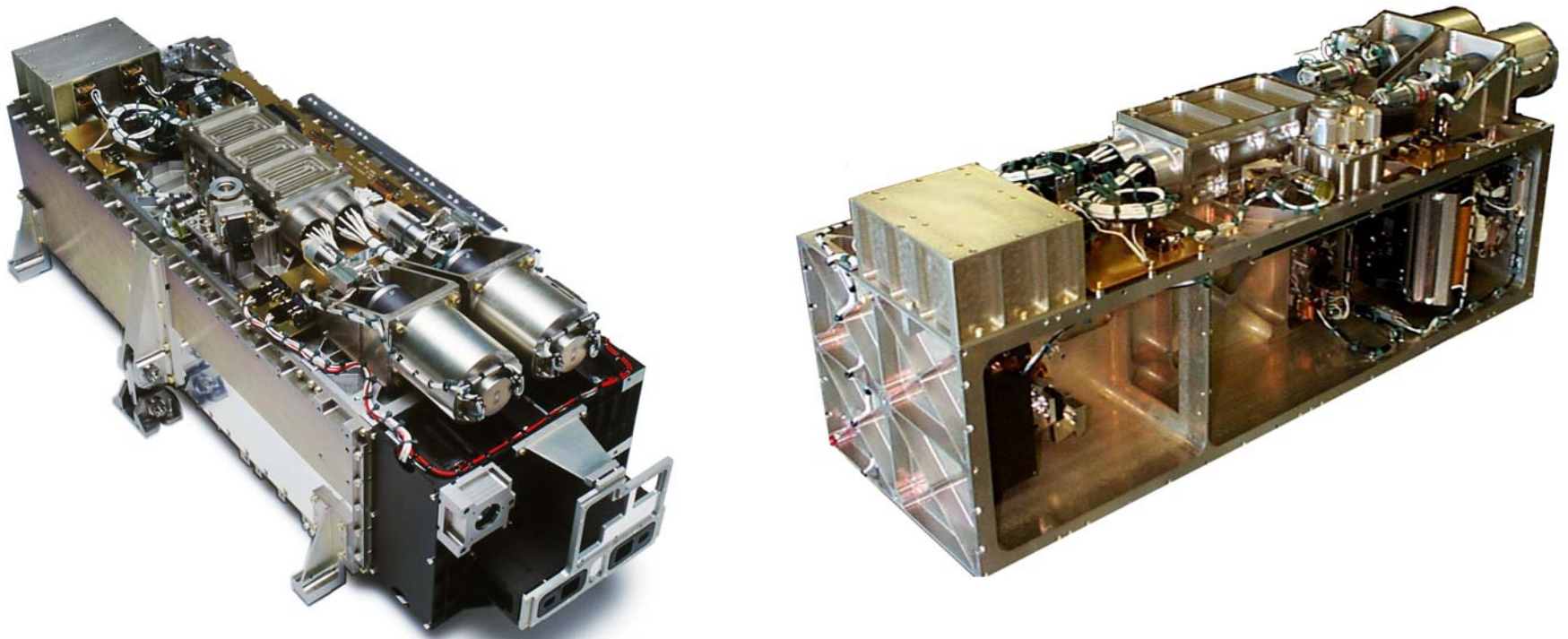


Solar Spectral Variability as Measured by the **SORCE SIM** Instrument



**Jerald Harder, Juan Fontenla, Gary Rottman,
and Thomas Woods**

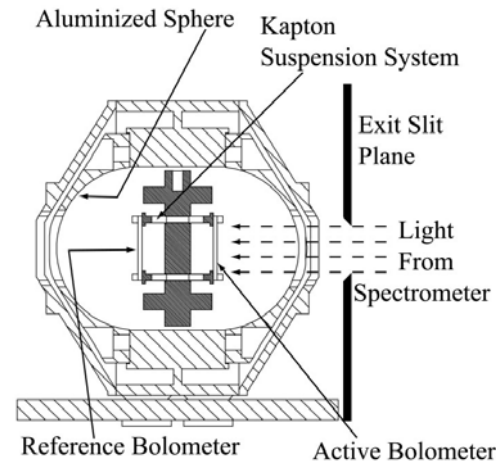
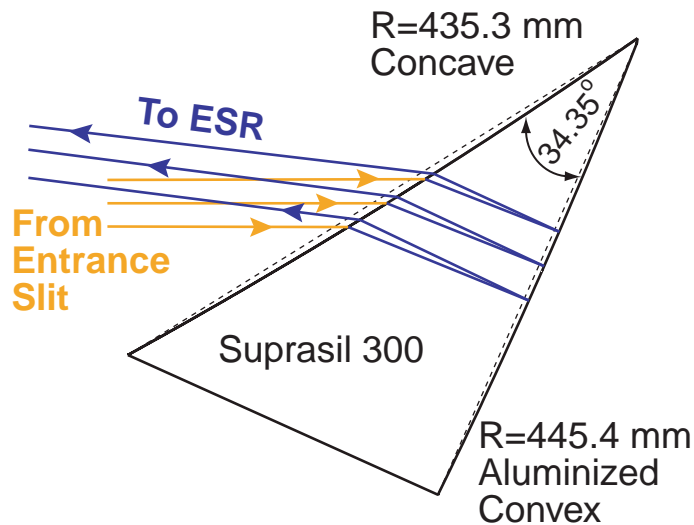
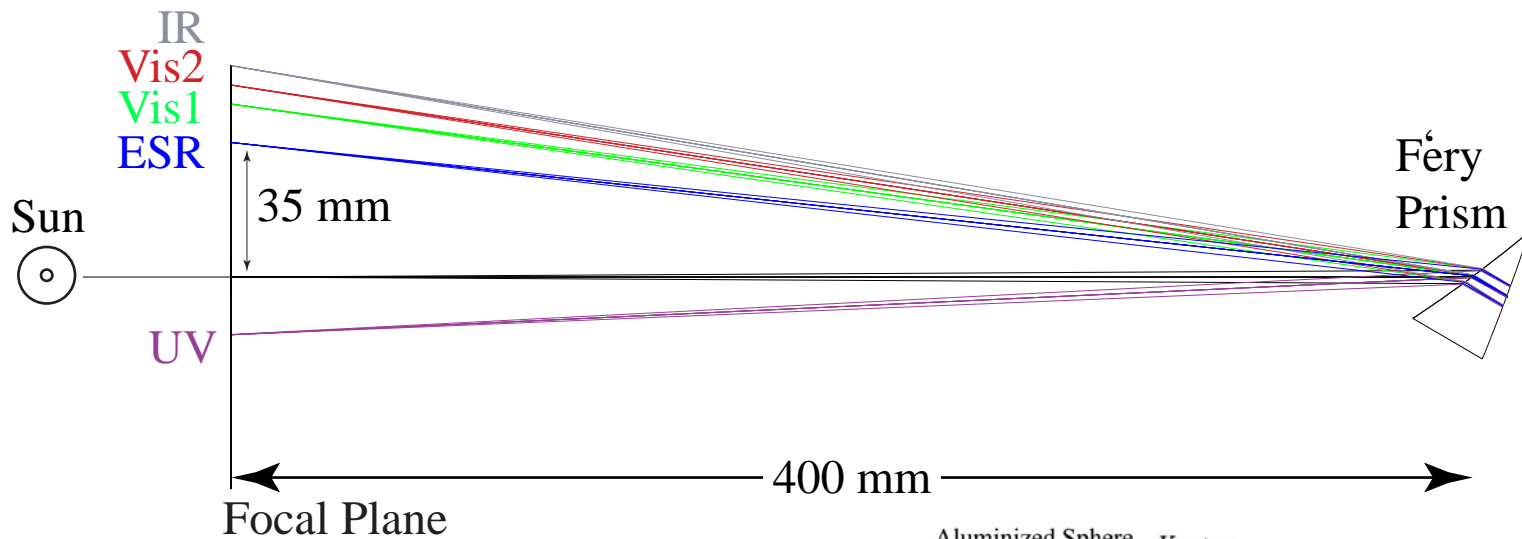
Presentation Outline

