Analysis of 4top process with VLL model

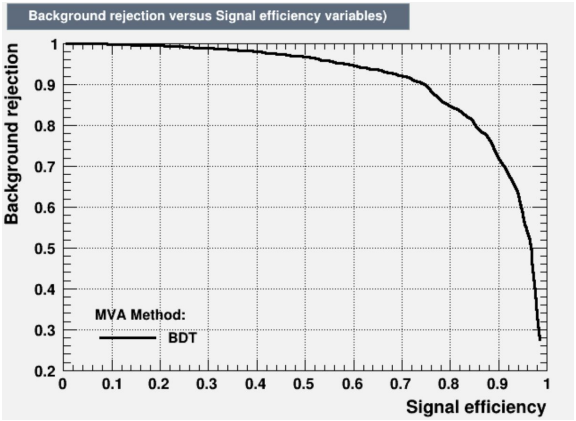
input variables list:

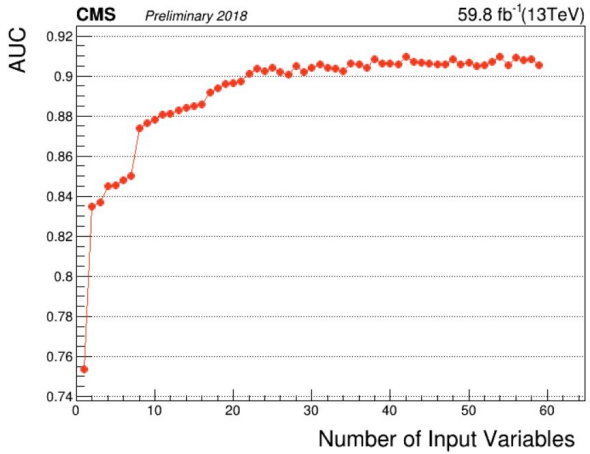
jets_centrality
jets_sphericity
jets_MHT
jets_3pt
jets_METDivideHT
jets_2pt
jets_4pt
jets_tausT_invariantMass
jets_rationHT_4toRest
jets_HTDivideMET

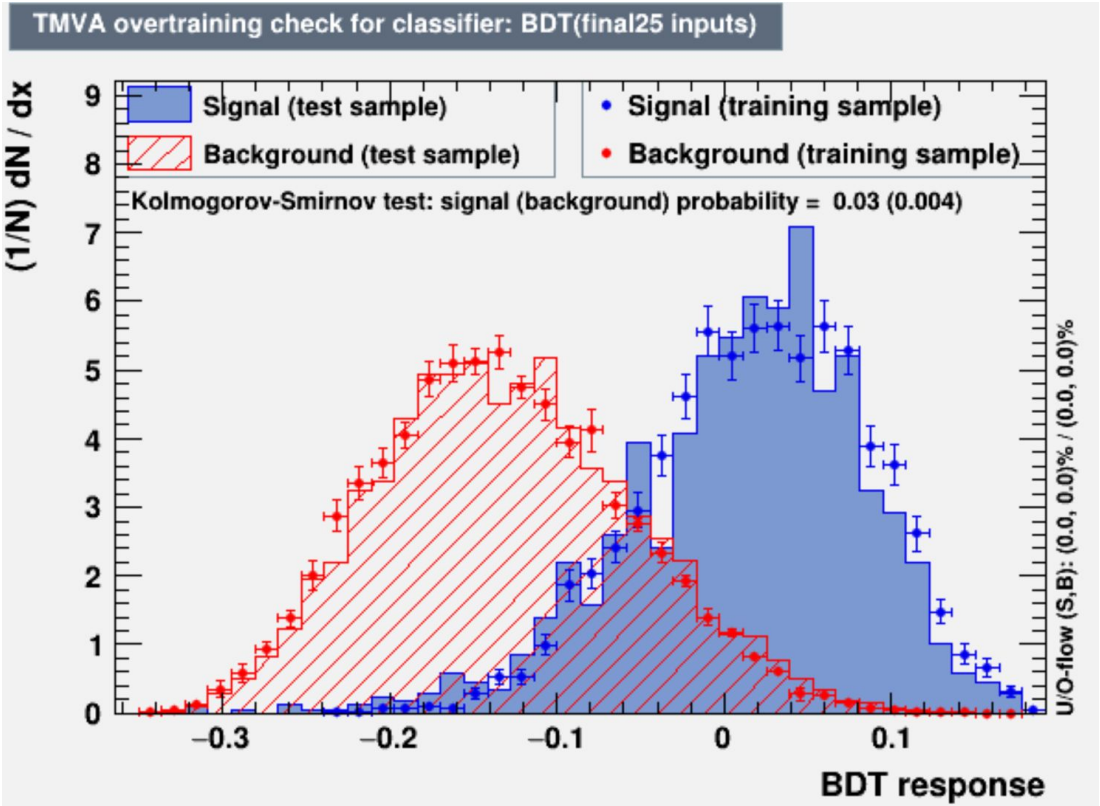
bjetsT_3pt
bjetsT_invariantMass
bjetsT_1pt
bjetsM_3pt
tausT_1Met_transMass
bjetsT_minDeltaR
bjetsM_minDeltaR
bjetsM_2MET_stransMass
bjetsT_leptons_minDeltaR
bjetsM_leptons_minDeltaR

tausT_1pt
tausT_1lepton1Met1_stransMass
tausT_1lepton1_deltaR
tausT_invariantMass
tausT_1lepton1_charge

