Reducing the effect of nominal background samples on signal sample systematics using an adversarial neural network in the tW dilepton channel

Christian Kirfel

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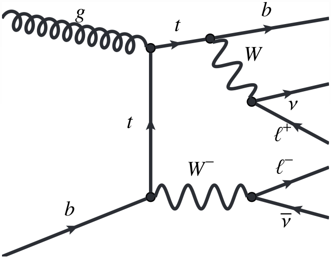
ATLAS EXPERIMENT

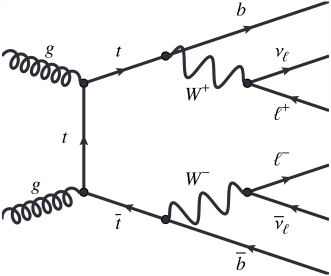
UNIVERSITÄT BONN

Outline

- tW and $t\bar{t}$ separation
- Artificial neural networks and adversarial neural networks as a possible solution
- Introduction to hyperparameters
- Preliminary training results for an adversarial neural network

tW and $t\bar{t}$ separation





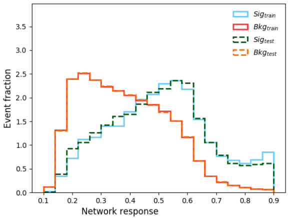
- Problem: Cross-sections of tW about 10 times smaller than $t\bar{t}$
- Interference in NLO order
- Instead of applying cut $\longrightarrow$ Neural networks

Setup of the classifier

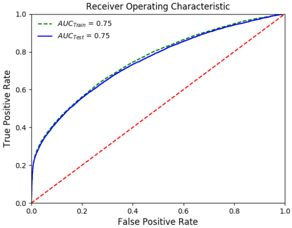
Hyper-parameter scan results

- Input: 14 variables motivated by a BDT variable scan.
- Hidden layers: 6 elu layers $\times$ 128 nodes each
- Output layer: 1 sigmoid node
- Optimisation: SGD, learning rate $= 0.06$, momentum $= 0.3$, no nesterov, no decay
- Duration: 600 epochs

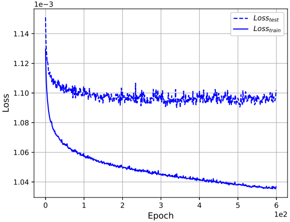
Simple network results



Separation



ROC curve

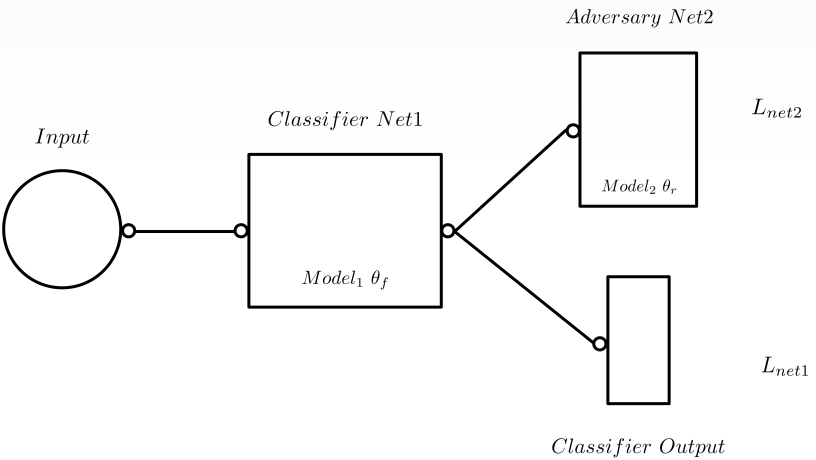


Losses

Adversarial Neural Networks

- Neural networks have no info on systematic uncertainties
- Introduction of a second, adversarial network classifying between nominal and systematic
- Combined loss function $\mathcal{L}_{adversarial}(\theta_f, \theta_t) = \mathcal{L}(\theta_f) - \lambda\mathcal{L}(\theta_f, \theta_r)$
- Network 1: signal/background separation
- Network 2: nominal/systematic separation
- Expectation: network 1 succeeds, network 2 fails

