Lunar Reflectance in Lyman α

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Outline

i. Scientific Background
ii. Data Reduction
iii. Lunar Albedo measurement
iv. Future Work

Why is the Lunar Albedo important?

- What is Albedo?
- Learn more about the Lunar Surface Properties
- Calibration for other Instruments

$$A_M = \frac{E_M / \Omega_M}{E_S / \pi}$$

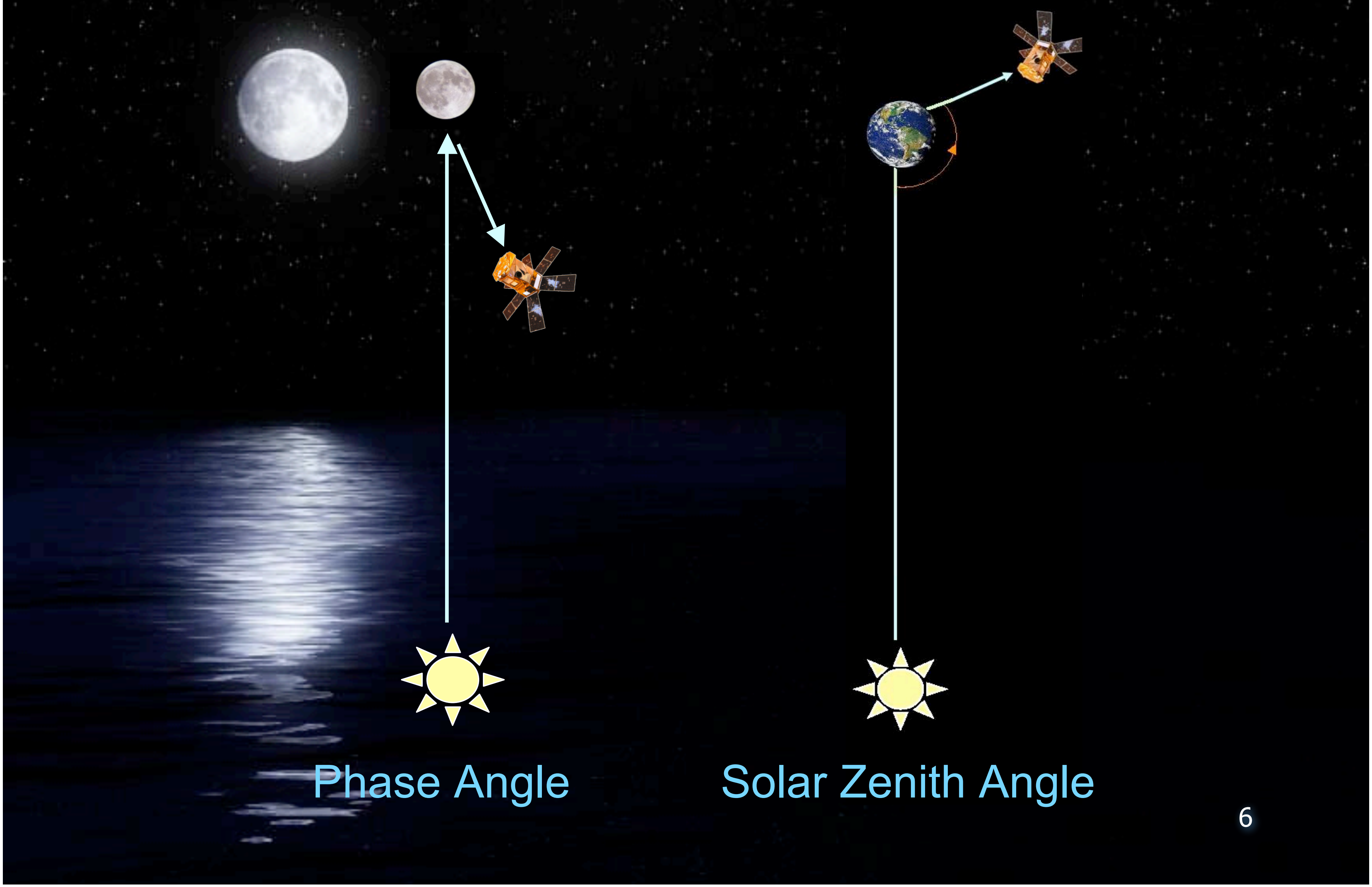
Remote Sensing of the Moon

- Mineralogy
  - Surface composition
- Space Weathering
  - Changes to the reflectance properties of a material that’s exposed to the space environment for long periods of time
- Photometry
  - Reflectance properties as a function of phase angle depends on details of the surface

