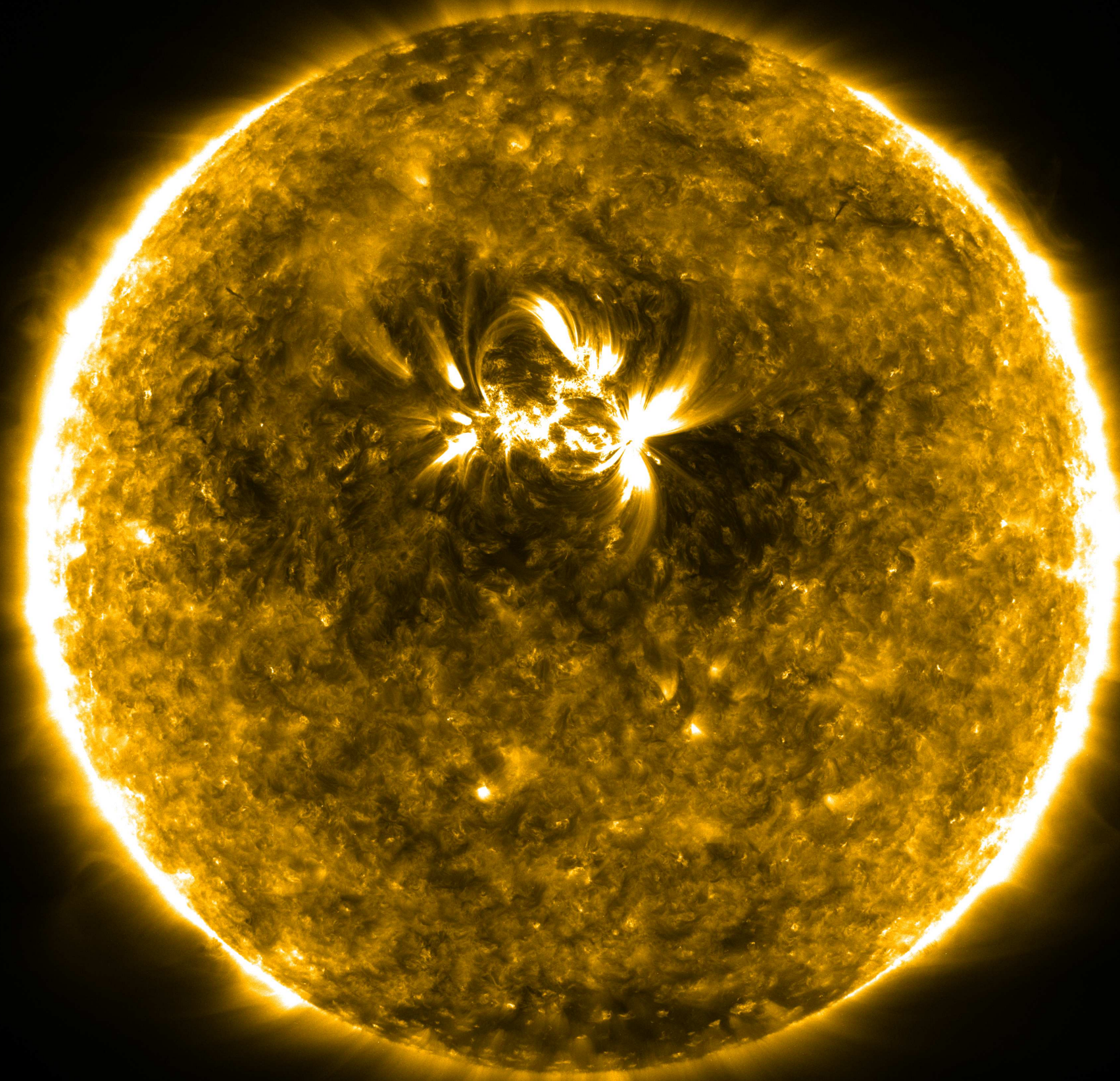


Dark Halos around solar Active Regions: emission properties of the Dark Halo around NOAA 12706



Serena Maria Lezzi

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University of Naples "Federico II" - Astronomical Observatory of Capodimonte, Naples

"Sun in Science and Society" Solarnet-S3, Venice Mestre - 11/09/2023



UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II



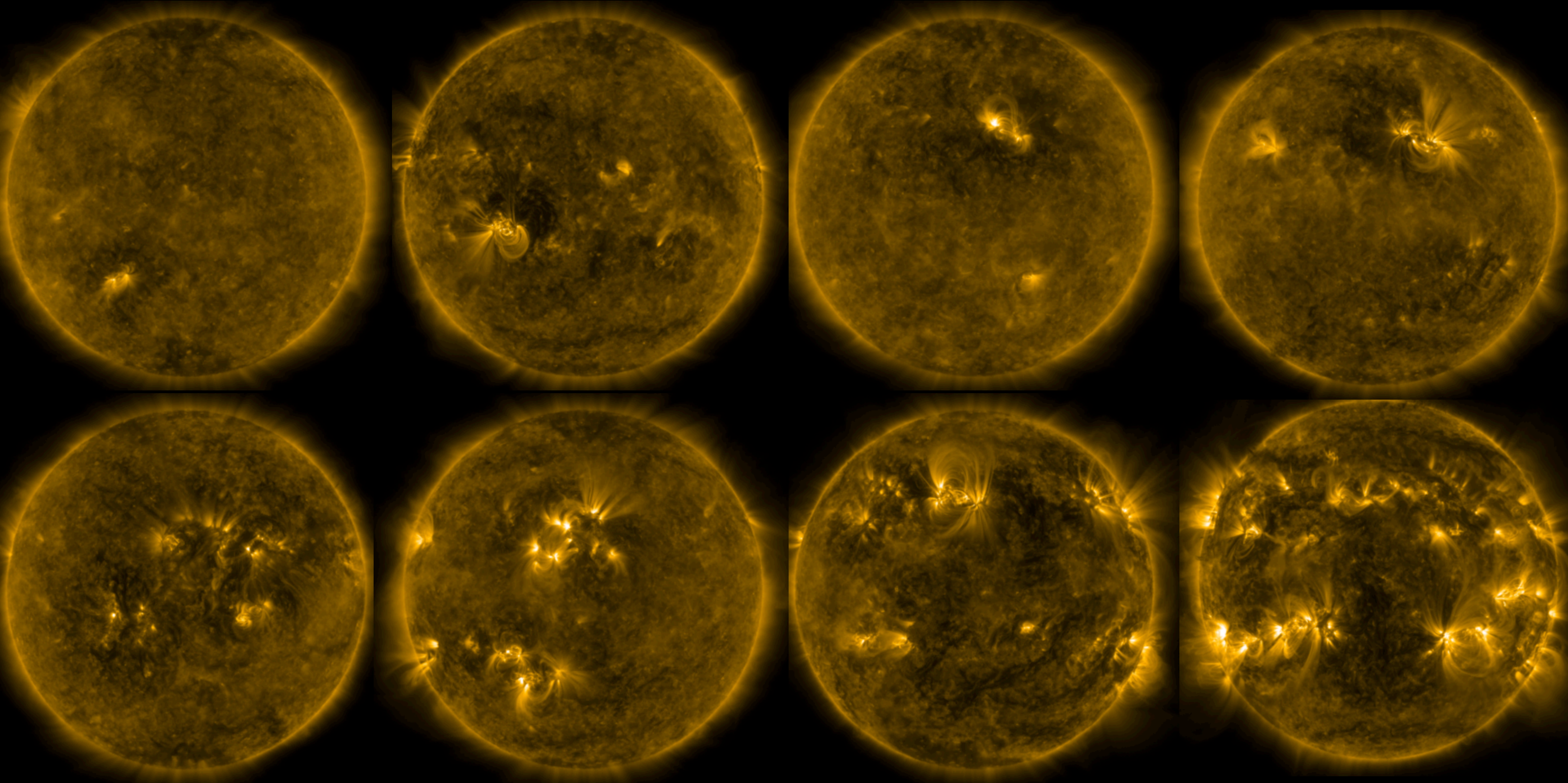
INAF
OBSERVATORIO ASTRONOMICCO
DI CAPODIMONTE



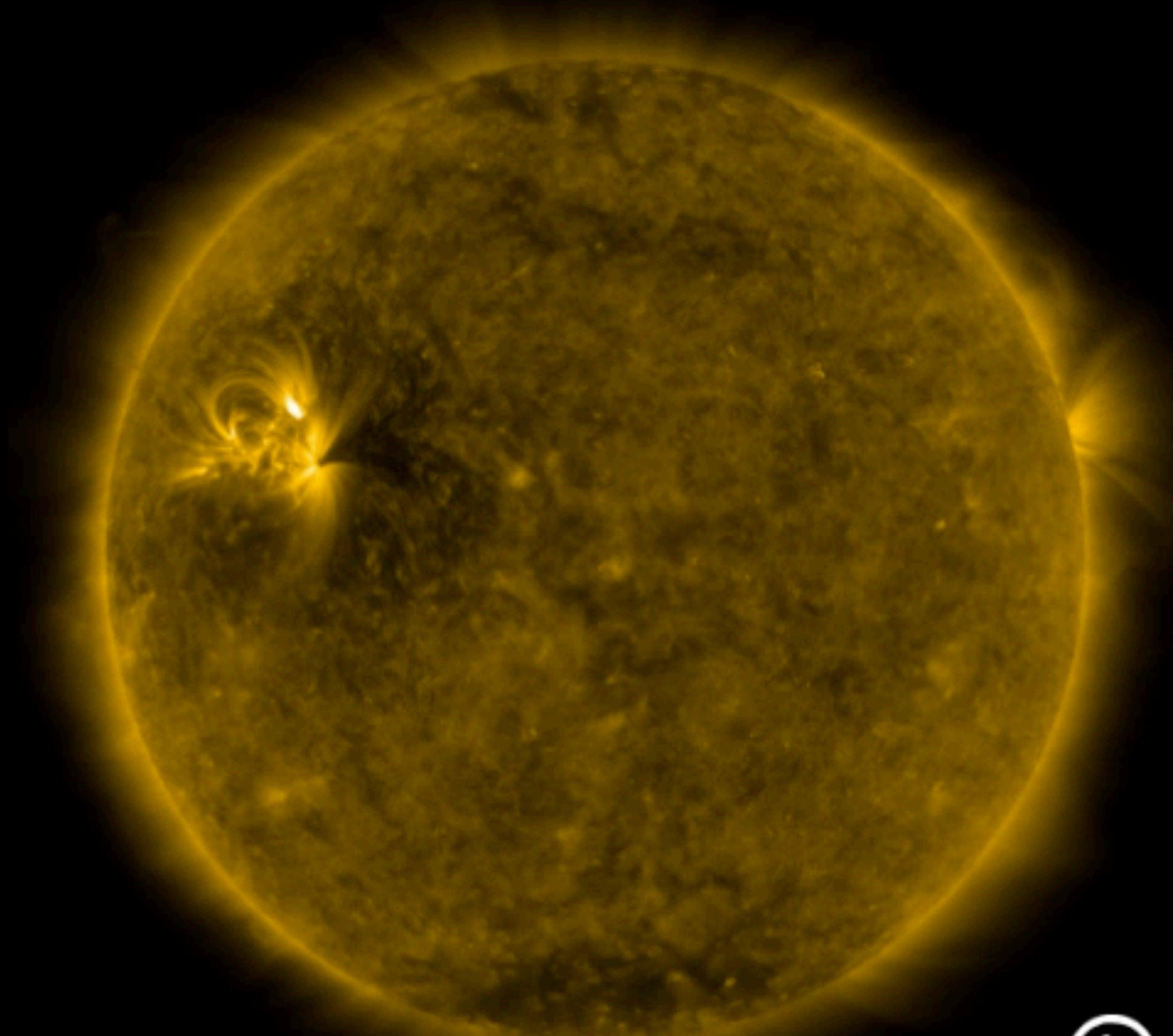
Agenzia Spaziale Italiana



Dark Halos are very common solar features



Dark Halos seem to have a slow temporal evolution



AIA 171

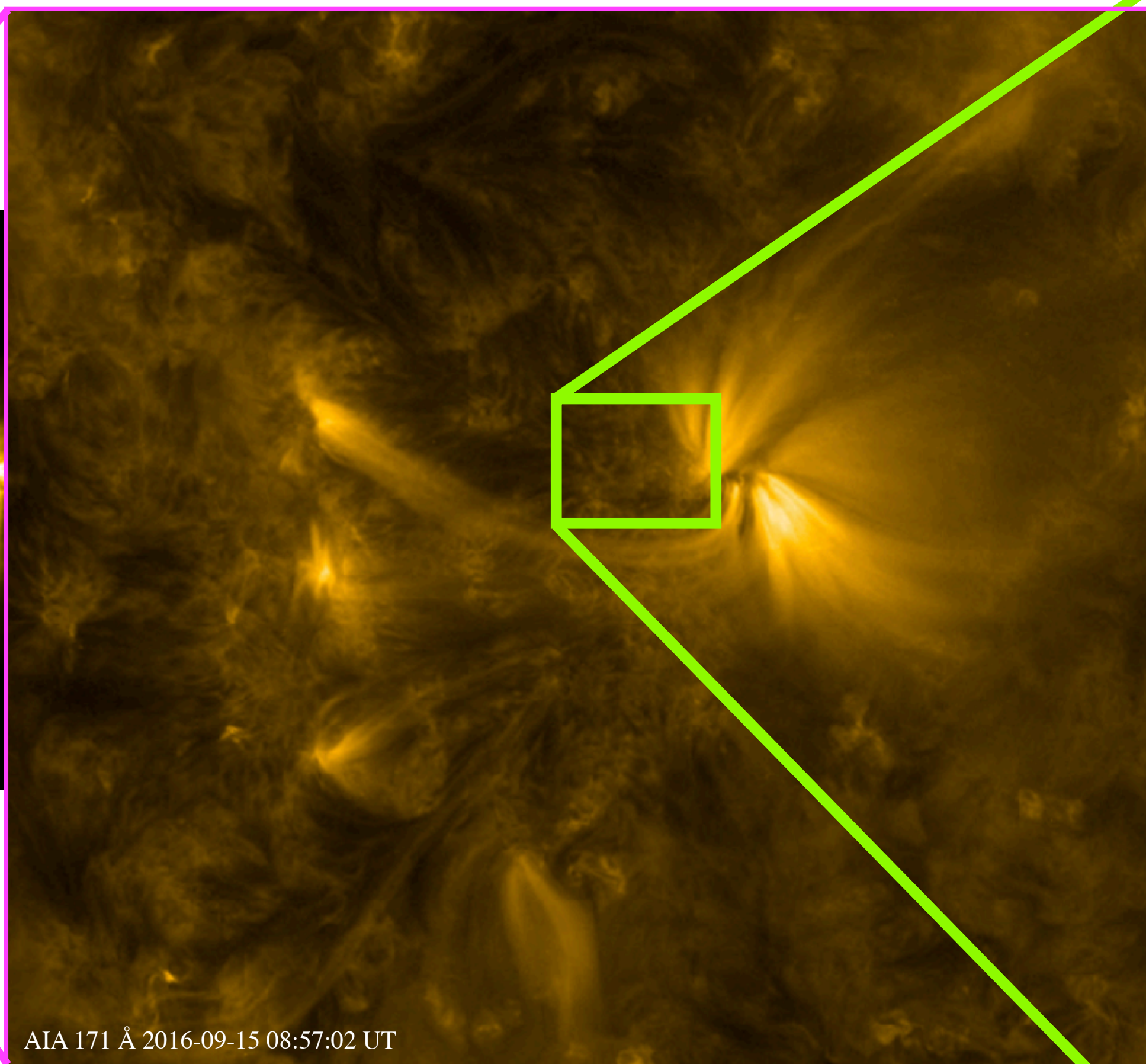
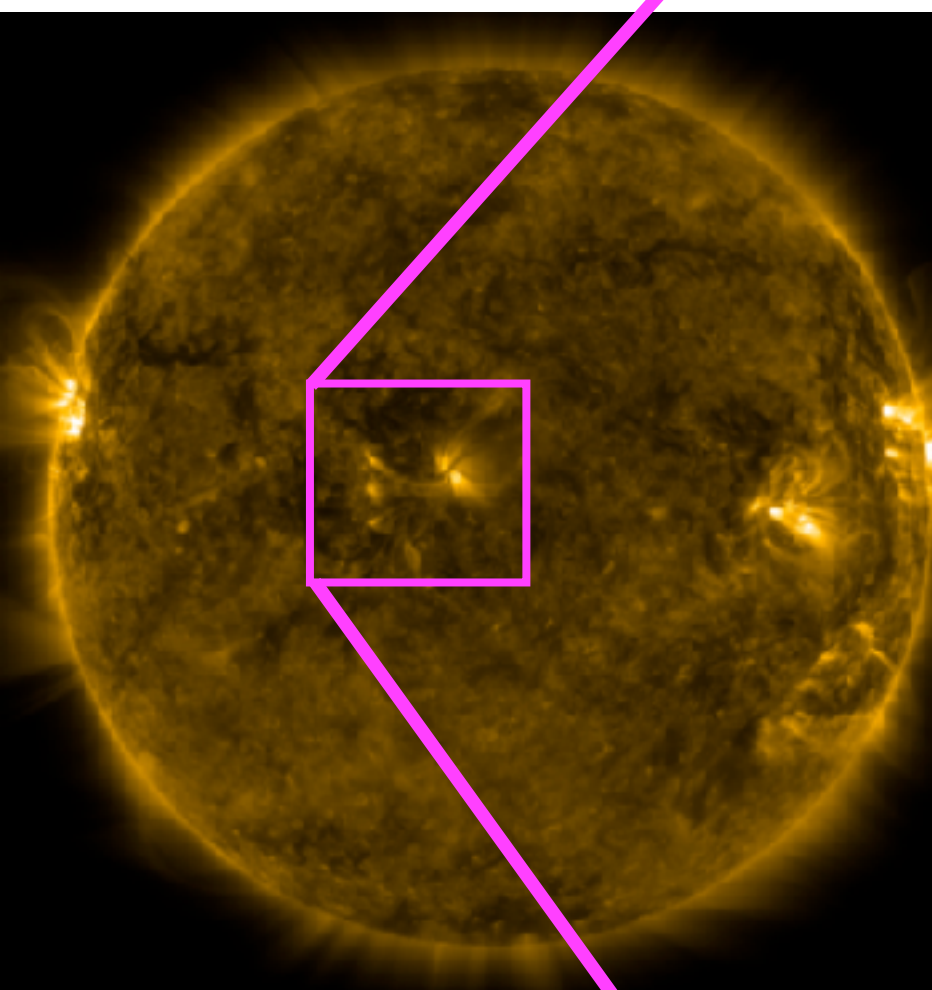
2019-04-10 21:10:45



A Dark Halo (DH) is a region of reduced emission in the neighborhood of an Active Region visible at many wavelengths

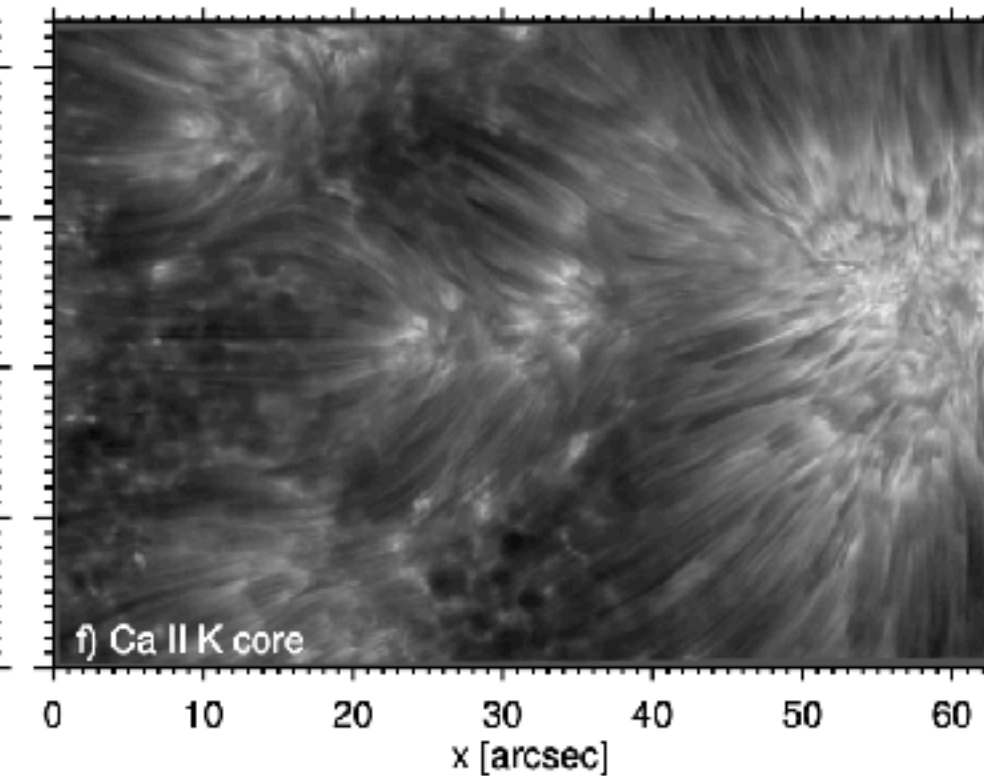
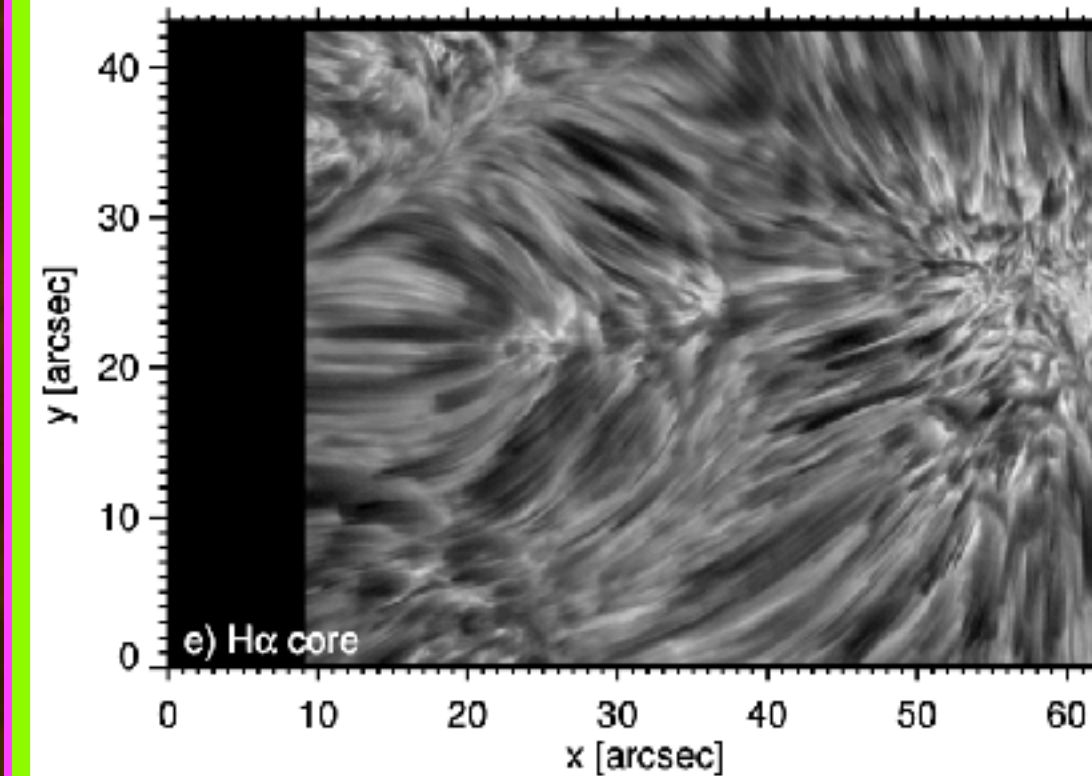
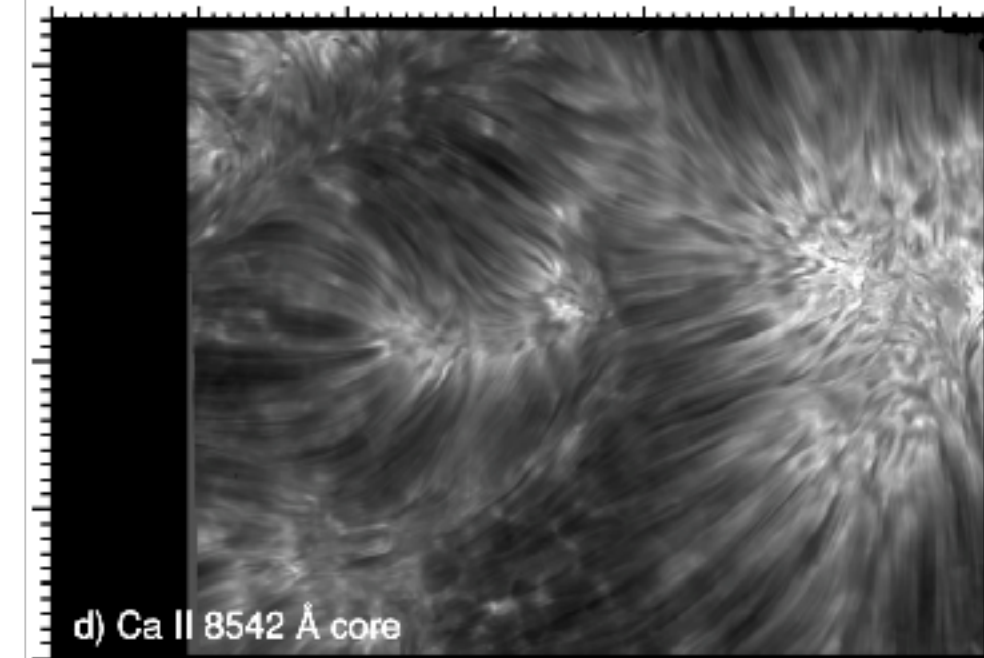
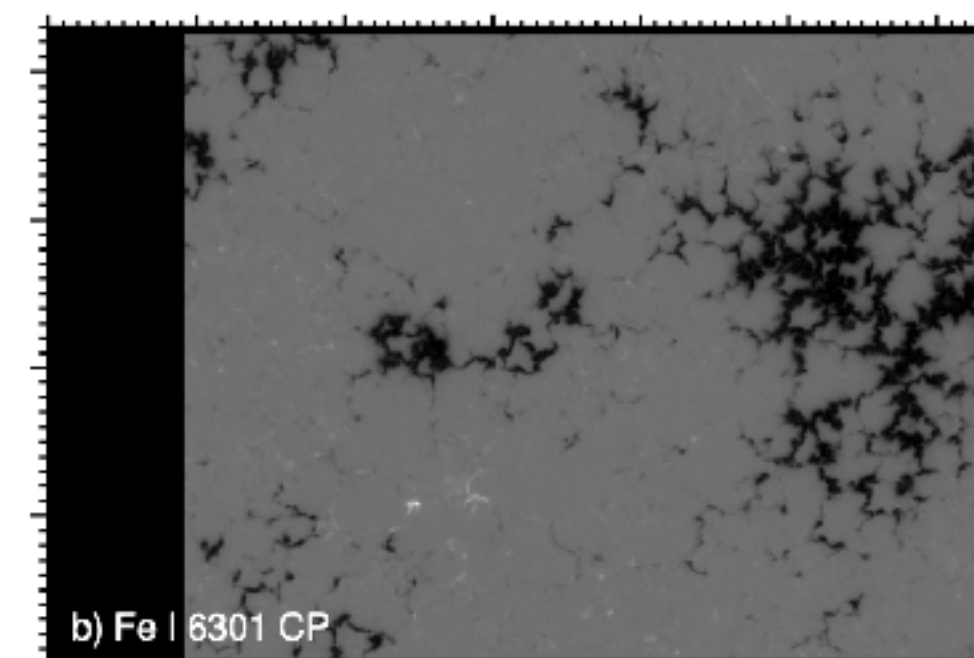
- *Circumfacules* (Deslanders 1930)
- *Dark Canopies* (Wang+ 2011)
- *Dark Halos* (Andretta+ 2014) (DHs)
- *Dark Moats* (Singh+ 2021)

