Rediscover the Higgs Boson with ML Techniques

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Abstract
In this report we observe the effects of different cuts on the performance of ML algorithms with the goal to find the ratio of signal to background for proton-proton collision CERN Open Data.

1 Introduction

There are many ways to improve the performance of ML algorithms. One of them is to reduce the data meaningfully. Here we use cuts on processes that we know are not of much importance. Cuts on 'lepton transverse momentum' turned out to be the best resulting.

2 Choosing Cuts

Because we are limited to 4-lepton decay in the data,

$$H \to ZZ^* \to 4l$$

candidates can be as below:

- lepton transverse momentum > 6 GeV
- sum of lepton charges = 0
- sum of lepton types = 44 ($eeee$) or 48 ($e\mu e\mu$) or 52 ($\mu\mu\mu\mu$)

There were some complications due to low amount of data, so these were the best resulting cuts.

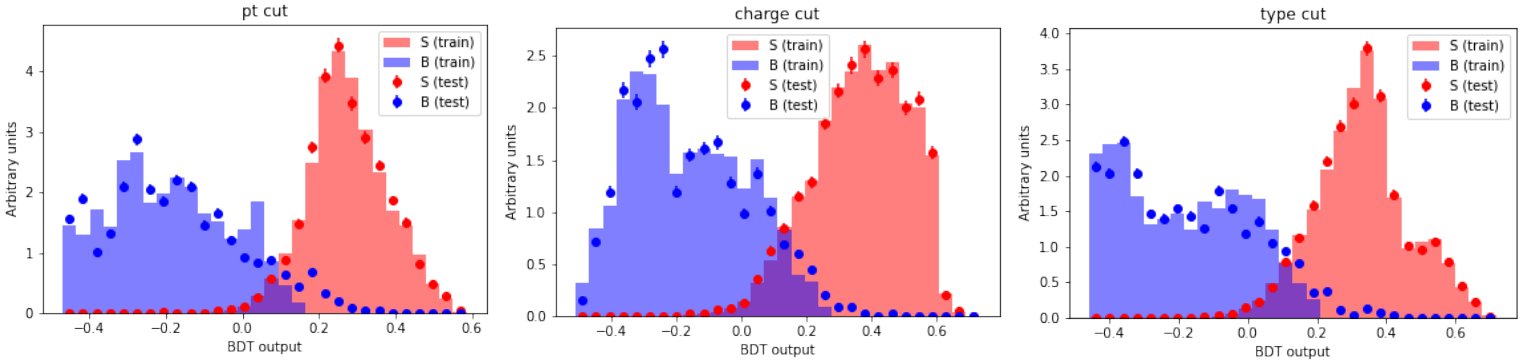
3 Results for Different Classification Algorithms

3.1 Boosted Decision Tree

The following are the performance on the test data.

BDT Results

Metrics	Pt cut	Charge cut	Type cut
Accuracy	0.98	0.97	0.98
F1-Score	0.93	0.91	0.91
AUC	0.98	0.98	0.98



Overfit checks for different cuts

3.2 Neural Network Model

NN Results

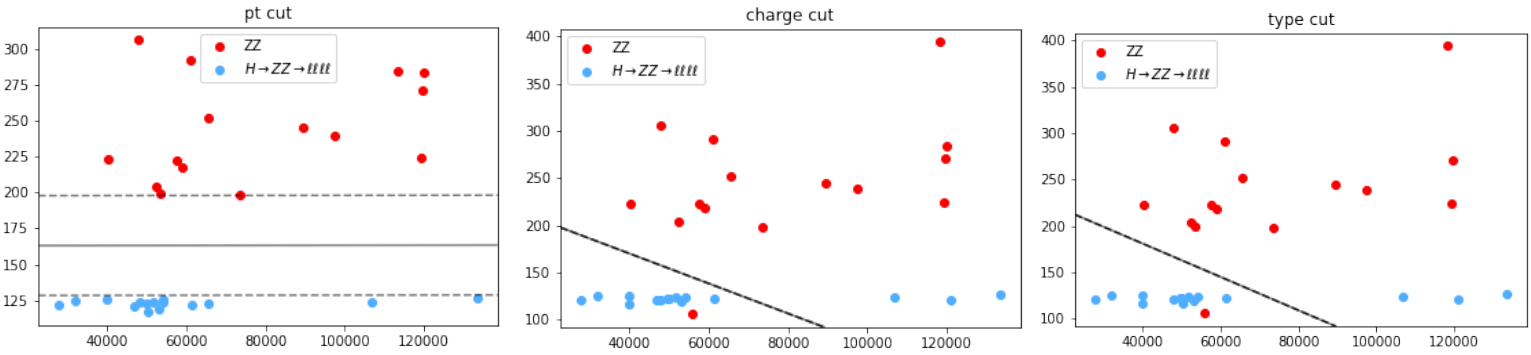
Metrics	Pt cut	Charge cut	Type cut
Accuracy	0.98	0.96	0.96
F1-Score	0.91	0.82	0.83
AUC	0.87	0.73	0.76

3.3 Support Vector Machine (SVM)

This is the result for a training on only 15 events of the dataset.

SVM Results

Metrics	Pt cut	Charge cut	Type cut
Accuracy	1.00	0.87	0.87
F1-Score	1.00	0.87	0.87
AUC	1.00	0.90	0.88



Decision function for different cuts

4 Conclusion

We can see that the cut on transverse momentum was able to remove background more effectively. That is transverse momentum is seen to be of the most importance to remove background in these classification ML algorithms.