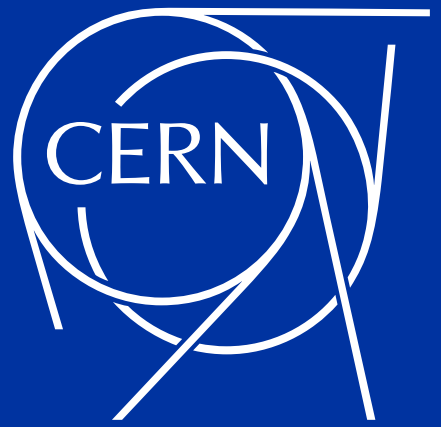

Summer Student Project: Machine Learning Classification of ttH Events at the ATLAS Experiment

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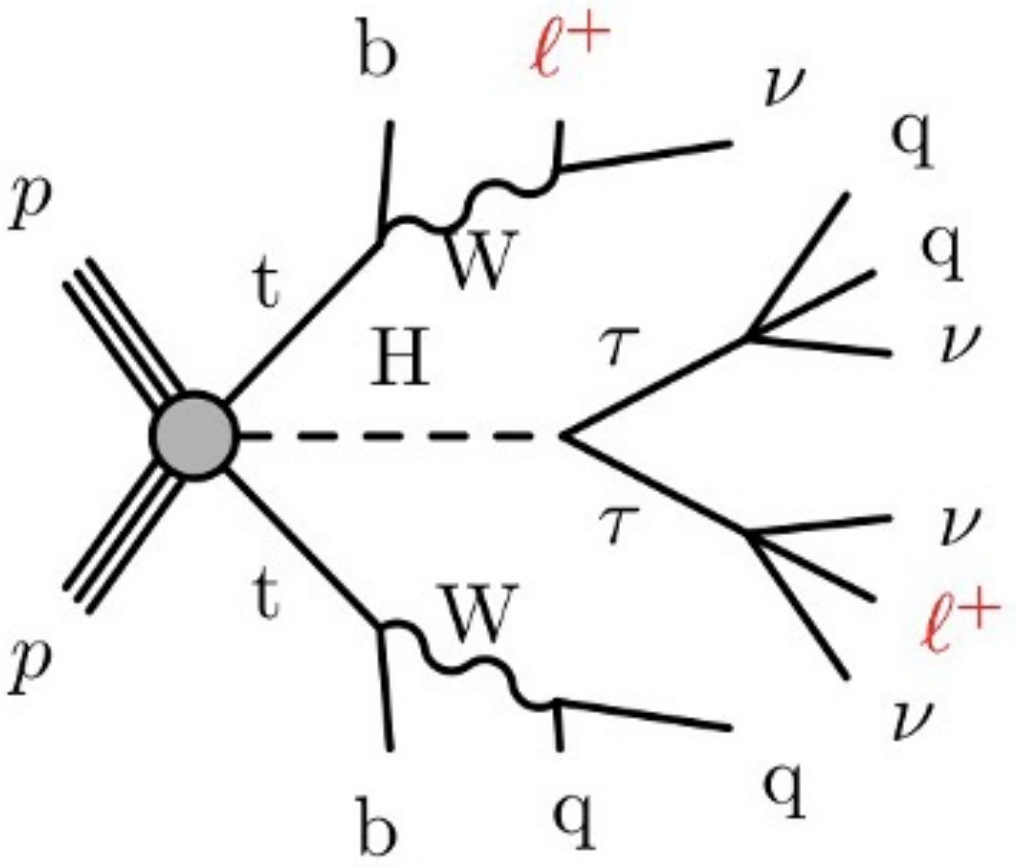
03.08.2022

