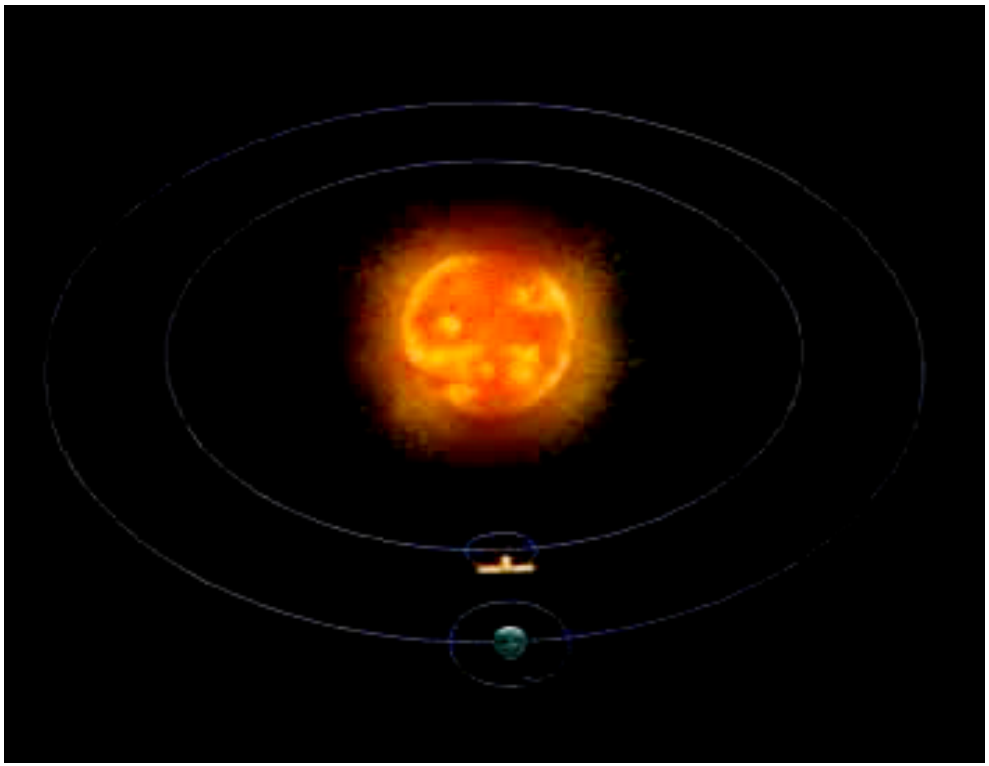
Aditya L1: India's first dedicated solar space mission



Dipankar Banerjee
(On Behalf of the SWG and Aditya team)
Indian Institute of Astrophysics
dipu@iiap.res.in

Plan

- Introduce the seven payloads
- Science Objectives X
- Importance of coordinated observations from ground and space (METIS, PROAB3)
- Identifying complementarity
- Time line, Launch 2020-21
- Data policy -- Open

The complete list of payloads: (ISRO website)

Visible Emission Line Coronagraph (VELC): To study the diagnostic parameters of solar corona and dynamics and origin of Coronal Mass Ejections (**3 visible and 1 Infra-Red channels**); magnetic field measurement of solar corona down to tens of Gauss – Indian Institute of Astrophysics (IIA)

Solar Ultraviolet Imaging Telescope (SUIT): To image the spatially resolved Solar Photosphere and Chromosphere in near Ultraviolet (200-400 nm) and measure solar irradiance variations - Inter-University Centre for Astronomy & Astrophysics (IUCAA)

Aditya Solar wind Particle Experiment (ASPEX) : (20 keV/n to 20 MeV/n) To study the variation of solar wind properties as well as its distribution and spectral characteristics – Physical Research Laboratory (PRL)

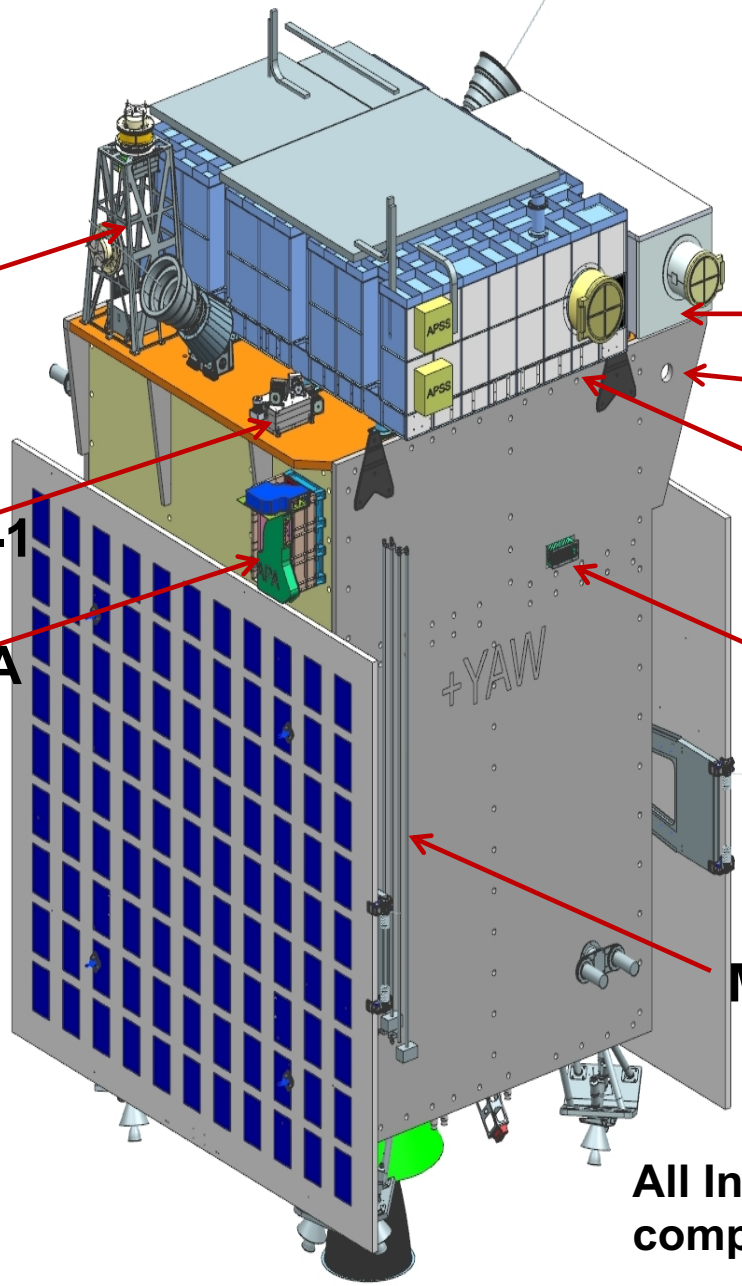
Plasma Analyser Package for Aditya (PAPA) : (10 eV to 3 keV) To understand the composition of solar wind and its energy distribution – Space Physics Laboratory

Solar Low Energy X-ray Spectrometer (SoLEXS) : (1 -- 30 keV) To monitor the X-ray flares for studying the heating mechanism of the solar corona – ISRO Satellite Centre

High Energy L1 Orbiting X-ray Spectrometer (HEL1OS): (10 -150 keV) To observe the dynamic events in the solar corona and provide an estimate of the energy used to accelerate the particles during the eruptive events - ISRO Satellite Centre (ISAC) and Udaipur Solar Observatory (USO), PRL

Magnetometer: To measure the magnitude and nature of the Interplanetary Magnetic Field – Laboratory for Electro-optic Systems (LEOS) and ISAC.

Payload STOWED VIEW OF ADITYA-L1



SWISS

Aditya Solar Particle Experiment (ASPEX) - PRL

STEPS-1

PAPA

Particle Analyzer Package for Aditya
•Solar Wind and Ion Spectrometer (SWIS)
•Solar Wind Ion Composition Analyser (SWICAR)

