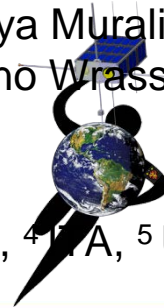

SPORT

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

James Spann¹, Charles Swenson², Otavio Durão³, Luis Loures⁴, Rod Heelis⁵, Rebecca Bishop⁶,
Guan Le⁷, Mangalathayil Abdu⁴, Linda Krause¹, Clezio Denardin³, Lidia Shibuya⁴, Joseph
Casas¹, Shelia Nash-Stevenson¹, Polinaya Muralikrishana³, Joaquim Costa³, Marcelo Padua³,
Cristiano Wrasse³, G. Fry¹



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

What is SPORT?

A science mission to understand the preconditions leading to equatorial plasma bubbles and scintillation

6U CubeSat deployed from ISS

International partnership between NASA, the Brazilian National Institute for Space Research (INPE), and the Technical Aeronautics Institute under the Brazilian Air Force Command Department (DCTA/ITA)

Value: \$7.5M mission - cost to NASA: \$3M

Significant DoD interest



8/8/2017



The University of Alabama in Huntsville



UtahStateUniversity

2



2

SPORT

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

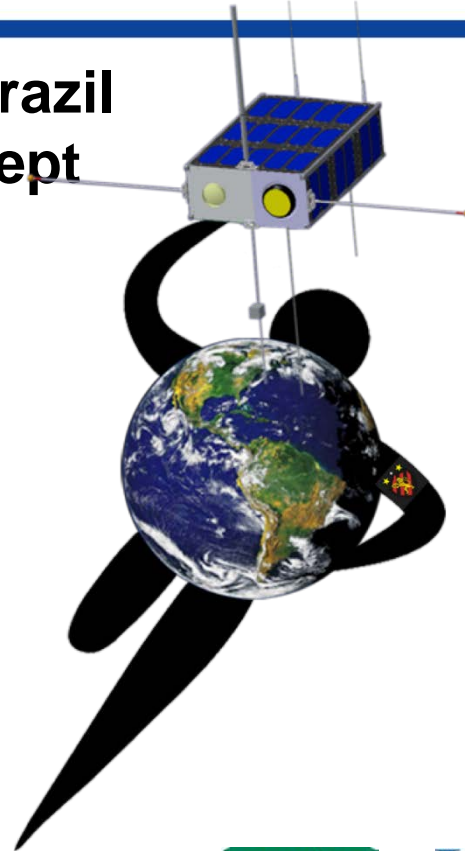
- **United States**

- Science Instruments

- **Brazil**

- Spacecraft

- Operations

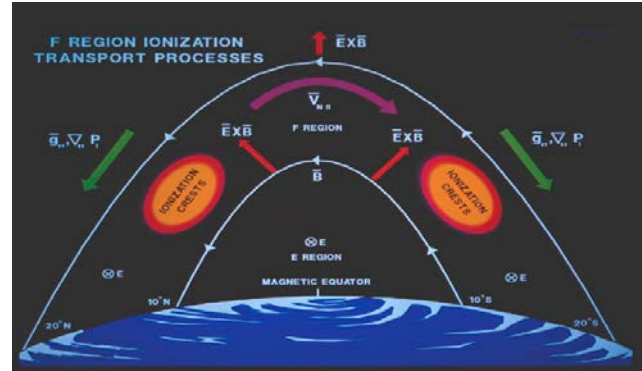


Joint Science Data Analysis



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?

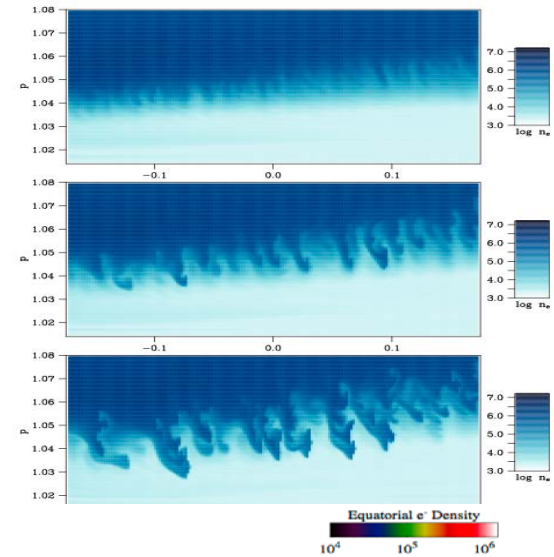
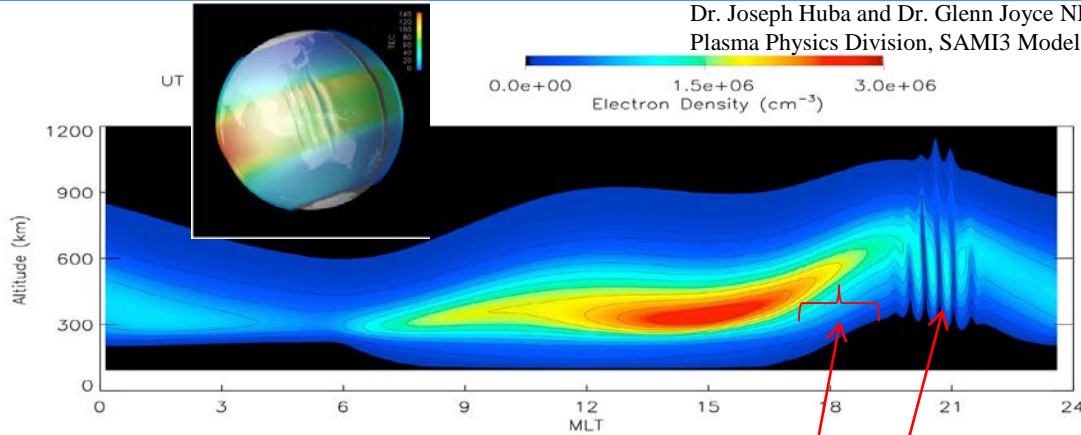


Kil, Hyosub, et al. "Coincident equatorial bubble detection by TIMED/GUVI and ROCSAT-1."
Geophysical research letters 31.3 (2004).



Plasma Bubbles

About 1.5 Hours to form a bubble

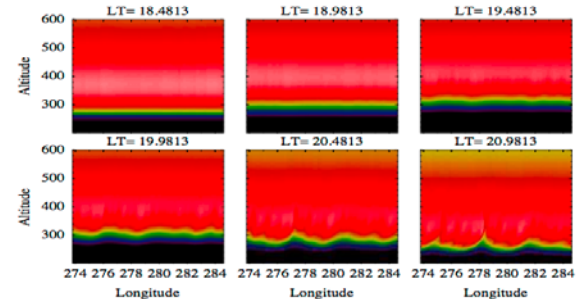


What is the state of the ionosphere here?

That leads to bubbles here ?

