JOINT AIA-SWAP OBSERVATIONS OF RECONNECTION RELATED PROCESSES DURING CORONAL ERUPTIONS

Dan Seaton, Elke D'Huys, Kathy Reeves, Terry Forbes, & Sabrina Savage

Royal Observatory of Belgium
SAO, UNH, & NASA GSFC

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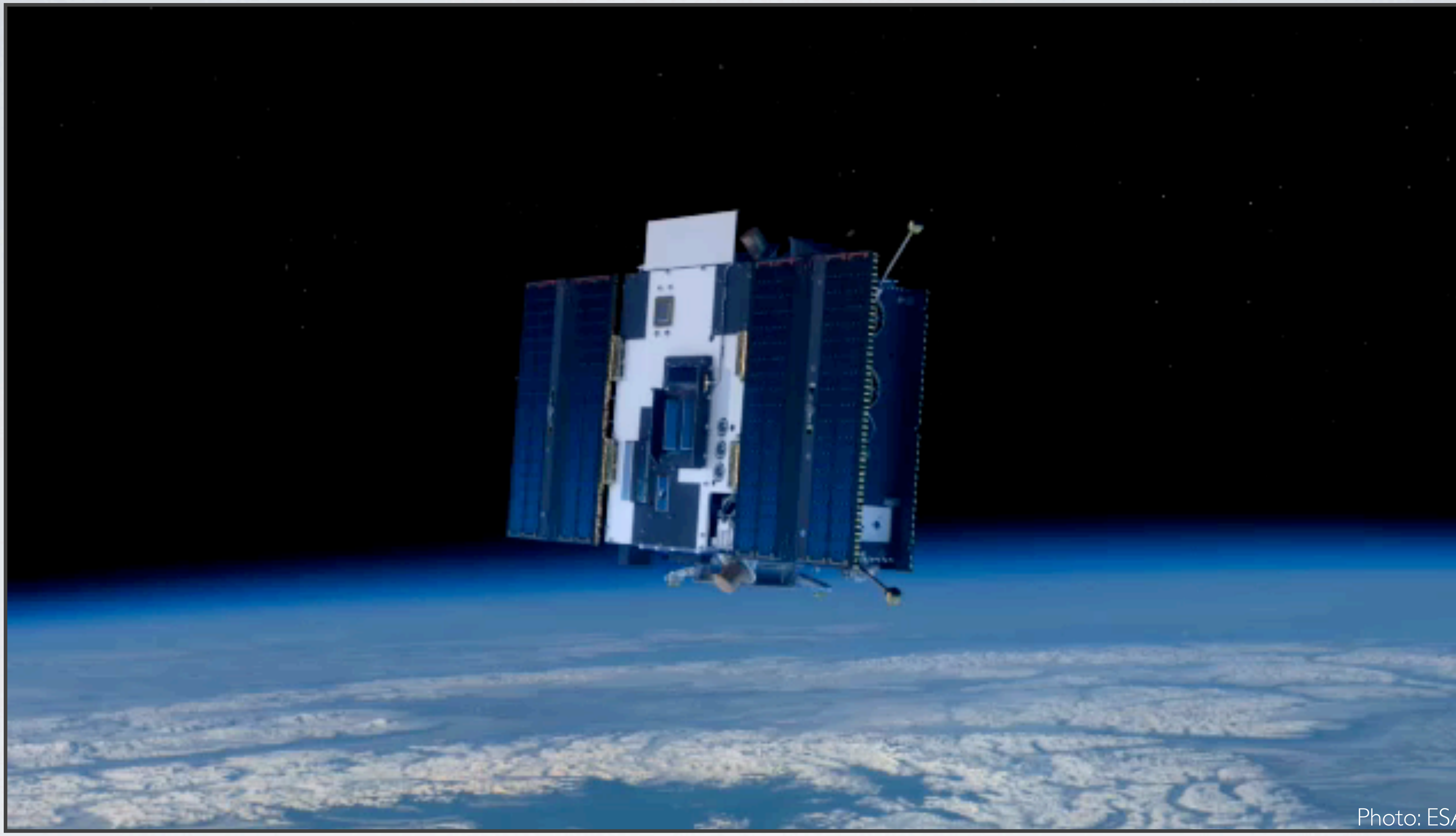
IN THREE PARTS

I. SWAP & PROBA2

II. The 12 January 2011 Eruption: Observations

III. A Little Bit of Analysis: Modeling the Event

I. SWAP & PROBA2



ESA'S PROBA PROGRAM

Project for **O**n-**B**oard **A**utonomy

The PROBA program's main goal is to provide a test platform for new technology.

ESA'S PROBA2 PROGRAM

4 science instruments: SWAP, LYRA, TPMU, DSLP
17 platform technology experiments

Platform technology experiments on PROBA2 include spacecraft propulsion and navigational hardware, computers, etc. Successfully tested technology will be incorporated into figure ESA missions.

PROBA2 INSTRUMENTATION

Sun **W**atcher with **A**ctive Pixel System & Image **P**rocessing

Belgian Instrument: Discussed in detail below

PROBA2 INSTRUMENTATION

Large Yield Radiometer

Belgian Instrument:
Four channel total solar irradiance measurements in UV & EUV wavelengths
Can operate at up to 100 Hz (but nominally is used between 20-50 Hz)

PROBA2 INSTRUMENTATION

Thermal **P**lasma **M**easurement **U**nit

Czech Instrument:
Measures: Electron & Ion Temperature, total ion density, ion composition

PROBA2 INSTRUMENTATION

Dual-**S**egmented **L**angmuir **P**robe

Czech Instrument:
Two Probes allow study of plasma flow
Study temperature anisotropy due to magnetic field direction

ORBIT

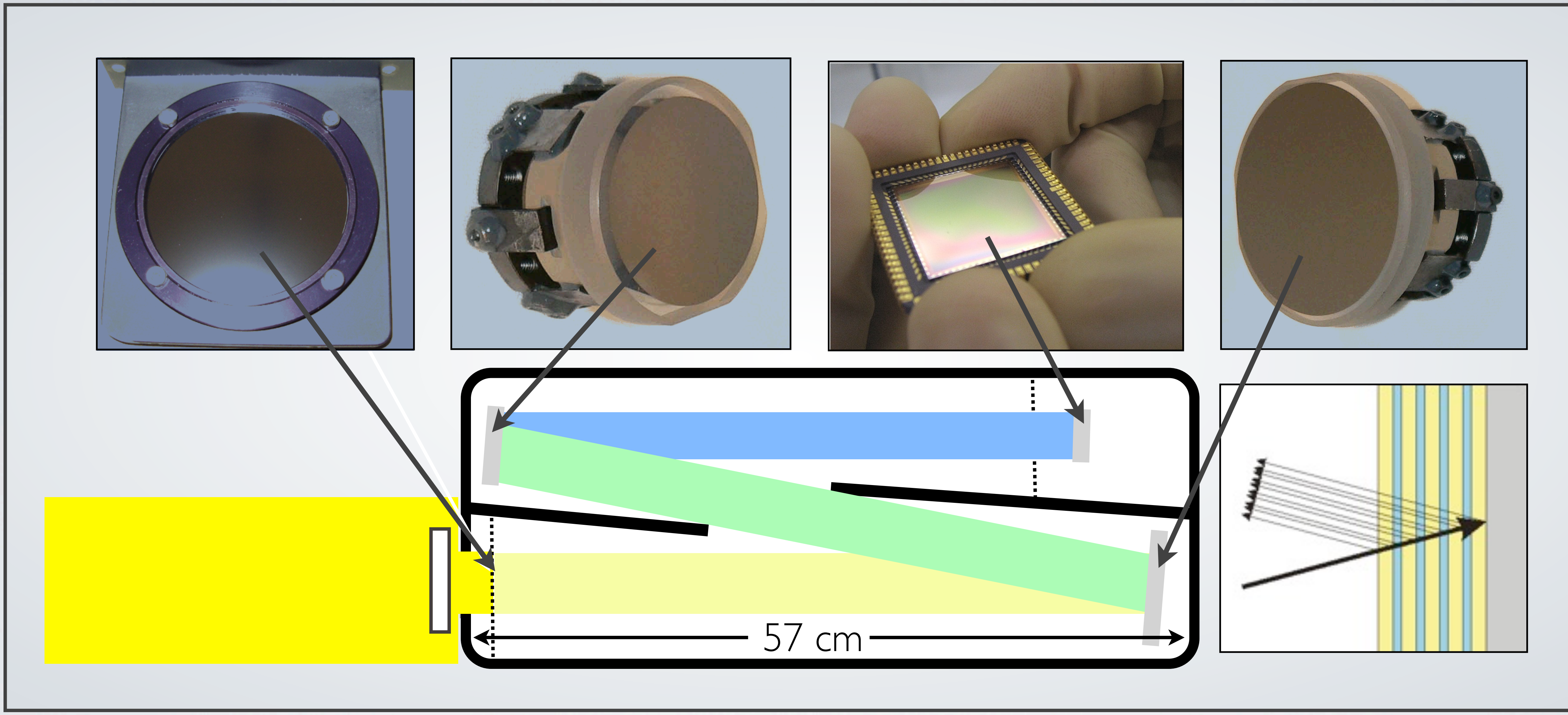
Polar Sun-Synchronous

725 km altitude

Eclipse Season Nov. – Jan.

