The *DARCSIDE* Concept Study for a CubeSat at Europa

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Motivation: Science questions and traceability matrix

- Want to improve our understanding of tenuous, sputter-induced atmospheres of icy satellites
- Has implications for other icy satellites in outer solar system
- Has implications for the detection of biomarkers from possible Europa plume (Fig. 1)
- Performed 9-month concept study for *DARCSIDE*, the *Deployable Atmospheric Reconnaissance CubeSat with Sputtering Ion Detector at Europa*
- 3U CubeSat (10 x 10 x 34 cm), max. mass 4.5 kg
- Deployed from *Europa Clipper*
- Perform single low-altitude pass above Europa to measure atmospheric drag & heavy ion flux

Figure 1. Artist's rendition of a plume emanating from Europa's surface (NASA image).

Key Science Questions

1. How dense is Europa's atmosphere?
2. How is it linked to the local charged particle environment?
3. Can a plume generate a localized density enhancement of Europa's atmosphere?

DARCSIDE Science Question	Science Objective	Measurement	Instrument	Functional Requirements
What is the nature of Europa's atmosphere?	Determine Europa's atmospheric structure	Atmospheric drag	accelerometer	Altitude < 19 km Sampling rate ~ 1 Hz Sensitivity < 100 ng
	Determine hot ion flux at Europa	Elemental ion flux	Solid state particle telescope	8-100 MeV/nuc Pitch angle info

DARCSIDE **Science Traceability Matrix**
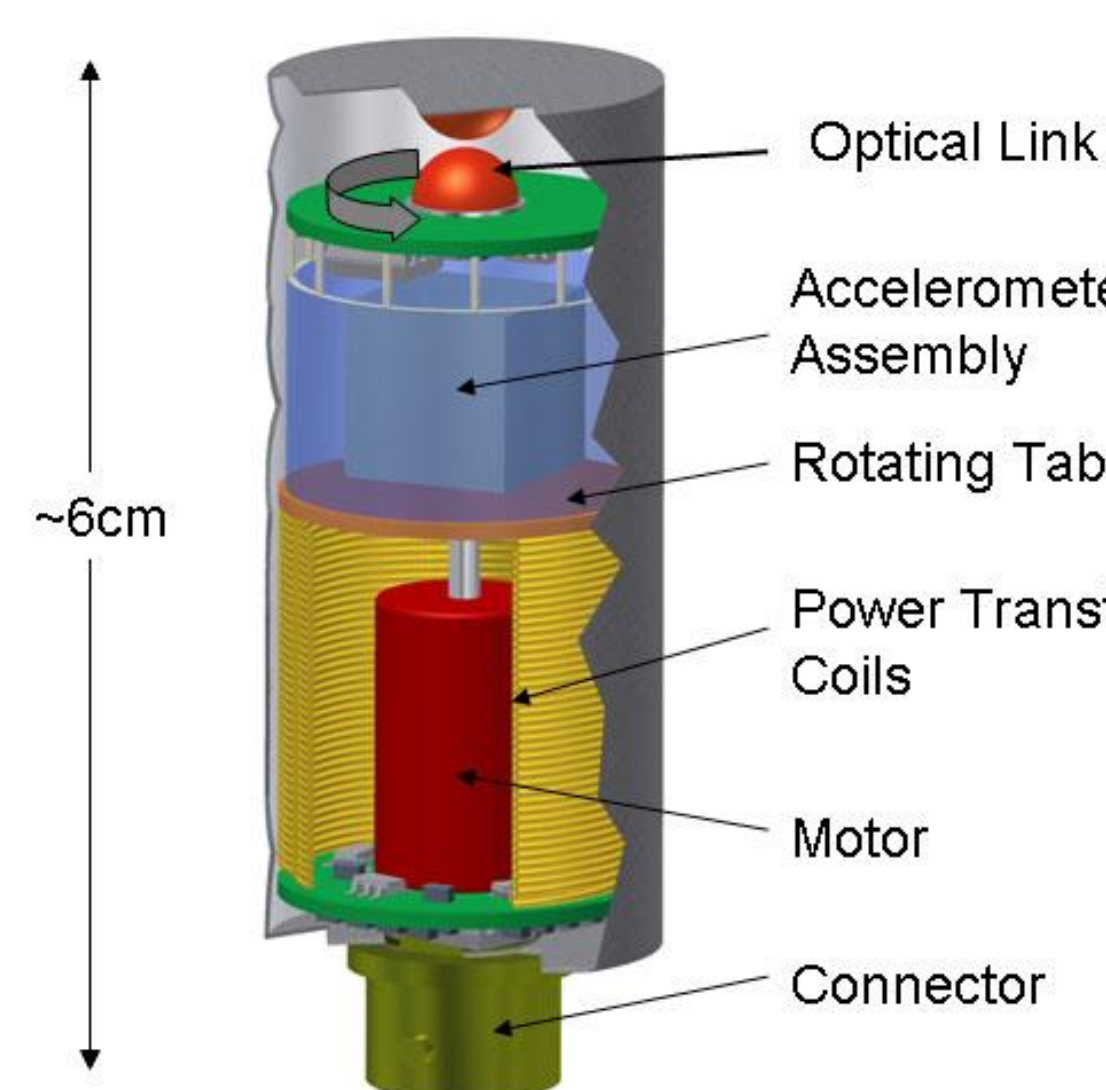
Instruments & Modeling

