

Preview of First Results from Hi-C 2.1 and Coordinated Observations



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Sanjiv Tiwari (BAERI)
Harry Warren (NRL)



Solar Instrumentation Programs at MSFC

SOUNDING ROCKETS

- **SUMI** (J. Cirtain, PI)
 - Launched from WSMR on July 2012
- **Hi-C 1** (J. Cirtain, PI)
 - Launched from WSMR on July 11, 2012
- **Hi-C 2** (J. Cirtain, PI)
 - Launched from WSMR on July 27, 2016
- **Hi-C 2.1** (A. Winebarger, PI)
 - Launched from WSMR on May 29, 2018
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 - Scheduled to launch Spring, 2019
- **MaGIXS** (A. Winebarger, PI)
 - Scheduled to launch in August 2019

OBSERVATORIES

HINODE (Solar B)

- SOT: Solar Optical Telescope
- XRT: X-Ray Telescope
- EIS: EUV Imaging Spectrometer

COSIE

- Coronal Spectrographic Imager in the EUV

... Cameras & Optics

OPERATIONAL
FLOWN
IN DEVELOPMENT
PROPOSED

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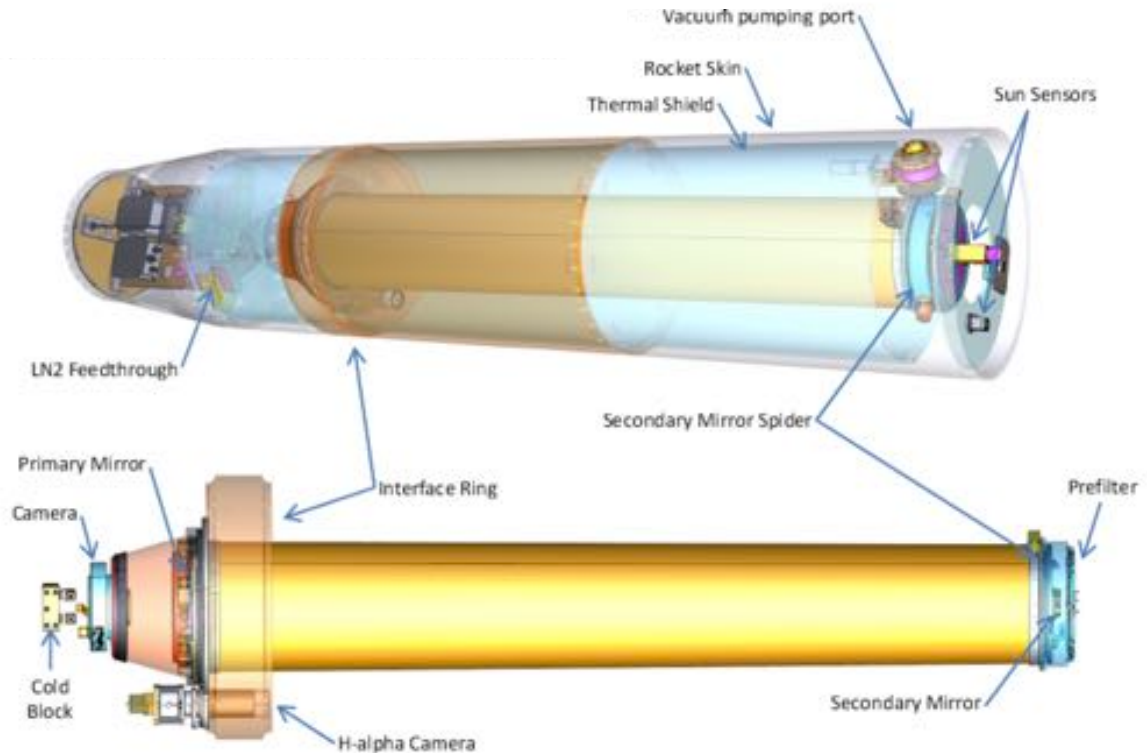
COSIE

- Coronal Spectrographic Imager in the EUV

... Cameras & Optics

Hi-C: High-resolution Coronal imager

- Telescope design capable of $\sim 0.2\text{-}0.3''$ (~ 150 km) spatial resolution imaging of the corona.
- Requires high rocket pointing stability to achieve resolution goal (Sparcs system).
- Capable of high-cadence observations through rapid CCD readout duration (~ 2 seconds) and data storage system.



Hi-C 1: High-resolution Coronal imager

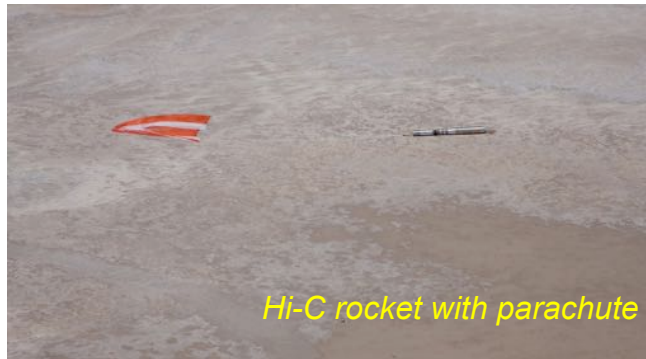
*Hi-C 1 Launch
White Sands, NM
July 11, 2012*



Hi-C recovery team



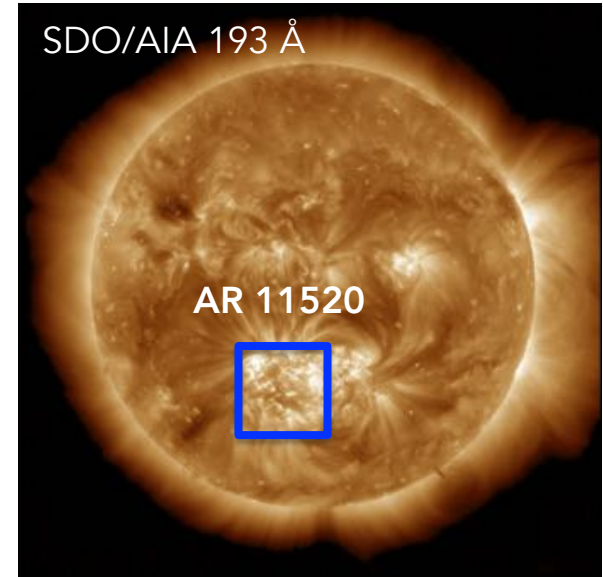
Hi-C rocket with parachute



Data available via the Virtual Solar Observatory (VSO).

Guidebooks available at hic.msfc.nasa.gov.

SDO/AIA 193 Å



AR 11520

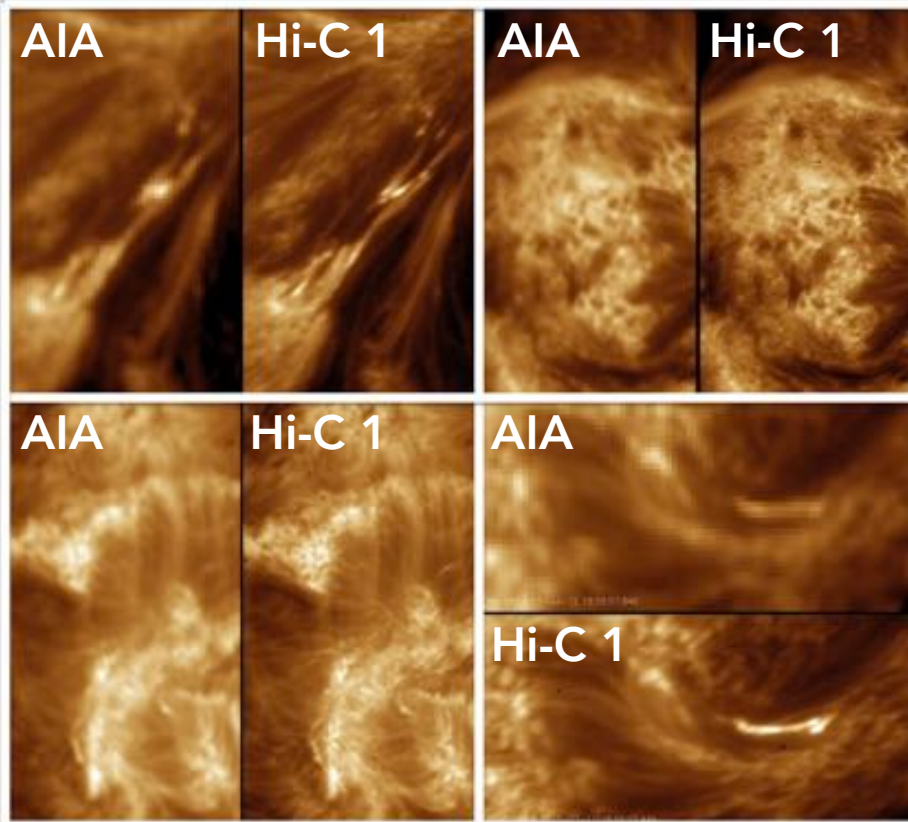
Hi-C 1: High-resolution Coronal imager

Bandpass – 193 Å [~ 1 & 10MK]

26 publications for 5 minutes of data! [<https://hic.msfc.nasa.gov/publications.html>]

Science highlights:

- Braided loops triggering energy release through magnetic reconnection
 - (*Cirtain et al. 2013, Nature*)
- Subflare triggers
- Nanoflare heating
- Loop sub-structure
- Moss dynamics
- Penumbral jets
- Flows along filament threads
- MHD waves



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Hi-C 2: High-resolution Coronal imager

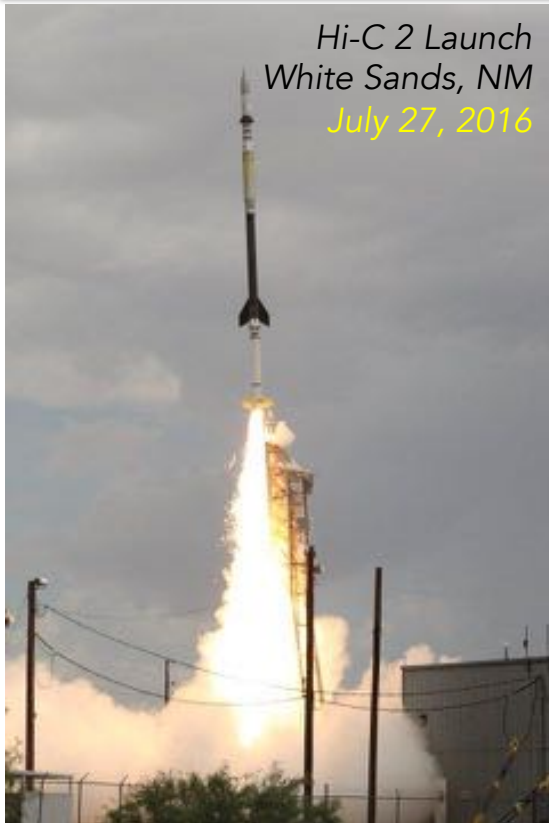
*Hi-C 2 Launch
White Sands, NM
July 27, 2016*

Hi-C 2 mirror recoated to explore the important Chromospheric-Coronal Connection by targeting specific candidates likely to contribute to coronal heating:

1. Type II spicules
2. Hot active region core loops

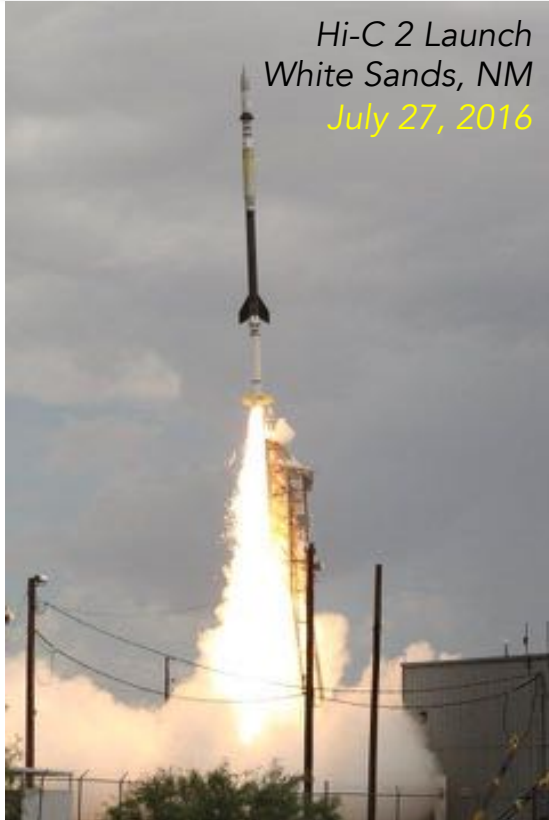
Updates for re-flight:

- Cooler bandpass centered on **172 Å** (~.6 MK)
- Significant improvement in camera quality (new MSFC-build designed for super low noise)
- **IRIS!**

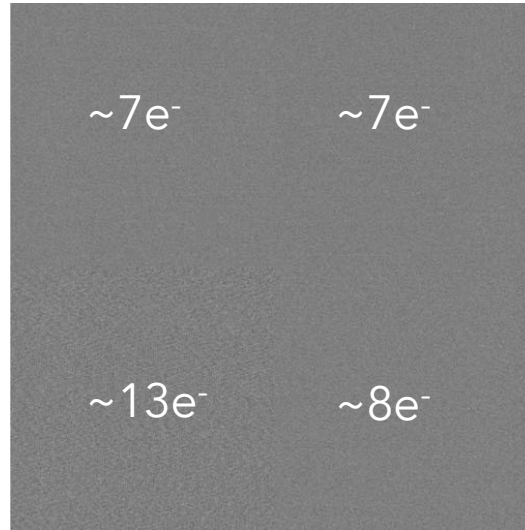


Hi-C 2: High-resolution Coronal imager

*Hi-C 2 Launch
White Sands, NM
July 27, 2016*



Fantastic flight performance
verification of the low-noise
MSFC-built camera.



