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Exploration of the Physical and Spectroscopic Characteristics of Coronal Rain

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Research Experience for Undergrads

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Background

- What is coronal rain?
  - Coronal rain typically occurs after destabilization of a filament/prominence or as a result of eruptive events in the solar corona where cool and dense clumps of plasma is kicked up from the solar surface and the “rain” is due to the plasma falling back down along the closed magnetic field entities, otherwise known as loops.

- Broader impact:
  - Data gathered from coronal rain helps us better understand the development of other solar phenomena.
  - To help us uncover the mysteries of the currently unknown heating and cooling mechanisms of the Sun.

Image courtesy of:
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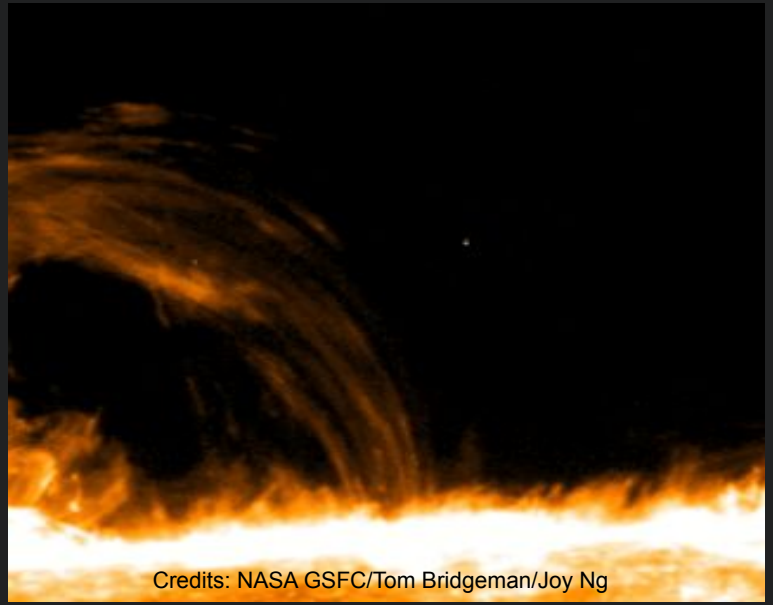
Our goals

Quiet loop: For our purposes, a quiet loop in this context describes a non-eruptive structure in an active region.

➔ Under quiet active region conditions or ***quiet loops***:

- Understanding how plasma flows work and how they move along closed magnetic field entities.
- Following the evolution of solar structures in detail.
- Specifically analyzing the Mg II spectroscopic emission lines from a coronal rain event.
- Exploring line characteristics.



