

# 3UCubed Instrument Calibration, Data Processing, and Science Operations



Devin Phyllides, Sanjeev Mehta, Adri Jackson, Noé Lugaz, Marc Lessard, Laura Peticolas, Jenna Burgett, 3UCubed team  
 devin.phyllides@unh.edu

## 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 science operations, we have developed the science operation and validation pipeline.



Figure 1: 3UCubed CubeSat render

## SCIENCE OPERATIONS

Instrument ON only between 60 and 85° GLAT (science mode). During Science Mode, ERPA samples every 6.25 ms (full 16-sample per 100 ms), PMT every 125 ms.

After exiting the Science Mode, processing on the OBC occurs to average ERPA samples into 8 energy samples/100 ms and to format the data into the file structures shown:

iHK file structure

Data Field	HDR (DDDD)	Unix Time	Up Time	SEQ	V sense	BusV mon	BusI mon	2v5 mon	3v3 mon	5v mon	n3v3 mon	n5v mon	15v mon	5vref mon	n200v mon	n800v mon	TEMP 1-4	And so on...
Byte	2	4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1-4	4+1

ERPA file structure

Data Field	HDR (EEEE)	Up Time	SEQ	SWP0	SWP1	SWP2	SWP3	SWP4	SWP5	SWP6	SWP7	SEQ	SWP0	SWP1	And so on...
Byte	2	4	2	ADC0	ADC1	ADC2	ADC3	ADC4	ADC5	ADC6	ADC7	2	ADC0	ADC1	on...

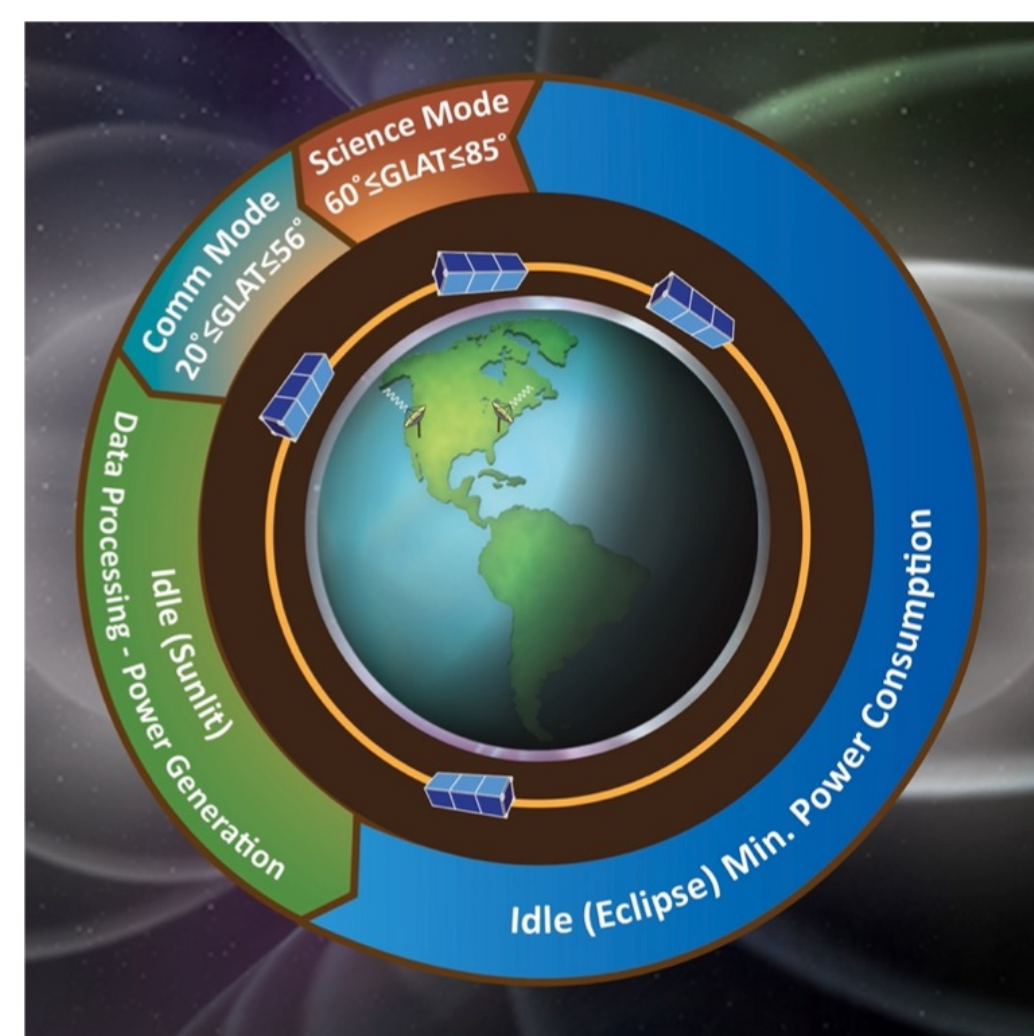
PMT file structure:

