

The LaTeX report

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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
```

```

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 ax = 9000005
ma5># apply selections
ma5>select PT(a[1]) > 250 and M(a[1] a[2]) > 400
ma5>select (sdETA(jets[1] jets[2]) > 2.6 or sdETA(jets[1] jets[2]) < -2.6) and M(jets[1]
jets[2]) > 1000
ma5>submit second_analysis_sdEta2.6_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/-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_100 | 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 \pm 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 \pm 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 \pm 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_cmerged_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_cmerged_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 $P_T (a[1]) > 250.0$ and $M (a[1] a[2]) > 400.0$

| Dataset | Events kept: K | Rejected events: R | Efficiency: K / (K + R) | Cumul. efficiency: K / Initial |
|-------------|-----------------|--------------------|-------------------------|--------------------------------|
| signal | 2954.1 +/- 28.7 | 1140.0 +/- 28.7 | 0.72154 +/- 0.00701 | 0.72154 +/- 0.00701 |
| bg_vbf_0_10 | 1.62 +/- 1.27 | 12148.7 +/- 23.1 | 0.000133 +/- 0.000105 | 0.000133 +/- 0.000105 |
| bg_vbf_100_ | 9.26 +/- 3.04 | 9686.1 +/- 16.9 | 0.000955 +/- 0.000314 | 0.000955 +/- 0.000314 |
| bg_vbf_200_ | 31.85 +/- 5.63 | 5381.4 +/- 12.2 | 0.00588 +/- 0.00104 | 0.00588 +/- 0.00104 |
| bg_vbf_400_ | 20.7 +/- 4.5 | 966.19 +/- 4.69 | 0.02094 +/- 0.00456 | 0.02094 +/- 0.00456 |
| bg_vbf_600_ | 8.98 +/- 2.94 | 243.10 +/- 2.96 | 0.0356 +/- 0.0117 | 0.0356 +/- 0.0117 |
| bg_vbf_800_ | 5.42 +/- 2.27 | 109.34 +/- 2.28 | 0.0472 +/- 0.0198 | 0.0472 +/- 0.0198 |
| bg_vbf_1200 | 1.15 +/- 1.04 | 19.44 +/- 1.04 | 0.0560 +/- 0.0507 | 0.0560 +/- 0.0507 |
| bg_vbf_1600 | 0.446 +/- 0.648 | 7.212 +/- 0.648 | 0.0583 +/- 0.0846 | 0.0583 +/- 0.0846 |
| bg_dip_0_10 | 143.4 +/- 12.0 | 2710703 +/- 4613 | 5.29e-05 +/- 4.42e-06 | 5.29e-05 +/- 4.42e-06 |
| bg_dip_100_ | 621.5 +/- 24.9 | 1094741 +/- 1526 | 5.67e-04 +/- 2.28e-05 | 5.67e-04 +/- 2.28e-05 |
| bg_dip_200_ | 1110.1 +/- 33.3 | 238438 +/- 413 | 0.004634 +/- 0.000139 | 0.004634 +/- 0.000139 |
| bg_dip_400_ | 465.3 +/- 21.4 | 28333.4 +/- 55.6 | 0.016158 +/- 0.000743 | 0.016158 +/- 0.000743 |
| bg_dip_600_ | 162.7 +/- 12.6 | 6511.7 +/- 29.7 | 0.02437 +/- 0.00189 | 0.02437 +/- 0.00189 |
| bg_dip_800_ | 90.22 +/- 9.35 | 2852.1 +/- 10.6 | 0.03066 +/- 0.00318 | 0.03066 +/- 0.00318 |
| bg_dip_1200 | 18.47 +/- 4.22 | 495.04 +/- 4.92 | 0.03596 +/- 0.00822 | 0.03596 +/- 0.00822 |
| bg_dip_1600 | 7.70 +/- 2.72 | 180.09 +/- 2.73 | 0.0410 +/- 0.0145 | 0.0410 +/- 0.0145 |

