Title: "MATHUSLA simulation studies of cosmic ray and displaced vertex reconstruction."

The focus of this project will be the study of long-lived particle (LLP) decay reconstruction at the proposed MATHUSLA detector. This involved simulation of decays in the detector's decay volume, and study of displaced vertex reconstruction efficiency as it depends on LLP properties and geometrical parameters of the detector.

The student will learn about long-lived particle signals of new physics at the LHC, and use a MATHUSLA detector simulation module in Python, which can interface with existing simulation software for high energy particle collisions at the LHC. This module allows for variable modular geometries of the MATHUSLA detector, as they are currently being studied by a CERN engineering team, to be described. The efficiency of various detector and module geometries at reconstructing displaced vertices arising from a variety of LLP production modes, boosts, masses and decay modes, and the dependence of these efficiencies on detector parameters, will be studied in detail. The efficiency studies will provide important information for the design of the MATHUSAL detector, and will also refine estimates of the new physics reach. Assuming all these studies are completed, is expected that the student will become a co-author on a MATHUSLA collaboration document which contains these results.

Since the results of this project will influence the design of a major new physics experiment, and since the simulation code will be made public, this project involves two students who will work together, but code up two versions of all analyses independently, and reproduce each other's results, for verification.