SPORT

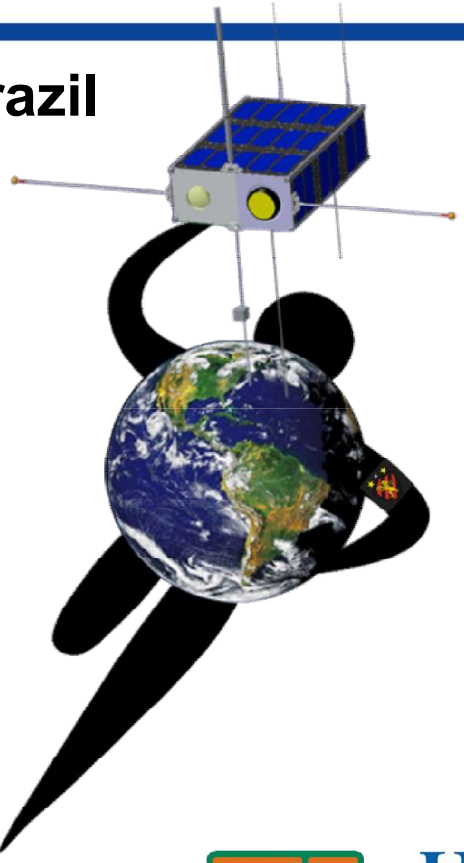
The Scintillation Prediction Observations Research Task: A Multinational Science Mission using a CubeSat

James Spann[1], Charles Swenson[2], Otavio Durão[3], Luis Loures[4], Rod Heelis[5], Rebecca Bishop[6], Guan Le[7], Mangalathayil Abdu [4], Linda Krause[1], Clezio Denardin[3], Lidia Shibuya[4], Joseph Casas[1], Shelia Nash-Stevenson[1], Polinaya Muralikrishana[3], Joaquim Costa[3], Marcelo Padua[3], Cristiano Wrasse[3], G. Fry[1]

[1] NASA/MSFC, [2] USU, [3] INPE, [4] [illegible]A, [5] UTD, [6] Aerospace, [7] NASA/GSFC

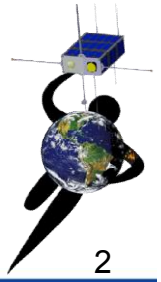
SPORT

- **Joint United States / Brazil Science Mission**

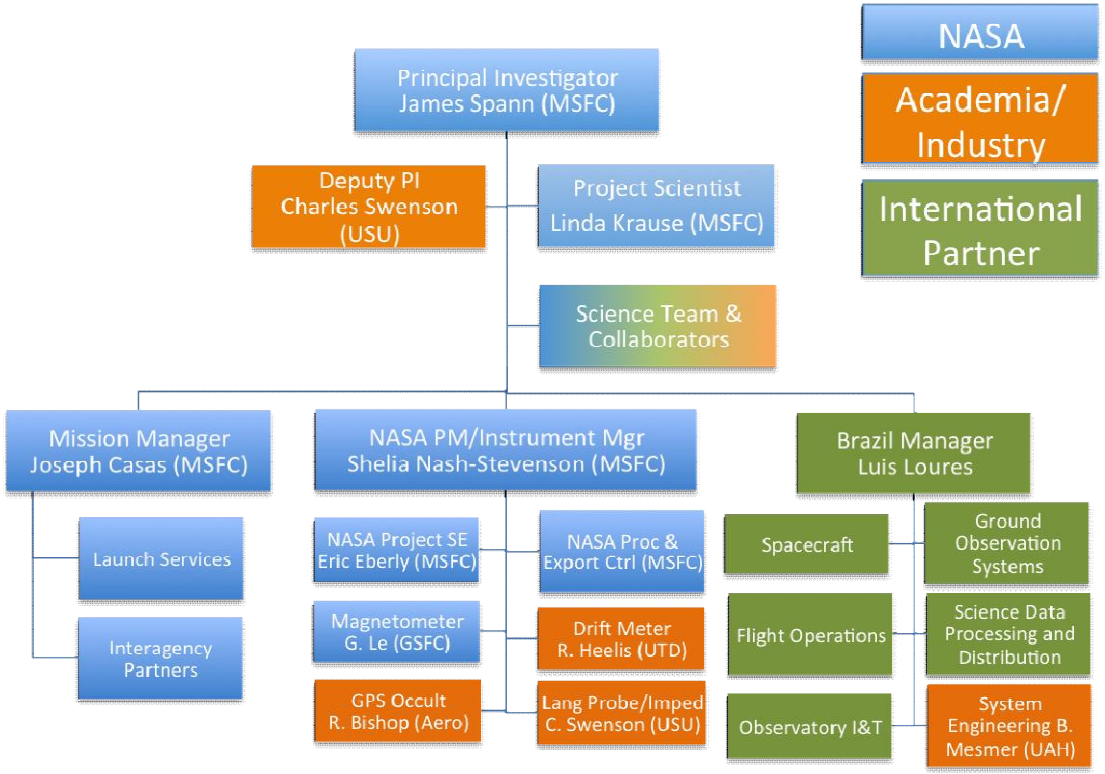


- **United States**
  - – Science Instruments
- **Brazil**
  - – Spacecraft
  - – Operations