Solar Ultra-violet Imaging Telescope - IUCAA

SUIT

SoLEXS

Solar Low-Energy X-ray Spectrometer - ISAC

VELC

Visible Emission Line Coronagraph - IIA

HEL1OS

High Energy L1 Orbiting X-ray Spectrometer - ISAC

MAGNETOMETER

+ R

- P

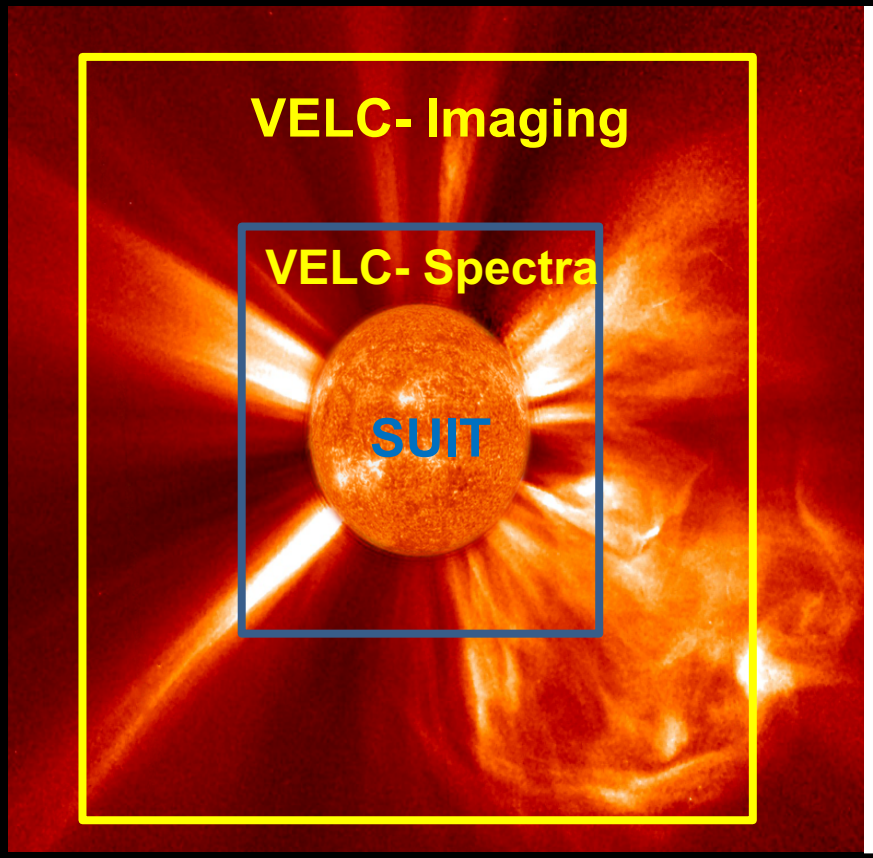
+ Y

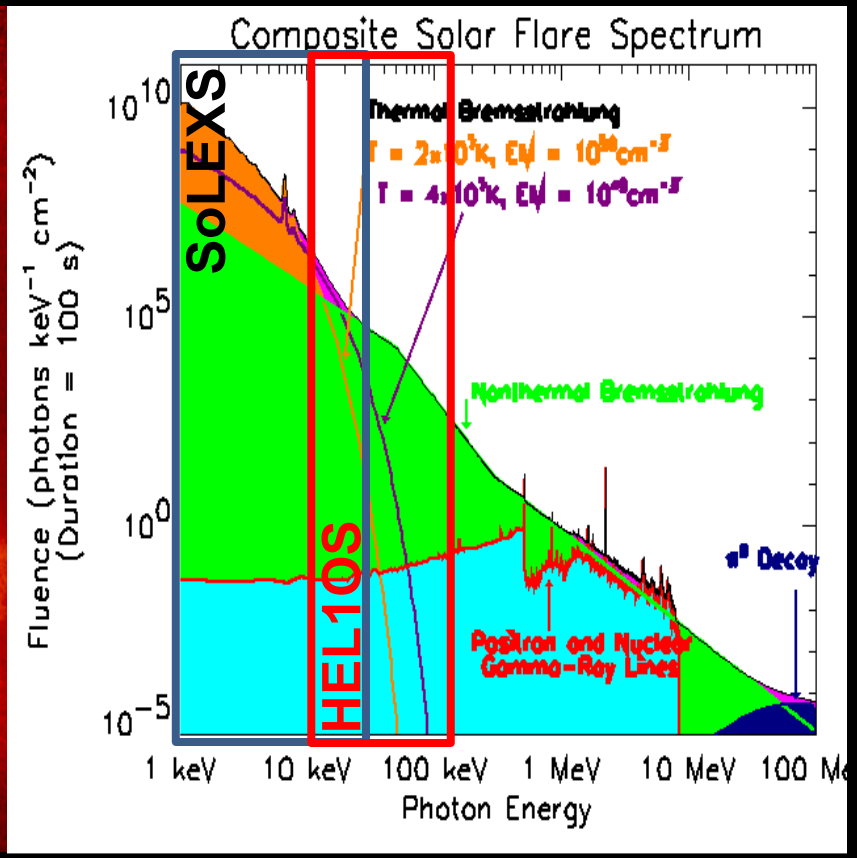
All Instruments are close to completion of EM development

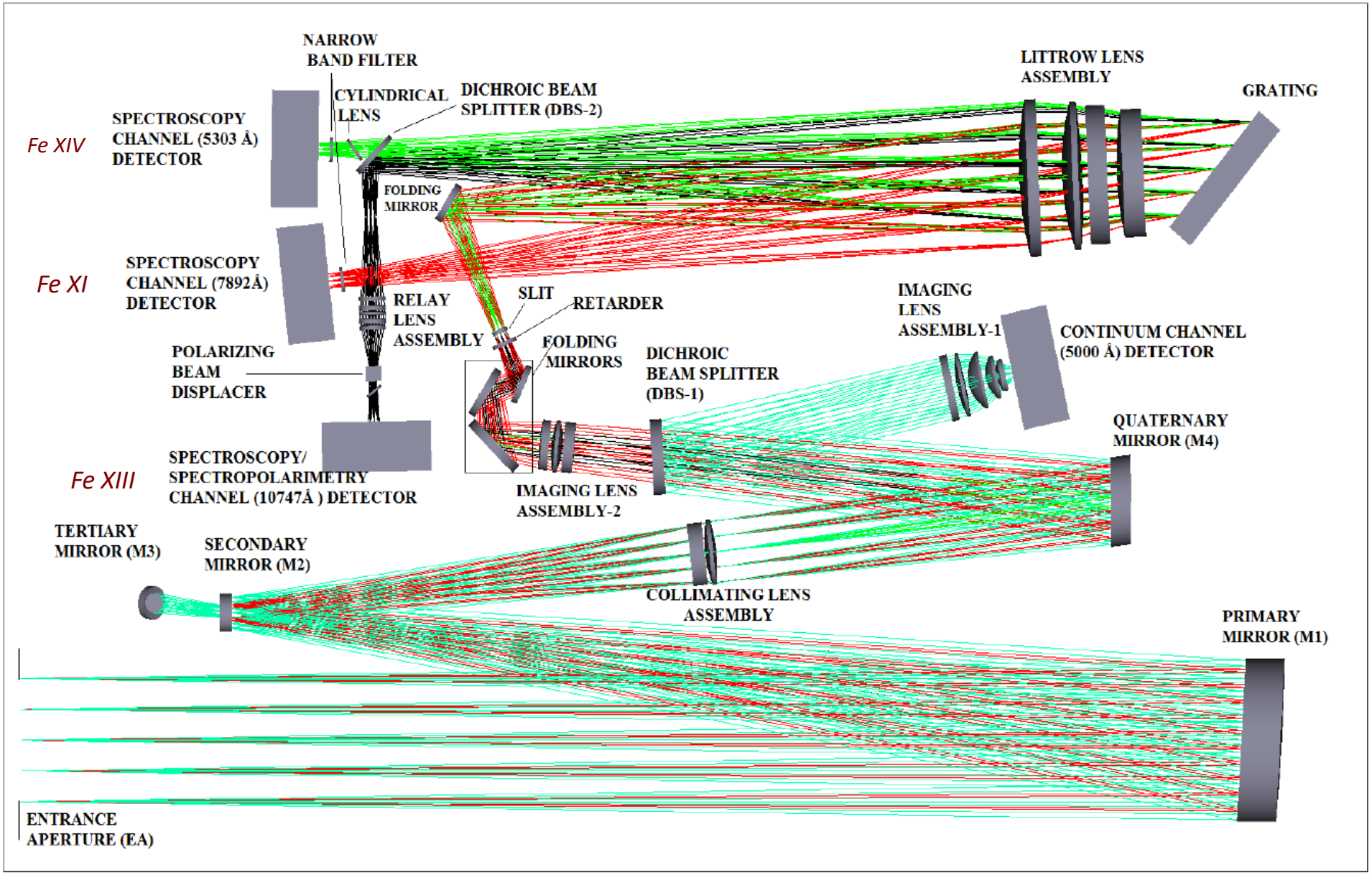
PAYLOADS: Remote Sensing (4) & In-situ (3) Instruments

* Visible Emission Line Coronagraph (VELC)
* Solar Ultra-violet Imaging Telescope (SUIT)
* Solar Low Energy X-ray spectrometer (SoLEXS)
* Hard X-ray L1 Orbiting Spectrometer (HEL1OS)