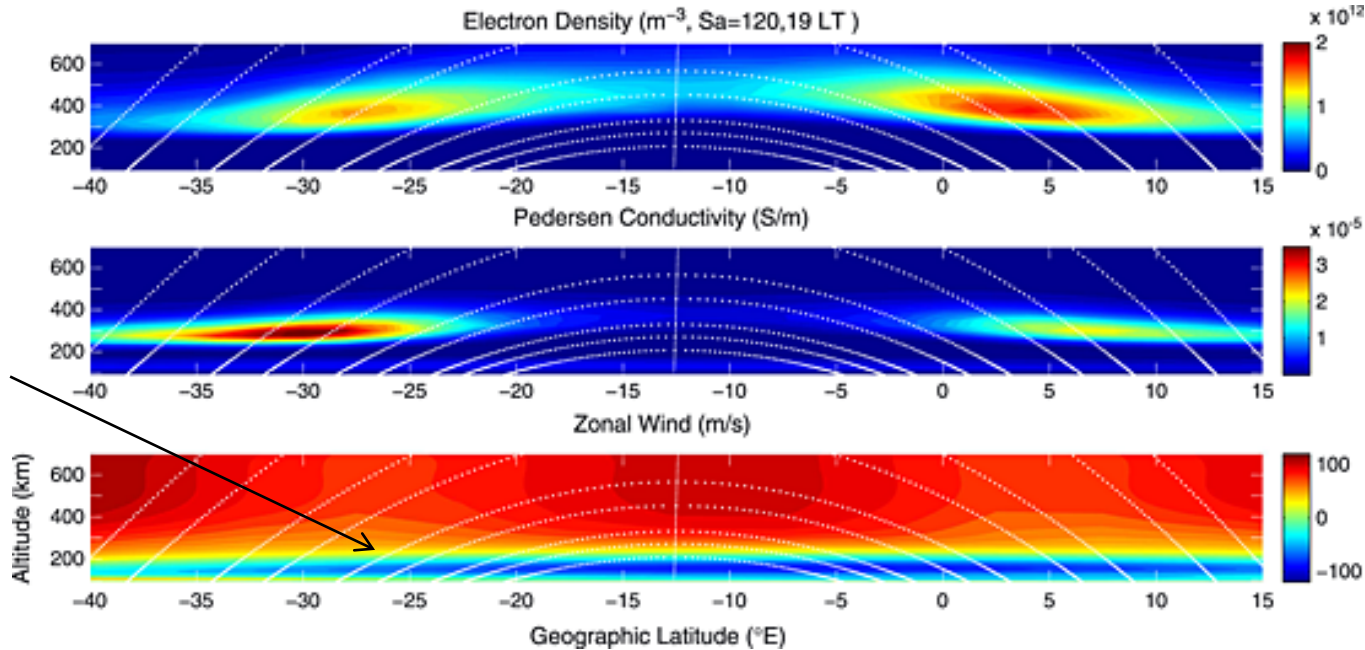
When bottom side seeding perturbations seem to always be present

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: 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>



UtahStateUniversity

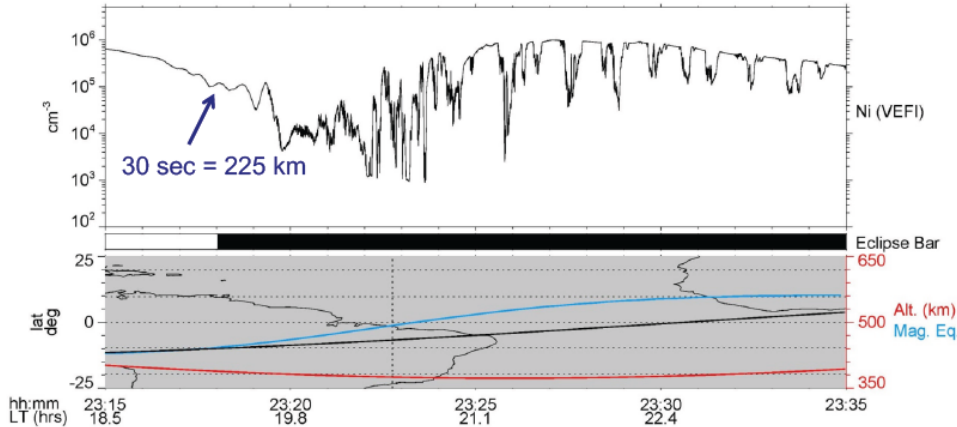


C/NOFS Observations

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.

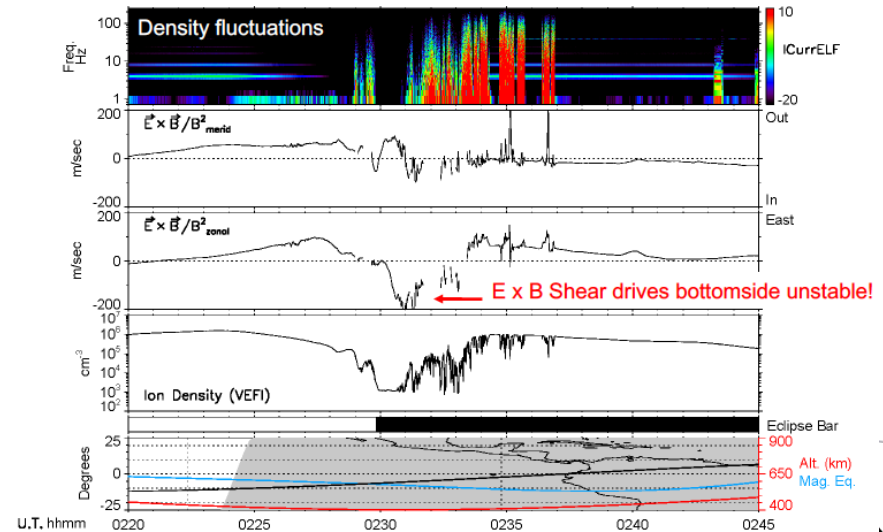
Large Scale “Undulations” (100’s of km) at Lower Ledge of Ionosphere at Sunset

C/NOFS Orbit 35080 -- Sept 16, 2014

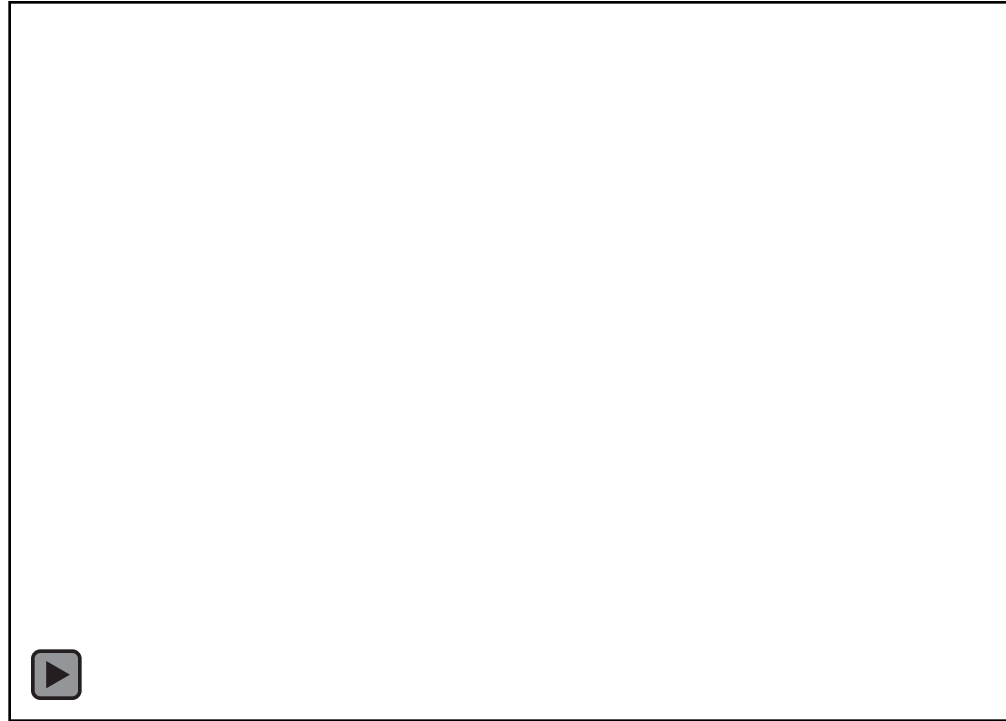


C/NOFS Orbit 16068 -- April 03, 2011 (Day 093)