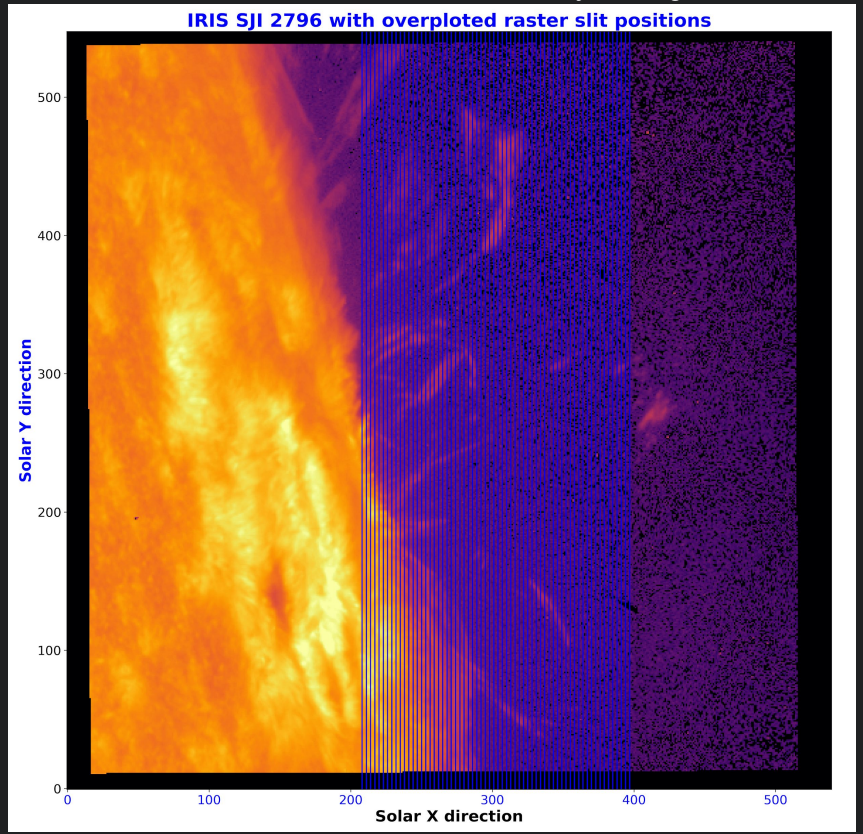
Credits: NASA GSFC/Tom Bridgeman/Joy Ng

➔ How do we obtain the data and imagery?

- Interface Region Imaging Spectrograph (IRIS) provides spectroscopic data.
- SDO/AIA observations

IRIS Image Credit: NASA/Lockheed Martin

Slit jaw image:



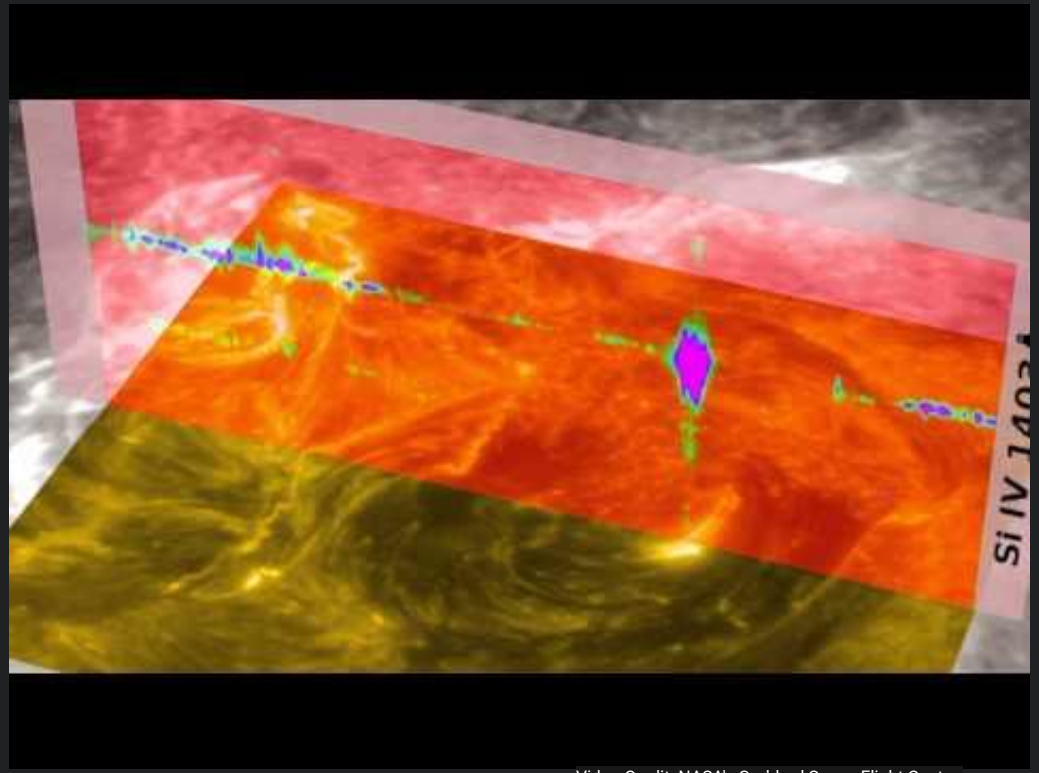
"An image tells us what something looks like; a spectrum tells us what it is." -NASA, Hubblesite

The visible spectrum of the Sun.