Joint Science Data Analysis

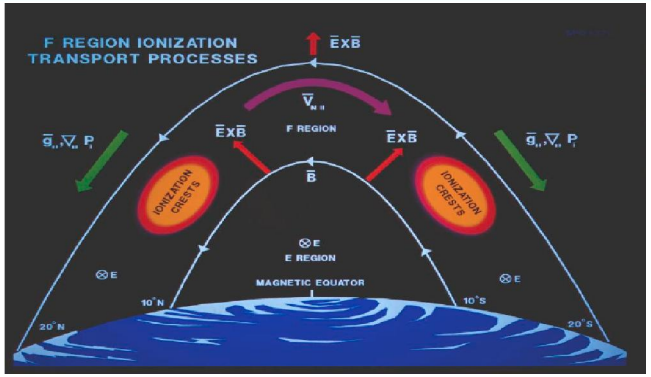


Organization



Science

- **The equatorial ionization anomalies**



Bela Fejer, The Equatorial Ionosphere: A Tutorial
CEDAR Meeting, Seattle Washington, 2015

- **Plasma Bubbles**

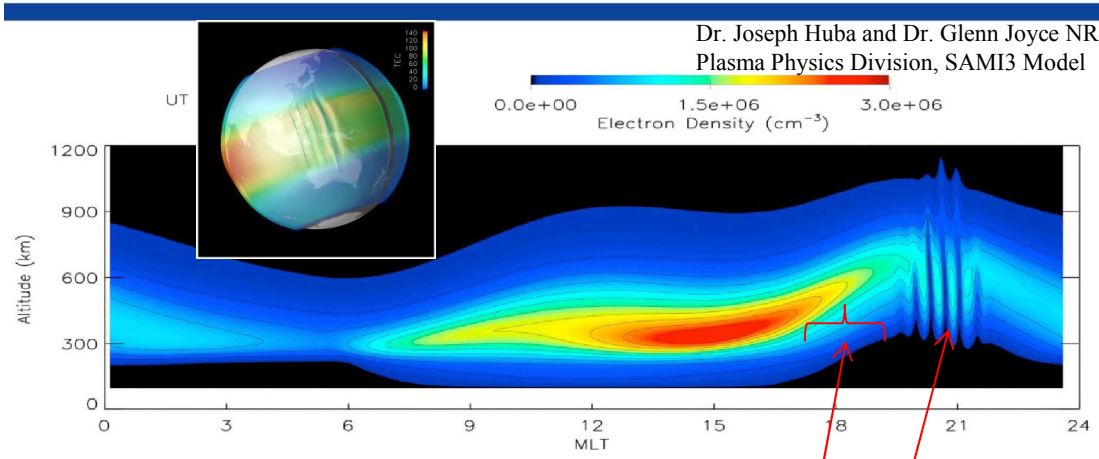
Why do bubbles form and sometimes not at Different Longitudes?

GUVI (Same Local Time, Different Longitudes)

Kil, Hyosub, et al. "Coincident equatorial bubble detection by TIMED/GUVI and ROCSAT-1." Geophysical research letters 31.3 (2004).

Plasma Bubbles

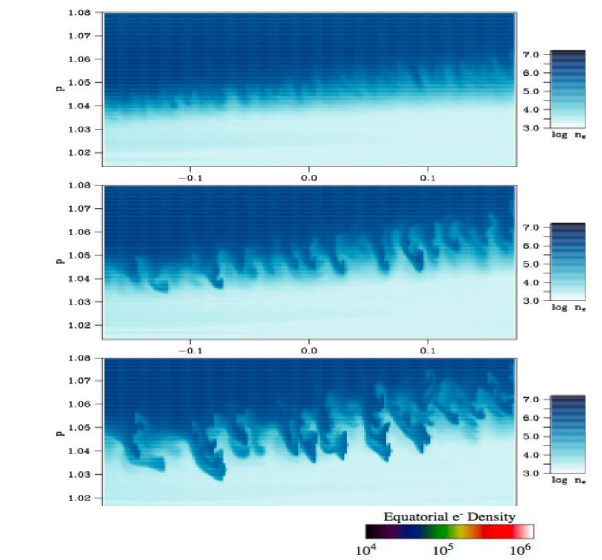
About 1.5 Hours to form a bubble

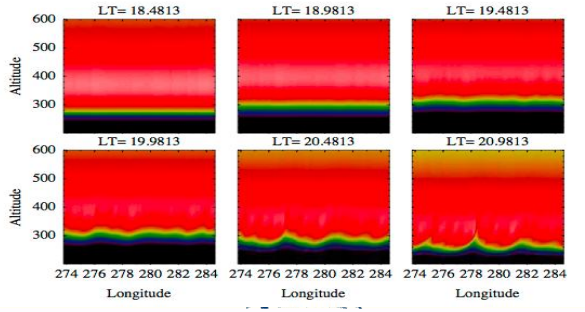


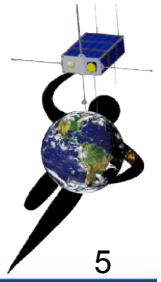
What is the state of the ionosphere here?

That leads to bubbles here ?

