

# The LaTeX report

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To contact us:

<http://madananalysis.irmp.ucl.ac.be>  
[ma5team@iphc.cnrs.fr](mailto:ma5team@iphc.cnrs.fr)

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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/madgraph_data
# need to change this directory path -> exit and type "pwd" to get the path
ma5>set main.lumi = 3000
ma5>set main.fom.formula = 5
ma5>set main.fom.x = 0.25
ma5># import samples -> change the path to the LHE file
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/madgraph_data/axion_signal/-
on_discovery_contour/ma100MeV_L1pt8TeV_deta2.lhe.gz as signal_1pt8TeV
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/madgraph_data/axion_signal/-
on_discovery_contour/ma100MeV_L2TeV_deta2.lhe as signal_2TeV
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/madgraph_data/axion_signal/-
on_discovery_contour/ma100MeV_L2pt2TeV_deta2.lhe.gz as signal_2pt2TeV
ma5>import /Users/elijahsheridan/MG5_aMC_v2_6_5/axion_pheno/madgraph_data/axion_signal/-
on_discovery_contour/ma100MeV_L2pt4TeV_deta2.lhe.gz as signal_2pt4TeV
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>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># define bg and signal samples
ma5>set signal_1pt8TeV.type = signal
ma5>set signal_2TeV.type = signal
ma5>set signal_2pt2TeV.type = signal
ma5>set signal_2pt4TeV.type = signal
ma5>set bg_vbf_0_100.type = background
ma5>set bg_vbf_100_200.type = background
ma5>set bg_vbf_200_400.type = background
ma5>set bg_vbf_400_600.type = background
ma5>set bg_vbf_600_800.type = background
ma5>set bg_vbf_800_1200.type = background
ma5>set bg_vbf_1200_1600.type = background
ma5>set bg_vbf_1600_inf.type = background
ma5>set bg_dip_0_100.type = background
ma5>set bg_dip_100_200.type = background
ma5>set bg_dip_200_400.type = background
ma5>set bg_dip_400_600.type = background
ma5>set bg_dip_600_800.type = background
ma5>set bg_dip_800_1200.type = background
ma5>set bg_dip_1200_1600.type = background
ma5>set bg_dip_1600_inf.type = background
ma5># a jet can be from a light quark or b quark
ma5>define jets = j
ma5>define e = e+ e-
ma5>define mu = mu+ mu-
ma5>define ta = ta+ ta-
ma5>define lept = e mu ta
ma5>define ax = 9000005
ma5># cuts
ma5>select ((sdETA(jets[1] jets[2]) > 3.6 or sdETA(jets[1] jets[2]) < -3.6) and M(jets[1]
jets[2]) > 750) and (PT(a[1]) > 300 and M(a[1] a[2]) > 500)
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 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].xmin = 0
ma5>set selection[2].xmax = 2000
ma5>set selection[2].nbins = 200
ma5>set selection[2].rank = PTordering
ma5>set selection[2].titleX = "p_{T}[j_{1}] (GeV)"
ma5>set selection[3].xmin = -8
ma5>set selection[3].xmax = 8
ma5>set selection[3].nbins = 160
ma5>set selection[3].rank = PTordering
ma5>set selection[3].titleX = "#eta[j_{1}]"
ma5>set selection[4].xmin = -3.2
ma5>set selection[4].xmax = 3.2
ma5>set selection[4].nbins = 64
ma5>set selection[4].rank = PTordering
ma5>set selection[4].titleX = "#phi[j_{1}]"
ma5>set selection[5].xmin = 0
ma5>set selection[5].xmax = 1000
ma5>set selection[5].nbins = 100
ma5>set selection[5].rank = PTordering
ma5>set selection[5].titleX = "p_{T}[j_{2}] (GeV)"
ma5>set selection[6].xmin = -8
ma5>set selection[6].xmax = 8
ma5>set selection[6].nbins = 160
ma5>set selection[6].rank = PTordering
ma5>set selection[6].titleX = "#eta[j_{2}]"
ma5>set selection[7].xmin = -3.2
ma5>set selection[7].xmax = 3.2
ma5>set selection[7].nbins = 64
ma5>set selection[7].rank = PTordering
ma5>set selection[7].titleX = "#phi[j_{2}]"
ma5>set selection[8].xmin = 0
ma5>set selection[8].xmax = 15
ma5>set selection[8].nbins = 75
ma5>set selection[8].rank = PTordering
ma5>set selection[8].titleX = "#DeltaR[j_{1},j_{2}]"
ma5>set selection[9].xmin = 750
ma5>set selection[9].xmax = 6000
ma5>set selection[9].nbins = 40
ma5>set selection[9].rank = PTordering
ma5>set selection[9].titleX = "M[j_{1},j_{2}] (GeV)"
ma5>set selection[10].xmin = 3.6
ma5>set selection[10].xmax = 9
ma5>set selection[9].nbins = 20
ma5>set selection[10].titleX = "#Delta#eta(j_{1},j_{2})"
ma5>set selection[11].xmin = 500
ma5>set selection[11].xmax = 4000
ma5>set selection[11].nbins = 40
ma5>set selection[11].rank = PTordering
ma5>set selection[11].titleX = "M[a_{1},a_{2}] (GeV)"

```

```

ma5>set selection[12].xmin = 300
ma5>set selection[12].xmax = 2000
ma5>set selection[12].nbins = 60
ma5>set selection[12].rank = PTordering
ma5>set selection[12].titleX = "p_{T}[a_{1}]"
ma5>set selection[13].xmin = 0
ma5>set selection[13].xmax = 2000
ma5>set selection[13].nbins = 400
ma5>set selection[13].rank = PTordering
ma5>set selection[13].titleX = "p_{T}[a_{2}] (GeV)"
ma5>set selection[14].xmin = 0
ma5>set selection[14].xmax = 4000
ma5>set selection[14].nbins = 80
ma5>set selection[14].rank = PTordering
ma5>set selection[14].titleX = "THT"
ma5>set selection[15].xmin = 0
ma5>set selection[15].xmax = 1000
ma5>set selection[15].nbins = 200
ma5>set selection[15].rank = PTordering
ma5>set selection[15].titleX = "MET"
ma5>set selection[16].xmin = 0
ma5>set selection[16].xmax = 8000
ma5>set selection[16].nbins = 80
ma5>set selection[16].rank = PTordering
ma5>set selection[16].titleX = "TET"
ma5>submit ma100MeV_L1pt8-2pt4TeV_binsize

```

## 1.2 Configuration

- MadAnalysis version 1.6.33 (2017/11/20).
- Histograms given for an integrated luminosity of  $3000.0\text{fb}^{-1}$ .

## 2 Datasets

### 2.1 signal\_1pt8tevl

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [signal](#) events.
- Generated events: [100000](#) events.
- Normalization to the luminosity: [13267](#)+/- [13](#) events.
- Ratio (event weight): [0.13](#) .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_pheno/- madgraph_data/axion_signal/- on_discovery_contour/- ma100MeV_L1pt8TeV_deta2.lhe.gz	100000	0.00442 @ 0.095%	0.0

### 2.2 signal\_2tevl

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [signal](#) events.
- Generated events: [100000](#) events.
- Normalization to the luminosity: [8014](#)+/- [12](#) events.
- Ratio (event weight): [0.08](#) .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_pheno/- madgraph_data/axion_signal/- on_discovery_contour/- ma100MeV_L2TeV_deta2.lhe	100000	0.00267 @ 0.14%	0.0

### 2.3 signal\_2pt2tevl

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [signal](#) events.
- Generated events: [100000](#) events.



- Normalization to the luminosity: 5208 $\pm$  5 events.
- Ratio (event weight): 0.052 .

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

## 2.4 signal\_2pt4tev1

- Samples stored in the directory: /Users/elijahsheridan/MG5\_aMC\_v2\_6\_5/axion\_pheno/-  
post\_optimization\_studies/mad\_analyses .
- Sample consisting of: signal events.
- Generated events: 100000 events.
- Normalization to the luminosity: 3556 $\pm$  4 events.
- Ratio (event weight): 0.036 .

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
/Users/elijahsheridan/- MG5_aMC_v2_6_5/- axion_pheno/- madgraph_data/axion_signal/- on_discovery_contour/- ma100MeV_L2pt4TeV_deta2.lhe.gz	100000	0.00119 @ 0.097%	0.0

## 2.5 bg\_dip\_0\_100

- Samples stored in the directory: /Users/elijahsheridan/MG5\_aMC\_v2\_6\_5/axion\_pheno/-  
post\_optimization\_studies/mad\_analyses .
- Sample consisting of: background events.
- Generated events: 1040000 events.
- Normalization to the luminosity: 203313540 $\pm$  345993 events.
- Ratio (event weight): 195 - 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

## 2.6 bg\_dip\_100\_200

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [1040000](#) events.
- Normalization to the luminosity: [82152210+/- 114532](#) events.
- **Ratio (event weight): 78 - 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

## 2.7 bg\_dip\_200\_400

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [1040000](#) events.
