SUSY and BSM in ATLAS
Recent Results and more

selected topics only!!!

G. Azuelos

BSM

- narrow resonances:
  - dileptons
  - lepton +MET
  - dijets
  - diphotons
- heavy quarks
- Monojets
- Leptoquarks

Supersymmetry

- inclusive signals:
  - Jets + Etmiss
  - … + 0, 1, 2 leptons
- multileptons
- stable hadronizing particles
- GMSB
  - displaced vertices
  - diphotons + MET

Introduction

Beyond the Standard Model

- wide variety of models and signatures, with unknown parameters
  - exclude regions of parameter space
  - interpret a signature in terms of different models
- narrow resonances relatively easy
  - knowledge of background less critical
- non-resonant signals probe high mass phenomena
  - where the backgrounds are low and where backgrounds, reconstruction efficiencies are well understood

Supersymmetry

- very large parameter space ➔ initial study of simplest models
- inclusive signals: excess in jets, Etmiss (and leptons)
- R-parity violation
- long-lived particles
- interpretation in terms mostly of SUGRA (5 parameters), but also GMSB, (AMSB)

Experimental Challenges

→ see talk by Michel Lefebvre

Impossible to discuss experimental methods in each case

Systematic errors:

- NLO, NNLO calculations, mass-dependent k-factors
- matching of matrix element and parton shower (for multijet processes)
- pdf, alpha_s, QCD scale factors
- QCD, W+jets have high cross sections ➔ data driven techniques, with their uncertaintes
- lepton reconstruction efficiencies, isolation, resolution
- Good Runs Lists…
- pileup reweighting
- luminosity
- limit extraction procedure

Narrow Dilepton resonances

- **Sequential Standard Model**
  - generic Z' with SM couplings to fermions but no coupling to gauge bosons
  - serves as a benchmark
- **E_6-inspired Z' (and other gauge symmetry extensions)**
  - $E_6 \rightarrow SO(10) + U(1)_\psi$
    $\hookrightarrow SU(5) + U(1)_\chi$

$$Z' = \cos\theta_{E6}\, Z'_\chi + \sin\theta_{E6}\, Z'_\psi$$

$$\theta_{E6} = \pi - \tan^{-1}\sqrt{5/3} \Rightarrow Z'_\eta$$

$$\theta_{E6} = \tan^{-1}\sqrt{3/5} \Rightarrow Z'_I$$

$$\theta_{E6} = \tan^{-1}\sqrt{15}/9 \Rightarrow Z'_S$$

$$\theta_{E6} = \tan^{-1}\sqrt{15} \Rightarrow Z'_N$$

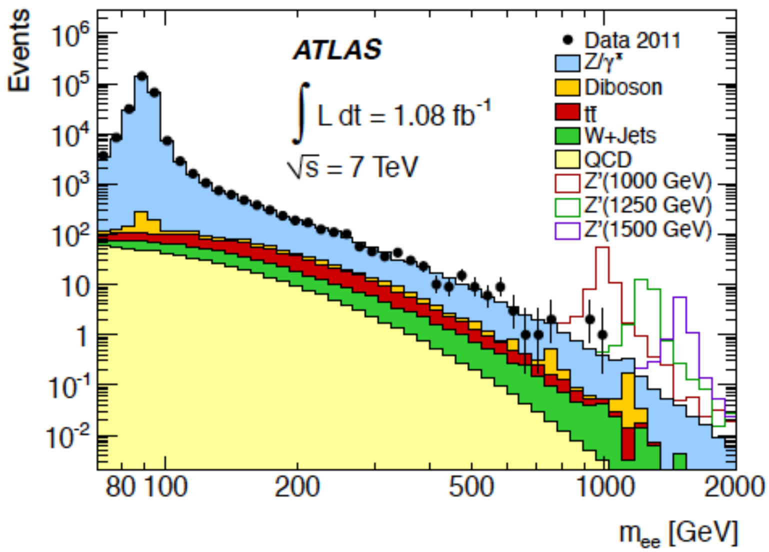
- **Graviton KK**
- **technirho, techniomega**
- **Various other models….**

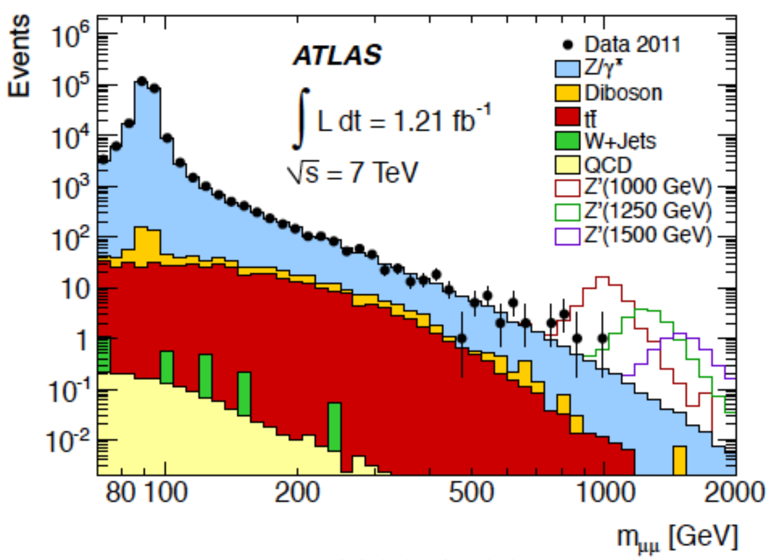
Z_{KK}, Z^*, **3-3-1**, little Higgs Z_H, $LRSM$

Stueckelberg Z', leptophobic or fermiophobic Z'

P. Langacker, Rev Mod Phys 81 (2009) 1199 arXiv:0801.1345v3

Resonant dileptons





arXiv:1108.1582

Drell-Yan production well predicted

NNLO calculations available; used to derive mass-dependent derive k-factors

Other backgrounds estimated by data-driven method or by MC

- multijets: reverse isolation
- W+jets
- top pair
- dibosons

Background scaled to data in Z peak region

uncertainties:

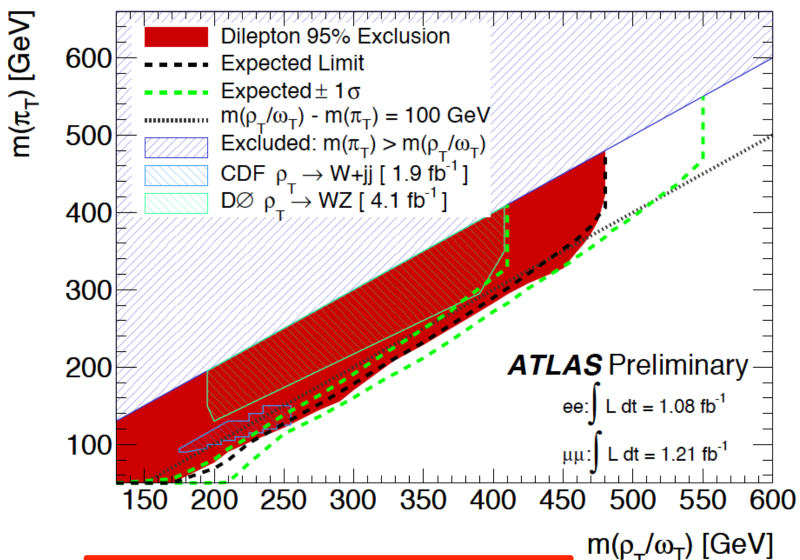
- k- factors, pdf's
- normalization
- trigger/reconstruction

Limits on dilepton resonances

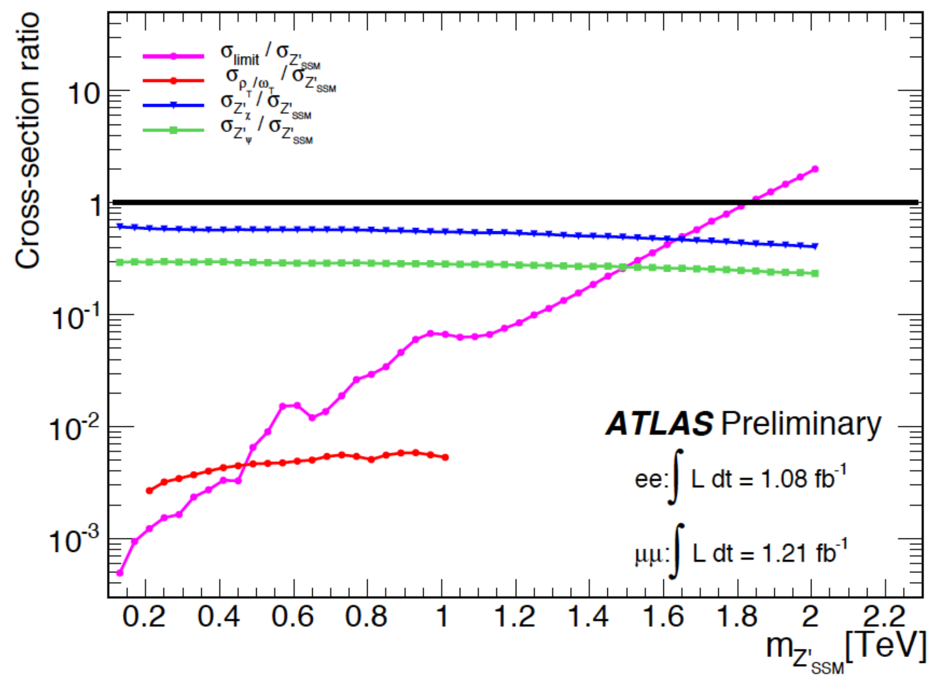
95% CL limits

Model	e^+e^-	$\mu^+\mu^-$	$\ell^+\ell^-$
Z'_{SSM}	1.70 (1.70)	1.61 (1.61)	1.83 (1.83)
G^*	1.51 (1.50)	1.45 (1.44)	1.63 (1.63)

	E_6 Z' Models						RS Graviton			
Model/Coupling	Z'_ψ	Z'_N	Z'_η	Z'_I	Z'_S	Z'_χ	0.01	0.03	0.05	0.1
Mass limit [TeV]	1.49	1.52	1.54	1.56	1.60	1.64	0.71	1.03	1.33	1.63



Low Scale Technicolor

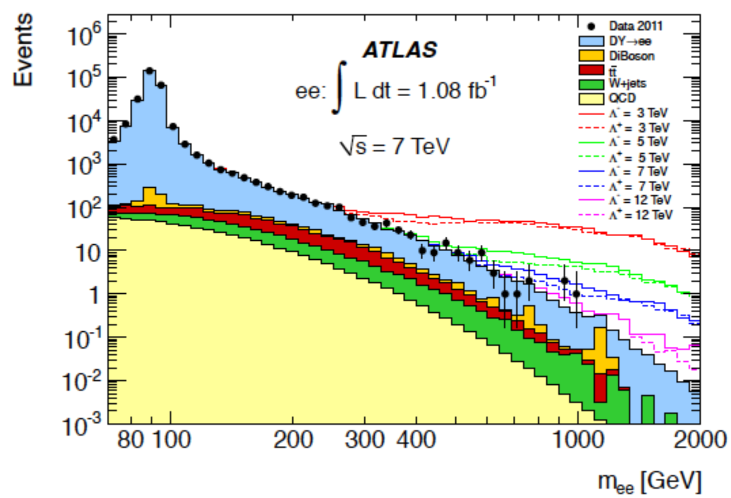


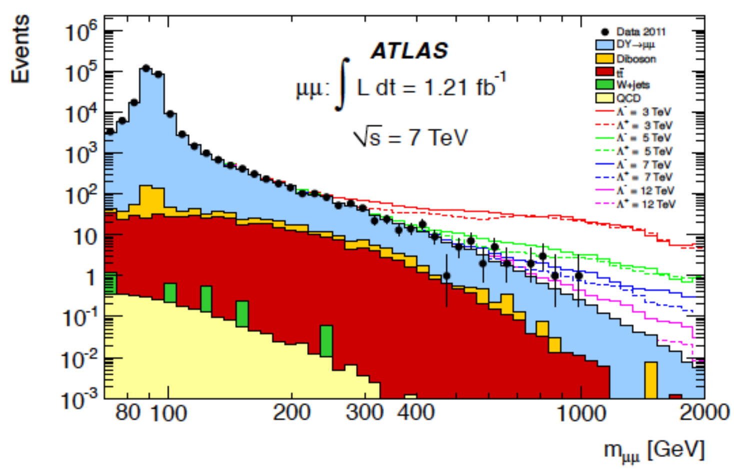
ATLAS-CONF-2011-125
20 September 2011

Contact Interactions

$$\mathcal{L} = \frac{g^2}{2\Lambda^2}\left[\eta_{LL}\cdot\bar{\ell}_L\gamma_\mu\ell_L\cdot\bar{q}_L\gamma_\mu q_L + 2\eta_{LR}\cdot\bar{\ell}_L\gamma_\mu\ell_L\cdot\bar{q}_R\gamma_\mu q_R + \eta_{RR}\cdot\bar{\ell}_R\gamma_\mu\ell_R\cdot\bar{q}_R\gamma_\mu q_R\right]$$

$$\left(g=\sqrt{4\pi}\right)$$





All quarks participate in contact interaction with the same strength.

Interference very important (dominant)

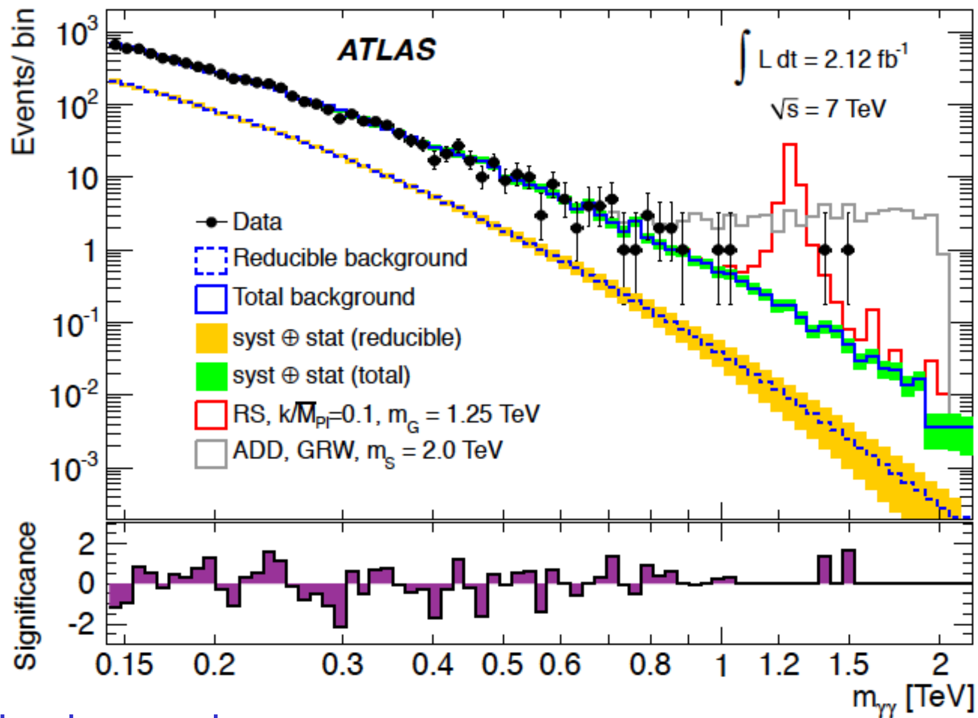
$$\frac{d\sigma}{dm_{\ell\ell}} = \frac{d\sigma_{DY}}{dm_{\ell\ell}} - \eta_{LL}\frac{F_I(m_{\ell\ell})}{\Lambda^2} + \frac{F_C(m_{\ell\ell})}{\Lambda^4}$$

TABLE V. Expected and observed 95% CL lower limits on the contact interaction energy scale Λ for the electron and muon channels, as well as for the combination of those channels. Separate results are provided for the different choices of flat priors: $1/\Lambda^2$ and $1/\Lambda^4$.

Channel	Prior	Expected limit (TeV) Constr.	Expected limit (TeV) Destr.	Observed limit (TeV) Constr.	Observed limit (TeV) Destr.
e^+e^-	$1/\Lambda^2$	9.6	9.3	10.1	9.4
	$1/\Lambda^4$	8.9	8.6	9.2	8.6
$\mu^+\mu^-$	$1/\Lambda^2$	8.9	8.6	8.0	7.0
	$1/\Lambda^4$	8.3	7.9	7.6	6.7
Comb.	$1/\Lambda^2$	10.4	10.1	10.2	8.8
	$1/\Lambda^4$	9.6	9.4	9.4	8.4

Diphotons

New



Large Extra Dimensions:
virtual graviton exchange

$$\sigma \sim \eta_G = \frac{\mathcal{F}}{M_S^4}$$

$\mathcal{F} = 1$, (GRW) [3];

$$\mathcal{F} = \begin{cases} \log\left(\frac{M_S^2}{\hat{s}}\right) & n = 2 \\ \frac{2}{n-2} & n > 2 \end{cases}, \text{ (HLZ) [4];}$$

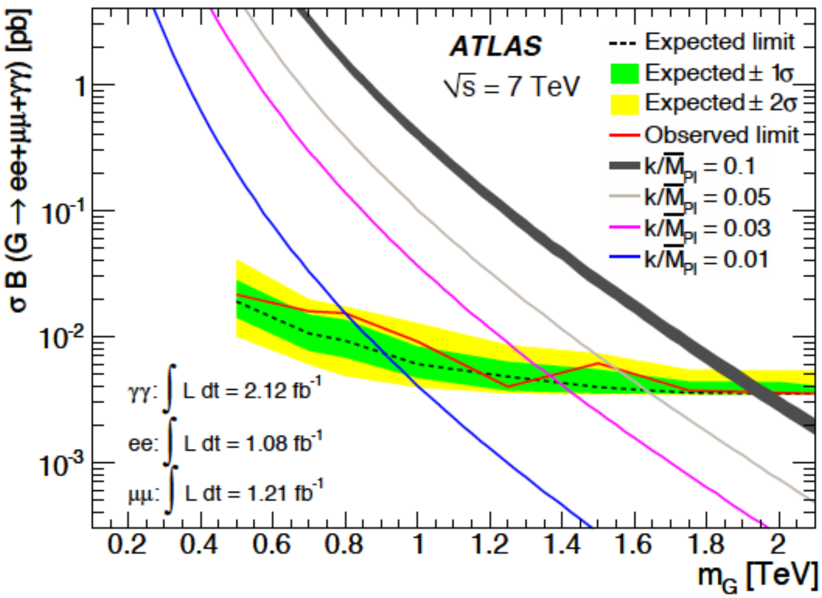
$\mathcal{F} = \pm\frac{2}{\pi}$, (Hewett) [5];

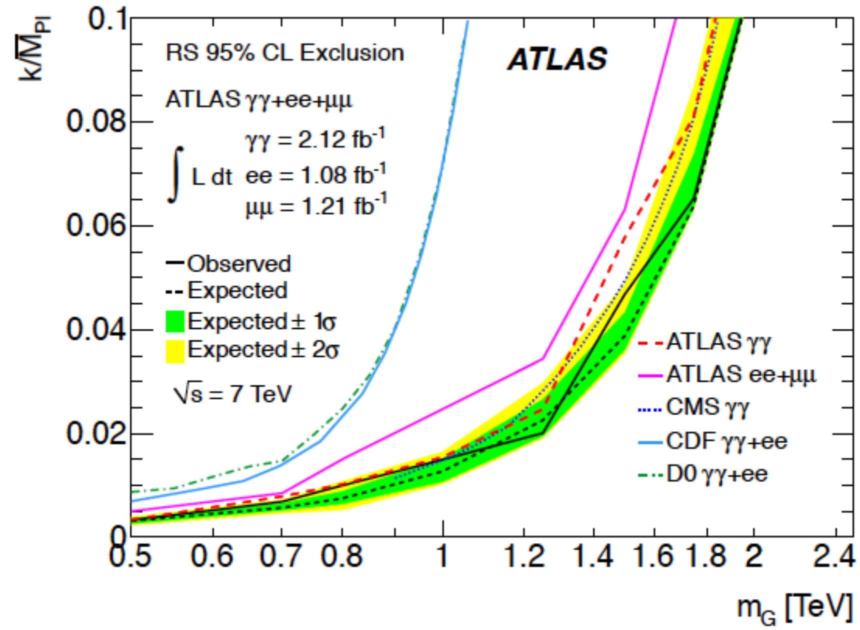
backgrounds

- prompt photons (pythia, DIPHOX for NLO)
- fakes: γ + j, j j by choosing non-tight photons

k-factor Value	GRW	Hewett Pos	Hewett Neg	HLZ $n=3$	HLZ $n=4$	HLZ $n=5$	HLZ $n=6$	HLZ $n=7$
1	2.73	2.44	2.16	3.25	2.73	2.47	2.30	2.17
1.70	2.97	2.66	2.27	3.53	2.97	2.69	2.50	2.36

