Searches for Supersymmetry in Final states with Jets, $E_{\mathrm{T}}^{\mathrm{miss}}$ and 0-leptons at the ATLAS and CMS experiments

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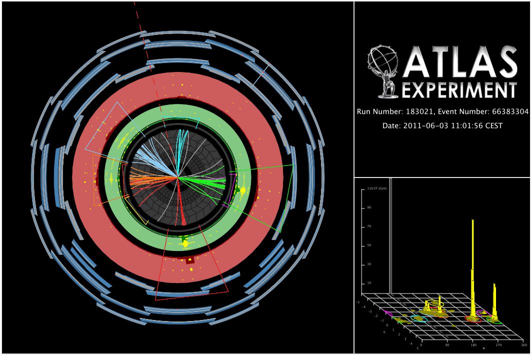
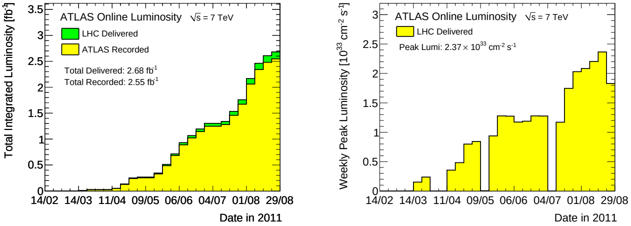


Introduction

- In 2011 the LHC's performance has been very impressive, rapidly increasing in luminosity and delivering over 1fb^{-1} before the summer conferences and over 2.5fb^{-1}to date.
- This large increase in luminosity at this new center of mass energy has allowed the ATLAS and CMS experiments to extend the search for supersymmetry to higher masses than before.



The sum (left) and peak (right) luminosity delivered and recorded by the ATLAS experiment per week throughout 2011

The Jets, $E_{\mathrm{T}}^{\mathrm{miss}}$ and 0-leptons Final State

- There are many scenarios in Supersymmetry which lead to final states with jets, $E_{\mathrm{T}}^{\mathrm{miss}}$ and no leptons;

$$\text{eg. } \tilde{g}\tilde{g} \rightarrow q\bar{q}q\bar{q} + 2\tilde{\chi}_1^0$$

$$\tilde{q}\tilde{q} \rightarrow qq + 2\tilde{\chi}_1^0$$

$$\tilde{g}\tilde{g} \rightarrow q\bar{q}q\bar{q} + 2(\tilde{\chi}_1^{\pm} \rightarrow (W^{\pm} \rightarrow q\bar{q}) + \tilde{\chi}_1^0)$$

- Both ATLAS and CMS have searched for SUSY in this final state using a variety of techniques to enhance signal significance and determine backgrounds.
- Reliable background prediction in this channel requires care with significant contributions from several different Standard Model processes.
- Data-driven techniques, the excellent performance of Monte-Carlo simulations and control regions have all been very important in the success of results so far in constraining the systematic uncertainties.

The Jets, $E_{\mathrm{T}}^{\mathrm{miss}}$ and 0-leptons Final State

- ATLAS and CMS have searched extensively in this final state publishing results with the 2010 dataset that have had a high impact with the physics community:
  - ATLAS "m_{eff}" 35pb^{-1} [1] - cited 80 times
  - CMS "Razor" 35pb^{-1} [2] - cited 6 times
  - CMS "HT/MHT" 36pb^{-1} [3] - cited 6 times
  - CMS "α_T" 35pb^{-1} [4] - cited 112 times
- Here I will focus on three of the very recent preliminary analyses all using > 1fb^{-1}.
- All three analyses use very different selections and variables of significance for their signal region selection.

