Fast Imaging Solar Spectrograph (FISS) Observations of the Chromosphere

Jongchul CHAE

Dept of Physics and Astronomy, Seoul National University

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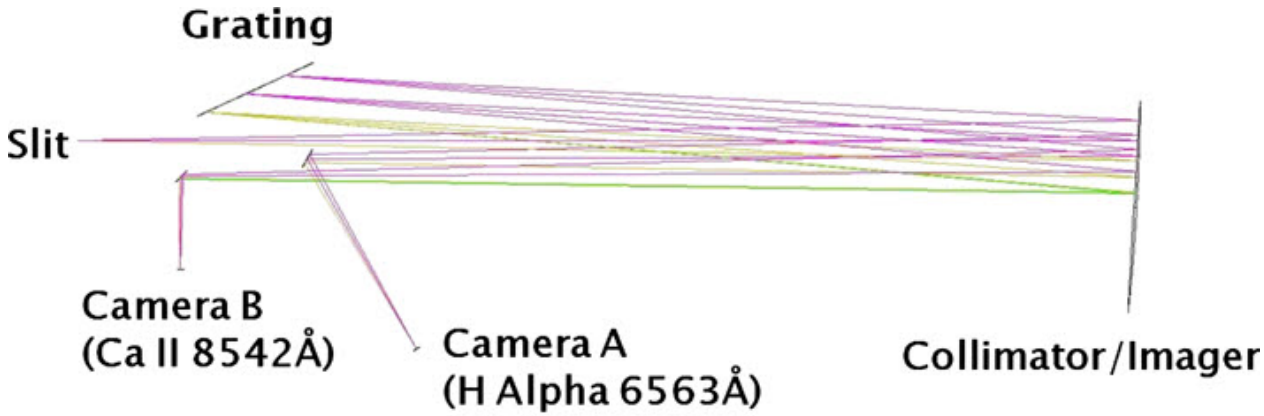
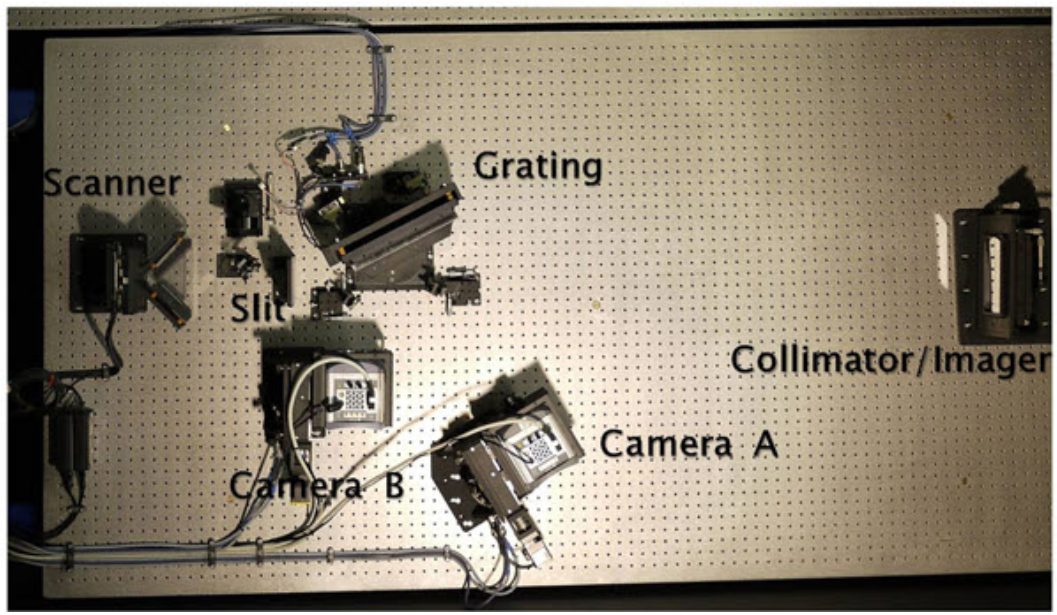
FISS on NST





installed in 2010 May

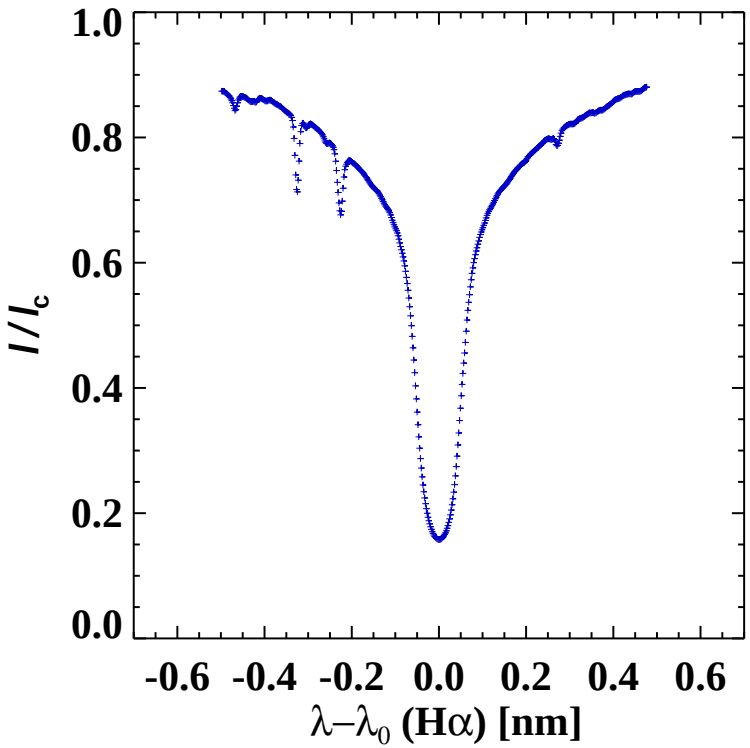
FISS was made by

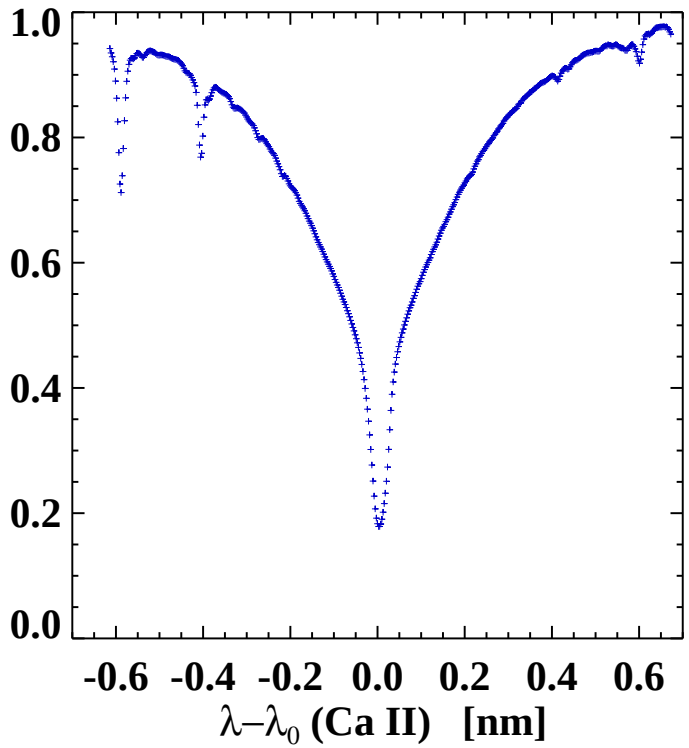
- Solar Astronomy Group at SNU
  - Jongchul Chae: PI, conceptual design
  - Hyung-Min Park: software & tests
  - Kwangsu Ahn: scanner & on-site support
  - Hee Su Yang: grating control & software
- Solar and Space Weather Group at KASI
  - Young-Deuk Park: Co-I, system management
  - Jakyoung Nah: optical engineering
  - Bi Ho Jang: mechanical & electrical engineering
  - Kyung-Suk Cho: administration & science promotion

FISS aims

- to precisely measure physical parameters of dynamic chromospheric features:
  - Velocity $\mathbf{v}$
  - Temperature T
  - Speed of non-thermal motion ξ
  - Electron density n_e
- by recording Hα line and Ca II 8542 line simultaneously with
  - high spectral resolution: $R > 10^5$
  - high spatial resolution: as high as 0.3”
  - high temporal resolution: as high as 10 s
  - high signal-to-noise ratio: better than 10

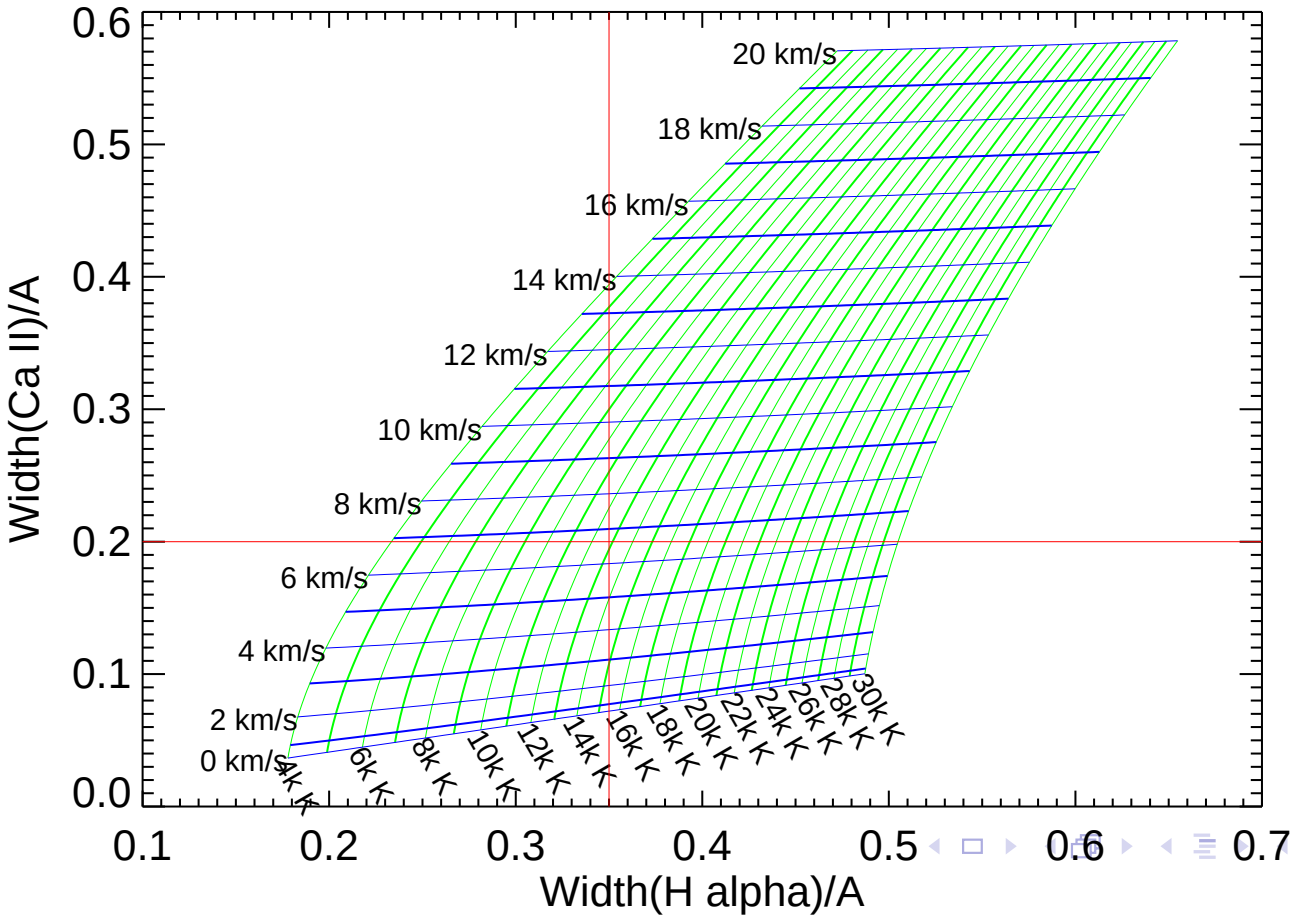
Hα line and Ca II 854.2 nm line



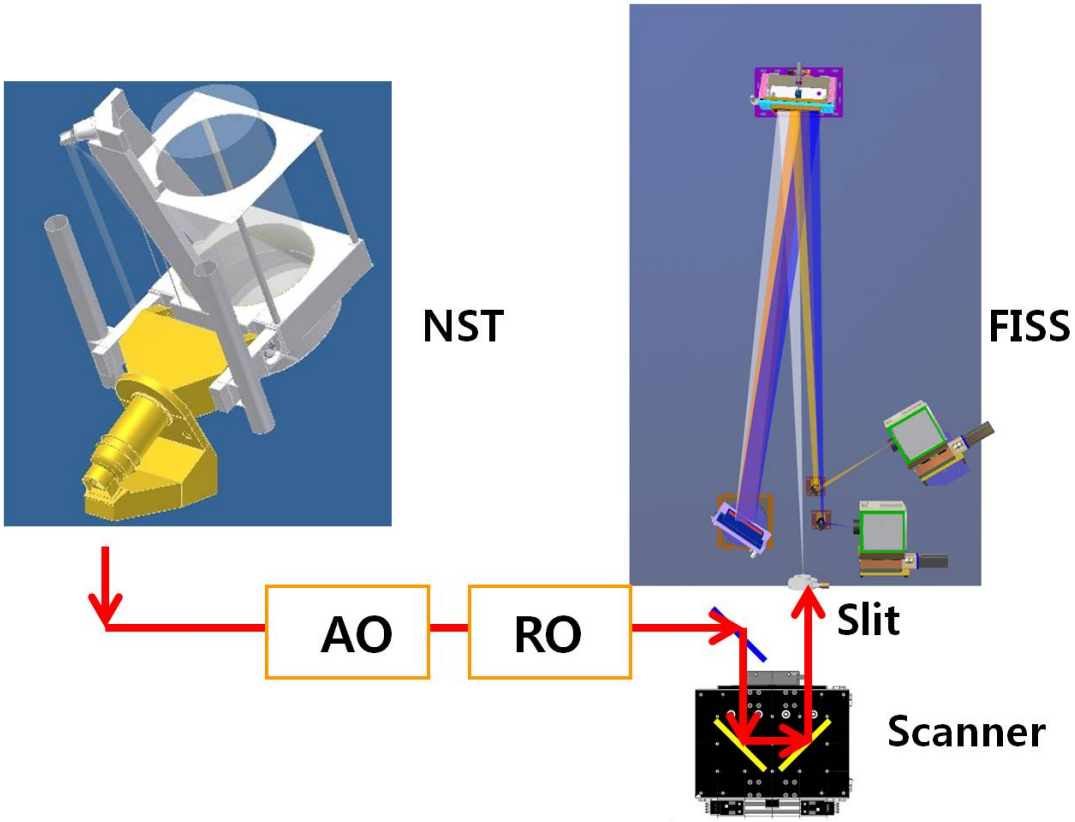


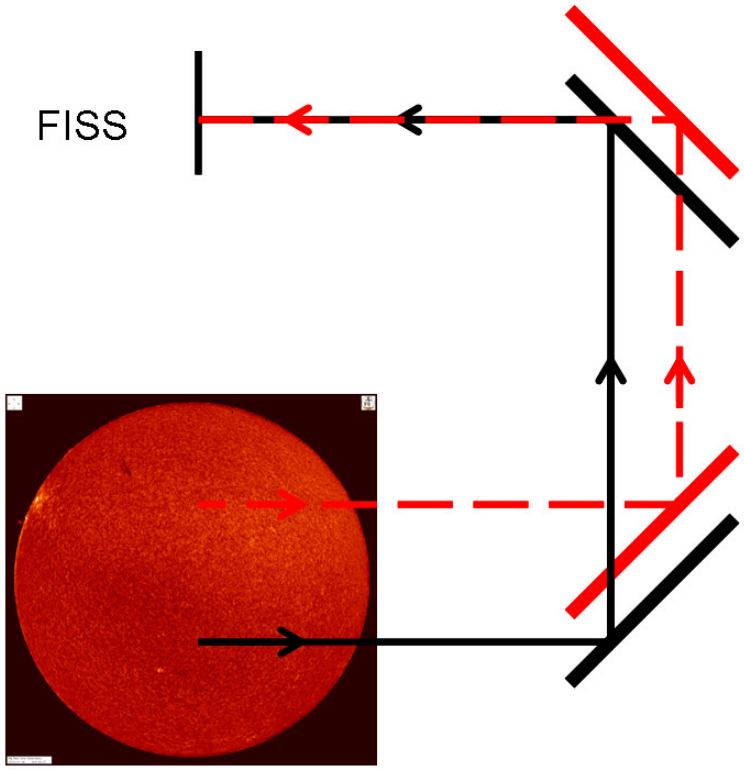
FISS as a plasma thermometer

$$\Delta\lambda_{D,H} = \frac{\lambda}{c}\sqrt{\frac{2kT}{m_H} + \xi^2} \quad \text{and} \quad \Delta\lambda_{D,CaII} = \frac{\lambda}{c}\sqrt{\frac{2kT}{40m_H} + \xi^2}$$



