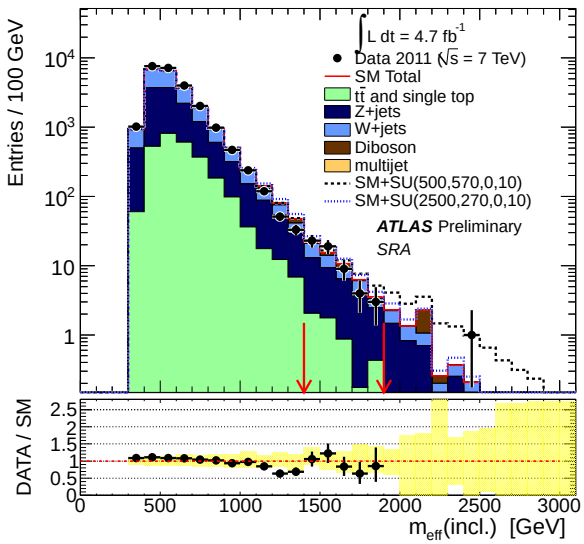
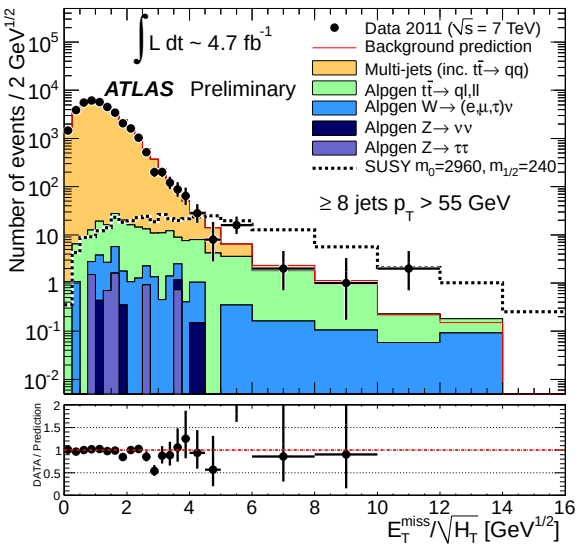
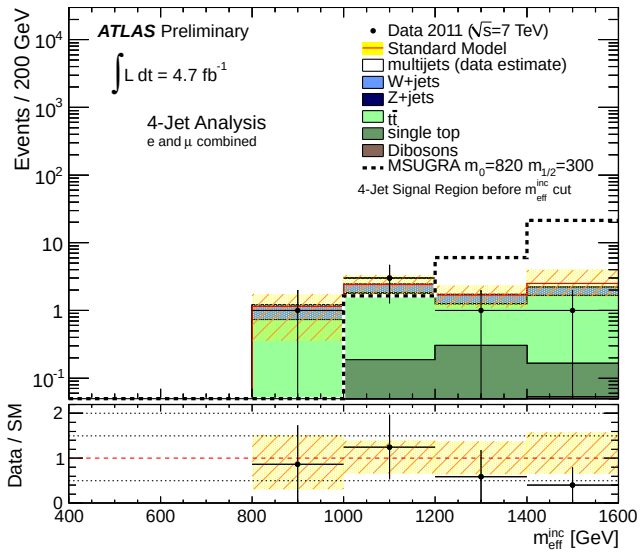
SUSY Strong Production Searches @ ATLAS

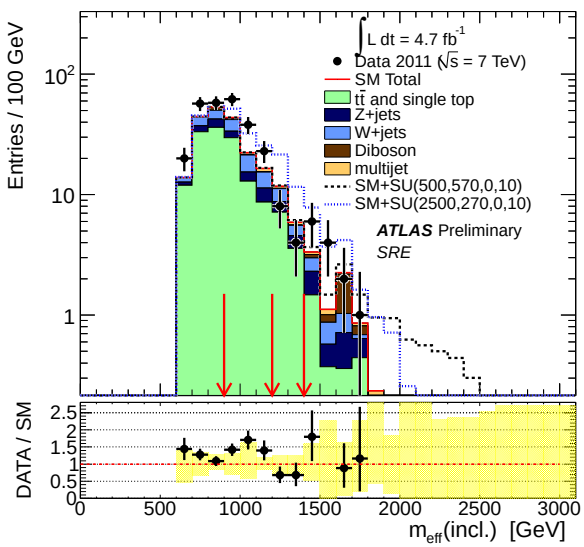
Christopher Young

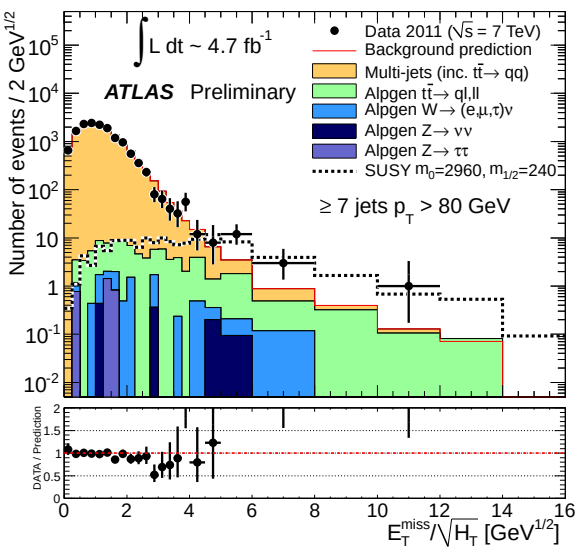
18th March 2012

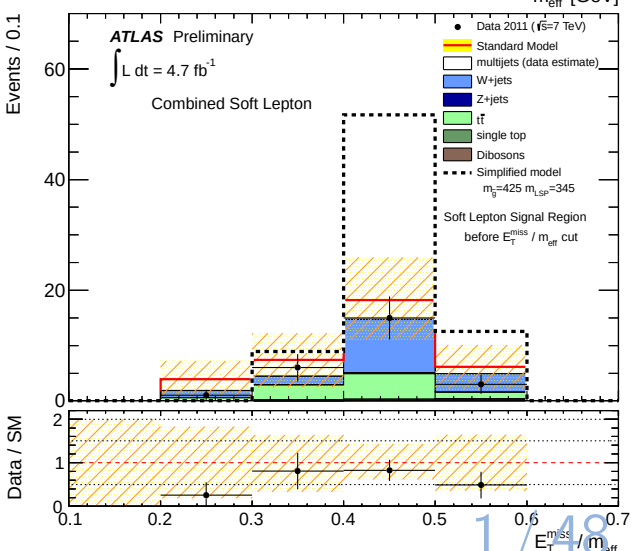












Contents

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- The suite of ATLAS searches for Strongly Produced SUSY
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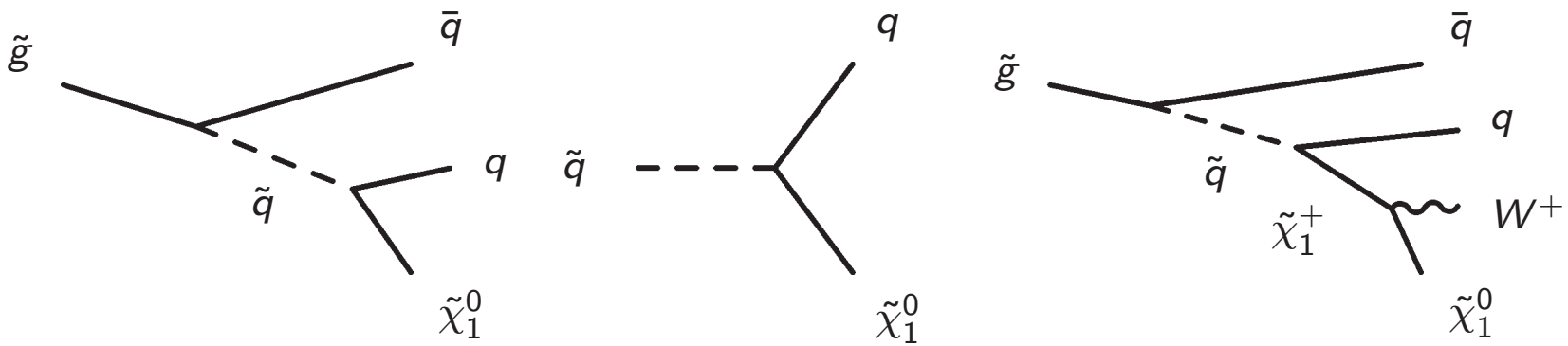
- 1-lepton search ($\geq 3-4$ jets) (hard and soft leptons) (ATLAS-CONF-2012-041) - **NEW this week!**
- Conclusions

Introduction

- SUSY strong production is characterised by the pair and associated production of squarks ($\tilde{q}$) and gluinos ($\tilde{g}$).
- These can then decay either directly to the LSP (usually assumed to be the lightest neutralino) or through a series of intermediate SUSY particles.



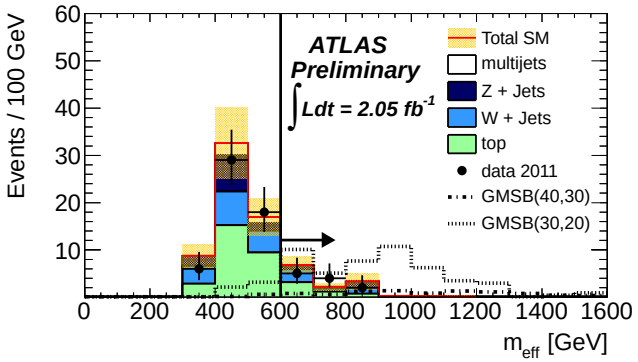
- In the R-Parity conserving models considered the lightest neutralino is assumed to be (collider) stable so passes through the detector undetected.
- Signatures therefore involve jets, missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$) and possibly leptons (inc. τs) from cascade decays (and, additionally, possibly photons).
- Searches for R-Parity violating SUSY, long lived charged particles and specific searches for gauginos and 3rd generation squarks are covered in separate talks.

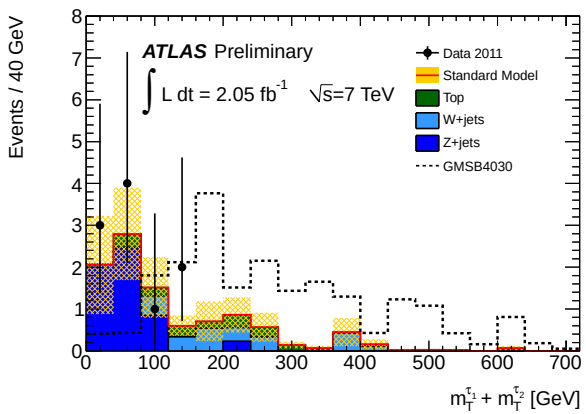
Introduction II

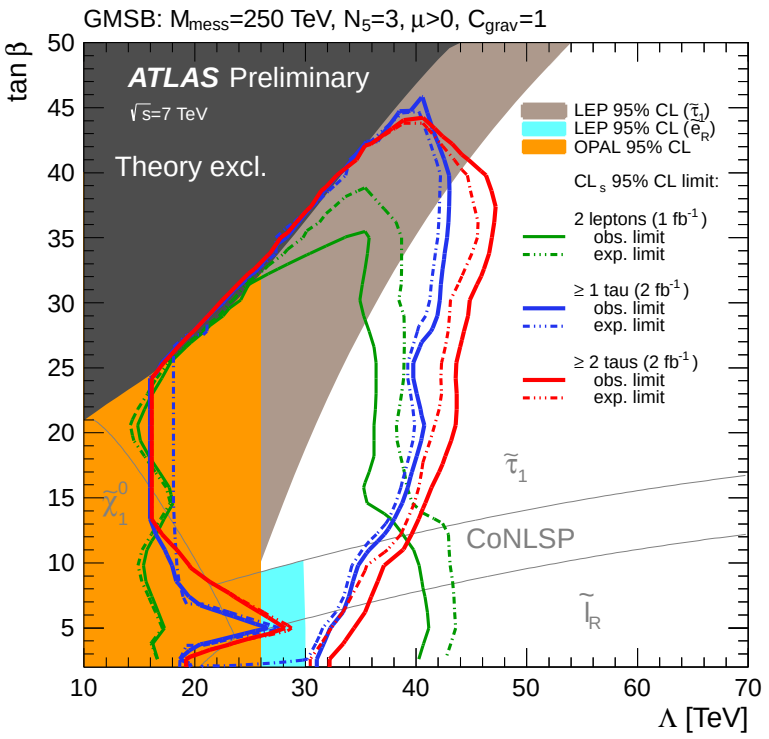
- Here I am presenting three ATLAS analyses with the full 2011 dataset which have sensitivity to these models of interest;
  1. 0-lepton m_{eff} ($\geq 2-6$ jets) (ATLAS-CONF-2012-033)
  2. 0-lepton high multiplicity ($\geq 6-9$ jets) (ATLAS-CONF-2012-037)
  3. 1-lepton ($\geq 3-4$ jets) (ATLAS-CONF-2012-041) - **NEW this week!**
- There are many other ATLAS analyses also sensitive to these models that are still in the process of being updated to the full dataset:
  - Di-photon + $E_{\text{T}}^{\text{miss}}$ (1.07fb^{-1}) arXiv:1111.4116
  - Di-lepton + jets + $E_{\text{T}}^{\text{miss}}$ (1.04fb^{-1}) arXiv:1110.6189
  - $\geq 1\tau$ + jets + $E_{\text{T}}^{\text{miss}}$ (2.05fb^{-1}) ATLAS-CONF-2012-005
  - $\geq 2\tau$s + $E_{\text{T}}^{\text{miss}}$ (2.05fb^{-1}) ATLAS-CONF-2012-002
  - 2 Same Sign leptons + jets + $E_{\text{T}}^{\text{miss}}$ (2.05fb^{-1}) ATLAS-CONF-2012-004
  - $\geq$4 leptons + $E_{\text{T}}^{\text{miss}}$ (2.05fb^{-1}) ATLAS-CONF-2012-001
- For a full list and more information please see; https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

$\geq 1\tau$ and $\geq 2\tau$ Analysis Results

- τ leptons can often be found in the cascade decays. (eg. $\tilde{\tau}$ NLSP)
- Dedicated searches have looked at the $\geq 1\tau$ and $\geq 2\tau$ final states.
- No significant excess was observed and limits were set in a GMSB model.
- Below are the signal regions before the final cuts for the $\geq 1\tau$ (upper) and $\geq 2\tau$ (lower) analyses and the two exclusion limits.







0-lepton m_{eff} Analysis

0-lepton $m_{\rm eff}$ Analysis

- Update of previous published result (arXiv:1109.6572) with **re-optimised** signal region definitions (including extension to $\geq$5 and $\geq$6 jets), improved background determination and increased integrated luminosity.
- Veto events with electons ($p_{\rm T} > 20$ GeV $|\eta| < 2.47$) or muons ($p_{\rm T} > 10$ GeV $|\eta| < 2.4$).
- The data is split into different streams by inclusive multiplicity ranging from ≥ 2 to ≥ 6 jets.
- This is designed to maintain good sensitivity to a large range of models from those with directly decaying squarks giving ≥ 2 jets in the final state to longer decay chains with many jets in the final state.
- The discriminating variable $m_{\rm eff}$(incl.) is defined as the scalar sum of the $E_{\rm T}^{\rm miss}$ and all the jets in the event with $p_T > 40$ GeV.
- Multi-jet processes with no/low real $E_{\rm T}^{\rm miss}$ are reduced to a very small level through cuts on the minimum azimuthal angle between jets and the $E_{\rm T}^{\rm miss}$ and on the ratio of $E_{\rm T}^{\rm miss}/m_{\rm eff}(N_J)$[1]
- A second 2-jet stream is defined with a tighter cut on $E_{\rm T}^{\rm miss}/m_{\rm eff}(N_J)$ designed to enhance sensitivity to models with smaller sparticle mass splittings.
- In total 11 signal regions are defined.

[1] When forming this ratio $m_{\rm eff}$ is computed from the leading N jets in the N jet stream.

0-lepton m_{eff} Analysis: Signal Region Cuts

Requirement	Channel					
	A	A'	B	C	D	E
$E_{\text{T}}^{\text{miss}}$[GeV] $>$	160					
$p_{\text{T}}(j_1)$ [GeV] $>$	130					
$p_{\text{T}}(j_2)$ [GeV] $>$	60					
$p_{\text{T}}(j_3)$ [GeV] $>$	–	–	60	60	60	60
$p_{\text{T}}(j_4)$ [GeV] $>$	–	–	–	60	60	60
$p_{\text{T}}(j_5)$ [GeV] $>$	–	–	–	–	40	40
$p_{\text{T}}(j_6)$ [GeV] $>$	–	–	–	–	–	40
$\Delta\phi(j_i, E_{\text{T}}^{\text{miss}})$ $>$	0.4 ($i = \{1, 2, (3)\}$)			0.4 ($i = \{1, 2, 3\}$), 0.2 ($p_{\text{T}} > 40$ GeV jets)		
$E_{\text{T}}^{\text{miss}}/m_{\text{eff}}(Nj)$ $>$	0.3 (2j)	0.4 (2j)	0.25 (3j)	0.25 (4j)	0.2 (5j)	0.15 (6j)
m_{eff}(incl.) [GeV] $>$	1900/1400/–	–/1200/–	1900/–/–	1500/1200/900	1500/–/–	1400/1200/900

Cuts used to define each of the channels in the analysis. SRs are defined by the last cut on m_{eff}(incl.). The $E_{\text{T}}^{\text{miss}}/m_{\text{eff}}$ cut in any N jet channel uses a value of m_{eff} constructed from only the leading N jets. However, the final m_{eff}(incl.) selection uses all jets with $p_{\text{T}} > 40$ GeV. The three m_{eff}(incl.) selections listed in the final row denote the 'tight', 'medium' and 'loose' selections respectively. Not all channels possess all three SRs.

