

Hinode Coronal Loop Observations

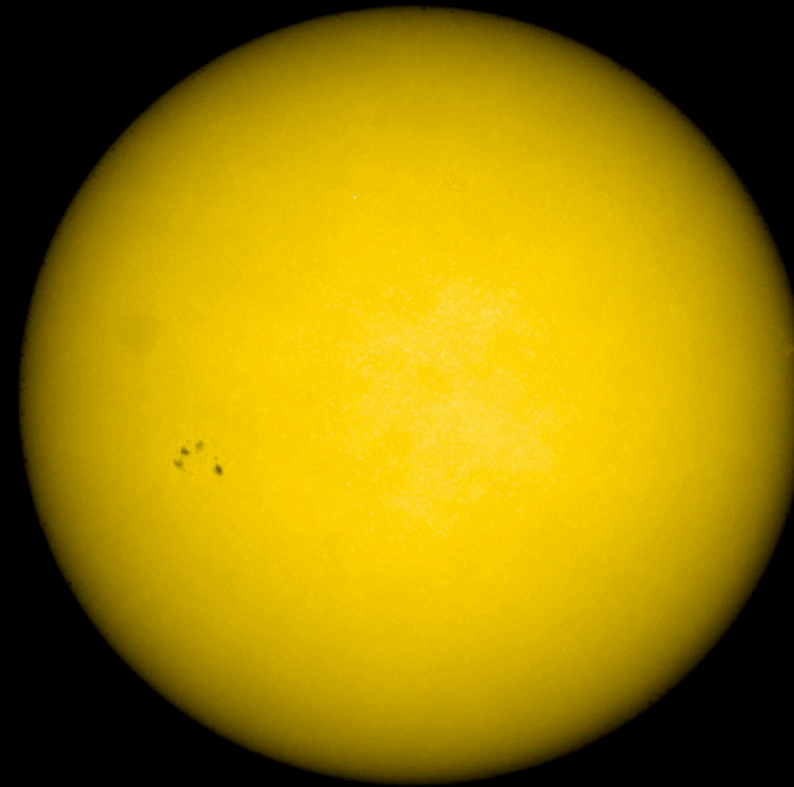
Ignacio Ugarte-Urra

Naval Research Laboratory
George Mason University



Second Hinode Science Meeting. October 1st 2008

SUN'S SURFACE
TEMPERATURE: 6000 K



XRT/Hinode

Harry P. Warren
Naval Research Laboratory

Rasters - DEM

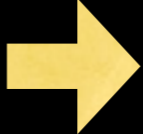
I. Ugarte-Urra
Naval Research Laboratory
George Mason University

Slot movies - Dynamics

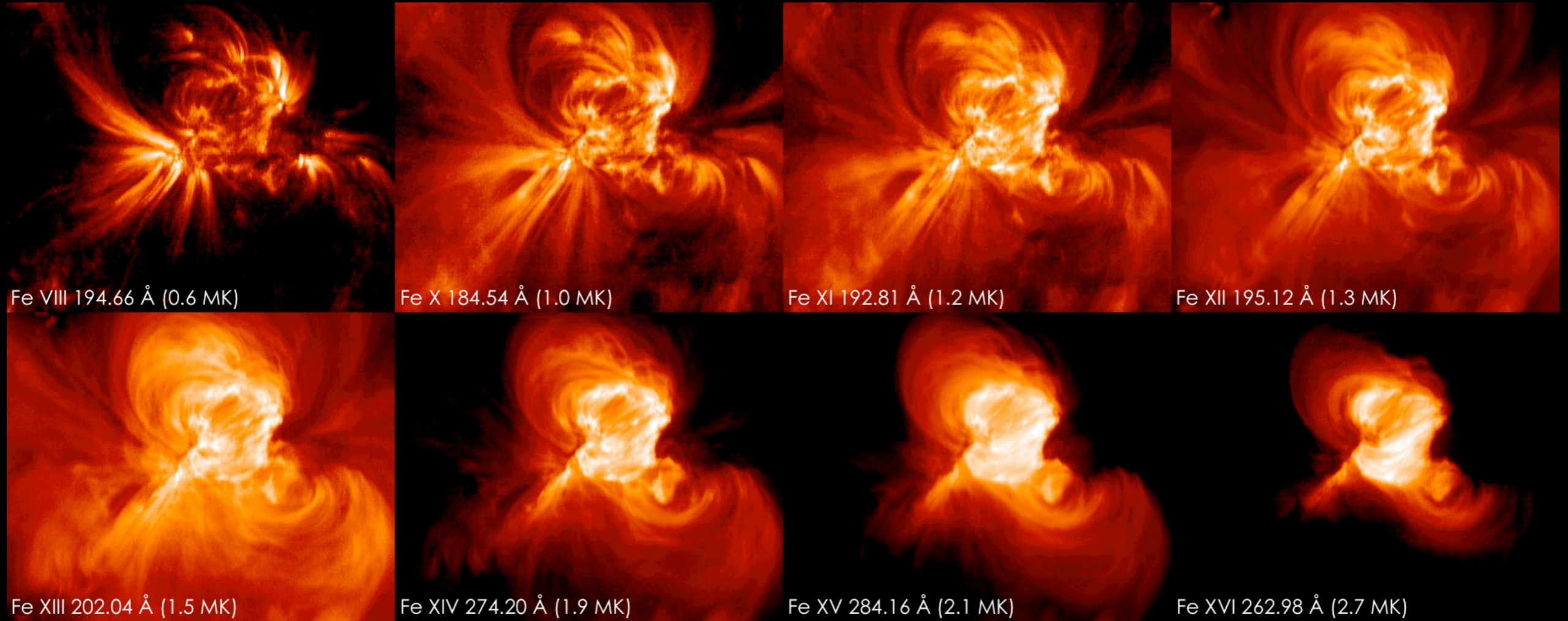
D. H. Brooks
Naval Research Laboratory
George Mason University

SOT - EUV/Mag. fields

Coronal loops in the HINODE era

- Coronal heating questions: nature, localization, timescales
- Lower level question: is the problem well constrained? Have we characterized what we want to understand?
- Building blocks  coronal loops:
 - Is there such a thing as a typical coronal loop? Are there several types? Have we characterize it/them? Is there a consensus?

Coronal loops in the HINODE era



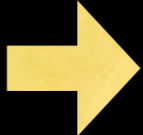
— $\neq T \Leftrightarrow \neq \text{loops??}$ iso/multi-thermal? time evolution?

Coronal loops in the HINODE era



- monolithic or multi-threading? if so, cross-field coherence?
- Need to build a coherent picture to feed loop models.

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What has HINODE in offer?

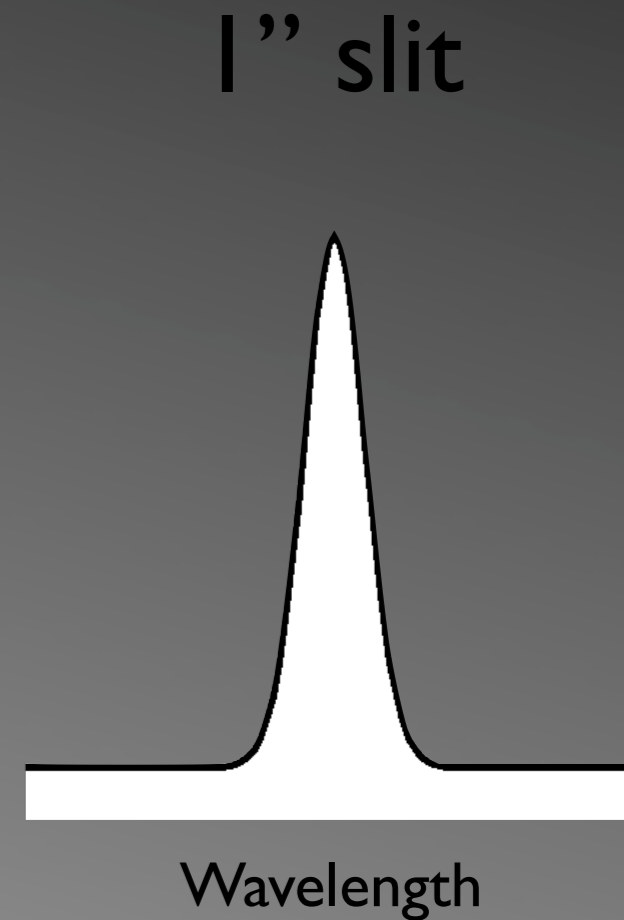
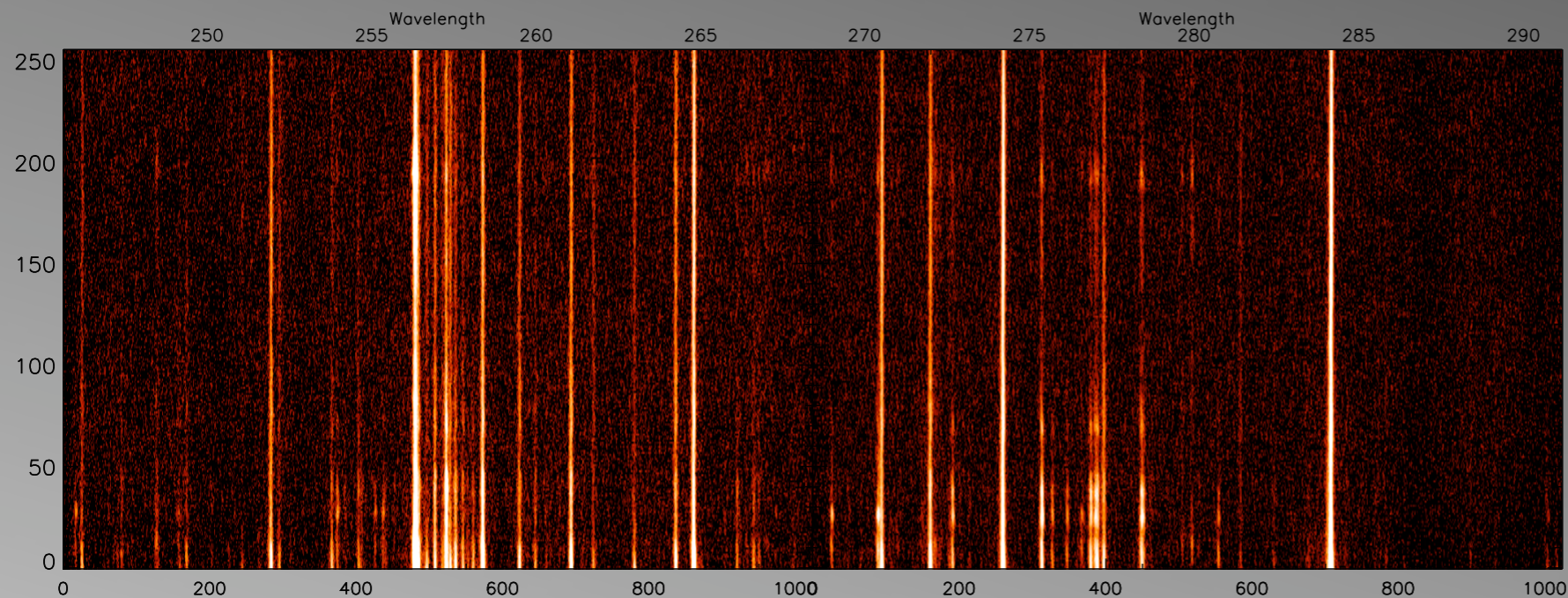
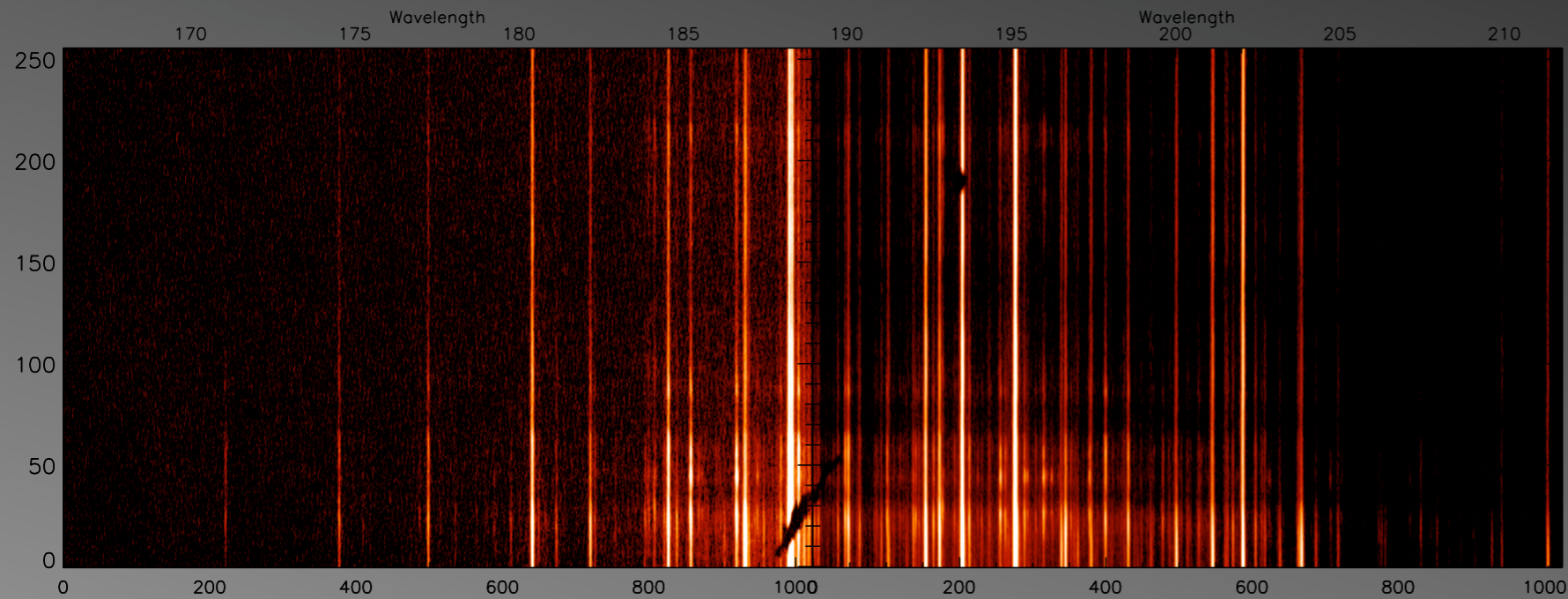
EIS biased