1. ATLAS Search for Squarks and Gluinos

- This extends the ATLAS 2010 analysis [1]
- Primary variables for selection are:
  1. Jet p_T ($|\eta| < 2.8$) and $E_{\mathrm{T}}^{\mathrm{miss}}$
  2. $\Delta\phi_{\mathrm{min}}$ between $E_{\mathrm{T}}^{\mathrm{miss}}$ and the 3 leading selected jets - QCD
  3. $m_{\mathrm{eff}} = E_{\mathrm{T}}^{\mathrm{miss}} + \sum_{i=1}^{n} |p_T^{\mathrm{jet}}|$ - a measure of mass scale [5]
  4. $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$ - QCD

Signal Region	≥ 2 jets	≥ 3 jets	≥ 4 jets	High mass
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 130	> 130	> 130	> 130
Leading jet p_{T}	> 130	> 130	> 130	> 130
Second jet p_{T}	> 40	> 40	> 40	> 80
Third jet p_{T}	–	> 40	> 40	> 80
Fourth jet p_{T}	–	–	> 40	> 80
$\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$	> 0.4	> 0.4	> 0.4	> 0.4
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$	> 0.3	> 0.25	> 0.25	> 0.2
m_{eff} [GeV]	> 1000	> 1000	> 500/1000	> 1100

1. ATLAS Search for Squarks and Gluinos - Backgrounds

- For each signal region a series of "Control Regions" are set up, 1 for each major background; W, Z, $t\bar{t}$ and QCD (2 for $Z \to \nu\nu$).
- These differ from the signal regions primarily by either by reversing and tightening a signal region cut or by requiring one or more electrons, muons or a hard photon.
- These are optimised to be as kinematically close as possible to the SR, to minimise the systematic uncertainties arising from extrapolation to the SR, while also maintaining adequate statistical weight.
- From Monte-Carlo the "Transfer Factors"(TF) and their associated experimental and theoretical errors are derived where the TFs are the ratio between the number of events from a particular background in a Control Region to the number in the signal region.
- For QCD a data-driven approach based on smearing low $E_{\mathrm{T}}^{\mathrm{miss}}$ events is employed rather than using Monte-Carlo to find the TF.

1. ATLAS Search for Squarks and Gluinos - Backgrounds

- To control the Z background two control regions are used; γ + jets and $Z \to (ee, \mu\mu)$ +jets.
- γ + jets are kinematically similar to Z + jets events especially if the p_T of the vector particle is $\gg m_Z$.
- To control W and $t\bar{t}$ backgrounds a well reconstructed lepton is required and this is required to have $30 \leq m_T \leq 100\,\mathrm{GeV}$ both to reduce contributions from fakes and any potential signal contamination.
- The W and $t\bar{t}$ control regions are separated by a b-tag/veto requirement.
- For the QCD control region the $\Delta\phi$ cut is reversed to select a region dominated by jets which are badly mis-measured such that the $E_{\mathrm{T}}^{\mathrm{miss}}$ lies along their direction.
- The purities of the CRs for the main background processes in which they are enriched exceed 50% in all cases.
- All 25 control regions (5 for each of the 5 signal regions) show good agreement with the Monte-Carlo and with the data-driven QCD background.

SUSY Searches with Jets, $E_{\mathrm{T}}^{\mathrm{miss}}$ + 0-Leptons

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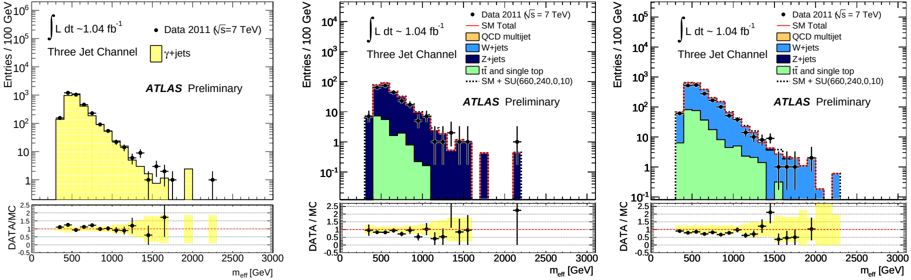
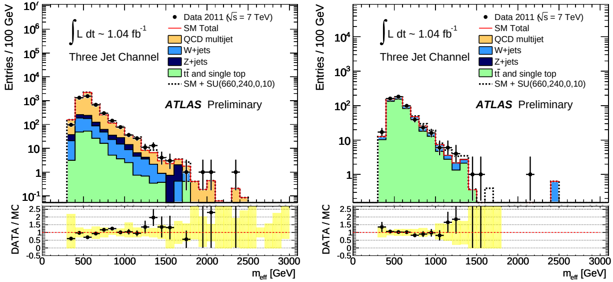
1. ATLAS Search for Squarks and Gluinos - Backgrounds