VEFI Observations



Scintillation and GPS



Courtesy Keith Groves
Boston University



UtahStateUniversity



Science Goals

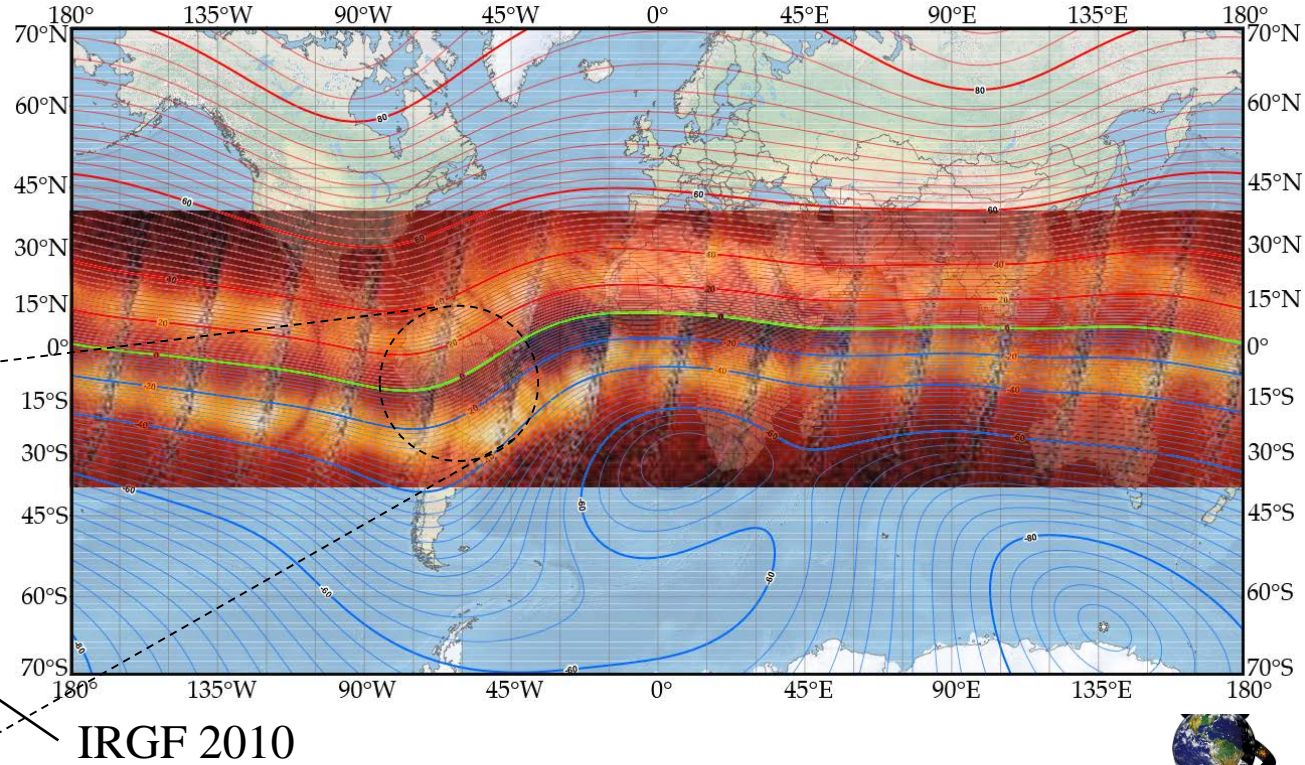
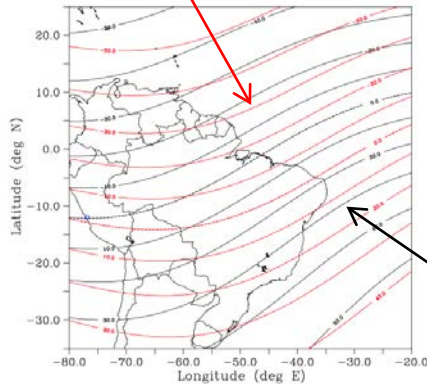
- 1) What is the state of the ionosphere that gives rise to the growth of plasma bubbles that extend into and above the F-peak at different longitudes?
- 2) How are plasma irregularities at satellite altitudes related to the radio scintillations observed passing through these regions?



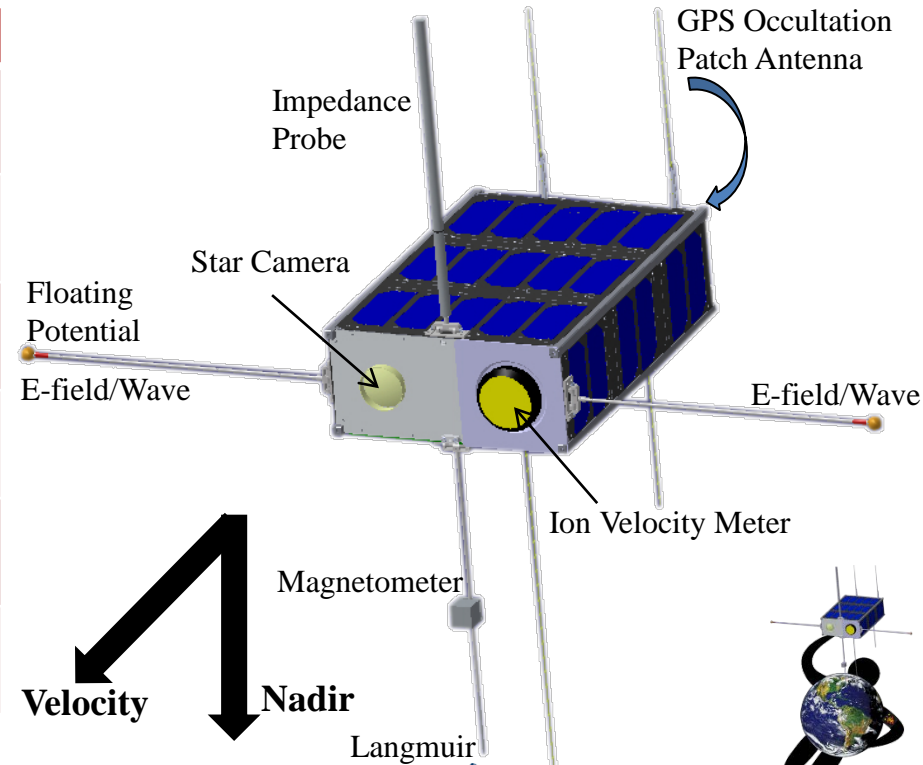
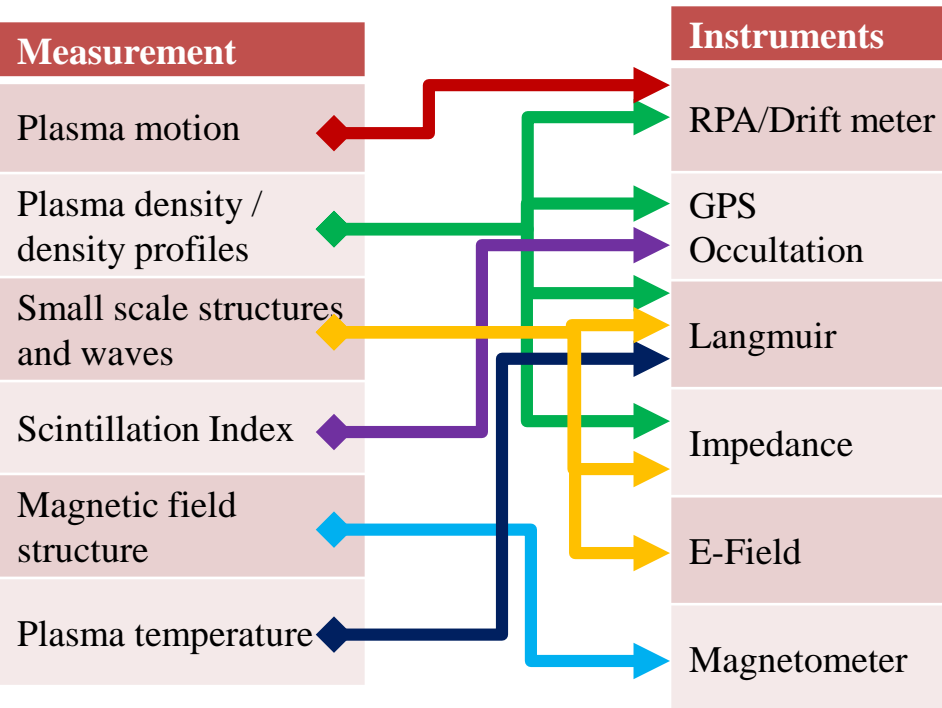
Magnetic Field