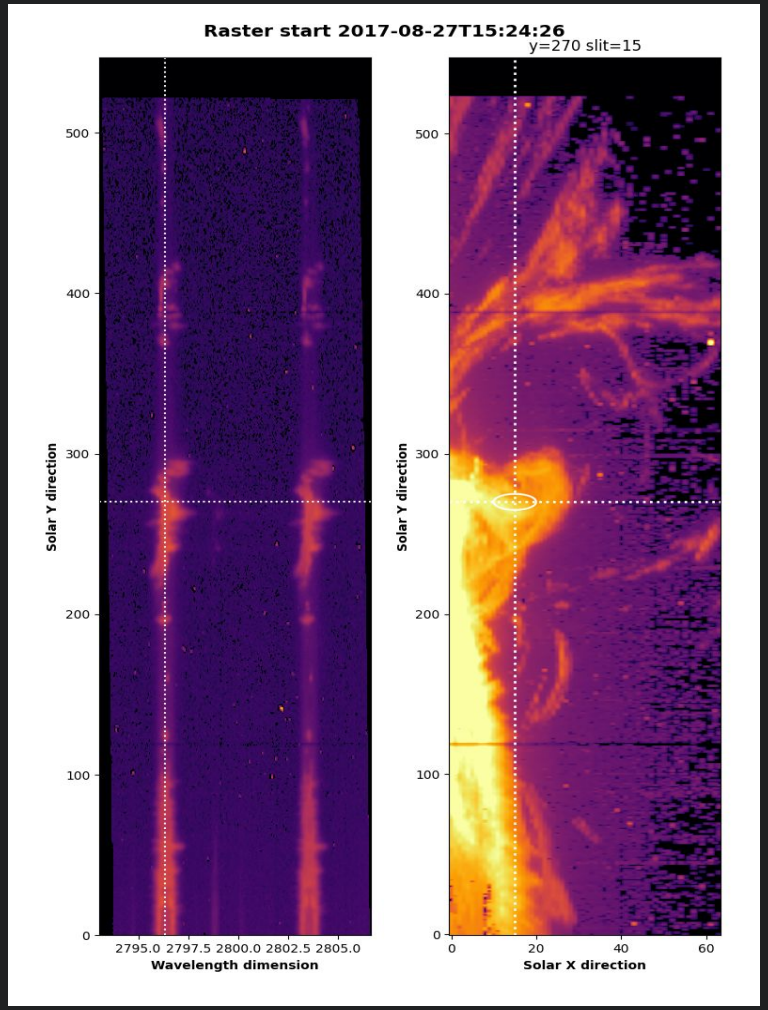
Credit:NOAO/AURA/NSF

Spectroscopic data from IRIS

- How IRIS captures its data:

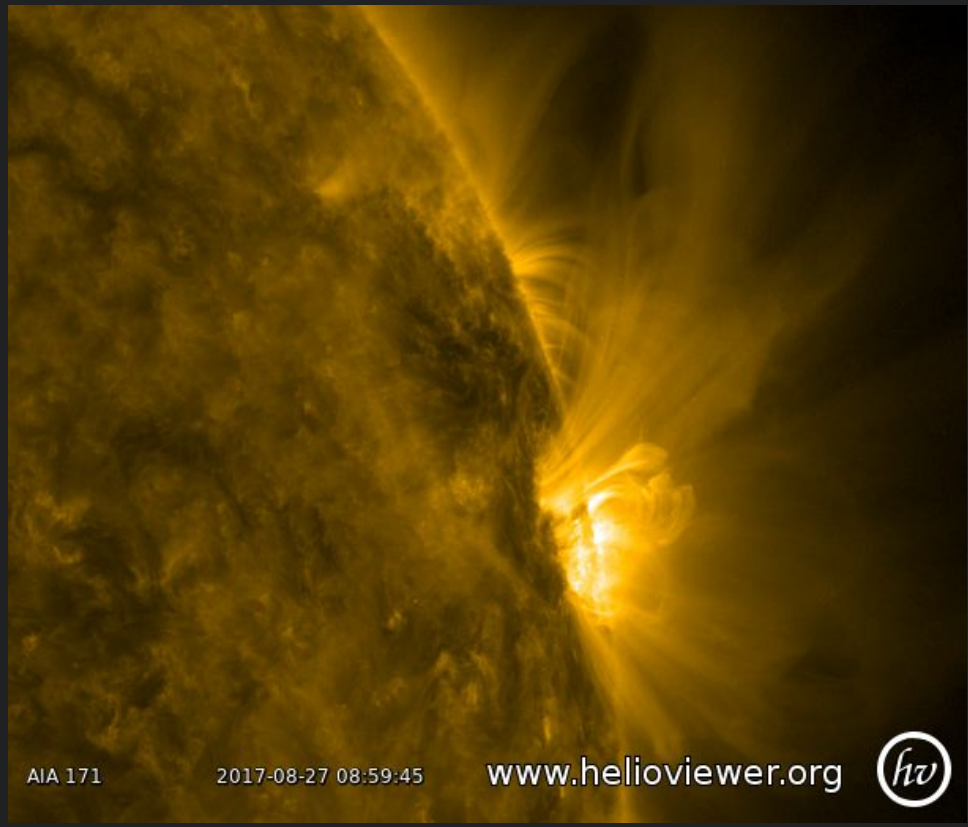


Video Credit: NASA's Goddard Space Flight Center.



Methodology

- **Visual observation**
  - **SAOImageDS9**
    - Supports a variety of tools and advanced features specifically useful for astronomical observations.
  - **Helioviewer**
    - Open-source Helioviewer Project
    - Visualization of solar and heliospheric data
    - Image and movie capture capabilities



Methodology

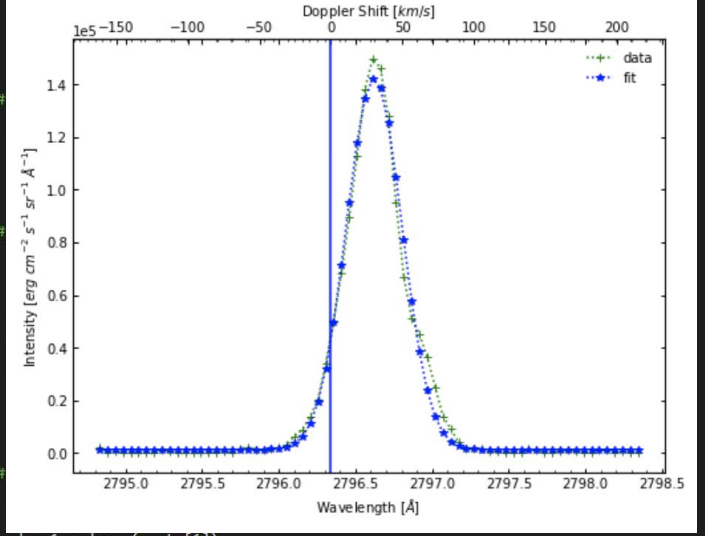
➔ **Data analysis using Python**

- Code packages
  - Matplotlib
  - Numpy
  - Scipy
  - Glob
  - Astropy

- IRIS data analysis of the Mg II emission lines
- SDO/AIA observations of higher temperature structures
- Creating functions and using them to simplify the coding process

```python
# Fitting k line
def new_function_k(x,y):

# Initial guesses of the properties of the distribution
```

