

The LaTeX report

Generated by elijahsheridan on 31 March 2020, 15:11:09

This report has been generated automatically by MADANALYSIS 5.

Please cite:

E. Conte, B. Fuks and G. Serret,
MadAnalysis 5, A User-Friendly Framework for Collider Phenomenology,
Comput. Phys. Commun. **184** (2013) 222-256,
arXiv:1206.1599 [hep-ph].

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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]) > 350
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 $PT(a[1]) > 250.0$ and $M(a[1] a[2]) > 350.0$

| Dataset | Events kept: K | Rejected events: R | Efficiency: K / (K + R) | Cumul. efficiency: K / Initial |
|-------------|-----------------|--------------------|-------------------------|--------------------------------|
| signal | 3059.5 +/- 27.8 | 1034.6 +/- 27.8 | 0.74729 +/- 0.00679 | 0.74729 +/- 0.00679 |
| bg_vbf_0_10 | 1.62 +/- 1.27 | 12148.7 +/- 23.1 | 0.000133 +/- 0.000105 | 0.000133 +/- 0.000105 |
| bg_vbf_100_ | 9.89 +/- 3.14 | 9685.4 +/- 16.9 | 0.001020 +/- 0.000324 | 0.001020 +/- 0.000324 |
| bg_vbf_200_ | 39.73 +/- 6.28 | 5373.5 +/- 12.5 | 0.00734 +/- 0.00116 | 0.00734 +/- 0.00116 |
| bg_vbf_400_ | 26.52 +/- 5.08 | 960.33 +/- 5.25 | 0.02688 +/- 0.00515 | 0.02688 +/- 0.00515 |
| bg_vbf_600_ | 11.35 +/- 3.29 | 240.73 +/- 3.31 | 0.0450 +/- 0.0131 | 0.0450 +/- 0.0131 |
| bg_vbf_800_ | 6.71 +/- 2.51 | 108.06 +/- 2.52 | 0.0584 +/- 0.0219 | 0.0584 +/- 0.0219 |
| bg_vbf_1200 | 1.41 +/- 1.15 | 19.19 +/- 1.15 | 0.0685 +/- 0.0556 | 0.0685 +/- 0.0556 |
| bg_vbf_1600 | 0.546 +/- 0.712 | 7.113 +/- 0.712 | 0.0713 +/- 0.0930 | 0.0713 +/- 0.0930 |
| 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_ | 712.0 +/- 26.7 | 1094650 +/- 1526 | 6.50e-04 +/- 2.44e-05 | 6.50e-04 +/- 2.44e-05 |
| bg_dip_200_ | 1517.5 +/- 38.9 | 238031 +/- 413 | 0.006335 +/- 0.000162 | 0.006335 +/- 0.000162 |
| bg_dip_400_ | 620.4 +/- 24.7 | 28178.3 +/- 56.7 | 0.021542 +/- 0.000856 | 0.021542 +/- 0.000856 |
| bg_dip_600_ | 208.8 +/- 14.2 | 6465.5 +/- 30.3 | 0.03129 +/- 0.00213 | 0.03129 +/- 0.00213 |
| bg_dip_800_ | 112.2 +/- 10.4 | 2830.1 +/- 11.5 | 0.03813 +/- 0.00353 | 0.03813 +/- 0.00353 |
| bg_dip_1200 | 22.64 +/- 4.65 | 490.86 +/- 5.29 | 0.04409 +/- 0.00906 | 0.04409 +/- 0.00906 |
| bg_dip_1600 | 9.43 +/- 2.99 | 178.35 +/- 3.01 | 0.0502 +/- 0.0159 | 0.0502 +/- 0.0159 |

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 | 1738.1 +/- 31.6 | 1321.4 +/- 29.9 | 0.56810 +/- 0.00896 | 0.42454 +/- 0.00772 |
| 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_ | 1.72 +/- 1.31 | 8.17 +/- 2.86 | 0.17 +/- 0.12 | 0.000177 +/- 0.000135 |
| bg_vbf_200_ | 14.61 +/- 3.82 | 25.1 +/- 5.0 | 0.3678 +/- 0.0765 | 0.002700 +/- 0.000705 |
| bg_vbf_400_ | 14.46 +/- 3.77 | 12.07 +/- 3.45 | 0.5450 +/- 0.0967 | 0.01465 +/- 0.00382 |
| bg_vbf_600_ | 6.53 +/- 2.52 | 4.82 +/- 2.17 | 0.576 +/- 0.147 | 0.03 +/- 0.01 |
| bg_vbf_800_ | 3.21 +/- 1.77 | 3.50 +/- 1.84 | 0.479 +/- 0.193 | 0.0280 +/- 0.0154 |
| bg_vbf_1200 | 0.432 +/- 0.650 | 0.978 +/- 0.965 | 0.306 +/- 0.388 | 0.021 +/- 0.032 |
| bg_vbf_1600 | 0.0785 +/- 0.2788 | 0.467 +/- 0.662 | 0.144 +/- 0.475 | 0.0103 +/- 0.0364 |
| 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 | 705.7 +/- 26.6 | 0.00888 +/- 0.00352 | 5.77e-06 +/- 2.30e-06 |
| bg_dip_200_ | 35.93 +/- 5.99 | 1481.6 +/- 38.5 | 0.0237 +/- 0.0039 | 1.50e-04 +/- 2.50e-05 |
| bg_dip_400_ | 42.75 +/- 6.53 | 577.6 +/- 23.8 | 0.0689 +/- 0.0102 | 0.001485 +/- 0.000227 |
| bg_dip_600_ | 20.80 +/- 4.55 | 188.0 +/- 13.5 | 0.0996 +/- 0.0207 | 0.003116 +/- 0.000682 |
| bg_dip_800_ | 10.16 +/- 3.18 | 102.04 +/- 9.93 | 0.0906 +/- 0.0271 | 0.00345 +/- 0.00108 |
| bg_dip_1200 | 1.37 +/- 1.17 | 21.27 +/- 4.52 | 0.0604 +/- 0.0501 | 0.00266 +/- 0.00227 |
| bg_dip_1600 | 0.239 +/- 0.488 | 9.20 +/- 2.96 | 0.0253 +/- 0.0511 | 0.00127 +/- 0.00260 |

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]) > 350 | 3059.5 +/- 27.8 | 3444.2 +/- 58.5 | 37.937 +/- 0.314 |
| SEL: (sdETA (jets[1] jets[2]) > 2.6 or sdETA (| 1738.1 +/- 31.6 | 158.6 +/- 12.6 | 39.909 +/- 0.415 |