

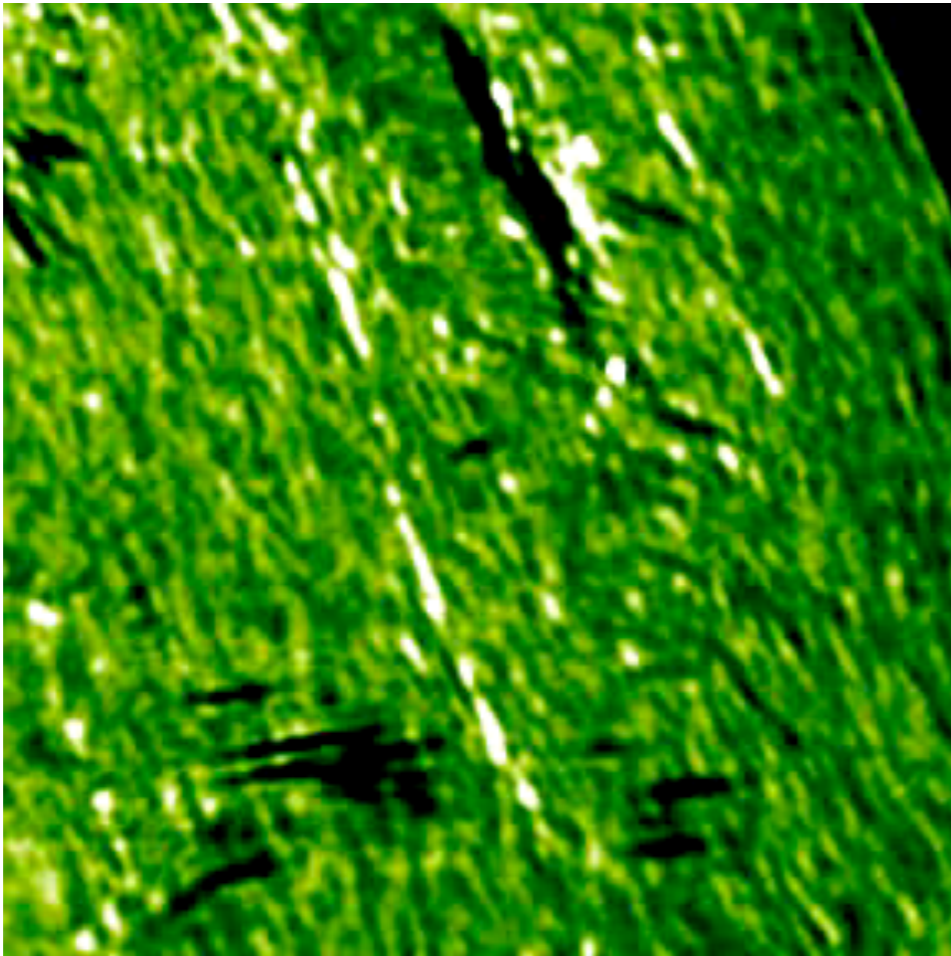
Analyzing High-Speed Phenomena in the Solar Atmosphere



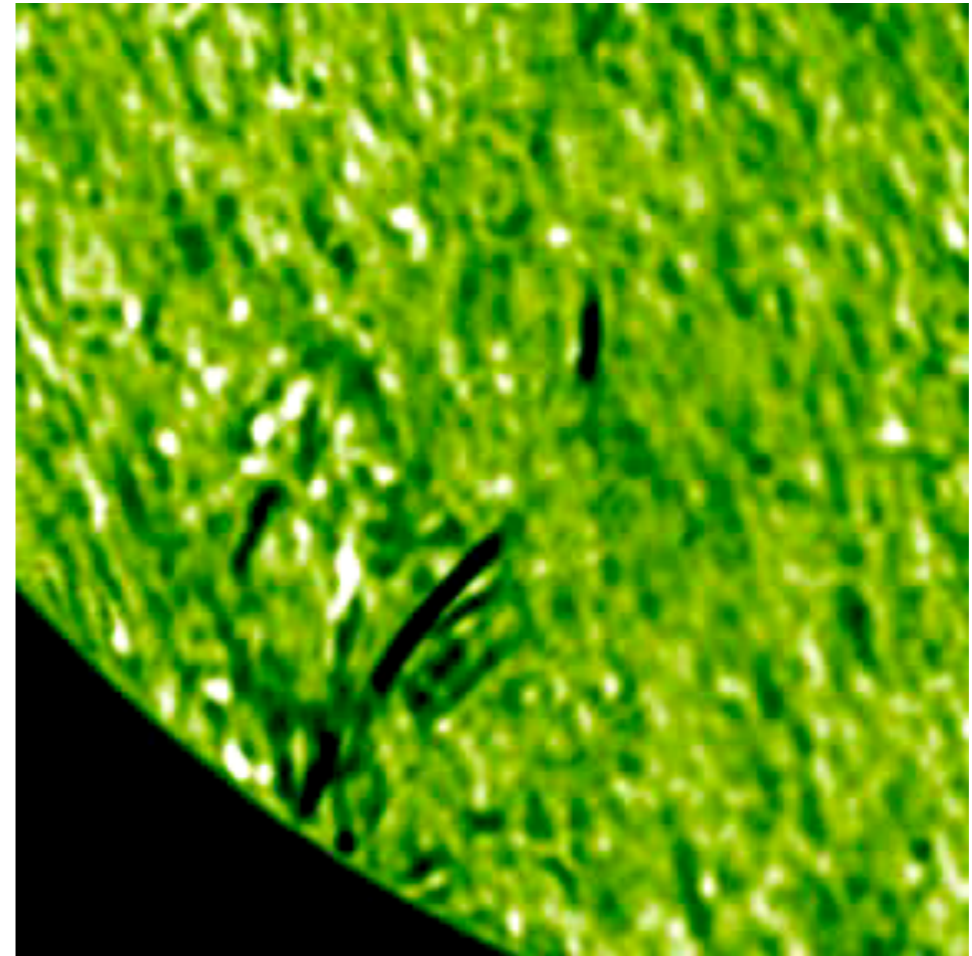
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What Interests Us?