SWAP

SWAP in the lab during spacecraft assembly and testing

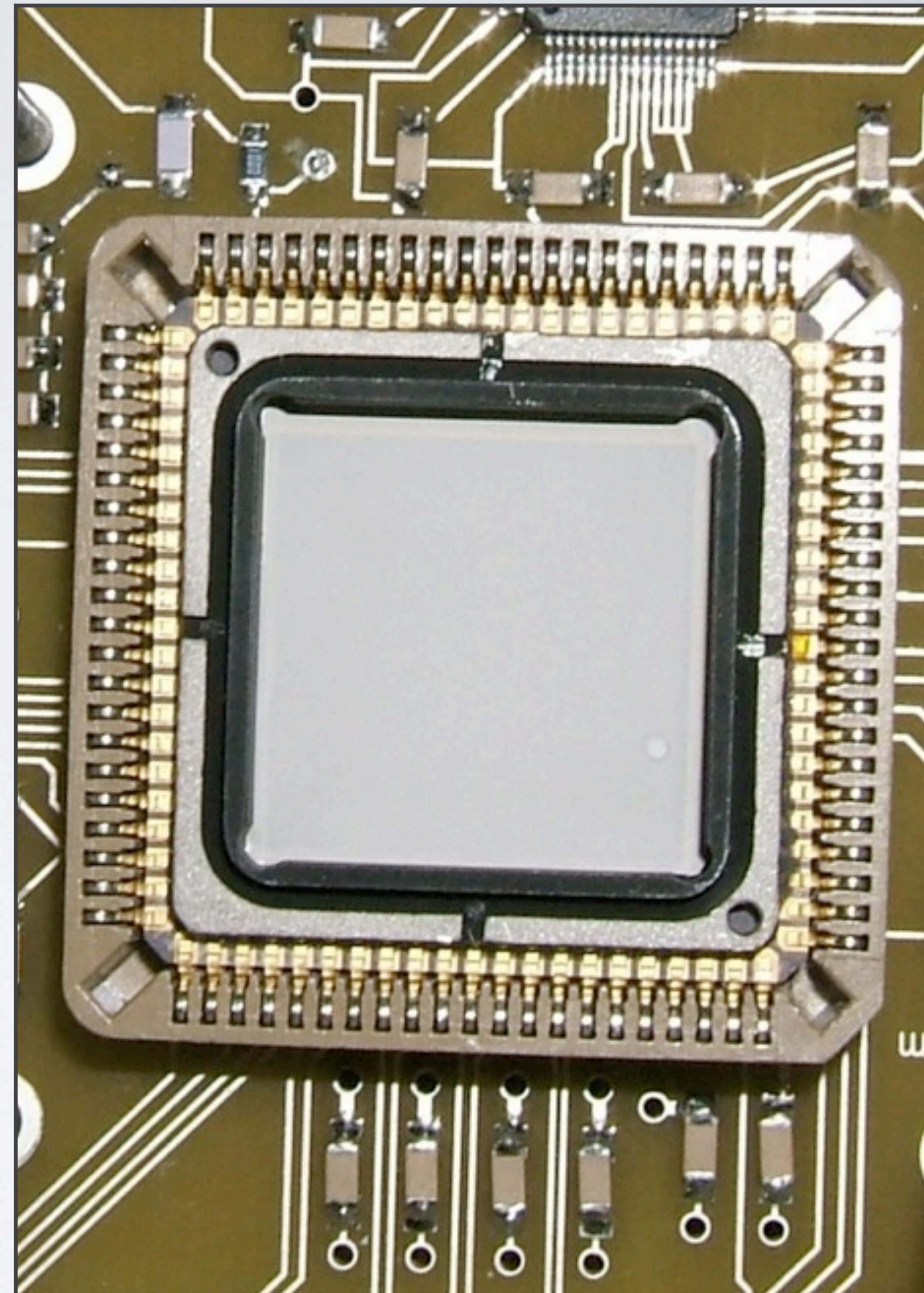


OPTICAL PATH

Off-Axis Ritchey-Chrétien Scheme

CMOS APS DETECTOR

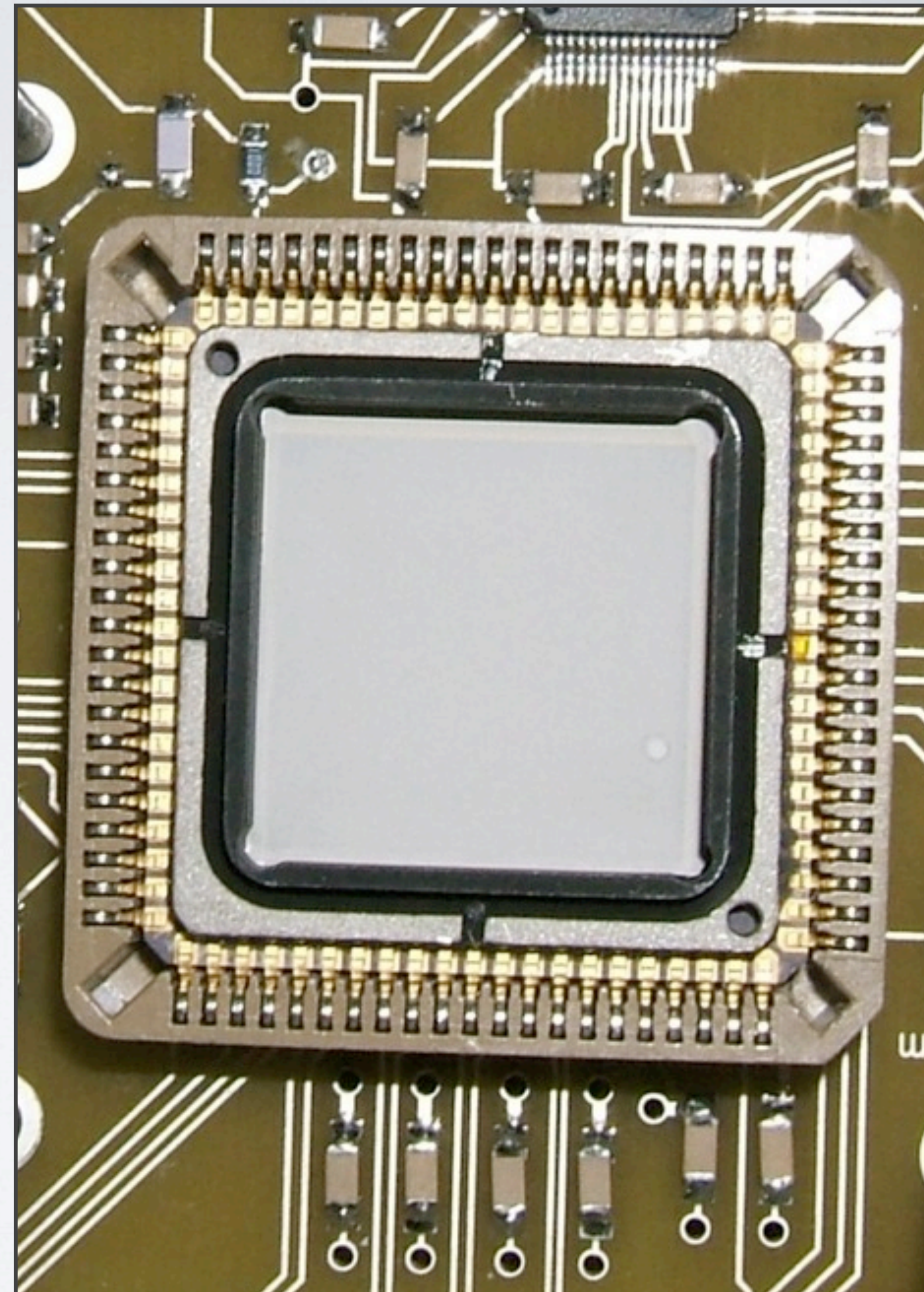
First CMOS for solar physics in orbit



CMOS APS: Compementary Metal-Oxide-Semiconductor Active Pixel System

CMOS APS DETECTOR

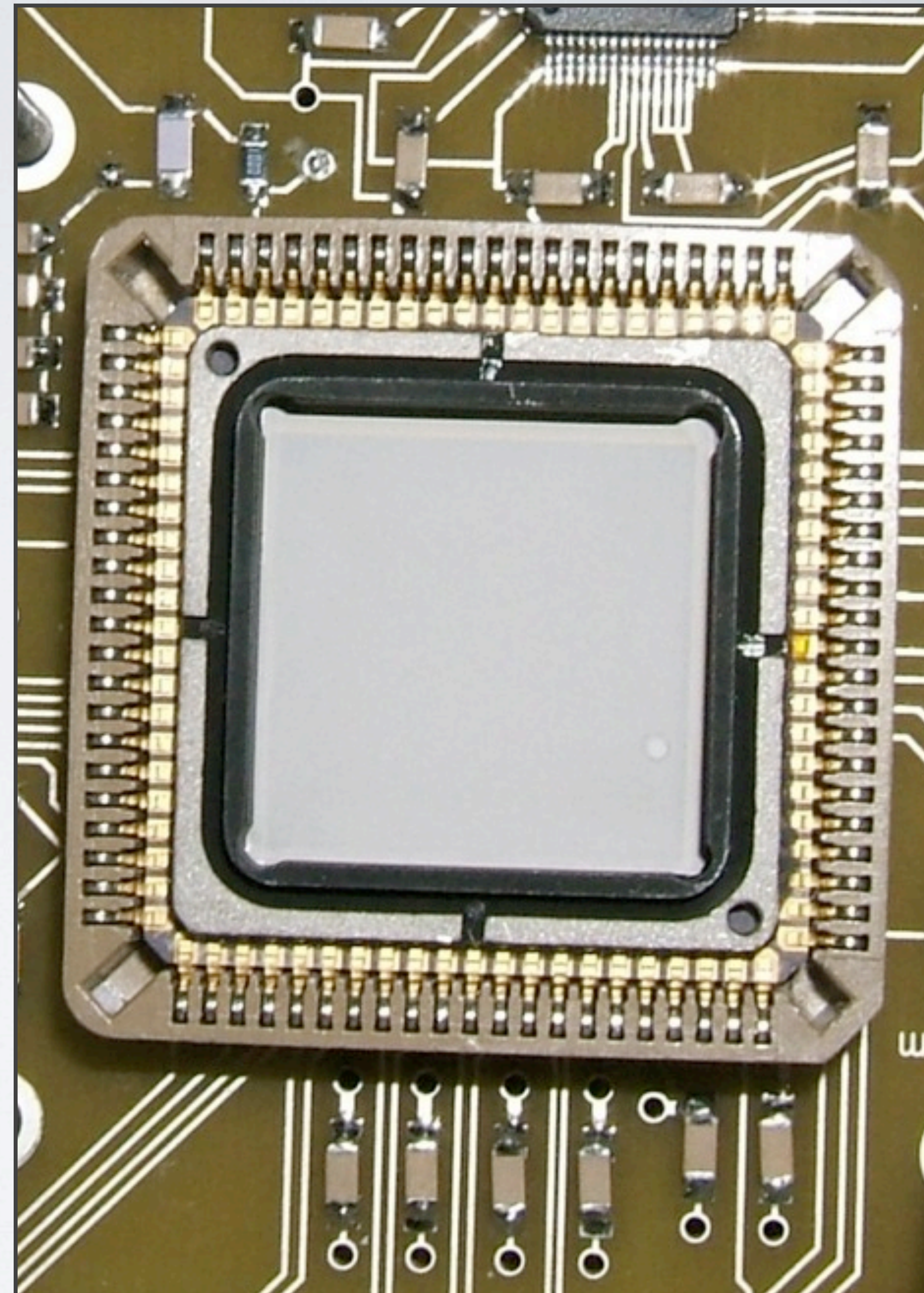
Low power consumption



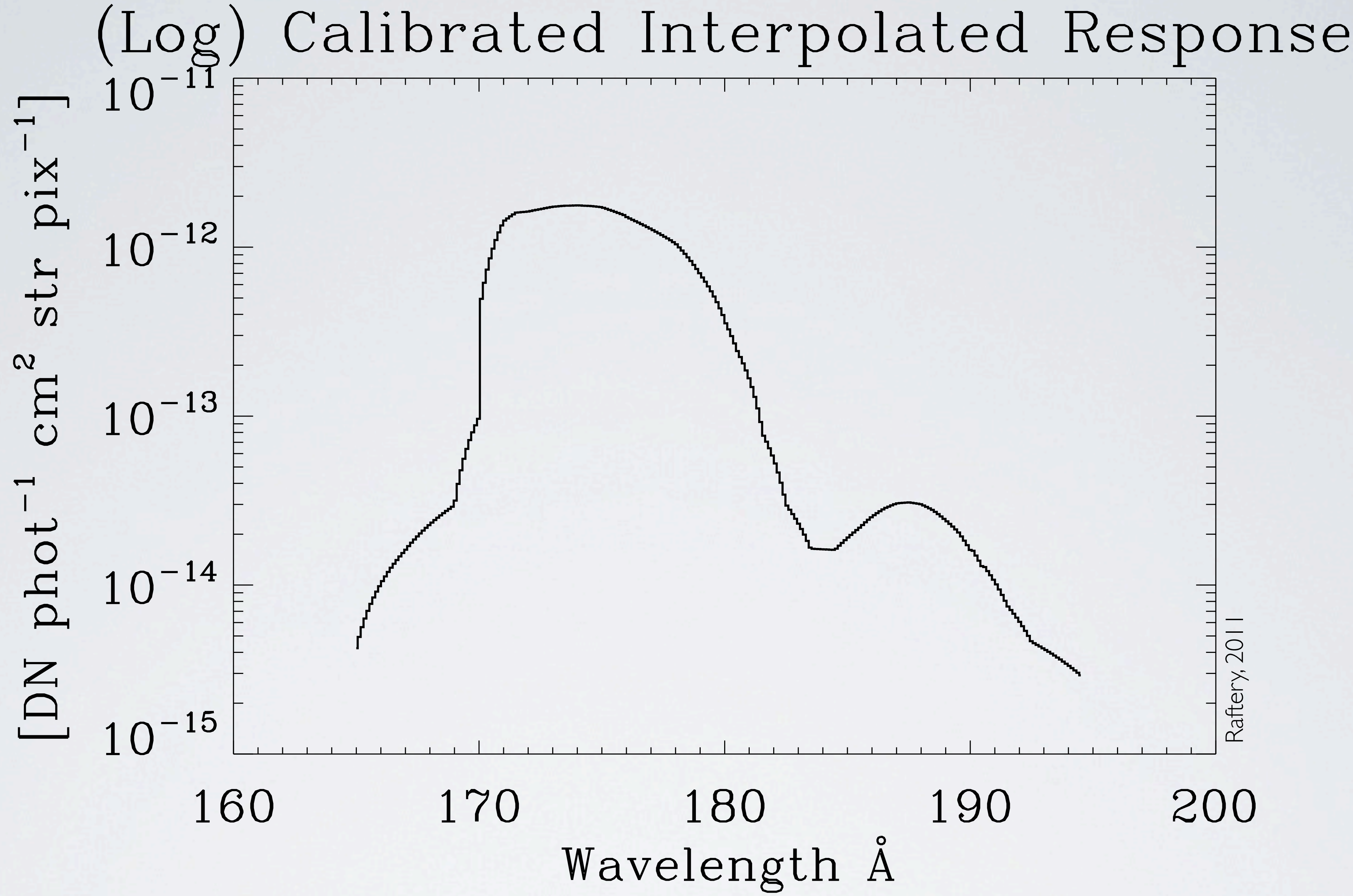
SWAP's energy budget is at maximum about 2.5 W

