

Correction Energy and Tau Tagging with Quantum Machine Learning

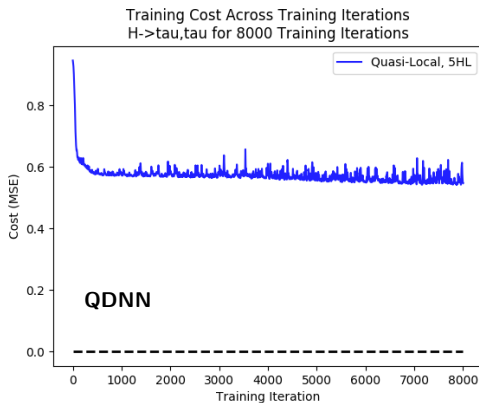
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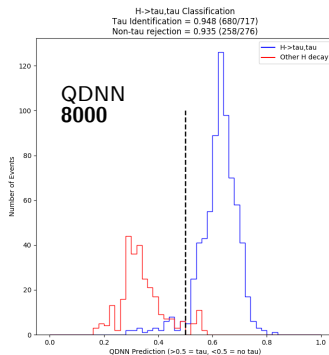
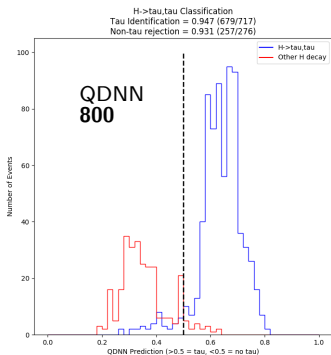
QML Tau Tagging - More Training Iterations

- Train for 8000 iterations (batch size 5, 500 training events)
- Compare performance to 800 iterations (used previously)



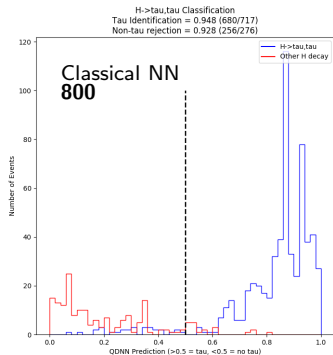
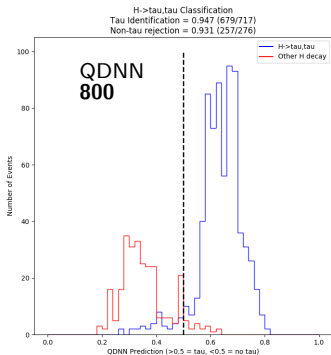
QML Tau Tagging - More Training Iterations

- Performance does not improve significantly with more training
- Agrees with training cost plot (loss roughly constant by 800 iterations)



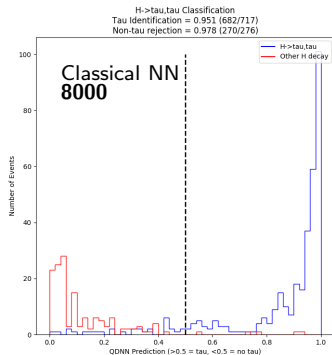
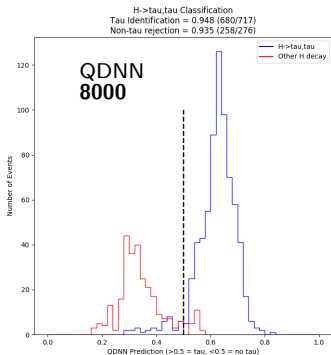
Fairer Quantum vs Classical Tests

- Train classical and quantum NNs on same data (PCA down to 8 inputs, 500 events, batch size 5, 800 or 8000 iterations)
- Classical NN is fully-connected, three layers (225 trainable parameters, comparable to 241 for QDNN used)
- Classical NN performed similarly to QDNN for 800 steps; performed better for 8000 steps



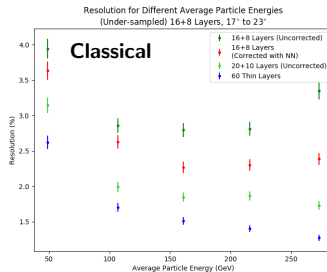
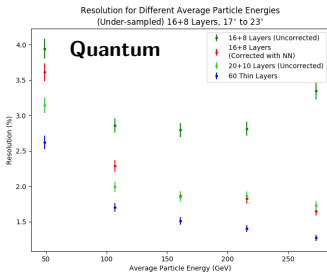
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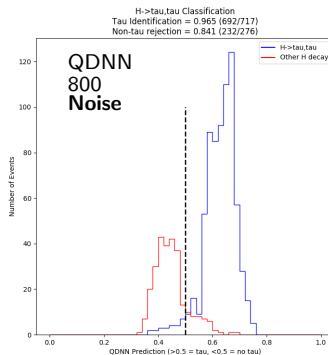
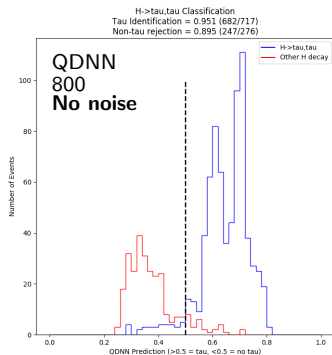
Fairer Quantum vs Classical Tests - ECal

- Train classical and quantum NNs on same data (PCA down to 8 inputs, 500 events, batch size 5)
- Classical NN is fully-connected, three layers (225 trainable parameters, comparable to QDNN)
- Classical NN performed worse than QDNN, even with arbitrarily many training iterations
- Still need larger-scale QDNN test (full 10000 events, 35 inputs, etc.)



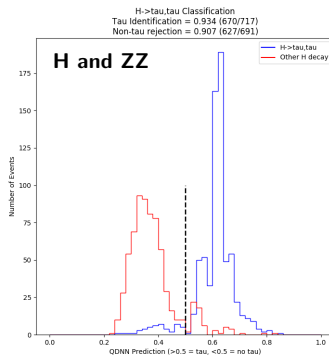
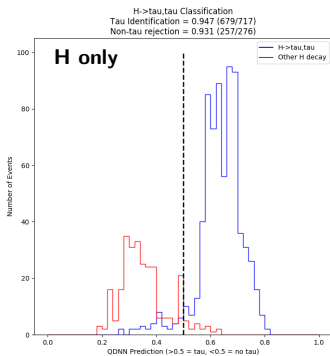
QML Tau Tagging in a Noisy Environment

- Slightly altered QDNN setup to make more readily-implementable on current quantum computers (only nearest-neighbor interactions in a straight line)
- Tested with and without a simplified noise model (noise based on ibmq_16_melbourne)
- Noise only applied after training
- Noise only slightly reduces performance



QML Tau Tagging with ZZ Background

- QDNN trained on a mix Higgs events and ZZ events
- Evaluated on 415 ZZ events (cut from 20000)
- Shows strong ZZ rejection (398/415) but somewhat worse non-tau Higgs rejection and tau tagging (229/276 and 670/717, respectively)



- Larger tests: more events, more training iterations, more qubits
- $Z \rightarrow \mu\mu$ tests with and without ZZ background
- Try different preliminary cuts and preprocessing to improve performance