FOVs of Aditya-L1

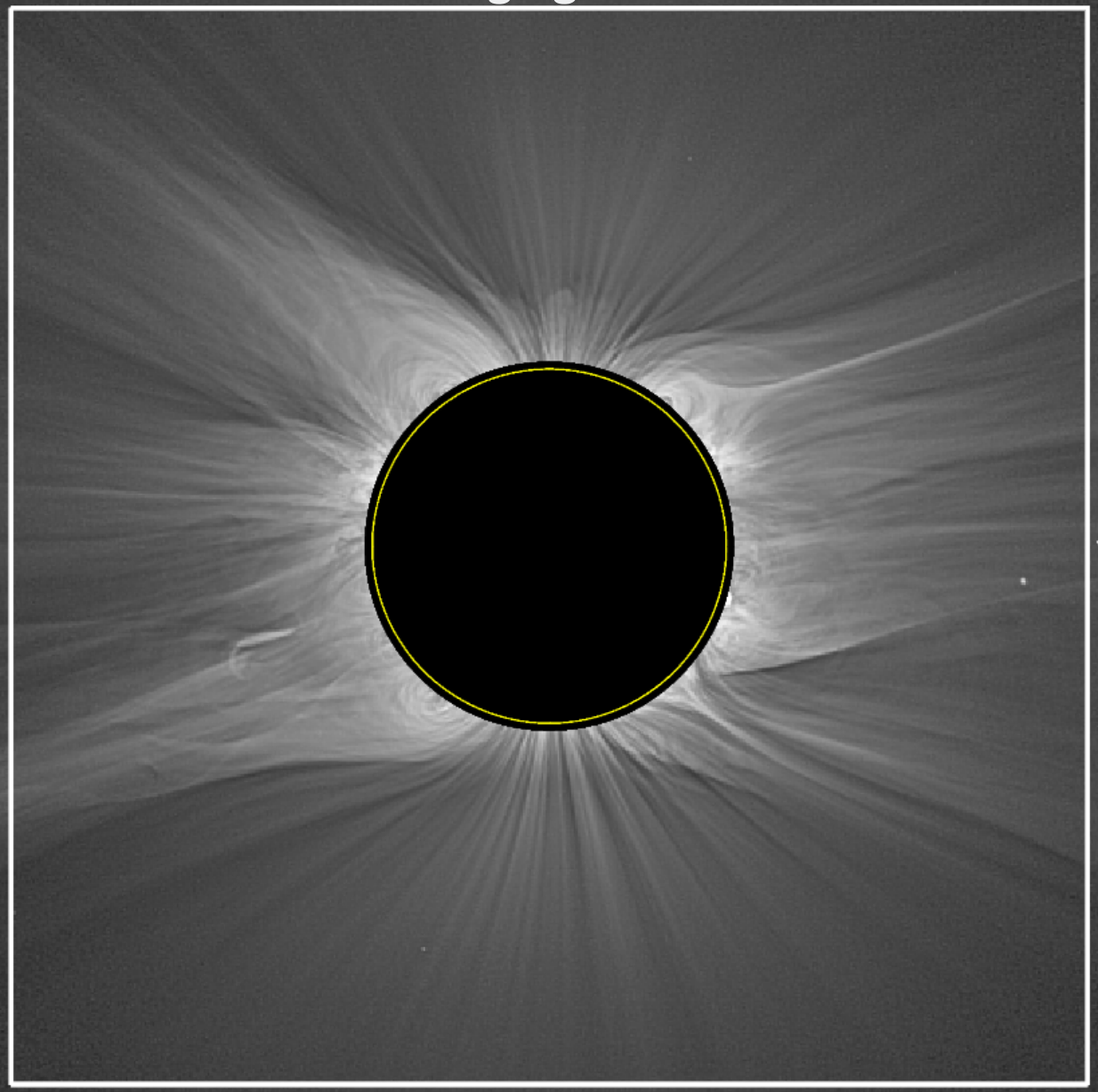




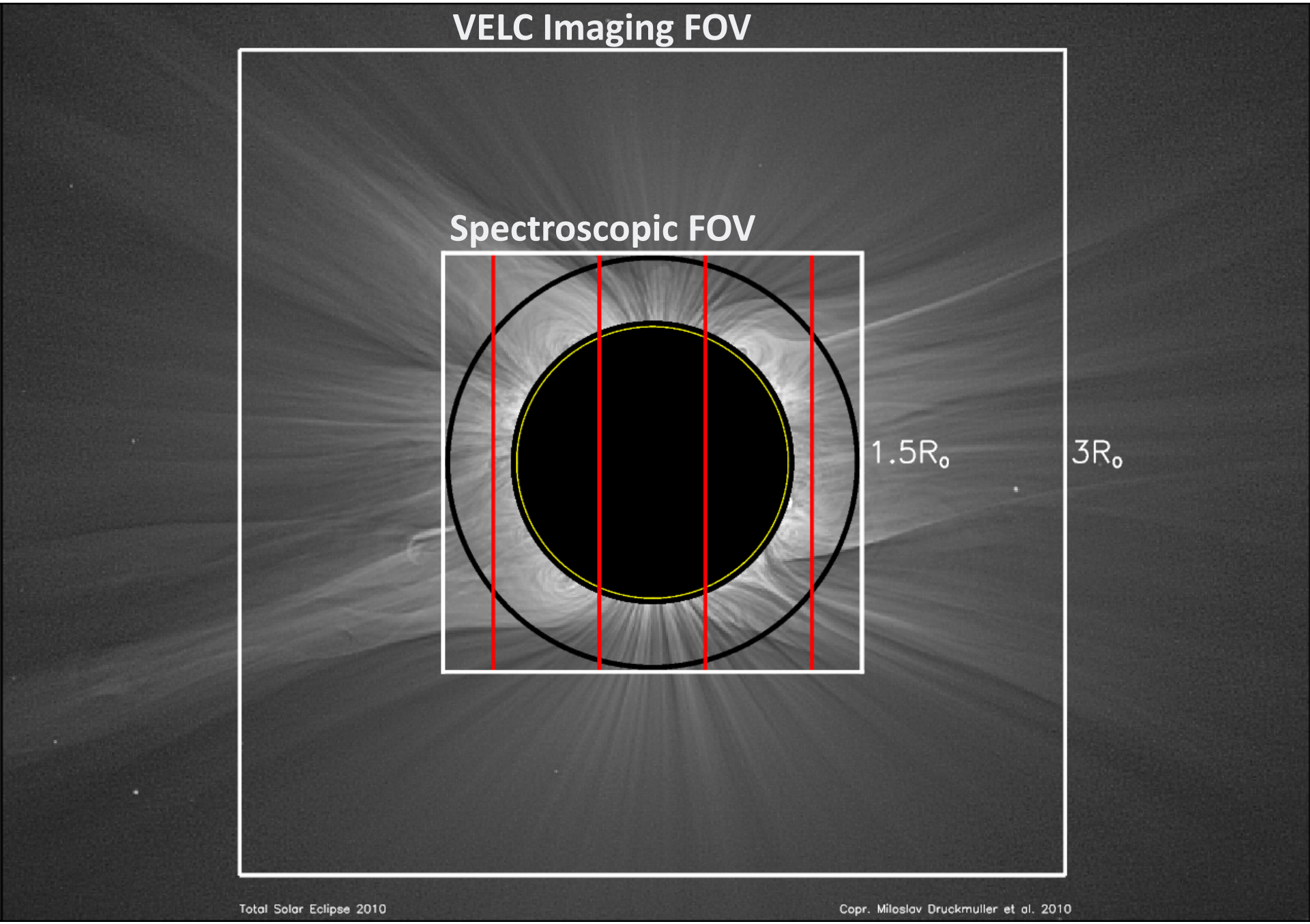


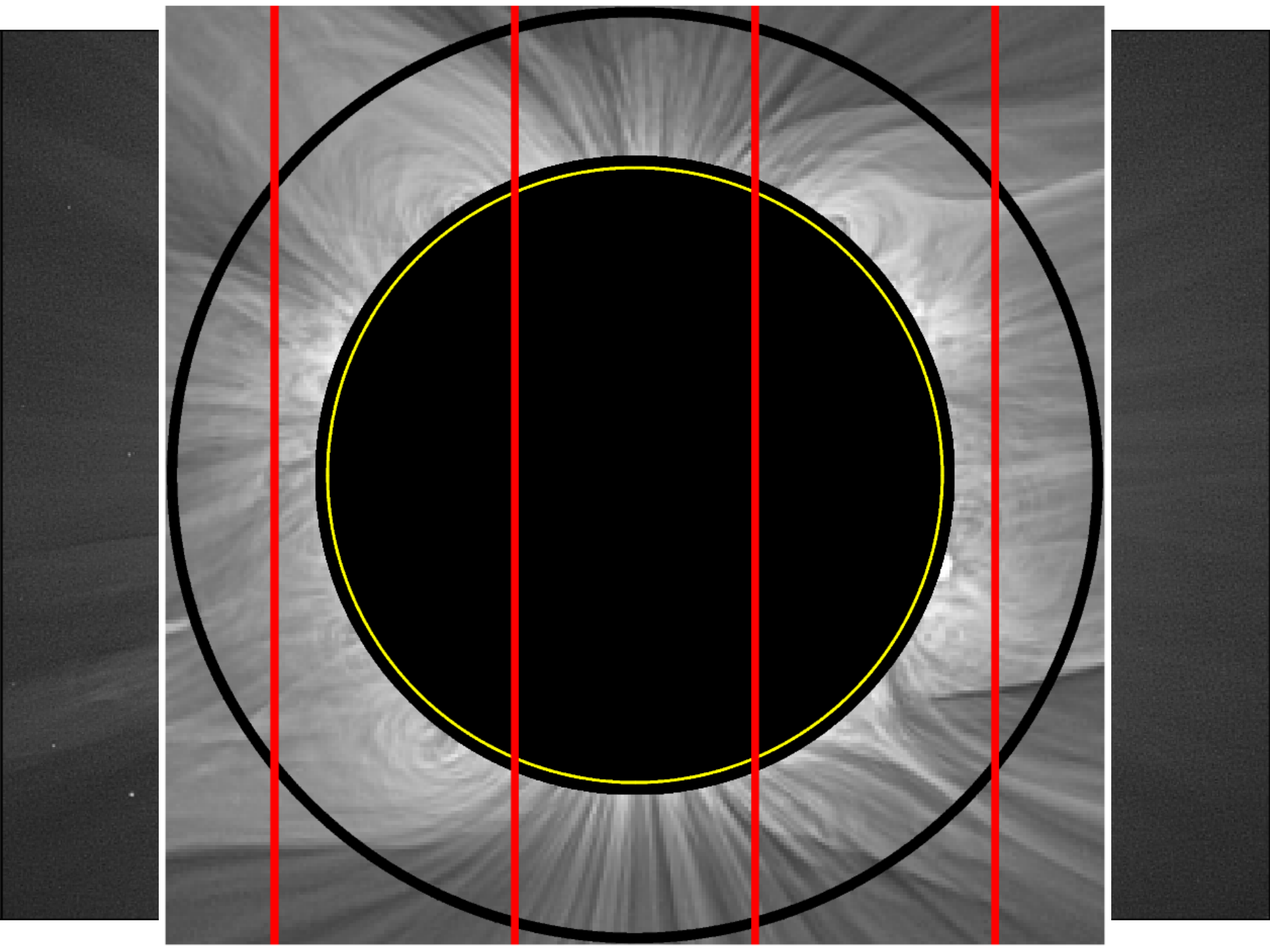
Optical Layout of VELC

VELC Imaging FOV



Total Solar Eclipse 2010

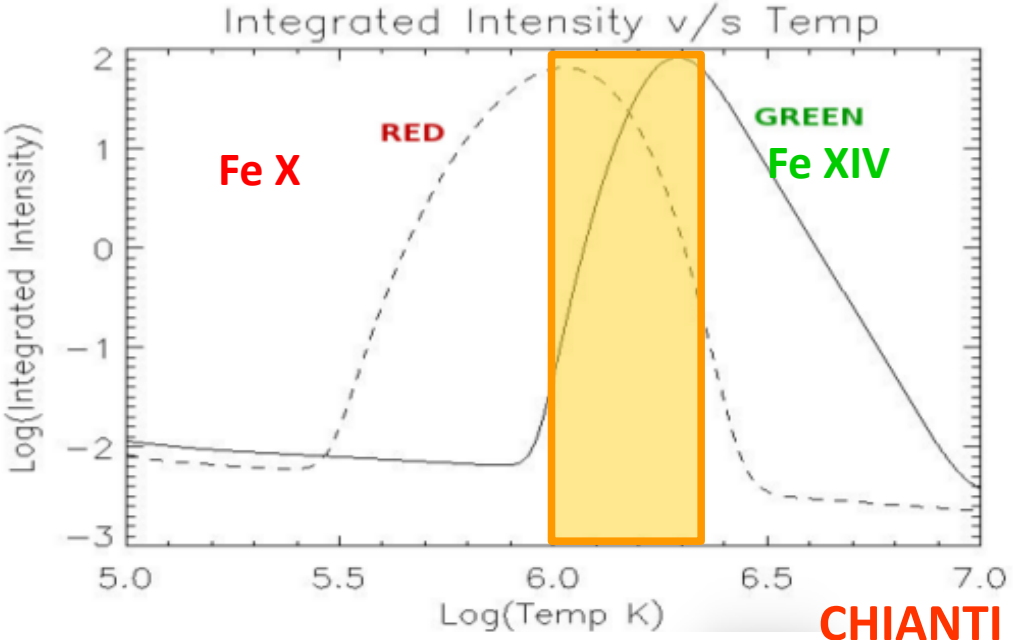

VELC Imaging FOV
Spectroscopic FOV
1.5R$_o$
3R$_o$
Total Solar Eclipse 2010
Copr. Miloslav Druckmuller et al. 2010