Hi-C 2...: High-resolution Coronal imager

Cleaned up

Checked alignment

Upgraded cooling system

Added Hall Effect Sensor

Re-proposed

Solar Instrumentation Programs at MSFC

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Hi-C **2.1**: High-resolution Coronal imager

3.5 months after ATP....

Hi-C 2.1: High-resolution Coronal imager

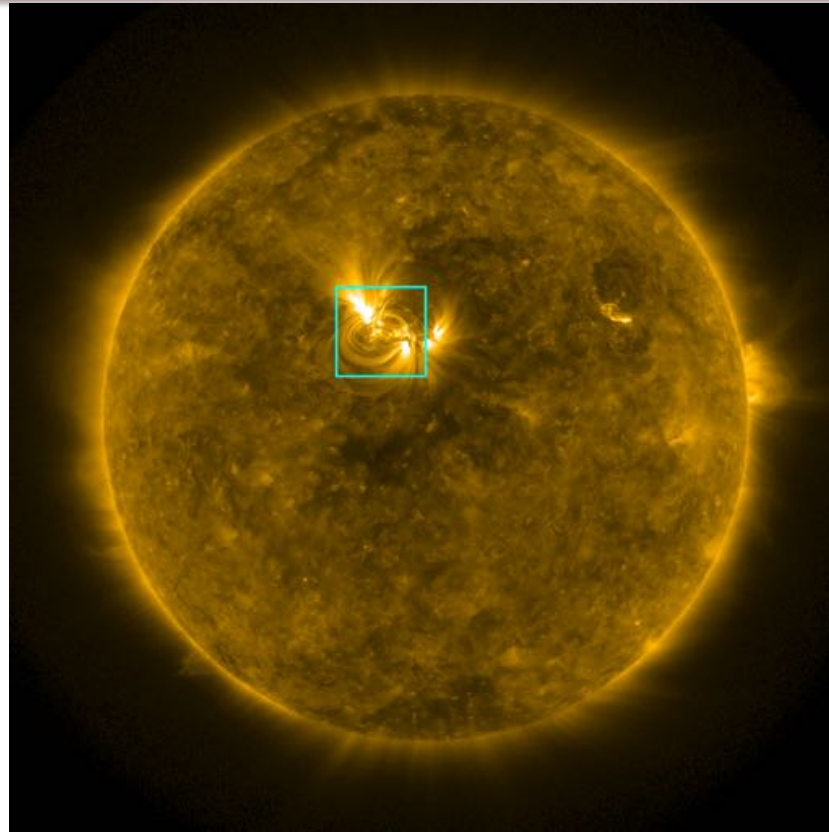
*Hi-C 2.1 Launch
White Sands, NM
May 29, 2018*



