



# ATLAS & CMS Searches for SUSY in Leptonic Final State

## Weak Gaugino Direct Production

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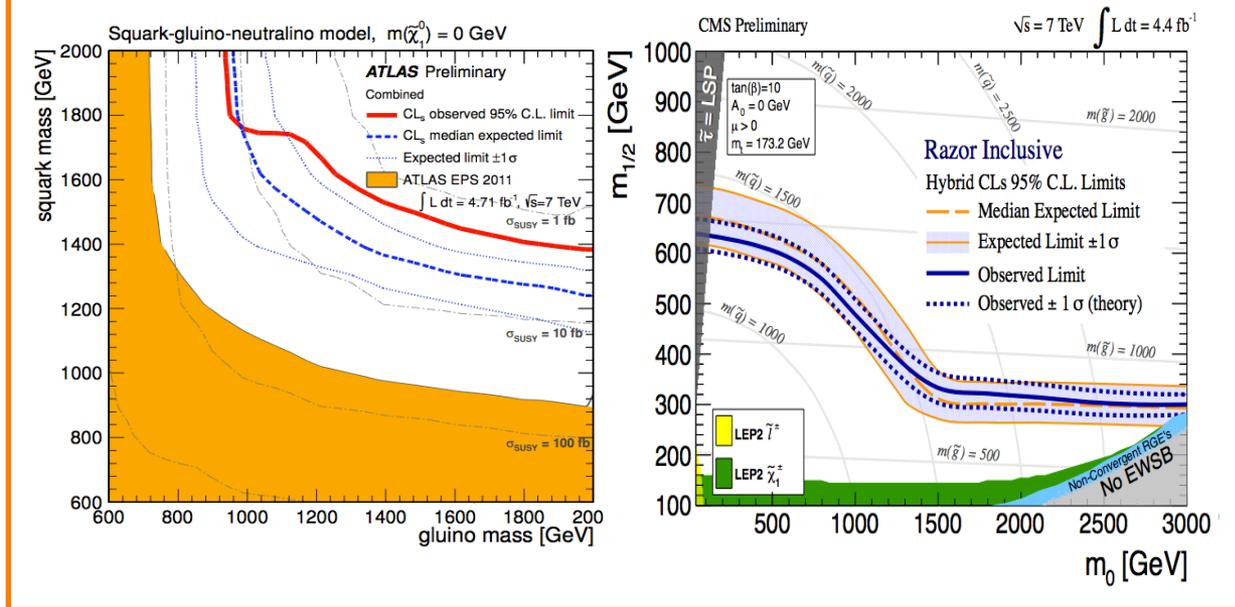


Implications of LHC results for TeV-scale physics

March 29, 2012

- Introduction
- Searches
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  - 3 Lepton
  - 4 Lepton
- Summary

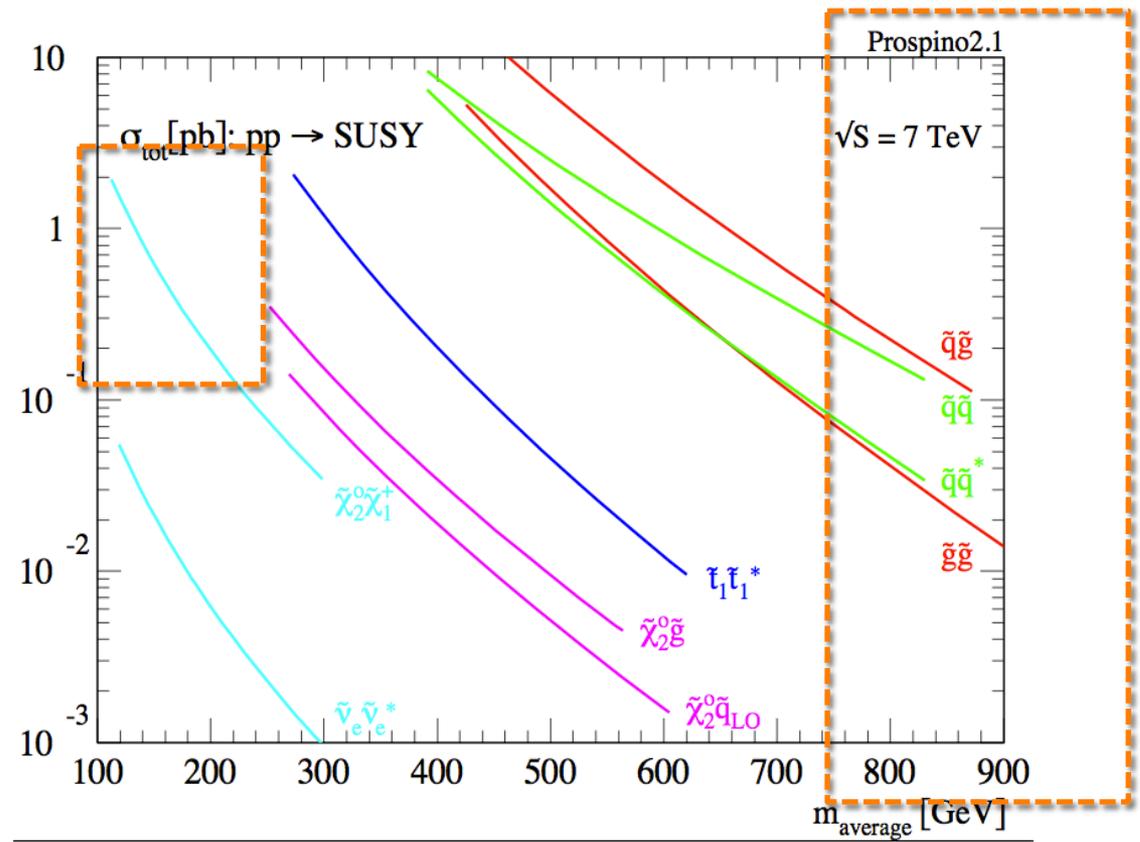
## Very stringent limits on squark and gluino (Simplified scenarios and mSUGRA)