Figure 2. ADES accelerometer

- Under development by AFRL (Fig. 2)
- Detection limit of 10 nano-g (10^{-7} m/s^2)
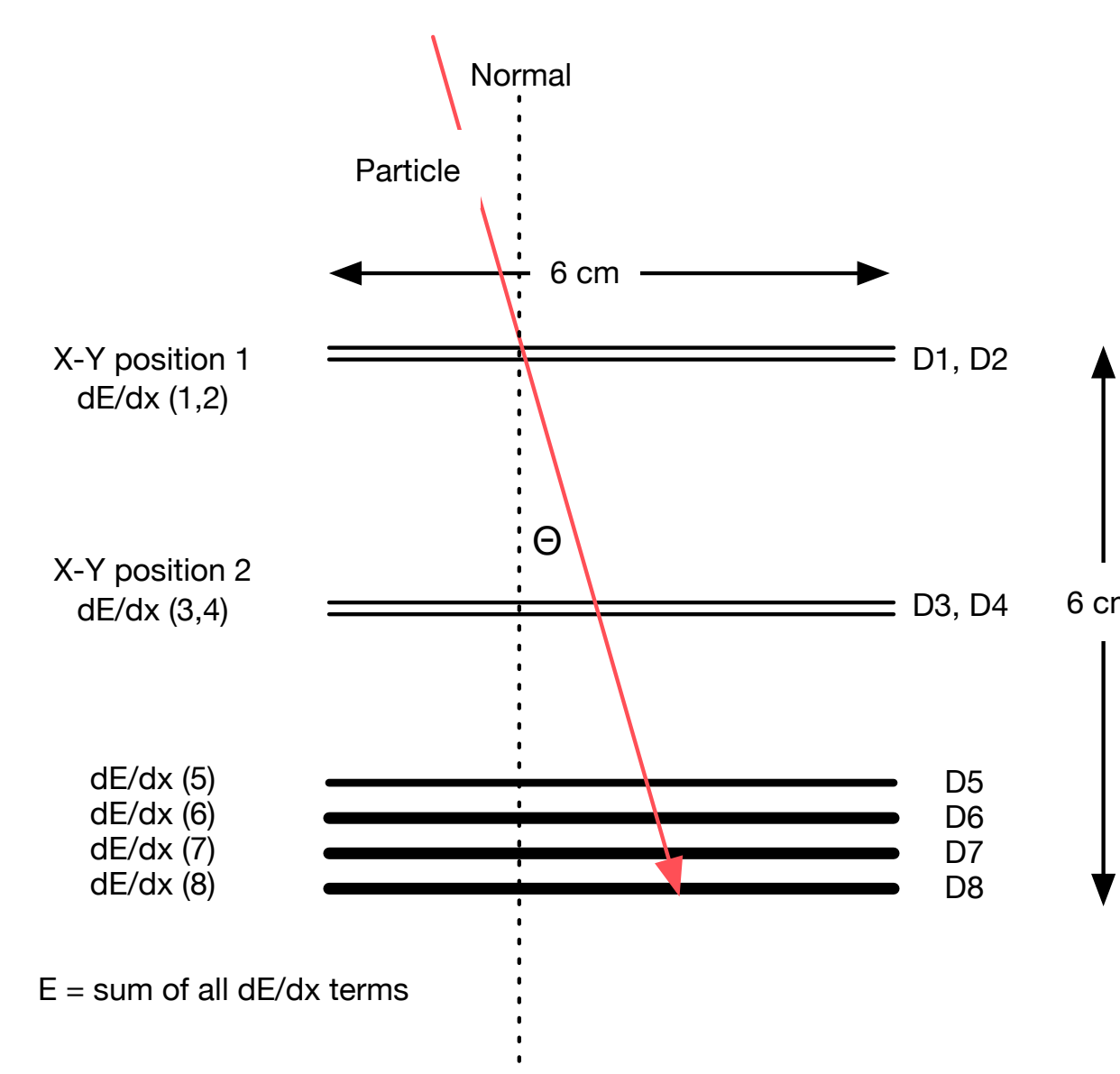- Capable of measuring predicted drag on *DARCSIDE*

