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# SPORT

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

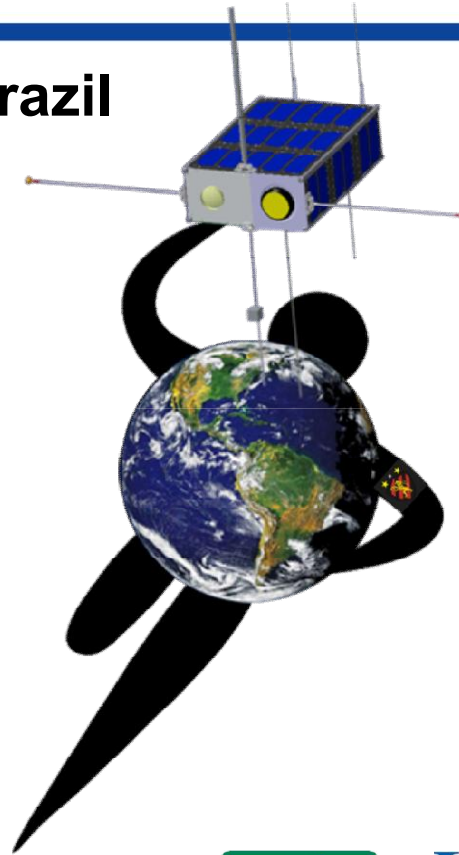
James Spann<sup>1</sup>, Charles Swenson<sup>2</sup>, Otavio Durão<sup>3</sup>, Luis Loures<sup>4</sup>, Rod Heelis<sup>5</sup>, Rebecca Bishop<sup>6</sup>, Guan Le<sup>7</sup>, Mangalathayil Abdu<sup>4</sup>, Linda Krause<sup>1</sup>, Clezio Denardin<sup>3</sup>, Lidia Shibuya<sup>4</sup>, Joseph Casas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

<sup>1</sup> NASA/MSFC, <sup>2</sup> USU, <sup>3</sup> INPE, <sup>4</sup> UTA, <sup>5</sup> UTD, <sup>6</sup> Aerospace, <sup>7</sup> NASA/GSFC



# SPORT

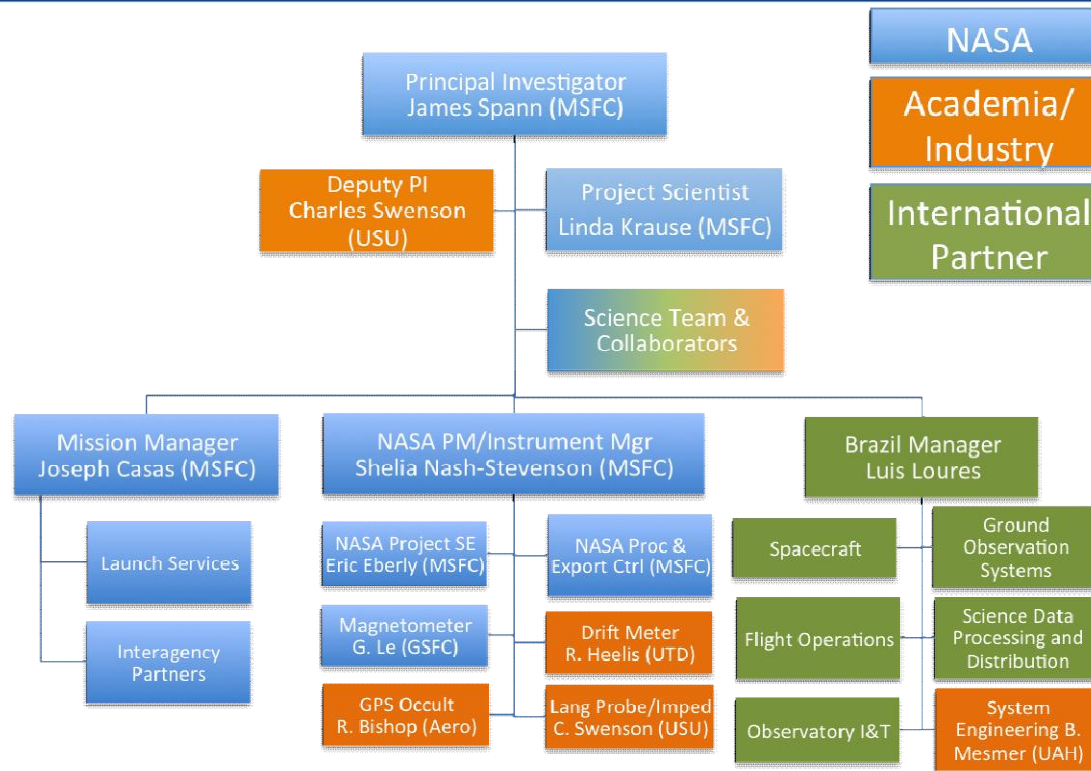
- **Joint United States / Brazil Science Mission**
- **United States**
  - Science Instruments
- **Brazil**
  - Spacecraft
  - Operations



**Joint Science Data Analysis**

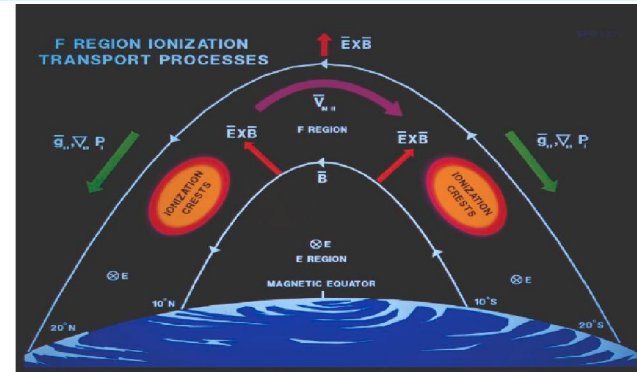


# Organization



# Science

- The equatorial ionization anomalies



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

- Plasma Bubbles

GUVI (Same Local Time, Different Longitudes)

Why do bubbles form and sometimes not at Different Longitudes?

