Resolving the unresolved background emission in the corona:

ubiquitous, low-emission coronal threads observed by the High Resolution Coronal Imager

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With the HiC Science and Operations Teams

Presentation outline

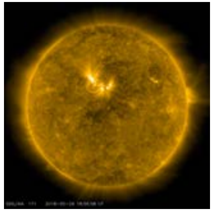
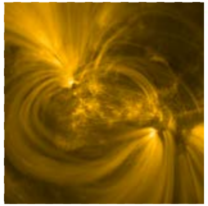
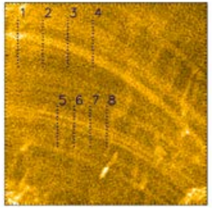
- The fundamental nature of coronal strands.

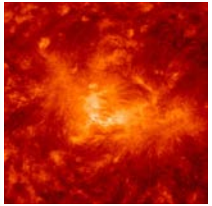
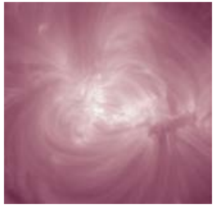
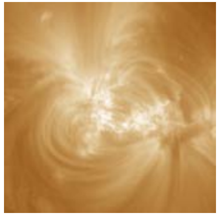
- High resolution coronal imager reflight, HiC 2.1, May 2018

- Multi-scale Gaussian normalisation of resulting data
- Analysis of AIA vs HiC 2.1 for the low emission corona

- Comparison of resolved structure widths – unique from HiC 2.1



The fundamental nature of a coronal plasma strands

Peter et al, 2013

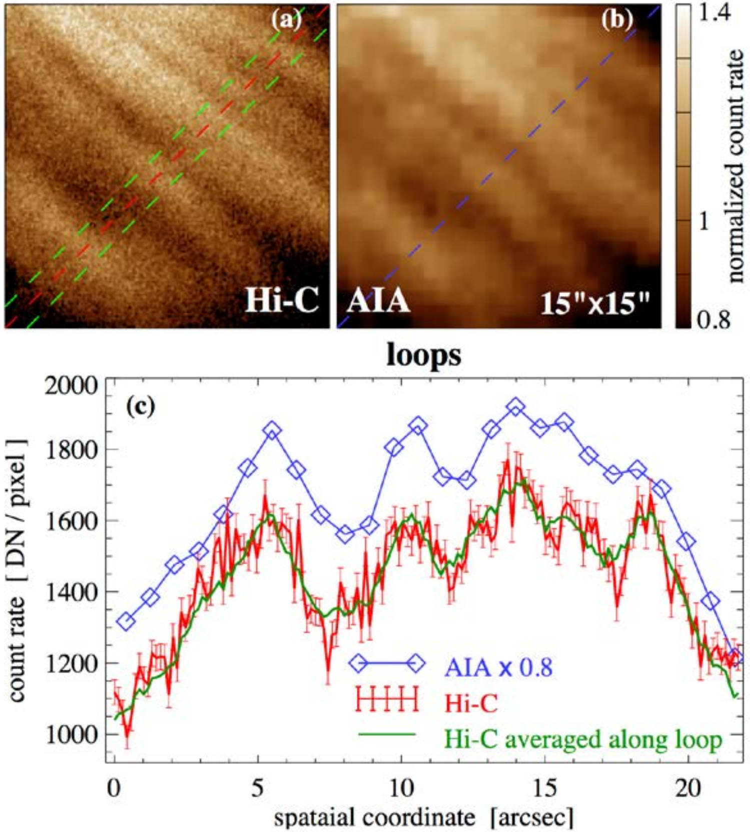
- no visible substructure across HiC 1 observed loops.

Thus either

- temperature and density varies smoothly across the loop or…
- loops are resolved in HiC.

- Argues that strand diameter ***d*** would need to be *20 m* < ***d*** < *15 km*

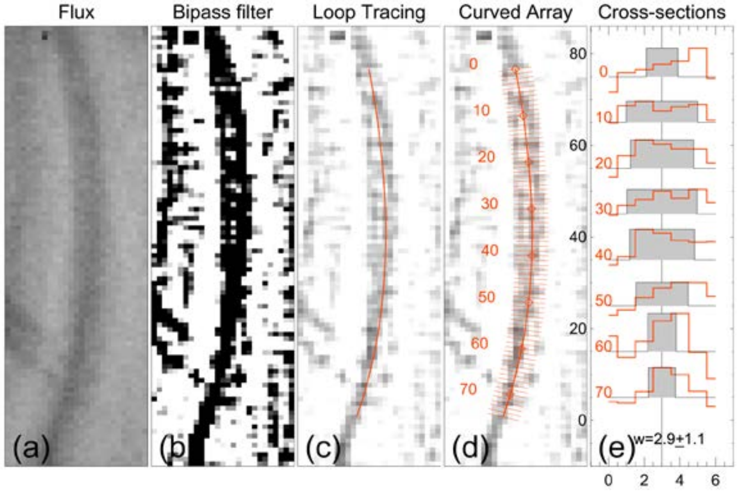
- Argues that HiC loop could have 7500 strands with 10% (750) “bright” at any one time.

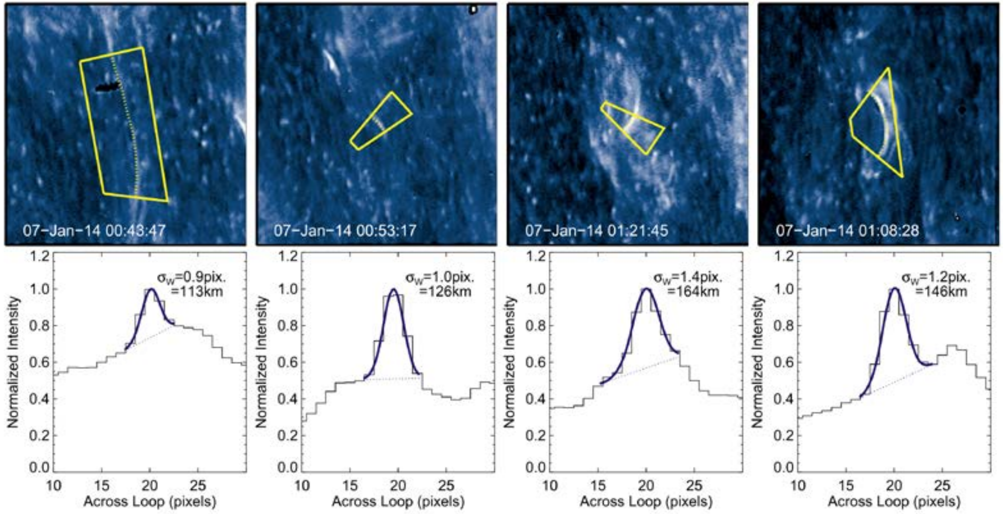


The fundamental nature of a coronal plasma strands

Brooks et al, 2016

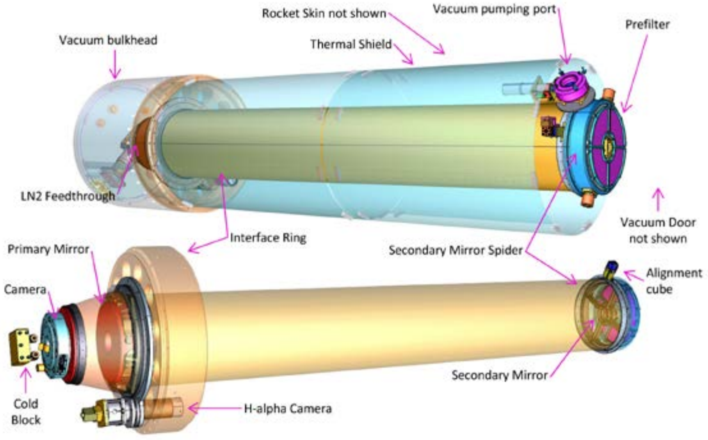
- IRIS observations, transition region temperatures
- Unresolved fine structure = 133km
- Can be modelled with a single strand approach.