Chromospheric fibrillar Dark Halo



AIA 171 Å 2016-09-15 08:57:02 UT

Chromospheric fibrils



Kianfar et al. 2020

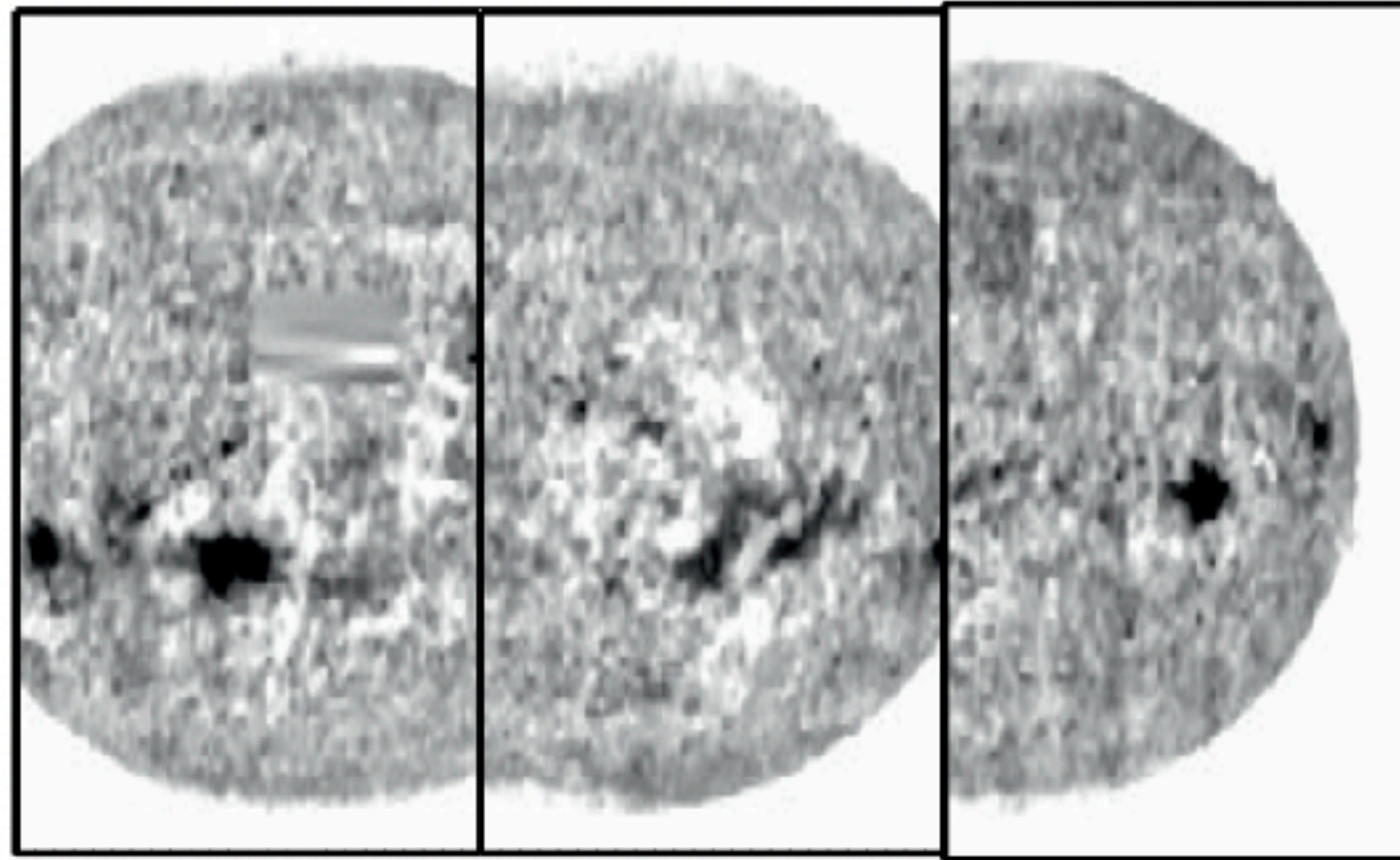
SOHO/CDS

01/Nov/04

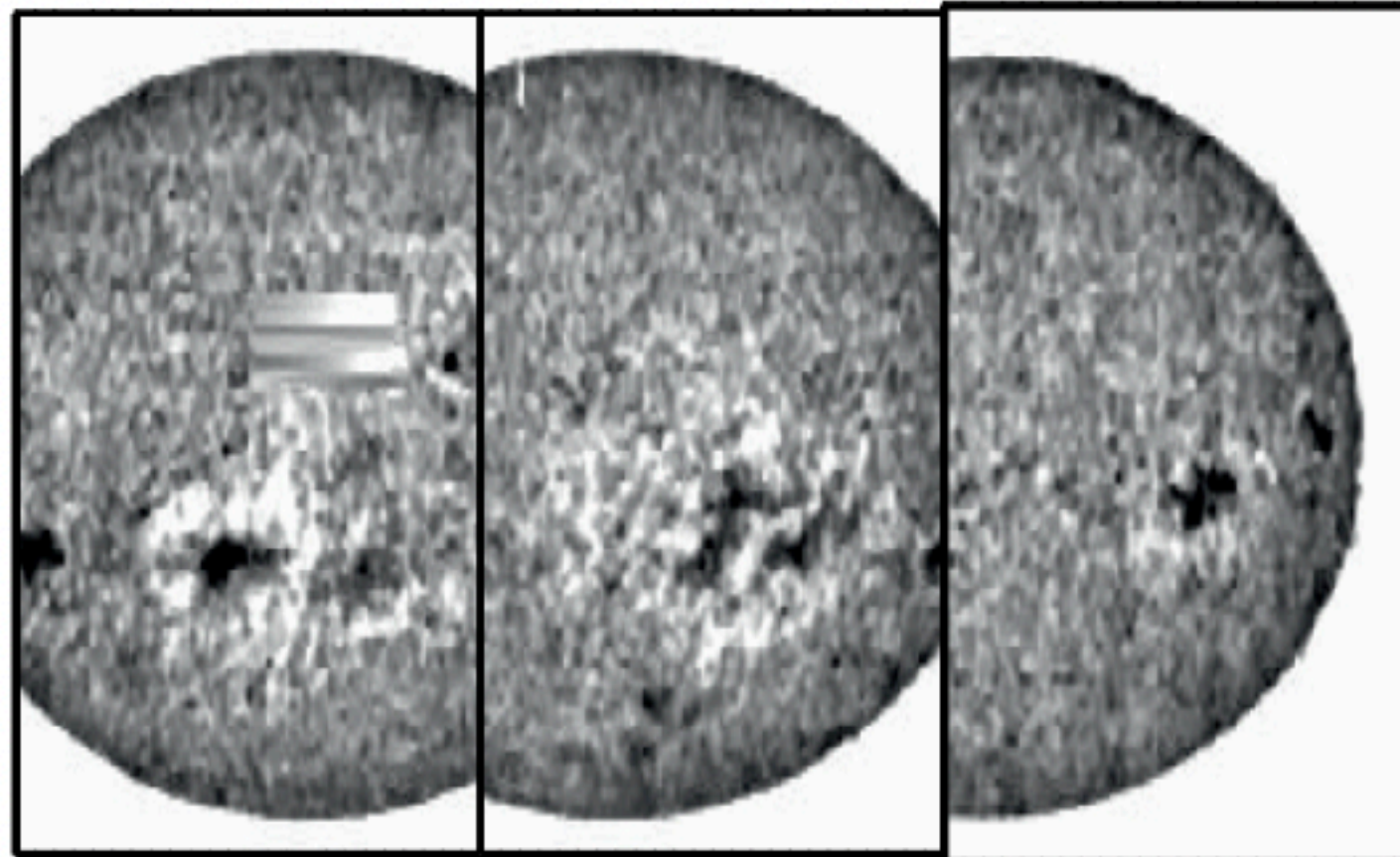
08/Nov/05

16/Jul/07

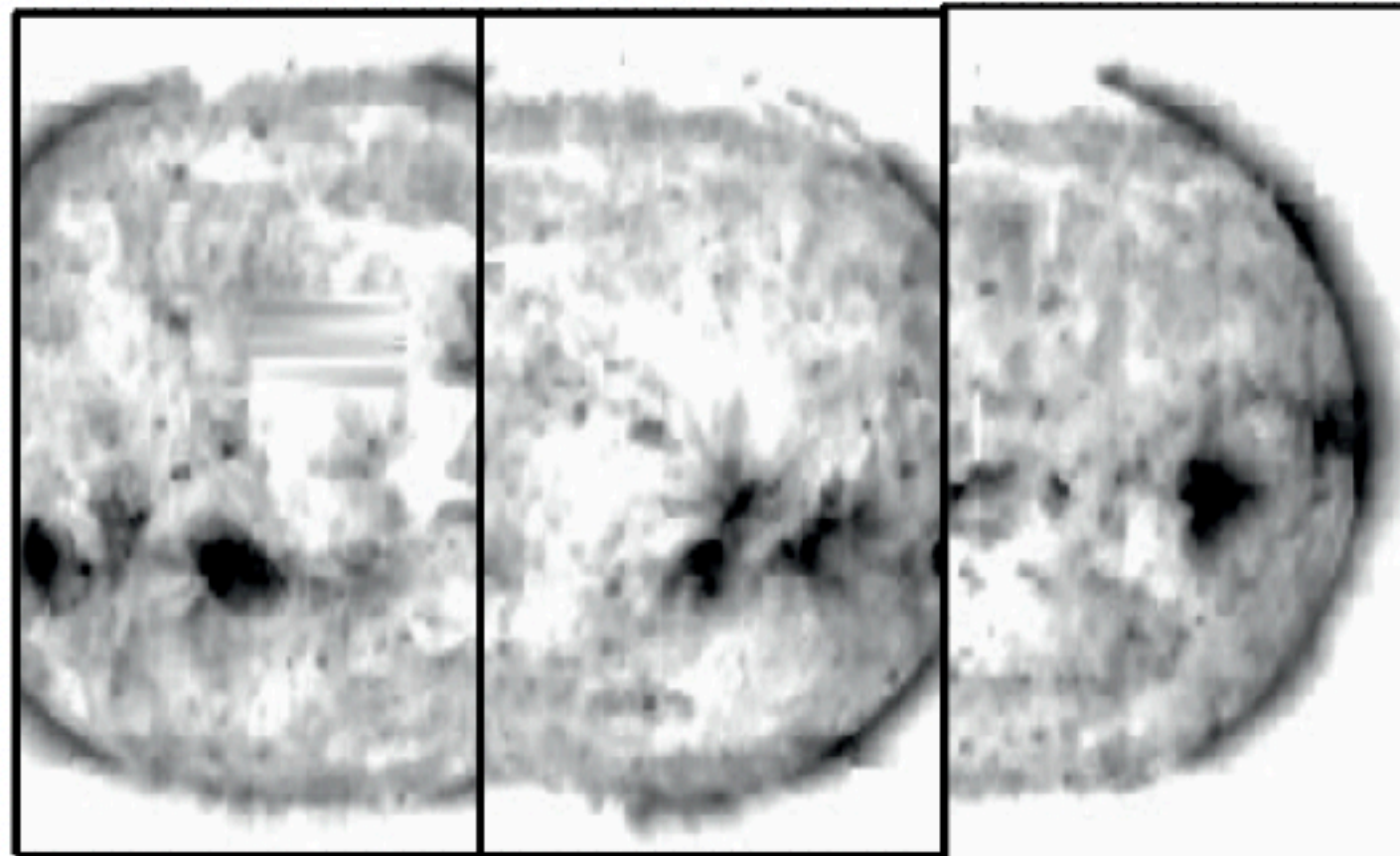
He II 303.8



O V 629.7



Mg X 624.9

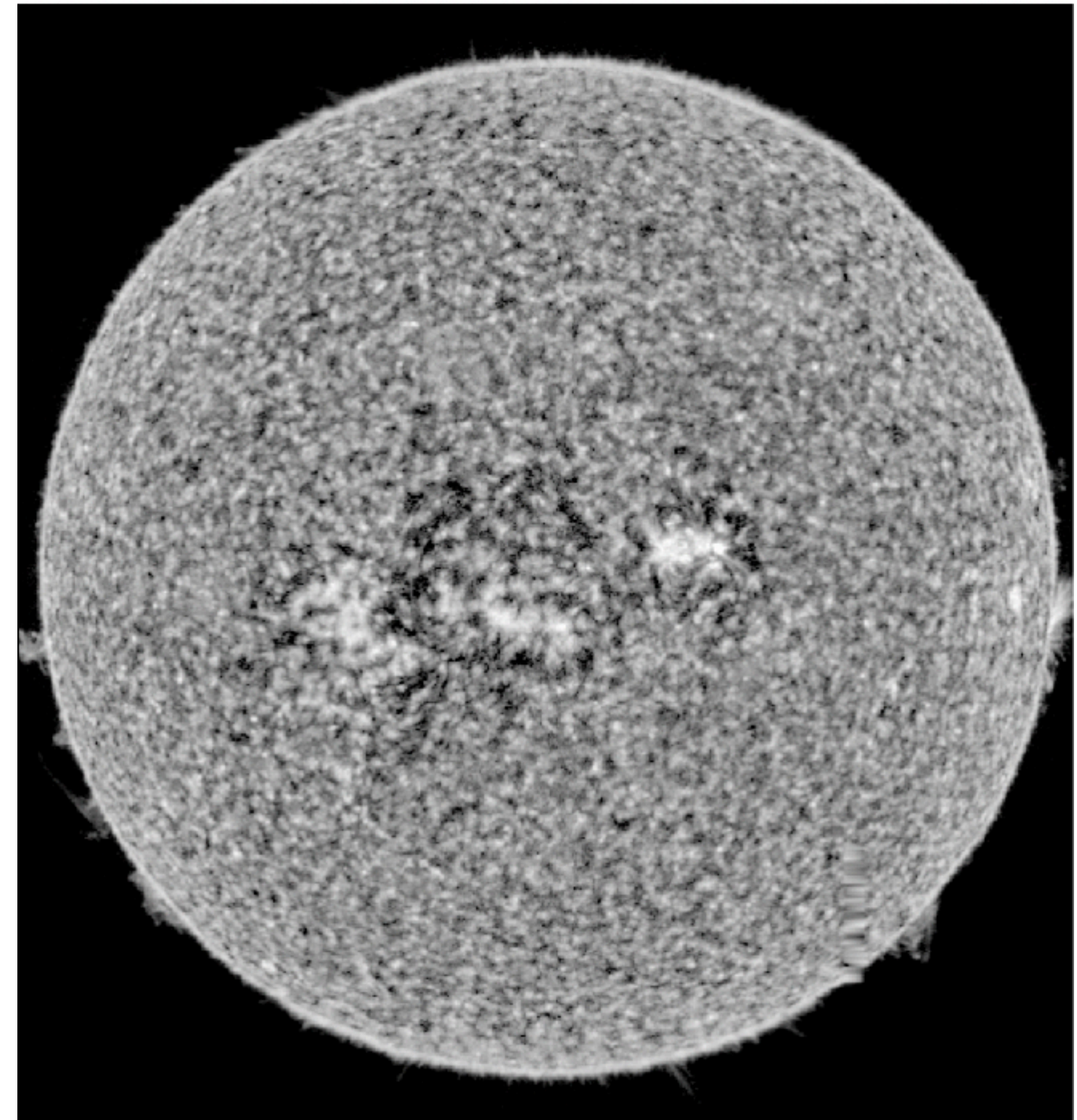


Andretta+ 2014

The upper Dark Halo

SOHO/SUMER

O V 629 Å

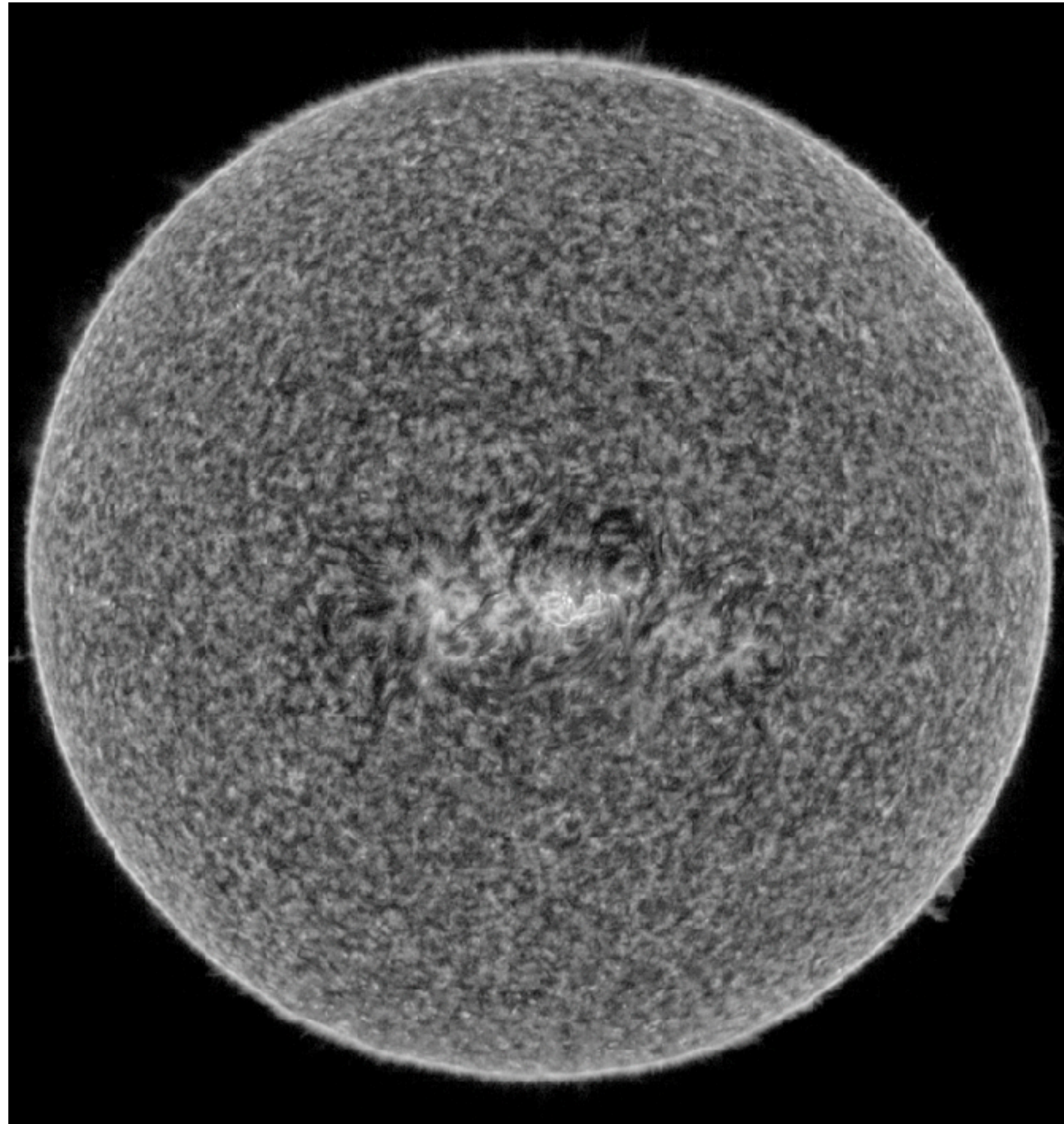


07 June 1996, 23:40—(08 June) 03:24 UTC, dt = 2 s

Absorption by neutral hydrogen cannot fully explain the DH

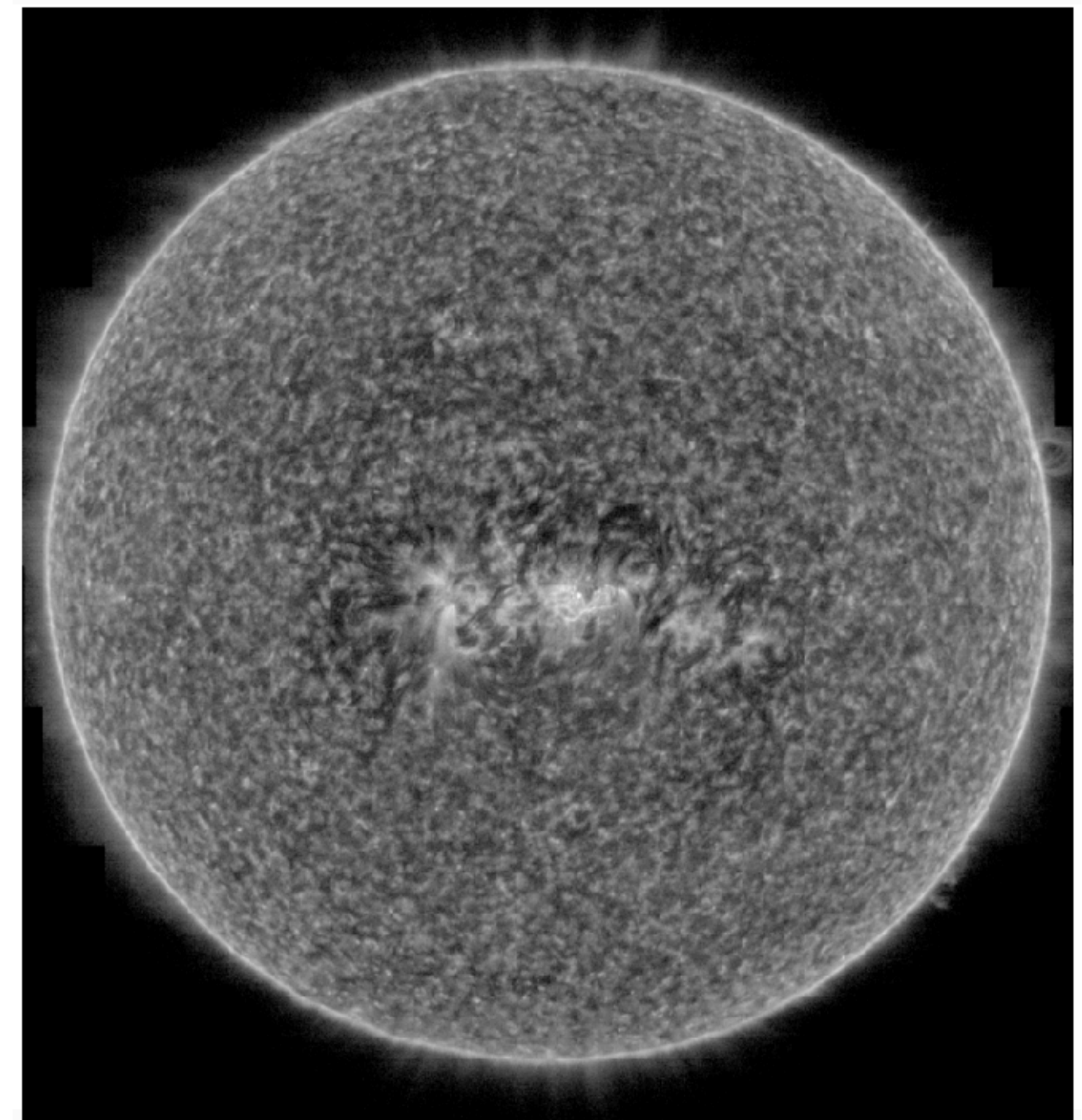
SOHO/SUMER

S VI 944 Å



12 May 1996, 23:02 - (13 May) 07:33 UTC, dt = 3 s

S VI 933 Å



12 May 1996, 23:02 - (13 May) 07:33 UTC, dt = 3 s

Above the edge of the Lyman continuum at 912 Å

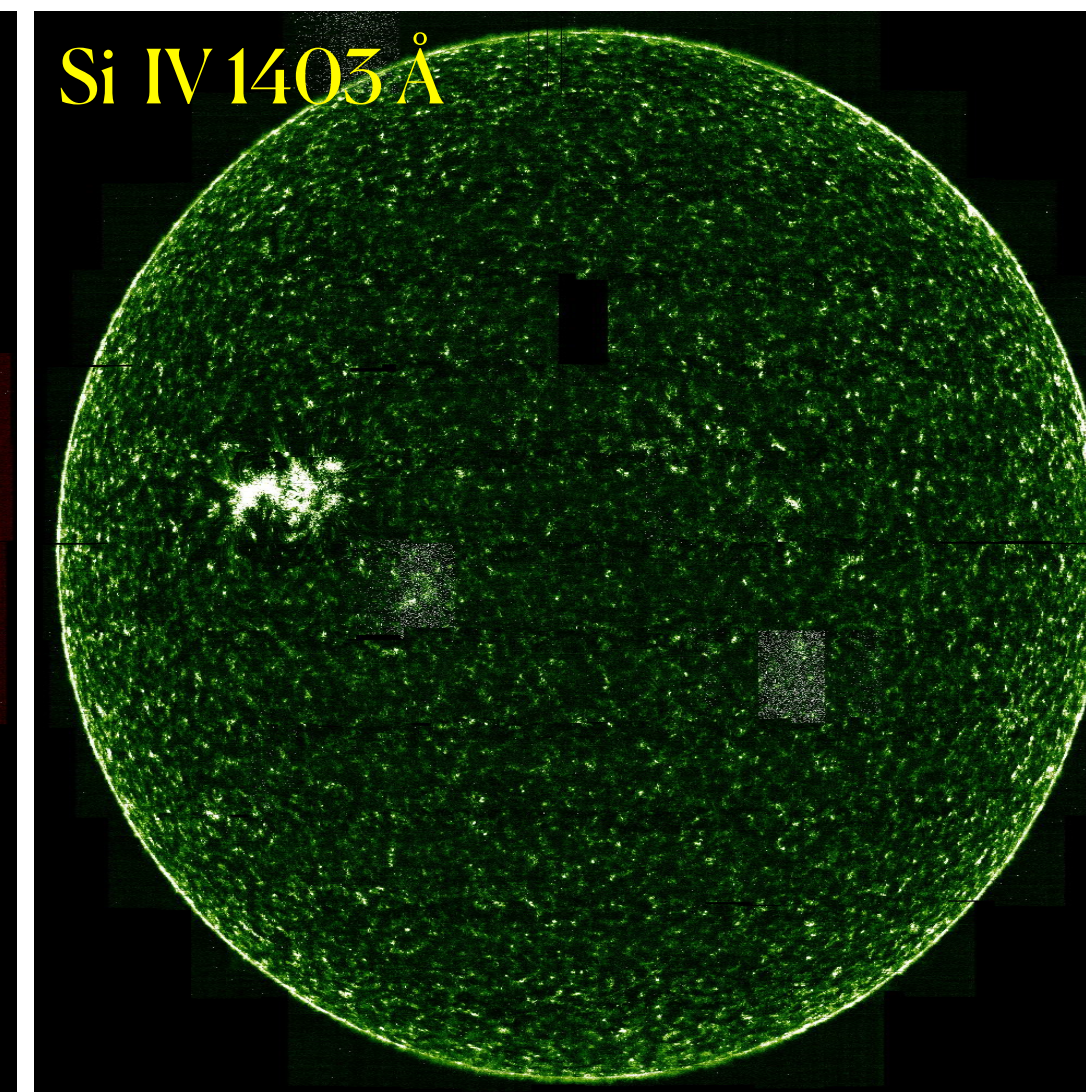
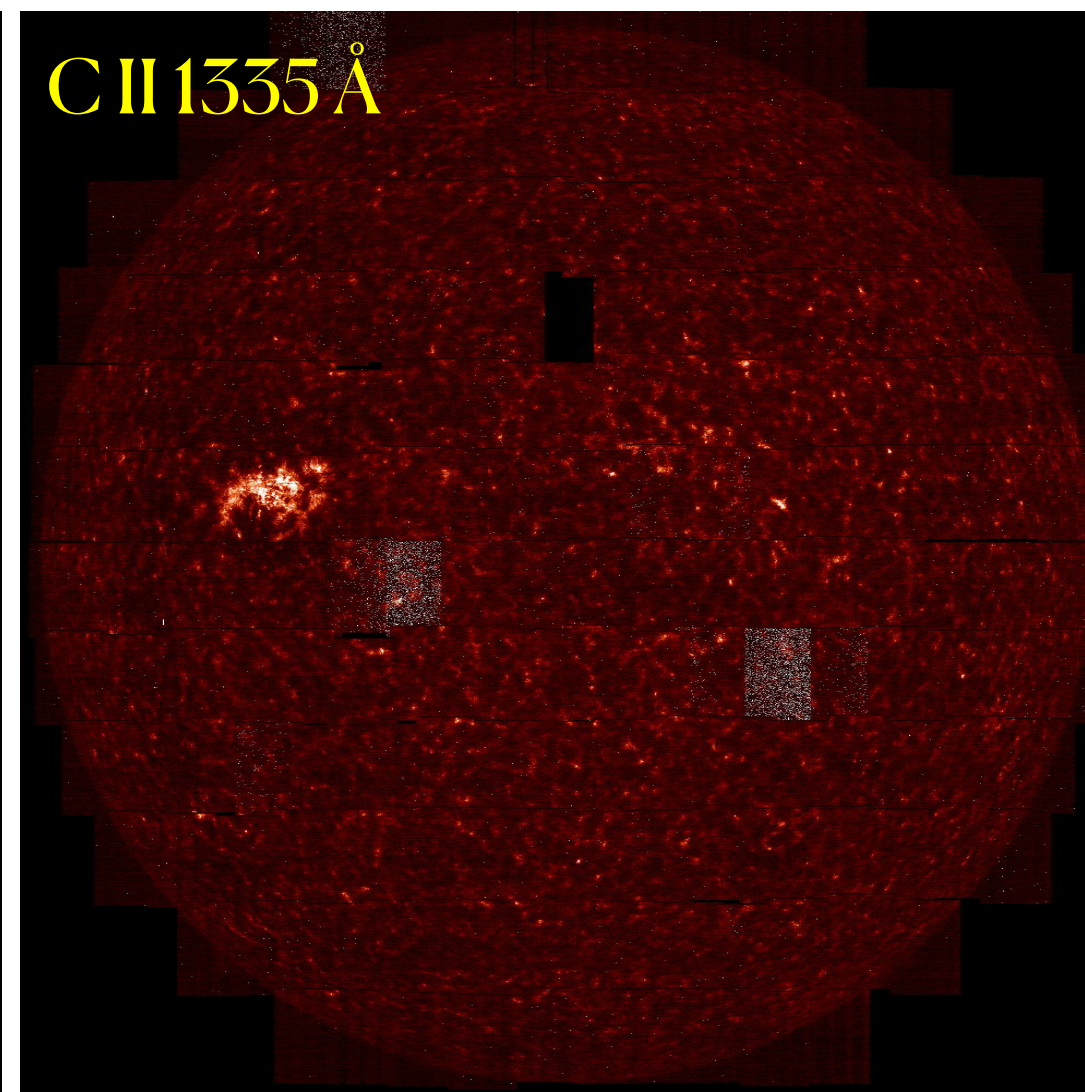
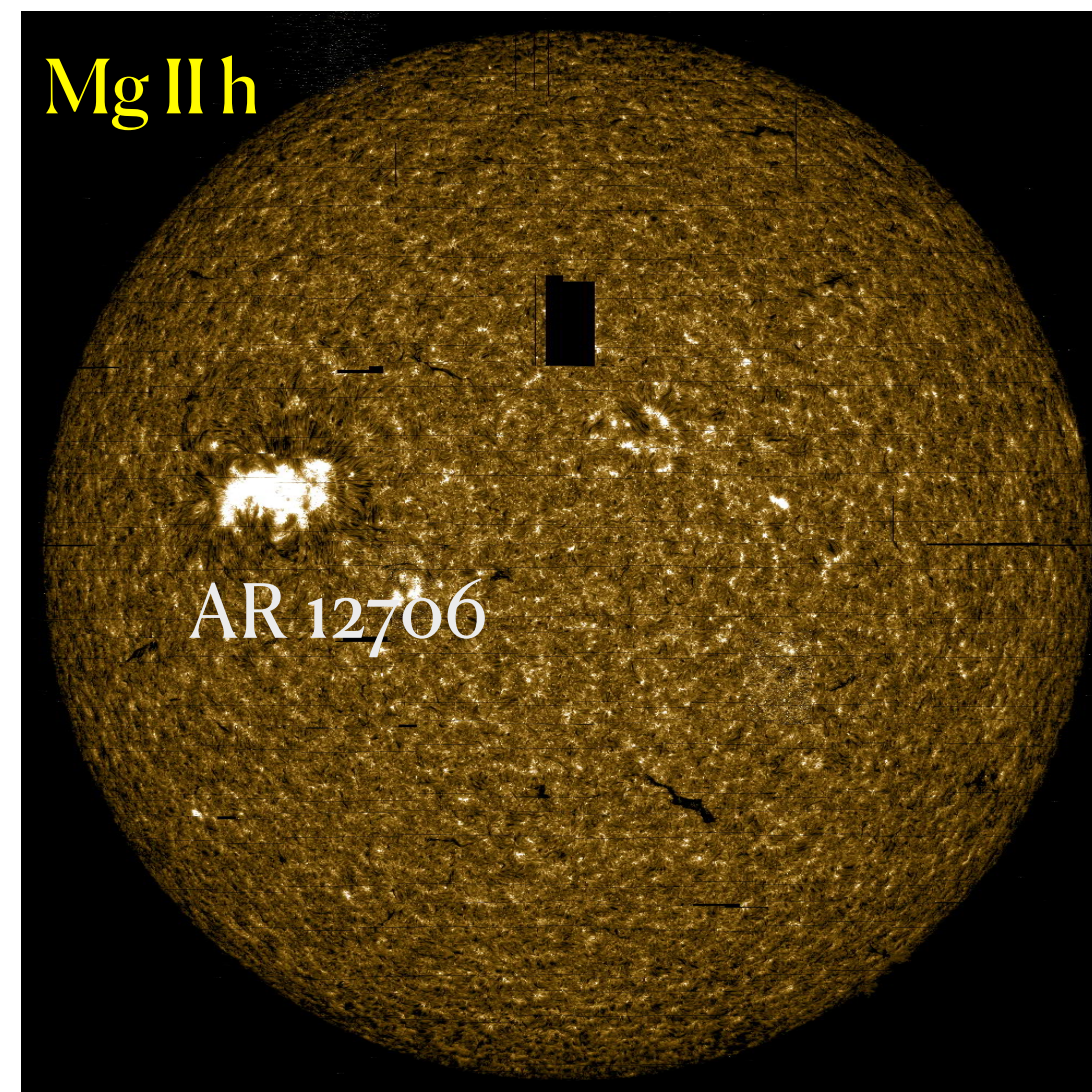
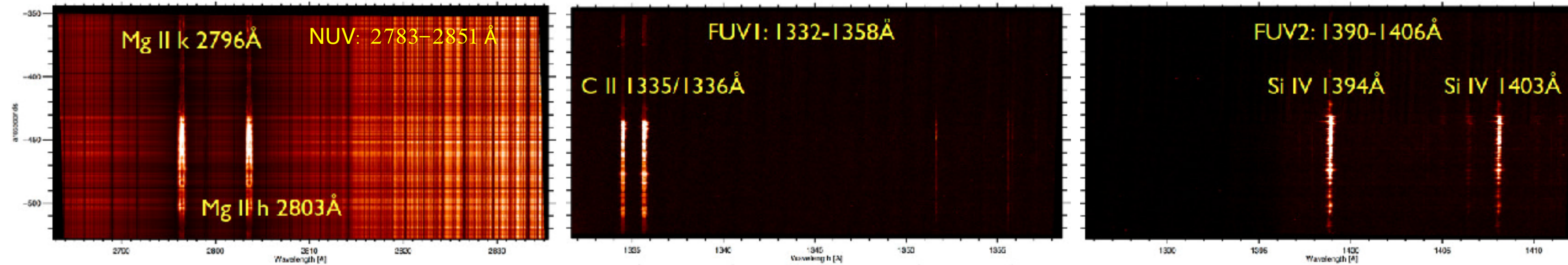
Aim

