Searches at ATLAS with leptons

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For the ATLAS collaboration

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Fermilab Joint Experimental-Theoretical Physics Seminar

Lawrence Berkeley
National Laboratory

Batavia, Illinois, USA

Outline

- Lepton Reconstruction
- Searches for Supersymmetry
- Exotic Searches

Why Leptons

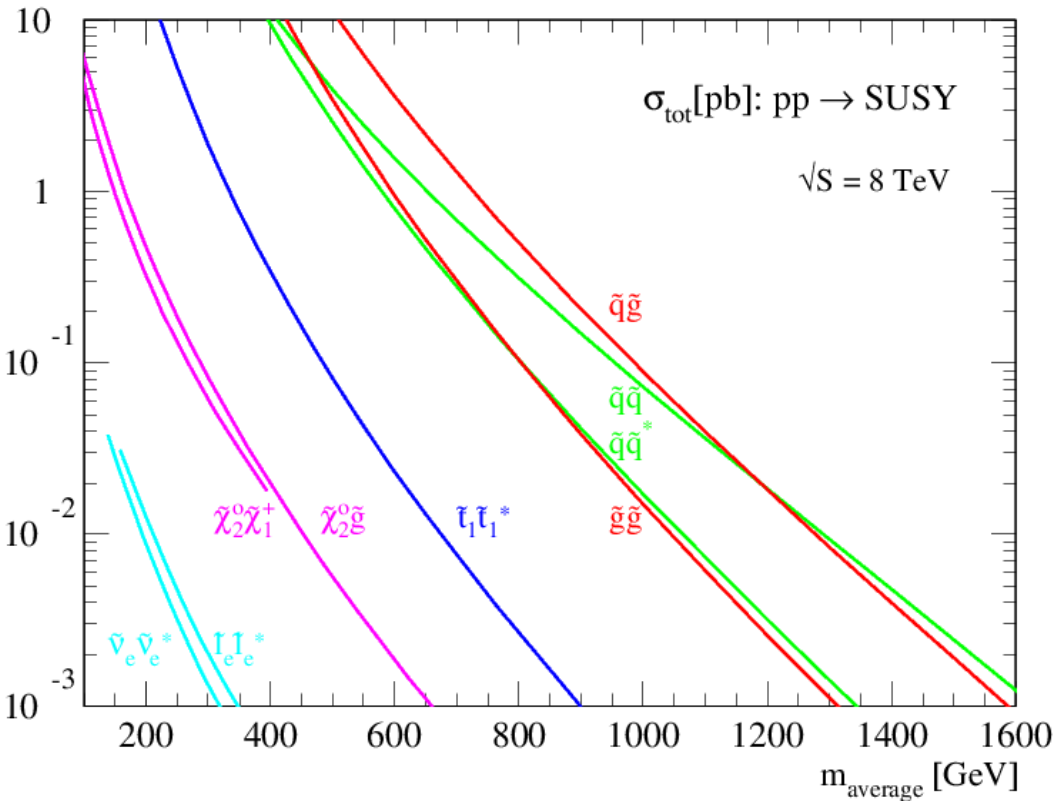
- Prompt leptons are rare at hadron colliders
- “Easy” to trigger and identify
- Signatures sensitive to a variety of new physics models

Excited neutrinos, Vector-like leptons, Vector-like quarks,
Doubly-charged Higgs bosons, Supersymmetry .....

Lepton Challenges

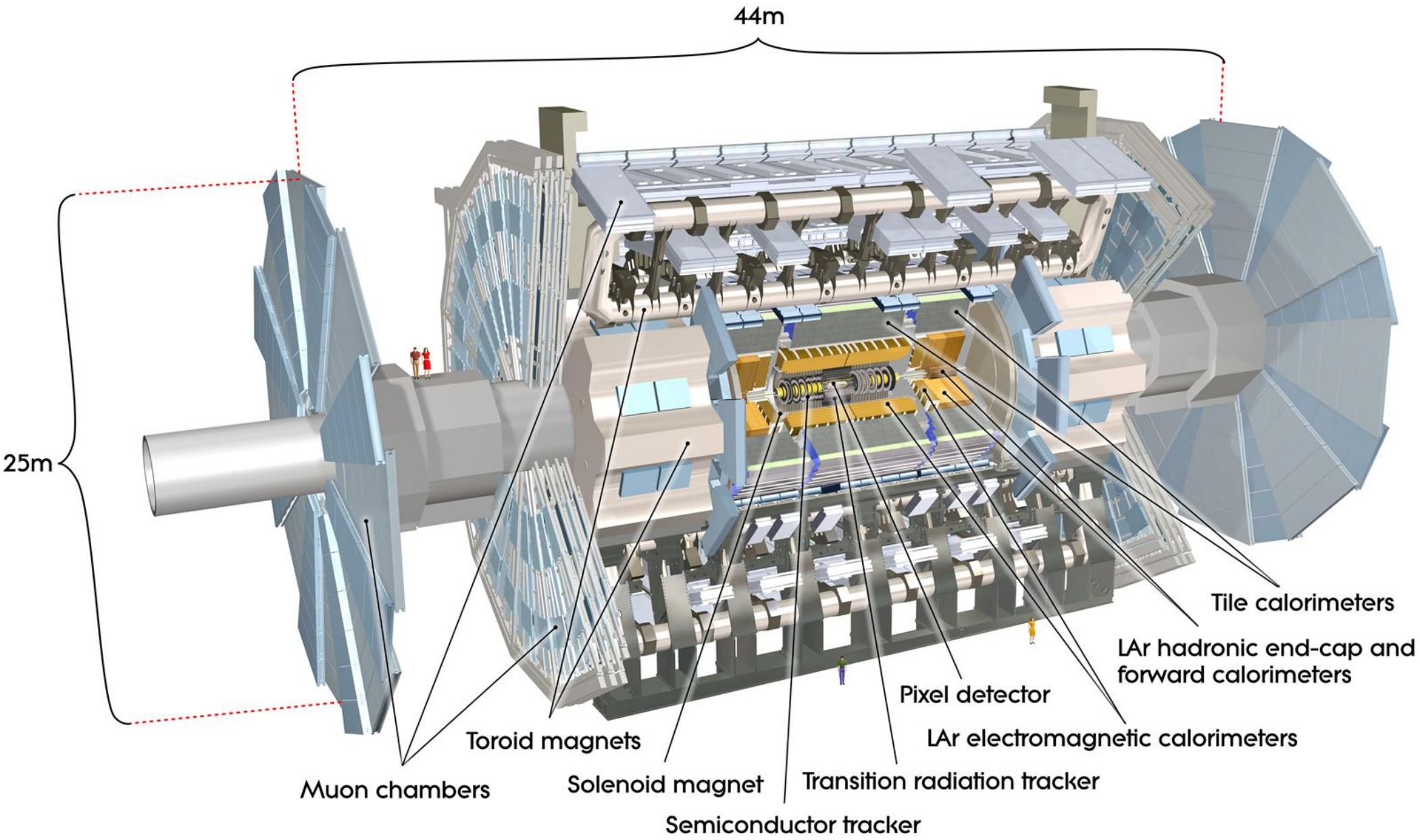
Leptons in weakly produced processes; cross sections can be lower

Misidentified leptons rare; estimating '*fake*' background is harder.

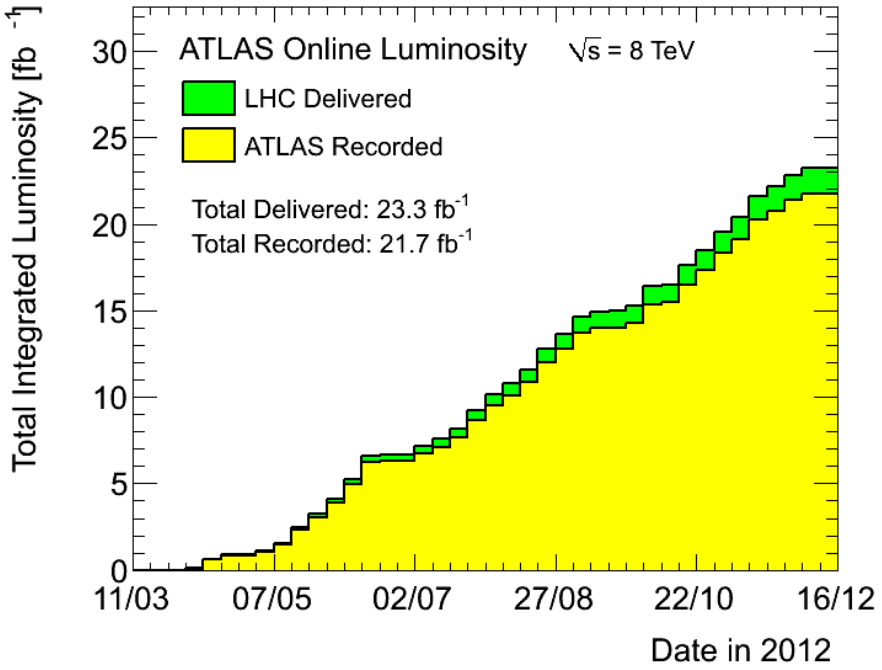


Prospino cross sections for some SUSY processes

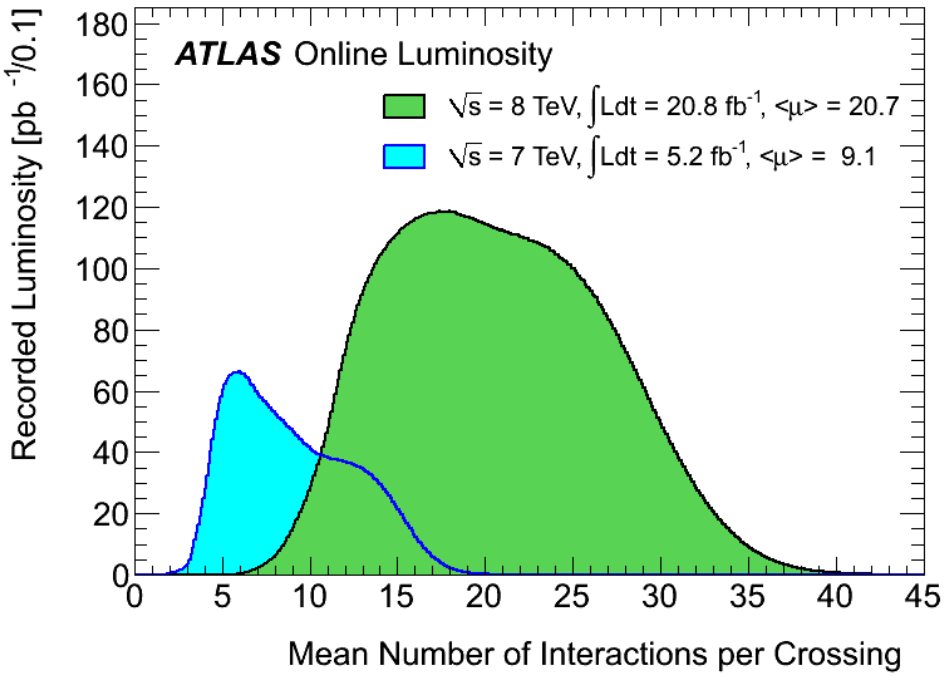
ATLAS Detector



ATLAS Performance



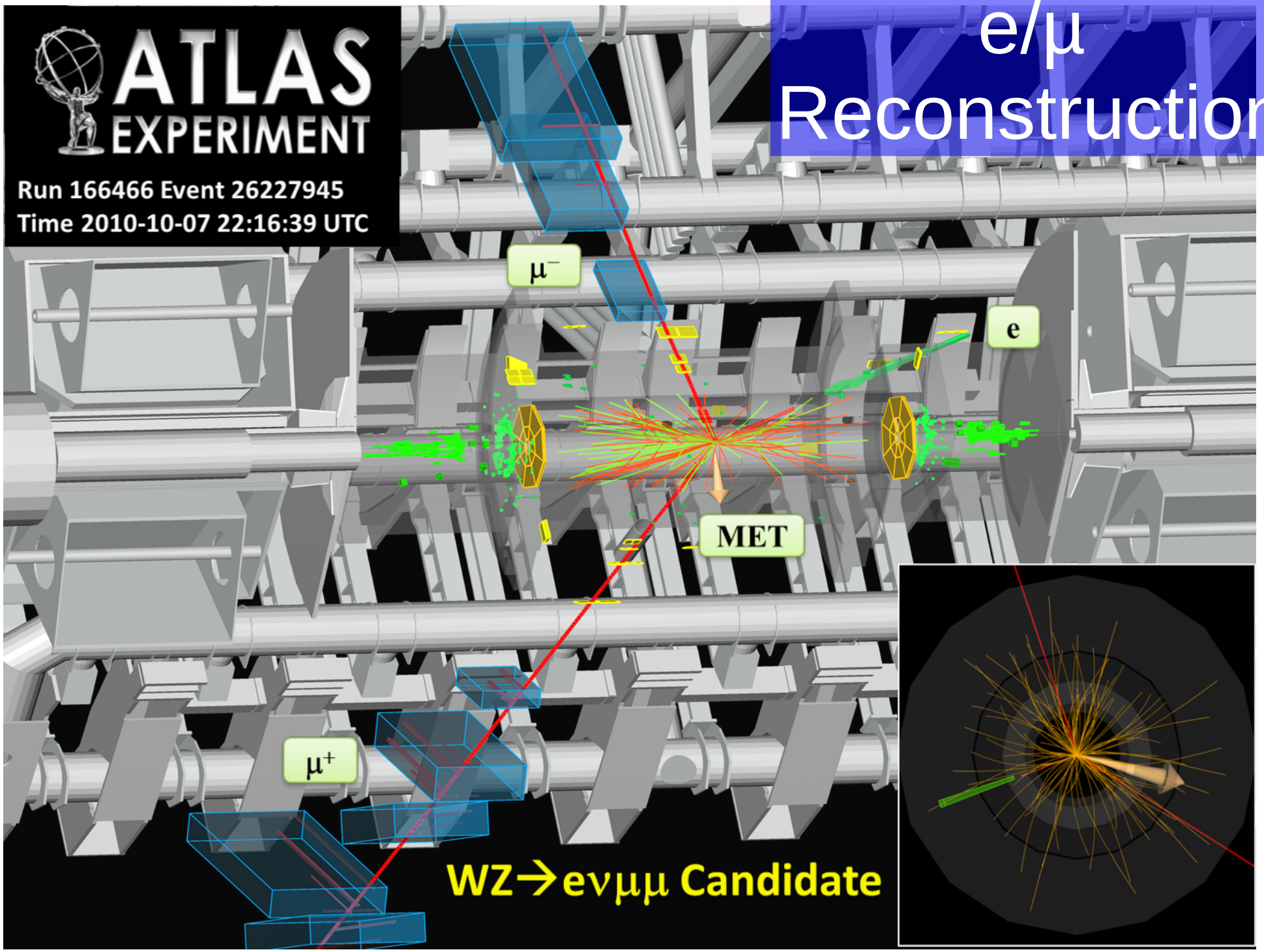
arXiv:1101.2185



ATLAS p-p run: April-December 2012										
Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.9	99.1	99.8	99.1	99.6	99.6	99.8	100.	99.6	99.8	99.5
All good for physics: 95.5%										

Luminosity weighted relative detector uptime and good quality data delivery during 2012 stable beams in pp collisions at √s=8 TeV between April 4th and December 6th (in %) – corresponding to 21.3 fb-1 of recorded data.

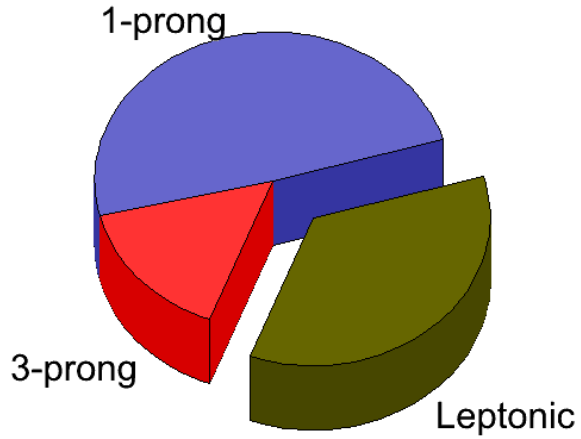
e/μ Reconstruction



Tau Reconstruction

Tau mass = 1.8 GeV
~ 65% of tau decays are to hadronic final states

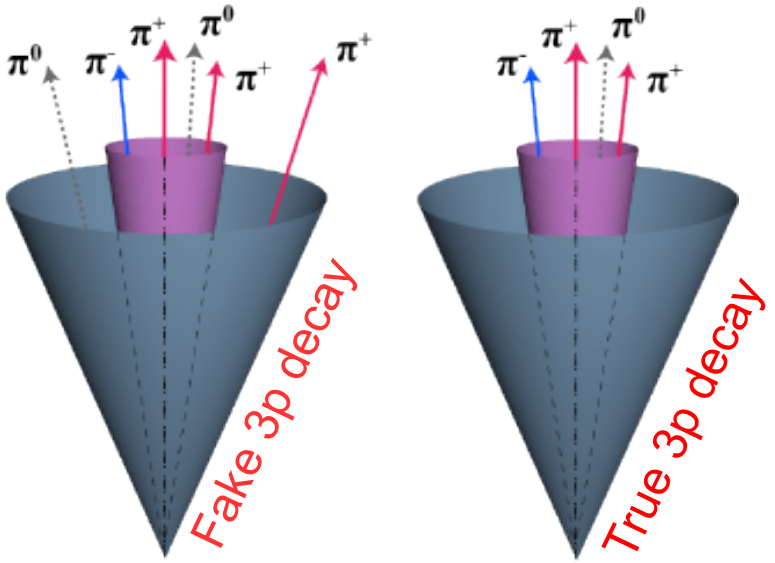
1-prong – 1 charged pion in final state
3-prong – 3 charged pions in final state



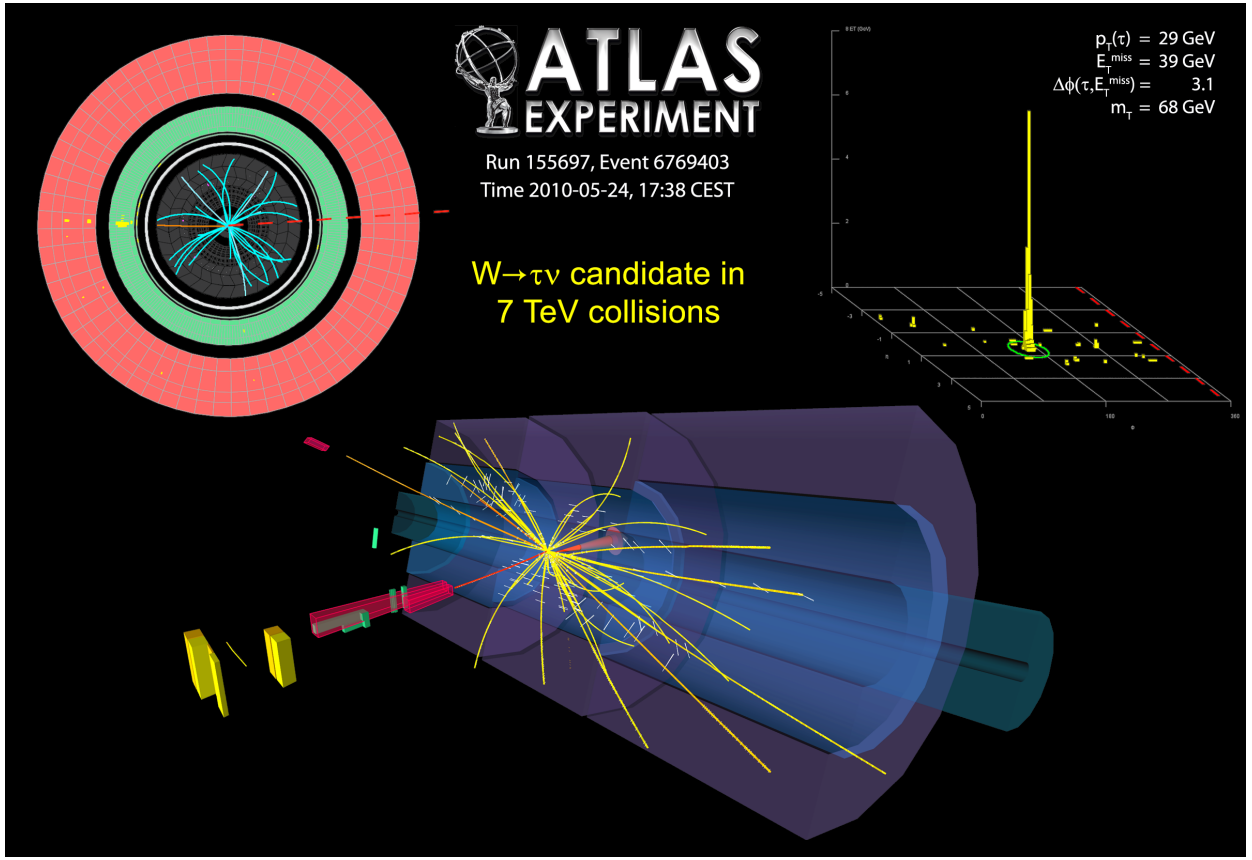
- Taus reconstructed from all jets with p_T > 10 GeV

