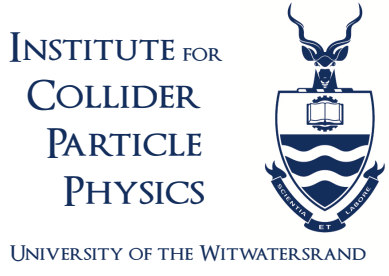
4ℓ + Met signal parametrisation

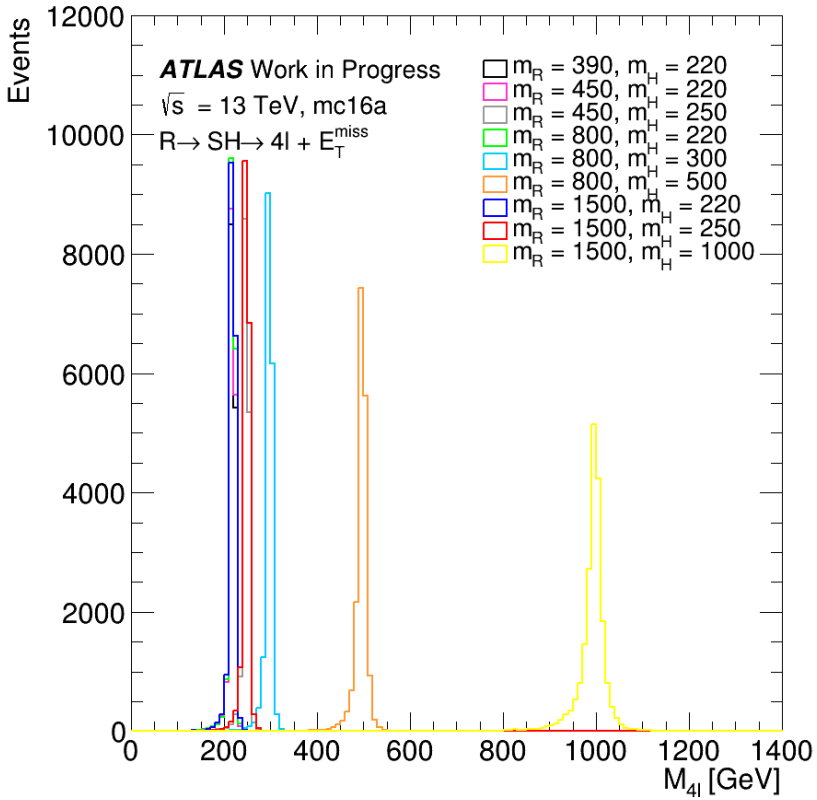
Abdualazem Fadol

July 8, 2019



Introduction

- Since the combinations between R and H peak around the mass of the H boson;



- The mass points from (220-1000) GeV are modelled using a Crystal ball plus Gaussian Pdf.

Introduction

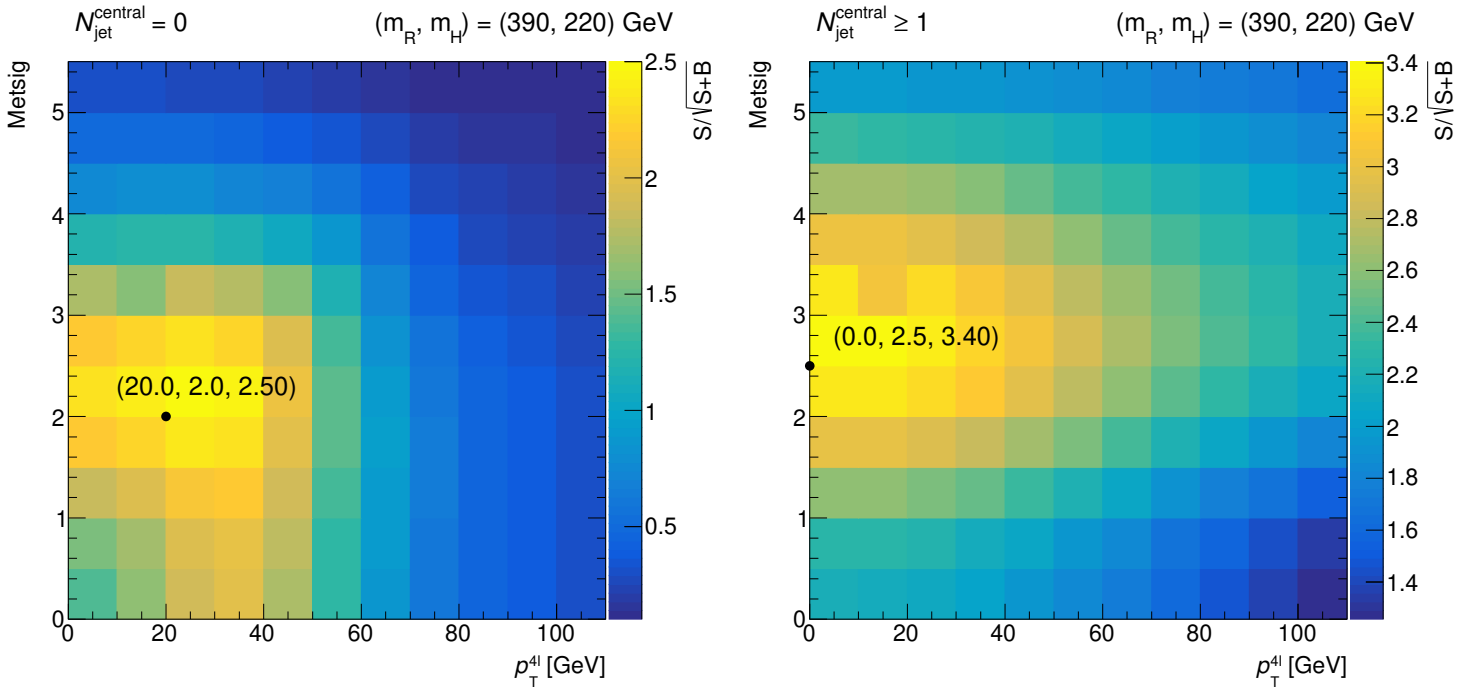
- The Crystal ball, CB, plus Gaussian, G, Pdf has the following form:

$$f(m_{4\ell}) = f_{\text{CB}} \cdot \text{CB}(m_{4\ell}; \mu, \sigma_{\text{CB}}, \alpha_{\text{CB}}, n_{\text{CB}}) + (1 - f_{CB}) \cdot \text{G}(m_{4\ell}; \mu, \sigma_{G})$$

  - σ_C and σ_G represent the invariant mass resolution;
  - μ is the mean value fixed to same parameter for both Pdf;
  - n_C and α_C model the shape and position of the non-Gaussian tail;
  - Where n_C is the slop of the tail and α_C measures how far from the peak the distribution become non-Gaussian;
  - f_C is the relative normalisation of the Pdf.

New optimal cuts on $p_T^{4\ell}$ and Metsig

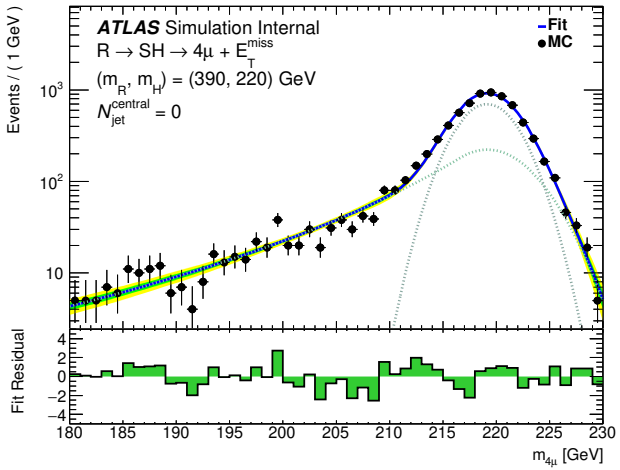
- There are new cuts after including JVT on Met calculation;
- The fake Met will be much smaller, old optimal cuts on backup slides;

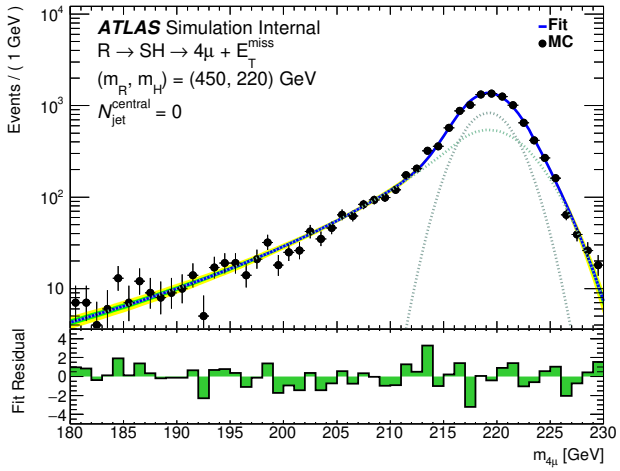


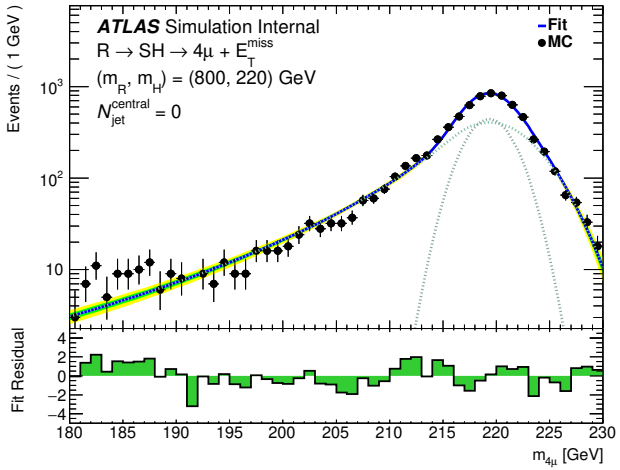
- The fit is performed after the 4-lepton cut and the following cuts:
  - $N_{\text{jet}}^{\text{central}} = 0$, $p_T^{4\ell} > 20$ GeV and Metsig > 2.0
  - $N_{\text{jet}}^{\text{central}} \geq 1$ and Metsig > 2.5

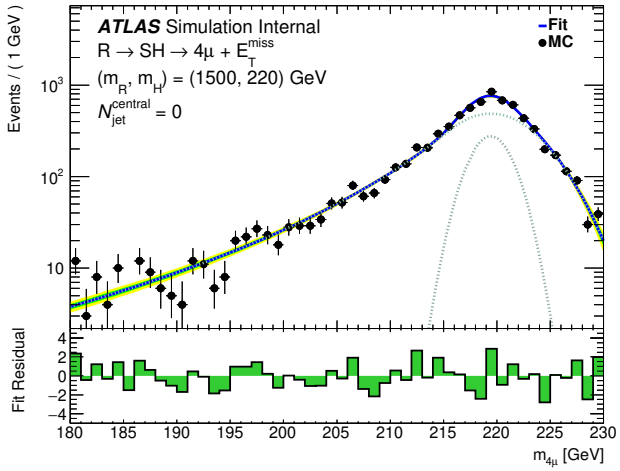
Zero central jet category

4μ-channel









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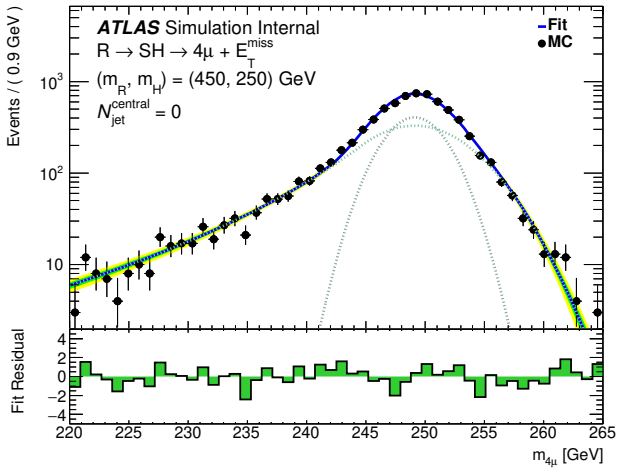
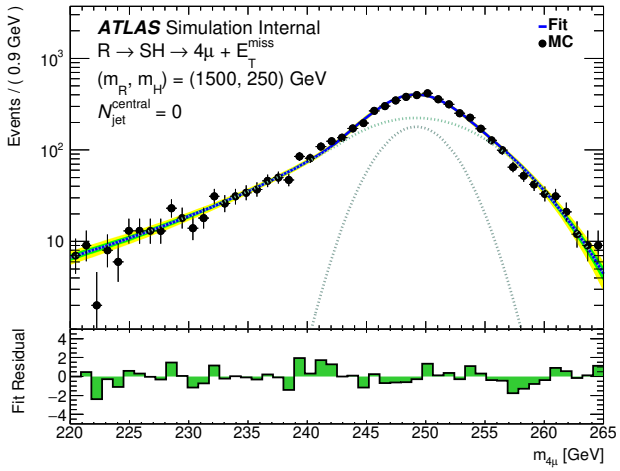
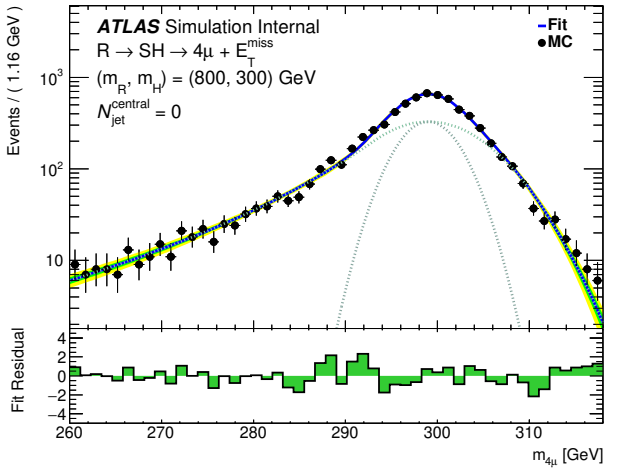
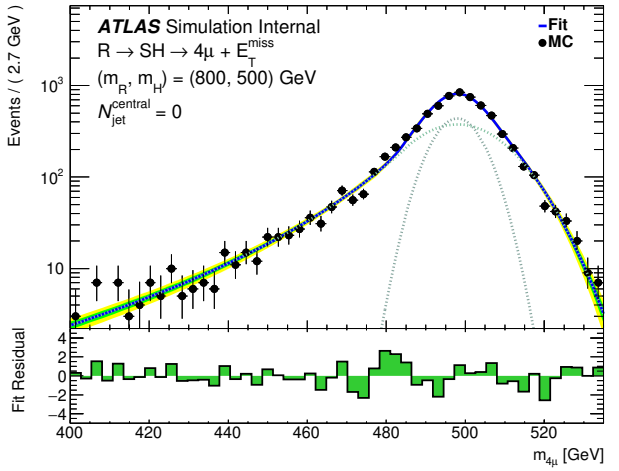


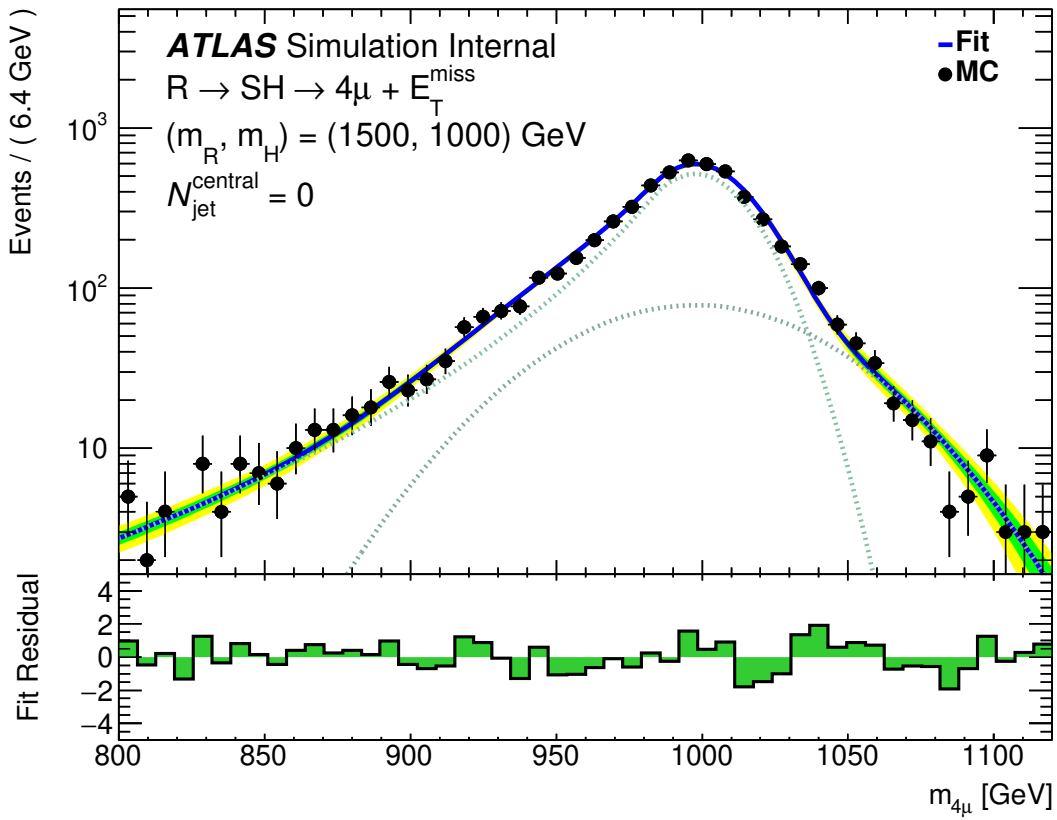






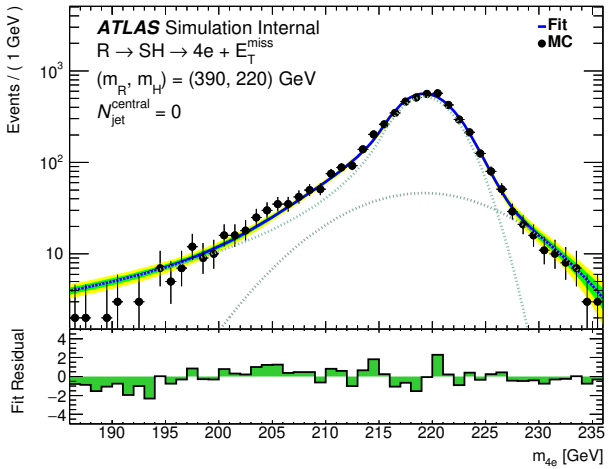
Zero central jet category

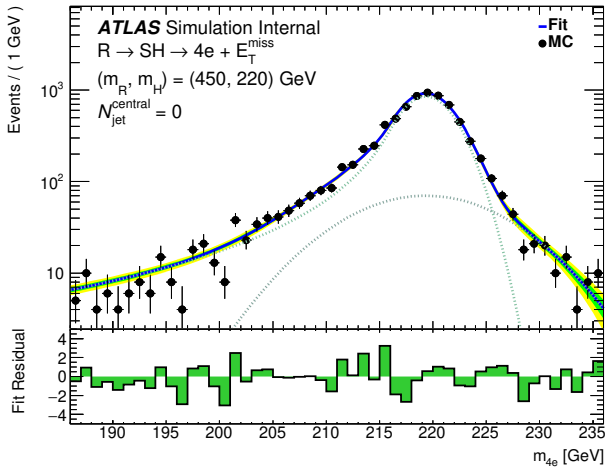
4μ-channel

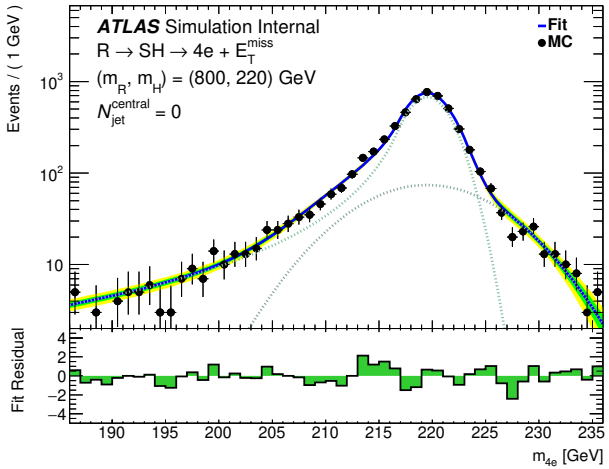


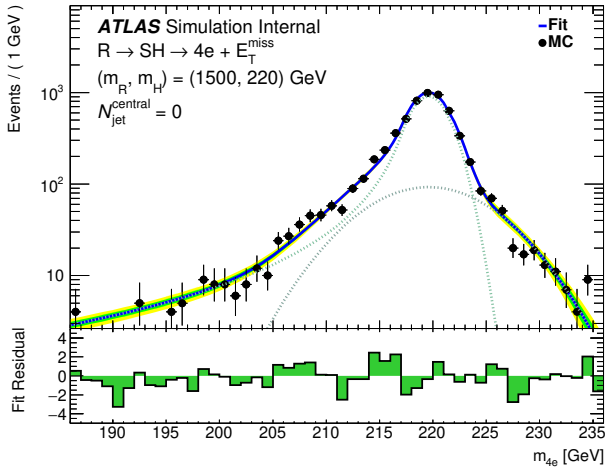
Zero central jet category

4*e*-channel









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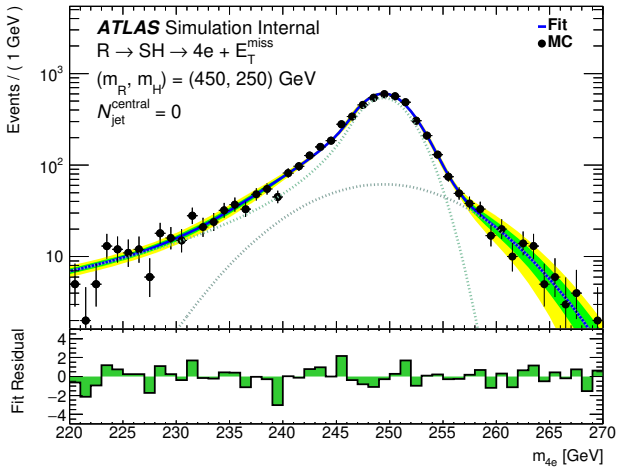