Observed m_{eff} distributions for the ≥ 3 jet channel for the γ +jets (left) and $Z \rightarrow (ee, \mu\mu)$ (center) Control Regions for Z backgrounds and the $W \rightarrow (e\nu, \mu\nu)$ Control Region for W backgrounds (right). The histograms denote the expectation from Monte-Carlo (γ +jets; SHERPA, W, Z +jets; ALPGEN, $t\bar{t}$; MC@NLO, QCD; PYTHIA)[a] all normalised to luminosity apart from the QCD jet background which is normalised to a $\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}}) < 0.4$ dijet control sample. The yellow band denotes the combined JES, JER and MC statistical uncertainties.

[a] For the ALPGEN and MC@NLO samples fragmantation and hadronisation were performed by HERWIG and JIMMY was used for the underlying event.

1. ATLAS Search for Squarks and Gluinos - Backgrounds



Observed m_{eff} distributions for the ≥ 3 jet channel for the QCD multijet background (left) formed from reversing the $\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})$ cut and the $t\bar{t}$ Control Region (right) formed from requiring an electron or muon. The histograms denote the expectation from Monte-Carlo (γ +jets; SHERPA, W, Z +jets; ALPGEN, $t\bar{t}$; MC@NLO, QCD; PYTHIA)[a] all normalised to luminosity apart from the QCD jet background which is normalised to a $\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}}) < 0.4$ dijet control sample. The yellow band denotes the combined JES, JER and MC statistical uncertainties.

[a] For the ALPGEN and MC@NLO samples fragmentation and hadronisation were performed by HERWIG and JIMMY was used for the underlying event.

1. ATLAS Search for Squarks and Gluinos - Results

- Good agreement between Monte-Carlo and also with data-driven QCD background and data is observed in all control regions.
- For each signal region a combined fit is performed across the five control regions giving the prediction for each background.
- The results of this fit can be seen below along with the number of observed signal region events.

Process	Signal Region				
	$\geq$ 2-jet	$\geq$ 3-jet	$\geq$ 4-jet, $m_{\text{eff}} > 500$ GeV	$\geq$ 4-jet, $m_{\text{eff}} > 1000$ GeV	High mass
Z/γ+jets	$32.5 \pm 2.6 \pm 6.8$	$25.8 \pm 2.6 \pm 4.9$	$208 \pm 9 \pm 37$	$16.2 \pm 2.1 \pm 3.6$	$3.3 \pm 1.0 \pm 1.3$
W+jets	$26.2 \pm 3.9 \pm 6.7$	$22.7 \pm 3.5 \pm 5.8$	$367 \pm 30 \pm 126$	$12.7 \pm 2.1 \pm 4.7$	$2.2 \pm 0.9 \pm 1.2$
$t\bar{t}$+ Single Top	$3.4 \pm 1.5 \pm 1.6$	$5.6 \pm 2.0 \pm 2.2$	$375 \pm 37 \pm 74$	$3.7 \pm 1.2 \pm 2.0$	$5.6 \pm 1.7 \pm 2.1$
QCD jets	$0.22 \pm 0.06 \pm 0.24$	$0.92 \pm 0.12 \pm 0.46$	$34 \pm 2 \pm 29$	$0.74 \pm 0.14 \pm 0.51$	$2.10 \pm 0.37 \pm 0.83$
Total	$62.3 \pm 4.3 \pm 9.2$	$55 \pm 3.8 \pm 7.3$	$984 \pm 39 \pm 145$	$33.4 \pm 2.9 \pm 6.3$	$13.2 \pm 1.9 \pm 2.6$
Data	58	59	1118	40	18