(Jets using anti-kt algorithm with R = 0.4)

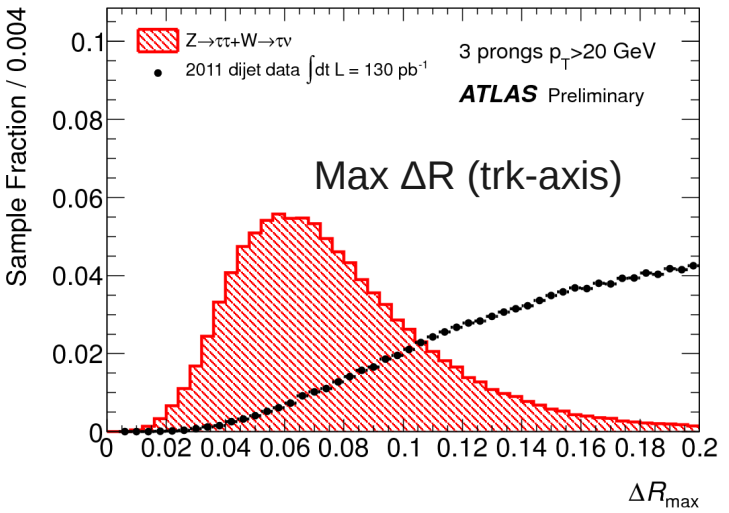
- Separate identification of 1p and 3p
- Multivariate discriminants based on tracking and calorimeter information
- Tau energy scale calibrated from MC based on visible energy, |η|, and number of prongs

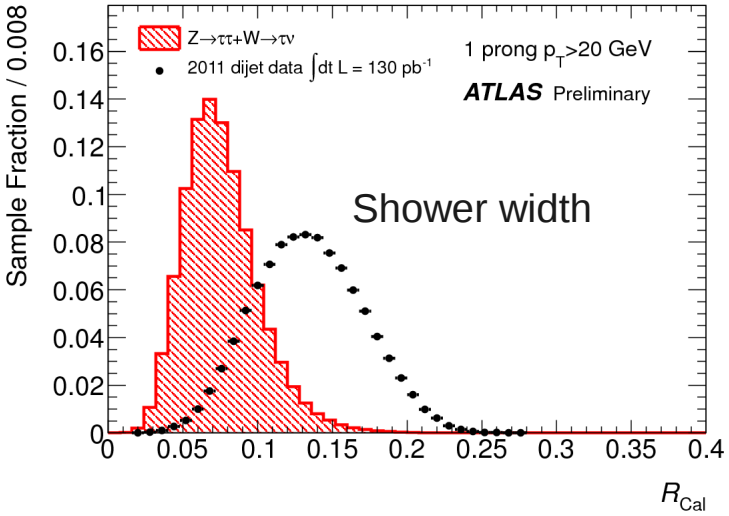


Tau Reconstruction



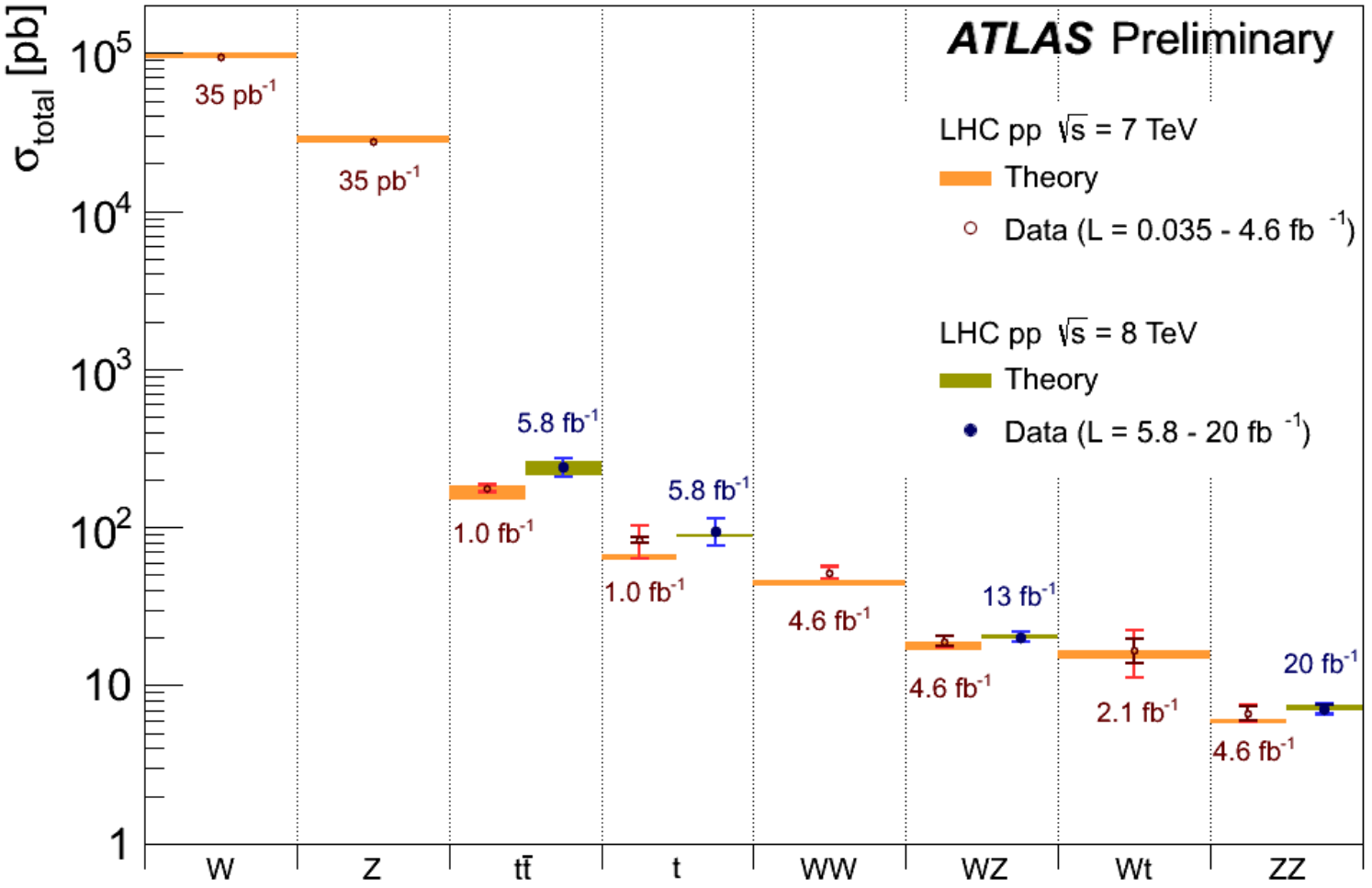
ATLAS-CONF-2011-152





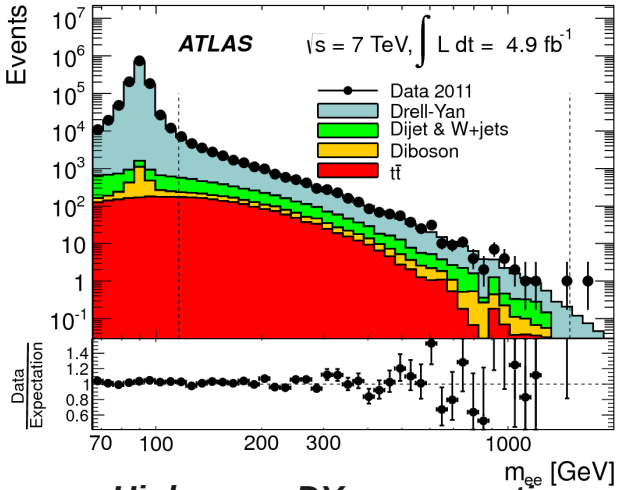
Variables used include
pT weighted track width, leading track momentum fraction, core energy fraction, cluster/track mass, flight path significance, ...

Understanding SM



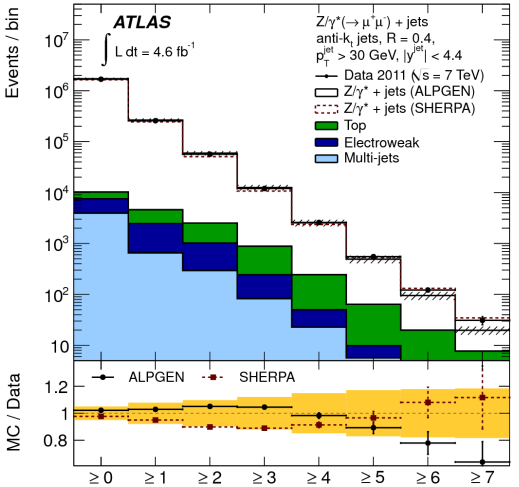
Understanding SM

arXiv:1305.4192



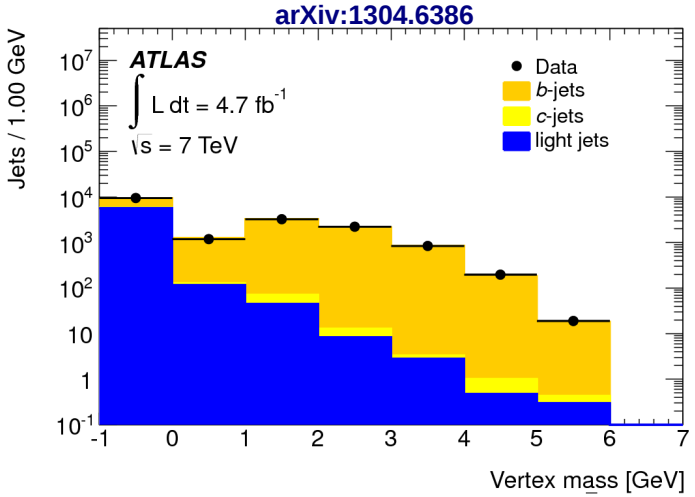
High mass DY cross section

arXiv:1304.7098



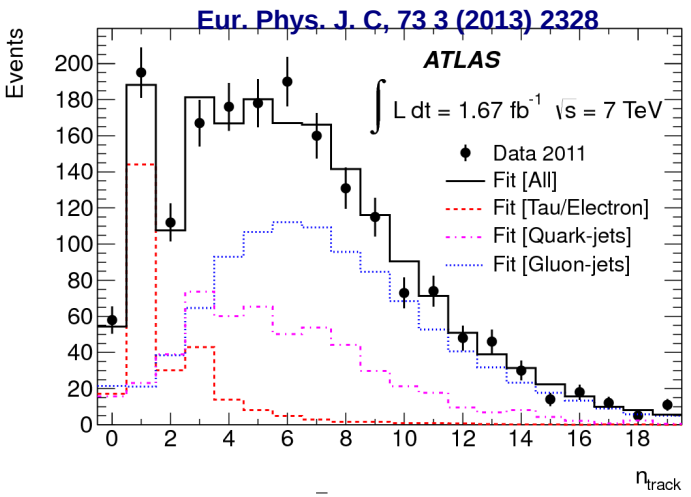
Z+jets cross section

arXiv:1304.6386



Heavy flavor quarks with tt̄

Eur. Phys. J. C, 73 3 (2013) 2328

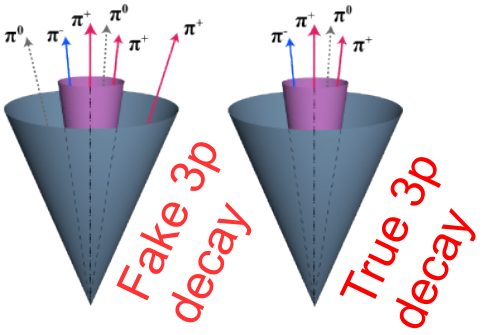


tt̄ → τ +jets

“Fake” lepton backgrounds

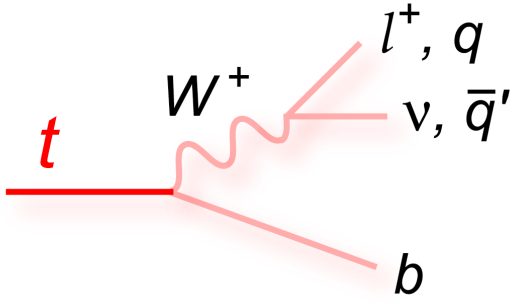
True Fakes:
Signal mimicked by other physics process, or failure of algorithm

Taus

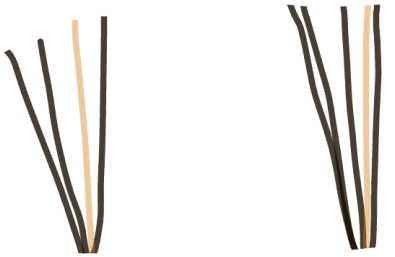


Muons: Track in inner detector matched to segments in muon spectrometer.
Electrons: Track paired with calorimeter deposit

Other “Fakes”:
Signal-like leptons from a process we do not want.



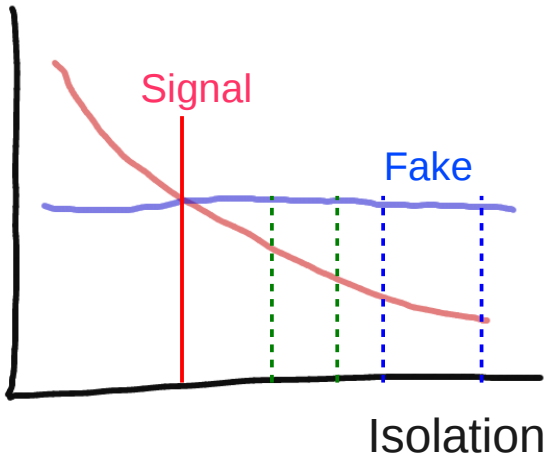
Lepton isolation used to discriminate



The b-quark can decay semi-leptonically, with the lepton embedded in a jet.

Estimating fake-lepton background

- Determine the processes that contribute
- Design a generic or specific method
- Preferably test method in validation regions



1D extrapolation

Estimating fake-lepton background

- Determine the processes that contribute
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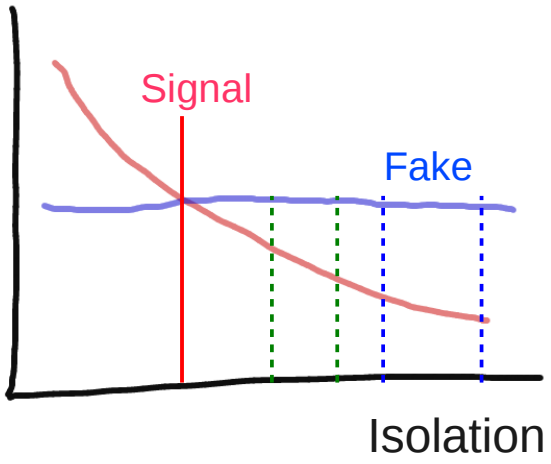
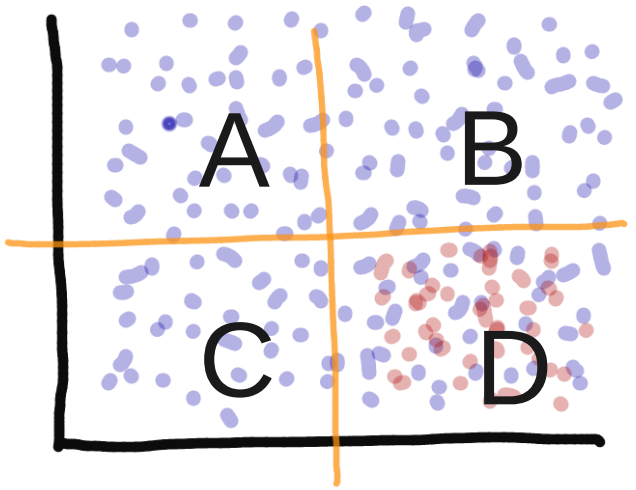
- Preferably test method in validation regions



1D extrapolation



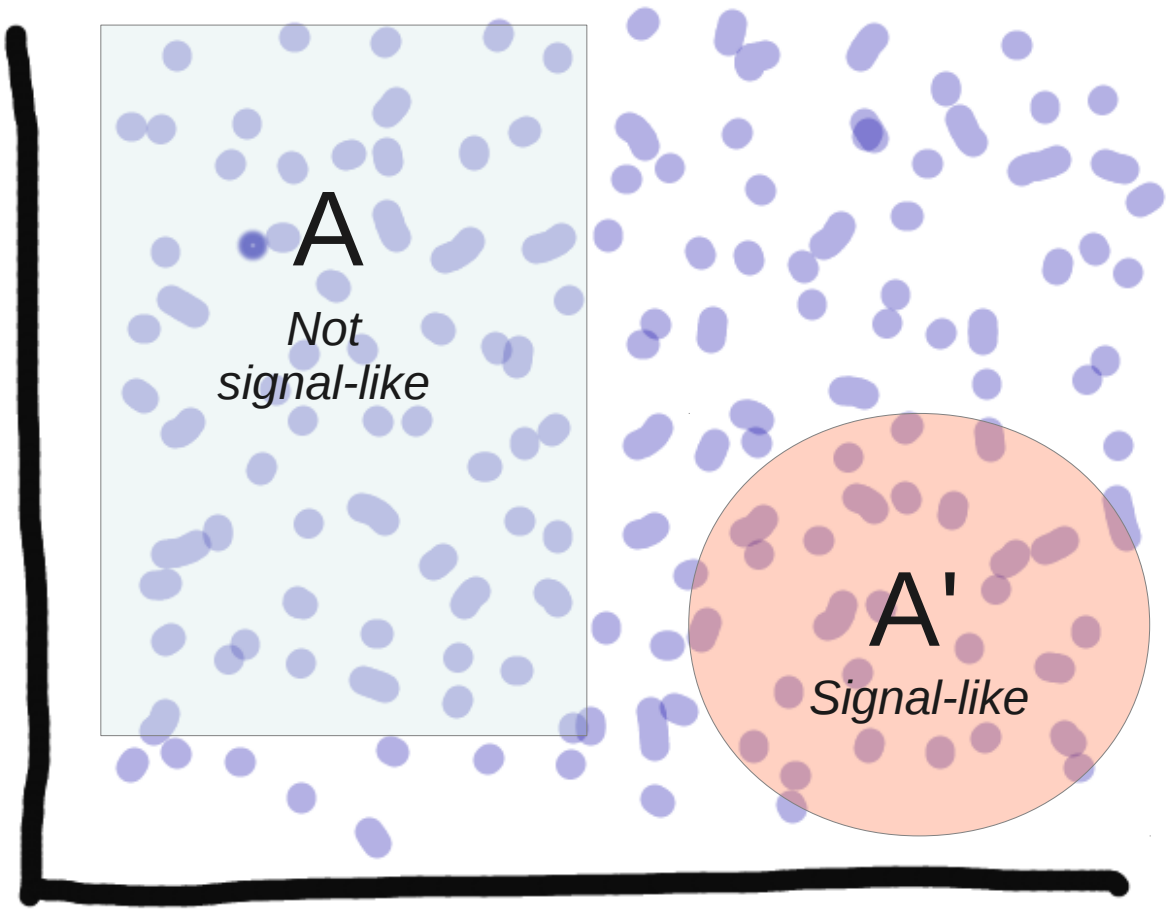
ABCD method : How many blue points in box D, given box A, B, C?

D =C• B/A

Estimating fake-lepton background

Fake Factor

$f = A' / A$



Estimating fake-lepton background

Matrix method

Relate Tight and Loose leptons (observed) with Real and Fake leptons (true)

So for dileptons, $N_{TT} = \epsilon_1\epsilon_2 \times N_{RR} + \epsilon_1 f_2 \times N_{RF} + f_1\epsilon_2 \times N_{FR} + f_1 f_2 \times N_{FF}$

And after some simplification for trileptons

$$\begin{pmatrix} N_{TT} \\ N_{TL'} \\ N_{L'T} \\ N_{L'L'} \end{pmatrix} = \begin{pmatrix} \epsilon_1\epsilon_2 & \epsilon_1 f_2 & f_1\epsilon_2 & f_1 f_2 \\ \epsilon_1(1-\epsilon_2) & \epsilon_1(1-f_2) & f_1(1-\epsilon_2) & f_1(1-f_2) \\ (1-\epsilon_1)\epsilon_2 & (1-\epsilon_1)f_2 & (1-f_1)\epsilon_2 & (1-f_1)f_2 \\ (1-\epsilon_1)(1-\epsilon_2) & (1-\epsilon_1)(1-f_2) & (1-f_1)(1-\epsilon_2) & (1-f_1)(1-f_2) \end{pmatrix} \cdot \begin{pmatrix} N_{RR} \\ N_{RF} \\ N_{FR} \\ N_{FF} \end{pmatrix}$$

Solve these to get N_{RR}+N_{RF}+N_{FR}.

