BSM in Generators: ATLAS Perspective

MC4BSM, Durham 2018 David Yallup





THE CHALLENGES

Brief of this talk:

- Don't talk too much about the physics -Want to think about the MC tools
- Don't talk about SM (background) MC too much
- Cover as much ATLAS as possible (A very birdseye view)

ATLAS Collaboration (Morad Aaboud (Oujda U.) et al.) Show all 2851 authors

Apr 10, 2018 - 39 pages

ATLAS is **BIG**

| D | ecember 2017 Model | e, μ, τ, γ | Jets | $E_{\rm T}^{\rm miss}$ | ∫L dt[fb | Mass limit | $\sqrt{s} = 7,3$ | $\frac{1}{\sqrt{s}} = 13 \text{ TeV}$ | $\sqrt{s} = 7, 8, 13 \text{ Te}$ Reference |
|-------------------|---|--|--|--|---|---|---------------------------------|--|---|
| e Searches | $\begin{array}{l} \bar{q}\bar{q}, \bar{q} \rightarrow q \bar{x}_{1}^{0} \\ \bar{q}\bar{q}, \bar{q} \rightarrow q \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q \bar{q} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q \bar{q} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q q \bar{x}_{1}^{0} \rightarrow q q W^{2} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q q (\ell \bar{x}_{1}^{0} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q q (\ell \bar{x}_{1}^{0} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q q (\ell \bar{x}_{1}^{0} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q q (\ell \bar{x}_{1}^{0} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q (\ell \bar{x}_{1}^{0} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q q (\ell \bar{x}_{1}^{0} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q (\ell \bar{x}_{1}^{0} \bar{x}_{1}^{0} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q (\ell \bar{x}_{1}^{0} \bar{x}_{1}^{0} \bar{x}_{1}^{0} \\ \bar{x}\bar{p}, \bar{x} \rightarrow q (\ell \bar{x}_{1}^{0} \bar{x}_{1}^{0} \bar{x}_{1}^{0} \bar{x}_{1}^{0} \bar{x}_{1}^{0} \\ \bar{x}\bar{y}, \bar{x} \rightarrow q (\bar{x} \bar{x}_{1}^{0} \bar{x}) \\ \bar{x}\bar{y}, \bar{x} \rightarrow q (\bar{x} \bar{x}) $ | 0 mono-jet 0 0 <i>ee</i> , μμ 3 <i>e</i> , μ | 2-6 jets 1-3 jets 2-6 jets 2-6 jets 2 jets 4 jets | Yes Yes Yes Yes Yes | 36.1 36.1 36.1 36.1 14.7 36.1 | 4 710 GeV 2 710 GeV 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 2 2 2 3 2 4 2 5 2 4 2 5 2 5 2 | 2.01 TeV 1.7 TeV 1.87 TeV | $m(\tilde{\chi}_1^0)$ <300 GeV, $m(\tilde{\chi}_1^0)$ =0 GeV | 1712.02332 1711.03301 1712.02332 1712.02332 1611.05791 1706.03731 |
| Inclusive | $\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq WZ\tilde{\xi}_{1}^{0}$ GMSB ($\tilde{\ell}$ NLSP) GGM (bino NLSP) GGM (higgsino-bino NLSP) Gravitino LSP | 0 1-2 τ + 0-1 ℓ 2 γ γ 0 | 7-11 jets 0-2 jets 2 jets mono-jet | Yes Yes Yes Yes Yes | 36.1 3.2 36.1 36.1 20.3 | 2 2 2 8 <i>P^{1/2} scale</i> 865 GeV | | $\begin{split} & m(\tilde{x}_1^0) < & 400 \ \mathrm{GeV} \\ & er(NLSP) < & 0.1 \ \mathrm{mm} \\ & m(\tilde{x}_1^0) = & 1700 \ \mathrm{GeV}, \ cr(NLSP) < & 0.1 \ \mathrm{mm}, \ \mu > & 0 \\ & m(\tilde{c}) > & 1.8 \times 10^{-4} \ \mathrm{eV}, \ m(\tilde{a}) = & m(\tilde{a}) = & 1.5 \ \mathrm{TeV} \end{split}$ | 1708.02794 1607.05979 ATLAS-CONF-2017-080 ATLAS-CONF-2017-080 1502.01518 |
| g med. | $\tilde{g}\tilde{g}, \tilde{g} \rightarrow b \bar{b} \tilde{\chi}_{1}^{0}$ $\bar{g}\tilde{g}, \tilde{g} \rightarrow t \bar{t} \tilde{\chi}_{1}^{0}$ | 0 0-1 <i>e</i> ,μ | 3 b 3 b | Yes Yes | 36.1 36.1 | ξ ξ | 1.92 TeV 1.97 TeV | $m(\tilde{\chi}_1^0)$ <600 GeV $m(\tilde{\chi}_1^0)$ <200 GeV | 1711.01901 1711.01901 |
