山东大学 SHANDONG UNIVERSITY

Department of Physics, Shandong University

Compressed EWK study(ISRC1N2)

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Tasklist

- ~~Obtain (120,90), (140,90) in ML result~~
- ~~Significance map in HH&LH channel~~
- BSc thesis: https://www.overleaf.com/project/674e7119837a2580151a0868
- ABCD method note/bkg estimation: any note or paper I can follow/ref?

SR definition

Pre-Selection

- lep-had channel:nTaus$\geq$1;nLeps$\geq$1
- had-had channel:nTaus$\geq$2;nLeps=0
- MET$\geq$ 200; pass MET trigger
- $1 \leq nBaseJet \leq 8$
- b-veto
- OS

SR for HH channel

hyper parameter: NTrees=500, learning rate=0.05, max depth=12, MinNodeSize=1%(default)

Pre-Selection + BDT score $\geq$ 0.91

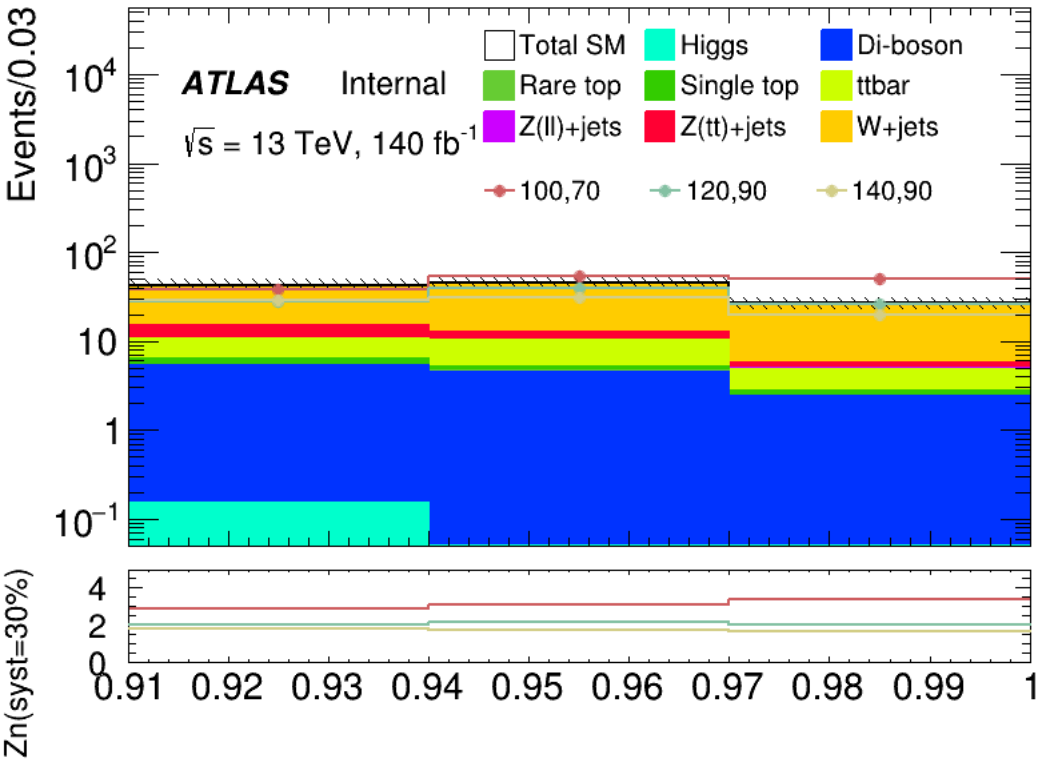
SR for LH channel

hyper parameter: NTrees=400, learning rate=0.01, max depth=10, MinNodeSize=1%(default)

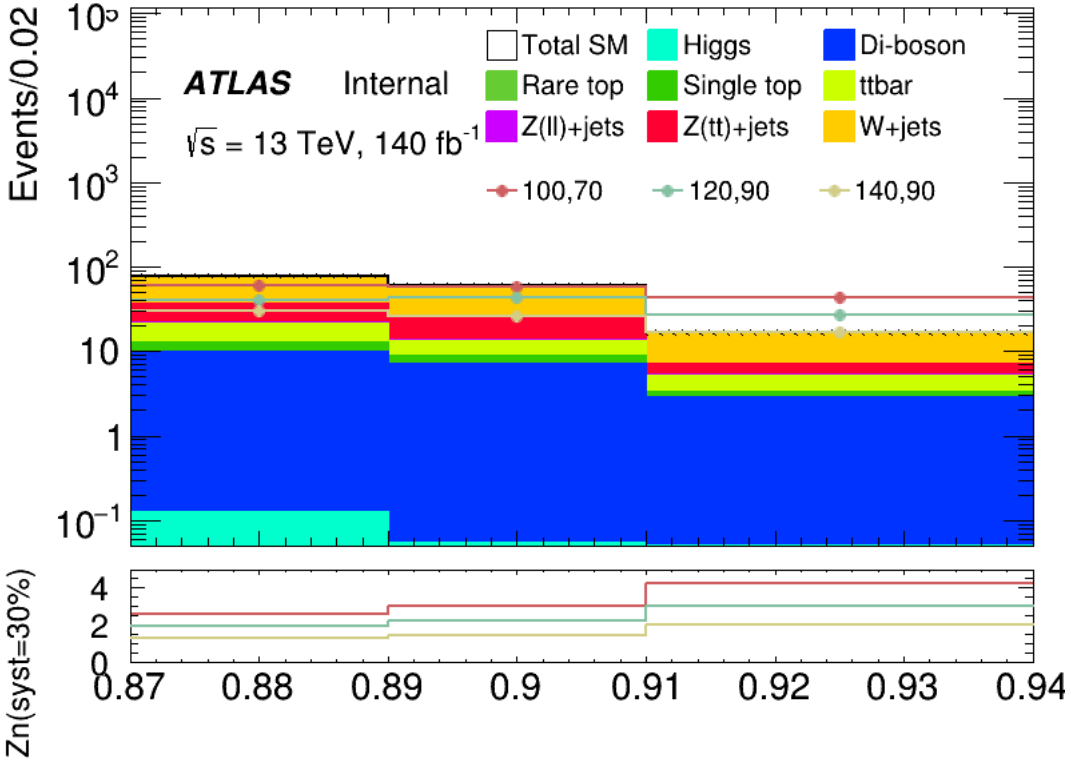
Pre-Selection + BDT score $\geq$ 0.87

Performance of Model(LH, HH)

