山东大学 SHANDONG UNIVERSITY

Department of Physics, Shandong University

Compressed EWK study(ISRC1N2)

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Outline

1. Hyperparameters optimization
2. Performance of Model

Task-list

- Machine learning for HH channel
  - ~~check more Variable and select significance var for ML(DONE)~~
  - ~~BDTG hyperparameters optimization/ Setup a Grid Search framework (DONE)~~

- Preliminary study on multibody quantum mechanics (In Progress)
  QFT Lecture (Peskin part I)

- BSc thesis: https://www.overleaf.com/project/674e7119837a2580151a0868

- CS61A (python): https://cs61a.vercel.app/index.html

Hyperparameters optimization

Input(HH-Channel):

Sample:

Sig: ISRC1N2(mass_C1 = 100GeV, mass_N2 = 70GeV)->12180 entries
Bkg: 513850 entries

All input data(C1N2_100_70 and Bkg) already passed pre-selection

Strategy:

method: BDTG
Separate sig(bkg) into five folders, one for test, the other three for train, and last one for validation set,then traverse all possibilities.

```
Number of training and testing events
-------------------------------------------------------
Signal     -- training events            : 7311
Signal     -- testing events             : 2436
Signal     -- training and testing events: 9747
Background -- training events            : 308329
Background -- testing events             : 102770
Background -- training and testing events: 411099
```

Pre-Selection

$$had\text{-}had\ \ channel: nTaus \geq 2, nLeps = 0$$
$$pass\ MET\ trigger;\ MET \geq 200$$
$$1 \leq nBaseJet \leq 8$$
$$b - Veto$$
$$OS$$

Hyperparameters optimization

Variables:

Obj kinematics
- pt_lep
- pt_tau
- mt_tau
- e_lep(energy of tau2)

Angular correlations
- dPhit1x
- dRt1x
- dRtt
- dPhitt

Event kinematics
- Mll(Invariant Mass of tau1 and tau2)
- METsig
- MT2_50
- Mwh(Invariant Mass of tau1 and MET)
- Mwl(Invariant Mass of tau2 and MET)
- MCT(Transverse Mass Squared)
- Proj_j(Projection of pt jet on zeta)
- Proj_tt(Projection of tau1+tau2 on zeta)

- mt_quad_sum
- mt_sum
- frac_MET_tau1
- frac_MET_tau2
- frac_MET_sqrtHT_40
- frac_jet_tau1
- frac_jet_tau2
- frac_jet_tt

Note:

zeta is bisector direction of tau1 and tau2[PhyUtils::bisector(tau1, tau2)]

Hyperparameters optimization

Grid Search:

Ntrees: 200, 300, 400
Max Depth: 6, 8, 10, 12
MinNodeSize: 1%, 2%, 3%
Learning Rate: 0.01, 0.05, 0.1

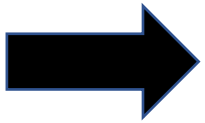
Binned significance: $Z = \sqrt{2((s_i + b_i)\log\left(1 + \frac{s_i}{b_i}\right) - s_i)}$

