

# 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># 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># 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># selections
ma5>select (sdETA(jets[1] jets[2]) > 2.6 or sdETA(jets[1] jets[2]) < -2.6) and M(jets[1]
jets[2]) > 1250
ma5>select PT(a[1]) > 450 and M(a[1] a[2]) > 600
ma5>submit analysis_loose_pta450_maa600

```

## 1.2 Configuration

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

## 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_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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>vbf_diphoton_background_data/-<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>vbf_diphoton_background_data/-<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>vbf_diphoton_background_data/-<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>vbf_diphoton_background_data/-<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>vbf_diphoton_background_data/-<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>vbf_diphoton_background_data/-<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>vbf_diphoton_background_data/-<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>diphoton_double_isr_background_c<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>diphoton_double_isr_background_c<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>diphoton_double_isr_background_c<br>merged_lhe/-<br>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 (%) |
|--|---------------|--------------------|-------------------|
| <a href="#">/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_data/-diphoton_double_isr_background_cmerged_lhe/-diphoton_double_isr_background_l</a> | 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 (%) |
|--|---------------|--------------------|-------------------|
| <a href="#">/Users/elijahsheridan/-MG5_aMC_v2_6_5/-axion_pheno/madgraph_data/-diphoton_double_isr_background_cmerged_lhe/-diphoton_double_isr_background_l</a> | 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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>diphoton_double_isr_background_c<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>diphoton_double_isr_background_c<br>merged_lhe/-<br>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/-<br>MG5_aMC_v2_6_5/-<br>axion_pheno/madgraph_data/-<br>diphoton_double_isr_background_c<br>merged_lhe/-<br>diphoton_double_isr_background_l | 1040000       | 0.00469 @ 0.15%    | 0.0               |

### 3 Histos and cuts

#### 3.1 Cut 1

\* **Cut:** select ( sdETA ( jets[1] jets[2] ) > 2.6 or sdETA ( jets[1] jets[2] ) < -2.6 ) and M ( jets[1] jets[2] ) > 1250.0

| Dataset     | Events kept: K  | Rejected events: R | Efficiency: K / (K + R) | Cumul. efficiency: K / Initial |
|-------------|-----------------|--------------------|-------------------------|--------------------------------|
| signal      | 1711.8 +/- 31.6 | 2382.3 +/- 31.6    | 0.41812 +/- 0.00771     | 0.41812 +/- 0.00771            |
| bg_vbf_0_10 | 204.2 +/- 14.2  | 11946.1 +/- 26.8   | 0.01681 +/- 0.00117     | 0.01681 +/- 0.00117            |
| bg_vbf_100_ | 950.9 +/- 29.3  | 8744.4 +/- 32.9    | 0.09808 +/- 0.00302     | 0.09808 +/- 0.00302            |
| bg_vbf_200_ | 1147.9 +/- 30.2 | 4265.4 +/- 31.3    | 0.21205 +/- 0.00556     | 0.21205 +/- 0.00556            |
| bg_vbf_400_ | 349.4 +/- 15.0  | 637.5 +/- 15.0     | 0.3540 +/- 0.0152       | 0.3540 +/- 0.0152              |
| bg_vbf_600_ | 111.21 +/- 7.88 | 140.87 +/- 7.89    | 0.4412 +/- 0.0313       | 0.4412 +/- 0.0313              |
| bg_vbf_800_ | 40.31 +/- 5.11  | 74.45 +/- 5.12     | 0.3513 +/- 0.0446       | 0.3513 +/- 0.0446              |
