CubeSat Relativistic Electron and Proton Energy Separator

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Introduction

CREPES is a undergrad student lead small cube satellite (CubeSat) project operating under the advisory of the Earth and Planetary Exploration Technology (EPET) program at the University of Hawaii at Manoa. The mission began with the NASA Heliophysics Road Map which aims to address fundamental mysteries in heliophysics, emphasizing a comprehensive understanding of the Sun's interaction with Earth and the solar system and space weather research. One pivotal component specifically focuses on understanding the plasma processes responsible for particle acceleration and transport. This entails characterizing the energy spectrum and fluences of particles resulting from phenomena like Coronal Mass Ejections (CME) and Solar Flares. By monitoring arrival times of relativistic electrons and high-energy protons, along with their incident angles, the spacecraft can collect data relevant to understanding particle transport mechanisms. This data, coupled with machine learning methods, may enable characterization and classification of CME, ultimately advancing our understanding and forecasting ability.

Science Objectives

In order to meet the goals of the mission objective, the spacecraft will be designed to do all of the following:

1. Monitor incoming high energy electron and proton fluxes
2. Determine the different directions of incoming fluxes around Earth
3. Be able to collect data in 20-60 min intervals
4. Monitor the number of peak high energy particles during SEP events

Technology Objectives

Despite their long and pioneering history in physics laboratories across the world, GEM detectors have not been flown in space before. Thus, by utilizing a prototype miniature GEM detector in our satellite, it opens the door for the development of many other detectors of its kind.

Payload Design and Implementation

The payload is a modified parallel plate detector that utilizes GEM foil technology (PRGEM) to induce further ionization in the gas volume (Ar/Co2 in a mass ratio of 70:30) to achieve higher proportional gain and amplification than traditional parallel plate detectors (Sauli, 2021). The detector has two mylar windows as outlined in Figure 1. To ensure particle acceptance only through the windows, the detector will implement tungsten shielding on the top and bottom of the detector. This ensures that any particles traveling outside the detector's solid angle do not enter the gas volume and deposit significant amounts of energy. Figure 2 shows how the payload will sit in the current satellite design.

Payload Fabricaiton

GEM foils are fabricated by CERN from their Micro Pattern Technology Labs using the combination of photolithography techniques, and chemical etching. In parallel, the CREPES team are making efforts to replicate the fabrication processes to manufacture them in-house at the University (see Figure 3), allowing for quick design iteration. The team is exploring the challenges with achieving biconical holes patterned out throughout the film by selecting chemicals with high anisotropic and selectivity properties.

