山东大学 SHANDONG UNIVERSITY

Department of Physics, Shandong University

Compressed EWK study(ISRC1N2)

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Apr, Wed 30, 2025

Tasklist

- FF method var distribution check
- Multiclass result(failed)
- BSc thesis: https://www.overleaf.com/project/674e7119837a2580151a0868 (need to submit before the end of Apr)

Introduction

Reference point: C1 mass = 100GeV, N2 mass = 70 GeV

SR optimization: BDT method, optuna to auto-optimize hps

For FF method constriant

HH Pre-Selection

Had-Had channel: nBaseTau=2; nMediumTau=2; nLeps=0
MET >= 200, MET trigger
Opposite-sign hadronic tau pair
bVeto
Mtt_reco < 40GeV && Mtt_reco > 130GeV
nBaseJet >= 1
Jet pt > 100GeV

HH Pre-Selection

Had-Had channel: nBaseTau=1; nMediumTau=1; nLeps>=1
MET >= 200, MET trigger
Opposite-sign hadronic tau pair
bVeto
Mtl_reco < 40GeV && Mtl_reco > 130GeV
nBaseJet >= 1
Jet pt > 100GeV

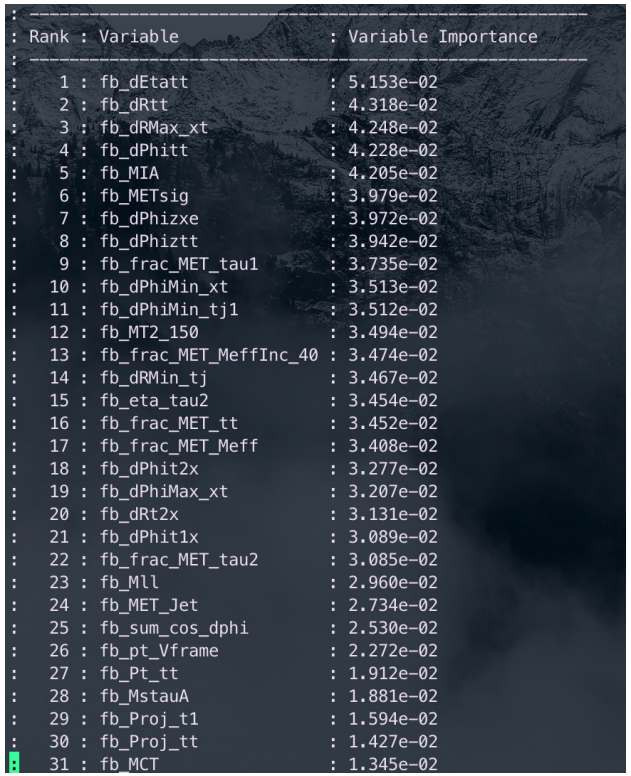
Binary class(HH)

Hyperparameters: Ntrees = 200, MaxDepth = 6, MinNodeSize = 2%, Learning rate = 0.03(initial setting)

Feature engineering:

Select a simple model and put all features into model, choose Top 30 vars based on importance list, drop high correlated vars

Final feature list:



Rank	Variable	Variable Importance
1	fb_dEtatt	5.153e-02
2	fb_dRtt	4.318e-02
3	fb_dRMax_xt	4.248e-02
4	fb_dPhitt	4.228e-02
5	fb_MIA	4.205e-02
6	fb_METsig	3.979e-02
7	fb_dPhizxe	3.972e-02
8	fb_dPhiztt	3.942e-02
9	fb_frac_MET_tau1	3.735e-02
10	fb_dPhiMin_xt	3.513e-02
11	fb_dPhiMin_tj1	3.512e-02
12	fb_MT2_150	3.494e-02
13	fb_frac_MET_MeffInc_40	3.474e-02
14	fb_dRMin_tj	3.467e-02
15	fb_eta_tau2	3.454e-02
16	fb_frac_MET_tt	3.452e-02
17	fb_frac_MET_Meff	3.408e-02
18	fb_dPhit2x	3.277e-02
19	fb_dPhiMax_xt	3.207e-02
20	fb_dRt2x	3.131e-02
21	fb_dPhit1x	3.089e-02
22	fb_frac_MET_tau2	3.085e-02
23	fb_Mll	2.960e-02
24	fb_MET_Jet	2.734e-02
25	fb_sum_cos_dphi	2.530e-02
26	fb_pt_Vframe	2.272e-02
27	fb_Pt_tt	1.912e-02
28	fb_MstauA	1.881e-02
29	fb_Proj_t1	1.594e-02
30	fb_Proj_tt	1.427e-02
31	fb_MCT	1.345e-02

Weight choose: no weight, abs(weight)

No weight have better performance
but abs(weight) fit our anaysis requirment

Split strategy: Separate entries by using mod 5, for Fake bkg, if separate follow sequence, all weighted entry will split into first fold

Binary class(HH)

Class: C1N2, bkg

Hyperparameter tune:
use optuna to auto-optimze

Test_auc = \sum{Test_auc_class}
Train_auc = \sum{Train_auc_class}

constraint:

average of AUC need to >= 0.6
penalty function: score = test_auc – 0.3*auc_gap (auc_gap = abs(train_auc- test_auc))
maximum(score)

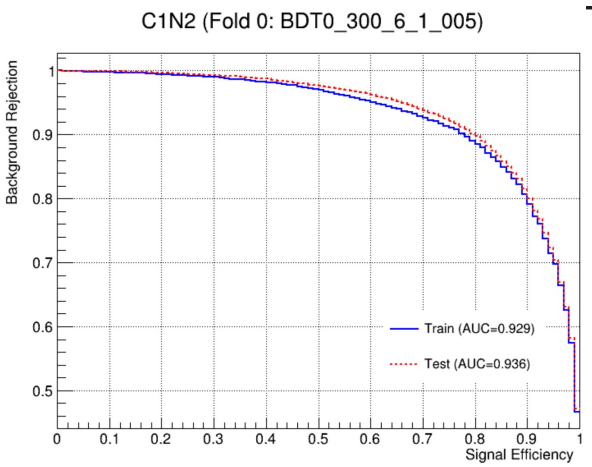
Grid Search
Ntrees: [200, 300, 400]
MaxDepth: [4, 6, 8, 10]
MinNode: [1, 3, 5, 7]
Learning rate: [0.001, 0.005, 0.01, 0.05, 0.1]

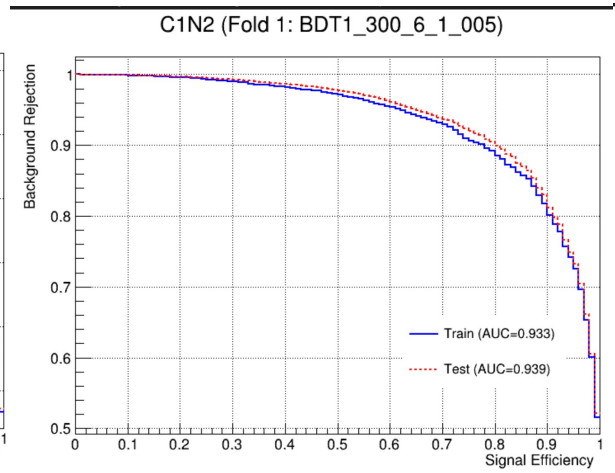
Best one: Ntree=300, MaxDepth=6, MinNode=1%, Learning Rate=0.05

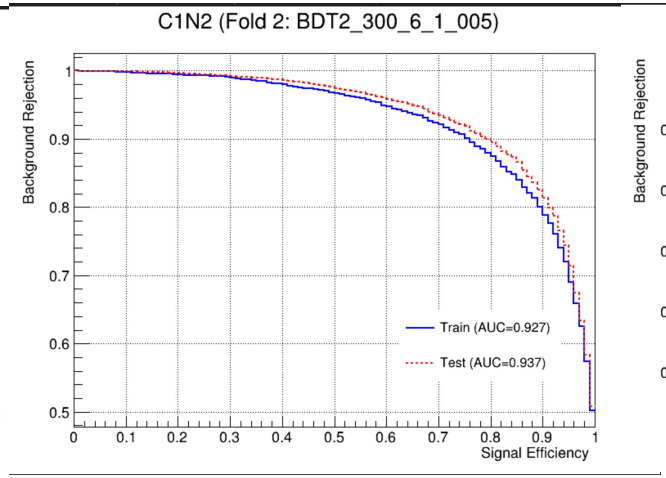
There still have rooms to optimize for lr