| direct production | $ \begin{split} \tilde{b}_1 \tilde{b}_1, \tilde{b}_1 \rightarrow b \tilde{k}_1^0 \\ \tilde{b}_1 \tilde{b}_1, \tilde{b}_1 \rightarrow b \tilde{k}_1^1 \\ \tilde{n}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow b \tilde{k}_1^2 \\ \tilde{n}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow b \tilde{k}_1^0 \\ \tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow c \tilde{k}_1^0 \\ \tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow c \tilde{k}_1^0 \\ \tilde{t}_2 \tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + Z \\ \tilde{t}_2 \tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + h \end{split} $ | 0 2 e, µ (SS) 0-2 e, µ 0-2 e, µ 0 2 e, µ (Z) 3 e, µ (Z) 1-2 e, µ | 2 b 1 b 1-2 b 1-2 jets/1-2 mono-jet 1 b 1 b 4 b | | 36.1 36.1 .7/13.3 0.3/36.1 36.1 20.3 36.1 36.1 36.1 | 6 950 GeV 51 275-700 GeV 71 170-700 GeV 71 90-198 GeV 0.195-10 TeV 71 90-190 GeV 0.195-10 TeV 72 150-600 GeV 1 72 290-790 GeV 1 72 290-790 GeV 1 72 320-800 GeV 1 | | $\begin{split} m(\tilde{c}_1^3) & < 420 \ \text{GeV} \\ m(\tilde{c}_1^3) & < 200 \ \text{GeV}, m(\tilde{c}_1^3) = m(\tilde{c}_2^3) + 100 \ \text{GeV} \\ m(\tilde{c}_1^3) & = m(\tilde{c}_1^3), m(\tilde{c}_1^3) = 56 \ \text{GeV} \\ m(\tilde{c}_1^3) = 1 \ \text{GeV} \\ m(\tilde{c}_1^3) = 150 \ \text{GeV} \\ m(\tilde{c}_1^3) = 150 \ \text{GeV} \\ m(\tilde{c}_1^3) = 150 \ \text{GeV} \end{split}$ | 1708.09266 1706.03731 1209.2102, ATLAS-CONF-2016-077 1506.08616, 1709.04183, 1711.11520 1711.03301 1403.5222 1706.03986 1706.03986 |
| direct | $ \begin{split} \tilde{t}_{1,k}\tilde{t}_{1,k}, \tilde{t} \rightarrow \mathcal{K}_1^0 \\ \tilde{x}_1\tilde{x}_1, \tilde{x}_1^+ \rightarrow \mathcal{K}(\tilde{x}) \\ \tilde{x}_1\tilde{x}_1, \tilde{x}_1^+ \rightarrow \mathcal{K}(\tilde{x}) \\ \tilde{x}_1^+\tilde{x}_1^+ \tilde{x}_2^+, \tilde{x}_1^+ \rightarrow \mathcal{K}(\tilde{x}) \\ \tilde{x}_1^+\tilde{x}_1^0 \rightarrow \mathcal{K}_1^+ \tilde{x}_1^0 \\ \tilde{x}_1^+\tilde{x}_2^0 \rightarrow \tilde{x}_1\ell \\ GGM (kino NLSP) weak prod., \tilde{x}_1^0 \rightarrow , \\ GGM (kino NLSP) weak prod., \tilde{x}_1^0 \rightarrow , \\ \end{split} $ | | 0 0 0-2 jets 0-2 <i>b</i> 0 - | Yes Yes Yes Yes Yes Yes Yes Yes | 36.1 36.1 36.1 36.1 20.3 20.3 20.3 36.1 | Image: Provide and Provided And Pr | $m(\tilde{\chi}_2^0)=$ | $\begin{split} m(\tilde{x}_{1}^{2}) &= 0 \\ m(\tilde{x}_{1}^{2}) &= 0, \ m(\tilde{x}_{1}^{2}) &= 0.5(m(\tilde{x}_{1}^{2}) + m(\tilde{x}_{1}^{2})) \\ m(\tilde{x}_{1}^{2}) &= 0, \ m(\tilde{x}_{1}^{2}) = 0.5(m(\tilde{x}_{1}^{2}) + m(\tilde{x}_{1}^{2})) \\ m(\tilde{x}_{1}^{2}) &= m(\tilde{x}_{1}^{2}) = 0.5(m(\tilde{x}_{1}^{2}) + m(\tilde{x}_{1}^{2})) \\ m(\tilde{x}_{1}^{2}) - m(\tilde{x}_{2}^{2}), \ m(\tilde{x}_{1}^{2}) &= 0.5(m(\tilde{x}_{1}^{2}) + m(\tilde{x}_{1}^{2})) \\ m(\tilde{x}_{1}^{2}) - m(\tilde{x}_{2}), \ m(\tilde{x}_{1}^{2}) = 0.5(m(\tilde{x}_{2}^{2}) + m(\tilde{x}_{1}^{2})) \\ m(\tilde{x}_{1}^{2}) - m(\tilde{x}_{1}^{2}) = 0.5(m(\tilde{x}_{2}^{2}) + m(\tilde{x}_{1}^{2})) \\ cr < 1 mm \\ cr < 1 mm \end{split}$ | ATLAS CONF-2017-039 ATLAS-CONF-2017-039 1708.07875 ATLAS-CONF-2017-039 1501.07110 1405.5086 15507.05493 ATLAS-CONF-2017-080 |
