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_pheno # need to
change this directory path -> exit and type "pwd" to get the path
ma5>set main.lumi = 40.0
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_pheno/madgraph_data/axion_signal/-
axion_signal_gurrola_cuts_1MeV.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
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```
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># line styles and colors
ma5>set signal.linecolor = red
ma5>set signal.linestyle = dashed
ma5>set signal.linewidth = 3
ma5>set bg_vbf_0_100.linecolor = blue-4
ma5>set bg_vbf_0_100.linestyle = dash-dotted
ma5>set bg_vbf_0_100.linewidth = 4
ma5>set bg_vbf_100_200.linecolor = blue-3
ma5>set bg_vbf_100_200.linestyle = dash-dotted
ma5>set bg_vbf_100_200.linewidth = 4
ma5>set bg_vbf_200_400.linecolor = blue-2
ma5>set bg_vbf_200_400.linestyle = dash-dotted
ma5>set bg_vbf_200_400.linewidth = 4
ma5>set bg_vbf_400_600.linecolor = blue-1
ma5>set bg_vbf_400_600.linestyle = dash-dotted
ma5>set bg_vbf_400_600.linewidth = 4
ma5>set bg_vbf_600_800.linecolor = blue
ma5>set bg_vbf_600_800.linestyle = dash-dotted
ma5>set bg_vbf_600_800.linewidth = 4
ma5>set bg_vbf_800_1200.linecolor = blue+1
ma5>set bg_vbf_800_1200.linestyle = dash-dotted
ma5>set bg_vbf_800_1200.linewidth = 4
ma5>set bg_vbf_1200_1600.linecolor = blue+2
ma5>set bg_vbf_1200_1600.linestyle = dash-dotted
ma5>set bg_vbf_1200_1600.linewidth = 4
ma5>set bg_vbf_1600_inf.linecolor = blue+3
ma5>set bg_vbf_1600_inf.linestyle = dash-dotted
ma5>set bg_vbf_1600_inf.linewidth = 4
ma5>set bg_dip_0_100.linecolor = green-4
ma5>set bg_dip_0_100.linestyle = dash-dotted
ma5>set bg_dip_0_100.linewidth = 4
ma5>set bg_dip_100_200.linecolor = green-3
ma5>set bg_dip_100_200.linestyle = dash-dotted
ma5>set bg_dip_100_200.linewidth = 4
```

```
ma5>set bg_dip_200_400.linecolor = green-2
ma5>set bg_dip_200_400.linestyle = dash-dotted
ma5>set bg_dip_200_400.linewidth = 4
ma5>set bg_dip_400_600.linecolor = green-1
ma5>set bg_dip_400_600.linestyle = dash-dotted
ma5>set bg_dip_400_600.linewidth = 4
ma5>set bg_dip_600_800.linecolor = green
ma5>set bg_dip_600_800.linestyle = dash-dotted
ma5>set bg_dip_600_800.linewidth = 4
ma5>set bg_dip_800_1200.linecolor = green+1
ma5>set bg_dip_800_1200.linestyle = dash-dotted
ma5>set bg_dip_800_1200.linewidth = 4
ma5>set bg_dip_1200_1600.linecolor = green+2
ma5>set bg_dip_1200_1600.linestyle = dash-dotted
ma5>set bg_dip_1200_1600.linewidth = 4
ma5>set bg_dip_1600_inf.linecolor = green+3
ma5>set bg_dip_1600_inf.linestyle = dash-dotted
ma5>set bg_dip_1600_inf.linewidth = 4
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 Zprime = 32 -32
ma5># reduce contribution from V+Zp ==> jj+Zpz
ma5>select M(jets[1] jets[2]) > 120
ma5># define which plots to make
ma5>plot PT(jets[1])
ma5>plot ETA(jets[1])
ma5>plot PHI(jets[1])
ma5>plot PT(jets[2])
ma5>plot ETA(jets[2])
ma5>plot PHI(jets[2])
ma5>plot DELTAR(jets[1], jets[2])
ma5>plot M(jets[1] jets[2])
ma5>plot MET
ma5>plot sdETA(jets[1] jets[2])
ma5>plot M(a[1] a[2])
ma5>plot PT(a[1])
ma5>plot PT(a[2])
ma5>plot THT
ma5>plot MET
ma5>plot TET
ma5>#set the plot/graph parameters
ma5>set selection[2].xmax = 1000
ma5>set selection[2].xmin = 0
ma5>set selection[2].nbins = 200
ma5>set selection[2].logY = true
```

```
ma5>set selection[2].logX = false
ma5>set selection[2].rank = PTordering
ma5>#set selection[2].stacking_method = normalize2one
ma5>set selection[2].titleX = "p_{T}[j_{1}] (GeV)"
ma5>set selection[3].xmax = 8
ma5>set selection[3].xmin = -8
ma5>set selection[3].nbins = 160
ma5>set selection[3].logY = false
ma5>set selection[3].logX = false
ma5>set selection[3].rank = PTordering
ma5>#set selection[3].stacking_method = normalize2one
ma5>set selection[3].titleX = "#eta[j_{1}]"
ma5>set selection[4].xmax = 3.2
ma5>set selection[4].xmin = -3.2
ma5>set selection[4].nbins = 64
ma5>set selection[4].logY = false
ma5>set selection[4].logX = false
ma5>set selection[4].rank = PTordering
ma5>#set selection[4].stacking_method = normalize2one
ma5>set selection[4].titleX = "#phi[j_{1}]"
ma5>set selection[5].xmax = 500
ma5>set selection[5].xmin = 0
ma5>set selection[5].nbins = 100
ma5>set selection[5].logY = true
ma5>set selection[5].logX = false
ma5>set selection[5].rank = PTordering
ma5>#set selection[5].stacking_method = normalize2one
ma5>set selection[5].titleX = "p_{T}[j_{2}] (GeV)"
ma5>set selection[6].xmax = 8
ma5>set selection[6].xmin = -8
ma5>set selection[6].nbins = 160
ma5>set selection[6].logY = false
ma5>set selection[6].logX = false
ma5>set selection[6].rank = PTordering
ma5>#set selection[6].stacking_method = normalize2one
ma5>set selection[6].titleX = "#eta[j_{2}]"
ma5>set selection[7].xmax = 3.2
ma5>set selection[7].xmin = -3.2
ma5>set selection[7].nbins = 64
ma5>set selection[7].logY = false
ma5>set selection[7].logX = false
ma5>set selection[7].rank = PTordering
ma5>#set selection[7].stacking_method = normalize2one
ma5>set selection[7].titleX = "#phi[j_{2}]"
ma5>set selection[8].xmax = 15
ma5>set selection[8].xmin = 0
ma5>set selection[8].nbins = 75
ma5>set selection[8].logY = false
ma5>set selection[8].logX = false
```

```
ma5>set selection[8].rank = PTordering
ma5>#set selection[8].stacking_method = normalize2one
ma5>set selection[8].titleX = "#DeltaR[j_{1},j_{2}]"
ma5>set selection[9].xmax = 8000
ma5>set selection[9].xmin = 0
ma5>set selection[9].nbins = 160
ma5>set selection[9].logY = false
ma5>set selection[9].logX = false
ma5>set selection[9].rank = PTordering
ma5>#set selection[9].stacking_method = normalize2one
ma5>set selection[9].titleX = "M[j_{1},j_{2}] (GeV)"
ma5>set selection[10].xmax = 1000
ma5>set selection[10].xmin = 0
ma5>set selection[10].nbins = 100
ma5>set selection[10].logY = true
ma5>set selection[10].logX = false
ma5>set selection[10].rank = PTordering
ma5>#set selection[10].stacking_method = normalize2one
ma5>set selection[10].titleX = "#slash{E}_{T} (GeV)"
ma5>#set selection[11].stacking_method = normalize2one
ma5>set selection[11].titleX = "#Delta#eta(j_{1},j_{2})"
ma5>#set selection[12].xmax = 2000
ma5>#set selection[12].xmin = 0
ma5>set selection[12].nbins = 400
ma5>set selection[12].logY = true
ma5>set selection[12].logX = false
ma5>set selection[12].rank = PTordering
ma5>#set selection[12].stacking_method = normalize2one
ma5>set selection[12].titleX = "M[a_{1},a_{2}] (GeV)"
ma5>#set selection[13].xmax = 4
ma5>#set selection[13].xmin = -4
ma5>set selection[13].nbins = 80
ma5>set selection[13].logY = false
ma5>set selection[13].logX = false
ma5>set selection[13].rank = PTordering
ma5>#set selection[13].stacking_method = normalize2one
ma5>set selection[13].titleX = "p_{T}[a_{1}]"
ma5>#set selection[14].xmax = 2000
ma5>#set selection[14].xmin = 0
ma5>set selection[14].nbins = 400
ma5>set selection[14].logY = true
ma5>set selection[14].logX = false
ma5>set selection[14].rank = PTordering
ma5>#set selection[14].stacking_method = normalize2one
ma5>set selection[14].titleX = "p_{T}[a_{2}] (GeV)"
ma5>#set selection[15].xmax = 4
ma5>#set selection[15].xmin = -4
ma5>set selection[15].nbins = 80
ma5>set selection[15].logY = false
```

```
ma5>set selection[15].logX = false
ma5>set selection[15].rank = PTordering
ma5>#set selection[15].stacking_method = normalize2one
ma5>set selection[15].titleX = "THT"
ma5>#set selection[16].xmax = 1000
ma5>#set selection[16].xmin = 0
ma5>set selection[16].nbins = 200
ma5>set selection[16].logY = true
ma5>set selection[16].logX = false
ma5>set selection[16].rank = PTordering
ma5>#set selection[16].stacking_method = normalize2one
ma5>set selection[16].titleX = "MET"
ma5>#set selection[17].xmax = 4
ma5>#set selection[17].xmin = -4
ma5>set selection[17].nbins = 80
ma5>set selection[17].logY = false
ma5>set selection[17].logX = false
ma5>set selection[17].rank = PTordering
ma5>#set selection[17].stacking_method = normalize2one
ma5>set selection[17].titleX = "TET"
ma5># apply selections
ma5>select (sdETA(jets[1] jets[2]) > 6.1 or sdETA(jets[1] jets[2]) < -6.1) and M(jets[1]
jets[2]) > 1250
ma5>submit analysis_deltaeta6.1_mmjj_1250
```

1.2 Configuration

- MadAnalysis version 1.6.33 (2017/11/20).
