



Space Weather Atmospheric Reconfigurable Multiscale Experiment (SWARM-EX)

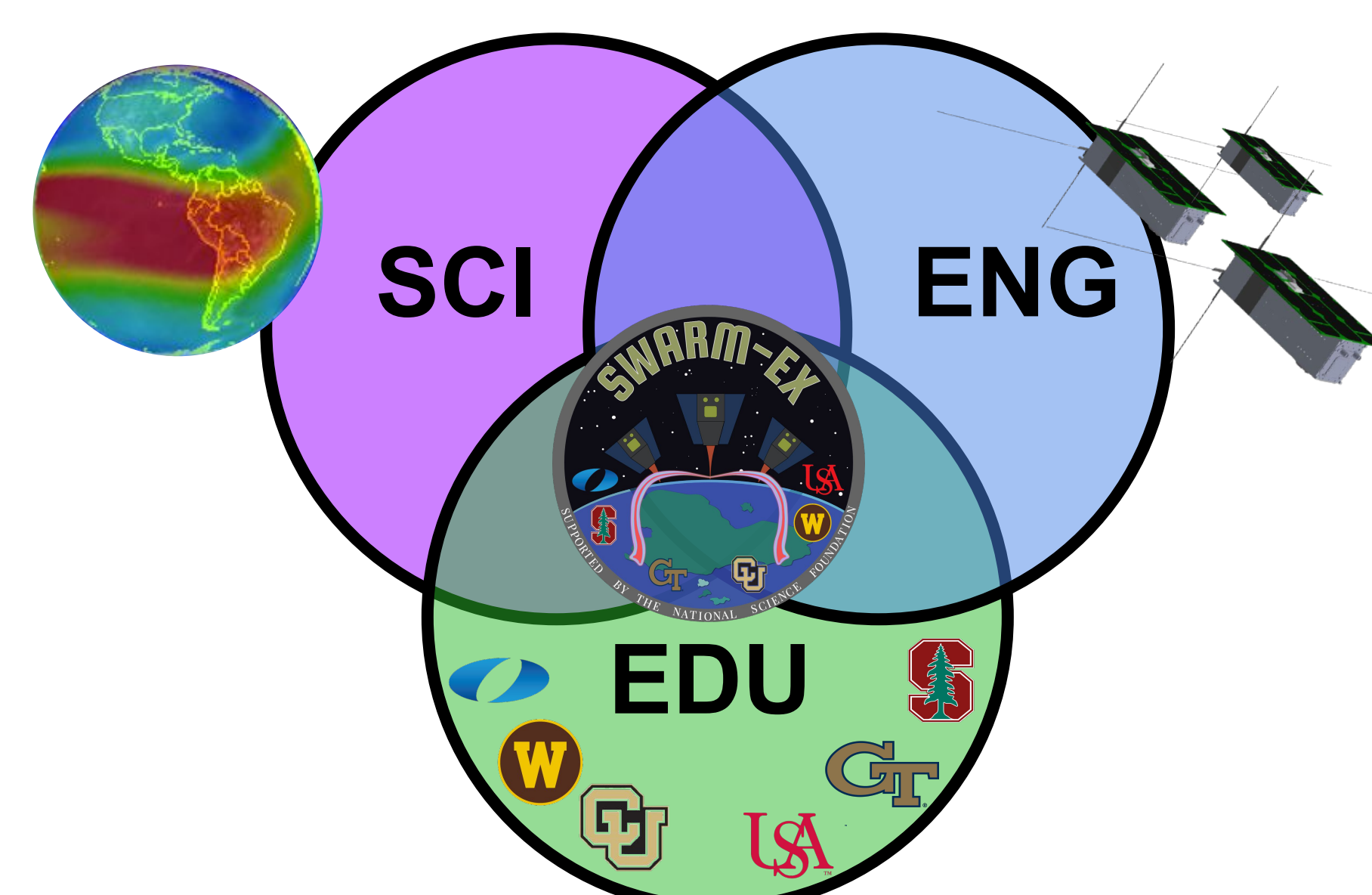
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Introduction

SWARM-EX is an NSF-funded inter-collegiate mission to design, build, and fly three 3U CubeSats in a swarm in order to address open aeronomy questions about the Equatorial Ionization Anomaly (EIA) and Equatorial Thermospheric Anomaly (ETA).