When bottom side seeding perturbations seem to always be present



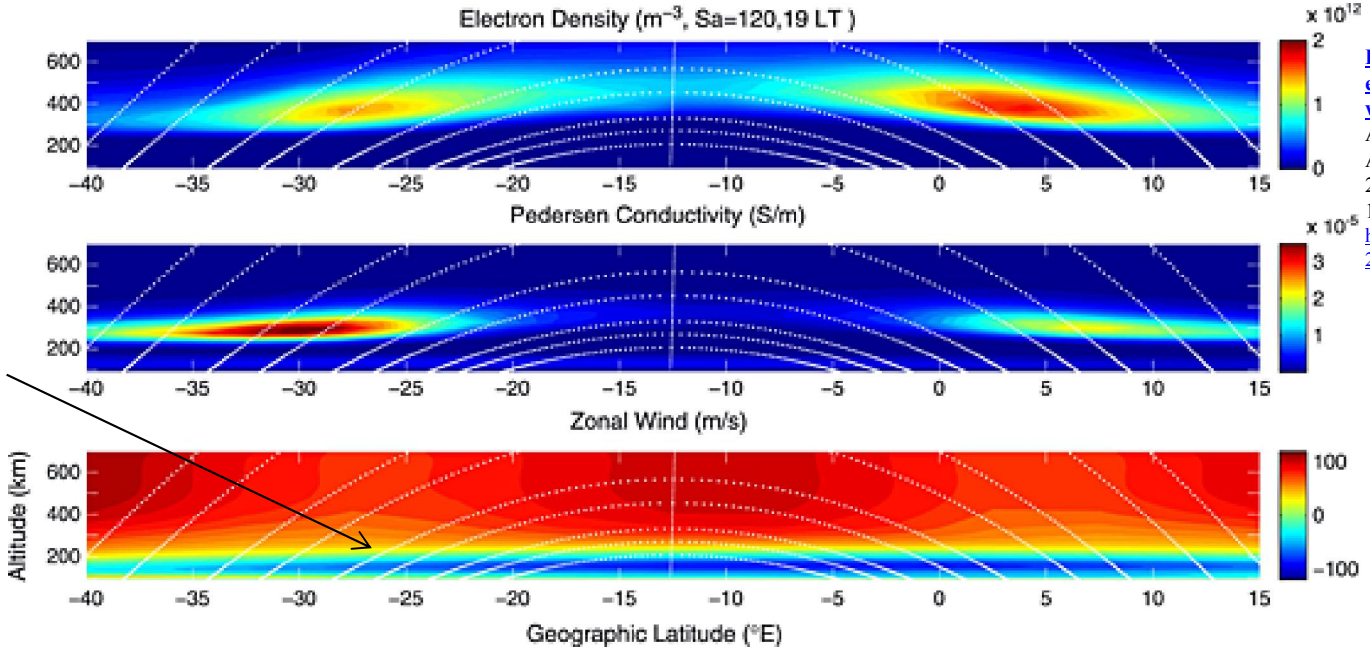




Retterer, J. M., and P. Roddy. "Faith in a seed: on the origins of equatorial plasma bubbles." Annales Geophysicae. Vol. 32. No. 5. Copernicus GmbH, 2014.

Neutral Winds and Conductivities

The importance of winds in different regions to triggering EPB particularly wind shears on the bottom of the ionosphere

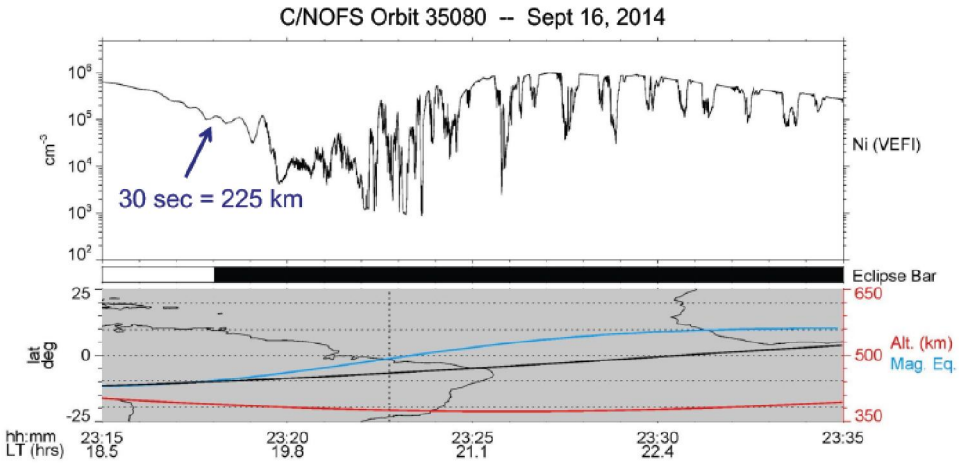


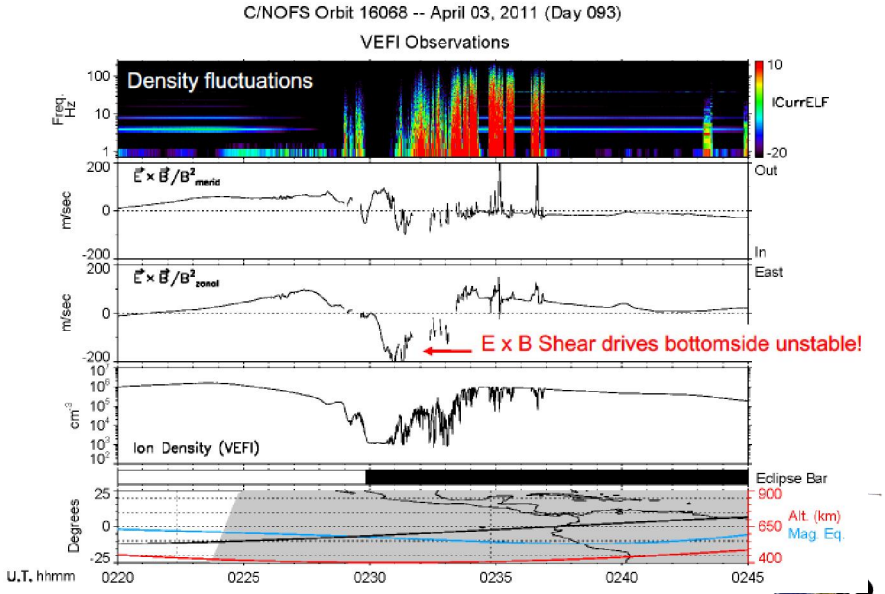
[Electrodynamics of the equatorial evening ionosphere: 1. Importance of winds in different regions](http://onlinelibrary.wiley.com/doi/10.1002/2014JA020934/full#jgra51625-fig-0001)
Authors A. D. Richmond, T.-W. Fang, A. Maute First Published: 7 March 2015 Vol: 120, Pages: 2118–2132 DOI: 10.1002/2014JA020934
http://onlinelibrary.wiley.com/doi/10.1002/2014JA020934/full#jgra51625-fig-0001

C/NOFS Observations

Pfaff, R. F., et al. (2017), Measurement of reversals in the horizontal plasma drifts below the elevated, low latitude F-region at sunset and their implication for the creation of large scale plasma undulations and spread-F irregularities, Journal of Geophysical Research.

