RADIO SCIENCE IN SPACE: AN OUTSIDER'S PERSPECTIVE

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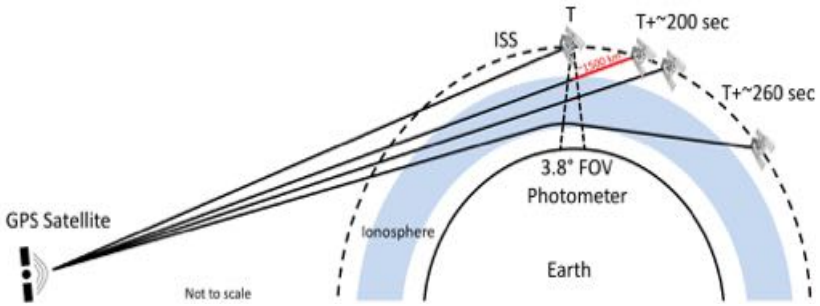
ONE OF OUR GROUP'S RECENT SPACE EXPERIMENTS

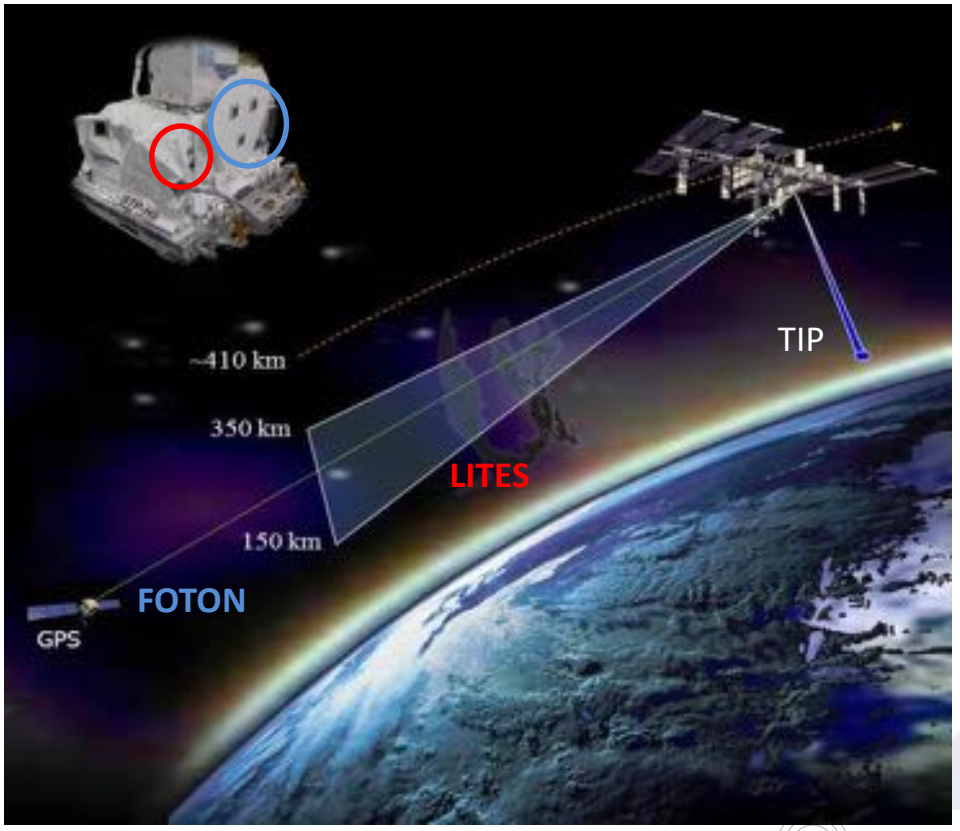
LITES AND GROUP-C FORM A 3-INSTRUMENT IONOSPHERIC SENSOR SUITE

LITES, an imaging UV spectrograph, is part of a suite of ionospheric instruments on the payload along with:

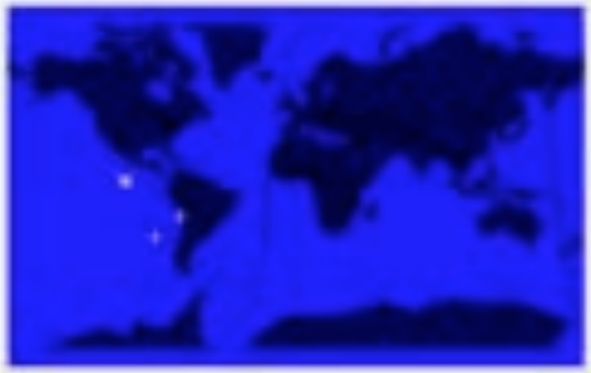
GPS **R**adio **O**ccultation and **U**ltraviolet **P**hotometry-**C**olocated (GROUP-C)

