AERO & VISTA
Demonstrating HF Radio Interferometry with Vector Sensors

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(On behalf of VISTA PI Frank Lind and AERO PI Phil Erickson)

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Target: The Radio Aurora

High-latitude aurora viewed from the ISS (~350 km altitude)
September, 2011 (NASA ISS Crew Earth Observations experiment)

Mission summary

AERO and VISTA are twin 3U CubeSats that will launch & deploy together into a polar orbit, using drag to control separation.

Individually, they will answer key scientific questions about the nature and sources of auroral radio emissions.

Together, they will demonstrate interferometric imaging, beamforming, and nulling using electromagnetic vector sensors at low frequencies (50 kHz – 5 MHz).

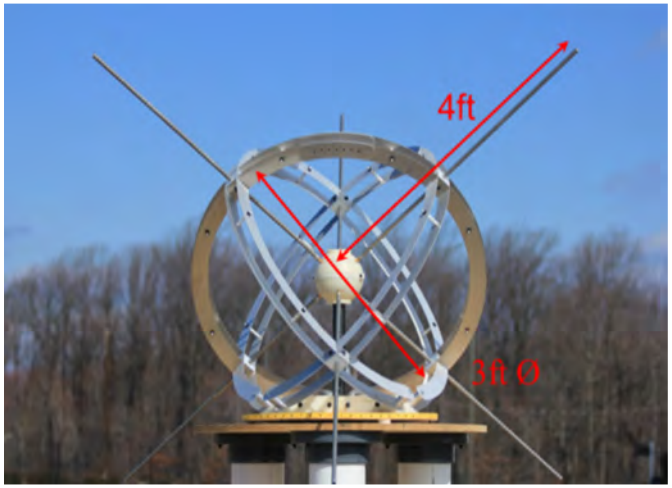
A key goal is to demonstrate that interferometric arrays of VS's will maintain sensitivity in the presence of terrestrial interference.

- This would allow low frequency interferometers be placed in LEO, reducing cost and increasing data volume.

