Trigger Level Analysis

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Summary

Here is my template for PhD or other theses, for pdfLaTeX (or LaTeX, but pdfLaTeX provides better internal hyperlinks).

It is based on the 'memoir' LaTeX class, which has a lot of useful features/options built-in. The documentation for the memoir class says that '[it] provides the functionality of over thirty of the more popular packages, thus simplifying document sources'.

If there is any specific typesetting feature you want to use in your thesis, you should first check in the comprehensive manual for the memoir class via the link above (which has a detailed index). It may well be that what you want is already provided by the memoir class (and it is better to use its built-in capabilities, rather than loading additional style files, unless you have to).

The rest of this template show various examples of features available.

See `http://www.mrao.cam.ac.uk/~dag/THESIS/` for the current version of this template. (This version is V1.12, dated 2016 September).

Contents

Declaration

This is the declaration. This is not too long, honest!

Acknowledgements

These are the acknowledgements.

[1]

CHAPTER 1

DETECTOR

1.1 *b*-Tagging

Identification of *b*-quarkjets in ATLAS is based on combining the output of three separate *b*-taggingalgorithms: Impact Parameter based (IP2D and IP3D, described in Section **??**), Secondary Vertex based (SV, described in Section **??**) and Decay Chain based (JetFitter, described in Section **??**)into a multivariate discriminant (MV2, covered in Section **??**) which is used to distinguish the jet flavours. These algorithms have undergone continuous improvement over the Run-2 cycle of the LHC to improve the separation of jet flavours.

1.1.1 IP2D and IP3D: Impact Parameter based Algorithms

The typical topology for a *b*-hadronof a secondary vertex displaced from the hard scatter interaction point as a results of the lifetime of *b*-quarkis used as the basis of these algorithms. Impact parameters of tracks from the secondary vertex are computed with respect to the primary vertex of the interaction. The IP2D algorithm uses a transverse impact parameter (d_0) defined as the distance of closest approach of a track to the primary vertex in r-ϕ plane around the vertex. The IP3D algorithm uses both the transverse and a correlated longitudinal impact parameter ($z_0 \sin\theta$), defined as the distance between the point of closest approach in r-ϕ and the primary vertex in the longitudinal plane. . These parameters typically have large values as a result of the lifetime of *b*-quark. The signs of the impact parameters are also defined to take account of if they lie infront or behind the primary vertex with respect to the jet direction, with secondary vertices occuring behind the primary vertex normally due to background.

To do: I kind of want a diagram here, but that doesn't appear to be the norm

The significance of the impact parameter values ($\frac{d_0}{\sigma_{d_0}}$, $\frac{z_0}{\sigma_{z_0 \sin\theta}}$) for each track are compared to probability density functions obtained from reference histograms derived from Monte Carlo simulation, with each track being compared to a selection of reference track categories. This results in weights which are combined using a log-likelihood ratio (LLR) discriminant to compute an overall jet weight separating the b, c, and light-jet flavours from each other. [1]

Chapter 2

Event Selection

This section describes the selection criteria required for the events and reconstructed objects used in the analysis. These cuts and criteria are designed with the VBF $H \rightarrow b\bar{b}$ event topology in mind, along with the limitations introduced by considering the available trigger chains as discussed in Section **??**. These cuts are applied in the VBF $H \rightarrow b\bar{b}$ analysis and the direct object comparison covered in Chapter 3.

2.1 Events

Data events were required to pass the all year 25ns Good Runs List[a] **??** and also be Clean **??**.

2.2 Offline Jets

Offline jet reconstruction was performed by the anti-k_t algorithm (R=0.4) as discussed in Section **??**. Jets were calibrated in line with the 20.7 recommendations **??**. When considering individual jets during the analysis, all jets were required to have a $p_{\mathrm{T}} > 45$ GeV to be recorded.

2.3 Online Jets

Online Jet reconstruction is a mystery. A full collection of online jets was recovered by extracting the split jets (Section

[a] data16_13TeV.periodAllYear_DetStatus-v88-pro20-21_DQDefects-00-02-04_PHYS_StandardGRL_All_Good_25ns.xml

2.4 Offline *b*-jets

The specifics of *b*-tagging are covered in Section **??**. Offline *b*-jets were tagged using the *MV2c10*-tagger[b] with two defined efficiency working points: *Tight*, with an overall efficiency of 70% and *Loose* with 85% tagging efficiency.

