Alex Marshall

Bristol University

Particle Physics

Project title:

Machine Learning at SHiP

About me:

Always had interest in computing. Using computational techniques to solve problems is extremely satisfying to me. Employing high level machine learning and data intensive techniques is even more so.

Outside of computing and physics, I am a keen cyclist, I enjoy café stops and spending too much on gear. I love running, enjoying long distance running especially, on and off road. I enjoy any outside activities really.

Science/research area:

Keywords: particle physics, fast simulation, machine learning, neural networks, classifiers.

I work on the SHiP experiment at CERN. SHiP is a future experiment designed to look for new physics at the intensity frontier.

SHiP is looking for extremely rare predicted BSM (beyond standard model) particles. These are particles that could explain discrepancies between the standard model of particle physics and macroscopic phenomena we see in the Universe, such as dark matter and baryonic asymmetry. Looking for such rare events requires an extremely high intensity beam and a close to zero background environment. The current design has a beam of 4E13 protons hitting the target every second, producing large numbers of background particles (muons, which are highly penetrating and capable of traveling the length of the experiment and mimicking signal in detectors) which must be separated from signal.

Due to the high intensity of the beam, the SHiP experiment is very computationally expensive to accurately simulate (simulation required to verify claims of the sensitivity and performance of the experiment). Large simulation runs have been completed but they only represent about a second of the experiment. The experiment will run for 5 years.

I currently have two main arms of my research.

Firstly, I am investigating the use of generative neural networks, GANs and VAEs, to remove bottlenecks in the simulation. As a collaboration we must produce more simulated data to better understand any backgrounds we are to expect. Traditional simulation methods cannot provide the speed required. Using generative networks to approximate (accurately) bottlenecks in the

simulation is a powerful tool which is yet to be broadly applied in particle physics. With the intensities of future experiments being higher and higher, fast techniques such as this will only become more important.

Secondly, I am using the current archive of simulated data to study one source of muon background in the detectors, and verify SHiP will be a zero background environment with current design. This involves using a special BDT method to cut on background events.

Data Intensive Research Skills and Interests:

Extensively used neural networks, specifically studied generative techniques such a GANs and VAEs. Keen interest in applying neural networks to realistic situations. Understanding limitations and potential use cases.

Large scale simulation on CPU and neural network training GPU clusters.

Experience with parallel computing, knowledge of MPI and OpenMP

Use of high level classifiers such as BDTs.

High level use of python and popular scientific/data analysis packages.

Completed a course giving me a foundation of SQL knowledge.