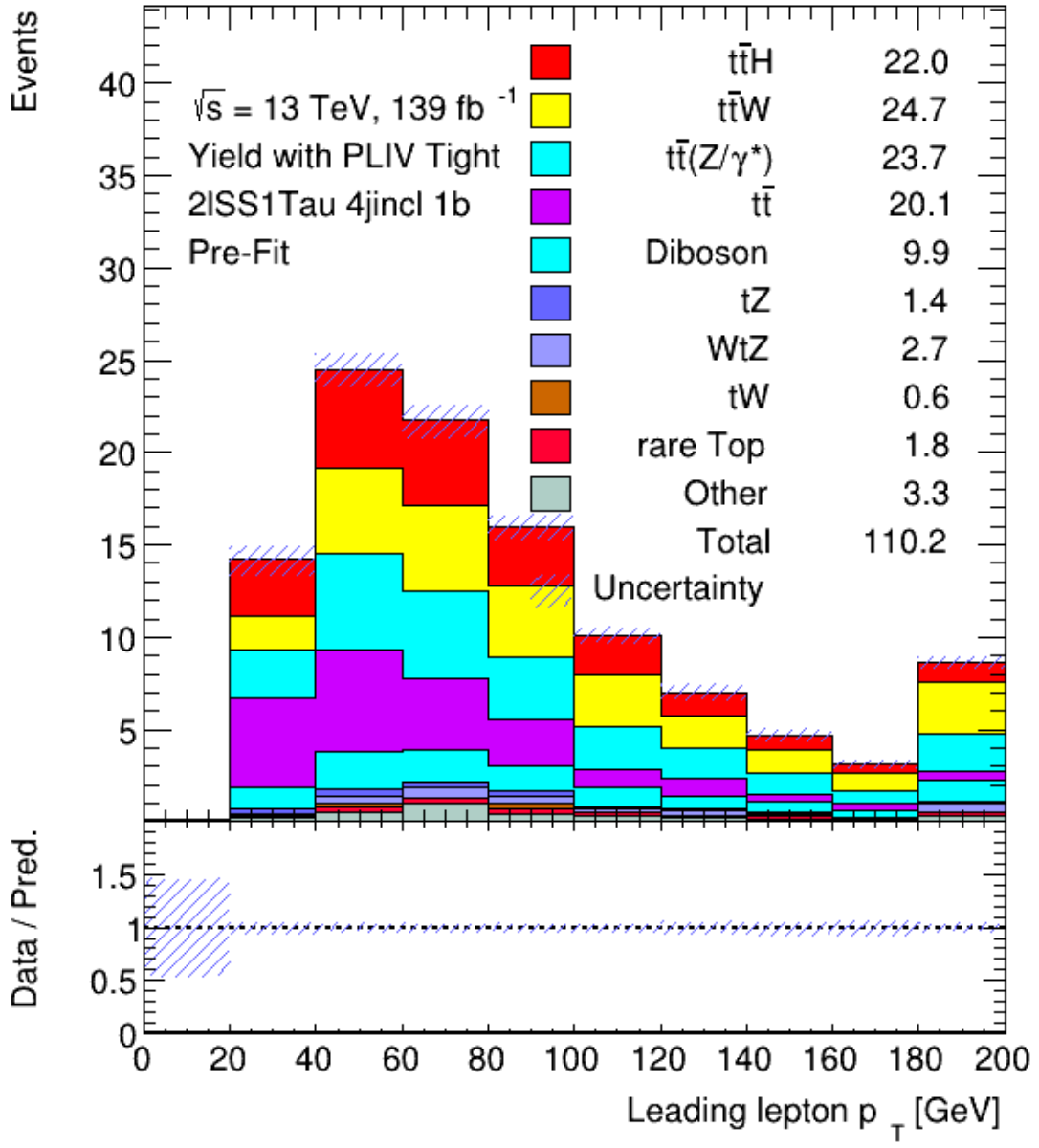
Theoretical Background

- **Process of Interest: ttH**
- **Important process for study of the Higgs boson at CERN**
- **Both top quarks and Higgs have several decay modes.**
- **Focus on 2LSS1Tau channel which requires two same-sign light leptons and a hadronically decaying tau**
- **Task: machine learning optimization following up on the Masters thesis [1]**