- Histograms given for an integrated luminosity of $40.0\mathrm{fb}^{-1}$.

2 Datasets

2.1 signal

- Samples stored in the directory: /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/-optimization .
- Sample consisting of: signal events.
- Generated events: 1000000 events.
- Normalization to the luminosity: 4094+/- 2 events.
- Ratio (event weight): 0.0041 .

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/-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_pheno/-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/-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/-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/-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/-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/-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/-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/-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/-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_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_pheno/-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_c-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/-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_c-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/-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/-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/-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/-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/-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 M (jets[1] jets[2]) > 120.0**

Dataset	Events kept: K	Rejected events: R	Efficiency: K / (K + R)	Cumul. efficiency: K / Initial
signal	4094.04 +/- 1.14	0.04 +/- 0.20	1.00e+00 +/- 4.89e-05	1.00e+00 +/- 4.89e-05
bg_vbf_0_10	3934.7 +/- 52.1	8215.6 +/- 53.9	0.32384 +/- 0.00425	0.32384 +/- 0.00425
bg_vbf_100_	8757.0 +/- 32.7	938.4 +/- 29.2	0.903 +/- 0.003	0.903 +/- 0.003
bg_vbf_200_	5358.8 +/- 13.1	54.50 +/- 7.35	0.98993 +/- 0.00136	0.98993 +/- 0.00136
bg_vbf_400_	983.78 +/- 2.22	3.07 +/- 1.75	0.99689 +/- 0.00177	0.99689 +/- 0.00177
bg_vbf_600_	251.851 +/- 0.571	0.226 +/- 0.475	0.99910 +/- 0.00189	0.99910 +/- 0.00189
bg_vbf_800_	114.64 +/- 0.39	0.12 +/- 0.35	0.99895 +/- 0.00302	0.99895 +/- 0.00302
bg_vbf_1200_	20.553 +/- 0.209	0.0426 +/- 0.2061	1.00 +/- 0.01	1.00 +/- 0.01
bg_vbf_1600_	7.513 +/- 0.378	0.146 +/- 0.378	0.9810 +/- 0.0494	0.9810 +/- 0.0494
bg_dip_0_10	714692 +/- 1416	1996154 +/- 3473	0.263642 +/- 0.000268	0.263642 +/- 0.000268
bg_dip_100_	855479 +/- 1268	239882 +/- 546	0.781001 +/- 0.000395	0.781001 +/- 0.000395
bg_dip_200_	234627 +/- 411	4920.9 +/- 69.9	0.97946 +/- 0.00029	0.97946 +/- 0.00029
bg_dip_400_	28616.2 +/- 53.6	182.4 +/- 13.5	0.993665 +/- 0.000468	0.993665 +/- 0.000468
bg_dip_600_	6658.9 +/- 27.8	15.43 +/- 3.92	0.997689 +/- 0.000588	0.997689 +/- 0.000588
bg_dip_800_	2939.96 +/- 5.28	2.38 +/- 1.54	0.999192 +/- 0.000524	0.999192 +/- 0.000524
bg_dip_1200_	513.34 +/- 2.66	0.17 +/- 0.41	0.999669 +/- 0.000803	0.999669 +/- 0.000803
bg_dip_1600_	187.742 +/- 0.345	0.0414 +/- 0.2034	0.99978 +/- 0.00108	0.99978 +/- 0.00108

3.2 Histogram 1

*** Plot: PT (jets[1])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	445.82	317.0	0.0	6.28
bg_vbf_0_100	3934	1.0	46.784	11.01	0.0	0.0
bg_vbf_100_20	8756	1.0	87.0579	20.21	0.0	0.0
bg_vbf_200_40	5358	1.0	159.249	38.06	0.0	0.0
bg_vbf_400_60	983	1.0	274.434	50.77	0.0	0.0
bg_vbf_600_80	251	1.0	386.332	64.57	0.0	0.0
bg_vbf_800_12	114	1.0	524.594	93.61	0.0	0.1816
bg_vbf_1200_1	20.6	1.0	738.34	109.5	0.0	3.383
bg_vbf_1600_i	7.66	1.0	1048.57	221.9	0.0	46.27
bg_dip_0_100	714691	1.0	44.2861	11.5	0.0	0.0
bg_dip_100_20	855479	1.0	84.0902	19.87	0.0	0.0
bg_dip_200_40	234627	1.0	155.663	38.1	0.0	0.0
bg_dip_400_60	28616	1.0	272.939	53.09	0.0	0.0
bg_dip_600_80	6658	1.0	382.903	65.7	0.0	0.0
bg_dip_800_12	2939	1.0	517.996	90.51	0.0	0.2342
bg_dip_1200_1	513	1.0	728.639	100.1	0.0	2.272
bg_dip_1600_i	187	1.0	1036.29	211.5	0.0	43.96

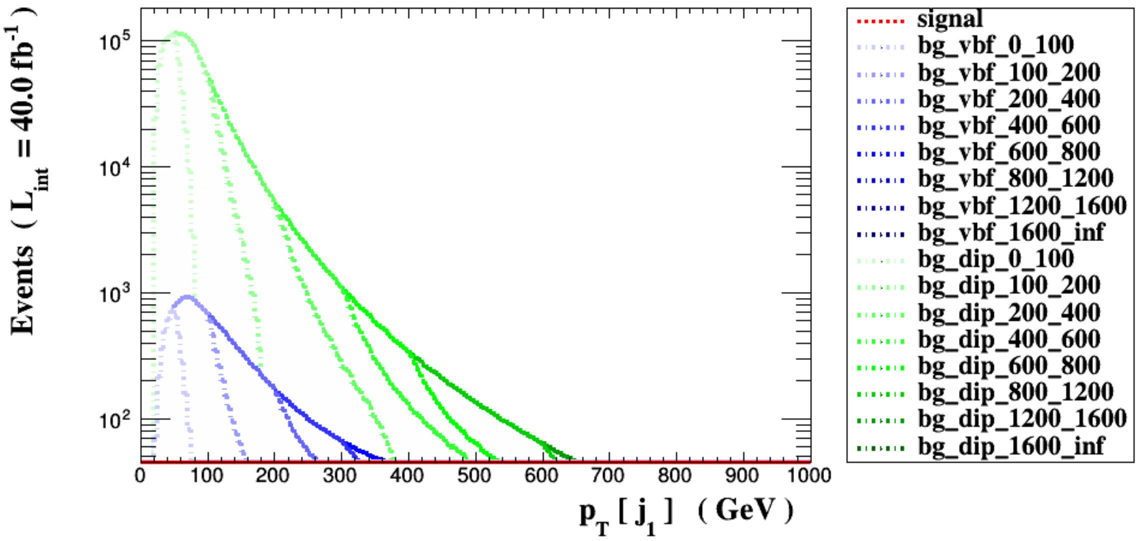

Figure 1.