- SOT: high spatial resolution, high cadence look at the root of the loops on the photosphere.
- XRT: high cadence continuous look at the high temperature end of coronal loop emission.
- EIS: great potential for improved loop characterization.
 - Improved coronal plasma diagnostics: N_e , v , DEM.
 - High cadence monochromatic imaging at a wide range of temperatures.

Active Region 2-D N_e and DEM maps
(1 min cadence)

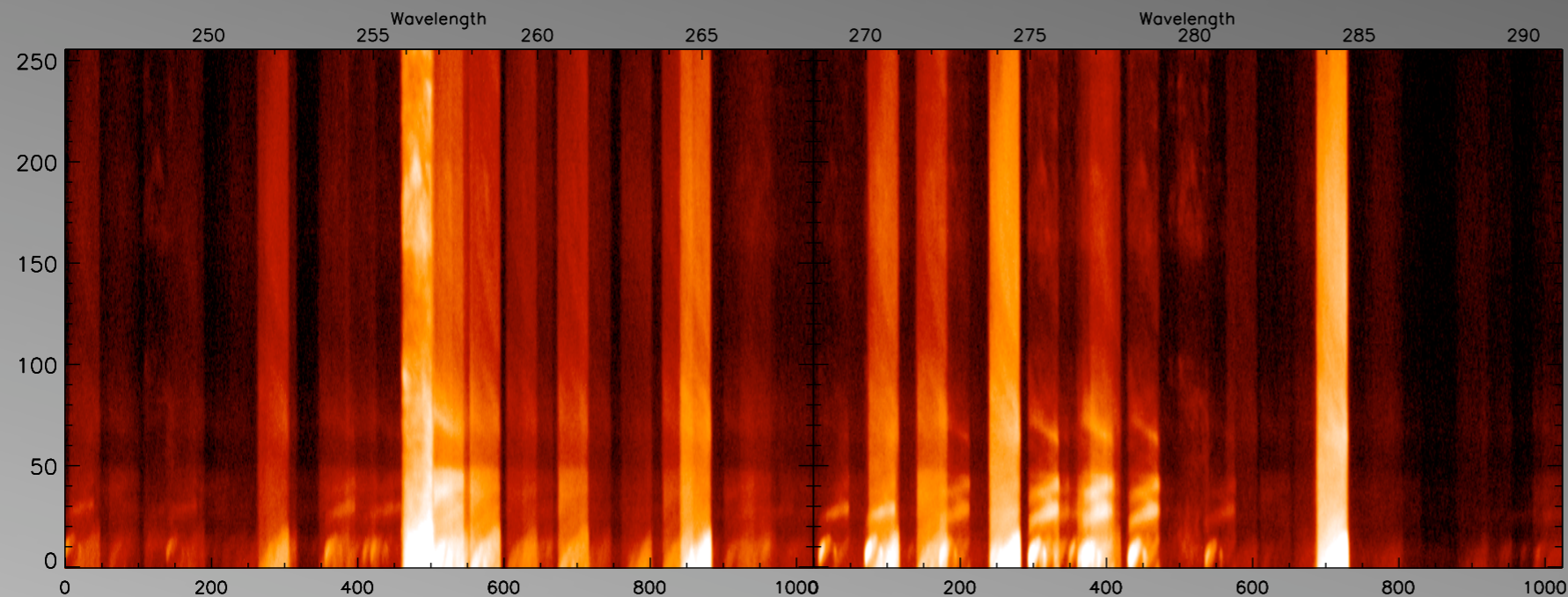
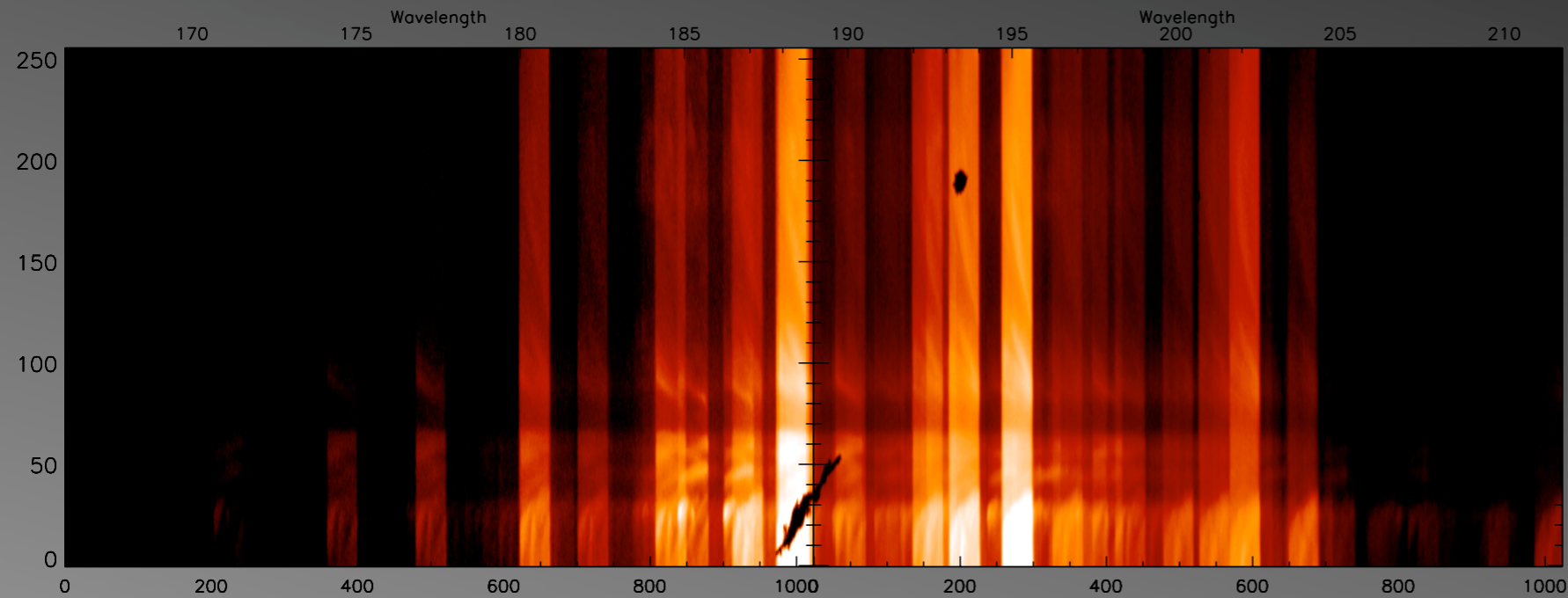
Extreme-ultraviolet Imaging Spectrometer EIS/HINODE