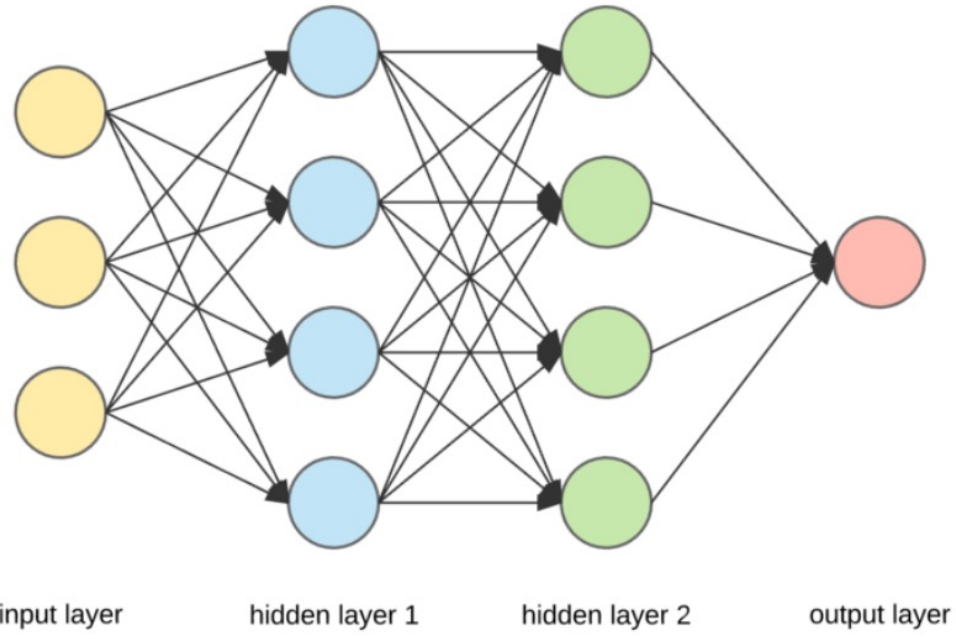
Theoretical Background

- **Large number of background reactions require machine learning to separate ttH signal**
- **TRExFitter [2] used to illustrate preselected events as input for the machine learning**