- ◆ **The SIM Instrument (Briefly)**
- ◆ **The Solar Spectrum and Solar Variability as Measured by SIM**
 - **Discussion on SIM Spectral Irradiance Time Series at Different Levels of Solar Activity**
 - **Target the April 21 through October 1 time period**

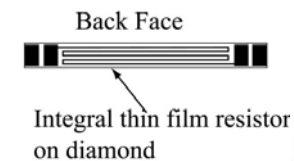
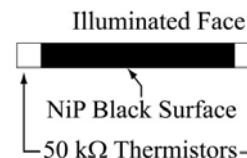
Executive Summary on SIM – The First 642 Days

- ◆ All instrument subsystems functional
- ◆ Produces high precision data for characterization of spectral solar variability. (See contents of this presentation & Fontenla et al., in preparation for *Solar Physics*)
- ◆ Important information about the infrared behavior of plage inferred from analysis of the SIM IR channel. (Fontenla et al., *Ap. J. Lett.*, 2003)

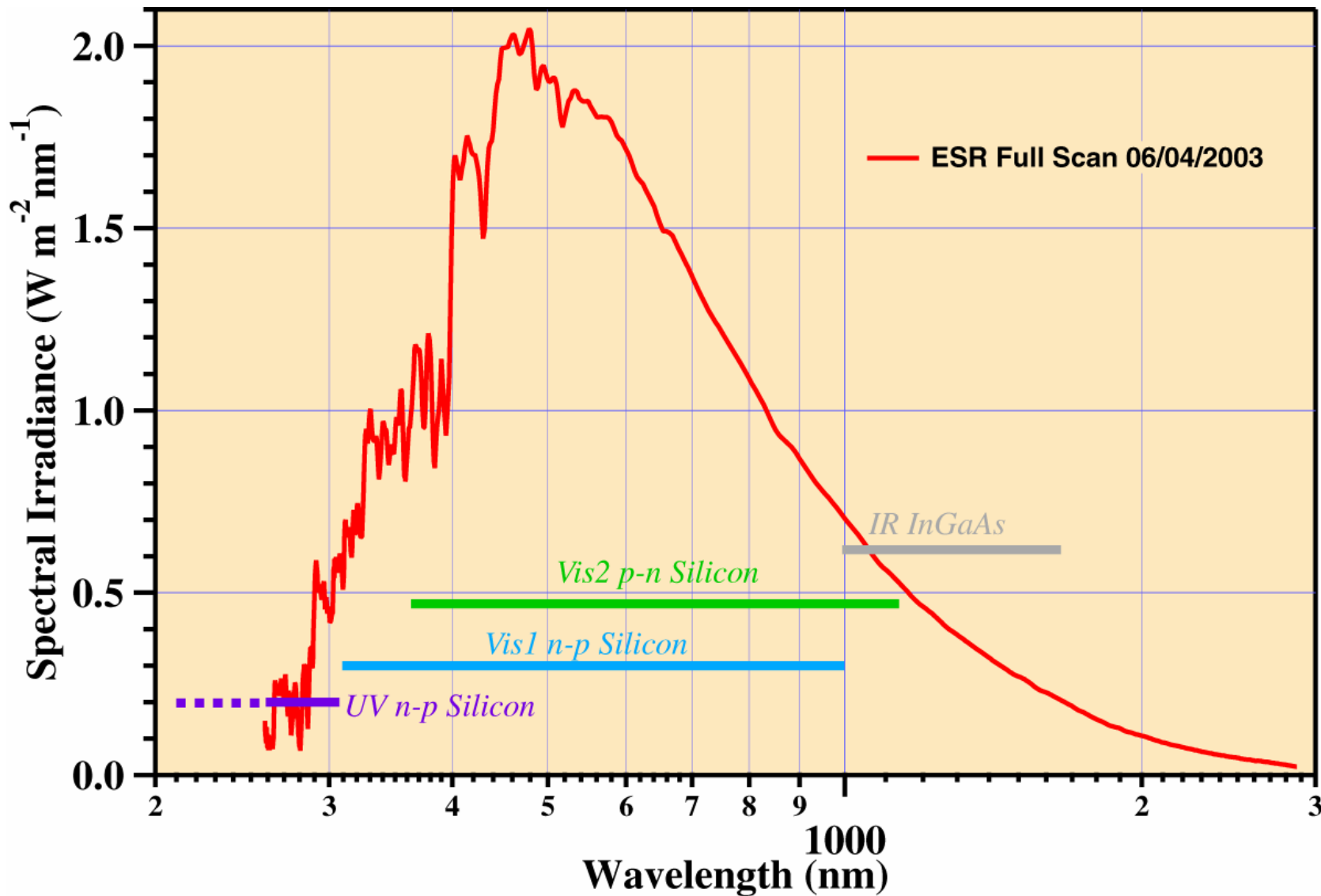
Instrument Attributes Overview



Bolometer Detail

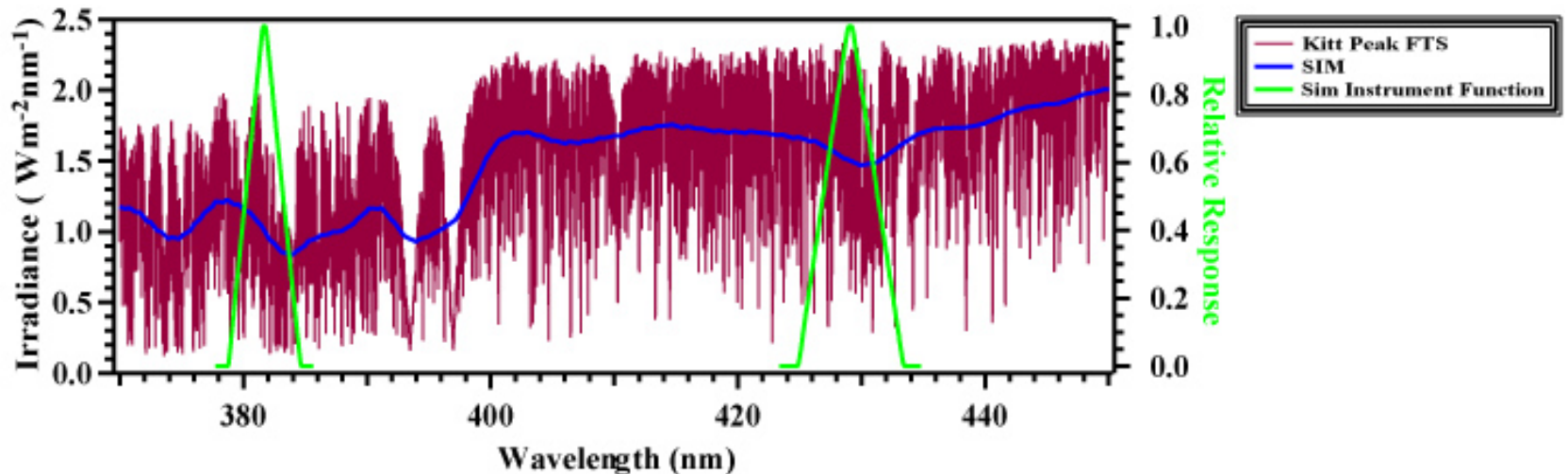
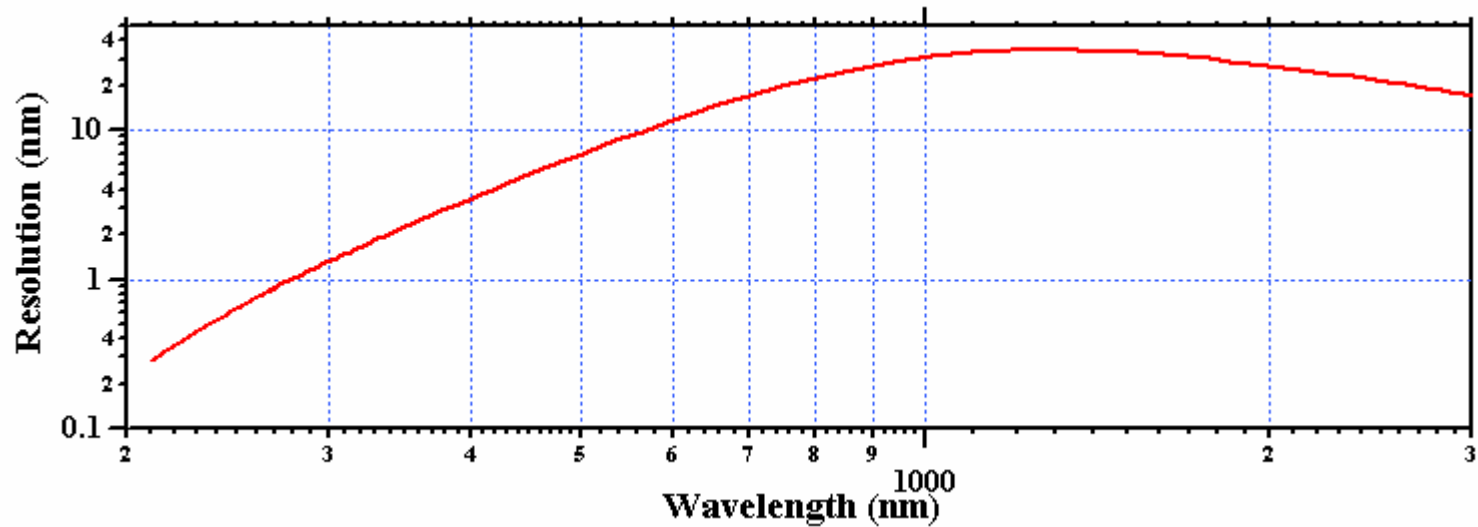