| particles | Direct $\hat{x}_1^{\dagger} \hat{x}_1^{-}$ prod., long-lived \hat{x}_1^{\dagger} Direct $\hat{x}_1^{\dagger} \hat{x}_1^{-}$ prod., long-lived \hat{x}_1^{-} Stable \hat{g} R-hadron Stable \hat{g} R-hadron Metastable \hat{g} R-hadron, $\hat{g} \rightarrow q \hat{q}_1^{0}$ GMSB, stable $\hat{\tau}, \hat{x}_1^{0} \rightarrow \hat{\tau}(\hat{\epsilon}, \hat{\mu}) + \tau(\epsilon, \mu)$ GMSB, $\hat{x}_1^{0} \rightarrow \hat{\tau}(\hat{\epsilon}, \hat{\mu}) + \tau(\epsilon, \mu)$ GMSB, $\hat{x}_1^{0} \rightarrow \hat{\tau}(\hat{\epsilon}, \hat{\mu}) + \tau(\epsilon, \mu)$ | Disapp. trk dE/dx trk 0 trk dE/dx trk displ. vtx 1-2 µ 2 γ displ. ee/eµ/µ, | 1 jet - 1-5 jets - - - - - - - | Yes Yes - Yes - Yes - Yes | 36.1 18.4 27.9 3.2 3.2 32.8 19.1 20.3 20.3 | X ⁺ 460 GeV X ⁺ 495 GeV Z 850 GeV Z 950 GeV Z 1.0 TeV | | $\begin{split} m(\tilde{\xi}_{1}^{*}) - m(\tilde{\xi}_{1}^{*}) &= 160 \ \text{MeV}, \ \tau(\tilde{\xi}_{1}^{*}) &= 0.2 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) - m(\tilde{\xi}_{1}^{*}) &= 160 \ \text{MeV}, \ \tau(\tilde{\xi}_{1}^{*}) < 15 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ 10 \ \mu\text{s} < \tau(\tilde{\xi}_{2}^{*}) < 100 \ \text{s} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \\ m(\tilde{\xi}_{1}^{*}) &= 100 \ \text{GeV}, \ \tau_{2} \to 10 \ \text{ns} \ \text{ns} \ \tau_{2} \to 10 \ \text{ns} \ \text{ns} \ \tau_{2} \to 10 \ $ | 1712.02118 1506.05332 1310.6564 1606.05129 1604.04520 1710.04901 1411.6795 1409.5542 1504.05162 |
| A | $ \begin{split} & LFV \; pp \rightarrow \overline{v}_r + X_r \bar{v}_r \rightarrow e\mu/e\tau/\mu\tau \\ & Bilinear \; RPV \; CMSSM \\ & \mathcal{K}_1^* \mathcal{K}_1, \mathcal{K}_1^* \rightarrow W \mathcal{K}_1^* \mathcal{K}_1^* \rightarrow eve, e\mu\nu, \mu\mu\nu \\ & \mathcal{K}_1^* \mathcal{K}_1, \mathcal{K}_1^* \rightarrow W \mathcal{K}_1^* \mathcal{K}_1^* \rightarrow eve, e_{T^*\tau} \\ & \mathcal{K}_2^*, \mathcal{K}_1^* \rightarrow \mathcal{K}_1^* \rightarrow qqq \\ & \mathcal{K}_2^*, \mathcal{K}_2^* \rightarrow E \mathcal{K}_1^*, \mathcal{K}_1^* \rightarrow qqq \\ & \mathcal{K}_2^*, \mathcal{K}_2^* \rightarrow E \mathcal{K}_1^*, \mathcal{K}_1^* \rightarrow qqq \\ & \mathcal{K}_2^*, \mathcal{K}_1^*, \mathcal{K}_1^* \rightarrow bs \\ & \mathcal{K}_1^*, \mathcal{K}_1^* \rightarrow bs \end{split} $ | 1 e,μ 8 1 e,μ 8 0 | 0-3 <i>b</i> | b - | 3.2 20.3 13.3 20.3 36.1 36.1 36.1 36.7 | X-1 450 GeV 2 2 2 2 7i 100-470 GeV 480-510 GeV 480-510 GeV | 1.65 TeV | $ \begin{split} \lambda_{111}^{\prime} = 0.11, \lambda_{132/133/233} = 0.07 \\ m(\tilde{q}) = m(\tilde{g}), c_{T_2SP} < 1 mm \\ m(\tilde{k}_1^{T_1}) > 0.2 m(\tilde{k}_1^{T_1}), \lambda_{132} \neq 0 \\ m(\tilde{k}_1^{T_1}) > 0.2 m(\tilde{k}_1^{T_1}), \lambda_{132} \neq 0 \\ m(\tilde{k}_1^{T_1}) = 1 \text{TeV}, \lambda_{123} \neq 0 \\ m(\tilde{k}_1^{T_1}) = 1 \text{TeV}, \lambda_{123} \neq 0 \end{split} $ | 1607.08079 1404.2500 ATLAS-CONF-2016-075 1405.5506 SUSY-2016-22 1704.08493 1704.08493 1710.07171 |
| | $\tilde{i}_1 \tilde{i}_1, \tilde{i}_1 \rightarrow b\ell$ Scalar charm, $\tilde{c} \rightarrow c \tilde{\chi}_1^0$ | 2 e, µ | 2 b 2 c | Yes | 36.1 20.3 | ī ₁ 0 ō 510 GeV | 0.4-1.45 TeV | $BR(\tilde{t}_1 \rightarrow be/\mu) > 20\%$ $m(\tilde{\chi}_1^0) < 200 \text{ GeV}$ | 1710.05544 1501.01325 |

phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

ATLAS SUSY summary

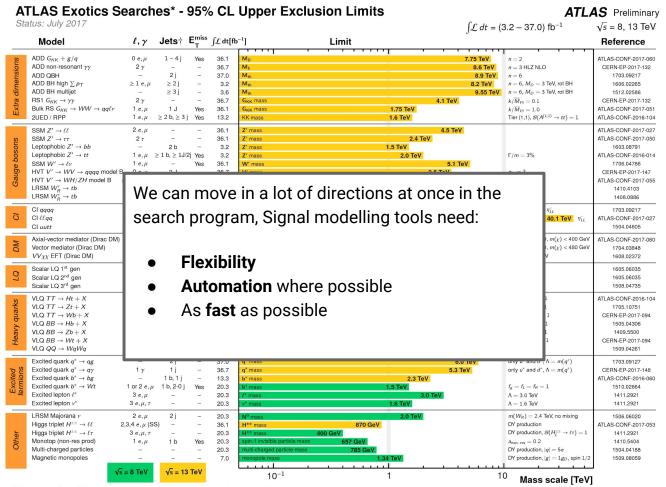
ATLAS Exotics Searches* - 95% CL Upper Exclusion Limits ATLAS Preliminary Status: July 2017 $\int \mathcal{L} dt = (3.2 - 37.0) \text{ fb}^{-1}$ $\sqrt{s} = 8.13 \text{ TeV}$ Jets† E_T^{miss} ∫⊥ dt[fb⁻¹] Model ℓ, γ Limit Reference ADD $G_{KK} + g/q$ 0 e, µ 1 - 4jYes 36.1 7.75 TeV n = 2ATLAS-CONF-2017-060 ADD non-resonant yy 2γ 36.7 Me 8.6 TeV n = 3 HLZ NLO CERN-EP-2017-132 ADD QBH 2 j _ 37.0 8.9 TeV 1703.09217 n = 6ADD BH high $\sum p_T$ $\geq 1 \ e, \mu$ n = 6, $M_{\rm D} = 3$ TeV, rot BH ≥ 2 j 3.2 M., 8.2 TeV 1606.02265 ADD BH multijet ≥ 3 j 3.6 Mrh 9.55 TeV n = 6, $M_D = 3$ TeV, rot BH 1512.02586 RS1 $G_{KK} \rightarrow \gamma \gamma$ 2γ 36.7 G_{KK} mass 4.1 TeV $k/\overline{M}_{Pl} = 0.1$ CERN-EP-2017-132 Bulk RS $G_{KK} \rightarrow WW \rightarrow qq\ell v$ 1 e, µ 1 J Yes 36.1 KK mass 1.75 TeV $k/\overline{M}_{Pl} = 1.0$ ATLAS-CONF-2017-051 2UED / RPP 1 e, µ $\geq 2 \text{ b}, \geq 3 \text{ j}$ Yes 13.2 1.6 TeV Tier (1,1), $\mathcal{B}(A^{(1,1)} \to tt) = 1$ ATLAS-CONF-2016-104 (K mass SSM $Z' \rightarrow \ell \ell$ 2 e, µ 36.1 4.5 TeV ATLAS-CONF-2017-027 " mass 36.1 2.4 TeV SSM $Z' \rightarrow \tau \tau$ 2τ " mass ATLAS-CONF-2017-050 Leptophobic $Z' \rightarrow bb$ 2 b 3.2 Z' mass 1.5 TeV 1603.08791 Leptophobic $Z' \rightarrow tt$ $1 e, \mu \ge 1 b, \ge 1J/2j$ Yes 2.0 TeV $\Gamma/m = 3\%$ ATLAS-CONF-2016-014 3.2 " mass SSM $W' \rightarrow \ell \gamma$ 1 e, µ W' mass Yes 36.1 5.1 TeV 1706.04786 HVT $V' \rightarrow WV \rightarrow qqqq$ model B 0 e, µ 36.7 3.5 TeV $g_V = 3$ CERN-EP-2017-147 2 J V' mass HVT $V' \rightarrow WH/ZH$ model B 36.1 2.93 TeV multi-channel V' mass $g_V = 3$ ATLAS-CONF-2017-055 LRSM $W'_{a} \rightarrow tb$ 1 e, µ 2 b, 0-1 j Yes 20.3 1.92 TeV 1410.4103 LRSM $W'_R \rightarrow tb$ 0 e, µ \geq 1 b, 1 J -20.3 1408.0886 2 j 21.8 TeV 11L CI qqqq 37.0 1703 09217 -5 Clllgg 2 e, µ 36.1 ATLAS-CONF-2017-027 40.1 TeV 71 CI uutt 2(SS)/≥3 e,µ ≥1 b, ≥1 j Yes 20.3 4.9 TeV $|C_{RR}| = 1$ 1504.04605 Axial-vector mediator (Dirac DM) 0 e, µ 1 – 4 j 36.1 1.5 TeV $g_q=0.25, g_{\chi}=1.0, m(\chi) < 400 \text{ GeV}$ ATLAS-CONF-2017-060 Yes DM Vector mediator (Dirac DM) 1.2 TeV $g_q=0.25, g_{\chi}=1.0, m(\chi) < 480 \text{ GeV}$ 0 e, µ, 1 γ ≤ 1 j Yes 36.1 1704.03848 VV XX EFT (Dirac DM) $1 J_{i} \leq 1 j$ $m(\chi) < 150 \text{ GeV}$ 0 e, µ Yes 3.2 700 GeV 1608.02372 Scalar LQ 1st gen 2e ≥ 2 j 3.2 1.1 TeV $\beta = 1$ 1605.06035 Q mass LQ Scalar LQ 2nd gen 2μ ≥2j -3.2 1.05 TeV $\beta = 1$ 1605.06035 O mass Scalar LQ 3rd gen $\geq 1 \text{ b}, \geq 3 \text{ j}$ Yes $\beta = 0$ 1 e, µ 20.3 1508 04735 VLQ $TT \rightarrow Ht + X$ 0 or 1 $e, \mu \ge 2b, \ge 3j$ Yes 1.2 TeV $\mathcal{B}(T \rightarrow Ht) = 1$ 13.2 ATLAS-CONF-2016-104 VLQ $TT \rightarrow Zt + X$ $1e, \mu \ge 1b, \ge 3j$ Yes 36.1 mass 1.16 TeV $\mathcal{B}(T \rightarrow Zt) = 1$ 1705,10751 $1 e, \mu \ge 1 b, \ge 1J/2j$ Yes VLQ $TT \rightarrow Wb + X$ 36.1 mass 1.35 TeV $\mathcal{B}(T \rightarrow Wb) = 1$ CERN-EP-2017-094 $VLQ BB \rightarrow Hb + X$ $1 e, \mu \ge 2 b, \ge 3 j$ Yes $\mathcal{B}(B \rightarrow Hb) = 1$ 20.3 1505 04306 $VLQ BB \rightarrow Zb + X$ 2/≥3 e, µ ≥2/≥1 b 20.3 $\mathcal{B}(B \rightarrow Zb) = 1$ 1409,5500 $VLQ BB \rightarrow Wt + X$ $\mathcal{B}(B \rightarrow Wt) = 1$ $1 e, \mu \ge 1 b, \ge 1J/2j$ Yes 36.1 mass 1.25 TeV CERN-EP-2017-094 $VLQ QQ \rightarrow WqWq$ 1 e, µ ≥ 4 j Yes 20.3 1509.04261 Excited quark $q^* \rightarrow qg$ _ 2 j 37.0 mass 6.0 TeV only u^* and d^* , $\Lambda = m(q^*)$ 1703 09127 Excited quark $q^* \rightarrow q\gamma$ 5.3 TeV 1γ 1 j 36.7 * mass only u^* and d^* , $\Lambda = m(q^*)$ CERN-EP-2017-148 Excited quark $b^* \rightarrow bg$ 1 b, 1 j 13.3 2.3 TeV ATLAS-CONF-2016-060 b* mass Excited quark $b^* \rightarrow Wt$ 1 or 2 e, µ 1 b, 2-0 j Yes 20.3 1.5 TeV $f_R = f_L = f_R = 1$ 1510.02664 Excited lepton ℓ^* 3 e, µ 20.3 $\Lambda=3.0~\text{TeV}$ 1411.2921 Excited lepton v* 3 e, µ, τ 20.3 1.6 TeV $\Lambda = 1.6 \text{ TeV}$ 1411.2921 LRSM Majorana v 2 e, µ 2 j 20.3 $m(W_R) = 2.4$ TeV, no mixing 1506.06020 Higgs triplet $H^{\pm\pm} \rightarrow \ell \ell$ 870 GeV DY production 2,3,4 e, µ (SS) 36.1 H^{±±} mass ATLAS-CONF-2017-053 Higgs triplet $H^{\pm\pm} \rightarrow \ell \tau$ 3 e, µ, τ 20.3 DY production, $\mathcal{B}(H_{\ell}^{\pm\pm} \rightarrow \ell \tau) = 1$ 1411.2921 Monotop (non-res prod) 1 e. u 1 b Yes 20.3 $a_{non-res} = 0.2$ 1410.5404 Multi-charged particles 20.3 DY production, |q| = 5e1504.04188 -785 GeV Magnetic monopoles DY production, $|g| = 1g_D$, spin 1/2 7.0 1509 08059 1.34 TeV $\sqrt{s} = 8 \text{ TeV}$ √s = 13 TeV 10^{-1} 10

