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# SPORT

## The Scintillation Prediction Observations Research Task: An International Science Mission using a CubeSat

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# SPORT

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

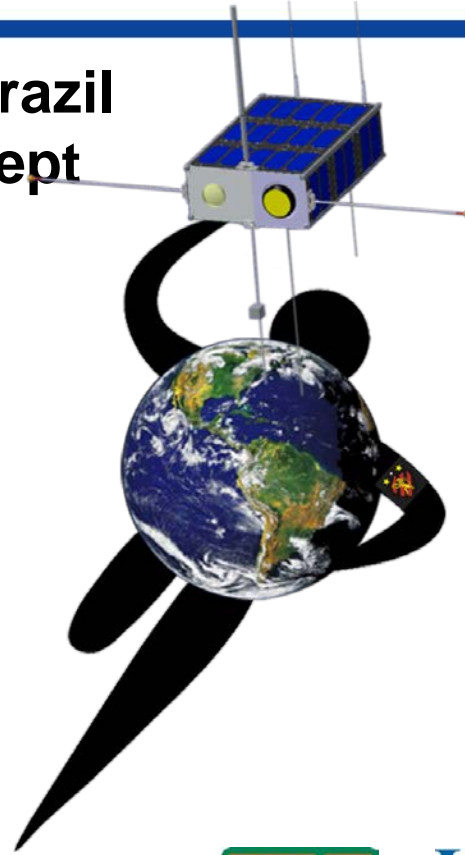
- **United States**

- Science Instruments

- **Brazil**

- Spacecraft

- Operations

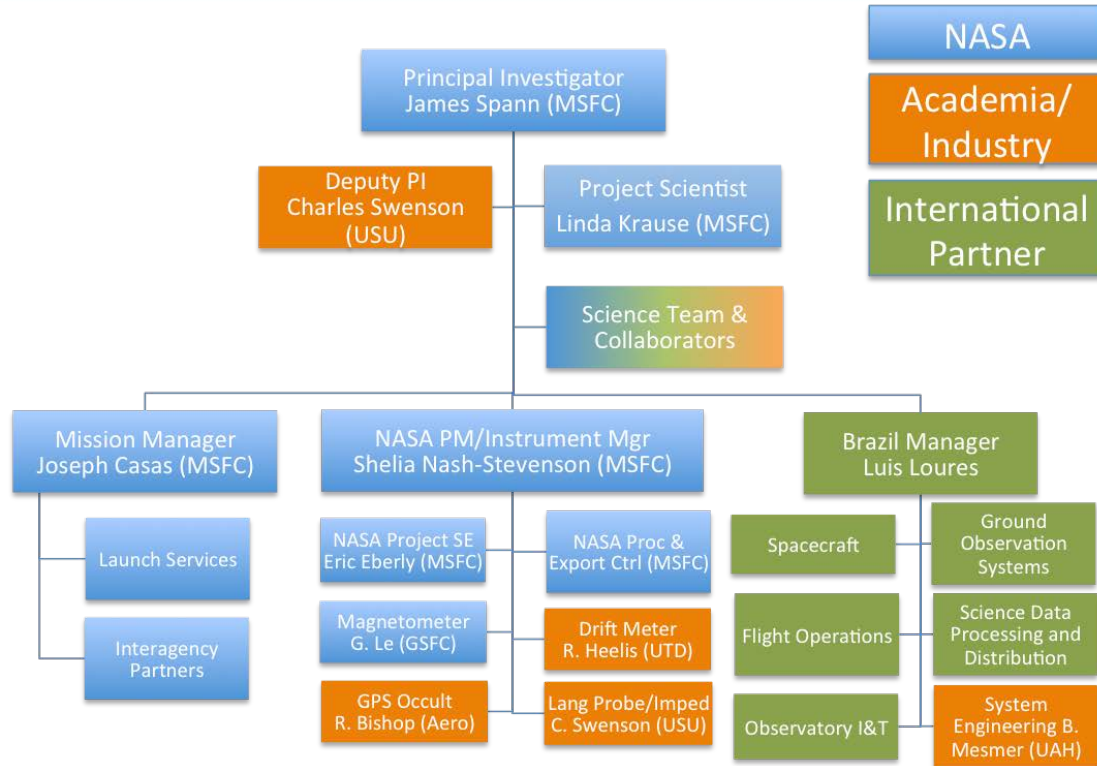


**Joint Science Data Analysis**



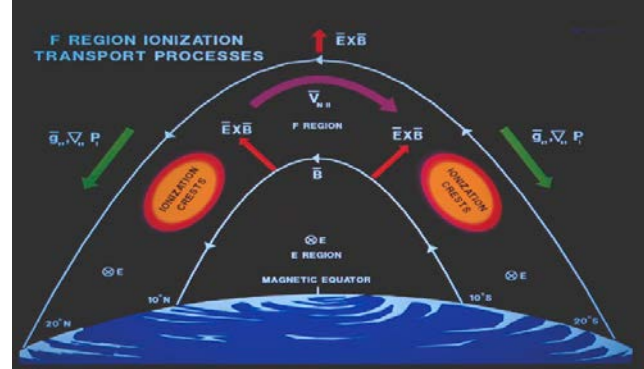


# Organization



# 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).

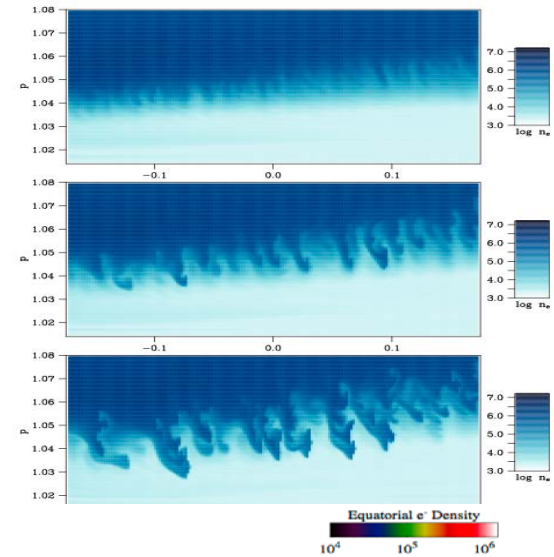
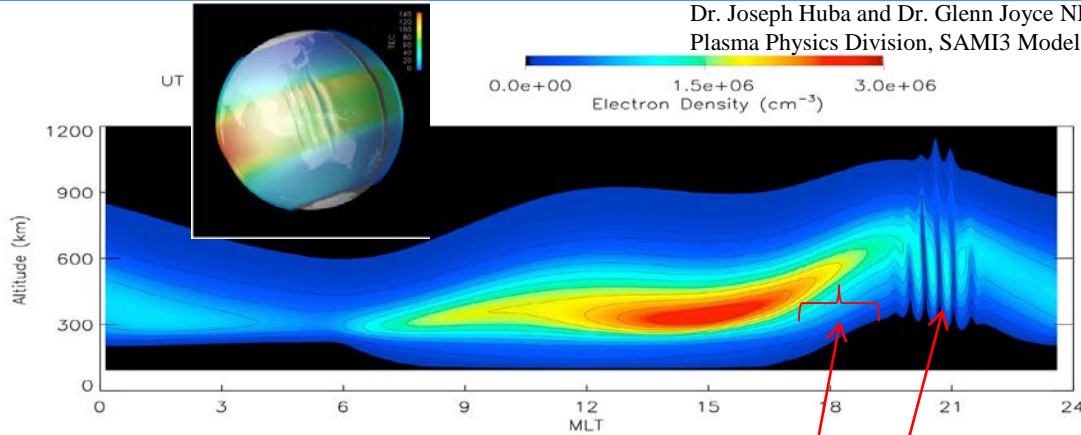


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# Plasma Bubbles

About 1.5 Hours to form a bubble

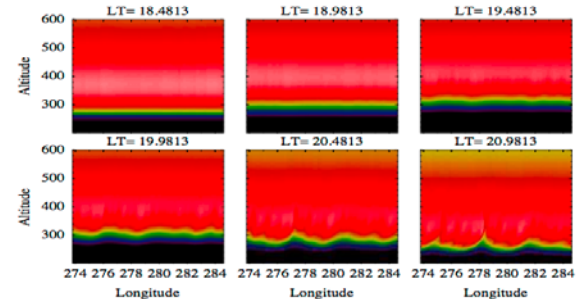


What is the state of the ionosphere here?

