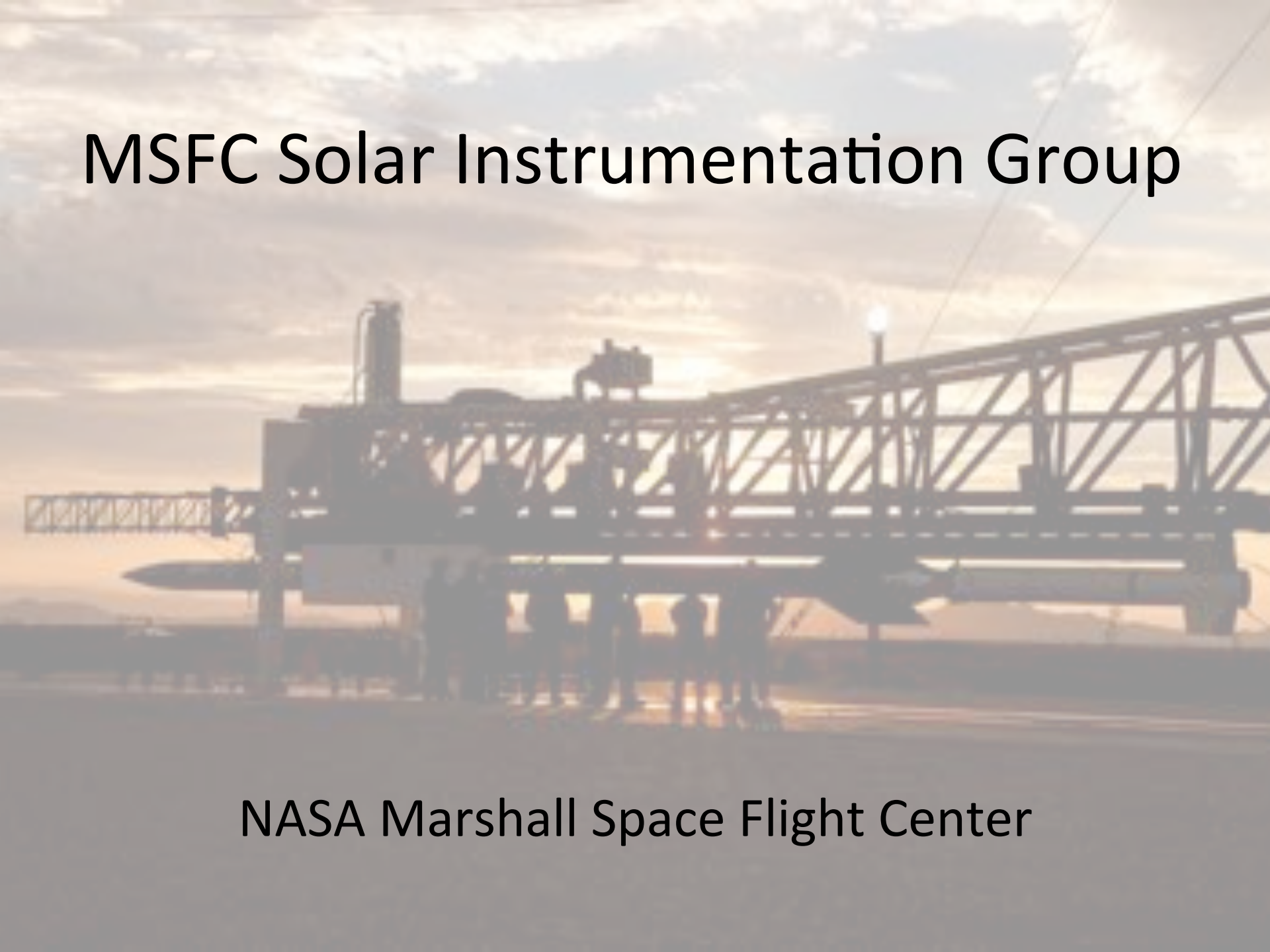
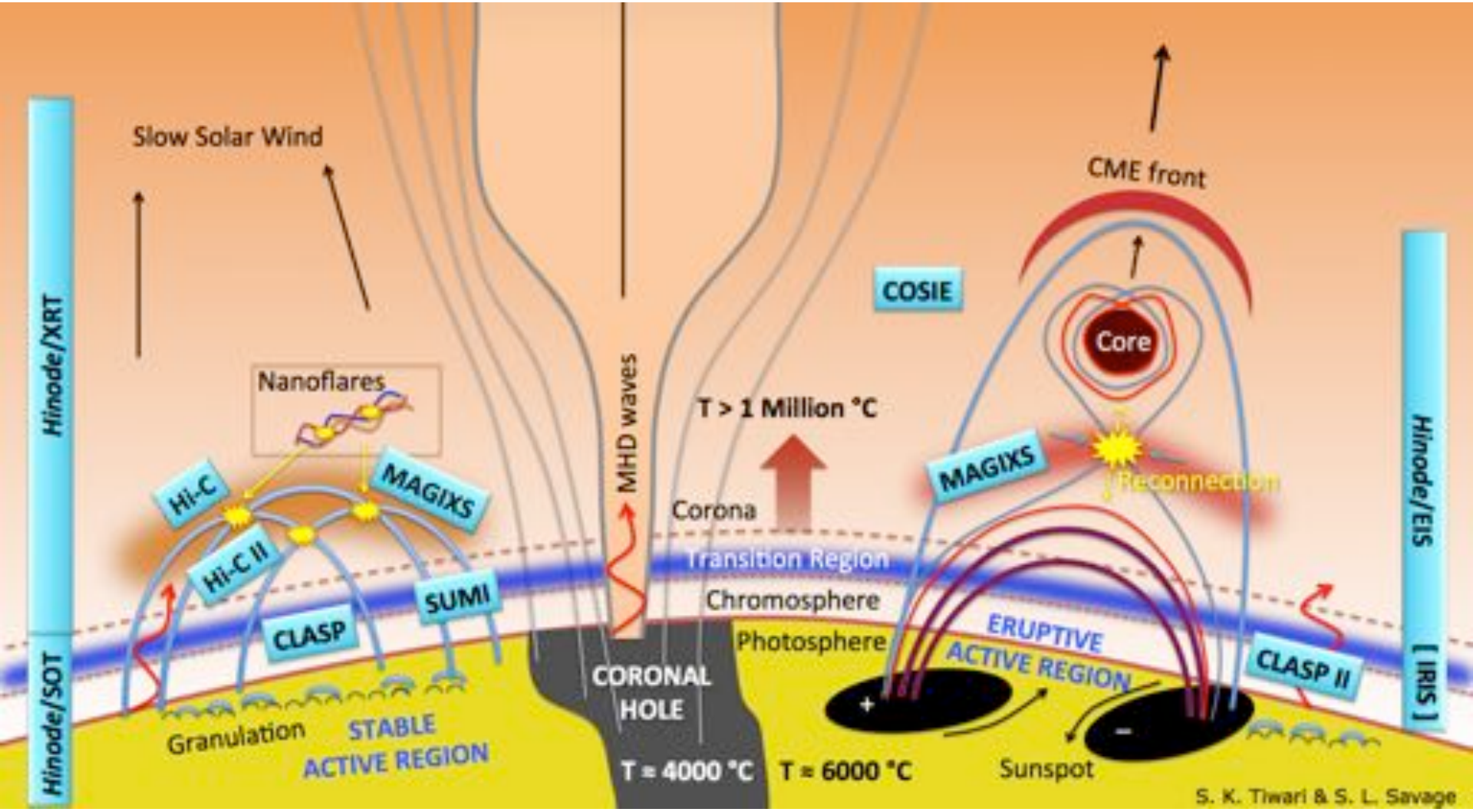
MSFC Solar Instrumentation Group



NASA Marshall Space Flight Center

Sounding Rocket Instruments at MSFC



Sounding Rocket Instruments at MSFC

Hi-C I (J. Cirtain, PI)
Flew from WSMR on July 11, 2012

Hi-C II (J. Cirtain, PI)
Will be launched July, 2016

CLASP I (A. Winebarger, PI)
Launched from WSMR on September 3, 2015

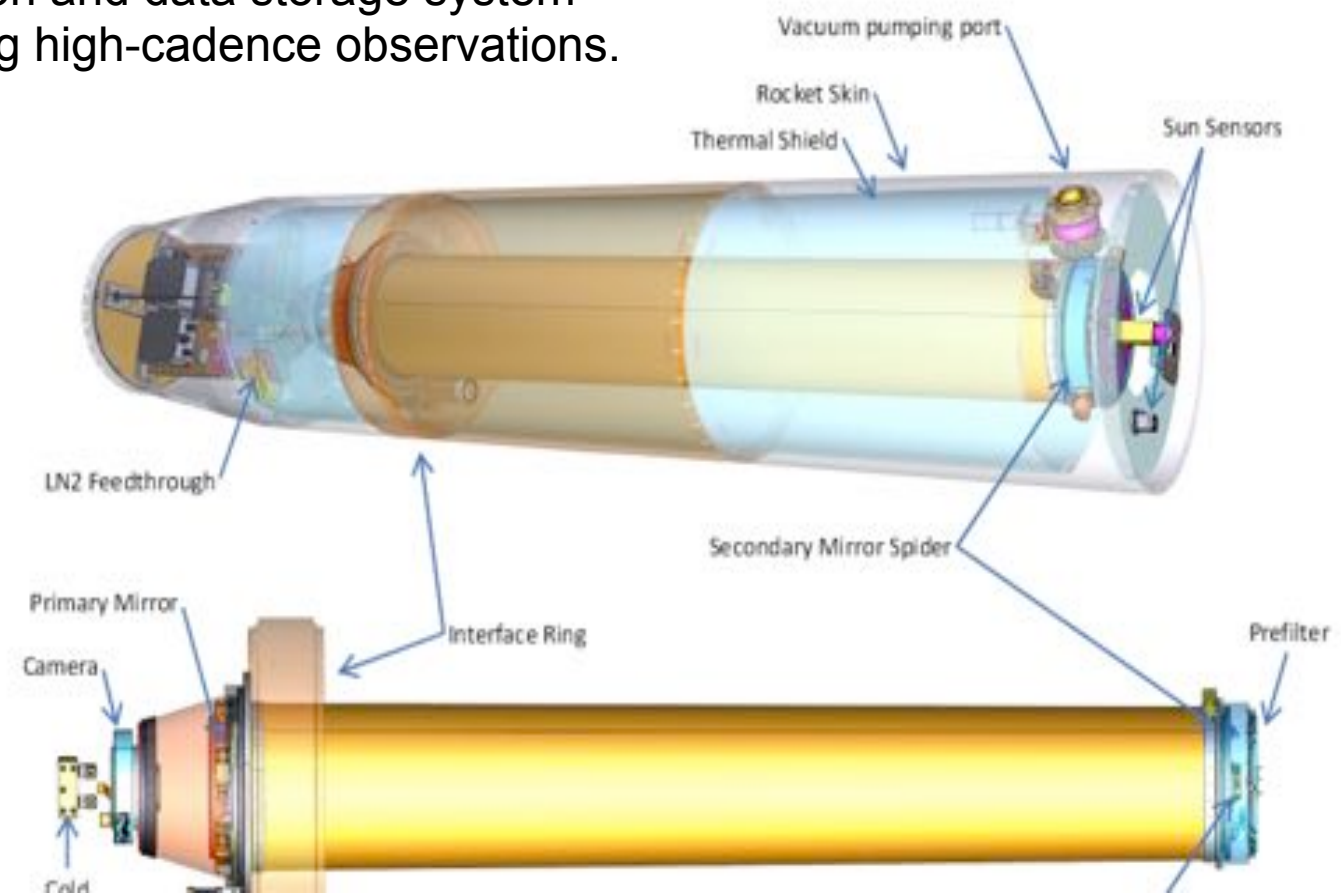
CLASP II (J. Cirtain, PI)
Proposed to launch Spring, 2018

