SPORT

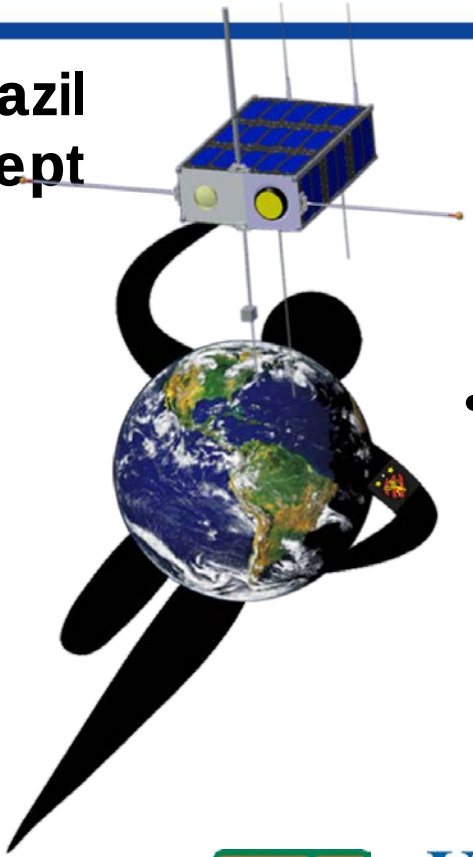
The Scintillation Prediction Observations Research Task: An International Science Mission using a CubeSat

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] ITA, [5] UTD, [6] Aerospace, [7] NASA/GSFC

SPORT

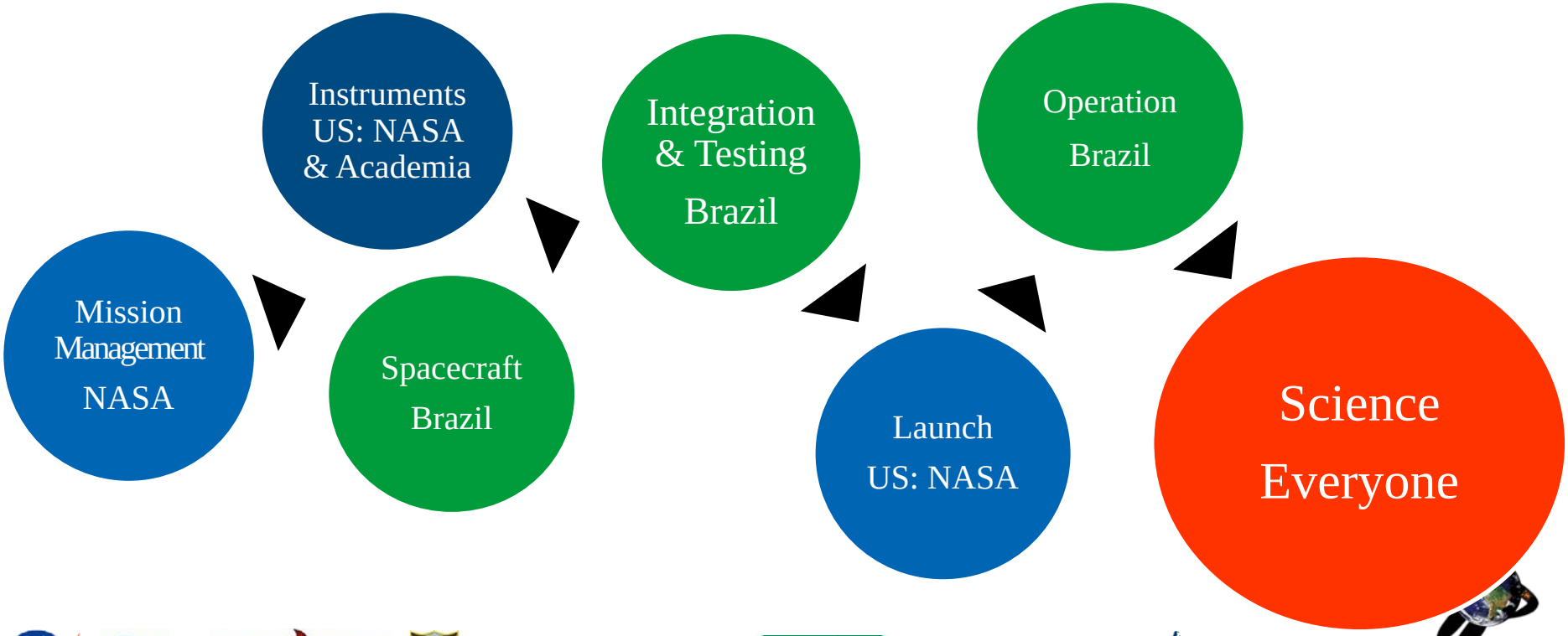
- **Joint United States / Brazil Science Mission Concept**



