The LaTeX report

Contents

1 Setup

1.1 Command history

```
ma5># set directory where running "./bin/ma5"; set lumi; define the signal significance
ma5>set main.currentdir = /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data # need to
change this directory path -> exit and type "pwd" to get the path
ma5>set main.lumi = 150.0
ma5>set main.SBratio = 'S/sqrt(S+B)'
ma5># import samples -> change the path to the LHE file
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/axion_signal/axion_signal_gurrola_cuts_
as signal
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/vbf_diphoton_background_data/-
merged_lhe/vbf_diphoton_background_ht_0_100_merged.lhe.gz as bg_vbf_0_100
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/vbf_diphoton_background_data/-
merged_lhe/vbf_diphoton_background_ht_100_200_merged.lhe.gz as bg_vbf_100_200
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/vbf_diphoton_background_data/-
merged_lhe/vbf_diphoton_background_ht_200_400_merged.lhe.gz as bg_vbf_200_400
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/vbf_diphoton_background_data/-
merged_lhe/vbf_diphoton_background_ht_400_600_merged.lhe.gz as bg_vbf_400_600
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/vbf_diphoton_background_data/-
merged_lhe/vbf_diphoton_background_ht_600_800_merged.lhe.gz as bg_vbf_600_800
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/vbf_diphoton_background_data/-
merged_lhe/vbf_diphoton_background_ht_800_1200_merged.lhe.gz as bg_vbf_800_1200
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/vbf_diphoton_background_data/-
merged_lhe/vbf_diphoton_background_ht_1200_1600_merged.lhe.gz as bg_vbf_1200_1600
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/vbf_diphoton_background_data/-
merged_lhe/vbf_diphoton_background_ht_1600_inf_merged.lhe.gz as bg_vbf_1600_inf
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/diphoton_double_isr_background_data/-
merged_lhe/diphoton_double_isr_background_ht_0_100_merged.lhe.gz as bg_dip_0_100
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/diphoton_double_isr_background_data/-
merged_lhe/diphoton_double_isr_background_ht_100_200_merged.lhe.gz as bg_dip_100_200
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/diphoton_double_isr_background_data/-
merged_lhe/diphoton_double_isr_background_ht_200_400_merged.lhe.gz as bg_dip_200_400
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/diphoton_double_isr_background_data/-
merged_lhe/diphoton_double_isr_background_ht_400_600_merged.lhe.gz as bg_dip_400_600
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/diphoton_double_isr_background_data/-
merged_lhe/diphoton_double_isr_background_ht_600_800_merged.lhe.gz as bg_dip_600_800
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/diphoton_double_isr_background_data/-
merged_lhe/diphoton_double_isr_background_ht_800_1200_merged.lhe.gz as bg_dip_800_1200
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/diphoton_double_isr_background_data/-
merged_lhe/diphoton_double_isr_background_ht_1200_1600_merged.lhe.gz as bg_dip_1200_1600
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/diphoton_double_isr_background_data/-
merged_lhe/diphoton_double_isr_background_ht_1600_inf_merged.lhe.gz as bg_dip_1600_inf
ma5># define bg and signal samples
ma5>set signal.type = signal
ma5>set bg_vbf_0_100.type = background
ma5>set bg_vbf_100_200.type = background
ma5>set bg_vbf_200_400.type = background
ma5>set bg_vbf_400_600.type = background
```

```
ma5>set bg_vbf_600_800.type = background
ma5>set bg_vbf_800_1200.type = background
ma5>set bg_vbf_1200_1600.type = background
ma5>set bg_vbf_1600_inf.type = background
ma5>set bg_dip_0_100.type = background
ma5>set bg_dip_100_200.type = background
ma5>set bg_dip_200_400.type = background
ma5>set bg_dip_400_600.type = background
ma5>set bg_dip_600_800.type = background
ma5>set bg_dip_800_1200.type = background
ma5>set bg_dip_1200_1600.type = background
ma5>set bg_dip_1600_inf.type = background
ma5># define weights for the samples
ma5>#set sample_1.weight = 1
ma5>#set sample_2.weight = 1
ma5># a jet can be from a light quark or b quark
ma5>define jets = j
ma5>define e = e+ e-
ma5>define mu = mu+ mu-
ma5>define ta = ta+ ta-
ma5>define lept = e mu ta
ma5># reduce contribution from V+Zp ==> jj+Zp
ma5>select sdETA(jets[1] jets[2]) > 2.6 and M(jets[1] jets[2]) > 1250
ma5>submit lum_probe_150_loose
```

1.2   Configuration

- MadAnalysis version 1.6.33 (2017/11/20).

