Signal extraction study

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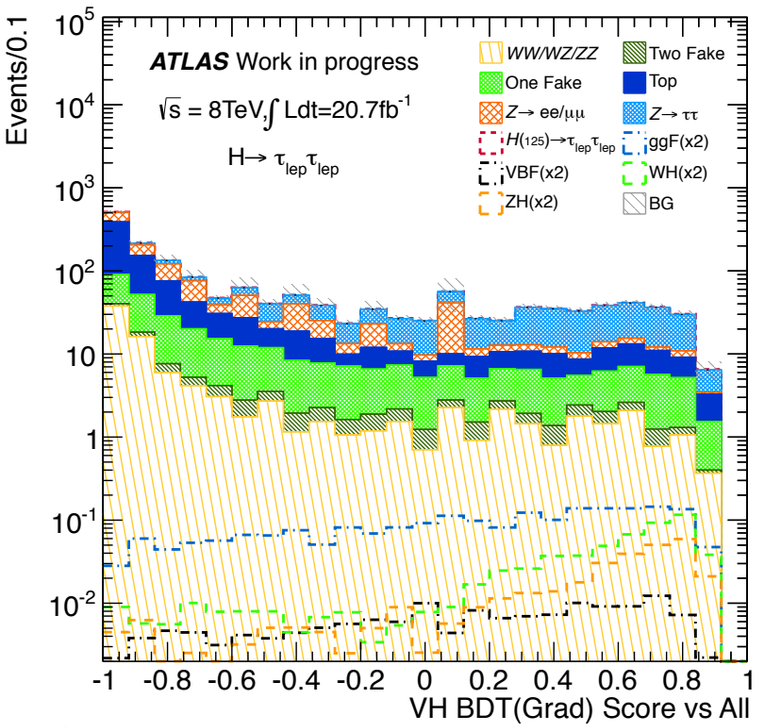
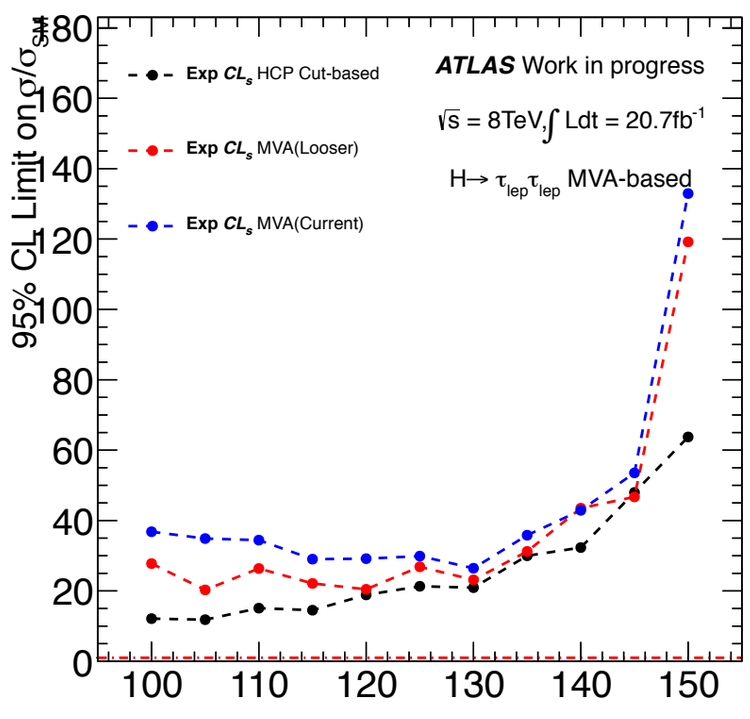
Outline

- Impact of VH category
- Signal extraction
- Input variables
- 2D correlations
- Cut BDT, Fit MMC
- Cut MMC, Fit BDT
- Conclusion

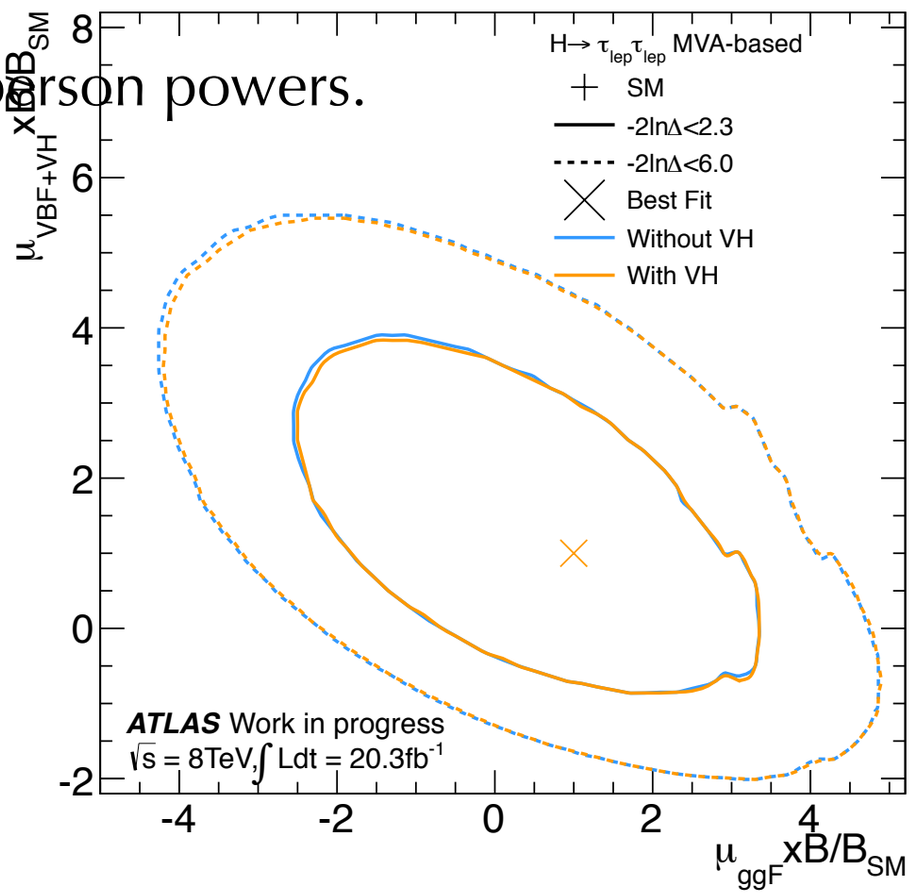
Impact of VH category

- In oder to harmonize other two sub-channels, I investigated the impact of adding the VH category.
- The sensitivity of VH SR is very low→ It seems small effects for combined sensitivity.
- Other motivation is improvement on 2D contour fit (mu_VBFVH v.s. mu_ggF).
  - I check the 2D contour with VH SR or without VH SR. (VBF-Bst-VH-1jet / VBF-Bst-1jet)
- VH definition: Red line: w/o X1,2 cut and many input variable.
  - → Maximum sensitivity at the moment.
- There are very small improvement on the 2D contour.
  - We can drop this category, if we do not have enough person powers.





m_H=125GeV,μ=1
Injection Asimov



Signal extraction study

- There are some methodology as a signal extraction.

Pre-selection
Cut $X_{1,2}$
Not Cut $X_{1,2}$

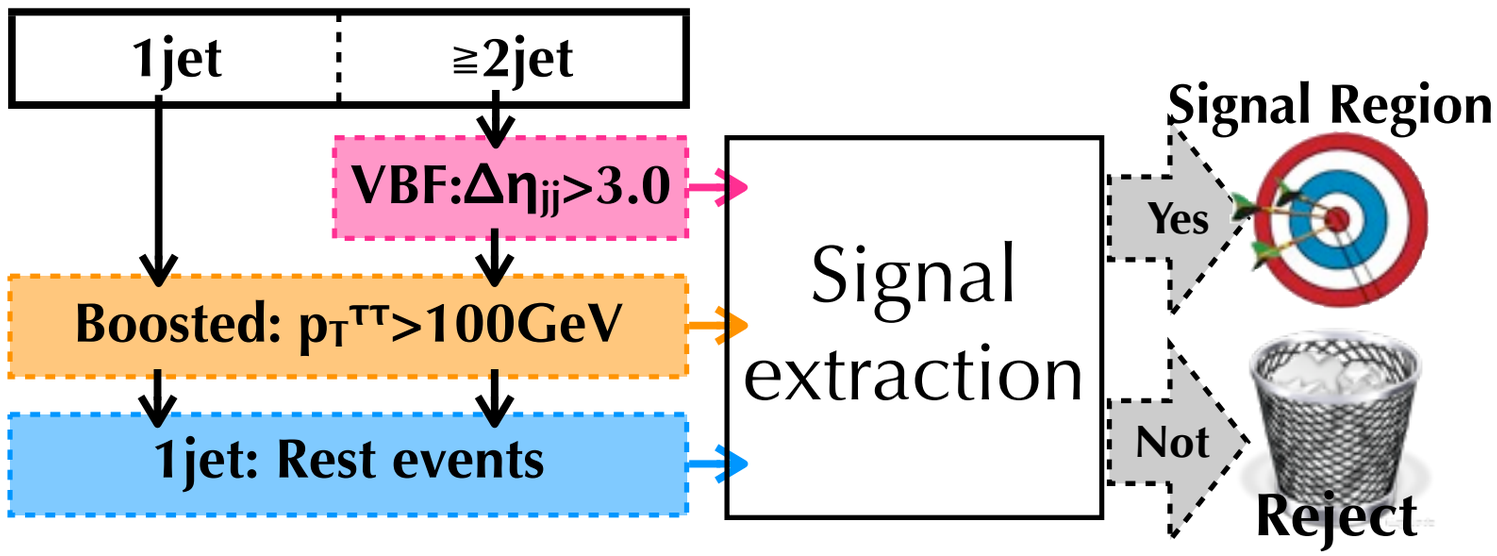
X

input variables
1) w/o MMC, w/o MMC variables
2) w/ MMC
3) w/o MMC, w/ MMC variables(e.g. $\Delta R_{\ell\ell}$)

X

Cut/Fit
Cut BDT, Fit MMC
Cut MMC, Fit BDT

- Procedure of this study,



Input variables

- Input variables for each situation are here,

Category	Variables(w/o $x_{1,2}$,w/o MMC)
VBF	$m_{jj}, \Delta\eta_{jj}, C_\eta^{\ell_1} \times C_\eta^{\ell_2}, C_\eta^{j_3}$ $p_T^{jj}, C_\phi^{\rm MET}, \Delta R_{\ell\ell}, \Delta\eta(\ell\ell, \text{jets})$
Boosted	$m_T^{\ell_1}, m_T^{\ell_2}, H_T, C_\phi^{\rm MET}, \Delta R_{\ell\ell}, \Delta\eta_{\ell\ell}$
1jet	$m_T^{\ell_1}, m_T^{\ell_2}, H_T, C_\phi^{\rm MET}$ $\Delta R_{\ell\ell}, \Delta\eta_{\ell\ell}, E_T^{\rm miss}/p_T^{\ell_2}$

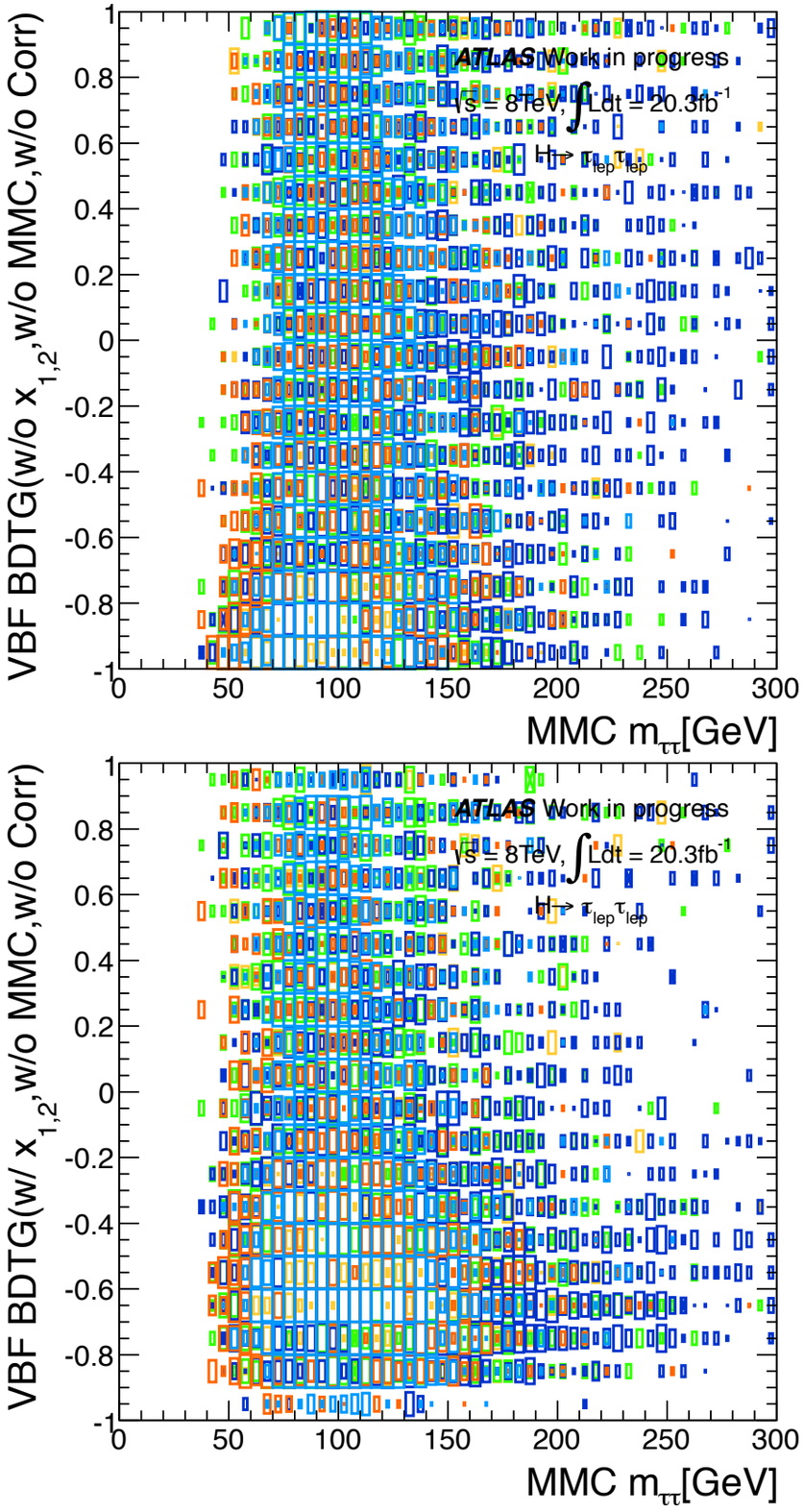
Category	Variables(w/ $x_{1,2}$,w/o MMC)
VBF	$m_{jj}, \Delta\eta_{jj}, C_\eta^{\ell_1} \times C_\eta^{\ell_2}, C_\eta^{j_3}$ $p_T^{jj}, m_T^{\ell_1}, \Delta R_{\ell\ell}, \Delta\eta(\ell\ell, \text{jets})$
Boosted	$m_T^{\ell_1}, m_T^{\ell_2}, H_T, \Delta R_{\ell\ell}, \Delta\phi_{\ell\ell}$,Sphericity
1jet	$m_T^{\ell_1}, m_T^{\ell_2}, H_T, C_\phi^{\rm MET}$ $\Delta R_{\ell\ell}, \Delta\eta_{\ell\ell}, E_T^{\rm miss}/p_T^{\ell_2}$

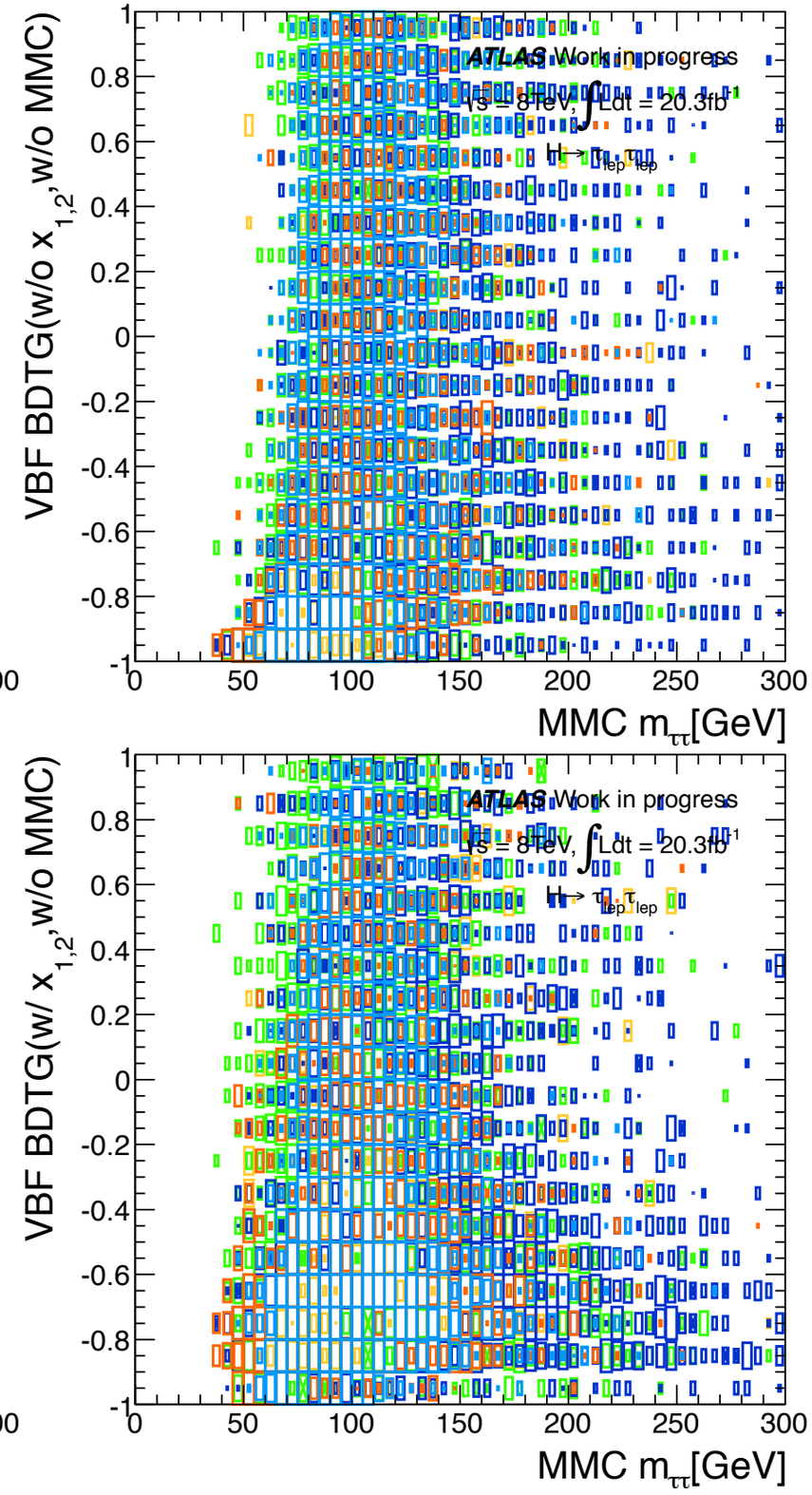
Category	Variables(w/o $x_{1,2}$,w/o Corr)
VBF	$m_{jj}, \Delta\eta_{jj}, C_\eta^{\ell_1} \times C_\eta^{\ell_2}, C_\eta^{j_3}$ $p_T^{jj}, C_\phi^{\rm MET}, \Delta\eta(\ell\ell, \text{jets})$
Boosted	$m_T^{\ell_1}, m_T^{\ell_2}, H_T, C_\phi^{\rm MET}$,Sphericity
1jet	$m_T^{\ell_1}, m_T^{\ell_2}, C_\phi^{\rm MET}$,Sphericity

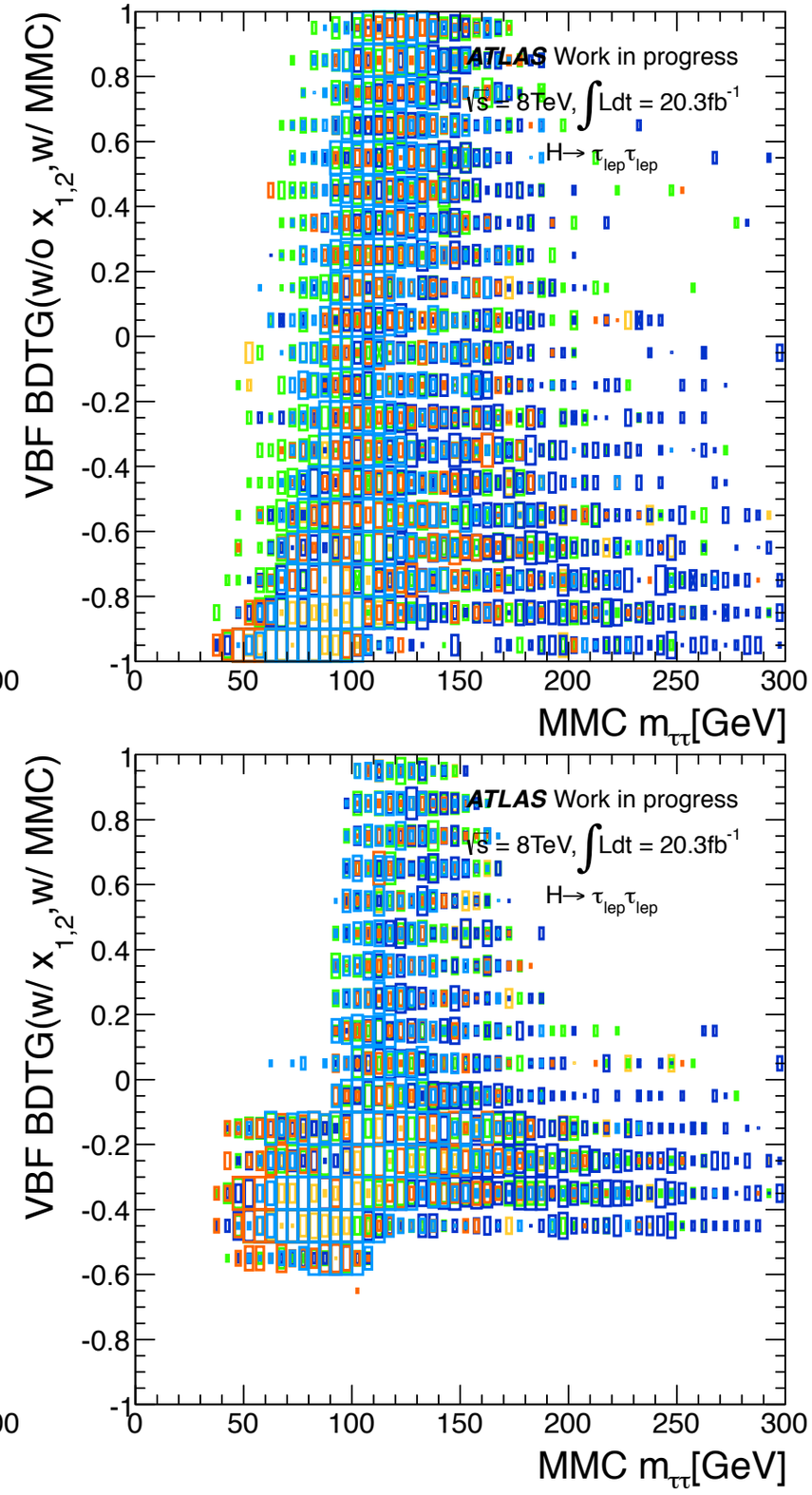
Category	Variables(w/ $x_{1,2}$,w/o Corr)
VBF	$m_{jj}, \Delta\eta_{jj}, C_\eta^{\ell_1} \times C_\eta^{\ell_2}, C_\eta^{j_3}$ $p_T^{jj}, m_T^{\ell_1}, \Delta\eta(\ell\ell, \text{jets})$
Boosted	$m_T^{\ell_1}, m_T^{\ell_2}, H_T, C_\phi^{\rm MET}$,Sphericity
1jet	$m_T^{\ell_1}, m_T^{\ell_2}, C_\phi^{\rm MET}$,Sphericity