MaGIXS (A. Winebarger, PI)
Will be launched in 2018-19

FLOWN
FUNDED
PROPOSED

High-resolution Coronal Imager (Hi-C)

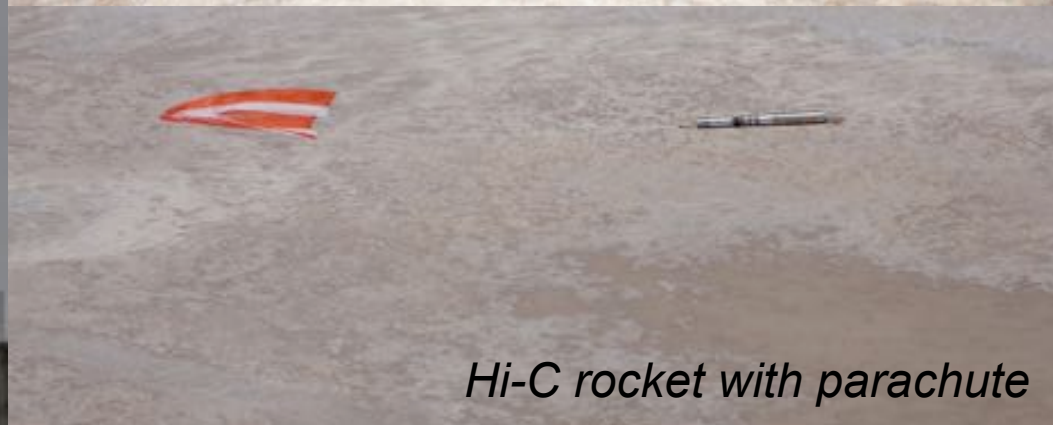
Telescope design capable of ~150km spatial resolution
Pointing stability necessary to achieve resolution goal
Image readout duration and data storage system capable of maintaining high-cadence observations.



Hi-C

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

Hi-C recovery team



Hi-C rocket with parachute

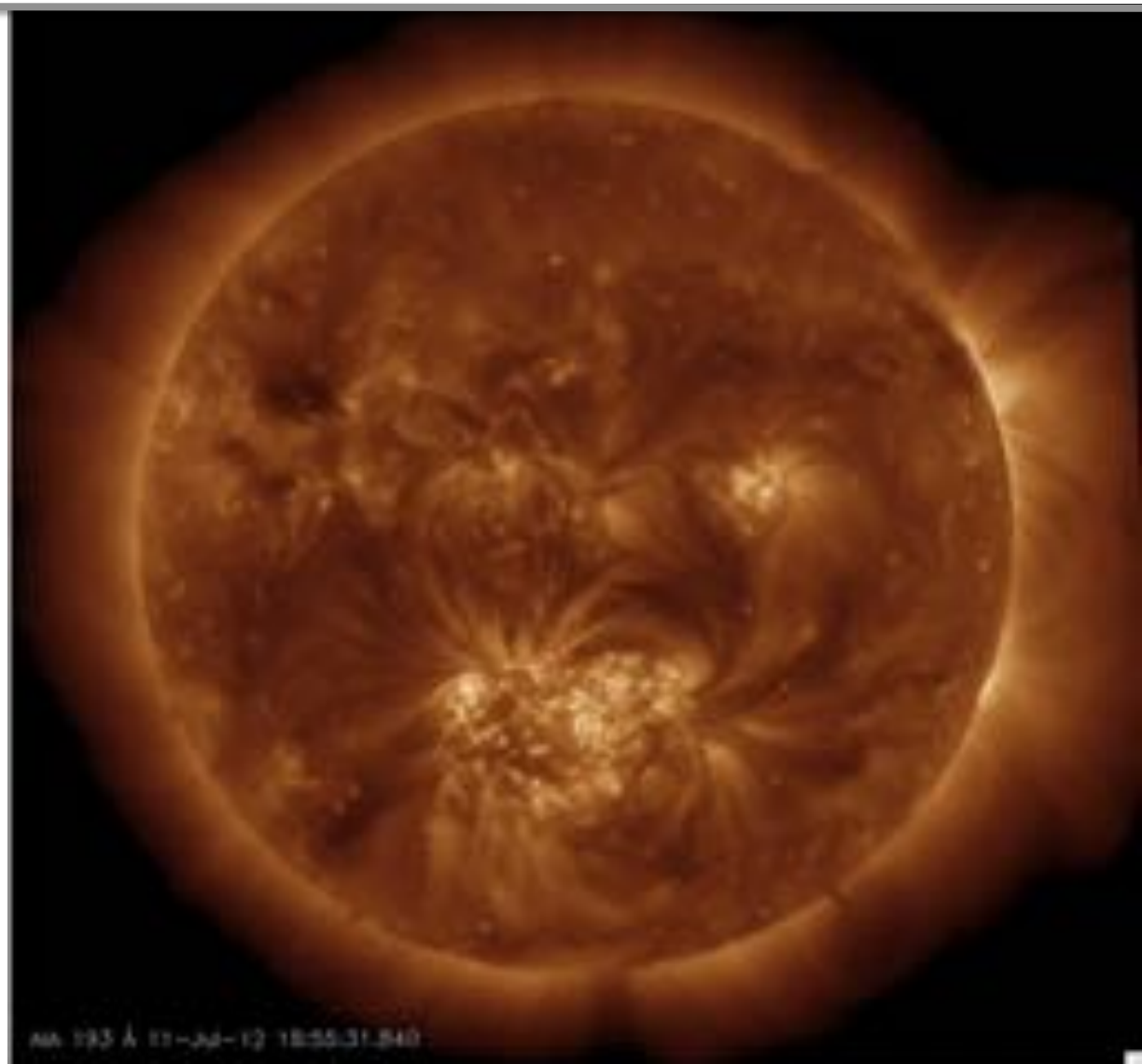
Hi-C

Active Region 11520
July 11, 2012

18 publications for 5 minutes of data!

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



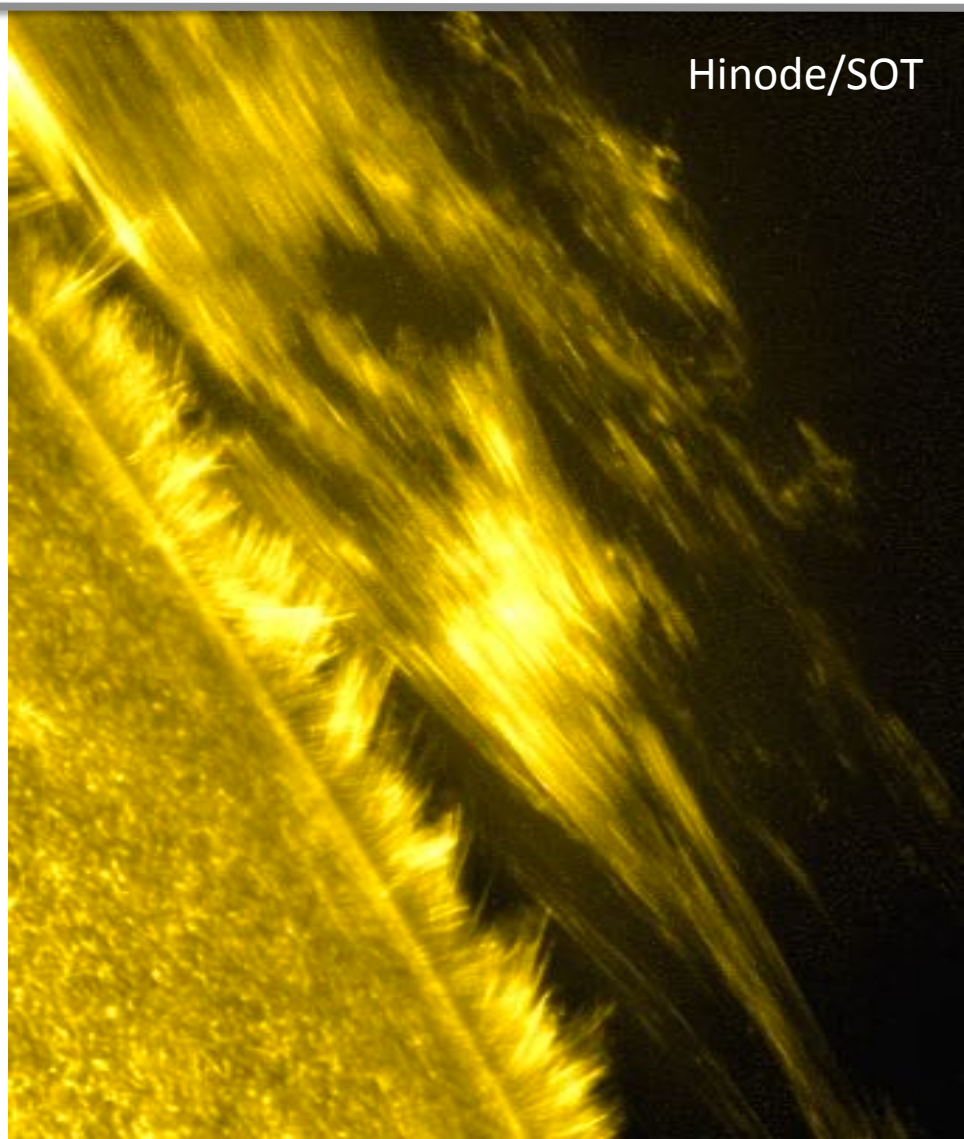
Hi-C II

Hi-C II will explore the important Chromospheric-Coronal Connection by targeting specific candidates likely to contribute to coronal heating:

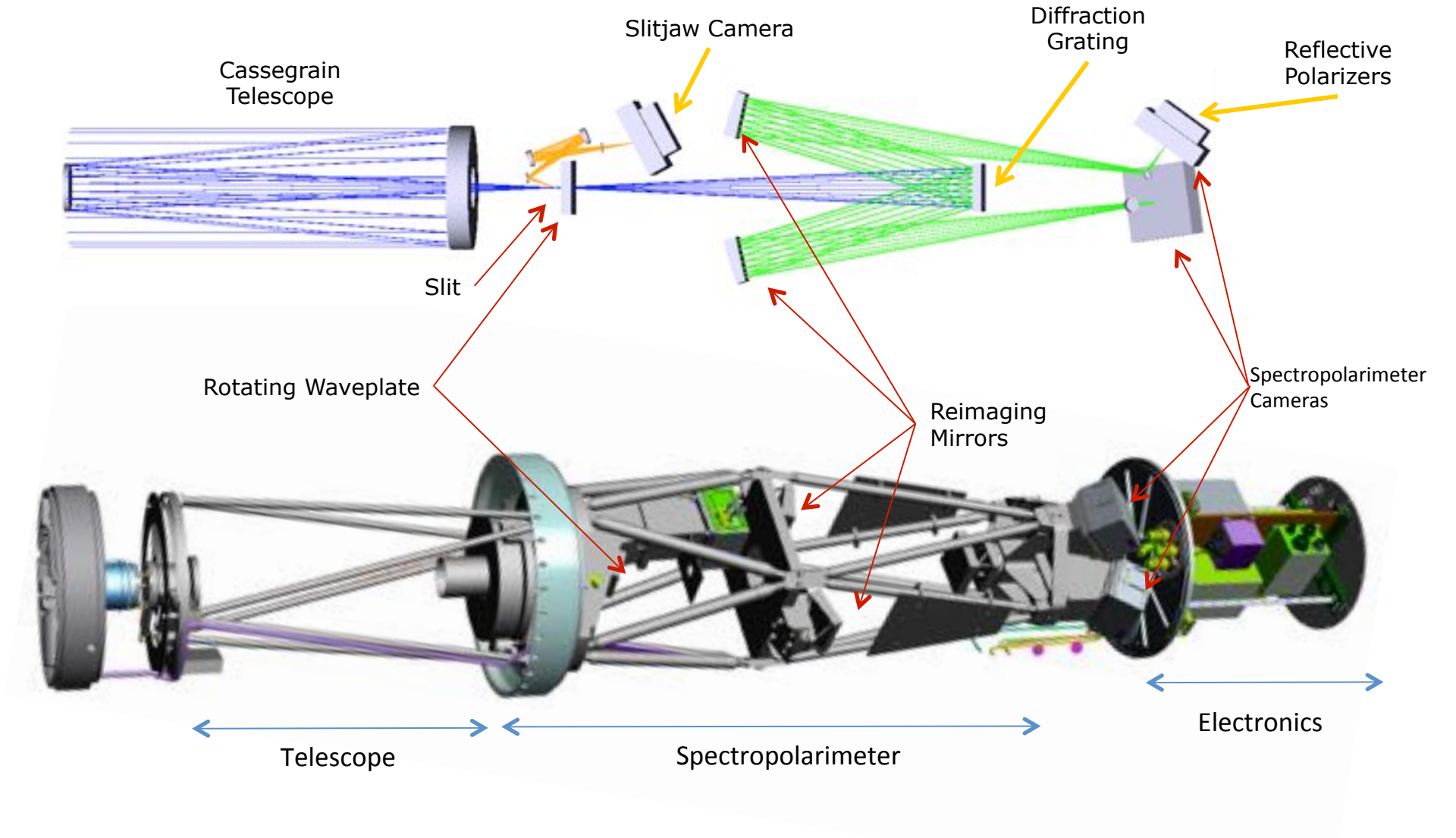
1. Type II spicules
2. Hot active region core loops

Updates for re-flight:

- Cooler bandpass centered on 173 Angstroms
- Significant improvement in camera quality (cameras for this instrument being developed concurrently for other instrumentation where low noise is critical)



Chromospheric Lyman-Alpha Spectropolarimeter (CLASP)