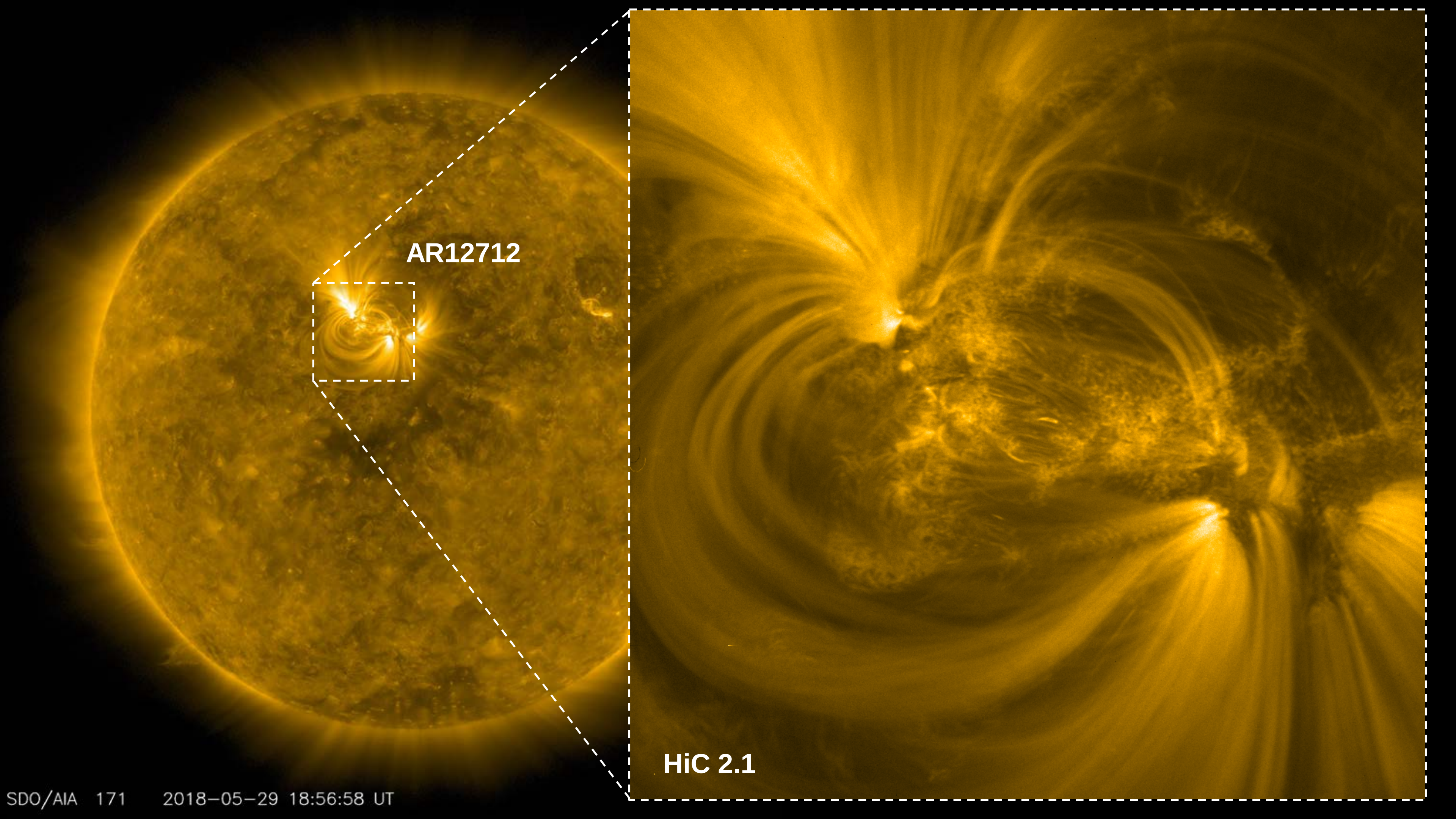
Aschwanden & Peter 2017

- Coronal loop widths fully resolved by HiC
- 100-550 km, monolithic structures



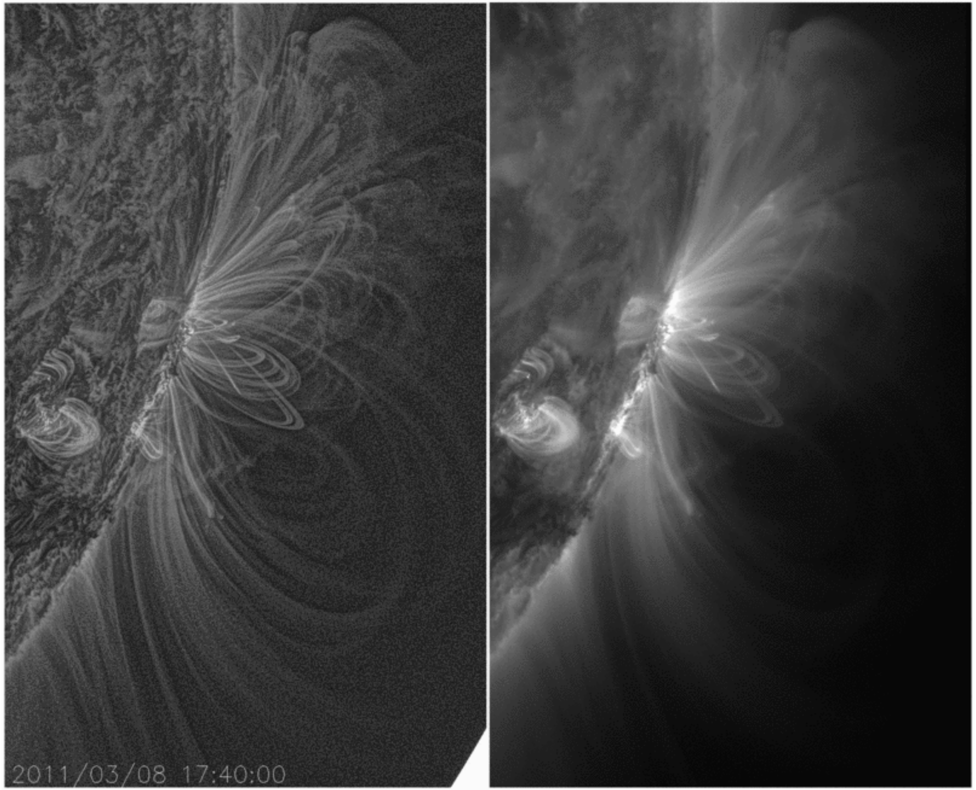
High Resolution Coronal Imager 2.1

- Launch: 29th May 2018 at ~1850 UT.
- Fe IX 17.2 nm EUV emission.
- 2k x 2k resolution at 0.13 x 0.13 arcsec^2/pixel compared to AIA: 0.6 arcsec.
- ~329 s of data captured at ~5.5s cadence for a total of 78 images.



