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Pion-Production Target for Mu2e-II: Simulation Design and Prototype

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The main goal of the Mu2e experiment at Fermilab is to search for indications of charged lepton flavor violation [1]. To achieve this goal, experimenters will be searching for the coherent neutrinoless conversion of a negative muon into an electron in the field of a nucleus by measuring 105-MeV electrons emitted in conversions of negative muons into electrons in the nuclear field of an Al target. This will allow Mu2e to probe effective new physics mass scales up to the 10^3–10^4 TeV range. One of the central elements of the Mu2e experimental facility is its target station, where negative pions are generated in interactions of the 8 GeV primary proton beam with a tungsten target, shaped similar to a rod, which will be capable of producing around $3.6 \cdot 10^{20}$ stopped negative muons in three years of running [2]. The Mu2e experiment is planned to be extended to a next-generation experiment, Mu2e-II, with a single event sensitivity improved by a factor of 10 or more. Mu2e-II will probe new physics mass scales up to 10^5 TeV by utilizing an 800-MeV 100-kW proton beam. This greater sensitivity is within reach by using the PIP-II accelerator upgrade, a 250-meter-long LINAC capable of accelerating a 2-mA proton beam to a kinetic energy of 800 MeV corresponding to 1.6 MW (the power not used by Mu2e-II will be directed to a neutrino experiment). The higher beam intensity would require a substantially more advanced target design. We are studying a novel conveyor target with tungsten or carbon spherical target elements moved through the beam path. The motion of the elements can be ensured either just mechanically or both mechanically and via He-gas flow. In this talk, we will discuss our recent advances in conceptual design R&D for a Mu2e-II target station based on energy deposition and radiation damage simulations. Our study involves Monte-Carlo codes (MARS15 [3], G4beamline [4], and FLUKA [5]) and thermal and mechanical ANSYS analyses to estimate the stability of the system. The concurrent use of the aforementioned simulation software is intended to allow us to determine and minimize the systematic uncertainty of the simulations. Our simulations allowed us to rule out some other designs (rotated and fixed granular targets) as less practical and supported our assessment of the new target station's required working parameters and constraints. The thermal and mechanical analyses we performed enabled us to determine the choice of cooling scheme and prospective materials for the conveyor's spherical elements. We will discuss the first prototype of the Mu2e-II target and its mechanical tests performed at Fermilab that indicated the feasibility of the proposed design and its weaknesses, and we will suggest directions for its further improvement.

References

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In-person participation

Yes

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