characterization of the emission properties of a DH by evaluating its average intensity in a wide range of wavelengths, from chromosphere to corona

Observations

- **IRIS full-disk mosaics**

- Obs time ~ 19h (2018-04-22 from 10:42 to 04:06 UT)
- Raster on AR 12706 lasts ~ 4h
- Relatively low exposure time (2s)



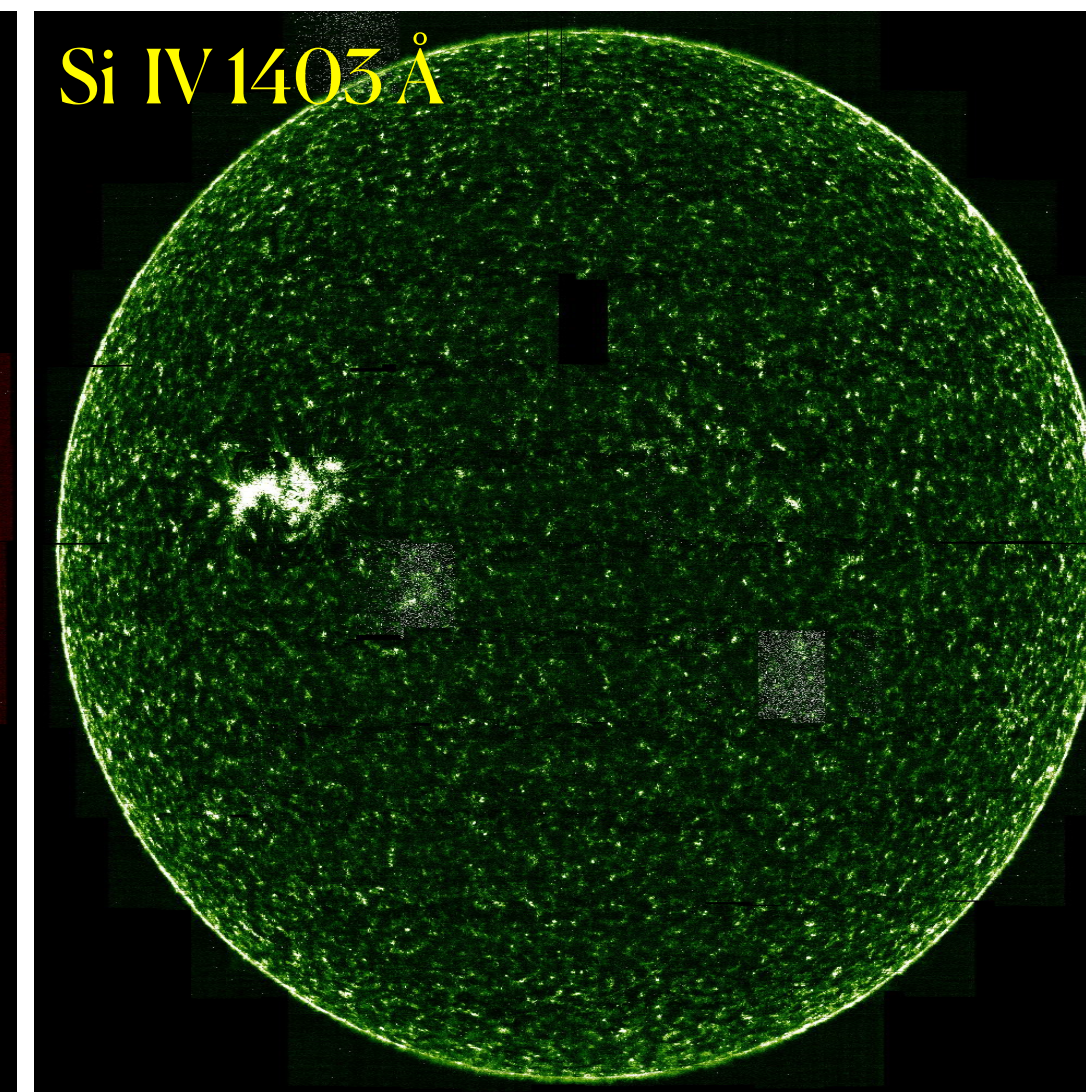
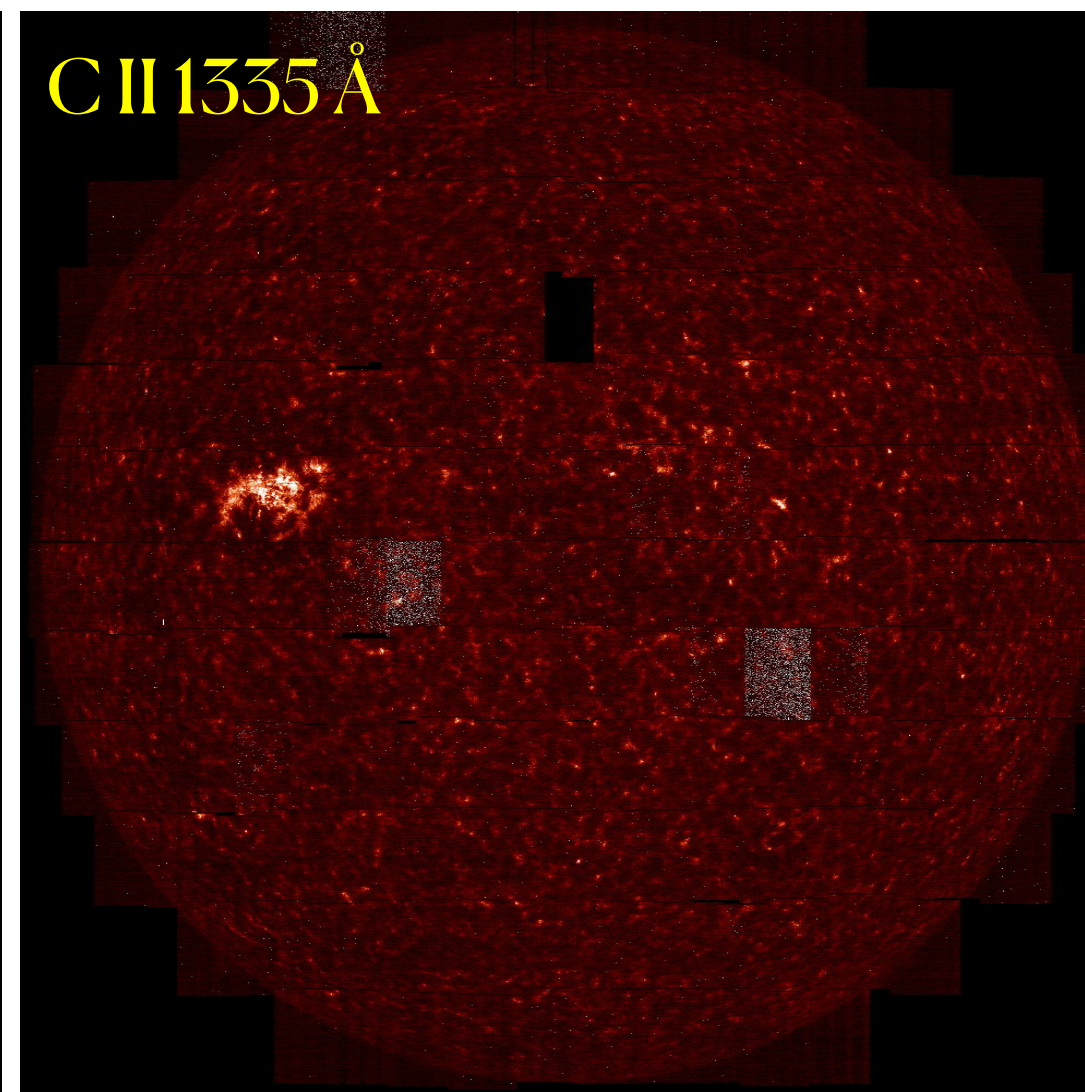
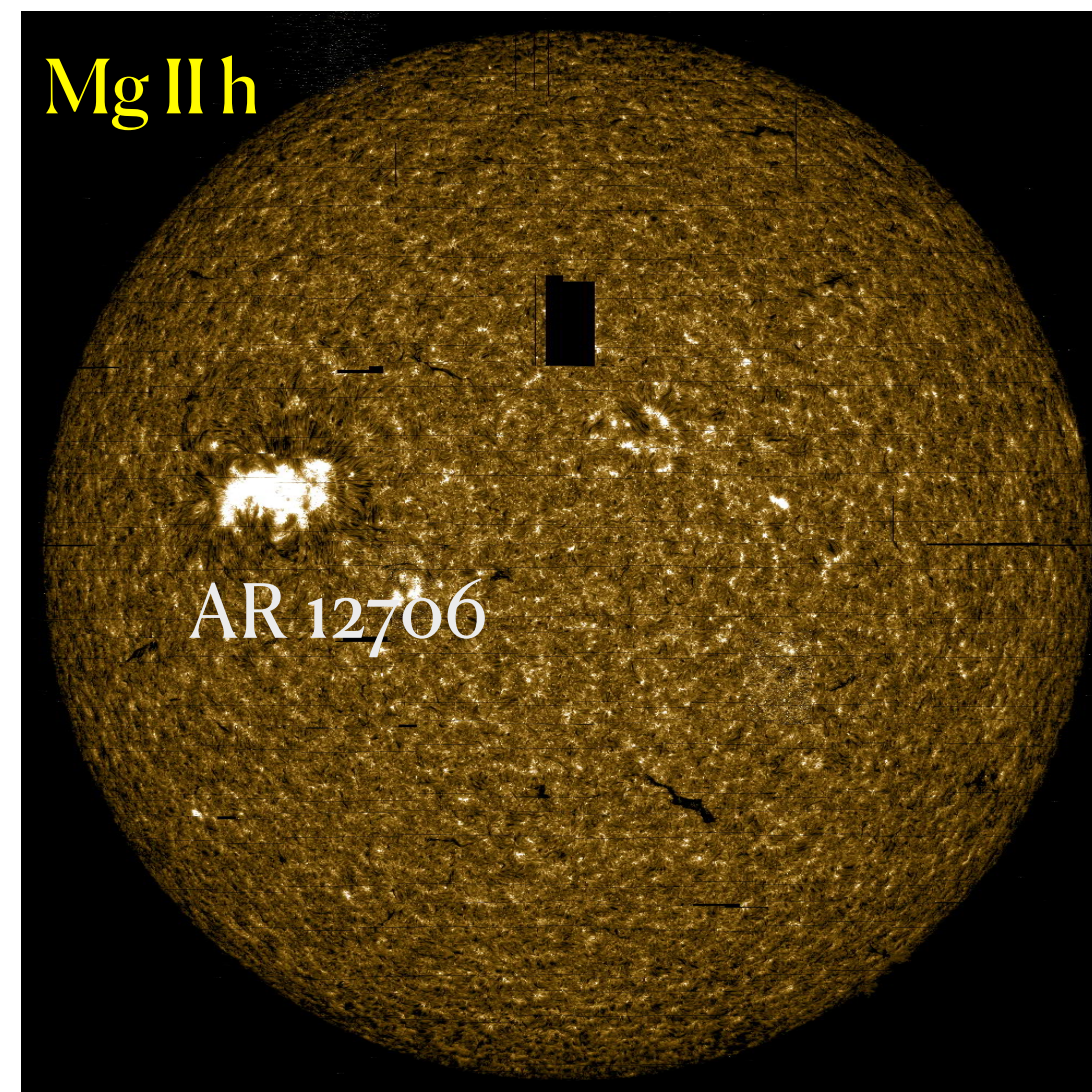
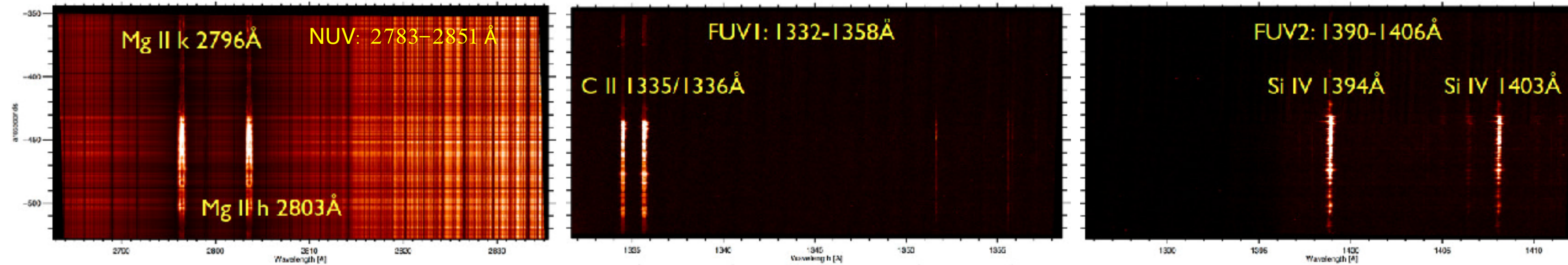
- **AIA images**

- 2018-04-22 19:24 UT, within the 4h interval taken by IRIS to cover AR 12706

Observations

- **IRIS full-disk mosaics**

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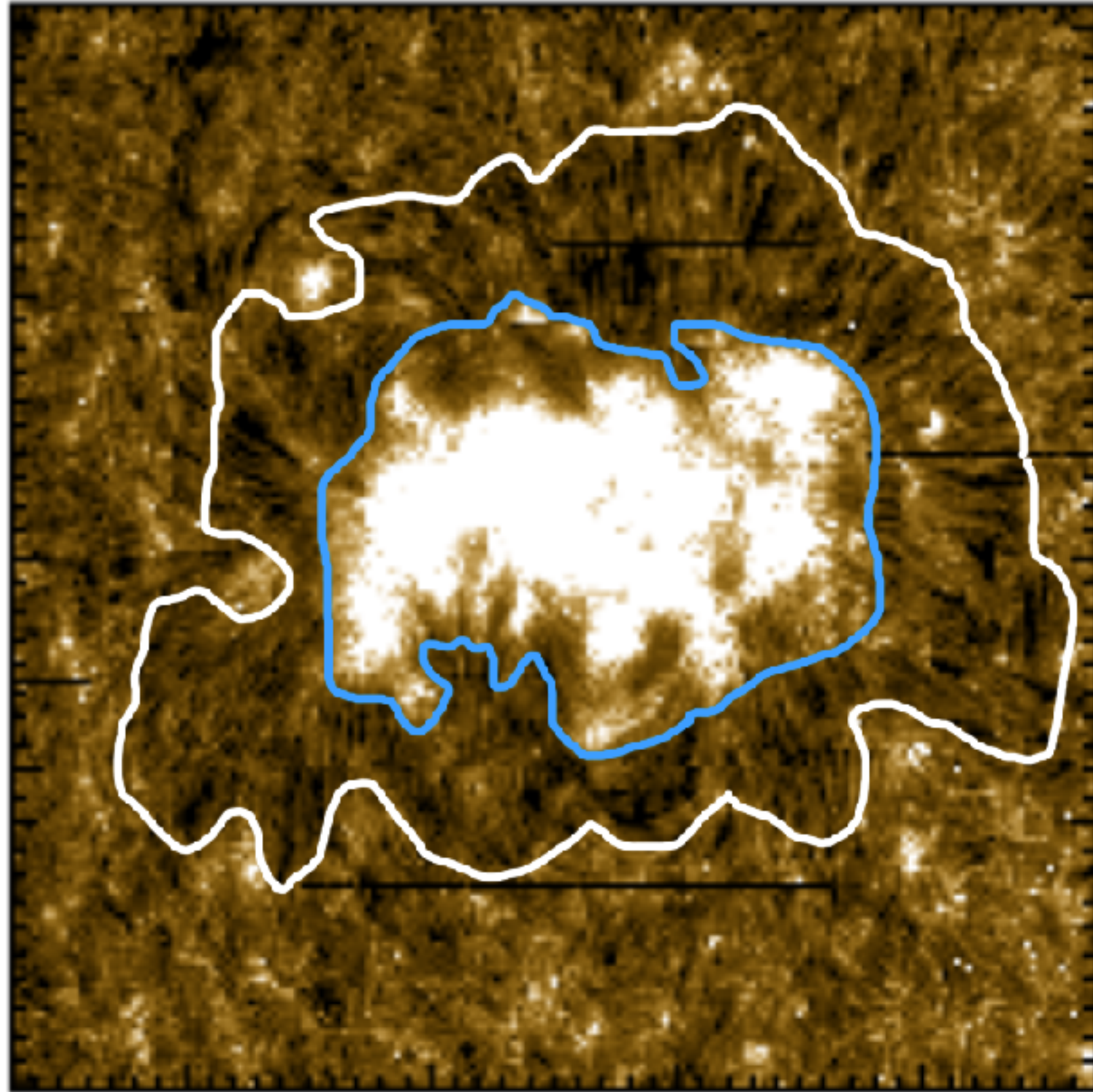


- **AIA images**

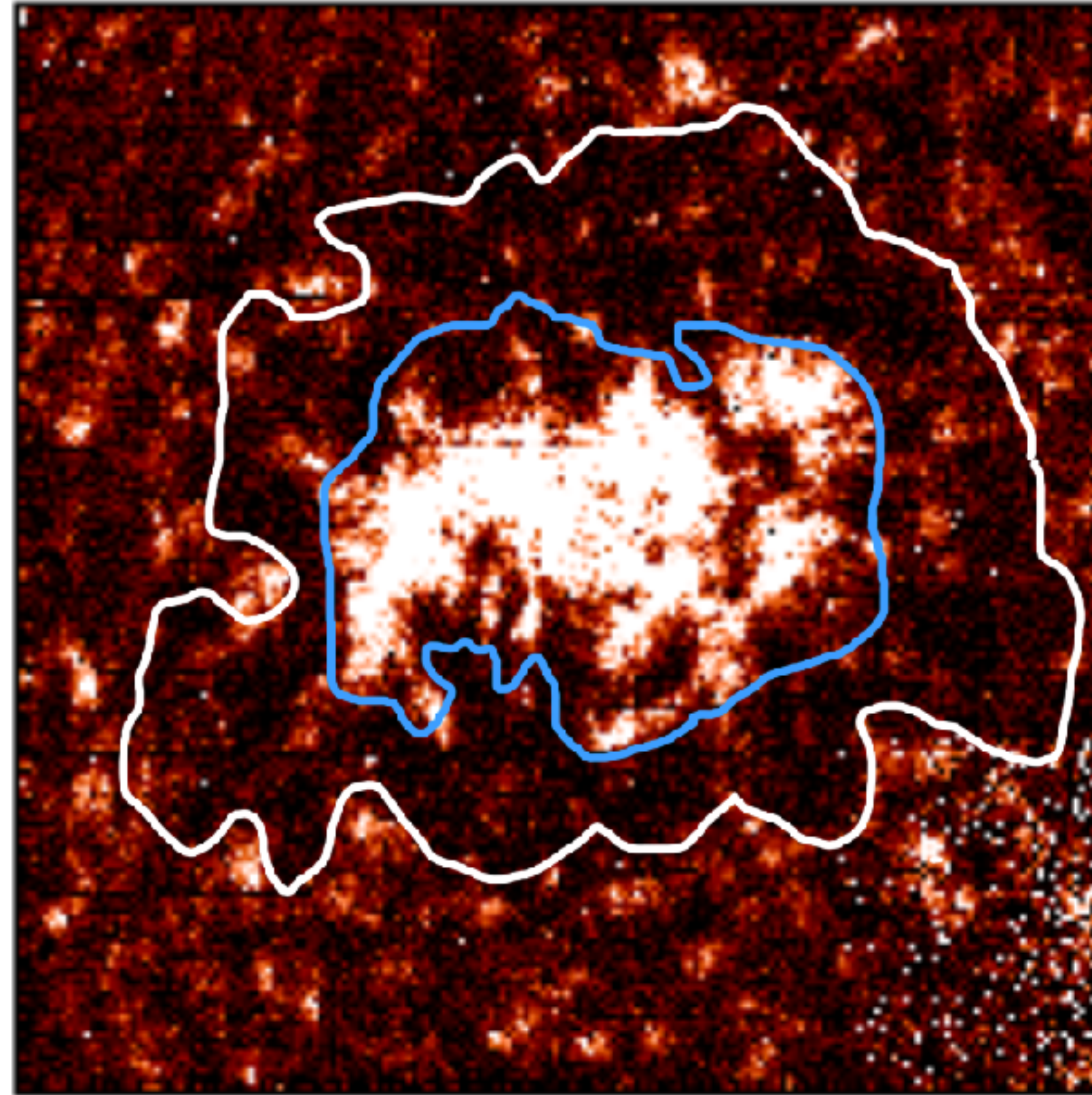
- 2018-04-22 19:24 UT, within the 4h interval taken by IRIS to cover AR 12706

