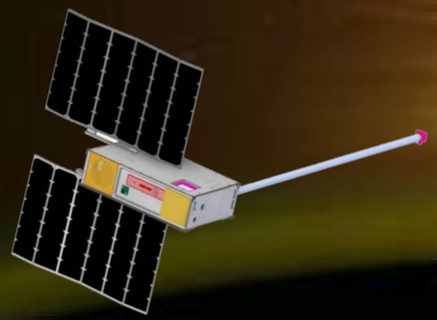
COSPAR - Busan

July 2024



cross-track

Instrument Teams

GRIDS: Ryan Davidson, Greg Earle

DESA: Marilia Samara, Glyn Collinson

NMS: Nick Paschalidis

MAG: Eftyhia Zesta

Dione: Using Cubesats for understanding how magnetospheric energy input impacts Earth's upper atmosphere

Eftyhia Zesta, Marilia Samara, George Khazanov, Hyunju Connor, Nick Paschalidis, Glyn Collinson, Greg Dechaine, and Muzar Jah: NASA-GSFC

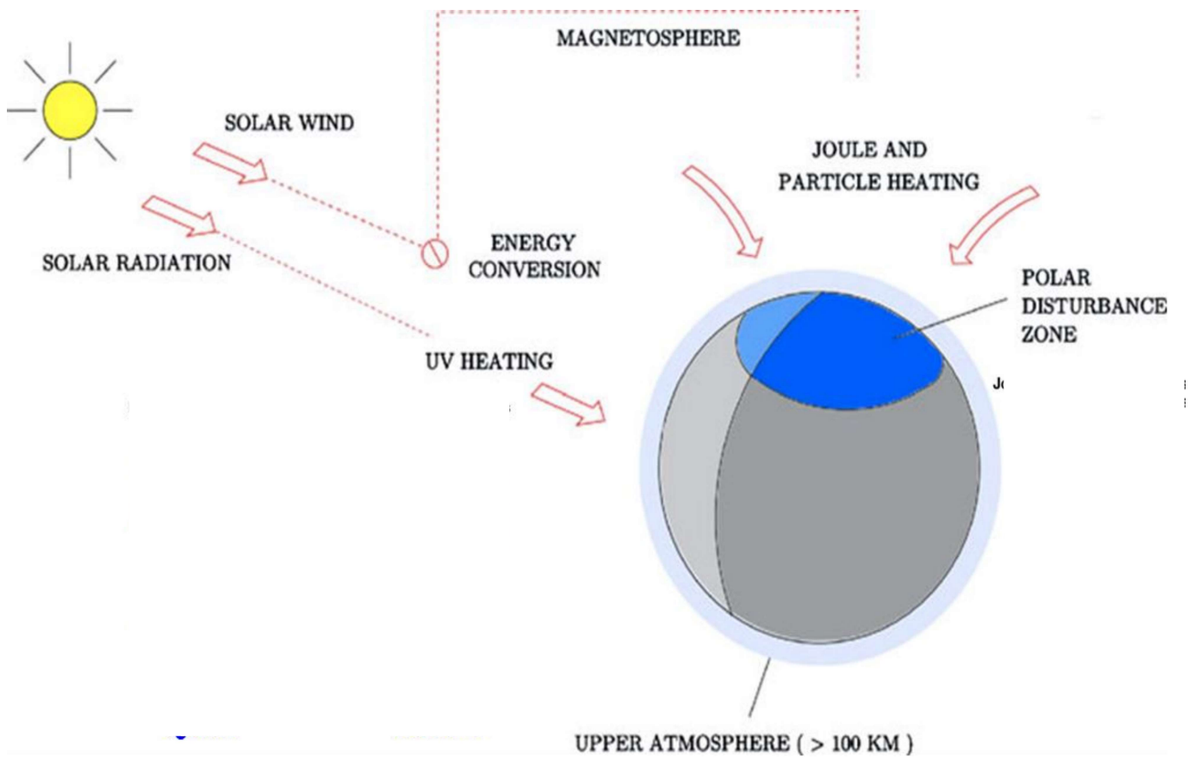
Ryan Davidson: Air Force Research Laboratory

Greg Earle: Virginia Tech

Kyoung-Joo Hwang: SWRI

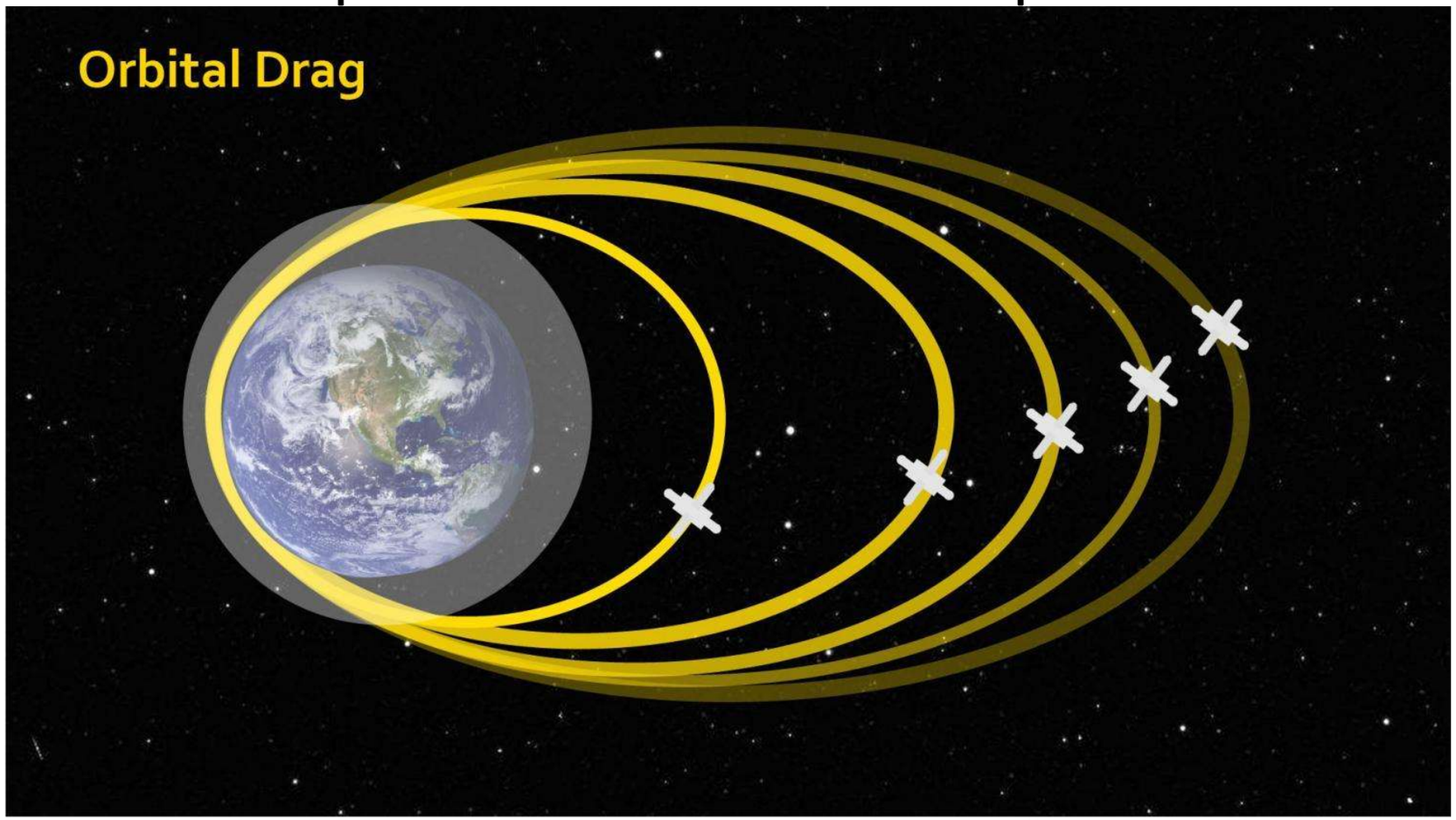
Magnetosphere-Ionosphere-Thermoshere (MIT) Coupling Impacts: GIC, orbit uncertainties, RF signal disruption

Two types of magnetospheric energy input:
1. Electromagnetic (coverts to Joule Heating)
2. Kinetic (precipitating particles)



Measurements needed:
1. Poynting flux (**B-field, E-field**)
2. Kinetic (**precipitating electrons and ions**)
3. Ionospheric responses
   - **a. Ion drifts**
   - **b. Ion Temperature**
   - **c. Electron Temperature**
   - **d. Ion (plasma) density**
   - **e. Ion basic composition**
   - **f. Secondary electrons**
4. Thermospheric responses
   - **a) Neutral density (mass density)**
   - **b) Neutral composition**
   - **c) Neutral temperature**
   - **d) Neutral wind**

Space Weather Impact



The question we study: How does the strength of geomagnetic activity (storms/substorms) impact MI coupling and the Ionosphere-Thermosphere system?