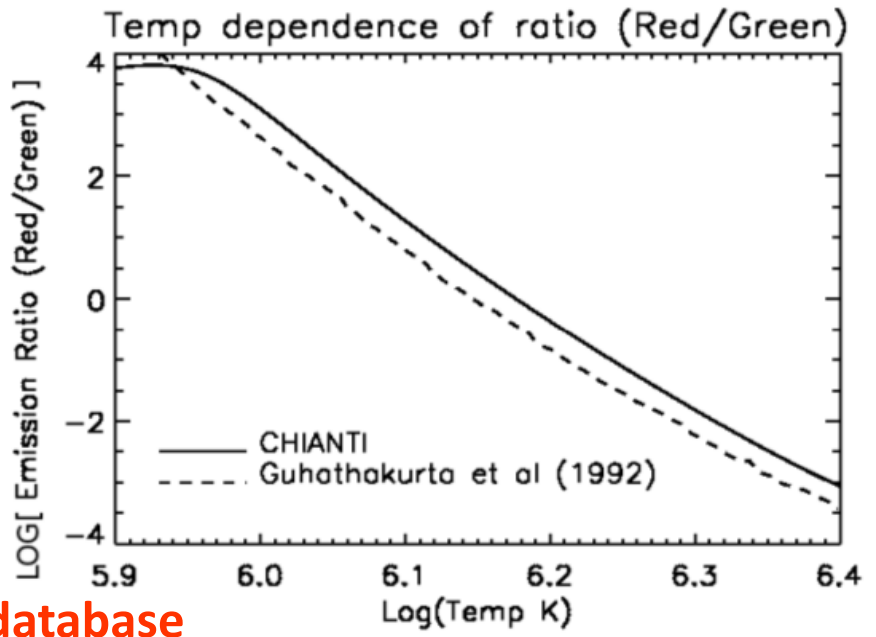


Instrument capabilities

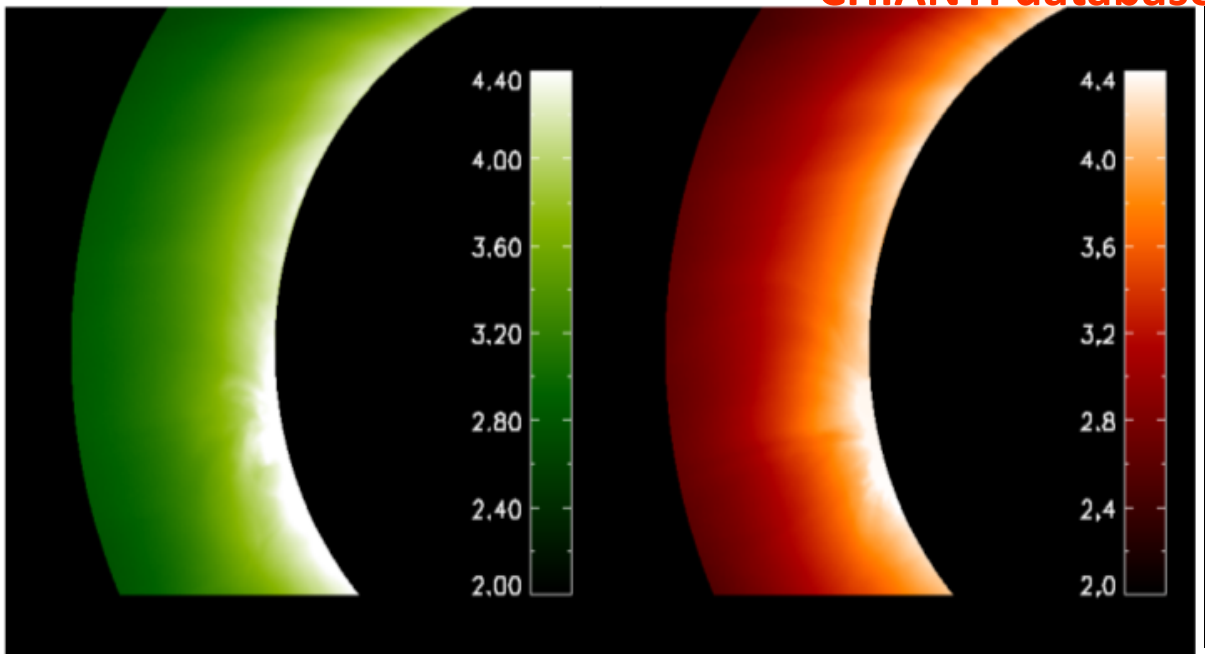
Instrument specifications	Visible	Infrared
Spectral lines (A)	5303 A and 7892 A	10747 A
Continuum (A)	5000 A & 10 A bandwidth	----
Detector size (pixels)	2160 x 2560 pixels	512 x 640
Field of view (R_{sun})	1.05 – 3.0 continuum; 1.05 – 1.5 emission lines	1.05 – 1.5
Spatial resolution	1.25 arcsec / pixel in emission; twice in cont.	4.0 arcsec / pixel
Spectral resolution	0.065 and 0.095 A	0.200 A
Velocity resolution	3.6 km/s; 1 pixel	5 km/s; 1 pixel
Exposure times	0.1 – 5 sec	1-5 sec for spectroscopy Multiples of 10 sec for polarimetry
Observing cadence	1 – 60 sec or slower	1- 60 sec or slower
Polarimetric accuracy		Better than 10^{-4}
Observables	Emission line profiles Images in continuum	Emission line profiles

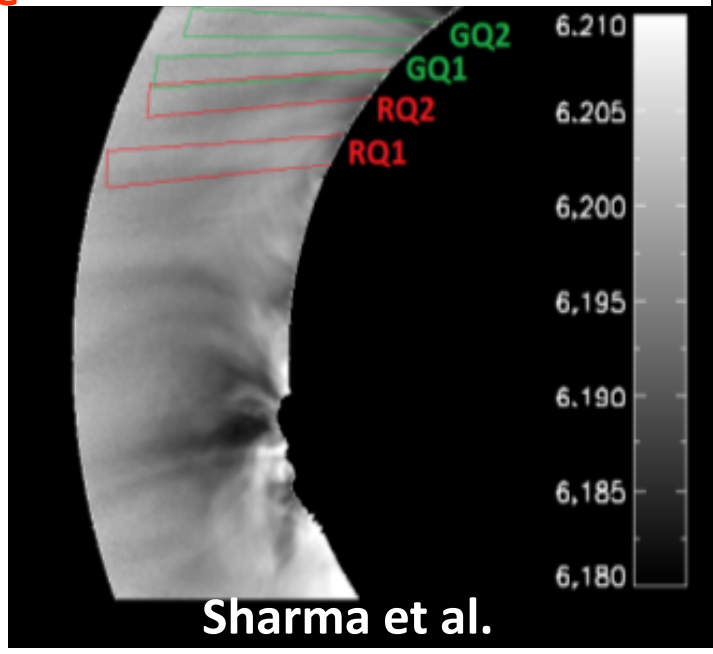
Temperature





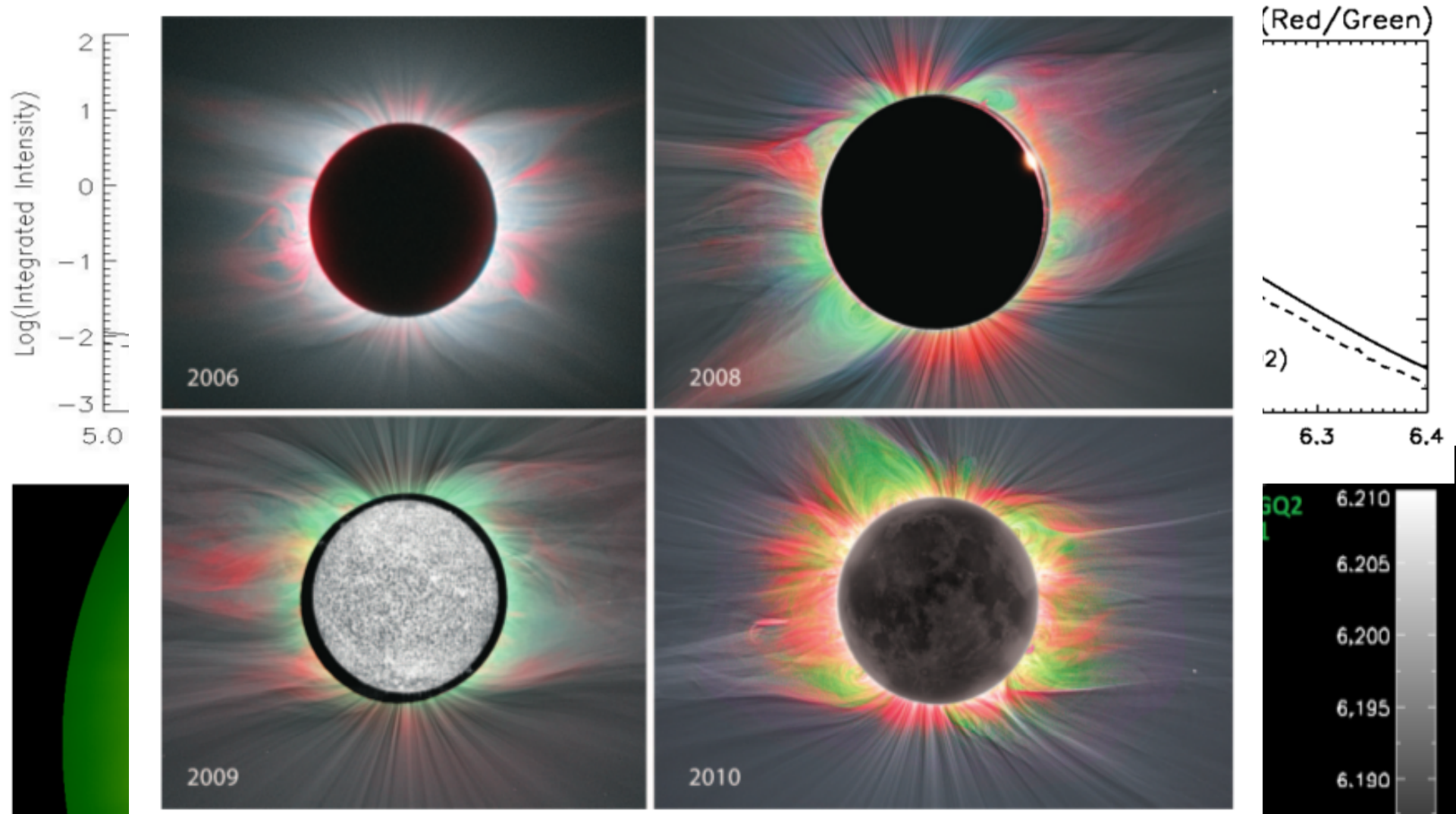
CHIANTI database





Sharma et al.