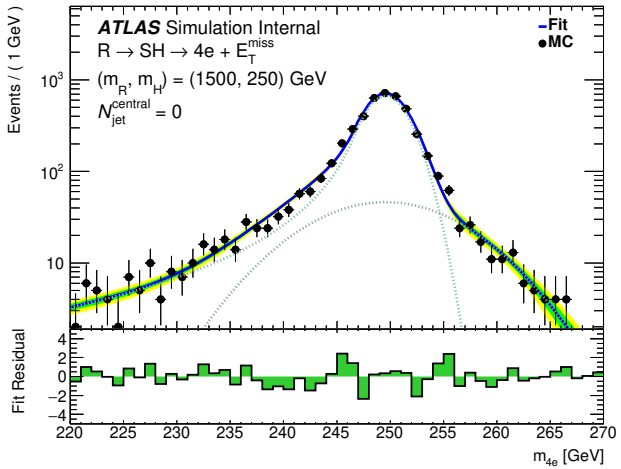

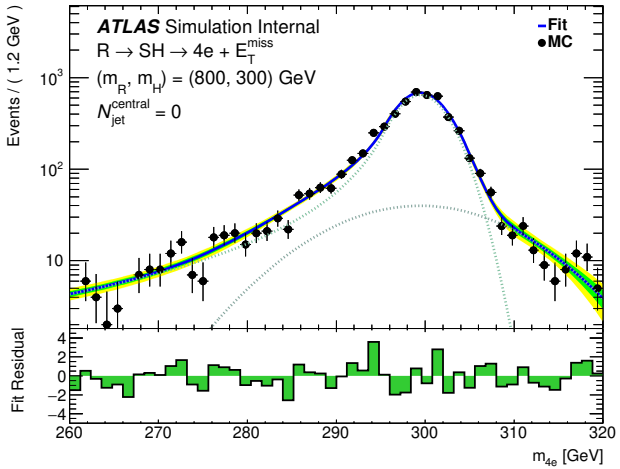

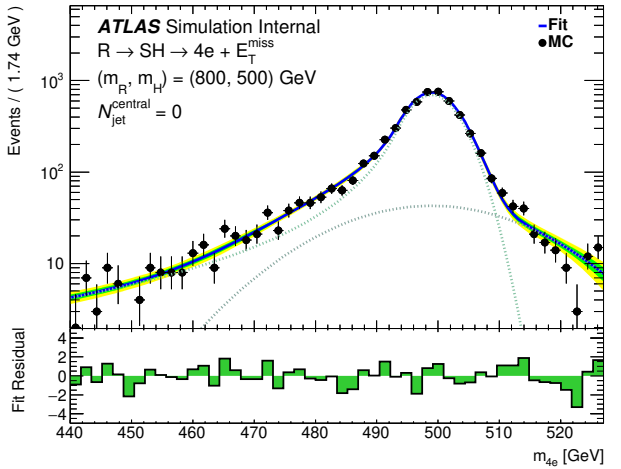

Zero central jet category

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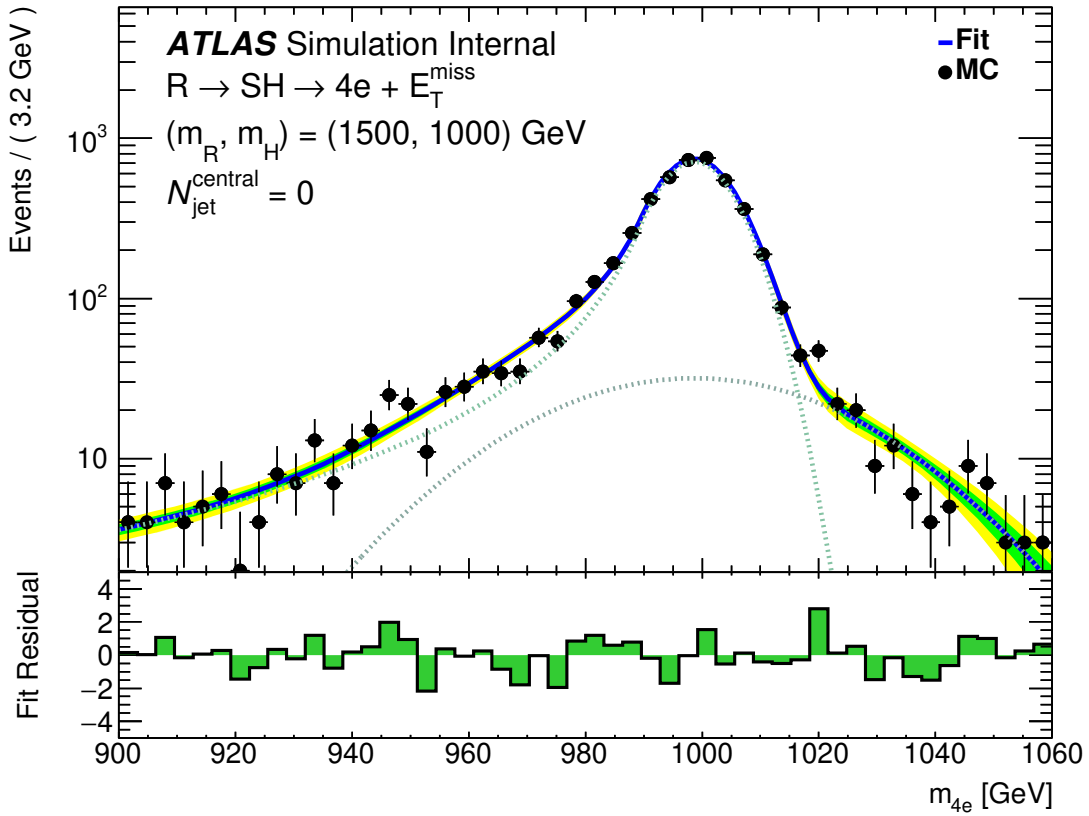
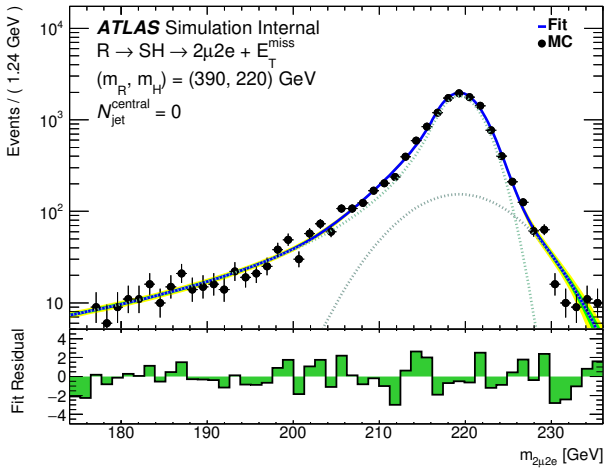
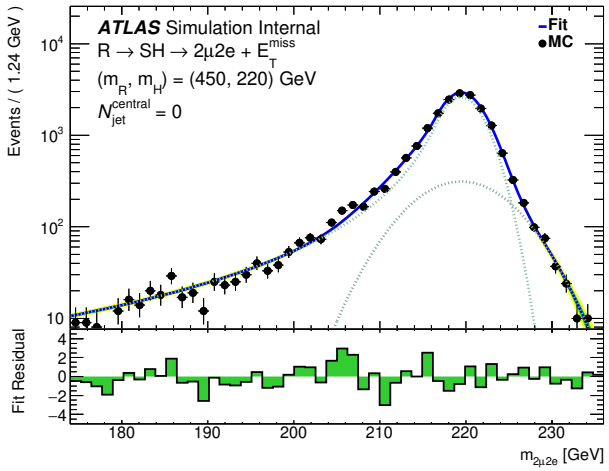
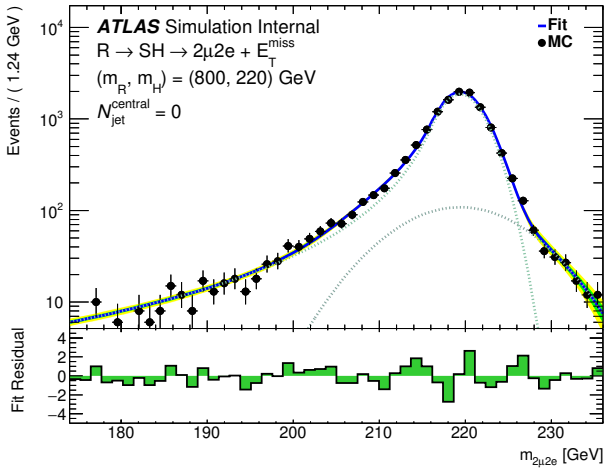


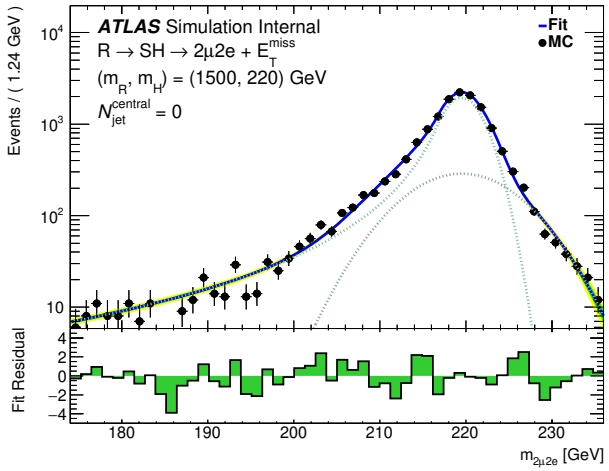
Zero central jet category

$2\mu 2e$-channel









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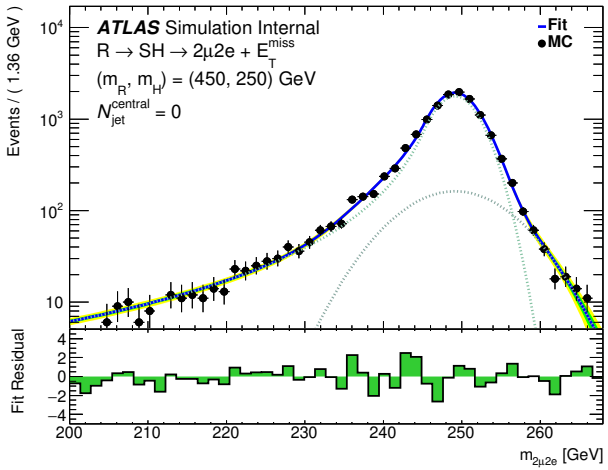

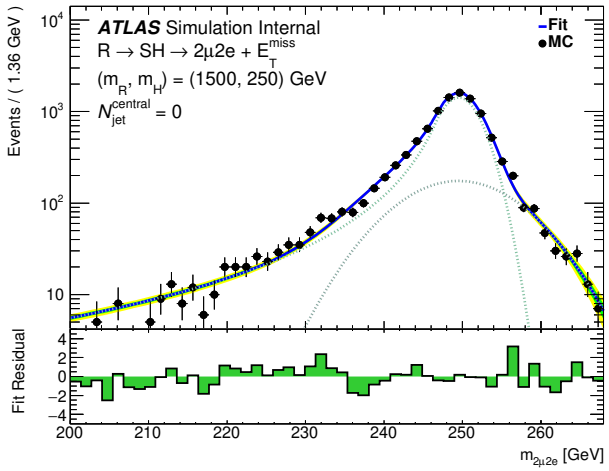

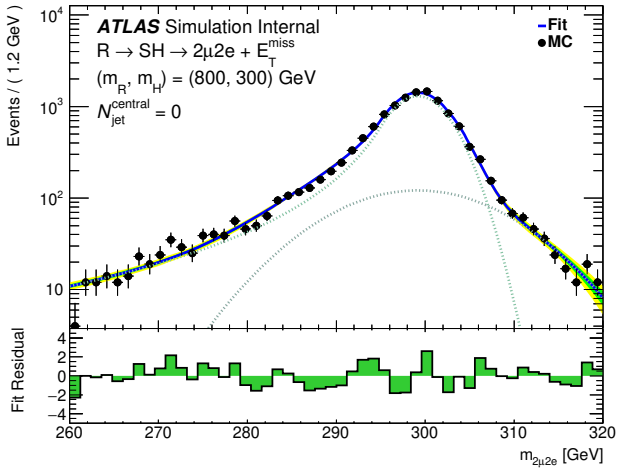

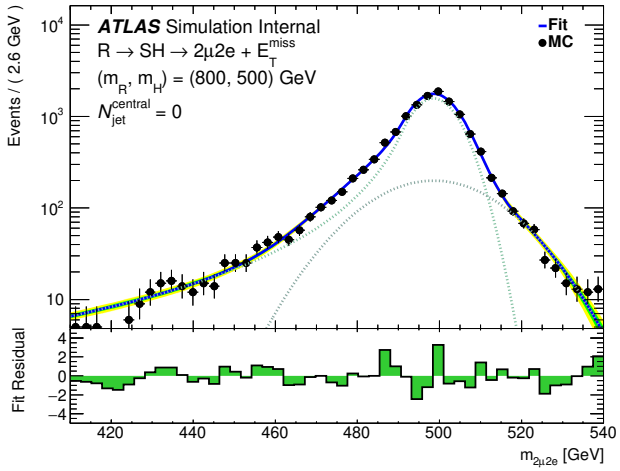

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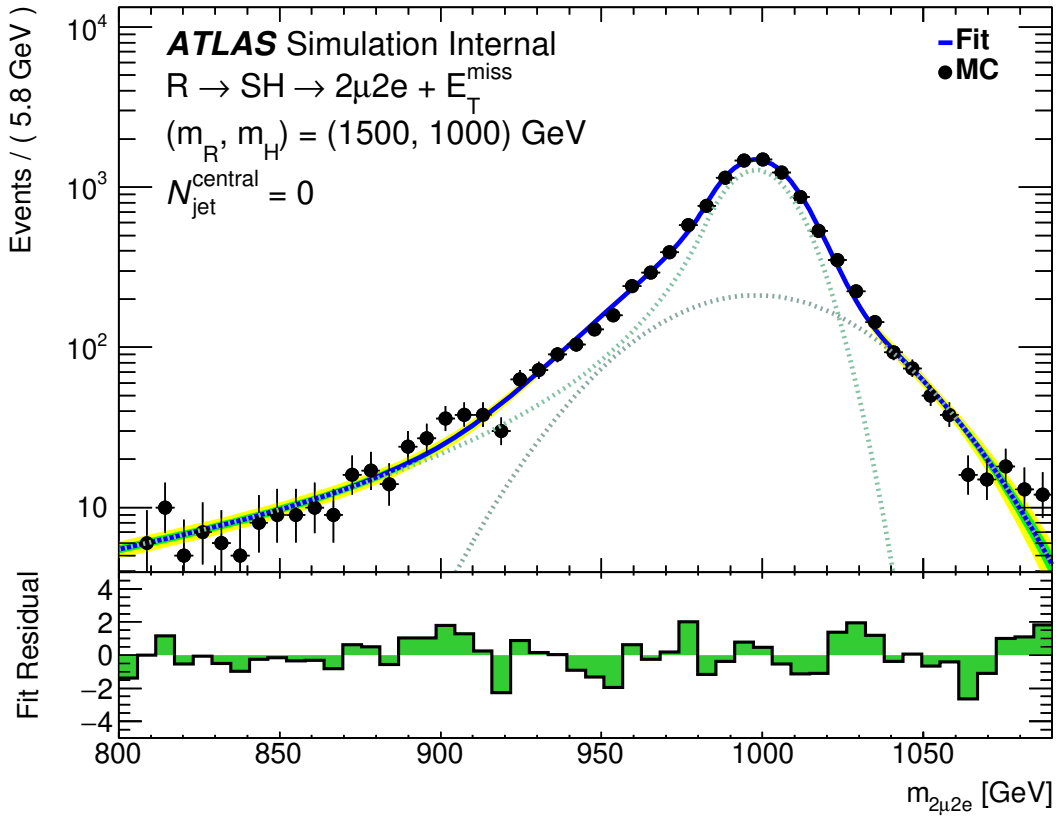
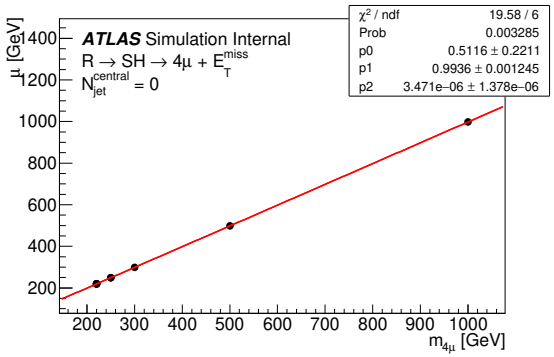
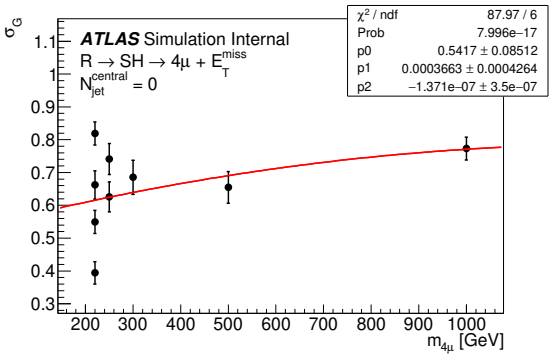
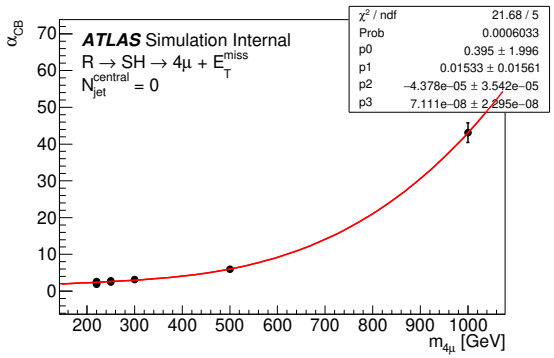


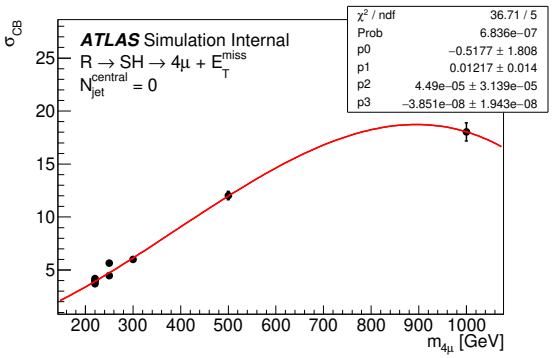
Interpolation of μ, f_C, σ_G, σ_C and α_C parameters

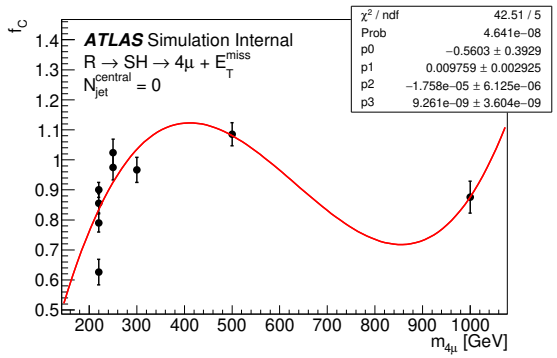
4μ-channel





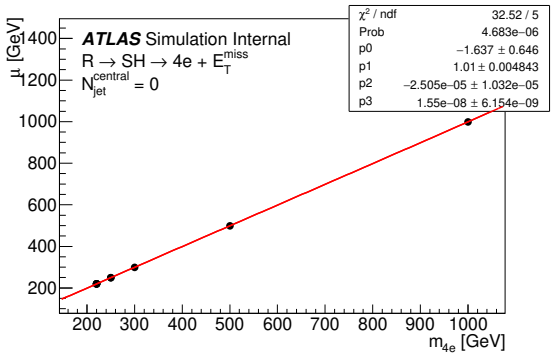


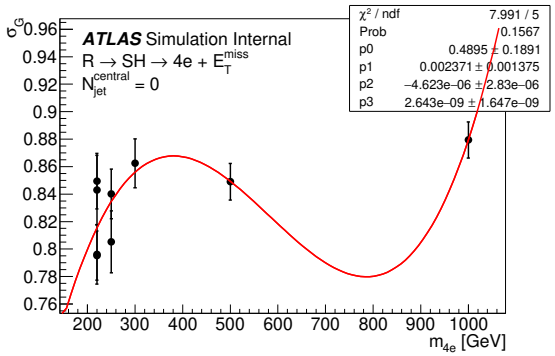


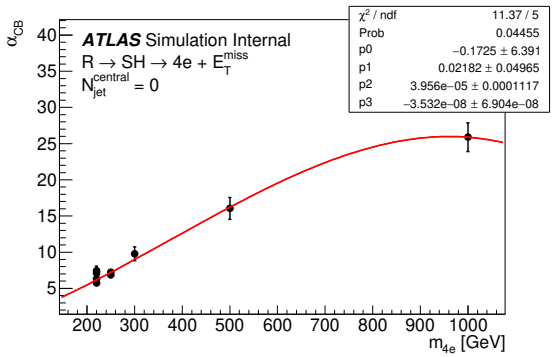


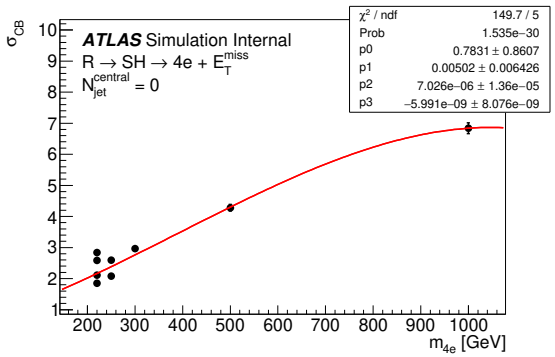
Interpolation of μ, f_C, σ_G, σ_C and α_C parameters

