Neural Network techniques for a separation of pair and single top quark contributions to tWb final state

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Outline

- p,p -> t,W,b modeling task
- Machine learning base
- Input variables used are used in NN
- NN separation power
- Results and Plans

tWb simulation

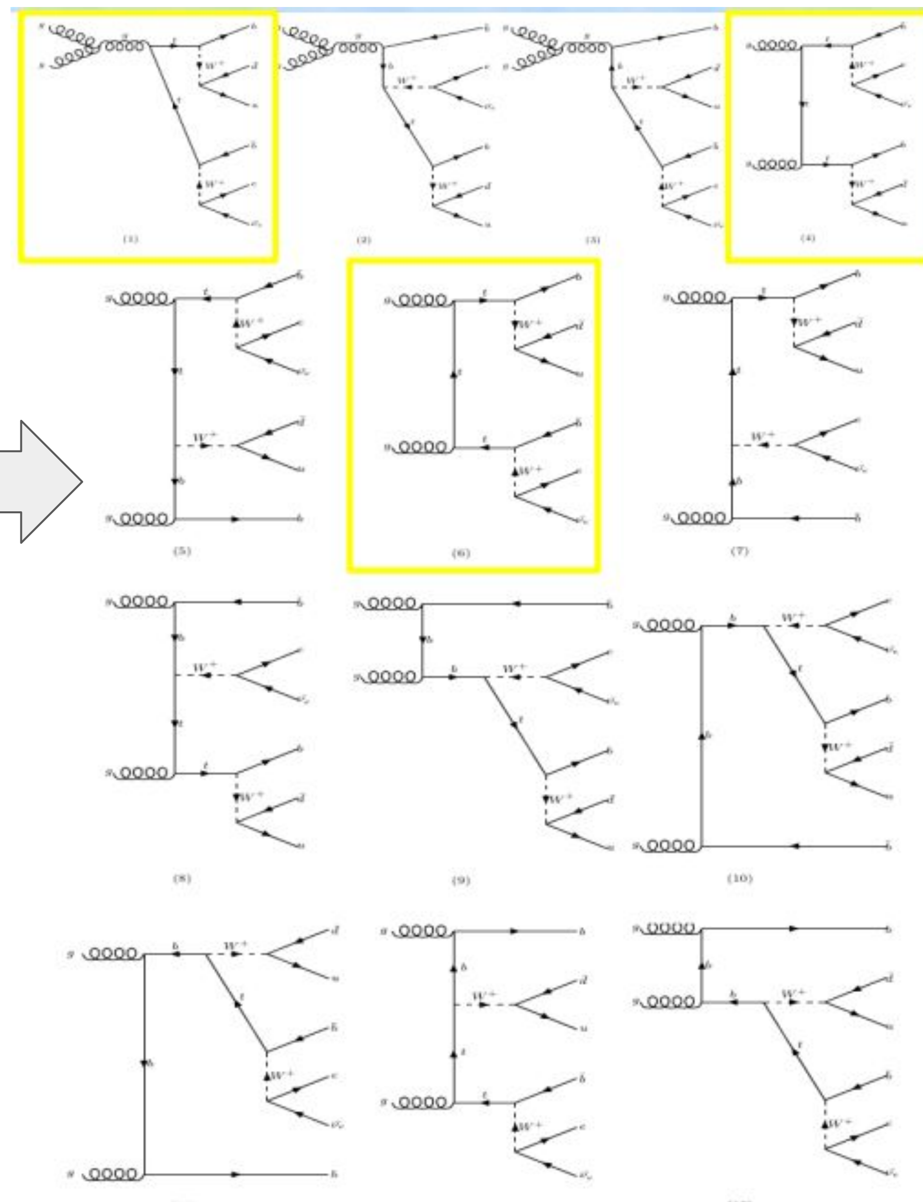
tWb process at NLO level can be simulated with Diagram removal scheme [arXiv:1607.05862 [hep-ph]. But with gauge invariance violation and loss of the interference between tT and tWb diagrams..