Is this the best we've got?

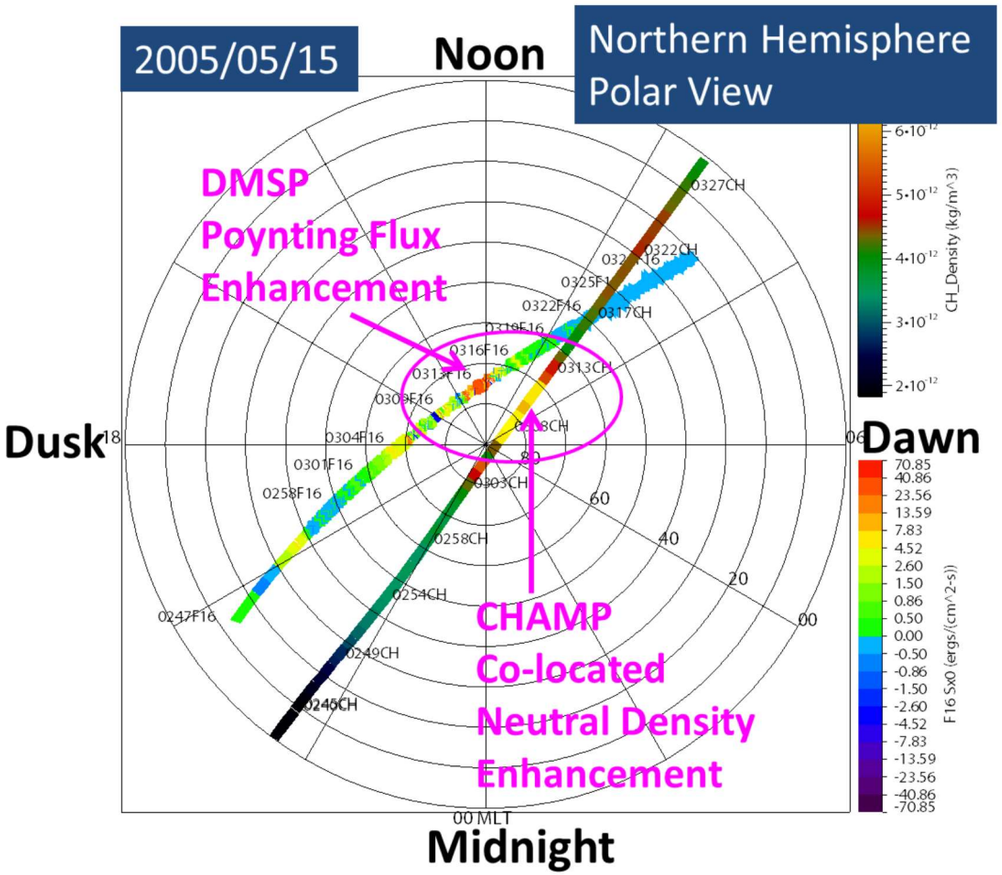
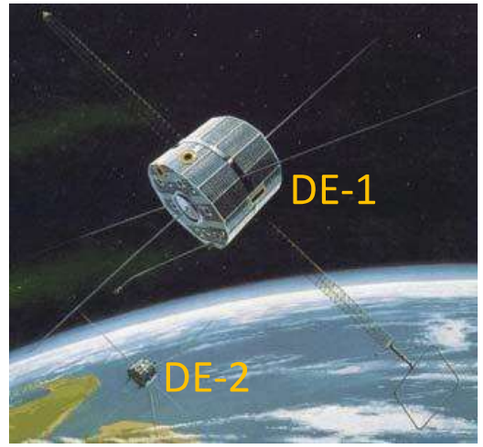


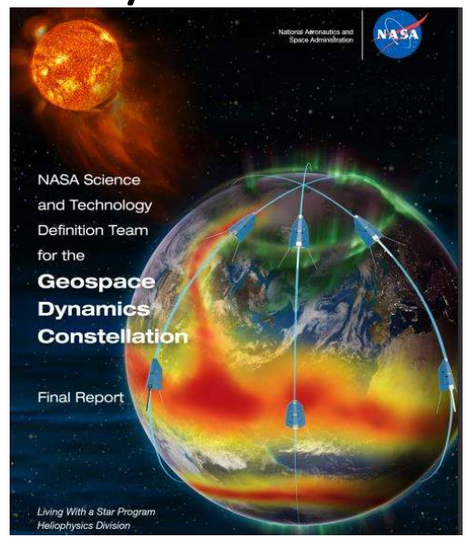
Figure 1: CHAMP thermospheric density and DMSP F16 Poynting flux after the pre-storm shock of May 15, 2005. **Density enhancements are co-located with downward Poynting flux. From Shi, Zesta, Connor et al. [2017]**

Yes! Since DE2

(~40 yrs ago)



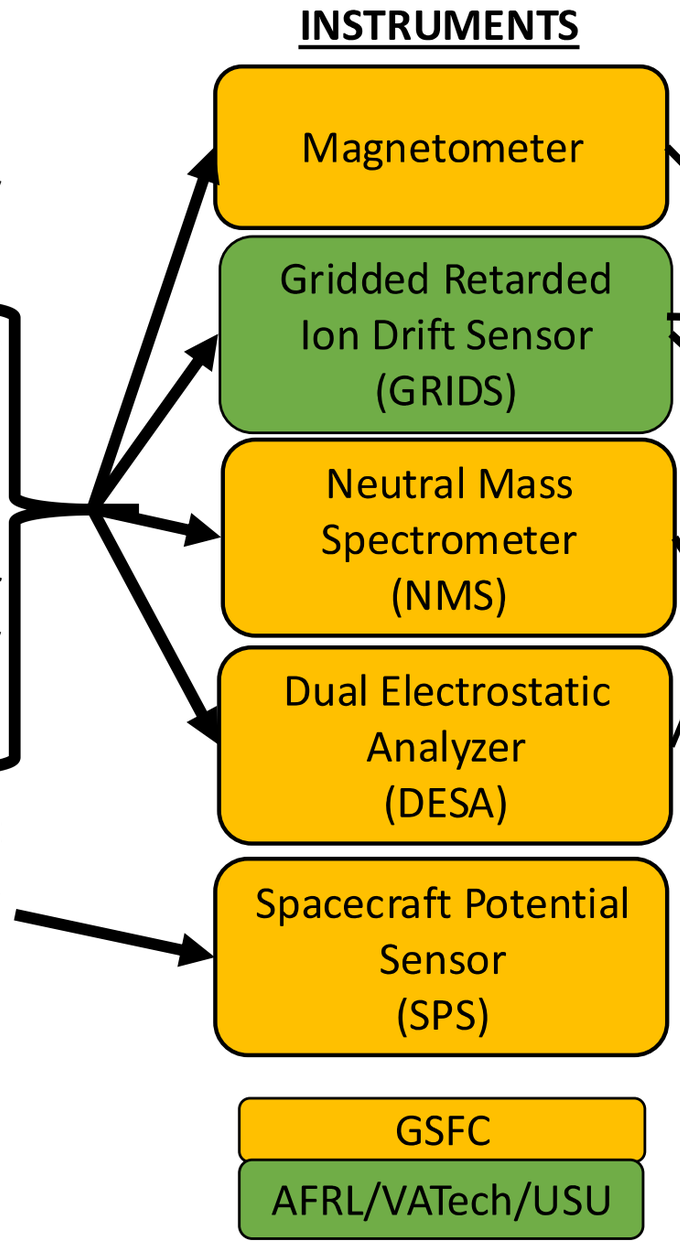
Current Strategic Mission in Phase A: Geospace Dynamics Constellation (GDC)



Dione Overview: Instrument Science Measurements

DIONE Mission Objectives per Concept Study Report (CSR)

1. **MO2:** Explore key MIT coupling science questions through conjunction with ground observations and theoretical analysis and simulations.
2. **MO3:** Provide a prototype Cubesat for future constellations that can answer fundamental questions in MIT and complement strategic missions, like GDC.
3. **MO4:** Have a technology development component to provide observations for a realistic Cubesat spacecraft charging model for future Cubesat missions.