- In the case of inputting MMC, I just added MMC into the “w/o MMC table”.
- I used gradient boosting for all training and tuning study done. (please see backup slide)

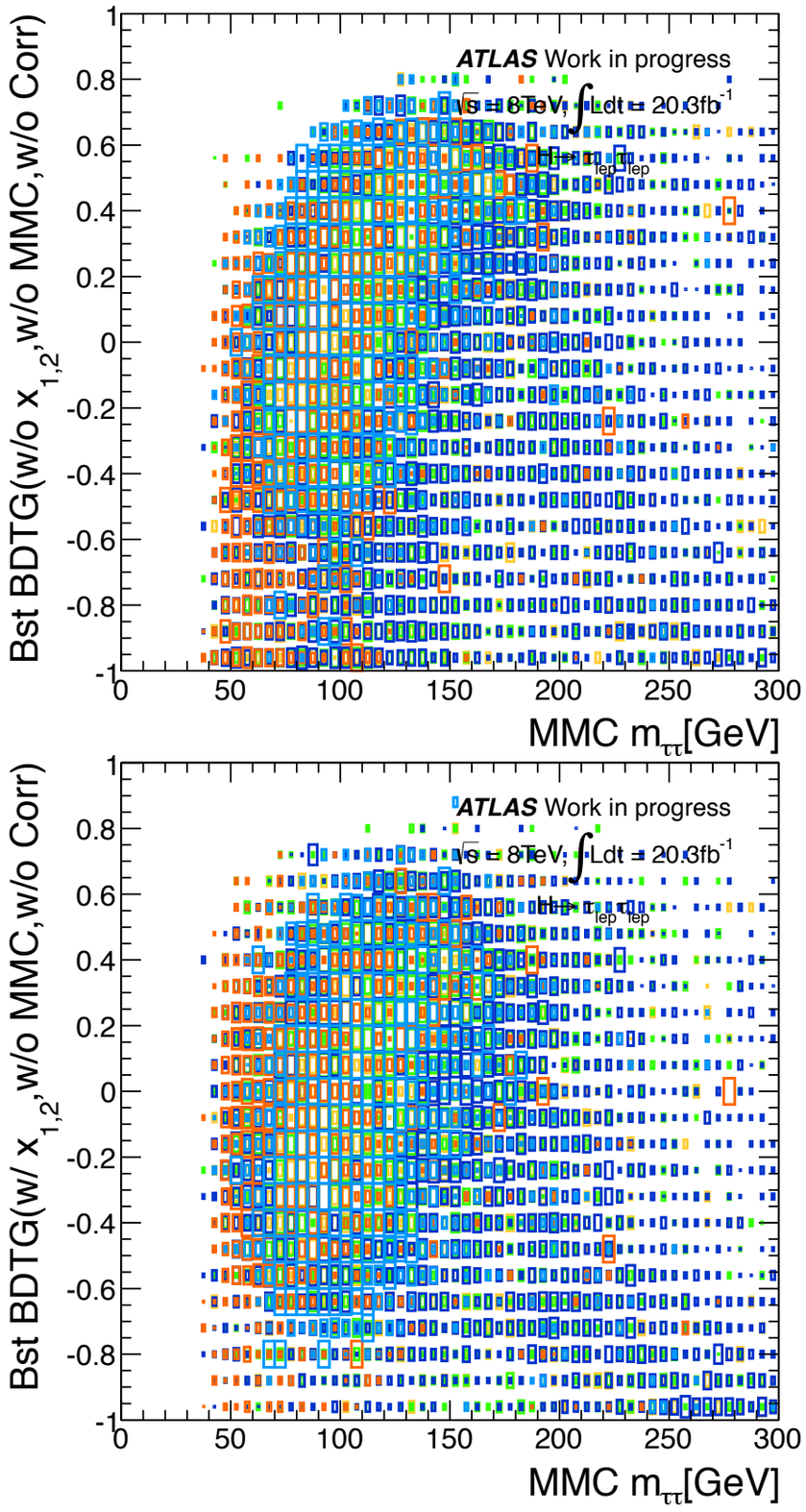
2D correlation VBF(bkg)

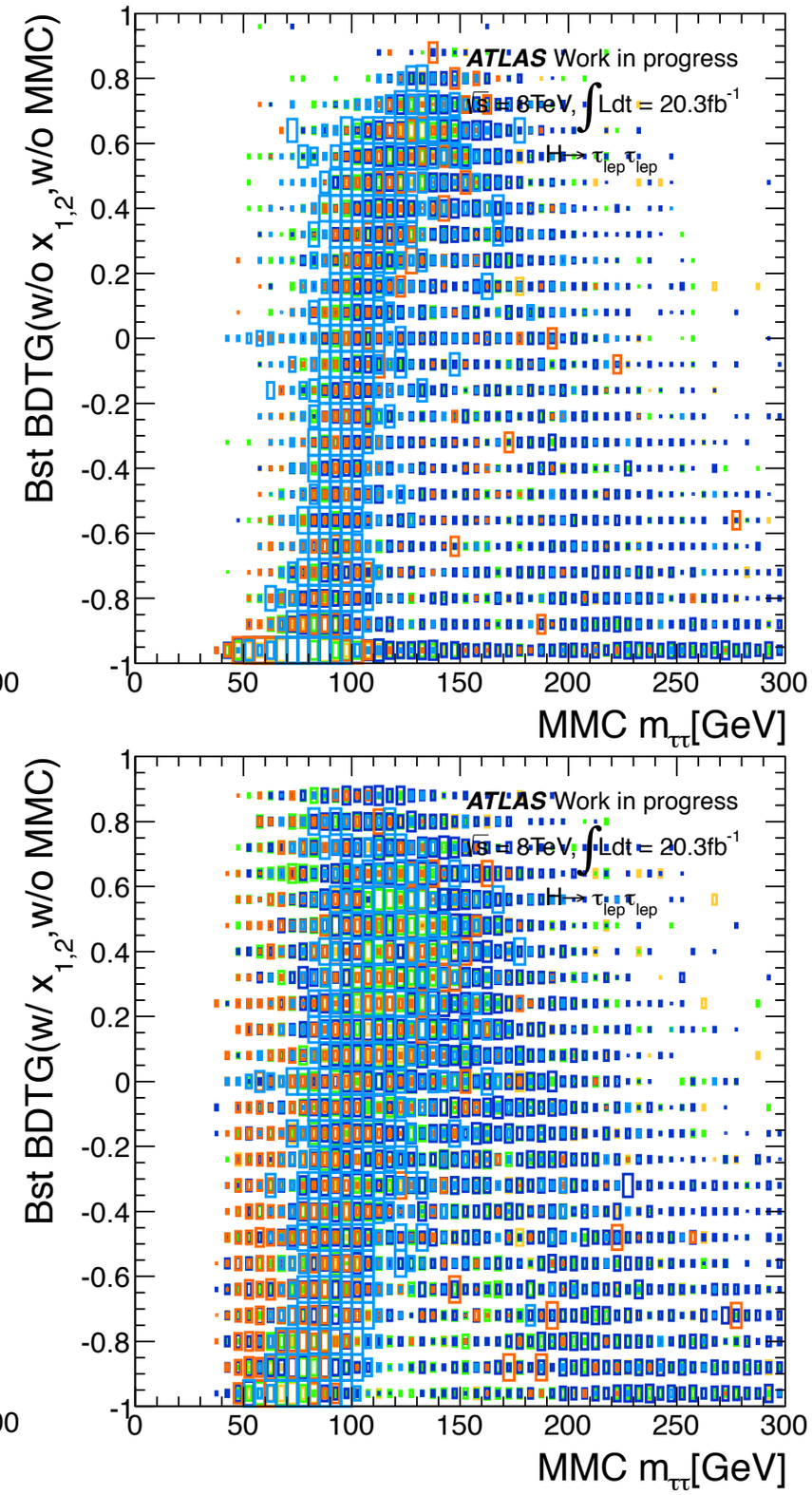


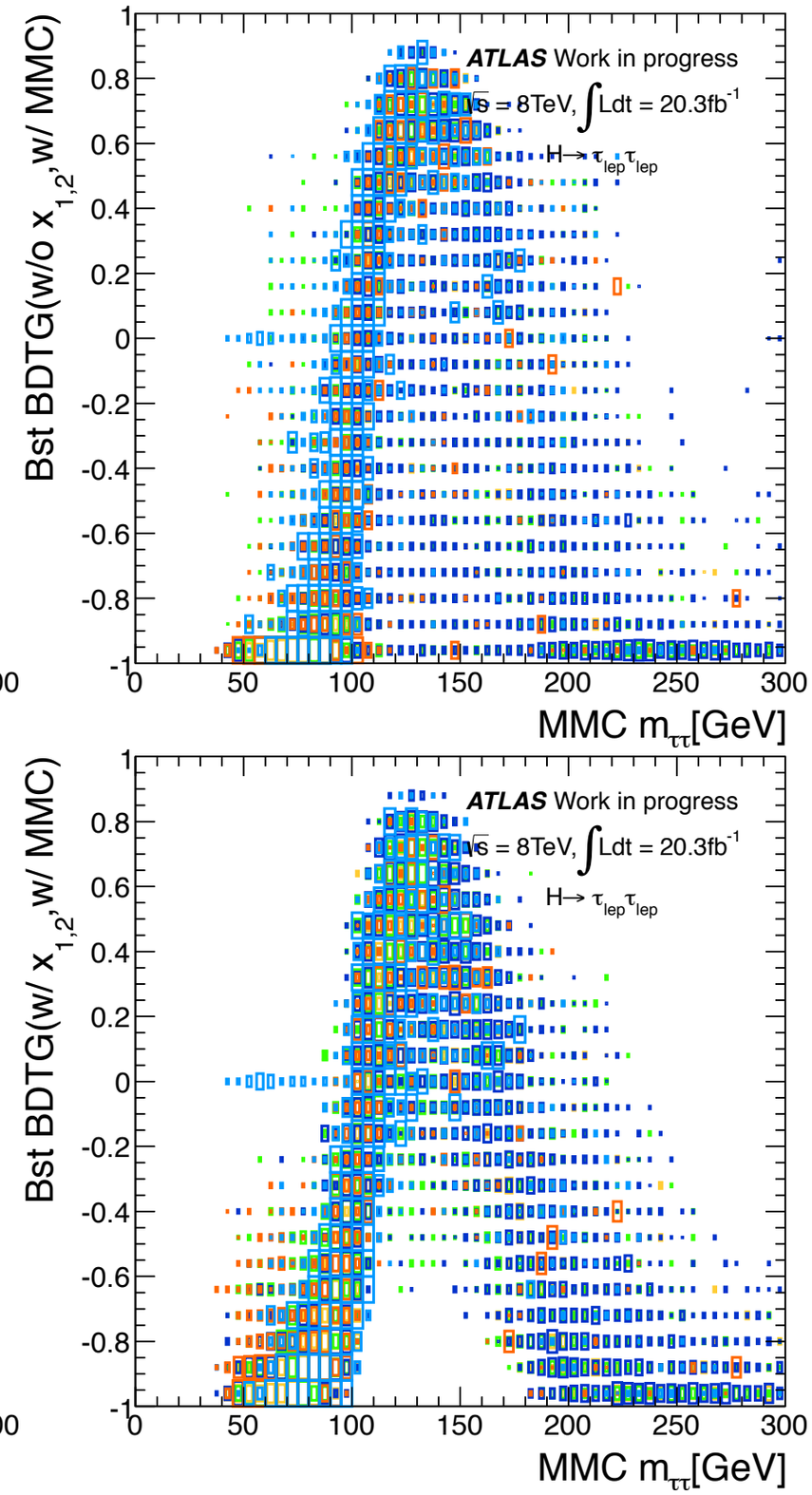




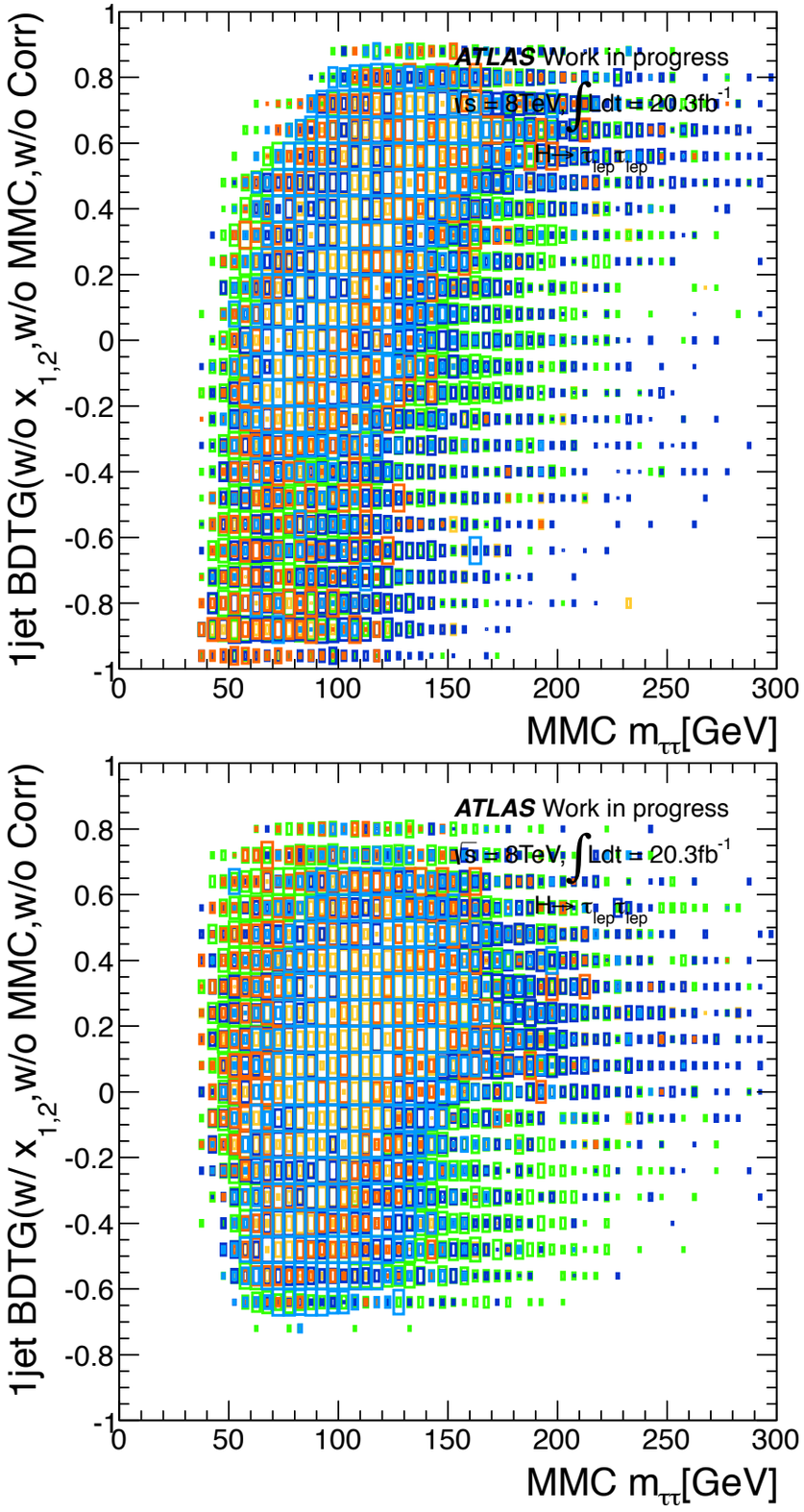
2D correlation Boosted(bkg)

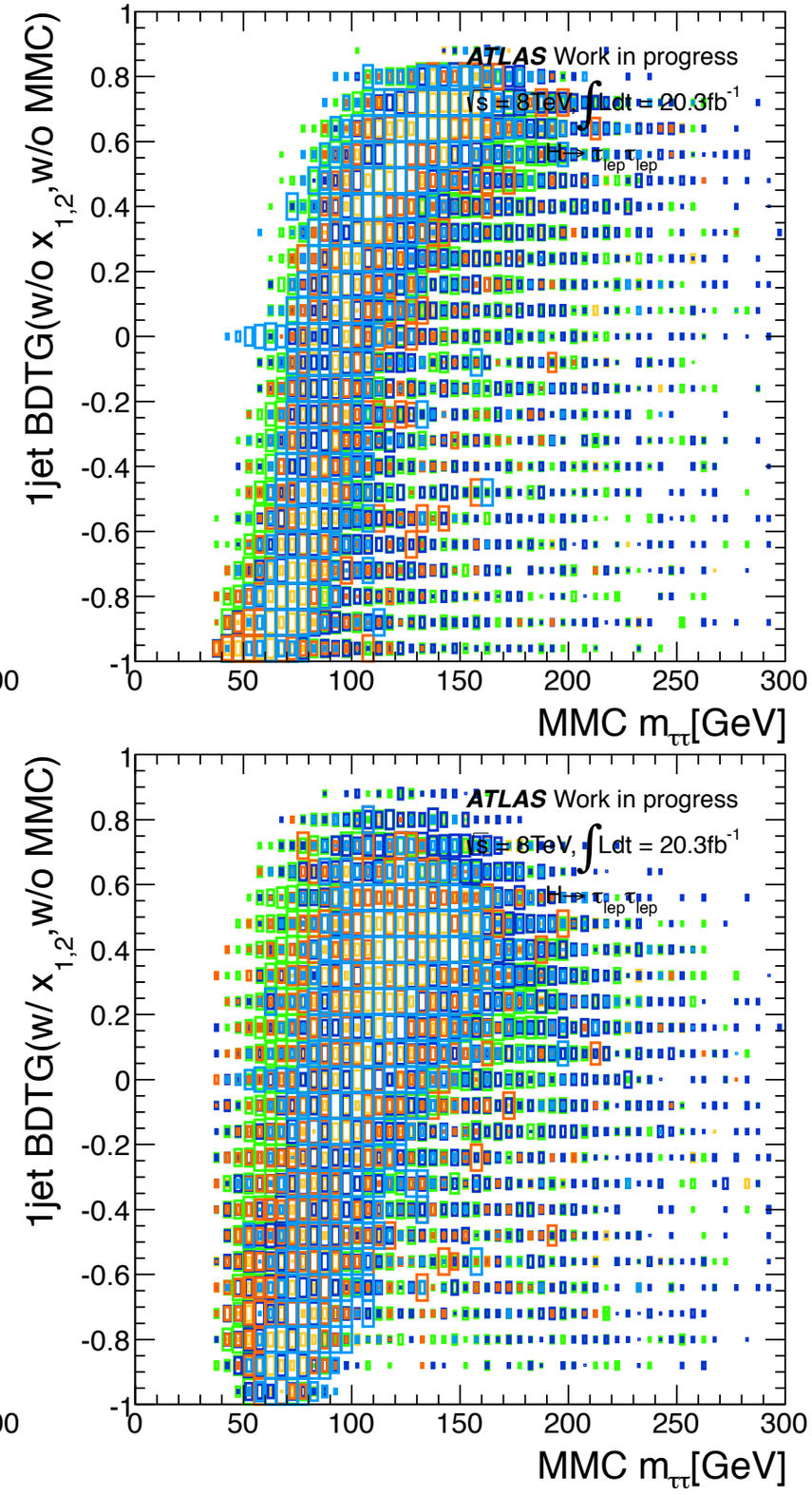


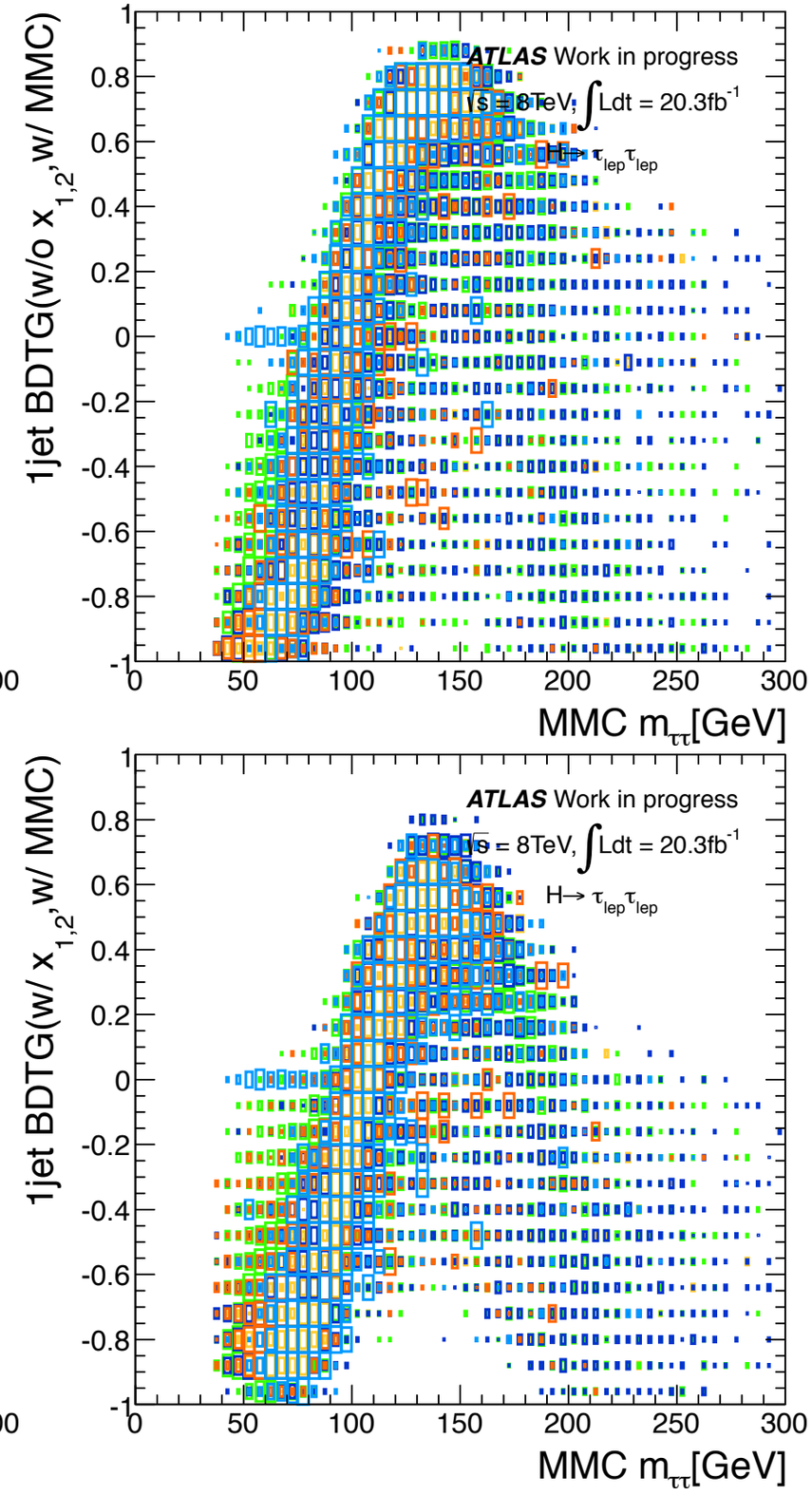




2D correlation 1jet(bkg)