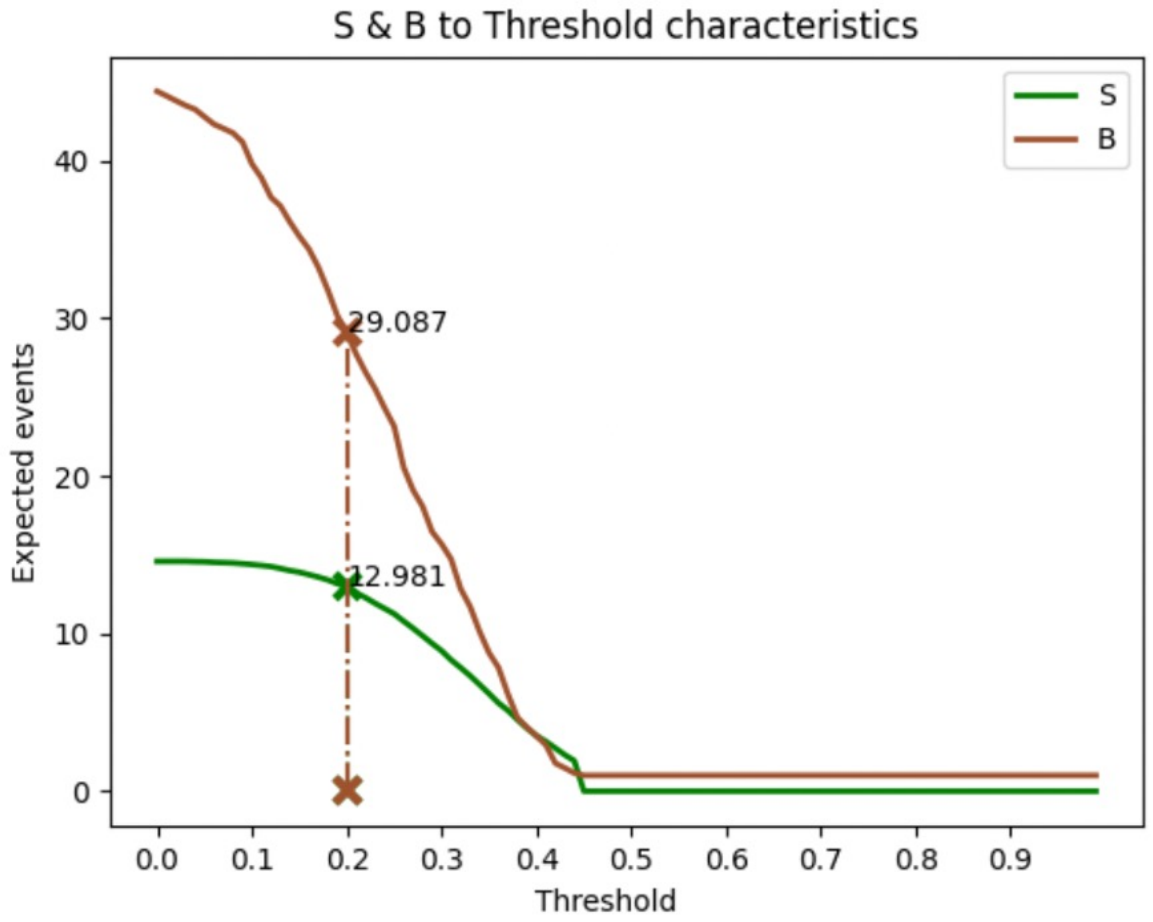
Neural Network Approach

- Commonly used machine learning algorithm: Multi-Layer Perceptron(MLP)
- Choose Network Architecture, i.e. number of nodes and layers, and other hyperparameters
- Train with simulated input data using weights to scale to expected events
- Network output: probability score (0-1) for signal and background classes
- Alternative method also tested: Gradient boosting