Hi-C 2.1: High-resolution Coronal imager

2018 May 29
18:54 UT

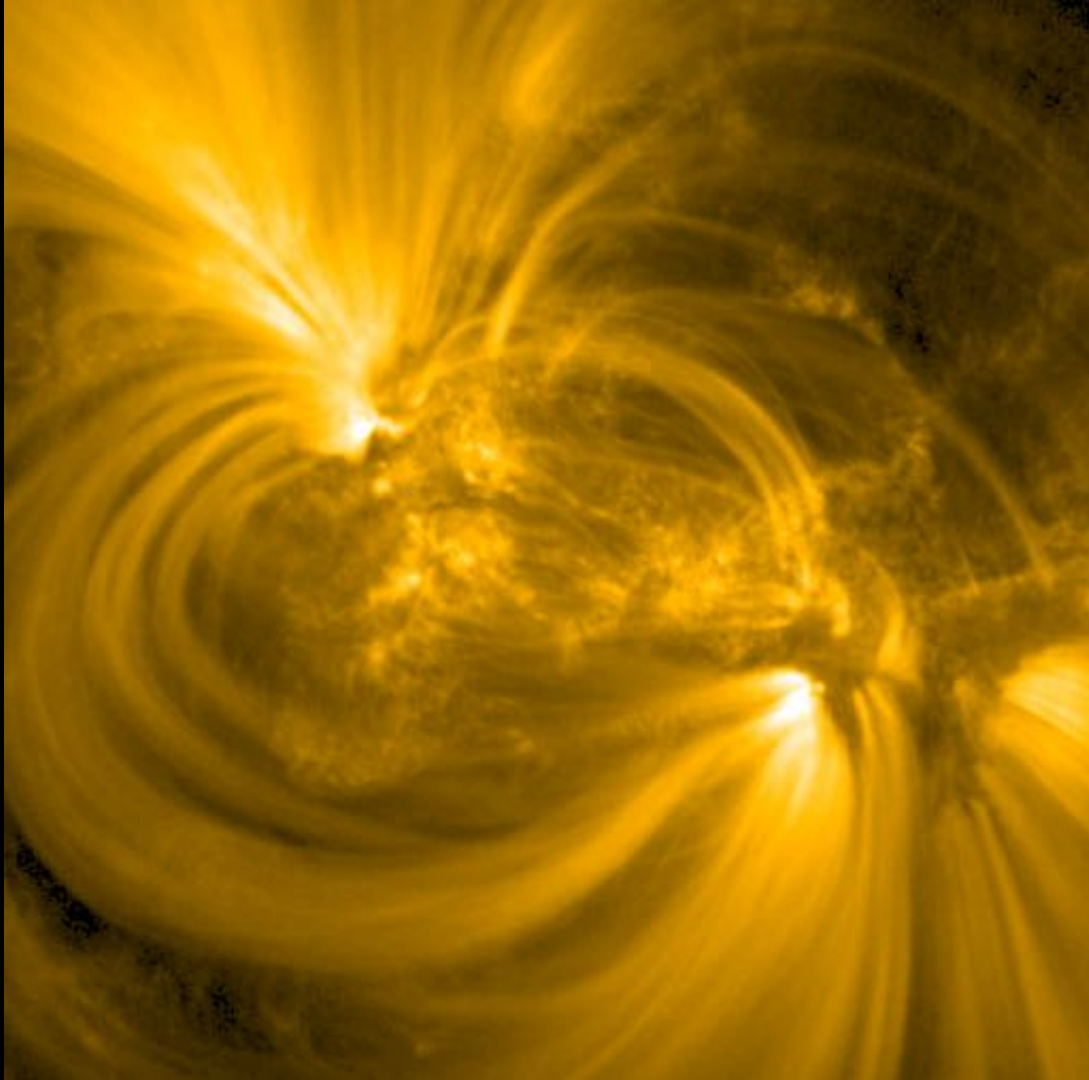
Target: AR 12712



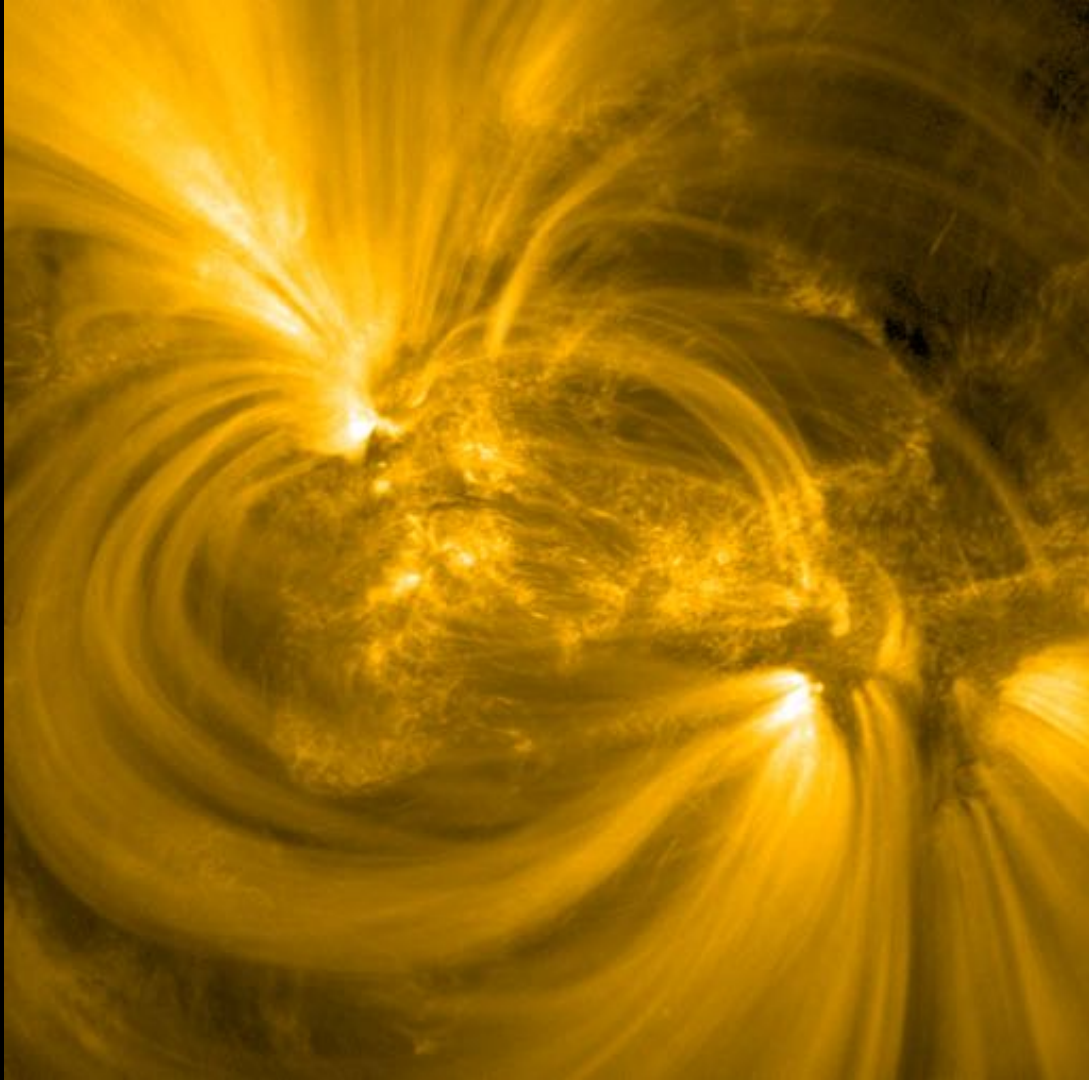
~ 15 minute flight

~ 5 minutes of solar
viewing data

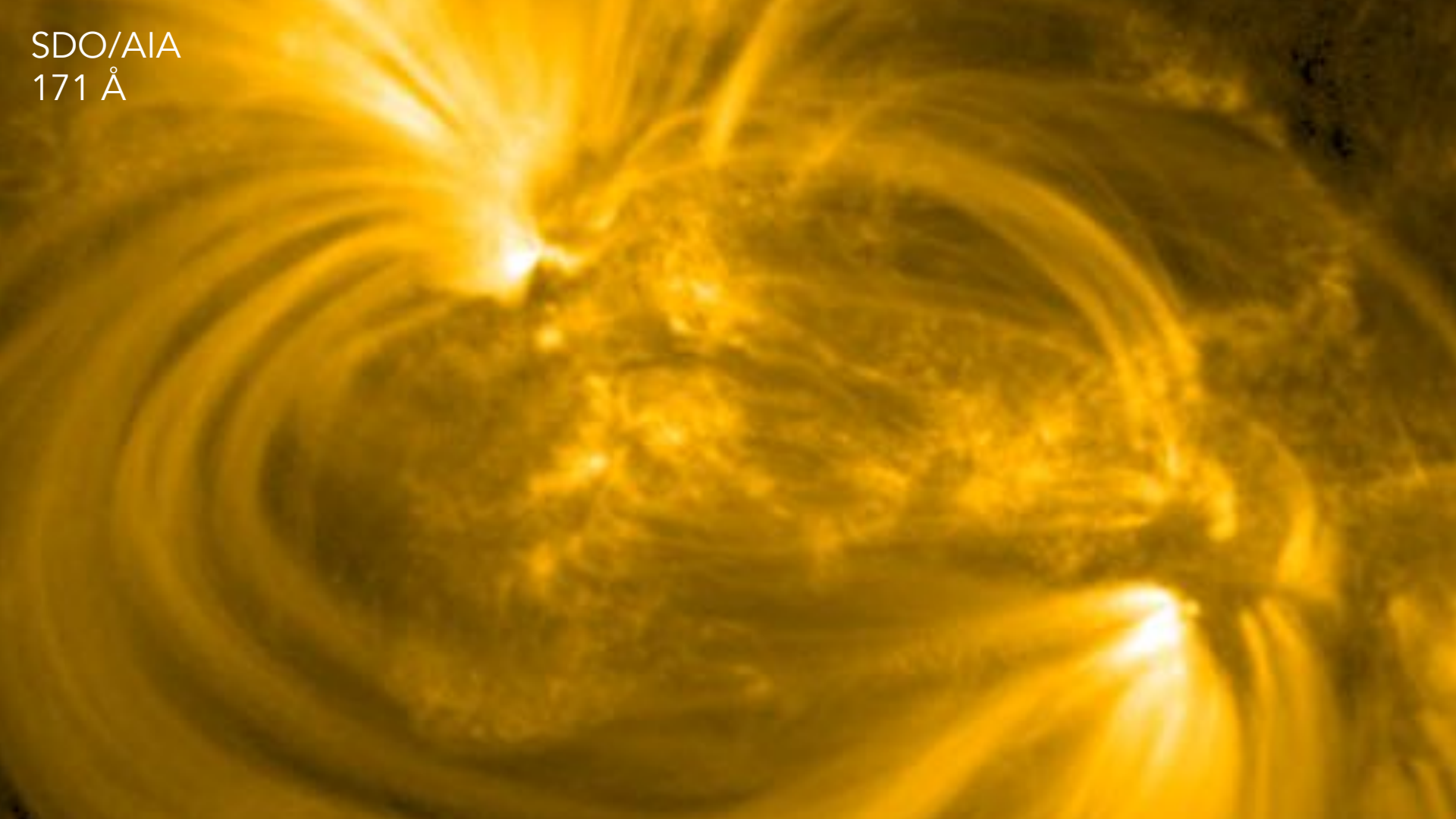
SDO/AIA
171 Å



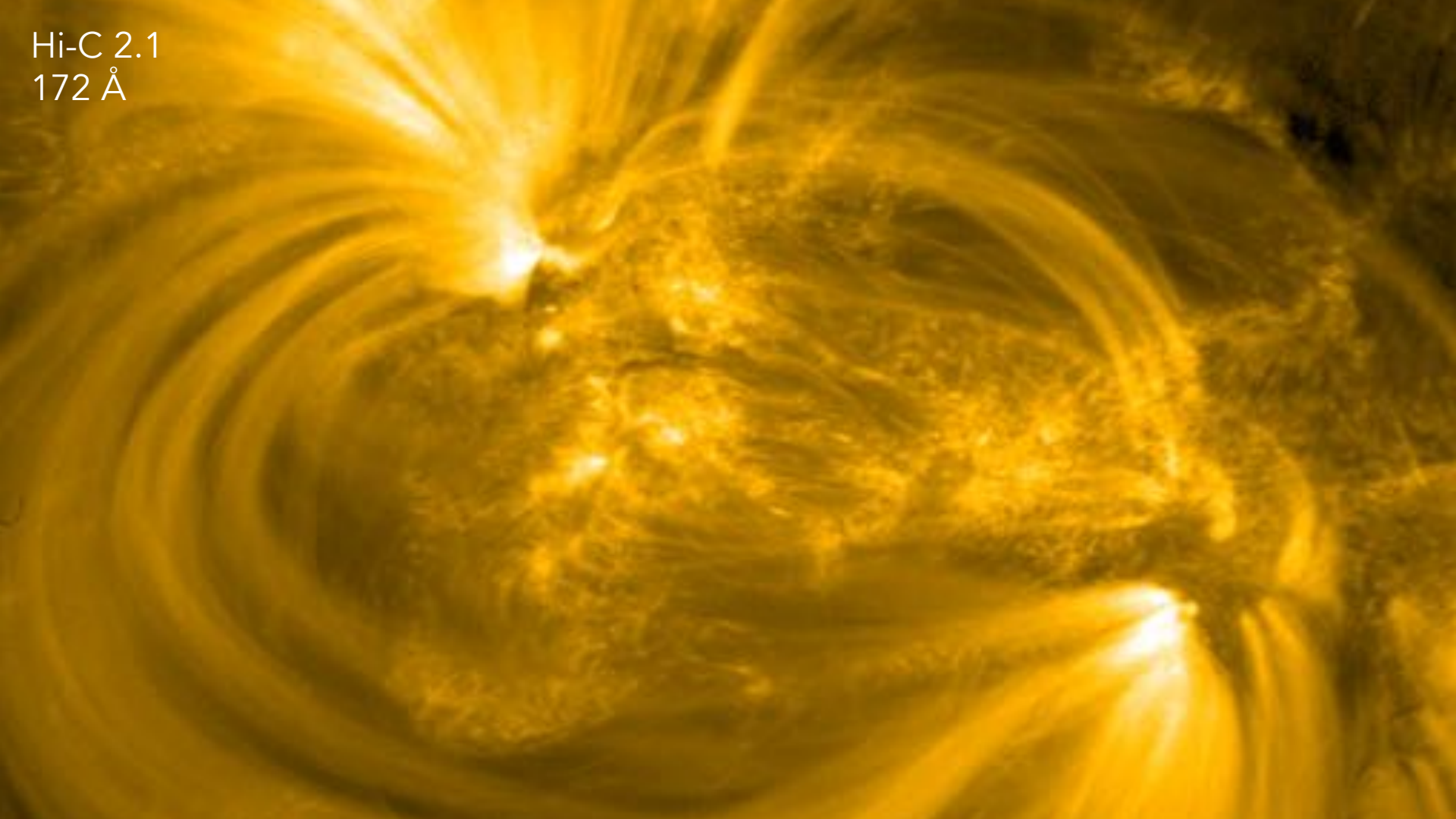
Hi-C 2.1
172 Å



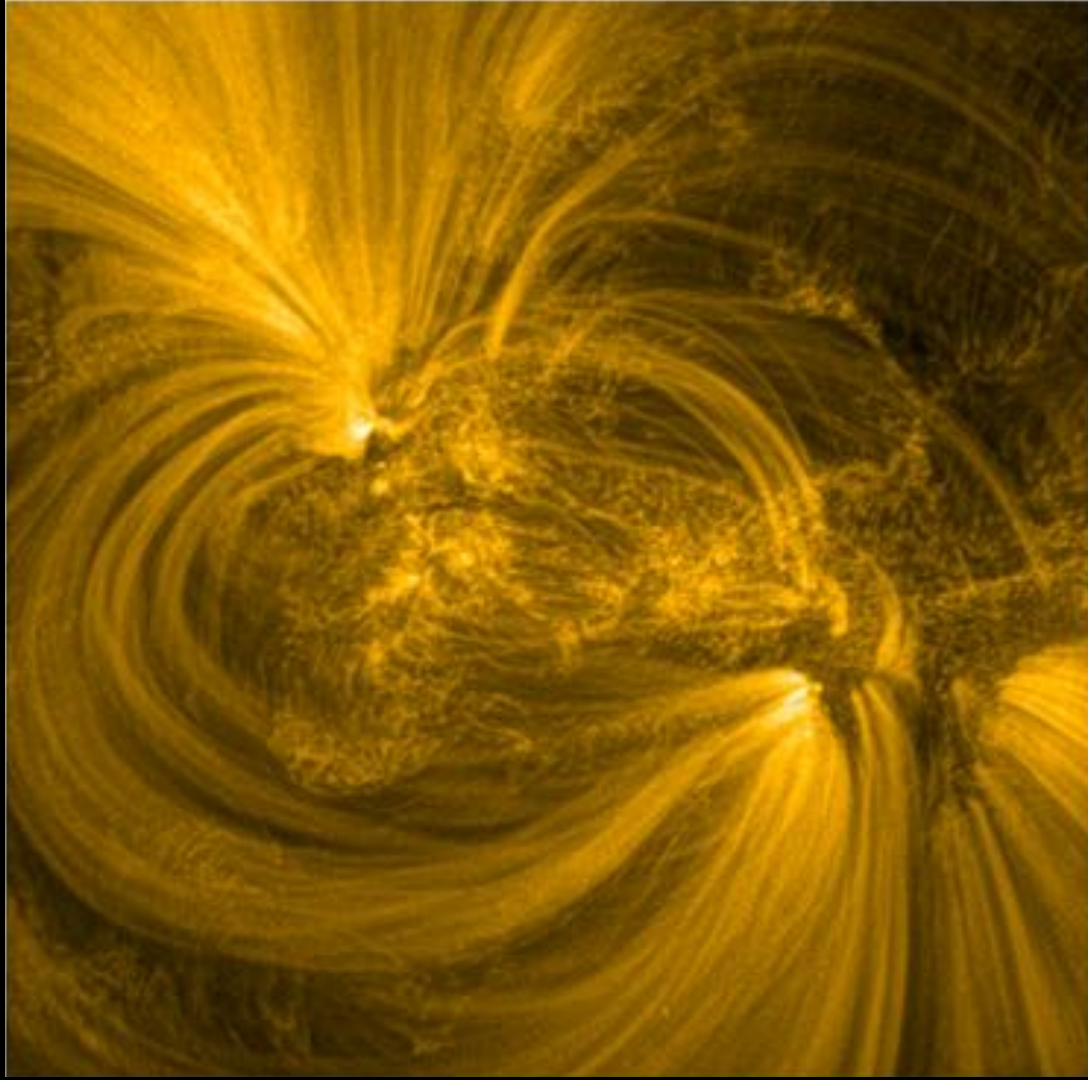