FISS Imaging





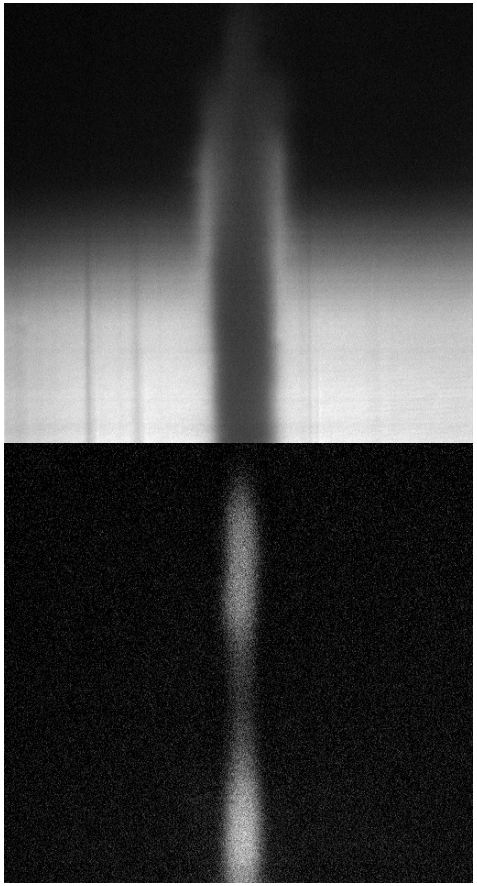
FISS Parameters and Data

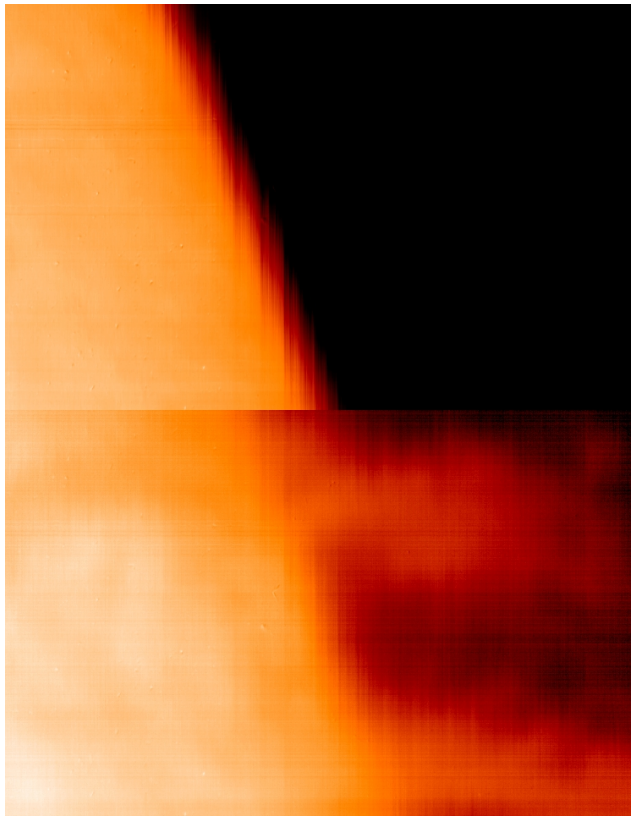
- Parameters

Parameter	Value for Hα/CaIIλ8542
Telescope	$D = 1.6$ m, F/26
Slit	32 μm $\times$ 10 mm
Collimator/Imager	f =1.5 m, F/26
Grating	$1/\sigma = 79$ mm^{-1}, $\phi = 63^\circ$
Camera	512(16μm) $\times$ 512(16μm)
Slit width	0.16″
Pixel size	0.019/0.025 Å$\times 0.16'' \times 0.16''$
Spectral resolution	0.046/0.065 Å ($R = 1.4./1.3 \times 10^5$)
Coverage	9.7/13.1 Å$\times 0.16'' N \times 40''$
Typical exposure time	0.03 s
Scan cadence	20 s (for $N = 100$)

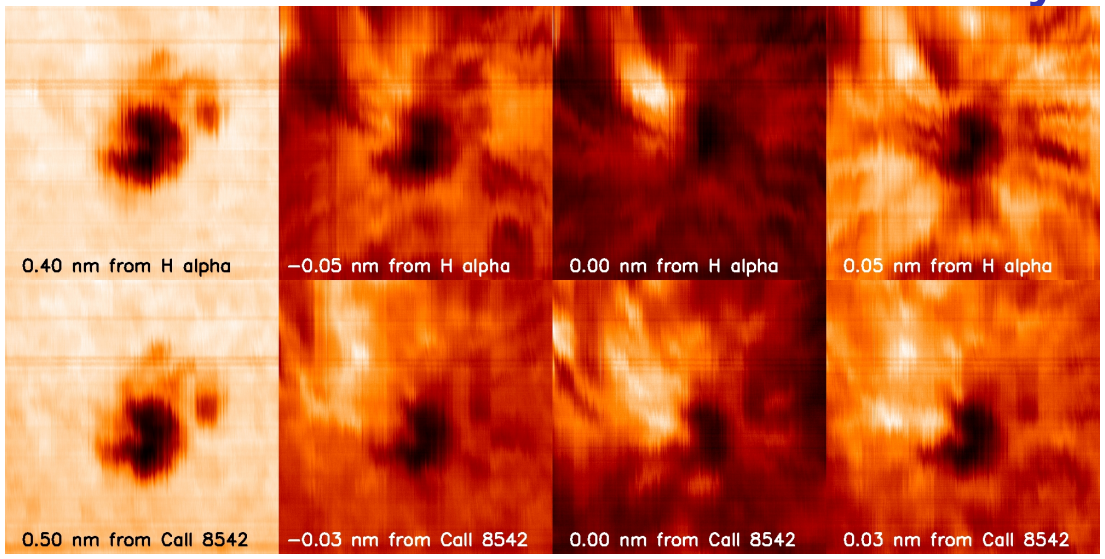
- Data
  - $D_A(\lambda, y; x; t)$ for the Hα band
  - $D_B(\lambda, y; x; t)$ for the Ca II 854.2 nm band

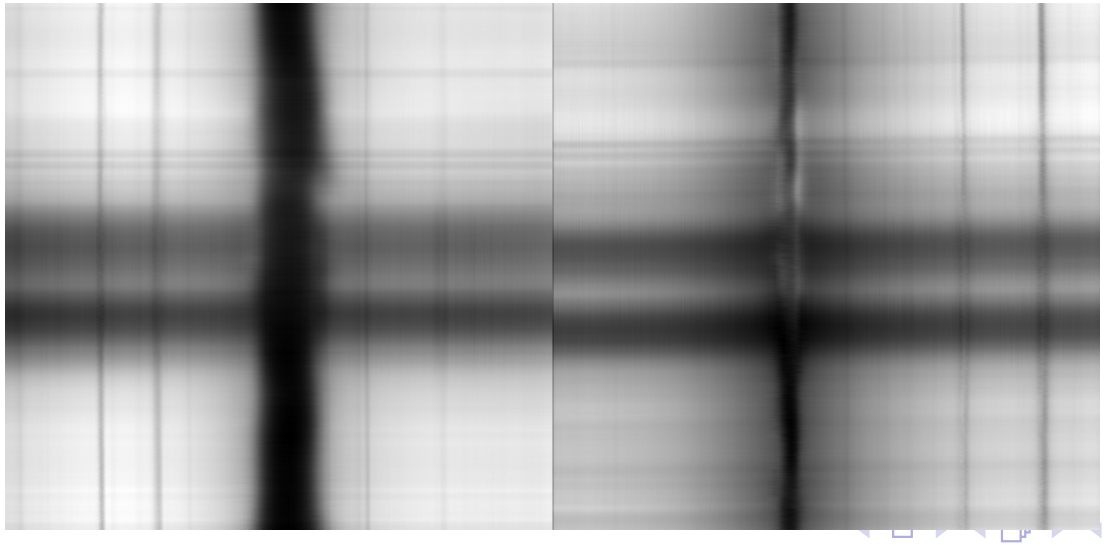
First light observation at BBSO: 2010 May 20