SWARM-EX Objectives

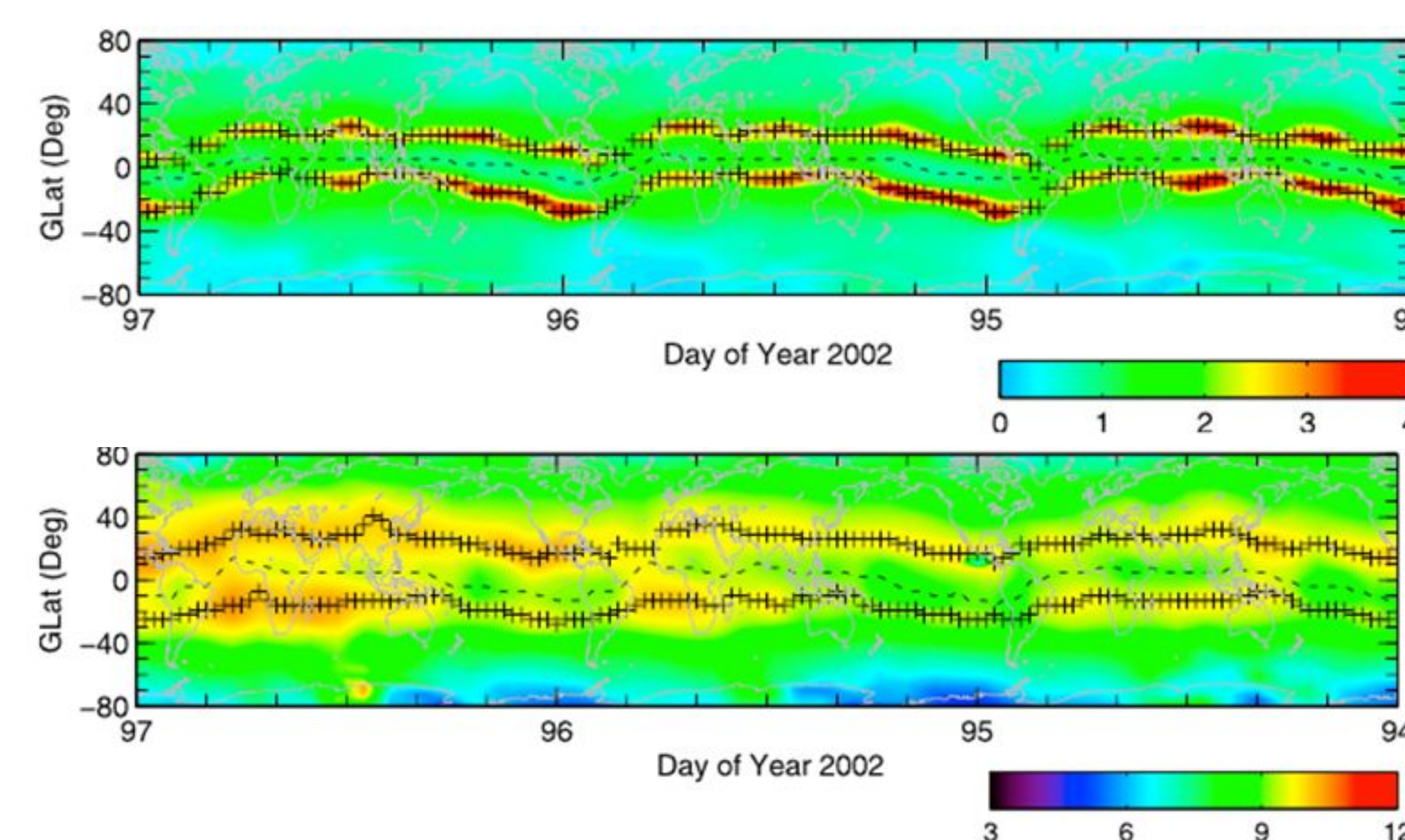
- Persistence and correlation in EIA/ETA
- Changes in EIA/ETA
- Formation flying
- Swarm reconfiguration
- Collision avoidance



- Mentorship and collaboration between six schools
- Education and public outreach program

