Alignment and Calibration for AIR-Spec

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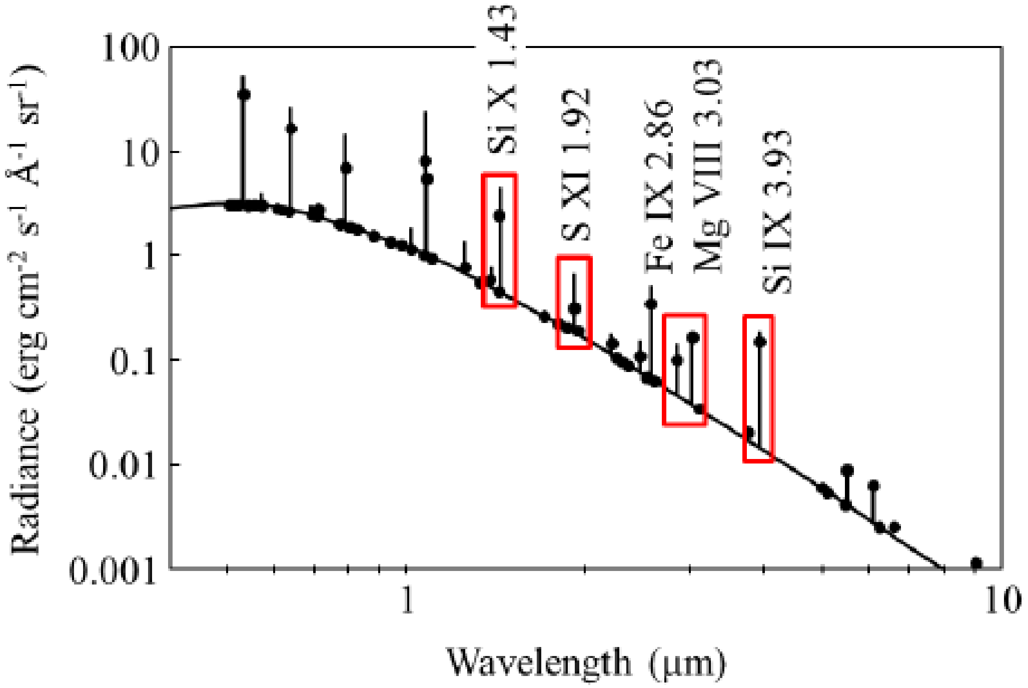
Background

AIR-Spec Goal: measure coronal plasma emission lines in the infrared region to characterize the lines and determine whether they could be useful probes of the coronal magnetic fields.

- Interested in Si X, S XI, Fe IX, MG VIII, and SI IX emission lines
- Take data from GV HIAPER at an altitude of 45,000 feet during eclipse