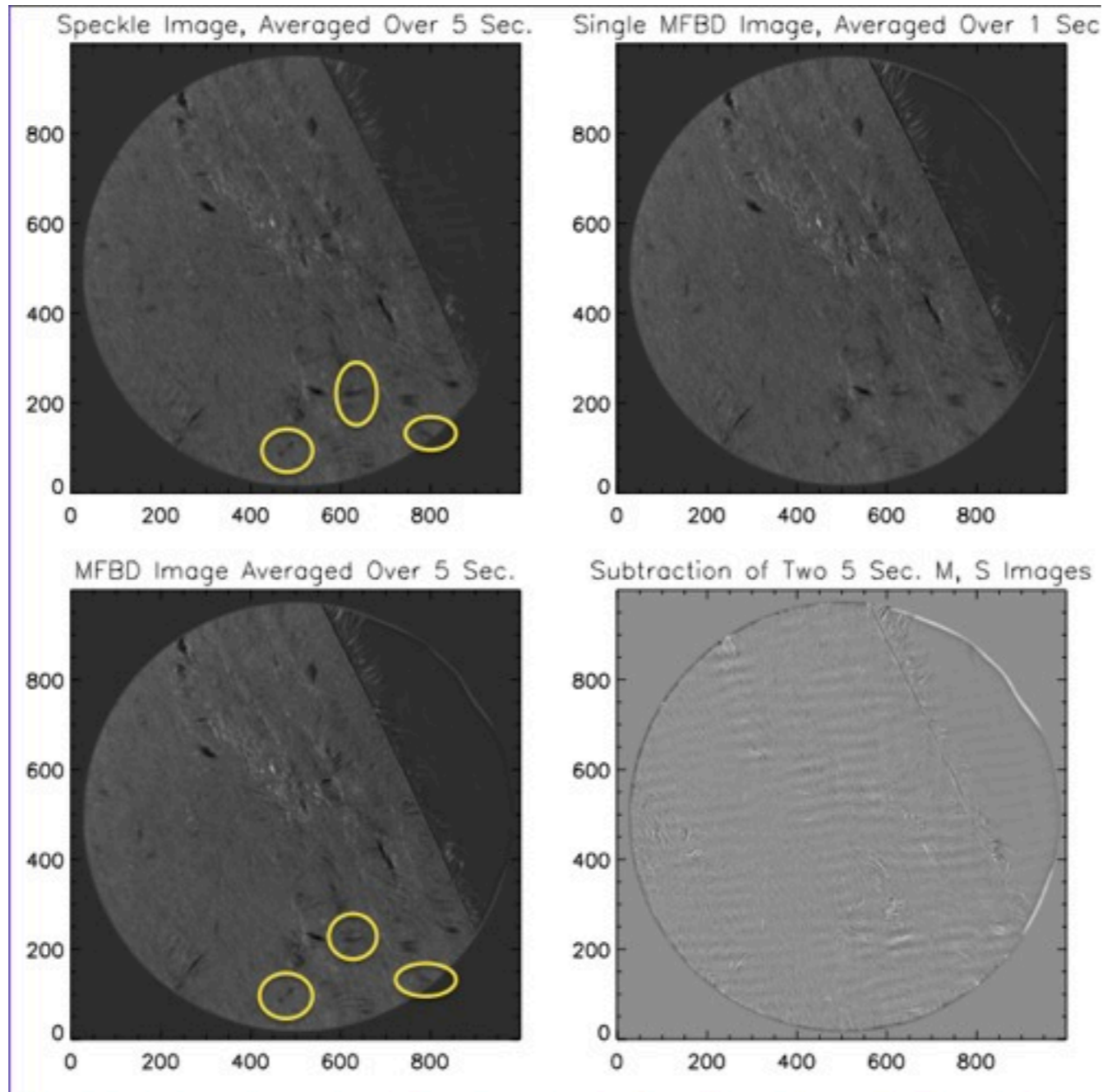


Sheets?



Flux Tubes?

Speckle VS. MFBD



The Debate At Hand

Flux Tube Picture

Basic Claims

- Type II spicules are plasma propagating through a tube of flux from photosphere to corona
- Motion includes field-aligned flows, torsional motion, and transverse swaying

Supporting Evidence

- Spicules of type II certainly **appear** tube or straw-like in nature
- **Type I spicules are compatible** with field-aligned flows (Hansteen and colleagues)

Unresolved Issues

- Model of tubes generally ignore 'weak' solutions to MHD equations and the resultant tangential discontinuities that can result in sheet structures
- Wave reflection or highly oblique waves are **required** to account for observed very high phase speeds
- Generally, there is **lack of evidence for (1) steep thermal gradients at transition region to ensure wave reflection,**
- **and (2) for oblique waves.**

The Debate At Hand

Plasma Sheet Picture

Basic Claims

- Many, if not a majority, of the spicules we are observing are actually optical manifestations of plasma sheets moving around like partially opaque (lace) curtains in the wind
- The observed motions appear fast because of optical superposition effects. The question of **plasma acceleration** is **neither required nor rejected**.

Supporting Evidence

- The equations of MHD have weak solutions which result in **tangential discontinuities** that can in principle produce sheets of plasma
- Sheets might more readily explain the **high aspect ratio** (length/radius) and **collective behavior** (movies) seen in many fibril groups
- They appear the **only** reasonable explanation compatible with the data we have analyzed (Judge et al. 2012)
- **Occam's Razor**: is this picture then **the simplest compatible with the data?**