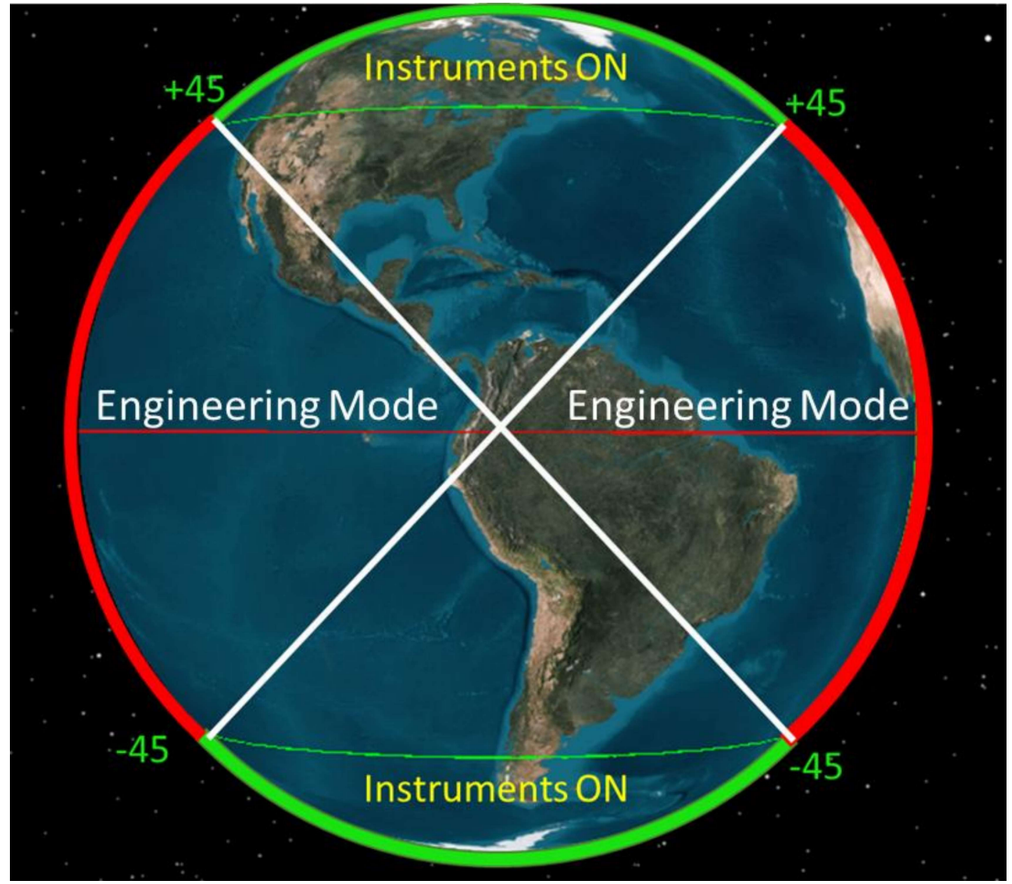
Science Measurements Needed:

1. Poynting flux (**B-field, E-field**)
2. Kinetic (**precipitating electrons and ions**)
3. Ionospheric responses
   - **a. Ion drifts**
   - **b. Ion Temperature**
   - c. Electron Temperature
   - **d. Ion (plasma) density**
   - **e. Ion basic composition**
   - **f. Secondary electrons**
4. Thermospheric responses
   - **a) Neutral density (mass density)**
   - **b) Neutral composition**
   - c) Neutral temperature
   - d) Neutral wind

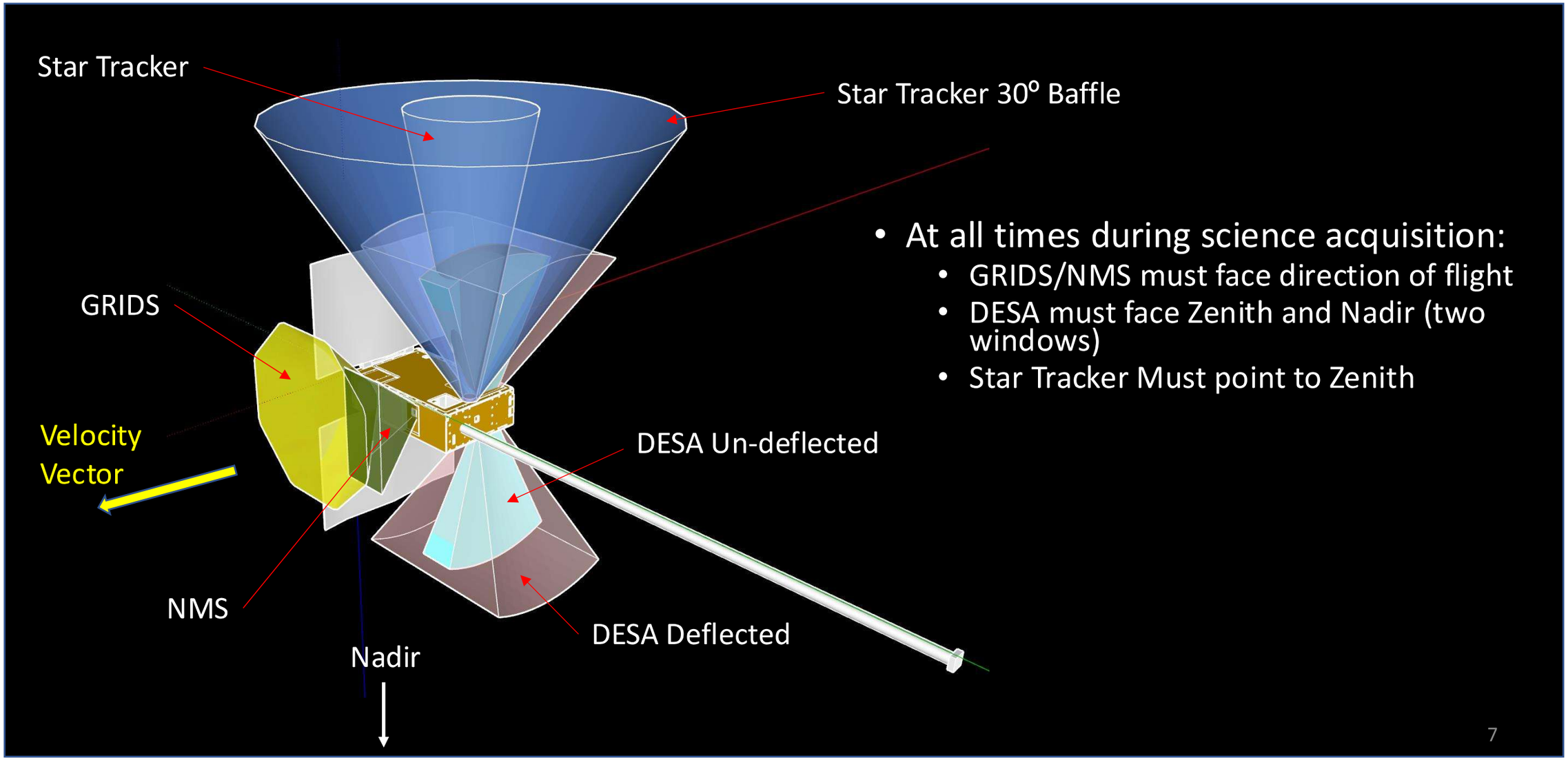
Dione Mission Overview

PI: Eftyhia Zesta **DPI:** Marilia Samara
Co-Is: George Khazanov (GSFC), Glyn Collinson (GSFC), Nick Paschalidis (GSFC), Ryan Davidson (Air Force Research Laboratory), Greg Earle (Virginia Tech)
MSE: Greg Dechaine **PSE:** Muzar Jah

- Mission Life: 9 months
- 6U CubeSat, 5 Science Payloads
- Gimbaled Solar Arrays
- Deployable Boom – 1.2 meters
- Launch date: ~4/15/2025, with TRACERS
- Altitude: 540 km-590 km km Circular Orbit
- Inclination: *97.3° SSO*
- LTAN: 22:30
- Science Mode @ Latitude > +/-45^0
- Engineering Mode @ Latitude < +/-45^0