Show top Zn

	Model Name	Binned Significance	Max Zn	Max Zn Bin
137	100_8_3_005	12.1380	3.27179	48
128	100_6_1_01	12.9663	3.24539	49
15	100_12_3_005	12.1254	3.22901	48
85	100_10_3_005	12.1150	3.20722	48
105	200_10_1_01	13.1608	3.19603	50
104	100_8_1_01	12.8853	3.18398	50
63	200_6_1_005	12.7673	3.17520	49
2	200_6_1_01	12.9052	3.17138	50
38	100_6_2_01	12.8248	3.16297	49
131	300_8_2_01	13.1256	3.16255	50
93	300_6_1_005	12.9703	3.14200	50
73	100_6_1_005	12.4457	3.14142	48
69	400_6_1_01	12.9285	3.14074	50
54	200_8_3_01	12.8685	3.13397	50
12	200_6_2_005	12.7035	3.12582	49
33	100_6_2_005	12.2453	3.11746	48
66	400_6_1_005	12.9369	3.10400	50
45	100_10_3_01	12.7388	3.10074	49
7	100_12_3_01	12.6318	3.10071	49
48	400_12_2_01	12.9393	3.09236	50
72	400_12_2_005	12.9179	3.06882	50
62	300_6_1_01	12.8501	3.06869	50
133	400_10_1_01	12.9846	3.06413	50
91	100_6_3_01	12.6291	3.06320	49
9	400_8_3_01	12.9337	3.06226	50
58	300_10_3_005	12.8854	3.05992	49
36	300_10_1_01	12.9906	3.05755	50
89	100_10_2_01	12.8406	3.05210	49
43	200_8_2_01	13.2400	3.04952	50
19	400_6_2_005	12.8263	3.04206	50

Show top binned significance

	Model Name	Binned Significance	Max Zn	Max Zn Bin
43	200_8_2_01	13.2400	3.04952	50
105	200_10_1_01	13.1608	3.19603	50
131	300_8_2_01	13.1256	3.16255	50
122	200_10_2_01	13.0536	2.99067	50
47	400_10_1_005	13.0323	2.98703	50
90	200_12_3_01	13.0177	2.94662	50
10	400_8_2_01	12.9907	2.99914	50
36	300_10_1_01	12.9906	3.05755	50
133	400_10_1_01	12.9846	3.06413	50
93	300_6_1_005	12.9703	3.14200	50
128	100_6_1_01	12.9663	3.24539	49
65	400_12_3_01	12.9592	3.01186	50
130	400_10_3_01	12.9586	2.95314	50
51	400_10_2_005	12.9529	3.01081	50
138	300_12_2_01	12.9479	3.02381	50
48	400_12_2_01	12.9393	3.09236	50
66	400_6_1_005	12.9369	3.10400	50
9	400_8_3_01	12.9337	3.06226	50
59	300_10_1_005	12.9324	2.92715	50
135	400_12_1_005	12.9313	2.99309	50
69	400_6_1_01	12.9285	3.14074	50
24	400_10_2_01	12.9241	2.90401	50
72	400_12_2_005	12.9179	3.06882	50
120	300_10_2_01	12.9143	3.02559	50
123	400_8_2_005	12.9119	3.01028	50
2	200_6_1_01	12.9052	3.17138	50
71	200_8_1_005	12.8962	2.98534	50
40	400_10_3_005	12.8961	2.94119	50
103	300_12_3_01	12.8872	2.91552	50



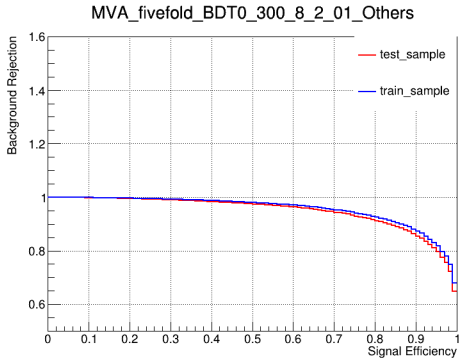
300_8_2_01
300_6_1_005

Performance of Model

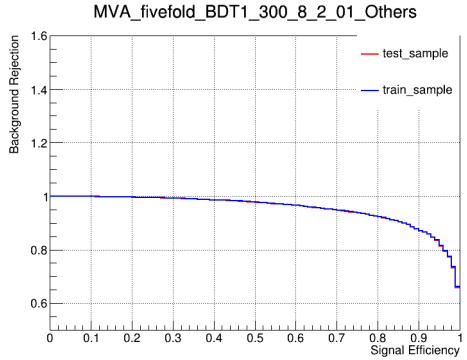
Model

hyper parameter: NTrees=300, learning rate=0.1, max depth=8, MinNodeSize=2%(default)