- Nadir-viewing UV photometer (TIP)
- GPS receiver (FOTON)

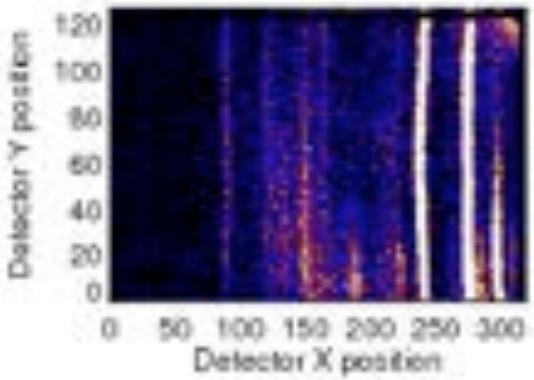


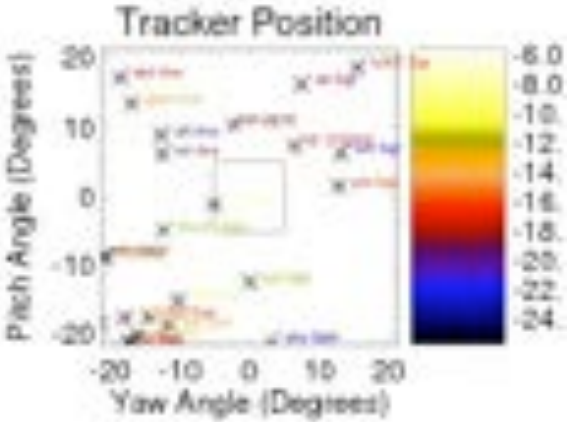


FLIGHT DATA



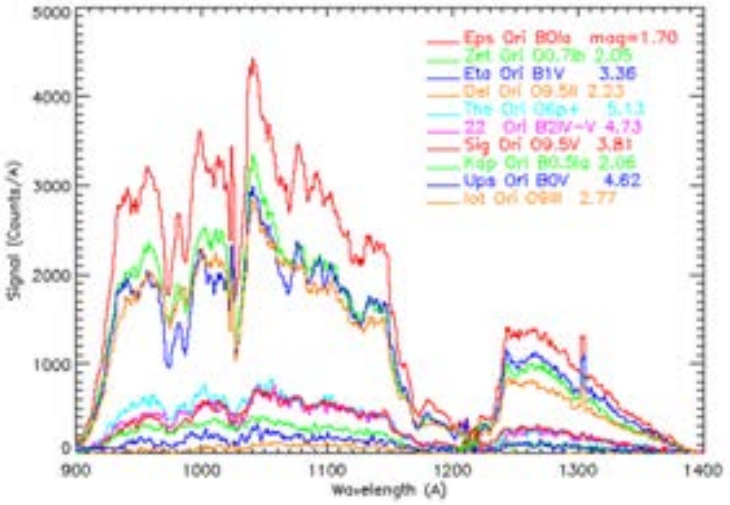

1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

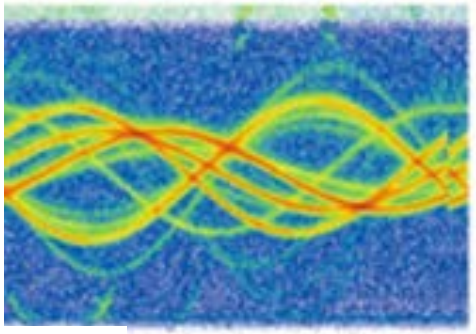

Detector Y position
120
100
80
60
40
20
0
0
50
100
150
200
250
300
Detector X position

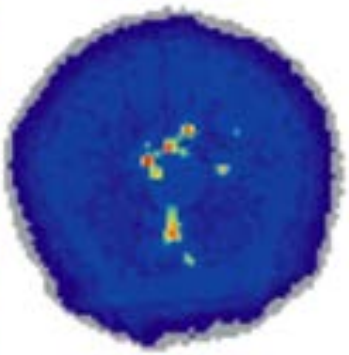

Tracker Position
Pitch Angle (Degrees)
20
10
0
-10
-20
-20
-10
0
10
20
Yaw Angle (Degrees)
-6.0
-8.0
-10.
-12.
-14.
-16.
-18.
-20.
-22.
-24.