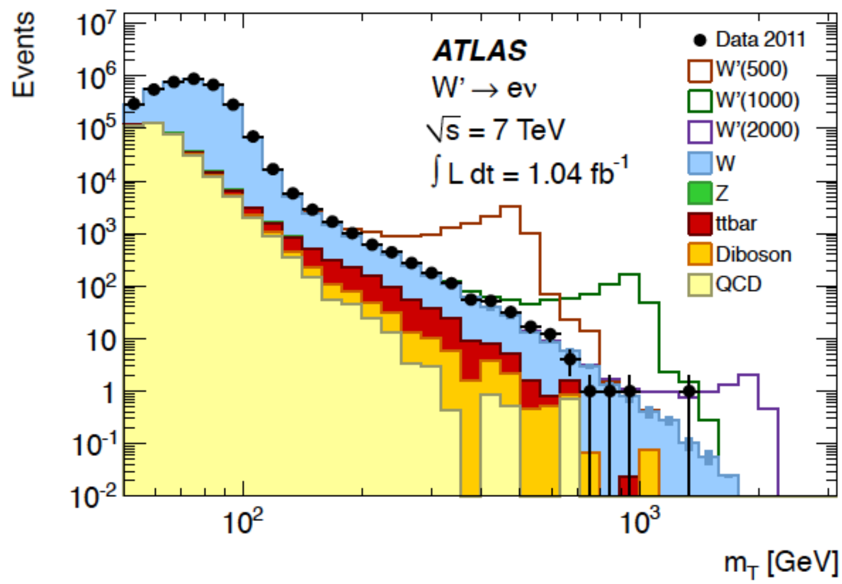
diphotons – Bounds on RS Graviton

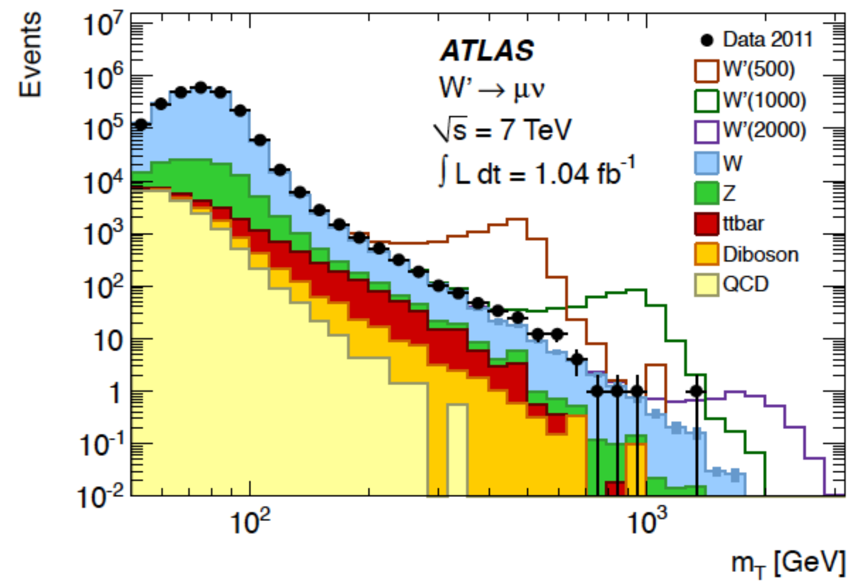


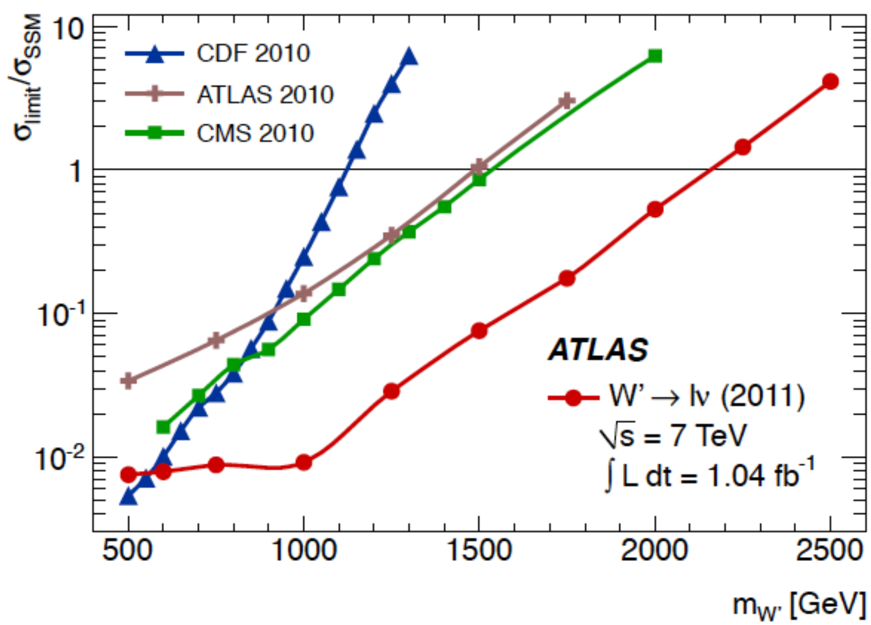


k-Factor Value	Channel(s) Used	95% CL Limit [TeV] k/M_{Pl} Value 0.01	0.03	0.05	0.1
1	$G \to \gamma\gamma$	0.74	1.26	1.41	1.79
	$G \to \gamma\gamma/ee/\mu\mu$	0.76	1.32	1.47	1.90
1.75	$G \to \gamma\gamma$	0.79	1.30	1.45	1.85
	$G \to \gamma\gamma/ee/\mu\mu$	0.80	1.37	1.55	1.95

W’





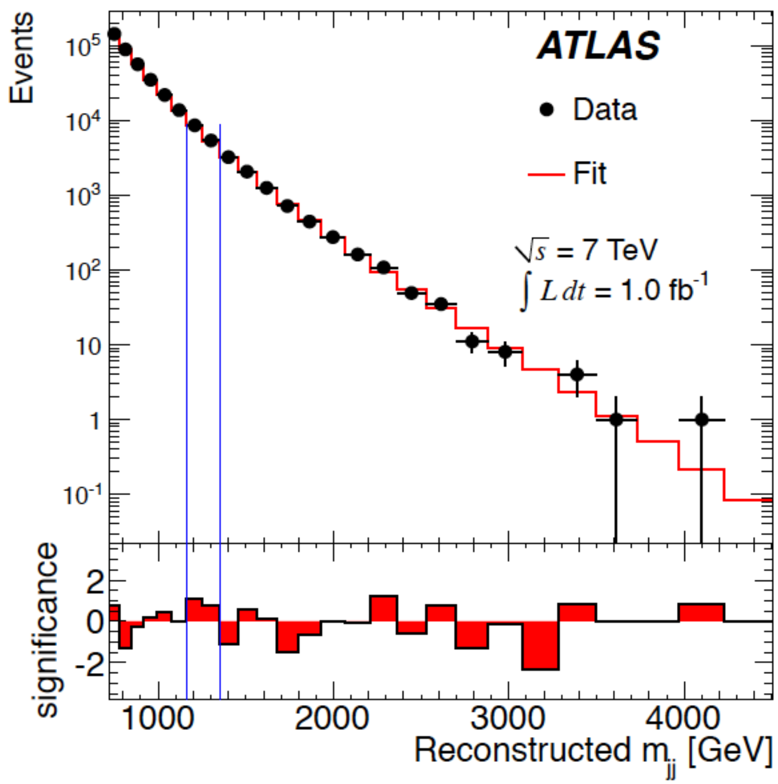


Sequential Standard Model used as benchmark

$$m_T = \sqrt{2 p_T E_T^{\text{miss}} (1 - \cos\varphi_{\ell\nu})}$$

mass-dependent k-factors to NNLO

dijet resonance search



$$f(x) = p_1(1-x)^{p_2} x^{p_3 + p_4 \ln x}$$

Various models

- excited quark q* (contact interaction)

$$q\,g \to q^* \Rightarrow \text{compositeness scale } \Lambda \equiv m_{q^*}$$

- axigluon: axial coupling to quarks

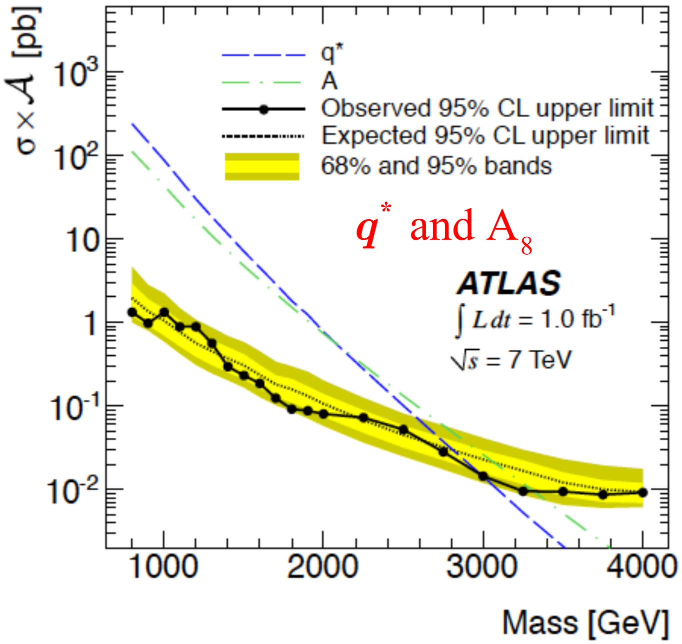
$$\mathcal{L}_{Aq\bar{q}} = g_{\text{QCD}}\,\bar{q}\,A^a_\mu \frac{\lambda^a}{2} \gamma^\mu \gamma_5\, q; \quad g_{\text{QCD}} = \sqrt{4\pi\alpha_s}$$

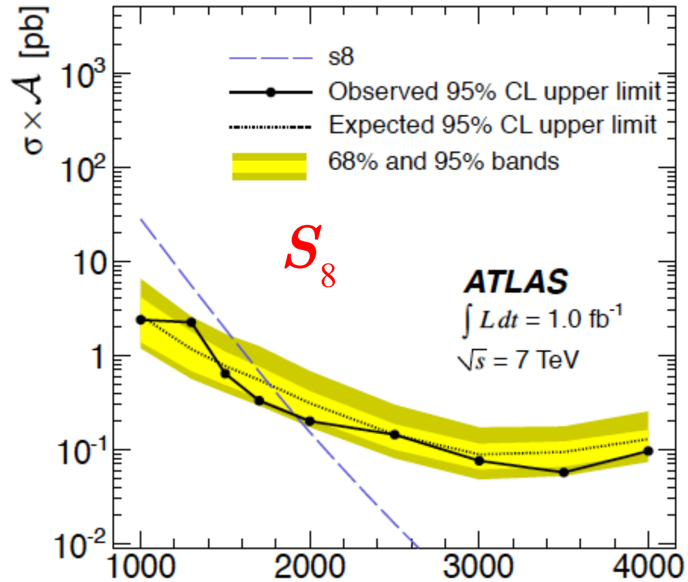
- color-octet scalar

$$\mathcal{L}_{gg8} = g_{\text{QCD}}\, d^{ABC} \frac{\kappa_s}{\Lambda_s} S^A_8 F^B_{\mu\nu} F^{C,\mu\nu}$$

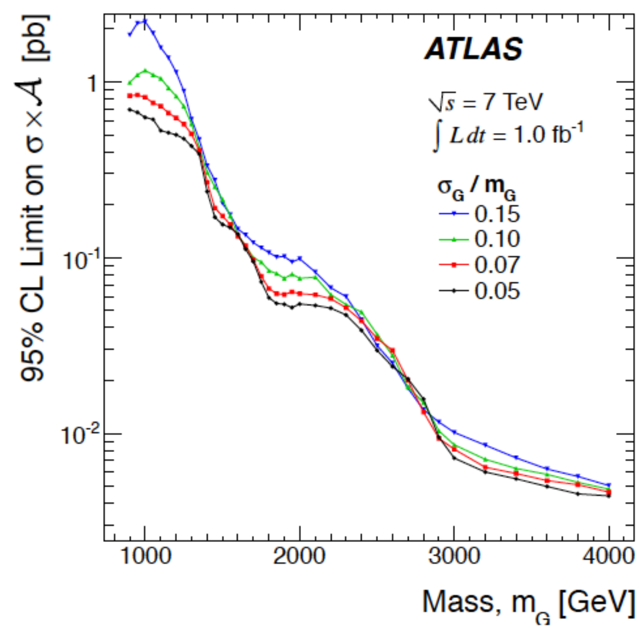
$F^B_{\mu\nu}$ = gluon field strength tensor (color index A)

dijets





Model	95% CL Limits (TeV)	
	Expected	Observed
Excited Quark q^*	2.81	2.99
Axigluon	3.07	3.32
Colour Octet Scalar	1.77	1.92

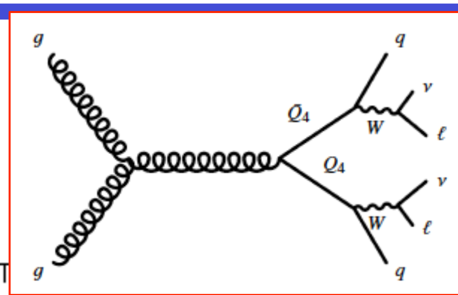


4^{th} family quarks

arXiv:1108.0366v2 [hep-ex]

from same sign dilepton events

$$d_4\bar{d}_4 \rightarrow W^- t\, W^+ \bar{t}$$



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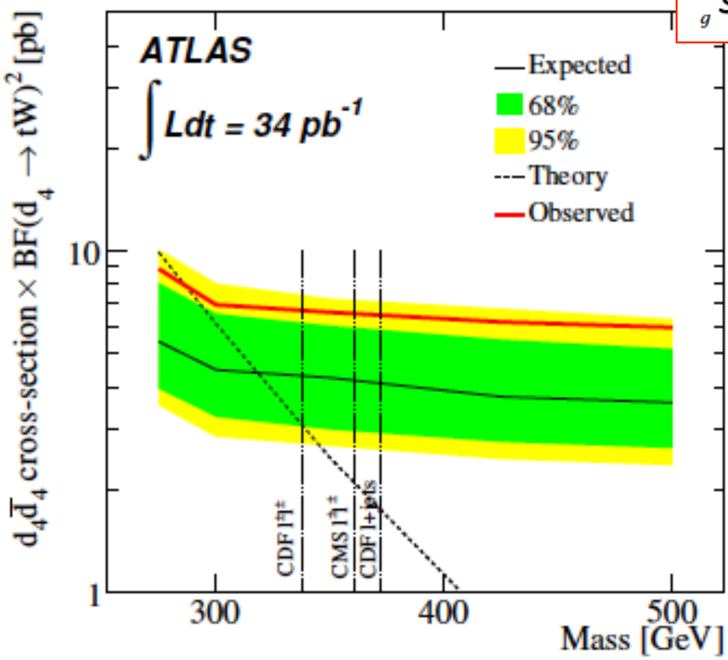
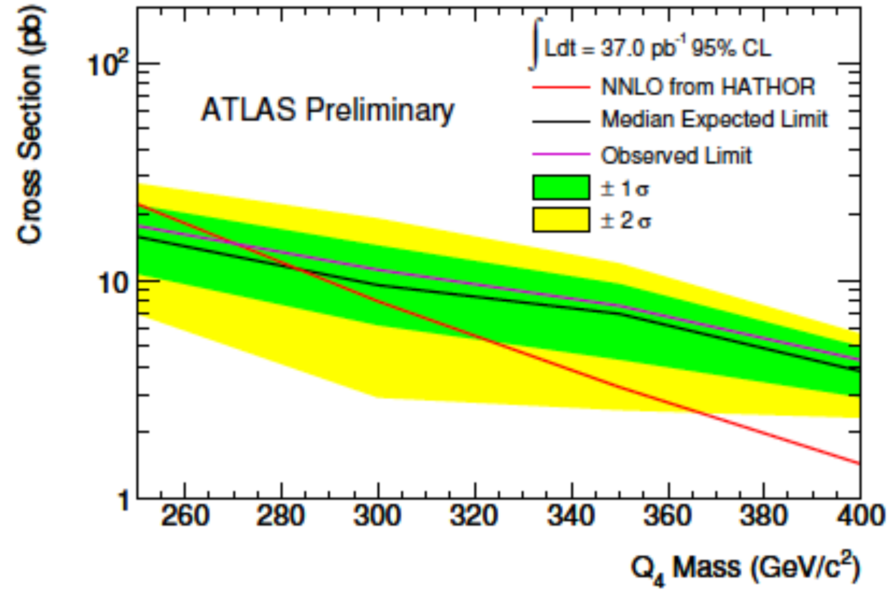
$$u_4\bar{u}_4 \rightarrow W^+ b\, W^- \bar{b}$$





… more soon with higher luminosity

SM 4^{th} family quarks

- allow the Higgs mass to be heavy (but now excluded…)
- cannot be too heavy without causing vacuum instability or violation of perturbative unitarity

New

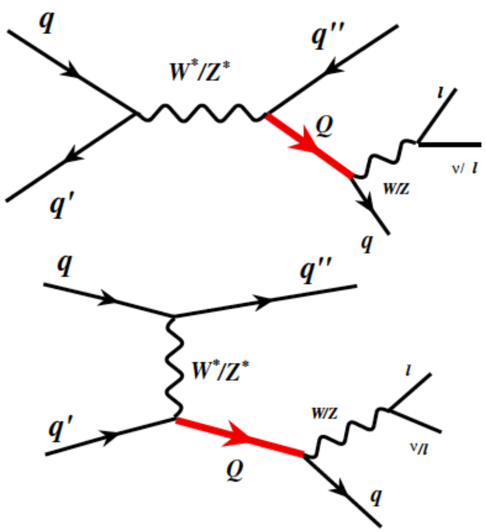
Vector-Like Quarks coupling to light generations

vector-like quarks:

- both chiralities have the same transformation properties: singlets or doublets in SU(2)
- predicted by many models
  - E_6 : down-type quarks
  - DEWSB: little Higgs, top condensation, beautiful mirrors, composite Higgs
  - extra dimensions, for even number of spatial dimensions
- EW constraints
  - expected generally to couple to 3rd generation because less contrained
  - in certain scenarios, mixings with SM quarks can cancel
    - → no EWPM constraint from first generations
    - → strong signal at LHC
- motivation
  - BSM models with custodial symmetry to protect Zbb (Agashe et al., Physics Letters B 641 (2006) 62–66)
  - extra dimension models
  - composite Higgs model (M Redi and A. Weiler, JHEP11 (2011) 108)

CMS has looked for T → t Z in pair production (Z + 1 lepton): mT > 475 GeV if 100% BR
arXiv:1109.4985

vector-like quarks



$$\mathcal{L} = \frac{g}{\sqrt{2}}\left(\kappa_{uD}\, W_\mu^+\, \bar{u}_R \gamma^\mu D_R + \kappa_{dU}\, W_\mu^-\, \bar{d}_R \gamma^\mu U_R\right) + \frac{g}{2\cos\theta_W}\left(\kappa_{uU} \bar{u}_R \gamma^\mu U_R + \kappa_{dD} \bar{d}_R \gamma^\mu D_R\right)$$

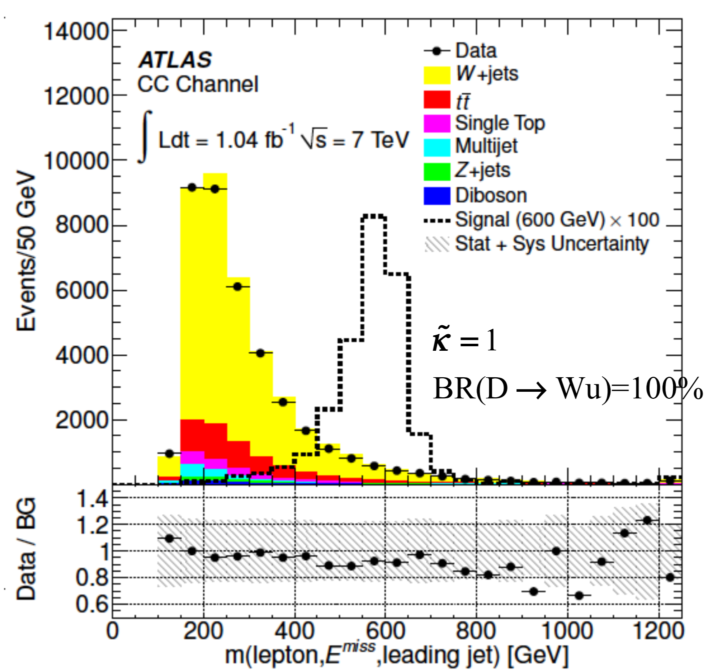
$$\tilde{\kappa} = \frac{v}{M}\kappa$$

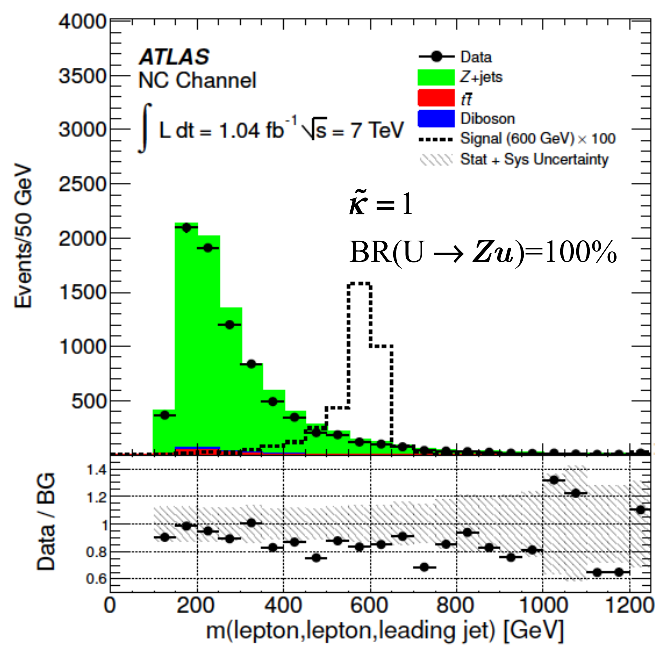
(only RH coupling shown, for doublet vlq)

single production more sensitive

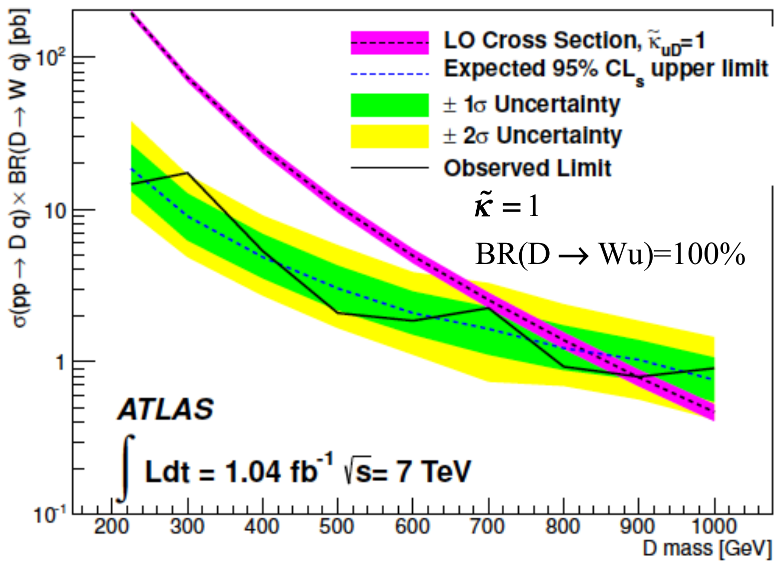
dominated by t-channel ➔ forward jet

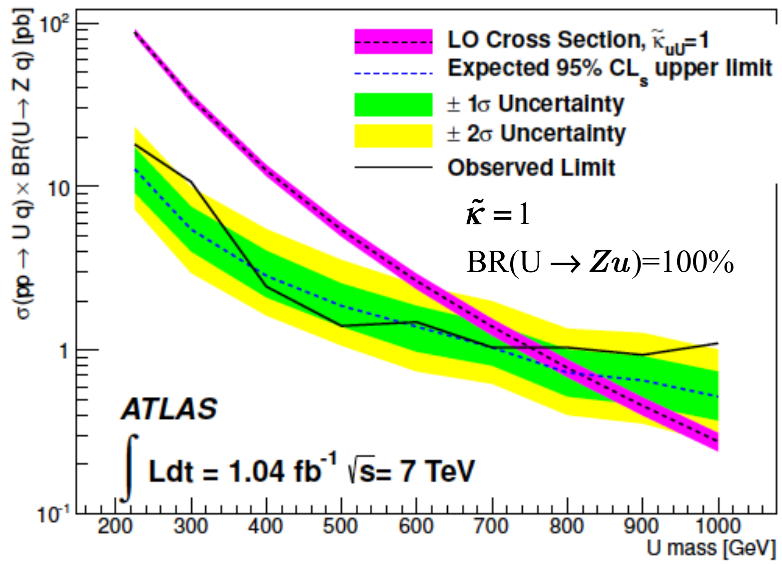
both charged and neutral current channels





vlq





Mass [GeV]	CC $\sigma\times$ BR [pb]	NC $\sigma\times$ BR [pb]	$\tilde{\kappa}^2_{uD}$	$\tilde{\kappa}^2_{uU}$	CC$^-$ $\sigma\times$ BR [pb]
225	15	18	0.075	0.21	12
300	17	11	0.24	0.31	5.6
400	5.3	2.4	0.21	0.19	3.8
500	2.1	1.4	0.19	0.26	1.1
600	1.9	1.5	0.37	0.56	1.9
700	2.2	1.0	0.86	0.75	2.2
800	0.93	1.0	0.66	1.33	0.97
900	0.80	0.9	1.0	2.1	0.70
1000	0.91	1.1	1.9	4.0	0.50

constraints on coupling in degenerate bi-doublet model

Degenerate bidoublet:

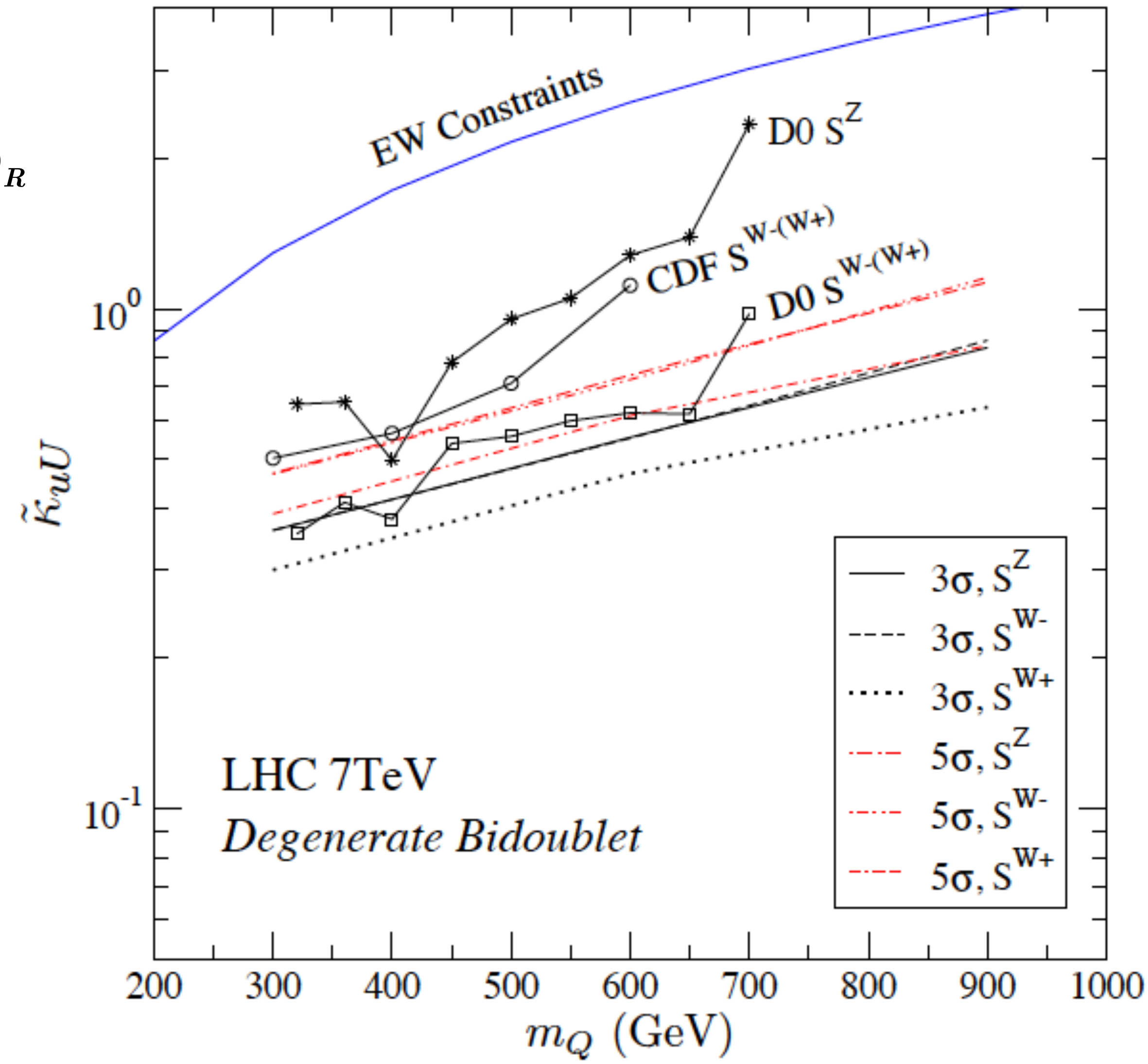
$$(2,2) \text{ in } SU(2)_L \otimes SU(2)_R$$

hypercharges 1/6 and 7/6

$$\begin{pmatrix} X_{5/3} \\ X'_{2/3} \end{pmatrix} \text{ and } \begin{pmatrix} U_{2/3} \\ D_{-1/3} \end{pmatrix}$$

same Yukawa couplings to SM u quark.

Mixing of up with the two charge 2/3 quarks cancel exactly, leaving no observable correction to SM coupling



A. Atre et al., arXiv:1102.1987v1

Monojets

High pT Jet recoiling against an invisible particle such as

- graviton in ADD model of large extra dimensions
- Wimp pairs

3 regions selected: LowPT, HighPT, VeryHighPT

- pt(j1) > 120, 250, 350 GeV
- MET > 120, 220, 300 GeV
- pt(j2) < 30, 60, 60 GeV

Z+j, W+j are dominant backgrounds, but also QCD (data driven) and beam related background

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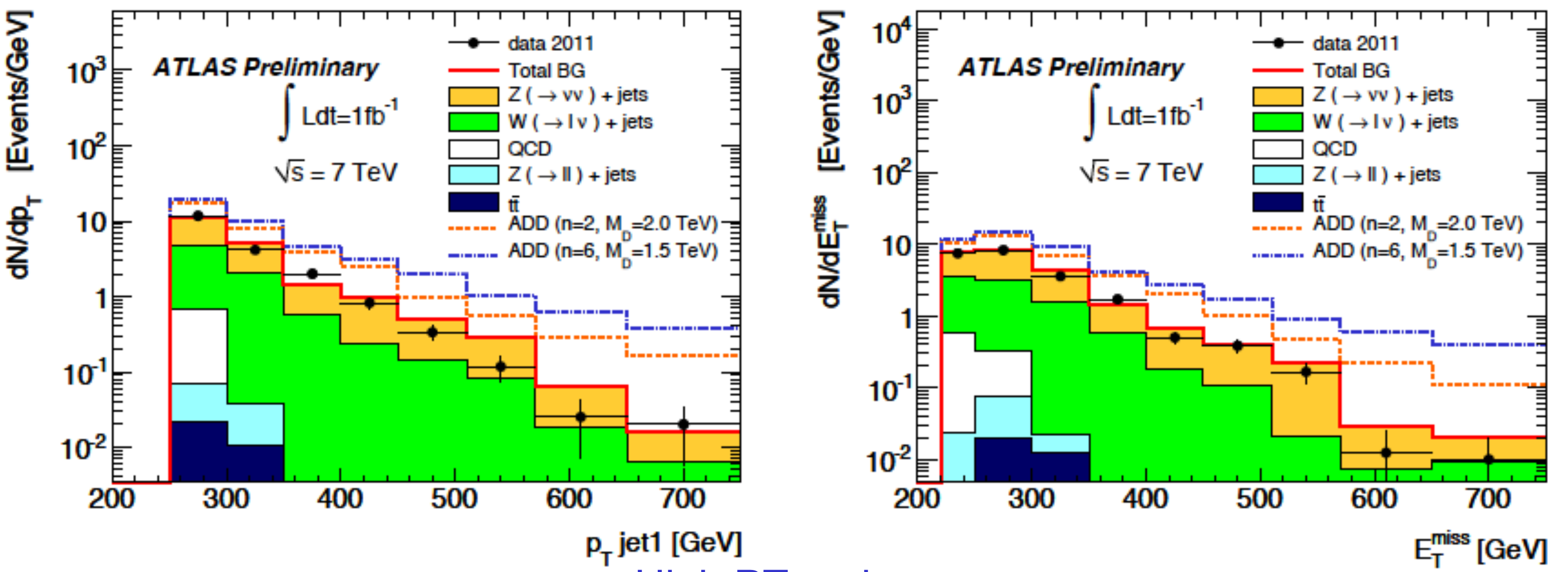
21 July 2011



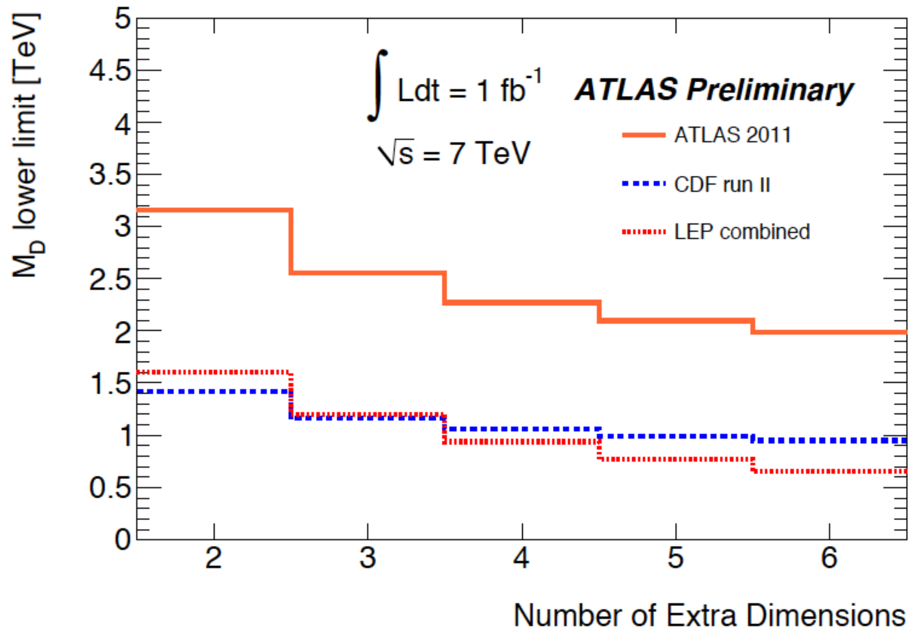
High PT region

limits on ADD

Limit on MD depends on the number of extra dimensions

Validity of the theory breaks when $\sqrt{s} \sim M_D$

- ➔ truncate phase space for cross section evaluation
- ➔ changes the limit by a few percent



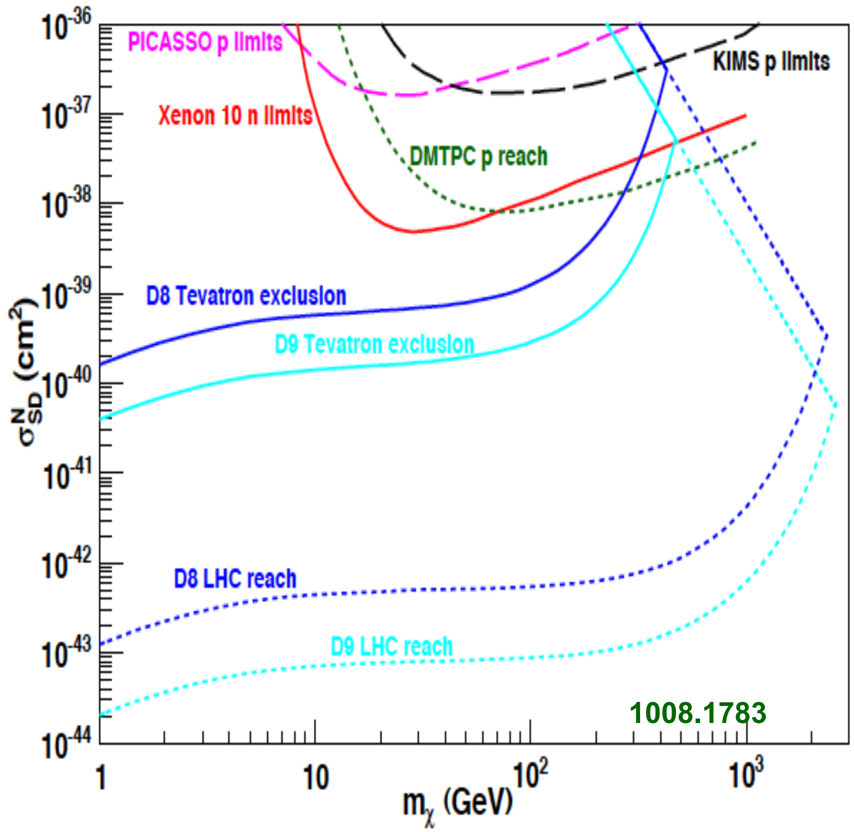
Model-independent cross section limit (95% CL)
2.02 pb, 0.13 pb and 0.045 pb for the LowPt, HighPt and veryHighPt regions

monojets and dark matter

→ *see seminar by W. Shepherd on Monday*

Assume effective interaction qqχχ due to exchange of heavy particle

- coupling can be scalar, vector, axial-vector…, can involve gluons
- the same coupling (diagram) applies to dark matter direct detection:
  χ + (A,Z) → χ + (A,Z)
- interpret the LHC limit in terms of WIMP cross section on nucleons
- very good sensitivity to spin-dependent interactions
- also to spin-independent interaction for low mass WIMP



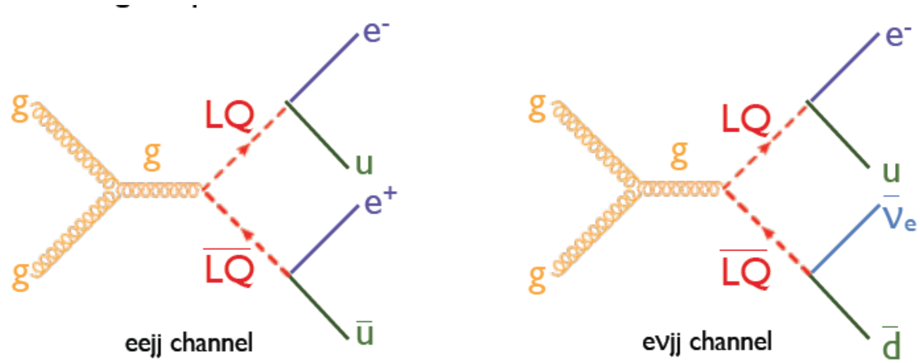
Name	Operator	Coefficient
D8	$\bar{\chi}\gamma^\mu\gamma^5\chi\bar{q}\gamma_\mu\gamma^5 q$	$1/M_*^2$
D9	$\bar{\chi}\sigma^{\mu\nu}\chi\bar{q}\sigma_{\mu\nu}q$	$1/M_*^2$

Bai, Fox and Harnik, 1005.3797
J. Goodman et al., 1008.1783
Akula et al., 1103.5061
J. Goodman and W. Shepherd, 1111.2359

scalar Leptoquarks

showing the 35pb-1 analysis

New results coming out very soon…

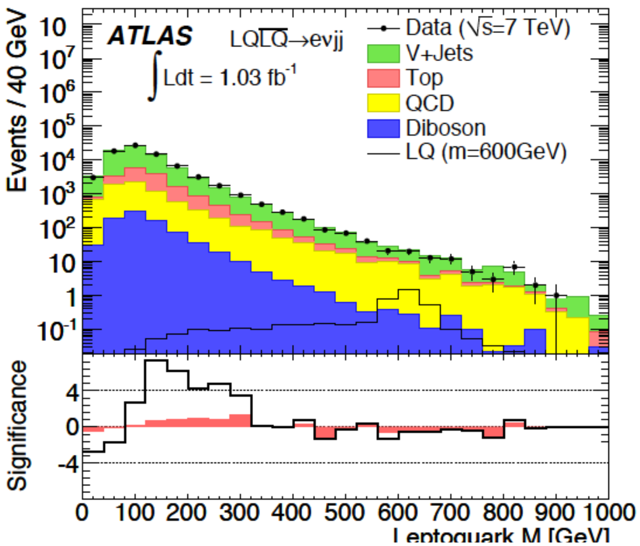


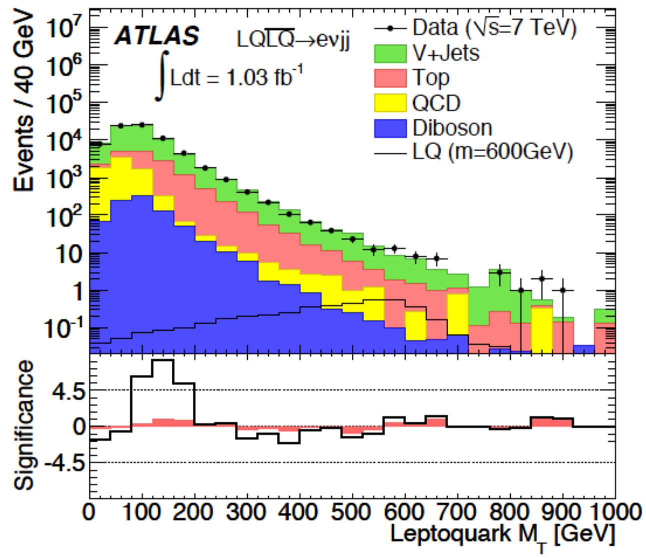
clean, simple signal

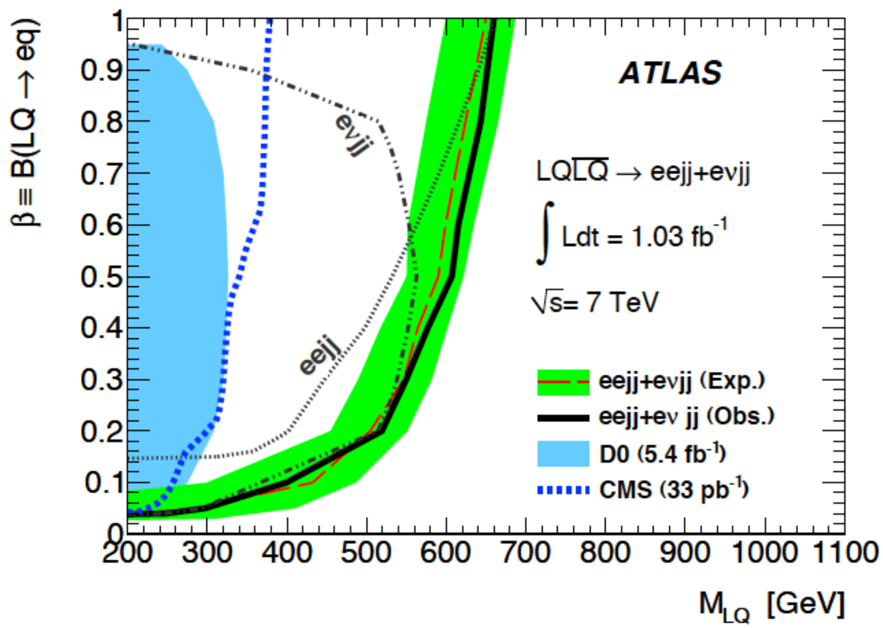
pair production cross section is (almost) model-independent

$eejj$ and $\mu\mu jj$	$e\nu jj$	$\mu\nu jj$
$M_{ll} > 120$ GeV	$M_T > 200$ GeV	$M_T > 160$ GeV
$M_{LQ} > 150$ GeV	$M_{LQ} > 180$ GeV	$M_{LQ} > 150$ GeV
$p_T^{all} > 30$ GeV	$M_{LQ}^T > 180$ GeV	$M_{LQ}^T > 150$ GeV
$S_T^\ell > 450$ GeV	$S_T^\nu > 410$ GeV	$S_T^\nu > 400$ GeV

scalar Leptoquarks







similar limit contour for muon channels

Other interesting BSM topics…

- **Diboson resonances**
  - Neutral resonances
    - Signals similar to Higgs, but could be vector or tensor

$$G^* \to ZZ \to 4\ell \text{ or } 2\ell 2j \text{ or } 2\ell + \text{MET}$$

$$Z' \text{ or } \rho_T \text{ or } G^* \to \text{WW} \to \ell\nu\ell\nu \text{ or } \ell\nu jj$$

  - Charged resonances

$$W' \text{ or } \rho_T \text{ or } G^* \to WZ \to \ell\nu\ell\ell \text{ or } \ell\nu jj \text{ or } \ell\ell jj$$

Results coming out soon…

- **Left-Right Symmetric model**
  - WR and heavy Majorana neutrino

$q\bar{q} \to W_R \to lN$, with N decaying subsequently to $N \to lW_R^* \to ljj$

