

Department of Physics, Shandong University

Compressed EWK study(ISRC1N2)

Chengxin Liao
liaocx@ihep.ac.cn

Wed, Jan 22, 2024



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-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

Show top binned significance

	Model Name	Binned Significance	Max Zn	Max Zn Bin		Model Name	Binned Significance	Max Zn	Max Zn Bin
137	100_8_3_005	12.1380	3.27179	48	43	200_8_2_01	13.2400	3.04952	50
128	100_6_1_01	12.9663	3.24539	49	105	200_10_1_01	13.1608	3.19603	50
15	100_12_3_005	12.1254	3.22901	48	131	300_8_2_01	13.1256	3.16255	50
85	100_10_3_005	12.1150	3.20722	48	122	200_10_2_01	13.0536	2.99067	50
105	200_10_1_01	13.1608	3.19603	50	47	400_10_1_005	13.0323	2.98703	50
104	100_8_1_01	12.8853	3.18398	50	90	200_12_3_01	13.0177	2.94662	50
63	200_6_1_005	12.7673	3.17520	49	10	400_8_2_01	12.9907	2.99914	50
2	200_6_1_01	12.9052	3.17138	50	36	300_10_1_01	12.9906	3.05755	50
38	100_6_2_01	12.8248	3.16297	49	133	400_10_1_01	12.9846	3.06413	50
131	300_8_2_01	13.1256	3.16255	50	93	300_6_1_005	12.9703	3.14200	50
93	300_6_1_005	12.9703	3.14200	50	128	100_6_1_01	12.9663	3.24539	49
73	100_6_1_005	12.4457	3.14142	48	65	400_12_3_01	12.9592	3.01186	50
69	400_6_1_01	12.9285	3.14074	50	130	400_10_3_01	12.9586	2.95314	50
54	200_8_3_01	12.8685	3.13397	50	51	400_10_2_005	12.9529	3.01081	50
12	200_6_2_005	12.7035	3.12582	49	138	300_12_2_01	12.9479	3.02381	50
33	100_6_2_005	12.2453	3.11746	48	48	400_12_2_01	12.9393	3.09236	50
66	400_6_1_005	12.9369	3.10400	50	66	400_6_1_005	12.9369	3.10400	50
45	100_10_3_01	12.7388	3.10074	49	9	400_8_3_01	12.9337	3.06226	50
7	100_12_3_01	12.6318	3.10071	49	59	300_10_1_005	12.9324	2.92715	50
48	400_12_2_01	12.9393	3.09236	50	135	400_12_1_005	12.9313	2.99309	50
72	400_12_2_005	12.9179	3.06882	50	69	400_6_1_01	12.9285	3.14074	50
62	300_6_1_01	12.8501	3.06869	50	24	400_10_2_01	12.9241	2.90401	50
133	400_10_1_01	12.9846	3.06413	50	72	400_12_2_005	12.9179	3.06882	50
91	100_6_3_01	12.6291	3.06320	49	120	300_10_2_01	12.9143	3.02559	50
9	400_8_3_01	12.9337	3.06226	50	123	400_8_2_005	12.9119	3.01028	50
58	300_10_3_005	12.8854	3.05992	49	2	200_6_1_01	12.9052	3.17138	50
36	300_10_1_01	12.9906	3.05755	50	71	200_8_1_005	12.8962	2.98534	50
89	100_10_2_01	12.8406	3.05210	49	40	400_10_3_005	12.8961	2.94119	50
43	200_8_2_01	13.2400	3.04952	50	103	300_12_3_01	12.8872	2.91552	50
19	400_6_2_005	12.8263	3.04206	50					