HYPERSPECTRAL IMAGING IN UV USING TOMOGRAPHIC RECONSTRUCTION FROM A ROCKET

Spectra of 10 bright stars in the field



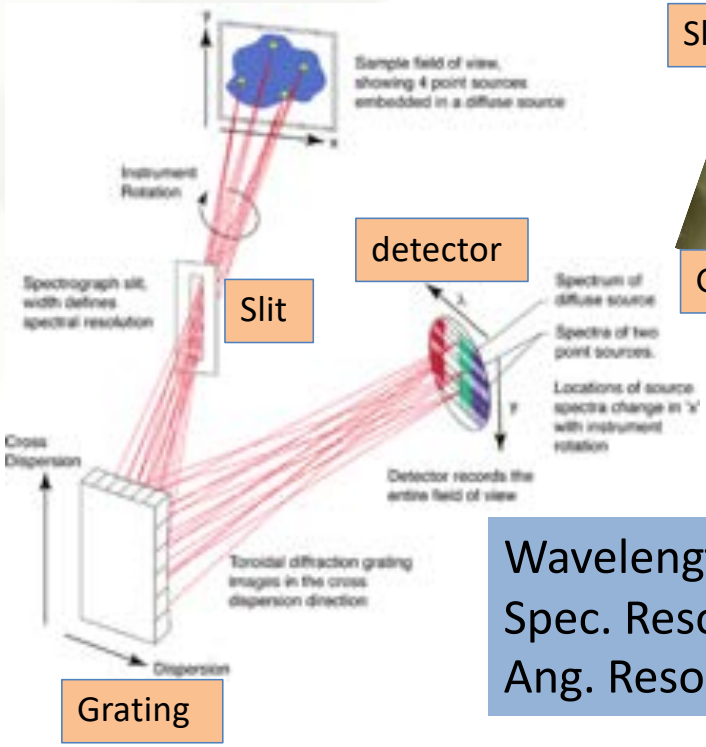


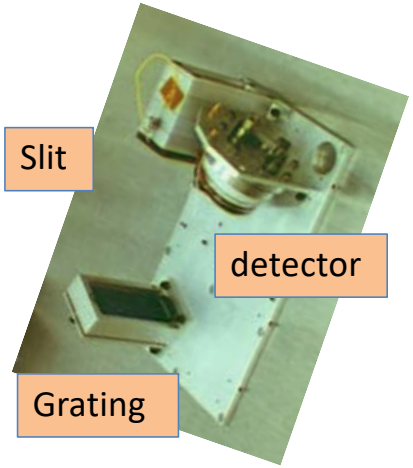


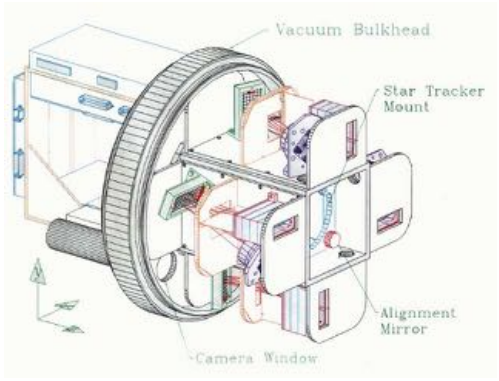
Broad-band (5-minute rocket flight required co-adding several wavelength bins) data transformed into image

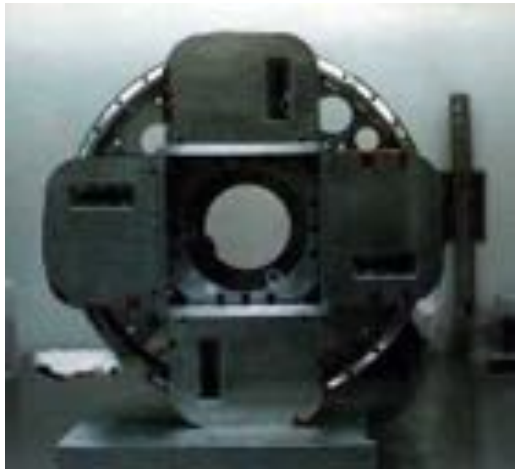
N. Lewis, T. A. Cook, K. Wilton and S. Chakrabarti, "Far-Ultraviolet Dust Albedo Measurements in the Upper Scorpius Cloud Using the SPINR Sounding Rocket Experiment", *Astrophys. J.*, **706**, 306-318, 2009.