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

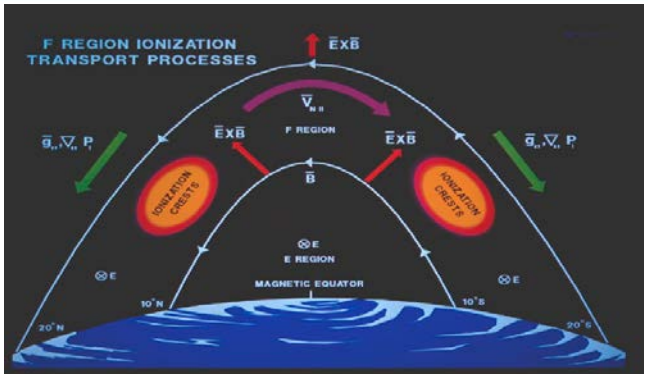
- **Joint Science Data Analysis**

Integrated Partnership



Science

- **The equatorial ionization anomalies**



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

- **Plasma Bubbles**

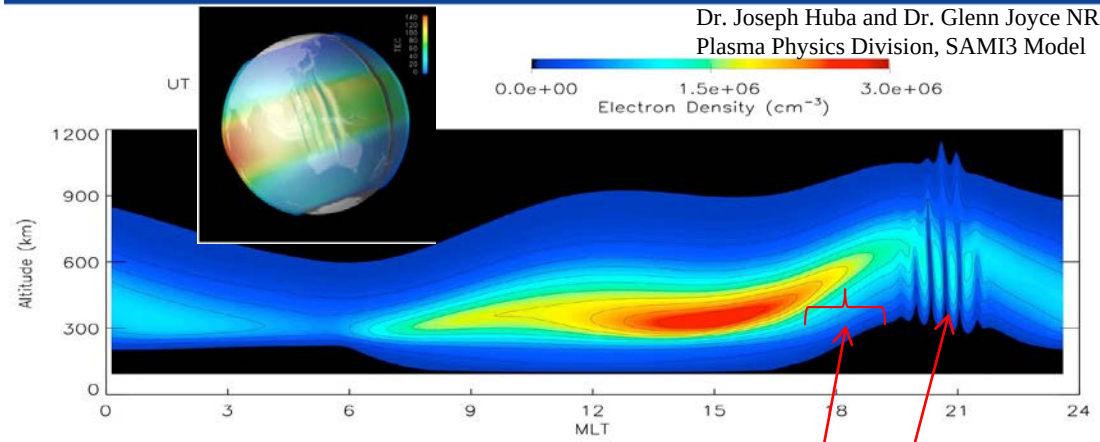
GUVI (Same Local Time, Different Longitudes)

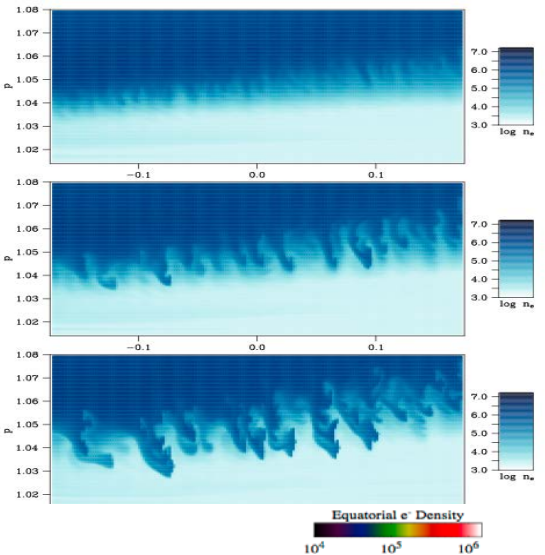
Why do bubbles form and sometimes not at Different Longitudes?

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

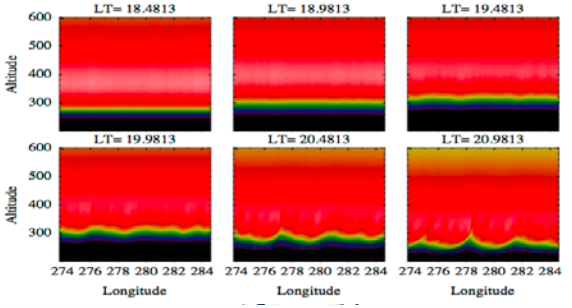




What is the state of the ionosphere here?

That leads to bubbles here ?

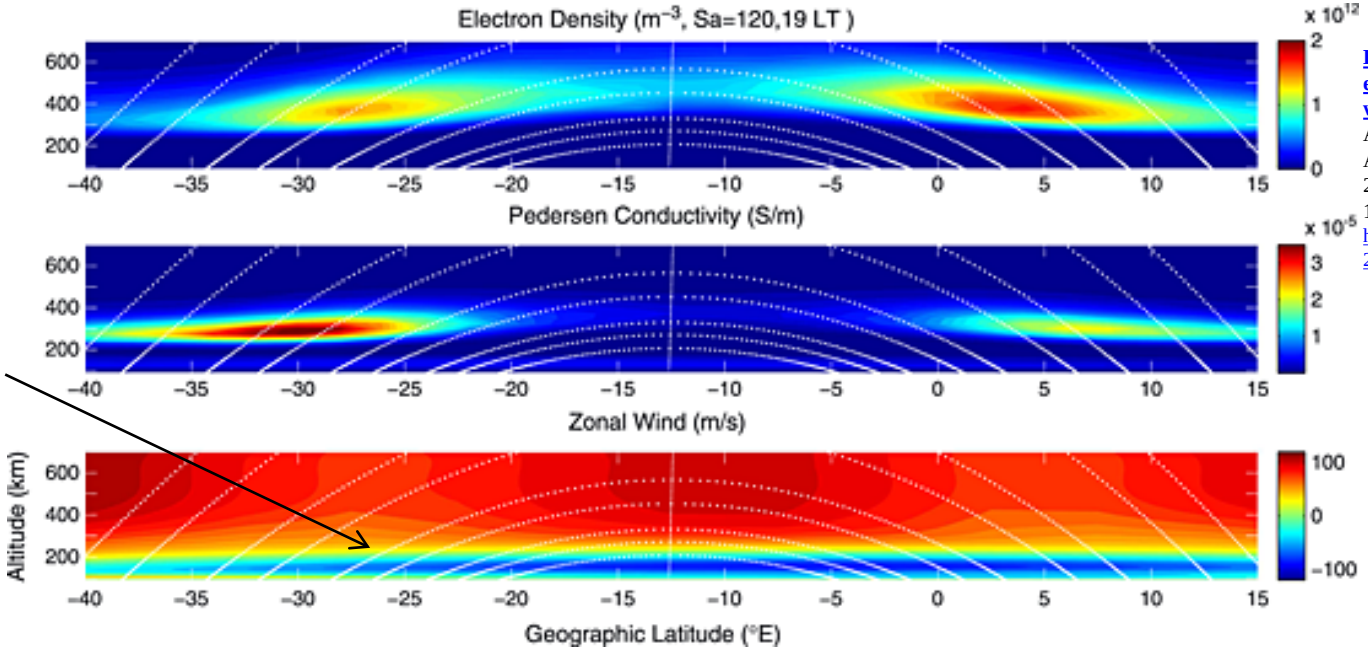
When bottom side seeding perturbations seem to always be present



