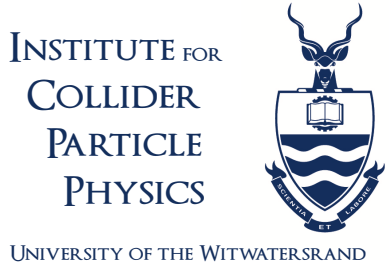
# $4\ell$+MET: Analysis update

Abdualazem Fadol

November 2, 2020





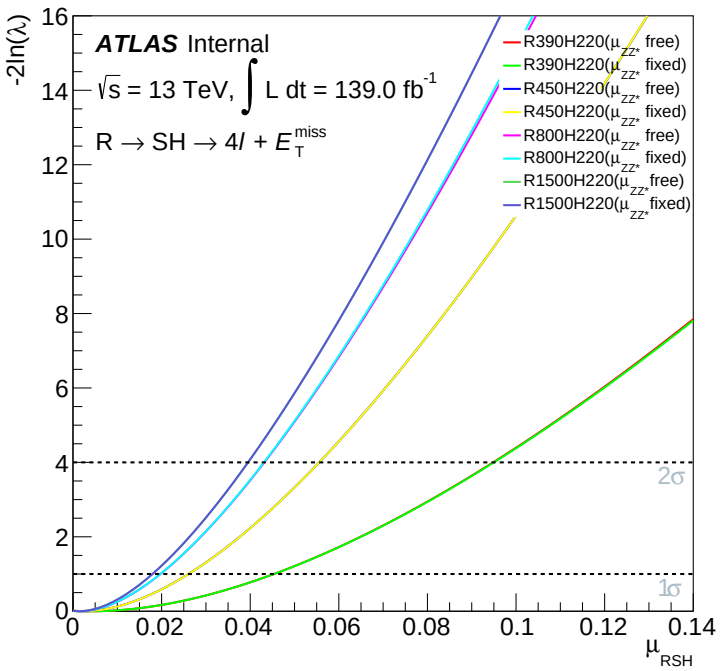
# Study the effect of $ZZ^*$ normalisation

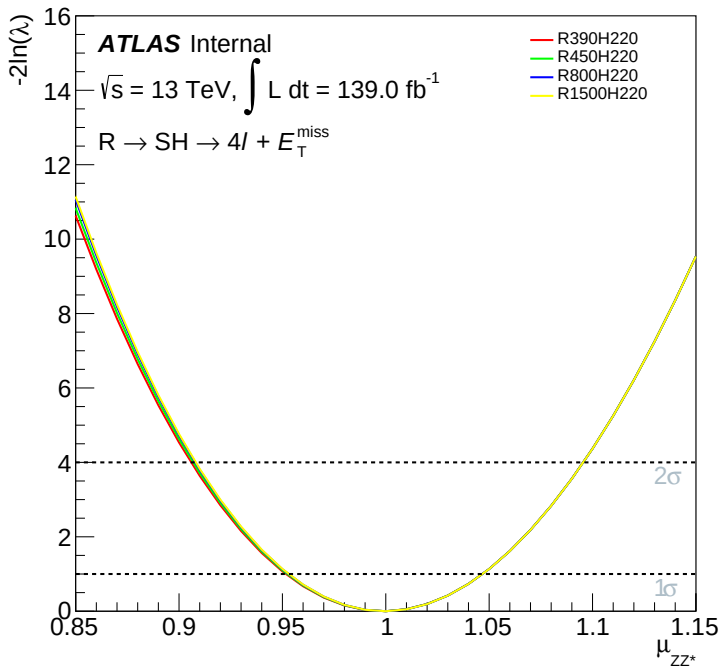


- Study the effect of fixing/floating the $ZZ^*$ normalisation factor.
- The only systematic considered are those of the signal mass points.
- Building two workspaces one with setting the normalisation to be free, and fixing it on the other.
- Then compare the signal strength and the upper limit @95 CLs in the two cases.
- The fit is performed on background only Asimov data ($\mu_{\mathrm{RSH}} = 0$).

# Upper limits on the cross-section



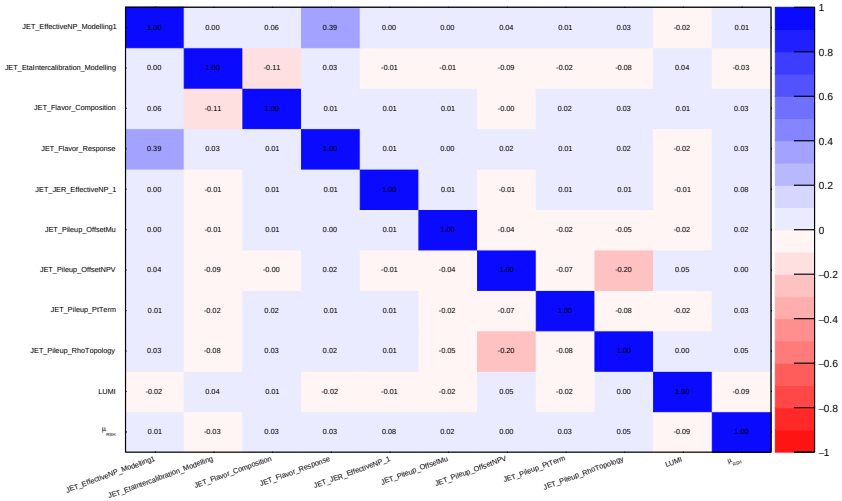


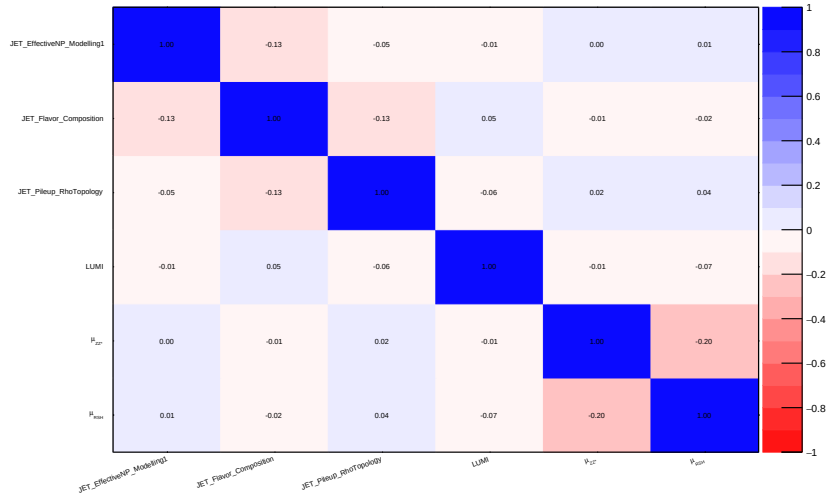



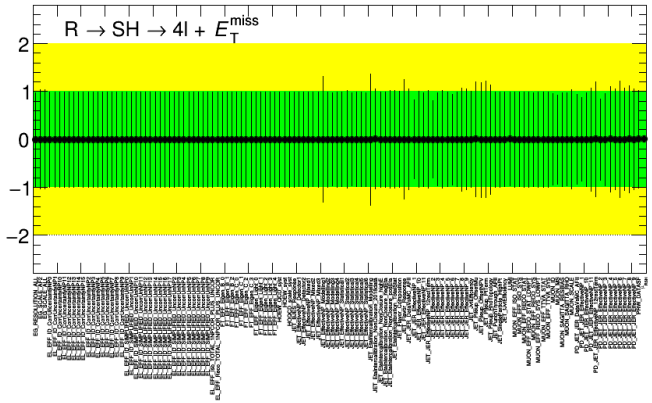

| Mass point = $m_R$, $m_H$ [GeV] | Strength | Strength value | $\sigma_{RSH} \times \mathrm{BR}(H \to ZZ \to 4\ell)^{+1\sigma_s,+2\sigma}_{-1\sigma_s,-2\sigma}$ [fb] @95 CLs |
|---|---|---|---|
| 390, 220 | $\mu_{ZZ^*}$ | $0.99^{+0.0410}_{-0.0390}$ | - |
| | $\mu_{RSH}$ fixed | $0.0050^{0.0500}_{-0.2050}$ | $0.115^{+0.172,+0.240}_{-0.083,-0.062}$ |
| | $\mu_{RSH}$ float | $0.0049^{+0.0501}_{-0.2049}$ | $0.119^{+0.178,+0.249}_{-0.086,-0.064}$ |
| 450, 220 | $\mu_{ZZ^*}$ | $0.99^{+0.041}_{-0.039}$ | - |
| | $\mu_{RSH}$ fixed | $0.0031^{+0.0324}_{-0.1531}$ | $0.067^{+0.101,+0.141}_{-0.048,-0.036}$ |
| | $\mu_{RSH}$ float | $0.0027^{+0.0328}_{-0.1427}$ | $0.069^{+0.103,+0.145}_{-0.049,-0.037}$ |
| 800, 220 | $\mu_{ZZ^*}$ | $0.99^{+0.041}_{-0.039}$ | - |
| | $\mu_{RSH}$ fixed | $0.0018^{+0.0277}_{-0.1718}$ | $0.051^{+0.078,+0.110}_{-0.037,-0.028}$ |
| | $\mu_{RSH}$ float | $0.0021^{+0.0274}_{-0.2421}$ | $0.052^{+0.079,+0.112}_{-0.028,-0.038}$ |
| 1500, 220 | $\mu_{ZZ^*}$ | $0.99^{+0.041}_{-0.039}$ | - |
| | $\mu_{RSH}$ fixed | $0.00163^{+0.0164}_{-0.1616}$ | $0.047^{+0.071,+0.102}_{-0.034,-0.025}$ |
| | $\mu_{RSH}$ float | $0.00162^{+0.0164}_{-0.1616}$ | $0.048^{+0.072,+0.103}_{-0.034,-0.026}$ |

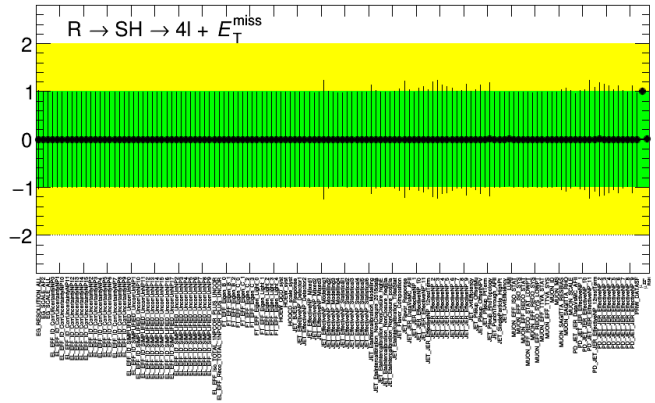
# NPs correlation matrix





# Summary



- We study the effect of fixing/floating the $ZZ^*$ backgrounds normalisation.
- The difference in signal strength values between fixing/floating is not big.
- When the $\mu_{ZZ^*}$ is free we get batter fit and estimate of NPs.
- We can have a look also at the ranking plots to see it better.

# Thank you!

# Additional slides
## Event selection

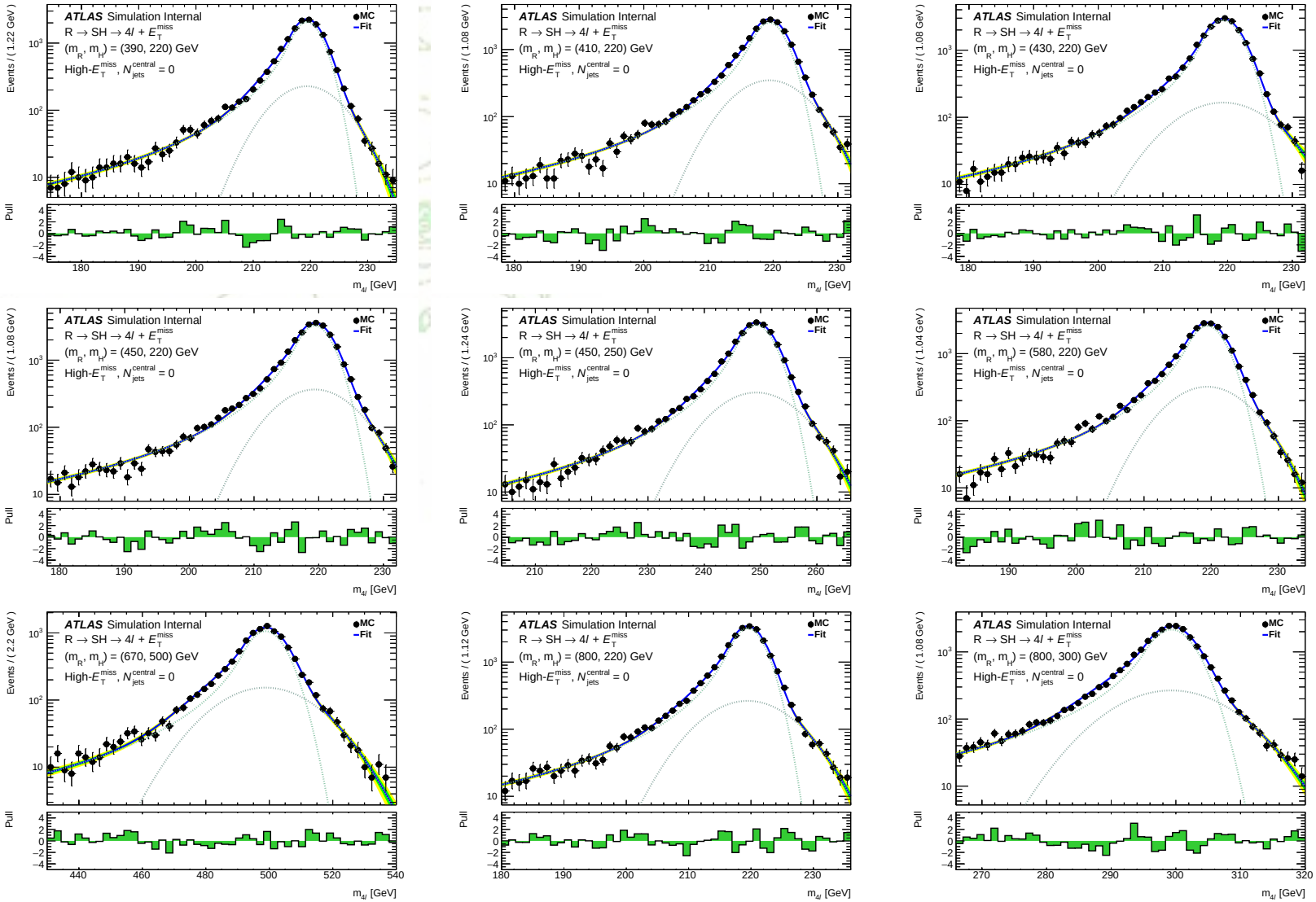


| Event Selection | |
|---|---|
| QUADRUPLET SELECTION | - Require at least one quadruplet of leptons consisting of two pairs of same-flavour opposite-charge leptons fulfilling the following requirements:<br>- $p_T$ thresholds for three leading leptons in the quadruplet: 20, 15 and 10 GeV<br>- Maximum one calo-tagged or stand-alone muon or silicon-associated forward per quadruplet<br>- Leading di-lepton mass requirement: $50 < m_{12} < 106$ GeV<br>- Sub-leading di-lepton mass requirement: $m_{\text{threshold}} < m_{34} < 115$ GeV<br>- $\Delta R(\ell, \ell') > 0.10$ for all leptons in the quadruplet<br>- Remove quadruplet if alternative same-flavour opposite-charge di-lepton gives $m_{\ell\ell} < 5$ GeV<br>- Keep all quadruplets passing the above selection |
| ISOLATION | - Contribution from the other leptons of the quadruplet is subtracted<br>- FixedCutPFlowLoose WP for all leptons |
| IMPACT PARAMETER SIGNIFICANCE | - Apply impact parameter significance cut to all leptons of the quadruplet<br>- For electrons: $d_0/\sigma_{d_0} < 5$<br>- For muons: $d_0/\sigma_{d_0} < 3$ |
| BEST QUADRUPLET | - If more than one quadruplet has been selected, choose the quadruplet with highest Higgs decay ME according to channel: $4\mu$, $2e2\mu$, $2\mu2e$ and $4e$ |
| VERTEX SELECTION | - Require a common vertex for the leptons:<br>- $\chi^2/\text{ndof} < 5$ for $4\mu$ and $< 9$ for others decay channels |

# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

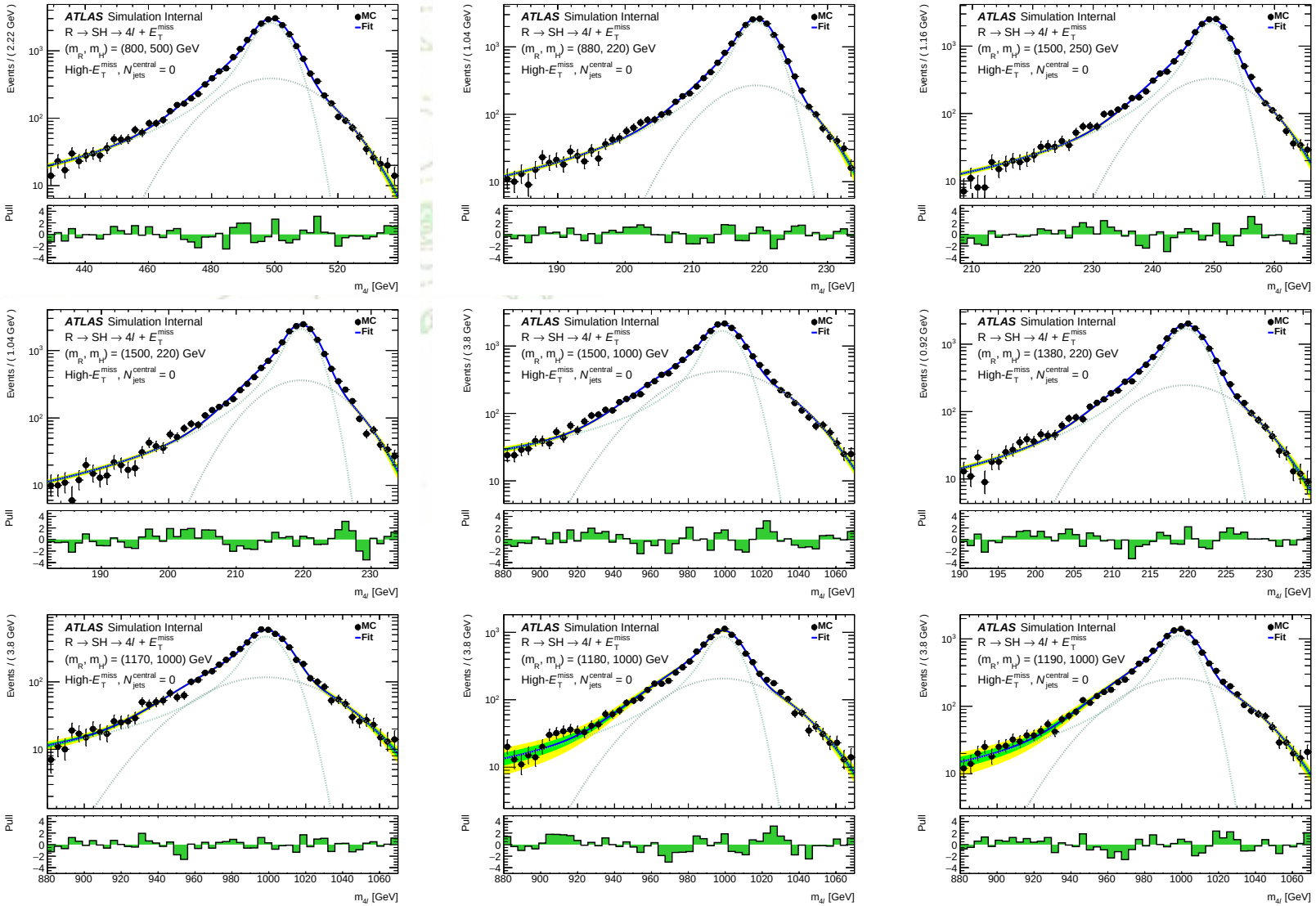




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

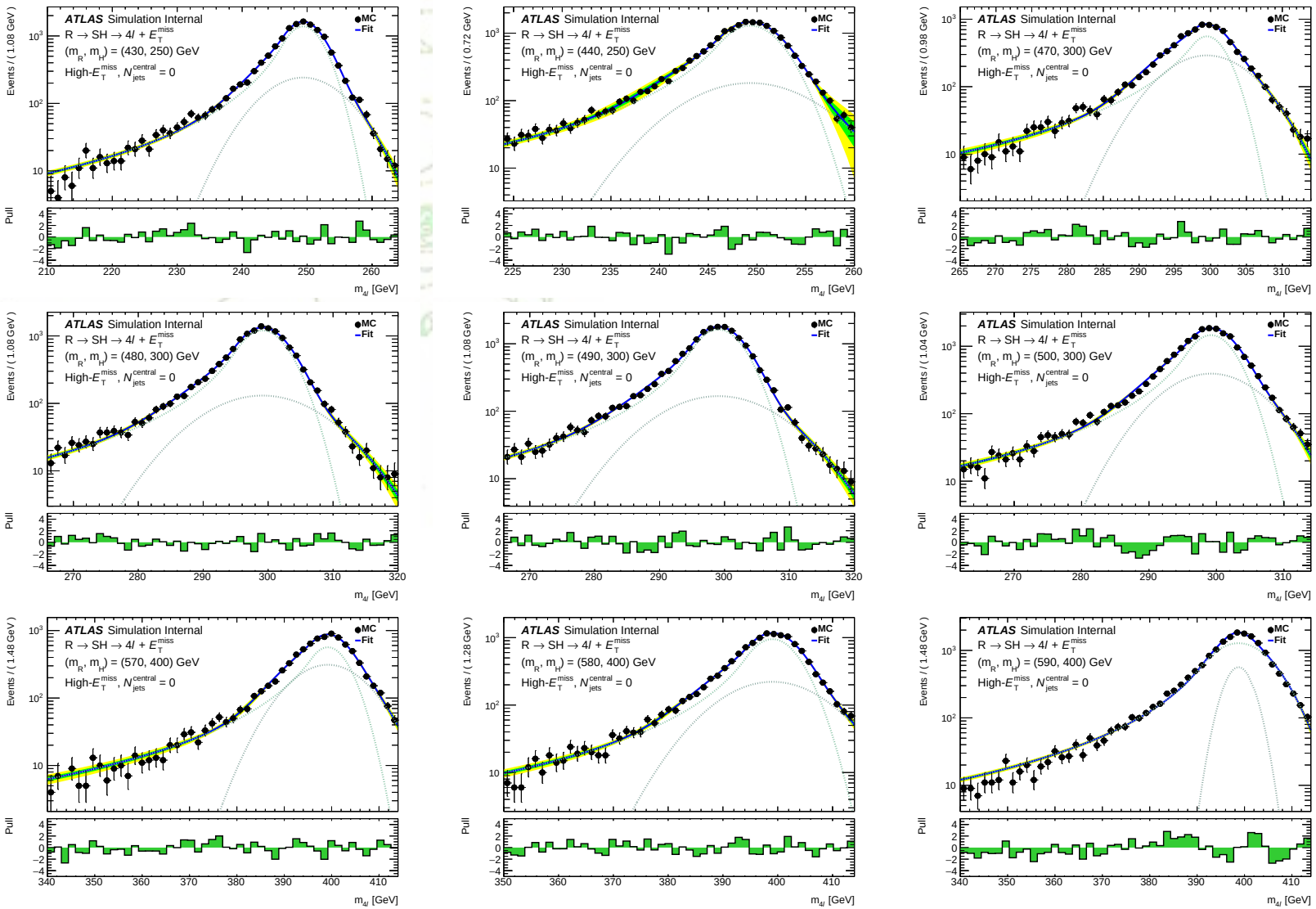




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

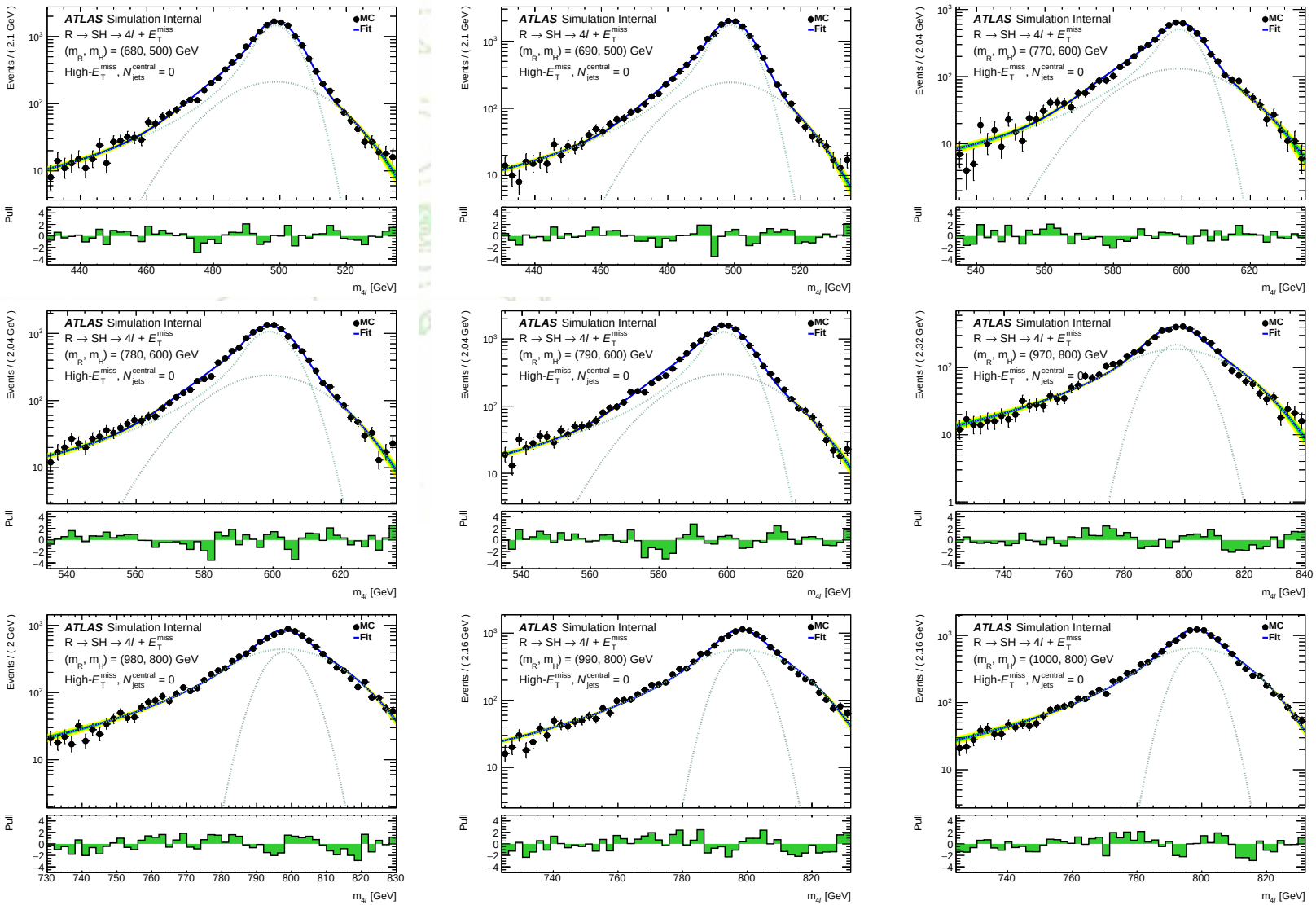




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

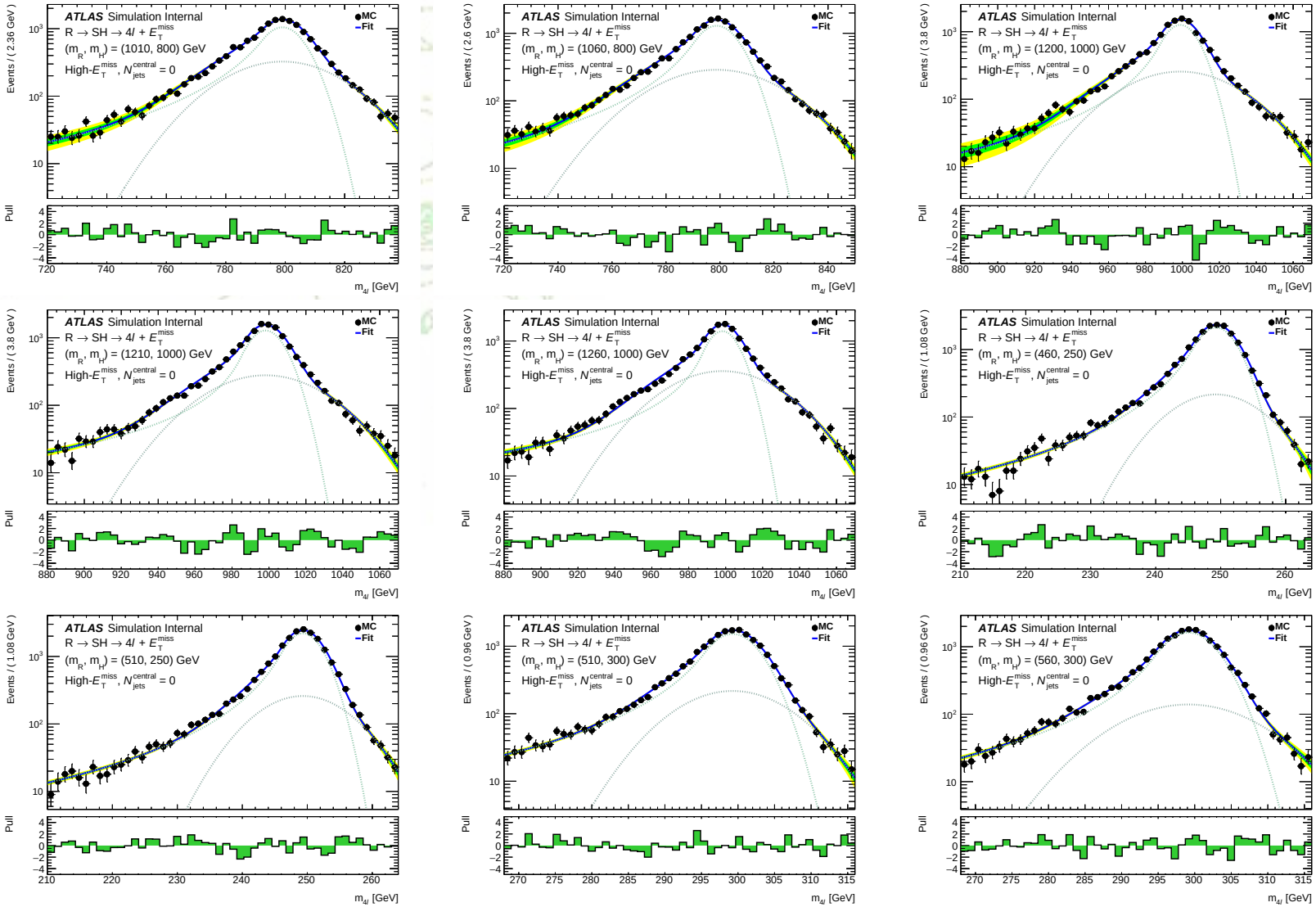




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

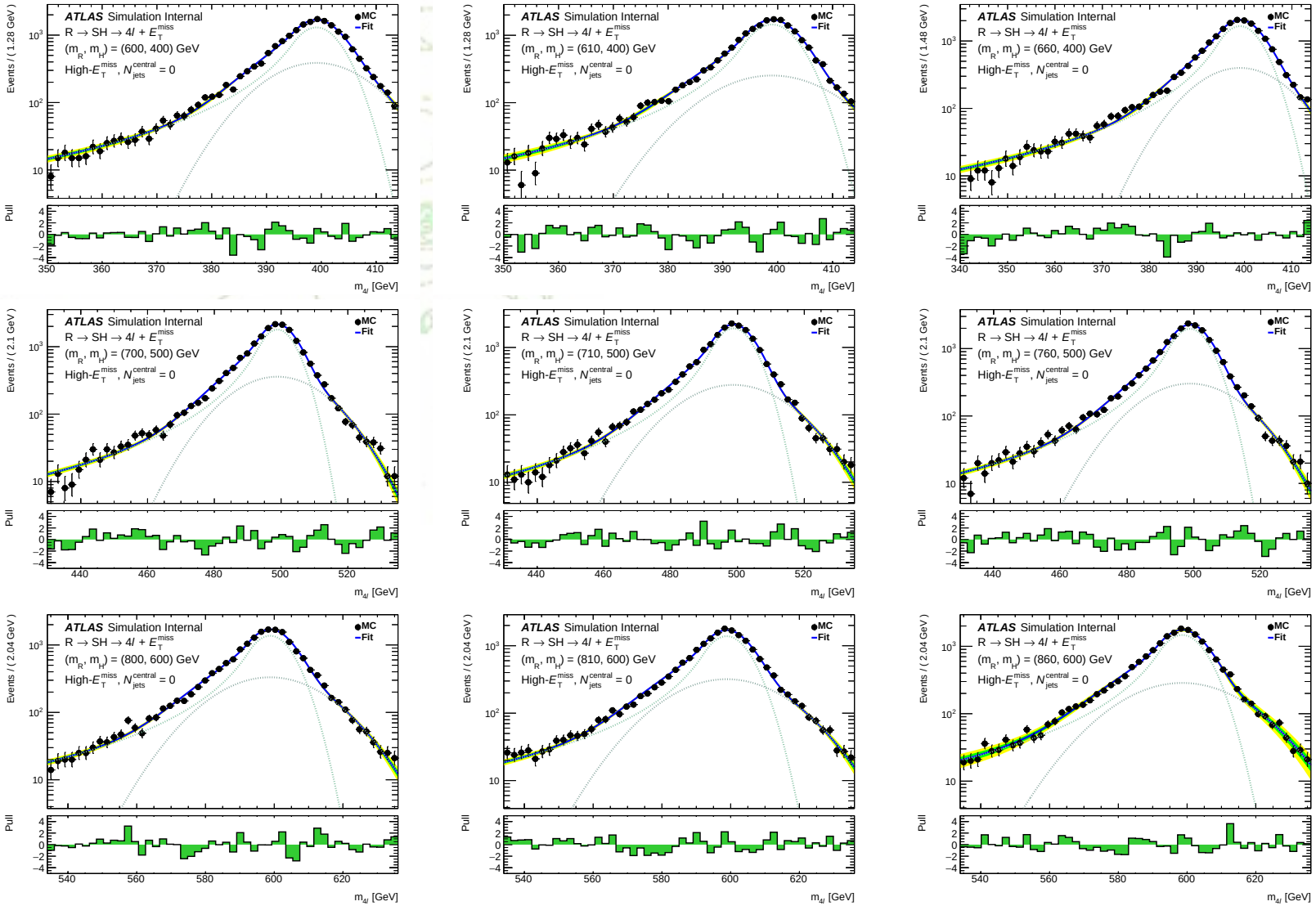




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

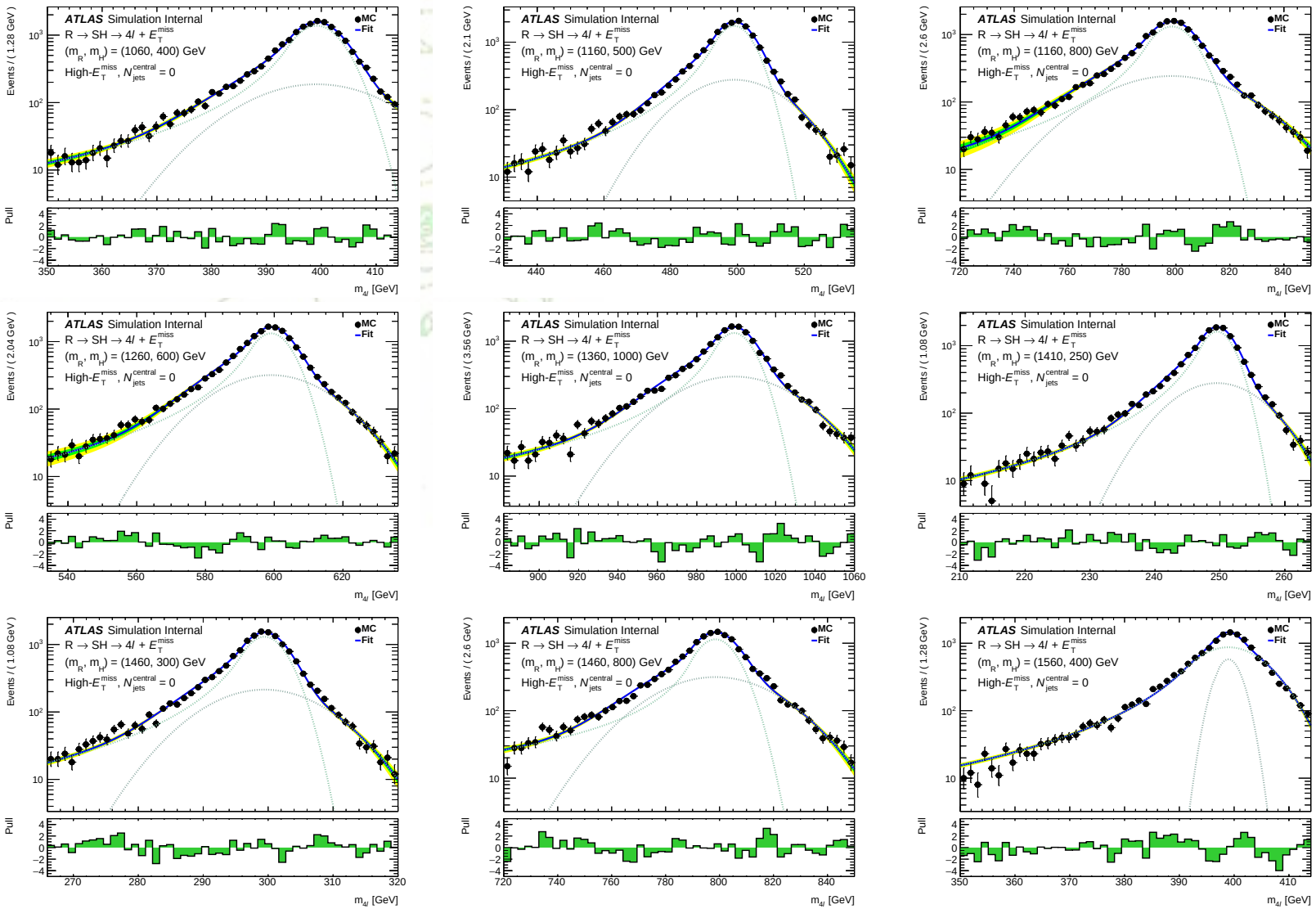




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

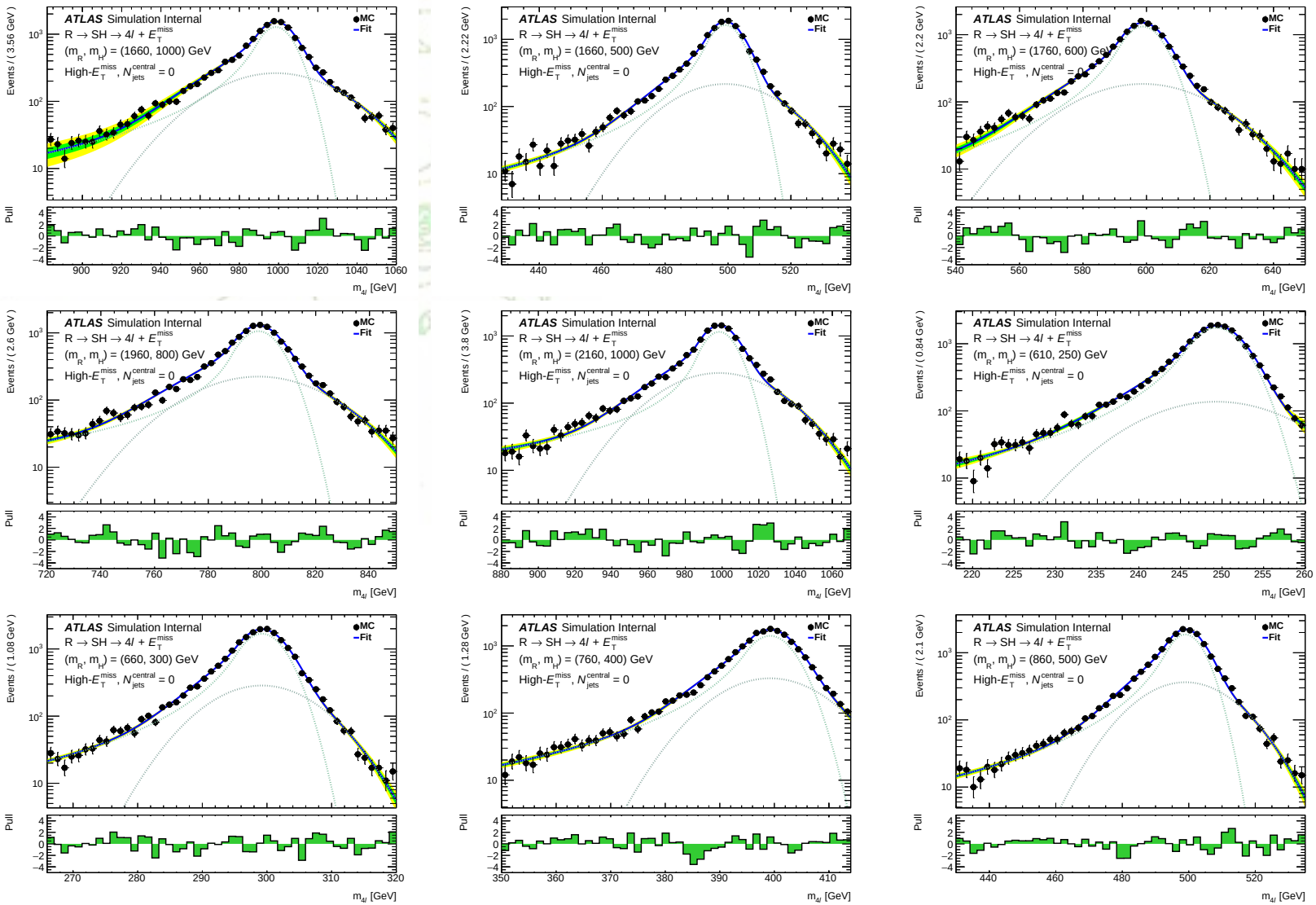




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

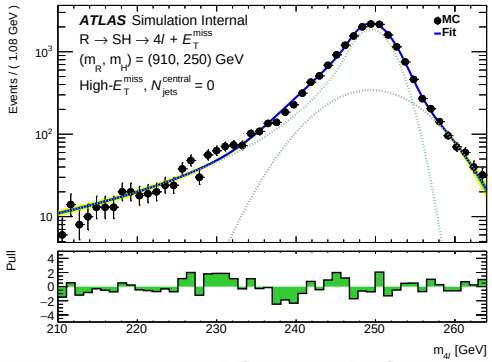


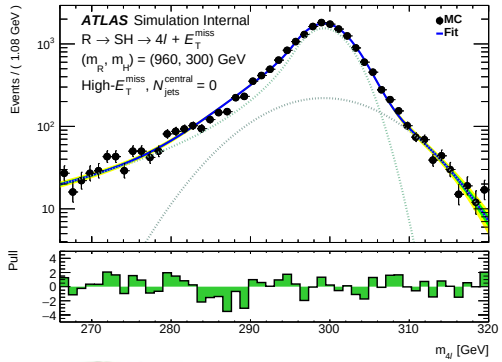


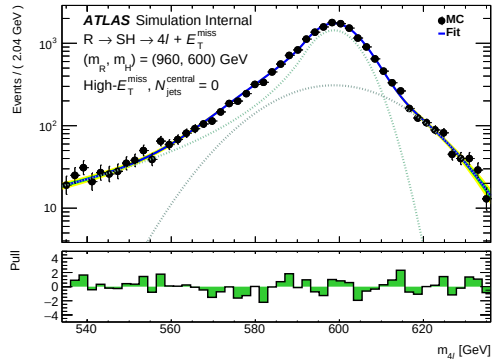
# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$:Summary of $\chi^2/\mathrm{ndof}$ values for all signal mass points






| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 390, 220 | 0.98 |
| 450, 220 | 1.58 |
| 800, 220 | 1.29 |
| 1500, 220 | 1.90 |
| 450, 250 | 1.35 |
| 1500, 250 | 1.73 |
| 800, 300 | 1.48 |
| 800, 500 | 1.57 |
| 1500, 1000 | 1.75 |
| 410, 220 | 1.33 |
| 430, 220 | 1.37 |
| 580, 220 | 1.71 |
| 880, 220 | 1.15 |
| 1380, 220 | 1.40 |
| 670, 500 | 1.06 |
| 610, 250 | 1.51 |
| 660, 300 | 1.58 |