Searches for Supersymmetry

Supersymmetry

Symmetry between fermions and bosons; particle spectrum x2

Solves the hierarchy problem, provides a dark matter candidate

Over 100 parameters in MSSM→rich phenomenology; large number of final states to probe different flavors of susy models.

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: LP 2013

ATLAS Preliminary

$\int \mathcal{L}\, dt$ = (4.4 - 22.9) fb^{-1} $\sqrt{s}$ = 7, 8 TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt$[fb^{-1}]	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.2 TeV	any m($\tilde{q}$)	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	any m($\tilde{q}$)	ATLAS-CONF-2013-054
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$ 740 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$ 1.3 TeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.18 TeV	m($\tilde{\chi}_1^0$)<200 GeV, m($\tilde{\chi}^\pm$)=0.5(m($\tilde{\chi}_1^0$)+m($\tilde{g}$))	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}\to qqqq\ell\ell(\ell\ell)\tilde{\chi}_1^0\tilde{\chi}_1^0$	2 e, μ (SS)	3 jets	Yes	20.7	$\tilde{g}$ 1.1 TeV	m($\tilde{\chi}_1^0$)<650 GeV	ATLAS-CONF-2013-007
	GMSB ($\tilde{\ell}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$ 1.24 TeV	tanβ<15	1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$ 1.4 TeV	tanβ >18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	0	Yes	4.8	$\tilde{g}$ 1.07 TeV	m($\tilde{\chi}_1^0$)>50 GeV	1209.0753
	GGM (wino NLSP)	1 e, μ + γ	0	Yes	4.8	$\tilde{g}$ 619 GeV	m($\tilde{\chi}_1^0$)>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$ 900 GeV	m($\tilde{\chi}_1^0$)>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e, μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$ 690 GeV	m($\tilde{H}$)>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale 645 GeV	m($\tilde{g}$)>10^{-4} eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$ 1.2 TeV	m($\tilde{\chi}_1^0$)<600 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.14 TeV	m($\tilde{\chi}_1^0$) <200 GeV	ATLAS-CONF-2013-054
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	m($\tilde{\chi}_1^0$)<400 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$ 1.3 TeV	m($\tilde{\chi}_1^0$)<300 GeV	ATLAS-CONF-2013-061
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$ 100-630 GeV	m($\tilde{\chi}_1^0$)<100 GeV	ATLAS-CONF-2013-053
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$ 430 GeV	m($\tilde{\chi}_1^\pm$)=2 m($\tilde{\chi}_1^0$)	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$ 167 GeV	m($\tilde{\chi}_1^0$)=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 220 GeV	m($\tilde{\chi}_1^0$) =m($\tilde{t}_1$)-m(W)-50 GeV, m($\tilde{t}_1$)<<m($\tilde{\chi}_1^\pm$)	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 150-440 GeV	m($\tilde{\chi}_1^0$)=0 GeV, m($\tilde{t}_1$)-m($\tilde{\chi}_1^\pm$)=10 GeV	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$ 150-580 GeV	m($\tilde{\chi}_1^0$)<200 GeV, m($\tilde{\chi}_1^\pm$)-m($\tilde{\chi}_1^0$)=5 GeV	ATLAS-CONF-2013-053
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e, μ	1 b	Yes	20.7	$\tilde{t}_1$ 200-610 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$ 320-660 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$ 500 GeV	m($\tilde{\chi}_1^0$)>150 GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$ 520 GeV	m($\tilde{t}_1$)=m($\tilde{\chi}_1^0$)+180 GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$ 85-315 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$ 125-450 GeV	m($\tilde{\chi}_1^0$)=0 GeV, m($\tilde{\ell}$, $\tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 180-330 GeV	m($\tilde{\chi}_1^0$)=0 GeV, m($\tilde{\tau}$, $\tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 600 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, m($\tilde{\ell}$, $\tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W^*\tilde{\chi}_1^0 Z^*\tilde{\chi}_1^0$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 315 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, sleptons decoupled	ATLAS-CONF-2013-035
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	0	1 jet	Yes	4.7	$\tilde{\chi}_1^\pm$ 220 GeV	1<τ($\tilde{\chi}_1^\pm$)<10 ns	1210.2852
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$ 857 GeV	m($\tilde{\chi}_1^0$)=100 GeV, 10 μs<τ($\tilde{g}$)<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}$	1-2 μ	0	-	15.9	$\tilde{\tau}$ 385 GeV	5<tanβ<50	ATLAS-CONF-2013-058
	Direct $\tilde{\tau}\tilde{\tau}$ prod., stable $\tilde{\tau}$ or $\tilde{\ell}$	1-2 μ	0	-	15.9	$\tilde{\tau}$ 395 GeV	m($\tilde{\tau}$)=m($\tilde{\ell}$)	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{g}$, long-lived $\tilde{\chi}_1^0$	2 γ	0	Yes	4.7	$\tilde{\chi}_1^0$ 230 GeV	0.4<τ($\tilde{\chi}_1^0$)<2 ns	1304.6310
	$\tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ	0	Yes	4.4	$\tilde{q}$ 700 GeV	1 mm<cτ<1 m, $\tilde{g}$ decoupled	1210.7451
RPV	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e+\mu$	2 e, μ	0	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e(\mu)+\tau$	1 e, μ + τ	0	-	4.6	$\tilde{\nu}_\tau$ 1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e, μ	7 jets	Yes	4.7	$\tilde{q}$, $\tilde{g}$ 1.2 TeV	m($\tilde{q}$)=m($\tilde{g}$), $c\tau_{LSP}$<1 mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 760 GeV	m($\tilde{\chi}_1^0$)>300 GeV, λ_{121}>0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 e, μ + τ	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 350 GeV	m($\tilde{\chi}_1^0$)>80 GeV, λ_{133}>0	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6 jets	-	4.6	$\tilde{g}$ 666 GeV		1210.4813
	$\tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$ 880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon	0	4 jets	-	4.6	sgluon 100-287 GeV	incl. limit from 1110.2693	1210.4826
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale 704 GeV	m(χ)<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

10^{-1} 1

Mass scale [TeV]

$\sqrt{s}$ = 7 TeV full data | $\sqrt{s}$ = 8 TeV partial data | $\sqrt{s}$ = 8 TeV full data

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: LP 2013

ATLAS Preliminary

$\int \mathcal{L}\, dt$ = (4.4 - 22.9) fb^{-1} $\sqrt{s}$ = 7, 8 TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt$[fb^{-1}]	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.2 TeV	any m($\tilde{q}$)	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	any m($\tilde{q}$)	ATLAS-CONF-2013-054
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$ 740 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$ 1.3 TeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.18 TeV	m($\tilde{\chi}_1^0$)<200 GeV, m($\tilde{\chi}^\pm$)=0.5(m($\tilde{\chi}_1^0$)+m($\tilde{g}$))	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}\to qqqq\ell\ell(\ell\ell)\tilde{\chi}_1^0\tilde{\chi}_1^0$	2 e, μ (SS)	3 jets	Yes	20.7	$\tilde{g}$ 1.1 TeV	m($\tilde{\chi}_1^0$)<650 GeV	ATLAS-CONF-2013-007
	GMSB ($\tilde{\ell}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$ 1.24 TeV	tanβ<15	1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$ 1.4 TeV	tanβ >18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	0	Yes	4.8	$\tilde{g}$ 1.07 TeV	m($\tilde{\chi}_1^0$)>50 GeV	1209.0753
	GGM (wino NLSP)	1 e, μ + γ	0	Yes	4.8	$\tilde{g}$ 619 GeV	m($\tilde{\chi}_1^0$)>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$ 900 GeV	m($\tilde{\chi}_1^0$)>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e, μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$ 690 GeV	m($\tilde{H}$)>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale 645 GeV	m($\tilde{g}$)>10^{-4} eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$ 1.2 TeV	m($\tilde{\chi}_1^0$)<600 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.14 TeV	m($\tilde{\chi}_1^0$) <200 GeV	ATLAS-CONF-2013-054
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	m($\tilde{\chi}_1^0$)<400 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$ 1.3 TeV	m($\tilde{\chi}_1^0$)<300 GeV	ATLAS-CONF-2013-061
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$ 100-630 GeV	m($\tilde{\chi}_1^0$)<100 GeV	ATLAS-CONF-2013-053
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$ 430 GeV	m($\tilde{\chi}_1^\pm$)=2 m($\tilde{\chi}_1^0$)	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$ 167 GeV	m($\tilde{\chi}_1^0$)=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 220 GeV	m($\tilde{\chi}_1^0$) =m($\tilde{t}_1$)-m(W)-50 GeV, m($\tilde{t}_1$)<<m($\tilde{\chi}_1^\pm$)	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 150-440 GeV	m($\tilde{\chi}_1^0$)=0 GeV, m($\tilde{t}_1$)-m($\tilde{\chi}_1^\pm$)=10 GeV	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$ 150-580 GeV	m($\tilde{\chi}_1^0$)<200 GeV, m($\tilde{\chi}_1^\pm$)-m($\tilde{\chi}_1^0$)=5 GeV	ATLAS-CONF-2013-053
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e, μ	1 b	Yes	20.7	$\tilde{t}_1$ 200-610 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$ 320-660 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$ 500 GeV	m($\tilde{\chi}_1^0$)>150 GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$ 520 GeV	m($\tilde{t}_1$)=m($\tilde{\chi}_1^0$)+180 GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$ 85-315 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$ 125-450 GeV	m($\tilde{\chi}_1^0$)=0 GeV, m($\tilde{\ell}$, $\tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 180-330 GeV	m($\tilde{\chi}_1^0$)=0 GeV, m($\tilde{\tau}$, $\tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 600 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, m($\tilde{\ell}$, $\tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W^*\tilde{\chi}_1^0 Z^*\tilde{\chi}_1^0$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 315 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, sleptons decoupled	ATLAS-CONF-2013-035
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	0	1 jet	Yes	4.7	$\tilde{\chi}_1^\pm$ 220 GeV	1<τ($\tilde{\chi}_1^\pm$)<10 ns	1210.2852
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$ 857 GeV	m($\tilde{\chi}_1^0$)=100 GeV, 10 μs<τ($\tilde{g}$)<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}$	1-2 μ	0	-	15.9	$\tilde{\tau}$ 385 GeV	5<tanβ<50	ATLAS-CONF-2013-058
	Direct $\tilde{\tau}\tilde{\tau}$ prod., stable $\tilde{\tau}$ or $\tilde{\ell}$	1-2 μ	0	-	15.9	$\tilde{\tau}$ 395 GeV	m($\tilde{\tau}$)=m($\tilde{\ell}$)	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{g}$, long-lived $\tilde{\chi}_1^0$	2 γ	0	Yes	4.7	$\tilde{\chi}_1^0$ 230 GeV	0.4<τ($\tilde{\chi}_1^0$)<2 ns	1304.6310
	$\tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ	0	Yes	4.4	$\tilde{q}$ 700 GeV	1 mm<cτ<1 m, $\tilde{g}$ decoupled	1210.7451
RPV	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e+\mu$	2 e, μ	0	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e(\mu)+\tau$	1 e, μ + τ	0	-	4.6	$\tilde{\nu}_\tau$ 1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e, μ	7 jets	Yes	4.7	$\tilde{q}$, $\tilde{g}$ 1.2 TeV	m($\tilde{q}$)=m($\tilde{g}$), $c\tau_{LSP}$<1 mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 760 GeV	m($\tilde{\chi}_1^0$)>300 GeV, λ_{121}>0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 e, μ + τ	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 350 GeV	m($\tilde{\chi}_1^0$)>80 GeV, λ_{133}>0	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6 jets	-	4.6	$\tilde{g}$ 666 GeV		1210.4813
	$\tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$ 880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon	0	4 jets	-	4.6	sgluon 100-287 GeV	incl. limit from 1110.2693	1210.4826
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale 704 GeV	m(χ)<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

$\sqrt{s}$ = 7 TeV full data

$\sqrt{s}$ = 8 TeV partial data

$\sqrt{s}$ = 8 TeV full data

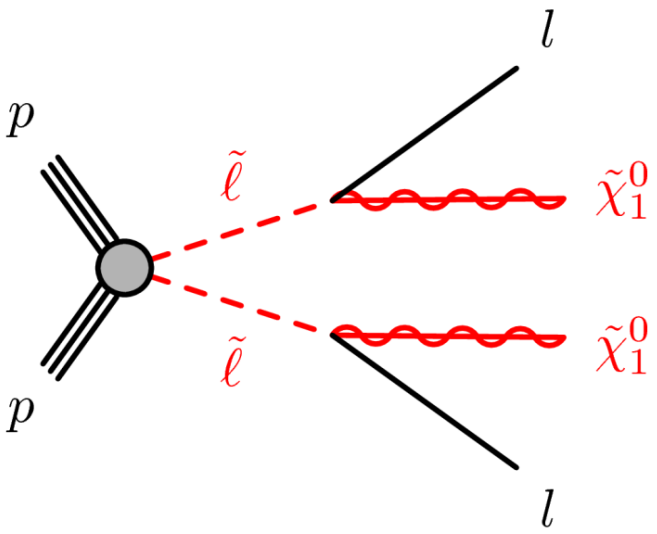
10^{-1} 1

Mass scale [TeV]

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

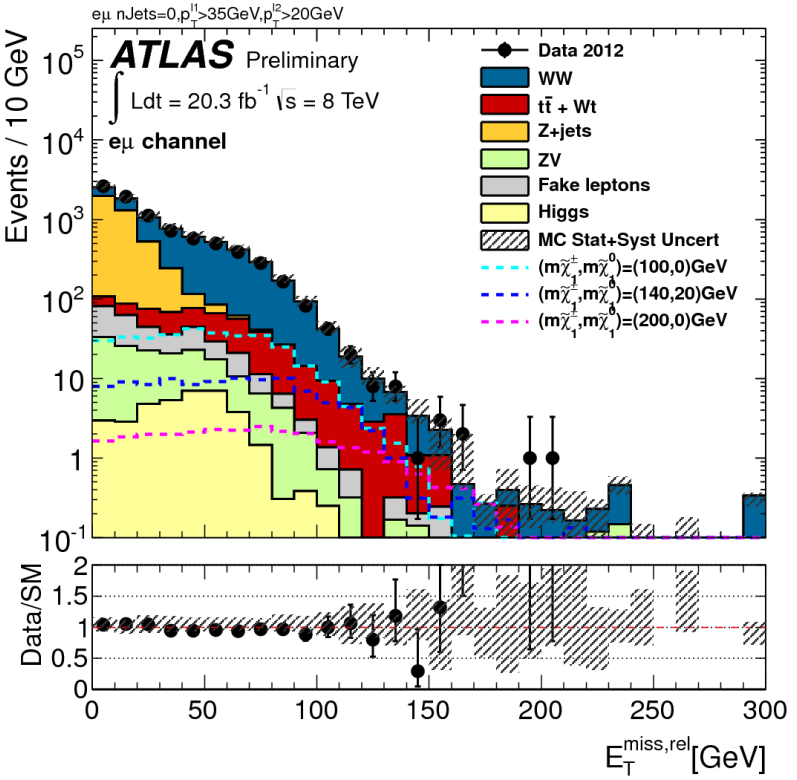
2 Lepton + Etmiss

ATLAS-CONF-2013-049



$$q\bar{q} \to \tilde{\ell}^+\tilde{\ell}^-; \tilde{\ell}^\pm \to \ell^\pm\tilde{\chi}_1^0$$

$$q\bar{q} \to \tilde{\chi}_1^+\tilde{\chi}_1^-; \tilde{\chi}_1^\pm \to \ell^\pm\nu\tilde{\chi}_1^0$$



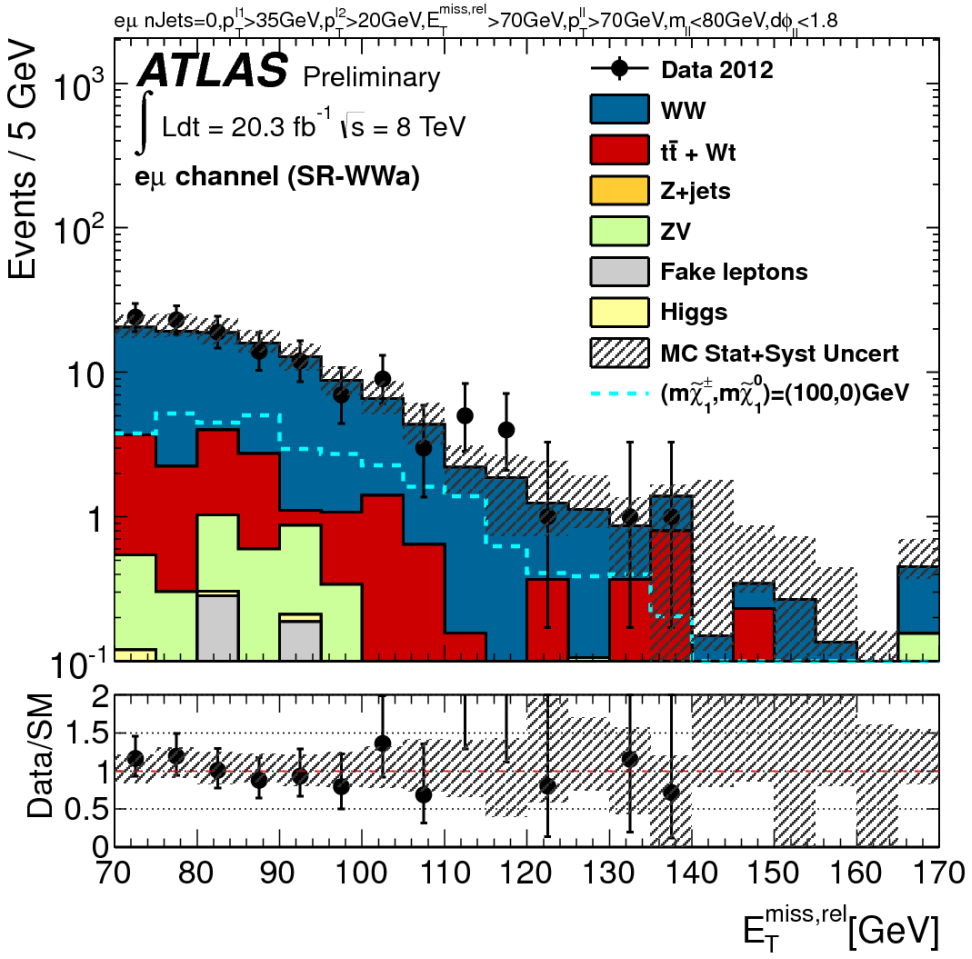
Two isolated e/μ (minp_T>10 GeV, single/di-lepton triggers)

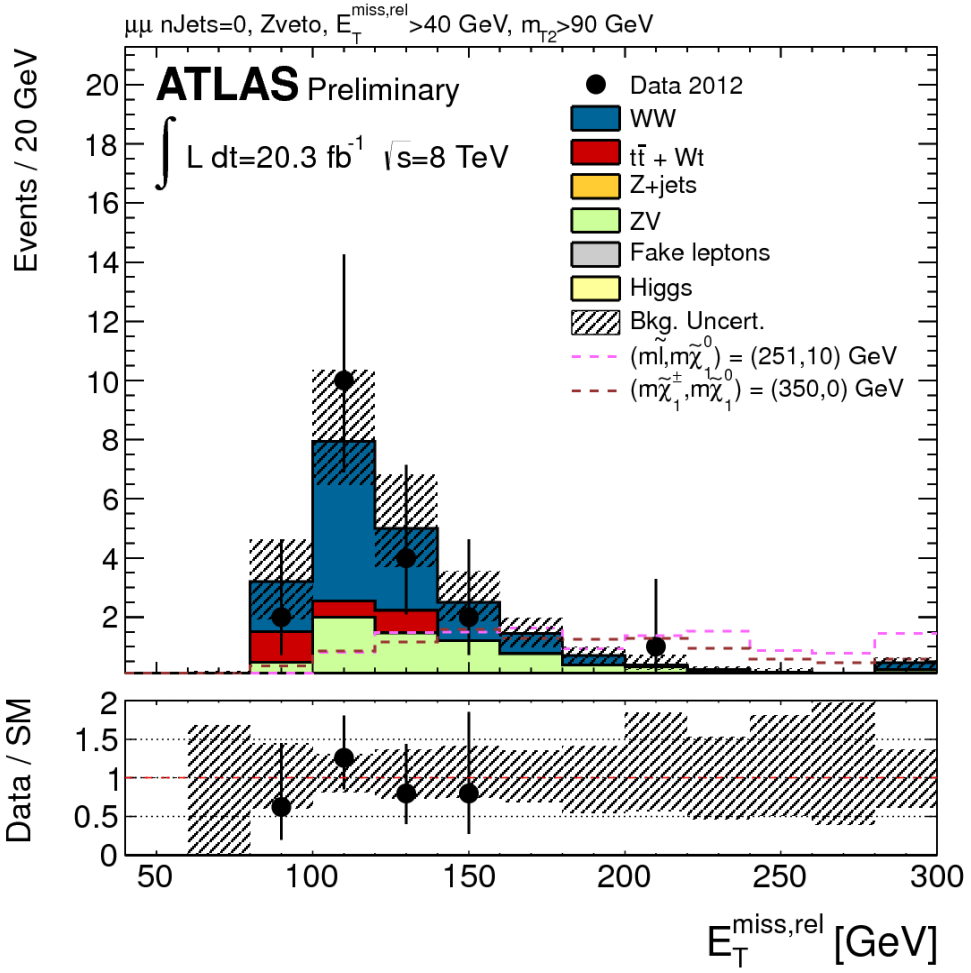
Jet veto: central 20 GeV jets , forward 30 GeV jets

	SR-$m_{T2,90}$	SR-$m_{T2,110}$	SR-WWa	SR-WWb	SR-WWc
lepton flavour	$e^+e^-, \mu^+\mu^-, e^\pm\mu^\mp$		$e^\pm\mu^\mp$		
$p_T^{\ell 1}$	—		> 35 GeV		
$p_T^{\ell 2}$	—		> 20 GeV		
$m_{\ell\ell}$	Z veto		< 80 GeV	< 130 GeV	—
$p_{T,\ell\ell}$	—		> 70 GeV	< 170 GeV	< 190 GeV
$\Delta\phi_{\ell\ell}$	—			< 1.8 rad	
$E_T^{miss,rel}$	> 40 GeV		> 70 GeV	—	
m_{T2}	> 90 GeV	> 110 GeV	—	> 90 GeV	> 100 GeV

2 Lepton + Etmiss

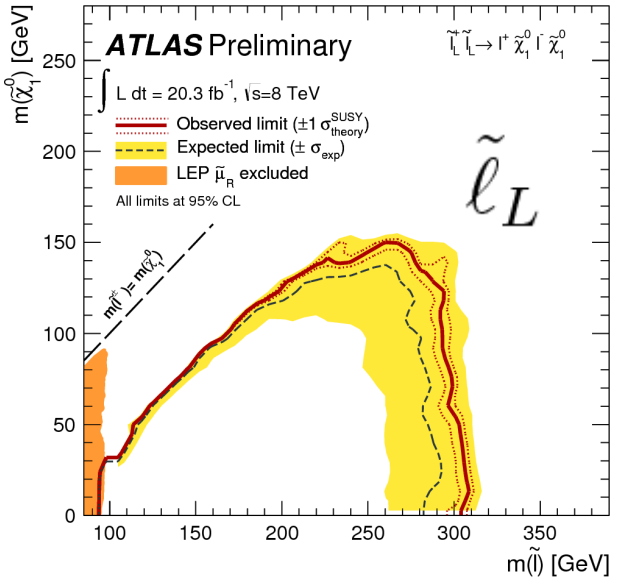
$E_T^{miss,rel}$ in two signal regions....