0-lepton m_{eff} Analysis: Background Estimation

- To evaluate the Standard Model background in the signal regions, **Control Regions** (CR) are formed enriched in the different primary background processes; $W \to l\nu$ +jets, $Z \to \nu\nu$ +jets, $t\bar{t}$ and jet miss-measurement in multi-jet events.

CR	SR Background	CR process	CR selection
CR1a	$Z(\to \nu\nu)$+jets	γ+jets	Isolated photon
CR1b	$Z(\to \nu\nu)$+jets	$Z(\to \ell\ell)$+jets	$\lvert m(\ell,\ell) - m(Z)\rvert < 25$ GeV
CR2	Multi-jets	Multi-jets	Reversed $\Delta\phi(j_i, E_{\text{T}}^{\text{miss}})$ cut
CR3	$W(\to \ell\nu)$+jets	$W(\to \ell\nu)$+jets	30 GeV $< m_T(\ell, E_{\text{T}}^{\text{miss}}) <$ 100 GeV, b-veto
CR4	$t\bar{t}$ and single-t	$t\bar{t} \to bbqq'\ell\nu$	30 GeV $< m_T(\ell, E_{\text{T}}^{\text{miss}}) <$ 100 GeV, b-tag

- Signal region style cuts are applied treating leptons as jets in W and $t\bar{t}$ CRs and adding the photon or Z p_{T} to the $E_{\text{T}}^{\text{miss}}$ in the Z CRs.
- Good agreement in the shape of the m_{eff} distribution is seen in these Control Regions.

0-lepton m_{eff} Analysis: Background Estimation

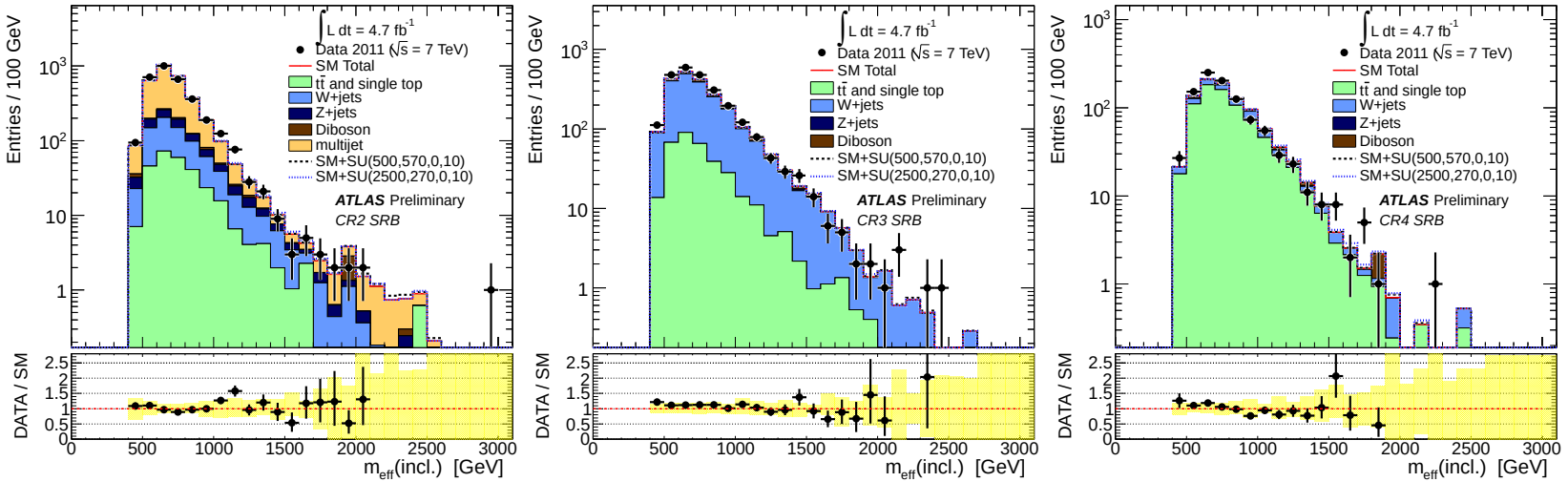
- Having defined a set of control regions for each signal region in similar kinematic regimes **transfer factors** are then defined;

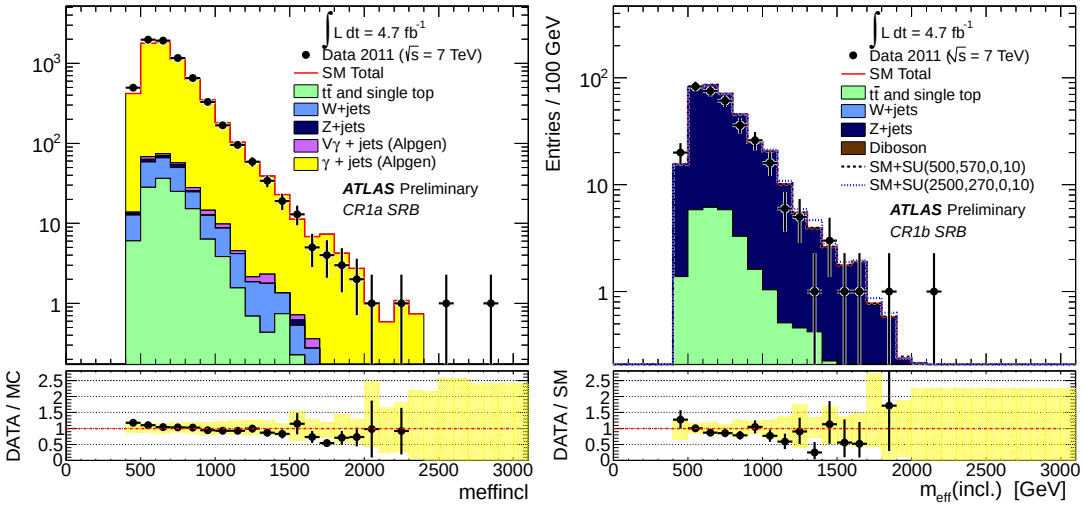
$$\begin{aligned} \mathrm{N}(\mathrm{SR},\mathrm{est},\mathrm{proc}) &= \mathrm{N}(\mathrm{CR},\mathrm{obs},\mathrm{proc}) \times (\mathrm{TransferFactor}) \\ &= \mathrm{N}(\mathrm{CR},\mathrm{obs},\mathrm{proc}) \times \left[\frac{\mathrm{N}(\mathrm{SR},\mathrm{raw},\mathrm{proc})}{\mathrm{N}(\mathrm{CR},\mathrm{raw},\mathrm{proc})}\right] \end{aligned} \quad (1)$$

- $\mathrm{N}(\mathrm{SR},\mathrm{est},\mathrm{proc})$ is the Signal Region background estimate for the process
- $\mathrm{N}(\mathrm{CR},\mathrm{obs},\mathrm{proc})$ is the observed number of data events in the Control Region for the process
- $\mathrm{N}(\mathrm{SR},\mathrm{raw},\mathrm{proc})$ and $\mathrm{N}(\mathrm{CR},\mathrm{raw},\mathrm{proc})$ are raw, un-normalised estimates of the contributions from the process to the Signal and Control Regions respectively.
- For the vector boson and $t\bar{t}$ backgrounds these transfer factors are taken from Monte-Carlo.
- For the Multi-jet background a data driven technique based on smearing low $E_{\mathrm{T}}^{\mathrm{miss}}$ events by the detector resolution is employed.
- By using these ratios several of the systematics partially cancel.
- A global fit for the normalisation of each background from the 5 control regions is simulataneously performed separately for each signal region.

0-lepton m_{eff} Analysis: Background Estimation

- As an example here I show the 5 Control Regions (before final m_{eff} cuts) for the 3 jet stream.





0-lepton m_{eff} Analysis: Results

- The results of the global fit, the oberserved number of data events and degree of statistical agreement for the first 6 Signal Regions. The numbers in brackets denote the background prediction before the fit is performed.

Process	Signal Region					
	SRC loose	SRE loose	SRA medium	SRAp medium	SRC medium	SRE medium
$t\bar{t}$+SingleTop	74 ± 13 (75)	66 ± 26 (64)	7 ± 5 (5.1)	11 ± 3.4 (10)	12 ± 4.5 (10)	17 ± 5.8 (13)
Z/γ+jets	70 ± 22 (61)	22 ± 6.4 (13)	31 ± 9.9 (34)	64 ± 20 (69)	17 ± 5.9 (16)	8 ± 2.9 (4.4)
W+jets	62 ± 9.3 (61)	23 ± 11 (23)	19 ± 4.5 (21)	26 ± 4.6 (30)	8.1 ± 2.9 (11)	5.9 ± 3 (4.7)
QCD jets	0.39 ± 0.4 (0.16)	3.7 ± 1.9 (3.8)	0.14 ± 0.24 (0.13)	0 ± 0.13 (0.38)	0.024 ± 0.034 (0.013)	0.8 ± 0.53 (0.64)
Di-Bosons	7.9 ± 4 (7.9)	4.2 ± 2 (4.2)	7.3 ± 3.7 (7.5)	15 ± 7.4 (16)	1.7 ± 0.87 (1.7)	2.7 ± 1.3 (2.7)
Total	214 ± 24.9 ± 13	119 ± 32.6 ± 11.6	64.8 ± 10.2 ± 6.92	115 ± 19 ± 9.69	38.6 ± 6.68 ± 4.77	34 ± 4.47 ± 5.57
Data	210	148	59	85	36	25
local p0 (Gaus. σ)	0.55(-0.14)	0.21(0.8)	0.65(-0.4)	0.9(-1.3)	0.6(-0.26)	0.85(-1)

- Good agreement within the uncertainties is seen between the predicted and observed numbers of events.

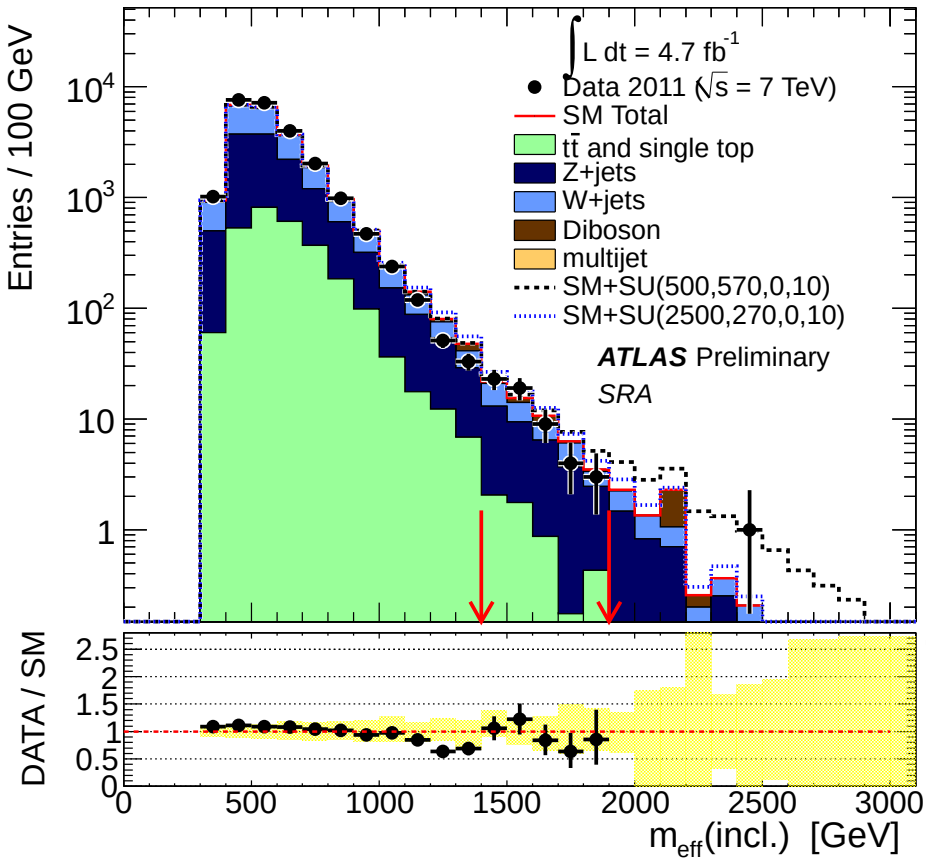
0-lepton m_{eff} Analysis: Results

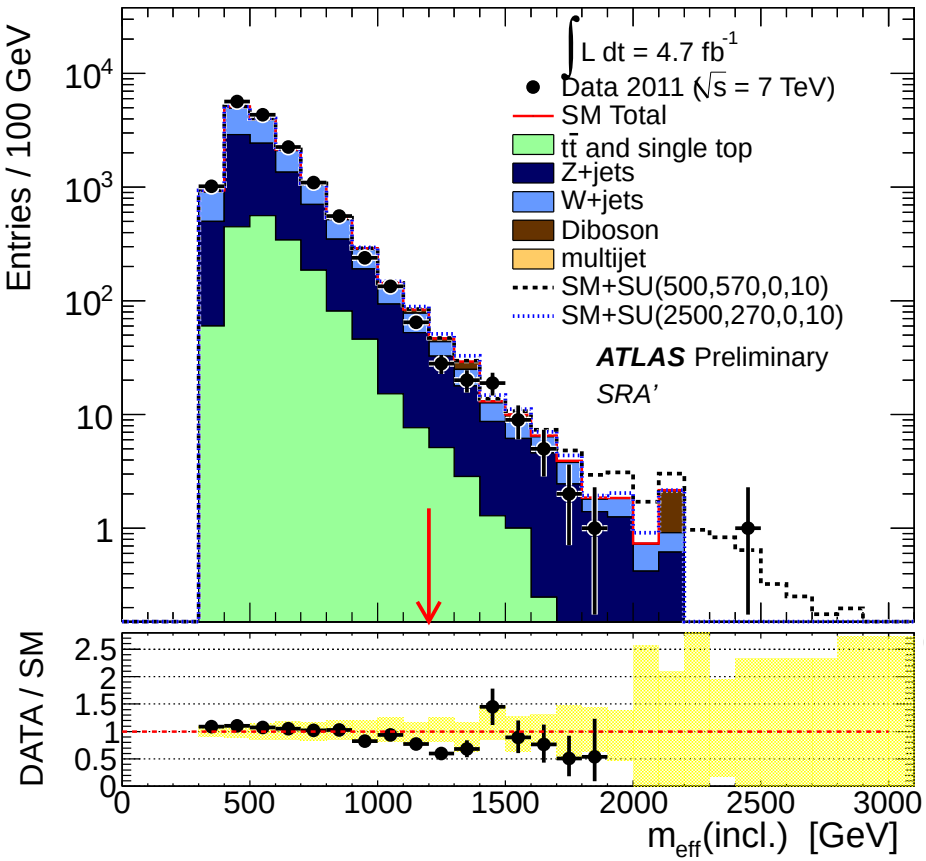
- The results of the global fit, the oberserved number of data events and degree of statistical agreement for the final 5 Signal Regions. The numbers in brackets denote the background prediction before the fit is performed.