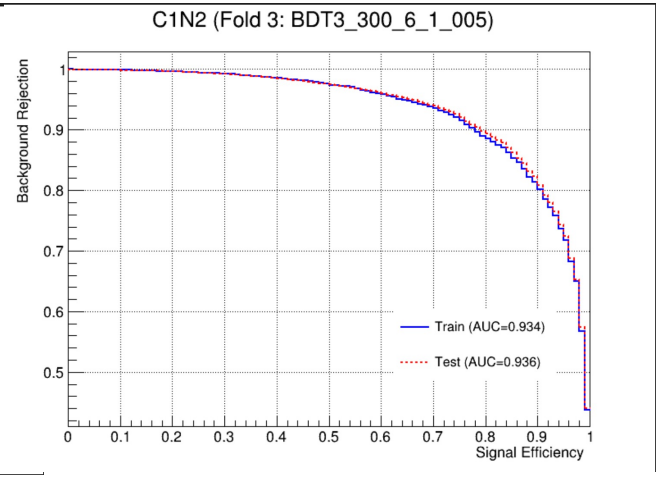
Binary class(HH)

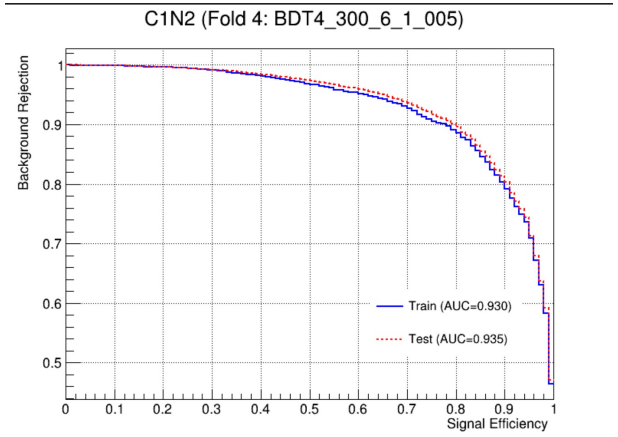
Overfit Check





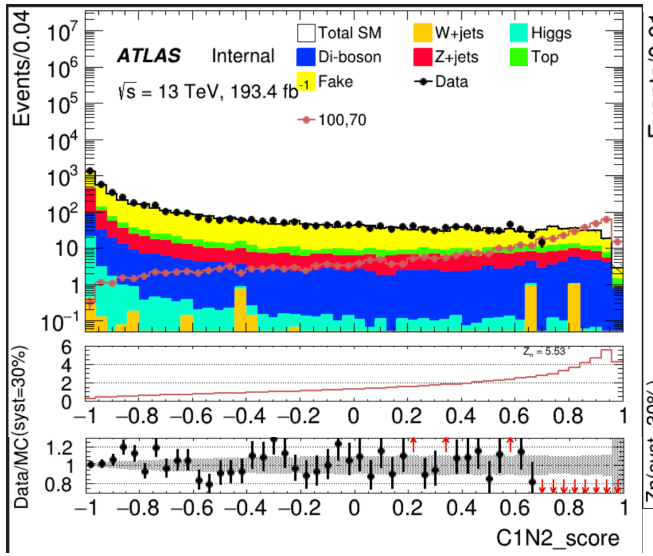




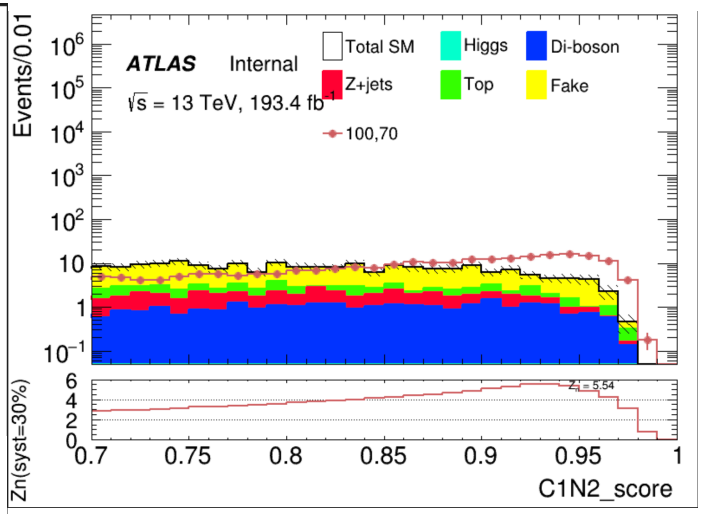


SR(HH) Binary

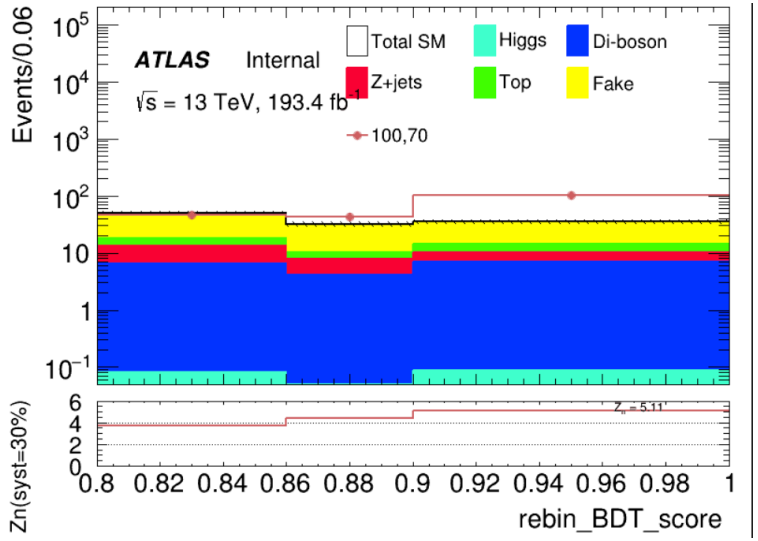
50 bins



Cut at 0.8



rebin



Sum Zn = 7.65

Bin Range	Zn	C1N2 (100_70) Yield ± Error	VV Yield ± Error	Top Yield ± Error	Fake Yield ± Error	Higgs Yield ± Error	Zjets Yield ± Error	Wjets Yield ± Error	Total Bkg Yield ± Error
[0.80,0.85]	3.65	46.569 ± 1.327	6.508 ± 0.368	4.719 ± 0.686	31.458 ± 3.898	0.080 ± 0.023	6.659 ± 0.416	0.978 ± 0.978	**50.402 ± 4.042**
[0.85,0.90]	4.37	43.128 ± 1.283	4.124 ± 0.341	2.663 ± 0.546	21.525 ± 3.292	0.045 ± 0.019	3.564 ± 0.286	0.000 ± 0.000	**31.921 ± 3.354**
[0.90,1.00]	5.11	101.059 ± 1.961	6.855 ± 0.398	4.331 ± 0.731	20.438 ± 2.976	0.086 ± 0.031	3.207 ± 0.250	0.000 ± 0.000	**34.917 ± 3.118**

Zjets(HH) Binary

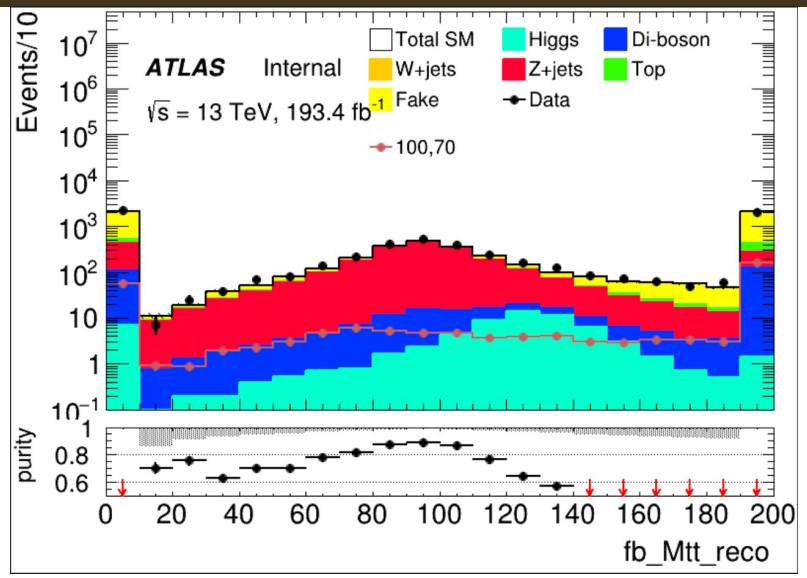
== 2 medium tau
== 0 lepton
METtrig && MET >= 200
OS
bVeto
nBaseJet >= 1
Jet pt > 100GeV

Same with pre-selection

C1N2 score <= 0.7(Othrogonal with SR)

CR: Mtt reco >= 80 && Mtt reco <= 110
VR: (Mtt reco >= 40 && Mtt reco < 80) || (Mtt reco > 110 && Mtt reco < 130)