HH channel

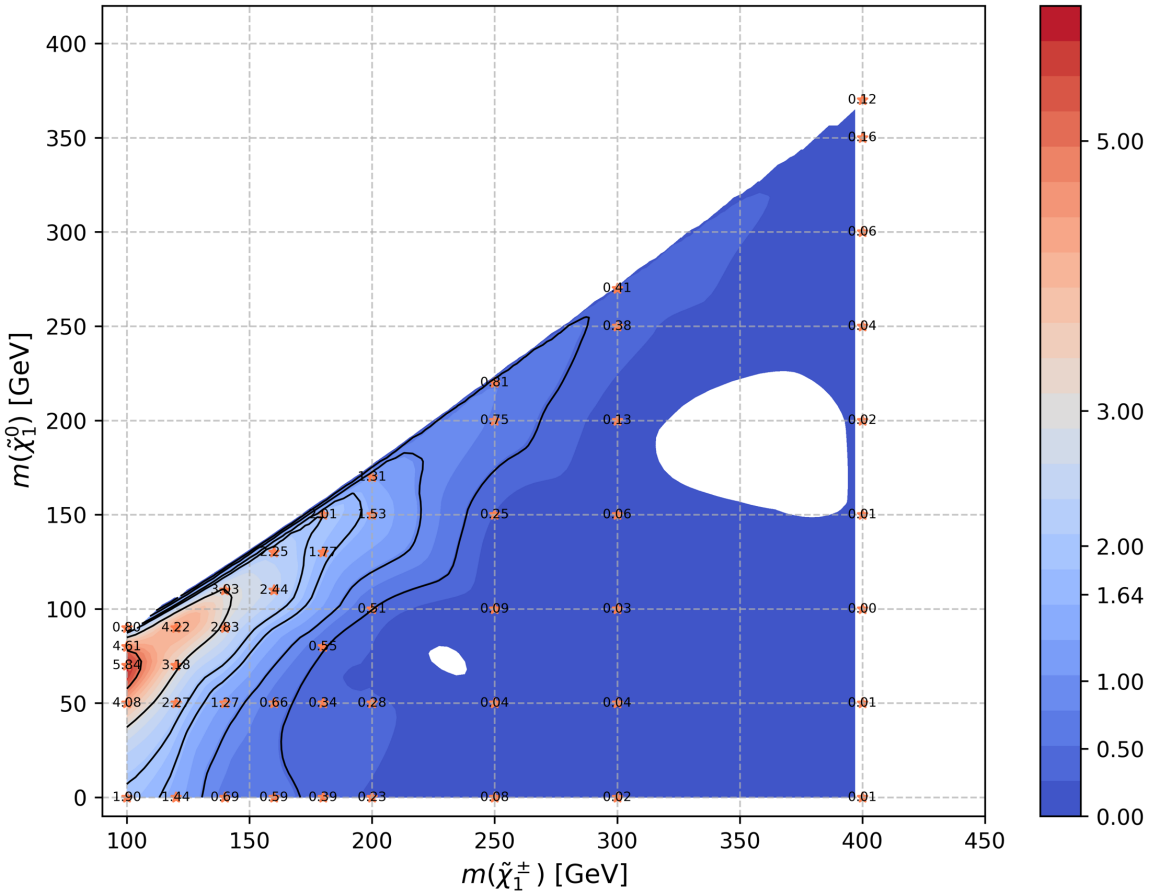


LH channel

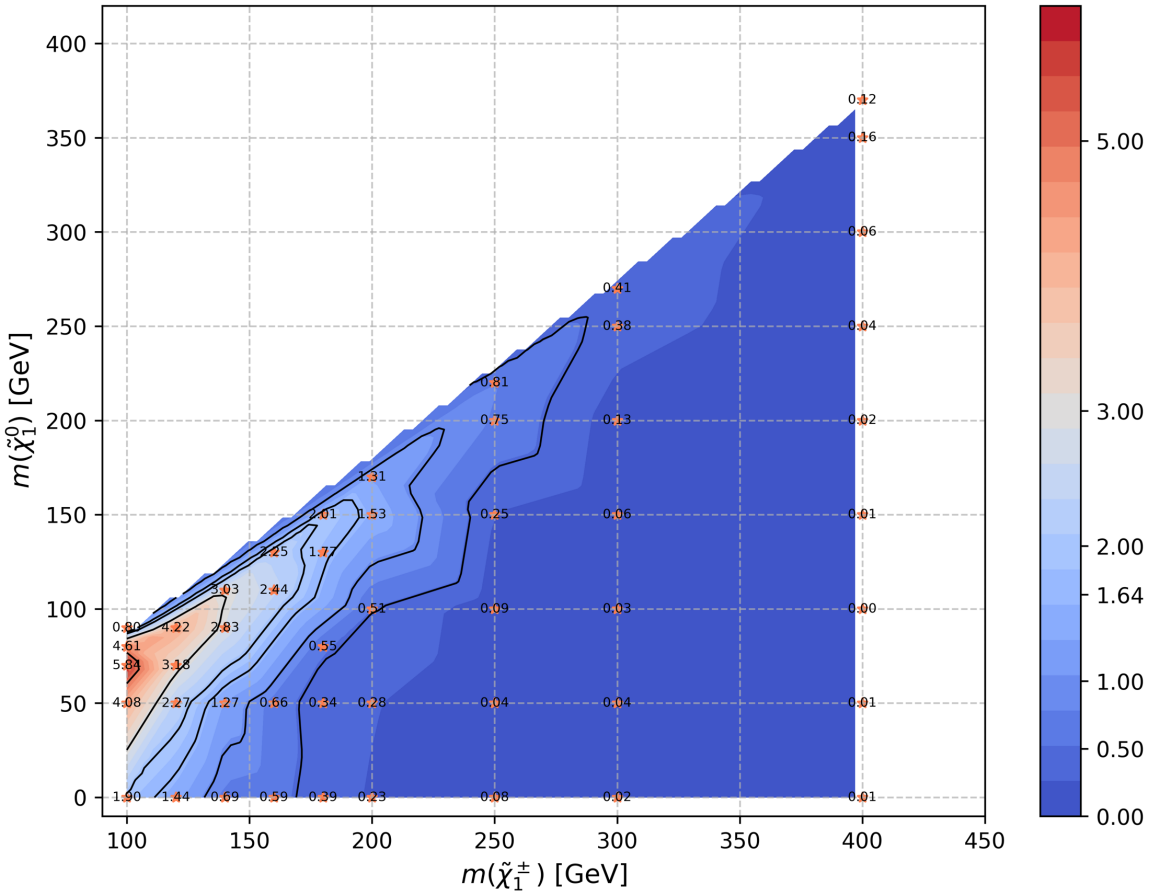


Significance Map(LH)