SDO/AIA
171 Å



Hi-C 2.1
172 Å

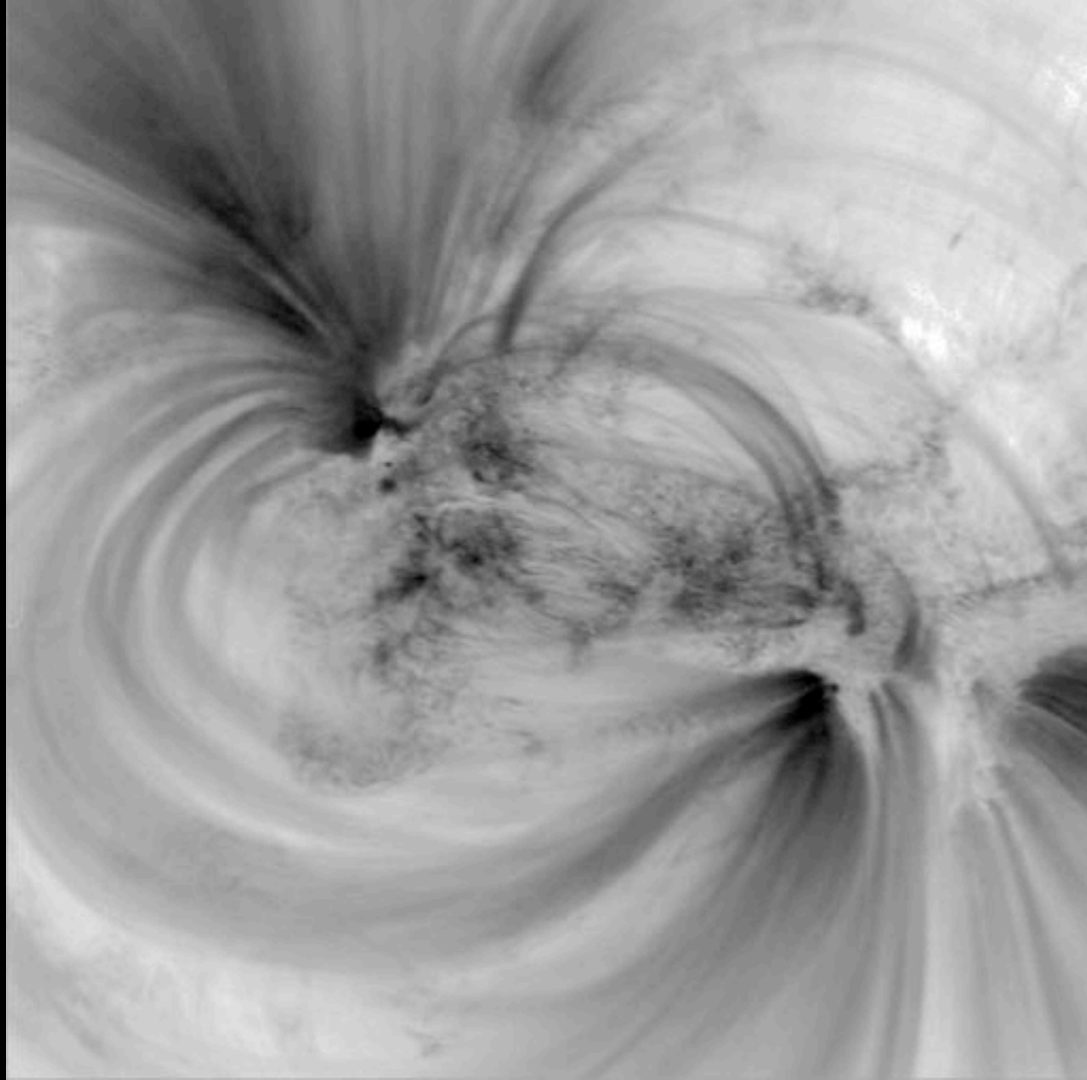


Hi-C 2.1
172 Å



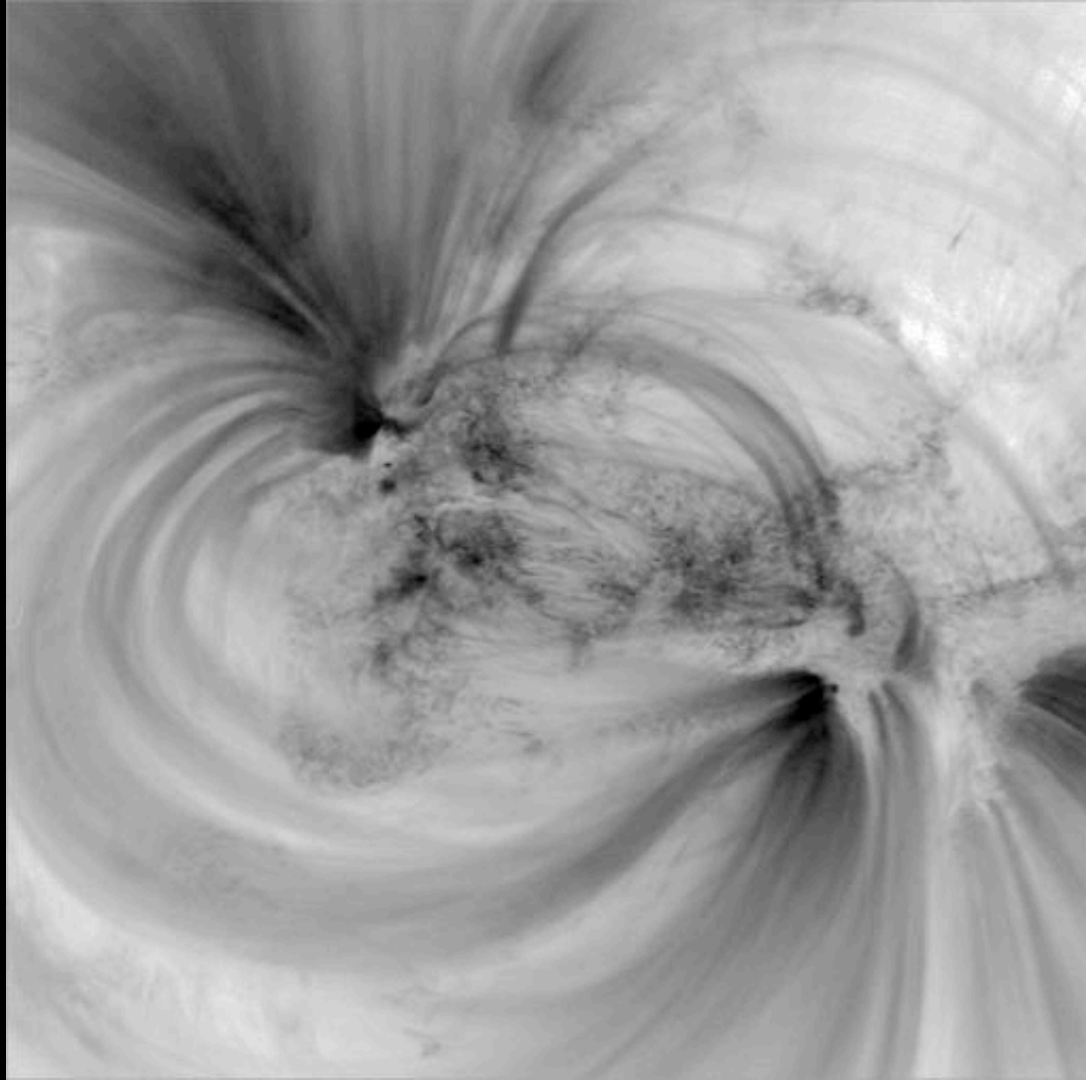
Sharpened

Hi-C 2.1
172 Å



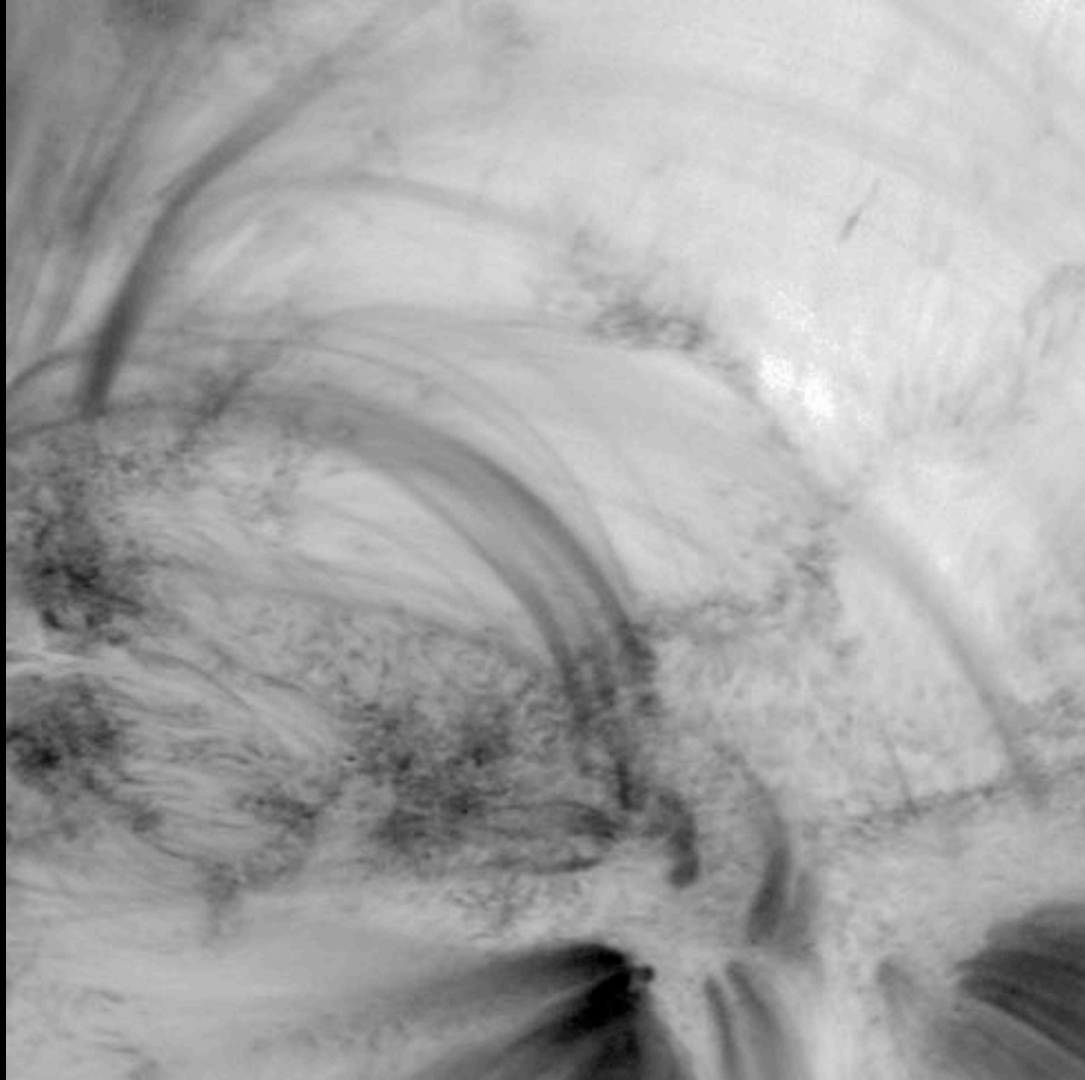
With Jitter

Hi-C 2.1
172 Å



Without Jitter

Hi-C 2.1
172 Å



Without Jitter
Zoomed in

Hi-C 2.1: What makes this instrument work?

