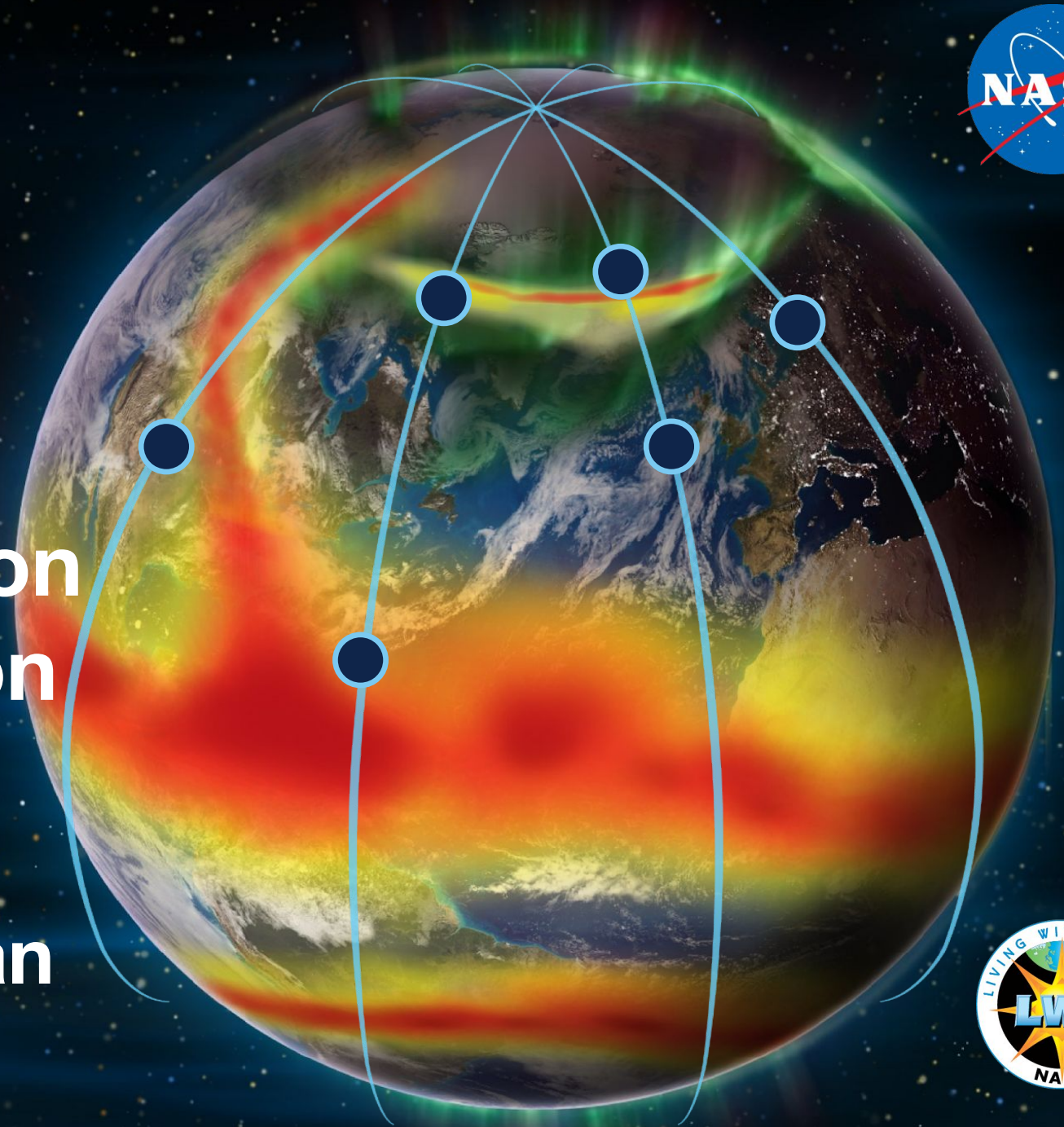




**GDC NEMISIS  
Magnetometer:  
Science Investigation  
and Instrumentation**

**Mark Moldwin  
University of Michigan  
NEMISIS PI**



# NEMISIS

NEAR EARTH MAGNETOMETER INSTRUMENT IN A SMALL INTEGRATED SYSTEM

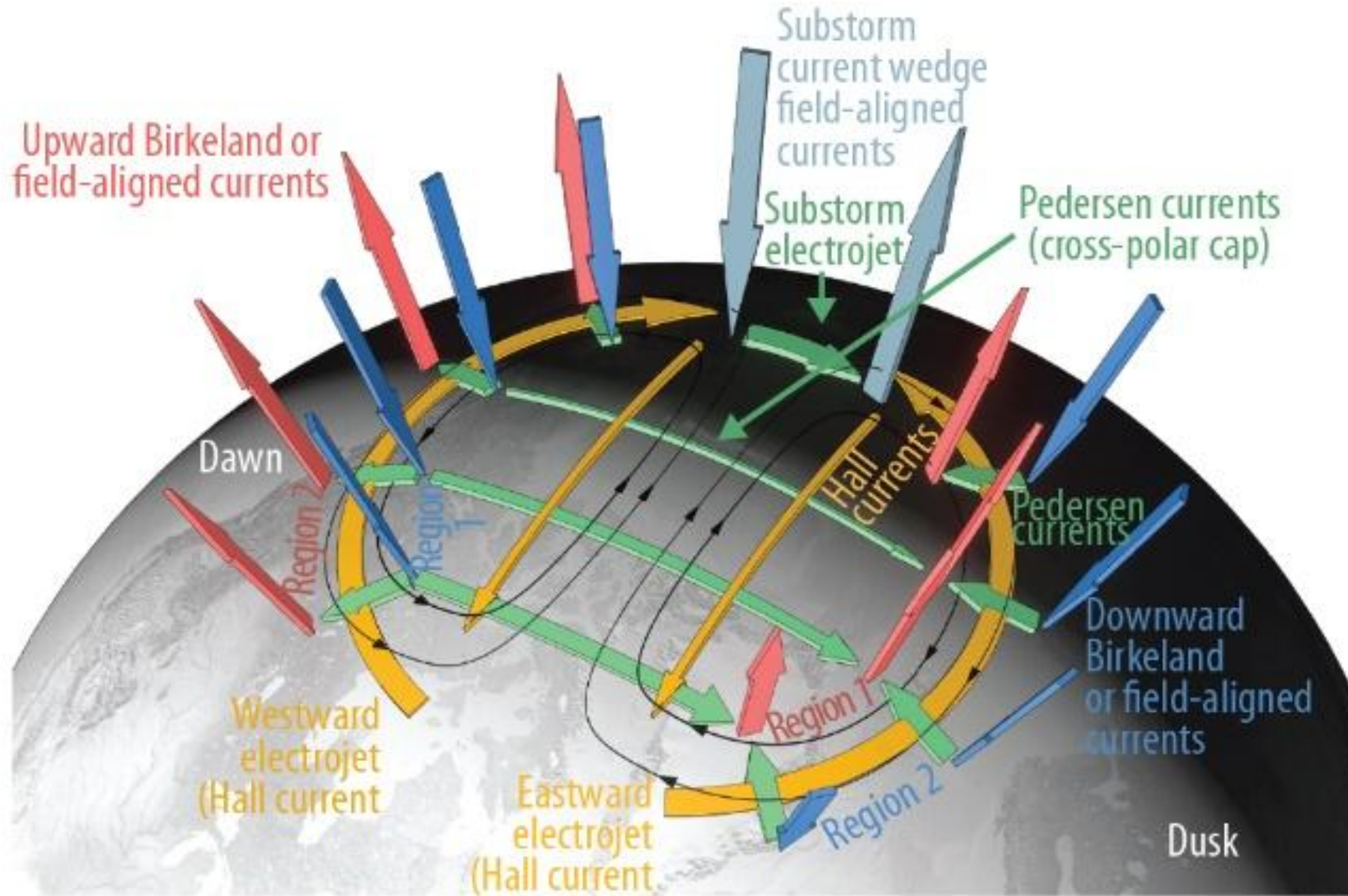


## Science and Instrument Design

NEMISIS addresses GDC's Goal 1 of understanding how the ionosphere-thermosphere (I-T) responds to magnetospheric forcing. NEMISIS measures a primary magnetospheric energy input (currents and Poynting flux) through observations of magnetic field variations

NEMISIS consists of two body mounted magneto-inductive low-resource sensors with a miniature fluxgate magnetometer on the end of the spacecraft provided boom to enable magnetic noise identification and cancellation using modern machine learning algorithms. These algorithms extend classic gradiometry enabling high-quality magnetic field observations using a short boom and magnetically noisy spacecraft.