IRIS chromospheric fibrillar DH

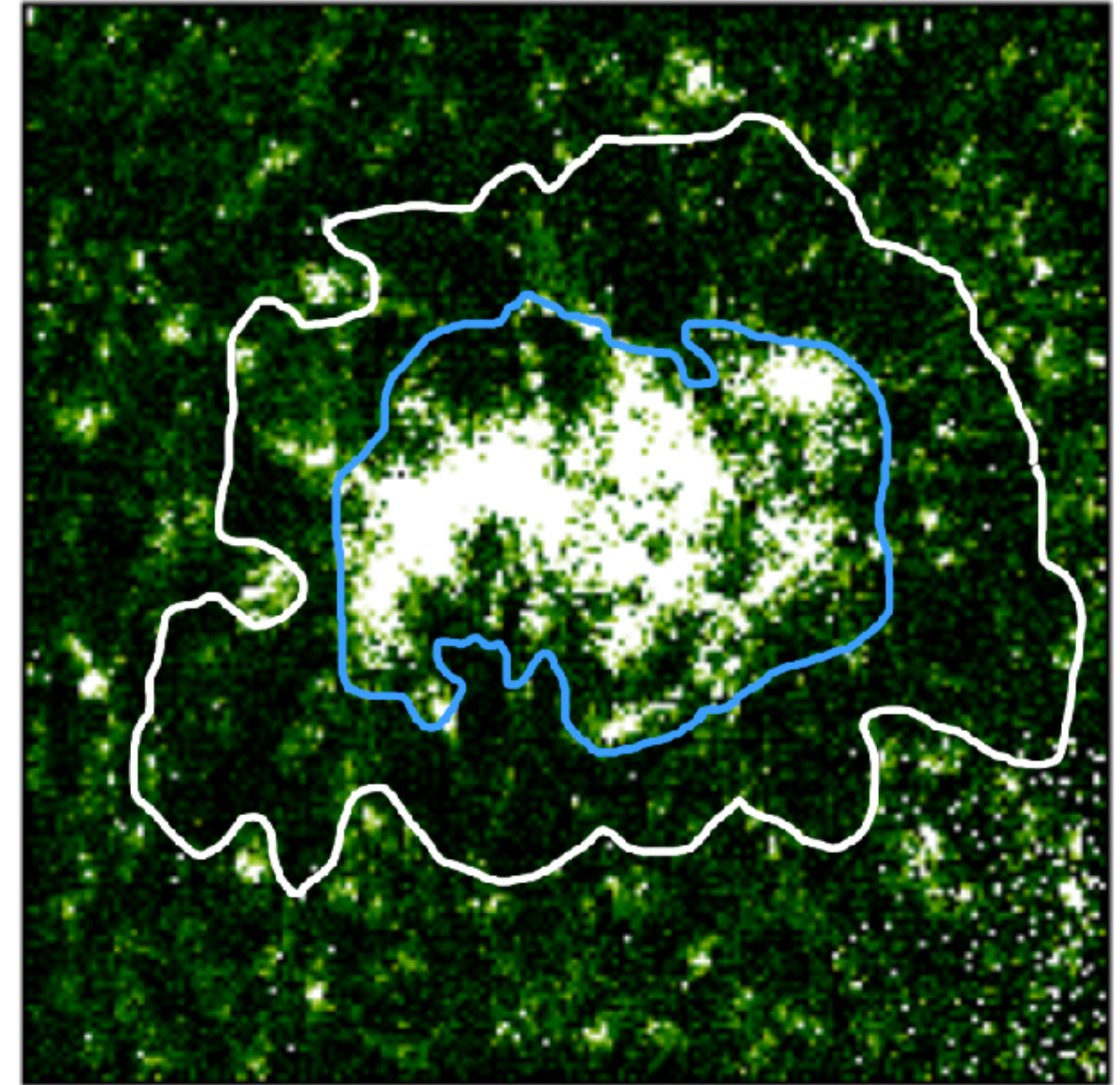
Mg II h core



C II 1335 Å



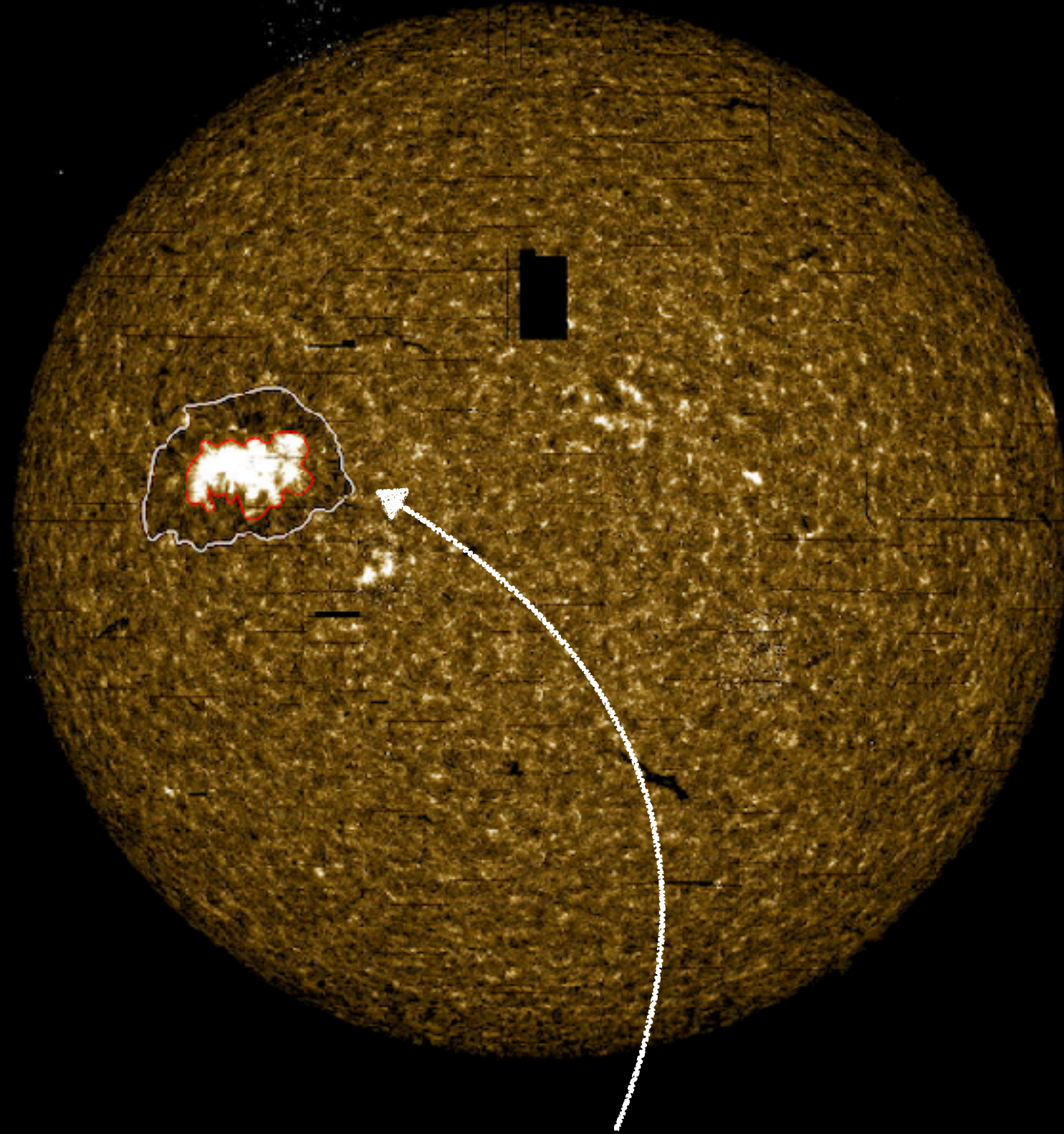
Si IV 1393 Å



ROIs definition

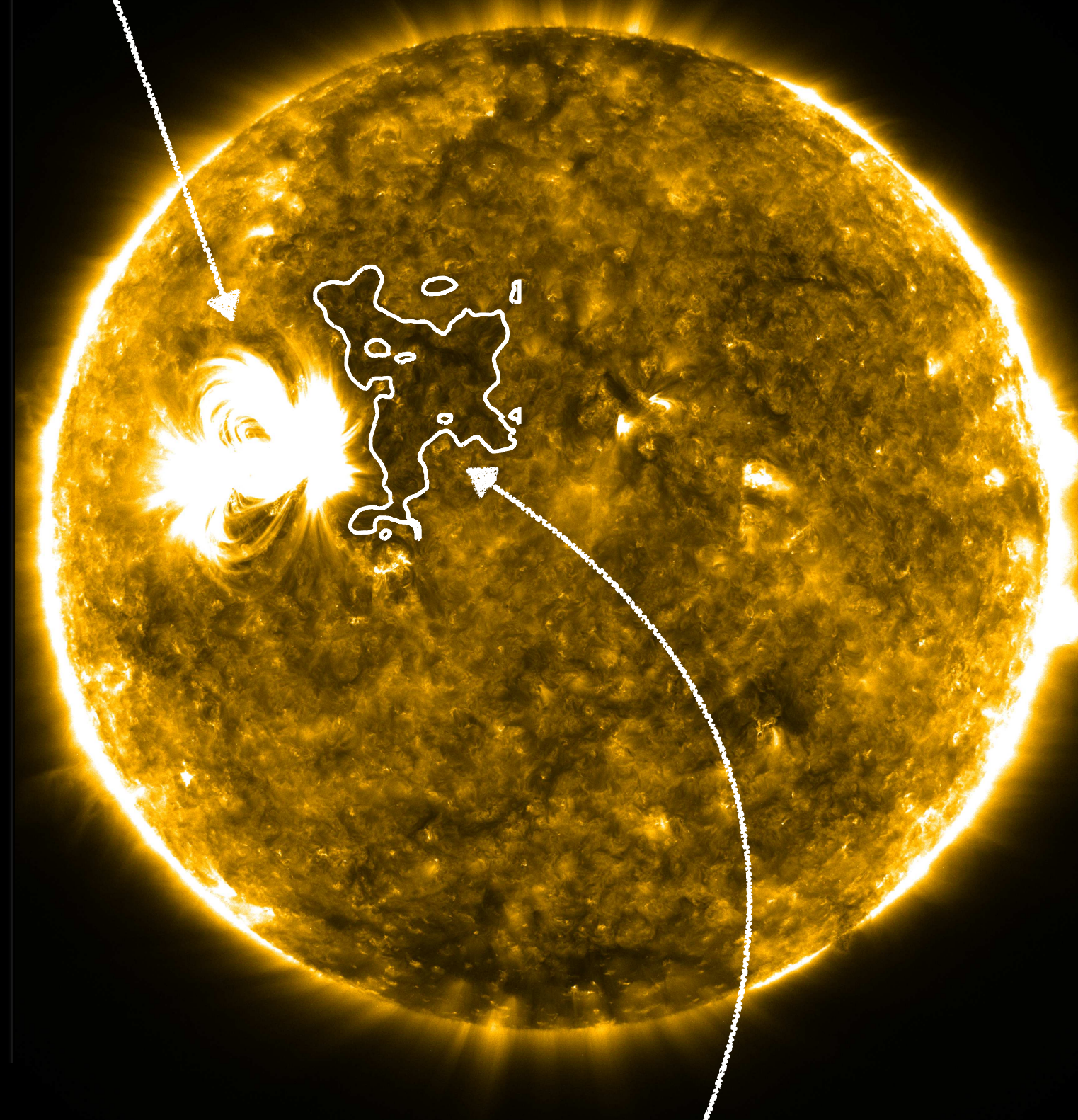
DH hidden below bright coronal loops

IRIS Mg II



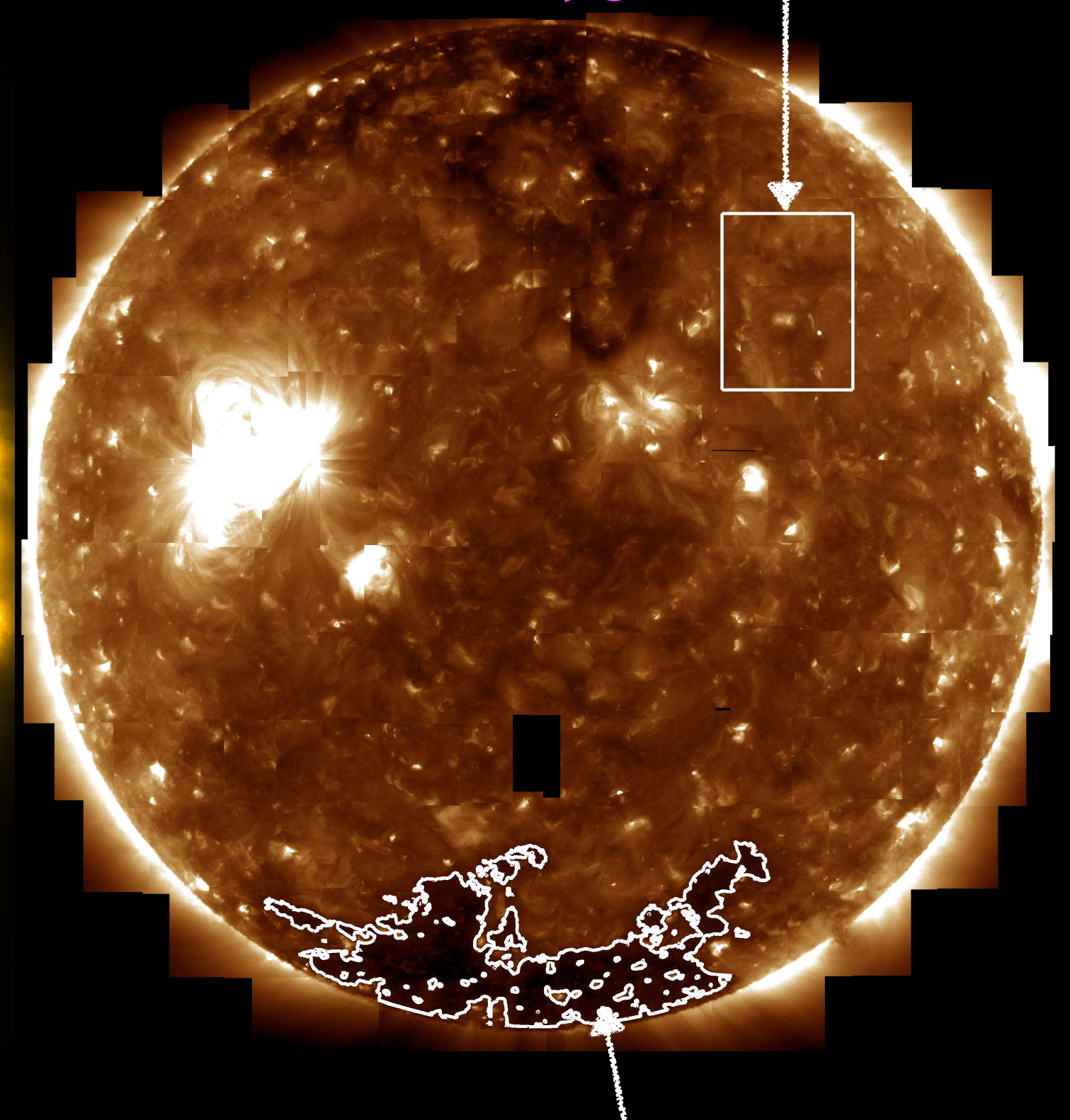
Chromospheric Fibrillar DH
Manually selected outer and inner edges

AIA 171 Å



Coronal DH
Contour through intensity threshold

AIA 193 Å

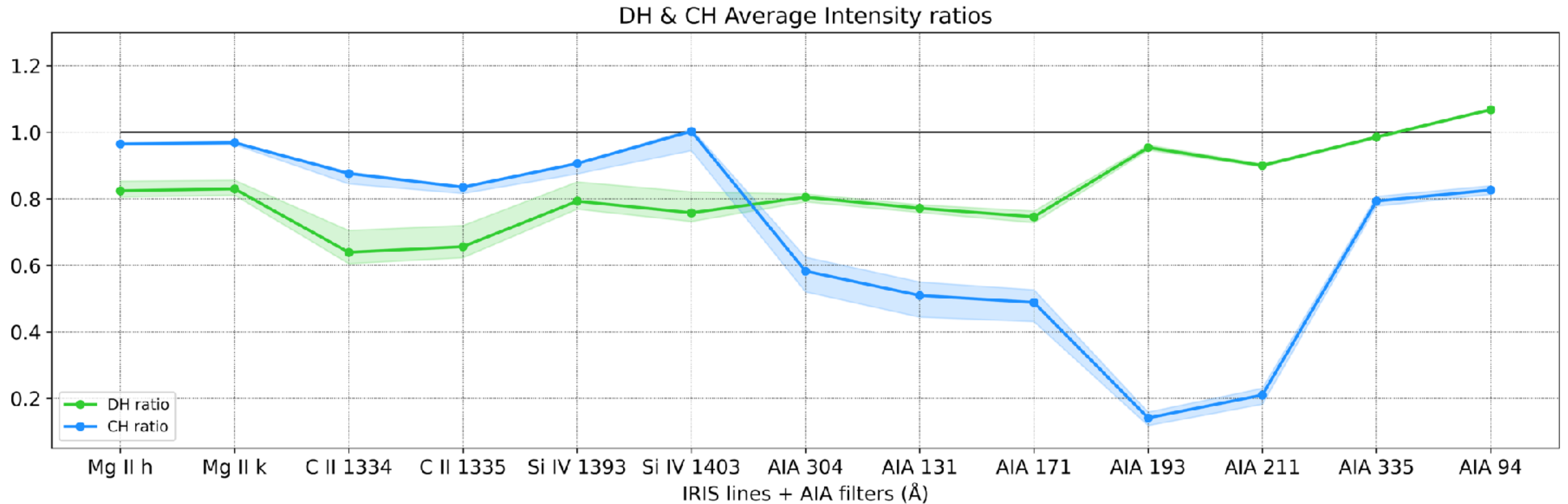


Southern Coronal Hole
Contour through intensity threshold

Quiet Sun
250'' x 445'' box

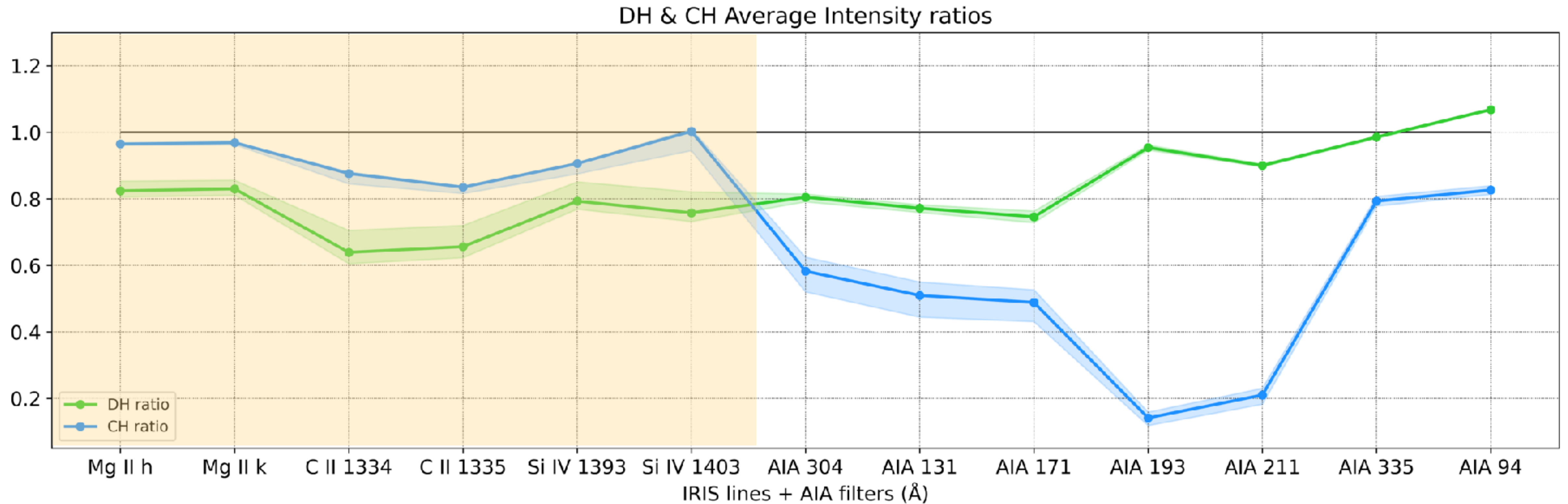
Results: DH & CH ratios

$$\text{Ratio} = \frac{\text{DH (CH) average intensity}}{\text{QS average intensity}}$$



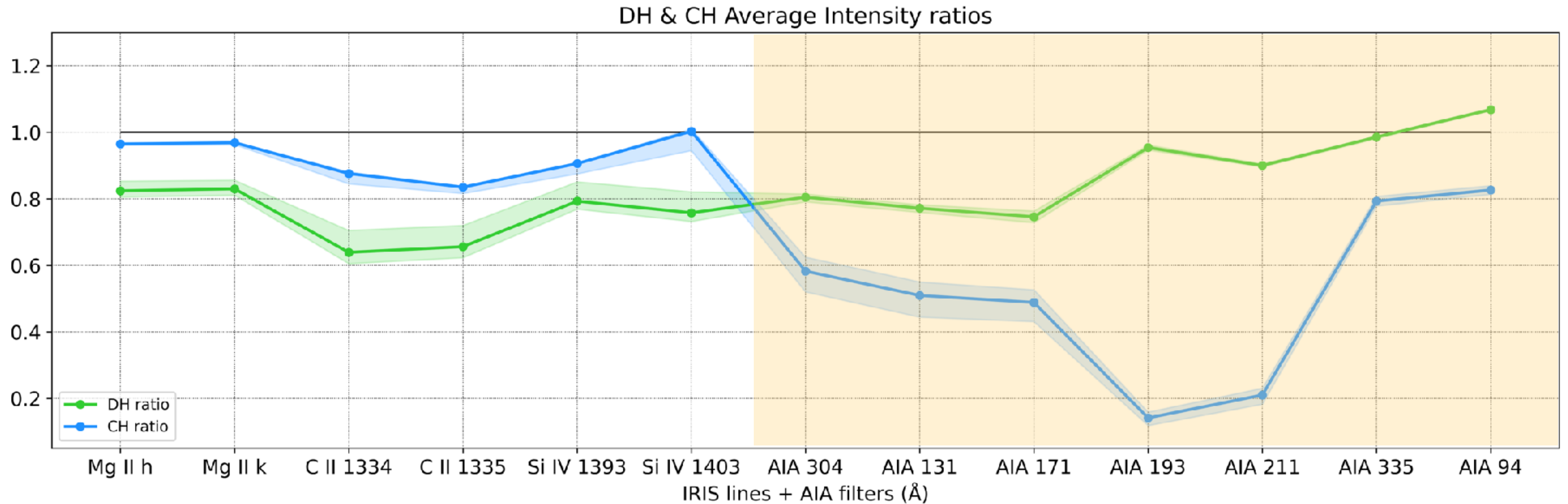
Results: DH & CH ratios

$$\text{Ratio} = \frac{\text{DH (CH) average intensity}}{\text{QS average intensity}}$$



Results: DH & CH ratios

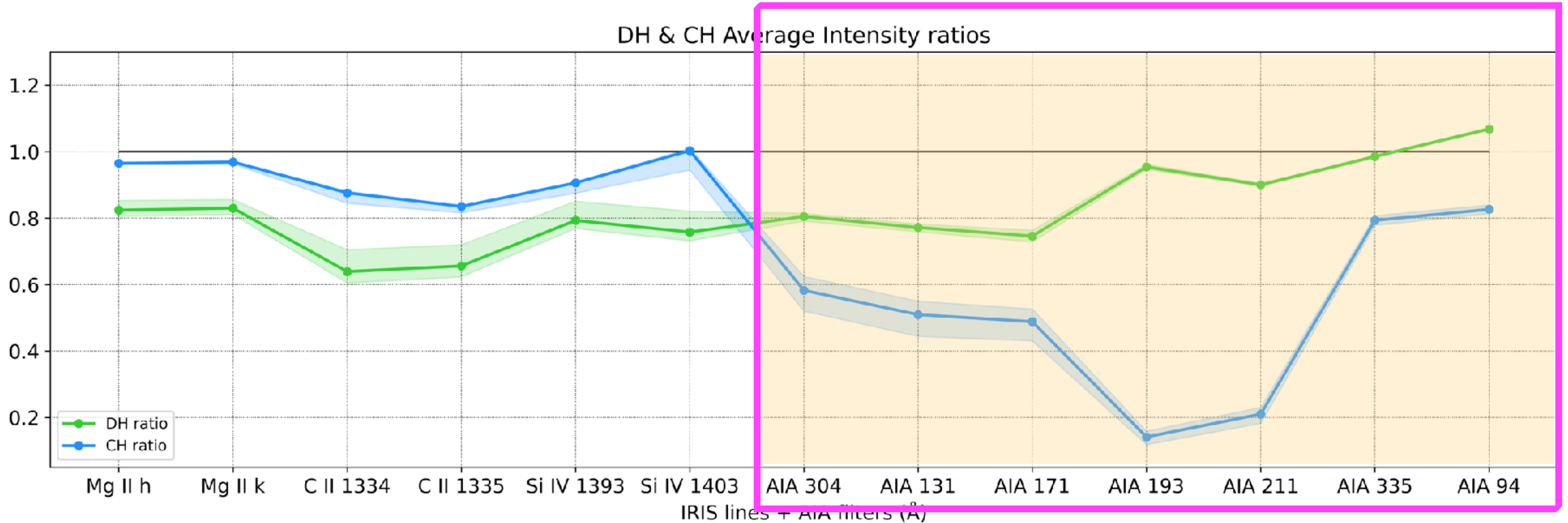
$$\text{Ratio} = \frac{\text{DH (CH) average intensity}}{\text{QS average intensity}}$$



Results: DH & CH ratios

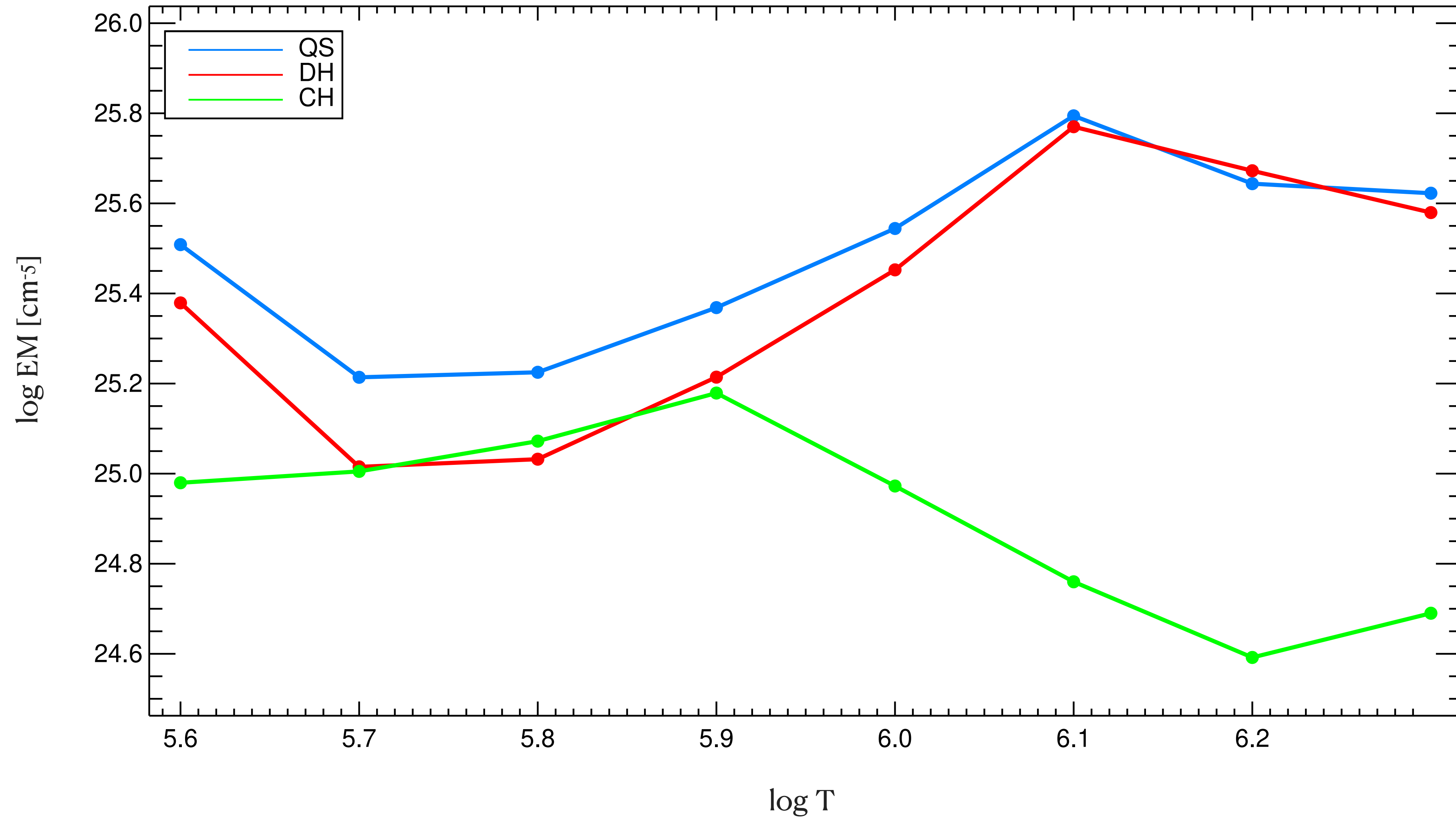
$$\text{Ratio} = \frac{\text{DH (CH) average intensity}}{\text{QS average intensity}}$$

A substantial difference between CH and DH emerges

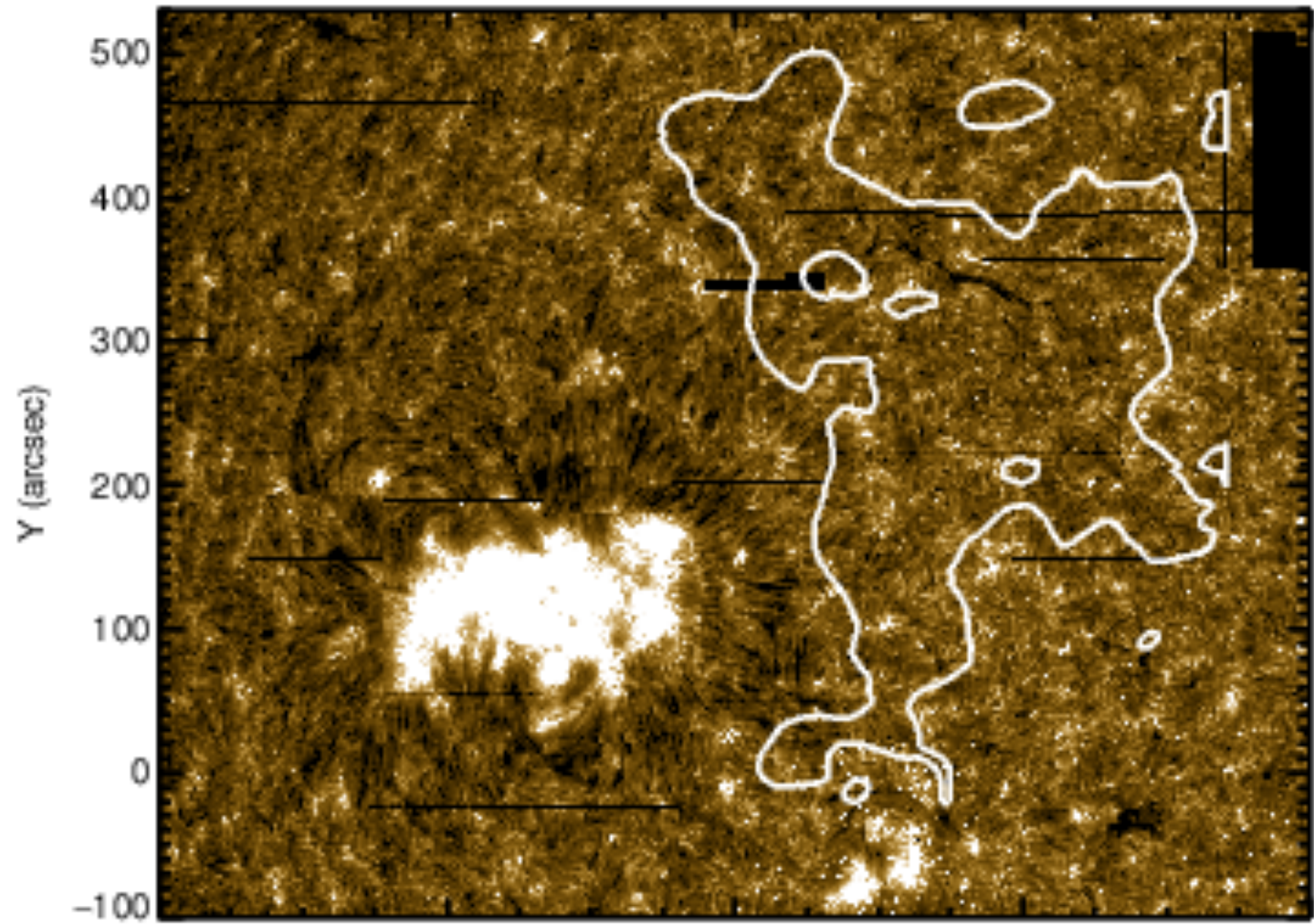


DH seen in TR, CH seen in corona!