- Normalization to the luminosity: [17966163+/- 31035](#) events.
- **Ratio (event weight): 17 - 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	5.99 @ 0.17%	0.0

## 2.8 bg\_dip\_400\_600

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [1040000](#) events.
- Normalization to the luminosity: [2159901](#)+/- [3916](#) events.
- **Ratio (event weight): 2.1 - warning: please generate more events (weight larger than 1)!**

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

## 2.9 bg\_dip\_600\_800

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [662009](#) events.
- Normalization to the luminosity: [500577](#)+/- [2070](#) events.
- Ratio (event weight): [0.76](#) .

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

## 2.10 bg\_dip\_800\_1200

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [1040000](#) events.
- Normalization to the luminosity: [220675](#)+/- [380](#) events.

- Ratio (event weight): [0.21](#) .

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

### 2.11 bg\_dip\_1200\_1600

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-  
post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [337115](#) events.
- Normalization to the luminosity: [38512+/- 198](#) events.
- Ratio (event weight): [0.11](#) .

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

### 2.12 bg\_dip\_1600\_inf

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-  
post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [1040000](#) events.
- Normalization to the luminosity: [14083+/- 21](#) events.
- Ratio (event weight): [0.014](#) .

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

### 2.13 bg\_vbf\_0\_100

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [1000000](#) events.
- Normalization to the luminosity: [911274](#)+/- [1733](#) events.
- Ratio (event weight): [0.91](#) .

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/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_0_100</a>	1000000	0.304 @ 0.19%	0.0

### 2.14 bg\_vbf\_100\_200

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [965662](#) events.
- Normalization to the luminosity: [727149](#)+/- [1245](#) events.
- Ratio (event weight): [0.75](#) .

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/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_100_200</a>	965662	0.242 @ 0.17%	0.0

### 2.15 bg\_vbf\_200\_400

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [984165](#) events.
- Normalization to the luminosity: [405994](#)+/- [819](#) events.

- Ratio (event weight): 0.41 .

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

## 2.16 bg\_vbf\_400\_600

- Samples stored in the directory: /Users/elijahsheridan/MG5\_aMC\_v2\_6\_5/axion\_pheno/-  
post\_optimization\_studies/mad\_analyses .
- Sample consisting of: background events.
- Generated events: 1000000 events.
- Normalization to the luminosity: 74013+/- 104 events.
- Ratio (event weight): 0.074 .

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

## 2.17 bg\_vbf\_600\_800

- Samples stored in the directory: /Users/elijahsheridan/MG5\_aMC\_v2\_6\_5/axion\_pheno/-  
post\_optimization\_studies/mad\_analyses .
- Sample consisting of: background events.
- Generated events: 1000000 events.
- Normalization to the luminosity: 18905+/- 24 events.
- Ratio (event weight): 0.019 .

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

### 2.18 bg\_vbf\_800\_1200

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [400839](#) events.
- Normalization to the luminosity: [8607](#)+/- [14](#) events.
- Ratio (event weight): [0.021](#) .

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/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_800_</a>	400839	0.00287 @ 0.16%	0.0

### 2.19 bg\_vbf\_1200\_1600

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [953803](#) events.
- Normalization to the luminosity: [1544](#)+/- [3](#) events.
- Ratio (event weight): [0.0016](#) .

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/-vbf_diphoton_background_data/-merged_lhe/-vbf_diphoton_background_ht_1200</a>	953803	0.000515 @ 0.16%	0.0

### 2.20 bg\_vbf\_1600\_inf

- Samples stored in the directory: [/Users/elijahsheridan/MG5\\_aMC\\_v2\\_6\\_5/axion\\_pheno/-post\\_optimization\\_studies/mad\\_analyses](#) .
- Sample consisting of: [background](#) events.
- Generated events: [270148](#) events.
- Normalization to the luminosity: [574](#)+/- [1](#) events.

- Ratio (event weight): 0.0021 .

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



### 3 Histos and cuts

#### 3.1 Cut 1

\* **Cut:** select ( ( sdETA ( jets[1] jets[2] ) > 3.6 or sdETA ( jets[1] jets[2] ) < -3.6 ) and M ( jets[1] jets[2] ) > 750.0 ) and ( PT ( a[1] ) > 300.0 and M ( a[1] a[2] ) > 500.0 )

Dataset	Events kept: K	Rejected events: R	Efficiency: K / (K + R)	Cumul. efficiency: K / Initial
signal_1pt8tev	3595.0 +/- 51.3	9672.7 +/- 52.0	0.27096 +/- 0.00386	0.27096 +/- 0.00386
signal_2tevl	2333.1 +/- 40.8	5681.3 +/- 41.4	0.29111 +/- 0.00507	0.29111 +/- 0.00507
signal_2pt2tev	1578.2 +/- 33.2	3630.3 +/- 33.3	0.30301 +/- 0.00637	0.30301 +/- 0.00637
signal_2pt4tev	1103.9 +/- 27.6	2452.3 +/- 27.7	0.31041 +/- 0.00776	0.31041 +/- 0.00776
bg_dip_0_10	0.0 +/- 0.0	203313540 +/- 345993	0.0 +/- 0.0	0.0 +/- 0.0
bg_dip_100_	237.1 +/- 15.4	82151972 +/- 114530	2.89e-06 +/- 1.87e-07	2.89e-06 +/- 1.87e-07
bg_dip_200_	1433.7 +/- 37.9	17964729 +/- 31031	7.98e-05 +/- 2.11e-06	7.98e-05 +/- 2.11e-06
bg_dip_400_	920.1 +/- 30.4	2158980 +/- 3913	4.26e-04 +/- 1.40e-05	4.26e-04 +/- 1.40e-05
bg_dip_600_	269.9 +/- 16.5	500307 +/- 2068	5.39e-04 +/- 3.28e-05	5.39e-04 +/- 3.28e-05
bg_dip_800_	110.3 +/- 10.5	220565 +/- 379	5.00e-04 +/- 4.76e-05	5.00e-04 +/- 4.76e-05
bg_dip_1200_	7.88 +/- 2.81	38505 +/- 197	2.05e-04 +/- 7.29e-05	2.05e-04 +/- 7.29e-05
bg_dip_1600_	0.731 +/- 0.855	14083.0 +/- 20.9	5.19e-05 +/- 6.07e-05	5.19e-05 +/- 6.07e-05
bg_vbf_0_10	3.64 +/- 1.91	911270 +/- 1732	4.00e-06 +/- 2.09e-06	4.00e-06 +/- 2.09e-06
bg_vbf_100_	87.35 +/- 9.35	727062 +/- 1244	1.20e-04 +/- 1.29e-05	1.20e-04 +/- 1.29e-05
bg_vbf_200_	453.4 +/- 21.3	405541 +/- 818	1.12e-03 +/- 5.24e-05	1.12e-03 +/- 5.24e-05
bg_vbf_400_	332.8 +/- 18.2	73680 +/- 104	0.004496 +/- 0.000246	0.004496 +/- 0.000246
bg_vbf_600_	123.0 +/- 11.1	18782.8 +/- 26.0	0.006504 +/- 0.000585	0.006504 +/- 0.000585
bg_vbf_800_	46.68 +/- 6.81	8560.5 +/- 15.1	0.005424 +/- 0.000792	0.005424 +/- 0.000792
bg_vbf_1200_	4.11 +/- 2.02	1540.57 +/- 3.23	0.00266 +/- 0.00131	0.00266 +/- 0.00131
bg_vbf_1600_	0.428 +/- 0.654	573.959 +/- 0.917	0.000744 +/- 0.001138	0.000744 +/- 0.001138

### 3.2 Histogram 1

\* Plot: PT ( jets[1] )

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	310.922	250.2	0.0	0.0626
signal_2tevl	2341	1.0	309.725	247.2	0.0	0.04447
signal_2pt2tevl	1587	1.0	307.2	245.8	0.0	0.06235
signal_2pt4tevl	1113	1.0	304.604	245.5	0.0	0.05431
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	98.8303	32.52	0.0	0.0
bg_dip_200_40	1433	1.0	243.87	57.21	0.0	0.0
bg_dip_400_60	920	1.0	405.044	76.84	0.0	0.0
bg_dip_600_80	269	1.0	583.265	92.47	0.0	0.0
bg_dip_800_12	110	1.0	800.398	151.0	0.0	0.0
bg_dip_1200_1	7.88	1.0	1173.89	227.2	0.0	0.0
bg_dip_1600_i	0.731	1.0	1675.33	329.4	0.0	11.11
bg_vbf_0_100	3.65	1.0	42.7818	7.815	0.0	0.0
bg_vbf_100_20	87.3	1.0	109.408	25.35	0.0	0.0
bg_vbf_200_40	453	1.0	214.843	58.14	0.0	0.0
bg_vbf_400_60	332	1.0	360.116	74.81	0.0	0.0
bg_vbf_600_80	122	1.0	512.148	95.26	0.0	0.0
bg_vbf_800_12	46.7	1.0	713.131	144.6	0.0	0.0
bg_vbf_1200_1	4.12	1.0	1037.47	214.8	0.0	0.0
bg_vbf_1600_i	0.436	1.0	1488.05	353.5	0.0	7.318

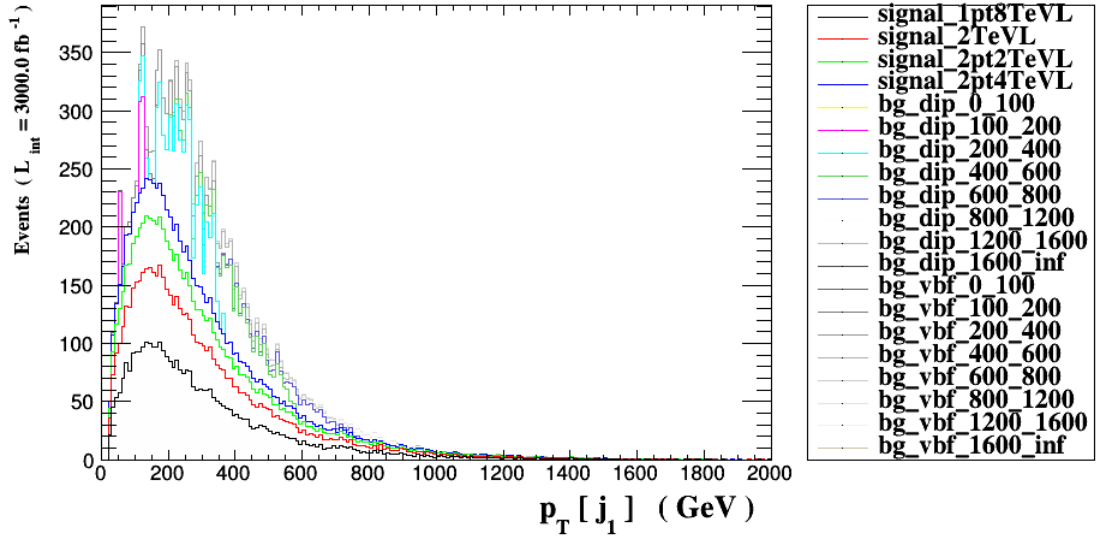


Figure 1.