Setup of the ANN



ANN

	Discriminator	Adversary
$t\bar{t}$	0	1
tW DR	1	1
tW DS	1	0

ANN setup

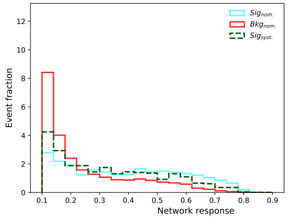
Discriminator setup

- Input: 14 variables motivated by a BDT variable scan.
- Hidden layers: 6 elu layers $\times$ 128 nodes each
- Output layer: 1 sigmoid node
- Optimisation: SGD, learning rate $= 0.01$, momentum $= 0.3$, no nesterov, no decay

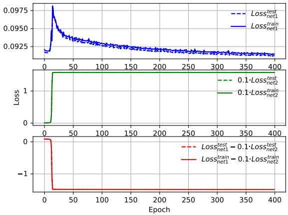
Adversary setup

- Input: 14 variables motivated by a BDT variable scan.
- Hidden layers: 6 elu layers $\times$ 128 nodes each
- Output layer: 1 sigmoid node
- Optimisation: SGD, learning rate $= 0.01$, momentum $= 0.3$, no nesterov, no decay

ANN results



Separation



Losses

- The separation is visibly bad.
- The agreement between nominal and systematics has barely improved
- Losses show bad behaviour

Improvement plans

Assumption

Labelling $t\bar{t}$ as a nominal sample results in a strong bias

Possible solution

- Randomly label $t\bar{t}$ events as either nominal or systematic
- Add additional weighting to the $t\bar{t}$ sample for the adversarial network only
- Exclude the $t\bar{t}$ sample for the adversarial training completely

Applied fixes

Re-labelling

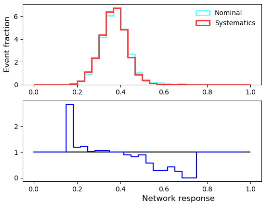
	Discriminator	Adversary
$t\bar{t}$	0	1/0 (50 % mix)
tW DR	1	1
tW DS	1	0

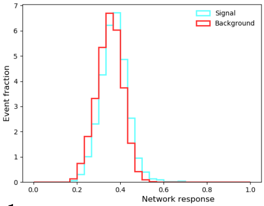
Weighting $t\bar{t}$ for the adversary

- Applying an additional weight to the $t\bar{t}$ events for the adversarial training only
- Varied the weights between 0.0 and 1.0

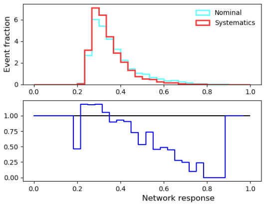
ttbar weights for the adversarial training

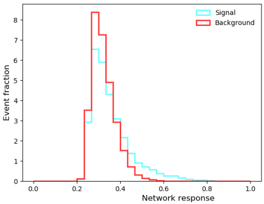
Weight = 0





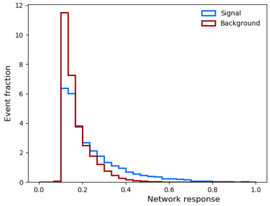
Weight = 1

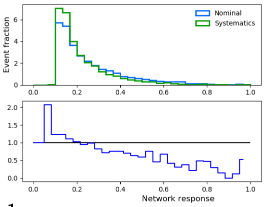




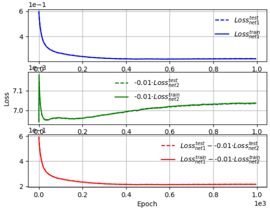
ttbar weights for the adversarial training

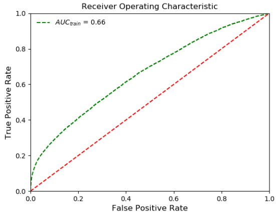
Weight $= 0$





Weight $= 1$





Conclusions

Improvements and insights

- sdfw

Weighting $t\bar{t}$ for the adversary

- Applying an additional weight to the $t\bar{t}$ events for the adversarial training only
- Varied the weights between 0.0 and 1.0