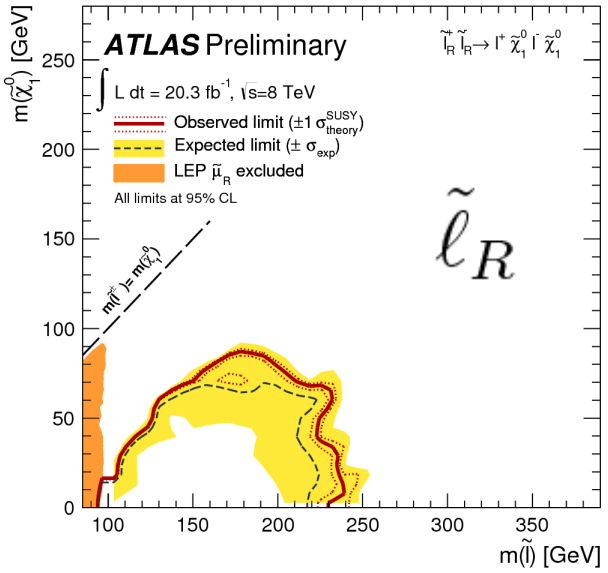




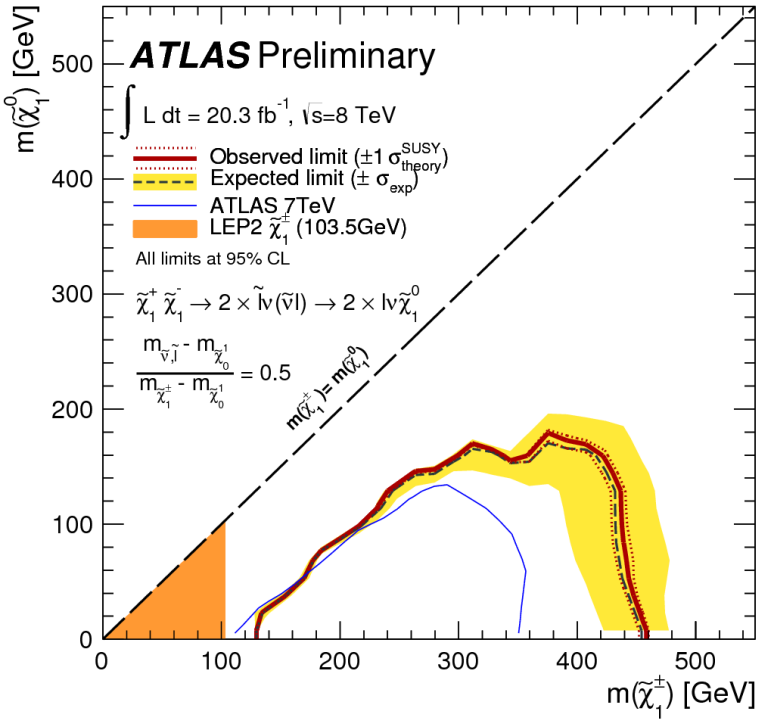
2 Lepton + Etmiss

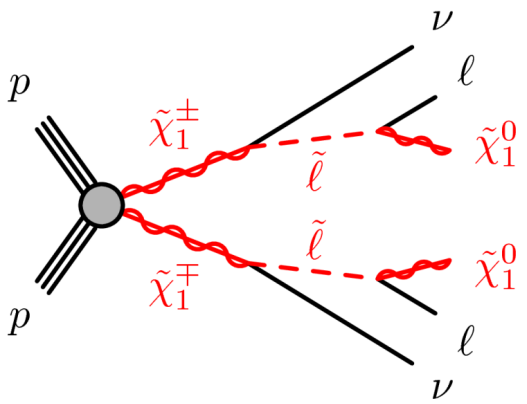
Slepton pair-production





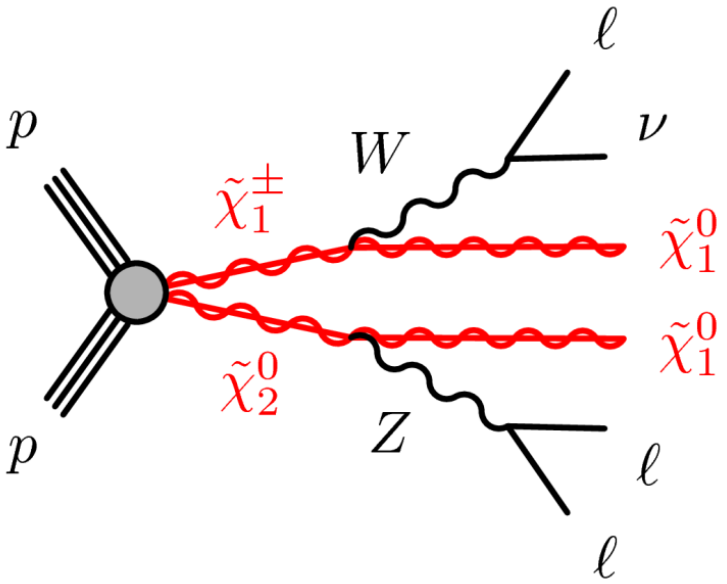
Chargino pair-production





3 Lepton + Etmiss

ATLAS-CONF-2013-035



$$q\bar{q} \rightarrow \tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$$

$$\tilde{\chi}_1^{\pm} \rightarrow (W^{\pm}\tilde{\chi}_1^0, \tilde{\nu}\ell^{\pm}, \tilde{\ell}^{\pm}\nu) \rightarrow \ell^{\pm}\nu\tilde{\chi}_1^0$$

$$\tilde{\chi}_2^0 \rightarrow (Z\tilde{\chi}_1^0, h\tilde{\chi}_1^0, \tilde{\ell}^{\pm}\ell^{\mp}) \rightarrow \ell^{\pm}\ell^{\mp}\tilde{\chi}_1^0(+X)$$

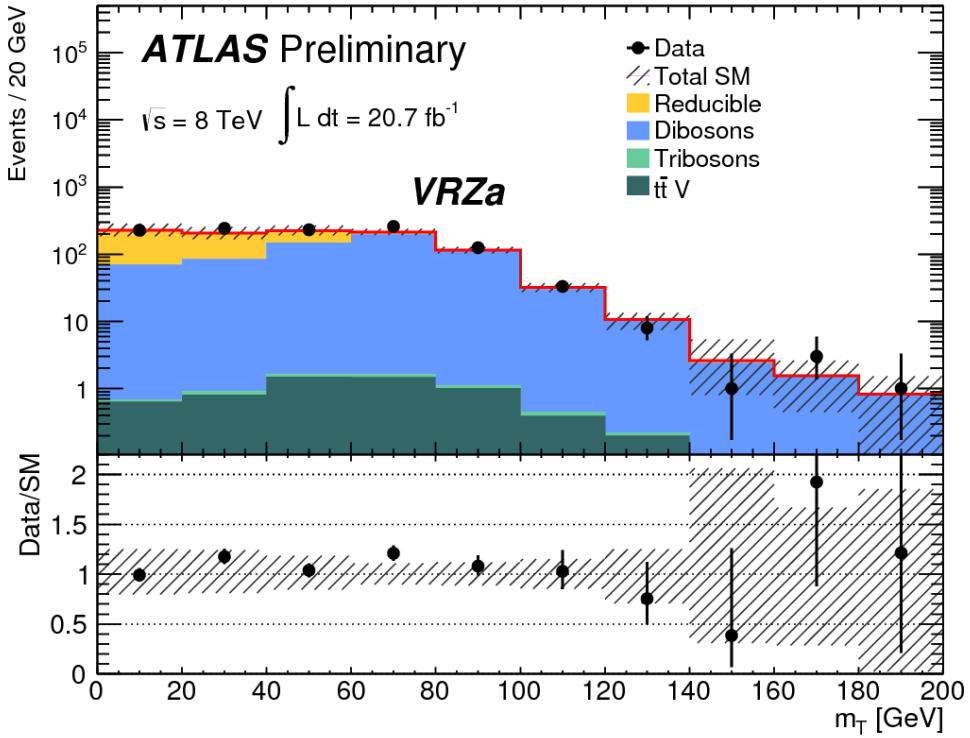
Three isolated e/μ (minp_T>10 GeV, single/di-lepton triggers)

Jet veto: central 20 GeV *b*-jets

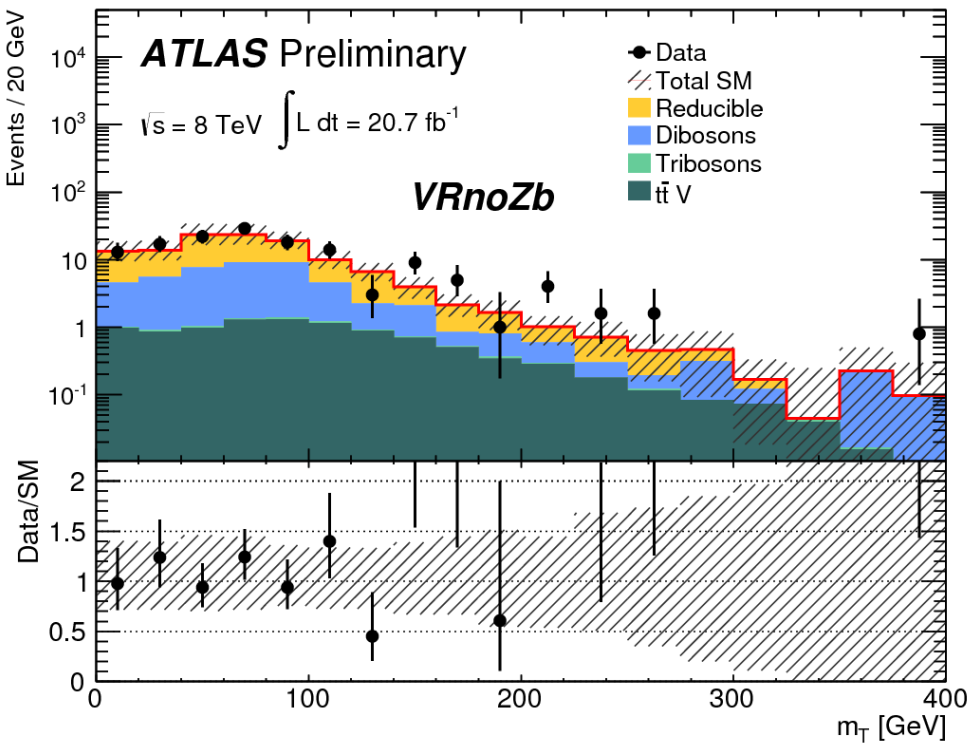
Selection	SRnoZa	SRnoZb	SRnoZc	SRZa	SRZb	SRZc
m_{SFOS} [GeV]	<60	60–81.2	<81.2 or >101.2	81.2–101.2	81.2–101.2	81.2–101.2
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	>50	>75	>75	75–120	75–120	>120
m_{T} [GeV]	–	–	>110	<110	>110	>110
p_{T} 3rd ℓ [GeV]	>10	>10	>30	>10	>10	>10
SR veto	SRnoZc	SRnoZc	–	–	–	–

3 Lepton + Etmiss

Validate background estimates in validation regions (VR)



m_T in events with *Z*-candidate, 30<Etmiss<50 GeV, no *b*-jets.



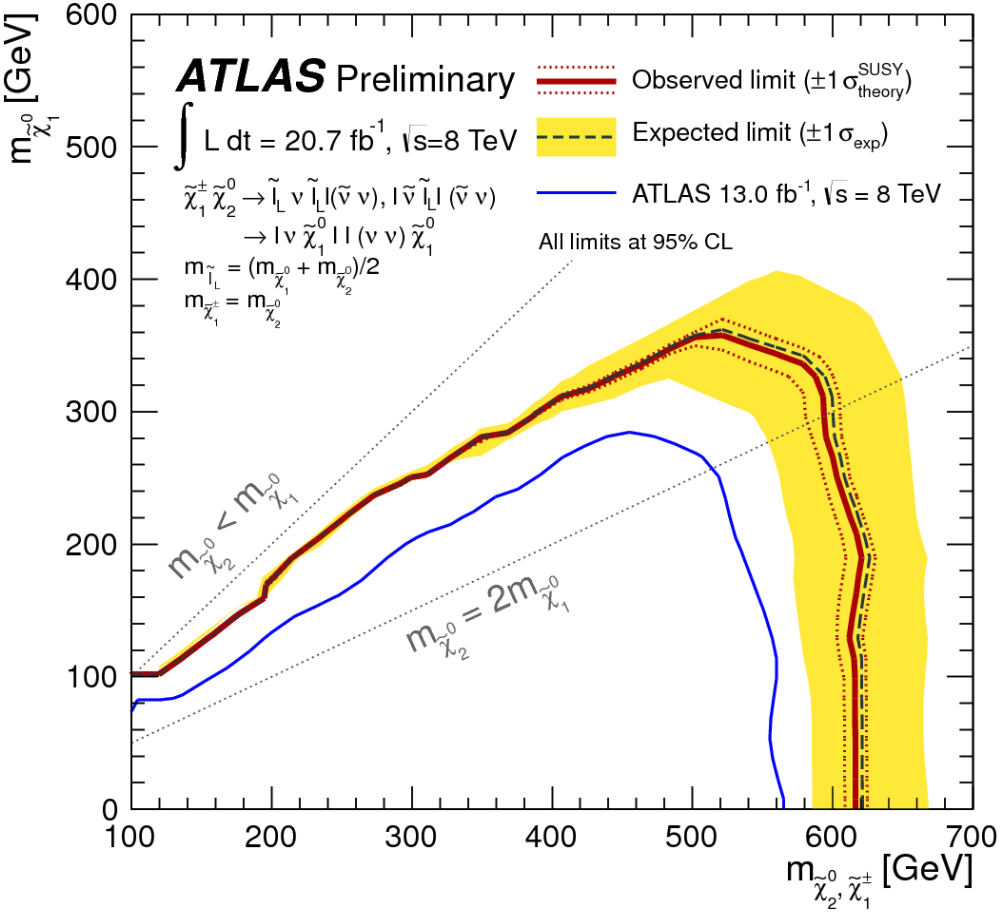
m_T in events with no *Z*-candidate, Etmiss>50 GeV, 1 *b*-jet.

3 Lepton + Etmiss

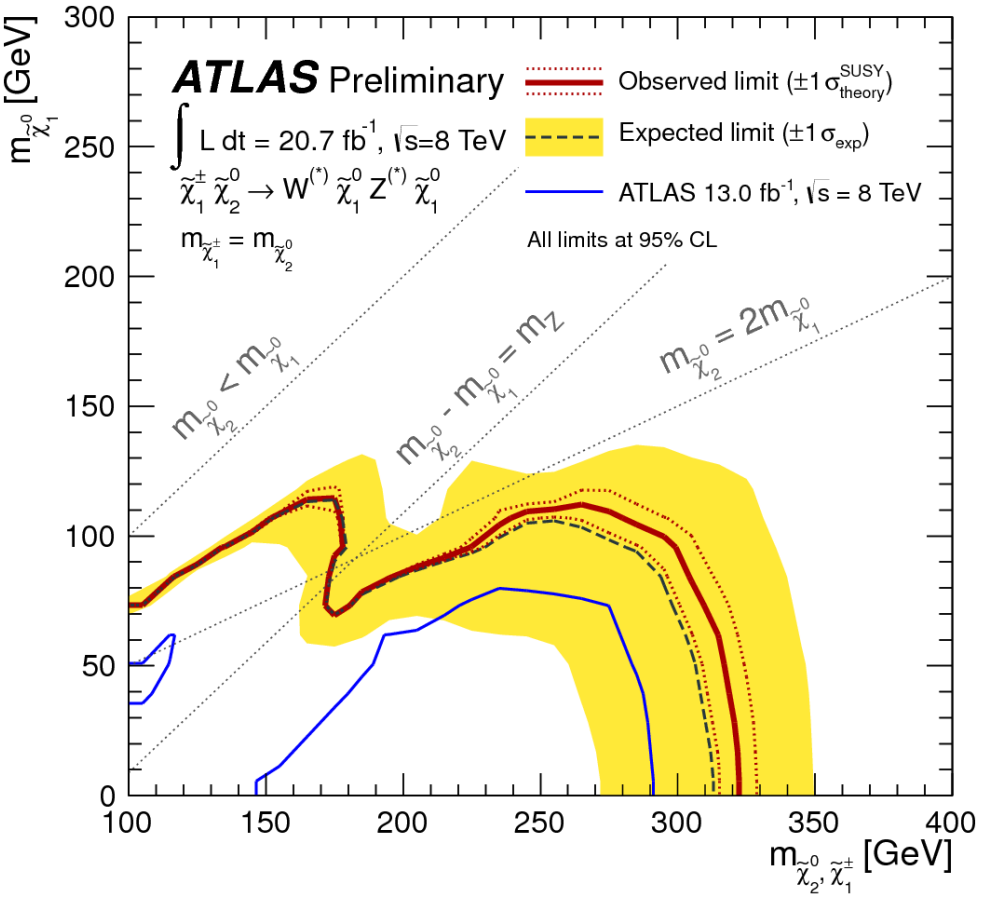
Counts in the Signal Regions

Selection	SRnoZa	SRnoZb	SRnoZc	SRZa	SRZb	SRZc
Tri-boson	1.7 ± 1.7	0.6 ± 0.6	0.8 ± 0.8	0.5 ± 0.5	0.4 ± 0.4	0.29 ± 0.29
ZZ	14 ± 8	1.8 ± 1.0	0.25 ± 0.17	8.9 ± 1.8	1.0 ± 0.4	0.39 ± 0.28
$t\bar{t}V$	0.23 ± 0.23	0.21 ± 0.19	$0.21^{+0.30}_{-0.21}$	0.4 ± 0.4	0.22 ± 0.21	0.10 ± 0.10
WZ	50 ± 9	20 ± 4	2.1 ± 1.6	235 ± 35	19 ± 5	5.0 ± 1.4
Σ SM irreducible	65 ± 12	22 ± 4	3.4 ± 1.8	245 ± 35	20 ± 5	5.8 ± 1.4
SM reducible	31 ± 14	7 ± 5	1.0 ± 0.4	4^{+5}_{-4}	1.7 ± 0.7	0.5 ± 0.4
Σ SM	**96 ± 19**	**29 ± 6**	**4.4 ± 1.8**	**249 ± 35**	**22 ± 5**	**6.3 ± 1.5**
Data	**101**	**32**	**5**	**273**	**23**	**6**
p_0-value	0.41	0.37	0.40	0.23	0.44	0.5
N_{signal} excluded (exp)	39.3	16.3	6.2	67.9	13.2	6.7
N_{signal} excluded (obs)	41.8	18.0	6.8	83.7	13.9	6.5
σ_{visible} excluded (exp) [fb]	1.90	0.79	0.30	3.28	0.64	0.32
σ_{visible} excluded (obs) [fb]	2.02	0.87	0.33	4.04	0.67	0.31