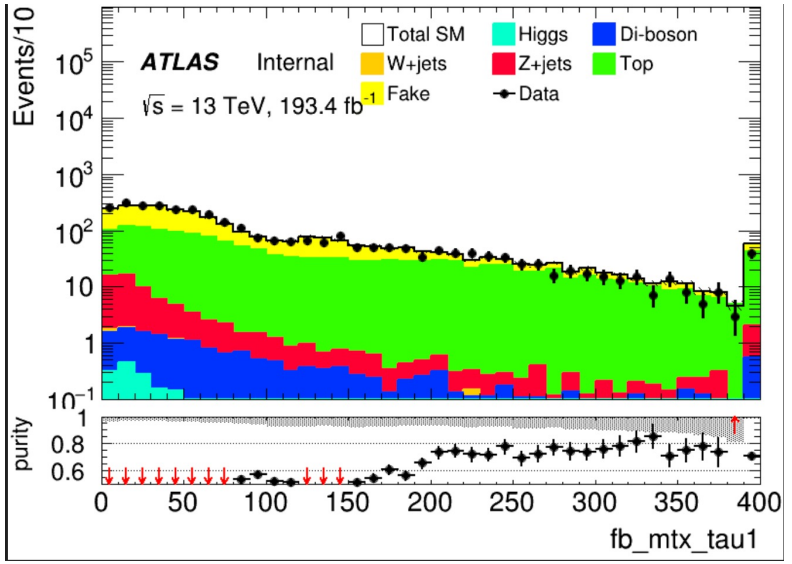
Region	TotalBkg	Zjets	purity	Data	Data/Bkg
CR	1420.2+-10.9304	1221.51+-5.434	0.860	1559	1.09
VR1	821.998+-9.435	673.277+-4.073	0.819	904	1.10
VR2	465.375+-7.800	320.194+-2.908	0.688	523	1.12



Top(HH) Binary

== 2 medium tau
== 0 lepton
METtrig && MET >= 200
OS
nBaseJet >= 1
Jet pt > 100GeV
Mtt_reco < 40GeV && Mtt_reco > 130GeV

Same with pre-selection



>= 1 bTag(improve top events)
C1N2 score <= 0.7(Othrogonal with SR)

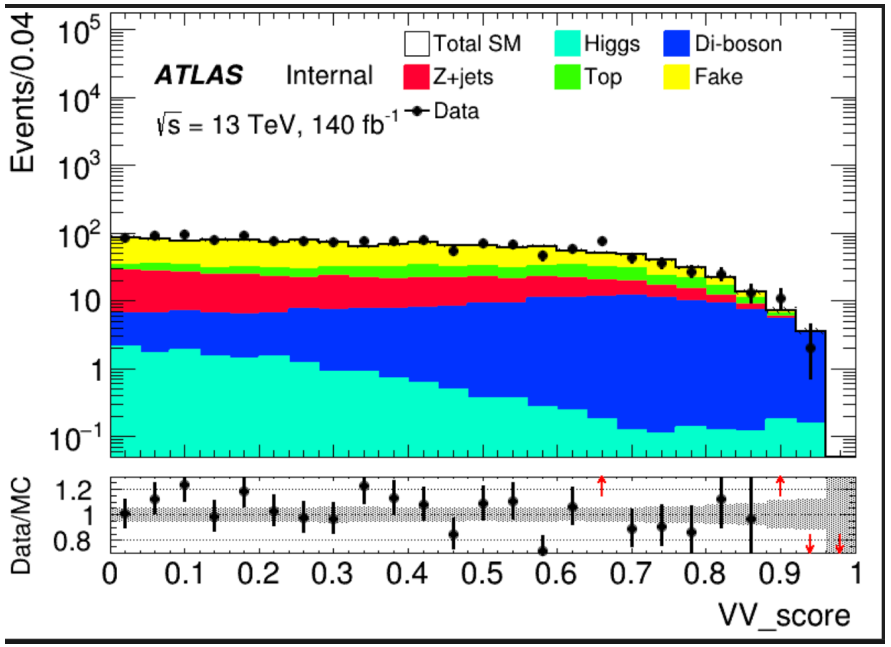
CR: $270 < M_T(\tau, MET) < 400$
VR: $230 < M_T(\tau, MET) < 270$

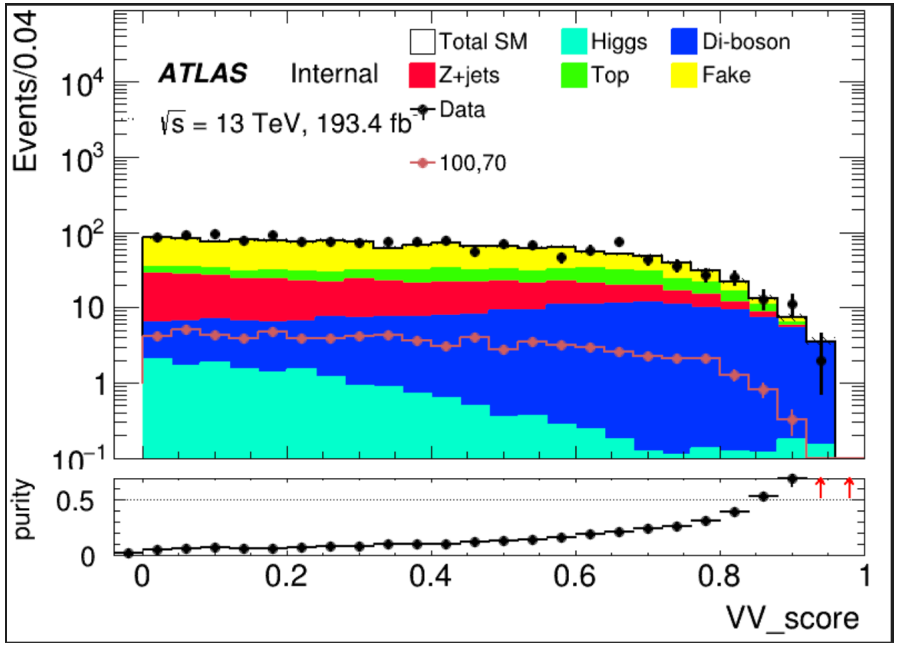
Huge overestimation

Region	TotalBkg	Top	purity	Data	Data/Bkg
CR	182.692+-5.738	140.981+-4.009	0.771	150	0.82
VR	140.228+-5.236	103.866+-3.445	0.740	134	0.94

VV(HH) Binary

Pre-selection && C1N2_score <= 0.7 && VV_score >= 0.80





Region	TotalBkg	VV	purity	Data	Data/Bkg
VR	46.6004+-2.77	24.193+-0.816	0.519	51	1.108

Binary class(LH)

Hyperparameters: Ntrees = 200, MaxDepth = 6, MinNodeSize = 2%, Learning rate = 0.03(initial setting)

Feature engineering:

Select a simple model and put all features into model, choose Top 30 vars based on importance list, drop high correlated vars

Final feature list:

Rank	Variable	Variable Importance
1	fb_frac_MET_tau2	8.270e-02
2	fb_dRtt	6.684e-02
3	fb_dPhitt	6.226e-02
4	fb_frac_MET_tt	5.197e-02
5	fb_frac_jet_tau2	5.179e-02
6	fb_MT2_50	5.077e-02
7	fb_dPhiMax_tj	4.779e-02
8	fb_dPhiMin_xj	4.343e-02
9	fb_mt_taumin	3.547e-02
10	fb_Mll	3.511e-02
11	fb_mtx_tau1	3.408e-02
12	fb_nBaseJet	3.146e-02
13	fb_frac_jet_tt	3.110e-02
14	fb_mtx_tau2	2.941e-02
15	fb_frac_MET_tau1	2.898e-02
16	fb_METsig	2.824e-02
17	fb_pt_Vframe	2.726e-02
18	fb_Mwh	2.684e-02
19	fb_Proj_j	2.678e-02
20	fb_frac_MET_sqrtHT_40	2.560e-02
21	fb_frac_jet_tau1	2.518e-02
22	fb_MCT	2.254e-02
23	fb_Mwl	2.185e-02
24	fb_mt_quad_sum	2.165e-02
25	fb_Proj_tt	2.038e-02
26	fb_ht_tau	1.992e-02
27	fb_e_tau2	1.819e-02
28	fb_mt_sum_ttj	1.624e-02
29	fb_mt_tau2	1.618e-02

Weight choose: no weight, abs(weight)

No weight have better performance
but abs(weight) fit our anaysis requirment

Split strategy: Separate entries by using mod 5, for Fake bkg, if separate follow sequence, all weighted entry will split into first fold

Binary class(LH)

Class: C1N2, bkg

Hyperparameter tune:
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Test_auc = \sum{Test_auc_class}
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constraint:

average of AUC need to >= 0.6
penalty function: score = test_auc – 0.3*auc_gap (auc_gap = abs(train_auc- test_auc))
maximum(score)