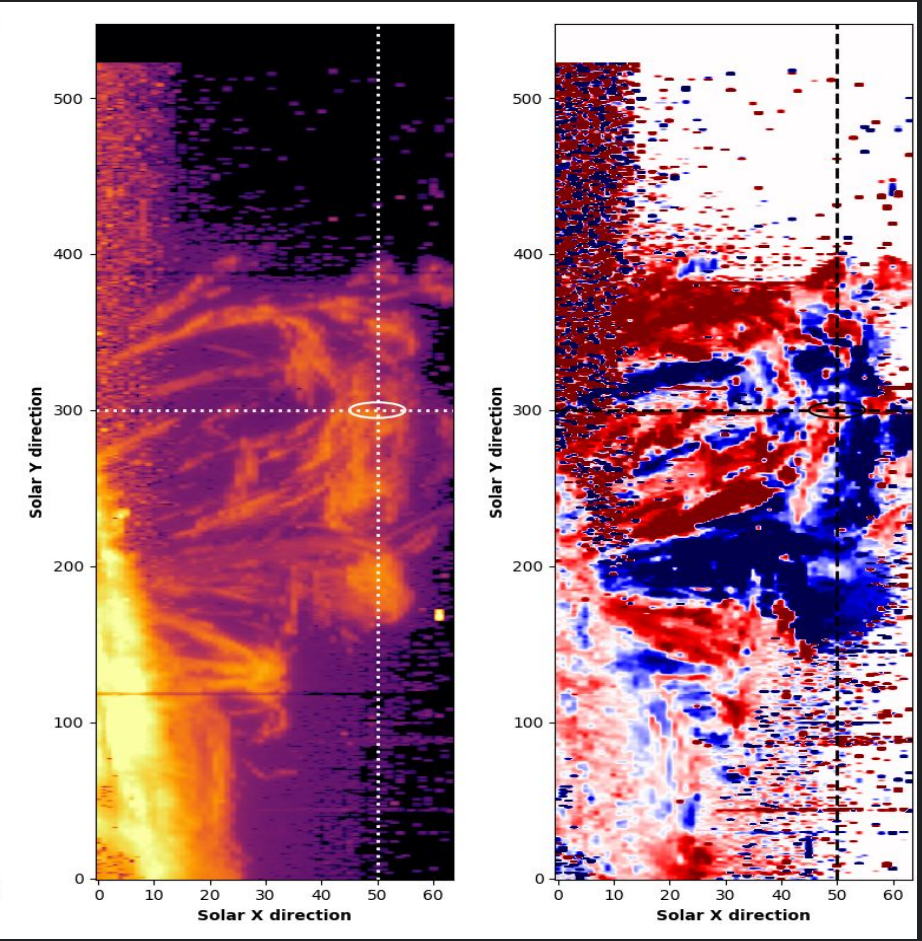
```
FWHM (fit width) =  0.4258303348008797
Doppler Shift =  30.30477915878428
Intensity =  60809.9033086258
```