That leads to bubbles here ?

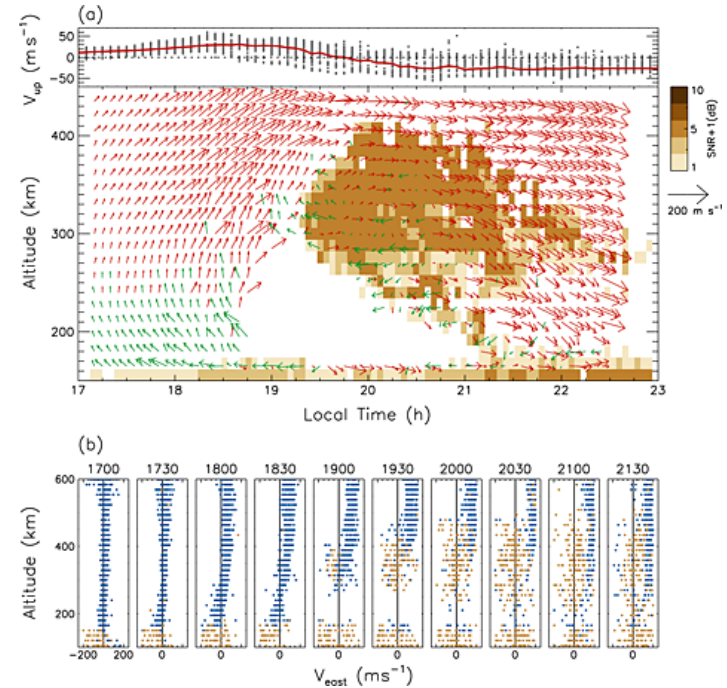
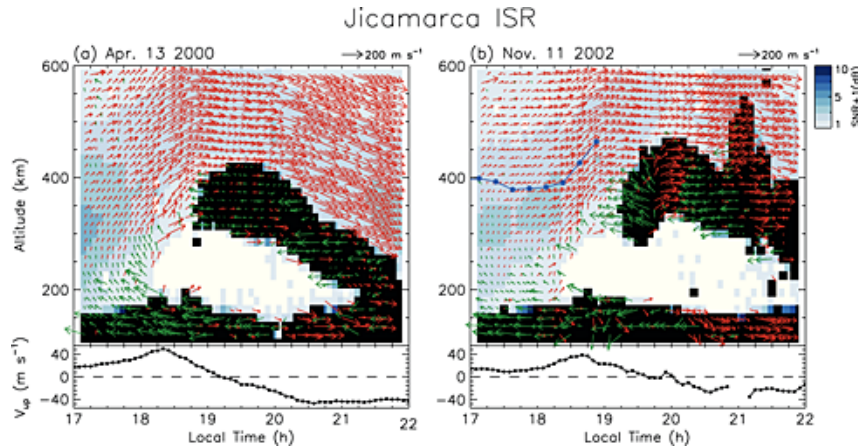
When bottom side seeding perturbations seem to always be present

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.



# Motion of Ionosphere (From Radar)

Morphology of the post-sunset vortex in the equatorial ionospheric plasma drift



Geophysical Research Letters

Volume 42, Issue 1, pages 9-14, 8 JAN 2015 DOI: 10.1002/2014GL062019

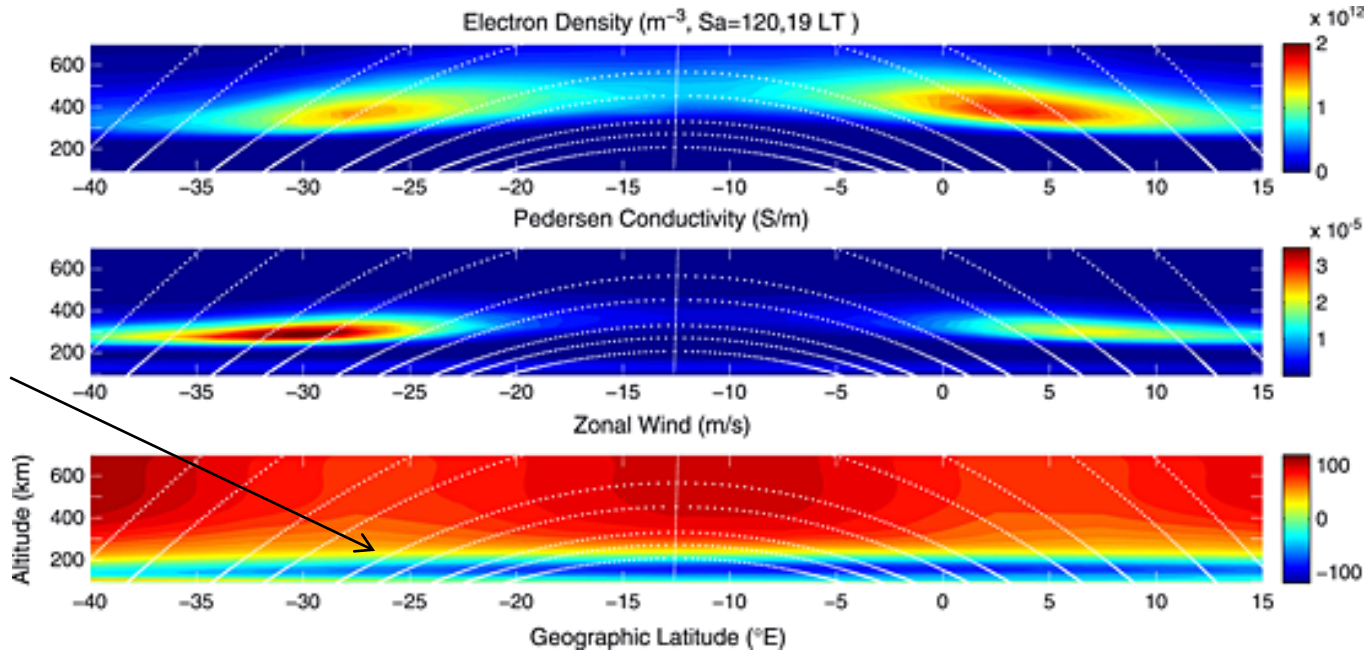
<http://onlinelibrary.wiley.com/doi/10.1002/2014GL062019/full#grl52441-fig-0001>