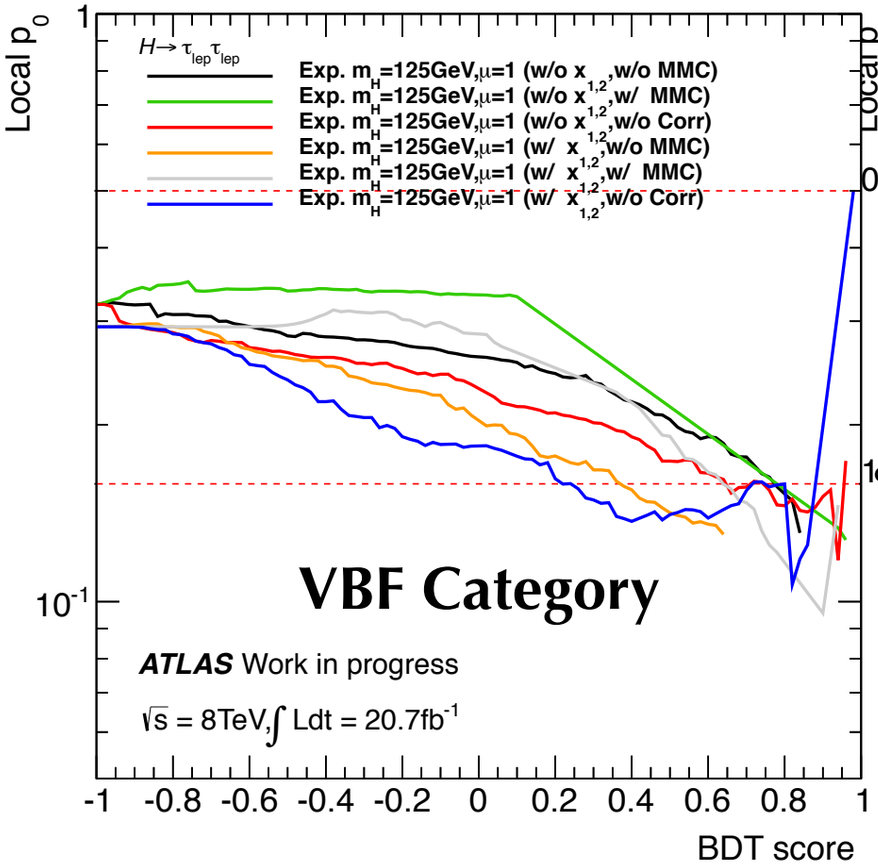


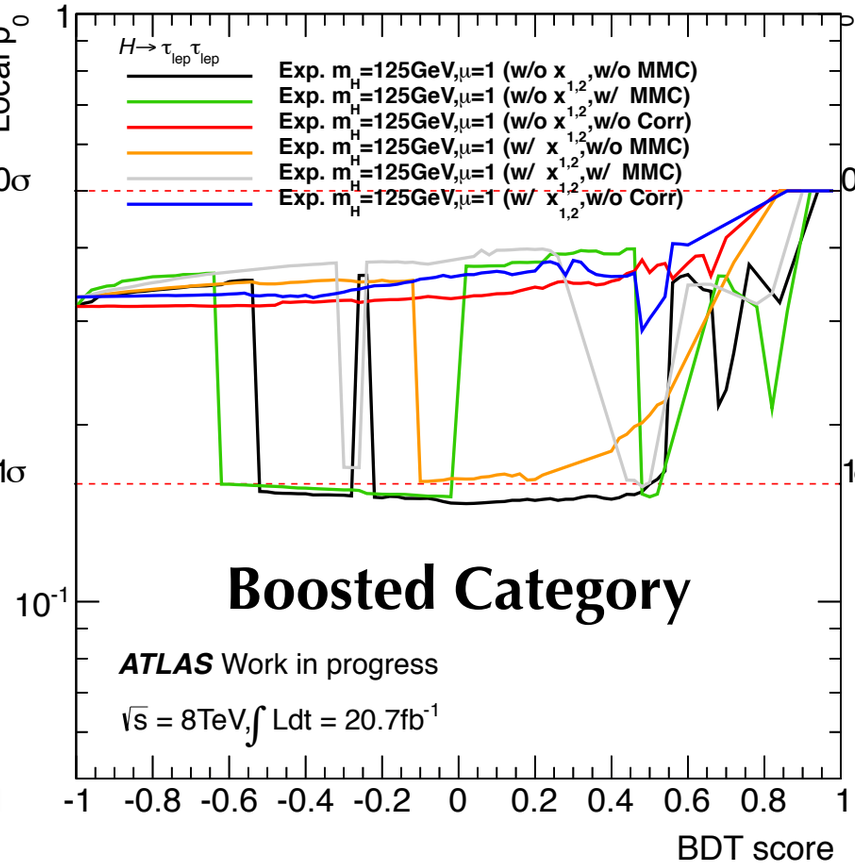


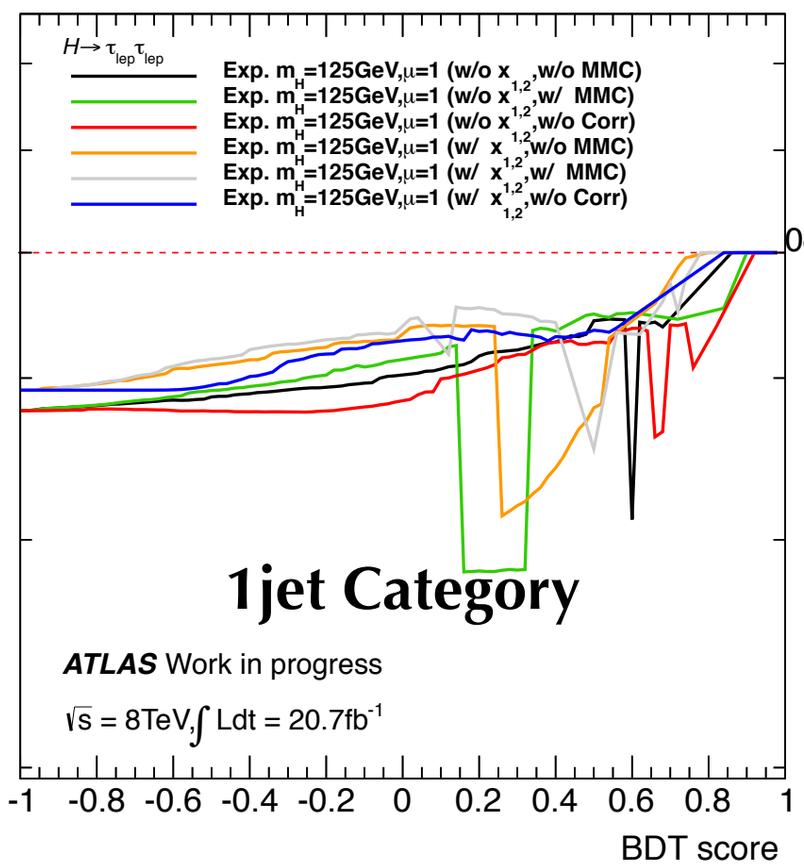


Cut BDT, Fit MMC

- Scanning local p0 as a function of threshold of BDT output.

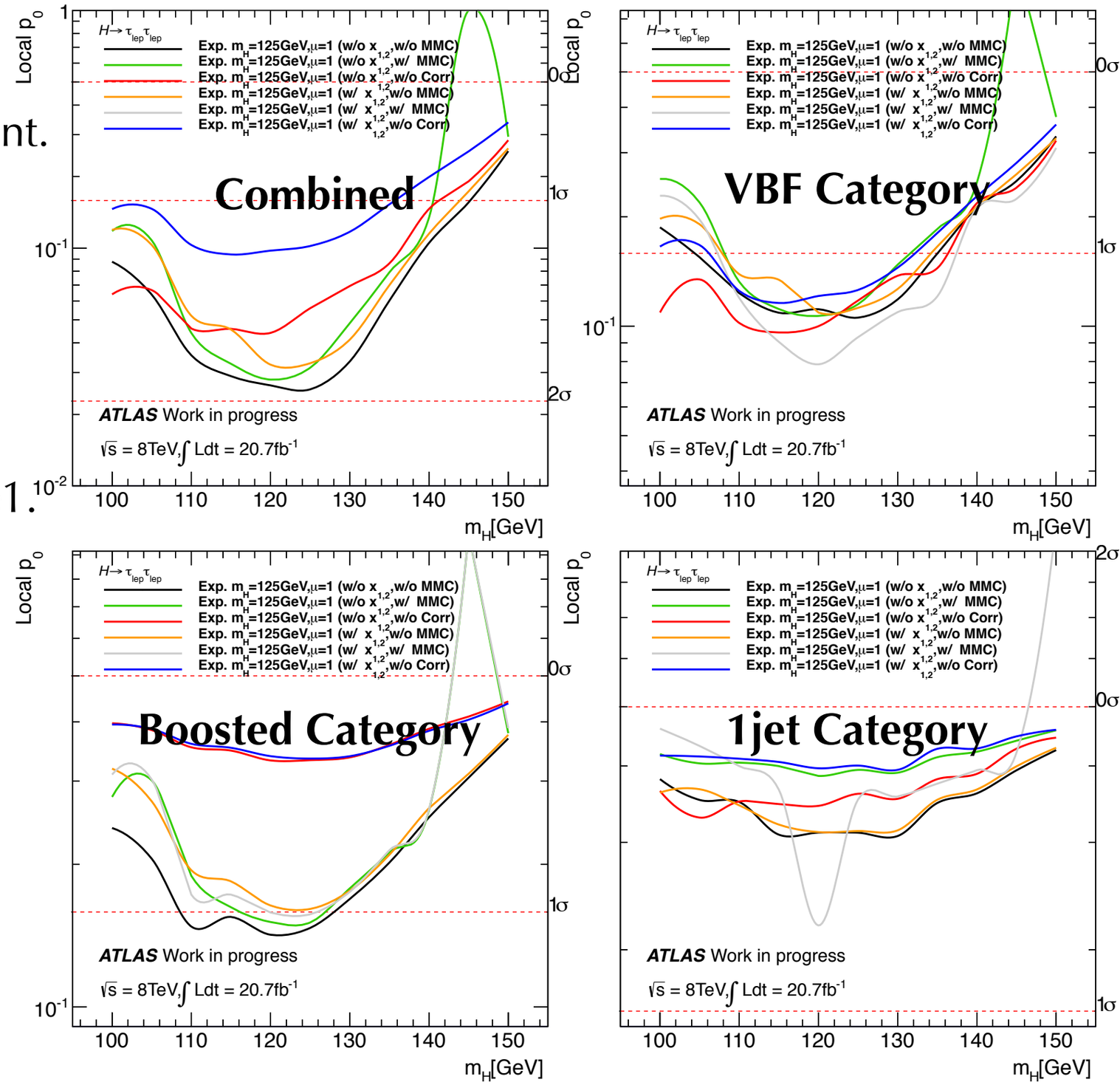






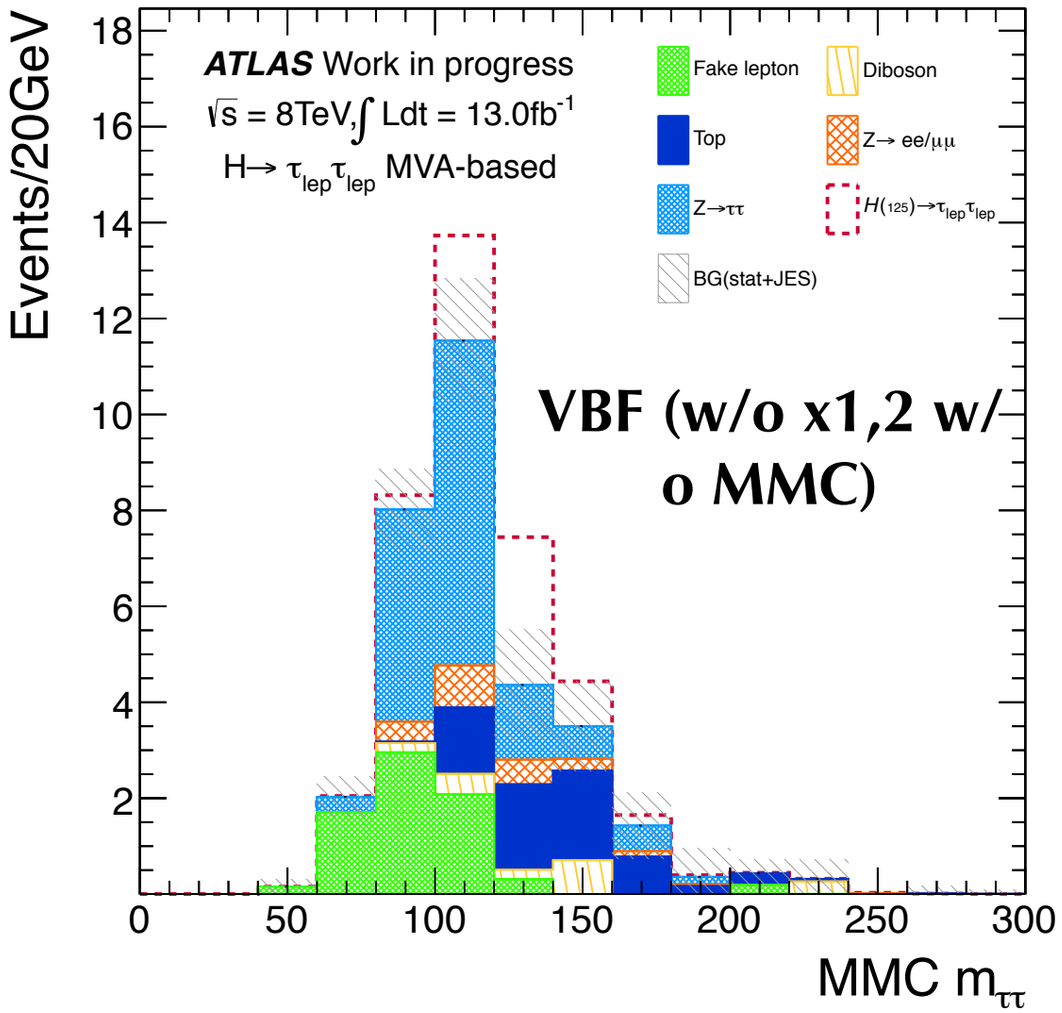
Cut BDT, Fit MMC

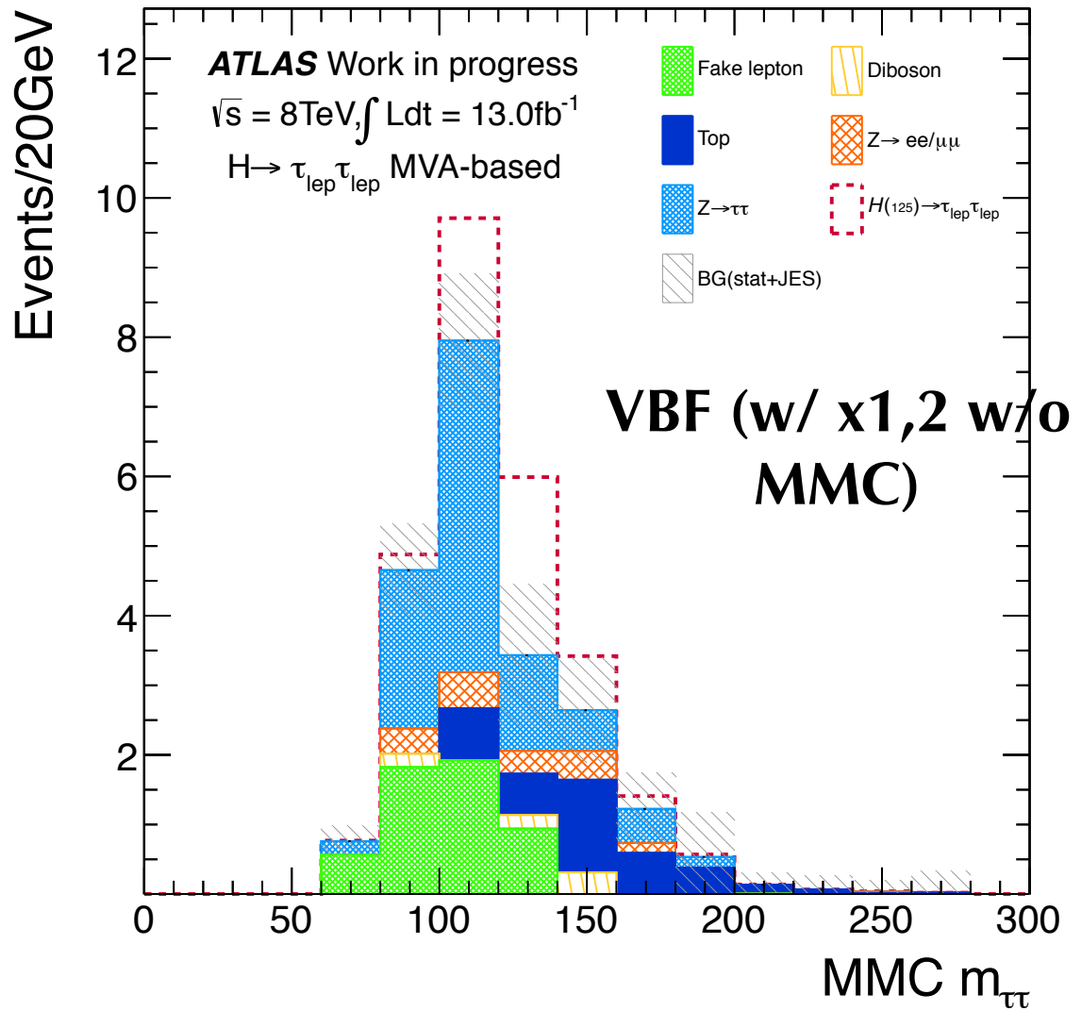
- Cut BDT score at most sensitive point.
- Fit MMC distribution.
- Plot local p0 as a function of mH.
  - 125GeV mu=1 injection.
- Most powerful method is
  - without X1,2 cut and input Type1.
- Or second candidate is
  - with X1,2 cut and input Type1.
- Maybe w/ X1,2 and input Type1 is less correlation than w/o X1,2



MMC distribution

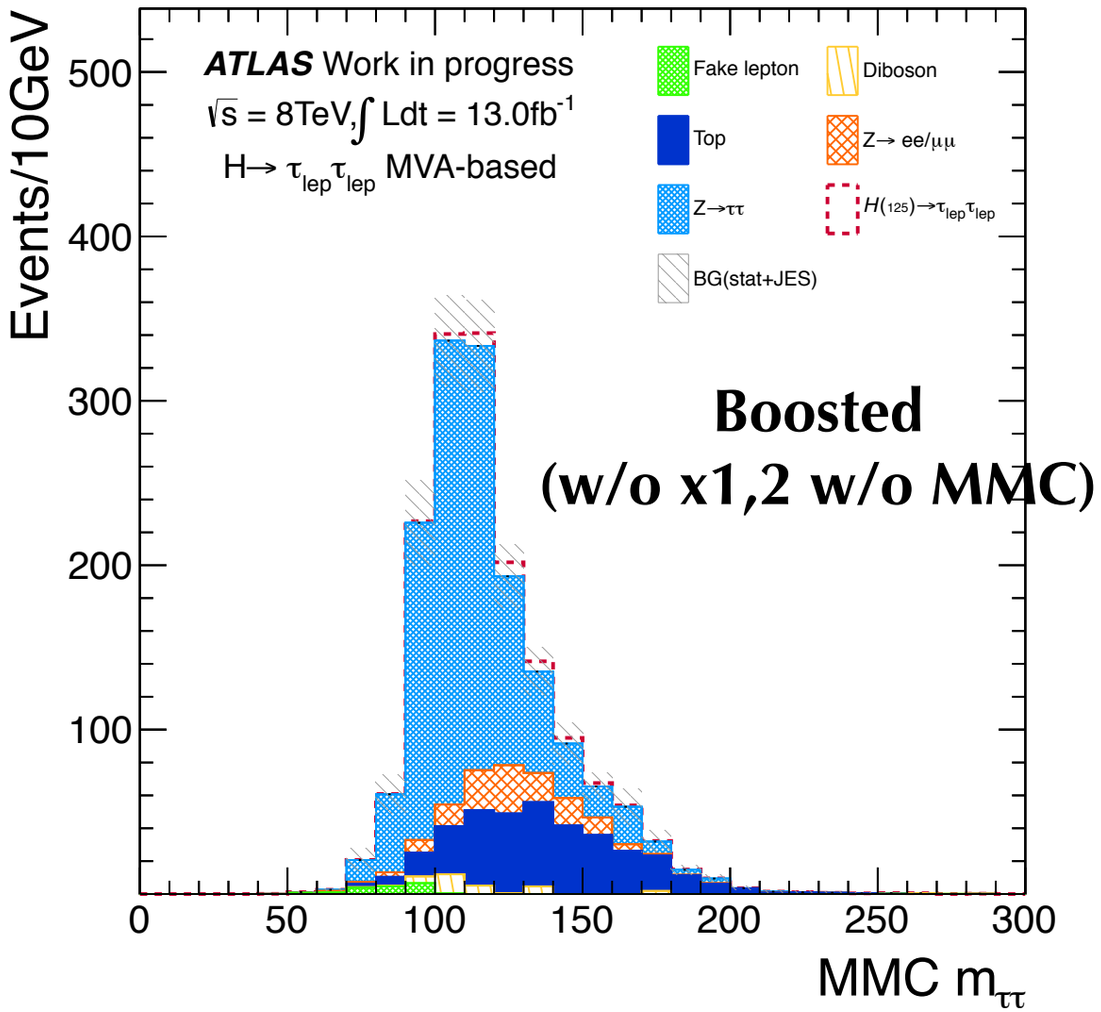
- Sightly mass shift can be seen, however this effect is small for VBF category.