Unresolved Issues

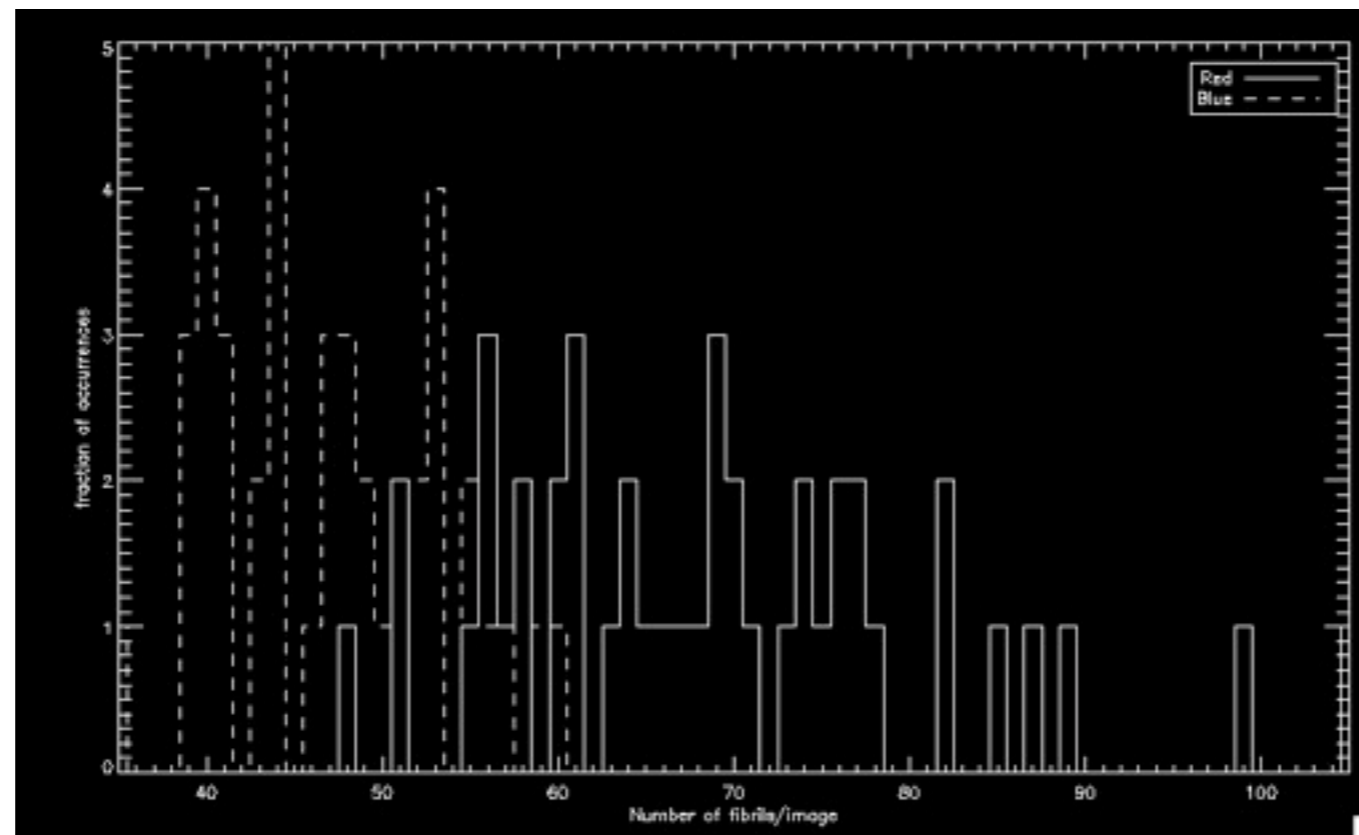
- Detecting solid evidence of sheets in the chromosphere (stereoscopy not possible)
- Can tangential discontinuities produce sheets with the right characteristic scales and behavior?
- Proportions of tubes compared to sheets

Statistical Analysis

We wanted the average number of fibrils per frame for images taken about the H-Alpha line.
We analyzed 40 blue frames; 56 red frames.

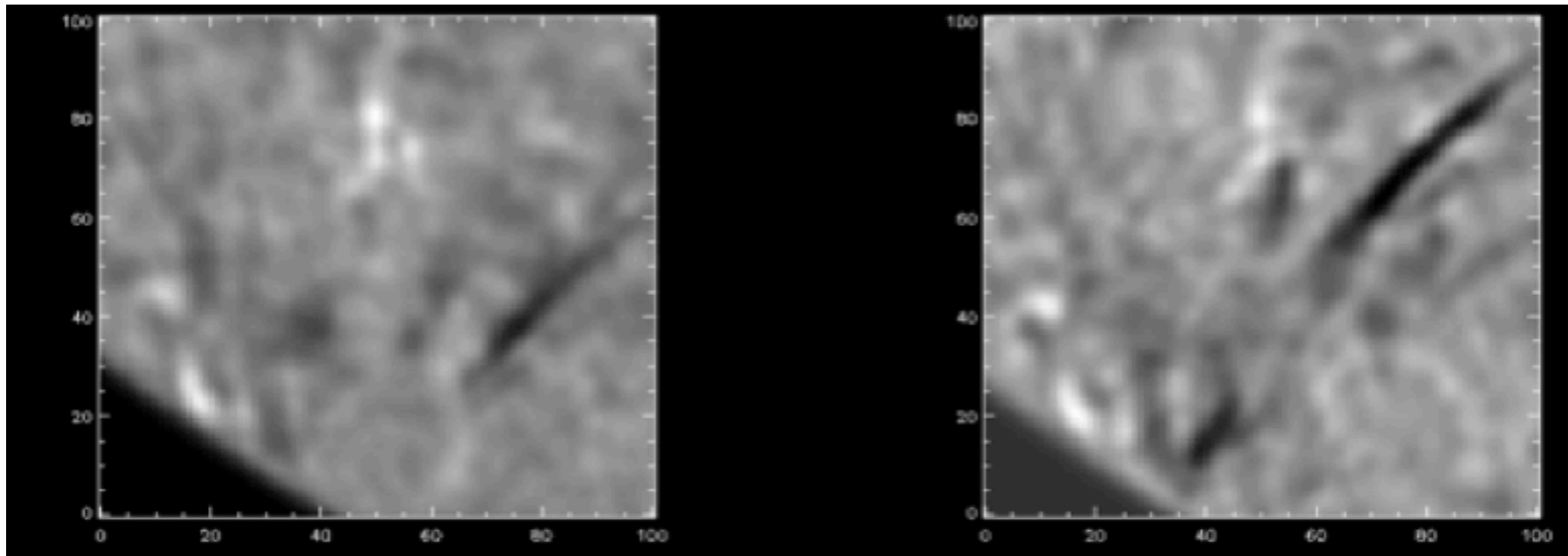
Conclusions

- Average number of fibrils per blue image: 48
- Average number of fibrils per red image: 74
- The area of the Solar disk in these images is about 100 square degrees (in heliographic coordinates) or about 0.03 steradians.
- This means that at any time we might find about 30,000 of them on the Sun.