AERO AURORAL EMISSIONS RADIO OBSERVER

VISTA VECTOR INTERFEROMETRY SPACE TECHNOLOGY USING AERO

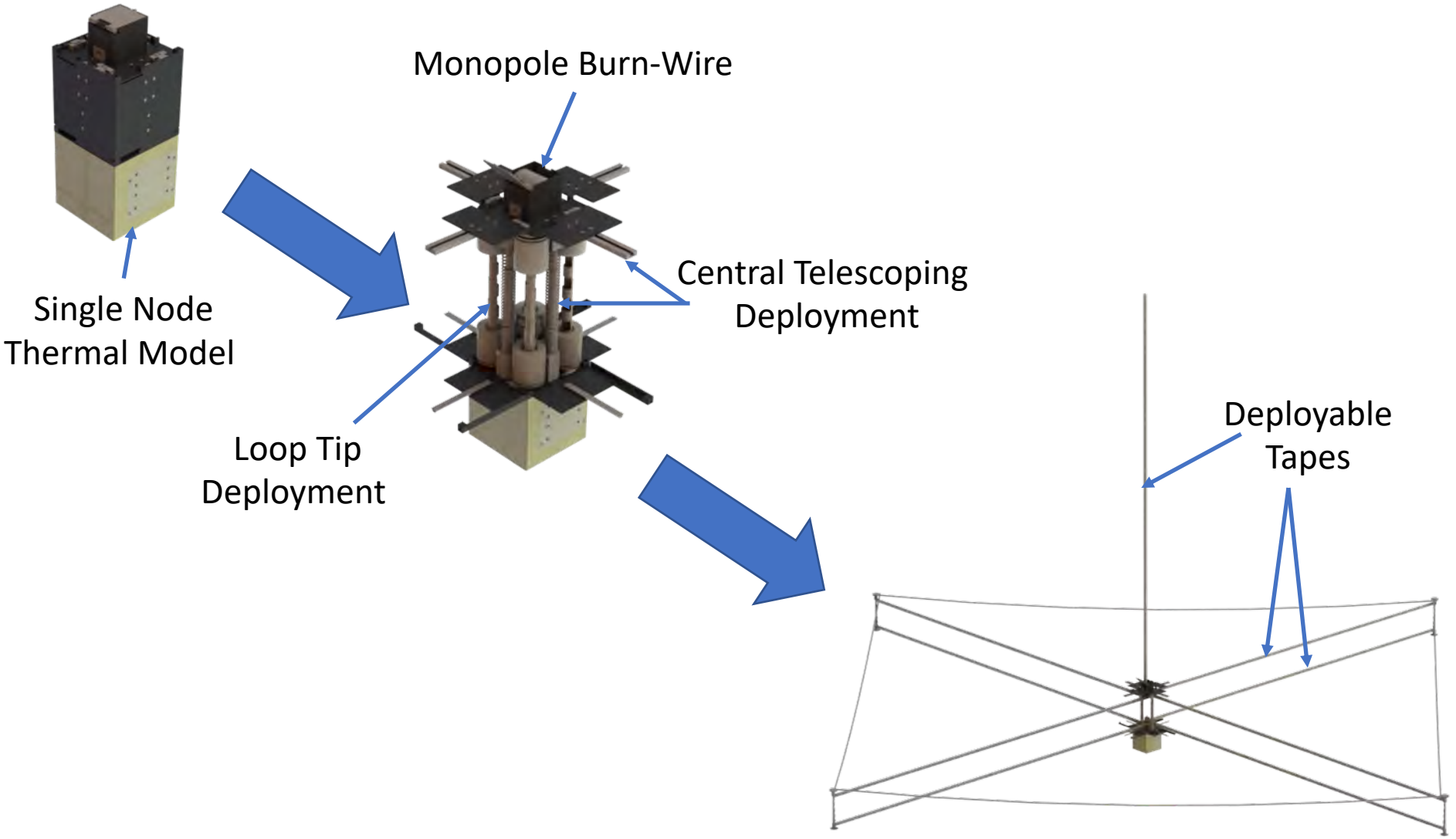
Electromagnetic Vector Sensing



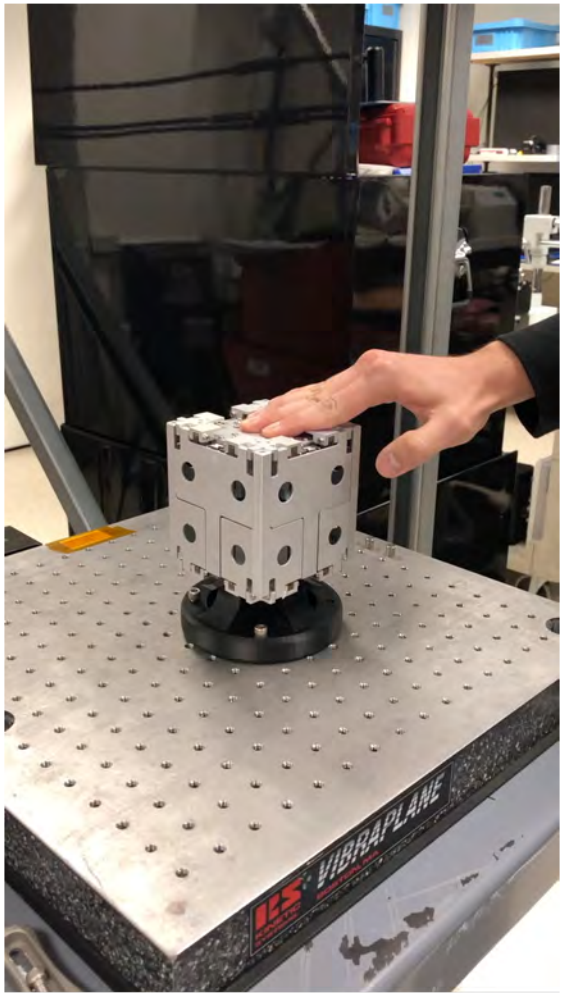
- 3 dipoles + 3 loops (electrically small)
- Measures full E and B field vectors
  - ExB = S (Poynting vector)
- Determines source intensity, polarization, and direction (to a few degrees)
- Some imaging capability

Spatially resolved detection with a single electrically small sensor!