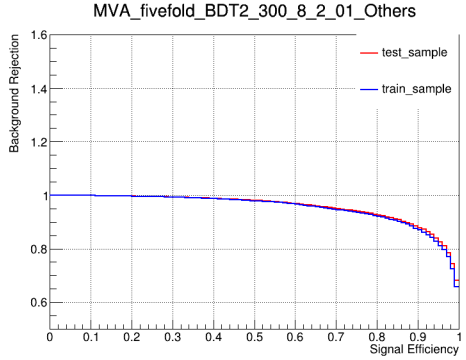
ROC Curve



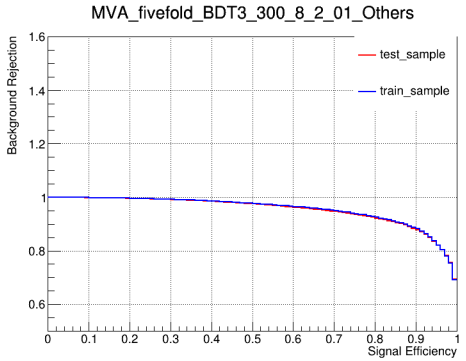
AUC: 0.949
sig eff from test(train)
@B = 0.01 0.308(0.363)
@B = 0.10 0.834(0.866)
@B = 0.30 0.988(0.992)



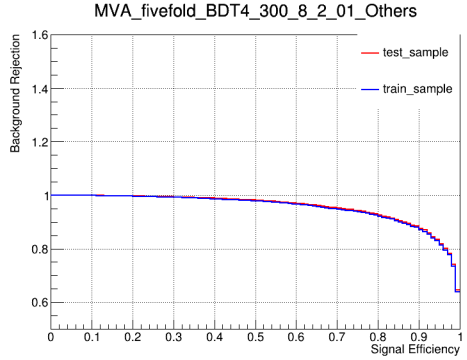
AUC: 0.954
sig eff from test(train)
@B = 0.01 0.345(0.350)
@B = 0.10 0.863(0.863)
@B = 0.30 0.989(0.990)



AUC: 0.957
sig eff from test(train)
@B = 0.01 0.366(0.350)
@B = 0.10 0.871(0.858)
@B = 0.30 0.992(0.989)



AUC: 0.954
sig eff from test(train)
@B = 0.01 0.321(0.343)
@B = 0.10 0.866(0.873)
@B = 0.30 0.994(0.994)



AUC: 0.956
sig eff from test(train)
@B = 0.01 0.382(0.341)
@B = 0.10 0.864(0.855)
@B = 0.30 0.989(0.989)

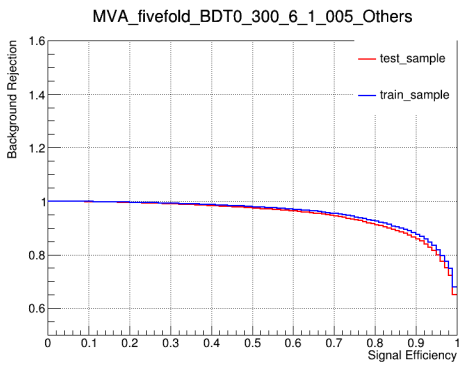
Conlusion: seems no overtraining in 300_8_2_01

Performance of Model

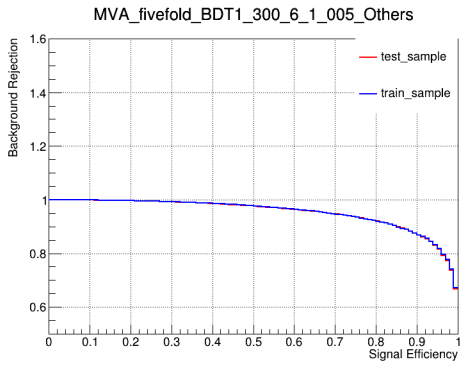
Model

hyper parameter: NTrees=300, learning rate=0.05, max depth=6, MinNodeSize=1%(default)