HIGH SPATIAL RESOLUTION

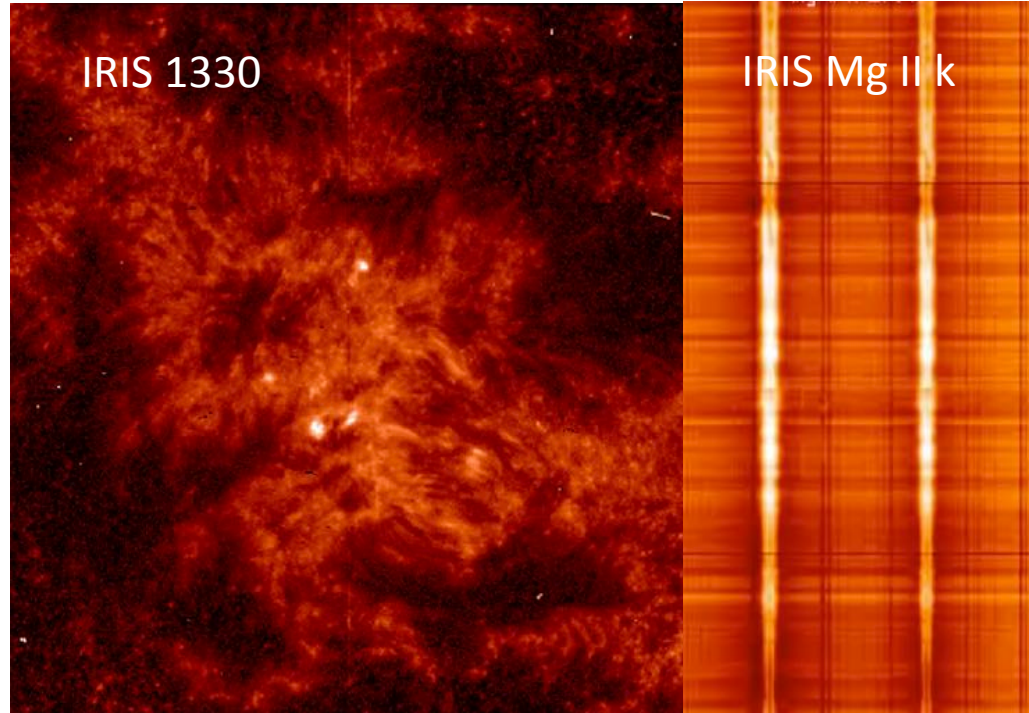
HIGH TEMPORAL RESOLUTION

LOW NOISE CAMERA

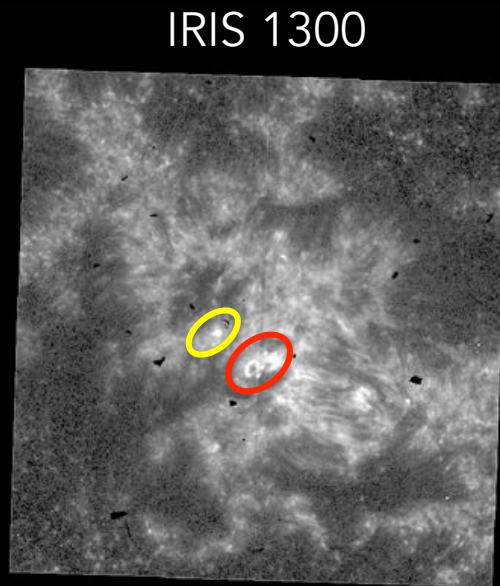
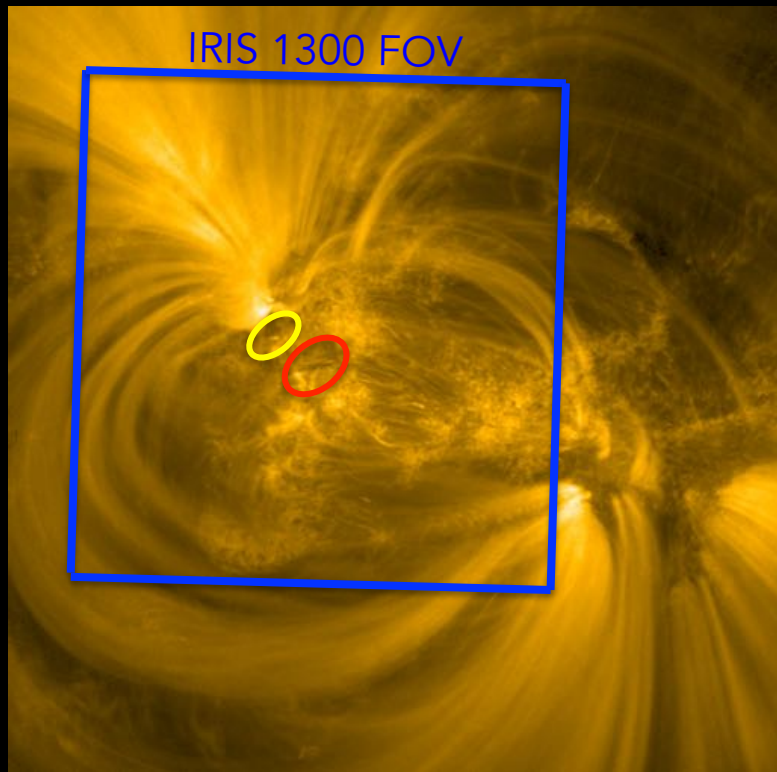
COORDINATED DATA SETS

Hi-C 2.1: IRIS coordinated data

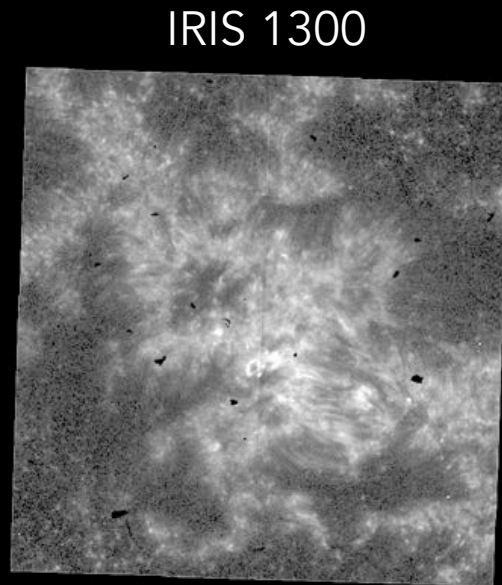
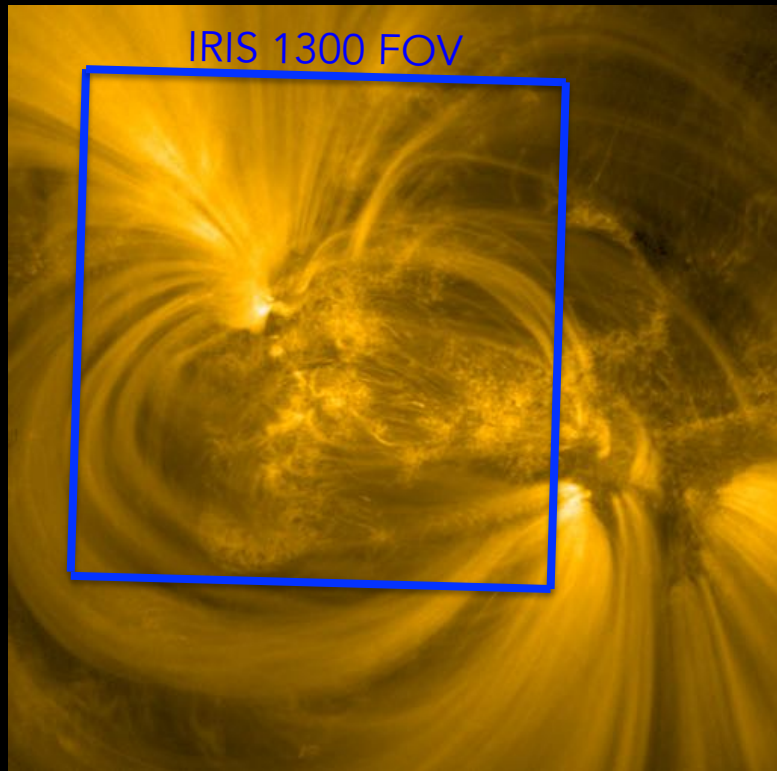
IRIS observations of a subset of the region at high resolution and spectra will be used to tie small features in the chromosphere to those in the corona.



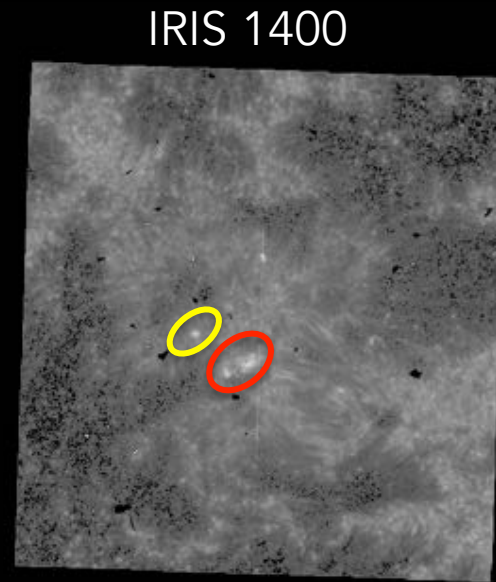
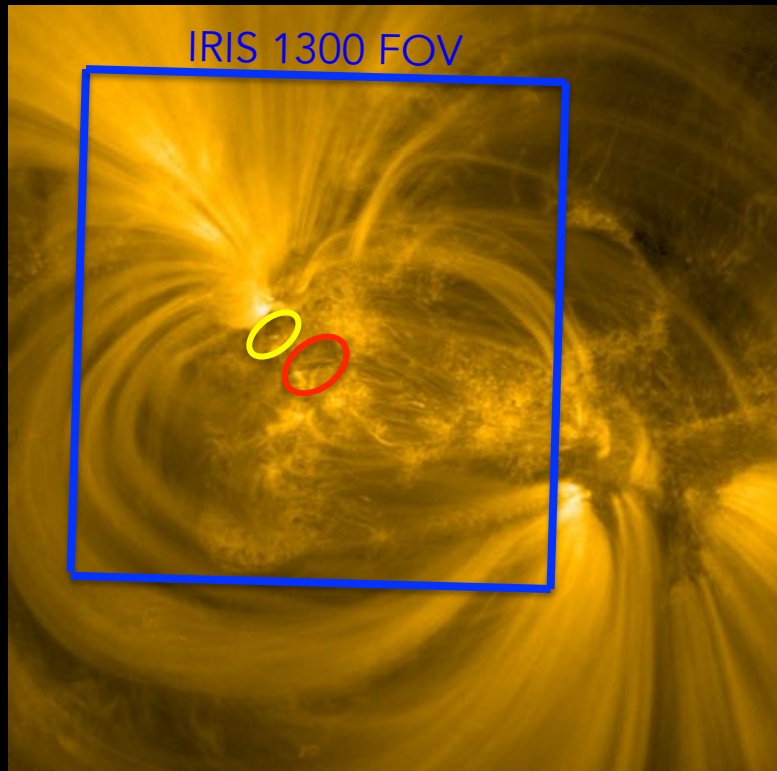
Hi-C 2.1: IRIS coordinated data