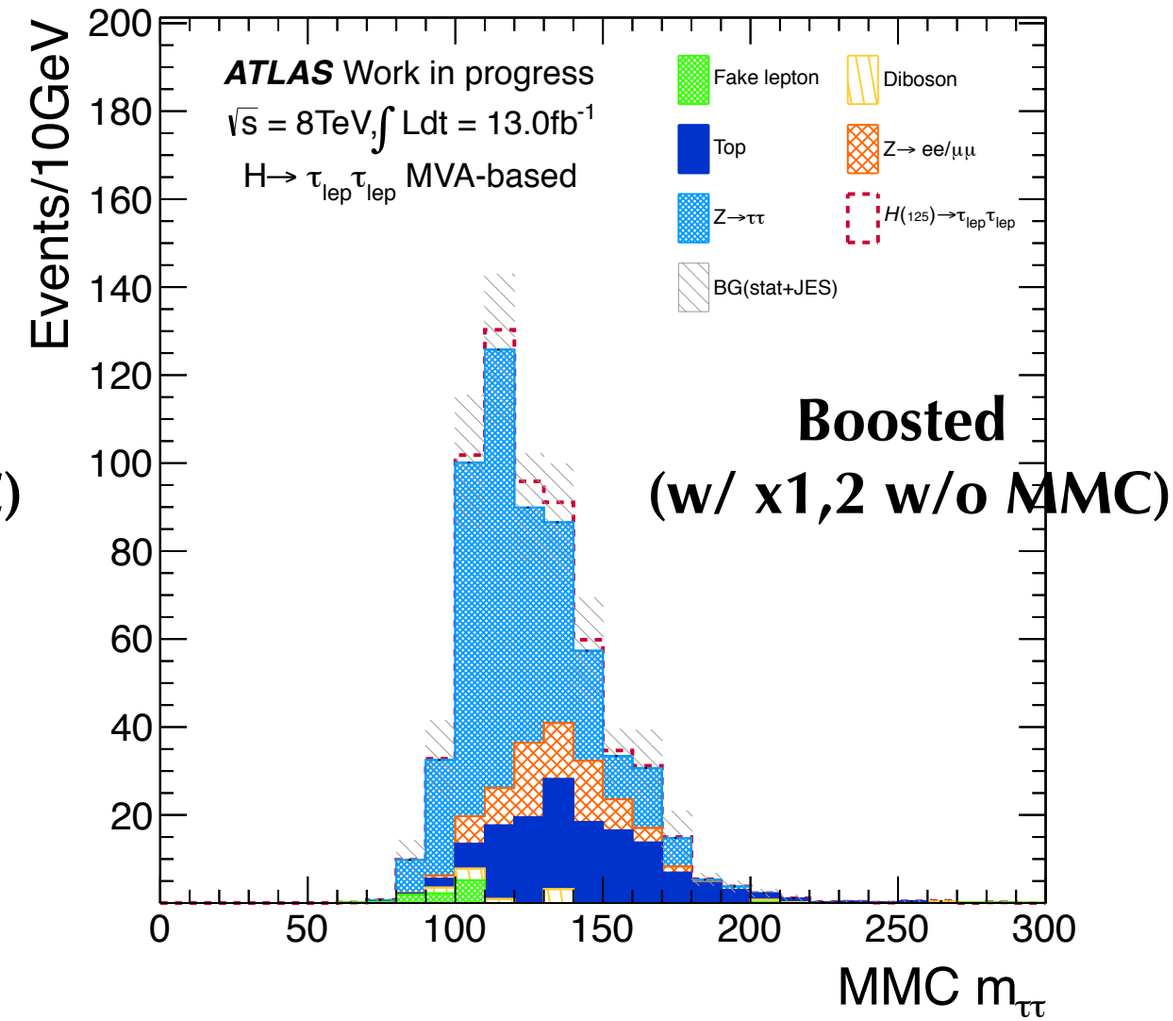




MMC distribution

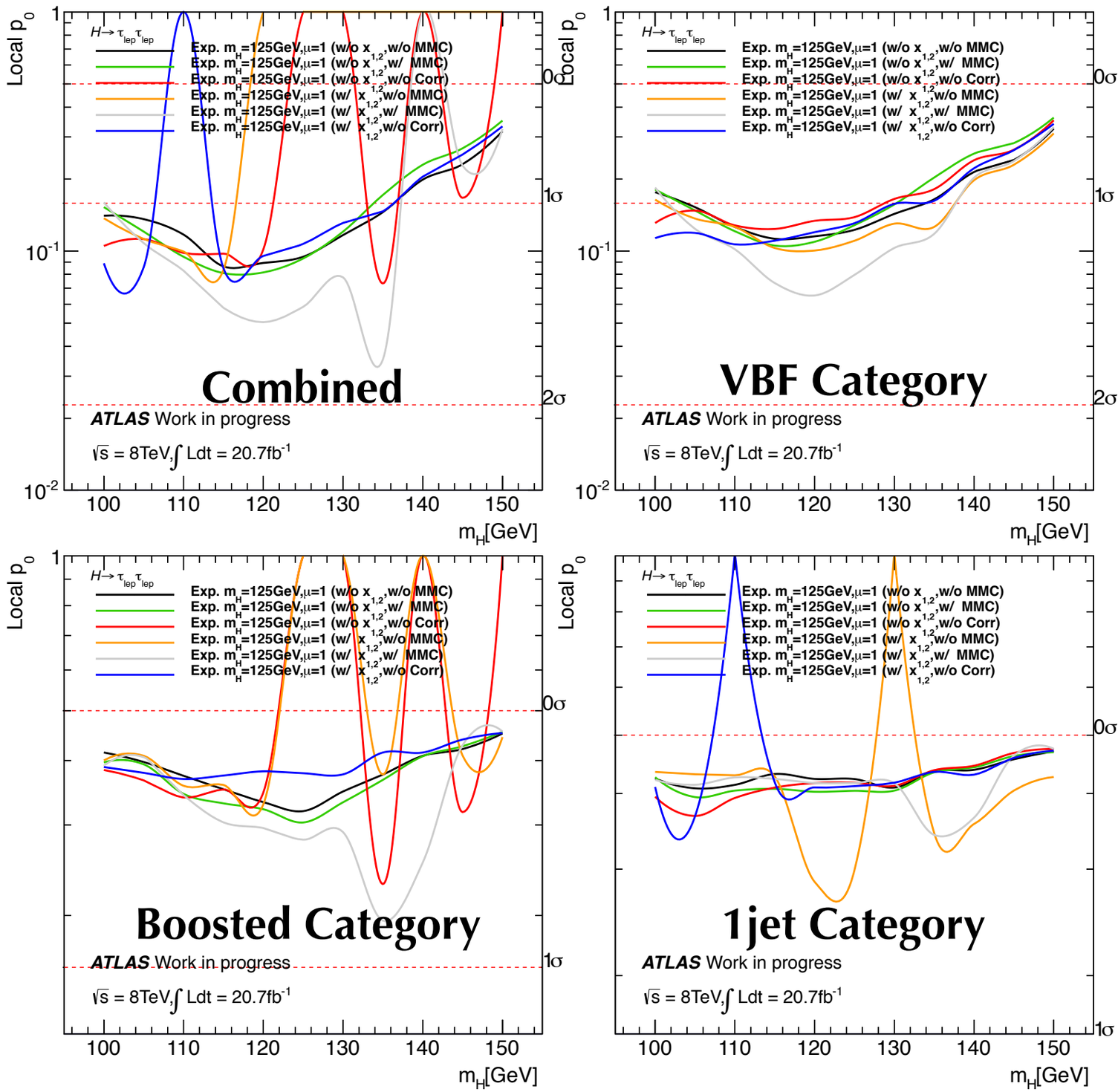
- Mass shift effects are quite large...





Cut MMC, Fit BDT

- Cut |mH-MMC| < 25GeV.
- Fit BDT score distribution.
  - Binning are forced by 20bins.
- Plot local p0 as a function of mH.
- Most powerful method is
  - with $X_{1,2}$ cut and input MMC.
- Strange behavior can be seen.
  - Maybe 0 bin effects.
- Need to optimize the binning.

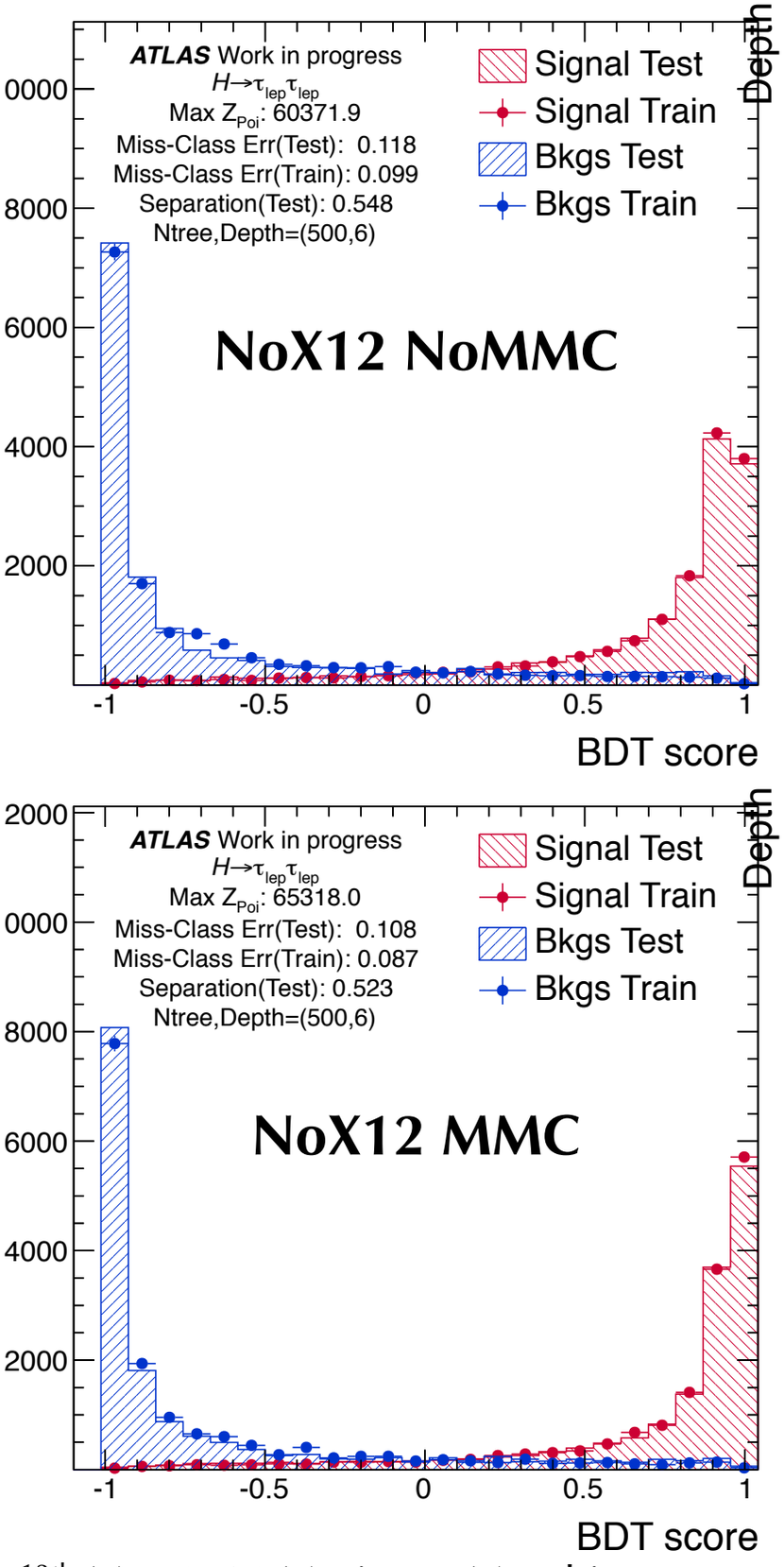


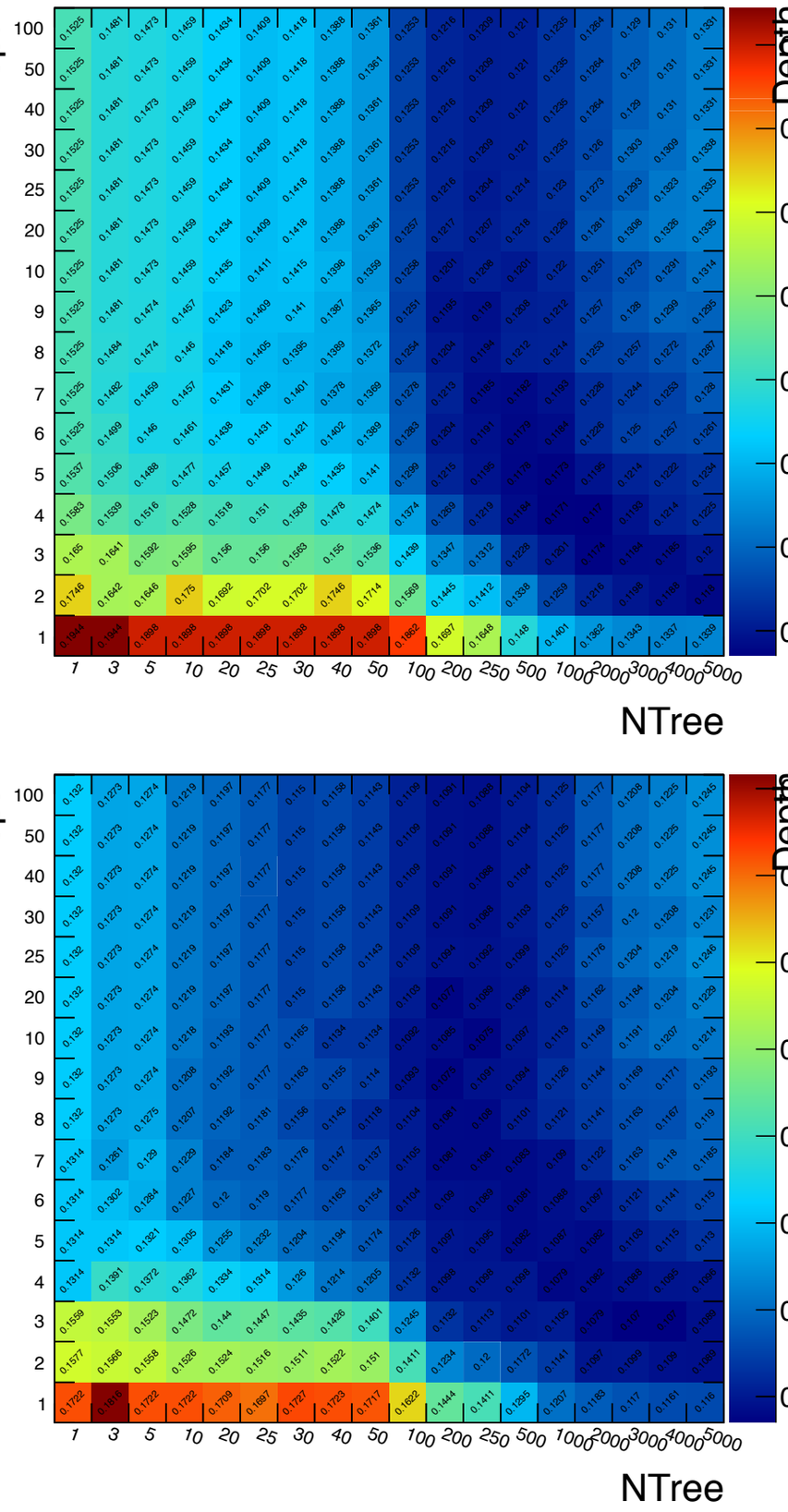
Conclusion

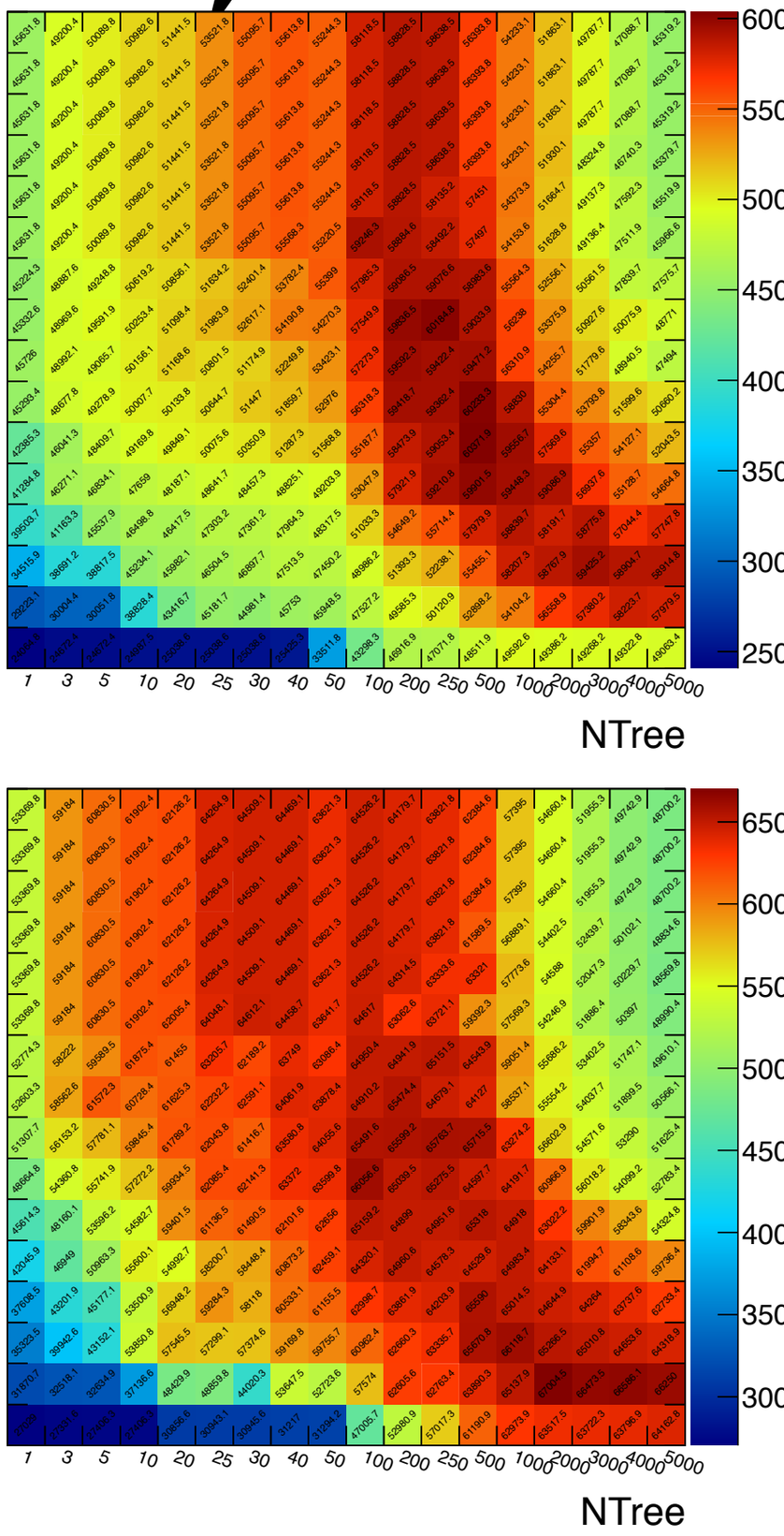
- The VH category is not effective to improve sensitivity and signal strength measurement.
  - I strongly recommend dropping this category.
- New variables (i.e. dRll,dPhill) has vary strong correlation with MMC mass.
- For the VBF category,
  - We can get additional sensitivities gain, if we input more two/three variables.
  - MMC or MMC variables slightly affect final mass.
- For the Boosted/1jet categories,
  - MMC or MMC variables has strong separating power.
  - But these variables has strong mass shift effects.
  - However if we do not input such variables, we cannot get better sensitivities...
  - (A solution of these mass shift effects seems to train with MMC window events?)
- Cut MMC, fit BDT:
  - All categories seem to improve sensitivities, if we input MMC directly.

Back Up!