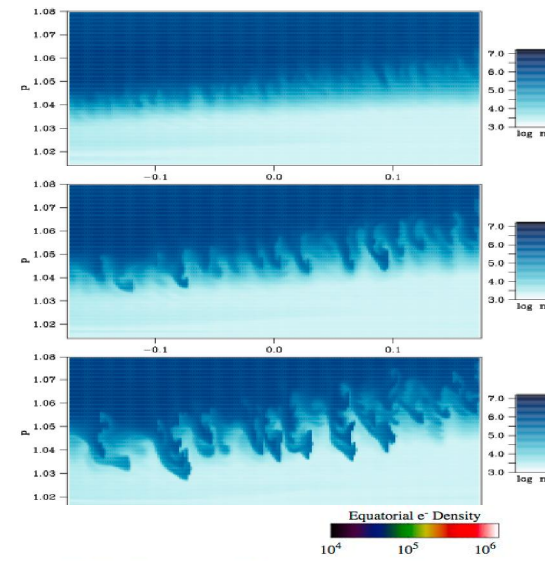
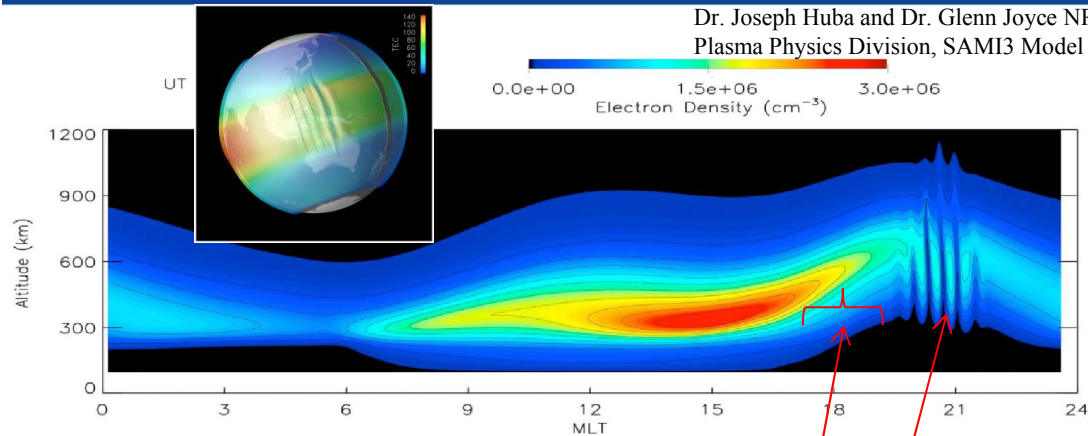


Kil, Hyosub, et al. "Coincident equatorial bubble detection by TIMED/GUVI and ROCSAT-1." Geophysical research letters 31.3 (2004).



# Plasma Bubbles

About 1.5 Hours to form a bubble

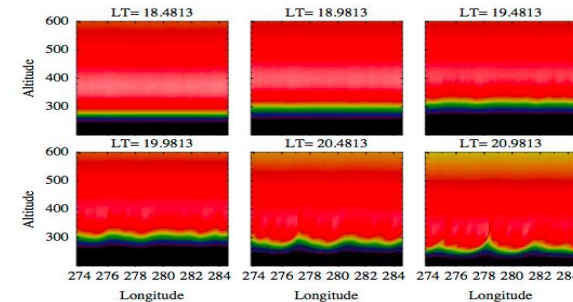


What is the state of the ionosphere here?

That leads to bubbles here ?

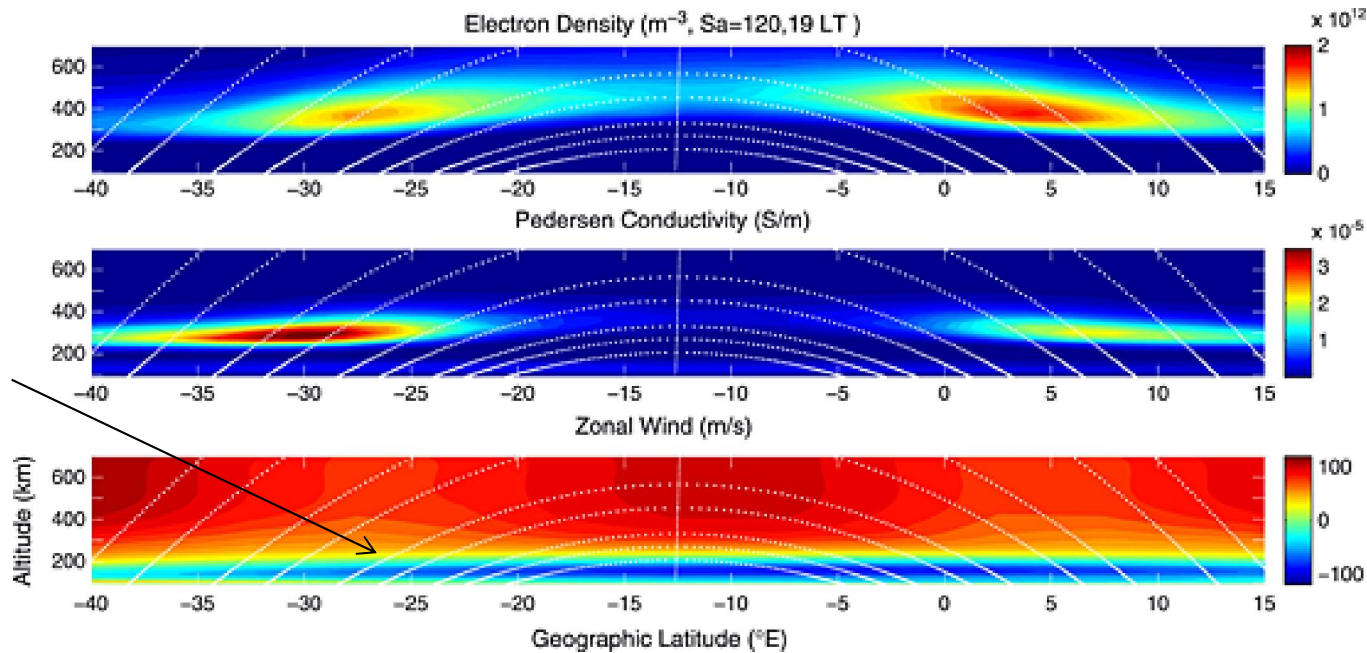
When bottom side seeding perturbations seem to always be present

