The LaTeX report

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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]) > 3.6 and M(jets[1] jets[2]) > 1250
ma5>submit lum_probe_150_tight
```

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_c-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_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_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_ 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_ 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_ 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]) > 3.6 and M (jets[1] jets[2]) > 1250.0**

Dataset	Events kept: K	Rejected events: R	Efficiency: K / (K + R)	Cumul. efficiency: K / Initial
signal	1519.8 +/- 37.0	13833.0 +/- 37.2	0.09899 +/- 0.00241	0.09899 +/- 0.00241
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_	512.9 +/- 21.0	3187.8 +/- 21.5	0.13858 +/- 0.00568	0.13858 +/- 0.00568
bg_vbf_600_	89.4 +/- 9.0	855.89 +/- 9.06	0.09457 +/- 0.00952	0.09457 +/- 0.00952
bg_vbf_800_	22.62 +/- 4.63	407.74 +/- 4.67	0.0526 +/- 0.0108	0.0526 +/- 0.0108
bg_vbf_1200_	1.26 +/- 1.11	75.97 +/- 1.12	0.0163 +/- 0.0144	0.0163 +/- 0.0144
bg_vbf_1600_	0.0927 +/- 0.3039	28.627 +/- 0.306	0.00323 +/- 0.01058	0.00323 +/- 0.01058
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_	1098.7 +/- 33.0	106896 +/- 196	0.010174 +/- 0.000305	0.010174 +/- 0.000305
bg_dip_600_	167.1 +/- 12.9	24861 +/- 103	0.006677 +/- 0.000515	0.006677 +/- 0.000515
bg_dip_800_	40.84 +/- 6.38	10992.9 +/- 19.9	0.003701 +/- 0.000578	0.003701 +/- 0.000578
bg_dip_1200_	2.53 +/- 1.59	1923.12 +/- 9.98	0.001314 +/- 0.000825	0.001314 +/- 0.000825
bg_dip_1600_	0.164 +/- 0.405	704.02 +/- 1.12	0.000233 +/- 0.000575	0.000233 +/- 0.000575

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]) > 3.6 and M (jets[	1519.8 +/- 37.0	11617 +/- 106	13.259 +/- 0.309