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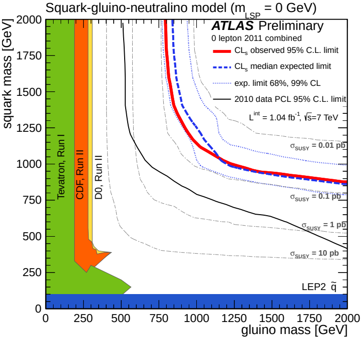
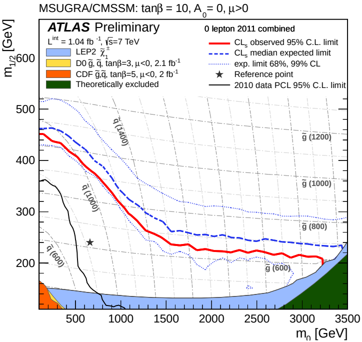
1. ATLAS Search for Squarks and Gluinos - Limits

- In the absence of a significant excess limits are set.
- These are presented as a model independent σ x Acc. x ϵ as well as limits in an MSUGRA plane and in a simplified model.

Process	Signal Region				
	≥ 2-jet	≥ 3-jet	≥ 4-jet, $m_{eff} > 500$ GeV	≥ 4-jet, $m_{eff} > 1000$ GeV	High mass
Excluded $\sigma \times$ Acc $\times \varepsilon$ (fb)	24	30	477	32	17





2. CMS Search with α_T

- This search uses a different approach to the ATLAS one based on the variable α_T inspired by [6].

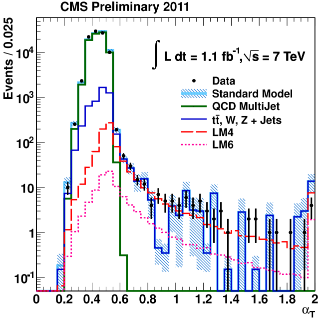
$$\alpha_T = \frac{E_T^{\mathrm{jet}_2}}{M_T} = \frac{E_T^{\mathrm{jet}_2}}{\sqrt{\left(\sum_{i=1}^{2} E_T^{\mathrm{jet}_i}\right)^2 - \left(\sum_{i=1}^{2} E_x^{\mathrm{jet}_i}\right)^2 - \left(\sum_{i=1}^{2} E_y^{\mathrm{jet}_i}\right)^2}}$$

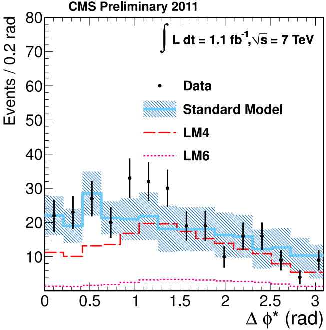
- For events with more than 2 jets, jets are combined into "pseudo jets" [4] and these are used as the inputs to α_T.
- If an event contains a jet close to a masked region of the ECAL or in the barrel-endcap gap, and if the jet is the closest in ϕ to the $\not{H}_T$[1] after removing the jet from the event, then the event is rejected.
- $\not{H}_T$ is also required to be $> 100\,\mathrm{GeV}$.
- The other variable of significance used is $H_T = \sum_{i=1}^{n} |p_T^{\mathrm{jet}_i}|$.

[1] $\not{H}_T$ is the CMS jet-based estimate of the missing transverse energy. If this quantity differs significantly from the calorimeter based $E_{\mathrm{T}}^{\mathrm{miss}}$ then events are also rejected.

2. CMS Search with α_T - Backgrounds

- α_T is designed to give good discrimination against QCD.
- After requiring $\alpha_T > 0.55$ the data shows no excess over EW backgrounds at low values of $\Delta\phi^*$, the minimum angle between any selected jet and the re-computed $\not{H}_T$ after removing the jet.
- This supports the hypothesis that the signal region selection is QCD free.

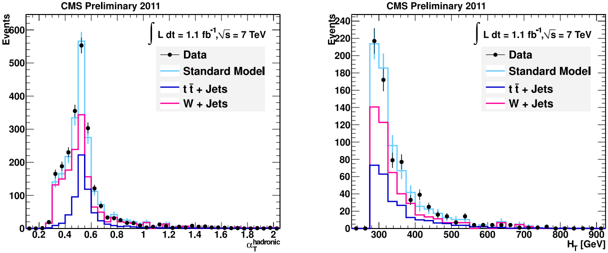




The distribution of α_T after basic cuts of $H_T \geq 375$ GeV and $\not{H}_T \geq 100$ GeV (left) and the distribution of $\Delta\phi^*$ after an addition cut of $\alpha_T > 0.55$. Errors are statistical only.