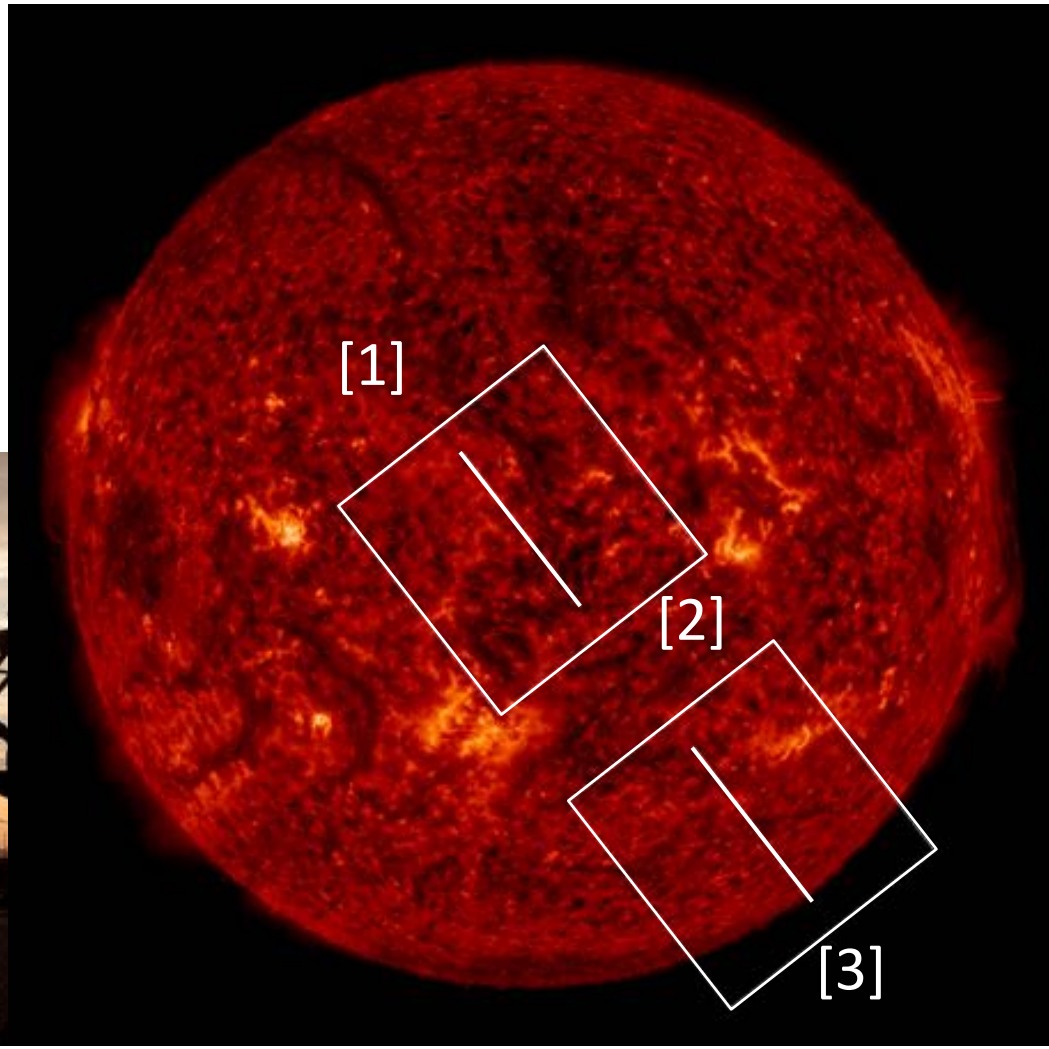


CLASP

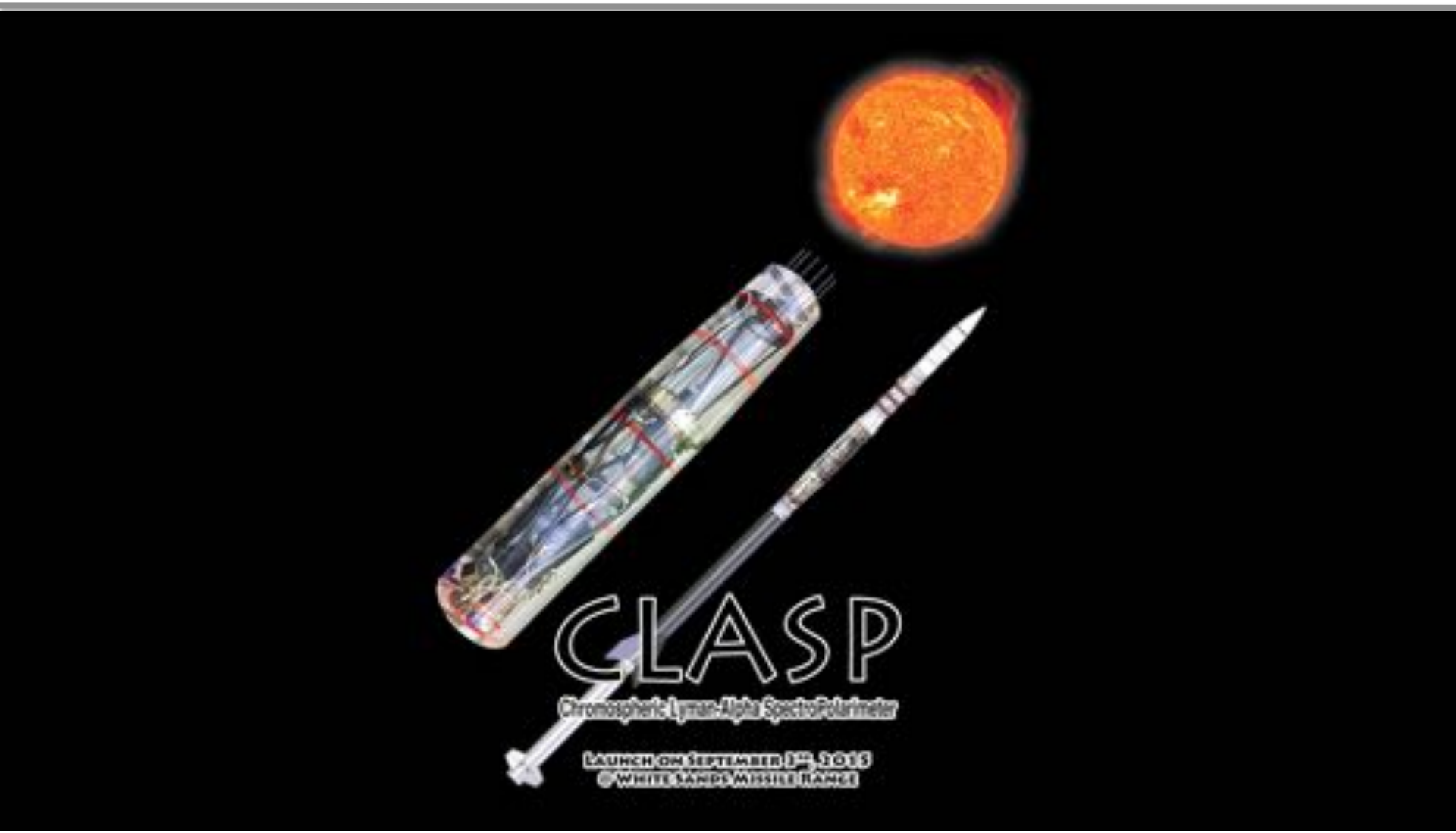
Objective: Use the polarization to infer the chromospheric thermal structure and magnetic field.

- Requires accurate calibration
- Requires advanced theoretical modeling for interpretation

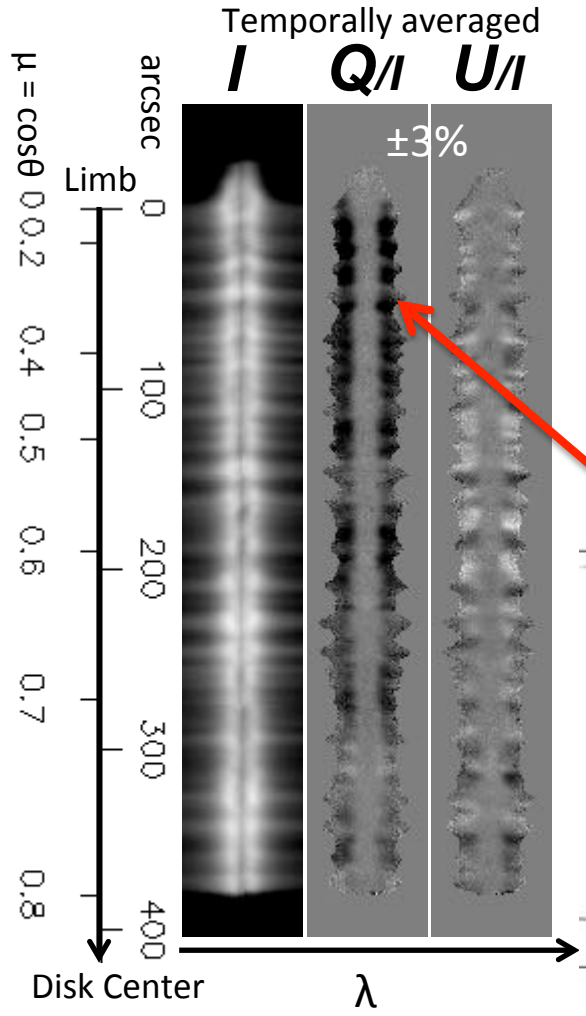
Launched September 3, 2015



CLASP

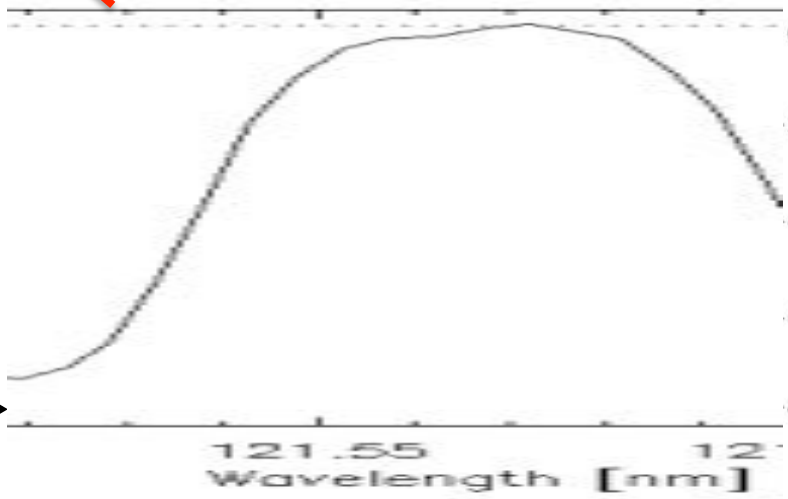

CLASP
Chromospheric Lyman-Alpha SpectroPolarimeter
LAUNCH ON SEPTEMBER 3RD, 2015
@ WHITE SANDS MISSILE RANGE

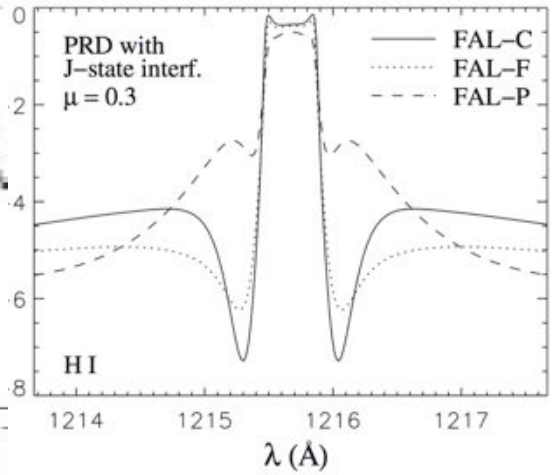
CLASP



Further calibrations/investigations are required, but …

- **A few %** of polarization in the wing, and **a few of 0.1 %** in the core.
- A clear **C-to-L variation** in the wing of Q/I.
- Small-scale structures along the slit.
- Q/I profile is essentially **consistent with the model prediction**.



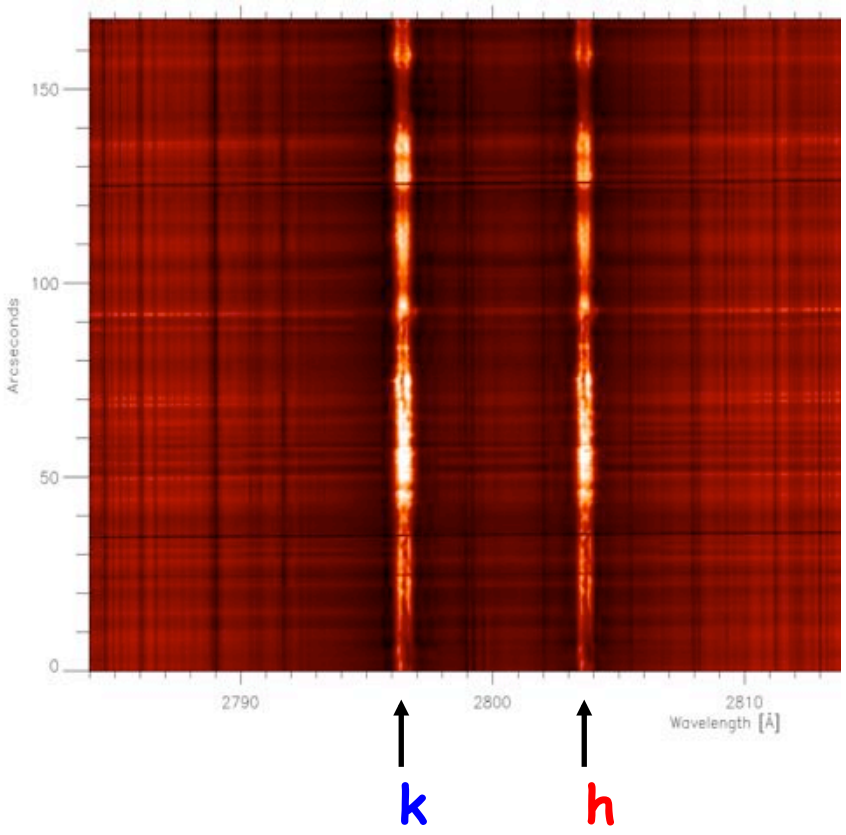


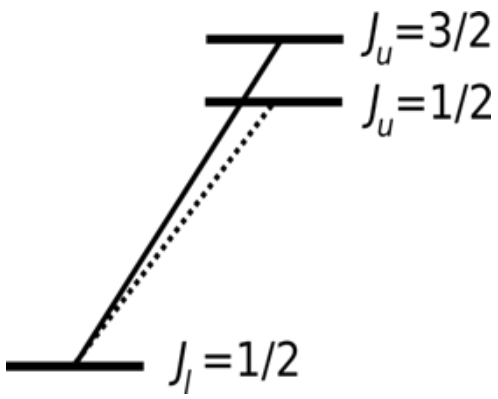
Belluzzi et al. 2012

CLASP 2

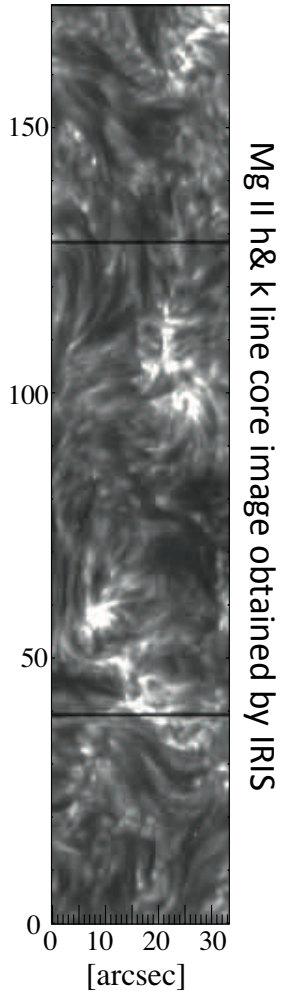
Proposed to fly in Spring 2018.