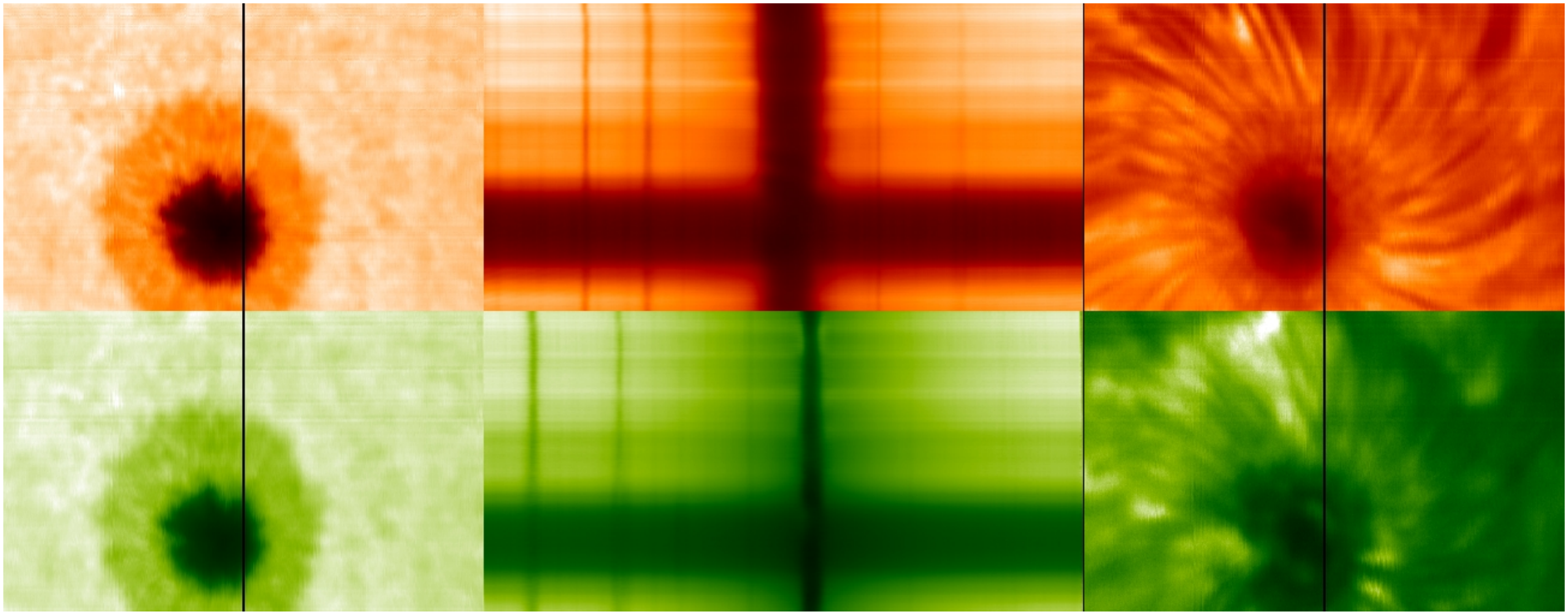


First disk observation at BBSO: 2010 May 21





sunspot



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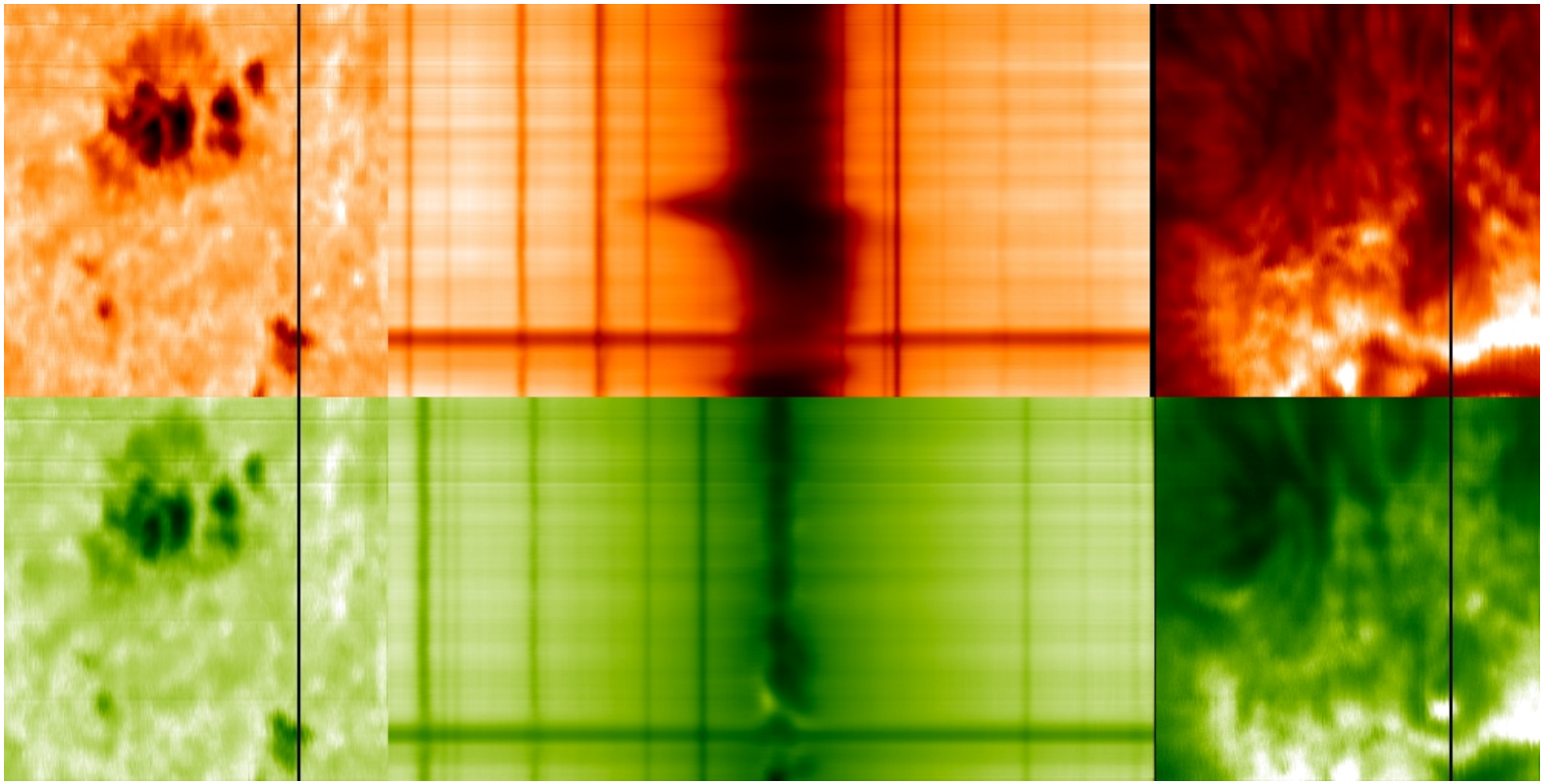
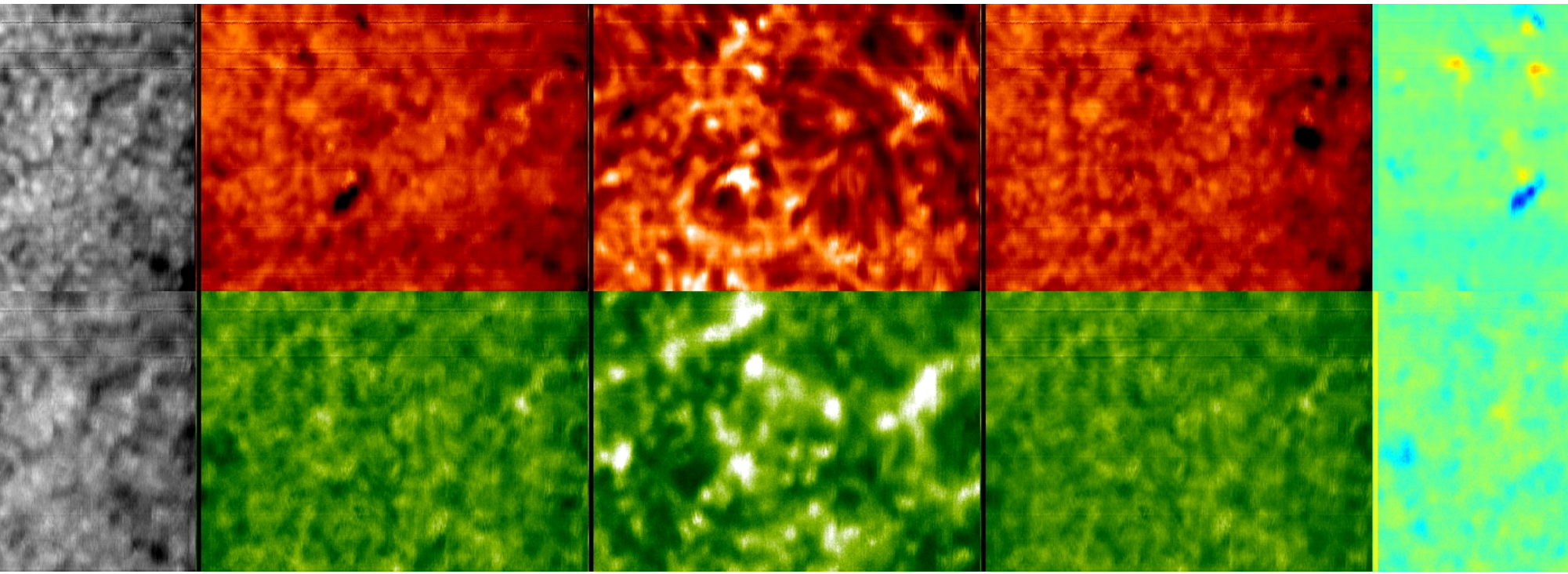
flare



20100722_181243

quiet region



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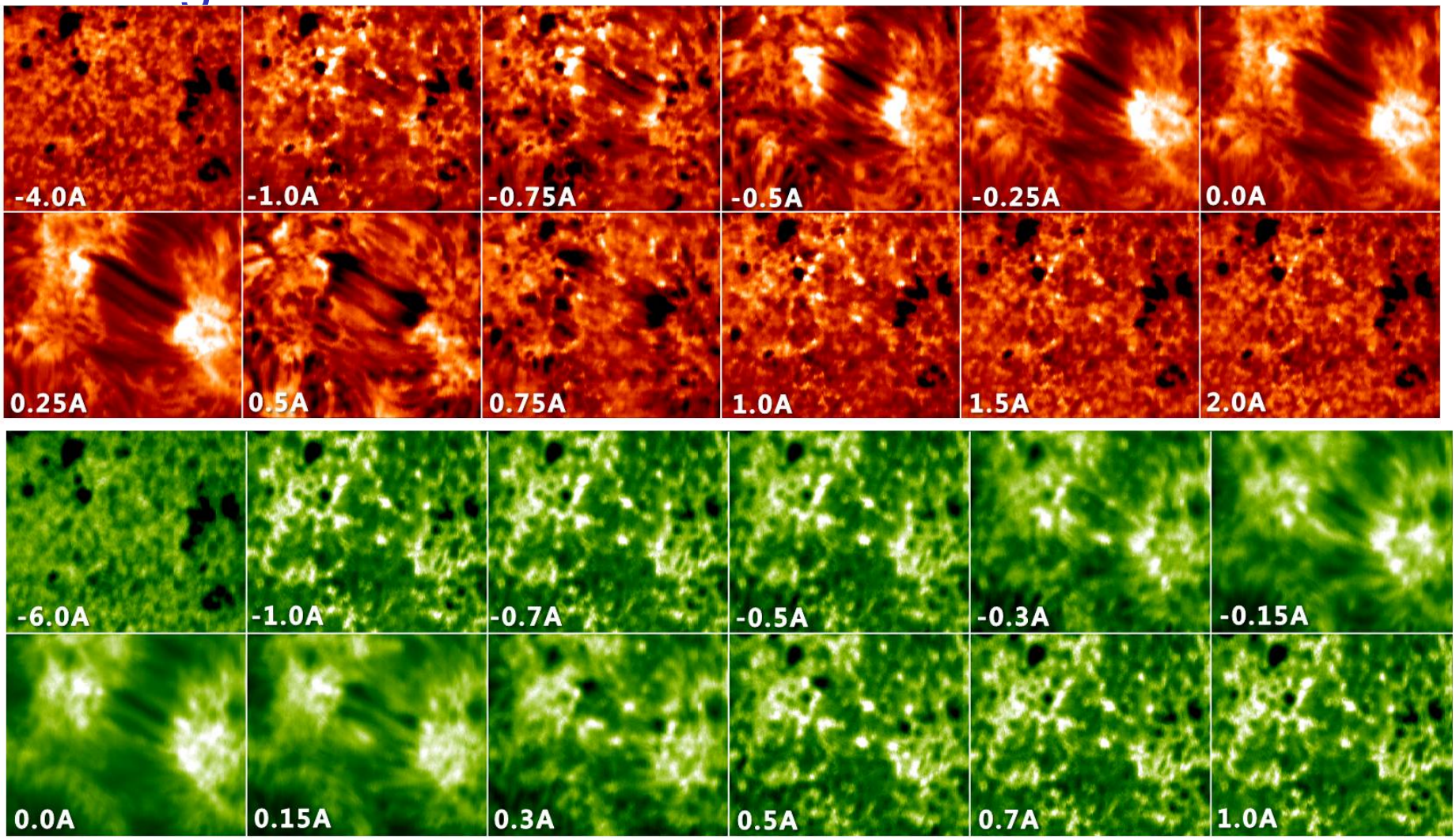
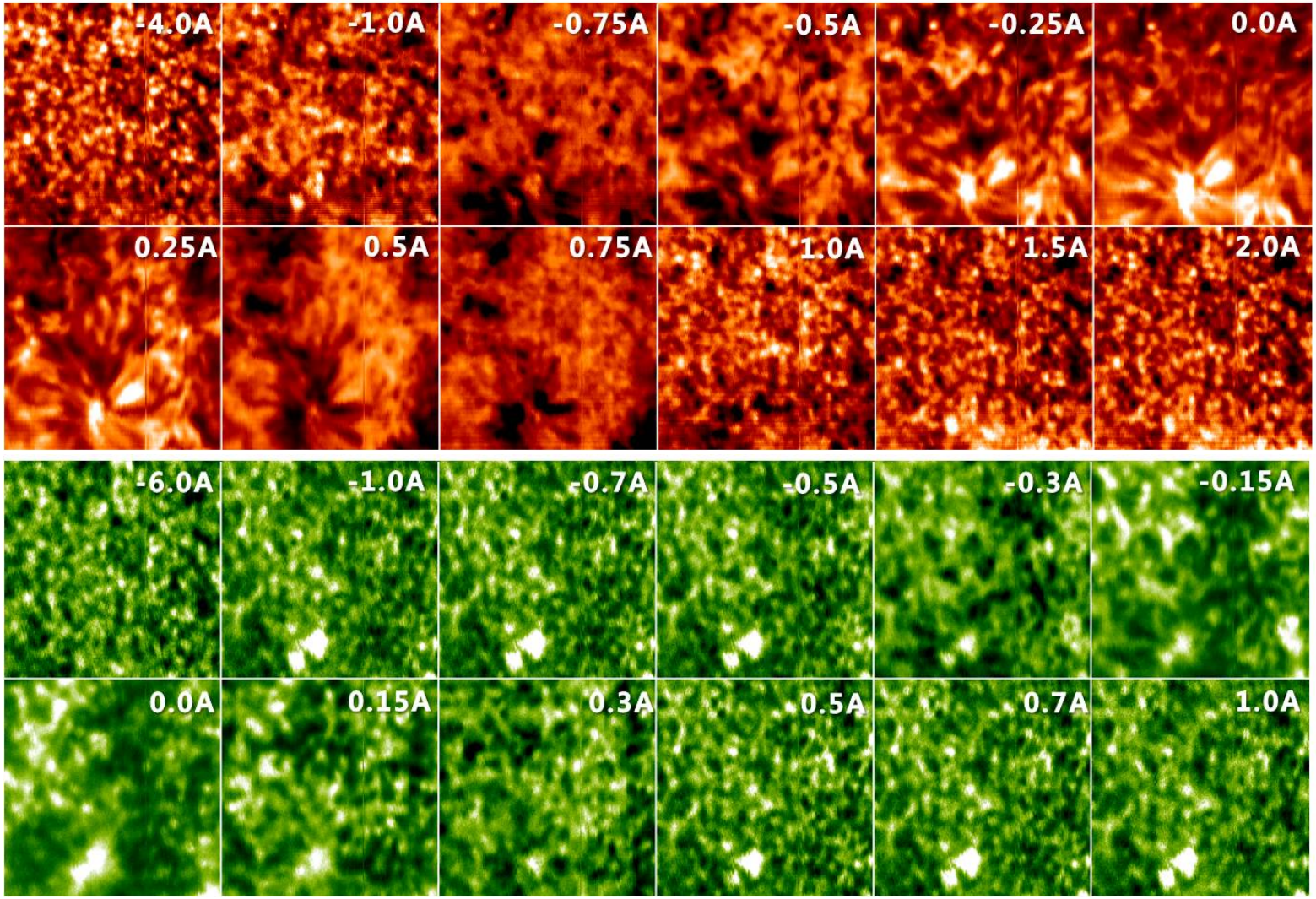
active region