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

IRGF 1960



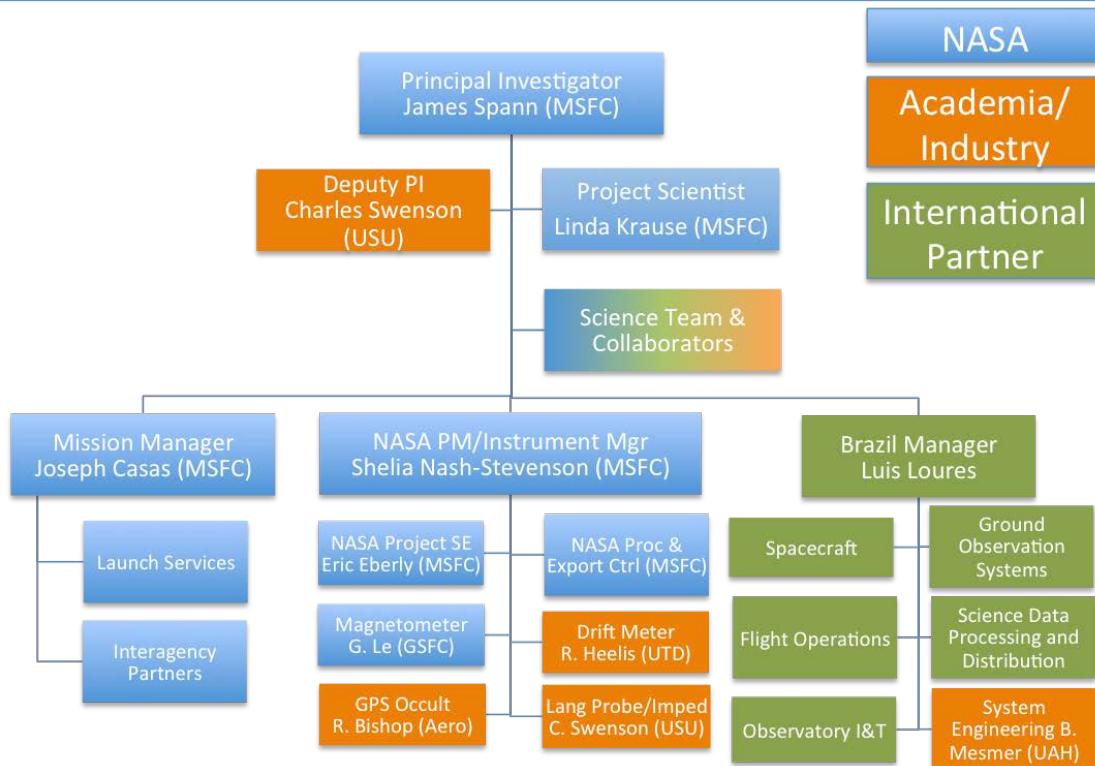
Measurement and Instrumentation



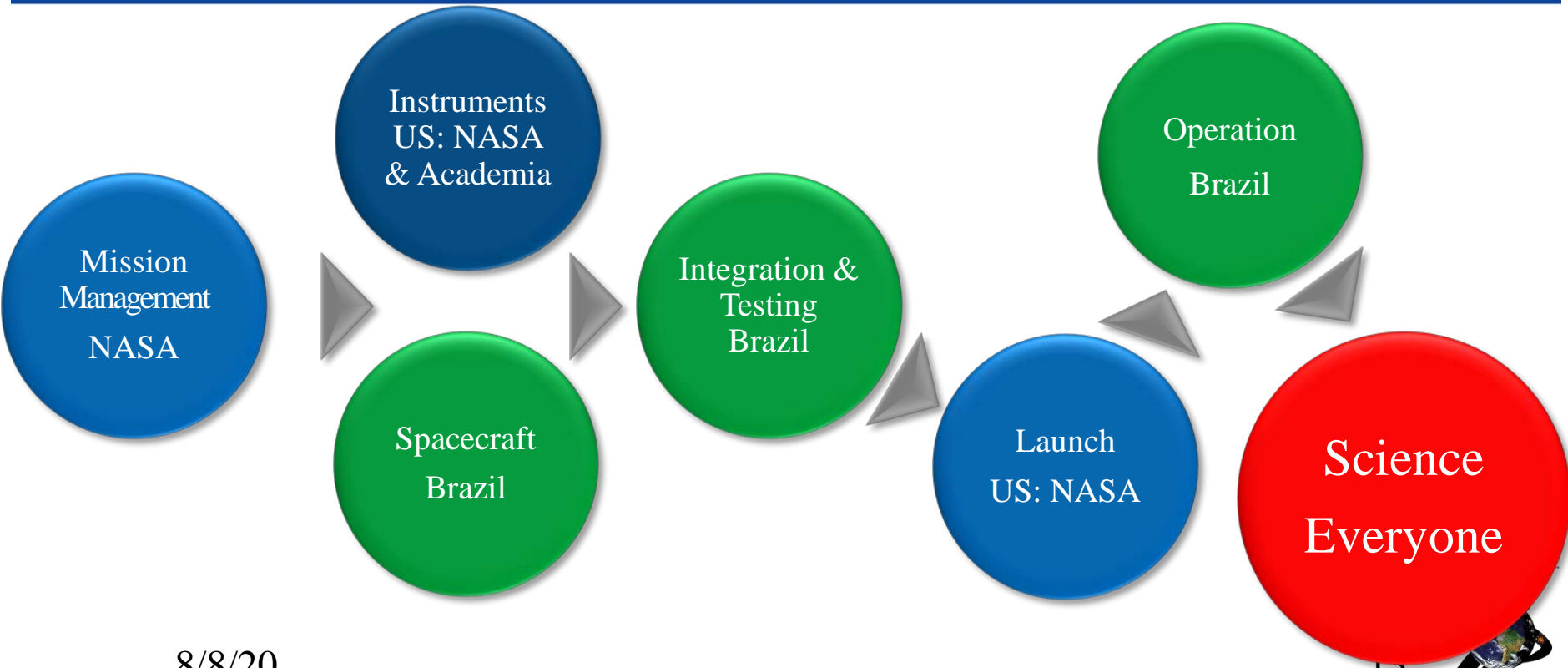
