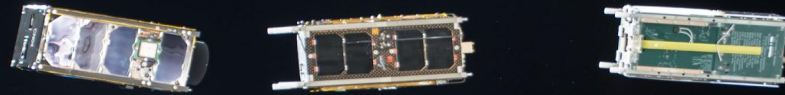


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# The impact of spacecraft charging on ionospheric plasma measurements: A CubeSats Tale



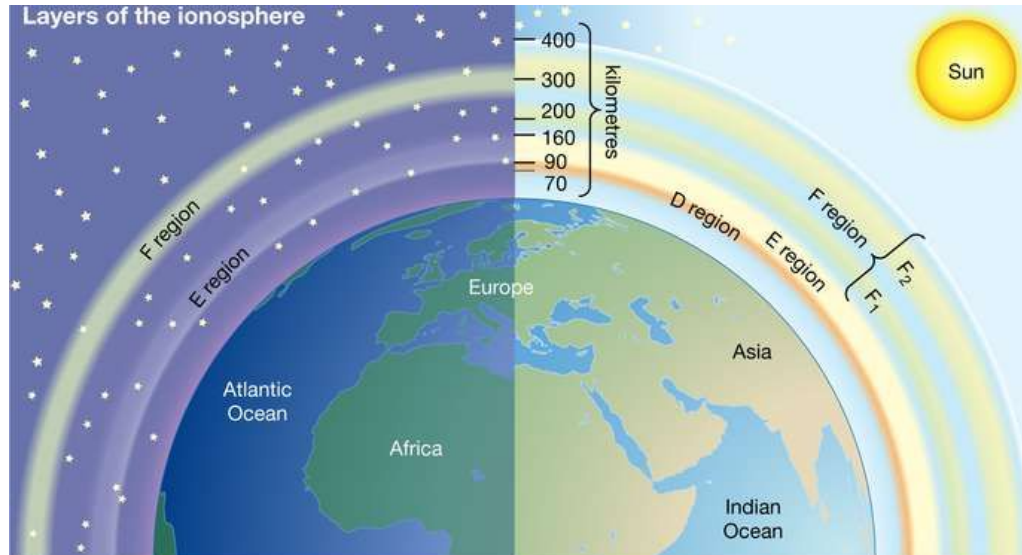
Sachin A. Reddy, Dhiren Kataria, Gethyn Lewis, Anasuya Aruliah  
Mullard Space Science Laboratory, UCL

SPINE 2021 - 9th June 2021

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# Background

## The Upper Thermosphere



A region within the Ionosphere, 300 - 500 km. Phoenix was at 380 km low latitude.

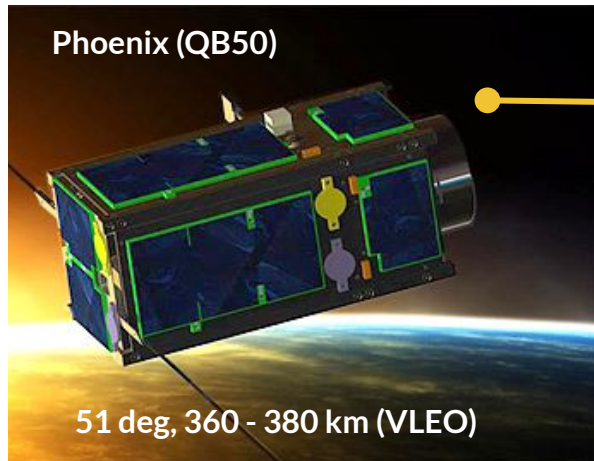
Contains ions, electrons and neutral particles. O<sup>+</sup> is most dominant, N<sup>+</sup> and NO<sup>+</sup> present in lower amounts

Collisional, but still collisionless. Mean free path  $\gg$  Debye Length

Britannica (2012)