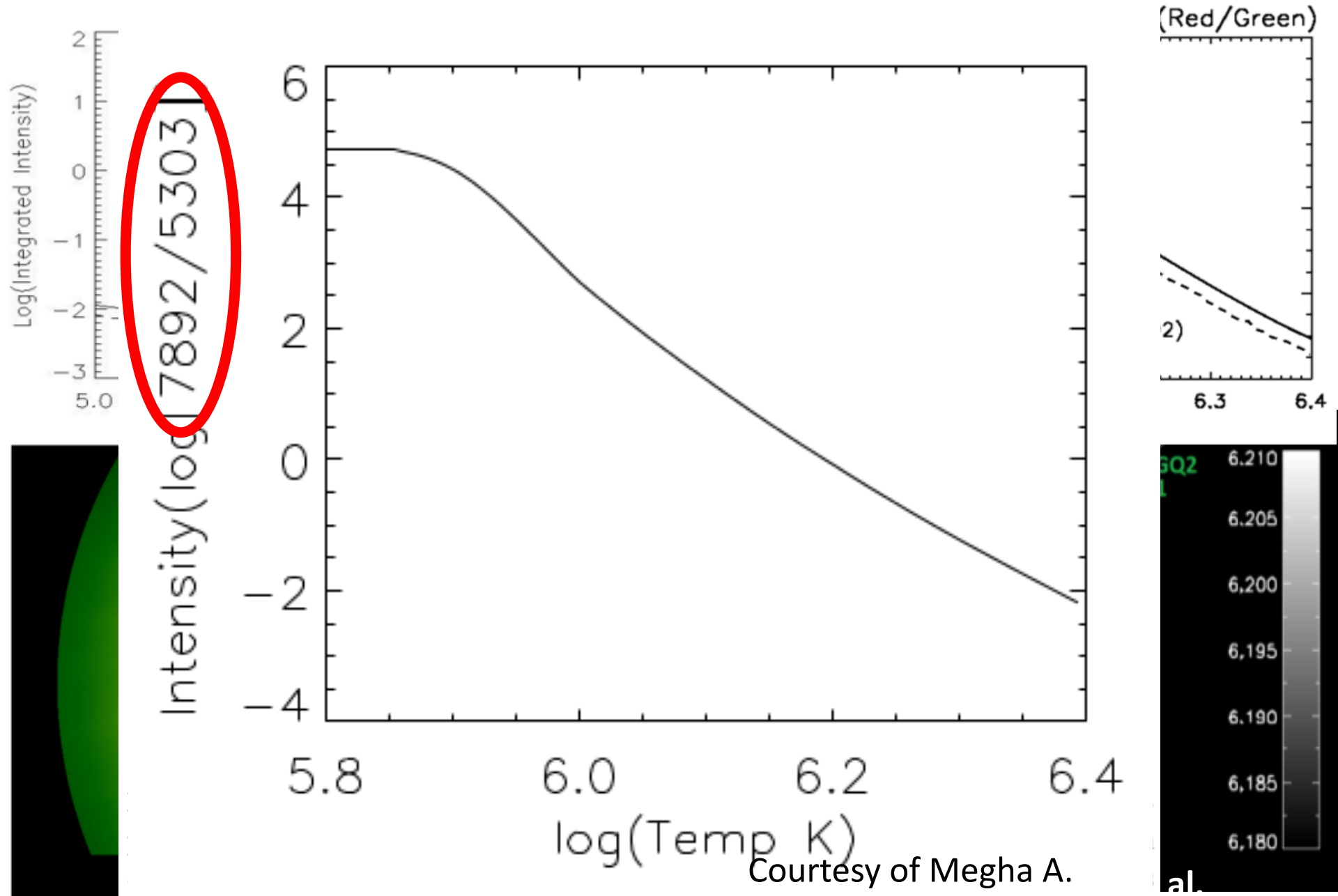
Temperature



Habbal et al. 2011

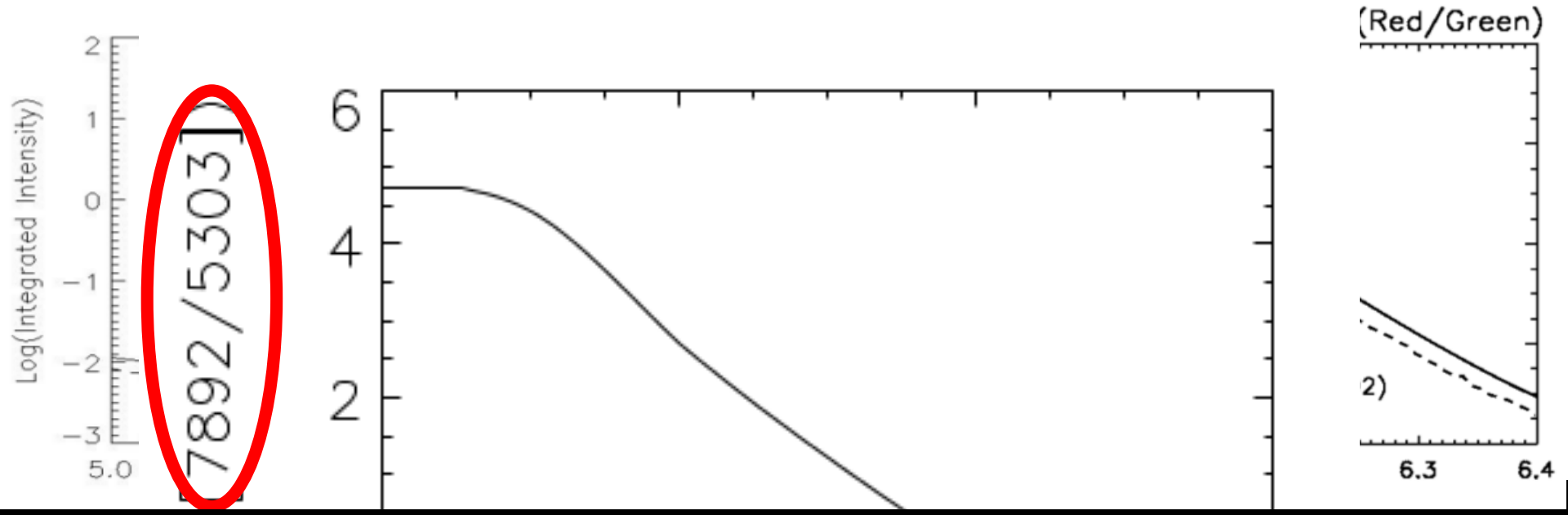
Figure 2. Overlay of white light, Fe XI 789.2 nm (red) and Fe XIV 530.3 nm (green) ACHF-processed images, from the 2008, 2009 and 2010 eclipses eclipse observations. He II 30.4 nm SOHO/EIT disk emission is shown for 2009 only. In 2006, only Fe XI with white light was

Temperature



Courtesy of Megha A.

Temperature

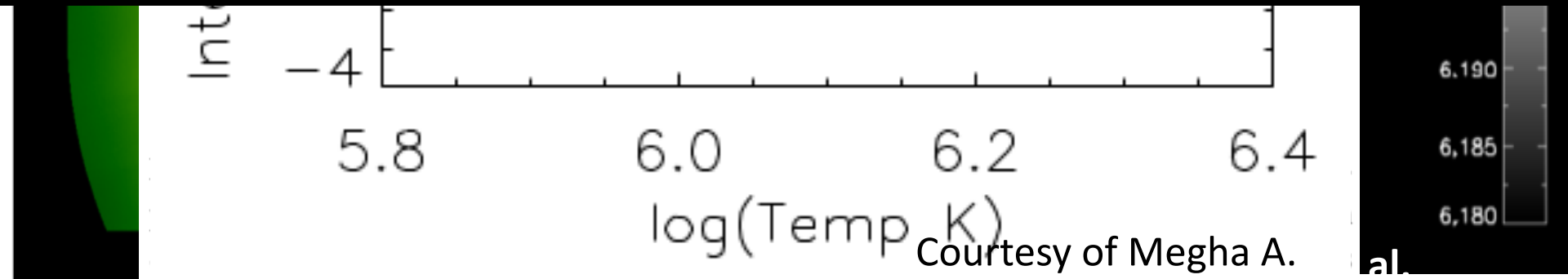


Unique data for monitoring temperature.

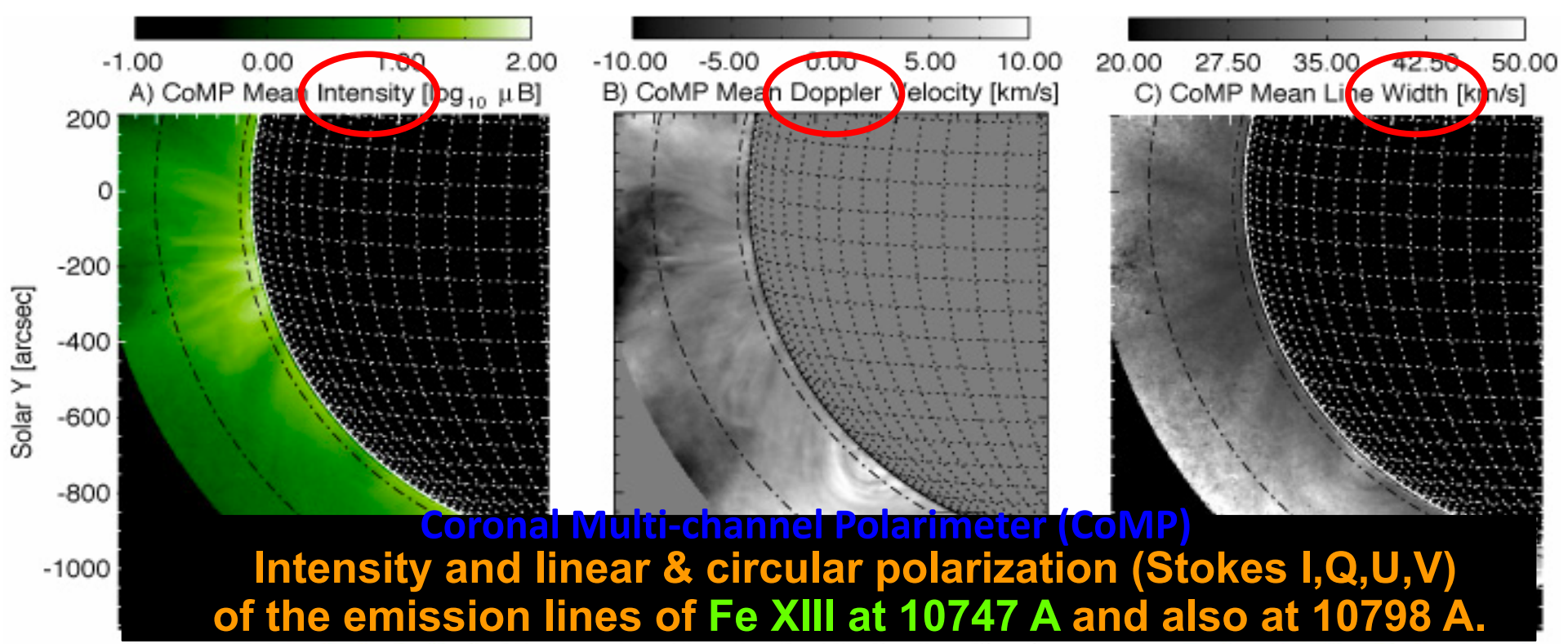
Temperature variations in corona:

different structures & different regions.