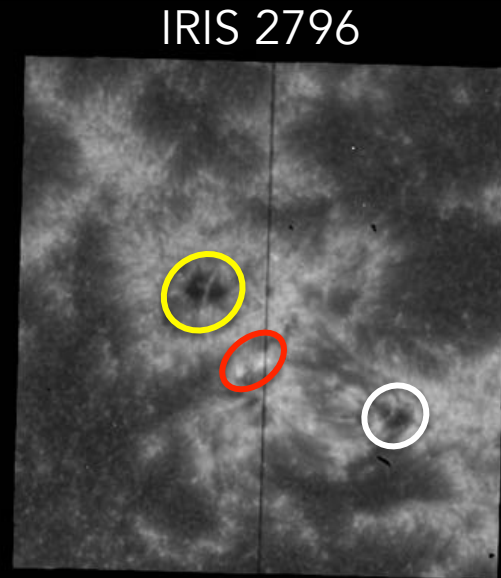
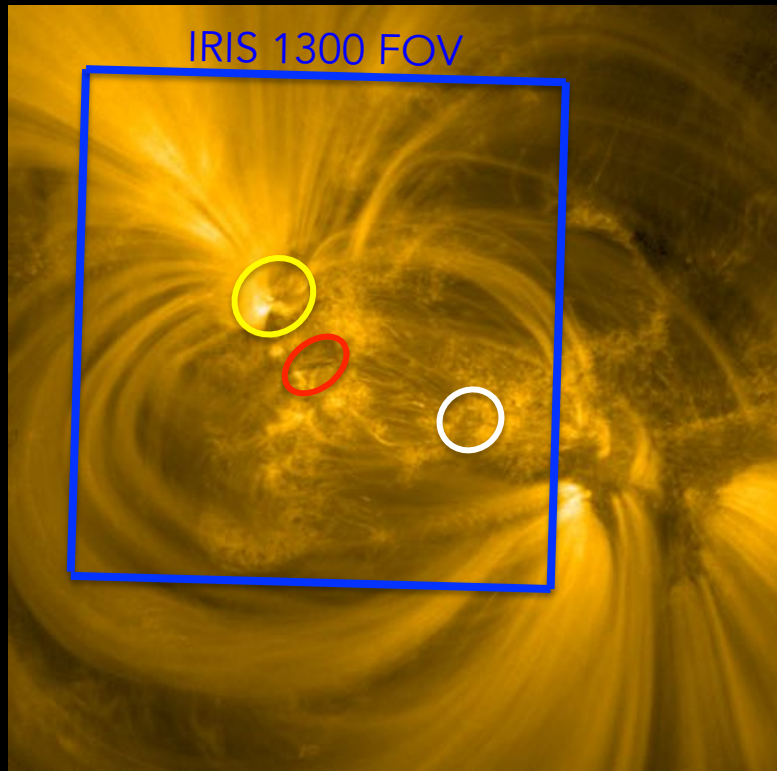
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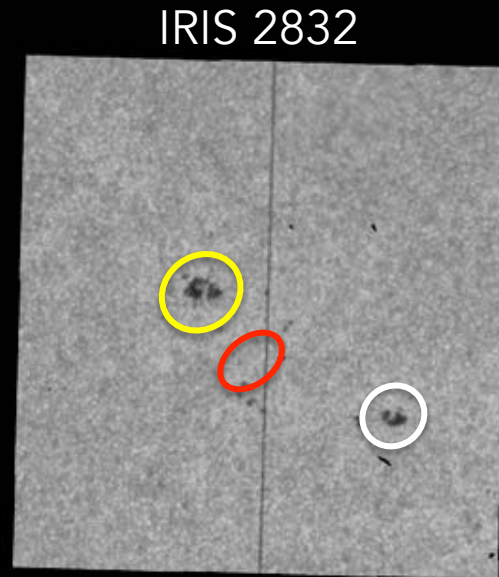
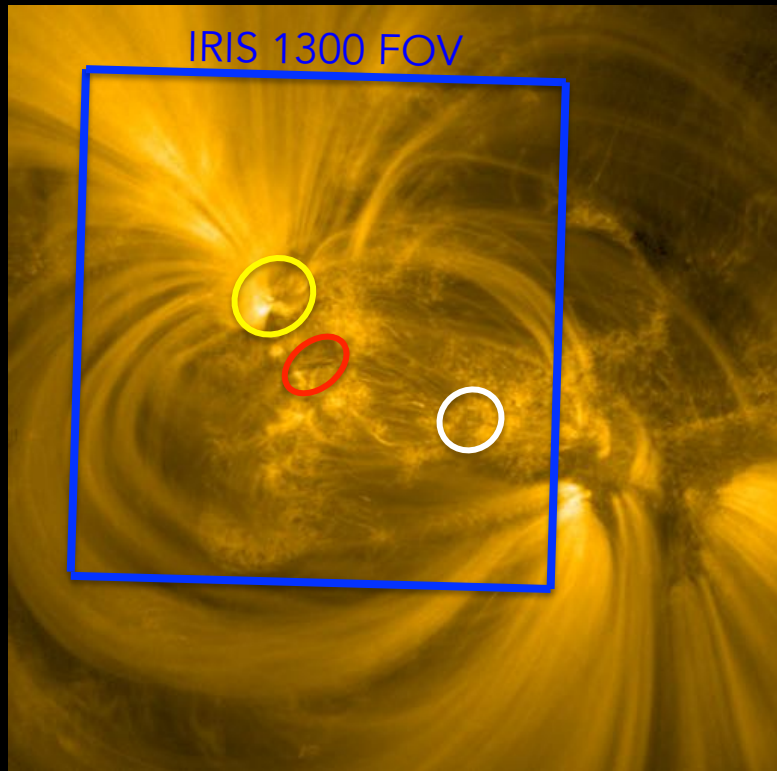
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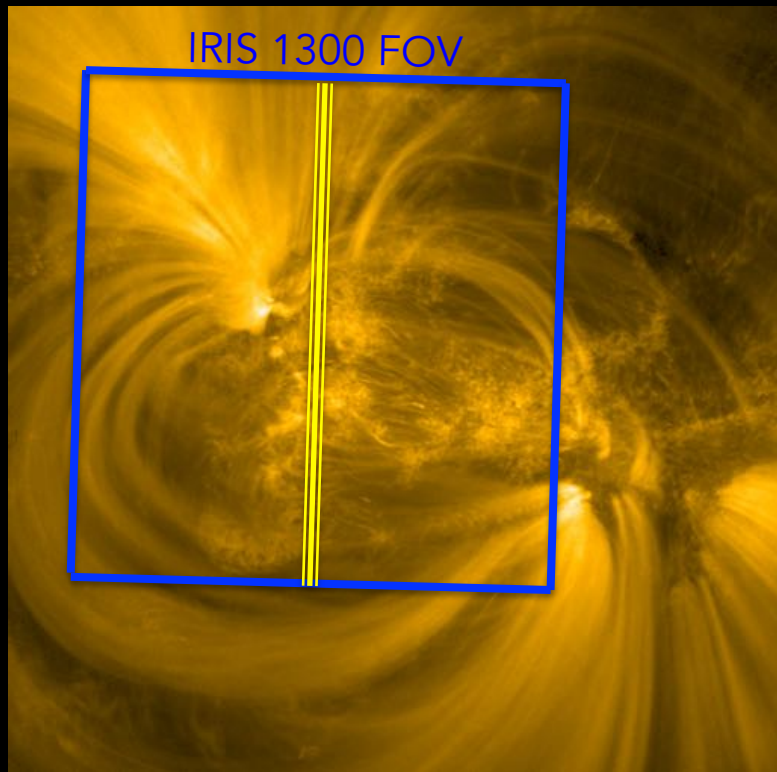
Hi-C 2.1: IRIS coordinated data



Hi-C 2.1: IRIS coordinated data



Hi-C 2.1: IRIS coordinated data



Hi-C 172



IRIS Si IV



IRIS Mg II k



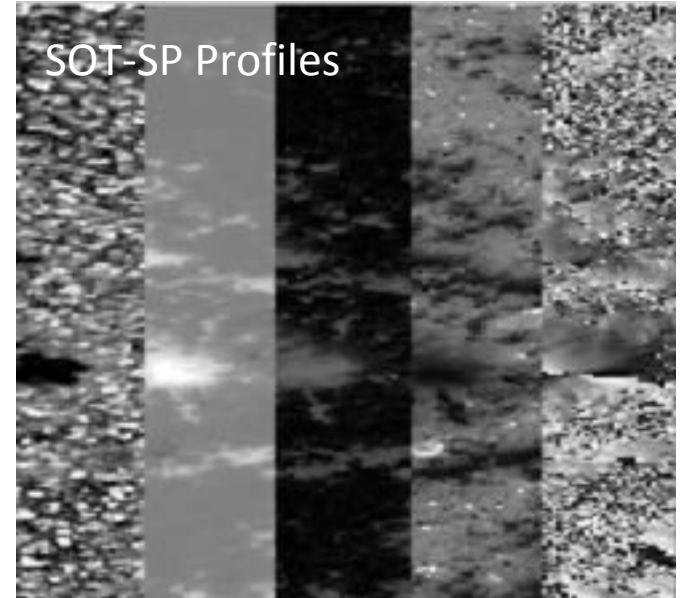
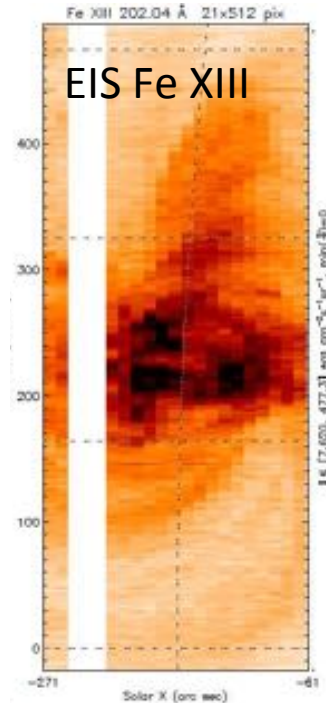
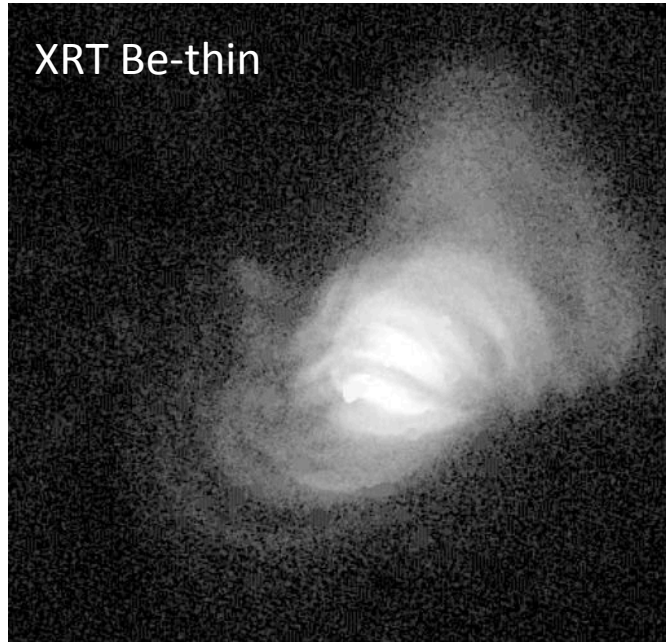
Hi-C 2.1: Hinode coordinated data

All three Hinode instruments successfully captured the Hi-C 2.1 region.

- XRT provides coronal context of the movement of hot plasma in the upper atmosphere above the Hi-C features.
 - EIS provides narrowband spectra of the hot coronal loops thereby precisely measuring plasma flow properties.
 - SOT-SP provides underlying magnetic field information to high precision.
-

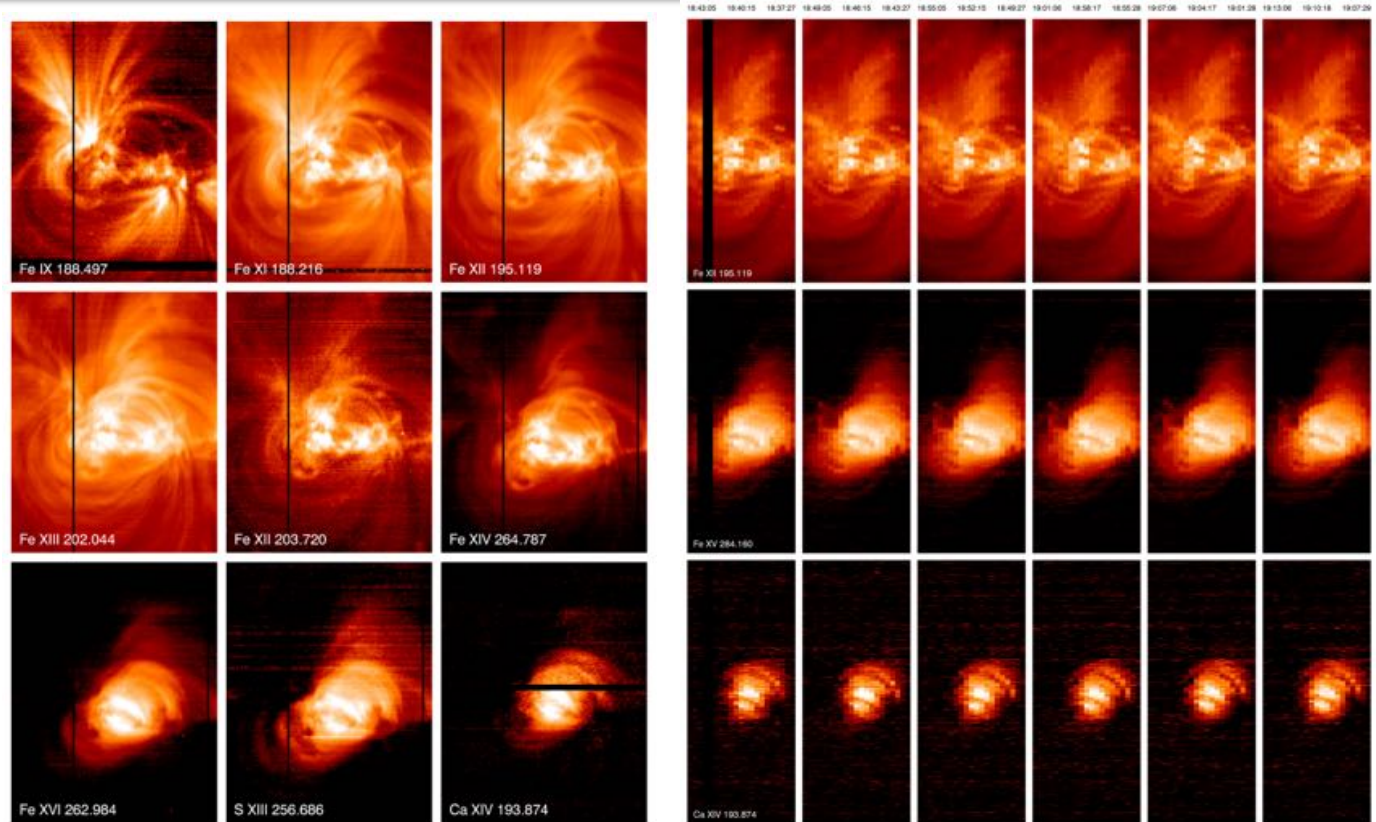
Hi-C 2.1: Hinode coordinated data

All three Hinode instruments successfully captured the Hi-C 2.1 region.