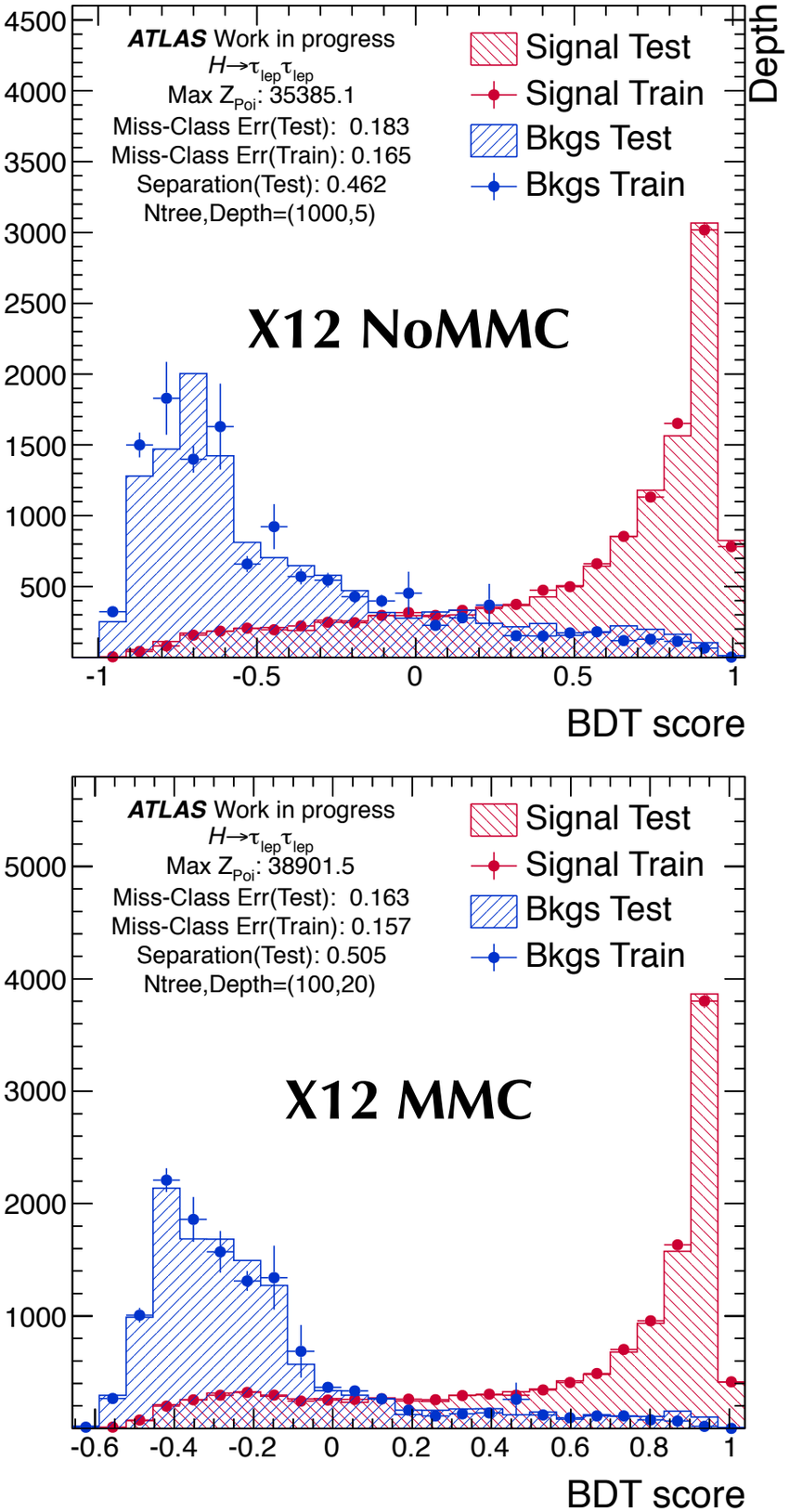
VBF BDTG w/o X1,2

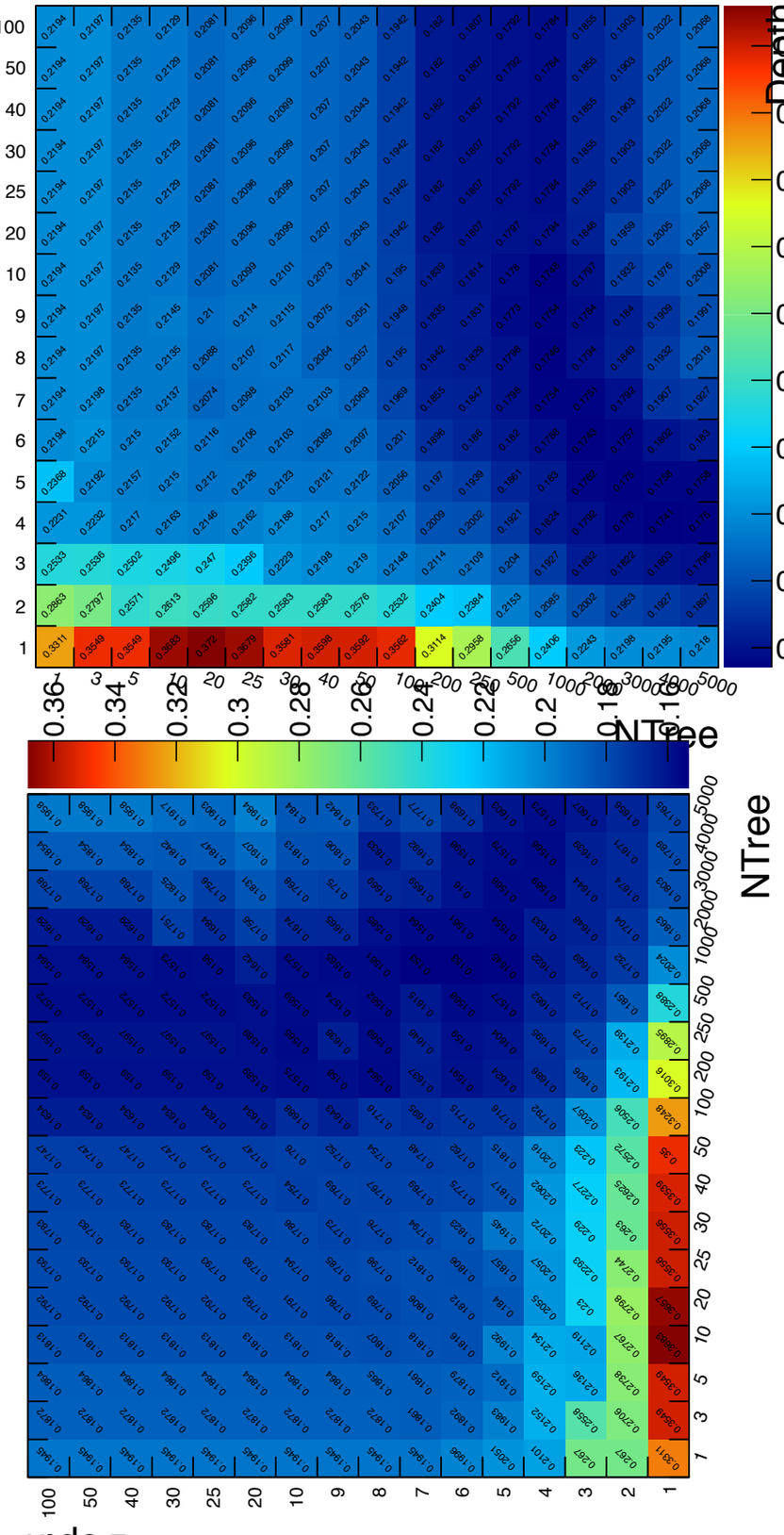


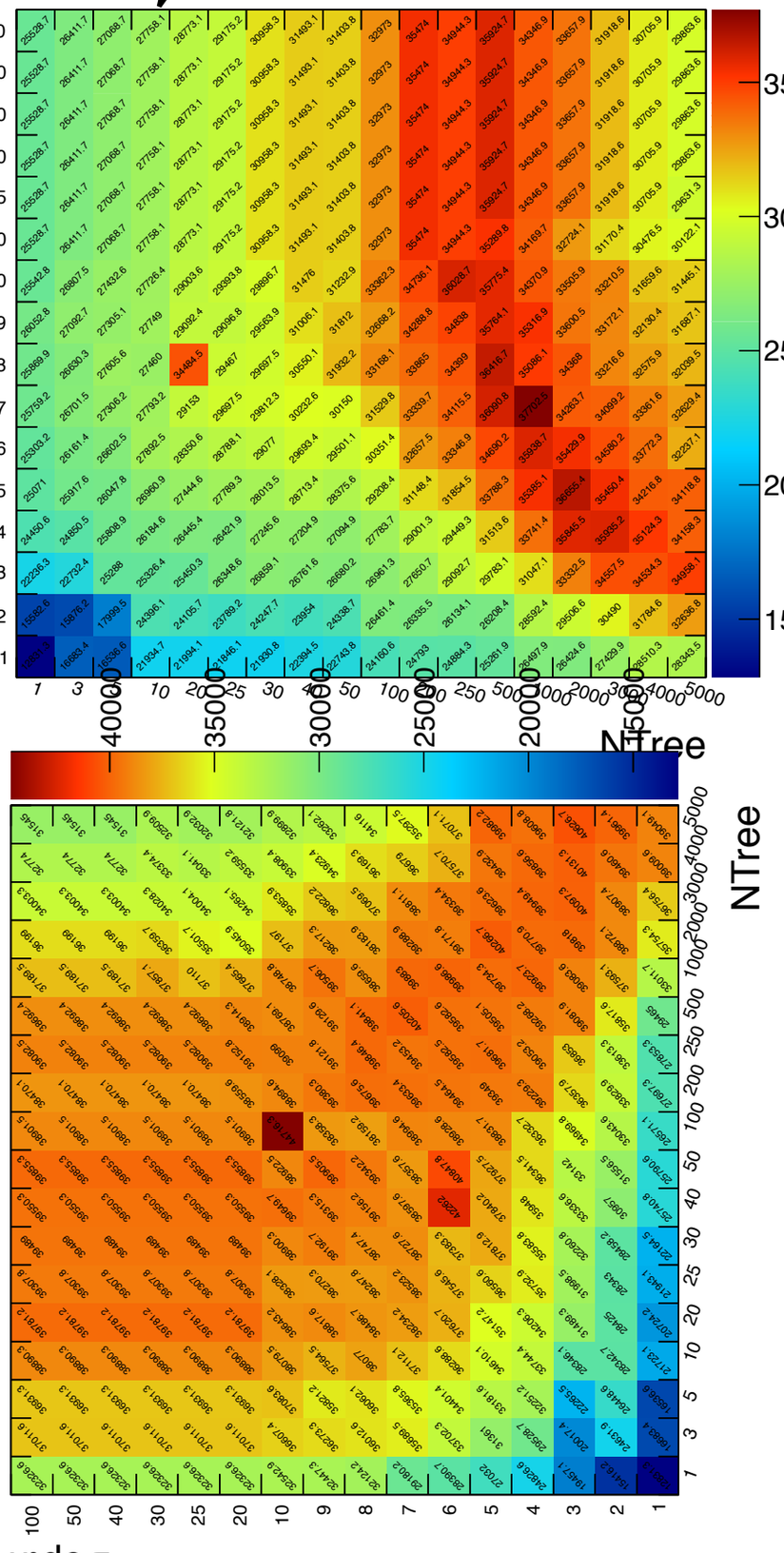




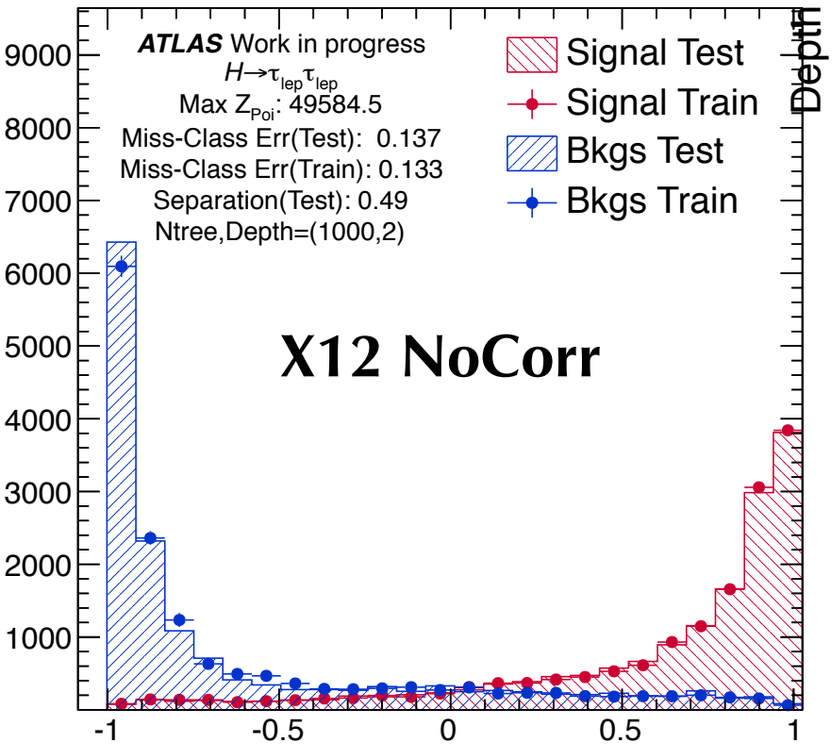
VBF BDTG w/ X1,2

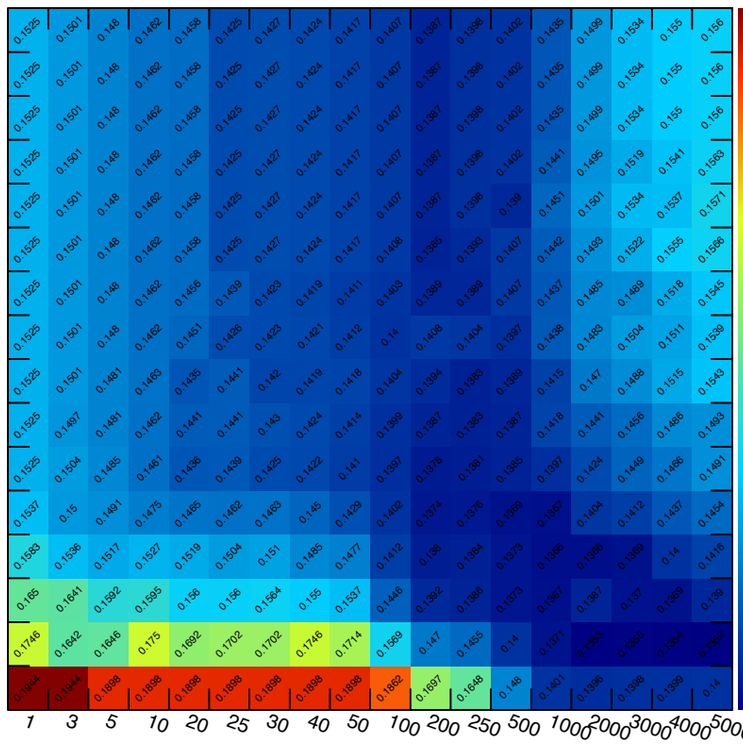


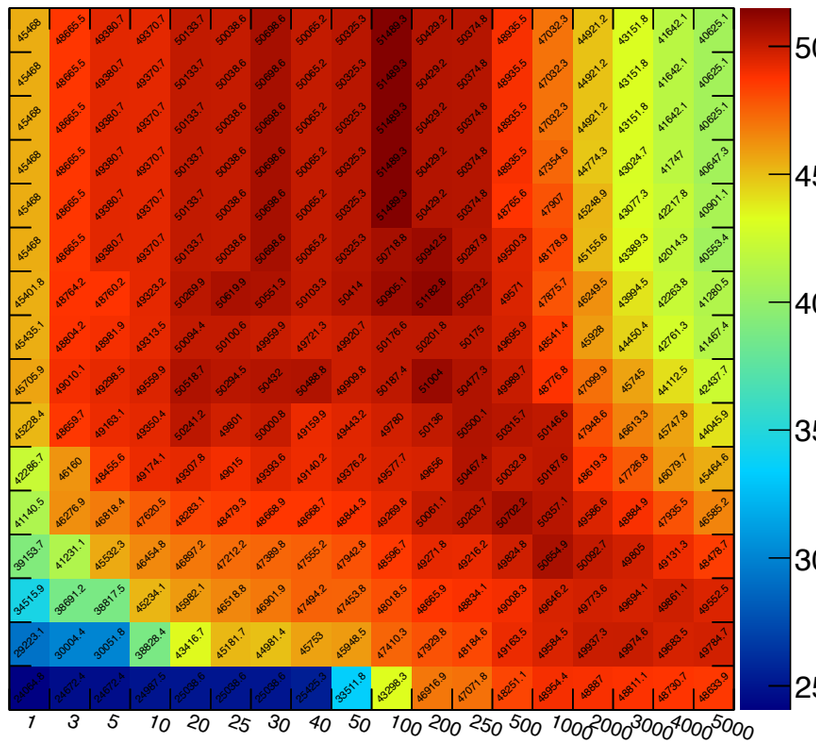


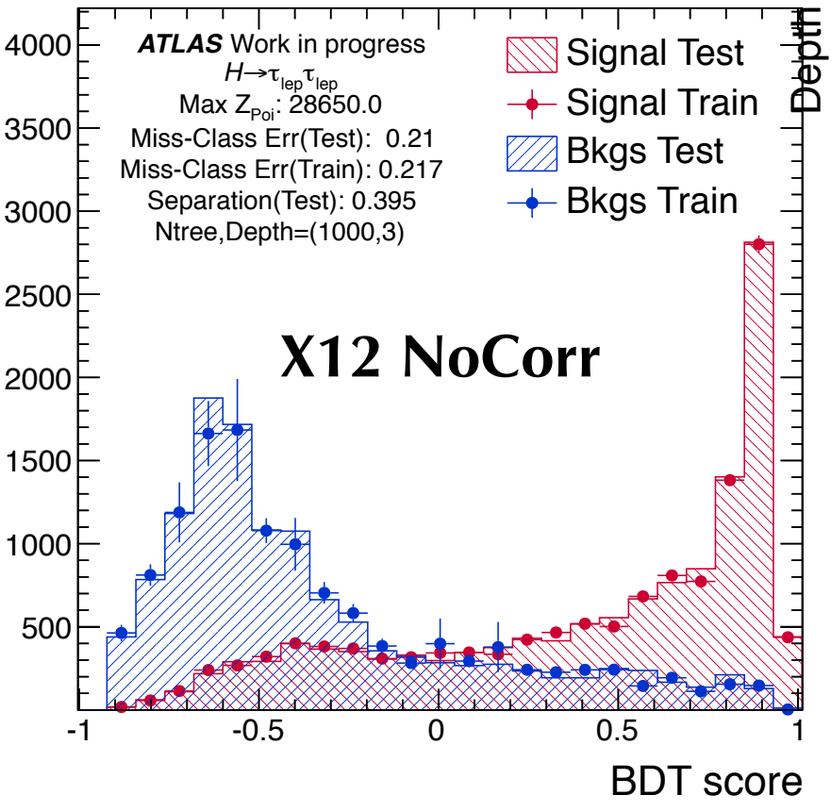


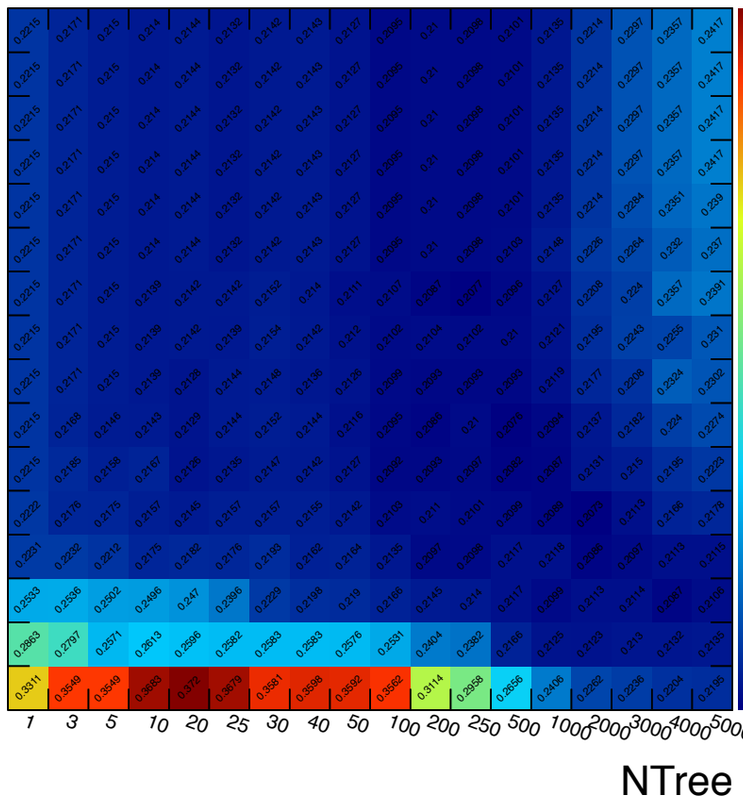
VBF BDTG w/o Corr

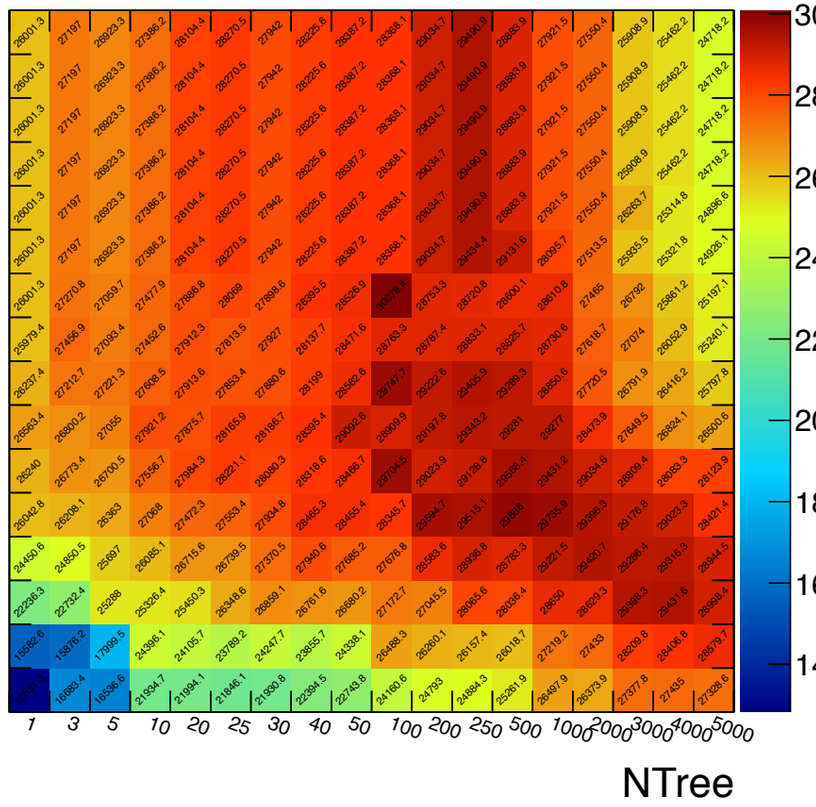




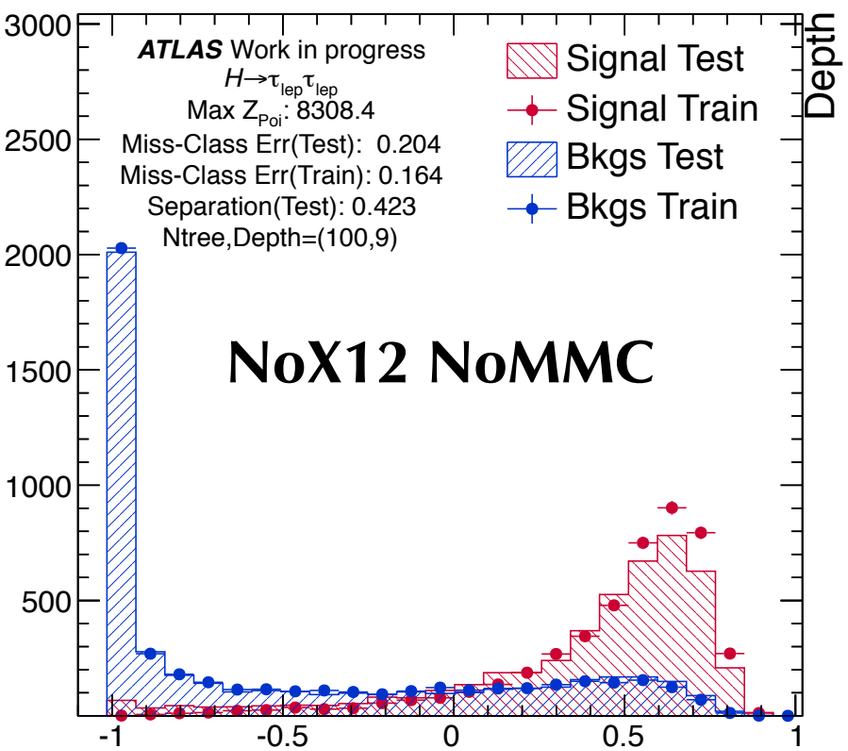


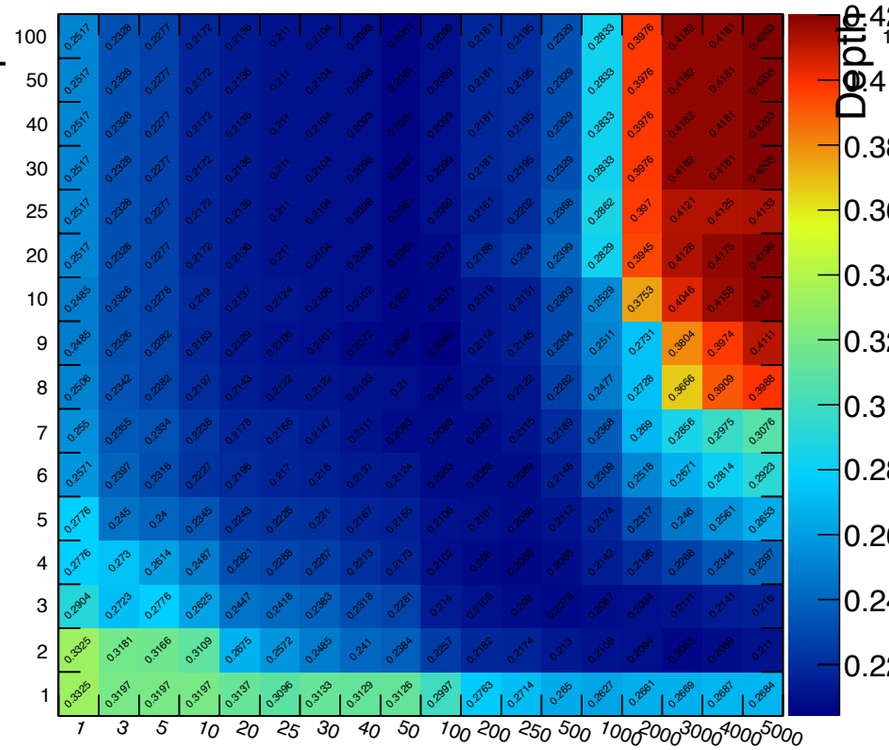