Cubic method to interpolation

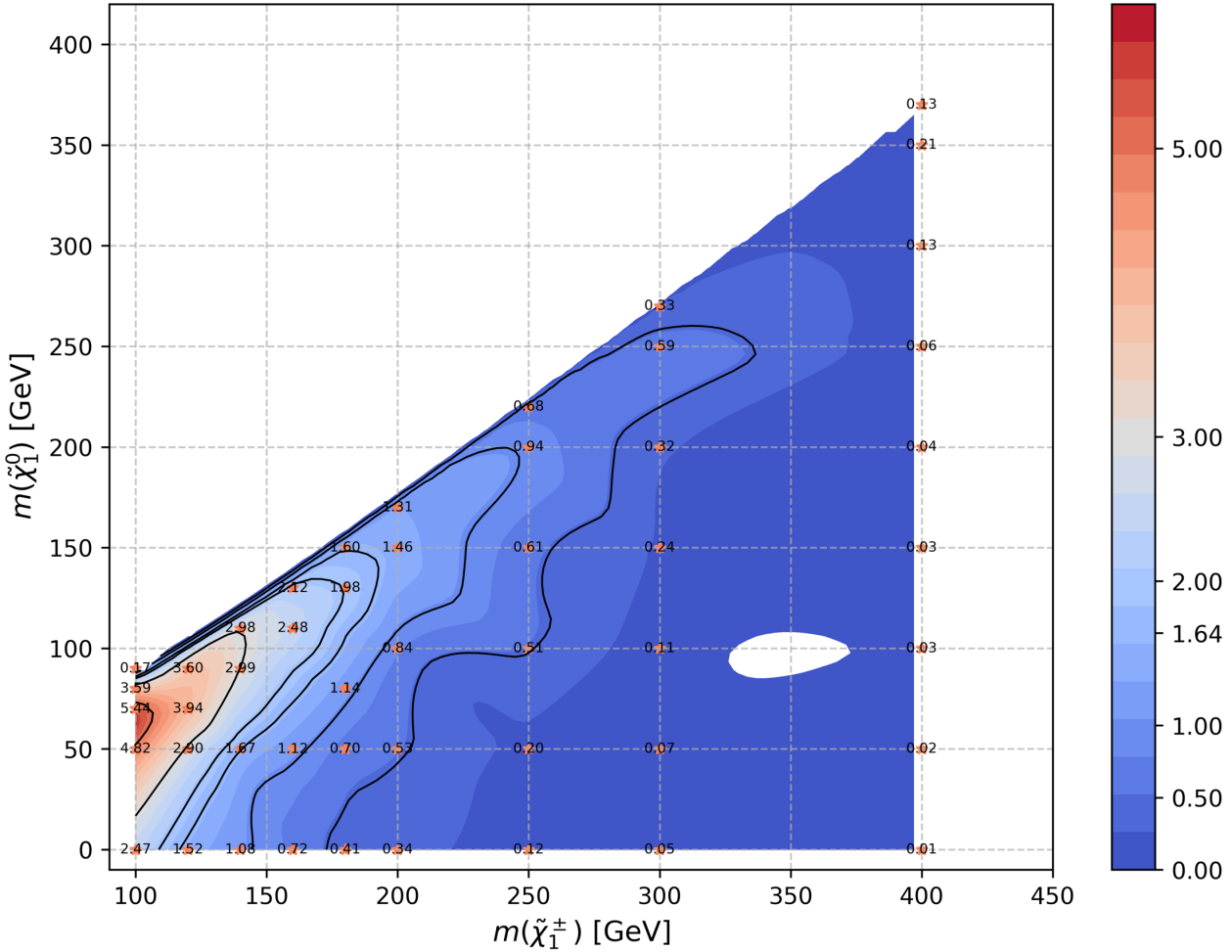


Linear method to interpolation

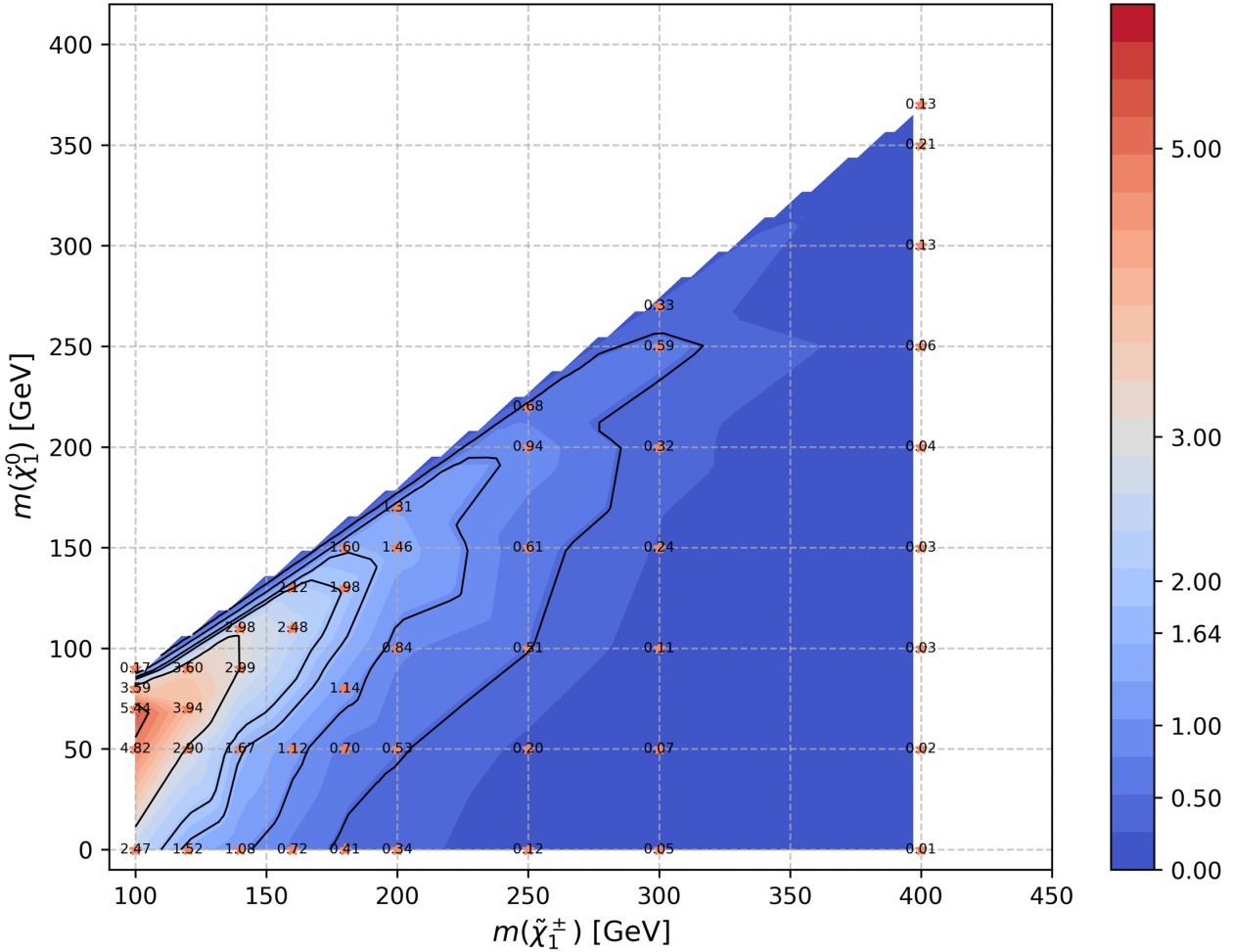


Significance Map(HH)

Cubic method to interpolation



Linear method to interpolation



Backup

Hyperparameters optimization(LH)

Input(LH-Channel):

Sample:

Sig: ISRC1N2(mass_C1 = 100GeV, mass_N2 = 70GeV)->21225 entries
Bkg: 1703476 entries

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

```
Signal     -- training events            : 12735
Signal     -- testing events             : 4245
Signal     -- training and testing events: 16980
Background -- training events            : 1022092
Background -- testing events             : 340692
Background -- training and testing events: 1362784
```