AUC plot and overtraining check



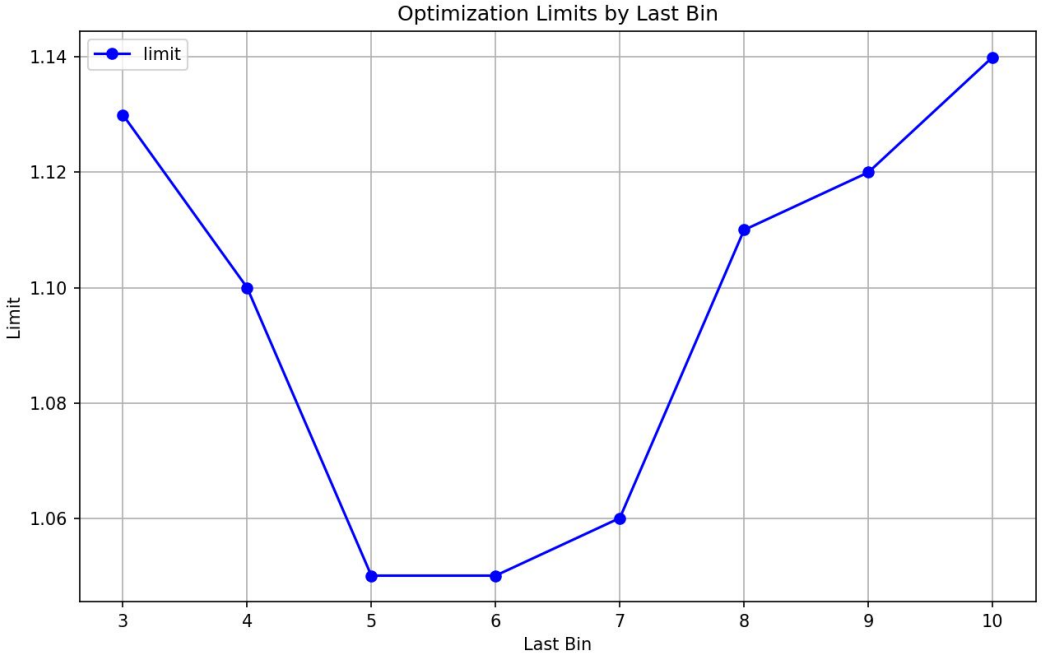




Only use autoMCStats in datacard

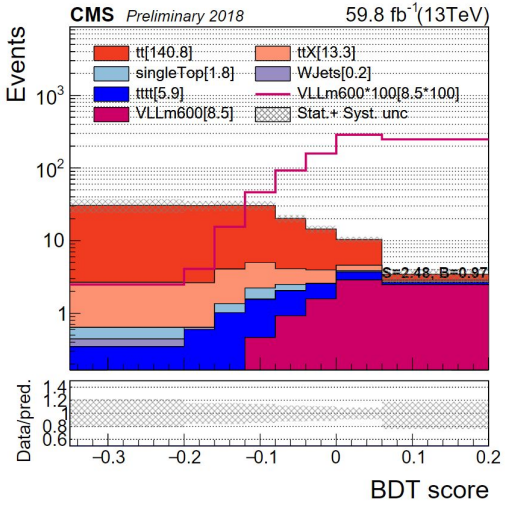
```
imax * number of bins
jmax * number of processes minus 1
kmax * number of nuisance parameters
----------------------------------------------------------------------------------------------------------------------------------
shapes *   SR1tau1l_2018  /publicfs/cms/user/turuobing/tauOfTTTT_NanoAODOfficial/forMVA/2018/v2cut1tau1lSRTauF_v76addTTExtra1Official/mc/v
----------------------------------------------------------------------------------------------------------------------------------
bin          SR1tau1l_2018
observation  -1
----------------------------------------------------------------------------------------------------------------------------------
bin                                 SR1tau1l_2018  SR1tau1l_2018  SR1tau1l_2018  SR1tau1l_2018  SR1tau1l_2018  SR1tau1l_2018
process                             tttt           singleTop      tt             ttX            WJets          VLLm600
process                             5              1              2              3              4              0
rate                                -1             -1             -1             -1             -1             -1
----------------------------------------------------------------------------------------------------------------------------------
SR1tau1l_2018 autoMCStats 10 0 1
```

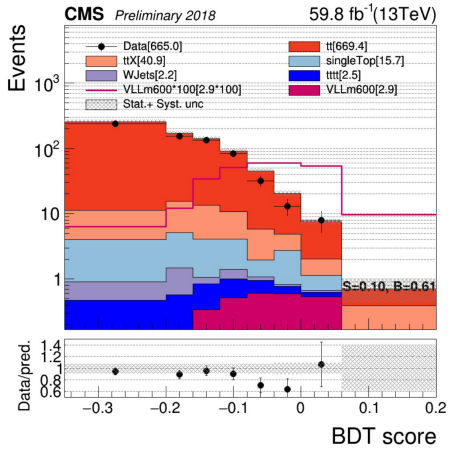
datacard with only MCstats.



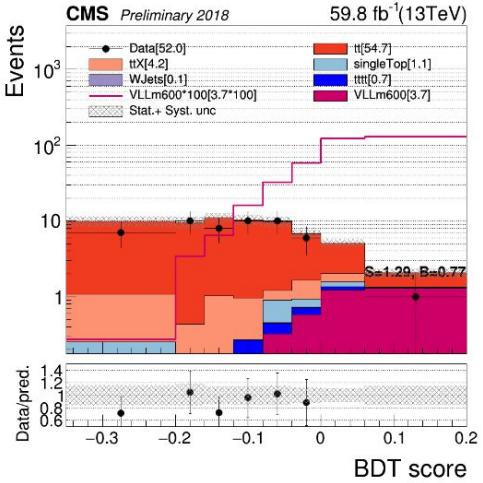

```
lastbin | limit | significance
{
    3 : [1.13, 1.96],
    4 : [1.10, 2.04],
    5 : [1.05, 2.20],
    6 : [1.05, 2.20],
    7 : [1.06, 2.21],
    8 : [1.11, 2.8],
    9 : [1.12, 2.07],
    10 : [1.14, 2.04],
}
```

The best binning（last bin : 0.06-0.2)