THE LINK BETWEEN THESE TWO: AN IMAGING SPECTROGRAPH





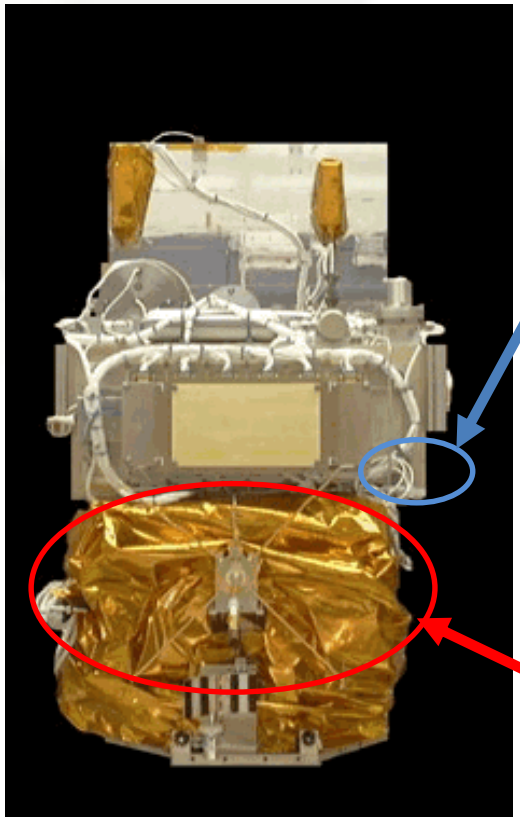




Wavelength: 80-140nm
Spec. Resolution: 0.5 nm
Ang. Resolution: 5 arcmin

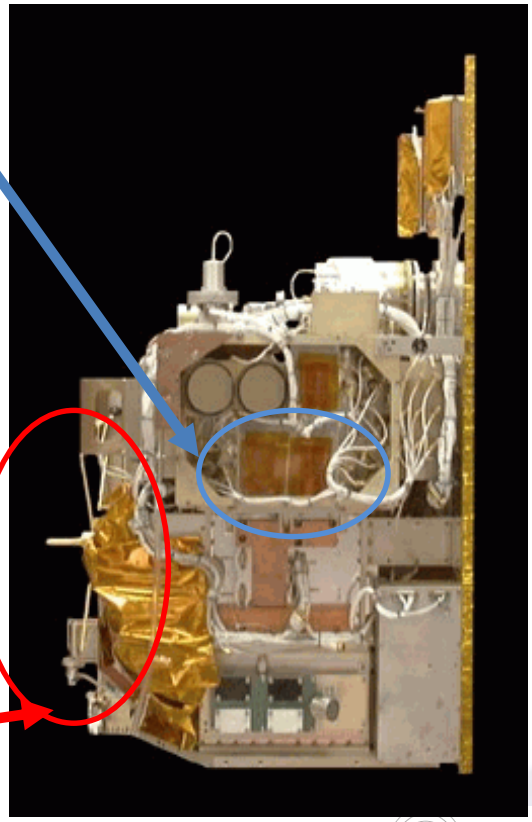
D. M. Cotton, T. Cook, and S. Chakrabarti, "A single element imaging spectrograph," Appl. Opt. **33,** 1958–1962 (1994).