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

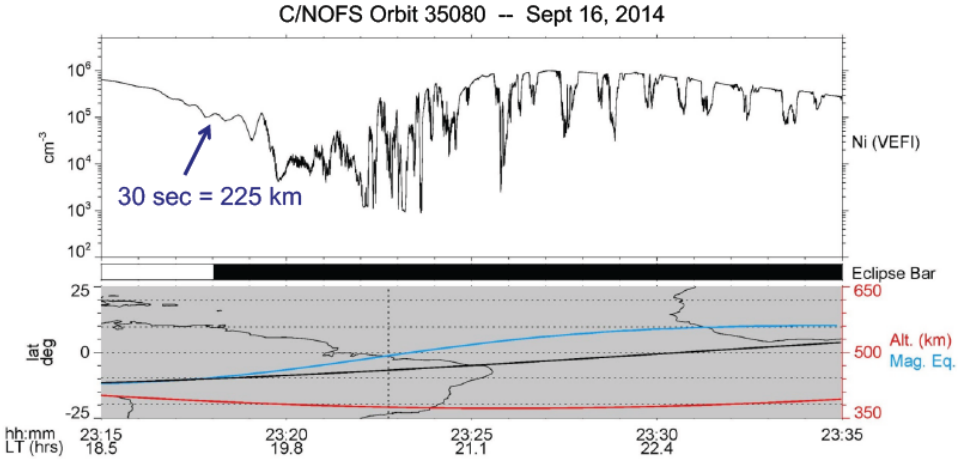


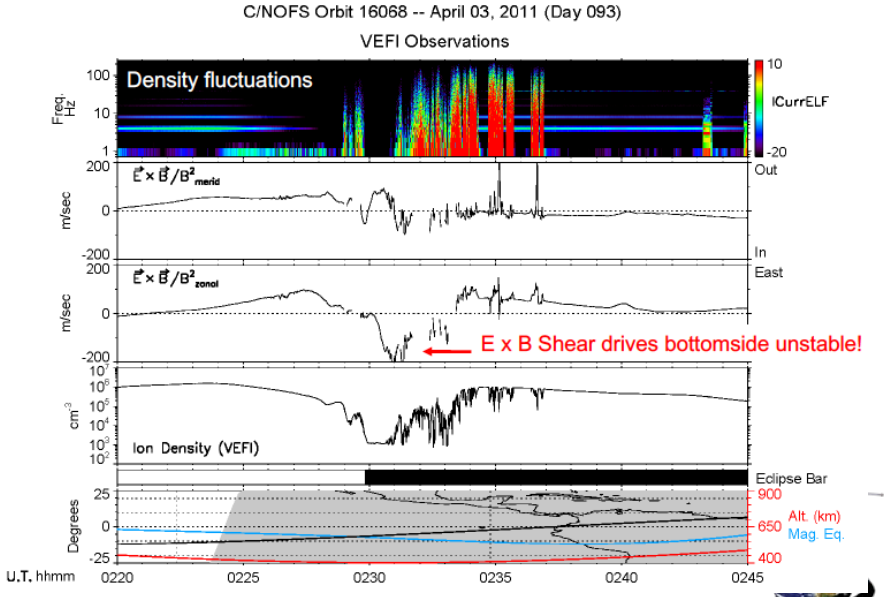
Electrodynamics of the equatorial evening ionosphere: 1. Importance of winds in different regions
Authors A. D. Richmond, T.-W. Fang, A. Maute First Published: 7 March 2015 Vol: 120, Pages: 2118–2132 DOI: 10.1002/2014JA020934
http://onlinelibrary.wiley.com/doi/10.1002/2014JA020934/full#jgra51625-fig-0001

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.

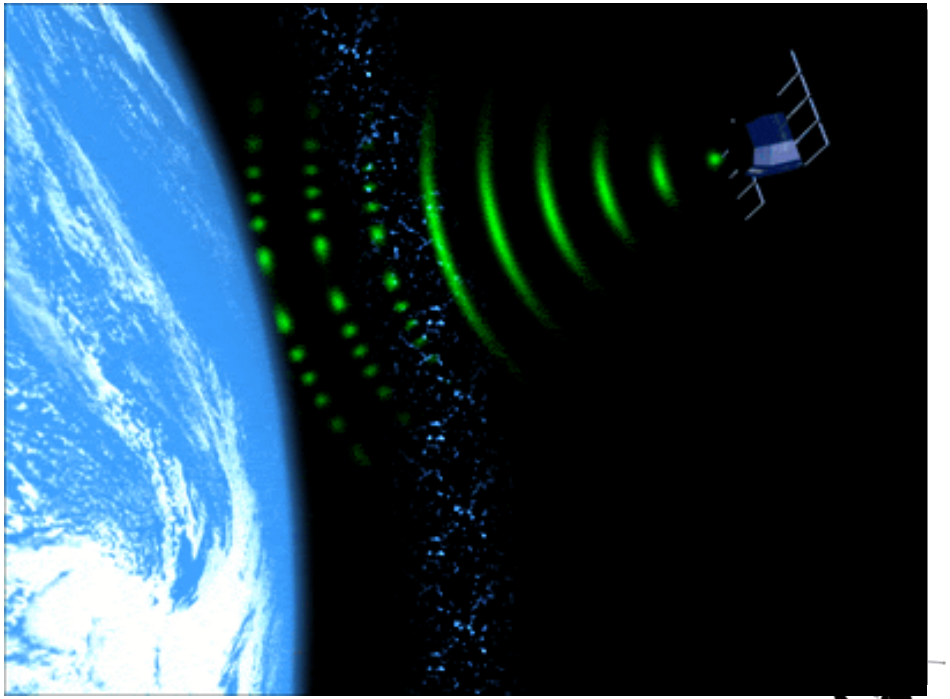
Large Scale "Undulations" (100's of km) at Lower Ledge of Ionosphere at Sunset





