

Neural Network Regression to Approximate Matrix Element Method Likelihoods

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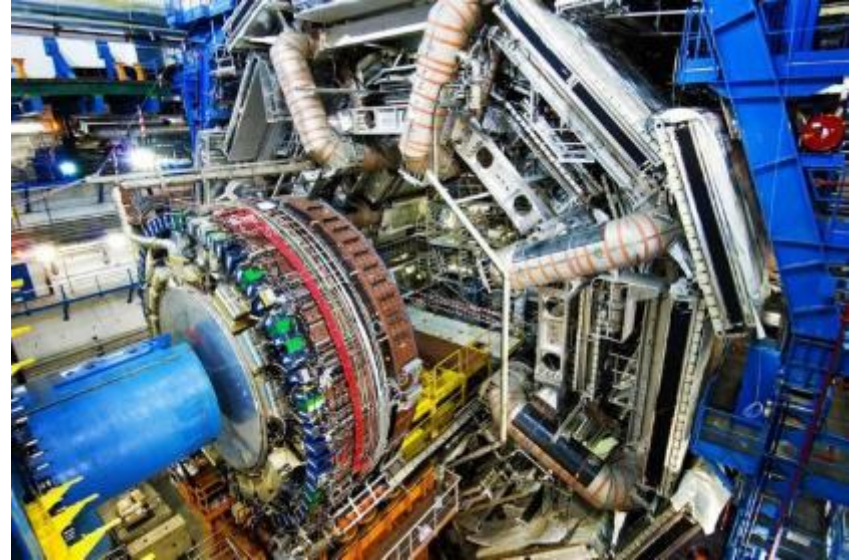
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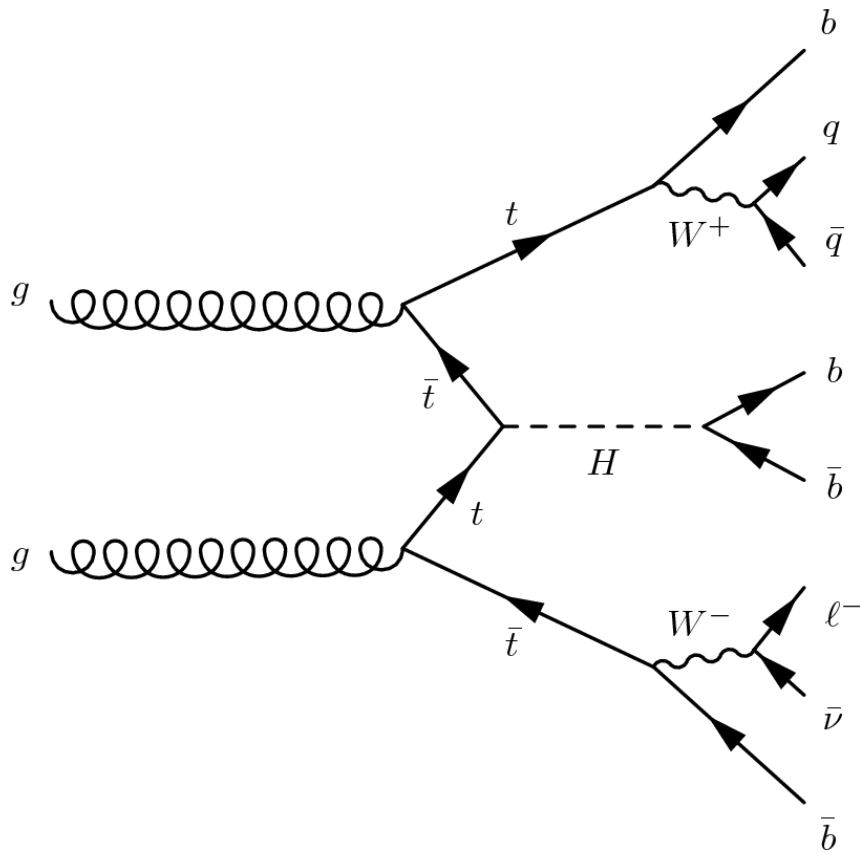


The Large Hadron Collider

- Collides protons at relativistic speeds
- The ATLAS experiment detects and tracks various particles produced
- Overall goals are to test the validity of the Standard Model and possibly beyond



The ttH process



- This year ATLAS has observed the process
- We want to further analyze and study it to test accuracy of the Standard Model
- Separate this signal from the background with multivariate analysis

Matrix Element Method (MEM)