For full tT+tWb we have diagrams in total:

yellow tT - diagrams

other tW-B, TW+b diagrams

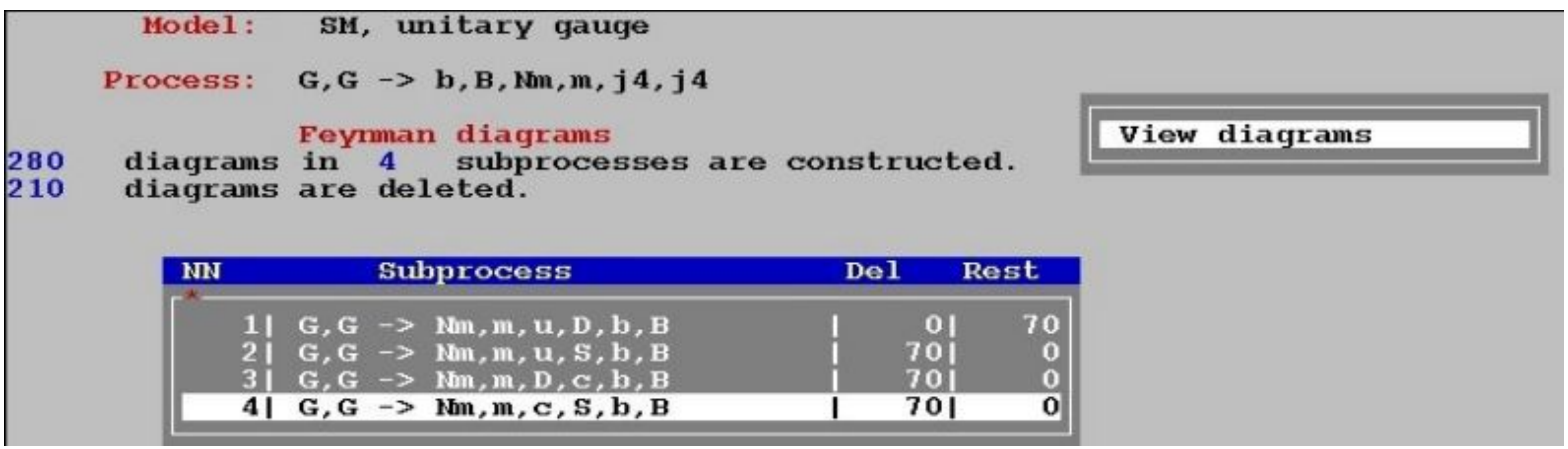
The idea is to extract tWb process from full scheme using neural networks.



tWb modeling

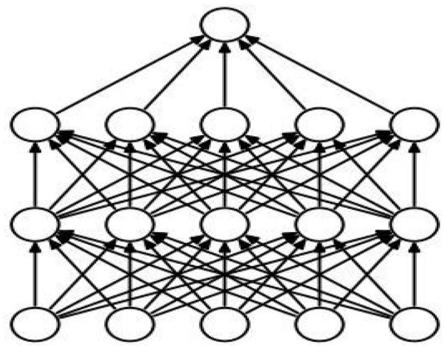
4 samples are generated in CompHEP package. In LHE format

Process	cross section	events	name
tW-B	1.413	~1 000 000	GG_NeeuDbB_tW-B.lhe
TW+b	1.413	~1 000 000	GG_NeeuDbB_TW+b.lhe
tT	15.200	~1 000 000	GG_NeeuDbB_tT.lhe
tT_tWb	16.020	~2 000 000	GG_NeeuDbB_tT_tWb_all.lhe



Machine learning base

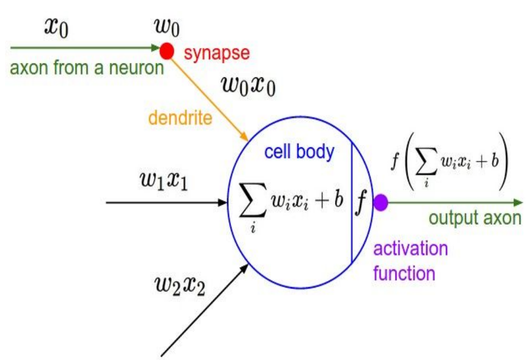
Tasks:
classification
regression
clastering

