FERMILAB-POSTER-21-087-STUDENT

MTA Pion Production Target Studies

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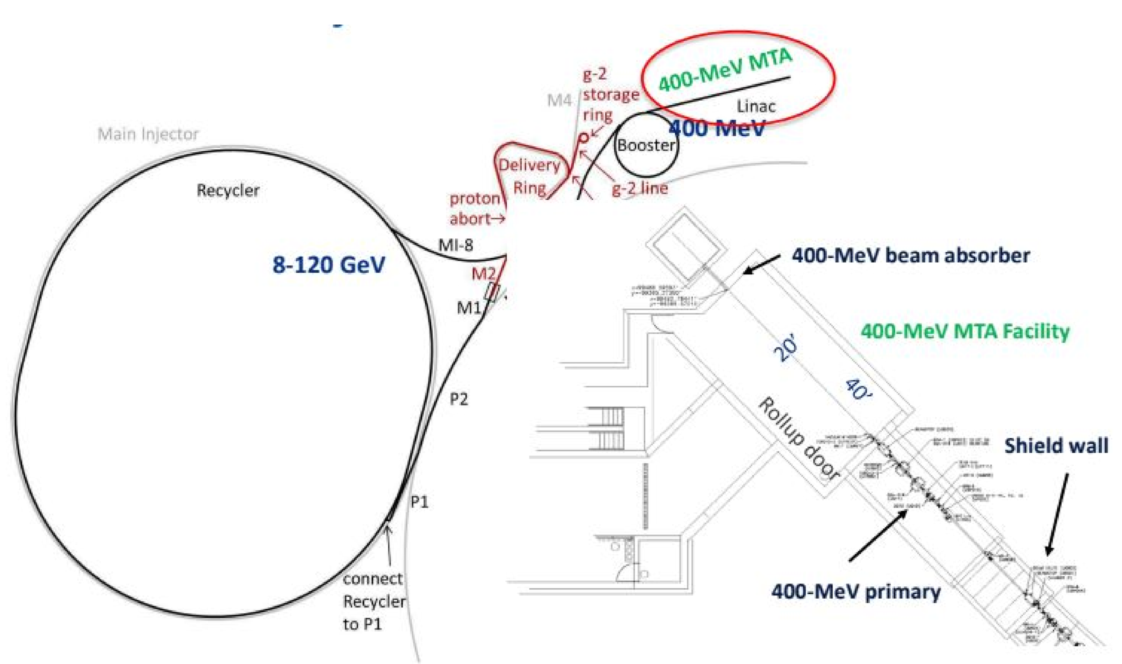
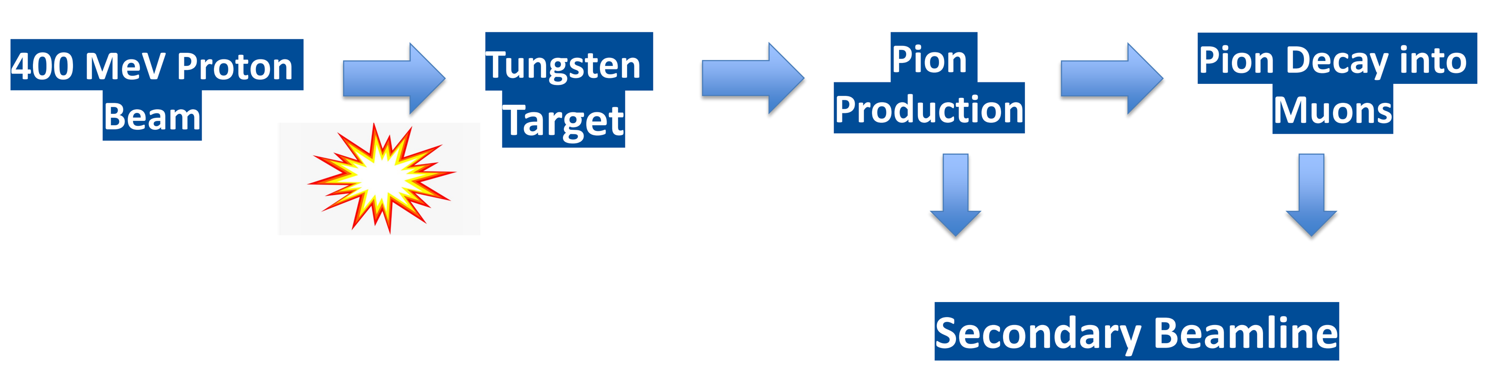
Background