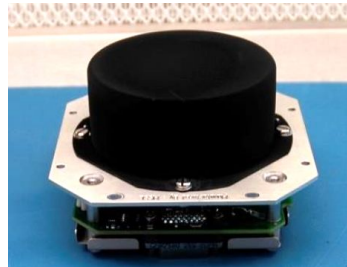
# Instrumentation

## The Ion Neutral Mass Spectrometer on Phoenix

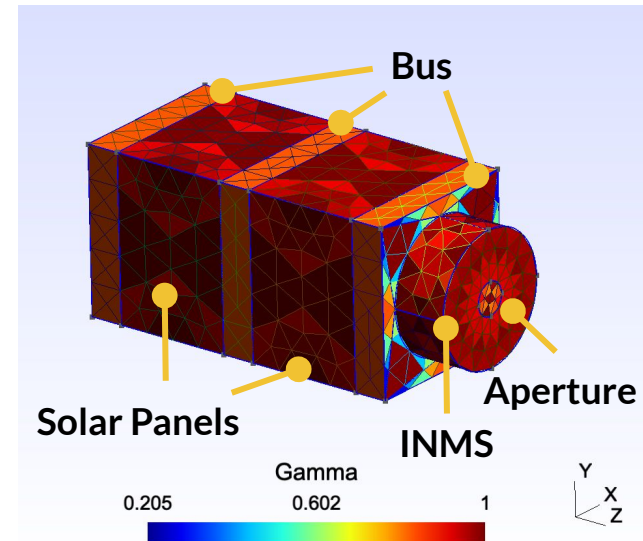


National Cheng Kung University (2017)

Measures in the  
ram direction of  
the spacecraft



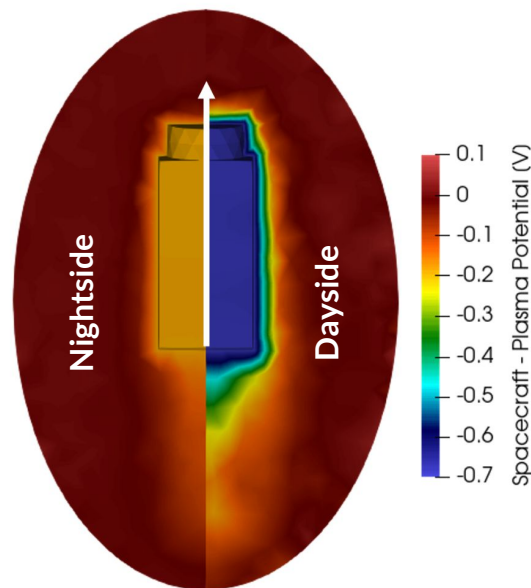
Kataria (2020)



# Results

## SPIS Analysis

Location	Density [m <sup>-3</sup> ]	eT [eV]	iT [eV]	Photo - emission
Day	1e+11	0.2	0.1	Yes
Night	7e+10	0.06	0.06	No
Ion Drift	SC Vel [km/s]	Ion		
No	7.7	O+		

