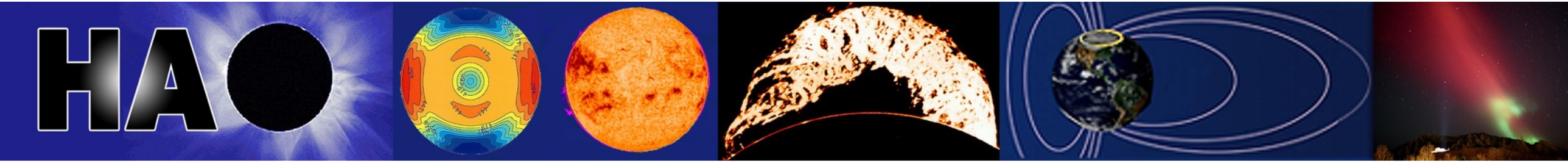


First results from ChroMag

Alfred de Wijn

High Altitude Observatory (HAO) – National Center for Atmospheric Research (NCAR)

NCAR

- What are the processes that transport energy and mass in the outer solar atmosphere?
- How do these processes accelerate the solar wind, and how do they heat the chromosphere and the corona?
- How are prominences formed, how do they evolve, and how do they relate to CMEs?Where does the solar wind originate and how is it accelerated?
- How is energy stored, and how is it released during flares and CMEs?
- What is the nature of the changes in the magnetic structure of the outer solar atmosphere and heliosphere that accompany the 11-year solar cycle?

Recent Developments

Significant progress has been made through high-resolution imaging of the Japanese Hinode mission, the Interface Region Imaging Spectrograph (IRIS), and continuous coverage by the Solar Dynamics Observatory (SDO).

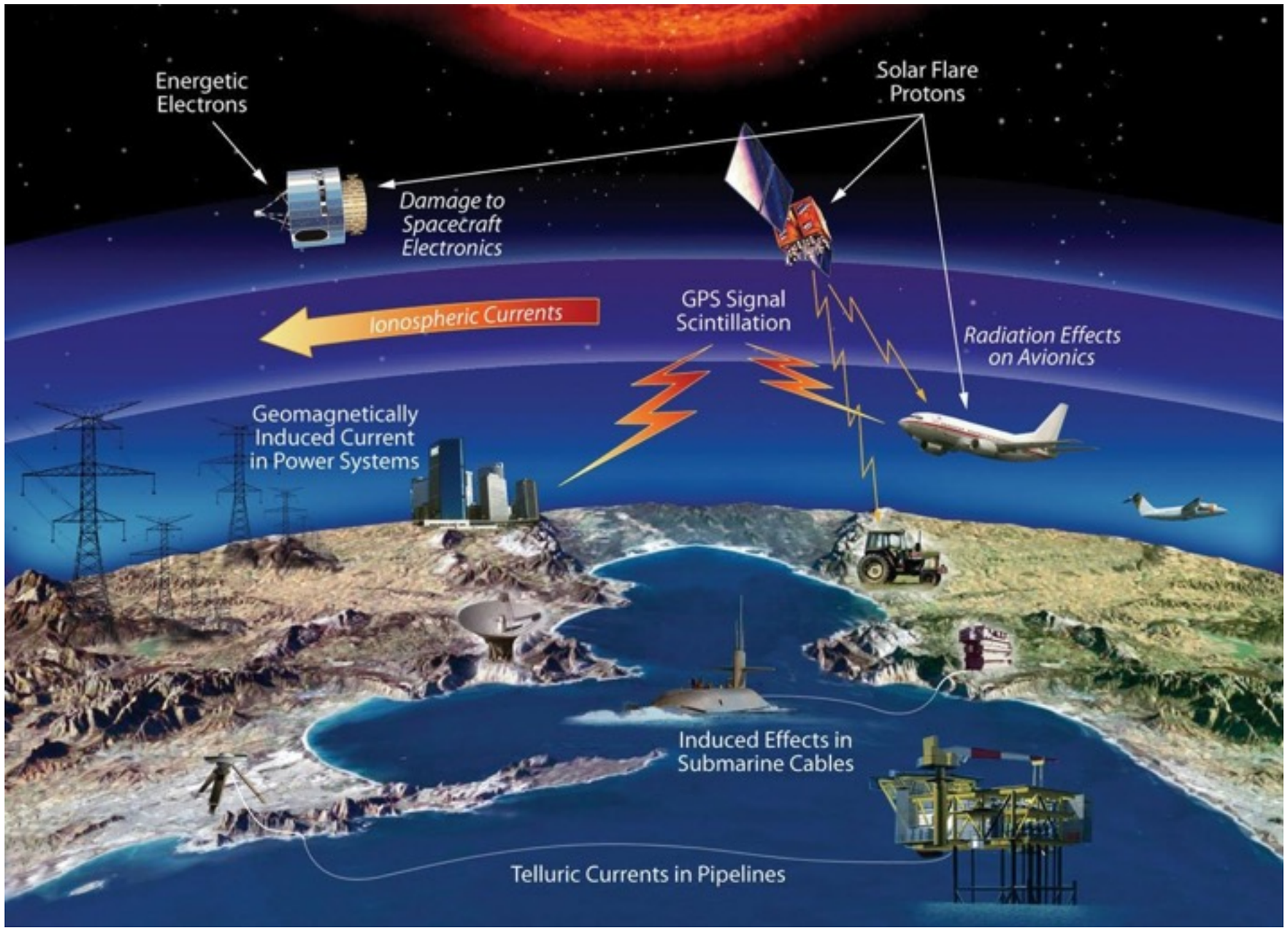
Diagnostics of chromospheric and coronal magnetic field are missing.

What is Space Weather?

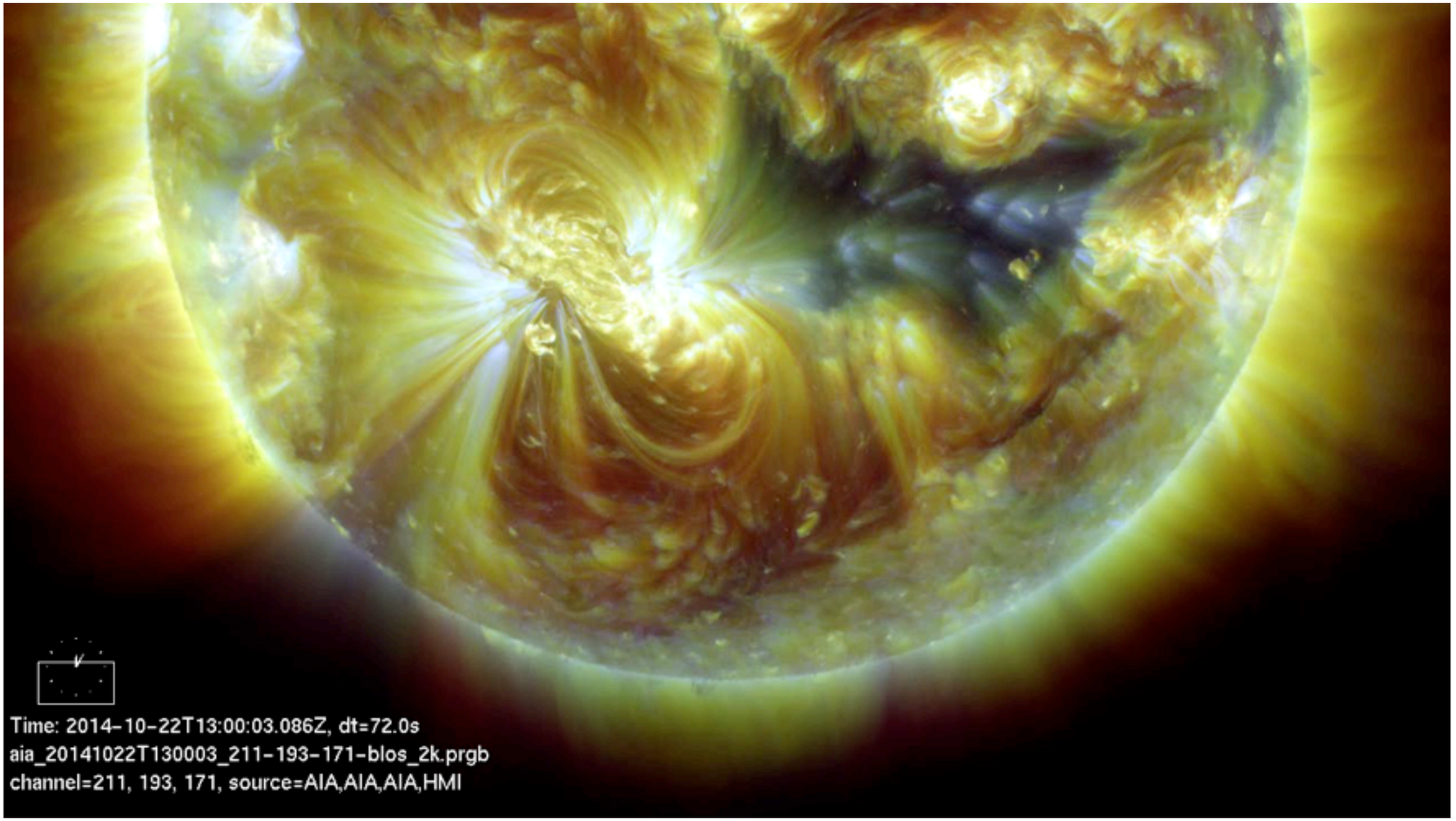
Space Weather:

The conditions on the Sun and in the space environment that can influence the performance and reliability of space-borne and ground-based technological systems.