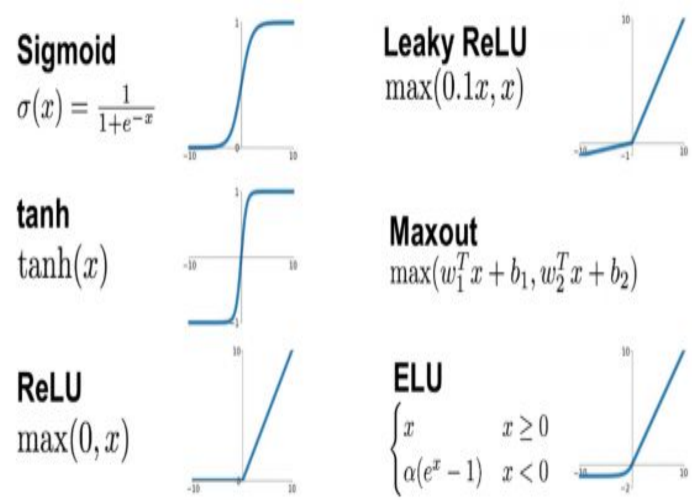


(a) Standard Neural Net

types:
fully connected
deep
convolution
recurent
bayesian

difference:
architecture
learning algorithms,
task types

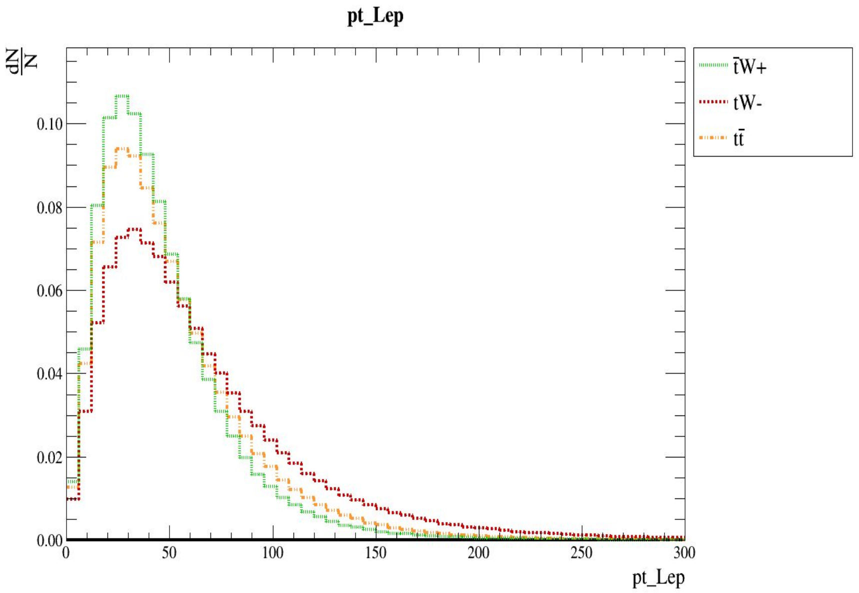


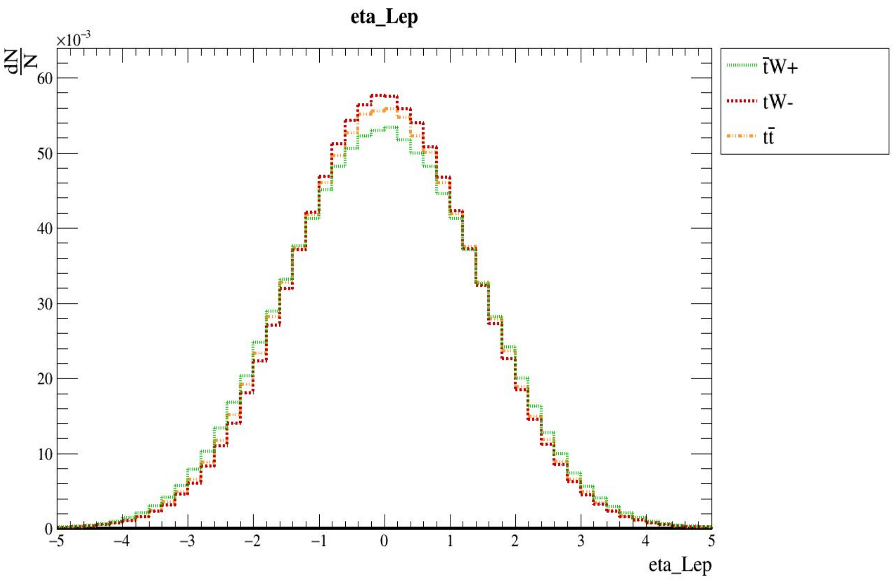


for the task we use fully connected DNN

Training set and input variables

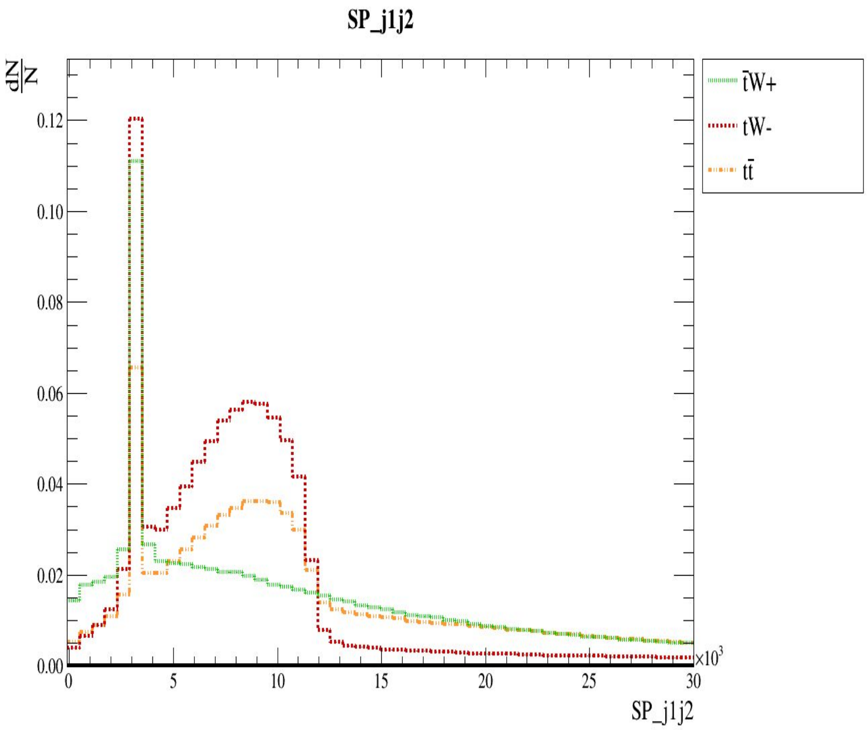
- Training set included top pair production process as background and single top and antitop process in DR scheme as signal.
