Contribution ID: **106**   Type: **Poster**

Variational AutoEncoders for Anomaly Detection in VBS events within an EFT framework

Tuesday, 25 October 2022 11:00 (30 minutes)

We present a machine-learning based method to detect deviations from a reference model, in an almost independent way with respect to the theory assumed to describe the new physics responsible for the discrepancies.

The analysis is based on an Effective Field Theory (EFT) approach: under this hypothesis the Lagrangian of the system can be written as an infinite expansion of terms, where the first ones are those from the Standard Model (SM) Lagrangian and the following terms are higher dimension operators. The presence of the EFT operators impacts the distributions of the observables by producing deviations from the shapes expected when the SM Lagrangian alone is considered .

We use a Variational AutoEncoder (VAE) trained on SM processes to identify EFT contributions as anomalies. While SM events are expected to be reconstructed properly, events generated taking into account EFT contributions are expected to be poorly reconstructed, thus accumulating in the tails of the loss function distribution. Since the training of the model does not depend on any specific new physics signature, the proposed strategy does not make specific assumptions on its nature. In order to improve the discrimination performances, we introduced a DNN classifier that distinguishes between EFT and SM events based on the values of the reconstruction and regularization losses of the model. In this second model a cross entropy term is added to the usual loss of the VAE, optimizing at the same time the reconstruction of the input variables and the classification. This procedure ensures that the model is optimized for discrimination, with a small price in terms of model independency due to the use of one of the 15 operators from the EFT model in the training.

In this talk we will discuss in detail the above-mentioned methods using generator level VBS events produced at LHC and assuming, in order to compute the significance of possible new physics contributions, an integrated luminosity of $350\,fb^{-1}$.

Significance

For the first time an Anomaly Detection strategy is applied to VBS events within an EFT framework: this new approach could deeply improve the strategy employed to address those kinds of analyses. Such an algorithm would deliver a list of anomalous events for further analysis and the recurring event topologies in this dataset could inspire novel new-physics models and new experimental searches.

References

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.120.081801
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.123.161801

Experiment context, if any

LHC

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Session Classification: Poster session with coffee break

Track Classification: Track 2: Data Analysis - Algorithms and Tools