AR12712
HiC 2.1
SDO/AIA 171 2018-05-29 18:56:58 UT

Multi-scale Gaussian Normalisation

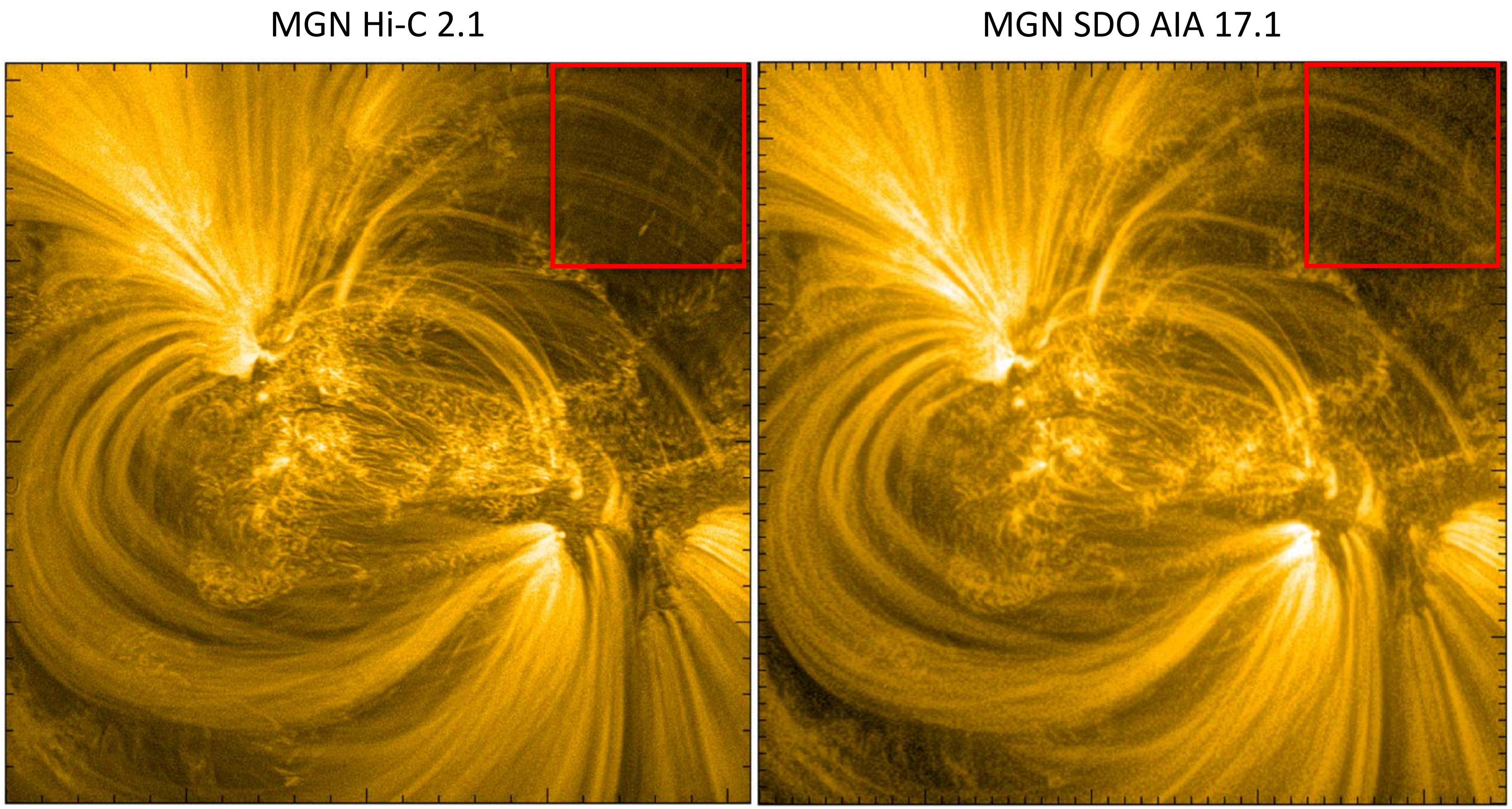


Morgan & Druckmüller (2014), SoPh, 289, 8, pp 2945-2955

The method **normalises** an image via the **local mean** and **standard deviation** using a **Gaussian-weighted** sample of local pixels.

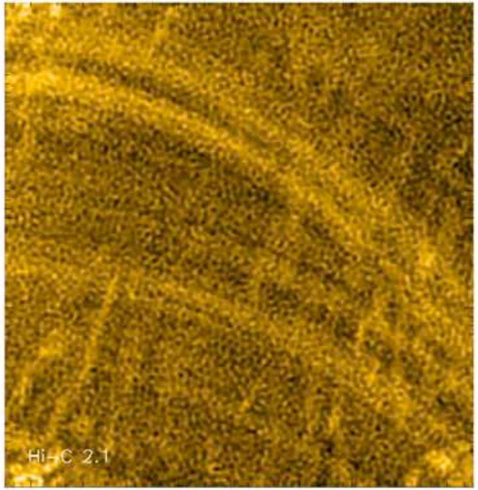
Normalised image is transformed by **arctan function** and applied over **several spatial scales**.

Final image is a **weighted combination** of the **normalised components**.