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: I. Importance of winds in different regions](#)

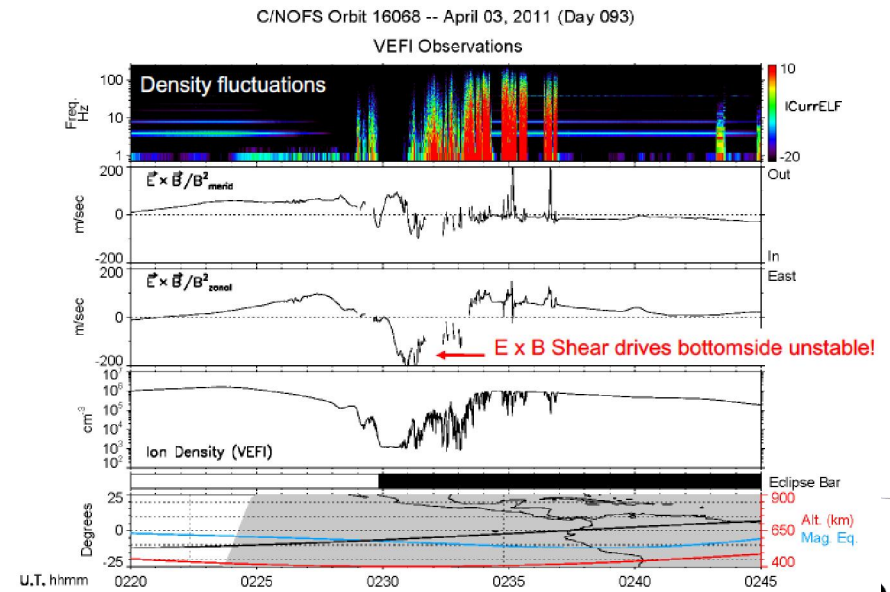
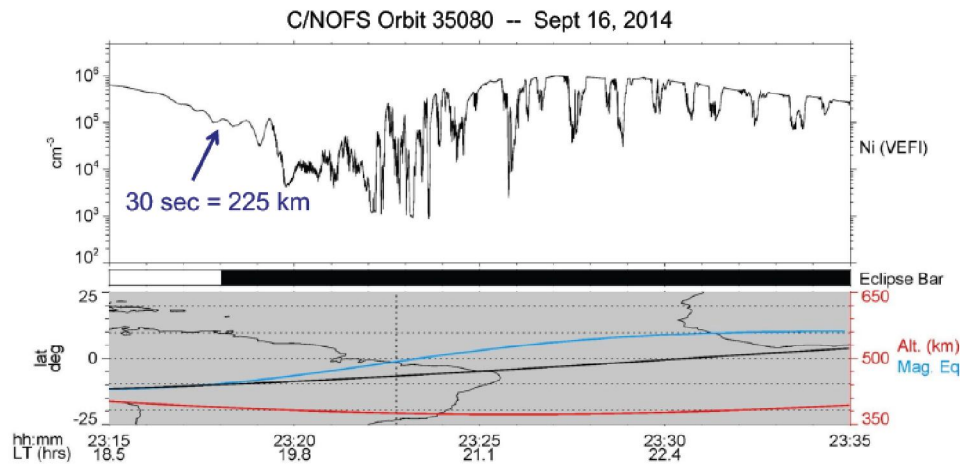
Authors A. D. Richmond, T.-W. Fang, A. Maute First Published: 7 March 2015 Vol: 120, Pages: 2118–2132 DOI: 10.1002/2014JA020934 <http://onlinelibrary.wiley.com/doi/10.1002/2014JA020934/full#jgra51625-fig-0001>



