

Setup



- **Input** : x:features (25) y:classID (signal1 background0)
- **Spectators**: llg_m_Zmassconstraint (for Disco)
- **Model**:event classifier transformer neural network
- **Loss function** :BCE (120-130)+ λ DisCo (110-160)
$$\text{BCE}(\hat{y}, y) = -y \ln(\hat{y}) - (1 - y) \ln(1 - \hat{y}),$$
- **output**: probability of the event (sigmoid)
- Batchsize 1000 epoch 1000

Key factor: loss, significance, AUC of ROC

Model selection: Significance-best

- Divide the dataset into 5 bins based on output. The bins are constructed to have an equal number of signal events. Calculate the significance of each bin and combine the significances of the bins.

$$\text{Significance} = \sqrt{2 \left[(N_S + N_B) \ln \left(1 + \frac{N_S}{N_B} \right) - N_S \right]},$$

$$\text{Total significance} = \sqrt{\sum_i^n (\text{Significance}_i)^2}$$

```
# VBF_DRmin_y_j
# VBF_Dphi_Zy_jj
# VBF_Dy_j_j
# VBF_N_j
# VBF_Zepp
# VBF_eta_j1
# VBF_eta_j2
# VBF_m_jj
# VBF_mass_j1
# VBF_mass_j2
# VBF_pT_j1
# VBF_pT_j2
# VBF_pT_jj
# VBF_pTt_Zy
# Zy_Dphi_j1
# ll_eta
# ll_pt
# llg_angles_cotheta_ginH
# llg_angles_cotheta_linZ
# llg_deta_Zy
# llg_dphi_Zy
# llg_eta
# llg_pt
# ph_eta
# ph_pt
```

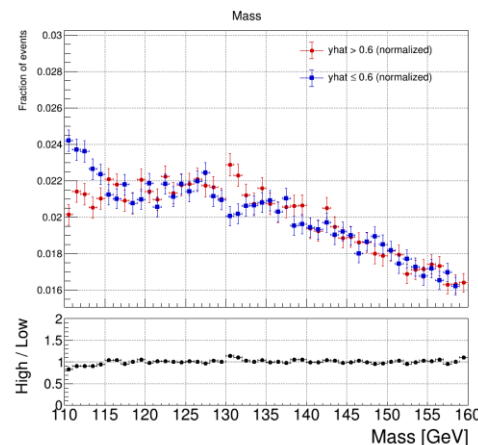
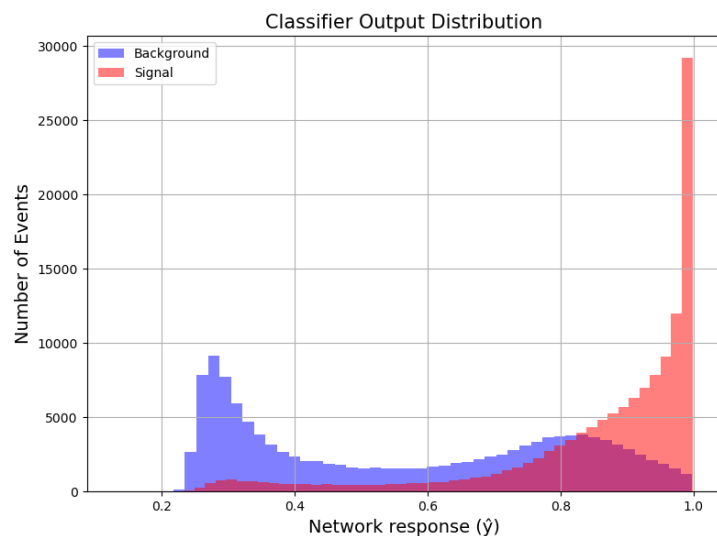
Variables	Definition
M_{jj}	Di-jet mass
$\Delta\eta_{jj}$	Pseudo-rapidity separation of dijet
pT_{j1}	lead-jet pT
M_{j1}	lead-jet mass
$\eta_{Zeppenfeld}$	$ \eta_{Z\gamma} - 0.5 * (\eta_{j1} + \eta_{j2}) $
η_{j2}	sublead-jet eta
pT_{jj}	Di-jet pT
$\Delta\Phi_{Z\gamma,jj}$	Azimuthal angle between Zgamma and dijet system
M_{j2}	sublead-jet mass
$\Delta R_{\gamma or Z,j}^{min}$	Minimum ΔR between one object of the Zgamma and jets
pT_{j2}	sublead-jet pT
η_{j1}	lead-jet eta
$pT_{l\gamma}$	$l\gamma$ pT
$\Delta\Phi_{Z\gamma,j1}$	Azimuthal angle between Zgamma and lead-jet
pT_{γ}	photon pT
pT_{ll}	ll pT
N_j	Number of jets pT
$\Delta\Phi_{Z,\gamma}$	Azimuthal angle between di-lepton system and photon
$\cos\theta(ll,\gamma)inZ$	$\cos\theta$ in Z rest system
η_{ll}	eta of Z
$\eta_{l\gamma}$	eta of $l\gamma$
$\cos\theta(ll,\gamma)inH$	$\cos\theta$ in Higgs rest system
η_{γ}	eta of photon
pT_{γ}	Zgamma p_T projected perpendicular to the Zgamma thrust axis
$\Delta\eta_{Z,\gamma}$	Pseudo-rapidity separation of Z γ