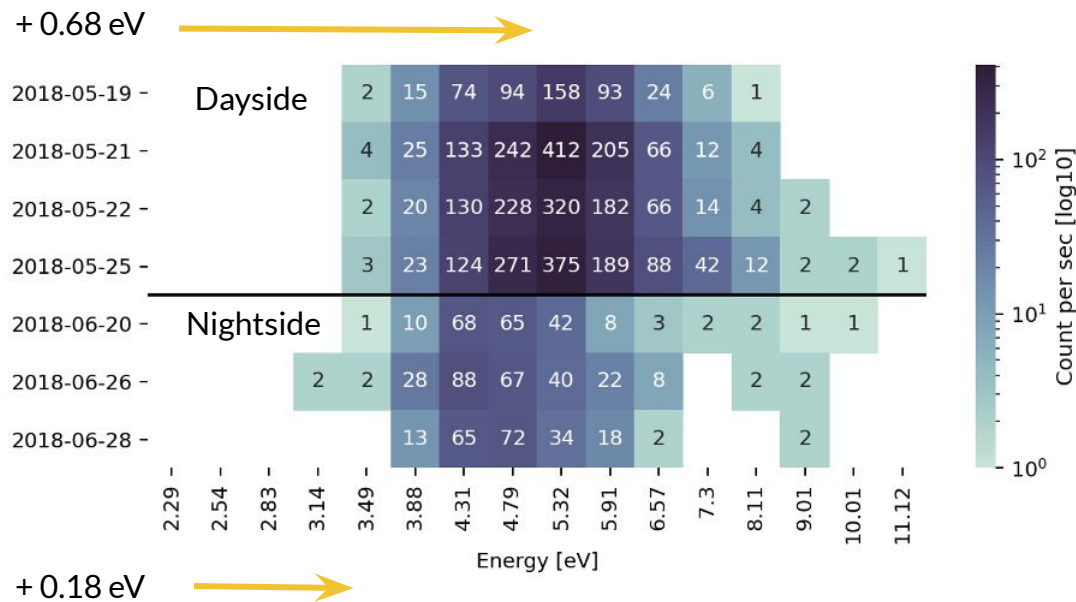


Potential is > 3x greater during the day

Photoemission is negligible even when 50% surface emits electrons. What could cause this?

