Higgs CP Property

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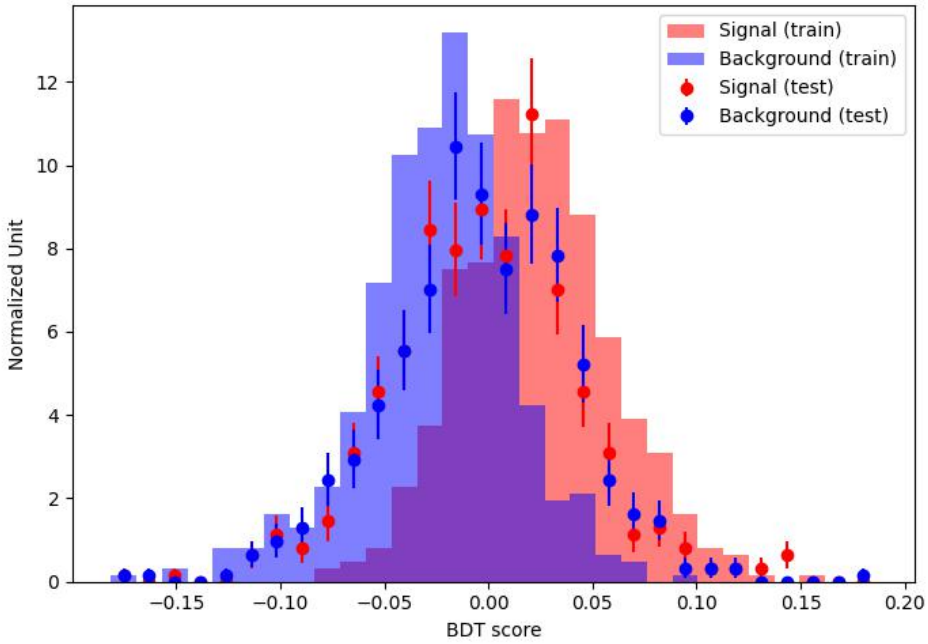
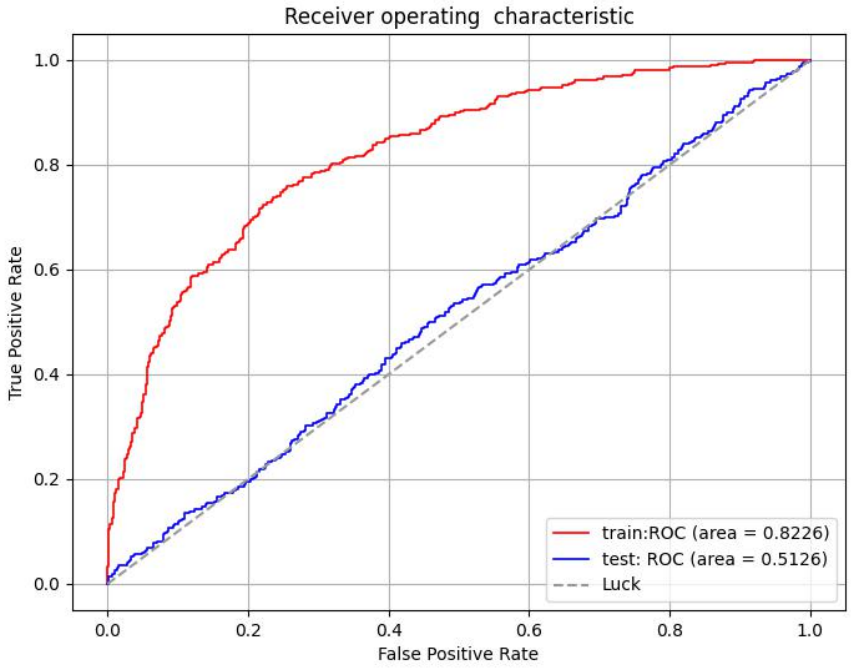
BDT analysis for HZZ channel

- Package installation on lxslc7 server without conda
- Use SM and BSM CP even HZZ events for BDT classification test

BDT analysis for HZZ channel(1)

- Channel ee->Z(->μμ)H(->ZZ)->6μ
- 1000 events, 500 for training and 500 for testing
- 32 parameters: four Lorentz vectors for eight particles (Z, Higgs, 6μ)