Hi-C 2.1: Hinode coordinated data

**EIS BACK
just in time!**



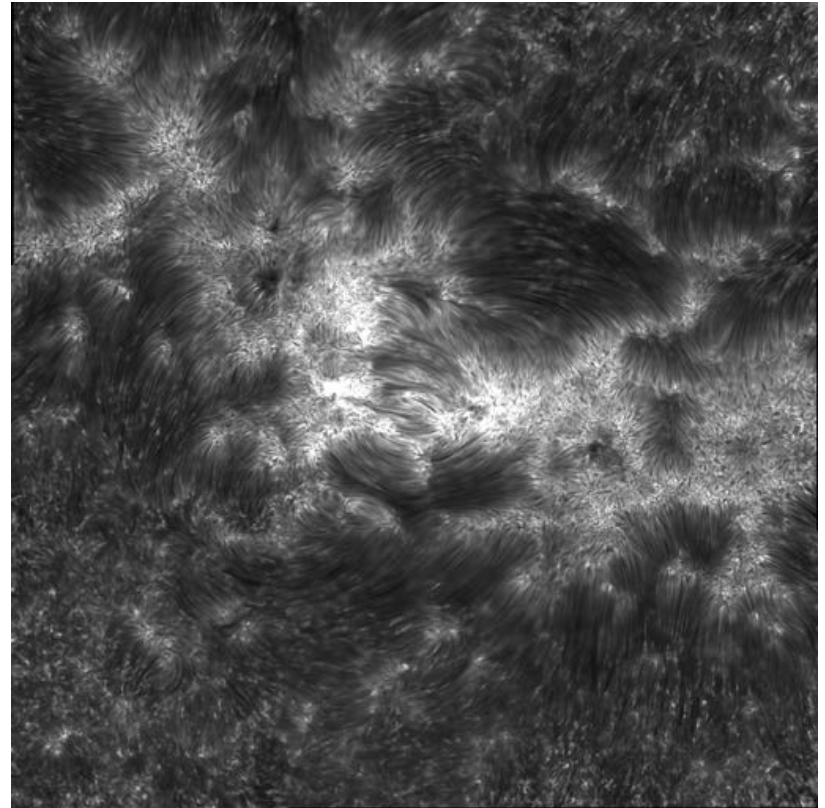
Hi-C 2.1: Additional Coordinated Data Sets

- ✧ NSO / IBIS
- ✧ NuSTAR
- ✧ BBSO
- ✧ Owens Valley
- ✧ ~SST

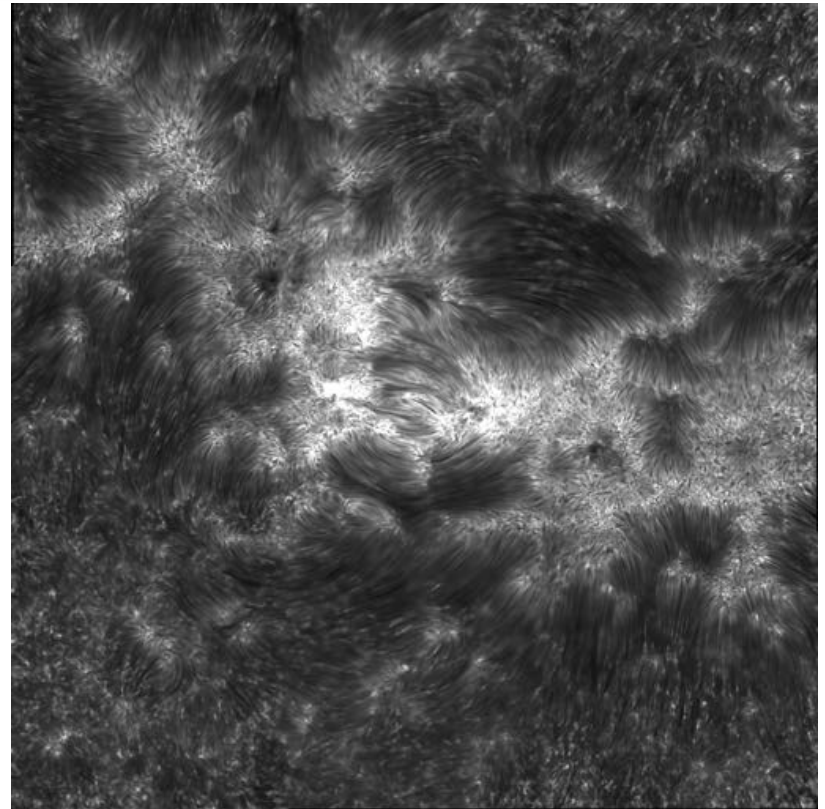
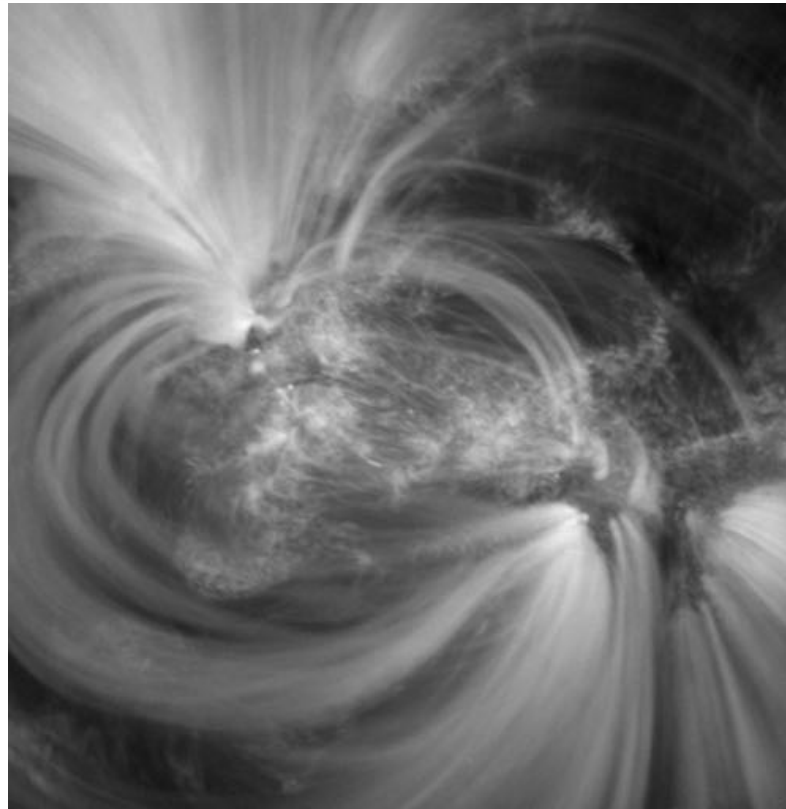
Hi-C 2.1: IBIS coordinated data