# Results

## In-flight data analysis from Phoenix



Higher counts = higher density. This is expected in the dayside

SCh shifts ions into higher energy

*Energy converted into velocity:*

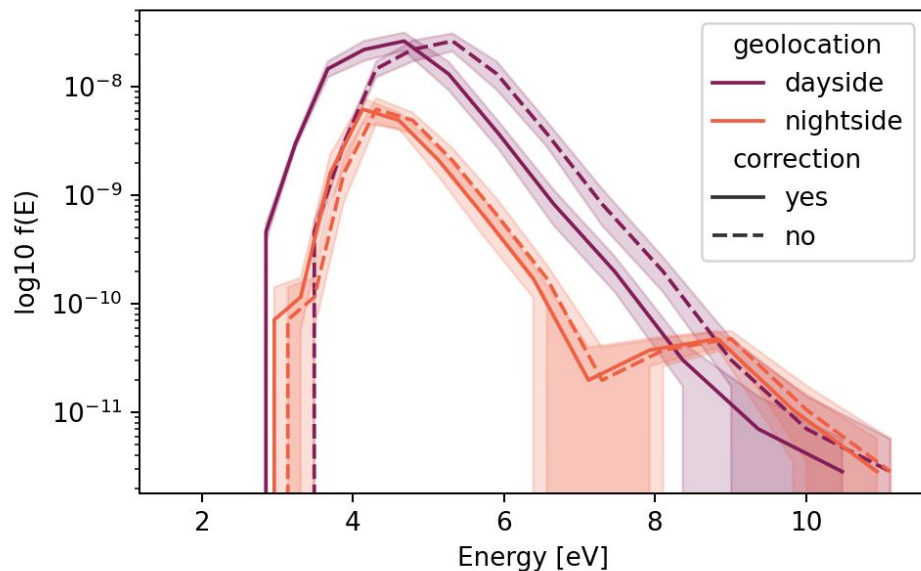
$$v = \sqrt{\frac{2E}{m}}$$

*Counts converted into phase space density:*

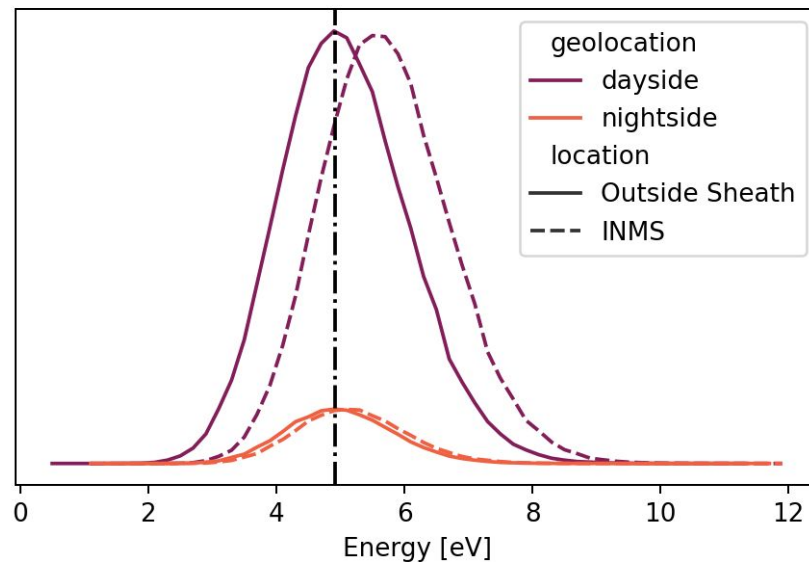
$$f(v) = \frac{2N}{t_a v^4 G_e}$$

# Results

## INMS Distribution

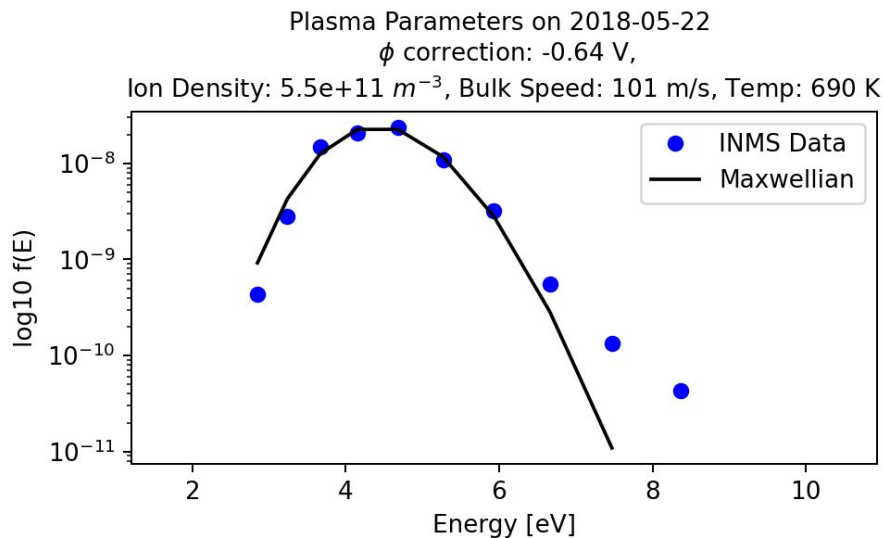


## SPIS Particle Detector



# Results

## Fitting the data to derive plasma parameters



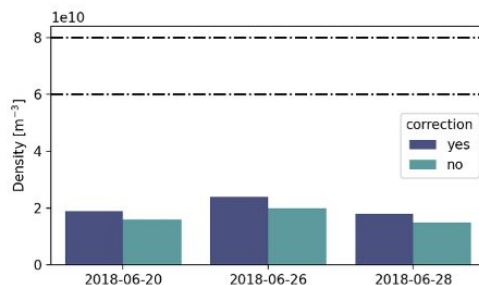
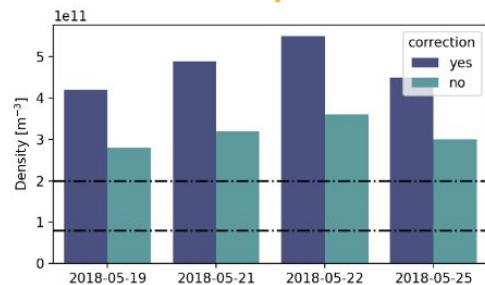
Least Squares fitting routine using  
Levenberg-Marquardt algorithm

Reduce the residual error by iteratively  
updating the the parameters

Requires (sensible) initial guesses for density,  
bulk speed and temperature

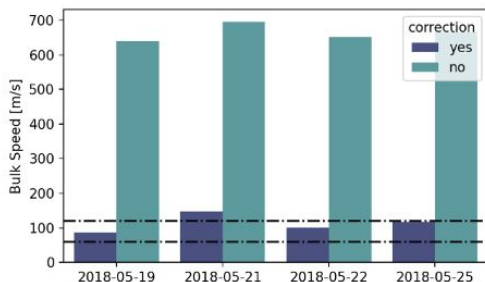
# Results

## Parameters comparison: correction vs. no correction

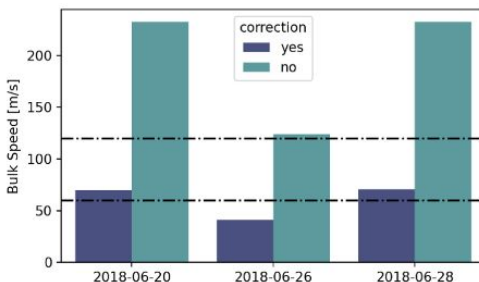


Density is within an OoM of the benchmark, but not within range.

Bulk speed is significantly improved with SCh corrections and within expected range. Further validation of SCh outputs.