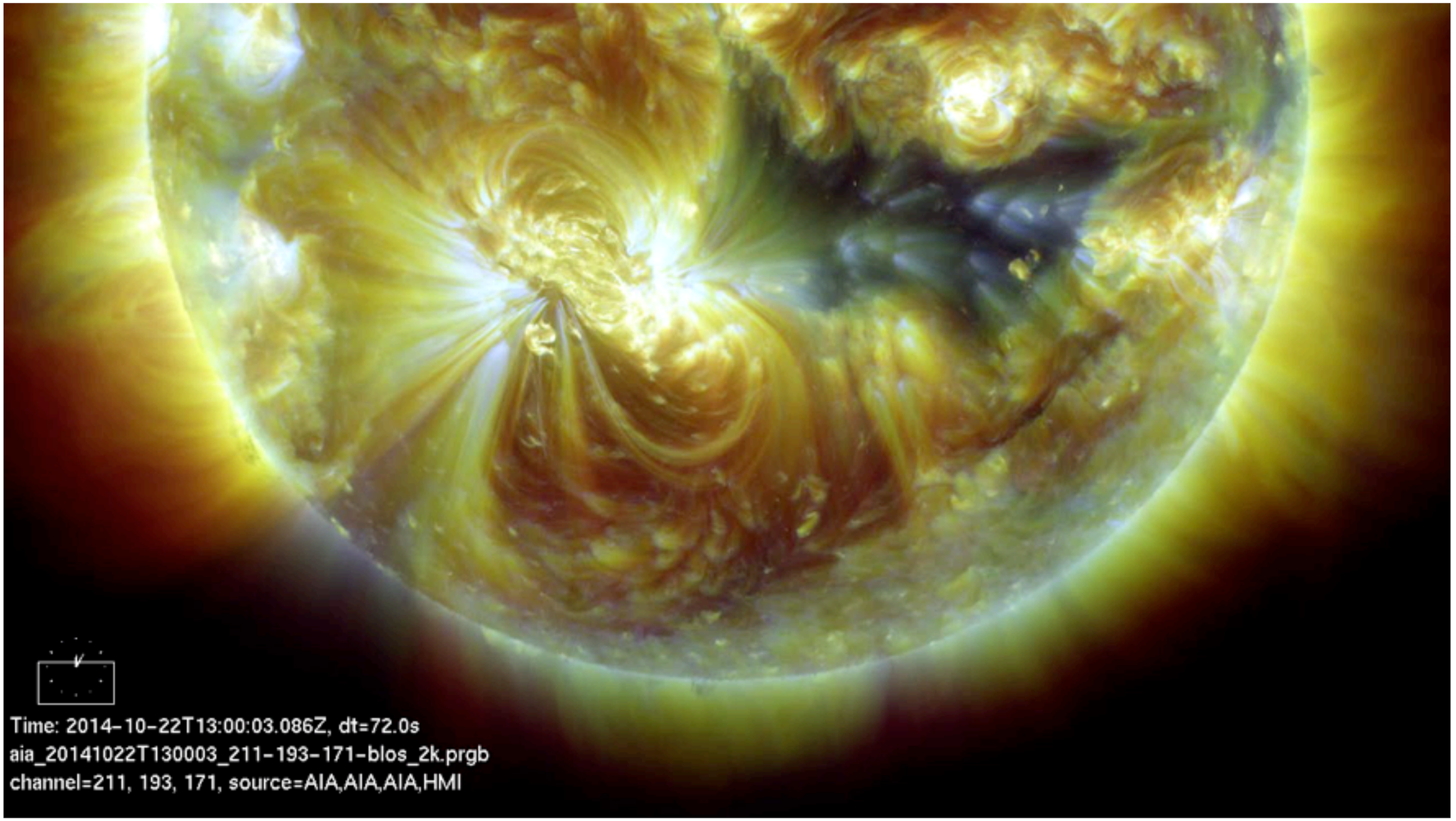
Space Weather Effects



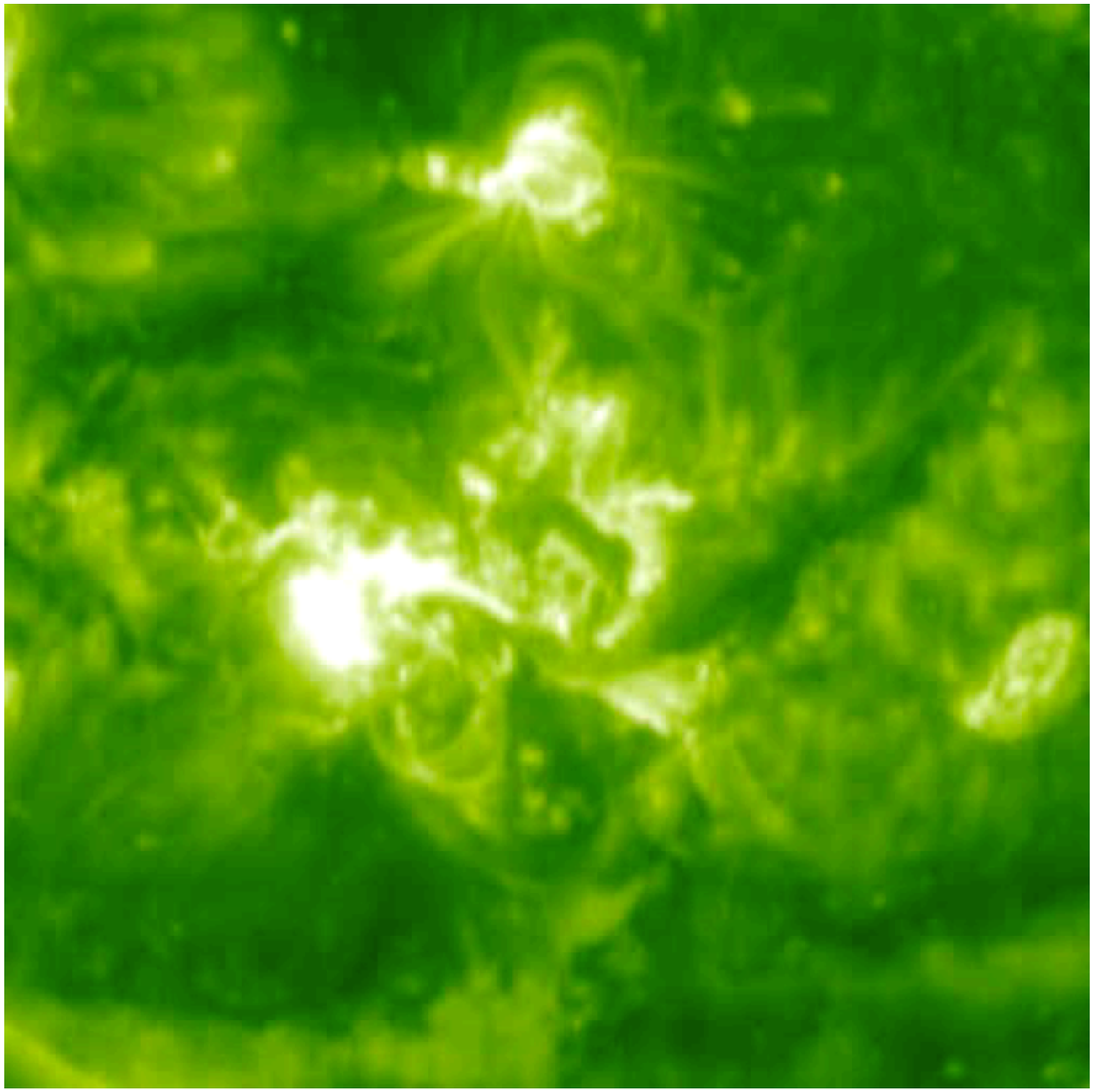
Space Weather Drivers



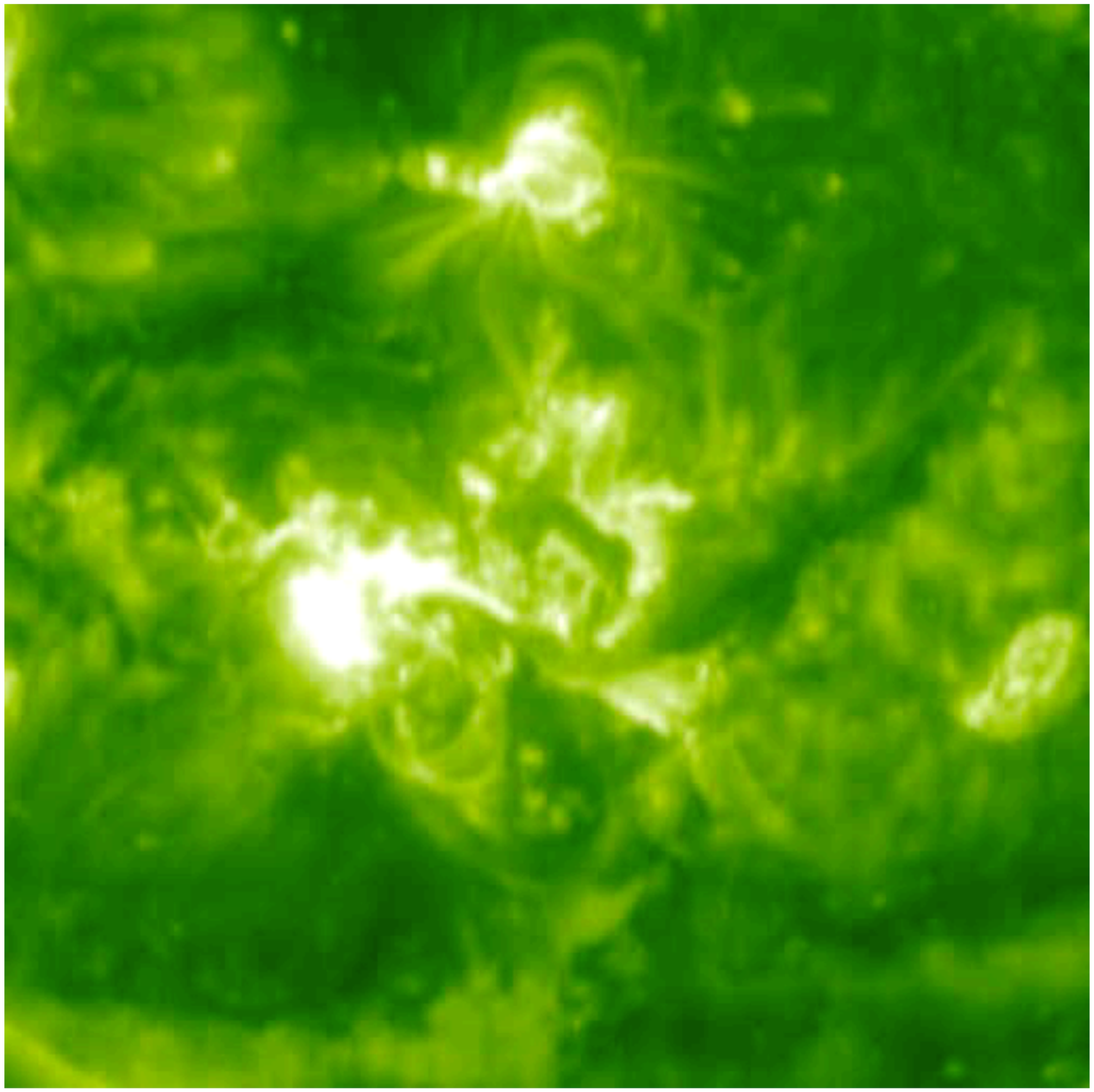
Space Weather Drivers



Space Weather Drivers

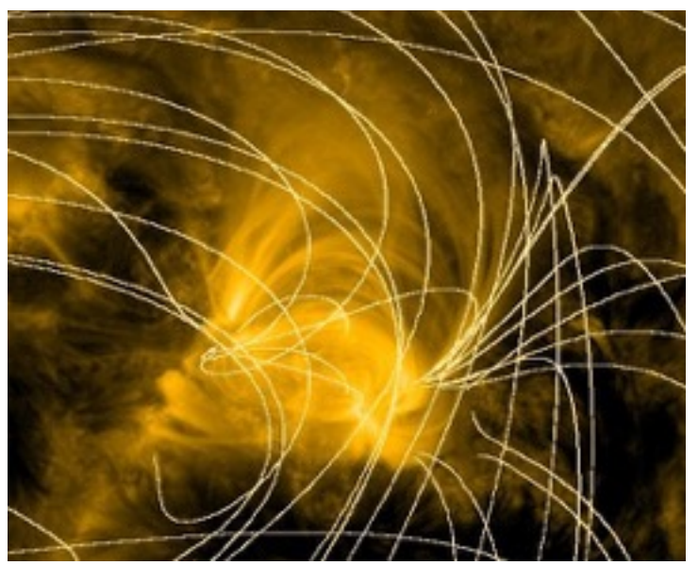


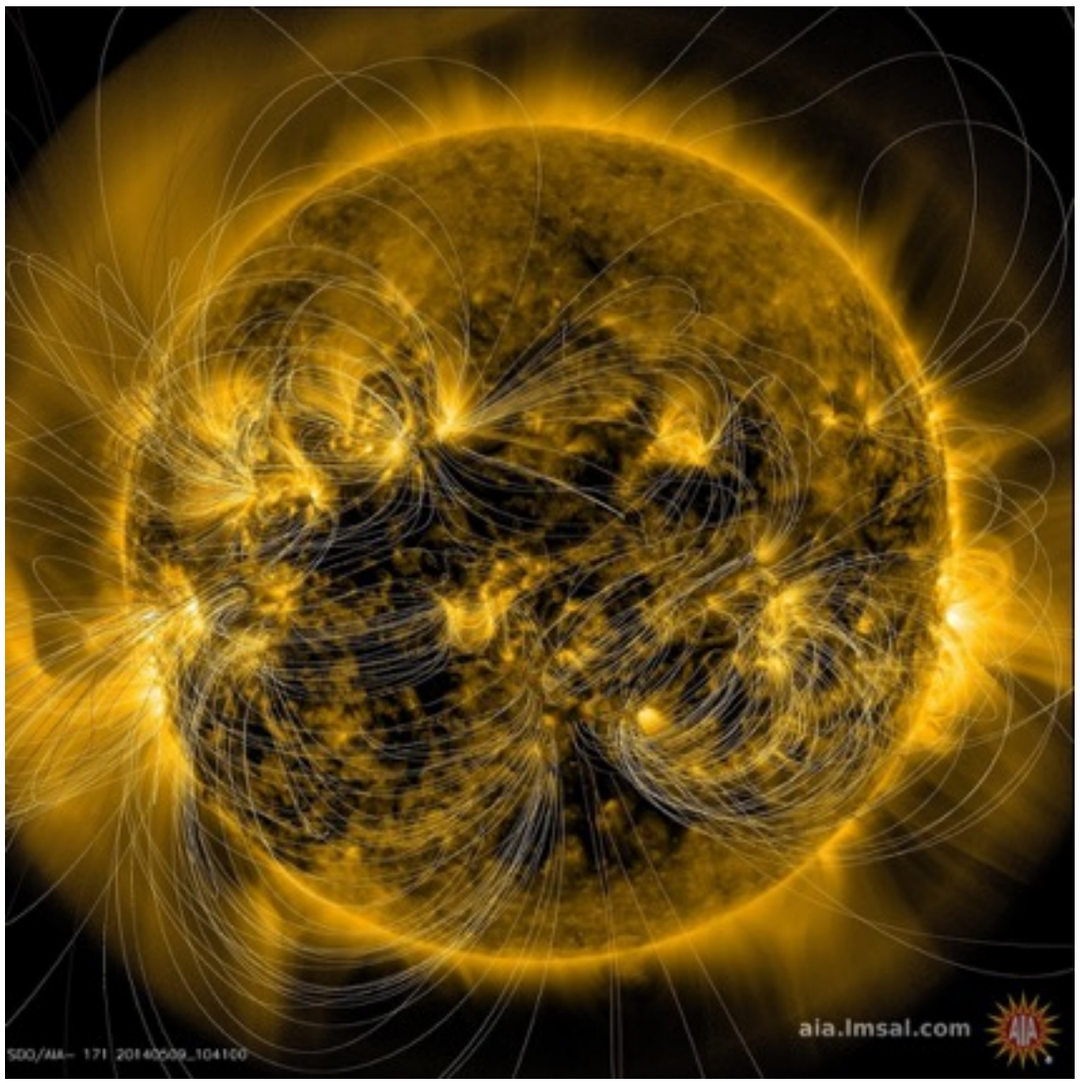
Space Weather Drivers



The Difficulty

Space Weather is driven by solar magnetic activity, but our diagnostic capabilities fall short of our needs.





