Using multilepton events in a global search for new physics

Mark Kruse, Duke University

CoEPP workshop, Cairns July 2013







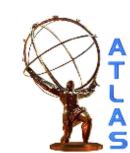


ARC Centre of Excellence for Particle Physics at the Terascale

ATLAS

Prelude

- CoEPP nodes (Melbourne, Sydney) and Duke (as a PI institution), over the last couple of years have been working on a novel technique for simultaneously measuring cross-sections of processes with dilepton final states (coined AIDA – An Inclusive Dilepton Analysis)
 - This has been a very effective and successful collaborative effort
 - In the final stages now of ATLAS approval, to be followed by a publication
 - Working now on developing the next generation of AIDA analysis(es)
 - ATLAS is very keen on the continuation of this analysis effort
- In addition Doug Benjamin (Duke) has started to collaborate with the Nectar Cloud and Research computing teams on using cloud computing for predominately user analysis
 - Test the use of local data caching at each cloud site and federated storage between the cloud sites to make it easier for Australian analyzers to access and use the derived data products
 - Setup a set of test programs to evaluate the performance of cloud sites for data analysis
 - See Tony Limosani's talk for more details





June 7, 2013



An Inclusive Analysis of $t\bar{t}$, WW, and $Z \rightarrow \tau\tau$ Production in the Dilepton Final State at $\sqrt{s} = 7$ TeV with the ATLAS Detector at the LHC Version 3.3.1

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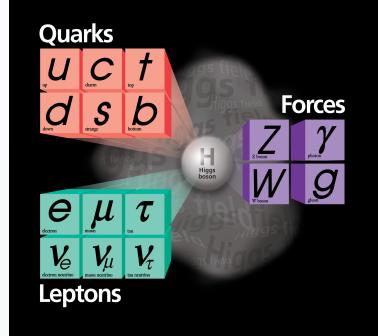
 Analysis has achieved considerable recognition, and is being driven by Sydney and Melbourne (and Kevin Finelli who will very soon be joining Sydney as a postdoc)

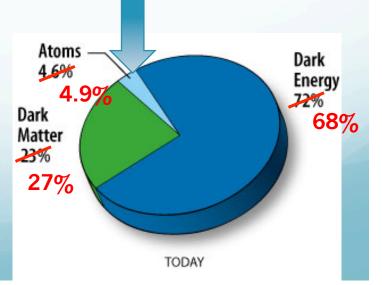
Outline

- Testing the Standard Model
- Searches for new physics beyond the SM using SUSY as a specific example
- The need for more global searches enter AIDA
- Final thoughts

Physics at ATLAS

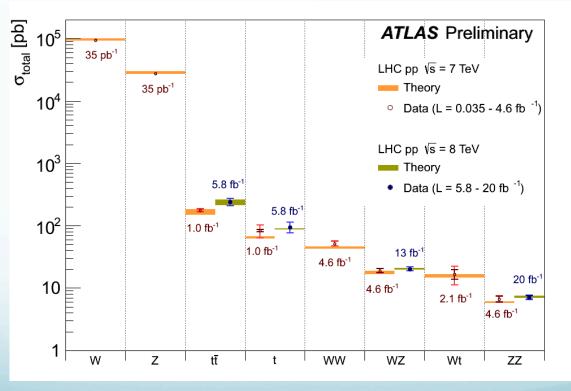
- An enormous variety of measurements and direct searches
- The SM has had remarkable success in describing our observations of the universe
- But, the SM is incomplete, so:
 - 1. Test it for indirect evidence of new physics
 - Precision measurements
 - Rare processes
 - 2. Directly search for physics beyond it:
 - SUSY (still our favourite!)
 - Many non-SUSY BSM searches





Testing the Standard Model

- SM makes specific predictions of the cross-sections of a wide variety of processes
- Major theoretical advances with new NLO/NNLO calculations and NLO with showering
- New physics can show up in the production and/or decay in some of these processes which might result in anomalous cross-section measurements



No such anomalies are being observed within the current precision of these measurements

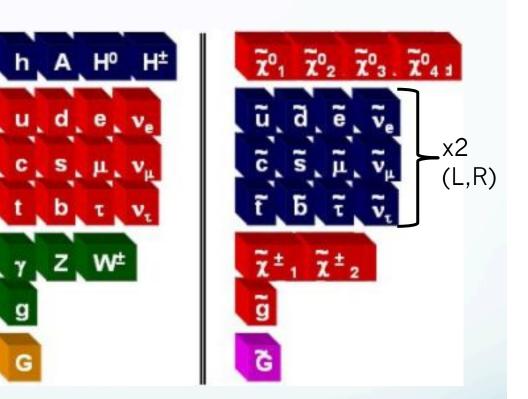
Direct searches beyond the SM – why?