Large Scale "Undulations" (100's of km) at Lower Ledge of Ionosphere at Sunset

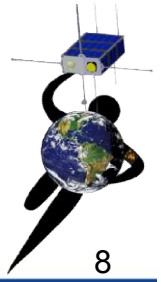




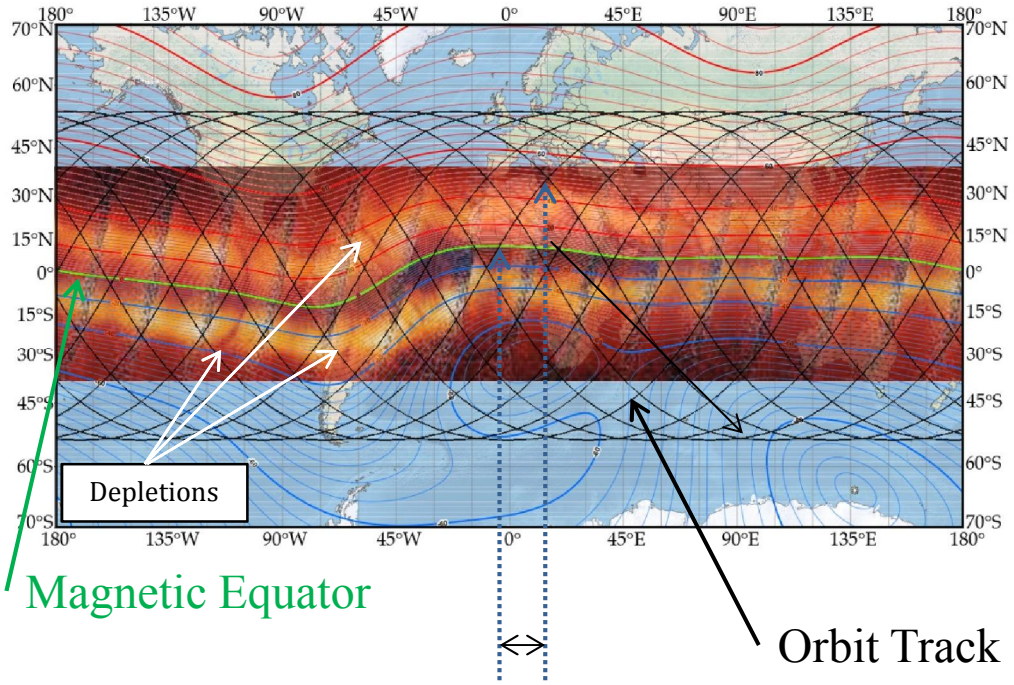
Science Goals

1) What is the state of the ionosphere that gives rise to the growth of plasma bubbles that extend into and above the F-peak at <u>different longitudes</u>?

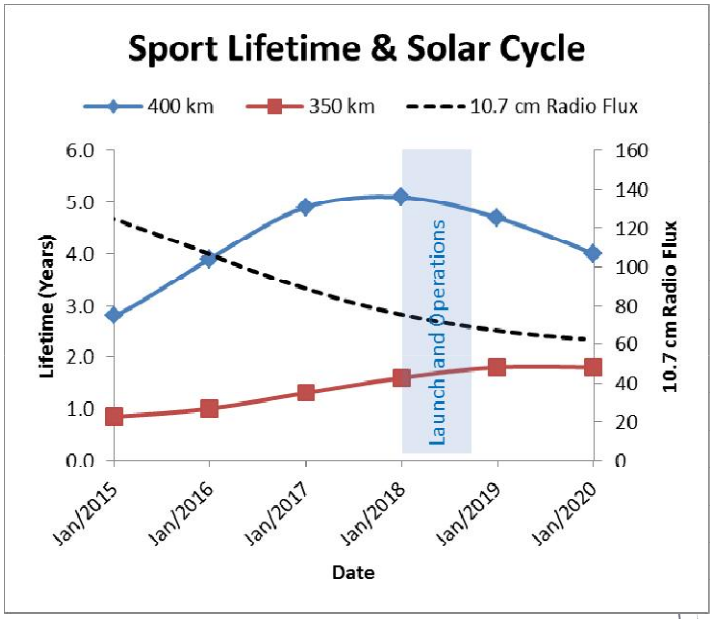
2) How are plasma irregularities at <u>satellite altitudes</u> related to the radio scintillations observed passing through these regions?