SIM ESR Irradiance Spectrum June 4, 2003



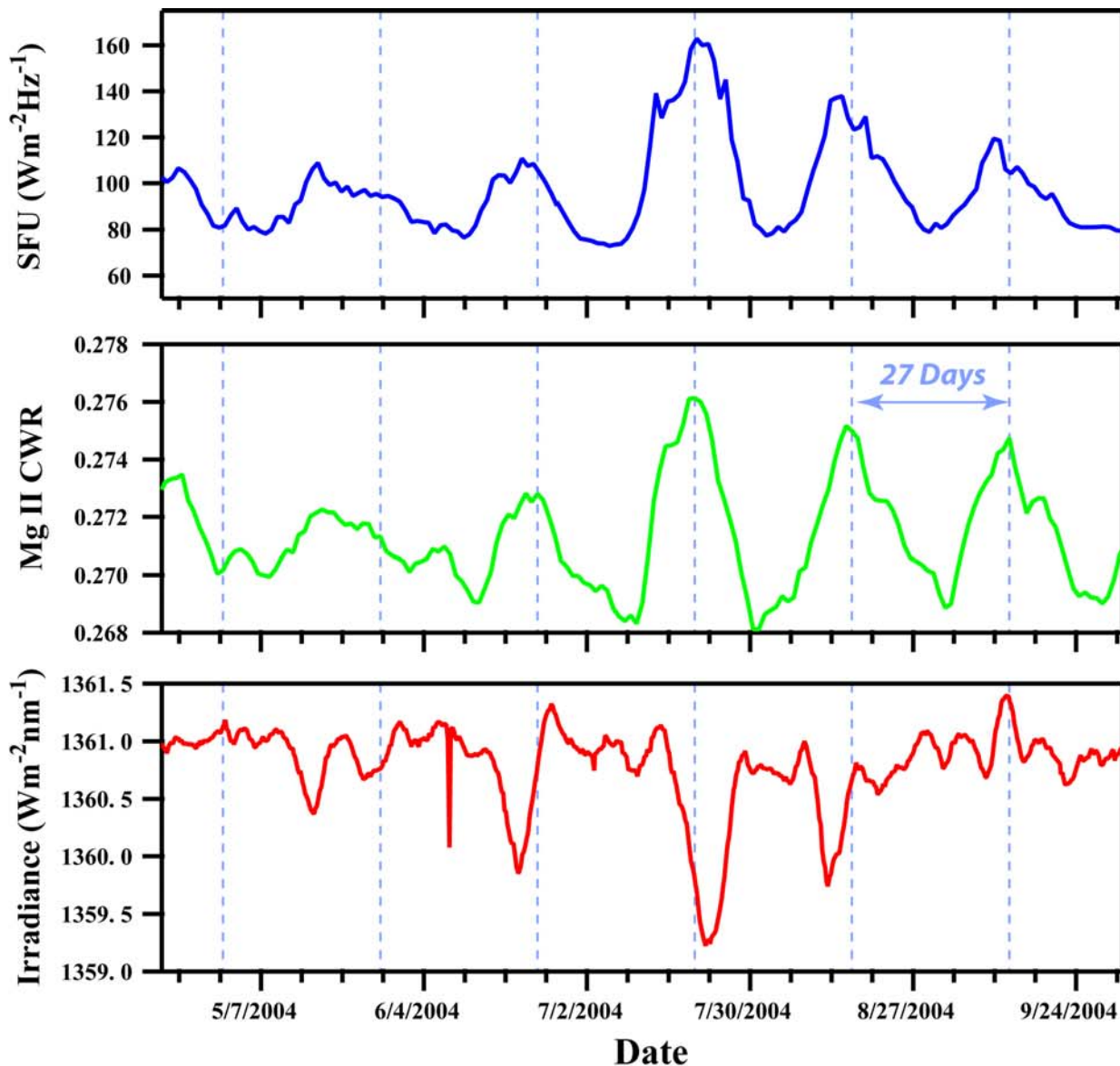
ESR full scan requires 15 orbits to complete

A Word About Resolution...



- ◆ Moderate resolution instruments respond to the *density* of lines, not necessarily to the lines themselves

Standard Indicators of Solar Activity



F10.7 Radio Flux

- Flux maxima occur on nearly 27-day centers in phase with Mg II.

Mg II Core-Wing Ratio (NOAA16)

- Structure shows more contrast than F10.7 and is more 'triangular' in nature

Total Solar Irradiance (TIM)

- The presence of sunspot groups on the solar disk cause a decrease in irradiance but are not in phase with the plage indicators.