Result of training set

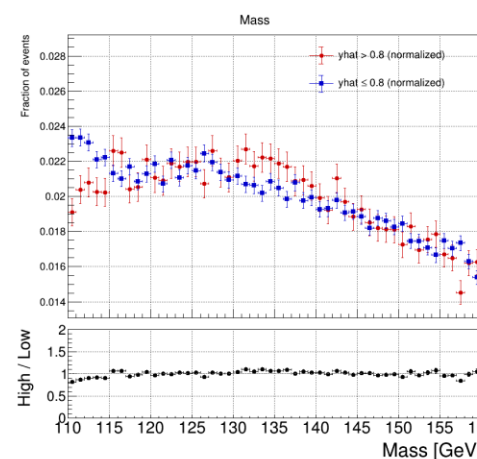


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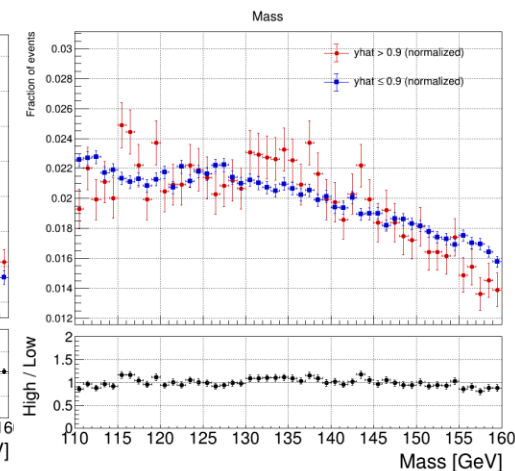
BCE(120-130) + 5 DisCo



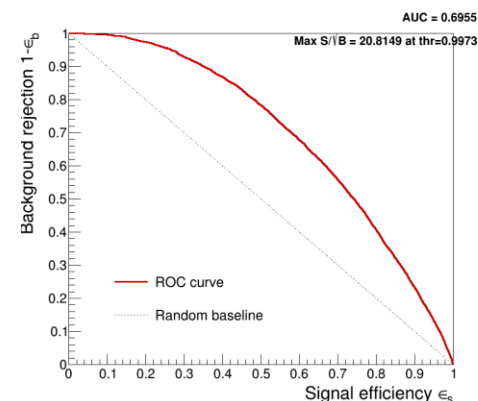
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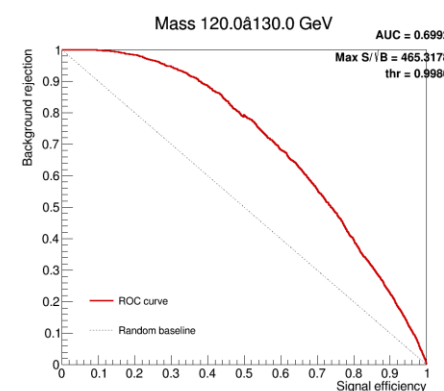
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ROC110-160