CMOS APS DETECTOR

No charge transfer as in CCD
No need for shutter
No blooming

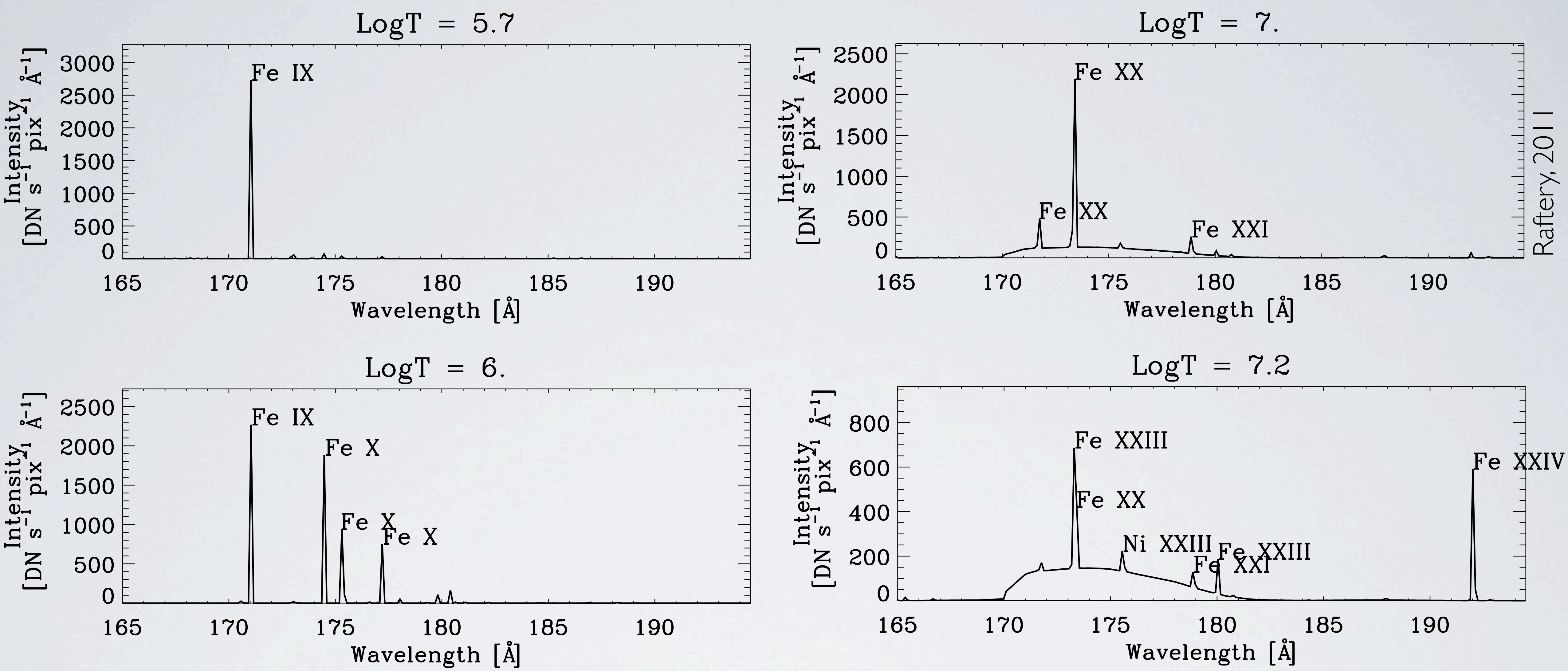


Each pixel has its own electronics, which has advantages and disadvantages



SPECTRAL RESPONSE

Measured with Synchrotron Beam at BESSY

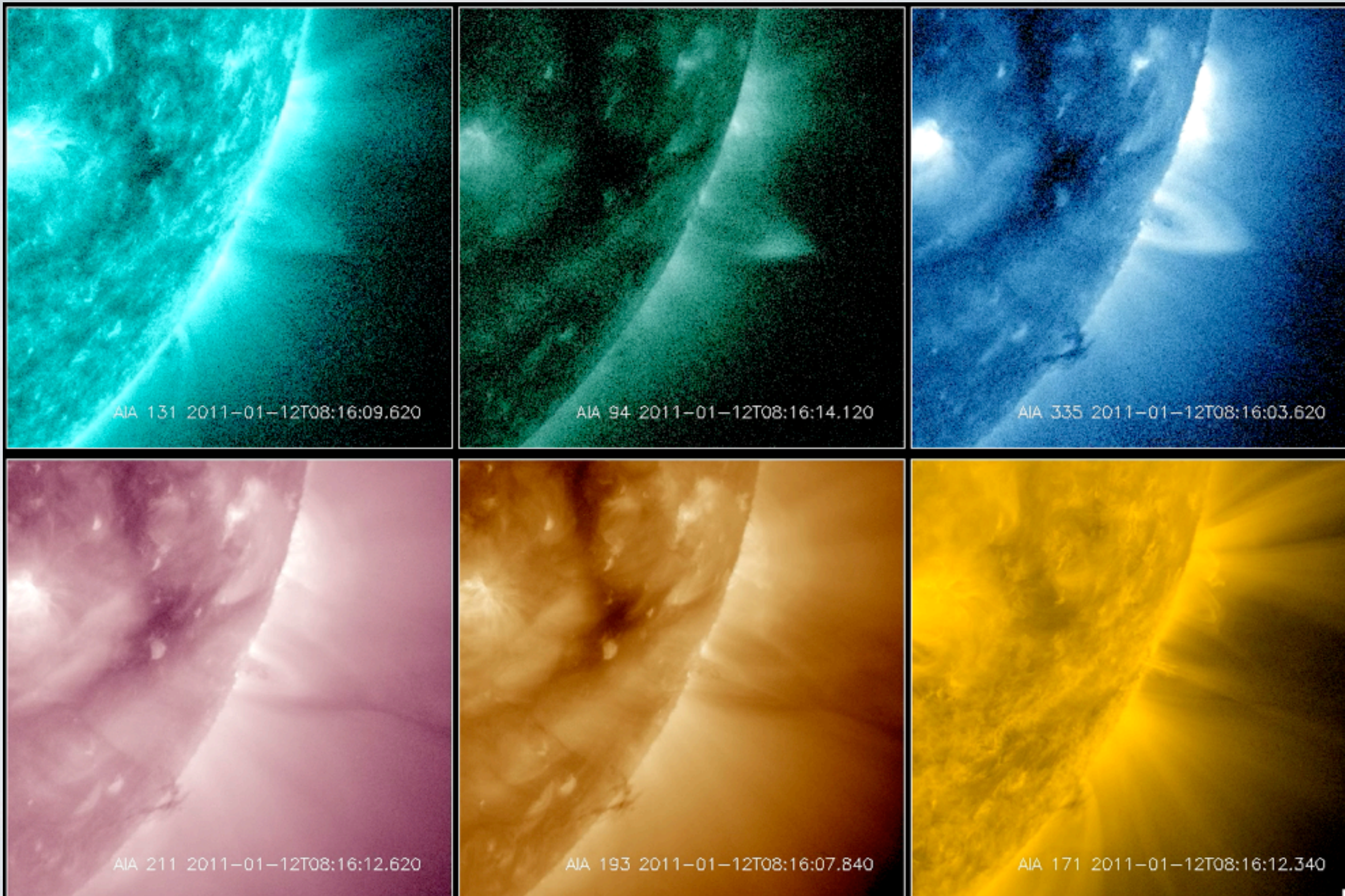


SPECTRAL RESPONSE

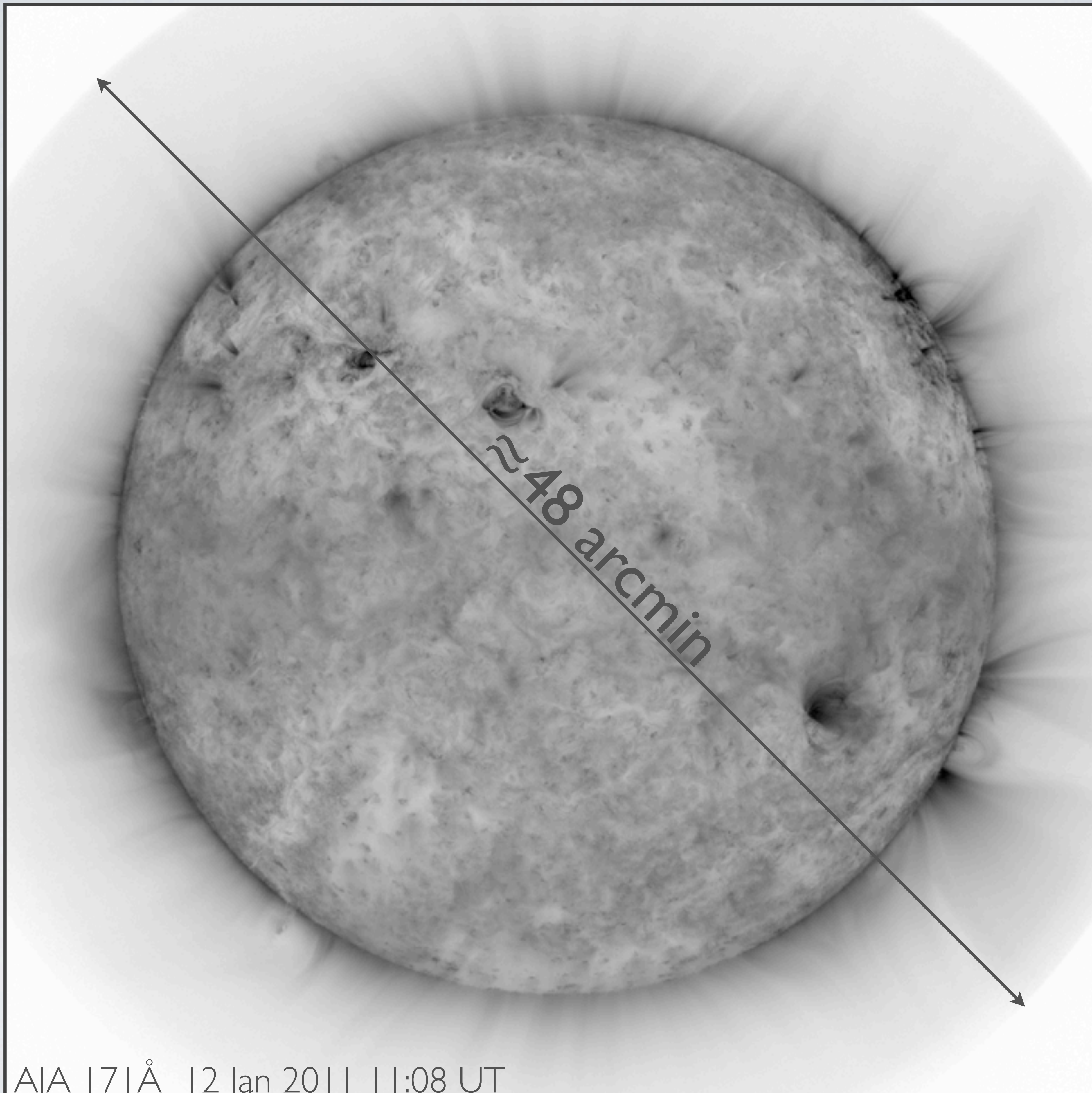
Transmitted Lines at Selected Temperatures

For considerably more detail see Raftery, 2009, PhD Thesis, Trinity College Dublin

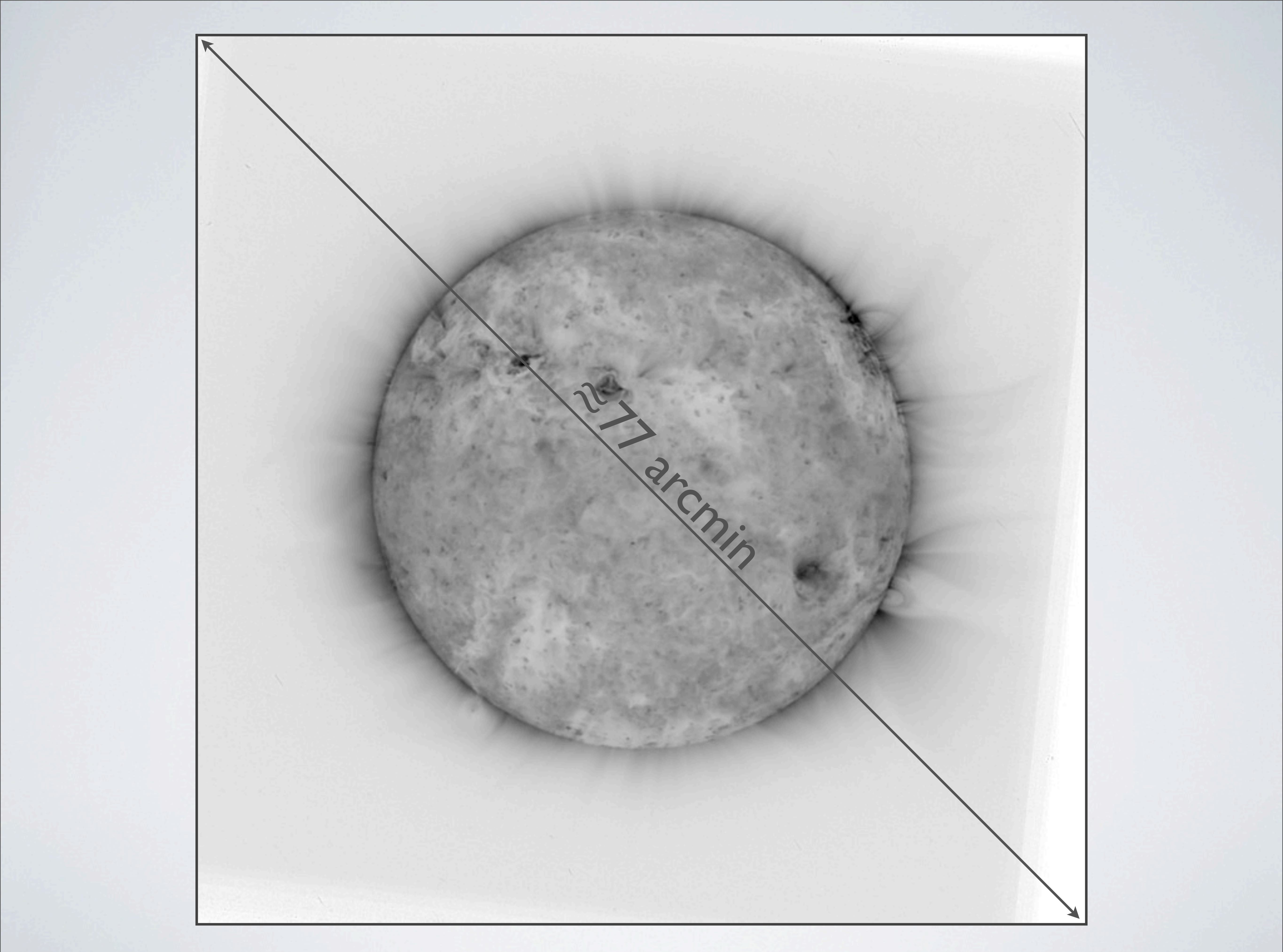
II. THE 12 JANUARY 2011 ERUPTION



Movie of the relatively non-impulsive eruption of 12 January 2011



AIA provides spatial resolution while SWAP's larger FOV and off-pointing capabilities provide imaging of extended structures