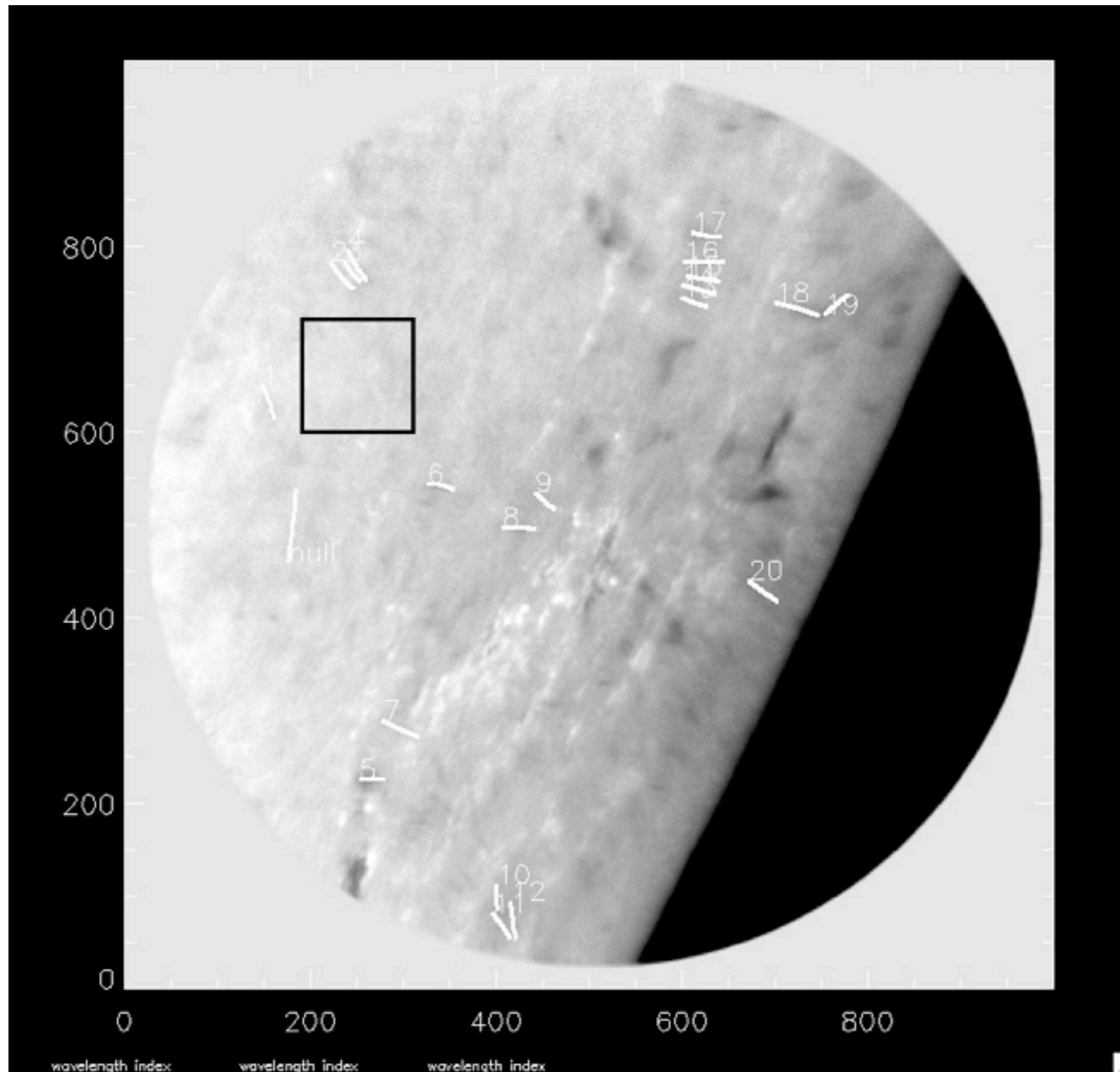
Red VS. Blue

- We compared fibrils within several simultaneous blue and red H-Alpha images. Below is an one example of many: left is blue, right is red