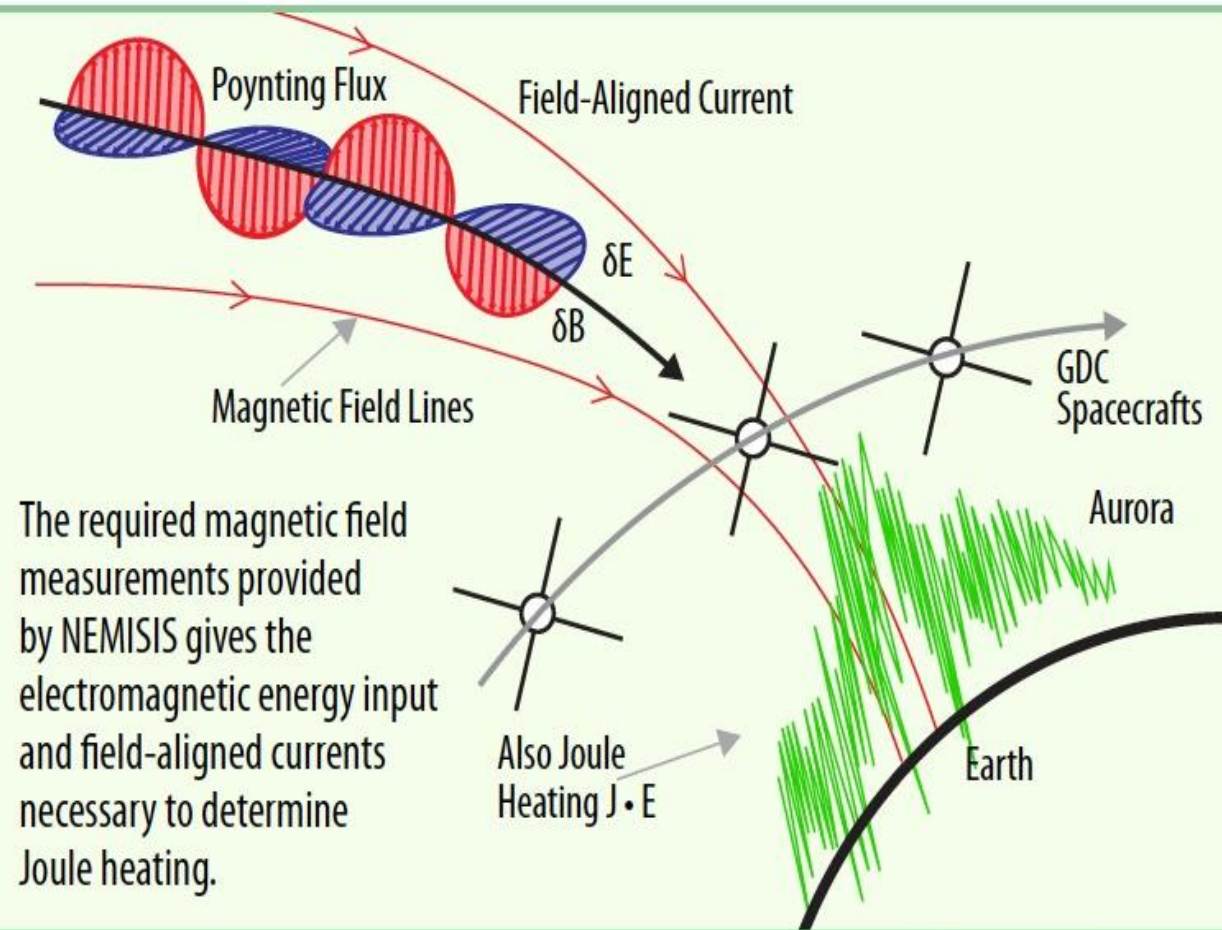
# MI-Coupling Region

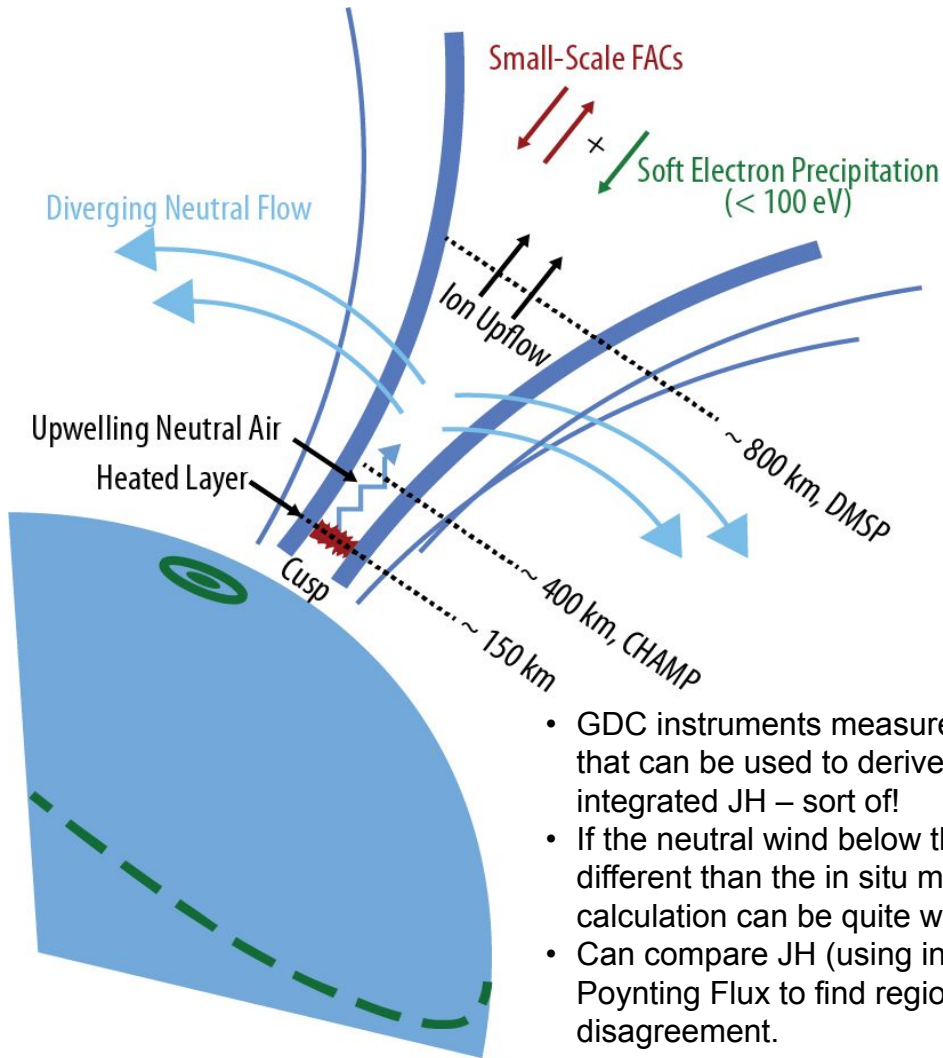


NM014

## NEMISIS SCIENCE

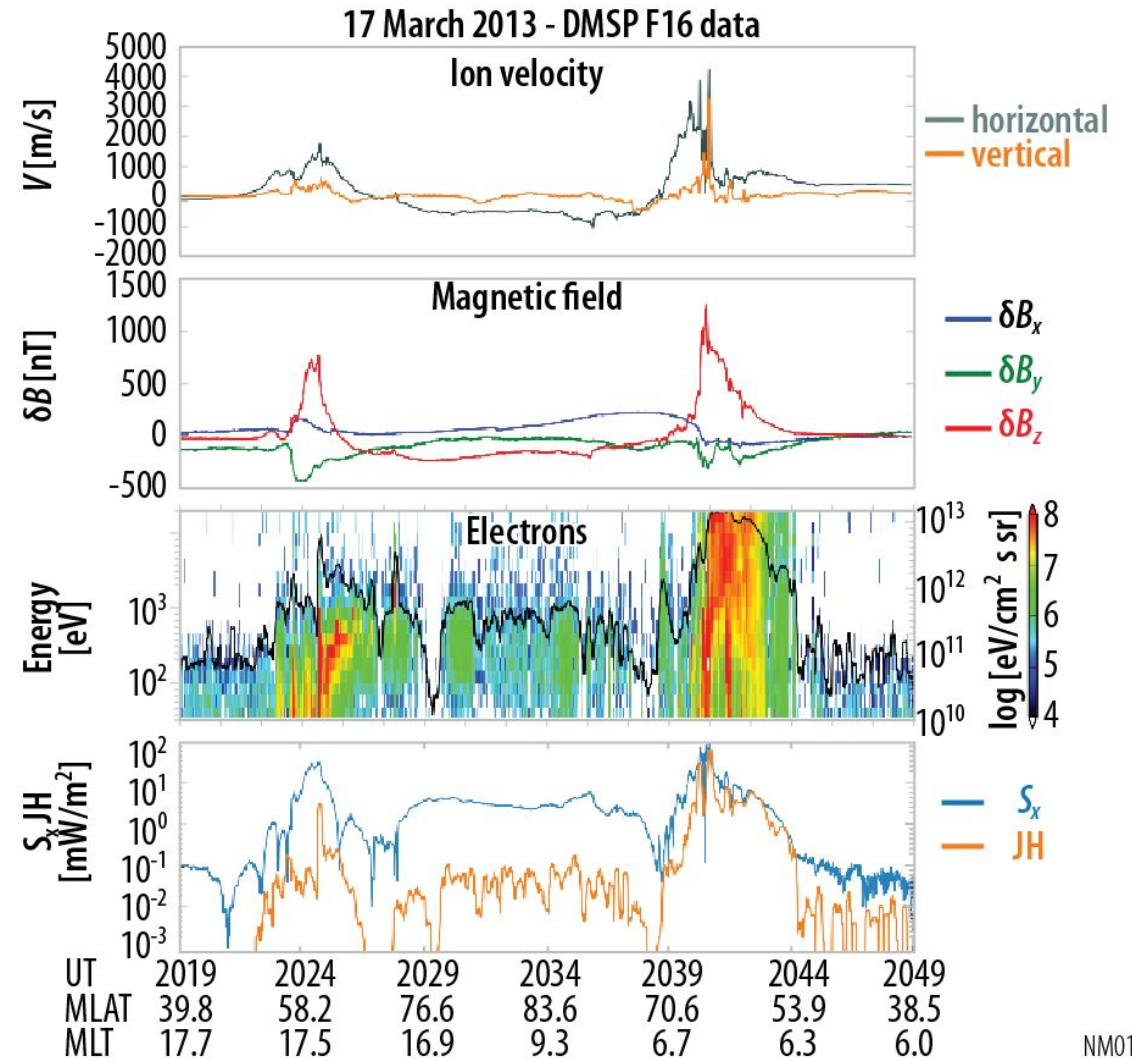
- NEMISIS directly measures the perturbation magnetic field that enables the determination of Field-aligned currents (FAC) and electromagnetic Poynting energy flux ( $S$ ) into the ionosphere-thermosphere (IT) system.
- At small scales, the GDC multiple satellites enable the calculation of FAC location, orientation, current density and motion and  $S$  intensity in the highly structured dayside magnetic cusp and nightside substorm regions.
- At regional and global scales NEMISIS enables simultaneous magnetic conjugate and inter-hemispheric observations of electromagnetic energy deposition during geomagnetic storms.