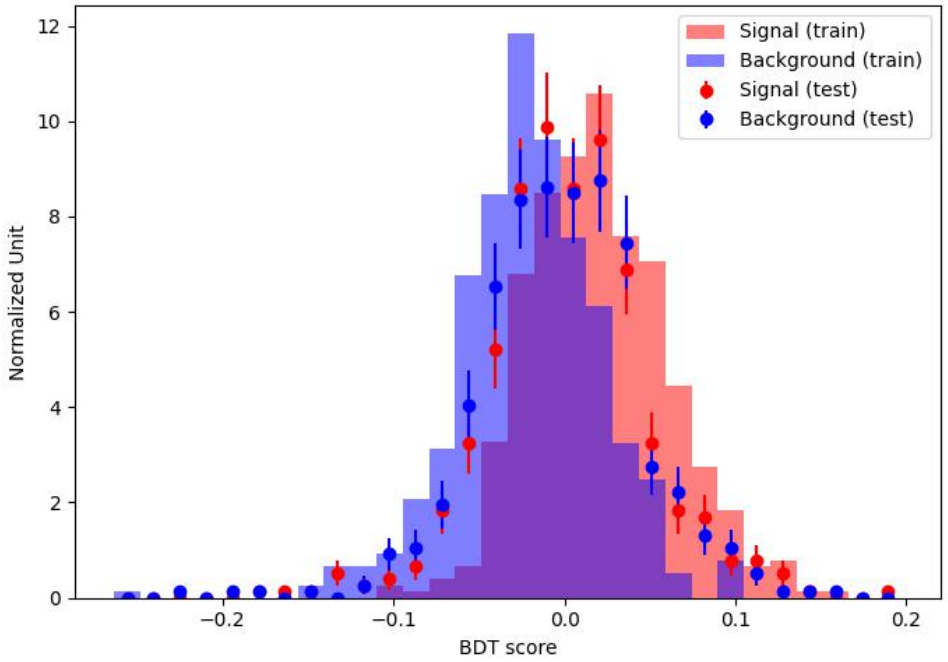
BDT analysis for HZZ channel(1)

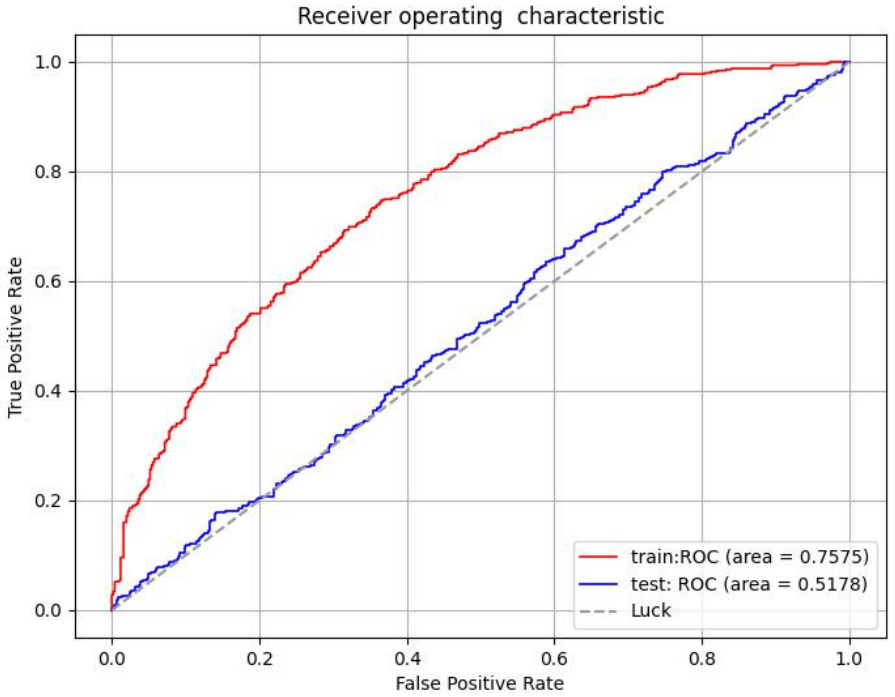
- 32 parameters: four Lorentz vectors for eight particles (Z, Higgs, 6μ)

```
Number of events:
signal:  1000  background:  1000
              precision    recall  f1-score   support

  background       0.74      0.76      0.75       501
      signal       0.75      0.74      0.74       499

    accuracy                           0.75      1000
   macro avg       0.75      0.75      0.75      1000
weighted avg       0.75      0.75      0.75      1000

Area under ROC curve: 0.8226
              precision    recall  f1-score   support

  background       0.52      0.54      0.53       499
      signal       0.52      0.50      0.51       501

    accuracy                           0.52      1000
   macro avg       0.52      0.52      0.52      1000
weighted avg       0.52      0.52      0.52      1000

Area under ROC curve: 0.5126
```

