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Instrumentation and optimization studies for a Beam Dump Experiment (BDX) at MESA

At the Institute for Nuclear Physics in Mainz the new electron accelerator MESA will go into operation within the next years. In the extracted beam operation (155 MeV, 150 μA) the P2 experiment will measure the weak mixing angle in electron-proton scattering in 10,000 hours operation time. Therefore the high-power beam dump of this experiment is ideally suited for a parasitic dark sector experiment.

Currently, the experiment is studied with a simulation based on MadGraph and Geant4. Theoretically dark photons γ' are generated in the beam dump by a process analog to electromagnetic bremsstrahlung and decay invisibly to pairs of dark matter particles. In a calorimeter behind the beam dump, electrons scattered off by dark matter particles can be detected. For maximizing the experimental sensitivity, the probability of detecting dark matter particles has to be optimized.

The Geant4 simulation was extended by an optical photon study, where the response of possible calorimeter materials - PbF_2, BGO, the lead glasses SF5, SF6 and SF57HTultra - was examined. In this contribution the simulation outcomes are compared with the results of first prototypes tested at MAMI with 14 MeV electrons.

In a first phase we will use more than 1,000 PbF_2 crystals from a previous experiment. The exclusion limits for this and a lead glass calorimeter with 11 m^3 active volume for a second phase are shown, and the current status of a prototype detector array including a veto system will be presented.

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