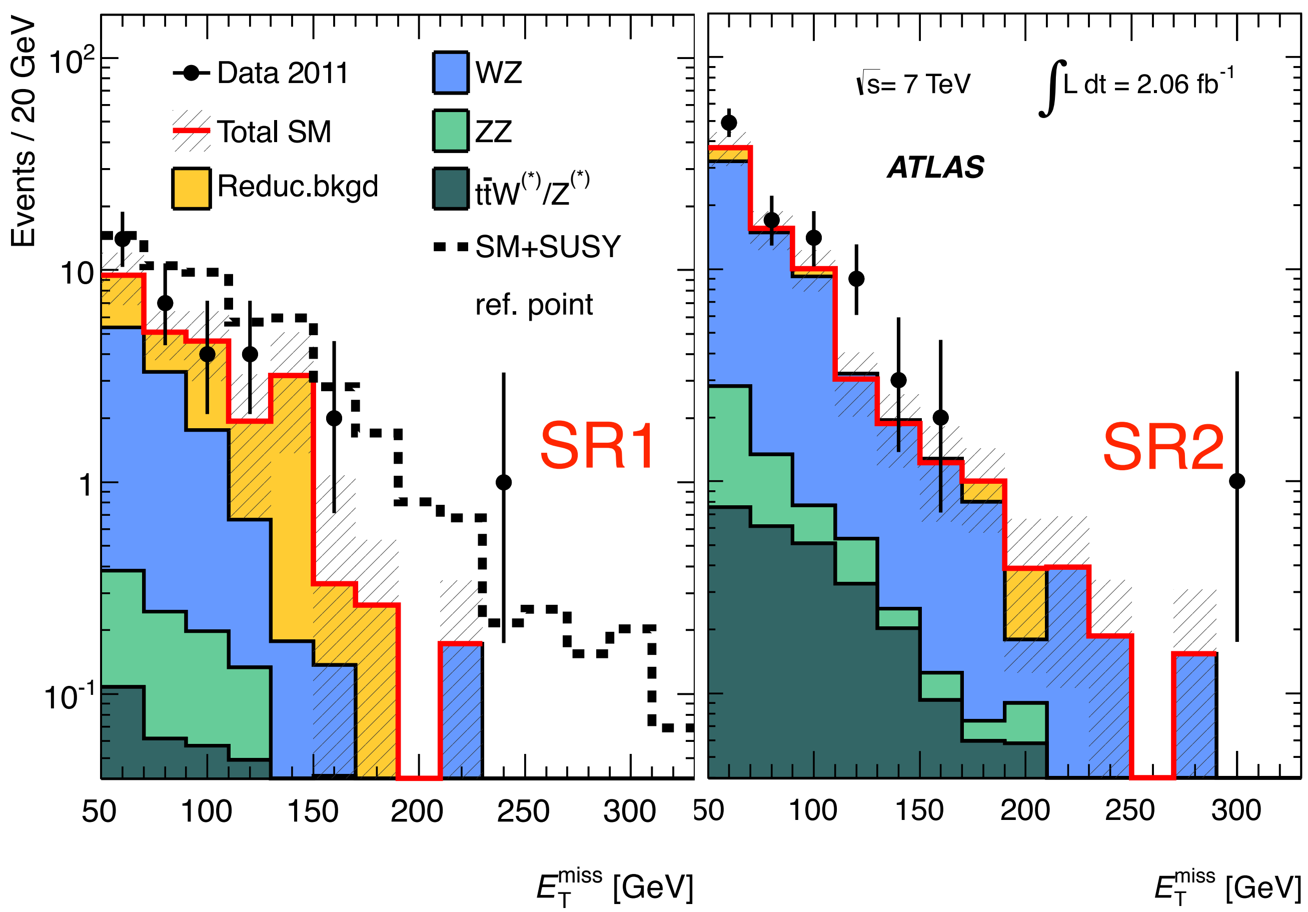
- Used CLs method for the limit setting. Visible cross section ($\sigma_{visible}$) upper limit = 14.8 fb.
- Exclusion contour at 95% CL assuming MSSM for the production cross section. Colors represent model-independent observed cross section (σ_{obs}) upper limits at 95% CL.
- <u>The first direct gaugino search in leptonic final states at the LHC</u>

cf.) ATLAS search in diphoton channel
Phys.Lett. B 710 (2012) 519

arXiv:1204.5638 (2012)

3-Lepton Search (2 fb^{-1})

SR1 (Z-veto): 3-lepton (e,μ), E_T^{miss}>50 GeV, SFOS lep $|m_{ll} - m_Z| > 10$ GeV, no b-jets
SR2 (Z-enrich): 3-lepton (e,μ), E_T^{miss}>50 GeV, SFOS lep $|m_{ll} - m_Z| < 10$ GeV



Selection	SR1	SR2
$t\bar{t}W^{(*)}/Z^{(*)}$	0.4±0.3	2.7±2.1
$ZZ^{(*)}$	0.7±0.2	3.4±0.8
$WZ^{(*)}$	11±2	58±11
Reducible Bkg.	14±4	7.5±3.9
Total Bkg.	26±5	72±12
Data	32	95

Observed no excess

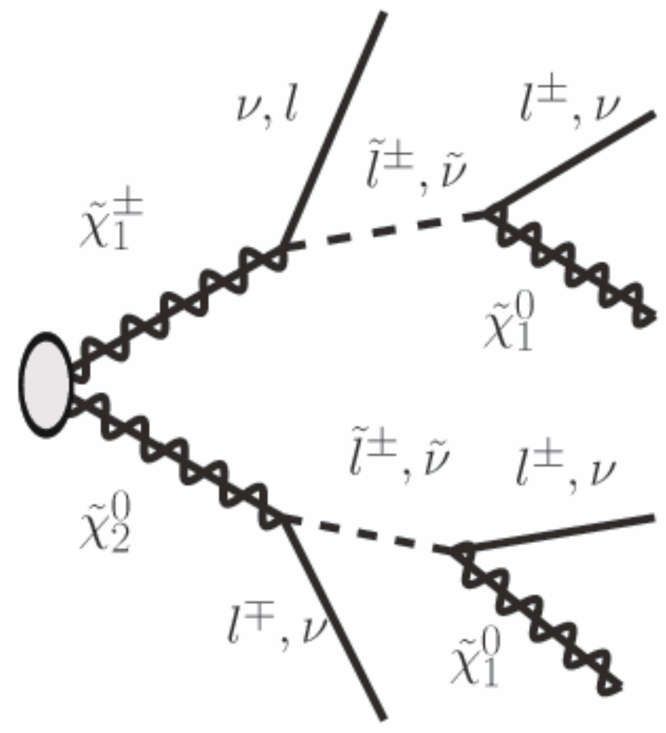
- Diboson & $t\bar{t}$+V BG estimated with MC
- Reducible BG corresponds to events coming from fake leptons
- Contributions from fake leptons are estimated using the 4×4 Matrix Method. Leading lepton is always assumed to be real (confirmed with MC studies).
- Photon conversions to muon pair (l→lγ*→lμμ) from data-driven estimation
  - Rescale number of events with exactly 2 muons by probability of a muon radiating a converted photon producing two muons. Probability is extracted from data.

arXiv:1204.5638 (2012)

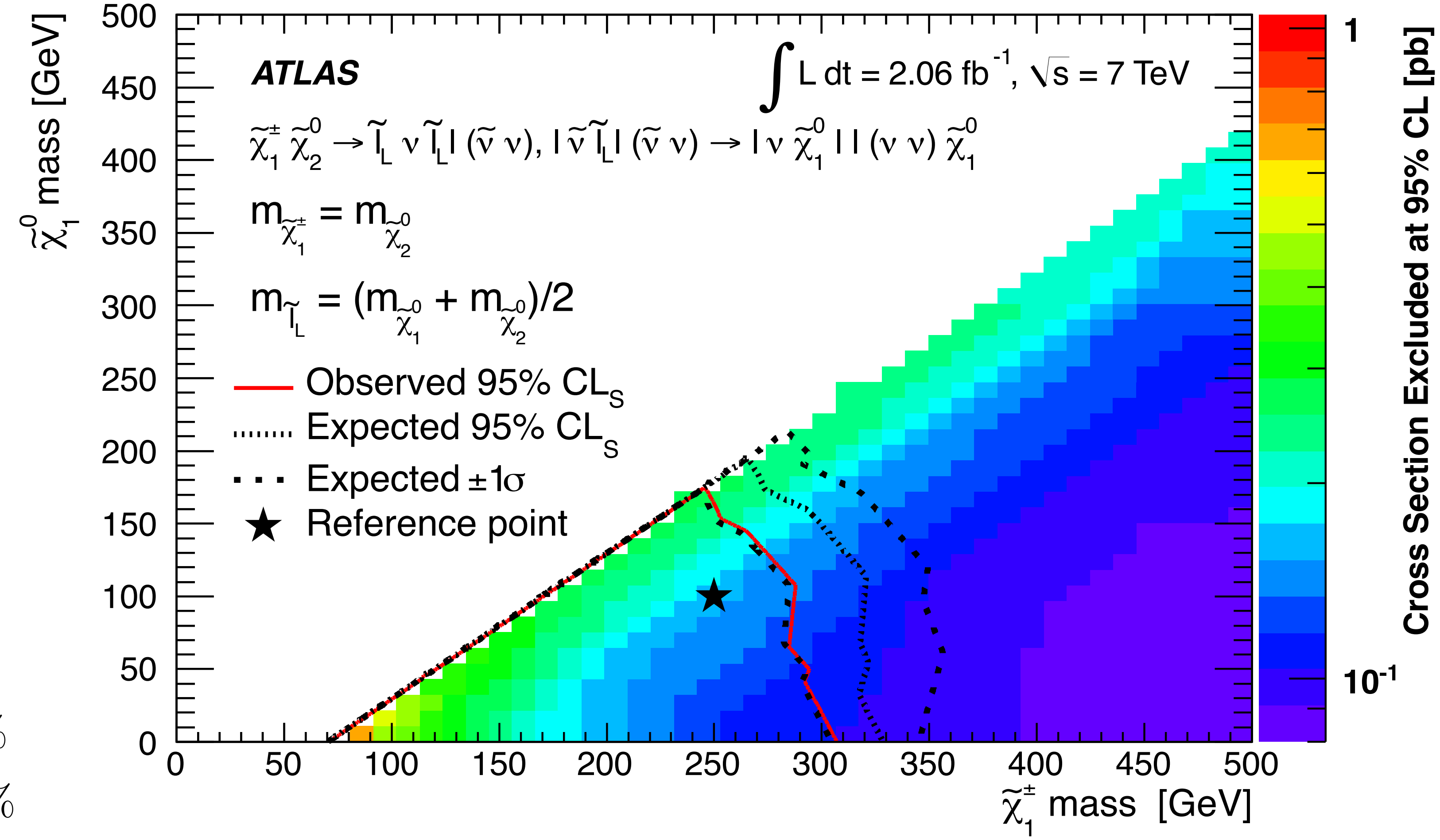
3-Lepton Interpretation

(Simplified Models)

$\tilde{\chi}_1^\pm \tilde{\chi}_2^0$ Process

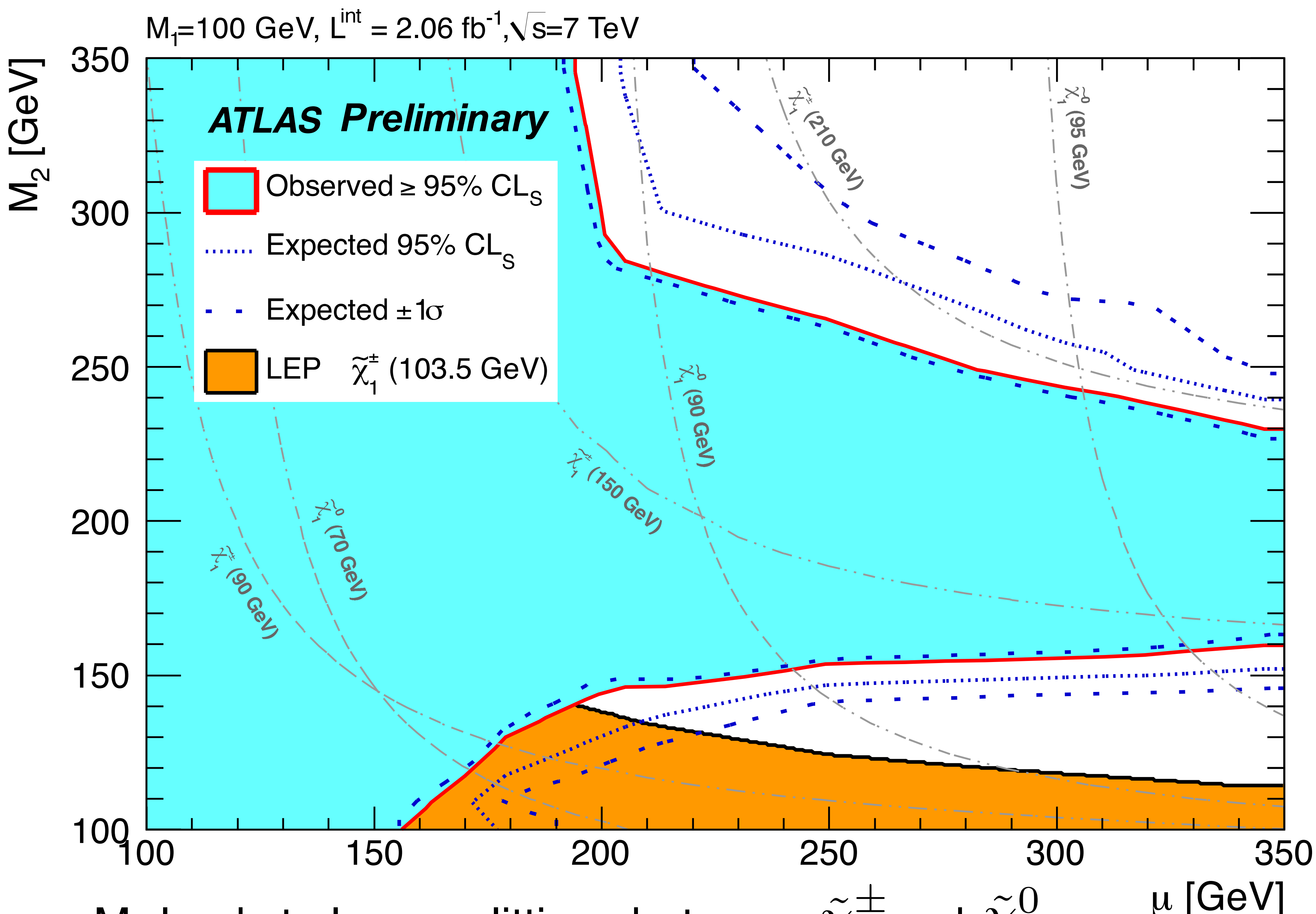


$$\mathbf{BR}(\tilde{\chi}_1^\pm \to \tilde{l}^\pm \nu) = \mathbf{BR}(\tilde{\chi}_1^\pm \to l^\pm \tilde{\nu}) = 50\%$$
$$\mathbf{BR}(\tilde{\chi}_2^0 \to \tilde{l}^\pm l^\mp) = \mathbf{BR}(\tilde{\chi}_2^0 \to \tilde{\nu}\nu) = 50\%$$



- Used CLs. SR1 used for the interpretation. σ_{visible} upper limit = 9.9 fb.
- Exclusion contours at 95% CL. Colors represent σ_{obs} upper limits at 95% CL.
- The exclusion limits are significantly extended from the SS 2-lepton search.