THIS SPECTROGRAPH WAS ORIGINALLY DESIGNED FOR TOMOGRAPHY FROM TERRIERS

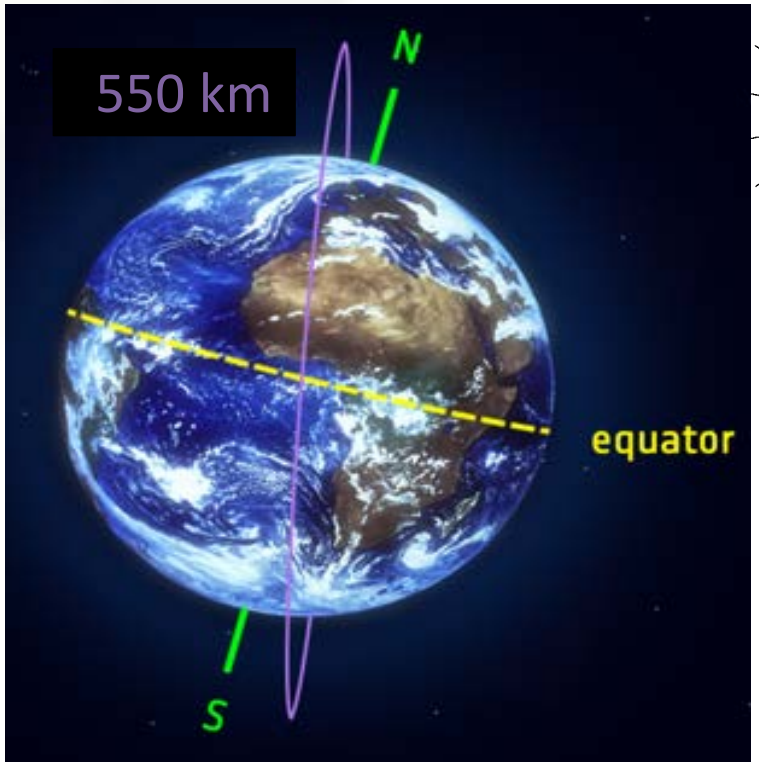


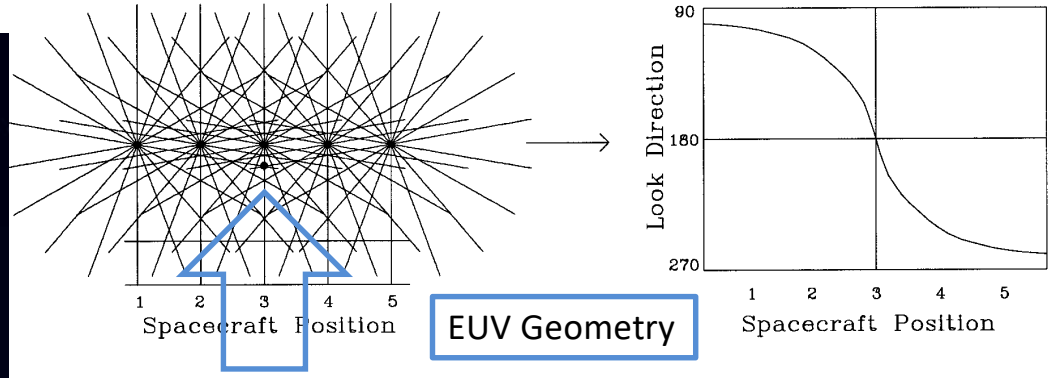
UV spectrograph (flew 5)

A radio beacon



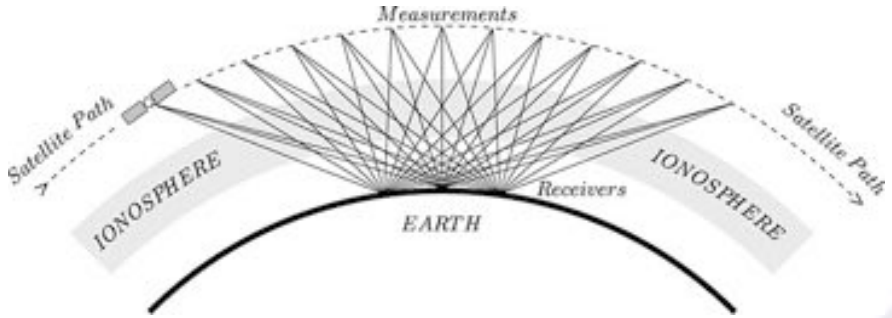
TERRIERS: TOMOGRAPHIC EXPERIMENT USING RADIATIVE RECOMBINATIVE IONOSPHERIC EUV AND RADIO SOURCES





EUV Geometry

D. Cotton, A. Stephan, T. Cook, J. Vickers, V. Taylor and S. Chakrabarti, "Tomographic Extreme ultraviolet spectrographs (TESS)," Appl. Opt. **39,** 3991–3999 (2000).