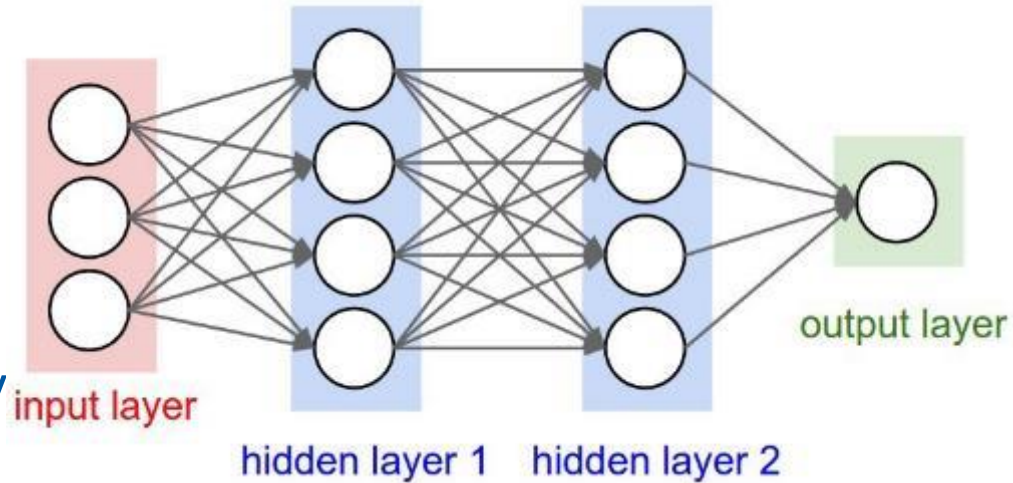
- Uses theory to exploit final state particle momenta
- Separate signal from background
- ttH process: 8 final state particles for 22 free parameters
- Slow and computationally expensive



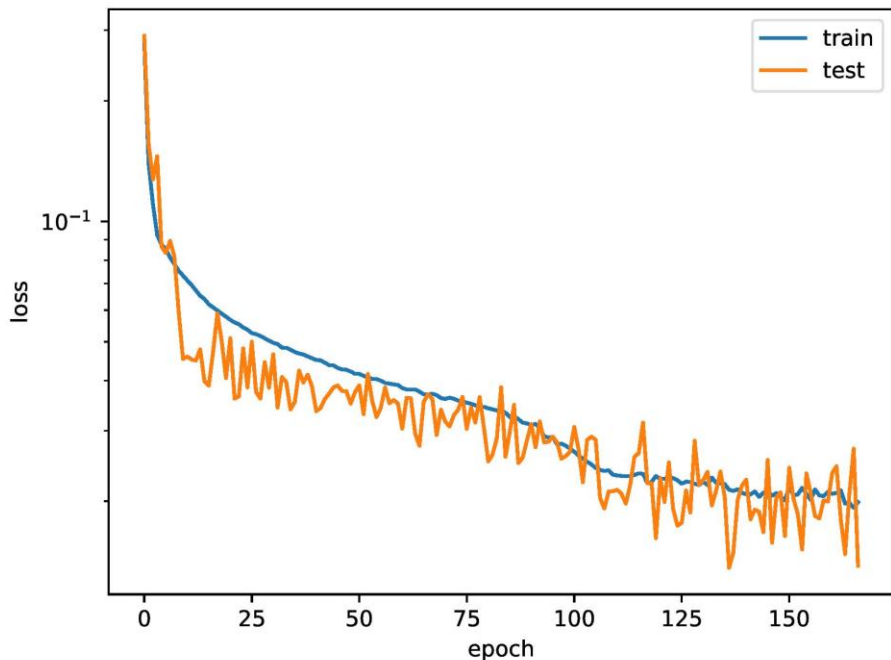
Neural Network (NN)

- Standard technique for classification
- Takes a set of input features and predicts the output
- Trains itself by regressively adjusting weights until the prediction is as accurate as possible