3 Lepton + Etmiss



Decay via sleptons



Decay via gauge bosons

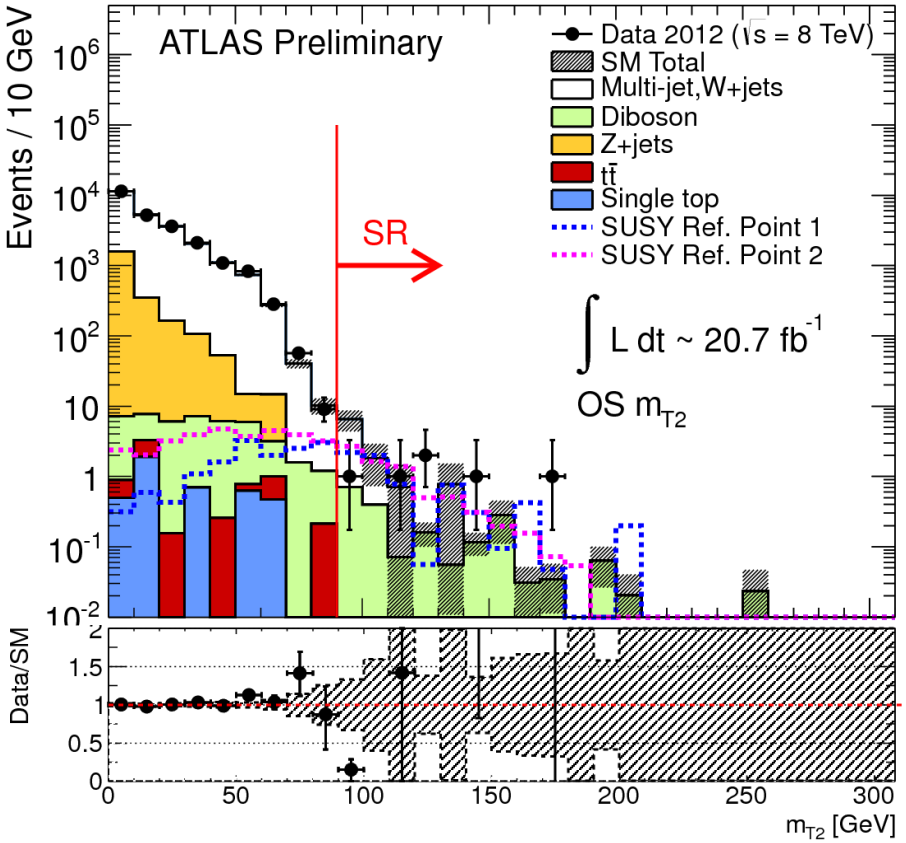
2 Tau + Etmiss

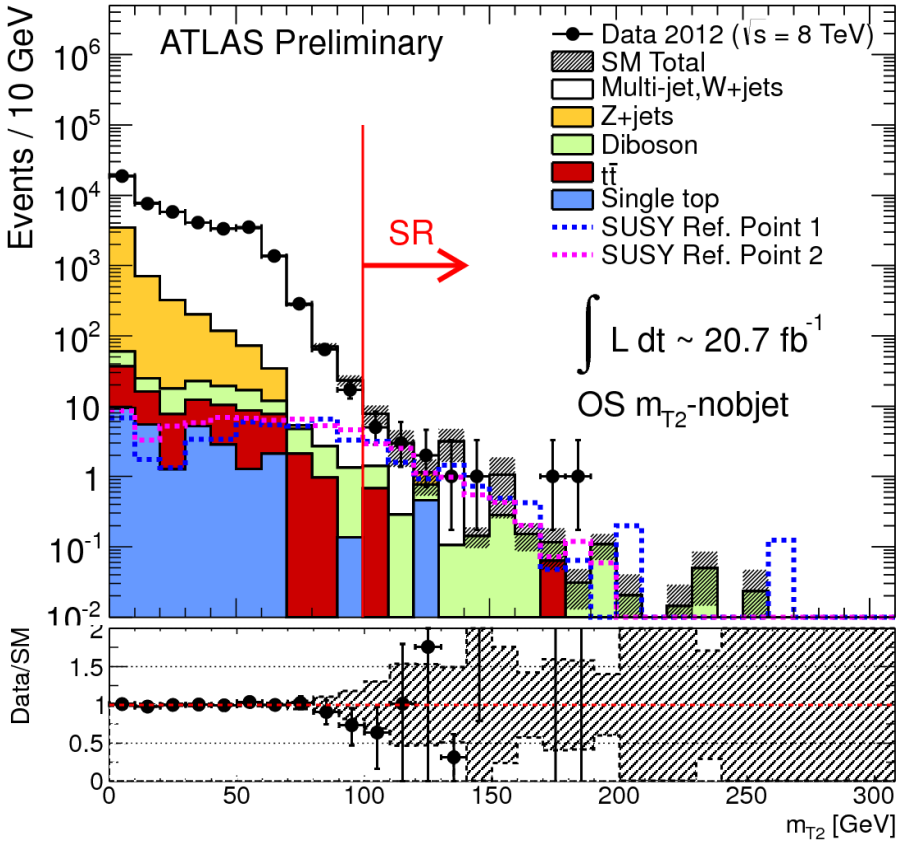
ATLAS-CONF-2013-028

At least two oppositely-charged taus (with visp$_T$ > 20 GeV , ditau/Etmiss trigger)

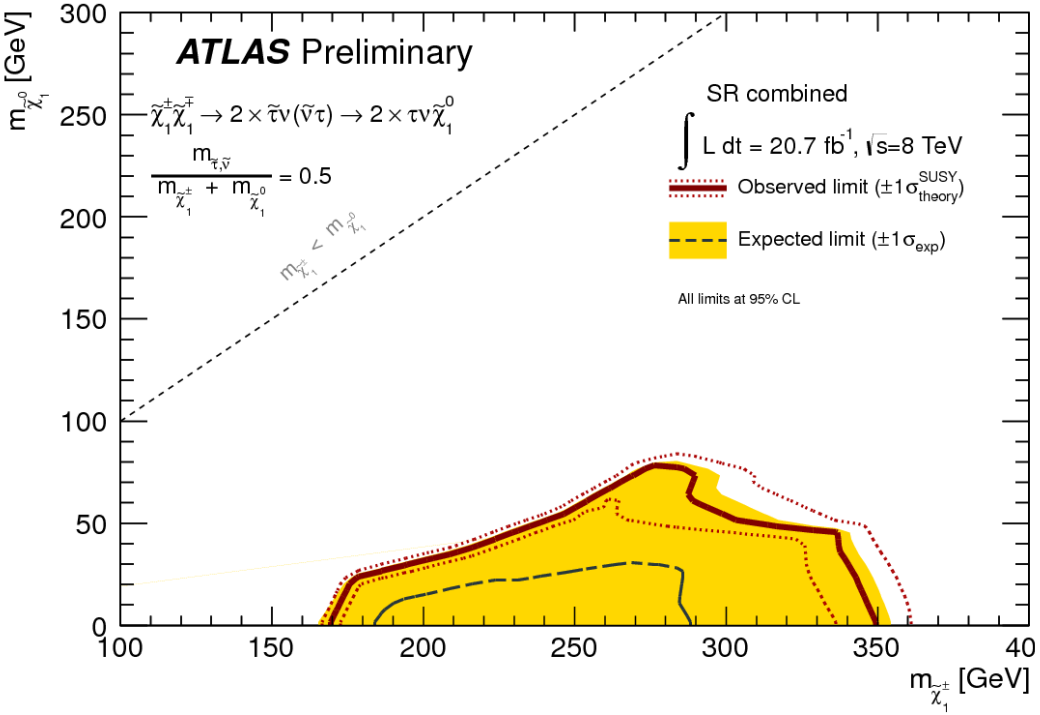
No e/μ with p_T>10 GeV. No jets p_T>25 GeV (no b-jets p_T>20 GeV)

Signal regions defined by Etmiss>40 GeV and m_{T2}

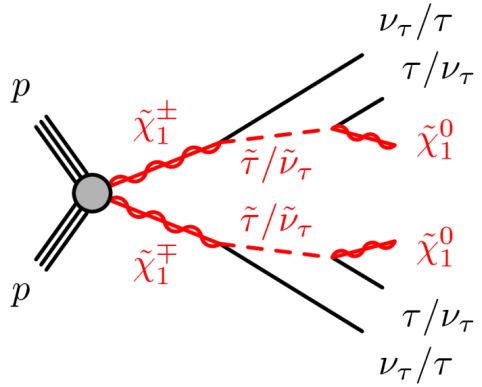


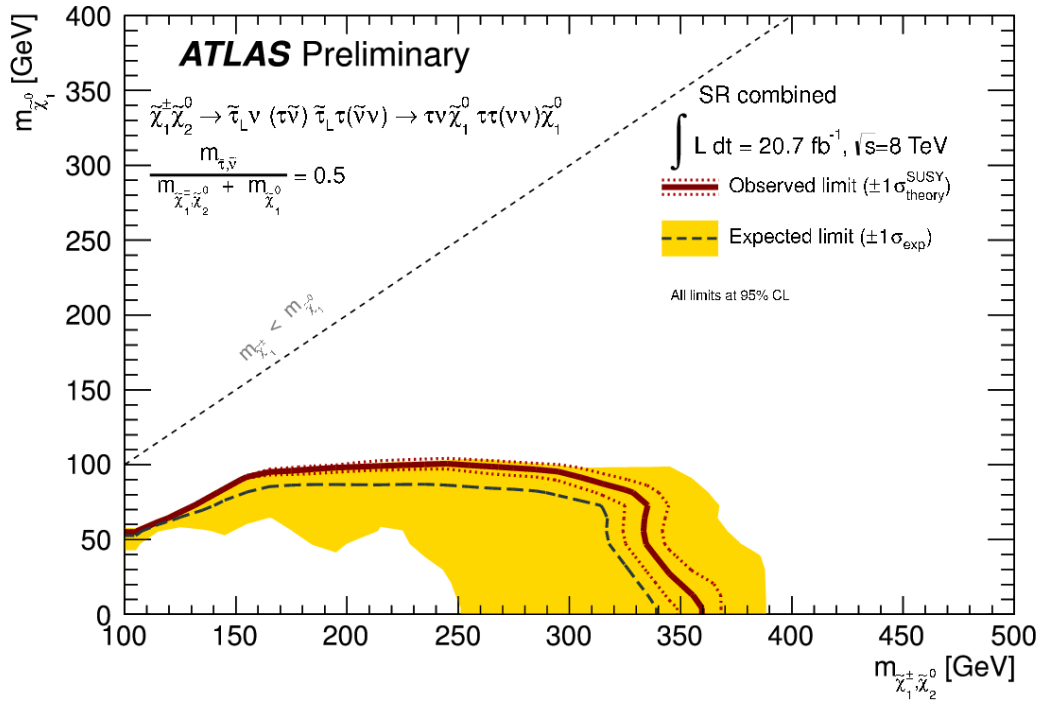


2 Tau + Etmiss

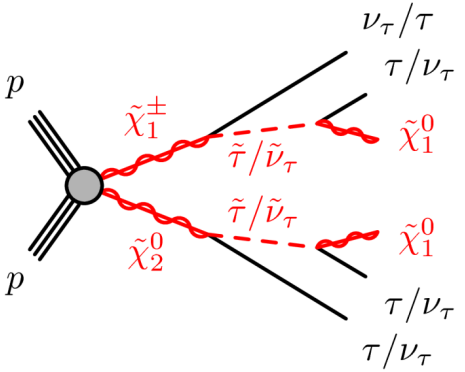


Chargino pair-production





Chargino-Neutralino production



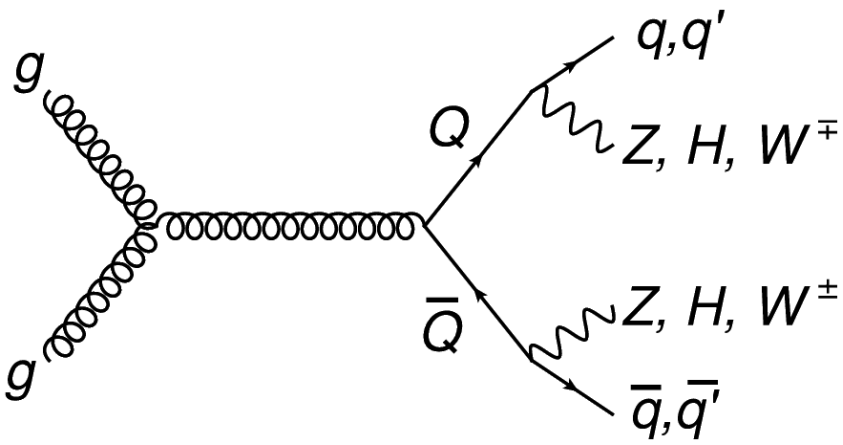
Exotic

Vector-like quarks

ATLAS-CONF-2013-056

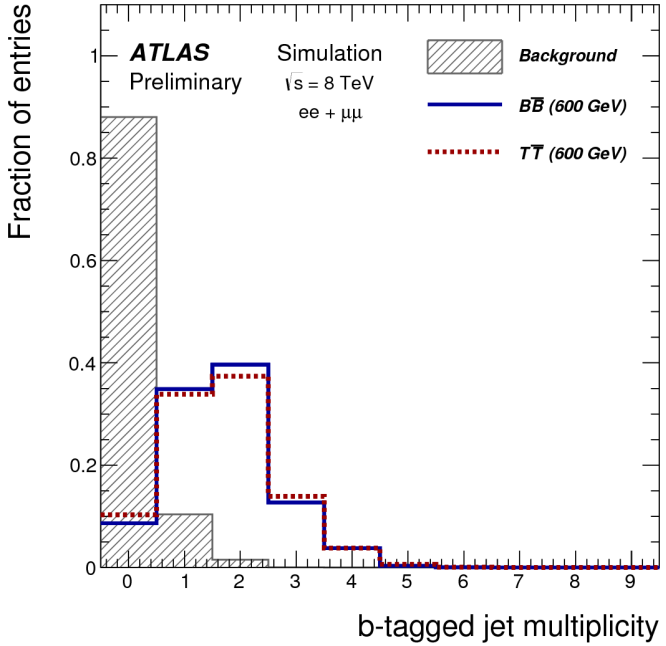
Vector-like quarks occur in different natural non-SUSY models
Little Higgs, composite Higgs, Topcolor etc.

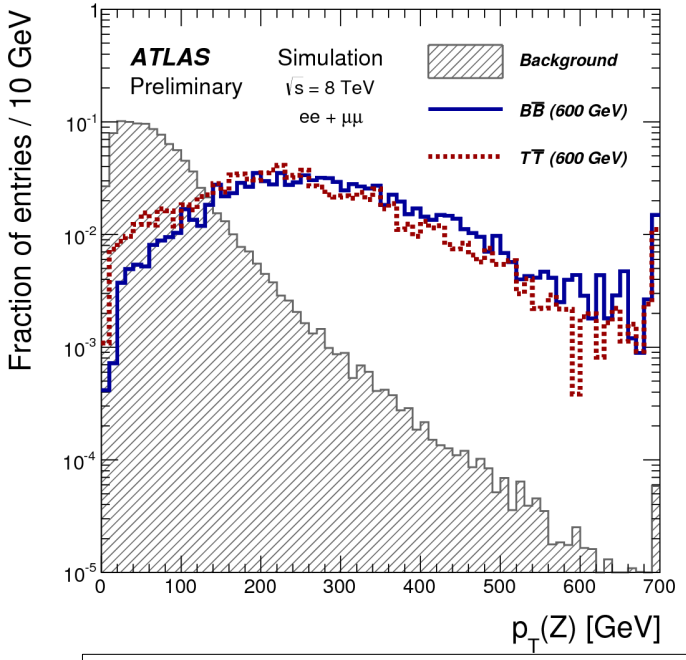
Two different VLQ (pair-produced) considered
- T → *Zt*
- B → *Zb*

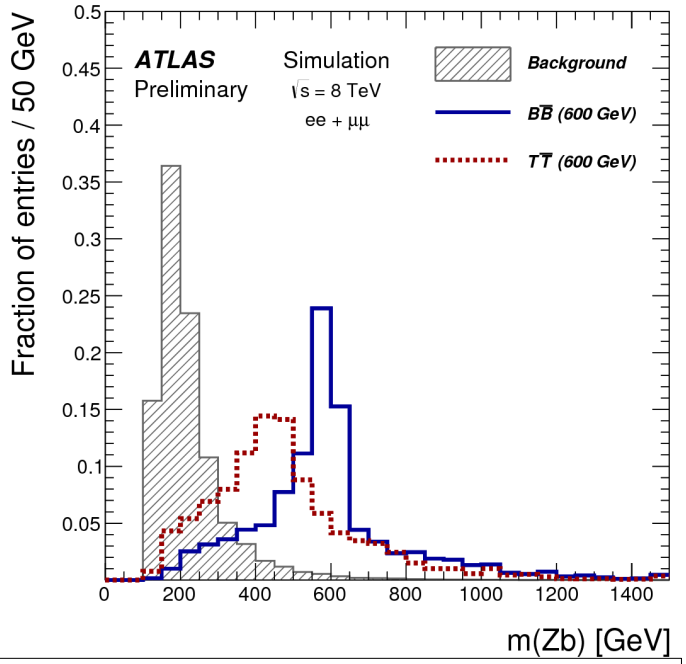


Final state
OS Leptons forming a *Z* candidate +
two central *b*-tagged jets with p_T> 25 GeV
(single-lepton triggers)

VLQ : *Zb*







Z + ≥ 2 jets

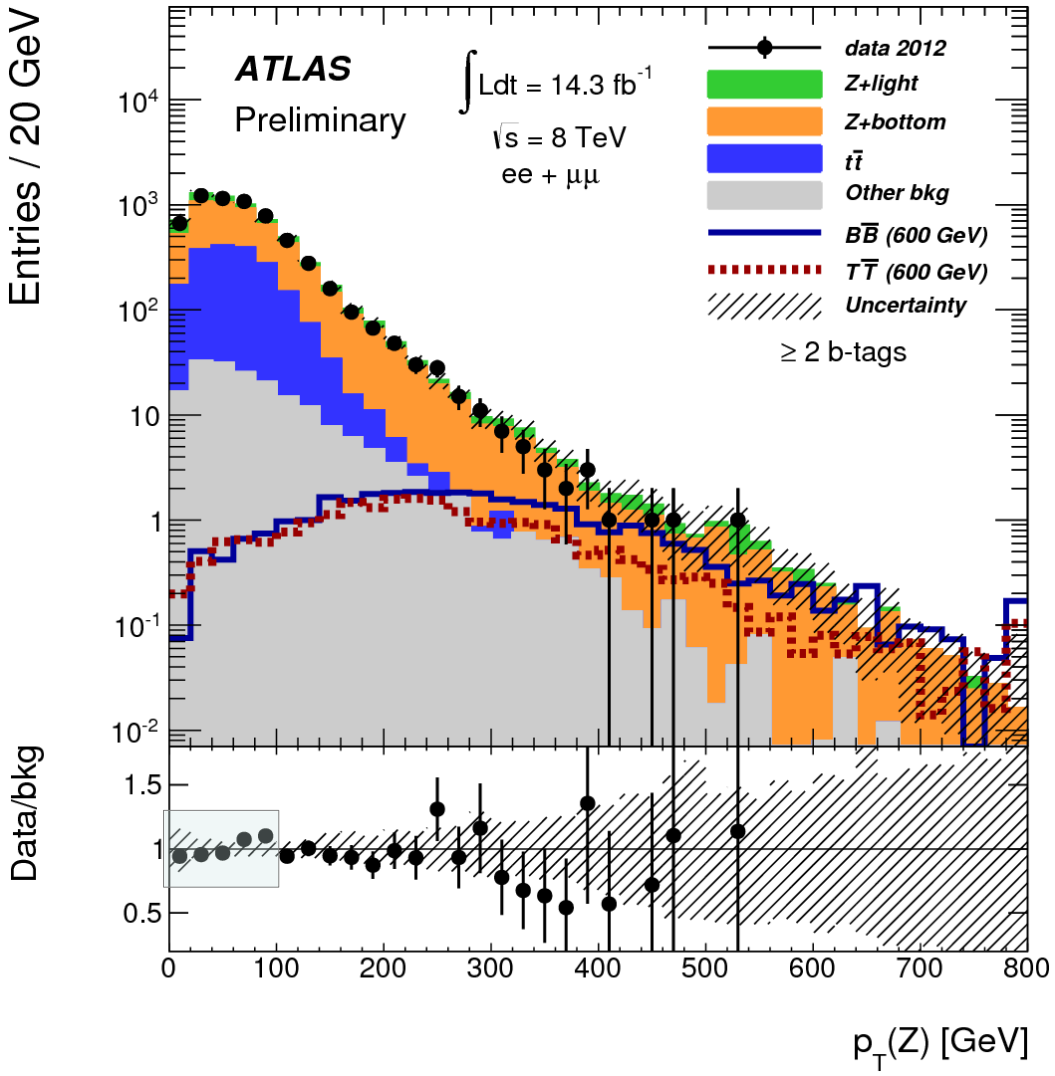
Z + ≥ 2 *b*-jets

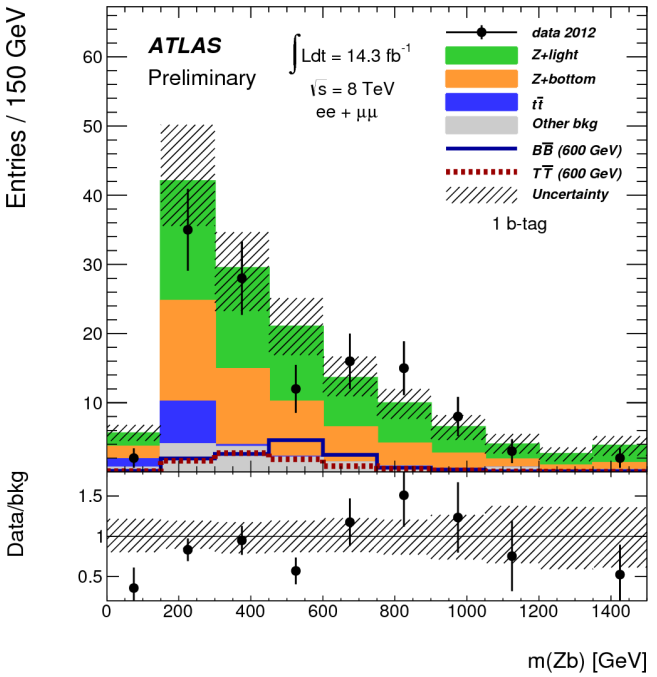
Require at least 2 b-tags, use <2 tag as control regions