 The SM is not a complete theory and new physics might show up at energy scales accessible at the LHC

- Although the parameter space for some of the simpler SUSY regimes is being constrained by LHC data, SUSY is probably still the most favoured theory to reveal new physics ?
 - But we have to look for all possibilities leave no stone unturned

Supersymmetry

- Symmetry between fermions and bosons
 - Different masses → symmetry broken
- Can solve Higgs mass divergence
- Can alleviate hierachy problem
- Has a natural candidate for DM (LSP stable if R-parity conserved)
 - Leads to signatures with large missing transverse energy
- SUSY implies many new particles
 - None of which have been observed
 - Unless we've found the h^o !
 - Current limits are certainly constraining some SUSY scenarios



Searching for SUSY

 An enormous array of analyses/signatures covering many different SUSY scenarios

2012 data (8 TeV)

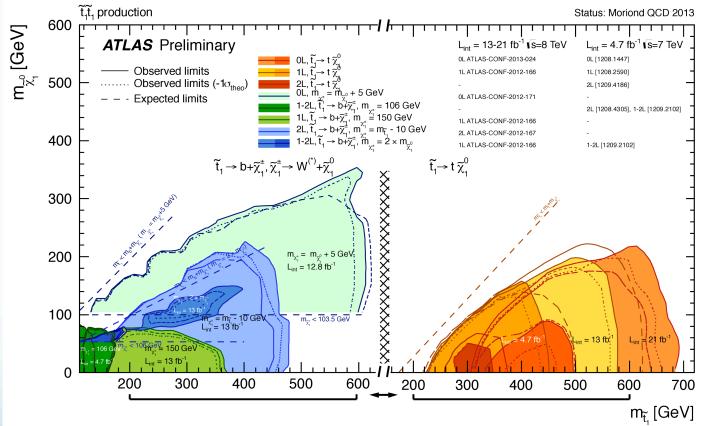
E.g.

Short Title of the CONF note	
0 lepton + 6 (2 b-)jets + Etmiss [Heavy stop] NEW	P
Z + b-jet + jets + Etmiss [Direct stop in GMSB, direct stop2] NEV	ŷ .
1-2 taus + jets + Etmiss [GMSB] NEW	000000
2 taus + Etmiss [EW production] NEW	
2 same-sign leptons + 0-3 b-jets + Etmiss NEW	j j j
0 lepton + 2 b-jets + Etmiss [Medium / heavy stop]	P
2 leptons + Etmiss [Medium stop]	
1 lepton + 4(1 b-)jets + Etmiss [Medium / heavy stop]	
2 bjets + Etmiss [Direct sbottom]	
3 leptons + Etmiss [EW production]	
4 leptons + Etmiss [RPV]	
0 lepton + >=3 b-jets + Etmiss [3rd gen. squarks]	$\tilde{\chi}_1^+$
3 leptons + jets + Etmiss [3rd gen. squarks]	\tilde{b}_1^*
Monojet + Etmiss [WIMP, gravitino prod.]	
Z + jets + Etmiss [GGM, higgsino NLSP]	β ₁ μ _ν
0 leptons + >=2-6 jets + Etmiss	$\tilde{\chi}_{1}^{-}$
0 leptons + >=6-9 jets + Etmiss	
1 lepton + >=4 jets + Etmiss	''/
2 same-sign leptons + >=4 jets + Etmiss	

- -
- -

ATLAS searches for SUSY

- Example: summary of third generation searches
 - Expect stop to be light (<1 TeV) to cancel top mass contribution to m_H



 Contours overlayed from different stop decay channels, different sparticle mass hierachies, and simplified decay scenarios. Care must be taken when interpreting them – but shows reach

SUSY summary !