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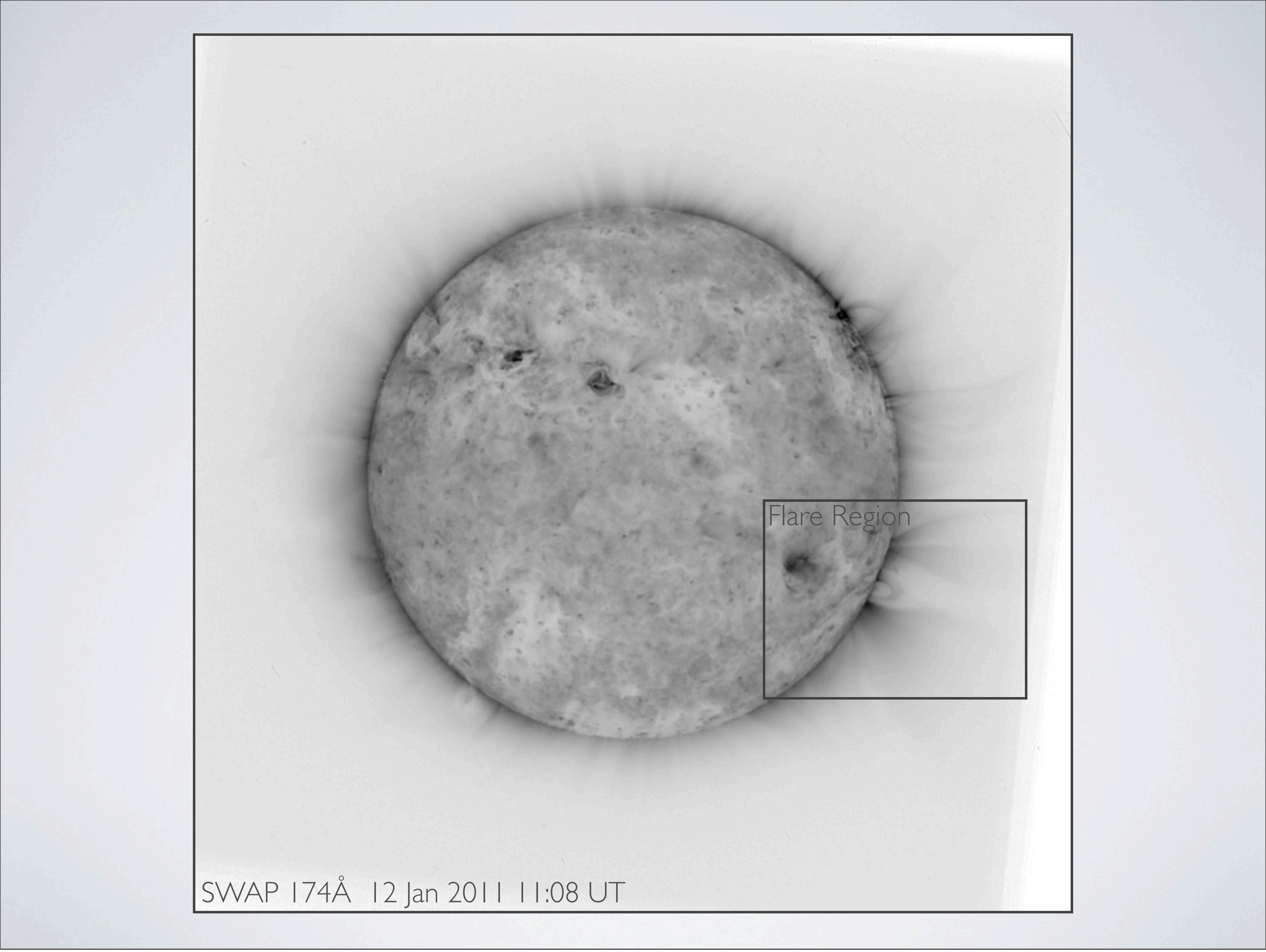
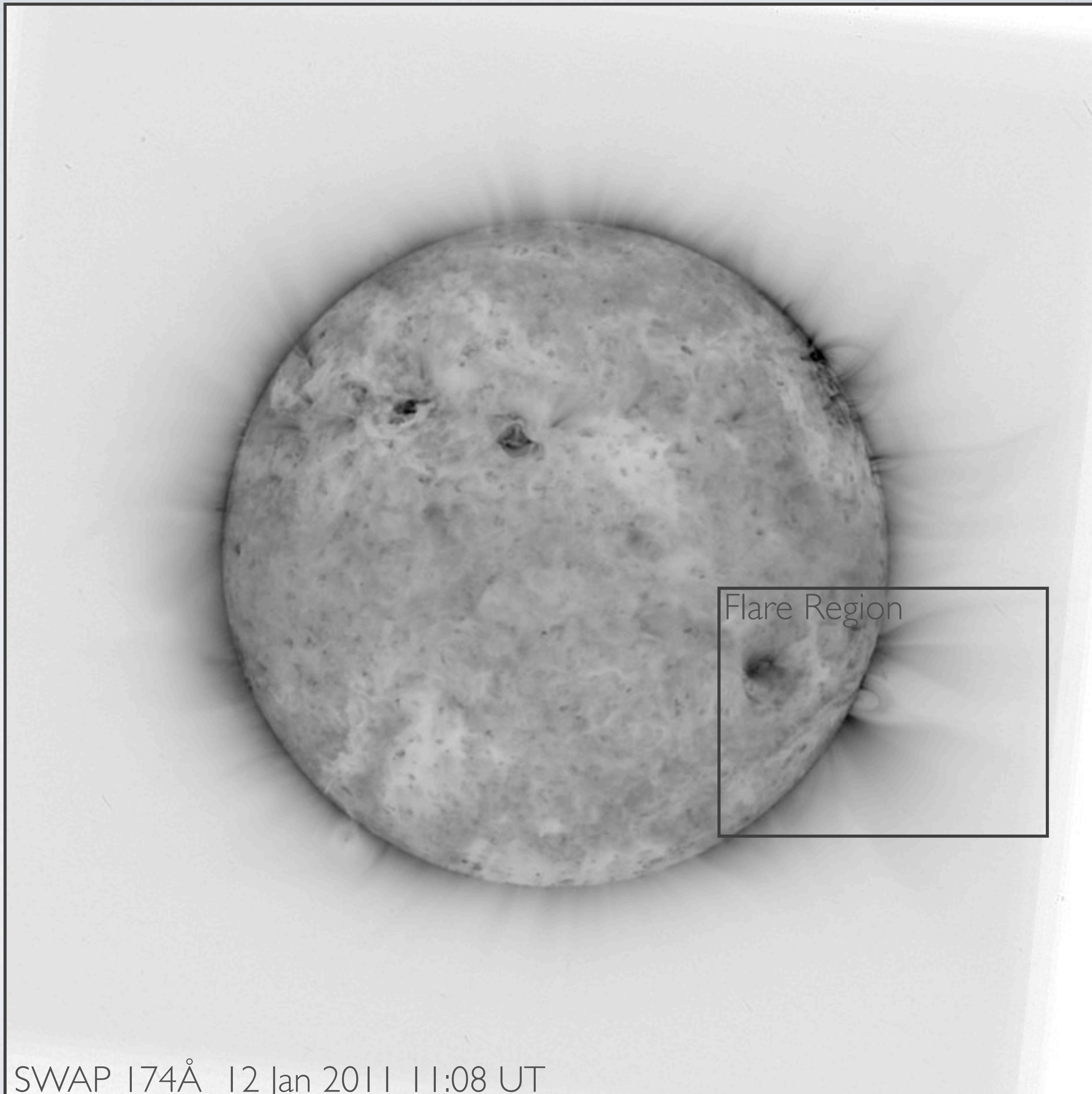


AIA cutout overlaid on SWAP showing full extent of bright extended structures near the current sheet during this event.



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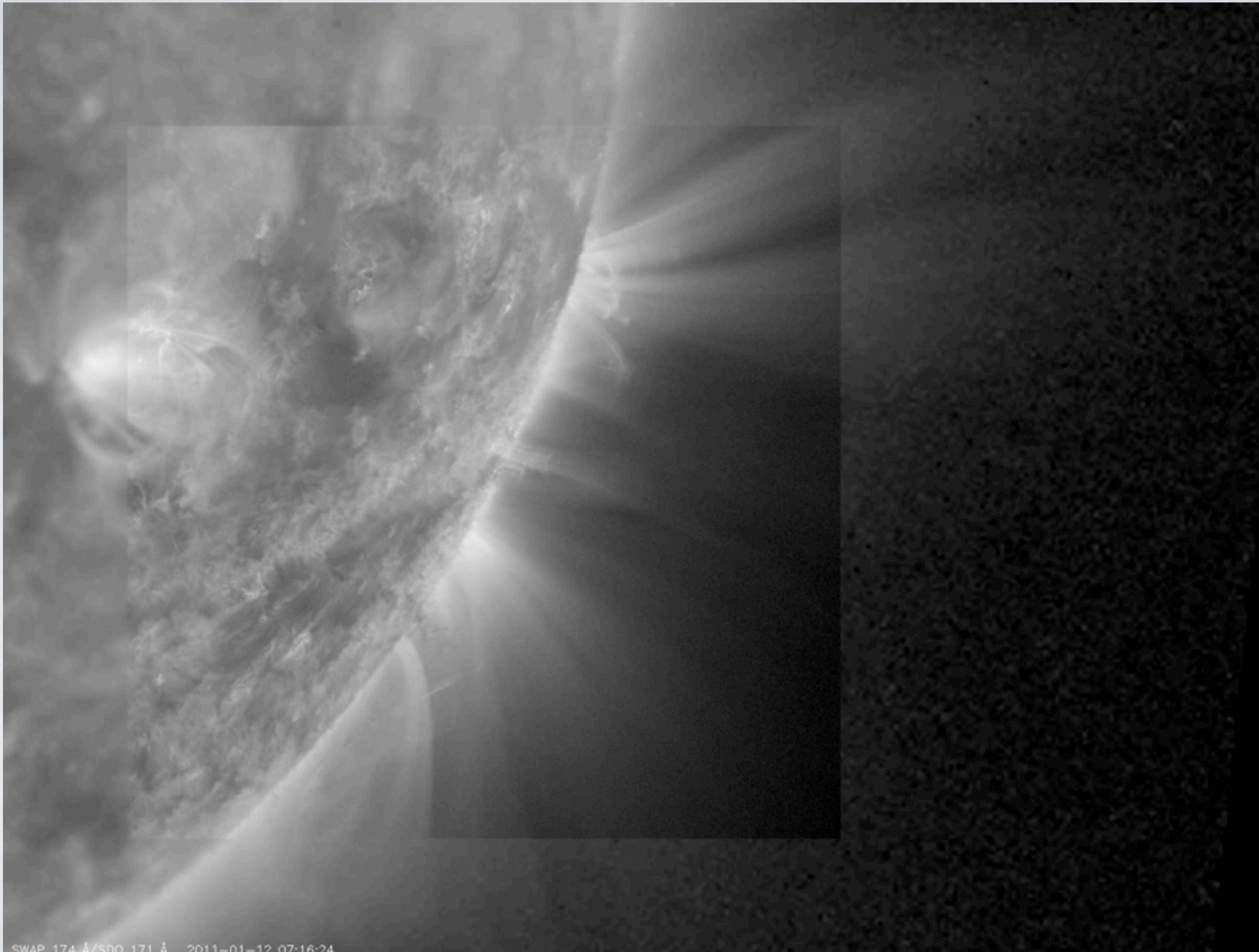

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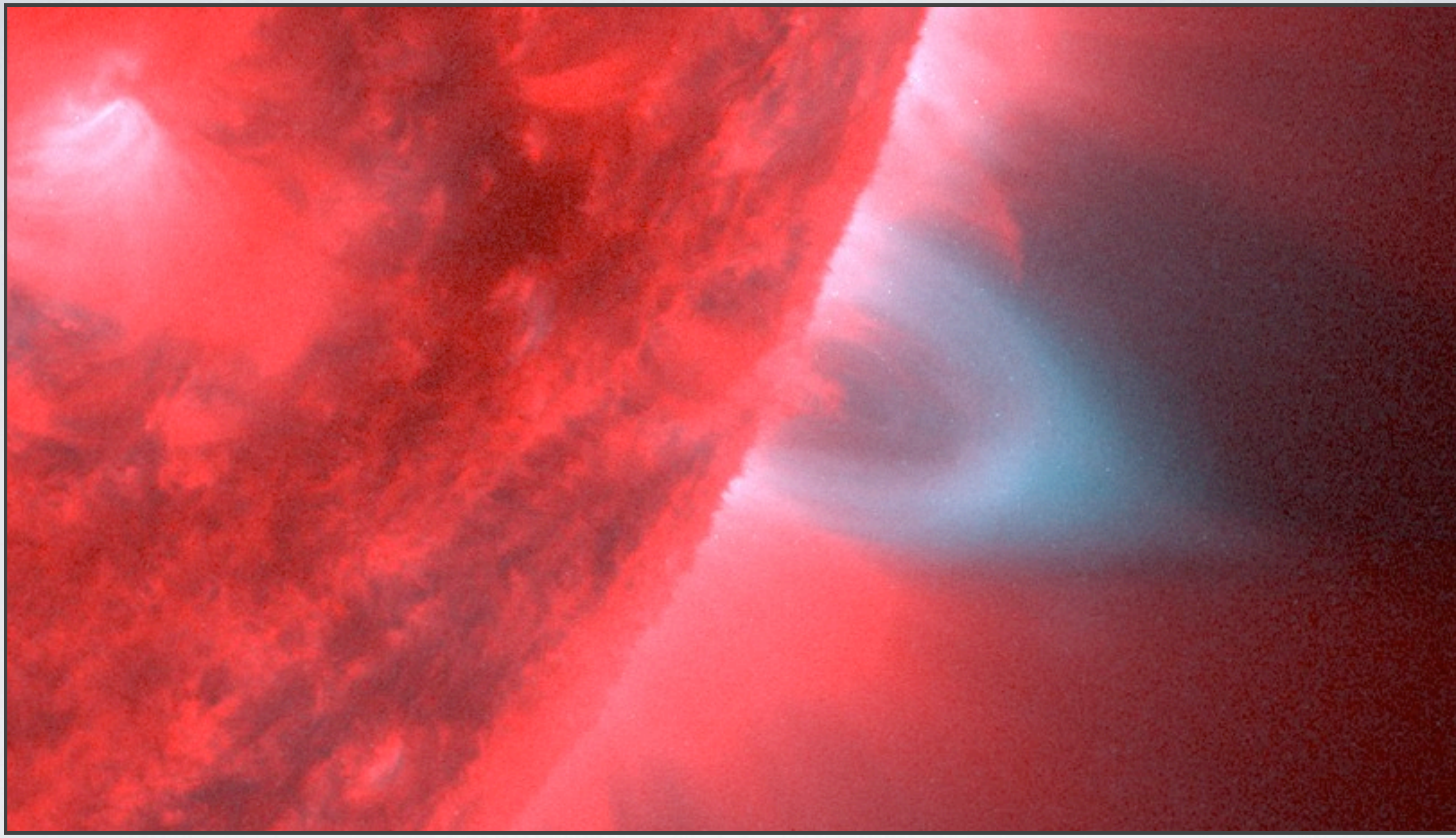
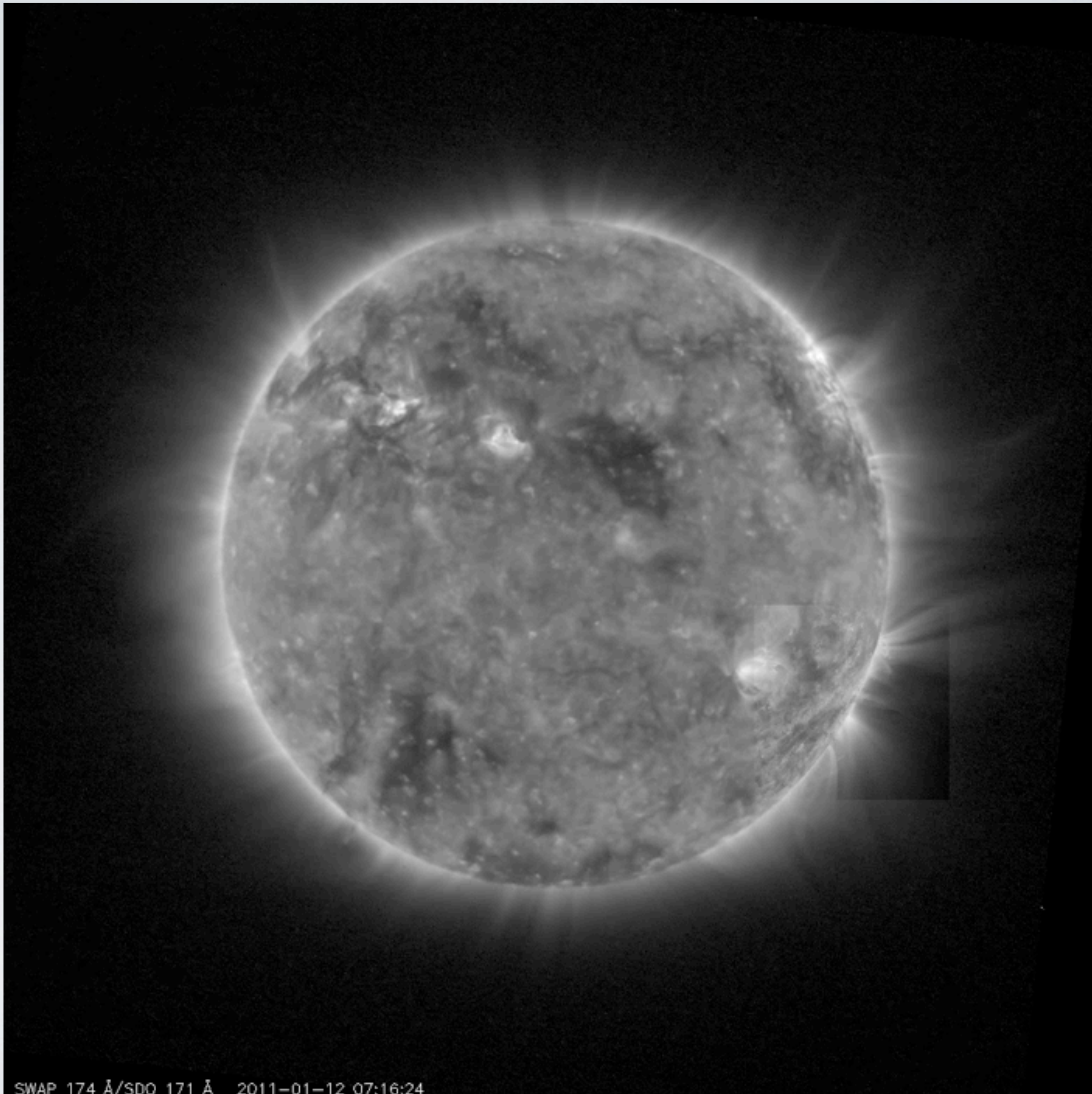


171 Å CURRENT LAYER VOID

Red: 171 Å (log $T \approx 5.8$) • Blue 335 Å (log $T \approx 6.4$)

SWAP and AIA's 171/4 channels provide a good proxy for the location of the current sheet. The dark void in these channels is essentially coincident with bright structures in higher-temperature channels.