Figure 3. Energetic particle detector

- silicon strips and planes (Fig. 3)
- based on successful Low Energy Particle Telescope on *Voyager*'s Low Energy Charged Particle (LECP) experiment

Europa Atmosphere Models

- Used published models to initialize Europa's neutral atom torus
- Assumed atmospheric models based on two particle populations:
  - Bound (but exponentially decreasing w/altitude)
  - Escaping
- Computed family of atmospheric density profiles with range of surface gas densities (Fig. 4)
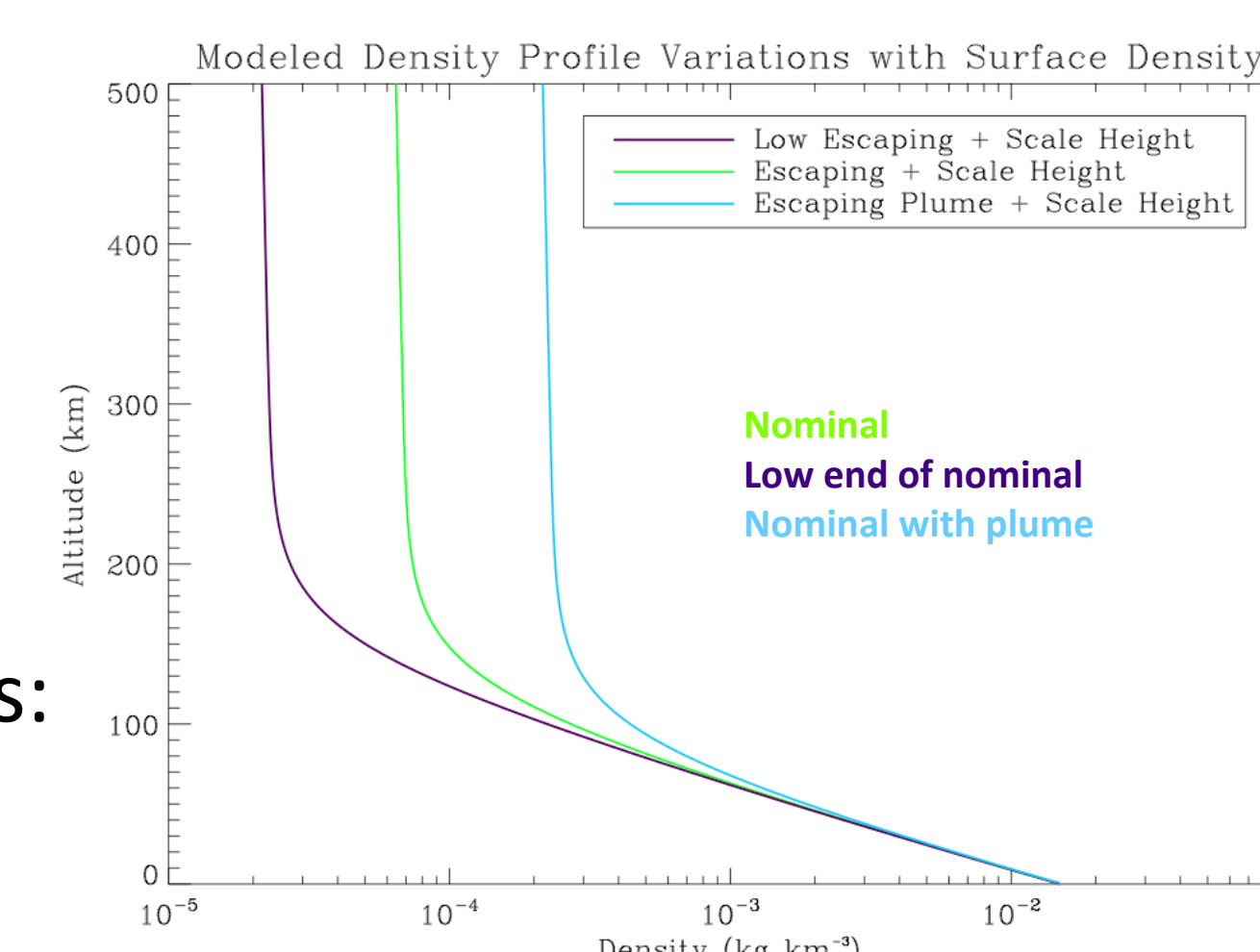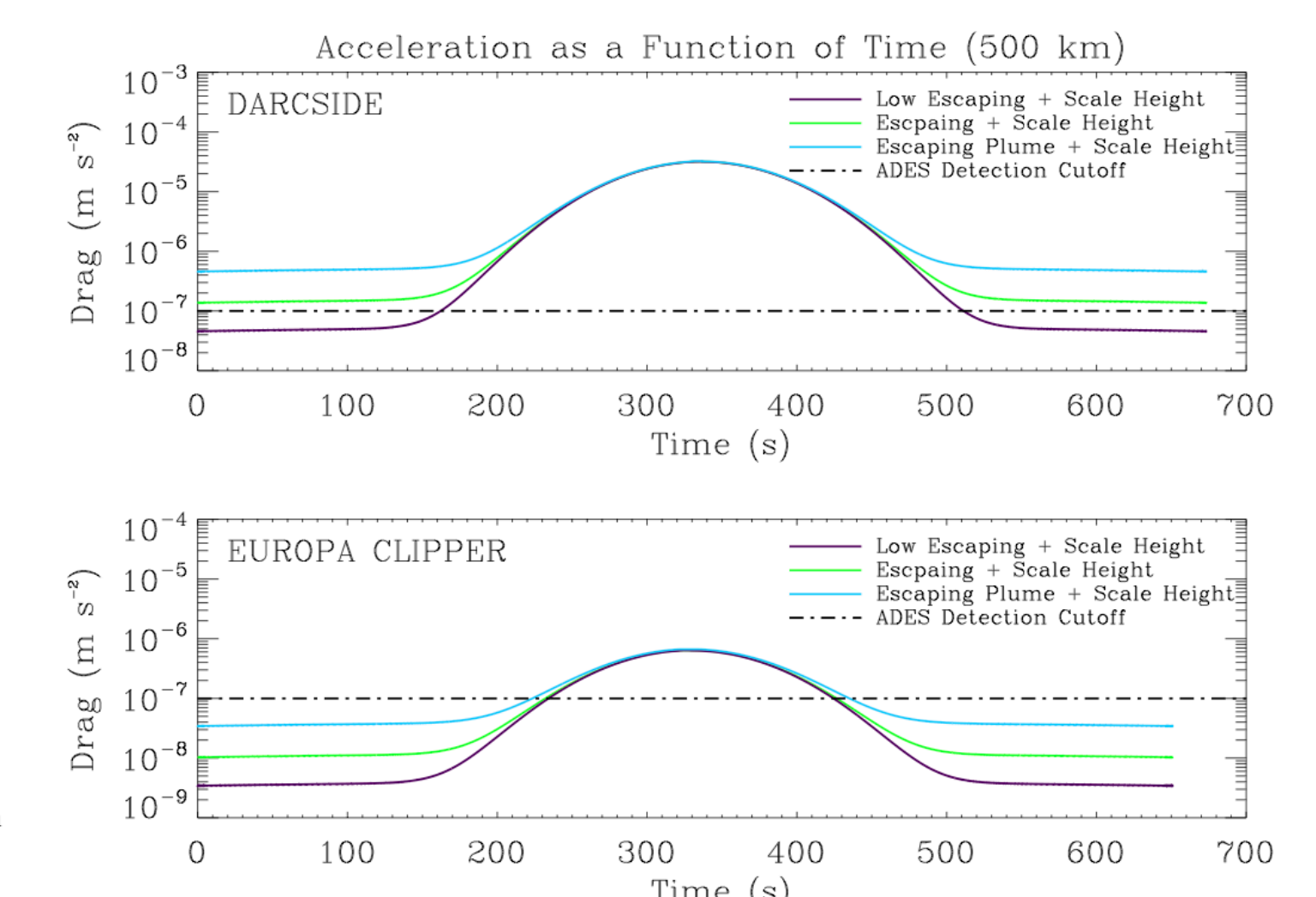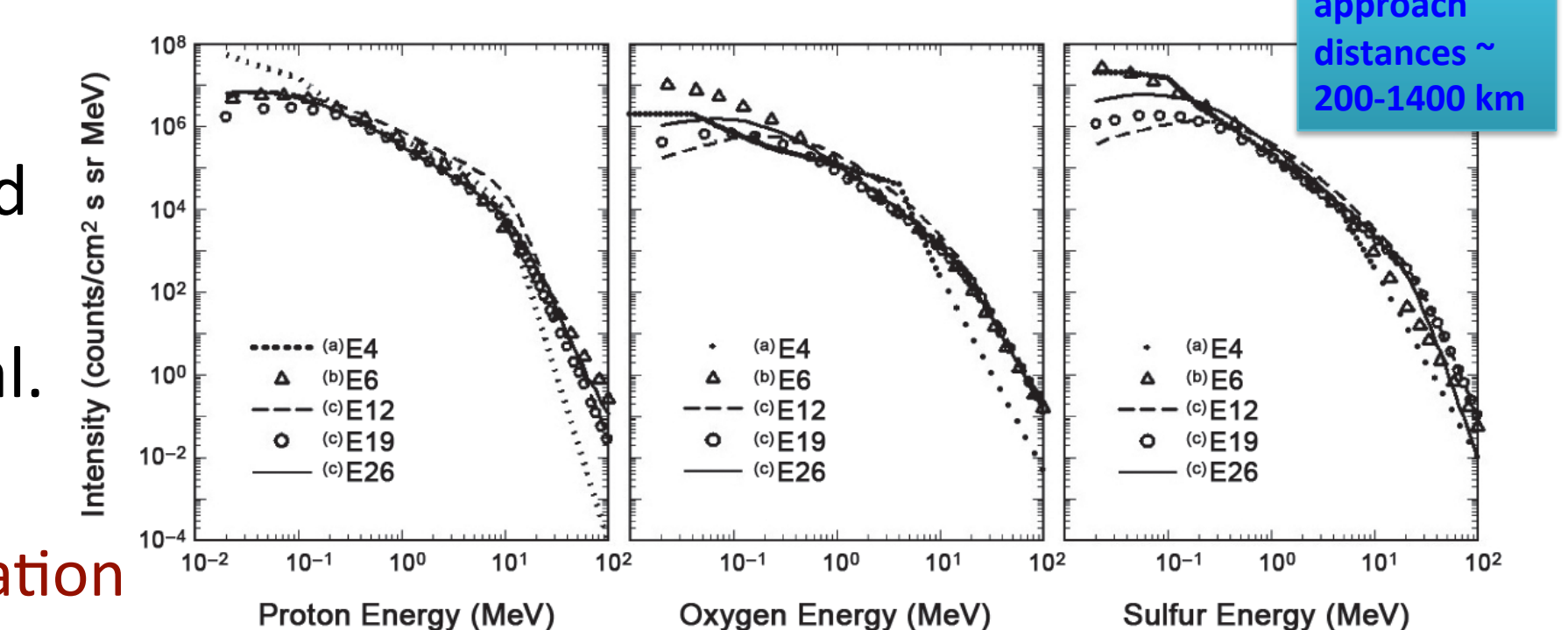- Predicted drag felt by *DARCSIDE* (Fig. 5)