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

+Small-radius (large-radius) jets are denoted by the letter j (J)

ATLAS Exotics summary

Mass scale [TeV]



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

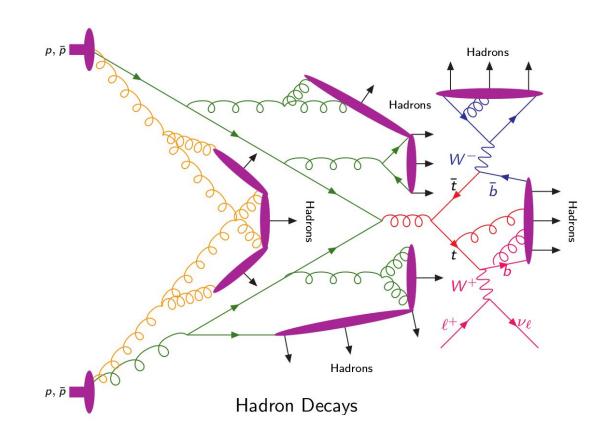
†Small-radius (large-radius) jets are denoted by the letter j (J). ATLAS Exotics summary

ATLAS BSM Modelling challenge – Accuracy

LHC theoretical predictions (BSM and SM)

- Tools need to lead to predictions of particle level final states in a hadron collider
- Complicated!

Continually demand higher precision in SM backgrounds, when do we worry about Signal modelling?



Stolen from P. Richardson

Aside – Precision

Background (SM) modelling ties into a lot of this discussion (again not the focus of this conference!)

Searches generally seen to be:

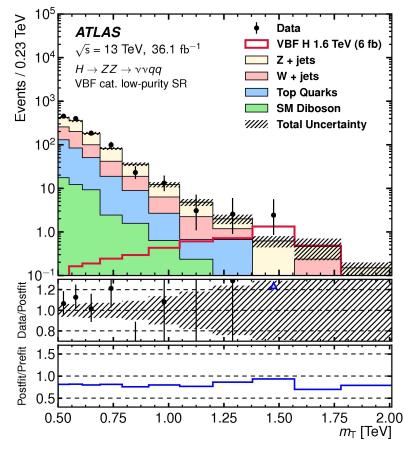
- Stat limited
- Systematically limited

Limitation often driven from SM modelling e.g.:

- Top/V pT
- Higher jet multiplicities
- Exotic phase space (e.g. VBF)
- etc.

Does precision QCD necessitate precision signal - claim sensitivity down to O(signal size)

SM processes missing comparable to signal size? e.g. EW corrections



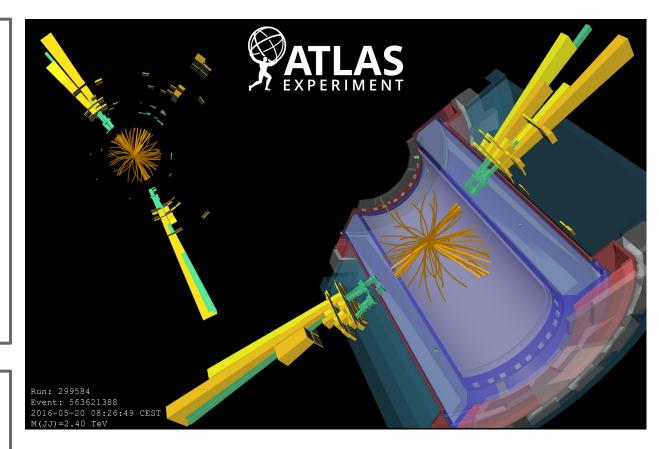
ATLAS ZZ/ZW (VBF) <u>1708.09638</u>

ATLAS BSM Modelling challenge – The detector

The detector itself presents a big challenge to BSM modelling

- Some BSM is very dependent on our detector response (e.g. Long Lived Particles)
- It can be a big barrier to getting information out of the collaboration

Simulation not in the scope of this conference (GEANT4 etc.) but worth remembering