3.3 Histogram 2

*** Plot: ETA (jets[1])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	-0.0023996	1.616	0.0	0.0
bg_vbf_0_100	3934	1.0	-0.00133609	2.635	0.0	0.0
bg_vbf_100_20	8756	1.0	0.0043695	2.247	0.0	0.0
bg_vbf_200_40	5358	1.0	0.00194377	1.965	0.0	0.0
bg_vbf_400_60	983	1.0	-0.000999715	1.682	0.0	0.0
bg_vbf_600_80	251	1.0	0.000513382	1.499	0.0	0.0
bg_vbf_800_12	114	1.0	-0.00310292	1.329	0.0	0.0
bg_vbf_1200_1	20.6	1.0	-0.000169046	1.134	0.0	0.0
bg_vbf_1600_i	7.66	1.0	0.00127081	0.9541	0.0	0.0
bg_dip_0_100	714691	1.0	0.000508343	2.224	0.0	0.0
bg_dip_100_20	855479	1.0	0.00260979	1.71	0.0	0.0
bg_dip_200_40	234627	1.0	-0.0010006	1.468	0.0	0.0
bg_dip_400_60	28616	1.0	-0.00170173	1.279	0.0	0.0
bg_dip_600_80	6658	1.0	-0.0049065	1.157	0.0	0.0
bg_dip_800_12	2939	1.0	0.00133618	1.052	0.0	0.0
bg_dip_1200_1	513	1.0	-0.00486624	0.9226	0.0	0.0
bg_dip_1600_i	187	1.0	-0.00107396	0.8	0.0	0.0

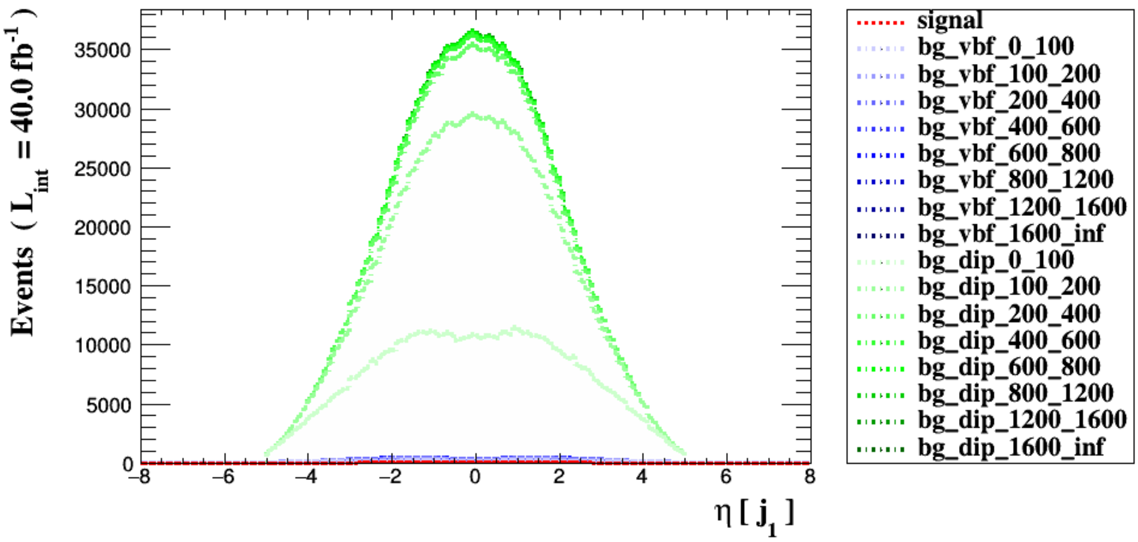

Figure 2.

3.4 Histogram 3

*** Plot: PHI (jets[1])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	0.00102738	1.813	0.0	0.0
bg_vbf_0_100	3934	1.0	0.00419195	1.813	0.0	0.0
bg_vbf_100_20	8756	1.0	-0.00148977	1.814	0.0	0.0
bg_vbf_200_40	5358	1.0	0.00192437	1.814	0.0	0.0
bg_vbf_400_60	983	1.0	-0.00356173	1.813	0.0	0.0
bg_vbf_600_80	251	1.0	- 0.000882503	1.813	0.0	0.0
bg_vbf_800_12	114	1.0	-0.00348627	1.813	0.0	0.0
bg_vbf_1200_1	20.6	1.0	0.00205129	1.813	0.0	0.0
bg_vbf_1600_i	7.66	1.0	0.00218185	1.813	0.0	0.0
bg_dip_0_100	714691	1.0	-0.00108067	1.816	0.0	0.0
bg_dip_100_20	855479	1.0	0.00213448	1.814	0.0	0.0
bg_dip_200_40	234627	1.0	-0.00158683	1.812	0.0	0.0
bg_dip_400_60	28616	1.0	-0.00239958	1.813	0.0	0.0
bg_dip_600_80	6658	1.0	0.00121432	1.814	0.0	0.0
bg_dip_800_12	2939	1.0	0.000396081	1.814	0.0	0.0
bg_dip_1200_1	513	1.0	6.26217e-05	1.814	0.0	0.0
bg_dip_1600_i	187	1.0	0.0014267	1.814	0.0	0.0

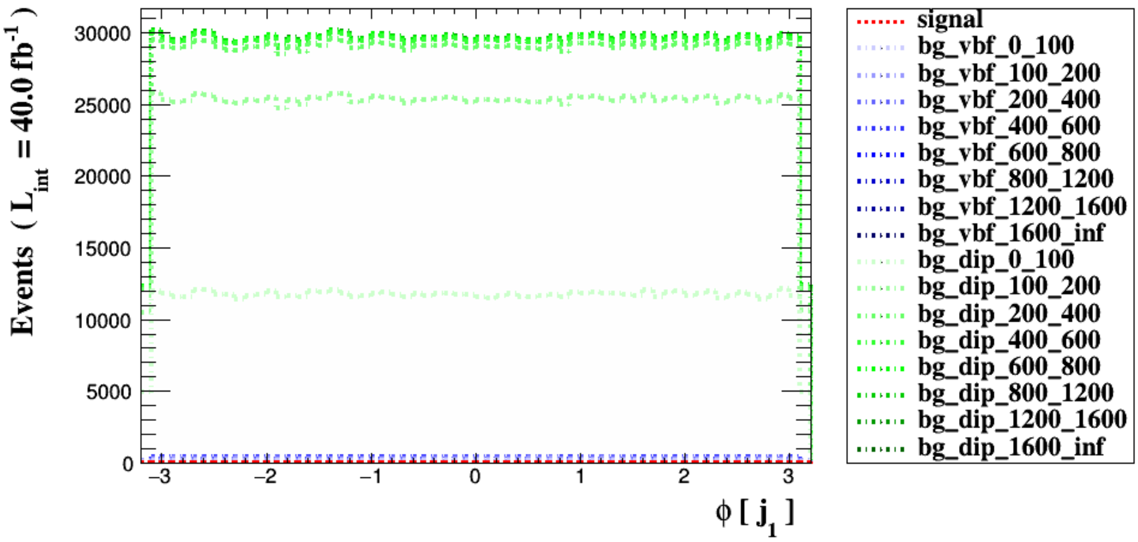

Figure 3.

3.5 Histogram 4

*** Plot: PT (jets[2])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	161.87	136.0	0.0	3.02
bg_vbf_0_100	3934	1.0	31.2504	7.217	0.0	0.0
bg_vbf_100_20	8756	1.0	57.5348	16.74	0.0	0.0
bg_vbf_200_40	5358	1.0	111.536	32.69	0.0	0.0
bg_vbf_400_60	983	1.0	201.545	47.5	0.0	0.0
bg_vbf_600_80	251	1.0	293.986	62.63	0.0	0.0
bg_vbf_800_12	114	1.0	415.077	90.48	0.0	15.1
bg_vbf_1200_1	20.6	1.0	613.849	108.4	0.0	90.47
bg_vbf_1600_i	7.66	1.0	917.972	221.8	0.0	98.03
bg_dip_0_100	714691	1.0	29.8777	7.014	0.0	0.0
bg_dip_100_20	855479	1.0	54.688	15.89	0.0	0.0
bg_dip_200_40	234627	1.0	106.13	33.69	0.0	0.0
bg_dip_400_60	28616	1.0	201.059	51.01	0.0	0.0
bg_dip_600_80	6658	1.0	296.97	64.64	0.0	0.0
bg_dip_800_12	2939	1.0	421.627	88.69	0.0	16.13
bg_dip_1200_1	513	1.0	623.471	99.67	0.0	93.34
bg_dip_1600_i	187	1.0	926.302	210.5	0.0	98.92

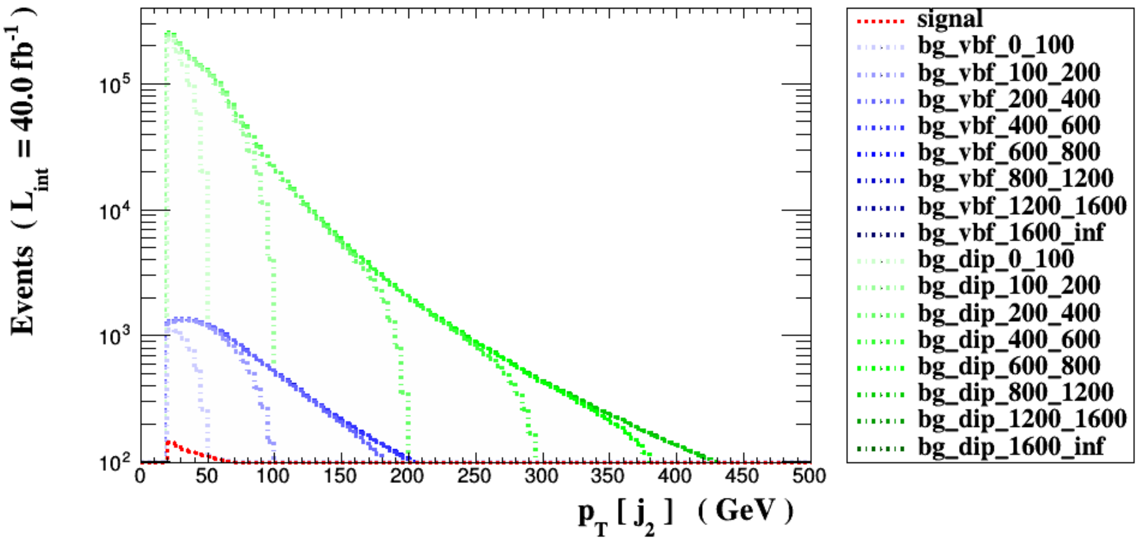

Figure 4.