	MSUGRA/CMSSM : 0 lep + j's + E _{T, miss}	1-5 9 fb ⁻¹ 9 Toy (AT) AS COME 2012 1001	1.50 TeV q = g mass	
	MSUGRA/CMSSM : 1 lep + j's + $E_{T,miss}$	L=5.8 fb ⁻¹ 8 TeV [AT] AS_CONE-2012-104]	1.24 TeV q = g mass	
	Pheno model : 0 lep + j's + $E_{T,miss}$	(=5.6 fb ⁻¹ , 8 TeV [AT] AS-CONE-2012-109]	1.18 TeV g mass (m(g) < 2 TeV, light	🚓 ATLAS
	Pheno model : 0 lep + j's + $E_{T,miss}$	(=5.8 fb ⁻¹ 8 TeV (ATLAS_CONE_2012_109)	1.38 TeV Q Mass (m(g) < 2 TeV, lig	
	Gluino med. $\tilde{\chi}^{\pm}$ ($\tilde{g} \rightarrow q\bar{q}\tilde{\chi}^{\pm}$) : 1 lep + j's + $E_{T \text{ miss}}$	L=4.7 fb ⁻¹ , 7 TeV [1208.4688]	900 GeV \tilde{g} mass $(m(\chi^0) < 200 \text{ GeV}, m(\chi^{\pm})$	
¢	GMSR(INISP) : 2 lon (OS) + i's + F	L=4.7 fb ⁻¹ , 7 TeV [1208.4688]	1.24 TeV $\tilde{\mathbf{g}}$ mass $(\tan\beta < 15)$	2
(GMSB ($\overline{1}$ NLSP) : 2 lep (OS) + j's + $E_{T,miss}$ GMSB ($\overline{\tau}$ NLSP) : 1-2 τ + 0-1 lep + j's + $E_{T,miss}$	L=4.7 fb ⁻¹ , 7 TeV [1210.1314]	1.20 TeV ĝ mass (tanβ > 20)	c
	GGM (bino NLSP) : $\gamma\gamma + E^{7}$	L=4.8 fb ⁻¹ , 7 TeV [1209.0753]	1.07 TeV \tilde{g} mass $(m(\chi^0) > 50 \text{ GeV})$	$Ldt = (2.1 - 13.0) \text{fb}^{-1}$
	GGM (wino NLSP) : γ + lep + E	L=4.8 fb ⁻¹ , 7 TeV [ATLAS-CONF-2012-144]	619 GeV g mass	$\int Ldt = (2.1 - 13.0)$ ID
	GGM (higgsino-bino NLSP) : $\gamma + b + E'$	L=4.8 fb ⁻¹ , 7 TeV [1211.1167]	900 GeV g mass (m(x) > 220 GeV)	s = 7, 8 TeV
	GGM (higgsino NLSP) : Z + jets + $E_{T,miss}^{T,miss}$	L=5.8 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-152]	690 GeV g mass (m(H) > 200 GeV)	10 110 101
	Gravitino LSP : 'monojet' + ET miss	L=10.5 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-147]	645 GeV F ^{7/2} scale (m(G) > 10 ⁻⁴ eV)	
	$\tilde{g} \rightarrow b \bar{b} \bar{\chi}^0$ (virtual \tilde{b}) : 0 lep + 3 b-j's + E_T miss	L=12.8 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-145]	1.24 TeV g mass (m(x) < 200 GeV	1
gluino med.	$\tilde{g} \rightarrow tt \tilde{\chi}_{*}$ (virtual \tilde{t}) : 2 lep (SS) + j's + $E_{T,miss}$	L=5.8 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-105]	850 GeV \tilde{g} mass $(m(\bar{\chi}^0) < 300 \text{ GeV})$	
5	$\tilde{g} \rightarrow t t \tilde{\chi}_{e}^{0}$ (virtual t): 2 lep (00) + j's + $E_{T,miss}$	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-151]	860 GeV $\tilde{\mathbf{g}}$ mass $(m(\overline{\chi}) < 300 \text{ GeV})$	8 TeV results
, ii	$\tilde{g} \rightarrow t \tilde{\chi}_{\chi}^{\prime}$ (virtual \tilde{t}): 0 lep + multi-j's + $E_{T,miss}$	L=5.8 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-103]	1.00 TeV \tilde{g} mass $(m(\bar{\chi}^0) < 300 \text{ GeV})$	7 TeV results
glt	$\tilde{g} \rightarrow t \tilde{t} \chi$ (virtual \tilde{t}): 0 lep + 3 b-j's + $E_{T,miss}$	L=12.8 fb ⁻¹ . 8 TeV IATLAS-CONF-2012-1451	1.15 TeV g mass (m(x ⁰) < 200 GeV)	7 Tev Tesuits
	bb, b, $\rightarrow b\bar{\chi}$: 0 lep + 2-b-jets + $E_{T,miss}$	L=12.8 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-165]	620 GeV b mass (m(χ ⁰) < 120 GeV)	
и	$bb, b \rightarrow t\bar{x}^{\pm}$; 3 len + i's + E-	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-151]	405 GeV \vec{b} mass $(m(\vec{\chi}_{1}^{\pm}) = 2m(\vec{\chi}_{1}))$	