CR1



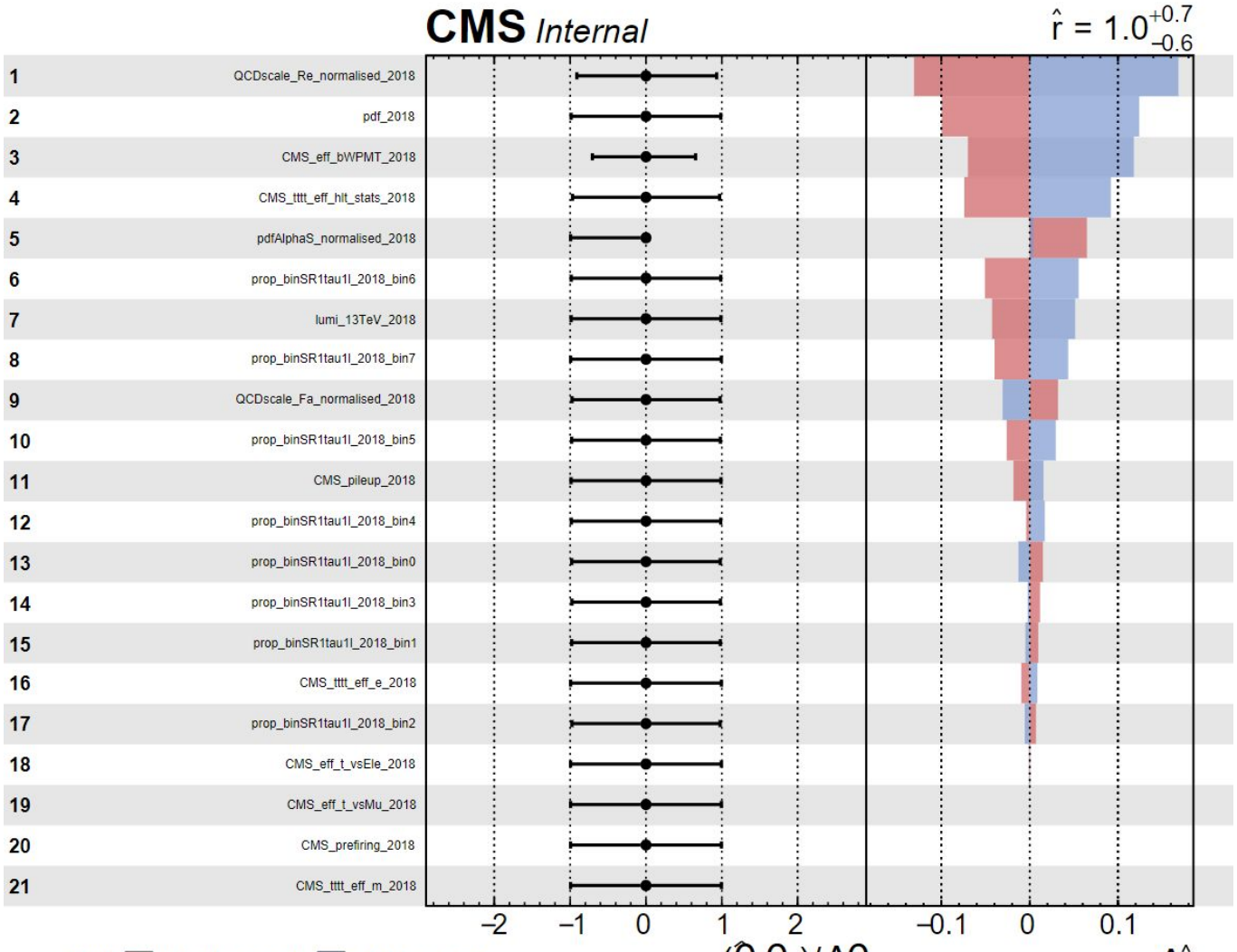
CR2

limit: 1.05
significance：2.20
AUC: 0.910
last bin: 0.06-0.2
Only MC stat. when doing combination

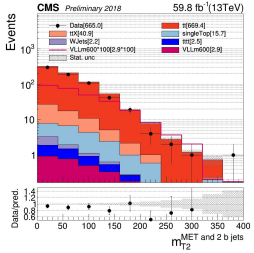
datacard with system uncertainty

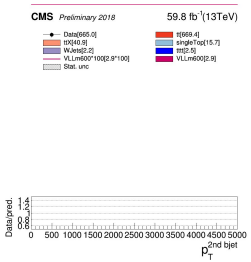
limit: 1.15
significance： 1.91

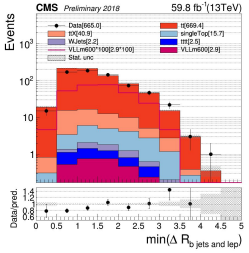
```
imax * number of bins
jmax * number of processes minus 1
kmax * number of nuisance parameters
--------------------------------------------------------------------------------------------------------------------------------
shapes *   SR1tau1l_2018  /publicfs/cms/user/turuobing/tauOfTTTT_NanoAODOfficial/forMVA/2018/v0baselineHardroSR_v81addSysSum/mc/variableHists_v0Basict
--------------------------------------------------------------------------------------------------------------------------------
bin          SR1tau1l_2018
observation  -1
--------------------------------------------------------------------------------------------------------------------------------
bin                                 SR1tau1l_2018  SR1tau1l_2018  SR1tau1l_2018  SR1tau1l_2018  SR1tau1l_2018  SR1tau1l_2018
process                             tttt           singleTop      tt             ttX            WJets          VLLm600
process                             5              1              2              3              4              0
rate                                -1             -1             -1             -1             -1             -1
--------------------------------------------------------------------------------------------------------------------------------
lumi_13TeV_2018 lnN                 1.025          1.025          1.025          1.025          1.025          1.025
CMS_pileup_2018 shape               1              1              1              1              1              1
CMS_prefiring_2018 shape            1              1              1              1              1              1
CMS_eff_t_vsJet_2018 shape          1              1              1              1              1              1
CMS_eff_t_vsMu_2018 shape           1              1              1              1              1              1
CMS_eff_t_vsEle_2018 shape          1              1              1              1              1              1
CMS_tttt_eff_e_2018 shape           1              1              1              1              1              1
CMS_tttt_eff_m_2018 shape           1              1              1              1              1              1
CMS_tttt_eff_hlt_stats_2018 shape   1              1              1              1              1              1
CMS_eff_bWPMT_2018 shape            1              1              1              1              1              1
pdf_2018     shape                  1              1              1              1              1              1
pdfAlphaS_normalised_2018 shape     1              1              1              1              1              1
QCDscale_Re_normalised_2018 shape   1              1              1              1              1              1
QCDscale_Fa_normalised_2018 shape   1              1              1              1              1              1
--------------------------------------------------------------------------------------------------------------------------------
SR1tau1l_2018 autoMCStats 10 0 1
```

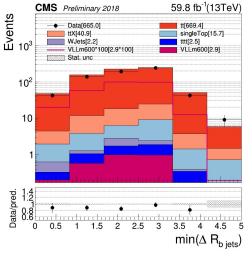

CMS Internal
$\hat{r} = 1.0^{+0.7}_{-0.6}$
1 QCDscale_Re_normalised_2018
2 pdf_2018
3 CMS_eff_bWPMT_2018
4 CMS_tttt_eff_hlt_stats_2018
5 pdfAlphaS_normalised_2018
6 prop_binSR1tau1l_2018_bin6
7 lumi_13TeV_2018
8 prop_binSR1tau1l_2018_bin7
9 QCDscale_Fa_normalised_2018
10 prop_binSR1tau1l_2018_bin5
11 CMS_pileup_2018
12 prop_binSR1tau1l_2018_bin4
13 prop_binSR1tau1l_2018_bin0
14 prop_binSR1tau1l_2018_bin3
15 prop_binSR1tau1l_2018_bin1
16 CMS_tttt_eff_e_2018
17 prop_binSR1tau1l_2018_bin2
18 CMS_eff_t_vsEle_2018
19 CMS_eff_t_vsMu_2018
20 CMS_prefiring_2018
21 CMS_tttt_eff_m_2018
−2 −1 0 1 2
−0.1 0 0.1