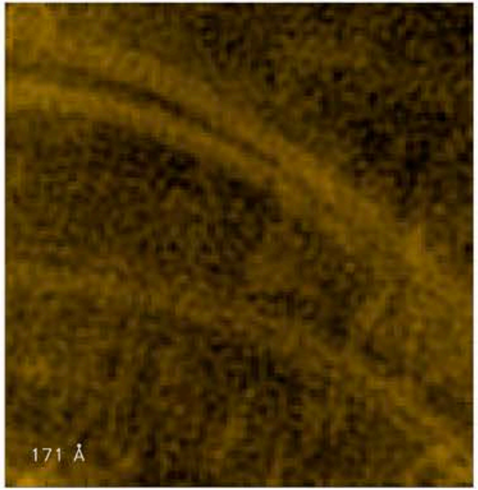

MGN Hi-C 2.1
MGN SDO AIA 17.1

Low emission corona – HiC 2.1 and SDO AIA

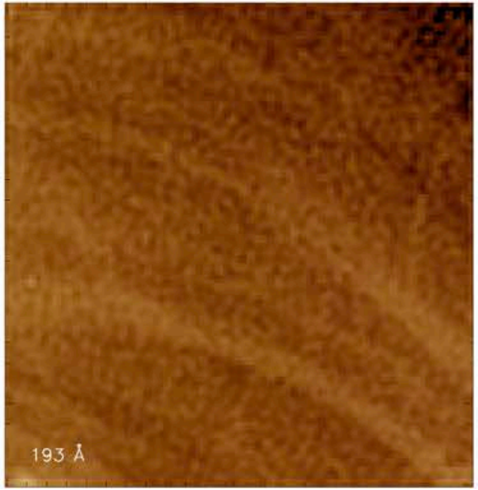
MGN HiC 17.2



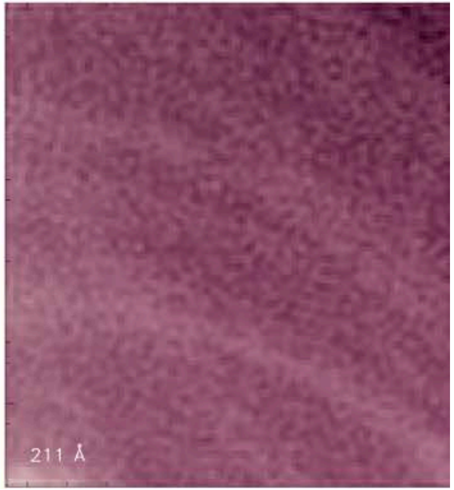
MGN AIA 17.1



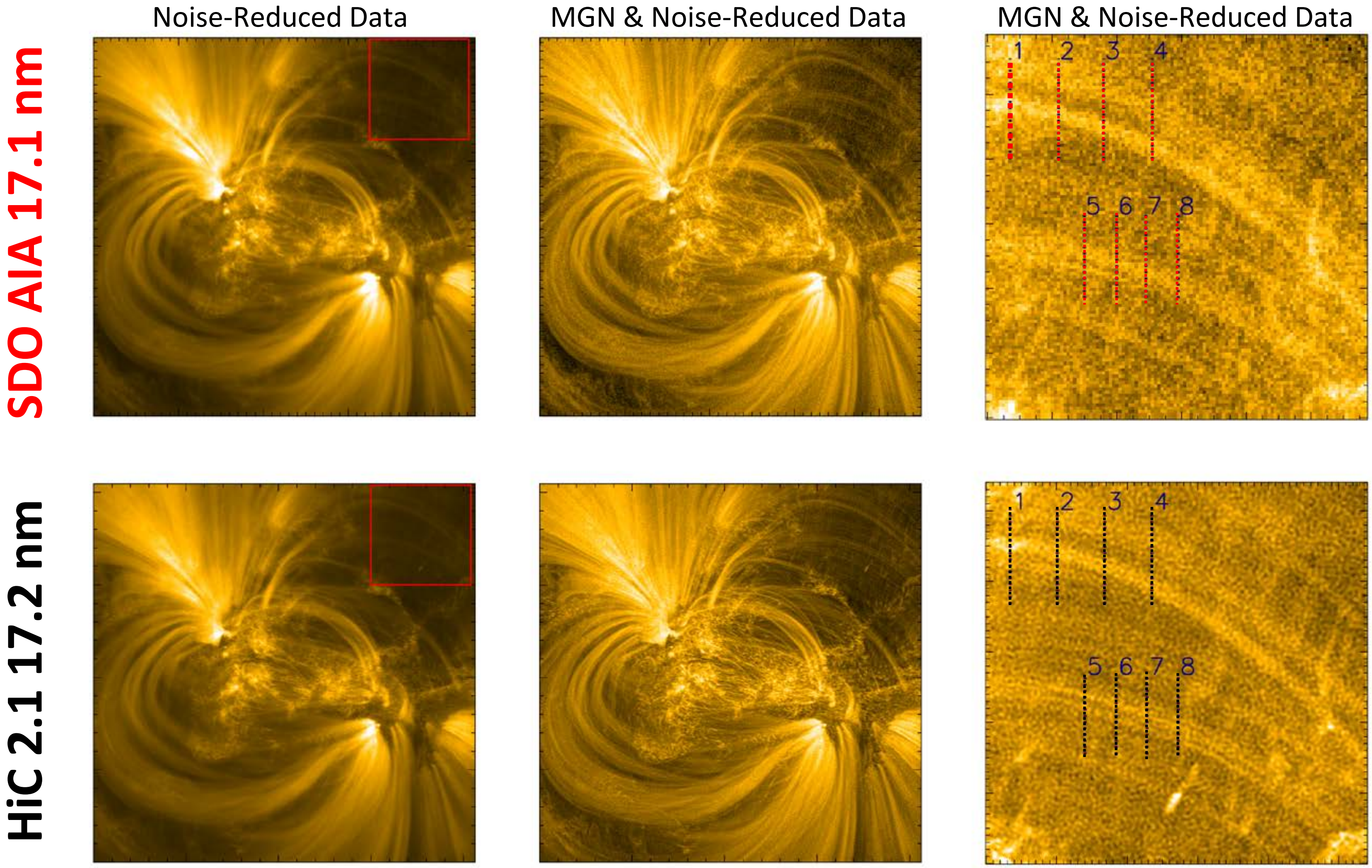
MGN AIA 19.3



MGN AIA 21.1



Instrument	Field of view (pixels)	Low emission region of interest (pixels)
SDO AIA	450 x 450	114 x 115
HiC 2.1	2064 x 2048	540 x 540


Noise-Reduced Data
MGN & Noise-Reduced Data
MGN & Noise-Reduced Data
SDO AIA 17.1 nm
HiC 2.1 17.2 nm
1
2
3
4
5
6
7
8
1
2
3
4
5
6
7
8

Mean, normalised intensity along slices (south to north)

HiC 2.1 --------

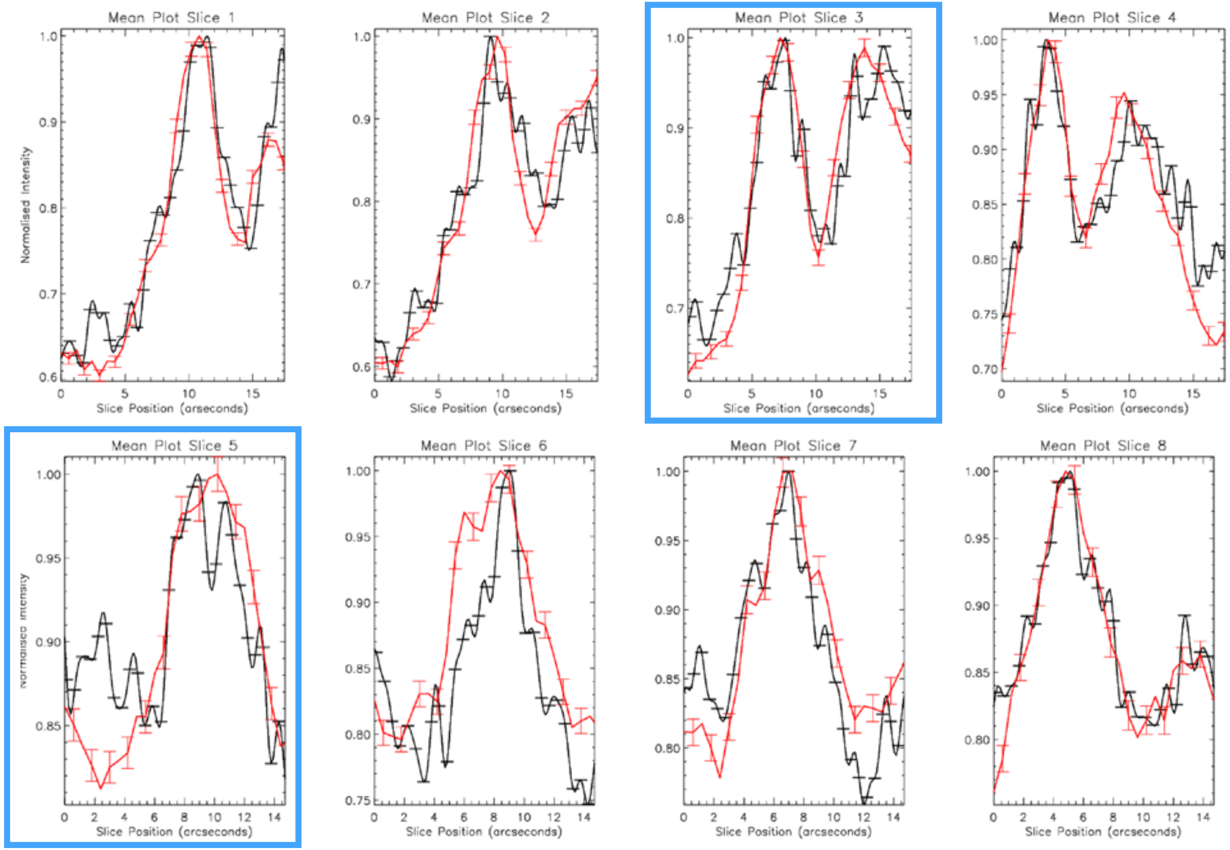
SDO AIA --------

HiC 2.1 “jitter images” removed (35 images considered).