SPORT Mission and ORBIT



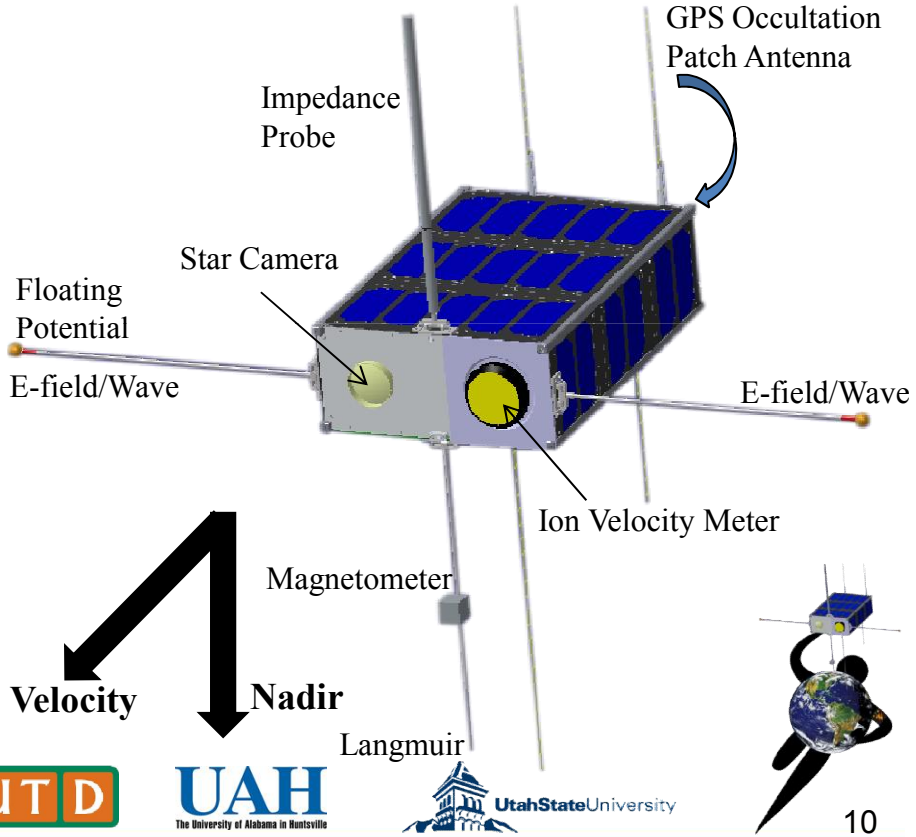
20° latitude or 1.3 hr LT across an EIA arc



Launch from ISS, 400 km Alt
~3 year life

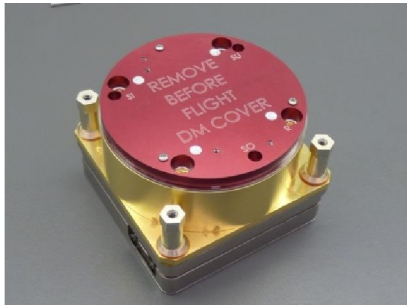
Measurement and Instrumentation

Measurement	Instruments
Plasma motion	RPA/Drift meter
Plasma density / density profiles	GPS Occultation
Small scale structures and waves	Langmuir
Scintillation Index	Impedance
Magnetic field structure	E-Field
Plasma temperature	Magnetometer