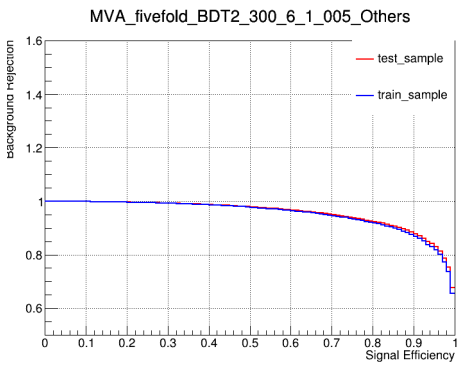
ROC Curve



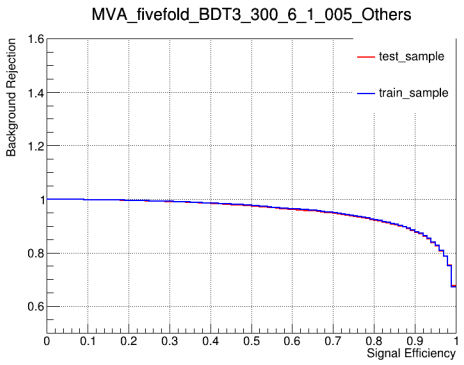
AUC: 0.949
sig eff from test(train)
@B = 0.01 0.305(0.349)
@B = 0.10 0.834(0.861)
@B = 0.30 0.988(0.992)



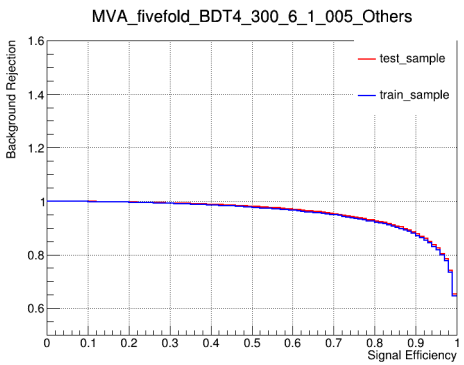
AUC: 0.953
sig eff from test(train)
@B = 0.01 0.341(0.343)
@B = 0.10 0.852(0.851)
@B = 0.30 0.990(0.991)



AUC: 0.956
sig eff from test(train)
@B = 0.01 0.358(0.349)
@B = 0.10 0.867(0.855)
@B = 0.30 0.992(0.990)



AUC: 0.954
sig eff from test(train)
@B = 0.01 0.321(0.339)
@B = 0.10 0.865(0.871)
@B = 0.30 0.992(0.992)



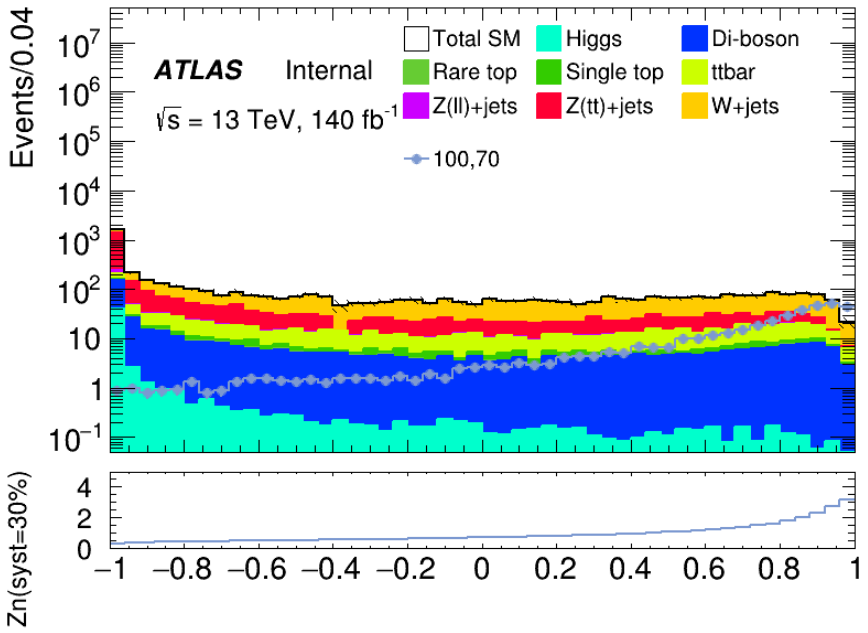
AUC: 0.957
sig eff from test(train)
@B = 0.01 0.376(0.337)
@B = 0.10 0.870(0.860)
@B = 0.30 0.990(0.989)

