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Cosmogenic activation calculation of experiments with LAr target

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In rare event search experiments, activation of detector materials can lead to significant backgrounds. Typically, trace radioactive contaminants are activated by cosmic-ray interactions while the detector materials are being stored or transported above ground. In highly sensitive experiments, these cosmogenic backgrounds can limit sensitivity. It is therefore necessary to determine the cosmogenic activation of detector materials before installation. Liquid Argon (LAr) is used as a target for many future experiments, including DarkSide-20k (DS-20k) and DarkSide-LowMass (DS-LM). The dominant radioactive isotopes produced in LAr include ^{3}H, ^{37}Ar, ^{39}Ar, and ^{42}Ar. Due to its long half-life and the difficulty separating it from ^{40}Ar, ^{39}Ar is especially important for experiments looking for signals below 565 keV, while ^{42}Ar may pose a background to MeV-scale rare event searches. In experiments looking for a rare event like DS-20K and DS-LM, the presence of ^{39}Ar can cause a signal pile up or limiting backgrounds. Atmospheric argon (AAr) has a specific activity of 1 Bq/kg for ^{39}Ar, and DS-50 measured the specific activity of 7.4×10^{-4} Bq/kg in underground argon (UAr). Additional reduction may be achievable through isotopic distillation with the Aria facility. At these levels, cosmogenic activation of radioactive isotopes may pose a significant contribution to the total activity, and achieving high radiopurity requires transportation and storage plans that account for the target's activation in transit and storage. To this end, a software package is being developed for evaluating the activation of radioisotopes in UAr and AAr, based on a compiled selection of reaction cross-section measurements and models, the PARMA and Gordon cosmic-ray flux models, and the user-specified transportation history and initial composition of the target argon. These calculations will be validated for ^{37}Ar activation in DS-50, comparing the software's predictions to the measured activity in DS-50 after the initial UAr fill. This code is designed to be flexible and easily extensible. The flux and reaction cross-section models can easily be changed, different cross-section estimates and scaling factors can be used over different energy ranges, and capabilities for calculating the activation of other target materials may be added in the future. In the talk, I will discuss the importance of cosmogenic activation calculations for low-background experiments, and how this code works.

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