Days of Maximum Mg II Activity

05/01

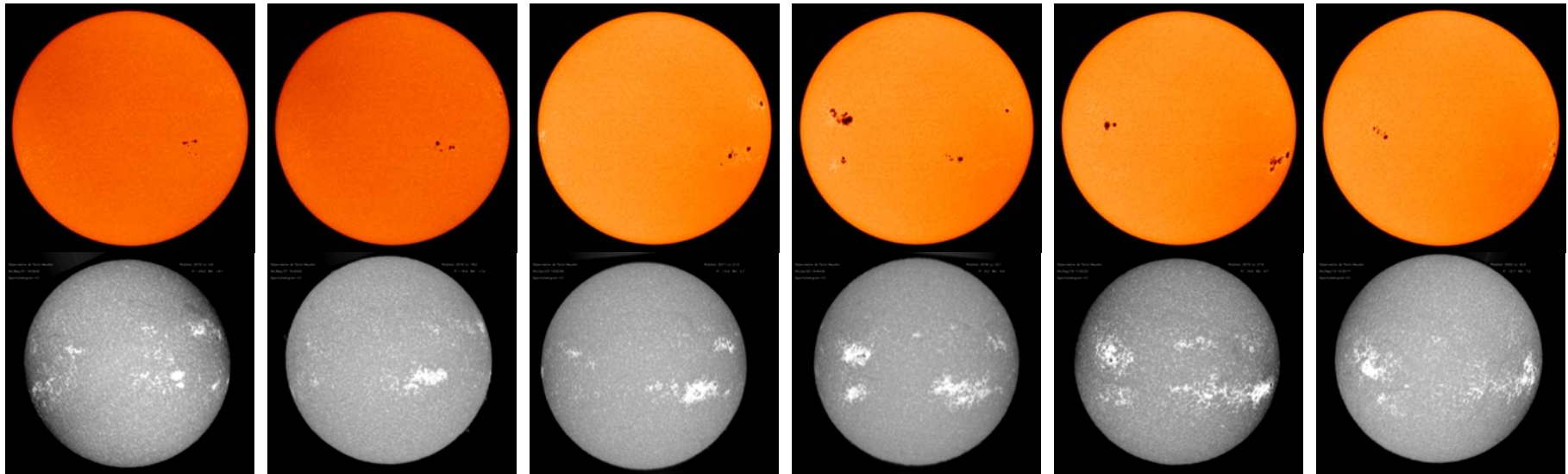
05/27

06/23

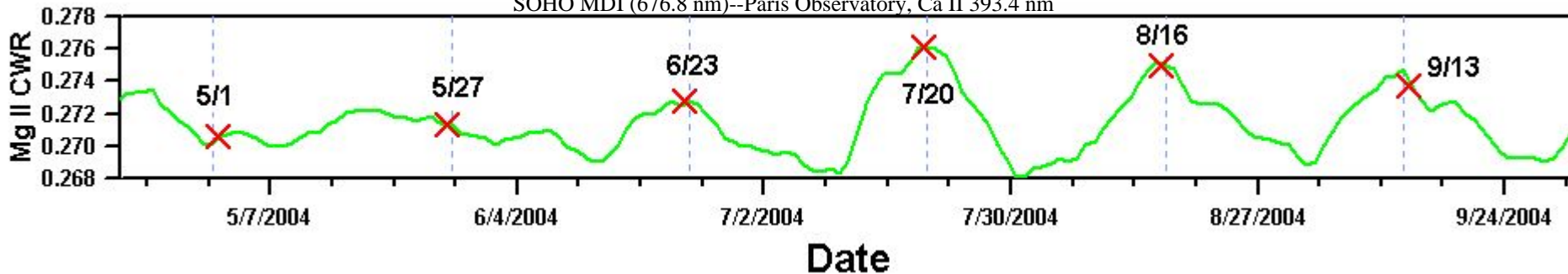
07/20

08/16

09/13



SOHO MDI (676.8 nm)--Paris Observatory, Ca II 393.4 nm



- ◆ Maxima do not correspond to a single active region but to a distribution of active regions and active network over a hemisphere.
- ◆ Some active regions seen in Ca II are not associated with sunspots but occur at times and places where sunspots were located.

Days of Minimum Mg II Activity

05/17

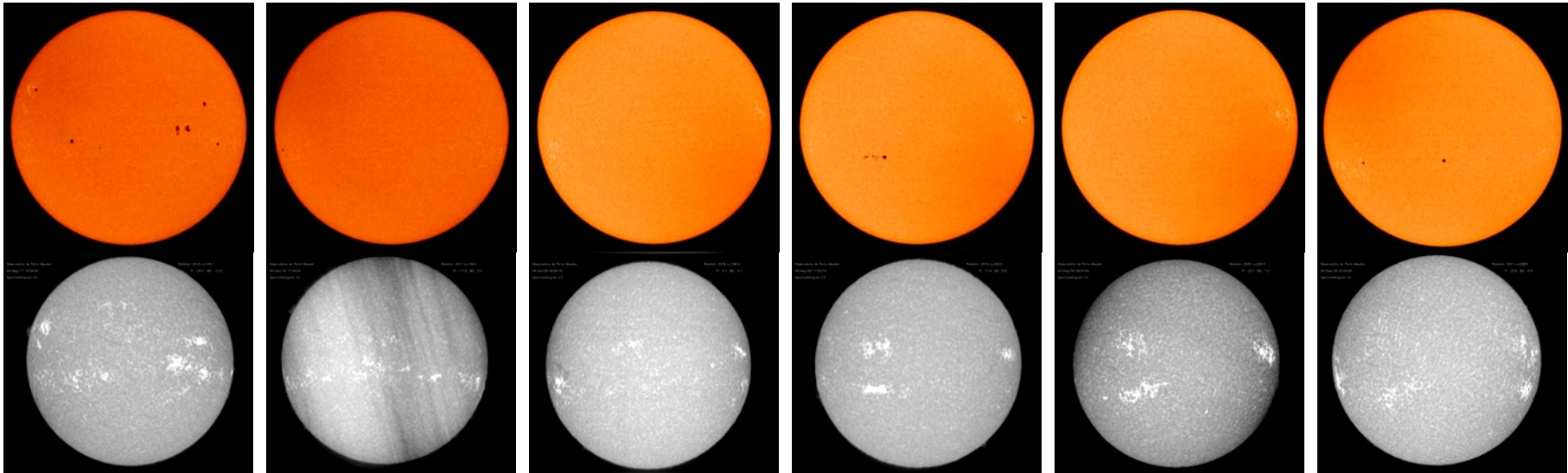
06/10

07/08

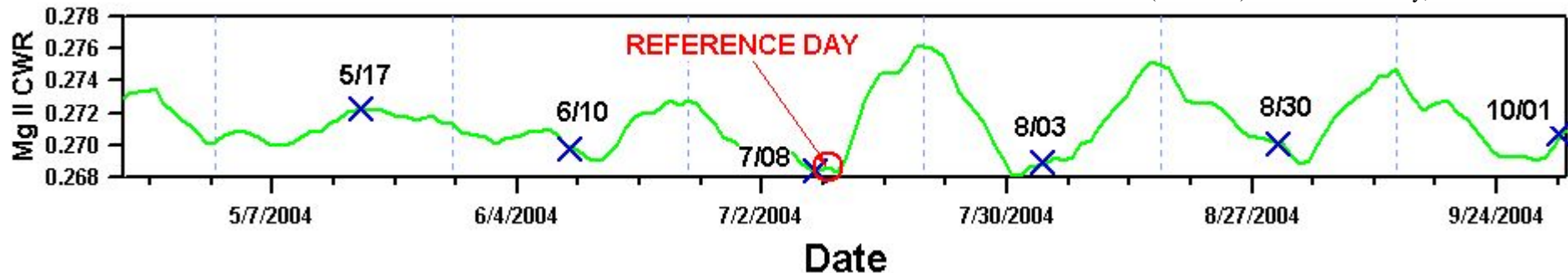
08/03

08/30

10/01&9/27



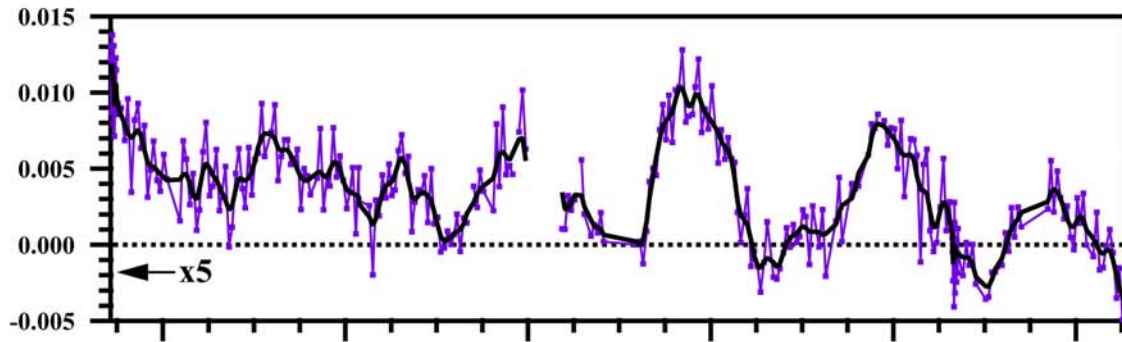
SOHO MDI (676.8 nm)--Paris Observatory, Ca II 393.4 nm