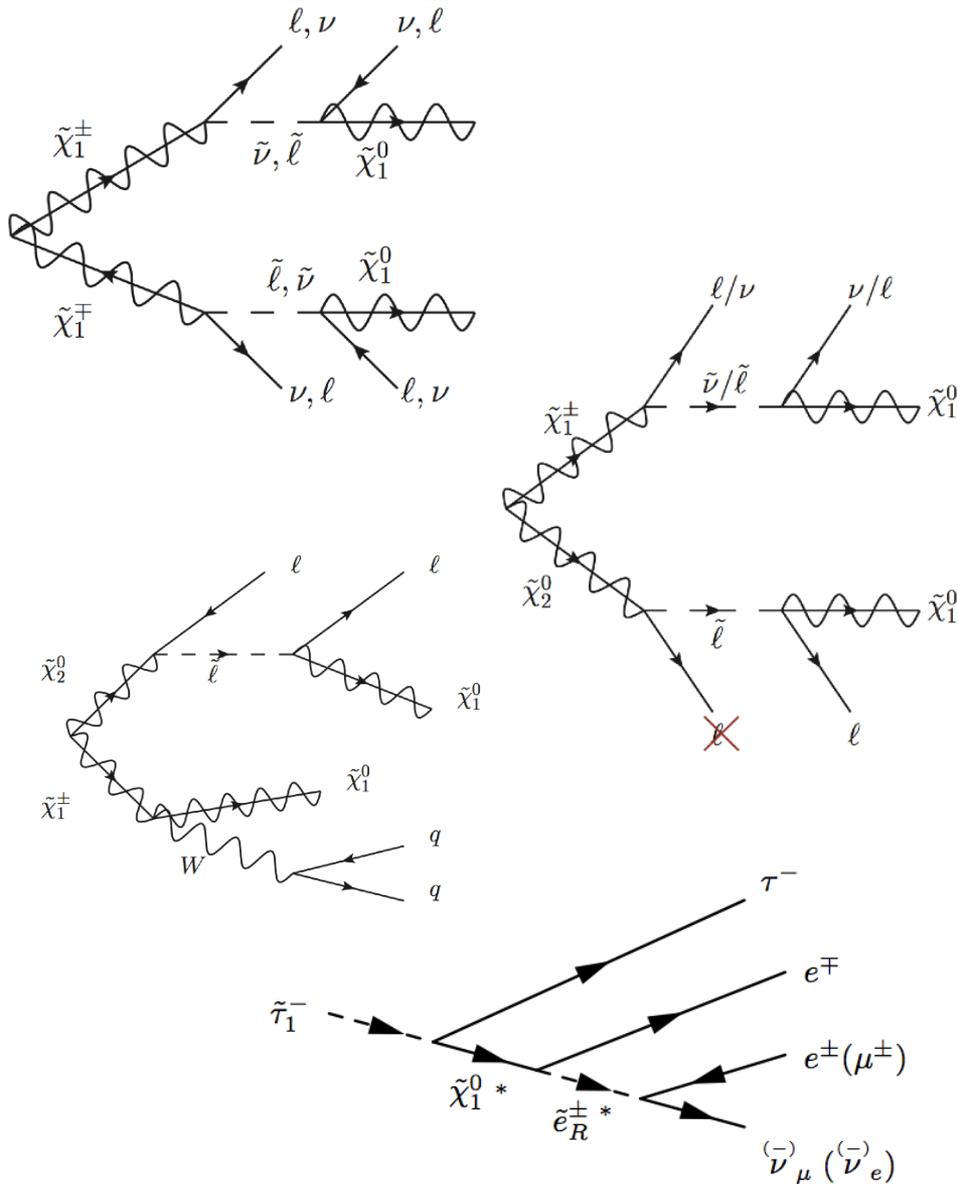
*In this talk, analyses with direct gaugino interpretation or with signal regions sensitive to direct gaugino production*

# Is Natural SUSY Excluded?

- The limits apply to first and second generation squarks and gluino
- For SUSY to regulate the electroweak scale only the mass of the sparticles coupling to the Higgs sector has to be small
  - Squarks can be heavy (decoupled scenarios)
  - Gauginos (and 3<sup>rd</sup> generation squarks) have to be light!



# ATLAS and CMS Multi-lepton Searches



Signature	ATLAS	CMS
2L OS + met	✓	
2L SFOS + met	✓	
2L SFOS + 2j + met	✓	
2L SFOS + met + !Z	✓	
2L SFOS 2j + met + Z		✓
2L SS + met	✓	
3L + met + Z	✓	
3L + met + !Z	✓	
3L + met + Z + low/high HT/ST		✓
3L + met + !Z + low/high HT/ST		✓
4L + met + Z	✓	
4L + met + !Z	✓	
4L + met + Z + low/high HT/ST		✓
4L + met + !Z + low/high HT/ST		✓

# 2 Opposite Sign Lepton Analysis

arXiv:1110.6189v2

- **1.04/fb**, single lepton trigger

Selection	Value
Lead Lep $p_T$ (GeV)	> 25(ele); 20 (mu)
Lep $p_T$ (GeV)	> 20(ele); 10(mu)
$M_{ll}$	> 12 GeV
Jet $E_T$	> 20 GeV



SR1 SR1 SR2 SR3

Signal Region	OS-inc	FS-no Z	FS-2j	FS-inc
$E_T^{\text{miss}}$ [GeV]	250	80	80	250
Leading jet $p_T$ [GeV]	-	-	-	-
Second jet $p_T$ [GeV]	-	-	-	-
Third jet $p_T$ [GeV]	-	-	-	-
Fourth jet $p_T$ [GeV]	-	-	-	-
Number of jets	-	-	$\geq 2$	-
$m_{ll}$ veto [GeV]	-	80-100	-	-

CMS-SUS-11-021

- **4.7/fb**, di-lepton trigger

Selection	Value
Lep $p_T$ (GeV)	> 20
Jet $E_T$	>30 GeV



Signal Region	Loose	Tight
NJets	$\geq 2$	$\geq 2$
Z request [81:101] GeV	yes	yes
MET (GeV)	100	200

## Background

- **Irreducible:** top pair (dominant if !Z), Z (dominant if Z), diboson, Single top
- **Reducible:** 1 or 2 fakes from HF, prompt photons, conversions

# Background Estimate



- **tt** Normalized to data in tt control region extrapolated to SR (**total uncertainty ~27%**)
- **Z** Normalized to data in Z control region (low met, in Z window) and extrapolated to SR
- **Diboson, single top** based on MC NLO
- **Reducible** using data driven 'matrix method'

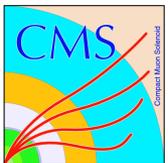


## Top Control Region

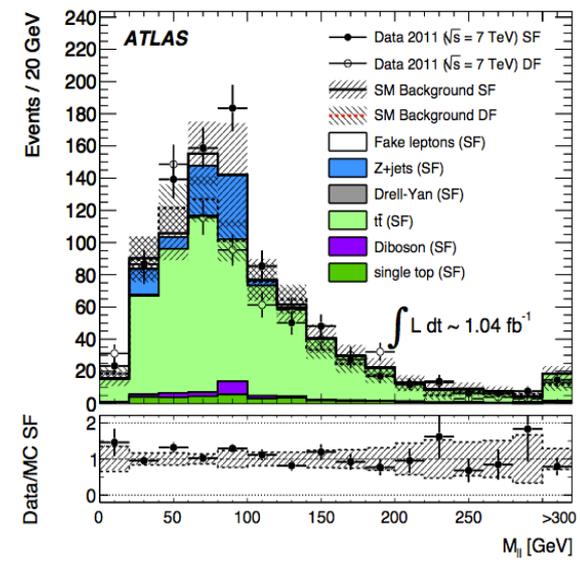
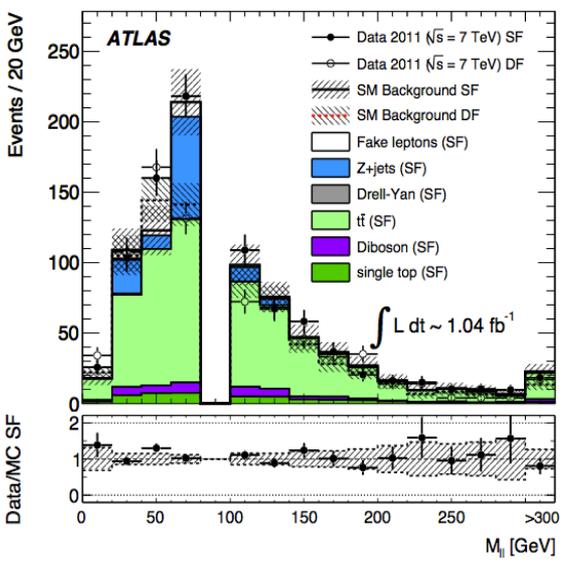
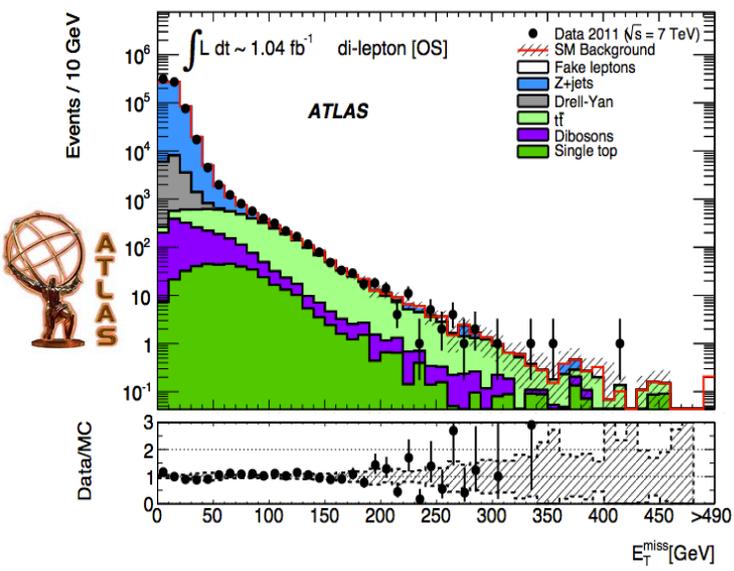
$$m_{CT}^2(v_1, v_2) = [E_T(v_1) + E_T(v_2)]^2 - [\mathbf{p}_T(v_1) - \mathbf{p}_T(v_2)]^2$$

v1, v2 are lepton, jets, lepton-jet  
cut on kinematic edge  
3 MCT variables+jet mass  
compatible with top