Process	Signal Region				
	SRA tight	SRB tight	SRC tight	SRD tight	SRE tight
$t\bar{t}$+SingleTop	0.22 ± 0.35 (0.046)	0.21 ± 0.33 (0.066)	1.8 ± 1.6 (0.96)	2 ± 1.7 (0.92)	3.9 ± 4 (2.6)
Z/γ+jets	2.9 ± 1.5 (3.1)	2.5 ± 1.4 (1.6)	2.1 ± 1.1 (4.4)	0.95 ± 0.58 (2.7)	3.2 ± 1.4 (1.8)
W+jets	2.1 ± 0.99 (1.9)	0.97 ± 0.6 (0.84)	1.2 ± 1.2 (2.7)	1.7 ± 1.5 (2.5)	2.3 ± 1.7 (1.5)
QCD jets	0 ± 0.0024 (0.002)	0 ± 0.0034 (0.0032)	0 ± 0.0058 (0.0023)	0 ± 0.0072 (0.021)	0.22 ± 0.25 (0.24)
Di-Bosons	1.7 ± 0.95 (2)	1.7 ± 0.95 (1.9)	0.49 ± 0.26 (0.51)	2.2 ± 1.2 (2.2)	2.5 ± 1.3 (2.5)
Total	7 ± 0.999 ± 2.26	5.39 ± 0.951 ± 2.01	5.68 ± 1.79 ± 1.51	6.84 ± 1.7 ± 2.1	12.1 ± 4.59 ± 3.04
Data	1	1	14	9	13
local p0 (Gaus. σ)	0.98(-2.1)	0.95(-1.7)	0.018(2.1)	0.29(0.55)	0.45(0.13)

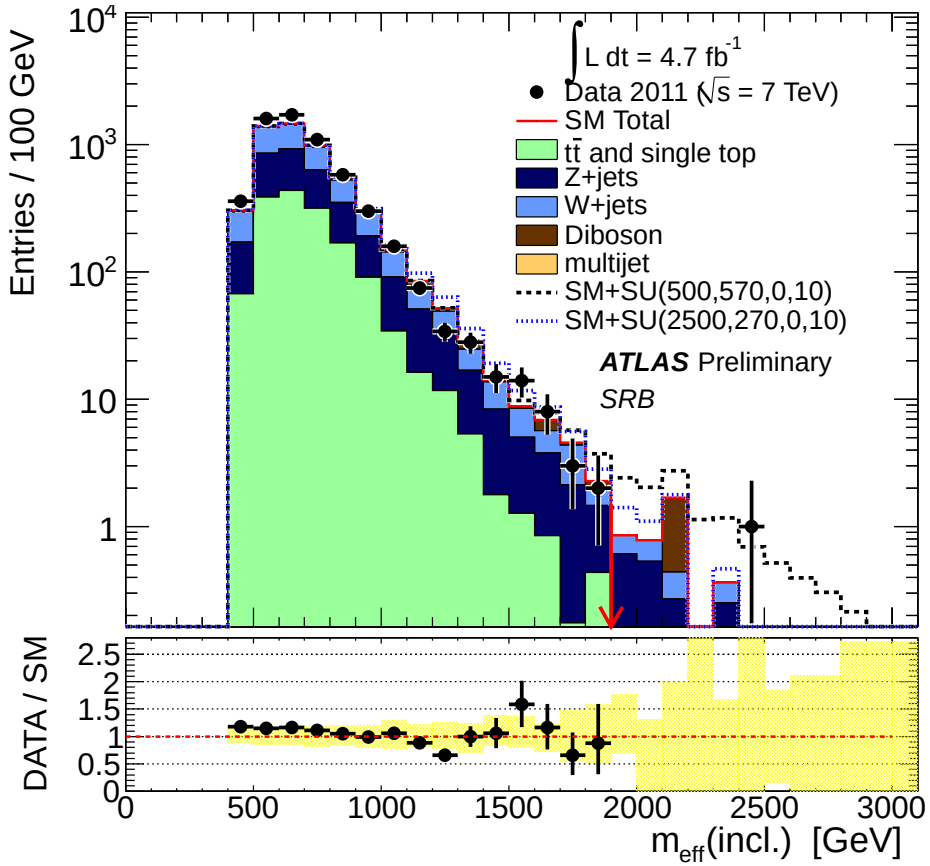
- Good agreement within the uncertainties is seen between the predicted and observed numbers of events.

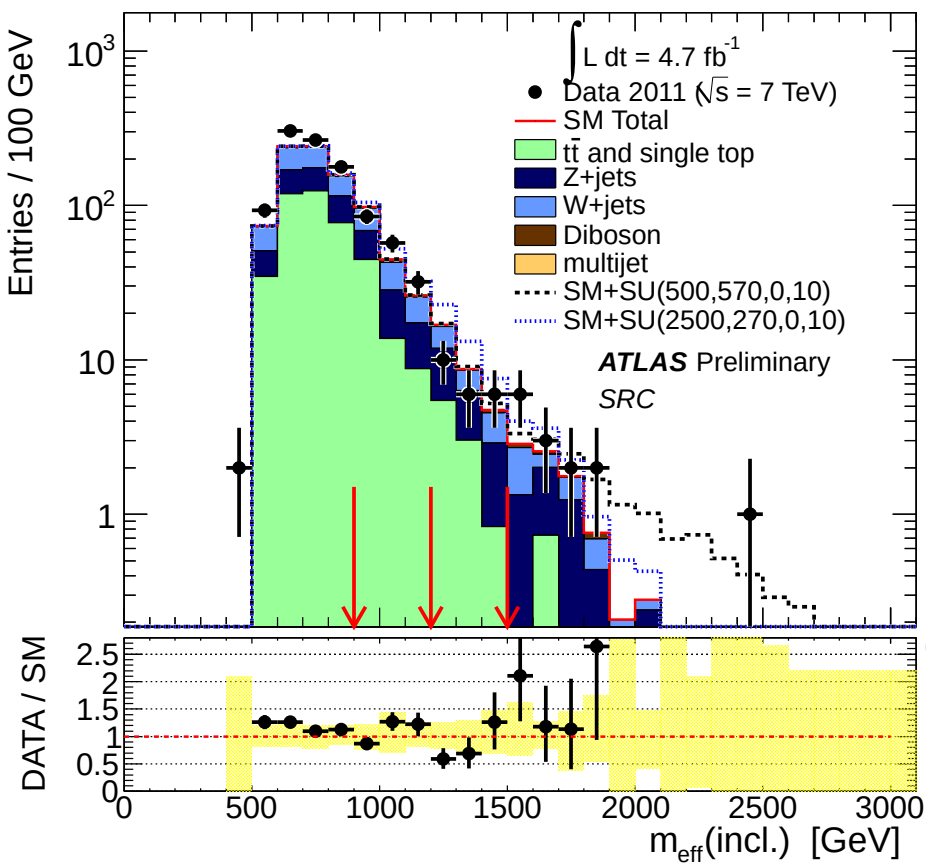
0-lepton m_{eff} Analysis: Results





0-lepton m_{eff} Analysis: Results





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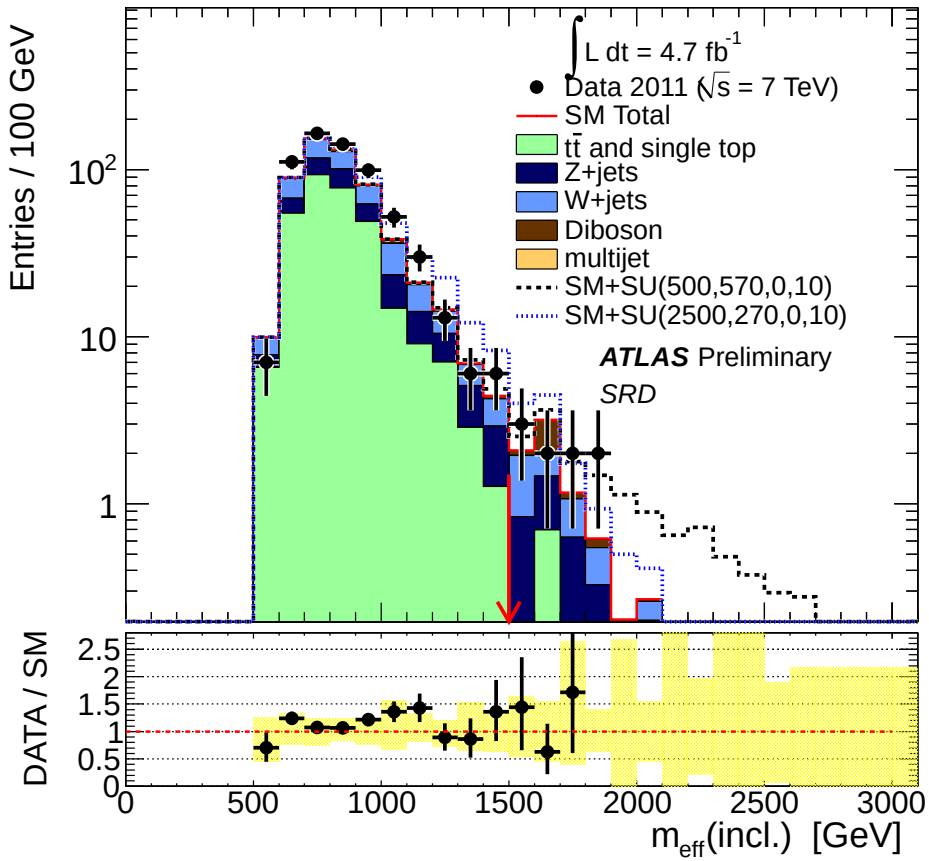
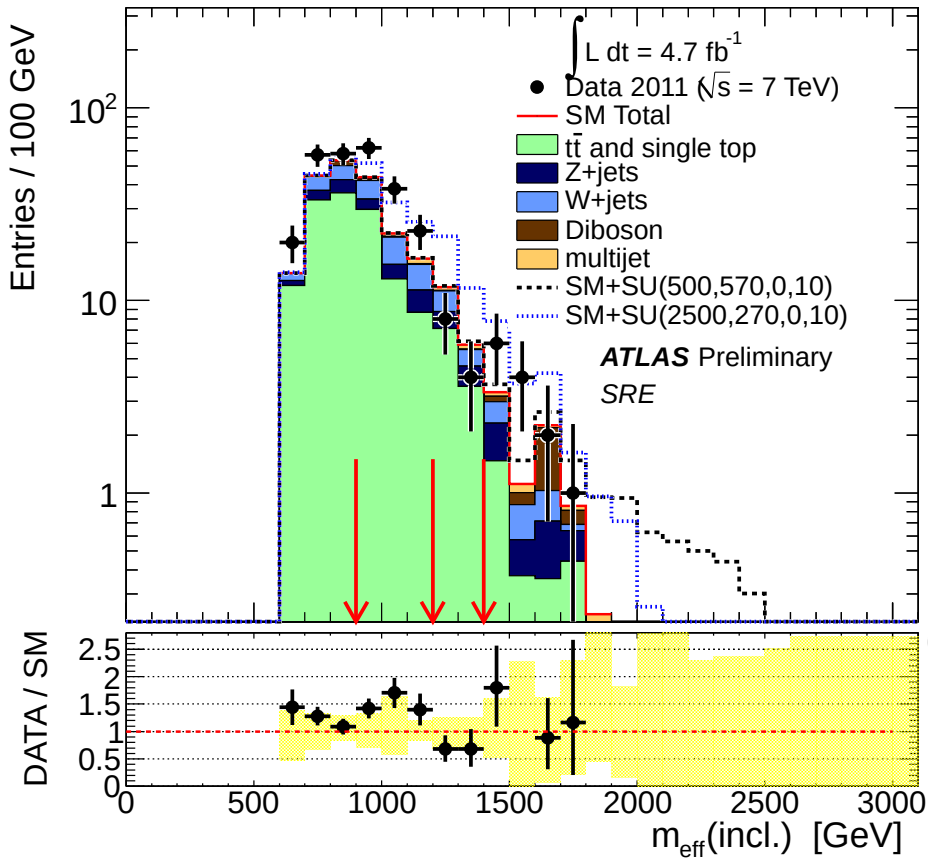
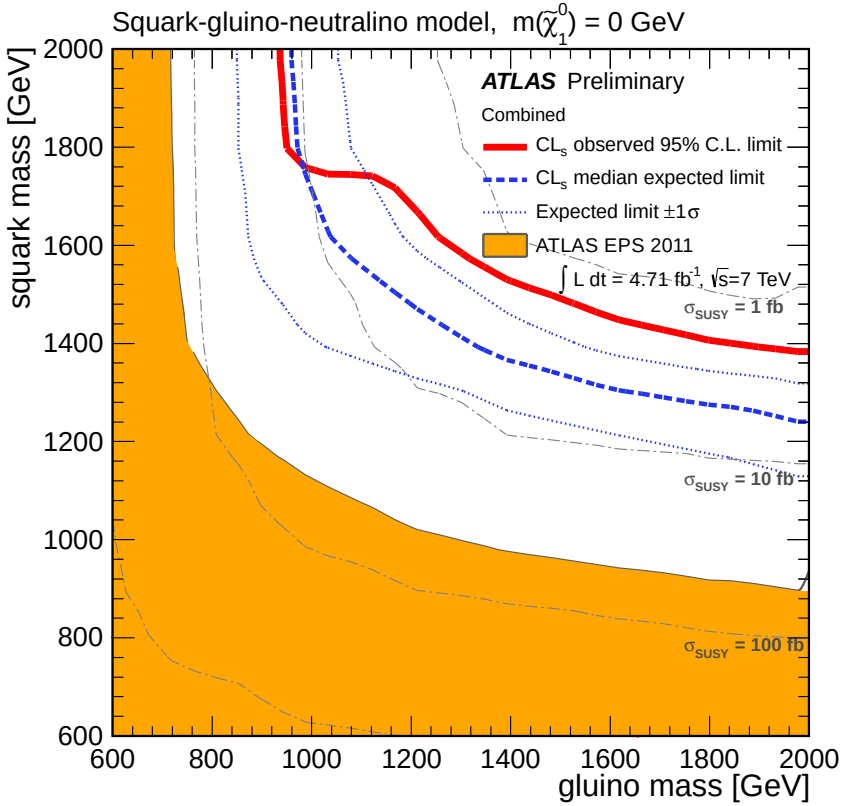
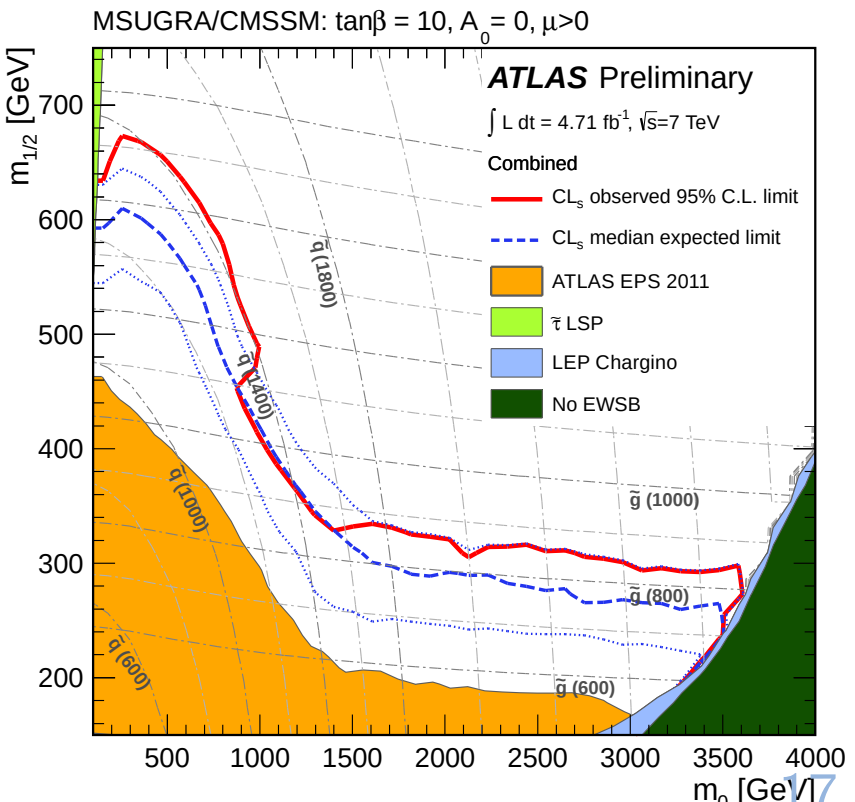




0-lepton m_{eff} Analysis: Limits

- Having not observed any significant excess limits are set on a simplified model consisting of first and second generation squarks, a gluino octet and a massless LSP and in the MSUGRA/CMSSM plane with $\tan\beta = 10$; $A_0 = 0$; $\mu > 0$
- For each point in the planes the signal region with the best expected exclusion is used to evaluate whether the point is excluded or not.