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.

Pre-Selection

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

Hyperparameters optimization(LH)

Variables(30):

Obj kinematics
- nBase_Jet
- mt_lep
- e_lep(energy of tau2)

Angular correlations
- dPhitt
- dRtt
- dRt1x
- dPhiMin_xj
- dPhiMax_tj

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)
- mtx_tau
- Mtx_lep
- ht_tau
- mt_quad_sum
- mt_sum
- frac_MET_tau1
- frac_MET_tau2
- frac_MET_tt
- frac_MET_sqrtHT_40
- frac_jet_tau1
- frac_jet_tau2
- frac_jet_tt
- MT_taumin
- pt_Vframe

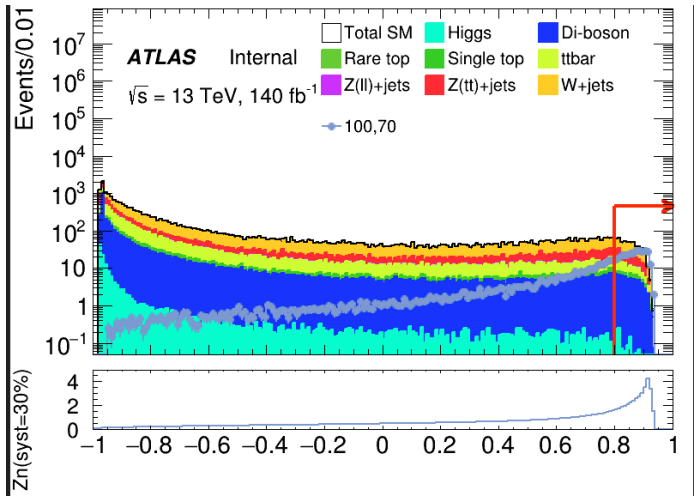
High importance at shiyi's feature

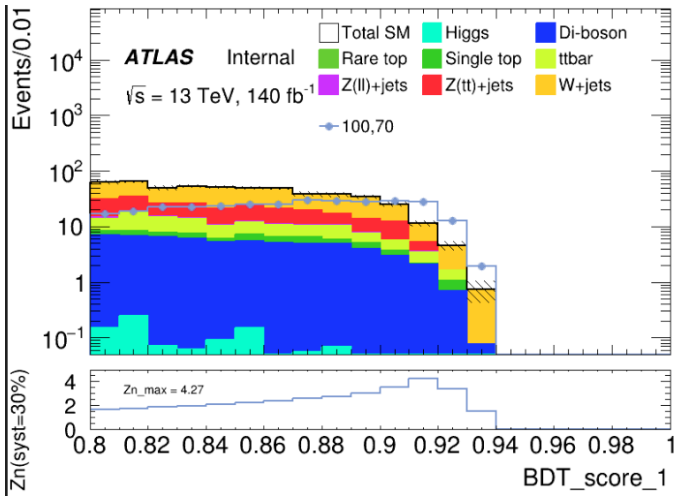
Note:

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

Hyperparameters optimization(LH)