3-Lepton Interpretation
(pMSSM)



- Chosen M_1 leads to large splittings between $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_1^0$
- $\tilde{\chi}_1^{\pm}$ is excluded up to ~200 GeV in pMSSM

R-Parity Violation

R-Parity Violation

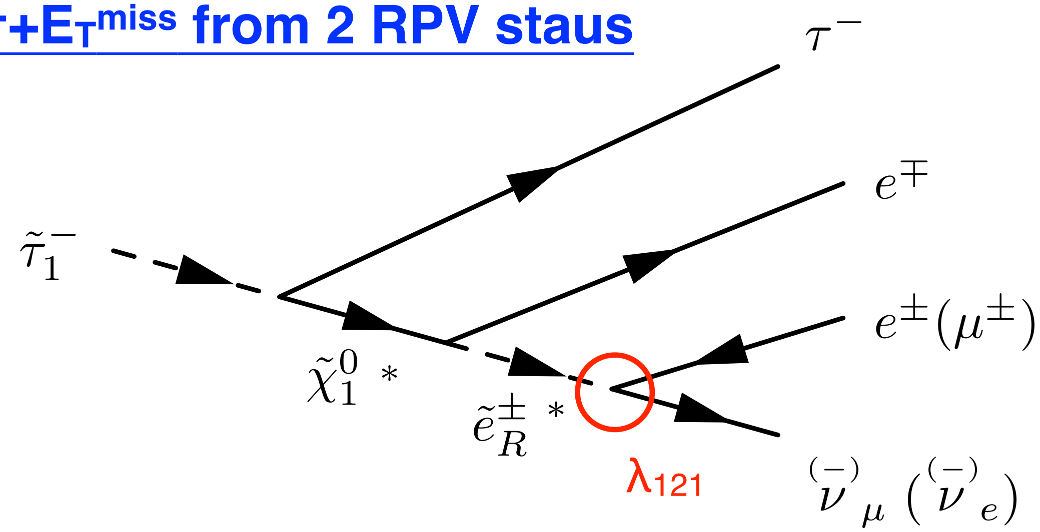
$$W_{RPV} = \underbrace{\lambda_{ijk} L_i L_j \bar{E}_k + \lambda'_{ijk} L_i Q_j \bar{D}_k + \kappa_i L_i H_2}_{\text{Lepton Number Violation}} + \underbrace{\lambda''_{ijk} \bar{U}_i \bar{D}_j \bar{D}_k}_{\text{Baryon Number Violation}}$$

i, j, k: fermion generations (=1-3)

- Large constraints on the parameters (λ_{ijk}, λ'_{ijk}, λ''_{ijk}, κ_i) from previous experiments and the stability of protons
- LSP is unstable → Dark matter could be axion or axino
- RPV-specific phenomenology
  - Single sparticle production/exchange → e.g.) e-μ resonance/continuum
  - Unstable LSP → It could be anything; will show the stau-LSP case (w/ multilepton signature) in this talk
- Leptonic channels are highly effective for RPV searches
  → non-zero λ_{ijk} and/or λ'_{ijk}

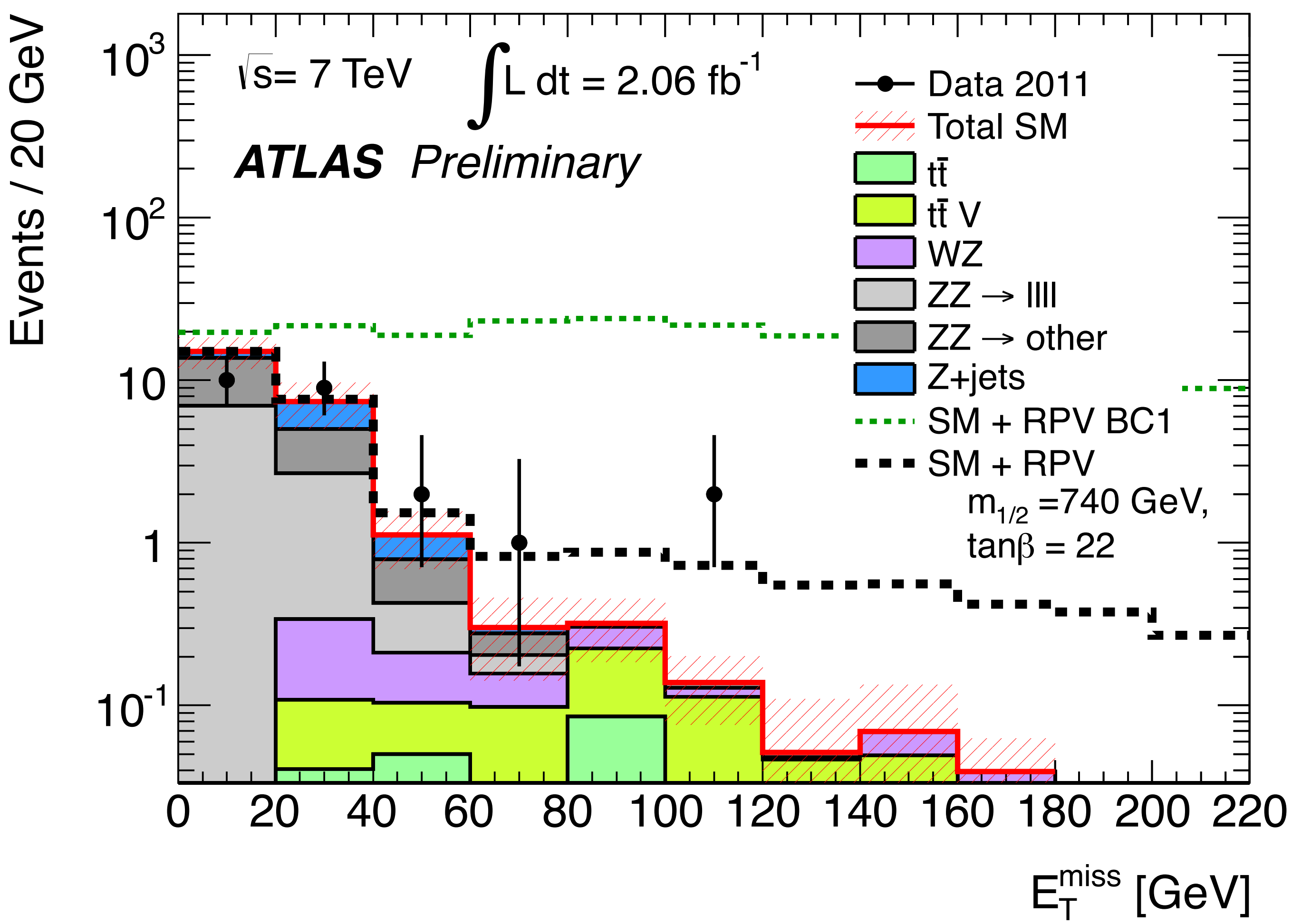
4-Lepton Searches (2 fb^{-1})

$4l+2\tau+E_T^{miss}$ from 2 RPV staus



SR1: ≥4 isolated leptons (e,μ). E_T^{miss}>50 GeV.
SR2: SR1 cuts + SFOS lep $|m_{ll} - m_Z| > 10$ GeV

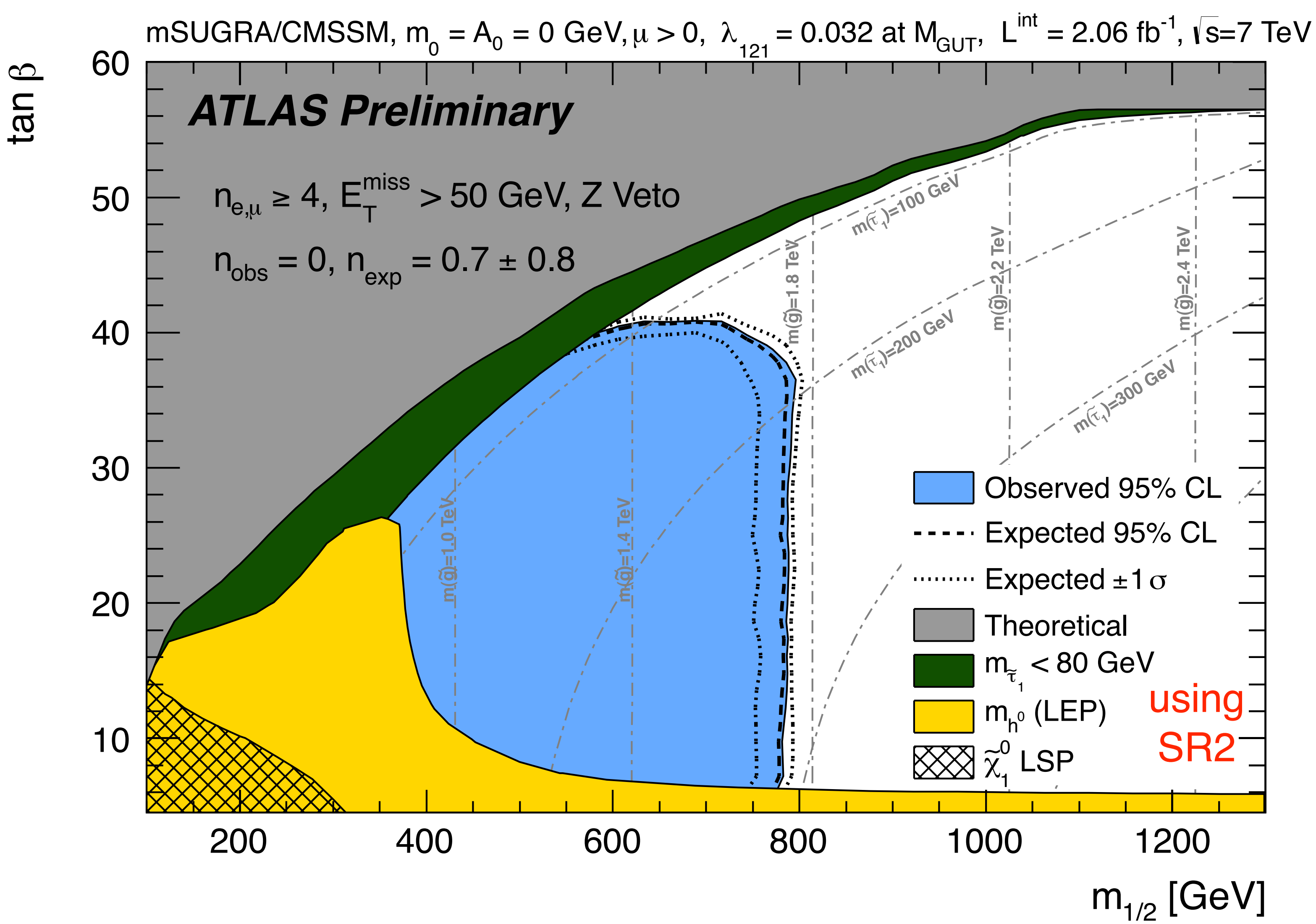
- BG was estimated using the MC, except for the photon conversion BG ($Z\gamma^* \to ll\gamma^*$) estimated from data. BG was validated using the $t\bar{t}$-rich & low E_T^{miss} ZZ-rich control regions in data (see extra slides)



	SR1	SR2
$t\bar{t}$	0.17±0.14	0.13±0.11
Single t	0±0.04	0±0.04
$t\bar{t}V$	0.48±0.21	0.07±0.04
ZZ	0.44±0.19	0.019±0.020
WZ	0.25±0.10	0.09±0.05
WW	0±0.015	0±0.015
$Z\gamma$	0±0.5	0±0.5
$Z+(u,d,s$ jets)	0.33±0.67	0.33±0.67
$Z+(c,b$ jets)	0.024±0.035	0.024±0.035
Drell-Yan	0±0.05	0±0.05
Σ SM	1.7±0.9	0.7±0.8
Data	4	0

No significant deviation is seen for each flavor final state (detailed tables in the extra slides)

RPV Interpretation (≥4-lep)



- Stau-LSP scenario in mSUGRA/CMSSM + RPV
- 6 parameters: m_0, $m_{1/2}$, A_0, tanβ, sign(μ), λ_{121}
- RPV coupling (λ_{121}=0.032): small enough that sparticle pair productions dominate, but <u>large enough to have promptly decaying stau LSPs</u>