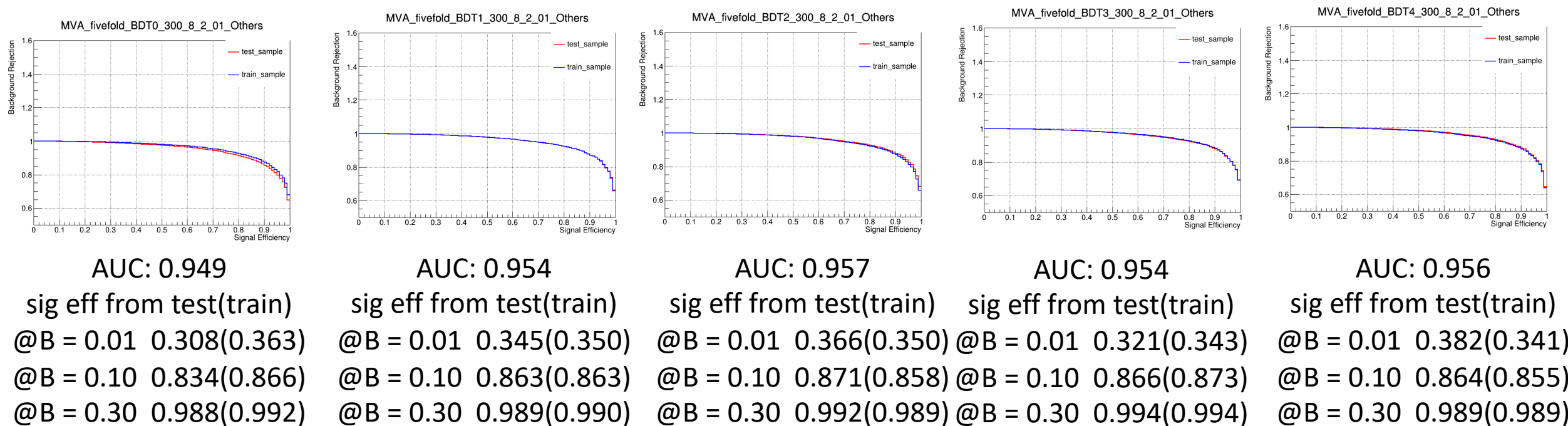
300_8_2_01
300_6_1_005

Performance of Model

Model

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

ROC Curve



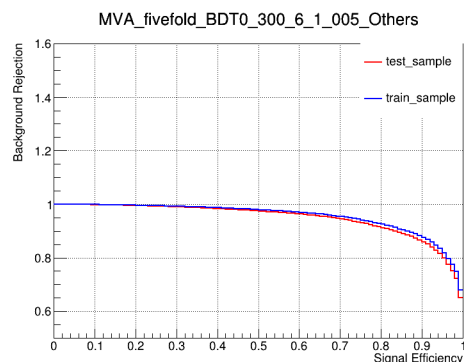
Conclusion: seems no overtraining in 300_8_2_01

Performance of Model

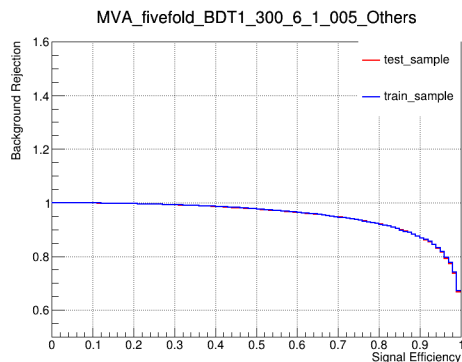
Model

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

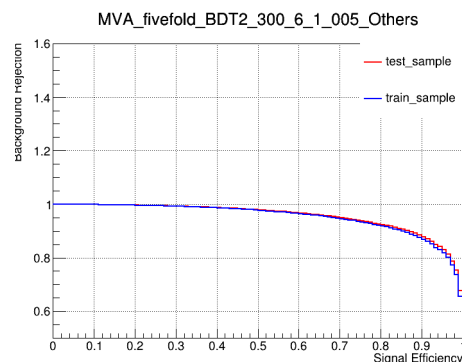
ROC Curve



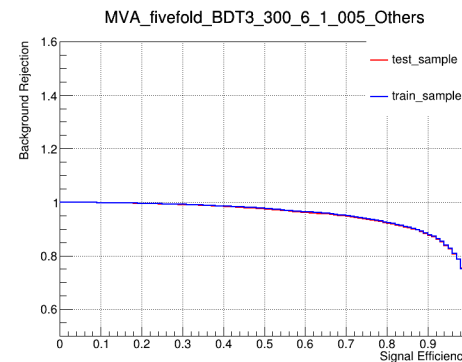
AUC: 0.949



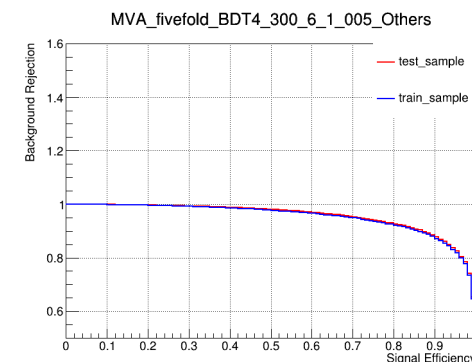
AUC: 0.953



AUC: 0.956



AUC: 0.954



AUC: 0.957

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)

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)

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)

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)

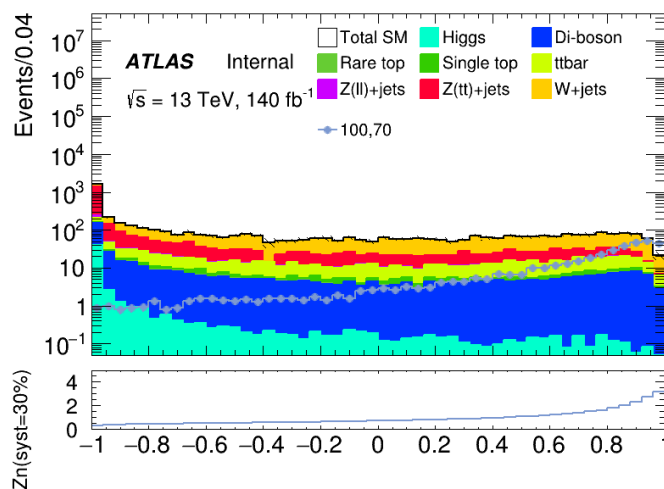
sig eff from test(train)
@B = 0.01 0.376(0.337)
@B = 0.10 0.870(0.860)
@B = 0.30 0.990(0.989)