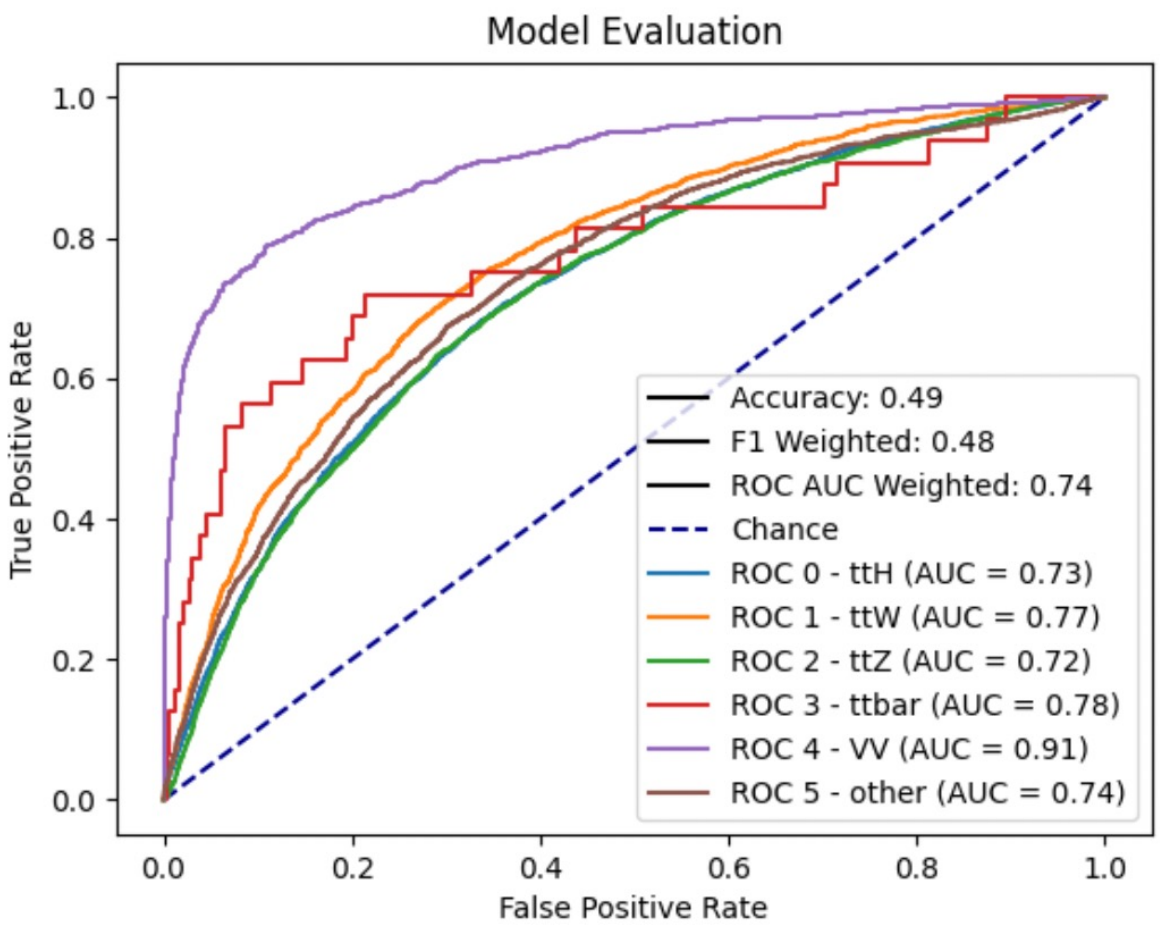


Results: Optimal threshold search

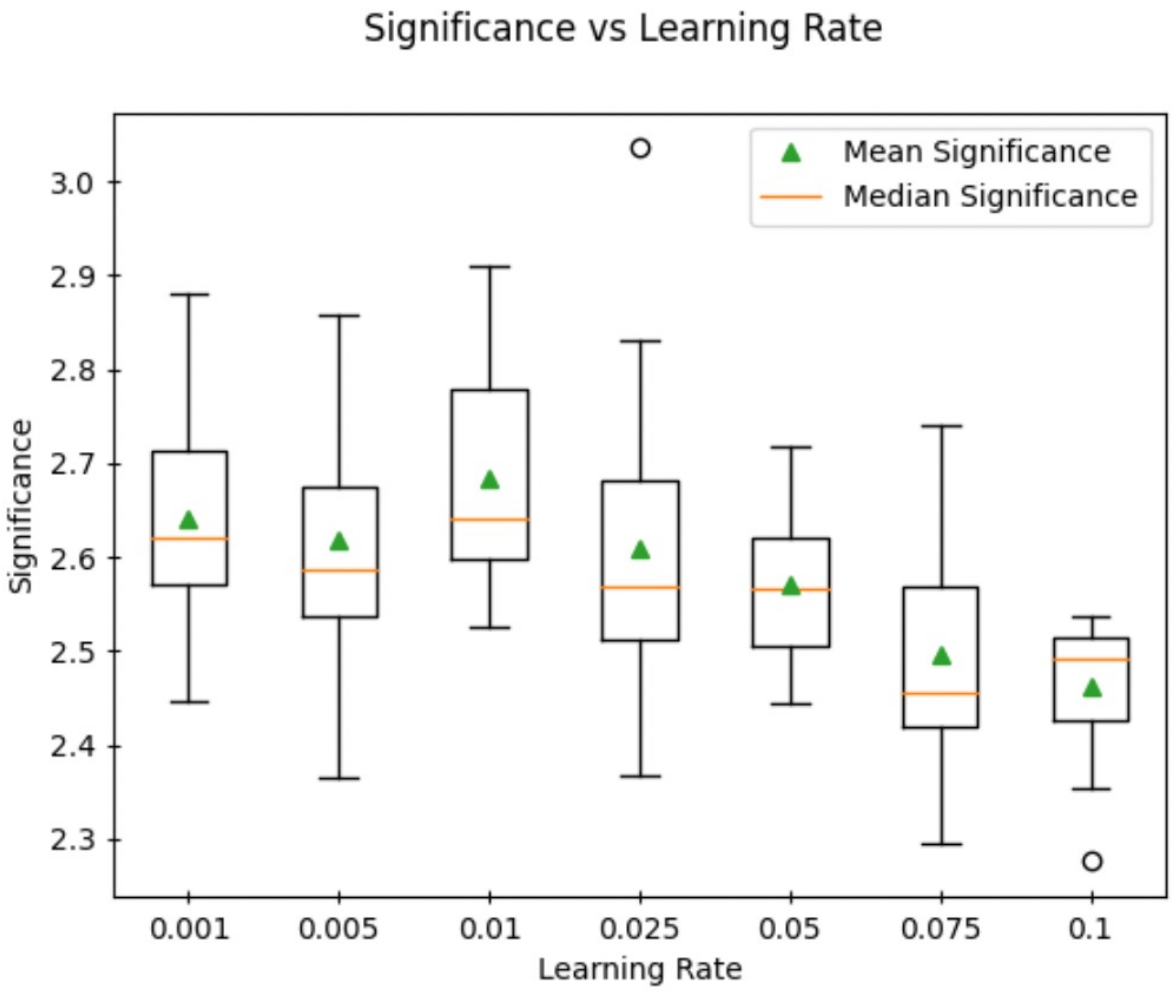
Signal/Background vs threshold



ROC curve



Results: Hyperparameter Optimization



- **Significance approximated as**

  $\frac{S}{\sqrt{B}}$**, where S = no. of signal events,**

  B = no. of background events

- **Optimization also performed for other parameters**

Summary

- **Study of ttH production with machine learning**
- **Optimization of machine learning with different preselections**
- **Goal: increasing sensitivity for ttH events by reducing background events**