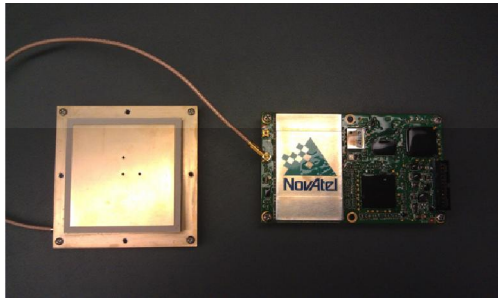


SPORT Instruments

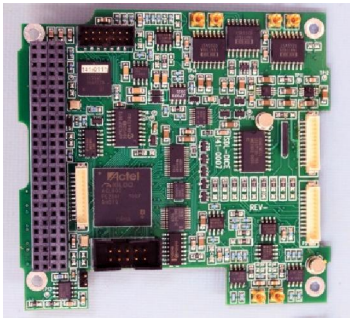
Ion Velocity Meter
UTD

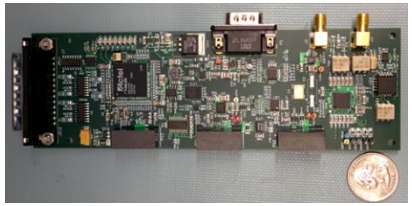


GPS Occultation
Receiver
Aerospace

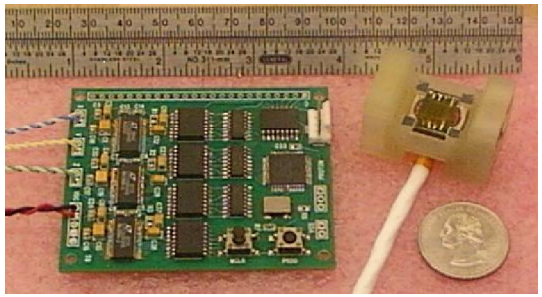


Langmuir, E-field,
Impedance Probe
USU

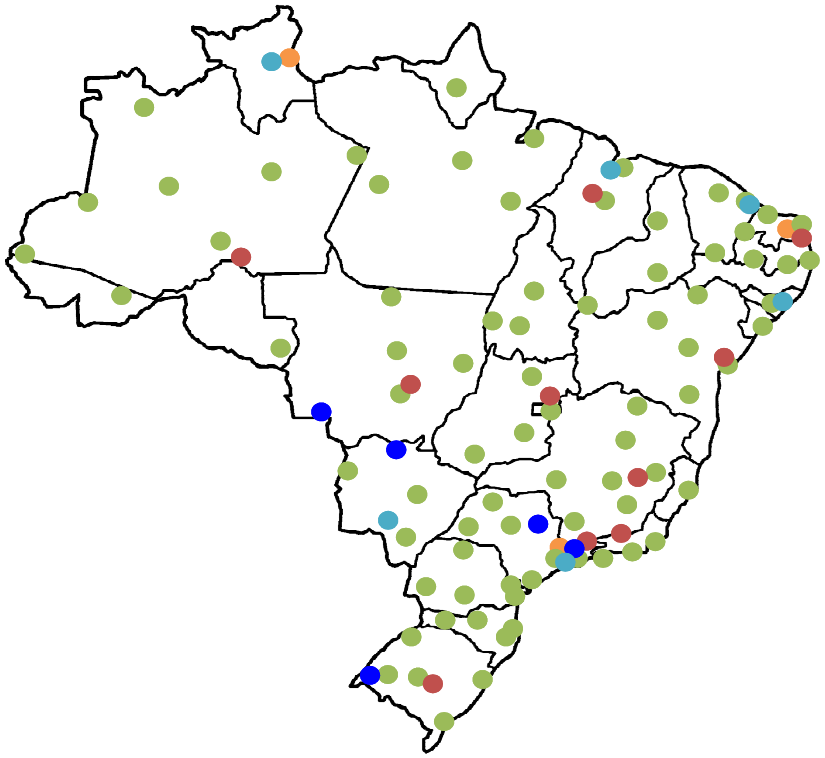




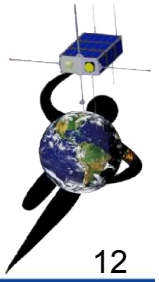
Fluxgate Magnetometer
NASA Goddard



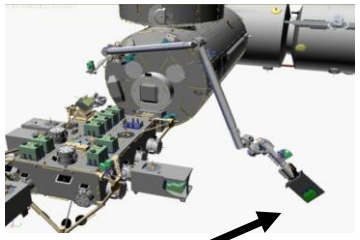
Ground Network



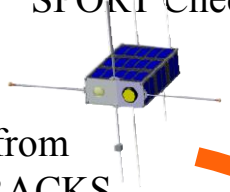
- Magnetometers
- Scintillation sensors
- TEC stations
- Imagers
- Ionosondes



Mission ConOps

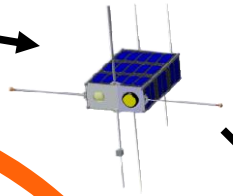


SPORT Checkout



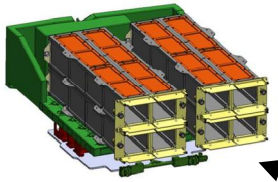
SPORT Operations

On-orbit Operations
(> 12 months)

