Signal to background discrimination for the production of double Higgs boson events via vector boson fusion mechanism in the decay channel with four charged leptons and two b-jets in the final state at the LHC experiment

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1. Signal topology

- Despite the signal rarity, an area under the ROC curve (AUC) ~ 98% with the DNN algorithm has been computed.
- A similar binary classification task can be performed for discriminating the VBF HH production under Effective Field Theory (EFT) models vs SM bkgs. The former have enhanced cross-sections, and therefore are simpler to be selected.

2. Analysis strategy

- Event selection [generator level]
  - At least one Primary Vertex
  - Z candidates 12 < m_t+1 < 120 GeV/c²
  - ZZ candidates are built from a pair of Z candidates which do not have common leptons [non-overlapping]
  - SM Higgs candidate from ZZ pairs, channels 4e, 4μ and 2e2μ selected separately.

- VBF signal region (SR)
  - Full selection of H → 4t
  - Four charged leptons:
    - Number of jets ≥ 4,
    - ∆R_i,j ≥ 0.3, |η| < 4.7

- Backgrounds (bkgs)
  - SM single Higgs processes [irreducible]
  - HH gluon-gluon fusion (ggF) events [irreducible]
  - GCD backgrounds.

3. Multivariate analysis


- b) Deep Neural Network (DNN)
  - hyper-parameters scanning
  - Plots of x × ε_x - purity [η] = TP / (TP + FP), sign_eff (ε_x) = TP / (TP + FN) - vs i-th model

4. Results

- Merging the 3 channels [4e, 4μ and 2e2μ] for the NN training

5. Conclusions

- At the LHC experiment, the non-resonant double Higgs [HH] production via vector-boson fusion (VBF) represents the unique means to probe the VHVV (V=Z, W) Higgs coupling (G_VV).

References

- Search for double Higgs events produced via a vector boson fusion mechanism in the decay channel bb-4l with the CMS experiment at the LHC
- Signal/background discrimination for the VBF Higgs four lepton decay channel with the CMS experiment using Machine Learning classification techniques, ML_INFN project