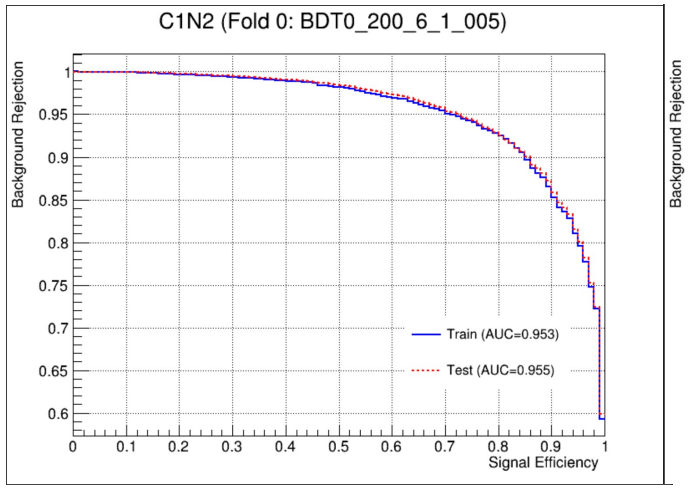
Grid Search
Ntrees: [200, 300, 400]
MaxDepth: [4, 6, 8, 10]
MinNode: [1, 3, 5, 7]
Learning rate: [0.001, 0.005, 0.01, 0.05, 0.1]

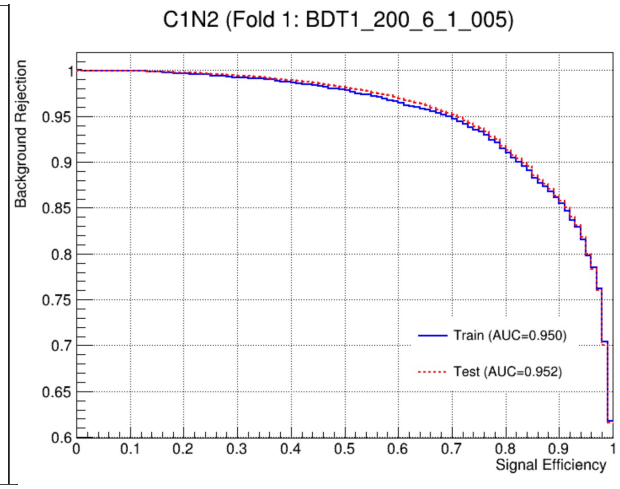
Best one: Ntree=200, MaxDepth=8, MinNode=1%, Learning Rate=0.05

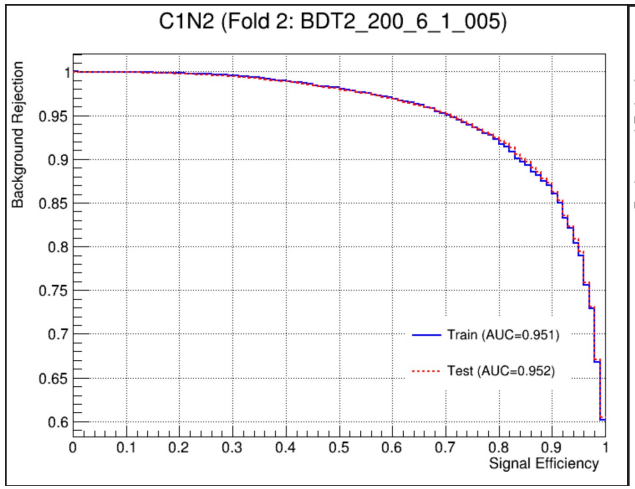
There still have rooms to optimize for lr

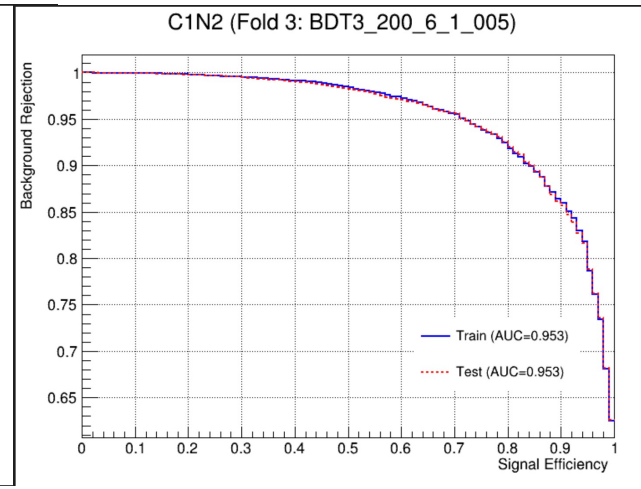
Binary class(LH)