3.6 Histogram 5

*** Plot: ETA (jets[2])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	0.00500696	2.329	0.0	0.0
bg_vbf_0_100	3934	1.0	-0.0019532	2.674	0.0	0.0
bg_vbf_100_20	8756	1.0	-0.0066	2.371	0.0	0.0
bg_vbf_200_40	5358	1.0	0.000228824	2.132	0.0	0.0
bg_vbf_400_60	983	1.0	-0.000744275	1.863	0.0	0.0
bg_vbf_600_80	251	1.0	-0.00168321	1.667	0.0	0.0
bg_vbf_800_12	114	1.0	-0.000452317	1.473	0.0	0.0
bg_vbf_1200_1	20.6	1.0	0.000595874	1.238	0.0	0.0
bg_vbf_1600_i	7.66	1.0	-0.00207042	1.017	0.0	0.0
bg_dip_0_100	714691	1.0	1.01009e-05	2.147	0.0	0.0
bg_dip_100_20	855479	1.0	-0.00108977	1.645	0.0	0.0
bg_dip_200_40	234627	1.0	-0.00265008	1.446	0.0	0.0
bg_dip_400_60	28616	1.0	-0.000387923	1.29	0.0	0.0
bg_dip_600_80	6658	1.0	-0.000303381	1.182	0.0	0.0
bg_dip_800_12	2939	1.0	0.00119018	1.078	0.0	0.0
bg_dip_1200_1	513	1.0	-0.000424092	0.9457	0.0	0.0
bg_dip_1600_i	187	1.0	0.000907805	0.8179	0.0	0.0

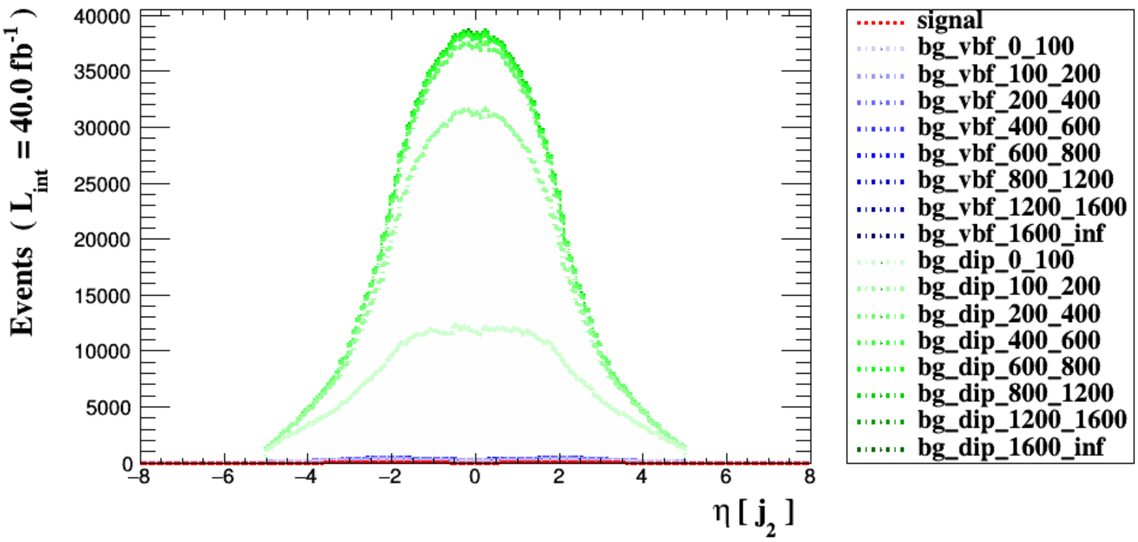
Events (L_{int} = 40.0 fb^{-1})
40000
35000
30000
25000
20000
15000
10000
5000
0
−8
−6
−4
−2
0
2
4
6
8
η [j_2]
signal
bg_vbf_0_100
bg_vbf_100_200
bg_vbf_200_400
bg_vbf_400_600
bg_vbf_600_800
bg_vbf_800_1200
bg_vbf_1200_1600
bg_vbf_1600_inf
bg_dip_0_100
bg_dip_100_200
bg_dip_200_400
bg_dip_400_600
bg_dip_600_800
bg_dip_800_1200
bg_dip_1200_1600
bg_dip_1600_inf

Figure 5.

3.7 Histogram 6

*** Plot: PHI (jets[2])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	-0.00274458	1.814	0.0	0.0
bg_vbf_0_100	3934	1.0	-0.00276363	1.814	0.0	0.0
bg_vbf_100_20	8756	1.0	-3.00875e-05	1.815	0.0	0.0
bg_vbf_200_40	5358	1.0	-0.00153572	1.814	0.0	0.0
bg_vbf_400_60	983	1.0	0.00312538	1.814	0.0	0.0
bg_vbf_600_80	251	1.0	0.00050346	1.815	0.0	0.0
bg_vbf_800_12	114	1.0	0.000132195	1.813	0.0	0.0
bg_vbf_1200_1	20.6	1.0	-0.0034209	1.815	0.0	0.0
bg_vbf_1600_i	7.66	1.0	-0.00282812	1.814	0.0	0.0
bg_dip_0_100	714691	1.0	0.00324102	1.813	0.0	0.0
bg_dip_100_20	855479	1.0	-0.00116298	1.815	0.0	0.0
bg_dip_200_40	234627	1.0	0.000793162	1.815	0.0	0.0
bg_dip_400_60	28616	1.0	-1.20627e-05	1.814	0.0	0.0
bg_dip_600_80	6658	1.0	-0.00250468	1.815	0.0	0.0
bg_dip_800_12	2939	1.0	-0.000669513	1.813	0.0	0.0
bg_dip_1200_1	513	1.0	-0.00203746	1.813	0.0	0.0
bg_dip_1600_i	187	1.0	0.00234294	1.814	0.0	0.0

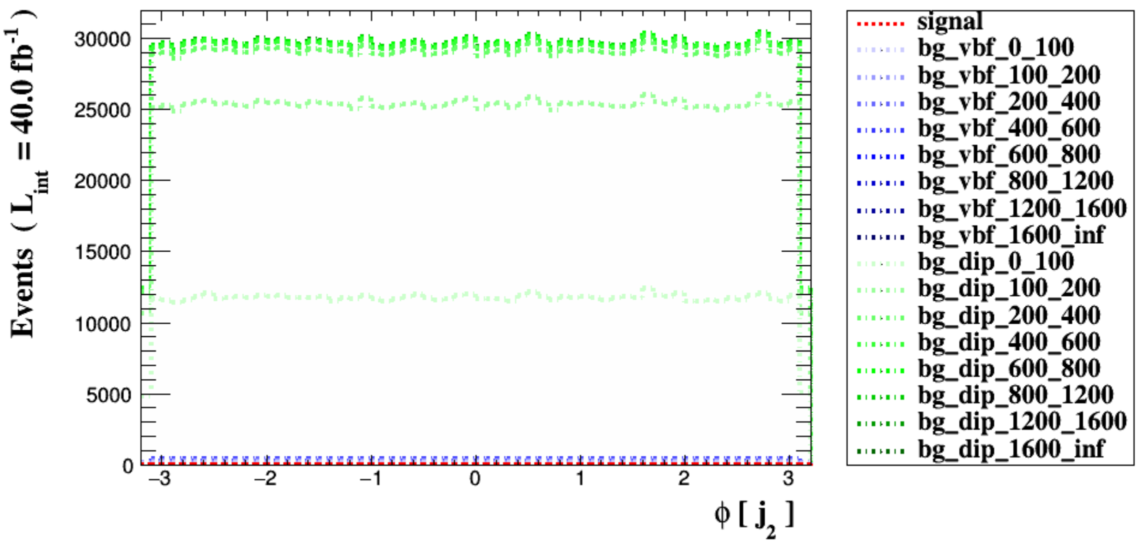

Figure 6.

3.8 Histogram 7

*** Plot: DELTAR (jets[1] , jets[2])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	4.02835	1.056	0.0	0.0
bg_vbf_0_100	3934	1.0	5.21509	1.267	0.0	0.0
bg_vbf_100_20	8756	1.0	4.68485	1.264	0.0	0.0
bg_vbf_200_40	5358	1.0	4.4049	1.096	0.0	0.0
bg_vbf_400_60	983	1.0	4.11552	0.8948	0.0	0.0
bg_vbf_600_80	251	1.0	3.92644	0.7722	0.0	0.0
bg_vbf_800_12	114	1.0	3.75826	0.6584	0.0	0.0
bg_vbf_1200_1	20.6	1.0	3.58482	0.5257	0.0	0.0
bg_vbf_1600_i	7.66	1.0	3.44779	0.4108	0.0	0.0
bg_dip_0_100	714691	1.0	4.20916	0.7369	0.0	0.0
bg_dip_100_20	855479	1.0	3.45656	0.6833	0.0	0.0
bg_dip_200_40	234627	1.0	3.29993	0.6389	0.0	0.0
bg_dip_400_60	28616	1.0	3.28686	0.5815	0.0	0.0
bg_dip_600_80	6658	1.0	3.28486	0.5273	0.0	0.0
bg_dip_800_12	2939	1.0	3.28621	0.4662	0.0	0.0
bg_dip_1200_1	513	1.0	3.28098	0.3842	0.0	0.0
bg_dip_1600_i	187	1.0	3.26771	0.3022	0.0	0.0

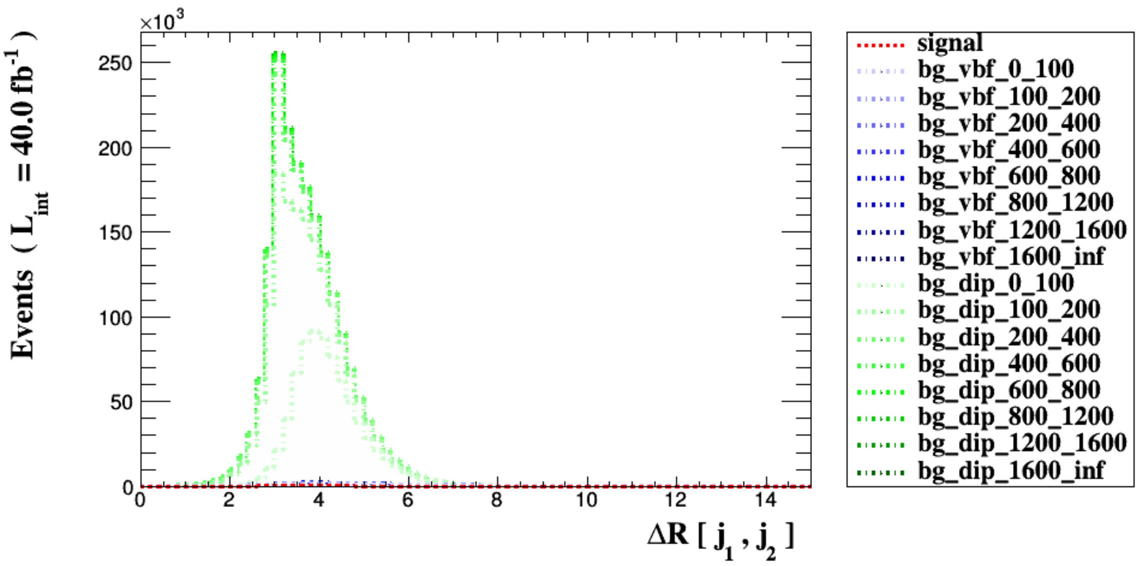

Figure 7.

