3UCubed Flight Build, Instrument Calibration, and Data Processing

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INTRODUCTION

The student collaboration of IMAP is a NASA-funded project to give hands-on experience in space hardware and software to undergraduate students, building a collaboration between the University of New Hampshire, Sonoma State University, and Howard University. 3UCubed is a 3U CubeSat project set to launch in 2025 to investigate thermospheric upwelling in the cusp region in response to electron precipitation. In preparation for mission launch, we have developed extensive modeling and are undergoing thorough testing.

Figure 1: *3UCubed CubeSat CAD model.*

THERMAL ANALYSIS

Thermal analysis for the CubeSat was performed in Ansys Thermal Desktop, an extension of AutoCAD designed for satellite simulation. The model itself was constructed of finite difference surfaces. Then, material properties, conduction pathways, and orbit parameters were defined to yield temperature plots.

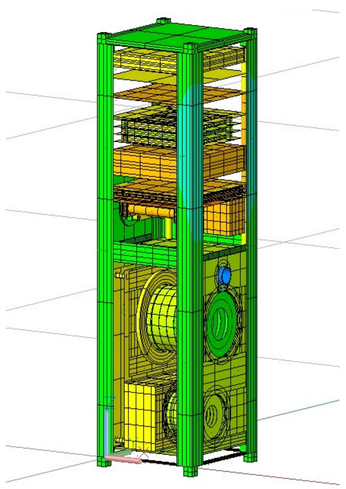


Figure 2: *Thermal simulation render.*

The temperature plots are referenced against the various operational temperature limits for the different components, including those for the UV-PMT and ERPA to ensure the satellite remains functional during flight.

The satellite is currently expected to follow a circular orbit at an altitude of 510 kilometers, with a local time descending node of 10:00 am.

ERPA

Electron Retarding Potential Analyzer

The primary data product of the ERPA is electron energy measurements. The ERPA uses a selection screen with a swept retarding potential and measures the current incident to an anode. The ERPA measures flux of suprathermal electrons in eight energy bands of >10 to 150 eV at a cadence of 100 ms (6.25 ms instantaneous measurements).

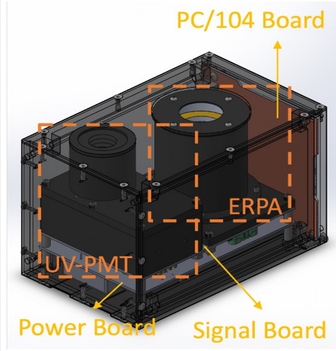


Figure 3: *Instrument and housing schematic model*

UV-PMT

Ultraviolet Photomultiplier Tube

The UV-PMT measures spectral UV emissions of neutral atomic oxygen. The current produced is directly related to the photoelectron flux[1]. The device is filtered around a 20 nm passband to measure primarily UV emissions of oxygen at 130.4 nm and 135.6 nm.

INSTRUMENT TESTING/CALIBRATION

The UV-PMT is calibrated at UNH, where it is placed on a rotating plate in a vacuum chamber with a NIST-calibrated photodiode for cross-calibration. A UV source with interchangeable neutral density filters is placed opposite the plate and has a known flux spectrum. The plate's orientation is then swapped to compare the reading with the UV-PMT's, and the voltages are used to calibrate the UV light flux.