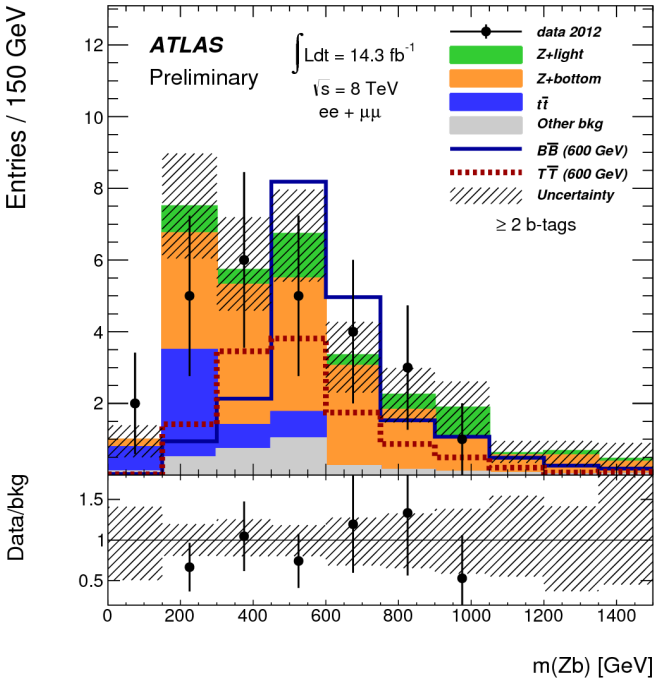
Require $p_T(Z)>150$ GeV, HT(jets) > 600 GeV (use $p_T(Z)<100$ GeV as CR)

Test hypothesis in m(Zb) distribution

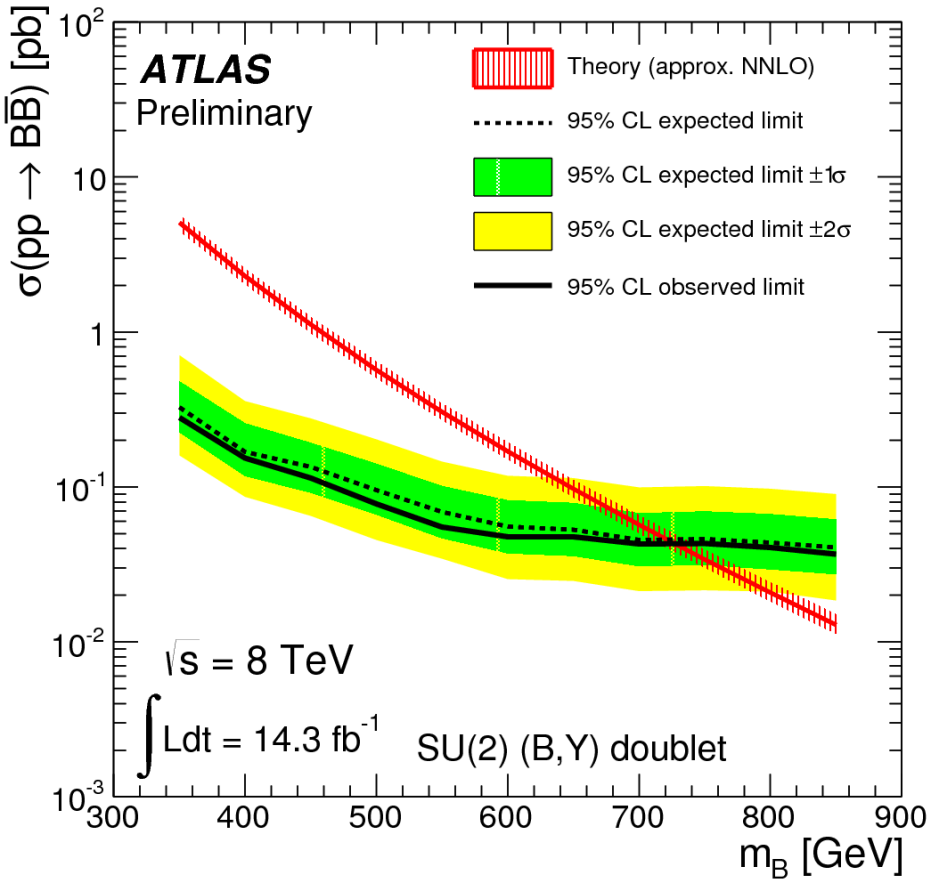
VLQ : *Zb*


ATLAS
Preliminary
∫Ldt = 14.3 fb-1
√s = 8 TeV
ee + μμ
data 2012
Z+light
Z+bottom
tt̄
Other bkg
BB̄ (600 GeV)
TT̄ (600 GeV)
Uncertainty
≥ 2 b-tags
Entries / 20 GeV
Data/bkg
pT(Z) [GeV]

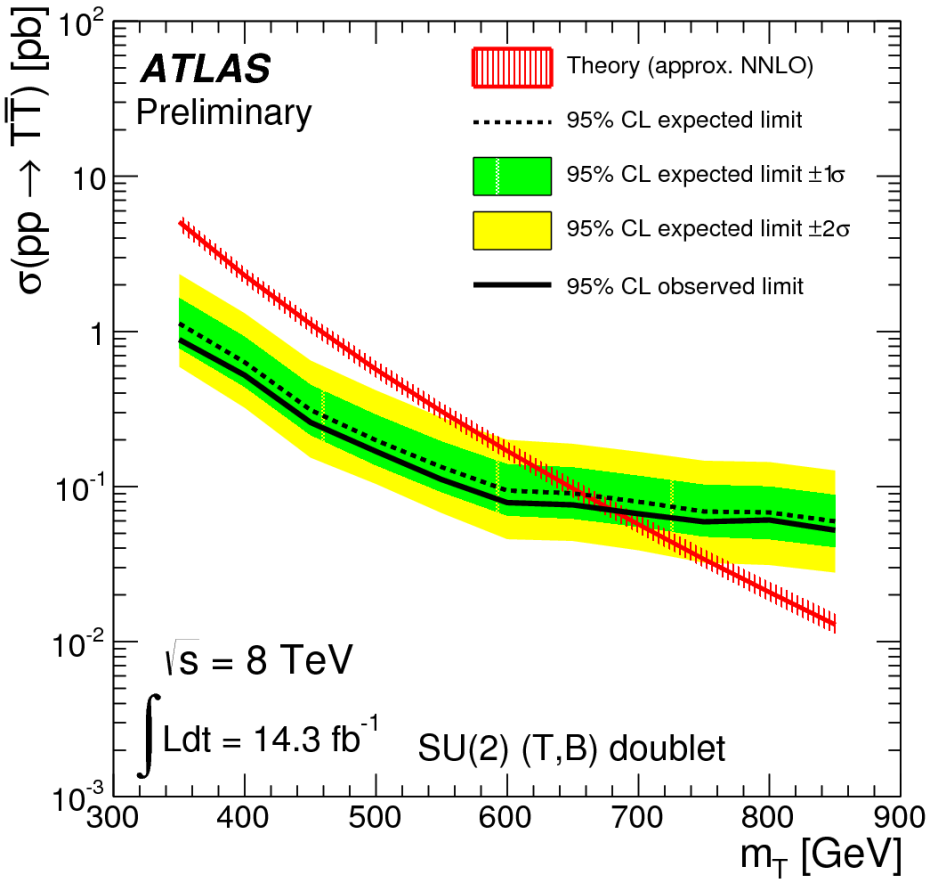

ATLAS
Preliminary
∫Ldt = 14.3 fb-1
√s = 8 TeV
ee + μμ
data 2012
Z+light
Z+bottom
tt̄
Other bkg
BB̄ (600 GeV)
TT̄ (600 GeV)
Uncertainty
1 b-tag
Entries / 150 GeV
Data/bkg
m(Zb) [GeV]


ATLAS
Preliminary
∫Ldt = 14.3 fb-1
√s = 8 TeV
ee + μμ
data 2012
Z+light
Z+bottom
tt̄
Other bkg
BB̄ (600 GeV)
TT̄ (600 GeV)
Uncertainty
≥ 2 b-tags
Entries / 150 GeV
Data/bkg
m(Zb) [GeV]

VLQ : *Zb*



m_B < 725 GeV ruled out



m_T < 680 GeV ruled out

SS leptons + *b*-jets

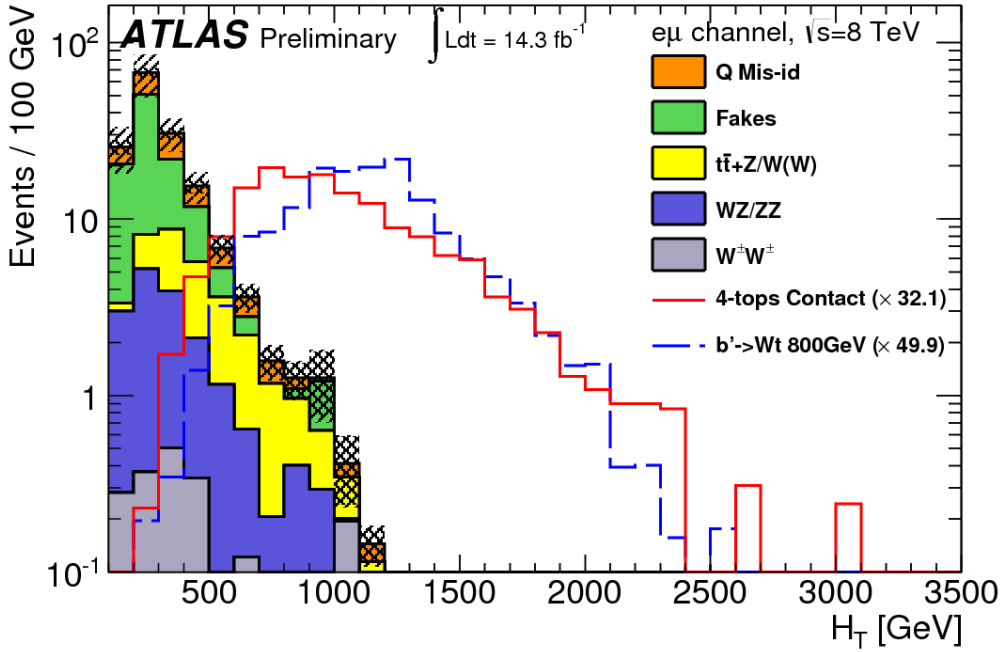
ATLAS-CONF-2013-051

Pair produced VLQ can produce leptons of same charge
- T → *Zt*, *Ht*
- B → *Wt*

Or 4-generation SM quarks (Two-Higgs-doublet model)
- b' → *Wt*

Or non-resonant production of 4-tops – $t\bar{t}t\bar{t}$

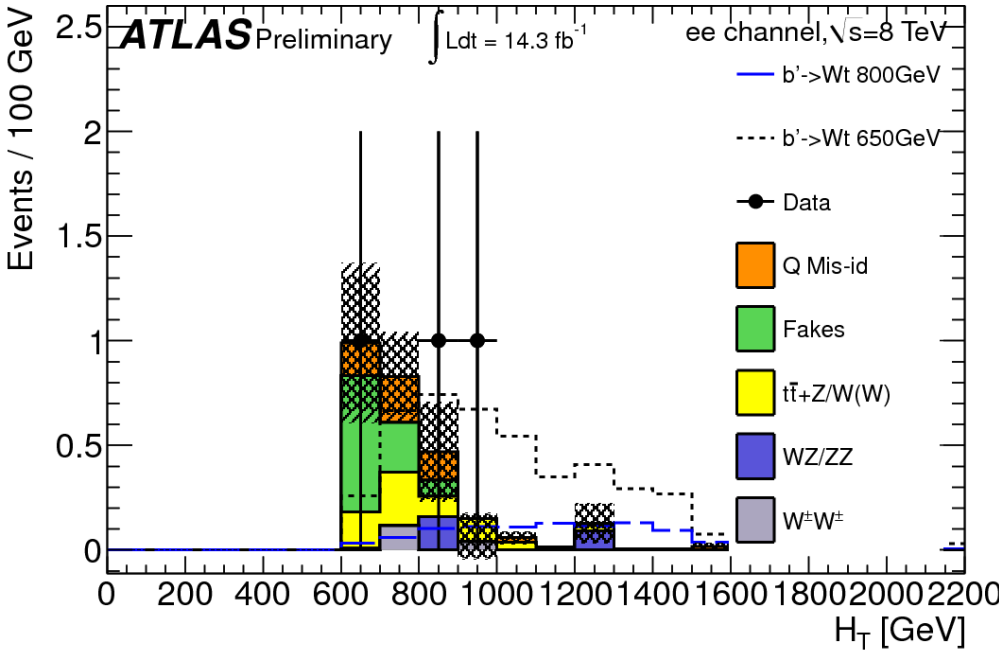
Or
$uu \rightarrow tt$ mediated via *s*- or *t*-channel exchange of heavy particle.

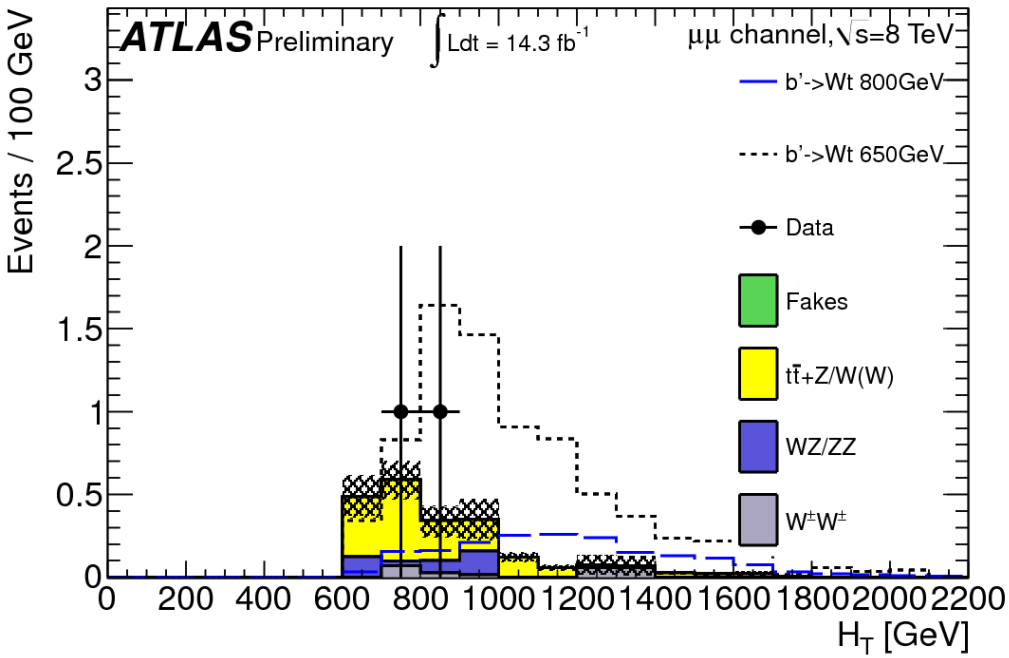


e/μ with pT>25 GeV, single-lepton triggers
≥ 2 jets with pT>25 GeV, Etmiss > 40 GeV

Variable	b' and VLQ	tt	$t\bar{t}t\bar{t}$
H_T	> 650 GeV	> 550 GeV	> 650 GeV
N_{b-jets}	≥ 1	≥ 1	≥ 2
Charge	±±	++	±±

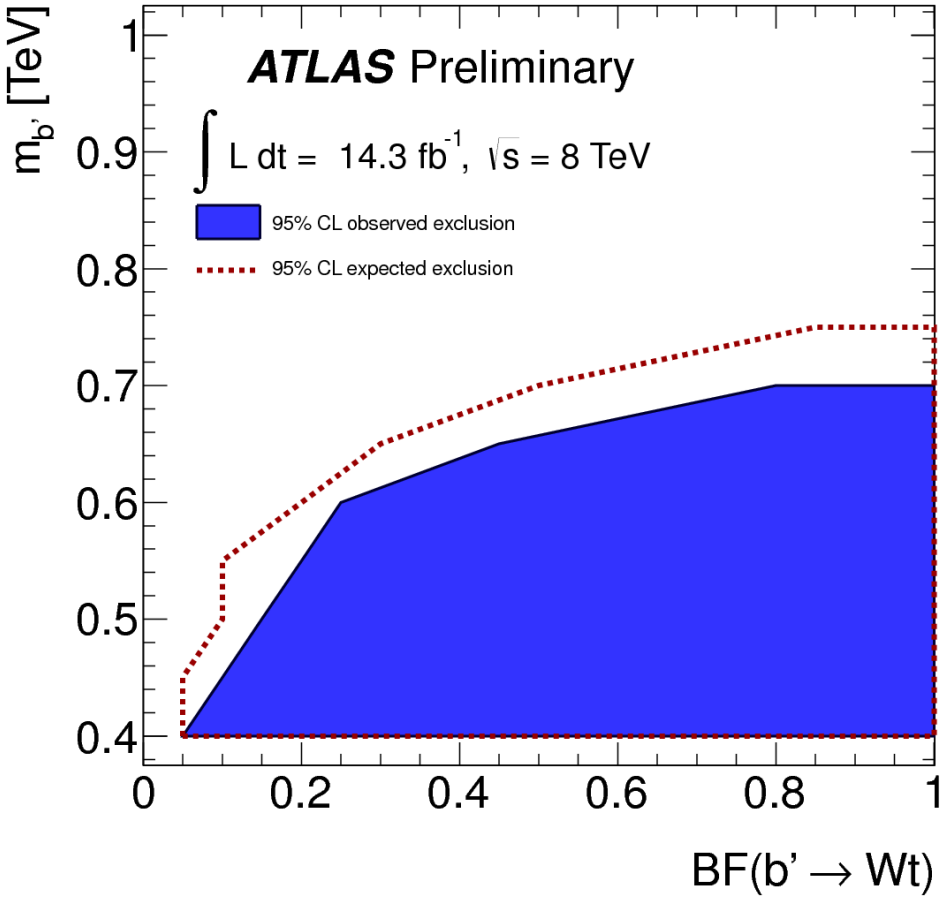
SS leptons + *b*-jets



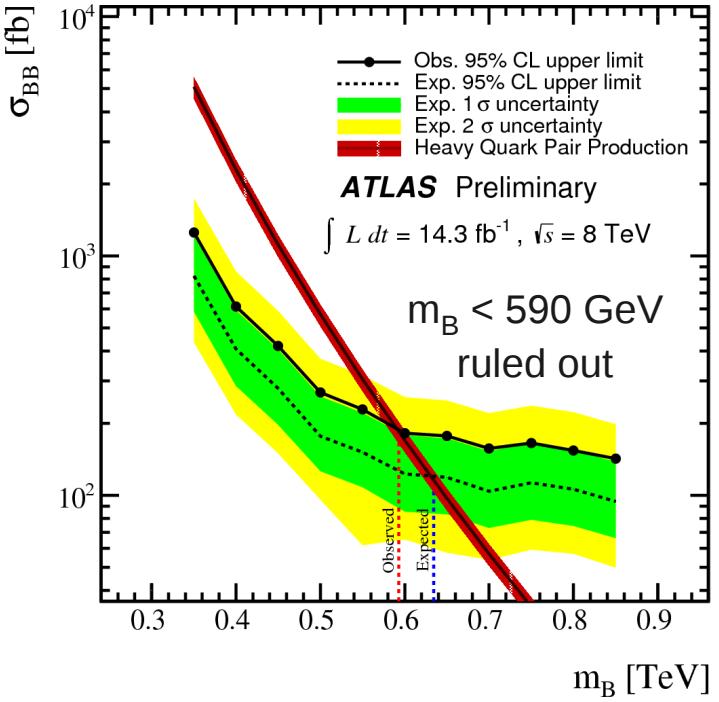


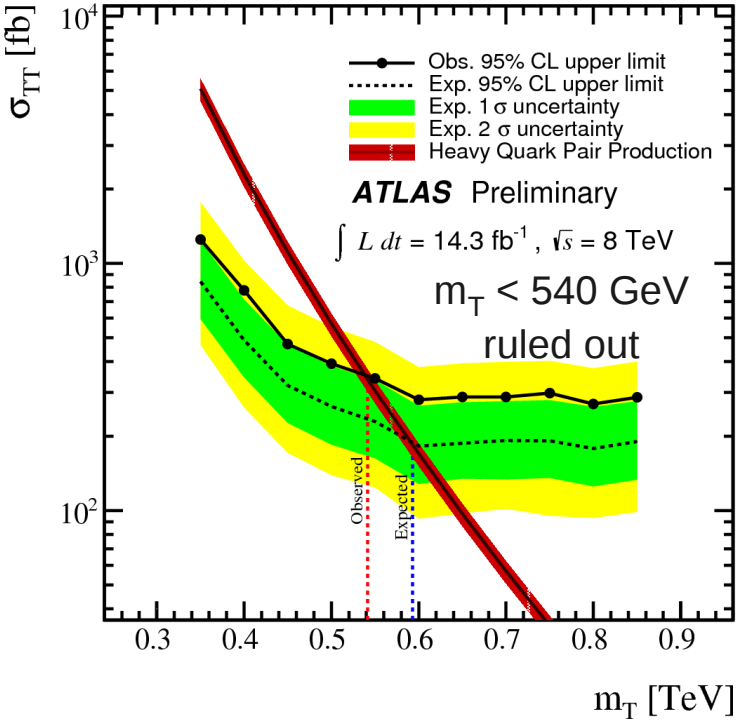
HT(jets) in signal regions for ee and μμ

