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Power conversion for HEP using piezoelectric elements

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Efficient power conversion and distribution is an important consideration for advanced detectors as power requirements and channel density increase. Future detectors will have unique requirements such as very low mass, and ability to operate in environments with high magnetic fields or radiation. Switched power converters using inductive elements are difficult to miniaturize, generate electromagnetic interference, and are not inherently magnetic field tolerant. They suffer from inefficiency and reduced power density as the size of the magnetic elements are reduced. Switched capacitor converters can achieve higher power densities, but cannot achieve continuously variable voltage regulation with only capacitors as the energy storage element. Power conversion using piezoelectric materials as the energy storage element presents exciting possibilities for front end detector mounted converters. Piezoelectric resonators can achieve very high quality factors as compared to inductors. When used in power converters, they can achieve a degree of voltage regulation with potential to be used for biasing in pixel and silicon photomultiplier detectors. This talk will present an overview of the physics of operation of piezoelectric boost and buck converters, and discuss power converter work at the University of Pennsylvania. Topics included will be: proof of concept results and lessons learned; switch design using a bipolar-CMOS-DMOS (BCD) process and comparisons to other processes; resonator design using promising materials such as lithium niobate, which can achieve very high Q factors; and comments on future work including constraints on mounting and packaging, alternate resonator geometries and electrode design, and regulation control at high frequencies.

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