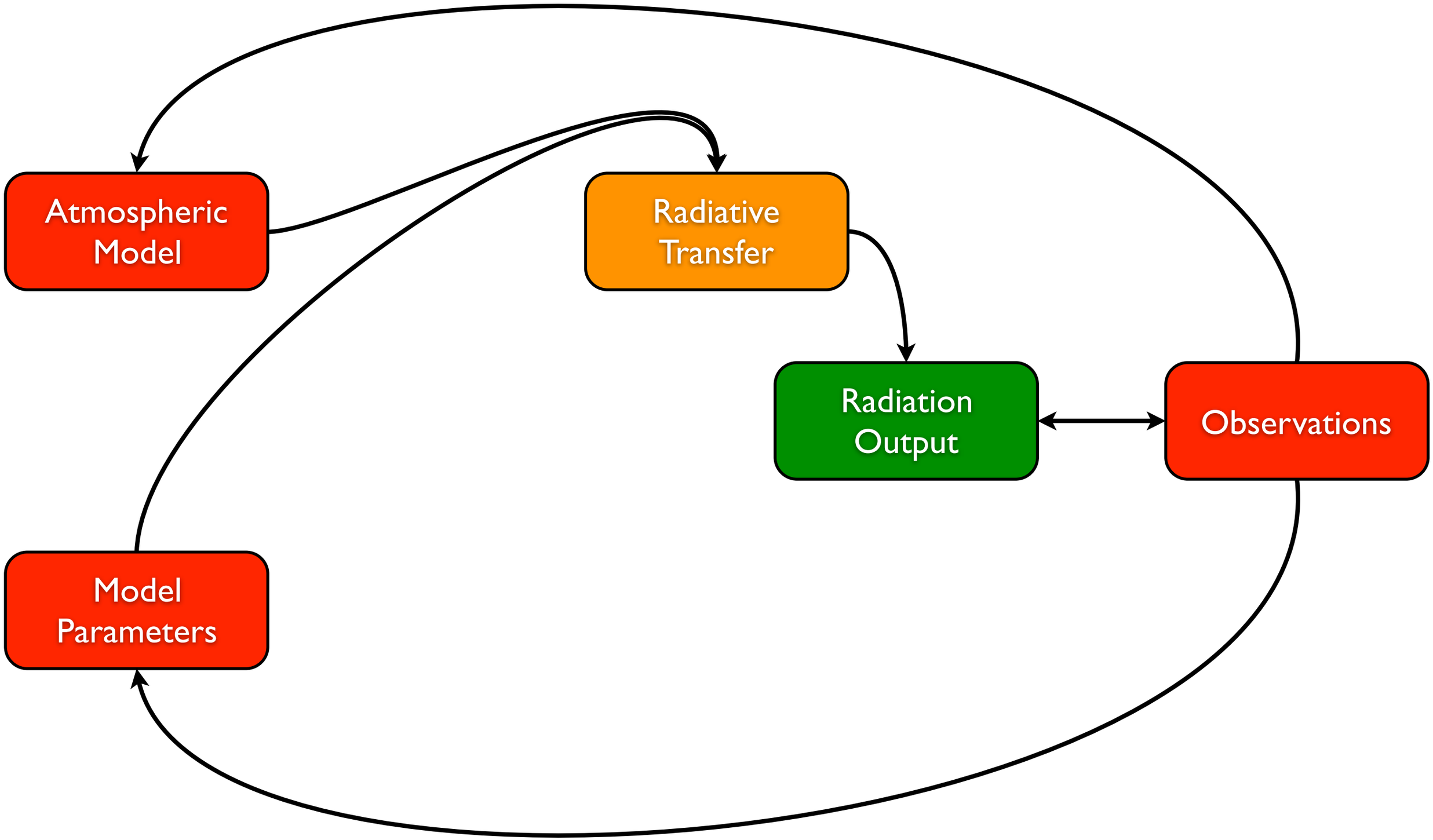
Motivation for New Diagnostics

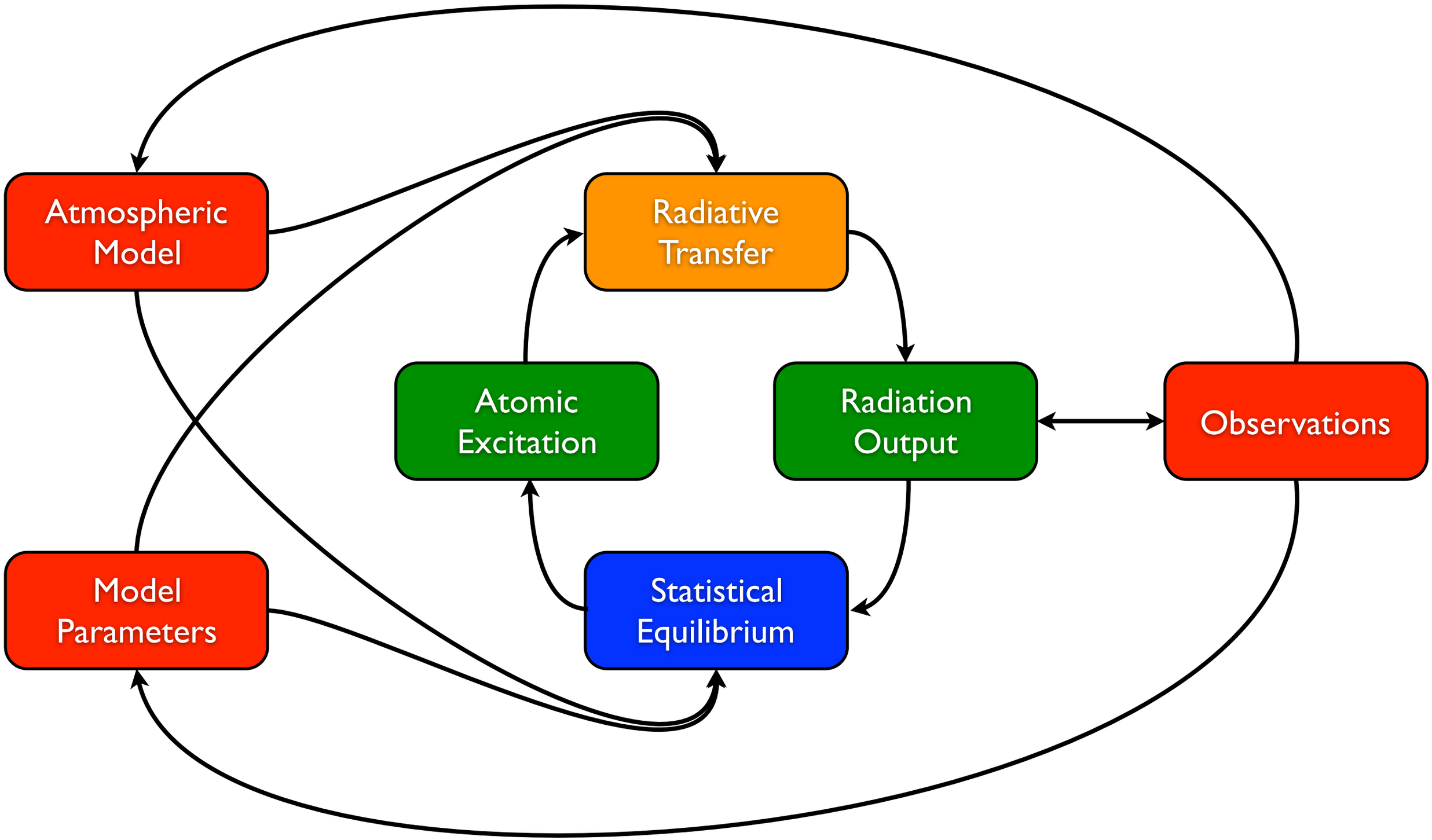
- Chromospheric and coronal structure is dominated by magnetic field.
- We must know the magnetic field through the solar atmosphere and up into the heliosphere in order to understand solar activity: flares, CMEs, etc.
- Extrapolating from photospheric (vector) field doesn't really work.