- ◆ Mostly quiet, but some periods had randomly distributed small sunspot groups.
- ◆ Images show band of active network close to the equator
- ◆ Ca II plage with no sunspots was common

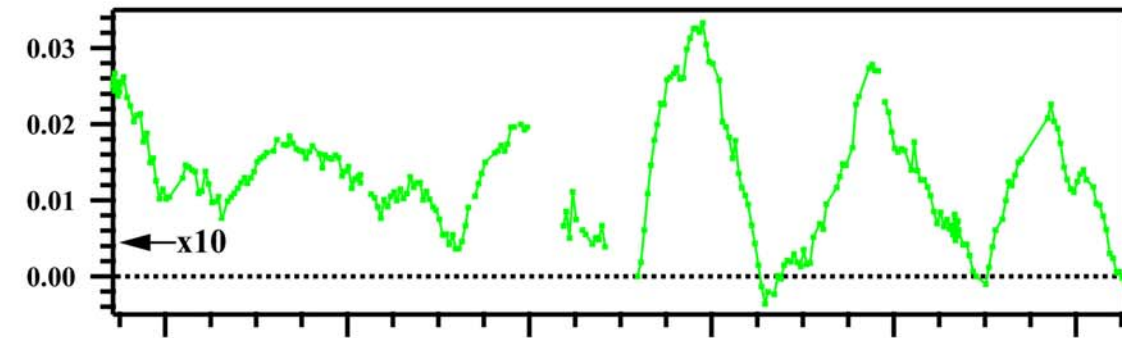
Solar Variability in the Ultraviolet

Fractional Difference (Rel. to 7/10/2004)



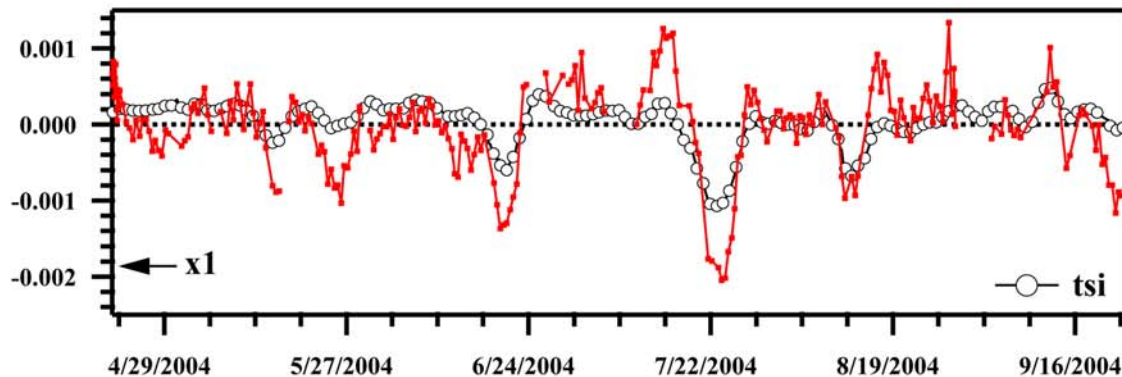
250 nm: UV Pseudo-Continuum

- Formed from continuum flux from the top of the photosphere and densely spaced spectral lines in the lower chromosphere.
- Continuum contribution decreases with sunspot blocking, lines increase intensity due to presence of plage.
- Chromospheric component tends to dominate.



280 nm: Mg II

- Resolution 1.1 nm, so contains pseudo-continuum & the cores of the Mg II lines.
- 280 nm peaks when the plage areas are the largest.
- Flux is affected by the presence of active network structures.