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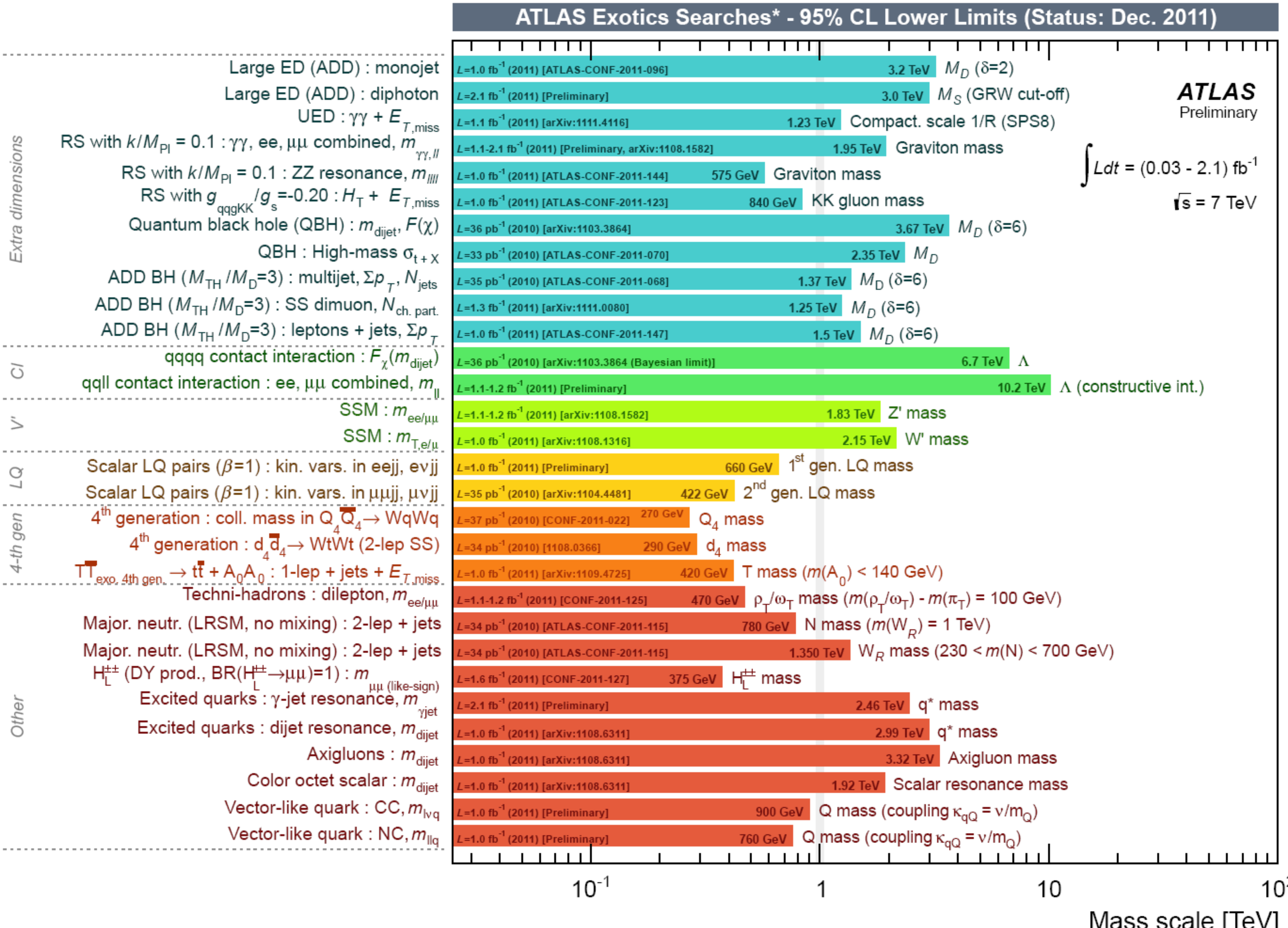
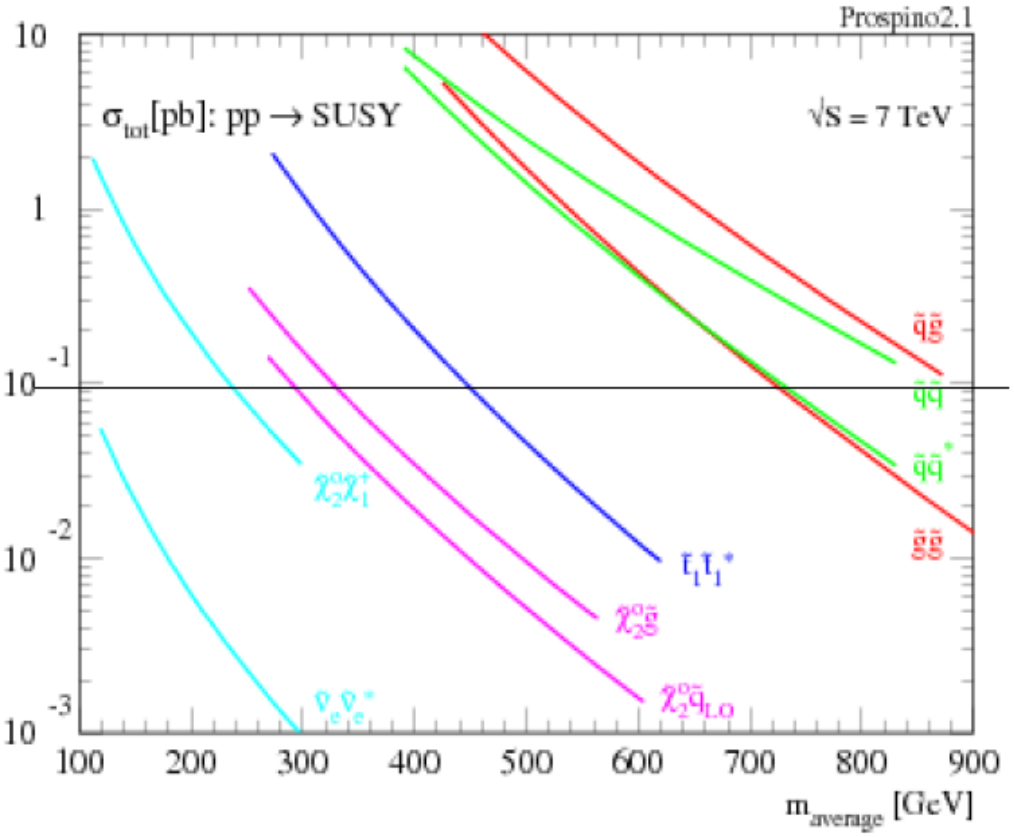
- **strong gravity, black holes, ttbar charge asymmetry,**
- **many others …**

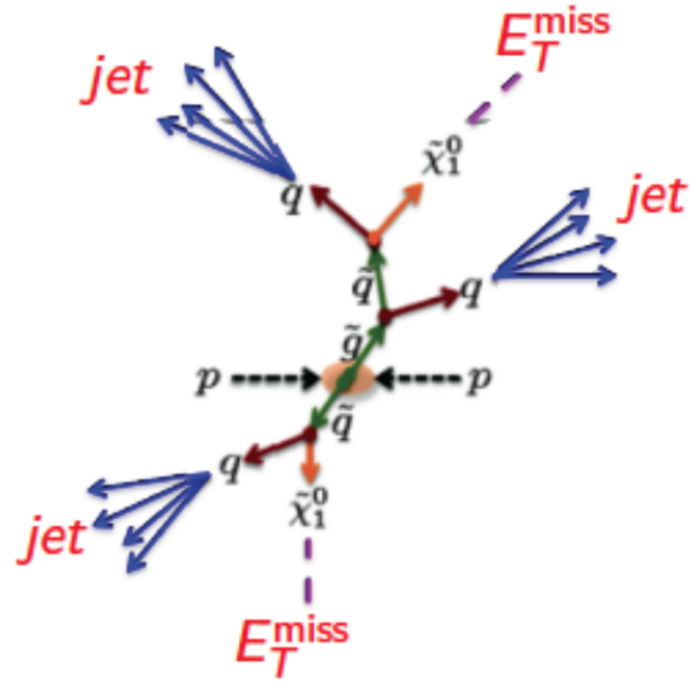
Summary Tables

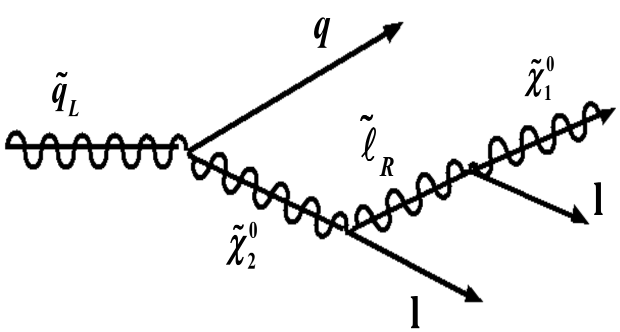


*Only a selection of the available results leading to mass limits shown

Supersymmetry: jets, MET and leptons

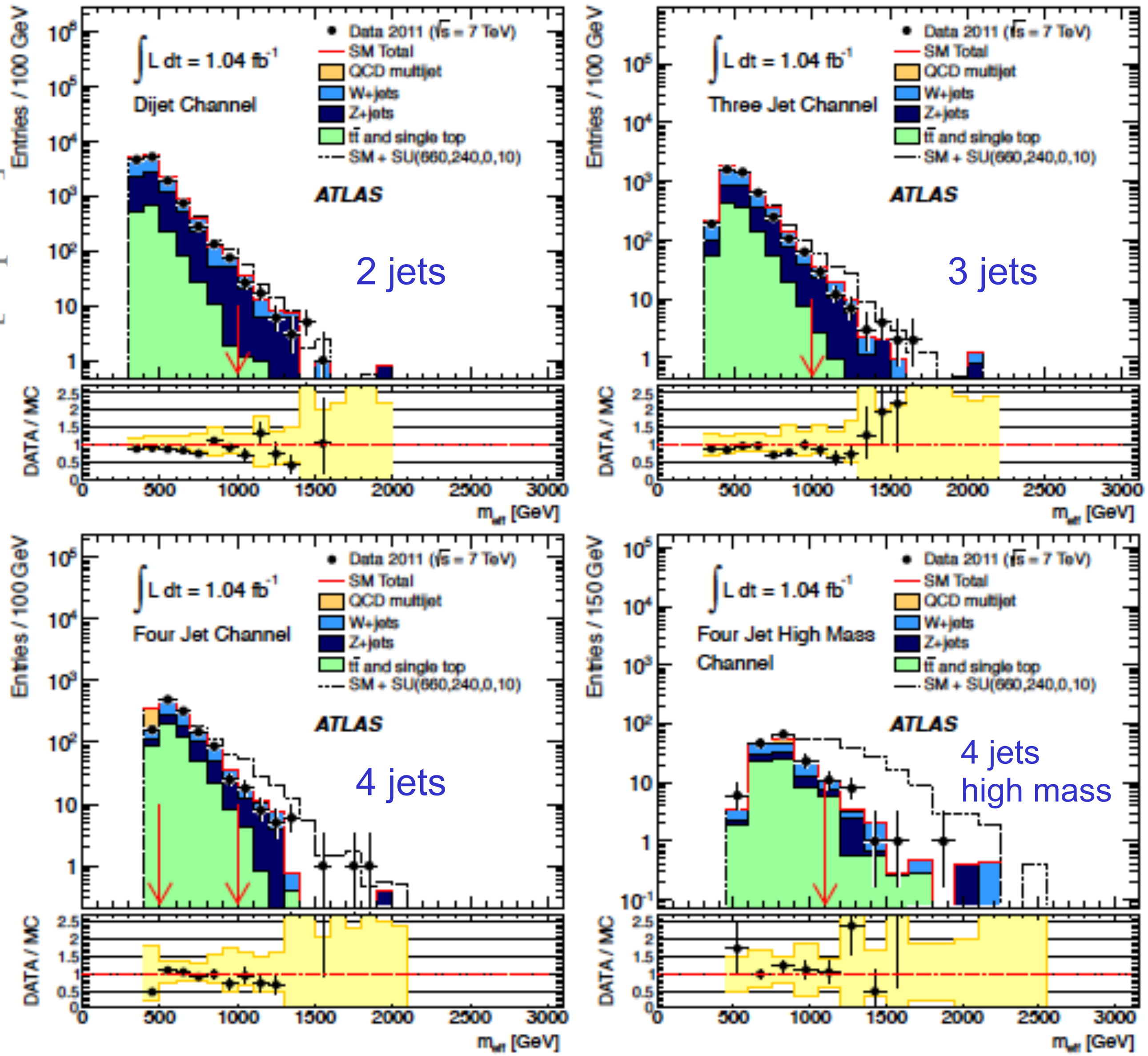






$$\tilde{g} \rightarrow \tilde{q}\, q$$
$$\hookrightarrow \chi^{\pm} q$$
$$\hookrightarrow \ell\, \nu\, \tilde{\chi}_1^0$$

Jets, MET and no lepton



$E_T^{\text{miss}} > 130$ GeV

$p_T(\text{jet1}) > 130$ GeV

$p_T(\text{jet2+}) > 40$ GeV

$\text{m}_{eff} > 1000$ GeV

$$m_{eff} \equiv E_T^{\text{miss}} + \sum |p_T(\text{jets})|$$

high mass:

$p_T(\text{jet2+}) > 80$ GeV

$\text{m}_{eff} > 1100$ GeV

signal:

$m_0 = 660$ GeV,

$m_{1/2} = 240$ GeV,

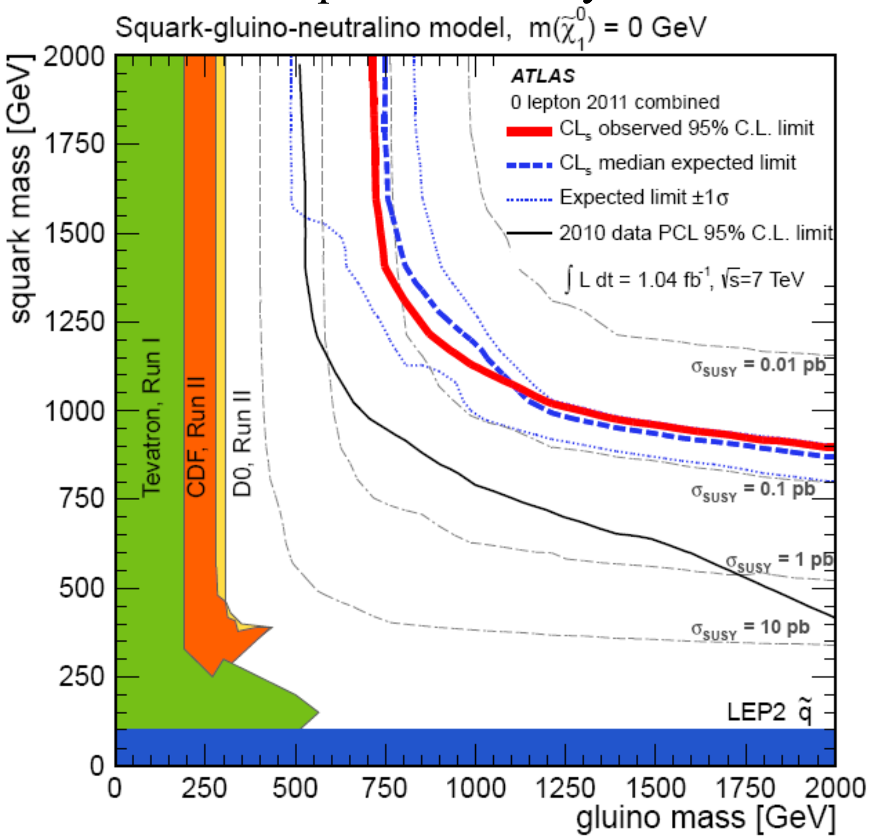
$A_0 = 0,\ \tan\beta = 10,\ \mu > 0$

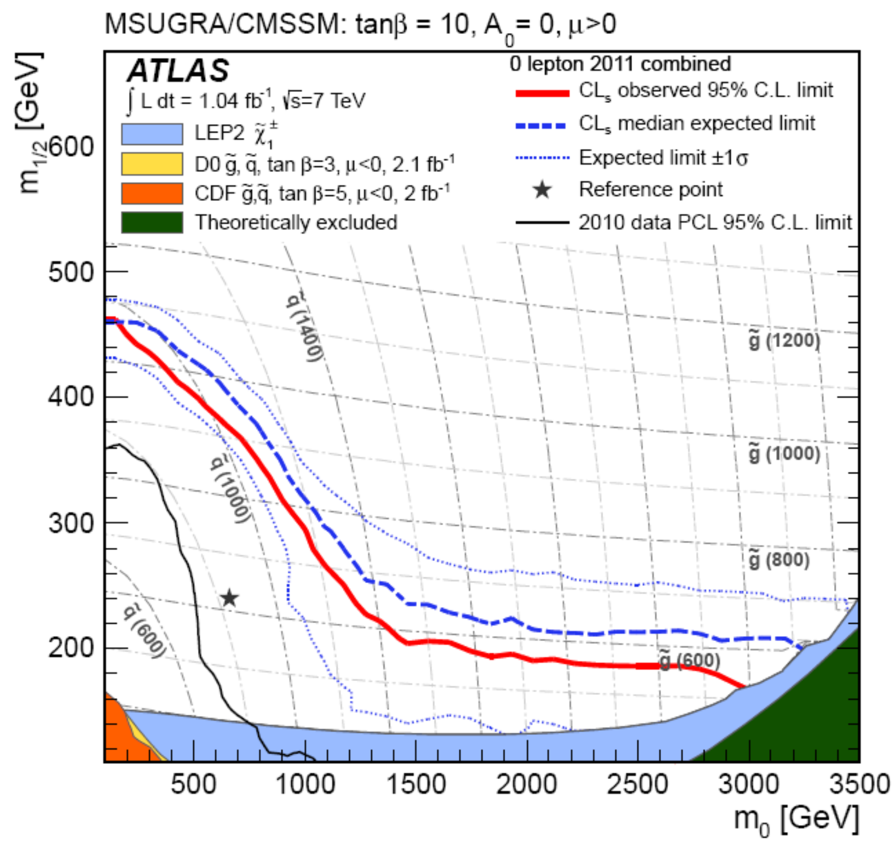
Jets + ETmiss

simplified model:

$m(\tilde{\chi}_1^0) = 0$

other particles heavy



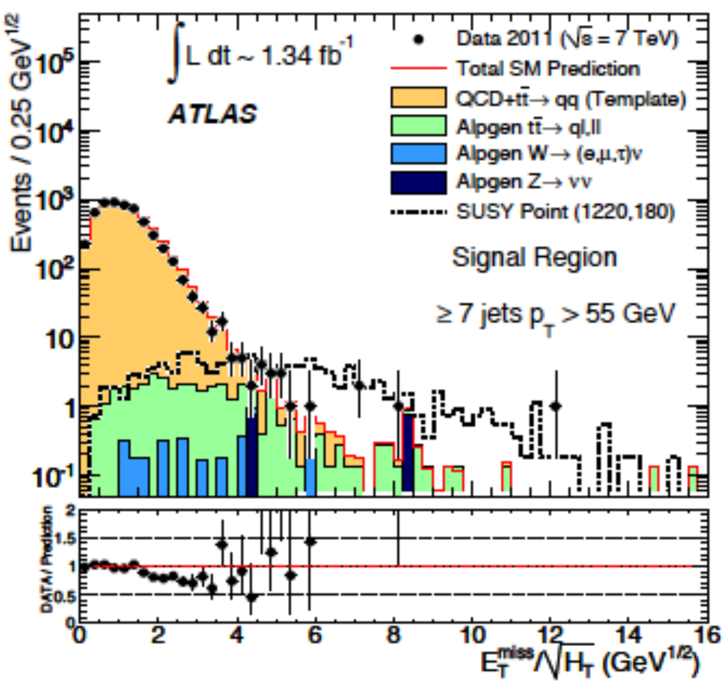


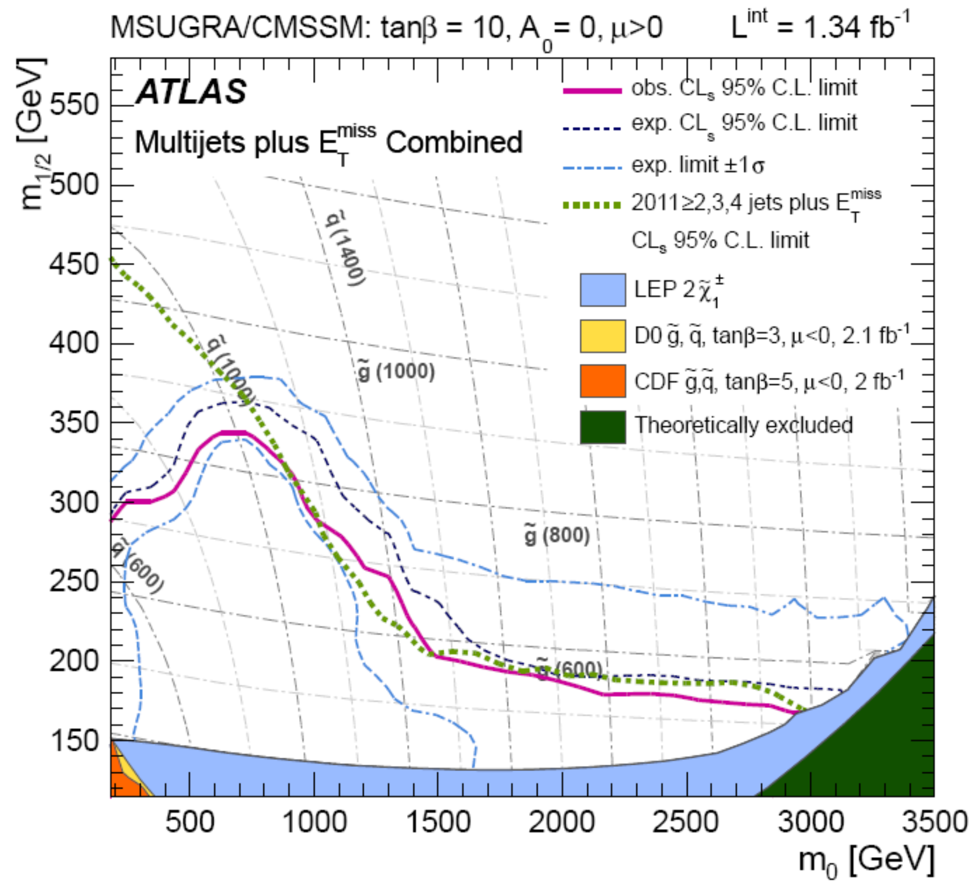
High Jet multiplicity + MET

6 or more jets

Signal region	7j55	8j55	6j80	7j80
Jet p_T	> 55 GeV		> 80 GeV	
Jet $\lvert\eta\rvert$	< 2.8			
ΔR_{jj}	> 0.6 for any pair of jets			
Number of jets	≥ 7	≥ 8	≥ 6	≥ 7
$E_T^{miss} / \sqrt{H_T}$	> 3.5 $\mathrm{GeV}^{1/2}$			

Table 1: Definitions of the four signal regions.