UtahStateUniversity



Organization



SPORT



8/8/20
17



AEROSPACE

UTD

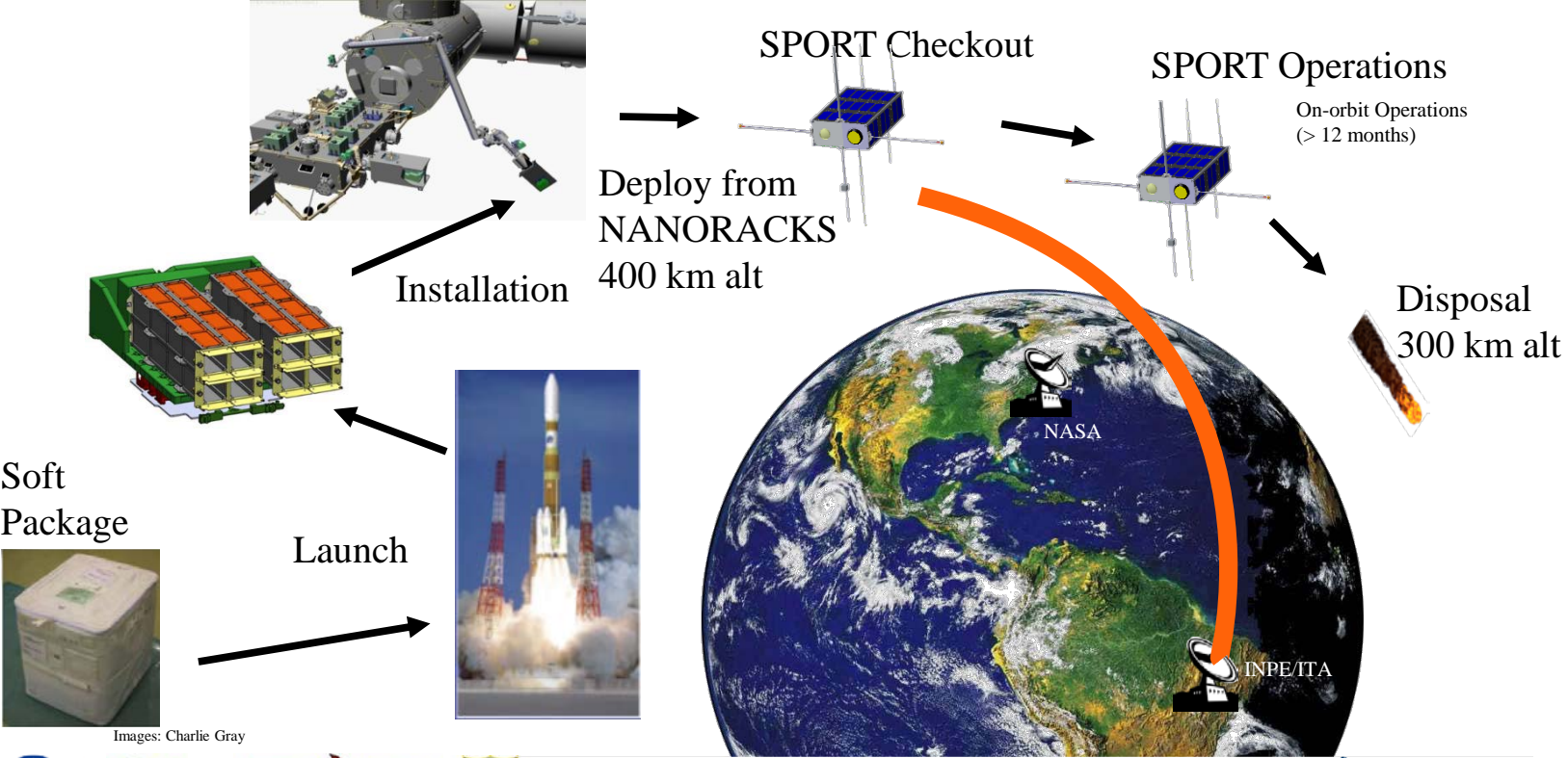
UAH
The University of Alabama in Huntsville