Fly on GV HIAPER

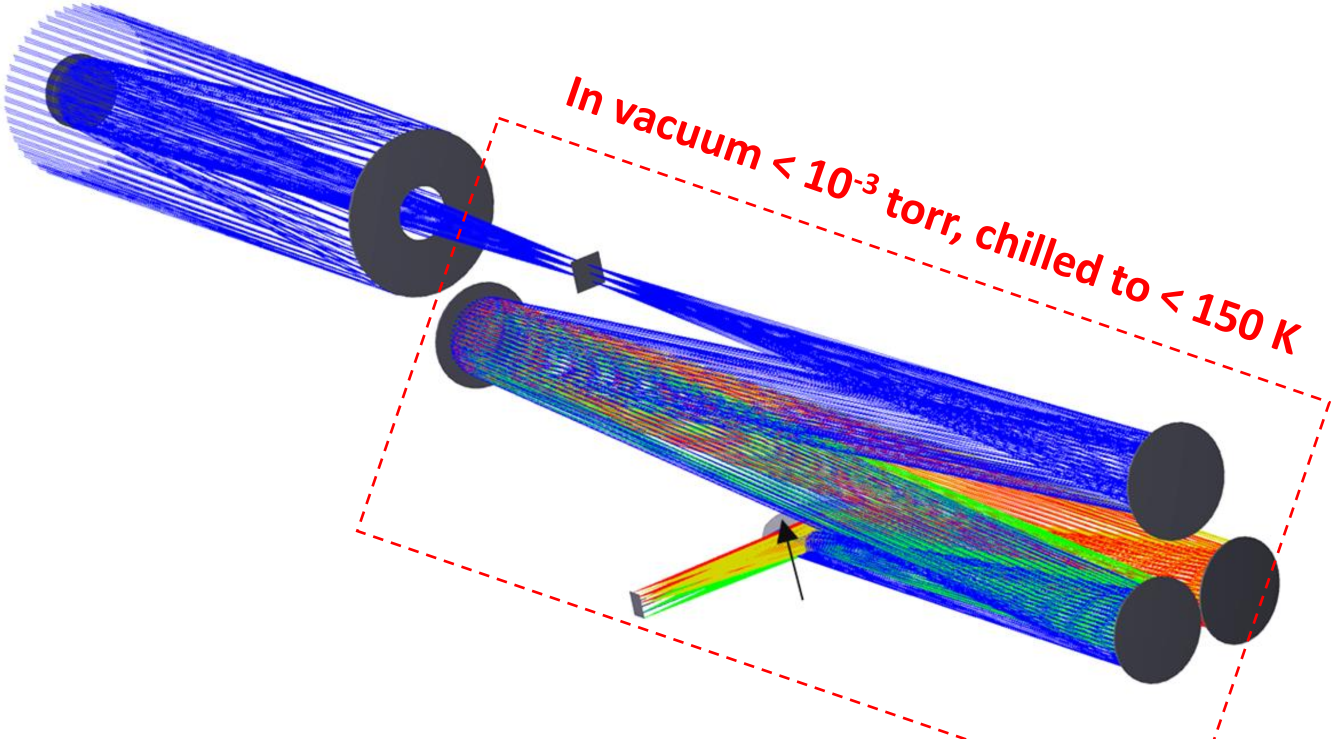


Different emission lines of interest

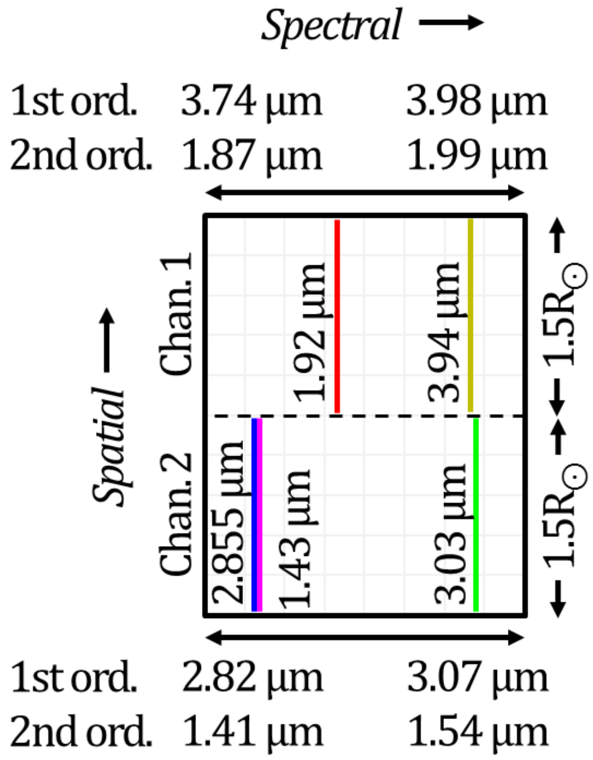
Judge, P.G., "Spectral lines for polarization measurements of the coronal magnetic fields. I. Theoretical intensities", *The Astrophysical Journal* 500(2), 1009 (1998)

Overview

- Light comes in from the telescope goes into the grating spectrometer
- The grating spectrometer consists of a collimator, grating, and two focus mirrors
- The light is separated into different wavelengths and mapped to two halves of the detector