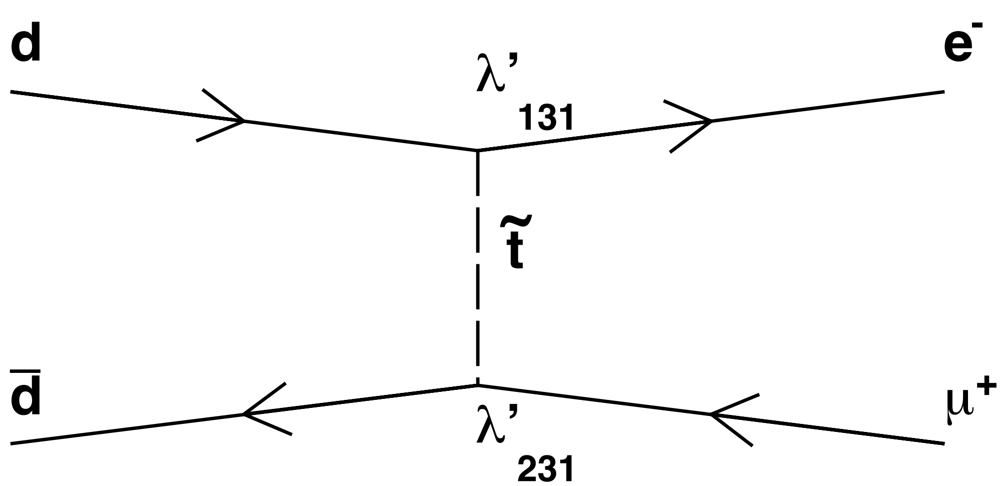
- The most dominant process in SR highly depends on $m_{1/2}$ & tanβ (see extra slides)
- $m_{1/2}$ < 800 GeV excluded for tanβ<40 → m_{gluino}~1.77 TeV for m_0=0, A_0=0, tanβ<40
- <u>The first RPV search w/ stau LSP at the LHC</u>

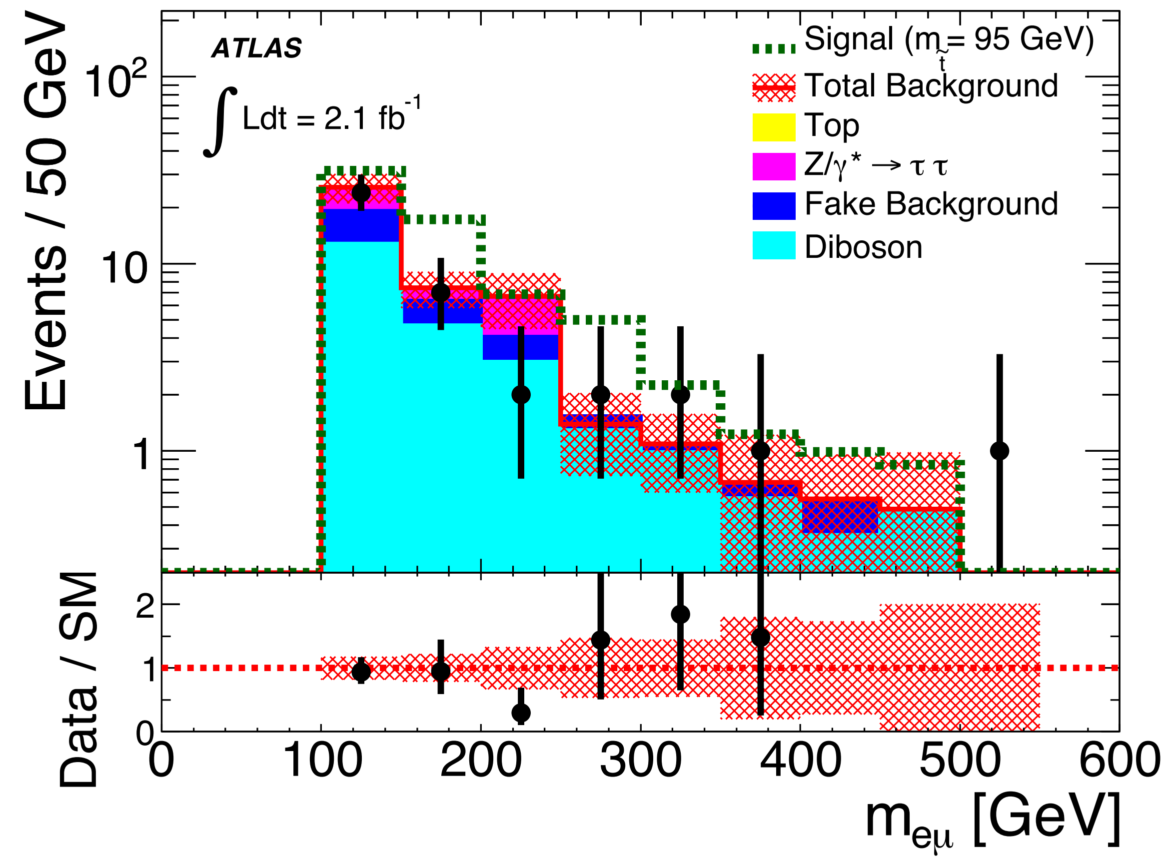
arXiv:1205.0725 (2012)

e-μ Continuum (2 fb^{-1})

SR: Opposite-sign e+μ, e,μ p_T>25 GeV, jet veto (pT>30 GeV, |η|<2.5), $m_{e\mu}$>100 GeV, $\Delta\phi_{e\mu}$>3.0 rad, E_T^{miss}<25 GeV

Search for t-channel RPV stop





BG

- Real prompt leptons: (Diboson, Z/γ*→ττ, $t\bar{t}$, single top) estimated with MC
- Fake lepton(s): W/Z+jets, multijets were estimated with data-driven method (Matrix Method). MC was used for W/Z+γ.

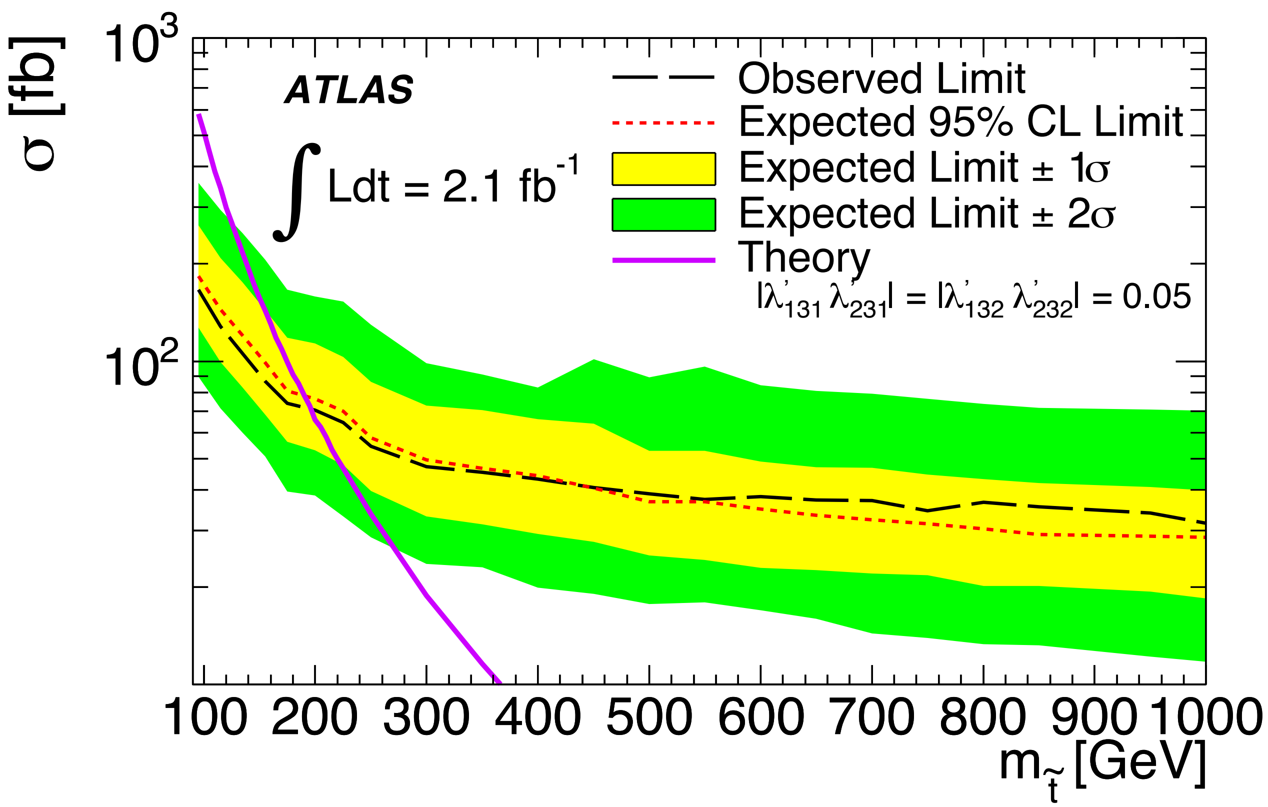
Process	Preselection	Final selection
WW	640 ± 50	23.4 ± 3.3
$Z/\gamma^* \to \tau\tau$	1210 ± 110	10 ± 4
Fake Background	290 ± 40	9.6 ± 1.9
WZ	36 ± 4	0.76 ± 0.31
$t\bar{t}$	2800 ± 400	0.25 ± 0.17
Single top	270 ± 40	0.22 ± 0.20
$W/Z + \gamma$	20 ± 7	0.04 ± 0.04
ZZ	4.0 ± 0.4	0.042 ± 0.028
Total background	5300 ± 400	44 ± 6
Data	5387	39

Observed no excess

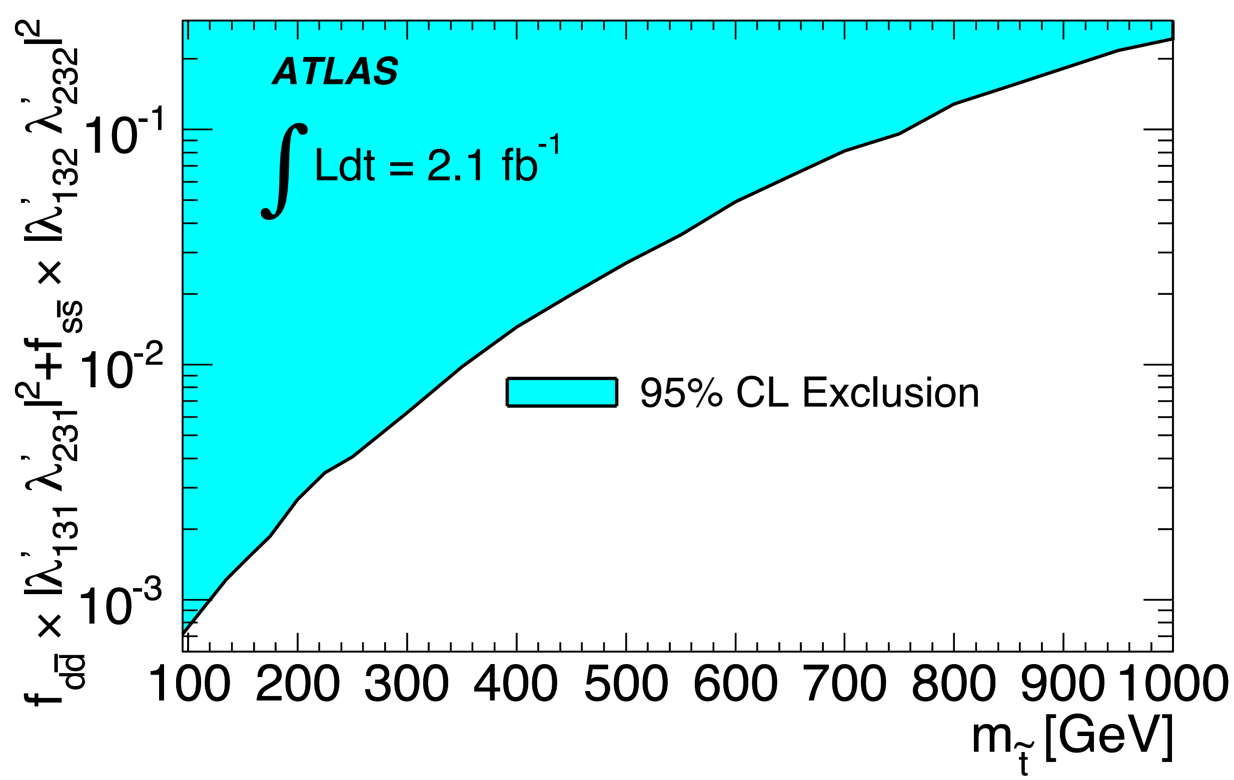
[arXiv:1205.0725 (2012)]

RPV $\tilde{t}$ Interpretation

- Invariant mass of e,μ ($m_{e\mu}$) is used to set limits on the production cross section of stops.
- Used a modified frequentist approach w/ a binned log-likelihood ratio