- **tt, WW, ZTT** MC based OF contribution normalized to data  $e^\pm\mu^\mp$  yield
- **Z** using 'met template method':
  - Templates built in control sample with no true met (gamma-jet; QCD) and with same hadronic system as Z (with the same jet multiplicity and  $H_T$  as the Z background (**total uncertainty ~15%**))
- **Diboson, single top** based on MC NLO



# Background Composition



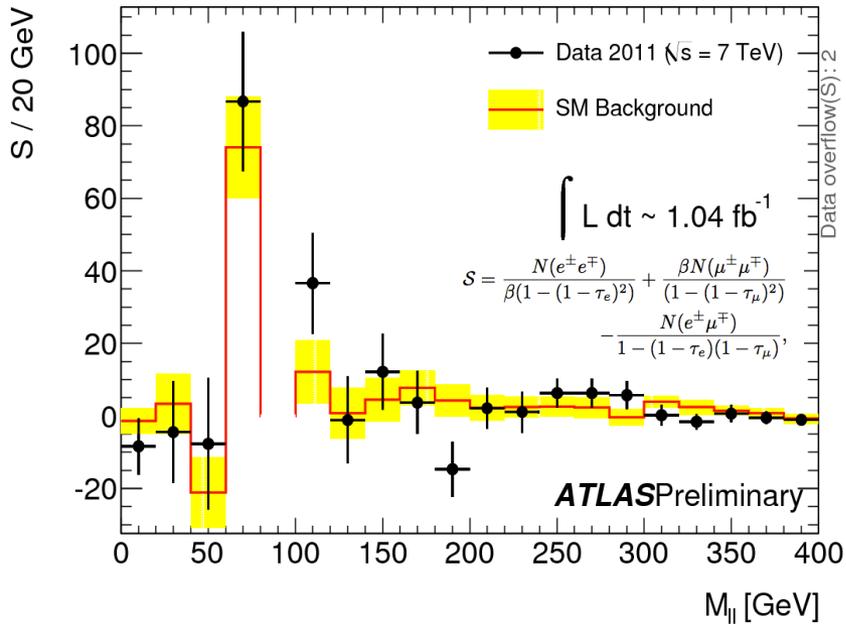
SF Signal region  
MET > 80 GeV, !Z

SF Signal region  
MET > 80 GeV, 2 jets

	$E_T^{\text{miss}} > 30 \text{ GeV}$	$E_T^{\text{miss}} > 60 \text{ GeV}$
Z bkg	15070 ± 4825	484 ± 156
OF bkg	1116 ± 101	680 ± 62
VZ bkg	252 ± 126	79 ± 39
<b>total bkg</b>	<b>16438 ± 4828</b>	<b>1243 ± 173</b>
<b>data</b>	<b>16483 (8243,8240)</b>	<b>1169 (615,554)</b>



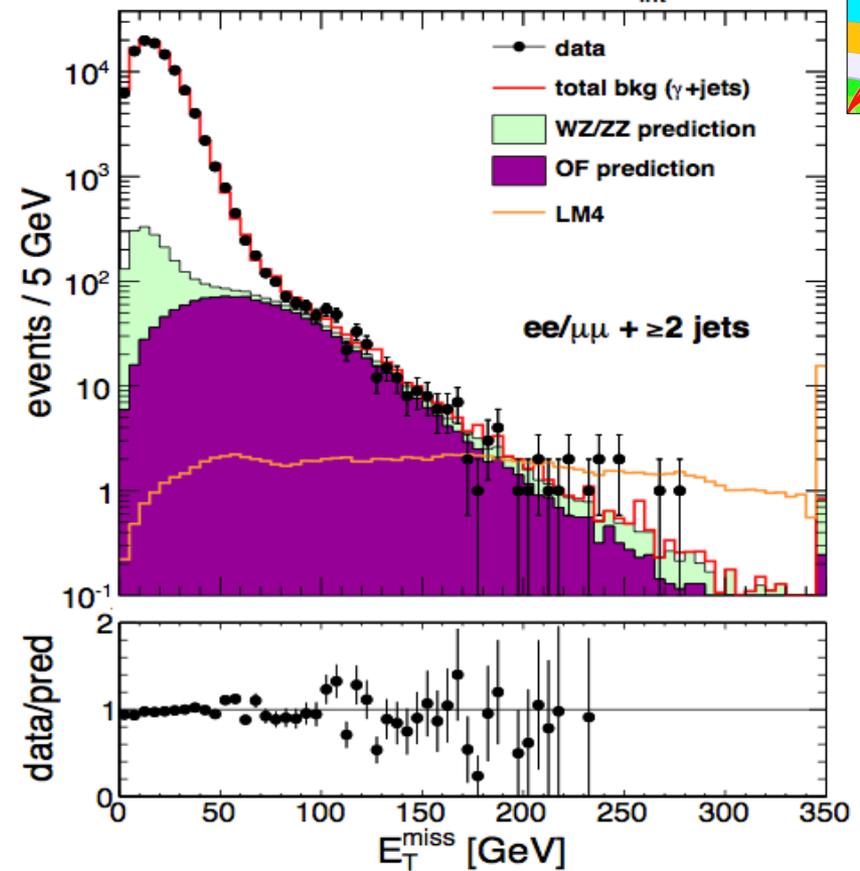
# Results



	Background	Obs.	95% CL
OS-SR1	$15.5 \pm 4.0$	13	9.9 fb
OS-SR2	$13.0 \pm 4.0$	17	14.4 fb
OS-SR3	$5.7 \pm 3.6$	2	6.4 fb

	$S_{obs}$	$\bar{S}_b$	RMS
FS-SR1	$131.6 \pm 2.5(\text{sys})$	$118.7 \pm 27.0$	48.6
FS-SR2	$142.2 \pm 1.0(\text{sys})$	$67.1 \pm 28.6$	49.0
FS-SR3	$-3.06 \pm 0.04(\text{sys})$	$0.7 \pm 1.6$	4.5

CMS Preliminary  $\sqrt{s} = 7 \text{ TeV}$ ,  $L_{\text{int}} = 4.7 \text{ fb}^{-1}$



	$E_T^{\text{miss}} > 100 \text{ GeV}$	$E_T^{\text{miss}} > 200 \text{ GeV}$	$E_T^{\text{miss}} > 300 \text{ GeV}$
Z bkg	$36 \pm 12$	$2.4 \pm 0.9$	$0.4 \pm 0.3$
OF bkg	$227 \pm 21$	$11.4 \pm 3.2$	$1.6 \pm 0.6$
VZ bkg	$32 \pm 16$	$5.0 \pm 2.5$	$1.1 \pm 0.7$
<b>total bkg</b>	<b><math>295 \pm 29</math></b>	<b><math>18.8 \pm 4.2</math></b>	<b><math>3.1 \pm 1.0</math></b>
<b>data</b>	<b>290 (142,148)</b>	<b>14 (8,6)</b>	<b>0</b>