3.9 Histogram 8

*** Plot: M (jets[1] jets[2])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	1376.2	772.9	0.0	0.0
bg_vbf_0_100	3934	1.0	469.964	412.4	0.0	0.0
bg_vbf_100_20	8756	1.0	609.152	529.4	0.0	0.0
bg_vbf_200_40	5358	1.0	888.626	671.3	0.0	0.0003082
bg_vbf_400_60	983	1.0	1211.77	761.1	0.0	0.0006018
bg_vbf_600_80	251	1.0	1465.23	805.1	0.0	0.001401
bg_vbf_800_12	114	1.0	1732.47	822.0	0.0	0.002495
bg_vbf_1200_1	20.6	1.0	2125.32	815.8	0.0	0.002832
bg_vbf_1600_i	7.66	1.0	2691.74	857.1	0.0	0.01037
bg_dip_0_100	714691	1.0	202.321	105.0	0.0	0.0
bg_dip_100_20	855479	1.0	222.194	129.4	0.0	0.0
bg_dip_200_40	234627	1.0	364.432	195.6	0.0	0.0
bg_dip_400_60	28616	1.0	626.063	277.8	0.0	0.0
bg_dip_600_80	6658	1.0	872.986	337.8	0.0	0.0
bg_dip_800_12	2939	1.0	1178.48	408.8	0.0	0.0
bg_dip_1200_1	513	1.0	1647.88	468.4	0.0	0.0
bg_dip_1600_i	187	1.0	2311.56	635.4	0.0	0.0001923

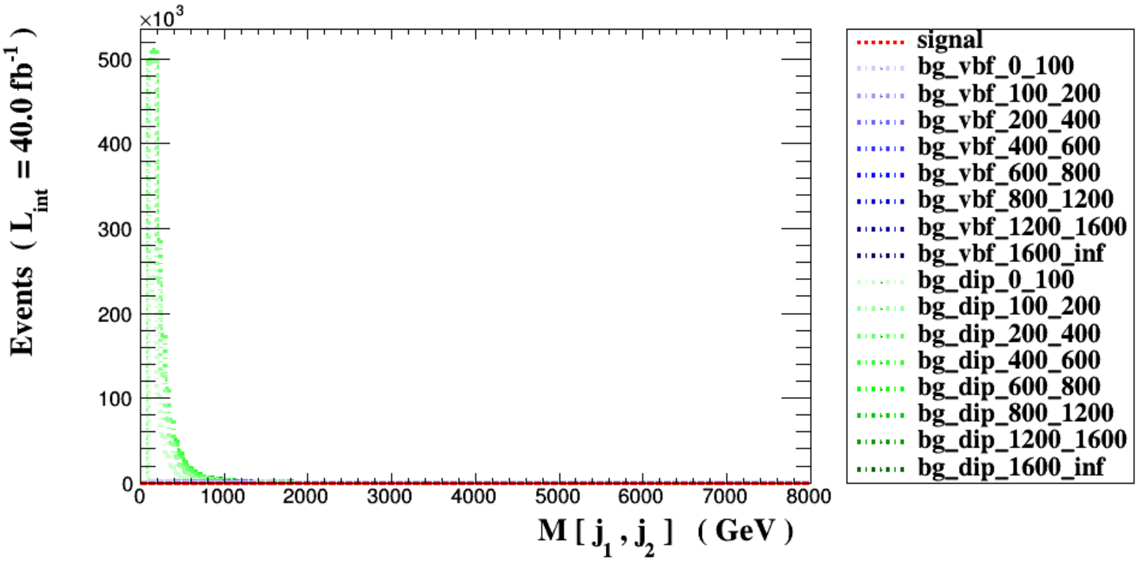

Figure 8.

3.10 Histogram 9

*** Plot: MET**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	8.33083e-09	1.078e-08	0.0	0.0
bg_vbf_0_100	3934	1.0	5.97855e-10	4.233e-10	0.0	0.0
bg_vbf_100_20	8756	1.0	9.55638e-10	1.098e-09	0.0	0.0
bg_vbf_200_40	5358	1.0	3.23057e-09	2.219e-09	0.0	0.0
bg_vbf_400_60	983	1.0	4.52485e-09	2.611e-09	0.0	0.0
bg_vbf_600_80	251	1.0	4.90226e-09	2.72e-09	0.0	0.0
bg_vbf_800_12	114	1.0	5.15622e-09	2.979e-09	0.0	0.0
bg_vbf_1200_1	20.6	1.0	5.81971e-09	5.339e-09	0.0	0.0
bg_vbf_1600_i	7.66	1.0	1.30635e-08	1.639e-08	0.0	0.0
bg_dip_0_100	714691	1.0	5.87329e-10	4.134e-10	0.0	0.0
bg_dip_100_20	855479	1.0	8.95295e-10	1.036e-09	0.0	0.0
bg_dip_200_40	234627	1.0	3.11256e-09	2.186e-09	0.0	0.0
bg_dip_400_60	28616	1.0	4.43451e-09	2.58e-09	0.0	0.0
bg_dip_600_80	6658	1.0	4.80208e-09	2.678e-09	0.0	0.0
bg_dip_800_12	2939	1.0	5.06231e-09	3.026e-09	0.0	0.0
bg_dip_1200_1	513	1.0	5.58908e-09	4.823e-09	0.0	0.0
bg_dip_1600_i	187	1.0	1.25075e-08	1.605e-08	0.0	0.0

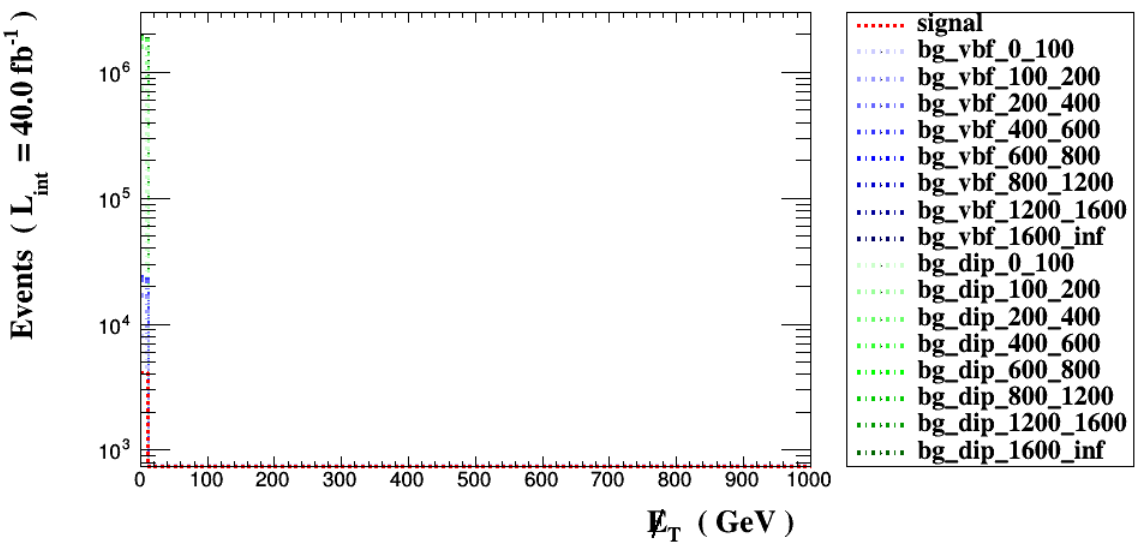

Figure 9.