Vector antenna deployment



Central Telescoping Deployment



Deployable Vector Antenna Prototype

Mission Objectives

Table 1: Top level objectives for AERO and VISTA missions.

AERO	VISTA
AO1: Characterize auroral radio emissions in the ionosphere	VO1: Demonstrate vector sensor interferometry (VSI) in space
AO2: Connect radio emissions to overall auroral geospace system	VO2: Apply VSI to auroral radio emissions
AO3: Demonstrate polarimetric HF radio signal detection [Tech validation]	VO3: Characterize low Earth orbit (LEO) radio frequency interference (RFI) environment [at HF frequencies]

Nominal launch date in 1st Quarter of 2022

Backup

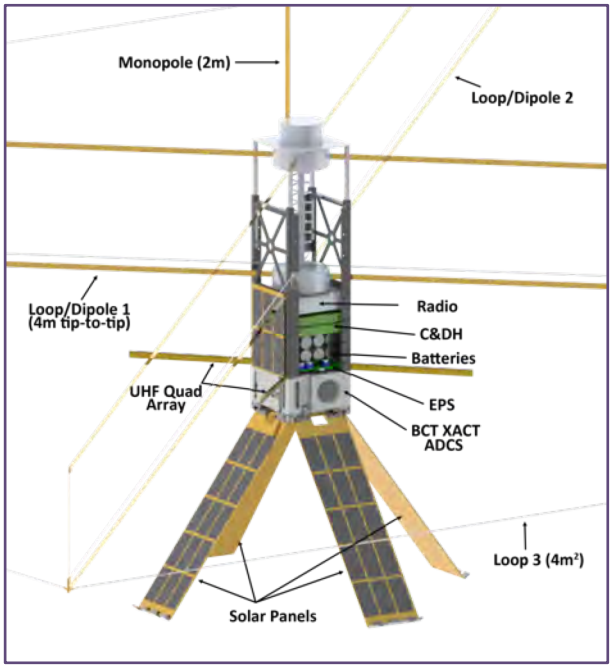
AERO AURORAL EMISSIONS RADIO OBSERVER

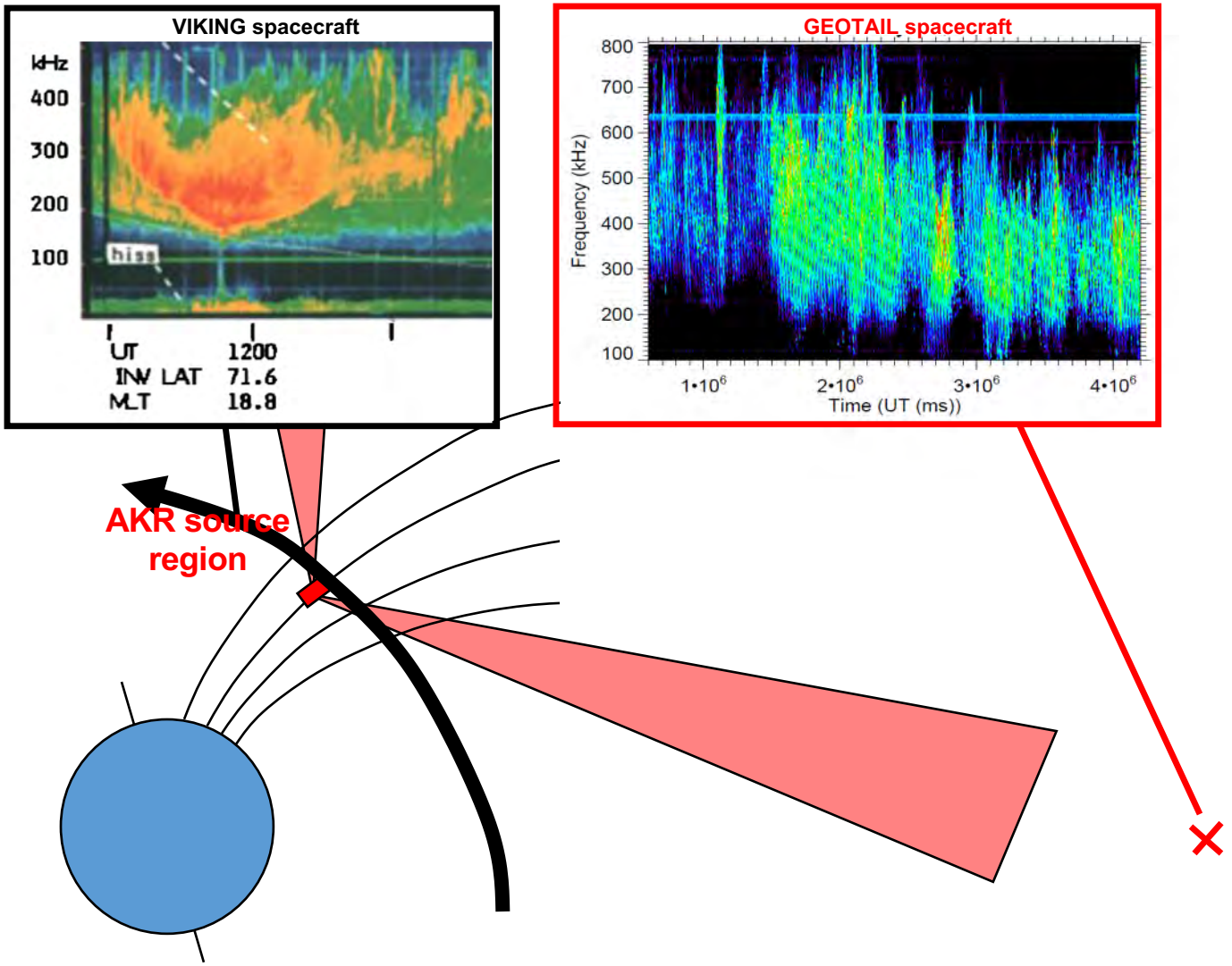
VISTA VECTOR INTERFEROMETRY SPACE TECHNOLOGY USING AERO

Twin 3U CubeSats will be placed in polar orbit for a nominal 90-day mission to:

- Qualify and validate a novel electromagnetic Vector Sensor (VS)
- Answer key scientific questions about the nature and sources of auroral radio emissions.
- **Demonstrate low frequency interferometry**