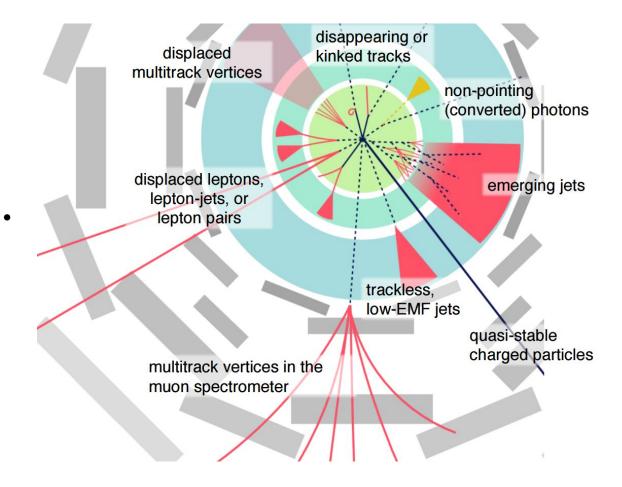
Resonance search with boson tagged jets

ATLAS BSM Modelling challenge – The detector

The detector itself presents a big challenge to BSM modelling

- Some BSM is very dependent on our detector response (e.g. Long Lived Particles)
- It can be a big barrier to getting information out of the collaboration

Simulation not in the scope of this conference (GEANT4 etc.) but worth remembering



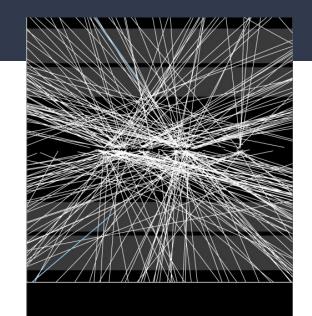
WHERE WE ARE AT

Personal perspective:

- Largely appear to be happy with the tools we have from an experimental PoV
- Not uncommon to hear people grabbing a model from theory friends to test - standardized formats to get these into ATLAS simulation exist
 - This is a big positive

BUT

- Can we rest on our laurels on the BSM side?
- Where do we need to push for progress?





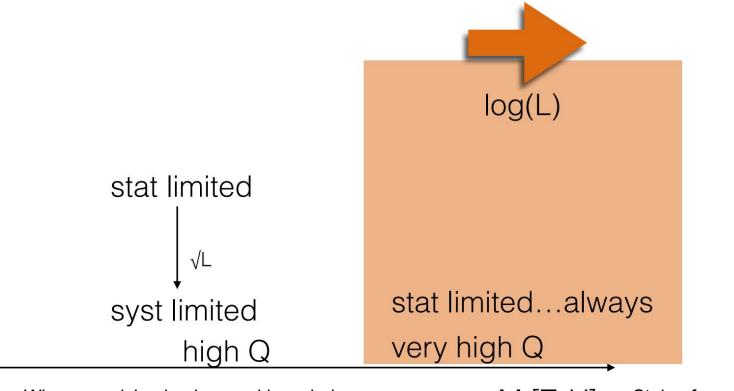
Run Number: 348197, Event Number: 562578

Date: 2018-04-17 13:05:13 CEST

Where we are at

We are no longer jumping in Energy, and there's still no new physics, this challenges our search approach





Where precision background knowledge makes a difference

Stolen from G. Facini

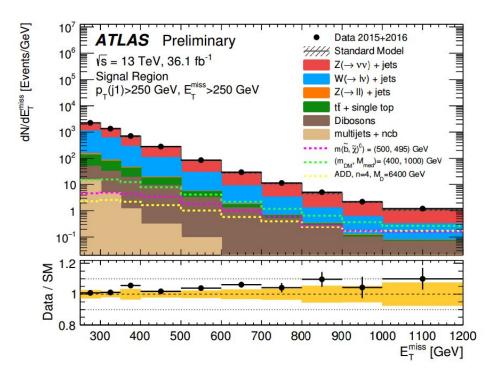
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Obvious benefits from SM modelling in increasing order of perturbative accuracy:

- Can we repeat same recipe for BSM
 - Do we need to?
- At very least we do analysis optimisation to BSM shape
 - Often in a "cut and count" paradigm
 - Do NLO shape differences yield much over k-factors?

→ **Pragmatism** is important

Some cases of NLO BSM implemented in generators, initiatives such as LHCDMWG helpful here

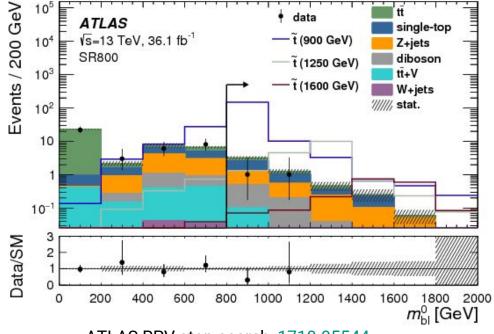


ATLAS Monojet, <u>1711.03301</u>

SUSY in ATLAS

Procedure fairly Standardised across most SUSY analyses

- Signal ME production MG5_aMC@NL0
 - Up to two additional partons in the ME
- Merged and Matched to Pythia 8 (CKKW-L)
- Use Simplified Models (decouple everything you aren't studying)
- Cross section normalised in nearly all cases to NLO+NLL



ATLAS RPV stop search, <u>1710.05544</u>

| | | SR800 | | |
|--------------------------------|---------------------|---------------------|---------------------|---------------------|
| | inclusive | ee | еµ | μμ |
| S ⁹⁵ _{exp} | $6.4^{+3.0}_{-1.9}$ | $4.1^{+1.8}_{-1.1}$ | $4.0^{+2.2}_{-0.9}$ | $3.9^{+1.6}_{-0.7}$ |
| S ⁹⁵ _{obs} | 4.0 | 3.0 | 3.0 | 4.8 |
| $\sigma_{\rm vis}[{\rm fb}]$ | 0.11 | 0.08 | 0.08 | 0.13 |