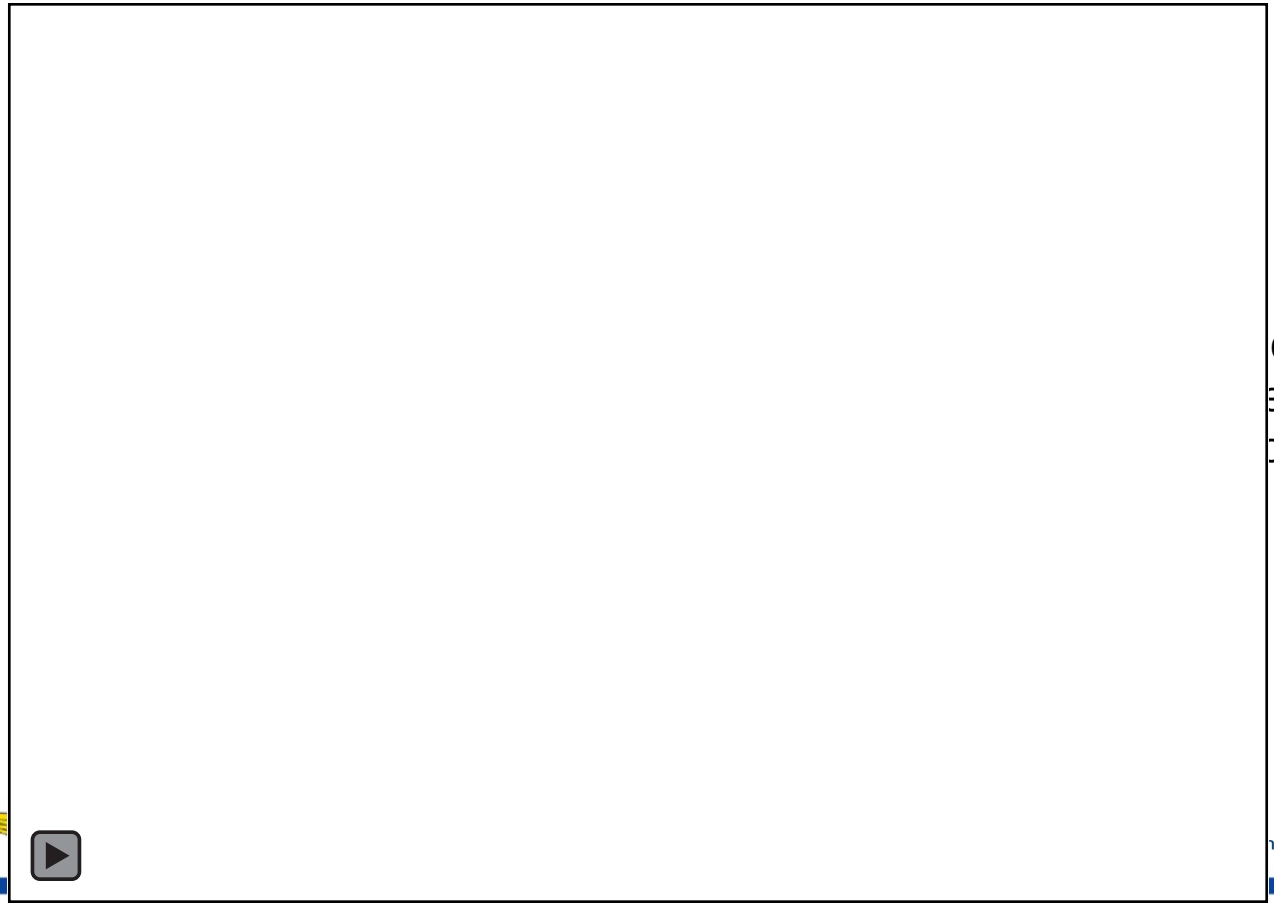
Scintillation

- Phase variations on wave front from satellite cause diffraction pattern on ground
- Interference pattern changes in time and space
- User observes rapid fluctuations of signal amplitude and phase



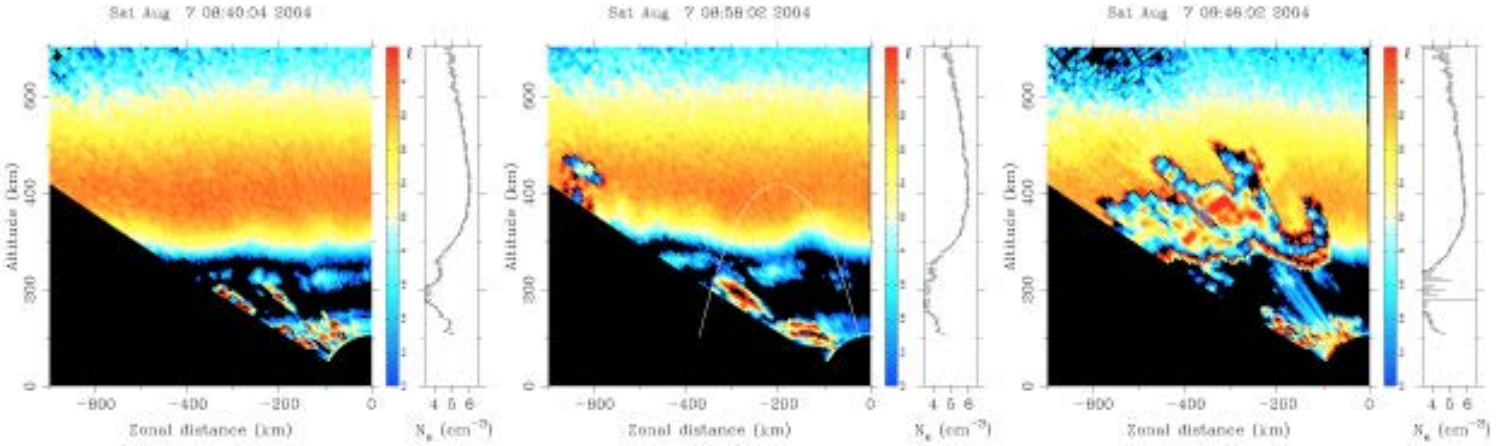
Courtesy C. Miller, Bath Univ.

Impact of Scintillations



ourtesy of
eith Groves,
oston College

Bubbles Lead to Scintillations



David Hysell Altair Observations

Not all plasma bubble depletions are associated with scintillations?

Old Bubbles?

New Bubbles?

Science Goals

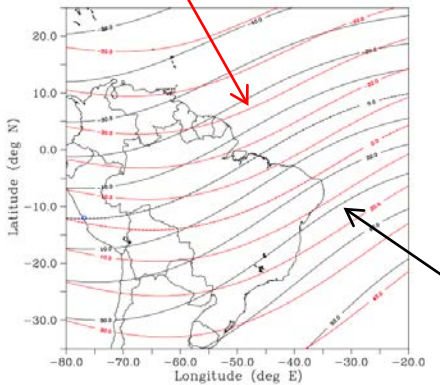
1) What is the state of the ionosphere that gives rise to the growth of plasma bubbles that extend into and above the F-peak at <u>different longitudes</u>?