# 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](#)

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>

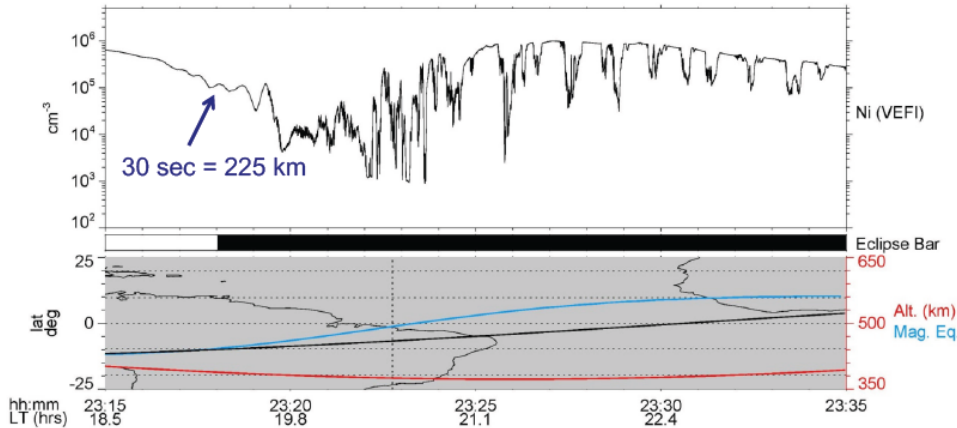


# C/NOFS Observations

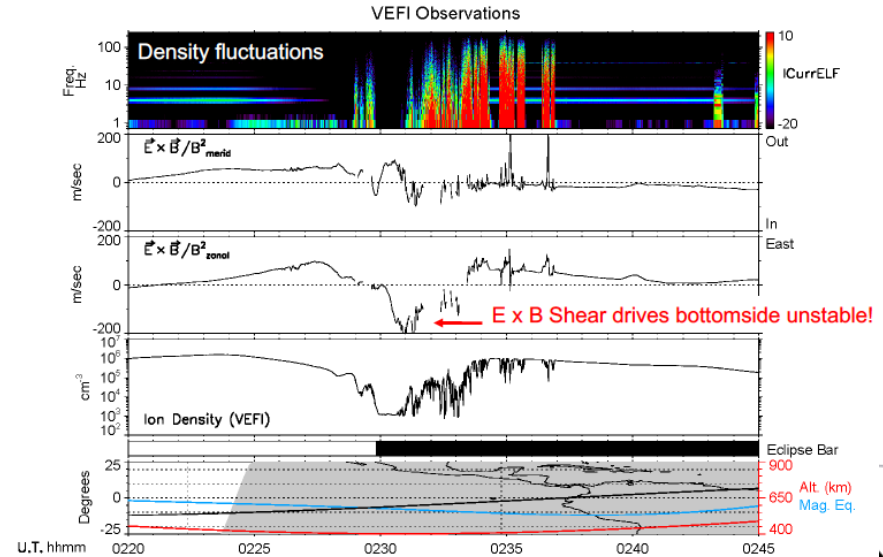
Pfaff, R. F., et al. (2017), Measurement of reversals in the horizontal plasma drifts below the elevated, low latitude F-region at sunset and their implication for the creation of large scale plasma undulations and spread-F irregularities, Journal of Geophysical Research.

Large Scale “Undulations” (100’s of km) at Lower Ledge of Ionosphere at Sunset

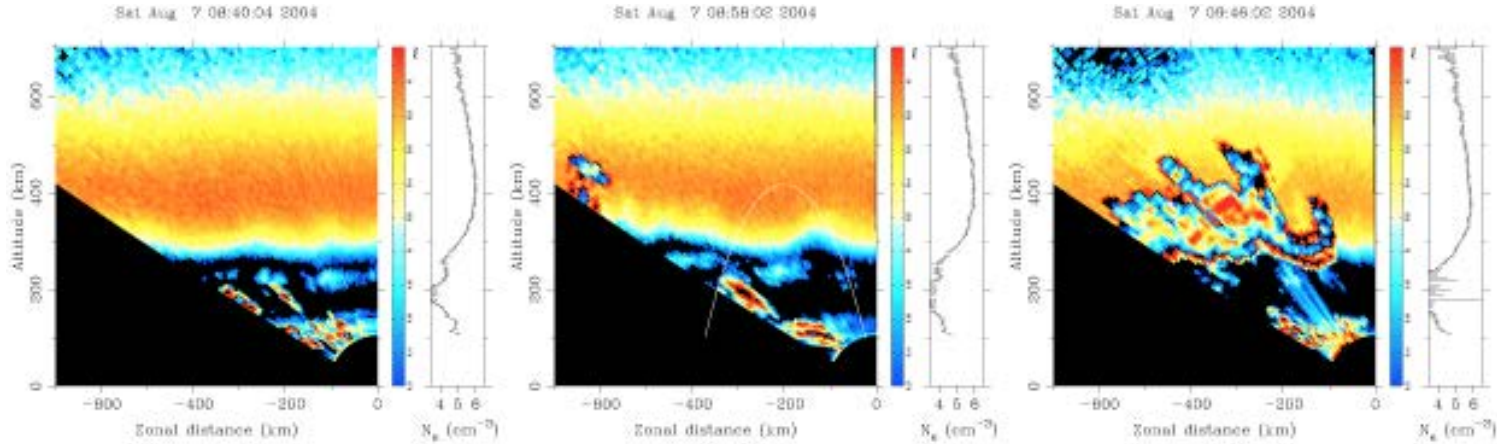
C/NOFS Orbit 35080 -- Sept 16, 2014



C/NOFS Orbit 16068 -- April 03, 2011 (Day 093)



# Bubbles Lead to Scintillations



David Hysell Altair Observations

Not all plasma bubble depletions are associated with scintillations?

Old Bubbles?

New Bubbles?



# 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?

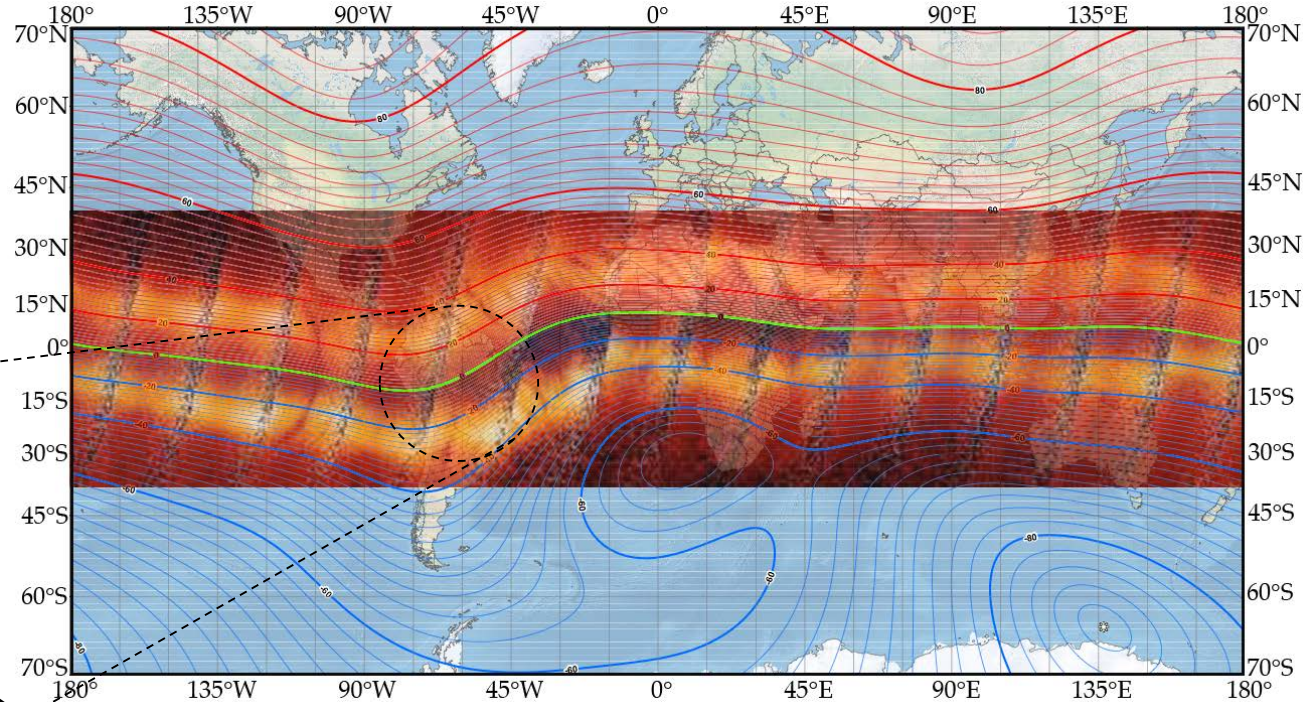
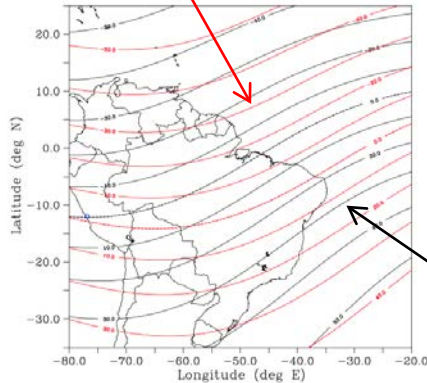




