SENSEI

Sub-Electron Noise Skipper-CCD Experimental Instrument

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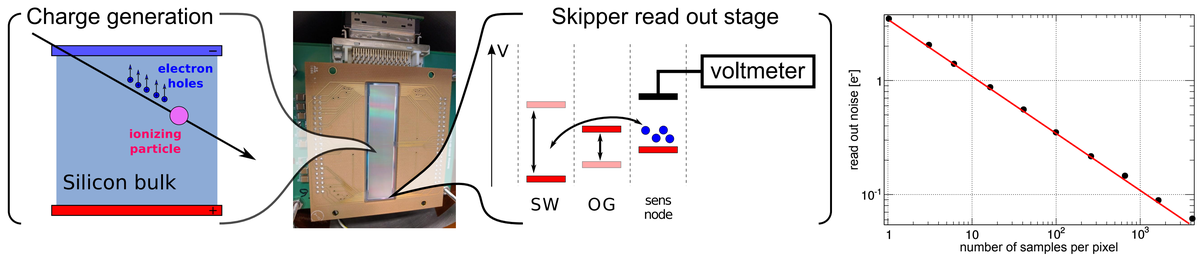
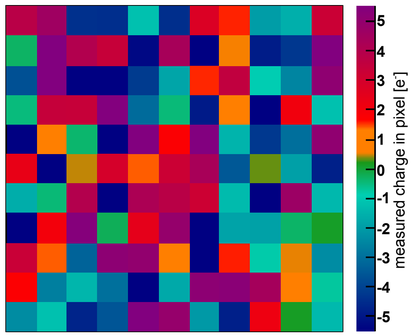
Skipper-CCD non-destructive readout

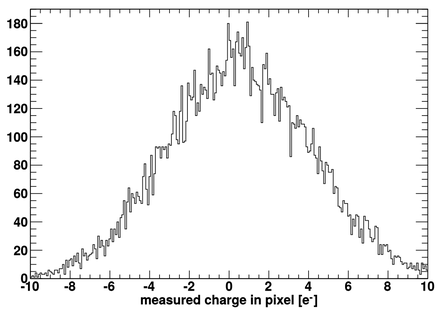
The deposited charge in each pixel can be measured multiple times to reduce the noise



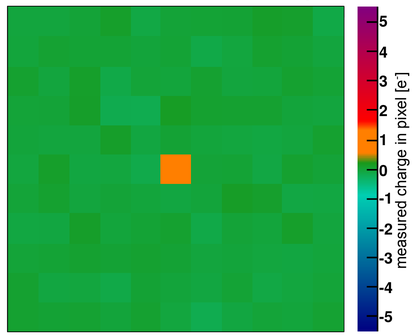
Standard CCD: charge in each pixel is measured only once



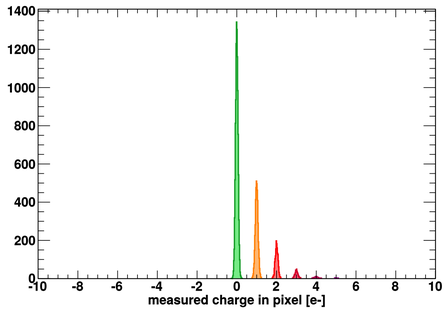
Readout-noise: 3.5 e RMS



New Skipper CCD: charge in each pixel is measured multiple times



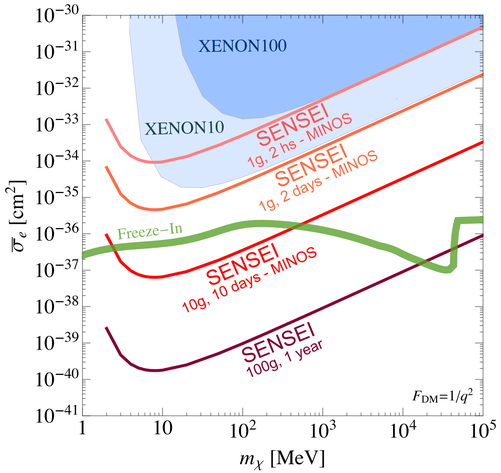
Readout-noise: 0.067 e RMS



Important technological breakthrough: The Skipper CCD concept was proposed 27 years ago, but only now has the concept been fully brought to fruition. For the first time, the number of electrons in each pixel, across a large CCD consisting of millions of pixels, can be counted precisely. This is irrespective if the pixel contains only zero or one electron, or if it contains more than 1000 electrons.

New Searches for Dark Matter

The ability to precisely count the number of electrons in a pixel has a significant and immediate impact on searches for rare events. SENSEI is a new dark matter direct-detection experiment with unprecedented sensitivity to several types of dark matter particles including dark-photons and axion like particles. The SENSEI experiment would be deployed in several stages with different target masses: 1 gram, 10 gram, and 100 grams, each consisting of an increasing number of Skipper CCDs (up to about 100) CCDs. Each stage has a significant discovery potential.



The figure illustrates SENSEI's reach (thin colored lines) for a scenario in which the dark-matter abundance is generated through "freeze-in" (thick green line). The strongest constraints on this candidate come from XENON10 data (shaded light blue region). A 1-gram SENSEI detector running for 2 days would already improve on the XENON10 limit.

Item	Cost
Sensors & package *(only item needed for 10 g)*	$450k
Readout electronics	$200k
Vessel & support systems	$215k
Installation	$50k
Contingency	$200k
Total	**$1,115k**

The Table shows the funds required for a 100-gram SENSEI detector. A 10-gram detector installed at MINOS only requires the first line-item (Sensors & package).

Other applications

SENSEI technology will impact other scientific areas and enable:

* Table-top search for low-energy neutrino oscillations to probe for sterile neutrinos.
* New measurements of coherent neutrino-nucleus scattering
* A factor of two reduction in exposure times for the imaging of terrestrial exoplanets.

The SENSEI team has established collaborations with these projects. The Skipper CCDs procured here can also be used for testing these other implementations.