QCD background from control regions with fewer jets
(MET/sqrt(H_T) ~ independent of number of jets)

additional model interpretation

considered direct decays

$$\tilde{q}\tilde{q} \rightarrow q\chi_1^0\, q\chi_1^0$$

$$\tilde{g}\tilde{g} \rightarrow q\bar{q}\chi_1^0\, q\bar{q}\chi_1^0$$

or 2-step processes

$$\tilde{q} \rightarrow q\tilde{\chi}_1^{\pm} \rightarrow qW^{(*)}\tilde{\chi}_1^0$$

$$\tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^{\pm} \rightarrow q\bar{q}W^{(*)}\tilde{\chi}_1^0$$

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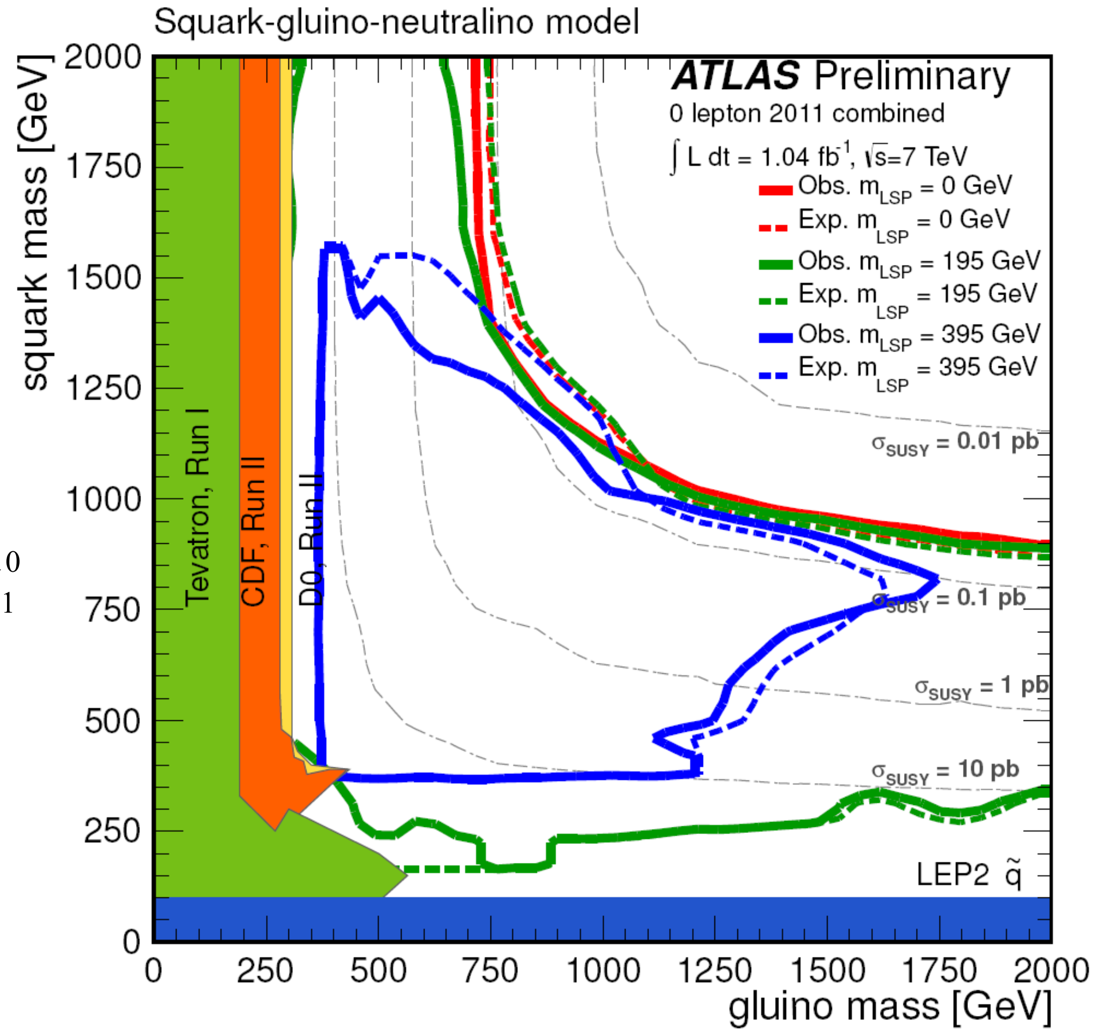


UED

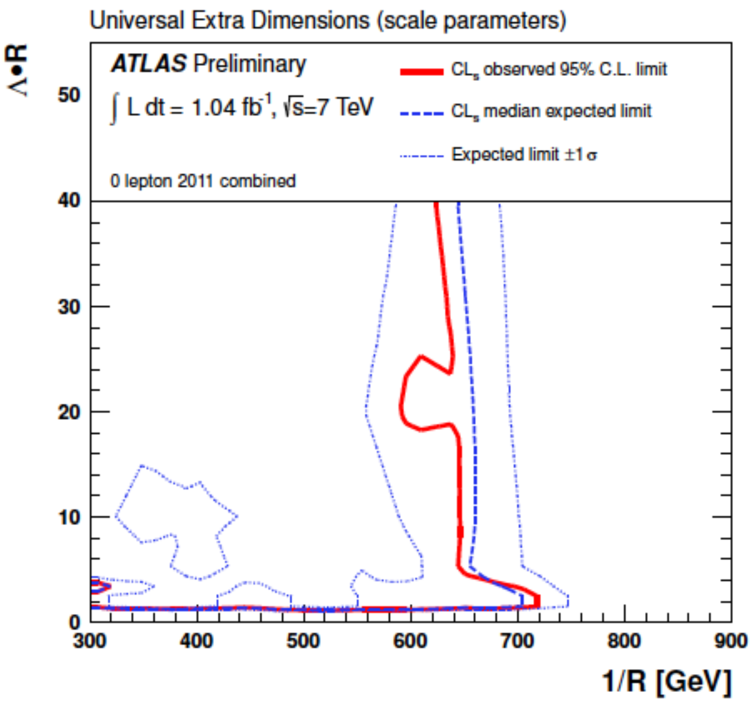
Similarity between SUSY and UED

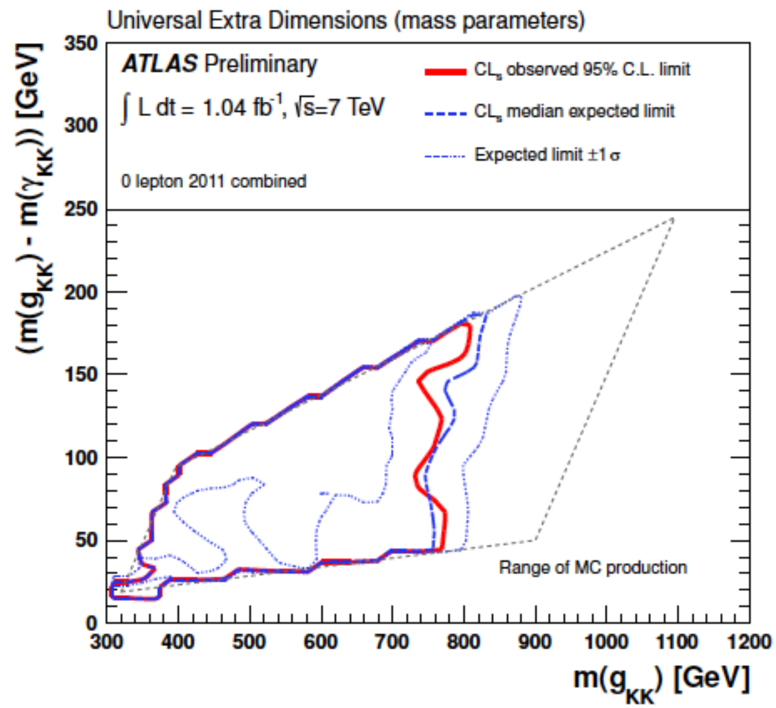
- partner or KK state (but spin is different)
- conservation of R parity or KK state
- LSP or LKP escapes detection

UED characterized by compactification radius R and cut-off scale $\Lambda > R^{-1}$

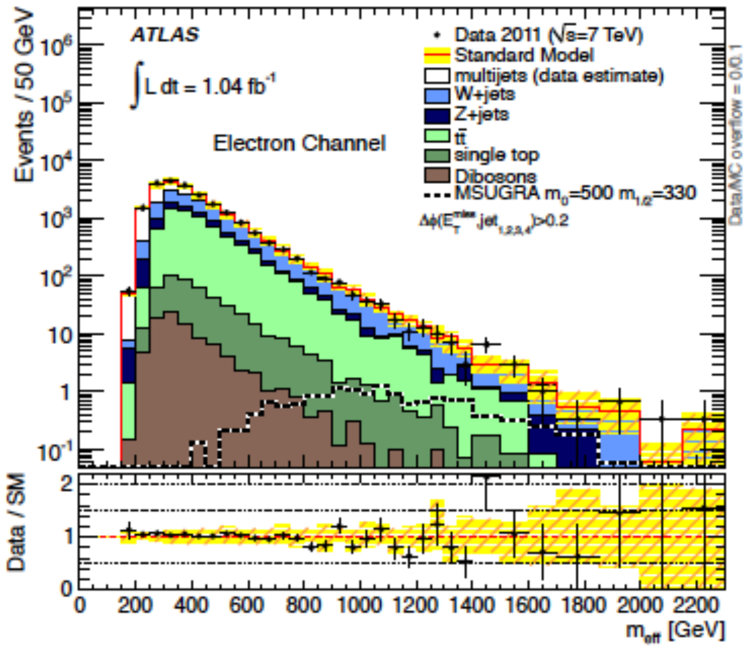
$$m_{KK} = \sqrt{m_{SM}^2 + R^{-2}}$$

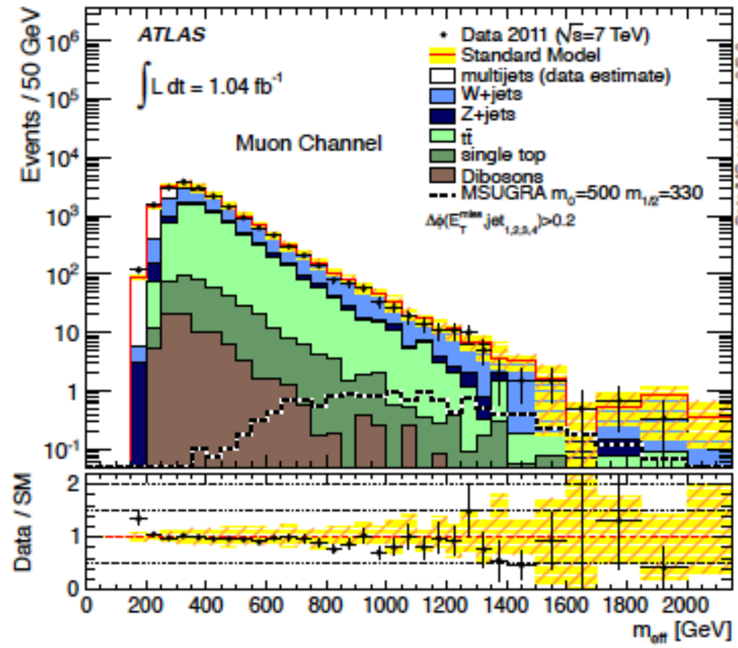
radiative correction ~ $\ln(\Lambda R)$





Jets + Etmiss + 1 lepton





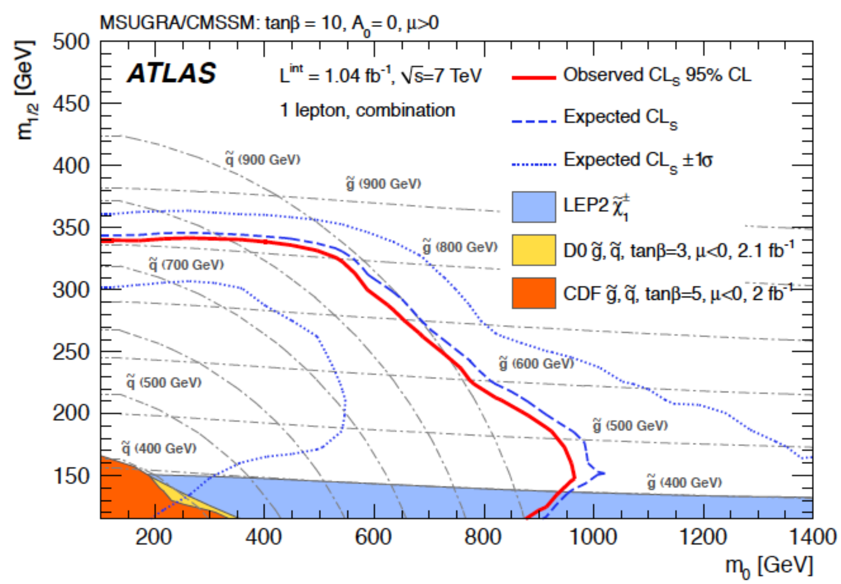
arXiv:1109.6606v1 [hep-ex]

at least 3 jets

$$m_{eff} = p_T^{\ell} + \sum_{i=1}^{3(4)} p_T^{jet_i} + E_T^{\text{miss}}$$

cuts on MET, mT

also limits on model with bilinear RPV

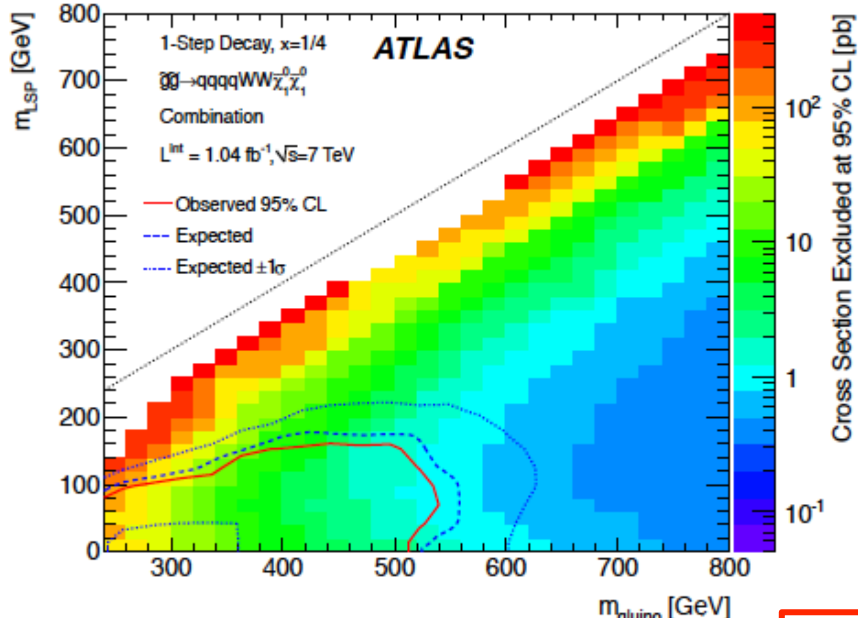


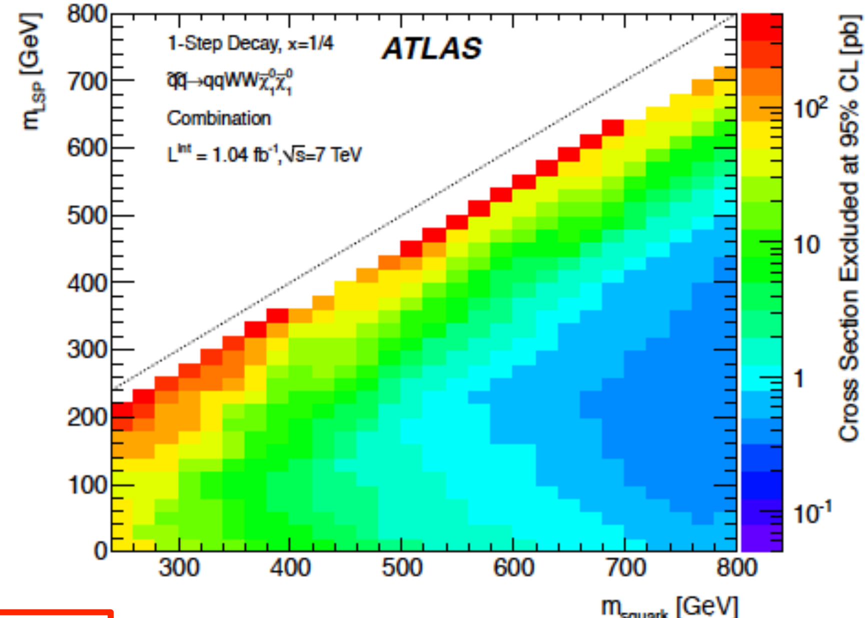
simplified model with 1-lepton

$$\tilde{q} \rightarrow q\tilde{\chi}_1^{\pm} \rightarrow qW^{(*)}\tilde{\chi}_1^0$$

$$\tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^{\pm} \rightarrow q\bar{q}W^{(*)}\tilde{\chi}_1^0$$

$$x = \frac{m_{\tilde{\chi}^{\pm}} - m_{\tilde{\chi}^0}}{m_{\tilde{g}} - m_{\tilde{\chi}^0}}$$

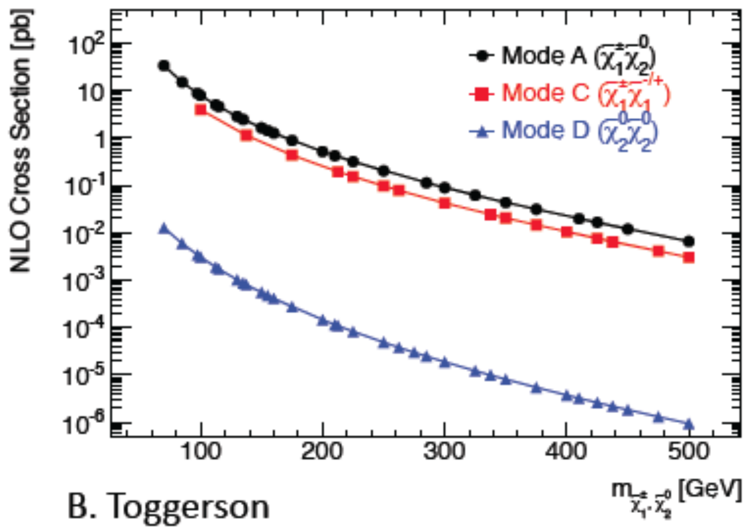




$$x = \frac{1}{4}$$

DIRECT GAUGINO PRODUCTION

Carleton UNIVERSITY
Canada's Capital University



B. Toggerson

- DG production via different modes:
  - C1N2 production has largest cross section
  - There are four possible final states we can look for a signal
  - Focus on one and optimize

Signal Region	#lept.	Signal	≥2 lepton signals
3-lepton	=3	(A0)	$\tilde{\chi}_2^0\tilde{\chi}_1^{\pm} \rightarrow (l^+l^-\tilde{\chi}_1^0) + (l^{\pm}\nu\tilde{\chi}_1^0)$
OSSF & jet-veto	=2	(A1)	$\tilde{\chi}_2^0\tilde{\chi}_1^{\pm} \rightarrow (l_{rec}^+l_{rec}^-\tilde{\chi}_1^0) + (l^{\pm}\nu\tilde{\chi}_1^0)$
SS & jet-veto	=2	(A2)	$\tilde{\chi}_2^0\tilde{\chi}_1^{\pm} \rightarrow (l_{rec}^+l^-\tilde{\chi}_1^0) + (l_{rec}^{\pm}\nu\tilde{\chi}_1^0)$
		(A3)	$\tilde{\chi}_2^0\tilde{\chi}_1^{\pm} \rightarrow (l^+l_{rec}^-\tilde{\chi}_1^0) + (l_{rec}^{\pm}\nu\tilde{\chi}_1^0)$
OSSF ≥2-jets & b-jet-veto	=2	(A4)	$\tilde{\chi}_2^0\tilde{\chi}_1^{\pm} \rightarrow (ll\tilde{\chi}_1^0) + (q\bar{q}'\tilde{\chi}_1^0)$

C. Clement

transparency from Ryuichi Ueno, https://indico.cern.ch/getFile.py/access?contribId=16&sessionId=3&resId=0&materialId=slides&confId=161358

Jets + MET + 2 leptons

Limits obtained on production cross section for same-sign and for opposite sign lepton pairs

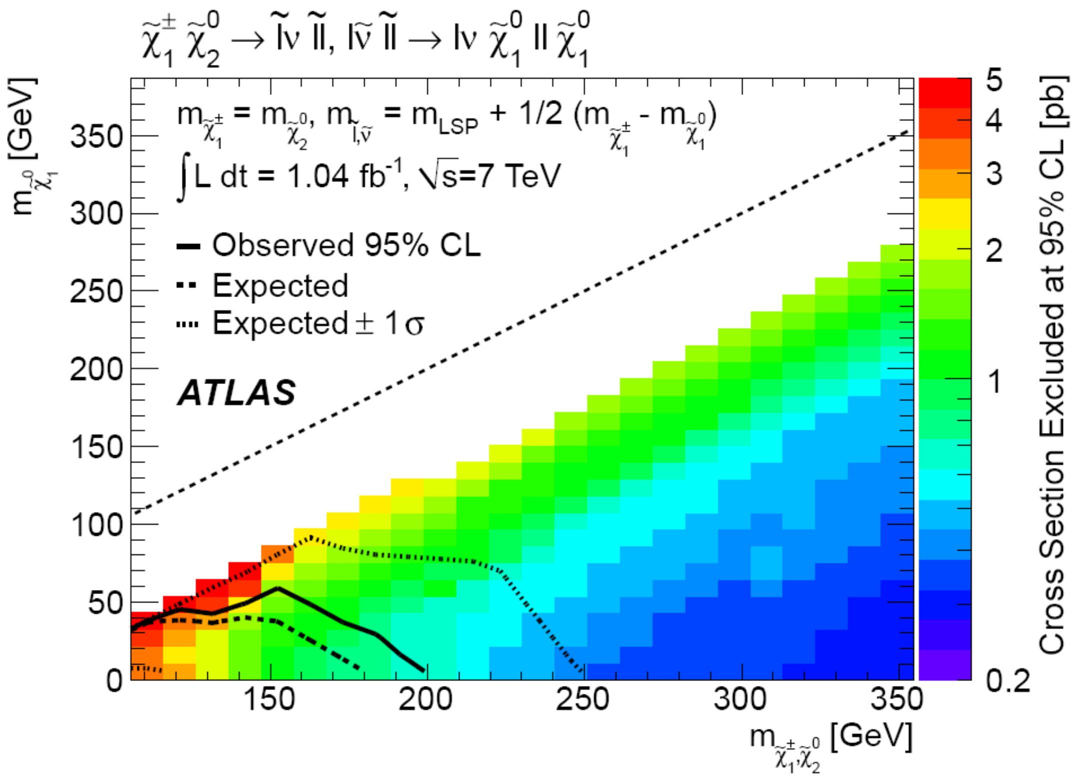


Figure 2: 95% CL cross section upper limits (CL_s) in pb and observed and expected limit contours for $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ production in direct gaugino simplified models.