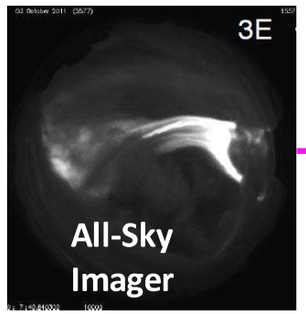


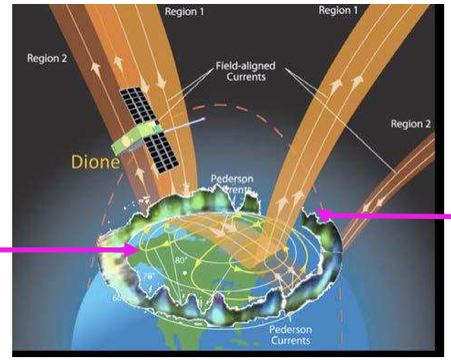
Instrument Field of Views and Spacecraft Attitude

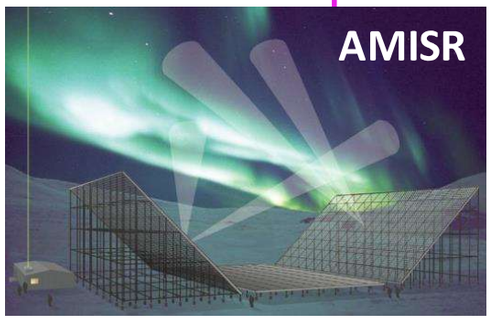


- At all times during science acquisition:
  - GRIDS/NMS must face direction of flight
  - DESA must face Zenith and Nadir (two windows)
  - Star Tracker Must point to Zenith

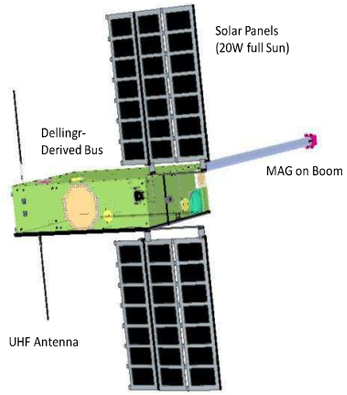
Dione – Ground ASI and Radar required for the science objectives



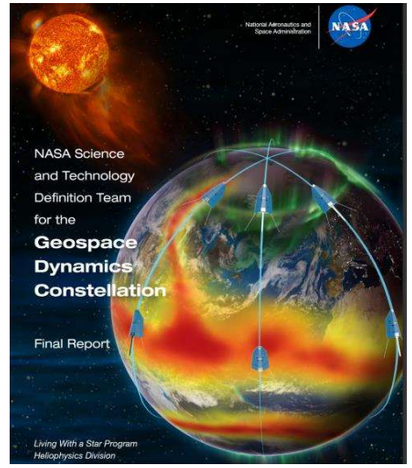




Dione



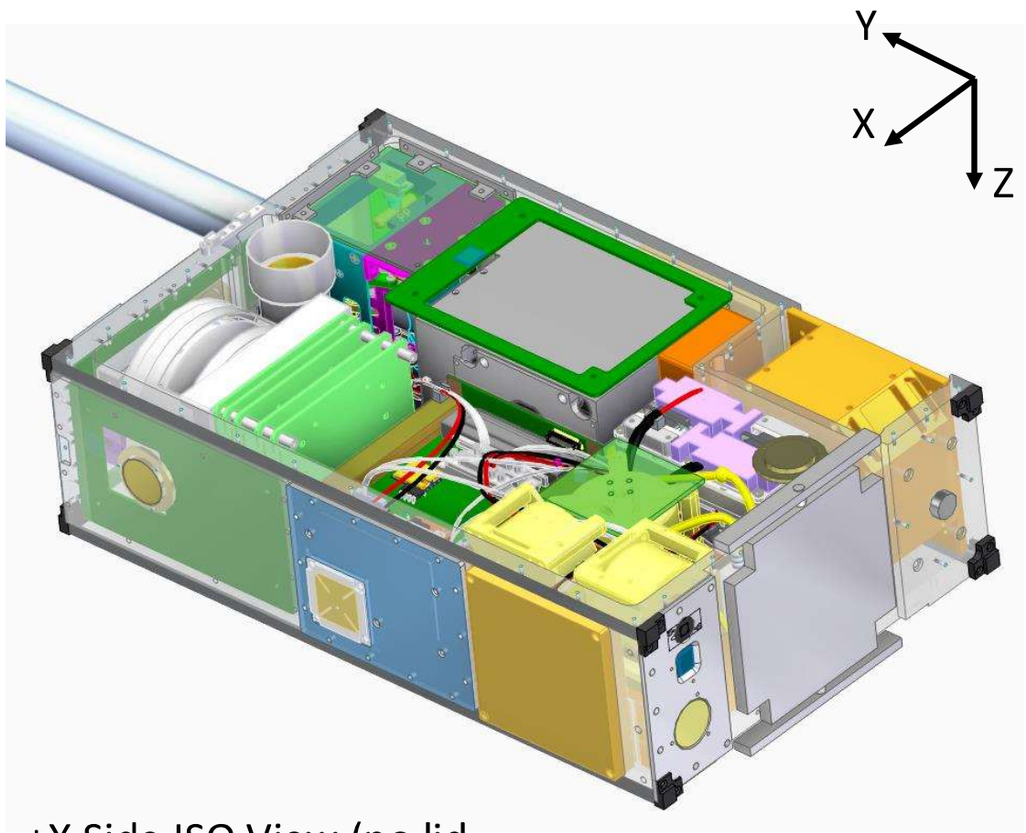
GDC



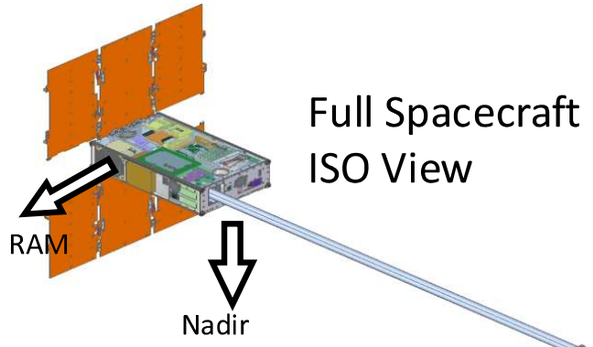
Dione – Radar/ASI conjunctions over the cusp and midnight region

Dione : 5 instruments ( )