2. CMS Search with α_T - Backgrounds

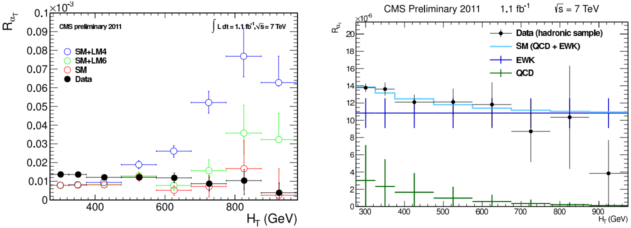
- A Control Region requiring a muon is used to constrain W and $t\bar{t}$ backgrounds and a Conrtol Region requiring a hard photon is used to constrain the Z background. The W background prediction is cross-cheched using the photon sample.
- Ratios between these control regions and the signal regions are taken from Monte-Carlo and applied to get the relevant prediction.
- Good agreement is seen in these control regions within systematics.



The distribution in the muon control sample of α_T after a cuts of $H_T \geq 375$ GeV (left) and of H_T, after an addition cut of $\alpha_T > 0.55$ (right). Errors are statistical only.

2. CMS Search with α_T - Stat. Interpretation

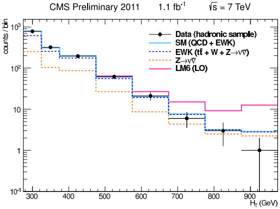
- To make full use of the data, a fit is performed across 8 bins in H_T.
- For the electroweak backgrounds, W,Z and $t\bar{t}$, the predicted values and their associated errors obtained from the control regions are used as inputs for the fit.
- For QCD, which is thought to be negligible, a parameterisation of the form $R_{\alpha_T}(H_T) = Ae^{-kH_T}$ is used where R_{α_T} is the ratio $\frac{N(\alpha_T>0.55)}{N(\alpha_T<0.55)}$.
- R_{α_T} should have no dependence on H_T if there is only W,Z and $t\bar{t}$ events in the signal region.



The distribution of $R_{\alpha_T}(H_T)$ for the signal selection against Monte-Carlo (left) and against the results of the combined fit (right).

2. CMS Search with α_T - Results

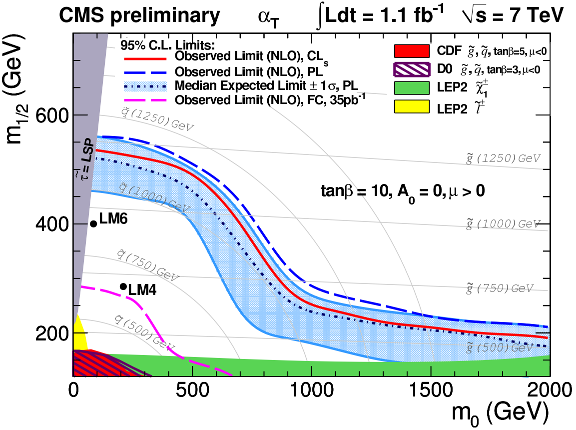
- The fit across the 8 bins of H_T gives a good description of the variable.
- The values of the two QCD parameters; $A_{QCD} = (1.4 \pm 1.9) \text{ x } 10^{-5}$ and $k_{QCD} = (5.2 \pm 5.6) \text{ x } 10^{-3}$, are compatible with 0.
- No excess over the Standard Model prediction is seen.
- This lack of excess is interpreted as a limit in a plane of the MSUGRA/CMSSM space.



H_T Bin (GeV)	275–325	325–375	375–475	475–575
W + $t\bar{t}$ background	363.7	152.2	88.9	28.8
$Z \to \nu\bar{\nu}$ background	251.4	103.1	86.4	26.6
QCD background	172.4	55.1	26.9	5.0
Total Background	787.4	310.4	202.1	60.4
Data	782	321	196	62
H_T Bin (GeV)	575–675	675–775	775–875	875–∞
W + $t\bar{t}$ background	10.6	3.1	0.6	0.6
$Z \to \nu\bar{\nu}$ background	8.7	4.3	2.5	2.2
QCD background	1.0	0.2	0.1	0.0
Total Background	20.3	7.7	3.2	2.9
Data	21	6	3	1

The 8 H_T signal region bins; data (black points), the results of the fit (blue line) and the breakdown into individual components as predicted by the control samples (left). The results of the fit across the different backgrounds for the 8 bins of H_T (right).