CLASP 2 proposes to change the wavelength to Mg II h&k, another set of magnetically sensitive spectral lines in the UV at ~ 280 nm.

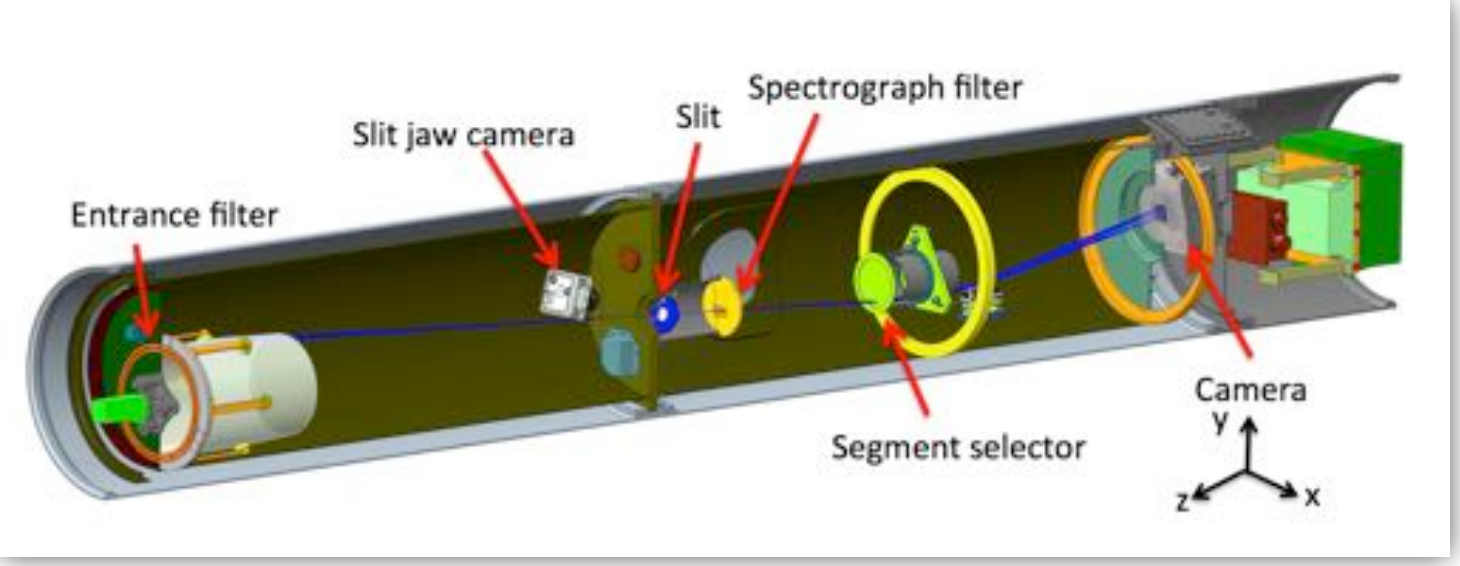




Observing target: QS and plage (if available)



Marshall Grazing Incidence X-ray Spectrometer (MaGIXS)



Telescope: Wolter Type-I
Effective Focal Length ~ 1 m

Slit jaw imaging system for pointing and co-alignment

Detector : Low noise, 2kx1k frame transfer

Spectrograph: Two matched parabolic mirrors + Grating

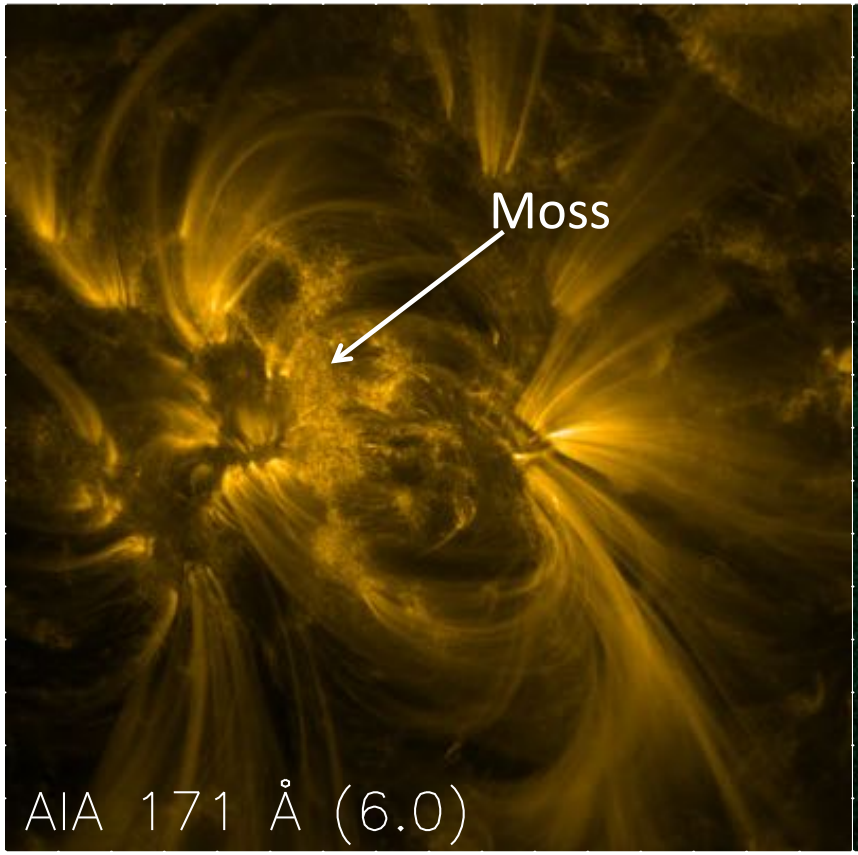
6.0 - 24.0 Å (0.5 - 2.0 keV)
11 mÅ / pixel
2.8 arcsec / pixel

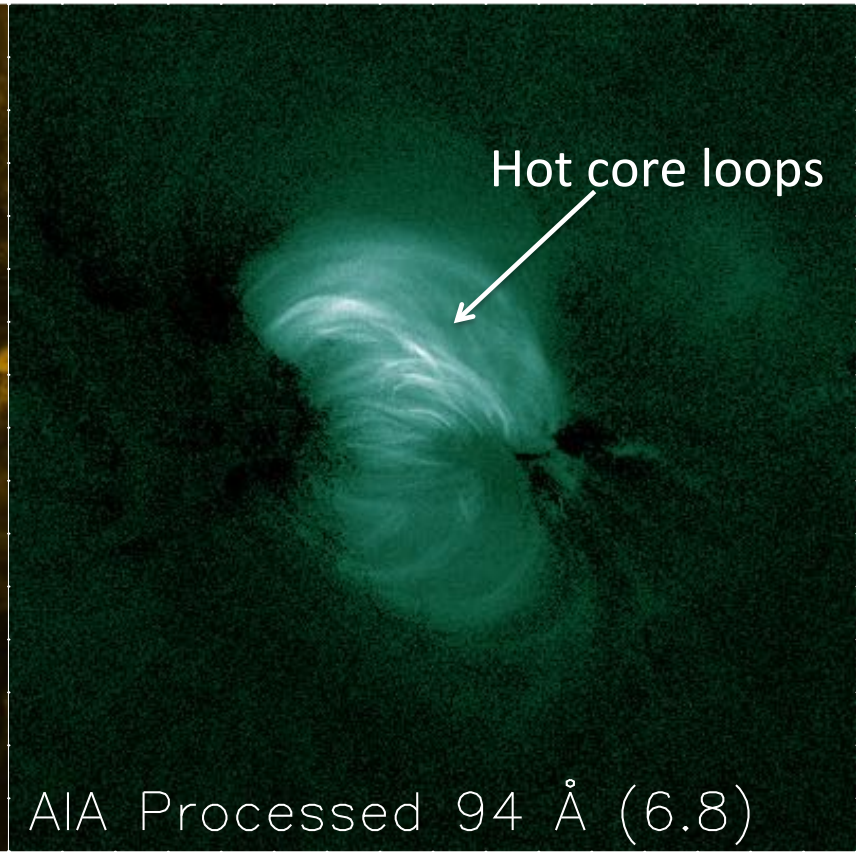
Grating: Blazed Planar Varied Line Space

MaGIXS will be launched in summer 2018 or 2019.