ROC120-130

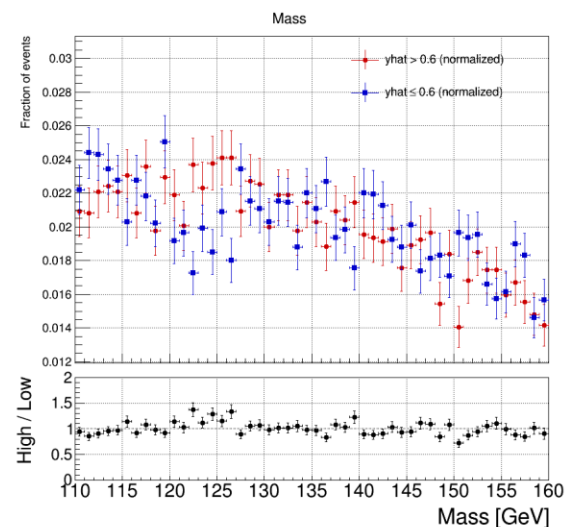
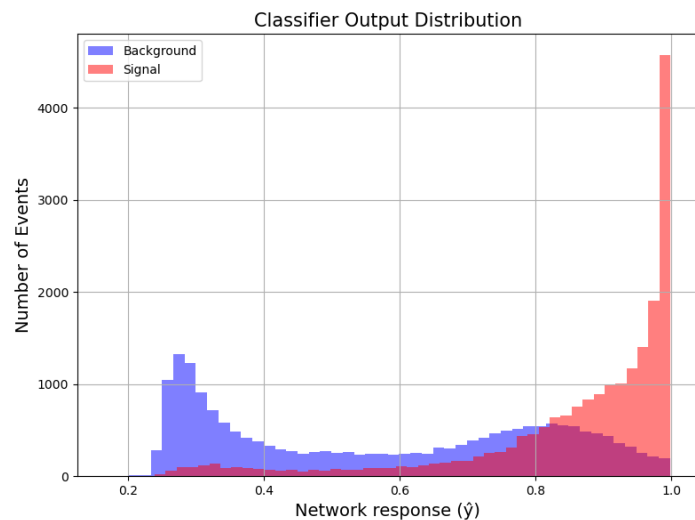
loss	0.657696
significance	40.077 +- 2.999