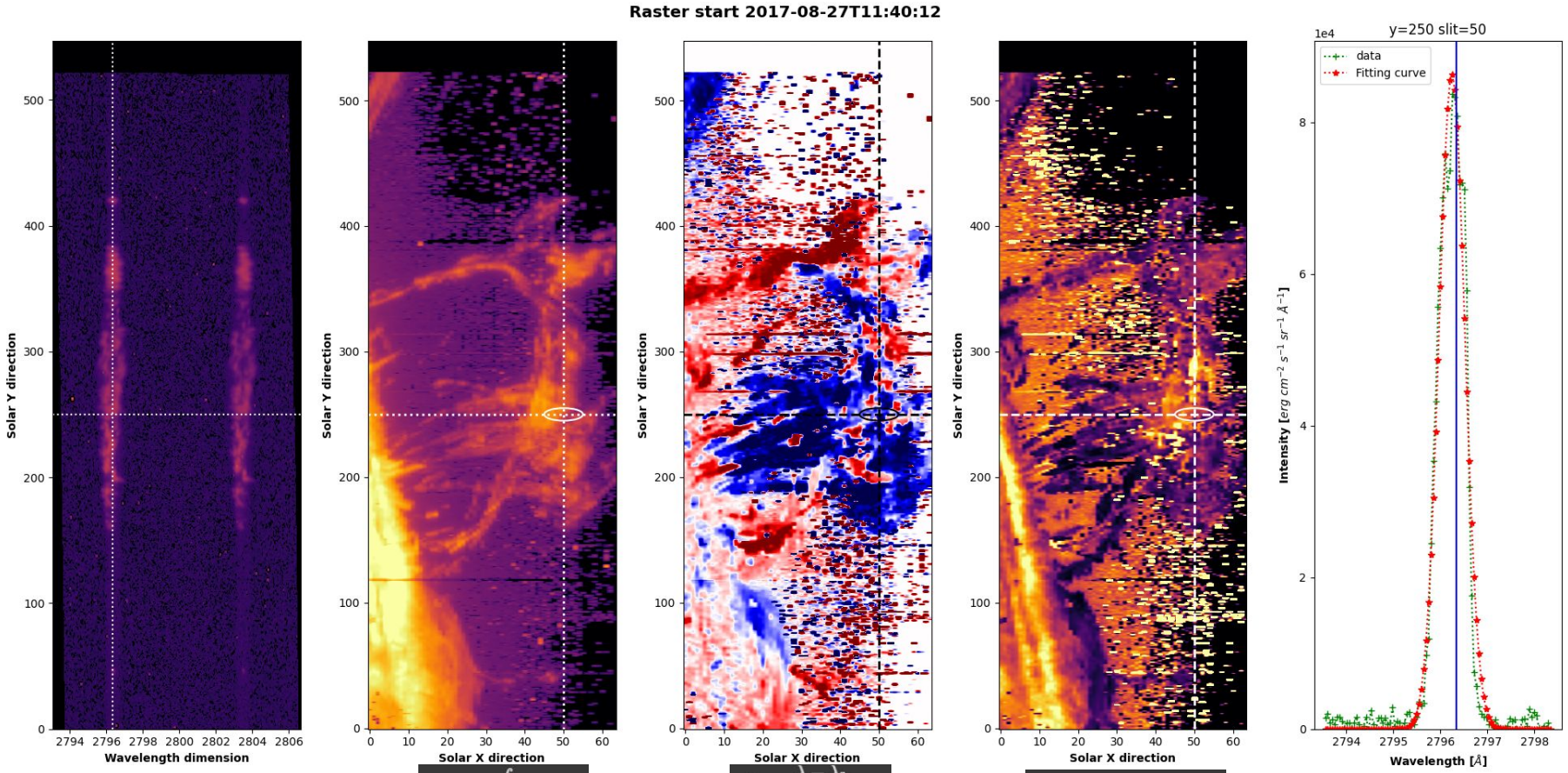

```python
#

#

#

dopp1 = dopp (popt [1])
print('Doppler Shift) = ',dopp1)
fwhm = line_width(popt [2])
print('FWHM (fit width) = ',fwhm)
```