- GDC instruments measure in situ quantities that can be used to derive the column integrated JH – sort of!
- If the neutral wind below the S/C is significantly different than the in situ measured wind, this calculation can be quite wrong
- Can compare JH (using in situ variables) and Poynting Flux to find regions of agreement and disagreement.

NM016



NM013



# NEMISIS Science Team and Innovation

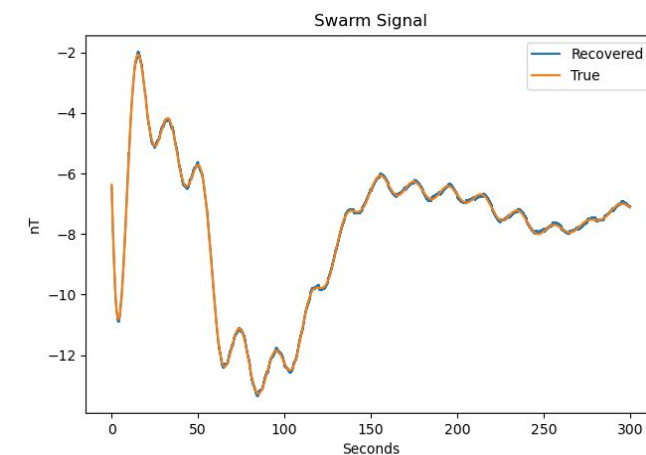
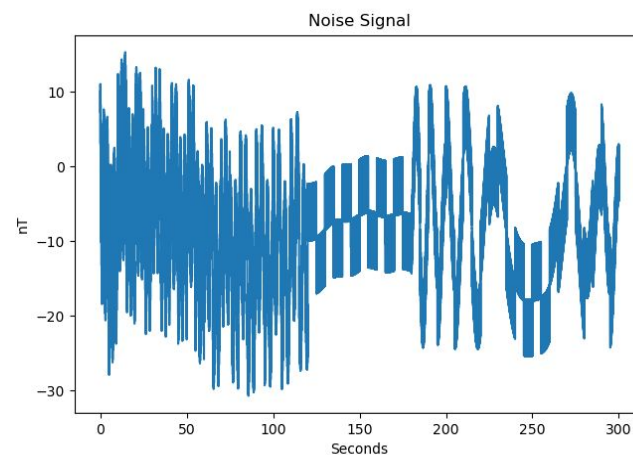
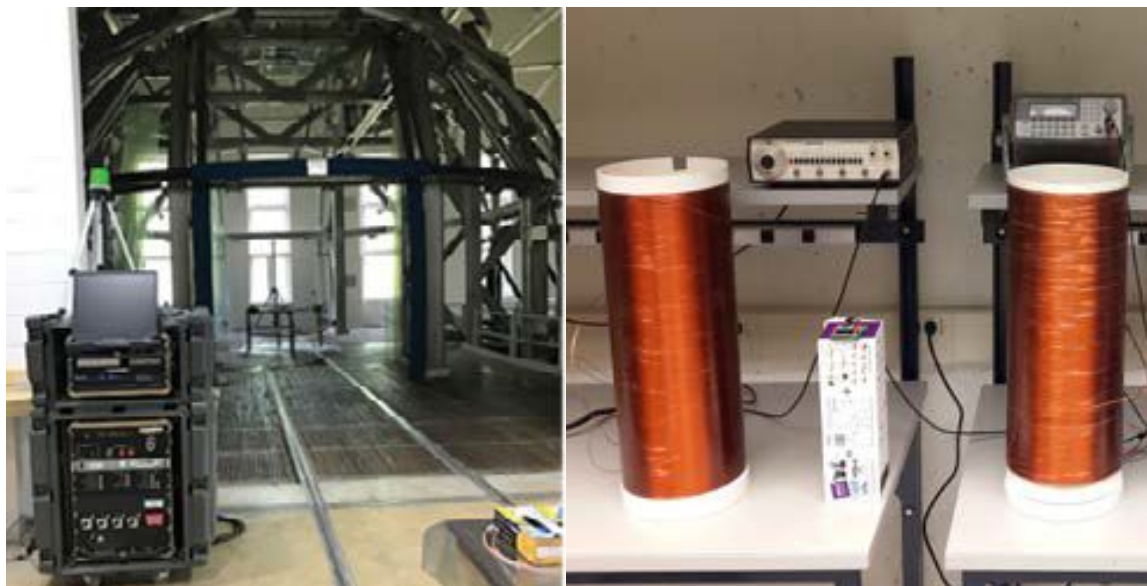