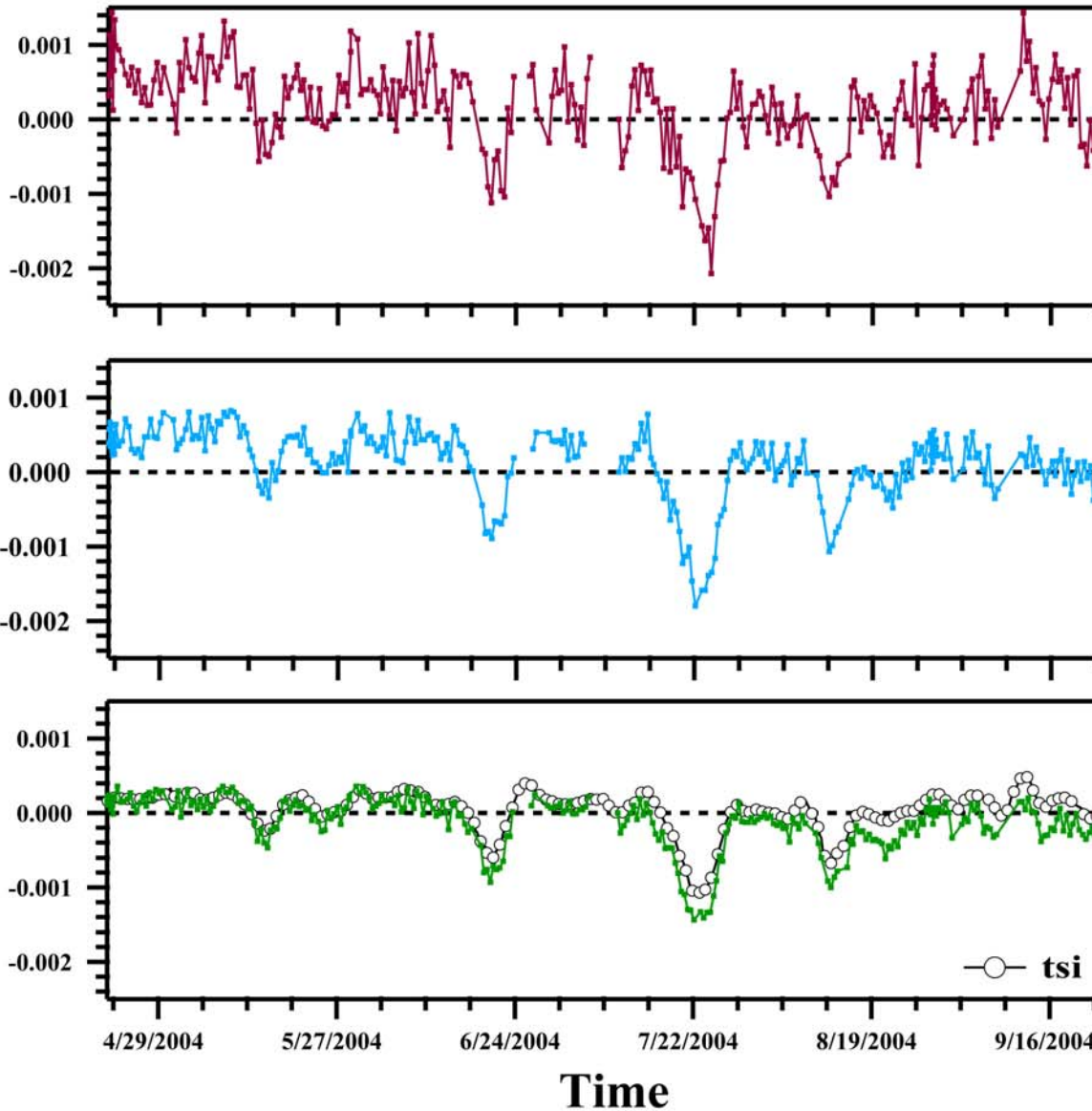
304 nm: Near-UV Pseudo-Continuum

- Continuum formed in deeper layers of the photosphere with less densely spaced lines than at 250 nm.
- Time series resembles TSI and is more photospheric in nature than chromospheric.
- A factor of ~2x contrast enhancement compared to TSI

Date

Solar Variability in the Visible – Short Wavelengths

Fractional Difference (Rel. to 7/10/2004)



430 nm: G Band

- Formed from densely spaced spectral lines; CH molecular, Fe I resonance and H Balmer γ (434.25 nm)
- Molecular lines formed at the top of the photosphere and bottom of chromosphere.
- Time series resembles TSI but about 2x more contrast

480 nm: Irradiance Peak

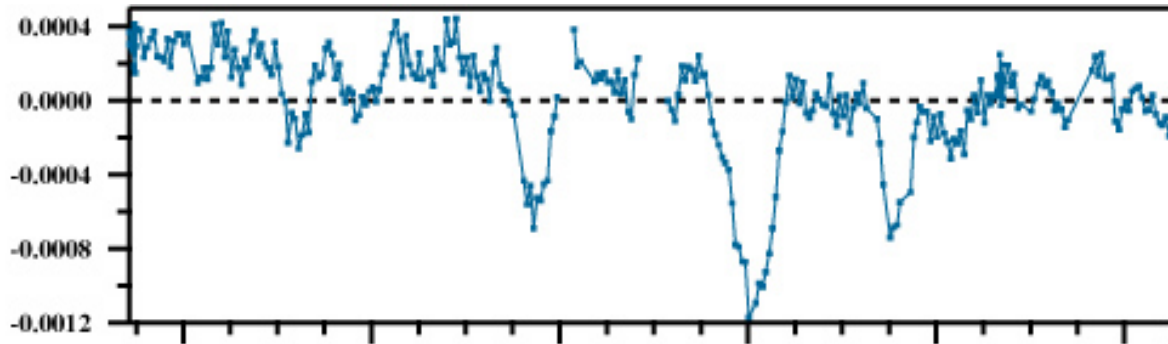
- Predominately Continuum with low density atomic lines
- Photosphere in character
- Time series resembles G Band

589 nm: Na I D

- Na I D lines formed in the lower chromosphere but with large departures from LTE and do not display emission at the core.
- Very similar in character to TSI, but broader in extent.

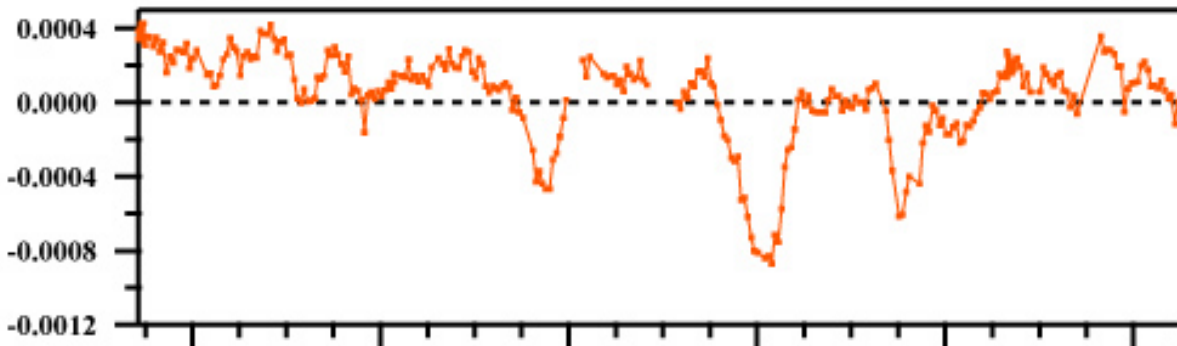
Solar Variability in the Visible – Long Wavelengths

Fractional Difference (Rel. to 7/10/2004)