- Histograms given for an integrated luminosity of 150.0fb^{-1}.

2 Datasets

2.1 signal

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: signal events.

- Generated events: 1000000 events.

- Normalization to the luminosity: 15352+/- 5 events.

- Ratio (event weight): 0.015 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/axion_signal/-axion_signal_gurrola_cuts_1MeV.lh	1000000	0.102 @ 0.028%	0.0

2.2 bg_vbf_0_100

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 1000000 events.

- Normalization to the luminosity: 45563+/- 87 events.

- Ratio (event weight): 0.046 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_0_1(	1000000	0.304 @ 0.19%	0.0

2.3 bg_vbf_100_200

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 965662 events.

- Normalization to the luminosity: 36357+/- 63 events.

- Ratio (event weight): 0.038 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_100_	965662	0.242 @ 0.17%	0.0

2.4   bg_vbf_200_400

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 984165 events.

- Normalization to the luminosity: 20299+/- 41 events.

- Ratio (event weight): 0.021 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_200_	984165	0.135 @ 0.2%	0.0

2.5   bg_vbf_400_600

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 1000000 events.

- Normalization to the luminosity: 3700+/- 6 events.

- Ratio (event weight): 0.0037 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_400_	1000000	0.0247 @ 0.14%	0.0

2.6 bg_vbf_600_800

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 1000000 events.

- Normalization to the luminosity: 945+/- 2 events.

- Ratio (event weight): 0.00094 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_600_	1000000	0.0063 @ 0.13%	0.0

2.7 bg_vbf_800_1200

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 400839 events.

- Normalization to the luminosity: 430+/- 1 events.

- Ratio (event weight): 0.0011 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_800_	400839	0.00287 @ 0.16%	0.0

2.8 bg_vbf_1200_1600

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 953803 events.

- Normalization to the luminosity: 77+/- 1 events.

- Ratio (event weight): 8.1e-05 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_data/- vbf_diphoton_background_data/- merged_lhe/- vbf_diphoton_background_ht_1200	953803	0.000515 @ 0.16%	0.0

2.9 bg_vbf_1600_inf

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/- optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 270148 events.

- Normalization to the luminosity: 28+/- 1 events.

- Ratio (event weight): 0.0001 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_data/- vbf_diphoton_background_data/- merged_lhe/- vbf_diphoton_background_ht_1600	270148	0.000191 @ 0.11%	0.0

2.10 bg_dip_0_100

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/- optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 10165677+/- 17300 events.

- Ratio (event weight): 9.8 - warning: please generate more events (weight larger than 1)!

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_data/- diphoton_double_isr_background_d merged_lhe/- diphoton_double_isr_background_l	1040000	67.8 @ 0.17%	0.0

2.11 bg_dip_100_200

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 4107610+/- 5727 events.

- Ratio (event weight): 3.9 - warning: please generate more events (weight larger than 1)!

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-diphoton_double_isr_background_o merged_lhe/-diphoton_double_isr_background_l	1040000	27.4 @ 0.14%	0.0

2.12 bg_dip_200_400

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 898308+/- 1552 events.

- Ratio (event weight): 0.86 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-diphoton_double_isr_background_o merged_lhe/-diphoton_double_isr_background_l	1040000	5.99 @ 0.17%	0.0

2.13 bg_dip_400_600

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 107995+/- 196 events.

- Ratio (event weight): 0.1 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_data/- diphoton_double_isr_background_d merged_lhe/- diphoton_double_isr_background_l	1040000	0.72 @ 0.18%	0.0

2.14   bg_dip_600_800

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/- optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 662009 events.

- Normalization to the luminosity: 25028+/- 104 events.

- Ratio (event weight): 0.038 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_data/- diphoton_double_isr_background_d merged_lhe/- diphoton_double_isr_background_l	662009	0.167 @ 0.41%	0.0

2.15   bg_dip_800_1200

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/- optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 11033+/- 19 events.