### 3.3 Histogram 2

\* Plot:  $\text{ETA}(\text{jets}[1])$

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	-0.00955319	2.227	0.0	0.0
signal_2tevl	2341	1.0	-0.00387268	2.234	0.0	0.0
signal_2pt2tevl	1587	1.0	-0.0184585	2.251	0.0	0.0
signal_2pt4tevl	1113	1.0	-0.000218535	2.251	0.0	0.0
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_200	236	1.0	1.65038	2.73	0.0	0.0
bg_dip_200_400	1433	1.0	0.146548	1.676	0.0	0.0
bg_dip_400_600	920	1.0	0.1076	1.425	0.0	0.0
bg_dip_600_800	269	1.0	-0.0364249	1.3	0.0	0.0
bg_dip_800_1200	110	1.0	-0.0506134	1.215	0.0	0.0
bg_dip_1200_1600	7.88	1.0	0.0264047	1.124	0.0	0.0
bg_dip_1600_inf	0.731	1.0	-0.0490747	0.8389	0.0	0.0
bg_vbf_0_100	3.65	1.0	0.873486	2.934	0.0	0.0
bg_vbf_100_200	87.3	1.0	0.133336	2.773	0.0	0.0
bg_vbf_200_400	453	1.0	-0.006481	2.235	0.0	0.0
bg_vbf_400_600	332	1.0	-0.0267496	1.928	0.0	0.0
bg_vbf_600_800	122	1.0	0.00605067	1.754	0.0	0.0
bg_vbf_800_1200	46.7	1.0	-0.0592612	1.598	0.0	0.0
bg_vbf_1200_1600	4.12	1.0	-0.0746631	1.45	0.0	0.0
bg_vbf_1600_inf	0.436	1.0	0.0871655	1.227	0.0	0.0

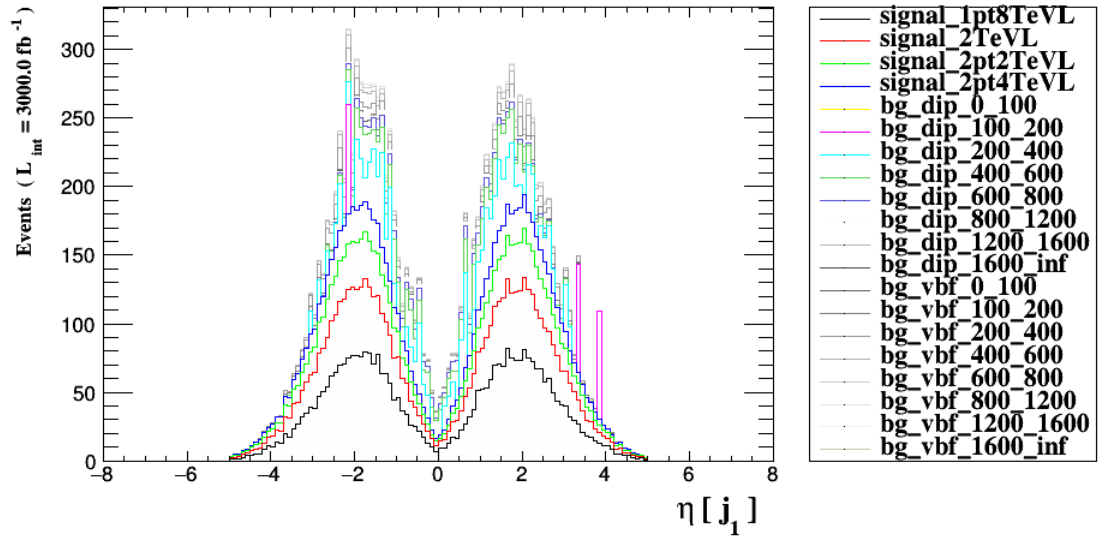


Figure 2.

### 3.4 Histogram 3

\* Plot: PHI ( jets[1] )

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	-0.00556715	1.81	0.0	0.0
signal_2tevl	2341	1.0	-0.0112916	1.829	0.0	0.0
signal_2pt2tevl	1587	1.0	0.0206288	1.816	0.0	0.0
signal_2pt4tevl	1113	1.0	-0.0212621	1.821	0.0	0.0
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	0.466209	0.3607	0.0	0.0
bg_dip_200_40	1433	1.0	-0.0522949	1.826	0.0	0.0
bg_dip_400_60	920	1.0	-0.125515	1.849	0.0	0.0
bg_dip_600_80	269	1.0	-0.113698	1.83	0.0	0.0
bg_dip_800_12	110	1.0	0.0576669	1.795	0.0	0.0
bg_dip_1200_1	7.88	1.0	-0.152016	1.941	0.0	0.0
bg_dip_1600_i	0.731	1.0	-0.0323032	1.815	0.0	0.0
bg_vbf_0_100	3.65	1.0	-0.168141	1.997	0.0	0.0
bg_vbf_100_20	87.3	1.0	-0.0767497	1.778	0.0	0.0
bg_vbf_200_40	453	1.0	-0.0816388	1.818	0.0	0.0
bg_vbf_400_60	332	1.0	0.0212645	1.801	0.0	0.0
bg_vbf_600_80	122	1.0	-0.00569695	1.808	0.0	0.0
bg_vbf_800_12	46.7	1.0	0.0641089	1.814	0.0	0.0
bg_vbf_1200_1	4.12	1.0	0.0646329	1.787	0.0	0.0
bg_vbf_1600_i	0.436	1.0	0.217904	1.755	0.0	0.0

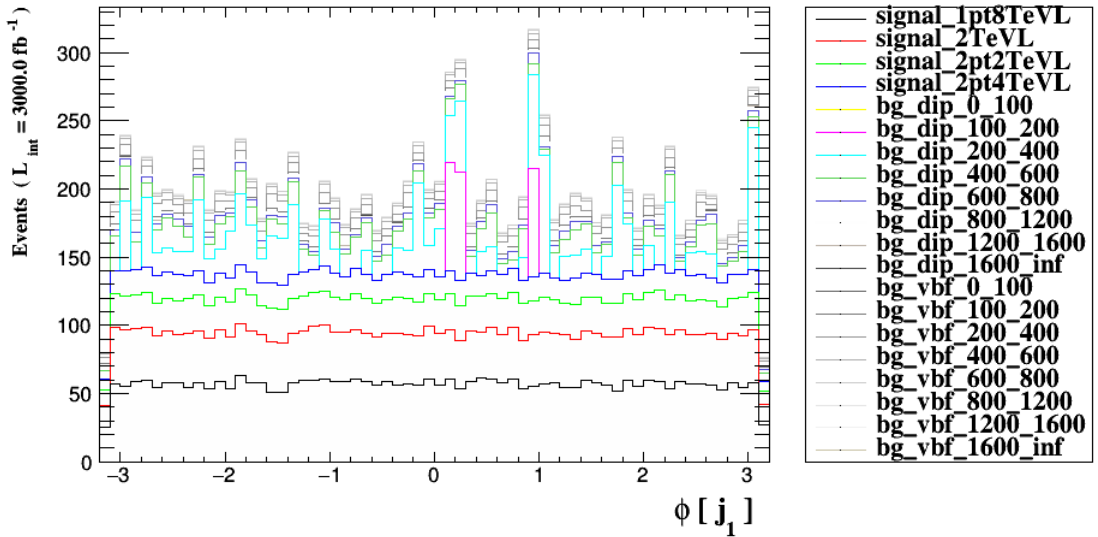


Figure 3.