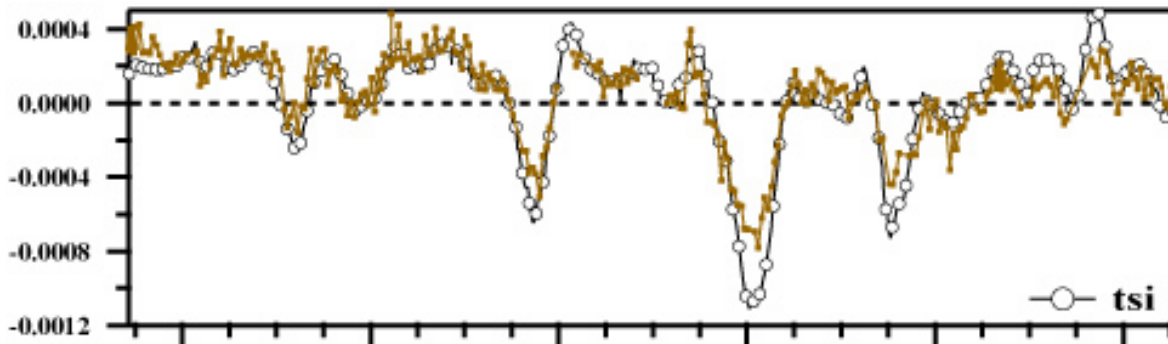
656 nm: H α

- Instrument function ~ 15 nm FWHM at this point so time series contains continuum contribution
- Almost identical in character to TSI



857 nm: Ca II Triplet

- Instrument function ~ 25 nm FWHM
- Contrast is now less than that for TSI



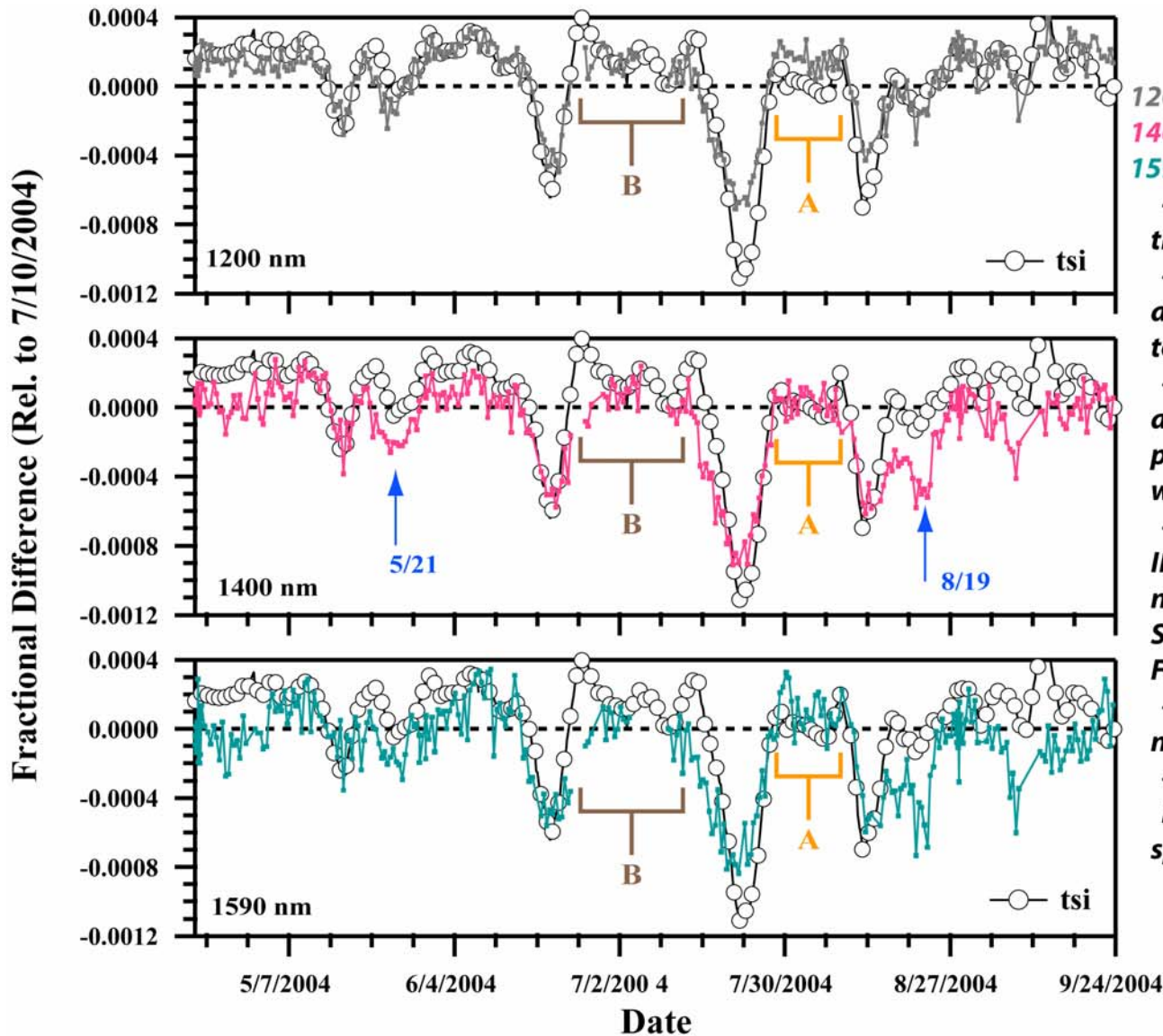
1000 nm: Ca I Resonance

- Facular brightening on the limb just barely compensates for sunspot areas still on the disk at this wavelength

4/29/2004 5/27/2004 6/24/2004 7/22/2004 8/19/2004 9/16/2004

Date

Solar Variability in the Infrared



- 1200 nm
- 1400 nm
- 1590 nm : H^- Opacity Minimum
- In all cases, less sunspot contrast than TSI.
- For 1400 & 1590 nm traces, no appearance of brightness enhancements due to presence of plage on the solar limbs.
- On 5/21 and 8/19 differences from TSI are attributable to the appearance of plage structures on the limb from other wavelengths.
- Feature A shows an enhancement of IR brightness above that of TSI that is not present at the visible wavelengths. Same observation as discussed in Fontenla et al.
- Notice that the enhancement does not appear time period B.
- What is the nature of Feature A? Possibly an extended deep photospheric feature with very low contrast.

CONCLUSIONS

- ◆ **SIM is ultraviolet, visible and infrared channels yield excellent information on solar spectral variability.**
- ◆ **Plage, network, and sunspot solar surface features contribute to the variability signal observed by the SIM.**
- ◆ **Solar images, TSI, and solar modeling in conjunction with SIM measurements provide an effective suite research tools to investigate solar variability.**
- ◆ **The characterization of solar features in the infrared remain one of the more important research questions that SIM can address.**