3.11 Histogram 10

*** Plot: sdETA (jets[1] jets[2])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	-0.00740656	3.704	0.2057	0.2022
bg_vbf_0_100	3934	1.0	0.000617109	4.726	0.5803	0.6083
bg_vbf_100_20	8756	1.0	0.0109695	4.015	0.1029	0.1176
bg_vbf_200_40	5358	1.0	0.00171495	3.569	0.004928	0.003696
bg_vbf_400_60	983	1.0	- 0.000255441	3.09	0.0	0.0
bg_vbf_600_80	251	1.0	0.00219659	2.754	0.0	0.0
bg_vbf_800_12	114	1.0	-0.0026506	2.428	0.0	0.0
bg_vbf_1200_1	20.6	1.0	-0.00076492	2.046	0.0	0.0
bg_vbf_1600_i	7.66	1.0	0.00334122	1.694	0.0	0.0
bg_dip_0_100	714691	1.0	0.000498242	3.363	0.0	0.0007299
bg_dip_100_20	855479	1.0	0.00369956	2.156	0.0001229	0.0
bg_dip_200_40	234627	1.0	0.00164949	1.795	0.0	0.0
bg_dip_400_60	28616	1.0	-0.00131381	1.639	0.0	0.0
bg_dip_600_80	6658	1.0	-0.00460312	1.539	0.0	0.0
bg_dip_800_12	2939	1.0	0.000145998	1.448	0.0	0.0
bg_dip_1200_1	513	1.0	-0.00444215	1.327	0.0	0.0
bg_dip_1600_i	187	1.0	-0.00198176	1.196	0.0	0.0

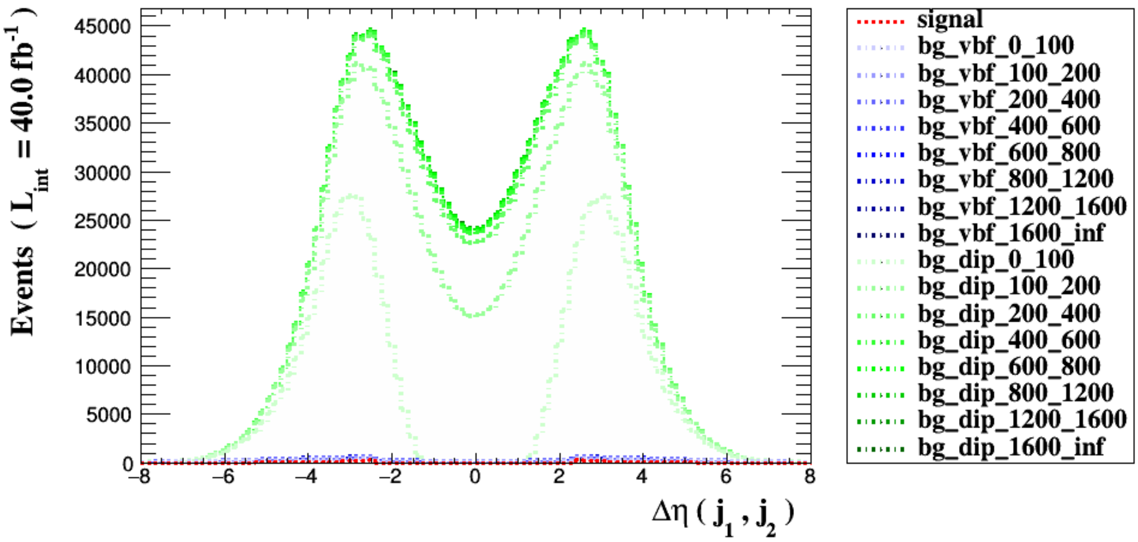

Figure 10.

3.12 Histogram 11

*** Plot: M (a[1] a[2])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	950.206	725.5	0.0	36.84
bg_vbf_0_100	3934	1.0	59.2471	49.28	0.0	0.002778
bg_vbf_100_20	8756	1.0	70.2822	64.56	0.0	0.01548
bg_vbf_200_40	5358	1.0	92.2723	92.82	0.0	0.0622
bg_vbf_400_60	983	1.0	117.071	124.4	0.0	0.1777
bg_vbf_600_80	251	1.0	132.524	146.0	0.0	0.3347
bg_vbf_800_12	114	1.0	143.801	162.6	0.0	0.5078
bg_vbf_1200_1	20.6	1.0	153.519	177.9	0.0	0.6926
bg_vbf_1600_i	7.66	1.0	159.525	184.7	0.0	0.7897
bg_dip_0_100	714691	1.0	48.4767	39.08	0.0	0.002553
bg_dip_100_20	855479	1.0	55.4245	50.97	0.0	0.004558
bg_dip_200_40	234627	1.0	74.3979	76.83	0.0	0.0267
bg_dip_400_60	28616	1.0	95.1626	107.9	0.0	0.1108
bg_dip_600_80	6658	1.0	108.836	127.8	0.0	0.2203
bg_dip_800_12	2939	1.0	119.749	143.7	0.0	0.3484
bg_dip_1200_1	513	1.0	131.534	157.2	0.0	0.4736
bg_dip_1600_i	187	1.0	143.672	167.2	0.0	0.5656

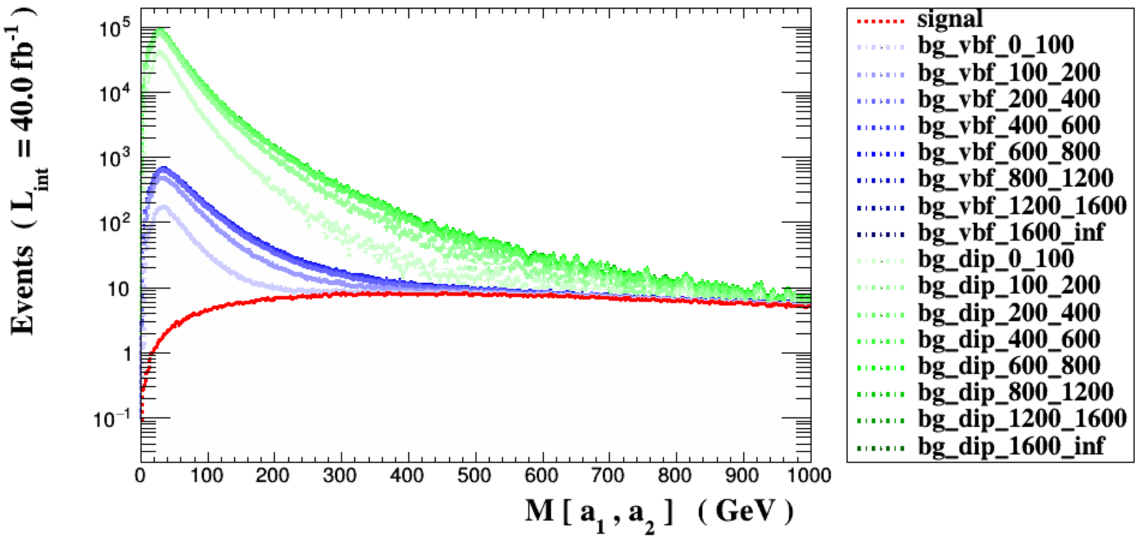

Figure 11.

3.13 Histogram 12

*** Plot: PT (a[1])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	588.092	368.7	0.0	12.98
bg_vbf_0_100	3934	1.0	33.0393	18.87	0.0	0.0
bg_vbf_100_20	8756	1.0	46.4939	31.54	0.0	0.0
bg_vbf_200_40	5358	1.0	72.005	60.42	0.0	0.000308
bg_vbf_400_60	983	1.0	106.886	103.6	0.0	0.002407
bg_vbf_600_80	251	1.0	132.381	141.7	0.0	0.009208
bg_vbf_800_12	114	1.0	154.148	182.0	0.0	0.3163
bg_vbf_1200_1	20.6	1.0	172.887	223.7	0.0	1.906
bg_vbf_1600_i	7.66	1.0	181.168	246.2	0.0	2.06
bg_dip_0_100	714691	1.0	29.8019	18.74	0.0	0.0
bg_dip_100_20	855479	1.0	42.2098	31.98	0.0	0.0001231
bg_dip_200_40	234627	1.0	67.1266	63.03	0.0	9.834e-05
bg_dip_400_60	28616	1.0	95.4197	106.8	0.0	0.001258
bg_dip_600_80	6658	1.0	113.382	139.4	0.0	0.00999
bg_dip_800_12	2939	1.0	126.721	168.3	0.0	0.3807
bg_dip_1200_1	513	1.0	138.701	193.4	0.0	1.426
bg_dip_1600_i	187	1.0	146.238	198.9	0.0	1.065

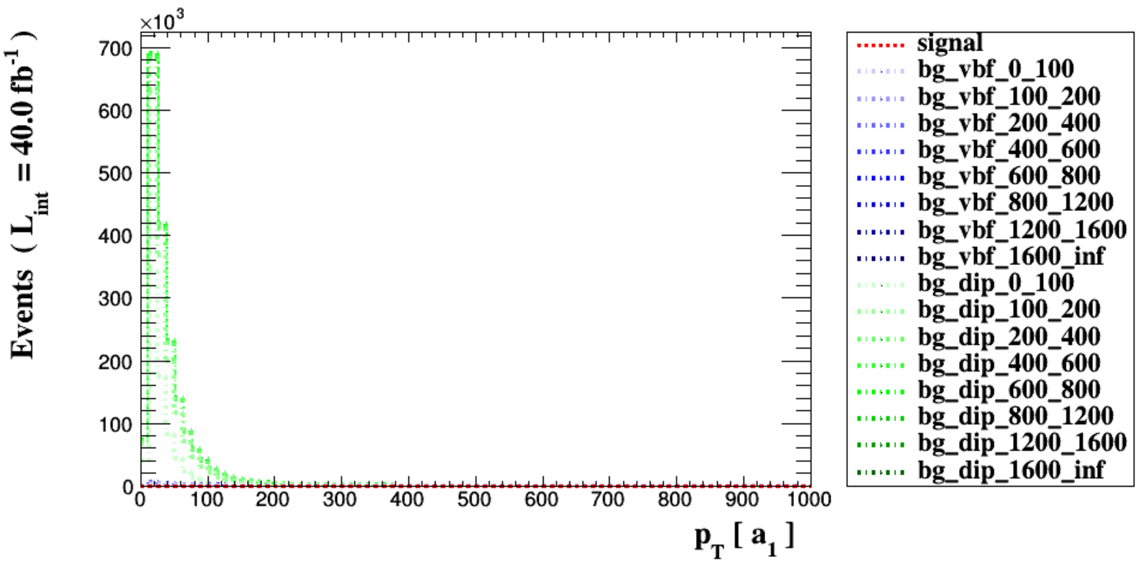

Figure 12.