Result of validation set

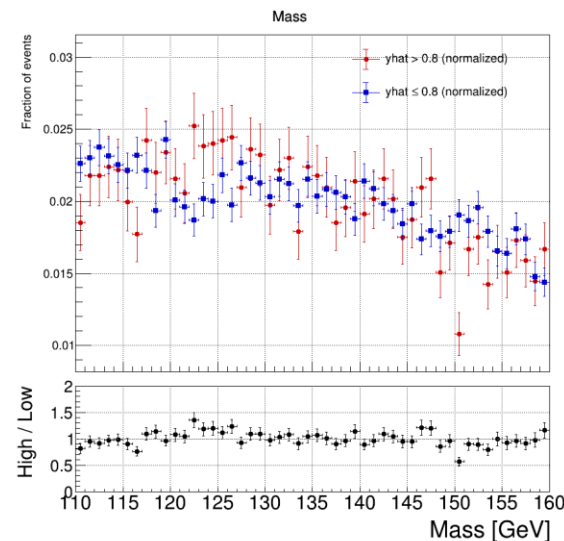


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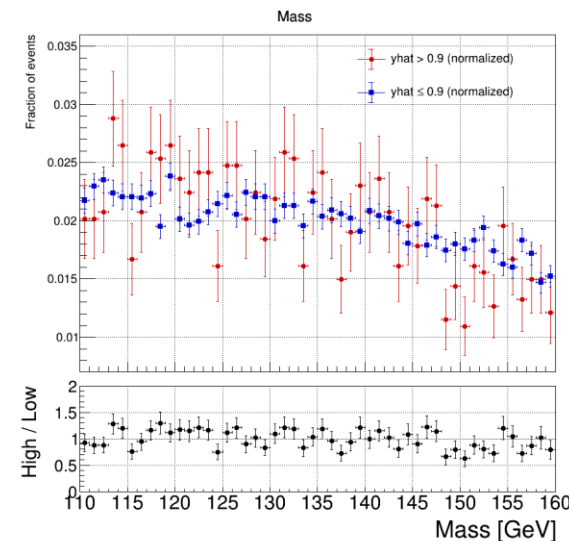
BCE + 5 DisCo



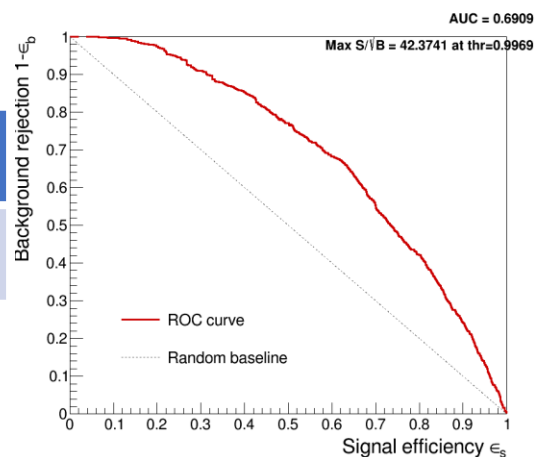
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Cut >0.8



Cut >0.9



ROC110-160

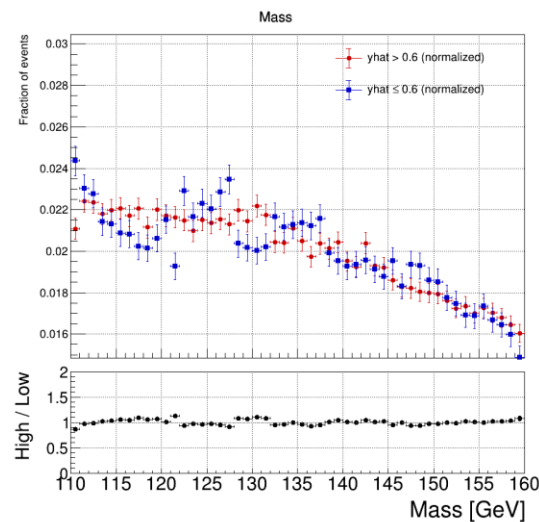
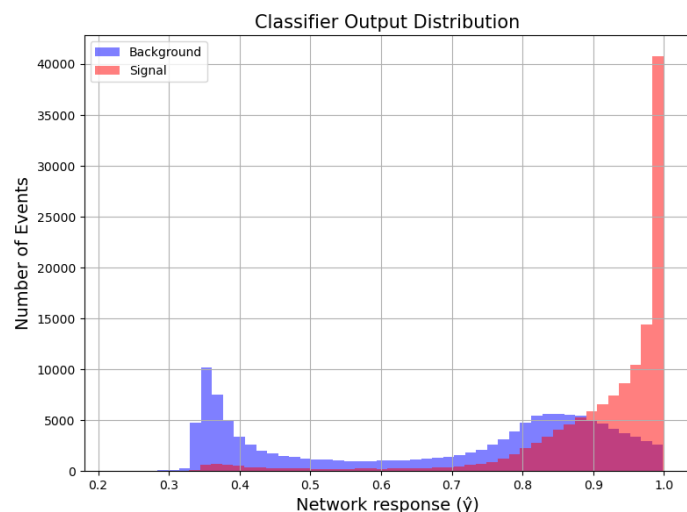
loss	0.712229
significance	21.060 +- 12.582

