**IRIS-HEP Fellowship Proposal**

**Kyle Feist**

**Duration: May 17th, 2021 – August 17th, 2021**

**Project: Muon Collider Tracking Software**

**Mentors: Sergo Jindariani, Simone Pagan**

**Background and Proposal**

Muon colliders are a promising option to achieve particle collisions with higher energy, which is key to discovering new particles physics. Muons are fundamental particles, and thus have no particles that make them up, unlike the proton, another particle that can be used in particle colliders, which is made of quarks and gluons. Because of the muon’s fundamental nature, a muon collision uses the full energy of those colliding muons. Additionally, muons are 200 times more massive than electrons, which means the loss of energy from synchrotron radiation, the radiation emitted when a charge is accelerated, is orders of magnitude less than the energy lost from electron synchrotron radiation, meaning muons can be accelerated with minimal energy loss, which is extremely important in circular path, magnetic coil based colliders.

Although muon colliders are the most energy efficient option, they have a drawback that makes particle path reconstruction tricky for current algorithms to handle— Muons decay rapidly. Thus, before a collision occurs, the muons will shed many secondary particles that will act like noise for a collider detector. To investigate options to reduce the effect of that noise in particle path reconstruction, this project will analyze the effects of directional information from specially arranged silicon-detector layers being used with existing path reconstruction algorithms through muon collider simulations in C++.

**Timeline**

The proposed timeline will be a three-month period from May 17th to August 17th. I will devote forty hours a week working on this project. I will have no other responsibilities or job during this time period.

* **Late May**- *Initial Phase*: get used to working with existing muon collider simulation and path reconstruction code in C++

Deliverables: Data analysis in Python including efficiency of algorithm reconstructing particle paths, and probability of producing incorrect path reconstruction combinations, detailed analysis of path reconstruction algorithm in order to understand how to modify code with directional information from VXD detector

* **June**-*Inclusion of Filtering and Inclusion of Directional Data into Algorithm*: utilize directional information from VXD detector to filter measurements of secondary particles by main detector, use directional information directly in track reconstruction algorithm

Deliverables: Analysis of impact on performance of algorithm as well as memory usage of algorithm in the filtering case, modified algorithm using directional information in C++, analysis of algorithm performance in direct modification case

* **Early July**- *Manual Optimization*: Study the effects of changing the number, position, and orientation of VXD detectors on path reconstruction algorithm efficiency and effectiveness

Deliverables: Analysis of different sensor layouts and associated effects on performance

* **Late July and Early August**- *Automatic Optimization*: Use automatic optimization code to find the most efficient layout of detectors while still maintaining fast track reconstruction algorithm performance

Deliverables: Optimization code in C++, analysis of different sensor layouts and associated effects on performance

**References**

1. Long, K., Lucchesi, D., Palmer, M., Pastrone, N., Schulte, D., & Shiltsev, V. (2020). Muon Colliders: Opening New Horizons for Particle Physics. Nature Phys., 4 p.