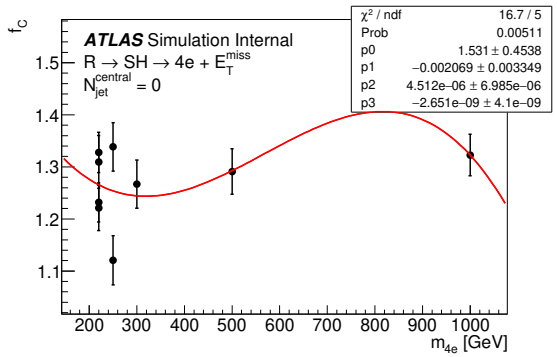
4e-channel



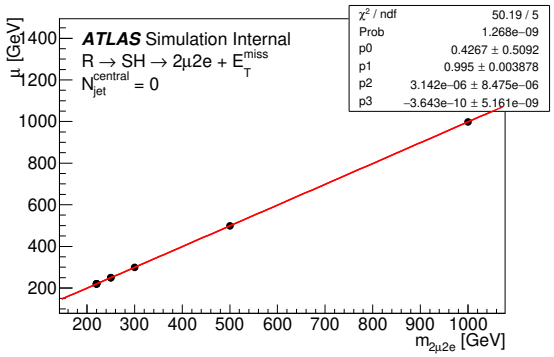


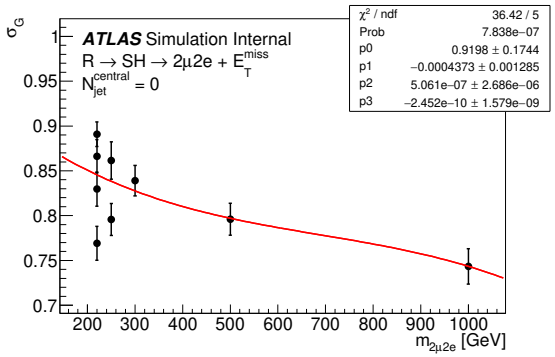


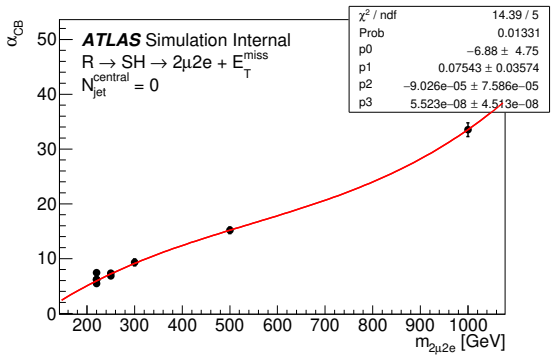


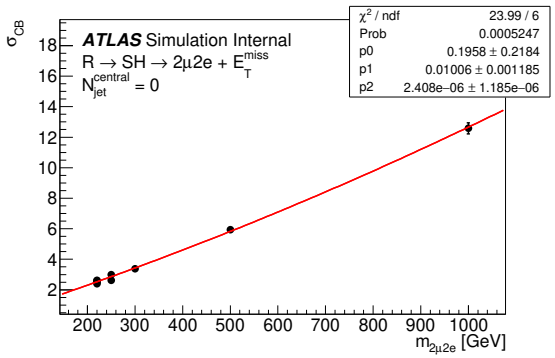


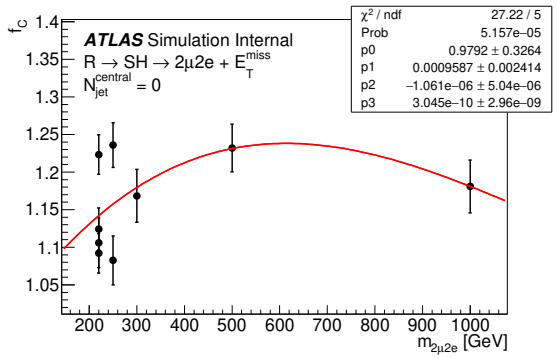
Interpolation of μ, f_C, σ_G, σ_C and α_C parameters
$2\mu 2e$-channel