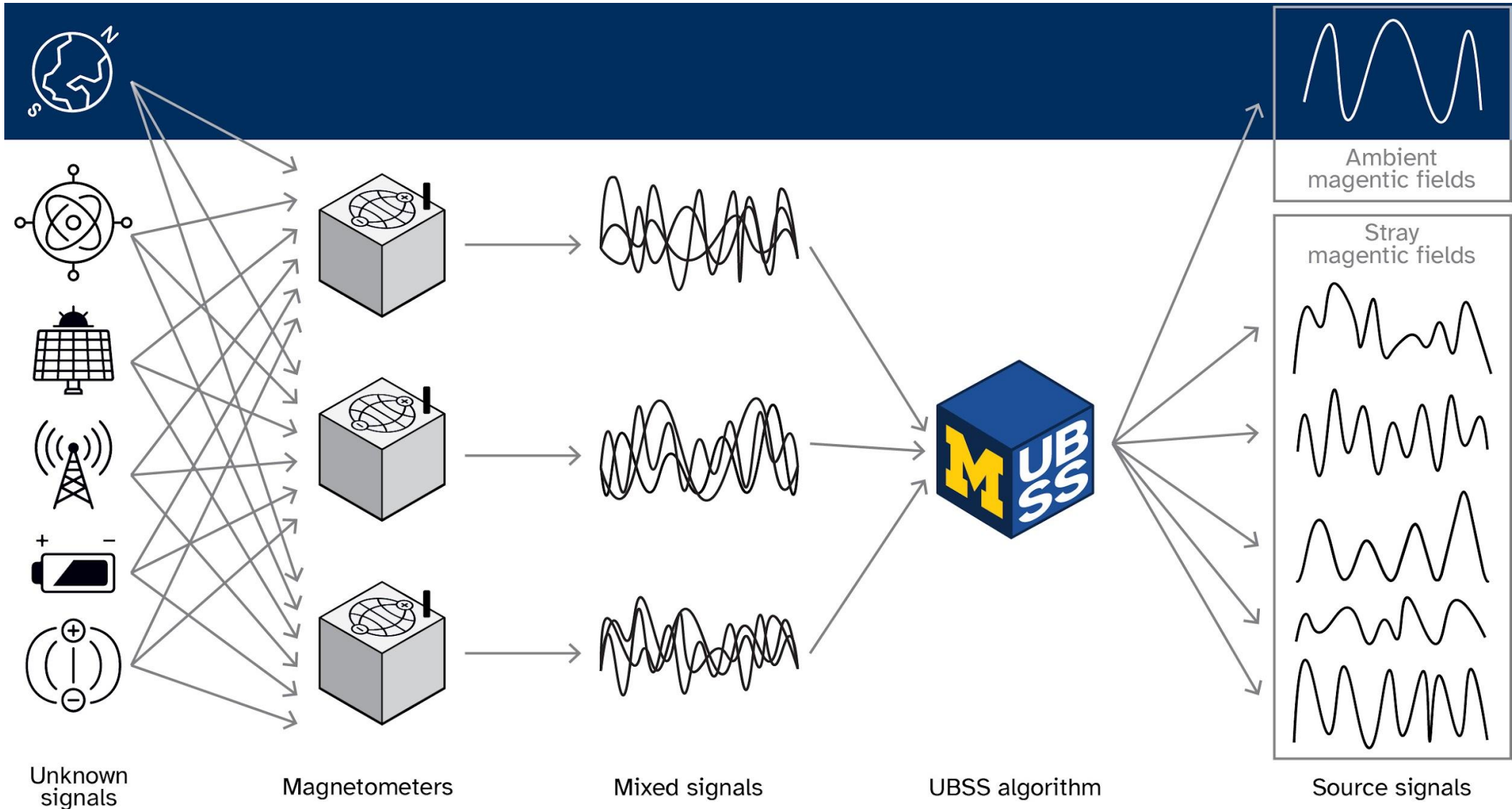
UM PI-led with GSFC Deputy PI and instrument management and significant hardware and I&T at both institutions. Small, Diverse (gender and career stage-balanced) team with mentoring and equitable and inclusive team professional development plan extended to other GDC instrument and IDS teams.

Team Member	Institution	Role
Mark Moldwin	UM	PI
Eftyhia Zesta	GSFC Code 673	D-PI
Aaron Ridley	UM	Modeling (GITM, member of 4 instrument teams)
Shasha Zou	UM	Modeling, data analysis (Member of TPS team)
Alex Hoffmann	UM	Noise Algorithms (PhD Student)
Mojtaba Akhavan-Tafti	UM	Process Engineer/Science (MMS team)
Meghan Burleigh	NRL	Modeling (Global to Regional Model)
Seebany Datta-Barua	Illinois Institute of Tech	Data Analysis (ITM, data assimilation)
Mike Hartinger	SSI	Data Analysis (Poynting Flux Guru)
Denny Oliveira	GSFC Code 673	Data Analysis and Modeling
Deirdre Wendel	GSFC Code 673	Data Analysis and Modeling
Matt Finley	GSFC Code 673	Noise Algorithms & Data Analysis (Postdoc)

# Enabling Technology for short boom, reduced magnetic cleanliness requirements

- Innovative magnetic noise identification algorithms (including machine learning) enables easy accommodation of NEMISIS and relaxation of magnetic requirements on spacecraft and instrument.