### 3.5 Histogram 4

\* Plot: PT ( jets[2] )

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	91.1707	68.0	0.0	0.0
signal_2tevl	2341	1.0	91.1025	68.01	0.0	0.0
signal_2pt2tevl	1587	1.0	90.116	67.08	0.0	0.0
signal_2pt4tevl	1113	1.0	89.6662	66.85	0.0	0.0
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	49.3379	16.83	0.0	0.0
bg_dip_200_40	1433	1.0	68.617	36.13	0.0	0.0
bg_dip_400_60	920	1.0	78.6224	56.28	0.0	0.0
bg_dip_600_80	269	1.0	94.6258	83.07	0.0	0.0
bg_dip_800_12	110	1.0	124.553	124.0	0.0	0.0
bg_dip_1200_1	7.88	1.0	176.706	198.4	0.0	0.0
bg_dip_1600_i	0.731	1.0	138.5	204.7	0.0	0.0
bg_vbf_0_100	3.65	1.0	31.916	8.29	0.0	0.0
bg_vbf_100_20	87.3	1.0	53.936	17.53	0.0	0.0
bg_vbf_200_40	453	1.0	90.5854	37.67	0.0	0.0
bg_vbf_400_60	332	1.0	125.017	60.47	0.0	0.0
bg_vbf_600_80	122	1.0	168.787	85.77	0.0	0.0
bg_vbf_800_12	46.7	1.0	215.936	127.0	0.0	0.0
bg_vbf_1200_1	4.12	1.0	286.77	196.2	0.0	0.0
bg_vbf_1600_i	0.436	1.0	301.151	261.1	0.0	0.0

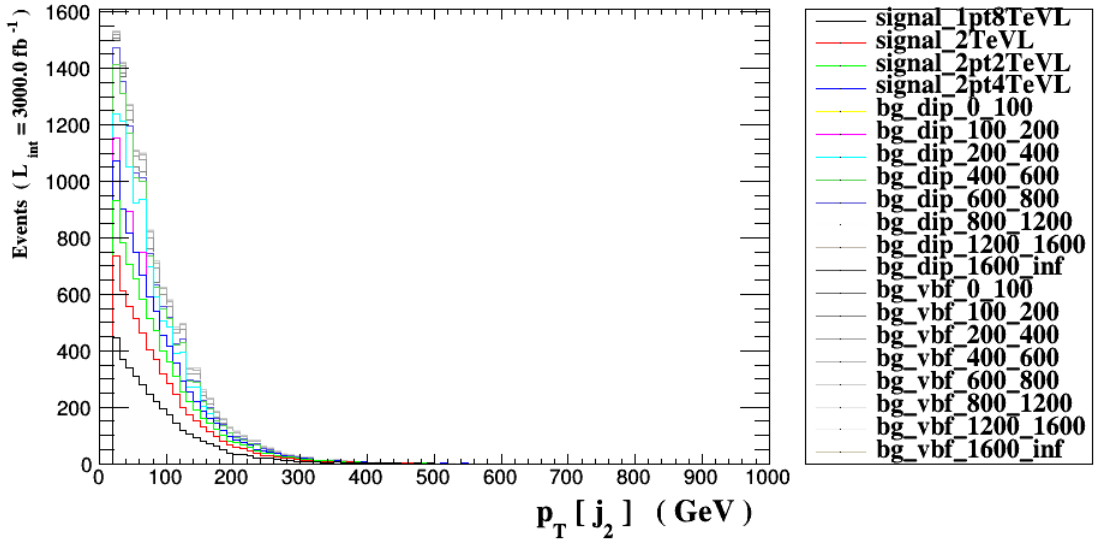


Figure 4.

### 3.6 Histogram 5

\* Plot:  $\text{ETA}(\text{jets}[2])$

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	-0.000149935	3.17	0.0	0.0
signal_2tevl	2341	1.0	-0.00981831	3.181	0.0	0.0
signal_2pt2tevl	1587	1.0	0.0171954	3.187	0.0	0.0
signal_2pt4tevl	1113	1.0	-0.00501176	3.191	0.0	0.0
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_200	236	1.0	0.140052	2.918	0.0	0.0
bg_dip_200_400	1433	1.0	0.291332	3.134	0.0	0.0
bg_dip_400_600	920	1.0	-0.0693841	3.116	0.0	0.0
bg_dip_600_800	269	1.0	0.0792687	3.236	0.0	0.0
bg_dip_800_1200	110	1.0	0.0158785	3.221	0.0	0.0
bg_dip_1200_1600	7.88	1.0	-0.142349	3.23	0.0	0.0
bg_dip_1600_inf	0.731	1.0	-0.328753	3.419	0.0	0.0
bg_vbf_0_100	3.65	1.0	1.04772	3.507	0.0	0.0
bg_vbf_100_200	87.3	1.0	-0.324417	3.174	0.0	0.0
bg_vbf_200_400	453	1.0	0.0275519	2.946	0.0	0.0
bg_vbf_400_600	332	1.0	0.0664249	2.847	0.0	0.0
bg_vbf_600_800	122	1.0	-0.00657983	2.765	0.0	0.0
bg_vbf_800_1200	46.7	1.0	0.123933	2.754	0.0	0.0
bg_vbf_1200_1600	4.12	1.0	0.151477	2.787	0.0	0.0
bg_vbf_1600_inf	0.436	1.0	-0.203626	2.95	0.0	0.0

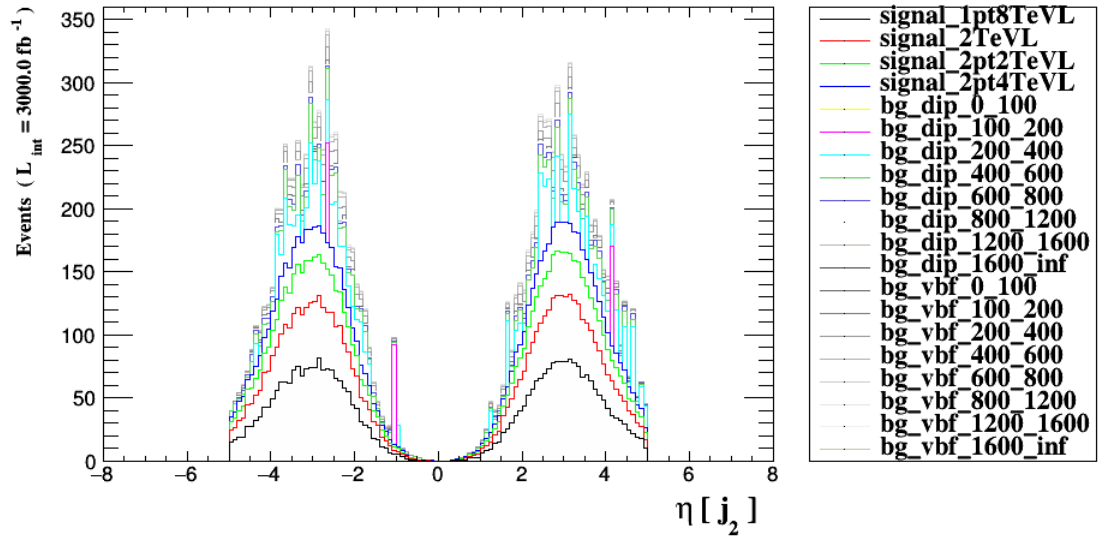


Figure 5.