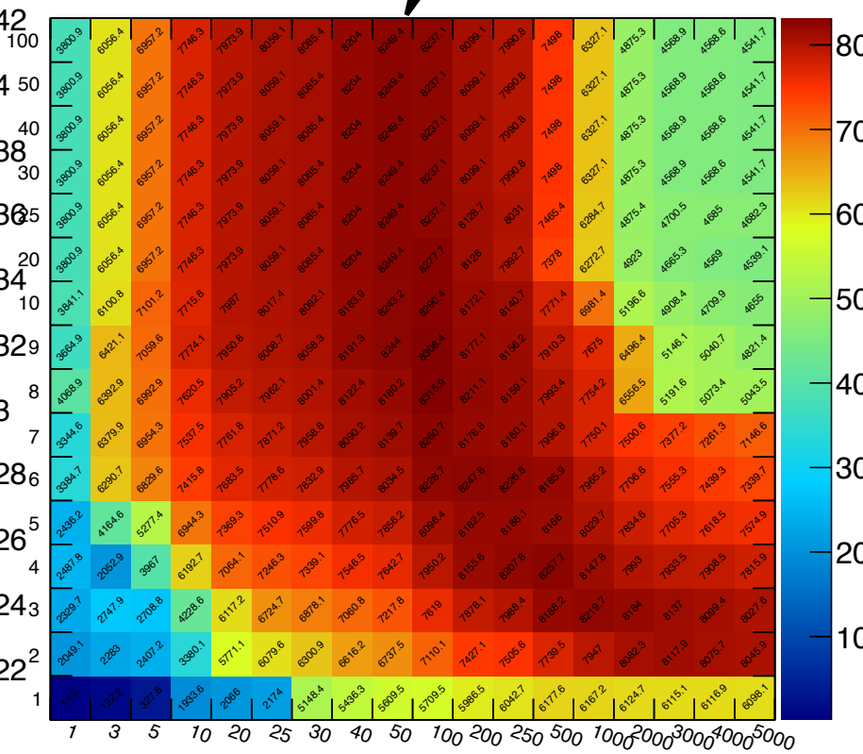


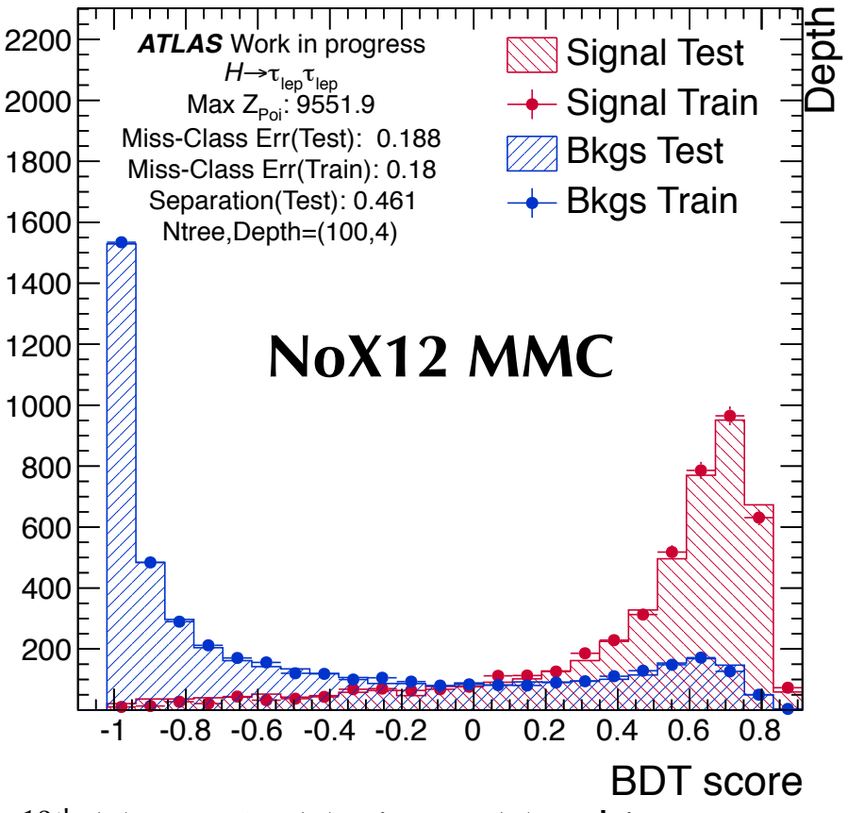


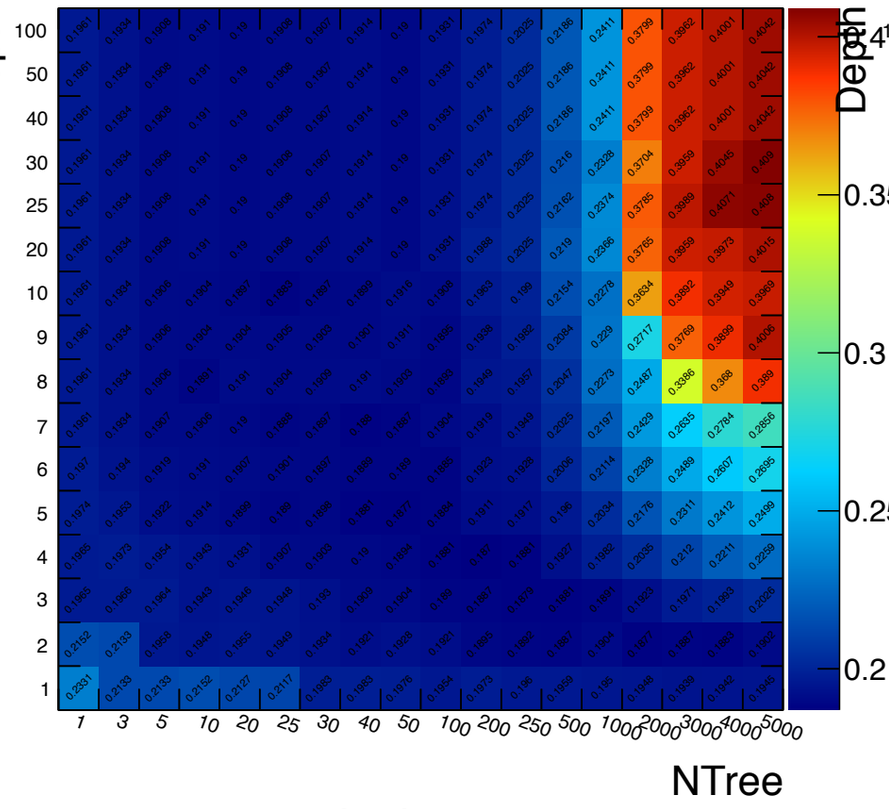
Boosted BDTG w/o X1,2

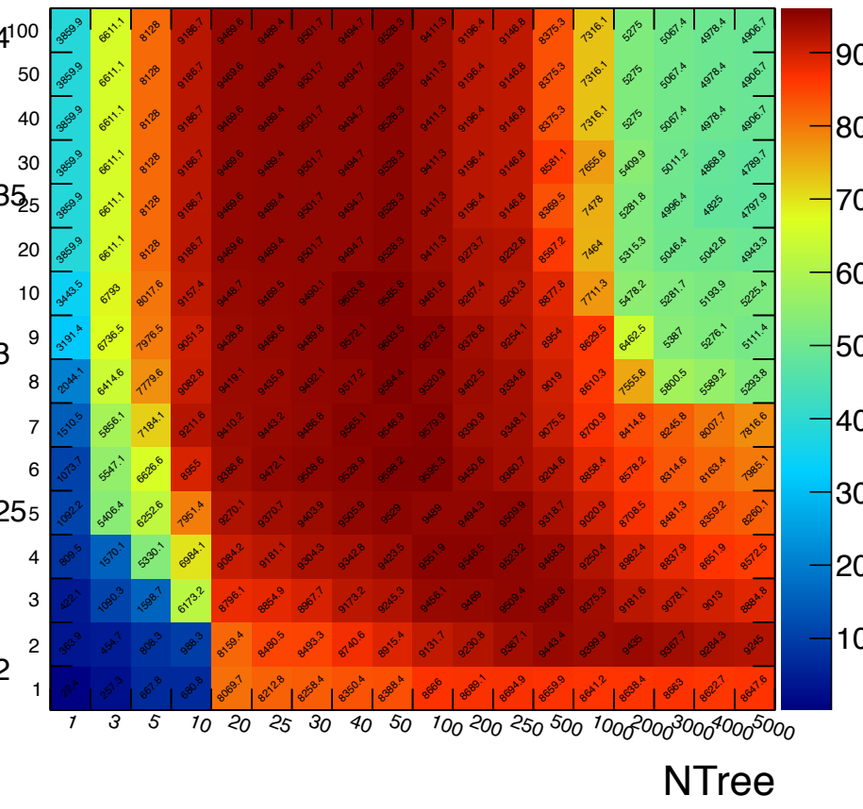




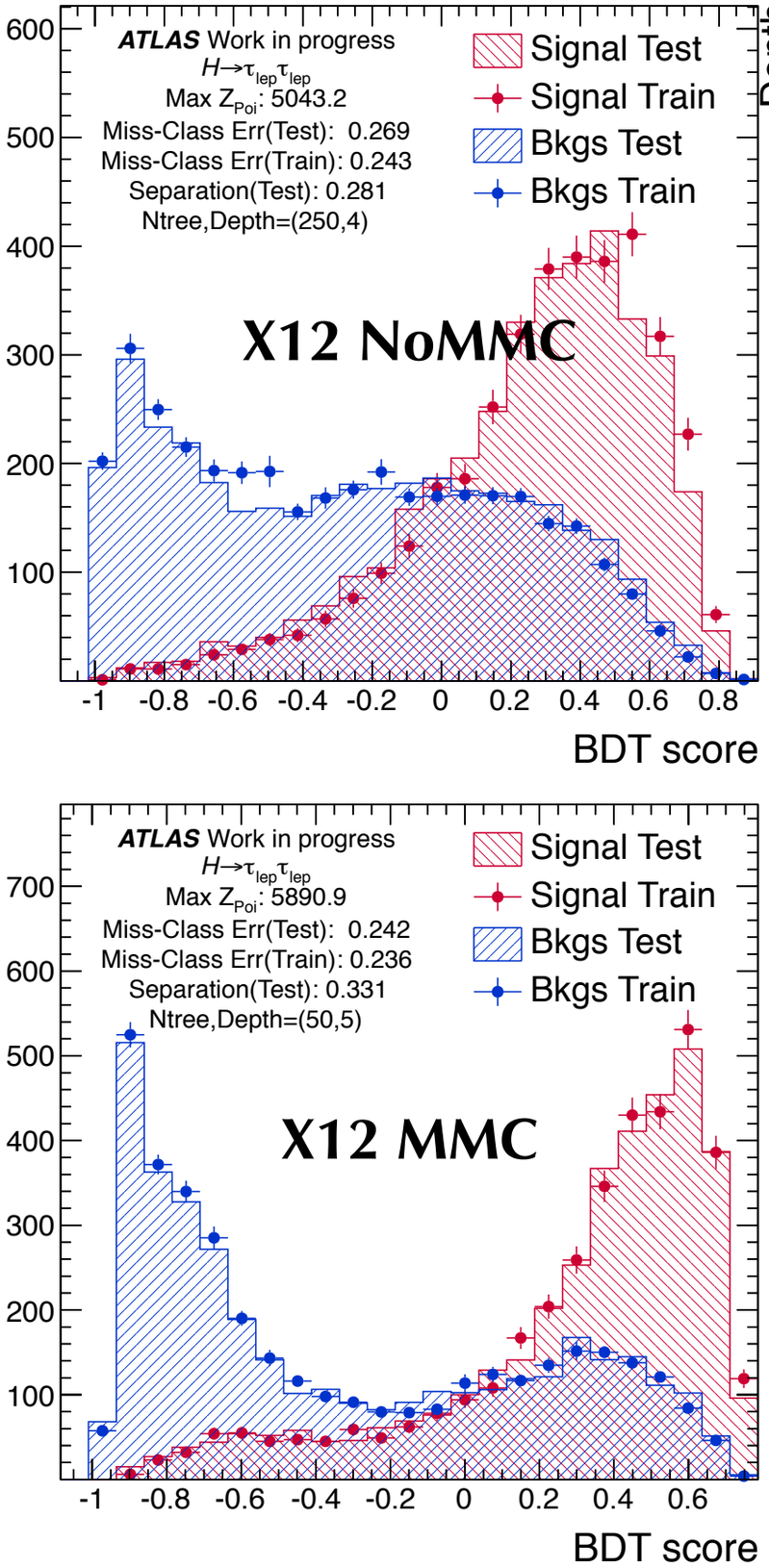


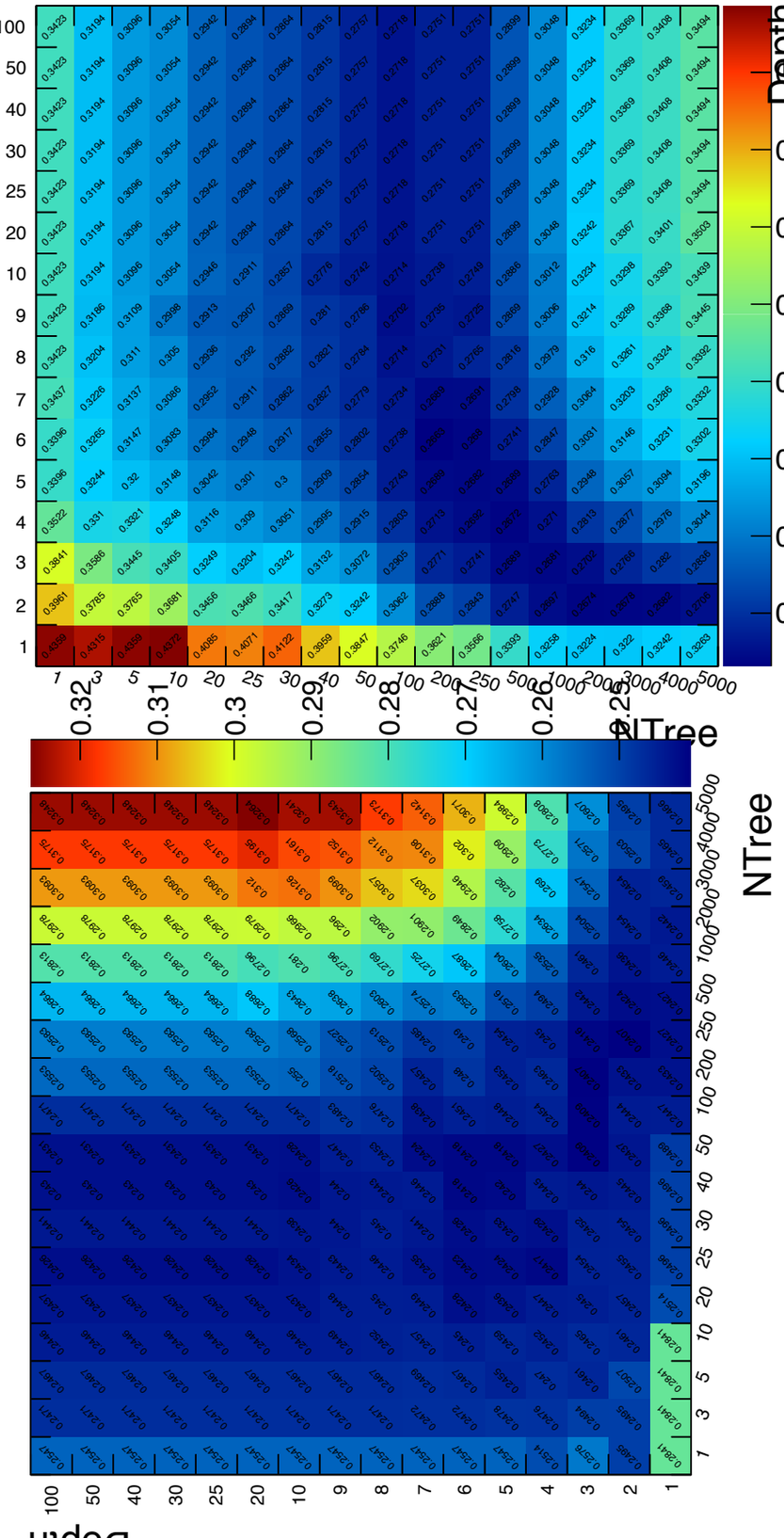


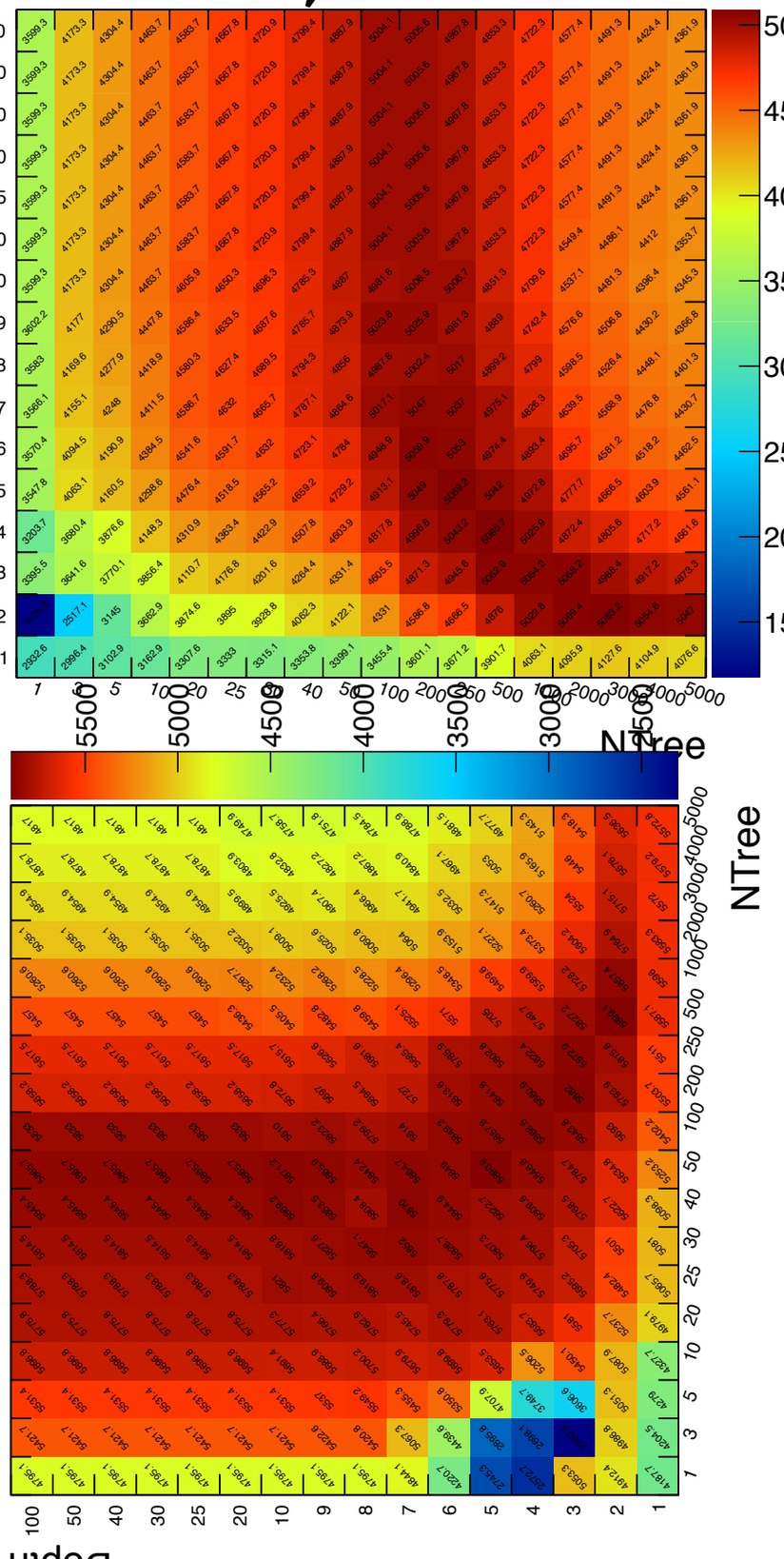




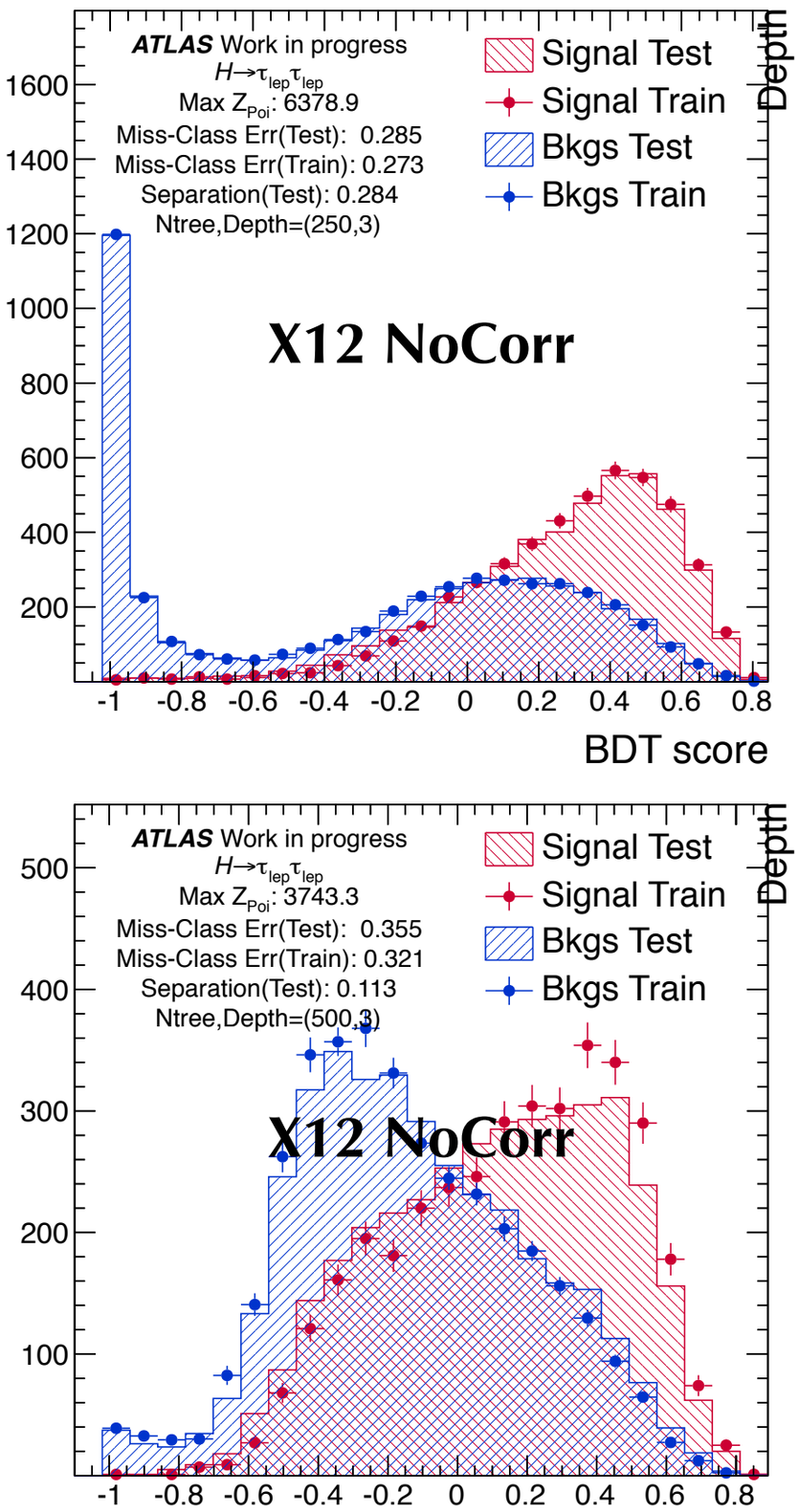
Boosted BDTG w/ X1,2

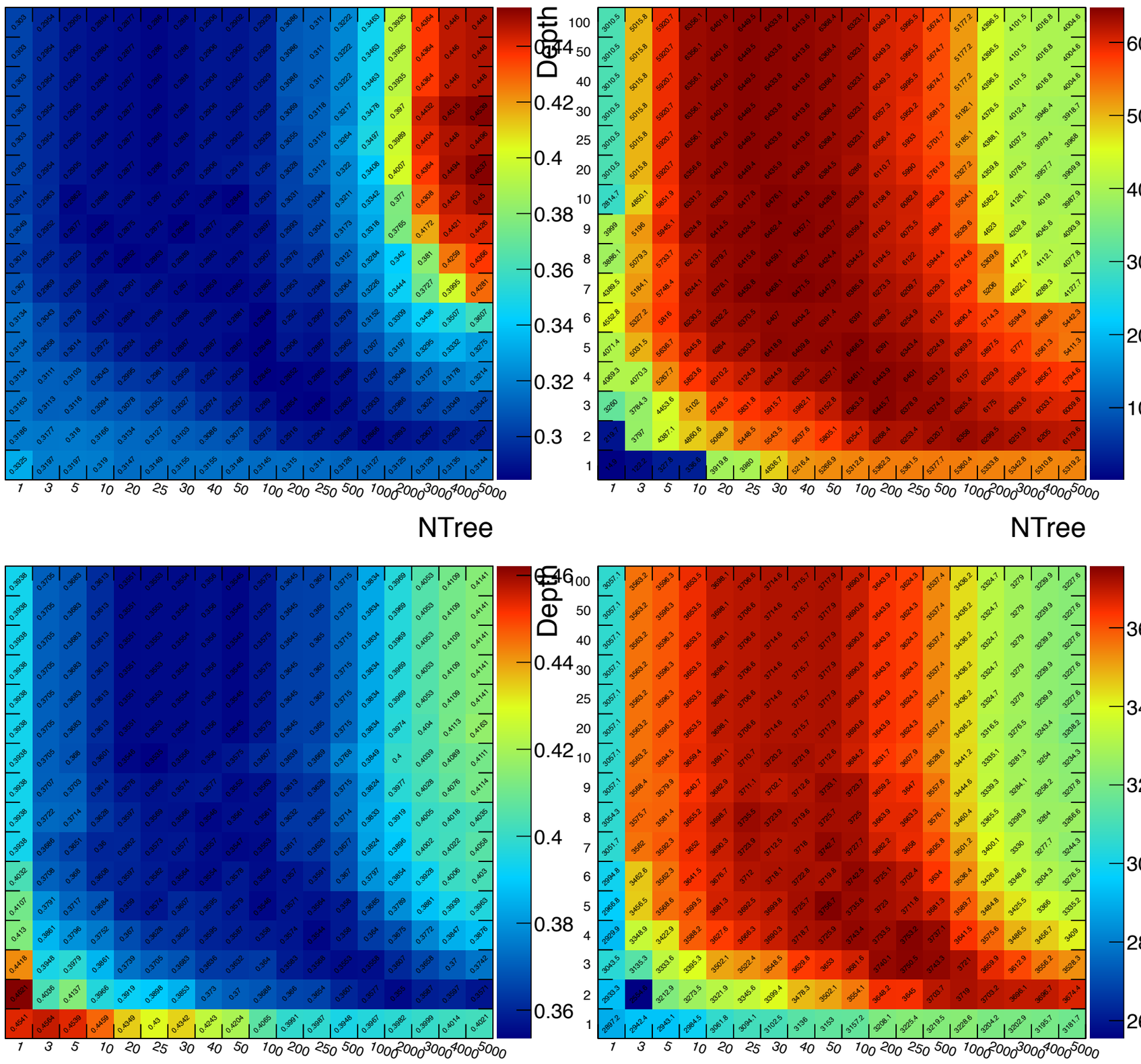




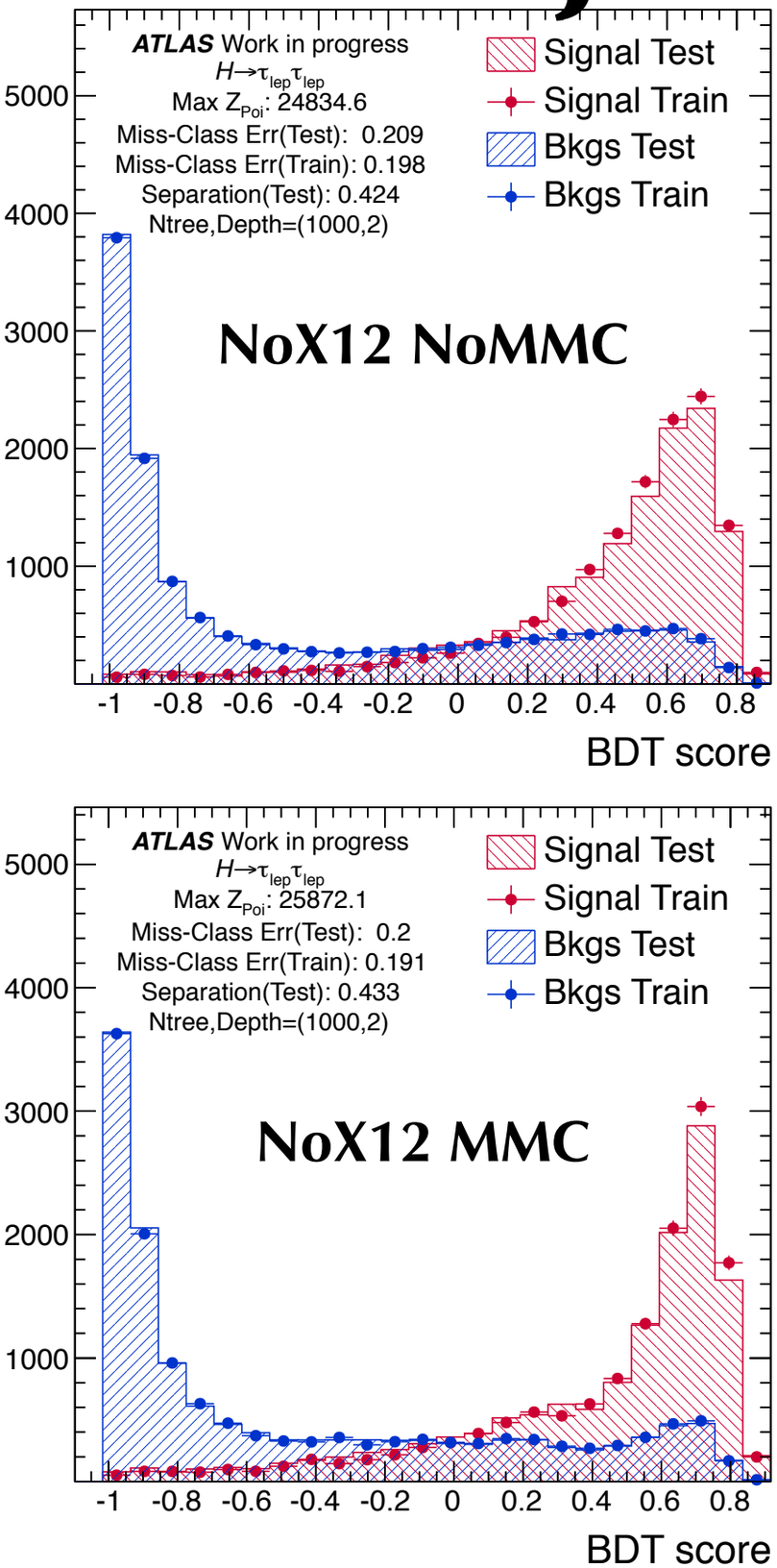


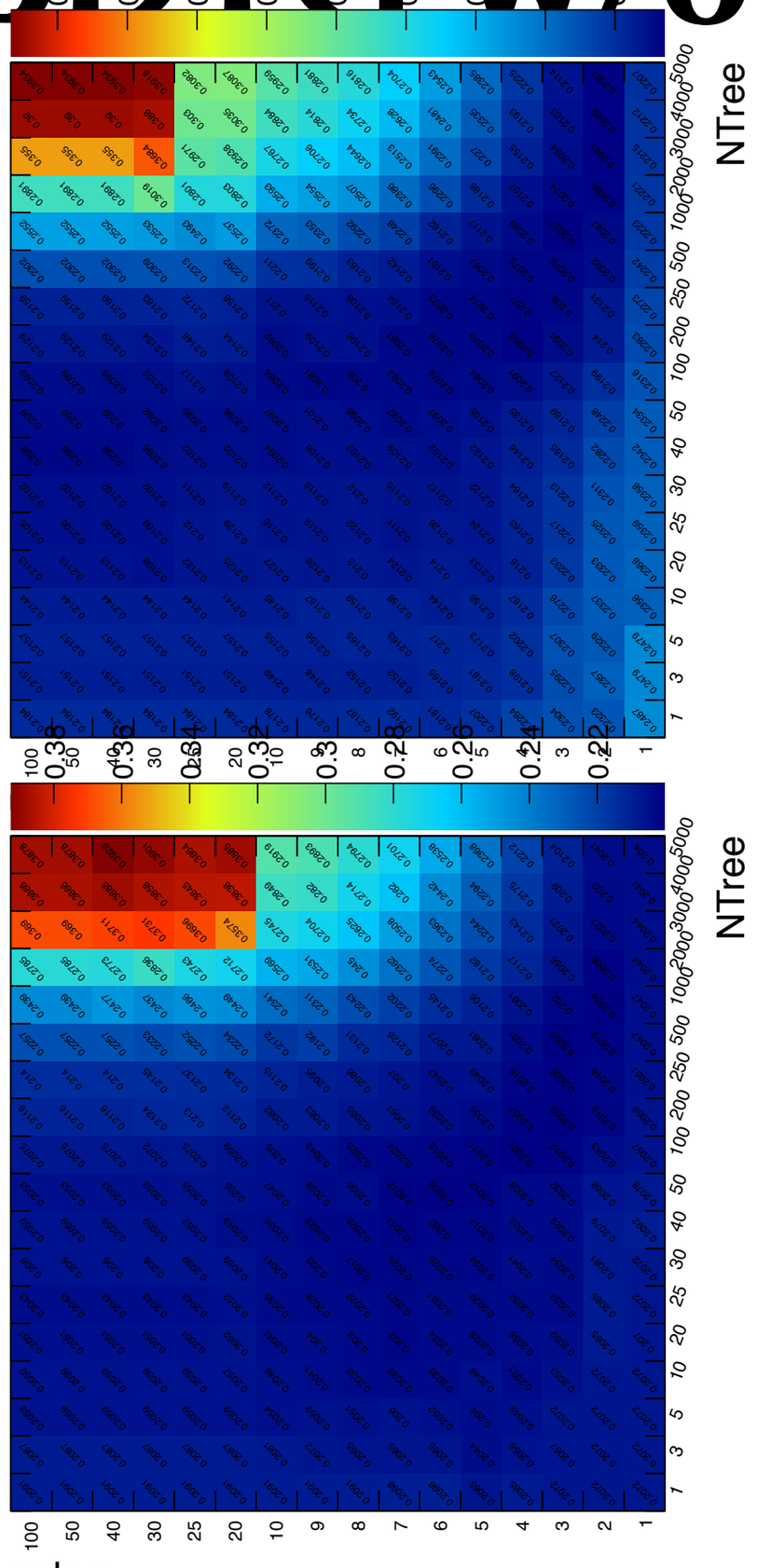