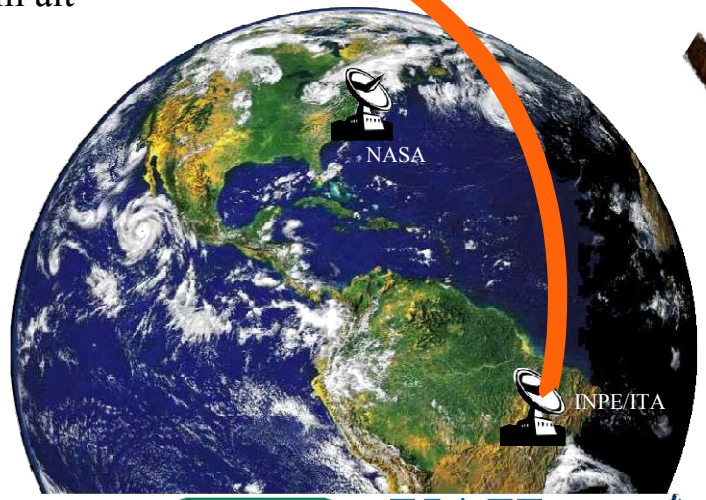


Deploy from
NANORACKS
400 km alt

Installation



Disposal
300 km alt



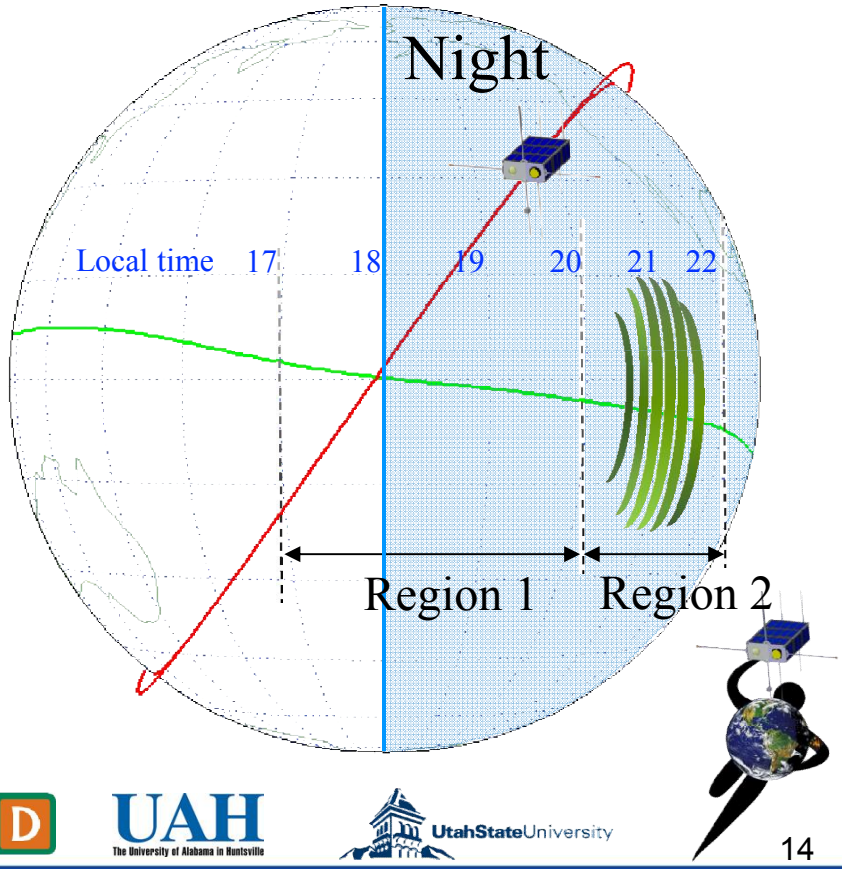
Soft
Package

Launch

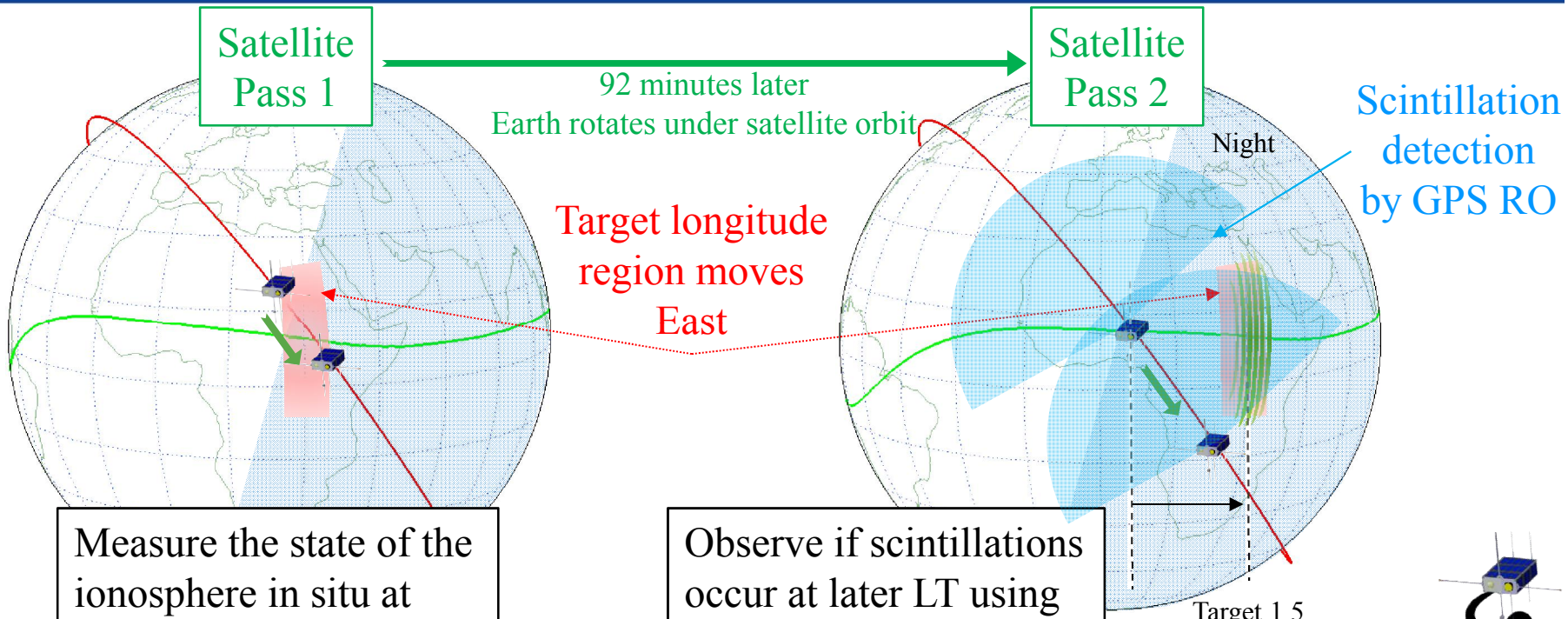
Images: Charlie Gray

SPORT Methodology

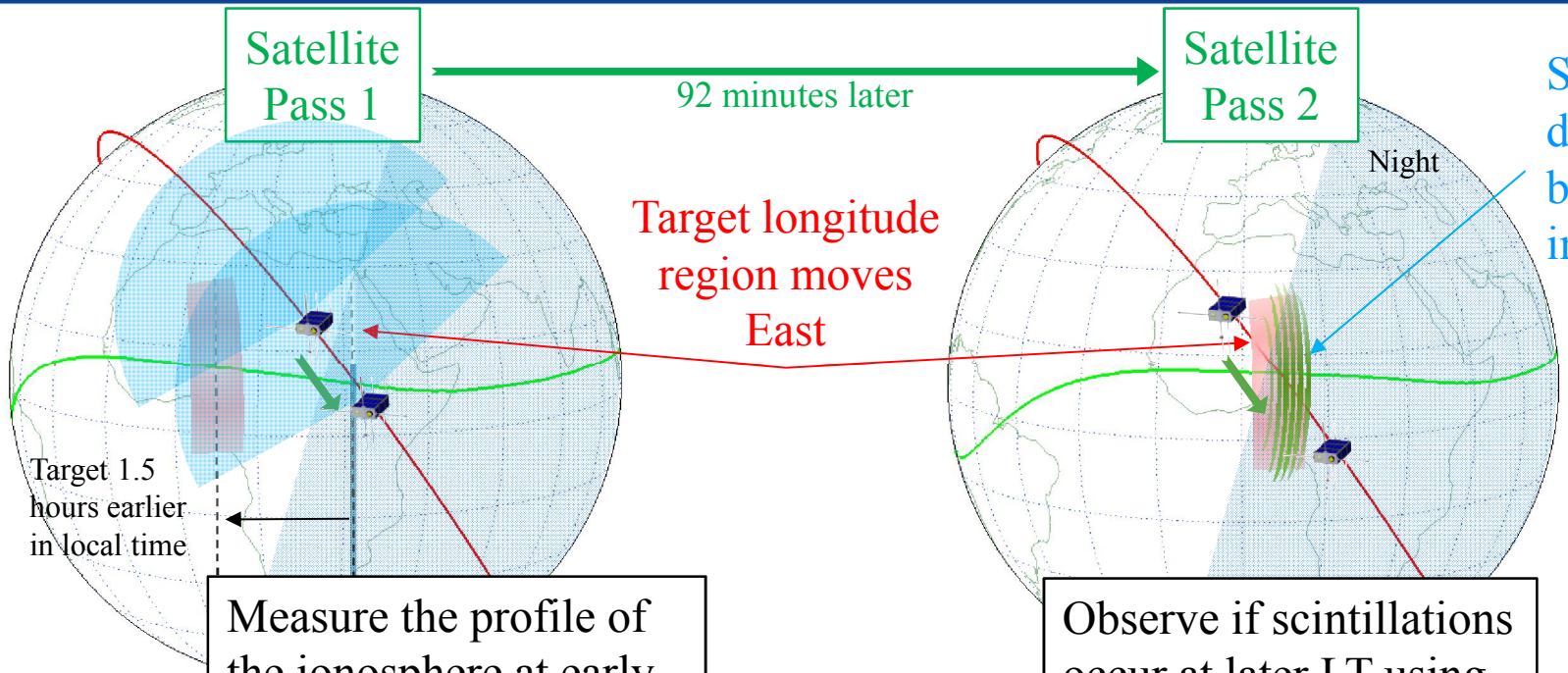
- **The state of the ionosphere at early local times is related to the occurrence of scintillations at later local times.**
  - How does this relation vary with longitude?
- **Use case studies when SPORT ascending or descending node is within 17 to 24 LT sector.**
- **Examine ~15 degree longitude sectors**

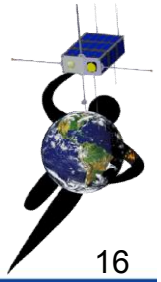