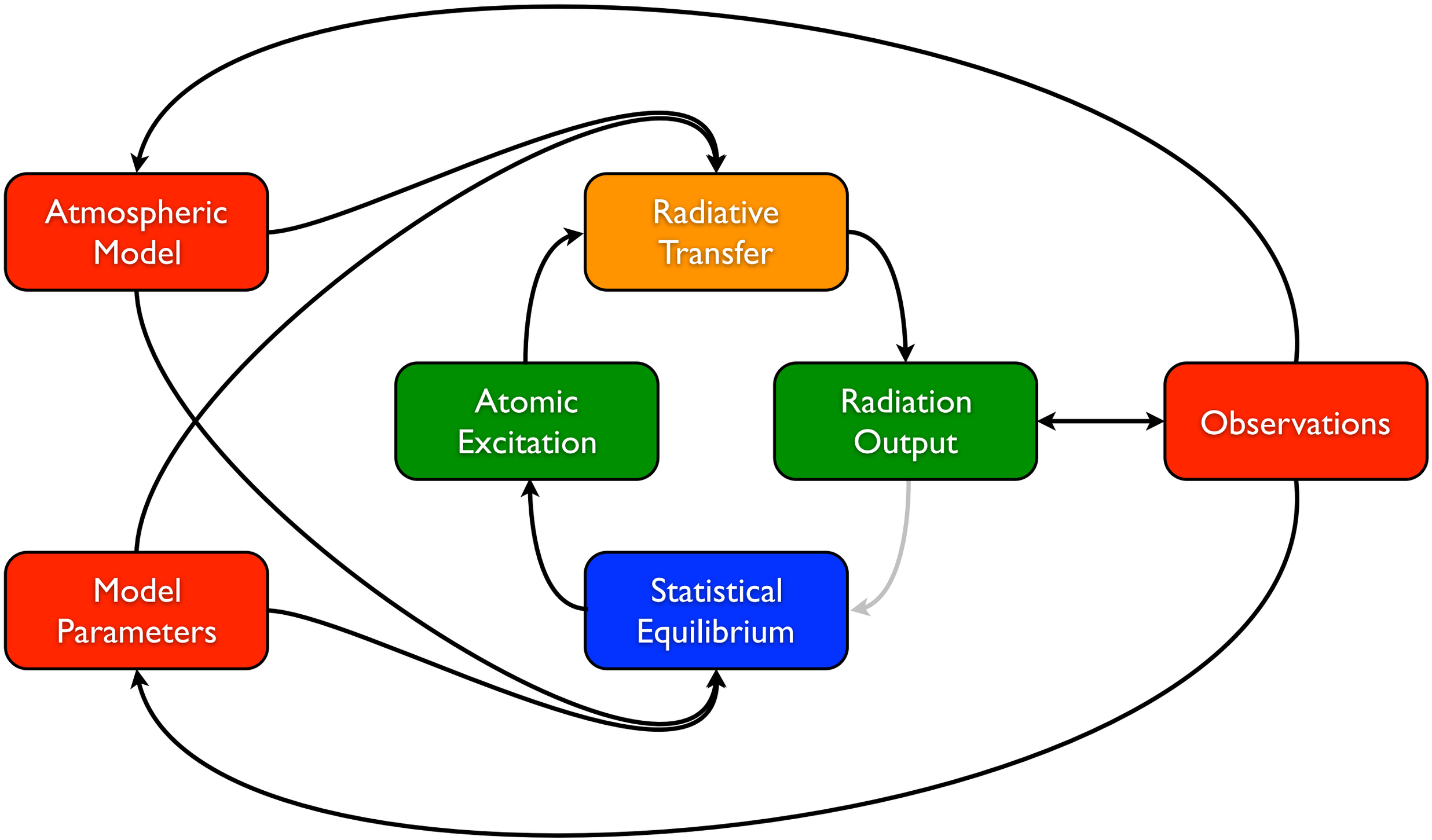
Often-requested Diagnostics

- Velocity maps at several heights
- Vector field maps at several heights
- With high sensitivity, cadence, duty cycle, and lifetime
- Typically: Hα 656.3 nm, and full-Stokes polarimetry in some photospheric diagnostic, Ca II 854.2 nm, and He I 1083.0 nm.


HAO


Atmospheric Model
Radiative Transfer
Radiation Output
Observations
Model Parameters


Atmospheric Model
Radiative Transfer
Atomic Excitation
Radiation Output
Observations
Model Parameters
Statistical Equilibrium


Atmospheric Model
Radiative Transfer
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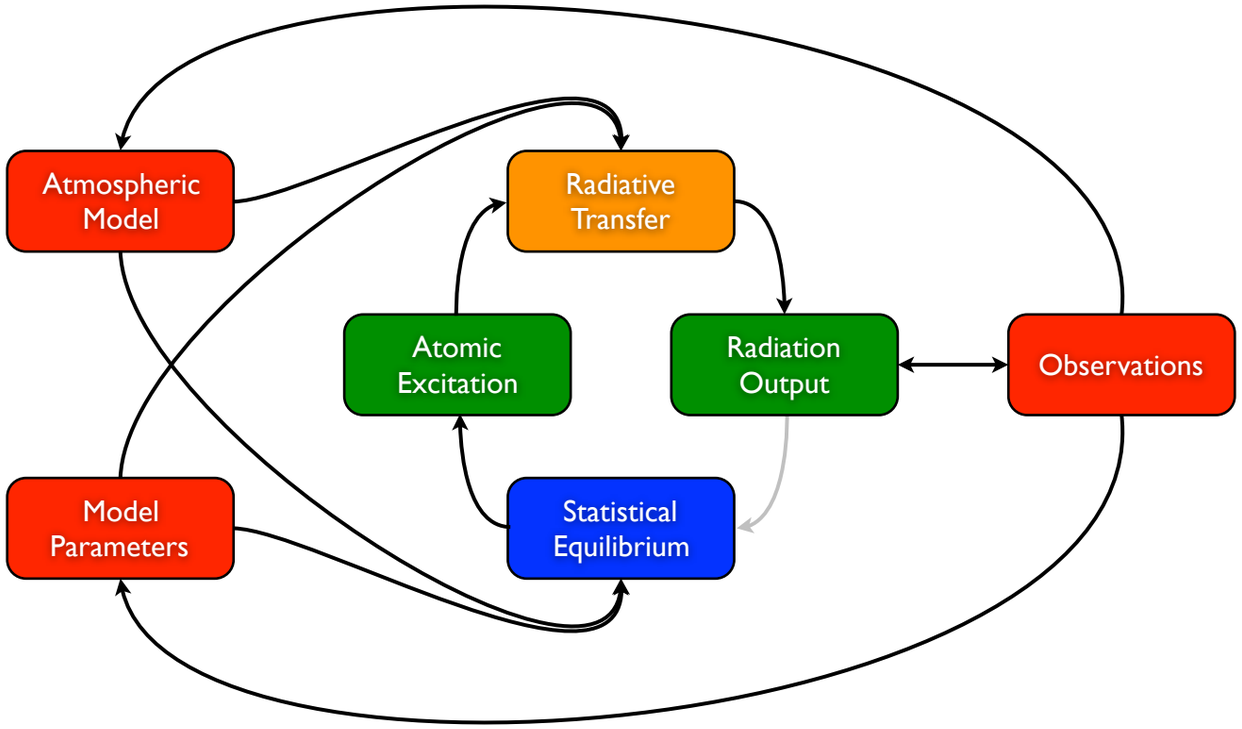


- The best minimum is hard to find.
- Solutions may depend on assumptions made in the model.
- Ambiguities exist in the solution.

COSMO

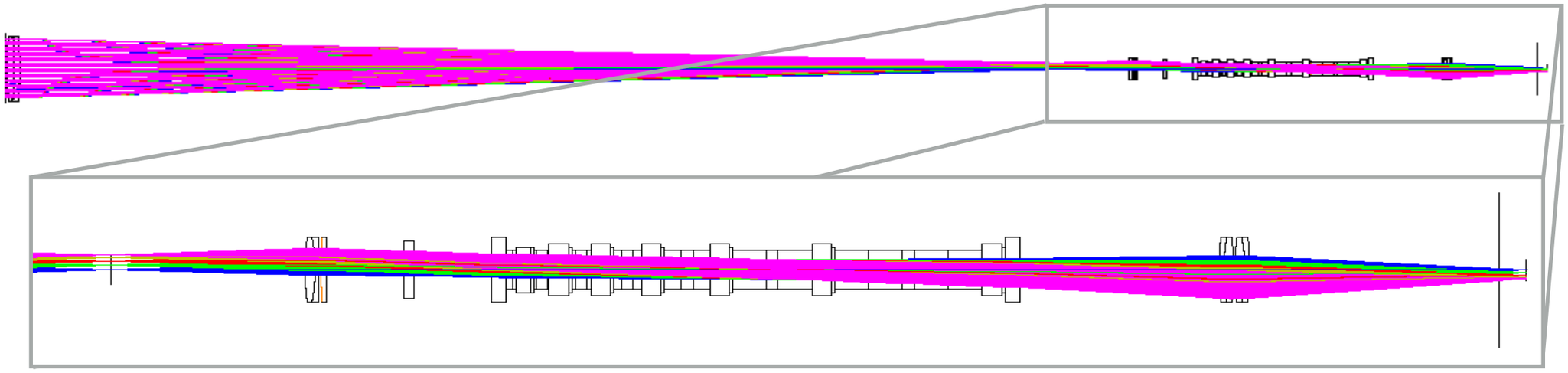
The Coronal Solar Magnetism Observatory is a proposed facility dedicated to studying solar magnetic fields and their role in driving space weather. It comprises:

1. The "K-Coronagraph" for real-time monitoring of the solar corona;
2. The "Large Coronagraph" for measurement of coronal magnetic field;
3. "ChroMag" for on-disk plasma diagnostics.

ChroMag

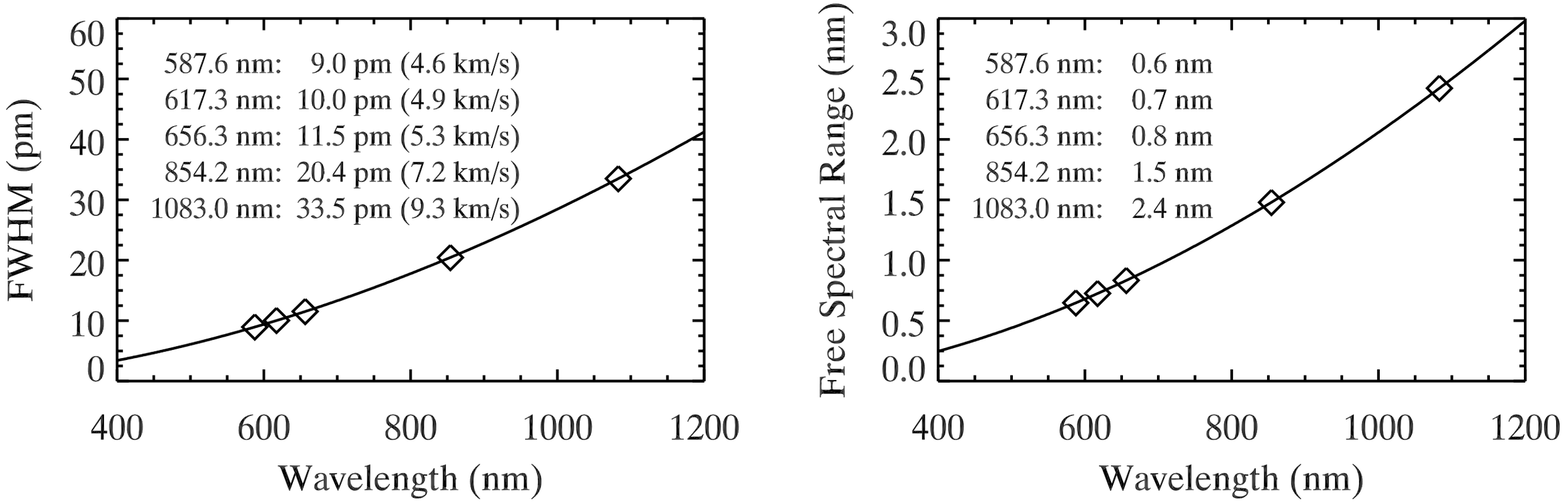
- Observes the Sun in a synoptic fashion with the intent to provide the capability to infer the condition of the magnetized plasma at the base of the heliosphere.
- Imaging spectro-polarimetry in:
  - He I 587.6 & 1083.0 nm: chromospheric magnetograms
  - Hα 656.3 nm: chromospheric structure and dynamics
  - Ca II 854.2 nm: chromospheric magnetograms
  - Fe I 617.3 nm: photospheric magnetograms
- Flexible! New wavelengths can be added.

