SuperCDMS HVeV: Single Charge Resolving Silicon Detectors with eV-scale Resolution
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Single Charge Detection with HV Gain
SuperCDMS employs phonon calorimeters with eV-scale resolution to detect athermal phonons generated in Si crystals. With a high crystal bias, the total phonon energy is proportional to the charge produced by an event. We can achieve exquisite charge resolution by operating around 100V bias.

Surface Event Rejection
- 1.9 eV laser photons are injected into the cryostat by an optical fiber. Photon pulses, with an average of ~2 photons/pulse are generated uniformly across the instrumented detector surface.
- Rapid absorption of near-surface phonons produces pulse shape differences that allow us to discriminate between bulk and surface events (shown in upper plot).
- The two-channel sensor design (an inner and outer channel) also allows for radial event reconstruction, and rejection of events near the outer walls of the detector (shown in lower plot).

Phonon Sensor Optimization
- Detector resolution depends on the energy transport efficiency from the crystal to the TES, and minimizing thermal noise in the TES by minimizing heat capacity.
- This produces an optimization space (above) that we have begun to probe with a dedicated fabrication run of 1cm detectors. The first tested detector achieved 3 eV resolution and 0.03 charge resolution at 100V.

Scaling Up in Fiducial Mass
- 3 eV resolution demonstrated across an order of magnitude in mass.
- Scaling above 10g in mass at the same phonon resolution requires lowering intrinsic sensor noise and faster signal bandwidth.
- Larger mass single electron detectors can also be achieved by increasing maximum bias voltage.

Scan for references and more information

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Laser Calibration
100V Crystal Bias
3 eV Energy resolution
0.03 Charge Resolution


Top: Pulse shape rejection (integral versus amplitude) demonstrating rejection of direct surface hits. Bottom: Radial rejection of non-quantized charge events along the side wall.

Scaling Up in Fiducial Mass

Detector resolution measurements, showing how resolution scales with mass for different readout strategies.

Setz Operating Voltage for NTL Single-Charge Readout
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