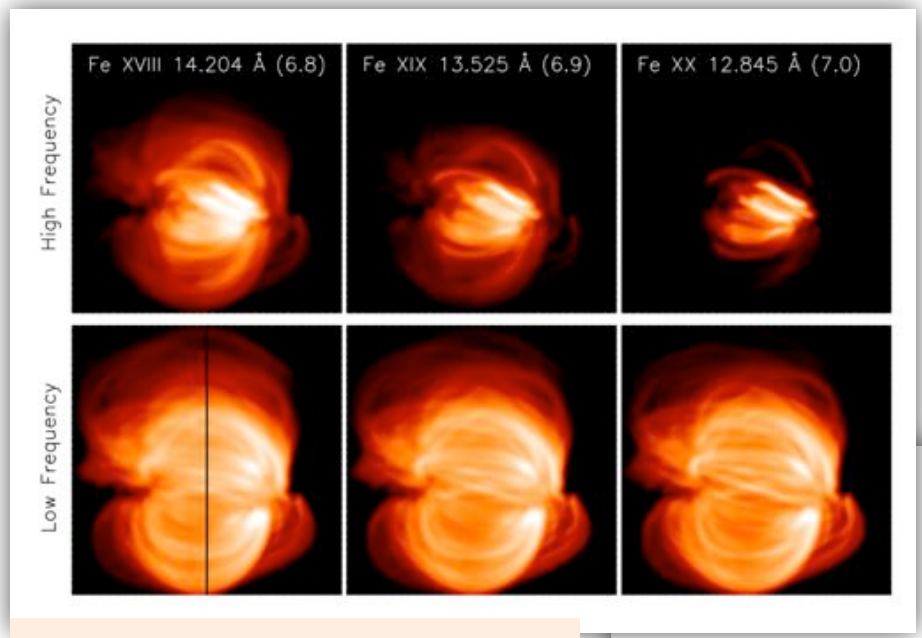
MaGIXS

Science Goal: Determine the frequency of heating in active region cores.
Is heating sporadic (nanoflares) or frequent (waves)?





MaGIXS



Simulated active region core using 0-D EBTEL:

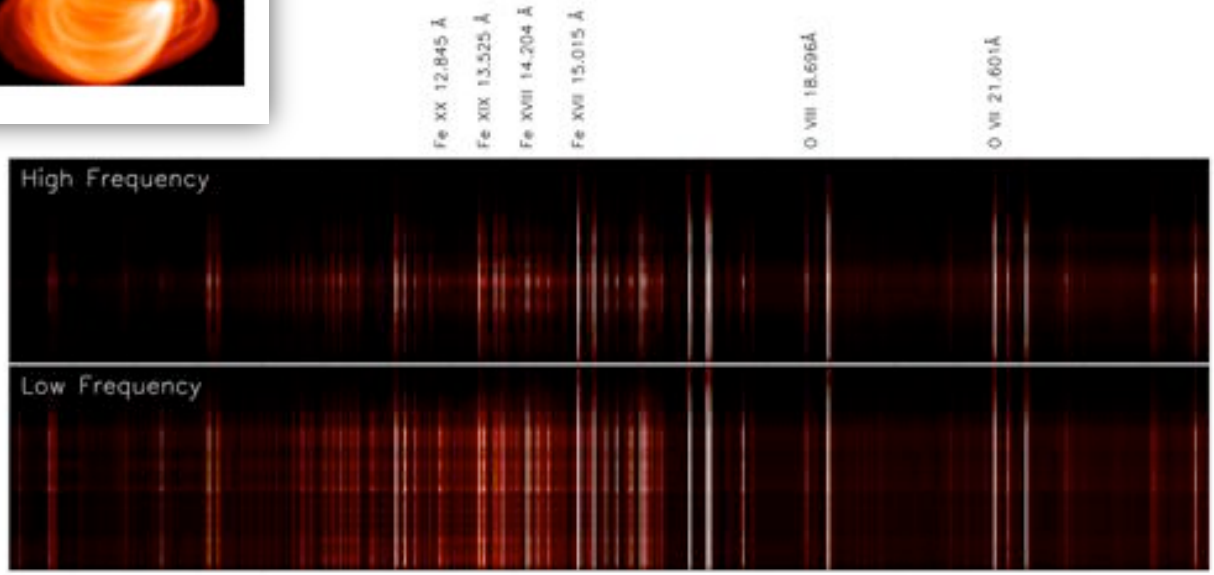
- Random heating events
- Heating event cadence 1575 s versus 6300 s

Expected emission quite different at higher temperature lines.

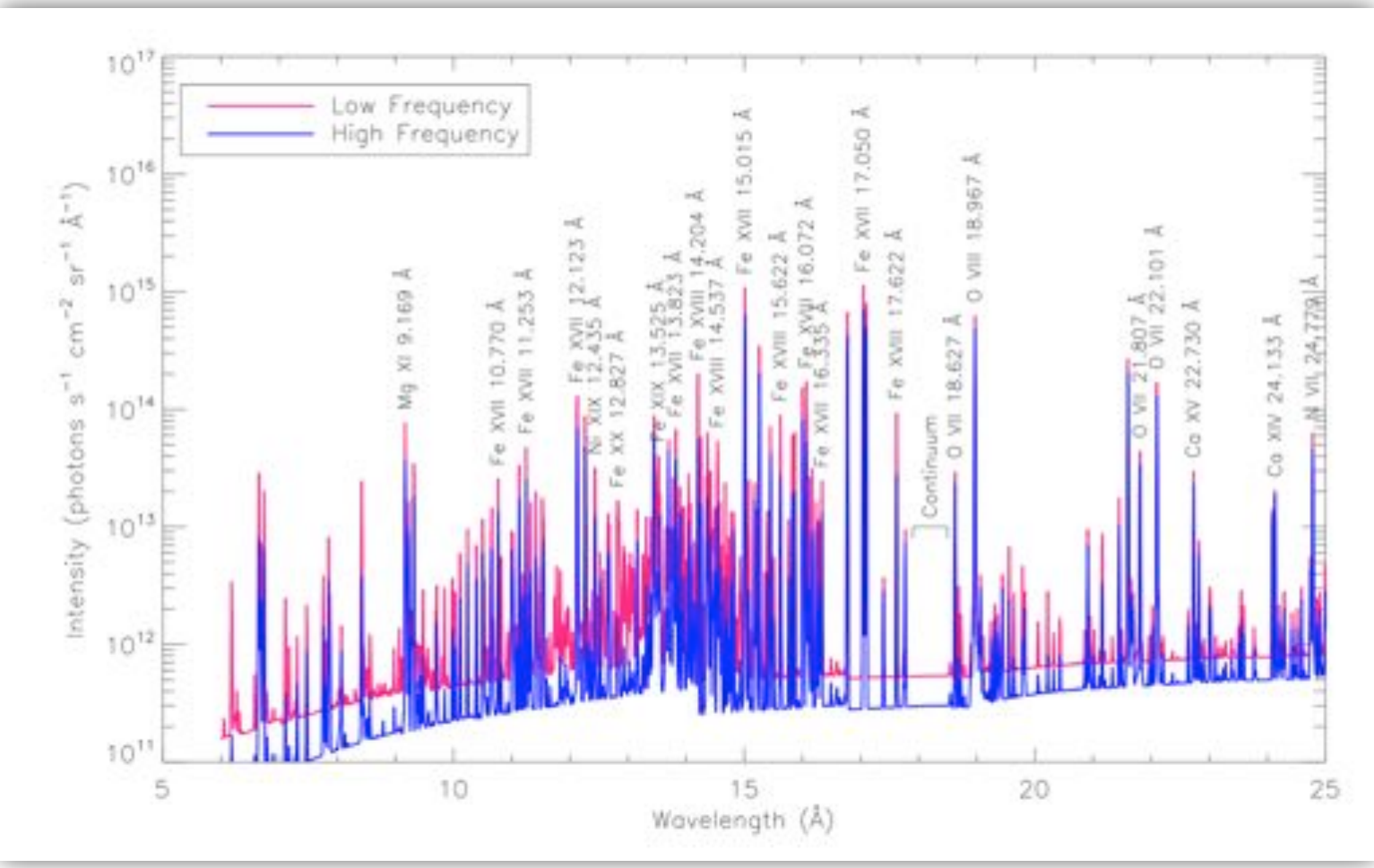
Simulated MaGIXS spectra

Biggest difference in Fe XX (12.845 Å).

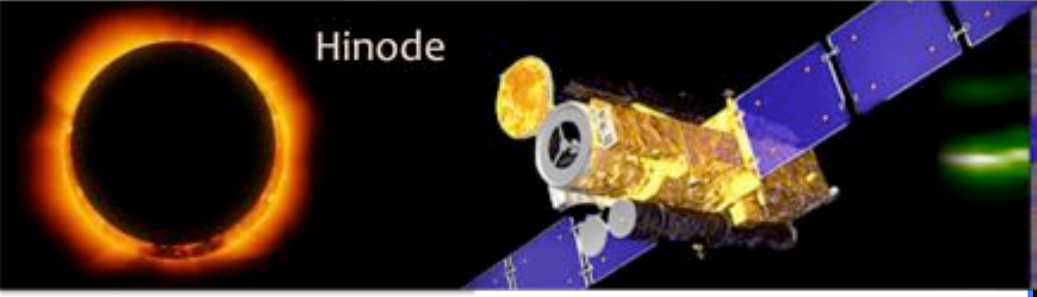
Multiple high temperature spectra lines necessary for interpretation.

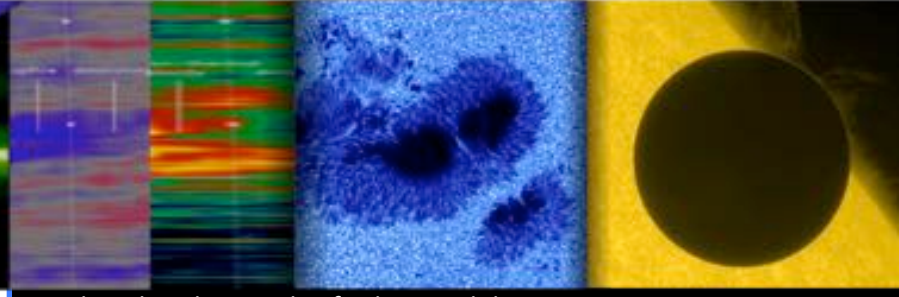


MaGIXS

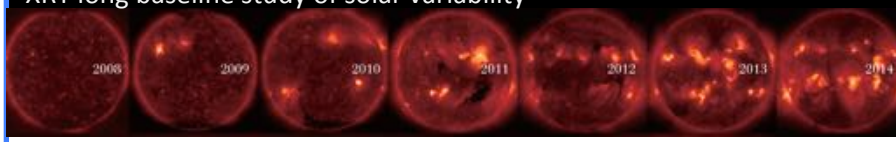


Simulated spectra from a single spatial position along the MaGIXS slit.





