

Electron identification in ATLAS using a deep neural network

Lukas Ehrke

Johnny Raine, Tobias Golling

13.05.2022 - IML workshop 2022



UNIVERSITÉ
DE GENÈVE

DNN vs current ID

Current recommended ID (LH)

- Built of one dimensional PDFs for several variables
- PDFs data driven
 - Signal enriched in prompt electrons
 - Background enriched in hadronic background
- Likelihood of being signal or bkg given by product
 - Correlations not taken into account
- Final discriminant:

$$d = \frac{L_S}{L_S + L_B}$$

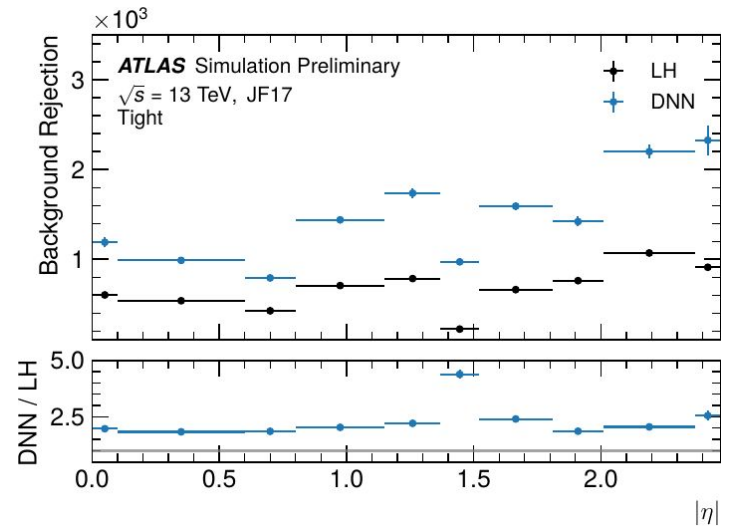
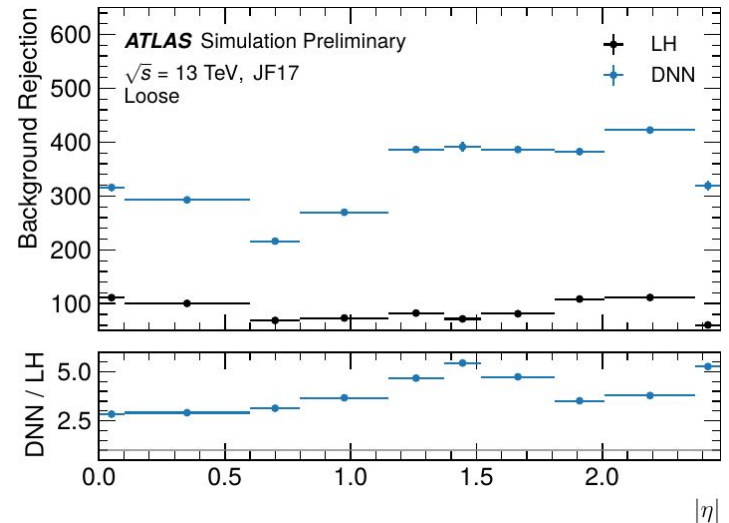
Newly developed DNN ([link](#))

- Uses (almost) same high level features as input
- Training in MC
- Simple DNN with just dense layers
- Multinomial classification with total of six classes
- Final discriminant:

$$d = \frac{f_{Sig} p_{Sig} + (1 - f_{Sig}) p_{CF}}{\sum_{X \in \{PC, HF, LFEg, LFH\}} f_X p_X}$$

Comparison with LH

- DNN tuned to same signal efficiency as LH in bins of (ET, $|\eta|$)
- Increase in rejection on MC sample over **whole phase space**
- **Up to 5.5 times higher rejection**
- Improvement smaller for tighter working points (lower signal efficiency)
- Values with ET < 17 GeV biased wrt data due to filter requirement of MC sample