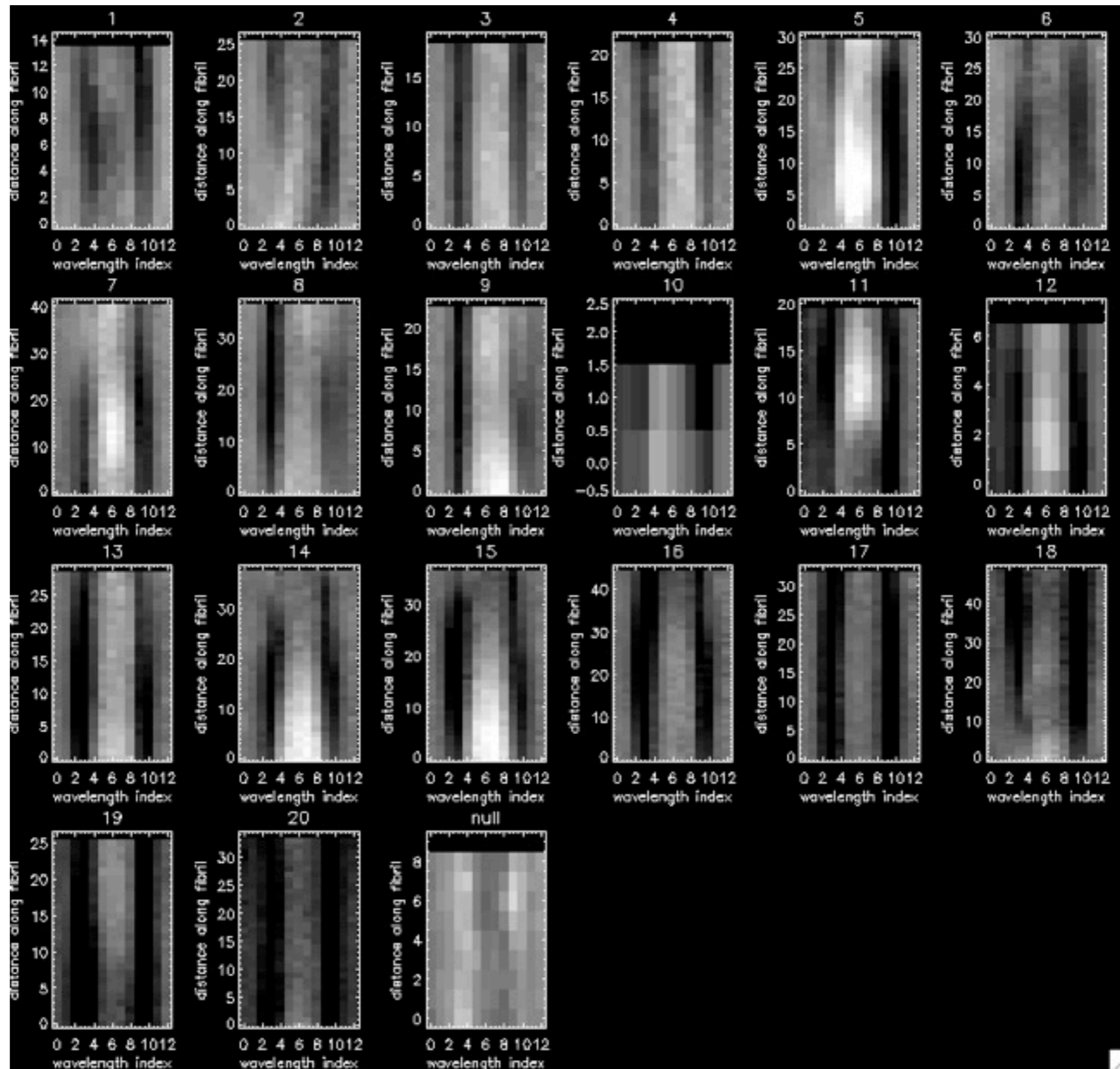


- The fibrils seen in the red images are consistently longer and higher than the ones in the blue images. Near-simultaneous red and blue fibrils almost never overlap