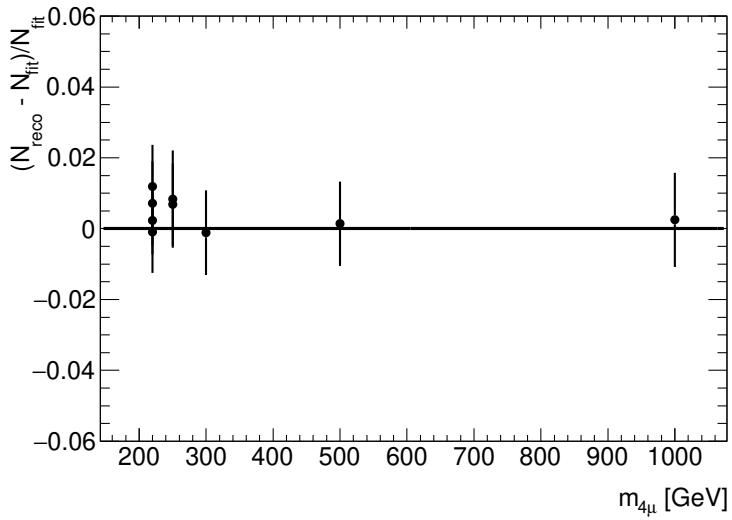


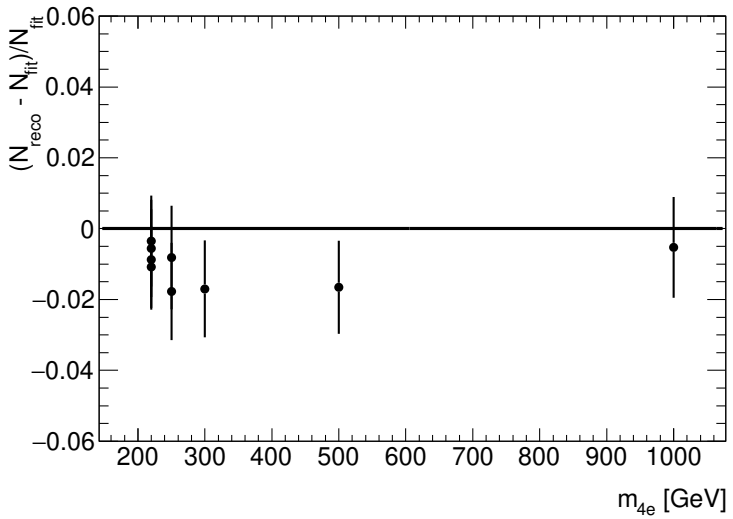


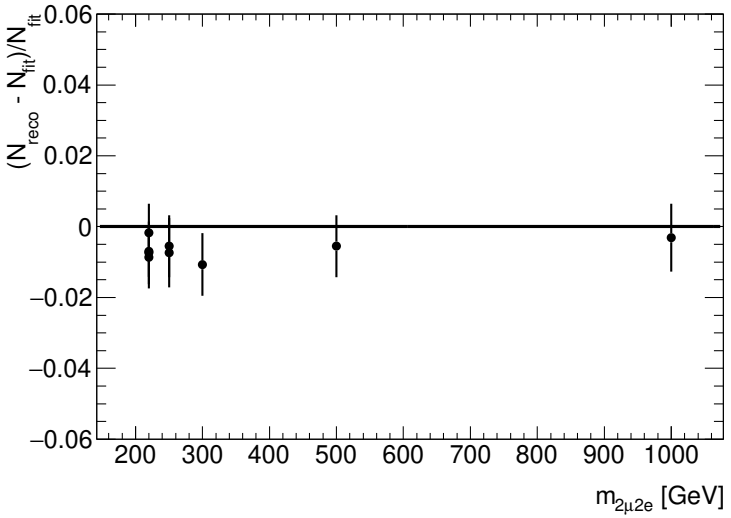


Study the bias inducted by the signal extraction

Zero central jet category

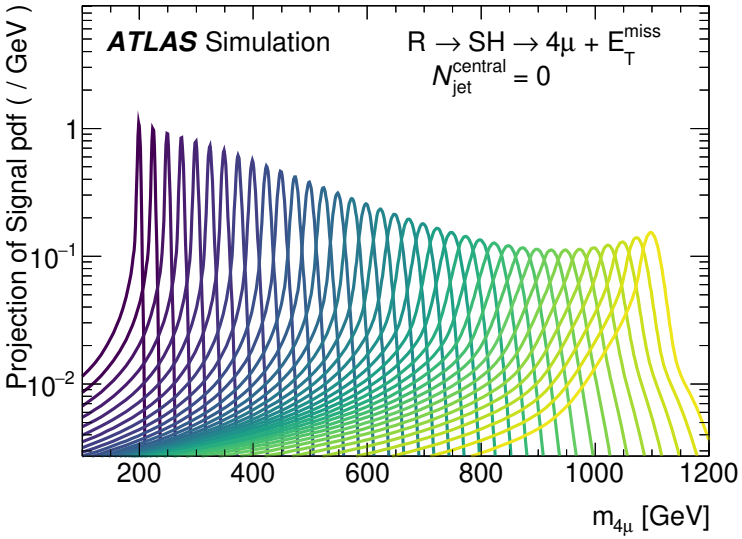


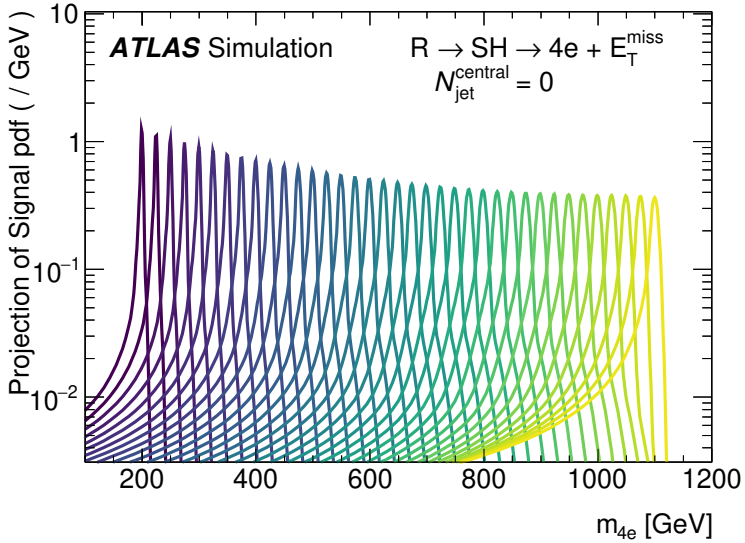


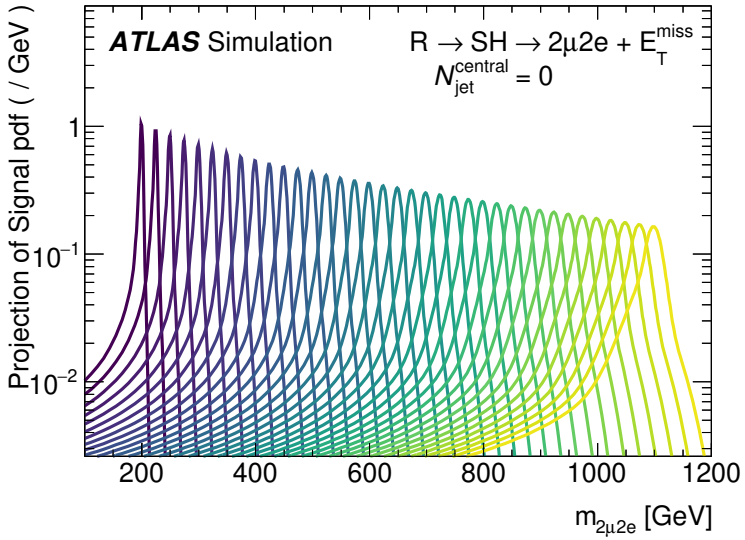


The final signal shapes, interpolated from the polynomial fit parameters

Zero central jet category

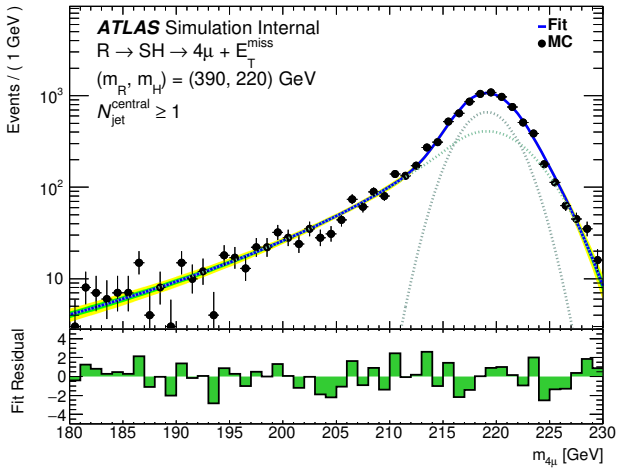


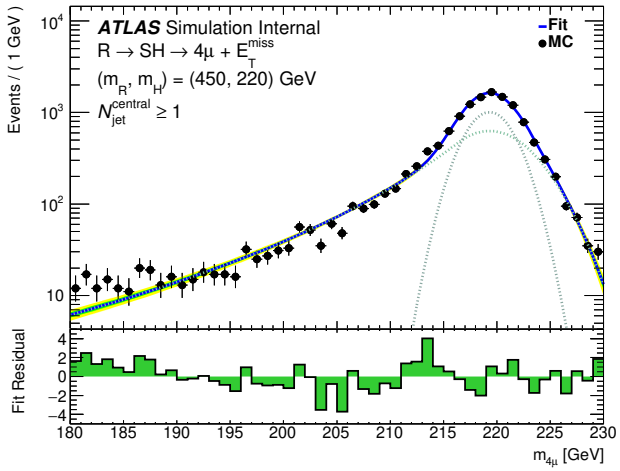


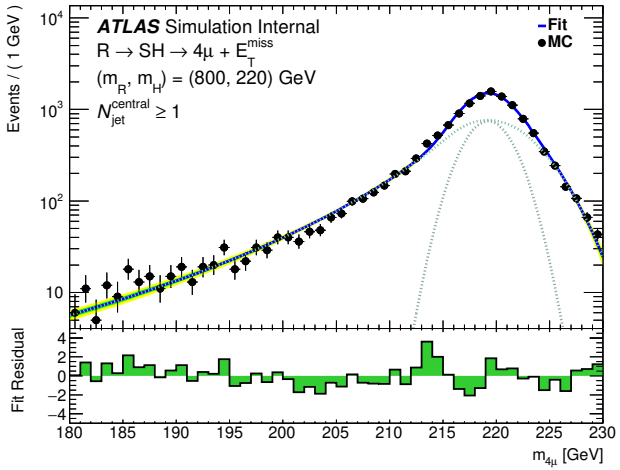


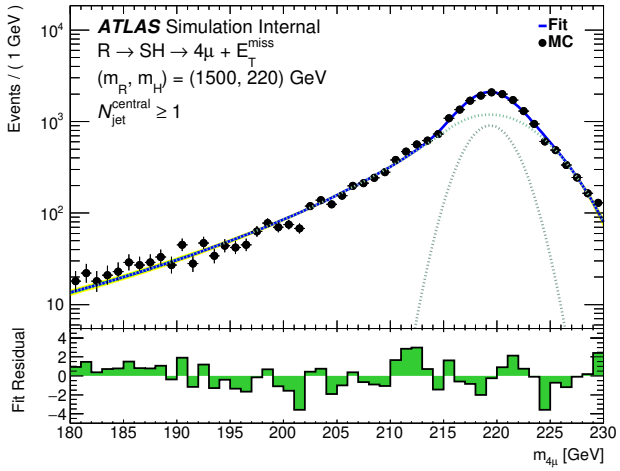
At least one central jet category

4μ-channel



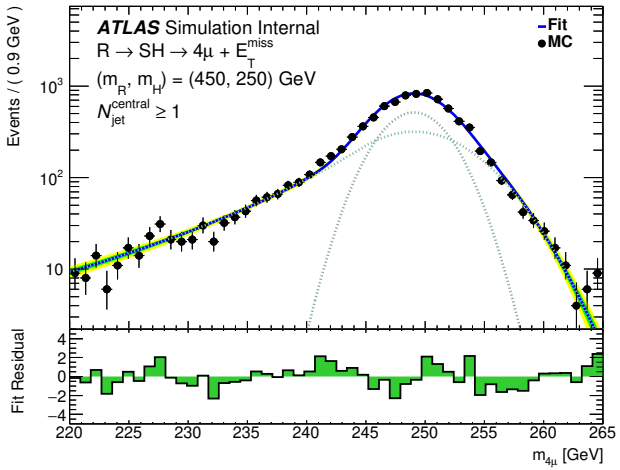


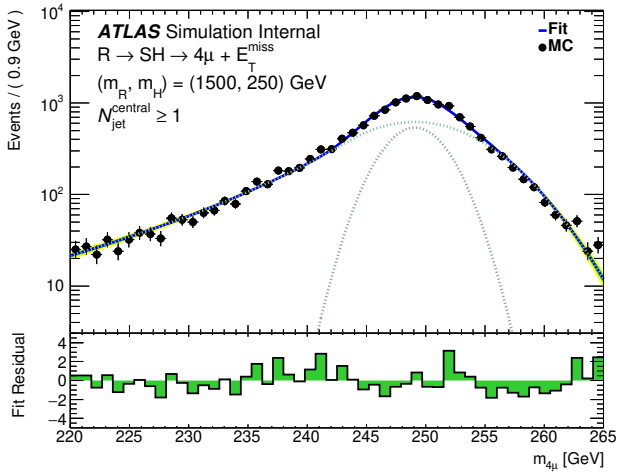


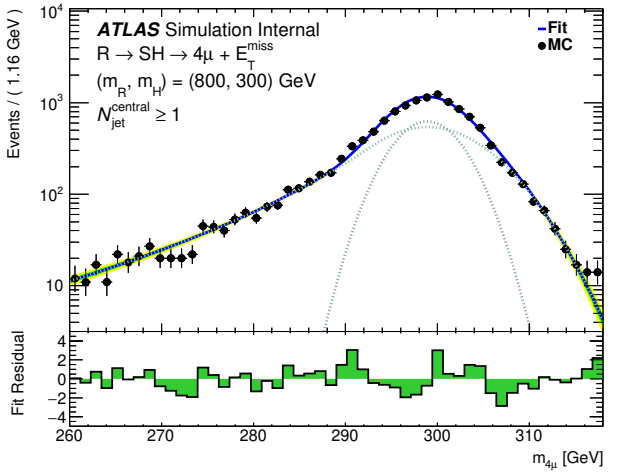


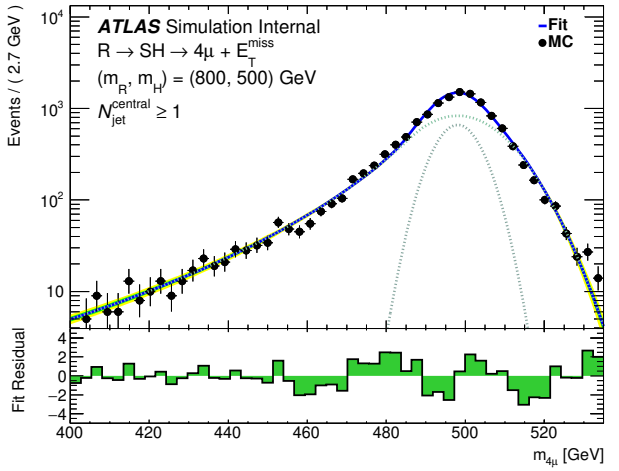
At least one central jet category

4μ-channel



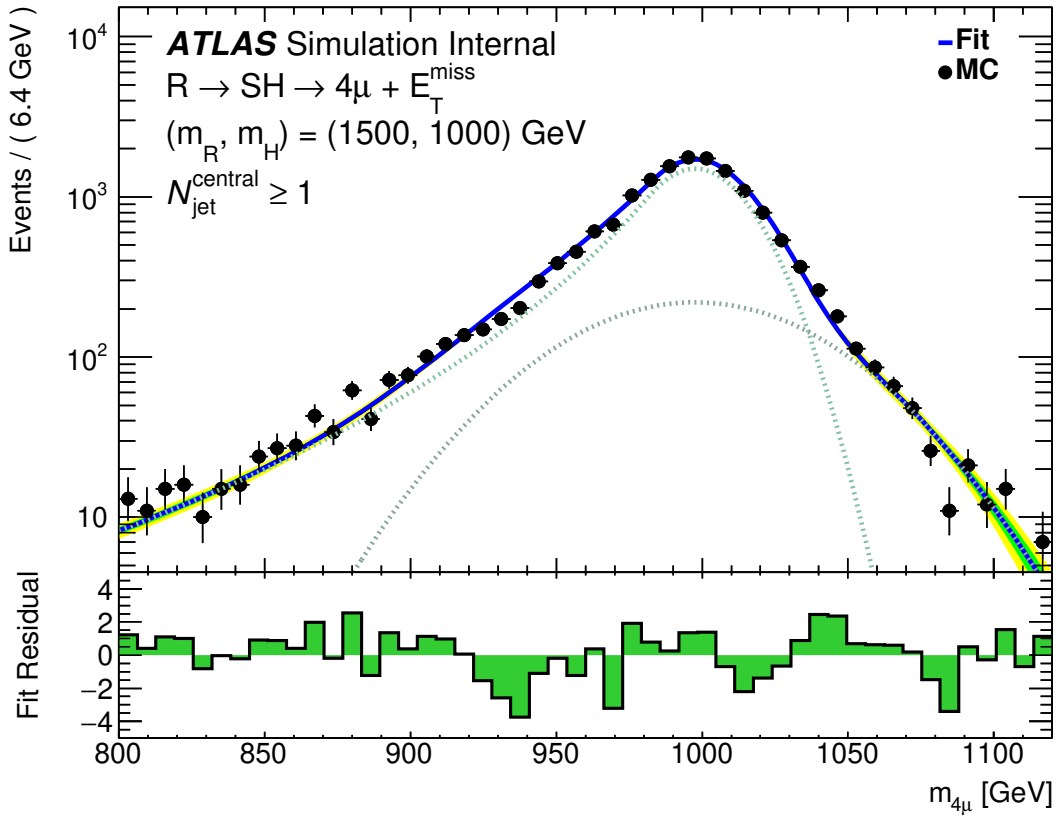






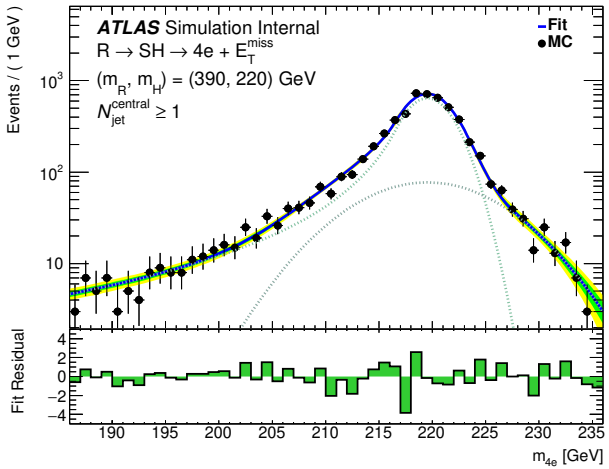
At least one central jet category

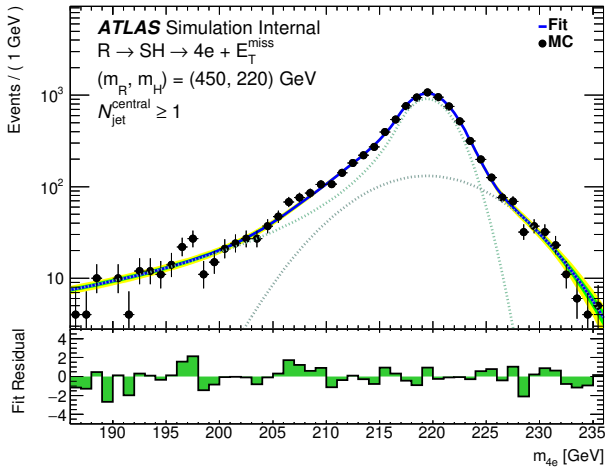
4μ-channel

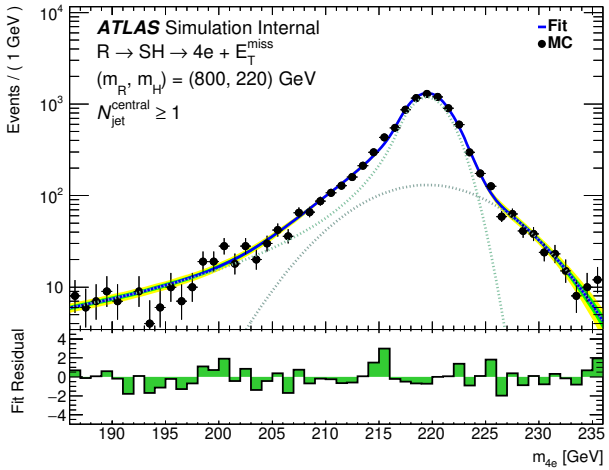


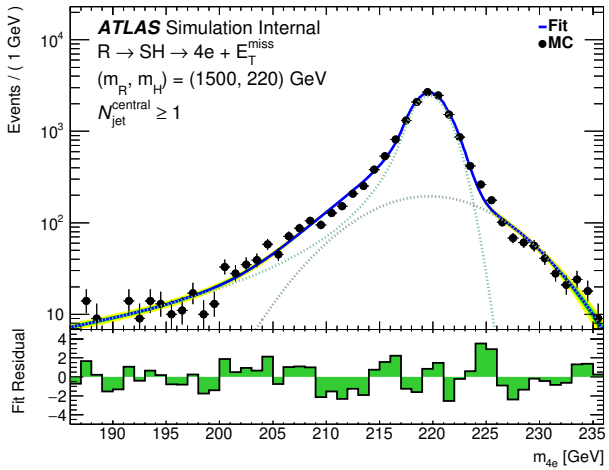
At least one central jet category

4*e*-channel



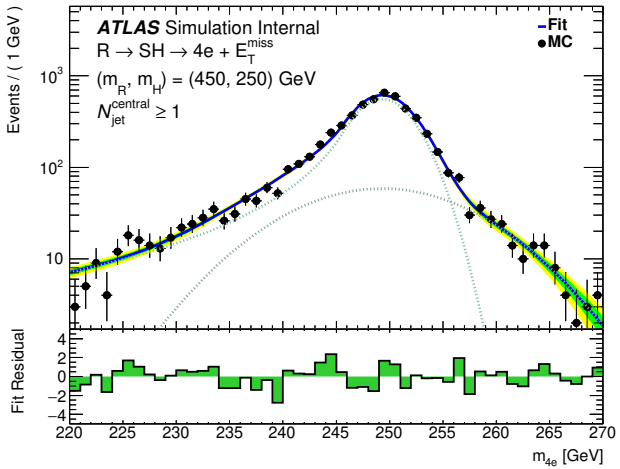


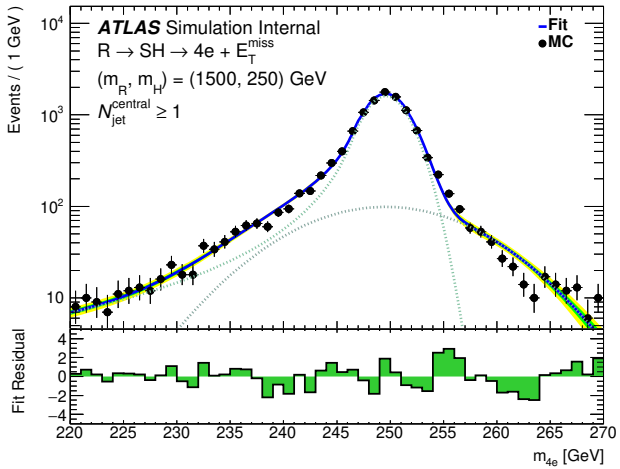


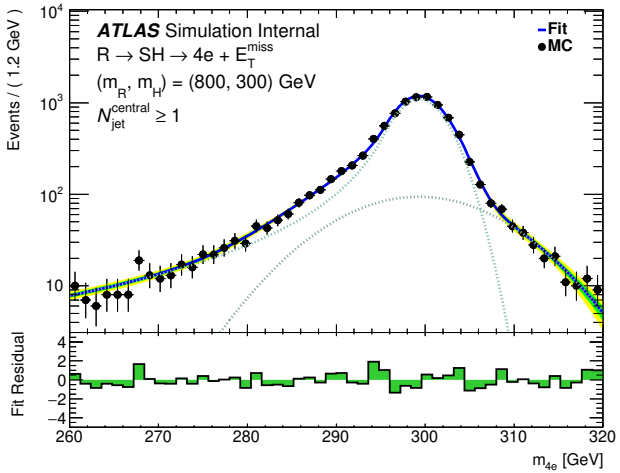


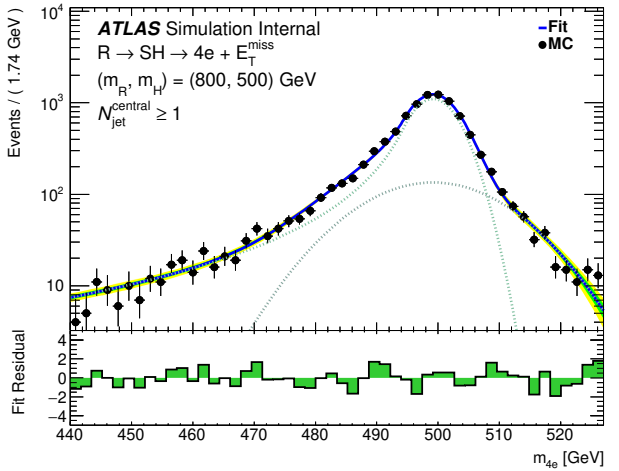
At least one central jet category

4*e*-channel



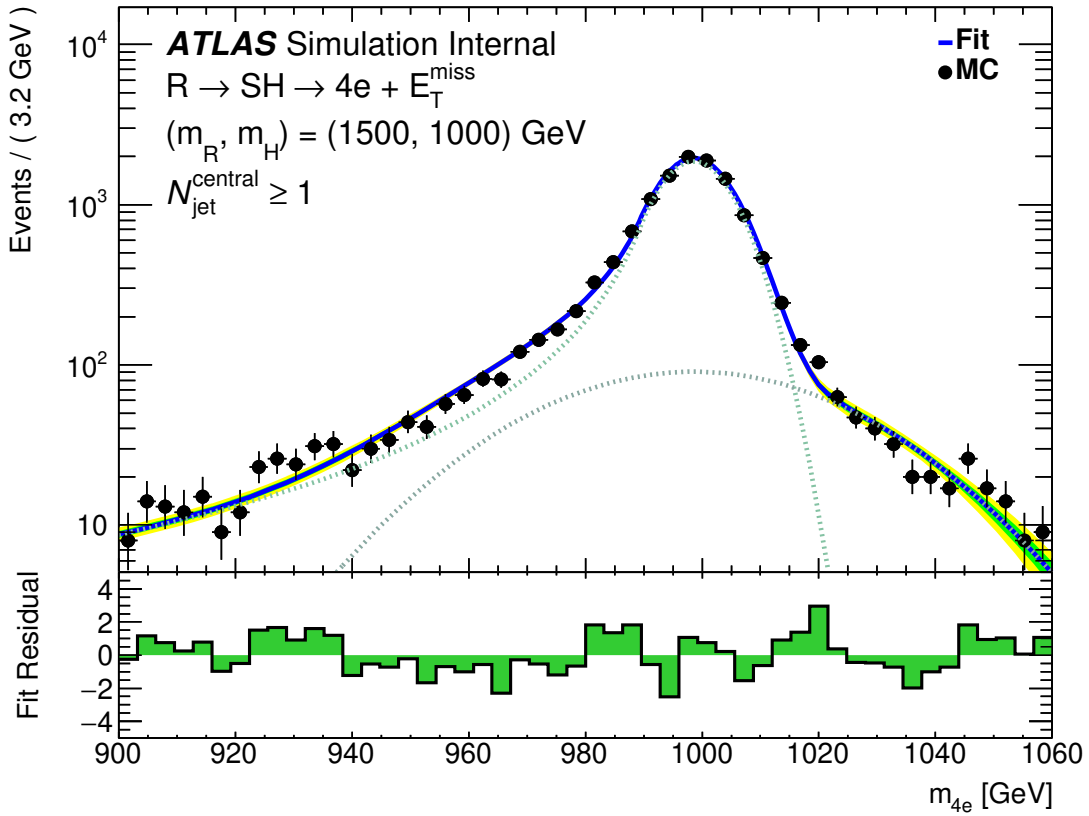






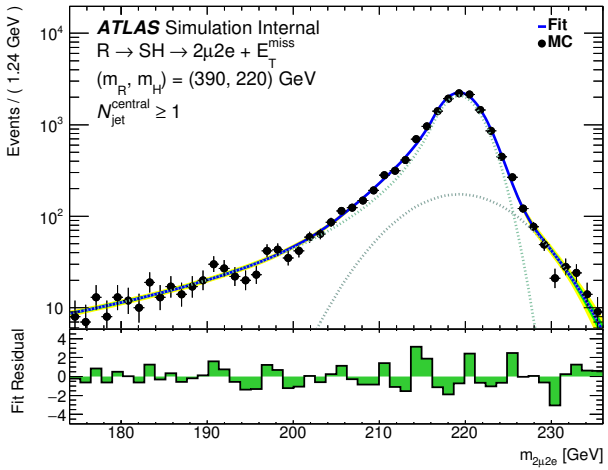
At least one central jet category

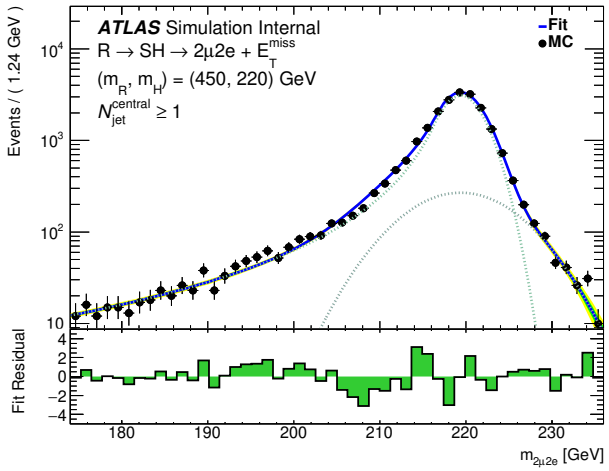
4*e*-channel

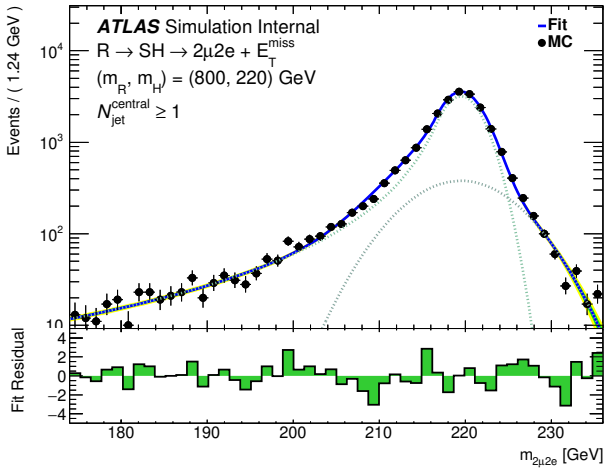


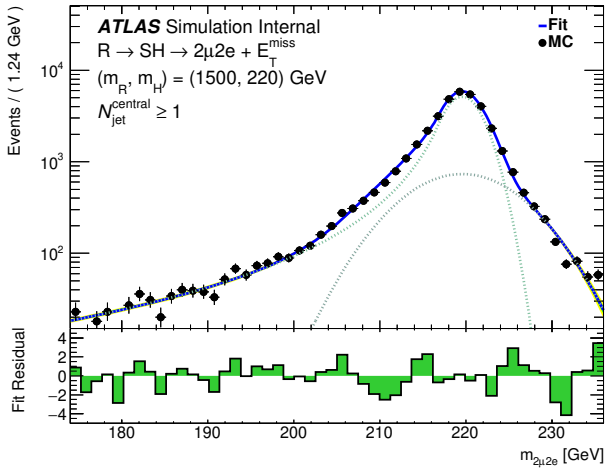
At least one central jet category

$2\mu 2e$-channel



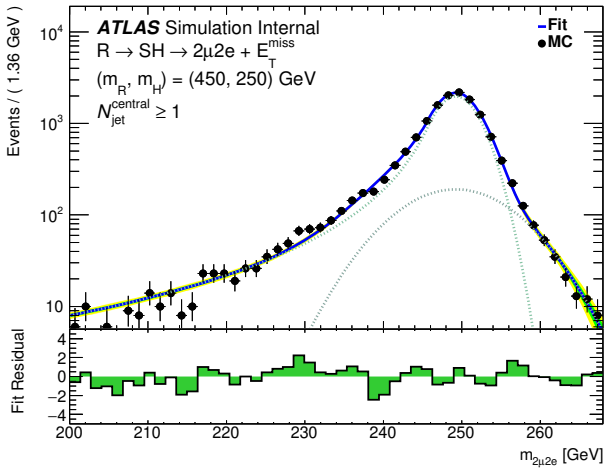


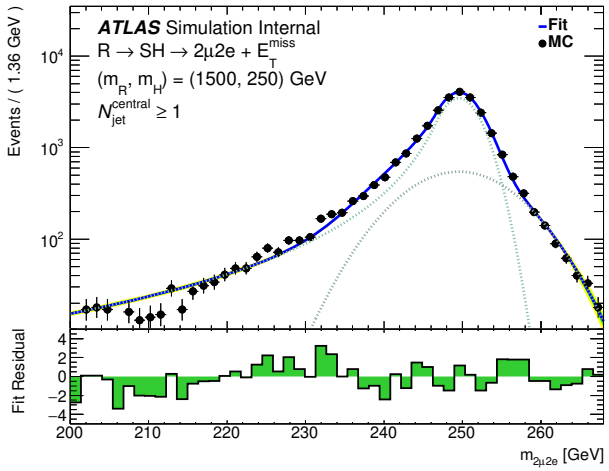


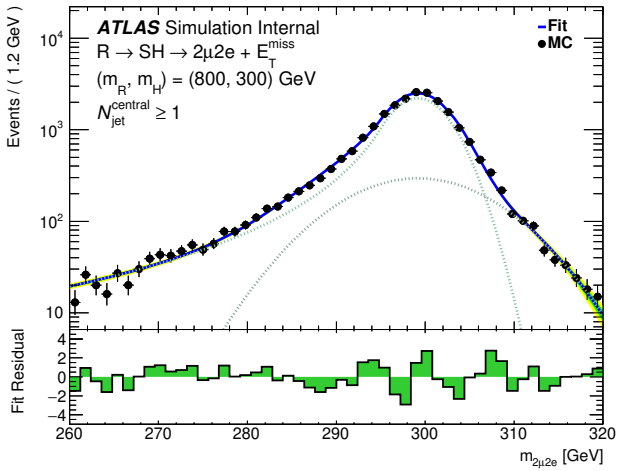


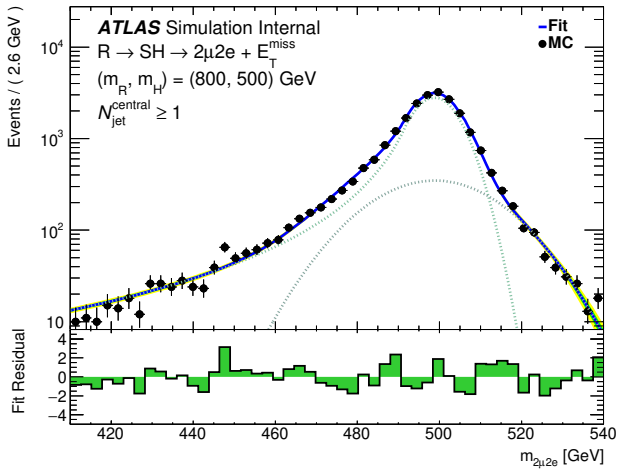
At least one central jet category

$2\mu 2e$-channel



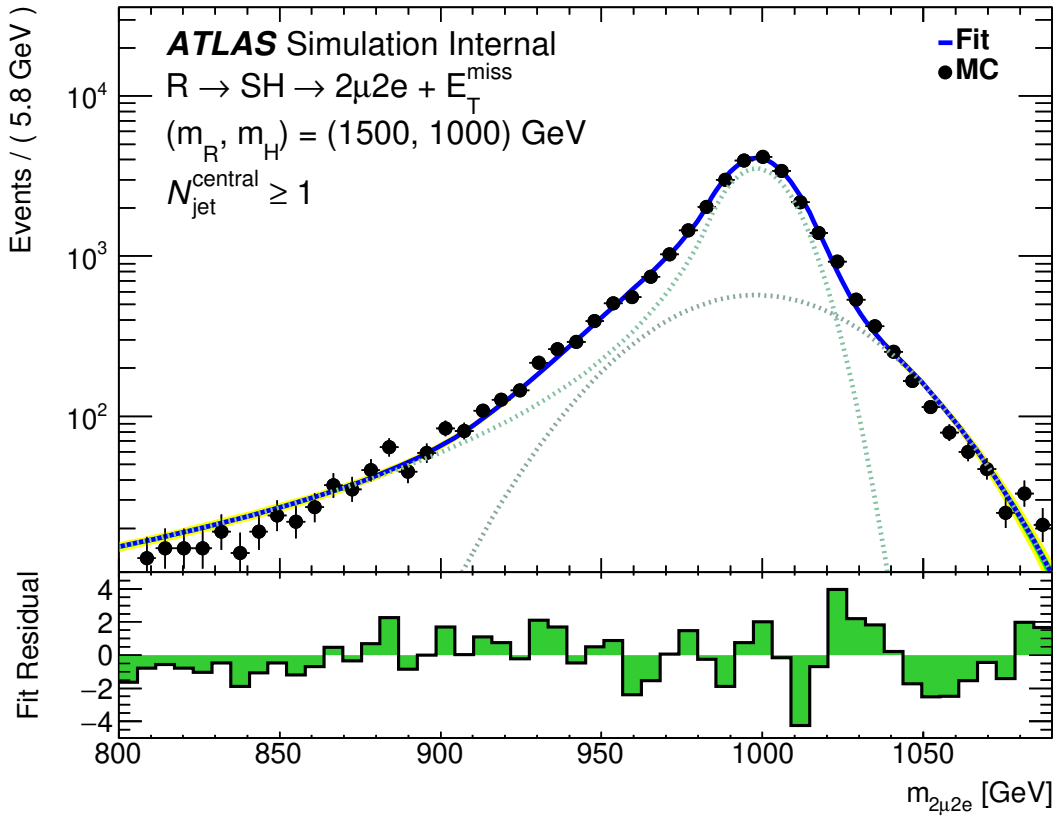






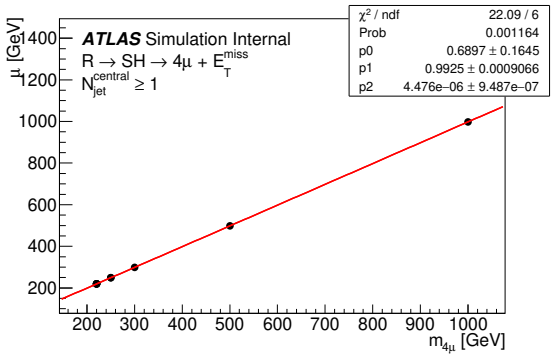
At least one central jet category

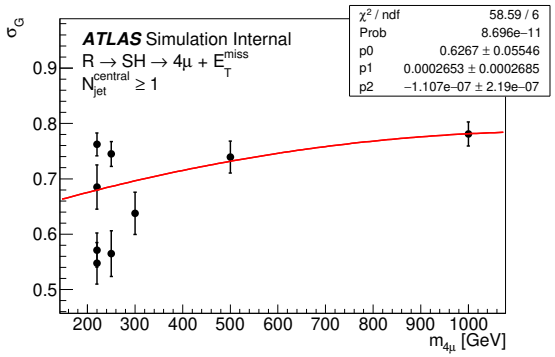
$2\mu 2e$-channel

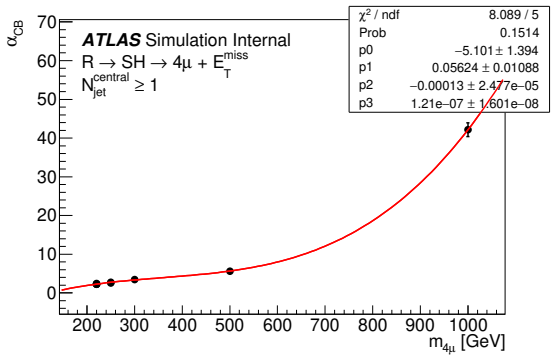


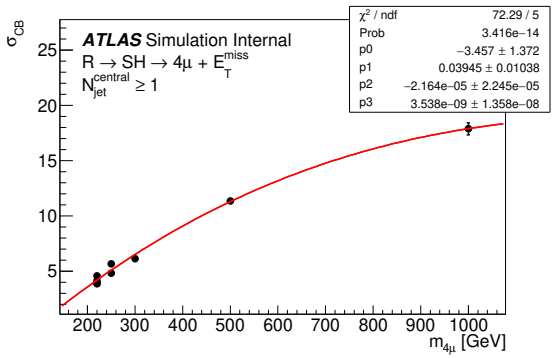
Interpolation of μ, f_C, σ_G, σ_C and α_C parameters