2.5 Online *b*-jets

Online *b*-jets were tagged using the *MV2c20*-tagger[c] with two defined efficiency working points: *Tight*, with an overall efficiency of 70% and *Loose* with 85% tagging efficiency.

[b] Jan 2017 Recommendations: 2016-20_7-13TeV-MC15-CDI-2017-01-31_v1.root
[c] Mar 2016 Recommendations: 2016-Winter-13TeV-MC15-CDI-March10_v1.root

Chapter 3

Object Performance

Prior to conducting a full study of TLA on the VBF $H \rightarrow b\bar{b}$ channel, the features of jet objects reconstructed offline and within the HLT were compared to identify any performance differences in the base components of an event reconstruction. The jet objects were compared on a one to one basis, by matching an online jet to an offline jet by requiring the ΔR value between the two jets to be below a threshold value of 0.3[a].

To do: Does this need a plot, or is this sufficient?

3.1 Leading *b*-jets

The leading p_{T} offline *b*-jet selected using the *Tight* working point was matched to a corresponding *b*-jet using ΔR matching. The following figures show the ratio of the difference in value between the offline and online jet calculated using the following formula for jet feature X:

$$\Delta X_{ratio} = \frac{X_{Offline} - X_{Online}}{X_{Offline}} \tag{3.1}$$

where $X_{Offline}$ is the value of the feature on the offline jet, and X_{Online} is from the HLT jet.

[a]Determined from a plot of ΔR values between all pairs of jets

3.1.1 Monte-Carlo

3.1.1.1 Plots of b-jet features

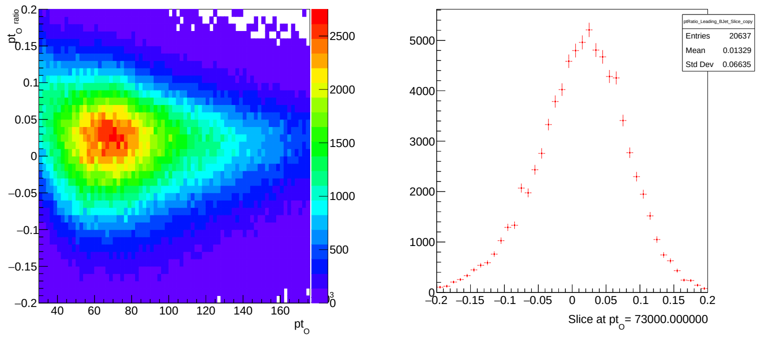

Figure 3.1: $\Delta p_{\mathrm{T}\ ratio}$ for the leading p_{T} b-jet from MC events against p_{T} of the offline b-jet. A slice across the y-axis has been taken at p_{T} = 79GeV.

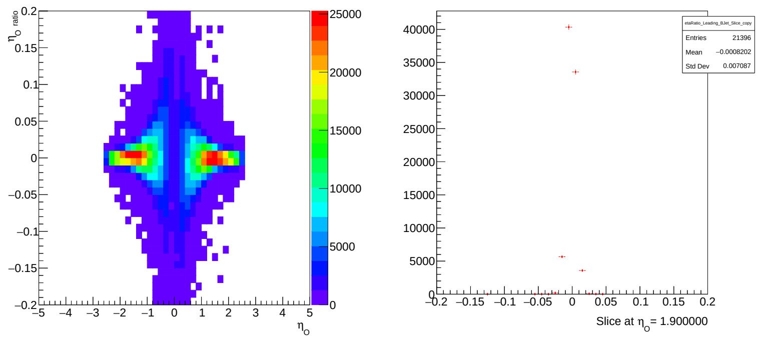

Figure 3.2: $\Delta\eta_{ratio}$ for the leading p_{T} b-jet from MC events against η of the offline b-jet. A slice across the y-axis has been taken at $\eta = -1.9$.

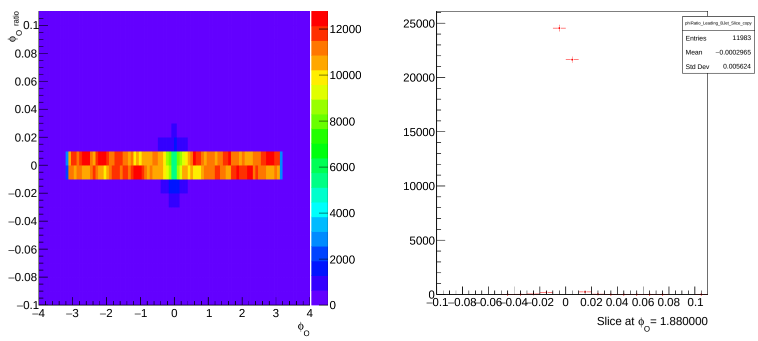

Figure 3.3: $\Delta\phi_{ratio}$ for the leading p_{T} b-jet from MC events against ϕ of the offline b-jet. A slice across the y-axis has been taken at $\phi = -1.64$.