BDT analysis for HZZ channel(2)

- Channel ee->Z(->μμ)H(->ZZ)->6μ
- 1000 events, 500 for training and 500 for testing
- 8 parameters: four Lorentz vectors for Higgs and Z





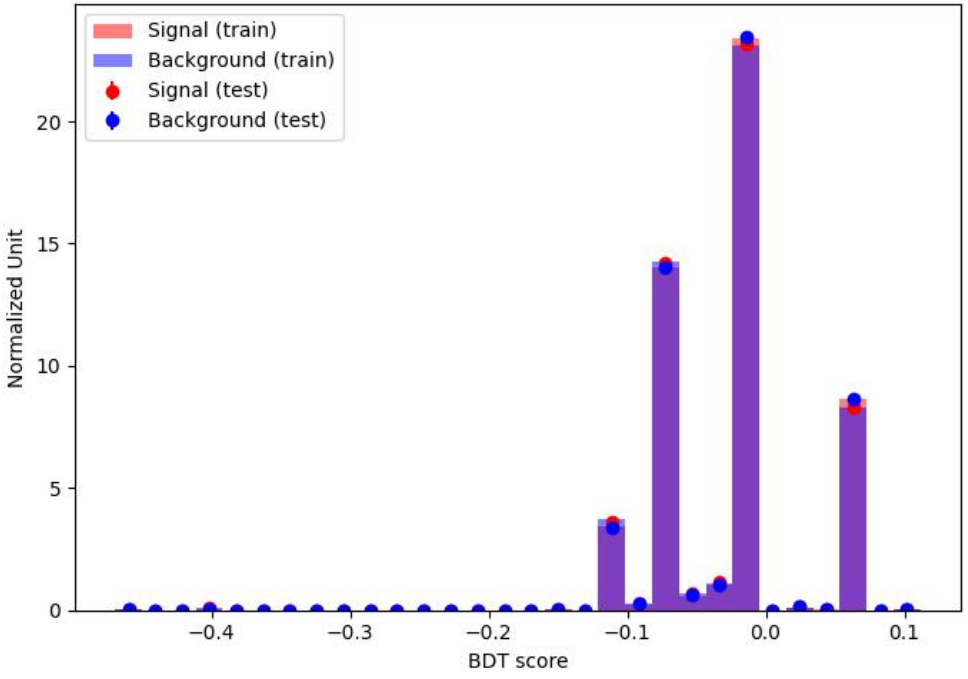
BDT analysis for HZZ channel(2)

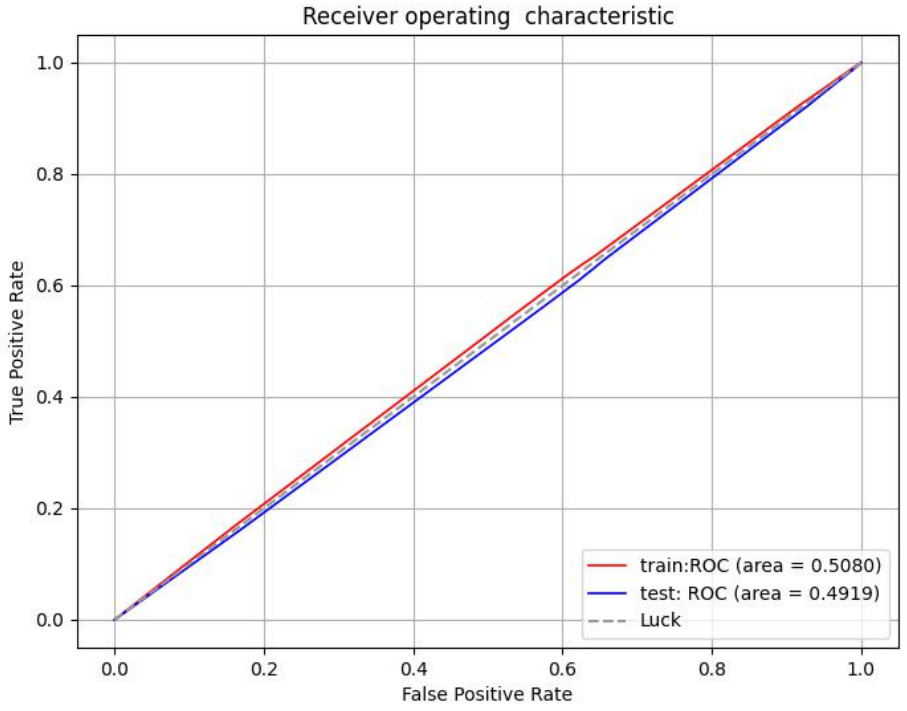
- 8 parameters: four Lorentz vectors for Higgs and Z

```
Number of events:
signal:  1000  background:  1000
              precision    recall  f1-score   support

  background       0.68      0.70      0.69       501
      signal       0.69      0.67      0.68       499

    accuracy                           0.68      1000
   macro avg       0.68      0.68      0.68      1000
weighted avg       0.68      0.68      0.68      1000

Area under ROC curve: 0.7575
              precision    recall  f1-score   support

  background       0.51      0.52      0.52       499
      signal       0.51      0.50      0.51       501

    accuracy                           0.51      1000
   macro avg       0.51      0.51      0.51      1000
weighted avg       0.51      0.51      0.51      1000

Area under ROC curve: 0.5178
```

