IRIS-HEP Fellows Program Project Proposal

Applicant: Natalie Bruhwiler

Mentors: Simone Pagan Griso and Sergo Jindariani

Project: Muon Collider Tracking Software

Background:

One option for the future of high energy particle colliders is a muon collider. Muons are leptons with a mass over 200 times that of an electron. Their large mass means less energy is lost to synchrotron radiation when muons are accelerated in a ring, which eliminates the need for a long linear collider. These high energy muon collisions could allow for many exciting experiments, including the investigation of dark matter and further study of the Higgs boson. The muon collider is also predicted to be the most energy-efficient option for the future of particle colliders.

The problem:

Although a muon collider has a lot of scientific potential, it also provides some challenges. Muons have a very short lifetime (about 2 μs in the frame of the muon), which means they must be created, cooled, and accelerated very quickly. The short lifetime also means that they produce decay products, which then cause secondary and tertiary reactions. The huge number of particles from these reactions are referred to as Beam Induced Background (BIB), which includes photons, neutrons, electrons, and positrons. The high-energy physics community is working to find a reliable way to differentiate the BIB from the actual collision products, which are what we are interested in studying. This is done by simulating muon collisions and using algorithms that track the paths of particles, which is known as charged particle reconstruction.

Goals:

The first concrete goal of this project is to accumulate a number of examples where the algorithms are misidentifying reconstructed tracks. Using this, the next goal is to identify notable improvements in the algorithms based on where they are going wrong.

Methods/timeline: May 23 - August 12

- Understand and become familiar with existing simulations and the tracking algorithms that attempt to separate BIB from collision products. This can be accomplished by running tutorials on the INFN Confluence website.[1] (~2 weeks)
- Create tracking performance plots using Python in combination with uproot. Through a sequence of simulations, accumulate a significant number of examples where the algorithm is right or wrong and investigate ways to improve it. (~2 weeks)
- Apply changes to existing algorithms based on analysis. Produce new simulation samples and compare them to old ones. (~2 weeks)
- Fix bugs and repeat the above process as many times as needed, hopefully much more quickly after gaining familiarity. (4-6 weeks)

Deliverables:

- Collection of examples where reconstructed tracks have been misidentified
  - Includes relevant ROOT files and python plots of algorithm performance
- Hypotheses regarding how or why the existing algorithms might be failing
- Modified tracking algorithm, based on one or more of the above hypotheses
  - Simulations and algorithms are written in C++, based on the iLCSoft[2] framework
- Output of modified algorithm, including examples where the modified algorithm shows improved results over the existing code

Solving potential problems:

- Unexpected roadblocks in the proposed plan will be addressed via daily communication between the applicant and the mentors, with a weekly meeting to discuss progress and next steps.

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[1] https://confluence.infn.it/display/muoncollider/Software
[2] https://ilcsoft.desy.de/portal