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DAMIC-M electronics system, status and first results.

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DAMIC-M is an experiment that searches for low-mass dark matter particles through their interactions with silicon nuclei or electrons in the bulk of charge-coupled devices (CCDs).
The experiment has developed a new electronics which allows it to read skipper CCDs with a single-ionization charge resolution. An Acquisition and Control Module board (ACM) drives the multiple non-destructive measurements of the pixel charge, the signal digitization and FPGA-based signal processing. This talk will summarize the status of the experiment, and the electronic chain performances from prototype detectors installed at the Modane Underground Laboratory.

Summary (500 words)

The DAMIC-M experiment aims to detect nuclear and electronic recoils in a silicon CCD bulk for low-mass dark matter research (WIMPs < 10GeV and dark sector candidates). Our challenge is to reduce the detection resolution down to a single electron and push the energy threshold to the eV-scale, using skipper CCDs.

Charges generated by DM interactions with silicon are extracted from the bulk and transported to a readout amplifier thanks to electrodes, which attract them from one pixel to another (figure 1). We have implemented the Correlated Double Sampling, where a floating capacitor acts as a sense node which measures two levels, one corresponding to a no-charge pedestal, and the other one to a charge containing signal. The charges are then moved back and forth under the sense in order to carry out an average of several measurements. The meaningful information is the difference between these two levels, which tells us about the charge accumulated by a pixel (figure 2). This complex process leads to a significant reading time, a parameter which must be optimised to reduce its impact on the detection performances.

We developed an electronic chain which allows the multiple non-destructive measurements of the pixel charge, also called skips, with a readout noise of 0.1electronRMS. Its main element is a motherboard which integrates the CCD control functionalities such as biasing and clocking, in addition to signal digitization and pre-processing. This board is called Acquisition and Control Module (ACM).
The final detector will consist of 52 modules of four 6Kx1.5K pixels CCDs. A synchronisation board has been produced to synchronise the CCDs reading, with a start-up gap between cards of the order of a nanosecond.

The signal emitted by the CCD is amplified and digitised by high speed, 18-bit 15 mega samples per second ADCs . A pre-processing step is done by the FPGA, and consist of an integration of the pedestals and signals levels. This step allows us to reduce data throughput, offering the possibility to compute either the average of the differences between two levels, or the raw data. (figure 3)

A prototype of the detector and the final electronics are installed in Modane Underground Laboratory, and my contribution to the workshop would be an occasion to report on the progress of the experiment, including various aspects such as hardware firmware and software, and the first results we have obtained (figure 4).

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