- 200 k events are used in training and 200 k are used for validation.
- Signal and background are normalized one to one.
- Specific input features are used [Int.J.Mod.Phys.A 35 (2020) 21,2050119, hep-ph:2002.09350]. transverse momentum and pseudo-rapidity

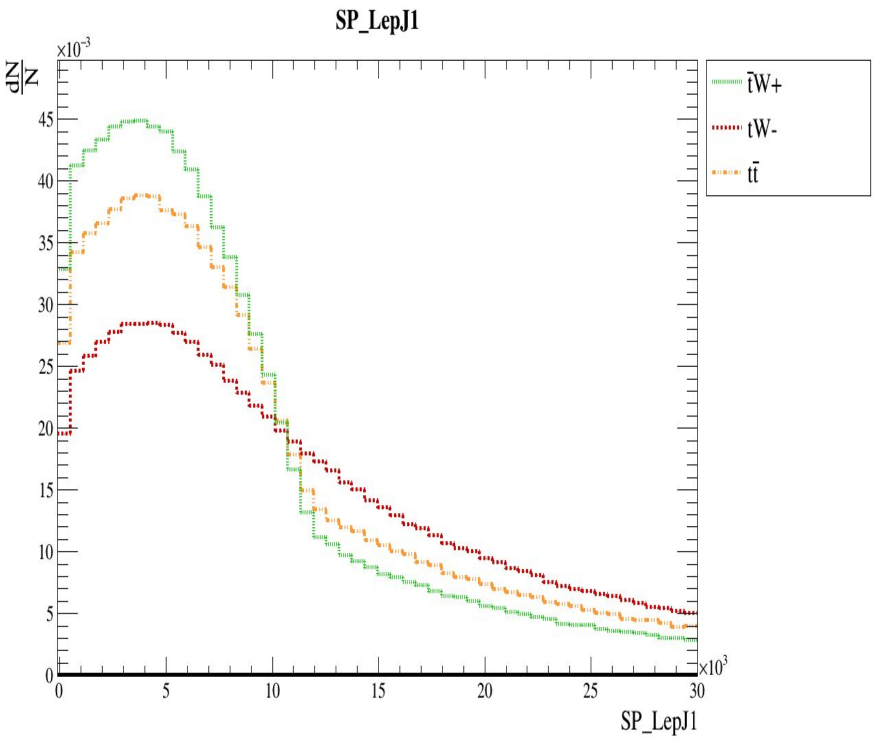




low level input variables

- Specific input features are used [Int.J.Mod.Phys.A 35 (2020) 21,2050119, hep-ph:2002.09350]. Scalar products.