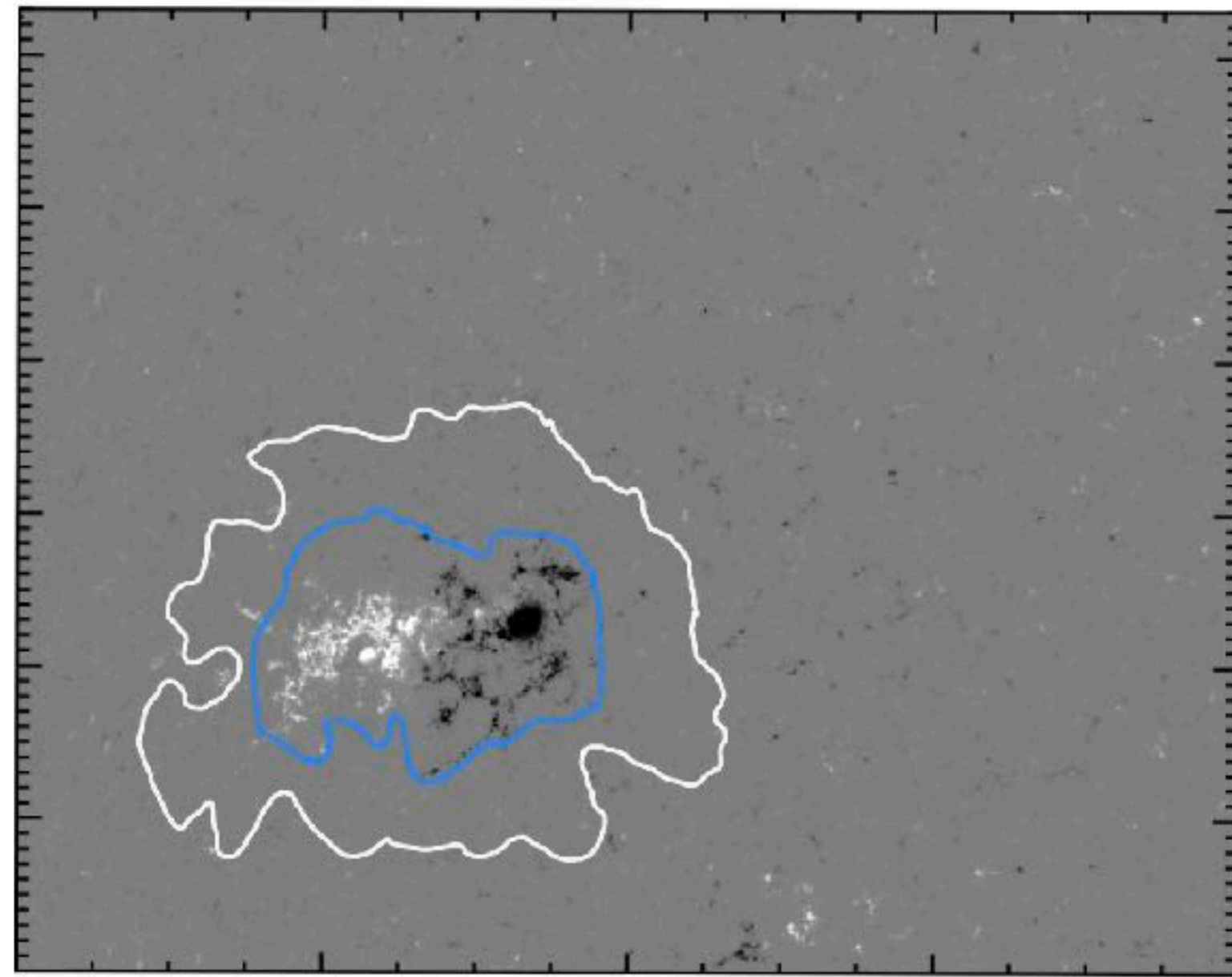
Emission measure - 22 April 2018



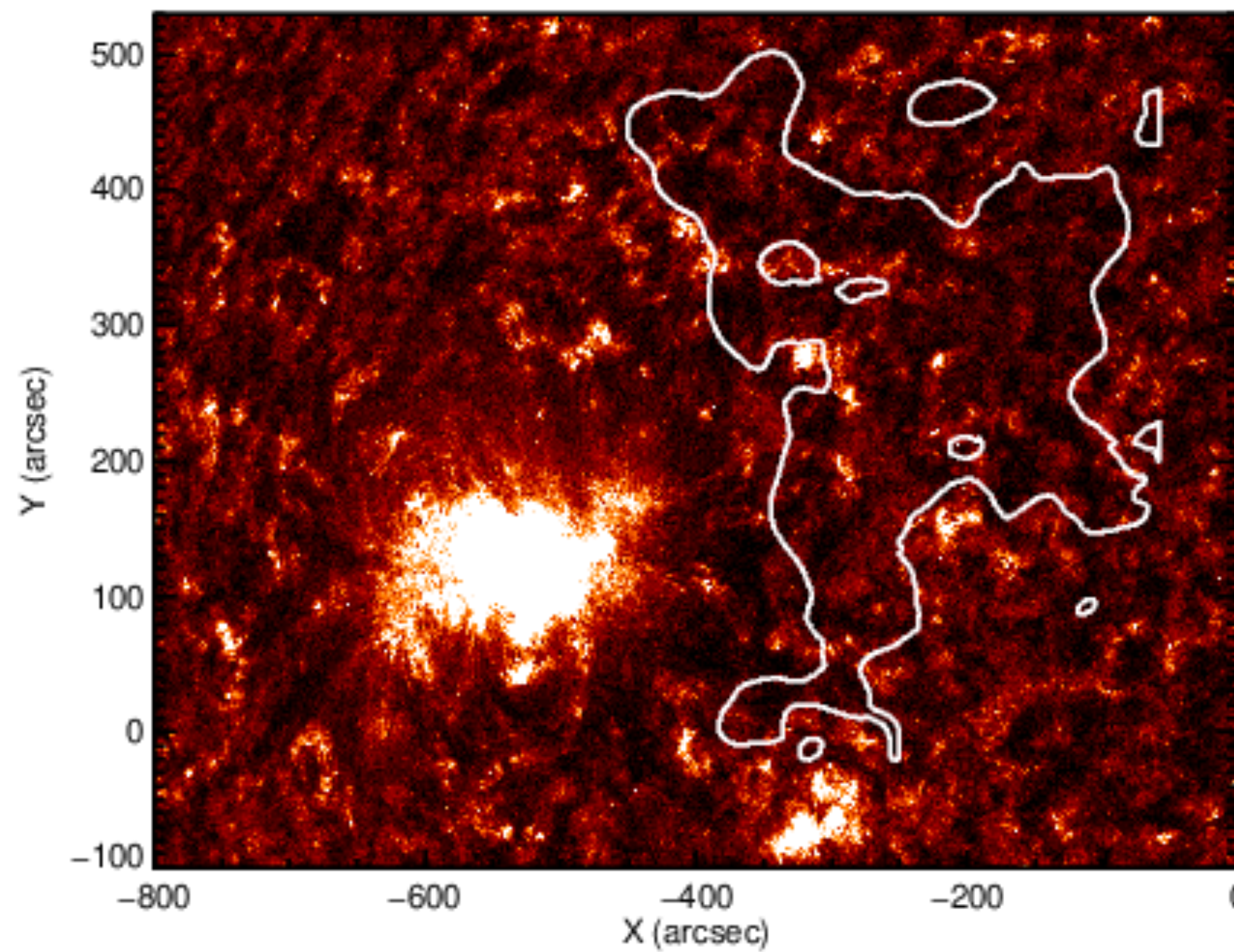
IRIS Mg II h core



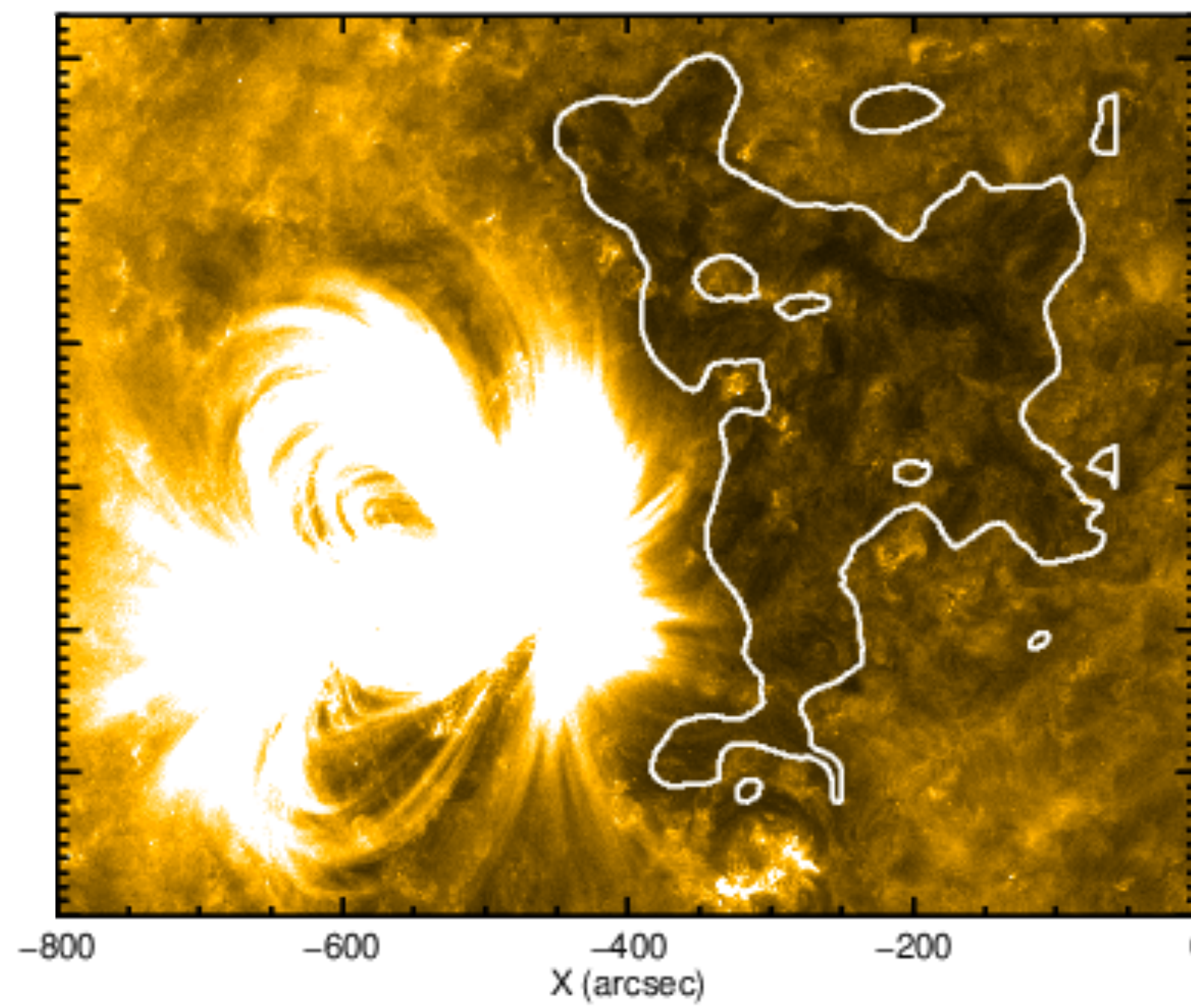
HMI magnetogram



AIA 304 Å



AIA 171 Å

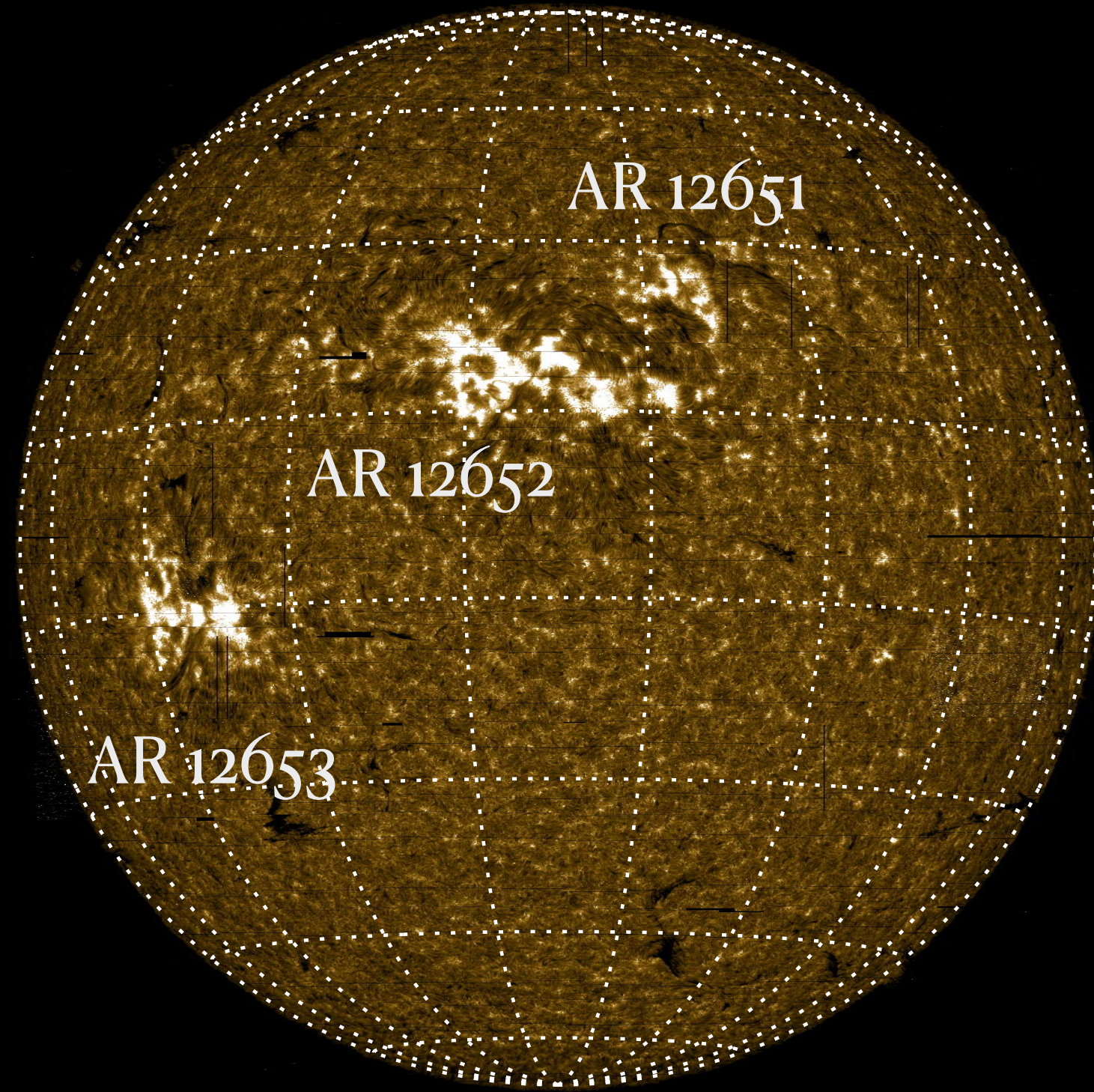


**Results:
an enlargement
with
Temperature**

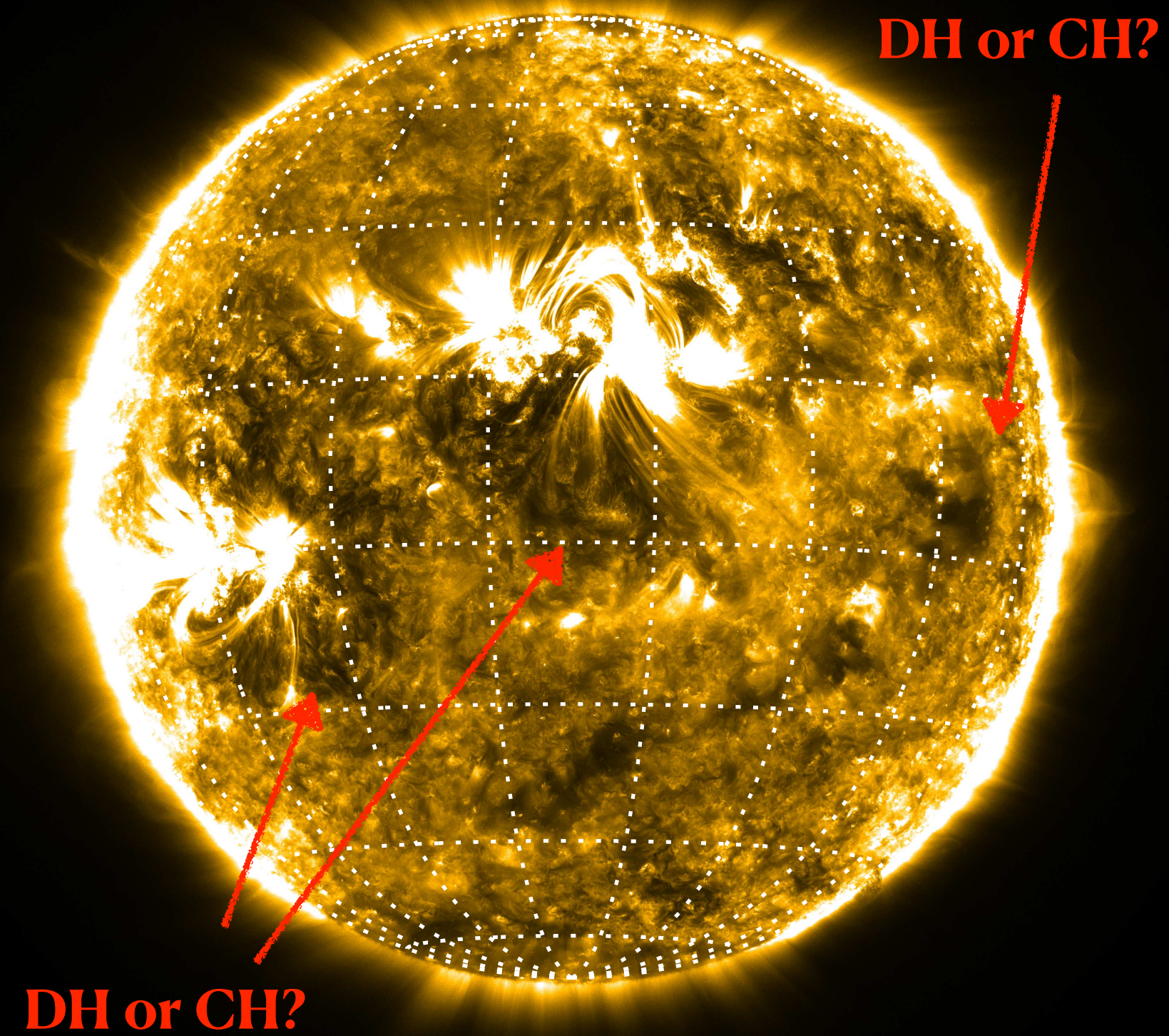
DHs vs CHs: a recipe to distinguish them

24 April 2017

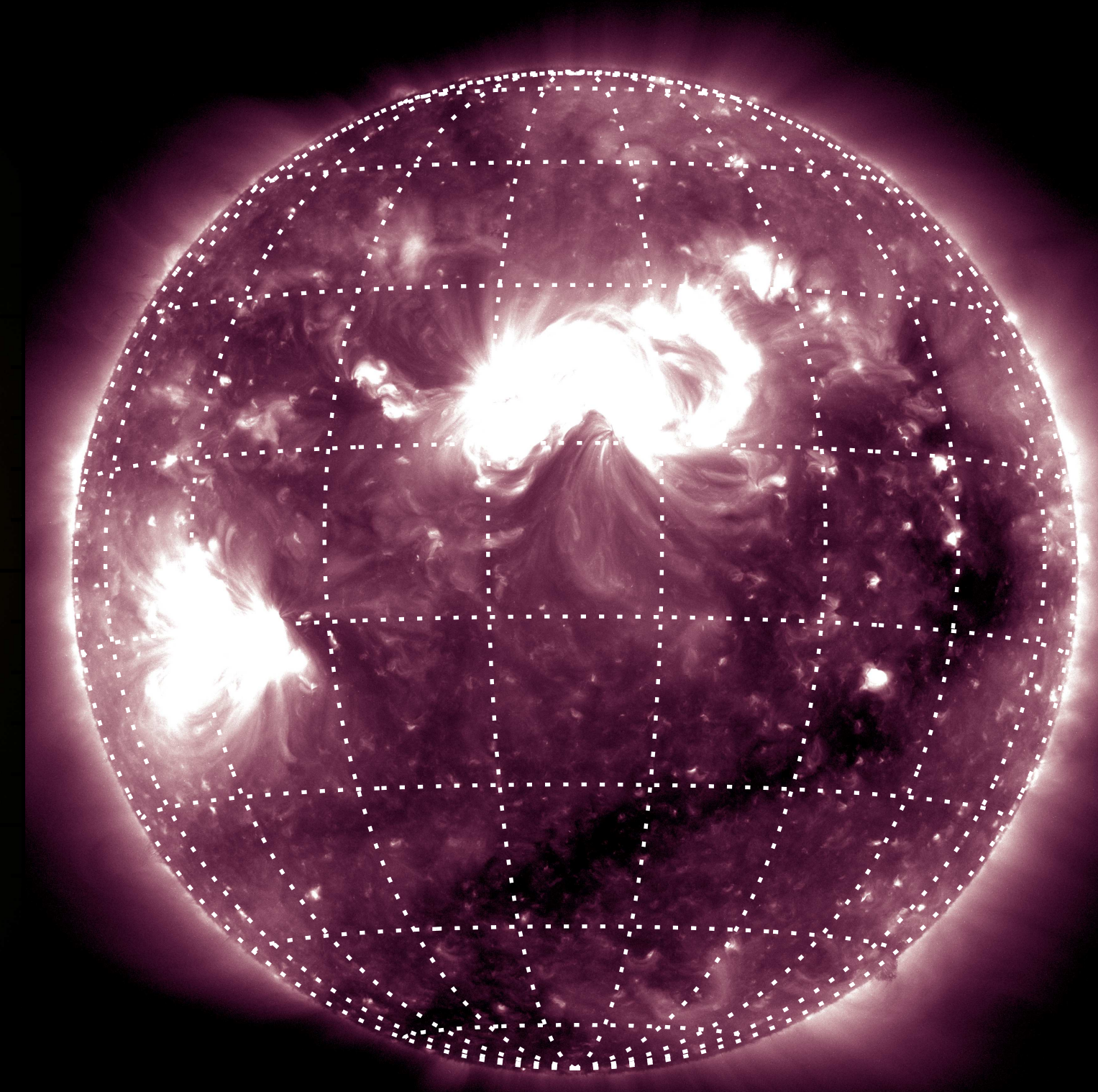
IRIS Mg II h core



AIA 171 Å



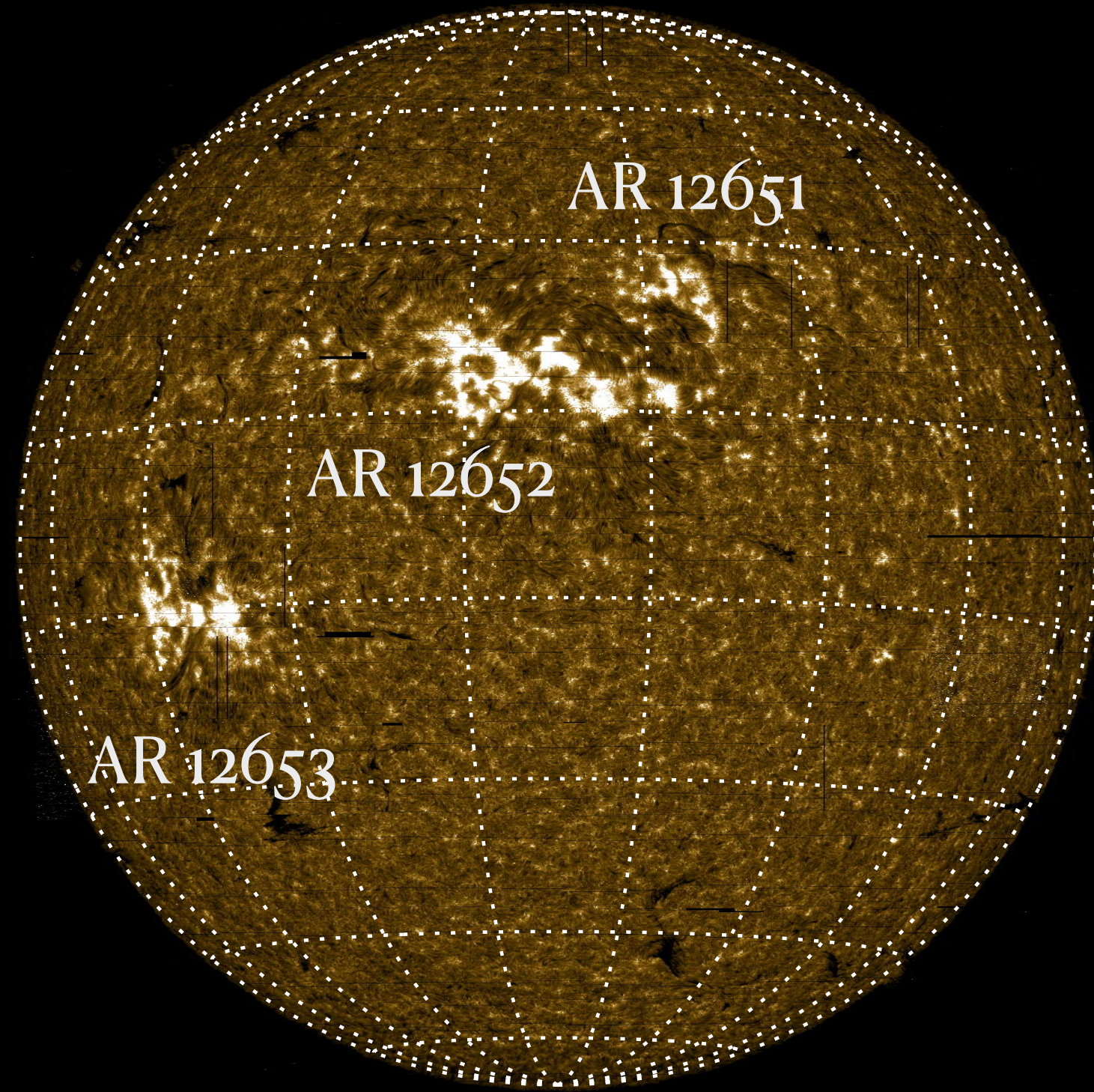
AIA 211 Å



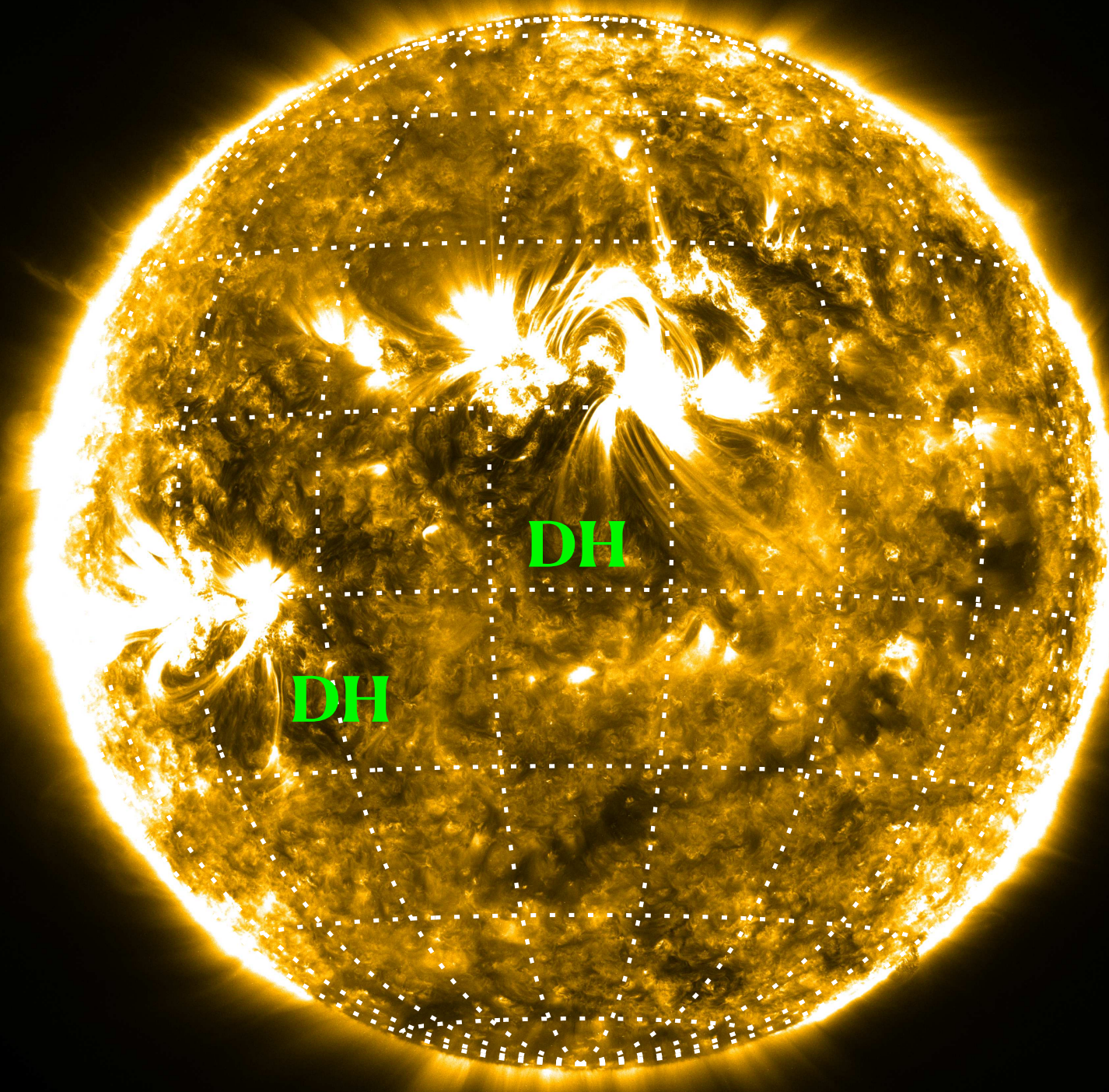
DHs vs CHs: a recipe to distinguish them