- Orbiting at >400 km, above the ionospheric peak, allows sensing of radiation not visible from Earth
- Each deployable *vector sensor* (50 kHz – 5 MHz) can determine direction of arrival of auroral radio emission
- Together, they demonstrate how interferometry enables high resolution imaging
- An Auxiliary Sensor Package includes magnetometers and optical aurora sensors





MIT HAYSTACK OBSERVATORY
MIT Lincoln Laboratory
MIT Aeronautics and Astronautics
MOREHEAD STATE UNIVERSITY
DARTMOUTH
MERRIMACK COLLEGE
NASA

Developments in auroral radio emissions

Type	frequency	polariz'n	outstanding problems
Auroral Hiss	<1 MHz (below f_{ce})	Right (W-mode)	**Structure: hisslers, LF cutoff etc.** **Dayside/nightside** **Source altitudes**
AKR	50-750 kHz (below f_{ce})	Right	**Confirm connection** **How W-mode generated?** **Ducted? Area illuminated?** **Remote sensing application?**
Auroral Roar	$2f_{ce}$, $3f_{ce}$, $4f_{ce}$, $5f_{ce}$	Left (sometimes Right?)	**Nonlinear mode conversion?**
Medium Freq Burst	1.5-4.5 MHz (above f_{ce})	Left (L-mode)	**Generation mechanism?** **Use for substorm onset timing?** **Connected to Langmuir cavitation?**

CubeSat Deployable Vector Sensor