Very long to short time variations.

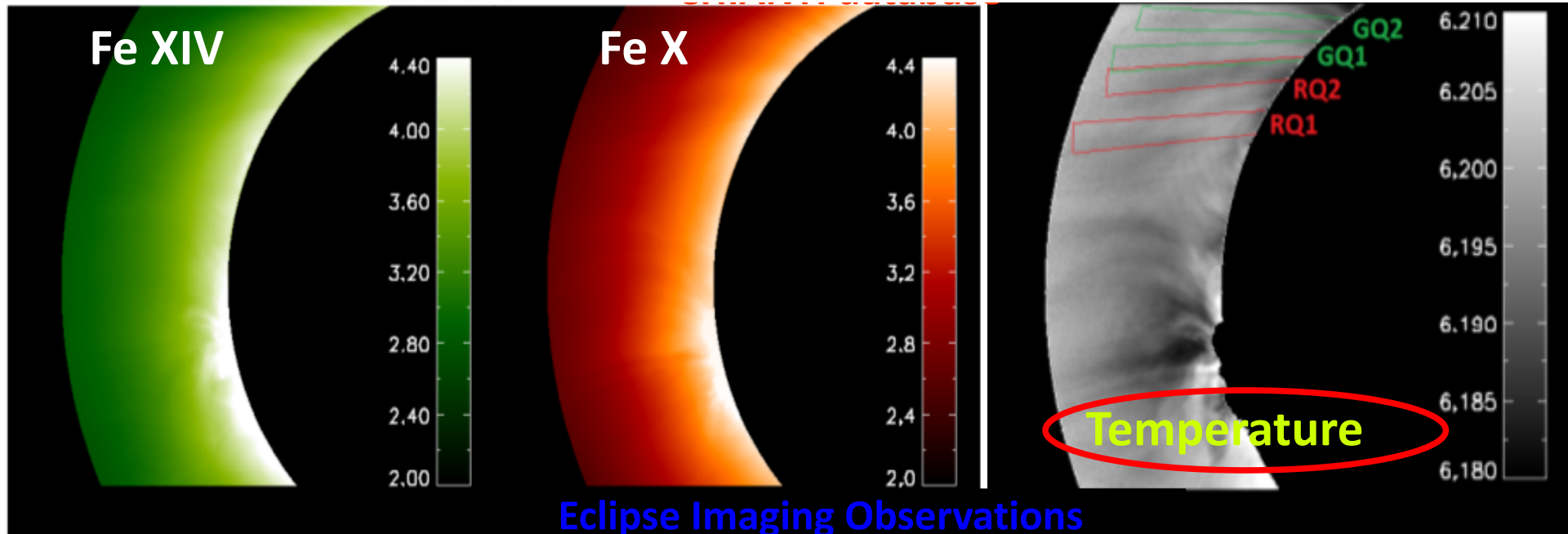


Courtesy of Megha A.

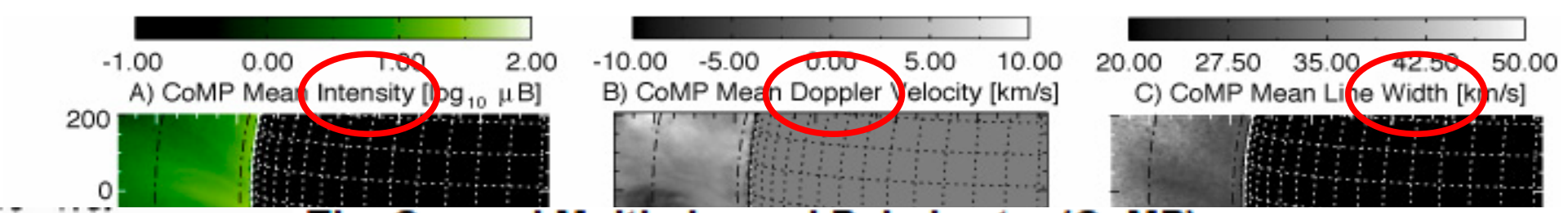


Coronal Multi-channel Polarimeter (CoMP)

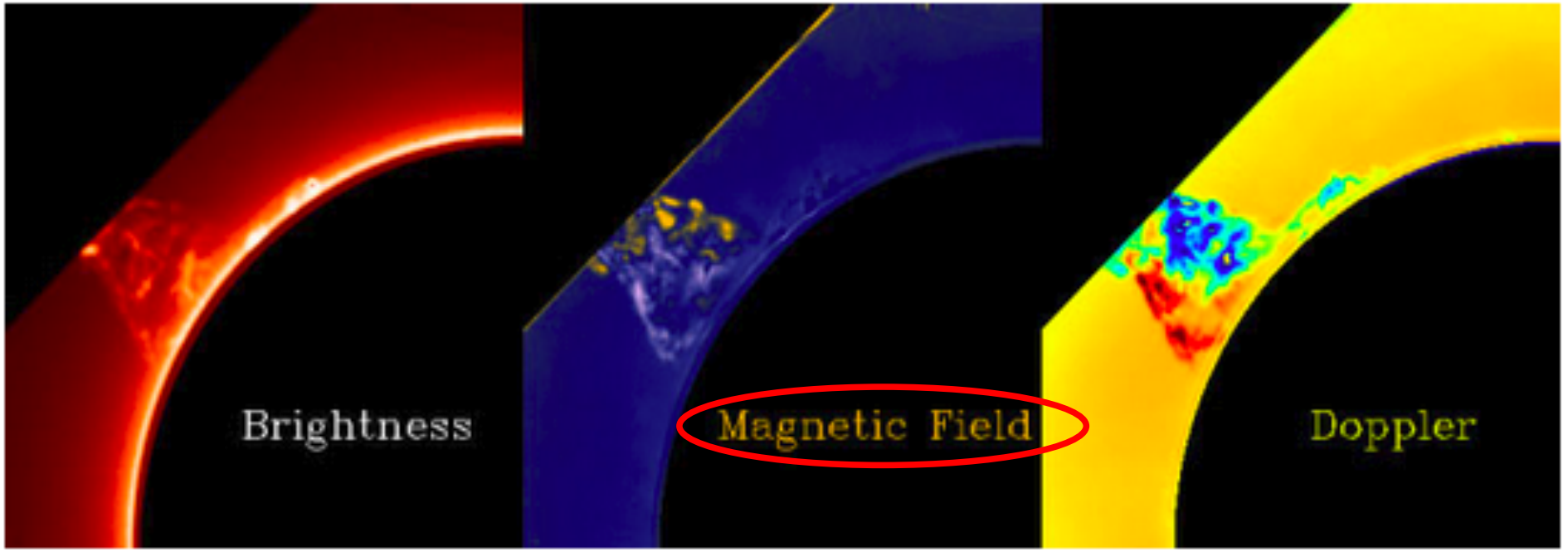
Intensity and linear & circular polarization (Stokes I,Q,U,V)
of the emission lines of Fe XIII at 10747 A and also at 10798 A.

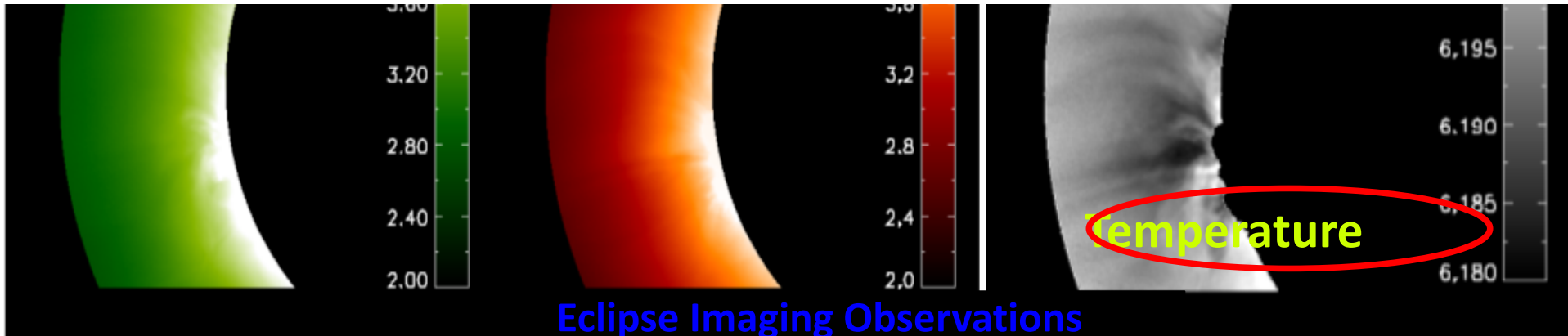


Eclipse Imaging Observations



The Coronal Multi-channel Polarimeter (CoMP)