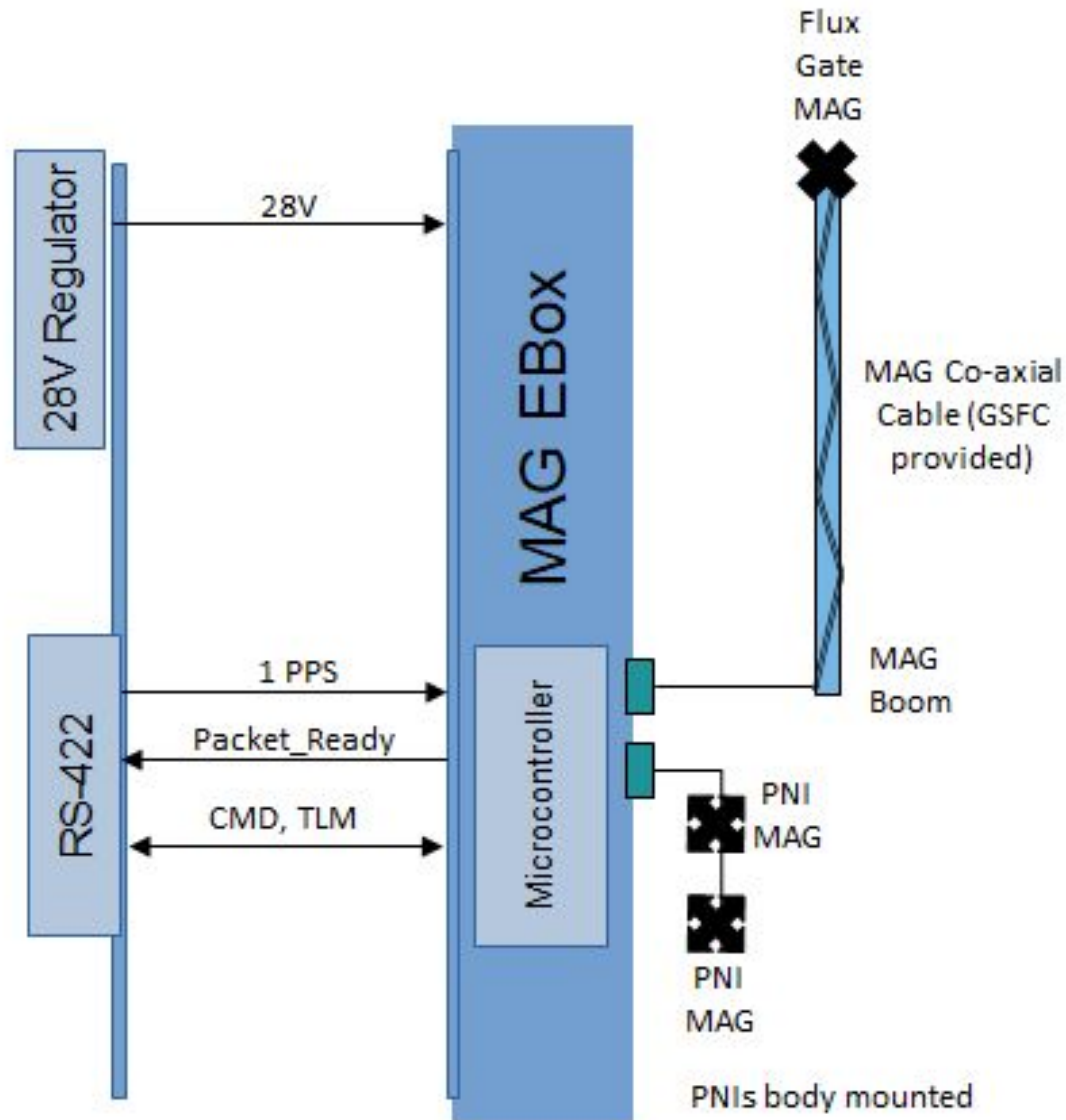






# Instrument Concept (1/4)

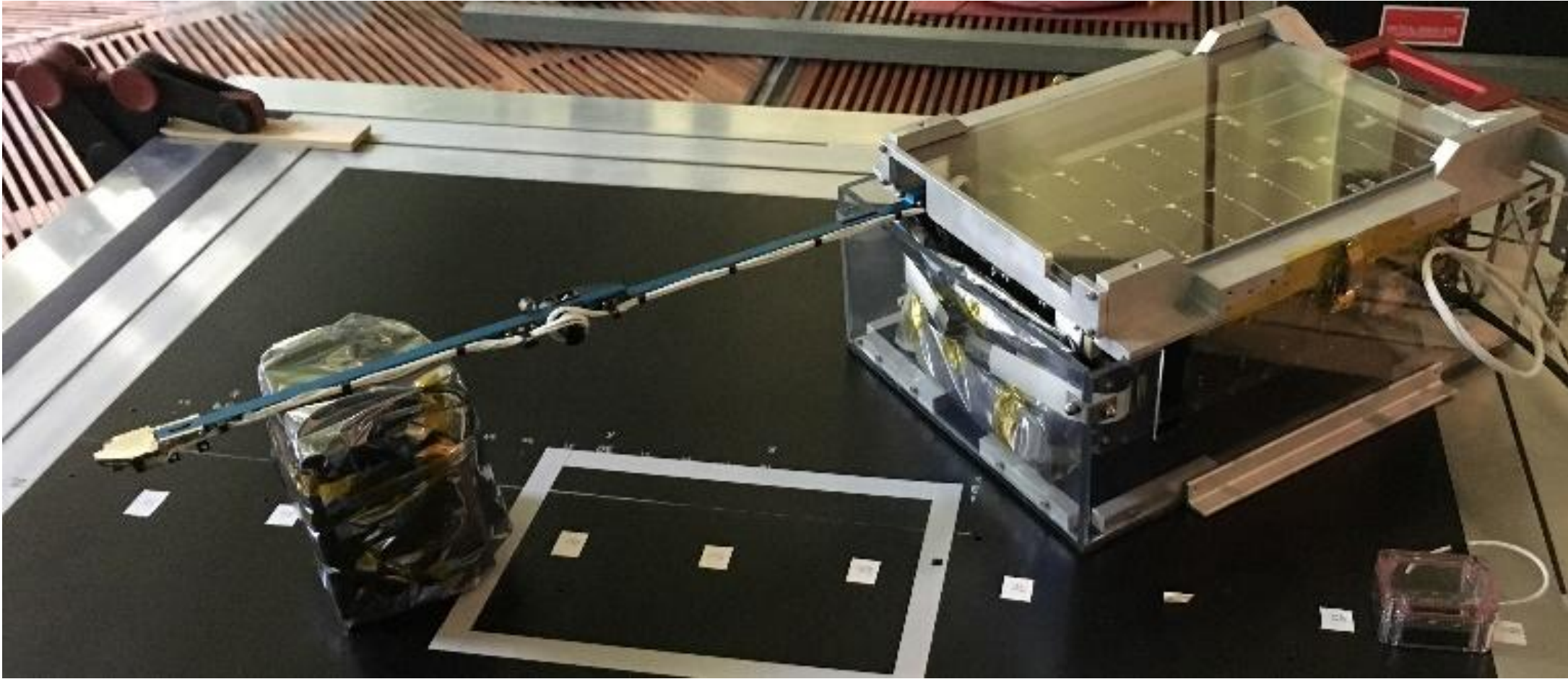
GDC SC



- Fluxgate (GSFC): TRL 9 heritage from Dellinger
- PNI (UM): Sensor TRL 9 heritage from SPIRE 70+ CubeSats; GDC packaging TRL 8 (essentially identical to