BDT analysis for HZZ channel(3)

- Channel ee->Z(->μμ)H(->ZZ)->6μ
- 100000 events, 50000 for training and 50000 for testing
- 16 parameters: four Lorentz vectors for Higgs->ZZ->4μ





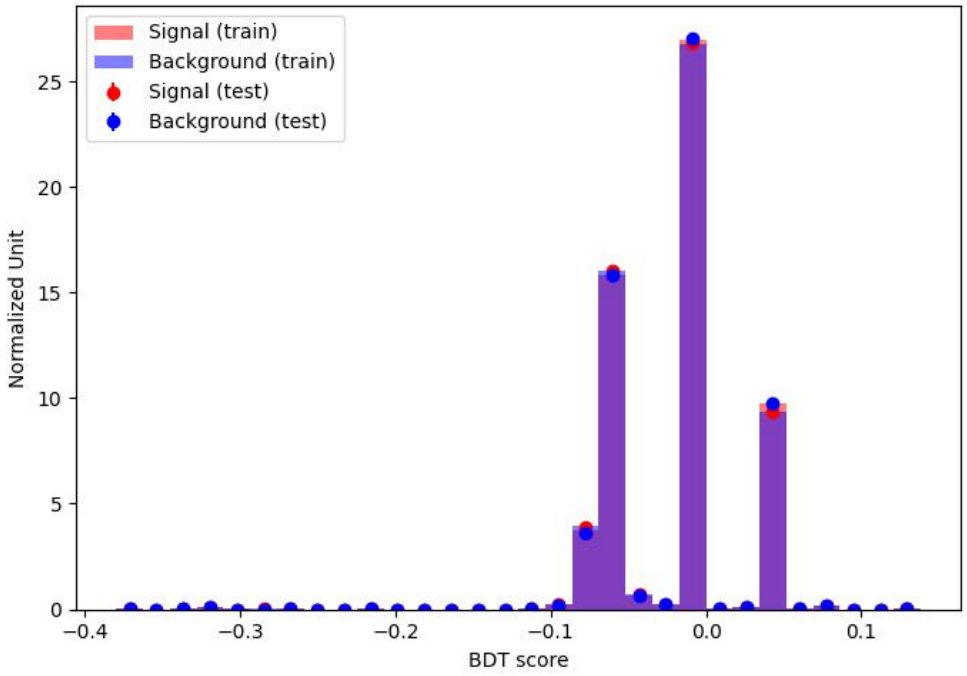
BDT analysis for HZZ channel(3)