### 3.7 Histogram 6

\* Plot: PHI ( jets[2] )

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	-0.00144685	1.818	0.0	0.0
signal_2tevl	2341	1.0	-0.00298964	1.815	0.0	0.0
signal_2pt2tevl	1587	1.0	-0.00263454	1.813	0.0	0.0
signal_2pt4tevl	1113	1.0	0.0090896	1.809	0.0	0.0
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	1.00733	1.634	0.0	0.0
bg_dip_200_40	1433	1.0	-0.0248154	1.887	0.0	0.0
bg_dip_400_60	920	1.0	-0.0373808	1.79	0.0	0.0
bg_dip_600_80	269	1.0	0.0797356	1.824	0.0	0.0
bg_dip_800_12	110	1.0	0.124598	1.781	0.0	0.0
bg_dip_1200_1	7.88	1.0	-0.323666	1.753	0.0	0.0
bg_dip_1600_i	0.731	1.0	-0.421228	1.806	0.0	0.0
bg_vbf_0_100	3.65	1.0	0.0859607	1.498	0.0	0.0
bg_vbf_100_20	87.3	1.0	0.17327	1.879	0.0	0.0
bg_vbf_200_40	453	1.0	-0.0817648	1.828	0.0	0.0
bg_vbf_400_60	332	1.0	-0.0599984	1.828	0.0	0.0
bg_vbf_600_80	122	1.0	0.0117494	1.812	0.0	0.0
bg_vbf_800_12	46.7	1.0	-0.0684445	1.824	0.0	0.0
bg_vbf_1200_1	4.12	1.0	-0.0586342	1.806	0.0	0.0
bg_vbf_1600_i	0.436	1.0	-0.198205	1.858	0.0	0.0

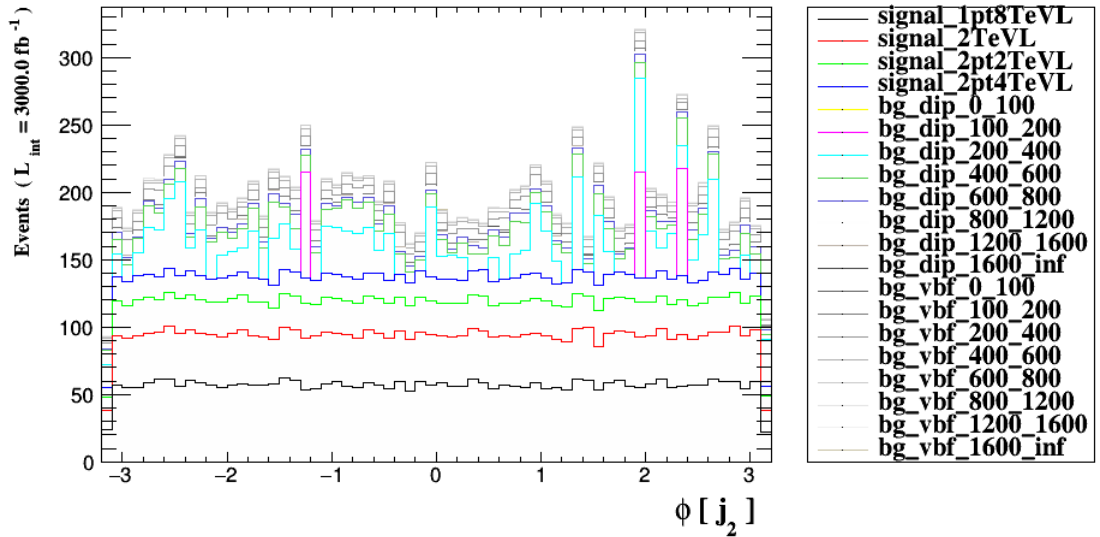


Figure 6.

### 3.8 Histogram 7

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

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	5.37976	1.111	0.0	0.0
signal_2tevl	2341	1.0	5.396	1.112	0.0	0.0
signal_2pt2tevl	1587	1.0	5.4204	1.112	0.0	0.0
signal_2pt4tevl	1113	1.0	5.41805	1.118	0.0	0.0
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	5.99929	0.4811	0.0	0.0
bg_dip_200_40	1433	1.0	4.87458	0.6286	0.0	0.0
bg_dip_400_60	920	1.0	4.6746	0.5749	0.0	0.0
bg_dip_600_80	269	1.0	4.64892	0.5595	0.0	0.0
bg_dip_800_12	110	1.0	4.61435	0.495	0.0	0.0
bg_dip_1200_1	7.88	1.0	4.51401	0.442	0.0	0.0
bg_dip_1600_i	0.731	1.0	4.44387	0.4353	0.0	0.0
bg_vbf_0_100	3.65	1.0	6.62263	0.3293	0.0	0.0
bg_vbf_100_20	87.3	1.0	5.99091	0.8146	0.0	0.0
bg_vbf_200_40	453	1.0	5.24335	0.8413	0.0	0.0
bg_vbf_400_60	332	1.0	4.96829	0.7025	0.0	0.0
bg_vbf_600_80	122	1.0	4.83273	0.5935	0.0	0.0
bg_vbf_800_12	46.7	1.0	4.73982	0.5158	0.0	0.0
bg_vbf_1200_1	4.12	1.0	4.67427	0.4511	0.0	0.0
bg_vbf_1600_i	0.436	1.0	4.62399	0.461	0.0	0.0

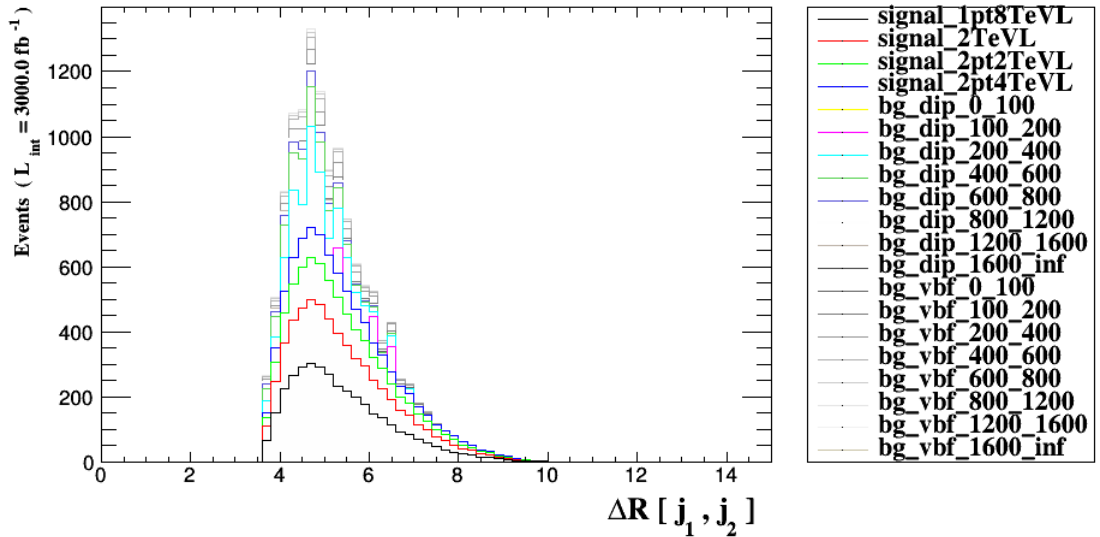


Figure 7.

### 3.9 Histogram 8

\* Plot:  $M(j_1, j_2)$

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	1814.06	849.7	0.0	0.08101
signal_2tevl	2341	1.0	1828.4	853.8	0.0	0.1232
signal_2pt2tevl	1587	1.0	1833.94	855.3	0.0	0.1017
signal_2pt4tevl	1113	1.0	1821.78	850.3	0.0	0.04153
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	1172.68	166.8	0.0	0.0
bg_dip_200_40	1433	1.0	1168.01	358.4	0.0	0.0
bg_dip_400_60	920	1.0	1373.0	458.4	0.0	0.0
bg_dip_600_80	269	1.0	1704.65	623.1	0.0	0.0
bg_dip_800_12	110	1.0	2097.6	885.2	0.0	0.0
bg_dip_1200_1	7.88	1.0	2709.62	1239	0.0	0.0
bg_dip_1600_i	0.731	1.0	2721.5	1274	0.0	0.0
bg_vbf_0_100	3.65	1.0	886.102	84.95	0.0	0.0
bg_vbf_100_20	87.3	1.0	1373.99	562.4	0.0	0.0
bg_vbf_200_40	453	1.0	1686.56	787.6	0.0	0.0
bg_vbf_400_60	332	1.0	2066.12	824.9	0.0	0.04443
bg_vbf_600_80	122	1.0	2497.1	840.0	0.0	0.2305
bg_vbf_800_12	46.7	1.0	2990.13	928.2	0.0	0.4593
bg_vbf_1200_1	4.12	1.0	3719.45	1119	0.0	2.558
bg_vbf_1600_i	0.436	1.0	4126.54	1410	0.0	6.321

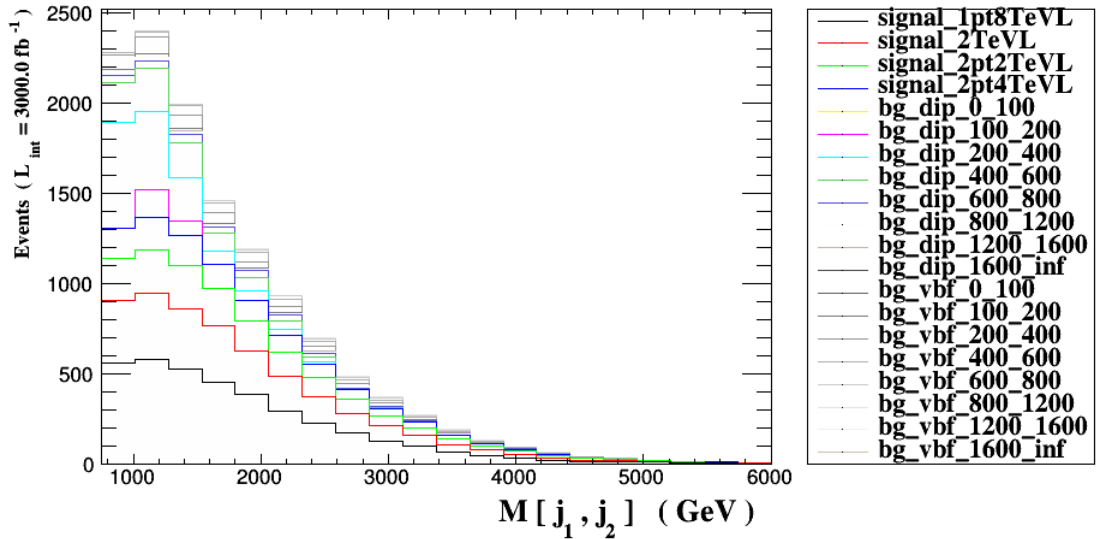


Figure 8.

