DarkNESS Project Testing

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Abstract

This internship involved the design and assembly of a mechanical system for testing skipper-Charge Couple Devices (CCDs) for the DarkNESS project. Skipper-CCDs are highly-sensitive sensors with ultra-low readout noise that are deployed for direct detection of dark matter. DarkNESS is a CubeSat that aims to use skipper-CCDs to search for dark matter decaying into X-rays. Currently, in the testing phase, the design process involved creating 3D models of mechanical adapters to operate a prototype space-Multi Chip Module (sMCM) package in existing testing chambers in the CCD lab at Fermilab's IERC. The drawings were sent out to be machined, and while waiting to receive the finished adapters, we assembled a vacuum chamber for skipper-CCD testing and performed initial testing of a single CCD controlled by the space-Low Threshold Acquisition (sLTA) board that will be employed on the CubeSat. The results showed that the testing conditions are optimal for data to start being taken and analyzed.

Schematic of the DarkNESS CubeSat pointing towards the center of the Galaxy

Photo of a space Multi-Chip Module (sMCM) with 4 CCDs mounted on a ceramic plate

Methods

The design involved using Autodesk Fusion 360 to create an adapter to mount and electrically isolate the sMCM in the vacuum vessel. The assembly work involved installing mechanical parts in the vacuum cube for testing a single CCD. After the setup was completed we achieved an operational pressure of 10^{-4} bar using a Pfeiffer vacuum HiCube turbo pumping station.

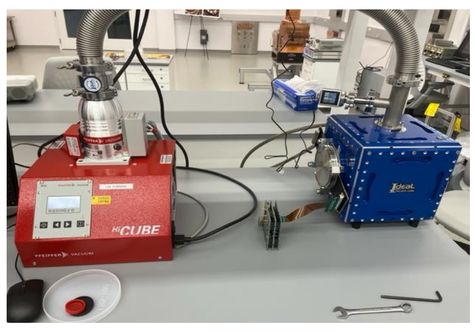
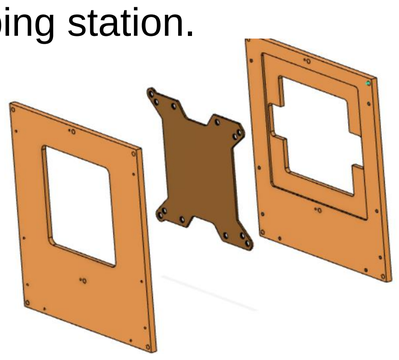
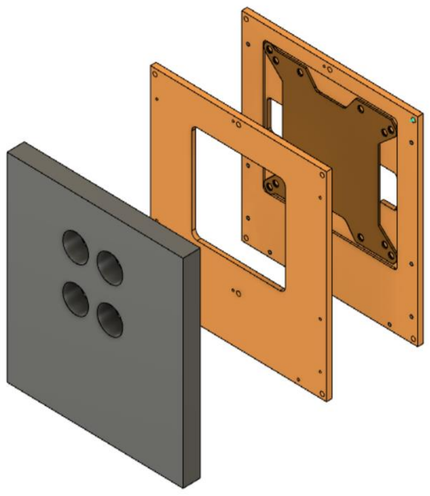


Photo of the general testing setup. Skipper-CCDs operated in vacuum chamber, with signals passed out of vacuum to sLTA through Vacuum Interface Board

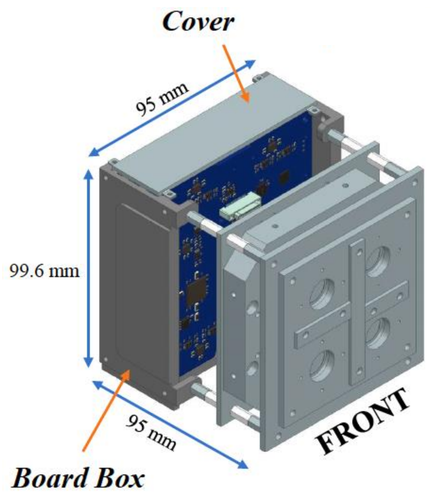


3D view of the CCD ceramic plate and adapter



3D view of the aluminum window shielding sMCM adapter

Here we have also designed an aluminum window to restrict the field of view (FOV) that the skipper-CCDs are exposed to, following the preliminary design of DarkNESS.



Preliminary design of DarkNESS detector payload

Current Results

We were able to read the data from a single CCD in the vacuum chamber. Tracks from cosmic ray muons and electrons can be observed which demonstrates that the sLTA is operating well in the lab environment. We are currently waiting to receive the mechanical adapter and flex cable for the sMCM but have plans to perform X-ray calibration with the integrated sMCM and sLTA system in future testing.

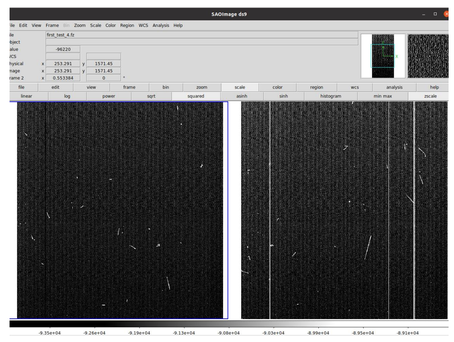


Image of cosmic ray events from skipper-CCD in testing setup

Conclusion

This work developed a suitable design for a mechanical adapter that will be manufactured and installed for calibration of the DarkNESS mission's detector module. The next steps consist of mounting the space-MCM adapter in the vacuum chamber to collect the X-ray calibration data, analyze the data, and assess if the CCD readout electronics meet the DarkNESS performance requirements in preparation for the Critical Design Review.

Acknowledgment

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References

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