Boosted BDTG w/o Corr

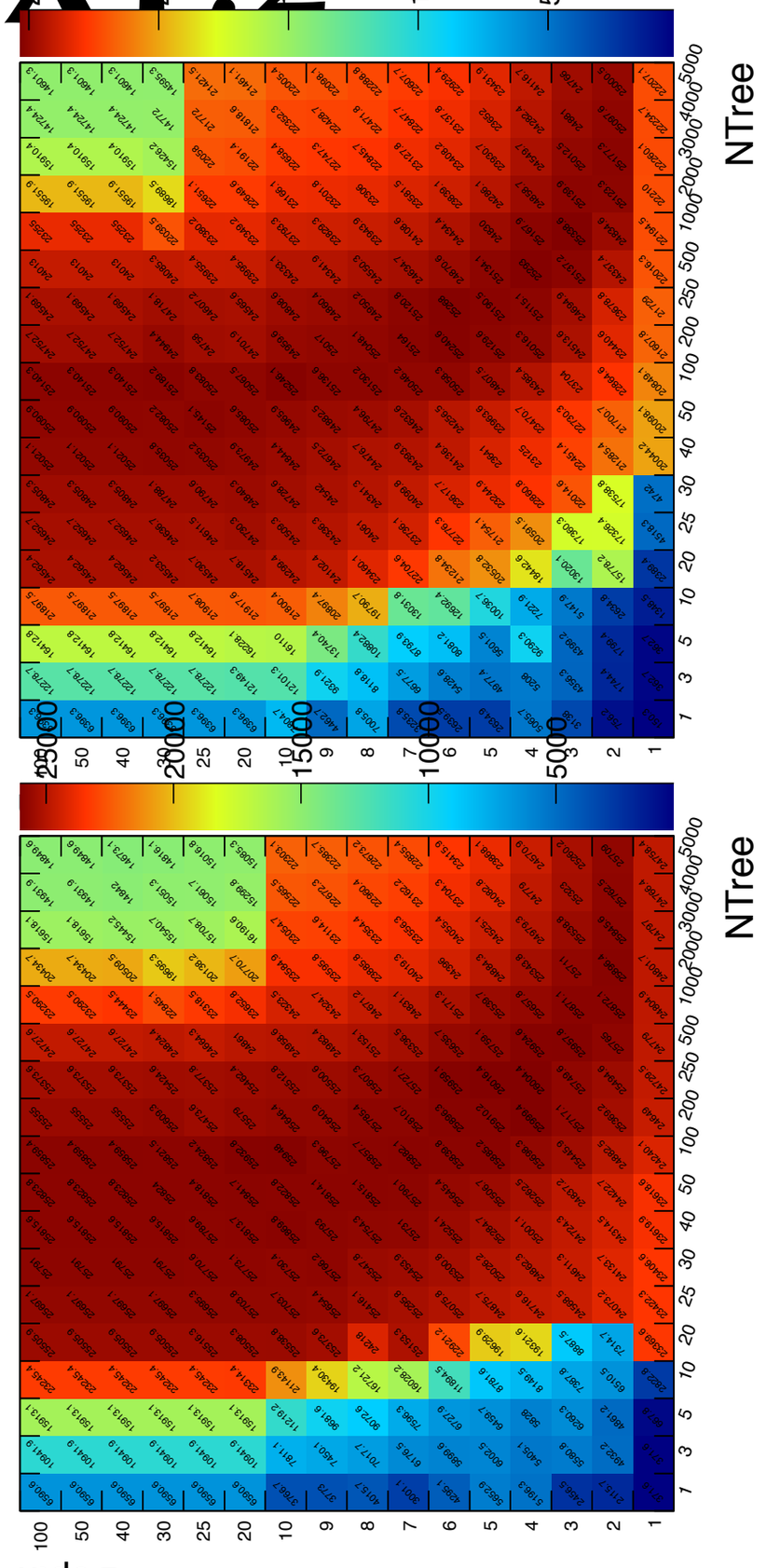




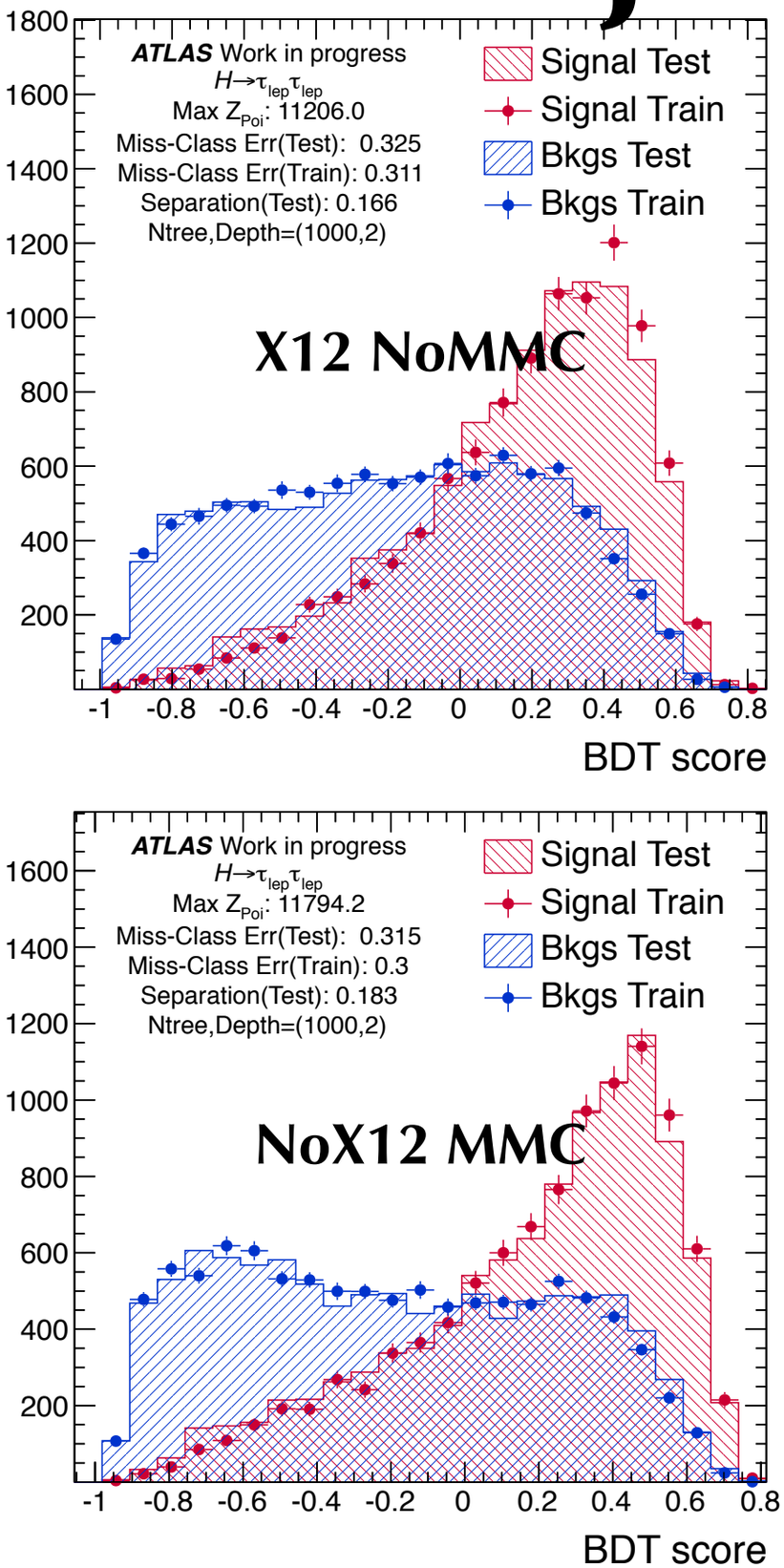
1jet BDTG w/o X1.2

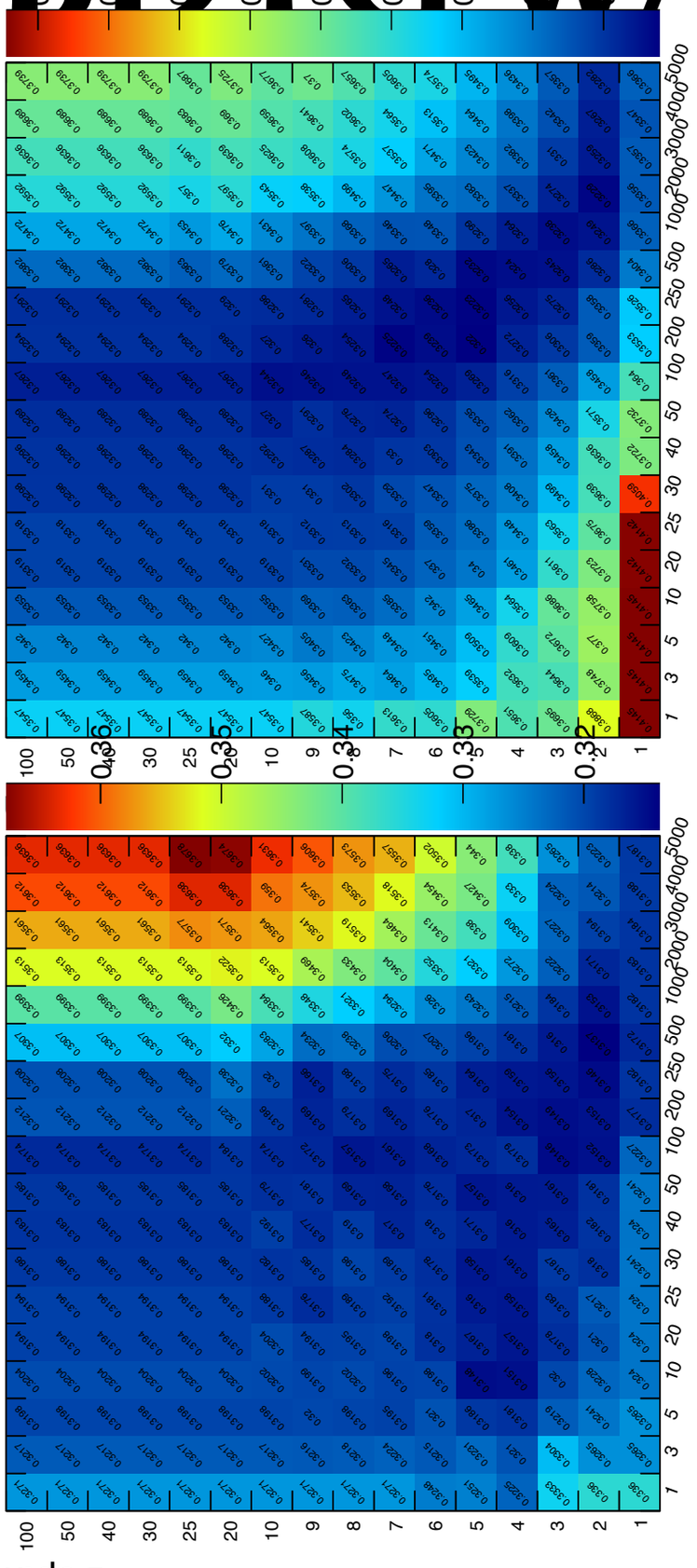


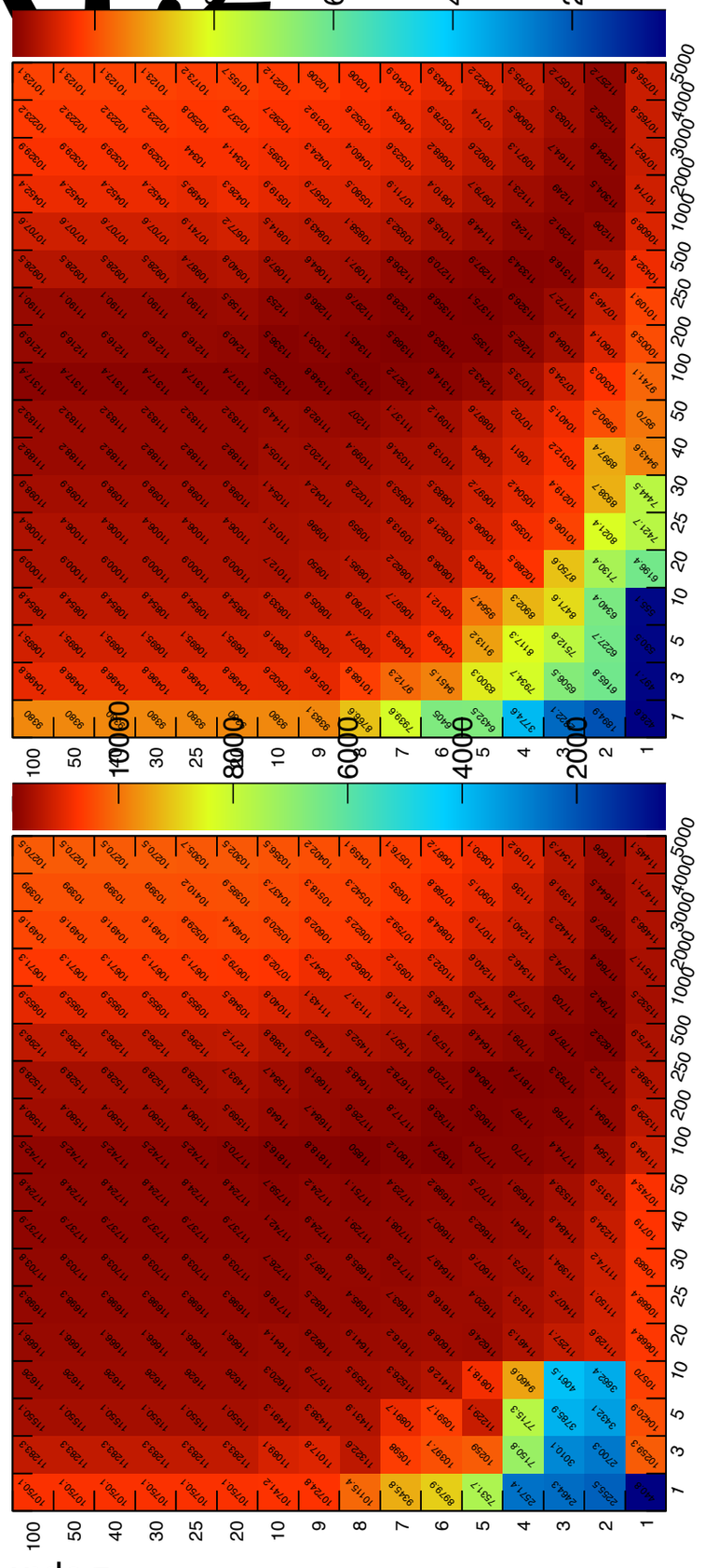




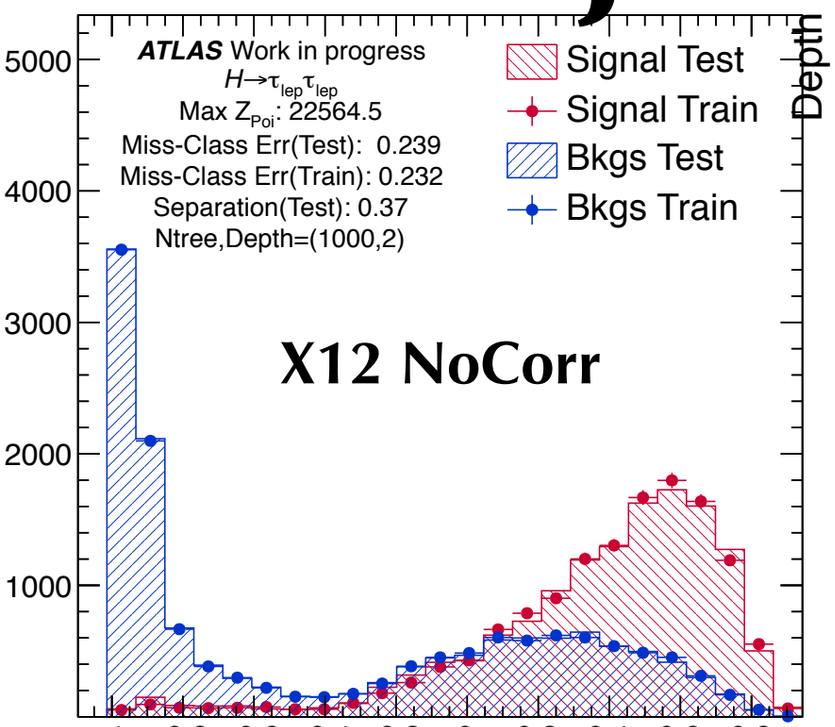
1jet BDTG w/ X1.2

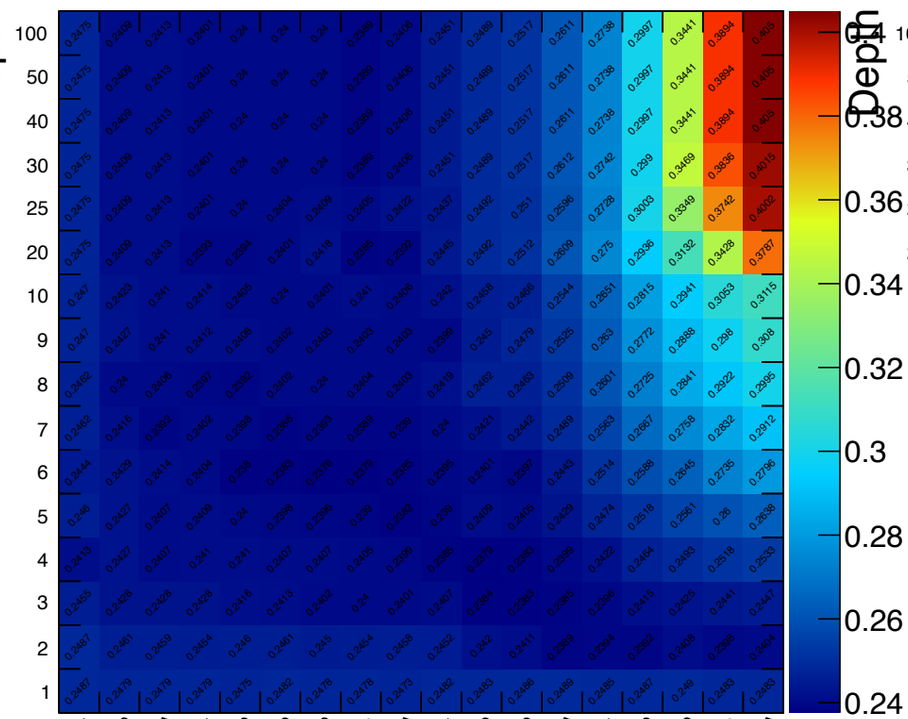


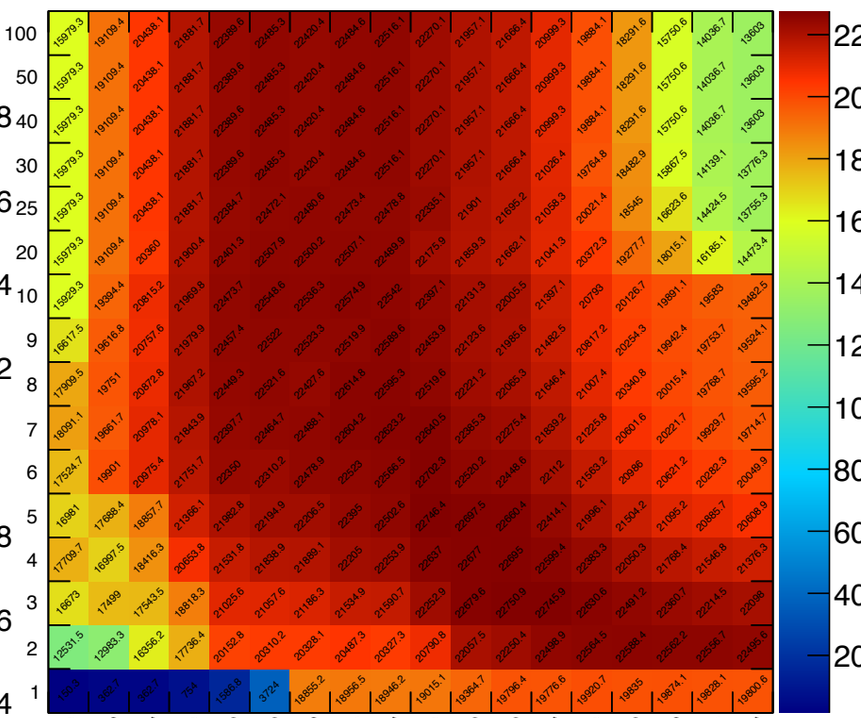


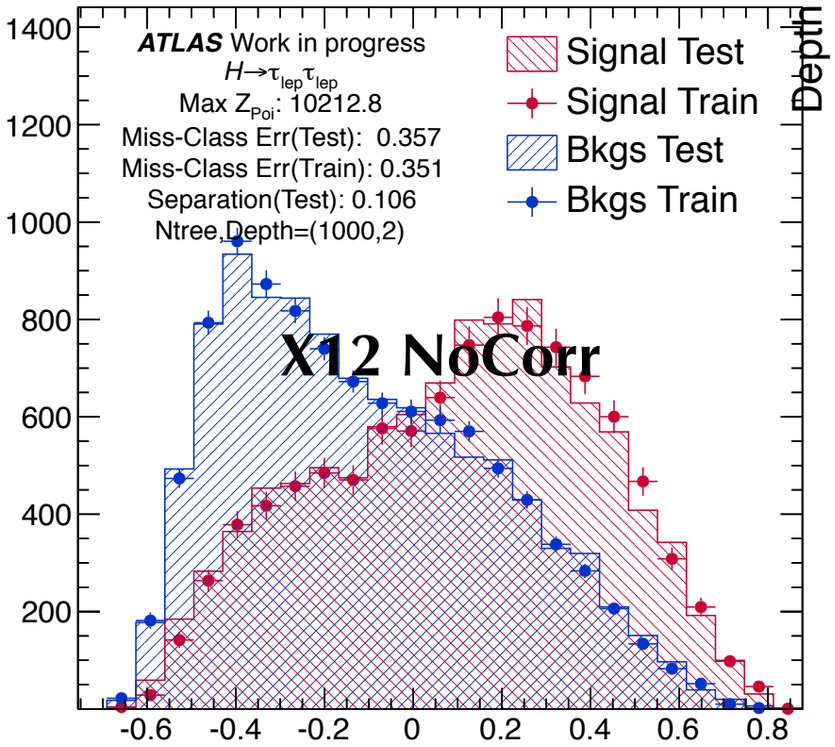


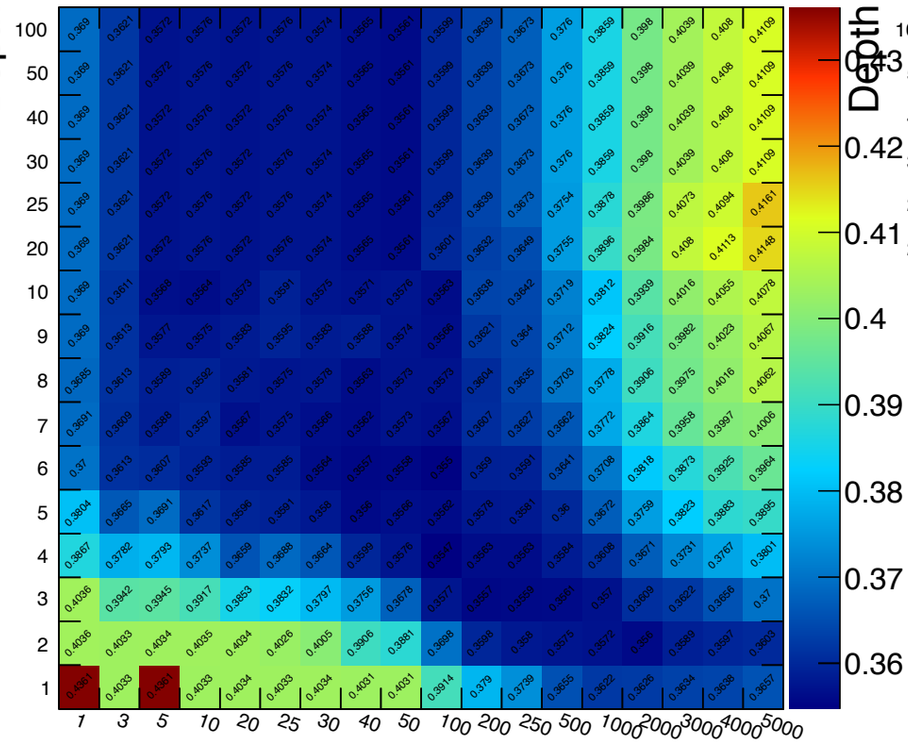
1jet BDTG w/o Corr

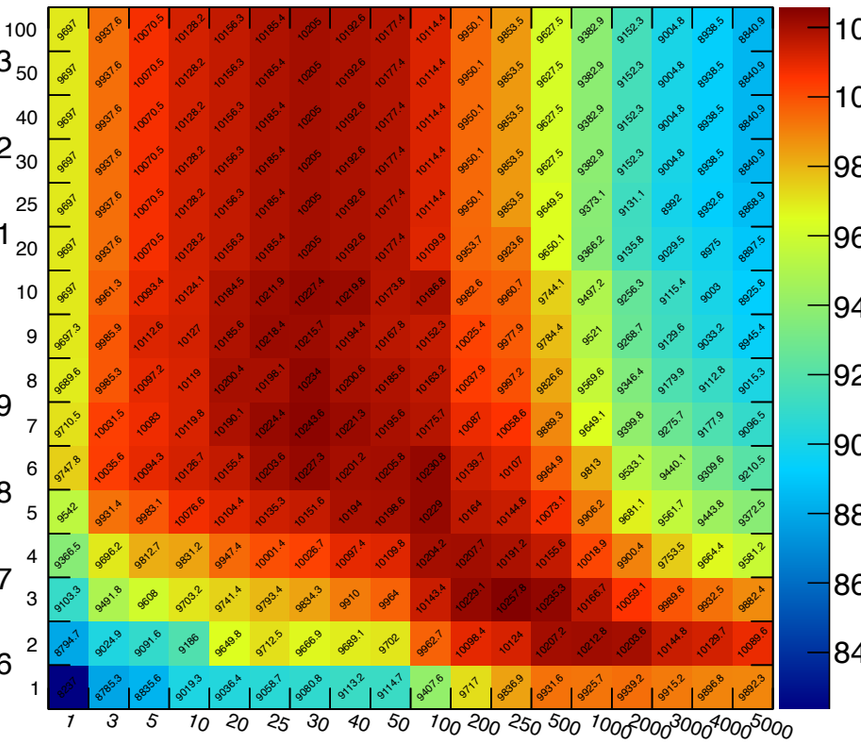






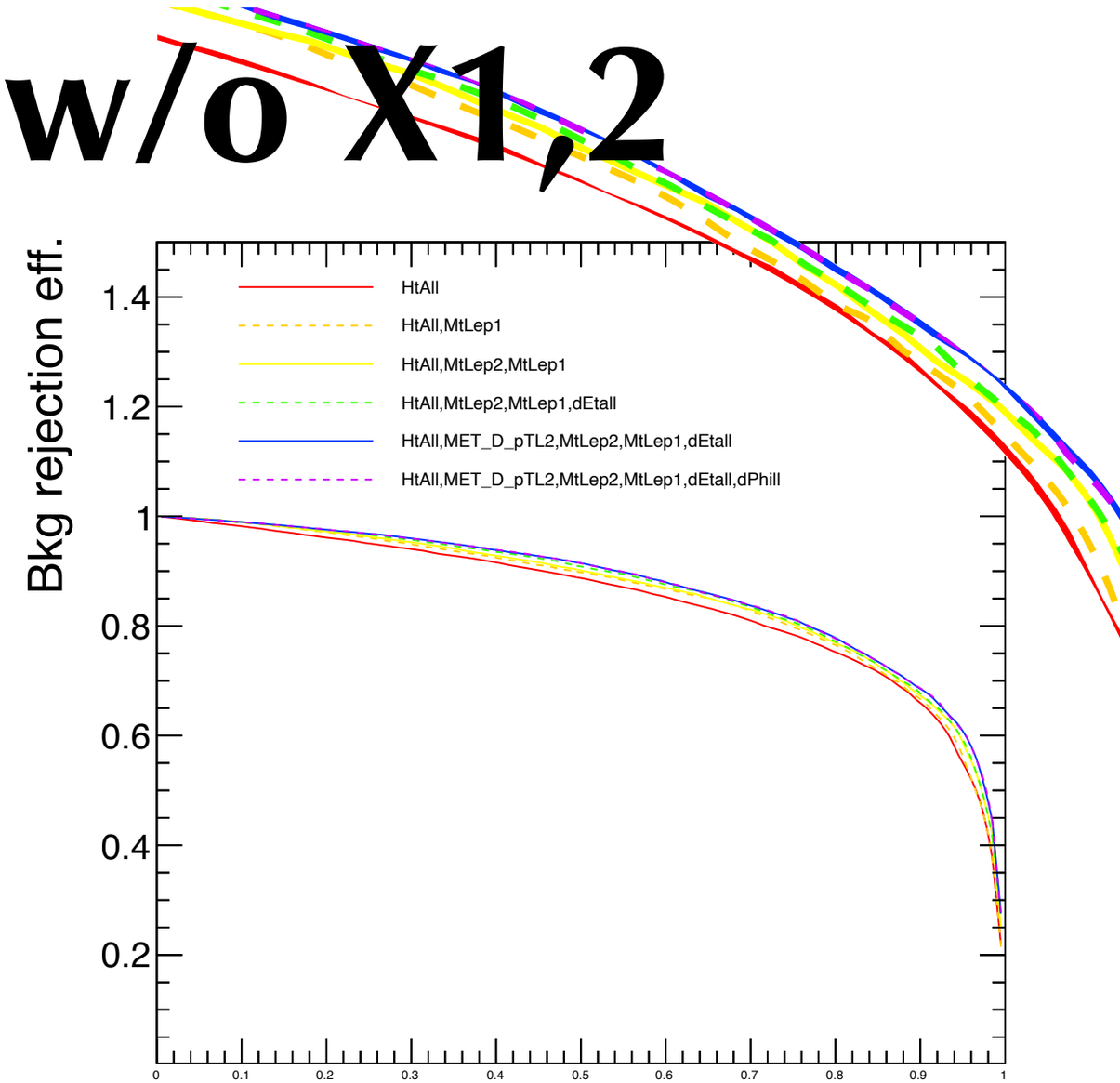