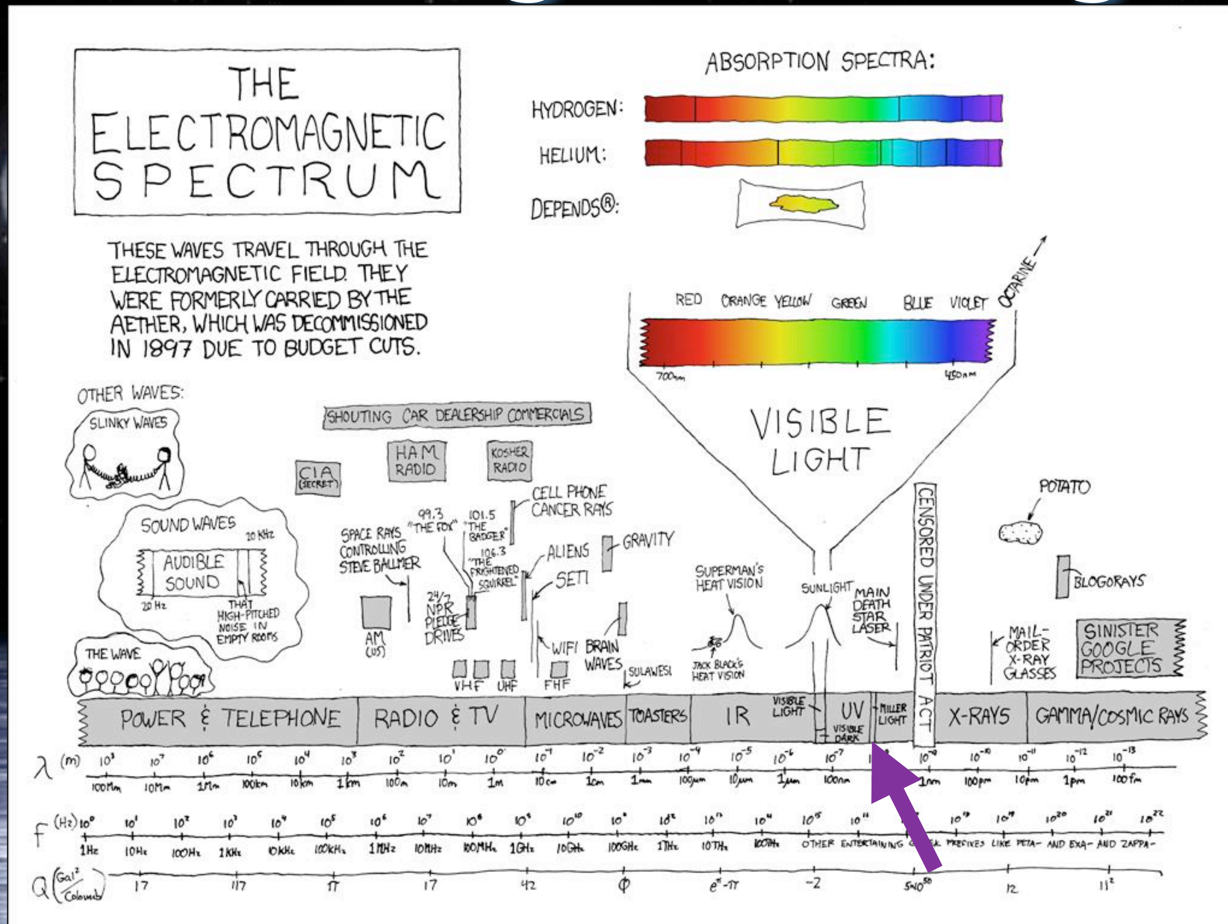
Lunar Observations as a Calibration Standard

- Photometrically stable
- Visible from any Earth orbit
- Ultraviolet instruments are difficult to calibrate accurately
- Limited sources that are well-characterized
- Carefully measuring the Moon with SOLSTICE could provide an ultraviolet standard from which future instruments could benefit
- The Robotic Lunar Observatory (ROLO) is a US Geological Survey project with this goal in the visible to near-infrared; SOLSTICE would extend this to the UV