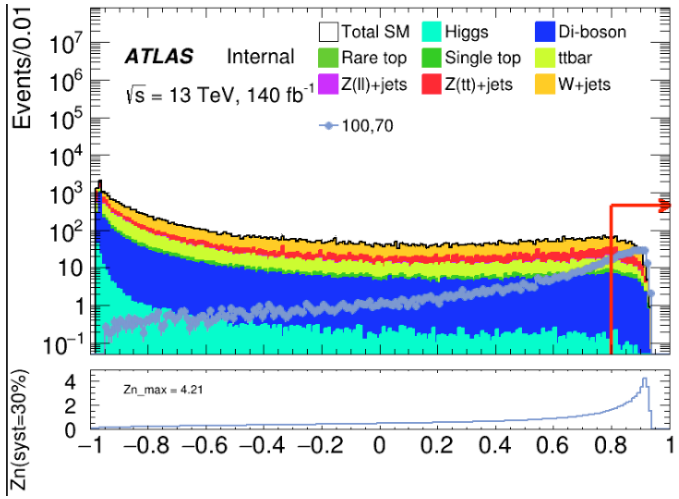
hyper parameter: NTrees=400, learning rate=0.01, max depth=10, MinNodeSize=1%(default)

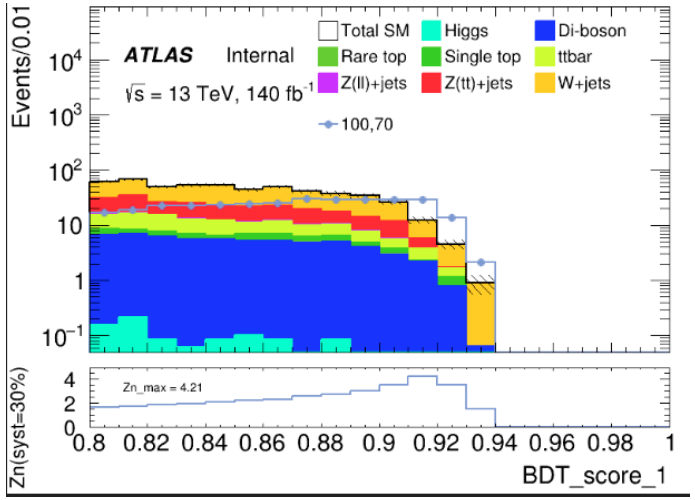




Cut at BDT_score = 0.8

hyper parameter: NTrees=400, learning rate=0.01, max depth=12, MinNodeSize=1%(default)





Hyperparameters optimization(HH)

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(HH)

Variables(26):

Obj kinematics

Pt_tt

Angular correlations

dPhit1x
dEtatt
dPhiMax_xt
dPhiztt
dPhitt
dPhizxe
dPhiMin_xt
dPhit2x
dPhiMin_tj1
dRt2x
dRMax_xt
dRMin_tj
dRtt
sum_cos_dphi

Event kinematics

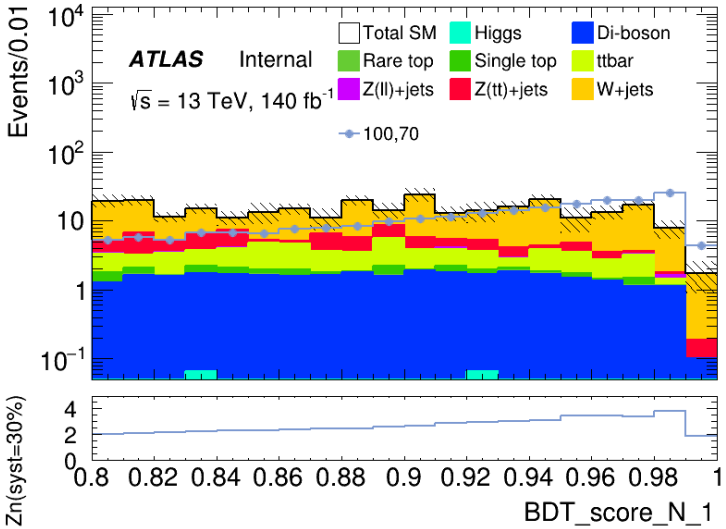
Mll(Invariant Mass of tau1 and tau2)
MIA
MT2_150
MET_Tau
Proj_tt
MstauA
MCT
frac_MET_tt
frac_MET_tau1
frac_MET_MeffInc_40
frac_MET_Meff

These vars are selected based on the importance

Hyperparameters optimization(HH)

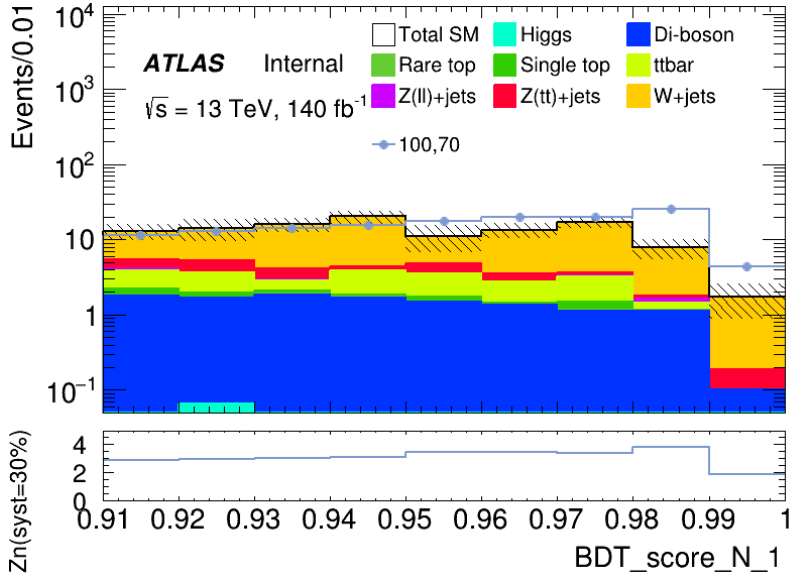
hyper parameter: NTrees=500, learning rate=0.05, max depth=12, MinNodeSize=1%(default)