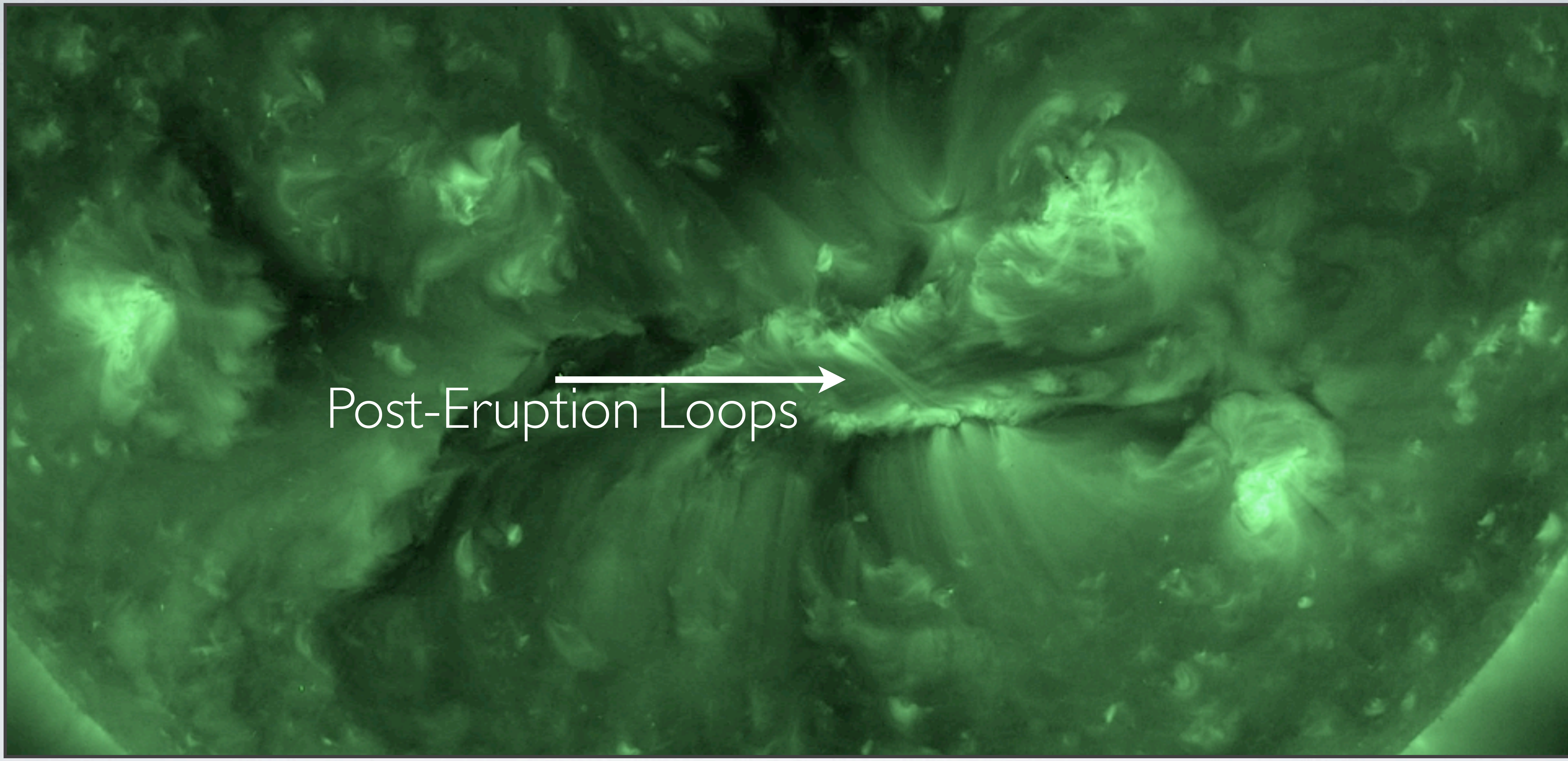
MODEL INPUT I: RECONNECTION RATE



Extended structures are being convected into the current sheet. The rate of convection provides an estimate of the reconnection rate during the eruption.

174 Å MOTIONS PROVIDE AN ESTIMATE OF THE RECONNECTION RATE

MODEL INPUT II: POST-ERUPTIVE LOOP GEOMETRY



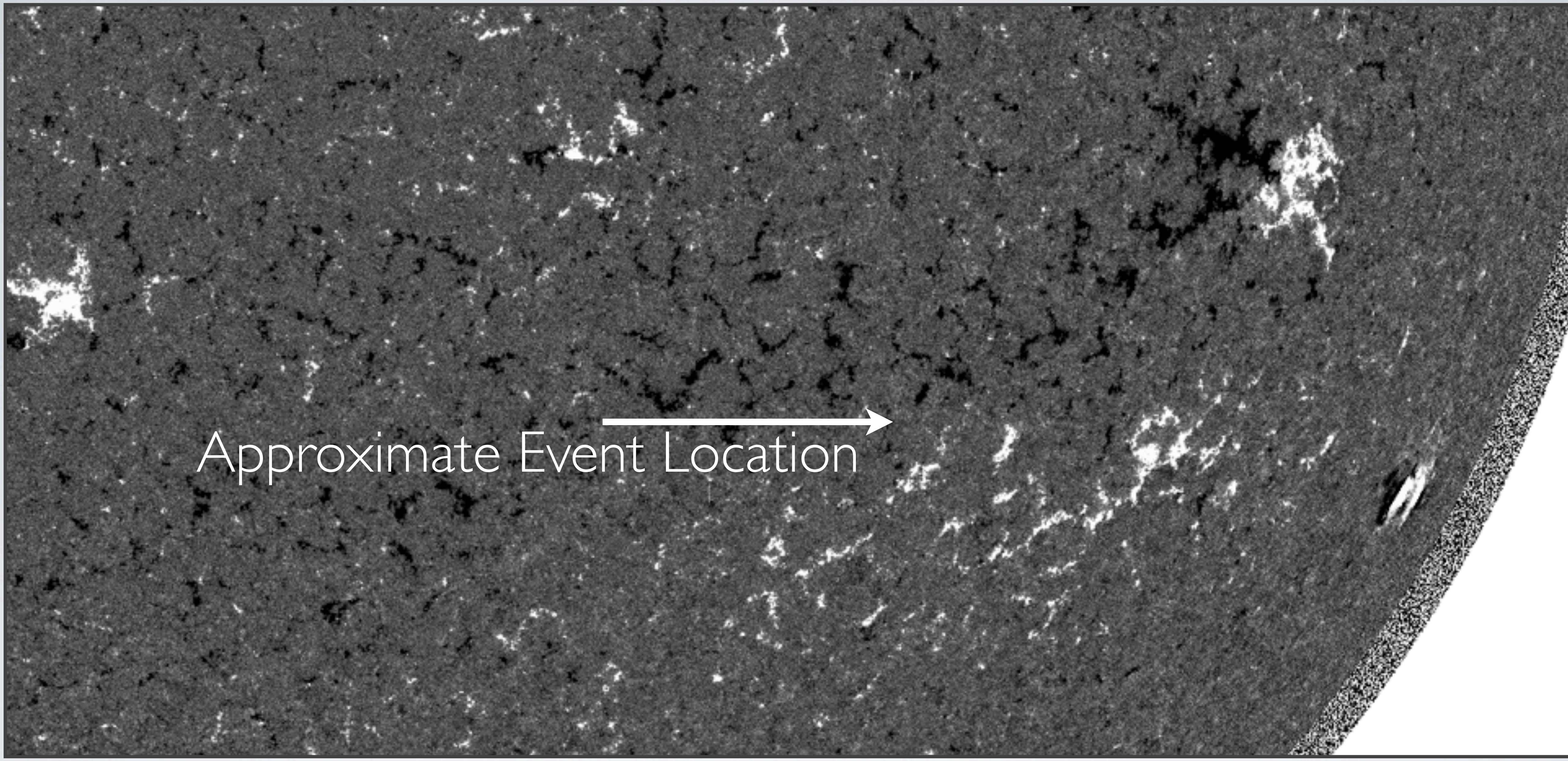
STEREO-A 195 Å

12 January 2011 11:00 UT

STEREO shows that this event is very much confined to only a few loops.

STEREO-A REVEALS 2D NATURE OF EVENT & LOOP FOOTPOINT SEPARATION

MODEL INPUT III: BACKGROUND FIELD STRENGTH



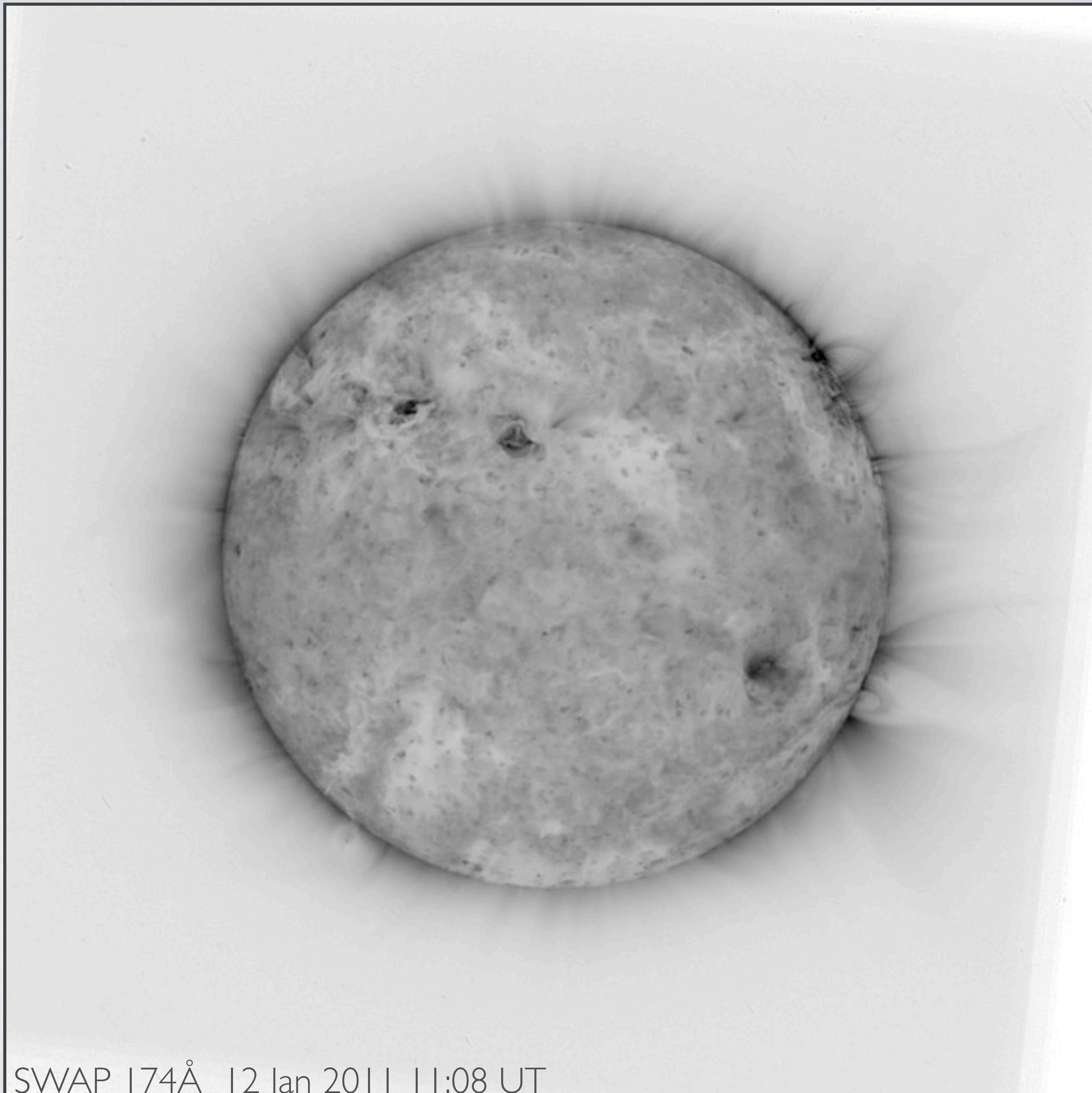
HMI MAGNETOGRAM

8 January 2011

We use HMI magnetograms from several days earlier to estimate the background field strength during this event. Fields are weak, on the order of 10’s of Gauss.

HMI OBSERVATIONS FROM 8 JANUARY REVEAL ONLY RELATIVELY WEAK FIELDS

MODEL INPUT IIII:
ERUPTING FLUX ROPE



LASCO reveals the position of the erupting structures in time.