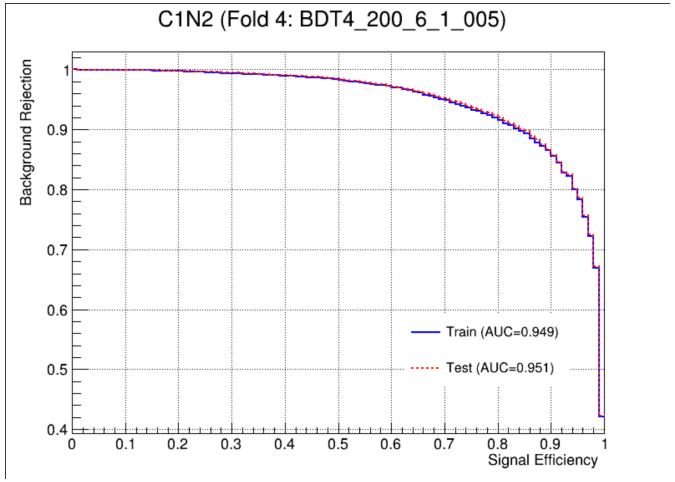
Overfit Check





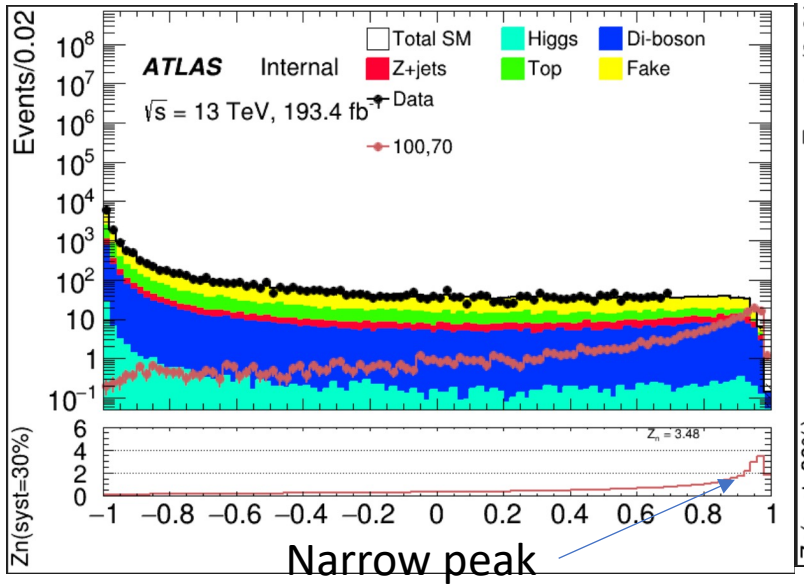






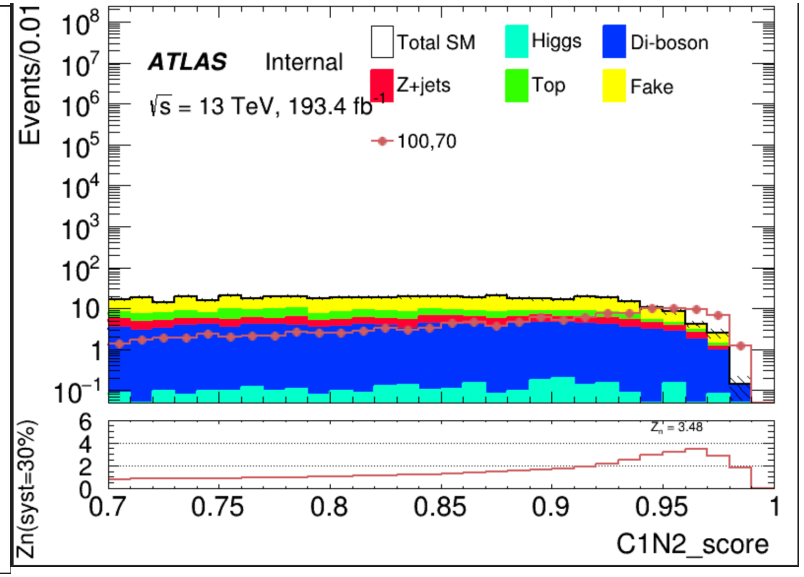
SR(LH) Binary

100 bins

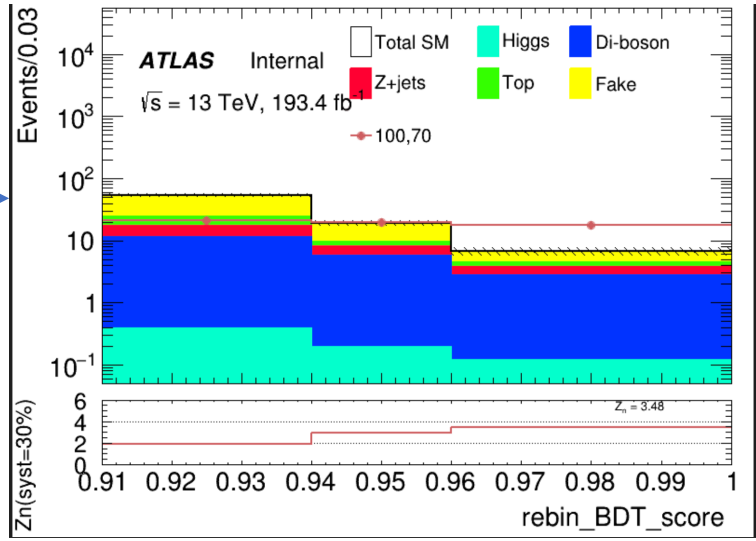


Narrow peak

Cut at 0.91



rebin



Sum Zn = 4.934

Bin Range	Zn	C1N2 (100_70) Yield ± Error	VV Yield ± Error	Top Yield ± Error	Fake Yield ± Error	Higgs Yield ± Error	Zjets Yield ± Error	Wjets Yield ± Error	Total Bkg Yield ± Error
[0.91,0.94]	1.90	21.447 ± 0.901	11.105 ± 0.565	7.432 ± 0.956	28.625 ± 3.295	0.376 ± 0.057	5.515 ± 0.357	0.173 ± 0.142	**53.226 ± 3.497**
[0.94,0.96]	2.94	19.678 ± 0.874	5.550 ± 0.367	1.524 ± 0.441	9.404 ± 1.929	0.189 ± 0.052	2.251 ± 0.222	0.000 ± 0.000	**18.918 ± 2.018**
[0.96,1.00]	3.47	17.543 ± 0.820	2.666 ± 0.263	0.578 ± 0.237	2.400 ± 1.009	0.118 ± 0.040	1.026 ± 0.118	0.000 ± 0.000	**6.788 ± 1.067**

Zjets(LH) Binary

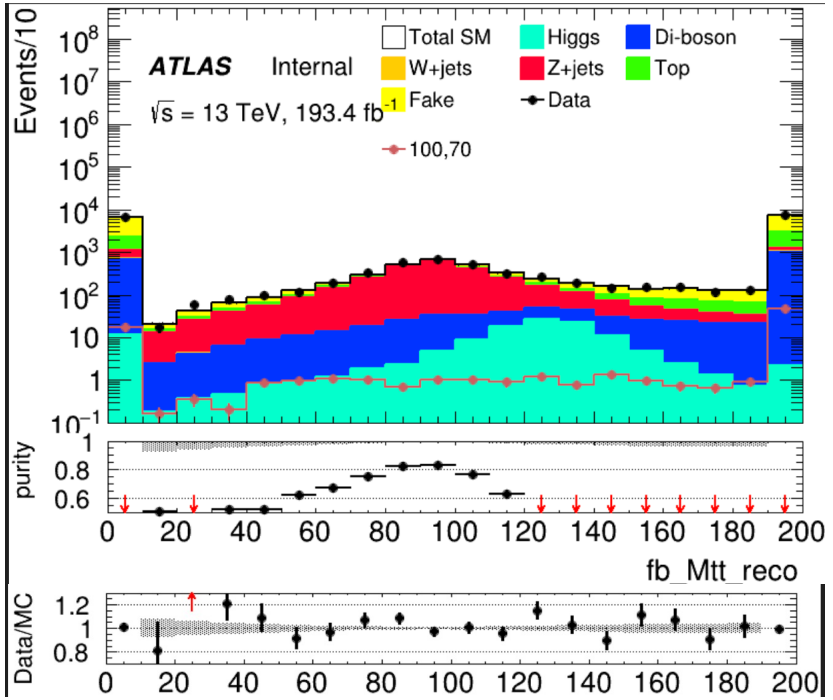
== 1 medium tau
>= 1 lepton
METtrig && MET >= 200
OS
bVeto
nBaseJet >= 1
Jet pt > 100GeV

Same with pre-selection

C1N2 score <= 0.7(Othrogonal with SR)

CR: Mlt reco >= 80 && Mlt reco <= 110
VR: (Mlt reco >= 40 && Mlt reco < 80) || (Mlt reco > 110 && Mlt reco < 130)

Region	TotalBkg	Zjets	purity	Data	Data/Bkg
CR	2048.51+-12.873	1600.7+-6.313	0.781	2064	1.0078
VR1	1238.27+-10.537	915.681+-4.726	0.739	1296	1.046
VR2	746.998+-9.369	385.547+-3.280	0.516	774	1.037

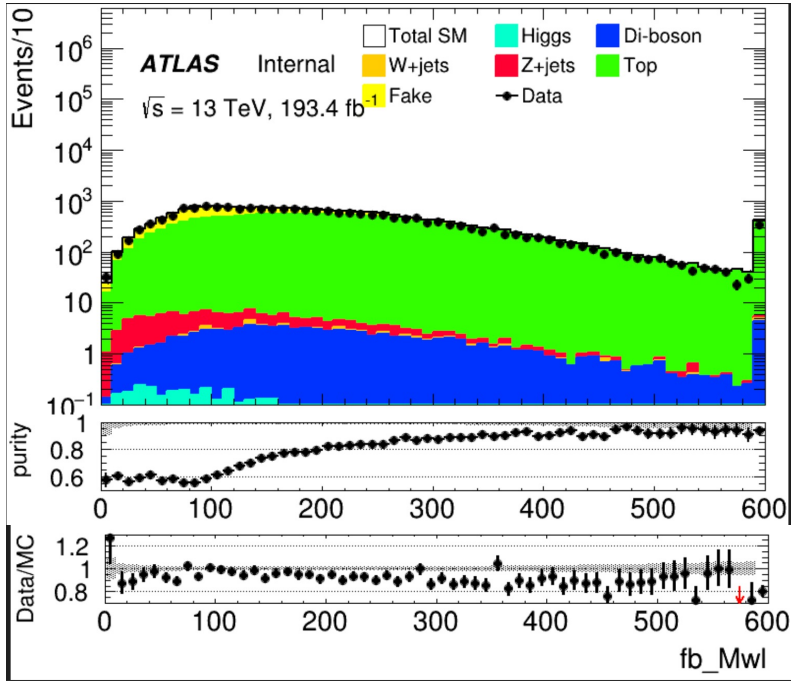


Top(LH) Binary

== 1 medium tau
>= 0 lepton
METtrig && MET >= 200
OS
nBaseJet >= 1
Jet pt > 100GeV
Mtt_reco < 40GeV && Mtt_reco > 130GeV

Same with pre-selection

>= 1 bTag(improve top events)
C1N2 score <= 0.7(Othrogonal with SR)



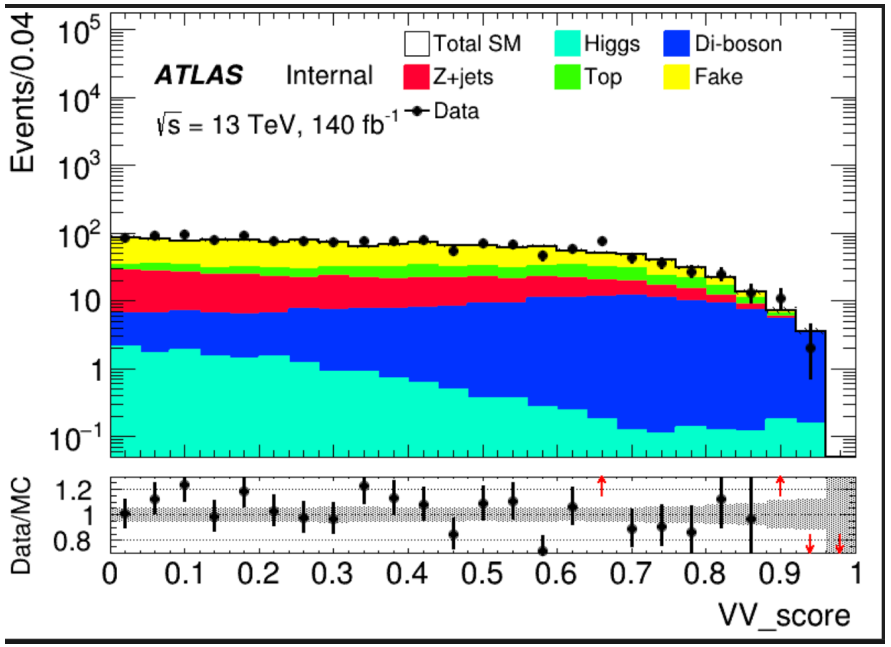
CR: $300 < M_{inv}(l, MET) < 550$
VR: $250 < M_{inv}(l, MET) < 300$