- ✧ NSO / IBIS
- ✧ NuSTAR
- ✧ BBSO
- ✧ Owens Valley
- ✧ ~SST

IBIS Mosaic
14:19 – 15:13 UT
Ca II 8542 Å

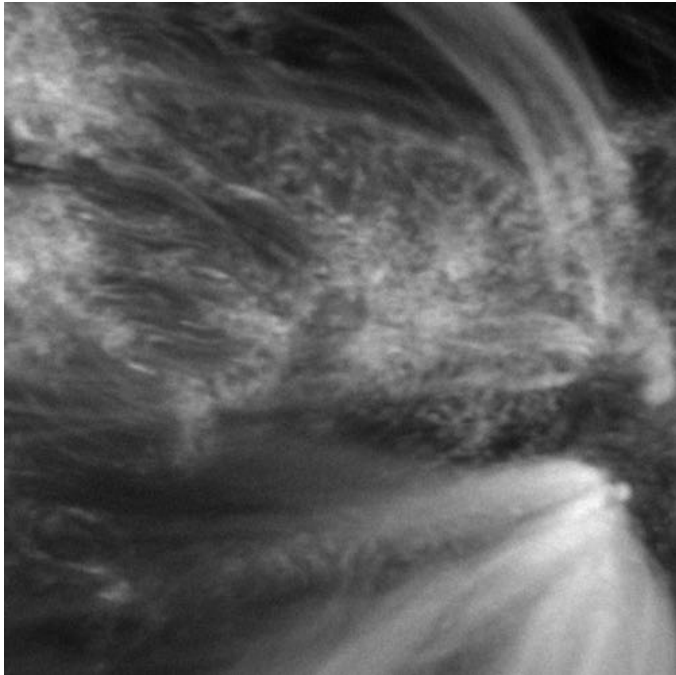


Hi-C 2.1: IBIS coordinated data

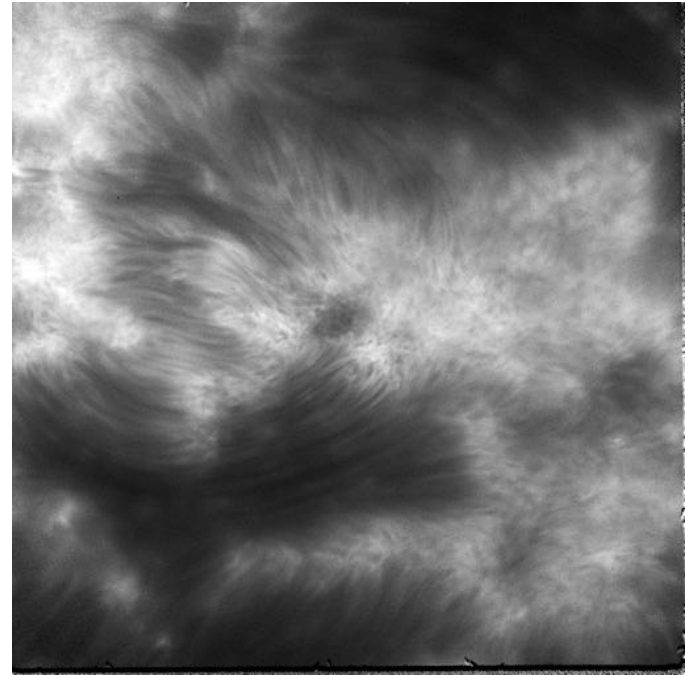


Hi-C 2.1: IBIS coordinated data

Hi-C 172 Å
18:56:22 UT

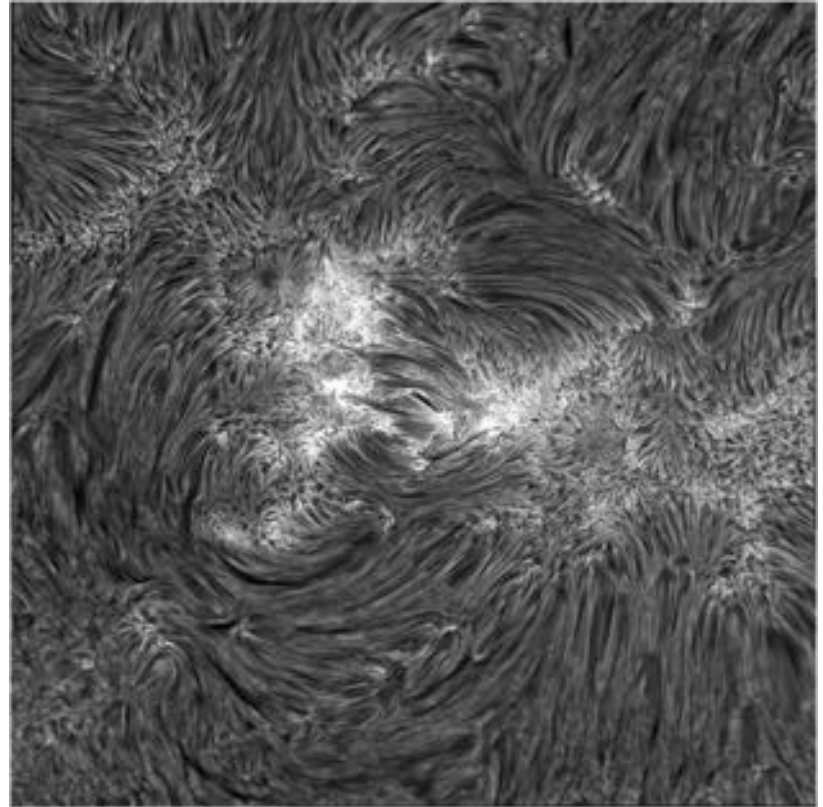


IBIS Ca II 8542 Å
18:56:53 UT

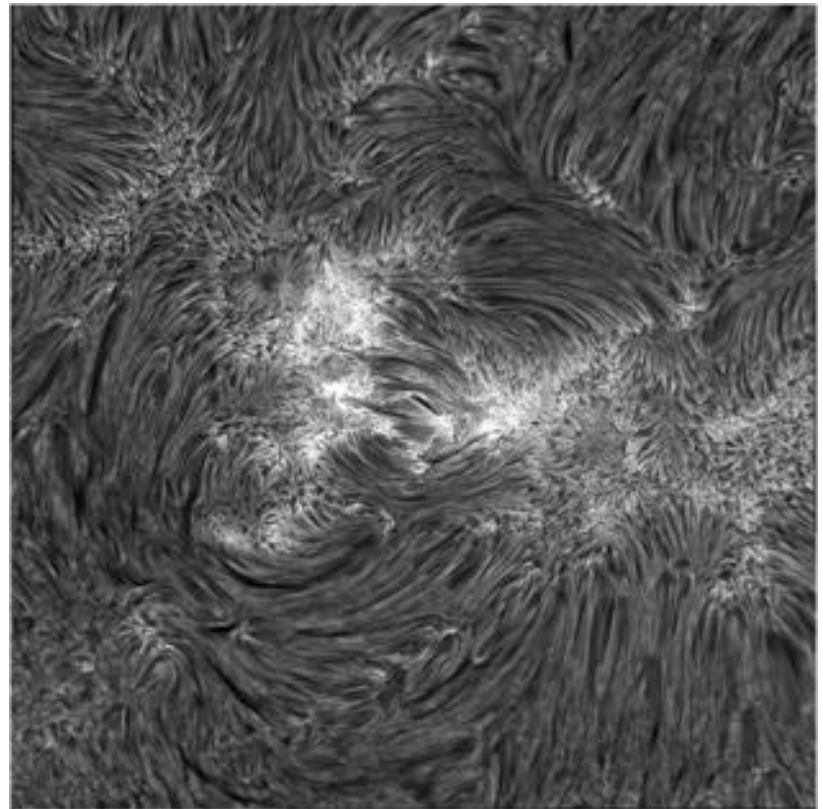
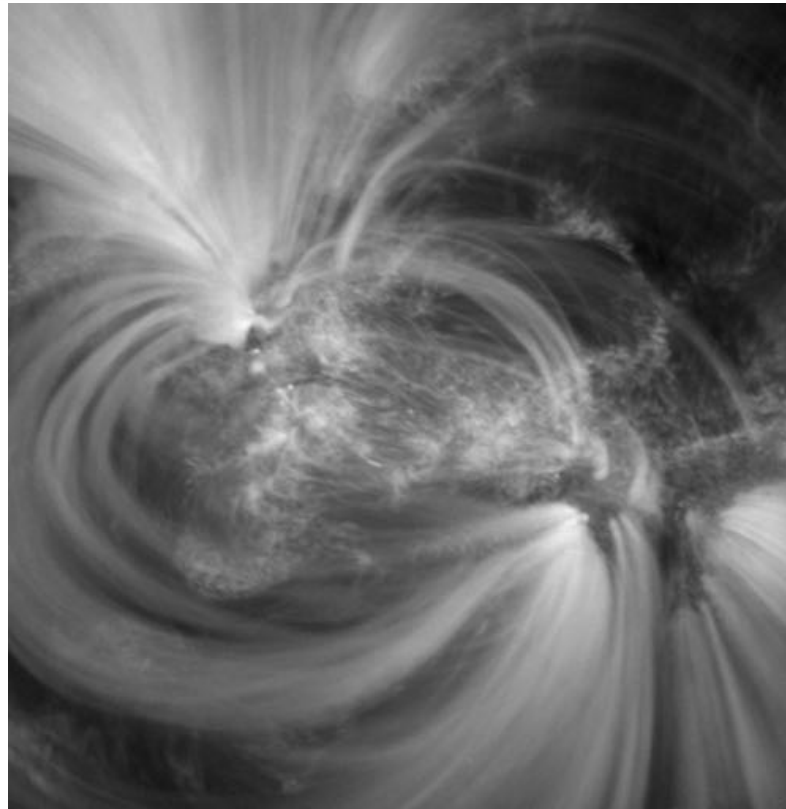


Hi-C 2.1: IBIS coordinated data

IBIS Mosaic
14:19 – 15:13 UT
H α 6563 Å
0.098 "/pixel

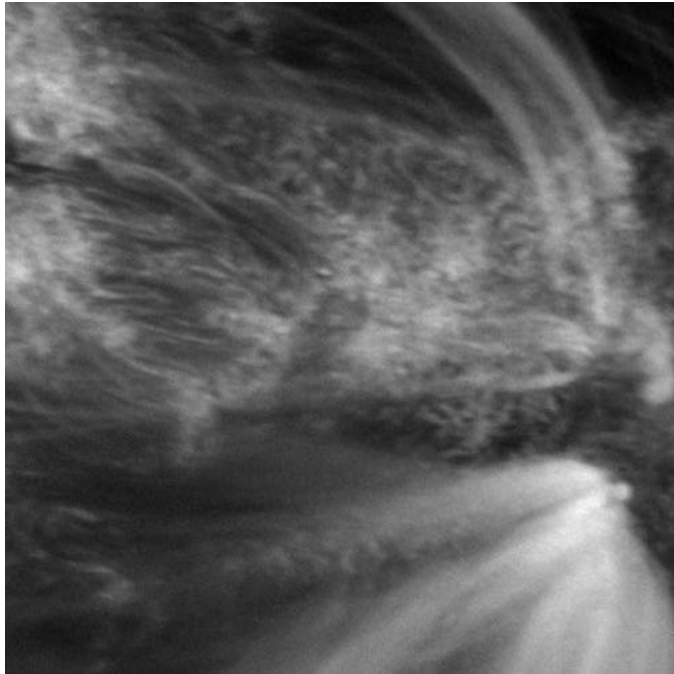


Hi-C 2.1: IBIS coordinated data

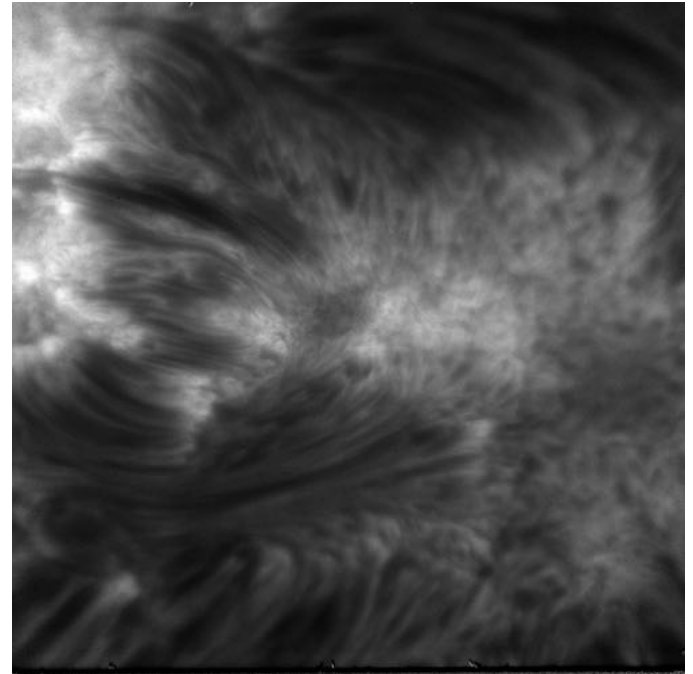


Hi-C 2.1: IBIS coordinated data

Hi-C 172 Å
18:56:22 UT



IBIS H α 6563 Å
18:56:22 UT



Hi-C 2.1: NuSTAR coordinated data

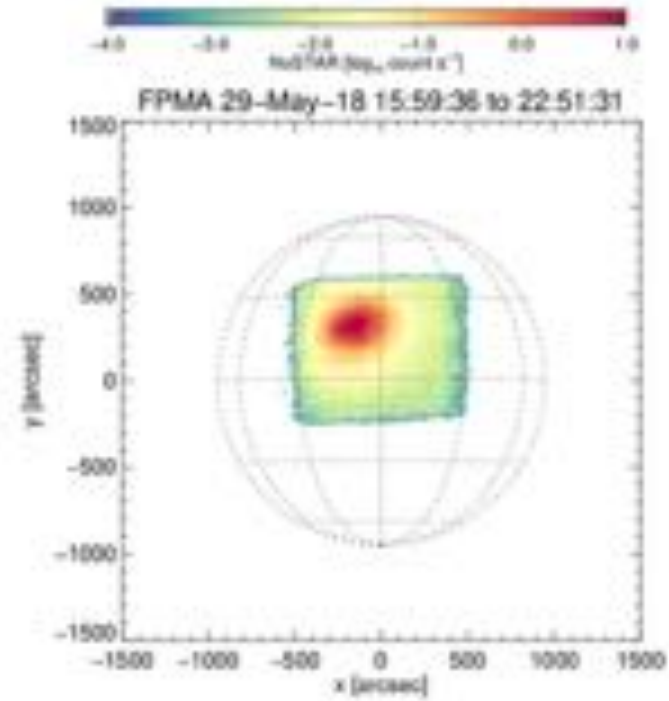
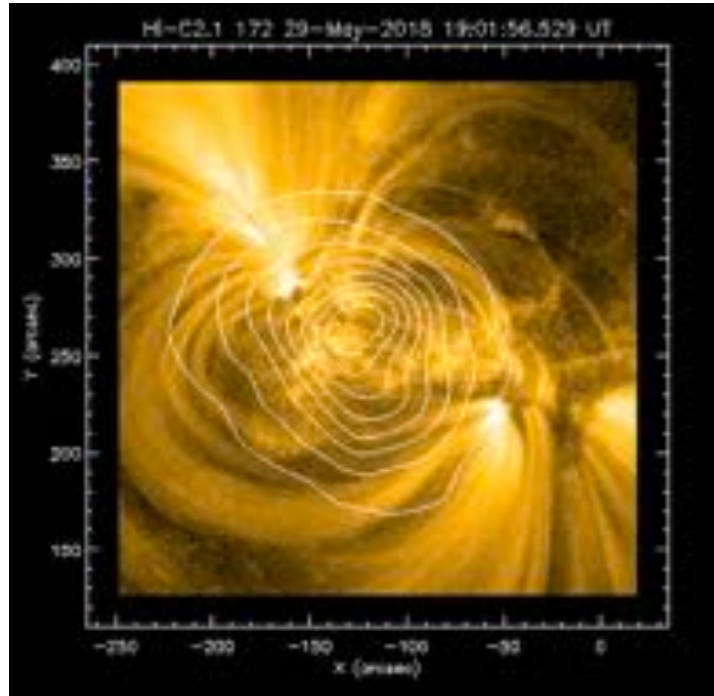
- ✧ NSO / IBIS
- ✧ NuSTAR
- ✧ BBSO
- ✧ Owens Valley
- ✧ ~SST

Hard X-ray Astrophysics Mission
High Sensitivity

5 orbits on day of launch,
primarily targeting AR 12712

Hi-C 2.1: NuSTAR coordinated data

- ✧ NSO / IBIS
- ✧ NuSTAR
- ✧ BBSO
- ✧ Owens Valley
- ✧ ~SST



Hi-C 2.1: Additional Coordinated Data Sets

- ✧ NSO / IBIS
- ✧ NuSTAR
- ✧ BBSO
- ✧ Owens Valley
- ✧ ~SST

** Special thanks for assisting with the coordinations goes out to:

L. Glesener,
K. Reardon,
B. Chen,
Y. Chai,
N. Karuda,
P. Antolin,
J. Leenaarts,
G. Vissers

Hi-C 2.1: Science topics being pursued

- Thin, stranded loops [width variations]
 - Flows between transition region, chromosphere, and corona
 - Spicules
 - Nano/microflares
 - Moss/Plage brightenings
 - Flows along loops
 - Waves
 - Mini-jets
 - Etc.
-

Hi-C 2.1: AGU plug

Add AGU session approved for highlighting suborbital results.

Hi-C 2.1 science results expected to be presented in this session!



FALL MEETING

Washington, D.C. | 10-14 Dec 2018

Hi-C 2.1: POCs

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Thanks, and stay tuned....