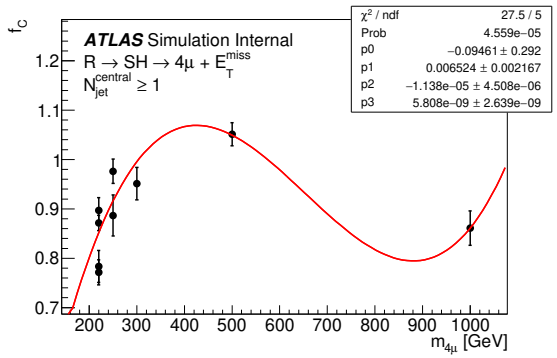
4μ-channel



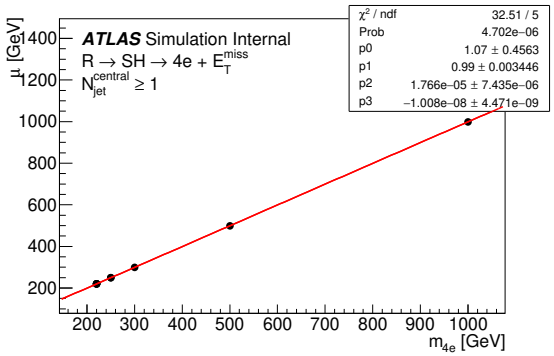


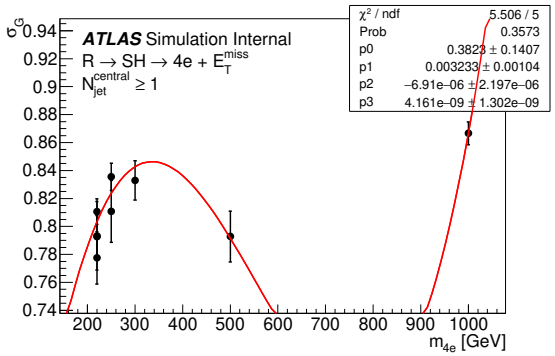


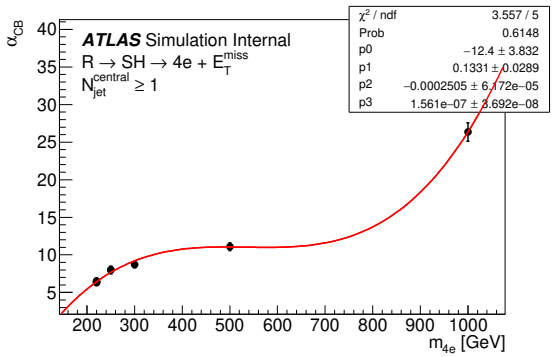


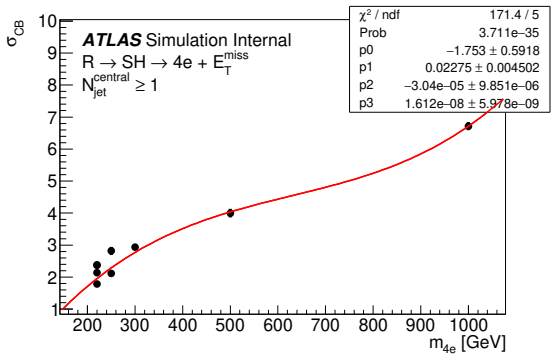


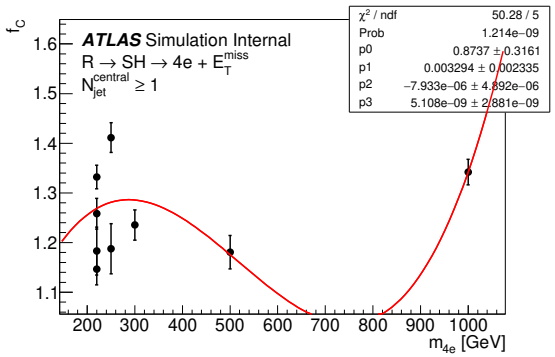
Interpolation of μ, f_C, σ_G, σ_C and α_C parameters
4e-channel



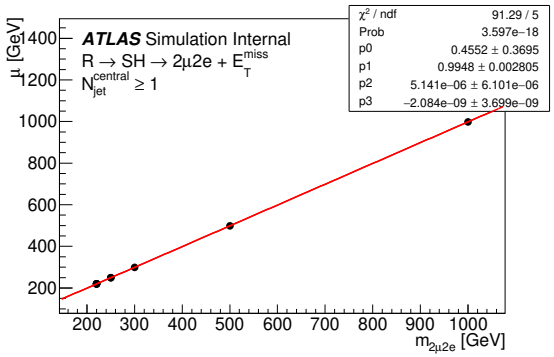


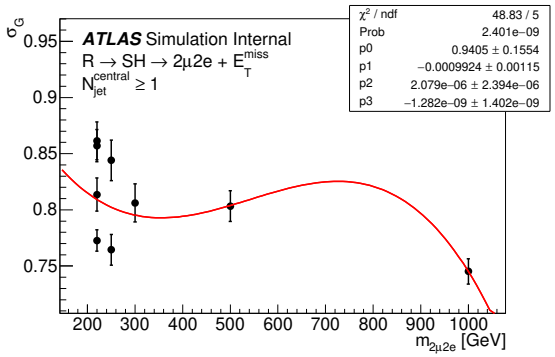


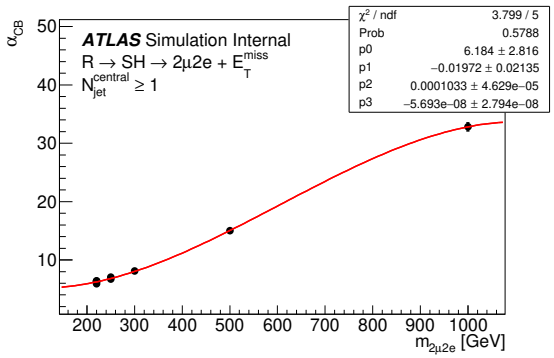


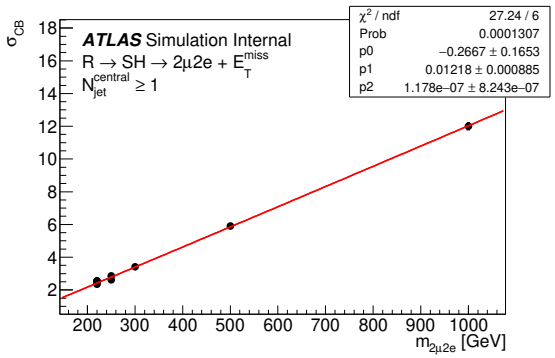


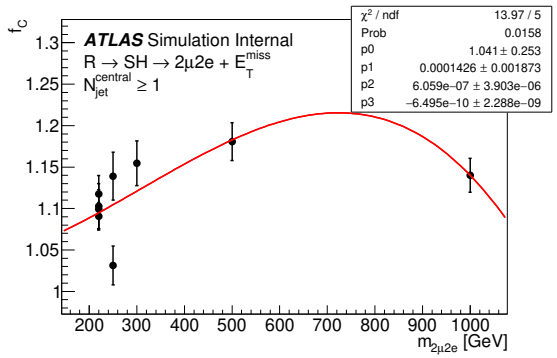
Interpolation of μ, f_C, σ_G, σ_C and α_C parameters
$2\mu 2e$-channel





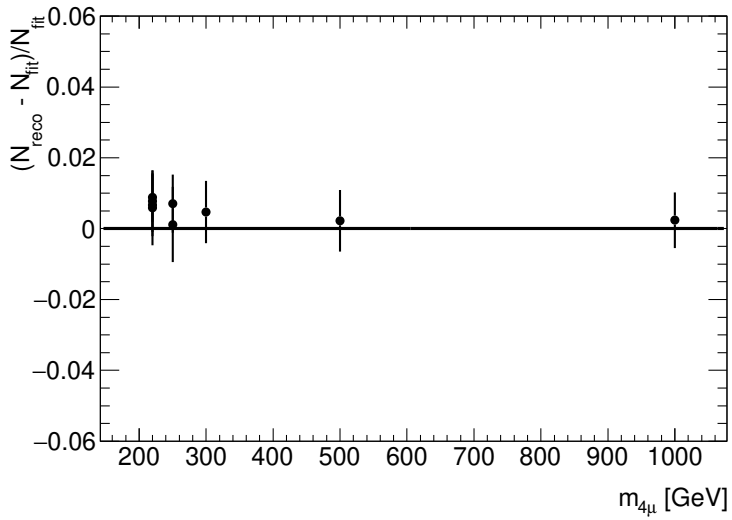


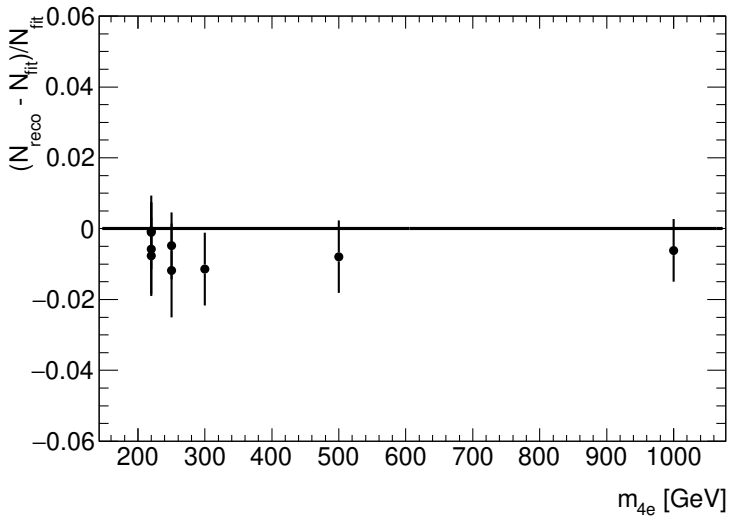


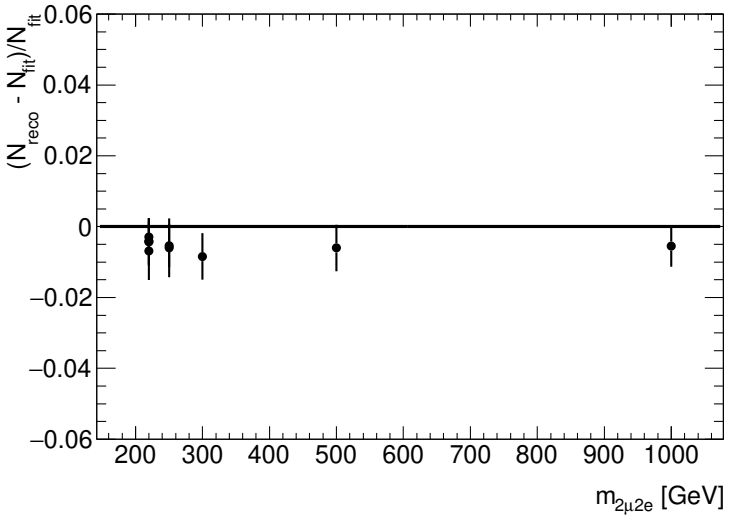


Study the bias inducted by the signal extraction

At least one central jet category

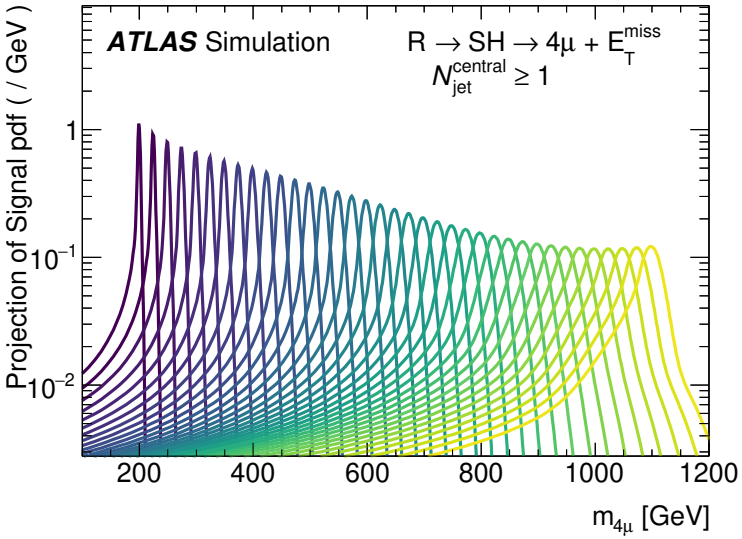


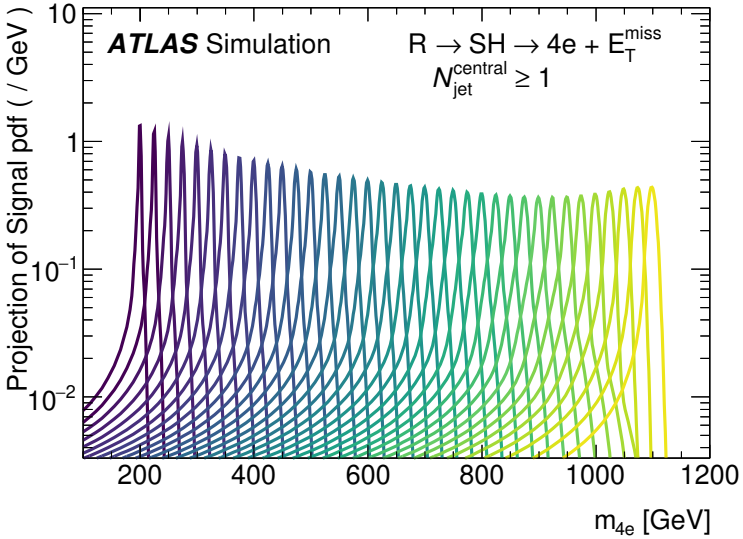


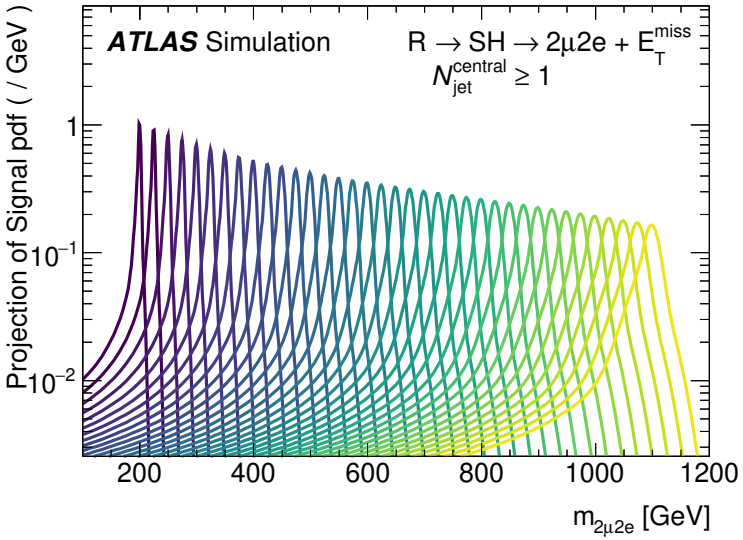


The final signal shapes, interpolated from the polynomial fit parameters

At least one central jet category







Summary

- A good fit quality is obtained in the whole mass points;
- The extraction of signal yields using the analytical function introduces about 1.5% bias;
- And can be included with the systematics uncertainty in the final fit.

Thank you!

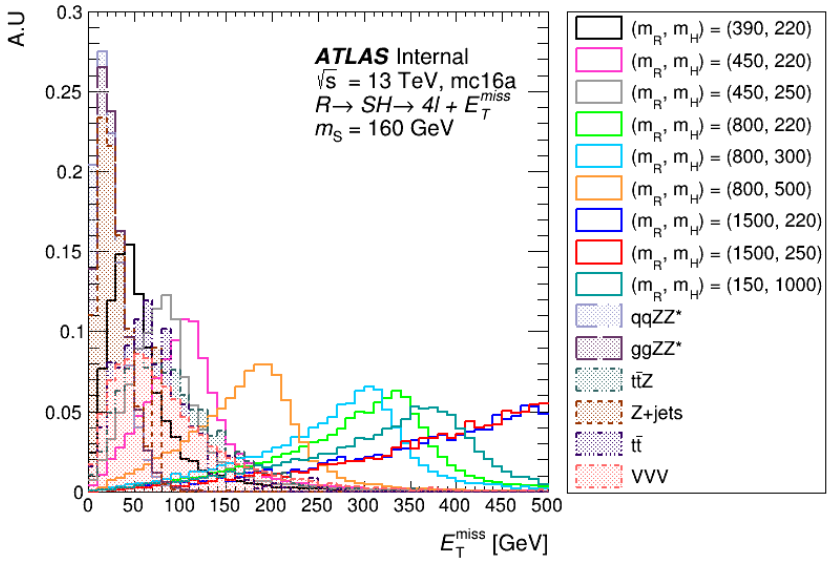
Signal samples have already been produced, JIRA, as follows:

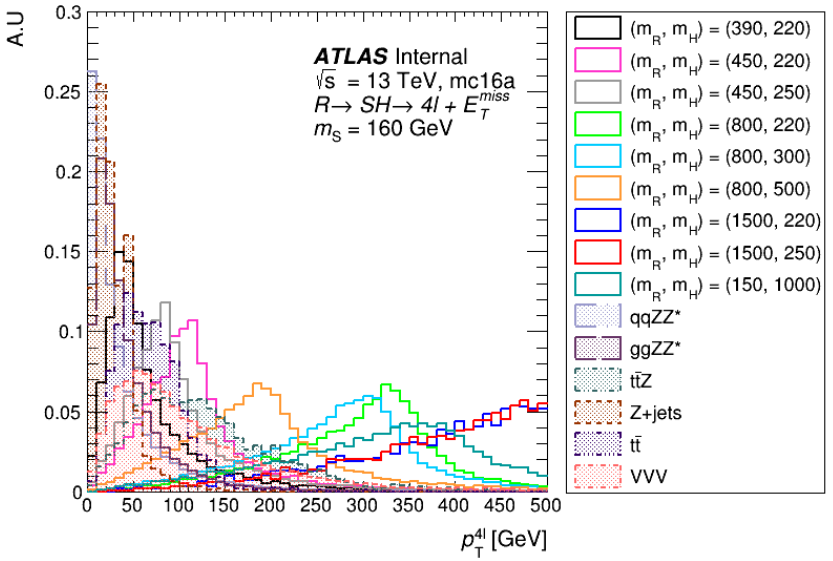
- The mass of S is fixed to 160 GeV;
- The masses of R are 390 GeV, 450 GeV, 800 GeV and 1500 GeV:
  - $m_R = 390$ GeV: $m_H = 220$ GeV
  - $m_R = 450$ GeV: $m_H = 220$ GeV and 250 GeV
  - $m_R = 800$ GeV: $m_H = 220$ GeV, 300 GeV and 500 GeV
  - $m_R = 1500$ GeV:$m_H = 220$ GeV, 250 GeV and 1000 GeV
- Requested HIGG2D1 derivation with cache: 21.2.55 and p-tag: p3782. All jobs are finished see here; and
- The mini-tree production is done using HZZAnalRun2Code.

Background samples

- $qqZZ^*$, $ggZZ^*$, $t\bar{t}Z$, $Z + jets$, $t\bar{t}$ and VVV.

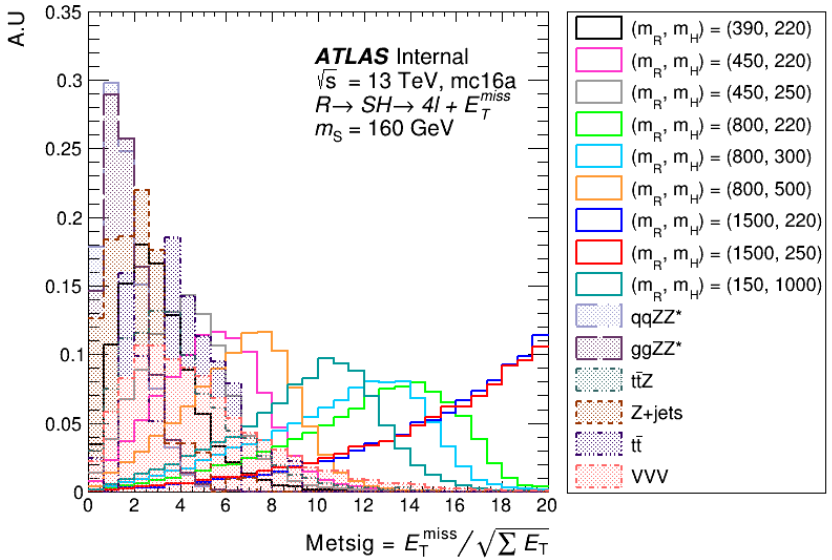
Additional slides
RSH-signal optimisation

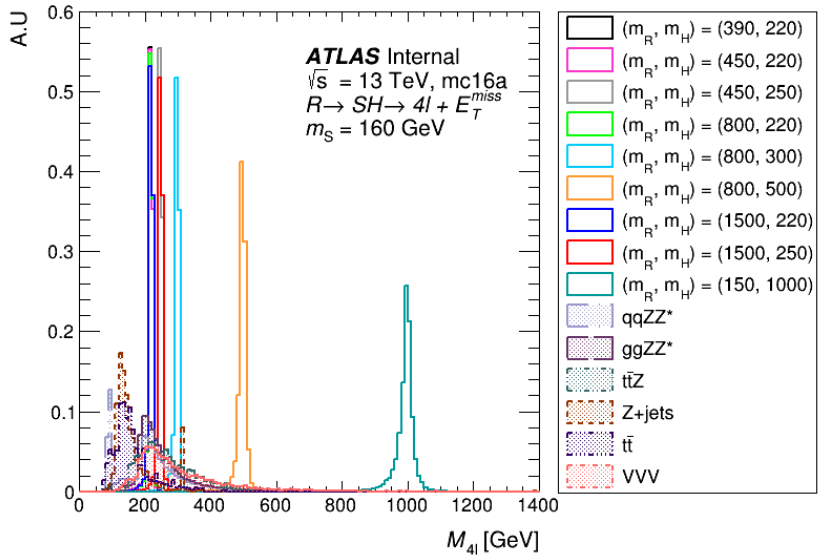




Optimise the $m_{4\ell}$ of the RSH-signal by doing 2D scan of $p_{\mathrm{T}}^{4\ell}$ and $E_{\mathrm{T}}^{\mathrm{miss}}$, and select the cut that gives maximum significance.

Additional slides
RSH-signal optimisation





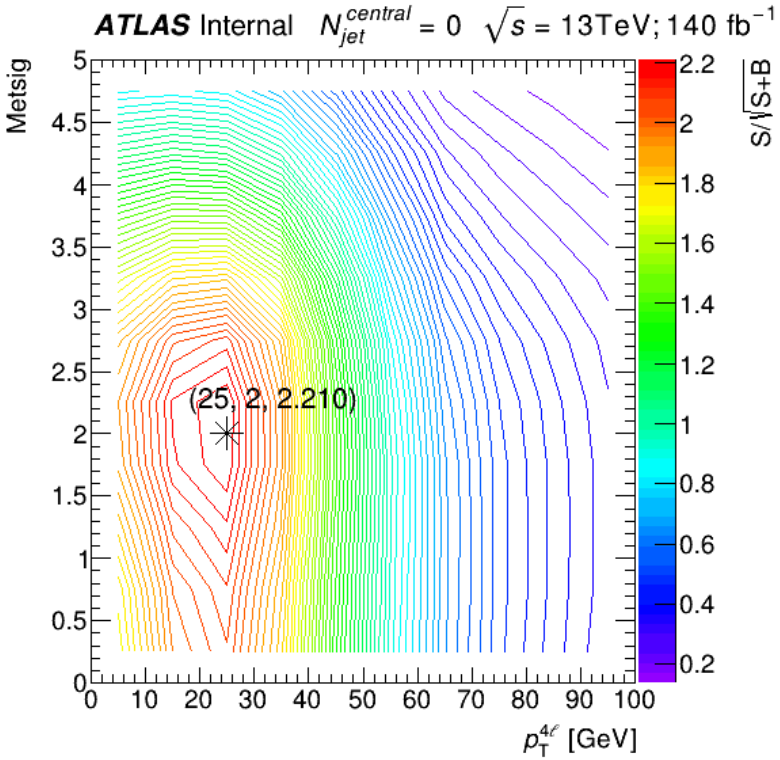
Optimise the $m_{4\ell}$ of the RSH-signal by doing 2D scan of $p_{\mathrm{T}}^{4\ell}$ and Metsig, and select the cut that gives maximum significance.