Wavelength Scans

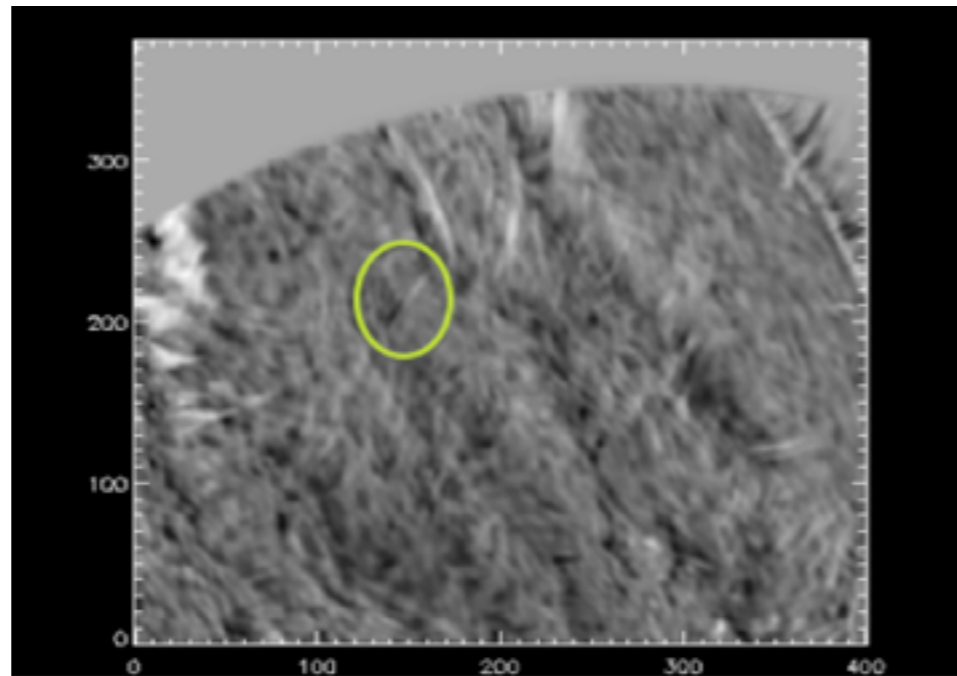


Wavelength Scans



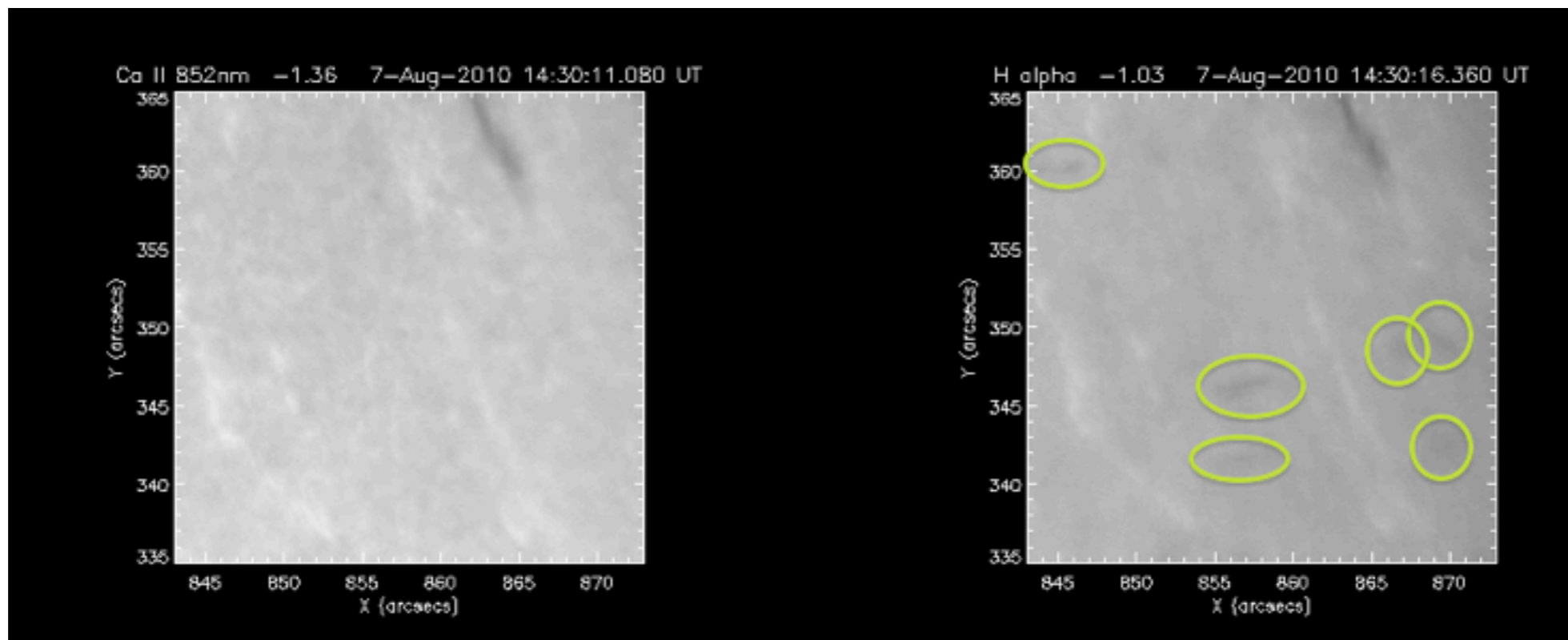
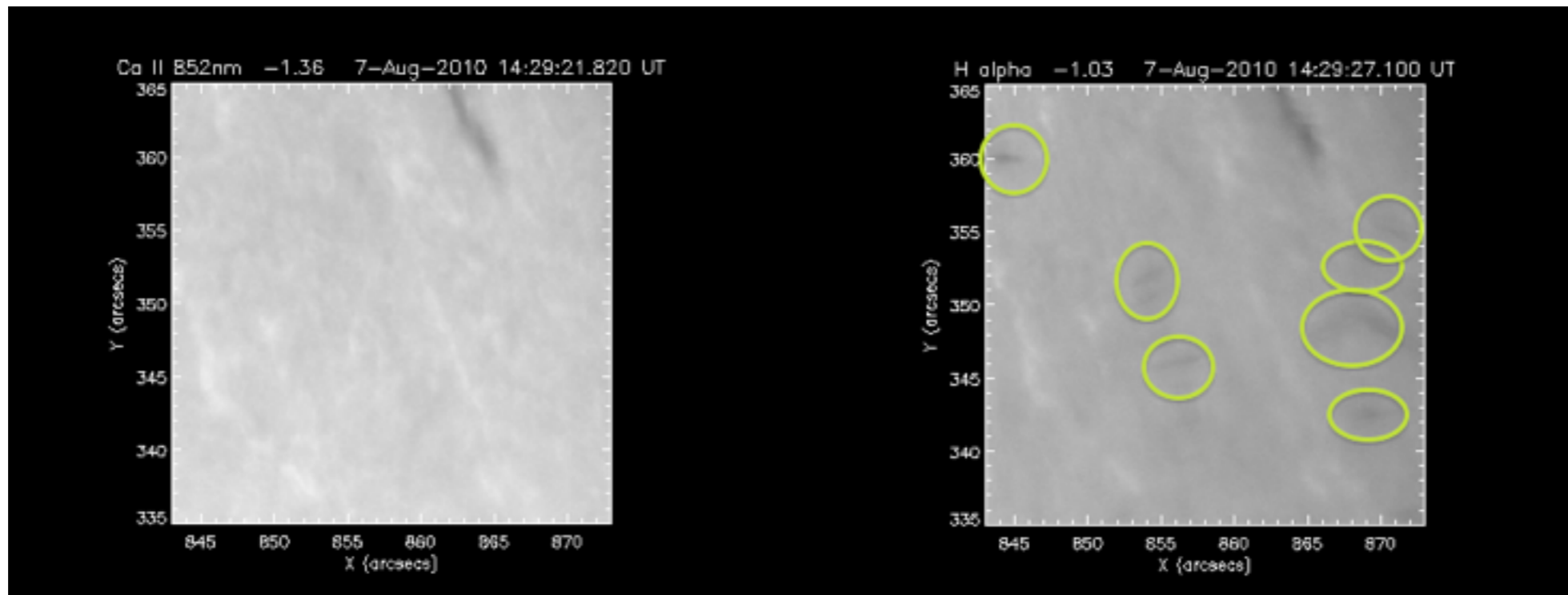
Calcium VS. H-Alpha

- We compared Ca II and H-Alpha images taken close in time, searching for evidence of acceleration along flux tubes. Ca II images were taken at ± 0.06 nm (21 km/s) and H-Alpha images were taken at ± 0.11 nm (50 km/s).
- We subtracted Ca images from H-Alpha images. If acceleration were common we should observe multiple connected fibrils in the resultant image like thus