24 April 2017

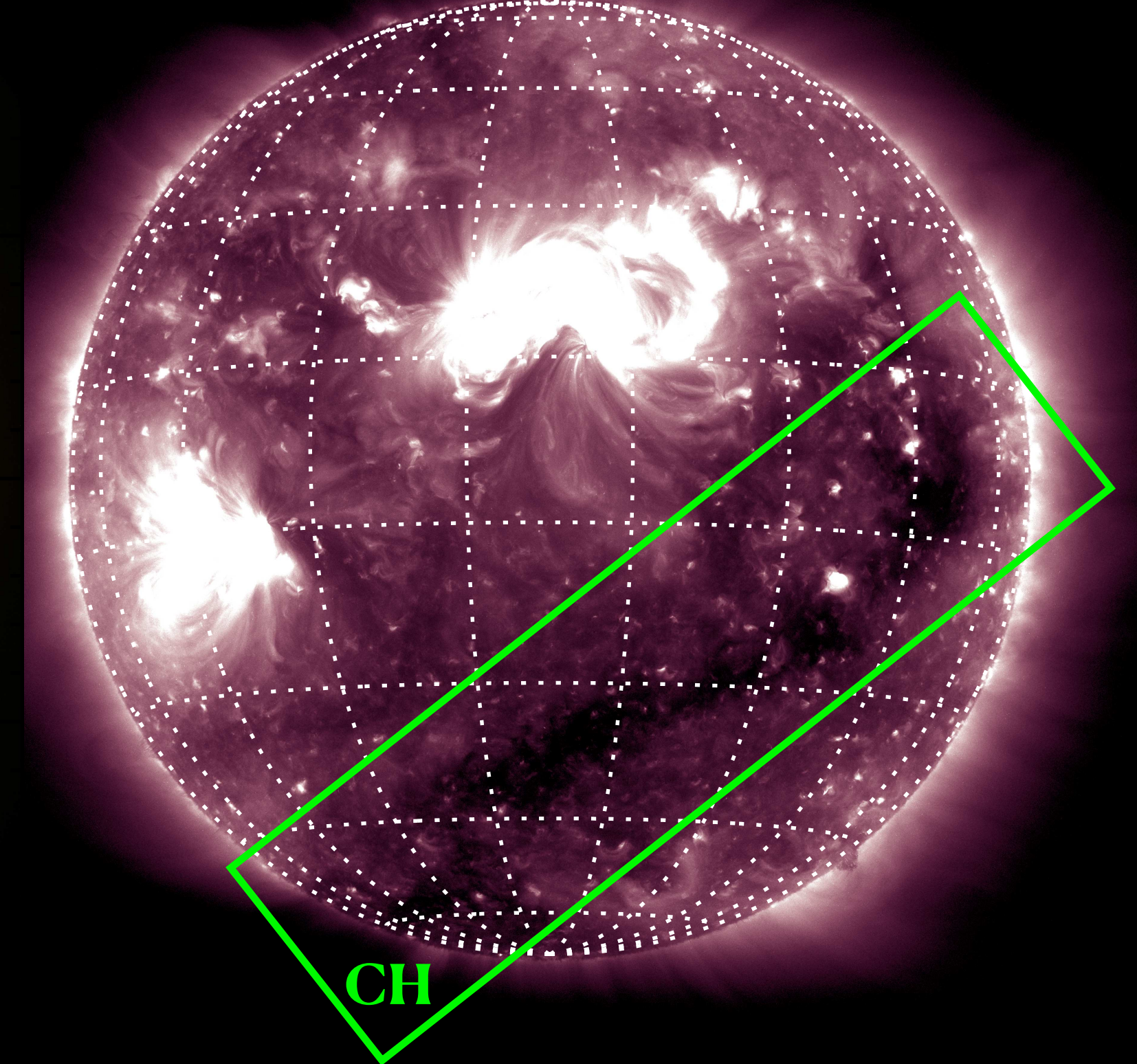
IRIS Mg II h core



AIA 171 Å



AIA 211 Å



All discussion is in the paper under revision

Ongoing Work

Statistical work -> enlarge the sample of DHs and of lines analysed, including other spacecrafts, e.g. Hinode/EIS

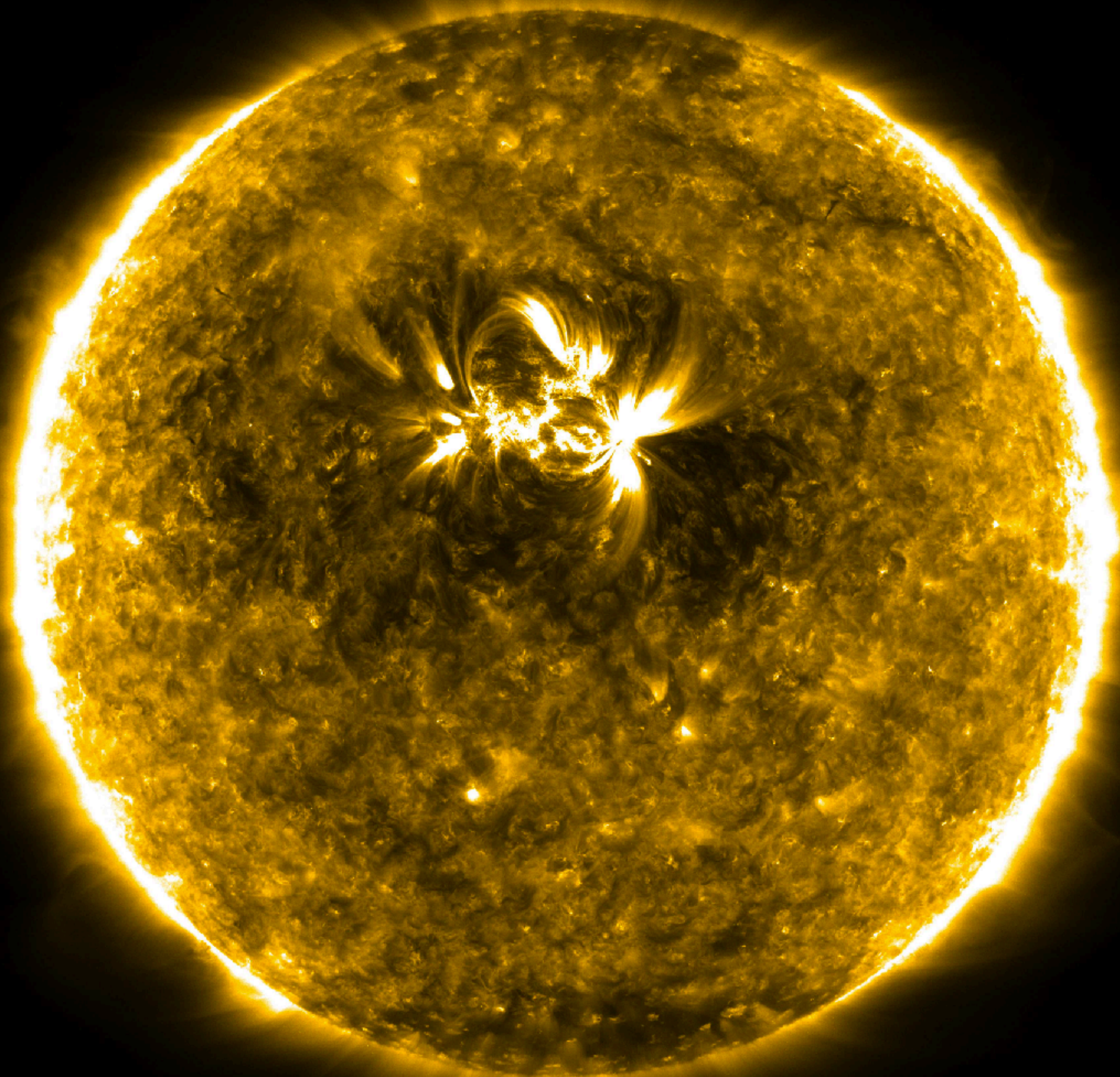
Future Work

Magnetic field extrapolations

Study the evolution of DHs together with the associated ARs

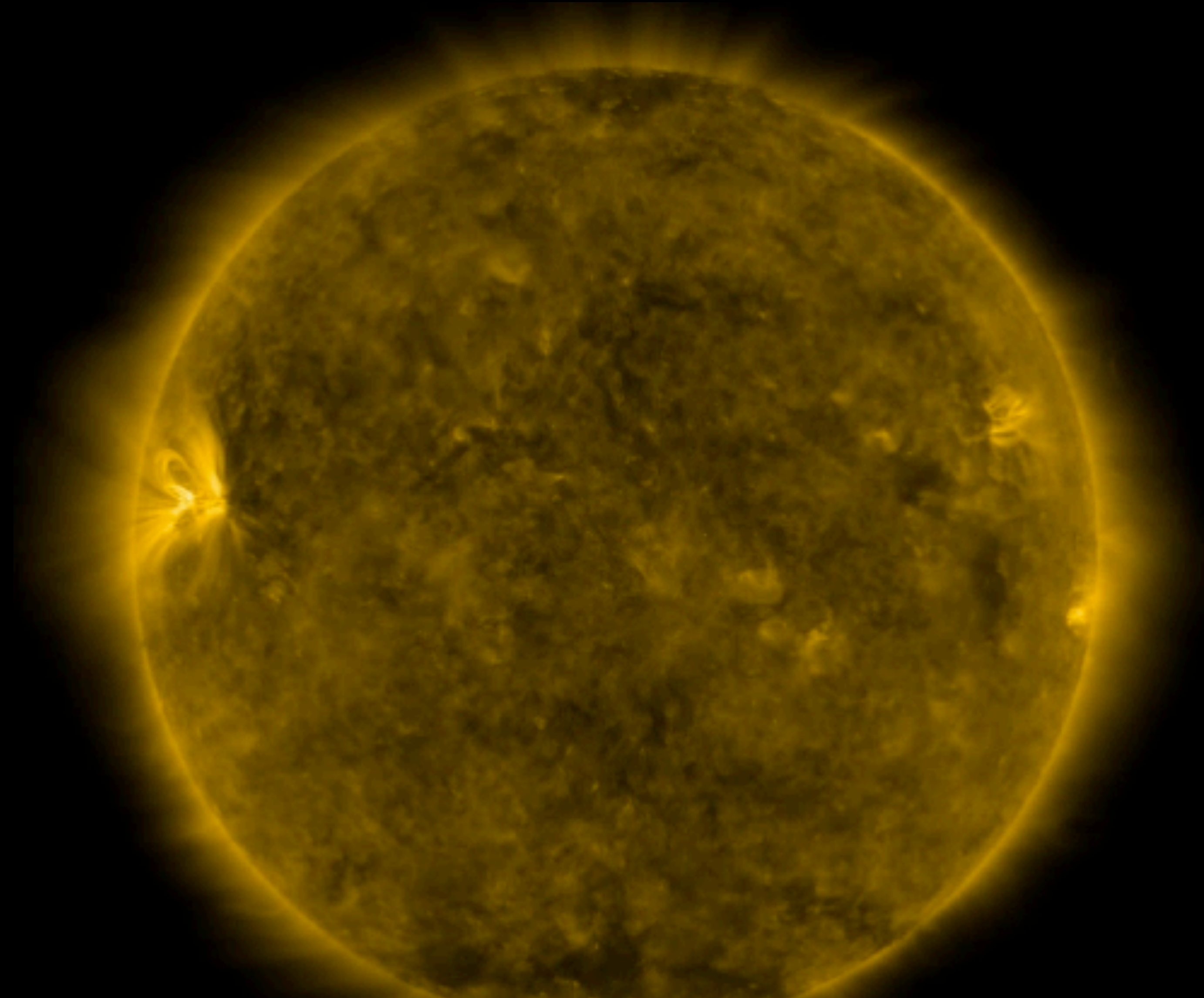
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**Thank you for
your
attention!**

AR 12706 temporal evolution



AIA 193
AIA 171

2018-04-20 20:44:29
2018-04-20 20:44:21

Hale & Ellerman 1903

PLATE VI

N



FIG. 1. 3^h 47^m. FACULÆ
Slit Set on Continuous Spectrum at λ 3921

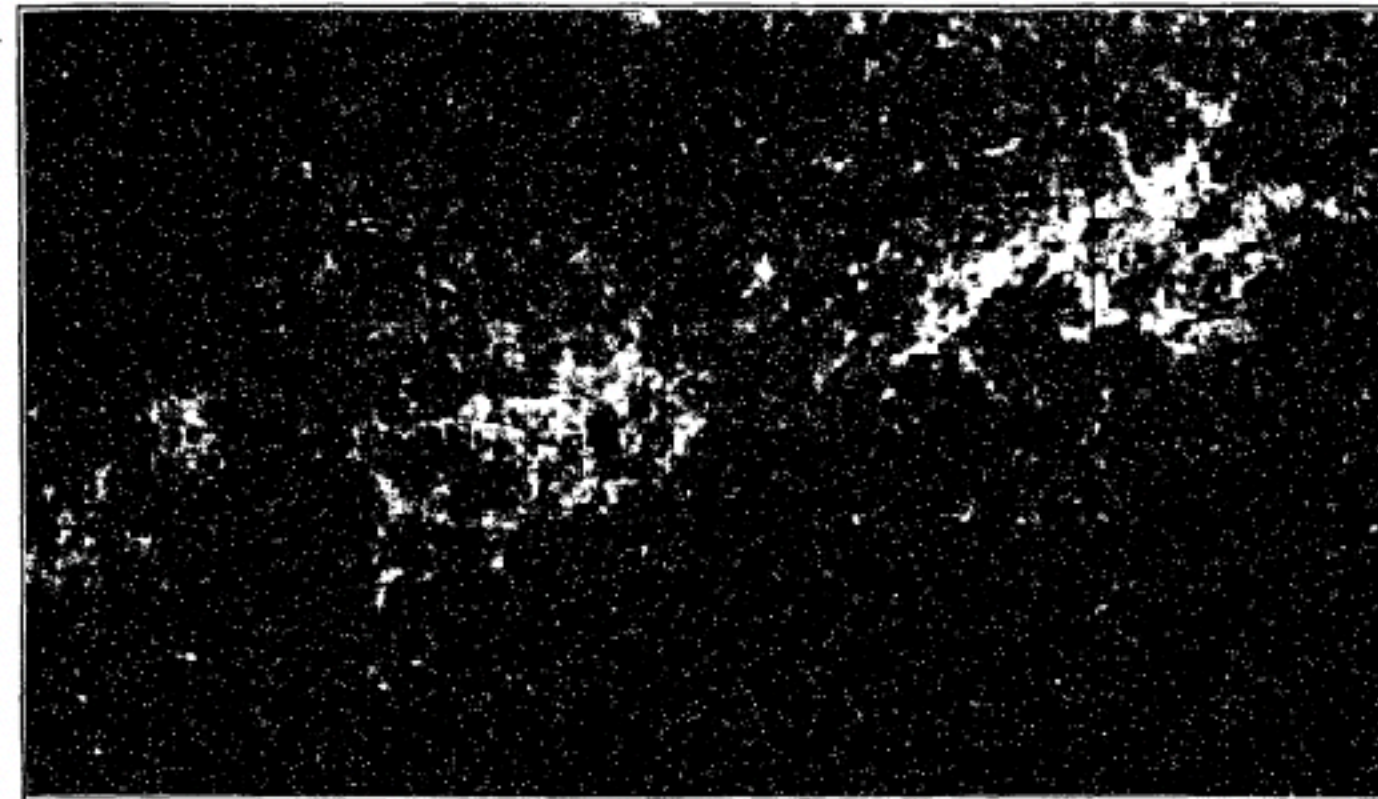


FIG. 2. 4^h 0^m. CALCIUM FLOCCULI, LOW K_1 LEVEL
Slit at λ 3929

1st observation of a DH

W

- *Circumfacules* (Deslanders 1930)
- *Dark Canopies* (Wang+ 2011)
- *Dark Halos* (Andretta+ 2014) (DHs)
- *Dark Moats* (Singh+ 2021)

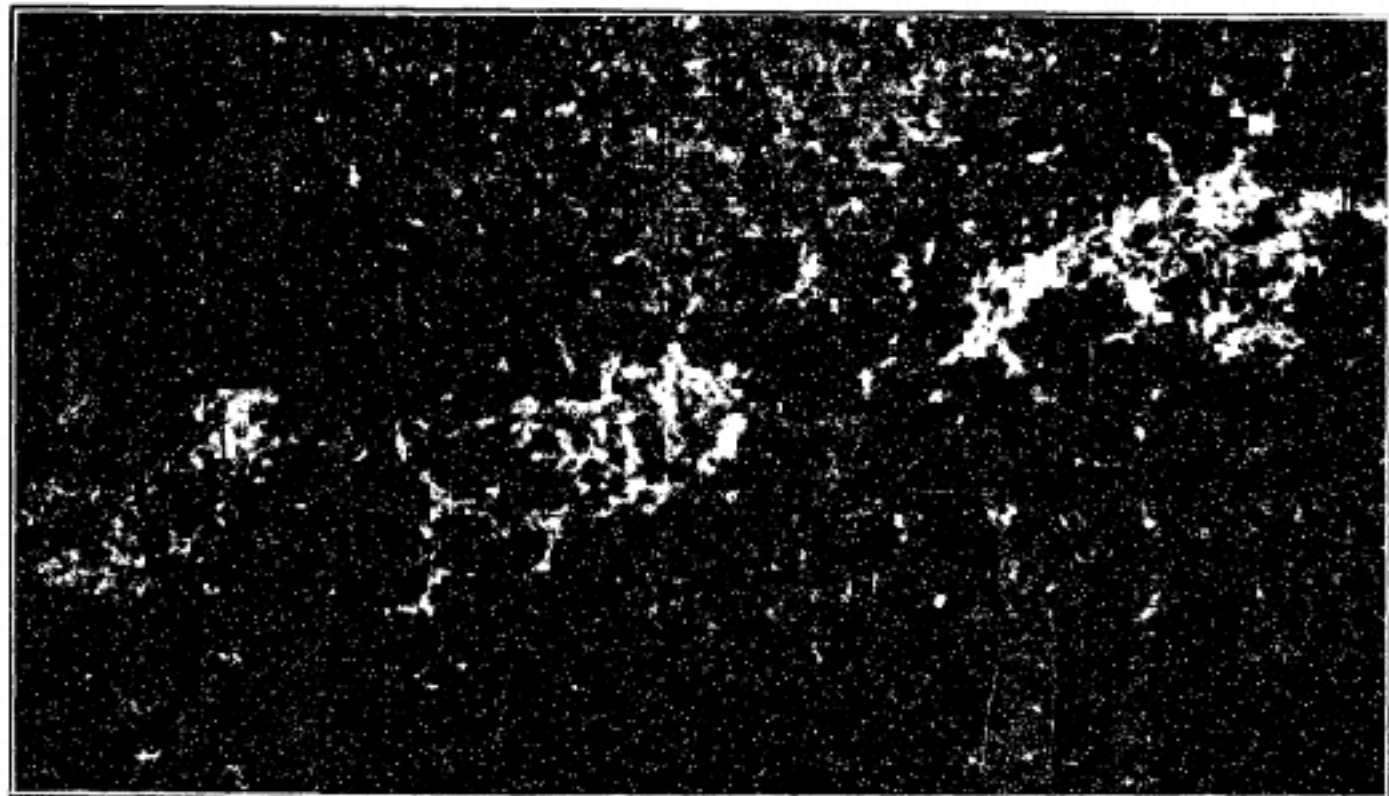


FIG. 3. 3^h 55^m. CALCIUM FLOCCULI, HIGHER K_1 LEVEL
Slit at λ 3932

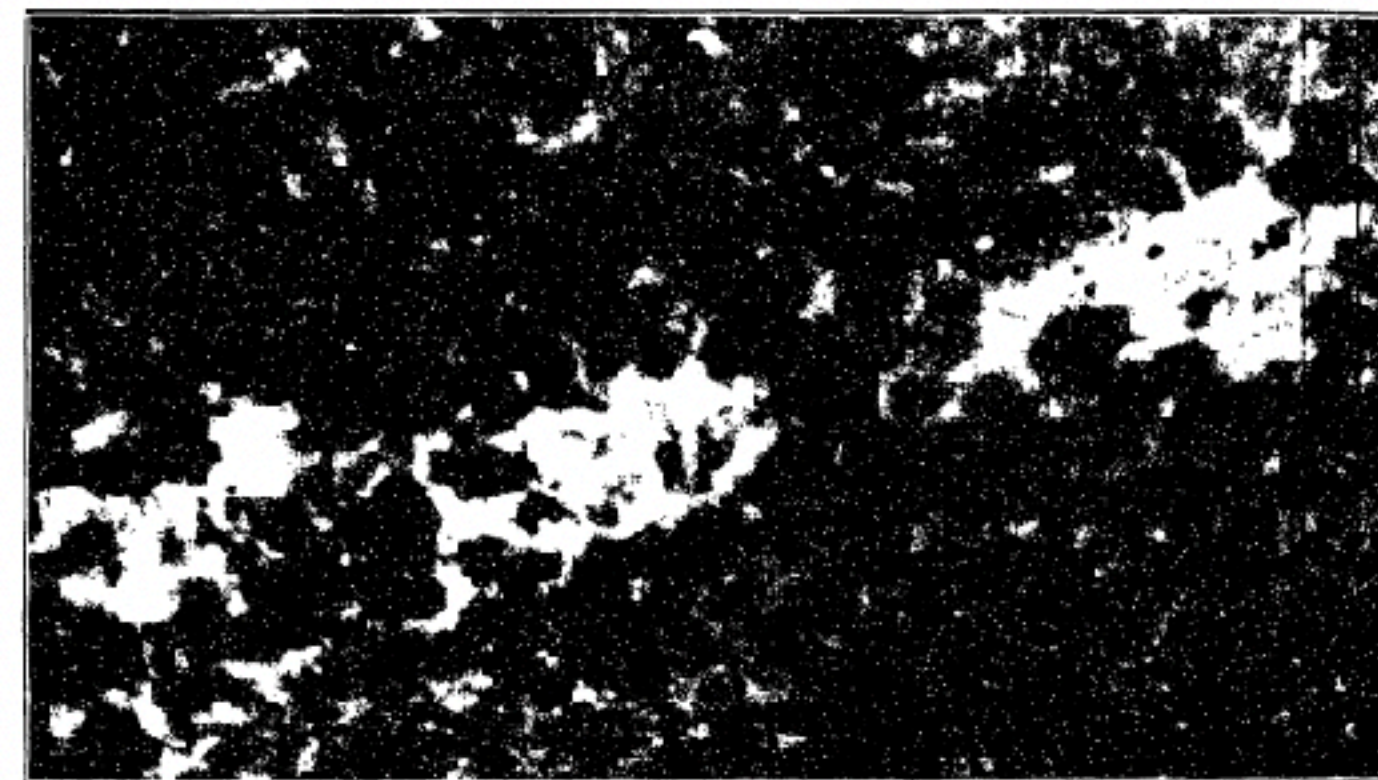
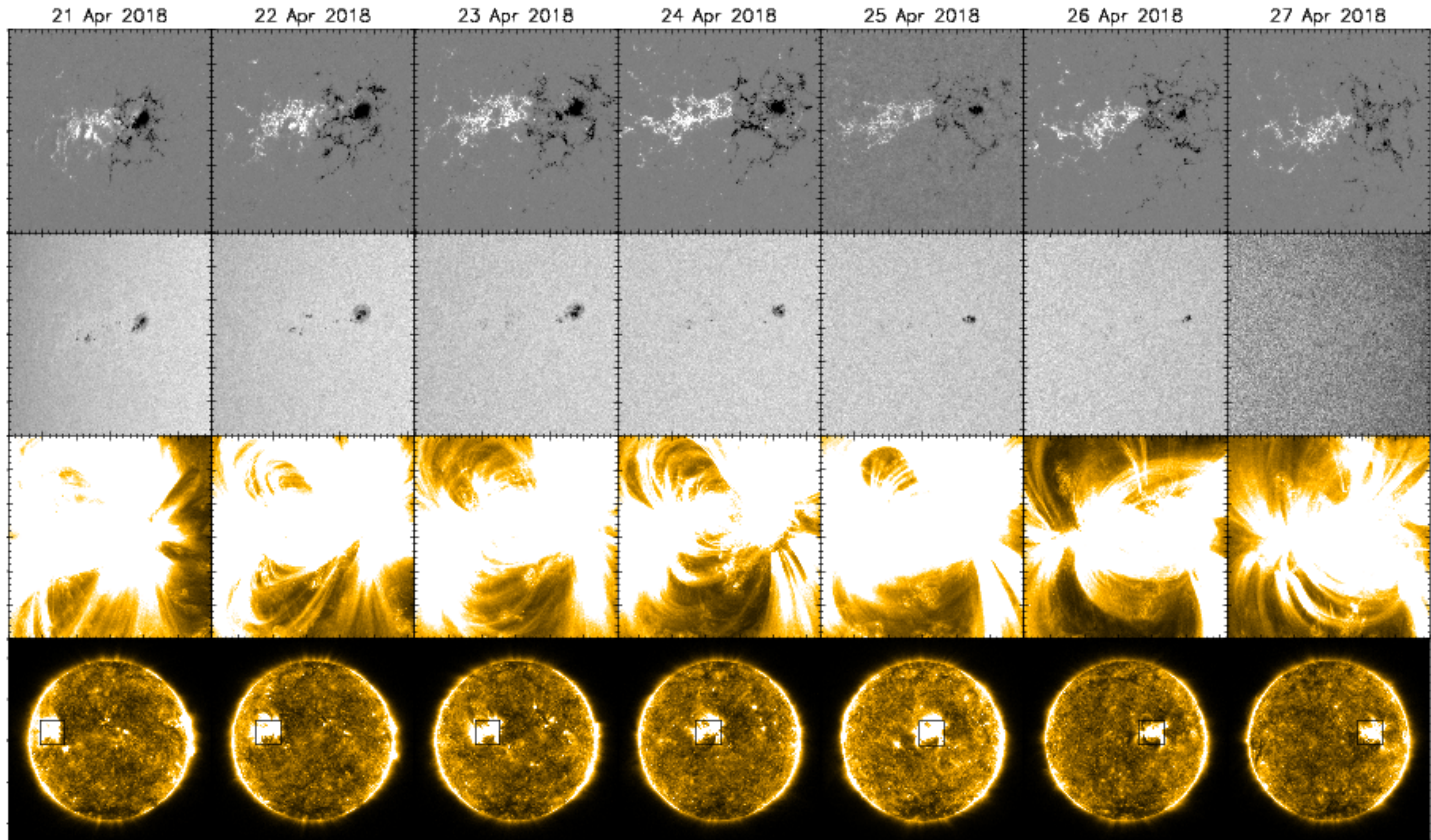