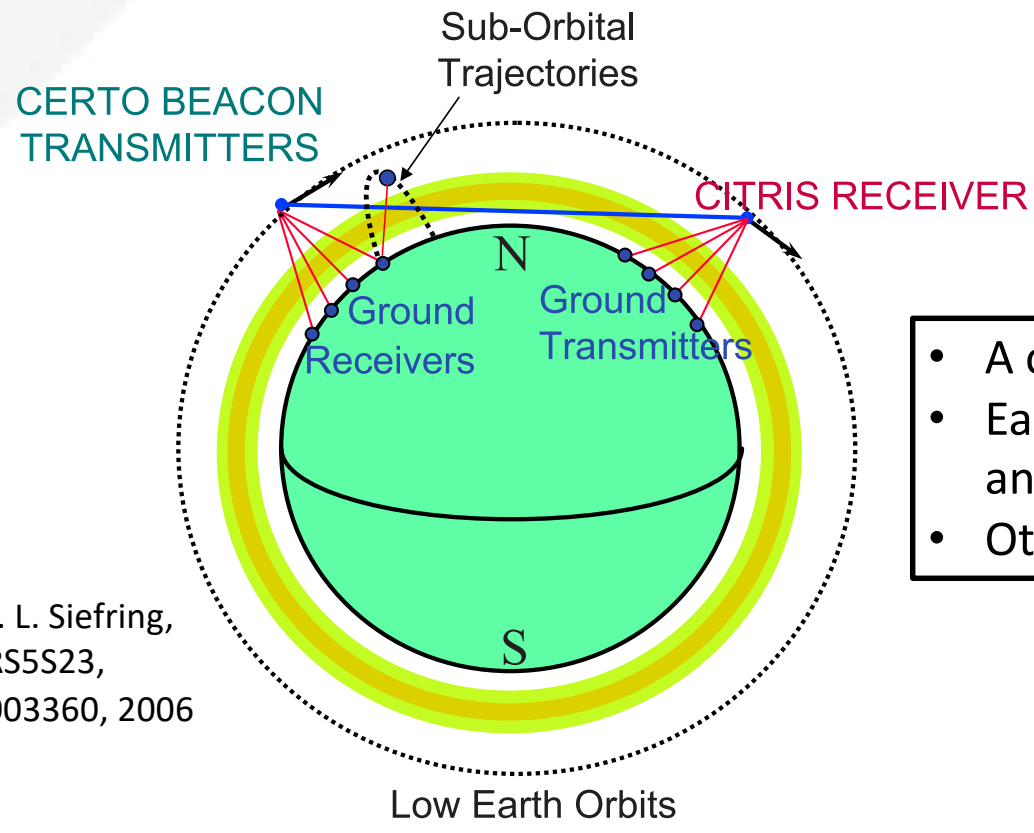


https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014RS005434

https://www.esa.int/ESA_Multimedia/Images/2020/03/Polar_and_Sun-synchronous_orbit