# ATLAS 2L SS Limit Interpretation

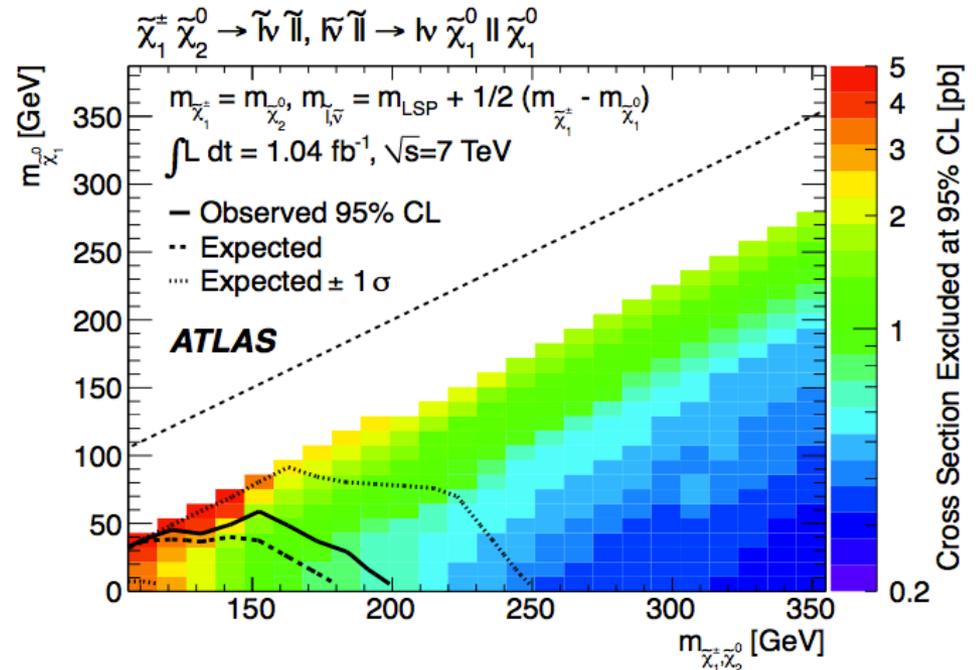
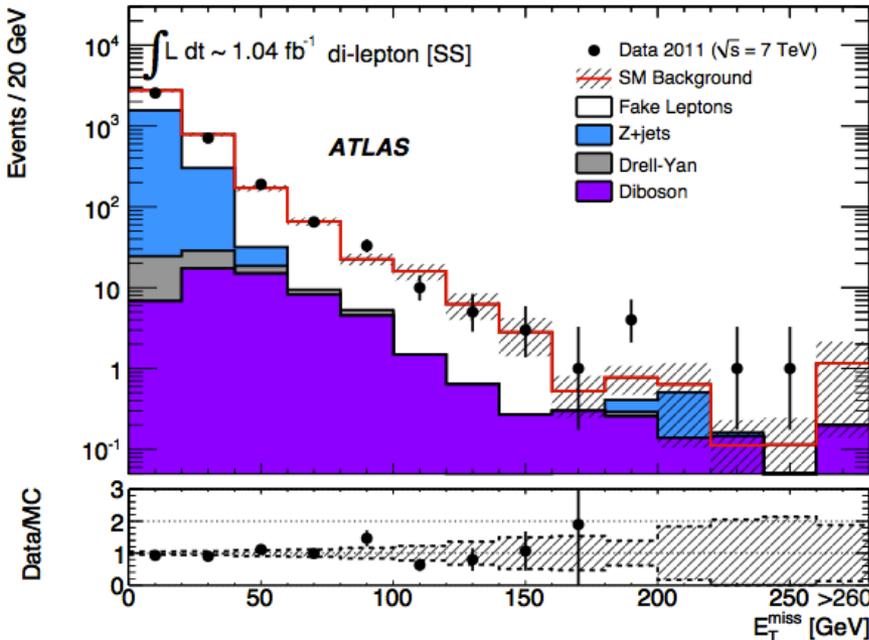
arXiv:1110.6189v2

- **1.04/fb**, same trigger and lepton selection as OS 2L search

Selection	Vaalue
SS leptons	$\geq 2$
MET (GeV)	100

- Dominant background: reducible and diboson
  - Background from charge misidentification estimated using a partially data-driven technique

Background	$32.6 \pm 7.9$
Observed	25
95% C.L	14.8 fb



# 3 Lepton Analysis

ATLAS-CONF-2012-023

- **2/fb**, single lepton trigger

Selection	Value
Lead Lep $p_T$ (GeV)	> 25(ele); 20 (mu)
Lep $p_T$ (GeV)	> 10
No. SFOS	$\geq 1$
SFOS $M_{ll}$	> 20 GeV
Jet $E_T$	> 20 GeV



- **SR1: Z depleted signal region**
  - MET > 50 GeV
  - Veto Zs [ $|M_{SFOS}-M_Z| < 10$  GeV]
  - Veto b-jets
- **SR2: Z enriched signal region**
  - MET > 50 GeV
  - Require Z [ $|M_{SFOS}-M_Z| < 10$  GeV]

CMS-EXO-11-045, CMS-SUS-11-013

- **4.7/fb**, single or di-lepton trigger

Selection	Value
Lead Lep $p_T$ (GeV)	> 70(ele); 20 (mu)
or	15,10(mu); 20,10 (ele); 20,10 (ele,mu)
Lep $p_T$ (GeV)	> 8
Tau <sub>em</sub> $E_T$ (GeV)	> 8
Tau vis $E_T$ (GeV)	>15
SFOS $M_{ll}$ (GeV)	> 12
Jet $E_T$ (GeV)	> 40



- **21 signal regions**
- Based on a combination of:

Selection	Value
No. SFOS	1
Z [75-105] GeV	Veto/request
MET (GeV)	50
$H_T$ (GeV)	200
$S_T$ (GeV)	300, 600

# Background Model

- **Irreducible:** process with 3 real leptons
  - WZ (dominant), ZZ, ttbar+V
- **Reducible:** process with fake leptons
  - Top pair (dominant), single top, WW, V production

Process	ATLAS	CMS
WZ, ZZ	MC	MC
ttV	MC	MC
top	DD	MC
WW	DD	MC
Z+jets	DD	DD
Int. Conv.	DD	DD

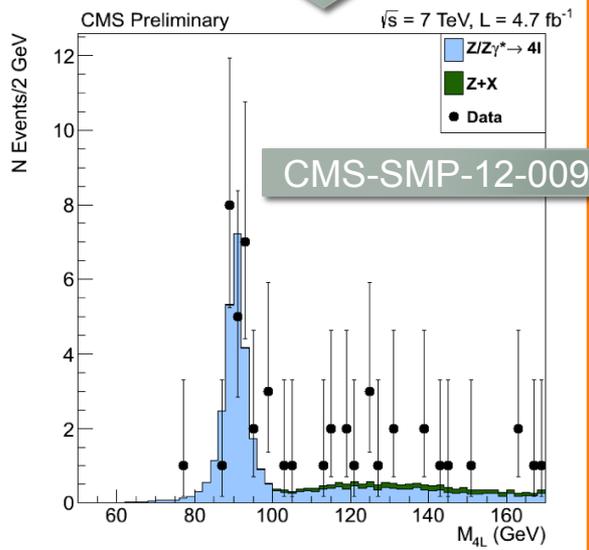
## Internal conversions



- Probability that a **lepton radiates internal conversion decaying into di-muon pair** measured in a control sample and applied to di-lepton events



- Probability that a **photon decays into di-lepton pair** measured in a control sample and applied to di-lepton+gamma events