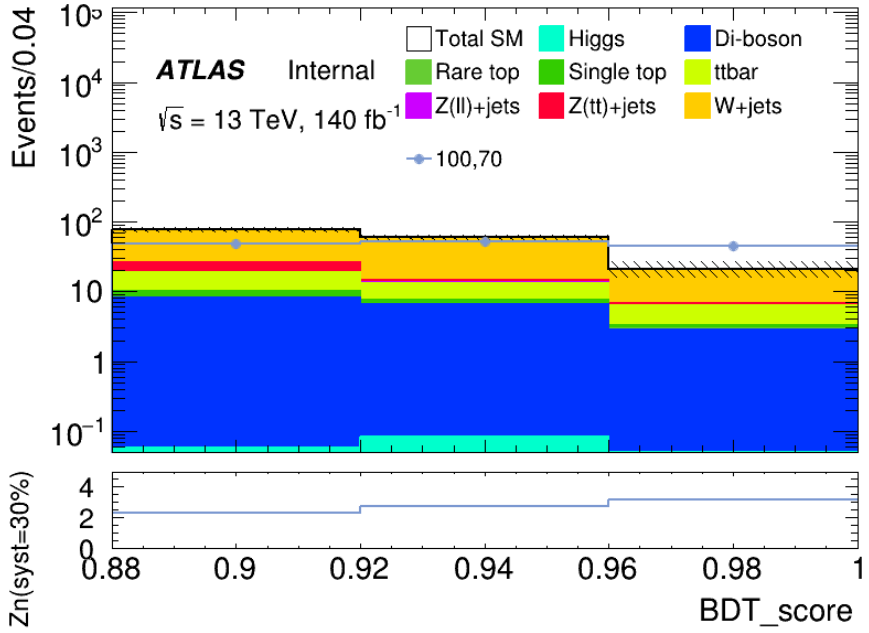
Conlusion: seems no overtraining in 300_6_1_005