AN IDEA FOR COLLABORATION AMONG NEROC COLLEAGUES

POSSIBILITIES: MORE SOPHISTICATED GEOMETRY

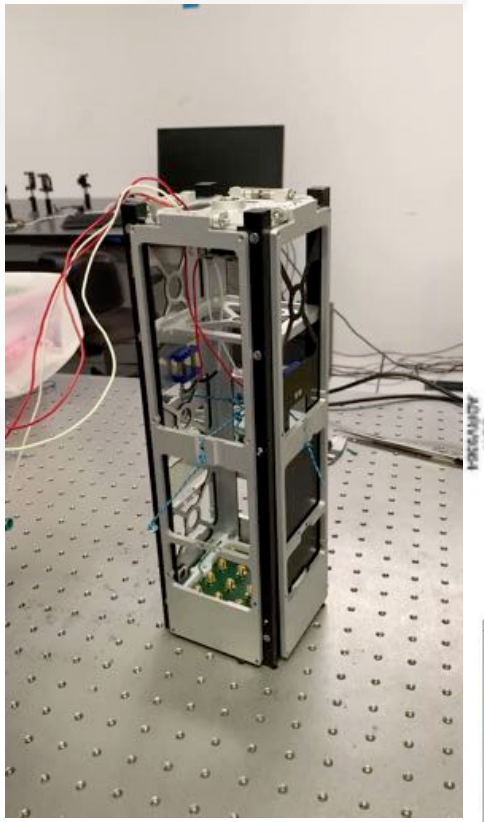


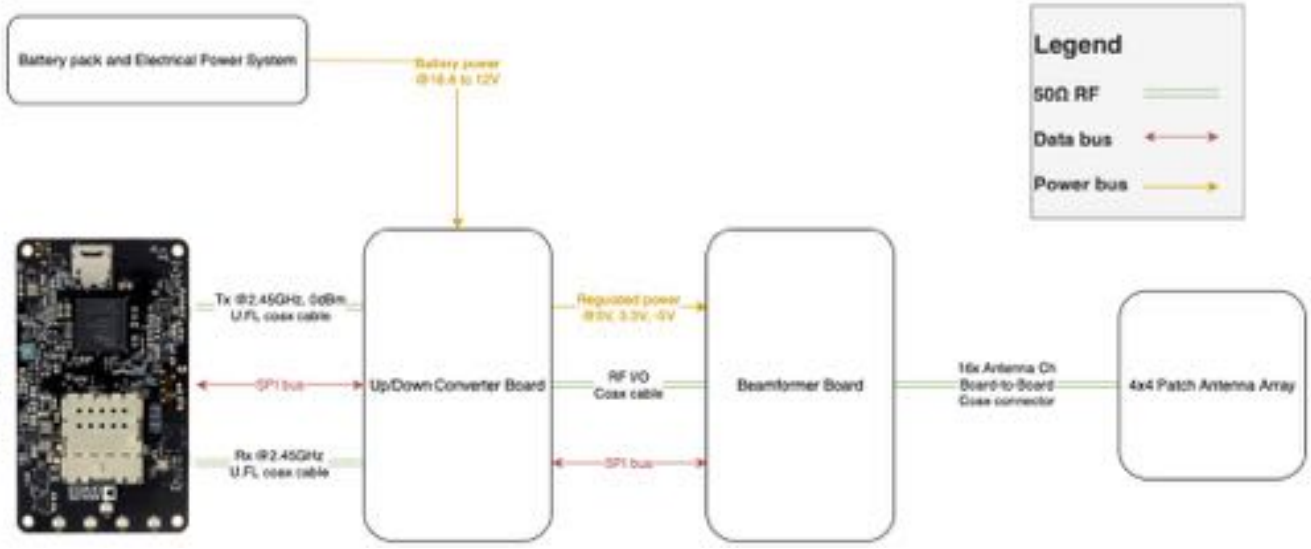
- A constellation of CubeSats?
- Each carrying a transmitter and a receiver?
- Other diagnostics?

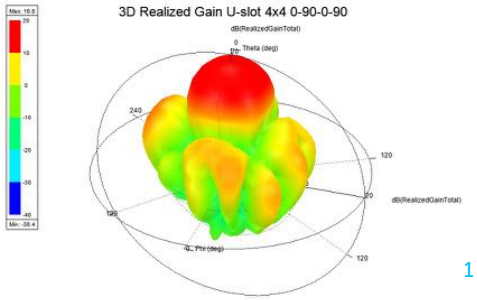
P. A. Bernhardt and C. L. Siefring, RADIO SCIENCE, **41**, RS5S23, doi:10.1029/2005RS003360, 2006

