Physics studies for the Muon Collider target system

This 3.5-year PhD project, starting in Autumn 2023, will study the pion-to-muon production yields and radiation dose (energy deposition rates) for the target system that is being designed for the Muon Collider, which has enormous potential to be a future facility for high-energy physics research. Simulations using the BDSIM, GEANT4 and FLUKA software toolkits will be used to compare different target and pion focusing options, with the aim of finding the best choice that will provide the optimal physics performance within the engineering constraints for safe and reliable operation.

A beam of protons collides with the target to create secondary pions which are then focused by the surrounding magnetic field before they eventually decay to muons. The energy, size and trajectory of the proton beam needs to be optimised to provide the best muon yield for the given target choice. Previous studies considered the baseline target as either a liquid mercury jet, which has significant safety handling issues, or graphite rods, which is a more mature and safer target technology but produces lower muon yields. The baseline for this project will consider a fluidised tungsten powder target, which is being technically developed by the RAL High Power Targets Group and is expected to give comparable muon yields to the mercury jet option. However, other potential target choices will also be investigated, such as solid metal rods or spheres.

For the focusing system, the main idea is to use a high intensity solenoidal magnetic field, but this has various technical challenges associated to the superconducting magnets' expected radiation dose and mechanical support requirements, and so other alternatives such as the more mature magnetic horn technology need to be investigated. Furthermore, detailed studies of the shielding requirements need to be made to ensure safe operation of the target and focusing system, based on the expected radiation dose (deposited energy) from the proton beam and secondary particles interacting with the various target station components.

The work involved in the studentship will be published and presented internationally at workshops and conferences. In addition, this research has the potential to influence target technology choices for other pioneering accelerator projects such as the nuSTORM (Neutrinos from Stored Muons) proposal and Fermilab's mu2e (muon-to-electron-conversion) experiment.

This project is a close collaboration between the University of Warwick and the Rutherford Appleton Laboratory (RAL), which is the UK’s national centre for experimental particle physics research. The student would spend time both at Warwick and at RAL, with the possibility of visits to CERN. Supervision will be provided by Dr John Back at Warwick, an expert on hadron target systems for high power beams, and by Dr Chris Densham at RAL who, with his High Power Targets Group, stands at the leading edge of novel target engineering.

Applicants need to follow the “How to Apply” process, which has an application deadline of 2nd February 2023, given by the webpage:

https://www.ppd.stfc.ac.uk/Pages/Students.aspx