For |λ′₁₃₁ λ₂₃₁| = |λ′₁₃₂ λ₂₃₂| = 0.05, stop mass of ~ 200 GeV is excluded



Exclusion on PDF-weighted sum of couplings

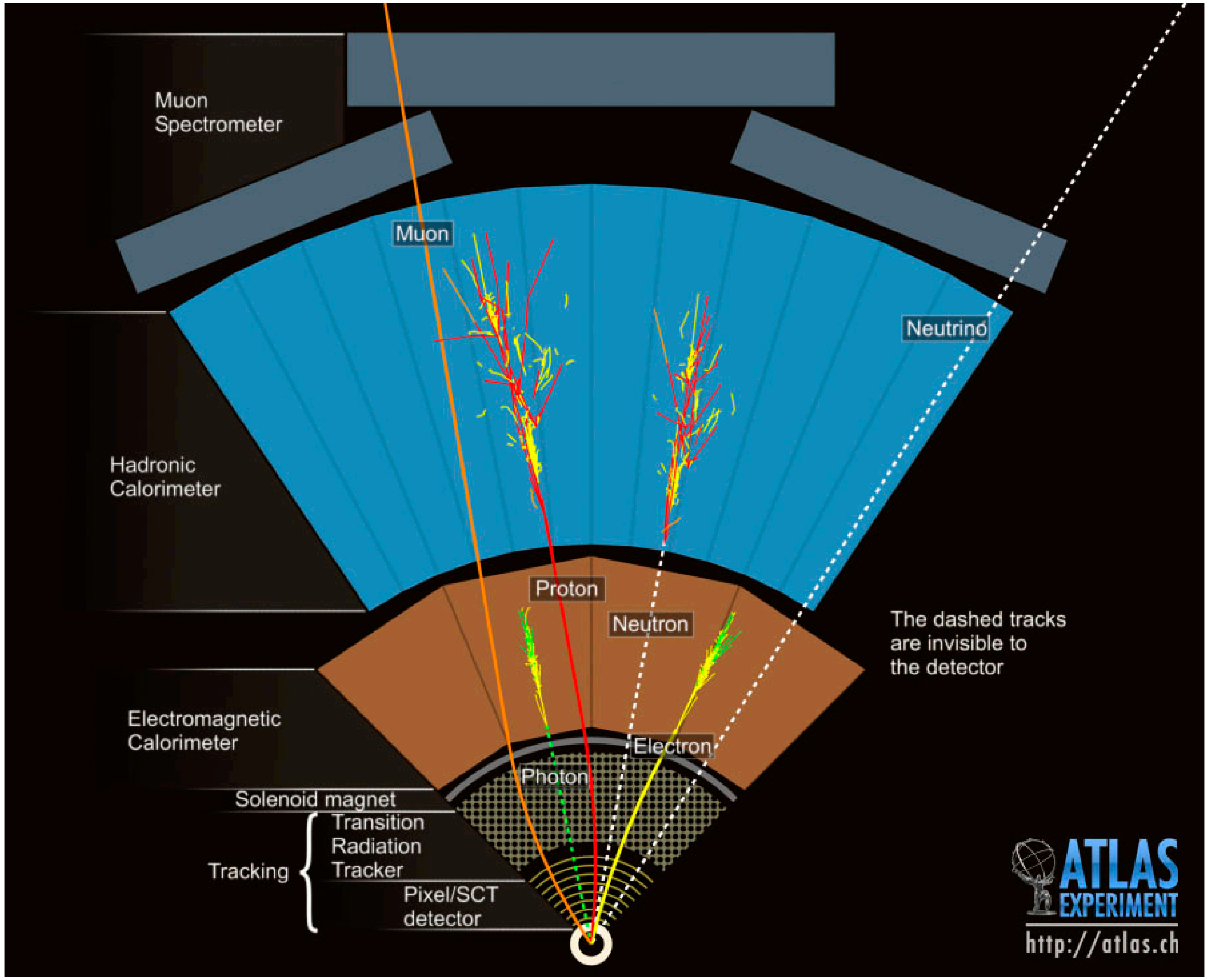
$$f_{d\bar{d}} \times |\lambda'_{131}\lambda'_{231}|^2 + f_{s\bar{s}} \times |\lambda'_{132}\lambda'_{232}|^2$$

Summary

- Presented the results of supersymmetry searches with leptons with the ATLAS detector using 1-2 fb^{-1} of 2011 data.
- No excess was observed, so the results were interpreted with various approaches
  - R-parity conserving cases: direct gaugino production in 2 & 3-lepton channels with simplified models & pMSSM
  - R-parity violating cases: stau LSP in ≥4-lep, e-μ resonances (see extra slides), e-μ continuum, binear RPV mSUGRA with 1-lepton (see extra slides)
- Analyses with ~5 fb^{-1} of 2011 data coming soon, covering a wider range of SUSY scenarios
- 2012 data analyses at $\sqrt{s}$=8 TeV will follow. Stay tuned!

Backups

Object Reconstruction



- **Electrons:** reconstructed from energy deposit in the electromagnetic (EM) calorimeter & an associated inner detector (ID) track
- **Muons:** reconstructed by combining ID and muon spectrometer (MS) tracks
- **Jets:** Reconstructed from calorimeter clusters using anti-k_t algorithm with a radius parameter of 0.4
- **Missing E_T (E_T^{miss}):** Reconstructed from the transverse momenta of the electron & muon candidates, all jets which are not electron candidates, and all calorimeter clusters with $|\eta|<4.5$ not associated to electrons/muons/jets.

Lepton Definitions

- 2-lepton channel (1 fb^{-1}):
  - Electron E_T > 20 GeV, $|\eta|<2.47$. p_T-sum of tracks above 1 GeV within $\Delta R<0.2$ is required to be less than 10% of electron E_T.
  - Muon p_T > 10 GeV, $|\eta|<2.4$. p_T-sum of tracks within $\Delta R<0.2$ is required to be less than 1.8 GeV. Impact parameter $|z_0|<1$ mm, transverse impact parameter $|d_0|<0.2$ mm.
  - Leading lepton p_T>25 GeV (20 GeV) if it is an electron (muon).
- 3-lepton channel (2 fb^{-1}):
  - Electron E_T > 10 GeV, $|\eta|<2.47$. p_T-sum of tracks above 1 GeV within $\Delta R<0.2$ is required to be less than 10% of electron E_T.
  - Muon p_T > 10 GeV, $|\eta|<2.4$. p_T-sum of tracks within $\Delta R<0.2$ is required to be less than 1.8 GeV. Transverse impact parameter $|d_0|<0.2$ mm.
  - Leading lepton p_T>25 GeV (20 GeV) if it is an electron (muon).

Lepton Definitions

- $\geq$4-lepton channel (2 fb^{-1}):
  - Electron E_T > 10 GeV, $|\eta|<2.47$ (but E_T > 15 GeV for $1.37<|\eta|<1.52$). p_T-sum of tracks above 1 GeV within $\Delta R<0.2$ is required to be less than 10% of electron E_T.
  - Muon p_T > 10 GeV, $|\eta|<2.4$. p_T-sum of tracks within $\Delta R<0.2$ is required to be less than 1.8 GeV. Total transverse energy in the calorimeter within $\Delta R<0.3$ is required to be less than 4 GeV. Impact parameter $|z_0|<1$ mm, transverse impact parameter $|d_0|<0.2$ mm.
  - Leading lepton p_T>25 GeV (20 GeV) if it is an electron (muon).
- eμ-continuum (2 fb^{-1}):
  - Electron E_T > 25 GeV, $|\eta|<2.47$ & muon p_T > 25 GeV, $|\eta|<2.4$.
  - p_T-sum of tracks above 1 GeV within $\Delta R<0.2$ is required to be less than 10% of E_T or p_T. Total transverse energy in the calorimeter within $\Delta R<0.2$ is required to be less than 15% of E_T or p_T.

Lepton Definitions

- 1-lepton channel (1 fb^{-1}):
  - Electron $E_T > 25$ GeV, $|\eta|<2.47$. p_T-sum of tracks above 1 GeV within $\Delta R<0.2$ is required to be less than 10% of electron E_T. Looser electron definition with $E_T > 20$ GeV was considered for vetoing the second leading electron.
  - Muon $p_T > 20$ GeV, $|\eta|<2.4$. p_T-sum of tracks within $\Delta R<0.2$ is required to be less than 1.8 GeV. Impact parameter $|z_0|<5$ mm, transverse impact parameter $|d_0|<2$ mm. Muons without isolation condition with $p_T > 10$ GeV are considered for vetoing the second leading muon.
- eμ-resonance (1 fb^{-1}):
  - Electron $E_T > 25$ GeV, $|\eta|<2.47$. Total transverse energy in the calorimeter within $\Delta R<0.4$ is required to be less than 10 GeV.
  - Muon $p_T > 25$ GeV, $|\eta|<2.4$. p_T-sum of tracks within $\Delta R<0.4$ is required to be less than 10 GeV.

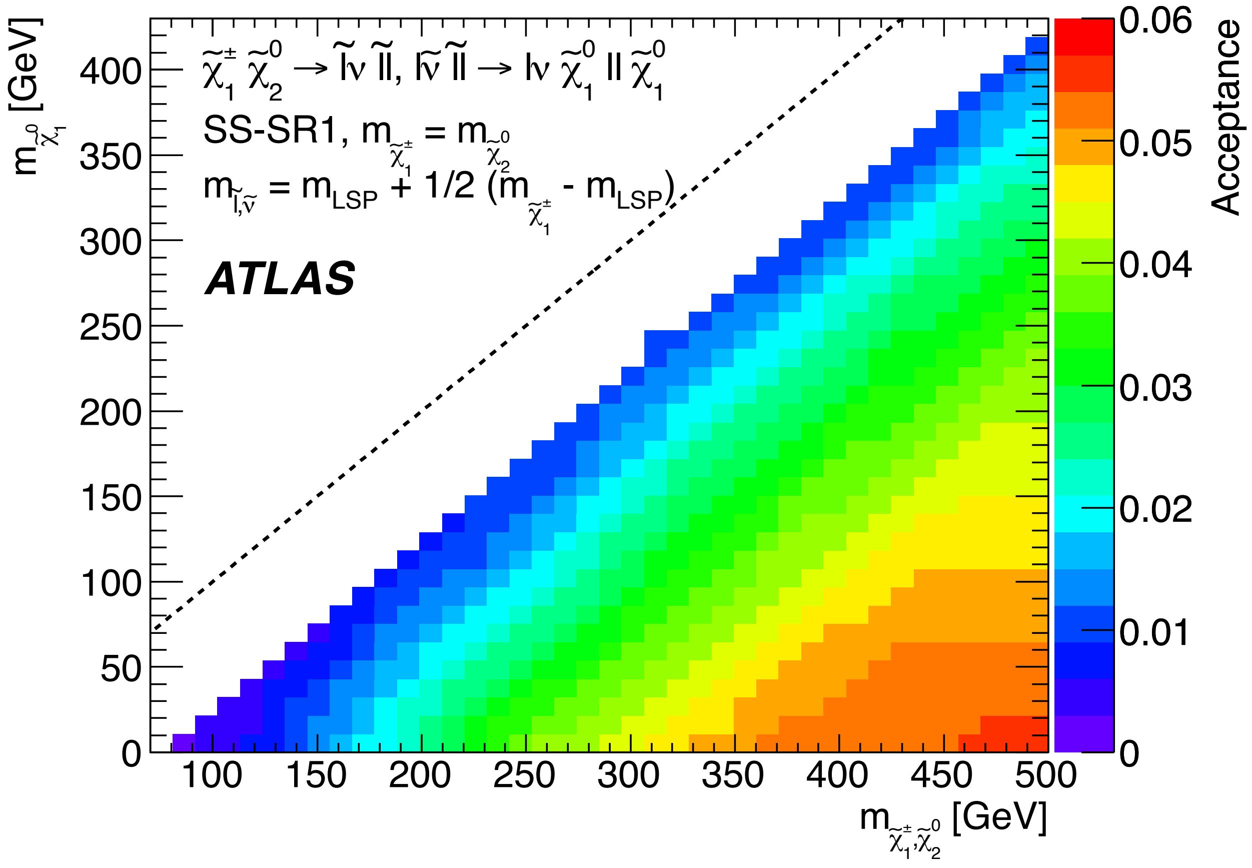
Backups for

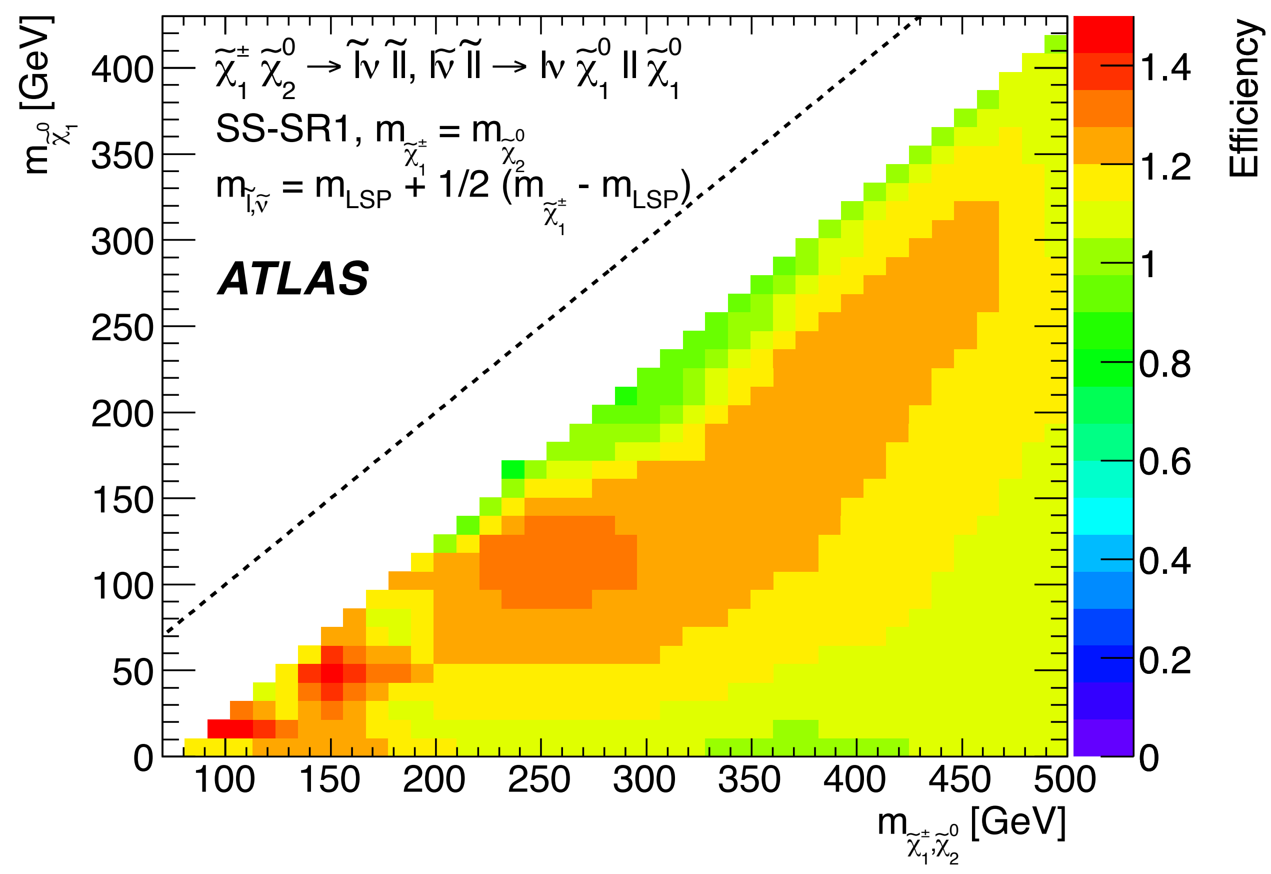
Direct Gaugino Searches

Direct Gaugino Simplifed Models

Acceptance & Efficiency

SS 2-Lepton Search (1 fb^{-1})