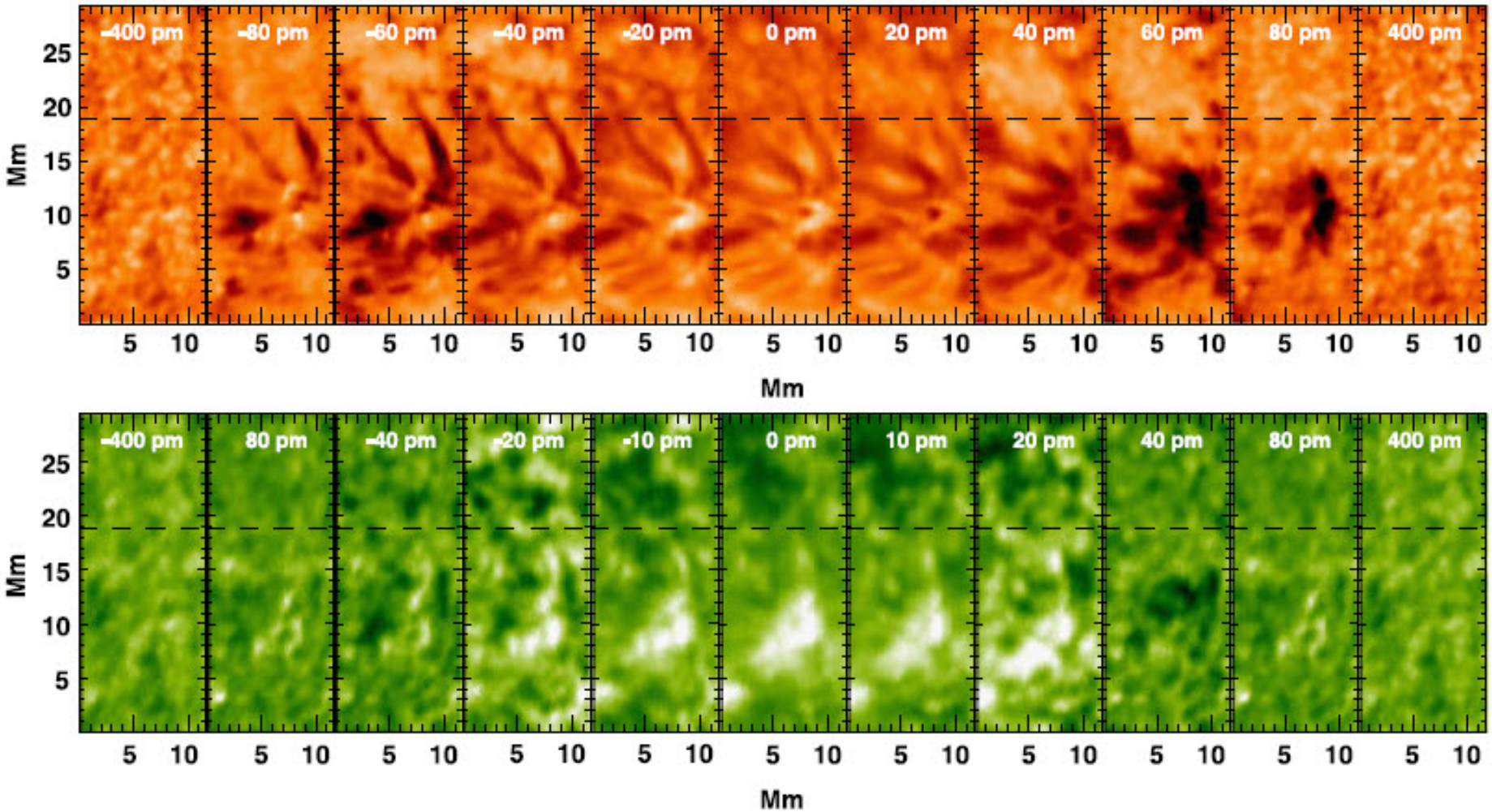
20110624_0905

quiet region



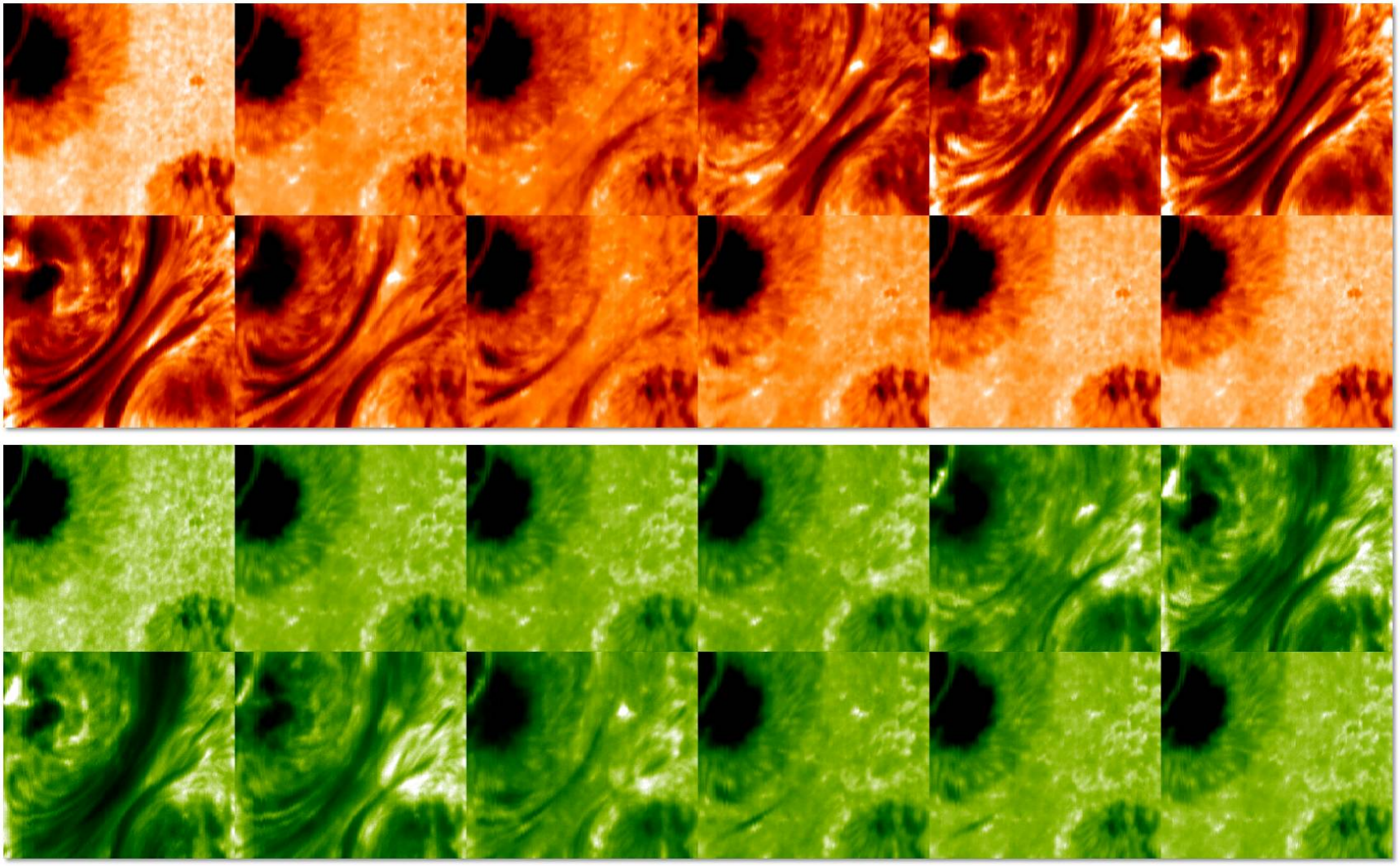
20110610_2044

quiet region



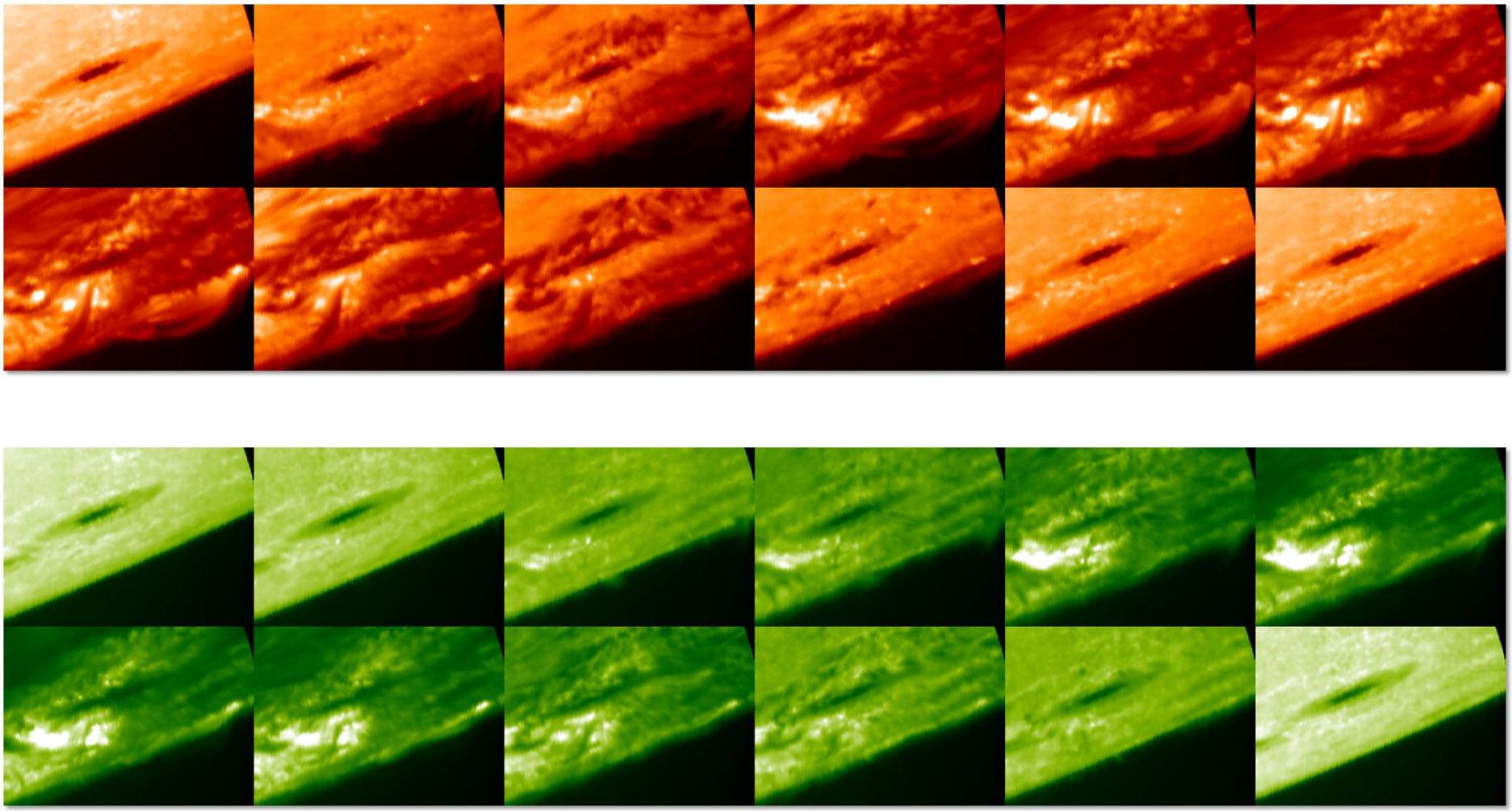
20110713

active region



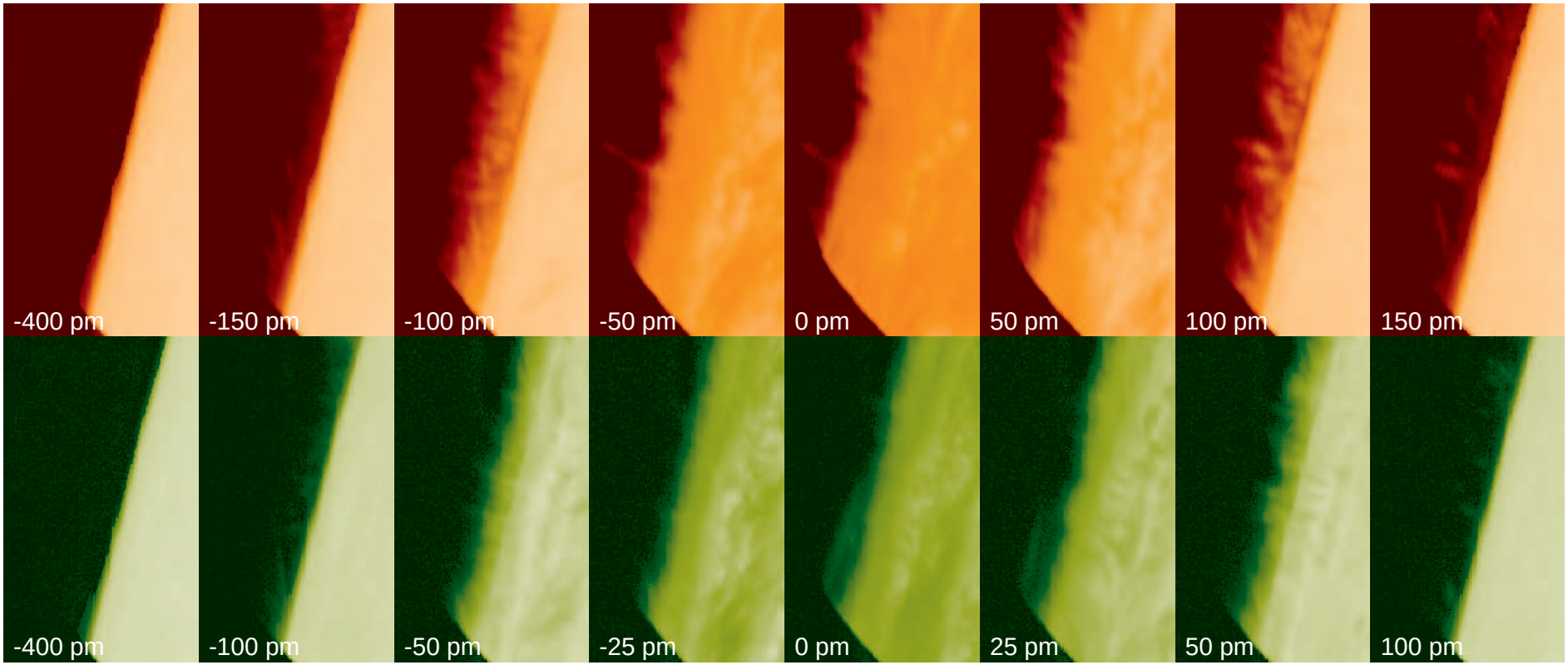
20120710_1710

near-limb active region



20120903_1724

limb chromosphere



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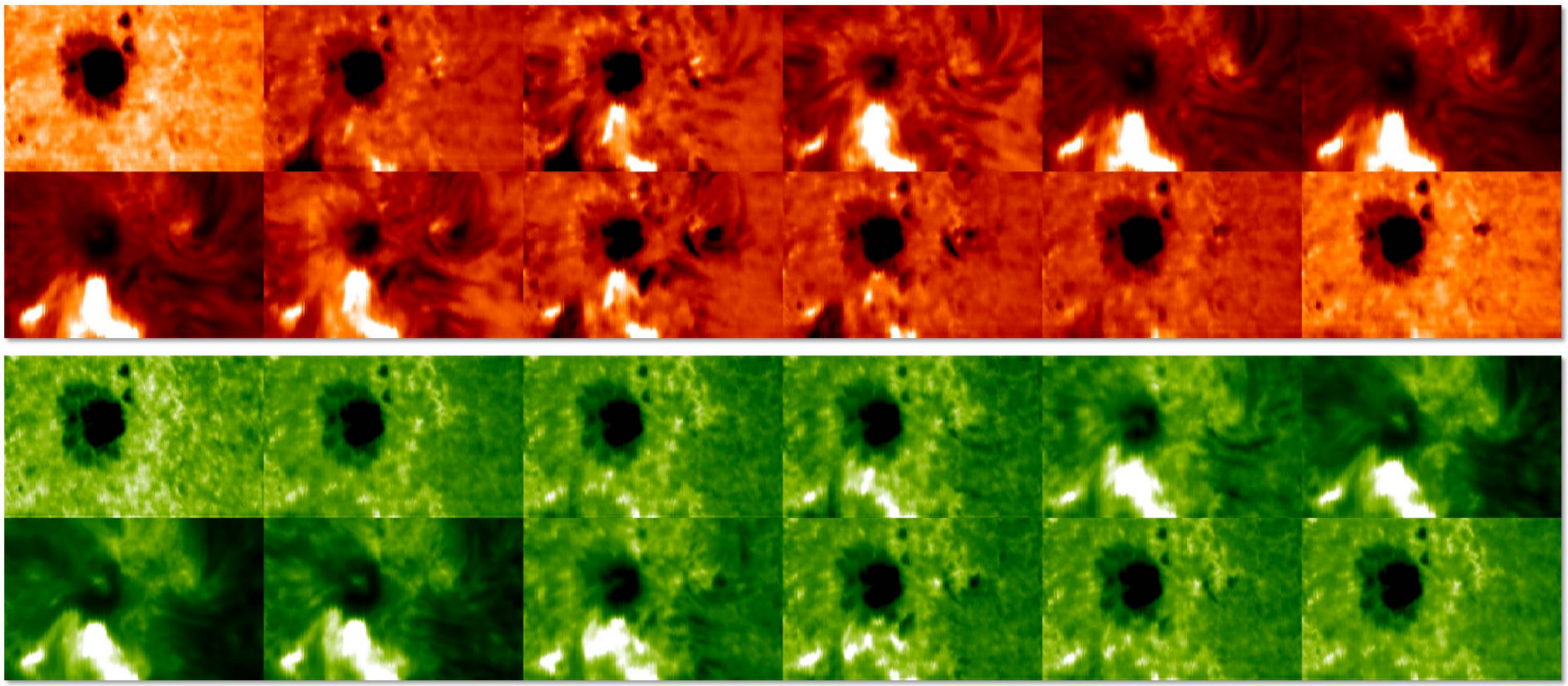
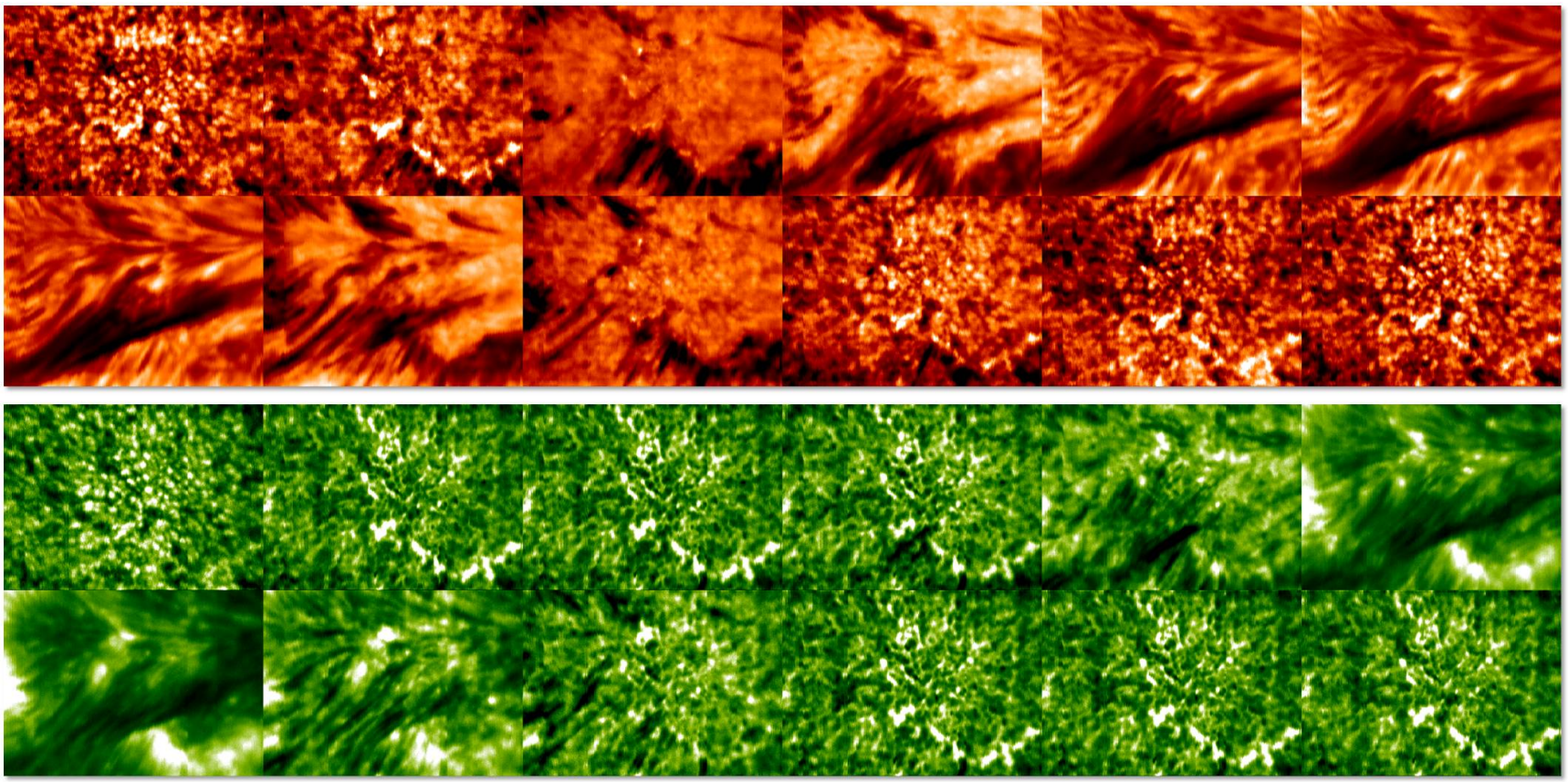
flare