15



Mission ConOps

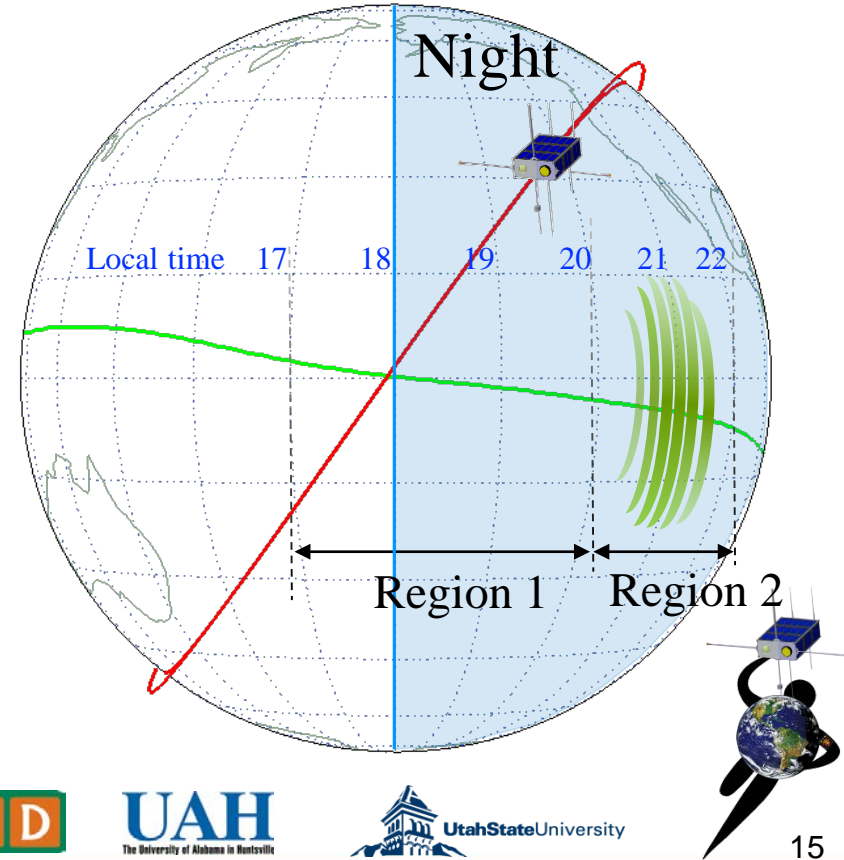


Images: Charlie Gray

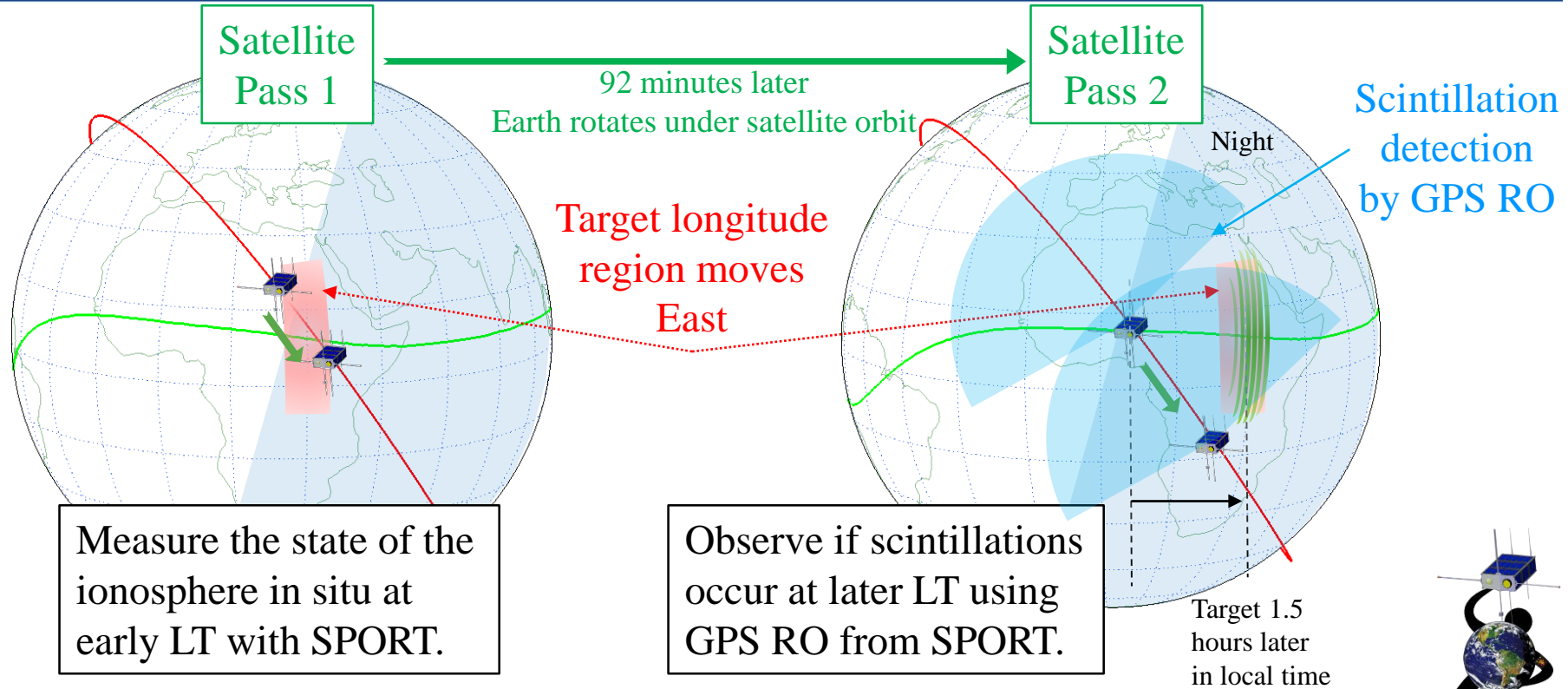


SPORT Methodology

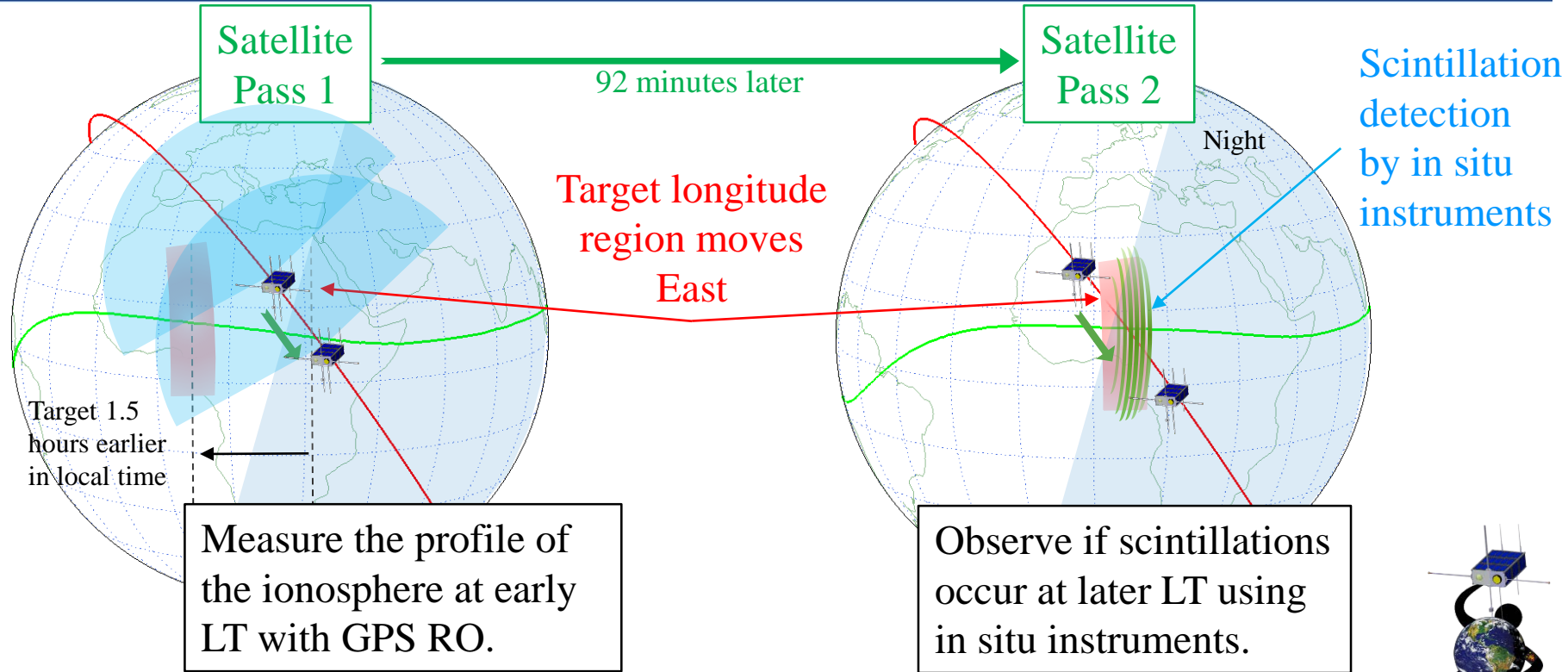
- The state of the ionosphere at early local times is related to the occurrence of scintillations at later local times.
 - How does this relation vary with longitude?
- Use case studies when SPORT ascending or descending node is within 17 to 24 LT sector.
- Examine ~15 degree longitude sectors