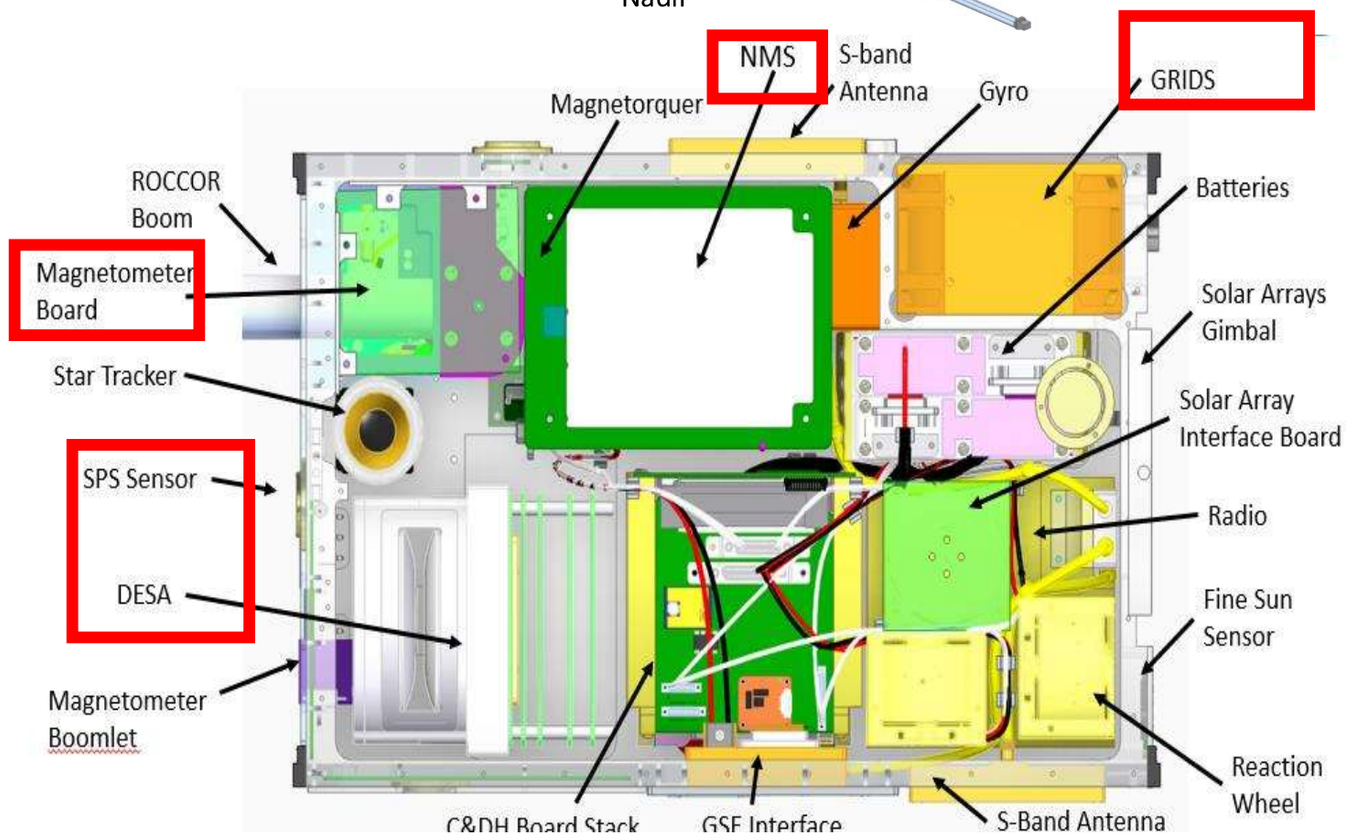
4 primary, 1 Tech Demo



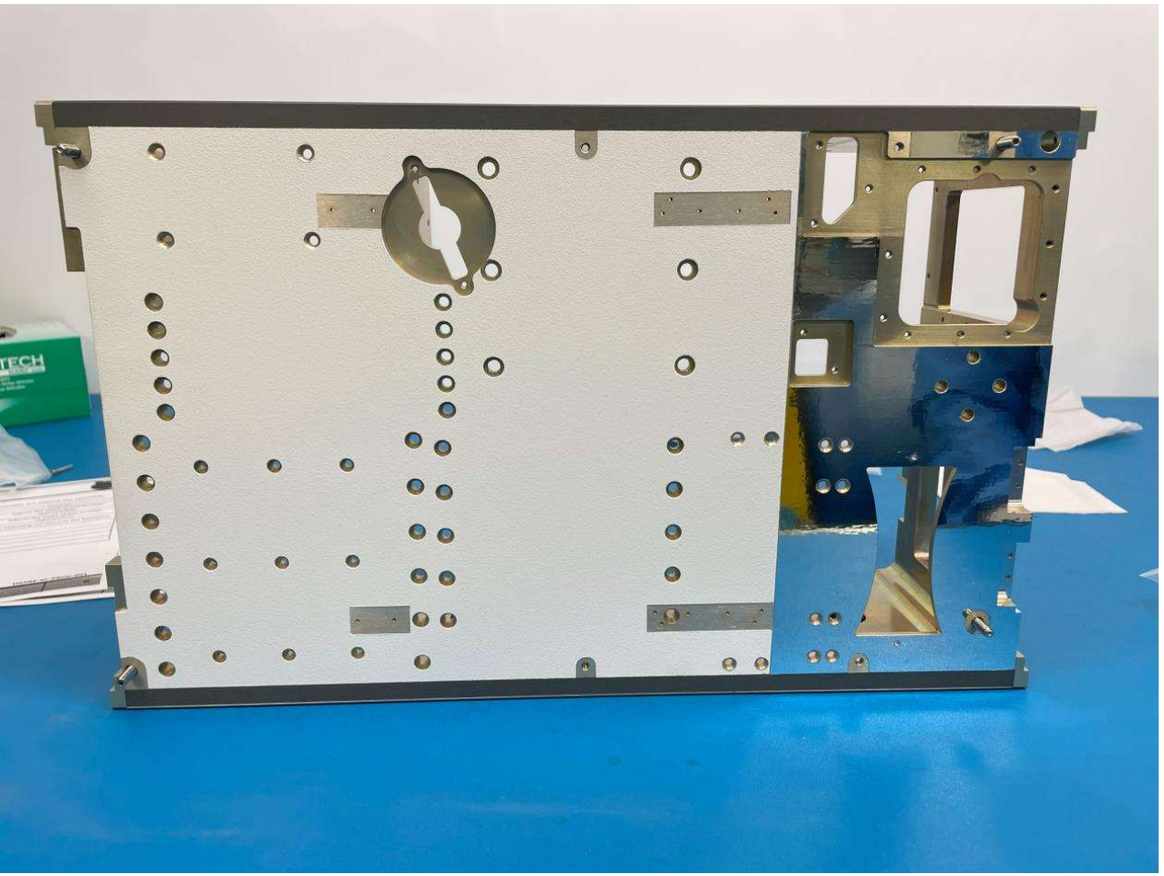
+X Side ISO View (no lid, no solar arrays)