Science Questions

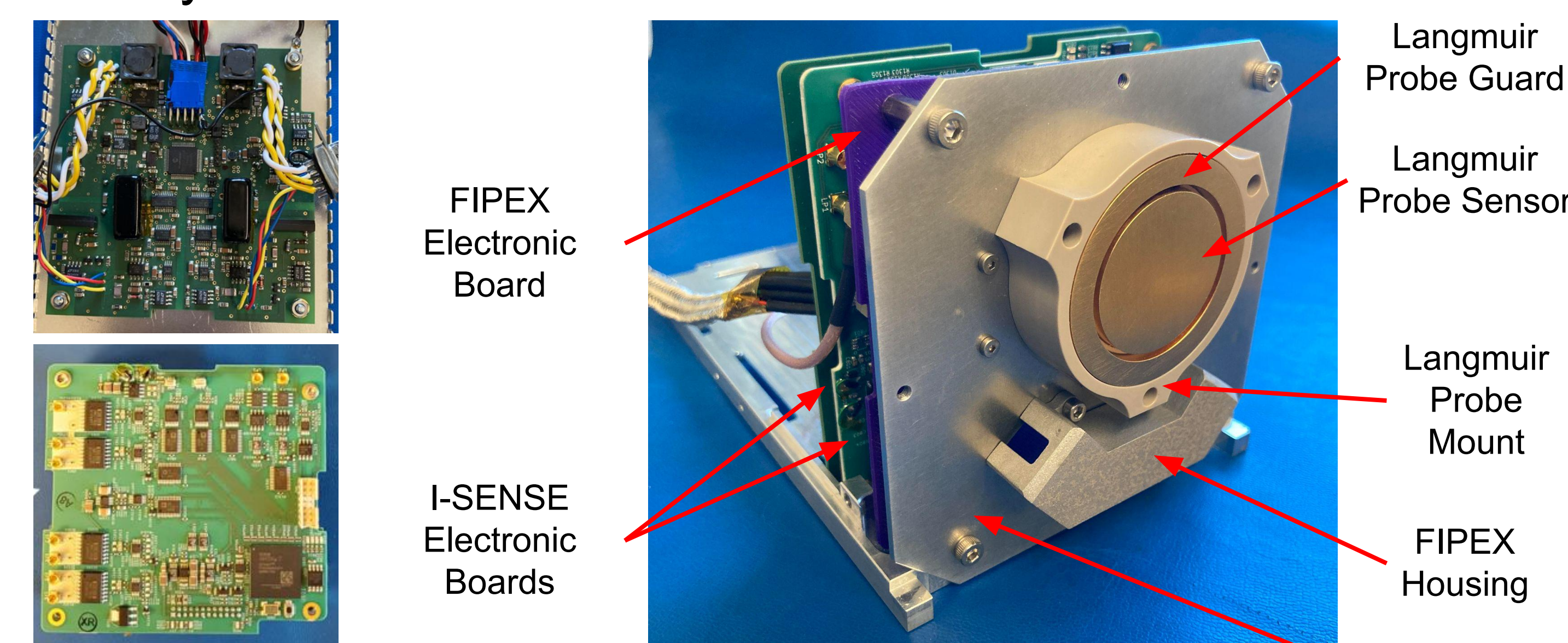
- How persistent and correlated are the plasma density and neutral oxygen in the EIA and ETA features?
- What changes in the EIA/ETA properties can we observe over timescales of less than one orbital period (~90 min)?



Plasma density (in units of 10^{12} m^{-1}) and neutral mass density (in units of 10^{-12} kg/m^3) at 400 km from CHAMP satellite at about 1800 local time (LT) during days of the year 94-97, 2022. Crosses mark the location of the ETA/EIA crests while the dashed line represents the troughs.

