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Status and prospects for SABRE North

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The SABRE project aims to produce ultra-low background NaI(Tl) scintillating detectors to carry out a model-independent search for dark matter through the annual modulation signature, with an unprecedented sensitivity to confirm or refute the DAMA/LIBRA claim. The ultimate goal of SABRE is to operate two independent NaI(Tl) crystal arrays located in the northern (SABRE North) and southern (SABRE South) hemispheres to identify possible contributions to the modulation from seasonal or site-related effects. SABRE North has carried out an extensive R&D on the production of ultra radio-pure NaI(Tl) crystals, as a large fraction of the background in (1- 6) keV energy region-of-interest (ROI) for Dark Matter search come from radioactive contaminants in the crystal themselves, most notably ^{40}K, ^{87}Rb, ^{210}Pb, and ^{3}H. A definitive test of the annual modulation claim has to be addressed by next-generation experiments using NaI(Tl) crystals with radio-purity similar to or below the DAMA level, such as in the proposed SABRE experiment. Direct counting of beta and gamma particles with the SABRE Proof-of-Principle detector, equipped with a liquid scintillator active veto and operated at the Gran Sasso National Laboratory (LNGS) has already demonstrated very low internal radioactivity for the so-called NaI-33 crystal. The amount of potassium contamination is found to be (2.2 ± 1.5) ppb, lowest ever achieved for NaI(Tl) crystals. With the active veto, the average background rate in the crystal in the ROI is (1.20 ± 0.05) counts/day/kg/keV, which is a breakthrough since the DAMA/LIBRA experiment. Our background model indicates that the rate is dominated by ^{210}Pb and that about half of this contamination is located in the PTFE reflector. The liquid scintillator veto was initially proposed to effectively reduce the ^{40}K background from a predicted contamination of natK at a level of (10-20) pbb. As presented here, data acquired for about one year with the NaI-33 detector into a purely passive shielding made of copper, polyethylene and water (PoP-dry setup), have shown that, if the crystal vetoable internal contaminations are the order of that of NaI-33, the active veto is no longer a crucial feature to achieve a background rate lower or comparable to that of DAMA/LIBRA.
We discuss ongoing developments of the crystal manufacture aimed at the further reduction of the background. These results represent a benchmark for the development of next-generation NaI(Tl) detector arrays for the direct detection of dark matter particles. A projected background rate of the order of 0.3 counts/day/kg/keV in the ROI is within reach. With this level of background it is possible to design a fully operational detector based on an array of ultra-high purity NaI(Tl) scintillating crystals with a total mass only a fraction of present generation detectors, yet surpassing the sensitivity so far achieved.

In-person participation

Yes

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