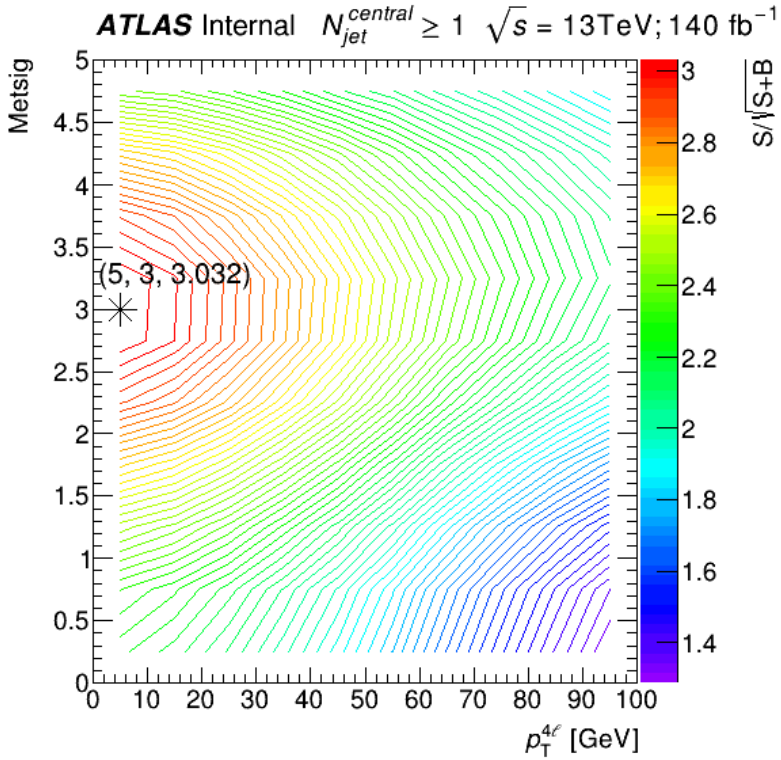
Additional slides
RSH-signal optimisation

- Signal and background are mc16a, mc16d and mc16e combined;
- The signal cross section (xsection$\times$BR) is 1 fb^{-1} (set by hand);
- The significance is calculated using $S/\sqrt{S+B}$ and $S/\sqrt{B}$;
- S, and B are the signal and background event, respectively;
- Background events are normalised to cross section for the $m_{4\ell} > 200$ GeV;
- Scaling background events by 20.3% uncertainty. It's calculated as follow:

The background scaled by a number extracted as follows: For instance, for $m_H = 220$, and $m_R = 390$: events in $m_{4\ell}(210 - 230)$ GeV over the full range of $m_{4\ell}(> 200)$ GeV.

Additional slides
2D mapping of $p_{\mathrm{T}}^{4\ell}$ and Metsig

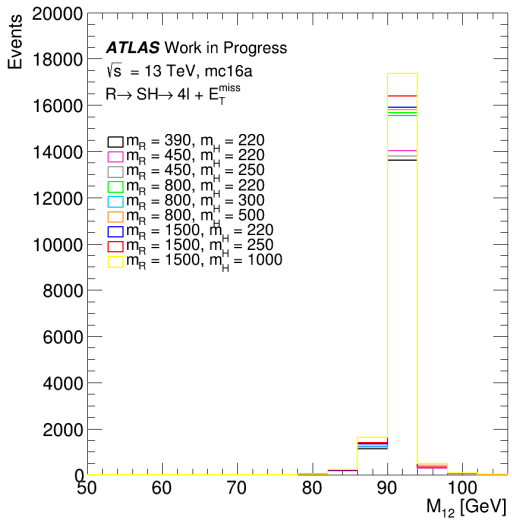


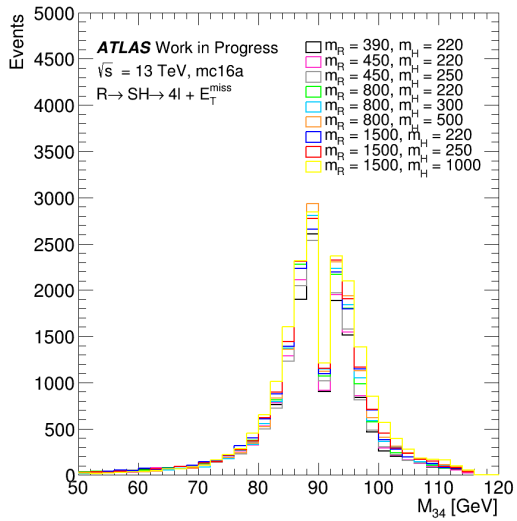


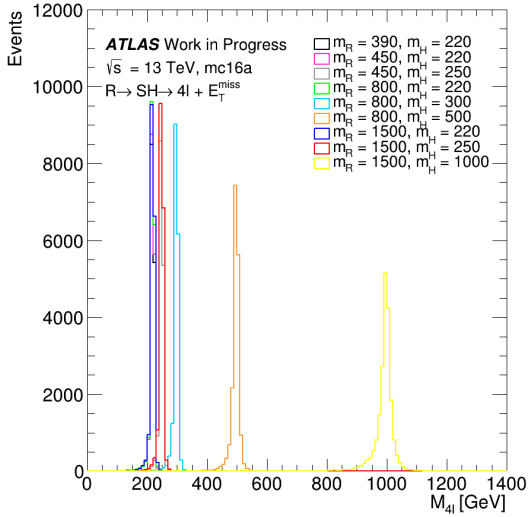
Additional slides

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: - p_T thresholds for three leading leptons in the quadruplet: 20, 15 and 10 GeV - At most 1 calo-tagged, stand-alone or silicon-associated muon per quadruplet - Leading di-lepton mass requirement: $50 < m_{12} < 106$ GeV - Sub-leading di-lepton mass requirement: $m_{\text{threshold}} < m_{34} < 115$ GeV - $\Delta R(\ell, \ell') > 0.10$ for all lepton pairs in the quadruplet - Remove quadruplet if alternative same-flavour opposite-charge di-lepton gives $m_{\ell\ell} < 5$ GeV - Keep all quadruplets passing the above selection
Isolation Needs updating	- Contribution from the other leptons of the quadruplet is subtracted - Muon track isolation ($\Delta R = 0.30$): $\Sigma p_T / p_T < 0.15$ - Muon calorimeter isolation ($\Delta R = 0.20$): $\Sigma E_T / p_T < 0.30$ - Electron track isolation ($\Delta R = 0.20$) : $\Sigma E_T / E_T < 0.15$ - Electron calorimeter isolation ($\Delta R = 0.20$) : $\Sigma E_T / E_T < 0.20$
Impact Parameter Significance	- Apply impact parameter significance cut to all leptons of the quadruplet - For electrons: $d_0/\sigma_{d_0} < 5$ - 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: 4μ, $2e2\mu$, $2\mu2e$ and $4e$
Vertex Selection	- Require a common vertex for the leptons: - $\chi^2/\text{ndof} < 5$ for 4μ and < 9 for others decay channels

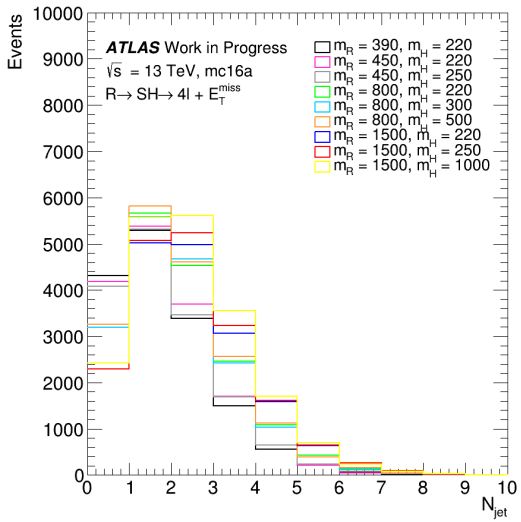
Additional slides
Kinematic distributions for the signal

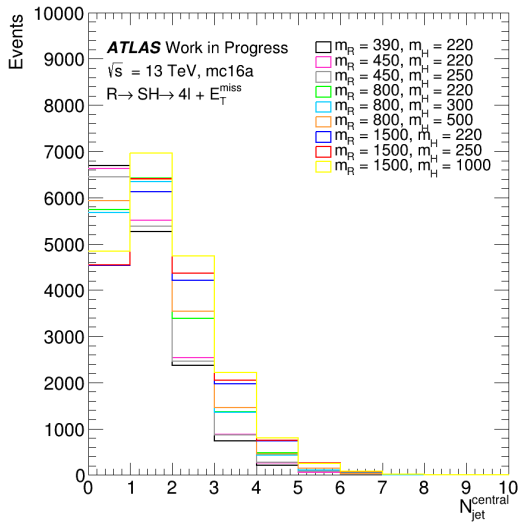


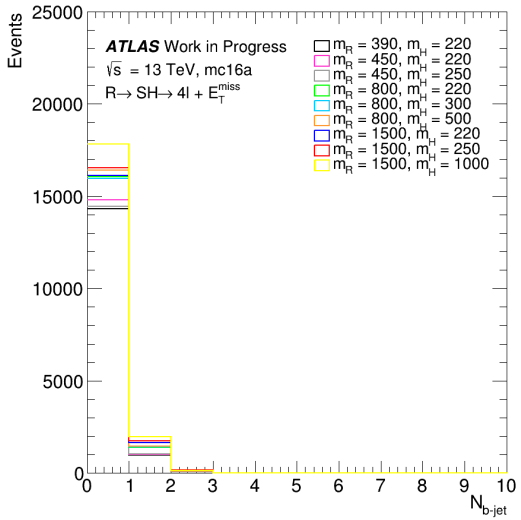




Additional slides
Kinematic distributions for the signal

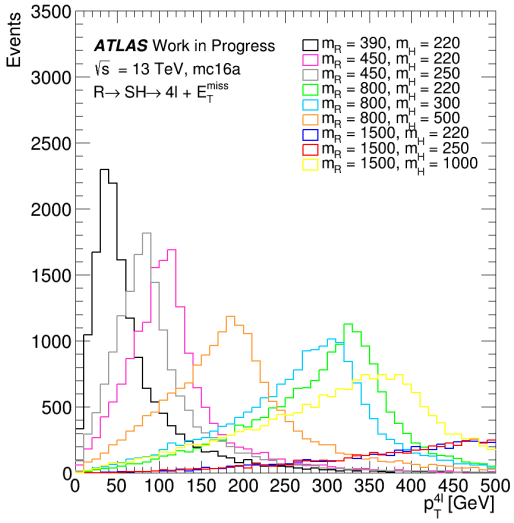


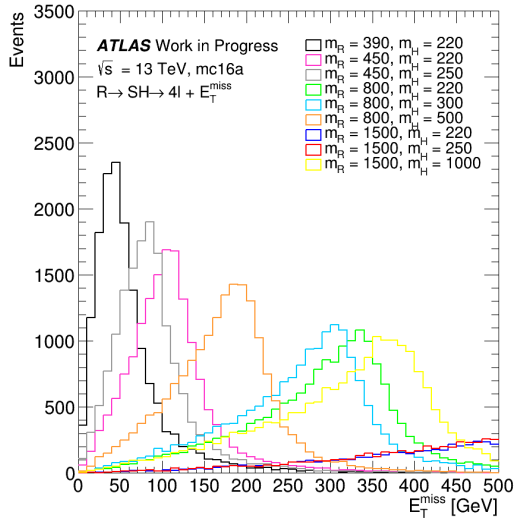


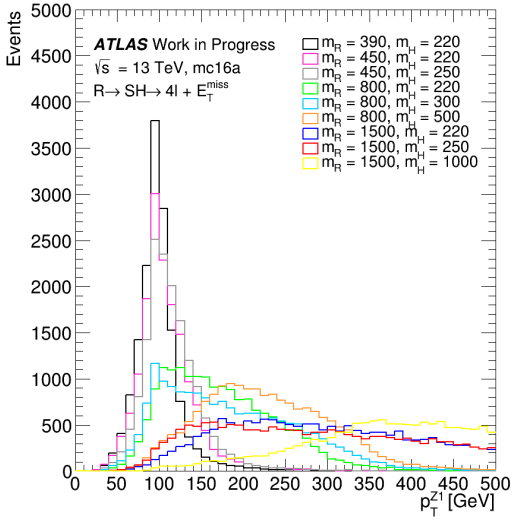


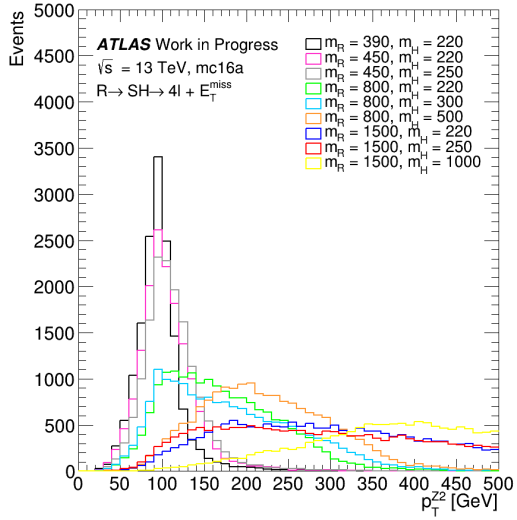
Additional slides

Kinematic distributions for the signal









Additional slides
Kinematic distributions for signal & background

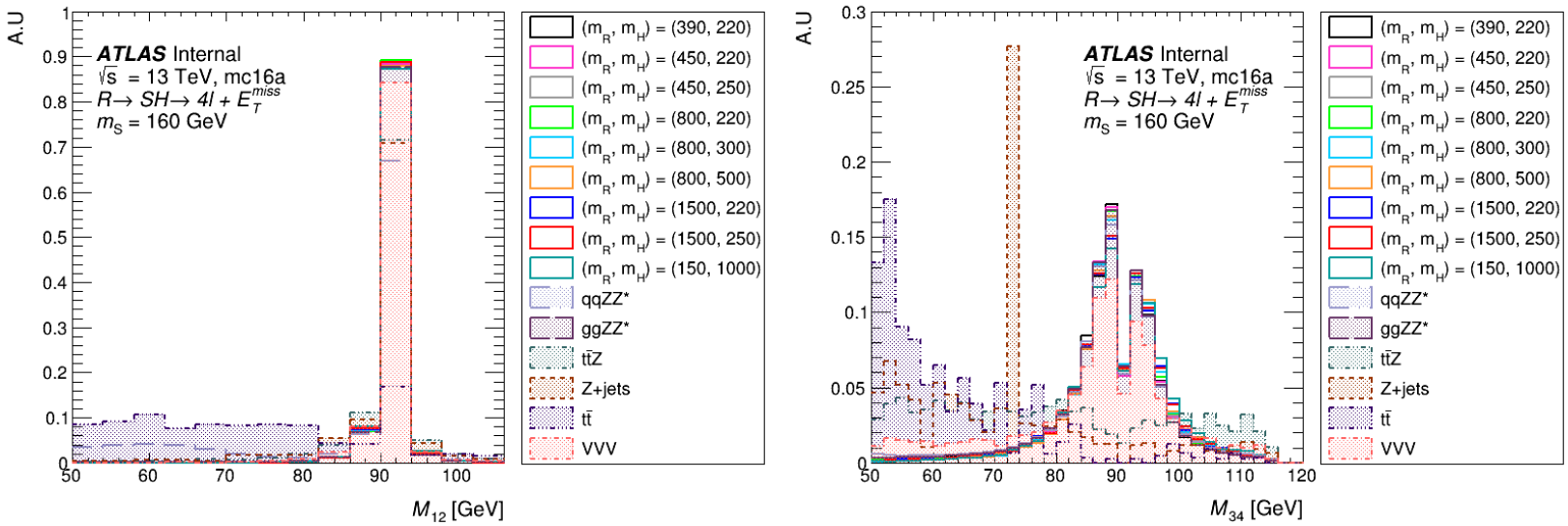


Figure: The invariant mass of the first (left) and the second (right) lepton pairs.

Additional slides
Kinematic distributions

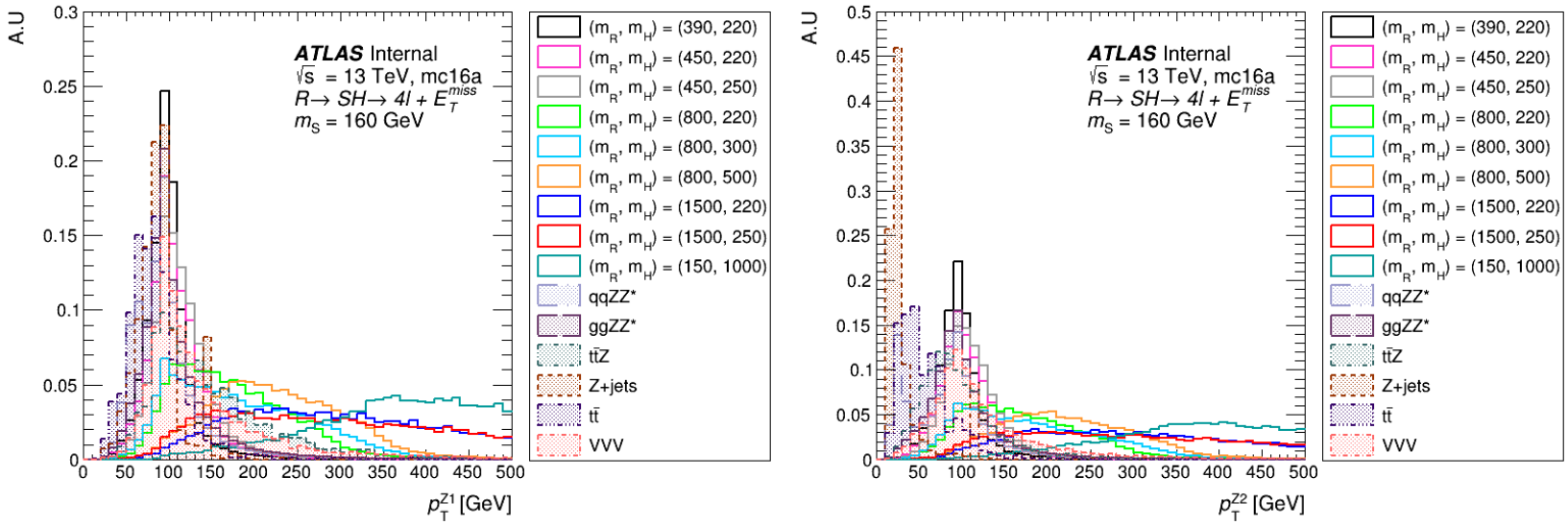
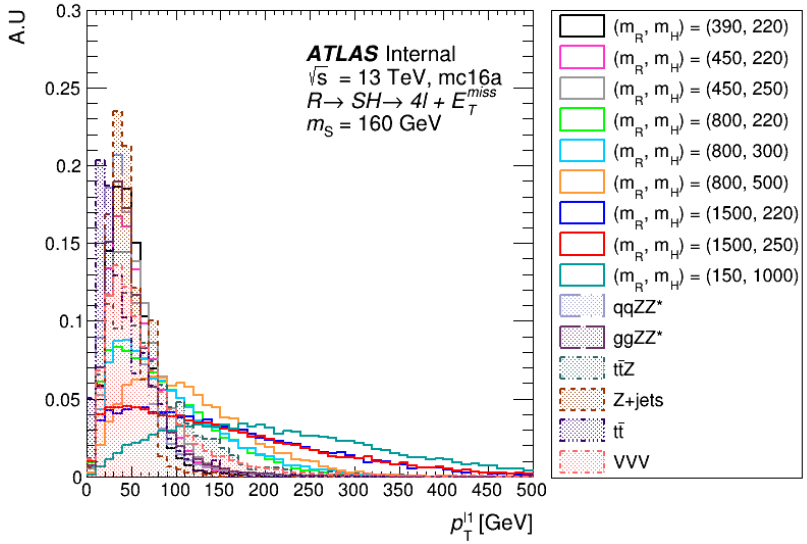
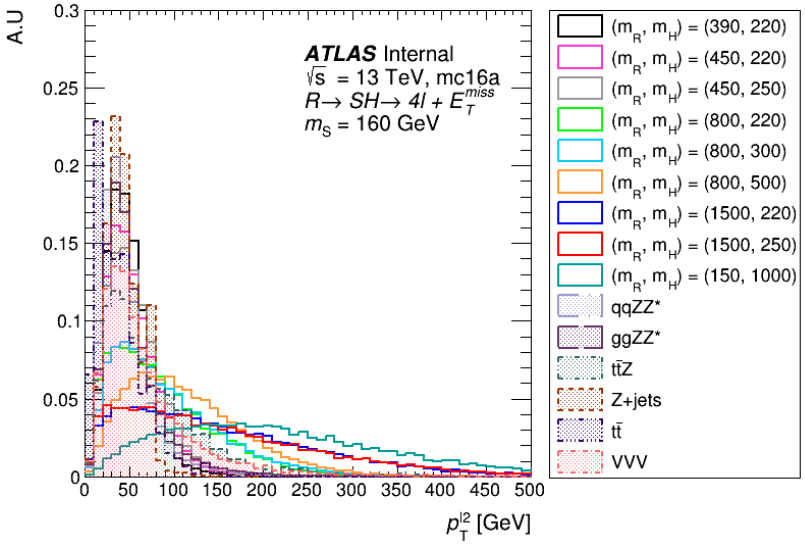
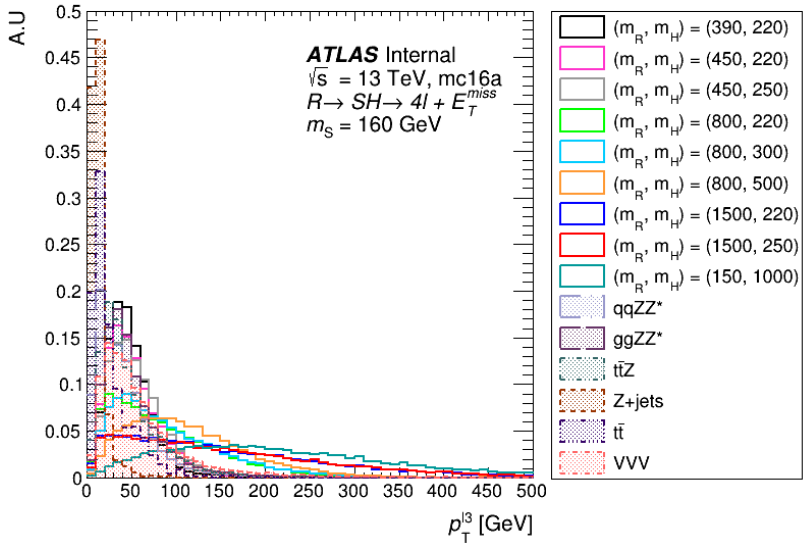


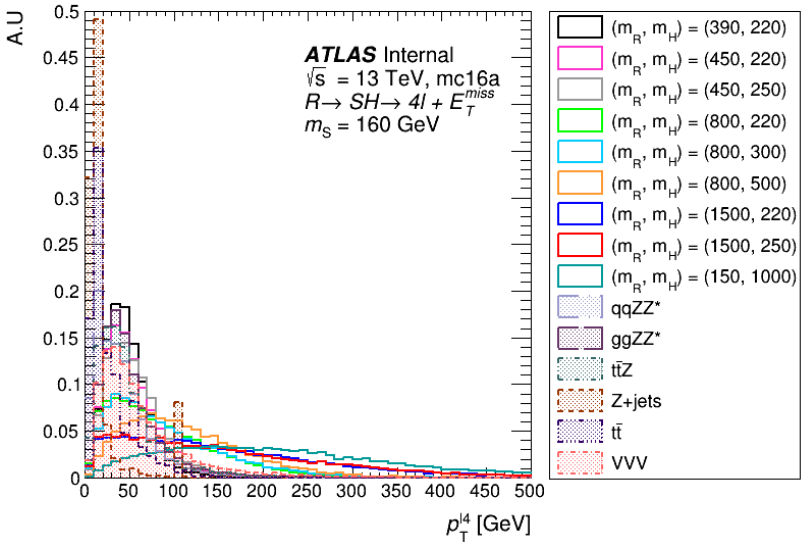
Figure: The invariant mass of the first (left) and the second (right) lepton pairs.