0-lepton High Multiplicity Analysis

0-lepton High Multiplicity Analysis

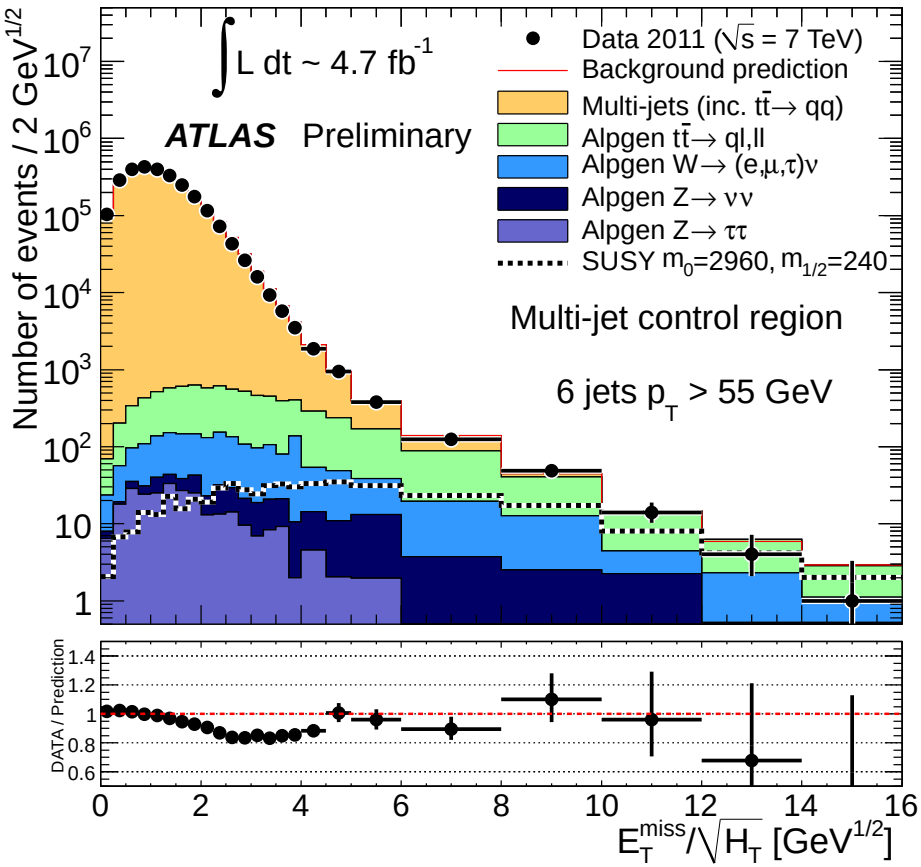
- Analysis targeting longer decay chains of SUSY particles resulting in final states with very large jet multiplicity and lower $E_{\mathrm{T}}^{\mathrm{miss}}$.
- Update of previous 1.34fb^{-1} analysis (arXiv: 1110.2299) with increased number of signal regions and increased luminosity.
- Updated procedures and more detailed study allowed removal of the $\Delta R(\mathrm{jet,jet})$ cut present in the previous version.
- Large increase in signal acceptance.
- Object definitions, event cleaning and lepton veto the same as 0-lepton m_{eff} analysis.
- 6 signal regions defined.

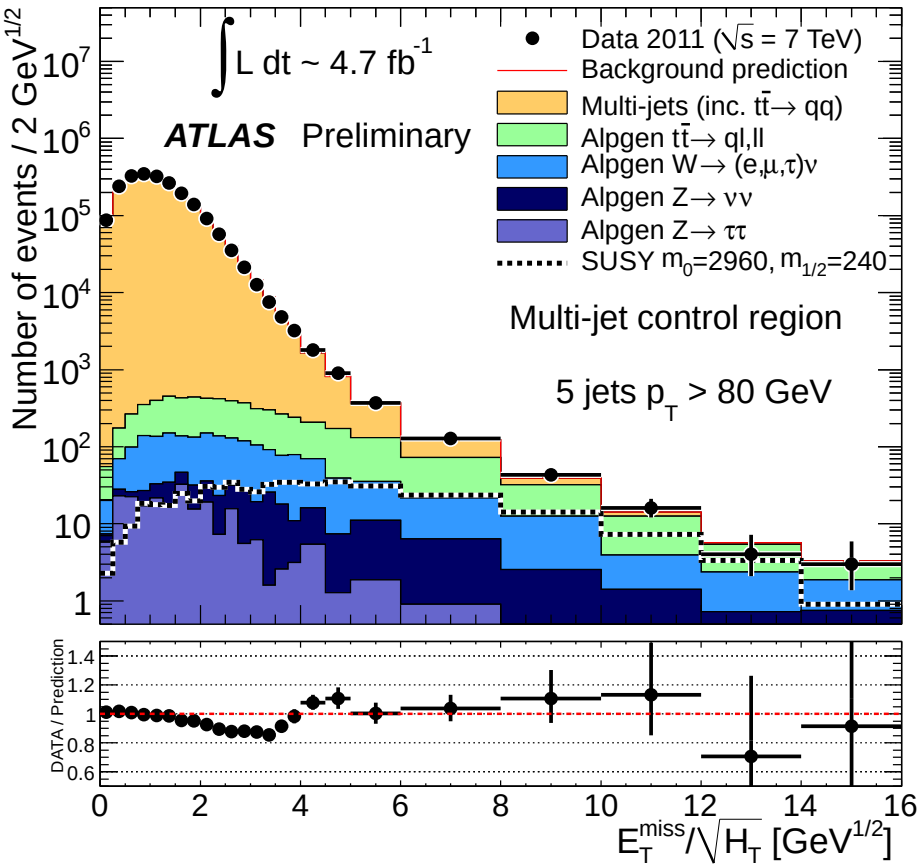
Signal region	**7j55**	**8j55**	**9j55**	**6j80**	**7j80**	**8j80**
Isolated Leptons (e, μ)	$=0$					
Jet p_T	$>55\,\mathrm{GeV}$			$>80\,\mathrm{GeV}$		
Jet $\lvert\eta\rvert$	<2.8					
Number of jets	≥ 7	≥ 8	≥ 9	≥ 6	≥ 7	≥ 8
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_T}$	$>4\ \mathrm{GeV}^{1/2}$					

0-lepton High Multiplicity Analysis: Backgrounds

- Due to the softer $E_{\mathrm{T}}^{\mathrm{miss}}$ requirements and lack of $\Delta\phi(j_i, E_{\mathrm{T}}^{\mathrm{miss}})$ cuts, jet miss-measurement is a primary background in this search.
- The cuts are designed to allow a robust estimation of this background.
- The $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$ distribution is observed to be stable under changes in nJet.
- This is due to the jet resolution dependence of the ATLAS detector.
- Shape is taken from lower multiplicity (after subtracting other backgrounds) and normalised at low $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$.
- Primary systematics are; closure at lower multiplicity/lower $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$, the varying amounts of heavy flavour jets at different nJet and the subtraction of the other backgrounds in forming the template.

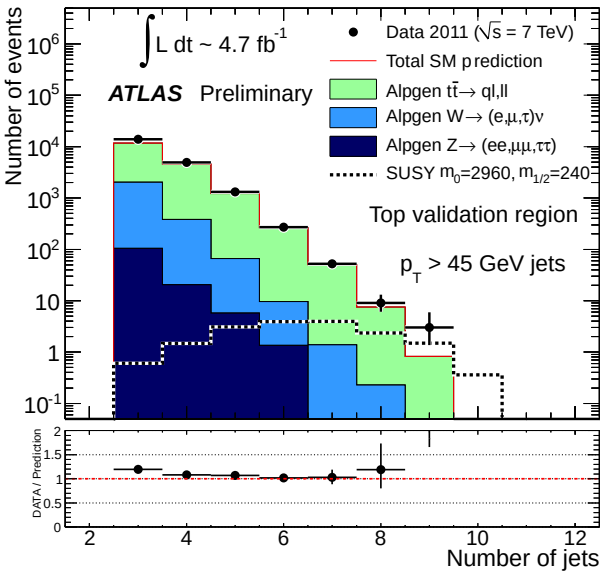
0-lepton High Multiplicity Analysis: Backgrounds

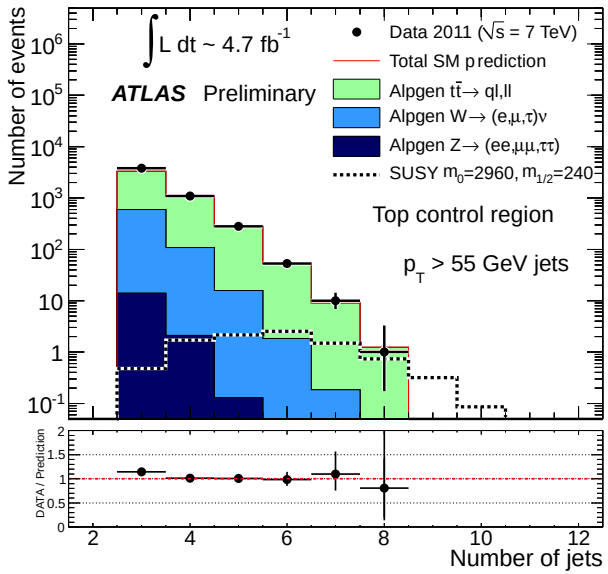


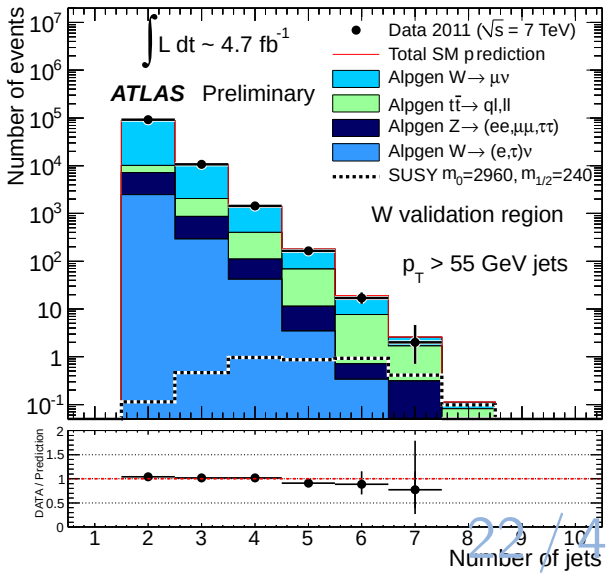


0-lepton High Multiplicity Analysis: Backgrounds

- $t\bar{t}$, W+jets and Z+jets backgrounds follow a similar approach to the 0-lepton m_{eff} analysis.
- Valiation regions are formed requiring muons.
- Control regions are defined applying SR cuts and treating the muon as a jet (for W and $t\bar{t}$) or adding them to the $E_{\text{T}}^{\text{miss}}$ (for Z).
- Transfer functions are used when adequate CR statistics are present, otherwise Monte-Carlo estimations are used.
- Monte-Carlo is validated at high multiplicity by looking at jet multiplicity distributions with reduced jet p_{T} cuts.





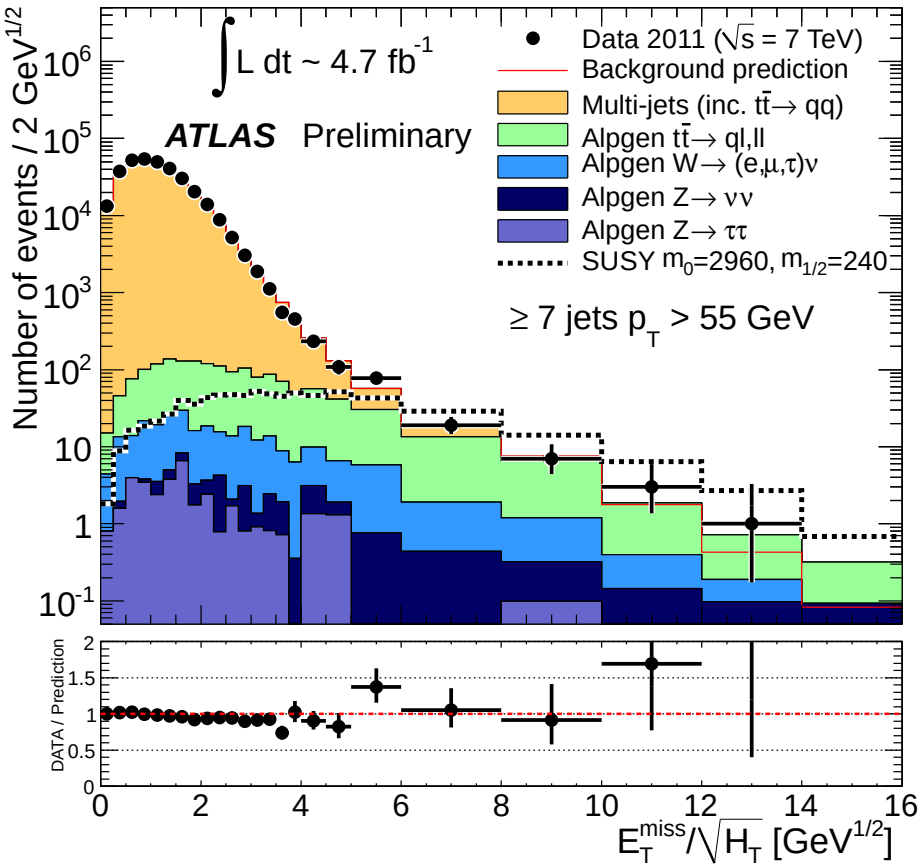


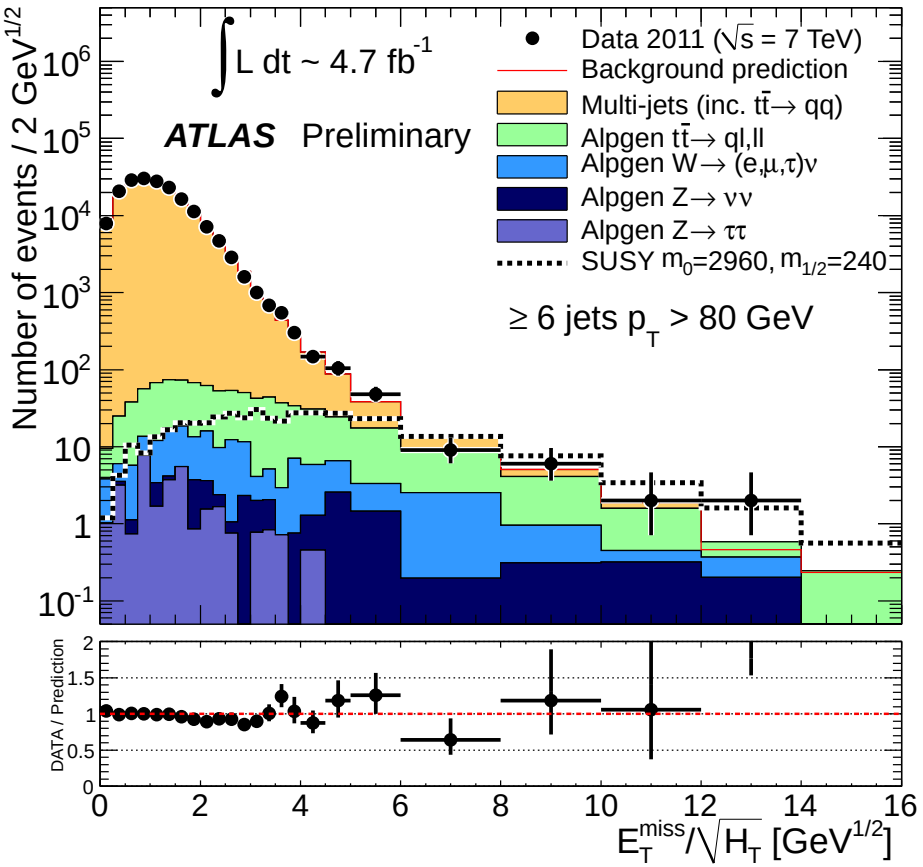
0-lepton High Multiplicity Analysis: Results

- No significant excess is observed in any of the six signal regions.

