IMAP Student Collaboration: 3UCubed Instruments, Calibration, Science, and Science Operations

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INTRODUCTION

The student collaboration of IMAP is a NASA-funded initiative to provide hands-on experience in space hardware and software to undergraduate students and building a collaboration between the University of New Hampshire, Sonoma State University, and Howard University. 3UCubed is a 3U CubeSat project that launched November 28th, 2025, on SpaceX's Transporter-15 to investigate thermospheric upwelling in the Earth's cusp regions. In preparation for mission science operations, we have developed the science operation and validation pipeline.

Figure 1: *3UCubed CubeSat CAD model*

SCIENCE OPERATIONS

Instrument ON only between 60 and 85° GLAT (science mode). Instruments point up: ERPA measures precipitating electrons in the cusp, UV-PMT measures the thermosphere above ~500 km.

During Science Mode, ERPA samples every 6.25 ms (full 16-sample per 100 ms), PMT every 125 ms.

Processing on the OBC occurs during Sunlit Idle Mode to average ERPA samples into 8 energy samples/100 ms and to average the double samples of PMT data. During Eclipse Idle Mode, power consumption is minimized.

Data is downlinked to ground stations through UHF (MOC at SSU) during Comm Mode. Three sets of files are further processed for data, ERPA (ERP), UV-PMT (PMT) and Housekeeping (HK).

Data processed through pipeline (SOC at UNH).

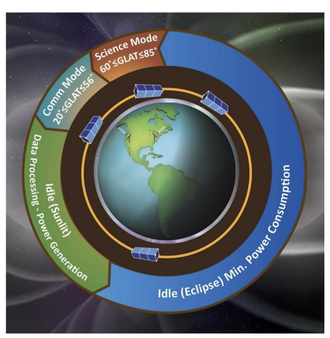


Figure 2: *3UCubed CONOPS Model*

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.

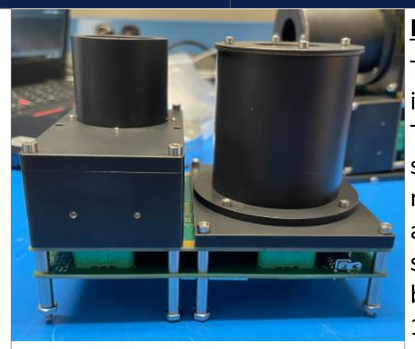


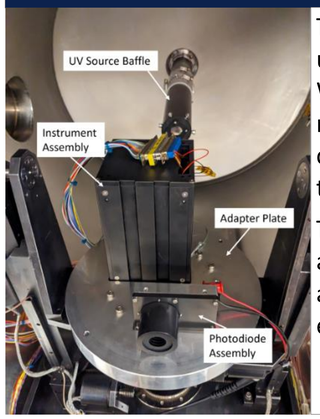
Figure 3: *3UCubed Flight Model instrument assembly without housing.*

ERPA

Electron Retarding Potential Analyzer

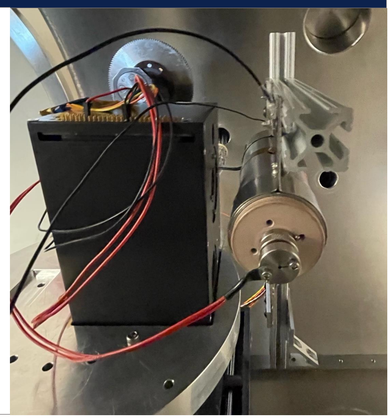
The primary data product of the ERPA is electron energy measurements. The ERPA uses a selection screen with a swept retarding potential and measures the current incident to an anode. The ERPA measures flux of suprathermal electrons in eight energy bands of >10 to 150 eV at a cadence of 100 ms (6.25 ms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

INSTRUMENT TESTING



The UV-PMT is calibrated at UNH using an ultraviolet source with a known flux spectrum. We use a rotating plate to compare the voltage reading between the UV-PMT and a NIST-calibrated photodiode, which we use to calibrate the UV light flux.

The ERPA is calibrated for energy because we can assume flux is exact. We use a filament tube set at a specific voltage to measure the energetic electrons and to validate energy sampling.



CALIBRATION

The angular responses for each neutral density filter test are averaged and centered at 0 degrees. We take the maximum ADC reading at the peak of each curve and create a linear fit to predict ADC readings for a given proxy brightness. This is an ongoing work in progress to be continued through Spring 2026.

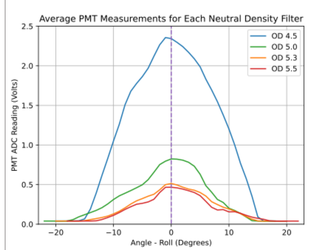


Figure 4: *Averaged PMT ADC angular responses centered at 0 degrees for each OD filter*

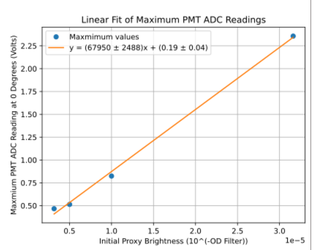


Figure 5: *Linear fit from maximum PMT ADC readings for each OD filter*

DATA PROCESSING

Files are received as binary from the ground station for processing using a Python script. We separate each level of processing as follows:

ERPA: Voltage vs time → Current vs time → Current vs screen voltage vs time

PMT: Voltage vs time → Current vs time → Watts vs time

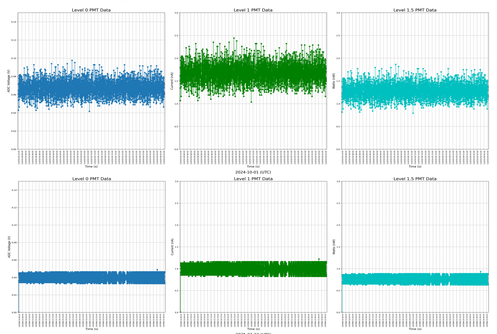
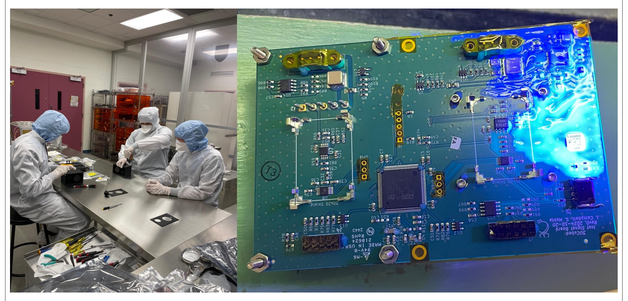


Figure 6: *PMT Level 0 to Level 1.5 Data comparison for Revision C (top) vs Revision D (bottom) for a test file.*

FLIGHT BUILD

The flight model (FM) instrument build was initially completed at UNH November 21st, 2024. We spent the last year before integration preparing for final assembly, which was completed September 16th, 2025.



ACKNOWLEDGMENT

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REFERENCES

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

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