HiC every 4th error bar.

AIA every 2nd error bar.

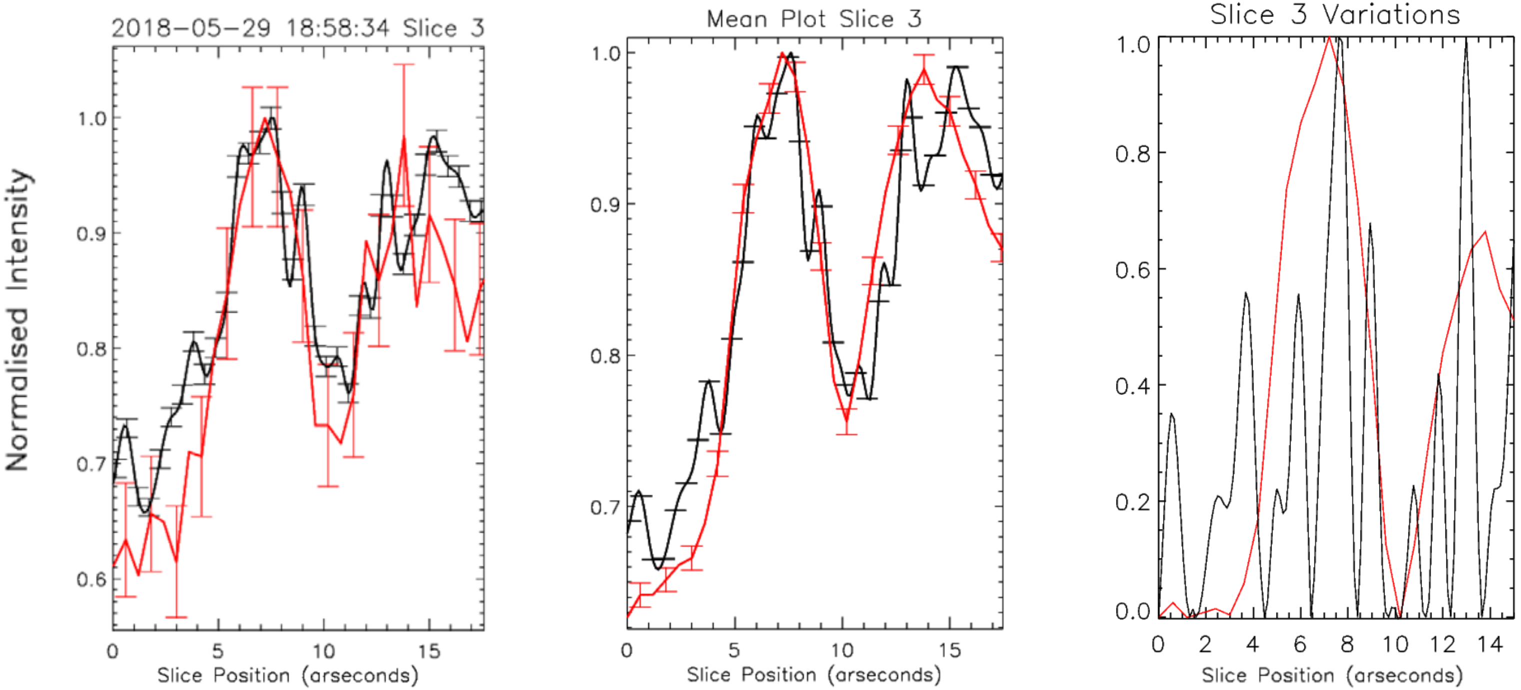
Instrument	No of pixels
HiC 2.1	109
SDO AIA	25

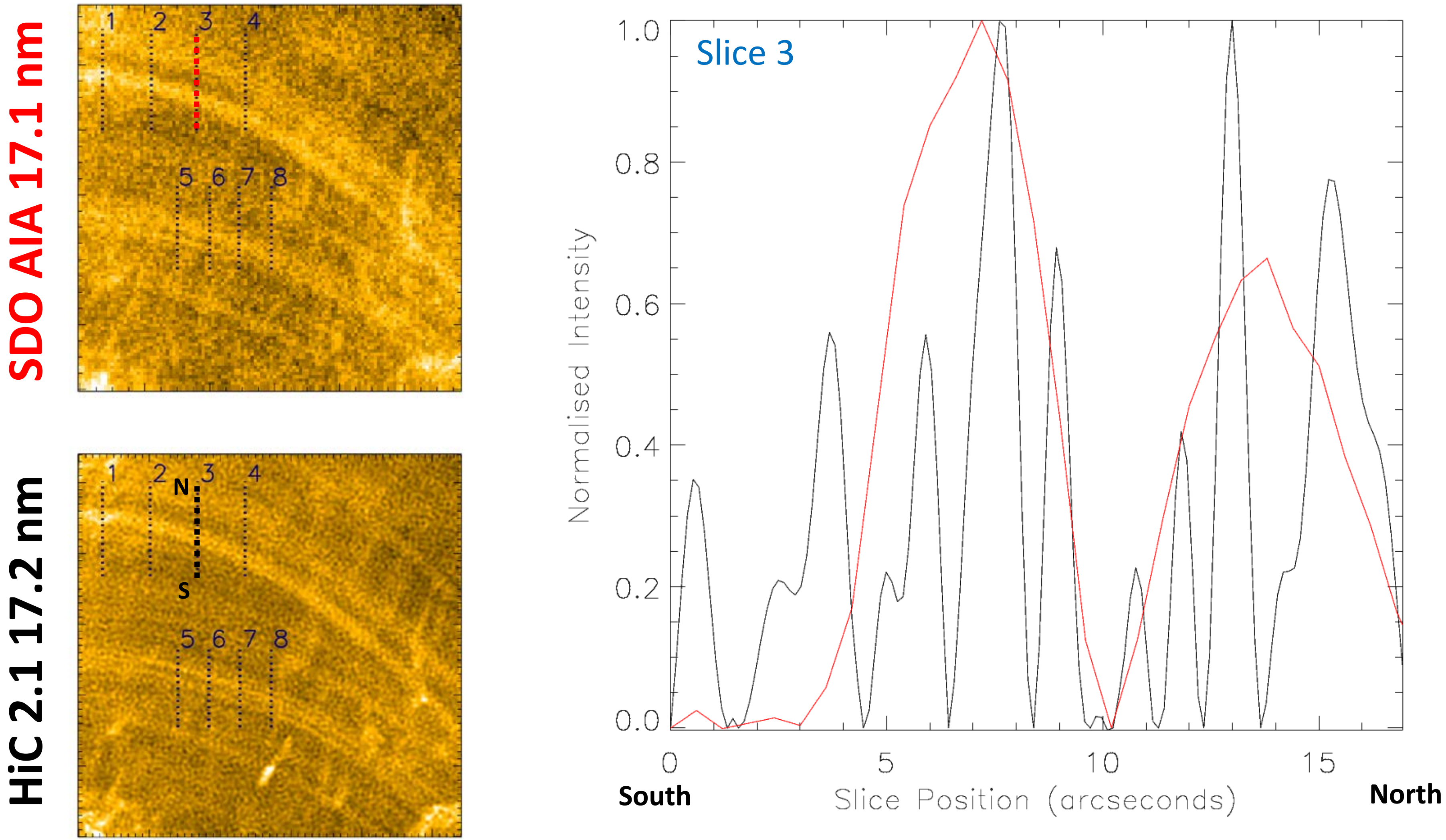


Normalised intensity along slice 3 (south to north)