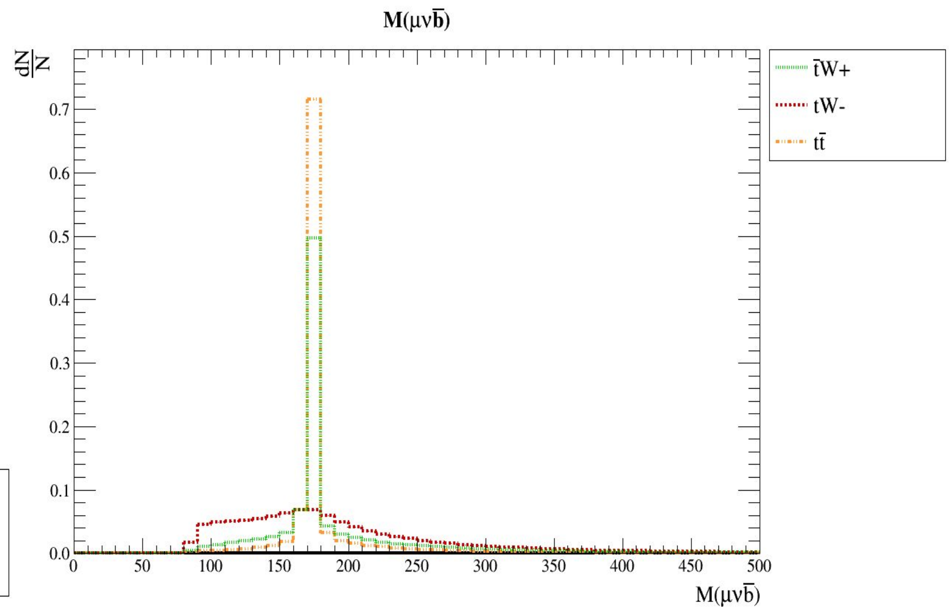


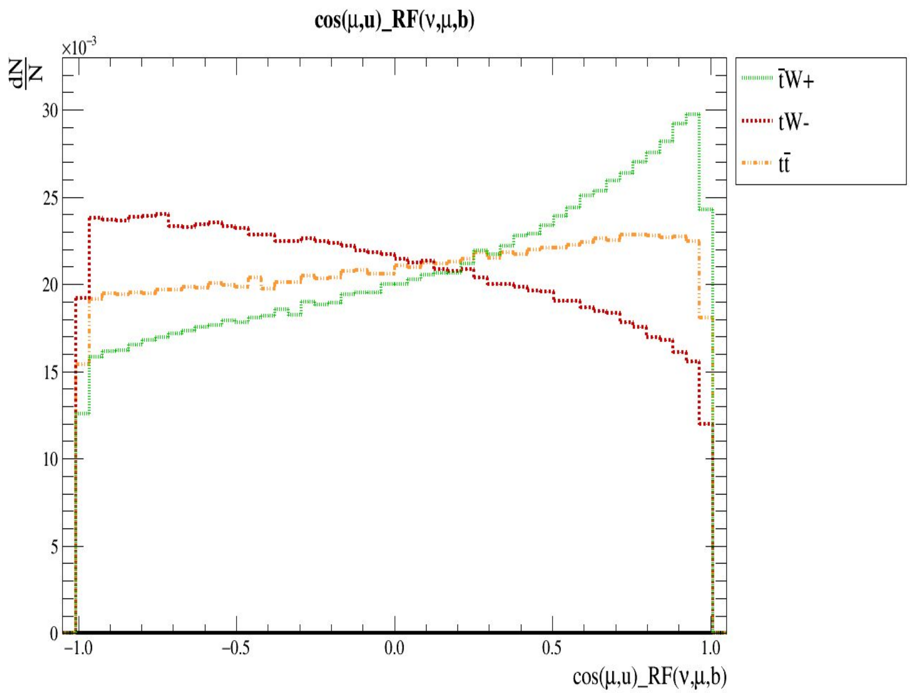


expert input variables

To improve DNN separation power we used additional input variables, named expert or “high level”. For example.

- Top1(Lep+Nu+B)/ Top2(W(u+D)+b) recovered mass.
- angular variables.
- W bosons pt
- etc