Optical Layout



- 13.5 cm aperture
- 2.6” resolution
- But: 2.75×2.75 R_{sun} FOV, i.e., full disk
- High polarimetric sensitivity: SNR > 10^3
- High cadence: ~10s per line scan

Lyot filter overview



- Electro-optically tunable with LCVRs (0.2s)
- Usable range: 587–1085 nm
- 6 stages, thickest stage has 88mm of calcite

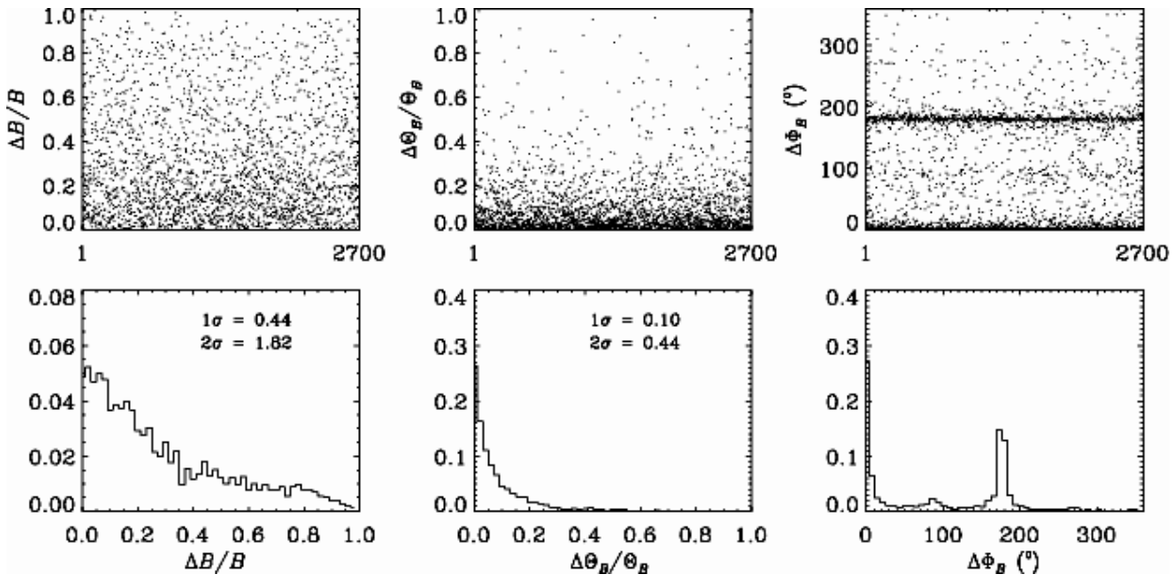
Data Products

- Line selection, spectral sampling, & cadence are flexible and can be tailored to science cases.
- Low-level product: calibrated line scans
  - Fe I 617.3 nm, Hα 656.3 nm, Ca II 854.2 nm, and He I 587.6 & 1083.0 nm
- Currently planned higher-level products:
  - Photospheric Dopplergrams & vector magnetograms
  - Chromospheric Dopplergrams from Hα & 854.2 nm
  - Prominence & chromospheric vector magnetograms from 1083.0 nm, 854.2 nm? Interpretation techniques are not mature.

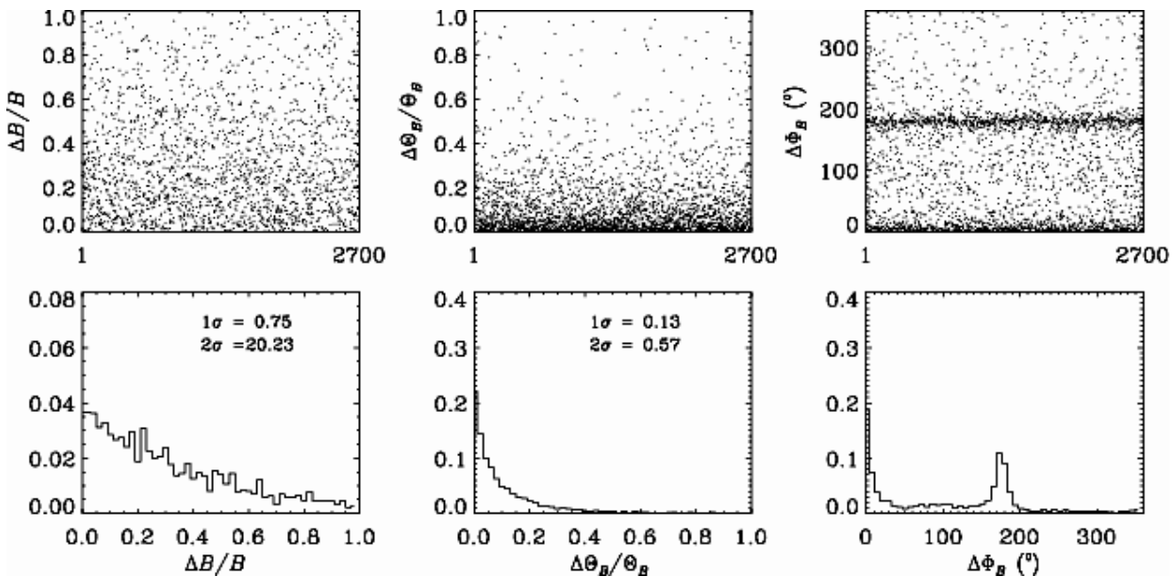
Spectro-polarimeter

R = 180000 (0.048 Å sampling)

No noise



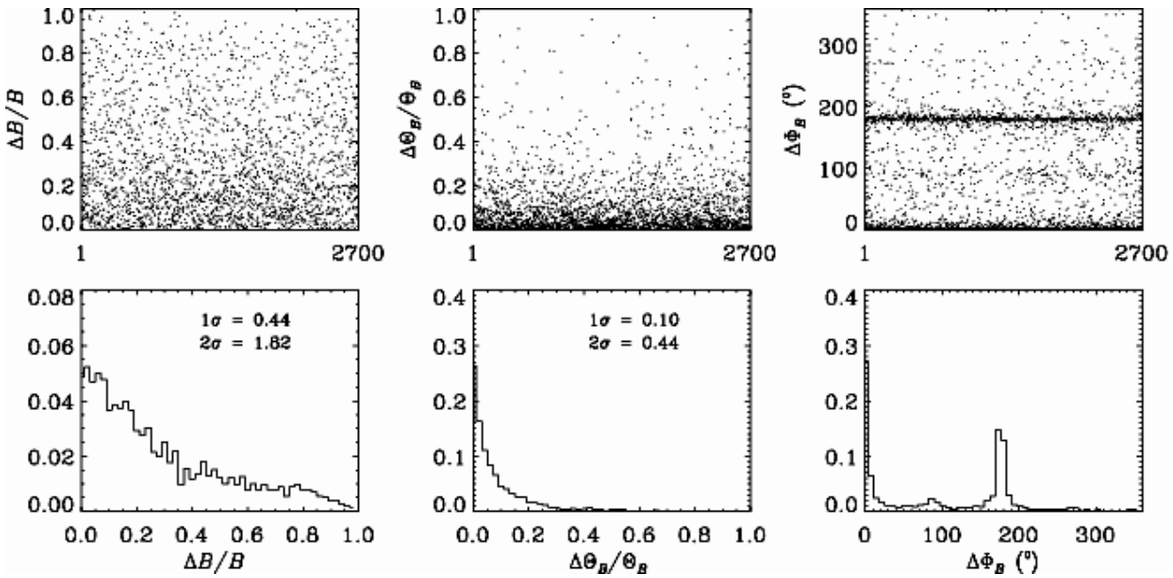
S/N = 10^3



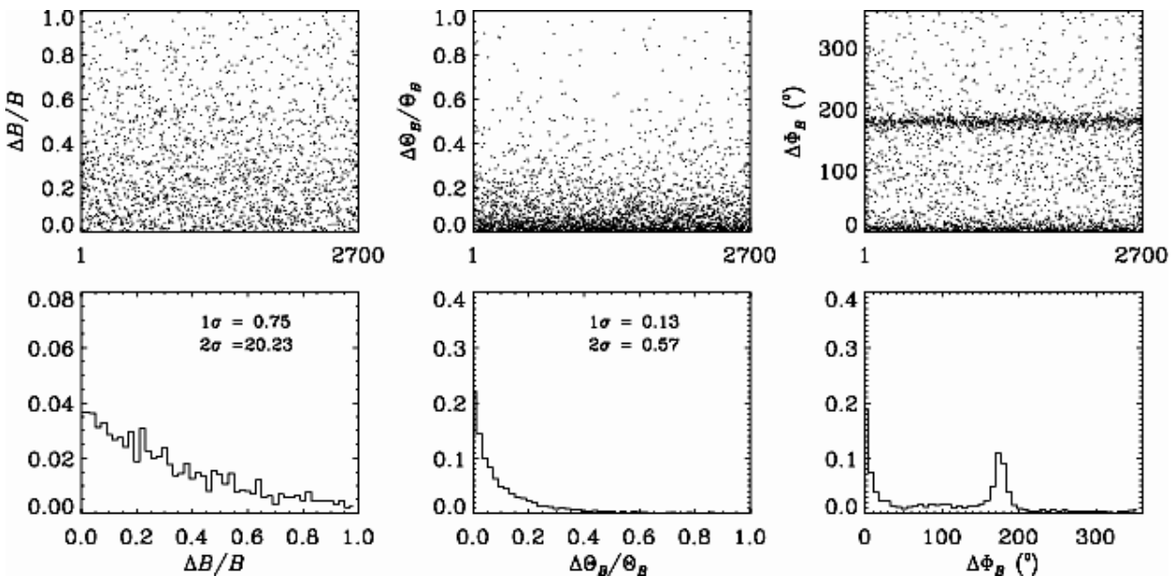
Spectro-polarimeter

R = 180000 (0.048 Å sampling)

No noise



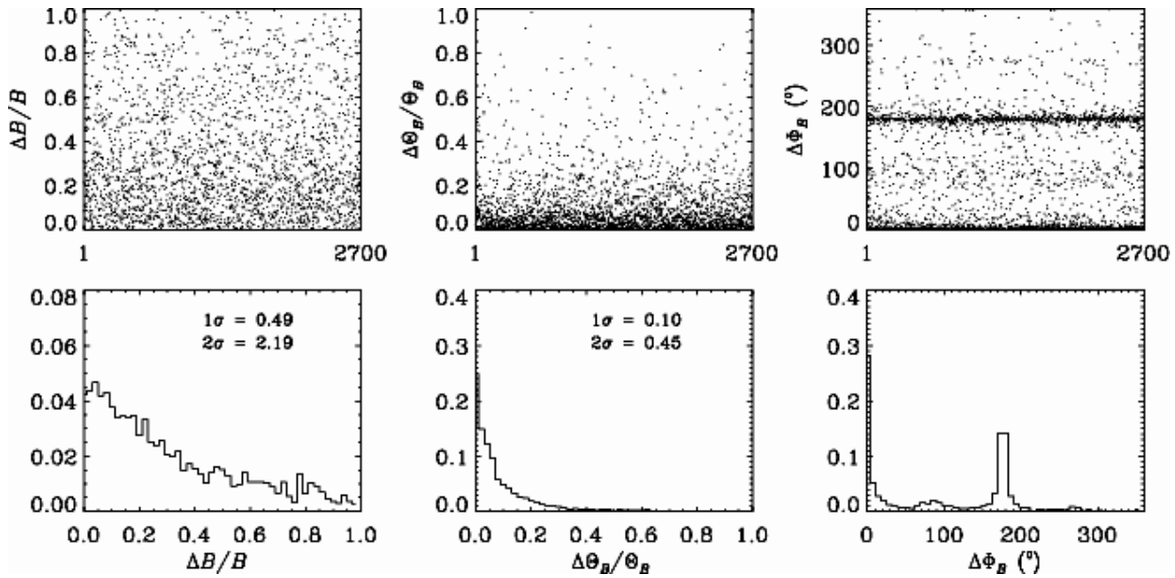
S/N = 10^3



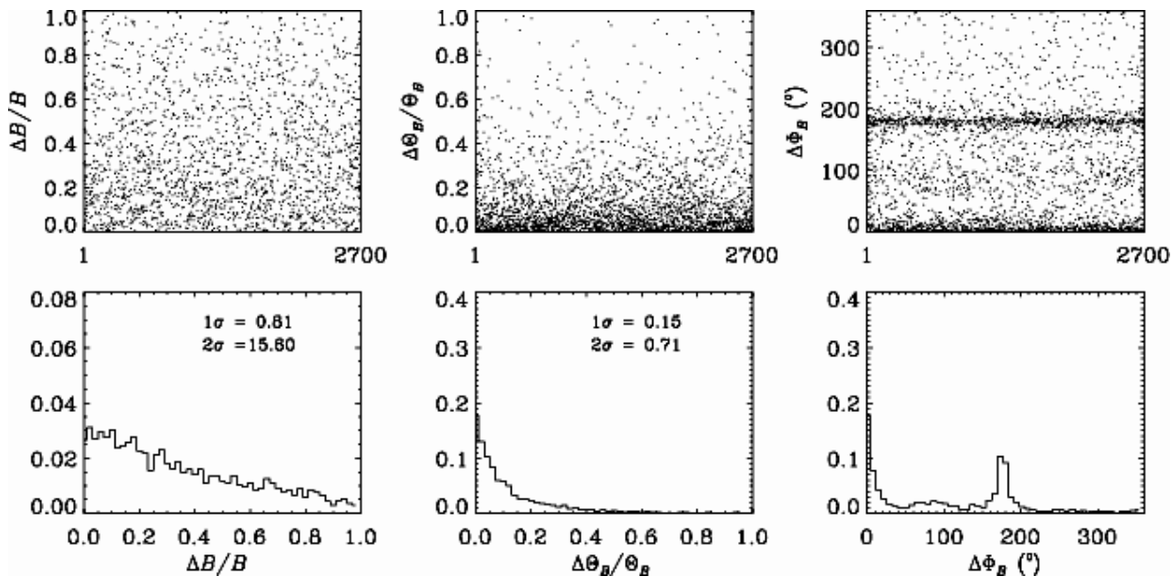
Lyot filter (ChroMag)