Methodology Strategy 1

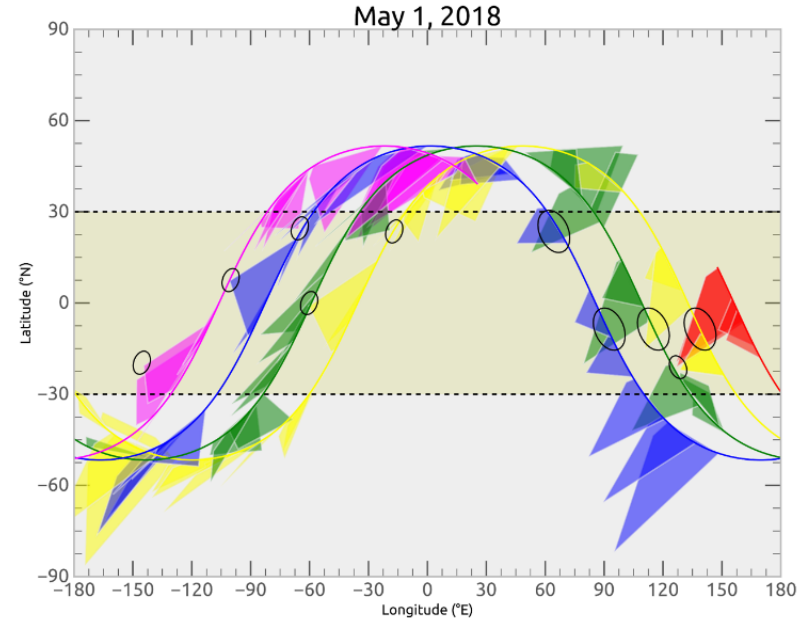


Methodology Strategy 2

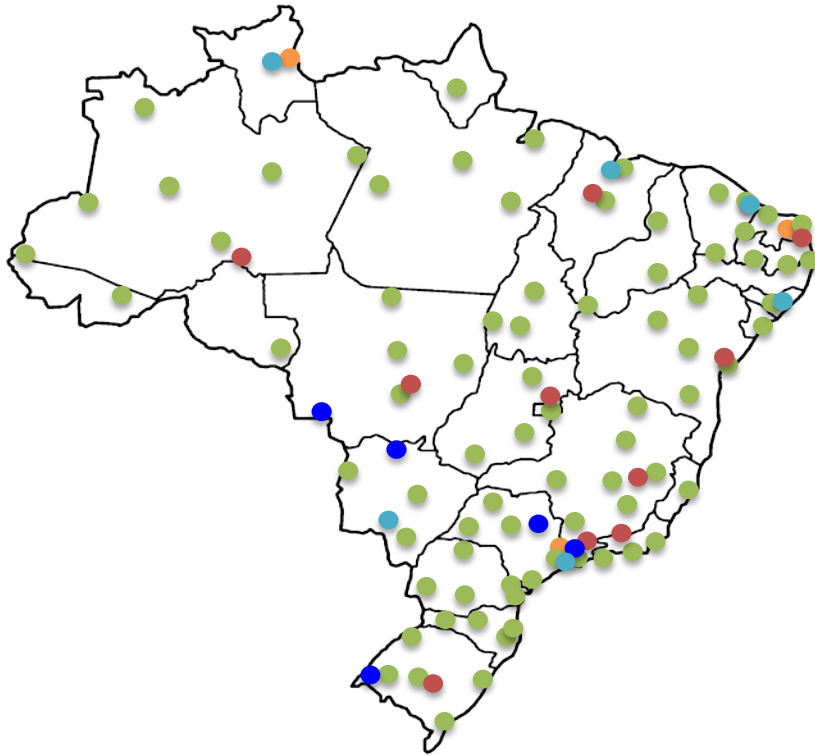


How often are ideal occultation

- 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.



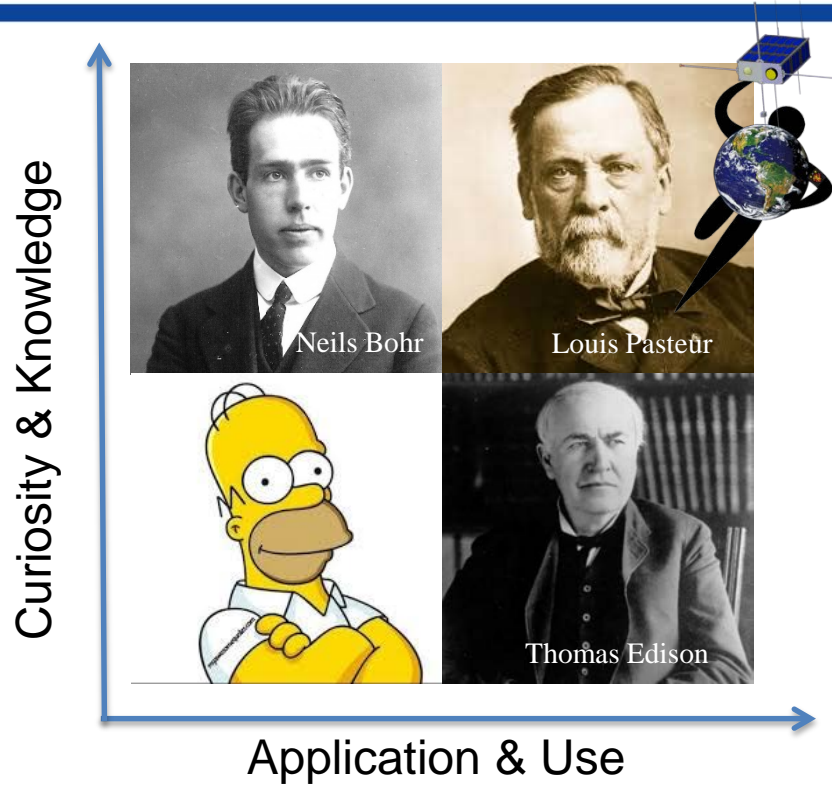
Ground Network



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

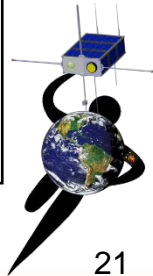
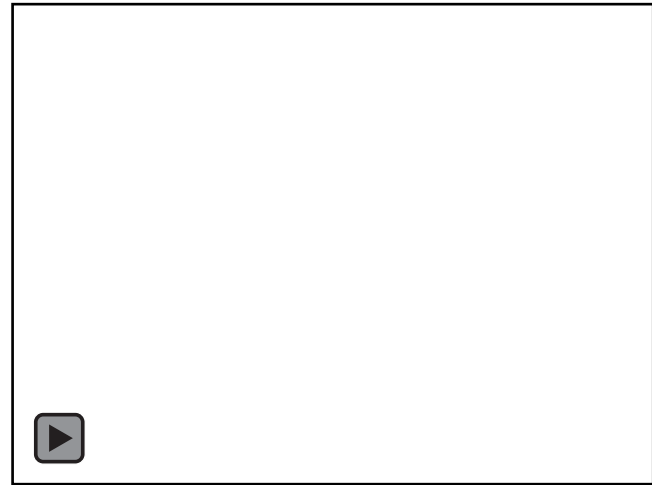