3.14 Histogram 13

*** Plot: PT (a[2])**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	334.941	290.0	0.0	3.619
bg_vbf_0_100	3934	1.0	18.2641	11.16	0.0	0.0
bg_vbf_100_20	8756	1.0	21.2596	15.54	0.0	0.0
bg_vbf_200_40	5358	1.0	25.9605	23.17	0.0	0.0002055
bg_vbf_400_60	983	1.0	31.2333	32.38	0.0	0.0009032
bg_vbf_600_80	251	1.0	34.5946	38.91	0.0	0.0001002
bg_vbf_800_12	114	1.0	37.1093	44.62	0.0	0.0009971
bg_vbf_1200_1	20.6	1.0	39.4356	49.91	0.0	0.002623
bg_vbf_1600_i	7.66	1.0	40.8098	52.8	0.0	0.004823
bg_dip_0_100	714691	1.0	16.5201	9.637	0.0	0.0
bg_dip_100_20	855479	1.0	18.8185	12.99	0.0	0.0
bg_dip_200_40	234627	1.0	22.8735	19.58	0.0	0.0
bg_dip_400_60	28616	1.0	26.8872	27.11	0.0	0.0001937
bg_dip_600_80	6658	1.0	29.3925	32.02	0.0	0.0003031
bg_dip_800_12	2939	1.0	31.3973	35.97	0.0	0.0007697
bg_dip_1200_1	513	1.0	33.6461	39.79	0.0	0.001184
bg_dip_1600_i	187	1.0	35.6015	42.32	0.0	0.002116

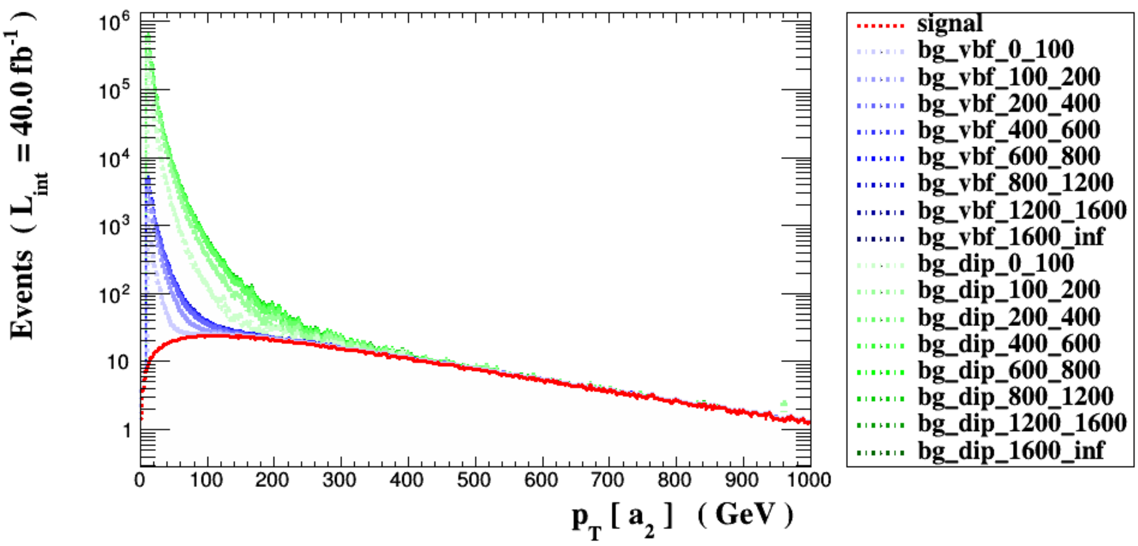

Figure 13.

3.15 Histogram 14

*** Plot: THT**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	607.69	391.1	0.0	15.4
bg_vbf_0_100	3934	1.0	78.0345	14.32	0.0	0.0
bg_vbf_100_20	8756	1.0	144.593	27.95	0.0	0.0
bg_vbf_200_40	5358	1.0	270.786	53.37	0.0	0.0
bg_vbf_400_60	983	1.0	475.979	55.0	0.0	0.0
bg_vbf_600_80	251	1.0	680.318	55.83	0.0	0.0
bg_vbf_800_12	114	1.0	939.672	106.7	0.0	27.89
bg_vbf_1200_1	20.6	1.0	1352.19	109.7	0.0	100.0
bg_vbf_1600_i	7.66	1.0	1966.54	391.6	0.0	100.0
bg_dip_0_100	714691	1.0	74.1637	15.18	0.0	0.0
bg_dip_100_20	855479	1.0	138.778	26.45	0.0	0.0
bg_dip_200_40	234627	1.0	261.793	50.89	0.0	0.0
bg_dip_400_60	28616	1.0	473.998	54.59	0.0	0.0
bg_dip_600_80	6658	1.0	679.873	55.79	0.0	0.0
bg_dip_800_12	2939	1.0	939.623	106.7	0.0	27.8
bg_dip_1200_1	513	1.0	1352.11	109.8	0.0	100.0
bg_dip_1600_i	187	1.0	1962.59	386.0	0.0	100.0

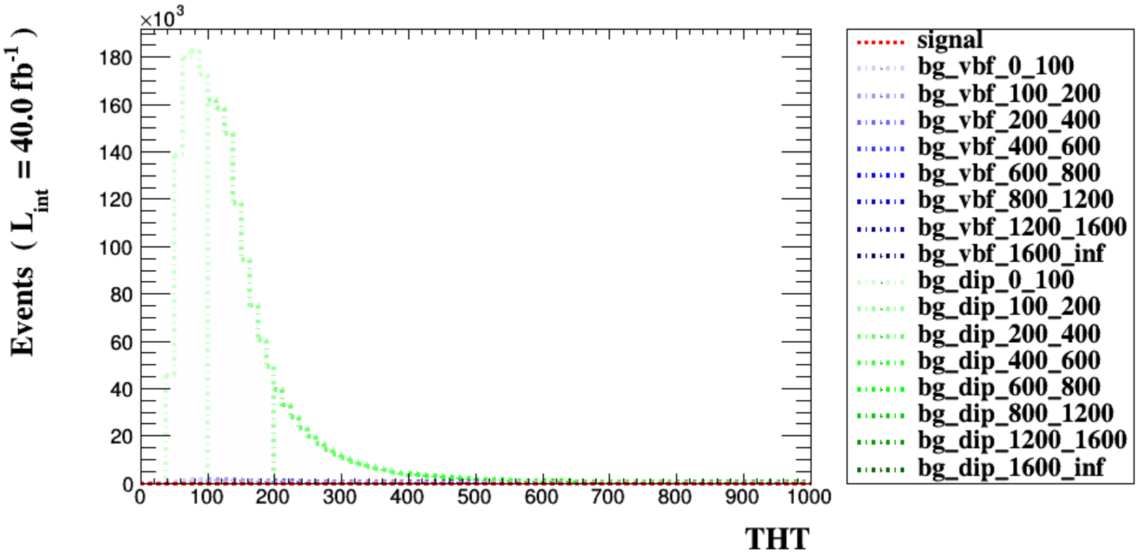

Figure 14.