Data Field	HDR (FFFF)	Time	SEQ	ADC	SEQ	ADC	SEQ	ADC	SEQ	ADC	And so on...
Byte	2	4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	on...

Instruments point up: ERPA measures precipitating electrons in the cusp, UV-PMT measures the thermosphere above ~500 km.

Data downlinked to ground stations through UHF (MOC at SSU).

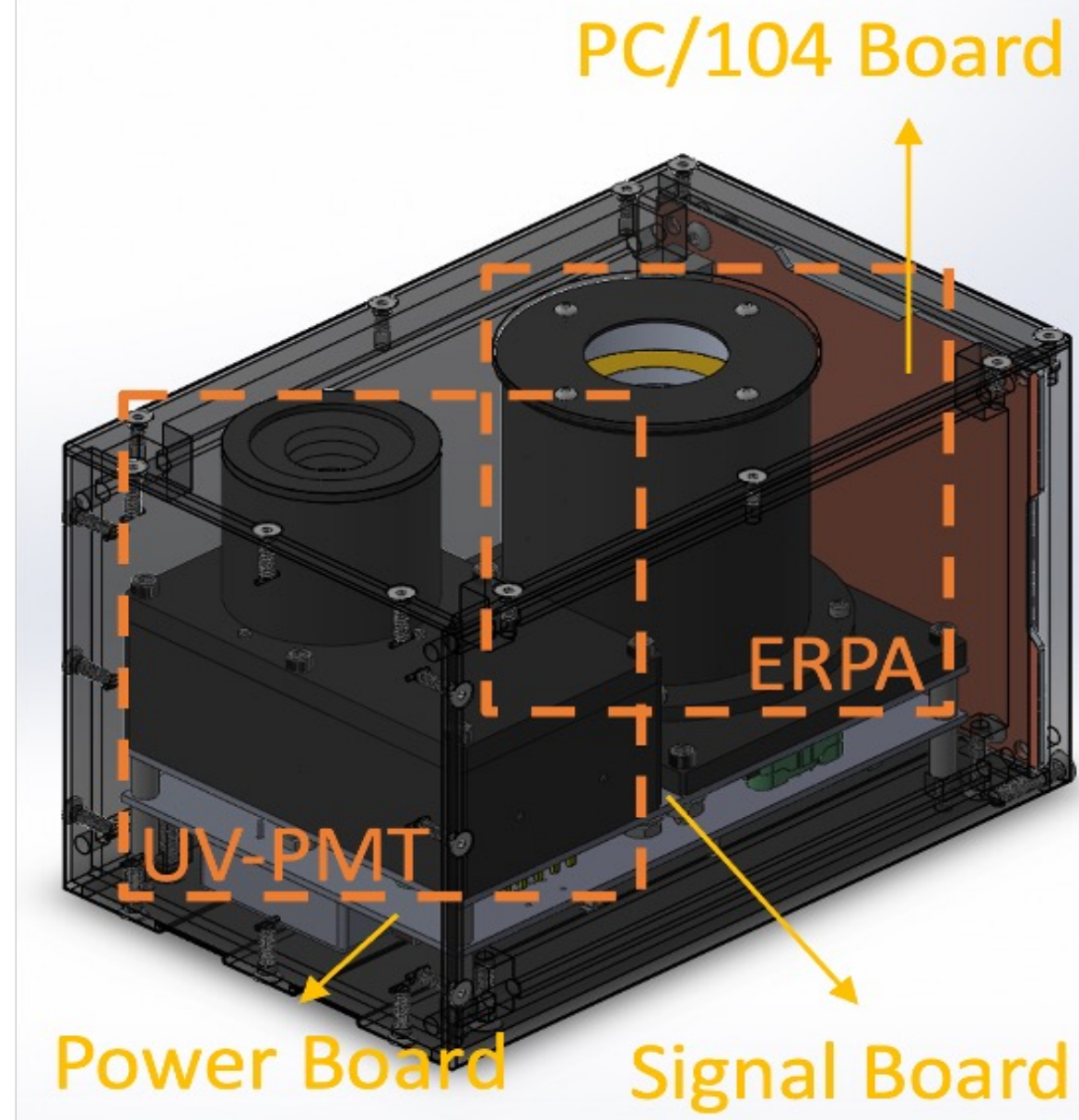
Data processed through pipeline (SOC at UNH)