eis_I0_20071211_101526 -- Exposure #: 1 -- Exp. time: 89.9995s

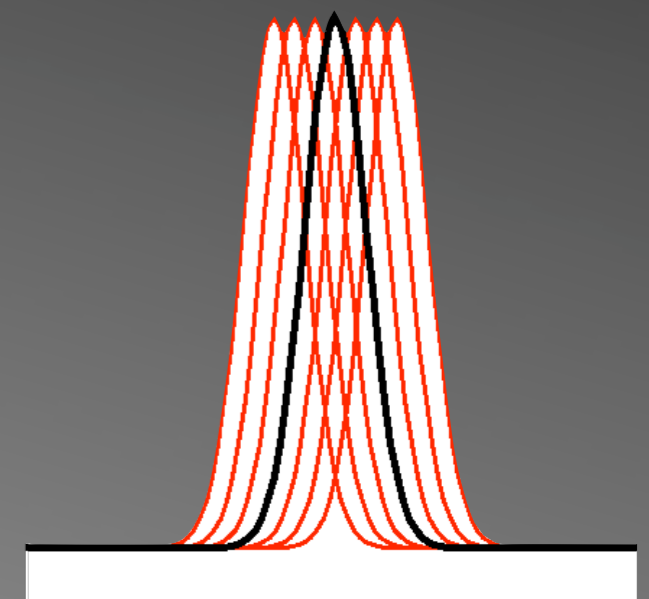


Extreme-ultraviolet Imaging Spectrometer EIS/HINODE

eis_I0_20071211_101526 -- Exposure #: 1 -- Exp. time: 89.9995s



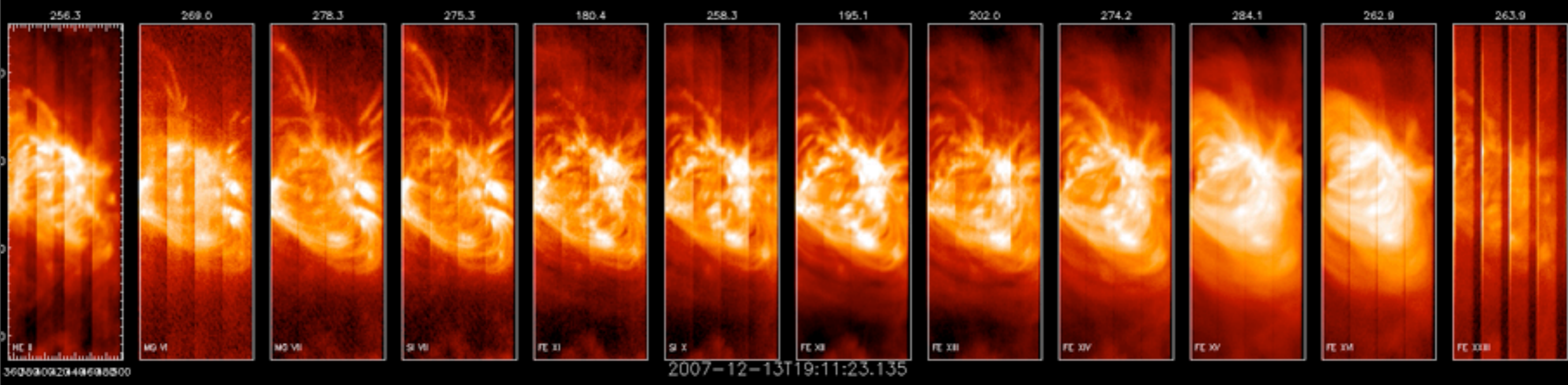
40" slit



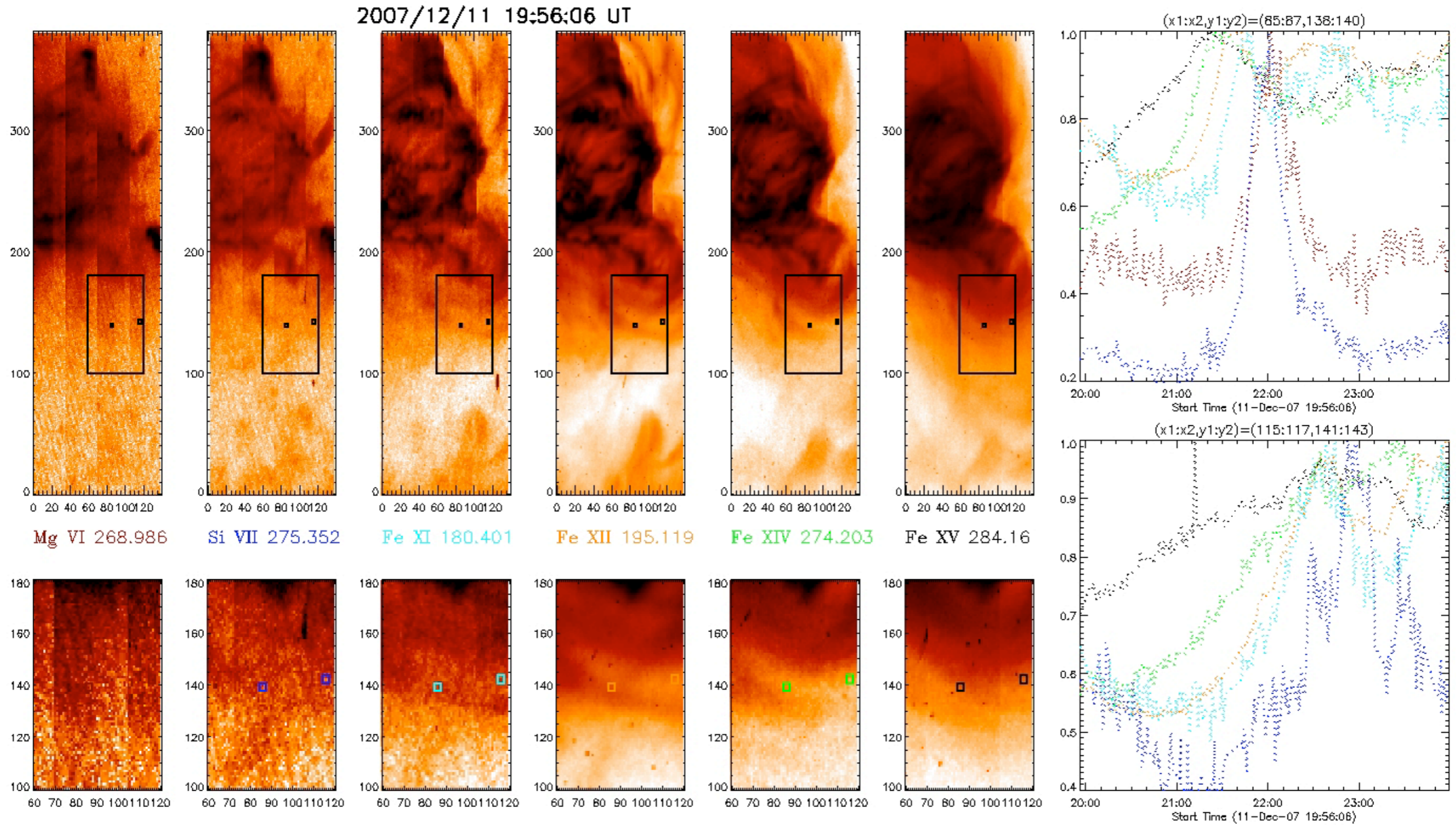
Wavelength

+

Solar X

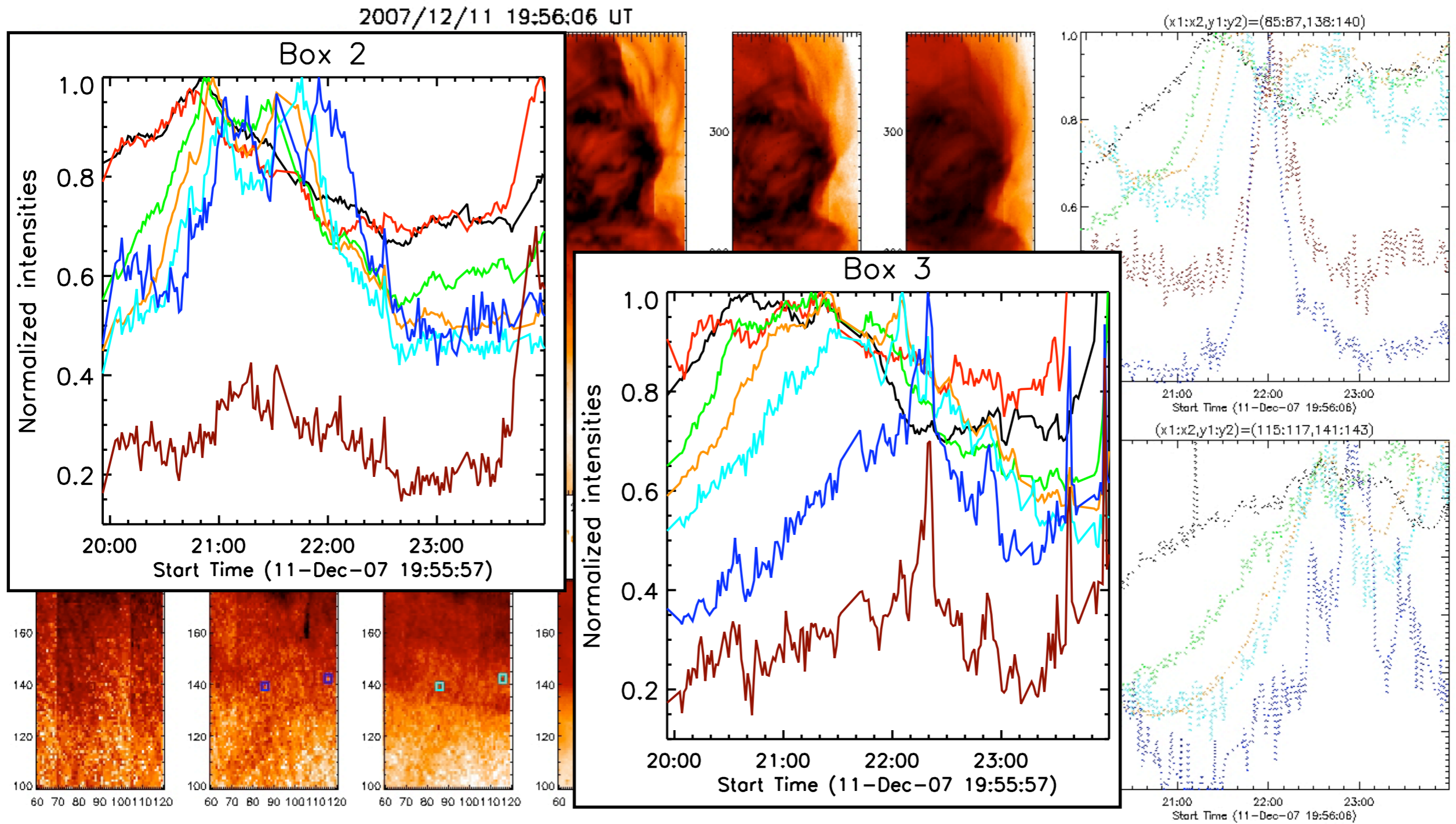