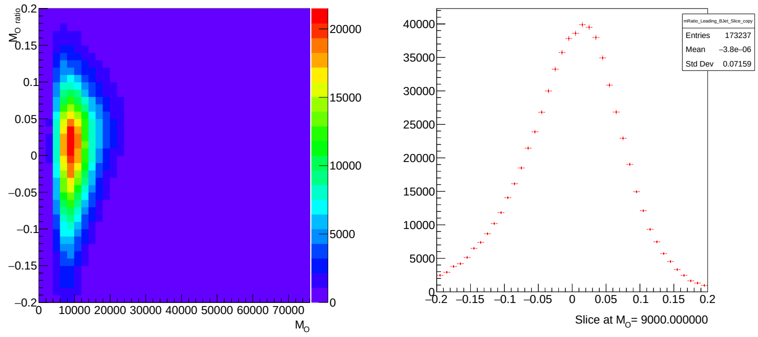

Figure 3.4: ΔM_{ratio} for the leading p_{T} b-jet from MC events against M of the offline b-jet. A slice across the y-axis has been taken at $M = 7\mathrm{GeV}$.

3.1.1.2 Conclusions from MC jet features

3.1.2 Data

Figure 3.5: **Figure 3.6:**

Figure 3.7: **Figure 3.8:**

Figure 3.9: **Figure 3.10:**

Figure 3.11:

Figure 3.12:

3.2 Leading Non *b*-jets

The non *b*-jet category is defined as the jets exclusive to those tagged in Section 3.1. Again, the leading p_{T} offline jet from this list is matched with an online jet for the comparison.

3.2.1 Monte-Carlo

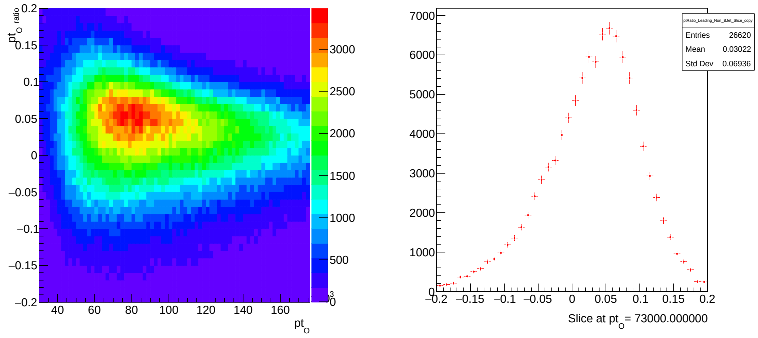

Figure 3.13: $\Delta p_{\mathrm{T}\ ratio}$ for the leading p_{T} non b-jet from MC events against p_{T} of the offline b-jet. A slice across the y-axis has been taken at $p_{\mathrm{T}} = 79$GeV.

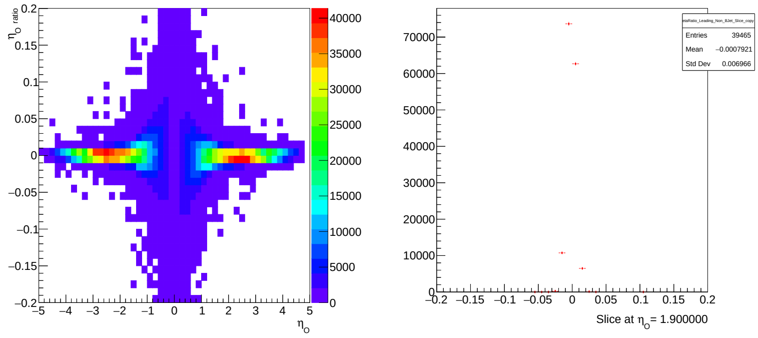

Figure 3.14: $\Delta\eta_{ratio}$ for the leading p_{T} non b-jet from MC events against η of the offline b-jet. A slice across the y-axis has been taken at $\eta = -1.9$.