# Data Driven Estimate of Reducible Bkg.

- **For tt, WW, Z, W, single top production**

- Linear equations relating lepton kinematic properties to the real and fake lepton composition
  - leading lepton is real 99% of the times, build a 4x4 matrix using the 2 sub-leading leptons
- **Mis-identification probabilities are parameterized in fake type,  $p_T$ , eta**


$$\begin{pmatrix} N_{TT} \\ N_{TL} \\ N_{LT} \\ N_{LL} \end{pmatrix} = \begin{pmatrix} \epsilon_1 \epsilon_2 & \epsilon_1 f_2 & f_1 \epsilon_2 & f_1 f_2 \\ \epsilon_1 (1 - \epsilon_2) & \epsilon_1 (1 - f_2) & f_1 (1 - \epsilon_2) & f_1 (1 - f_2) \\ (1 - \epsilon_1) \epsilon_2 & (1 - \epsilon_1) f_2 & (1 - f_1) \epsilon_2 & (1 - f_1) f_2 \\ (1 - \epsilon_1)(1 - \epsilon_2) & (1 - \epsilon_1)(1 - f_2) & (1 - f_1)(1 - \epsilon_2) & (1 - f_1)(1 - f_2) \end{pmatrix} \cdot \begin{pmatrix} N_{RR} \\ N_{RF} \\ N_{FR} \\ N_{FF} \end{pmatrix}$$

- **For Z production**

- Probability that an isolated track is mis-identified as a lepton is measured in di-jet samples
- Events with two identified leptons + one isolated track are rescaled by the fake probability
- For  $\tau_h$  reconstructed as isolated tracks, fake background is extrapolated from the side band of the isolation



# Systematics



Systematic Unc.	SR1	SR2
Reducible bkg	15%	6%
PDF (acceptance)	14%	14%
Limited MC Nev	10%	4%
Cross section	7%	7%

- **Reducible background**

- MC Fake rate:
  - MET dependence: 0.4-17%
- Data/ MC Scale factors: 10-50%
- MC Process fractions:
  - 10% for muons, 30% for electrons

Source of Uncertainty	Uncertainty
Luminosity	4.5%
PDF	14%
Renormalization Scale	10%
Muon ID	0.1 %
Electron ID	0.3%
$\tau$ ID	3.7 %
Muon isolation at 8 (100) GeV/c	11% (0.2%)
Electron isolation at 8 (100) GeV/c	14% (0.6%)
Single Muon trigger efficiency	0.5%
Single Electron trigger efficiency	0.7%
Double Muon trigger efficiency	2.5%
Double Electron trigger efficiency	2%
Electron-Muon trigger efficiency	3.7%
$t\bar{t}$ background	50%
WZ background	40%
ZZ background	40%

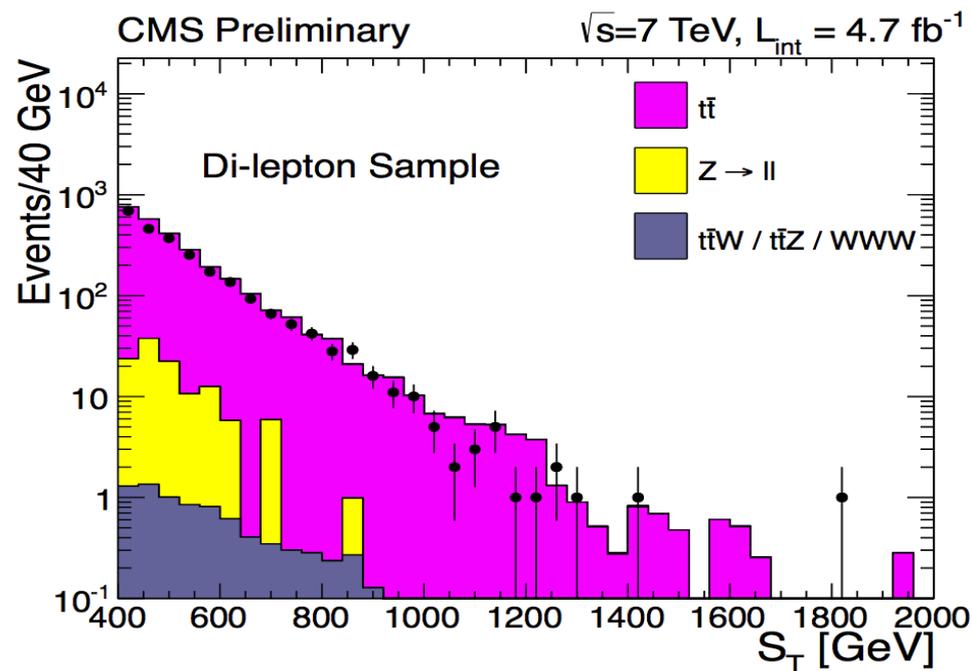
*(systematics as reported for the 2/fb analyses)*

# Validation Regions



Selection	VR1	VR2
$t\bar{t}W^{(*)}/Z^{(*)}$	$1.4 \pm 1.1$	$0.7 \pm 0.6$
$ZZ^{(*)}$	$6.7 \pm 1.5$	$0.03 \pm 0.0$
$WZ^{(*)}$	$61 \pm 11$	$0.4 \pm 0.2$
Reducible Bkg.	$56 \pm 35$	$14 \pm 9$
Total Bkg.	$125 \pm 37$	$15 \pm 9$
Data	122	12

- VR1:
  - Low MET (**Z+jet control region**)
  - 3 signal leptons
  - $30 \text{ GeV} < \text{MET} < 50 \text{ GeV}$
- VR2
  - High MET (**tt control region**)
  - 3 signal leptons
  - $\text{MET} > 50 \text{ GeV}$
  - Veto events with SFOS pair



Di-lepton  $t\bar{t}$  control channel

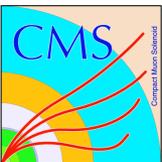
# Results



Selection	VR1	VR2	SR1	SR2
$t\bar{t}V$	1.4±0.6	0.7±0.6	0.4±0.3	2.7±2.1
ZZ	6.7±1.8	0.03±0.04	0.7±0.2	3.4±0.9
WZ	61±15	0.4±0.2	11±3	58±14
Reducible Bkg.	56±35	14±9	14±4	7.5±3.9
Total Bkg.	125±38	15±9	26±5	72±15
Data	122	12	32	95