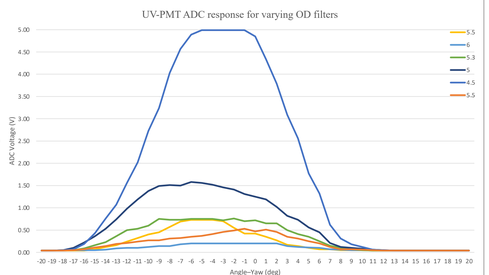
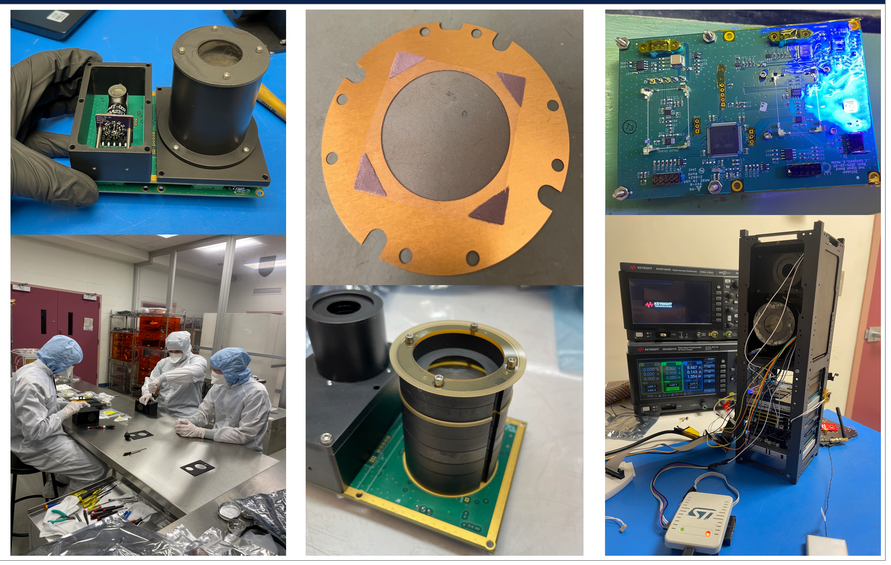


Figure 4: *UV-PMT response for various neutral density (OD) Filters.*

FLIGHT MODEL BUILD

The flight model (FM) instrument test build was completed at UNH on November 21, 2024. The engineering model (EM) stacksat is newly in use for software testing by the CS team. The flight spare was functionally tested in a vacuum chamber after initial assembly. We are now preparing for final assembly by applying conformal coating to the circuitry, stabilizing the PMT with epoxy, staking the screws for vibration security, and continuing calibration testing.



DATA PROCESSING

Data is processed by the OBC during Idle Mode, then files are downlinked to the ground station via UHF during Comm Mode, and finally, the files are received as binary for processing using a Python script.

ERPA:

Level 0 – Voltage vs time, separated by screen voltage
Level 1 – Current vs time, separated by screen voltage
Level 1.5 – Current vs screen voltage vs time

PMT:

Level 0 – Voltage vs time
Level 1 – Current vs time
Level 1.5 – Watts vs time

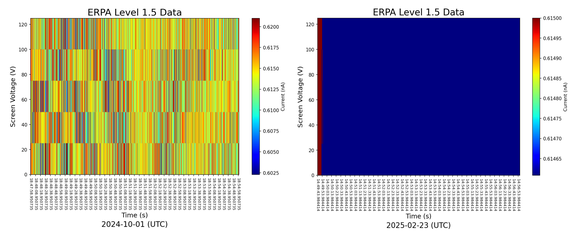


Figure 5: *ERPA Level 1.5 Data comparison for Revision C (left) vs Revision D (right) using test files.*

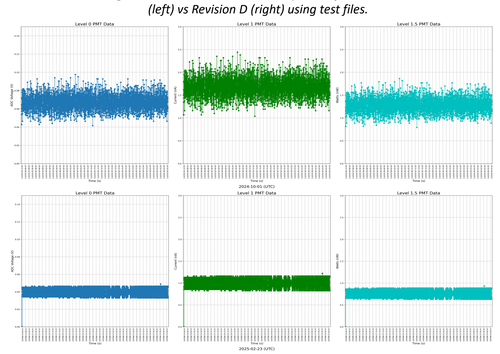


Figure 6: *PMT Level 0 to Level 1.5 Data comparison for Revision C (top) vs Revision D (bottom) for a test file.*

ACKNOWLEDGMENT

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REFERENCES

[1]Cohen, I. et al., 2016 (ERPA)
Fritz et al., 2018 (UV-PMT)

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