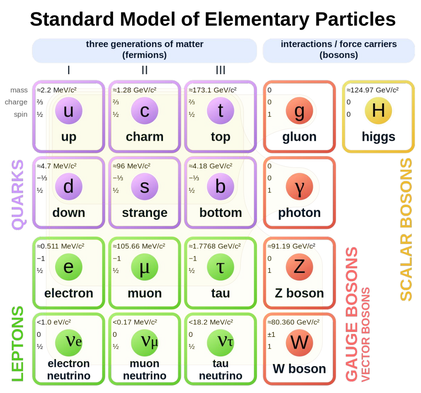
The Standard Model

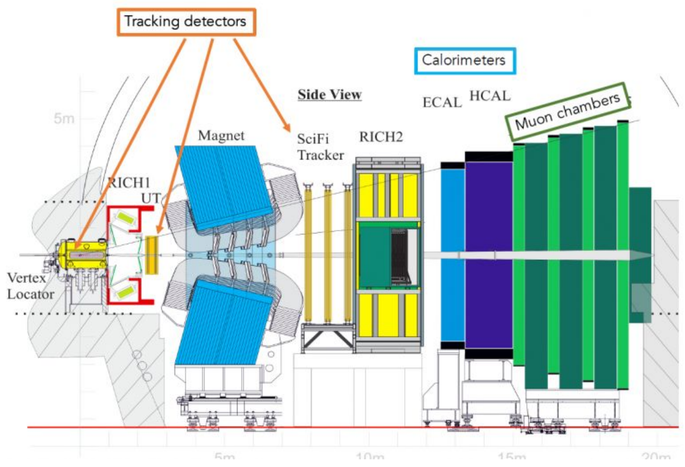
- There are **four** known **fundamental interactions** in nature:
  - Gravity
  - Electromagnetism
  - Strong interaction
  - Weak interaction
- The **Standard Model** (SM) describes electromagnetism, strong interaction and weak interaction.
- These are the **elementary particles** in the SM:



- **3 generations** of leptons and quarks
- Stable matter is made of the first generation

LHCb experiment

- **LHCb** is one of the detectors at the Large Hadron Collider (**LHC**) at the European Organization for Nuclear Research (**CERN**)
- LHC is the **most energetic particle accelerator** in the world
- LHCb experiment (b stands for beauty) specializes in investigating the slight **differences between matter and antimatter** by studying a type of particle called the "**beauty quark**", or "b quark"
- Around **1 trillion** b-quarks are produced at LHC every year



Flavour anomalies

In recent LHCb measurements, deviations with respect to the SM model have been seen (**flavour anomalies**). Is this due to **systematic uncertainties** or **new physics**?

- Systematic uncertainties:
  - Statistical fluctuation
  - Underestimated theory uncertainties
  - Detector effects

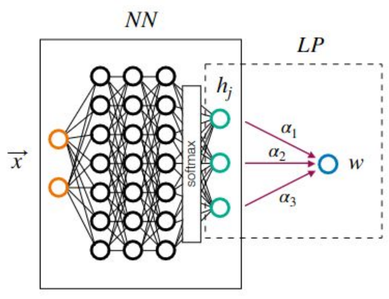
A fifth force?

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

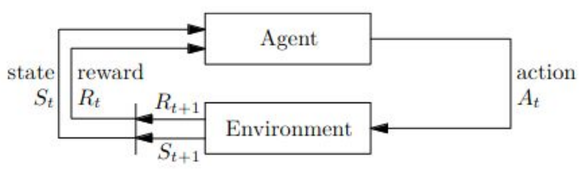
Previous works

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:



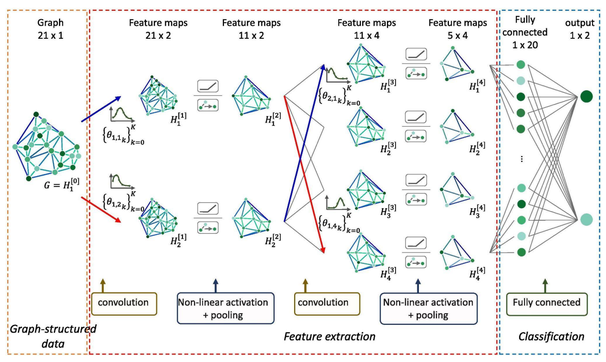
- Another technique was based on a **Reinforcement Learning** (RL) algorithm



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**
- **And much more!**



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

Uncovering hidden backgrounds

- **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

We strongly believe this tool has the potential to revolutionize the field of particle physics

References:
[1] https://hal.science/hal-03777958/document
[2] https://arxiv.org/pdf/2303.15956.pdf

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