

# **New frontiers in multi-messenger neutrino astronomy with machine learning imaging**

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## **Overview**

The most exciting chapter in the history of multi-messenger neutrino astronomy is about to unfold. The recent IceCube's discovery of neutrinos from supermassive black holes has opened a new window on our cosmos. These neutrinos coming from the edge of the observable universe are revolutionising our understanding of astrophysical systems at the ultimate energy and gravitational frontiers. This motivated the construction of several new neutrino telescopes that will soon get online, increasing our detection sensitivity to the level needed to discover multiple new neutrino sources per year. The data analysis of these massive particle-physics detectors will be extraordinarily challenging. Still, it will rely on the rapidly growing field of machine learning techniques for image recognition and processing, which is becoming increasingly crucial for high-energy physics.

## **Aims**

This project will focus on algorithms and statistical analysis methods for image recognition in particle-physics experiments. While the analysis techniques will be developed for generic applications as part of a cross-disciplinary effort carried out within the CDT, the student will have the opportunity to apply them to extract physics results from P-ONE, one of the most promising future neutrino telescope experiments.

## **Work summary**

The project will develop machine-learning methods to simulate and reconstruct events in particle-physics detectors, exploiting image recognition techniques such as convolutional or graph networks. The development of these techniques will be initially driven by the data and simulations of events in the large neutrino-telescope Cherenkov detectors. These detectors provide an ideal case study, as they behave as a colossal camera sensitive only to Cherenkov light. Depending on the interest and skills of the student, the work can then develop towards implementing these techniques on FPGAs or TPU for in-situ triggering and fast data reduction or on their offline application to optimise the design of P-ONE. In both cases, broad physics analysis is expected with connections to elementary neutrino properties and astrophysics. This project will bolster connections within the CDT, and we hope it will ultimately create a long-lasting cross-experiment group of experts on this emerging field of machine learning. Although the work will focus on P-ONE and its physics case, our findings will be valuable for several CDT activities and facilitate the initiation of similar analysis within ATLAS and other research groups at UCL.