ctic	$\widetilde{t}\widetilde{t}(light), \widetilde{t} \rightarrow b\widetilde{\chi}^{\pm}: 1/2' lep (+ b - jet) + E_{T,miss}$	L=4.7 fb ⁻¹ , 7 TeV [1208.4305, 1209.2102][67 Ge		
-np	$\widetilde{t}t$ (medium), $\widetilde{t} \rightarrow b \widetilde{\chi}_{1}^{\pm}$: 1 lep + b-jet + $E_{T,miss}$	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-166]	160-350 GeV \tilde{t} mass $(m(\chi^0) = 0 \text{ GeV}, m(\chi^\pm) = 150 \text{ GeV})$	
brd	$\tilde{t}\tilde{t}$ (medium), $\tilde{t} \rightarrow b\tilde{\chi}_{1}^{\pm}$: 2 lep + $E_{T,miss}^{\prime,mas}$	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-167]	160-440 GeV \tilde{t} mass $(m(\bar{\chi}^0) = 0 \text{ GeV}, m(\tilde{t}) - m(\bar{\chi}^{\pm}) = 10 \text{ GeV})$	
g a	$\widetilde{t}, \widetilde{t} \rightarrow t \widetilde{\chi}$: 1 lep + b-jet + $E_{T,miss}$	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-166]	230-560 GeV \tilde{t} mass $(m(\chi^0) = 0)$	
direct production	$\widetilde{tt}, \widetilde{t} \rightarrow t \widetilde{\chi}_{4}^{0}$: 0/1/2 lep (+ b-jets) + $E_{T \text{ miss}}$	L=4.7 fb ⁻¹ , 7 TeV [1208.1447,1208.2590,1209.418		
0	tt (natural GMSB) : $Z(\rightarrow II) + b - iet + F$	L=2.1 fb ⁻¹ , 7 TeV [1204.6736]	310 GeV \tilde{t} mass (115 < $m(\chi^0)$ < 230 GeV)	
	$ \rightarrow \overline{\gamma} $; 2 lep + E _T min	L=4.7 fb ⁻¹ , 7 TeV [1208.2884] 85-195	GeV $\int mass (m(\overline{\chi}^0) = 0)$	
direct	$\begin{array}{c} \overline{\chi}_{1}^{+}\overline{\chi}_{1}^{-}\overline{\lambda}^{+}(\overline{k}) = h\overline{\chi}_{1}^{+}\overline{\lambda}^{+}(\overline{k}) \\ \overline{\chi}_{1}^{+}\overline{\chi}_{2}^{-} \to h\overline{\chi}_{1}^{+}(\overline{k}\overline{\chi}), \overline{h}\overline{\chi}_{1}(\overline{k}\overline{\chi}) : 3 \text{ lep } + \overline{E}_{T, miss} \\ \overline{\chi}_{1}^{+}\overline{\chi}_{2}^{-} \to M^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{2}^{+}\cdot\overline{\chi}_{2}^{+}: 3 \text{ lep } + \overline{E}_{T, miss} \\ \overline{\mu}_{1}\overline{\chi}_{1}^{+}\overline{\chi}_{2}^{+} \to M^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{2}^{+}\cdot\overline{\chi}_{2}^{+}: 3 \text{ lep } + \overline{E}_{T, miss} \\ \overline{\mu}_{1}\overline{\chi}_{1}^{+}\overline{\mu}_{2}^{+}\overline{\mu}_{1}^{+}\overline{\mu}_{2}^{+}(\overline{\lambda}) (\overline{\lambda}) \\ \overline{\mu}_{1}\overline{\chi}_{1}^{+}\overline{\mu}_{2}^{+}\overline{\mu}_{1}^{+}\overline{\chi}_{2}^{+}(\overline{\lambda}) \\ \overline{\mu}_{1}\overline{\chi}_{1}^{+}\overline{\mu}_{2}^{+}\overline{\mu}_{1}\overline{\chi}_{2}^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{1}^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{1}^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{2}^{+}\overline{\chi}_{1}^{+}\overline{\chi}_{2}^{$	L=4.7 fb ⁻¹ , 7 TeV [1208.2884]	110-340 GeV $\tilde{\chi}_{*}^{\pm}$ MASS $(m(\chi_{*}^{0}) < 10 \text{ GeV}, m(\tilde{l}, \tilde{v}) = \frac{1}{2}(m(\chi_{*}^{\pm}) + m(\chi_{*}^{0}))$	0)