# Magnetic Field

Most ground/radar observations come from the American sector of unique magnetic geometry

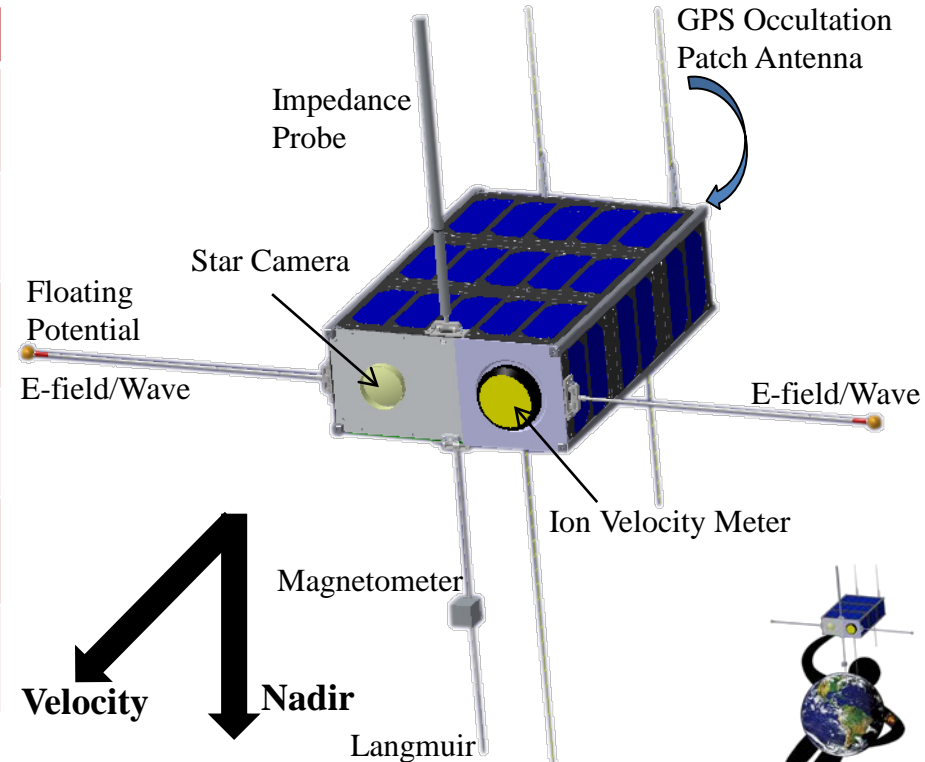
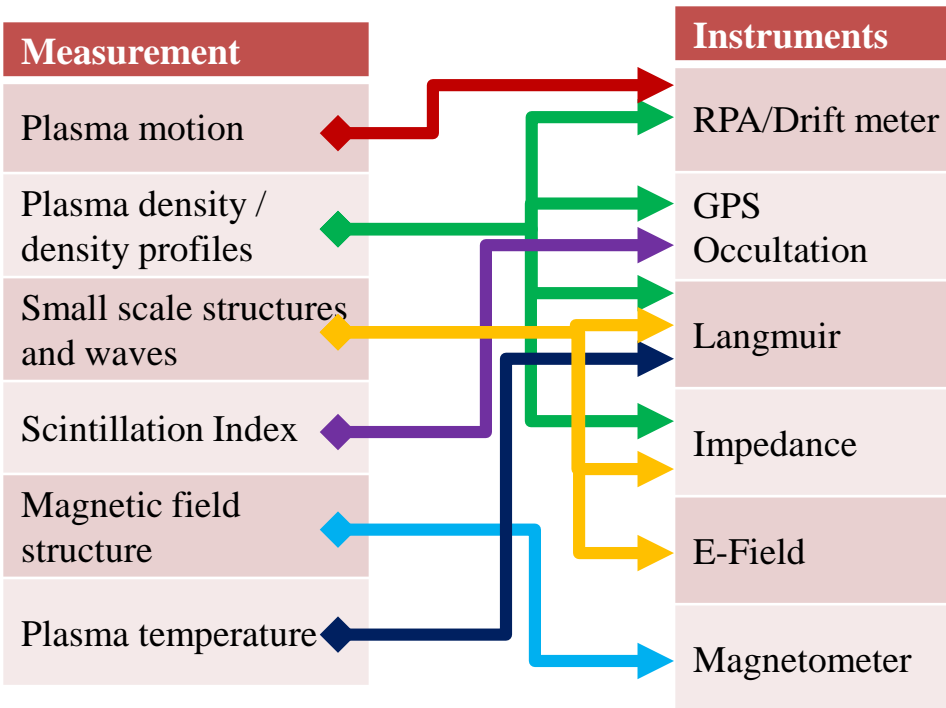
IRGF 1960