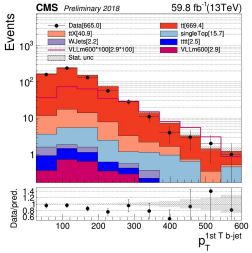
BDT inputs in control region 1

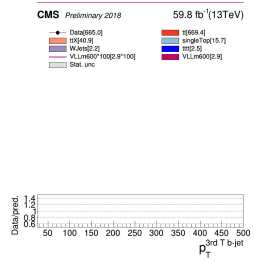


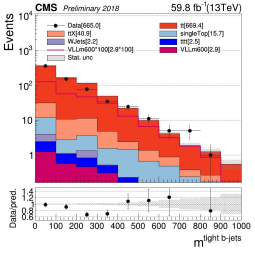


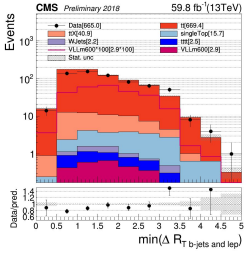


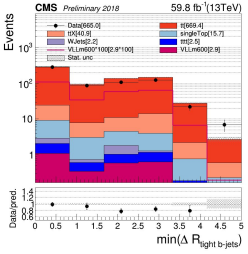


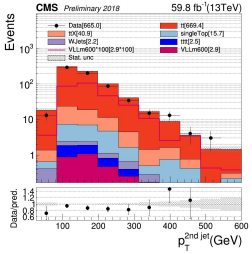


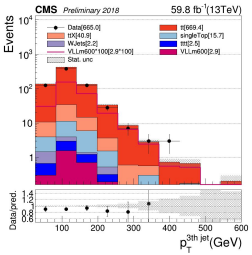


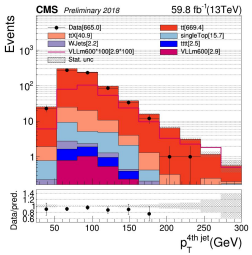


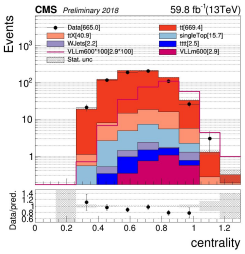


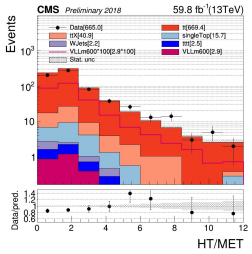


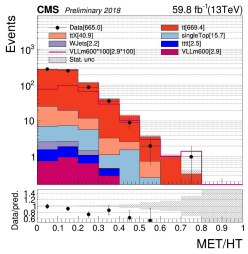


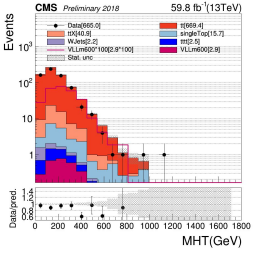

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
$p_T^{3th\ jet}$(GeV)

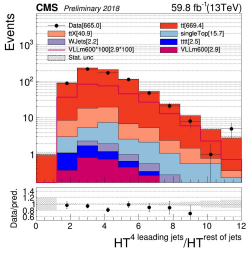

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
$p_T^{4th\ jet}$(GeV)

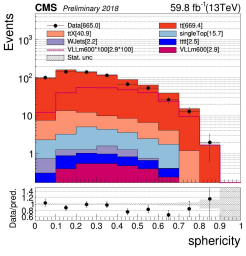

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
centrality

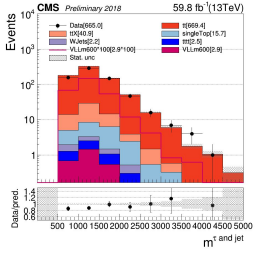

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
HT/MET

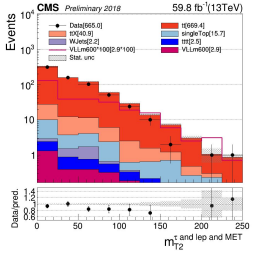

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
MET/HT

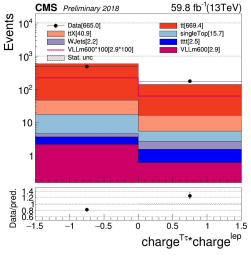

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
MHT(GeV)

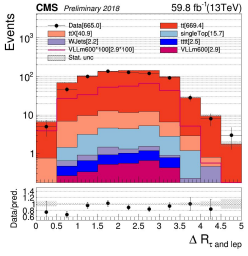

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
HT4 leaading jets/HTrest of jets