Performance of Model

BDT distribution

300_8_2_01





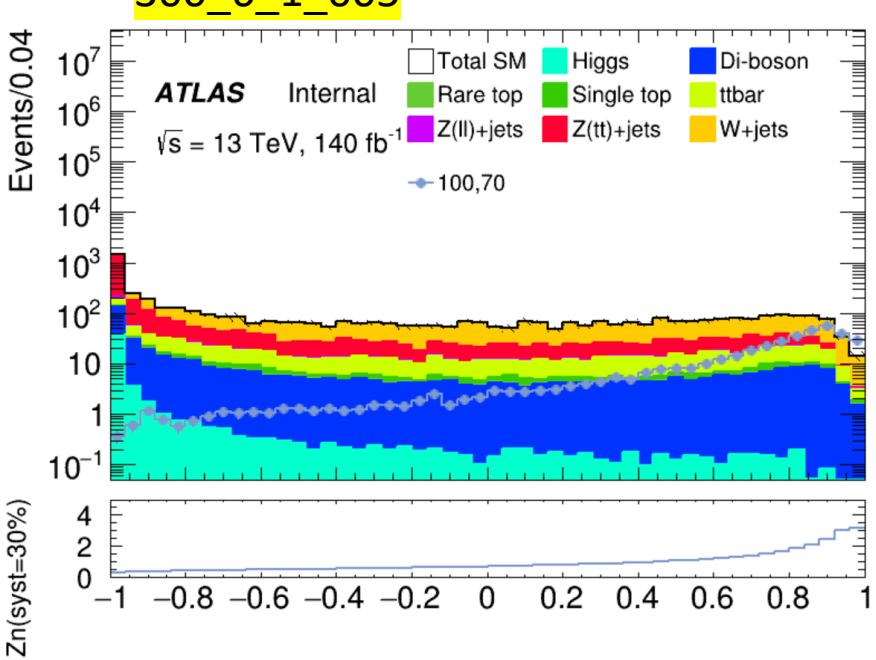
Apply BDT score cut > 0.88

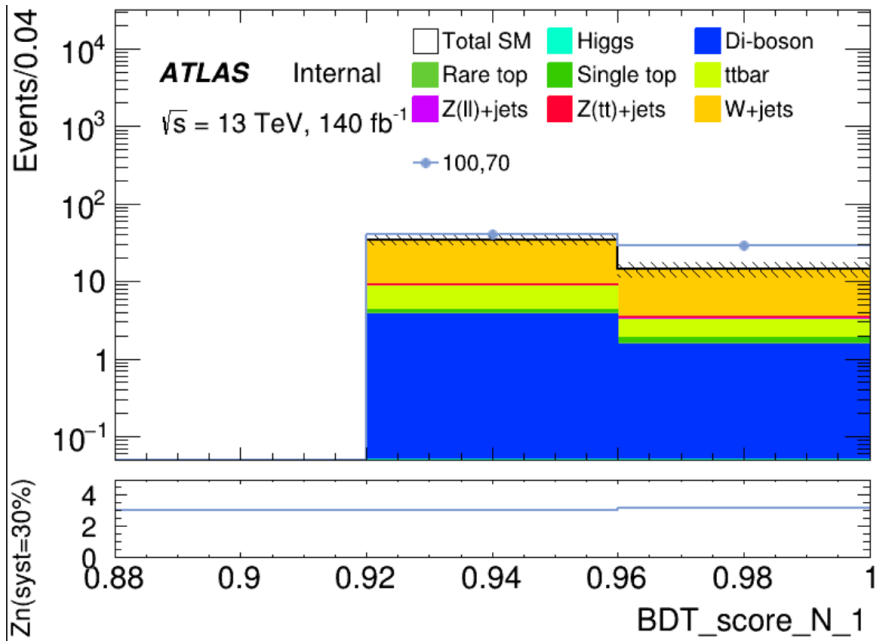
C1N2ISR (100,70)	bkg	Higgs	OtherTop	SingleTop	TopPair	VV	Wjets	Zlljets	Zttjets
145.4848+-2.3131	157.261+-14.7159	0.1491+-0.0407	0.1557+-0.0524	3.088+-0.6327	17.2339+-1.6324	17.4035+-0.6829	109.5969+-11.3263	0.4297+-0.1394	9.2042+-1.7708

Performance of Model

BDT distribution

300_6_1_005





Apply BDT score cut > 0.90

C1N2ISR (100,70)	bkg	Higgs	OtherTop	SingleTop	TopPair	VV	Wjets	Zlljets	Zttjets
69.3519 +- 1.6014	48.4064+- 5.9886	0.0353 +- 0.0168	0.0656 +- 0.0274	0.7116 +- 0.3145	5.4903 +- 0.9186	5.2399 +- 0.2973	35.7085 +- 5.8902	0.2026 +- 0.1229	0.9527 +- 0.1545

TODO

1. Optimize ML model and try other method
2. Completing the theoretical section of the my thesis