GMSB interpretation – jets + MET + 2 leptons

Gauge Mediated Supersymmetry breaking parameters

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Λ : SUSY breaking scale in separate sector $\ll M_{Planck}$

$\tan\beta$: ratio of vevs

M_{mess} : mass scale of messenger fields = 250 GeV~ weak scale

N_5 : number of messenger fields = 5

$\mathrm{sgn}(\mu)$: sign of Higgsino mass term > 0

C_{grav} : multiplicative factor of gravitino mass

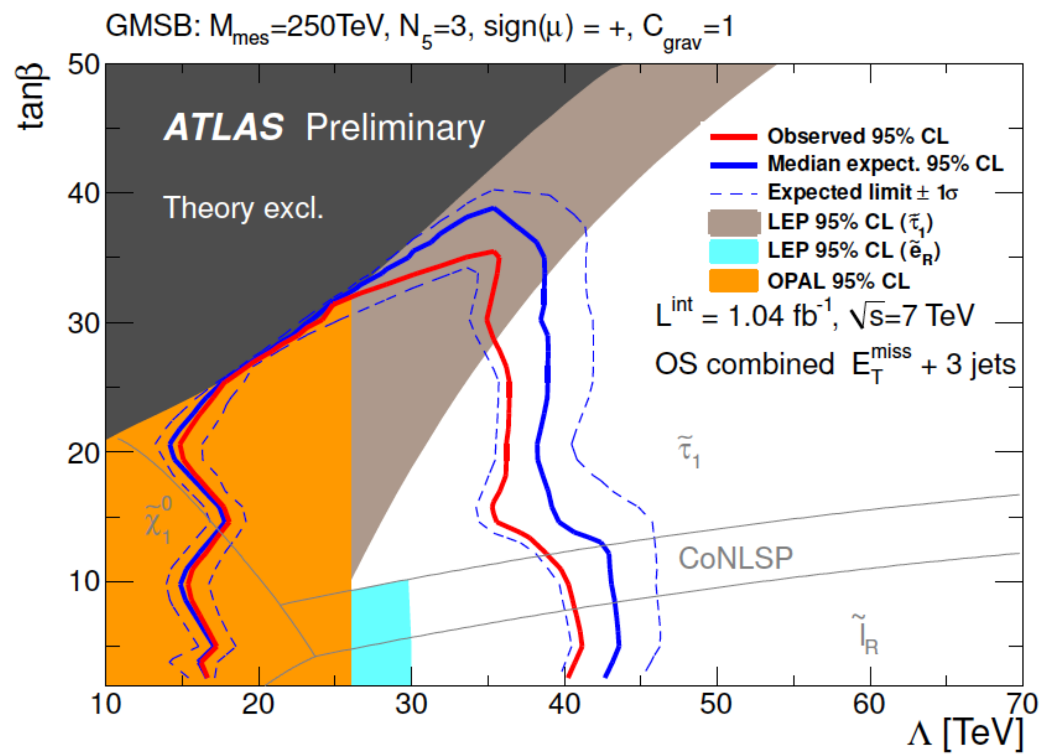
exactly 2 leptons of opposite charge

$m_{\ell\ell} > 12$ GeV

$E_T^{\mathrm{miss}} > 220$ GeV

at least 3 jets with $p_{T1} > 80$ GeV

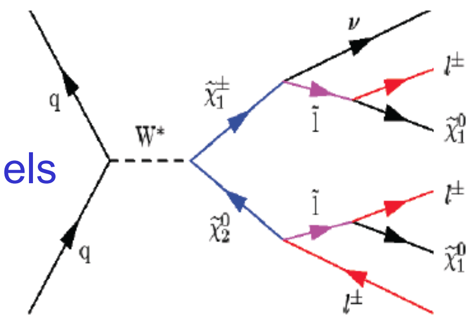
and other p_T(jets) > 40 GeV



multileptons

Showing the 35 pb-1 result. More recent result will be available soon…

- Low background
- CMS sees some excess (1106.0933) in 3 and 4-lepton channels



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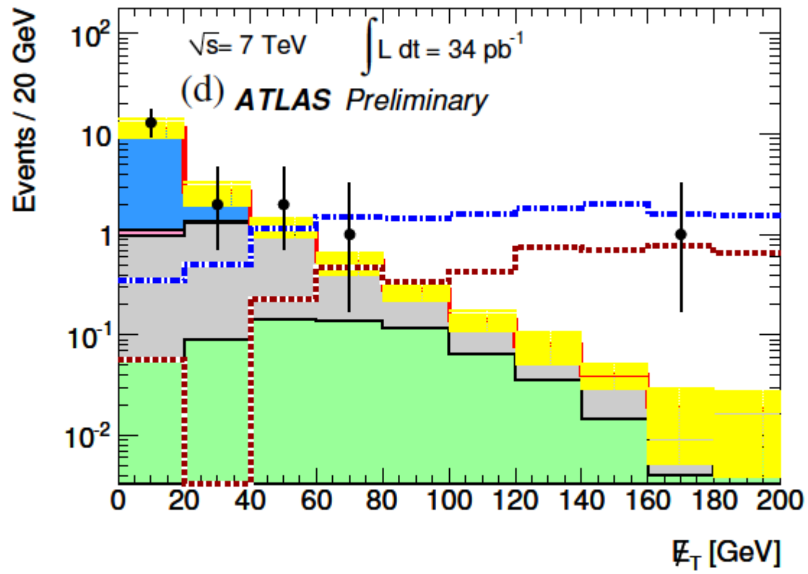
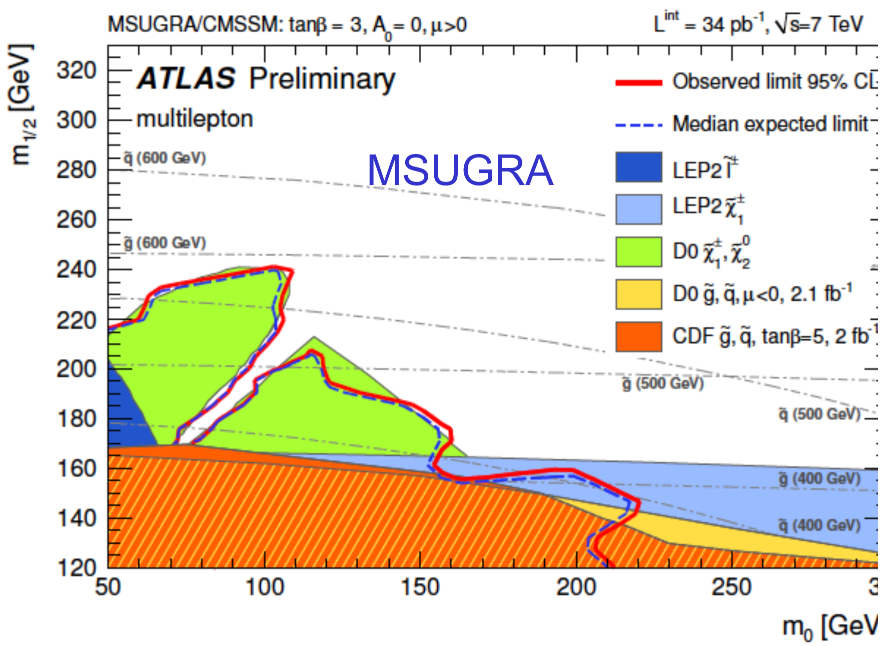
Selection

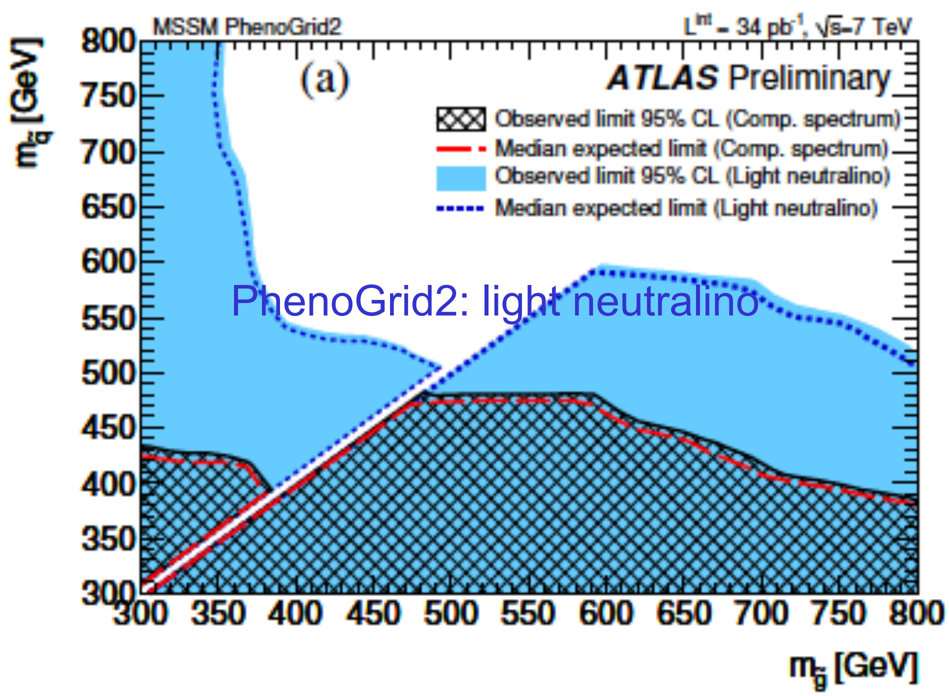
- at least 3 leptons
  - pT1, pT2 > 20 GeV, pT3>20(10) for e, μ
- at least 2 jets with pT > 50 GeV
- MET > 50 GeV
- Z veto
- low mass DY rejected (mll >20 GeV) for SFOS pairs

Multilep. events	All	*eee*	*eeμ*	*eμμ*	*μμμ*
$t\bar{t}$	0.68±0.16	0.032±0.016	0.24±0.07	0.31±0.08	0.096±0.030
Z backgrounds	15.6±1.3	3.8±0.8	1.60±0.34	7.9±1.0	2.4±0.4
Other backgrounds	0.28±0.13	0.02±0.14	0.03±0.06	0.21±0.09	0.01±0.11
Total SM	16.6±1.3	3.8±0.8	1.9±0.4	8.4±1.0	2.5±0.4
Data	19	2	1	10	6

multileptons







b-jet + MET + 0l

large mixing with 3rd generation squarks $\tilde{b}_L - \tilde{b}_R$ or $\tilde{t}_L - \tilde{t}_R$

can result in low mass eigenstate

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21 July 2011

Scenarios:

1) $\tilde{g} \to \tilde{b}_1 b$ $\quad\quad m_{\tilde{\chi}_1^0} = 60$ GeV

$\quad\quad \hookrightarrow b\tilde{\chi}_1^0$

2) $\tilde{g} \to b\bar{b}\,\tilde{\chi}_1^0$ (off-shell)

3) $SO(10)$ – inspired:

$\tilde{g} \to b\bar{b}\,\tilde{\chi}_1^0$ and $\tilde{g} \to b\bar{b}\,\tilde{\chi}_2^0$ are dominant

(D-term and Higgs splitting models)

b-jet + MET + 0l

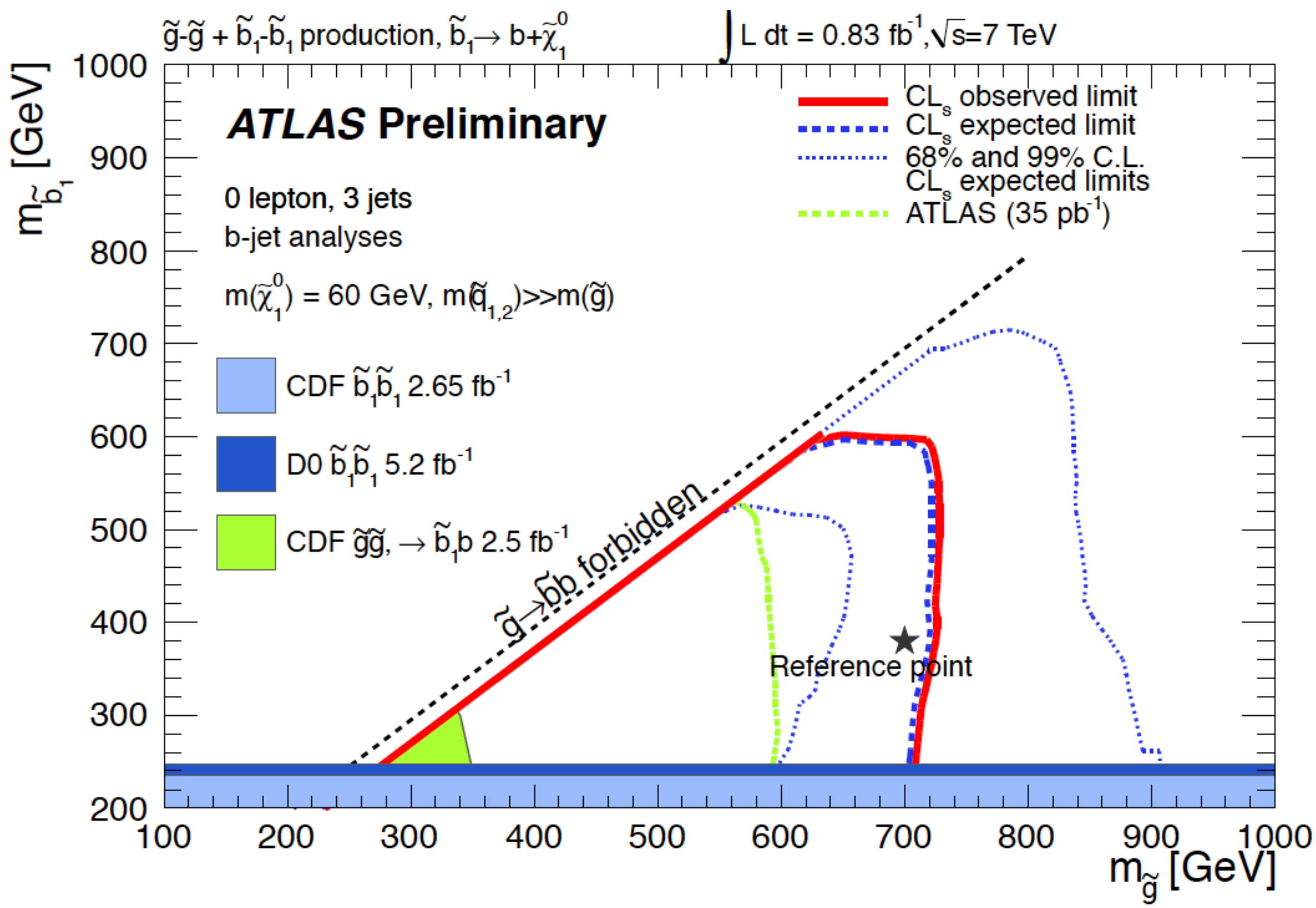
at least 3 jets: $p_{T1} > 130$ GeV, $p_{T3} > 50$ GeV

at least one jet is b-tagged

$E_T^{miss} > 130$ GeV

$E_T^{miss} / m_{eff} > 0.25$

$\Delta\phi_{E_T^{miss}-jet} > 0.4$



b-jet + MET + 1 lepton

1) $\tilde{g} \to \tilde{t}_1 t \qquad m_{\tilde{\chi}_1^0} = 60\ \text{GeV}$

$\quad \hookrightarrow b\tilde{\chi}_1^{\pm} \to b\tilde{\chi}_1^0 \ell \nu$

2) $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ (off-shell)

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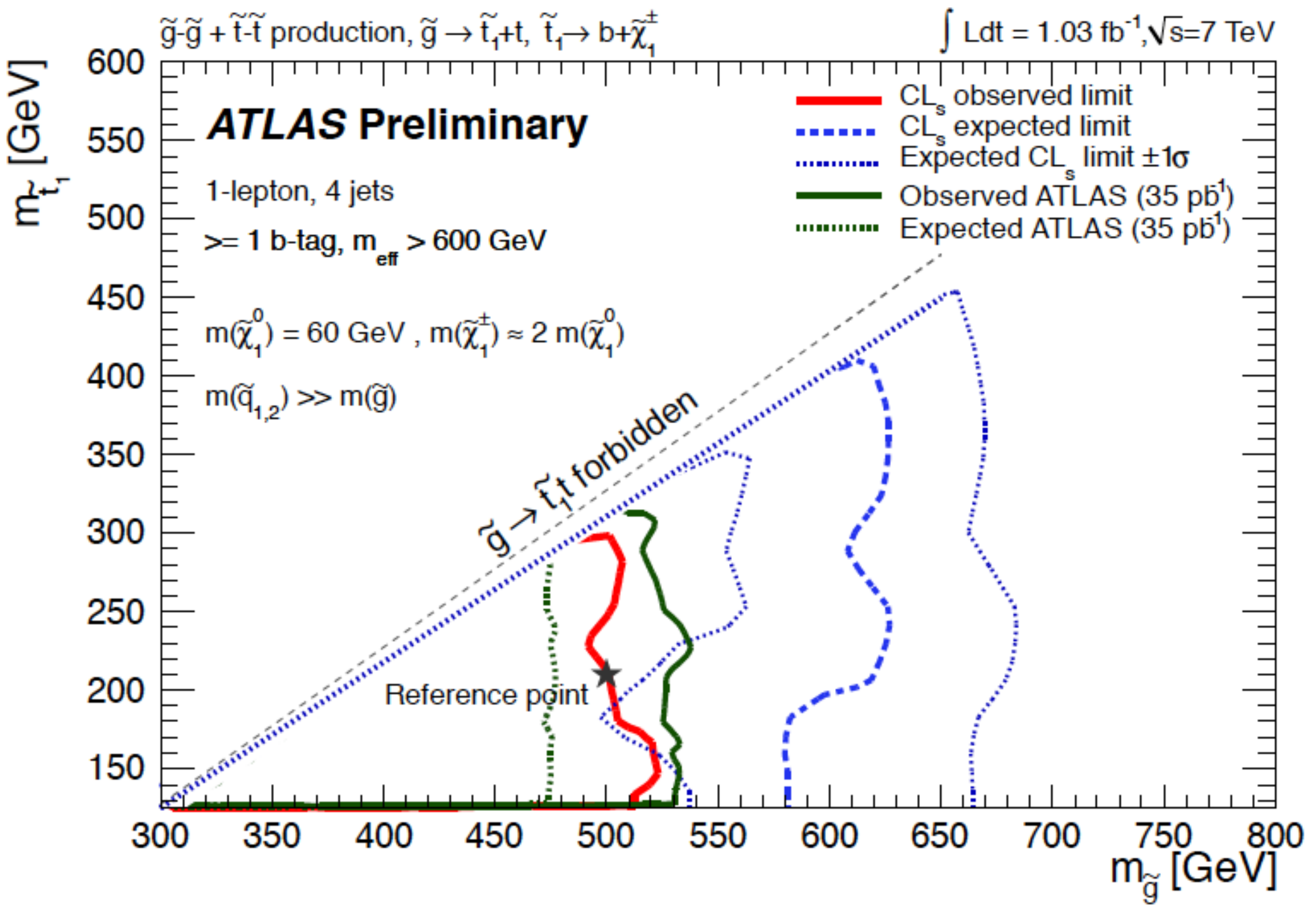
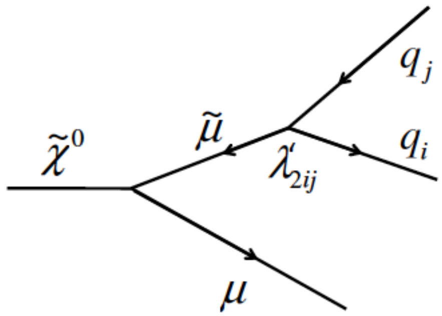
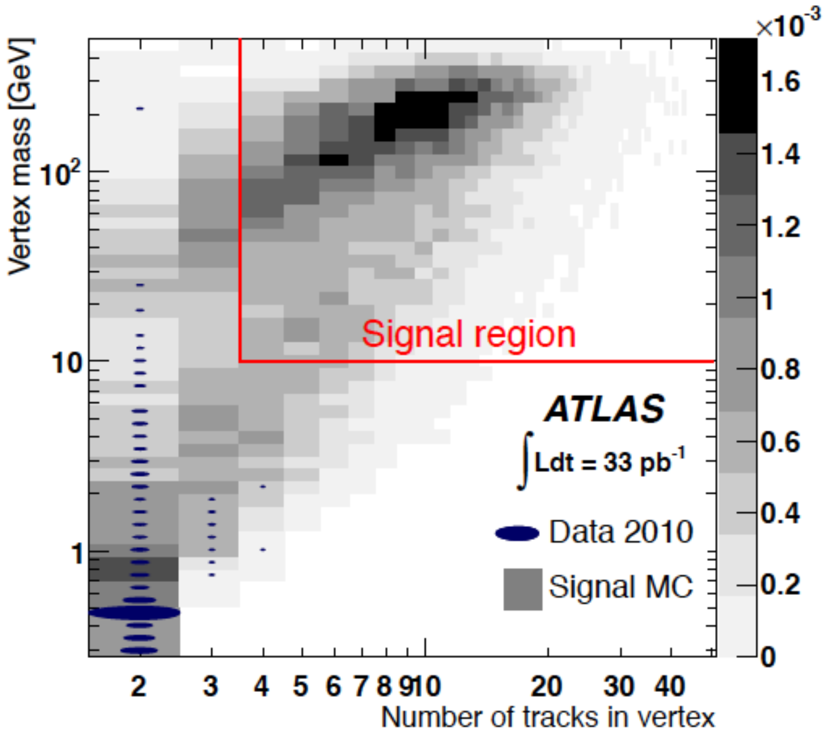
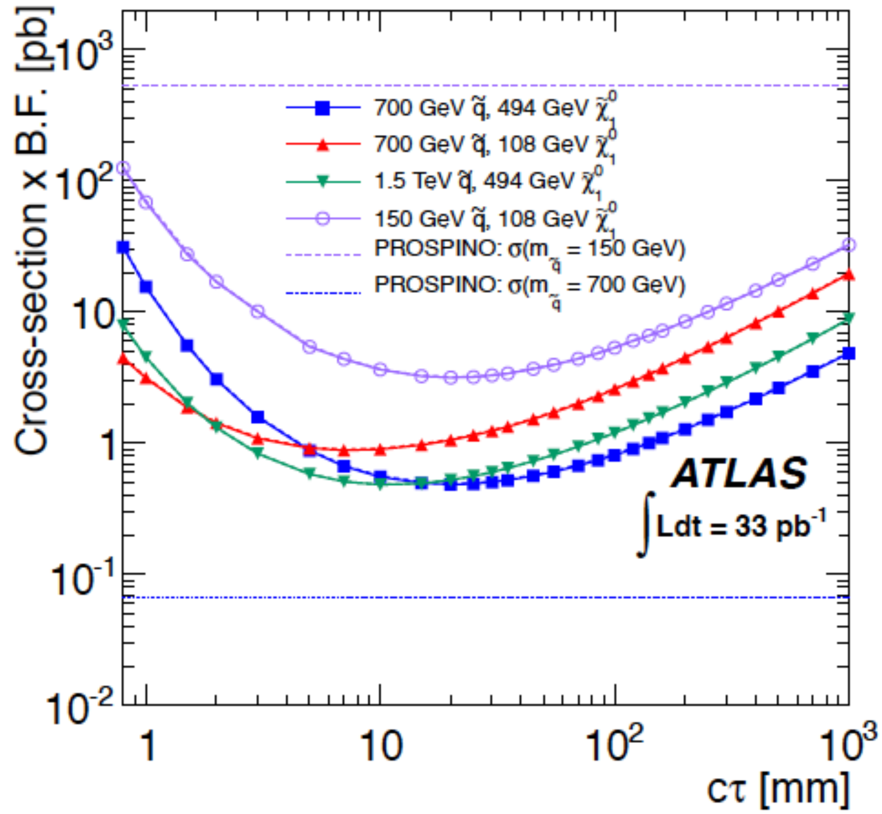
20 September 2011