Geometrical Terms

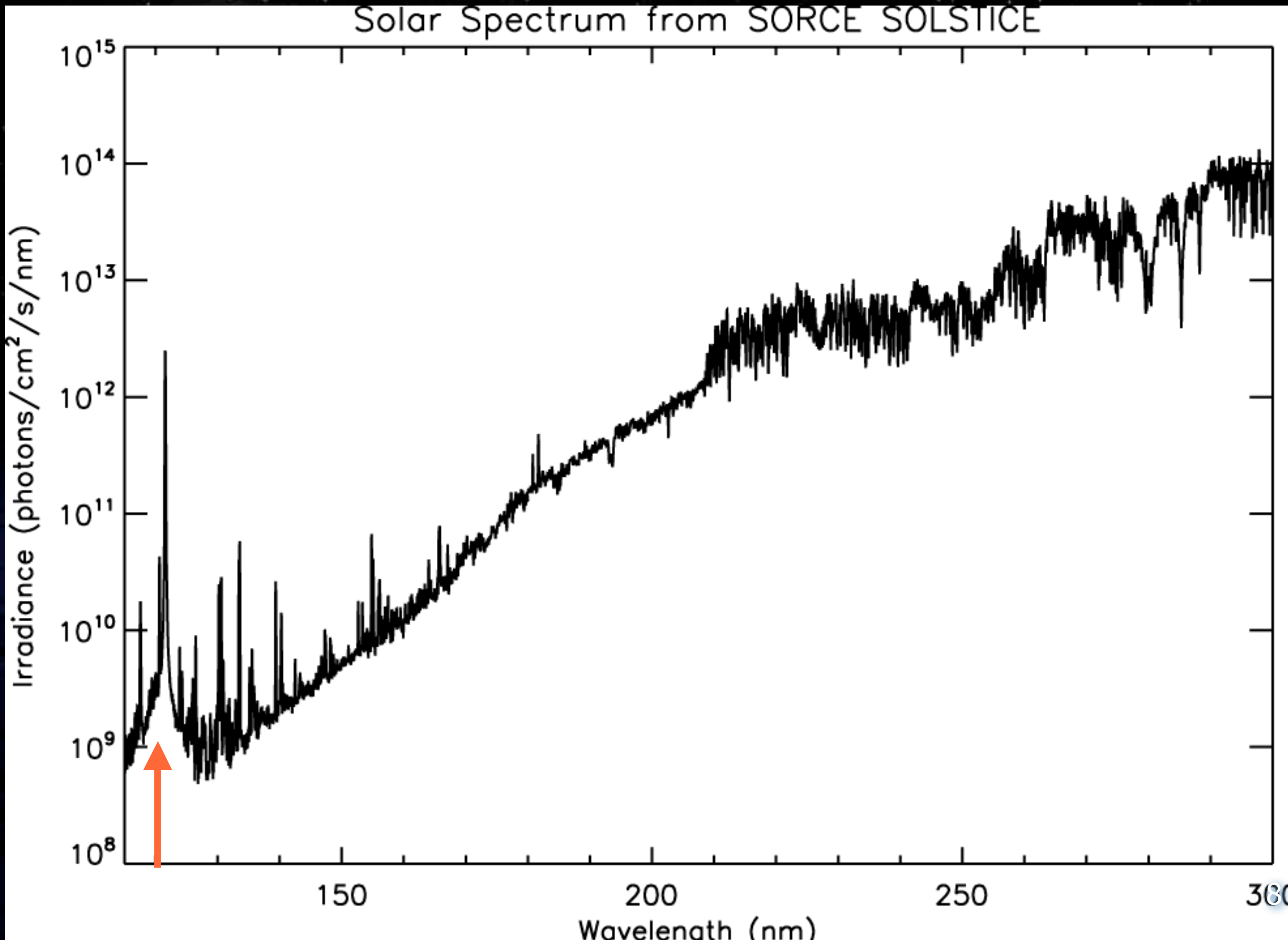


Wavelength Coverage

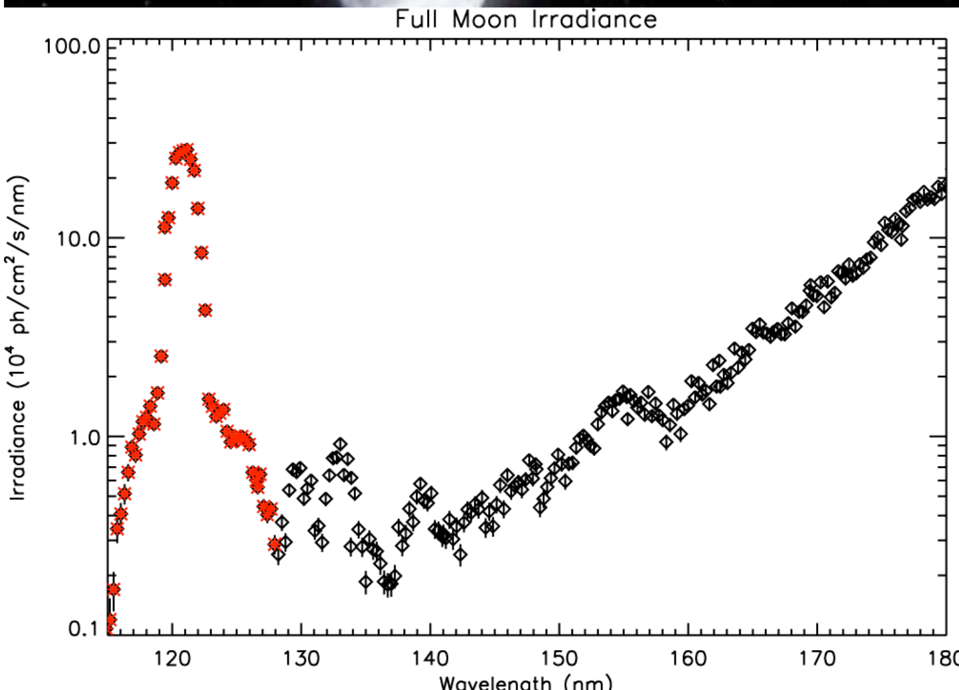


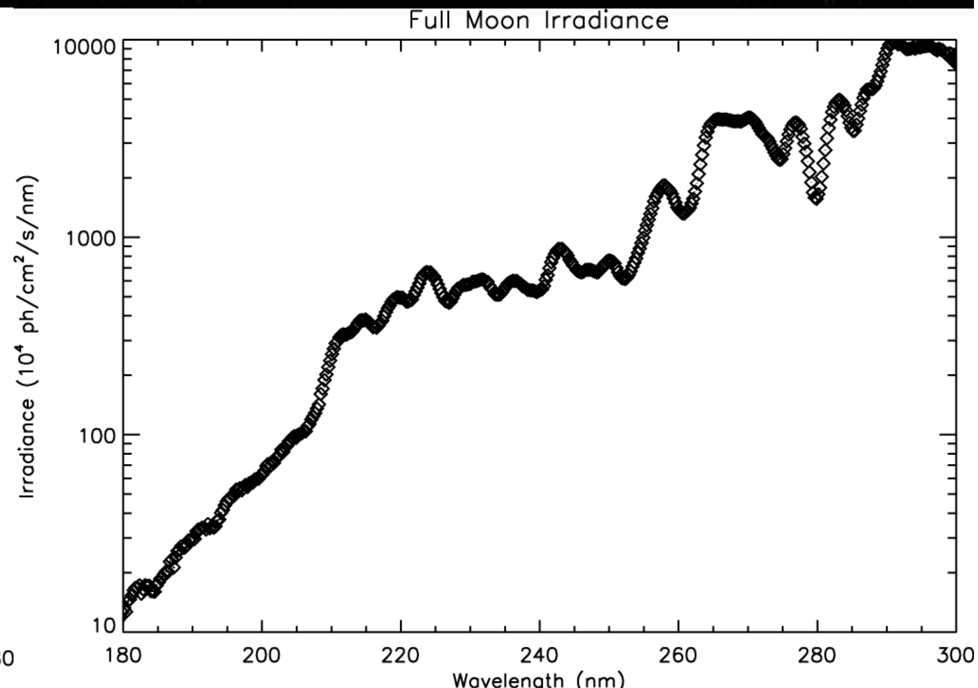
- ✦ SORCE Satellite – SOLSTICE instrument
  - ✦ measures UV (~115-310 nm) – Lyman α (121.6nm)
  - ✦ 1 nm resolution in stellar mode and 0.1 nm resolution in solar mode