Additional slides
Kinematic distributions









Additional slides

$p_{\mathrm{T}}^{4\ell}$ and $E_{\mathrm{T}}^{\mathrm{miss}}$ scan for zero central jet

	$(m_R, m_H) = (390, 220)$	$qqZZ^*$	$ggZZ^*$	$t\bar{t}Z$	$Z + jets$	$t\bar{t}$	VVV	$s/\sqrt{s+b}$	$s/\sqrt{b}$
4ℓ	65.92±0.29	2474.93±7.43	345.02±1.04	26.89±0.61	2.59±0.24	3.28±0.56	13.74±0.15	2.59	2.73
B-veto	61.32±0.28	2358.82±7.33	330.25±1.02	4.45±0.25	2.38±0.23	1.94±0.41	12.96±0.15	2.48	2.61
$N_{\mathrm{Cjet}} = 0$	28.64±0.19	1582.11±6.15	208.34±0.81	0.99±0.10	1.82±0.20	0.65±0.23	7.22±0.10	1.44	1.50
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	28.64±0.19	1582.11±6.15	208.34±0.81	0.99±0.10	1.82±0.20	0.65±0.23	7.22±0.10	1.44	1.50
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	27.76±0.19	1340.84±5.70	184.65±0.76	0.98±0.09	1.67±0.19	0.65±0.23	7.11±0.10	1.51	1.57
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	24.99±0.18	958.03±4.79	137.07±0.66	0.96±0.09	1.35±0.17	0.57±0.22	6.80±0.10	1.58	1.67
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	20.74±0.16	603.46±3.81	89.74±0.53	0.94±0.09	1.01±0.15	0.48±0.20	6.38±0.09	1.62	1.74
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	15.31±0.14	349.69±2.81	53.37±0.41	0.83±0.09	0.64±0.12	0.40±0.18	5.86±0.09	1.54	1.68
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	10.20±0.11	188.73±1.98	29.02±0.30	0.72±0.08	0.37±0.09	0.40±0.18	5.29±0.09	1.37	1.51
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	6.30±0.09	98.23±1.43	14.80±0.21	0.66±0.08	0.21±0.07	0.40±0.18	4.69±0.08	1.14	1.28
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	3.76±0.07	47.62±0.97	7.24±0.15	0.53±0.07	0.16±0.06	0.21±0.13	4.10±0.08	0.94	1.08
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	2.12±0.05	22.15±0.64	3.49±0.10	0.44±0.07	0.10±0.05	0.09±0.09	3.58±0.07	0.74	0.86
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	1.20±0.04	10.53±0.43	1.64±0.07	0.40±0.06	0.10±0.05	0.09±0.09	3.11±0.07	0.57	0.67
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.65±0.03	4.90±0.29	0.76±0.05	0.32±0.05	0.02±0.02	0.09±0.09	2.66±0.06	0.42	0.49
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	27.71±0.19	1047.97±5.52	177.23±0.75	0.99±0.10	1.55±0.19	0.57±0.22	7.10±0.10	1.66	1.75
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	26.92±0.18	927.53±5.17	160.03±0.71	0.98±0.09	1.44±0.18	0.57±0.22	7.01±0.10	1.70	1.80
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	24.38±0.17	665.13±4.35	119.53±0.61	0.96±0.09	1.19±0.16	0.57±0.22	6.73±0.10	1.79	1.92
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	20.31±0.16	429.67±3.48	79.14±0.50	0.94±0.09	0.87±0.14	0.48±0.20	6.33±0.09	1.81	1.98
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	15.00±0.14	253.40±2.57	47.59±0.39	0.83±0.09	0.57±0.11	0.40±0.18	5.83±0.09	1.70	1.89
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	10.01±0.11	138.63±1.80	26.04±0.29	0.72±0.08	0.35±0.09	0.40±0.18	5.26±0.09	1.50	1.70
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	6.18±0.09	73.15±1.31	13.38±0.20	0.66±0.08	0.21±0.07	0.40±0.18	4.67±0.08	1.24	1.43
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	3.71±0.07	36.28±0.89	6.57±0.14	0.53±0.07	0.16±0.06	0.21±0.13	4.09±0.07	1.01	1.19
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	2.09±0.05	16.98±0.59	3.18±0.10	0.44±0.07	0.10±0.05	0.09±0.09	3.57±0.07	0.79	0.94
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	1.19±0.04	8.09±0.39	1.49±0.07	0.40±0.06	0.10±0.05	0.09±0.09	3.10±0.07	0.60	0.72
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.65±0.03	3.85±0.27	0.68±0.05	0.32±0.05	0.02±0.02	0.09±0.09	2.65±0.06	0.44	0.52
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	24.98±0.18	560.98±4.37	116.70±0.61	0.97±0.09	1.20±0.17	0.57±0.22	6.78±0.10	1.95	2.11
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	24.35±0.17	508.27±4.16	107.26±0.58	0.96±0.09	1.14±0.16	0.57±0.22	6.72±0.10	1.98	2.16
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	22.29±0.17	386.27±3.58	83.74±0.51	0.94±0.09	1.04±0.15	0.57±0.22	6.52±0.09	2.04	2.26
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	18.80±0.15	255.52±2.90	56.67±0.42	0.92±0.09	0.76±0.13	0.48±0.20	6.19±0.09	2.05	2.33
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	13.94±0.13	155.77±2.14	35.07±0.33	0.81±0.09	0.46±0.10	0.40±0.18	5.74±0.09	1.89	2.20
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	9.33±0.11	87.44±1.47	19.67±0.25	0.71±0.08	0.28±0.08	0.40±0.18	5.20±0.08	1.64	1.94
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	5.74±0.08	47.35±1.07	10.27±0.18	0.65±0.08	0.14±0.05	0.40±0.18	4.65±0.08	1.33	1.60
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	3.41±0.06	24.19±0.73	5.06±0.13	0.52±0.07	0.09±0.04	0.21±0.13	4.07±0.07	1.06	1.29
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	1.94±0.05	11.82±0.48	2.52±0.09	0.43±0.07	0.05±0.03	0.09±0.09	3.57±0.07	0.81	1.00
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	1.09±0.04	5.49±0.33	1.19±0.06	0.39±0.06	0.05±0.03	0.09±0.09	3.10±0.07	0.61	0.76
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.59±0.03	2.70±0.22	0.53±0.04	0.31±0.05	0.02±0.02	0.09±0.09	2.65±0.06	0.43	0.52
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	20.20±0.16	306.80±2.95	69.12±0.47	0.93±0.09	0.87±0.14	0.49±0.20	6.30±0.09	2.04	2.29
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	19.77±0.16	279.66±2.82	64.10±0.45	0.91±0.09	0.83±0.14	0.49±0.20	6.26±0.09	2.07	2.34
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	18.32±0.15	218.73±2.50	51.98±0.40	0.90±0.09	0.81±0.13	0.49±0.20	6.13±0.09	2.12	2.43
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	15.85±0.14	151.09±2.02	36.70±0.34	0.89±0.09	0.61±0.12	0.40±0.18	5.91±0.09	2.13	2.51
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	12.00±0.12	93.75±1.40	23.23±0.27	0.79±0.09	0.39±0.09	0.40±0.18	5.54±0.09	1.97	2.39
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	8.07±0.10	53.87±1.05	13.61±0.21	0.69±0.08	0.26±0.08	0.40±0.18	5.08±0.08	1.68	2.08

Additional slides

$p_{\mathrm{T}}^{4\ell}$ and $E_{\mathrm{T}}^{\mathrm{miss}}$ scan for zero central jet

	$(m_R, m_H) = (390, 220)$	$qqZZ^*$	$ggZZ^*$	$t\bar{t}Z$	$Z + jets$	$t\bar{t}$	VVV	$s/\sqrt{s+b}$	$s/\sqrt{b}$
4ℓ	65.92±0.29	2474.93±7.43	345.02±1.04	26.89±0.61	2.59±0.24	3.28±0.56	13.74±0.15	2.59	2.73
B-veto	61.32±0.28	2358.82±7.33	330.25±1.02	4.45±0.25	2.38±0.23	1.94±0.41	12.96±0.15	2.48	2.61
$N_{\mathrm{Cjet}} = 0$	28.64±0.19	1582.11±6.15	208.34±0.81	0.99±0.10	1.82±0.20	0.65±0.23	7.22±0.10	1.44	1.50
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	5.01±0.08	30.02±0.75	7.28±0.15	0.64±0.08	0.14±0.05	0.40±0.18	4.58±0.08	1.35	1.69
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	2.99±0.06	15.89±0.53	3.64±0.11	0.51±0.07	0.09±0.04	0.21±0.13	4.04±0.07	1.06	1.34
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	1.70±0.05	8.17±0.36	1.85±0.08	0.43±0.07	0.05±0.03	0.09±0.09	3.55±0.07	0.80	1.01
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.97±0.03	4.02±0.24	0.91±0.05	0.39±0.06	0.05±0.03	0.09±0.09	3.08±0.07	0.59	0.74
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.52±0.03	1.87±0.17	0.41±0.04	0.31±0.05	0.02±0.02	0.09±0.09	2.64±0.06	0.41	0.50
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	13.66±0.13	164.79±1.84	39.99±0.36	0.89±0.09	0.47±0.10	0.39±0.18	5.69±0.09	1.81	2.08
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	13.41±0.13	151.54±1.74	37.26±0.34	0.87±0.09	0.47±0.10	0.39±0.18	5.67±0.09	1.84	2.12
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	12.47±0.12	120.21±1.52	30.67±0.31	0.86±0.09	0.47±0.10	0.39±0.18	5.61±0.09	1.87	2.20
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	10.96±0.12	86.25±1.24	22.39±0.27	0.84±0.09	0.38±0.09	0.30±0.16	5.47±0.09	1.87	2.26
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	8.73±0.10	55.08±0.96	14.63±0.21	0.75±0.08	0.29±0.08	0.30±0.16	5.25±0.09	1.77	2.22
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	6.03±0.09	32.14±0.72	8.86±0.17	0.66±0.08	0.16±0.06	0.30±0.16	4.87±0.08	1.53	1.95
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	3.80±0.07	18.76±0.54	4.84±0.12	0.61±0.08	0.09±0.04	0.30±0.16	4.45±0.08	1.22	1.56
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	2.37±0.05	10.59±0.39	2.47±0.09	0.49±0.07	0.07±0.04	0.21±0.13	3.97±0.07	0.97	1.25
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	1.36±0.04	5.59±0.28	1.23±0.06	0.42±0.07	0.03±0.02	0.09±0.09	3.51±0.07	0.72	0.92
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.77±0.03	3.11±0.19	0.63±0.04	0.39±0.06	0.03±0.02	0.09±0.09	3.06±0.06	0.51	0.63
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.42±0.02	1.55±0.13	0.31±0.03	0.31±0.05	0.00±0.00	0.09±0.09	2.63±0.06	0.36	0.43
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	7.39±0.10	92.53±1.23	23.15±0.27	0.82±0.09	0.34±0.09	0.30±0.16	5.14±0.08	1.30	1.48
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	7.22±0.09	85.85±1.18	21.58±0.26	0.80±0.09	0.34±0.09	0.30±0.16	5.13±0.08	1.31	1.50
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	6.69±0.09	69.21±1.01	17.86±0.24	0.79±0.08	0.34±0.09	0.30±0.16	5.10±0.08	1.32	1.54
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	5.88±0.09	50.27±0.82	13.11±0.20	0.76±0.08	0.27±0.08	0.30±0.16	5.02±0.08	1.31	1.56
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	4.79±0.08	32.77±0.66	8.72±0.17	0.68±0.08	0.22±0.07	0.30±0.16	4.88±0.08	1.26	1.54
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	3.58±0.07	20.41±0.51	5.46±0.13	0.61±0.08	0.14±0.05	0.30±0.16	4.62±0.08	1.13	1.42
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	2.35±0.05	12.13±0.39	3.10±0.10	0.58±0.08	0.09±0.04	0.30±0.16	4.29±0.08	0.92	1.15
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	1.51±0.04	7.12±0.29	1.64±0.07	0.47±0.07	0.07±0.04	0.21±0.13	3.88±0.07	0.73	0.91
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	0.89±0.03	3.84±0.21	0.82±0.05	0.42±0.06	0.03±0.02	0.09±0.09	3.44±0.07	0.55	0.67
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.53±0.03	2.24±0.14	0.42±0.04	0.38±0.06	0.03±0.02	0.09±0.09	3.03±0.06	0.39	0.47
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.31±0.02	1.14±0.10	0.21±0.02	0.29±0.05	0.00±0.00	0.09±0.09	2.62±0.06	0.29	0.33
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	3.93±0.07	56.19±0.90	13.71±0.21	0.73±0.08	0.20±0.07	0.27±0.15	4.55±0.08	0.90	1.00
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	3.84±0.07	52.00±0.86	12.85±0.20	0.72±0.08	0.20±0.07	0.27±0.15	4.54±0.08	0.90	1.01
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	3.53±0.07	41.55±0.74	10.65±0.18	0.71±0.08	0.20±0.07	0.27±0.15	4.53±0.08	0.90	1.03
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	3.06±0.06	30.67±0.59	7.91±0.16	0.69±0.08	0.18±0.06	0.27±0.15	4.49±0.08	0.88	1.02
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	2.51±0.06	20.57±0.48	5.29±0.13	0.63±0.08	0.15±0.06	0.27±0.15	4.40±0.08	0.84	0.99
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	1.98±0.05	12.93±0.37	3.44±0.10	0.58±0.08	0.09±0.04	0.27±0.15	4.23±0.08	0.78	0.94
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	1.37±0.04	7.80±0.29	1.99±0.08	0.57±0.08	0.07±0.04	0.27±0.15	4.02±0.07	0.66	0.79
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	0.93±0.03	4.75±0.21	1.11±0.06	0.46±0.07	0.07±0.04	0.17±0.12	3.69±0.07	0.54	0.65
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	0.58±0.03	2.66±0.15	0.59±0.04	0.40±0.06	0.03±0.02	0.09±0.09	3.33±0.07	0.41	0.49
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.37±0.02	1.71±0.12	0.31±0.03	0.36±0.06	0.03±0.02	0.09±0.09	2.97±0.06	0.31	0.35
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.25±0.02	0.96±0.08	0.17±0.02	0.28±0.05	0.00±0.00	0.09±0.09	2.59±0.06	0.24	0.27

Additional slides

$p_{\mathrm{T}}^{4\ell}$ and $E_{\mathrm{T}}^{\mathrm{miss}}$ scan for one or more central jet

	$(m_R, m_H) = (390, 220)$	$qqZZ^*$	$ggZZ^*$	$t\bar{t}Z$	$Z + jets$	$t\bar{t}$	VVV	$s/\sqrt{s+b}$	$s/\sqrt{b}$
4ℓ	65.92±0.29	2474.93±7.43	345.02±1.04	26.89±0.61	2.59±0.24	3.28±0.56	13.74±0.15	2.59	2.73
B-veto	61.32±0.28	2358.82±7.33	330.25±1.02	4.45±0.25	2.38±0.23	1.94±0.41	12.96±0.15	2.48	2.61
$N_{\mathrm{Cjet}} \geq 1$	32.68±0.19	776.71±6.15	121.91±0.81	3.46±0.10	0.56±0.20	1.30±0.23	5.74±0.10	2.22	2.41
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	32.68±0.19	776.71±6.15	121.91±0.81	3.46±0.10	0.56±0.20	1.30±0.23	5.74±0.10	2.22	2.41
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	32.11±0.19	699.06±5.70	111.29±0.76	3.42±0.09	0.47±0.19	1.30±0.23	5.69±0.10	2.28	2.49
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	30.40±0.18	534.26±4.79	87.26±0.66	3.32±0.09	0.38±0.17	1.30±0.22	5.52±0.10	2.41	2.68
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	27.59±0.16	364.50±3.81	60.72±0.53	3.11±0.09	0.30±0.15	1.30±0.20	5.27±0.09	2.56	2.94
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	24.23±0.14	225.64±2.81	38.50±0.41	2.97±0.09	0.16±0.12	1.22±0.18	4.94±0.09	2.71	3.25
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	20.57±0.11	130.91±1.98	22.70±0.30	2.70±0.08	0.05±0.09	0.99±0.18	4.54±0.09	2.81	3.59
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	17.11±0.09	73.40±1.43	12.71±0.21	2.49±0.08	0.01±0.07	0.99±0.18	4.09±0.08	2.85	3.92
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	14.05±0.07	38.36±0.97	6.89±0.15	2.18±0.07	0.01±0.06	0.82±0.13	3.62±0.08	2.83	4.33
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	11.32±0.05	20.64±0.64	3.59±0.10	1.94±0.07	0.01±0.05	0.65±0.09	3.27±0.07	2.71	4.58
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	9.08±0.04	10.47±0.43	1.80±0.07	1.73±0.06	0.03±0.05	0.57±0.09	2.93±0.07	2.56	4.82
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	7.40±0.03	5.45±0.29	0.92±0.05	1.46±0.05	0.03±0.02	0.48±0.09	2.62±0.06	2.39	4.96
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	32.17±0.19	756.97±5.52	120.08±0.75	3.48±0.10	0.56±0.19	1.30±0.22	5.69±0.10	2.21	2.40
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	31.60±0.18	680.91±5.17	109.59±0.71	3.43±0.09	0.47±0.18	1.30±0.22	5.65±0.10	2.27	2.48
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	29.91±0.17	519.30±4.35	85.85±0.61	3.33±0.09	0.38±0.16	1.30±0.22	5.48±0.10	2.40	2.68
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	27.14±0.16	353.42±3.48	59.68±0.50	3.13±0.09	0.30±0.14	1.30±0.20	5.23±0.09	2.55	2.93
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	23.83±0.14	218.62±2.57	37.84±0.39	2.98±0.09	0.16±0.11	1.22±0.18	4.91±0.09	2.70	3.24
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	20.28±0.11	126.73±1.80	22.31±0.29	2.71±0.08	0.05±0.09	0.99±0.18	4.51±0.09	2.81	3.59
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	16.89±0.09	70.99±1.31	12.50±0.20	2.49±0.08	0.01±0.07	0.99±0.18	4.07±0.08	2.84	3.93
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	13.89±0.07	37.21±0.89	6.78±0.14	2.19±0.07	0.01±0.06	0.82±0.13	3.61±0.07	2.83	4.33
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	11.23±0.05	20.06±0.59	3.53±0.10	1.96±0.07	0.01±0.05	0.65±0.09	3.26±0.07	2.71	4.59
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	9.04±0.04	10.21±0.39	1.77±0.07	1.74±0.06	0.03±0.05	0.57±0.09	2.92±0.07	2.55	4.83
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	7.36±0.03	5.33±0.27	0.91±0.05	1.47±0.05	0.03±0.02	0.48±0.09	2.62±0.06	2.38	4.96
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	30.64±0.18	717.49±4.37	113.74±0.61	3.44±0.09	0.56±0.17	1.30±0.22	5.56±0.10	2.16	2.34
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	30.11±0.17	644.57±4.16	103.66±0.58	3.39±0.09	0.47±0.16	1.30±0.22	5.52±0.10	2.22	2.43
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	28.46±0.17	490.94±3.58	81.12±0.51	3.30±0.09	0.38±0.15	1.30±0.22	5.36±0.09	2.35	2.62
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	25.83±0.15	333.22±2.90	56.28±0.42	3.10±0.09	0.30±0.13	1.30±0.20	5.12±0.09	2.50	2.87
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	22.70±0.13	205.37±2.14	35.67±0.33	2.95±0.09	0.16±0.10	1.22±0.18	4.82±0.09	2.65	3.18
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	19.38±0.11	118.81±1.47	21.06±0.25	2.70±0.08	0.05±0.08	0.99±0.18	4.44±0.08	2.76	3.54
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	16.22±0.08	66.49±1.07	11.79±0.18	2.48±0.08	0.01±0.05	0.99±0.18	4.02±0.08	2.80	3.89
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	13.41±0.06	35.08±0.73	6.41±0.13	2.20±0.07	0.01±0.04	0.82±0.13	3.57±0.07	2.79	4.29
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	10.93±0.05	18.87±0.48	3.33±0.09	1.97±0.07	0.01±0.03	0.65±0.09	3.22±0.07	2.68	4.58
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	8.85±0.04	9.70±0.33	1.64±0.06	1.76±0.06	0.03±0.03	0.57±0.09	2.89±0.07	2.53	4.82
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	7.25±0.03	5.21±0.22	0.85±0.04	1.48±0.05	0.03±0.02	0.48±0.09	2.60±0.06	2.36	4.93
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	28.32±0.16	660.79±2.95	102.60±0.47	3.36±0.09	0.52±0.14	1.21±0.20	5.38±0.09	2.08	2.26
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	27.81±0.16	593.58±2.82	93.47±0.45	3.31±0.09	0.45±0.14	1.21±0.20	5.34±0.09	2.14	2.34
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	26.26±0.15	451.85±2.50	73.18±0.40	3.22±0.09	0.38±0.13	1.21±0.20	5.19±0.09	2.26	2.52
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	23.81±0.14	306.11±2.02	50.74±0.34	3.02±0.09	0.30±0.12	1.21±0.18	4.96±0.09	2.40	2.76
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	20.91±0.12	188.86±1.40	32.19±0.27	2.88±0.09	0.16±0.09	1.13±0.18	4.68±0.09	2.54	3.06
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	17.93±0.10	109.05±1.05	19.10±0.21	2.63±0.08	0.05±0.08	0.99±0.18	4.32±0.08	2.66	3.41

