MAD Analysis 5 The LaTeX report

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To contact us:

http://madanalysis.irmp.ucl.ac.be
ma5team@iphc.cnrs.fr

Contents

1 Setup

1.1 Command history

```
ma5>set main.currentdir = /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/optimization/-
ma_scripts
ma5># set directory where running "./bin/ma5"
ma5>set main.currentdir = /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/madgraph_data
# need to change this directory path -> exit and type "pwd" to get the path
ma5>set main.lumi = 40
ma5>set main.fom.formula = 5
ma5>set main.fom.x = 0.0
ma5># import samples -> change the path to the LHE file
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/madgraph_data/axion_signal/-
on_discovery_contour/ma100MeV_L2pt2TeV_deta2.lhe.gz as signal
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/madgraph_data/vbf_diphoton_background_
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_pheno/madgraph_data/vbf_diphoton_background_
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_pheno/madgraph_data/vbf_diphoton_background_
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_pheno/madgraph_data/vbf_diphoton_background_
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_pheno/madgraph_data/vbf_diphoton_background_
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_pheno/madgraph_data/vbf_diphoton_background_
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_pheno/madgraph_data/vbf_diphoton_background_
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_pheno/madgraph_data/vbf_diphoton_background_
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_pheno/madgraph_data/diphoton_double_isr_back
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_pheno/madgraph_data/diphoton_double_isr_back
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_pheno/madgraph_data/diphoton_double_isr_back
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_pheno/madgraph_data/diphoton_double_isr_back
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_pheno/madgraph_data/diphoton_double_isr_back
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_pheno/madgraph_data/diphoton_double_isr_back
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_pheno/madgraph_data/diphoton_double_isr_back
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_pheno/madgraph_data/diphoton_double_isr_back
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># 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>define ax = 9000005
ma5>select ((sdETA(jets[1] jets[2]) > 3.1 or sdETA(jets[1] jets[2]) < -3.1) and M(jets[1]
jets[2]) > 1000) and (PT(a[1]) > 300 and M(a[1] a[2]) > 500)
ma5>submit disc_contour_sdEta3.1_mjj1000
```

1.2   Configuration

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

- Histograms given for an integrated luminosity of 40.0fb^{-1}.

2 Datasets

2.1 signal

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: signal events.

- Generated events: 100000 events.

- Normalization to the luminosity: 69+/- 1 events.

- Ratio (event weight): 0.00069 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/-madgraph_data/axion_signal/-on_discovery_contour/-ma100MeV_L2pt2TeV_deta2.lhe.gz	100000	0.00174 @ 0.094%	0.0

2.2 bg_vbf_0_100

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 1000000 events.

- Normalization to the luminosity: 12150+/- 24 events.

- Ratio (event weight): 0.012 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_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_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 965662 events.

- Normalization to the luminosity: 9695+/- 17 events.

- Ratio (event weight): 0.01 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_pheno/madgraph_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_pheno/- post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 984165 events.

- Normalization to the luminosity: 5413+/- 11 events.

- Ratio (event weight): 0.0055 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_pheno/madgraph_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_pheno/- post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 1000000 events.

- Normalization to the luminosity: 986+/- 2 events.

- Ratio (event weight): 0.00099 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_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_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 1000000 events.

- Normalization to the luminosity: 252+/- 1 events.

- Ratio (event weight): 0.00025 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_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_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 400839 events.

- Normalization to the luminosity: 114+/- 1 events.

- Ratio (event weight): 0.00028 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_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_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 953803 events.

- Normalization to the luminosity: 20+/- 1 events.

- Ratio (event weight): 2.1e-05 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_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_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 270148 events.

- Normalization to the luminosity: 7+/- 1 events.

- Ratio (event weight): 2.6e-05 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_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_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 2710847+/- 4614 events.

- Ratio (event weight): 2.6 - 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_pheno/madgraph_data/- diphoton_double_isr_background_o 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_pheno/- post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 1095362+/- 1528 events.

- Ratio (event weight): 1.1 - 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_pheno/madgraph_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_pheno/- post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 239548+/- 414 events.

- Ratio (event weight): 0.23 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_pheno/madgraph_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_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 28798+/- 53 events.

- Ratio (event weight): 0.028 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_data/-diphoton_double_isr_background_c 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_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 662009 events.