Solar Spectrum - Lyman α



Lunar Spectrum

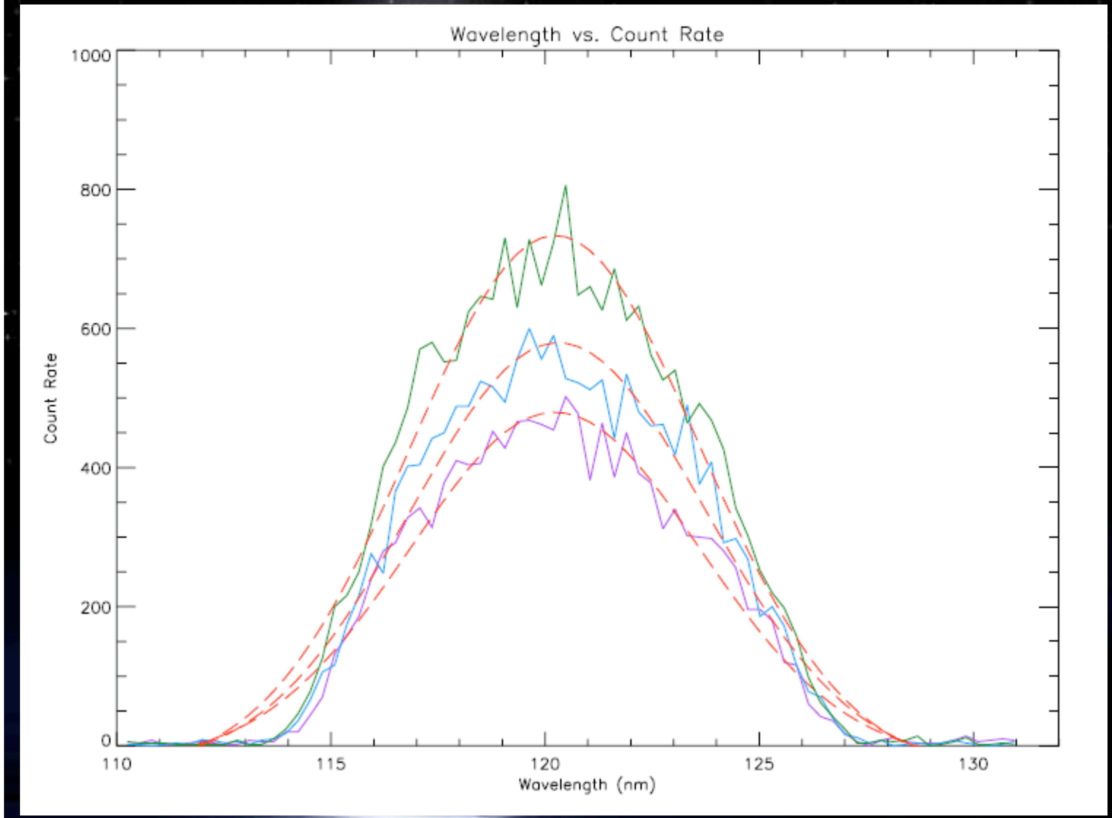




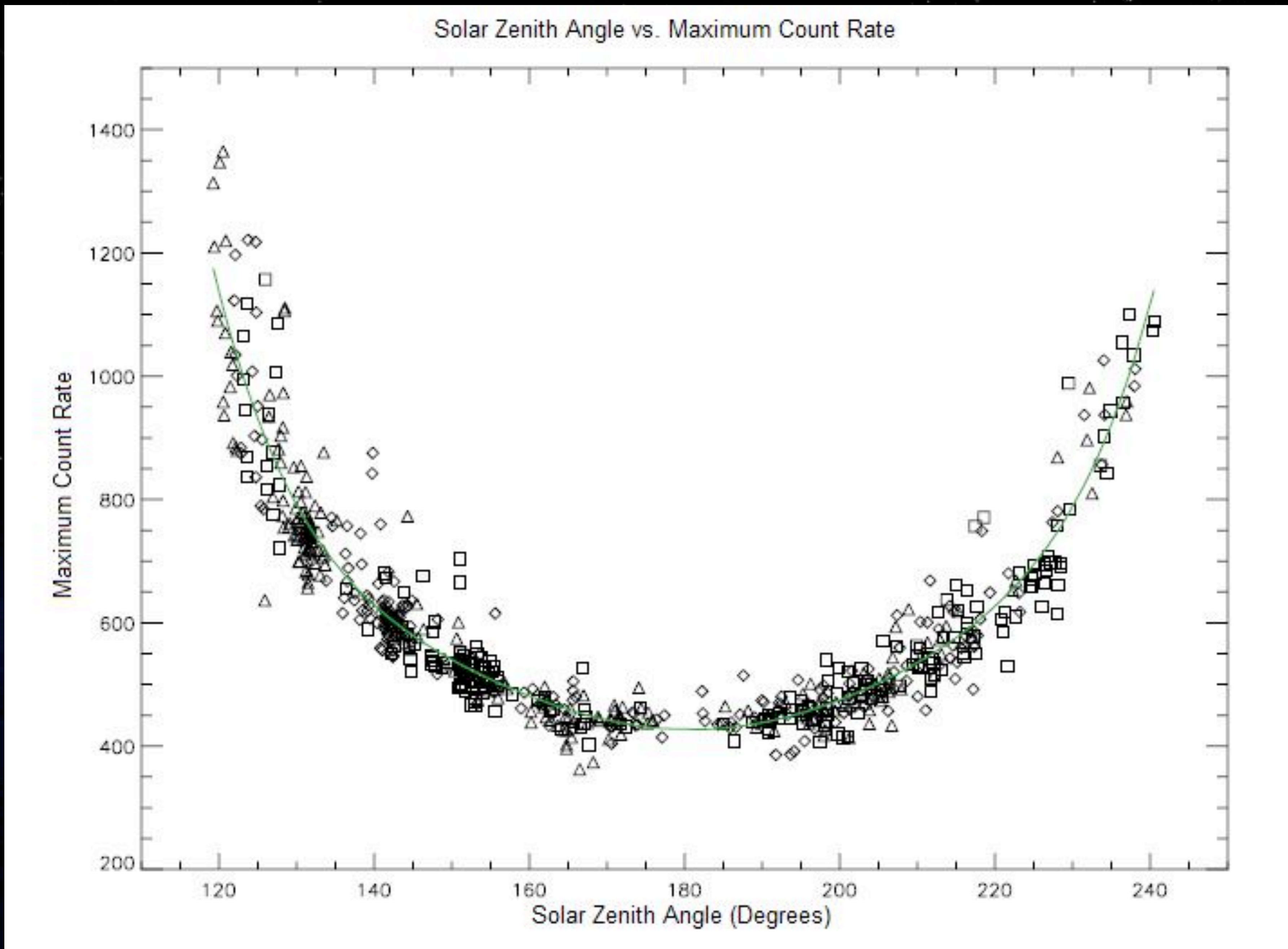
Airglow

- SORCE satellite is still within part of the Earth’s atmosphere
- Caused by light scattering off the hydrogen atoms of the atmosphere
- This background light adds to the lunar signal that SOLSTICE observes