2. CMS Search with α_T - Limits



Observed and expected 95% CL exclusion contours in the CMSSM (m_0 , $m_{1/2}$) plane ($\tan\beta = 10$, $A_0 = 0$, $\mu > 0$) using NLO signal cross sections using the Profile Likelihood (PL) method. The expected limit is shown with its 68% CL range. The observed limit using the CLs method is shown as well.

3. CMS Search with M_{T2}

- The second CMS search uses a different kinematic variable; M_{T2} [7][8]

$$M_{T2}(m_\chi) = \min_{\vec{p}_T^{\chi(1)} + \vec{p}_T^{\chi(1)} = \vec{p}_T^{\mathrm{miss}}} \left[\max(m_T^{(1)}, m_T^{(2)}) \right]$$
$$m_T^{(i)} = (m^{\mathrm{vis}(i)})^2 + m_\chi^2 + 2\left(E_T^{\mathrm{vis}(i)} E_T^{\chi(i)} - \vec{p}_T^{\mathrm{vis}(i)} \cdot \vec{p}_T^{\chi(i)} \right)$$

- These minimisations are over all possible splittings of the $E_{\mathrm{T}}^{\mathrm{miss}}$ into any two vectors that still sum to the observed $E_{\mathrm{T}}^{\mathrm{miss}}$.
- This variable was originally proposed as a mass measurement variable [7] but subsequently was shown to give good discoverability prospects [9].
- This variable gives the maximal lower bound on the mass of pair produced SUSY particles if each decays to a visible and an invisible particle.
- Therefore, for pair produced $\tilde{q}$ decaying into 2 jets + 2 $\tilde{\chi}_1^0$ there should be an endpoint at the $\tilde{q}$ mass.
- For events with more than two jets, these jets are combined into "pseudo jets" in an attempt to reconstruct the visible systems from the decay of SUSY particles into a several jets and an invisible particle.

3. CMS Search with M_{T2} - Protection against QCD

- The use of the M_{T2} variable naturally leads to protection against QCD.
- For example, if we take $m_{\chi} = 0$, as is done in this analysis, then for a massless dijet system with no "upstream transverse momentum";

$$M_{T2} = \sqrt{2|p_T^{\mathrm{vis}(1)}||p_T^{\mathrm{vis}(2)}|(1+\cos\phi_{1,2})}$$

  so $M_{T2} = 0\,\mathrm{GeV}$ for back-to-back di-jets.
- To supress contributions from QCD two additional means of protection were employed;
  1. Pseudo-jets were defined to be massless
  2. If the $E_{\mathrm{T}}^{\mathrm{miss}}$ lay within $\Delta\phi \leq 0.3$ of a selected jet then the event was rejected.
- Together these reduce QCD to a very low level and this is checked using a variety of methods.

3. CMS Search with M_{T2} - 2 Searches

- Two separate searches are set up;
  1. A High M_{T2} search designed to find heavy squarks/gluinos
     - ≥ 3 Jets ($p_T > 20$ GeV $|\eta| < 2.4$)
     - $|p_T^{(1,2)}| \geq 100, 100$ GeV
     - $\Delta\phi(\text{jet}, E_T^{miss}) > 0.3$; $E_T^{miss} > 30$ GeV
     - $H_T \geq 600$ GeV
     - $M_{T2} \geq 400$ GeV
  2. A Low M_{T2} search designed to find lighter gluinos
     - ≥ 4 Jets, ≥ 1 b-tagged
     - $|p_T^{(1,2)}| \geq 150, 100$ GeV
     - $\Delta\phi(\text{jet}, E_T^{miss}) > 0.3$; $E_T^{miss} > 30$ GeV
     - $H_T \geq 650$ GeV
     - $M_{T2} \geq 150$ GeV
- The two searches show very different sensitivity to particular models.
- Both searches use similar methods to determine primary backgrounds.

