ADVANCED COMPUTING

Rare event detection in High Energy Physics

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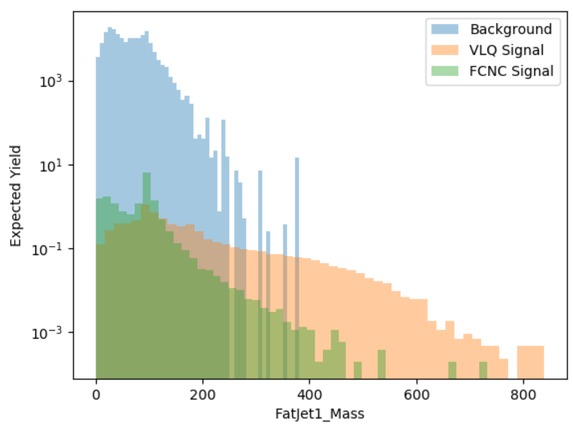
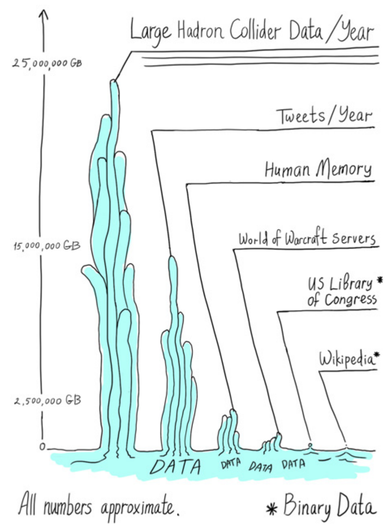
Background

High Energy Physics (HEP) creates and requires analysis of large amounts of data. In searches for new physics, the relevant processes can be several orders of magnitude less likely to occur than the irreducible background. Machine learning aids in this task of signal vs background classification and is becoming more relevant as more data is collected and the interesting events become more rare.

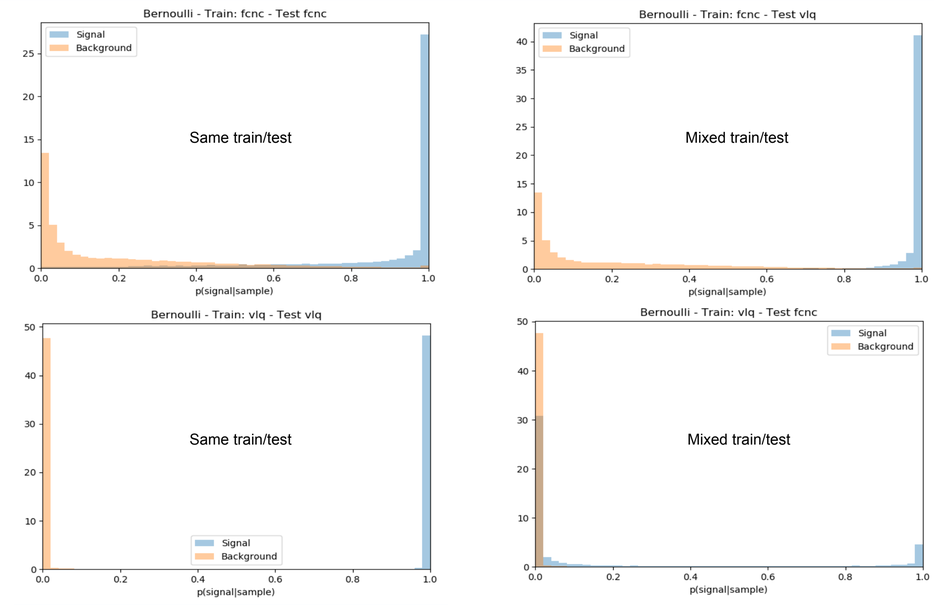




https://www.symmetrymagazine.org/article/august-2012/particle-physics-tames-big-data

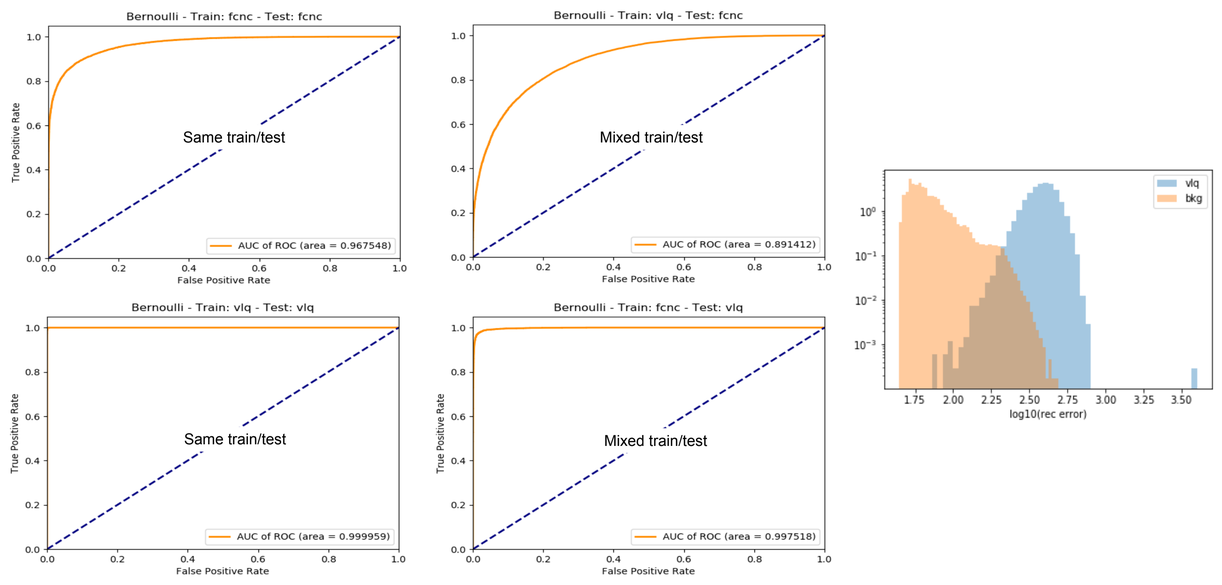
Methodology

Neural networks (NN) provide very powerful models for classification in HEP. However they can lead to model dependent results if the training is not general enough. The first approach taken in this project is to build a NN that learns all background and can be sensitive to a broad class of signal events. These results will later be complemented with a generative model to provide a full fledged anomaly detector for rare physics events.



Results

First results suggest a very promising discrimination. It can be seen that these generalize for new physics models not included in the training.
The reconstruction error of a Variational Auto Encoder that was trained exclusively with background events can provide a good discriminator. This is part of a general discriminator currently being developed using state of the art generative models.



Conclusions

As we collect more data and narrow down the possible scenarios for new physics we face a more challenging classification. New models become less likely to be probe in current experiments and their signatures harder to extract from the sea of irreducible background events. Machine learning is a very powerful tool to tackle this problem.

The challenge becomes twofold: being able to classify rare signal processes and make sure that possibly interesting detections do not go unnoticed because they were not foreseen by theory.

Therefore the necessity to build a general classifier is paramount. In this project we took the first steps. A general NN was built and it shows promising results when detecting signal events not included in training. Generalizing this framework with the inclusion of a generative model, making it an anomaly detector capable of flagging possible new physics events without the need to include them in training is the step we are currently taking.

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