| bg_vbf_1200 | 4.49 +/- 1.87   | 16.10 +/- 1.87     | 0.218 +/- 0.091         | 0.218 +/- 0.091                |
| bg_vbf_1600 | 0.784 +/- 0.839 | 6.874 +/- 0.839    | 0.102 +/- 0.110         | 0.102 +/- 0.110                |
| bg_dip_0_10 | 229.4 +/- 15.1  | 2710617 +/- 4612   | 8.46e-05 +/- 5.59e-06   | 8.46e-05 +/- 5.59e-06          |
| bg_dip_100_ | 990.1 +/- 31.5  | 1094372 +/- 1526   | 9.04e-04 +/- 2.87e-05   | 9.04e-04 +/- 2.87e-05          |
| bg_dip_200_ | 1641.8 +/- 40.5 | 237907 +/- 412     | 0.006854 +/- 0.000169   | 0.006854 +/- 0.000169          |
| bg_dip_400_ | 1066.5 +/- 32.1 | 27732.1 +/- 59.6   | 0.03703 +/- 0.00111     | 0.03703 +/- 0.00111            |
| bg_dip_600_ | 531.3 +/- 22.2  | 6143.1 +/- 33.7    | 0.07960 +/- 0.00331     | 0.07960 +/- 0.00331            |
| bg_dip_800_ | 193.3 +/- 13.4  | 2749.1 +/- 14.2    | 0.06568 +/- 0.00457     | 0.06568 +/- 0.00457            |
| bg_dip_1200 | 21.80 +/- 4.57  | 491.71 +/- 5.22    | 0.0424 +/- 0.0089       | 0.0424 +/- 0.0089              |
| bg_dip_1600 | 4.1 +/- 2.0     | 183.71 +/- 2.01    | 0.0217 +/- 0.0106       | 0.0217 +/- 0.0106              |

### 3.2 Cut 2

\* Cut: select PT ( a[1] ) > 450.0 and M ( a[1] a[2] ) > 600.0

| Dataset      | Events kept: K    | Rejected events: R | Efficiency: K / (K + R) | Cumul. efficiency: K / Initial |
|--------------|-------------------|--------------------|-------------------------|--------------------------------|
| signal       | 932.6 +/- 26.8    | 779.2 +/- 25.1     | 0.545 +/- 0.012         | 0.22779 +/- 0.00655            |
| bg_vbf_0_10  | 0.0 +/- 0.0       | 204.2 +/- 14.2     | 0.0 +/- 0.0             | 0.0 +/- 0.0                    |
| bg_vbf_100_  | 0.0904 +/- 0.3007 | 950.8 +/- 29.3     | 9.51e-05 +/- 3.16e-04   | 9.33e-06 +/- 3.10e-05          |
| bg_vbf_200_  | 0.583 +/- 0.764   | 1147.3 +/- 30.2    | 0.000508 +/- 0.000665   | 0.000108 +/- 0.000141          |
| bg_vbf_400_  | 1.19 +/- 1.09     | 348.2 +/- 15.0     | 0.00341 +/- 0.00312     | 0.0012 +/- 0.0011              |
| bg_vbf_600_  | 1.02 +/- 1.01     | 110.19 +/- 7.88    | 0.00914 +/- 0.00903     | 0.00403 +/- 0.00399            |
| bg_vbf_800_  | 0.771 +/- 0.875   | 39.54 +/- 5.09     | 0.0191 +/- 0.0216       | 0.00672 +/- 0.00762            |
| bg_vbf_1200_ | 0.131 +/- 0.361   | 4.36 +/- 1.85      | 0.0292 +/- 0.0795       | 0.00638 +/- 0.01754            |
| bg_vbf_1600_ | 0.0263 +/- 0.1620 | 0.758 +/- 0.826    | 0.0336 +/- 0.2034       | 0.00344 +/- 0.02115            |
| bg_dip_0_10  | 0.0 +/- 0.0       | 229.4 +/- 15.1     | 0.0 +/- 0.0             | 0.0 +/- 0.0                    |
| bg_dip_100_  | 0.0 +/- 0.0       | 990.1 +/- 31.5     | 0.0 +/- 0.0             | 0.0 +/- 0.0                    |
| bg_dip_200_  | 1.15 +/- 1.07     | 1640.7 +/- 40.5    | 0.000701 +/- 0.000653   | 4.81e-06 +/- 4.48e-06          |
| bg_dip_400_  | 2.16 +/- 1.47     | 1064.4 +/- 32.1    | 0.00202 +/- 0.00138     | 7.50e-05 +/- 5.10e-05          |
| bg_dip_600_  | 2.58 +/- 1.61     | 528.7 +/- 22.2     | 0.00486 +/- 0.00302     | 0.000387 +/- 0.000241          |
| bg_dip_800_  | 2.28 +/- 1.51     | 191.0 +/- 13.4     | 0.01180 +/- 0.00777     | 0.000775 +/- 0.000513          |
| bg_dip_1200_ | 0.382 +/- 0.618   | 21.42 +/- 4.53     | 0.0175 +/- 0.0281       | 0.000744 +/- 0.001204          |
| bg_dip_1600_ | 0.0663 +/- 0.2574 | 4.00 +/- 1.98      | 0.0163 +/- 0.0627       | 0.000353 +/- 0.001371          |

## 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: ( sdETA ( jets[1]<br>jets[2] ) > 2.6 or sdETA<br>(  | 1711.8 +/- 31.6  | 7487.3 +/- 82.9  | 17.848 +/- 0.309    |
| SEL: PT ( a[1] ) ><br>450.0 and M ( a[1] a[2]<br>) > 600 | 932.6 +/- 26.8   | 12.43 +/- 3.52   | 30.337 +/- 0.446    |