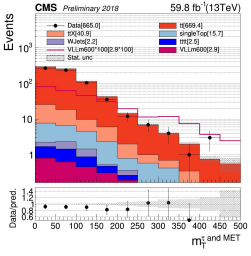

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
sphericity

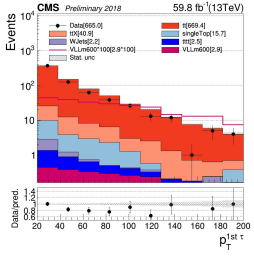

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
mτ and jet

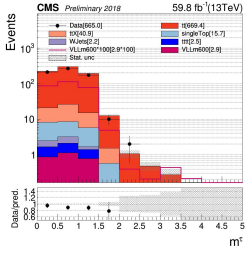

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
mτ and lep and MET


CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
chargeτ*charge lep

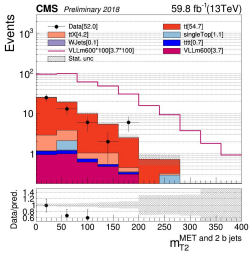

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
Δ Rτ and lep

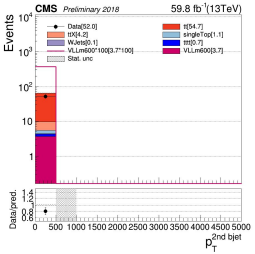

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
mTτ and MET

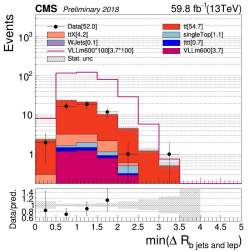

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
pT1st τ

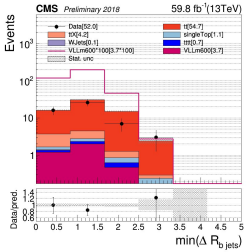

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
mτ

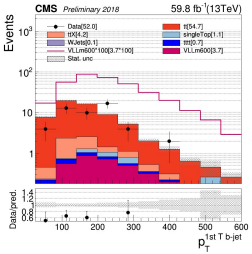
BDT inputs in control region 2

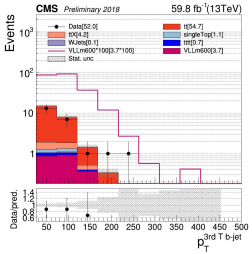


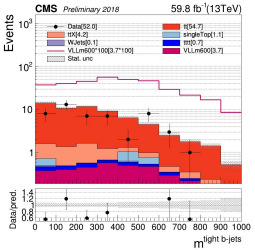


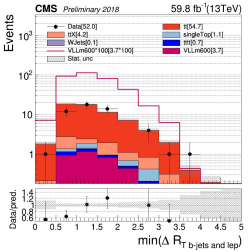


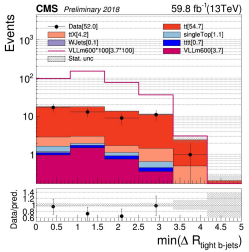


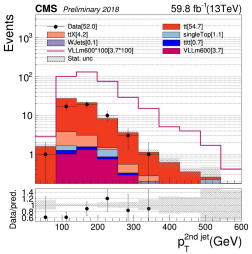


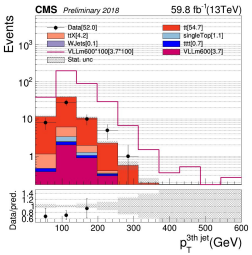


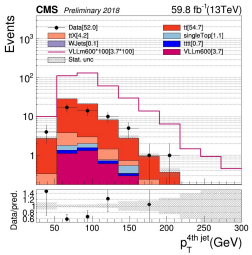


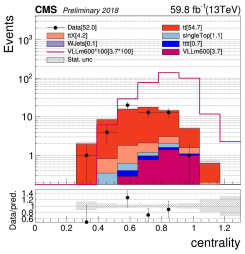


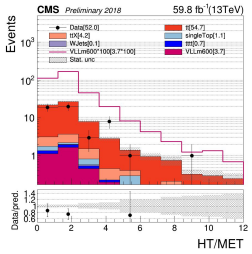


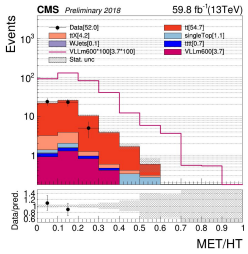


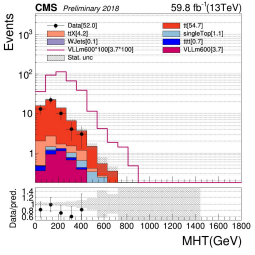

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
p_T^3th jet(GeV)

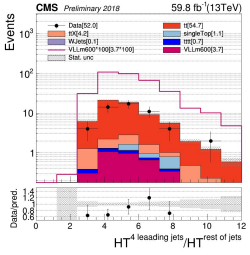

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
p_T^4th jet(GeV)

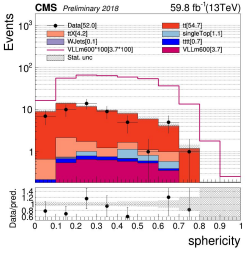

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
centrality

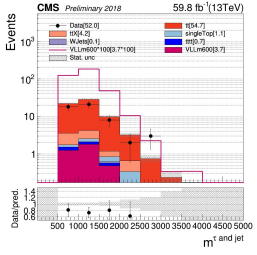

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
HT/MET

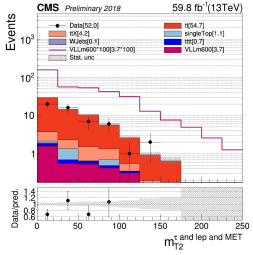

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
MET/HT

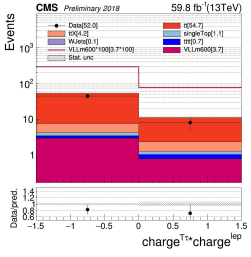

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
MHT(GeV)

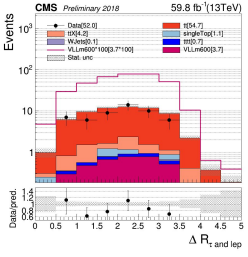

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
HT4 leaading jets /HTrest of jets