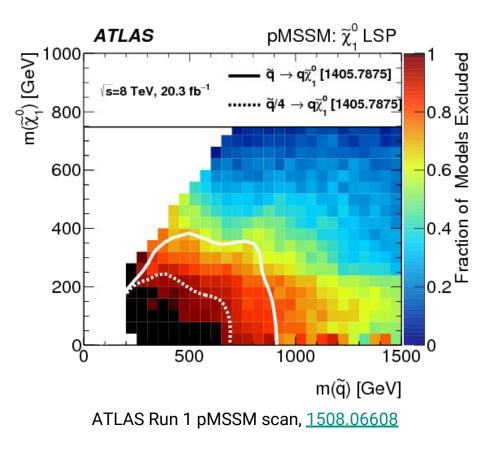
- Results largely limits on visible cross sections derived from simplified models.
- How do we interpret these (see SModelS, etc.)

SUSY in ATLAS

Interpretation of the base analyses can be done with more complete models:

- pMSSM
 - Decide on some base constraints to reduce parameter space
- Generate 310,327 model points
- SoftSUSY and MicroOMEGAs used to calculate sparticle spectrum (amongst other tools)
- Where needed use full MC tools as per previous slide, with ATLAS detector sim

We can use the full simulation to do this, how do we extend this to the outside world?



What Works:

- Simplified Model paradigm is very attractive from the experiments PoV
 - What do our results mean once we've decoupled the SUSY from a SUSY paper?
- Tools well established for both event generation and SUSY model study as a whole

What Doesn't:

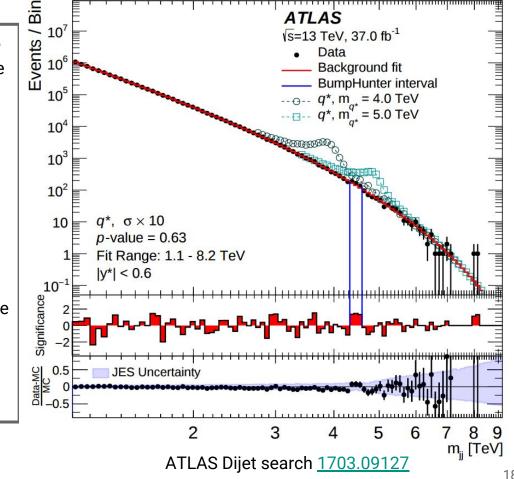
- Are we missing anything with a lack of diversity in generator setup
 - Uncertainties due to, e.g. PS modelling in signal samples should be negligible
- SUSY problem, mixed processes in LHE files (with merging)
 - How do we do merging with multiple signal processes in one file
 - Ongoing work to "guess" process for matching in Pythia

Exotics in ATLAS

Broader catch all for any BSM signal, largely done through a similar toolchain with more variety, here Dijet 2015+2016 (<u>1703.09127</u>) paper considers:

- Excited quarks [R] Pythia 8
- Black Holes BlackMax + Pythia
- W'/Z' MG + Pythia *
- W* CalcHEP + Pythia

Plus many more across the group, plus options we have but don't use. Simplified models with automated generator interfaces, via e.g. UFO (Feynrules) very successful



*Efforts on unity and benchmarking simplified DM models, <u>LHCDMWG</u>

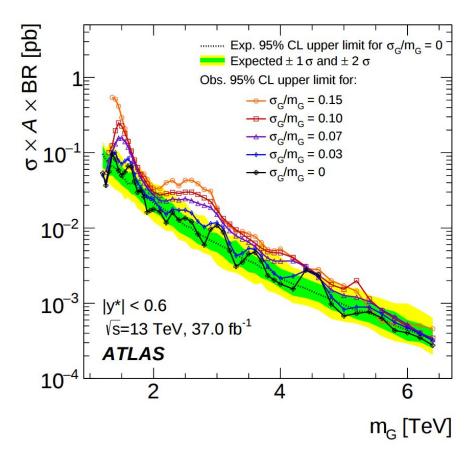
Exotics in ATLAS

Also effort made to do something more "model independent" for re-interpretability:

- In this case present limits on σ x
 Acceptance
 - For considered models
 - And hypothetical Gaussian signal

→Not perfect, Acceptance still dependent on considered model, e.g. in this example, what can we say about signals beyond narrow width Gaussian?

A lot of work/thought goes on at this interface



ATLAS Dijet search 1703.09127

Exotics in ATLAS

What Works:

- The move to emphasis on Simplified Models rather than "complete" implementations gives the desired flexibility and abstracts most of the more tricky model questions from the experiment
 - This is a good direction
 - Have to keep an eye on this Lot of work going into a simplified model with no viable UV complete embedding?

What Doesn't:

- Hopefully all UFO files can be public, Model database efforts welcome
- Flexibility begets instability
 - Use standarized PDG ID codes for common BSM (Z' etc.)
 - \circ More tests! Things can crash out of the box
- Similar question marks on diversity of tools, maybe not so important?
- When we cover something more unexpected, long lived particles, the tools are less mature

WHAT CAN THE EXPERIMENT DO TO HELP?

How can our results help - Signal regions

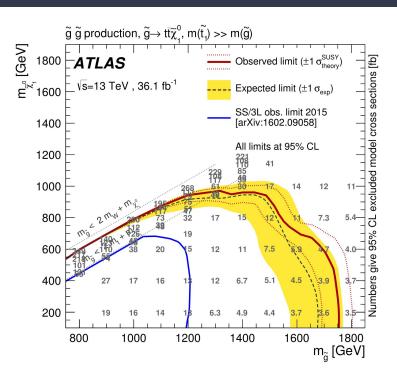
Example again from SUSY group

- Provide acceptance and efficiency numbers
- Validated cutflow
 - Can we harmonize with a tool like CheckMATE, Rivet etc.

Go beyond single regions?