Multi-temperature core loops: cooling



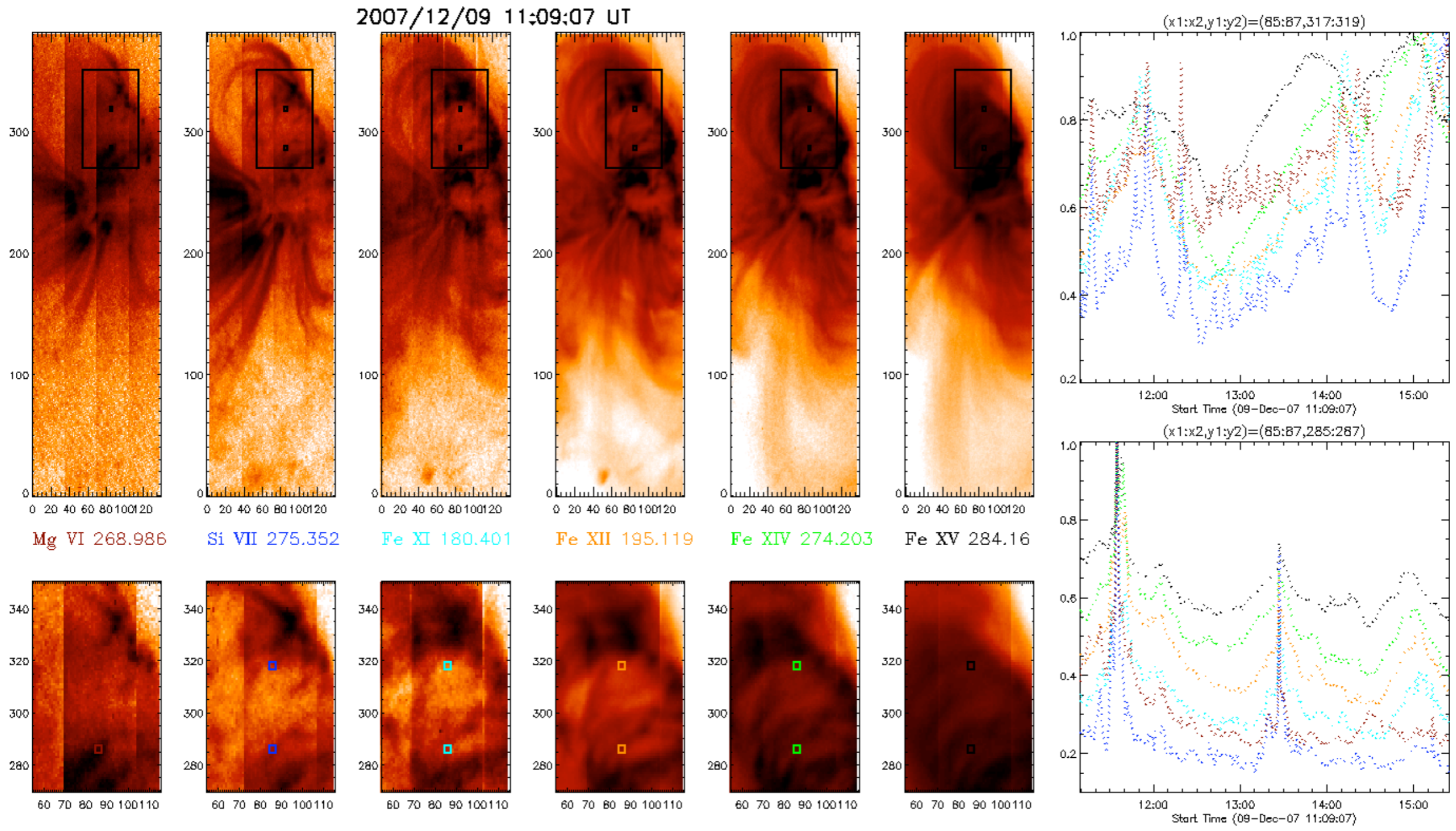
Overlap: width in temperature distrib.

Multi-temperature core loops: cooling



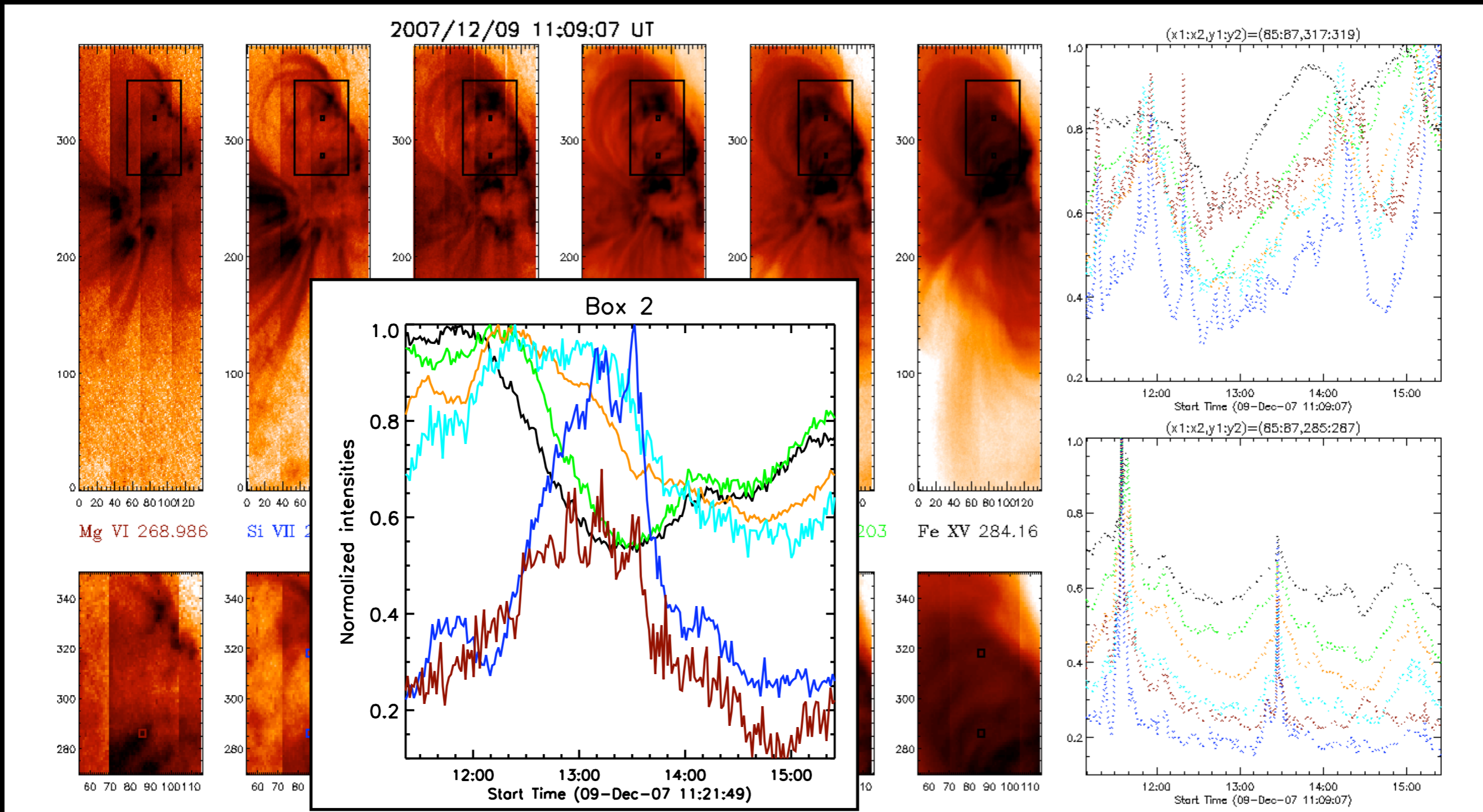
Overlap: width in temperature distrib.

Multi-temperature core loops: cooling



Recurrence

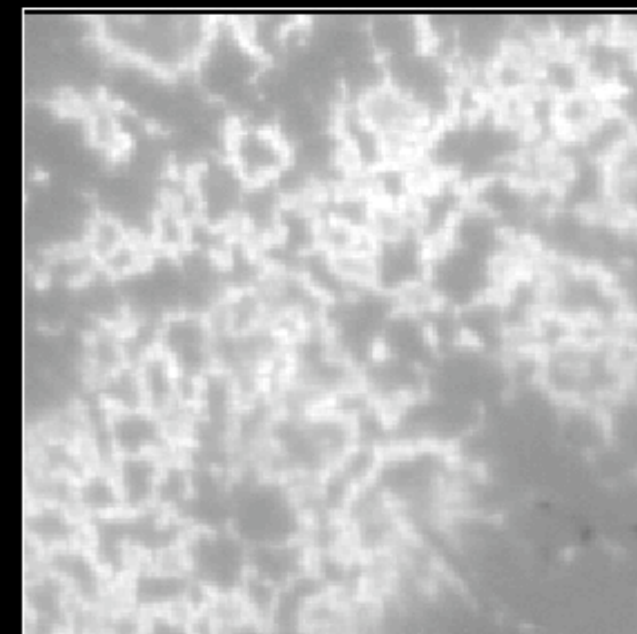
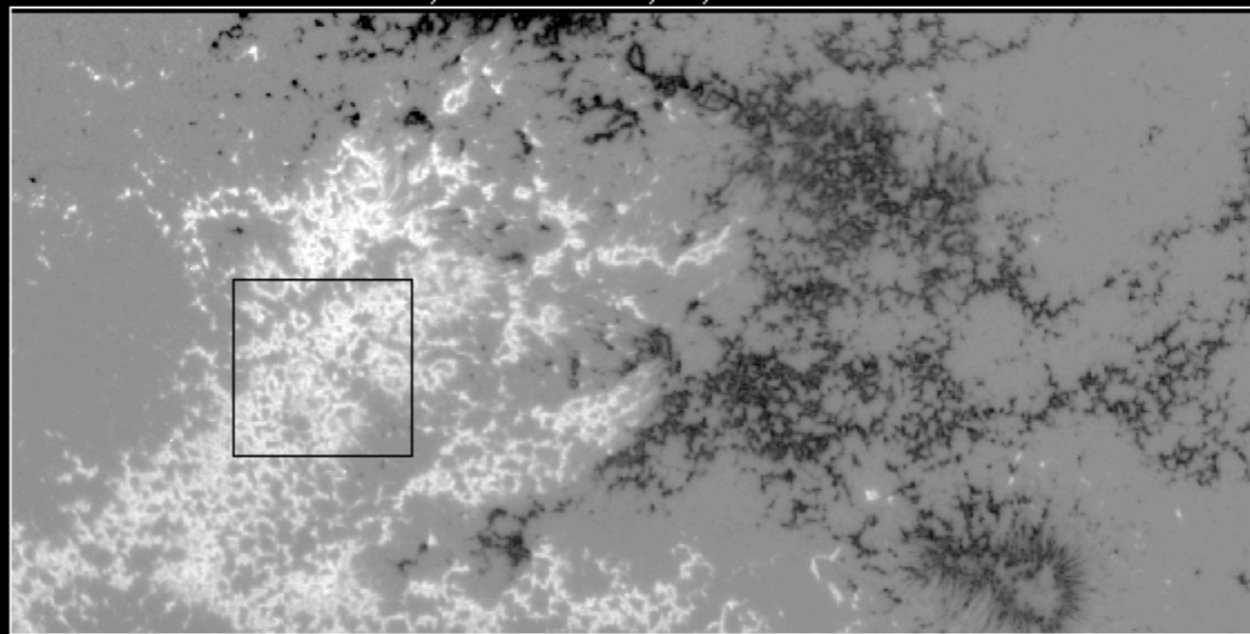
Multi-temperature core loops: cooling