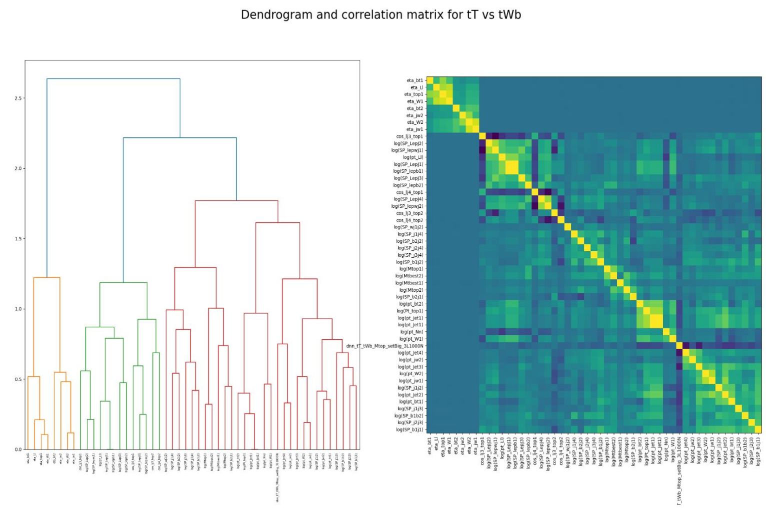
NN training

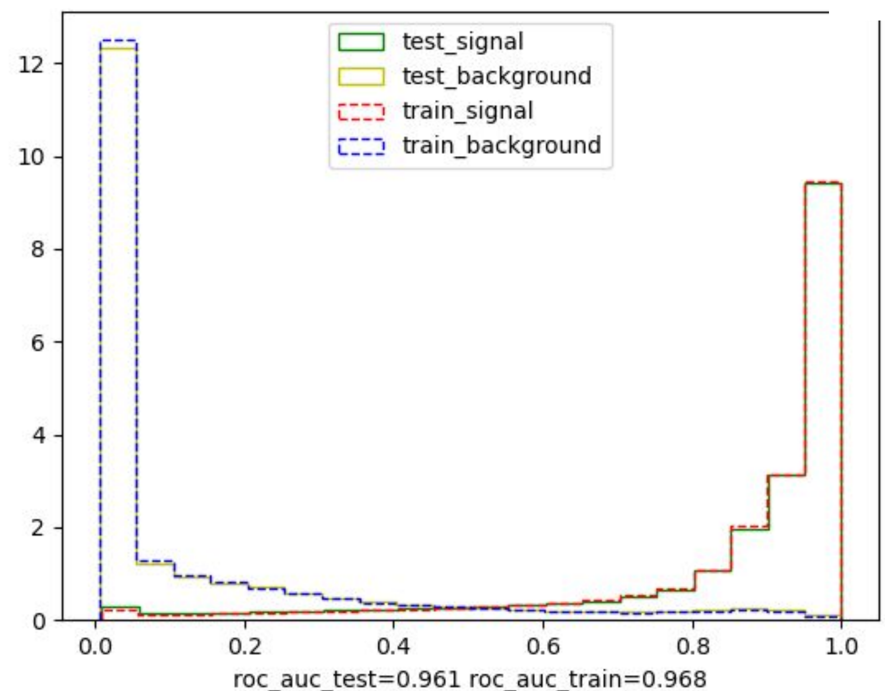
Tensorflow package was used for training.

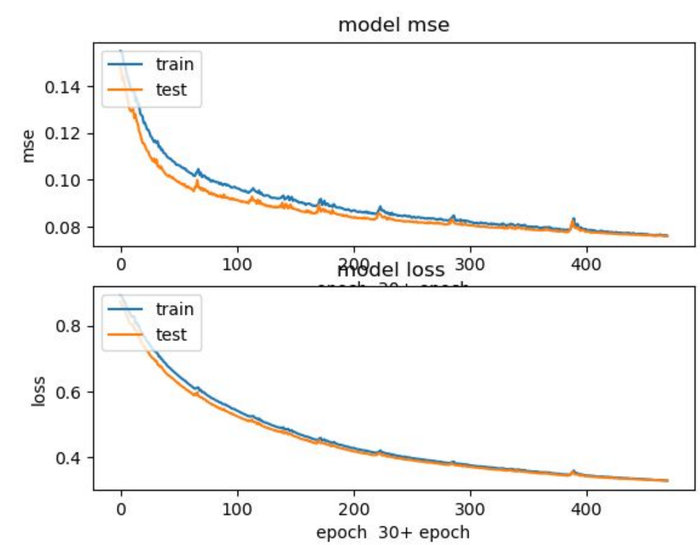
Few network configurations were checked.

as a result 3 layers of 100 neurons were selected. with using dropout and l2 regularization.

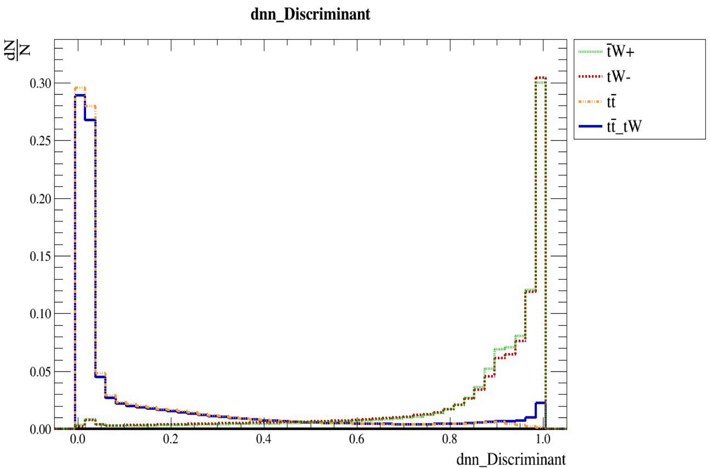
Also dendrogram and correlations matrix were used to create feathers sets.