- Correlations
- Simplified Likelihoods? (CMS progress here)

| SQRT(S) | | 13000.0 GEV | | | | |
|--------------------|-------------------------|-------------|----------------------|--------------|--------------|--|
| Signal regio | n | - | (best) | Rpc2L2bH | | |
| M(GLUINO) [GEV] | M(NEUTRALINO1) [GEV] | Best SR | SIG 95%CL [FB] | ACC [PCT] | EFF [PCT] | |
| 700 | 355 | Rpc2Lsoft2b | 125 | 0.1 | 51 | |
| 700 | 440 | Rpc2L2bS | 238 | 0 | 39 | |
| 700 | 490 | Rpc2Lsoft1b | 449 | 0 | 83 | |
| 800 | 455 | Rpc2Lsoft2b | 121 | 0.1 | 45 | |



ATLAS Same sign lepton, 1706.03731

lepData Record

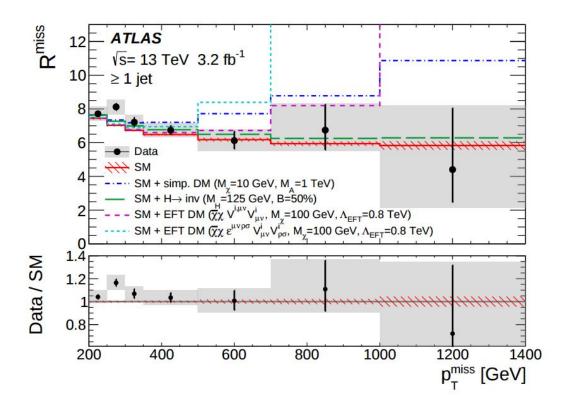
How can our results help - Signal regions

Exotics example, the "nuclear option"

Essentially unfold a search region

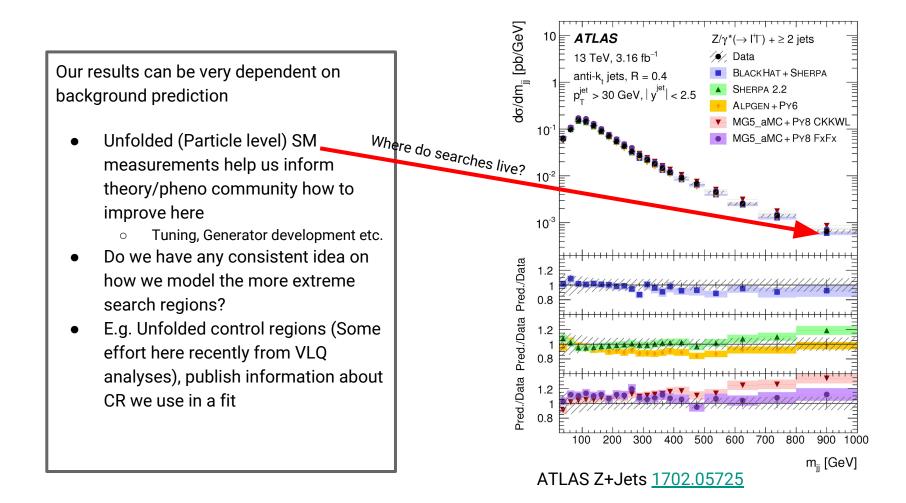
(Re)interpretability is now exactly as per the SM measurements, data is presented at the particle level

See e.g. Rivet, Contur



ATLAS Unfolded MET 1707.03263

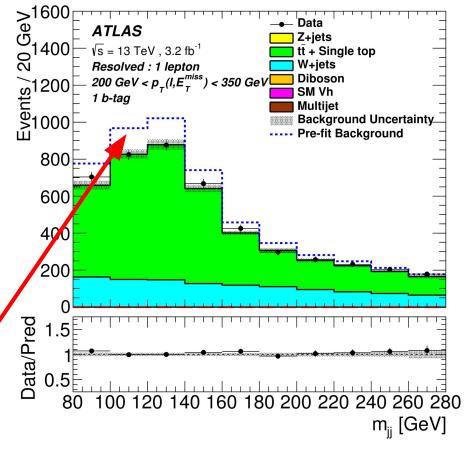
How can our results help - Control regions



How can our results help – Control regions

Our results can be very dependent on background prediction

- Unfolded (Particle level) SM measurements help us inform theory/pheno community how to improve here
 - Tuning, Generator development etc.
- Do we have any consistent idea on how we model the more extreme search regions?
- E.g. Unfolded control regions (Some effort here recently from VLQ analyses), publish information about CR we use in a fit



ATLAS DM + Higgs <u>1609.04572</u>

More than limits

- How do we compare non unfolded (detector level) results to MC outside of ATLAS
 - Applies to both SR's for recasting and CR's used for improving SM modelling
- Forward folding, prefit background calculations etc. useful?
 - \circ $\hfill Easy to say yes! But has to be used for the experiment to see it as useful effort$
- Where can we make measurements we don't already measure that will help BSM search region calculations
 - Where do we need to unfold and where do we not?

(Re)interpreting the results of new physics searches at the LHC

- I4 May 2018, 09:00 → 16 May 2018, 18:00 Europe/Zurich
- 500-1-001 Main Auditorium (CERN)
- Sabine Kraml (Centre National de la Recherche Scientifique (FR)), Pat Scott, Michelangelo Mangano (CERN)

The LHC collaborations are pursuing searches for new physics in a vast va

themselves interpretations of their results, for instance in terms of simplifi

Many recasting workshops and efforts to get involved with

Theory-experiment interactions vital

Description

searches requires the interpretation of the experimental results in the context of an kinds of theoretical mo with close theory-experiment interaction and with several public tools being developed.

Conclusion

Hopefully a snapshot of where we are at in ATLAS

- Theres a lot that seems to work well on the BSM front
 - Where do we need to do more

• Main challenges seem to be on feeding back the results to the broader community

Thanks for listening