Determine Airglow

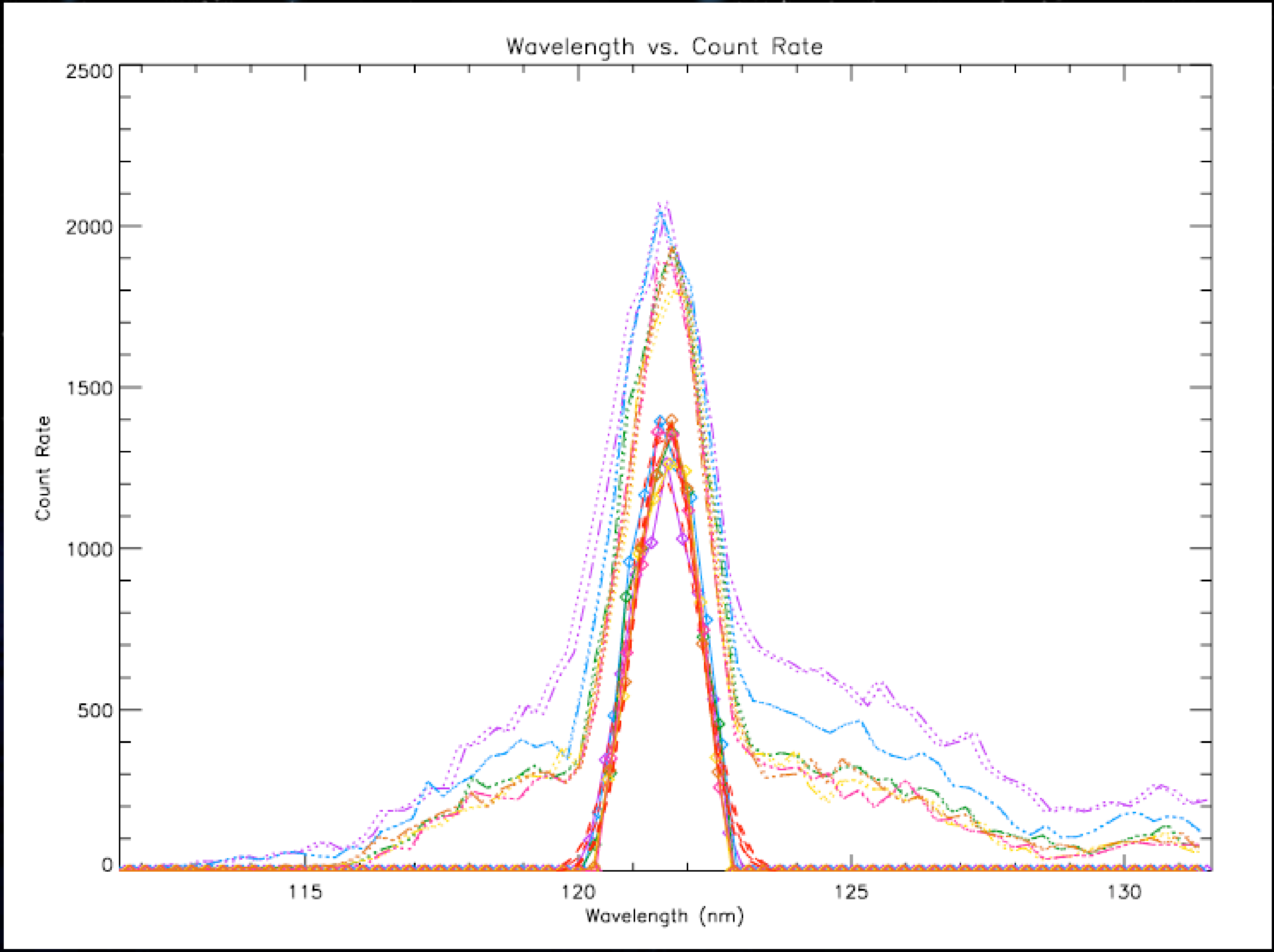


- Three scans of just the atmosphere
- Data Reduction
- Each peak is at a different Solar Zenith Angle
    - 218.6°
    - 207.4°
    - 196.2°
- Gaussian Fits