## 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).



## 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<sup>[1]</sup>. 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 that is then used 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.

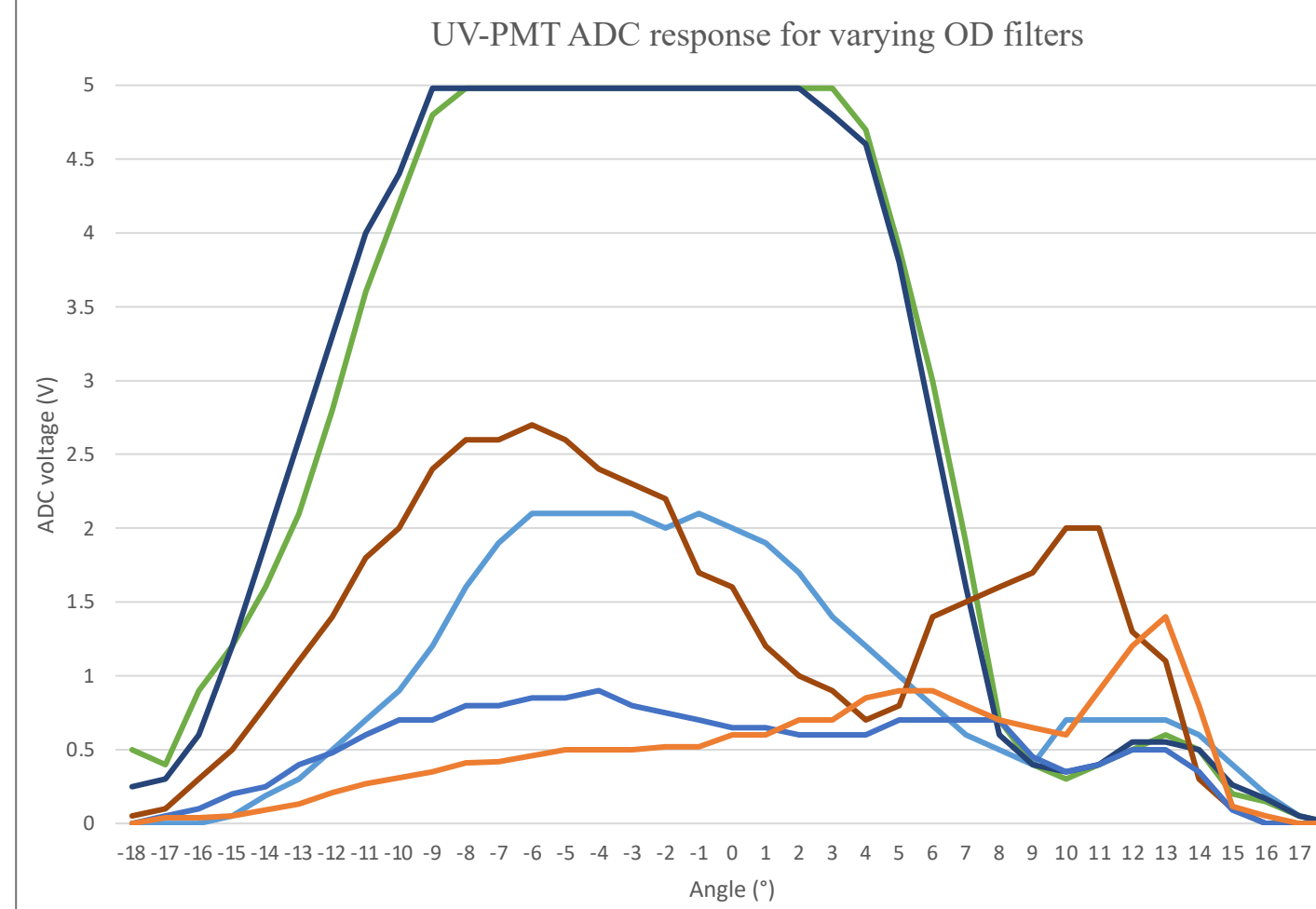


Figure 2: UV-PMT response for various OD Filters

## DATA PROCESSING PIPELINE

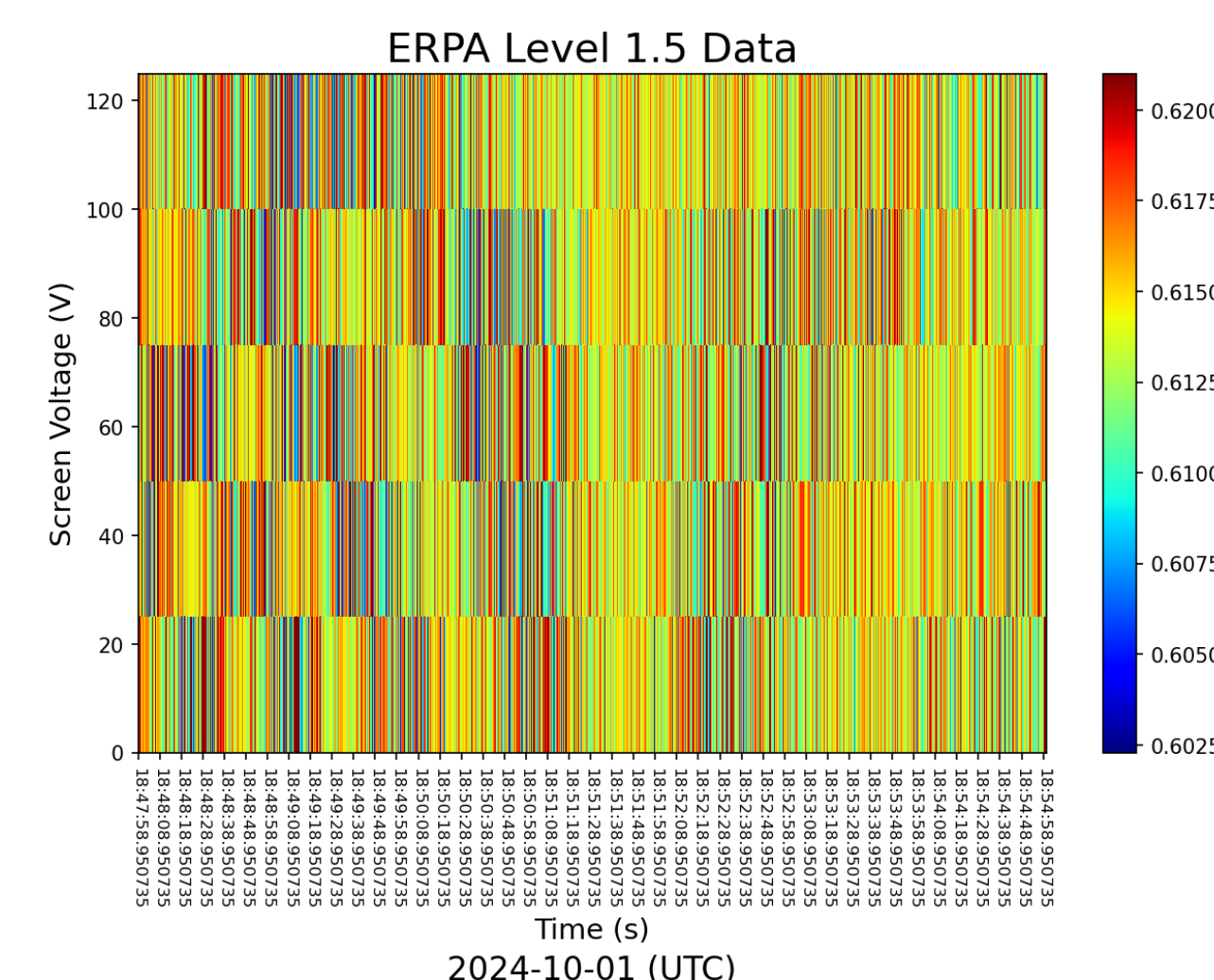
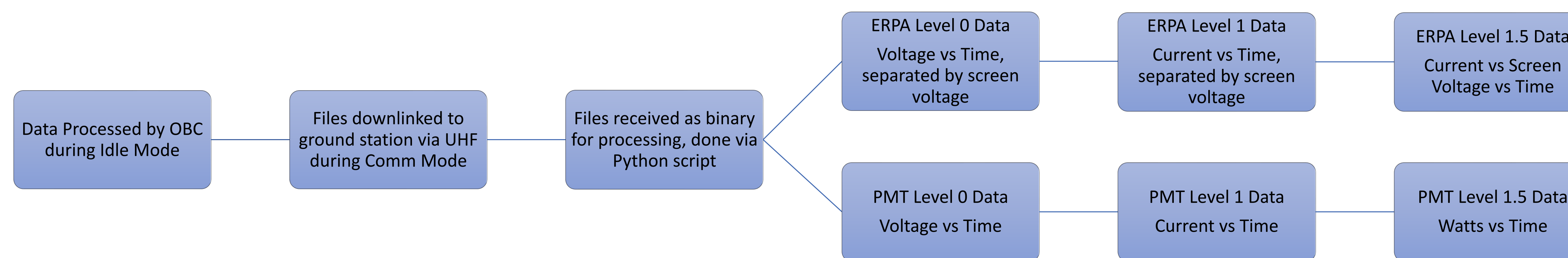