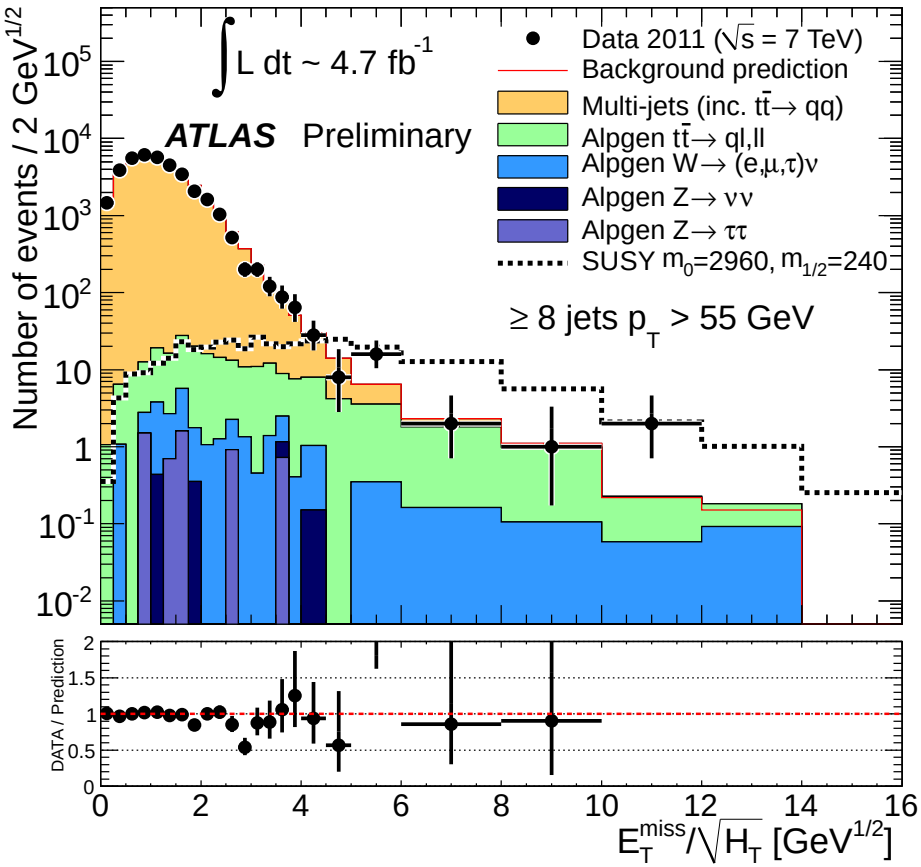
Signal region	**7j55**	**8j55**	**9j55**	**6j80**	**7j80**	**8j80**
Multi-jets	91±20	10±3	1.2±0.4	67±12	5.4±1.7	0.42±0.16
$t\bar{t} \to q\ell, \ell\ell$	55±18	5.7±6.0	0.70±0.72	24±13	2.8±1.8	0.38±0.40
W + jets	18±11	0.81±0.72	0+0.13	13±10	0.34±0.21	0+0.06
Z + jets	2.7±1.6	0.05±0.19	0+0.12	2.7±2.9	0.10±0.17	0+0.13
Total Standard Model	**167±34**	**17±7**	**1.9±0.8**	**107±21**	**8.6±2.5**	**0.80±0.45**
Data	**154**	**22**	**3**	**106**	**15**	**1**
p_{SM}	0.64	0.27	0.28	0.52	0.07	0.43

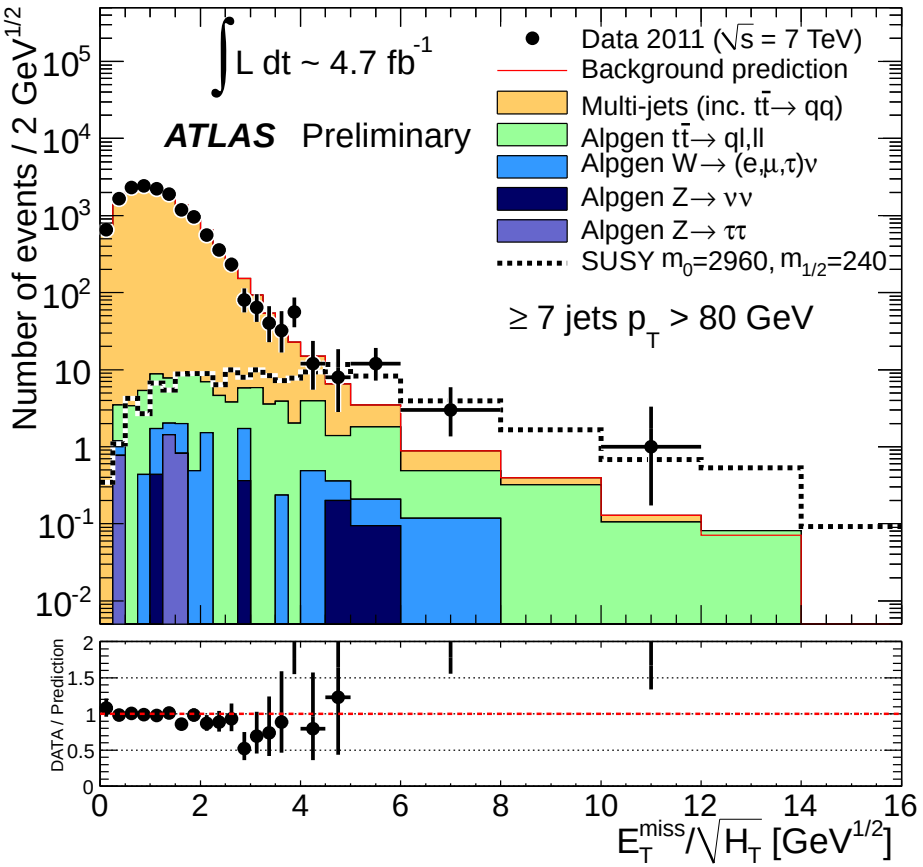
0-lepton High Multiplicity Analysis: Results



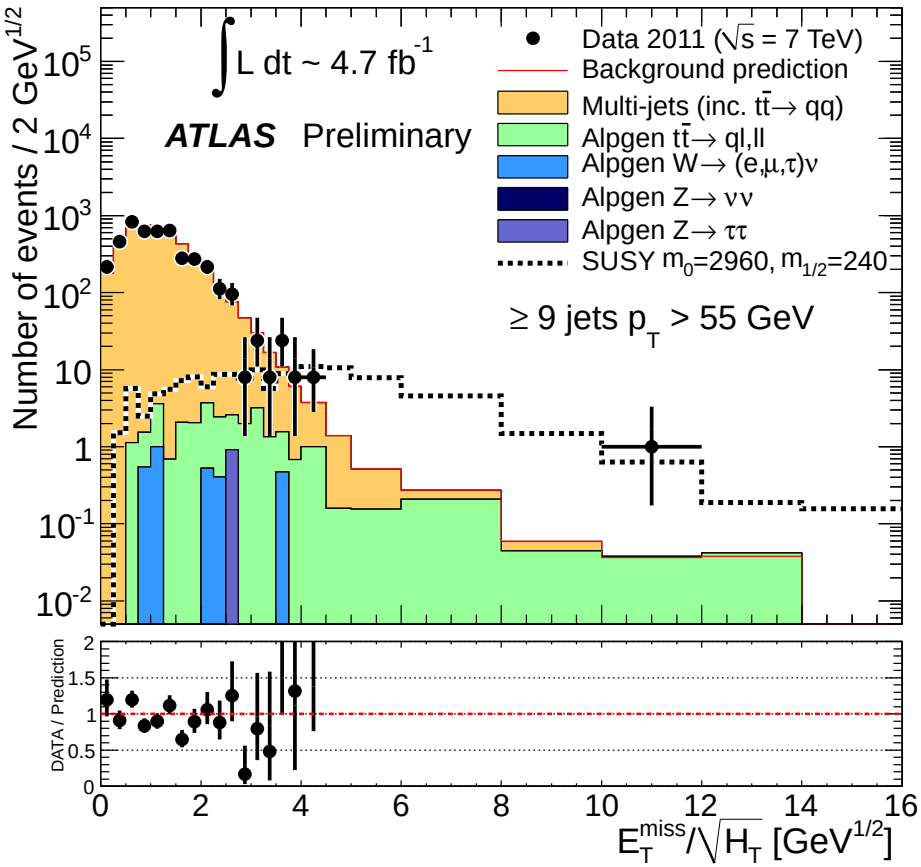


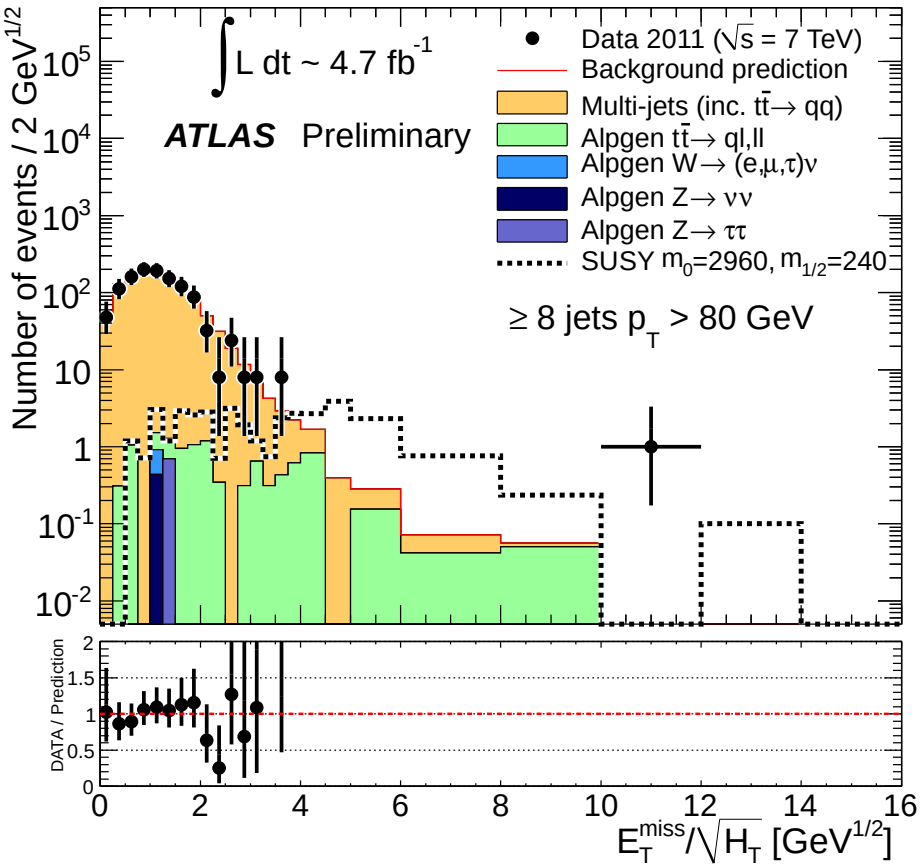
0-lepton High Multiplicity Analysis: Results



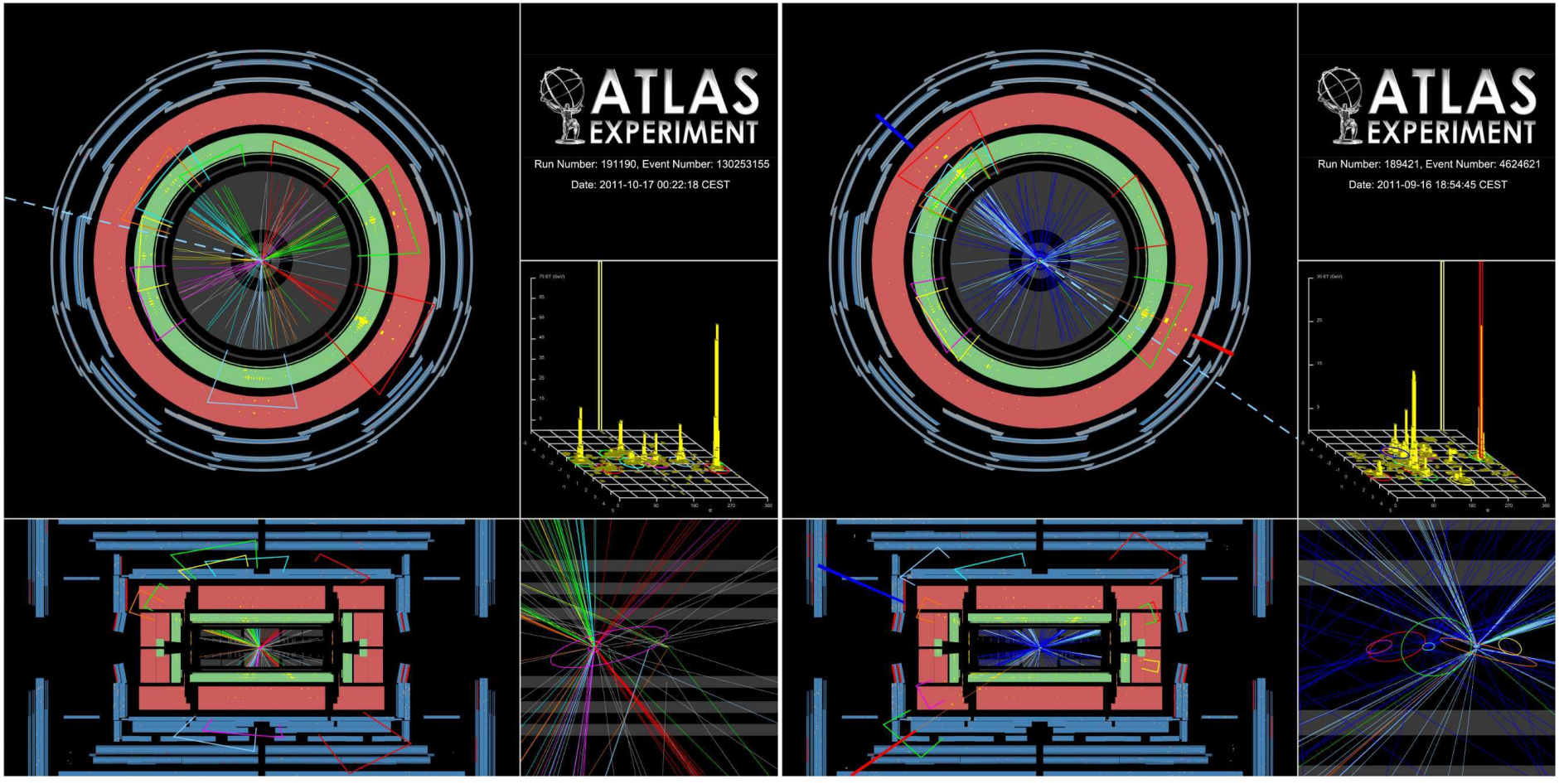


0-lepton High Multiplicity Analysis: Results



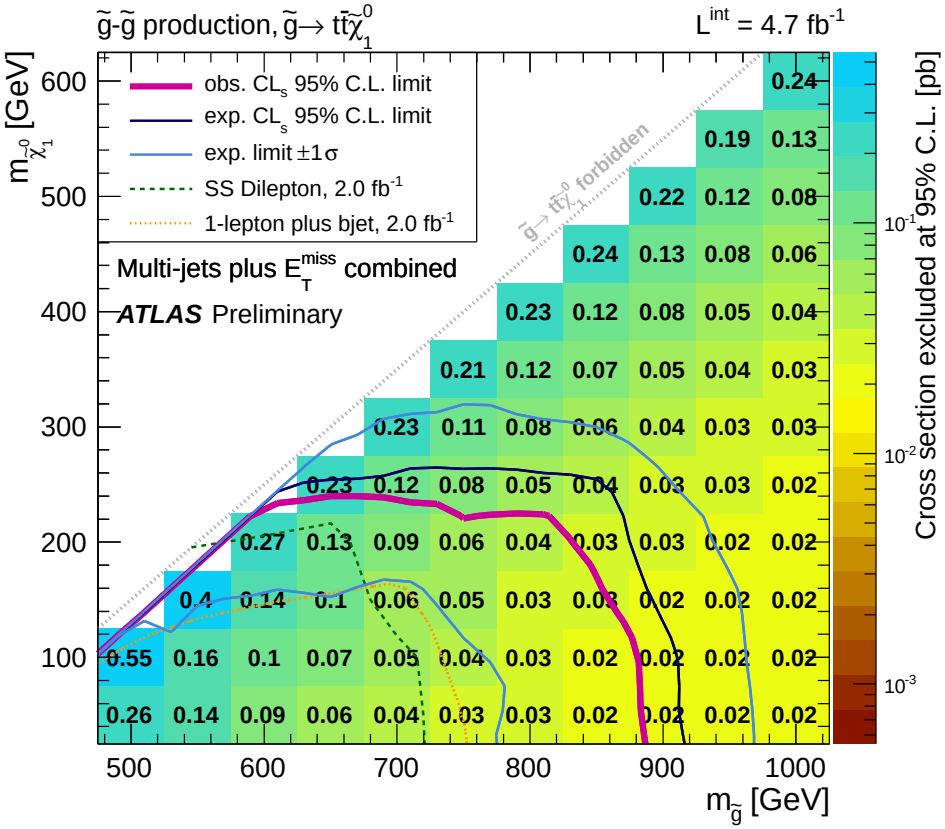


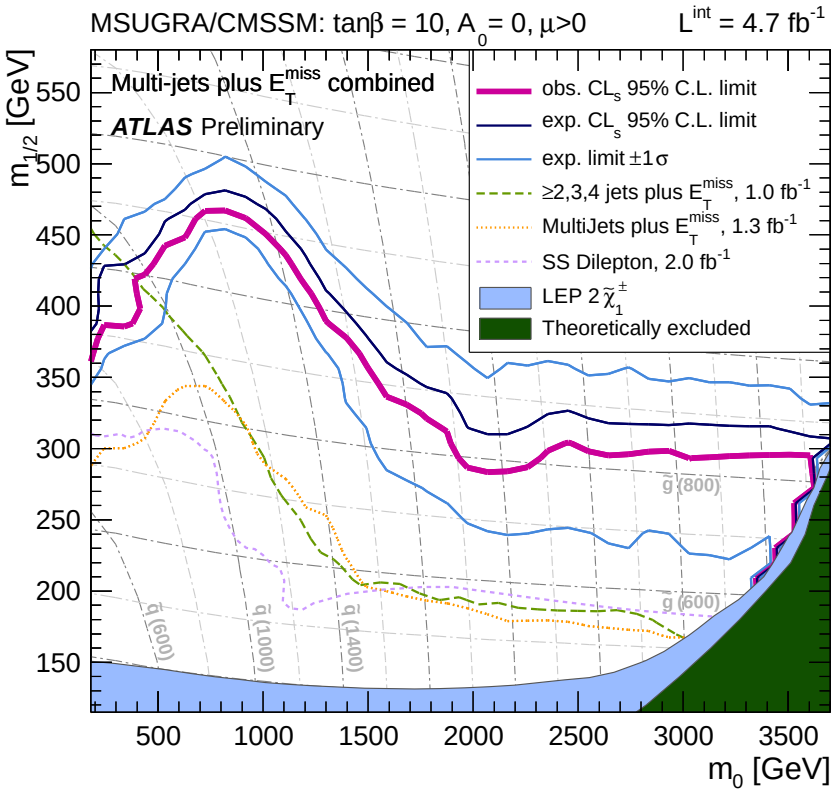
0-lepton High Multiplicity Analysis: Results



0-lepton High Multiplicity Analysis: Limits

- Having observed no significant excess we set limits.
- Limits are set in a simplified model with a gluino octet which decays to a $t\bar{t}$ pair and $\tilde{\chi}_1^0$, and in the MSUGRA/CMSSM plane with $\tan\beta = 10$; $A_0 = 0$; $\mu > 0$.