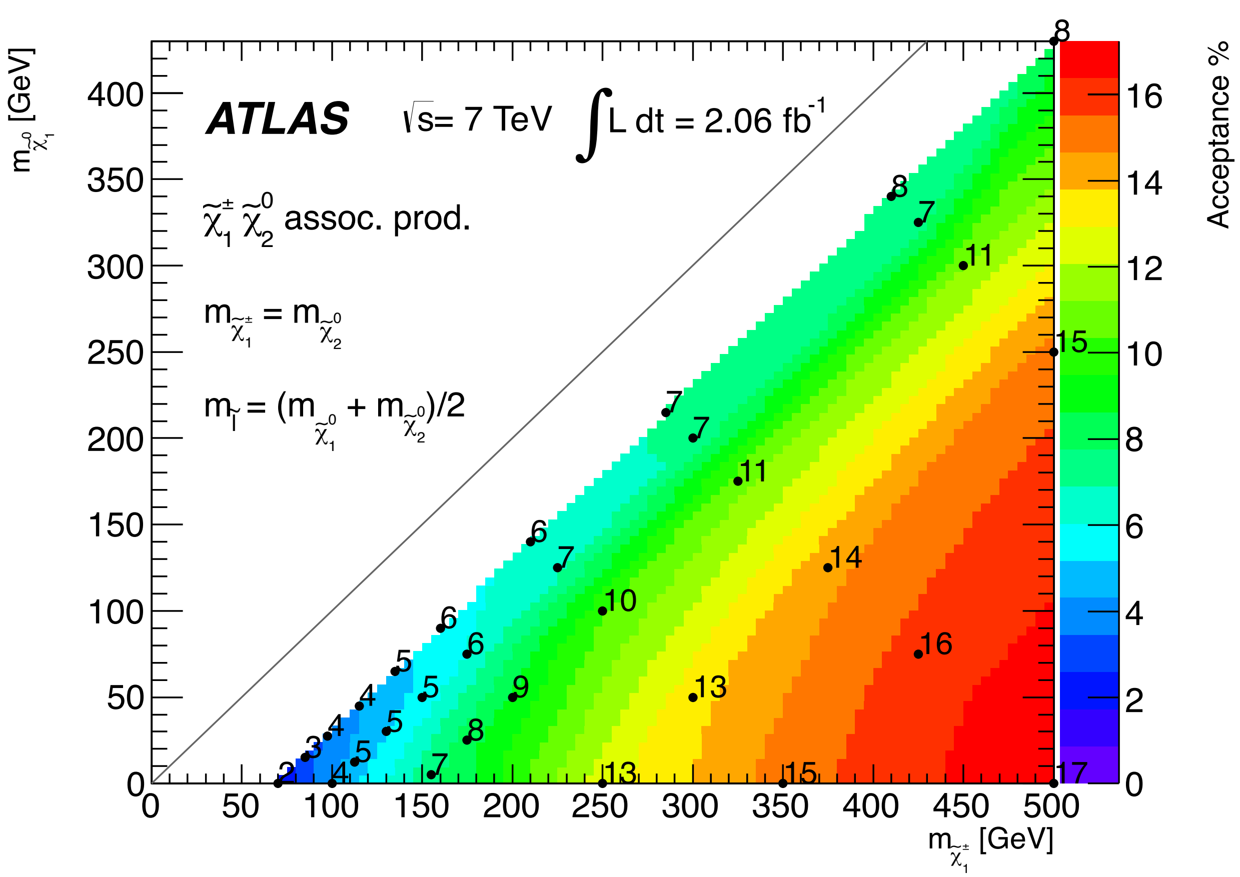


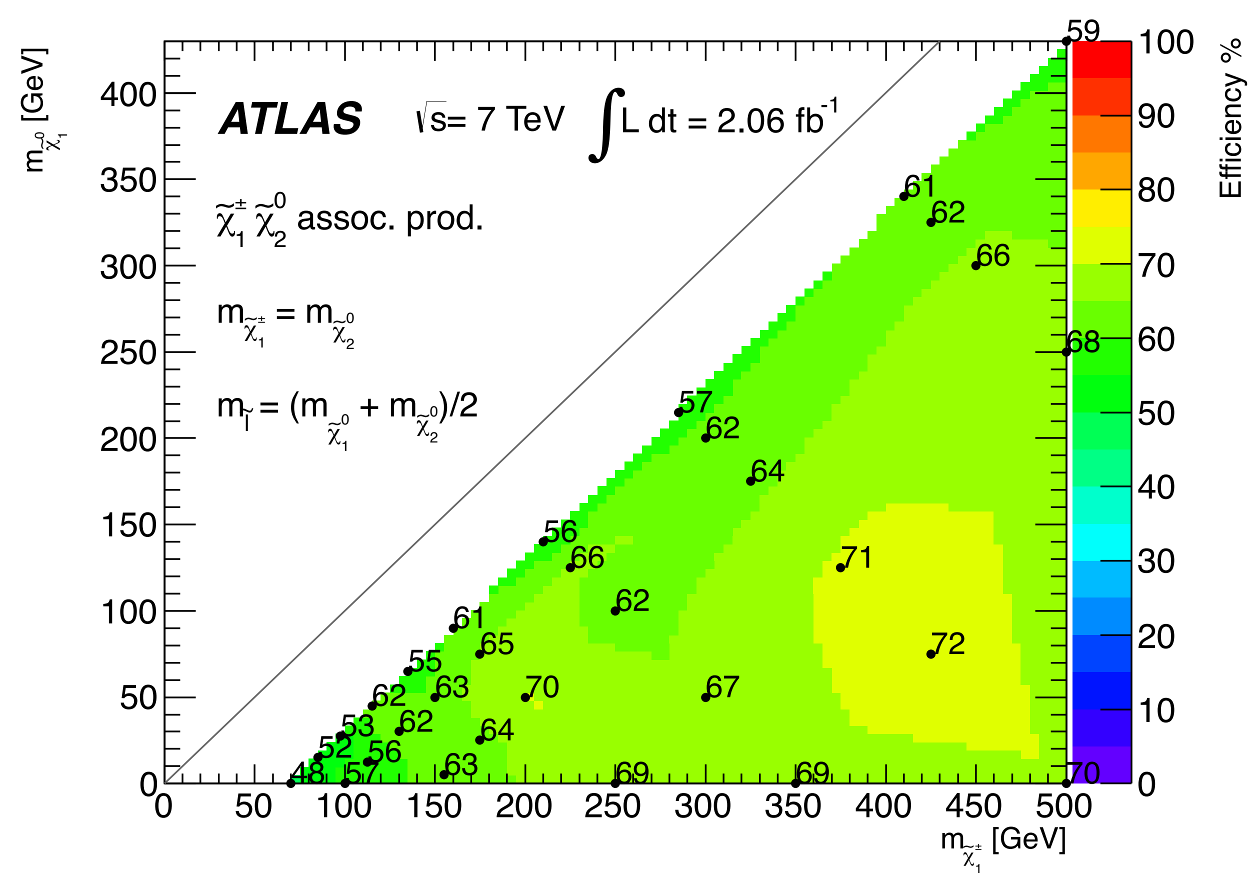


Direct Gaugino Simplifed Models

Acceptance & Efficiency

3-Lepton Search (2 fb^{-1})



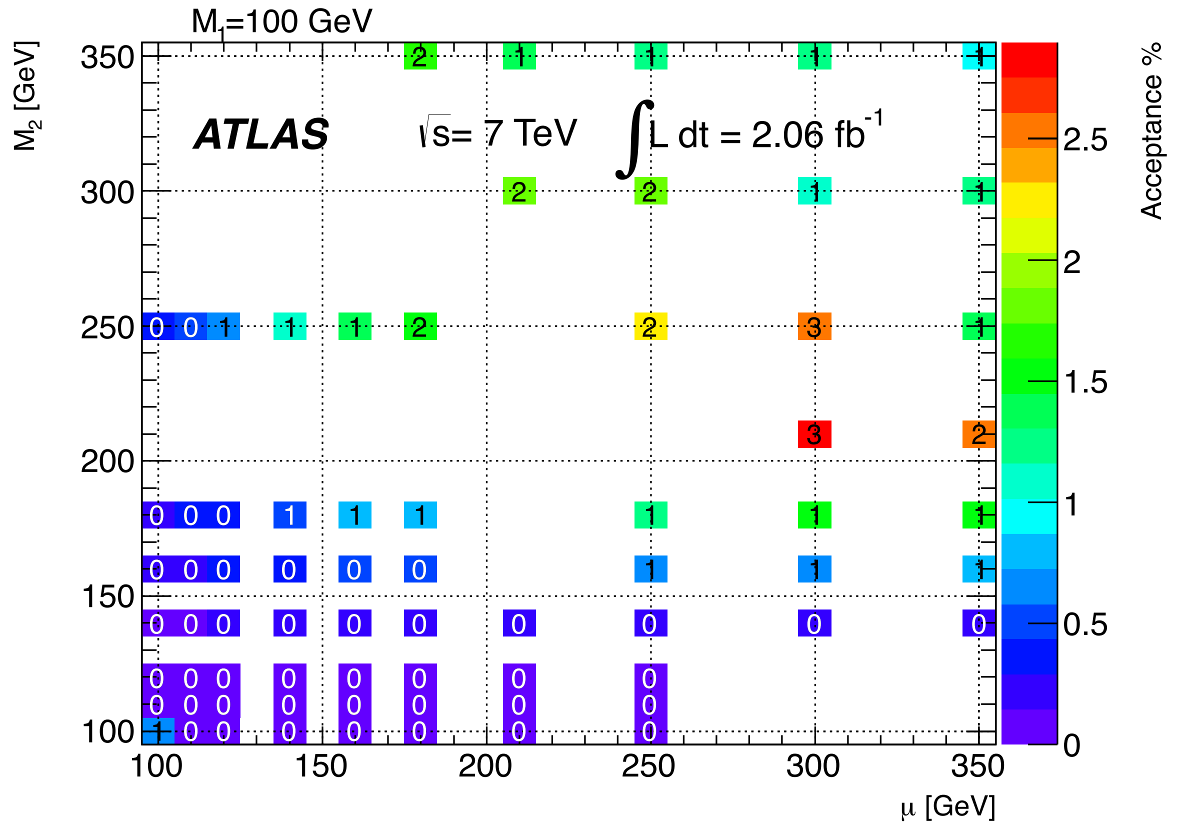


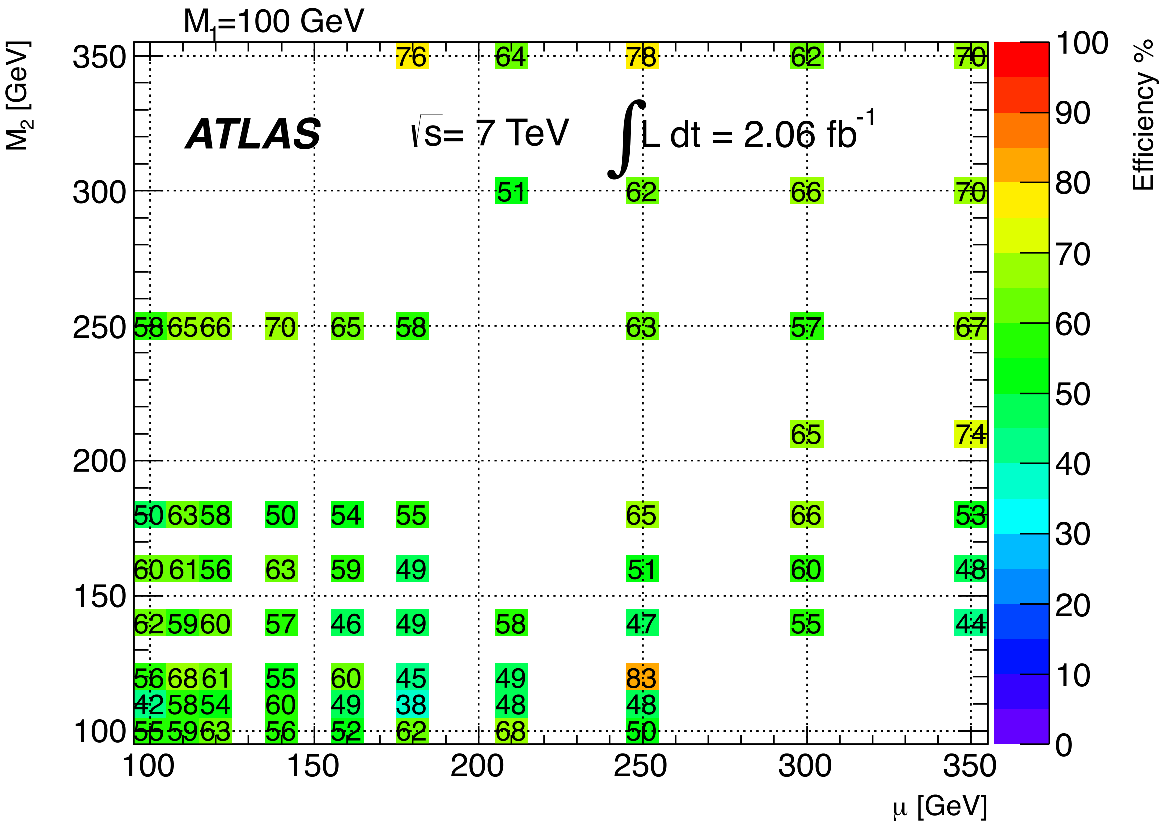
arXiv:1204.5638 (2012)