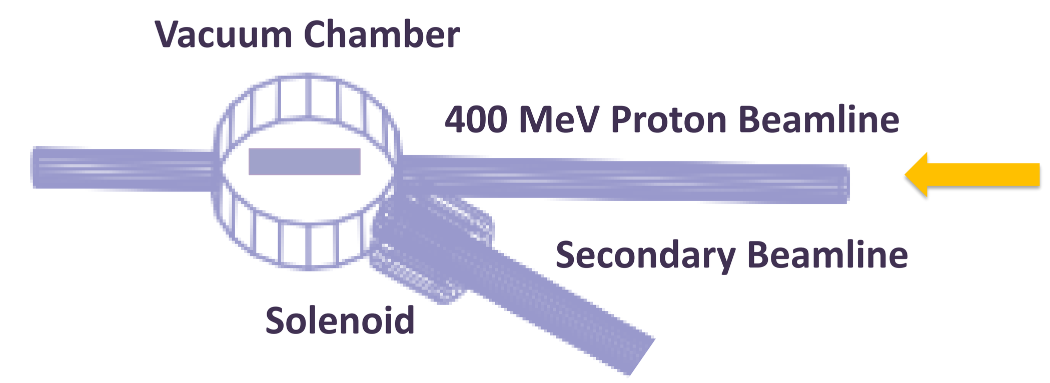
The muon is an elementary particle that can be produced using a particle accelerator to collide protons on a target, resulting in interactions that produce charged pions. The pions then mostly decay into a muon and a neutrino. The resulting muons can be collected into a beam that can offer several long-term opportunities for the advancement of HEP missions. The scientific community has a wide interest in future low energy muon experiments, such as lepton flavor violation experiments, muon decay to 3 electrons experiments, etc. Currently underway, the muon catalyzed nuclear fusion experiment will be the first to benefit from the muon beam.



Purpose

The goal of the project is to maximize the muon yield, which is sensitive to target material and geometry. Extensive studies using Monte Carlo techniques will guide the design of both the target and the secondary beamline by analyzing the predictions of interactions between the proton beam and the target. Comparing and analyzing simulated data to real data will validate the models that have been used.