### 3.10 Histogram 9

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

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	-0.00940325	5.206	50.16	0.1362
signal_2tevl	2341	1.0	0.00594562	5.226	49.91	0.1745
signal_2pt2tevl	1587	1.0	-0.0356539	5.25	50.23	0.09516
signal_2pt4tevl	1113	1.0	0.00479323	5.251	49.89	0.1246
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	1.51032	5.585	33.38	0.0
bg_dip_200_40	1433	1.0	-0.144784	4.518	51.81	0.0
bg_dip_400_60	920	1.0	0.176984	4.26	47.85	0.0
bg_dip_600_80	269	1.0	-0.115694	4.219	51.54	0.0
bg_dip_800_12	110	1.0	-0.0664918	4.119	50.96	0.0
bg_dip_1200_1	7.88	1.0	0.168753	4.051	47.8	0.0
bg_dip_1600_i	0.731	1.0	0.279678	4.007	46.29	0.0
bg_vbf_0_100	3.65	1.0	-0.174236	6.403	50.0	0.0
bg_vbf_100_20	87.3	1.0	0.457753	5.752	46.55	0.0
bg_vbf_200_40	453	1.0	-0.0340329	5.008	50.23	0.0
bg_vbf_400_60	332	1.0	-0.0931745	4.618	51.09	0.0
bg_vbf_600_80	122	1.0	0.0126305	4.376	49.93	0.0
bg_vbf_800_12	46.7	1.0	-0.183195	4.209	52.39	0.0
bg_vbf_1200_1	4.12	1.0	-0.226141	4.078	52.75	0.0
bg_vbf_1600_i	0.436	1.0	0.290791	3.996	45.88	0.0

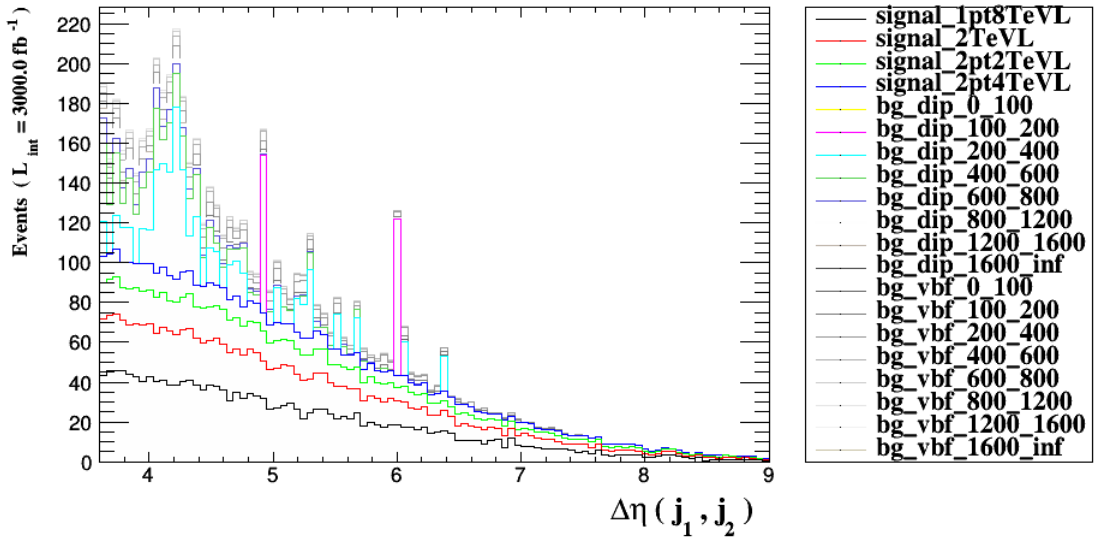


Figure 9.

### 3.11 Histogram 10

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

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	1478.13	826.9	0.0	1.495
signal_2tevl	2341	1.0	1483.58	832.5	0.0	1.441
signal_2pt2tevl	1587	1.0	1477.02	827.0	0.0	1.441
signal_2pt4tevl	1113	1.0	1484.45	830.6	0.0	1.485
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	674.287	36.08	0.0	0.0
bg_dip_200_40	1433	1.0	785.534	368.8	0.0	0.0
bg_dip_400_60	920	1.0	771.771	325.2	0.0	0.0
bg_dip_600_80	269	1.0	805.657	366.8	0.0	0.0
bg_dip_800_12	110	1.0	805.114	335.3	0.0	0.0
bg_dip_1200_1	7.88	1.0	924.629	435.1	0.0	0.0
bg_dip_1600_i	0.731	1.0	930.522	452.3	0.0	0.0
bg_vbf_0_100	3.65	1.0	999.408	375.3	0.0	0.0
bg_vbf_100_20	87.3	1.0	847.835	279.9	0.0	0.0
bg_vbf_200_40	453	1.0	806.306	333.7	0.0	0.0
bg_vbf_400_60	332	1.0	757.771	293.6	0.0	0.0
bg_vbf_600_80	122	1.0	774.989	292.6	0.0	0.0
bg_vbf_800_12	46.7	1.0	795.097	304.5	0.0	0.0
bg_vbf_1200_1	4.12	1.0	827.522	348.5	0.0	0.0
bg_vbf_1600_i	0.436	1.0	902.86	410.2	0.0	0.0

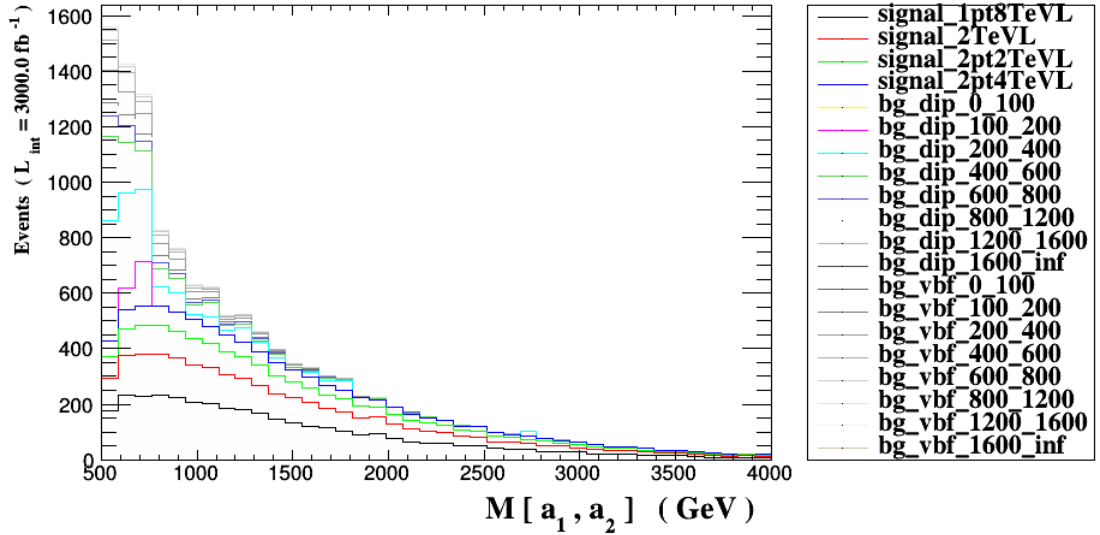


Figure 10.