Typical NN Architecture



Training the NN for 4-Particle Final State



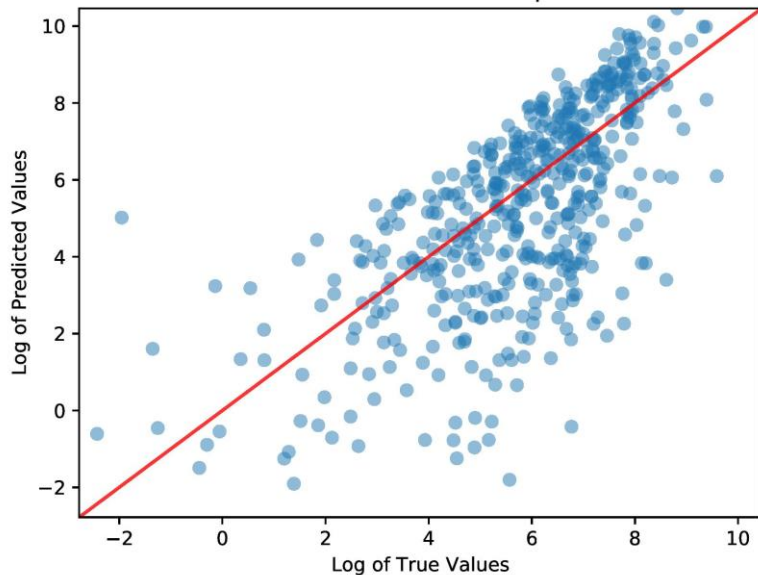
- Goal is to optimize the parameters to improve network accuracy
- The loss is a summation of errors for the training and testing sets

Evaluating the Network

For each event compare the true value to the predicted value (network output)

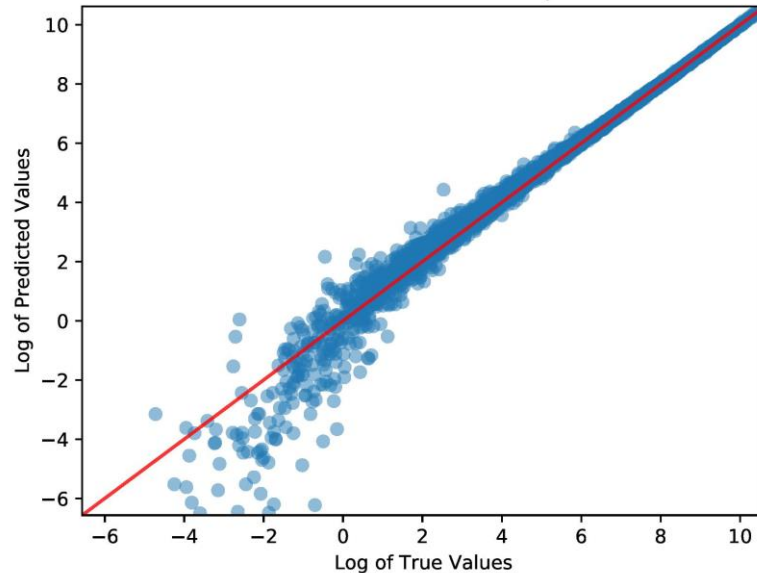
Initial Model

True vs Predicted for 500 points



Final Model

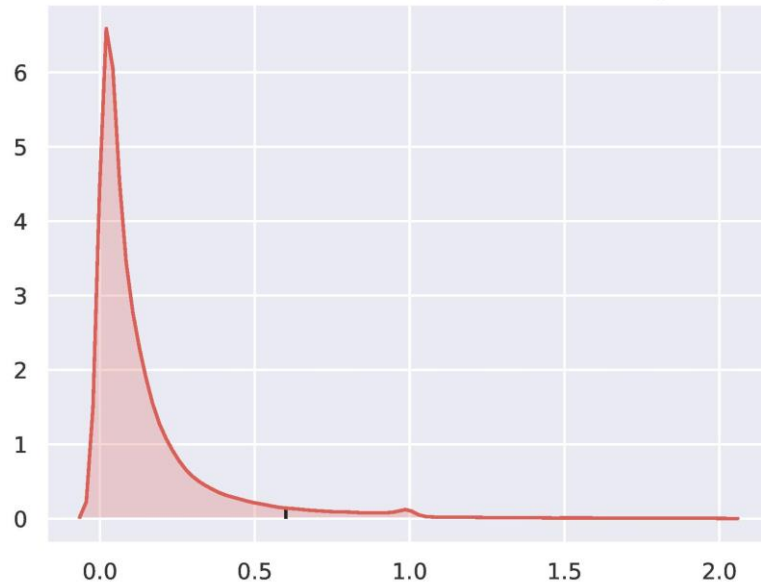
True vs Predicted for 5000 points



Evaluating the Network

Final Model

Distribution of the Deviation for 100000 Samples



| Error Method | Initial Model | Final Model |
|-------------------------|---------------|-------------|
| Mean Absolute Error | 0.3739 | 0.01379 |
| Root Mean Squared Error | 0.81348 | 0.0304 |
| Mean Percent Error | 4119.26 | 16.4895 |

$$D = |true - prediction|/true$$

In Conclusion

- I have learned much more about machine learning and data analysis techniques for particle physics
- I will work on improving accuracy and training time for the networks
- The work will need to be continued to model the full 8 particle system of the ttH process