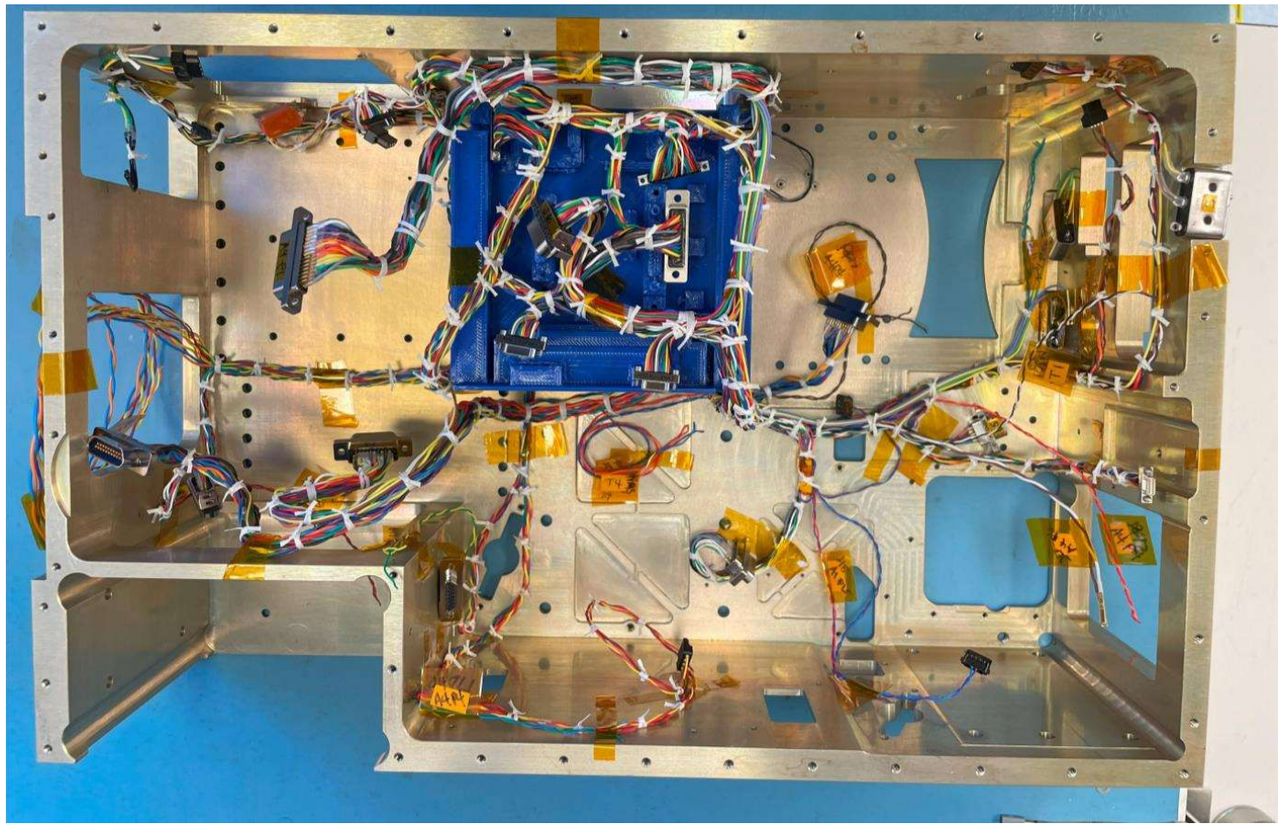


Full Spacecraft ISO View

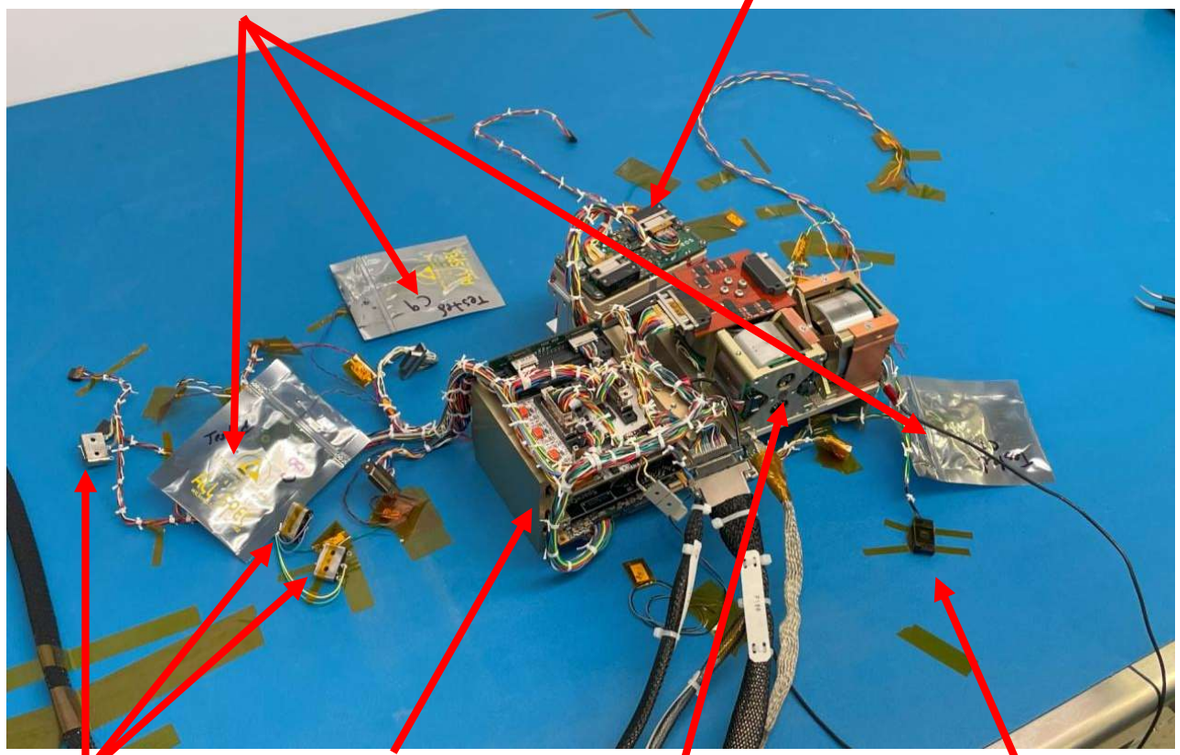


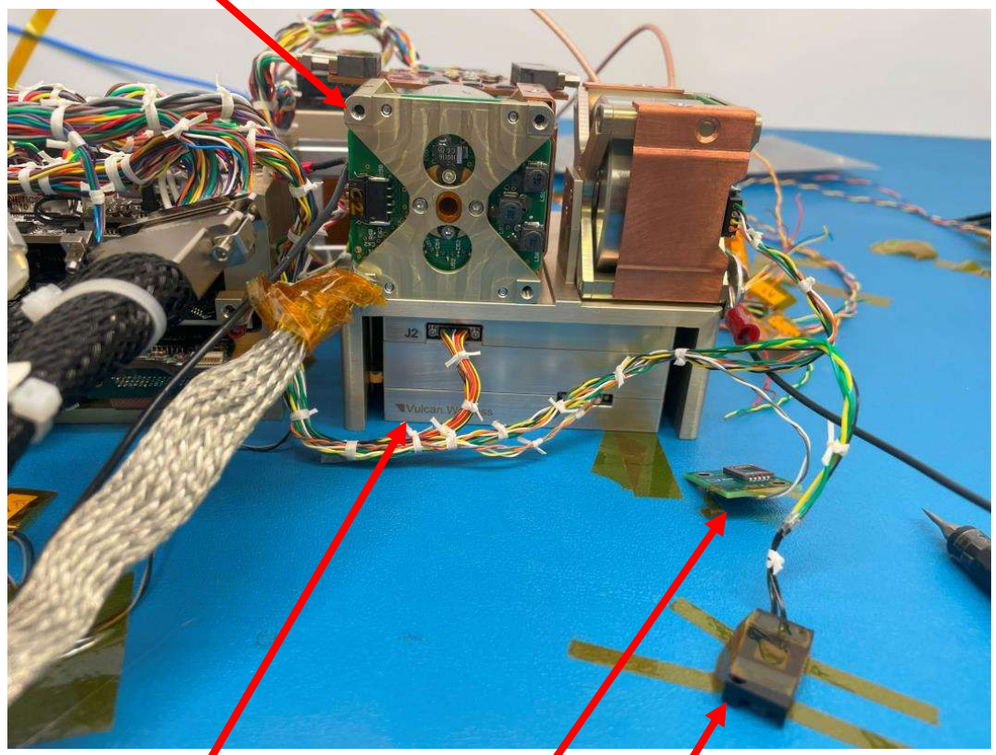
FLT Baseplate & Harness Fabrication





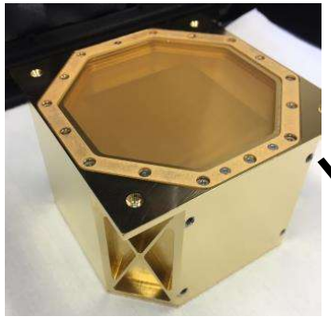
Dione Flight I&T Bench Testing

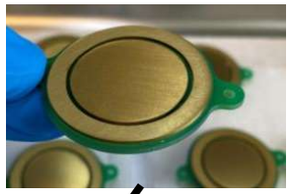




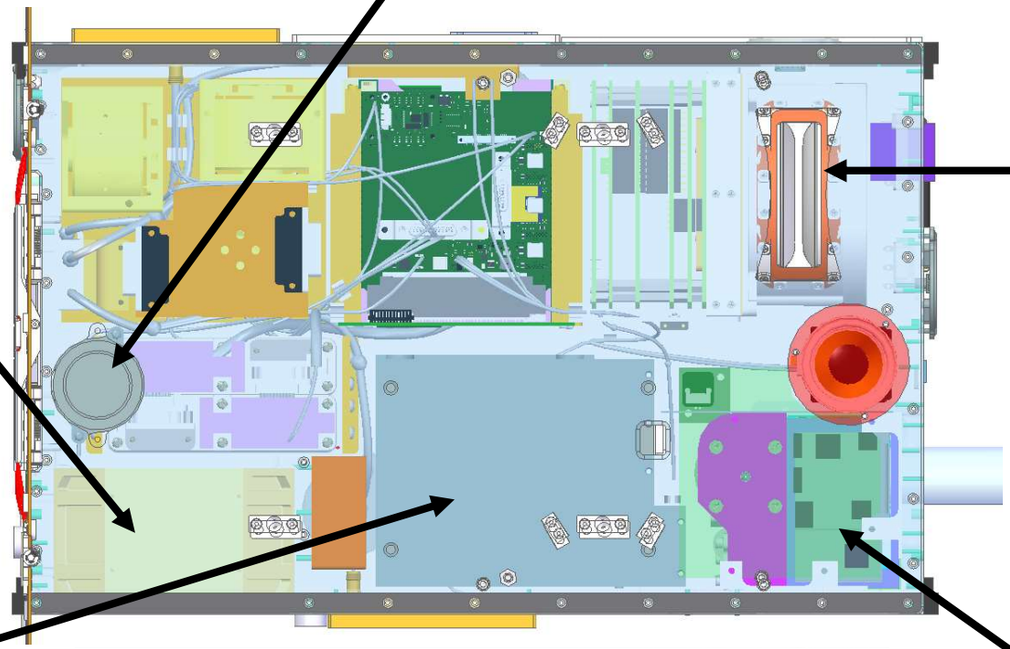
Dione Instruments and their heritage

GRIDS
(Petitsat)