3.2 Cut 2

* Cut: select (sdETA (jets[1] jets[2]) > 2.6 or sdETA (jets[1] jets[2]) < -2.6) and
M (jets[1] jets[2]) > 1000.0

| Dataset | Events kept: K | Rejected events: R | Efficiency: K / (K + R) | Cumul. efficiency: K / Initial |
|--------------|-------------------|--------------------|-------------------------|--------------------------------|
| signal | 1677.8 +/- 31.5 | 1276.3 +/- 29.6 | 0.56797 +/- 0.00911 | 0.40981 +/- 0.00769 |
| bg_vbf_0_10 | 0.0243 +/- 0.1559 | 1.59 +/- 1.26 | 0.015 +/- 0.096 | 2.00e-06 +/- 1.28e-05 |
| bg_vbf_100_ | 1.62 +/- 1.27 | 7.64 +/- 2.76 | 0.175 +/- 0.125 | 0.000167 +/- 0.000131 |
| bg_vbf_200_ | 11.89 +/- 3.44 | 19.96 +/- 4.46 | 0.3732 +/- 0.0857 | 0.002196 +/- 0.000636 |
| bg_vbf_400_ | 11.40 +/- 3.36 | 9.26 +/- 3.03 | 0.552 +/- 0.109 | 0.0116 +/- 0.0034 |
| bg_vbf_600_ | 5.21 +/- 2.26 | 3.77 +/- 1.93 | 0.580 +/- 0.165 | 0.02065 +/- 0.00896 |
| bg_vbf_800_ | 2.6 +/- 1.6 | 2.80 +/- 1.65 | 0.483 +/- 0.215 | 0.0228 +/- 0.0139 |
| bg_vbf_1200_ | 0.36 +/- 0.59 | 0.794 +/- 0.874 | 0.312 +/- 0.431 | 0.0175 +/- 0.0289 |
| bg_vbf_1600_ | 0.0657 +/- 0.2551 | 0.381 +/- 0.601 | 0.147 +/- 0.530 | 0.00857 +/- 0.03331 |
| bg_dip_0_10 | 0.0 +/- 0.0 | 143.4 +/- 12.0 | 0.0 +/- 0.0 | 0.0 +/- 0.0 |
| bg_dip_100_ | 6.32 +/- 2.51 | 615.1 +/- 24.8 | 0.01017 +/- 0.00403 | 5.77e-06 +/- 2.30e-06 |
| bg_dip_200_ | 27.86 +/- 5.28 | 1082.2 +/- 32.9 | 0.0251 +/- 0.0047 | 1.16e-04 +/- 2.20e-05 |
| bg_dip_400_ | 33.03 +/- 5.74 | 432.3 +/- 20.6 | 0.0710 +/- 0.0119 | 0.001147 +/- 0.000199 |
| bg_dip_600_ | 16.75 +/- 4.09 | 145.9 +/- 12.0 | 0.1029 +/- 0.0238 | 0.002509 +/- 0.000612 |
| bg_dip_800_ | 8.52 +/- 2.92 | 81.70 +/- 8.91 | 0.0945 +/- 0.0308 | 0.002897 +/- 0.000991 |
| bg_dip_1200_ | 1.15 +/- 1.07 | 17.32 +/- 4.09 | 0.0623 +/- 0.0562 | 0.00224 +/- 0.00209 |
| bg_dip_1600_ | 0.203 +/- 0.450 | 7.50 +/- 2.68 | 0.0264 +/- 0.0577 | 0.00108 +/- 0.00240 |

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: PT (a[1]) > 250.0 and M (a[1] a[2]) > 400 | 2954.1 +/- 28.7 | 2698.7 +/- 51.8 | 39.291 +/- 0.334 |
| SEL: (sdETA (jets[1] jets[2]) > 2.6 or sdETA (| 1677.8 +/- 31.5 | 127.0 +/- 11.3 | 39.493 +/- 0.415 |