Result of training set

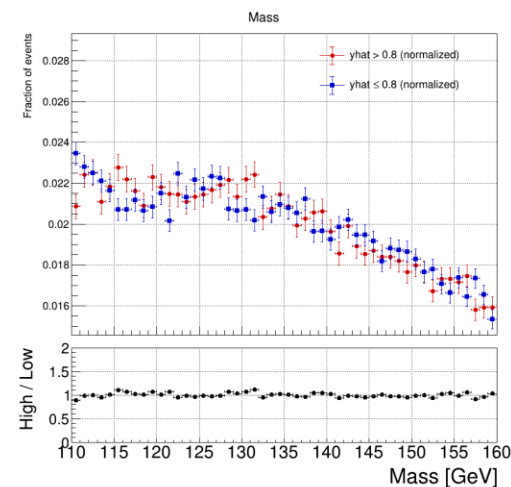


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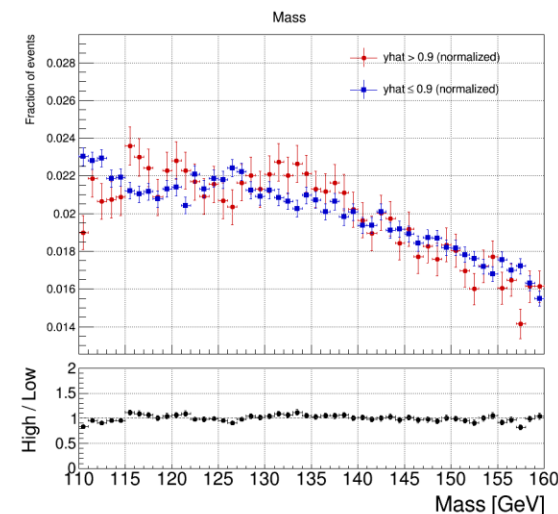
BCE(122-128) + 5 DisCo



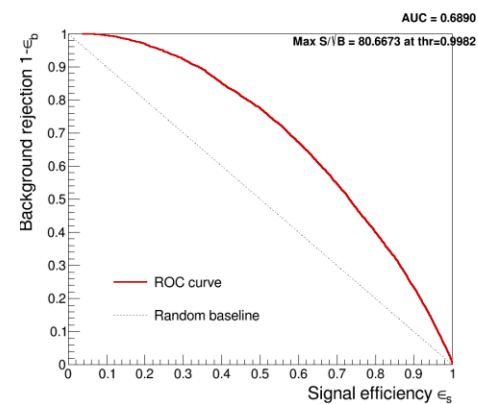
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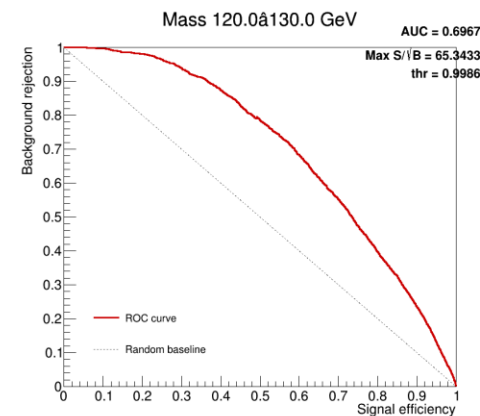
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ROC110-160