| 1170, 1000 | 0.85 |
| - | - |

| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 470, 300 | 1.21 |
| 570, 400 | 1.08 |
| 770, 600 | 1.14 |
| 970, 800 | 1.43 |
| 430, 250 | 1.28 |
| 480, 300 | 0.80 |
| 580, 400 | 0.99 |
| 680, 500 | 1.12 |
| 780, 600 | 1.75 |
| 980, 800 | 1.77 |
| 1180, 1000 | 1.82 |
| 440, 250 | 1.10 |
| 490, 300 | 1.21 |
| 590, 400 | 2.26 |
| 690, 500 | 1.29 |
| 790, 600 | 1.76 |
| 990, 800 | 1.98 |
| 1190, 1000 | 1.44 |
| 500, 300 | 1.72 |

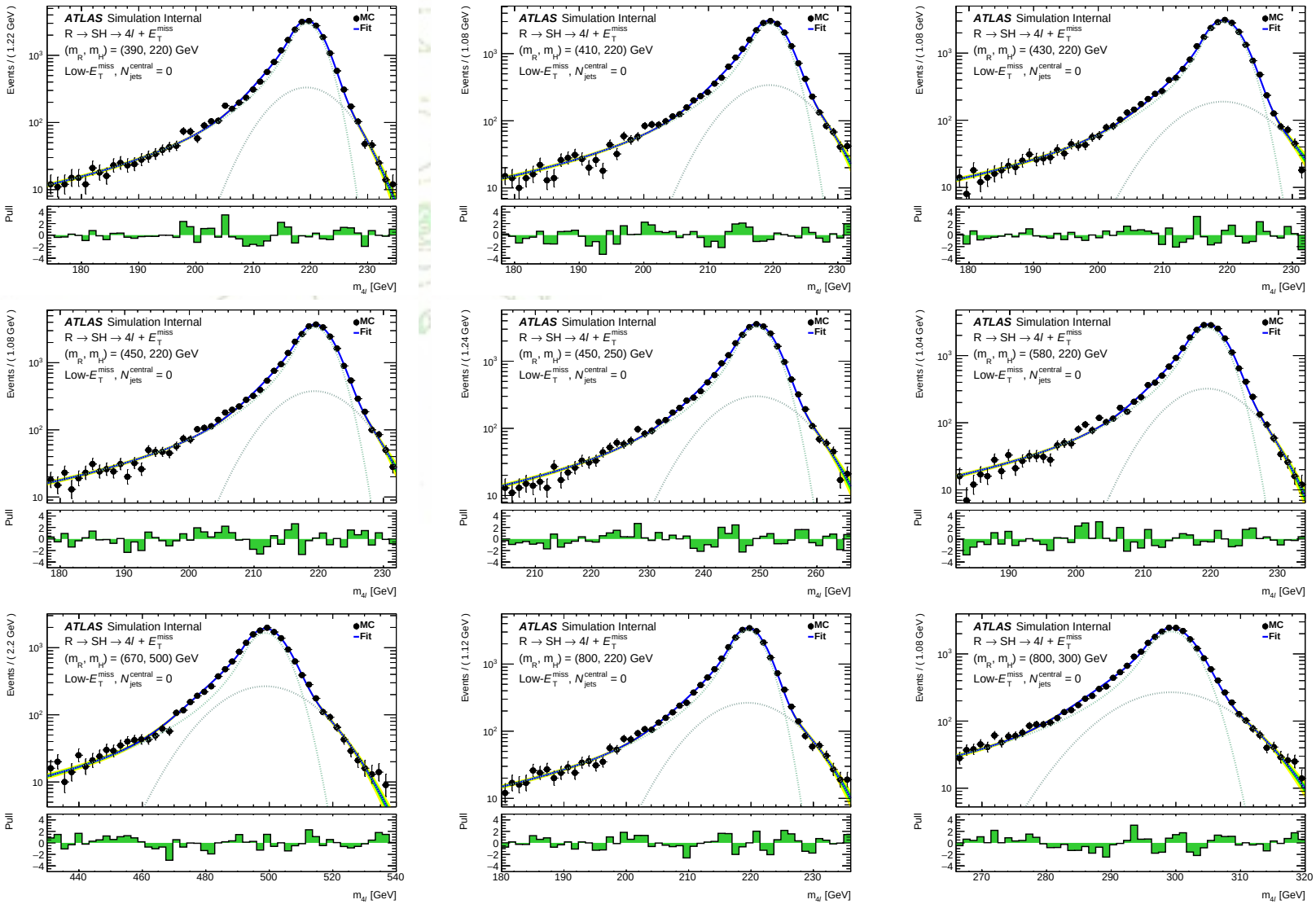
| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 600, 400 | 1.34 |
| 700, 500 | 1.86 |
| 800, 600 | 1.69 |
| 1000, 800 | 1.75 |
| 1200, 1000 | 2.00 |
| 460, 250 | 1.85 |
| 510, 300 | 1.09 |
| 610, 400 | 2.04 |
| 710, 500 | 1.48 |
| 810, 600 | 1.31 |
| 1010, 800 | 1.42 |
| 1210, 1000 | 1.86 |
| 510, 250 | 1.10 |
| 560, 300 | 1.49 |
| 660, 400 | 1.56 |
| 760, 500 | 1.85 |
| 860, 600 | 1.33 |
| 1060, 800 | 1.58 |
| 1260, 1000 | 1.72 |

| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 760, 400 | 1.46 |
| 860, 500 | 1.40 |
| 960, 600 | 1.13 |
| 1160, 800 | 1.78 |
| 1360, 1000 | 2.18 |
| 910, 250 | 1.43 |
| 960, 300 | 1.95 |
| 1060, 400 | 1.32 |
| 1160, 500 | 1.73 |
| 1260, 600 | 0.98 |
| 1460, 800 | 1.88 |
| 1660, 1000 | 1.56 |
| 1410, 250 | 1.54 |
| 1460, 300 | 1.60 |
| 1560, 400 | 2.64 |
| 1660, 500 | 2.00 |
| 1760, 600 | 1.78 |
| 1960, 800 | 1.98 |
| 2160, 1000 | 1.88 |

# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

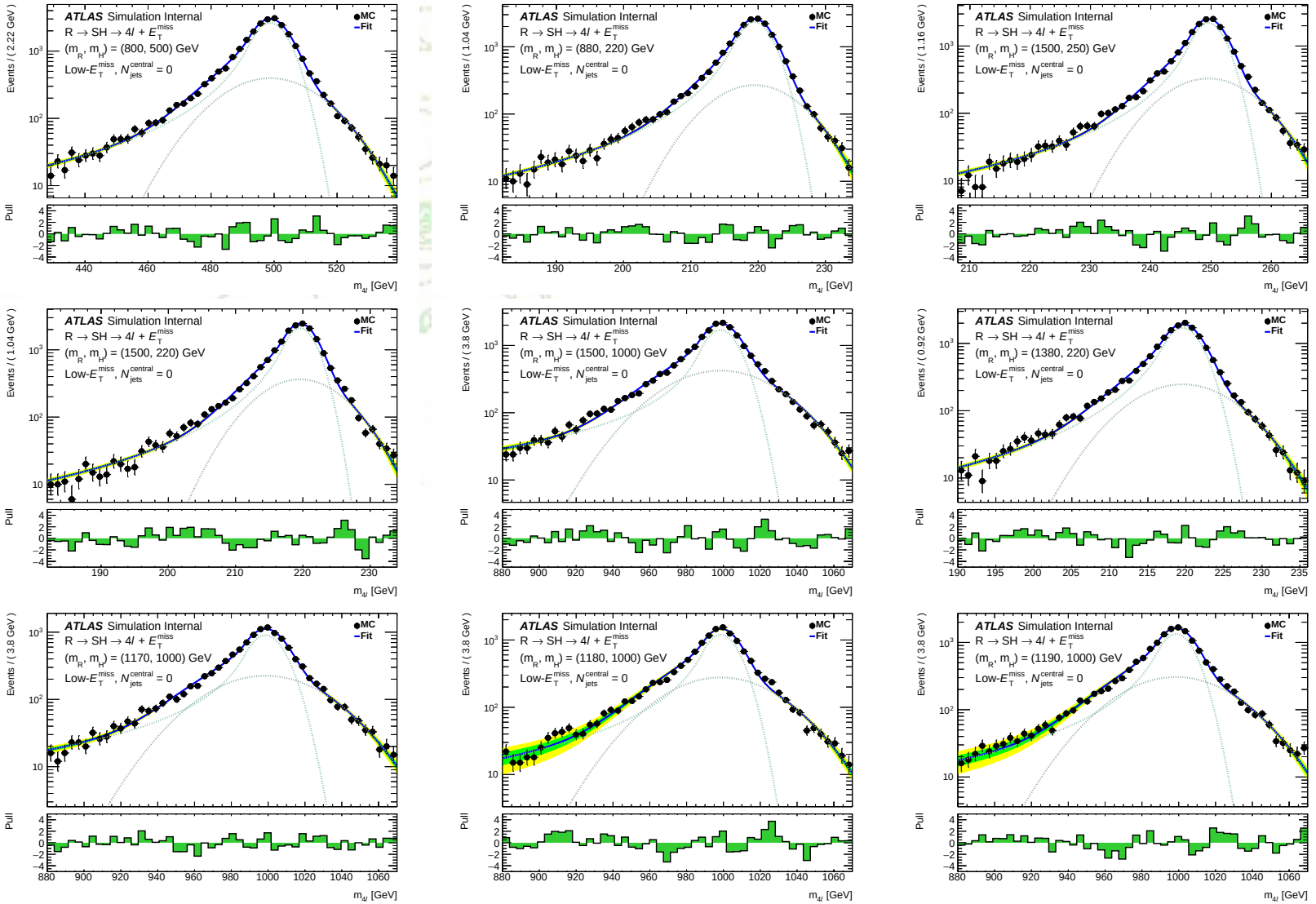




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

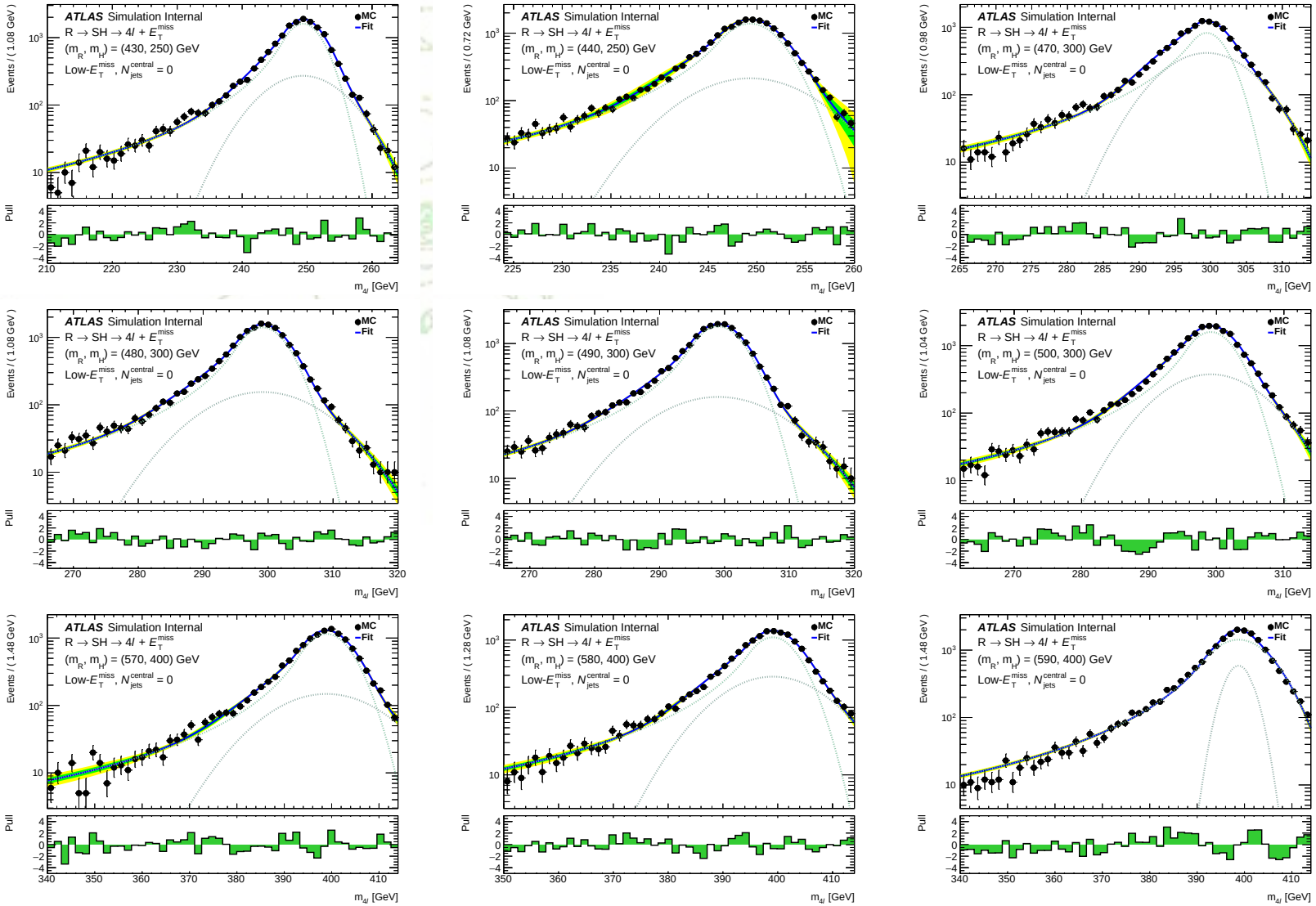




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

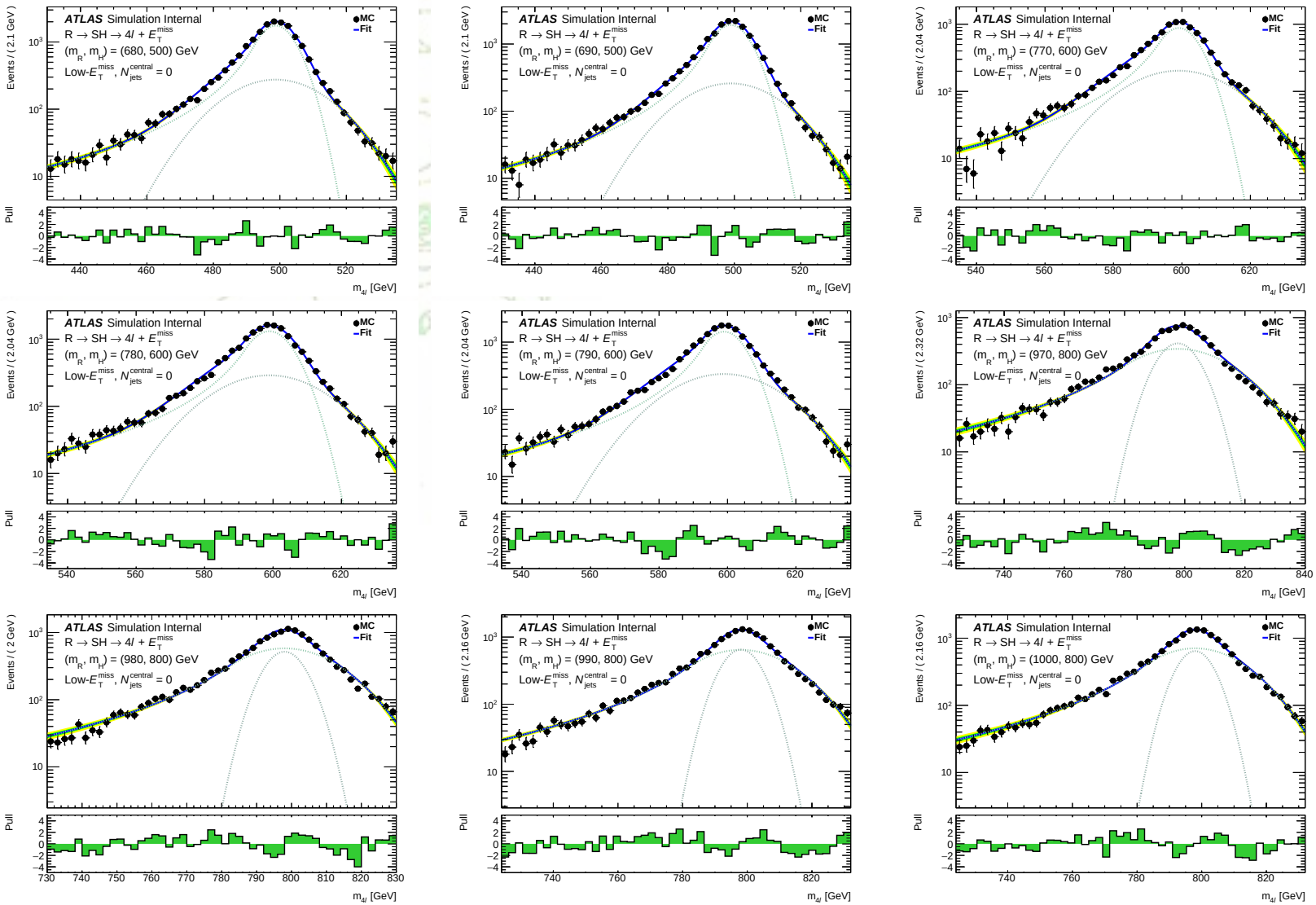




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

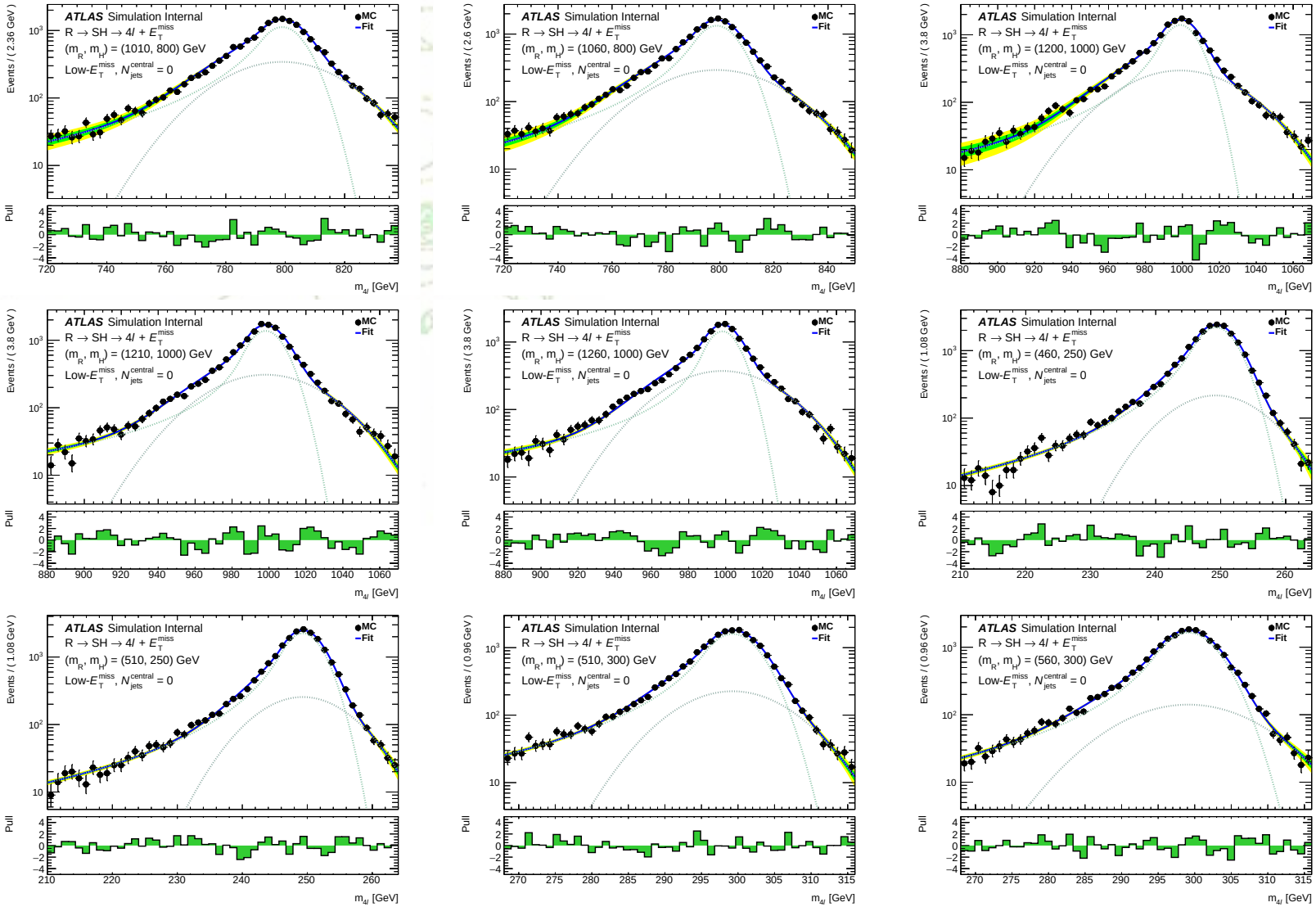




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

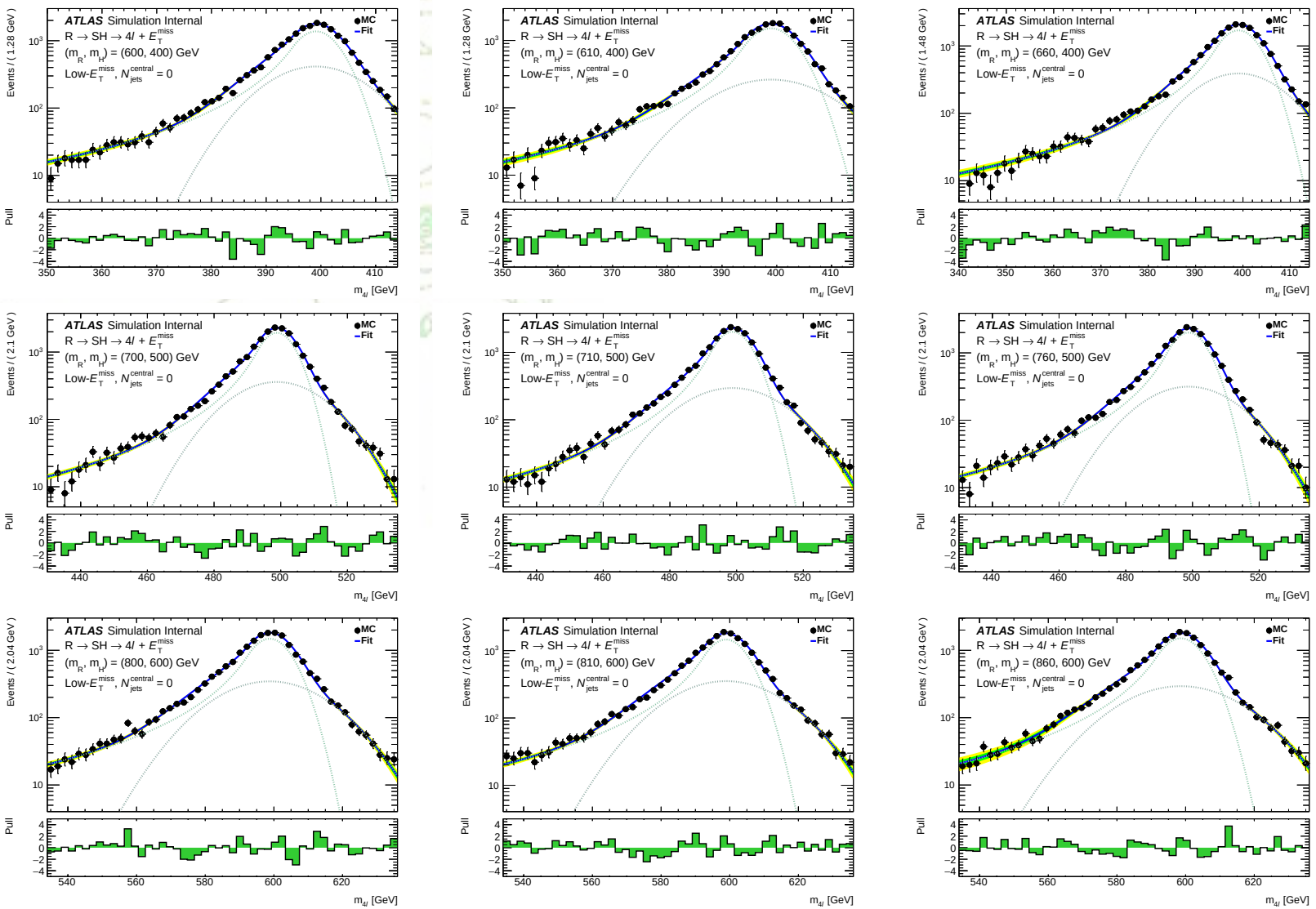




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

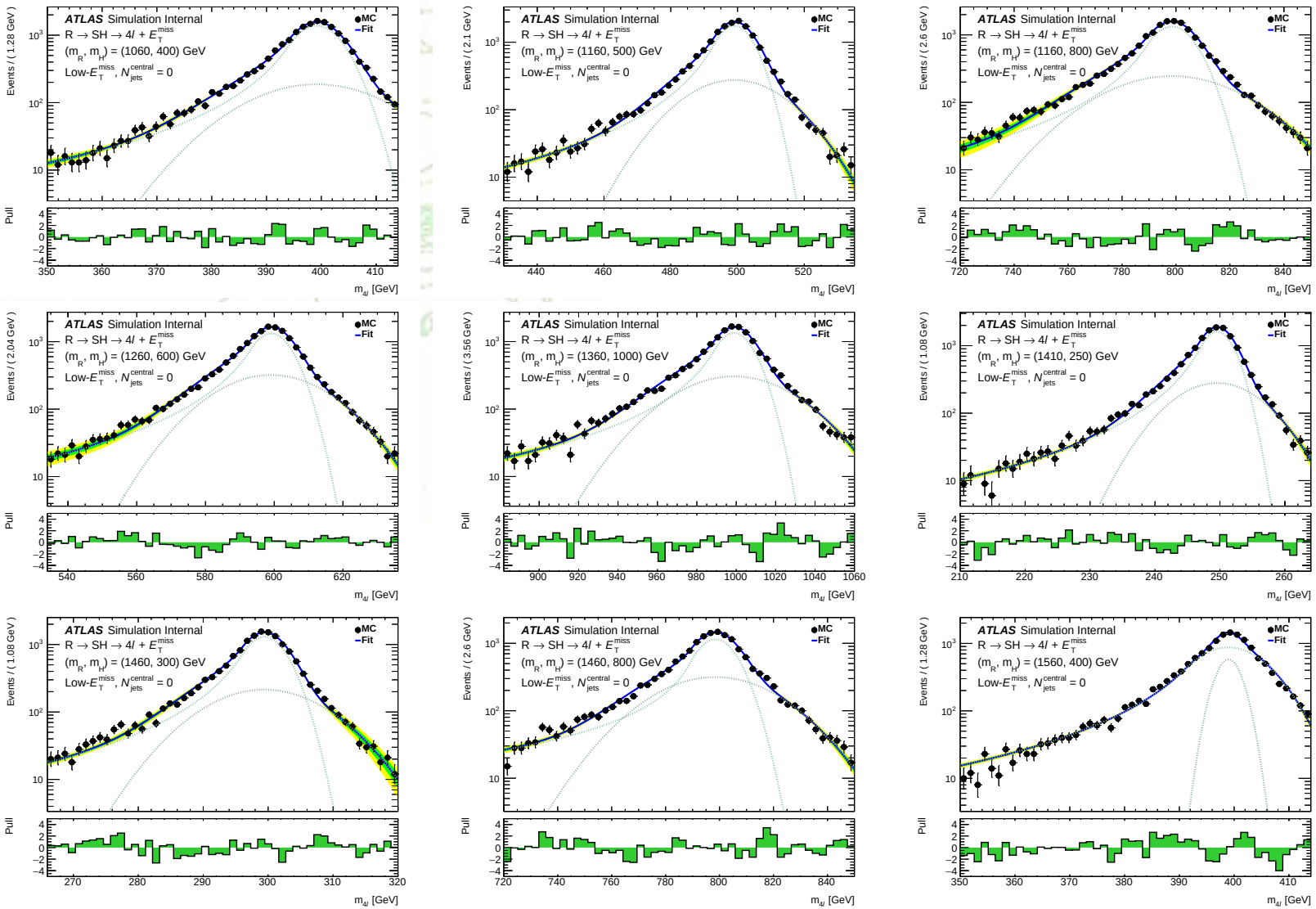




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

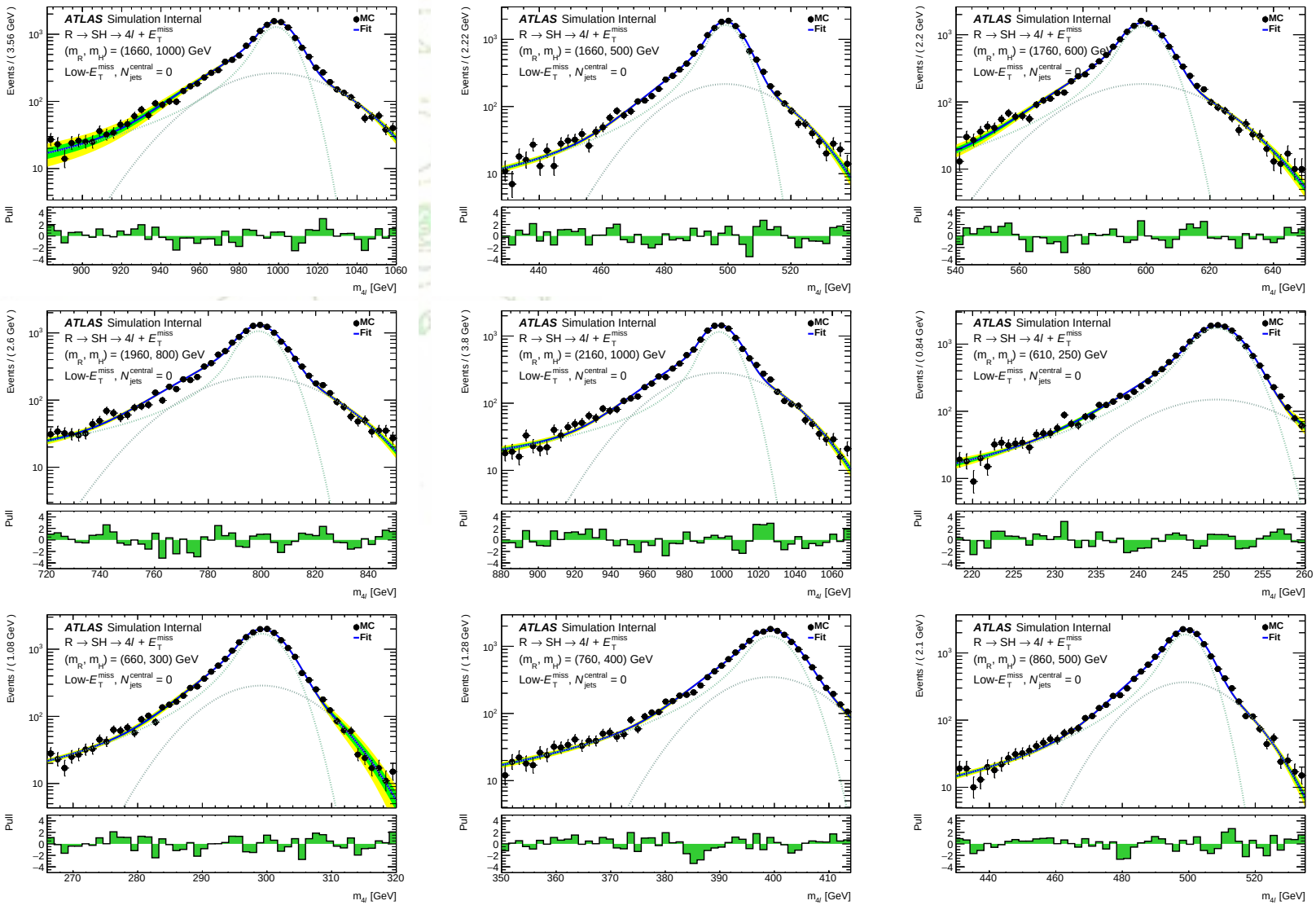




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$

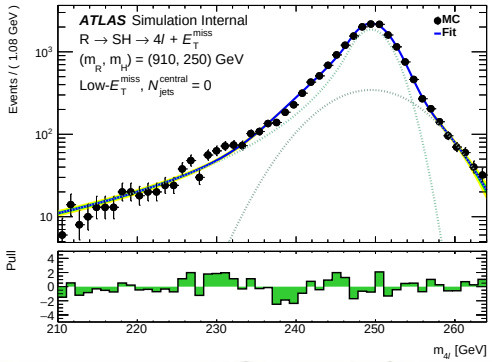


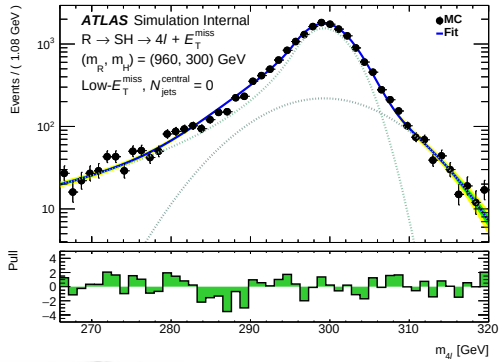


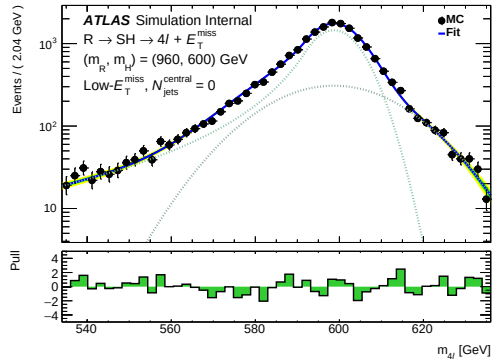
# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}}$: Summary of $\chi^2/\mathrm{ndof}$ values for all signal mass points






| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 390, 220 | 1.23 |
| 450, 220 | 1.63 |
| 800, 220 | 1.30 |
| 1500, 220 | 1.89 |
| 450, 250 | 1.40 |
| 1500, 250 | 1.72 |
| 800, 300 | 1.50 |
| 800, 500 | 1.60 |
| 1500, 1000 | 1.83 |
| 410, 220 | 1.57 |
| 430, 220 | 1.36 |
| 580, 220 | 1.73 |
| 880, 220 | 1.15 |
| 1380, 220 | 1.41 |
| 670, 500 | 1.18 |
| 610, 250 | 1.51 |
| 660, 300 | 1.58 |
| 1170, 1000 | 1.05 |
| - | - |

| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 470, 300 | 1.42 |
| 570, 400 | 1.69 |
| 770, 600 | 1.35 |
| 970, 800 | 2.14 |
| 430, 250 | 1.49 |
| 480, 300 | 0.97 |
| 580, 400 | 1.13 |
| 680, 500 | 1.31 |
| 780, 600 | 1.75 |
| 980, 800 | 2.26 |
| 1180, 1000 | 2.05 |
| 440, 250 | 1.32 |
| 490, 300 | 1.05 |
| 590, 400 | 2.44 |
| 690, 500 | 1.44 |
| 790, 600 | 1.87 |
| 990, 800 | 2.12 |
| 1190, 1000 | 1.76 |
| 500, 300 | 1.86 |

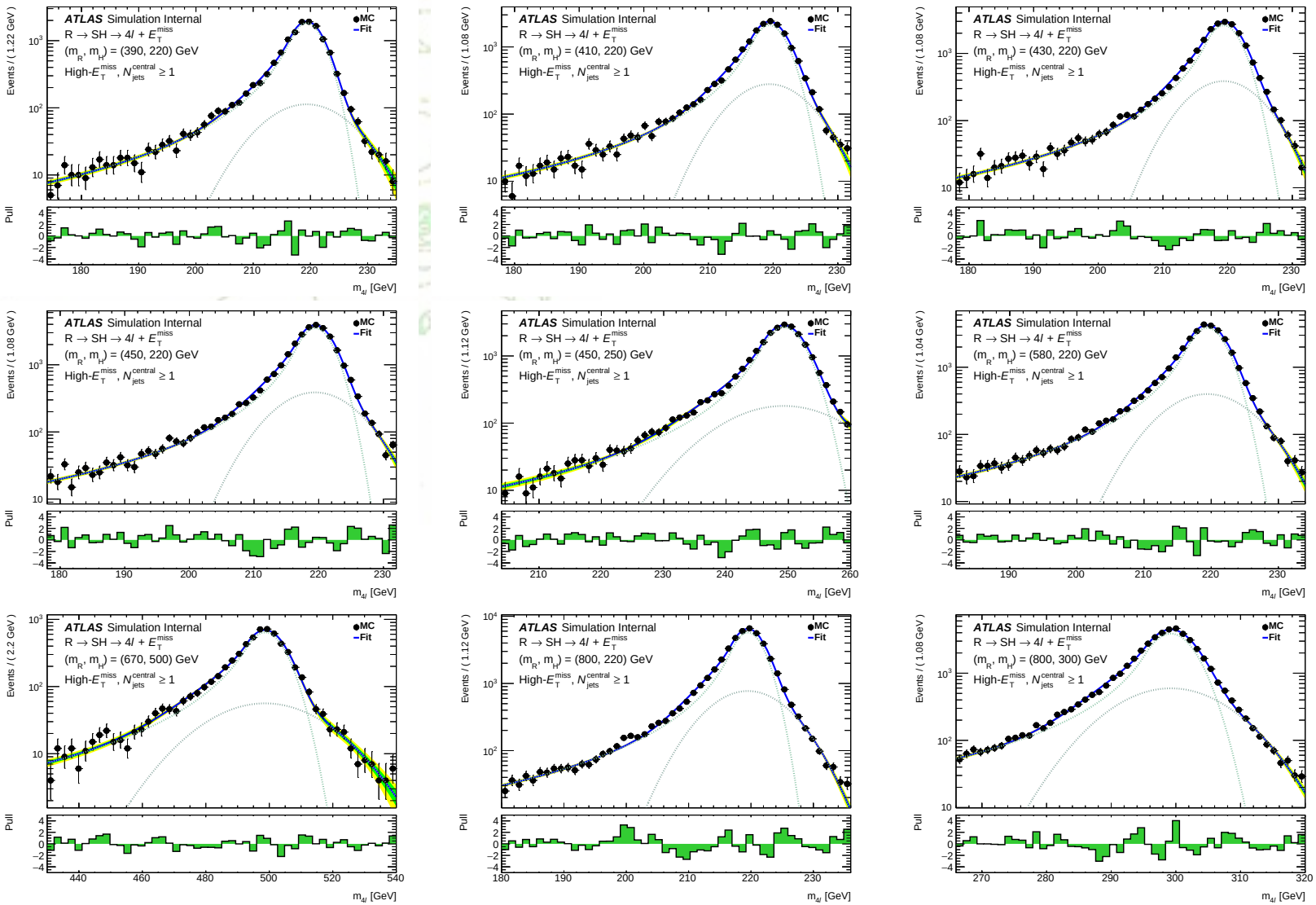
| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 600, 400 | 1.33 |
| 700, 500 | 1.88 |
| 800, 600 | 1.59 |
| 1000, 800 | 1.85 |
| 1200, 1000 | 2.26 |
| 460, 250 | 1.85 |
| 510, 300 | 1.09 |
| 610, 400 | 2.03 |
| 710, 500 | 1.53 |
| 810, 600 | 1.37 |
| 1010, 800 | 1.45 |
| 1210, 1000 | 2.25 |
| 510, 250 | 1.15 |
| 560, 300 | 1.45 |
| 660, 400 | 1.59 |
| 760, 500 | 1.86 |
| 860, 600 | 1.36 |
| 1060, 800 | 1.66 |
| 1260, 1000 | 1.82 |

| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 760, 400 | 1.44 |
| 860, 500 | 1.47 |
| 960, 600 | 1.14 |
| 1160, 800 | 1.78 |
| 1360, 1000 | 2.28 |
| 910, 250 | 1.45 |
| 960, 300 | 1.95 |
| 1060, 400 | 1.30 |
| 1160, 500 | 1.76 |
| 1260, 600 | 0.96 |
| 1460, 800 | 1.93 |
| 1660, 1000 | 1.53 |
| 1410, 250 | 1.50 |
| 1460, 300 | 1.59 |
| 1560, 400 | 2.63 |
| 1660, 500 | 1.98 |
| 1760, 600 | 1.79 |
| 1960, 800 | 1.99 |
| 2160, 1000 | 1.89 |

# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

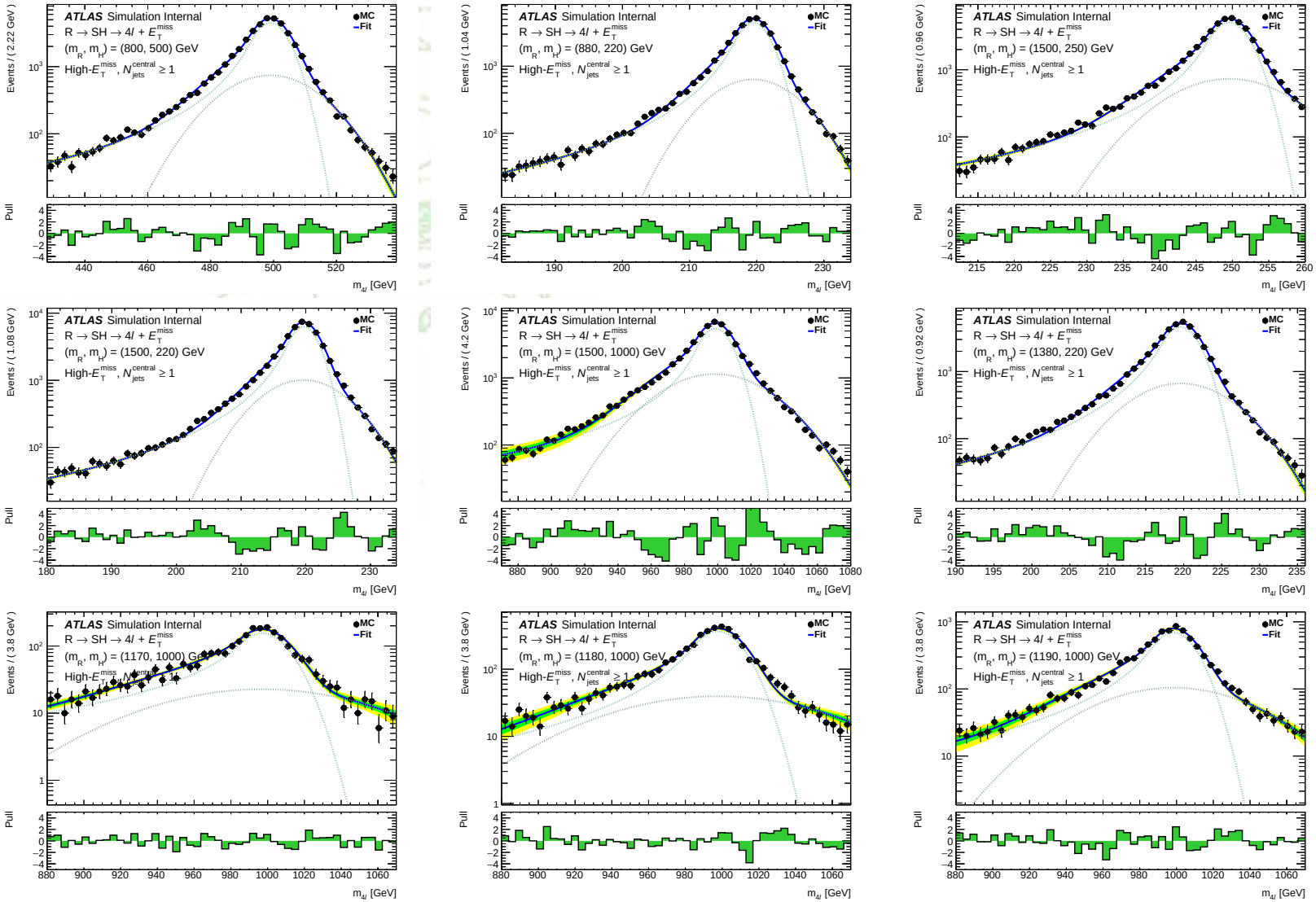




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

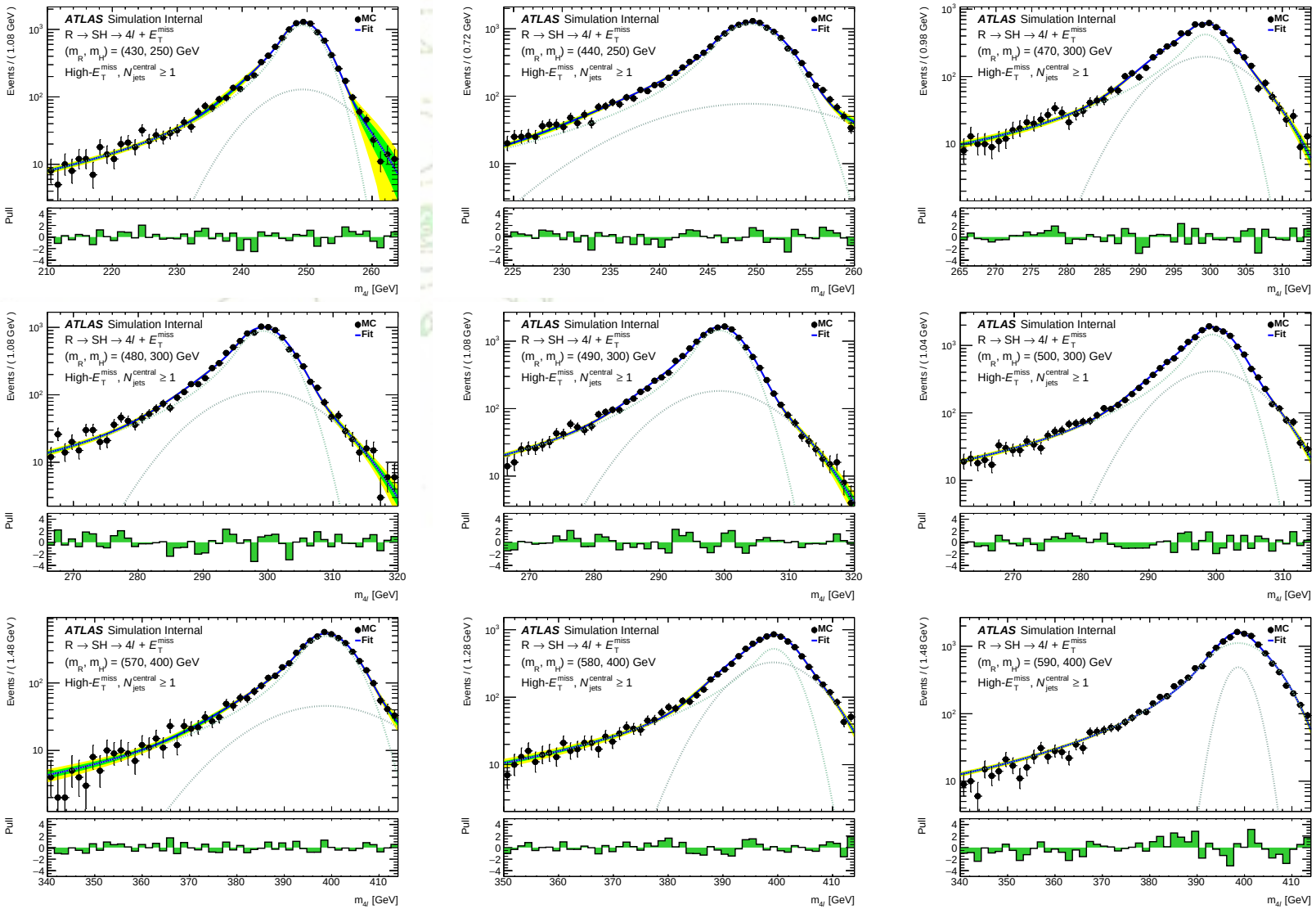




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

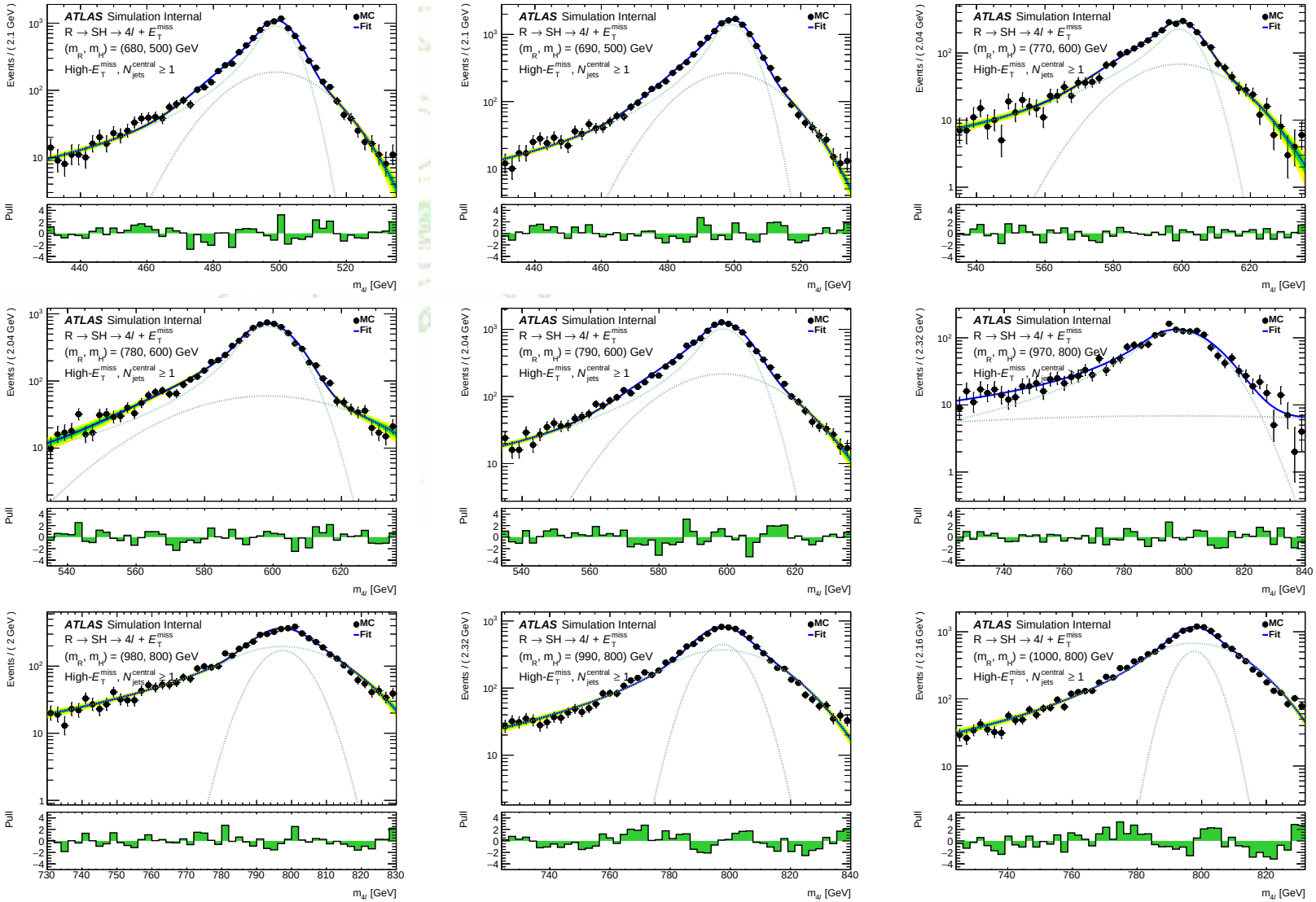




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

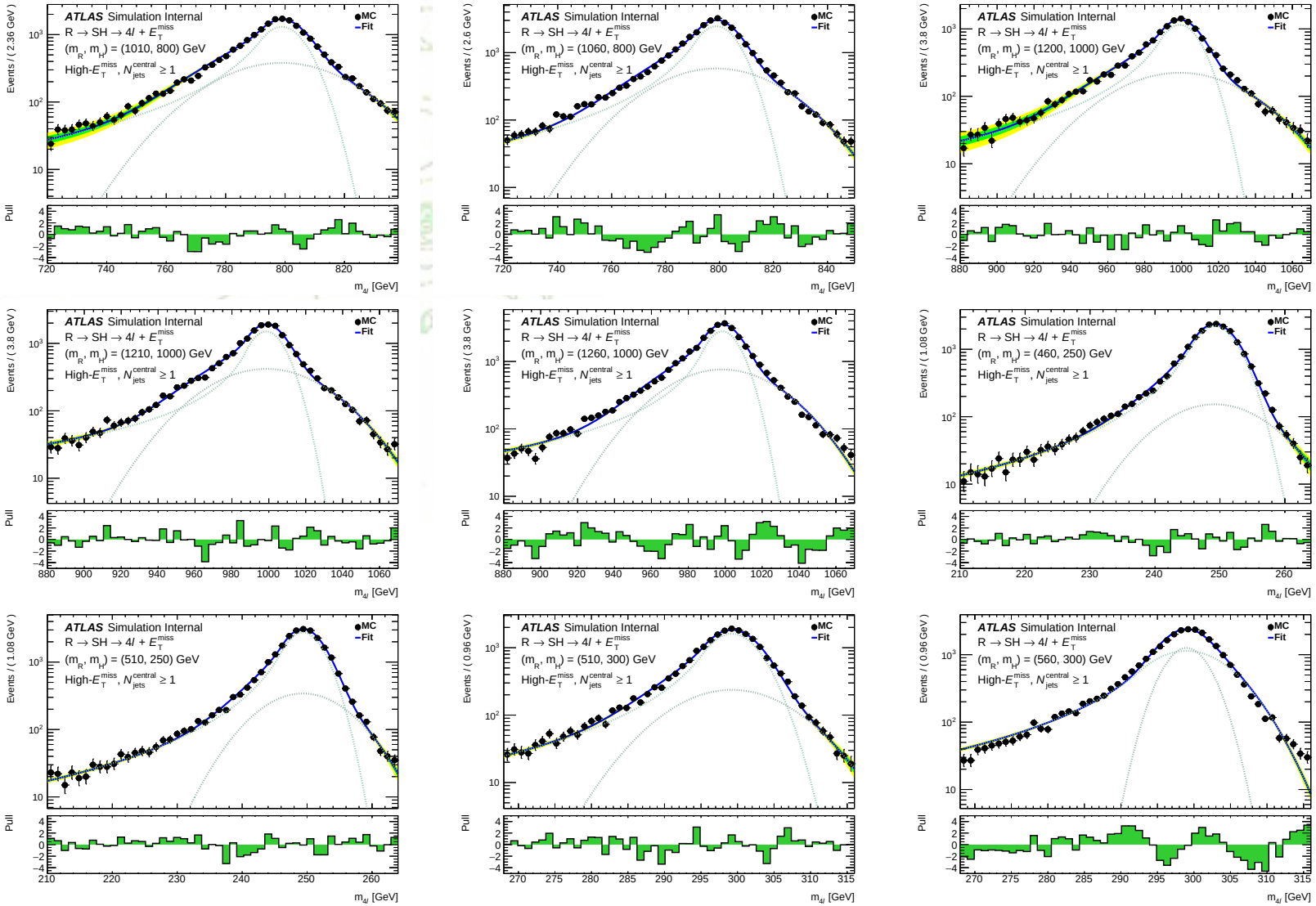




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

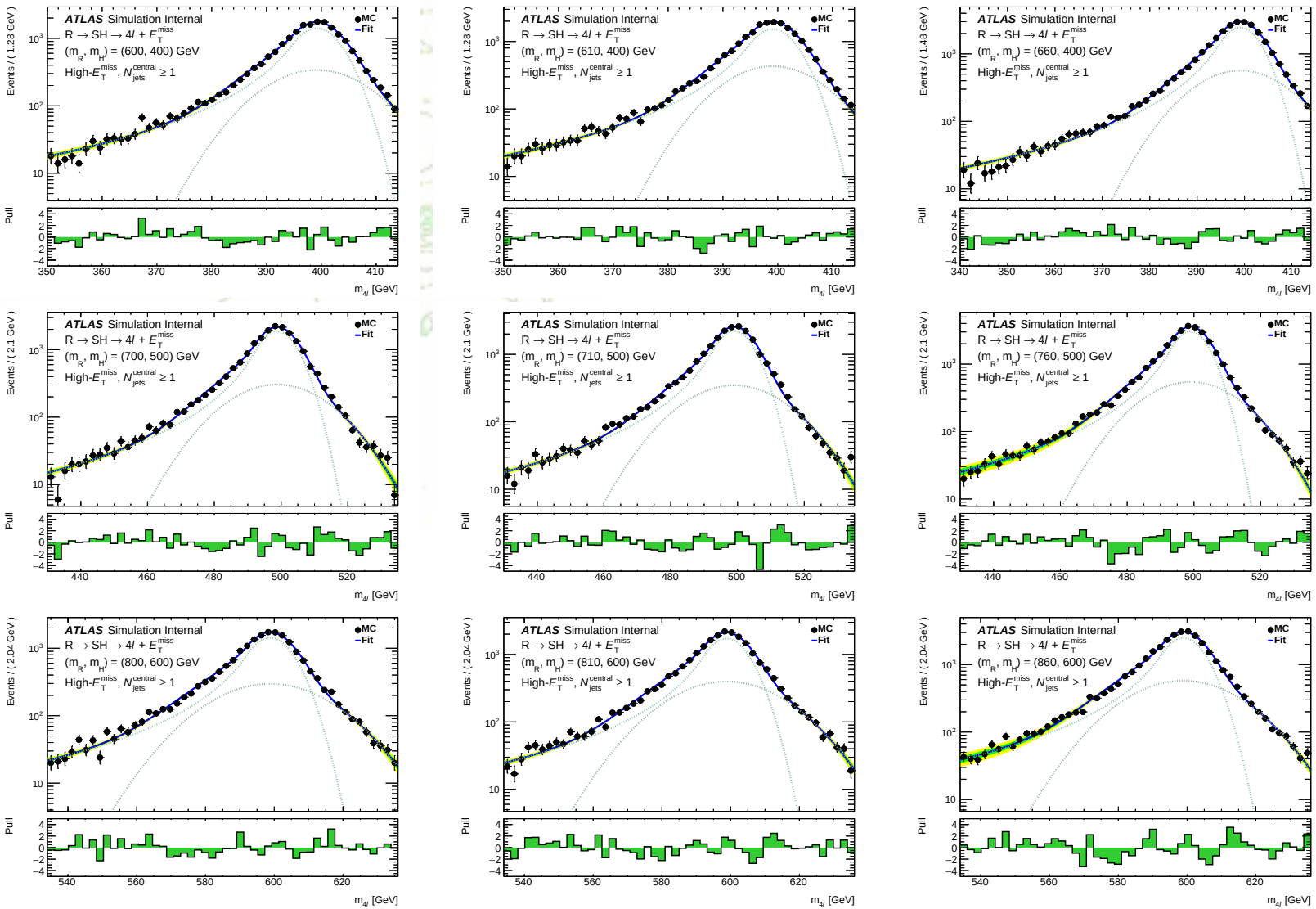




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

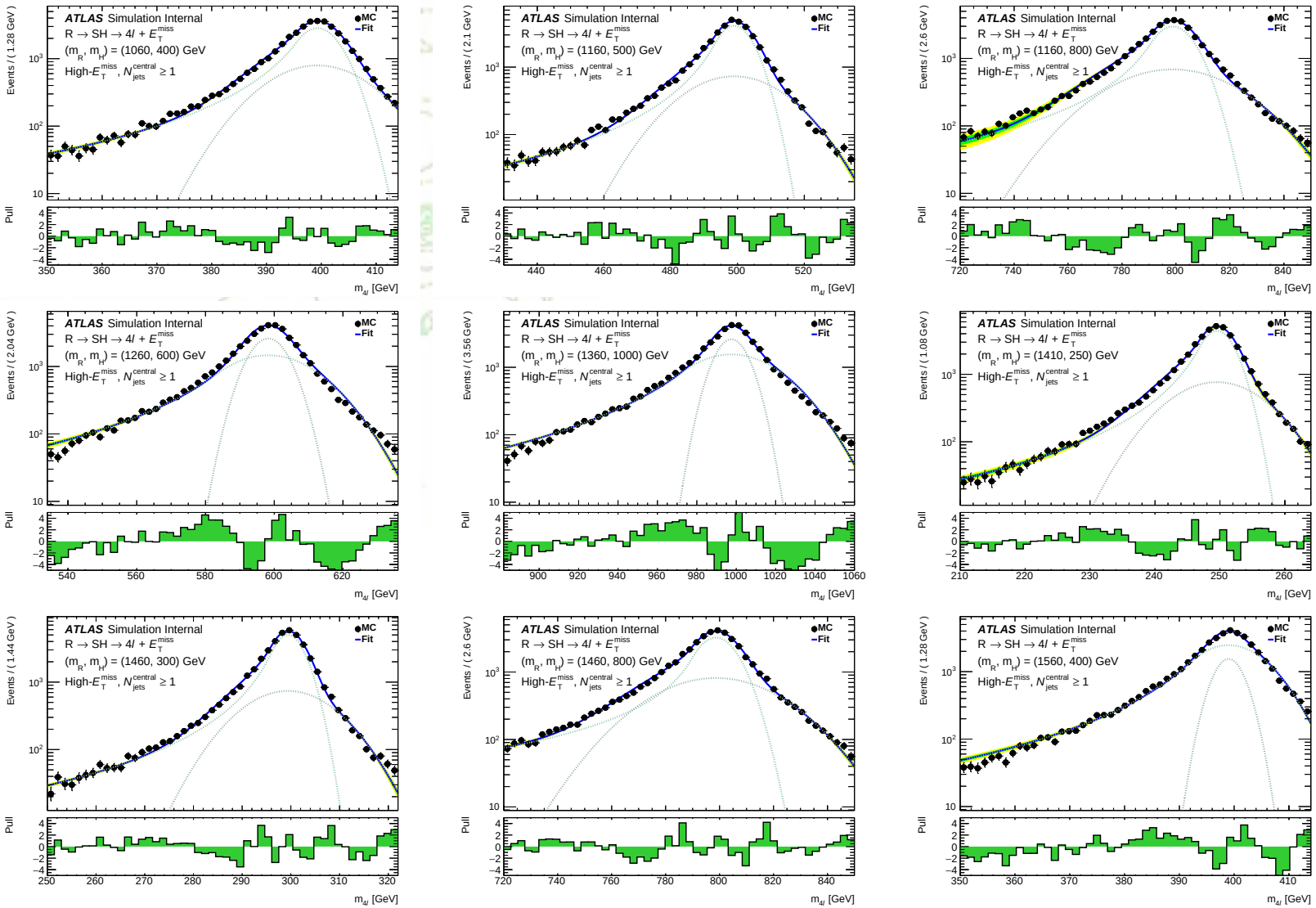




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

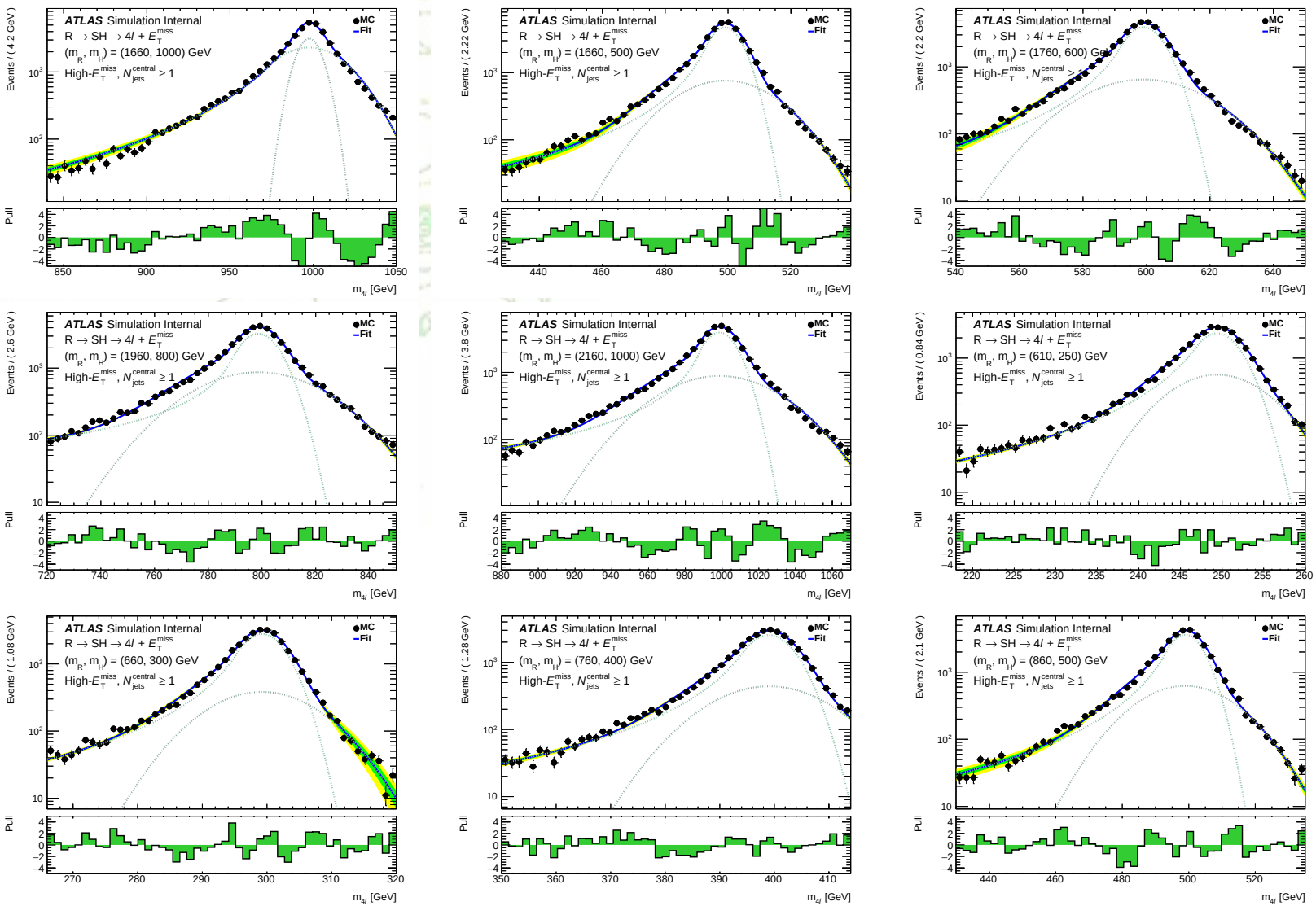




# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

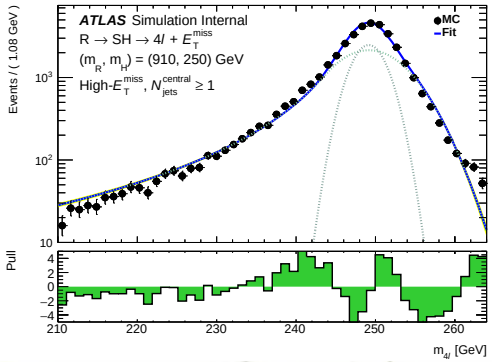


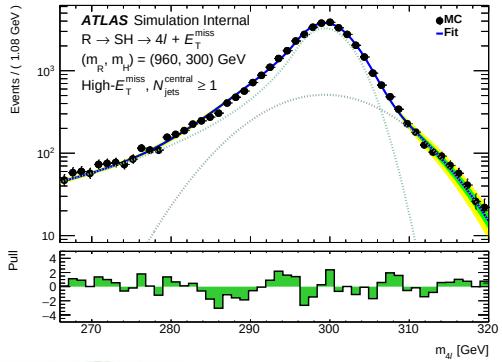


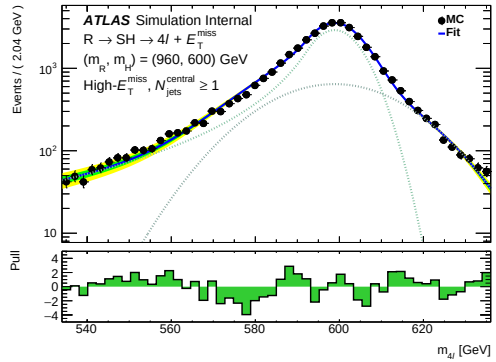
# Signal parametrisation for RSH model

## High-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$:Summary of $\chi^2/\mathrm{ndof}$ values for all signal mass points






| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 390, 220 | 1.26 |
| 450, 220 | 1.92 |
| 800, 220 | 2.13 |
| 1500, 220 | 2.64 |
| 450, 250 | 1.41 |
| 1500, 250 | 3.23 |
| 800, 300 | 2.09 |
| 800, 500 | 2.65 |
| 1500, 1000 | 5.79 |
| 410, 220 | 1.51 |
| 430, 220 | 1.28 |
| 580, 220 | 1.40 |
| 880, 220 | 1.87 |
| 1380, 220 | 3.27 |
| 670, 500 | 0.90 |
| 610, 250 | 2.15 |
| 660, 300 | 2.73 |
| 1170, 1000 | 0.91 |
| - | - |

| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 470, 300 | 1.31 |
| 570, 400 | 0.54 |
| 770, 600 | 0.83 |
| 970, 800 | 1.14 |
| 430, 250 | 1.06 |
| 480, 300 | 1.79 |
| 580, 400 | 0.76 |
| 680, 500 | 1.60 |
| 780, 600 | 1.29 |
| 980, 800 | 1.10 |
| 1180, 1000 | 1.45 |
| 440, 250 | 1.01 |
| 490, 300 | 1.17 |
| 590, 400 | 2.13 |
| 690, 500 | 1.32 |
| 790, 600 | 1.79 |
| 990, 800 | 1.84 |
| 1190, 1000 | 1.62 |
| 500, 300 | 1.20 |