## Consistency with SM

- SR1: p-value 0.19
- SR2: p-value 0.06

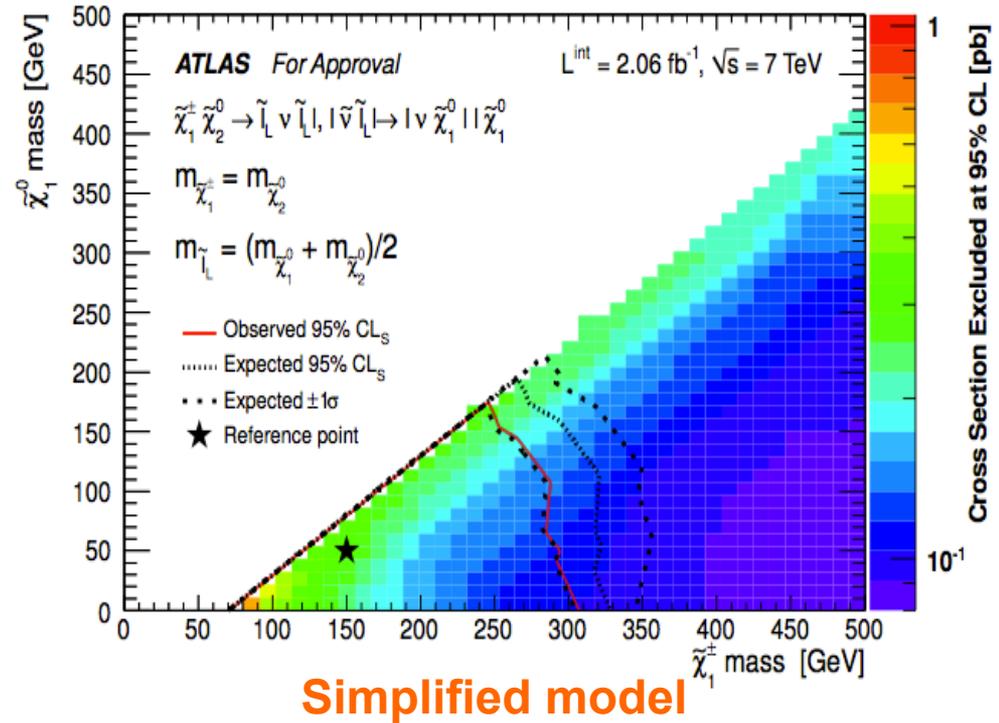
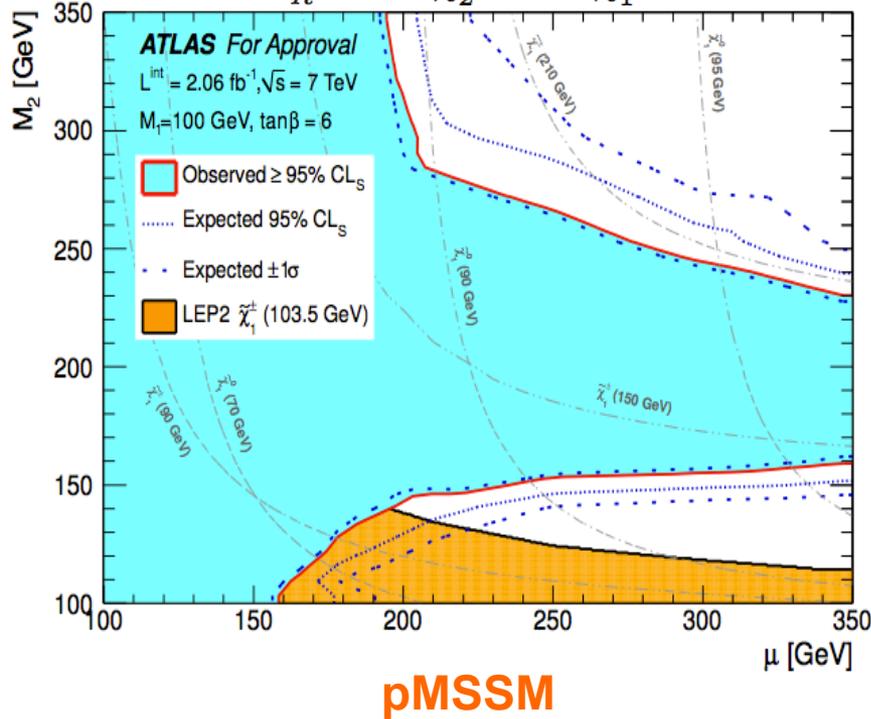


Selection	N( $\tau$ )=0		N( $\tau$ )=1		N( $\tau$ )=2	
	obs	expect	obs	expect	obs	expect
3 $\ell$ MET>50, $H_T$ >200, no-OSSF	2	1.5 ± 0.5	33	30.3 ± 9.6	15	13.5 ± 2.6
3 $\ell$ MET>50, $H_T$ <200, no-OSSF	7	6.5 ± 2.3	159	140 ± 37	82	106 ± 16
3 $\ell$ MET<50, $H_T$ >200, no-OSSF	1	1.2 ± 0.7	16	16.5 ± 4.5	18	31.9 ± 4.8
3 $\ell$ MET<50, $H_T$ <200, no-OSSF	14	11.6 ± 3.6	446	354 ± 55	1006	1025 ± 171
3 $\ell$ MET>50, $H_T$ >200, noZ	8	4.8 ± 1.3	16	31.0 ± 9.5	–	–
3 $\ell$ MET>50, $H_T$ >200, Z	20	17.8 ± 6.0	13	24.0 ± 4.9	–	–
3 $\ell$ MET>50, $H_T$ <200, noZ	30	25.9 ± 7.3	114	106 ± 27	–	–
3 $\ell$ MET<50, $H_T$ >200, noZ	11	4.4 ± 1.5	45	51.8 ± 6.2	–	–
3 $\ell$ MET>50, $H_T$ <200, Z	141	126 ± 47	107	115 ± 16	–	–
3 $\ell$ MET<50, $H_T$ >200, Z	15	18.4 ± 4.5	166	244 ± 24	–	–
3 $\ell$ MET<50, $H_T$ <200, noZ	123	142 ± 36	3721	2906 ± 412	–	–
3 $\ell$ MET<50, $H_T$ <200, Z	657	749 ± 181	17857	15516 ± 2421	–	–
<b>Total 3<math>\ell</math></b>	<b>1029</b>	<b>1109 ± 191</b>	<b>22693</b>	<b>19533 ± 2457</b>	<b>1121</b>	<b>1177 ± 172</b>
3 $\ell$ (DY0) $S_T$ (High)	2	1.12 ± 0.43	17	11.0 ± 3.2	20	22.3 ± 6.0
3 $\ell$ (DY0) $S_T$ (Mid)	5	7.3 ± 3.0	113	96 ± 31	157	181 ± 24
3 $\ell$ (DY0) $S_T$ (Low)	17	13.3 ± 4.1	522	413 ± 63	1631	2016 ± 253
3 $\ell$ (DY1,ZV) $S_T$ (High)	6	3.3 ± 0.9	10	13.0 ± 2.3	–	–
3 $\ell$ (DY1) $S_T$ (High)	17	17.6 ± 5.6	35	39.0 ± 4.7	–	–
3 $\ell$ (DY1,ZV) $S_T$ (Mid)	32	24.6 ± 6.4	159	141 ± 27	–	–
3 $\ell$ (DY1) $S_T$ (Mid)	89	97 ± 29	441	462 ± 41	–	–
3 $\ell$ (DY1,ZV) $S_T$ (Low)	126	147 ± 36	3721	2981 ± 418	–	–
3 $\ell$ (DY1) $S_T$ (Low)	727	797 ± 189	17631	15751 ± 2452	–	–
<b>Total 3<math>\ell</math></b>	<b>1021</b>	<b>1108 ± 195</b>	<b>22649</b>	<b>19906 ± 2489</b>	<b>1808</b>	<b>2220 ± 255</b>

# ATLAS 3L Limit Interpretation

- Limit on the visible cross section of New Physics
  - SR1: 9.9 fb observed
  - SR2: 23.8 fb observed
- Limits in pMSSM and Simplified Model (SR1, !Z)

$$m_{\tilde{\ell}_R} = (m_{\tilde{\chi}_2^0} + m_{\tilde{\chi}_1^0})/2$$



# 4 Lepton Search

- Final state can be sensitive to a variety of SUSY scenarios
  - **Direct production of weak gauginos with RPV** (stau1 as LSP)
- Same selection as in the 3L analyses for both CMS and ATLAS
  - In ATLAS electron (muon) ID is looser (tighter) in the 4L than in the 3L analysis

ATLAS-CONF-2012-001



- MET > 50 GeV !Z
- MET > 50 GeV with Z

EXO-11-045, SUS-11-013

- 23 Signal regions
- Based on a combination of:

Selection	Value
No. SFOS	1
Z [75-105] GeV	Veto/request
MET (GeV)	50
H <sub>T</sub> (GeV)	200
S <sub>T</sub> (GeV)	300, 600

Process	ATLAS	CMS
WZ, ZZ	MC	MC
ttV	MC	MC
top	MC	MC
Z+jets	MC	DD
Int. Conv.	DD	DD



# ATLAS Results

Validation Region	Prediction	Observation
tt-rich	$8.4 \pm 0.8$	8
ZZ-rich	$23 \pm 5$	20