Apply a rough cut at 0.80 to check the distribution



Precise cut at 0.91 to define signal region

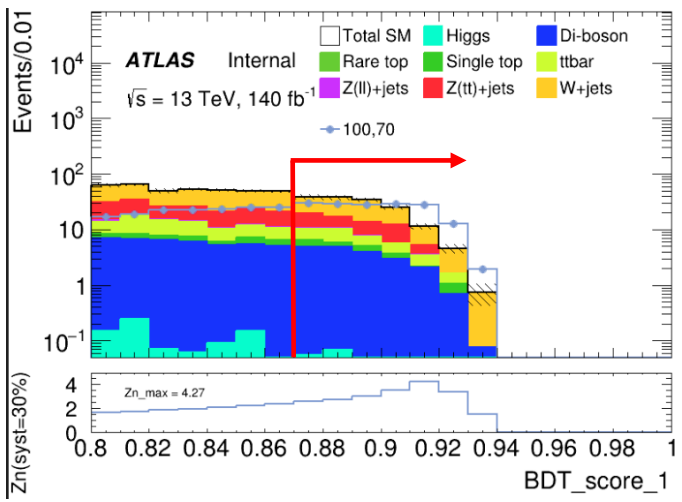
It has a wider peak than LH signal region

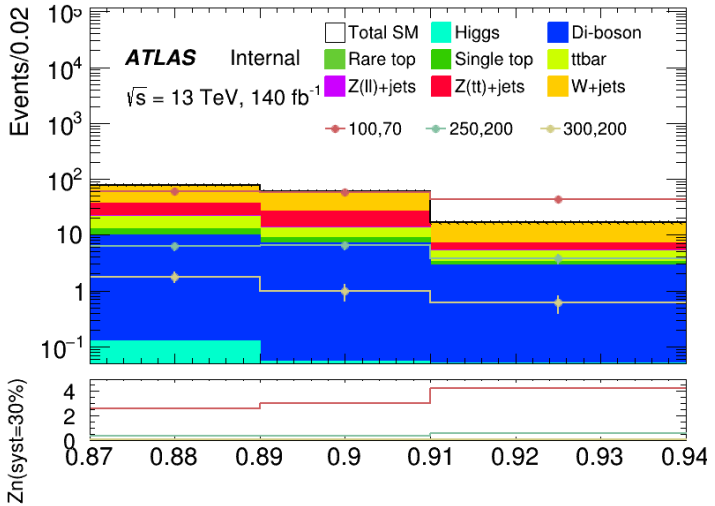


Rebin to: [0.91, 0.94, 0.97, 1.00]

Performance of Model(LH)

hyper parameter: NTrees=400, learning rate=0.01, max depth=10, MinNodeSize=1%(default)





Apply BDT score cut at 0.87

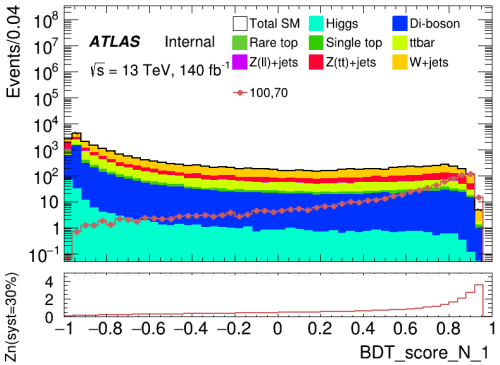
Root of square sum of Zn of each bin: 5.8479

Rebin to: [0.87, 0.89, 0.91, 0.94]

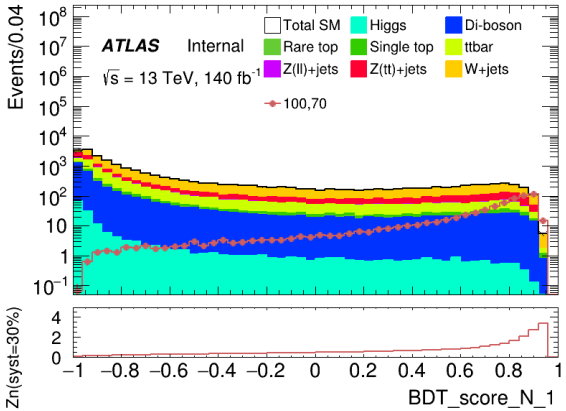
bin	max Zn	C1N2ISR (100,70)	bkg	Higgs	OtherTop	SingleTop	TopPair	VV	Wjets	Zlljets	Zttjets
(0.87-0.89)	2.59868	**59.238+-1.484**	**76.648+-5.530(7.21%)**	0.126+-0.034	0.033+-0.021	2.619+-0.548	8.311+-1.141	9.569+-0.520	**39.971+-5.074**	0.760+-0.130	15.259+-1.718
(0.89-0.91)	3.03656	**57.663+-1.447**	**59.803+-3.946(6.59%)**	0.053+-0.020	0.078+-0.030	1.761+-0.420	4.401+-0.823	6.851+-0.399	**33.586+-3.367**	0.453+-0.128	12.620+-1.792
(0.91-0.94)	4.26908	**42.715+-1.251**	**16.632+-1.683(10.11%)**	0.005+-0.004	0.006+-0.004	0.450+-0.202	1.819+-0.532	2.858+-0.249	**9.733+-1.536**	0.039+-0.020	1.722+-0.298

Performance of Model(LH)

hyper parameter: NTrees=400, learning rate=0.01, max depth=10, MinNodeSize=1%(default)