Value of Science



Conclusions

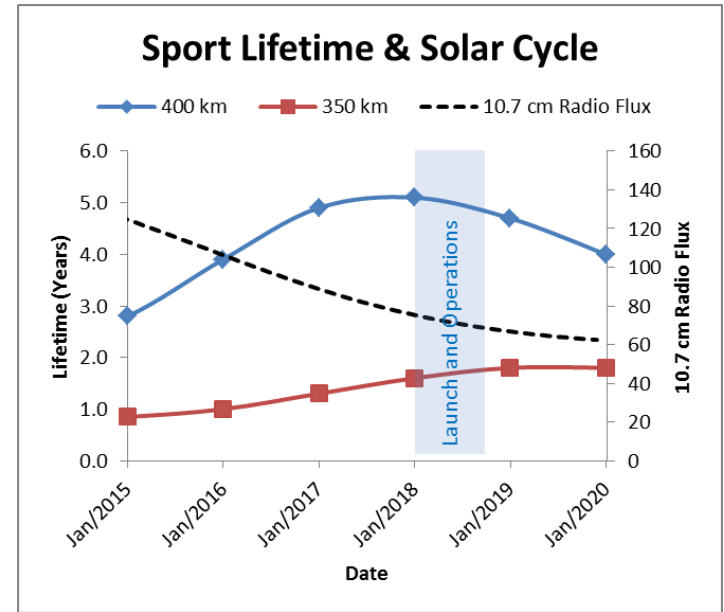
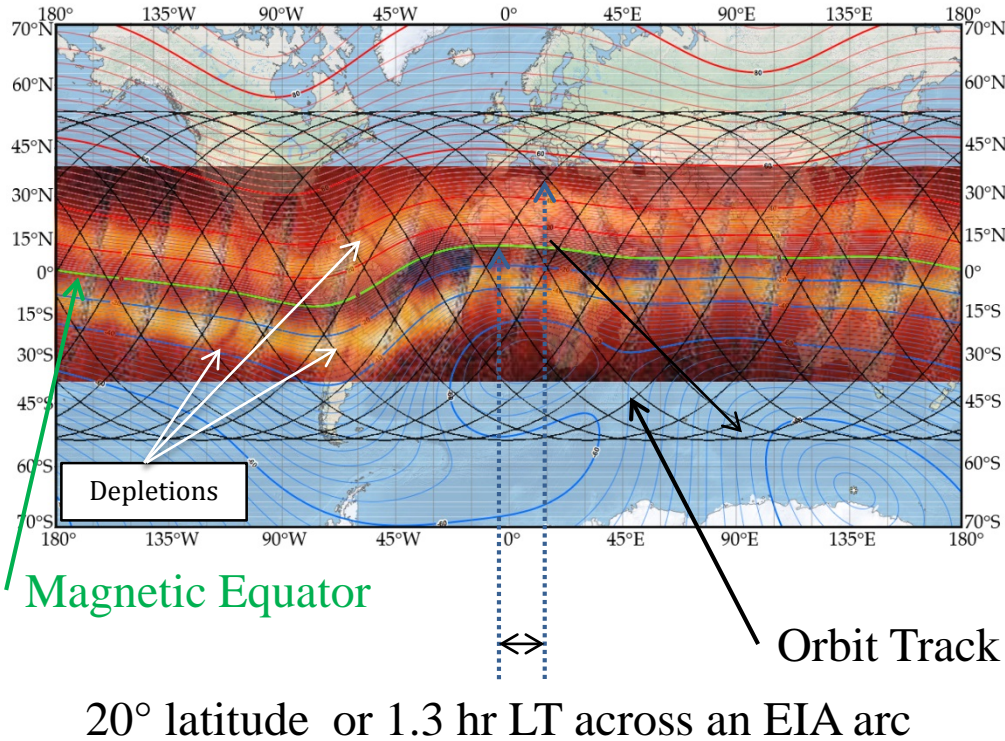
- **CubeSat missions can be developed with a full/regular suite of science instruments.**
- **Mid inclination ISS orbits allow for the deconvolution of local time and longitude at low-latitudes**
- **A String of pearls mission to increase time resolution**



Backup



SPORT Mission and ORBIT



Launch from ISS, 400 km Alt
~3 year life

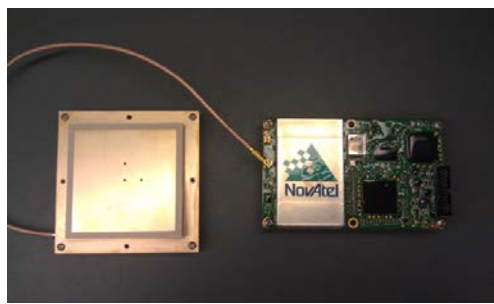


SPORT Instruments

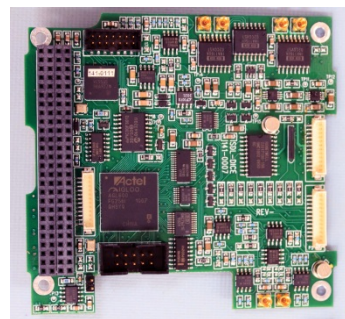
Ion Velocity Meter
UTD



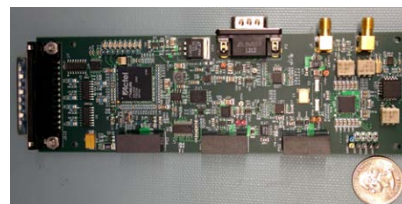
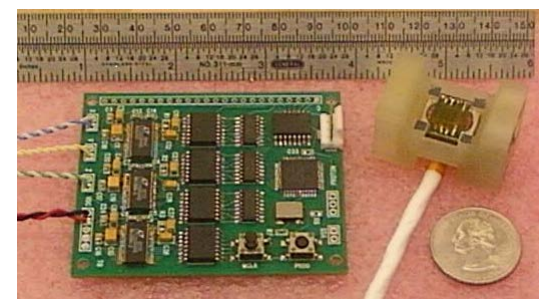
GPS Occultation
Receiver
Aerospace



Langmuir, E-field,
Impedance Probe
USU

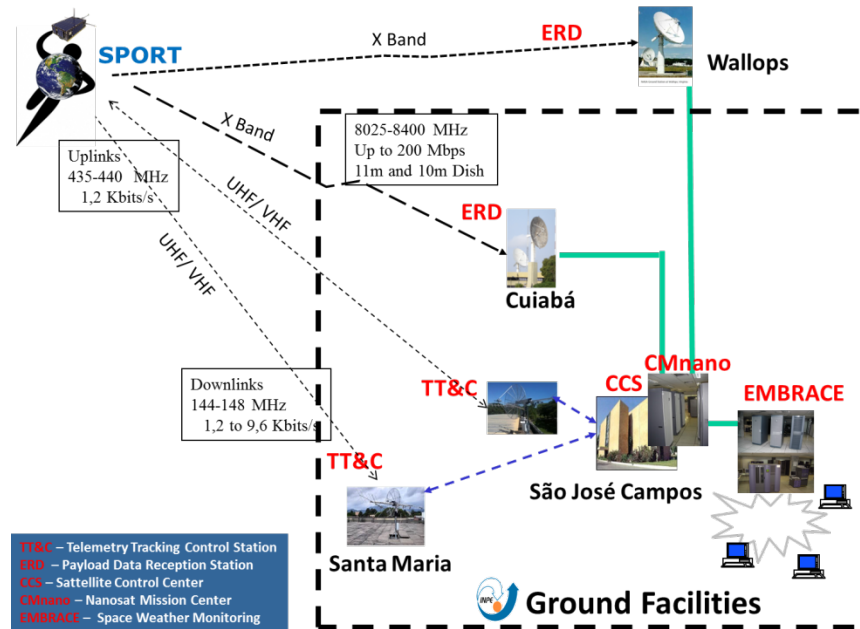


Fluxgate Magnetometer
NASA Goddard



SPORT Telemetry

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



50 Mbit/second Downlink giving a safety factor of 14