Lunar Gateway HERMES and fully qualified and delivered).
- Circuit Card (GSFC): TRL 6 heritage from Dellinger & SPORT and current HERMES-MAG ETU. HERMES design includes parts changes from Dellinger, and HERMES

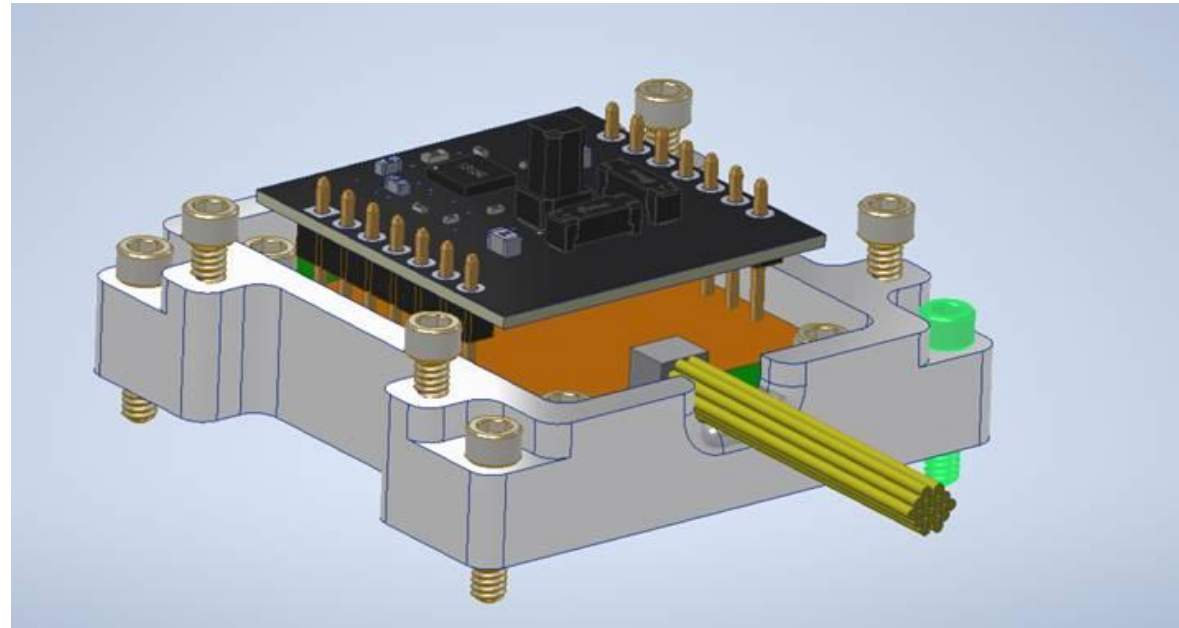
# Instrument Concept (2/4)