XRT long baseline study of solar variability



Hinode, Japanese for "Sunrise" and formerly Solar-B, is a solar satellite mission developed, launched, and operated by the Institute of Space and Astronautical Science (ISAS) -- a division of the Japanese Aerospace Exploration Agency (JAXA) -- in collaboration with space agency partners from the National Astronomical Observatory of Japan (NAOJ), the United Kingdom, ESA, the Norwegian Space Centre, and the United States.

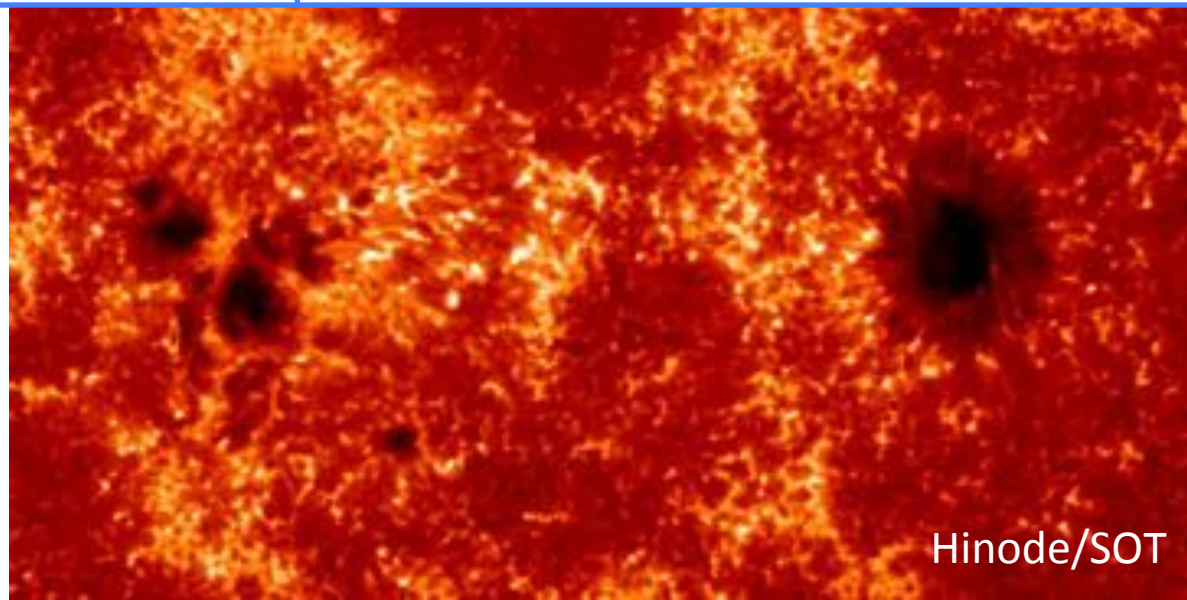
- Developed through Solar Terrestrial Probes Program
- US Program Office and Science Mgmt through NASA/MSFC
- Instrument US PI Institutions:
  - Lockheed Martin Solar and Astrophysics Laboratory (LMSAL)
  - Harvard-Smithsonian Center for Astrophysics (SAO/CFA)
  - Naval Research Laboratory (NRL)

Prioritized Science Goals

i. Study the sources and evolution of highly energetic dynamic events.
ii. Characterize cross-scale magnetic field topology and stability.
iii. Trace mass and energy flow from the photosphere to the corona.
iv. Continue long term synoptic support to quantify cycle variability.

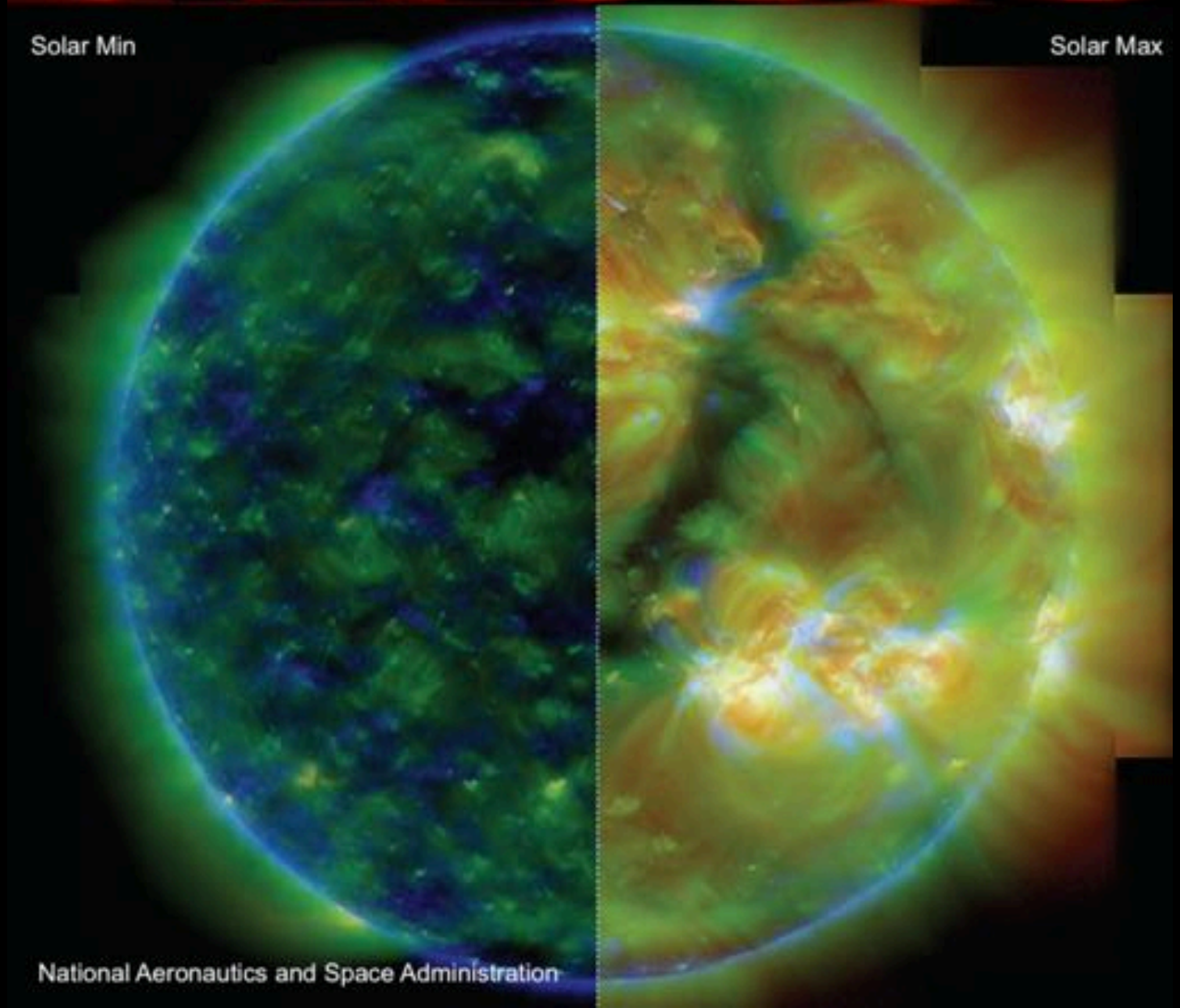
Instrumentation

1. SOT – Solar Optical Telescope (surface/ magnetic fields)
   - Spectro-polarimeter (SP) & Filtergram (FG – no longer in use as of March 2016)
2. EIS – Extreme ultraviolet Imaging Spectrometer (atmosphere/spectra – plasma diagnostics)
3. XRT – (Soft) X-Ray Telescope (coronal activity – long baseline synoptics)