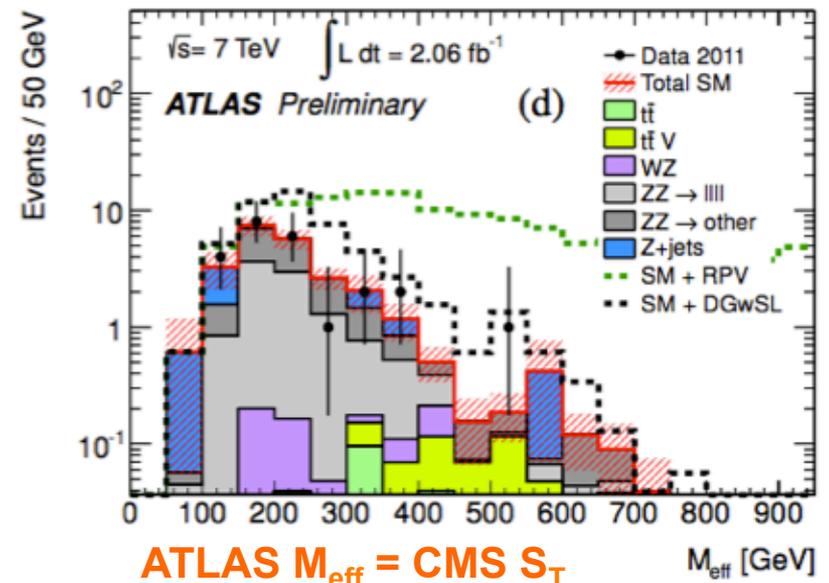
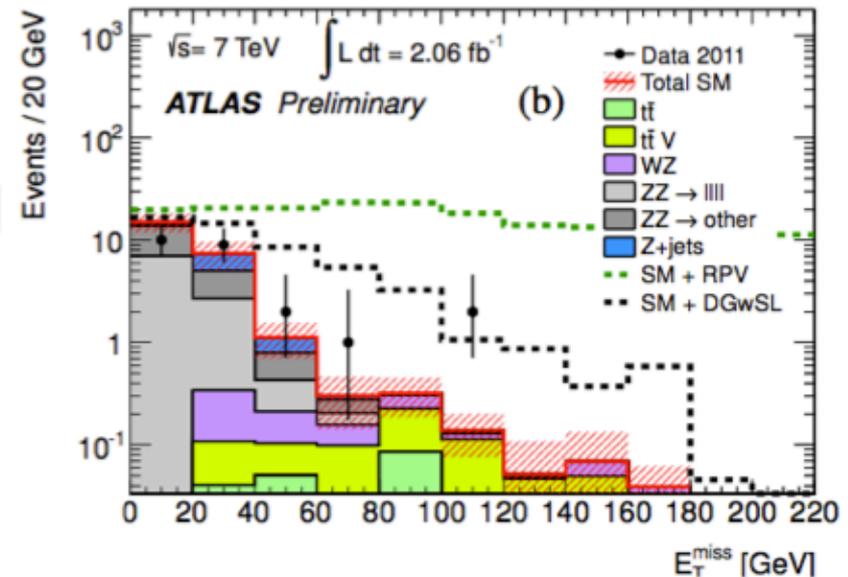
Z region

!Z region

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

SR1, p-value 0.10, 3.5/fb 95% C.L.

SR2, p-value > 0.5, 1.5/fb 95% C.L.



# CMS Results

Selection	N( $\tau$ )=0		N( $\tau$ )=1		N( $\tau$ )=2	
	obs	expect	obs	expect	obs	expect
<b>4<math>\ell</math> Lepton Results</b>						
4 $\ell$ >50, $H_T$ >200, noZ	0	0.017 $\pm$ 0.005	0	0.08 $\pm$ 0.06	0	0.6 $\pm$ 0.6
4 $\ell$ MET >50, $H_T$ > 200, Z	0	0.20 $\pm$ 0.04	0	0.25 $\pm$ 0.11	0	0.7 $\pm$ 1.0
4 $\ell$ MET >50, $H_T$ <200, noZ	1	0.19 $\pm$ 0.07	3	0.56 $\pm$ 0.16	1	1.4 $\pm$ 0.6
4 $\ell$ MET >50, $H_T$ <200, Z	1	0.74 $\pm$ 0.20	4	2.2 $\pm$ 0.6	0	1.1 $\pm$ 0.7
4 $\ell$ MET <50, $H_T$ >200, noZ	0	0.006 $\pm$ 0.001	0	0.13 $\pm$ 0.08	0	0.25 $\pm$ 0.07
4 $\ell$ MET <50, $H_T$ >200, Z	1	0.78 $\pm$ 0.31	0	0.52 $\pm$ 0.20	0	1.13 $\pm$ 0.42
4 $\ell$ MET <50, $H_T$ <200, noZ	1	2.4 $\pm$ 1.0	5	3.7 $\pm$ 1.2	17	10.5 $\pm$ 3.2
4 $\ell$ MET <50, $H_T$ <200, Z	33	35 $\pm$ 14	20	16.1 $\pm$ 4.9	62	42 $\pm$ 16
Total 4 $\ell$	37	39 $\pm$ 15	32	23.6 $\pm$ 5.1	80	58 $\pm$ 16