1-lepton Analysis

1-lepton Analysis

- Update of the 1fb^{-1} analysis (arXiv:1109.6606)
- A new signal region has been defined with a soft lepton and using a $E_{\mathrm{T}}^{\mathrm{miss}}$ trigger, designed to increase sensitivity to SUSY decay spectra involving small mass differences.
- Also, for the first time in ATLAS SUSY searches a procedure of performing a simultaneous fit across the shape of the signal distribution.
- Finally, **some** of the background uncertainties are constrained by fitting to the shape of the jet multiplicity in the background control regions.
- These updates have resulted in a large increase in the power of this search channel.

1-lepton Analysis: Lepton Definition

- In this analysis two kinds of signal region are considered; "hard" and "soft" lepton.
- **Hard electrons:** These are required to pass tighter identification requirements than those vetoed in the 0-lepton analyses, have survived the overlap removal, pass isolation criteria, not fall in unrespondent areas of the calorimeter and have $p_{\mathrm{T}} > 25\,\mathrm{GeV}$, $|\eta| < 2.47$.
- **Soft electrons:** These have to pass the above criteria, not lie in the calorimeter transition region ($1.37 < |\eta| < 1.52$) and have $7 < p_{\mathrm{T}} < 25\,\mathrm{GeV}$.
- **Hard muons:** These are to pass the identification criteria employed in the 0-lepton analysis, pass overlap removal, and in addition pass isolation criteria. They are required to have $p_{\mathrm{T}} > 20\,\mathrm{GeV}$, $|\eta| < 2.4$.
- **Soft muons:** These are required to pass the above criteria but have $6 < p_{\mathrm{T}} < 20\,\mathrm{GeV}$.
- The two criteria of leptons are therefore orthogonal allowing for channels to be combined in the future.
- Events with additional leptons are vetoed.
- Jets and $E_{\mathrm{T}}^{\mathrm{miss}}$ are defined as in the 0-lepton analyses.

1-lepton Analysis: Signal Regions

- Three different signal regions are defined for this analysis (although note that a shape fit is performed in the final discriminating variable for exclusion).

	3-jet	**4-jet**	**soft-lepton**
Trigger	Single electron or muon (+jet)		Missing E_{T}
N_{lep}	$== 1$	$== 1$	$== 1$
p_{T}^{ℓ} (GeV)	> 25 (20)	> 25 (20)	[7,25] ([6,20])
$p_{\mathrm{T}}^{\ell 2}$ (GeV)	< 10	< 10	< 7 (6)
N_{jet}	≥ 3	≥ 4	≥ 2
p_{T}^{jet} (GeV)	$> 100, 25, 25$	$> 80, 80, 80, 80$	$> 130,25$
$p_{\mathrm{T}}^{jet\ 4}$ (GeV)	< 80	—	—
$E_{\mathrm{T}}^{\mathrm{miss}}$ (GeV)	> 250	> 250	> 250
M_{T} (GeV)	> 100	> 100	> 100
$E_{\mathrm{T}}^{\mathrm{miss}}/M_{\mathrm{eff}}$	> 0.3	> 0.2	> 0.3
$M_{\mathrm{eff}}^{\mathrm{inc}}$ (GeV)	> 1200	> 800	—

The p_{T} selections for leptons are given for electrons (muons).

The transverse mass (M_{T}) of the lepton (ℓ) and $\vec{P}_{\mathrm{T}}^{\mathrm{miss}}$ is defined as

$$M_{\mathrm{T}} = \sqrt{2 p_{\mathrm{T}}^{\ell} E_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos(\Delta\phi(\vec{\ell}, \vec{P}_{\mathrm{T}}^{\mathrm{miss}})))}$$

The inclusive effective mass ($M_{\mathrm{eff}}^{\mathrm{inc}}$) is the scalar sum of the p_{T} of the lepton, the jets and $E_{\mathrm{T}}^{\mathrm{miss}}$:

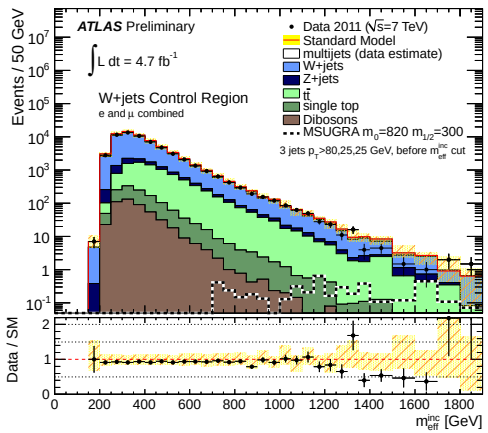
$$M_{\mathrm{eff}}^{\mathrm{inc}} = p_{\mathrm{T}}^{\ell} + \sum_{i=1} p_{\mathrm{T,i}} + E_{\mathrm{T}}^{\mathrm{miss}}$$

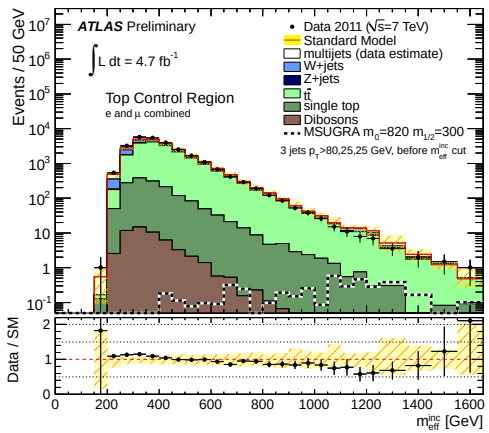
where the index i runs over all jets with $p_{\mathrm{T}} > 25$ GeV, $|\eta| < 2.5$ in the event.

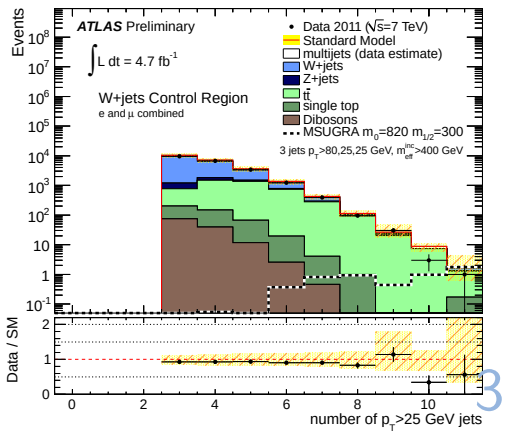
1-lepton Analysis: Backgrounds

- The main backgrounds to this search are;
  1. semi and fully leptonic $t\bar{t}$
  2. $W(\rightarrow l\nu)$+jets
- Control regions are formed for each of these backgrounds as defined below;

	3- and 4-jet W control	3- and 4-jet $t\bar{t}$ control	soft-lepton W control	soft-lepton $t\bar{t}$ control
N_{jet}	≥ 3	≥ 3	Same as signal region	
p_{T}^{jet} (GeV)	$>$ 80, 25, 25	$>$ 80, 25, 25	Same as signal region	
N_{jet} (b-tagged)	0	≥ 1	0	≥ 1
$E_{\mathrm{T}}^{\mathrm{miss}}$ (GeV)	[30,120]	[30,120]	[180,250]	[180,250]
M_{T} (GeV)	[40,80]	[40,80]	[40,80]	[40,80]
$M_{\mathrm{eff}}^{\mathrm{inc}}$ (GeV)	$>$ 400	$>$ 400	—	—





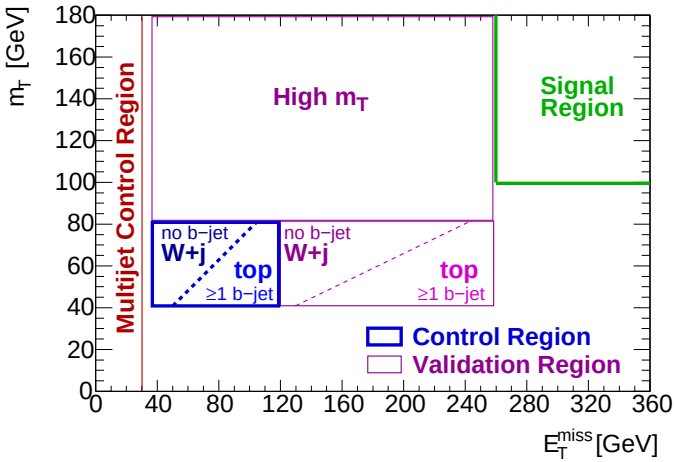


1-lepton Analysis: Background Fit

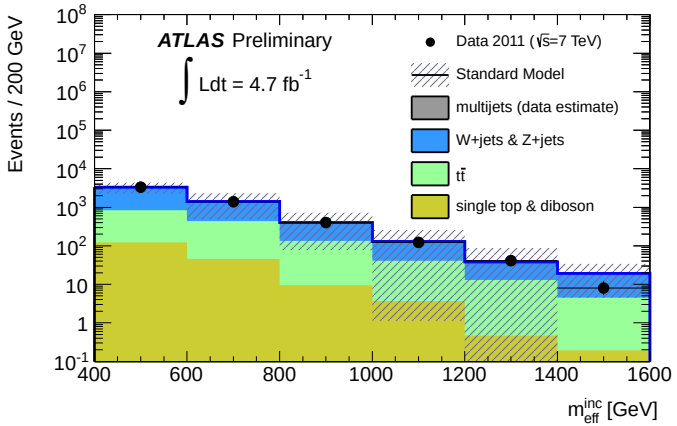
- A fit to the control region data is performed based on the profile likelihood method.
- There are 4 inputs to the fit:
  1. The observed number of events in each jet multiplicity bin of the W and $t\bar{t}$ Control Regions.
  2. The Transfer Factors that relate the number of observed events for each process in the different control and signal regions. When testing a signal model the signal contamination is also included.
  3. The fake lepton background (see CONF for details on the data-driven method used to find this).
  4. The Monte-Carlo estimations of the other small backgrounds.
- Uncertainties are treated as nuissance parameters in this fit and correlations of these nuissance parameters between bins is taken into account.
- It should be noted that the number of input measurements is sufficient for the fit to be over-constrained such that uncertainties can be reduced by the fit.
- Most notably the dependence on the matching scale parameter, $k_{T_{fac}}$ is greatly reduced (by $\sim$a factor of 2) by using the data to constrain the fit. (some uncertainties, most notably JES, are not constrained)

1-lepton Analysis: Fit Validation

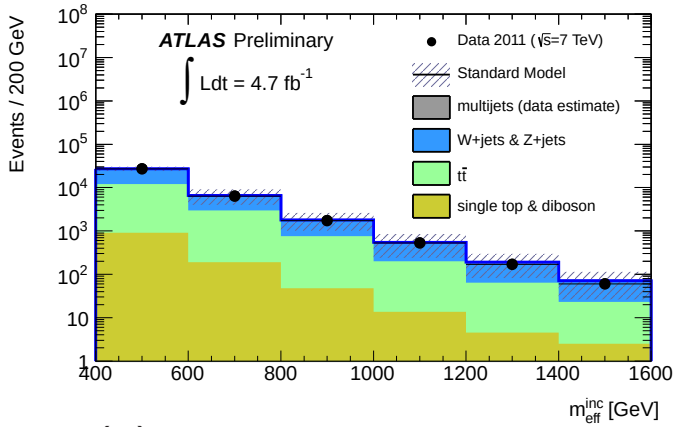
- The background fit is validated in an intermediate region of parameter space between the control and signal regions.



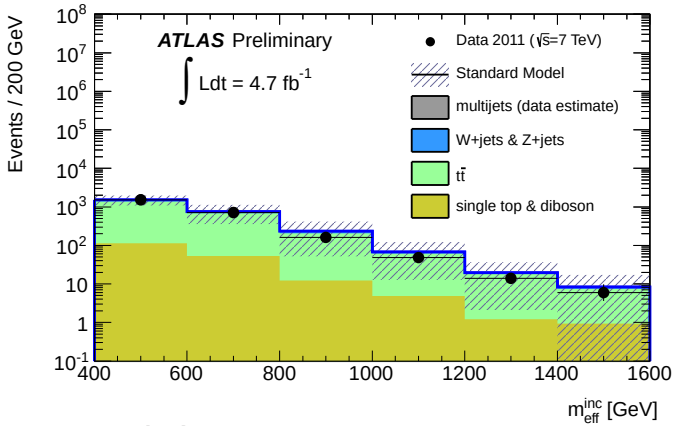
(a) Graphical Representation of regions.



(b) W Validation region



(c) High m_T Validation region



(d) Top Validation region

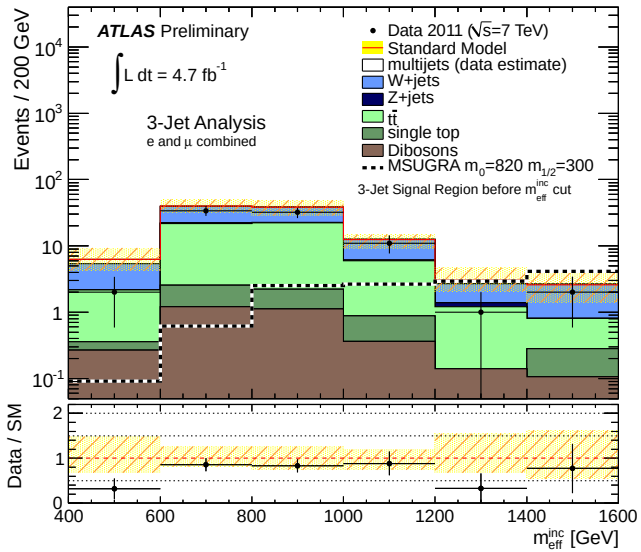
1-lepton Analysis: Results

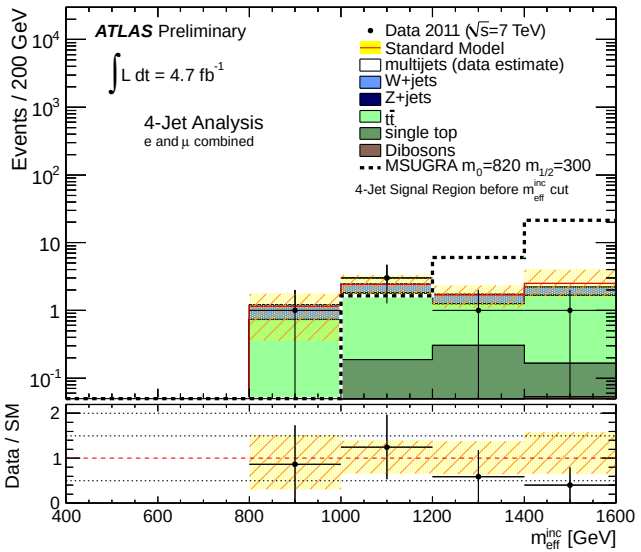
- When the fit is extended to the signal region (including the observed data) and a signal strength parameter is included the results are found to be consistent with the Standard Model.

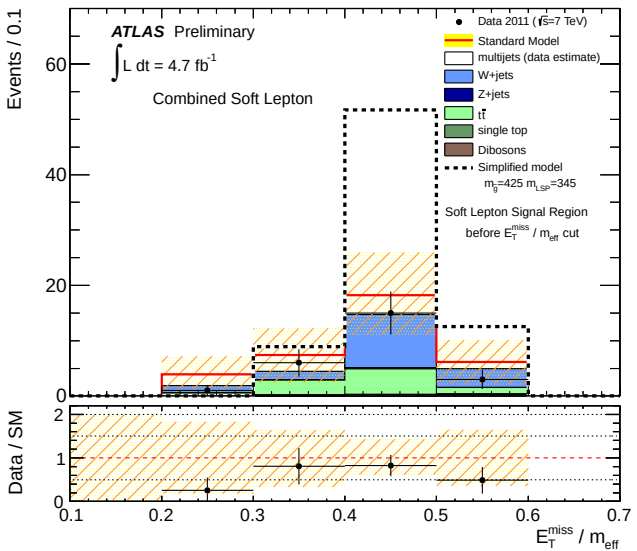
	3-jet	4-jet	soft lepton
Observed events	3	6	26
Fitted bkg events	5.7 ± 4.0	8.3 ± 3.1	32 ± 11
Fitted top events	2.0 ± 1.5	5.3 ± 2.1	8.6 ± 3.4
Fitted W/Z+jets events	2.9 ± 2.1	2.0 ± 0.7	15 ± 7
Fitted other bkg events	0.5 ± 0.7	0.9 ± 0.8	0.62 ± 0.24
Fitted multijet events	0.3 ± 0.4	0.17 ± 0.30	8 ± 4
MC exp. SM events	5.6	7.9	32
MC exp. top events	1.9	5.0	8.6
MC exp. W/Z+jets events	3.1	2.0	15
MC exp. other bkg events	0.3	0.7	0.62
Data-driven multijet events	0.3	0.17	8

Results of the fit in the signal regions. Nominal expectations from simulation (MC), normalized to theoretical cross-sections, are given for comparison. The errors shown are the statistical plus systematic uncertainties; there is a strong negative correlation between the uncertainties for the fitted $t\bar{t}$ versus W/Z+jets events.