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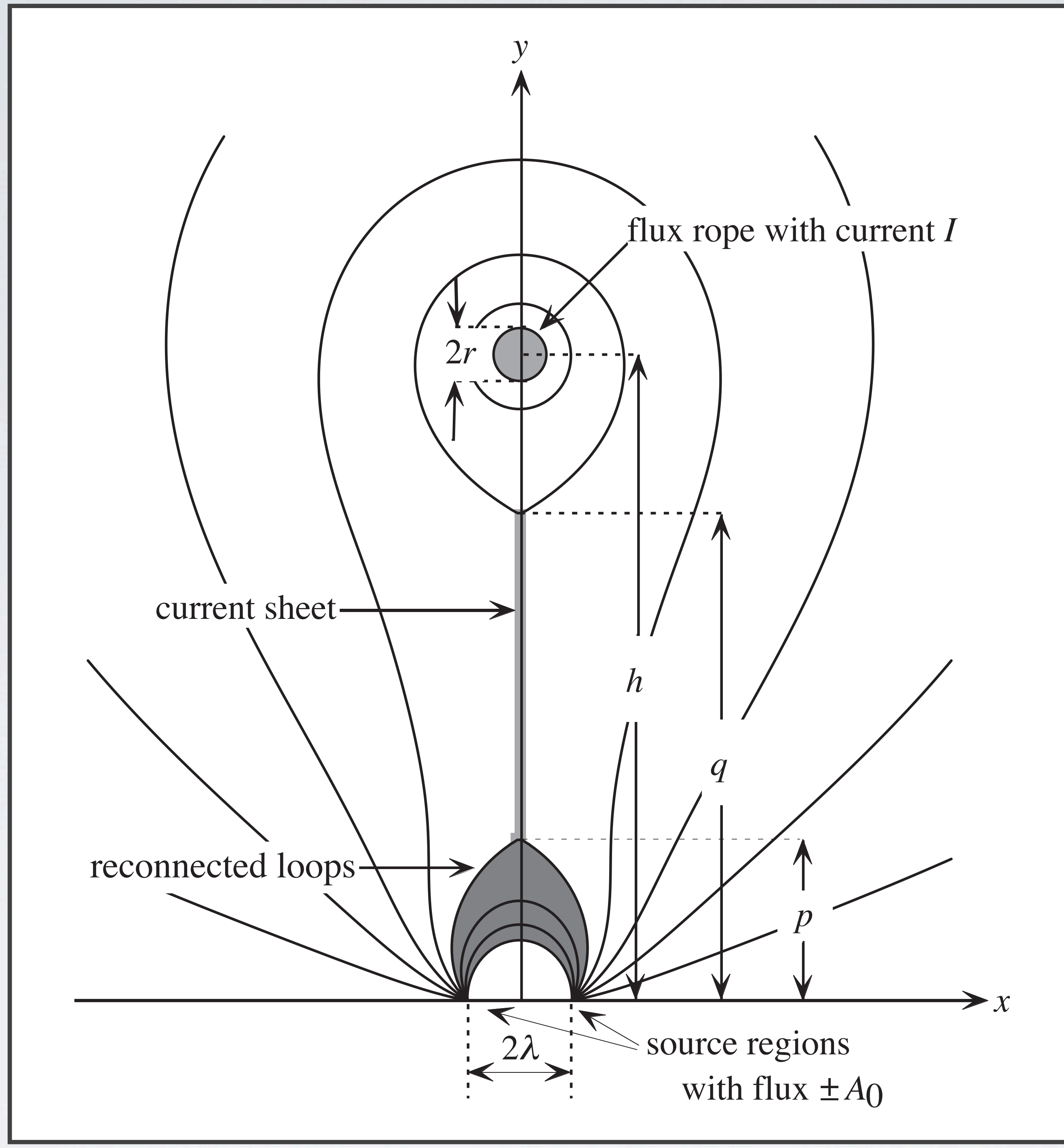
LASCO IMAGES GIVE US THE POSITION OF THE ERUPTING FLUX ROPE IN TIME

III. A BIT OF ANALYSIS



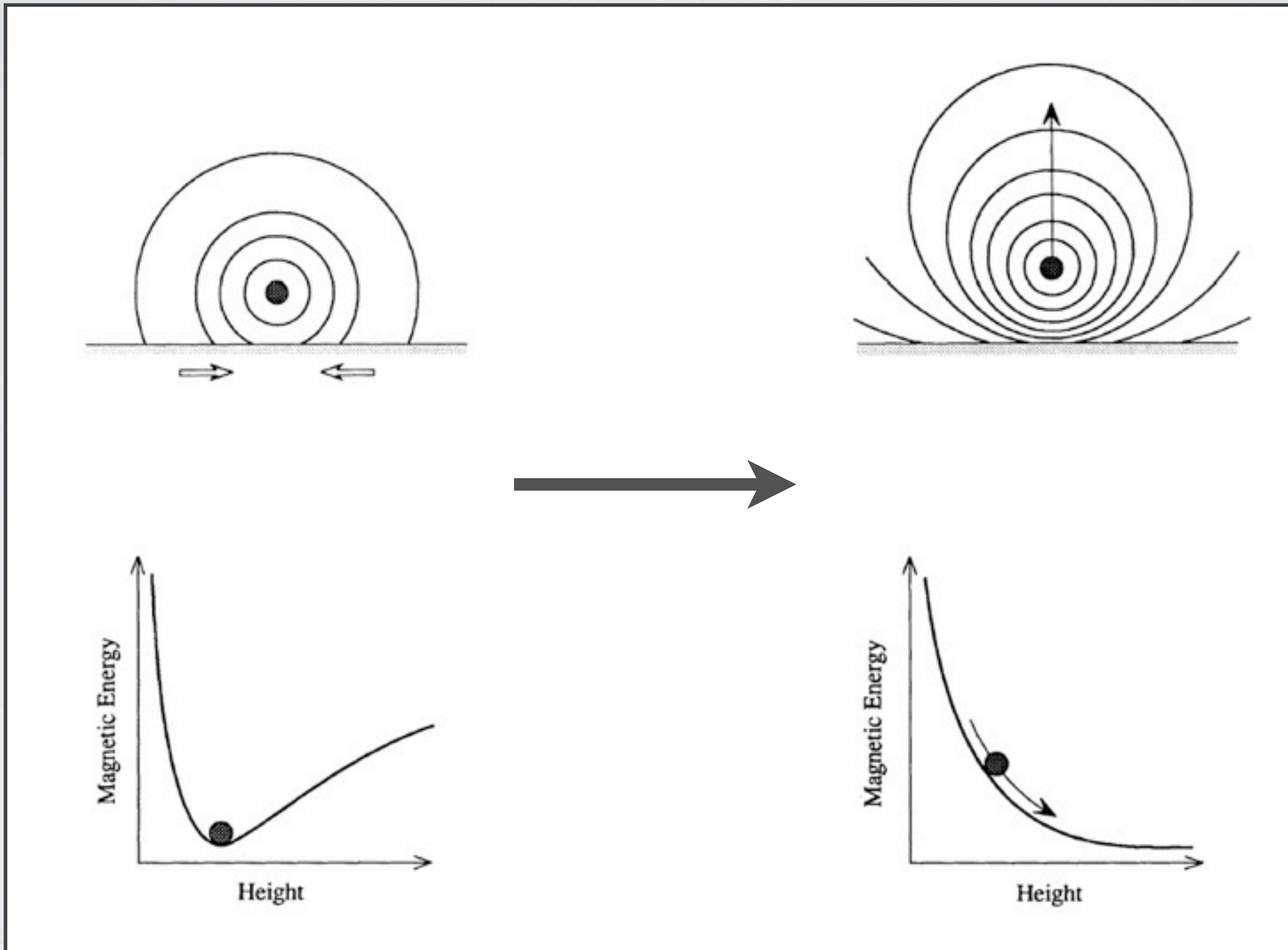
Reeves, 2006

LIN & FORBES 2D ANALYTIC MODEL

(With additional improvements by Reeves, Seaton, and others.)

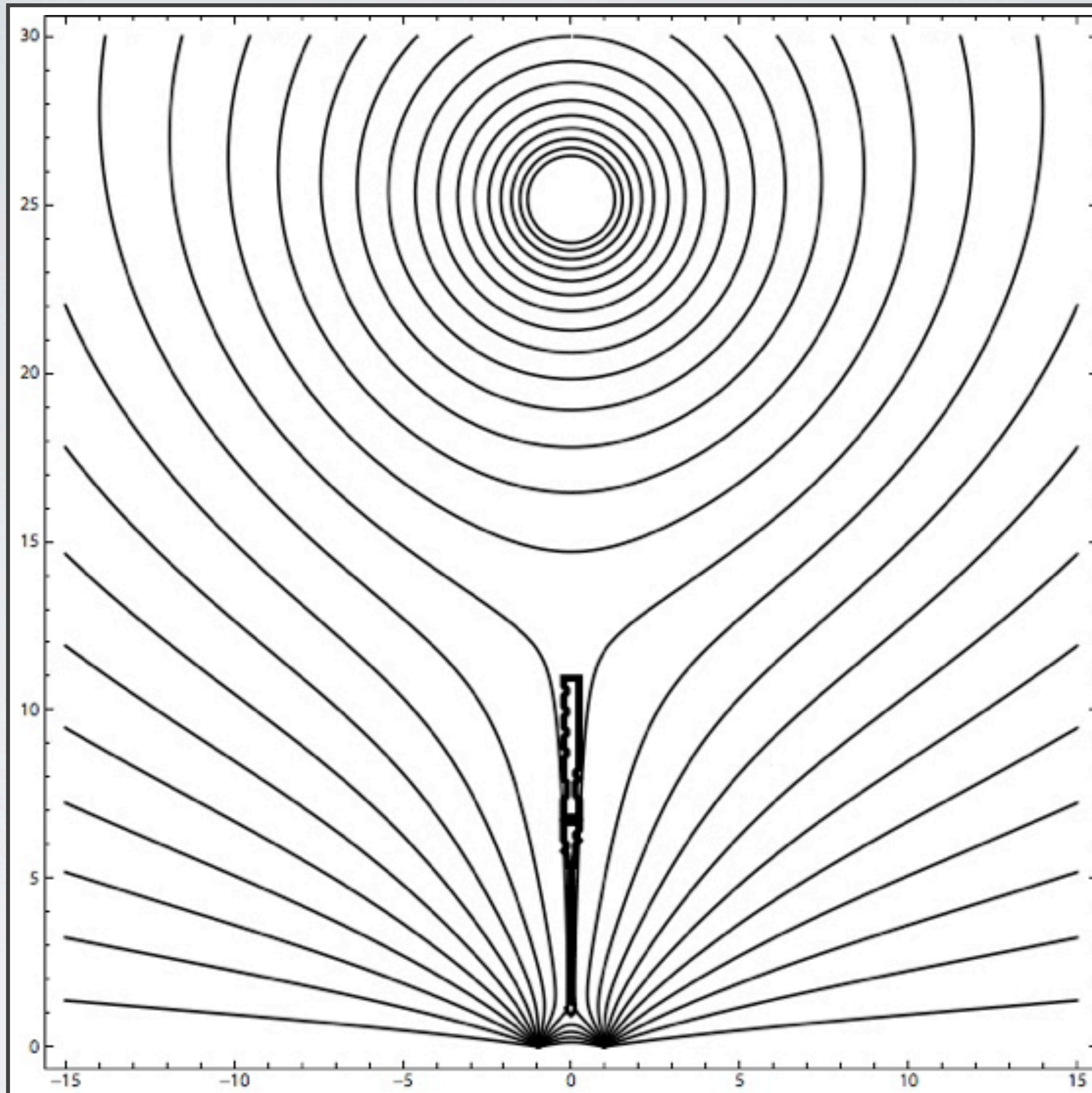
We modeled this event using the treatment of Lin & Forbes, modified to include a more realistic location for the x-line (see Seaton, 2008, PhD Thesis, UNH).

LOSS OF EQUILIBRIUM



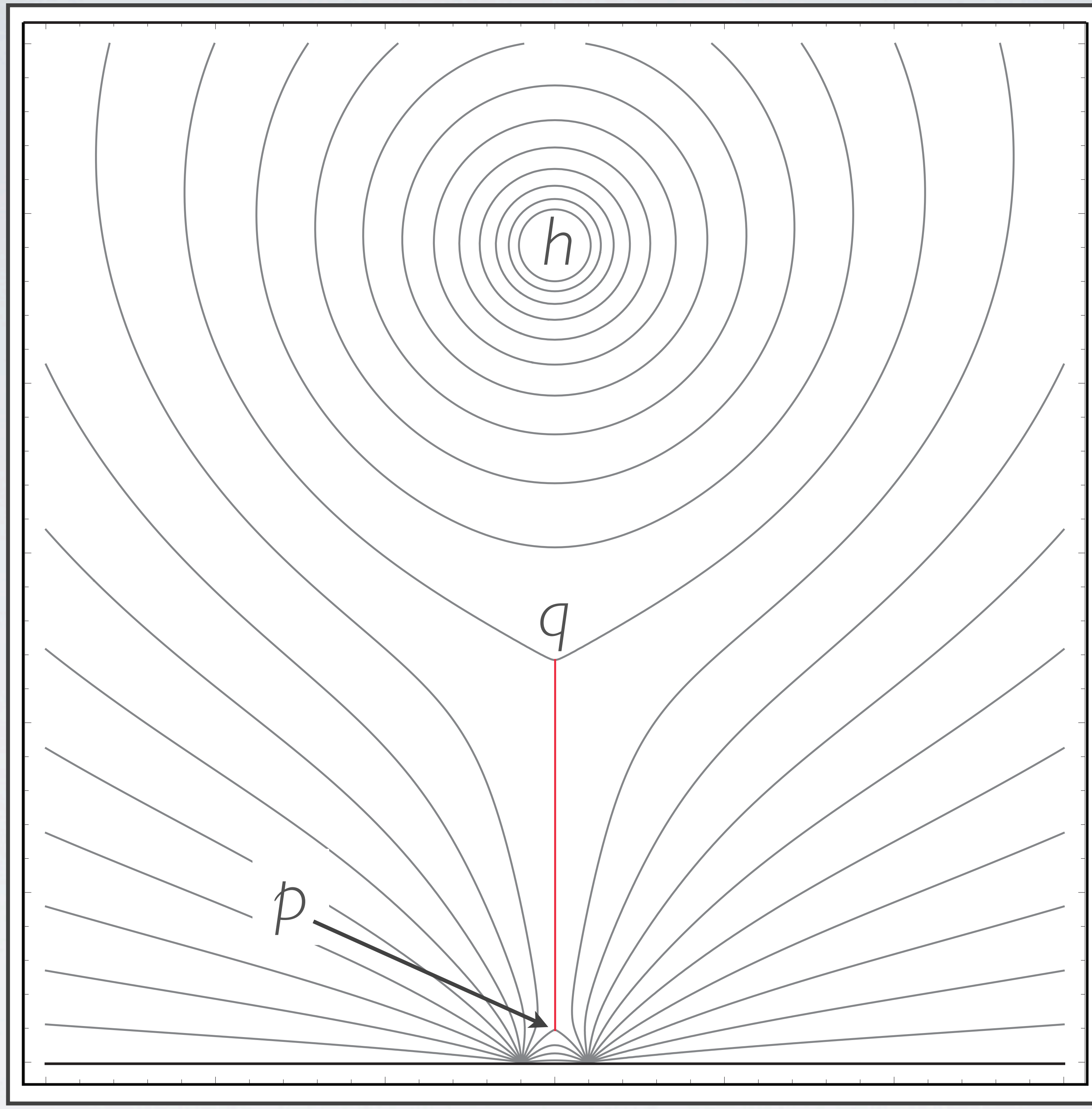
Forbes & Isenberg, 1991

This model is a Loss-of-Equilibrium model where motions of the footpoints lead to the destruction of the equilibrium that holds the flux rope in place. This illustration, from an earlier version of the model, shows how the eruption starts when the equilibrium disappears.