Optical diagram of the grating spectrometer



Wavelength positions on the detector

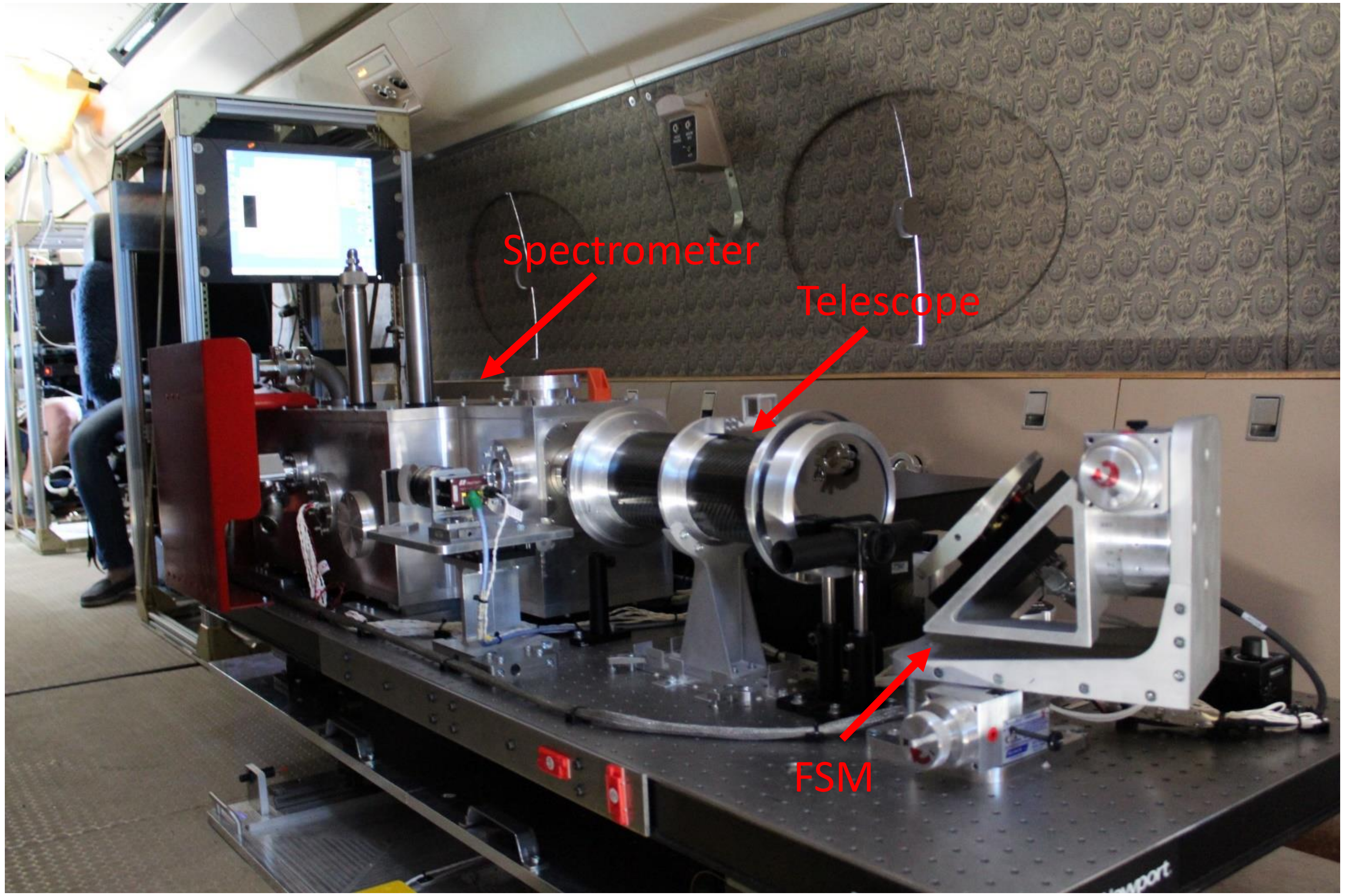
Optical Alignment

Alignment Procedure:

- Telescope alignment to spectrometer
  - Use parabolic mirror to collimate light going into telescope, adjust focus and position until the beam is focused on slitjaw

- Align remaining optics to telescope (such as fiber optic gyroscope and fast steering mirror- FSM)
  - Use theodolite to ensure the remaining optics are normal to the telescope

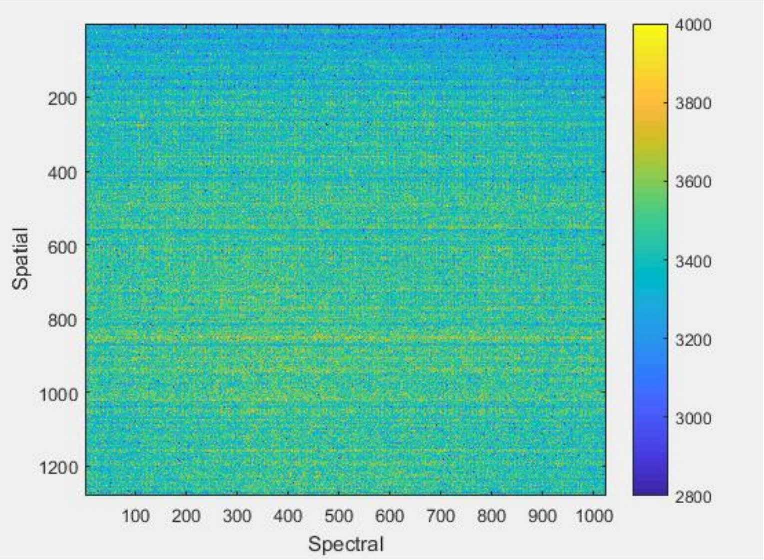
- Align internal spectrometer optics
  - Spatially align the wavelengths of interests on the detector