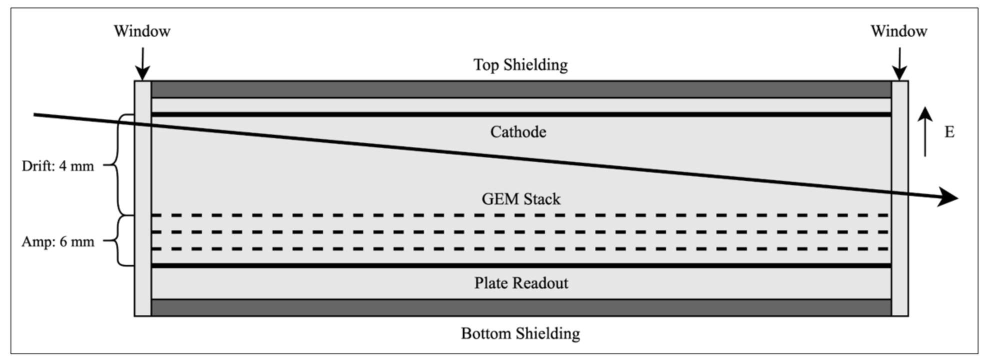

Figure 1. PRGEM Schematic

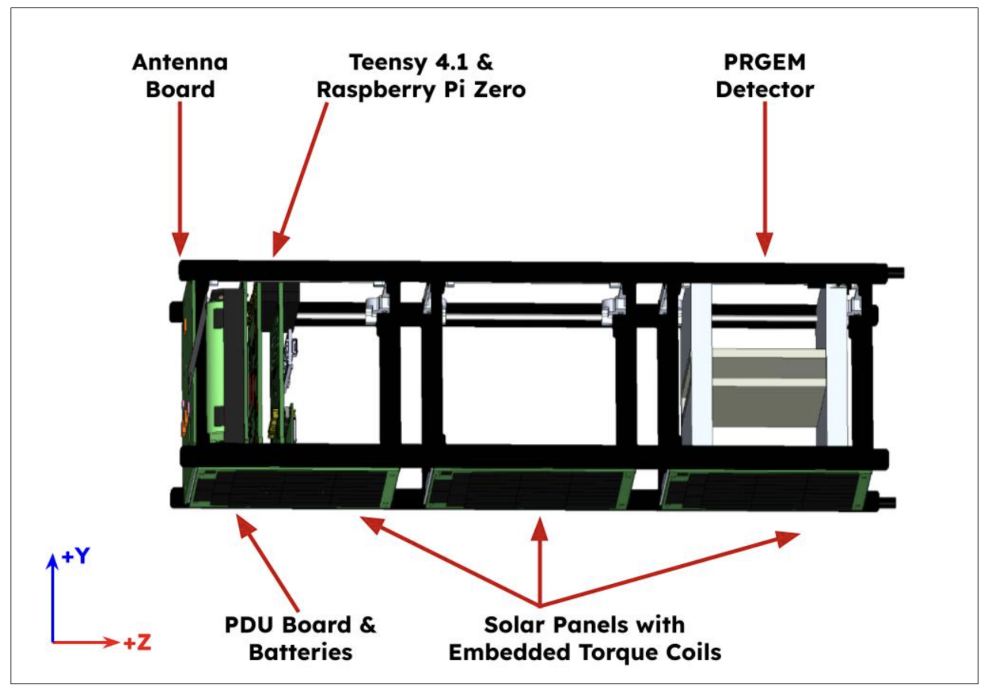

Figure 2. Model of CREPES

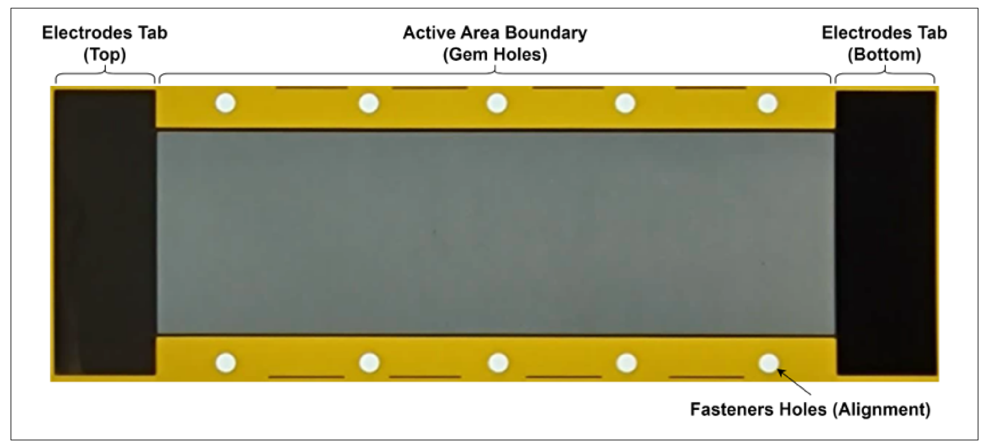

Figure 3. GEM Foil for Custom Payload

Conclusion

The CREPES mission holds merit through its three main objectives. Firstly, it aims to offer hands-on experience to students passionate about space exploration. Secondly, it endeavors to develop science-driven mission concepts aligned with NASA's goals. Lastly, it explores innovative technologies not yet utilized in space missions.