Results

➔ What does the data and imagery tell us?
- Evolving structures
- Timescales
- Intensity variation
- Magnetic structures
- Doppler shift



Results



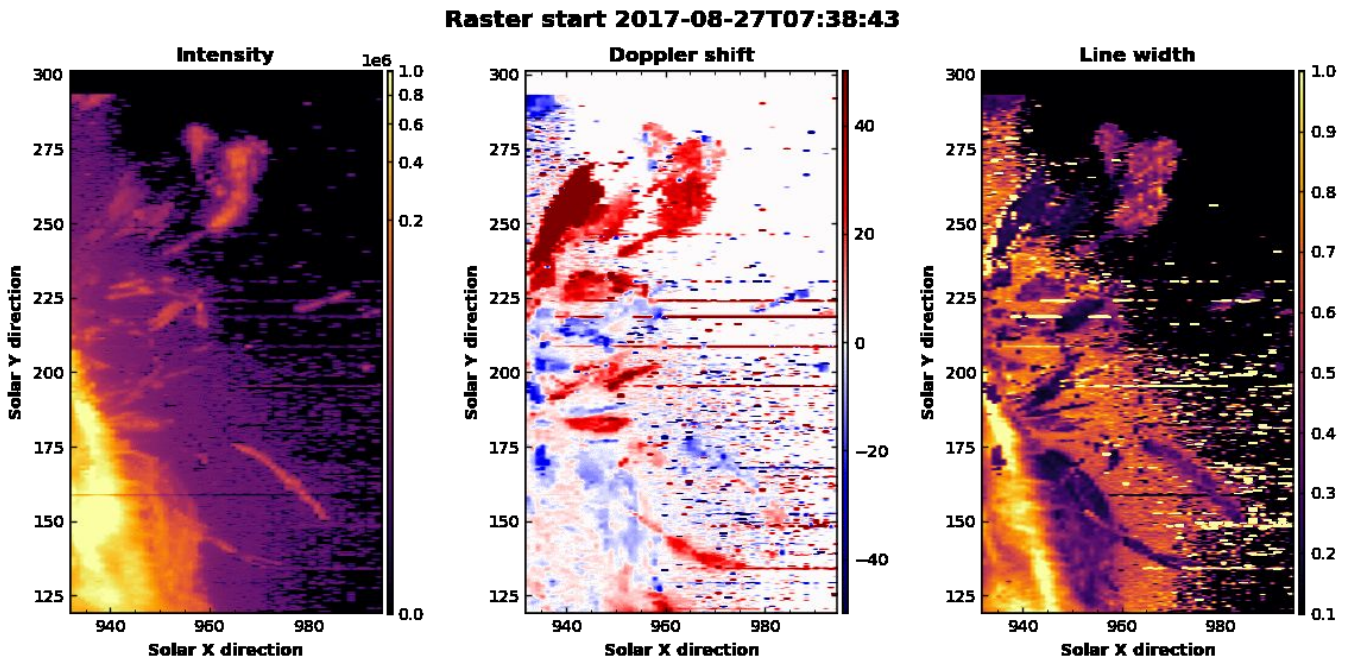
$$I_{core} = \int I(\lambda) d\lambda$$

$$\Delta v = \frac{\lambda - \lambda_0}{\lambda_0} \cdot c$$

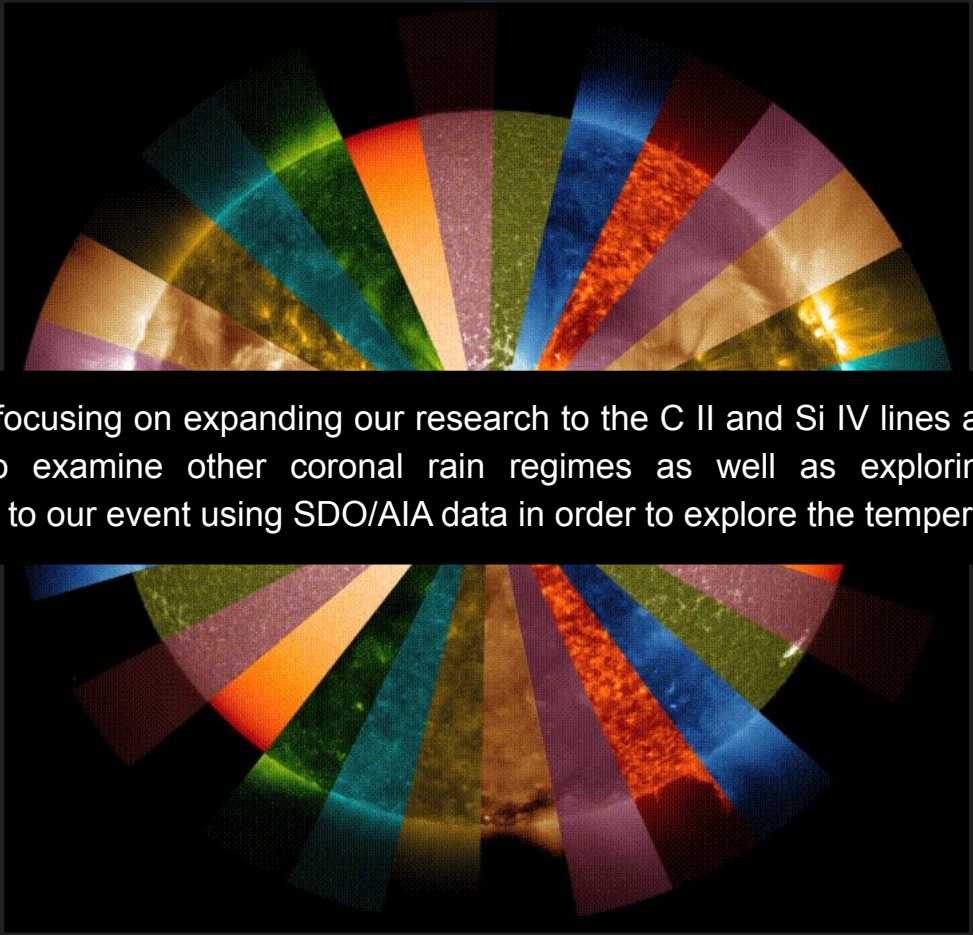
$$\mathrm{FWHM} = 2\sqrt{2\ln 2}\,\sigma$$

Conclusions

Our work reveals a multitude of complex, differently oriented, and turbulent, structures under what appeared to be a standard coronal rain event.



Future work:



We will be focusing on expanding our research to the C II and Si IV lines and using those methods to examine other coronal rain regimes as well as exploring the coronal counterpart to our event using SDO/AIA data in order to explore the temperature structure.

Thank you!

References:

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Acknowledgements: This research was supported by the National Science Foundation REU program, award #1659878.

Questions?