i iji	$\tilde{\chi}_{\chi}^{\pm} \tilde{\chi}_{\chi}^{\circ} \rightarrow I_{\chi} v I_{\chi} I(\tilde{v}v), \tilde{v} _{\chi} I(\tilde{v}v) : 3 \text{ lep } + E_{\chi}$	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-154]	580 GeV $\tilde{\gamma}^{\pm}$ mass $(m(\tilde{\tau}^{\pm}) = m(\tilde{\tau}^{0}) \tilde{m}(\tilde{\tau}^{0}) = 0 m(\tilde{\eta})$	() as above)
	$\tilde{\chi}_{\pm}^{\pm}\tilde{\chi}_{\pm}^{0} \rightarrow W^{(*)}\tilde{\chi}_{\pm}^{0}Z^{(*)}\tilde{\chi}_{\pm}^{0}: 3 \text{ lep } + E_{T,\text{miss}}^{T,\text{miss}}$	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-154]	40-295 GeV $\tilde{\chi}_{1}^{\pm}$ mass $(m(\tilde{\chi}_{1}^{\pm}) = m(\tilde{\chi}_{2}^{0}), m(\tilde{\chi}_{1}) = 0$, sleptons decouple	ed)
	Direct $\tilde{\chi}_{i}$ pair prod. (AMSB) : long-lived $\tilde{\chi}_{i}$	L=4.7 fb ⁻¹ , 7 TeV [1210.2852] 22	0 GeV $\tilde{\chi}_{4}^{\pm}$ mass $(1 < \tau(\tilde{\chi}_{4}^{\pm}) < 10 \text{ ns})^{2}$	
particles	Stable \tilde{g} R-hadrons : low β , $\beta\gamma$ (full detector)	L=4.7 fb ⁻¹ , 7 TeV [1211.1597]	985 GeV g mass	
tic	Stable t R-hadrons : low β, βγ (full detector)	L=4.7 fb ⁻¹ , 7 TeV [1211.1597]	683 GeV t mass	
pai	GMSB : stable 7	L=4.7 fb ⁻¹ , 7 TeV [1211.1597]	300 GeV τ mass (5 < tanβ < 20)	
	$\tilde{\chi}^0_{\star} \rightarrow qq\mu$ (RPV) : μ + heavy displaced vertex	L=4.4 fb ⁻¹ , 7 TeV [1210.7451]	700 GeV q̃ mass (0.3×10 ⁻⁵ < λ ₂₁₁ < 1.5×10 ⁻⁵ , 1 r	nm < cτ < 1 m, ĝ decoupled)
	LFV : pp $\rightarrow \tilde{v}_{\tau}+X, \tilde{v}_{\tau}\rightarrow e+\mu$ resonance	L=4.6 fb ⁻¹ , 7 TeV [Preliminary]	1.61 TeV V π Mass (λ ₃₁₁ =0.10,	λ ₁₃₂ =0.05)
	LFV : $pp \rightarrow \tilde{v}_{\tau} + X, \tilde{v}_{\tau} \rightarrow e(\mu) + \tau$ resonance	L=4.6 fb ⁻¹ , 7 TeV [Preliminary]	1.10 TeV \tilde{V}_{g} mass $(\lambda_{311}^{2}=0.10, \lambda_{1(2)33}=0.10)$	
	Bilinear RPV CMSSM : 1 lep + 7 j's + E _{7,miss}	L=4.7 fb ⁻¹ , 7 TeV [ATLAS-CONF-2012-140]	1.2 TeV $\tilde{q} = \tilde{g} \text{ mass } (c\tau_{LSP} < 1 \text{ mm})$	
	$ \widetilde{\chi}_{1}^{+} \widetilde{\chi}_{1}^{-} \widetilde{\chi}_{1}^{+} \rightarrow W \widetilde{\chi}_{0}^{0} \widetilde{\chi}_{0}^{0} \rightarrow eev_{\mu}, e\mu\nu : 4 lep + E_{T,miss} $	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-153]	700 GeV $\tilde{\chi}_{1}$ mass $(m(\tilde{\chi}_{1}^{0}) > 300 \text{ GeV}, \lambda_{121} \text{ or })$	λ ₁₂₂ > 0)
	$ _{L} _{L}, _{L} \rightarrow \tilde{\chi}_{1}, \tilde{\chi}_{1} \rightarrow eev_{\mu}, e\mu v_{\mu} : 4 lep + E_{T,miss}$	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-153]	430 GeV $ $ mass $(m(\chi_1^0) > 100 \text{ GeV}, m(\tilde{l}_0)=m(\tilde{l}_1)=m(\tilde{l}_1), \lambda_{12}$	₁₁ or λ ₁₂₂ > 0)
	$q \rightarrow qqq$: 3-jet resonance pair	L=4.6 fb ⁻¹ , 7 TeV [1210.4813]	666 GeV ĝ mass	
	Scalar gluon : 2-jet resonance pair P interaction (D5, Dirac χ) : 'monojet' + E_{r}	1	00-287 GeV Sgluon mass (incl. limit from 1110.2693)	
VIIVIE	 Interaction (D5, Dirac χ): monojet + E T_miss 	L=10.5 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-147]	704 GeV M* SCAIE (m _g < 80 GeV, limit of < 687	GeV for D8)
		· · · · · · · · · · · · · · · · · · ·		
		10 ⁻¹	1	10

