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 = 3000.0
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_3000_loose
```

1.2 Configuration

- MadAnalysis version 1.6.33 (2017/11/20).
- Histograms given for an integrated luminosity of 3000.0fb^{-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: 307056+/- 85 events.
- Ratio (event weight): 0.31 .

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: 911274+/- 1733 events.
- Ratio (event weight): 0.91 .

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: 727149+/- 1245 events.

- Ratio (event weight): 0.75 .

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: 405994+/- 819 events.
- Ratio (event weight): 0.41 .

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: 74013+/- 104 events.
- Ratio (event weight): 0.074 .

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: 18905+/- 24 events.
- Ratio (event weight): 0.019 .

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: 8607+/- 14 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_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: 1544+/- 3 events.

- Ratio (event weight): 0.0016 .

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: 574+/- 1 events.
- Ratio (event weight): 0.0021 .

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: 203313540+/- 345993 events.
- Ratio (event weight): 195 - 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: 82152210+/- 114532 events.
- Ratio (event weight): 78 - 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: 17966163+/- 31035 events.
- Ratio (event weight): 17 - 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	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: 2159901+/- 3916 events.

- Ratio (event weight): 2.1 - 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	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: 500577+/- 2070 events.
- Ratio (event weight): 0.76 .

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: 220675+/- 380 events.
- Ratio (event weight): 0.21 .

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: 38512+/- 198 events.
- Ratio (event weight): 0.11 .

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: 14083+/- 21 events.
- Ratio (event weight): 0.014 .

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	64004 +/- 225	243051 +/- 234	0.208445 +/- 0.000733	0.208445 +/- 0.000733
bg_vbf_0_10	7715.4 +/- 88.7	903558 +/- 1720	8.47e-03 +/- 9.60e-05	8.47e-03 +/- 9.60e-05
bg_vbf_100_	35835 +/- 194	691314 +/- 1197	0.049282 +/- 0.000254	0.049282 +/- 0.000254
bg_vbf_200_	43027 +/- 214	362967 +/- 757	0.105979 +/- 0.000483	0.105979 +/- 0.000483
bg_vbf_400_	13086 +/- 105	60927 +/- 134	0.1768 +/- 0.0014	0.1768 +/- 0.0014
bg_vbf_600_	4174.8 +/- 57.3	14731.0 +/- 60.0	0.22082 +/- 0.00302	0.22082 +/- 0.00302
bg_vbf_800_	1511.5 +/- 35.4	7095.7 +/- 37.0	0.1756 +/- 0.0041	0.1756 +/- 0.0041
bg_vbf_1200_	168.1 +/- 12.2	1376.6 +/- 12.4	0.10884 +/- 0.00792	0.10884 +/- 0.00792
bg_vbf_1600_	29.6 +/- 5.3	544.78 +/- 5.33	0.05155 +/- 0.00923	0.05155 +/- 0.00923
bg_dip_0_10	8795.2 +/- 95.0	203304744 +/- 345978	4.33e-05 +/- 4.61e-07	4.33e-05 +/- 4.61e-07
bg_dip_100_	37204 +/- 199	82115005 +/- 114479	4.53e-04 +/- 2.35e-06	4.53e-04 +/- 2.35e-06
bg_dip_200_	61065 +/- 268	17905097 +/- 30929	3.40e-03 +/- 1.37e-05	3.40e-03 +/- 1.37e-05
bg_dip_400_	39860 +/- 210	2120040 +/- 3848	1.85e-02 +/- 9.16e-05	1.85e-02 +/- 9.16e-05
bg_dip_600_	19786 +/- 160	480790 +/- 1992	0.039528 +/- 0.000275	0.039528 +/- 0.000275
bg_dip_800_	7246.8 +/- 84.6	213428 +/- 376	0.032839 +/- 0.000379	0.032839 +/- 0.000379
bg_dip_1200_	809.3 +/- 28.5	37703 +/- 195	0.021013 +/- 0.000731	0.021013 +/- 0.000731
bg_dip_1600_	152.1 +/- 12.3	13931.7 +/- 24.0	0.010799 +/- 0.000871	0.010799 +/- 0.000871

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)	307056.3 +/- 84.5	308513727 +/- 365809	17.4729 +/- 0.0114
SEL: sdETA (jets[1] jets[2]) > 2.6 and M (jets[	64004 +/- 225	280469 +/- 553	109.05 +/- 0.36