### 3.12 Histogram 11

\* Plot: PT ( a[1] )

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	734.584	373.0	0.0	1.049
signal_2tevl	2341	1.0	737.64	375.4	0.0	0.9548
signal_2pt2tevl	1587	1.0	732.38	370.6	0.0	0.9549
signal_2pt4tevl	1113	1.0	732.622	374.6	0.0	0.9903
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	327.174	7.434	0.0	0.0
bg_dip_200_40	1433	1.0	393.477	77.89	0.0	0.0
bg_dip_400_60	920	1.0	475.422	123.4	0.0	0.0
bg_dip_600_80	269	1.0	603.382	164.2	0.0	0.0
bg_dip_800_12	110	1.0	778.016	241.8	0.0	0.0
bg_dip_1200_1	7.88	1.0	1095.08	412.4	0.0	0.0
bg_dip_1600_i	0.731	1.0	1602.75	495.3	0.0	18.53
bg_vbf_0_100	3.65	1.0	379.899	64.59	0.0	0.0
bg_vbf_100_20	87.3	1.0	373.902	77.67	0.0	0.0
bg_vbf_200_40	453	1.0	391.46	92.25	0.0	0.0
bg_vbf_400_60	332	1.0	436.107	113.9	0.0	0.0
bg_vbf_600_80	122	1.0	516.8	150.3	0.0	0.0
bg_vbf_800_12	46.7	1.0	657.311	223.5	0.0	0.0
bg_vbf_1200_1	4.12	1.0	890.939	358.6	0.0	0.07854
bg_vbf_1600_i	0.436	1.0	1323.7	534.5	0.0	6.344

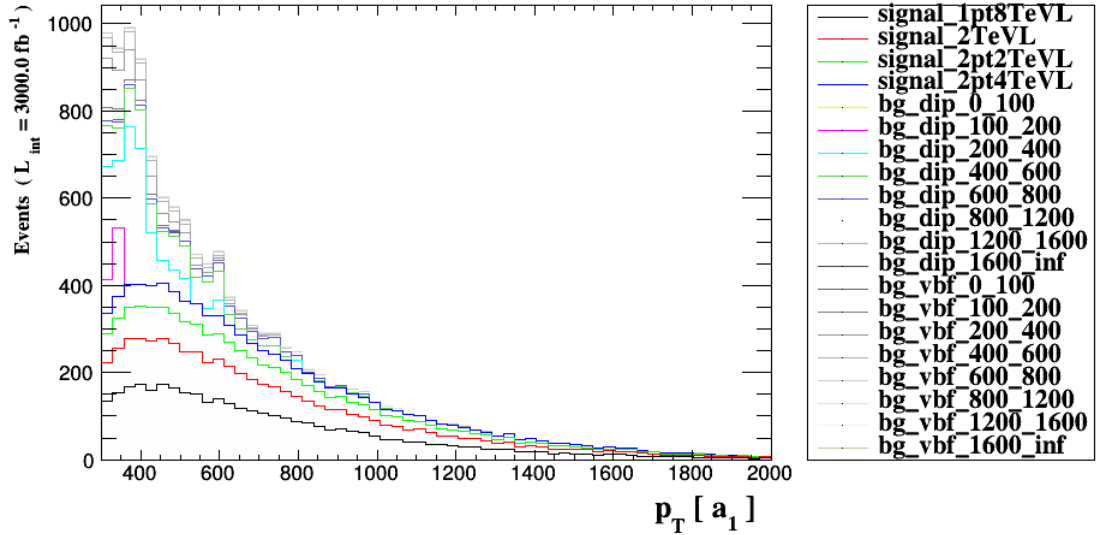


Figure 11.

### 3.13 Histogram 12

\* Plot: PT ( a[2] )

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	536.444	357.7	0.0	0.5266
signal_2tevl	2341	1.0	538.523	361.6	0.0	0.4996
signal_2pt2tevl	1587	1.0	535.47	356.9	0.0	0.4627
signal_2pt4tevl	1113	1.0	536.117	359.5	0.0	0.4952
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	253.391	44.39	0.0	0.0
bg_dip_200_40	1433	1.0	186.1	97.8	0.0	0.0
bg_dip_400_60	920	1.0	144.408	100.8	0.0	0.0
bg_dip_600_80	269	1.0	140.303	115.8	0.0	0.0
bg_dip_800_12	110	1.0	130.659	108.9	0.0	0.0
bg_dip_1200_1	7.88	1.0	151.48	146.8	0.0	0.0
bg_dip_1600_i	0.731	1.0	125.146	119.5	0.0	0.0
bg_vbf_0_100	3.65	1.0	359.837	74.21	0.0	0.0
bg_vbf_100_20	87.3	1.0	285.217	94.57	0.0	0.0
bg_vbf_200_40	453	1.0	209.251	118.9	0.0	0.0
bg_vbf_400_60	332	1.0	159.332	118.8	0.0	0.0
bg_vbf_600_80	122	1.0	157.378	113.0	0.0	0.0
bg_vbf_800_12	46.7	1.0	159.508	121.4	0.0	0.0
bg_vbf_1200_1	4.12	1.0	167.561	142.6	0.0	0.0
bg_vbf_1600_i	0.436	1.0	183.782	190.2	0.0	0.0

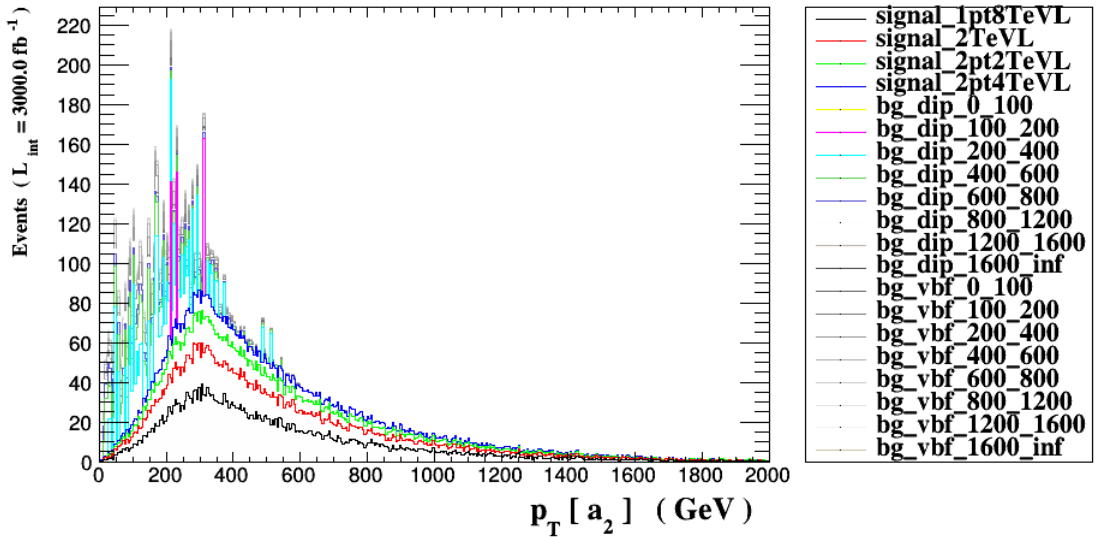


Figure 12.

### 3.14 Histogram 13

\* Plot: THT

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	402.093	272.0	0.0	0.0
signal_2tevl	2341	1.0	400.828	269.2	0.0	0.0
signal_2pt2tevl	1587	1.0	397.316	266.8	0.0	0.0
signal_2pt4tevl	1113	1.0	394.27	266.9	0.0	0.0
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	148.168	37.58	0.0	0.0
bg_dip_200_40	1433	1.0	312.487	53.59	0.0	0.0
bg_dip_400_60	920	1.0	483.667	56.67	0.0	0.0
bg_dip_600_80	269	1.0	677.891	53.6	0.0	0.0
bg_dip_800_12	110	1.0	924.952	102.7	0.0	0.0
bg_dip_1200_1	7.88	1.0	1350.6	122.7	0.0	0.0
bg_dip_1600_i	0.731	1.0	1813.83	223.3	0.0	0.0
bg_vbf_0_100	3.65	1.0	74.6978	15.53	0.0	0.0
bg_vbf_100_20	87.3	1.0	163.344	25.73	0.0	0.0
bg_vbf_200_40	453	1.0	305.428	55.11	0.0	0.0
bg_vbf_400_60	332	1.0	485.133	55.92	0.0	0.0
bg_vbf_600_80	122	1.0	680.936	55.85	0.0	0.0
bg_vbf_800_12	46.7	1.0	929.067	102.2	0.0	0.0
bg_vbf_1200_1	4.12	1.0	1324.24	99.5	0.0	0.0
bg_vbf_1600_i	0.436	1.0	1789.2	191.2	0.0	0.0

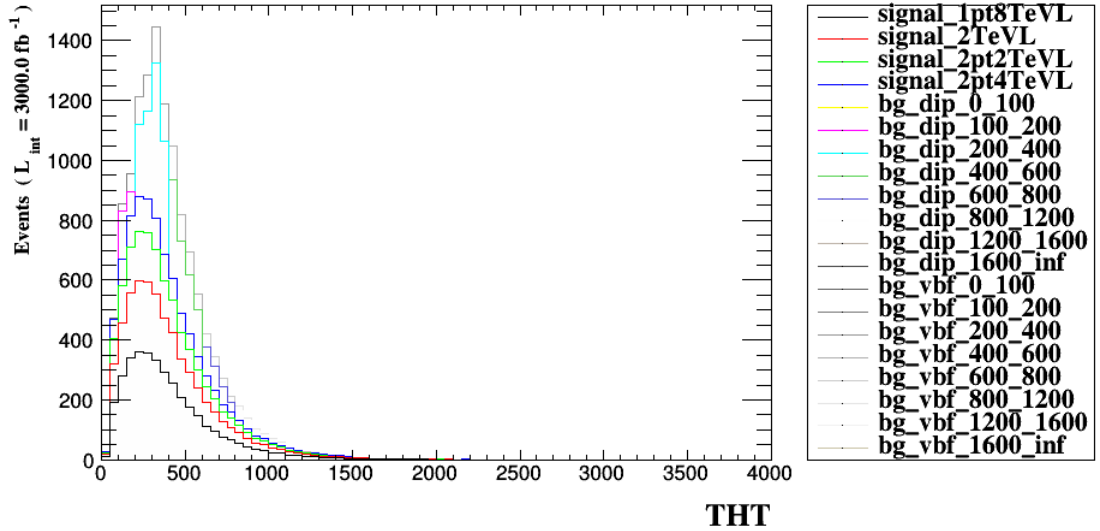


Figure 13.