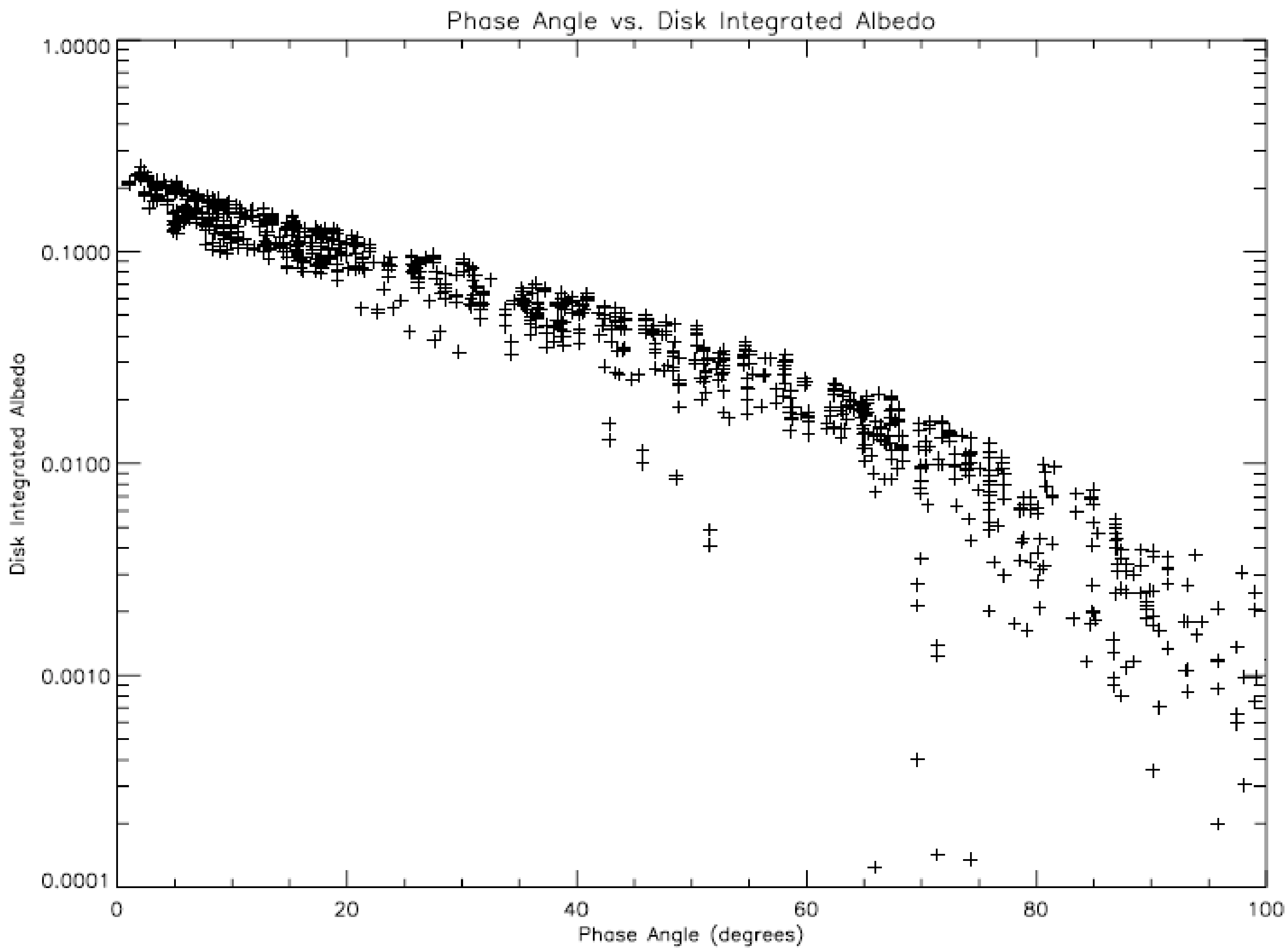


Solar Zenith Angle vs. Maximum Count Rate
Maximum Count Rate
Solar Zenith Angle (Degrees)
1400
1200
1000
800
600
400
200
120
140
160
180
200
220
240

Lyman Alpha after Background Subtraction



Lunar Phase Curve at Lyman Alpha



Opposition Effect

Summary

- Lunar albedo can be a good thing to know
  - Lunar properties
  - Calibration
- Reduced the SOLSTICE data
- Airglow subtraction
- Found the lunar albedo

Future Work

- Improving the model to prevent the scatter in albedo
  - Try other fits
  - Testing the background prediction to find the uncertainty

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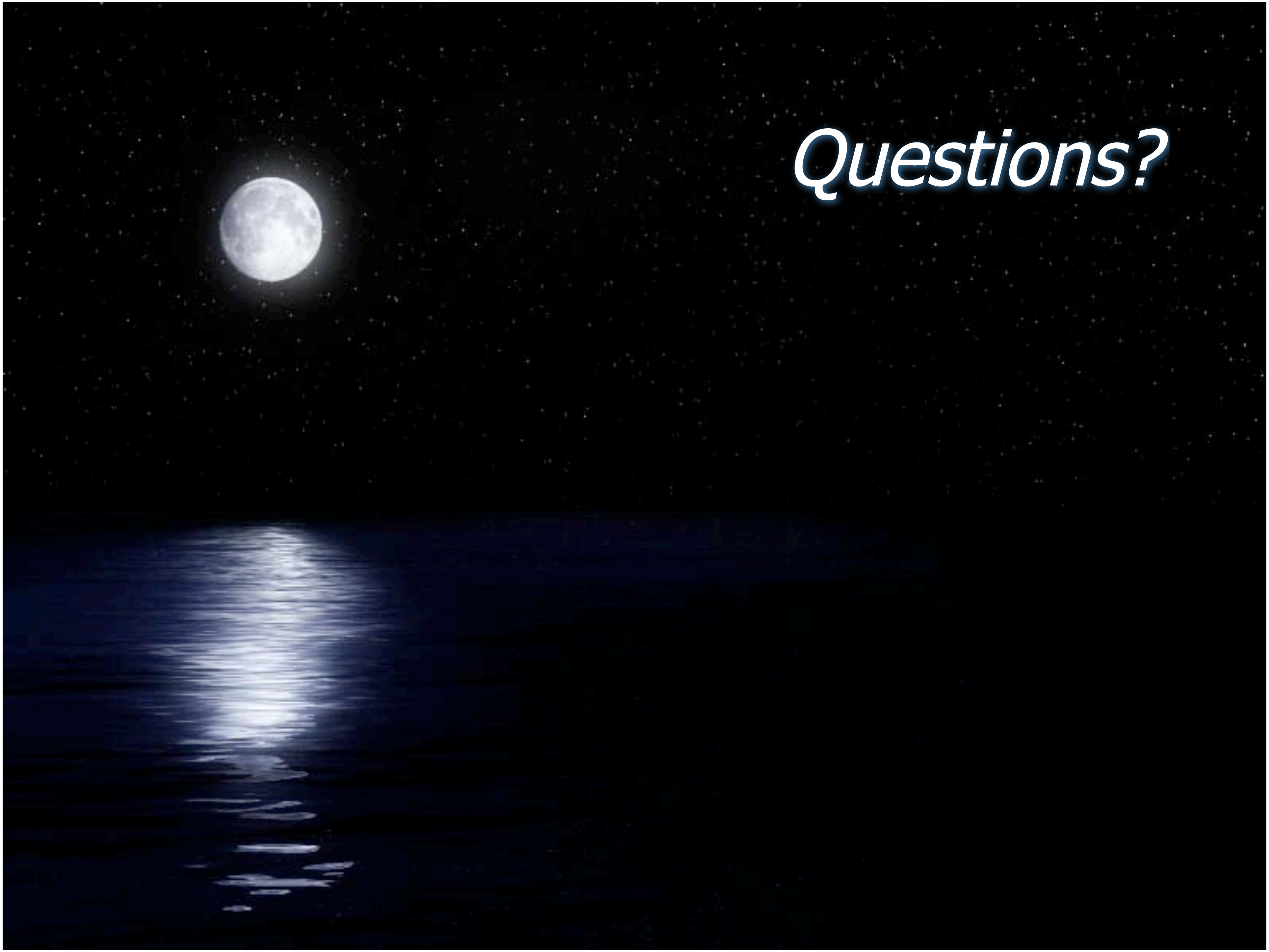

Questions?