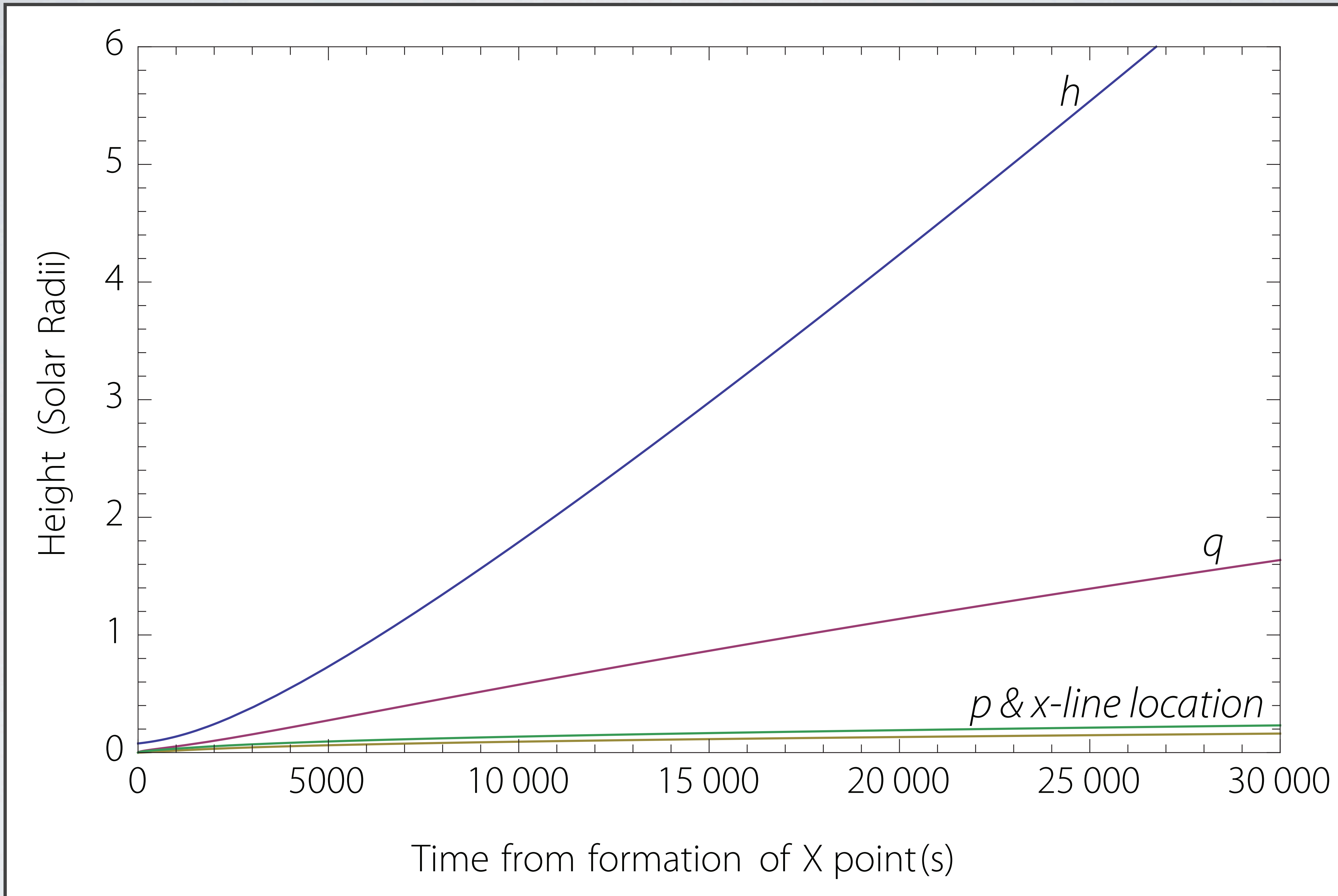
MODEL OUTPUT

You can see the same convection of field into the current sheet in the model output as we see in the 171 observations. Ignore the jagged field lines near the center, the code does a poor job of plotting field lines near the current sheet where the gradients become steep.



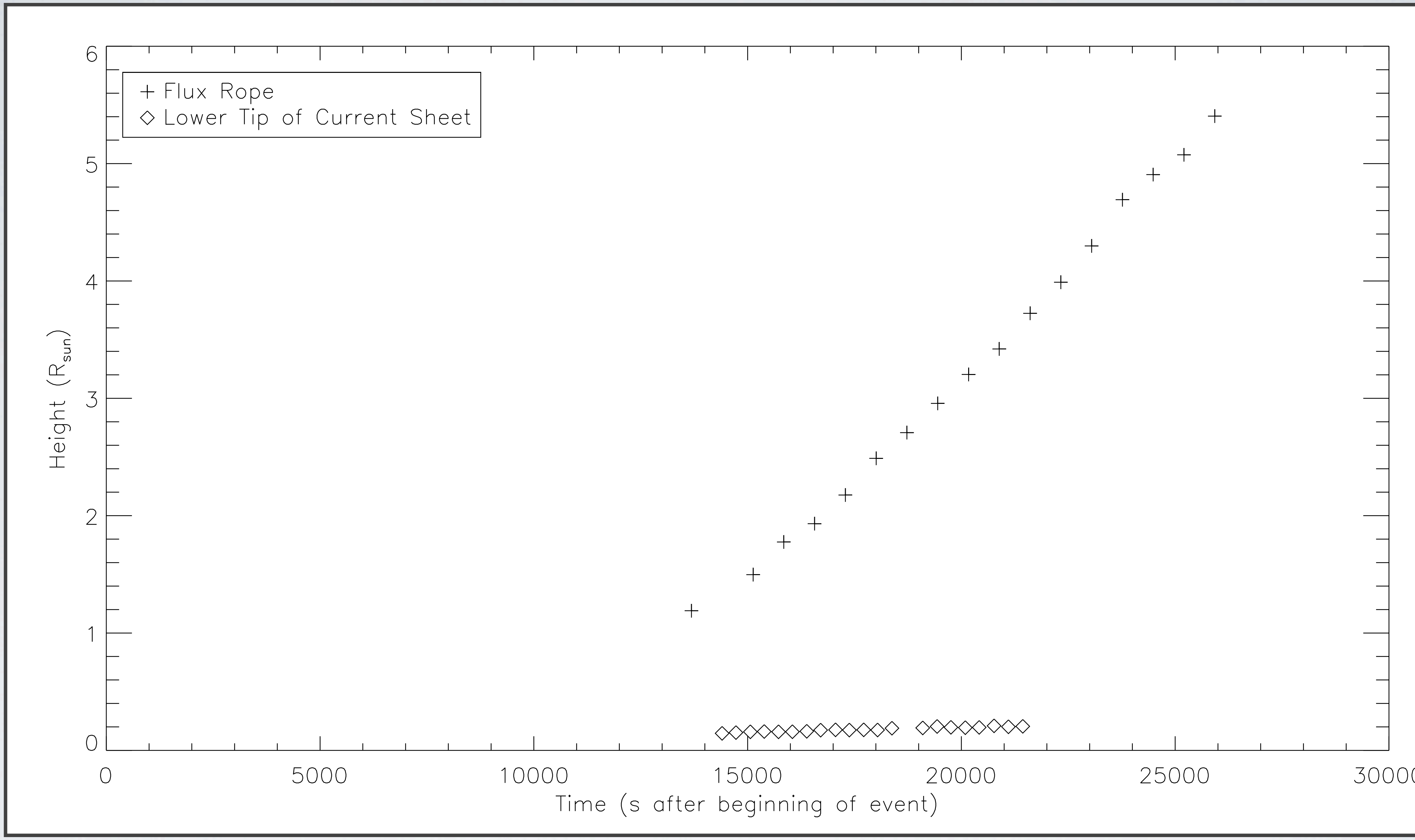
MODEL OUTPUT

We track the lower and upper tips of the current sheet (p & q, respectively) and the position of the flux rope (h)



MODEL PREDICTIONS

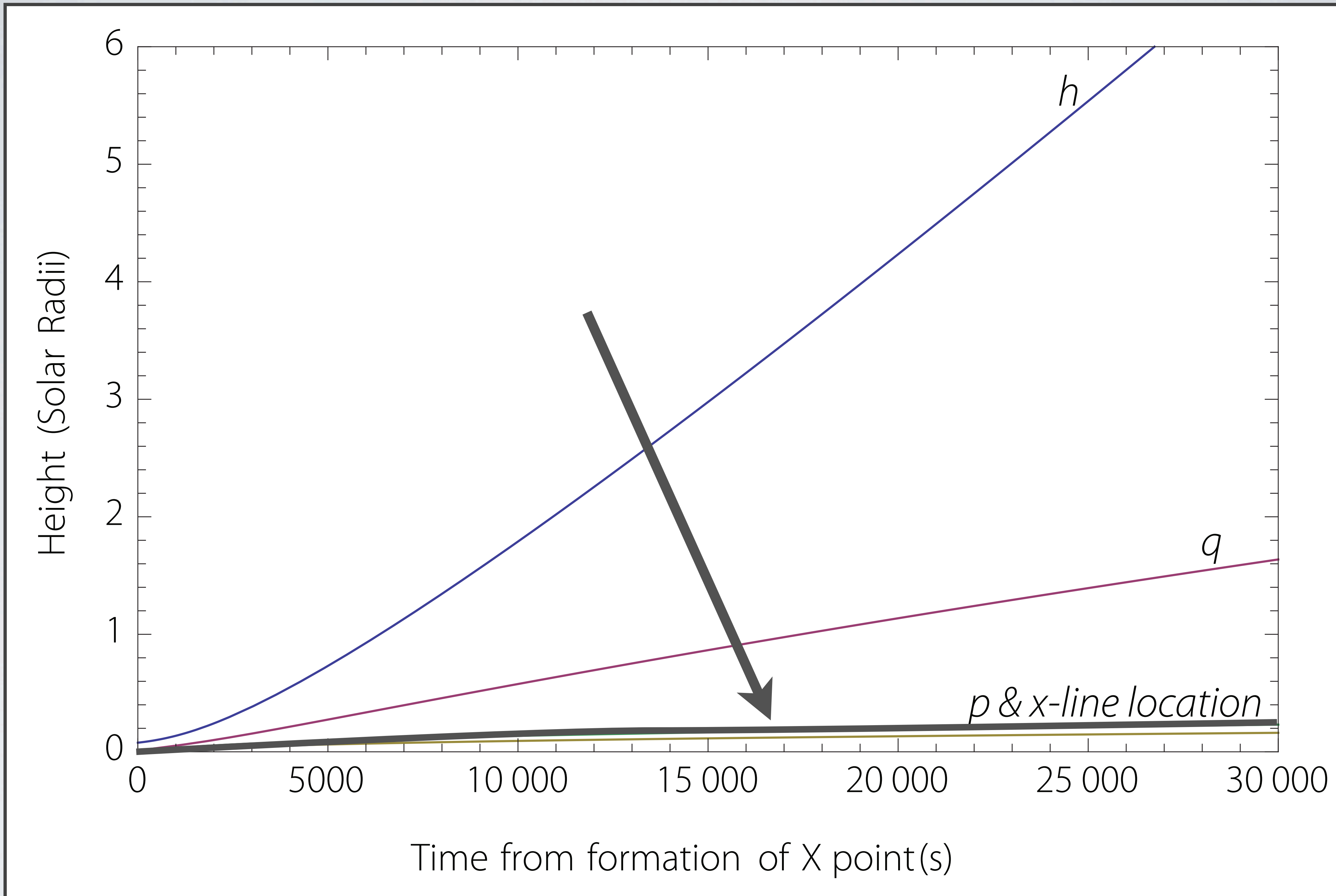
Model output agrees well with measured behavior.



OBSERVATIONS

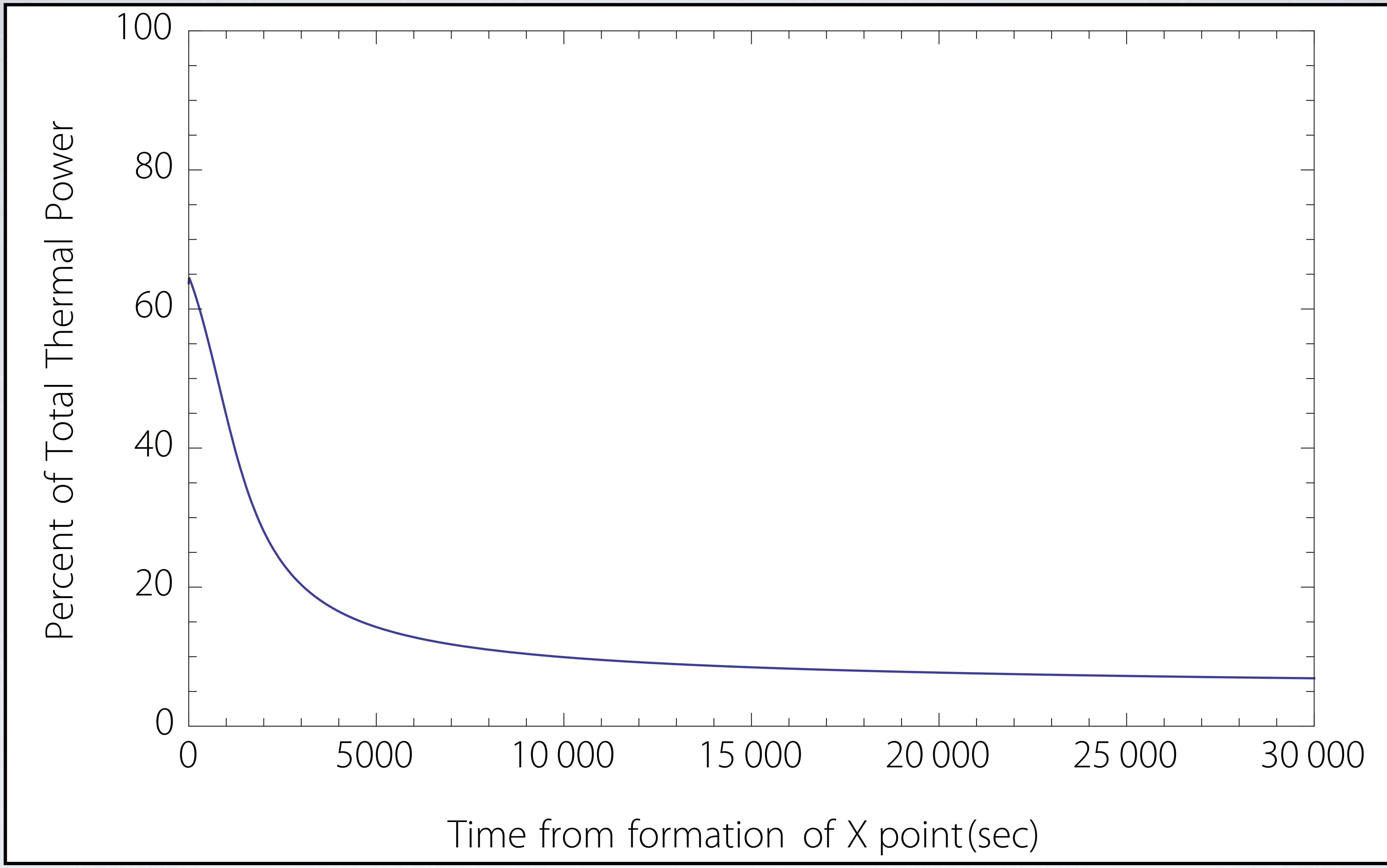
CONCLUSION 1:

EVENT IS RELATIVELY 2D,
MODEL IS WORKING WELL



X-LINE LOCATION

We can also track the location of the x–line, which remains low in the corona throughout the event. Savage et al. 2010 discusses some implications of this.