SS leptons + *b*-jets

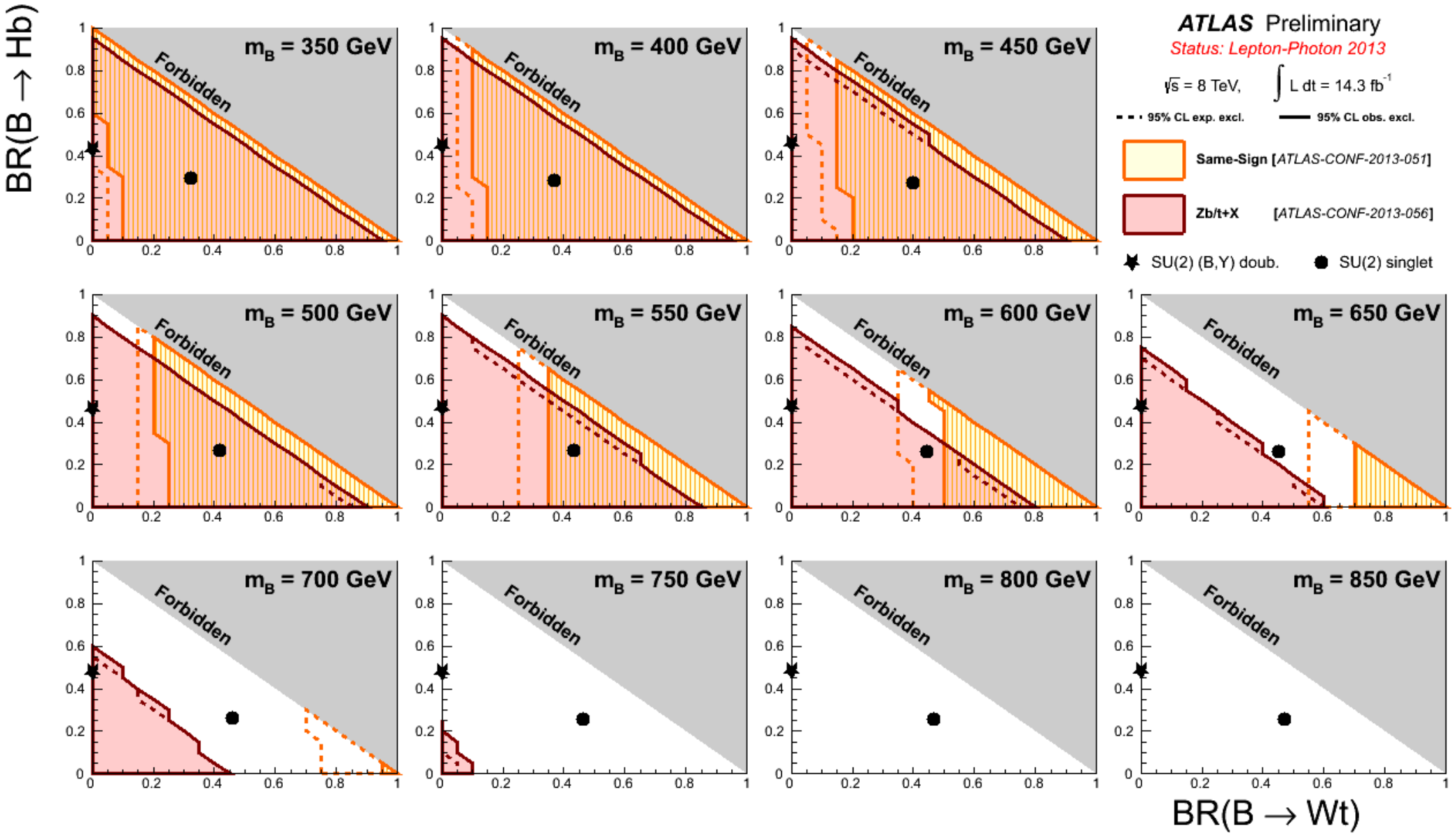


$m_{b'}$ < 720 GeV ruled out for BF=1





VLQ Summary


BR(B → Hb)
BR(B → Wt)
ATLAS Preliminary
Status: Lepton-Photon 2013
√s = 8 TeV, ∫ L dt = 14.3 fb-1
95% CL exp. excl.
95% CL obs. excl.
Same-Sign [ATLAS-CONF-2013-051]
Zb/t+X [ATLAS-CONF-2013-056]
SU(2) (B,Y) doub.
SU(2) singlet
m_B = 350 GeV
m_B = 400 GeV
m_B = 450 GeV
m_B = 500 GeV
m_B = 550 GeV
m_B = 600 GeV
m_B = 650 GeV
m_B = 700 GeV
m_B = 750 GeV
m_B = 800 GeV
m_B = 850 GeV
Forbidden

Microscopic black holes

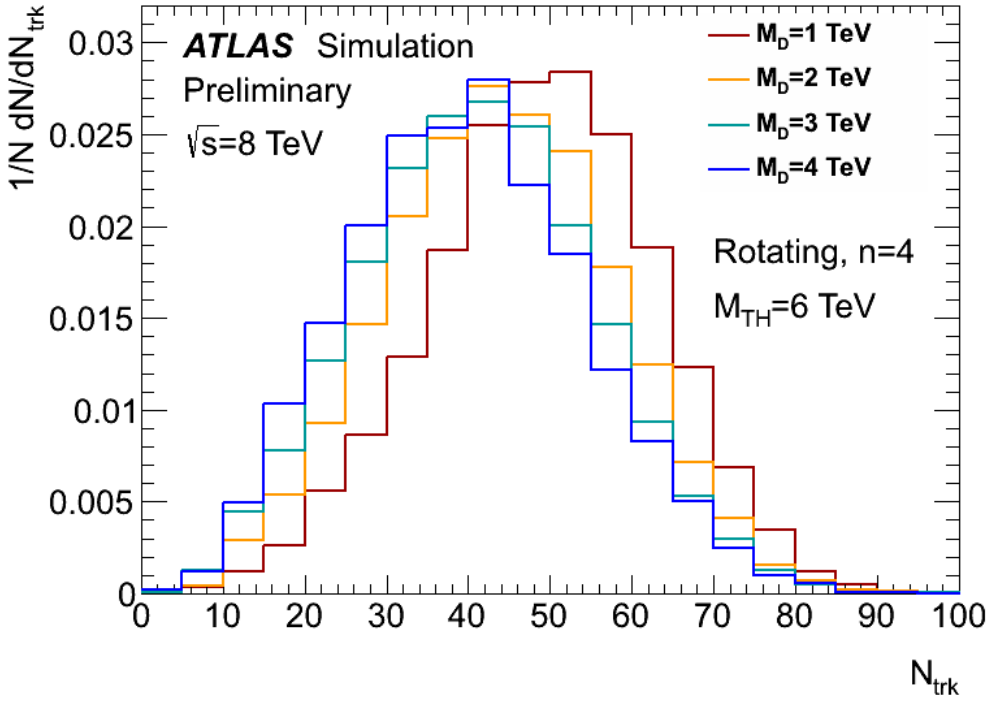
New

Black holes produced in the context of ADD models of flat extra dimensions.

Decay via Hawking radiation; characterized by large number of high pT particles.

Decay to all SM particles, i.e. all final states.

Search in a like-sign dimuon final state with high track multiplicity.



Track multiplicity with p_T(trk)>10 GeV

n = number of extra dimensions

M_D = Planck scale in D=4+n dim

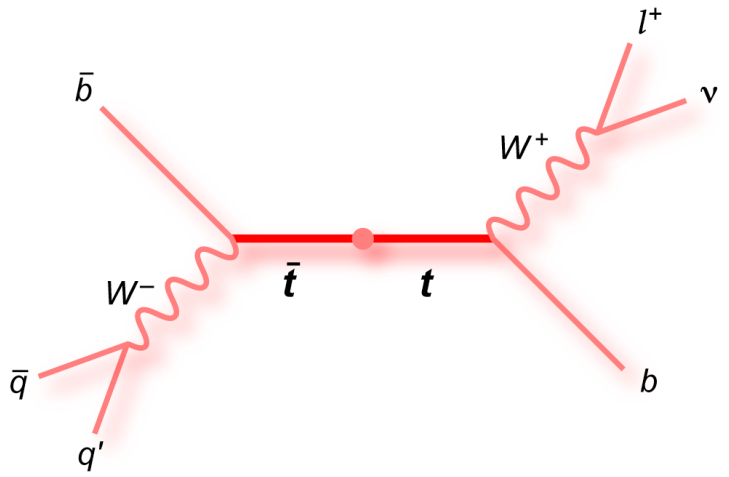
M_{TH} = threshold mass of black hole

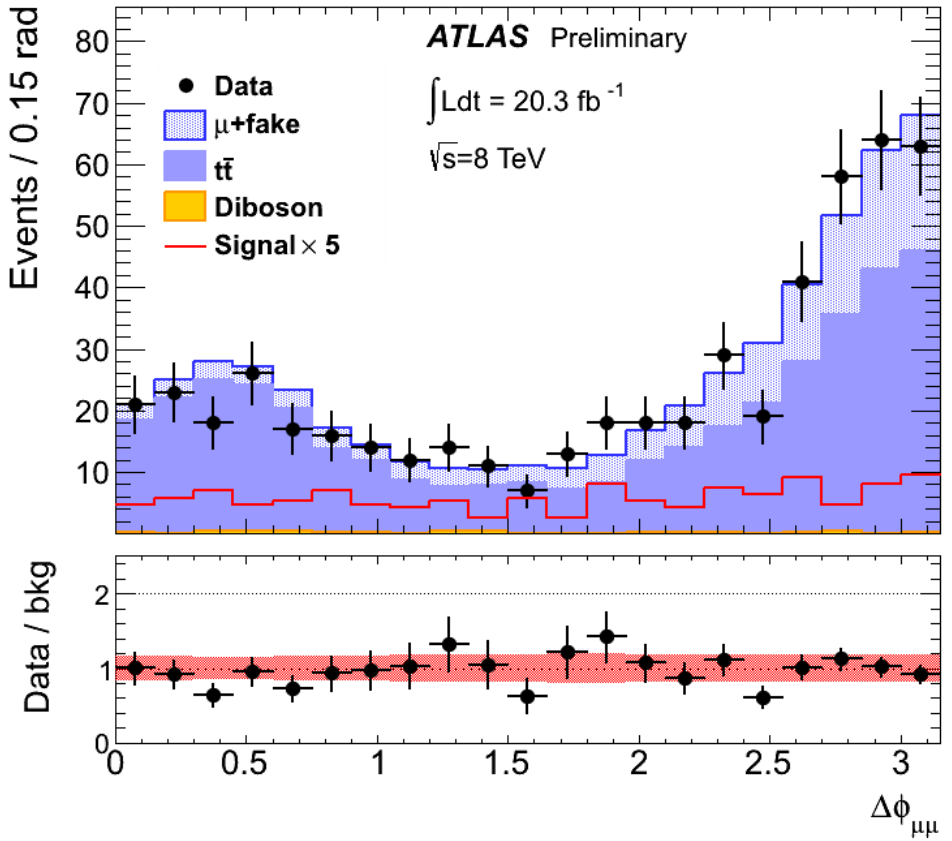
$\mu^{\pm}\mu^{\pm}$ + many tracks

New

Select events with two muons
p_T>100,15 GeV (single-muon trigger)
Loose isolation for leading muon,
no-isolation for second muon
(*uncommon selection at LHC*).

Dominant backgrounds from
Top-pair production and W+jets production

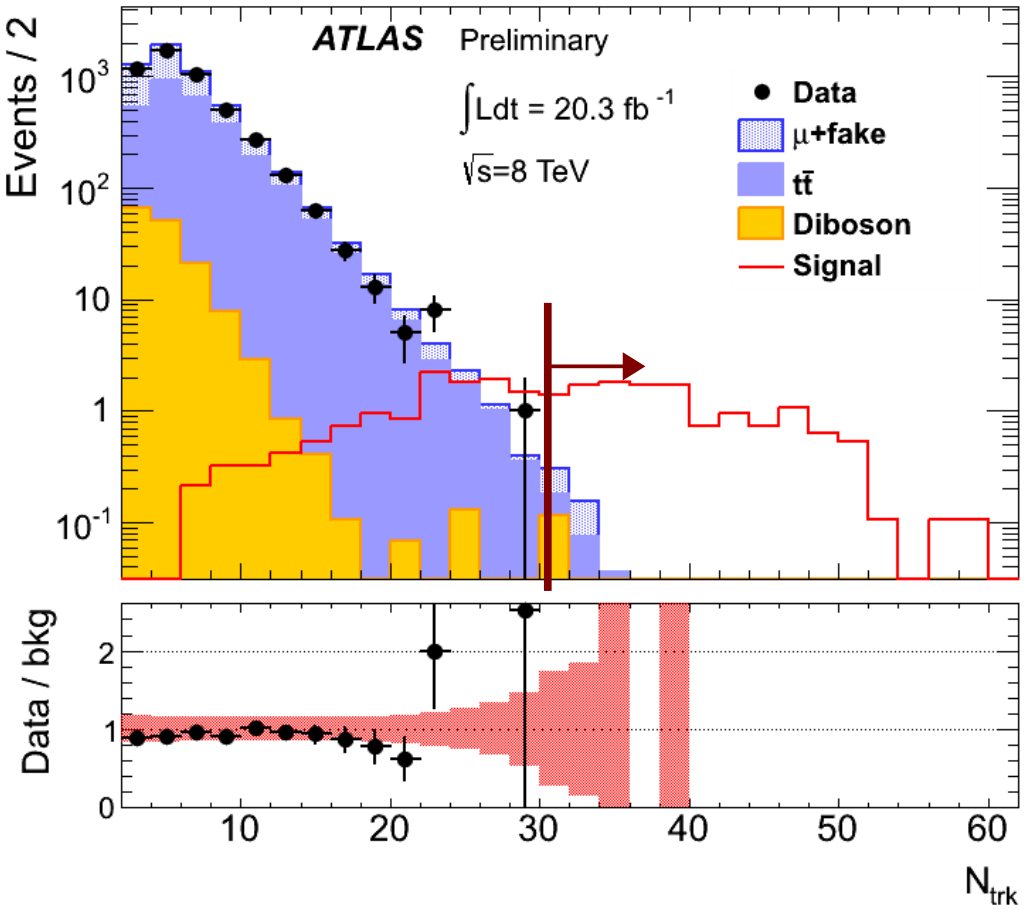


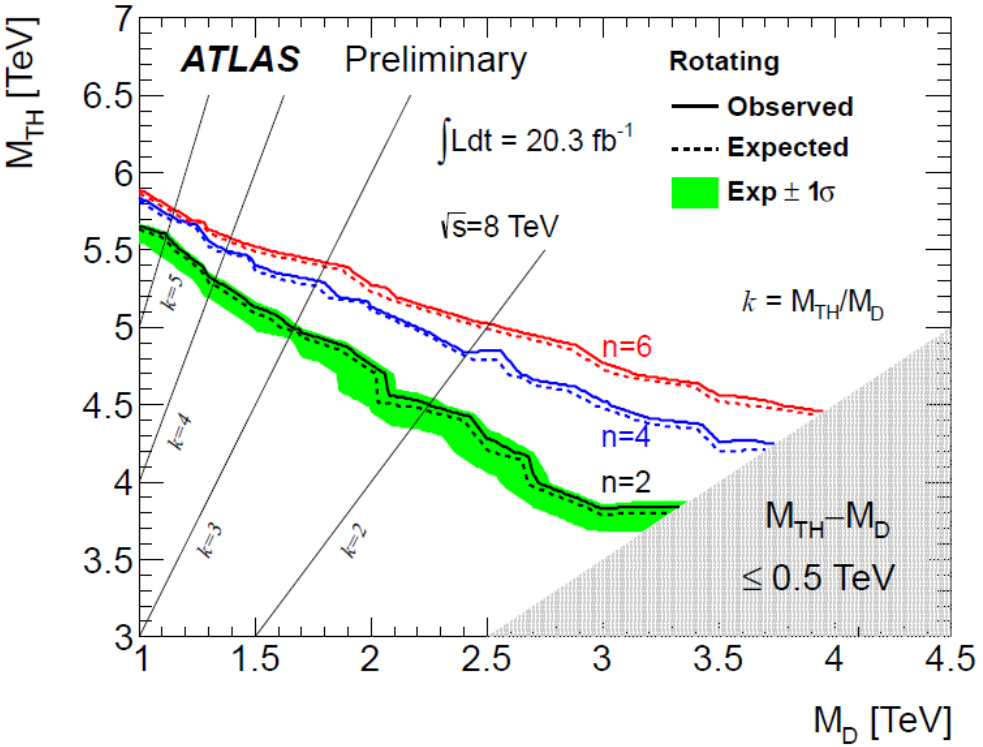


$\Delta\varphi_{\mu\mu}$ in events with $N_{trk} \geq 10$

Microscopic black holes

New





Signal region with μ_1 p_T> 100 GeV,
and **$N_{trk} \geq 30$**, Exp: 0.6 ± 0.2 events, Obs: 0

SUBMIT TO PRD ~ week(s)

Addressing model dependence

Usually results shown in context of a model.

In addition, lower limits on number of events (upper limits on cross section) provided. These might (or not) be fiducial limits.

$$\sigma_{95}^{fid} = \frac{N_{95}}{\epsilon^{fid} \int Ldt} = \frac{\sigma_{95}^{vis}}{\epsilon^{fid}}$$

Limitation on reinterpretation is determining this fiducial efficiency for an arbitrary model.