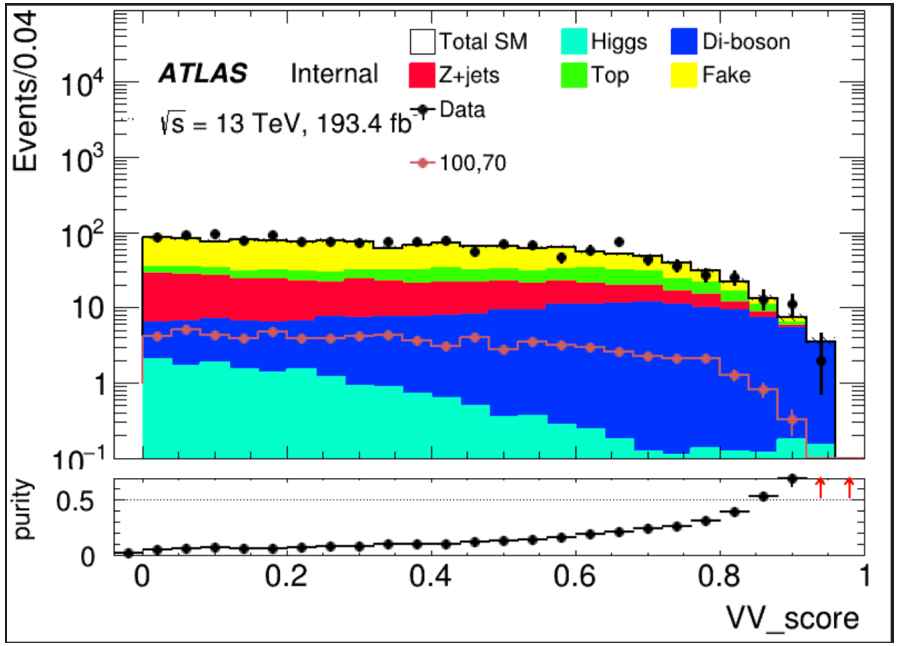
Huge overestimation

Region	TotalBkg	Top	purity	Data	Data/Bkg
CR	4657.04+-27.0028	4224.32+-21.804	0.907	4152	0.891
VR	2916.32+-22.0316	2532.7+-16.8751	0.868	2700	0.925

VV(LH) Binary

Pre-selection && C1N2_score <= 0.7 && VV_score >= 0.80





Region	TotalBkg	VV	purity	Data	Data/Bkg
VR	78.6819+-2.26	53.8201+-1.124	0.68402	72	0.92

Backup

Production issues

Task ID	Task name	N files total	N files done	N files failed	%	Status (JEDI)	Duration, days	Task logged status	Jobs failure, %	Top job errors, count [component:code] "sample message" [log example]
44282337	user.liaoc.542937.MGPy8EG_A14N23LO_C1N2ISR_100p0_0p0_2TFilt_run3.mc20d.r14860_p6284_stauhh_no_done_2/	11	0	0	0	exhausted	4.79	mc20_13TeV:mc20_...	0	-
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44281469	user.liaoc.542937.MGPy8EG_A14N23LO_C1N2ISR_100p0_0p0_2TFilt_run3.mc20d.r14860_p6284_stauhh_no_done_1/	11	0	0	0	exhausted	4.89	mc20_13TeV:mc20_...	0	-
44281451	user.liaoc.542971.MGPy8EG_A14N23LO_C1N2ISR_180p0_80p0_2TFilt_run3.mc20a.r13167_p6284_stauhh_no_done_1/	2	0	0	0	exhausted	4.89	mc20_13TeV:mc20_...	0	-

100_0_mc20d, 180_80_mc20a

Submit them twice but still failed

Bkg decay mode

Wjets: W->e/muon + nu
W->tau+nu(can contribute true tau_had)
jet misidentified to a fake tau

Zjets: Z->ll/tautau
jet misindentified to fake tau

Top: top->W+b, W can contribute a true tau_had
b-quark is a source of fake

VV: W/Z

LH channel: $\geq 1tau,\ \geq 1lep$
Wjets: W contribute lep, jets misidentified to fake
Zjets:
SingleTop: W contribute lep, b-quark misidentified to fake
VV:

HH channel: $\geq 2tau,\ == 0lep$
Wjets: W contribute tau_had, plus a fake tau
Zjets: Z->tautau(had) or 2 fake tau
SingleTop: W contribute a tau_had, plus a fake tau
VV:

Multiclass(HH)

Hyperparameters: Ntrees = 200, MaxDepth = 6, MinNodeSize = 2%, Learning rate = 0.03(initial setting)

Feature engineering:

Select a simple model and put all features into model, choose Top 30 vars based on importance list, drop high correlated vars

Final feature list:

Rank	Variable	Variable Importance
1	fb_dRtt	8.238e-02
2	fb_dRMax_xt	7.068e-02
3	fb_METsig	6.205e-02
4	fb_frac_MET_tt	6.050e-02
5	fb_dPhit1x	5.751e-02
6	fb_MIA	5.460e-02
7	fb_mt_taumin	5.411e-02
8	fb_Asy_tt	5.363e-02
9	fb_dEtat2j	4.903e-02
10	fb_MET_Soft	4.737e-02
11	fb_Asy_EH	4.625e-02
12	fb_Mll	4.447e-02
13	fb_frac_MET_MeffInc_40	4.317e-02
14	fb_eta_jet2	4.282e-02
15	fb_eta_jet1	4.229e-02
16	fb_transSphericity	4.140e-02
17	fb_dRMax_jets	4.086e-02
18	fb_frac_MET_Meff	4.007e-02
19	fb_m_jet1	3.421e-02
20	fb_nJets30	3.260e-02

Weight choose: no weight, abs(weight)

No weight have better performance
but abs(weight) fit our anaysis requirment

Split strategy: Separate entries by using mod 5, for Fake bkg, if separate follow sequence, all weighted entry will split into first fold

Multiclass(HH)

Class: C1N2, VV, Other_bkg

Test_auc = \sum{Test_auc_class}

Train_auc = \sum{Train_auc_class}

Hyperparameter tune:
use optuna to auto-optimze

constraint:

average of AUC need to >= 0.6

penalty function: score = test_auc – 0.3*auc_gap (auc_gap = abs(train_auc- test_auc))

maximum(score)

After check some models, find C1N2 result is great, so the constraint and AUC calculation only in VV and Other bkg

Grid Search
Ntrees: [200, 300, 400]
MaxDepth: [4, 6, 8, 10]
MinNode: [1, 3, 5, 7]
Learning rate: [0.001, 0.005, 0.01, 0.05, 0.1]

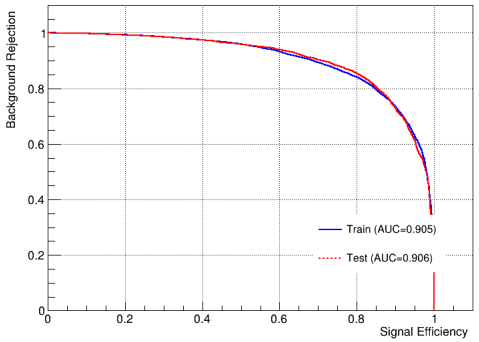
Best one: Ntree=300, MaxDepth=6, MinNode=1%, Learning Rate=0.05

There still have rooms to optimize for lr

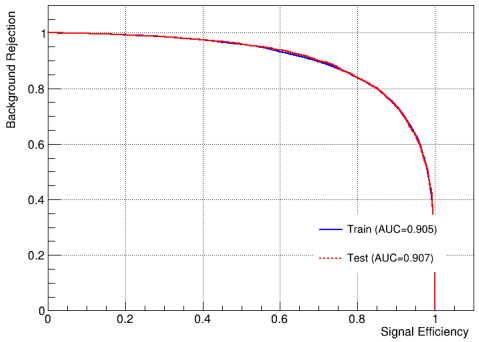
Multiclass(HH)

OverFit Check

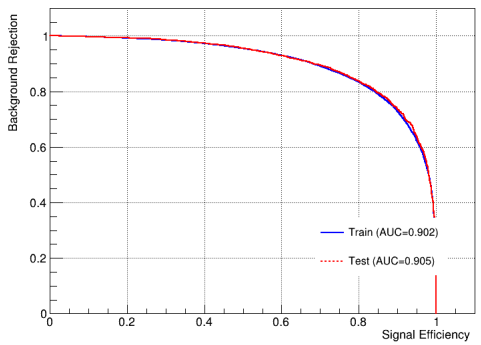
C1N2 (Fold 0: BDT0_300_6_1_005)