Analyses only now starting to produce results with full 2011/2012 dataset

After LHC shutdown, doubling of CM energy will extend reach

Non-susy BSM summary

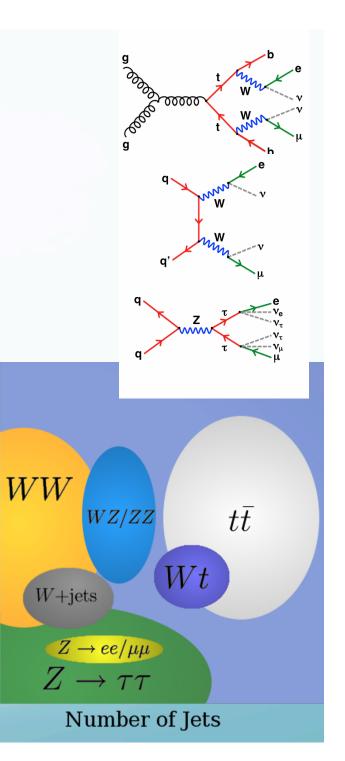
ATLAS Exotics Searches* - 95% CL Lower Limits (Status: HCP 2012) Large ED (ADD) : monojet + E_{T miss} 4.37 TeV M_D (δ=2) Large ED (ADD) : monophoton + E_{T miss} 1.93 TeV M_D (δ=2) ATLAS Large ED (ADD) : diphoton & dilepton, myy /II 4.18 TeV M_S (HLZ δ=3, NLO) Extra dimensions 7 TeV [1211.1150] Preliminary UED : diphoton + $E_{T miss}$ 1.41 TeV Compact. scale R⁻¹ 4.8 fb⁻¹, 7 TeV [ATLAS-CONF-2012-072] 4.71 TeV M_{KK} ~ R⁻¹ S¹/Z₂ ED : dilepton, m_i 7 TeV [1209.253] 2.23 TeV Graviton mass (k/Mpl = 0.1) RS1 : diphoton & dilepton, m_{yy (III} RS1 : ZZ resonance, m **845 GeV** Graviton mass $(k/M_{\rm Pl} = 0.1)$ TeV [1203.0718 $Ldt = (1.0 - 13.0) \text{ fb}^{-1}$ RS1 : WW resonance, mT.NN 1.23 TeV Graviton mass (k/M_{Pl} = 0.1) RS $g_{\mu\nu} \rightarrow tt$ (BR=0.925) : $tt \rightarrow l+jets, m_{\mu}$ 1.9 TeV g_{vv} mass TeV IATLAS-CONF-2012-136 ADD BH $(M_{\text{TH}}/M_{\text{D}}=3)$: SS dimuon, $N_{\text{ch. part.}}^{\text{ILDOUSIED}}$ ADD BH $(M_{\text{TH}}/M_{\text{D}}=3)$: leptons + jets, Σp_{T} s = 7.8 TeV 1.25 TeV M_D (δ=6) 1.5 TeV M_D (δ=6) TeV [1204.464] Quantum black hole : dijet, F. (m) 4.11 TeV M_D (δ=6) qqqq contact interaction : $\chi(m_{_{-}})$ 7.8 TeV A TeV [ATLAS-CONF-2012-038 0 qqll CI : ee & μμ, m 13.9 TeV A (constructive int.) =4.9-5.0 fb⁻¹. 7 TeV [1211.115 uutt CI : SS dilepton + jets + E_{T.miss} 1.7 TeV A =1.0 fb⁻¹, 7 TeV [1202.5520] Z' (SSM) : m_{ee/µµ} 8 TeV [ATLAS-CONF-2012-129 2.49 TeV Z' mass 1.4 TeV Z' mass Z' (SSM) : m,, 4.7 fb⁻¹, 7 TeV [1210.6604 W' (SSM) : m_{T,e/µ} =4.7 fb⁻¹, 7 TeV [1209.4446 2.55 TeV W' mass > W' (\rightarrow tq, g =1): m_{to} 4.7 fb⁻¹, 7 TeV [1209.6593] 430 Gev W' mass W'_{R} (\rightarrow tb, SSM) : m_{L} 1.13 TeV W' mass TeV [1205.1016] W* : m_{T,e/µ} 2.42 TeV W* mass TeV [1209.4446 660 Gev 1st gen. LQ mass Scalar LQ pair (β =1) : kin. vars. in eejj, evjj TeV [1112.4828] LO LO Scalar LQ pair (β =1) : kin. vars. in µµjj, µvjj 685 Gev 2nd gen. LQ mass 7 TeV [1203.3172] Scalar LQ pair (β=1) : kin. vars. in ττij, τvij 538 GeV 3rd