Addressing model dependence

TABLE V. The fiducial efficiency for electrons and taus in different p_T ranges. For tau candidates, $p_T \equiv p_T^{vis}$.

p_T [GeV]	
10–15	0.3
15–20	0.3
20–25	0.3
25–30	0.(
30–40	0.(

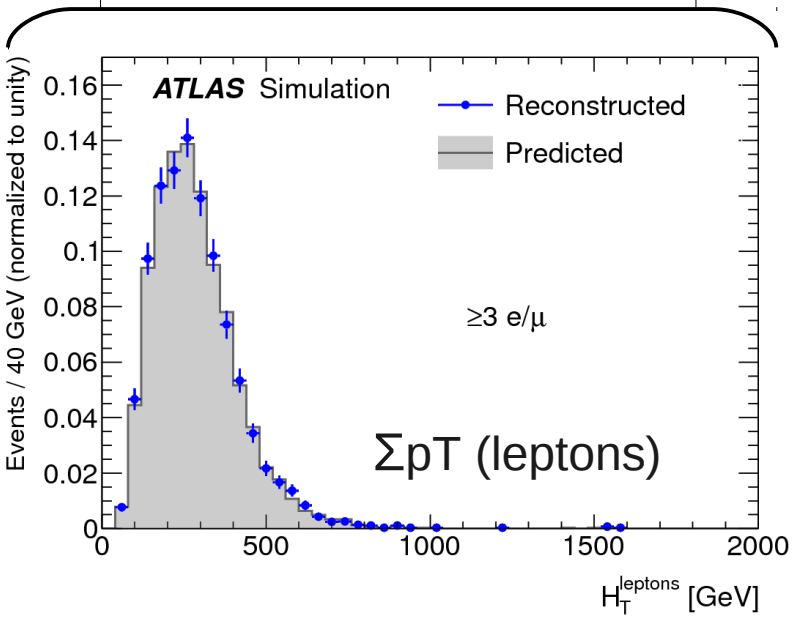
TABLE VII. The fiducial efficiency for muons in different p_T ranges.

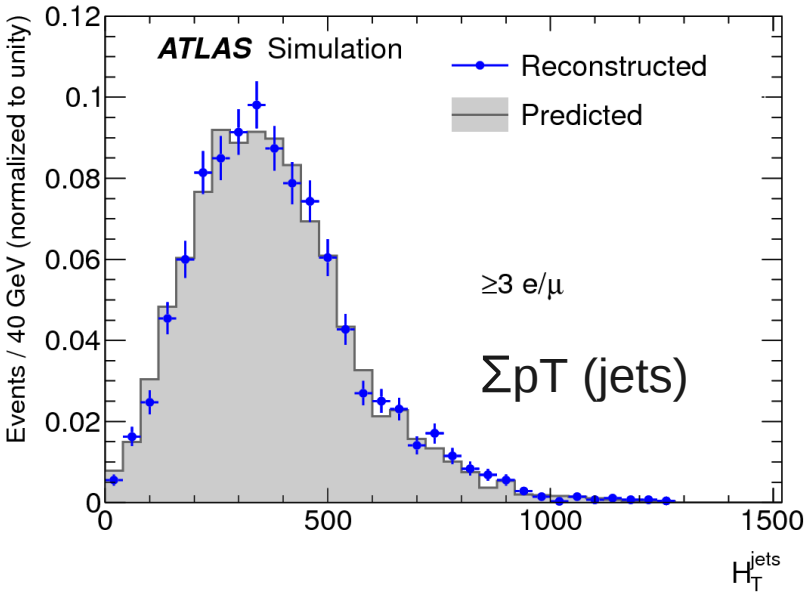
p_T	Prompt μ		$\tau \to \mu$	
[GeV]	$\lvert\eta\rvert > 0.1$	$\lvert\eta\rvert < 0.1$	$\lvert\eta\rvert > 0.1$	$\lvert\eta\rvert < 0.1$
10–15	0.852±0.002	0.47±0.02	0.66±0.004	0.36±0.02
15–20	0.896±0.002	0.51±0.01	0.71±0.005	0.38±0.02
20–25	0.912±0.001	0.52±0.01	0.734±0.005	0.43±0.03

TABLE VI. The fiducial efficiency for electrons and taus in different η ranges. For tau candidates, $\eta \equiv \eta^{vis}$.

$\lvert\eta\rvert$	Prompt e	$\tau \to e$	τ_{had}
0.0–0.1	0.675±0.003	0.52±0.01	0.210±0.009
0.1–0.5	0.757±0.001	0.595±0.005	0.195±0.004
0.5–1.0	0.747±0.001	0.581±0.005	0.179±0.004
1.0–1.5	0.666±0.002	0.494±0.006	0.138±0.004
1.5–2.0	0.607±0.002	0.465±0.006	0.170±0.004
2.0–2.5	0.591±0.002	0.475±0.007	0.163±0.005

$b'b' \to tWtW \to WWWWbb$



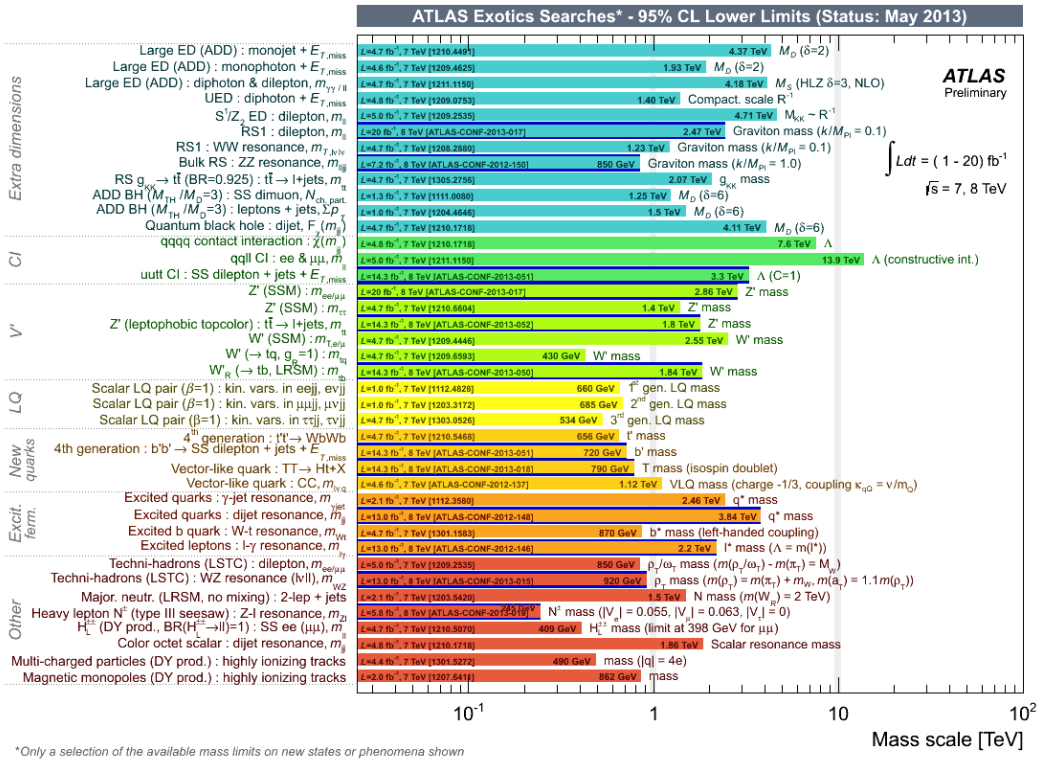


- Recipe to determine efficiency from particle-level information.
- Reproduces reconstructed quantities very well!

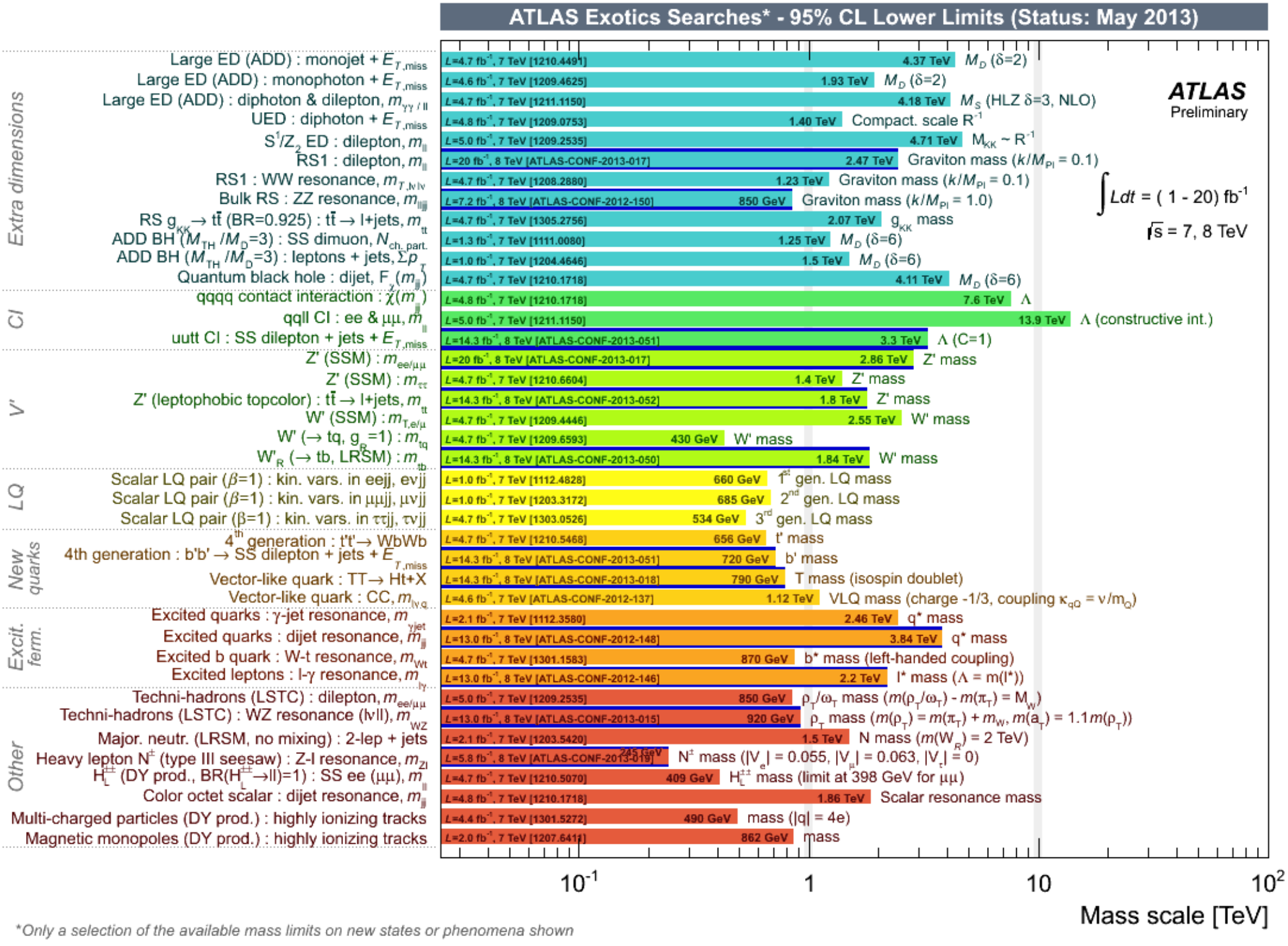
Phys. Rev. D 87, 052002 (2013)
http://hepdata.cedar.ac.uk/view/ins1204447

8 TeV results released next week

Summary



- Rich program of lepton searches at ATLAS, with many results coming out shortly.
- EWK direct SUSY limits flirting with 0.5 TeV (surpassing it in some cases)
- Next year and half will have lots of probing of data in anticipation of Run 2 and unexplored corners



*Only a selection of the available mass limits on new states or phenomena shown

Supplementary

ATLAS RESULTS:
https://twiki.cern.ch/twiki/bin/view/AtlasPublic/WebHome

This presentation...
SUSY
2L + Etmiss
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2013-049/
3L + Etmiss
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2013-035/
4L + Etmiss
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2013-036/
1-2 taus + jets + Etmiss
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2013-026/
2taus + Etmiss
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2013-028/

Exotic
Zb
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2013-056/
Anomalous same-sign dileptons + bjets
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2013-051/

Definitions

$$E_{\mathrm{T}}^{\mathrm{miss,rel.}} = \begin{cases} E_{\mathrm{T}}^{\mathrm{miss}} & \text{if } \Delta\phi_{\ell,j} \geq \pi/2 \\ E_{\mathrm{T}}^{\mathrm{miss}} \times \sin\Delta\phi_{\ell,j} & \text{if } \Delta\phi_{\ell,j} < \pi/2 \end{cases}$$

$$m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}, \mathbf{q}_{\mathrm{T}}) = \sqrt{2(p_{\mathrm{T}}q_{\mathrm{T}} - \mathbf{p}_{\mathrm{T}} \cdot \mathbf{q}_{\mathrm{T}})}$$

$$m_{\mathrm{T2}} = \min_{\mathbf{q}_{\mathrm{T}}} \left[\max \left(m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 1}, \mathbf{q}_{\mathrm{T}}), m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}} - \mathbf{q}_{\mathrm{T}}) \right) \right]$$

2L + Etmiss

SR-$m_{T2,90}$	e^+e^-	$e^\pm\mu^\mp$	$\mu^+\mu^-$	all
Observed	15	19	19	53
Background total	16.6 ± 2.3	20.7 ± 3.2	22.4 ± 3.3	59.7 ± 7.3
WW	9.3 ± 1.6	14.1 ± 2.2	12.6 ± 2.0	36.1 ± 5.1
ZV ($V = W$ or Z)	6.3 ± 1.5	0.8 ± 0.3	7.3 ± 1.7	14.4 ± 3.2
Top	$0.9^{+1.1}_{-0.9}$	5.6 ± 2.1	2.5 ± 1.8	8.9 ± 3.9
Higgs	0.11 ± 0.04	0.19 ± 0.05	0.08 ± 0.04	0.38 ± 0.08
Fake	$0.00^{+0.18}_{-0.00}$	$0.00^{+0.14}_{-0.00}$	$0.00^{+0.15}_{-0.00}$	$0.00^{+0.28}_{-0.00}$
Signal expectation				
$(m_{\tilde{\ell}}, m_{\tilde{\chi}_1^0}) = (191, 90)$ GeV	21.6	0	21.6	43.2
$(m_{\tilde{\ell}}, m_{\tilde{\chi}_1^0}) = (251, 10)$ GeV	12.2	0	12.5	24.7
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (350, 0)$ GeV	11.7	16.6	10.5	38.8
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (425, 75)$ GeV	4.3	6.7	4.4	15.4
Observed σ^{95}_{vis} (fb)	0.44	0.51	0.47	0.81
Expected σ^{95}_{vis} (fb)	$0.50^{+0.22}_{-0.15}$	$0.57^{+0.25}_{-0.17}$	$0.58^{+0.25}_{-0.17}$	$1.00^{+0.41}_{-0.28}$

SR-$m_{T2,110}$	e^+e^-	$e^\pm\mu^\mp$	$\mu^+\mu^-$	all
Observed	4	5	4	13
Background total	6.1 ± 2.2	4.4 ± 2.0	6.3 ± 2.4	16.9 ± 6.0
WW	2.7 ± 1.5	3.6 ± 2.0	2.9 ± 1.6	9.1 ± 4.9
ZV ($V = W$ or Z)	2.7 ± 1.4	0.2 ± 0.1	3.4 ± 1.8	6.3 ± 3.3
Top	0.7 ± 0.7	0.6 ± 0.4	0.0 ± 0.0	1.3 ± 1.0
Higgs	0.05 ± 0.03	0.12 ± 0.04	0.05 ± 0.02	0.22 ± 0.05
Fake	$0.00^{+0.09}_{-0.00}$	$0.00^{+0.13}_{-0.00}$	$0.00^{+0.12}_{-0.00}$	$0.00^{+0.28}_{-0.00}$
Signal expectation				
$(m_{\tilde{\ell}}, m_{\tilde{\chi}_1^0}) = (191, 90)$ GeV	12.3	0	12.0	24.3
$(m_{\tilde{\ell}}, m_{\tilde{\chi}_1^0}) = (251, 10)$ GeV	10.5	0	11.2	21.7
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (350, 0)$ GeV	9.5	14.0	8.7	32.2
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (425, 75)$ GeV	3.7	1.1	3.8	8.5
Observed σ^{95}_{vis} (fb)	0.27	0.35	0.28	0.54
Expected σ^{95}_{vis} (fb)	$0.33^{+0.16}_{-0.10}$	$0.33^{+0.16}_{-0.09}$	$0.33^{+0.16}_{-0.10}$	$0.62^{+0.23}_{-0.16}$

	SR-WWa	SR-WWb	SR-WWc
Observed	123	16	9
Background total	117.9 ± 14.6	13.6 ± 2.3	7.4 ± 1.5
Top	15.2 ± 6.6	2.7 ± 1.1	1.0 ± 0.7
WW	98.6 ± 14.6	10.2 ± 2.1	5.9 ± 1.3
ZV ($V = W$ or Z)	3.4 ± 0.8	$0.26^{+0.31}_{-0.26}$	0.29 ± 0.14
Higgs	0.76 ± 0.14	0.21 ± 0.06	0.10 ± 0.04
fake	$0.02^{+0.33}_{-0.02}$	$0.26^{+0.30}_{-0.26}$	$0.12^{+0.17}_{-0.12}$
Signal expectation			
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (100, 0)$ GeV	31	N/A	N/A
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (140, 20)$ GeV	N/A	8.2	N/A
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (200, 0)$ GeV	N/A	N/A	3.3
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (110, 113)$ GeV	18	4.3	N/A
Observed σ^{95}_{vis} (fb)	1.94	0.58	0.43
Expected σ^{95}_{vis} (fb)	$1.77^{+0.66}_{-0.49}$	$0.51^{+0.21}_{-0.15}$	$0.37^{+0.18}_{-0.11}$

2Tau + Etmiss

SM process	SR OS m_{T2}	SR OS m_{T2} -nobjet
top	$0.2 \pm 0.5 \pm 0.1$	$1.6 \pm 0.8 \pm 1.2$
Z+jets	$0.28 \pm 0.26 \pm 0.23$	$0.4 \pm 0.3 \pm 0.3$
diboson	$2.2 \pm 0.5 \pm 0.5$	$2.5 \pm 0.5 \pm 0.9$
multi-jet & W+jets	$8.4 \pm 2.6 \pm 1.4$	$12 \pm 3 \pm 3$
SM total	$11.0 \pm 2.7 \pm 1.5$	$17 \pm 4 \pm 3$
data	6	14
SUSY Ref. point 1	6.8 ± 1.0	9.2 ± 1.2
SUSY Ref. point 2	7.5 ± 0.7	8.9 ± 0.7

VLQ: *Zb*

	$Z+\geq 2$jets ($N_{tag}\geq 2$)	$p_{\mathrm{T}}(Z) > 150$ GeV	$H_{\mathrm{T}}(\mathrm{jets}) > 600$ GeV
Z+light	850 ± 240	58 ± 17	4.3 ± 1.8
Z+bottom	3380 ± 470	301 ± 55	17.8 ± 4.8
$t\bar{t}$	1730 ± 320	31.1 ± 6.2	5.1 ± 1.4
Other SM	190 ± 60	29.2 ± 7.0	3.0 ± 1.2
Total SM	$6,150 \pm 620$	419 ± 59	30.2 ± 5.3
Data	6,097	386	26
$B\bar{B}$ ($m_B = 600$ GeV)	31.0 ± 4.3	25.7 ± 3.6	19.8 ± 2.7
$T\bar{T}$ ($m_T = 600$ GeV)	21.9 ± 2.8	17.1 ± 2.2	12.2 ± 1.7

SS leptons + *b*-jets

Backgrounds	Channel		
Samples	ee	$e\mu$	$\mu\mu$
Charge misidentification	$0.6 \pm 0.1 \pm 0.2$	$0.9 \pm 0.1 \pm 0.3$	—
Fakes	$0.8 \pm 0.4 \pm 0.3$	$0.2 \pm 0.4 \pm 0.1$	< 1.1
Diboson			
• WZ/ZZ+jets	$0.3 \pm 0.2 \pm 0.1$	$0.3 \pm 0.1^{+0.4}_{-0.2}$	$0.4 \pm 0.2 \pm 0.1$
• $W^{\pm}W^{\pm}$+2 jets	$0.17 \pm 0.09 \pm 0.05$	$0.3 \pm 0.2 \pm 0.1$	$0.2 \pm 0.1 \pm 0.1$
$t\bar{t} + W/Z$			
• $t\bar{t}W$(+jet(s))	$0.6 \pm 0.2 \pm 0.3$	$1.9 \pm 0.2 \pm 0.6$	$1.3 \pm 0.2 \pm 0.4$
• $t\bar{t}Z$(+jet(s))	$0.18 \pm 0.03 \pm 0.06$	$0.66 \pm 0.05 \pm 0.22$	$0.31 \pm 0.04 \pm 0.10$
• $t\bar{t}W^{+}W^{-}$	$0.024 \pm 0.003^{+0.010}_{-0.007}$	$0.072 \pm 0.005^{+0.028}_{-0.020}$	$0.055 \pm 0.004^{+0.022}_{-0.016}$
Total expected background	$2.7 \pm 0.5 \pm 0.4$	$4.4 \pm 0.5^{+0.9}_{-0.7}$	$2.3 \pm 1.2 \pm 0.5$
Observed	3	10	2