- Normalization to the luminosity: 6674+/- 28 events.

- Ratio (event weight): 0.01 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_data/-diphoton_double_isr_background_c 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_pheno/-post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 2942+/- 6 events.

- Ratio (event weight): 0.0028 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_pheno/madgraph_data/- diphoton_double_isr_background_c 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_pheno/- post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 337115 events.

- Normalization to the luminosity: 513+/- 3 events.

- Ratio (event weight): 0.0015 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_pheno/madgraph_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_pheno/- post_optimization_studies/disc_contour_jet_optimization .

- Sample consisting of: background events.

- Generated events: 1040000 events.

- Normalization to the luminosity: 187+/- 1 events.

- Ratio (event weight): 0.00018 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_pheno/madgraph_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]) > 3.1 or sdETA (jets[1] jets[2]) < -3.1) and M (jets[1] jets[2]) > 1000.0) and (PT (a[1]) > 300.0 and M (a[1] a[2]) > 500.0)

Dataset	Events kept: K	Rejected events: R	Efficiency: K / (K + R)	Cumul. efficiency: K / Initial
signal	21.36 +/- 3.85	48.09 +/- 3.85	0.3075 +/- 0.0554	0.3075 +/- 0.0554
bg_vbf_0_10	0.0122 +/- 0.1103	12150.3 +/- 23.1	1.00e-06 +/- 9.08e-06	1.00e-06 +/- 9.08e-06
bg_vbf_100_	0.823 +/- 0.907	9694.5 +/- 16.6	8.49e-05 +/- 9.36e-05	8.49e-05 +/- 9.36e-05
bg_vbf_200_	5.13 +/- 2.26	5408.1 +/- 11.1	0.000947 +/- 0.000418	0.000947 +/- 0.000418
bg_vbf_400_	5.3 +/- 2.3	981.54 +/- 2.67	0.00538 +/- 0.00233	0.00538 +/- 0.00233
bg_vbf_600_	2.32 +/- 1.52	249.76 +/- 1.55	0.00919 +/- 0.00601	0.00919 +/- 0.00601
bg_vbf_800_	1.07 +/- 1.03	113.69 +/- 1.05	0.00936 +/- 0.00899	0.00936 +/- 0.00899
bg_vbf_1200	0.129 +/- 0.357	20.467 +/- 0.359	0.00624 +/- 0.01735	0.00624 +/- 0.01735
bg_vbf_1600	0.0174 +/- 0.1318	7.641 +/- 0.132	0.00227 +/- 0.01721	0.00227 +/- 0.01721
bg_dip_0_10	0.0 +/- 0.0	2710847 +/- 4613	0.0 +/- 0.0	0.0 +/- 0.0
bg_dip_100_	3.16 +/- 1.78	1095359 +/- 1527	2.89e-06 +/- 1.62e-06	2.89e-06 +/- 1.62e-06
bg_dip_200_	11.74 +/- 3.43	239537 +/- 413	4.90e-05 +/- 1.43e-05	4.90e-05 +/- 1.43e-05
bg_dip_400_	14.68 +/- 3.83	28784.0 +/- 52.3	0.000510 +/- 0.000133	0.000510 +/- 0.000133
bg_dip_600_	6.00 +/- 2.45	6668.4 +/- 27.7	0.000899 +/- 0.000367	0.000899 +/- 0.000367
bg_dip_800_	2.92 +/- 1.71	2939.42 +/- 5.33	0.00099 +/- 0.00058	0.00099 +/- 0.00058
bg_dip_1200	0.326 +/- 0.571	513.18 +/- 2.69	0.000635 +/- 0.001111	0.000635 +/- 0.001111
bg_dip_1600	0.0348 +/- 0.1866	187.749 +/- 0.335	0.000186 +/- 0.000994	0.000186 +/- 0.000994

4   Summary

4.1   Cut-flow charts

- How to compare signal (S) and background (B): S/sqrt(S+B+(xB)**2) .

- 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)	69.4462 +/- 0.0651	4113516 +/- 4877	3.42e-02 +/- 3.80e-05
SEL: ((sdETA (jets[1] jets[2]) > 3.1 or sdETA	21.36 +/- 3.85	53.66 +/- 7.32	2.466 +/- 0.399