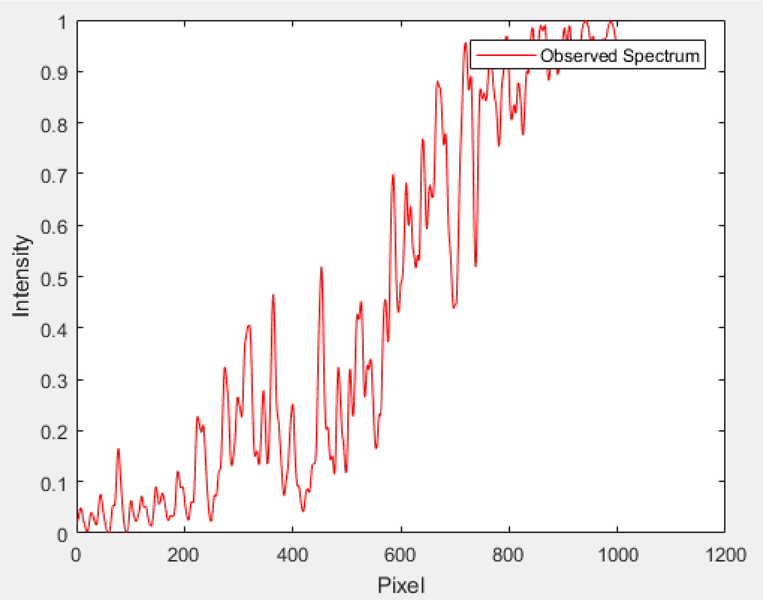
Instrument in the Aircraft

Calibration Overview

- **Flat Field**: measure of pixel to pixel variation