- Ratio (event weight): 0.011 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_data/- diphoton_double_isr_background_d merged_lhe/- diphoton_double_isr_background_l	1040000	0.0736 @ 0.17%	0.0

2.16   bg_dip_1200_1600

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 337115 events.

- Normalization to the luminosity: 1925+/- 10 events.

- Ratio (event weight): 0.0057 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-diphoton_double_isr_background_c merged_lhe/-diphoton_double_isr_background_l	337115	0.0128 @ 0.51%	0.0

2.17   bg_dip_1600_inf

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_data/-optimization/dEta_mmjj_cuts_plots .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 704+/- 2 events.

- Ratio (event weight): 0.00068 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_data/-diphoton_double_isr_background_c merged_lhe/-diphoton_double_isr_background_l	1040000	0.00469 @ 0.15%	0.0

3 Histos and cuts

3.1 Cut 1

* Cut: select sdETA (jets[1] jets[2]) > 2.6 and M (jets[1] jets[2]) > 1250.0

Dataset	Events kept: K	Rejected events: R	Efficiency: K / (K + R)	Cumul. efficiency: K / Initial
signal	3200.2 +/- 50.3	12152.6 +/- 50.4	0.20845 +/- 0.00328	0.20845 +/- 0.00328
bg_vbf_0_10	385.8 +/- 19.6	45177.9 +/- 88.1	0.008467 +/- 0.000429	0.008467 +/- 0.000429
bg_vbf_100_	1791.8 +/- 41.4	34565.7 +/- 72.1	0.04928 +/- 0.00114	0.04928 +/- 0.00114
bg_vbf_200_	2151.4 +/- 44.1	18148.4 +/- 57.1	0.10598 +/- 0.00216	0.10598 +/- 0.00216
bg_vbf_400_	654.3 +/- 23.2	3046.4 +/- 23.6	0.17681 +/- 0.00627	0.17681 +/- 0.00627
bg_vbf_600_	208.7 +/- 12.8	736.6 +/- 12.8	0.2208 +/- 0.0135	0.2208 +/- 0.0135
bg_vbf_800_	75.57 +/- 7.89	354.79 +/- 7.91	0.1756 +/- 0.0183	0.1756 +/- 0.0183
bg_vbf_1200	8.41 +/- 2.74	68.83 +/- 2.74	0.1088 +/- 0.0354	0.1088 +/- 0.0354
bg_vbf_1600	1.48 +/- 1.18	27.24 +/- 1.19	0.0516 +/- 0.0413	0.0516 +/- 0.0413
bg_dip_0_10	439.8 +/- 21.0	10165237 +/- 17298	4.33e-05 +/- 2.06e-06	4.33e-05 +/- 2.06e-06
bg_dip_100_	1860.2 +/- 43.2	4105750 +/- 5724	4.53e-04 +/- 1.05e-05	4.53e-04 +/- 1.05e-05
bg_dip_200_	3053.3 +/- 55.4	895254 +/- 1547	3.40e-03 +/- 6.14e-05	3.40e-03 +/- 6.14e-05
bg_dip_400_	1993.0 +/- 44.4	106002 +/- 197	0.01845 +/- 0.00041	0.01845 +/- 0.00041
bg_dip_600_	989.3 +/- 31.1	24039 +/- 104	0.03953 +/- 0.00123	0.03953 +/- 0.00123
bg_dip_800_	362.3 +/- 18.7	10671.4 +/- 26.2	0.0328 +/- 0.0017	0.0328 +/- 0.0017
bg_dip_1200	40.5 +/- 6.3	1885.2 +/- 11.5	0.02101 +/- 0.00327	0.02101 +/- 0.00327
bg_dip_1600	7.60 +/- 2.74	696.58 +/- 2.93	0.01080 +/- 0.00389	0.01080 +/- 0.00389

4 Summary

4.1 Cut-flow charts

- How to compare signal (S) and background (B): S/sqrt(S+B) .

- Object definition selections are indicated in cyan.

- Reject and select are indicated by 'REJ' and 'SEL' respectively

Cuts	Signal (S)	Background (B)	S vs B
Initial (no cut)	15352.82 +/- 4.23	15425686 +/- 18290	3.90706 +/- 0.00255
SEL: sdETA (jets[1] jets[2]) > 2.6 and M (jets[	3200.2 +/- 50.3	14023 +/- 116	24.385 +/- 0.358