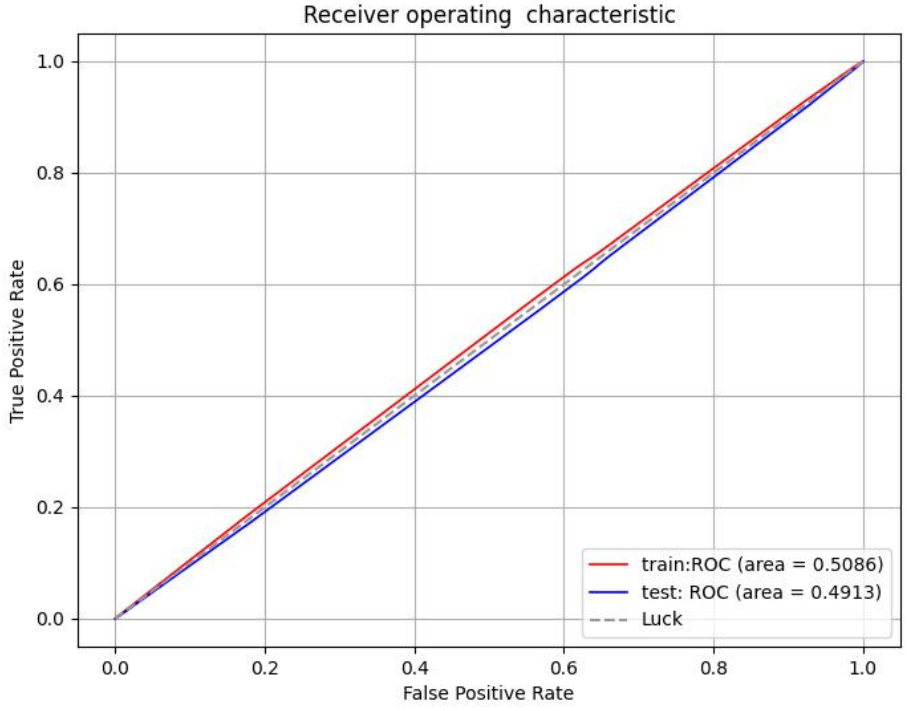
- **16 parameters: four Lorentz vectors for Higgs->ZZ->4μ**

```
Number of events:
signal:  100000  background:  100000
              precision    recall  f1-score   support

  background       0.50      0.84      0.63     50097
      signal       0.51      0.17      0.25     49903

    accuracy                           0.50    100000
   macro avg       0.51      0.50      0.44    100000
weighted avg       0.51      0.50      0.44    100000

Area under ROC curve: 0.5080
              precision    recall  f1-score   support

  background       0.50      0.83      0.62     49903
      signal       0.49      0.16      0.24     50097

    accuracy                           0.50    100000
   macro avg       0.49      0.50      0.43    100000
weighted avg       0.49      0.50      0.43    100000

Area under ROC curve: 0.4919
```

BDT analysis for HZZ channel(4)

- Channel ee->Z(->μμ)H(->ZZ)->6μ
- 100000 events, 50000 for training and 50000 for testing
- 24 parameters: four Lorentz vectors for 6μ





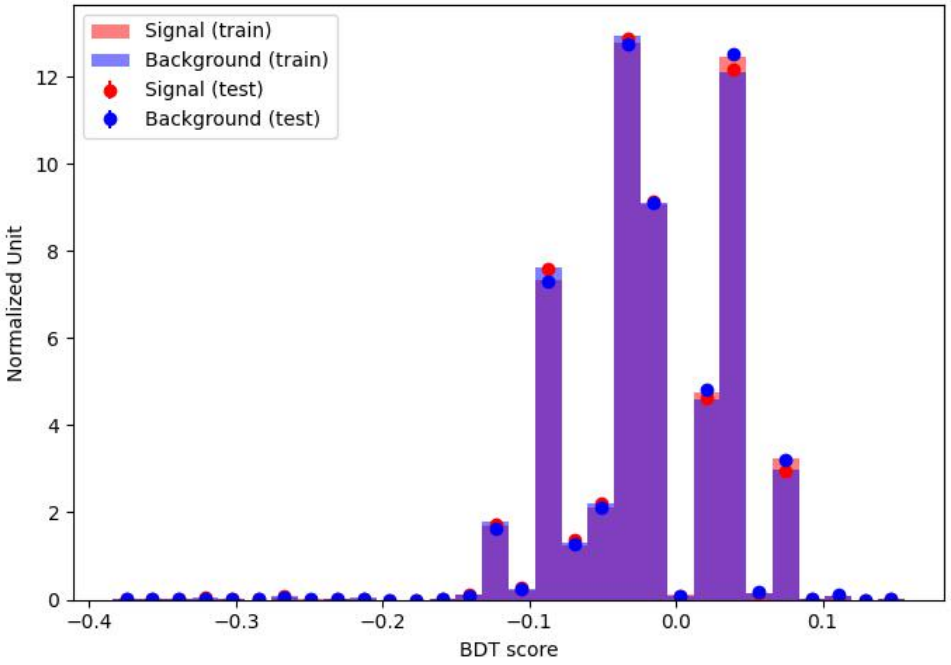
BDT analysis for HZZ channel(4)