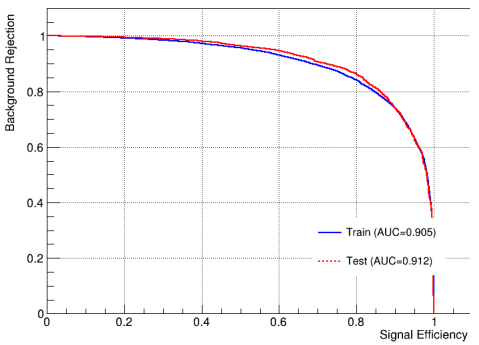
C1N2 (Fold 1: BDT1_300_6_1_005)



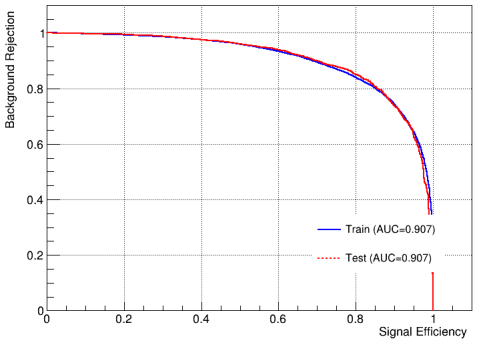
C1N2 (Fold 2: BDT2_300_6_1_005)



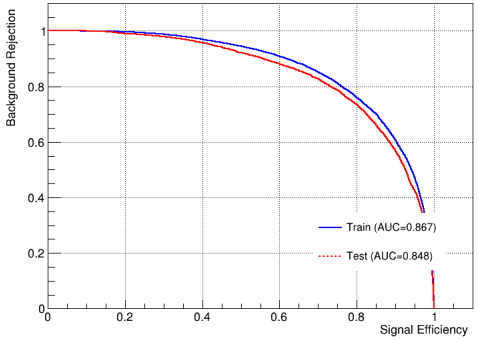
C1N2 (Fold 3: BDT3_300_6_1_005)



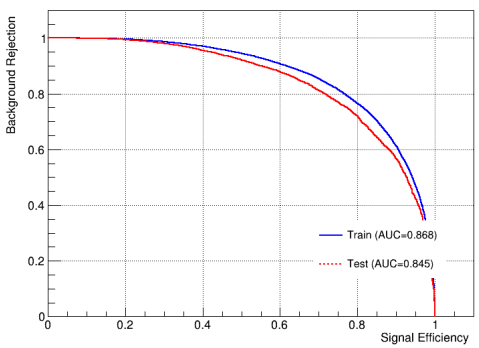
C1N2 (Fold 4: BDT4_300_6_1_005)



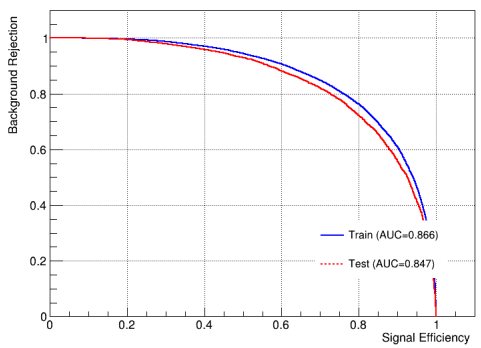
Other_bkg (Fold 0: BDT0_300_6_1_005)



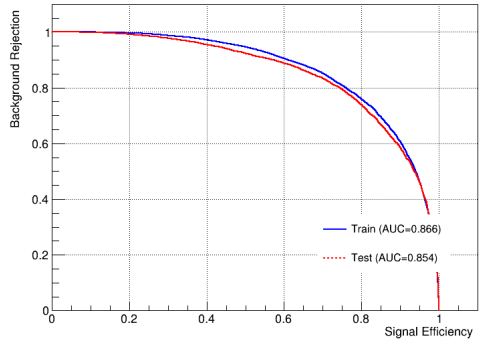
Other_bkg (Fold 1: BDT1_300_6_1_005)



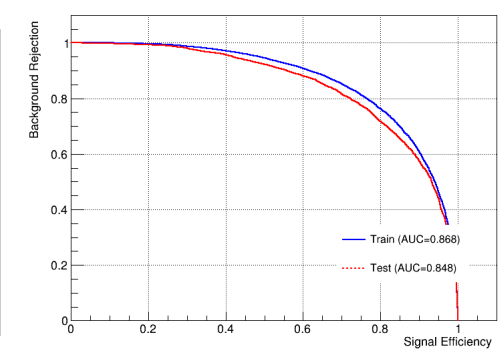
Other_bkg (Fold 2: BDT2_300_6_1_005)



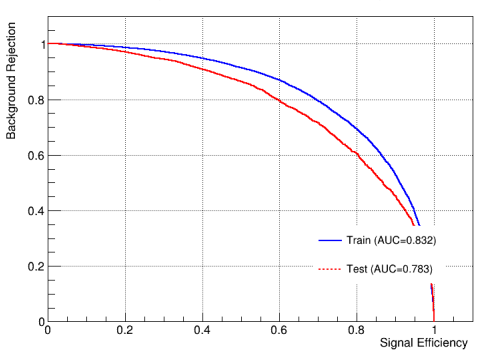
Other_bkg (Fold 3: BDT3_300_6_1_005)



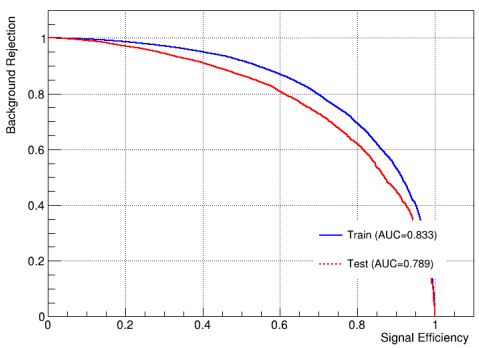
Other_bkg (Fold 4: BDT4_300_6_1_005)



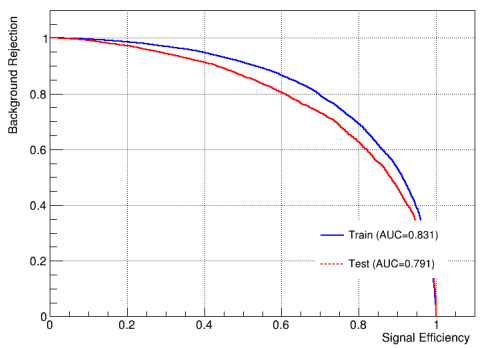
VV (Fold 0: BDT0_300_6_1_005)



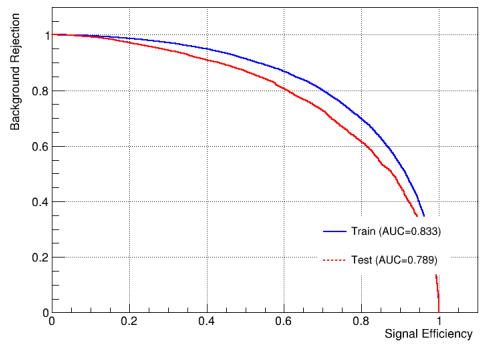
VV (Fold 1: BDT1_300_6_1_005)



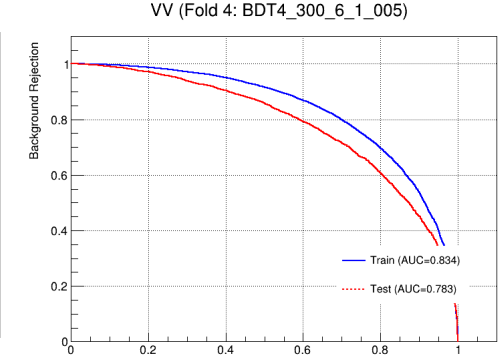
VV (Fold 2: BDT2_300_6_1_005)



VV (Fold 3: BDT3_300_6_1_005)