Displaced vertices: R-Parity Violation







diphotons + MET

One of the first ATLAS papers, where signal was interpreted in terms of UED

2 tight isolated photons with E_T > 25 GeV and MET > 125 GeV

5 events found, 4.1 expected

Here, 3 scenarios:

GGM: Generalized GMSB

If NLSP is bino, $\tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}$

Minimal GMSB: SPS8

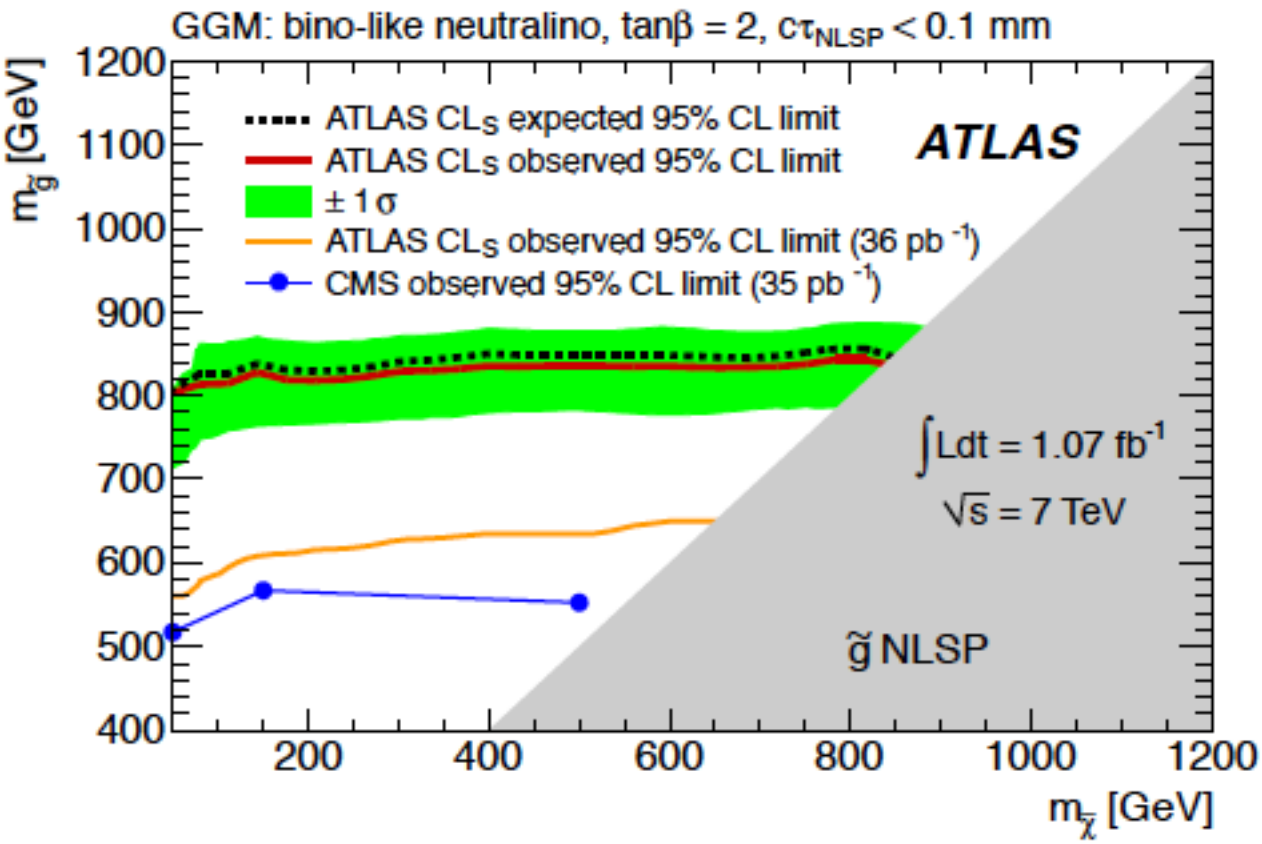
Heavy squarks and gluinos

Λ: only free parameter

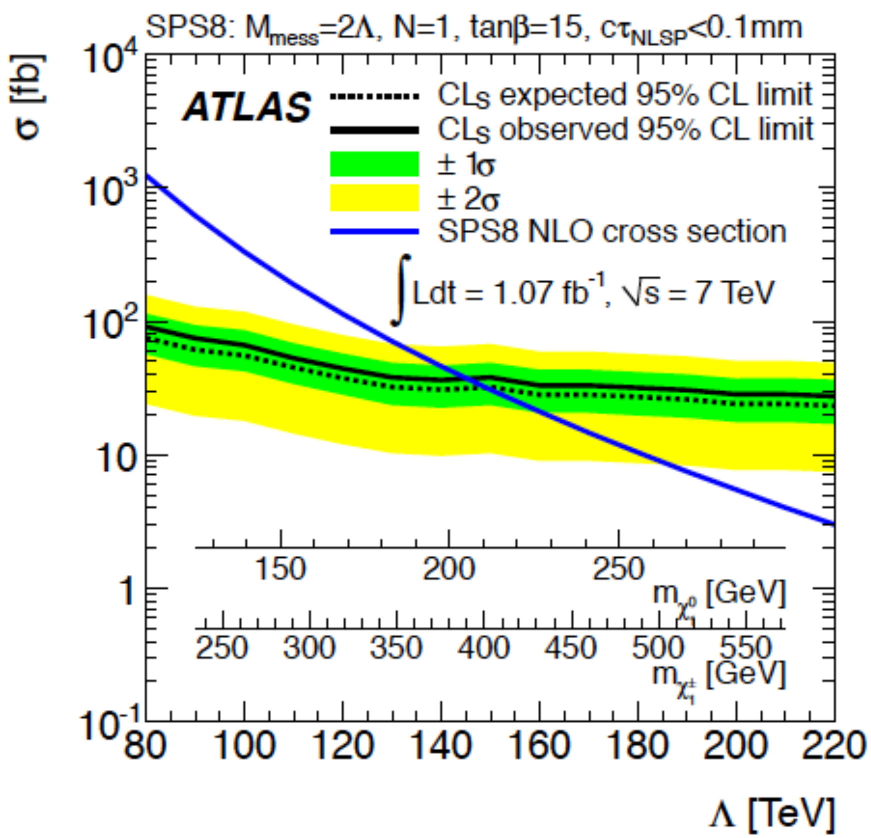
$M_{mess} = 2\Lambda;\ N_5 = 1;\quad \tan\beta = 15;\quad \mu > 0$

Universal Extra Dimensions

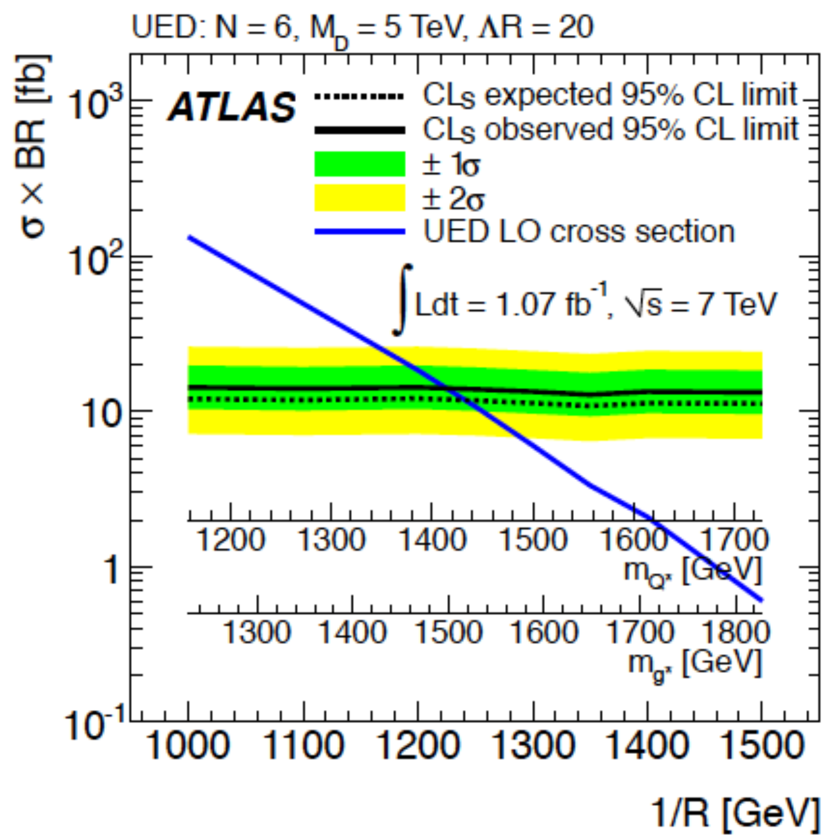
GGM


GGM: bino-like neutralino, tanβ = 2, cτ_NLSP < 0.1 mm
ATLAS CLs expected 95% CL limit
ATLAS CLs observed 95% CL limit
± 1 σ
ATLAS CLs observed 95% CL limit (36 pb -1)
CMS observed 95% CL limit (35 pb -1)
ATLAS
∫Ldt = 1.07 fb-1
√s = 7 TeV
g̃ NLSP
m_g̃ [GeV]
m_χ̃ [GeV]
400
500
600
700
800
900
1000
1100
1200
200
400
600
800
1000
1200

SPS8 and UED

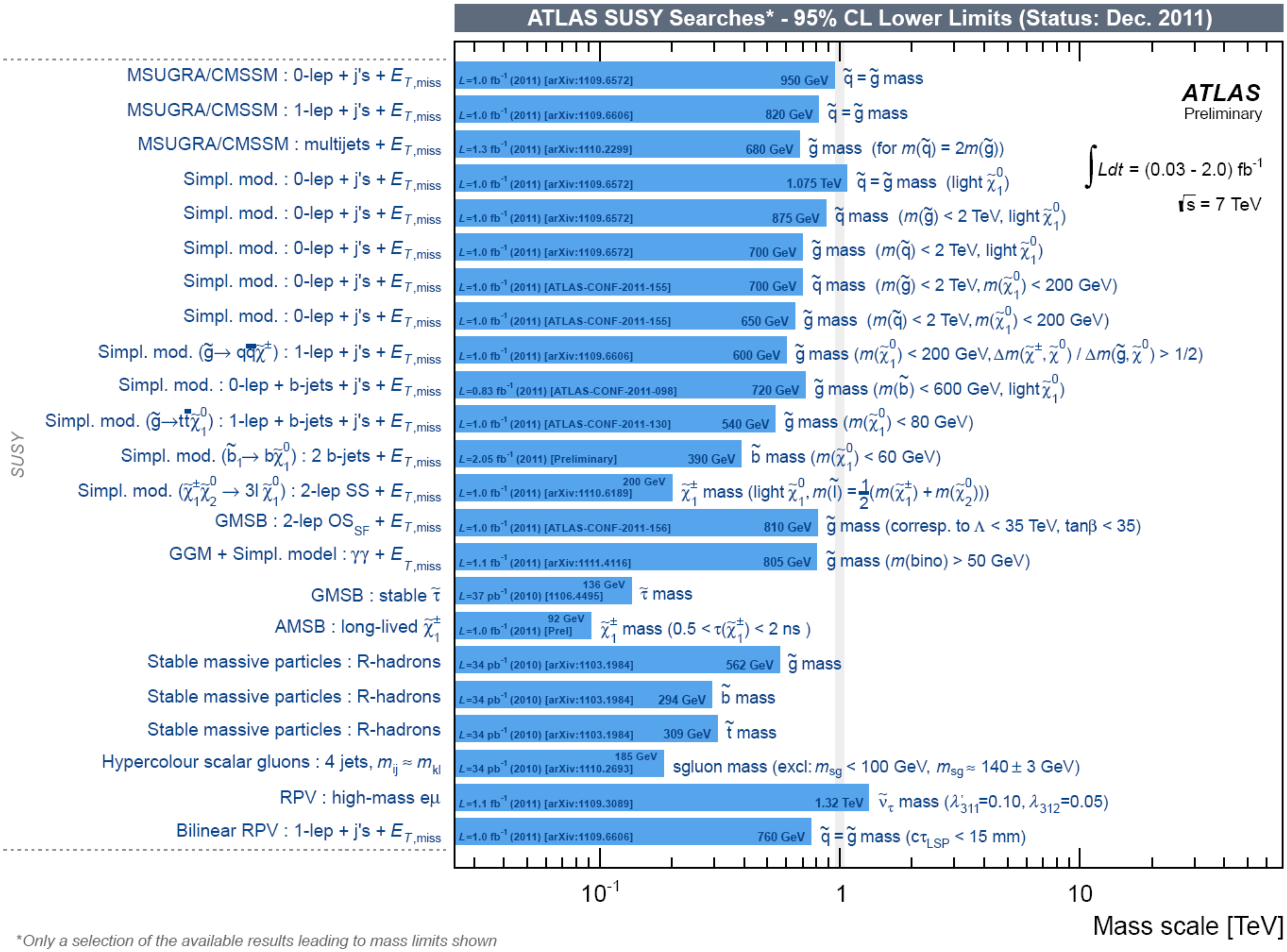


SPS8: M_{mess}=2Λ, N=1, tanβ=15, $c\tau_{NLSP}$<0.1mm
ATLAS
CL_S expected 95% CL limit
CL_S observed 95% CL limit
± 1σ
± 2σ
SPS8 NLO cross section
$\int Ldt$ = 1.07 fb^{-1}, $\sqrt{s}$ = 7 TeV
σ [fb]
Λ [TeV]
$m_{\chi_1^0}$ [GeV]
$m_{\chi_1^\pm}$ [GeV]



UED: N = 6, M_D = 5 TeV, ΛR = 20
ATLAS
CL_S expected 95% CL limit
CL_S observed 95% CL limit
± 1σ
± 2σ
UED LO cross section
$\int Ldt$ = 1.07 fb^{-1}, $\sqrt{s}$ = 7 TeV
σ × BR [fb]
1/R [GeV]
m_{Q^*} [GeV]
m_{g^*} [GeV]

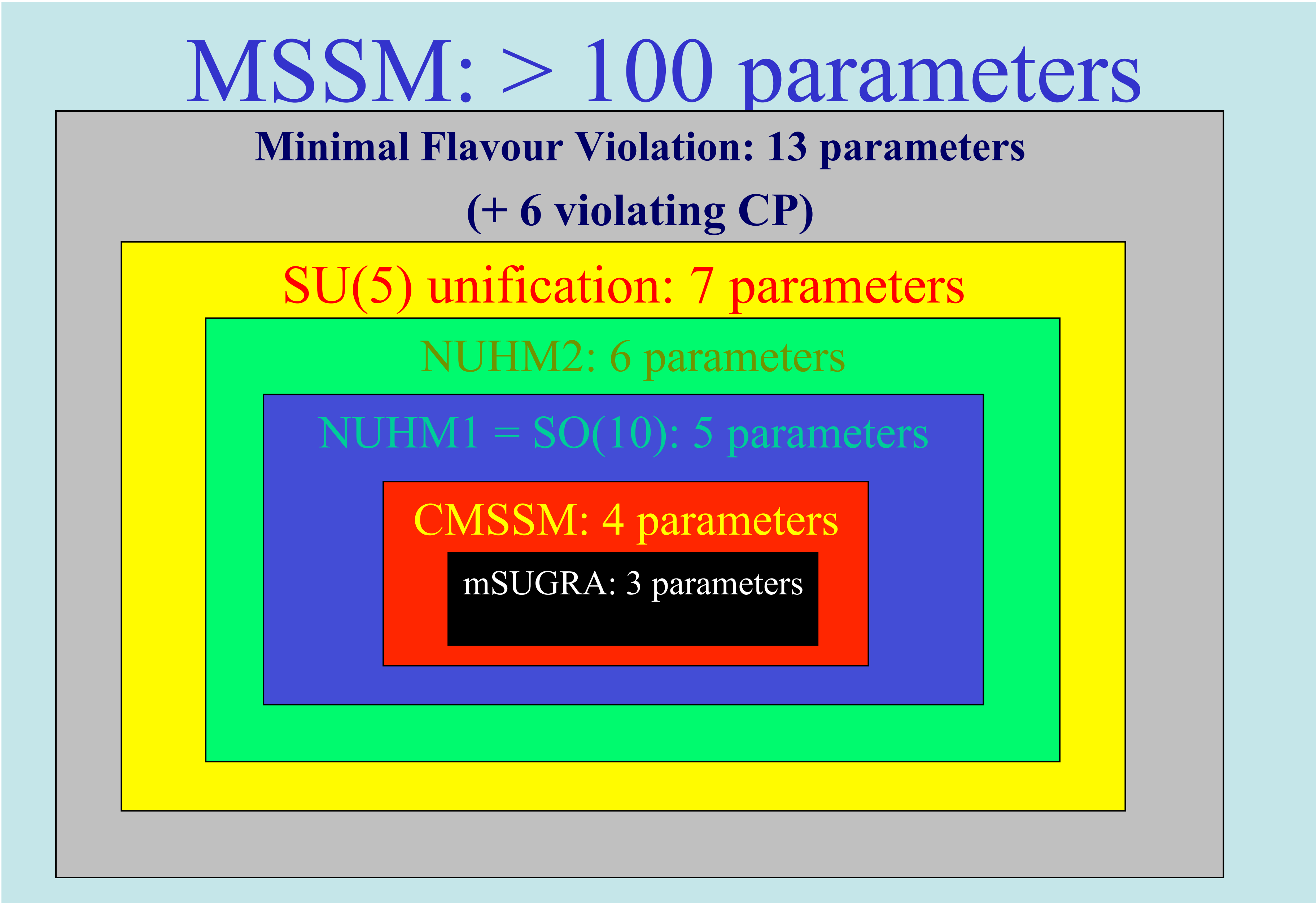
Summary Table - SUSY



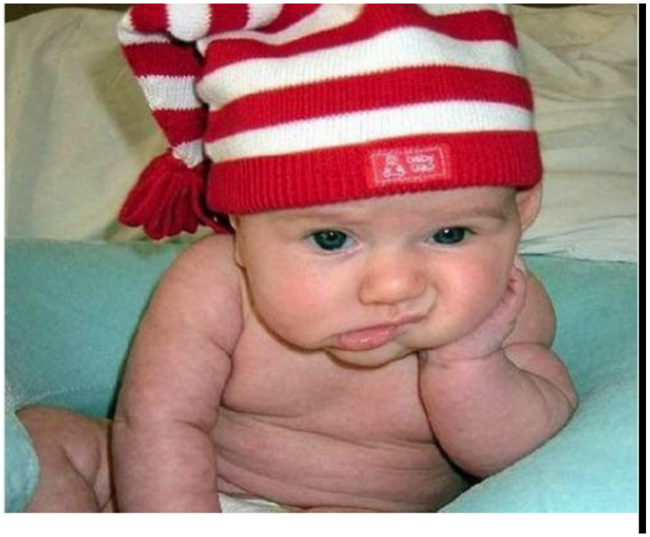
27 August 2011 Last updated at 02:41 ET

LHC results put supersymmetry theory 'on the spot'

By Pallab Ghosh
Science correspondent, BBC News


MSSM: > 100 parameters
Minimal Flavour Violation: 13 parameters
(+ 6 violating CP)
SU(5) unification: 7 parameters
NUHM2: 6 parameters
NUHM1 = SO(10): 5 parameters
CMSSM: 4 parameters
mSUGRA: 3 parameters

Conclusion



After first 2 years of LHC:

No SUSY so far… Nor any other BSM hints…

(but the Higgs??)