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

Magnetic Field

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

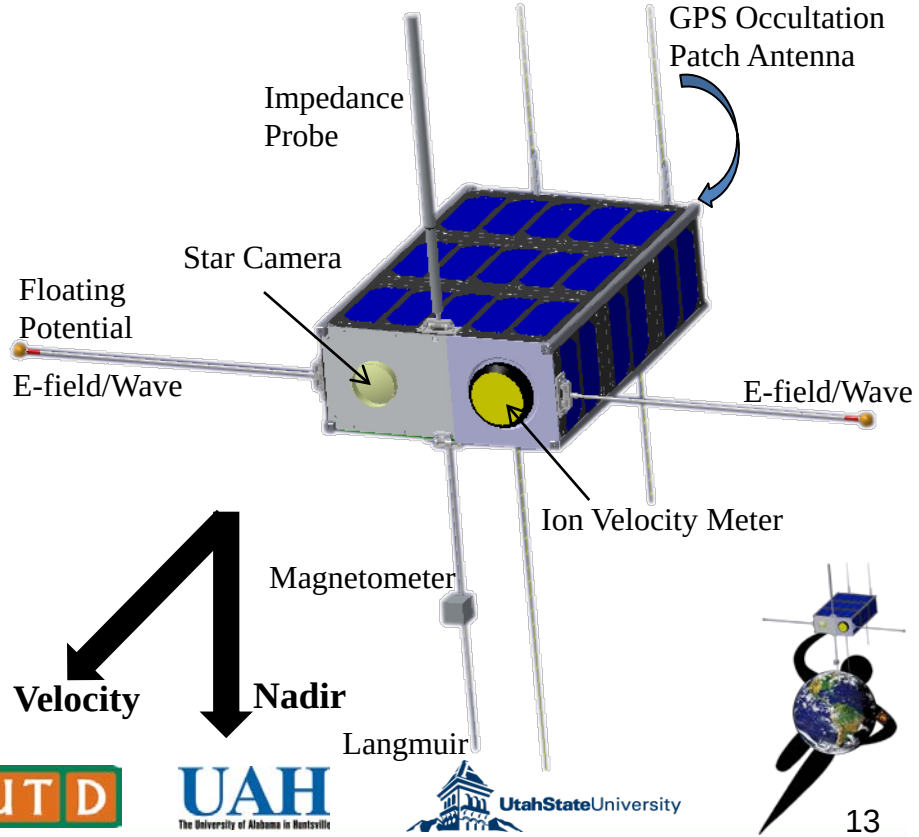
IRGF 1960



IRGF 2010

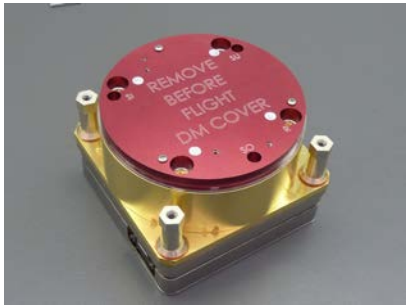
Measurement and Instrumentation

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

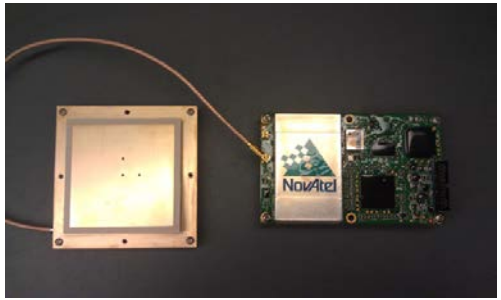


SPORT Instruments

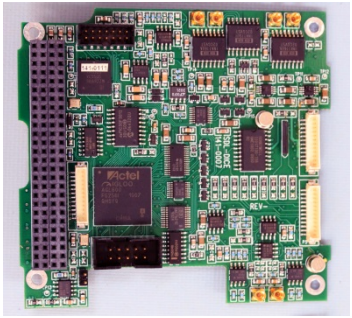
Ion Velocity Meter
UTD

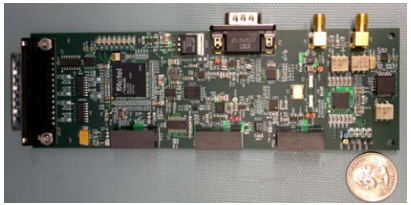


GPS Occultation
Receiver
Aerospace

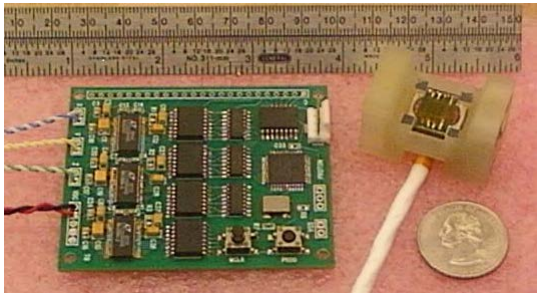


Langmuir, E-field,
Impedance Probe
USU

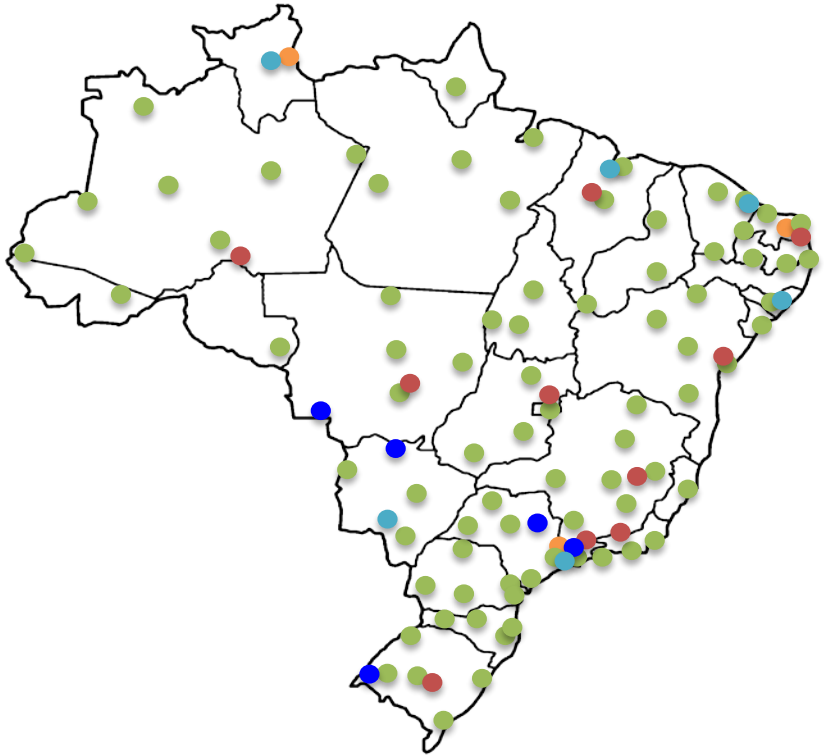




Fluxgate Magnetometer
NASA Goddard

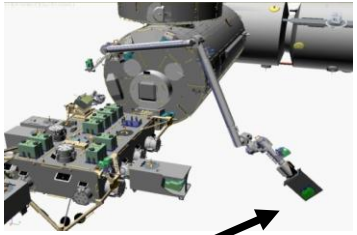


Ground Network

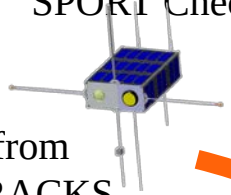


- Magnetometers
- Scintillation sensors
- TEC stations
- Imagers
- Ionosondes

Mission ConOps

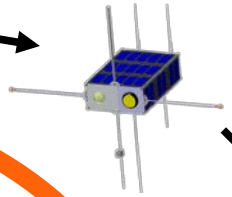


SPORT Checkout



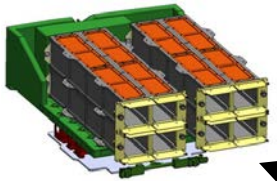
SPORT Operations

On-orbit Operations
(> 12 months)