gen. LQ mass =4.7 fb⁻¹, 7 TeV [Preliminary 656 GeV t' mass 4th generation : t't'→ WbWb Excit. New quarks ferm. TeV [1210 5468 4th generation : b'b'(T_{5/3})→ WtWt New quark b' : b'b'→ Zb+X, m_{2b} 670 Gev b' (T__) mass 400 Gev b' mass FeV [1204.126 Top partner : TT \rightarrow tt + A₀A₀ (dilepton, M₁₀) 483 GeV T mass (m(A) < 100 GeV) Vector-like quark : CC, mixed **1.12 TeV** VLQ mass (charge -1/3, coupling $\kappa_{aQ} = v/m_{O}$) =4.6 fb⁻¹, 7 TeV [ATLAS-CONF-2012-137 Vector-like quark : NC, mila **1.08 TeV** VLQ mass (charge 2/3, coupling $\kappa_{aQ} = v/m_{Q}$) 4.6 fb⁻¹, 7 TeV IATLAS-CONE-2012-1371 Excited quarks : y-jet resonance, m =2.1 fb⁻¹, 7 TeV [1112.3580 2.46 TeV q* mass Excited quarks : dijet resonance, m 3.84 TeV q* mass =13.0 fb⁻¹, 8 TeV [ATLAS-CONF-2012-148] Excited lepton : I-y resonance, m 2.2 TeV I* mass (Λ = m(I*)) =13.0 fb⁻¹, 8 TeV [ATLAS-CONF-2012-146] Techni-hadrons (LSTC) : dilepton, mee/uu **850 GeV** ρ_{-}/ω_{T} mass $(m(\rho_{-}/\omega_{T}) - m(\pi_{T}) = M_{-})$ Techni-hadrons (LSTC) : WZ resonance (vIII), m 483 GeV ρ_{τ} mass $(m(\rho_{\tau}) = m(\pi_{\tau}) + m_{w}, m(a_{\tau}) = 1.1 m(\rho_{\tau}))$ Other 1.5 TeV N mass (m(W_) = 2 TeV) Major. neutr. (LRSM, no mixing) : 2-lep + jets W_R (LRSM, no mixing) : 2-lep + jets 2.4 TeV W_R mass (m(N) < 1.4 TeV)</p> H_{i}^{\pm} (DY prod., BR($H_{i}^{\pm} \rightarrow II$)=1) : SS ee ($\mu\mu$), m_{i} 409 GeV H^{±±} mass (limit at 398 GeV for μμ) H[≟] (DY prod., BR(H[≟]→eμ)=1) : SS eμ, m["]_{eu} 375 Gev H^{±±} mass Color octet scalar : dijet resonance, m .86 TeV Scalar resonance mass I I I I I I10⁻¹ 10² 1 10 Mass scale [TeV]

Main point

- There are literally hundreds of dedicated searches looking for specific particles within somewhat constrained frameworks (assumptions on masses, BR's, ...)
- These are important, but not the only philosophy in searching for clues to physics beyond the SM
- We (Sydney, Melbourne, Duke) have been developing a more global analysis strategy, using dilepton events to test the SM
 - Might interface nicely into the framework of GAMBIT ?
- This strategy (AIDA) has just negotiated it's first milestone through the "approval" of its simultaneous measurement of SM cross sections