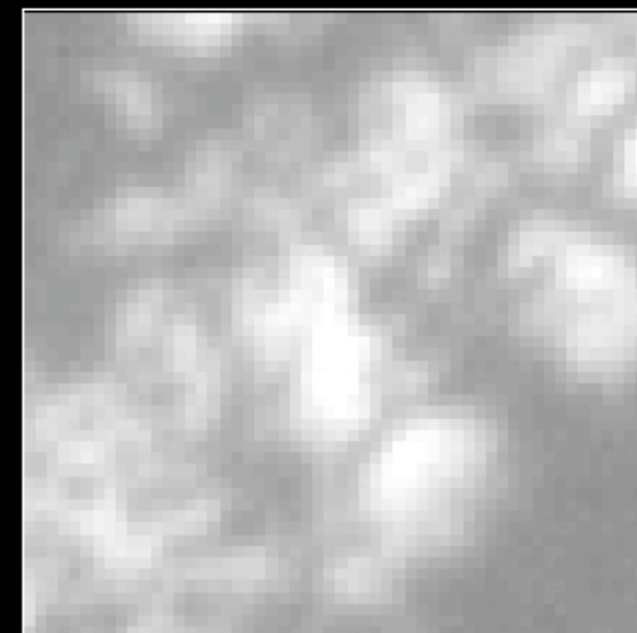
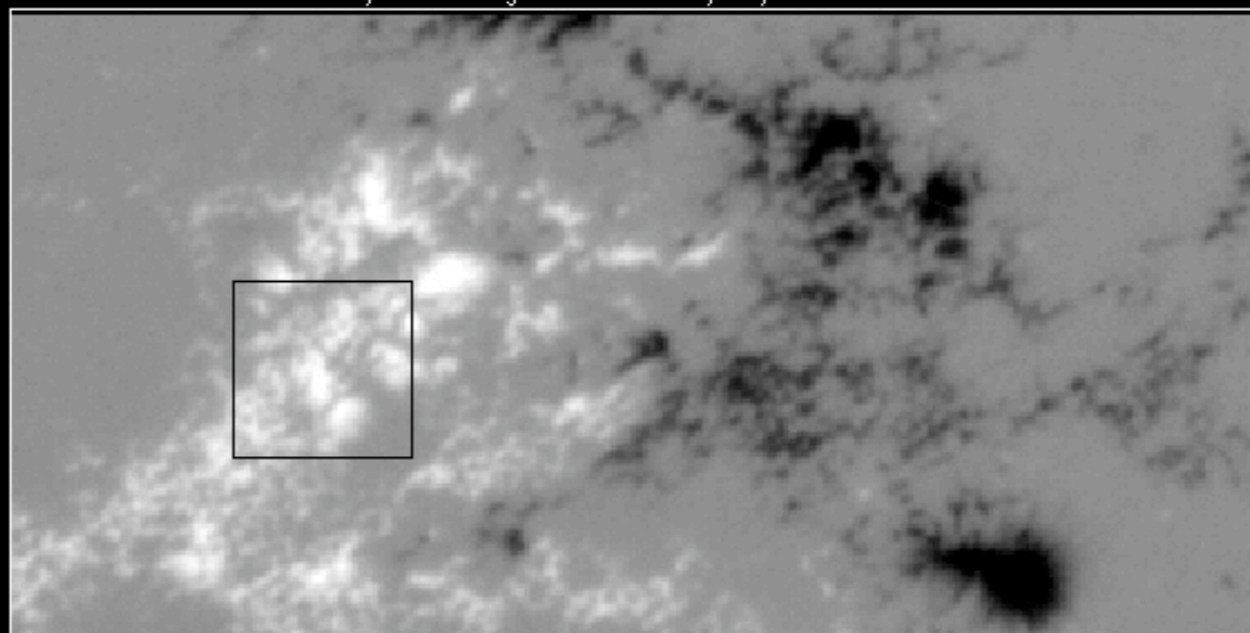
No independent 'transition region' loop population

Magnetic field evolution

SOT/Hinode 2007/12/11 22:17:37

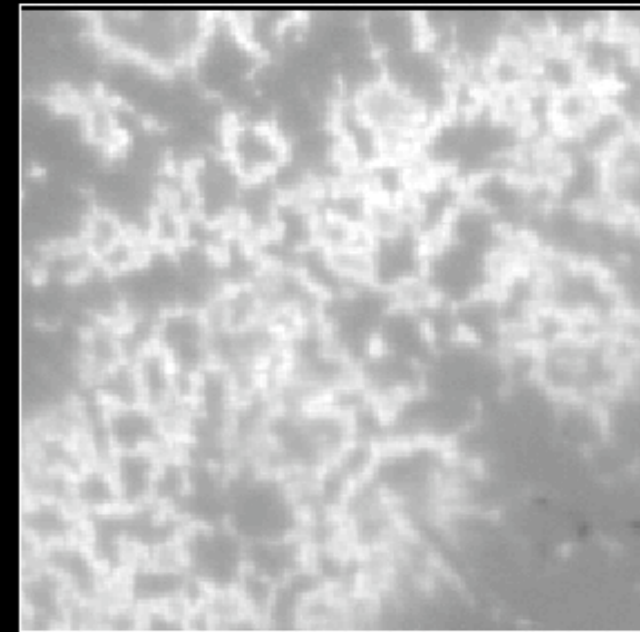
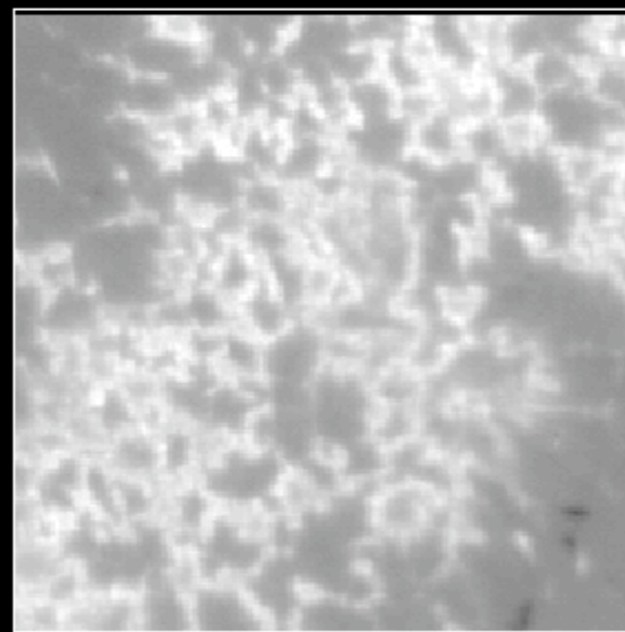
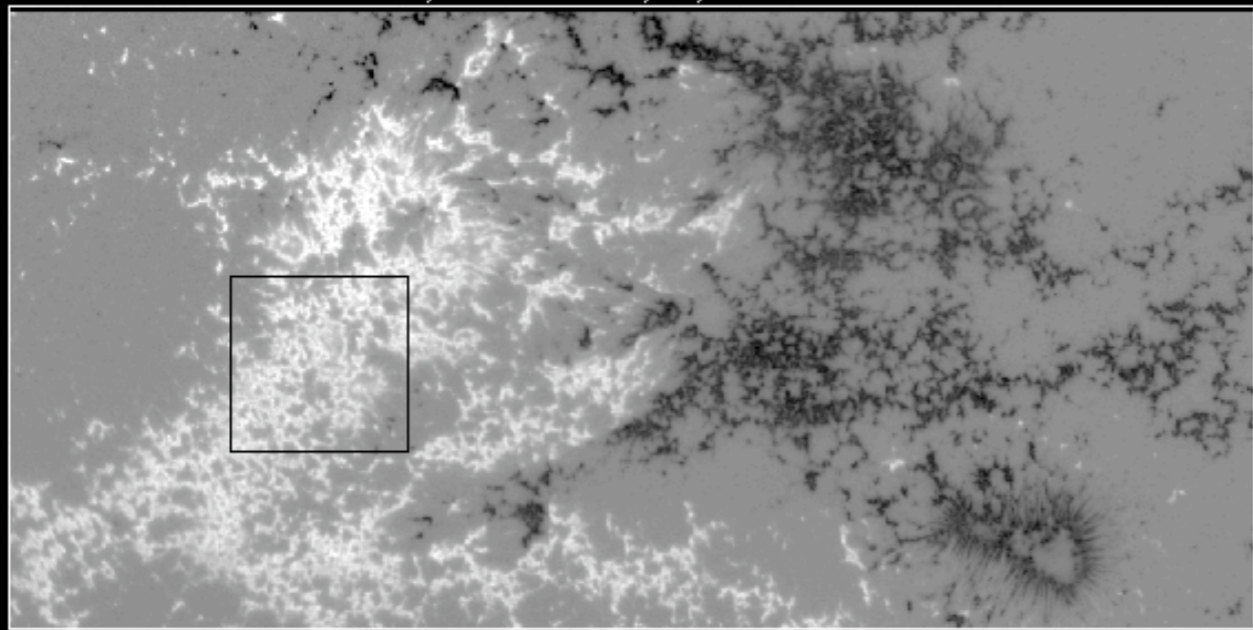