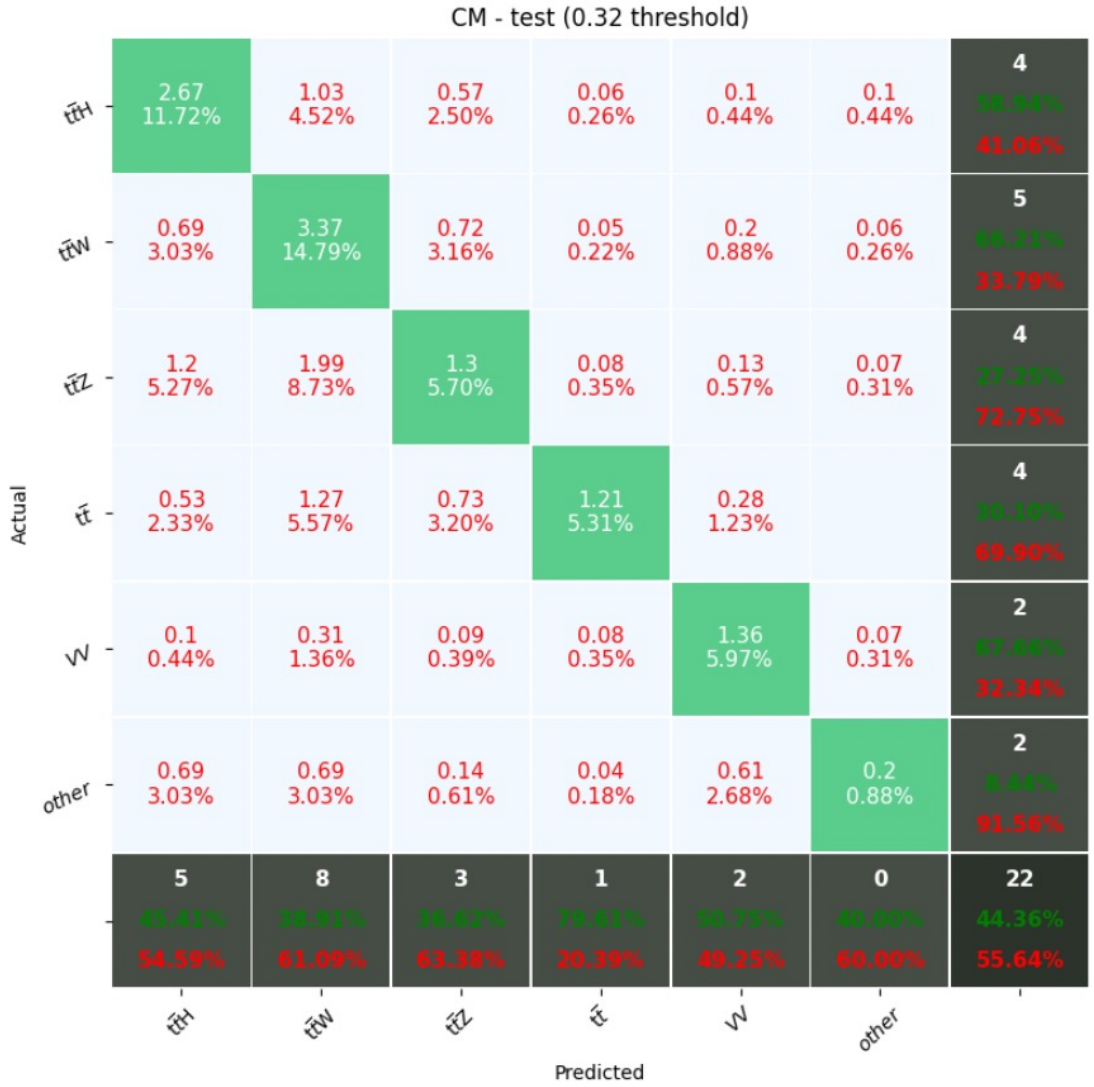
- **References:**

[1]: Presperín, Jan. *Machine Learning for ttH Mechanism Higgs Boson Detection from CERN ATLAS Data*. May 2022.