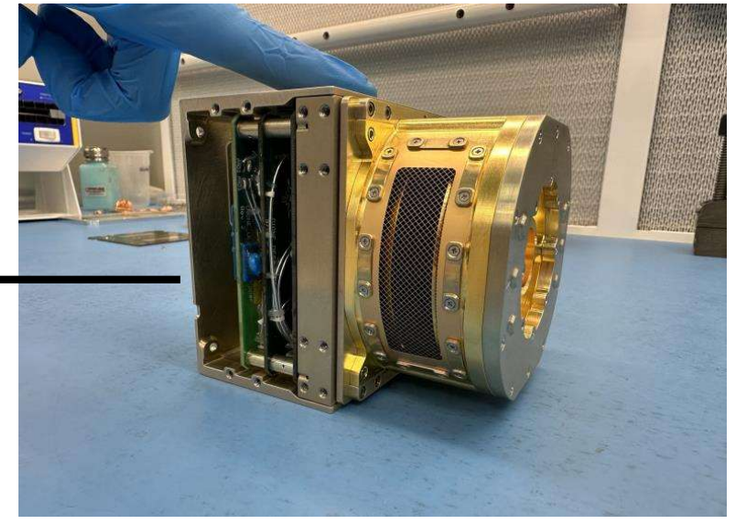




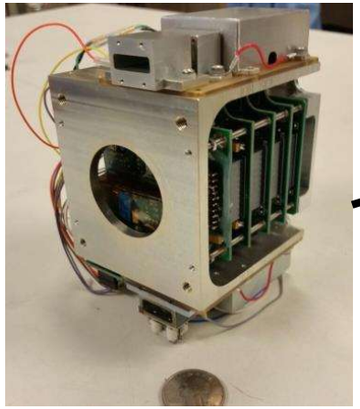
SPS

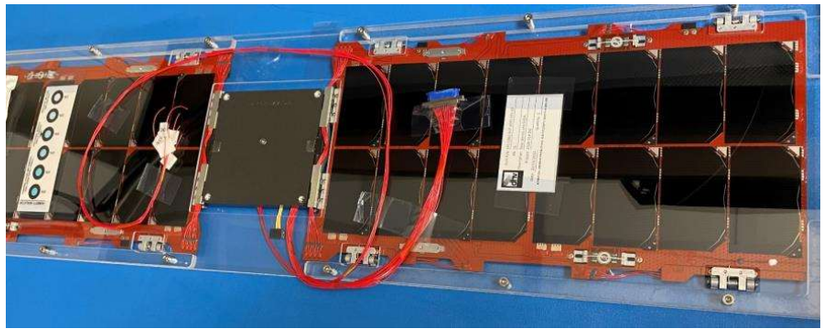


DESA
(HERMES EEA; MMS FPI)

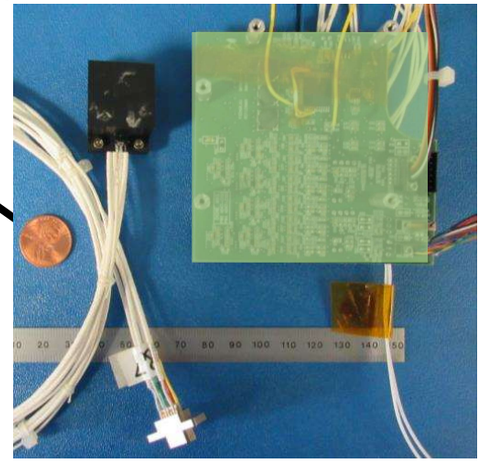


NMS
(Dellingr/PetitSat)

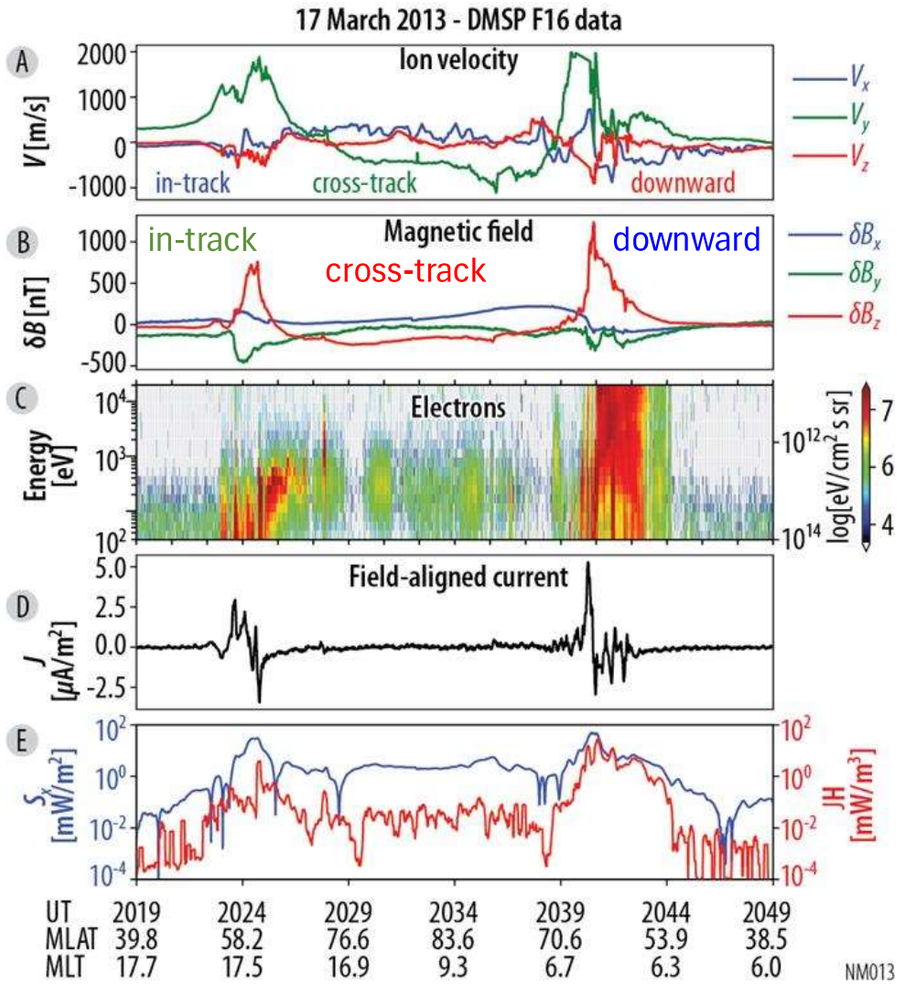




Magnetometer during tuning
(Dellingr; SPORT; HERMES)



Dione Observations



DMSP observations during the end of the main phase of the Mar 17, 2013 storm. In situ measurement of Poynting flux compared to JH estimate from electron precipitation observations. Poynting flux shows energy input that does not dissipate as Joule Heating.

Original measurements made by the instruments: B, V_i, Electron energy flux

Denote derived parameters from the original measurement of the indicated instruments

$E = -V \times B$ **Electric field**

$\mathbf{J_{//} = \partial B_z / \mu_0 \partial y}$ **Field Aligned Current**

$-J \cdot E = \Sigma_P (E)^2$ **Joule Heating**

Σ_P for electrons per Robinson et al. [1987] formula and electron precipitation measurements