FWHM = 0.2 Å, 0.1 Å sampling

No noise



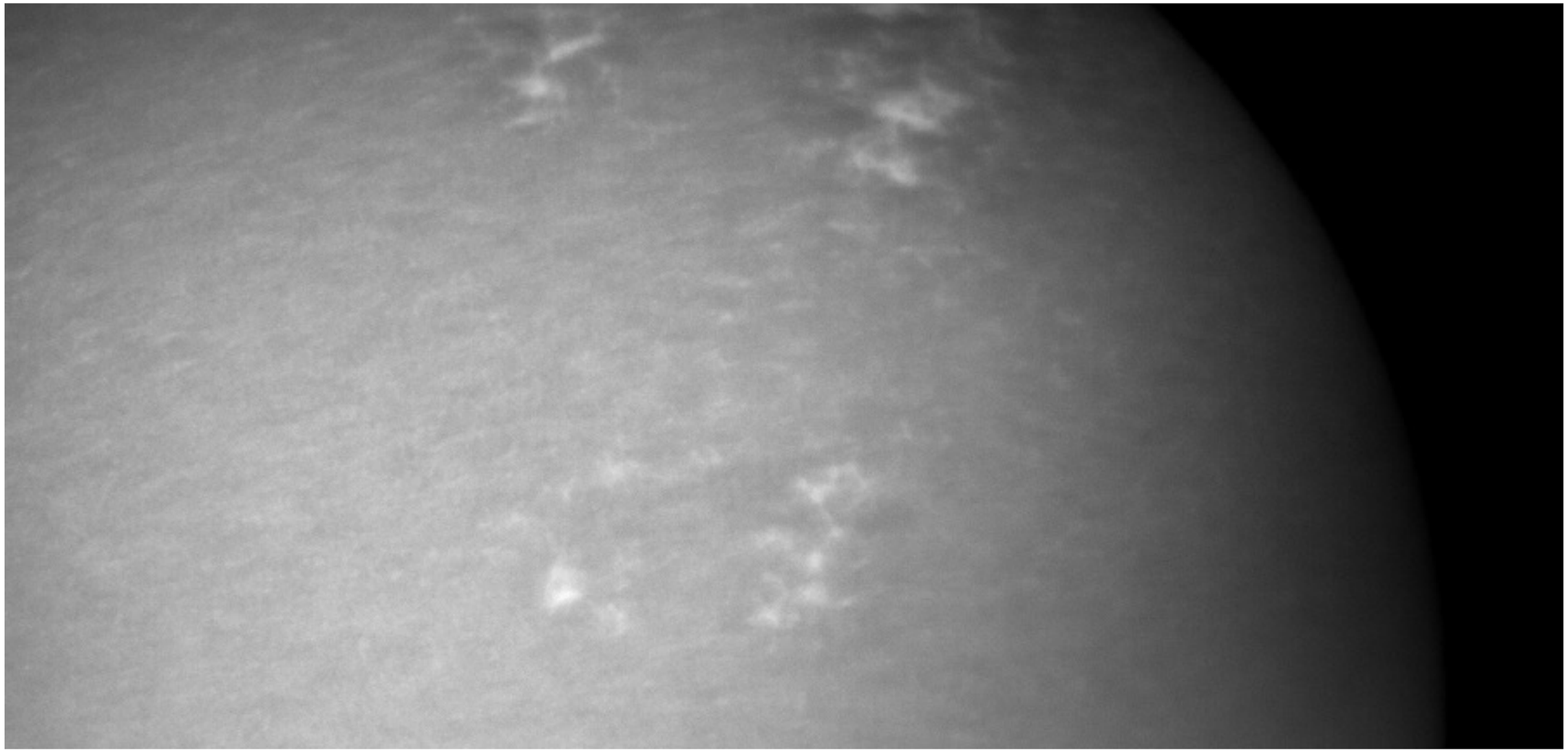
S/N = 10^3



Where are we now?

- Two-ish years ago: thermal instability
- Last year: modulator failure, some more thermal problems, and discovered the LCVR calibration was off
- Now: re-calibration complete, deployed to Mesa Lab
- First observations taken, initial data assessment indicates the instrument is working well

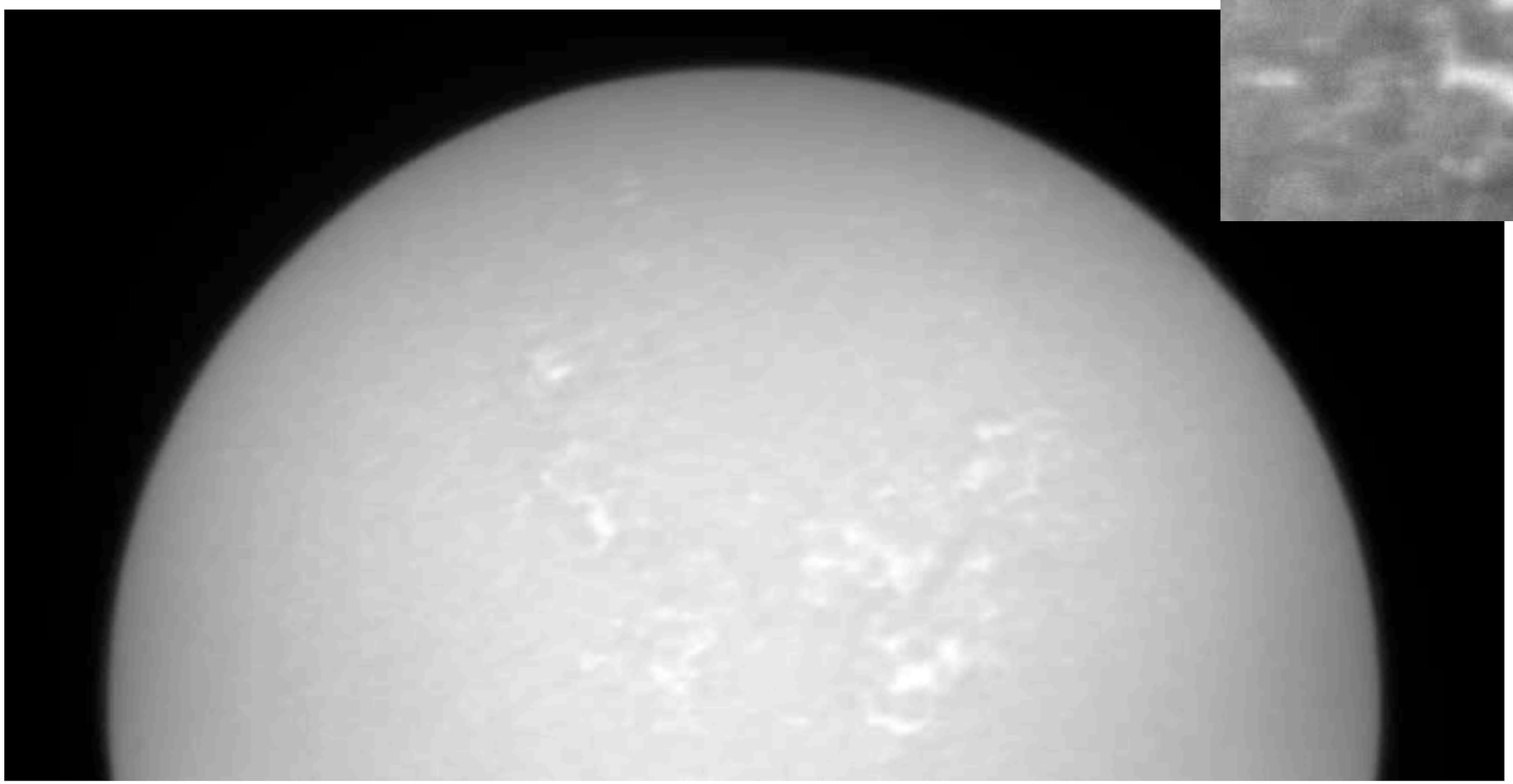
First Light on June 2!

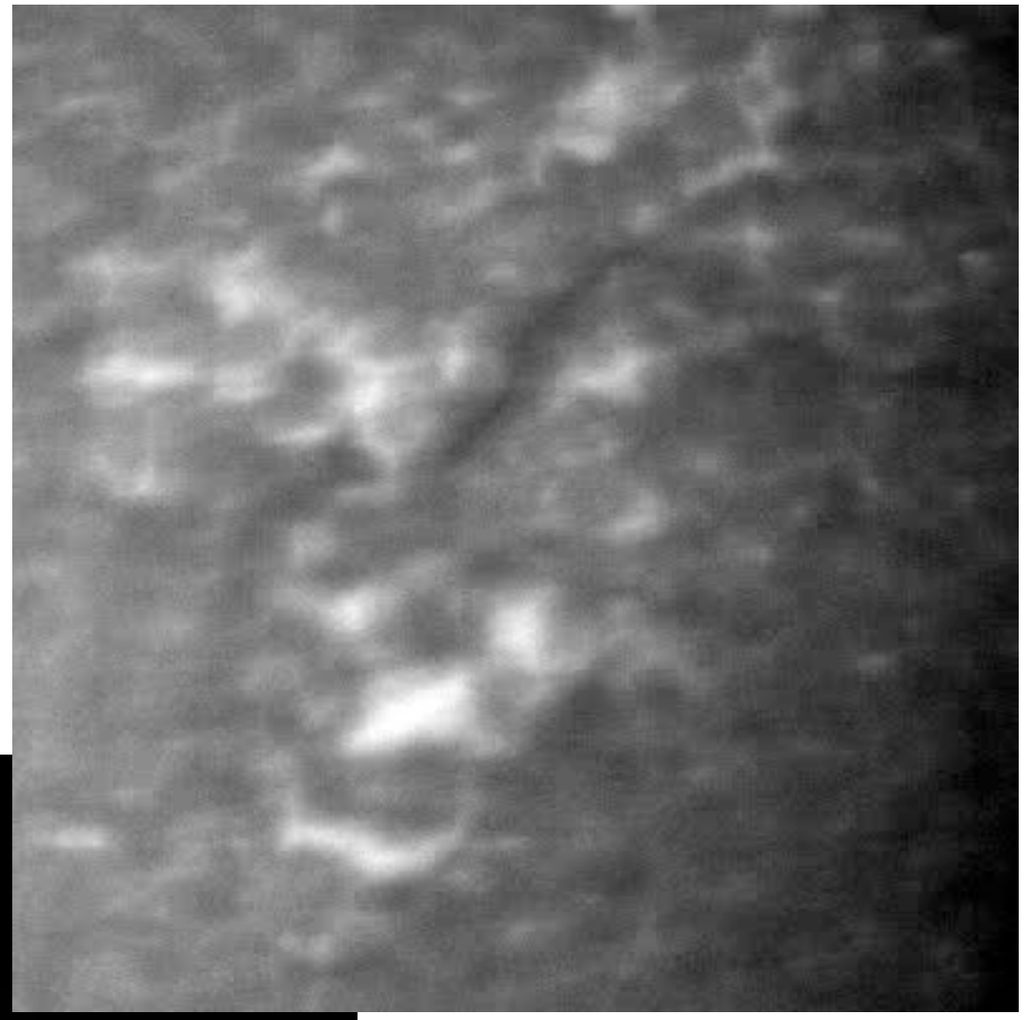


First Light on June 2!