Methodology Strategy 1



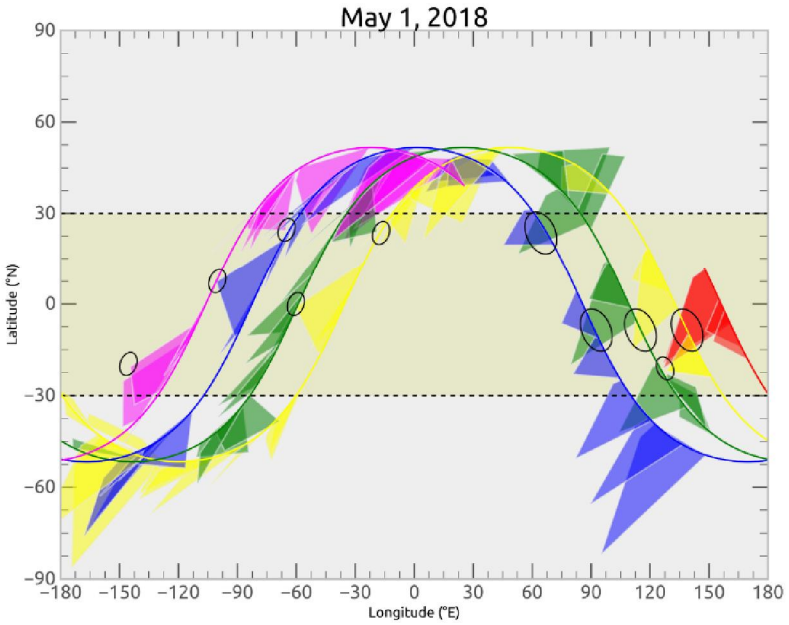
Methodology Strategy 2





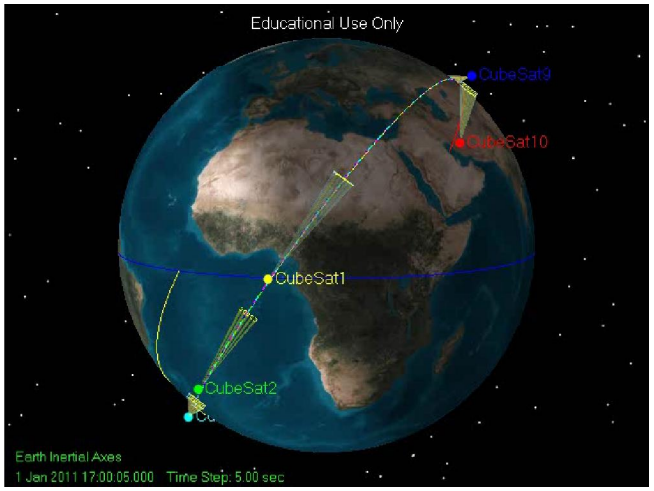
How often are ideal occultation

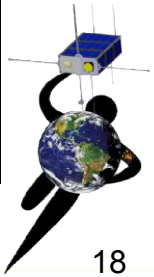
- **Study using SPORT in ISS orbit.**
- Over one orbit in the region within ±30°
  - ~2 profiles over the previous orbit traces
  - ~2 profiles occur over successive orbit traces.



Conclusions

- **CubeSat missions can be developed with a full/regular suite of science instruments**
- **Mid inclination ISS orbits allow for the deconvolution of local time and longitude at low-latitudes**
- **A String of pearls mission to increase time resolution**





Questions?