Space Weathering in the Ultraviolet

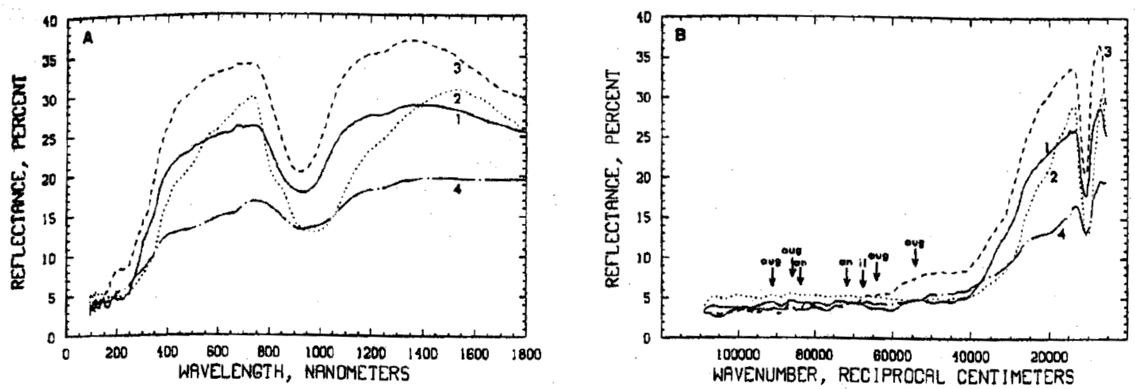


FIG. 13. Spectra of powdered samples of lunar rocks (see also Fig. 1). (A) Reflectance (%) vs wavelength (nm). (B) Reflectance (%) vs wavenumber (cm^{-1}). 1, Apollo sample 14310; 2, Apollo sample 15555; 3, Apollo sample 65015; 4, Apollo sample 70017.

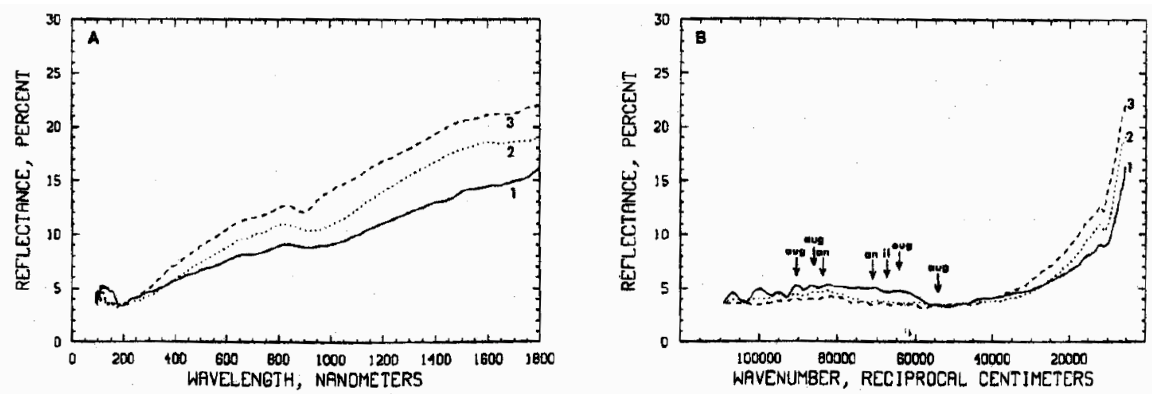
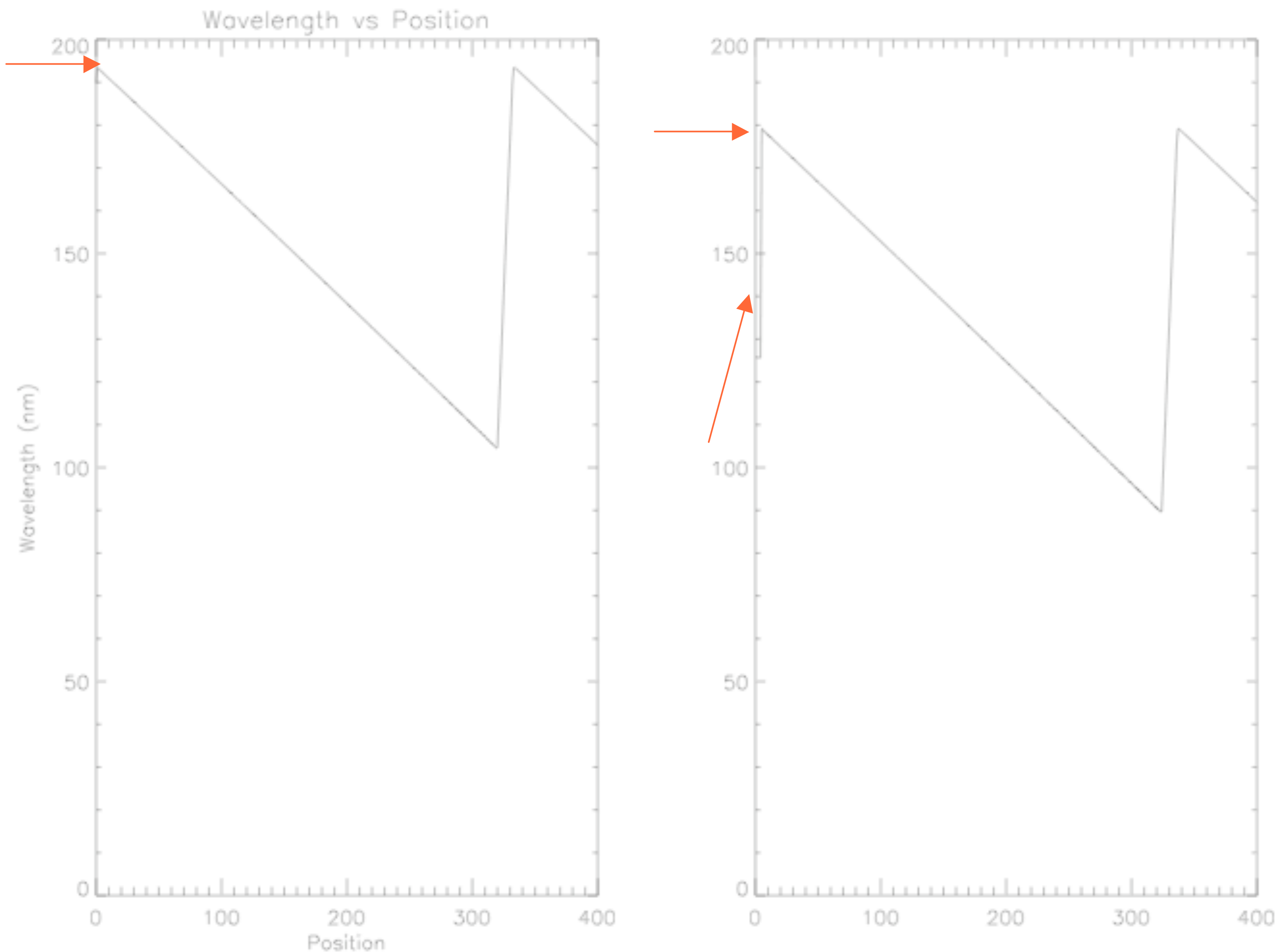


FIG. 14. Spectra of lunar soils. (A) Reflectance (%) vs wavelength (nm). (B) Reflectance (%) vs wavenumber (cm^{-1}). 1, Apollo sample 10084; 2, Apollo sample 12001; 3, Apollo sample 14003.