Direct Gaugino pMSSM Models

Acceptance & Efficiency

3-Lepton Search (2 fb^{-1})





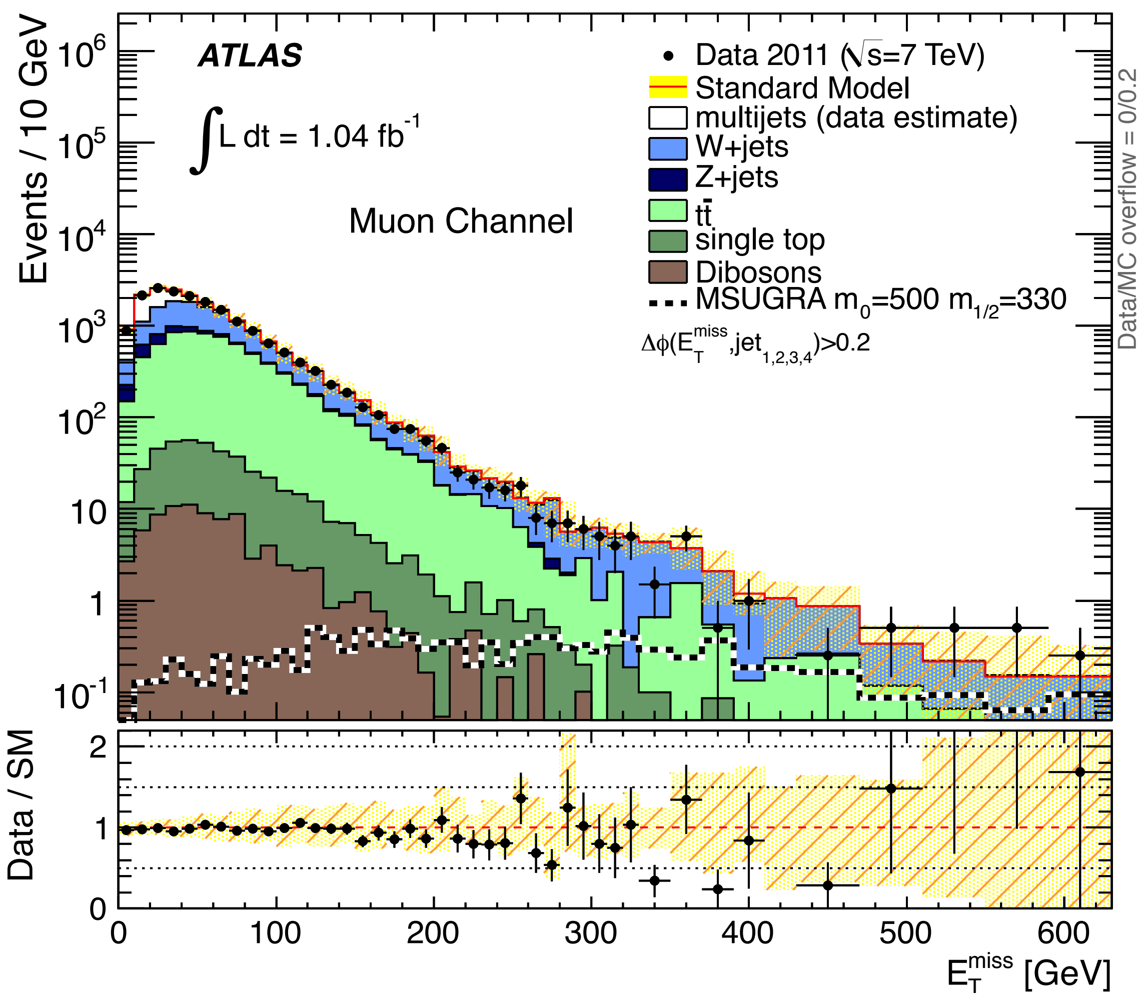
Backups for

R-parity Violation

Bilinear RPV search (1 fb^{-1})

1-Lepton Channel (1 fb^{-1})

- 1-muon tight 4-jet signal region (4JT) in the ATLAS 1-lepton search is used for bilinear RPV search
- Main BG: W+jets, $t\bar{t}$



Selection	Signal Regions 3JL	3JT	4JL	4JT	Control Regions 3J	4J
Number of Leptons	= 1					
Lepton p_T (GeV)	> 25(20) for electrons (muons)					
Veto lepton p_T (GeV)	> 20(10) for electrons (muons)					
Number of jets	≥ 3		≥ 4		≥ 3	≥ 4
Leading jet p_T (GeV)	60	80	60	60	60	60
Subsequent jets p_T (GeV)	25	25	25	40	25	25
$\Delta\phi(\vec{jet}_i, \vec{E}_T^{miss})$	[> 0.2 (mod.π)] for all 3 (4) jets					
m_T (GeV)	> 100				$40 < m_T < 80$	
E_T^{miss} (GeV)	> 125	> 240	> 140	> 200	$30 < E_T^{miss} < 80$	
E_T^{miss}/m_{eff}	> 0.25	> 0.15	> 0.30	> 0.15	–	–
m_{eff} (GeV)	> 500	> 600	> 300	> 500	> 500	> 300

- BG is estimated using data-driven technique
- W & Top control regions are considered for the BG estimation (next slide)

Bilinear RPV search (1 fb^{-1})

1-Lepton Search (1 fb^{-1})

- W+jets Control Regions (WR): The same lepton & jet requirements as the signal regions. 30 GeV<E_T^{miss}<80 GeV, 40 GeV<m_T<80 GeV. No b-tagged jets for the 3 or 4 leading ones.

- Top Control Regions (TR): The same requirements as WR except for the b-tag conditions. At least one b-tagged jet in the 3 or 4 leading jets.

Transfer Factor

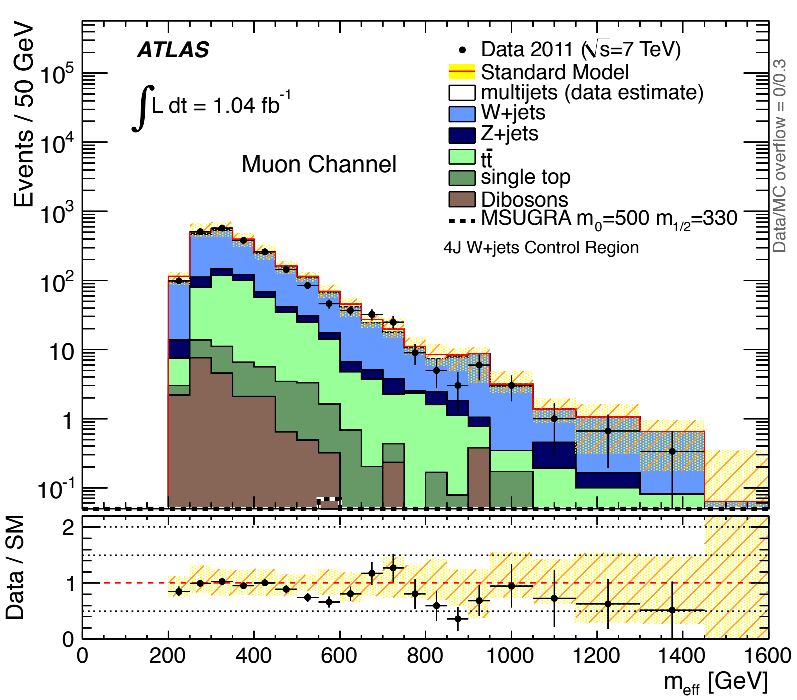
$$C^{j}_{iR\rightarrow SR} = \frac{N^{SR}_{MC,j}}{N^{iR}_{MC,j}}$$

N=number of events
iR=WR or TR
j=W+jets or Top

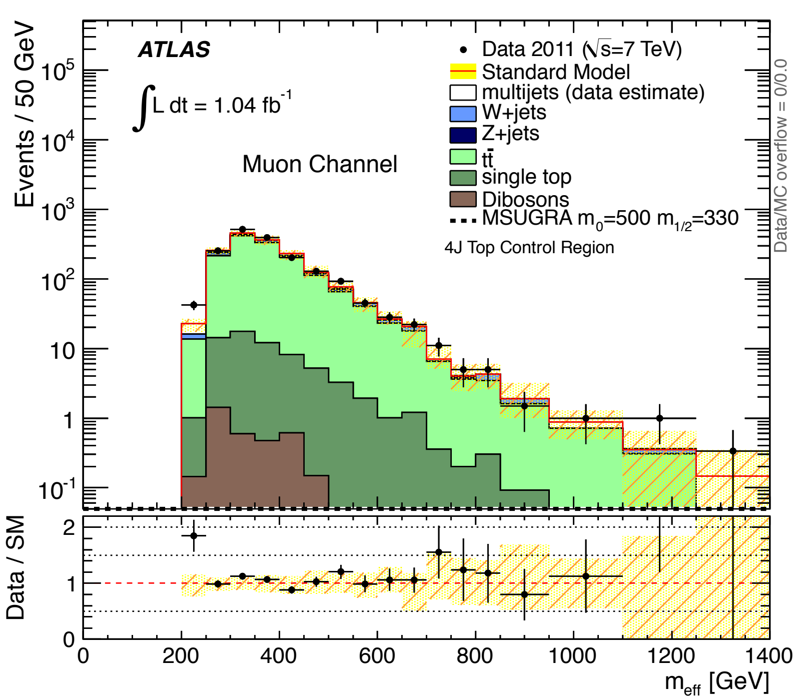
BG Prediction

$$N^{SR}_{pred,j} = \sum_{i=W,T} (N^{iR}_{data} \times C^{j}_{iR\rightarrow SR})$$

W+jets Control Region in 4JT



Top Control Region in 4JT



Muon channel	4JT Signal region
Observed events	7
Fitted top events	4.7 ± 2.2 (4.3)
Fitted W/Z events	1.4 ± 1.1 (1.4)
Fitted multijet events	$0.0^{+0.6}_{-0.0}$
Fitted sum of background events	6.0 ± 2.7

Observed no excess

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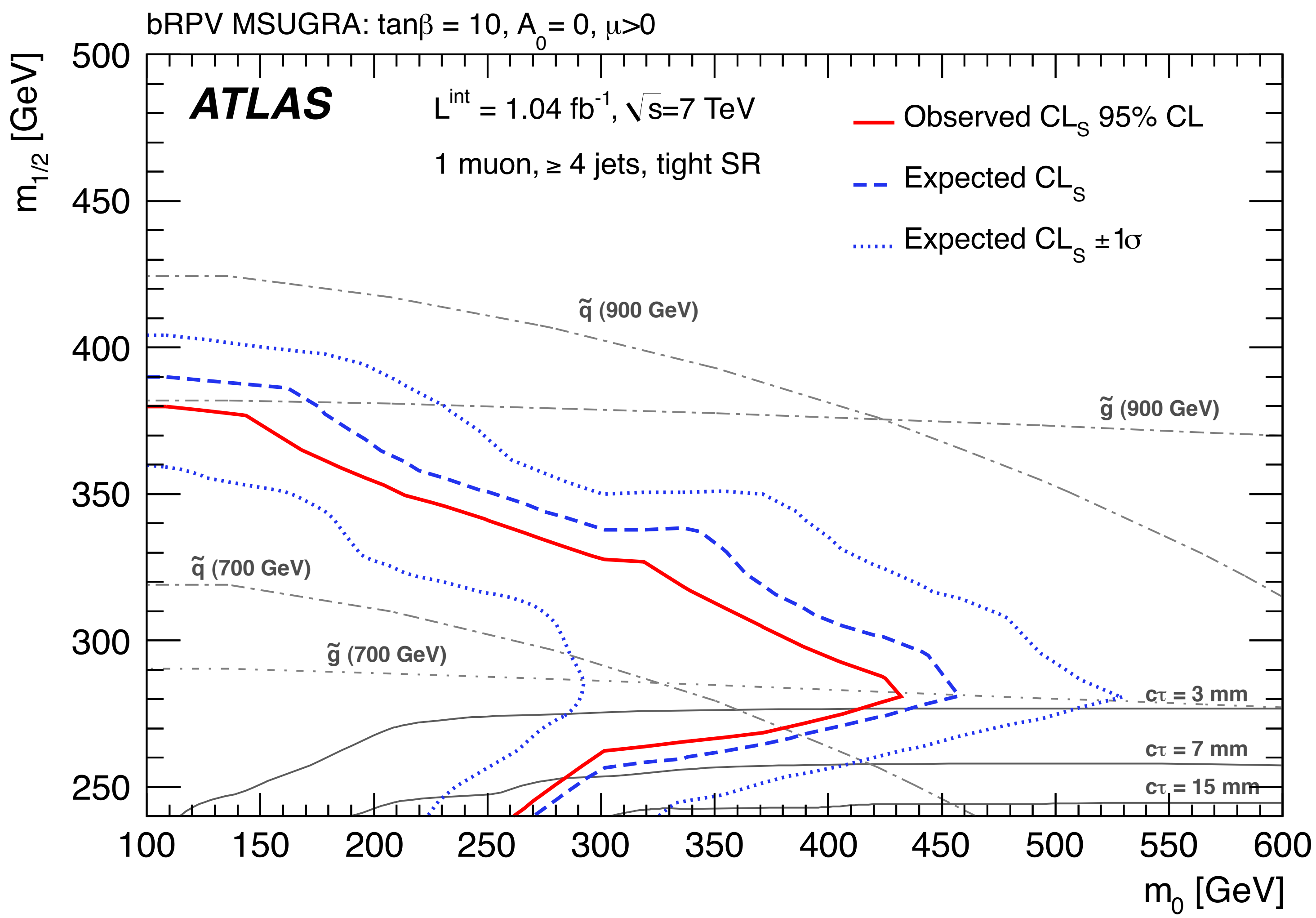
Bilinear RPV mSUGRA

1-Lepton Search (1 fb^{-1})

bRPV MSUGRA model

- RPV couplings were embedded in MSUGRA/CMSSM.
- bRPV parameters are determined under tree-level dominance scenario & fit to neutrino oscillation data (Y.Grossman,S.Rakshit, PRD69, 093002 (2004))
- The neutralino LSP's decay to electron is highly suppressed



- The model is not tested for regions where LSP's cτ>15 mm ($m_{1/2}$<~240 GeV)
- When $m_{gluino} \sim m_{squark}$, masses below 760 GeV is excluded.