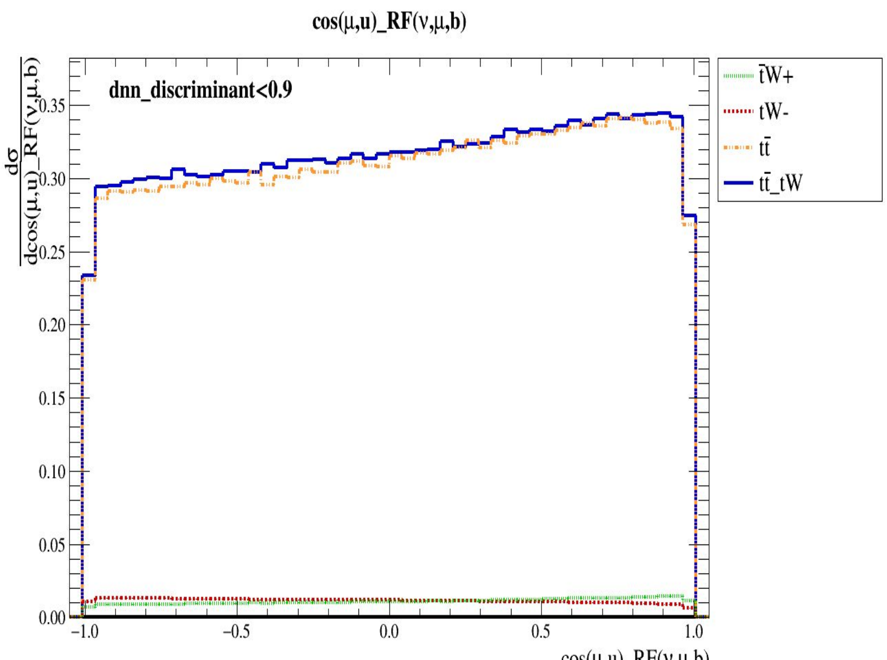


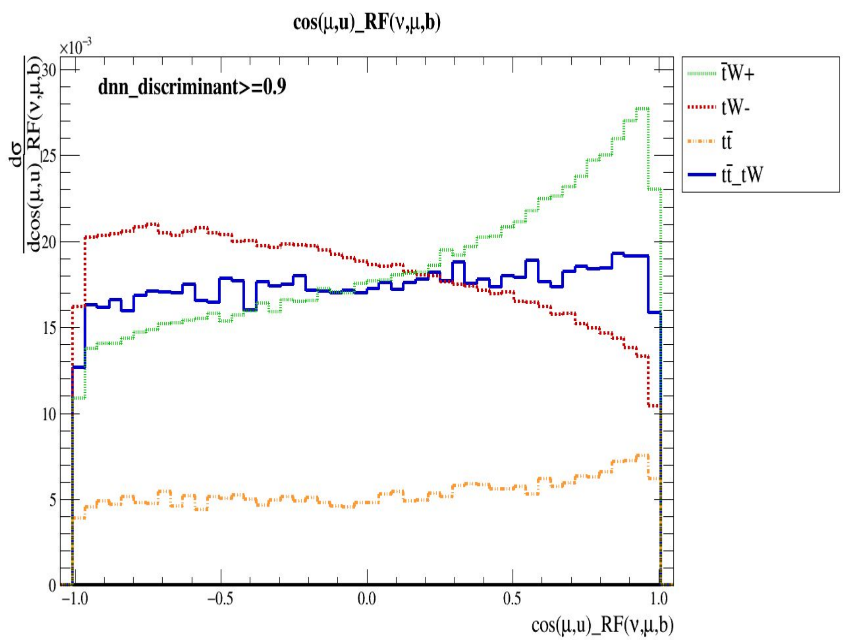


Results



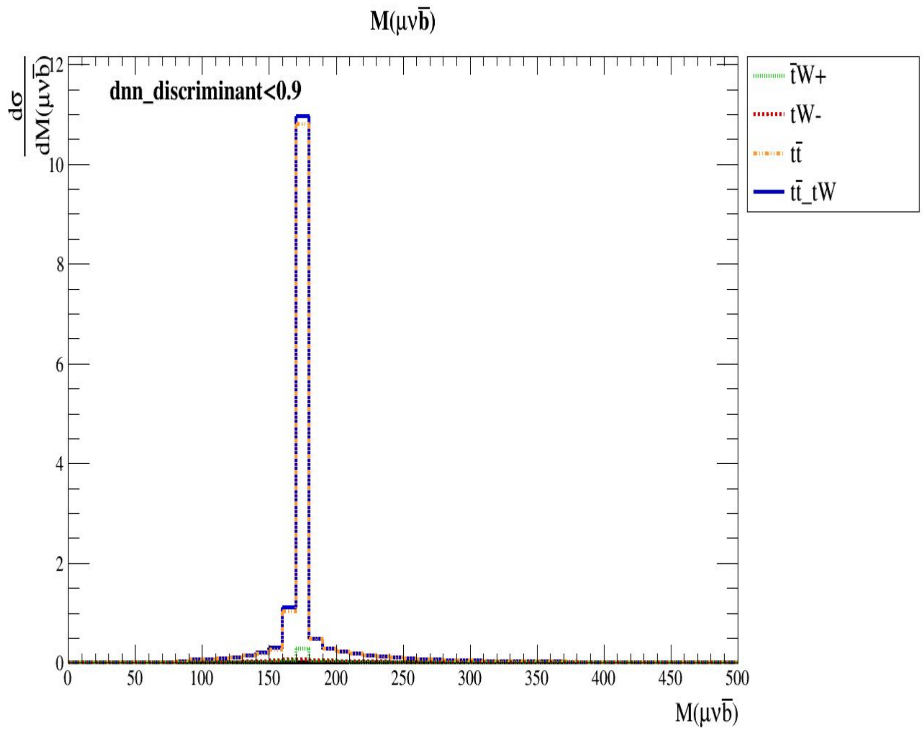
Neural network can be used to separate pair top quark and single top quark in full sheme. cos(Lep, u)_top1RF are shown. The histograms take into account cross sections. In region NN_dicriminant < 0.9 the fraction of the single top quark is almost zero.

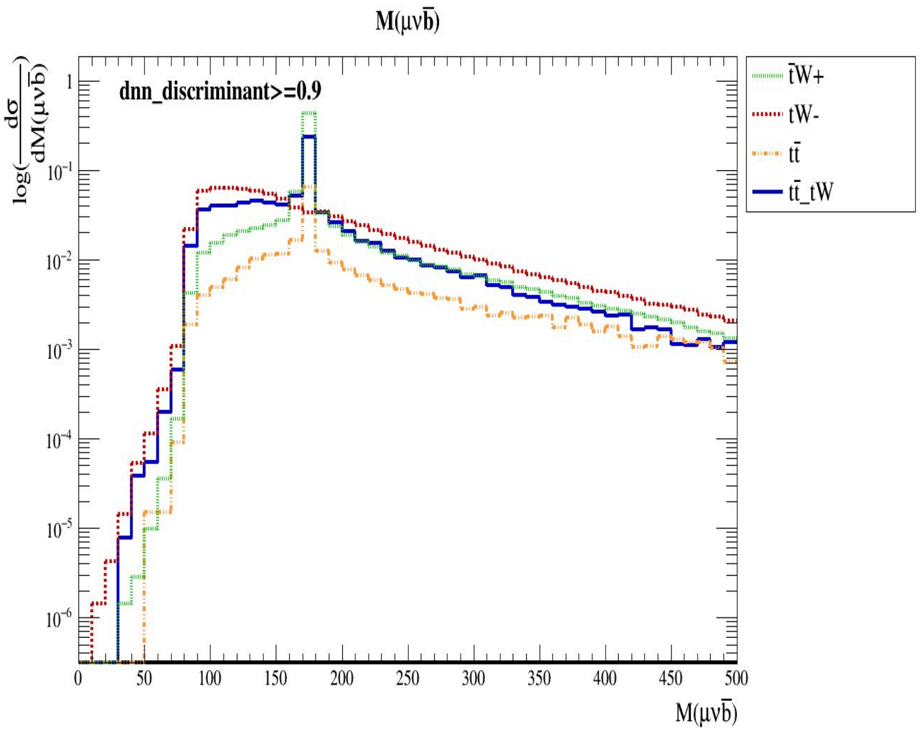




Results

Neural network can be used to separate pair top quark and single top quark in full sheme. Mtop1(Lep + Nu+ b) are shown. The histograms take into account cross sections. In region NN_dicriminant > 0.9 the fraction of the paired top quark is smaller relative to the single top quark.





Conclusion and Plans

- Consulison
  - tT, tWb(DT1), tT_tWb simulated.
  - NN input variables and architecture created.
  - Separated NN trained.
  - NN are implemented to tT_tWb samples, and good separation power shown.

- Plans
  - Apply detector response to simulation with delphes.
  - Train DNN on simulation after delphes.

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