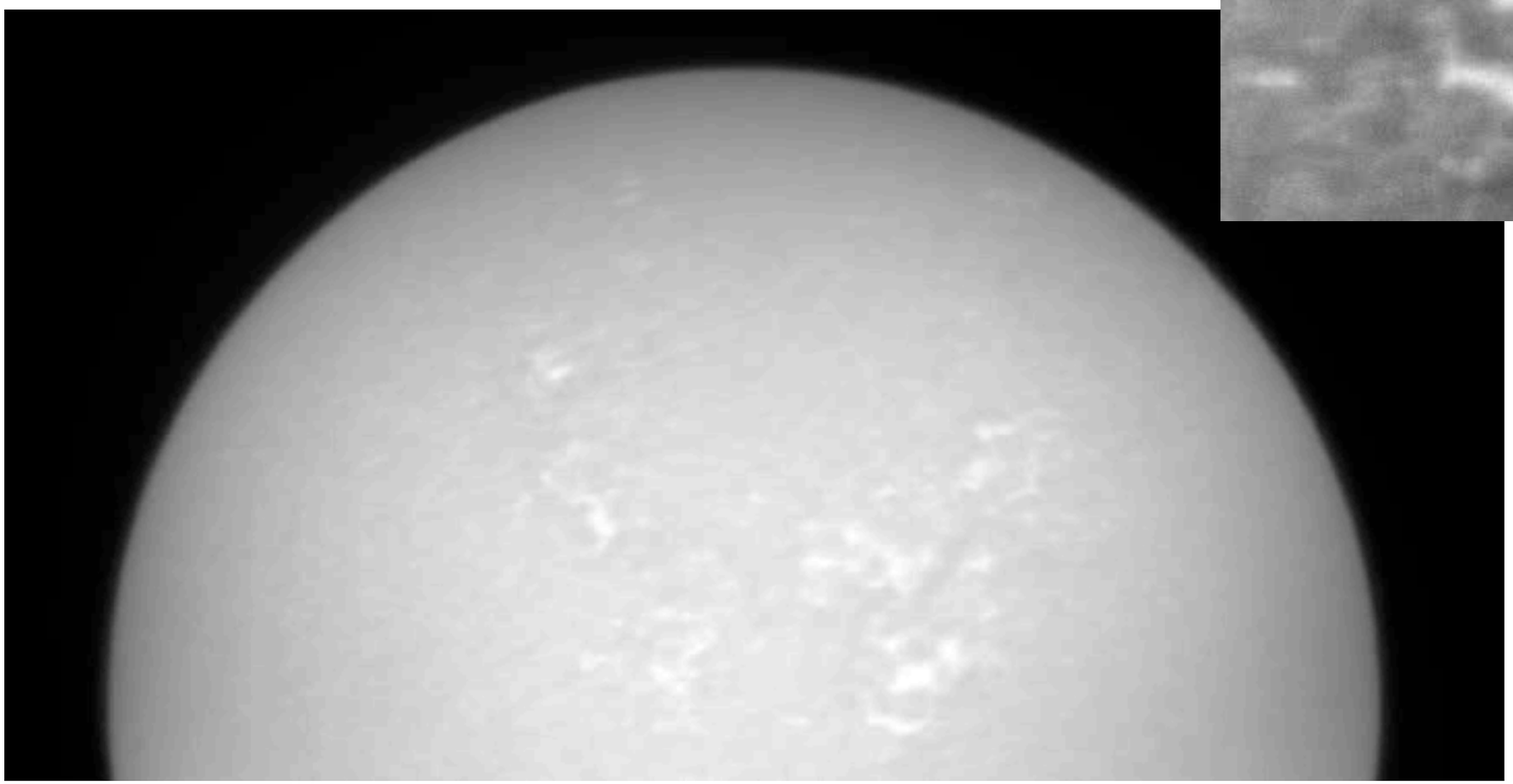
First Light on June 2!