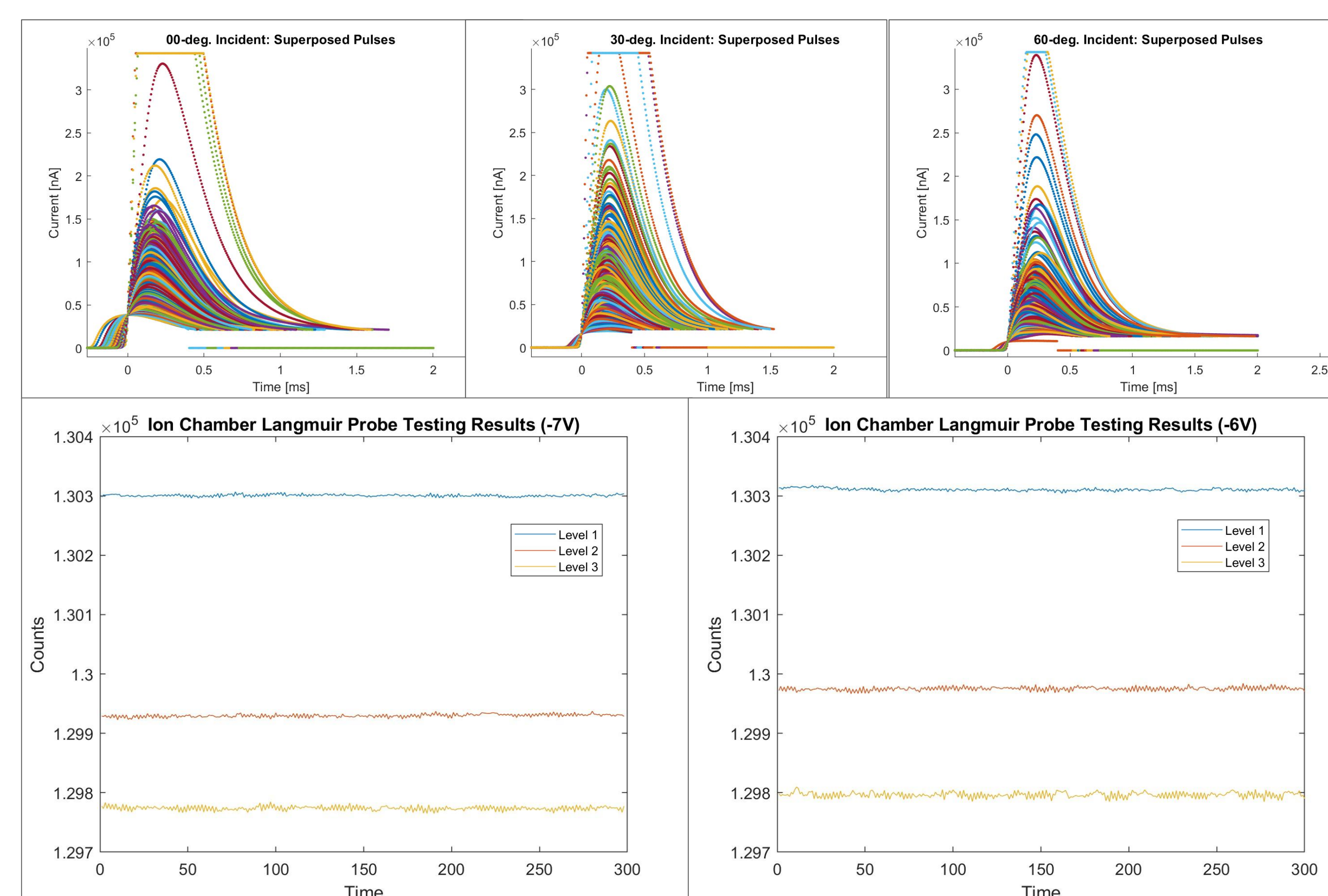
Current State of the Instruments

Each satellite will carry a FIPEX oxygen sensor and an I-SENSE Langmuir probe to measure the neutral and plasma density of the EIA/ETA.



Left Upper: FIPEX EDU provided by University of Stuttgart
 Left Lower: I-SENSE Science Board EDU provided by Orion Space Solutions
 Right: SWARM-EX instrument deck assembly