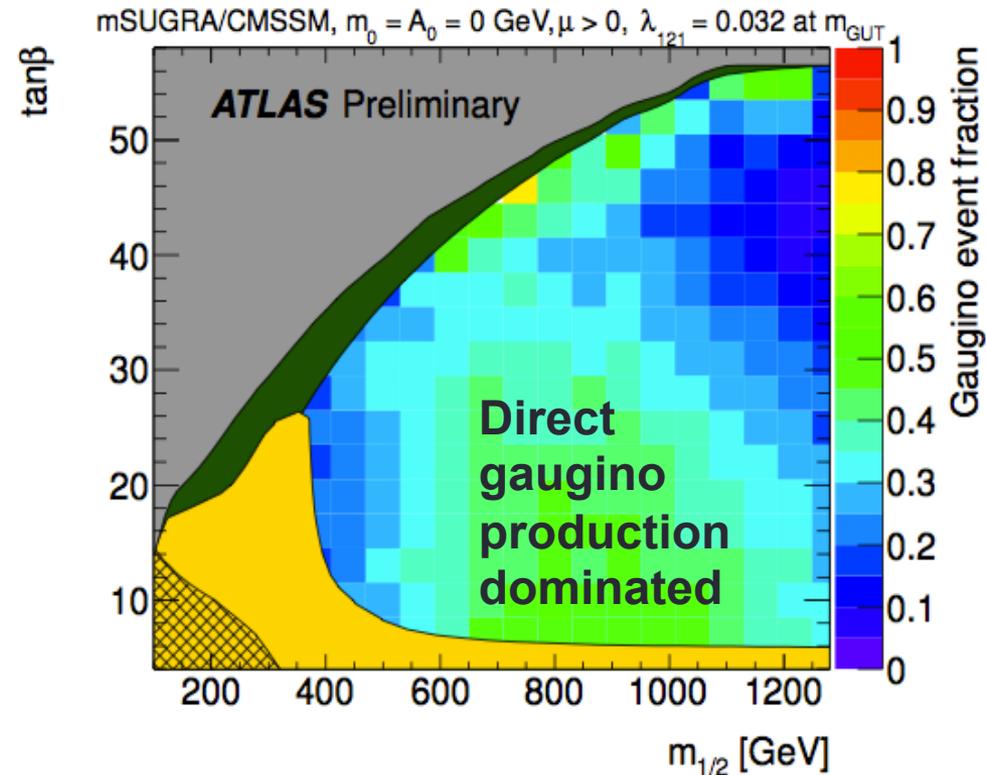
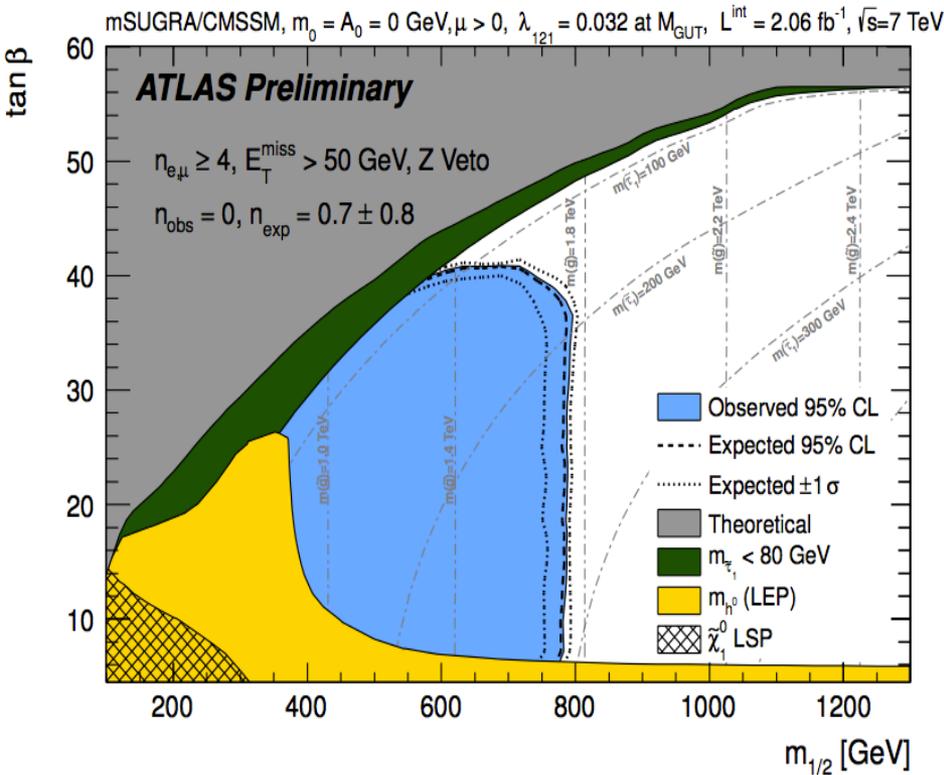
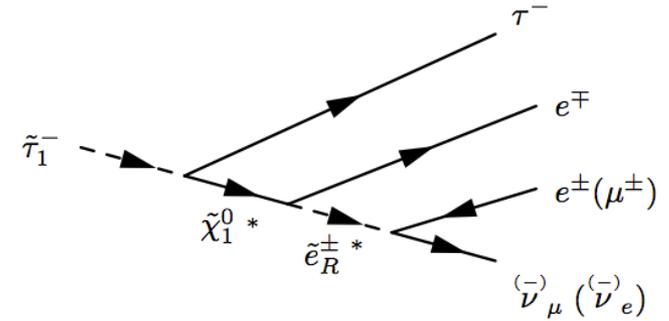
Selection	N( $\tau$ )=0		N( $\tau$ )=1		N( $\tau$ )=2	
	obs	expect	obs	expect	obs	expect
<b>4<math>\ell</math> Lepton Results</b>						
4 $\ell$ (DY0) $S_T$ (High)	0	0.0009 $\pm$ 0.0009	0	0.01 $\pm$ 0.09	0	0.17 $\pm$ 0.07
4 $\ell$ (DY0) $S_T$ (Mid)	0	0.004 $\pm$ 0.002	0	0.27 $\pm$ 0.10	2	2.5 $\pm$ 1.1
4 $\ell$ (DY0) $S_T$ (Low)	0	0.04 $\pm$ 0.02	0	2.98 $\pm$ 0.48	4	3.4 $\pm$ 1.0
4 $\ell$ (DY1,ZV) $S_T$ (High)	1	0.009 $\pm$ 0.004	0	0.09 $\pm$ 0.07	0	0.11 $\pm$ 0.05
4 $\ell$ (DY1) $S_T$ (High)	1	0.09 $\pm$ 0.01	0	0.48 $\pm$ 0.14	0	0.42 $\pm$ 0.15
4 $\ell$ (DY1,ZV) $S_T$ (Mid)	0	0.06 $\pm$ 0.02	1	0.83 $\pm$ 0.24	1	0.92 $\pm$ 0.29
4 $\ell$ (DY1) $S_T$ (Mid)	0	0.42 $\pm$ 0.10	5	3.9 $\pm$ 1.1	3	3.4 $\pm$ 0.9
4 $\ell$ (DY1,ZV) $S_T$ (Low)	0	0.08 $\pm$ 0.04	7	5.4 $\pm$ 2.2	19	13.6 $\pm$ 6.4
4 $\ell$ (DY1) $S_T$ (Low)	2	0.75 $\pm$ 0.32	19	16.9 $\pm$ 4.6	95	60 $\pm$ 31
4 $\ell$ (DY2,ZV) $S_T$ (High)	0	0.02 $\pm$ 0.01	–	–	–	–
4 $\ell$ (DY2) $S_T$ (High)	0	0.84 $\pm$ 0.32	–	–	–	–
4 $\ell$ (DY2,ZV) $S_T$ (Mid)	0	0.19 $\pm$ 0.08	–	–	–	–
4 $\ell$ (DY2) $S_T$ (Mid)	3	7.4 $\pm$ 3.0	–	–	–	–
4 $\ell$ (DY2,ZV) $S_T$ (Low)	1	2.3 $\pm$ 1.0	–	–	–	–
4 $\ell$ (DY2) $S_T$ (Low)	29	27 $\pm$ 11	–	–	–	–
Total 4 $\ell$	37	39 $\pm$ 12	32	30.8 $\pm$ 5.2	124	84 $\pm$ 32

# ATLAS 4L Limit Interpretation

ATLAS-CONF-2012-035

## RPV with stau1 LSP:

- mSUGRA/CMSSM
- BC1 point [hep-ph/0609263]
  - gaugino pair production dominant



# Summary

- **Weak gaugino direct production can be the dominant SUSY production**
  - In scenarios with heavy squarks
- **Multilepton final states provide significant sensitivity to**
  - **Associated production of charginos and neutralinos**
  - **Both for RPC and RPV decays**
- **Searches with 1.0 to 4.7 fb<sup>-1</sup> of 7 TeV data have been carried by CMS and ATLAS using 2, 3, and 4 lepton final states**
  - Signal regions with and without Z-boson decays have been investigated as a function of MET,  $H_T$ ,  $S_T$  ( $M_{\text{eff}}$ )
- **No excess with respect to the expected SM background is observed**
  - Results are interpreted in phenomenological MSSM and simplified models with RPC and in mSUGRA for RPV
- **More results expected soon!**

# Back Up Slides

# Definition of Models

- **pMSSM**: number of free parameters reduced to 19 by the following assumptions
  - CP conservation (removes all phases)
  - minimal flavour violation (removes off-diagonal terms in mass matrices)
  - negligible trilinear couplings for 1st and 2nd generation
  - degenerate 1st and 2nd generation sfermion masses
- Heavy squarks, gluinos and left-handed sleptons,  $\tan\beta=6$ ,  $m_A=500\text{GeV}$
- Right-handed slepton masses  $m_{\tilde{\ell}_R} = (m_{\tilde{\chi}_2^0} + m_{\tilde{\chi}_1^0})/2$
- **Free parameters remain: M1, M2,  $\mu$**

*SUSY model, charginos and neutralinos direct production*

- **Simplified models**

- For generic optimization of searches
- Framework for understanding the implication of NP searches
- Model defined by a TeV scale effective lagrangian describing its particle content and interactions
- Mass degenerate Chargino1 and Neutralino2, wino like
- Neutralino1, bino like
- BR into sleptons and sneutrinos set to 50%  $m_{\tilde{\nu}} = m_{\tilde{\ell}_L} = (m_{\tilde{\chi}_1^0} + m_{\tilde{\chi}_1^\pm})/2$
- **Free parameters: Charginos and neutralinos masses**
- Other particle masses are set to high values

*SUSY inspired model, chargino1-neutralino2 direct production*