- Used energy spectra of various ions as determined by *Galileo* near-Europa encounters (Paranicas et al. 2009) (Fig. 6)

Figure 4. Atmospheric density profiles

Figure 5. Predicted accelerations

Closest approach distances ~ 200-1400 km

Figure 6. Ion flux characterization

DARCSIDE Flight System

Mission Overview
- Notional mission designed for Europa-15 pass of *Europa Clipper* (29 Aug 2029)
- Release 3U CubeSat from *EC* near apojove
- Deploy drag panels (w/solar arrays) (Fig. 7)
- Single low altitude drag pass over Europa's surface
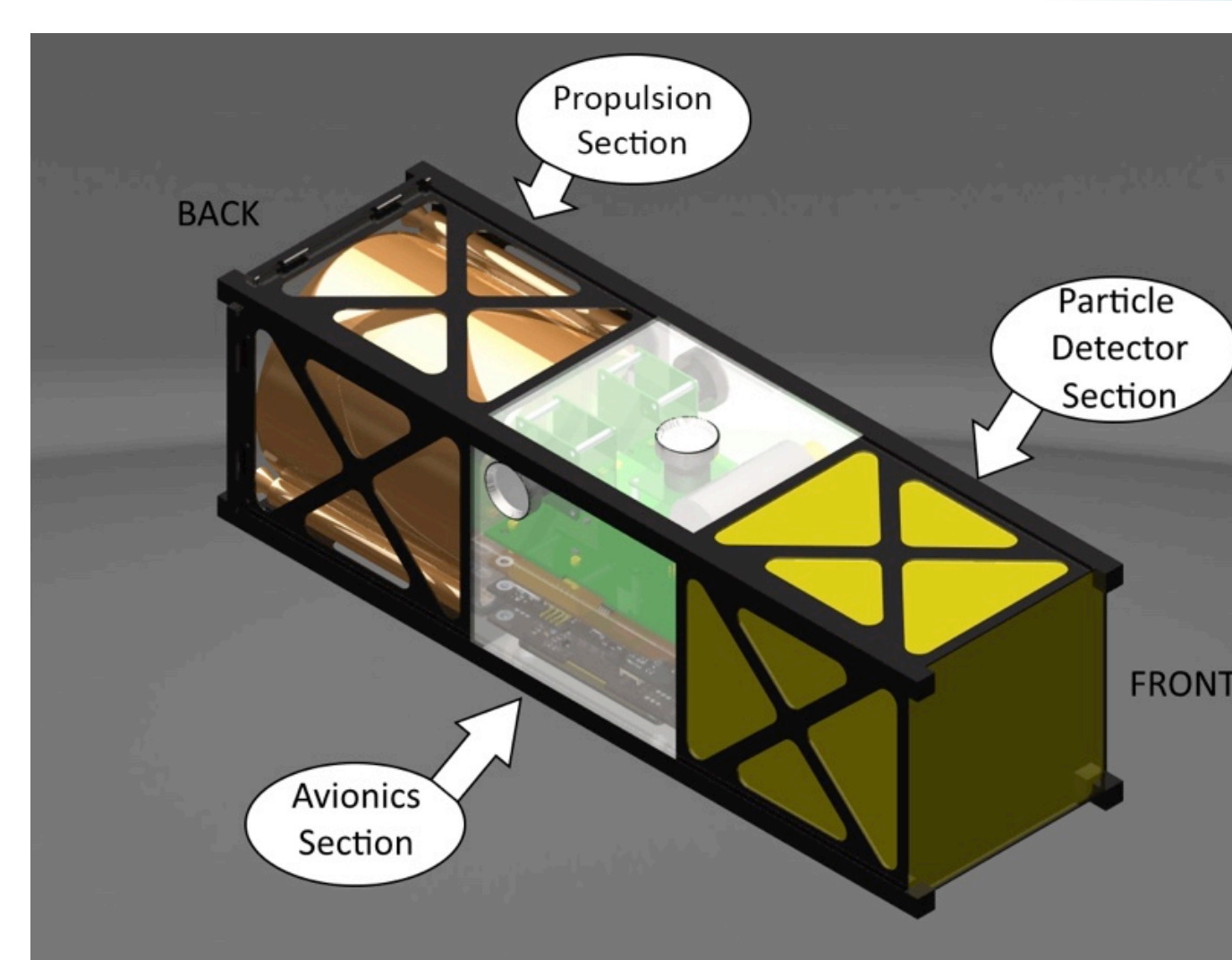- Data relayed back to *EC*
- Final EOM maneuver at apojove
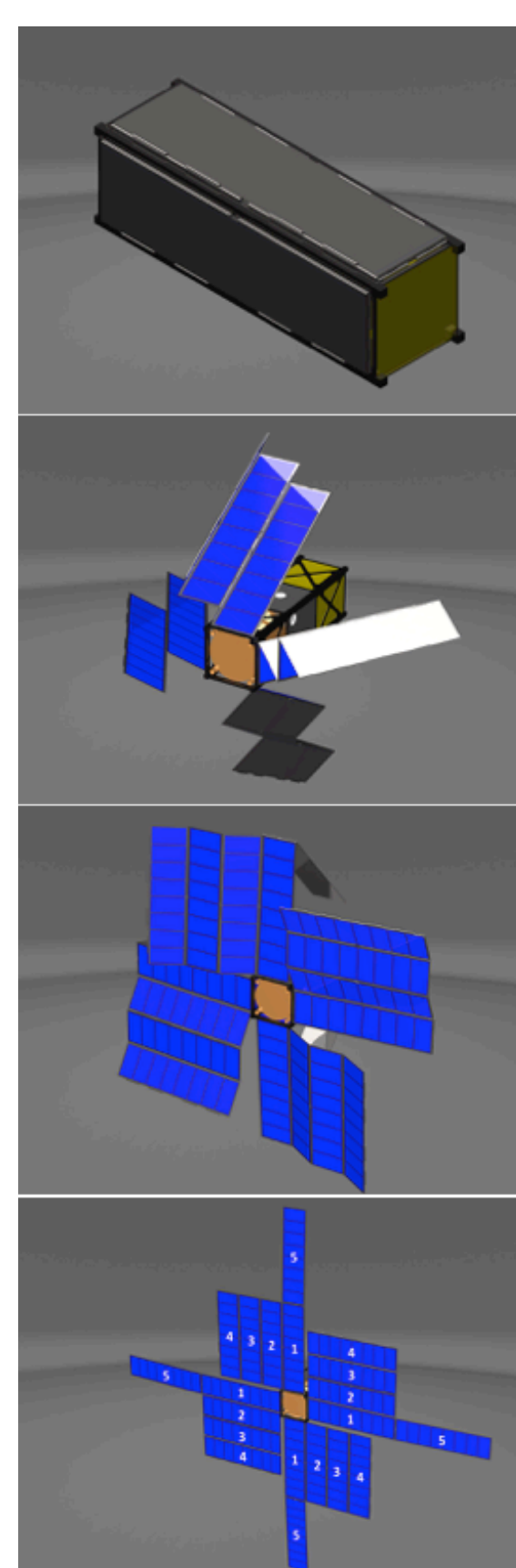
Figure 7: Deployment sequence for *DARCSIDE* drag panels