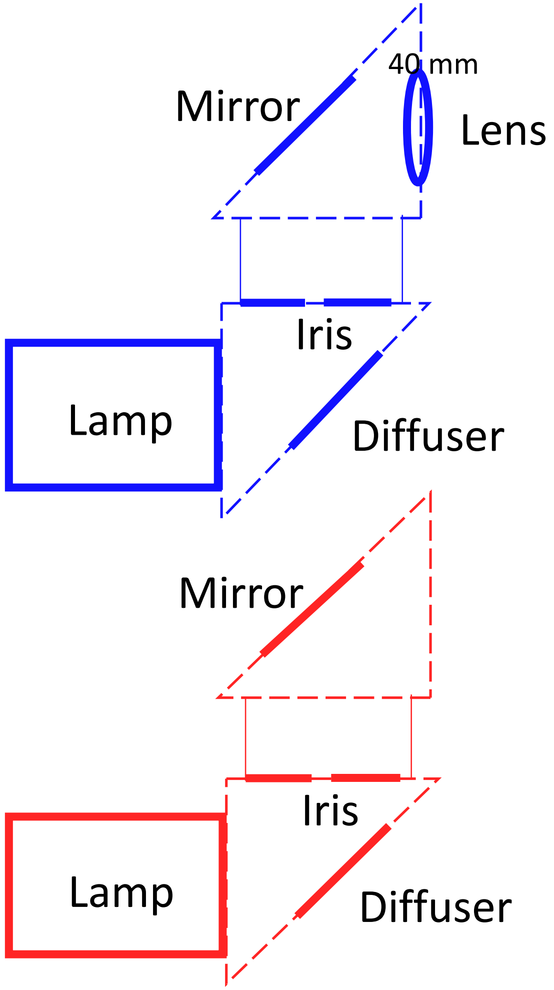


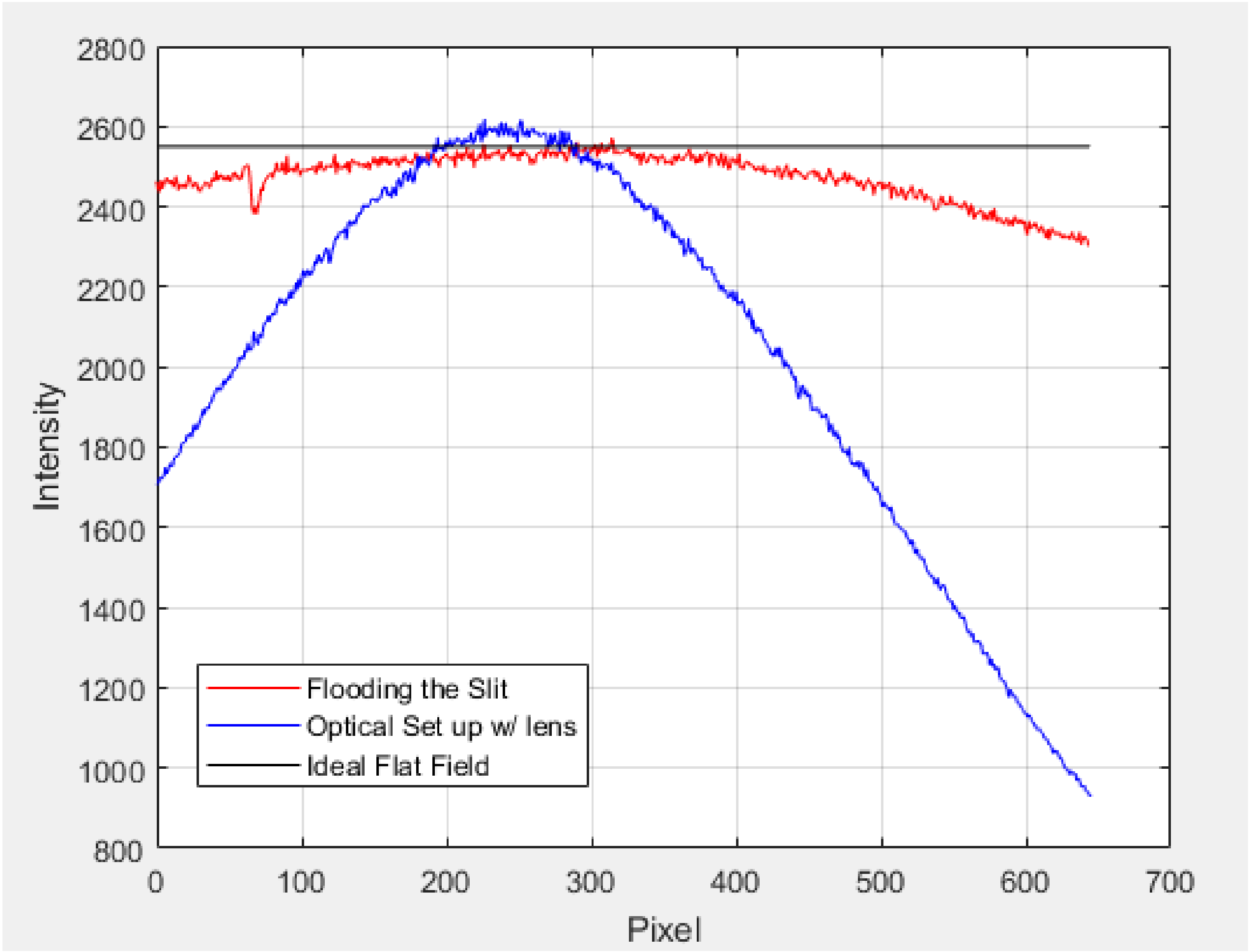
- **Wavelength Calibration**: conversion factor between wavelength and pixel