[2]: TRExFitter: https://trexfitter-docs.web.cern.ch/trexfitter-docs/

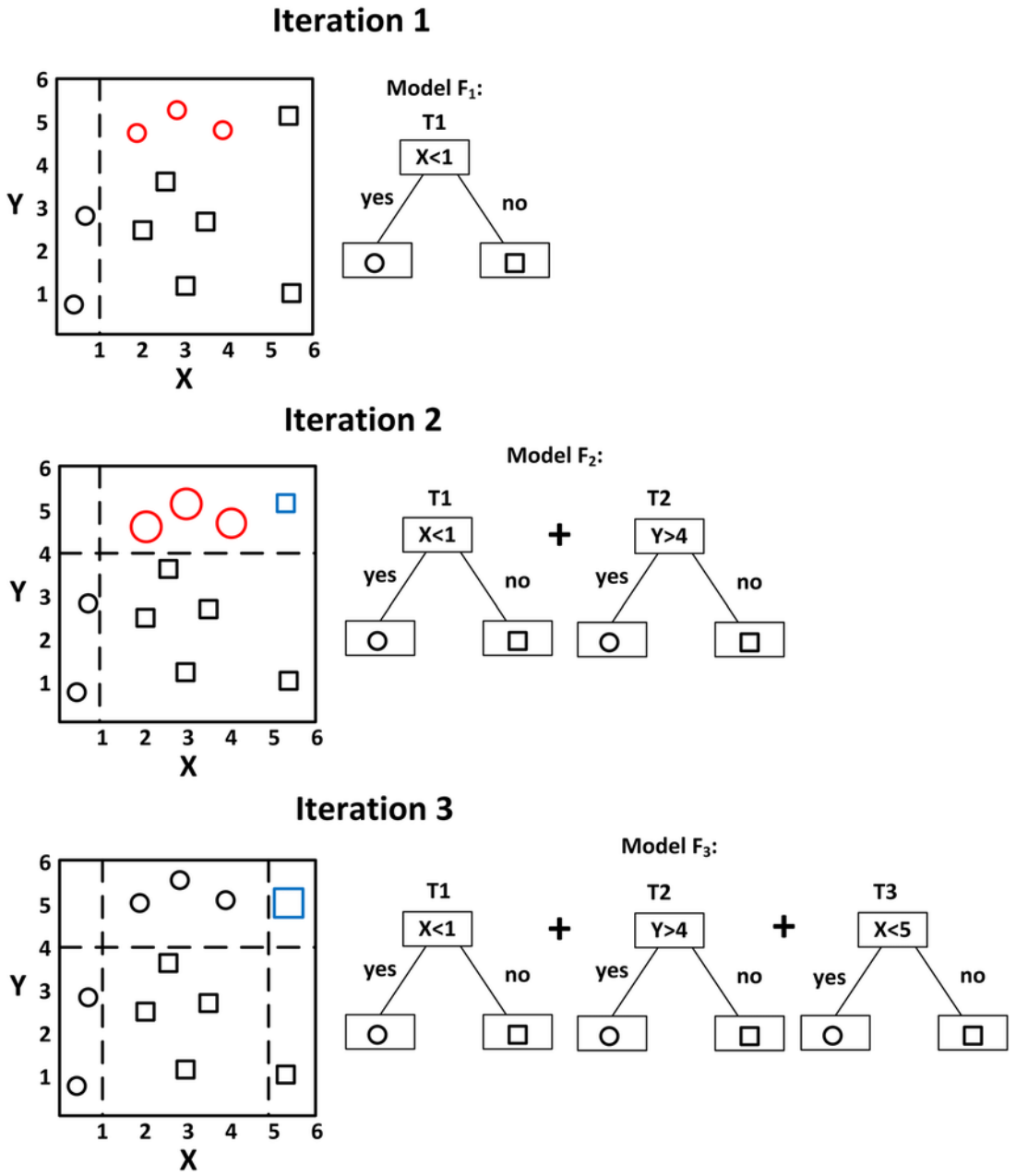
Supplement

Confusion Matrix



Gradient Boosting

- Alternative approach to machine learning algorithm
- Based on minimizing loss function by combining multiple ”weak learners” which correct each others mistakes
- In analogy with MLP analysis, hyperparameter optimization is performed



- Image credit: Zhang et. al. *Exploring the clinical features of narcolepsy type 1 versus narcolepsy type 2 from European Narcolepsy Network database with machine learning.* July 2018.

Results: Feature Importance