Component	Part Number	Supplier
Flight Computer	NanoMind AD712D	GOMSpace
Thruster	MPS-130	Aerojet Rocketdyne
Star Tracker	ST-200	Berlin Space Technology
Solar Cells	ZTJ	Emcore
EPS Board	CS-3UEPS2-NB	Clyde Space
Battery Pack Main	CS-SBAT2-10	Clyde Space
UHF halve duplex transceiver	U482C	GOMSpace

Figure 8: Spacecraft bus (above) uses COTS components

Budgets	System Totals with 10% Contingency
Mass	4.31 kg
Power	5.78 W
Data	1936 bits/s

DARCSIDE Concept of Operations

DARCSIDE separation from Europa Clipper 22-Aug-2029 00:10:00

Science pass through Europa's atmosphere 29-Aug-2029 10:51:30 - 11:14:45

Cruise to Europa 22-Aug-2029 - 29-Aug-2029

EOM at apojove 07-Sep-2029 09:10:00

Europa Clipper science mission begins 25-Feb-2029 17:45:14

SLS Launch

Atmospheric Drag	Energetic Particles
0.6 m² drag area	ions from He through O
10 nano-g sensitivity	8-100 MeV energy range
sampling for ~23 min.	pitch ange distribution

not to scale

Launch | EC Cruise to Jupiter | EC JOI | Deploy | Cruise to Europa | Science Pass | Downlink