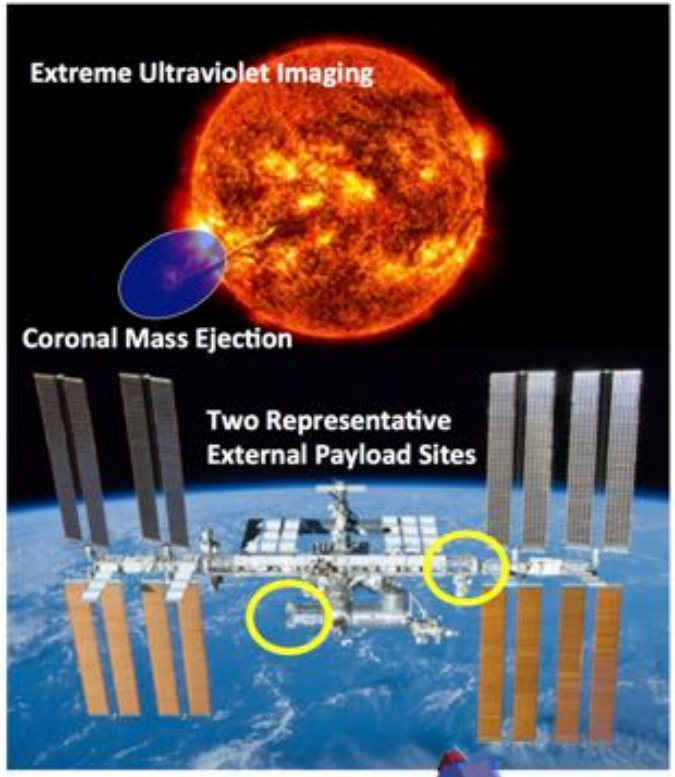
Hinode/XRT

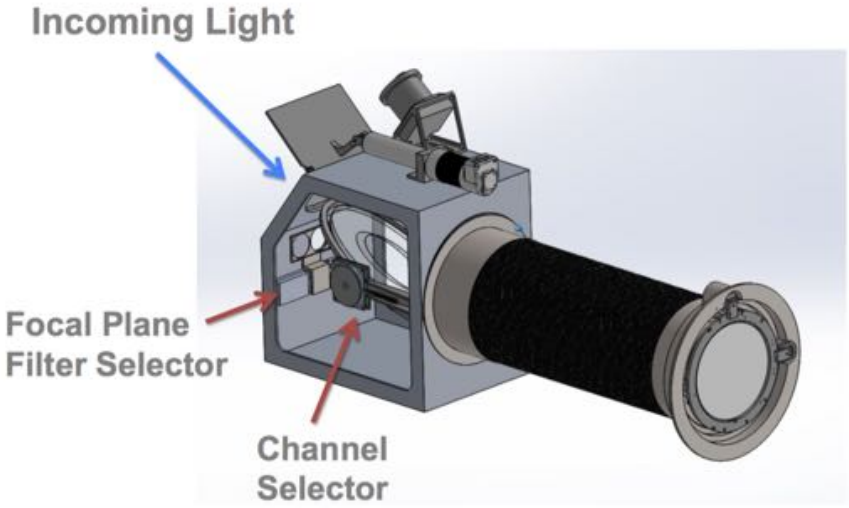
Hinode/EIS



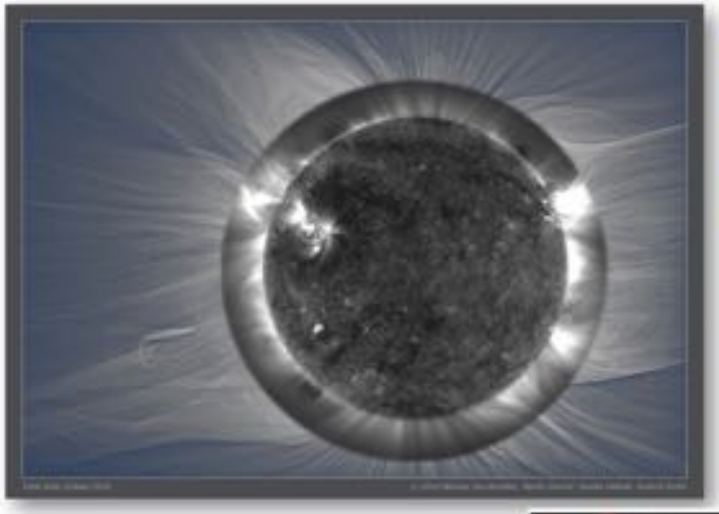
Coronal Spectrographic Imager in the EUV (COSIE)

Mission of Opportunity instrument being proposed for placement on the International Space Station to enhance our understanding of the dynamics of the Transition Corona and to provide improved detection and tracking of solar eruptive events for space weather research.





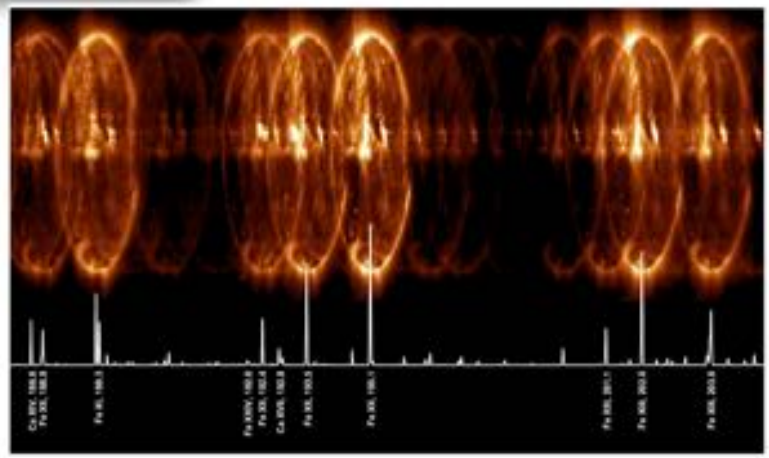
COSIE

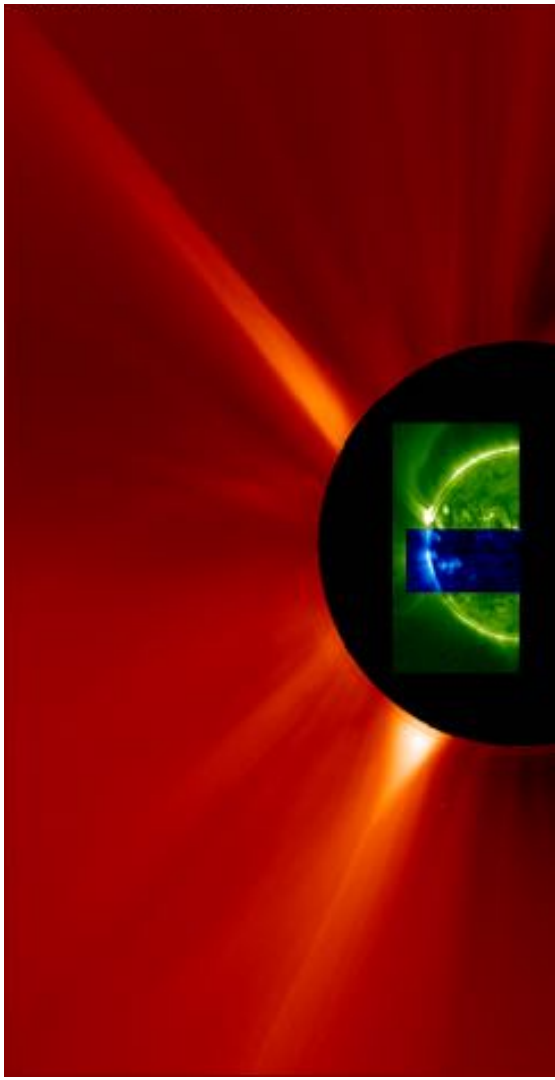


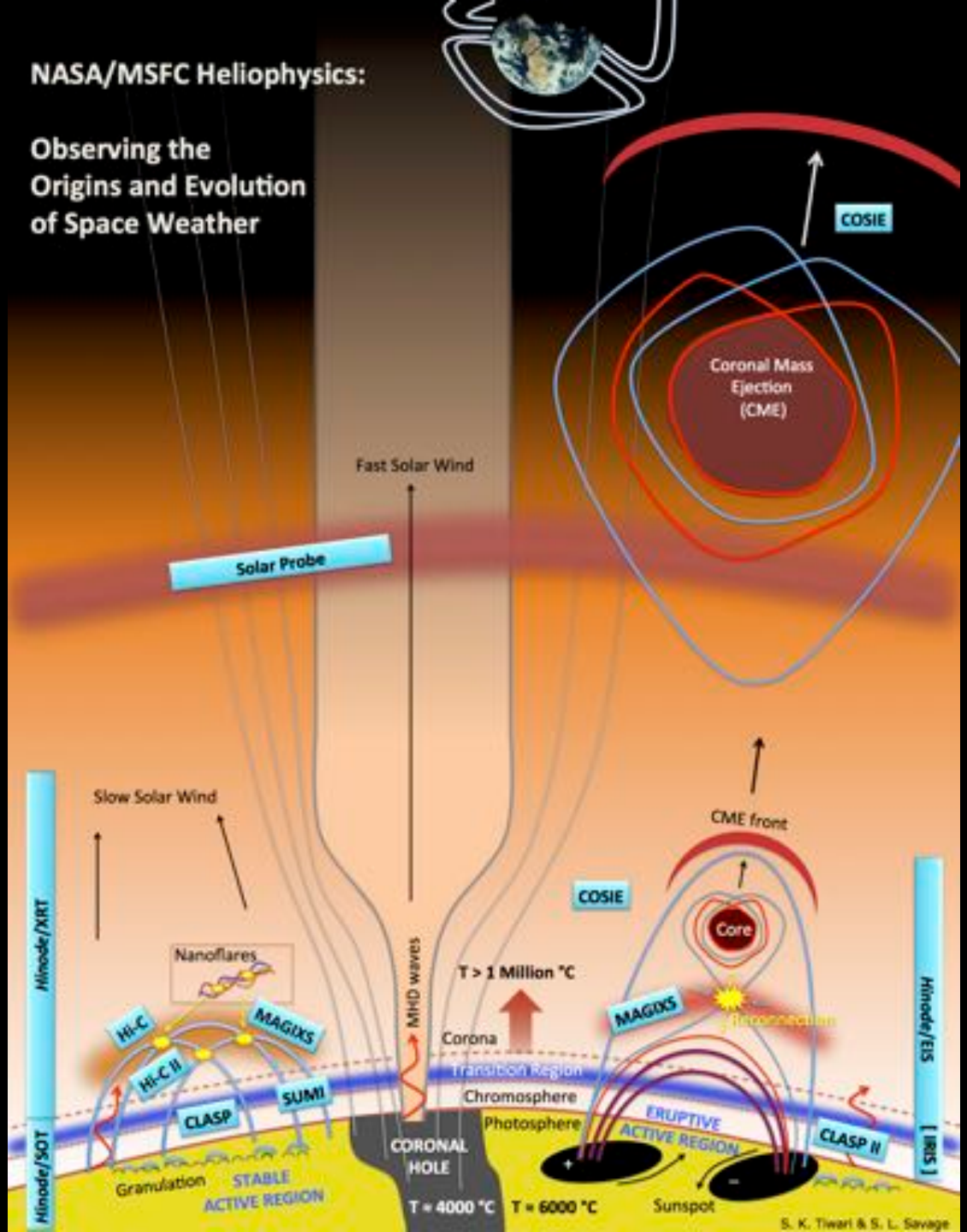
Spaceweather events and coronal magnetic connectivity are tracked through the corona:

EUV coronagraphs allow for visibility of both the source region *and* the propagating disturbance.

Spectral images provide plasma diagnostics (temperature, density and LOS velocity for fast flows ~100km/s).






NASA/MSFC Heliophysics:
Observing the Origins and Evolution of Space Weather
COSIE
Coronal Mass Ejection (CME)
Fast Solar Wind
Solar Probe
Slow Solar Wind
CME front
COSIE
Core
Hinode/XRT
Nanoflares
MHD waves
T > 1 Million °C
Hi-C
Hi-C II
MAGIXS
MAGIXS
Reconnection
Corona
Transition Region
Chromosphere
Photosphere
SUMI
CLASP
ERUPTIVE ACTIVE REGION
CLASP II
Hinode/EIS
IRIS
Hinode/SOT
Granulation
STABLE ACTIVE REGION
CORONAL HOLE
T = 4000 °C
T = 6000 °C
Sunspot
S. K. Tiwari & S. L. Savage

Sounding Rockets: Excellent Platform for Tech Dev*

*Plus they're really cool.