# 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

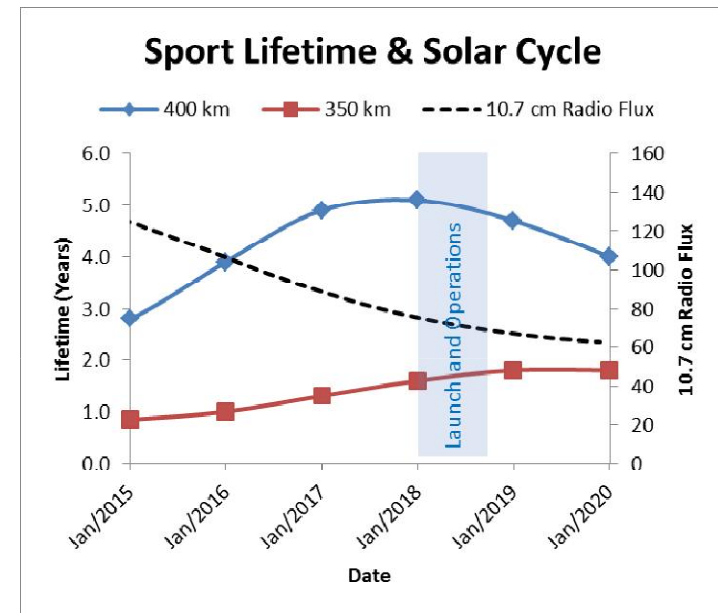
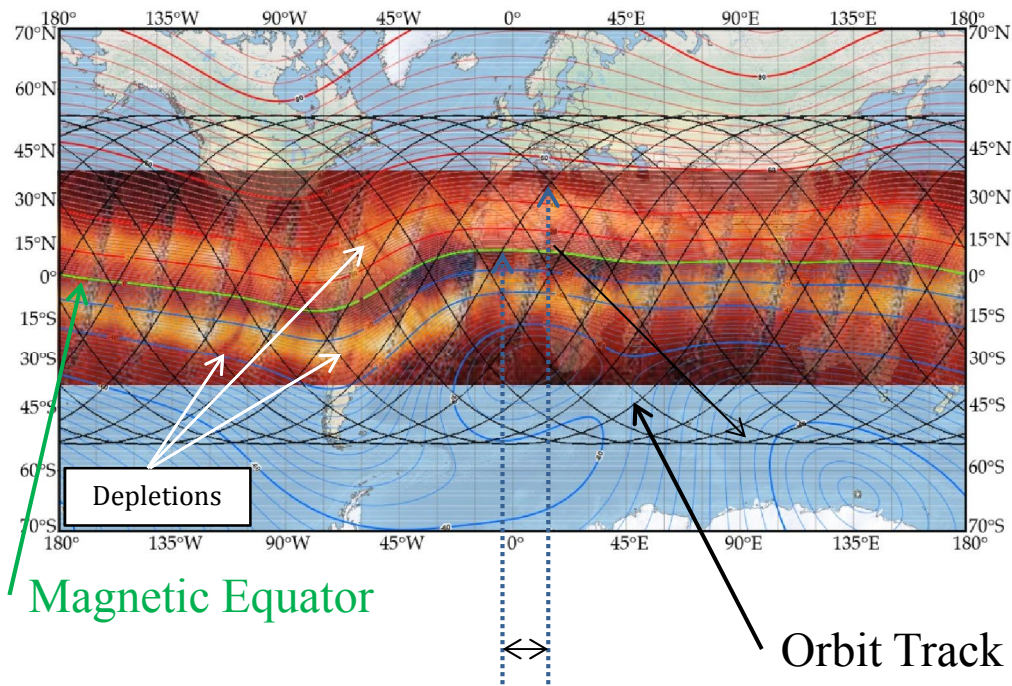
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- 1) What is the state of the ionosphere that gives rise to the growth of plasma bubbles that extend into and above the F-peak at different longitudes?
- 2) How are plasma irregularities at satellite altitudes related to the radio scintillations observed passing through these regions?





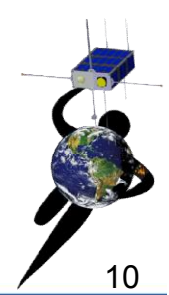
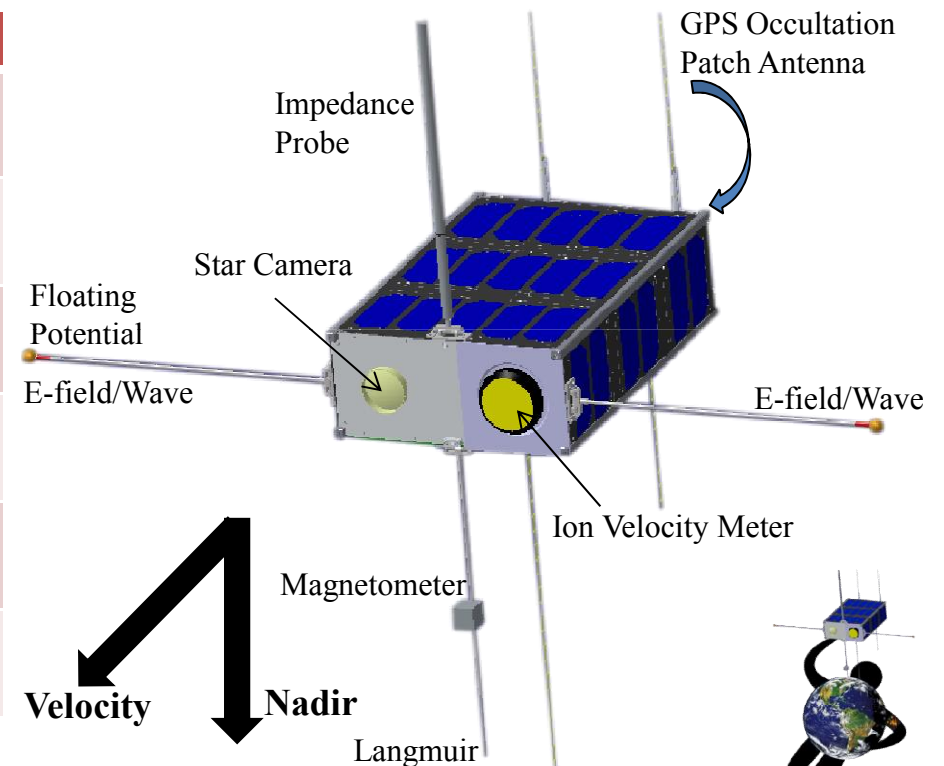
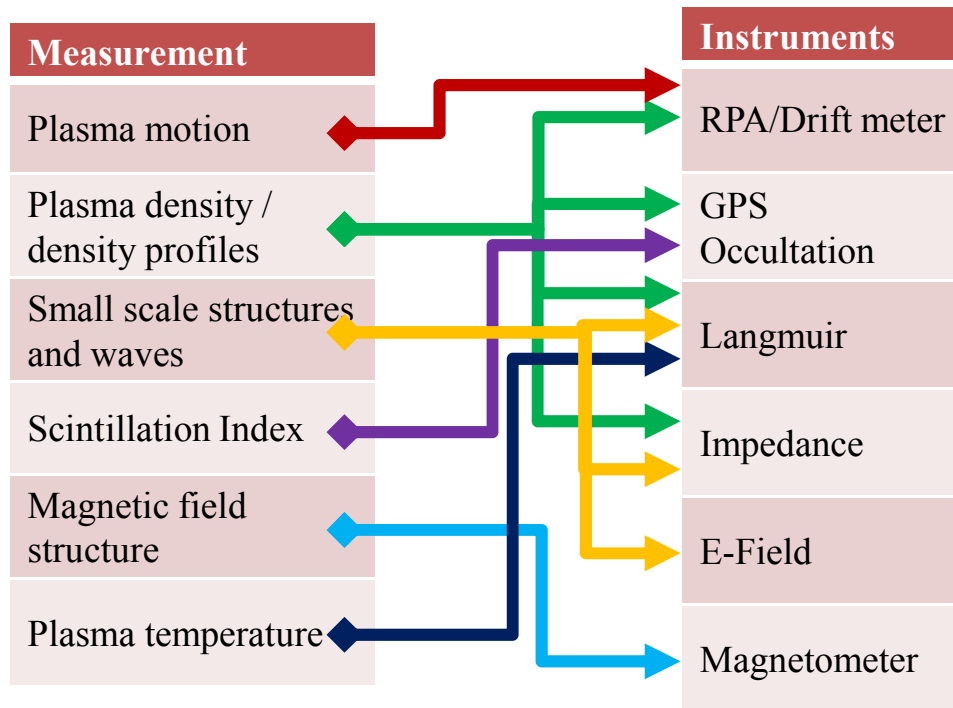
# SPORT Mission and ORBIT



