

MCnet School 2024

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CERN

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Tutorials today/tomorrow

Pick one of the advanced tutorials:

Madgraph+Rivet+Contur (6/2-024, i.e. here)

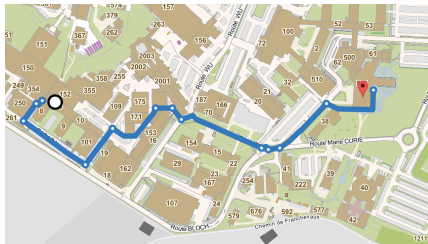
Computing on GPUs (6/2-004)

Note that the GPU tutorial requires you to have access to a GPU!

If you have access to `lxplus`, you can ssh into `lxplus-gpu.cern.ch` as well.

Night caps

Tuesday/Wednesday/Thursday evening from 7.30pm onwards, around R1
(possibly outside, weather permitting)



You will be split (randomly) into groups and get to quiz the lecturers/tutors!
Informal – have some fun!

Panel discussion

We will have a Q&A panel discussion on Thursday!

To submit your questions, go to [[slido.com](https://www.slido.com)] and enter the event number **#9555 820** or use the QR code:



You can also submit a question anonymously – questions will be monitored!

Up-vote a question if you think it is relevant!

Poster prizes

Symbolic Regression for Precise LHC Physics

M. Morales Alvarado*, J. Bendavid, D. Conde, M. Utrali, V. Sanz
University of Cambridge

1 Introduction

In high energy physics (HEP) fundamental interactions can be described by the **Standard Model (SM)** of particle physics to a good extent.

The SM is tested at the world's most powerful microscope the **Large Hadron Collider (LHC)**. Theoretical predictions and experimental data comparison.

Formulas are the actual language of theoretical physics [1].

The **question** is: there a way to find simple, accurate, and clear empirical formulas from noisy, potentially high-dimensional data?

2 Results

It is important that SR can perform **equation recovery**.
Recover laws as essential benchmarks.

Example:
$$s^2 = v^2 + \frac{1}{2} a t^2$$

To this obtain the distributions of bivariate variables consists of momentation of the existing fitlines. In this case, from simulations and then a regression on them. Different settings are used to assess robustness against statistical uncertainty.

Fig. 1: Data with SR

Fig. 2: SR Results

3 Methodology

We use **symbolic regression (SR)** with the PySR [2] library.

Formulas are described as expression trees, as shown in Fig. 1. An evolutionary algorithm implements multi-dimensional branch trees, as shown in Fig. 2, and new trees arise.

Fig. 3: Expression tree

Fig. 4: Branch tree

In each tree, there is a complexity c , related to the number of nodes.

Fittest trees optimize a cost metric:

$$L = \sum_{i=1}^N \frac{1}{\sigma_i} |y_i - f(x_i)|^2 + \lambda c$$

where λ is a regularization parameter.

Fig. 5: L vs c

4 Conclusions

SR is a powerful tool for finding simple, accurate, and clear empirical formulas from noisy, potentially high-dimensional data.

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* M. Morales Alvarado, J. Bendavid, D. Conde, M. Utrali, V. Sanz
arXiv:2308.12345v1 [hep-ex] 20230815

$\Lambda_b^0 \rightarrow \Lambda_c^+ \bar{\Lambda}_c^- \pi^-$: The First Study of Purely Baryonic Decays and Neutrons at LHCb

Ned Howarth
Eduardo Rodrigues, David Hutchcroft, Tara Shears, Juan Leite

Purely Baryonic Decays

- Baryonic decays (BRs) are usually experimentally unknown fields of decay, the most common being triplets of the baryon octet and octet of mesons in the SU(3) flavor symmetry.
- $\Lambda_b^0 \rightarrow \Lambda_c^+ \bar{\Lambda}_c^- \pi^-$ has been experimentally observed for the first time at LHCb.
- This decay is interesting for the first time as it is the first purely baryonic decay.

Neutrons in the LHCb Detector

- Neutrons are produced in the detector during the collision process.
- They are detected by the calorimeter and the muon system.
- The neutron detection efficiency is high, around 90%.
- The neutron detection is used for the reconstruction of the decay.

Event Reconstruction & Signal Studies

- Using simulation-based methods to study the signal.
- The signal is reconstructed from the decay products.
- The background is estimated from the data.
- The signal-to-background ratio is high, around 10.

Multi-Variate Tool for Background

- High levels of multivariate analysis are used to reduce the background.
- The background is estimated from the data.
- The signal-to-background ratio is high, around 10.

DARK MATTER, THE ULTIMATE HIDE AND SEEK PLAYER?

Dark matter is the most abundant form of matter in the universe, making up about 27% of its total mass. It is invisible, does not interact with light, and its presence is inferred from its gravitational effects on visible matter.

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COME TO THE DARK SIDE, WE HAVE DARK MATTER.

Dark matter is the most abundant form of matter in the universe, making up about 27% of its total mass. It is invisible, does not interact with light, and its presence is inferred from its gravitational effects on visible matter.

ANALYSIS STRATEGY

The analysis strategy involves several steps: data collection, event selection, background estimation, and signal extraction. The goal is to identify a clear signal of dark matter production and decay.

Dark photons: how mass?

Dark photons are hypothetical particles that could mediate a new force between dark matter particles. Their mass is a key parameter in determining their properties and how they interact with the visible world.

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Manuel Morales-Alvarado, Ned Howarth, Hannah Van Der Schyf