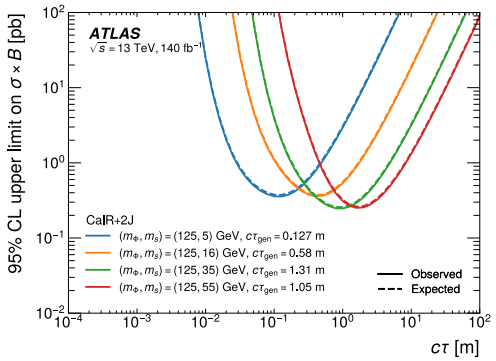
Machine-learning–based reinterpretation of an ATLAS search for Axion-like particles



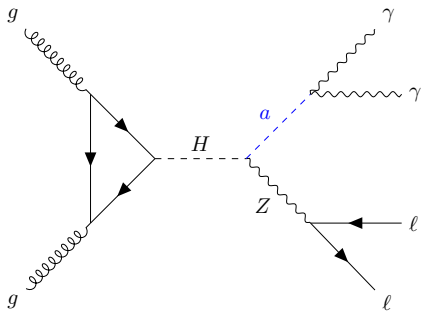


Figure 1: (left) Observed and expected upper limits on the cross-section times branching fraction as a function lifetime for a scalar mediator [JHEP **11** (2024), 036] (right) Feynman diagram for the production of an axion-like particles (a) in association with a Z boson as a result of a Higgs boson decay.

Abstract:
The ATLAS experiment at CERN is one of the major detectors at the Large Hadron Collider (LHC), designed to probe the fundamental structure of matter. Conducting an ATLAS analysis is a complex, multi-year effort by large teams targeting specific theoretical models. While most analyses conclude without discoveries, they often set stringent limits on the considered models (see Fig. 1, left). A key question then arises: how can we evaluate their sensitivity to new models without rerunning the full analysis?

To address this challenge, the ATLAS group at the Laboratoire de Physique de Clermont Auvergne (LPCA) has developed a machine-learning–based reinterpretation framework that reproduces and extends the reach of existing analyses with minimal additional computational and human effort, thereby maximizing the scientific impact of ATLAS results far beyond what is it was designed for initially (see Refs. [1,2]).

This internship offers an unique opportunity to contribute directly to an ATLAS search for new physics by developing its reinterpretation material. The student will first become familiar with the ongoing search for axion-like particles (ALPs), a promising candidate for physics beyond the Standard Model (see Fig. 2, right), gaining insight into the large-scale experimental workflows of a standard ATLAS analysis. He/she will then build upon the existing reinterpretation framework to apply it to the aforementioned ALP search, gaining a deep understanding of the method and its true value for the particle physics community. Familiarity with Linux and Python is an advantage but not required.

[1] **L. Corpe, A. Haddad and M. Goodsell**, *Recasting the ATLAS search for displaced hadronic jets in the ATLAS calorimeter with additional jets or leptons using surrogate models*, arXiv:2502.10231, 2025.

[2] **T. Chehab, L. Corpe, A. Goudelis, A. Haddad, L. Millot**, *Constraints on asymmetric production of long-lived scalars at the Large Hadron Collider*, Eur. Phys. J. C 85, 824 (2025), arXiv:2502.18021.

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