HiC 2.1 --------
SDO AIA --------

Single snapshot → **Time averaged** → **Remove interpolation through minima**



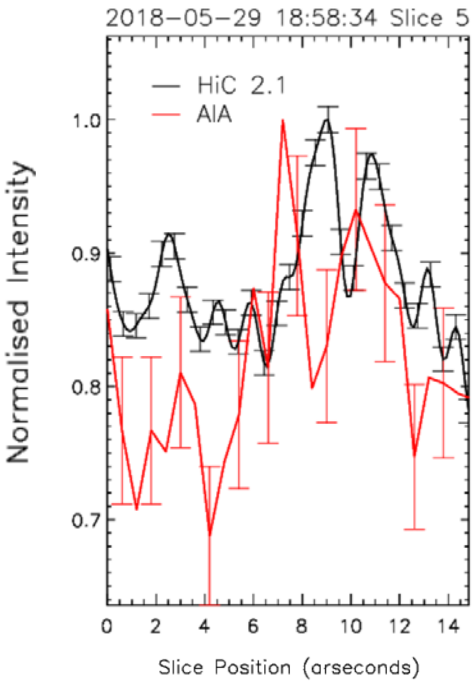


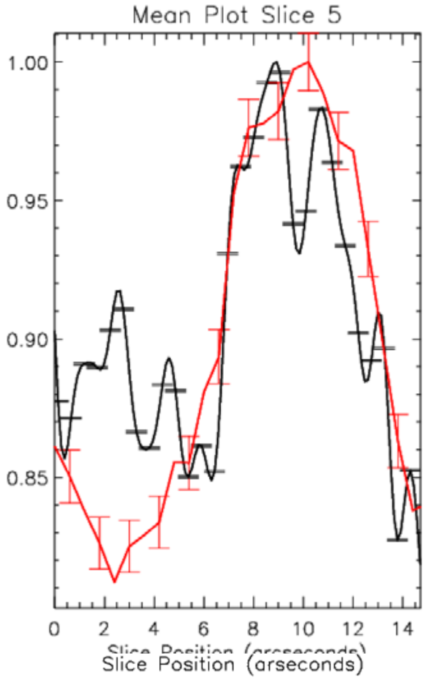
SDO AIA 17.1 nm
HiC 2.1 17.2 nm
1
2
3
4
5
6
7
8
N
S
Slice 3
Normalised Intensity
Slice Position (arcseconds)
South
North
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15

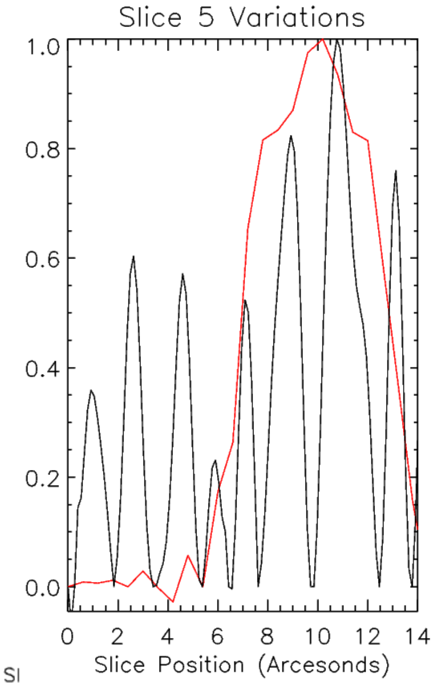
Normalised intensity along slice 5 (south to north)