ROC120-130

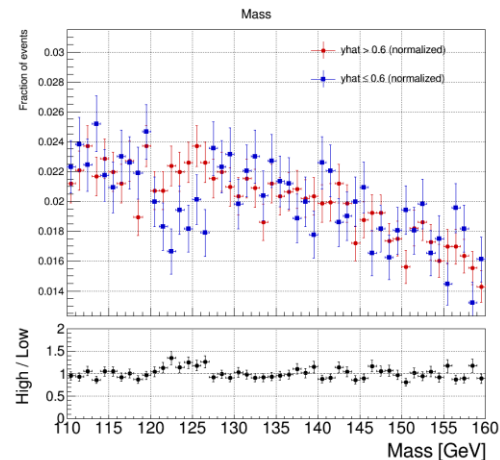
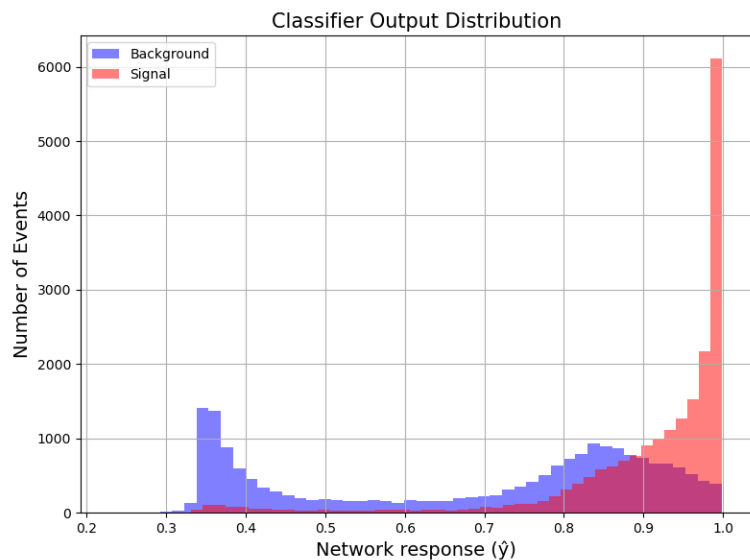
loss	0.826334
significance	40.249 +- 3.368

Result of validation set

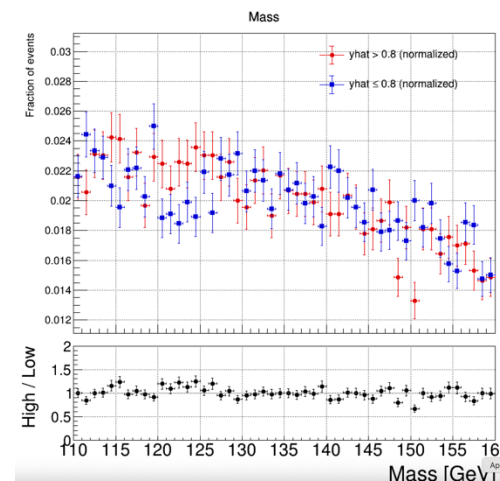


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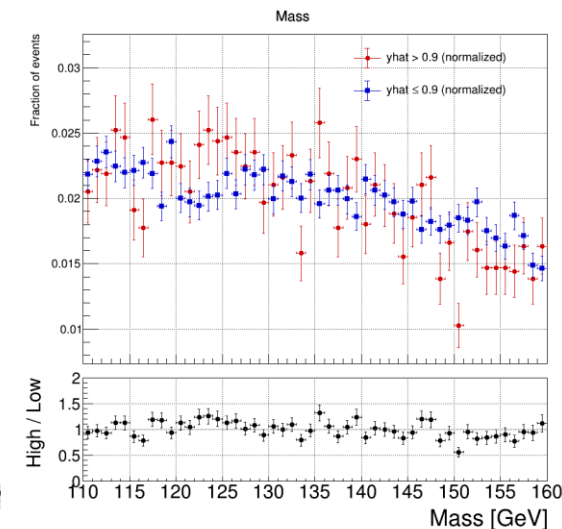
BCE(122-128) + 5 DisCo



Cut > 0.6

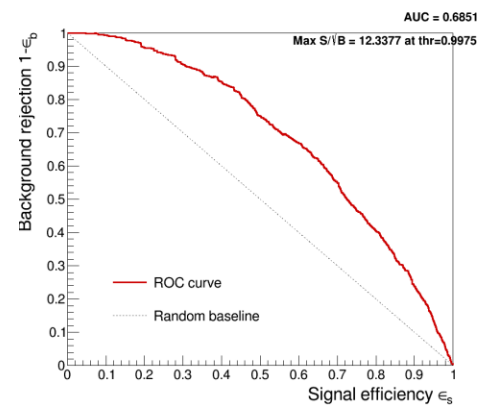


Cut > 0.8



Cut > 0.9

loss	0.835436
significance	14.428 $\pm$ 3.736



ROC110-160