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ASTAROTH, an innovative detector for dark matter direct detection experiments

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In the long standing search for dark matter's annual modulation with NaI(Tl) detectors, all current generation experiments are plagued with noise from the PMTs which is about an order of magnitude higher than the signal at the keV recoil energies of interest.
ASTAROTH is an R&D project aiming to replace PMTs with SiPM matrices in order to highly enhance the signal-to-noise in the region of interest and lower the detection threshold bew 1 keV where potentially a large fraction of signal awaits undetected.
SiPMs offer several advantages in terms of efficiency of light conversion, radiopurity, compactness and especially noise, if operated at cryogenic temperatures.
ASTAROTH has developed a cryostat where the 5-cm cubic crystals can be cooled gently in He atmosphere while the cooling power is provide by a liquid argon bath that could be instrumented and act as a veto detector.
The design is innovative as a tunable temperature con be kept constant in the inner copper chamber in the range 87-150 K allowing to find the optimal working point accounting for the crystal response and the SiPM noise. The cryostat was commissioned and operated successfully in 2023.
We are also developing a new technique to encapsulate crystals in epoxy resins in order to maintain the transparency on all sides and allow for safe manipulation through the cooling cycles. Early results
are encouraging and could be a breakthrough for NaI users.
Finally, we are comparing the performance of large area SiPM matrices from different vendors and developing different front-end electronics based on discrete and integrated technologies with the ambition of providing a working solution that goes beyond our physics scope and could replace PMTs for low energy astroparticle applications in a wide community.

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