S_x per the Kelley et al [1991] technique

Analysis done by Robert Michell and students

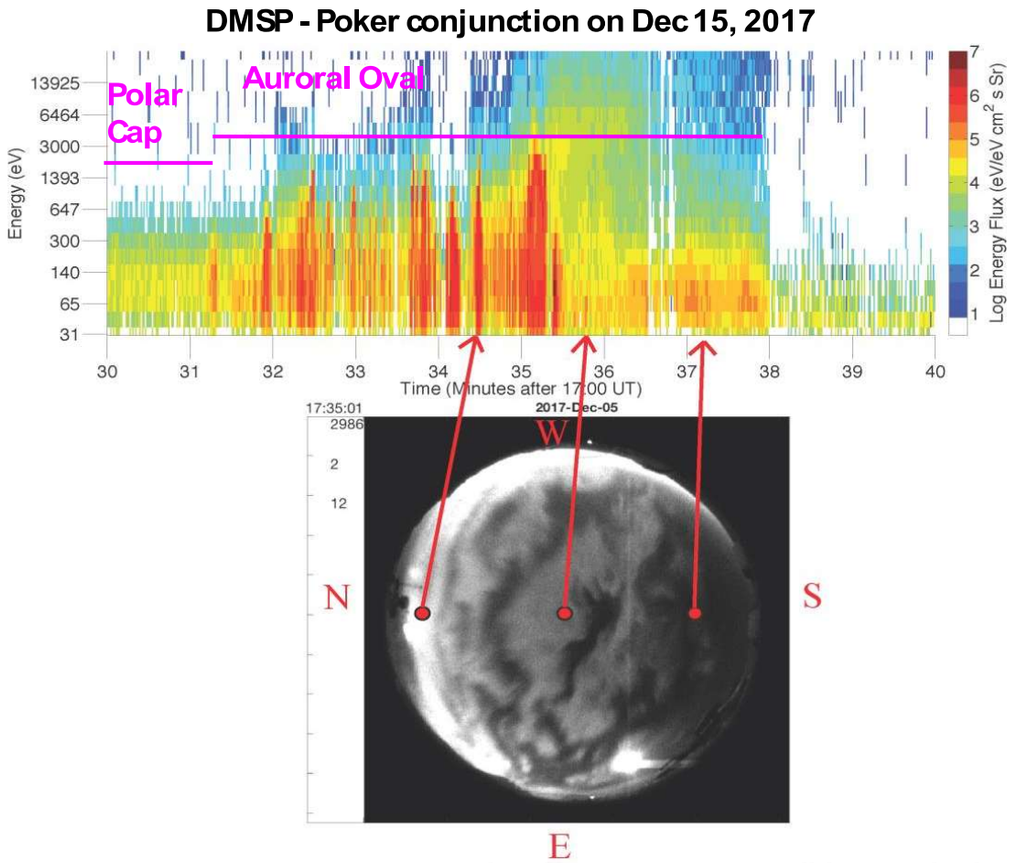
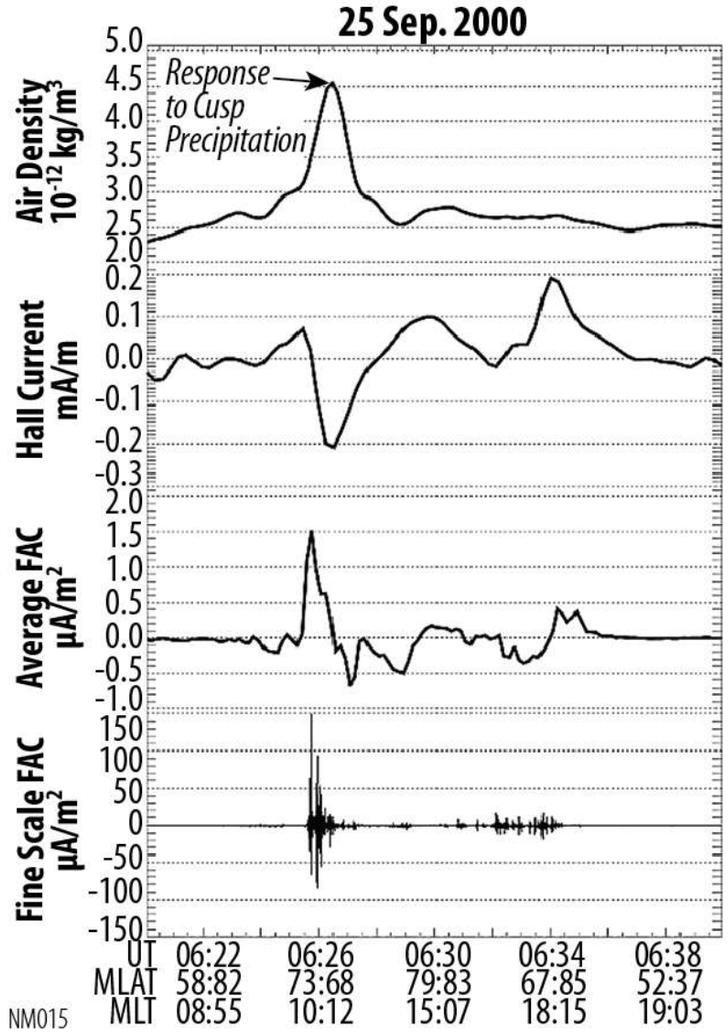


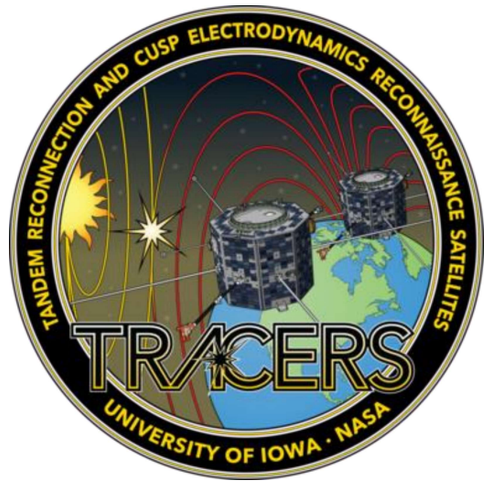
Figure 2: DMSP F17 conjunction with Poker imager. Dione will have multiple such conjunctions measuring both energy inputs and IT responses.

Lühr et al, GRL 2004



Summary and Status

- Currently in Flight I&T; Integrating and testing all flight components on bench before integration into the SC Bus.
- Manifested for launch with TRACERS April 2025.
- Currently investigating coordinated science observations with the TRACERS Mission.
- **Dione is a pathfinder for constellation missions**



TRACERS: Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites. SMEX mission on understanding transfer of energy from the Sun to near-Earth space.

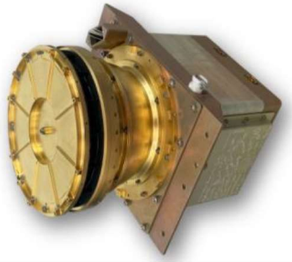
Dione: 6U Cubesat mission on understanding upper atmosphere response to magnetospheric energy input

Provided by TRACERS PI, Prof David Miles

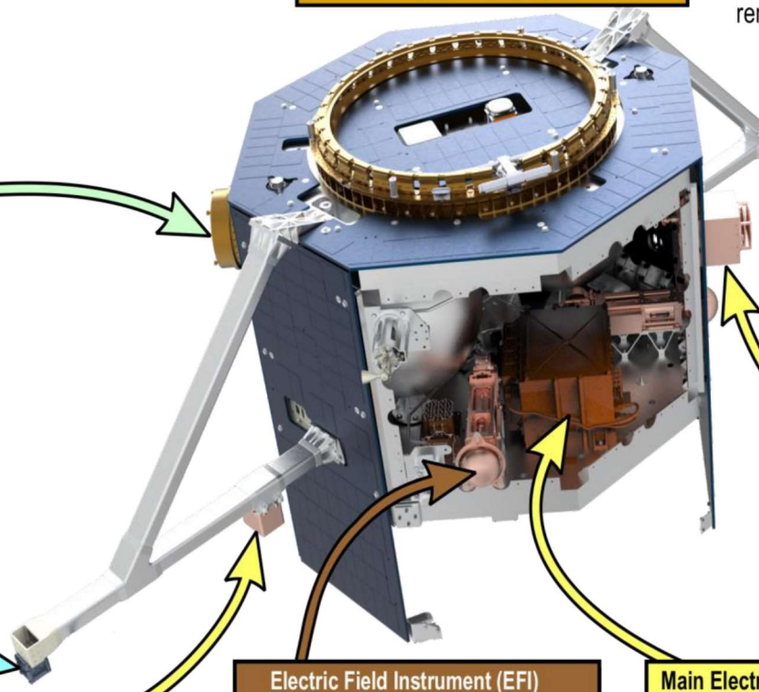
The Two TRACERS Satellites (T1 & T2) Comprise a Spacecraft and an Instrument Suite

Electric Field Instrument shown in stowed configuration. (Spacecraft components removed to emphasize instruments)

Analyzer for Cusp Ions (ACI)

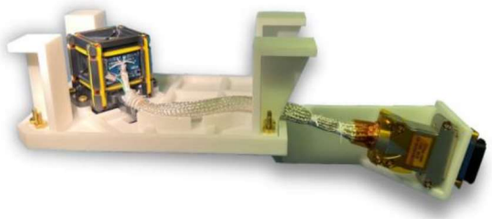


Space Vehicle (SV)

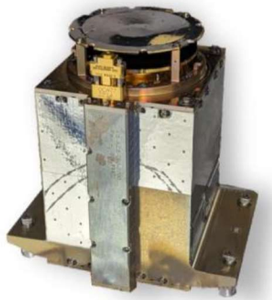


Magnetic Search Coil (MSC)

Magnetometer (MAG)



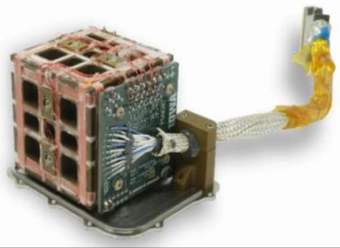
Analyzer for Cusp Electrons (ACE)



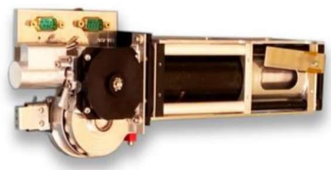
Legend

- SwRI
- UCLA
- Iowa
- UCB
- UNH
- MSS

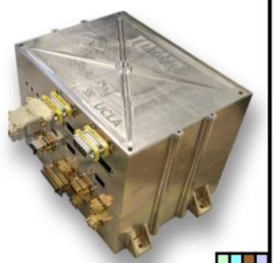
MAGIC Tech Demo



Electric Field Instrument (EFI)



Main Electronics Box (MEB)



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