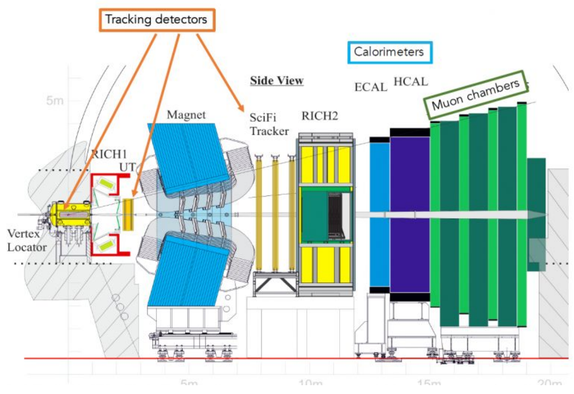
LHCb experiment

- LHCb experiment (b stands for beauty) at CERN specializes in investigating the slight **differences between matter and antimatter** by studying the **beauty quark**
- Whenever measurements show a deviation with respect to the Standard Model (SM) it is crucial to understand if it is due to **systematic uncertainties** or **new physics:**
  - Systematic uncertainties:
    - Statistical fluctuation
    - Underestimated theory uncertainties
    - Detector effects

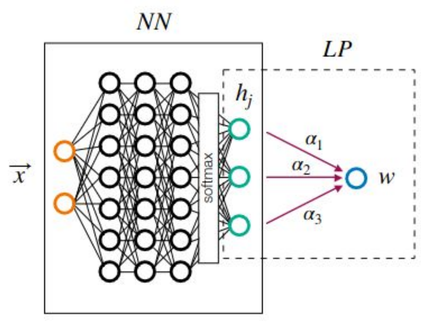
A fifth fundamental interaction?



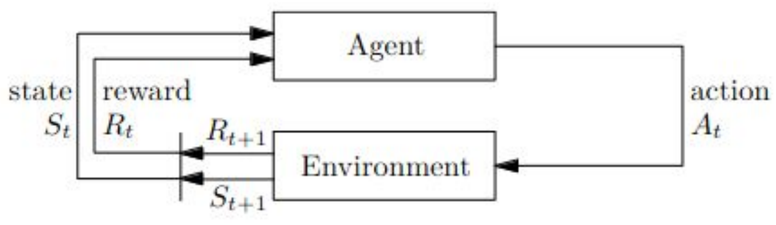
Previous works

Previous works have been made to play the devil's advocate (**DL Advocate project**) using Deep Learning techniques:

- One technique was built by combining a **Neural Network** (NN) with a **Linear Programming** (LP) solver:



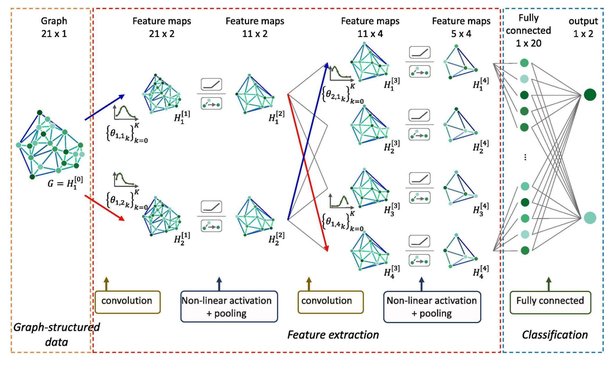
- Another technique was based on a **Reinforcement Learning** (RL) algorithm:



Future works

Future DL Advocate projects will involve:

- **Branching Ratio** (BR) predictions for decays not present in the Particle Data Group (PDG)
- Uncovering of **hidden backgrounds**
- Predictions of relevant **distributions of decays**



Taken from: ISPRS J. Photogramm. Remote Sens. **150**, 259-273 (2019).

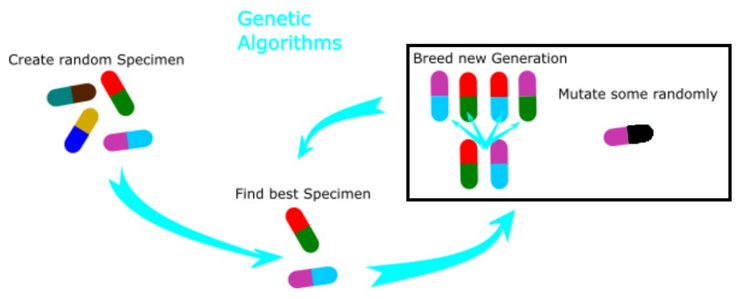
Playing the devil's advocate through deep learning: systematic uncertainties or new physics?

Uncovering hidden backgrounds: 1st approach

- **RL algorithm** where the **state** describes the **particles** in the decay
- The **agent** is described by a **NN** whose input is the state and whose output is an action that will define the next state
  - The NN of the agent is a **Graph Convolutional Network** (GCN), as this enforces permutation invariance
  - To avoid having a huge number of states, **actions** should be defined to always **transition among states with physical sense** (charge conservation…)
- The **reward** defines how dangerous the background (the final state) is for the signal

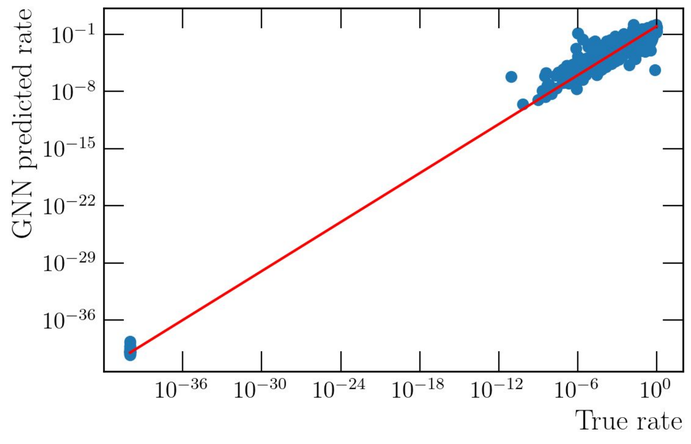
Uncovering hidden backgrounds: 2nd approach

- Use of **Genetic Algorithms** (GAs) to find the most **dangerous backgrounds**
- Each **individual** represents a possible background. The **genes** store the information of the involved particles, the possible intermediate resonances…
- The **fitness function** defines how dangerous each background is



Branching Ratio predictions

- Use of a **GCN** to **predict the BR** of decays not present in the Particle Data Group
- **10-folding** technique to maximize data utilization and obtain a better performance estimation
- PDG API as the source of our data



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[2] https://arxiv.org/pdf/2303.15956.pdf

Paula Álvarez, Andrei Golutvin, Guillermo Hijano, Aleksandr Iniukhin, Davide Lancierini, Alex Marshall, Andrea Mauri, Patrick Owen, Mitesh Patel, Konstantinos A. Petridis, Shah Rukh Qasim, Nicola Serra, William L. Sutcliffe, Hanae Tilquin, Andrey Ustyuzhanin

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