Eclipse Imaging Observations

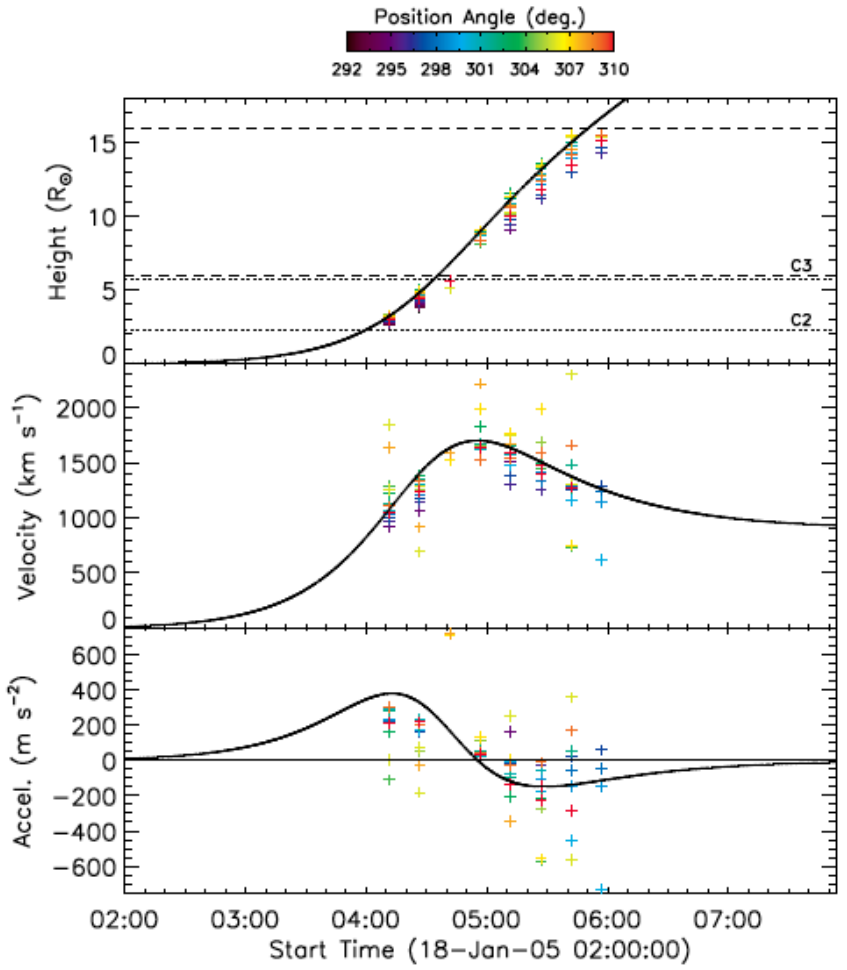
A sequence of CMEs above the western limb of the Sun in June 1996, observed by LASCO-C1 at a wave length of 5303 A. The time between two consecutive is roughly 45min. In the center of the images, the strength of the photospheric magnetic field is displayed in a color The photospheric magnetic field data from the Wilcox Solar Observatory.

CME: Initial Dynamics

3D study of acceleration of six CMEs using stereoscopic reconstruction on STEREO images (Joshi and Srivastava, 2011) shows that:

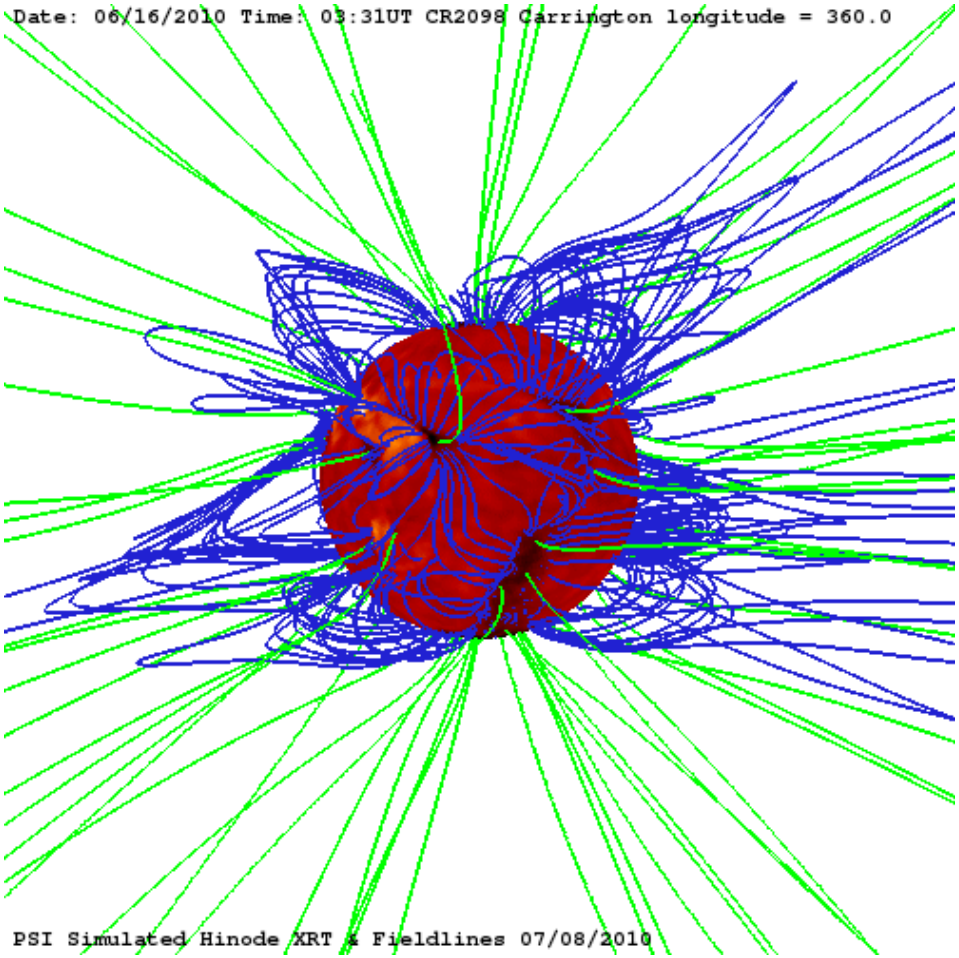
- Height of initial acceleration around $< 2\ R_{\odot}$, while earlier studies found this height to be 2-4 $R_{\odot}$ (Vrsnak 2001 ; Chen & Krall 2003).

Fast cadence observations from Aditya will help to confirm the above results and understand the role of initial acceleration in CMEs .



Global field

http://www.predsci.com/hmi/home.php



- What is the magnetic structure of the corona on large scales?
- How does the magnetic **fi**eld change on a global scale? **With different time scales.**

Coronal Structures

Eclipse Image (July 11, 2010) MHD Simulated Magnetic Conf

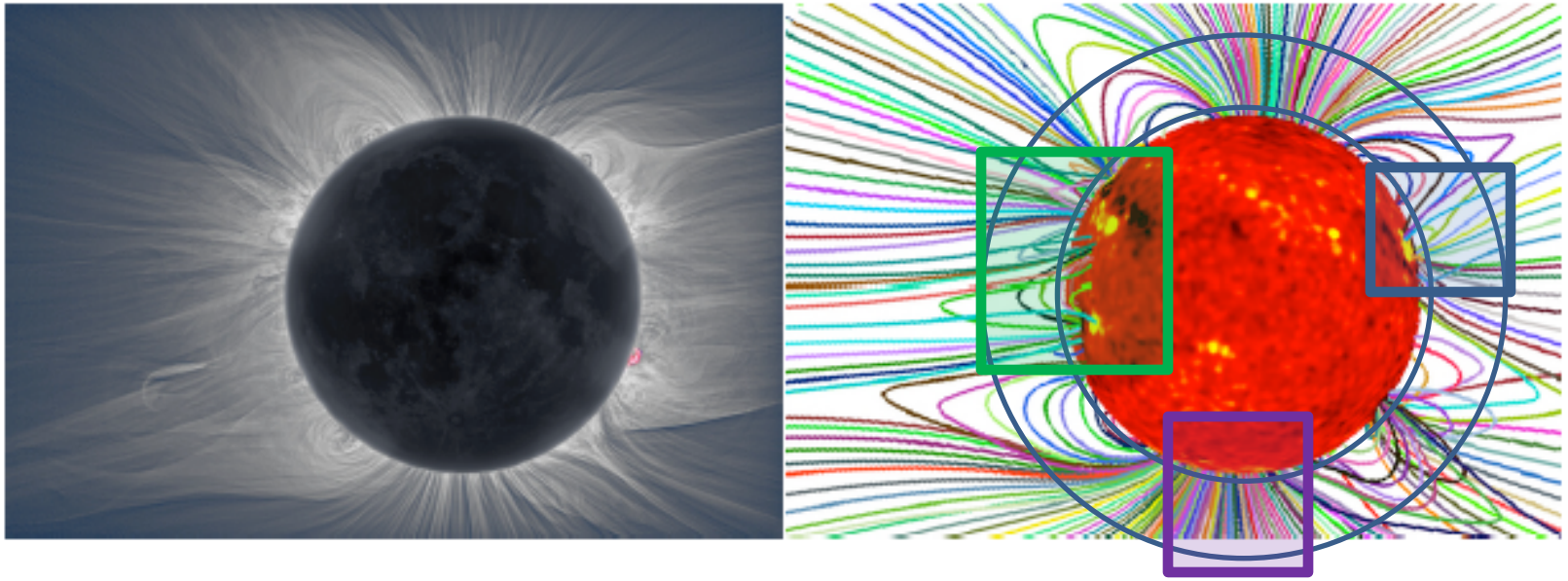


Image Courtesy: http: //www.zam.fme.vutbr.cz/~druck/eclipse

Model image: Linker
http://www.predsci.com/corona/jul10eclipse/july10eclipse.html

VELC

VELC Scientific objectives (Spectroscopy)