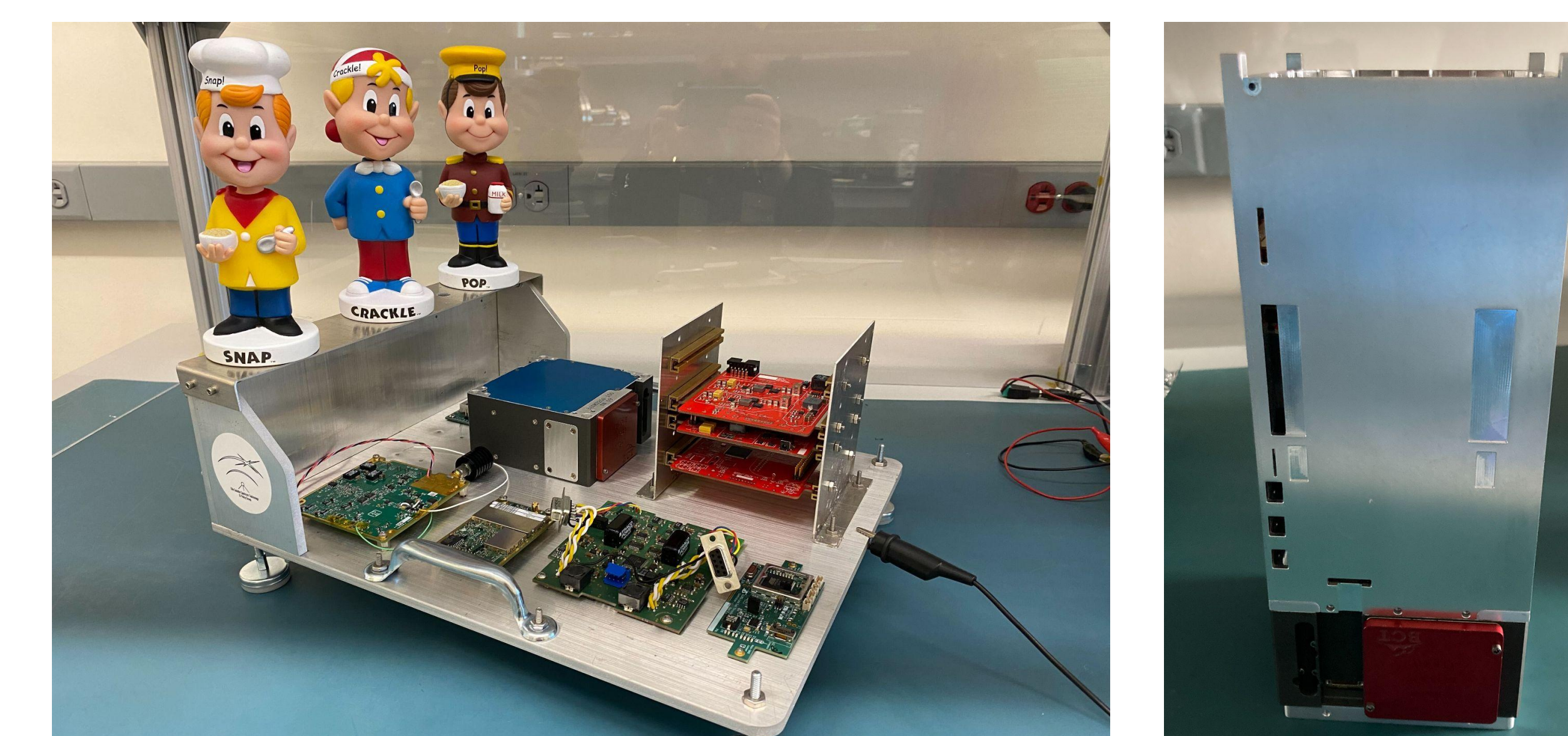
The mechanical design of the instrument deck been completed and verified through fit check. The Engineering Design Units (EDUs) for each of the instruments have completed preliminary integration testing and power testing. In addition, EDU performance testing was completed for the FIPEX in an AO-beam chamber and for the Langmuir probe in an ion chamber. Additional angle of incidence testing will take place for the Langmuir probe EDU through Summer and Fall 2023. The flight units of both instruments are scheduled to arrive by end of Summer 2023, and acceptance testing will be performed before final integration with the spacecrafts.



Top: FIPEX AO-beam chamber testing results (varying incidence angles)
 Bottom: Langmuir probe ion chamber testing results (varying voltage bias and ion source current level)

Current State of the Mission

The SWARM-EX mission is currently in the finishing the design phase and build phase. Final revisions of the SWARM-EX structure, Command and Data Handling Board, and Electrical Power System boards are currently being designed. Flight software is also currently under development. A number of long lead-time COTS flight components are already in-house, including the XACT ADCS units, the UHF antennas, and the solar cells. Flight units for the FIPEX and I-SENSE instruments, as well as the propulsion units being built by Georgia Tech, are expected to be delivered by the end of Summer 2023.

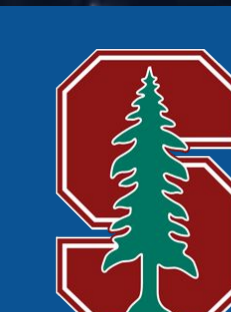
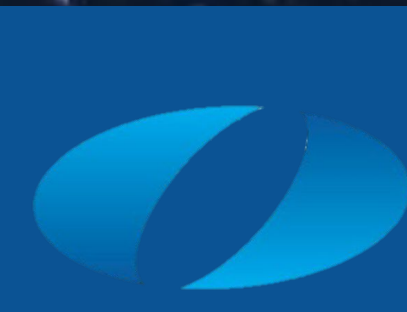


Left: assembled SWARM-EX flatsat
 Right: SWARM-EX upper structure and XACT during fit check

SWARM-EX Status Summary

The next major milestone for SWARM-EX is the Pre-Integration Review (PIR), which is currently expected to be held in Q4 2023/Q1 2024. In order to complete the entry criteria for PIR, the SWARM-EX hardware must be in-house and ready for integration, software must be written and tested, and a series of preliminary tests must be conducted: Complete Charge Cycle Test, Long-Range Communications Test, Command Execution Test, and Day in the Life Test. Once PIR is completed, integration and environmental testing can be conducted and launch can be expected in approximately a year.

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