FIG. 4. 4^h 06^m. CALCIUM FLOCCULI, K_2 LEVEL
Slit at λ 3933.8

S

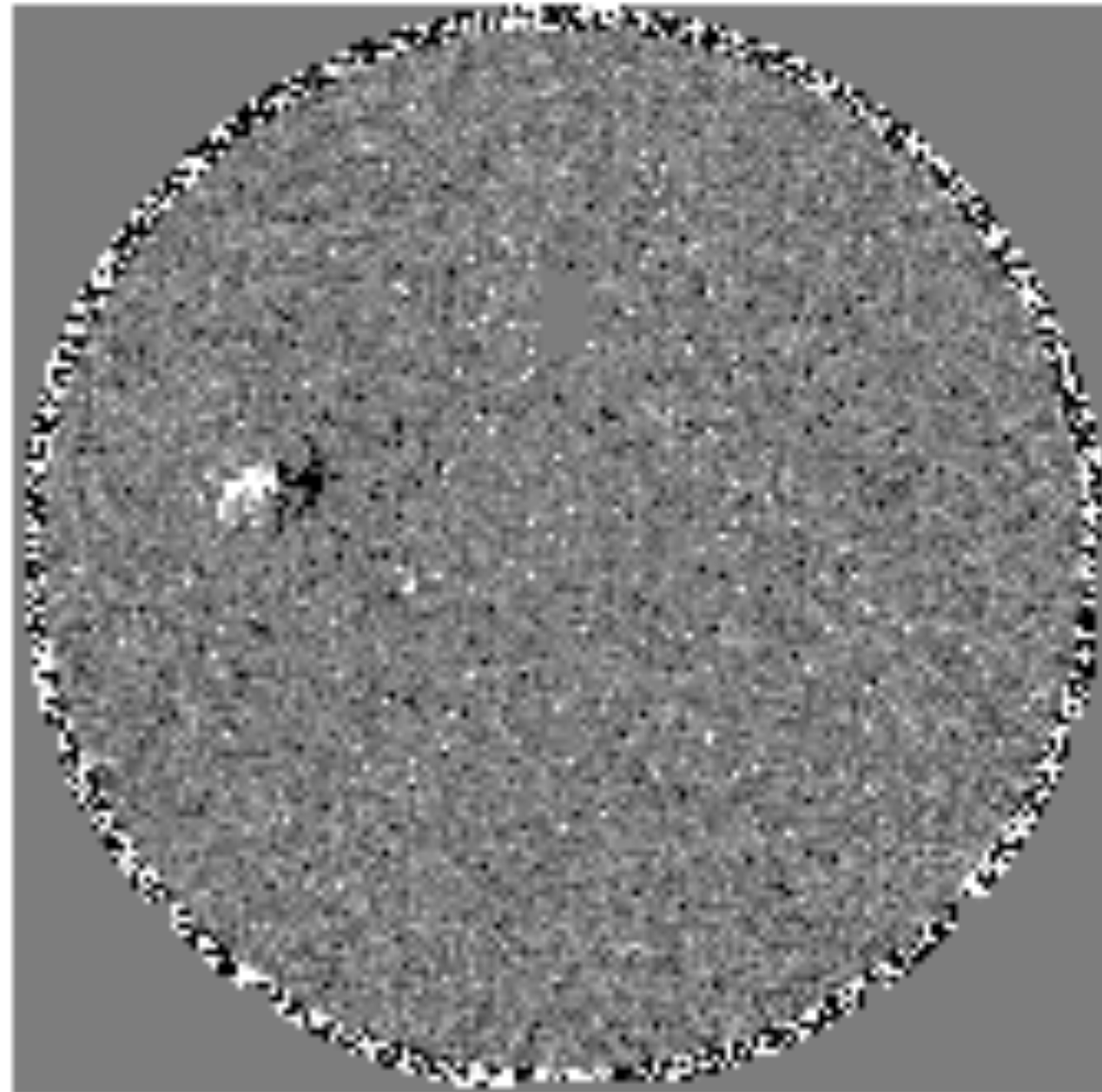
FACULÆ AND SECTIONS OF CALCIUM FLOCCULI AT DIFFERENT LEVELS, 1903, AUGUST 10
Scale: Sun's Diameter = 0.295 Meter