Additional slides

$p_{\mathrm{T}}^{4\ell}$ and $E_{\mathrm{T}}^{\mathrm{miss}}$ scan for one or more central jet

	$(m_R, m_H) = (390, 220)$	$qqZZ^*$	$ggZZ^*$	$t\bar{t}Z$	$Z + jets$	$t\bar{t}$	VVV	$s/\sqrt{s+b}$	$s/\sqrt{b}$
4ℓ	65.92±0.29	2474.93±7.43	345.02±1.04	26.89±0.61	2.59±0.24	3.28±0.56	13.74±0.15	2.59	2.73
B-veto	61.32±0.28	2358.82±7.33	330.25±1.02	4.45±0.25	2.38±0.23	1.94±0.41	12.96±0.15	2.48	2.61
$N_{\mathrm{Cjet}} \geq 1$	32.68±0.19	776.71±6.15	121.91±0.81	3.46±0.10	0.56±0.20	1.30±0.23	5.74±0.10	2.22	2.41
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	15.11±0.08	60.92±0.75	10.68±0.15	2.42±0.08	0.01±0.05	0.99±0.18	3.93±0.08	2.71	3.78
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	12.62±0.06	32.26±0.53	5.77±0.11	2.16±0.07	0.01±0.04	0.82±0.13	3.49±0.07	2.71	4.20
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	10.40±0.05	17.49±0.36	3.03±0.08	1.94±0.07	0.01±0.03	0.65±0.09	3.16±0.07	2.62	4.50
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	8.54±0.03	9.04±0.24	1.51±0.05	1.73±0.06	0.03±0.03	0.57±0.09	2.84±0.07	2.49	4.78
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	7.05±0.03	4.81±0.17	0.79±0.04	1.45±0.05	0.03±0.02	0.48±0.09	2.56±0.06	2.34	4.92
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	25.48±0.13	582.02±1.84	88.65±0.36	3.26±0.09	0.45±0.10	1.21±0.18	5.10±0.09	1.99	2.17
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	25.02±0.13	524.47±1.74	80.88±0.34	3.22±0.09	0.38±0.10	1.21±0.18	5.07±0.09	2.04	2.24
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	23.63±0.12	402.38±1.52	63.60±0.31	3.12±0.09	0.33±0.10	1.21±0.18	4.93±0.09	2.16	2.40
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	21.47±0.12	272.84±1.24	44.13±0.27	2.95±0.09	0.30±0.09	1.21±0.16	4.72±0.09	2.29	2.64
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	18.90±0.10	169.68±0.96	28.03±0.21	2.80±0.08	0.18±0.08	1.13±0.16	4.47±0.09	2.42	2.92
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	16.32±0.09	97.95±0.72	16.69±0.17	2.57±0.08	0.08±0.06	0.99±0.16	4.14±0.08	2.54	3.27
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	13.88±0.07	54.73±0.54	9.37±0.12	2.37±0.08	0.03±0.04	0.99±0.16	3.78±0.08	2.61	3.65
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	11.74±0.05	29.10±0.39	5.08±0.09	2.11±0.07	0.03±0.04	0.82±0.13	3.37±0.07	2.63	4.09
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	9.78±0.04	15.88±0.28	2.70±0.06	1.91±0.07	0.03±0.02	0.65±0.09	3.07±0.07	2.55	4.41
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	8.16±0.03	8.33±0.19	1.38±0.04	1.69±0.06	0.03±0.02	0.57±0.09	2.77±0.06	2.44	4.71
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	6.85±0.02	4.46±0.13	0.74±0.03	1.43±0.05	0.03±0.00	0.48±0.09	2.51±0.06	2.31	4.89
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	22.44±0.10	497.49±1.23	73.83±0.27	3.11±0.09	0.37±0.09	1.13±0.16	4.85±0.08	1.89	2.07
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	22.01±0.09	449.69±1.18	67.65±0.26	3.08±0.09	0.30±0.09	1.13±0.16	4.81±0.08	1.94	2.13
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	20.86±0.09	346.71±1.01	53.45±0.24	3.00±0.08	0.25±0.09	1.13±0.16	4.70±0.08	2.05	2.29
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	18.98±0.09	237.17±0.82	37.25±0.20	2.83±0.08	0.23±0.08	1.13±0.16	4.51±0.08	2.17	2.50
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	16.82±0.08	148.50±0.66	23.83±0.17	2.71±0.08	0.14±0.07	1.05±0.16	4.28±0.08	2.30	2.78
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	14.67±0.07	86.52±0.51	14.30±0.13	2.48±0.08	0.08±0.05	0.91±0.16	3.98±0.08	2.42	3.13
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	12.61±0.05	48.36±0.39	8.05±0.10	2.30±0.08	0.03±0.04	0.91±0.16	3.65±0.08	2.50	3.52
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	10.81±0.04	26.04±0.29	4.39±0.07	2.03±0.07	0.03±0.04	0.74±0.13	3.27±0.07	2.53	3.97
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	9.13±0.03	14.32±0.21	2.33±0.05	1.84±0.06	0.03±0.02	0.57±0.09	2.98±0.07	2.48	4.32
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	7.72±0.03	7.61±0.14	1.24±0.04	1.63±0.06	0.03±0.02	0.57±0.09	2.70±0.06	2.38	4.62
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	6.56±0.02	4.20±0.10	0.67±0.02	1.37±0.05	0.03±0.00	0.48±0.09	2.46±0.06	2.26	4.80
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	19.33±0.07	422.91±0.90	60.23±0.21	2.93±0.08	0.31±0.07	1.04±0.15	4.59±0.08	1.77	1.93
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	18.98±0.07	383.80±0.86	55.48±0.20	2.90±0.08	0.28±0.07	1.04±0.15	4.56±0.08	1.81	1.99
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	18.06±0.07	298.23±0.74	44.24±0.18	2.83±0.08	0.23±0.07	1.04±0.15	4.46±0.08	1.91	2.14
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	16.55±0.06	205.70±0.59	31.03±0.16	2.67±0.08	0.21±0.06	1.04±0.15	4.29±0.08	2.03	2.35
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	14.80±0.06	129.99±0.48	20.04±0.13	2.54±0.08	0.14±0.06	0.96±0.15	4.08±0.08	2.16	2.62
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	13.06±0.05	76.97±0.37	12.06±0.10	2.32±0.08	0.08±0.04	0.82±0.15	3.81±0.08	2.29	2.96
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	11.36±0.04	43.64±0.29	6.80±0.08	2.16±0.08	0.03±0.04	0.82±0.15	3.51±0.07	2.37	3.34
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	9.92±0.03	24.06±0.21	3.76±0.06	1.90±0.07	0.03±0.04	0.65±0.12	3.15±0.07	2.42	3.80
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	8.49±0.03	12.99±0.15	1.99±0.04	1.70±0.06	0.03±0.02	0.57±0.09	2.88±0.07	2.39	4.20
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	7.27±0.02	6.96±0.12	1.05±0.03	1.51±0.06	0.03±0.02	0.57±0.09	2.61±0.06	2.32	4.53
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	6.24±0.02	3.91±0.08	0.59±0.02	1.28±0.05	0.03±0.00	0.48±0.09	2.39±0.06	2.21	4.70

Additional slides

$p_{\mathrm{T}}^{4\ell}$ and $E_{\mathrm{T}}^{\mathrm{miss}}$ scan for zero jet

	$(m_R, m_H) = (390, 220)$	$qqZZ^*$	$ggZZ^*$	$t\bar{t}Z$	$Z + jets$	$t\bar{t}$	VVV	$s/\sqrt{s+b}$	$s/\sqrt{b}$
4ℓ	65.92±0.29	2474.93±7.43	345.02±1.04	26.89±0.61	2.59±0.24	3.28±0.56	13.74±0.15	2.59	2.73
B-veto	61.32±0.28	2358.82±7.33	330.25±1.02	4.45±0.25	2.38±0.23	1.94±0.41	12.96±0.15	2.48	2.61
$N_{\mathrm{jet}} = 0$	22.44±0.17	1434.33±5.84	176.34±0.75	0.65±0.08	1.52±0.19	0.61±0.23	6.47±0.09	1.20	1.24
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	22.44±0.17	1434.33±5.84	176.34±0.75	0.65±0.08	1.52±0.19	0.61±0.23	6.47±0.09	1.20	1.24
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	21.73±0.16	1204.91±5.39	155.38±0.70	0.65±0.08	1.37±0.17	0.61±0.23	6.36±0.09	1.26	1.30
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	19.51±0.16	847.15±4.55	114.02±0.60	0.65±0.08	1.05±0.15	0.53±0.21	6.08±0.09	1.33	1.39
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	16.02±0.14	522.45±3.58	73.28±0.48	0.64±0.08	0.75±0.13	0.44±0.20	5.68±0.09	1.36	1.45
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	11.48±0.12	295.20±2.62	42.67±0.37	0.54±0.07	0.46±0.10	0.36±0.18	5.23±0.08	1.27	1.37
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	7.21±0.09	154.78±1.81	22.52±0.27	0.48±0.07	0.23±0.07	0.36±0.18	4.71±0.08	1.08	1.18
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	4.15±0.07	77.93±1.28	11.26±0.19	0.42±0.07	0.12±0.05	0.36±0.18	4.18±0.08	0.86	0.95
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	2.21±0.05	36.36±0.85	5.33±0.13	0.34±0.06	0.07±0.04	0.17±0.12	3.64±0.07	0.65	0.73
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	1.10±0.04	16.33±0.56	2.55±0.09	0.30±0.06	0.05±0.03	0.09±0.09	3.17±0.07	0.46	0.52
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.58±0.03	7.61±0.37	1.19±0.06	0.27±0.05	0.05±0.03	0.09±0.09	2.74±0.06	0.33	0.37
$p_{\mathrm{T}}^{4\ell} > 0.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.27±0.02	3.57±0.25	0.55±0.04	0.20±0.05	0.00±0.00	0.09±0.09	2.34±0.06	0.21	0.23
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	21.67±0.16	923.94±5.20	146.79±0.68	0.66±0.08	1.26±0.17	0.53±0.21	6.36±0.09	1.40	1.46
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	21.05±0.16	814.40±4.86	132.27±0.65	0.66±0.08	1.15±0.16	0.53±0.21	6.28±0.09	1.44	1.51
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	19.04±0.15	574.75±4.11	97.82±0.55	0.65±0.08	0.89±0.14	0.53±0.21	6.02±0.09	1.52	1.62
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	15.71±0.14	365.01±3.27	63.76±0.45	0.65±0.08	0.62±0.12	0.44±0.20	5.65±0.09	1.54	1.67
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	11.27±0.12	210.28±2.39	37.65±0.34	0.55±0.07	0.39±0.09	0.36±0.18	5.21±0.08	1.42	1.57
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	7.09±0.09	111.80±1.64	20.05±0.25	0.48±0.07	0.21±0.07	0.36±0.18	4.69±0.08	1.20	1.34
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	4.08±0.07	57.28±1.17	10.12±0.18	0.42±0.07	0.12±0.05	0.36±0.18	4.17±0.08	0.94	1.06
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	2.18±0.05	27.58±0.78	4.82±0.12	0.34±0.06	0.07±0.04	0.17±0.12	3.64±0.07	0.70	0.80
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	1.08±0.04	12.43±0.51	2.33±0.08	0.30±0.06	0.05±0.03	0.09±0.09	3.17±0.07	0.49	0.56
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.57±0.03	5.80±0.33	1.08±0.06	0.27±0.05	0.05±0.03	0.09±0.09	2.74±0.06	0.35	0.40
$p_{\mathrm{T}}^{4\ell} > 10.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.27±0.02	2.80±0.23	0.49±0.04	0.20±0.05	0.00±0.00	0.09±0.09	2.34±0.06	0.22	0.25
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	19.42±0.16	462.06±4.02	90.05±0.53	0.65±0.08	0.92±0.14	0.53±0.21	6.06±0.09	1.68	1.82
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	18.95±0.15	419.23±3.84	83.09±0.51	0.65±0.08	0.86±0.14	0.53±0.21	6.00±0.09	1.71	1.86
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	17.41±0.15	316.75±3.35	65.02±0.45	0.64±0.08	0.77±0.13	0.53±0.21	5.83±0.09	1.77	1.96
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	14.61±0.13	207.08±2.71	43.62±0.37	0.63±0.08	0.53±0.11	0.44±0.20	5.53±0.09	1.79	2.02
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	10.57±0.11	124.27±1.99	26.80±0.29	0.53±0.07	0.30±0.08	0.36±0.18	5.13±0.08	1.62	1.87
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	6.70±0.09	68.25±1.33	14.71±0.21	0.47±0.07	0.17±0.06	0.36±0.18	4.65±0.08	1.35	1.58
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	3.87±0.07	35.87±0.95	7.60±0.15	0.41±0.07	0.08±0.04	0.36±0.18	4.16±0.07	1.05	1.23
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	2.06±0.05	18.03±0.63	3.66±0.11	0.33±0.06	0.03±0.02	0.17±0.12	3.63±0.07	0.76	0.90
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	1.03±0.04	8.54±0.41	1.82±0.08	0.29±0.06	0.03±0.02	0.09±0.09	3.17±0.07	0.53	0.61
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.54±0.03	3.94±0.27	0.87±0.05	0.26±0.05	0.03±0.02	0.09±0.09	2.74±0.06	0.37	0.43
$p_{\mathrm{T}}^{4\ell} > 20.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.25±0.02	2.07±0.18	0.39±0.03	0.19±0.04	0.00±0.00	0.09±0.09	2.34±0.06	0.22	0.25
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	15.35±0.14	228.23±2.62	47.47±0.39	0.61±0.08	0.64±0.12	0.45±0.20	5.61±0.09	1.80	2.03
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	15.07±0.14	209.57±2.52	44.52±0.37	0.61±0.08	0.60±0.11	0.45±0.20	5.57±0.09	1.83	2.07
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	14.08±0.13	165.15±2.26	36.86±0.34	0.61±0.08	0.58±0.11	0.45±0.20	5.47±0.09	1.87	2.16
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	12.25±0.12	114.20±1.82	26.27±0.29	0.61±0.08	0.41±0.09	0.36±0.18	5.27±0.08	1.89	2.24
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	9.11±0.11	70.12±1.24	16.77±0.23	0.52±0.07	0.25±0.07	0.36±0.18	4.96±0.08	1.72	2.10

Additional slides

$p_{\mathrm{T}}^{4\ell}$ and $E_{\mathrm{T}}^{\mathrm{miss}}$ scan for zero jet

	$(m_R, m_H) = (390, 220)$	$qqZZ^*$	$ggZZ^*$	$t\bar{t}Z$	$Z + jets$	$t\bar{t}$	VVV	$s/\sqrt{s+b}$	$s/\sqrt{b}$
4ℓ	65.92±0.29	2474.93±7.43	345.02±1.04	26.89±0.61	2.59±0.24	3.28±0.56	13.74±0.15	2.59	2.73
B-veto	61.32±0.28	2358.82±7.33	330.25±1.02	4.45±0.25	2.38±0.23	1.94±0.41	12.96±0.15	2.48	2.61
$N_{\mathrm{jet}} = 0$	22.44±0.17	1434.33±5.84	176.34±0.75	0.65±0.08	1.52±0.19	0.61±0.23	6.47±0.09	1.20	1.24
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	5.82±0.08	39.86±0.92	9.73±0.17	0.45±0.07	0.17±0.06	0.36±0.18	4.54±0.08	1.41	1.74
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	3.40±0.06	21.64±0.65	5.19±0.13	0.41±0.07	0.07±0.04	0.36±0.18	4.09±0.07	1.08	1.34
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	1.83±0.05	11.32±0.45	2.55±0.09	0.33±0.06	0.03±0.02	0.17±0.12	3.60±0.07	0.78	0.96
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	0.93±0.03	5.63±0.29	1.32±0.06	0.29±0.06	0.03±0.02	0.09±0.09	3.15±0.07	0.53	0.64
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.48±0.02	2.72±0.19	0.66±0.05	0.26±0.05	0.03±0.02	0.09±0.09	2.73±0.06	0.36	0.42
$p_{\mathrm{T}}^{4\ell} > 30.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.22±0.02	1.34±0.13	0.29±0.03	0.19±0.04	0.00±0.00	0.09±0.09	2.34±0.06	0.21	0.24
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	9.53±0.11	103.93±1.43	23.19±0.27	0.59±0.08	0.36±0.09	0.35±0.17	5.05±0.08	1.57	1.83
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	9.41±0.11	97.12±1.39	22.01±0.26	0.59±0.07	0.36±0.09	0.35±0.17	5.03±0.08	1.59	1.86
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	8.89±0.11	78.73±1.25	18.78±0.24	0.59±0.07	0.36±0.09	0.35±0.17	4.98±0.08	1.62	1.94
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	7.94±0.10	57.66±1.03	14.22±0.21	0.58±0.07	0.29±0.08	0.27±0.15	4.86±0.08	1.63	2.00
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	6.33±0.09	36.93±0.79	9.63±0.17	0.50±0.07	0.20±0.07	0.27±0.15	4.70±0.08	1.54	1.94
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	4.15±0.07	21.51±0.59	5.86±0.14	0.44±0.07	0.12±0.05	0.27±0.15	4.36±0.08	1.27	1.61
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	2.47±0.06	12.41±0.44	3.24±0.10	0.39±0.07	0.05±0.03	0.27±0.15	3.99±0.07	0.96	1.21
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	1.40±0.04	6.98±0.31	1.63±0.07	0.32±0.06	0.03±0.02	0.17±0.12	3.54±0.07	0.70	0.87
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	0.71±0.03	3.72±0.21	0.83±0.05	0.28±0.06	0.03±0.02	0.09±0.09	3.12±0.06	0.46	0.55
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.36±0.02	2.16±0.15	0.44±0.04	0.25±0.05	0.03±0.02	0.09±0.09	2.72±0.06	0.29	0.33
$p_{\mathrm{T}}^{4\ell} > 40.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.16±0.01	1.15±0.11	0.22±0.03	0.18±0.04	0.00±0.00	0.09±0.09	2.33±0.06	0.16	0.17
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	4.18±0.07	48.07±0.82	10.81±0.18	0.52±0.07	0.25±0.08	0.27±0.15	4.56±0.08	1.01	1.16
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	4.12±0.07	45.54±0.79	10.33±0.18	0.51±0.07	0.25±0.08	0.27±0.15	4.55±0.08	1.01	1.17
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	3.92±0.07	38.48±0.72	9.05±0.17	0.51±0.07	0.25±0.08	0.27±0.15	4.53±0.08	1.02	1.19
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	3.54±0.07	29.31±0.62	7.05±0.15	0.49±0.07	0.20±0.07	0.27±0.15	4.46±0.08	1.02	1.22
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	2.93±0.06	19.59±0.50	5.06±0.13	0.42±0.07	0.16±0.06	0.27±0.15	4.36±0.08	0.98	1.19
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	2.11±0.05	12.52±0.39	3.23±0.10	0.38±0.06	0.09±0.05	0.27±0.15	4.14±0.07	0.84	1.03
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	1.29±0.04	7.42±0.29	1.92±0.08	0.35±0.06	0.05±0.03	0.27±0.15	3.85±0.07	0.64	0.77
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	0.73±0.03	4.49±0.21	1.02±0.06	0.30±0.06	0.03±0.02	0.17±0.12	3.47±0.07	0.45	0.53
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	0.38±0.02	2.49±0.14	0.52±0.04	0.27±0.05	0.03±0.02	0.09±0.09	3.07±0.06	0.29	0.33
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.20±0.02	1.57±0.11	0.28±0.03	0.24±0.05	0.03±0.02	0.09±0.09	2.70±0.06	0.18	0.20
$p_{\mathrm{T}}^{4\ell} > 50.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.09±0.01	0.87±0.08	0.14±0.02	0.17±0.04	0.00±0.00	0.09±0.09	2.32±0.06	0.10	0.10
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 0.00$ GeV	1.55±0.04	23.90±0.53	4.96±0.12	0.46±0.07	0.13±0.05	0.27±0.15	4.02±0.07	0.53	0.59
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 10.00$ GeV	1.52±0.04	22.61±0.51	4.81±0.12	0.46±0.07	0.13±0.05	0.27±0.15	4.01±0.07	0.54	0.59
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 20.00$ GeV	1.46±0.04	19.14±0.47	4.30±0.12	0.45±0.07	0.13±0.05	0.27±0.15	4.00±0.07	0.54	0.61
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 30.00$ GeV	1.33±0.04	15.06±0.40	3.47±0.10	0.45±0.07	0.13±0.05	0.27±0.15	3.97±0.07	0.54	0.61
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 40.00$ GeV	1.13±0.04	10.70±0.33	2.59±0.09	0.39±0.06	0.11±0.05	0.27±0.15	3.91±0.07	0.52	0.59
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 50.00$ GeV	0.86±0.03	7.02±0.26	1.76±0.07	0.36±0.06	0.05±0.03	0.27±0.15	3.78±0.07	0.46	0.53
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 60.00$ GeV	0.56±0.03	4.36±0.21	1.10±0.06	0.35±0.06	0.03±0.02	0.27±0.15	3.60±0.07	0.35	0.40
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 70.00$ GeV	0.33±0.02	2.84±0.15	0.66±0.05	0.29±0.06	0.03±0.02	0.17±0.12	3.30±0.07	0.24	0.27
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 80.00$ GeV	0.17±0.01	1.75±0.11	0.37±0.03	0.27±0.05	0.03±0.02	0.09±0.09	2.97±0.06	0.15	0.16
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 90.00$ GeV	0.09±0.01	1.18±0.09	0.21±0.03	0.23±0.05	0.03±0.02	0.09±0.09	2.64±0.06	0.09	0.09
$p_{\mathrm{T}}^{4\ell} > 60.00$ & $E_{\mathrm{T}}^{\mathrm{miss}} > 100.00$ GeV	0.05±0.01	0.73±0.07	0.11±0.02	0.17±0.04	0.00±0.00	0.09±0.09	2.30±0.06	0.06	0.06