- **Radiometric Calibration**: map the camera output to radiance

Flat Field

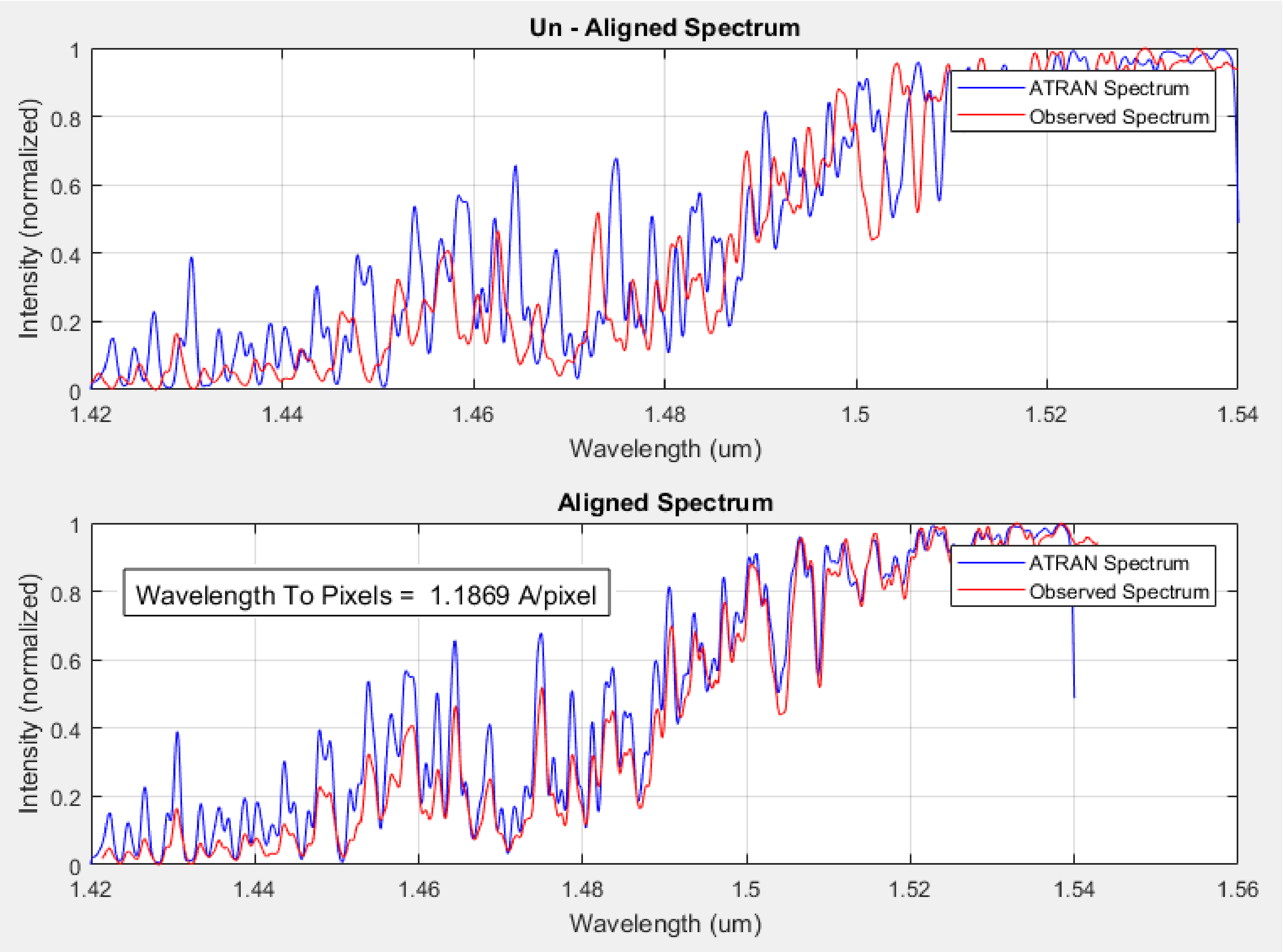




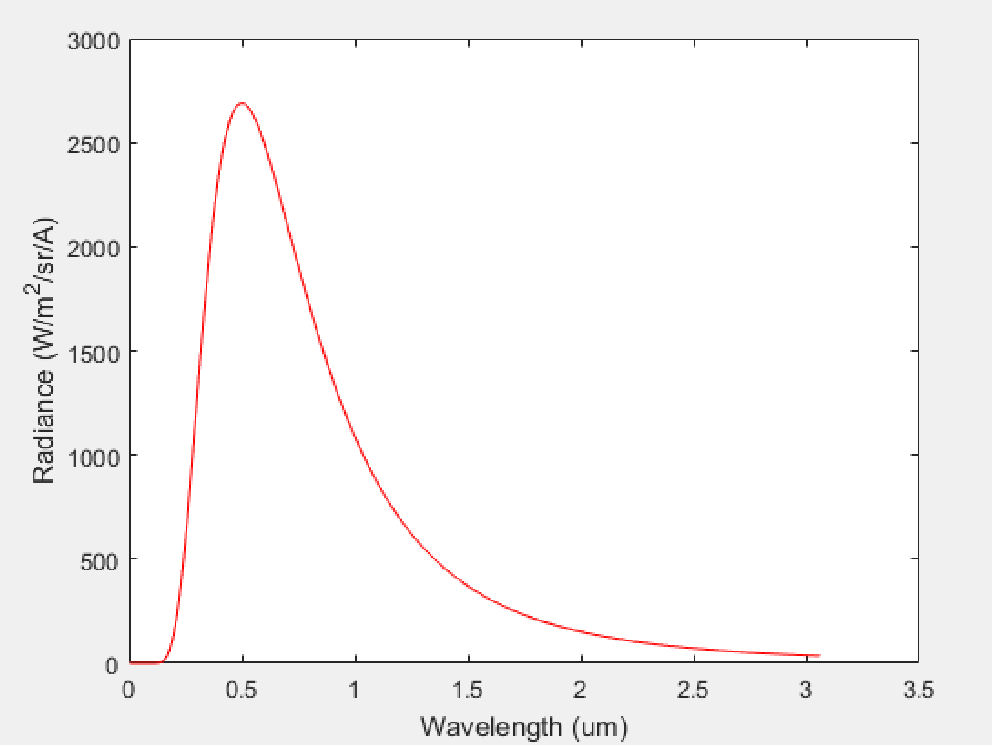
Problem: *Can't construct an optical set up that gives a flat field without flooding the slit and contaminating the rest of the spectrometer*