AR 12706 on the disk

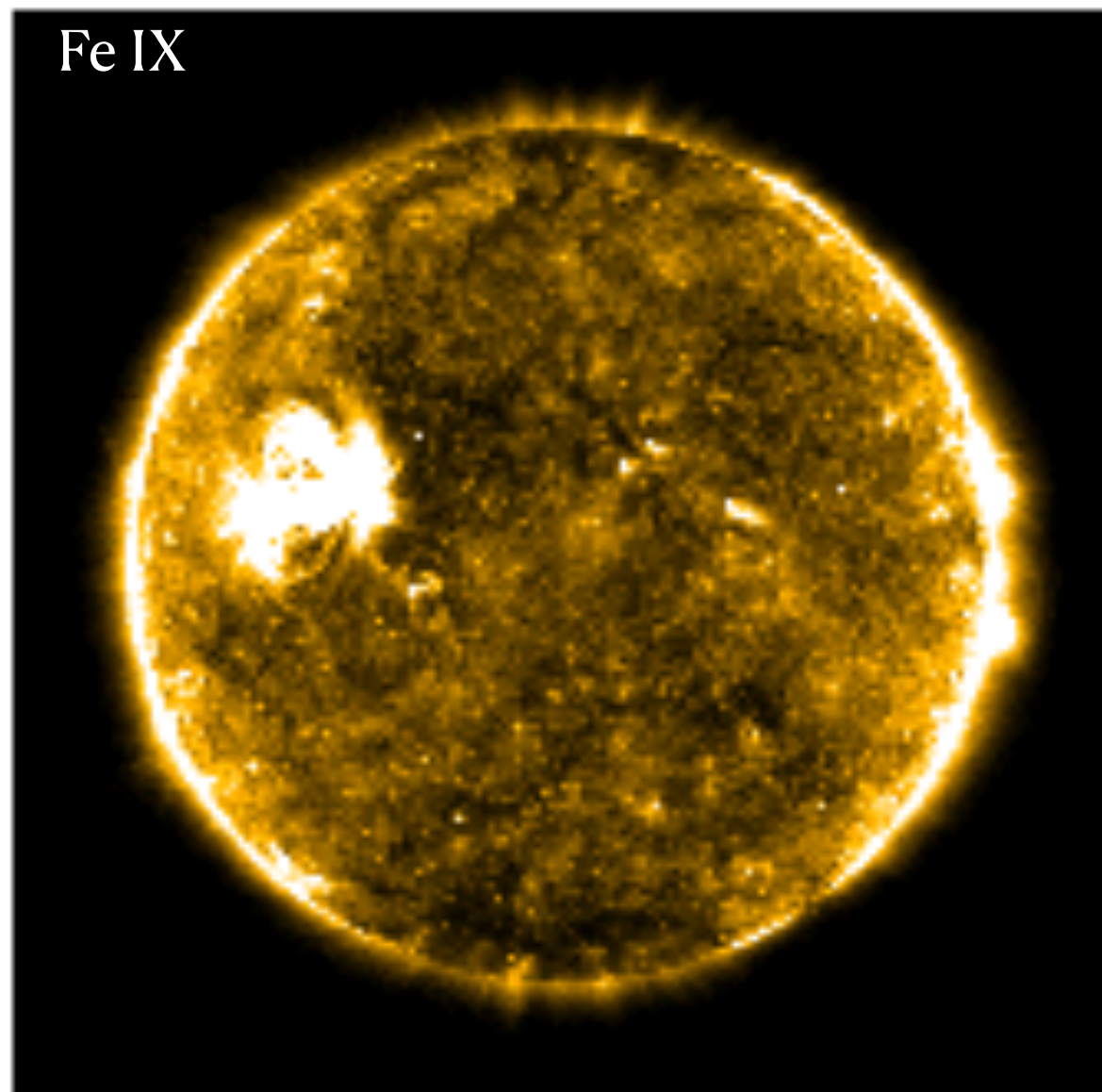


Observations: AIA images

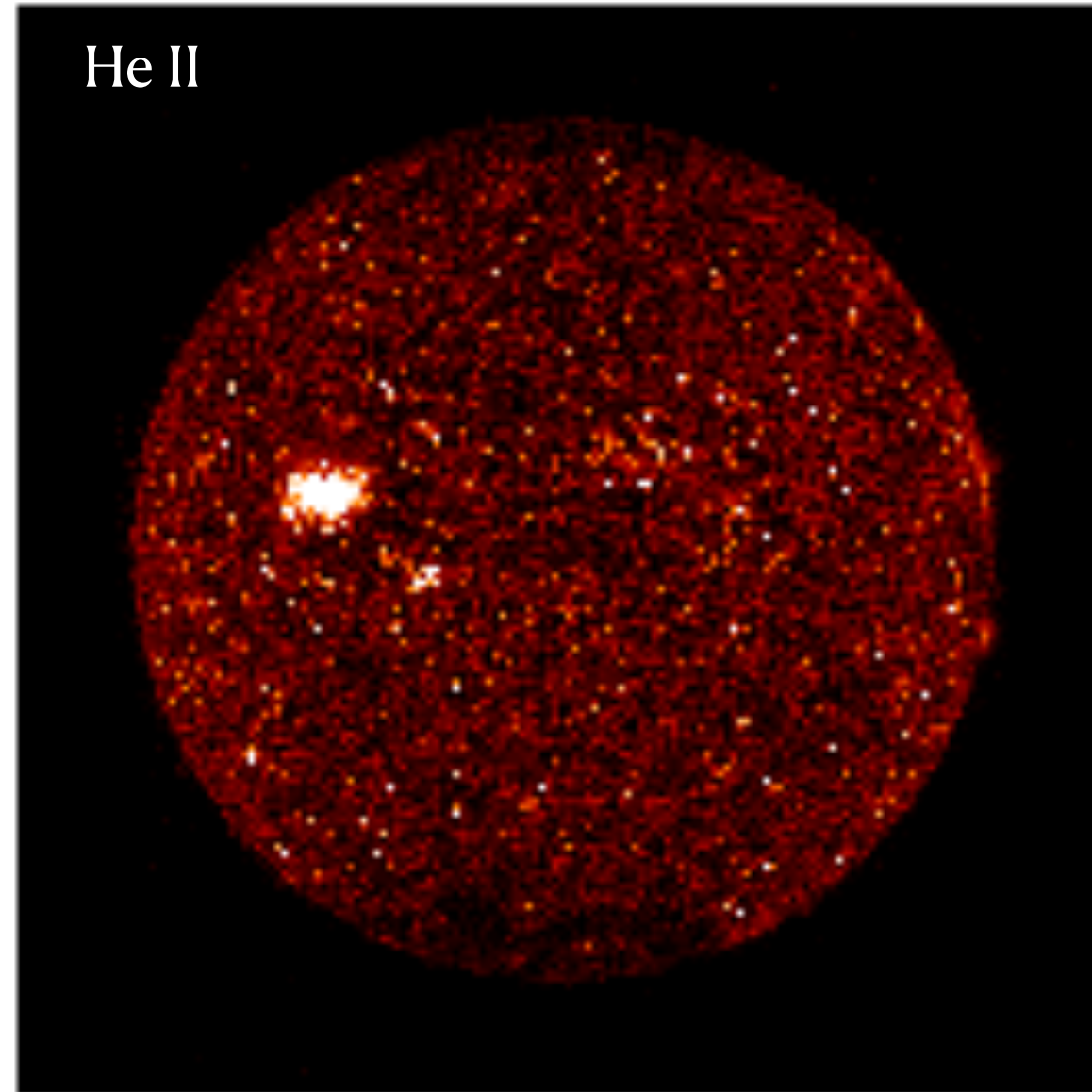
HMI magnetogram



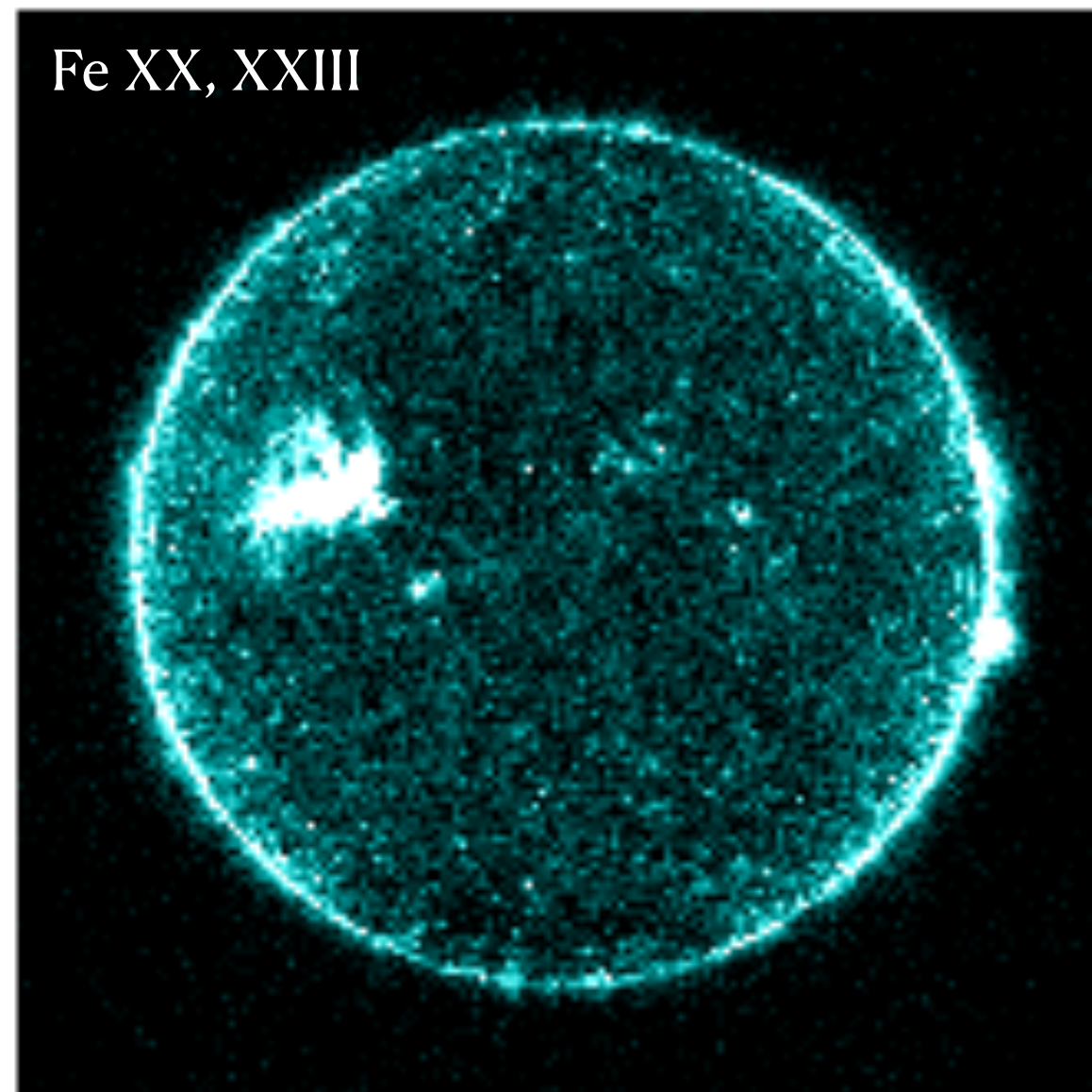
AIA 171 Å



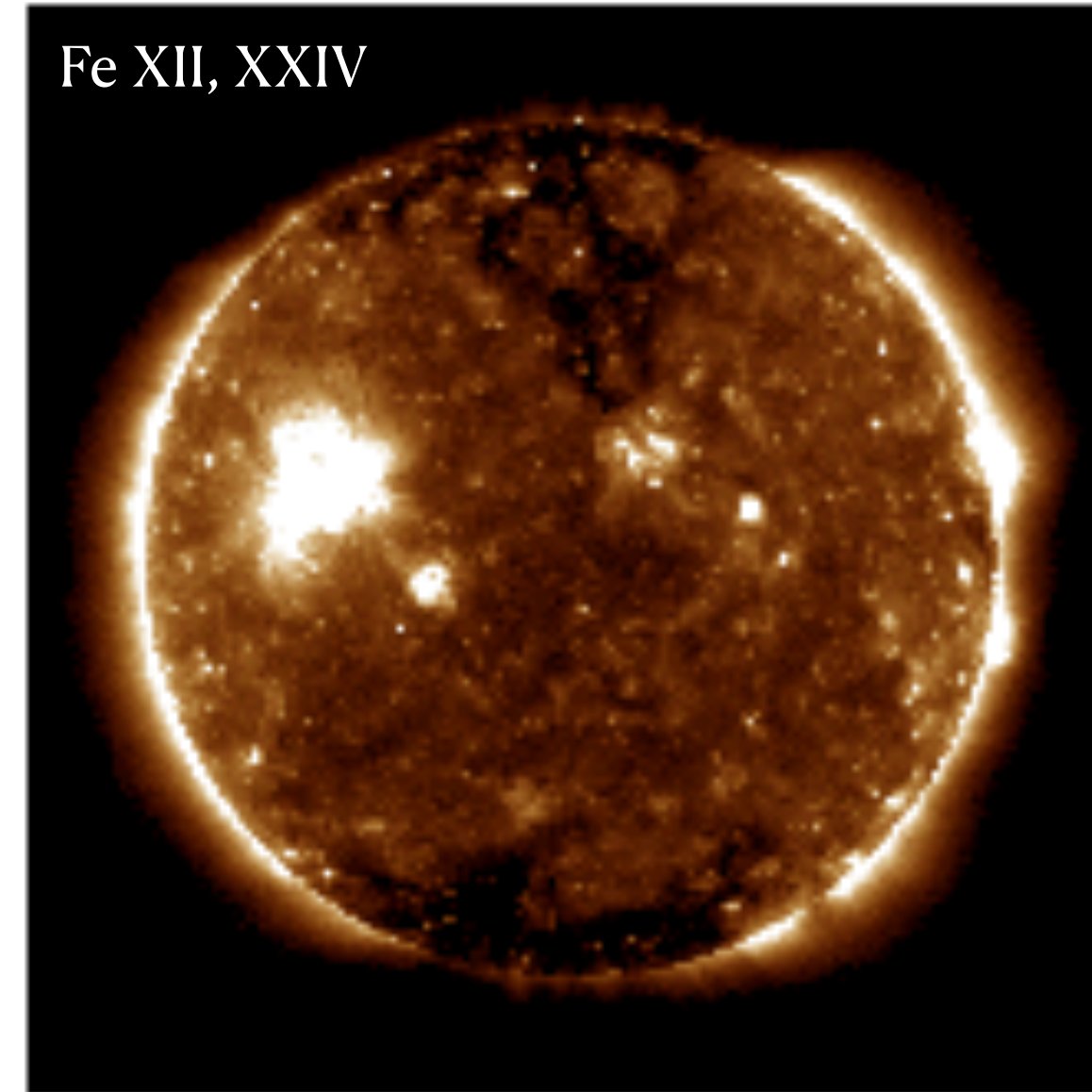
AIA 304 Å



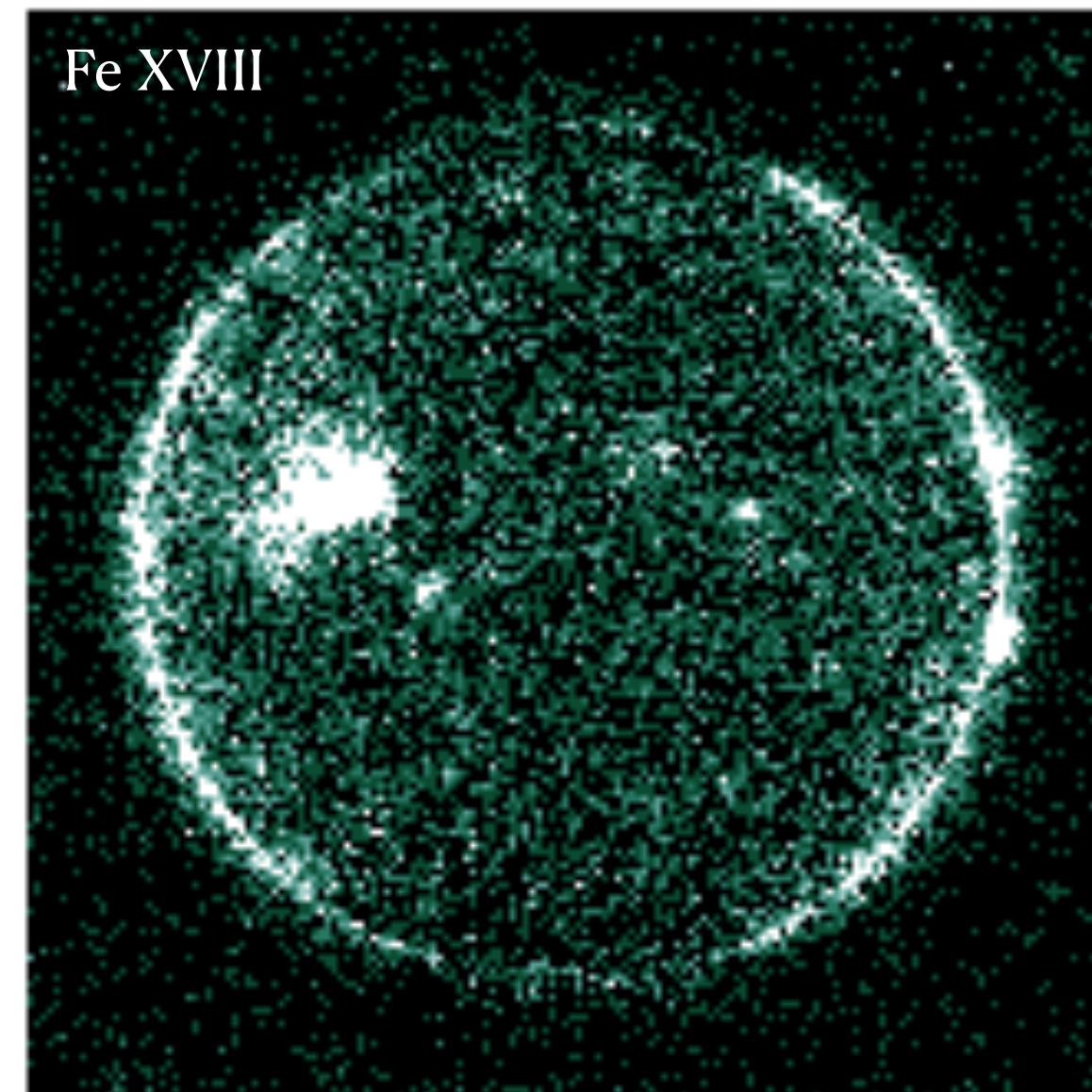
AIA 131 Å



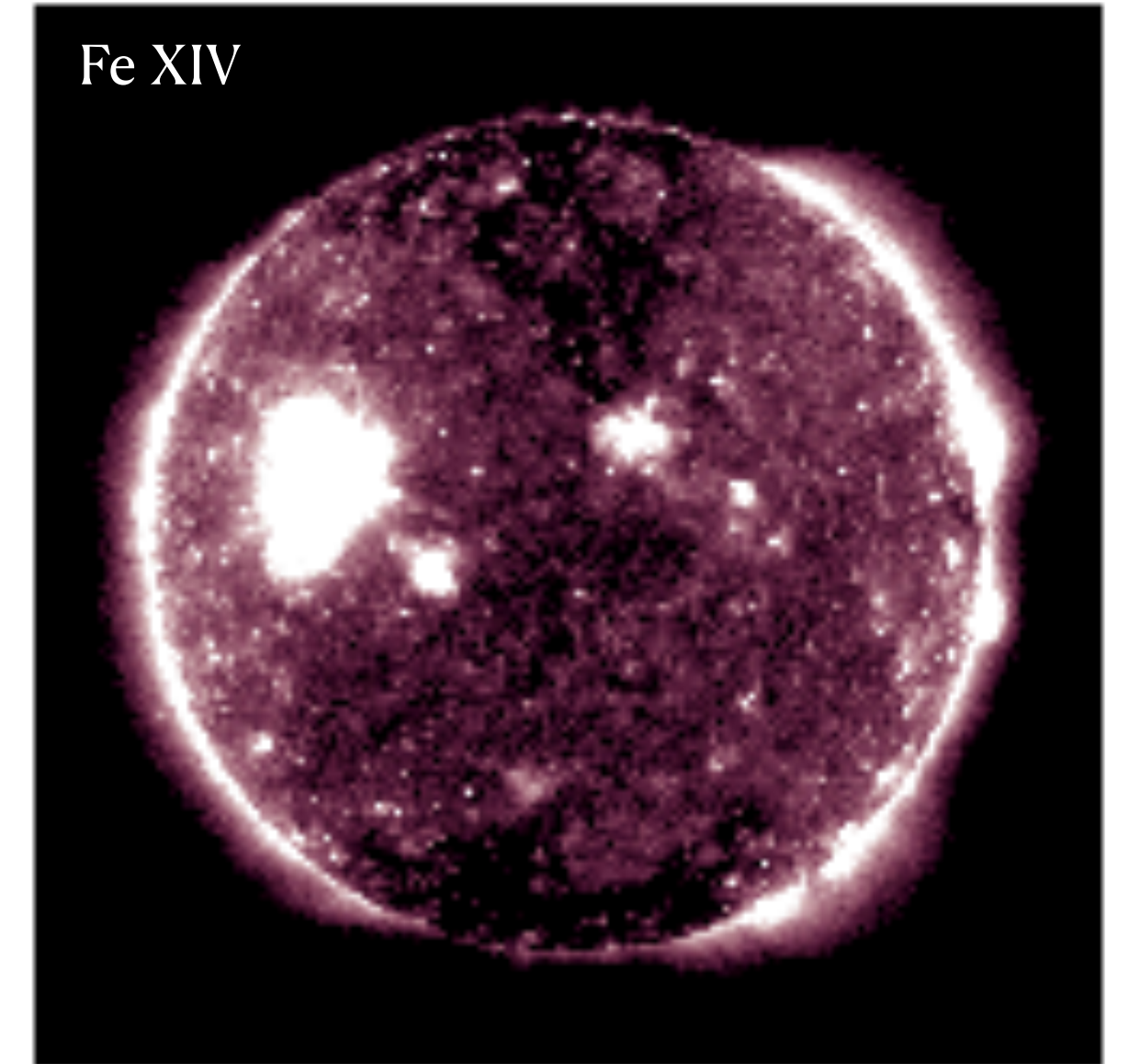
AIA 193 Å



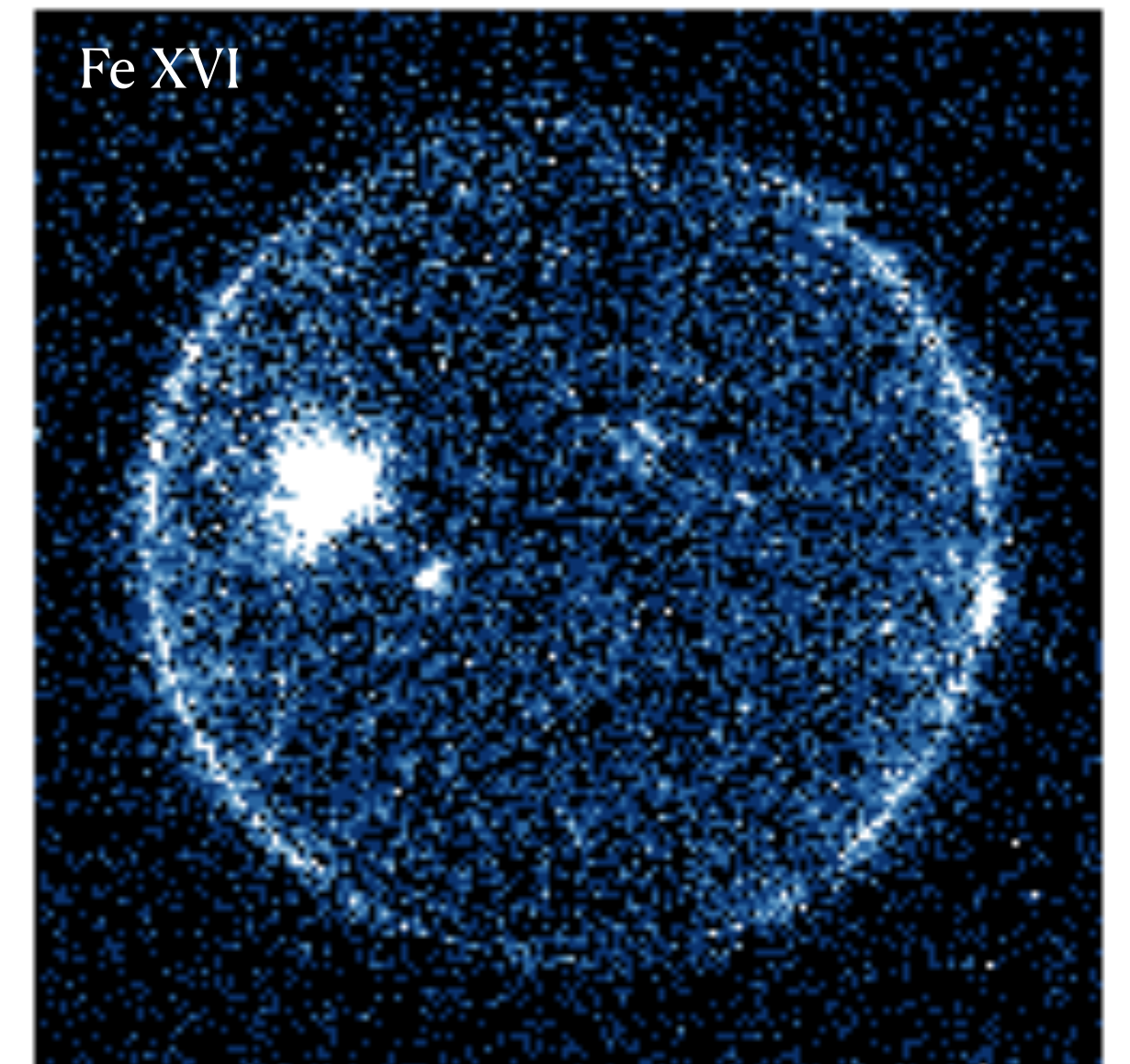
AIA 94 Å



AIA 211 Å

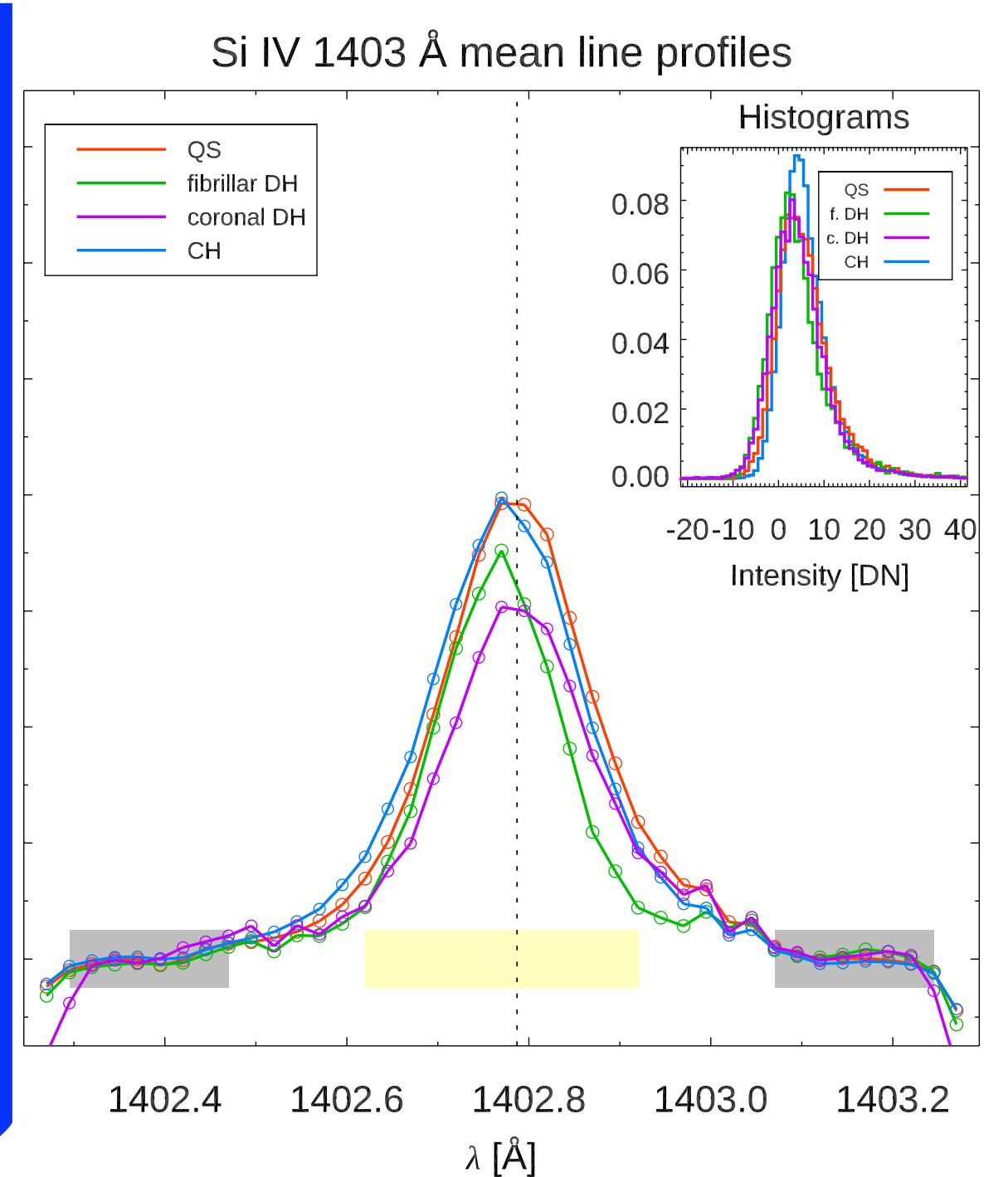
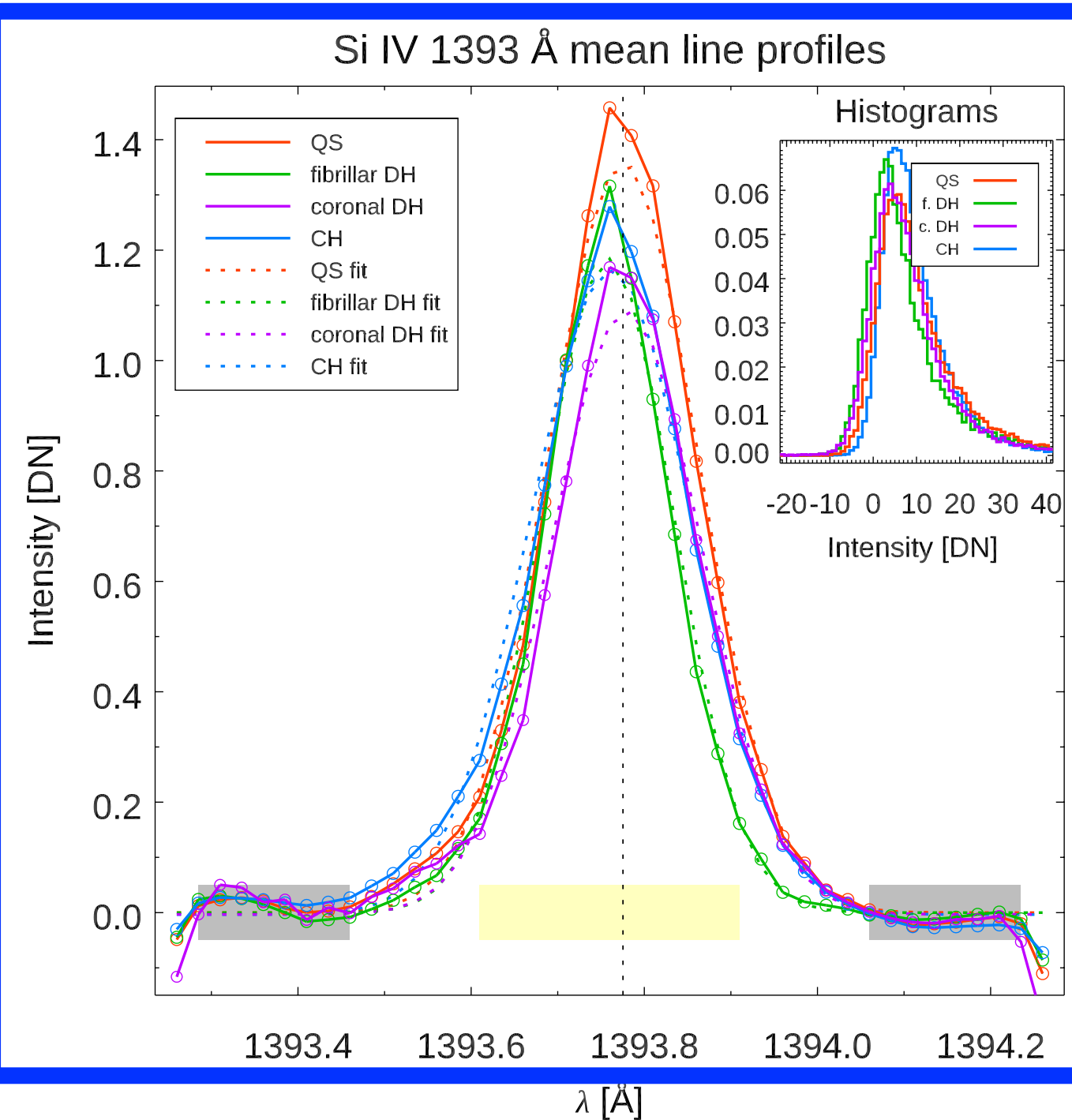
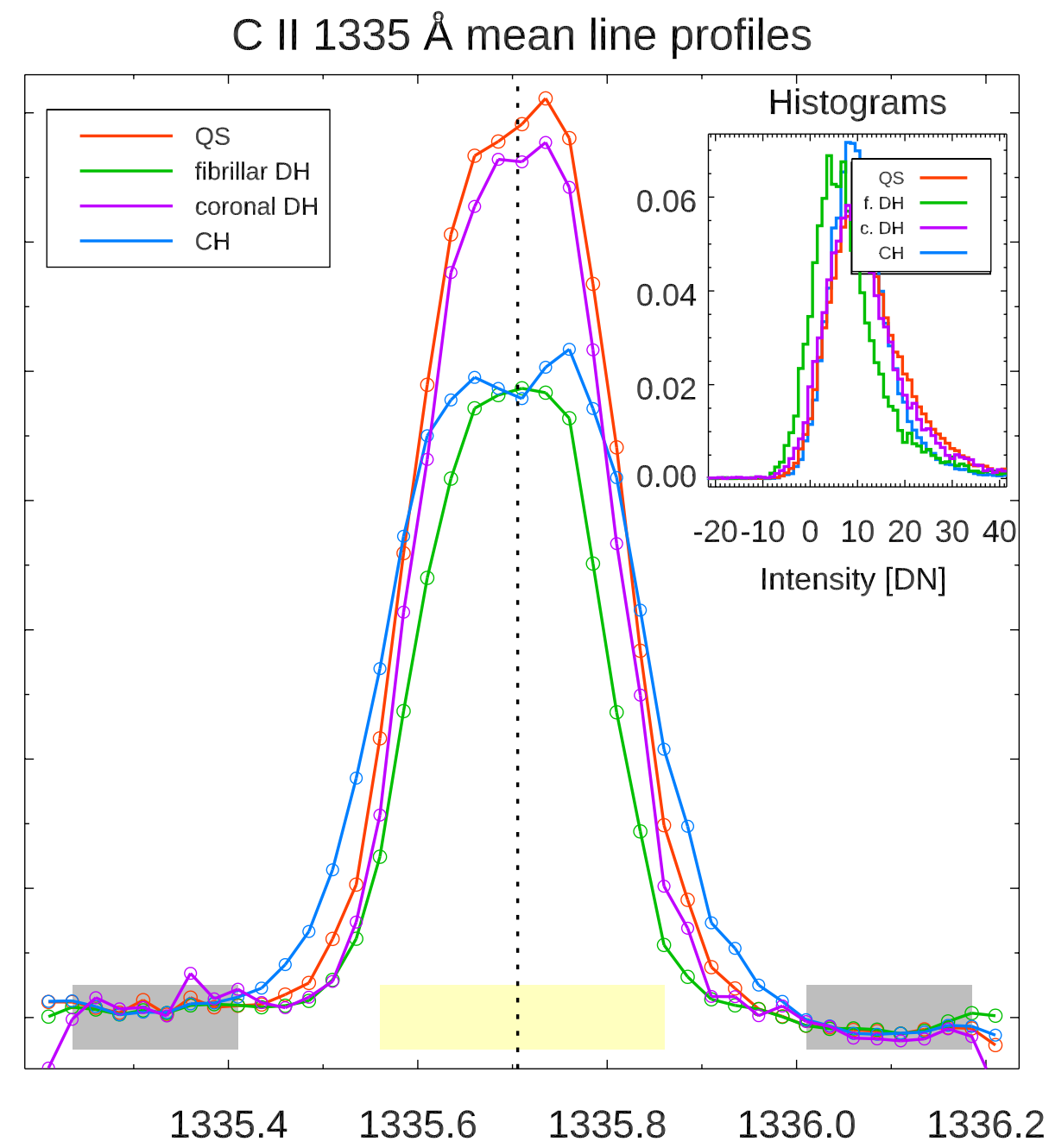
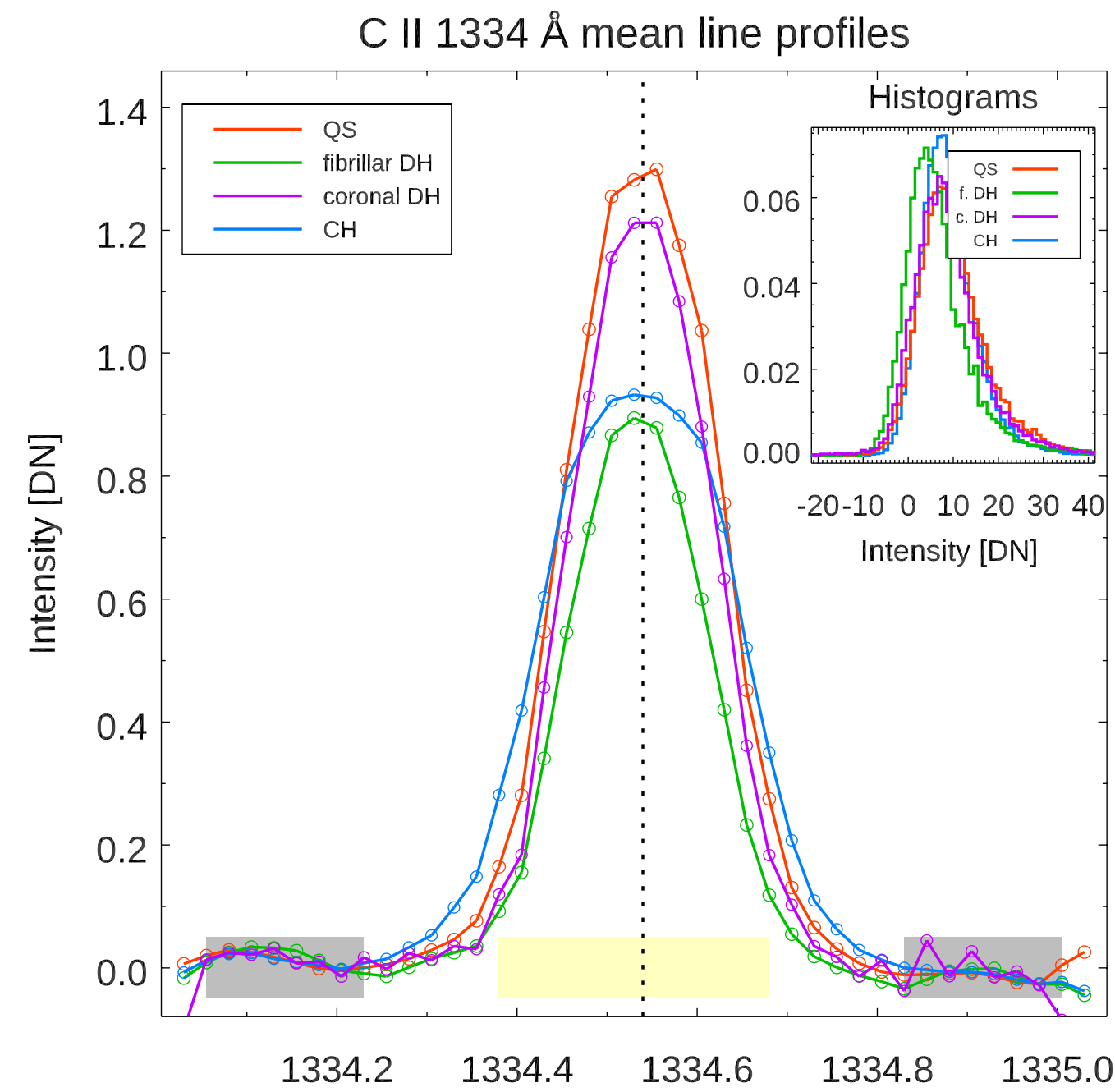


AIA 335 Å



IRIS mean line profiles

The different DH and CH line shapes suggest again that these are two distinct kind of structures

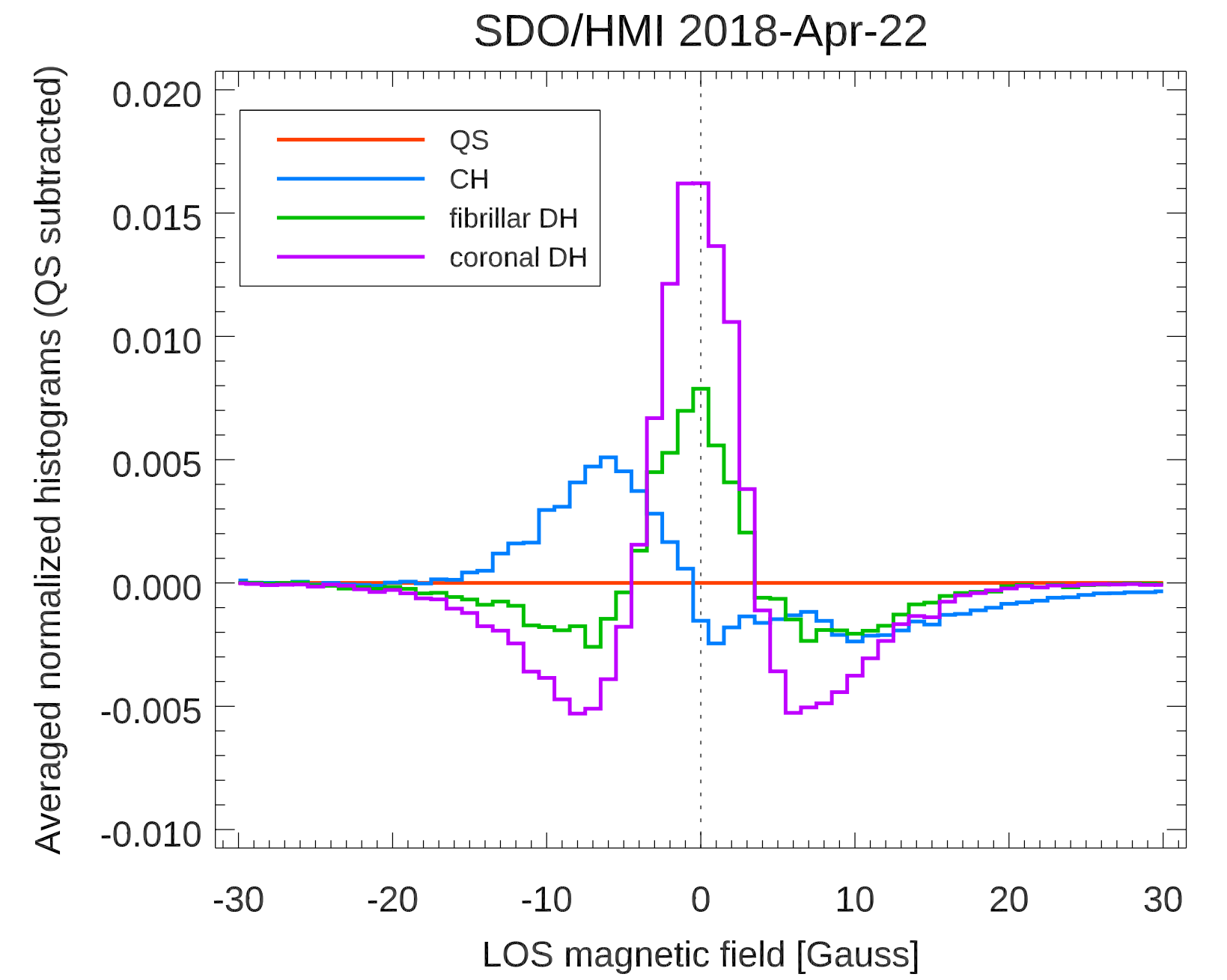
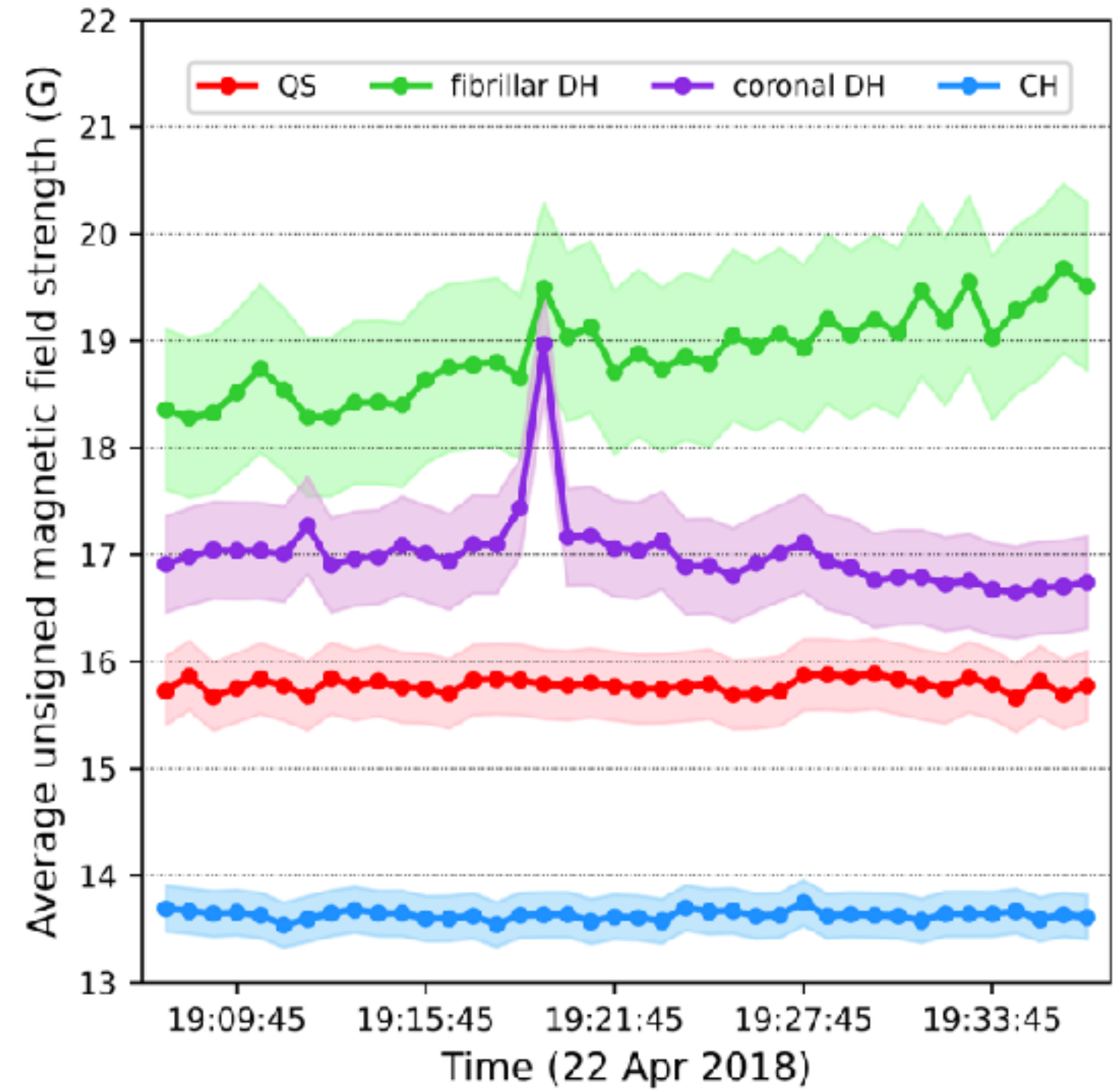
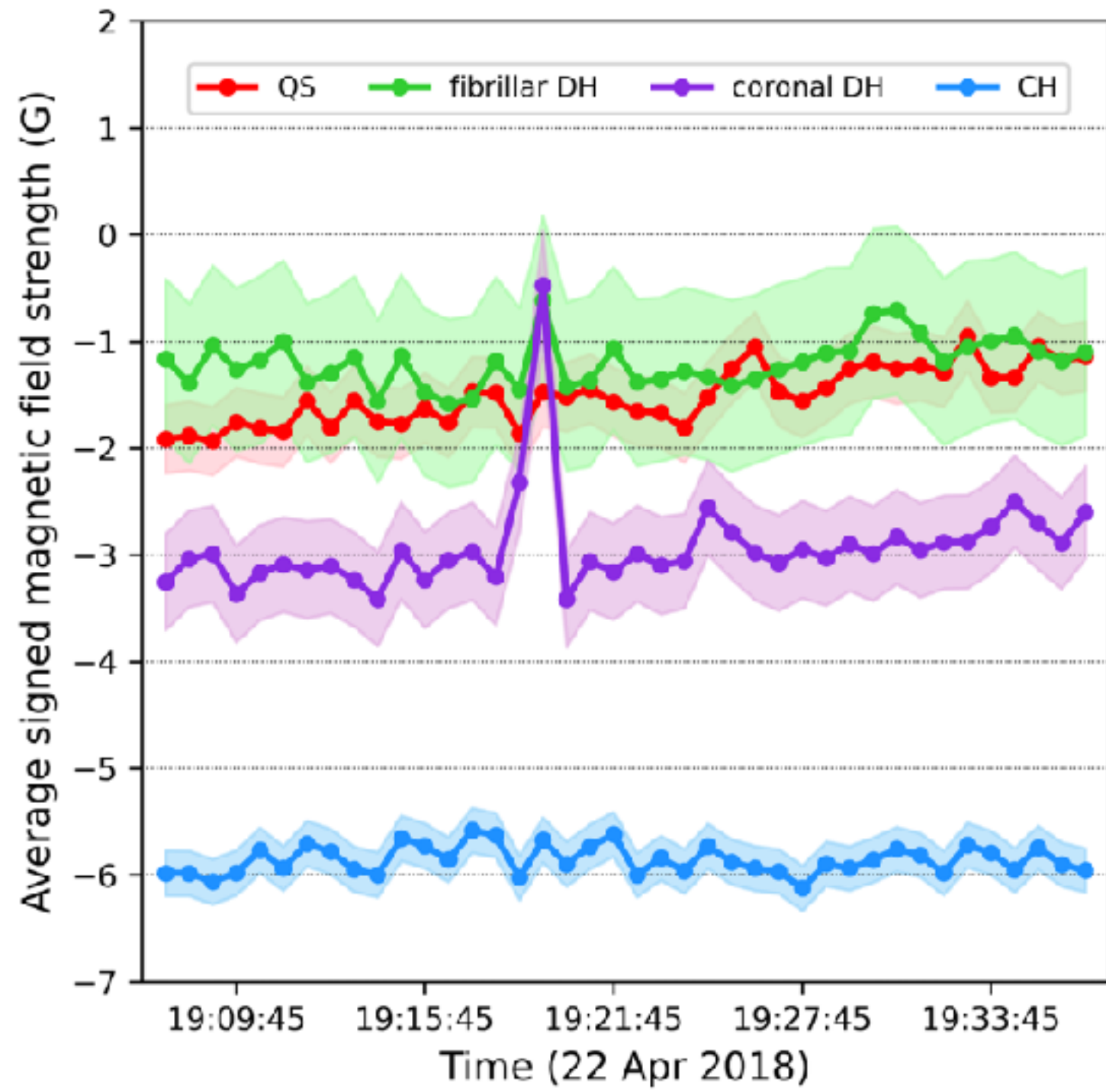


Si IV 1393 Å non-thermal velocities

$$\sigma^2 = \frac{\lambda_0^2}{2c^2} \left(\frac{2kT_i}{M} + \xi^2 \right) + \sigma_I^2$$

	ξ [km/s]
Fibrillar DH	22.2
Coronal DH	25.7
Quiet Sun	25.6
Coronal Hole	27.8

Magnetic field properties



CHIANTI v.9 vs v.7 (SSW)