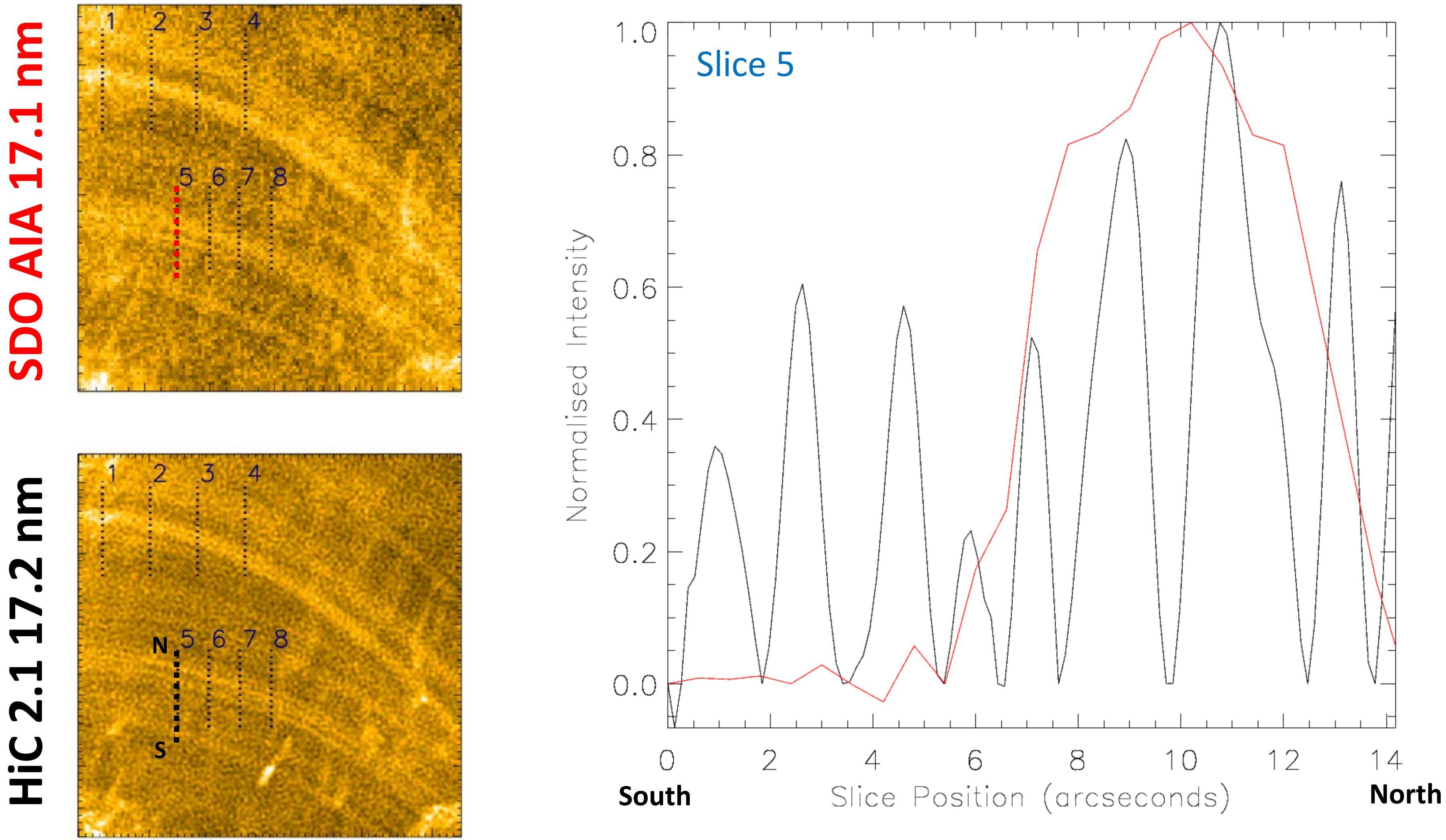
HiC 2.1 --------
SDO AIA --------

Single snapshot → **Time averaged** → **Remove interpolation through minima**

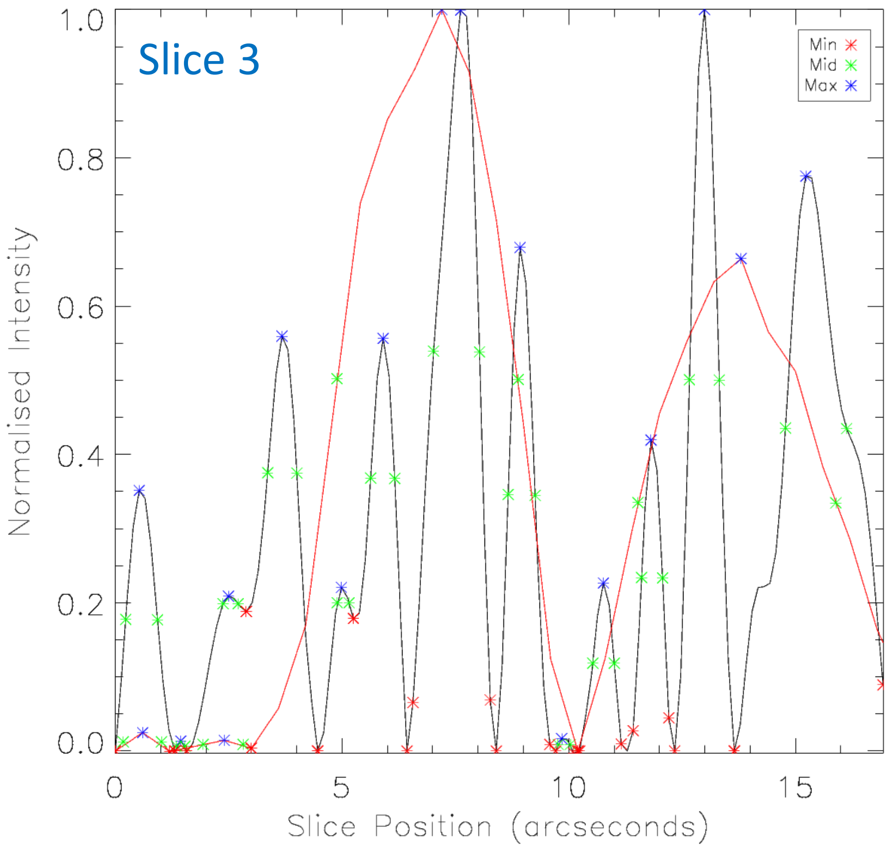


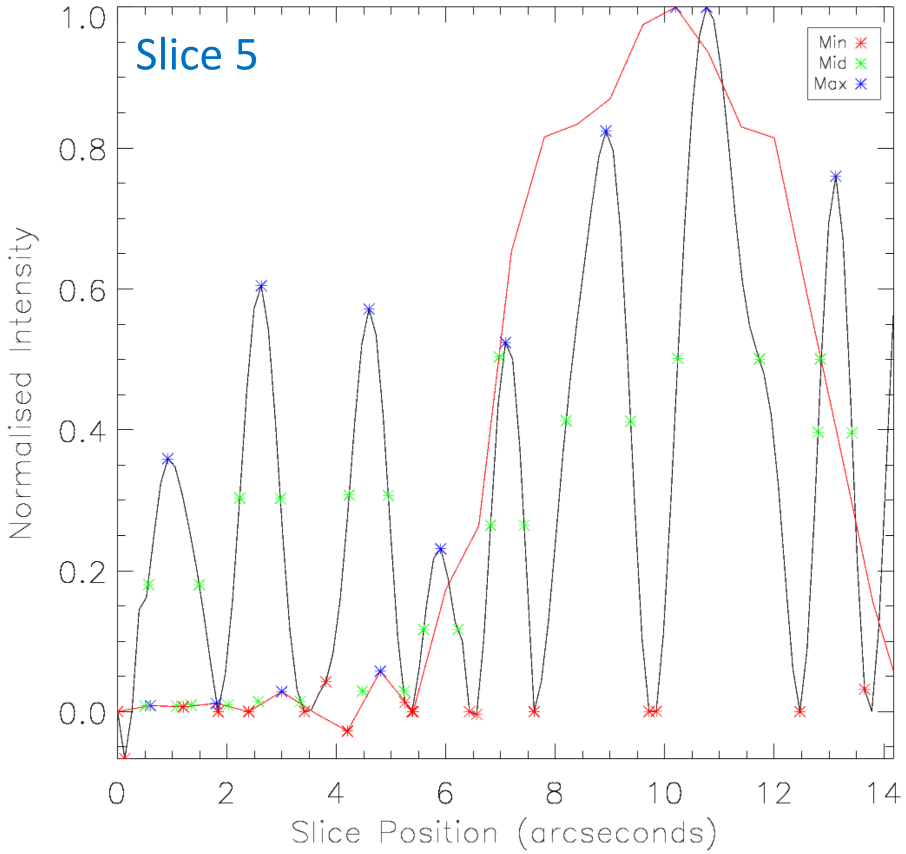




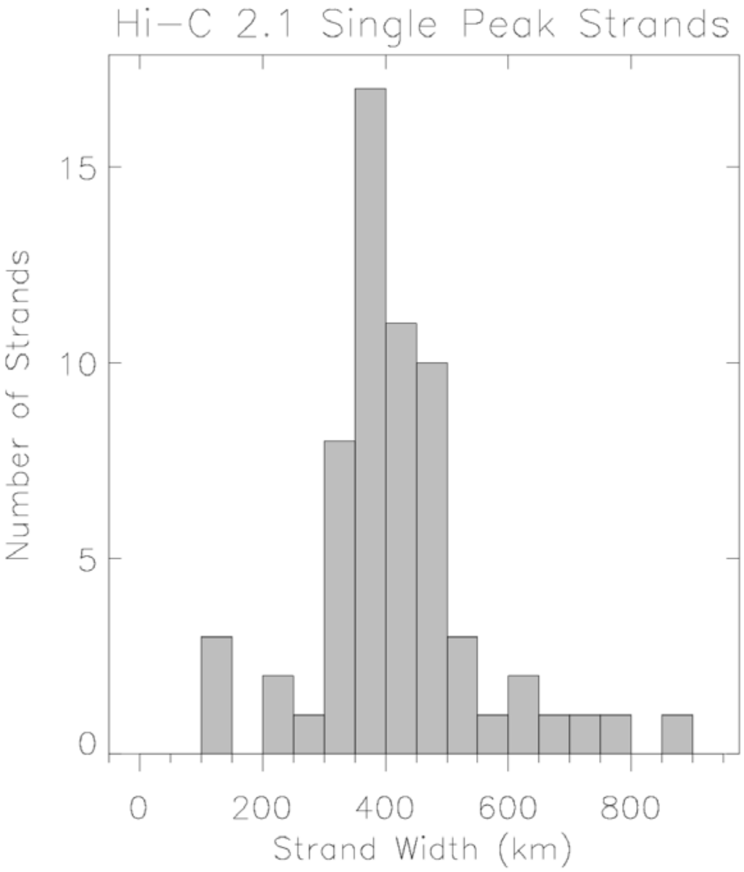

SDO AIA 17.1 nm
HiC 2.1 17.2 nm
1
2
3
4
5
6
7
8
N
S
Slice 5
Normalised Intensity
Slice Position (arcseconds)
South
North