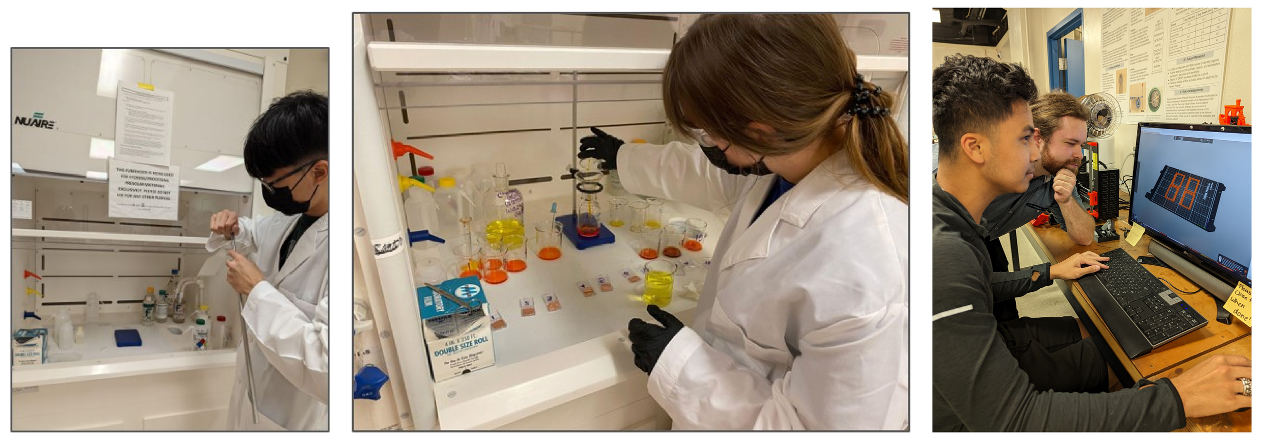

Figure 4. CREPES Team in Fabrication Lab

References

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Gaussian Process vs. Bayesian Neural Network Active Learning for Constrained Trajectory Exploration - *Sapphira Akins, Dr. Frances Zhu*