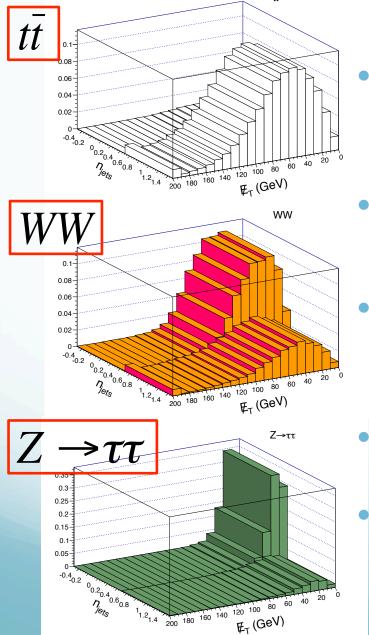
AIDA – the idea

- For **e** μ events:
 - Consider phase space defined by MET and N_{jets}
 - Main SM contributions nicely separated
 - Allows for simultaneous measurement of these cross sections (likelihood fit of data to SM templates) → done
 - Provides more global test of the SM
 - Use technique for more model-independent new physics searches → next
- The advantage of AIDA is a full understanding of the entire parameter space
 - One could also imagine this as a disadvantage!
 - But this understanding we have developed now creates a better foundation for new physics searches



Missing Transverse

AIDA: likelihood fit to templates

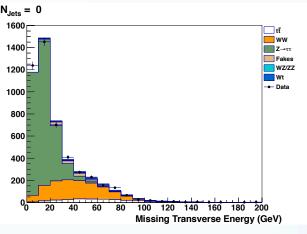


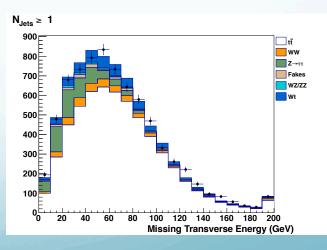
L =

(product of poisson probs for each bin) * (gaussian constraints)

- Normalization of "signal" templates float in the fit
- "Background" templates fixed within gaussian constraints
- Best fit → "signal" cross sections
- Analysis spans different physics groups







AIDA cross section results

 Production cross sections for pp@7TeV simultaneously extracted from the AIDA phase space with ~5 fb⁻¹ of ATLAS data:

> $\sigma(t\bar{t}) = 181.2 \pm 2.8(stat.) \stackrel{+12.1}{_{-11.1}}(syst.) \stackrel{+3.7}{_{-3.5}}(lum.) \text{ pb}$ $\sigma(WW) = 50.5 \pm 2.5(stat.) \stackrel{+6.5}{_{-7.6}}(syst.) \stackrel{+1.1}{_{-0.9}}(lum.) \text{ pb}$ $\sigma(Z \rightarrow \tau\tau) = 1158.0 \pm 23.9(stat.) \stackrel{+65.6}{_{-83.0}}(syst.) \stackrel{+21.4}{_{-20.3}}(lum.) \text{ pb}$

- Notes:
 - cf. SM predictions of: $\sigma(t\bar{t}) = 172.0 \pm 6.2 \text{ pb}$ (NNLO)

 $\sigma(WW) = 44.7 \pm 2.1 \text{ pb}$ (NLO)

 $\sigma(Z \rightarrow \tau \tau) = 964 \pm 48 \text{ pb} (\text{NNLO}, M_{\tau\tau} > 40 \text{ GeV})$

- Approval process includes both top and SM groups
- Only tt cross section measurement at 7 TeV in the dilepton channel
- Results comparable to, and competitive with, dedicated measurements

AIDA analysis phase 1 🖌

AIDA: next steps

- Develop metric for quantifying consistency of AIDA phase space with SM (started by Nik Patel, Sydney)
- Develop AIDA search strategies
- Inclusion of ee and μμ events
- Look into possibilities of extending the phase space
- E.g. third axis of N_{leptons}
- Look at same-sign dileptons with AIDA
- Include b-tagging information
- These, and more, will be discussed after this CoEPP workshop in an AIDA brainstorming week in Sydney

Final thoughts

- Although theories now exist that could account for inadequacies of the SM, it will be experiments such as those now being conducted at the LHC that will determine which, if any, of these theories might be right, and perhaps lead us to a more complete theory.
- There is a chance that results from the LHC experiments (together perhaps with current/future astrophysics experiments) could guide us in a completely different direction.
- We need to be open minded about how the SM could be extended → AIDA is one such idea being developed wholly within CoEPP and which has been gaining considerable recognition.
- These are exciting times, mechanism behind EWSB solved (at least partially), DM experiments making huge advances, neutrino sector increasingly better understood, etc., and LHC getting ready in a couple of years to run at double the energy.