Launch from ISS, 400 km Alt  
~3 year life

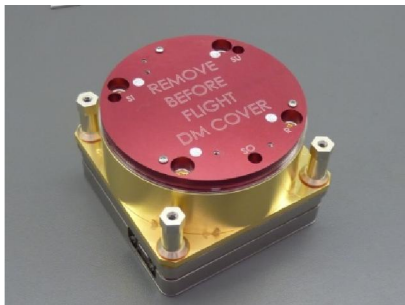


# Measurement and Instrumentation

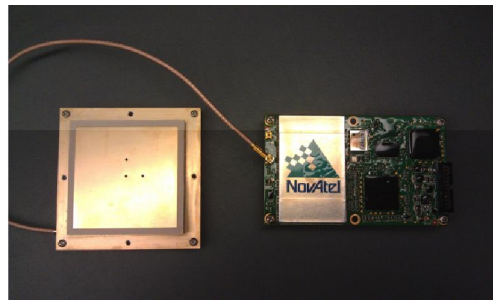


# SPORT Instruments

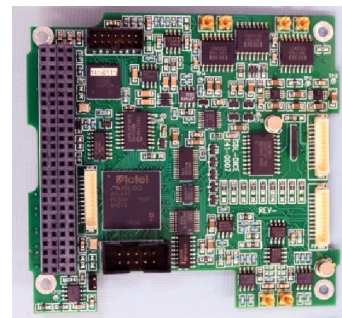
Ion Velocity Meter  
UTD



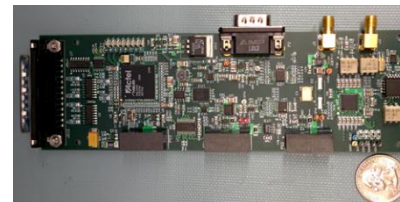
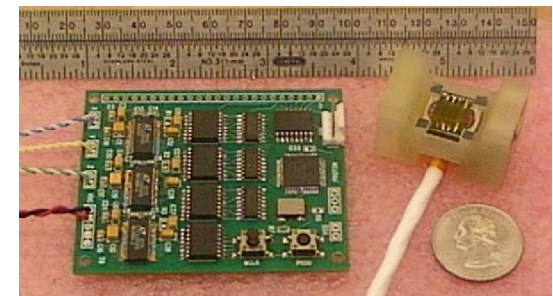
GPS Occultation  
Receiver  
Aerospace



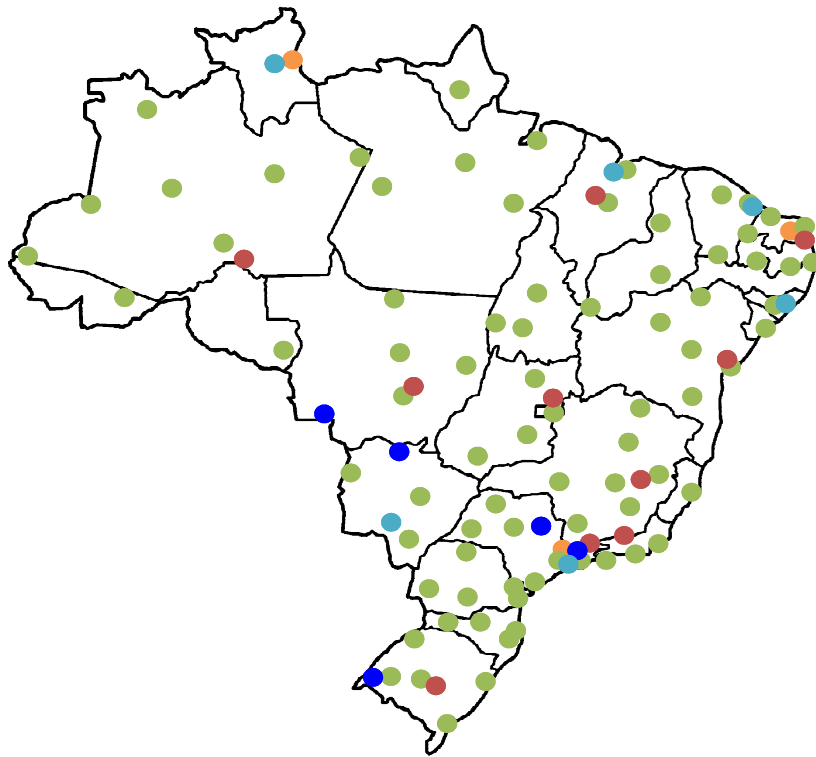
Langmuir, E-field,  
Impedance Probe  
USU