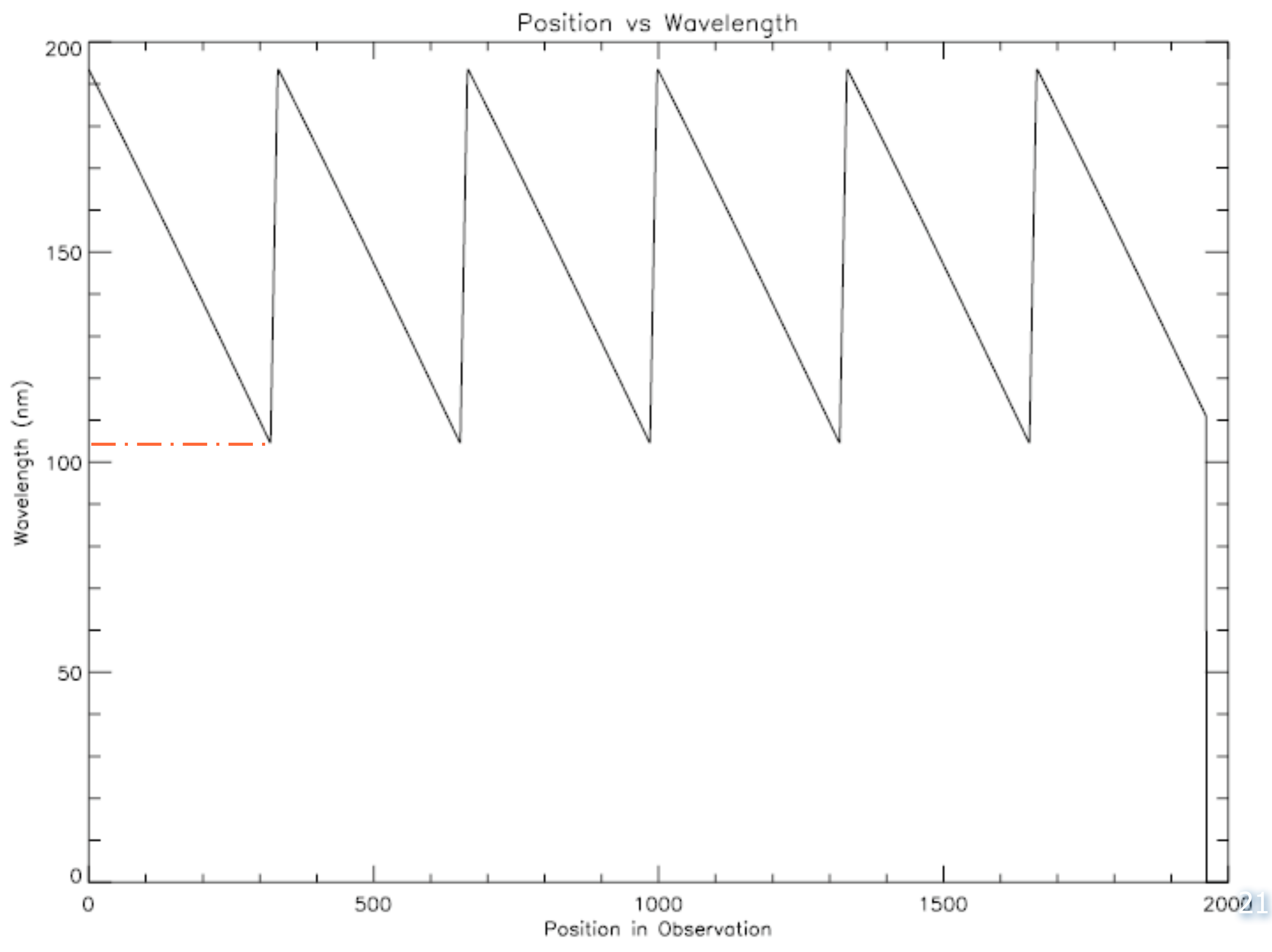
Lunar Rocks and Soil

- Spectra of lunar soils exhibit an upturn toward shorter wavelengths in the UV, while the spectra of lunar rocks do not exhibit this reversal, this suggests that the optical effects due to space weathering in the visible are different in the ultraviolet



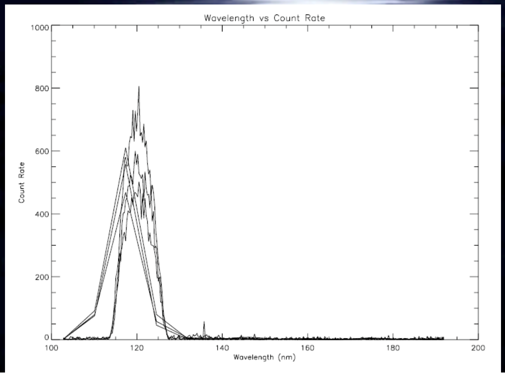
Wavelength vs Position
Wavelength (nm)
Position
200
150
100
50
0
0
100
200
300
400

Data Reduction



Data Reduction

- Filtering data points
- Observations without data
- Observations with bad data
- Shifting of Wavelength due to movement of the Moon



To Do This…

- Make Corrections
  - Issues with the data
    - Flybacks
    - Observations without data
    - Observations with bad data
    - Timing of instrument off
    - Shifting of Wavelength due to movement of the Moon
  - Remove background - Airglow according to the position of the satellite to predict the amount of background