1-lepton Analysis: Signal Regions

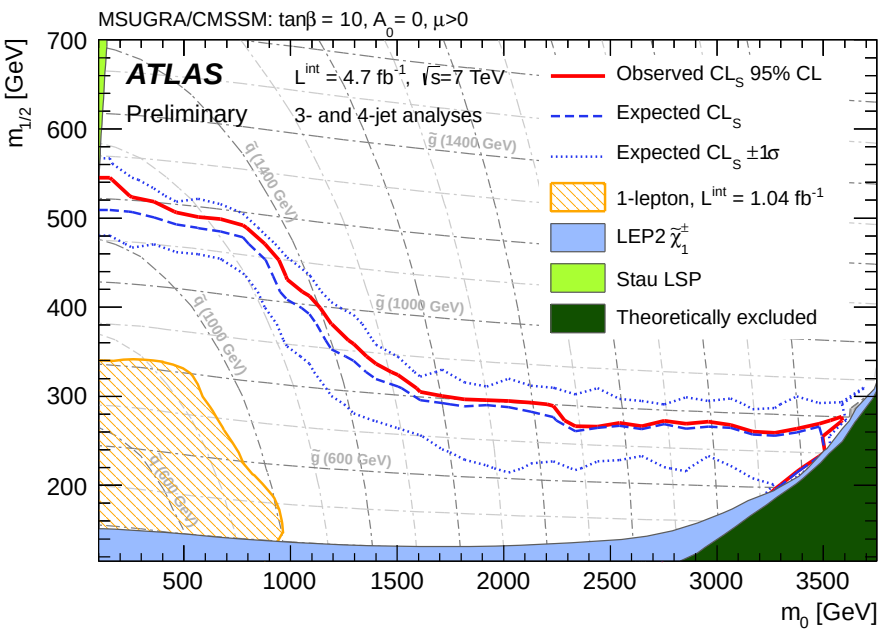


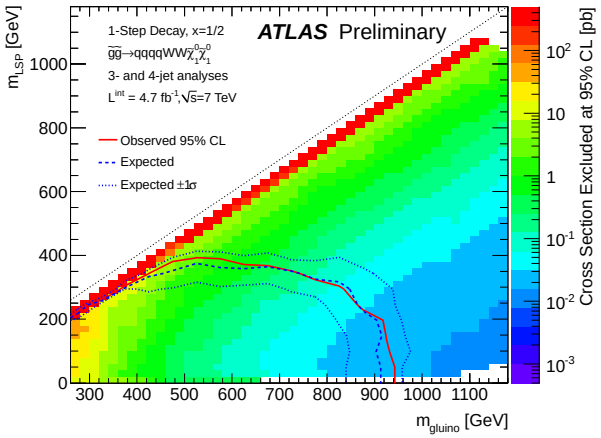


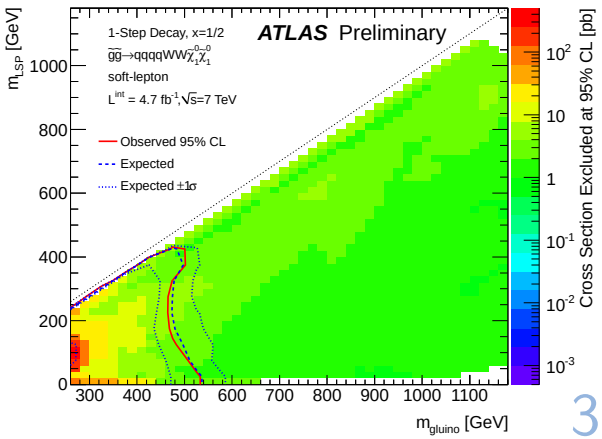


1-lepton Analysis: Limits

- When setting limits the m_{eff} shape of the signal in the signal region is used, along with the CR contamination, for the fit.
- Limits are set in the MSUGRA/CMSSM plane and in a simplified model defined by the pair production of gluinos followed by the decay; $\tilde{g} \rightarrow q\bar{q}'\tilde{\chi}_1^{\pm} \rightarrow q\bar{q}'W^{\pm}\tilde{\chi}_1^0$, where the chargino mass is fixed half way between that of the gluino and the neutralino.

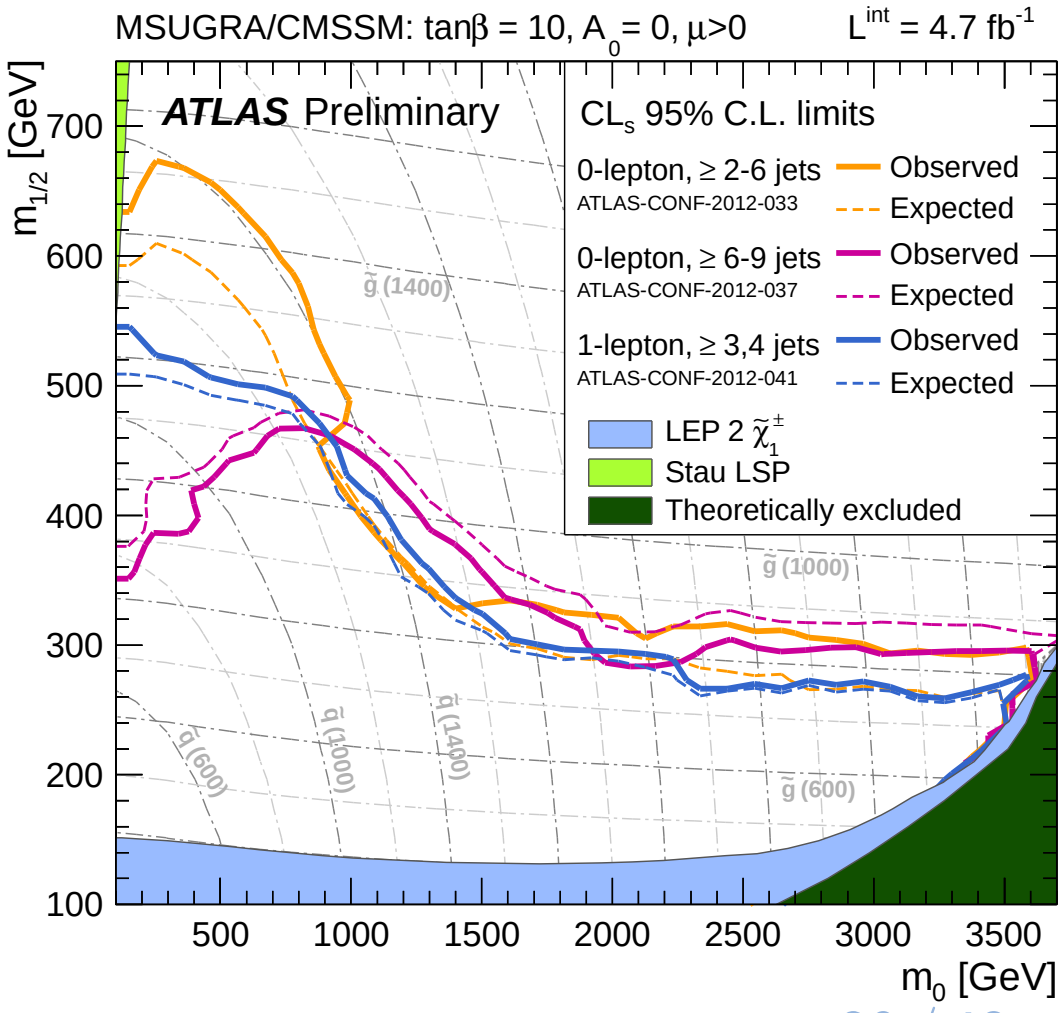






Conclusions

- Three analyses have been presented.
- All use 4.7fb^{-1} of 7 TeV data.
- No excess above the Standard Model expectation was observed.
- Limits were set in MSUGRA/CMSSM and some simplified models.
- Searches designed to be generic $\rightarrow$ should cover many other models.
- Other analyses are in the process of being updated to the full dataset.
- We look forward to 8 TeV running this year.
- Are there any questions?



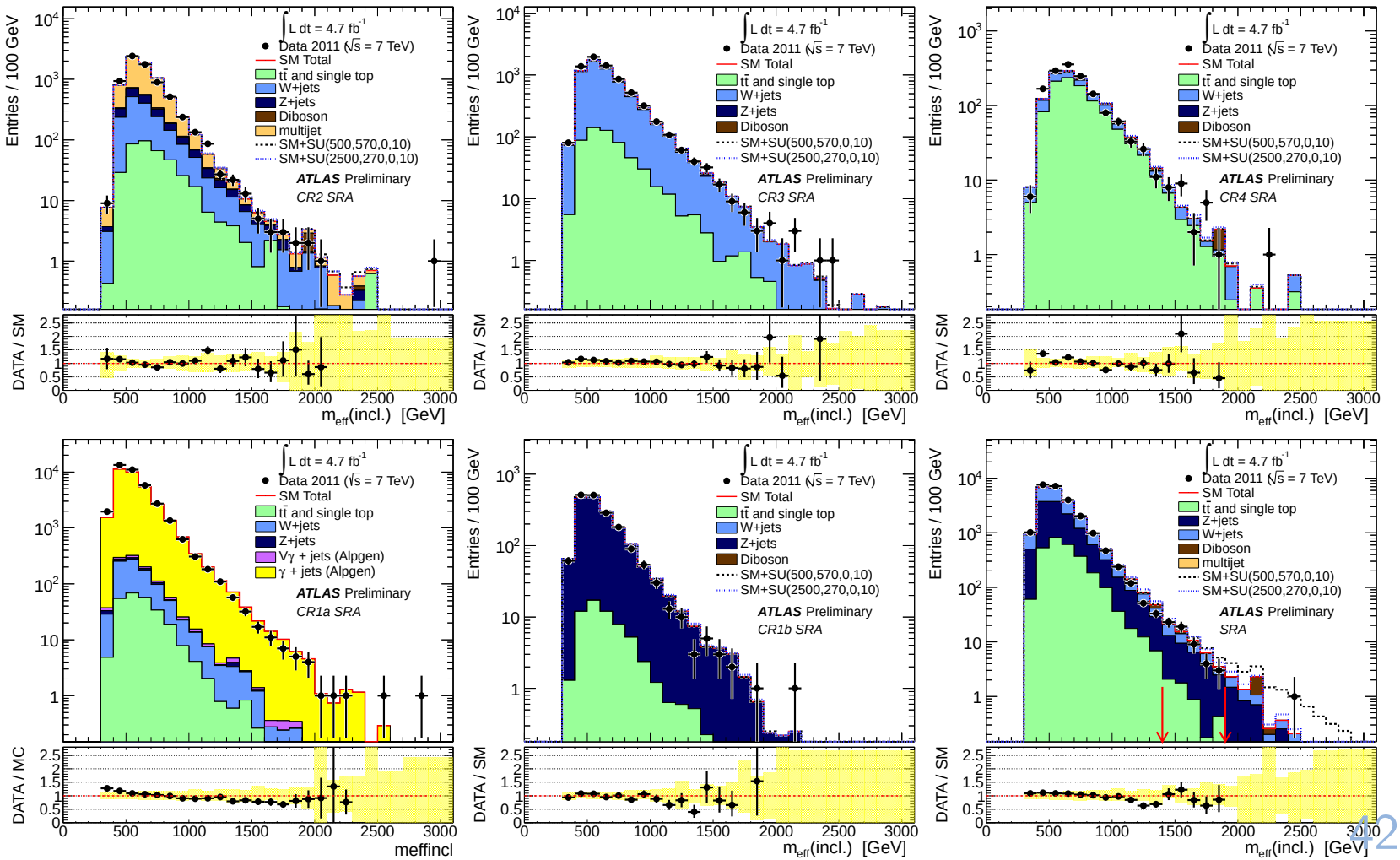
Back-Up Slides

0-lepton m_{eff} Analysis: Objects

- **Jets:** Candidates are reconstructed using the anti-k_t jet clustering algorithm with a distance parameter of 0.4. These are calibrated using p_{T} and η-dependent calibration factors based on Monte Carlo corrections validated with extensive test-beam and collision-data studies. Only jet candidates with $p_{\text{T}} > 20$ GeV are retained.
- **Electrons:** Candidates are required to have $p_{\text{T}} > 20\,\text{GeV}$, to have $|\eta| < 2.47$, and to pass electron shower shape and track selection criteria.
- **Muons:** Candidates are required to have $p_{\text{T}} > 10\,\text{GeV}$ and $|\eta| < 2.4$.
- **Overlap removal:** Jets within $\Delta R < 0.2$ of an electron candidate are removed. Following this any lepton within $\Delta R < 0.4$ of a jet are removed.
- **Lepton Veto:** If any electron or muon candidate is left after overlap removal the event is vetoed.
- **Missing Transverse Energy ($E_{\text{T}}^{\text{miss}}$):** The calculation of the $E_{\text{T}}^{\text{miss}}$ uses muon candidates before overlap removal and calorimeter clusters with $|\eta| < 4.5$ that are calibrated to physics objects that they are associated with. Clusters that are not associated with high p_{T} physics objects are also included uncalibrated.
- **Event Cleaning:** A series of cuts are also applied to reduce the non-collision and detector noise backgrounds to a very low level.

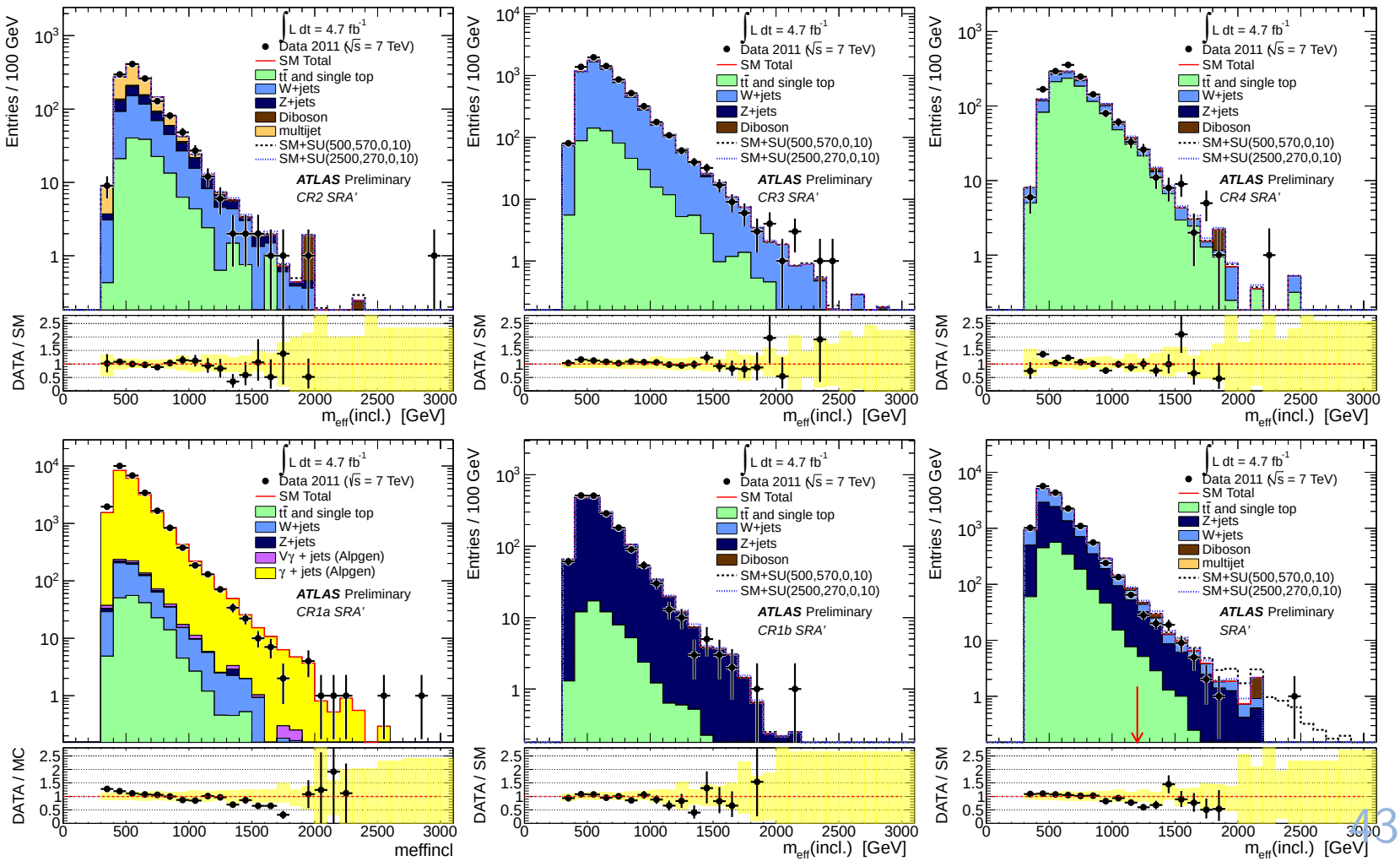
0-lepton m_{eff} Analysis: Background Estimation

- The 5 Control Regions and Signal Region (before final m_{eff} cuts) for the 2 jet stream.