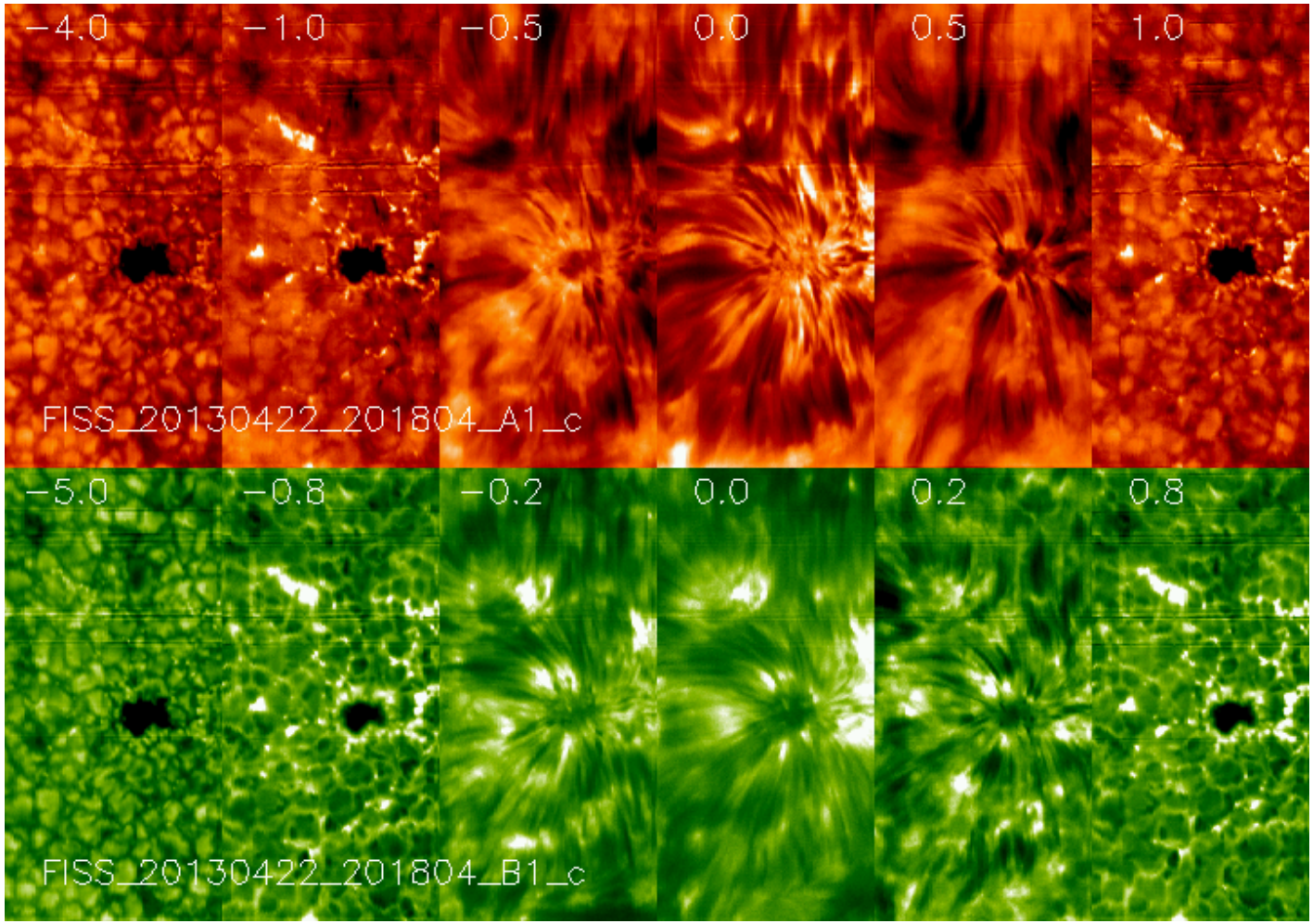
20120719_1837

filament



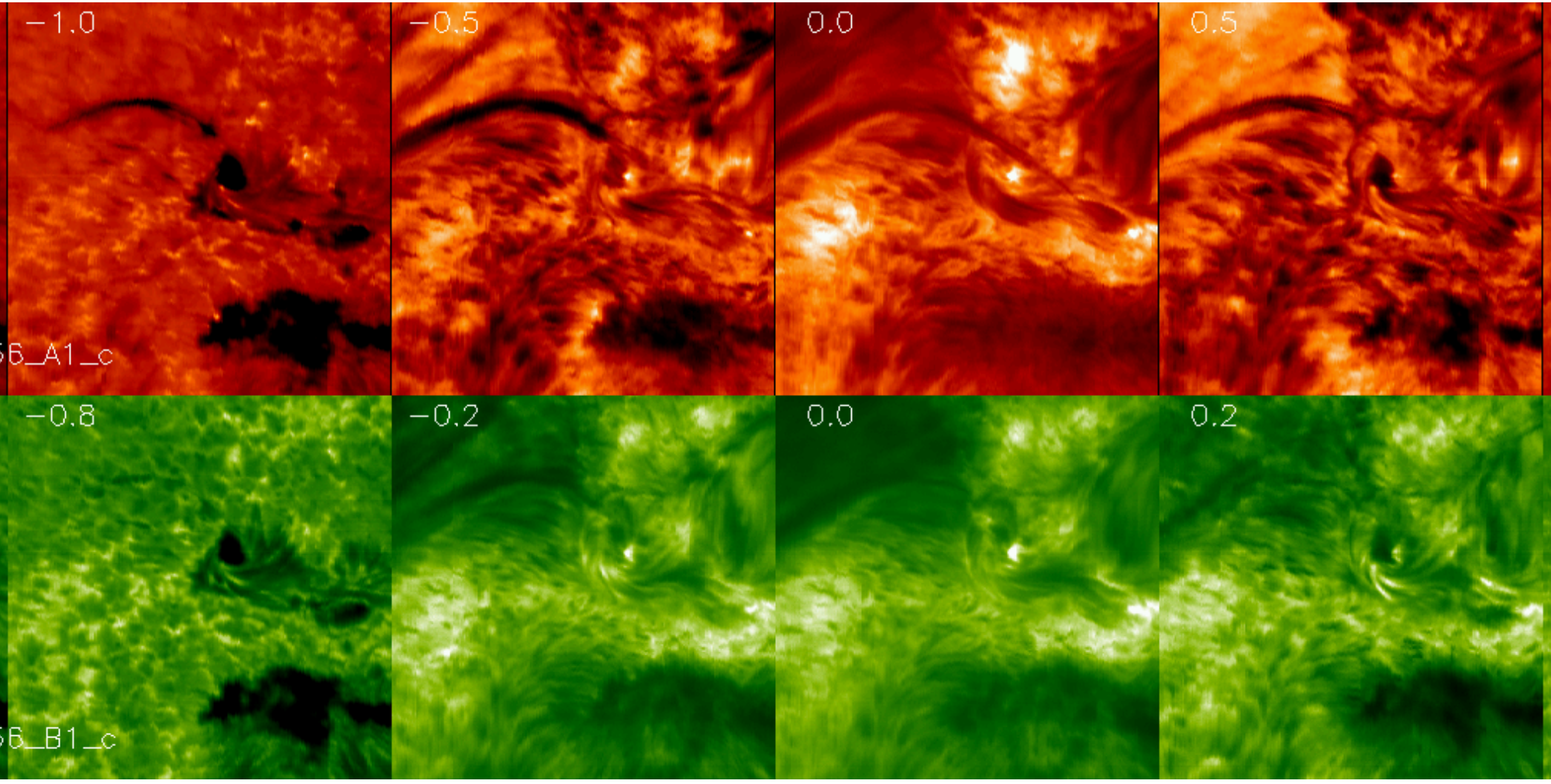
20120711_1816

active region



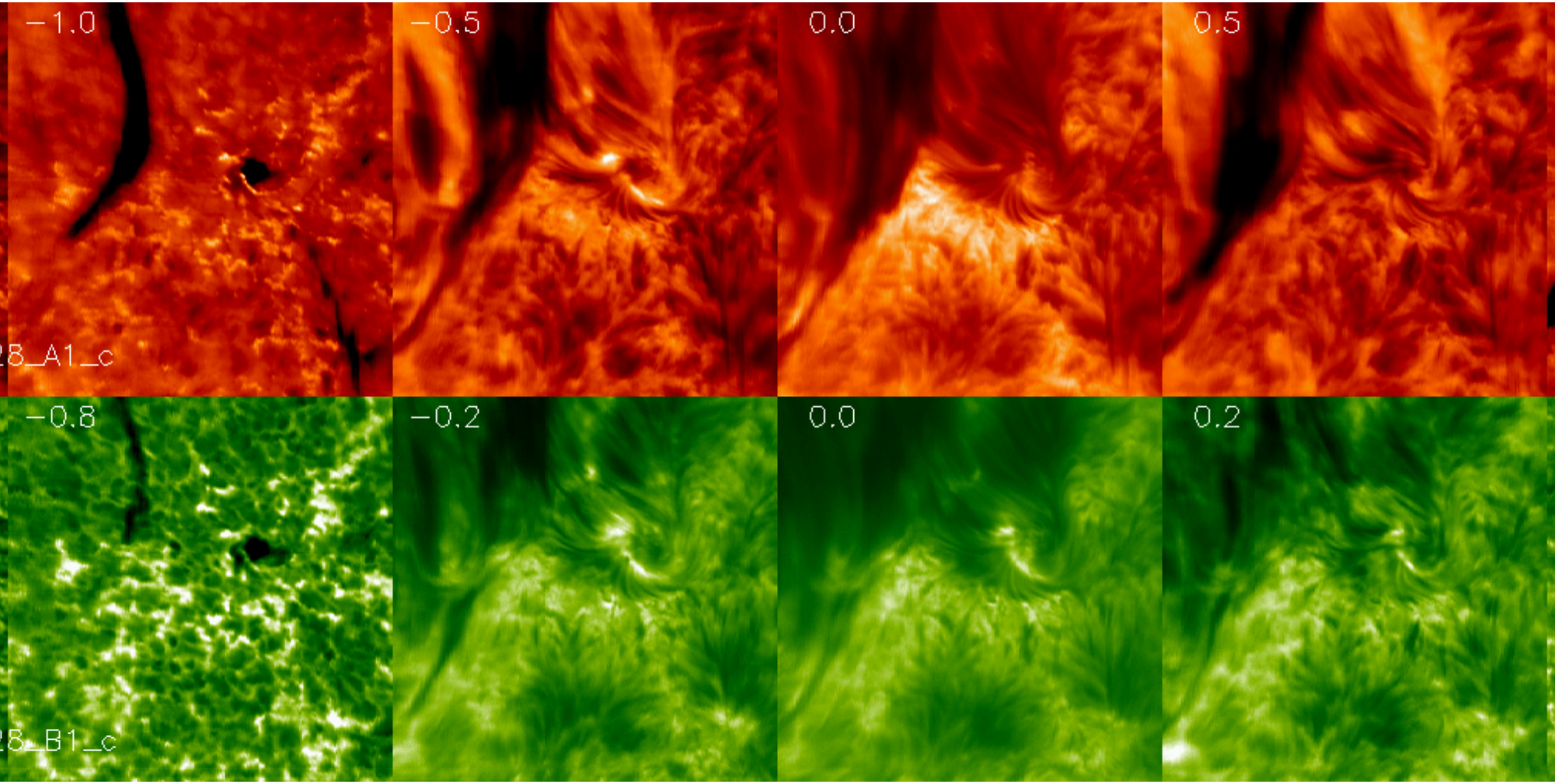
20130422_201804

active region



20130716_204956

active region