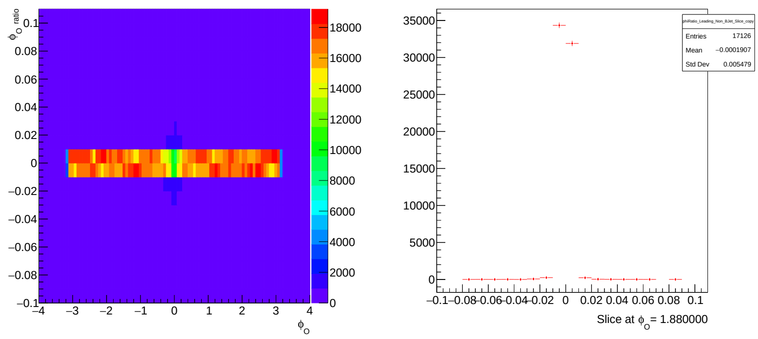

Figure 3.15: $\Delta\phi_{ratio}$ for the leading p_{T} non b-jet from MC events against ϕ of the offline b-jet. A slice across the y-axis has been taken at $\phi = -1.64$.

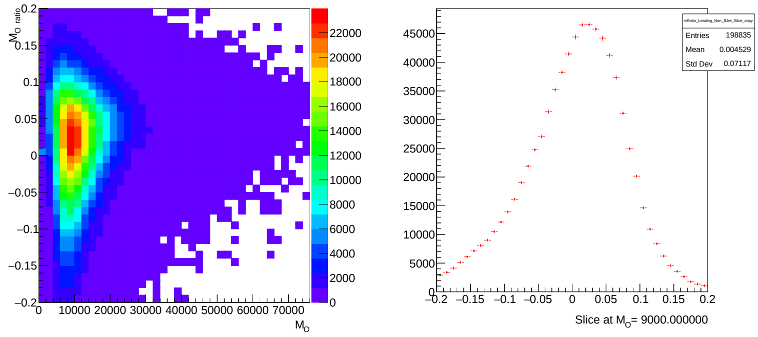

Figure 3.16: ΔM_{ratio} for the leading p_{T} non b-jet from MC events against M of the offline b-jet. A slice across the y-axis has been taken at $M = 7\mathrm{GeV}$.

3.2.2 Data

Figure 3.17:

Figure 3.18:

Figure 3.19:

Figure 3.20:

3.3 Central Jets

3.4 Forward Jets

3.5 Extremal? Jets

3.6 Jet Tagging Efficiency

As covered in Section **??**, the differences between the *b*-tagging methods for online and offline necessitates a comparison between the tagging efficiencies. This comparison could only be carried out on the MC, as the truth label of the offline jet was required to categorise each pair.

3.6.1 *b*-jet efficiency

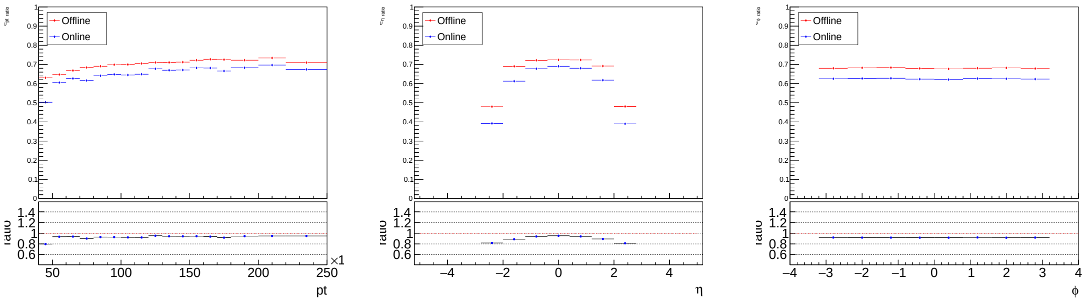

Figure 3.21:

To do: Options, could show more vars or alternatively the reference hists, or alternatively just reference the references

3.6.2 *c*-jet efficiency

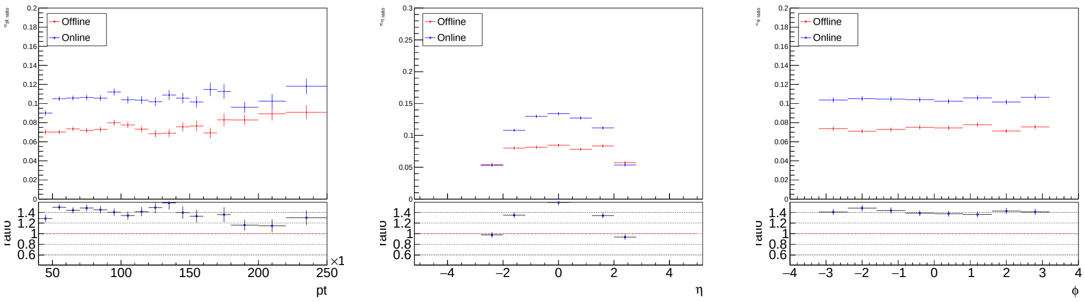

Figure 3.22:

3.6.3 Light-jet efficiency

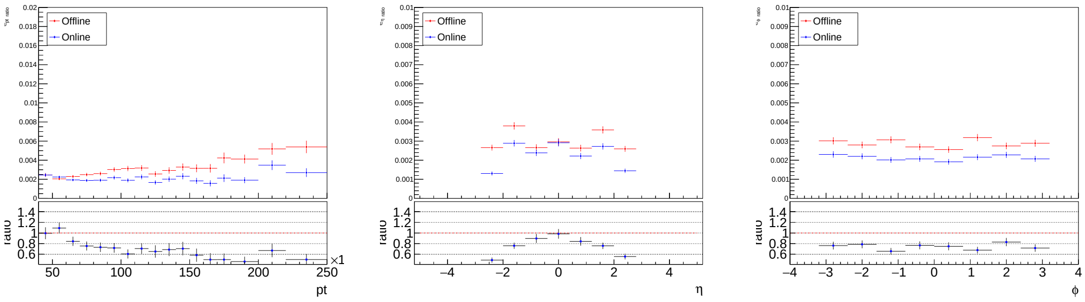

Figure 3.23:

3.6.4 Tag Matching

For each pair of jets that could be matched between online and offline, and then successfully have a b-tagging decision evaluated on the jets, the agreement of the b-tagging between the two jets was checked. These were found to match one another in 90.91% of cases.

3.7 MV2 Discriminant Values - ???

To do: Necessary

Here would show plots of the MV2 value against pt/eta or whatever

3.8 MV2 Input Variables - ???

CHAPTER 4

KINEMATICS

4.1 Specific Jet Feature Distributions

For the standard set of jet features, plot the overall distributions in a standard 2 hist ratio plot for data and MC. This also includes jet counts possibly

4.2 Specific Jet Feature Distributions

4.2.1 Two Central Channel

- b-jet1
- b-jet2
- F-jet
- jet

For each of these jets, which we can define, plot standard kinematic variables, p_{T} , η, ϕ, m. Torn as to the options here. could do more 2d jet to jet ratio plots, could do a more general distribution ratio for each one, and then there is s/b to consider. Could argue jet to jet comparisons moot as we already covered that.

4.3 BDT Input Variables

- M_{jj}
- $p_{\mathrm{T}\ jj}$

- $\cos\theta$
- $\Delta\eta_{jj}$
- $Max(\eta)$
- $\eta*$
- $min\Delta R(j_1)$
- $min\Delta R(j_1)$
- p_{T} balance
- $N_{TRK}(j_1)PV500$?
- $N_{TRK}(j_{)}PV500$?

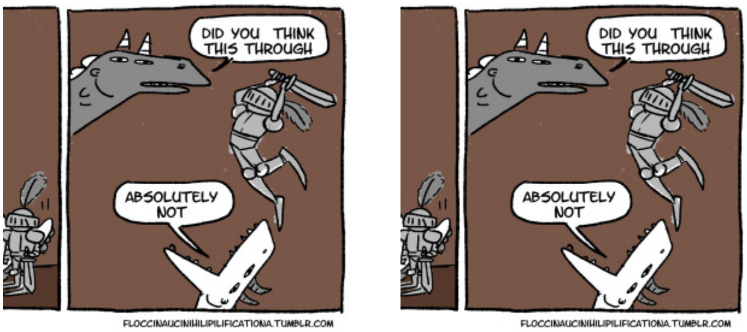

Figure 4.1: For Each channel, a standard 2 hist ratio plot fo the values of the BDT variables mentioned above, i.e. offline hist and online hists with a ratio. Each plot would have 4 lines, background(data) on/off, signal(MC) on/off and two ratios: data on/off + Mc on/off

4.4 Mbb Distribution

Prior paper suggests this is the 'final' plot, a shape comparison between BDT influenced control and signal regions of the Mbb distribution. A little confused as to exactly what we need here.

Bibliography

[1] A. Collaboration