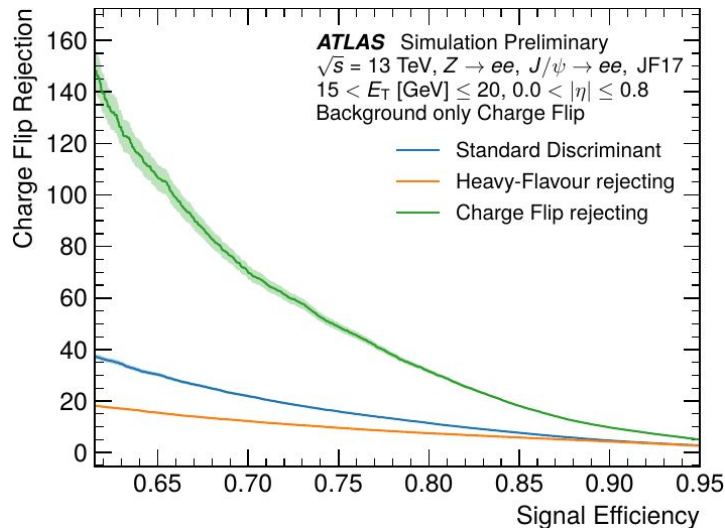
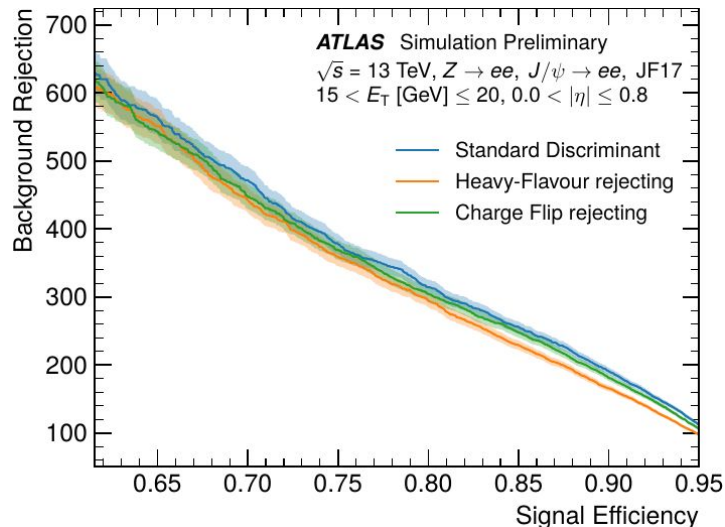


Added versatility

- Can modify discriminant to also **reject charge flip electrons** (green curve)

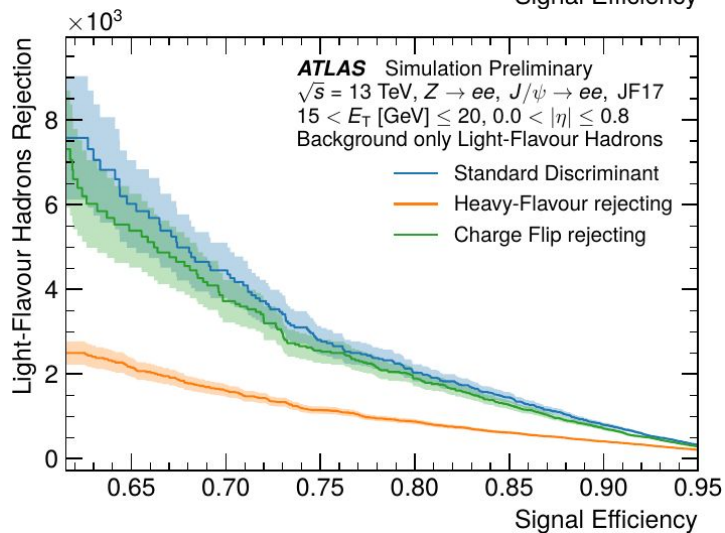
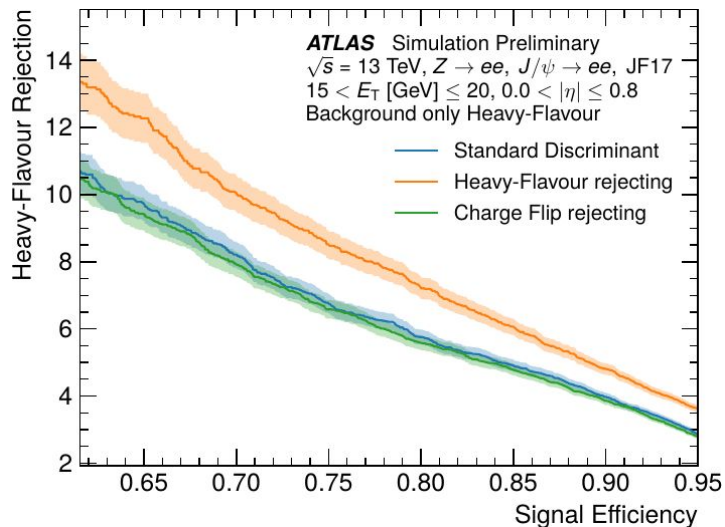
$$d' = \frac{P_{Sig}}{\sum_{X \in \{CF, HF, LFEg, LFH\}} f_X p_X}$$

- Or increase one of the f_X of the discriminant e.g. f_{HF} (orange curve)
- Little change in overall rejection
- But **much better charge flip rejection** for green curve
 - Potential to combine ID and charge flip rejection algorithms



Added versatility

- Increasing f_{HF} **greatly improves rejection** of electrons from heavy-flavour quark decays and in turn reduces rejection for other bkgs (here hadronic)
- On a dataset containing more heavy-flavour jets (e.g. $t\bar{t}$), could lead to increase in overall rejection



Summary

- Developed new electron identification algorithm based on a simple DNN
- Great increase in rejection over current ID method
- DNN performs multiclassification
 - Greater flexibility in defining the discriminant
 - Potential to use DNN in more areas than just simple electron identification