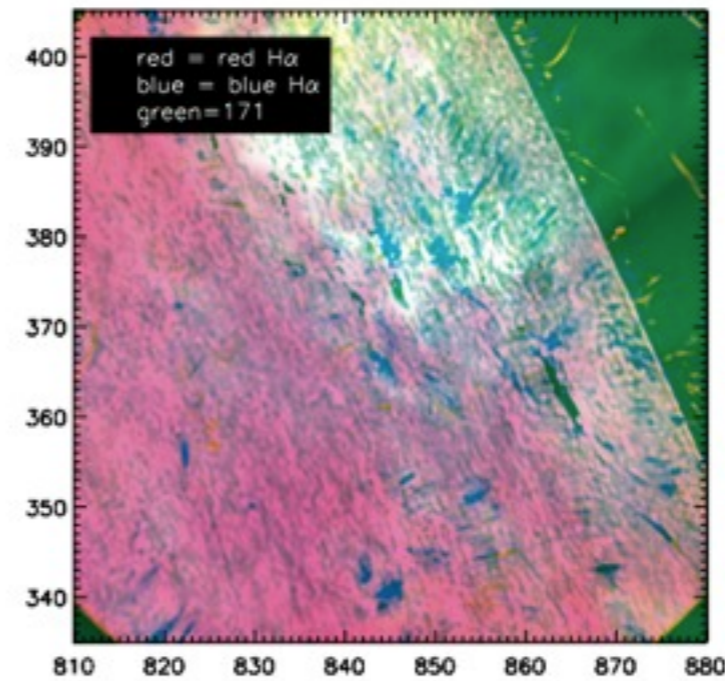
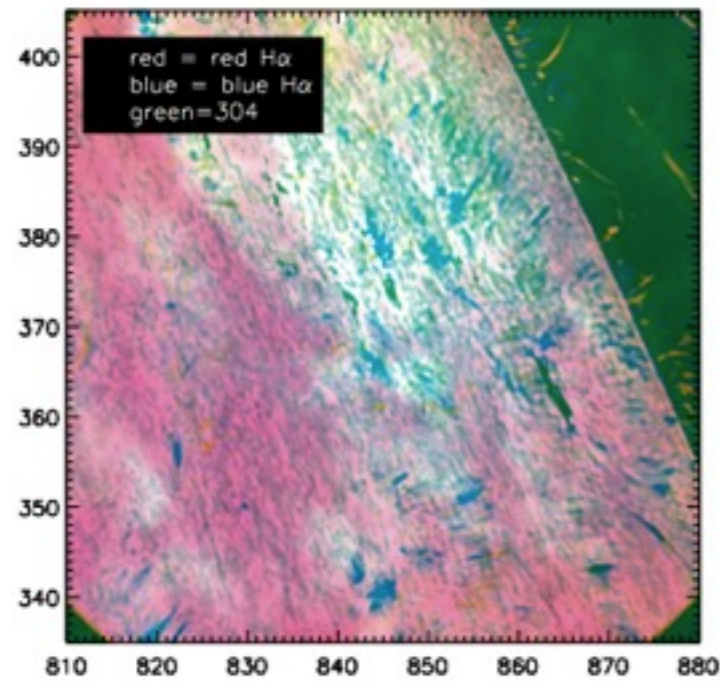
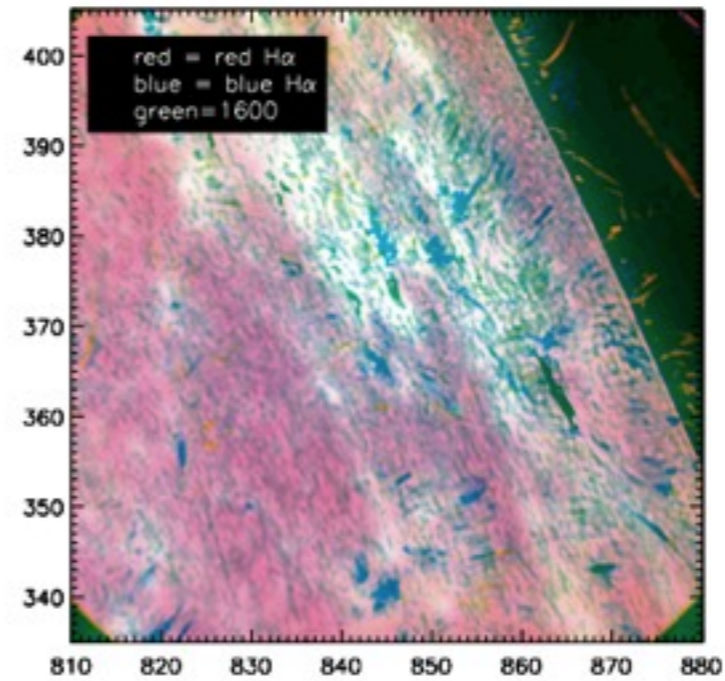
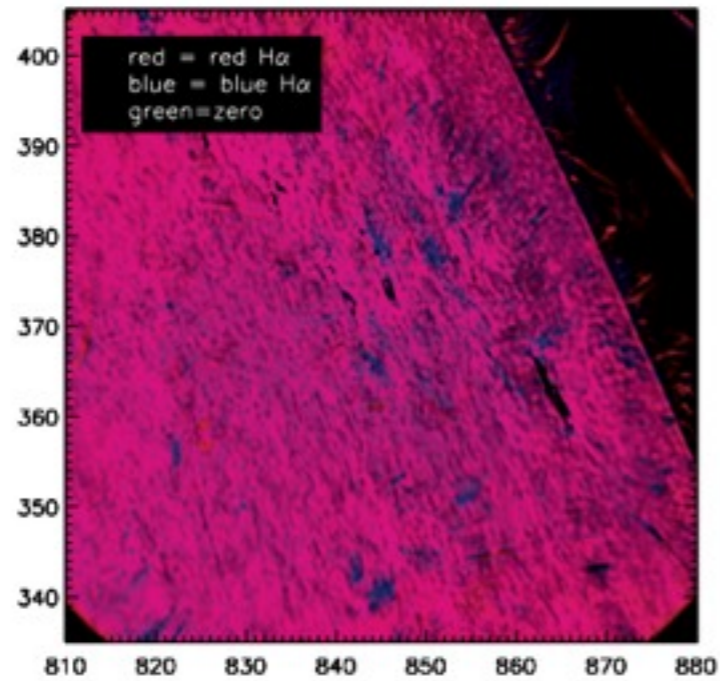


- The circled fibril is one example of a signal of plasma being accelerated within a flux tube. Significantly, this was the only clear example of acceleration we could find in 20 samples over this large field of view.
- And there is a chance that this is not even a valid example!