### 3.15 Histogram 14

\* Plot: MET

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	9.61803e-09	1.279e-08	0.0	0.0
signal_2tevl	2341	1.0	9.60927e-09	1.272e-08	0.0	0.0
signal_2pt2tevl	1587	1.0	9.6086e-09	1.274e-08	0.0	0.0
signal_2pt4tevl	1113	1.0	9.66474e-09	1.292e-08	0.0	0.0
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	2.6048e-09	5.584e-10	0.0	0.0
bg_dip_200_40	1433	1.0	5.15652e-09	2.886e-09	0.0	0.0
bg_dip_400_60	920	1.0	5.26293e-09	2.848e-09	0.0	0.0
bg_dip_600_80	269	1.0	5.42862e-09	2.905e-09	0.0	0.0
bg_dip_800_12	110	1.0	7.13192e-09	8.331e-09	0.0	0.0
bg_dip_1200_1	7.88	1.0	2.55869e-08	2.401e-08	0.0	0.0
bg_dip_1600_i	0.731	1.0	3.47198e-08	2.306e-08	0.0	0.0
bg_vbf_0_100	3.65	1.0	2.92664e-09	2.061e-09	0.0	0.0
bg_vbf_100_20	87.3	1.0	4.59216e-09	2.634e-09	0.0	0.0
bg_vbf_200_40	453	1.0	5.28184e-09	3.059e-09	0.0	0.0
bg_vbf_400_60	332	1.0	5.56314e-09	3.759e-09	0.0	0.0
bg_vbf_600_80	122	1.0	5.7028e-09	3.425e-09	0.0	0.0
bg_vbf_800_12	46.7	1.0	6.73764e-09	5.92e-09	0.0	0.0
bg_vbf_1200_1	4.12	1.0	1.72505e-08	1.831e-08	0.0	0.0
bg_vbf_1600_i	0.436	1.0	3.09154e-08	2.364e-08	0.0	0.0

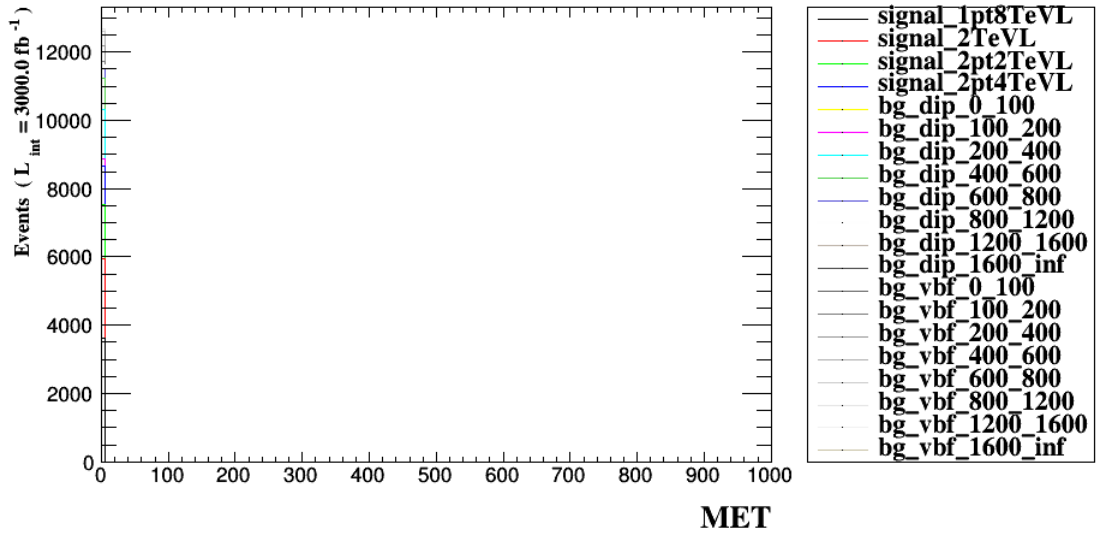


Figure 14.

### 3.16 Histogram 15

\* Plot: TET

Dataset	Integral	Entries per event	Mean	RMS	% underflow	% overflow
signal_1pt8tevl	3603	1.0	1673.12	775.0	0.0	0.0
signal_2tevl	2341	1.0	1676.99	779.8	0.0	0.00342
signal_2pt2tevl	1587	1.0	1665.17	770.4	0.0	0.0
signal_2pt4tevl	1113	1.0	1663.01	778.9	0.0	0.0
bg_dip_0_100	0.0 +/- 0.0	0.	0.0	0.0	0.0	0.0
bg_dip_100_20	236	1.0	728.733	80.65	0.0	0.0
bg_dip_200_40	1433	1.0	892.065	159.2	0.0	0.0
bg_dip_400_60	920	1.0	1103.5	208.7	0.0	0.0
bg_dip_600_80	269	1.0	1421.58	241.6	0.0	0.0
bg_dip_800_12	110	1.0	1833.63	311.4	0.0	0.0
bg_dip_1200_1	7.88	1.0	2597.16	496.1	0.0	0.0
bg_dip_1600_i	0.731	1.0	3541.73	662.3	0.0	0.0
bg_vbf_0_100	3.65	1.0	814.434	141.3	0.0	0.0
bg_vbf_100_20	87.3	1.0	822.463	164.7	0.0	0.0
bg_vbf_200_40	453	1.0	906.139	195.9	0.0	0.0
bg_vbf_400_60	332	1.0	1080.57	211.3	0.0	0.0
bg_vbf_600_80	122	1.0	1355.11	216.7	0.0	0.0
bg_vbf_800_12	46.7	1.0	1745.89	291.5	0.0	0.0
bg_vbf_1200_1	4.12	1.0	2382.74	401.9	0.0	0.0
bg_vbf_1600_i	0.436	1.0	3296.68	649.6	0.0	0.0

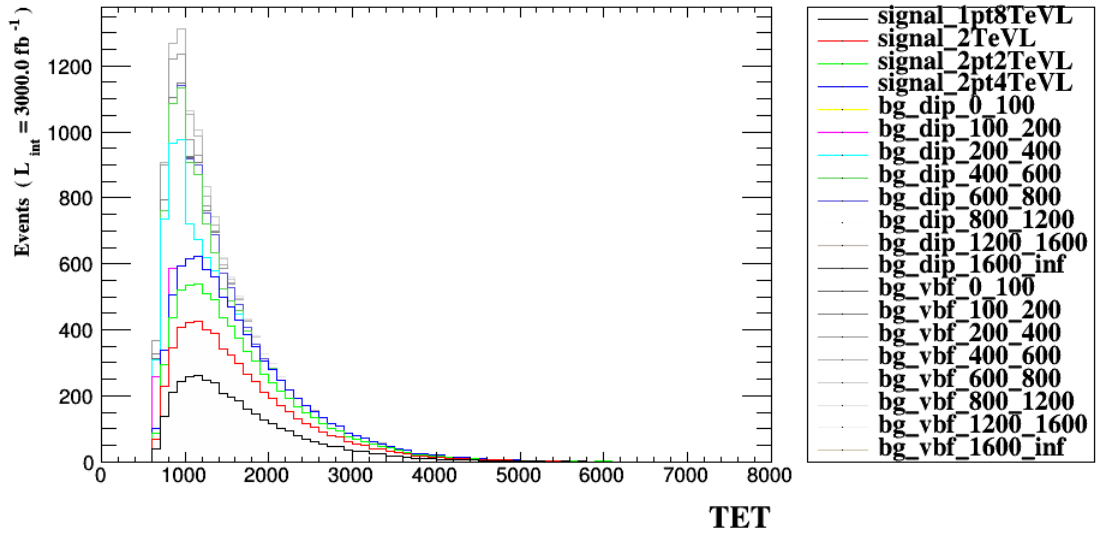


Figure 15.

## 4 Summary

### 4.1 Cut-flow charts

- How to compare signal (S) and background (B):  $S/\sqrt{S+B+(xB)^{**2}}$  .
- Object definition selections are indicated in cyan.
- Reject and select are indicated by 'REJ' and 'SEL' respectively

Cuts	Signal (S)	Background (B)	S vs B
Initial (no cut)	30046.7 +/- 17.8	308513727 +/- 365809	3.90e-04 +/- 2.58e-07
SEL: ( ( sdETA ( jets[1] jets[2] ) > 3.6 or sdETA	8610.2 +/- 78.5	4031.1 +/- 63.6	8.4910 +/- 0.0775