4-Lepton Control Regions
(2 fb^{-1})

- $t\bar{t}$-rich control region:
    - Presence of opposite-flavor opposite-sign lepton pair
    - Presence of a b-tagged jet
    - Reversing isolation requirements on two of the four leptons
    - The same E_T^{miss} cut as the signal regions (50 GeV)
- Low E_T^{miss} ZZ-rich control region:
    - Require four leptons
    - $E_T^{miss} < 50$ GeV

	MC	Data
$t\bar{t}$-rich	8.4 ± 0.8 (stat)	8
ZZ-rich	23 ± 5 (stat+sys)	20

≥4-lepton SR1 for RPV stau-LSP Search

SR1	All	$eeee$	$eee\mu$	$ee\mu\mu$	$e\mu\mu\mu$	$\mu\mu\mu\mu$
$t\bar{t}$	0.17±0.14	0.011±0.042	0.027±0.042	0.09±0.06	0.05±0.07	0±0.018
Single t	0±0.04	0±0.04	0±0.04	0±0.04	0±0.04	0±0.04
$t\bar{t}V$	0.48±0.21	0.072±0.037	0.12±0.06	0.14±0.07	0.08±0.04	0.059±0.032
ZZ	0.44±0.19	0.14±0.08	0.016±0.012	0.21±0.12	0.047±0.032	0.025±0.045
WZ	0.25±0.10	0.015±0.022	0.07±0.04	0.050±0.032	0.11±0.06	0±0.011
WW	0±0.015	0±0.015	0±0.015	0±0.015	0±0.015	0±0.015
$Z\gamma$	0±0.5	0±0.5	0±0.5	0±0.5	0±0.5	0±0.5
Z+(u, d, s jets)	0.33±0.67	0.33±0.67	0±0.29	0±0.29	0±0.29	0±0.29
Z+(c, b jets)	0.024±0.035	0±0.17	0±0.17	0±0.17	0.024±0.035	0±0.17
Drell-Yan	0±0.05	0±0.05	0±0.017	0±0.017	0±0.016	0±0.017
Σ SM	1.7±0.9	0.6±0.8	0.24±0.57	0.5±0.6	0.32±0.55	0.08±0.57
Data	4	0	1	2	0	1

No significant deviation is seen for each flavor final state

≥4-lepton SR2 for RPV stau-LSP Search

SR2	All	*eeee*	$eee\mu$	$ee\mu\mu$	$e\mu\mu\mu$	$\mu\mu\mu\mu$
$t\bar{t}$	0.13±0.11	0±0.018	0.027±0.042	0.05±0.04	0.05±0.07	0±0.018
Single t	0±0.04	0±0.04	0±0.04	0±0.04	0±0.04	0±0.04
$t\bar{t}V$	0.07±0.04	0.007±0.007	0.024±0.017	0.022±0.021	0.011±0.008	0.005±0.005
ZZ	0.019±0.020	0.008±0.011	0±0.012	0.010±0.018	0±0.012	0±0.012
WZ	0.09±0.05	0±0.020	0.0021±0.0024	0.050±0.032	0.039±0.028	0±0.011
WW	0±0.015	0±0.015	0±0.015	0±0.015	0±0.015	0±0.015
$Z\gamma$	0±0.5	0±0.5	0±0.5	0±0.5	0±0.5	0±0.5
Z+(u, d, s jets)	0.33±0.67	0.33±0.67	0±0.29	0±0.29	0±0.29	0±0.29
Z+(c, b jets)	0.024±0.035	0±0.17	0±0.17	0±0.17	0.024±0.035	0±0.17
Drell-Yan	0±0.05	0±0.05	0±0.017	0±0.017	0±0.016	0±0.017
Σ SM	0.7±0.8	0.35±0.83	0.05±0.57	0.13±0.57	0.12±0.55	0.005±0.567
Data	0	0	0	0	0	0

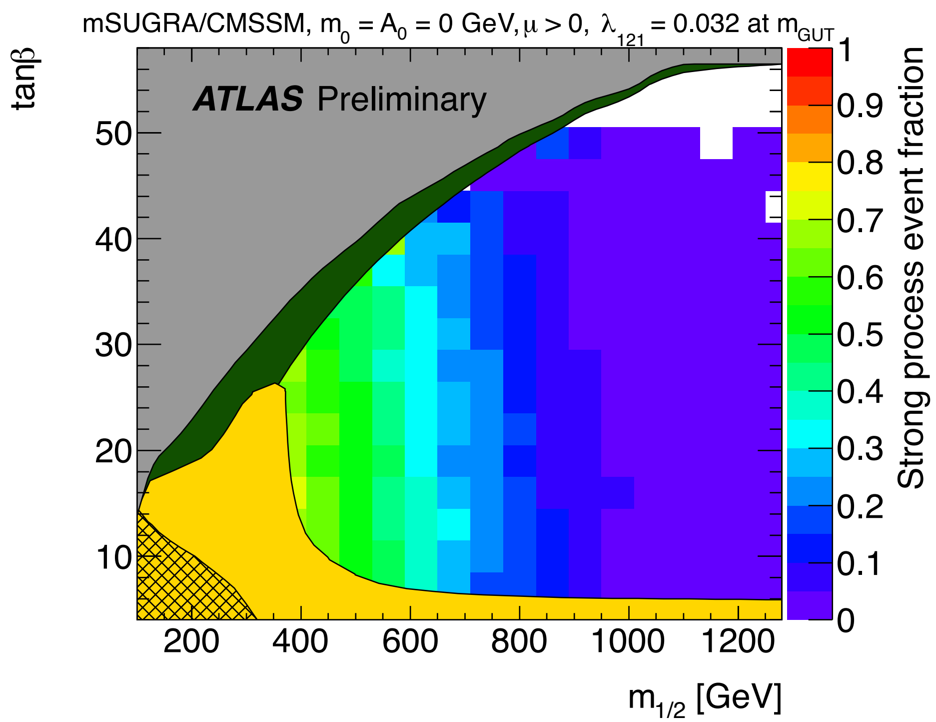
No significant deviation is seen for each flavor final state

ATLAS-CONF-2012-001, ATLAS-CONF-2012-035 (2012)

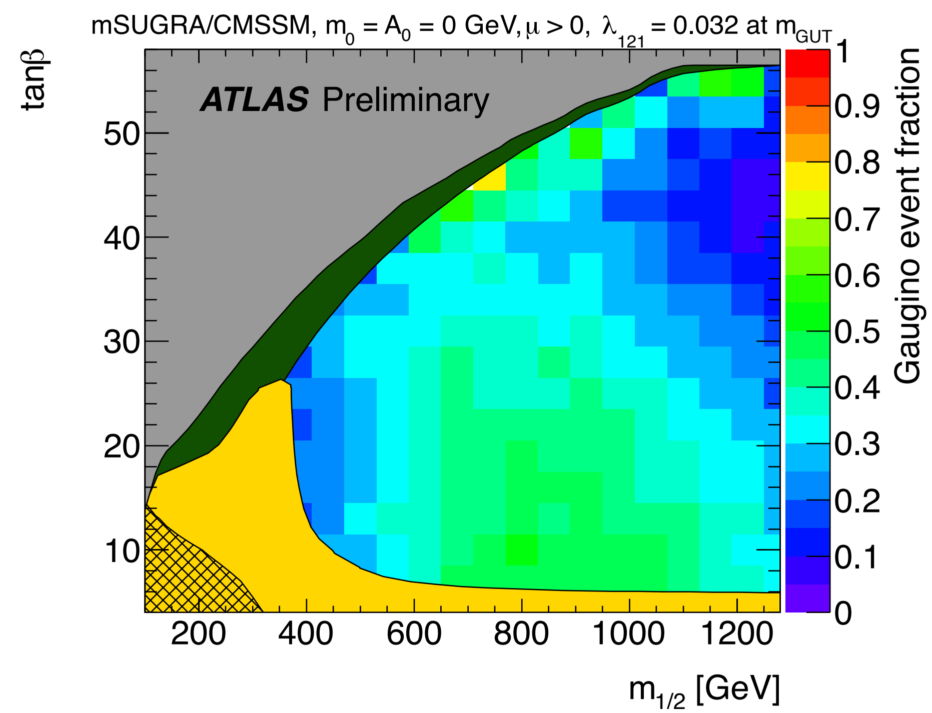
Relative Contribution

(≥4-lep RPV stau-LSP Search)

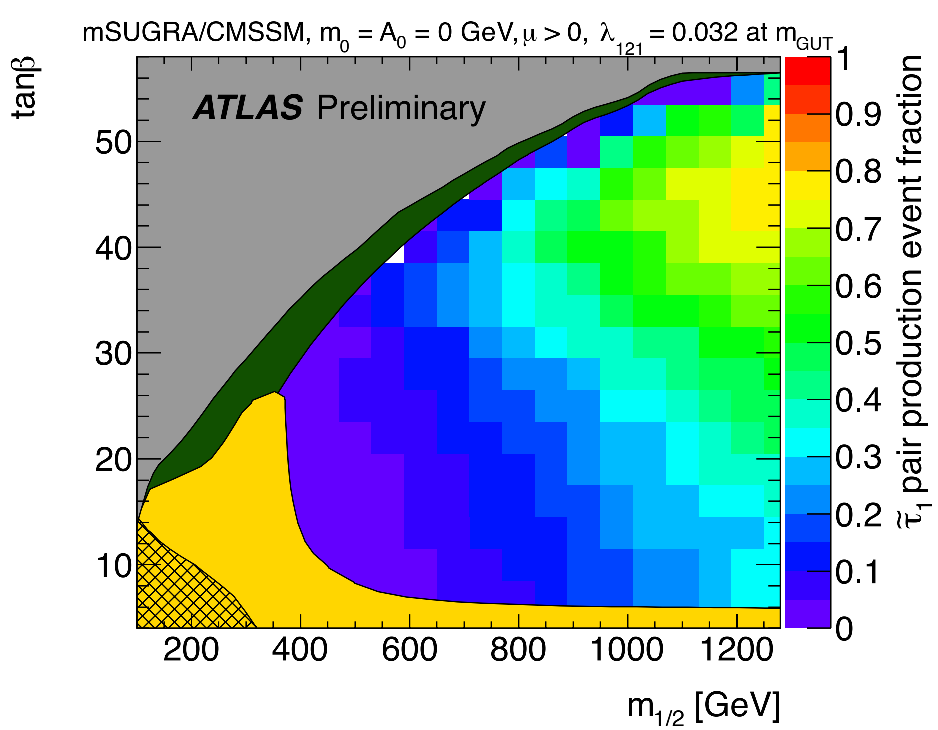
Strong Process



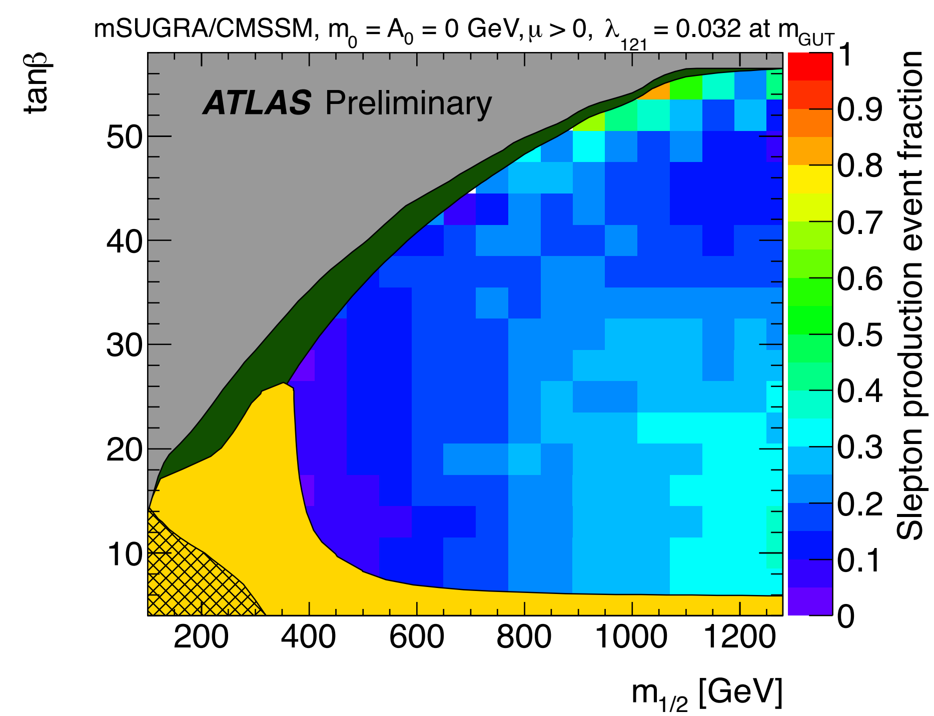
Gaugino Pair- Prod.