MODELED ENERGY RELEASE

Energy Available for Flare Heating

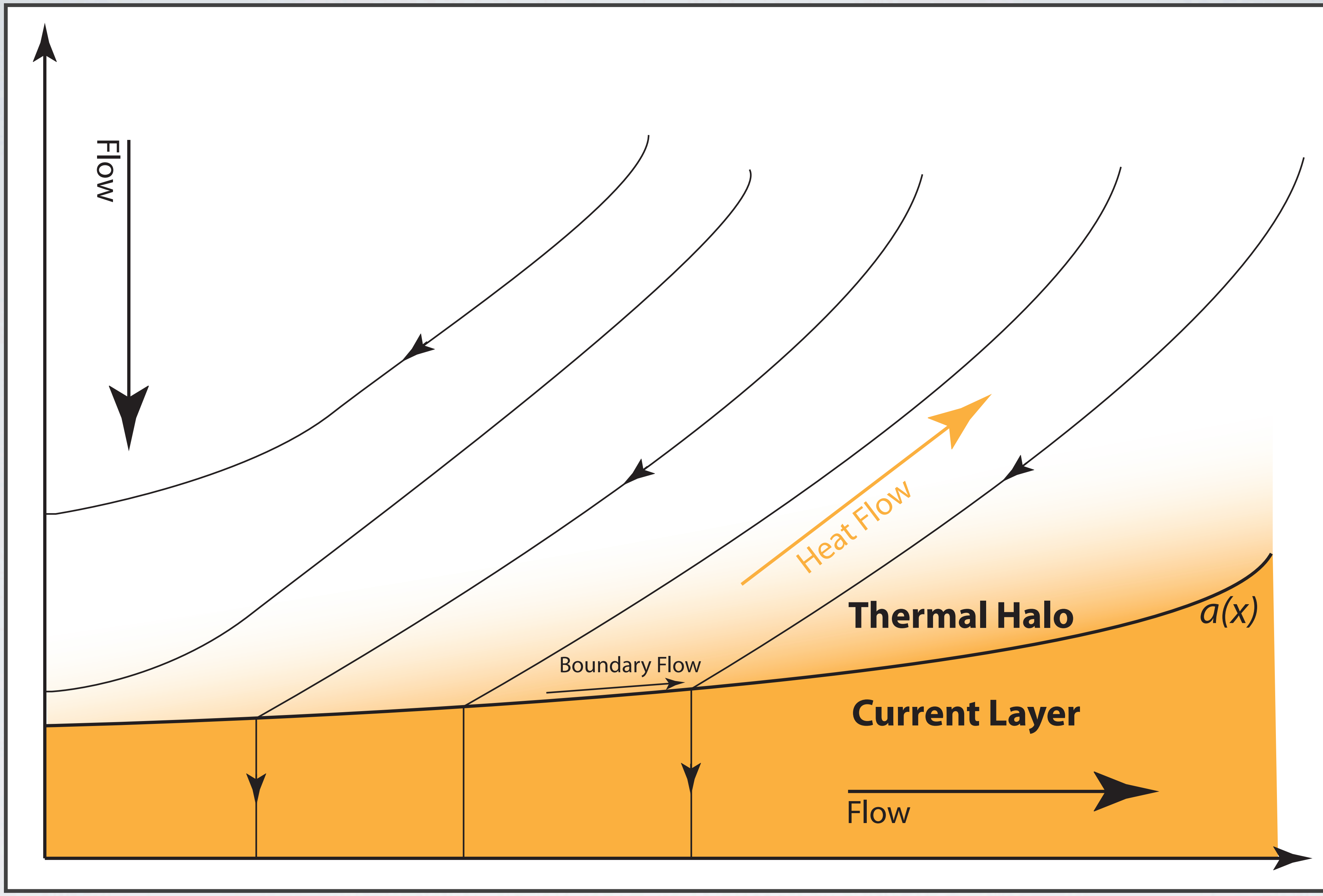
The low x-line has implications for the energy partition during this event.

CONCLUSION II:

BECAUSE X-LINE IS LOCATED VERY LOW IN THE CORONA…

CONCLUSION II:

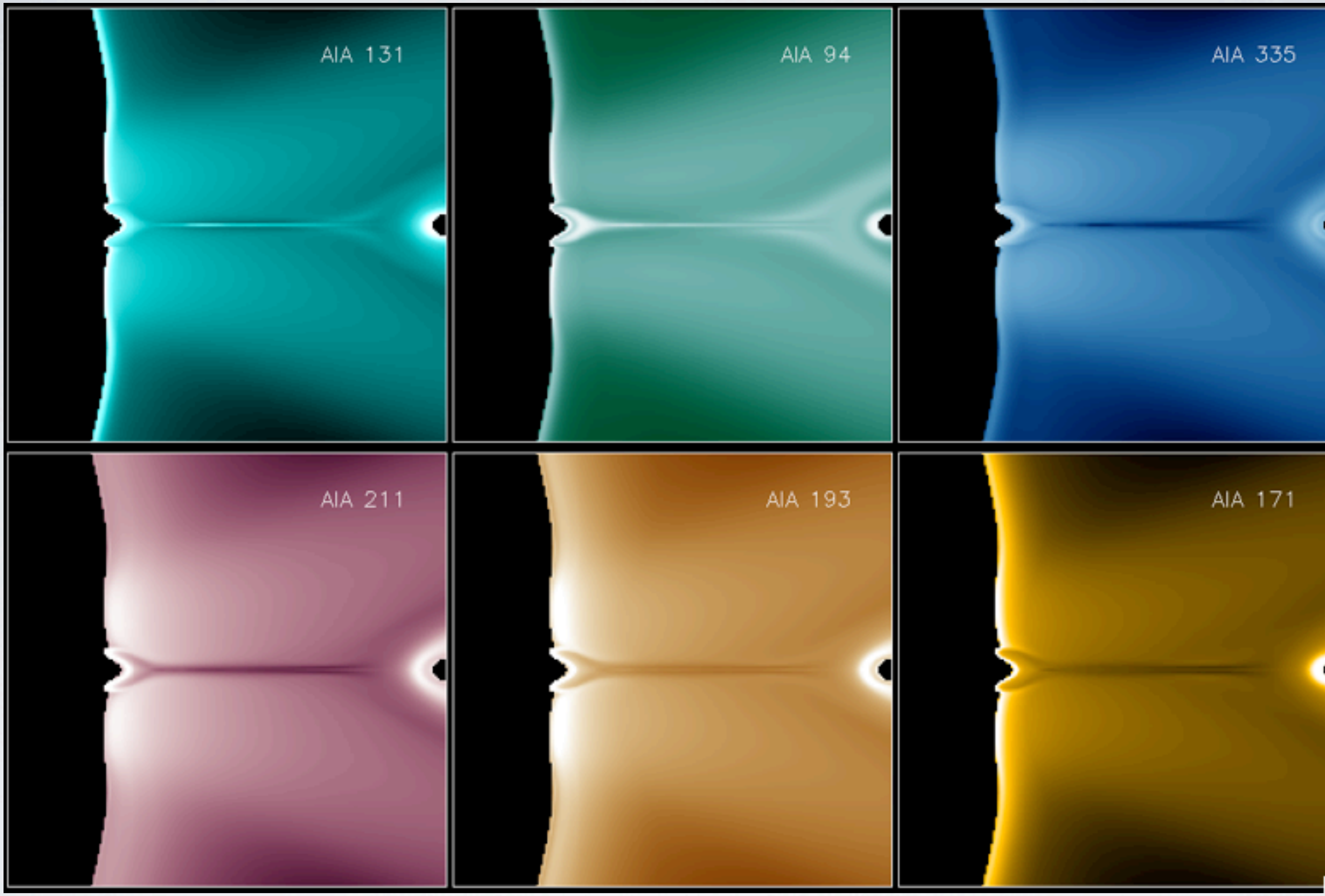
THE MAJORITY OF THERMAL ENERGY IS *NOT* AVAILABLE TO HEAT FLARE LOOPS



Seaton, 2008

THERMAL CONDUCTION

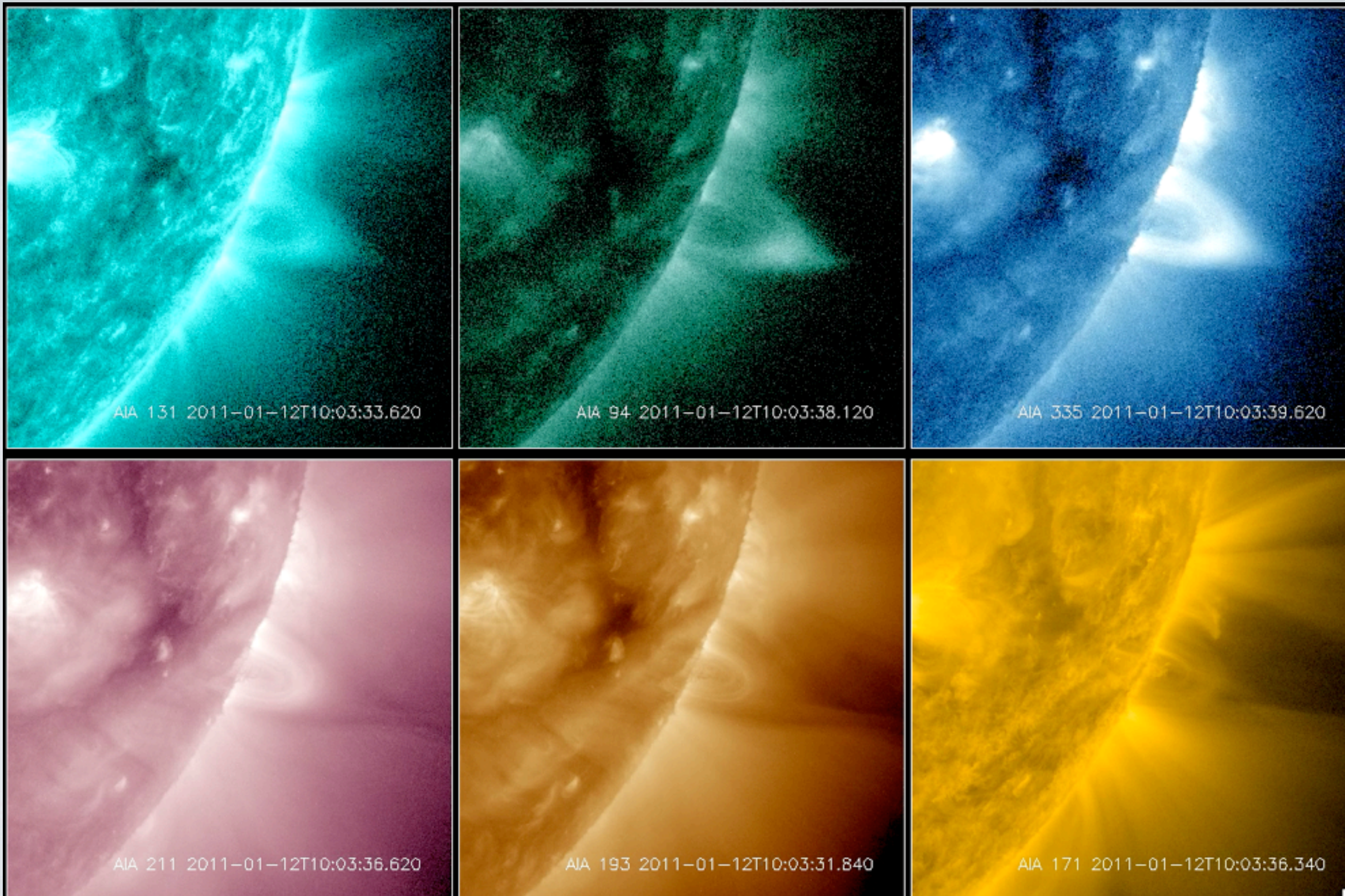
Thermal conduction also appears to play an important role in influencing the appearance of the eruption in AIA observations. This schematic shows how thermal conduction can create a halo around the current layer.



Reeves, 2011

PRED. SCI. 2.5D MHD CODE

Simulations, fed into the AIA temperature response, show how bright, hot structures in some passbands appear to be voids, in others, and shows what this halo might look like in observations.



We see similar effects in observations. Look particularly at the AIA 211 channel to see this.

CONCLUSION III:

CONDUCTION GENERATES THERMAL HALO AROUND CURRENT LAYER

A QUICK ADVERTISEMENT

GETTING SWAP DATA

Data are available via ROB website & via SSW SWAP Object

http://proba2.oma.be/swap/data/

All data ordered in year/month/day folders
Fancy data browser to come

Level 0: reformatted, decompressed, long header
Level 1: nominal calibration, science header
PNG Images & Daily Movies: for quicklook purposes

SSW calibration and analysis tools now available

HOW TO BE INVOLVED

All scientists are welcome to:

- use PROBA2 data
- propose special observation campaigns

Guest Investigator Program welcomes proposals for dedicated (joint) observations in the frame of a science project

- funds available for a stay at PROBA2 Science Center
- scientist can take part in the commanding of the instruments
- will gain expertise in the instrumental effects

GI proposal deadline: 30 June 2011 (visits start Sep 2011)

http://proba2.oma.be/index.html/community/guest-investigator-program/