3. CMS Search with M_{T2} - High M_{T2} Backgrounds: W

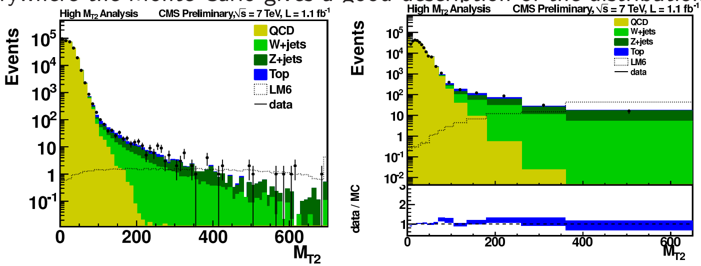
- The background to this signal region is completely dominated by W and Z + jets.
- The W+jets background is estimated by requiring an electron or muon in a control region of $200 \leq M_{T2} \leq 400\,\mathrm{GeV}$.
- To this event count the probablilty of a lepton being lost is applied. This is taken from Monte-Carlo but a systematic is applied to account for differences in reconstruction efficiencies between data and Monte-Carlo from studies of $Z \to l^+ l^-$.
- For the muon [electron] channel this gives an estimate of $7.6 \pm 1.9\,(\mathrm{stat.}) \pm 1.5\,(\mathrm{syst.})[7.4 \pm 1.8\,(\mathrm{stat.}) \pm 1.6\,(\mathrm{syst.})]$ which is in good agreement with the Monte-Carlo prediction of 10.5 (10.5).
- The degree of agreement and the uncertainty are propagated through to the signal region prediction giving an uncertainty of 39%
- For $W \to \tau\nu$ no specific data-driven method was employed but many relevant kinematic distributions of $W \to l\nu$ were checked.

3. CMS Search with M_{T2} - High M_{T2} Backgrounds: Z

- The $Z \rightarrow \nu\nu$ background estimation was obtained from $W \rightarrow l\nu$ events. The lepton was added to the $E_{\mathrm{T}}^{\mathrm{miss}}$ and corrections were made for lepton acceptance, lepton reconstruction efficiency and the ratio between W and Z cross sections (including differences in the shape of distribution on which cuts are applied).
- The $t\bar{t}$ contamination is also corrected for by looking at the fraction of events with b-tagged jets.
- Again the agreement with simulation in the control region was used to find the systematic; 26.3 ± 6.3 (stat.) ± 2.7 (syst.) compared with 36.5 in simulation.
- Propagating this to the signal region leads to an uncertainty of 38%.

3. CMS Search with M_{T2} - High M_{T2} Results

- The Monte-Carlo prediction is scaled to the observed events in the region; $200 \leq M_{T2} \leq 400\,\text{GeV}$ and the systematics are obtained from the data-driven estimates in the control region.
- This gives $12.6 \pm 1.3\,(\text{stat.}) \pm 3.5\,(\text{syst.})$ which is in good agreement with the 12 observed events.
- Everywhere the Monte-Carlo gives a good description of the distribution.



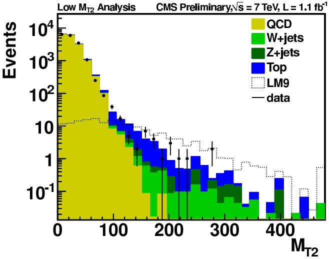
M_{T2} for massless pseudo-jets after having applied all selection cuts, with constant binning (left) and variable binning (right). The last bin contains the overflow. The different MC backgrounds are stacked on top of each other and normalized to 1.1 fb^{-1}. The LM6 signal distribution is normalized to the same integrated luminosity and overlayed on the Standard Model backgrounds.