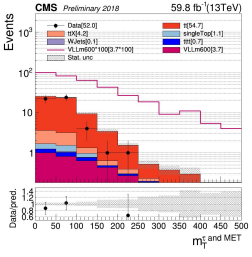

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
sphericity

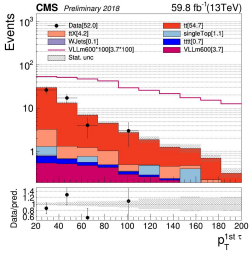

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
mτ and jet

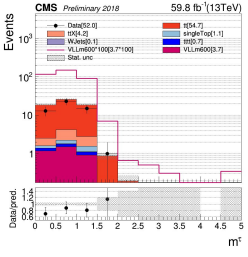

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
mTτ and lep and MET


CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
chargeTτ*chargelep

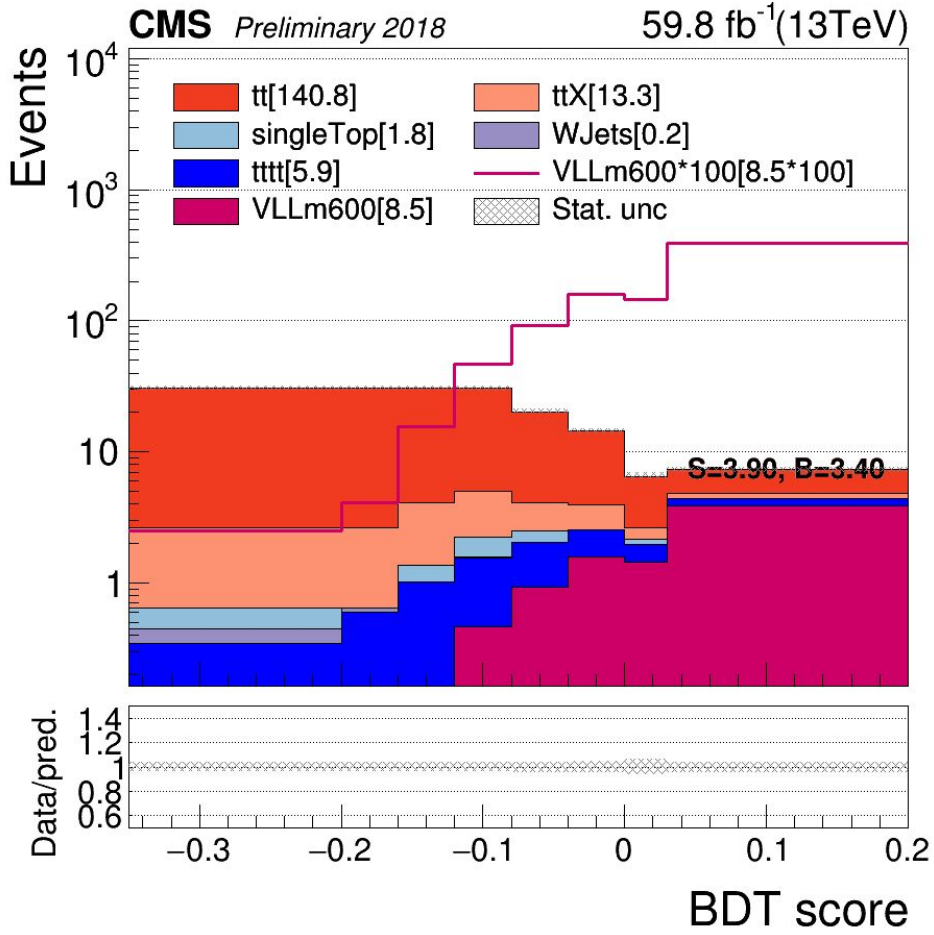

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
Δ Rτ and lep


CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
mTτ and MET

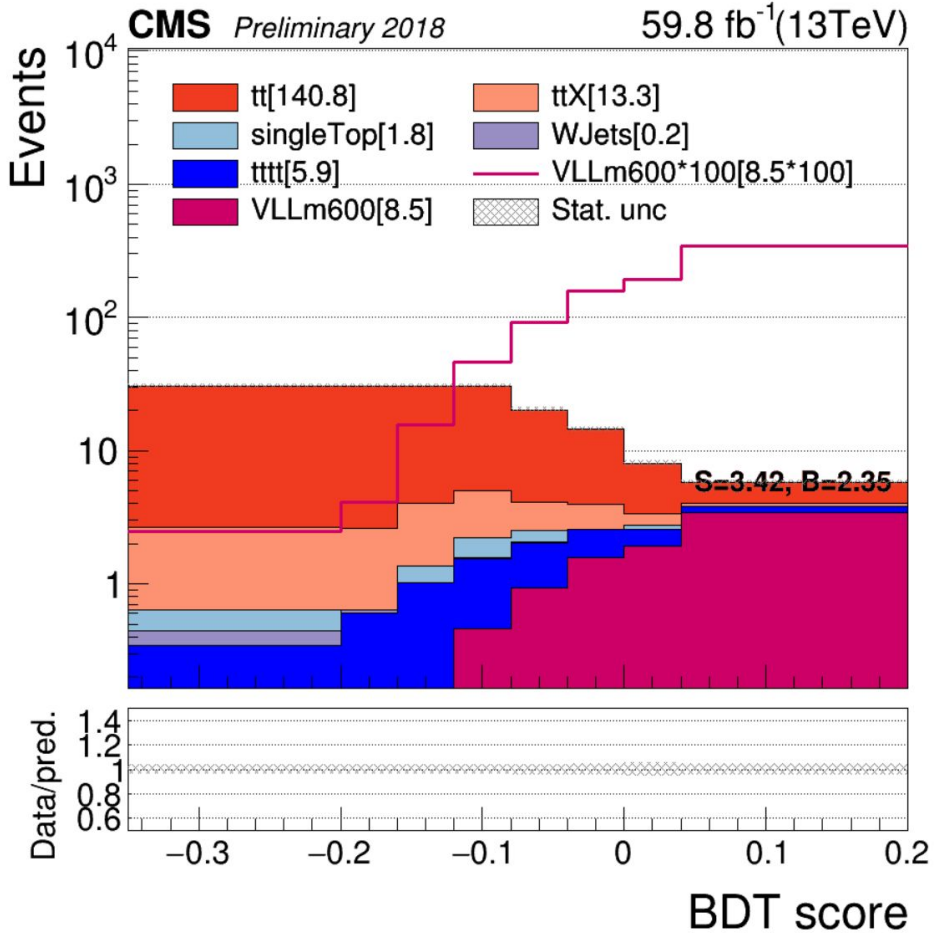

CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
pT1st τ


CMS Preliminary 2018
59.8 fb-1(13TeV)
Events
Data/pred.
mτ

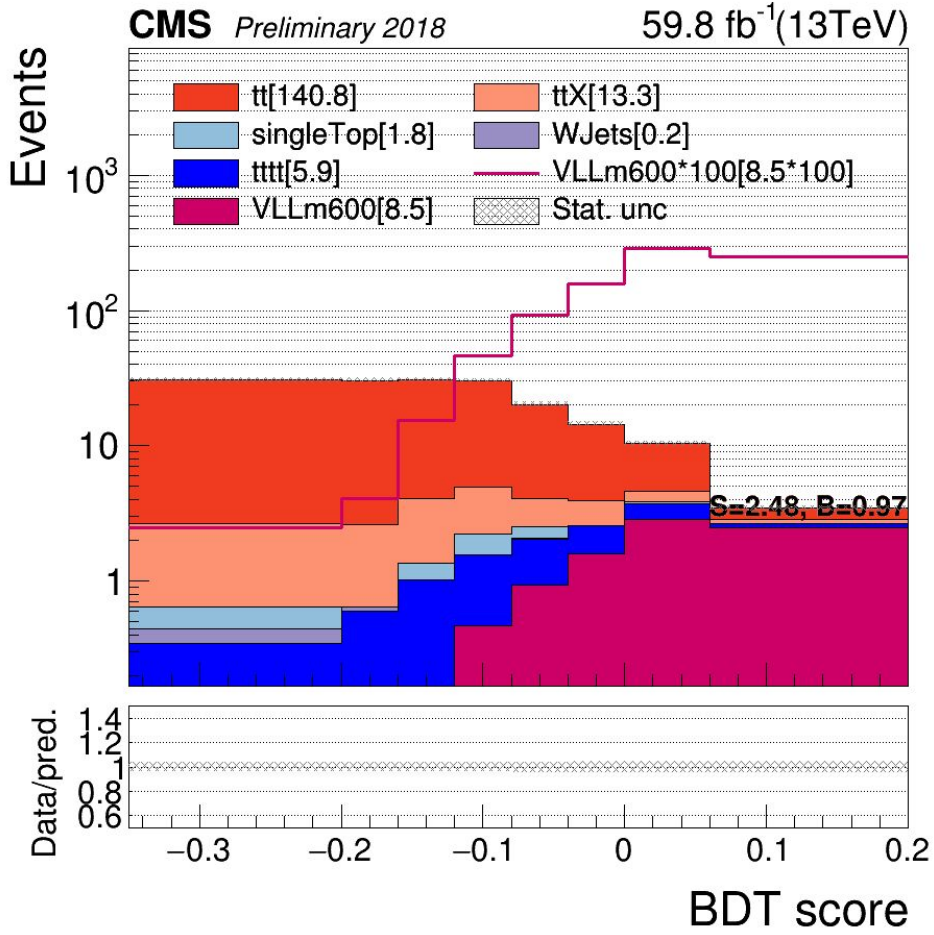
Back up



last bin : 0.03-0.2



last bin : 0.04-0.2



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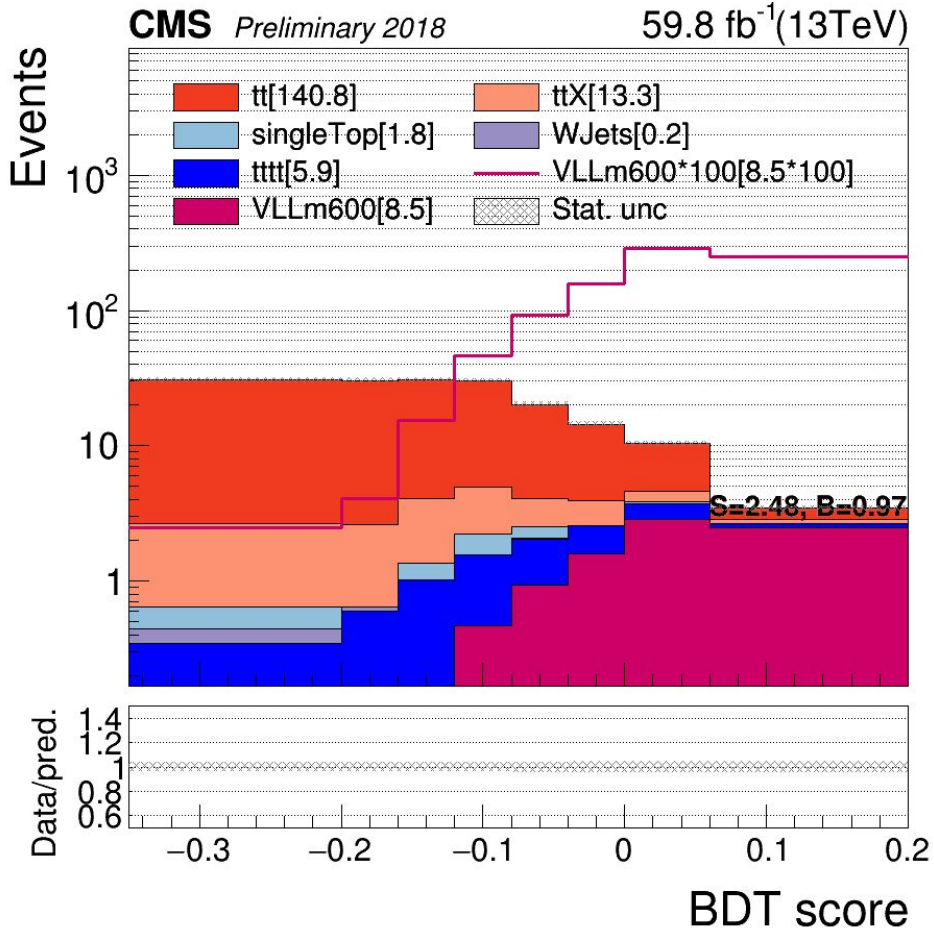

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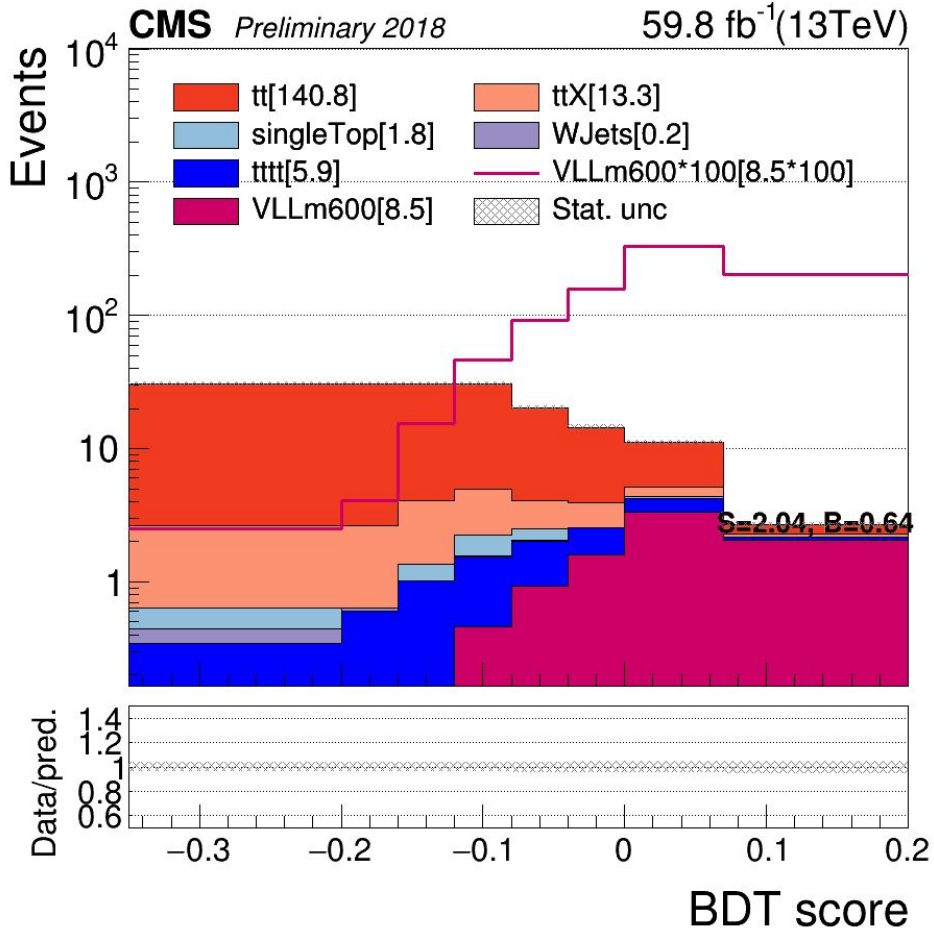