Fluxgate Magnetometer  
NASA Goddard



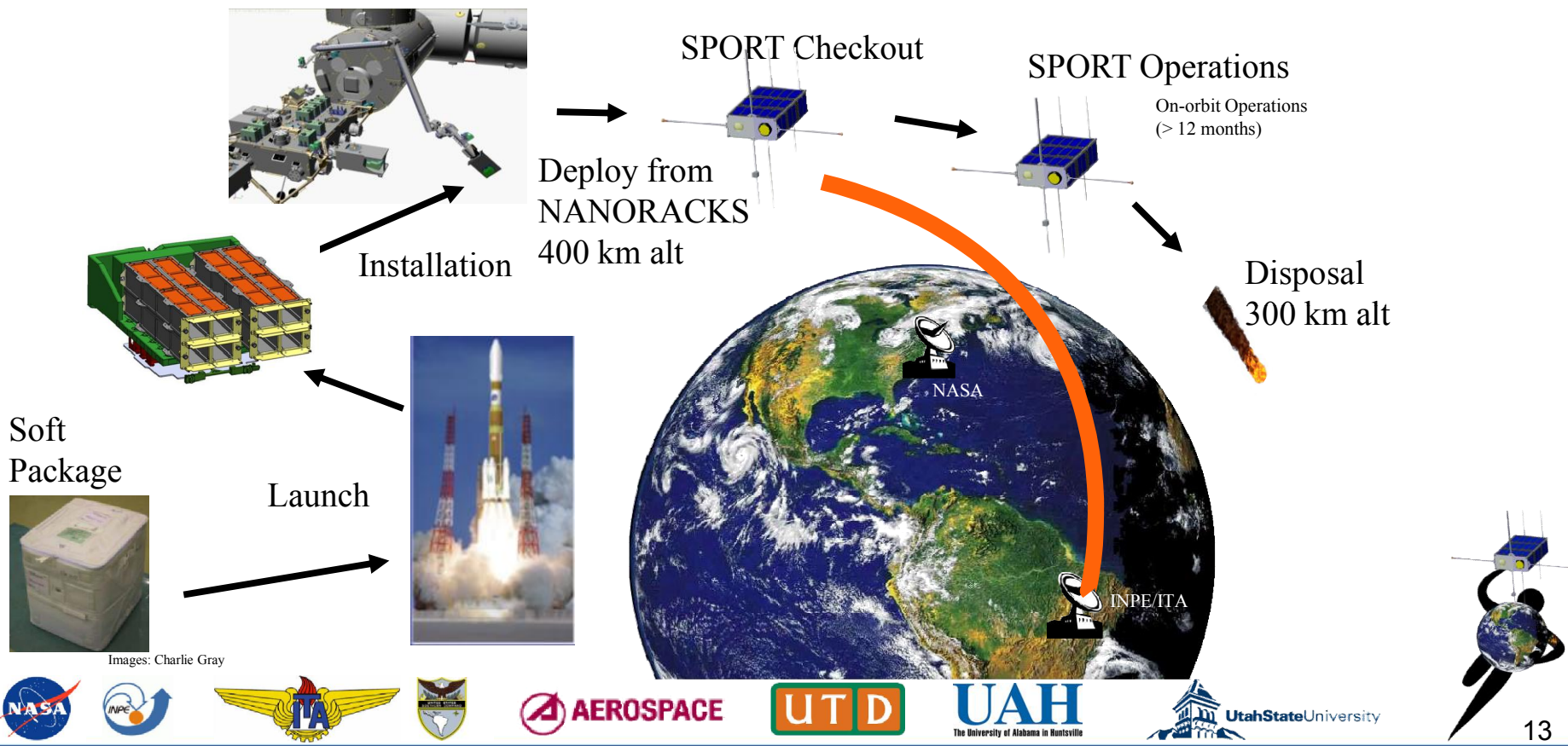
# Ground Network



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



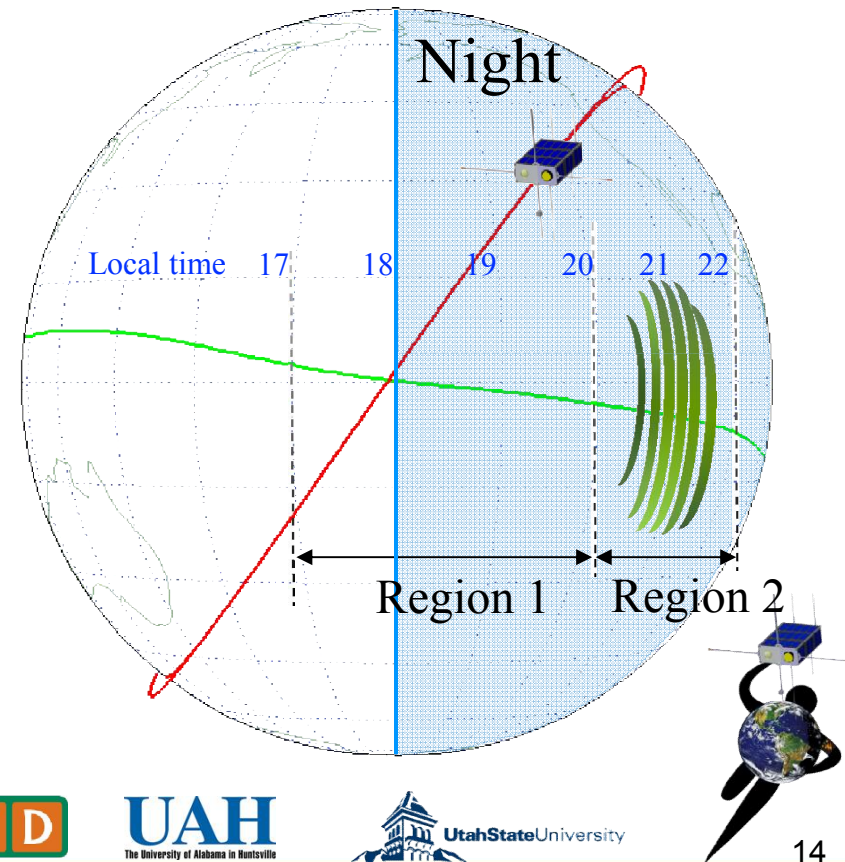
# Mission ConOps



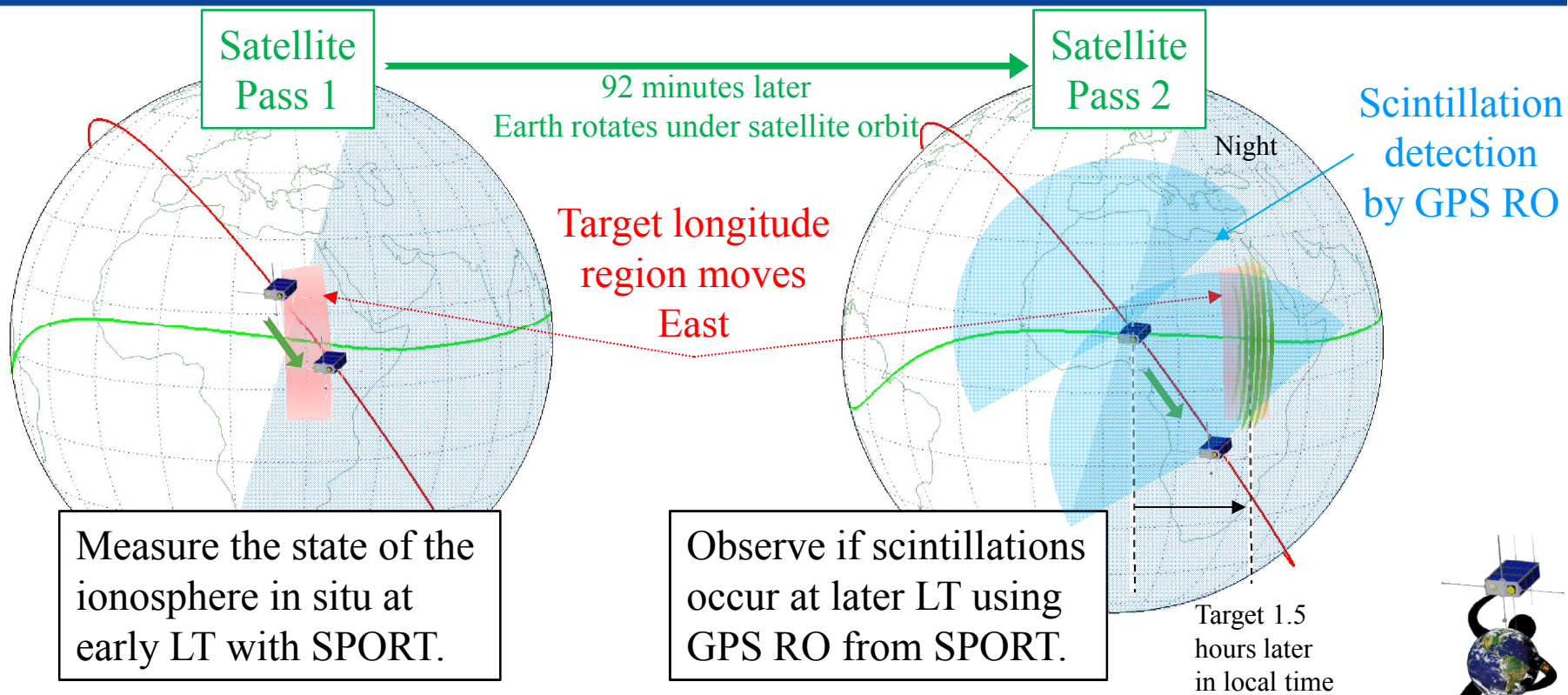
Images: Charlie Gray

# SPORT Methodology

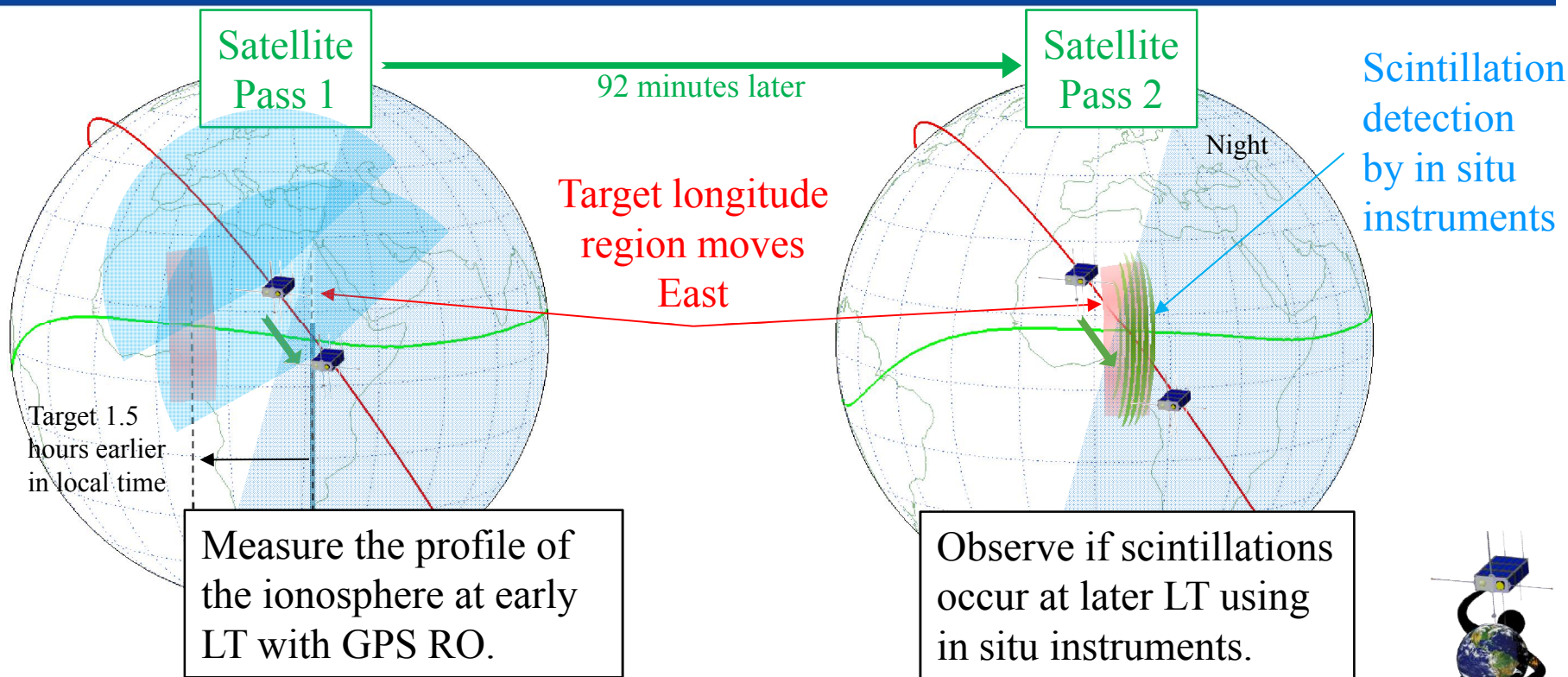