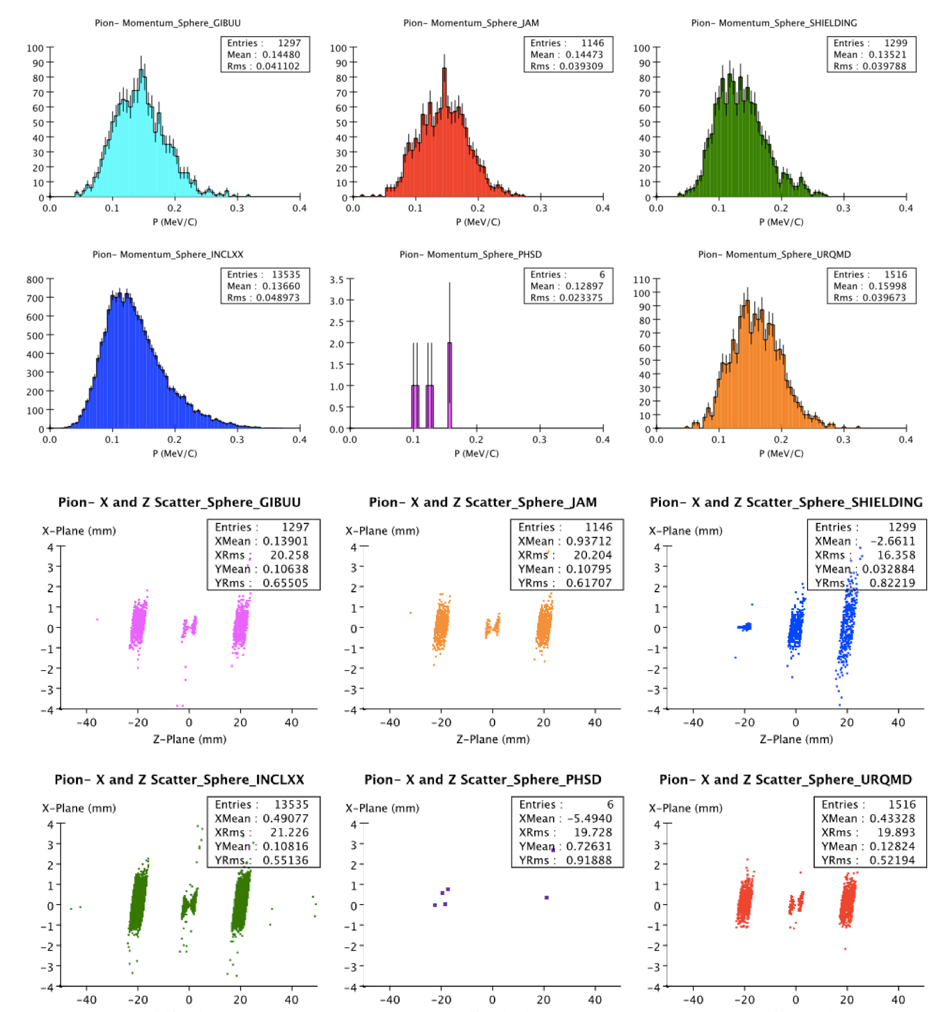




Simulations

The geometry description of the primary and secondary beamlines, the production chamber, and the target are all an essential part of the simulation studies. GDML (an XML-based geometry description language) has been chosen because it is compatible both with ROOT and GEANT4.

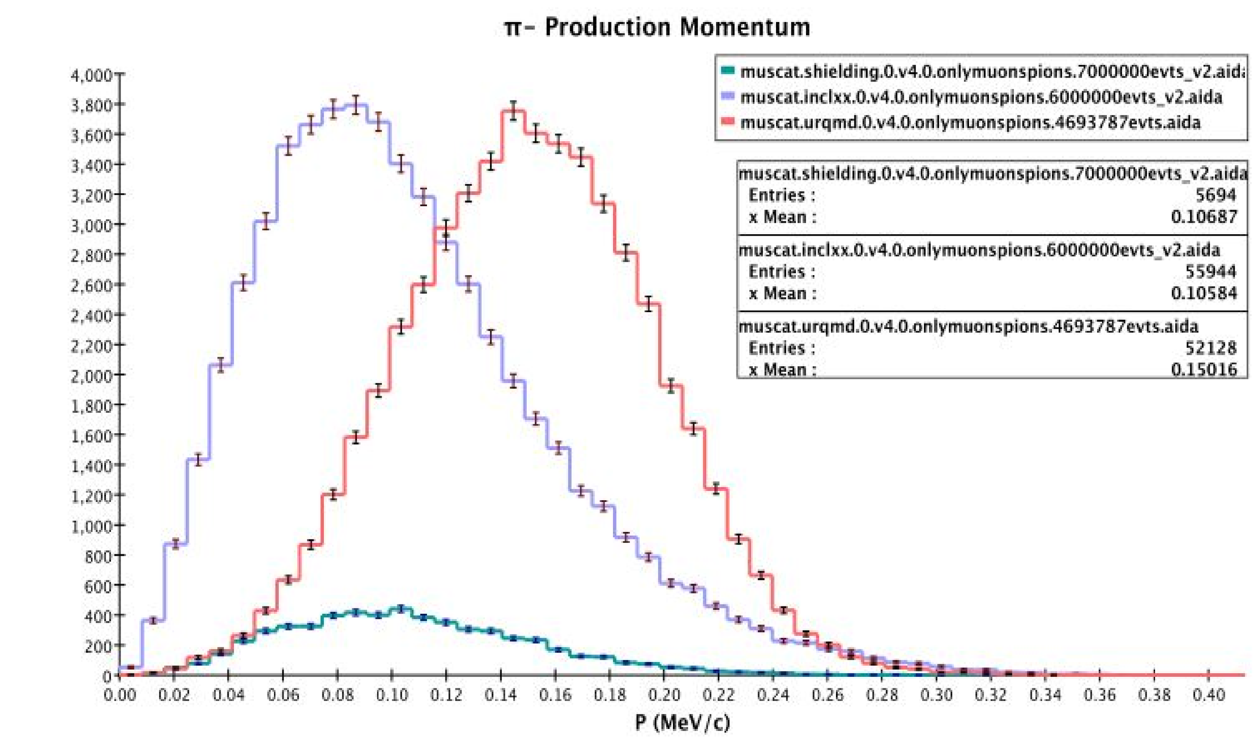
Preliminary studies used three thin target slices (3.3mm) to develop the analysis macro and to compare six different hadronic models.