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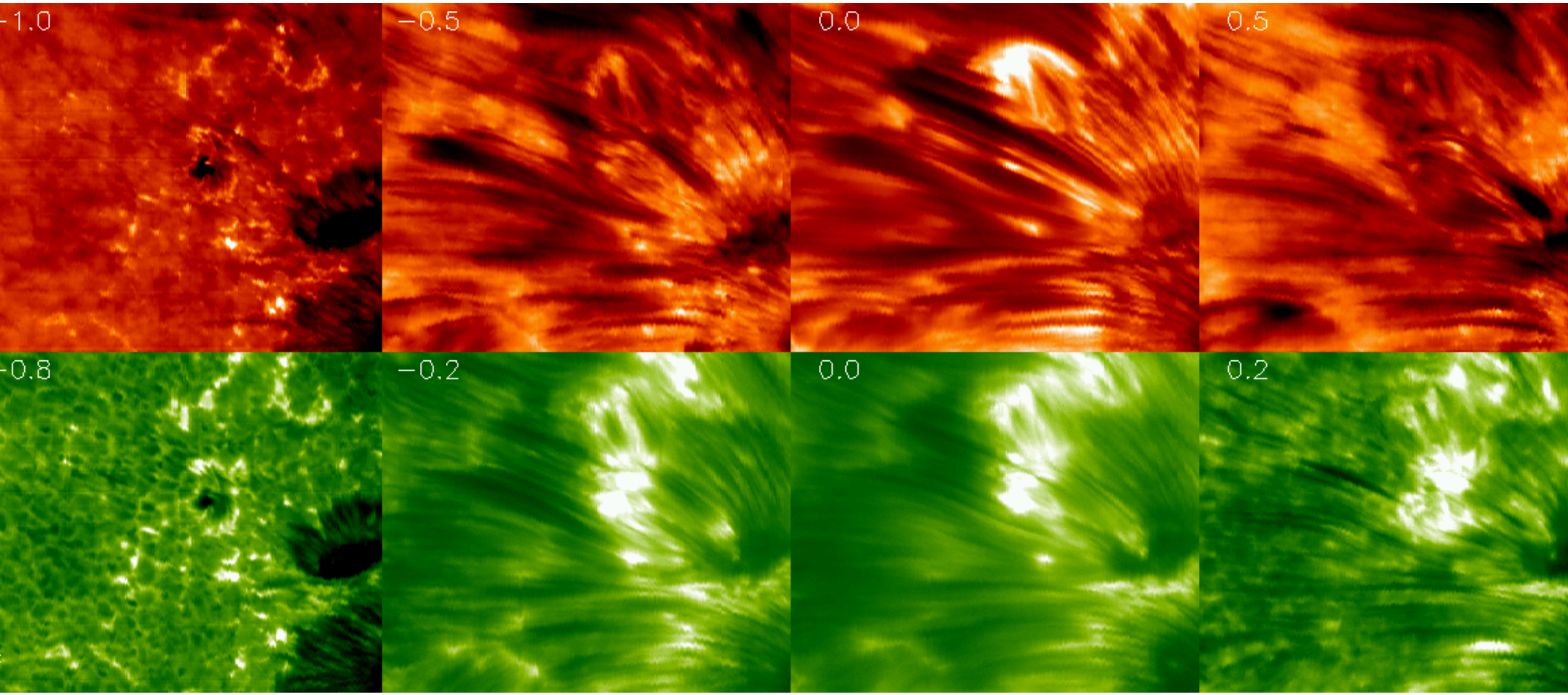
active region



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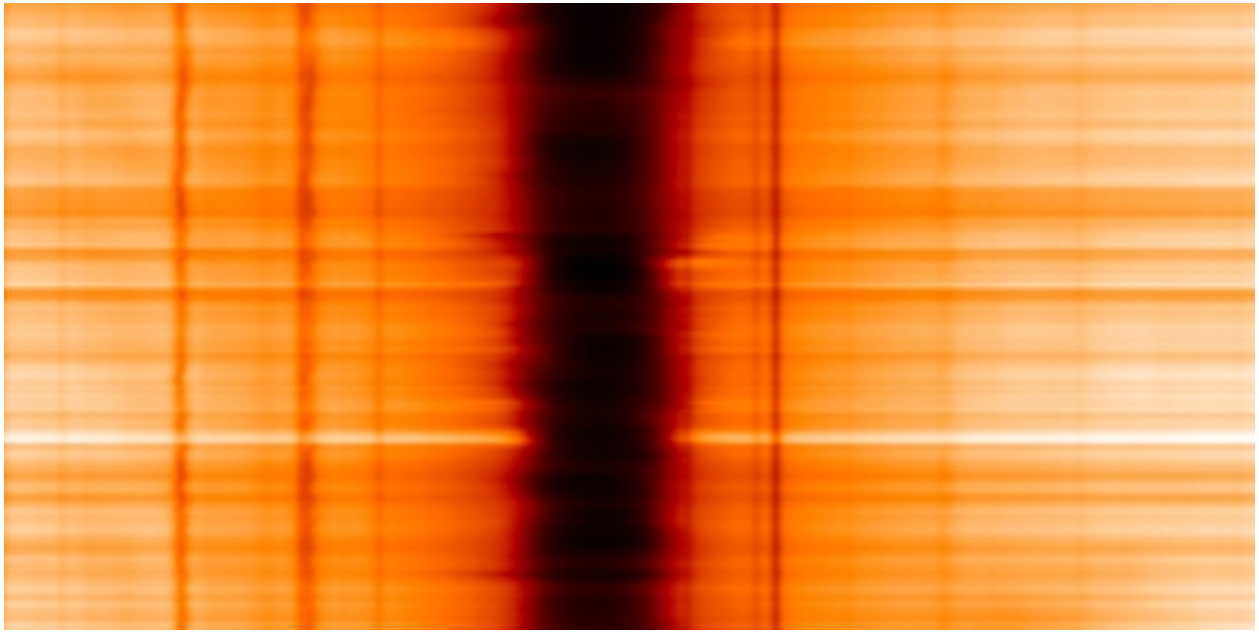
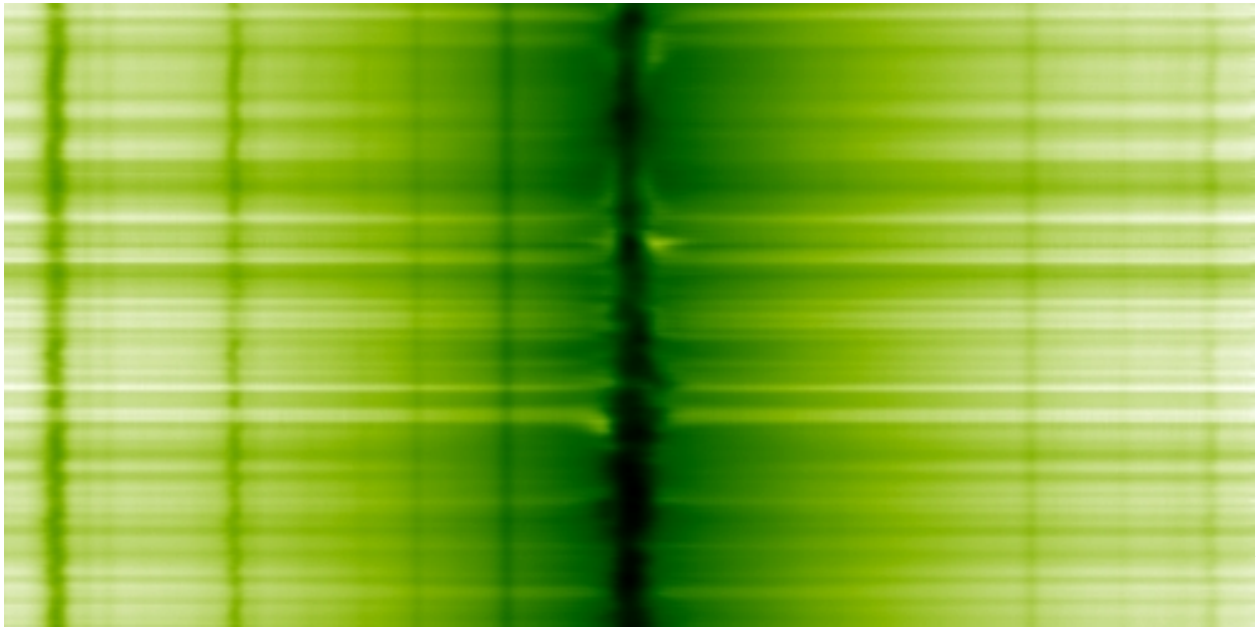
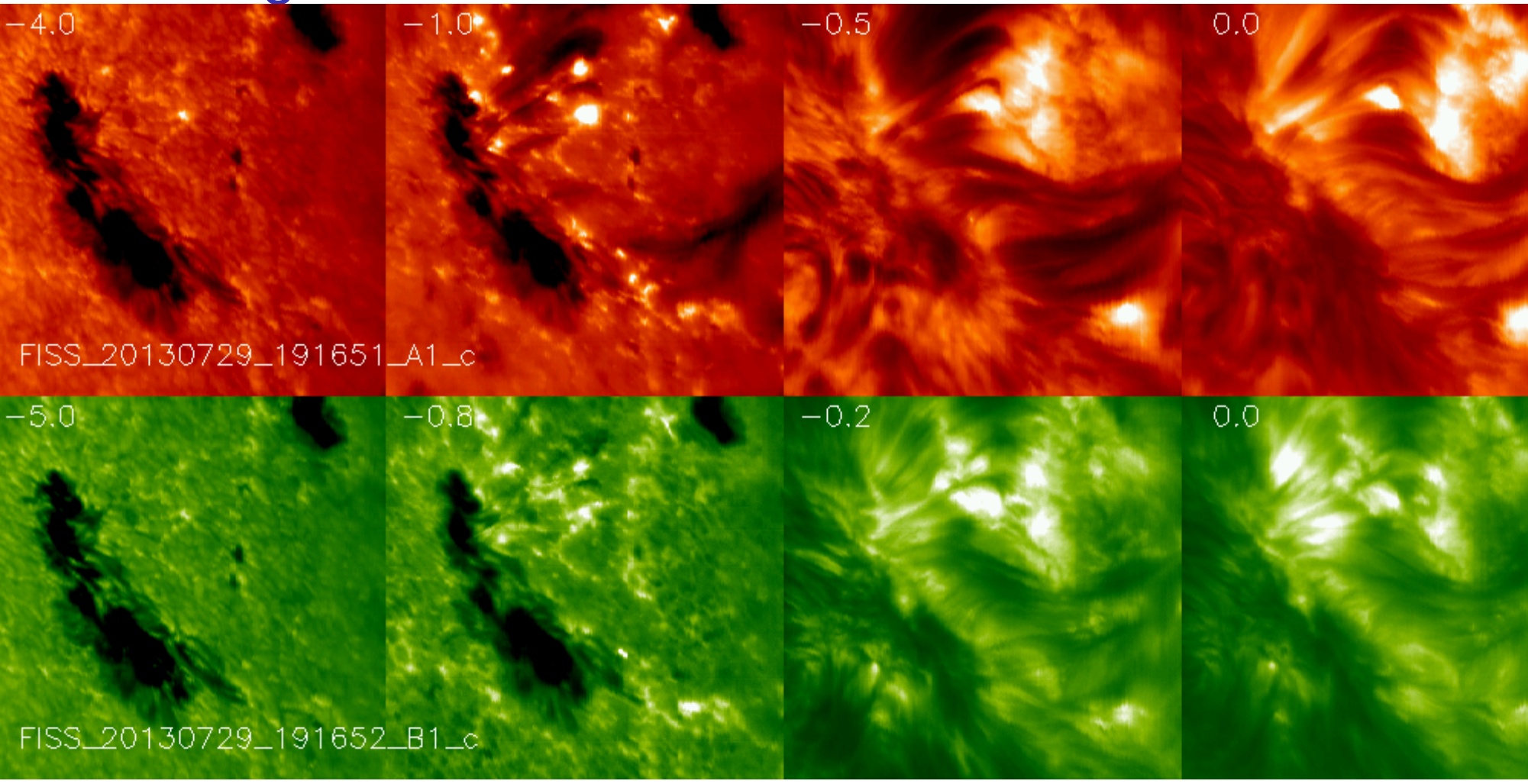
spatial resolution: 0.4″