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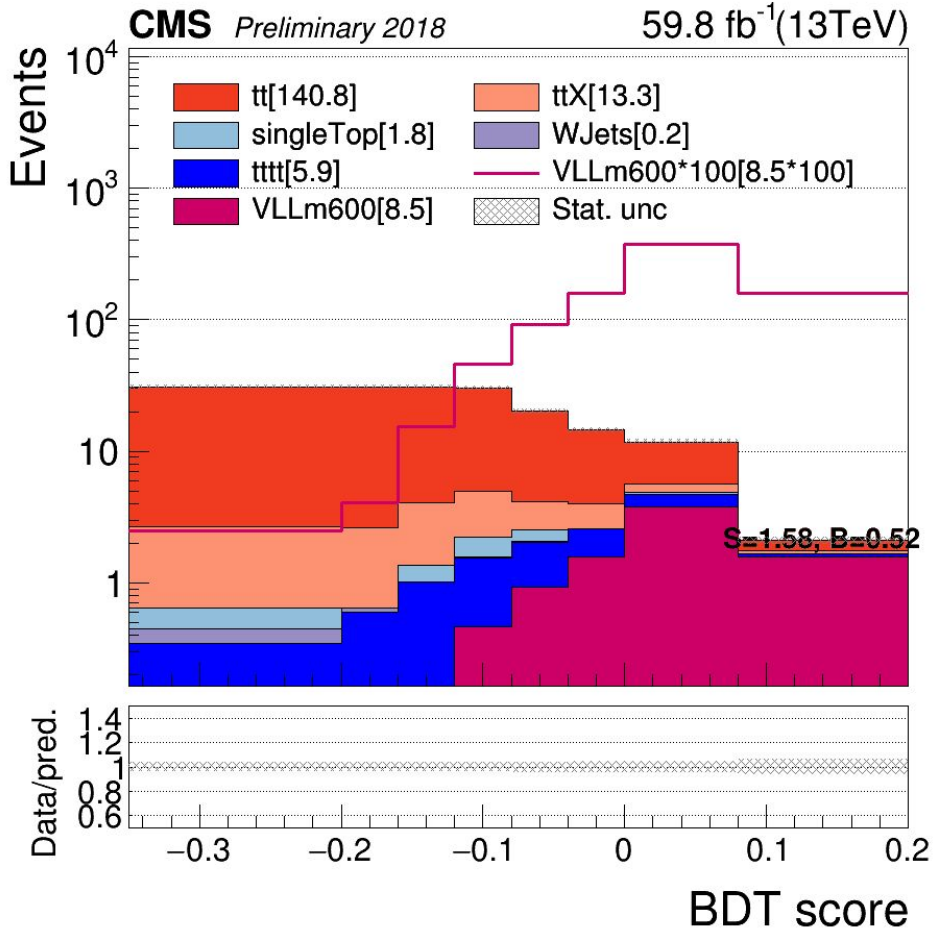
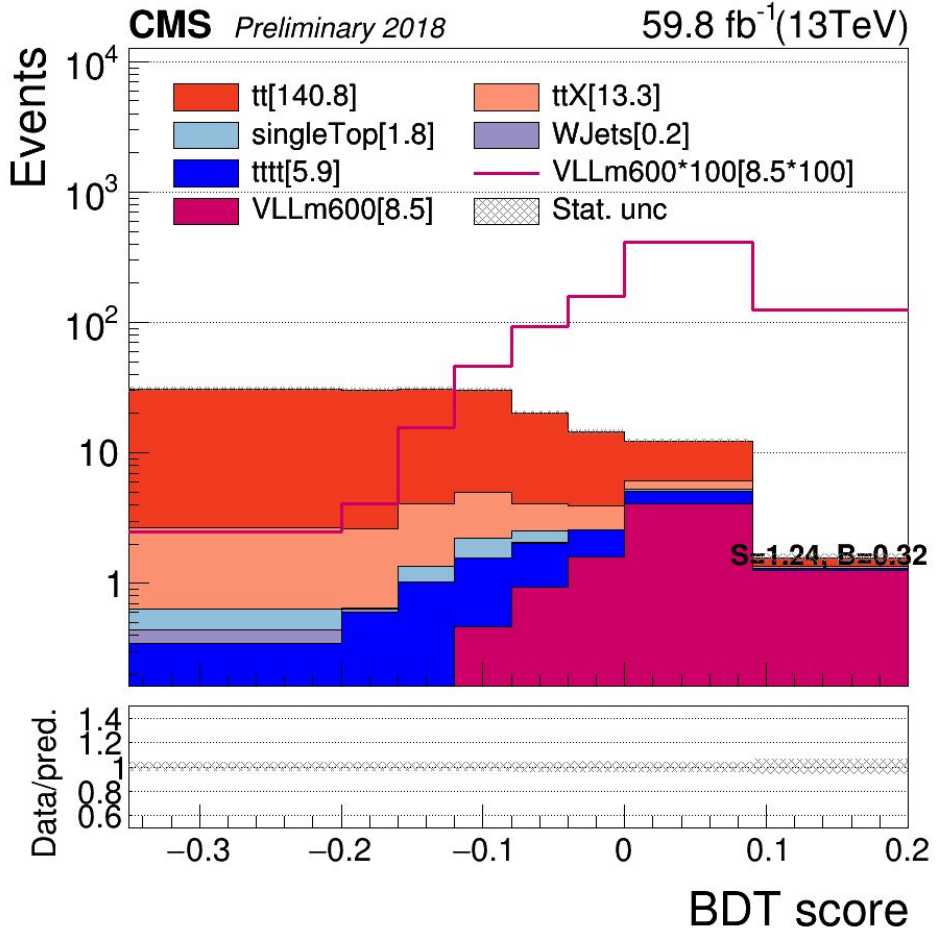
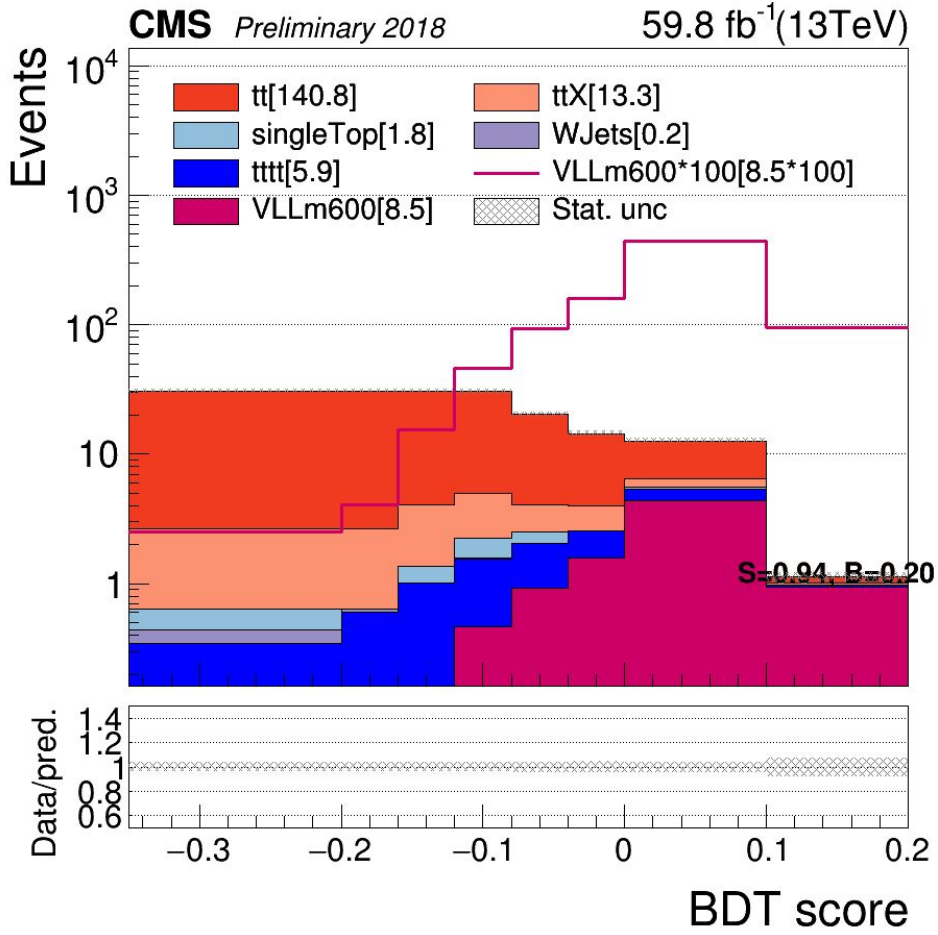


last bin : 0.08-0.2



last bin : 0.09-0.2



last bin : 0.10-0.2

To do list:

- ❑ adding figures for CR1 CR2 done!
- ❑ update the MC of ttbar done!
- ❑ label the data in corresponding figure done!
- ❑ Training performance: overtraining, ROC done!
- ❑ AUC Vs input number done!
- ❑ Results without theoretical uncertainties done!
- ❑ Investigate the problem with theorecitcal uncertainties done!
- ❑ Samples list with VLL
- ❑ VLL sample validation: event entries…
- ❑ Why the mismodeling of CR1? done!