OUR FORAY INTO THE RADIO DOMAIN: A X-BAND RETRODIRECTED PHASED ARRAY SYSTEM

This is an UNDEGRADUATE project – funded by the NASA USIP program

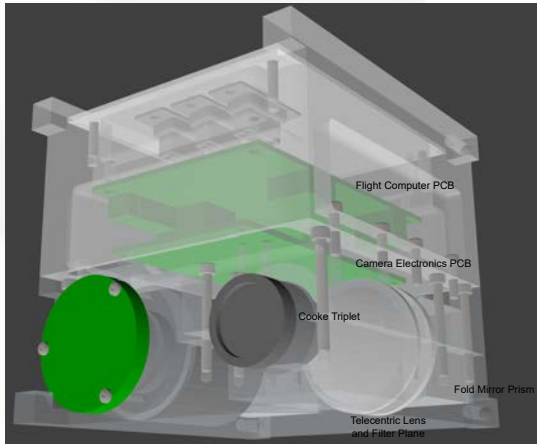


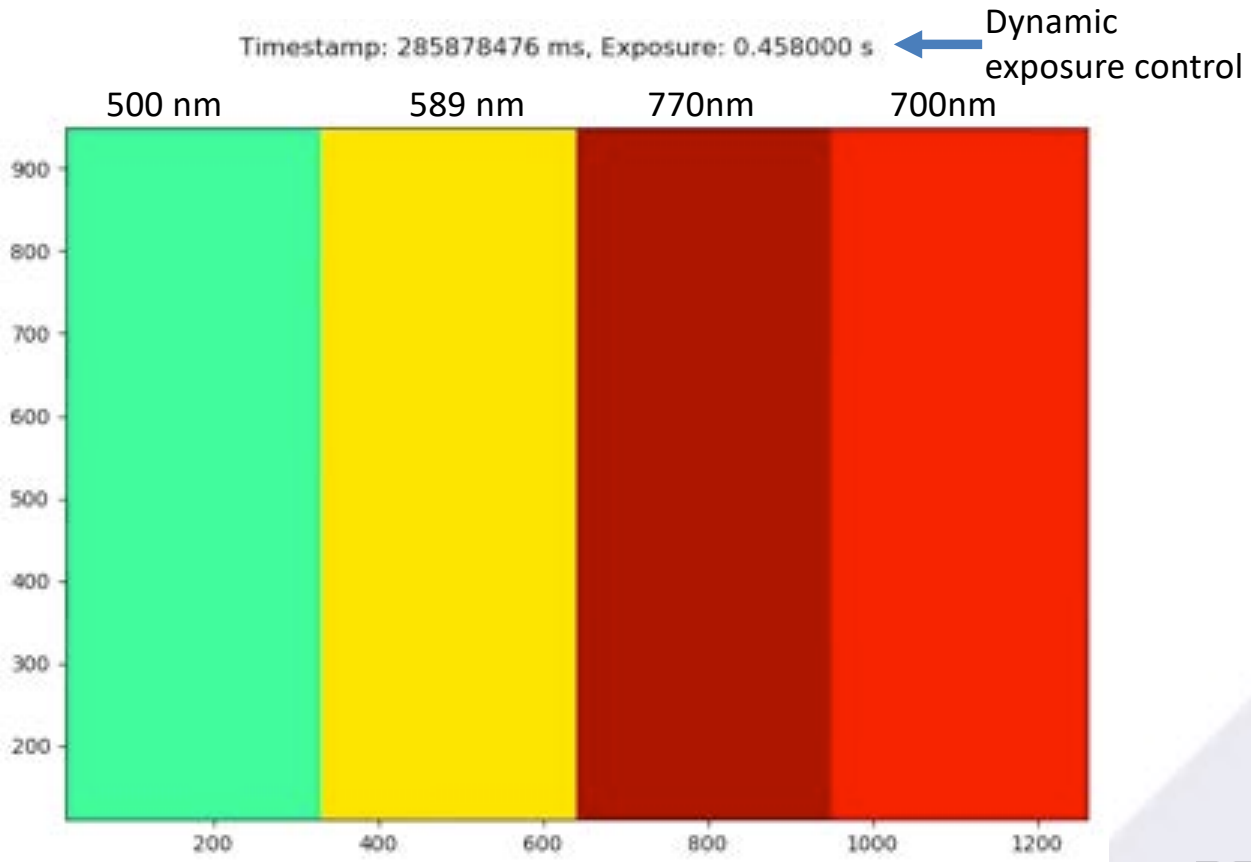




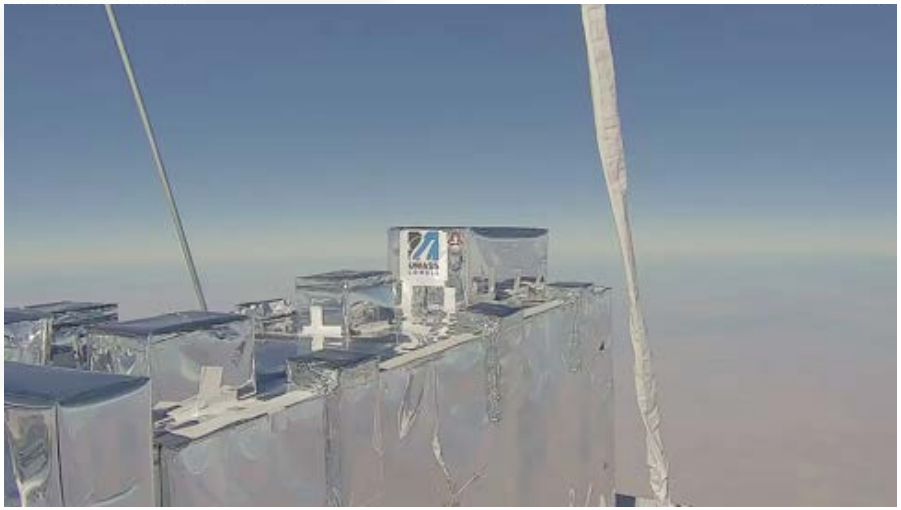
A 3U CubeSat
Student developed
Expected launch: May, 2017
Data rate: 20 – 50 Mbps
Uplink: UMass Lowell 1.7m
Downlink: Haystack 18 m

OPTICAL DIAGNOSTICS





ANOTHER POSSIBILITY (TO PROVE THAT I WAS LISTENING TO JIM)



20 Hour flight
220 Miles

SUMMARY

- We have some experience with radio experiments in space
- Recently we learned about some radio instrumentation
- A combination of optical and radio instruments could fit in a 3U CubeSats
- A constellation of CubeSats with these instruments will make significant contribution to solar-terrestrial relationships
- We look forward to working with you