2012 is poised to be a fantastic year!

slides from Bertolucci and deJog, at LHCP backups

W_R

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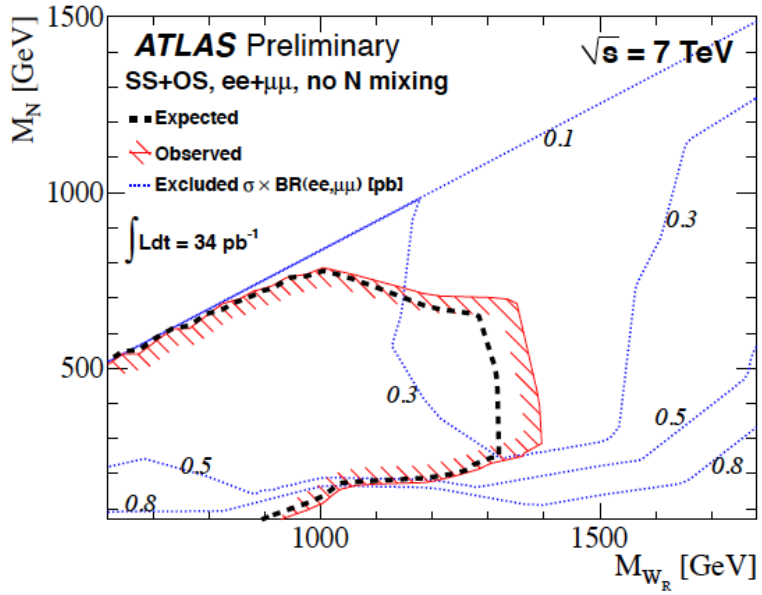
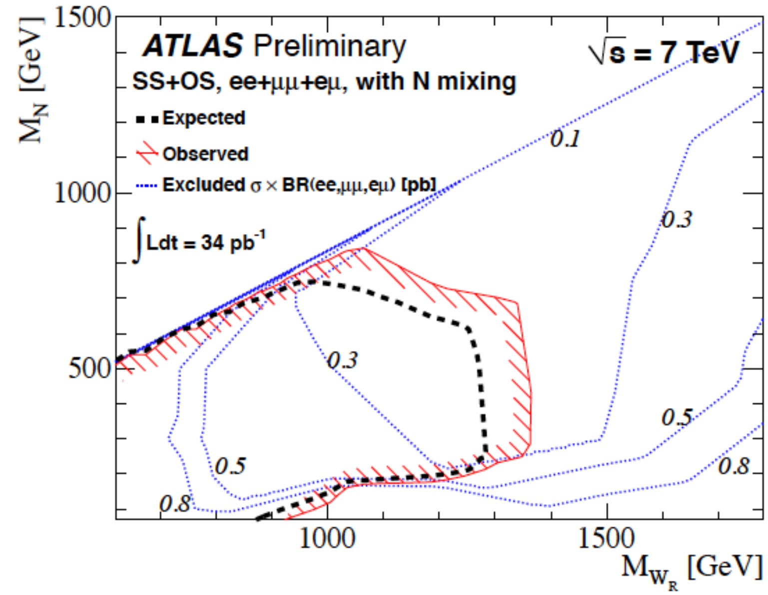
17 August 2011





$q\bar{q} \rightarrow W_R \rightarrow lN$, with N decaying subsequently to $N \rightarrow lW_R^* \rightarrow ljj$

ATLAS-CONF-2011-115

long-lived particles

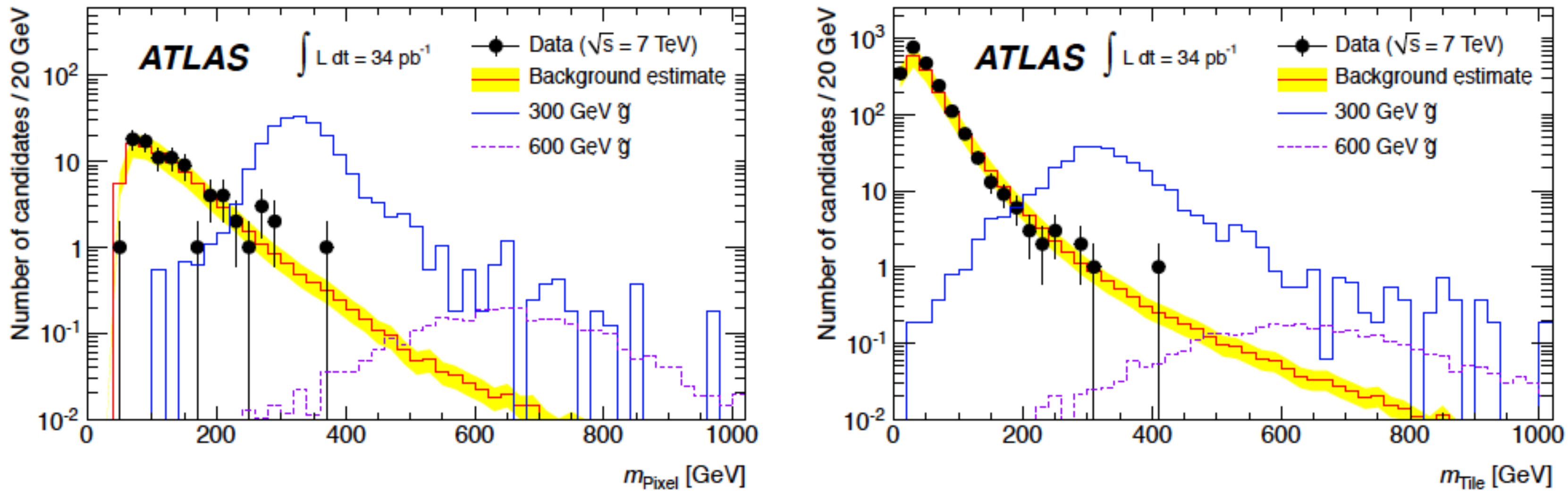


Figure 3: Background estimates for the pixel detector (left) and the tile calorimeter (right). Signal samples are superimposed on the background estimate. The total systematic uncertainty of the background estimate is indicated by the error band.

long-lived particles

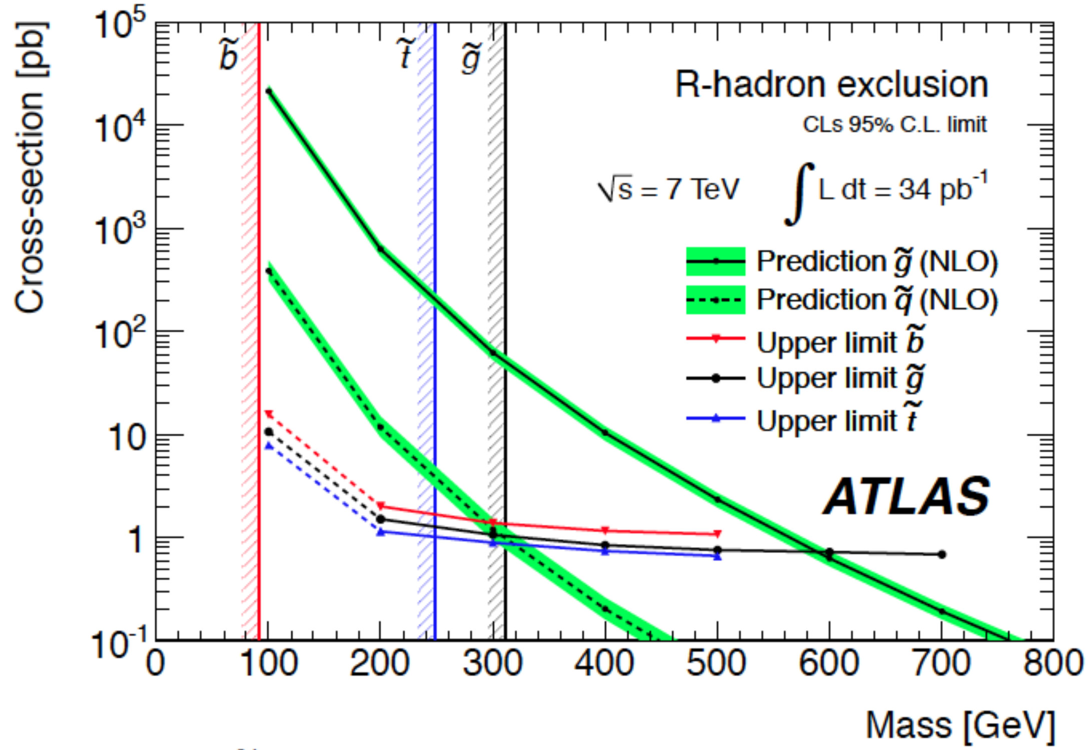


Figure 4: Cross-section limits at 95% CL as a function of sparticle mass. Since five candidate events are observed for the mass windows used for the 100 GeV mass hypotheses, the mass points between 100 and 200 GeV are connected with a dotted line. This indicates that fluctuations in the excluded cross-section will occur. The mass limits quoted in the text are inferred by comparing the cross-section limits with the model predictions. Systematic uncertainties from the choice of PDF and the choice of renormalisation and factorisation scales are represented as a band in the cross-section curves. Previous mass limits are indicated by shaded vertical lines for sbottom (ALEPH), stop (CDF) and gluino (CMS).

arXiv:1103.1984v1

strong gravity from ss dimuons

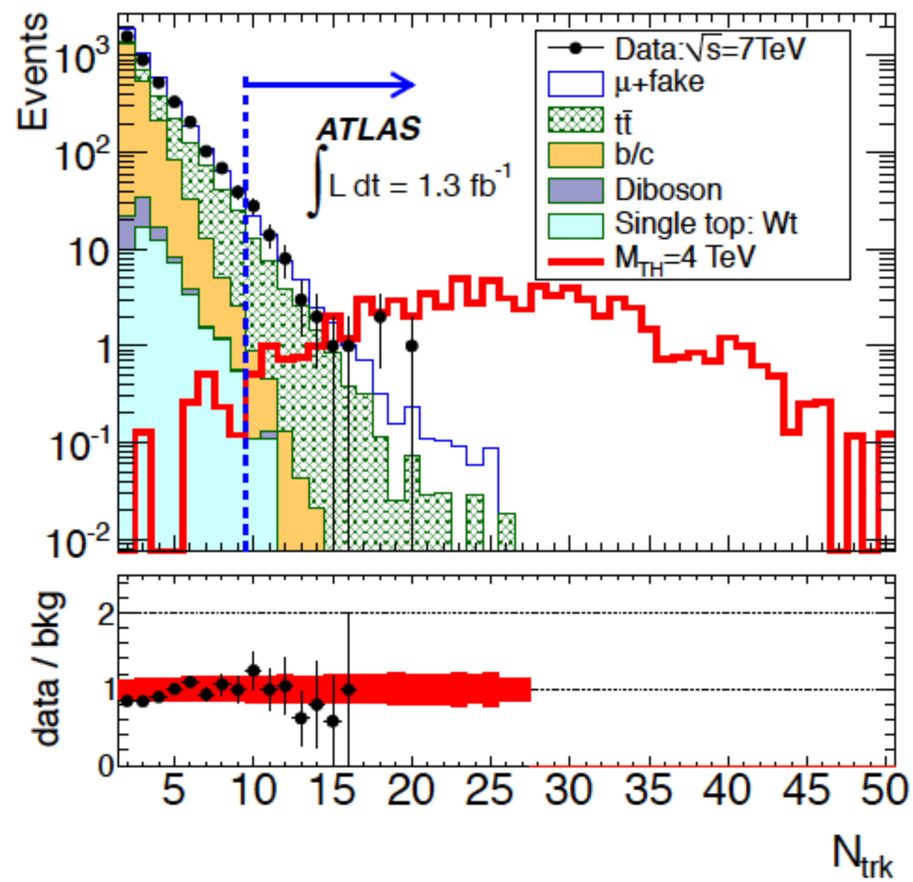


Figure 2: The track multiplicity distribution for same-sign dimuon events. The region with $N_{\rm trk} \geq 10$ is selected as the signal region. The background histograms are stacked. The signal expectation for a non-rotating black hole model with parameters $M_{\rm D} = 800$ GeV, $M_{\rm TH} = 4$ TeV, and six extra dimensions is overlaid for illustrative purposes. The bottom panel shows the ratio of data to the expected background (points) and the total systematic uncertainty on the background (shaded area).

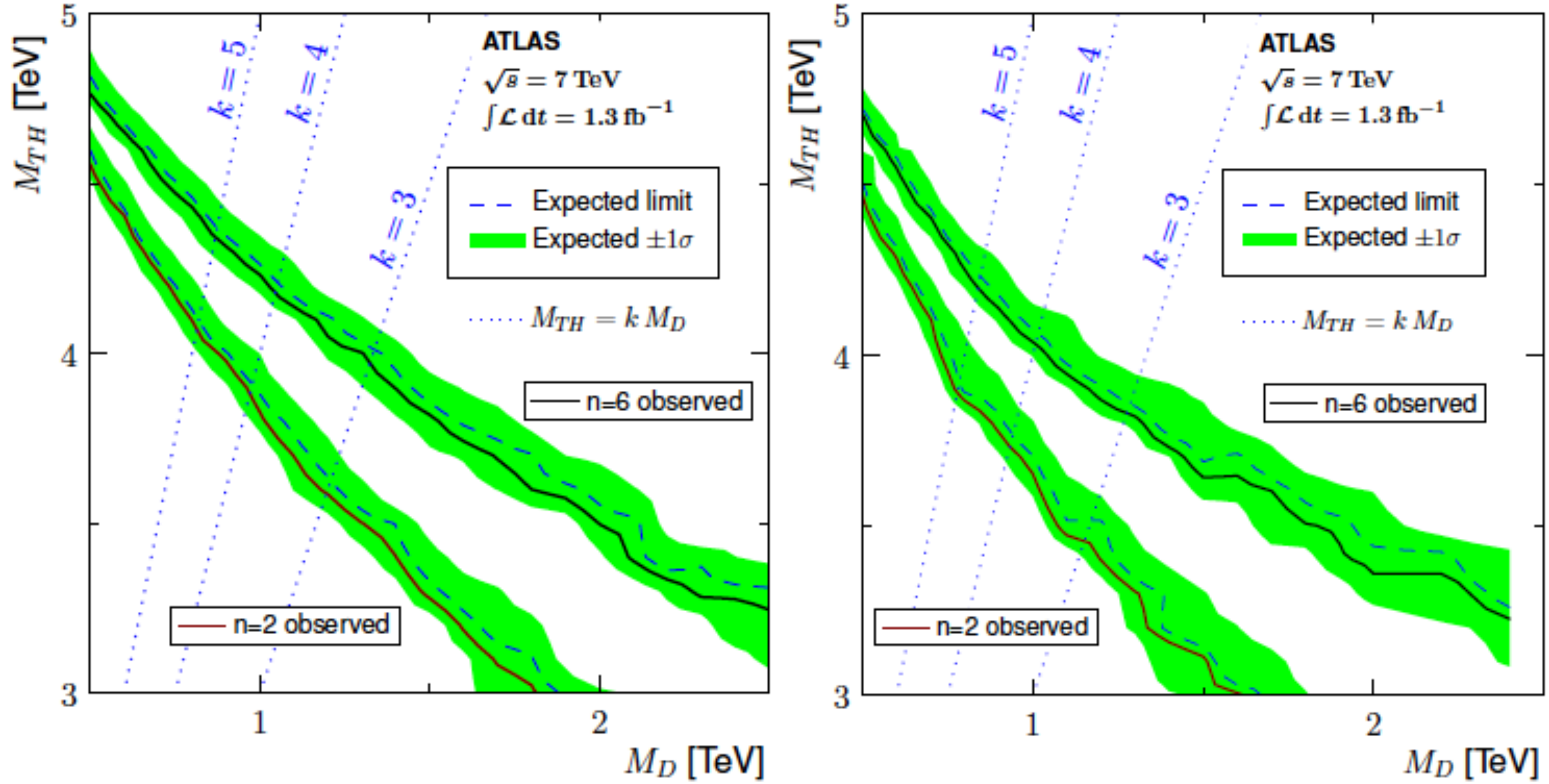
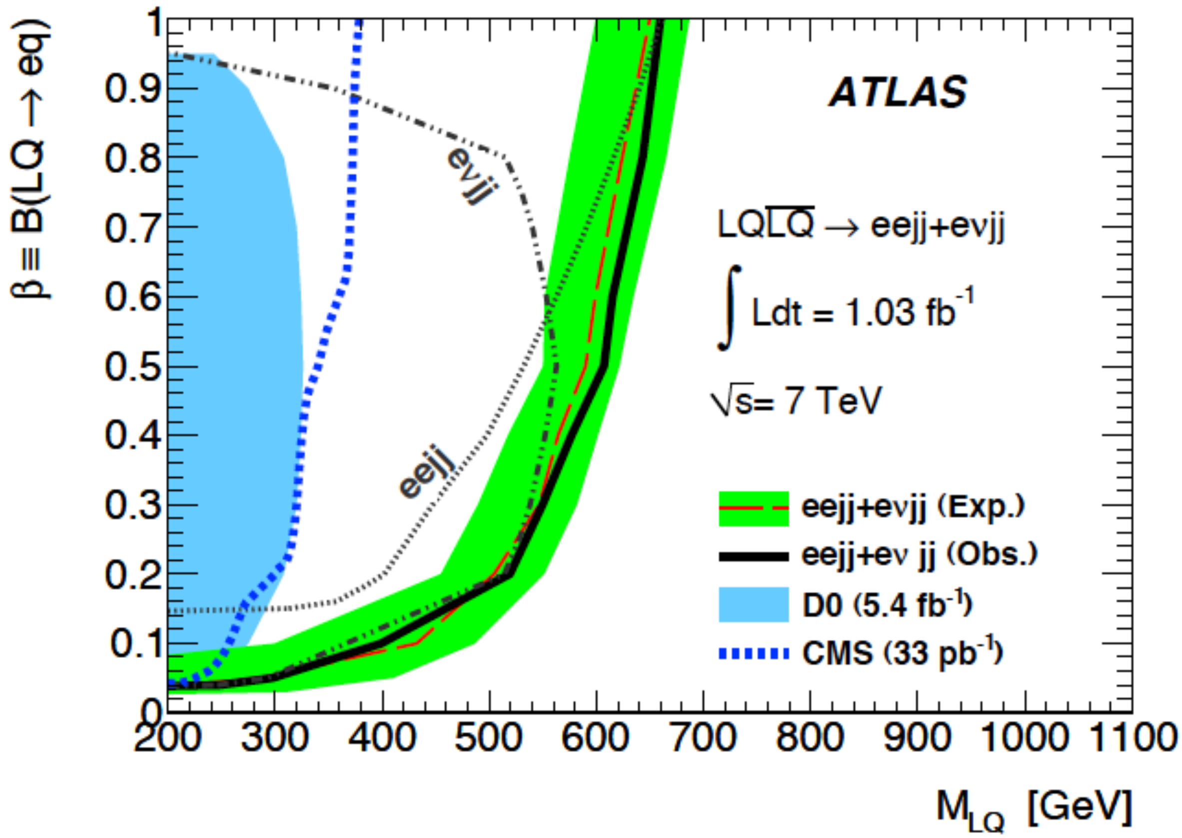


Figure 3: 95% confidence level exclusion contours for non-rotating (left) and rotating (right) black holes in models with two and six extra dimensions. The dashed lines show the expected exclusion contour with the 1σ uncertainty shown as a band. The solid lines show the observed exclusion contour. The regions below the contour are excluded by this analysis. The dotted lines show lines of constant slope equal to 3, 4, and 5. Only slopes much larger than 1 correspond to physical models.


ATLAS
$LQ\overline{LQ} \rightarrow eejj+e\nu jj$
$\int Ldt = 1.03\ fb^{-1}$
$\sqrt{s}= 7$ TeV
eejj+eνjj (Exp.)
eejj+eν jj (Obs.)
D0 (5.4 fb^{-1})
CMS (33 pb^{-1})
eνjj
eejj
$\beta \equiv B(LQ \rightarrow eq)$
M_{LQ} [GeV]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
200
300
400
500
600
700
800
900
1000
1100

bounds on MWT parameters from W' and Z'

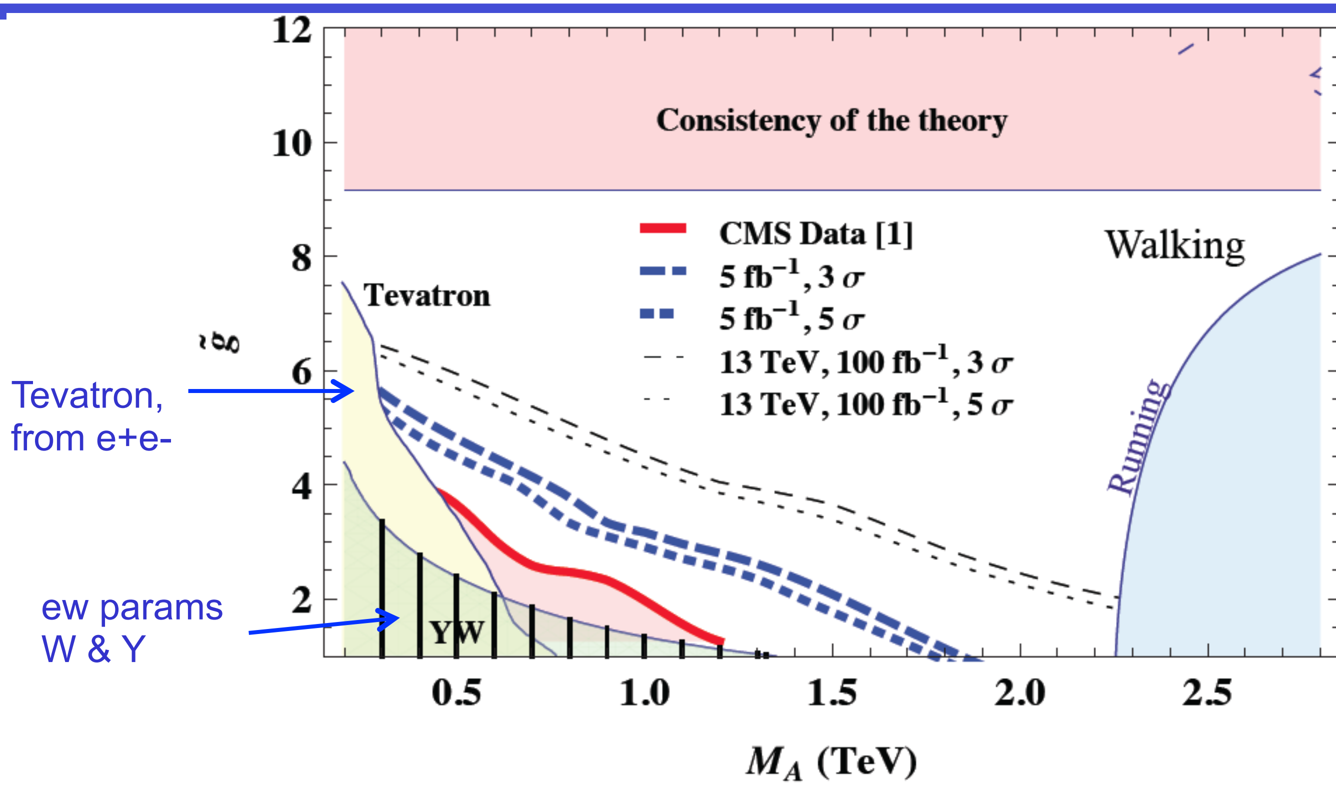


FIG. 1: Bounds in the $(M_A, \tilde{g})$ plane of the NMWT parameter space: (i) CDF direct searches of the neutral spin one resonance excludes the uniformly shaded area in the left, with $M_H = 200$ GeV and $s = 0$. (ii) The 95 % confidence level measurement of the electroweak precision parameters W and Y excludes the striped area in the left corner. (iii) Imposing the modified WRS's excludes the uniformly shaded area in the right corner. (iv) The horizontal stripe is excluded imposing reality of the axial and axial-vector decay constants. (v) The area below th thick uniform line is excluded by the CMS data [1]. (vi) Dashed and dotted lines are expected exclusions using different values of the integrated luminosity and center of mass energy.

J R Andersen, T Hapola and F Sannino, arXiv:1105.1433