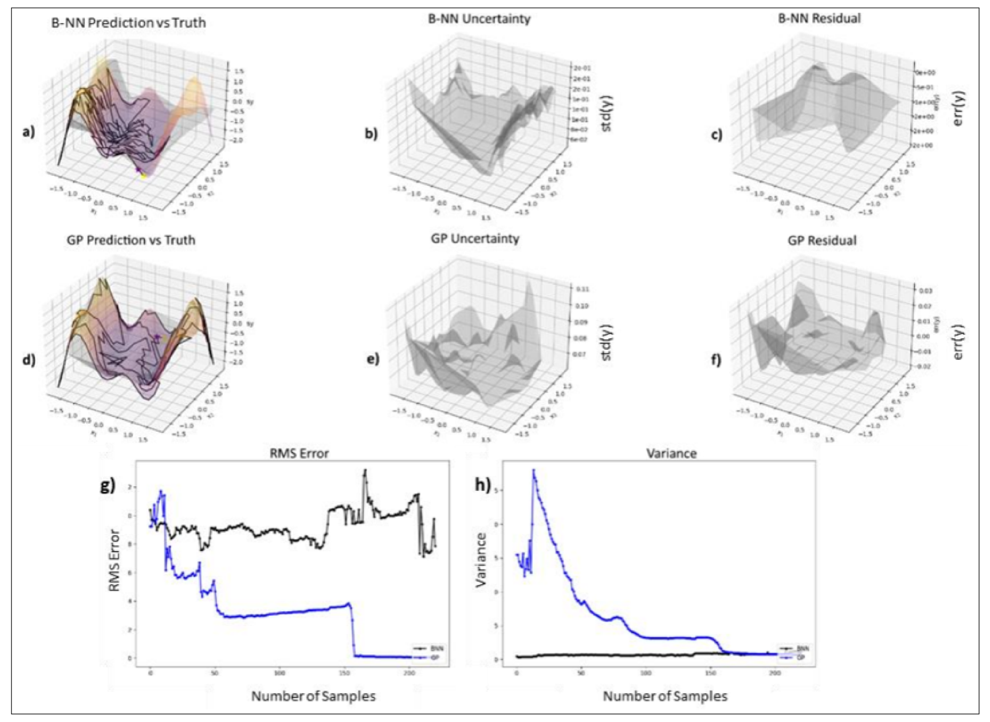

Figure 5. Example of an active learning GP and BNN model with a nearest neighbor prediction horizon and constrained movement horizon on a noiseless Townsend surface.

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Skin-interfaced Microfluidic Systems with Spatially Engineered 3D Fluidics for Sweat Capture and Analysis - *Wu, C. H., Ma, H. J. H., Baessler, P., Balanay, R. K., Ray, T. R.u*

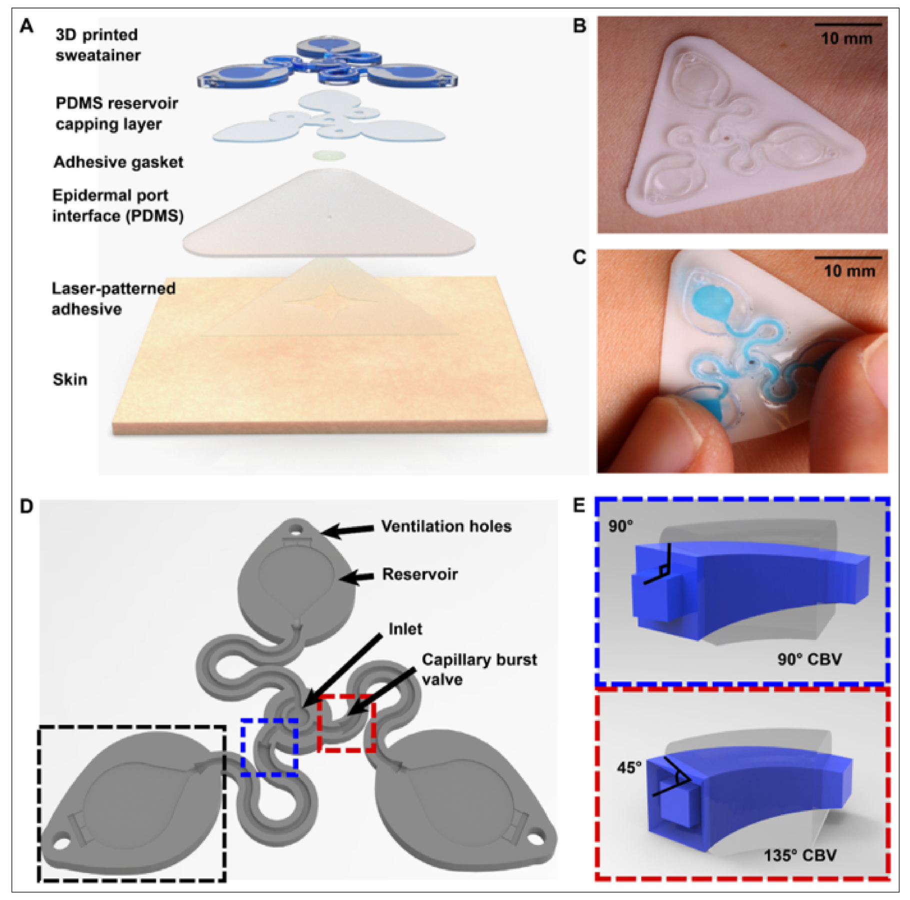

Figure 6. Schematic illustrations and optical images of the 3D printed epidermal microfluidic devices for the collection and analysis of sweat.