Dayside



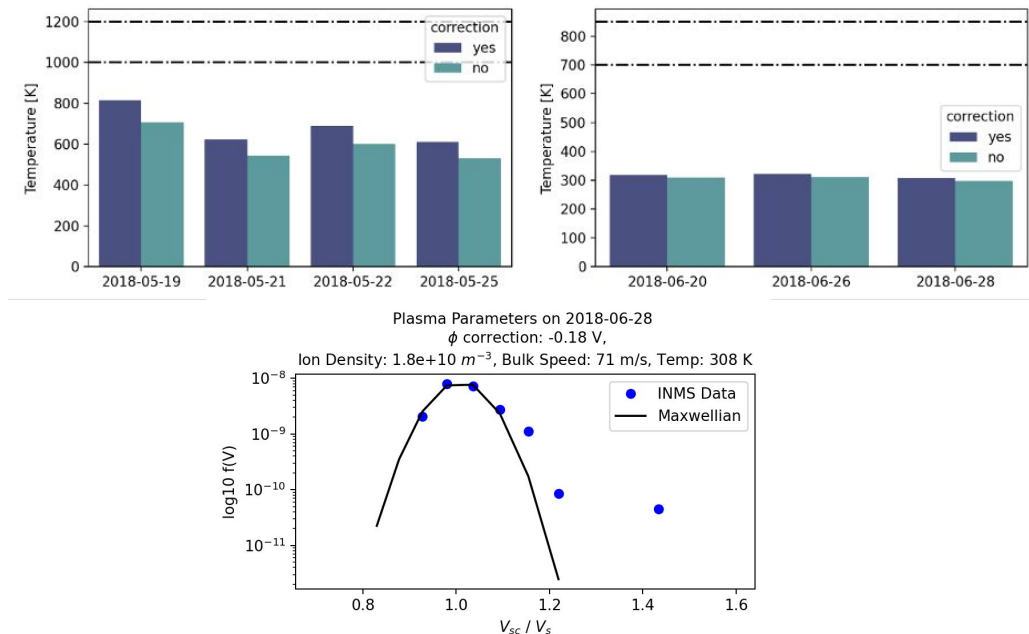
Nightside

Corrections less pronounced at night because potential is smaller



# Results

## Parameters comparison: correction vs. no correction (2)



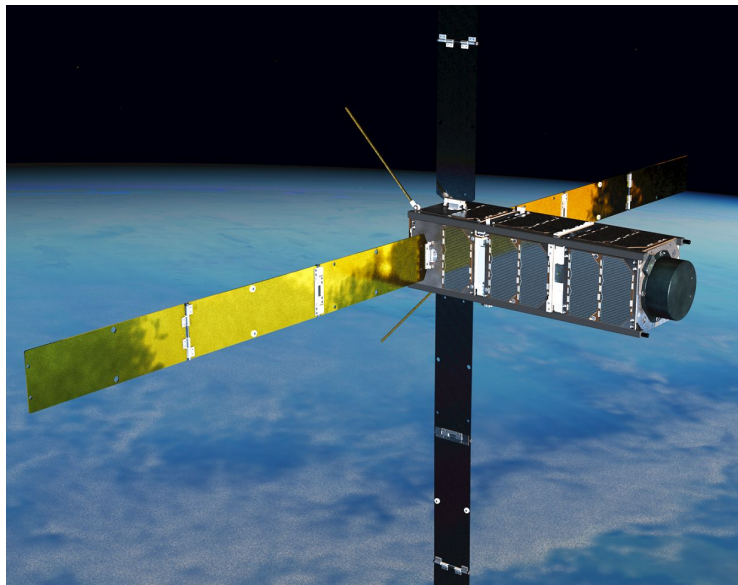
Temperature is too low across both day and night. SCh corrections do improve measurements though

Ram only (1D) capture = undersampling of data

Working on method to fold multiple angles to create 2D spread. Should improve fit, but won't be as good as 3D / full VDF

Very much welcome ideas

# New Mission



The Satellite for Orbital Aerodynamics Research (SOAR) launched to ISS on 03/06/21

A 3U CubeSat that will study the residual atmosphere and plasma interactions in very low earth orbits (VLEO).

Improved INMS with time-of-flight feature

**New data from July 2021**