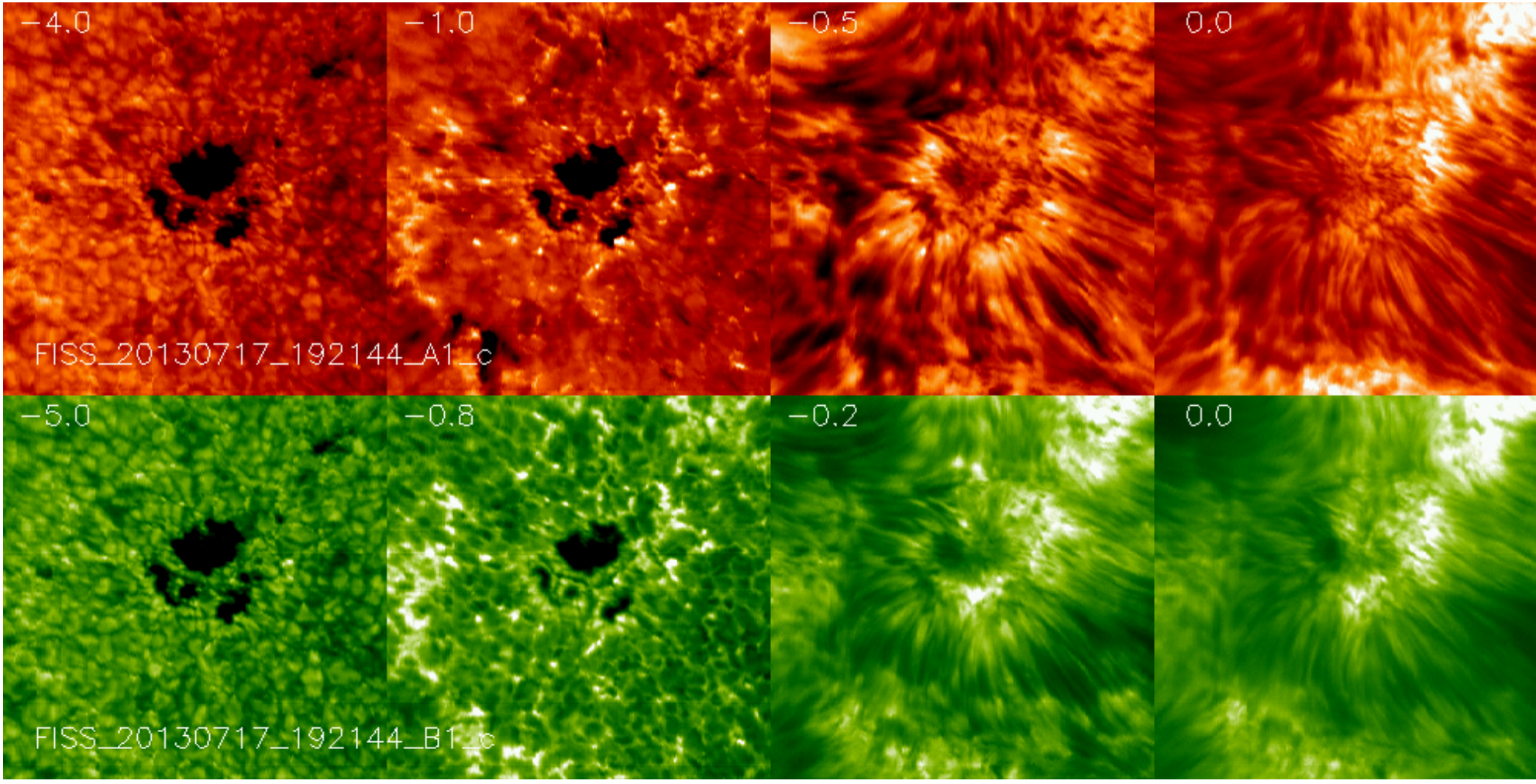


active region



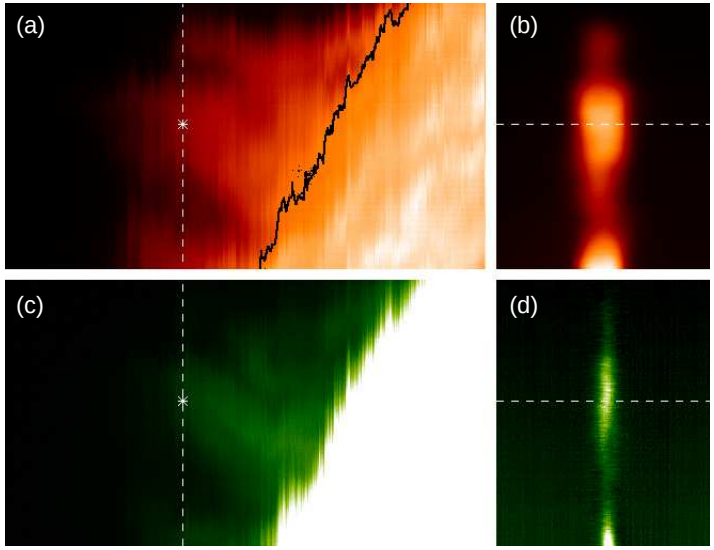
20130729_191651

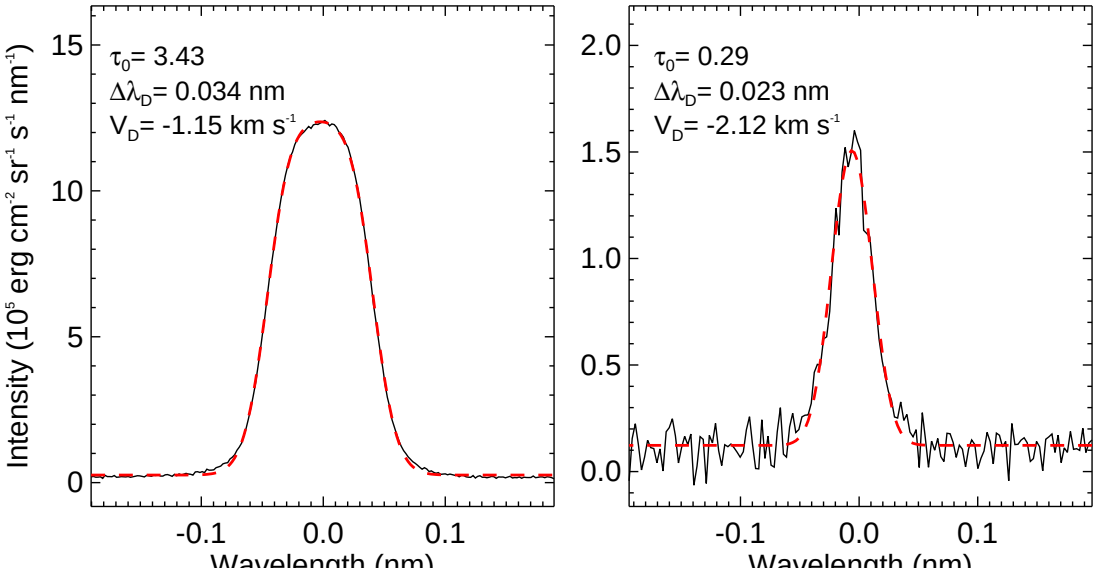
active region



20130717_192144

prominence temperature



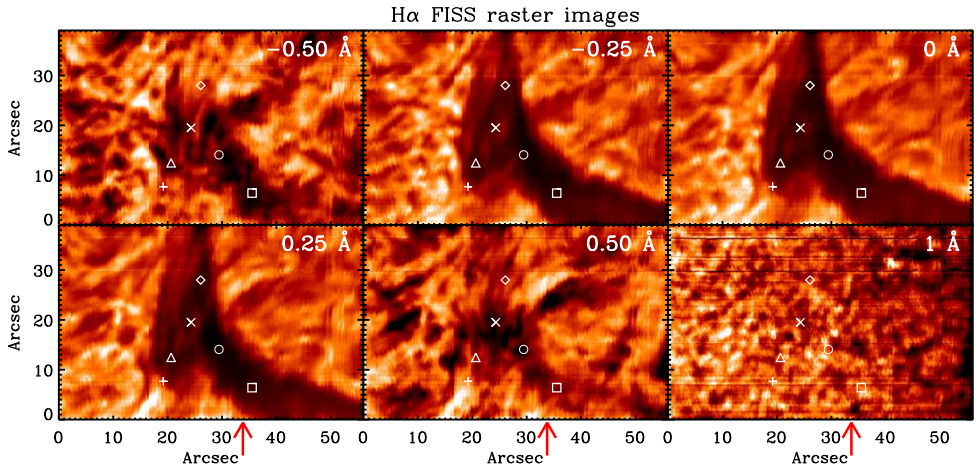


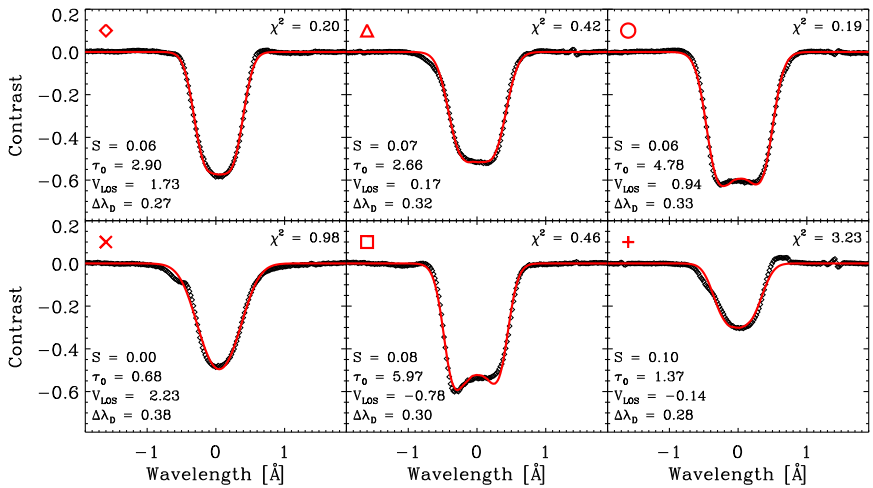
$$I_{\lambda,\mathrm{obs}} = S \cdot [1 - \exp(-\tau_\lambda)]$$

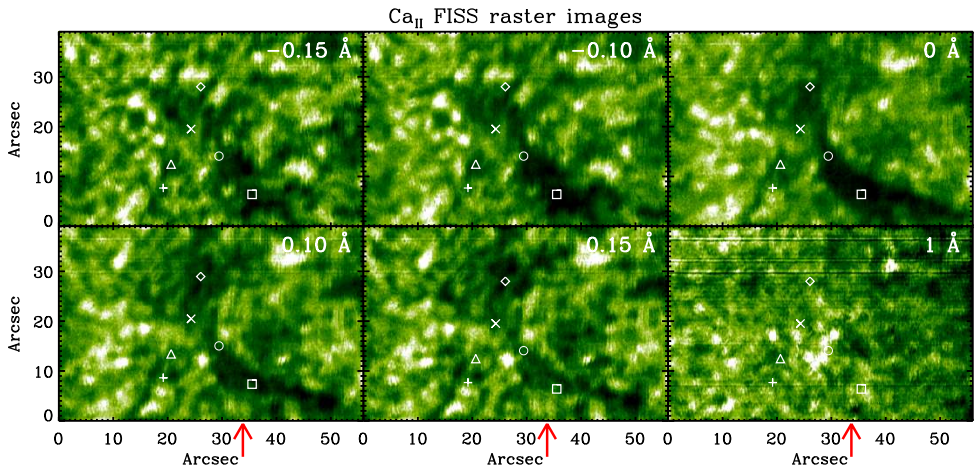
$$\tau_\lambda = \tau_0 \exp\left[-\left(\frac{\lambda - \lambda_1}{\Delta\lambda_D}\right)^2\right]$$

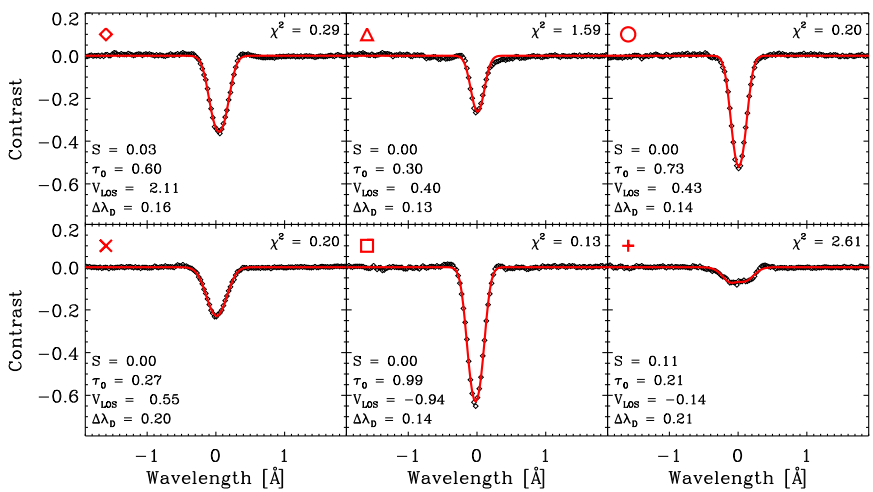
$$T = 11000\ \mathrm{K},\ \xi = 7.8\ \mathrm{km\ s^{-1}}$$

filament

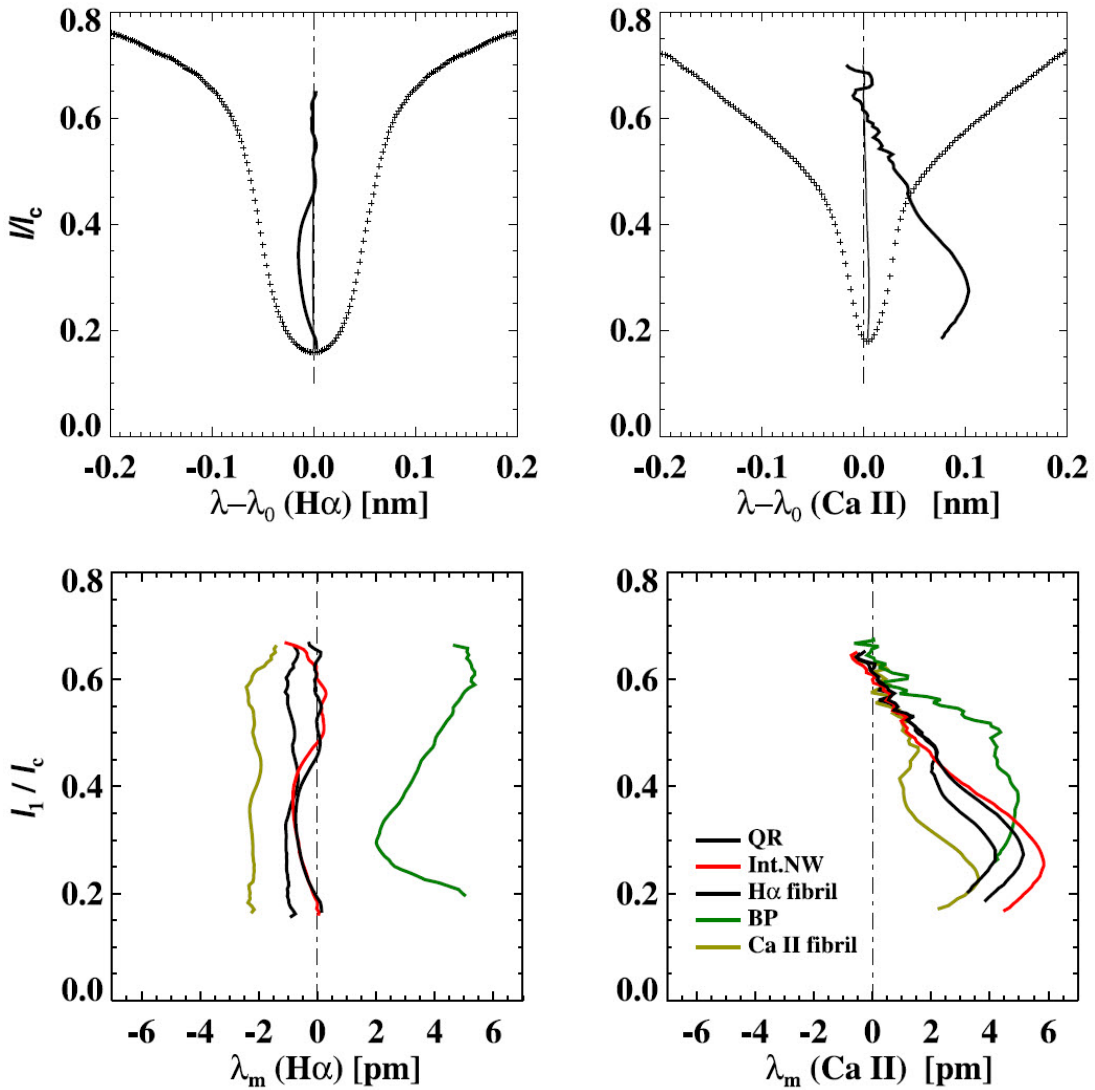

Hα FISS raster images
−0.50 Å
−0.25 Å
0 Å
0.25 Å
0.50 Å
1 Å
Arcsec


Contrast
Wavelength [Å]