Solution: *Scan the slit and look at the solar disk when in flight*

Wavelength Calibration



Radiometric Calibration



5800 K black body for the photosphere

$$B_\lambda(T) = \frac{2\,h\,c^2}{\lambda^5}\frac{1}{e^{\frac{10^6\,h\,c}{k\,T}} - 1}$$

Mapping camera output to radiance:

$$conversion\ factor = \frac{radiance\ * dispersion}{camera\ signal}$$

$$[radiance] \leftrightarrow [\frac{W}{m^2 sr\ A}]$$

$$[conversion\ factor] \leftrightarrow [\frac{W}{m^2 sr\ DN}]$$

$$[camera\ signal] \leftrightarrow [\frac{DN}{pixel}]$$

$$[dispersion] \leftrightarrow [\frac{A}{pixel}]$$

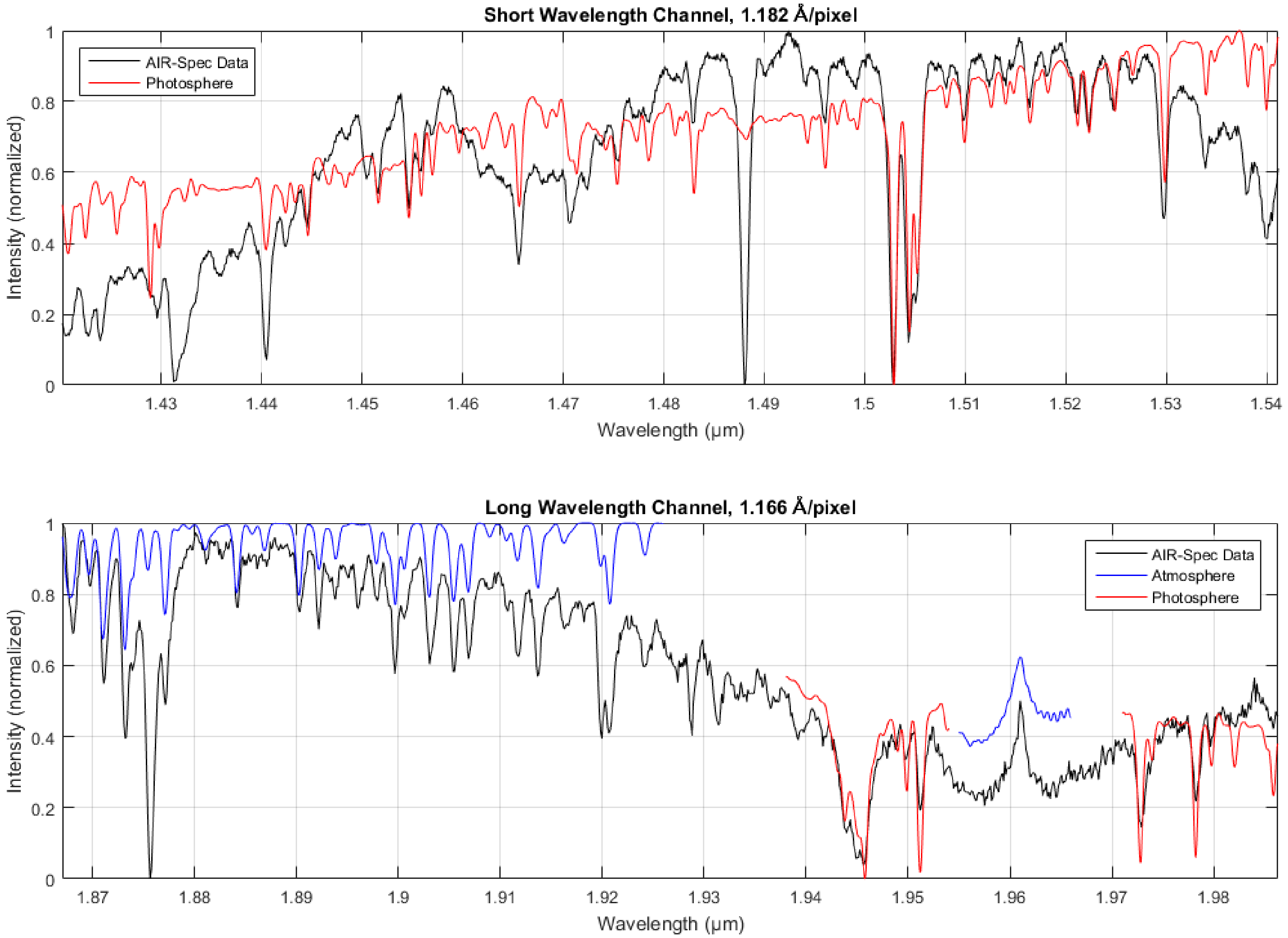
After calculating the conversion factor on the photosphere, we can use it on the coronal data to map data number to radiance.