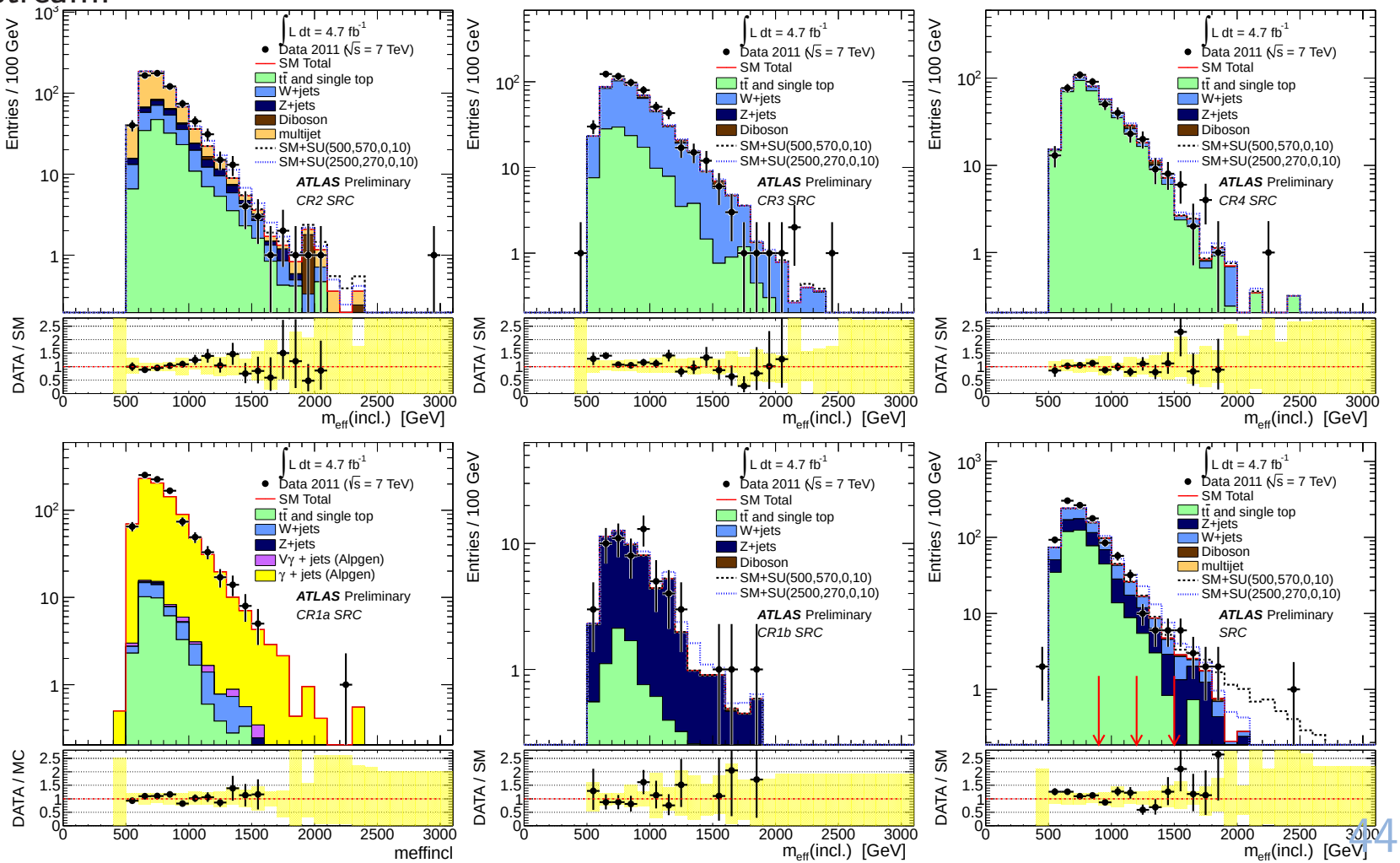
0-lepton m_{eff} Analysis: Background Estimation

- The 5 Control Regions and Signal Region (before final m_{eff} cuts) for the 2 jet "prime" stream.



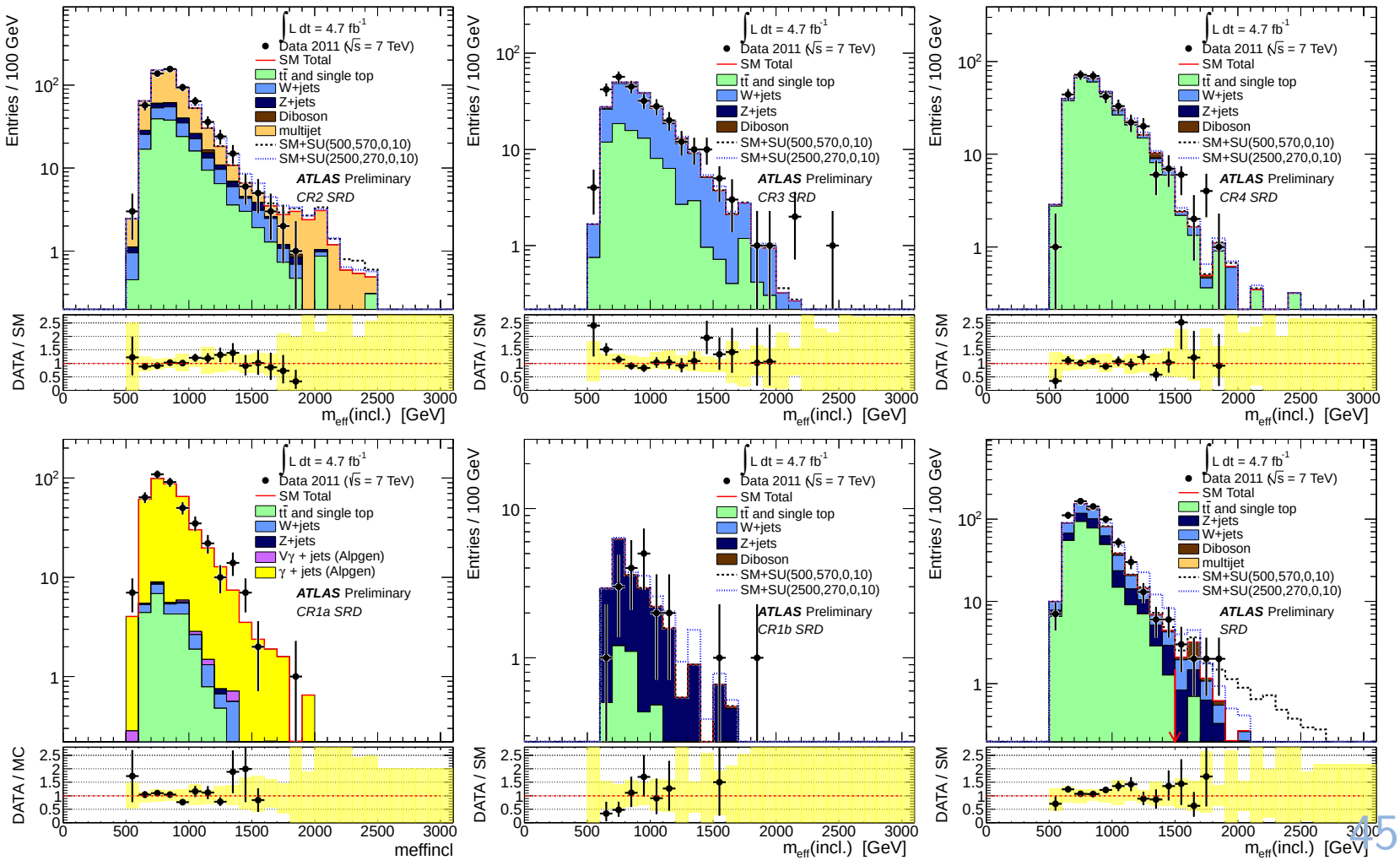
0-lepton m_{eff} Analysis: Background Estimation

- The 5 Control Regions and Signal Region (before final m_{eff} cuts) for the 4 jet stream.



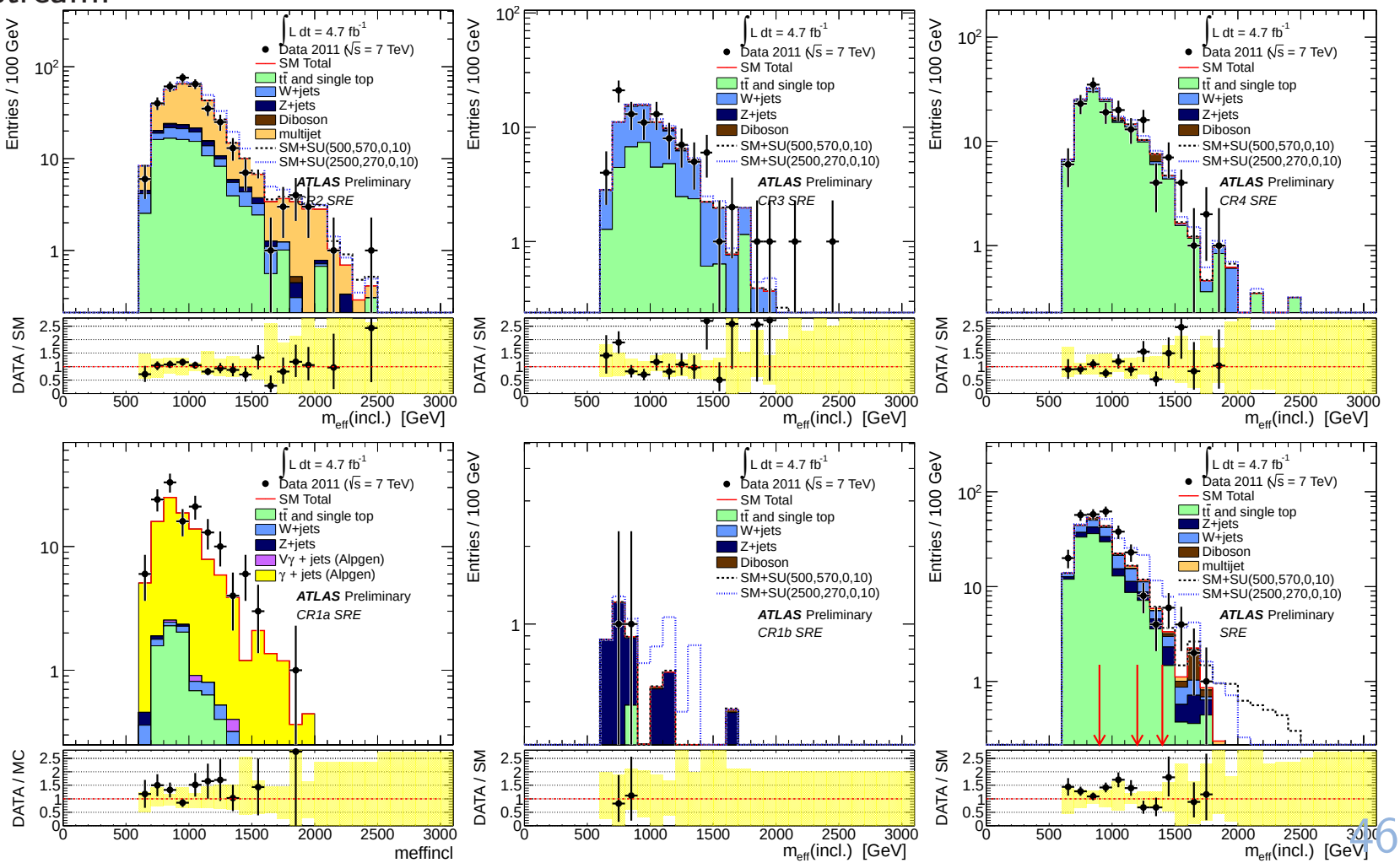
0-lepton m_{eff} Analysis: Background Estimation

- The 5 Control Regions and Signal Region (before final m_{eff} cuts) for the 5 jet stream.



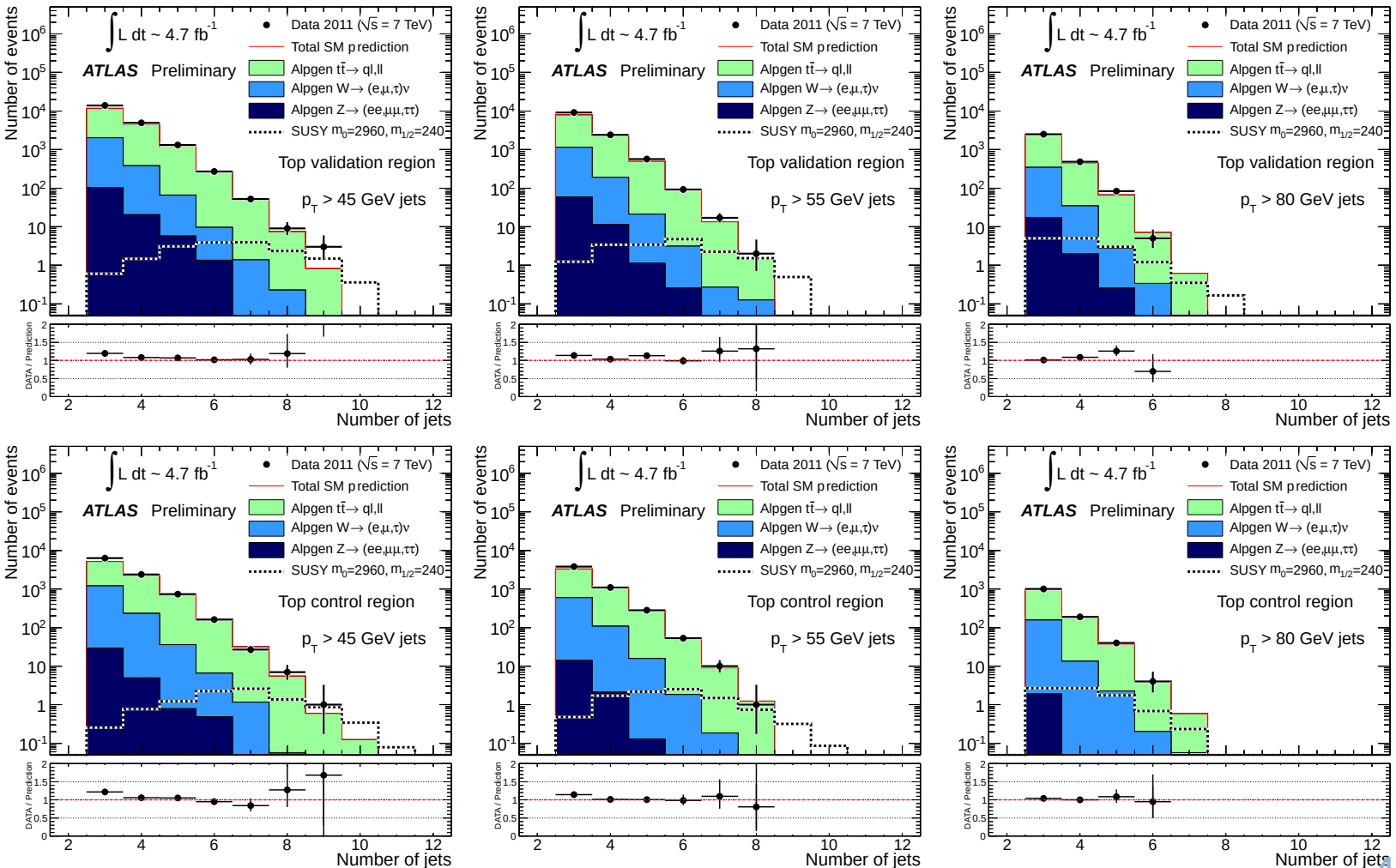
0-lepton m_{eff} Analysis: Background Estimation

- The 5 Control Regions and Signal Region (before final m_{eff} cuts) for the 6 jet stream.



Christopher Young

0-lepton High Multiplicity Analysis: $t\bar{t}$ Control and Validation Plots



1-lepton Analysis: Gains due to changes

- The plot below shows the ratio of the excluded cross-section from the hard and soft lepton analyses highlighting the gain in the compressed scenario region of the soft lepton analysis.