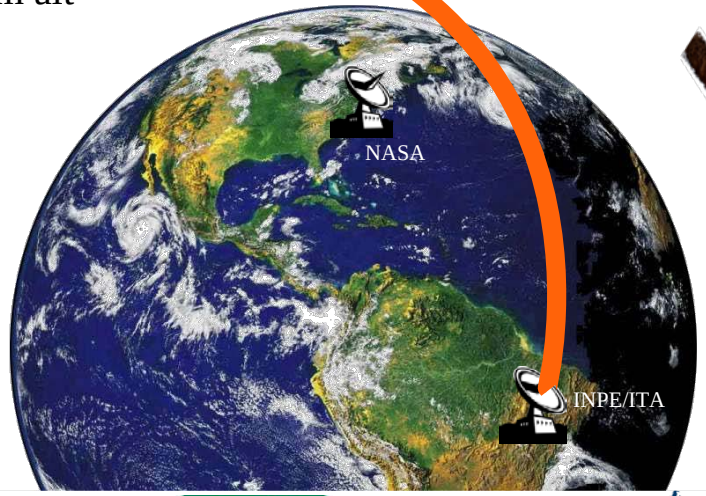


Deploy from
NANORACKS
400 km alt

Installation



Disposal
300 km alt



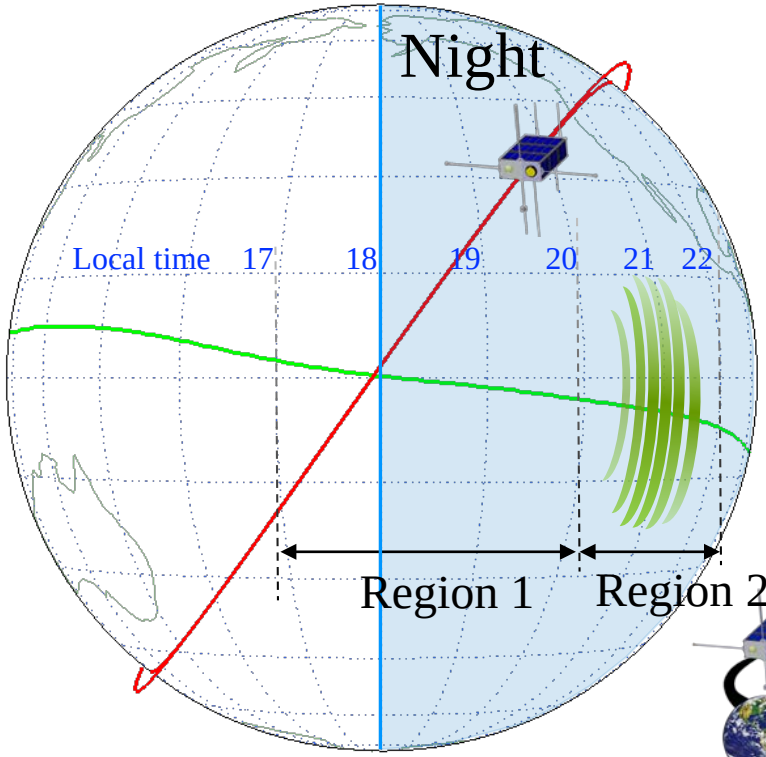
Soft
Package

Images: Charlie Gray

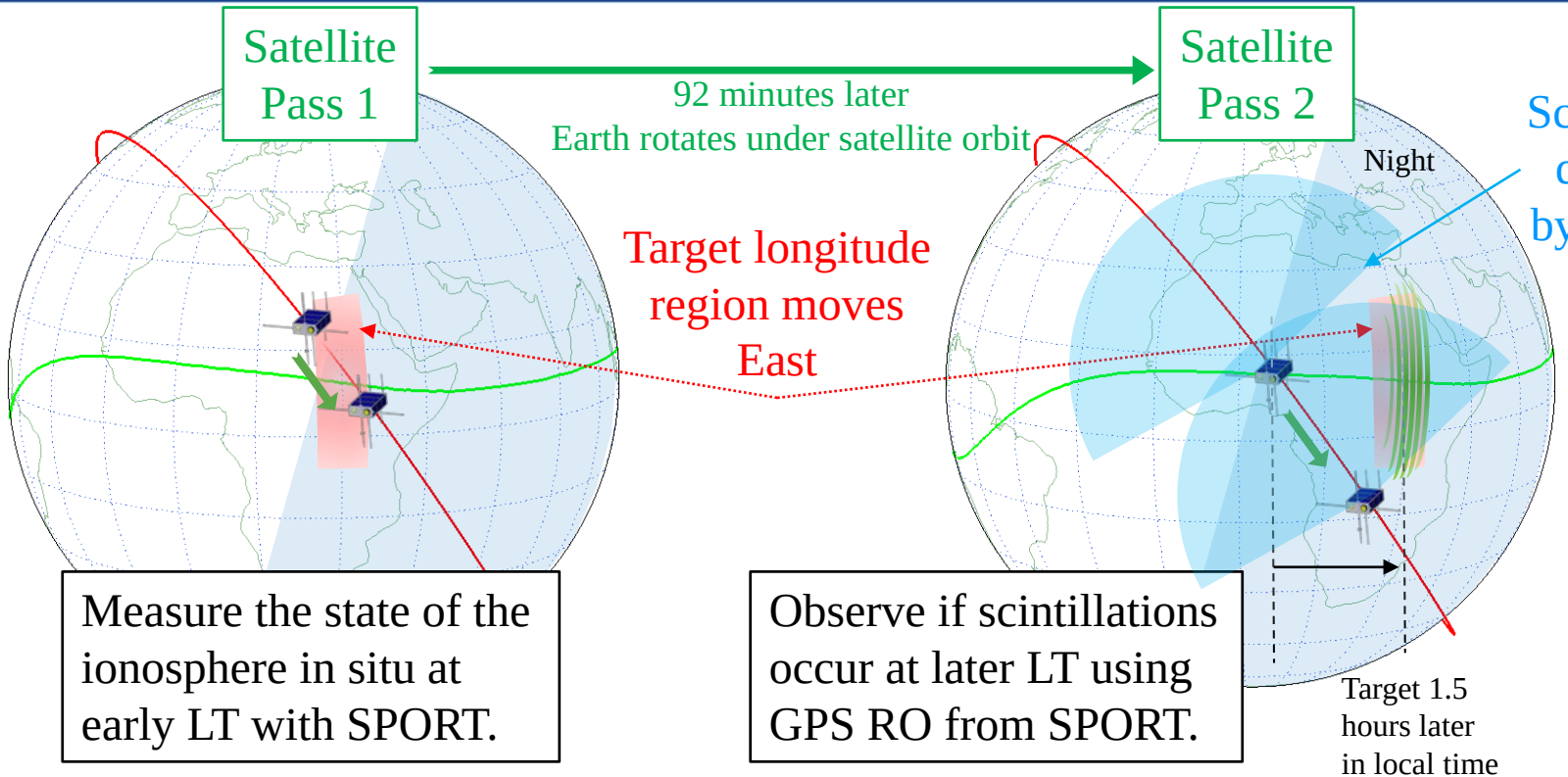
Launch

SPORT Methodology

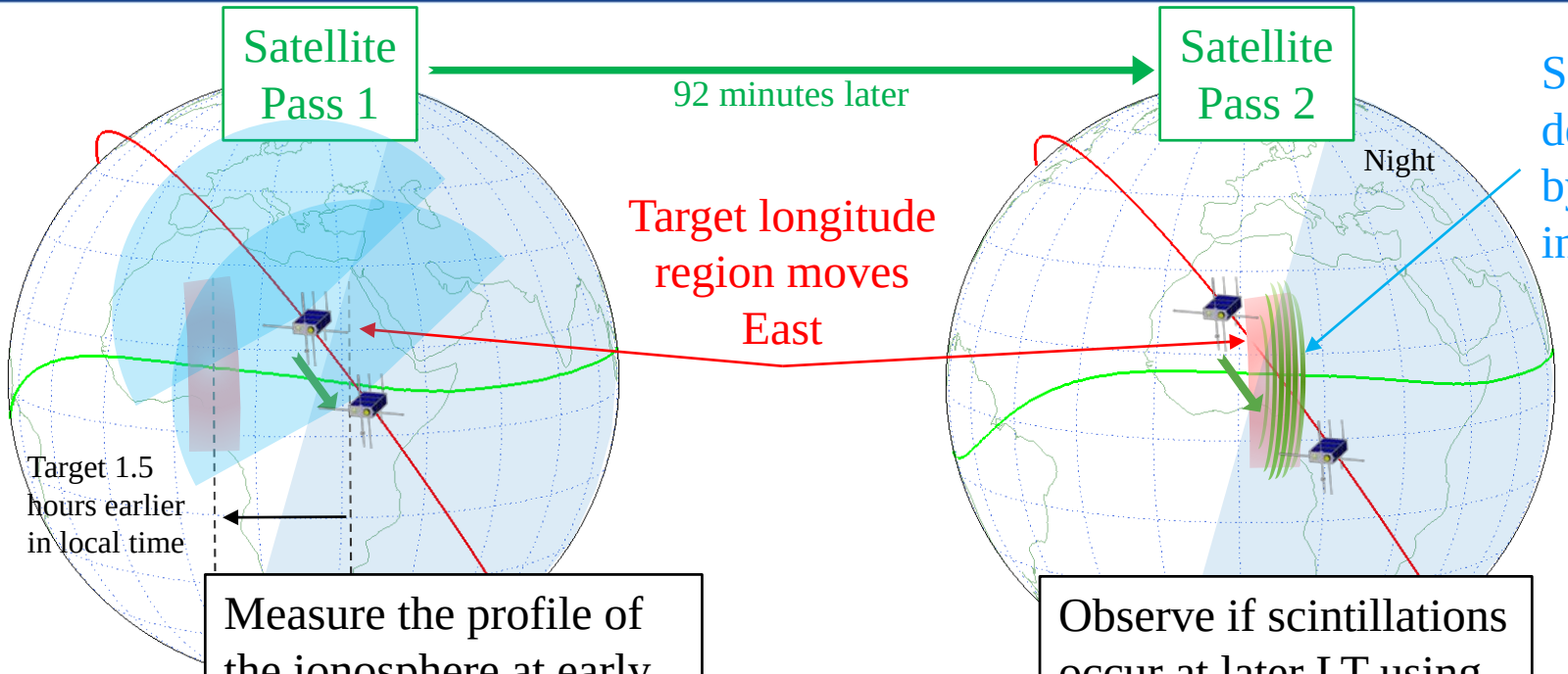
- **The state of the ionosphere at early local times is related to the occurrence of scintillations at later local times.**
  - How does this relation vary with longitude?
- **Use case studies when SPORT ascending or descending node is within 17 to 24 LT sector.**
- **Examine ~15 degree longitude sectors**