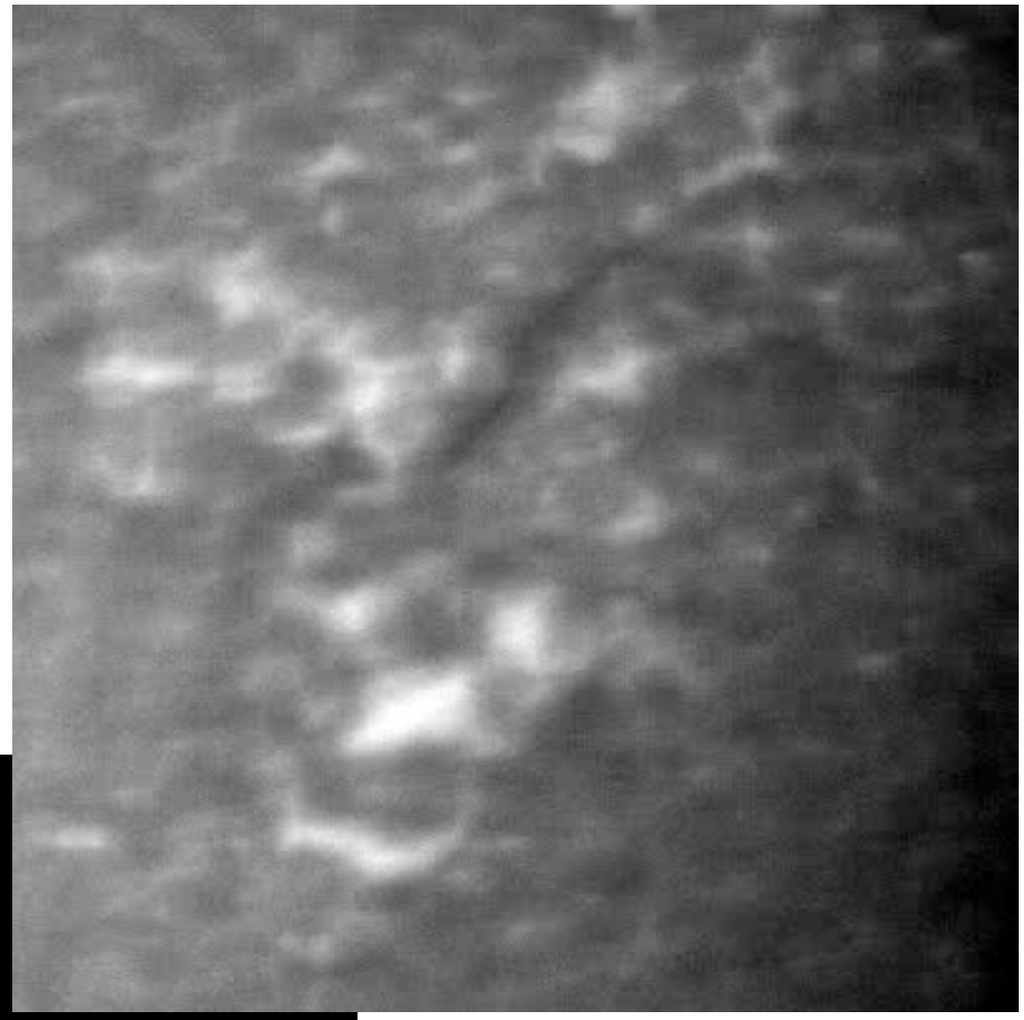
Ca II 854.2 nm
June 5



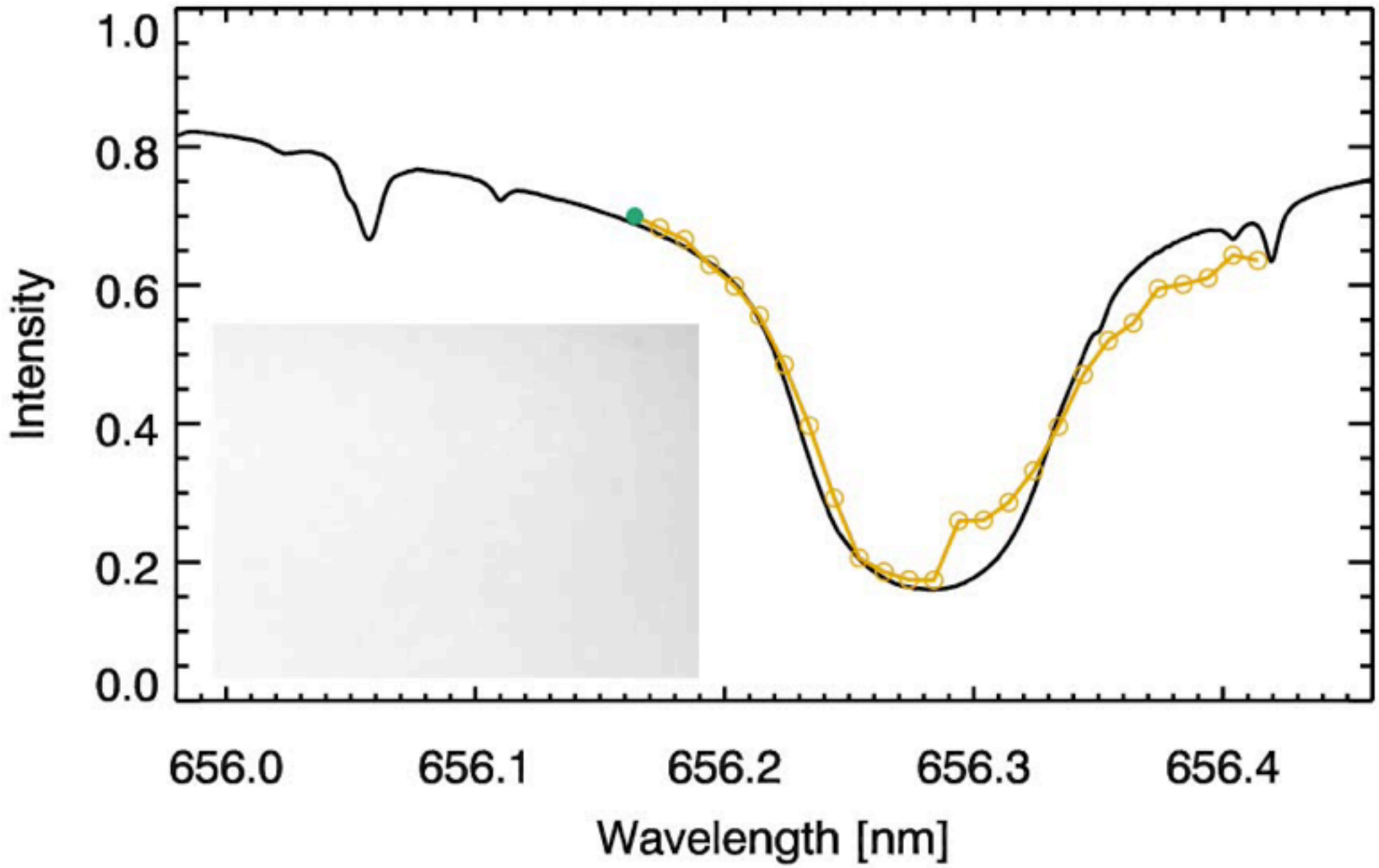


Ca II 854.2 nm
June 5

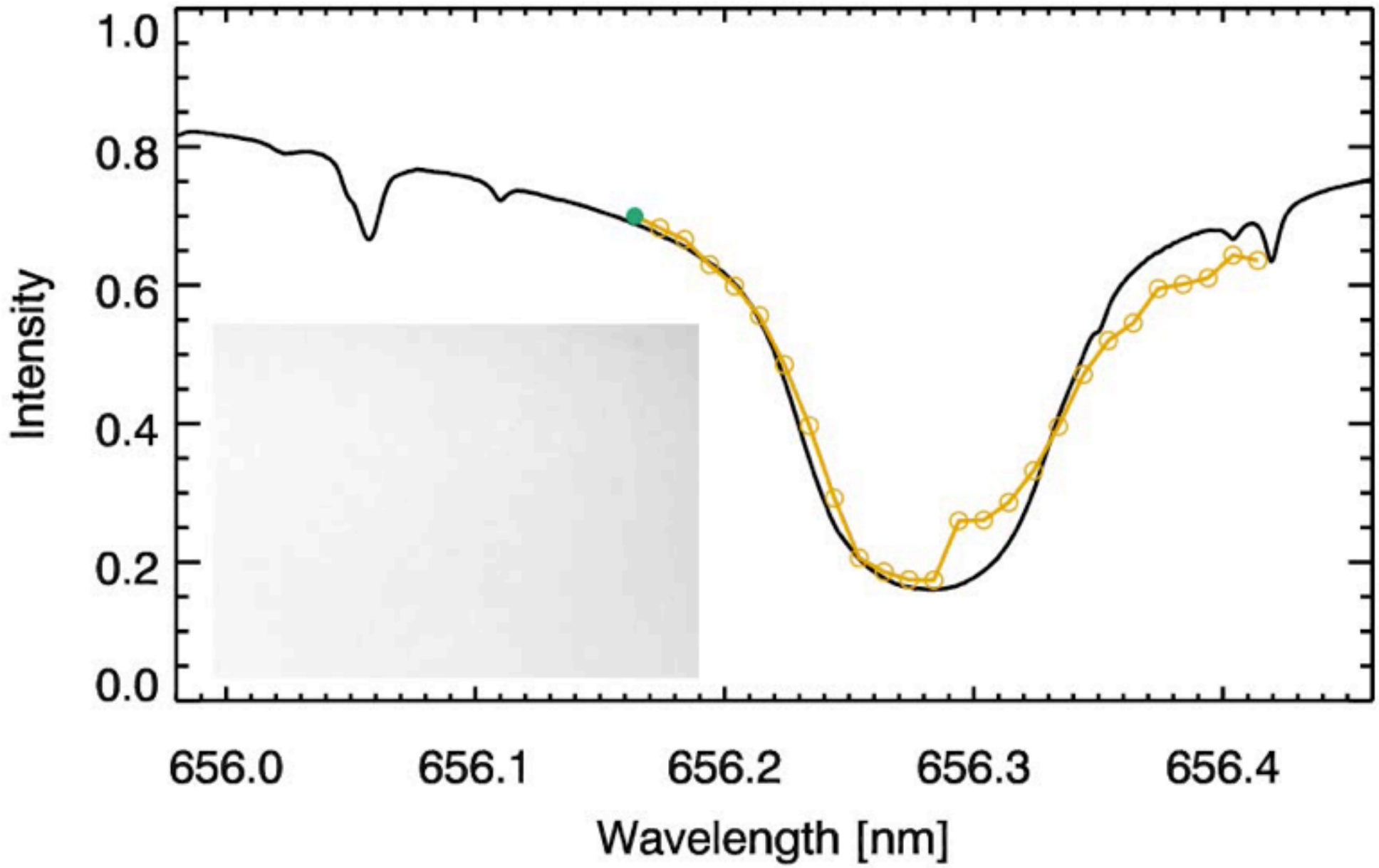




Hα 656.3 nm


1.0
0.8
0.6
0.4
0.2
0.0
Intensity
656.0
656.1
656.2
656.3
656.4
Wavelength [nm]

Hα 656.3 nm


1.0
0.8
0.6
0.4
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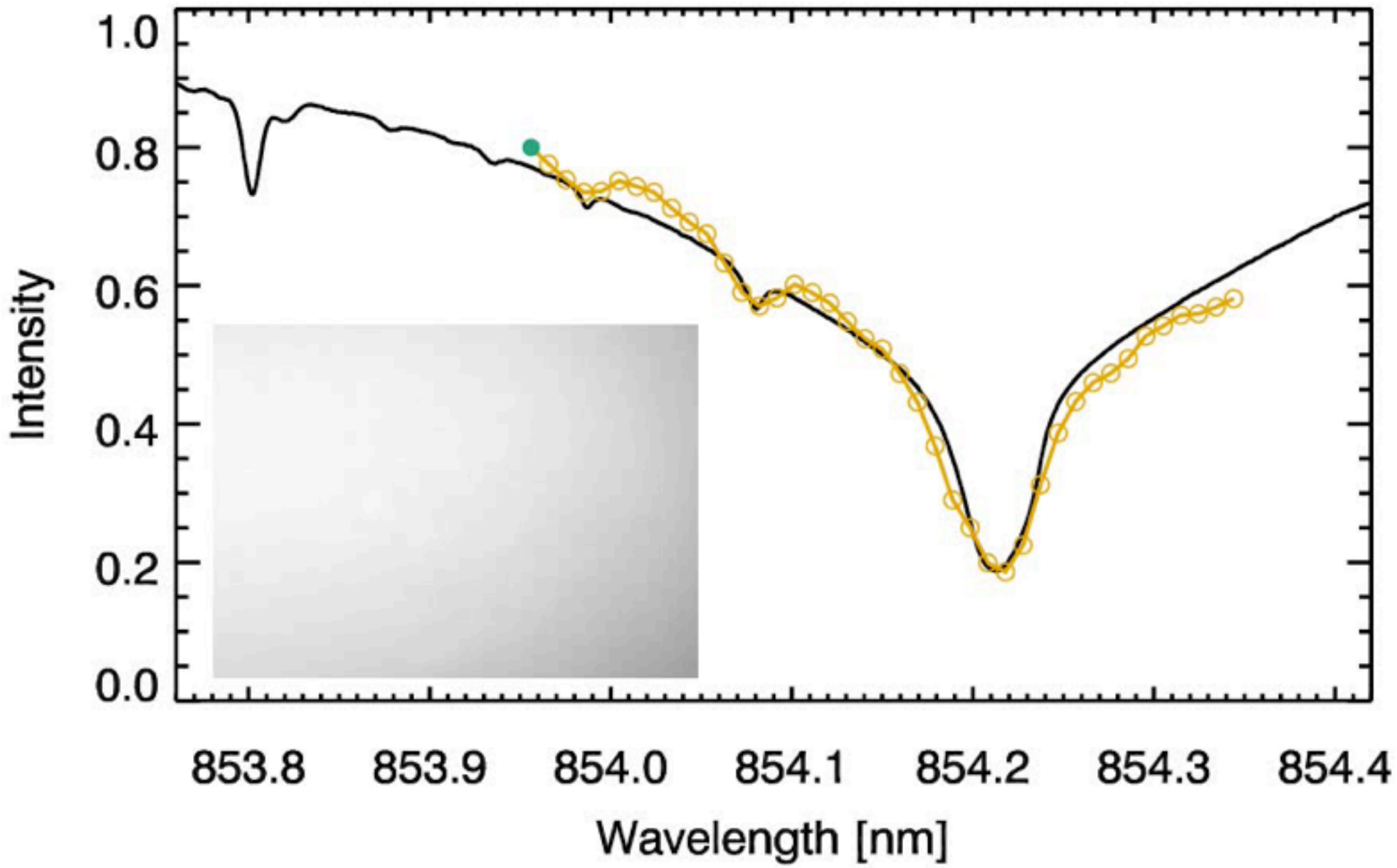
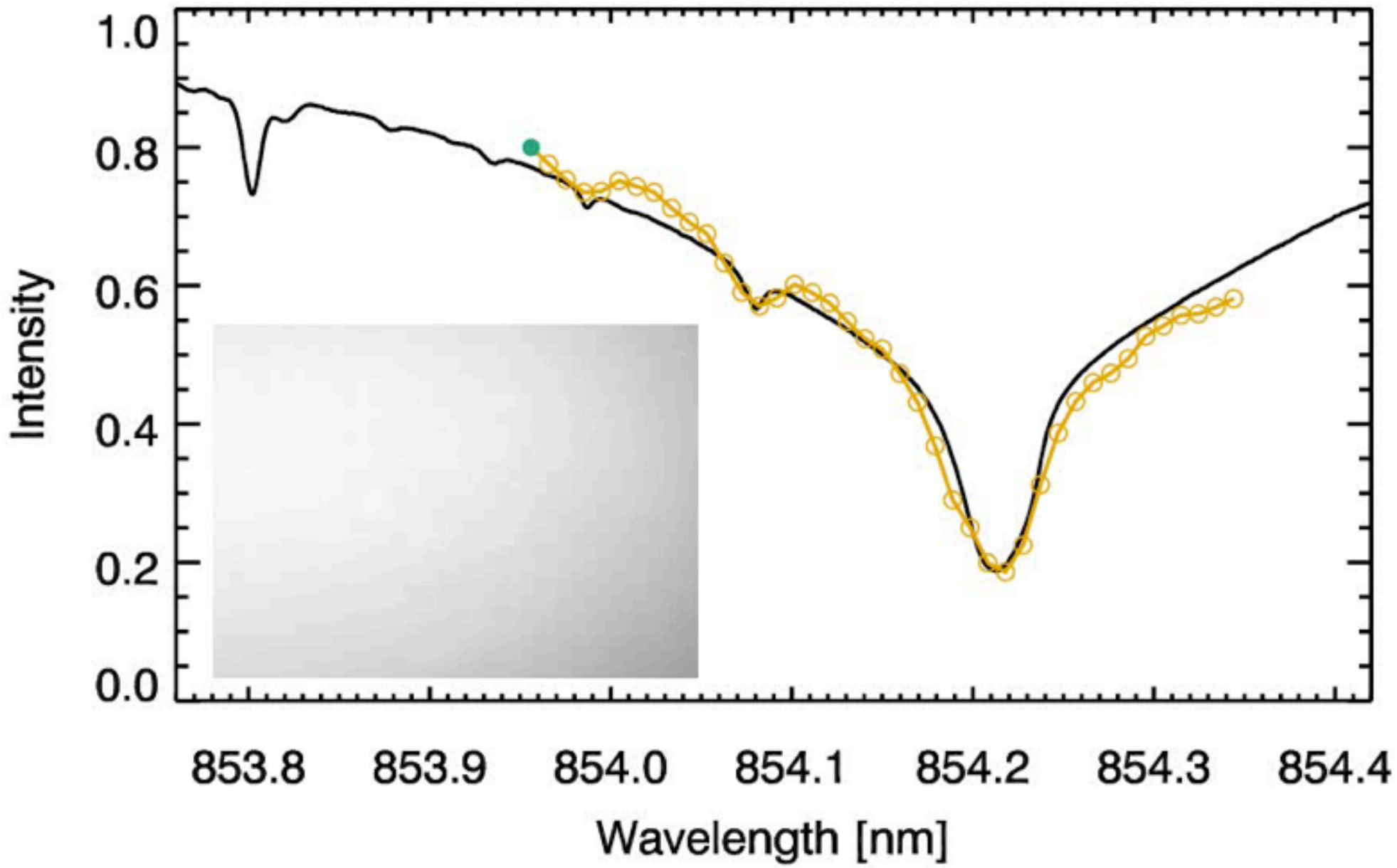
0.0
Intensity
656.0
656.1
656.2
656.3
656.4
Wavelength [nm]

Ca II 854.2 nm


1.0
0.8
0.6
0.4
0.2
0.0
Intensity
853.8
853.9
854.0
854.1
854.2
854.3
854.4
Wavelength [nm]

Ca II 854.2 nm


1.0
0.8
0.6
0.4
0.2
0.0
Intensity
853.8
853.9
854.0
854.1
854.2
854.3
854.4
Wavelength [nm]