Conclusion: seems no overtraining in 300_6_1_005

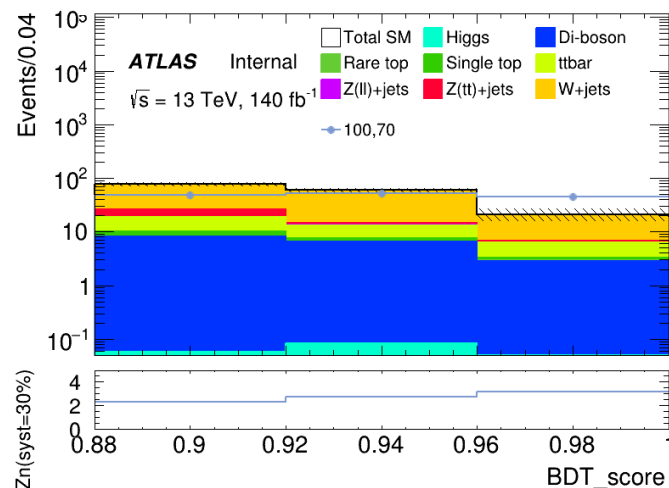
Performance of Model

BDT distribution

300_8_2_01



Apply BDT score cut > 0.88



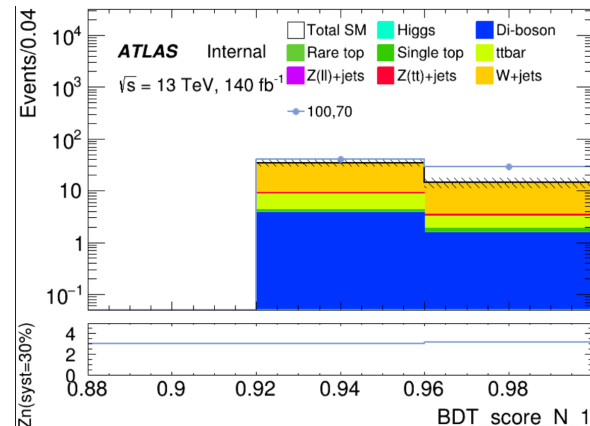
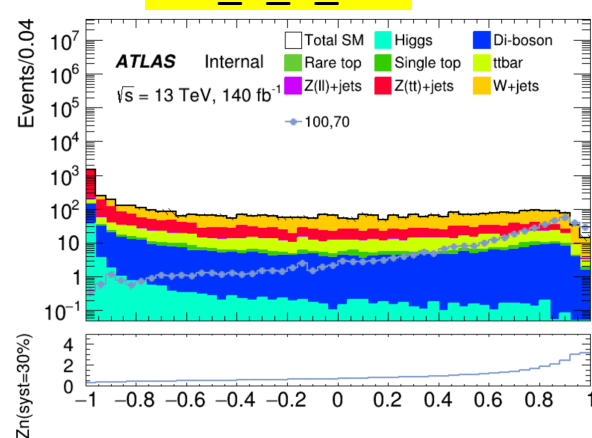
bin	max Zn	C1N2ISR (100,70)	bkg	Higgs	OtherTop	SingleTop	TopPair	VV	Wjets	Zlljets	Zttjets
48	2.31643	47.944+- 1.326	76.74+- 11.617(15%)	0.057+- 0.017	0.069+- 0.035	1.816+- 0.518	8.389+- 1.142	8.144+- 0.547	50.716+- 7.999	0.180+- 0.055	7.371+- 0.929
49	2.75157	52.649+- 1.922	59.26+- 8.262(14%)	0.083+- 0.040	0.028+- 0.045	0.883+- 0.591	5.847+- 1.486	6.432+- 0.646	44.437+- 9.834	0.116+- 0.084	1.430+- 1.767
50	3.16255	44.891+- 2.313	21.25+- 5.661(26%)	0.008+- 0.040	0.057+- 0.052	0.388+- 0.632	2.996+- 1.632	2.826+- 0.682	14.443+- 11.326	0.132+- 0.139	0.402+- 1.770

Performance of Model

BDT distribution

300_6_1_005

Apply BDT score cut > 0.90



bin	max Zn	C1N2ISR (100,70)	bkg	Higgs	OtherTop	SingleTop	TopPair	VV	Wjets	Zlljets	Zttjets
49	2.9951	40.056+- 1.219	34.064+- 5.980 (17%)	0.035+- 0.017	0.014+- 0.018	0.406+- 0.228	4.206+- 0.797	3.740+- 0.251	24.850+- 5.017	0.075+- 0.054	0.740+- 0.135
50	3.142	29.295+- 1.601	14.341+- 3.133(21%)	0.001+- 0.017	0.051+- 0.027	0.306+- 0.314	1.284+- 0.919	1.500+- 0.297	10.859+- 5.890	0.128+- 0.123	0.213+- 0.155

TODO

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