Methodology Strategy 1

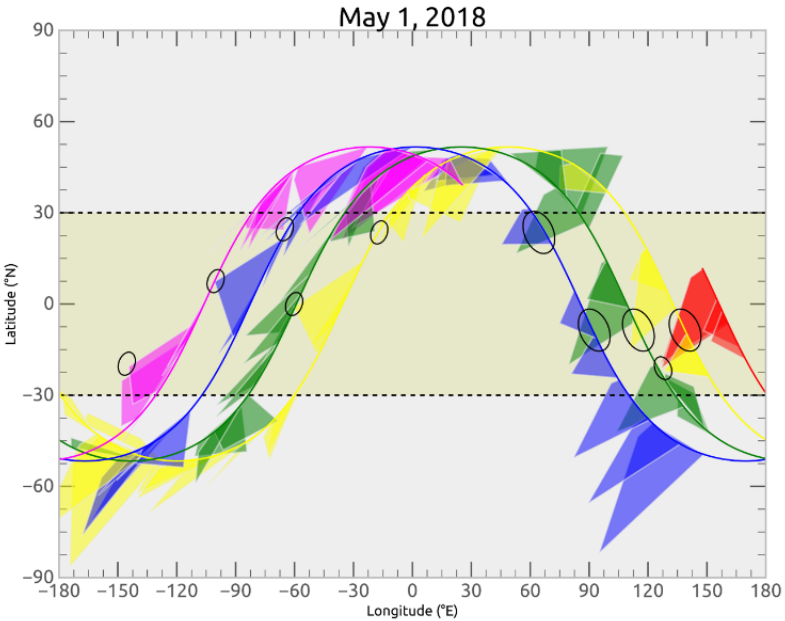


Methodology Strategy 2

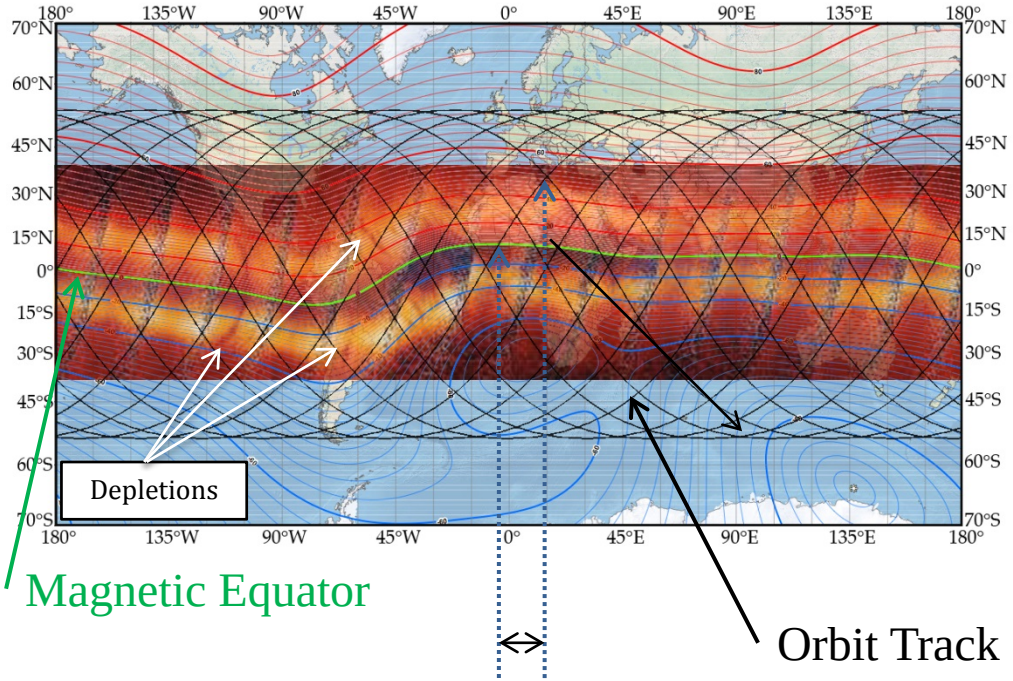


How often are ideal occultation

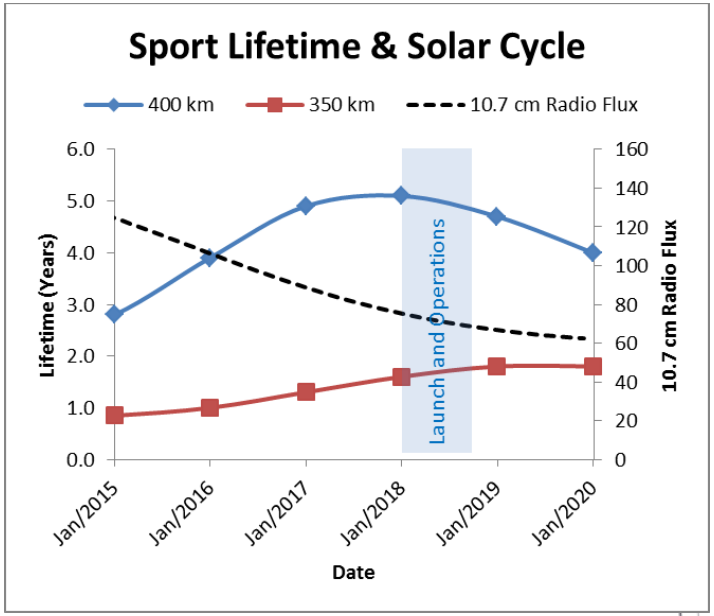
- **Study using SPORT in ISS orbit.**
- Over one orbit in the region within ±30°
  - ~2 profiles over the previous orbit traces
  - ~2 profiles occur over successive orbit traces.



SPORT Mission and ORBIT



20° latitude or 1.3 hr LT across an EIA arc



Launch from ISS, 400 km Alt
~3 year life

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**
- **Future: a string of pearls mission to increase time resolution**