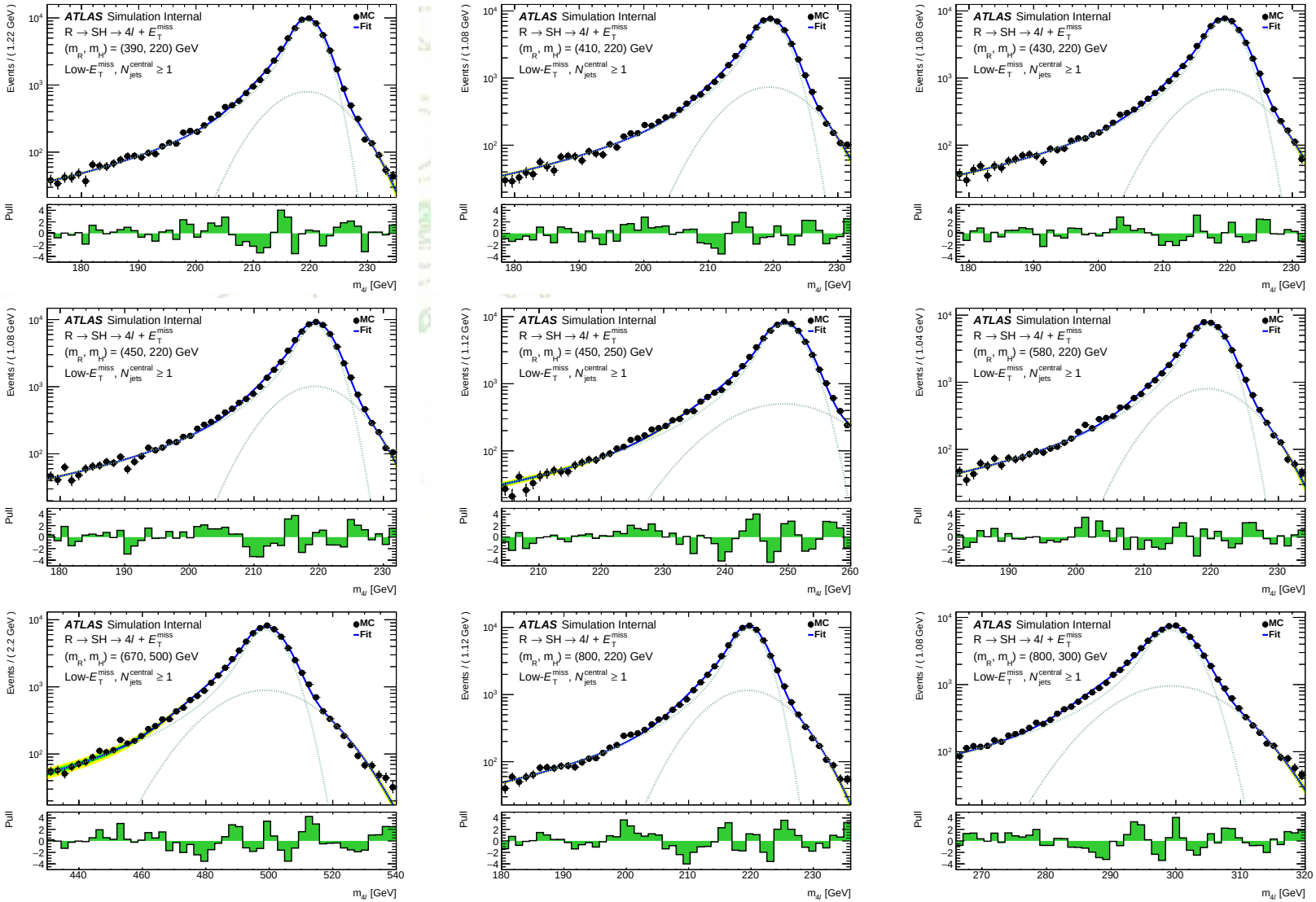
| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 600, 400 | 1.29 |
| 700, 500 | 1.82 |
| 800, 600 | 1.59 |
| 1000, 800 | 3.01 |
| 1200, 1000 | 1.62 |
| 460, 250 | 1.15 |
| 510, 300 | 1.84 |
| 610, 400 | 1.14 |
| 710, 500 | 2.10 |
| 810, 600 | 1.81 |
| 1010, 800 | 1.62 |
| 1210, 1000 | 1.68 |
| 510, 250 | 1.30 |
| 560, 300 | 4.74 |
| 660, 400 | 1.12 |
| 760, 500 | 1.95 |
| 860, 600 | 2.83 |
| 1060, 800 | 3.02 |
| 1260, 1000 | 3.63 |

| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 760, 400 | 1.70 |
| 860, 500 | 3.07 |
| 960, 600 | 2.63 |
| 1160, 800 | 3.76 |
| 1360, 1000 | 8.05 |
| 910, 250 | 7.68 |
| 960, 300 | 1.67 |
| 1060, 400 | 2.08 |
| 1160, 500 | 3.69 |
| 1260, 600 | 8.69 |
| 1460, 800 | 2.50 |
| 1660, 1000 | 7.62 |
| 1410, 250 | 2.78 |
| 1460, 300 | 2.92 |
| 1560, 400 | 4.57 |
| 1660, 500 | 4.47 |
| 1760, 600 | 4.28 |
| 1960, 800 | 2.50 |
| 2160, 1000 | 3.95 |

# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

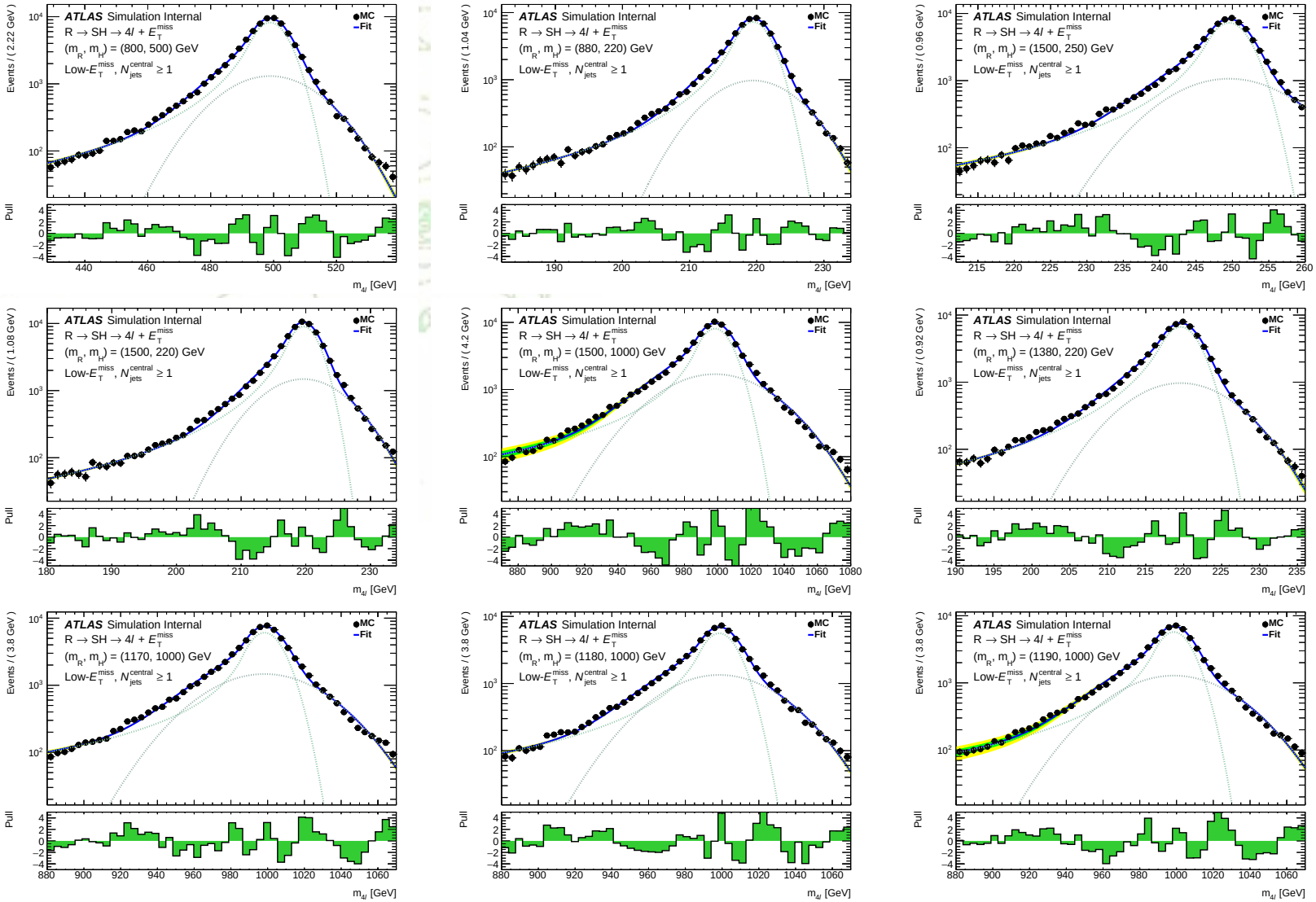




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

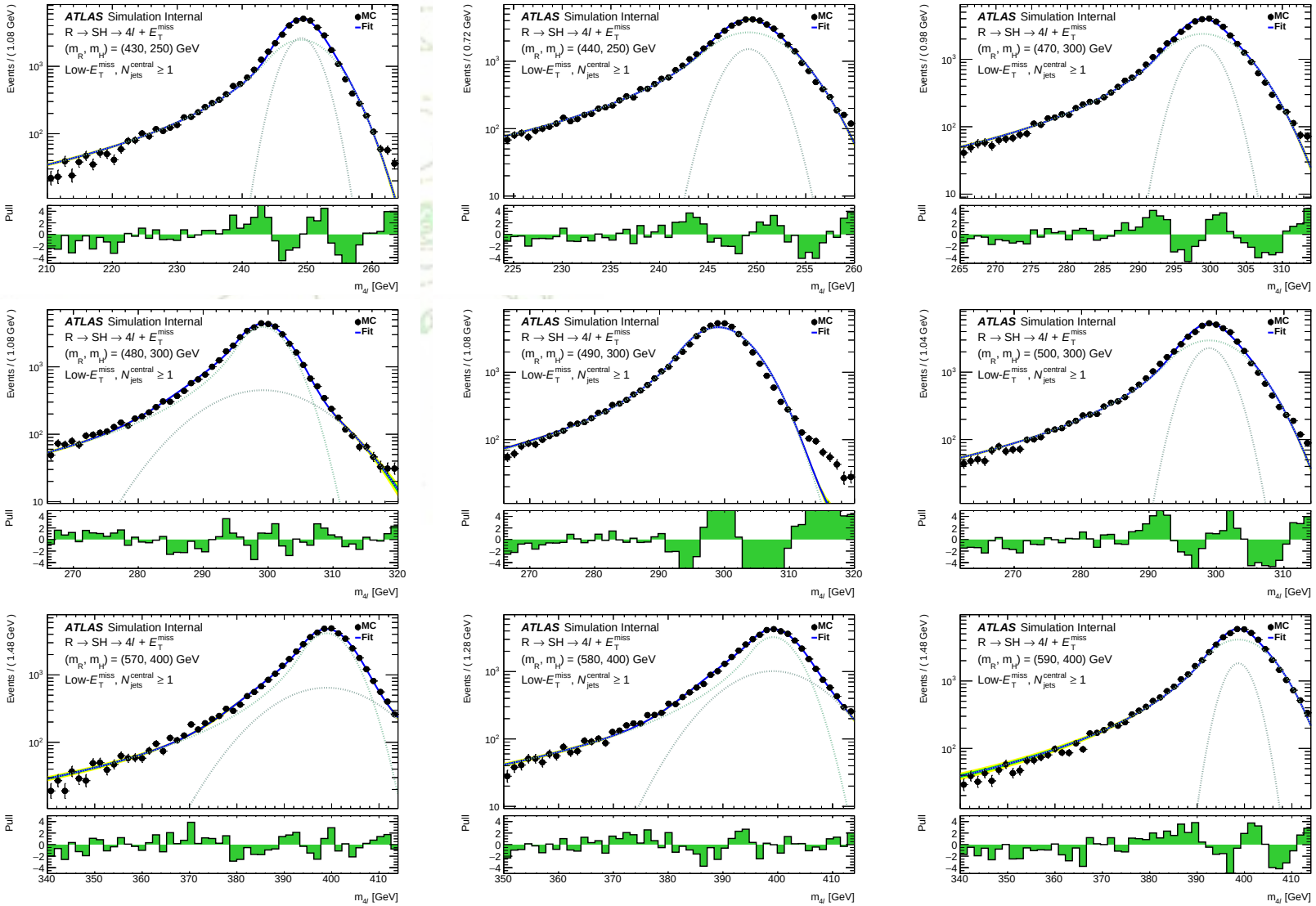




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

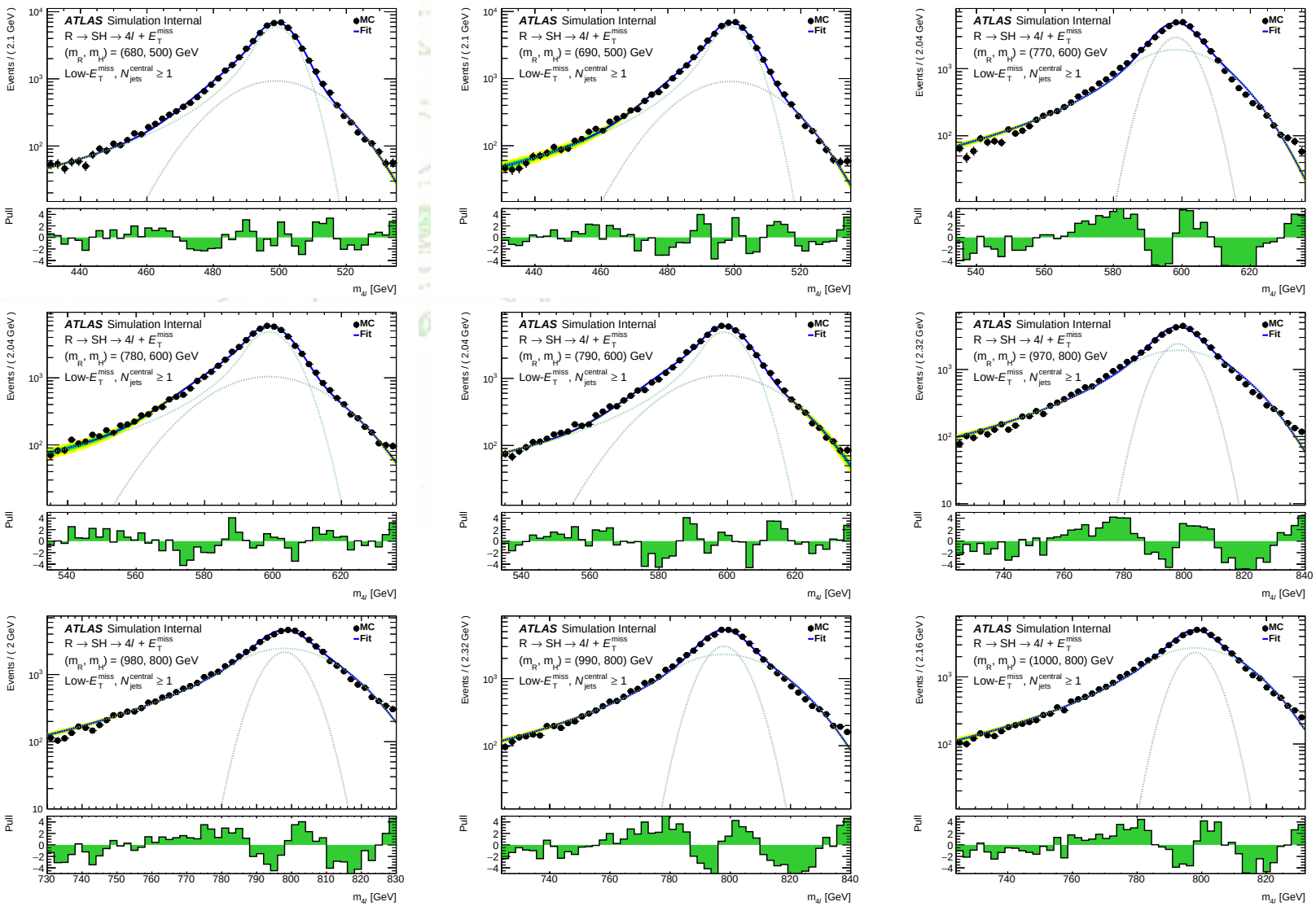




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

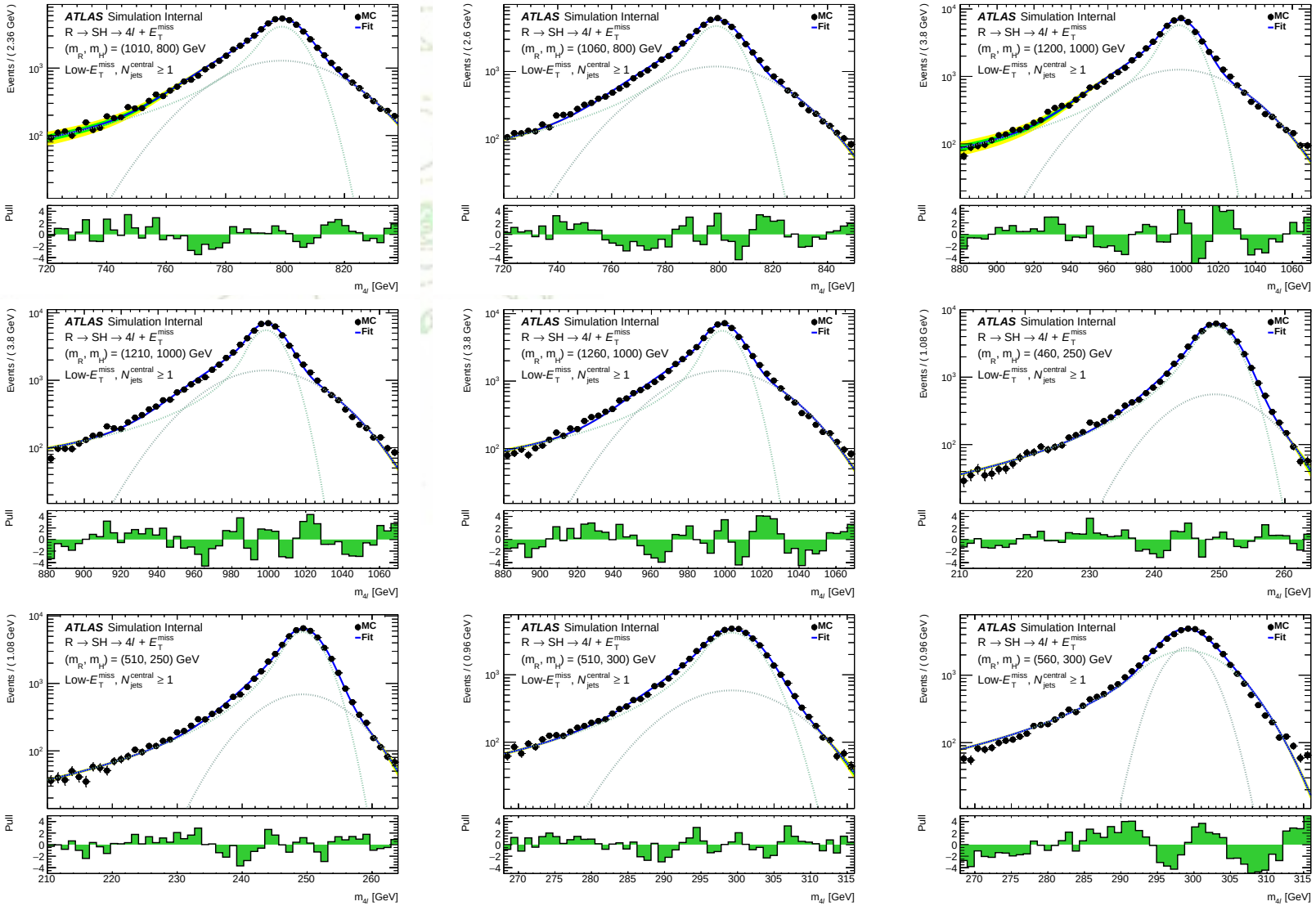




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

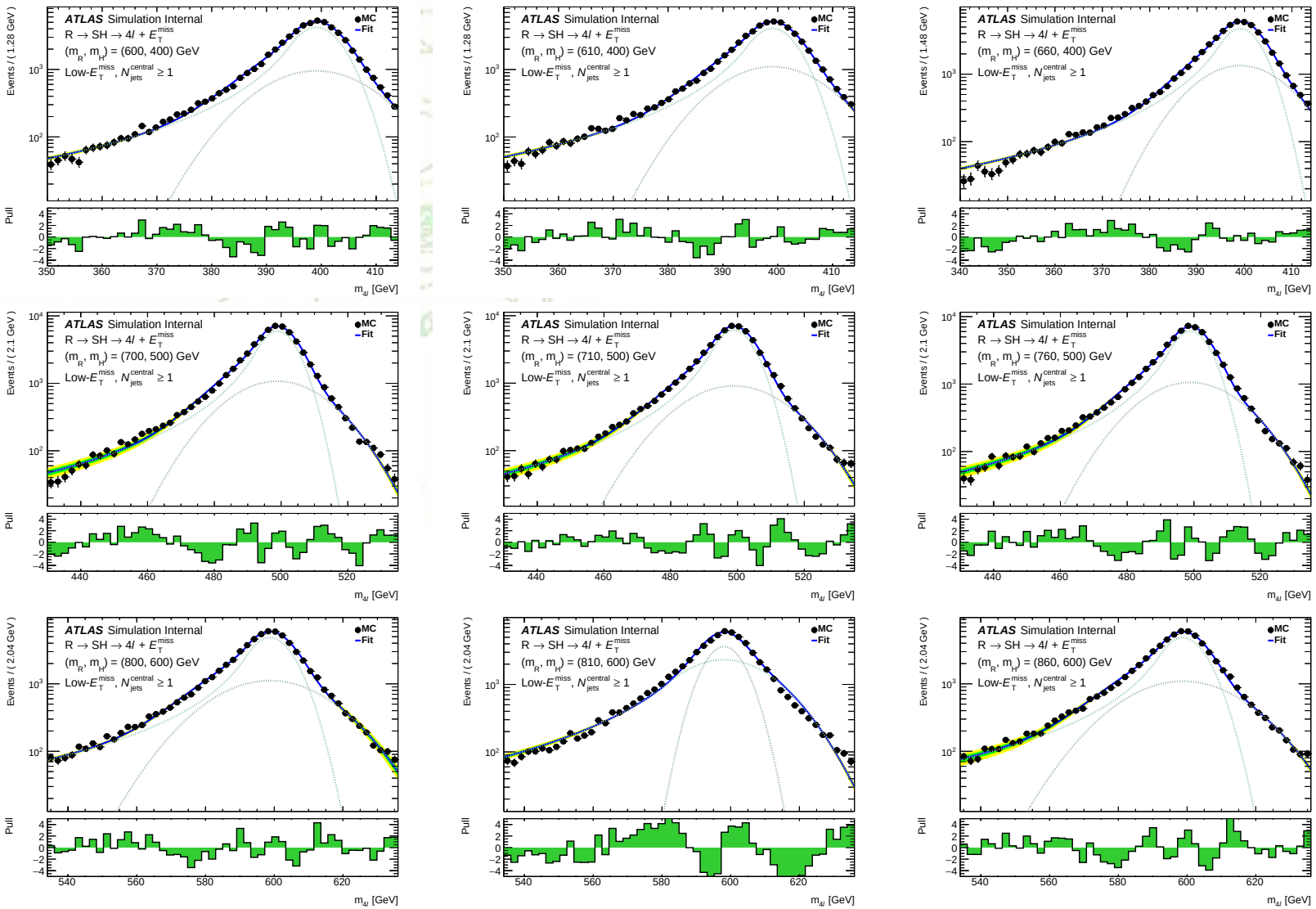




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

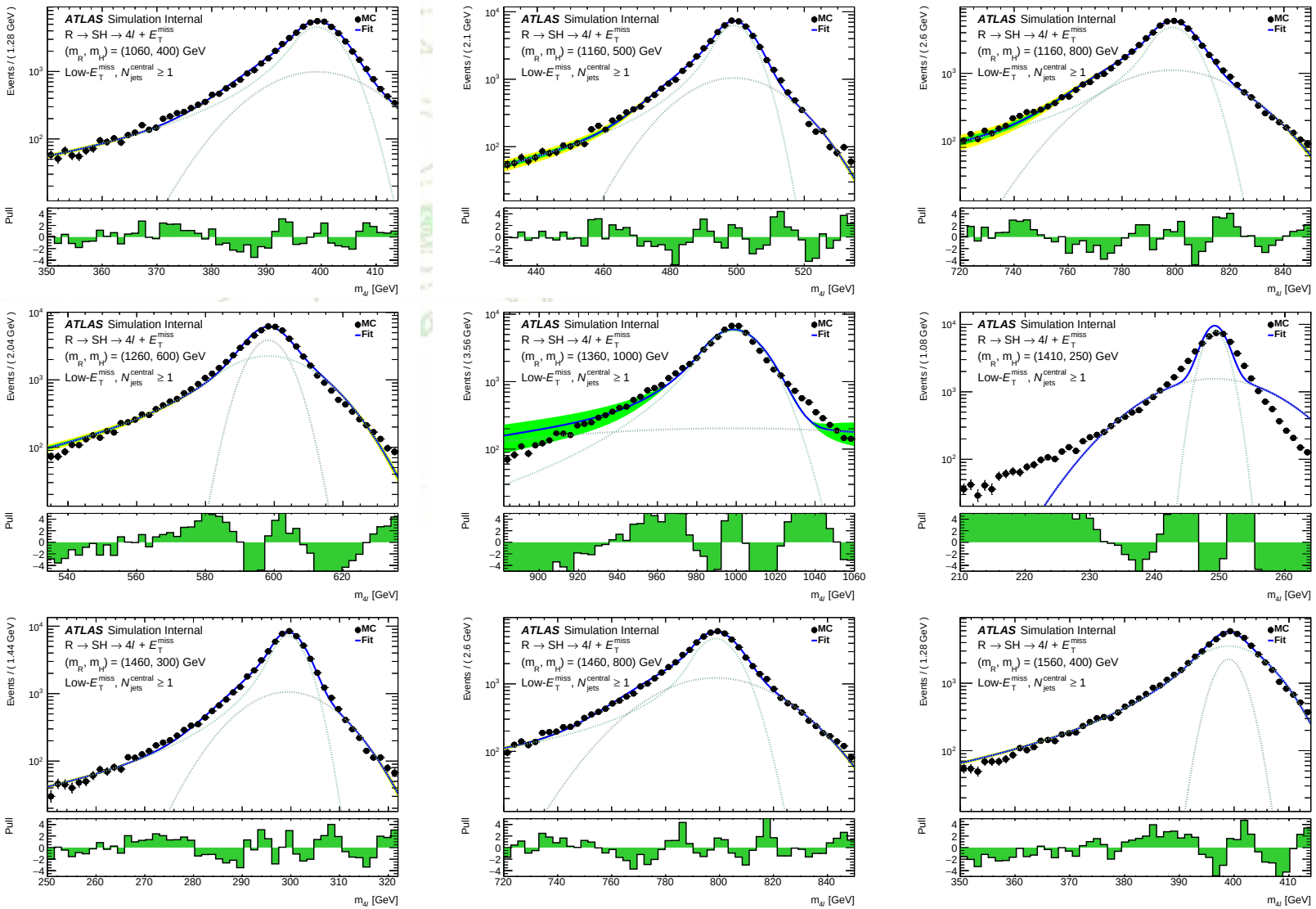




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

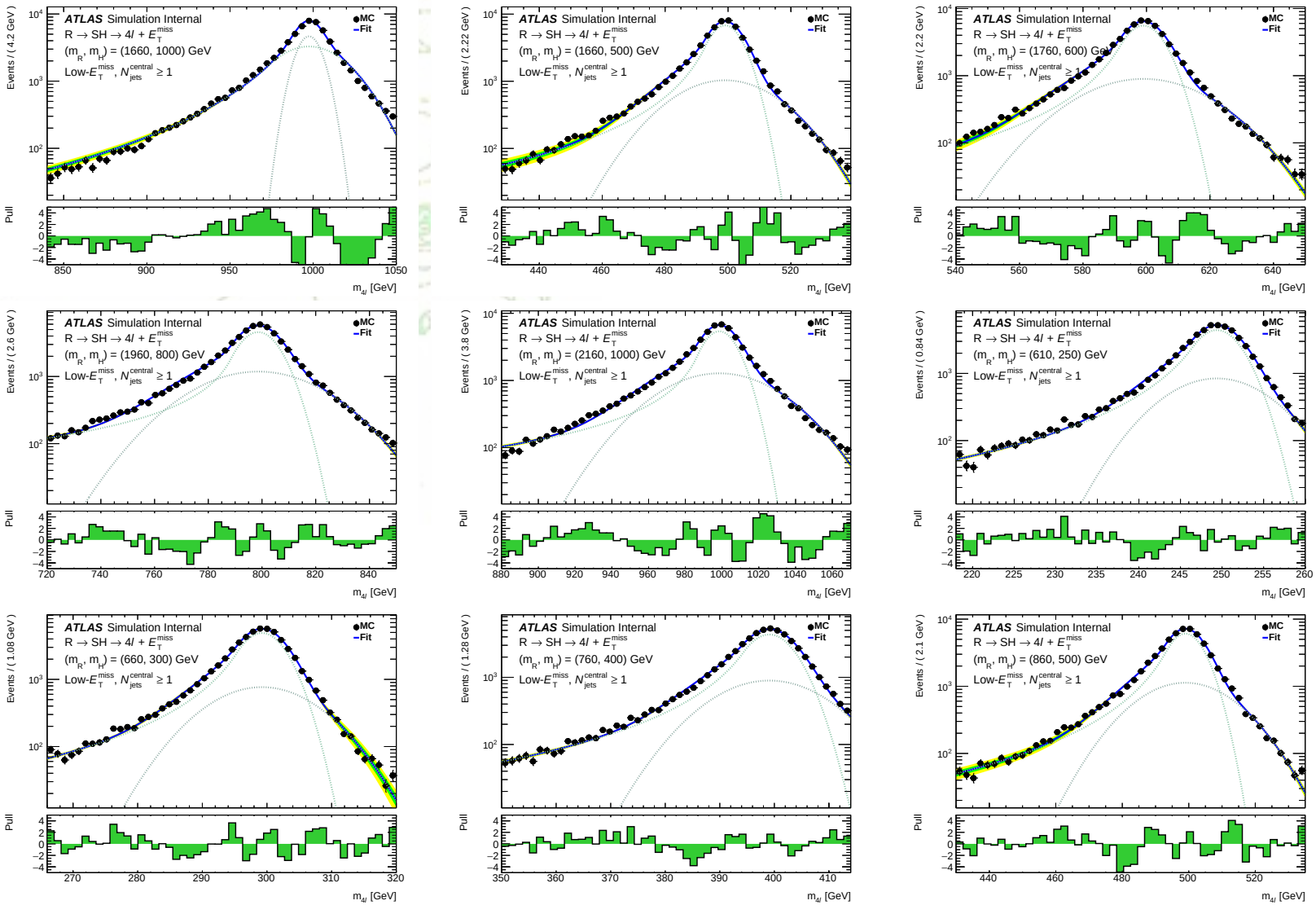




# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$

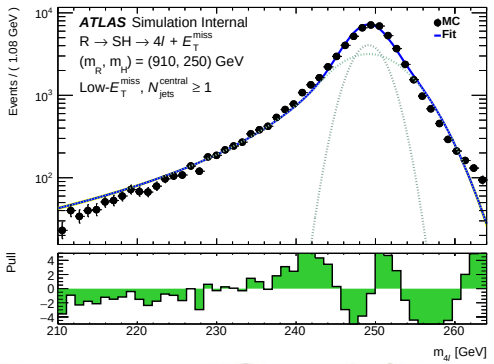


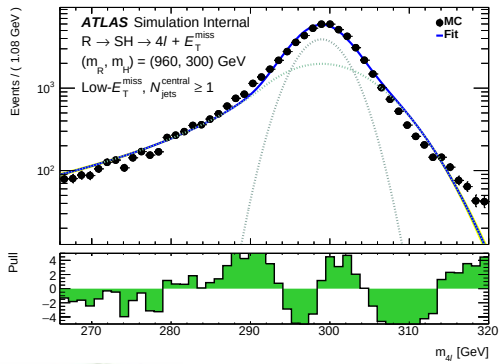


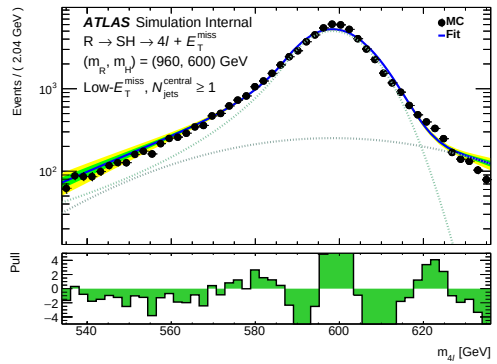
# Signal parametrisation for RSH model

## Low-$E_{\mathrm{T}}^{\mathrm{miss}}$, $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$: Summary of $\chi^2/\mathrm{ndof}$ values for all signal mass points






| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 390, 220 | 2.72 |
| 450, 220 | 2.89 |
| 800, 220 | 3.13 |
| 1500, 220 | 3.81 |
| 450, 250 | 3.50 |
| 1500, 250 | 4.11 |
| 800, 300 | 2.93 |
| 800, 500 | 3.95 |
| 1500, 1000 | 7.87 |
| 410, 220 | 2.47 |
| 430, 220 | 1.67 |
| 580, 220 | 2.27 |
| 880, 220 | 2.43 |
| 1380, 220 | 3.86 |
| 670, 500 | 3.37 |
| 610, 250 | 2.86 |
| 660, 300 | 3.45 |
| 1170, 1000 | 4.62 |
| - | - |

| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 470, 300 | 5.20 |
| 570, 400 | 2.52 |
| 770, 600 | 11.89 |
| 970, 800 | 8.10 |
| 430, 250 | 6.72 |
| 480, 300 | 2.49 |
| 580, 400 | 2.21 |
| 680, 500 | 2.82 |
| 780, 600 | 2.93 |
| 980, 800 | 6.51 |
| 1180, 1000 | 4.85 |
| 440, 250 | 3.90 |
| 490, 300 | 27.01 |
| 590, 400 | 5.04 |
| 690, 500 | 3.55 |
| 790, 600 | 4.21 |
| 990, 800 | 8.57 |
| 1190, 1000 | 4.76 |
| 500, 300 | 7.37 |

| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 600, 400 | 2.62 |
| 700, 500 | 4.11 |
| 800, 600 | 2.96 |
| 1000, 800 | 6.69 |
| 1200, 1000 | 6.21 |
| 460, 250 | 2.24 |
| 510, 300 | 2.08 |
| 610, 400 | 2.29 |
| 710, 500 | 3.17 |
| 810, 600 | 13.04 |
| 1010, 800 | 2.73 |
| 1210, 1000 | 4.85 |
| 510, 250 | 2.17 |
| 560, 300 | 7.89 |
| 660, 400 | 2.16 |
| 760, 500 | 3.63 |
| 860, 600 | 4.04 |
| 1060, 800 | 3.94 |
| 1260, 1000 | 5.59 |

| Mass point = $(m_X, m_H)$ [GeV] | $\chi^2/\mathrm{ndof}$ |
|---|---|
| 760, 400 | 2.11 |
| 860, 500 | 4.04 |
| 960, 600 | 18.24 |
| 1160, 800 | 4.39 |
| 1360, 1000 | 42.13 |
| 910, 250 | 13.08 |
| 960, 300 | 14.94 |
| 1060, 400 | 2.79 |
| 1160, 500 | 4.50 |
| 1260, 600 | 12.18 |
| 1460, 800 | 3.46 |
| 1660, 1000 | 10.40 |
| 1410, 250 | 180.50 |
| 1460, 300 | 3.83 |
| 1560, 400 | 6.35 |
| 1660, 500 | 5.38 |
| 1760, 600 | 5.24 |
| 1960, 800 | 3.60 |
| 2160, 1000 | 5.56 |

# Additional slides
## Nuisance parameters



| Normalisation | Shape |
|---|---|
| **Electrons** | |
| EL_EFF_ID_CorrUncertaintyNP[ 0-15] | EG_RESOLUTION_ALL |
| EL_EFF_ID_SIMPLIFIED_UncorrUncertaintyNP[0-17] | EG_SCALE_ALLCORR |
| EL_EFF_Iso_TOTAL_1NPCOR_PLUS_UNCOR | EG_SCALE_E4SCINTILLATOR |
| EL_EFF_Reco_TOTAL_1NPCOR_PLUS_UNCOR | EG_SCALE_LARCALIB_EXTRA2015PRE |
| | EG_SCALE_LARTEMPERATURE_EXTRA2015PRE |
| | EG_SCALE_LARTEMPERATURE_EXTRA2016PRE |
| **Muons** | |
| MUON_EFF_ISO_STAT | |
| MUON_EFF_ISO_SYS | MUON_ID |
| MUON_EFF_RECO_STAT | MUON_MS |
| MUON_EFF_RECO_STAT_LOWPT | MUON_SAGITTA_RESBIAS |
| MUON_EFF_RECO_SYS | MUON_SAGITTA_RHO |
| MUON_EFF_RECO_SYS_LOWPT | MUON_SCALE |
| MUON_EFF_TTVA_STAT | |
| MUON_EFF_TTVA_SYS | |
| **Jets** | |
| | JET_BJES_Response |
| | JET_EffectiveNP_[1-7] |
| | JET_EffectiveNP_8restTerm |
| | JET_EtaIntercalibration_Modelling |
| | JET_EtaIntercalibration_NonClosure_highE |
| | JET_EtaIntercalibration_NonClosure_negEta |
| | JET_EtaIntercalibration_NonClosure_posEta |
| | JET_EtaIntercalibration_TotalStat |
| | JET_Flavor_Composition |
| | JET_Flavor_Response |
| | JET_JER_DataVsMC |
| | JET_JER_EffectiveNP_[1-6] |
| | JET_JER_EffectiveNP_7restTerm |
| | JET_Pileup_OffsetMu |
| | JET_Pileup_OffsetNPV |
| | JET_Pileup_PtTerm |
| | JET_Pileup_RhoTopology |
| | JET_PunchThrough_MC16 |
| | JET_SingleParticle_HighPt |
| **Missing transverse energy** | |
| | MET_SoftTrk_ResoPara |
| | MET_SoftTrk_ResoPerp |
| | MET_SoftTrk_Scale |
| **Other** | |
| HOEW_QCD_syst | |
| HOEW_syst | |
| HOQCD_scale_syst | |
| PRW_DATASF | |

# Additional slides
## AZH kinematic distributions