3.16 Histogram 15

*** Plot: MET**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	8.33083e-09	1.078e-08	0.0	0.0
bg_vbf_0_100	3934	1.0	5.97855e-10	4.233e-10	0.0	0.0
bg_vbf_100_20	8756	1.0	9.55638e-10	1.098e-09	0.0	0.0
bg_vbf_200_40	5358	1.0	3.23057e-09	2.219e-09	0.0	0.0
bg_vbf_400_60	983	1.0	4.52485e-09	2.611e-09	0.0	0.0
bg_vbf_600_80	251	1.0	4.90226e-09	2.72e-09	0.0	0.0
bg_vbf_800_12	114	1.0	5.15622e-09	2.979e-09	0.0	0.0
bg_vbf_1200_1	20.6	1.0	5.81971e-09	5.339e-09	0.0	0.0
bg_vbf_1600_i	7.66	1.0	1.30635e-08	1.639e-08	0.0	0.0
bg_dip_0_100	714691	1.0	5.87329e-10	4.134e-10	0.0	0.0
bg_dip_100_20	855479	1.0	8.95295e-10	1.036e-09	0.0	0.0
bg_dip_200_40	234627	1.0	3.11256e-09	2.186e-09	0.0	0.0
bg_dip_400_60	28616	1.0	4.43451e-09	2.58e-09	0.0	0.0
bg_dip_600_80	6658	1.0	4.80208e-09	2.678e-09	0.0	0.0
bg_dip_800_12	2939	1.0	5.06231e-09	3.026e-09	0.0	0.0
bg_dip_1200_1	513	1.0	5.58908e-09	4.823e-09	0.0	0.0
bg_dip_1600_i	187	1.0	1.25075e-08	1.605e-08	0.0	0.0

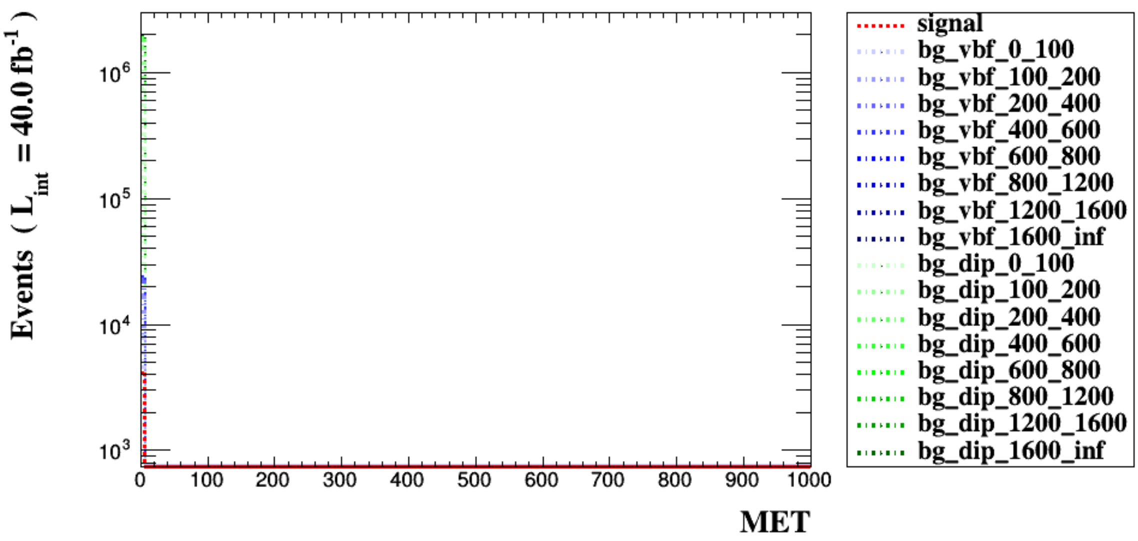

Figure 15.

3.17 Histogram 16

*** Plot: TET**

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal	4094	1.0	1530.72	825.3	0.0	70.59
bg_vbf_0_100	3934	1.0	129.338	32.52	0.0	0.001235
bg_vbf_100_20	8756	1.0	212.346	54.5	0.0	0.00344
bg_vbf_200_40	5358	1.0	368.751	98.32	0.0	0.04948
bg_vbf_400_60	983	1.0	614.098	136.7	0.0	1.955
bg_vbf_600_80	251	1.0	847.293	172.9	0.0	15.03
bg_vbf_800_12	114	1.0	1130.93	233.4	0.0	66.91
bg_vbf_1200_1	20.6	1.0	1564.51	271.2	0.0	100.0
bg_vbf_1600_i	7.66	1.0	2188.52	475.9	0.0	100.0
bg_dip_0_100	714691	1.0	120.486	31.72	0.0	0.0
bg_dip_100_20	855479	1.0	199.807	52.08	0.0	0.0009859
bg_dip_200_40	234627	1.0	351.793	94.87	0.0	0.02749
bg_dip_400_60	28616	1.0	596.305	134.8	0.0	1.993
bg_dip_600_80	6658	1.0	822.647	165.9	0.0	10.92
bg_dip_800_12	2939	1.0	1097.74	215.8	0.0	61.64
bg_dip_1200_1	513	1.0	1524.46	238.7	0.0	100.0
bg_dip_1600_i	187	1.0	2144.43	445.2	0.0	100.0

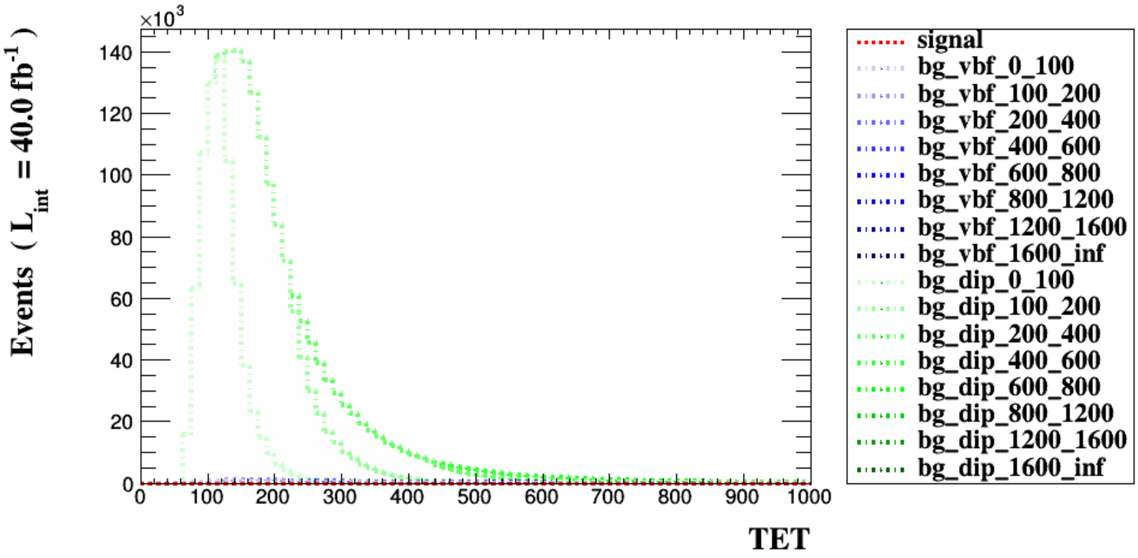

Figure 16.

3.18 Cut 2

*** Cut: select (sdETA (jets[1] jets[2]) > 6.1 or sdETA (jets[1] jets[2]) < -6.1) and M (jets[1] jets[2]) > 1250.0**

Dataset	Events kept: K	Rejected events: R	Efficiency: K / (K + R)	Cumul. efficiency: K / Initial
signal	134.7 +/- 11.4	3959.4 +/- 11.5	0.03290 +/- 0.00279	0.03290 +/- 0.00279
bg_vbf_0_10	204.2 +/- 14.2	3730.5 +/- 51.3	0.05190 +/- 0.00354	0.01681 +/- 0.00117
bg_vbf_100_	610.7 +/- 23.9	8146.3 +/- 38.7	0.06974 +/- 0.00272	0.06299 +/- 0.00247
bg_vbf_200_	145.6 +/- 11.9	5213.2 +/- 17.4	0.02717 +/- 0.00222	0.0269 +/- 0.0022
bg_vbf_400_	3.15 +/- 1.77	980.63 +/- 2.84	0.0032 +/- 0.0018	0.0032 +/- 0.0018
bg_vbf_600_	0.0761 +/- 0.2758	251.775 +/- 0.634	0.000302 +/- 0.001095	0.000302 +/- 0.001094
bg_vbf_800_	0.00285 +/- 0.05343	114.640 +/- 0.394	2.49e-05 +/- 4.66e-04	2.49e-05 +/- 4.66e-04
bg_vbf_1200_	6.47e-05 +/- 8.04e-03	20.553 +/- 0.209	3.15e-06 +/- 3.91e-04	3.14e-06 +/- 3.90e-04
bg_vbf_1600_	0.0 +/- 0.0	7.513 +/- 0.378	0.0 +/- 0.0	0.0 +/- 0.0
bg_dip_0_10	229.4 +/- 15.1	714463 +/- 1415	3.21e-04 +/- 2.12e-05	8.46e-05 +/- 5.59e-06
bg_dip_100_	506.6 +/- 22.5	854973 +/- 1268	5.92e-04 +/- 2.63e-05	4.63e-04 +/- 2.05e-05
bg_dip_200_	32.94 +/- 5.74	234594 +/- 411	1.40e-04 +/- 2.45e-05	1.38e-04 +/- 2.40e-05
bg_dip_400_	0.609 +/- 0.781	28615.6 +/- 53.6	2.13e-05 +/- 2.73e-05	2.12e-05 +/- 2.71e-05
bg_dip_600_	0.0504 +/- 0.2246	6658.9 +/- 27.8	7.57e-06 +/- 3.37e-05	7.56e-06 +/- 3.36e-05
bg_dip_800_	0.00849 +/- 0.09214	2939.95 +/- 5.28	2.89e-06 +/- 3.13e-05	2.89e-06 +/- 3.13e-05
bg_dip_1200_	0.0 +/- 0.0	513.34 +/- 2.66	0.0 +/- 0.0	0.0 +/- 0.0
bg_dip_1600_	0.0 +/- 0.0	187.742 +/- 0.345	0.0 +/- 0.0	0.0 +/- 0.0

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)	4094.08 +/- 1.13	4113516 +/- 4877	2.01760 +/- 0.00132
SEL: M (jets[1] jets[2]) > 120.0	4094.04 +/- 1.14	1863145 +/- 1947	2.99607 +/- 0.00177
SEL: (sdETA (jets[1] jets[2]) > 6.1 or sdETA (	134.7 +/- 11.4	1733.3 +/- 41.1	3.116 +/- 0.257