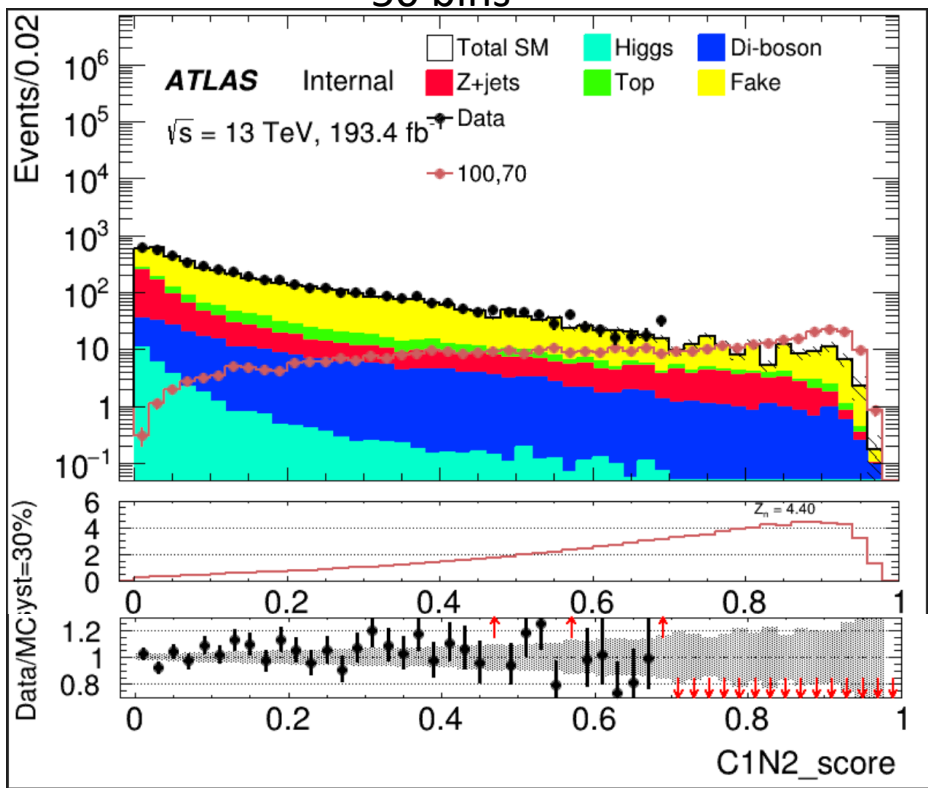


VV (Fold 4: BDT4_300_6_1_005)



SR(HH) Multi

50 bins



Each index stand for a region, and index 10 stands for sum

Zjets(HH)

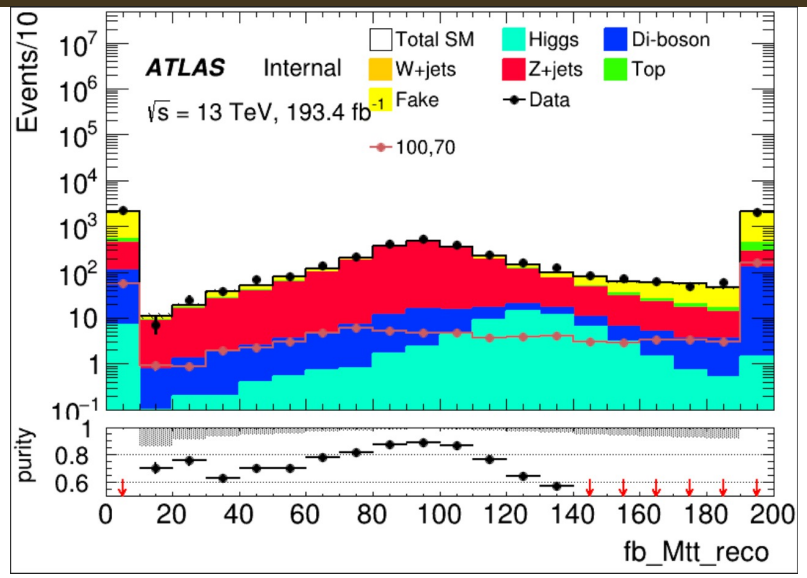
== 2 medium tau
== 0 lepton
METtrig && MET >= 200
OS
bVeto
nBaseJet >= 1
Jet pt > 100GeV

Same with pre-selection

C1N2 score <= 0.7(Othrogonal with SR)

CR: Mtt reco >= 80 && Mtt reco <= 110
VR: (Mtt reco >= 40 && Mtt reco < 80) || (Mtt reco > 110 && Mtt reco < 130)

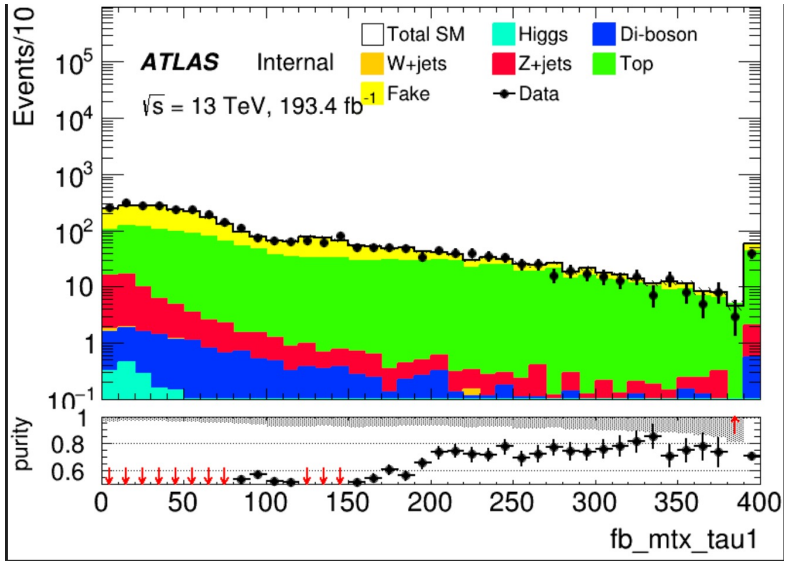
Region	TotalBkg	Zjets	purity	Data	Data/Bkg
CR	1433.93+-11.003	1232.36+-5.476	0.859	1571	1.096
VR1	824.938+-8.468	674.307+-4.082	0.817	904	1.097
VR2	469.252+-7.834	321.877+-2.913	0.685	524	1.117



Top(HH)

== 2 medium tau
== 0 lepton
METtrig && MET >= 200
OS
nBaseJet >= 1
Jet pt > 100GeV
Mtt_reco < 40GeV && Mtt_reco > 130GeV

Same with pre-selection



>= 1 bTag(improve top events)
C1N2 score <= 0.7(Othrogonal with SR)

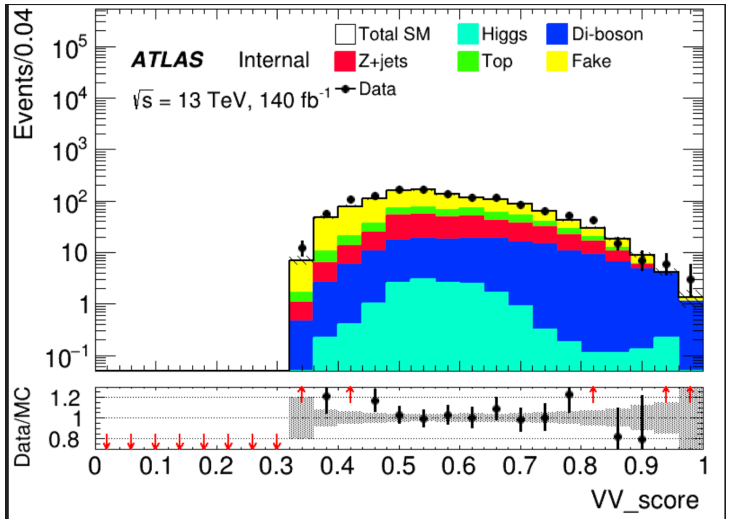
CR: $270 < M_T(\tau, MET) < 400$
VR: $230 < M_T(\tau, MET) < 270$

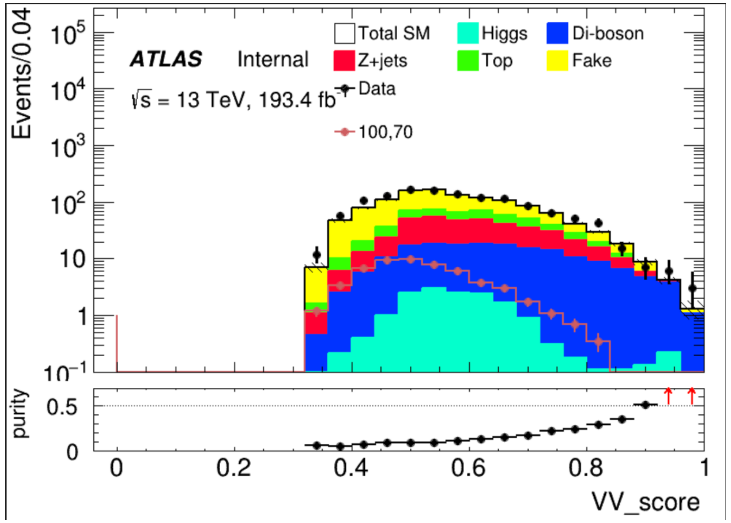
Huge overestimation

Region	TotalBkg	Top	purity	Data	Data/Bkg
CR	182.692+-5.738	140.981+-4.009	0.771	150	0.82
VR	140.228+-5.236	103.866+-3.445	0.740	134	0.94

VV(HH)

Pre-selection && C1N2_score <= 0.7 && Max(score) == VV_score && VV_score >= 0.85





Region	TotalBkg	VV	purity	Data	Data/Bkg
VR	32.4944+-2.09	15.4902	0.476	31	0.954