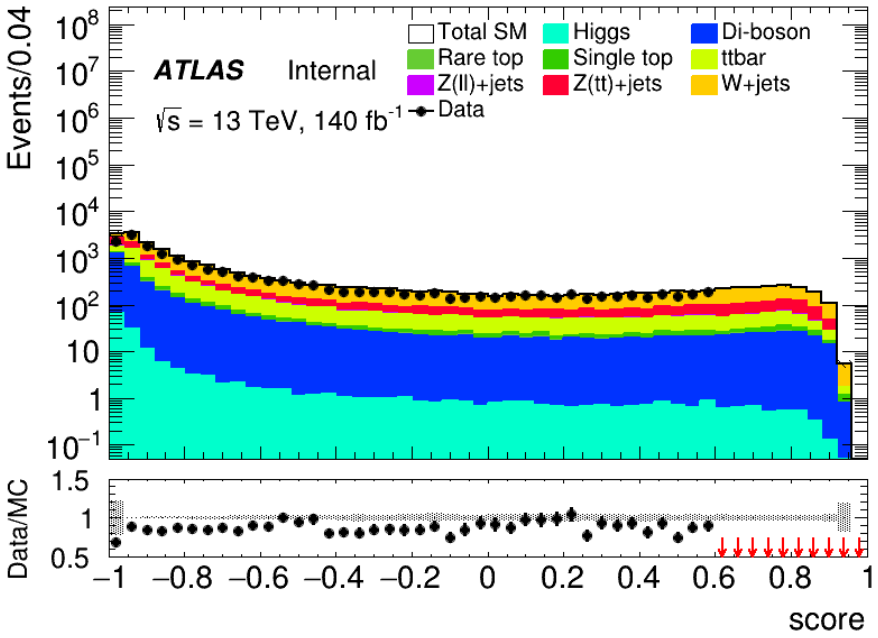


BDT score distribution of Validation set

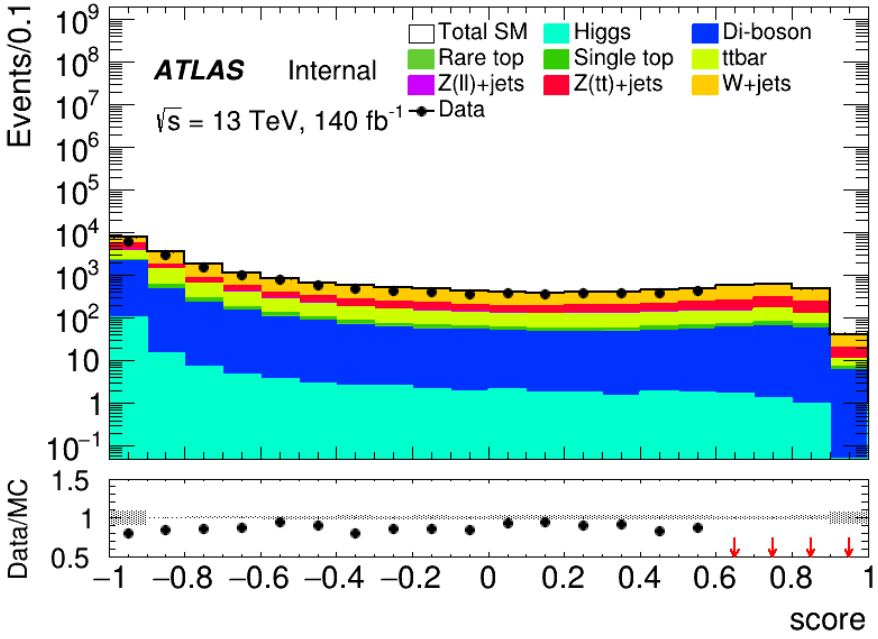


BDT score distribution of Test set

50 bins



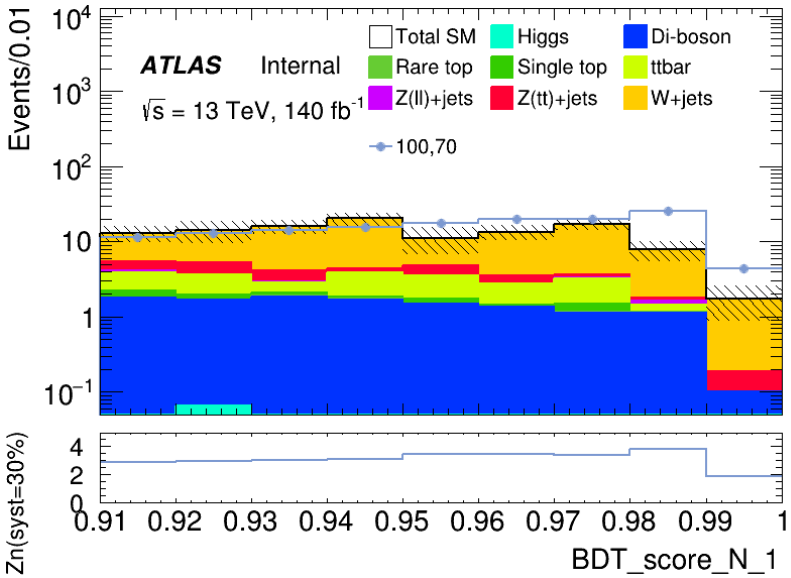
20 bins



BDT score distribution of test set and data
(Blind with events with score > 0.6)

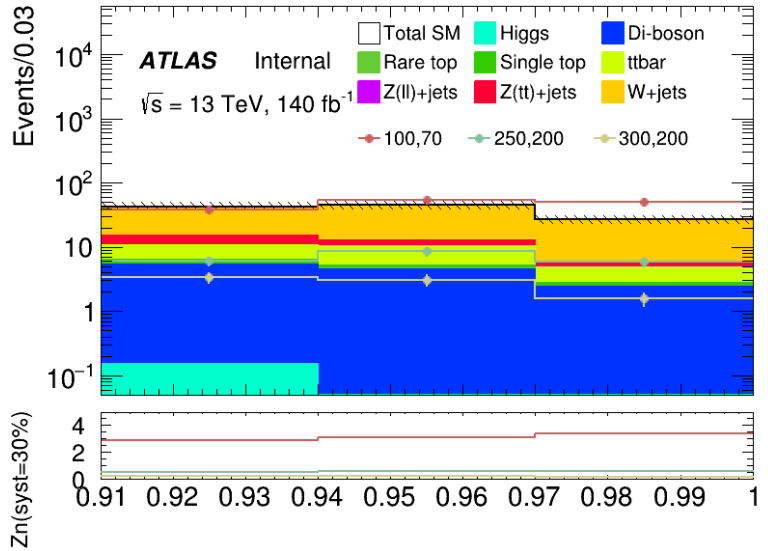
Performance of Model(HH)

hyper parameter: NTrees=500, learning rate=0.05, max depth=12, MinNodeSize=1%(default)