MDI/SOHO High Res. 2007/12/11 22:17:01

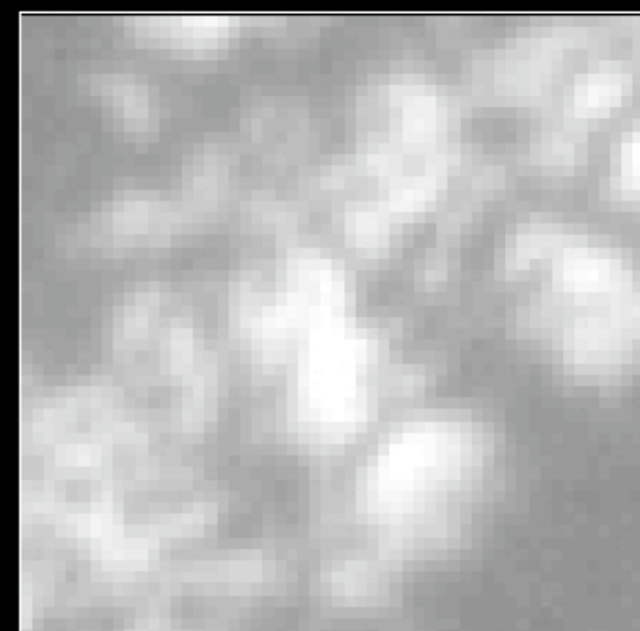
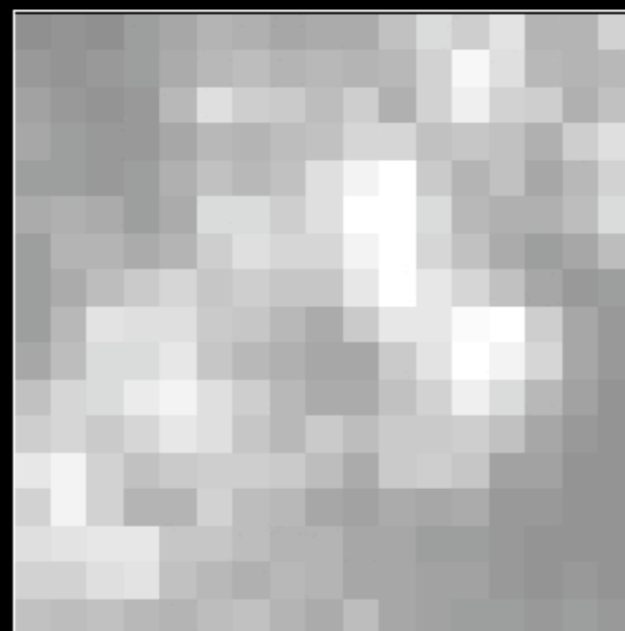
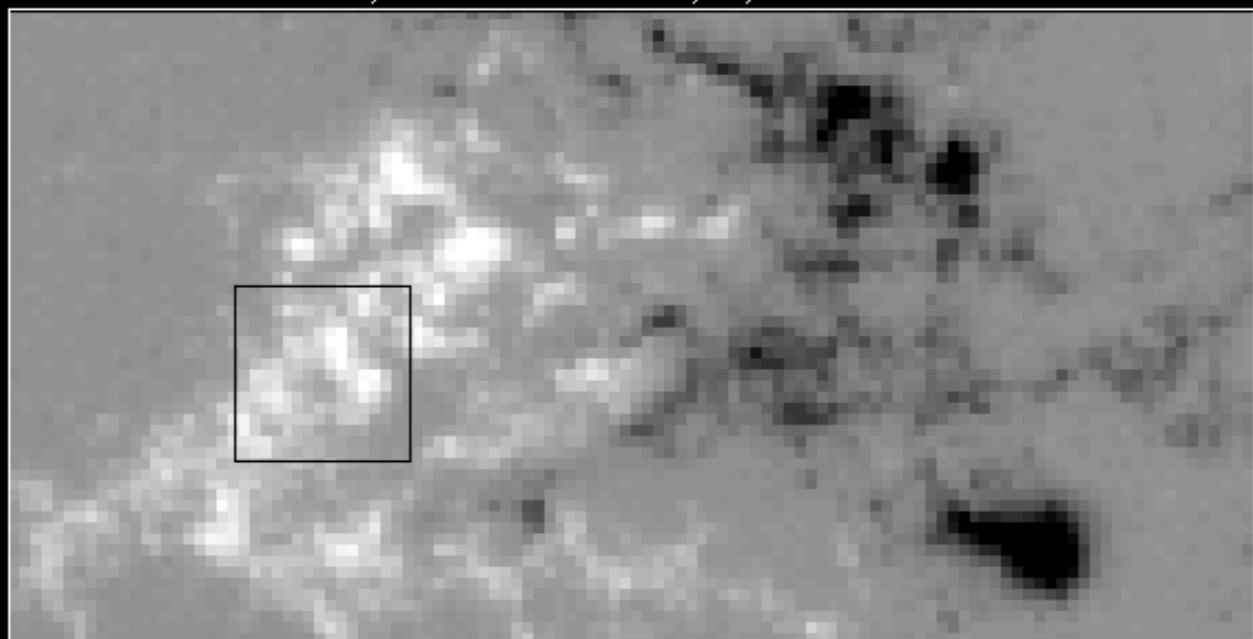


Magnetic field evolution

SOT/Hinode 2007/12/11 21:00:35



MDI/SOHO Full disk 2007/12/11 21:01:01



Magnetic field evolution

Brooks

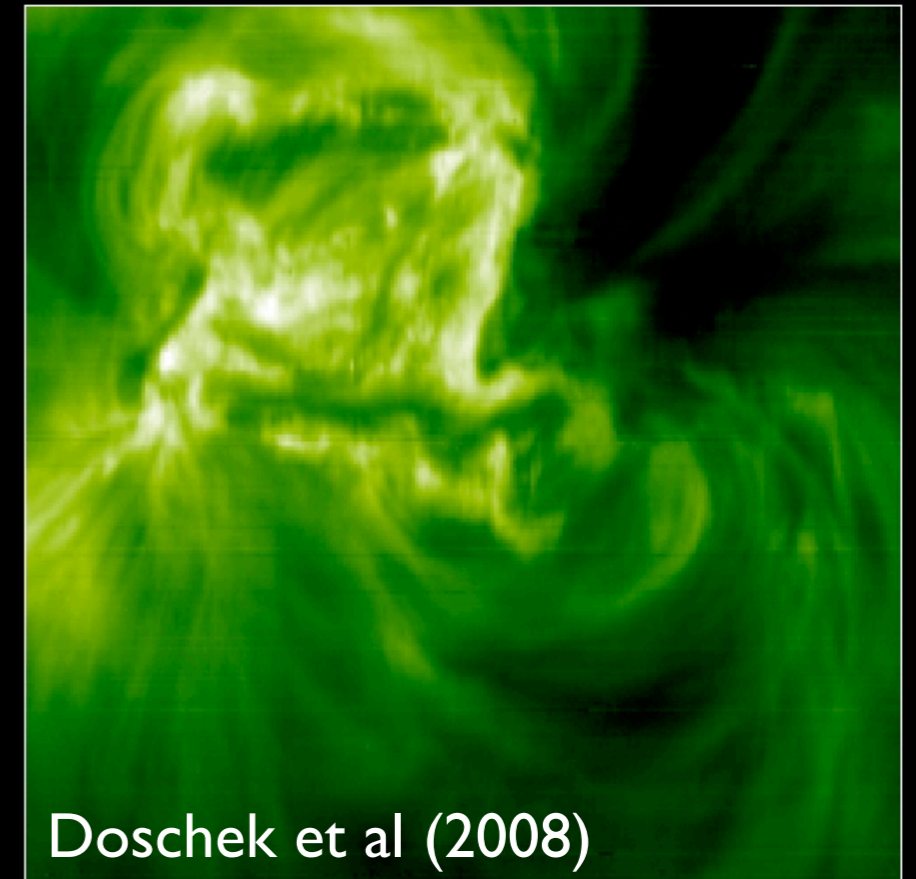
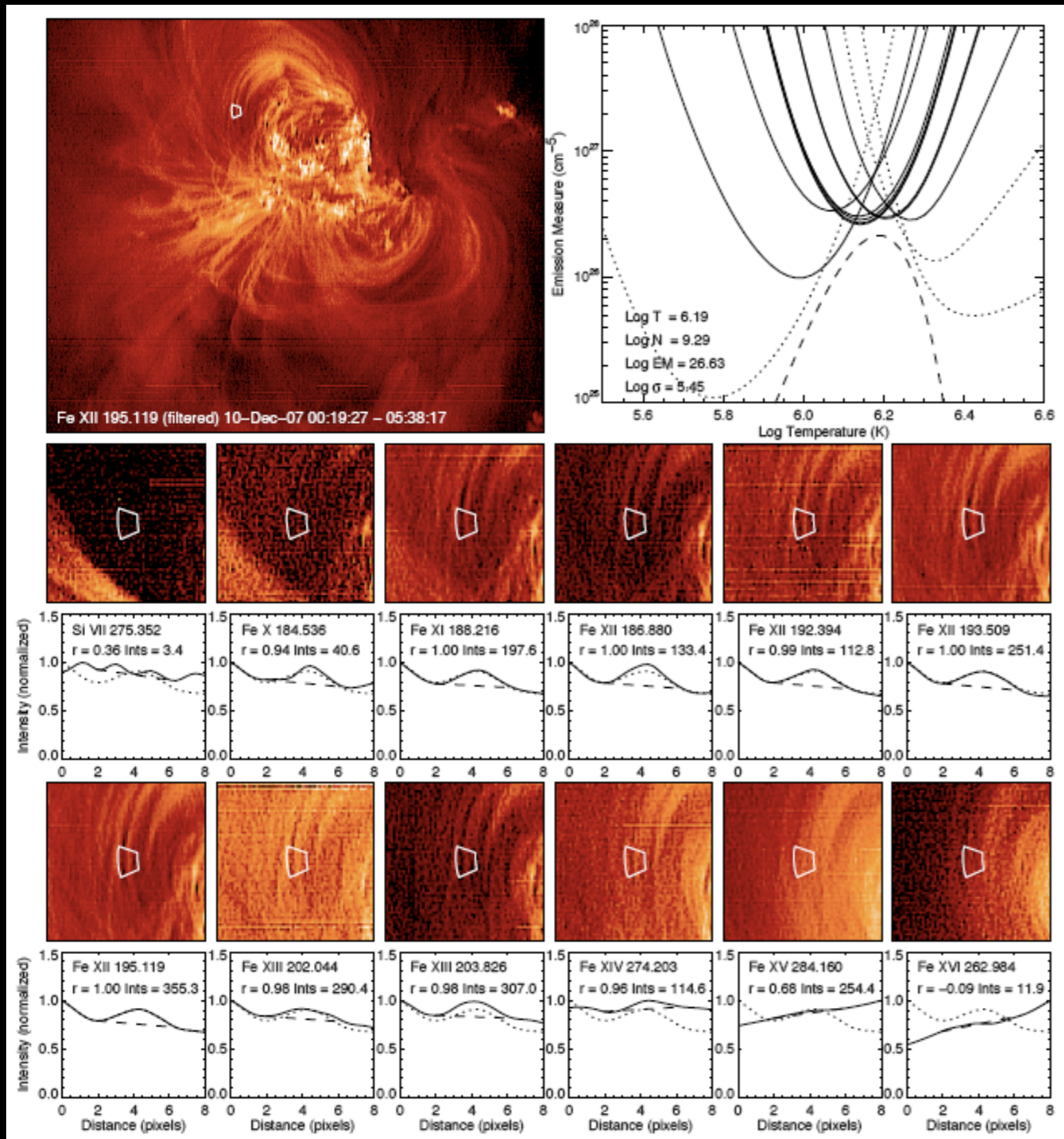
Ugarte-Urra & Warren