Full width half maximum of resolved structures





HiC 2.1 - Full width half maximum of resolved structures



For HiC 2.1 we have;

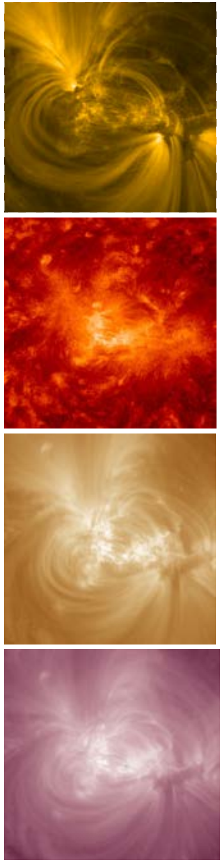
- Total No widths identified over 8 slices= 101
- Single resolved strands = 64 (63%)
- Minimum width = 108 km
- Maximum width = 976 km
- Mean width = 435 km

In comparison, for AIA 17.1nm;

- Total No widths identified over 8 slices= 39
- Single resolved strands = 24 (62%)
- Minimum width = 555 km
- Maximum width = 4252 km
- Mean width = 1515 km

Conclusions: resolving the low emission corona

Author	Instrument	Loop type	Mean width (range)
Peter *et al*, 2013	HiC	Long, bright	1500km (?)
Brooks *et al*, 2016	IRIS	Short, cool, bright	133 km (?)
Ashwanden & Peter, 2017	HiC	All types, bright	550 km (?)
Walsh, Williams, Winebarger, 2018	HiC 2.1	Long, low emission	434 km (?)



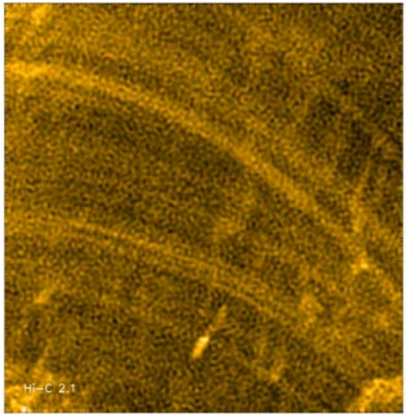
- At 17.2 nm, low emission corona filled with fine-scale structures.
- SDO AIA does not resolve the basic spatial scale of low emission features.
- HiC 2.1 reveals significant sub-structure where AIA does detect emission.
- HiC 2.1 detects and determines structure in AIA 17.1nm “noise”.
- Single resolved strands with a mean width of ~434km.

Further work on HiC 2.1

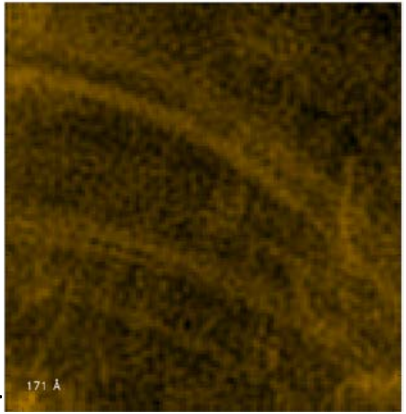
- Fitted Gaussians to the "double-peak" structures – reduce widths?
- Angle across the structures.

- What does this mean for determining coronal heating?
- Modelling observed strand widths.

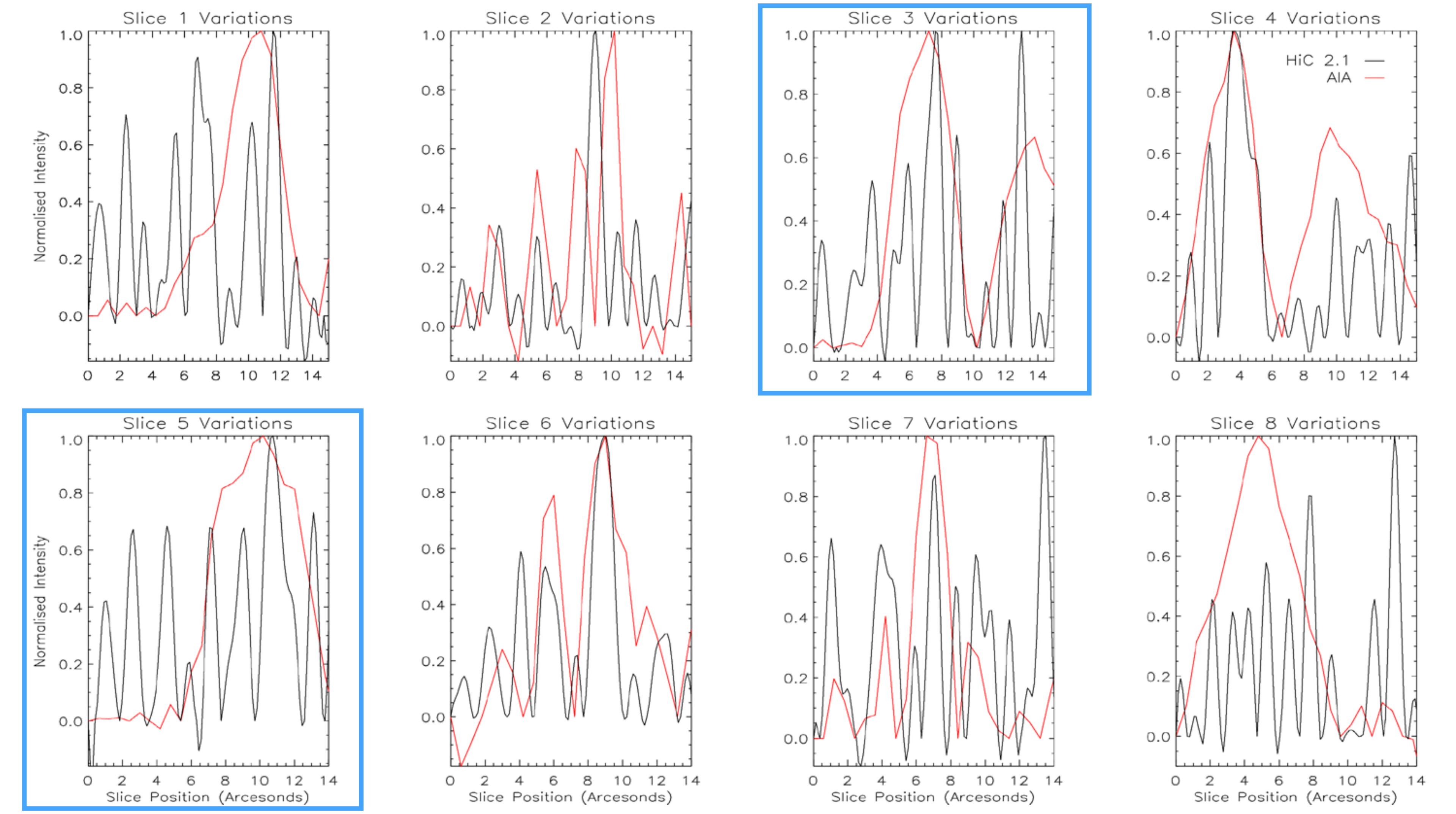
- With HiC science team, determine coronal structures properties with HiC 2.1 field of view.



HiC 2.1



AIA 17.1


Slice 1 Variations
Slice 2 Variations
Slice 3 Variations
Slice 4 Variations
Slice 5 Variations
Slice 6 Variations
Slice 7 Variations
Slice 8 Variations
HiC 2.1
AIA
Normalised Intensity
Slice Position (Arcesonds)