1jet BDTG w/o X1,2

- dRll+C_MET
  - +HT,MET/pTL2,mTl1,2,dEtall



HtAll

HtAll,MtLep1

HtAll,MtLep2,MtLep1

HtAll,MtLep2,MtLep1,dEtall

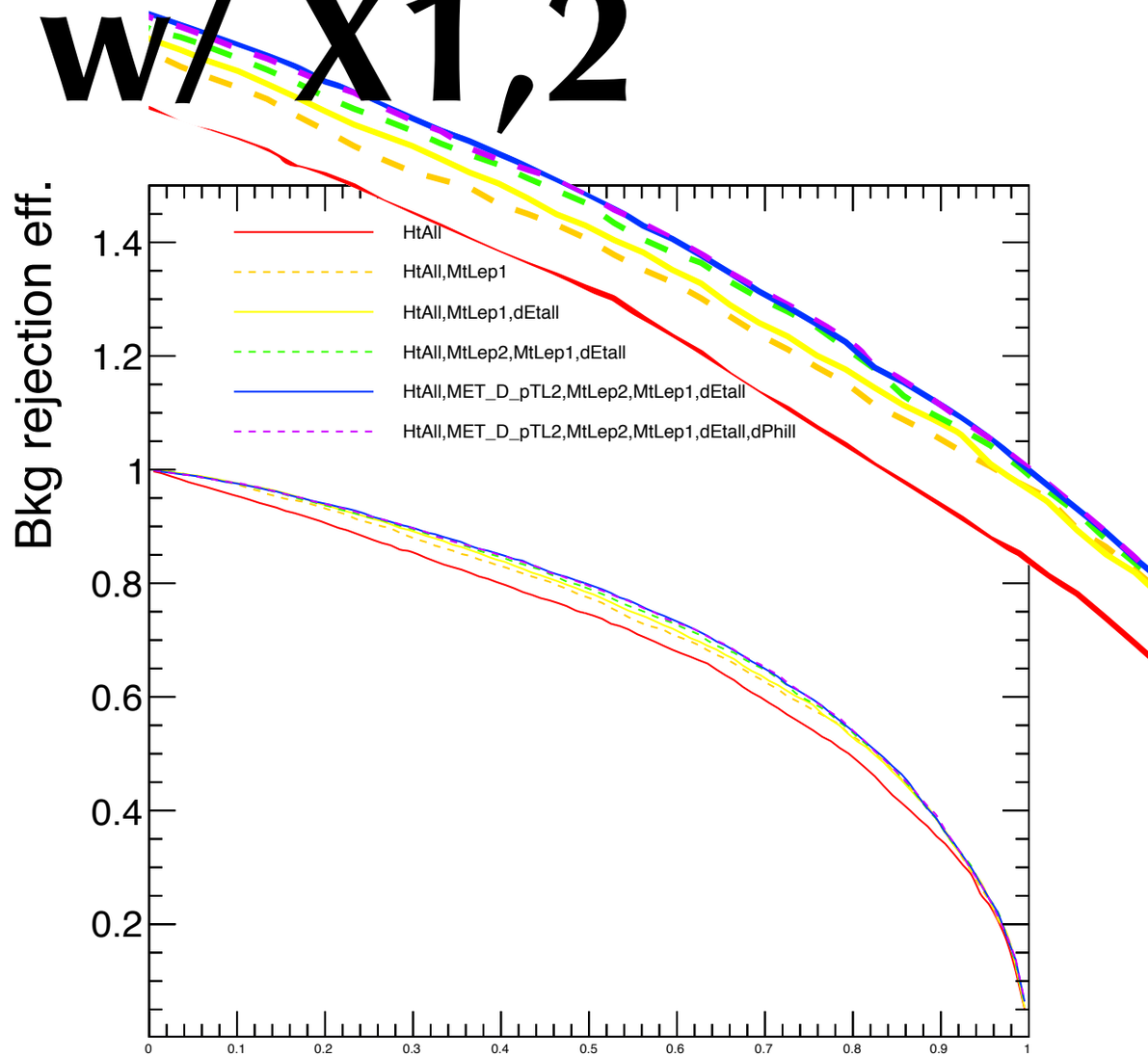
HtAll,MET_D_pTL2,MtLep2,MtLep1,dEtall

HtAll,MET_D_pTL2,MtLep2,MtLep1,dEtall,dPhill

Same power

1jet BDTG w/ X1,2

- dRll+C_MET
  - +HT,MET/pTL2,mTl1,2,dEtall



HtAll

HtAll,MtLep1

HtAll,MtLep1,dEtaII

HtAll,MtLep2,MtLep1,dEtaII

HtAll,MET_D_pTL2,MtLep2,MtLep1,dEtaII

HtAll,MET_D_pTL2,MtLep2,MtLep1,dEtaII,dPhill

Same power