Stau Pair Production

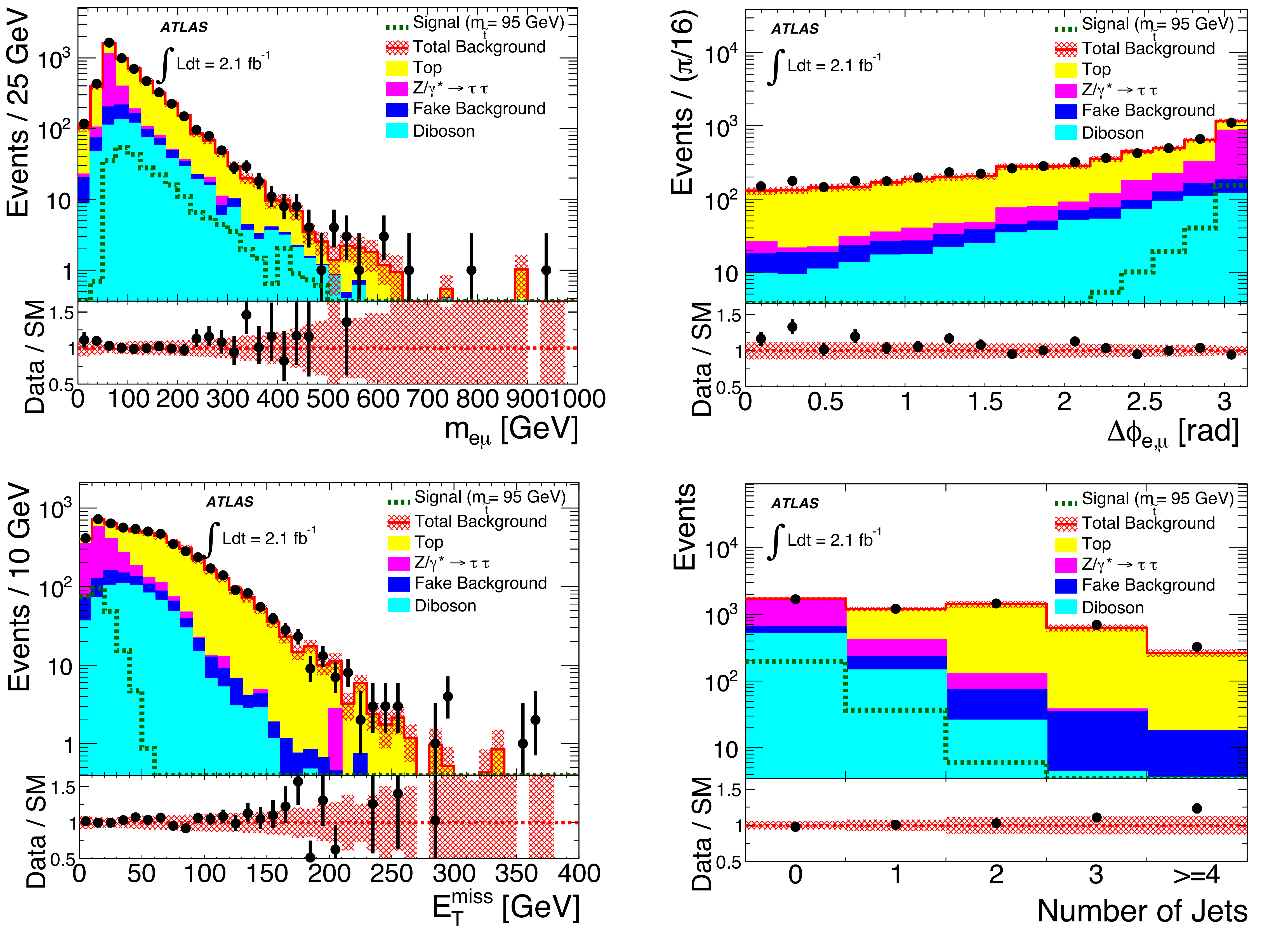


Slepton Pair- Prod.



[arXiv:1205.0725 (2012)]

e-μ Continuum Plots (2 fb^{-1})



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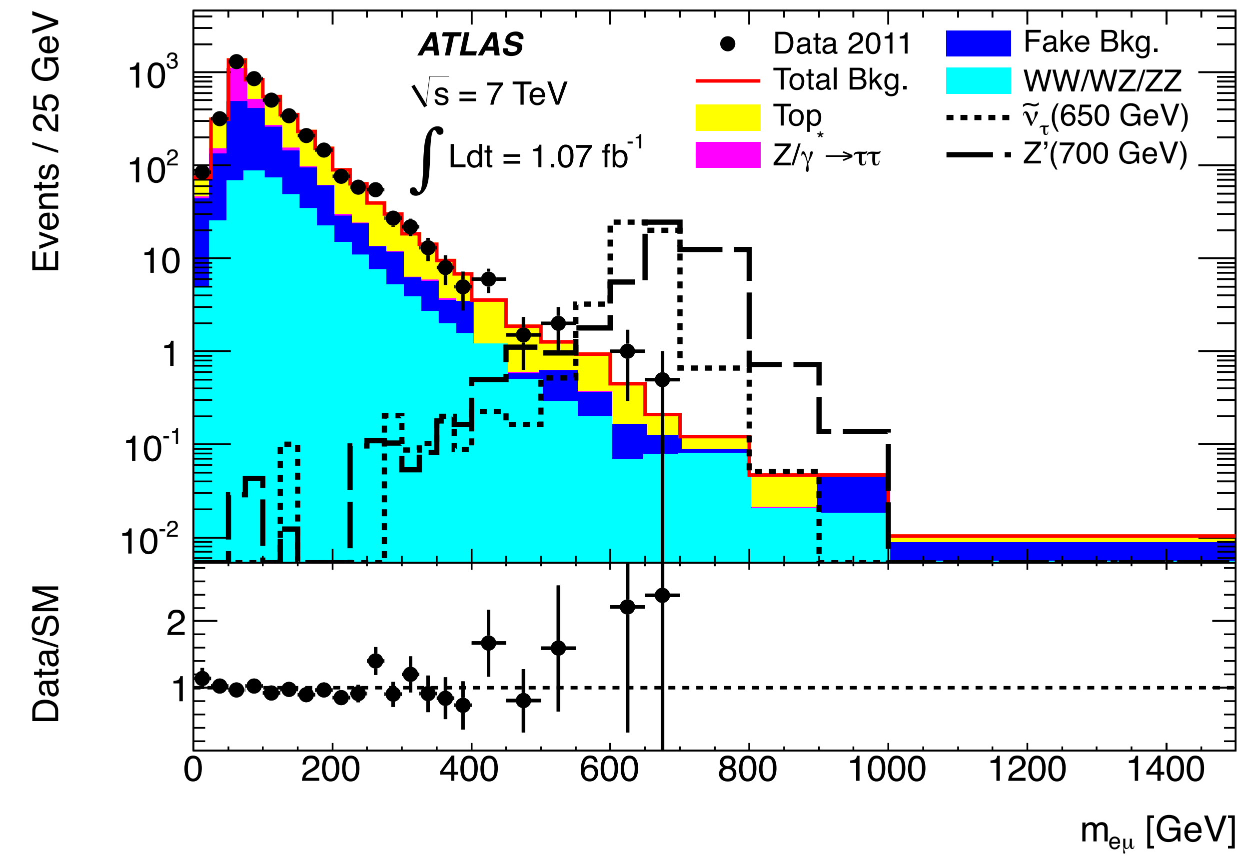
e-μ Resonance (1 fb^{-1})

Signal region: Opposite-sign e+μ, e,μ p_T>25 GeV

- Search for high mass neutral particle decaying to two different flavor leptons
- Sensitive to RPV tau sneutrinos & LPV Z′
- Clean signature & low BG



BG

- Real prompt leptons (ttbar, single top, Z/γ*→ττ, diboson) estimated with MC
- Fake lepton(s): W/Z+jets, multijets were estimated with data-driven method (Matrix Method). MC was used for W/Z+γ.

Process	Number of events
$t\bar{t}$	1580±170
Jet fake	1175±120
$Z/\gamma^* \to \tau\tau$	750±60
WW	380±31
Single top	154±16
$W/Z+\gamma$	82±13
WZ	22.4±2.3
ZZ	2.48±0.26
Total background	4145±250
Data	4053

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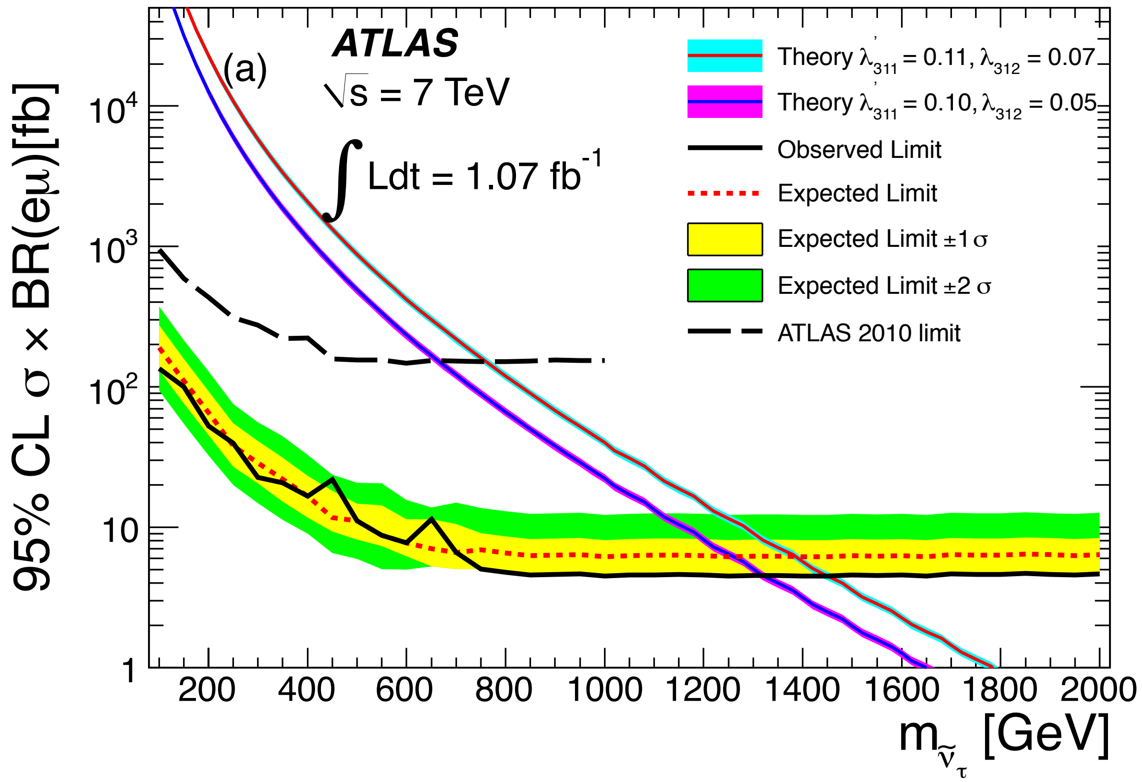
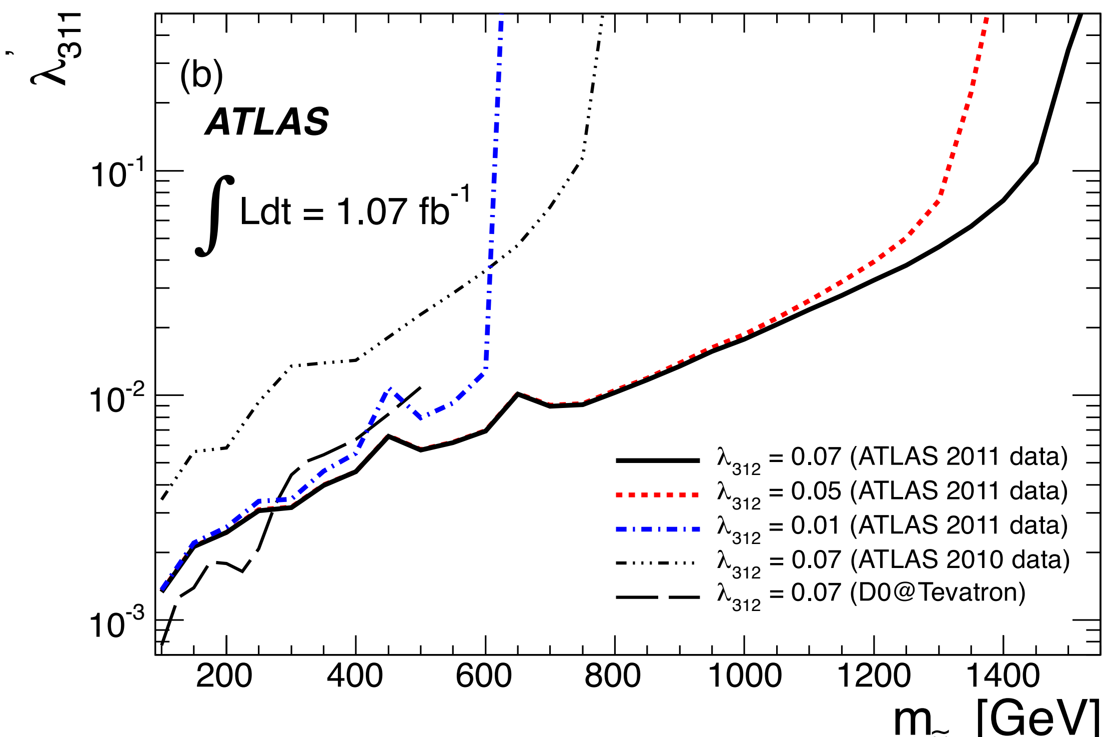
RPV $\tilde{\nu}_\tau$ Interpretation

e-μ Resonance (1 fb^{-1})





- Search region is basically (m_{stau}-3σ, m_{stau}+3σ) except for very high mass region. σ=resolution of invariant mass of e-μ
- For λ'_{311}=0.11, λ_{312}=0.07, tau sneutrino of 1.45 TeV mass excluded
- For λ'_{311}=0.10, λ_{312}=0.05, tau sneutrino of 1.32 TeV mass excluded
- Exclusion at 95% CL on λ'_{311} as a function of tau sneutrino mass
- Significant improvement on the limits from D0 & 2010 ATLAS results