Dellinger Boom sensor and flight board



# Instrument Concept (3/4)

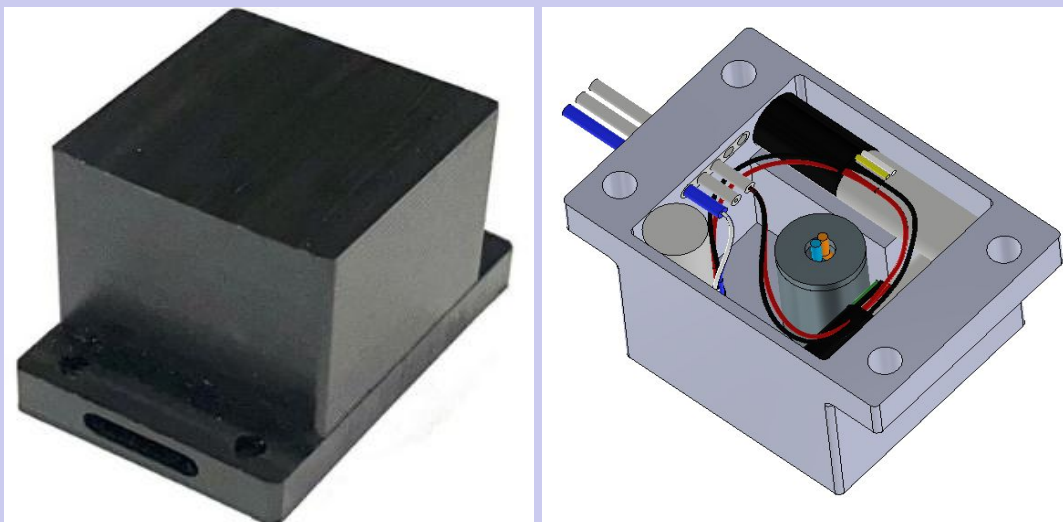
PNI & Daughter Board



# Instrument Concept (4/4)

## HERMES-NEMISIS FLIGHT UNIT

Flight Fluxgate



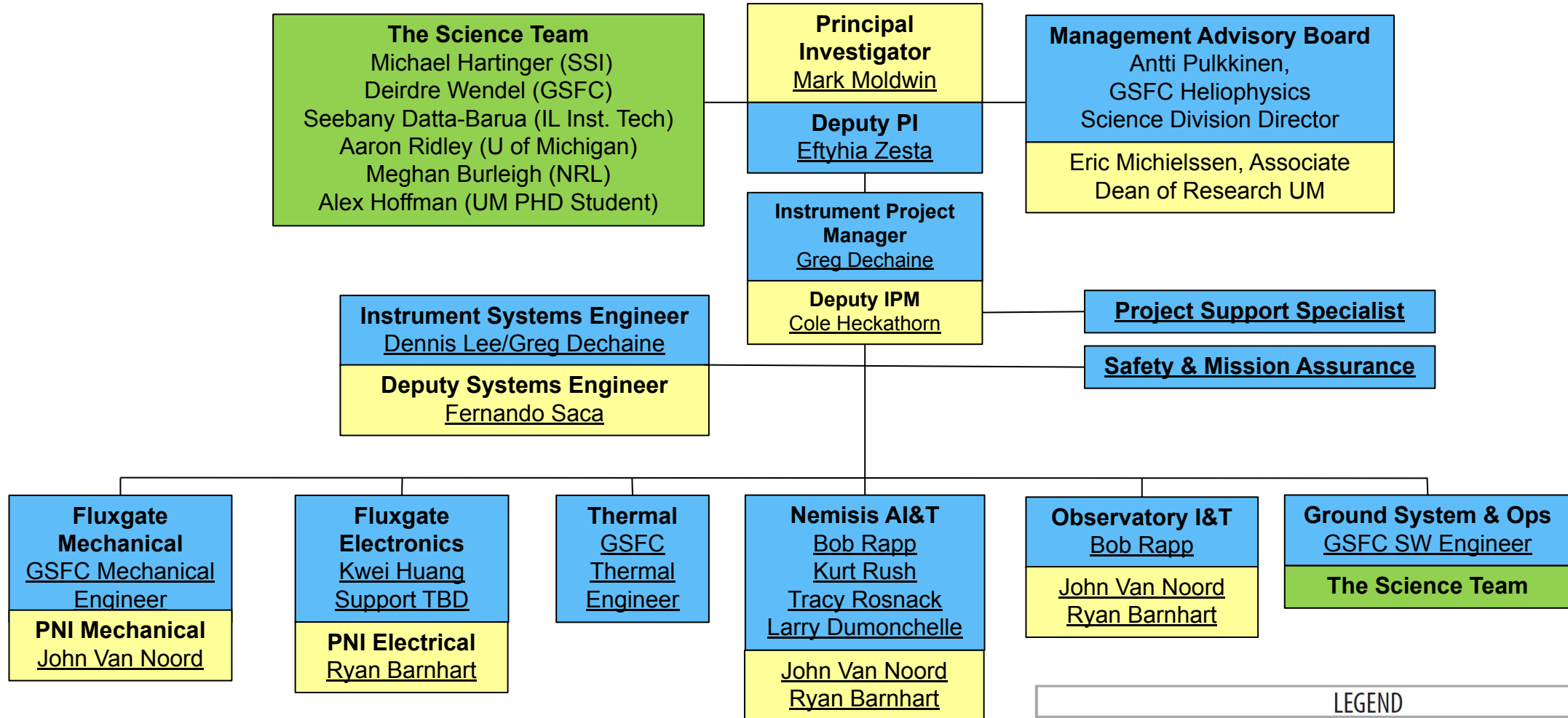
Flight PNIs



	Total Mass [kg] (CBE)	Total Power (w/ 30% contingency) [W] (MEV)
GSFC Fluxgate Sensor	0.15	-
UM PNI	0.17	0.01
Electronics	0.09	1.04
Instrument (per/SC) Total	0.42	1.05

**Total Mass includes Aluminum Chassis, harness, cable EMI shielding and screws**

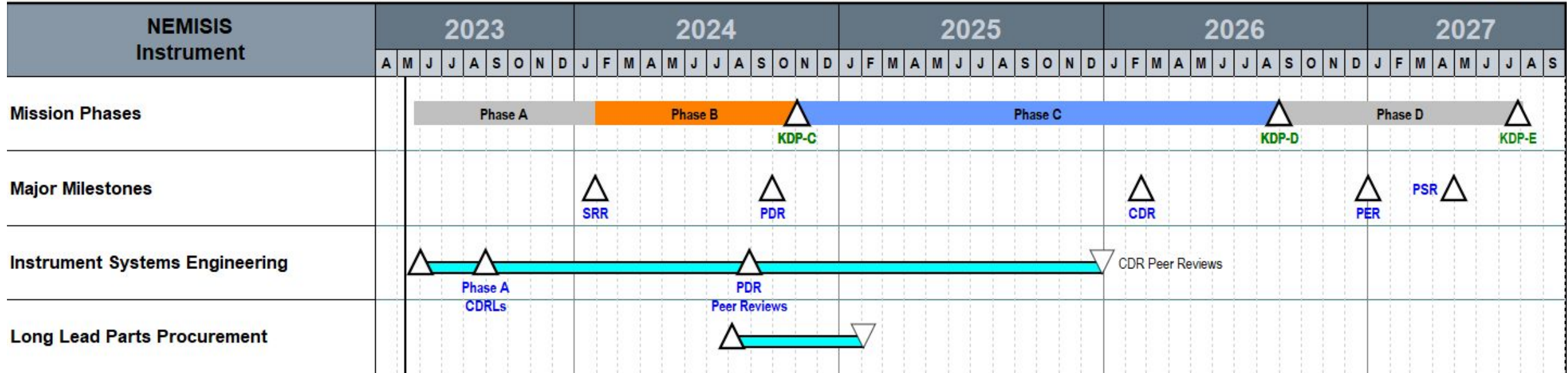
# NEMISIS Org Chart



LEGEND	
<span style="background-color: #ADD8E6; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> GSFC	<span style="background-color: #FFFF00; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> University of Michigan (UM)
<span style="background-color: #90EE90; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> Diverse multi-institutional team	<u>name</u> HERMES Team Member

## Geospace Dynamics Constellation (GDC) Schedule

5/12/23



\*Detailed schedule currently in work per replan activities resulting from GDC pause