EIS Fe XVI 40" slot raster
on SOT Magnetograms

START

Brooks et al. (2008)

Diagnostics and DEM analysis



- Narrow T distributions
 $\sigma_T \sim 3 \times 10^5 \text{ K}$
- Filling factors: 10%

See Poster: P4-16

2007/12/19 05:55:58 UT

Mg VI 268.986Å

Si VII 275.352Å

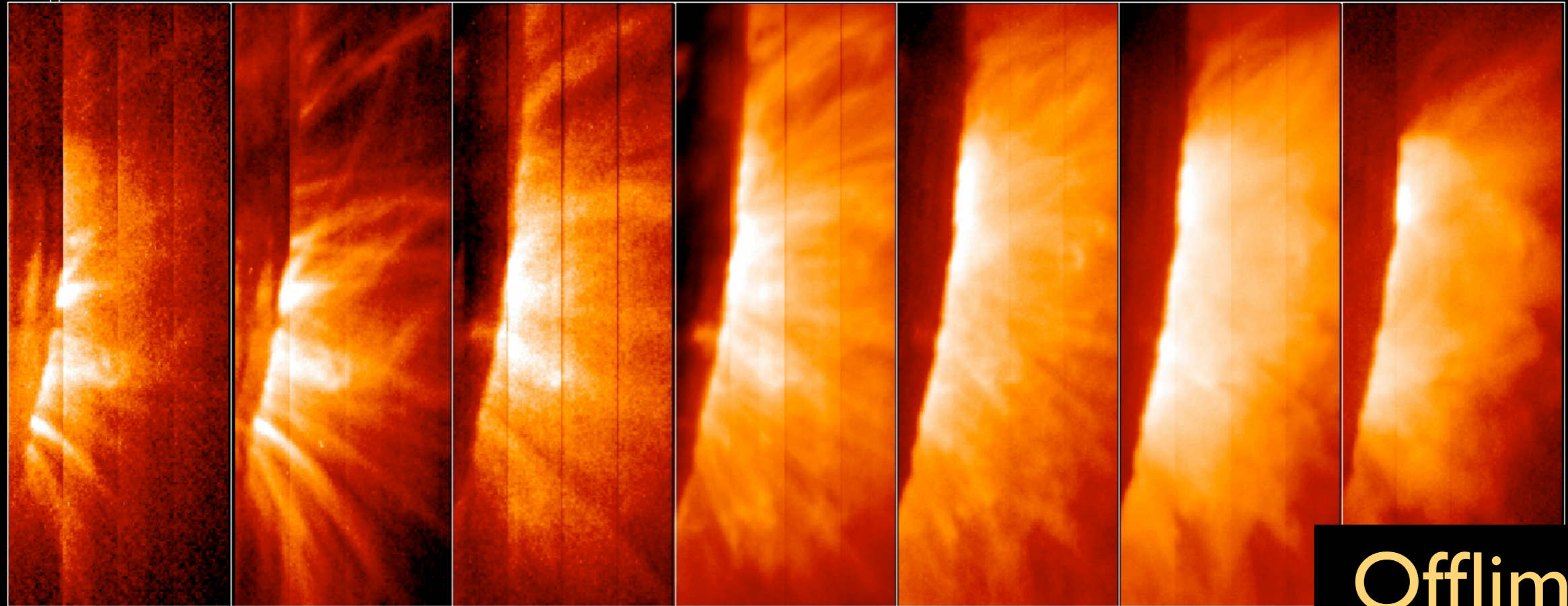
Fe XI 180.401Å

Fe XII 195.119Å

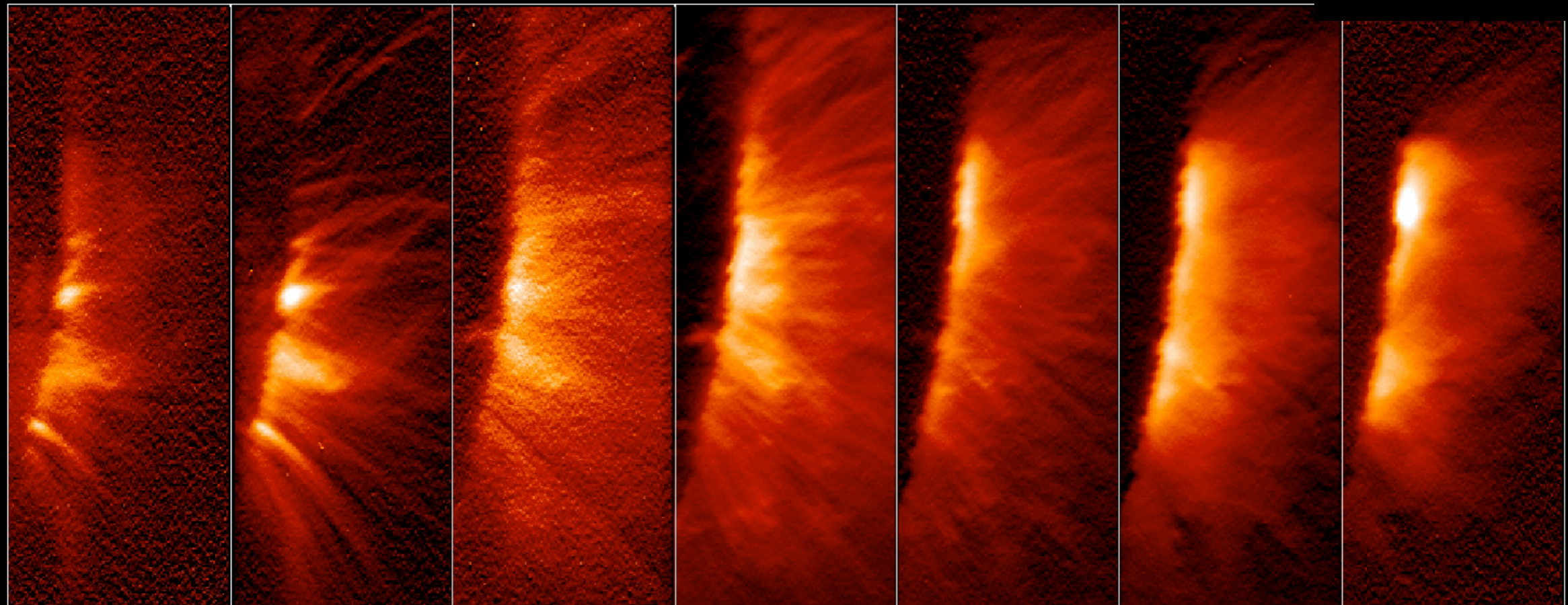
Fe XIV 274.203Å

Fe XV 284.16Å

Fe XVI 262.984Å



Offlimb



2007/12/19 05:55:58 UT

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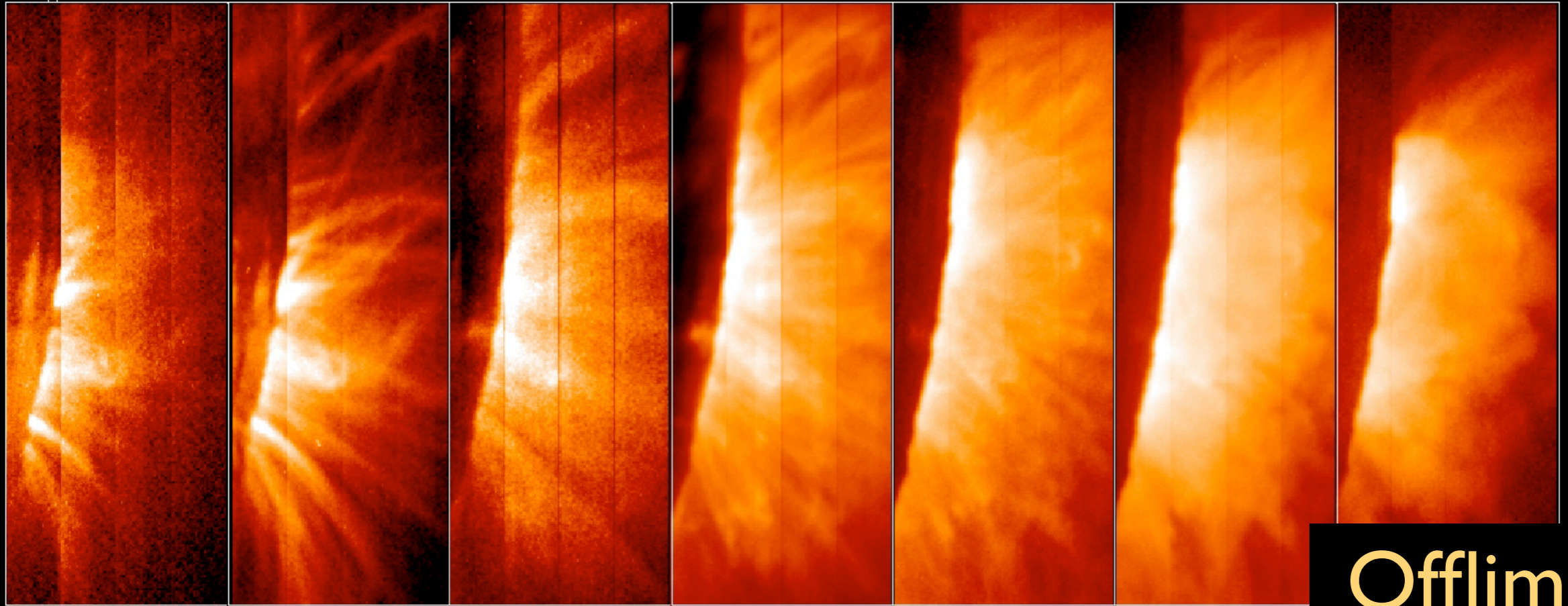
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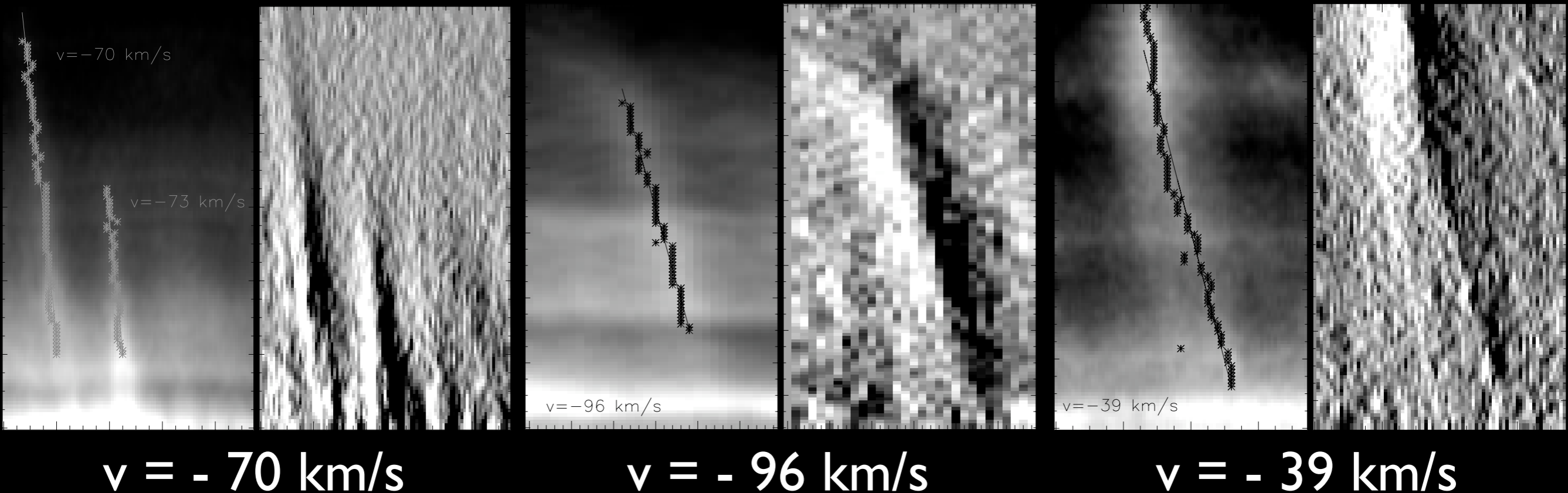
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Offlimb