$$radiance = \frac{conversion\ factor}{dispersion} * camera\ signal$$

Test Flight Results

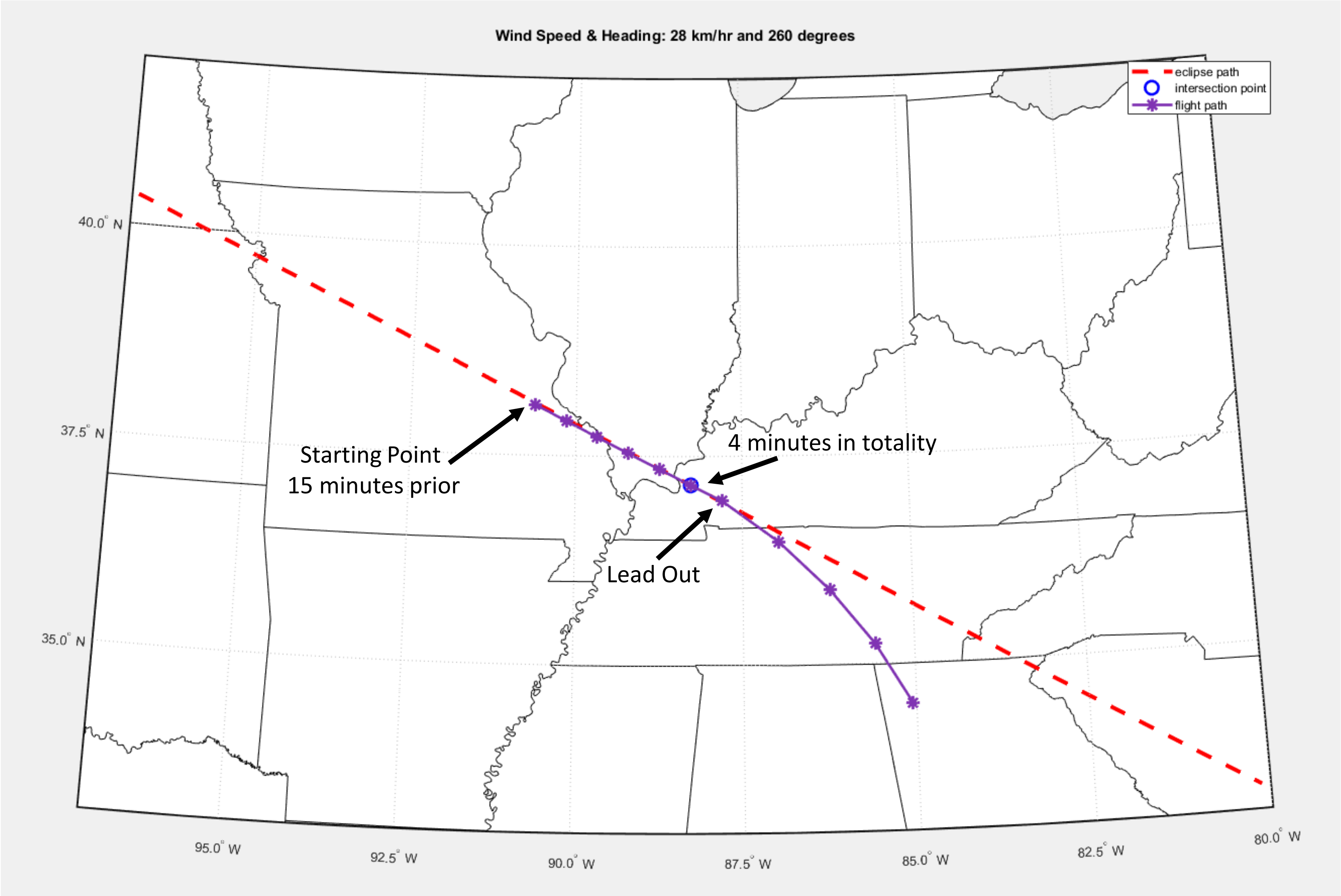
Test Flight	Objectives
TF01	- Test Image stabilization - Set Spectral Ranges in flight - Take Dark Data
TF02	- Test Image stabilization - Assess Spectral Alignment - Record Bench positions - Assess Flight Track - Take Dark Data

- *Both test flights were successful*
- *Still working on assessing our objectives from the second test flight*



Spectrum taken in flight

Day of the Eclipse



In-Flight Tasks:

Adjust the table settings to keep the sun in the window and set spectral ranges

Monitor the data and correct exposure time if needed

Communicate with Pilots

Monitor image stabilization and adjust fast steering mirror

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