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On the operation of silicon photomultipliers at temperatures of 1-4 kelvin

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Silicon PhotoMultipliers (SiPMs) are being considered as possible photodetectors operating at low temperatures for direct dark matter searches, neutrino detectors, telescopes in space, or at high energy beams.

When operating SiPMs or other solid-state devices for photon detection at liquid helium temperature, i.e. 4 kelvin, not only the electronic properties of Si can change, such as charge carrier mobility, carrier density, and electrical conductivity, but also fundamental detector properties such as absorption length for photons, quantum efficiency, time response, and noise. Some devices fail to operate at cryogenic temperatures because of their lost ability to quench pixel discharges, others exhibit a non-tolerable increase in after-pulsing probability because of carrier trapping.

We have tested different types of SiPMs at 4 kelvin and were able to operate one particular type after modifications. No after-pulses were seen and single-photon detection was possible. The device was fully characterized in this temperature range.

We are developing a charged particle detector immersed in the mixed He-3/He-4 liquid helium of a dilution refrigerator in which the SiPM devices must be operated at temperatures between 1 and 4 kelvin.

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