Root of quadratic sum of Zn = 5.3163

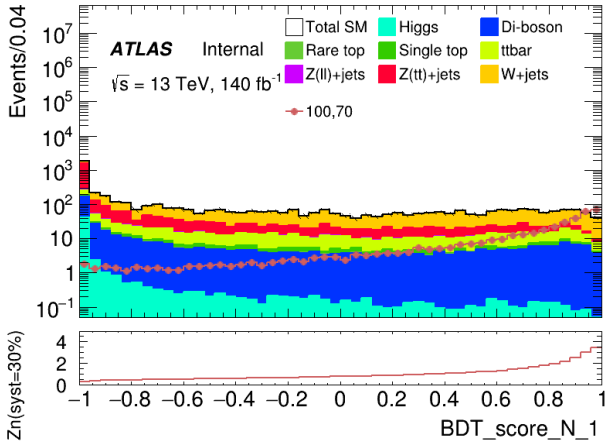
Rebin to: [0.91, 0.94, 0.97, 1.00]



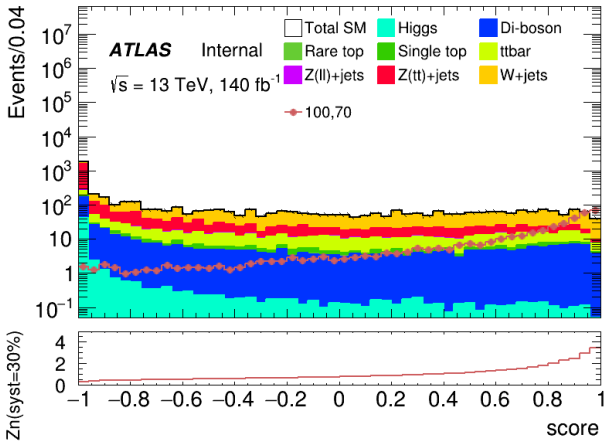
bin	Zn	C1N2ISR (100,70)	bkg	SingleTop	Zttjets	Wjets	OtherTop	VV	Zlljets	TopPair	Higgs
bin1	2.8678146	38.472+-1.192	42.986+-6.490(15.09%)	0.958+-0.303	4.090+-0.675	28.198+-6.388	0.026+-0.020	5.144+-0.289	0.265+-0.185	4.156+-0.802	0.150+-0.041
bin2	3.1193828	53.206+-1.399	44.788+-6.647(14.86%)	0.473+-0.239	2.435+-0.612	32.118+-6.547	0.033+-0.022	4.512+-0.303	0.040+-0.026	5.158+-0.888	0.019+-0.014
bin3	3.4088980	49.550+-1.350	26.640+-3.905(14.65%)	0.348+-0.184	0.600+-0.129	21.041+-3.850	0.034+-0.017	2.363+-0.189	0.196+-0.123	2.050+-0.570	0.007+-0.007

Performance of Model(HH)

hyper parameter: NTrees=500, learning rate=0.05, max depth=12, MinNodeSize=1%(default)

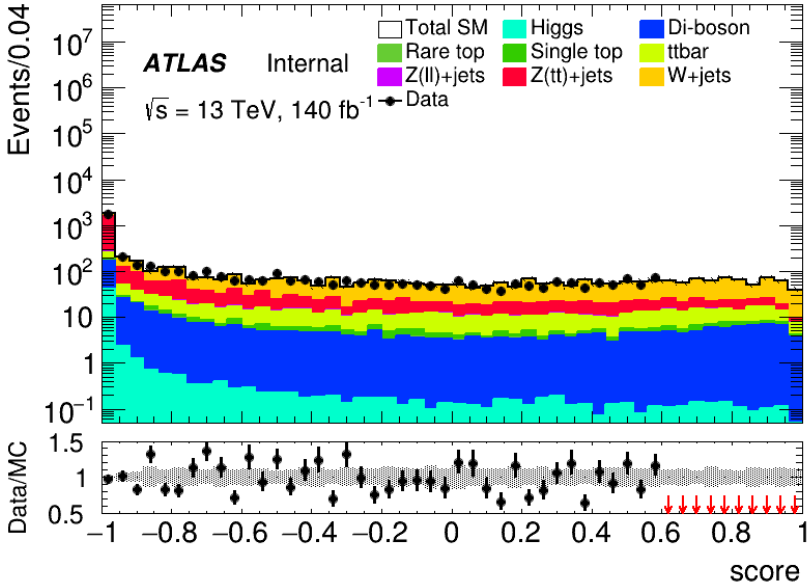


BDT score distribution of Validation set

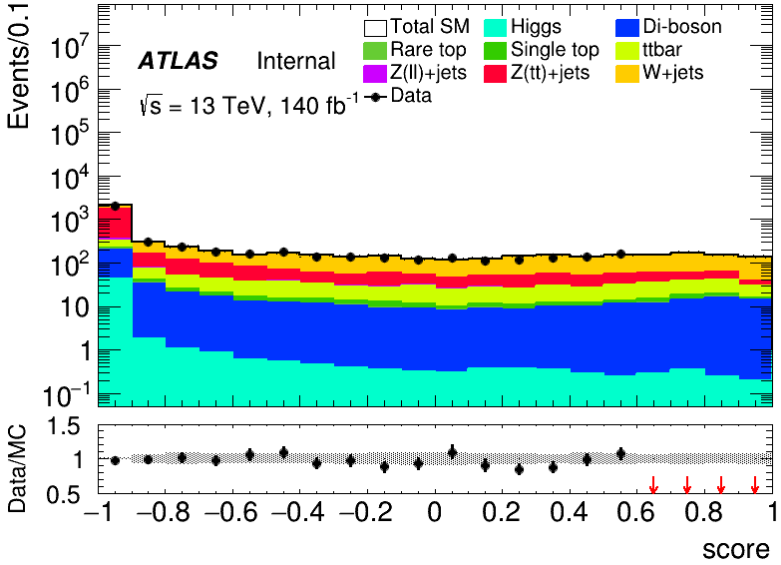


BDT score distribution of Test set

50 bins



20 bins



BDT score distribution of test set and data
(Blind with events with score > 0.6)