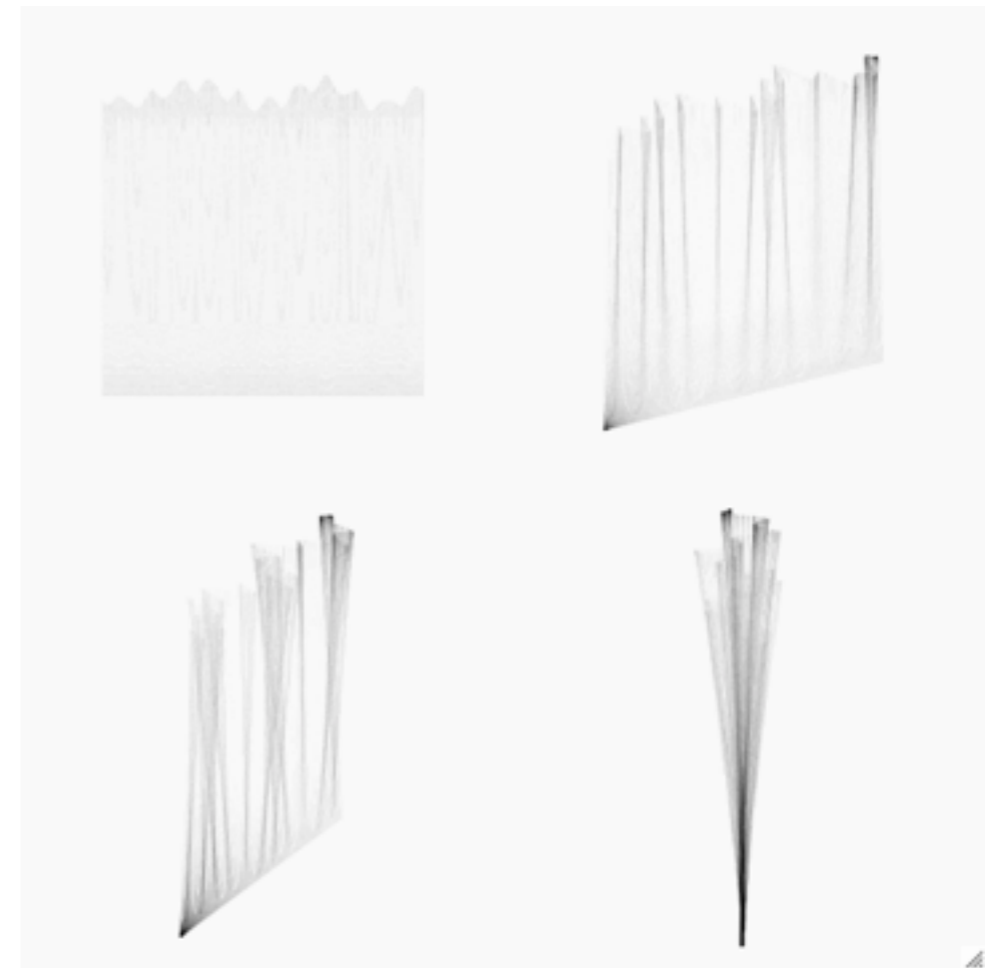
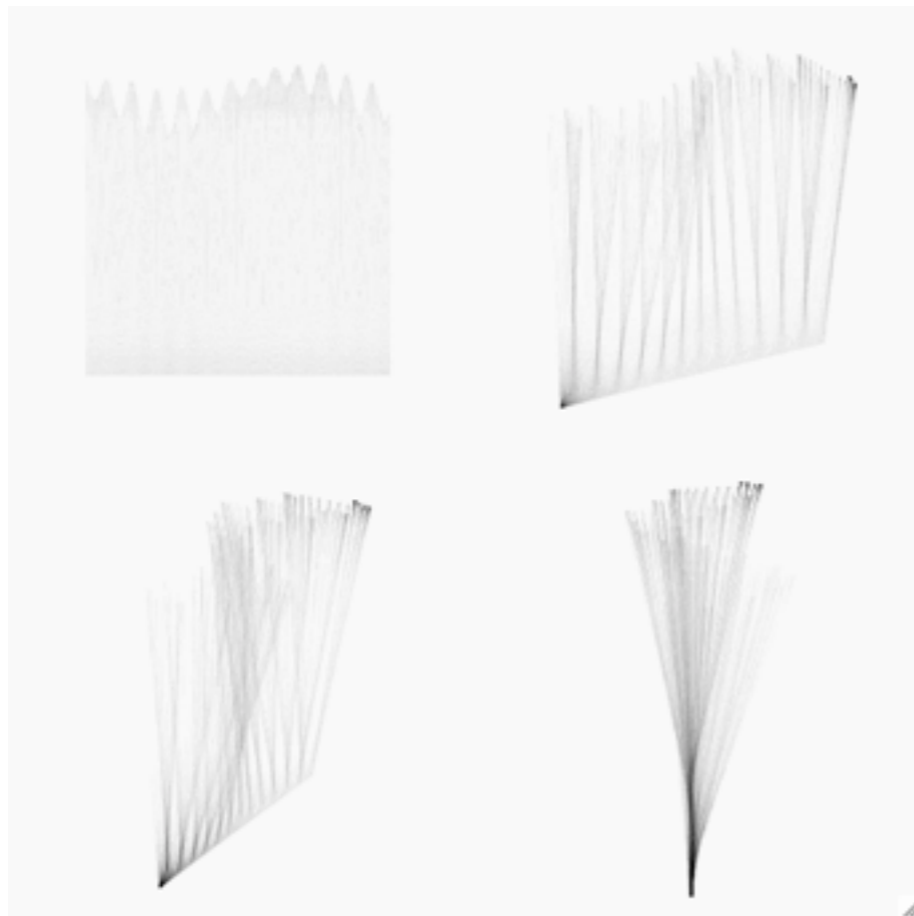
Ca VS. Ha Cont.



Coronal Connection



Curtain Models



Conclusions and Implications

- Red fibrils vary from blue fibrils.
- Apparent motion becoming an Occam's Razor
- Potential alternative explanation for coronal heating
- Neglected theoretical implications being appreciated
- Understanding the chromosphere a bit better
- Or at least gaining a greater realization of its complexities!!

Future Progress

- Publish a paper detailing discoveries
- Continue to challenge De Pontieu and associates with further analysis of this data
- Magnetic field/flux measurements
- Continue to explore sheet model; draw upon basic physics as a guide
- Maintain ‘good science’, follow scientific method.

Any Questions?