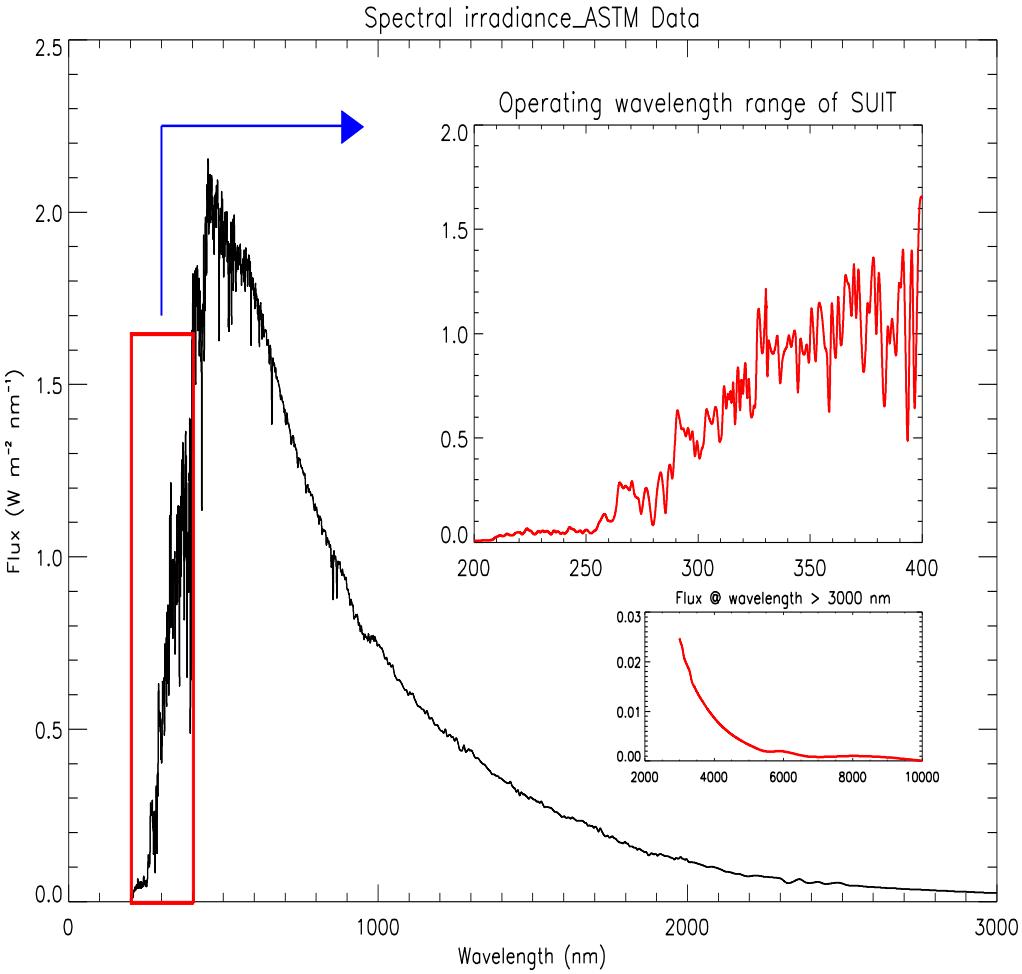
Diagnostics of the corona (Temperature, Velocity, & Density!).
Heating of the corona and solar wind acceleration.
Dynamics of the large scale transients (CMEs, Jets).

Uniqueness of the payload

High-cadence, high- spatial and spectral resolution
Simultaneous spectroscopic and imaging.
Observations very close to solar limb (1.05 R).
Magnetic field measurements.

SUIT instrument concept

- **Combined full disk medium- and narrow-band filter imager between 200nm and 400nm – covering different heights**
- low straylight, high constrast imager is important, but neglected near UV portion of solar spectrum - Prominences
- FOV ~ 1.2 R to overlap the FOV of VELC – CME initiation studies
- Important for the lower solar atmosphere: source regions
- Irradiance science: Sun-EARTH



SUIT Filters

S. No.	Centre (nm)	Bandpass (nm)	Description
1	214	1	Photosphere
2	274.7	0.4	Wing of Mg II k
3	279.6	0.4	Mg II k
4	280.3	0.4	Mg II h
5	283.2	0.4	Wing of Mg II h
6	300	1	Sunspots
7	388	1	Low
8	397.8	0.1	
9	200-242	42	
10	242-300	58	
11	320-360	40	

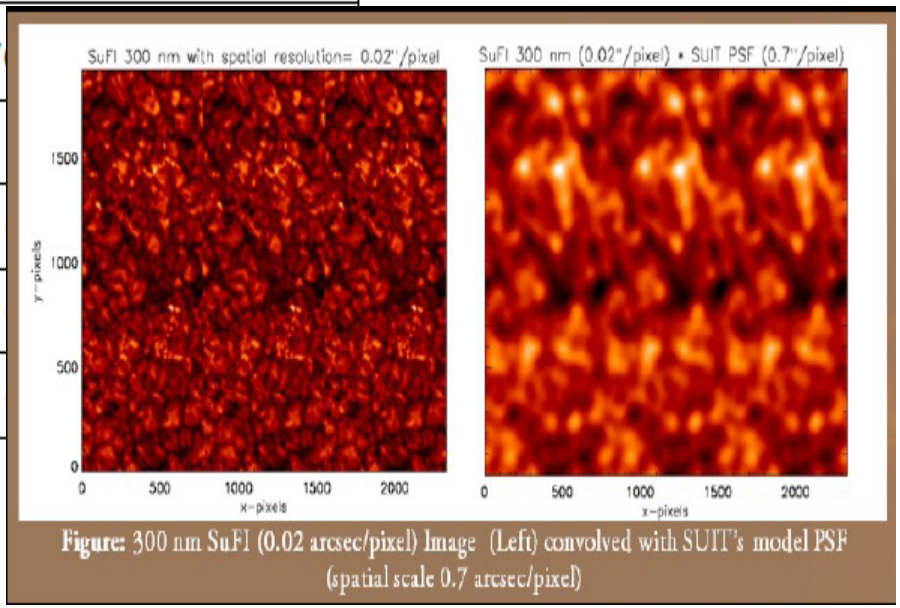
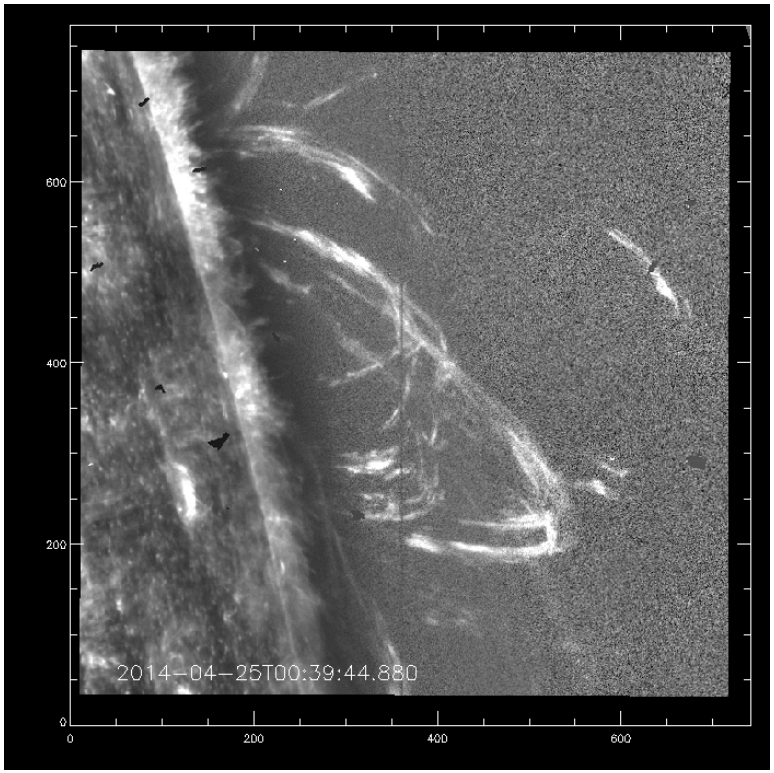


Figure: 300 nm SuFI (0.02 arcsec/pixel) Image (Left) convolved with SUIT's model PSF (spatial scale 0.7 arcsec/pixel)

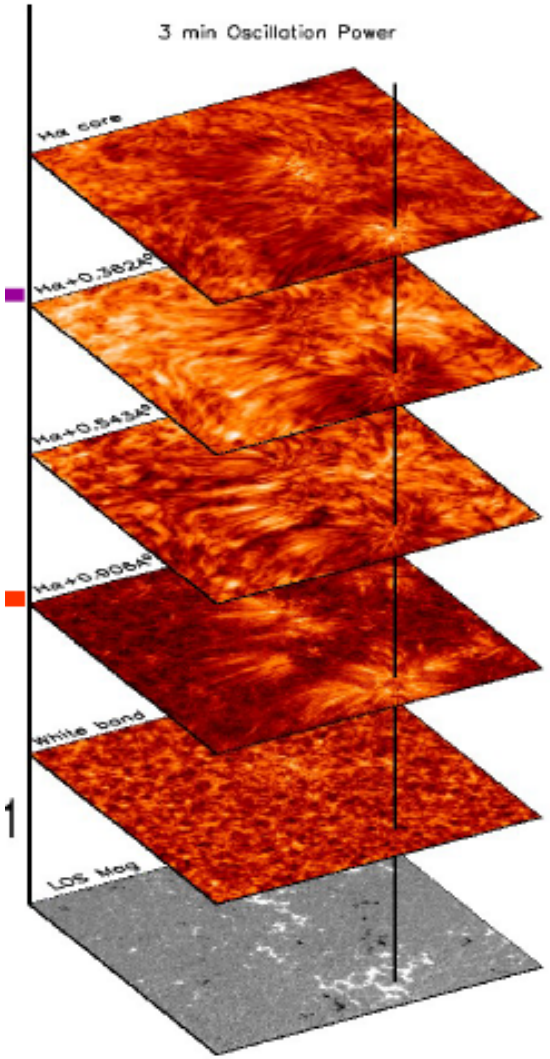
SUIT (NUV): Science Goals

- Evolution and Dynamics of Solar Prominences
- Sun-Climate Relationship



IRIS 1400 A
Slit jaw images
Radial gradient
Filtered

Coronal Rain: Pant et al. 2018



Power maps in the different layers at the 3 minutes period band with the magnetogram

Samanta et al (2015)

Table 2: Top Level Science requirements for SUIT

TOP LEVEL SCIENCE REQUIREMENTS	
Spectral Coverage	200-400 nm
Spectral Channels	11 (3 Broadband & 8 Narrowband- see Table 3 for details)
Spatial Coverage	a) Full disk (up to ~1.2 Solar Radii): ~38 arcmin b) Partial field (~512x512 sq. arcsecond adaptable region of interest on solar disk)
Temporal coverage	Uninterrupted 24x7 coverage of: a) Full disk: every 30 mins in all 11 filters irrespective of modes of operation b) Partial field: every ~40 seconds in all 8 Narrowband filters
Angular resolution	1.4 arcsec on the Sun
Minimum Signal to Noise Ratio	100 in dark regions
Contrast	10:1 contrast between bright and dark features at 10'' length scales
Scattered/Stray light	Combined scattering at 10" scales a) For Bright spots: Should be less than 0.11% of mean Solar flux b) For dark spots, it is 0.036% of mean Solar flux

Combined Observations with VELC, SUIT and X-ray payloads

Importance of coordinated observations between ground
And space from multiple vantage points

For coronal magnetic field measurements joint observing campaign with
SO - ASOS-S - DKIST
JOP/HOP/**SOOP?**

Launch Date: End of 2020
Nominal mission 5 years

Open Data Policy

Watch out for Aditya (the sun God from India) @Lagrangian1

Thank you for your attention