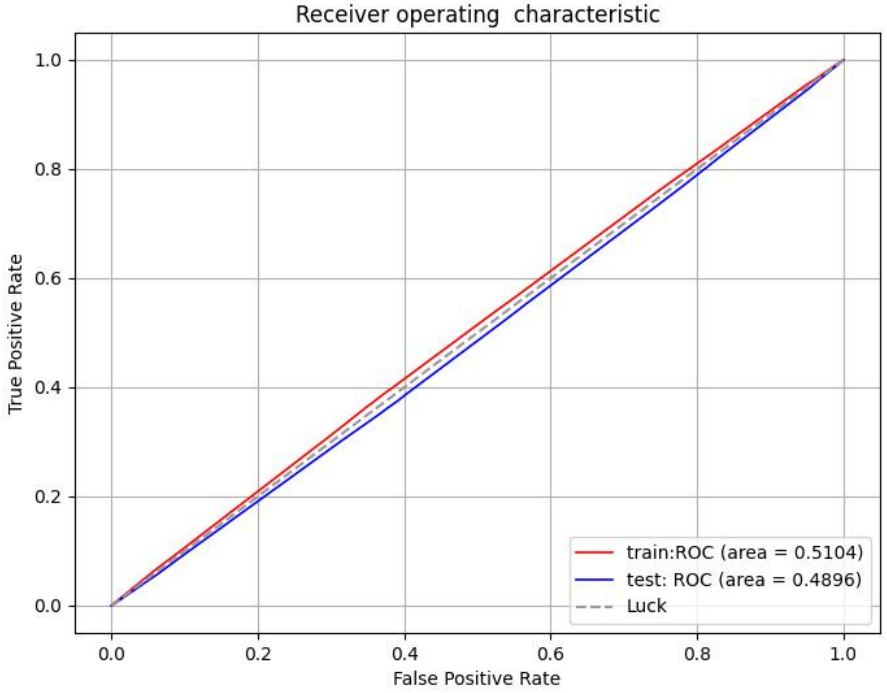
- 24 parameters: four Lorentz vectors for 6μ

```
Number of events:
signal:  100000  background:  100000
              precision    recall  f1-score   support

  background       0.50      0.83      0.63     50097
      signal       0.51      0.18      0.26     49903

    accuracy                           0.50    100000
   macro avg       0.51      0.50      0.44    100000
weighted avg       0.51      0.50      0.44    100000

Area under ROC curve: 0.5086
              precision    recall  f1-score   support

  background       0.50      0.82      0.62     49903
      signal       0.49      0.17      0.25     50097

    accuracy                           0.50    100000
   macro avg       0.49      0.50      0.43    100000
weighted avg       0.49      0.50      0.43    100000

Area under ROC curve: 0.4913
```

BDT analysis for HZZ channel(5)

- Channel ee->Z(->μμ)H(->ZZ)->6μ
- 100000 events, 50000 for training and 50000 for testing
- 32 parameters: four Lorentz vectors for eight particles (Z, Higgs, 6μ)





BDT analysis for HZZ channel(4)

- 32 parameters: four Lorentz vectors for eight particles (Z, Higgs, 6μ)

```
Number of events:
signal:  100000  background:  100000
              precision    recall  f1-score   support

  background       0.51      0.64      0.57     50097
      signal       0.51      0.37      0.43     49903

    accuracy                           0.51    100000
   macro avg       0.51      0.51      0.50    100000
weighted avg       0.51      0.51      0.50    100000

Area under ROC curve: 0.5104
              precision    recall  f1-score   support

  background       0.49      0.62      0.55     49903
      signal       0.49      0.36      0.42     50097

    accuracy                           0.49    100000
   macro avg       0.49      0.49      0.48    100000
weighted avg       0.49      0.49      0.48    100000

Area under ROC curve: 0.4896
```

Next to do

- Change the input variable from momentum (px,py,pz,E) to helicity angles (cos(theta), phi…).
- Check the angle distribution for HZZ and ZH
- Combine ee->ZH and H->ZZ(Yanxi Ke)