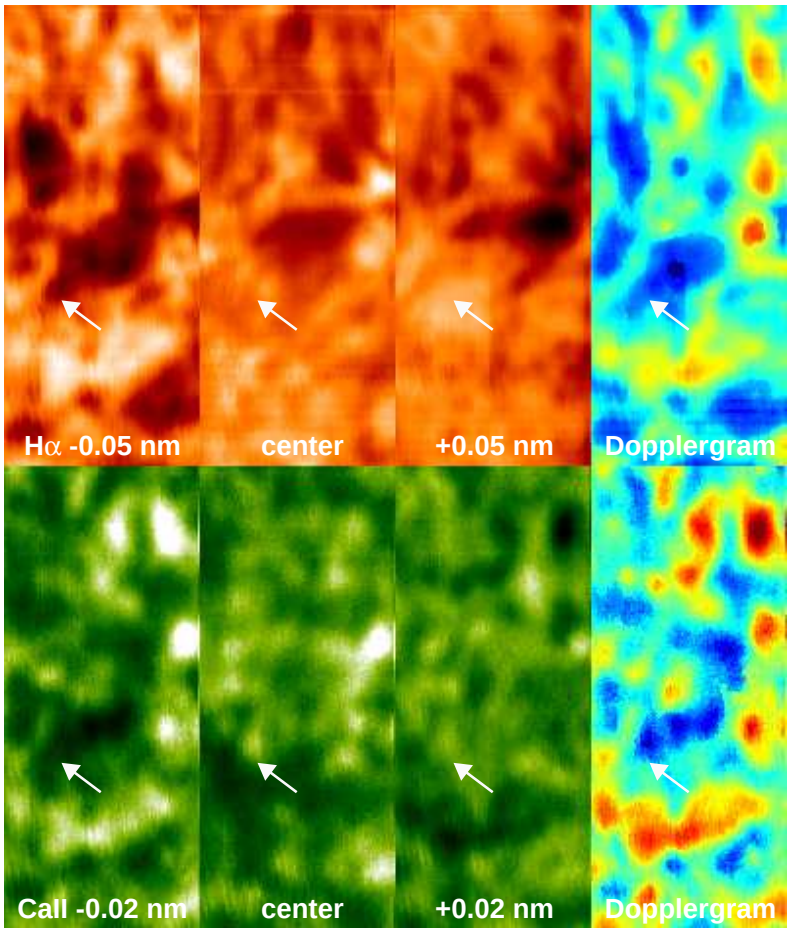

Ca II FISS raster images
−0.15 Å
−0.10 Å
0 Å
0.10 Å
0.15 Å
1 Å
Arcsec

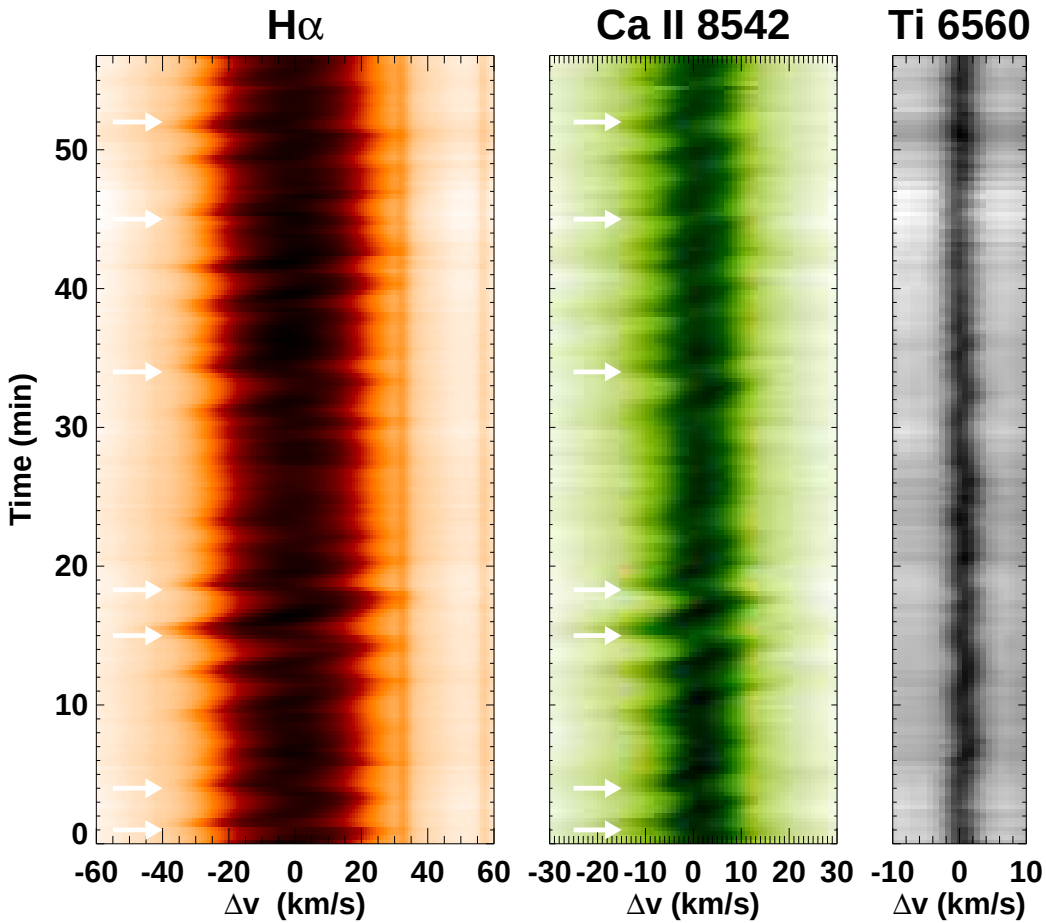

Contrast
Wavelength [Å]

bisectors of Hα and Ca II 854.2 nm lines

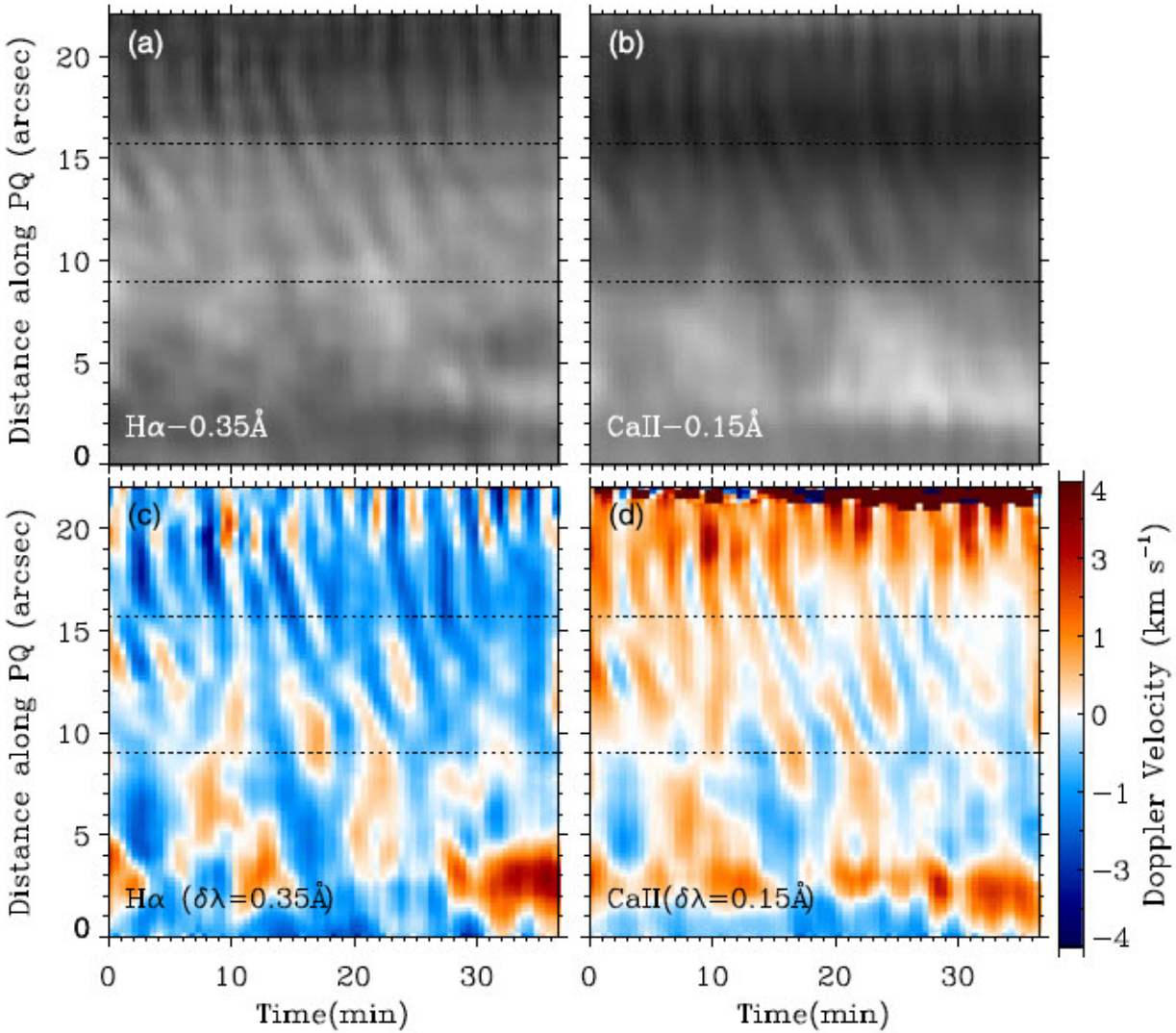


3-min oscillation as a shock wave

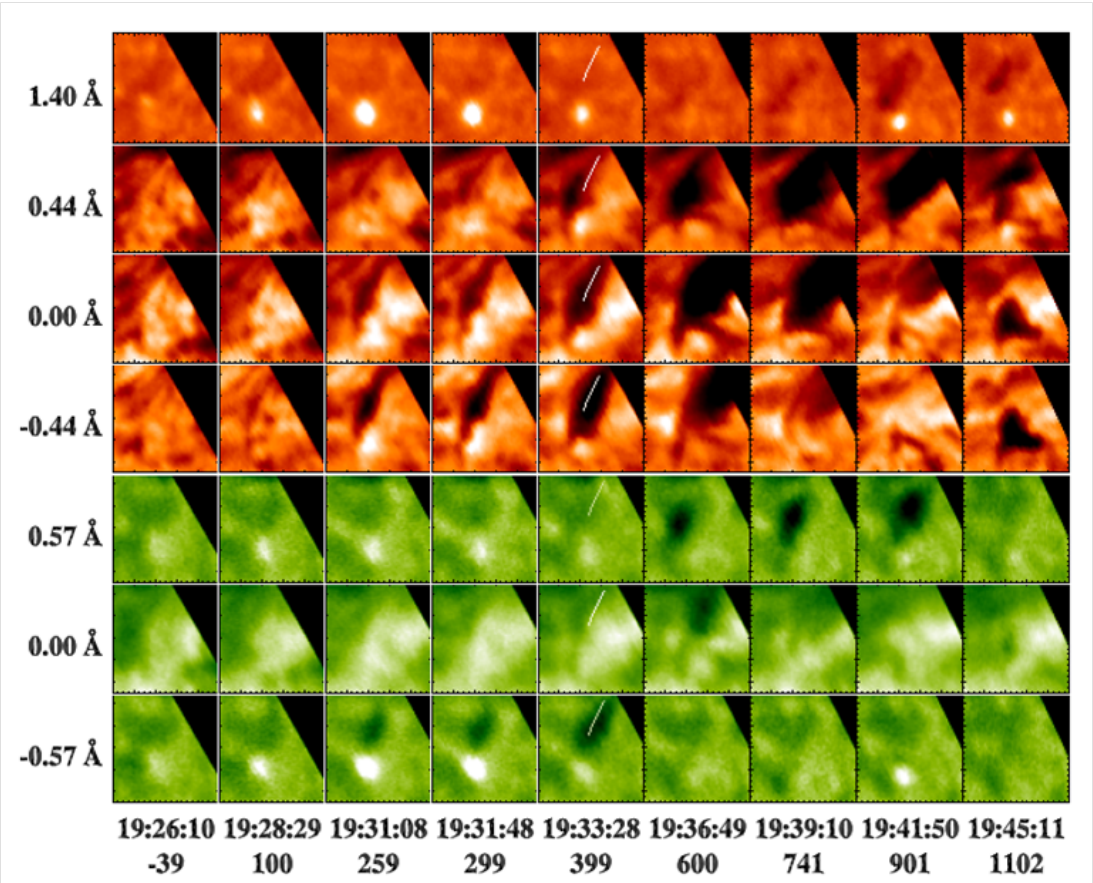


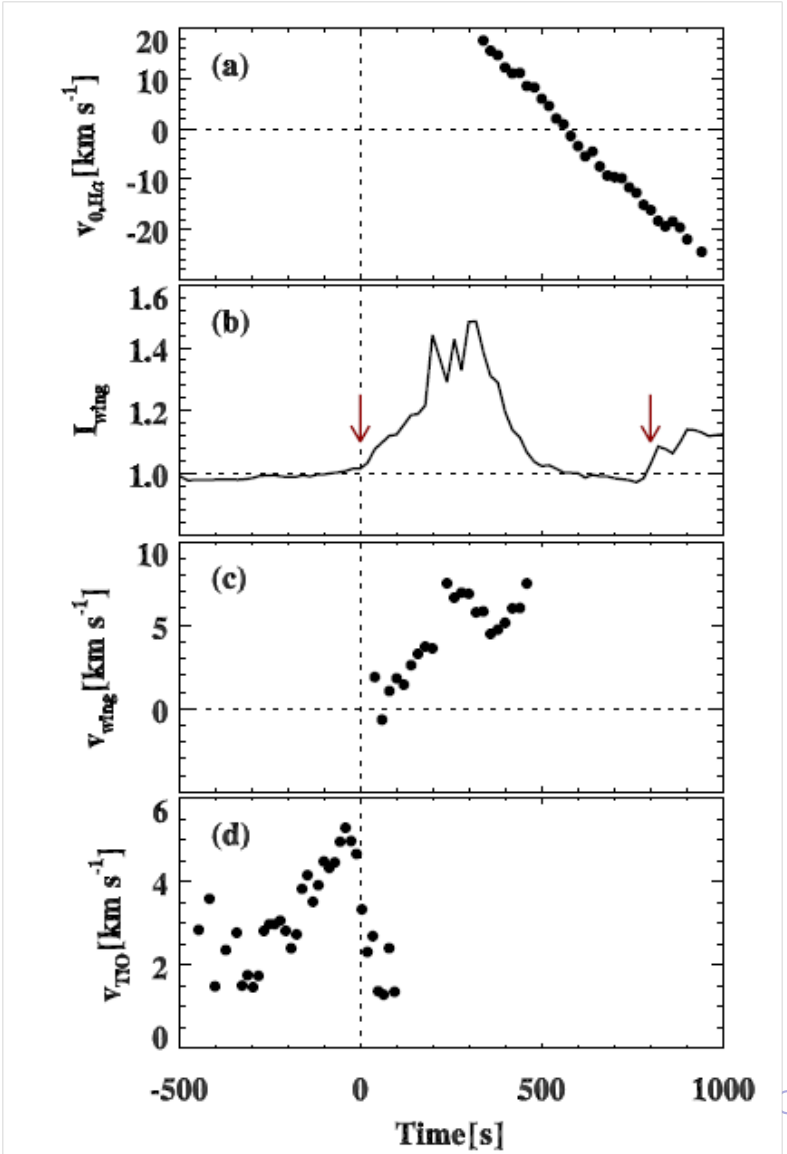


3-to-5 minute transition of sunspot oscillation



EB-surge connection





Conclusion

1. The description of FISS and some initial results were published in the mini-special-issue of *Solar Physics* in Volume 288, Issue 1, November 2013.
2. The performance of FISS on NST is now close to the goal: high spectral, high spatial, and high temporal observations of the chromosphere.
3. The FISS observations will contribute to our understanding of non-hydrostatic support and heating of chromospheric features on the Sun: waves, shocks, reconnection....