- The state of the ionosphere at early local times is related to the occurrence of scintillations at later local times.
  - How does this relation vary with longitude?
- Use case studies when SPORT ascending or descending node is within 17 to 24 LT sector.
- Examine ~15 degree longitude sectors



# Methodology Strategy 1



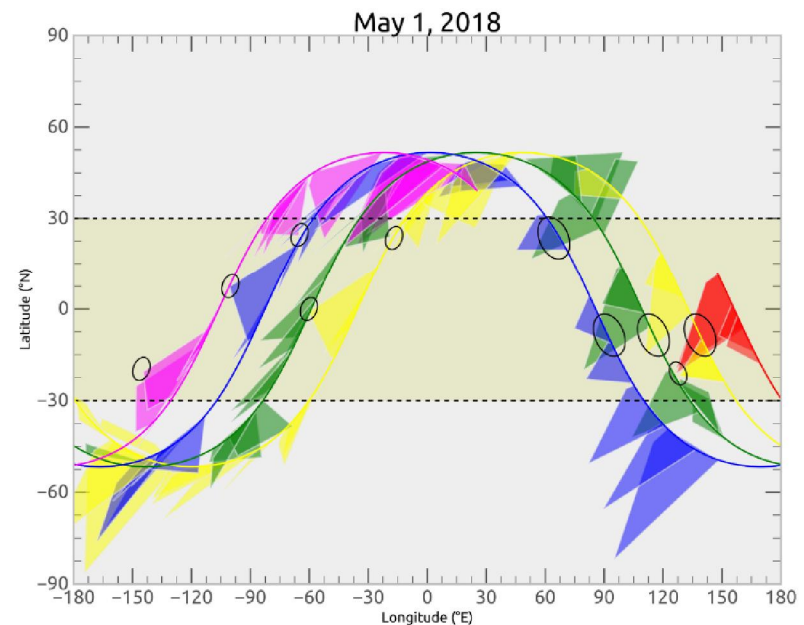
# Methodology Strategy 2





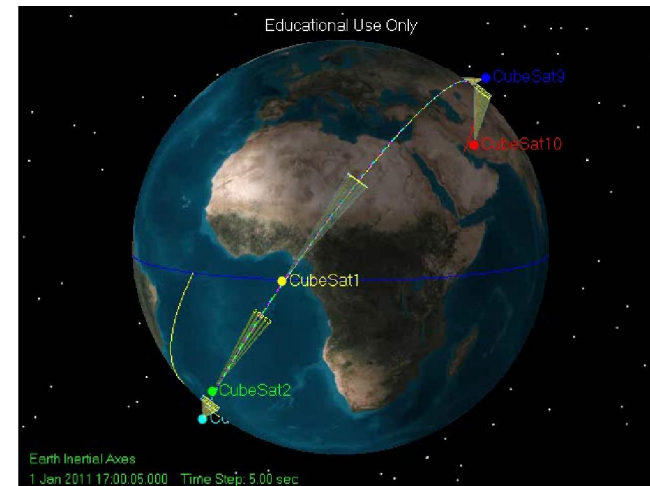
# How often are ideal occultation

- Study using SPORT in ISS orbit.
- Over one orbit in the region within  $\pm 30^\circ$ 
  - ~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?