IRGF 2010



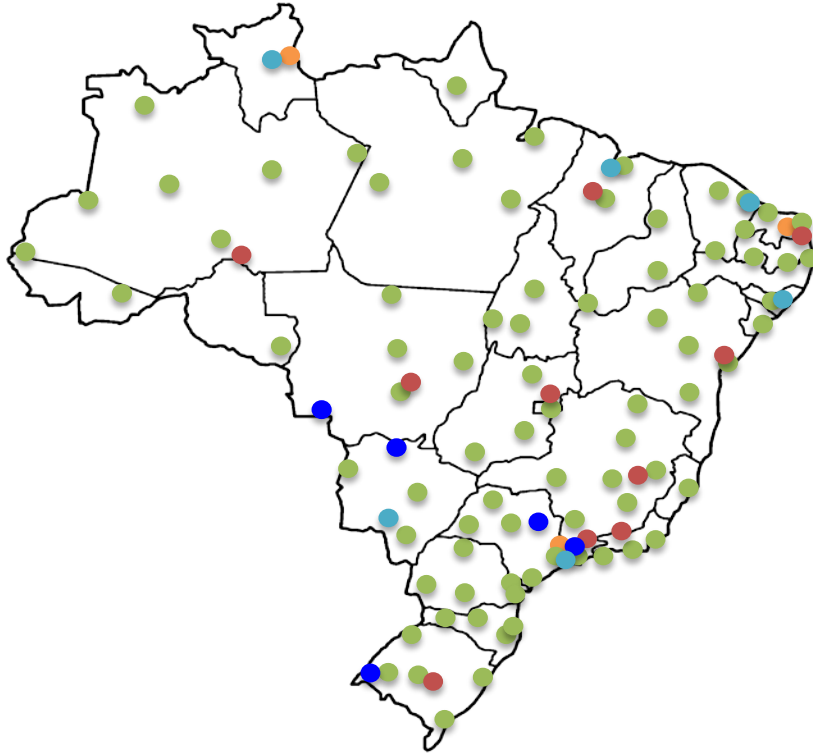
# Measurement and Instrumentation



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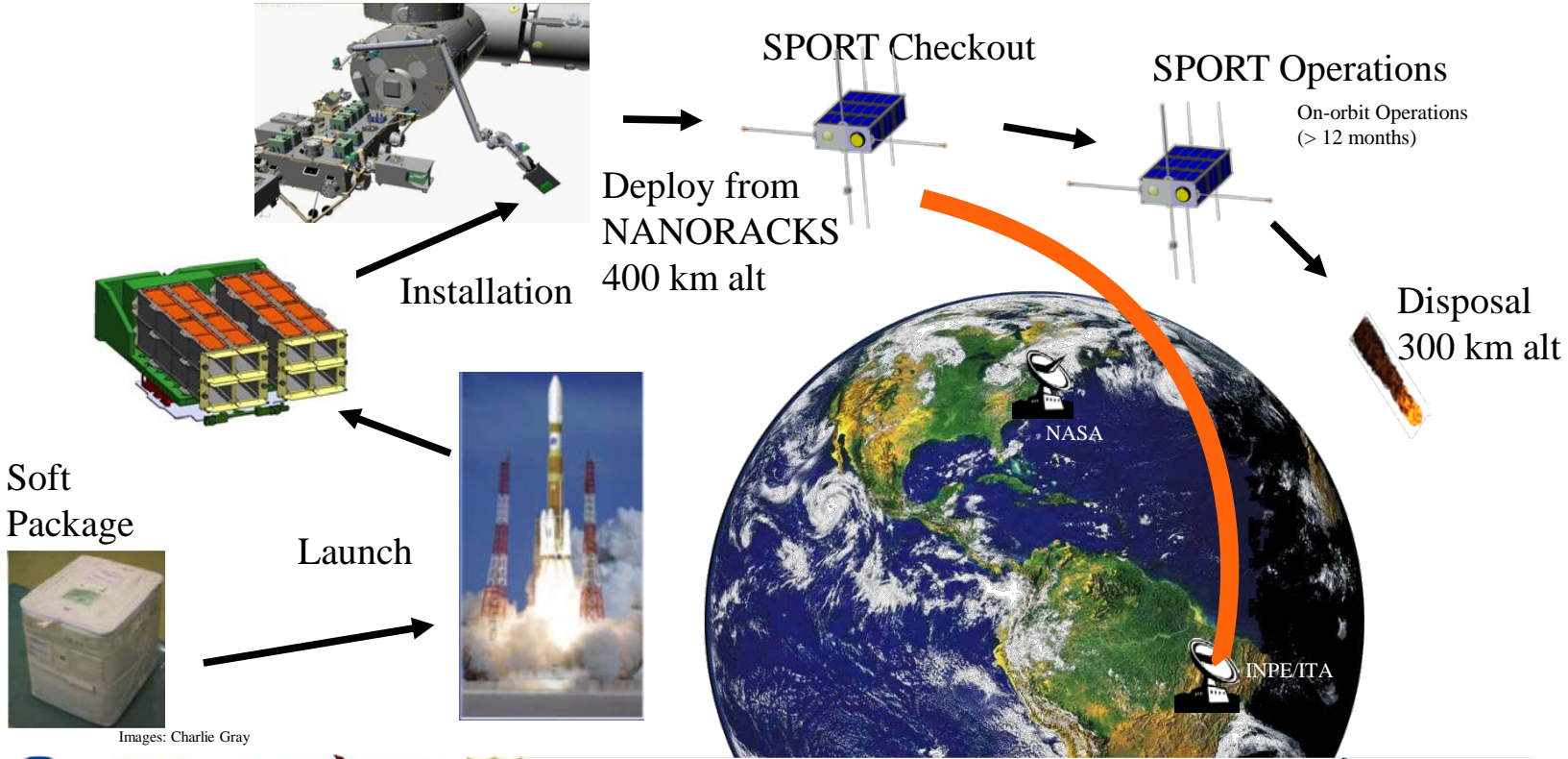
# Ground Network