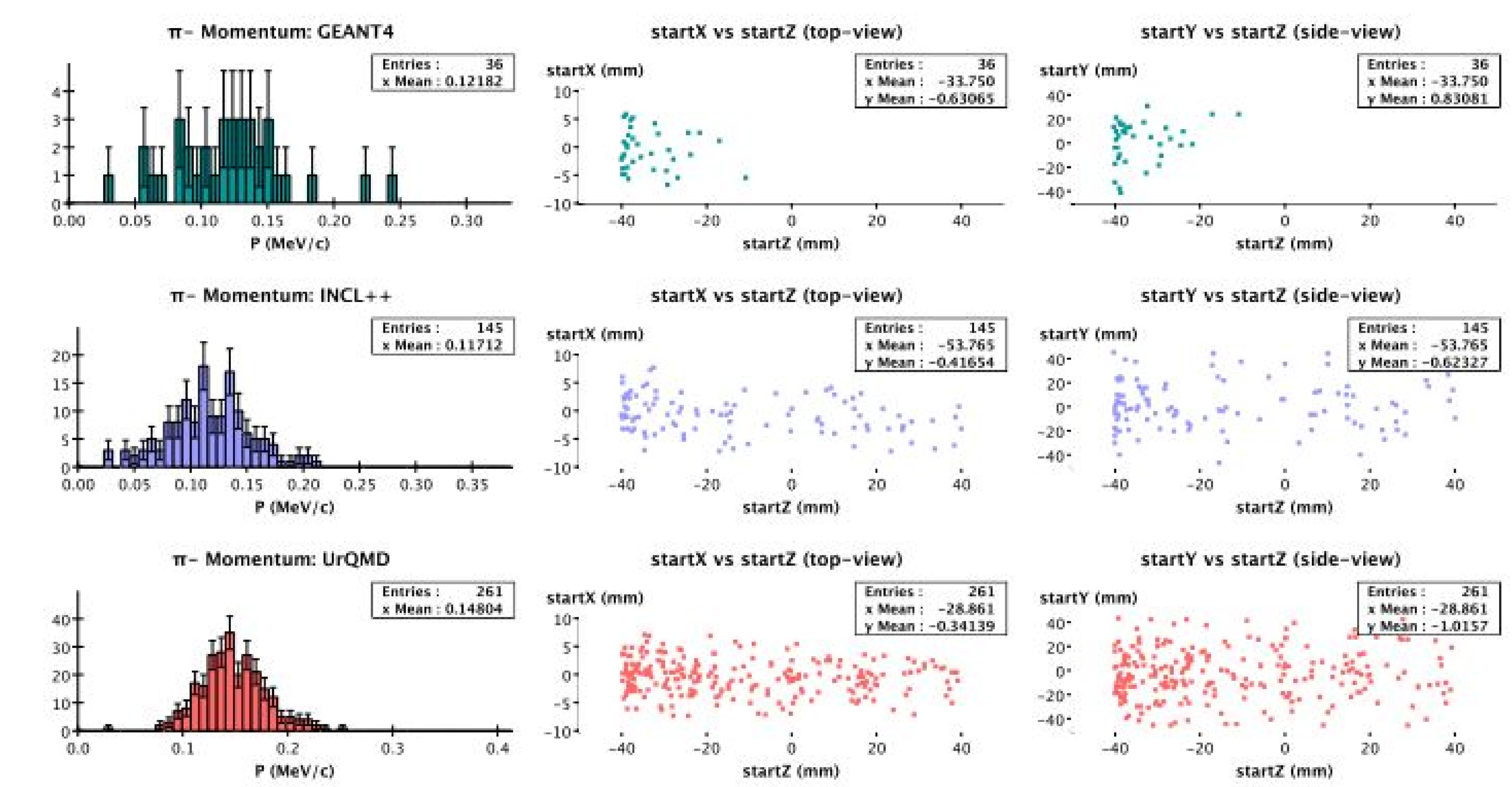
Studies

Primary hadronic interactions are simulated using different theoretical models, including GiBUU, INCL++, JAM, PHSD, and UrQMD, and are compared with GEANT4. Secondary particles are simulated using the GEANT4 toolkit, in order to study the momentum distribution of pions and muons and to track the pion origin and yield at the entrance to the secondary beamline. Data analysis is performed on Jas3, an AIDA (Abstract Interfaces for Data Analysis) compliant framework, and a Java-based macro was developed in order to plot relevant graphs and collect necessary data.

Results



Momentum distribution and origin of produced π- for three different models. GEANT4 π- are produced from 7,000,000 POT, INCL++ π- are produced from 8,128,044 POT, and UrQMD π- are produced from 6,358,551 POT.



Conclusion

The studies done in this project will help guide the decision regarding the best target for optimized pion production and muon beamline in the MTA facility. This work will initially be used by the muon catalyst fusion experiment.

Current studies show that the full picture of the pion production and their transport can be reliably obtained by comparing the different hadronic interaction models.

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