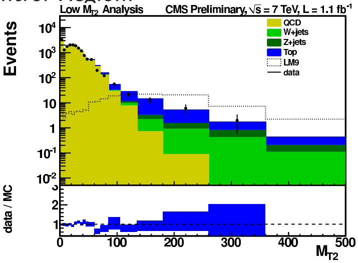
3. CMS Search with M_{T2} - Low M_{T2} Backgrounds

- In this channel $t\bar{t}$ dominates the Standard Model Background.
- $\sim 2/3$ of this comes from lost leptons and $\sim 1/3$ from hadronically decaying τs.
- The systematic on this background is evaluated in the same way as the W background of the high M_{T2} analysis but with a control region of $100 \leq M_{T2} \leq 150\,\mathrm{GeV}$.
- For events with muons, the prediction is $(6.4 \pm 2.6\ (\mathrm{stat.}) \pm 1.7\ (\mathrm{syst.}))$, compared to 7.6 events in the Monte-Carlo.
- Propagating the uncertainties leads to a relative uncertainty on this background of 41%.

3. CMS Search with M_{T2} - Low M_{T2} Results

- The Monte-Carlo prediction is scaled to the observed events in the region; $100 \leq M_{T2} \leq 150\,\text{GeV}$. (Note. There appears an underfluctuation in this bin; 41.9 exp. 30 obs.)
- This gives $10.6 \pm 1.9\,\text{(stat.)} \pm 4.8\,\text{(syst.)}$ which is in reasonable agreement with the 19 observed events, this difference is interpreted as due to the underfluctuation in the Control Region.



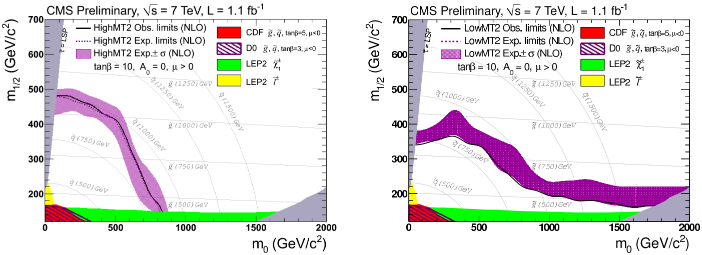


M_{T2} for massless pseudo-jets including at least one b-tagged jet after having applied all Low M_{T2} selection cuts. The left plot has constant bin size, the right plot variable bin size. The last bin contains the overflow. The different MC backgrounds are stacked on top of each other and normalized to 1.1 fb^{-1}. The LM9 signal distribution is normalized to the same integrated luminosity and overlayed on the SM.

3. CMS Search with M_{T2} - Limits

- No significant excess was observed in either the Low or High M_{T2} analyses. Therefore limits are set.
- This is done both as an exclusion in MSUGRA/CMSSM and a σ x BR ratio corrected for efficiency assuming efficiencies are similar for signal and SM.

Process	$\sigma\times$ BR (pb)	
	observed limit	expected limit
High M_{T2} analysis	0.010	0.011
Low M_{T2} analysis	0.020	0.014



The exclusion limits for the High (left) and Low (right) CMS M_{T2} analyses.

Conclusions

- Both ATLAS and CMS have looked at $> 1\mathrm{fb}^{-1}$ of data in the Jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ + 0-leptons channel.
- They have employed quite different signal selections.
- Neither has observed a significant excess.
- Limits have been set in specific models and model independent limits presented.
- In **specific models/regions of parameter space** limits on the masses of $\tilde{q}$s and $\tilde{g}$s have exceeded 1 TeV!
- For more information on the analyses presented here see:
  1. ATLAS: An upcoming paper
  2. CMS α_T: http://cdsweb.cern.ch/record/1370596?ln=en
  3. CMS M_{T2}: http://cdsweb.cern.ch/record/1377032?ln=en

What Next?

- More data - LHC is rapidly supplying data.
- Contraining systematics - the increased amount of data available by the end of the year will give much better Control Region Statistics and coupling this with the work of the performance groups to reduce uncertainties will improve the sensitivity of these searches.
- More signal regions?
  - Are there signals which would be missed by our current selections?
  - Limitations + Difficult Models - review later this workshop; 9am Friday
  - An ATLAS search requiring ≥ 6, ≥ 7 and ≥ 8 jets will be presented at SUSY 11 (this week) targetting longer decay chains.(https://indico.fnal.gov/conferenceDisplay.py?confId=3563)

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