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



# Mission ConOps

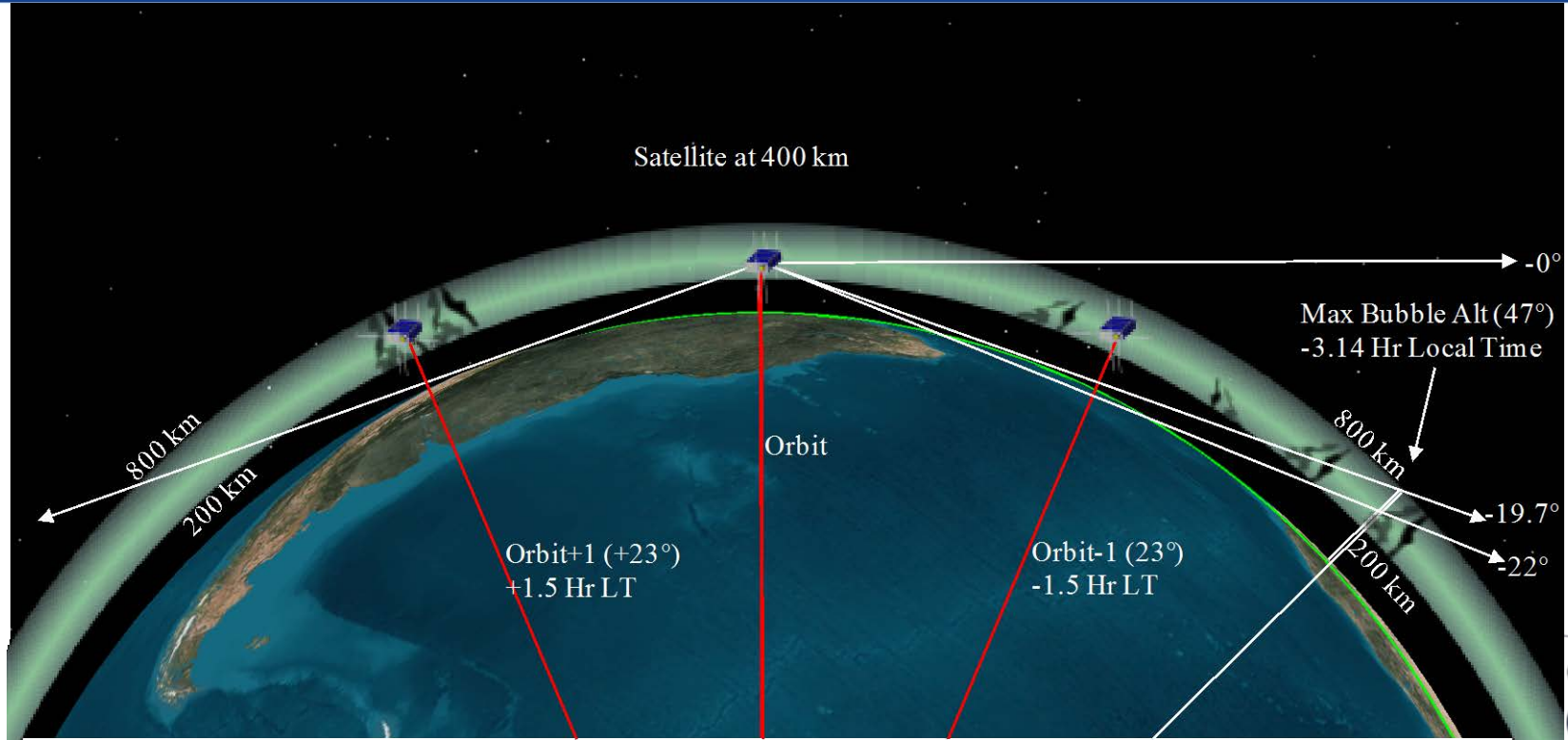


Images: Charlie Gray



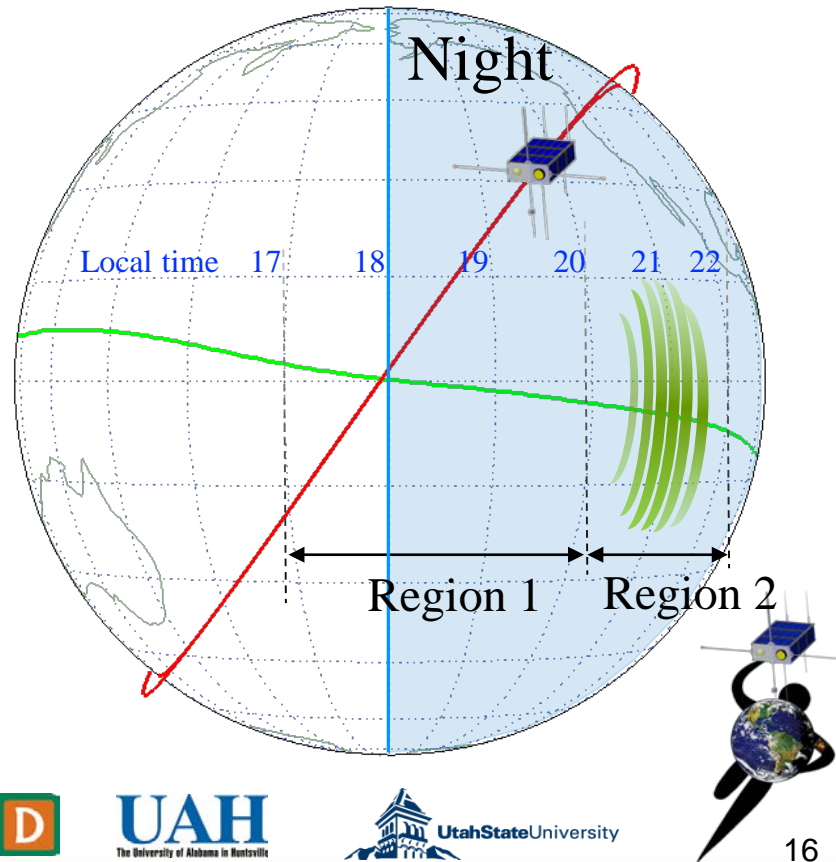


# GPS Radio Occultation and Scintillation

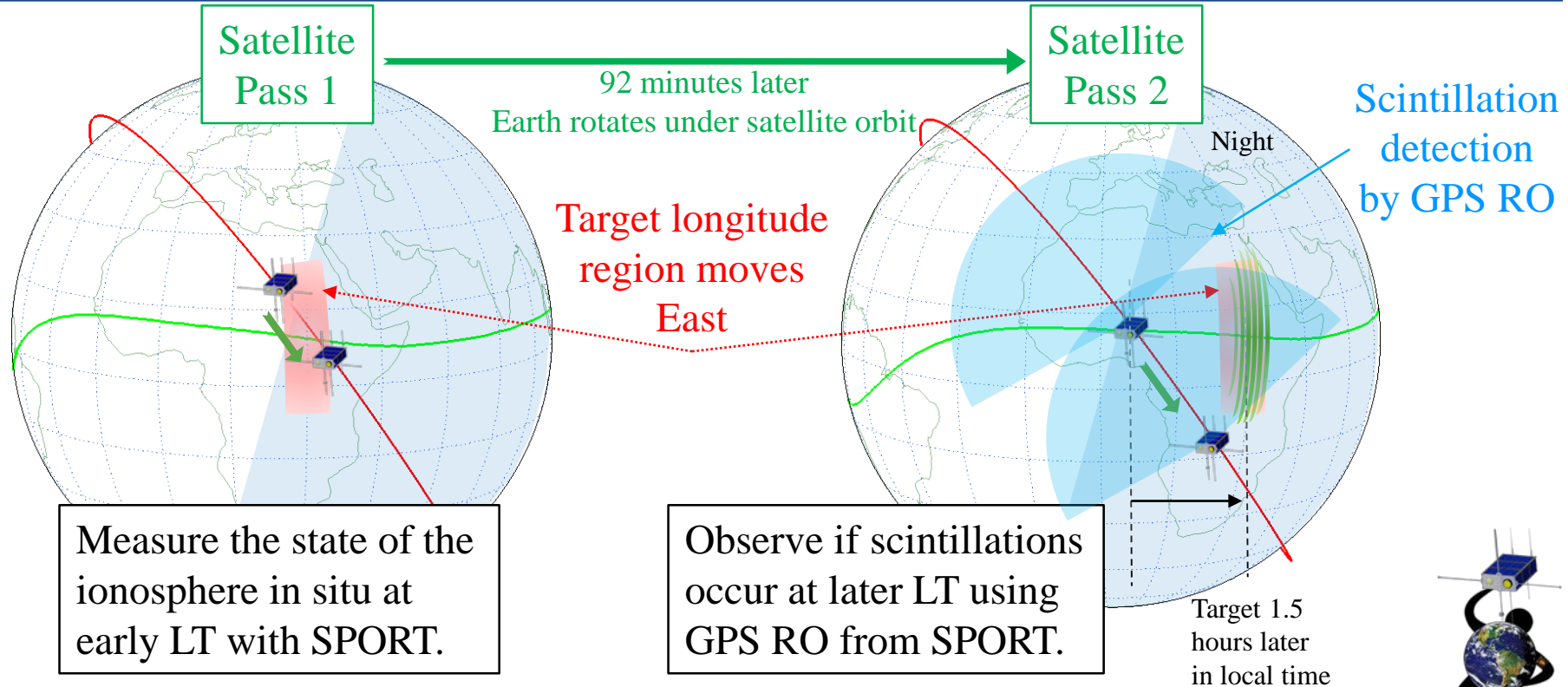


# SPORT Methodology

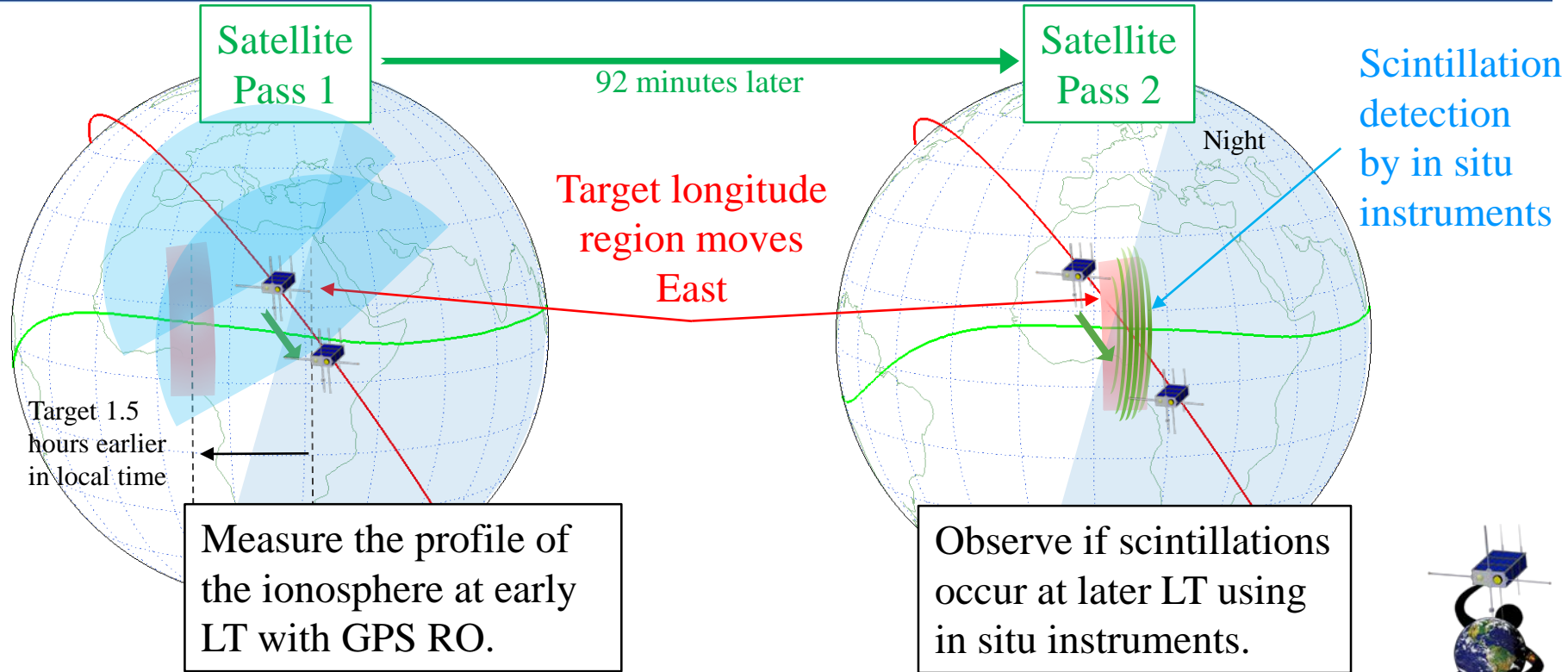
- The state of the ionosphere at early local times is related to the occurrence of scintillations at later local times.