Figure 3: ERPA Level 1.5 Data for a test file

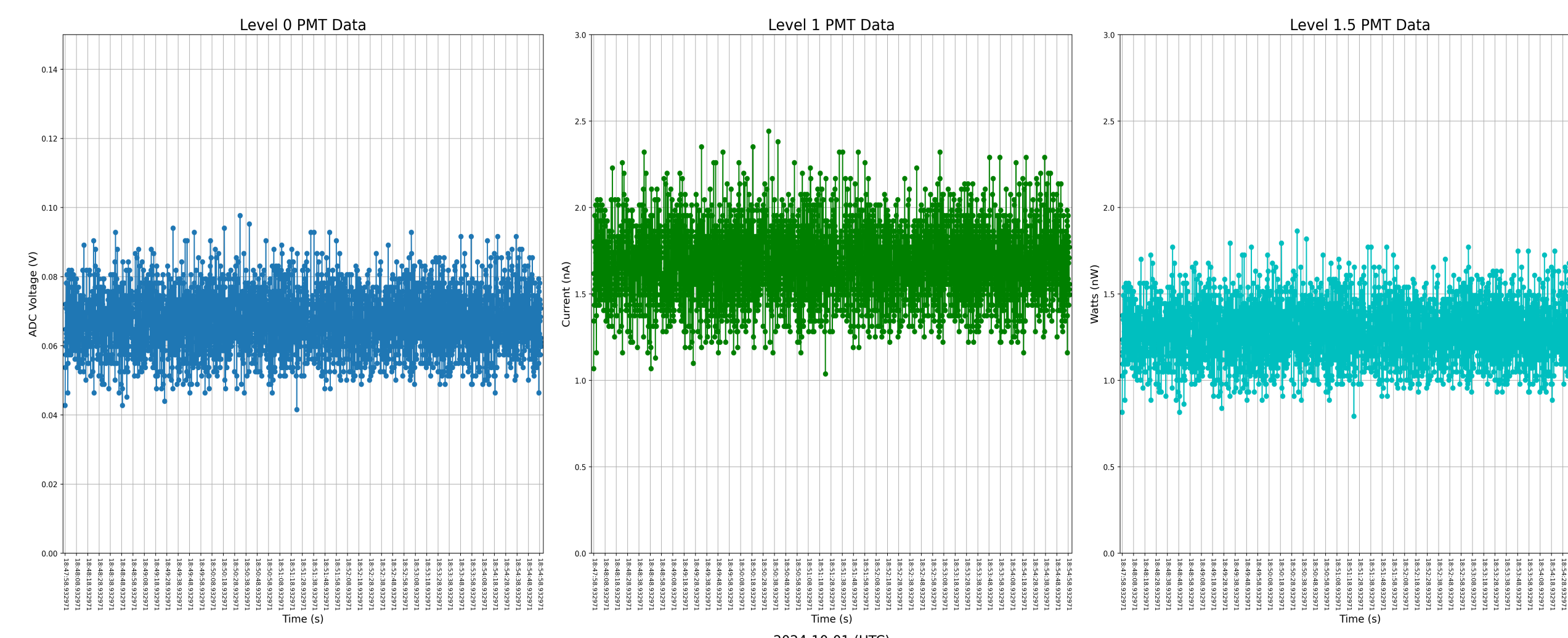
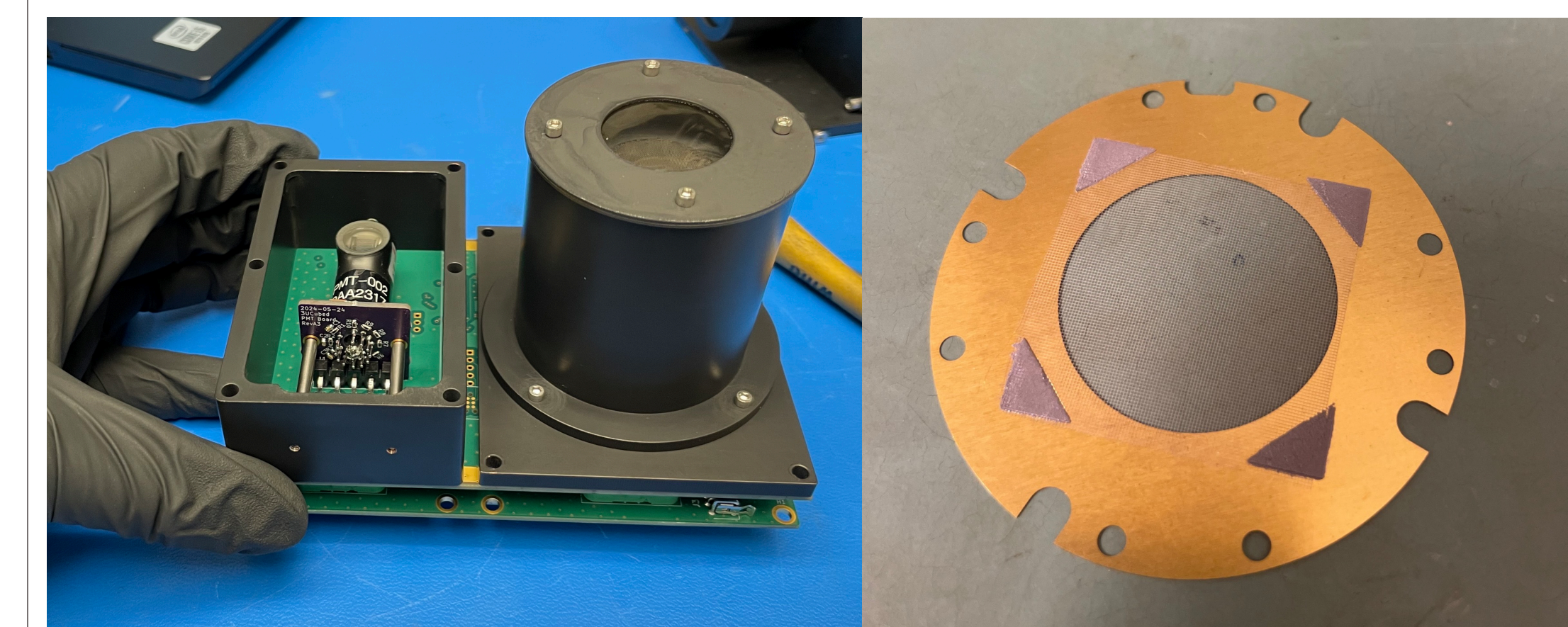
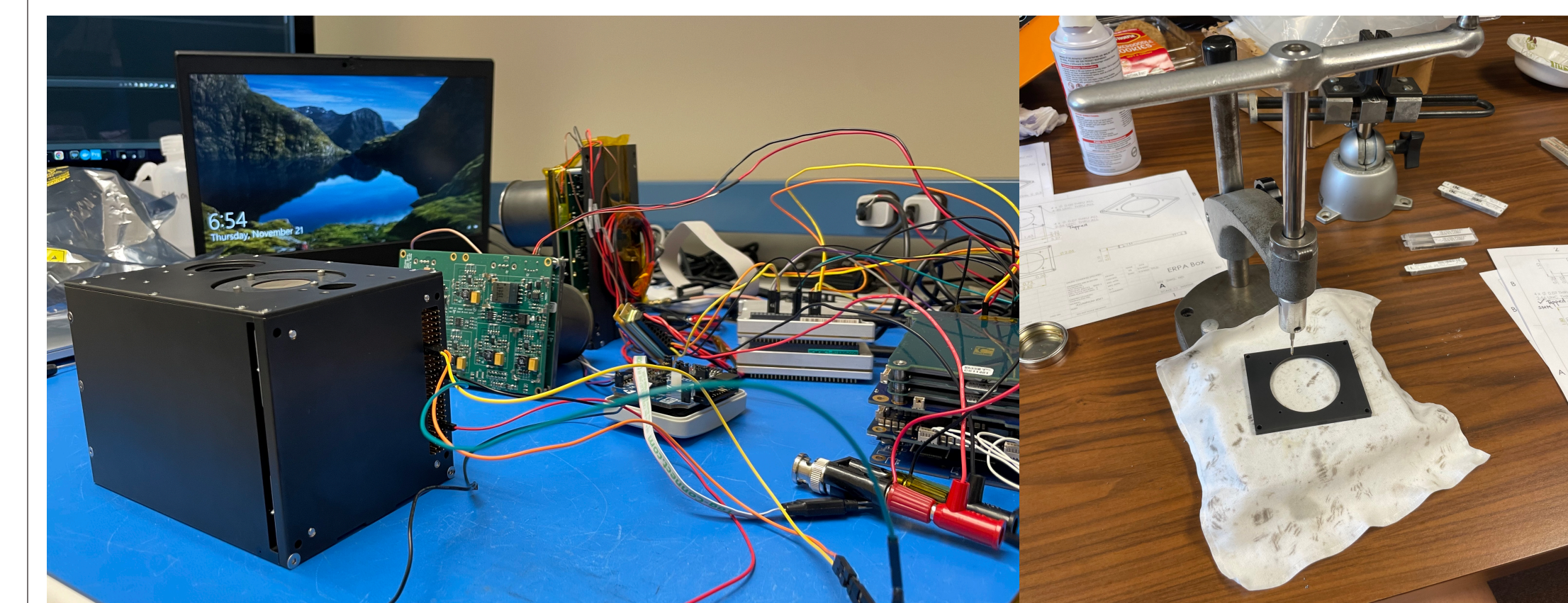
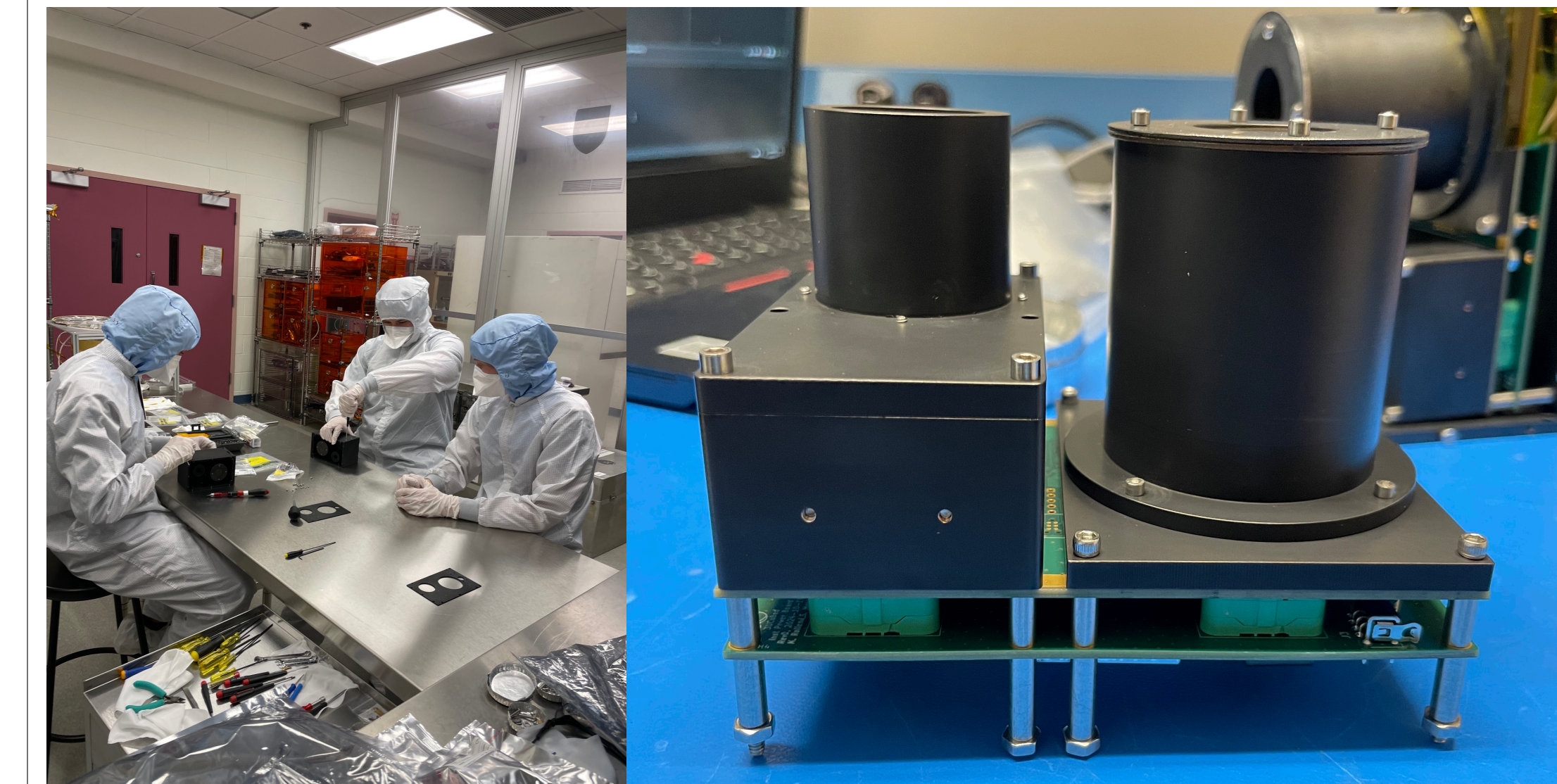


Figure 4: PMT Level 0 to Level 1.5 Data for a test file

## FLIGHT MODEL BUILD

The flight model (FM) instrument build was completed at UNH on November 21, 2024. The engineering model (EM) flatsat remains in use for software testing by the CS team. FM functionally tested on the flatsat. FM calibration to be run in Winter 2025.



## ACKNOWLEDGMENT

Special thanks to all who have contributed to the 3U Cubed mission including mentors, current and past students. This work is supported by NASA 80NSSC20K1110 as part of the IMAP Student Collaboration.

## REFERENCES

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