$v = -70$ km/s

$v = -96$ km/s

$v = -39$ km/s

Summary

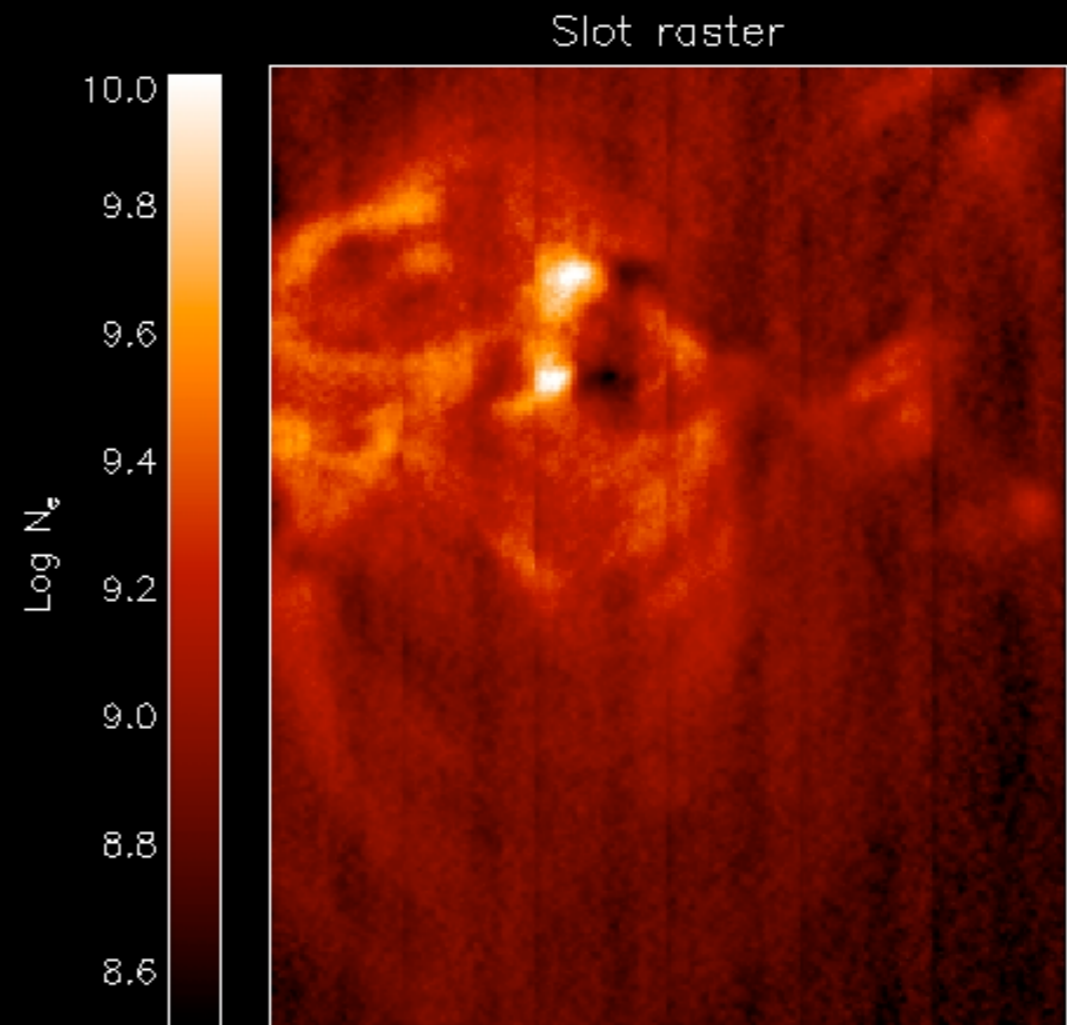
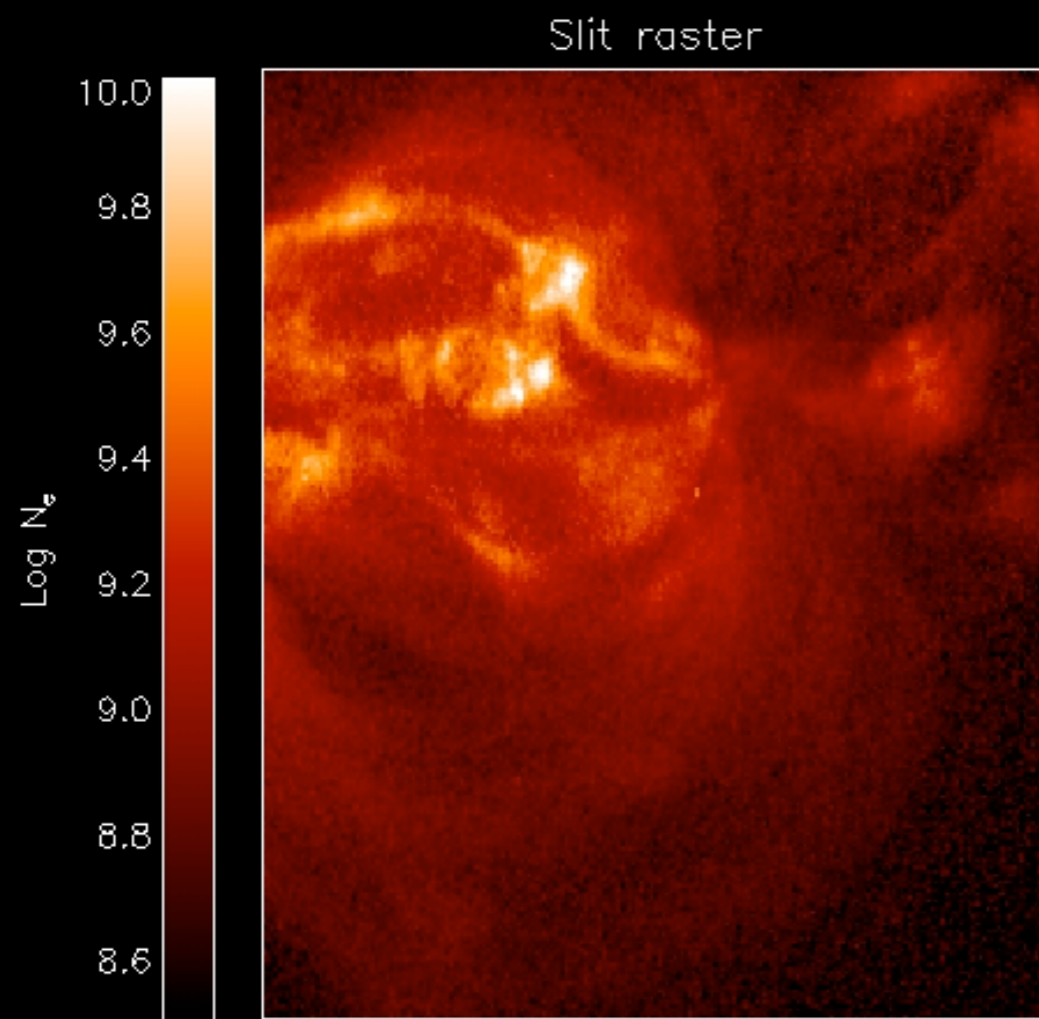
- Active region has two main loop populations.
 - Multi-temperature core loops.  ≤ 0.4 ≥ 2.5 MK
 - Peripheral cool loops.  ≤ 0.4 1.3 MK
 - Loops at different temperatures are time related (cooling)
 - Downflows: 39 - 105 km/s
 - Narrow temperature distributions: $\sim 3 \times 10^5$ K
 - Filling factors: 10% \Rightarrow filamentation
 - Loops rooted in monopolar dynamic regions.
- } Cross-field coherence

Final thoughts

- Where do we stand?
 - waiting for activity to show up! \Rightarrow systematic charact.
- Is continuous reprocessing (heating and cooling) an important part of AR evolution? Should we revisit the “Hot loop = Steady” picture in the XRT era?
- Are there differences between active regions or are the differences part of the evolution stages?

Future work

- Region to explore: deconvolution of slot images.
 - Ne and DEM maps with a 70 s cadence.



Thanks!

References

- Ugarte-Urra, Warren & Brooks. Submitted to ApJ.
“Active Region Transition Region Loop Populations and their Relationship to the Corona”
- Warren, Ugarte-Urra, Doschek, Brooks & Williams. ApJL in press.
“Observations of Active Region Loops with the EUV Imaging Spectrometer on Hinode”
- Brooks, Ugarte-Urra & Warren. Submitted to ApJL.
“The Role of Transient Brightenings in Heating the Solar Corona”