  - How does this relation vary with longitude?
- Use case studies when SPORT ascending or descending node is within 17 to 24 LT sector.
- Examine ~15 degree longitude sectors



# Methodology Strategy 1



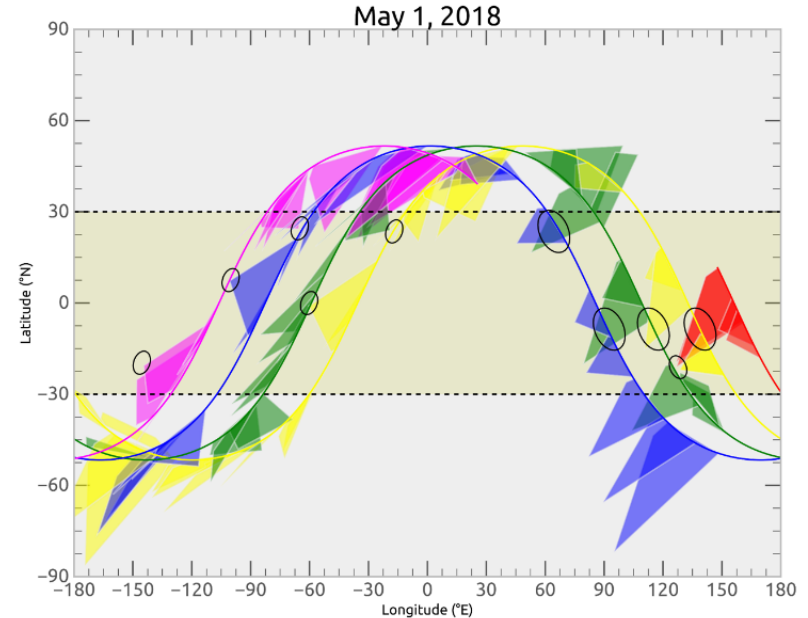
# Methodology Strategy 2





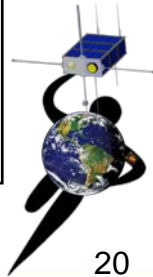
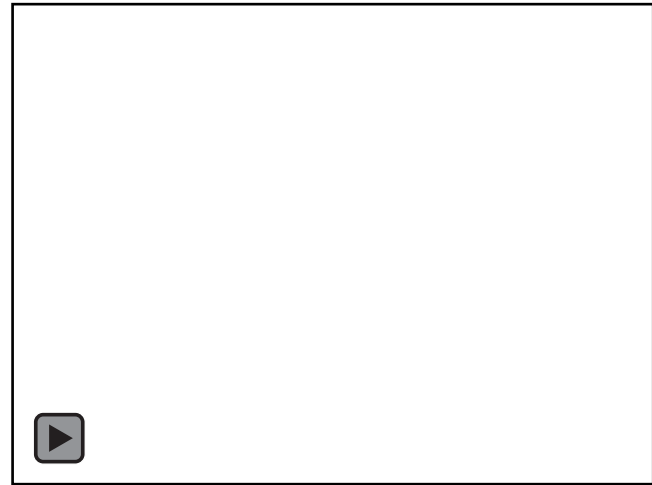
# How often are ideal occultation

- 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.

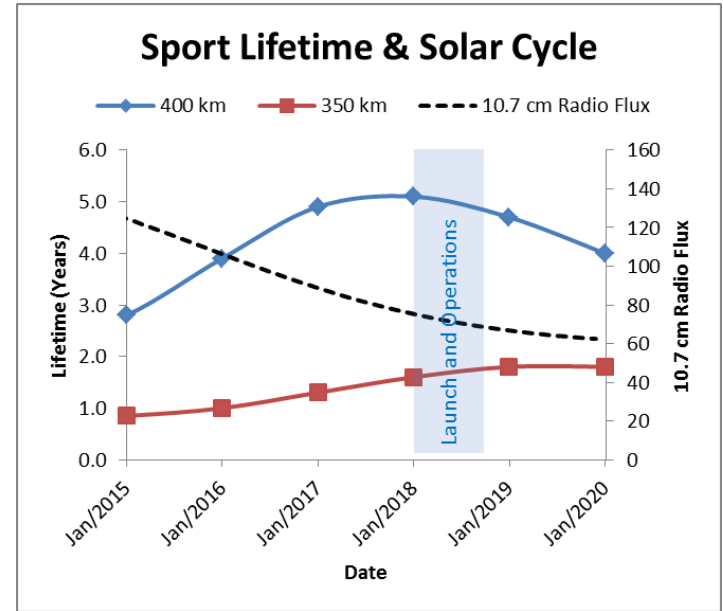
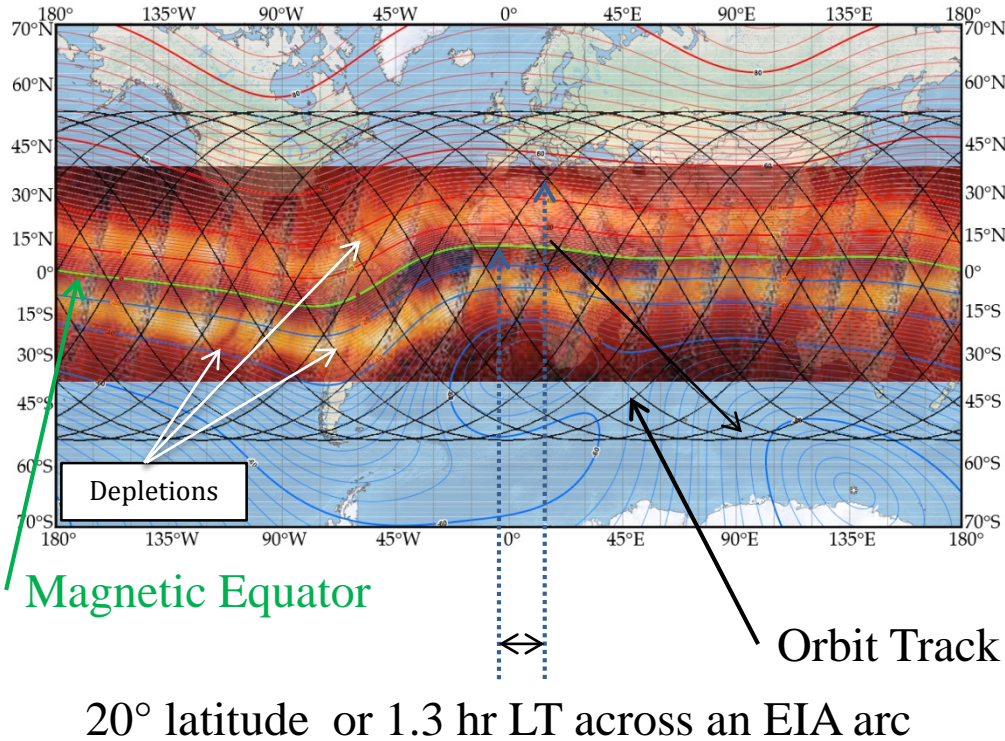


# Conclusions

- **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**



# SPORT Mission and ORBIT



Launch from ISS, 400 km Alt  
~3 year life

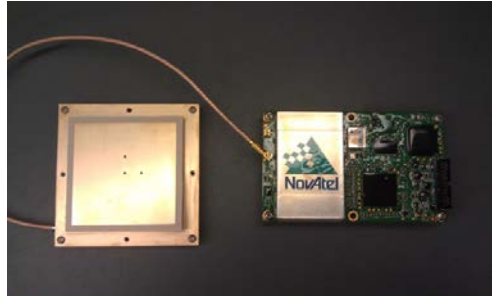


# SPORT Instruments

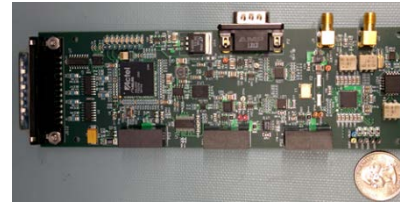
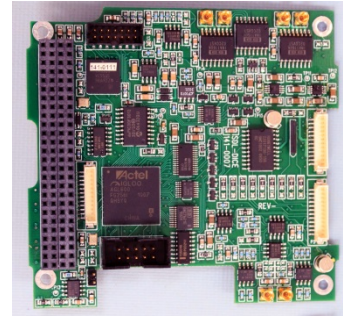
Ion Velocity Meter  
UTD



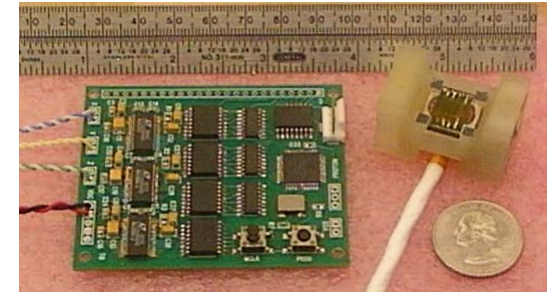
GPS Occultation  
Receiver  
Aerospace



Langmuir, E-field,  
Impedance Probe  
USU

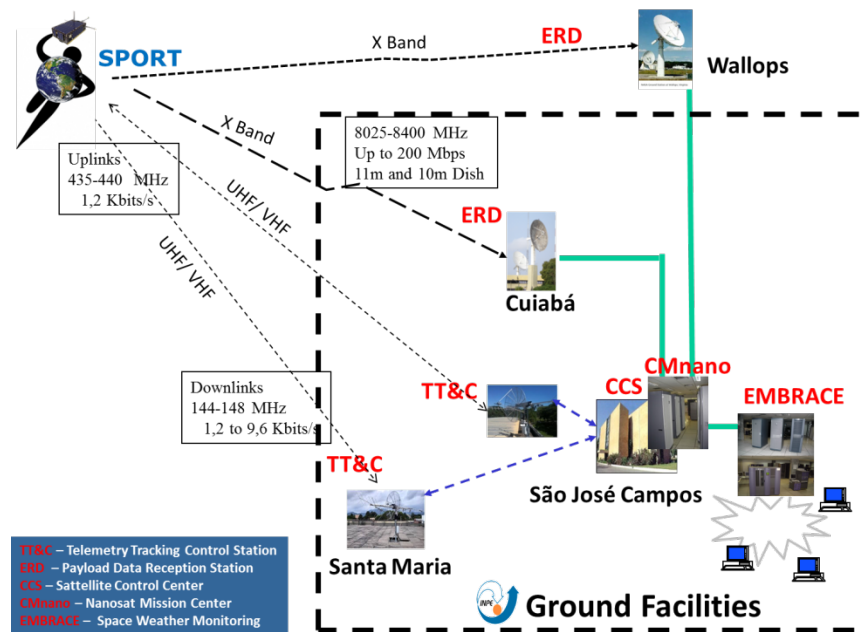


Fluxgate Magnetometer  
NASA Goddard



# SPORT Telemetry

Channel Name	Duty %	Rate Hz	Bit Rate bps	Alongtrack km
<b>Ion Velocity Meter</b>			<b>1824</b>	
Drifts	100%	2.00	288	3.83
Composition Sweeps	100%	2.00	1536	3.83
<b>GPS RO</b>			<b>16000</b>	
Dayside Tracking	50%	1.00	1000	7.66
Nightside Tracking	50%	50.00	15000	0.15
<b>Langmuir Probe</b>			<b>1984</b>	
DC Probe	100%	40.00	960	0.19
IV Sweeps	100%	0.04	491.52	191.43
Floating Probe Sweeps	100%	0.04	491.52	191.43
N <sub>e</sub> Wave Power	100%	0.04	40.96	191.43
<b>E-Field</b>			<b>1321</b>	
DC field	100%	40.00	1280	0.19
E-Field Wave Power	100%	0.04	40.96	191.43
<b>Impedance Probe</b>			<b>197</b>	
I & Q Sweep	20%	0.04	196	191.43
Tracking	20%	40.00	192	0.19
<b>Fluxgate Magnetometer</b>			<b>2880</b>	
DC field	100%	40.00	2880	0.19
<b>Star Imager</b>			<b>1500</b>	
Star Subimage	100%	1.00	1500	7.66
<b>Other</b>			<b>2624</b>	
Science GPS timing	100%	40.00	2560	0.19
Science Housekeeping	100%	0.10	64	76.57
<b>Rate collected on orbit</b>			<b>31210</b>	



50 Mbit/second Downlink giving a safety factor of 14

