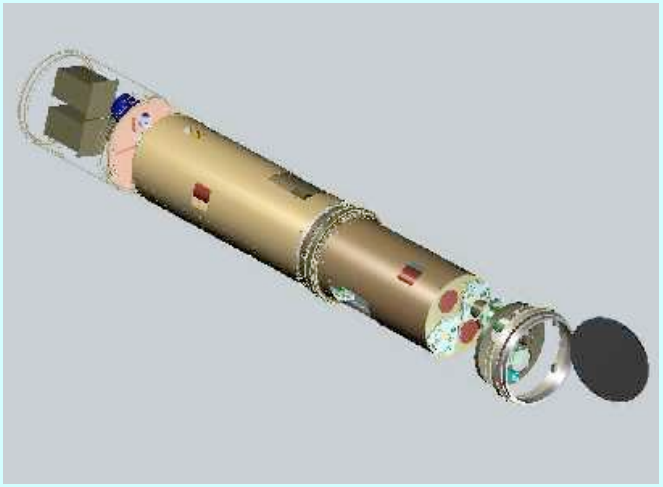

EUNIS

Extreme Ultraviolet Normal Incidence Spectrograph

eunis.gsfc.nasa.gov

First Flight – 12 April 2006 1910 UT
from White Sands Missile Range

On its first flight, EUNIS obtained 145 science images of the Sun in each of two wavelength channels and met all its comprehensive mission success criteria.

The first science results appeared in *Astrophysical Journal Letters* in February 2007 (Brosius et al.)

The EUNIS program is supported by the NASA Heliophysics Division through its Low Cost Access to Space Program.

The EUNIS Team

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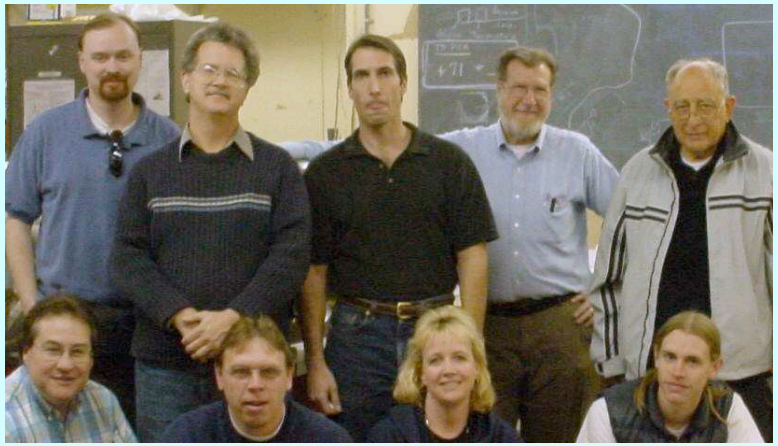

Top: EUNIS at Goddard. Bottom: With MOSES and Wallops Flight Facility telemetry teams at White Sands

Joe Novello
Maria Nowak
Les Payne
Tom Plummer
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Ivonne Rodriguez
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John Stewart
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SOHO & TRACE EOF

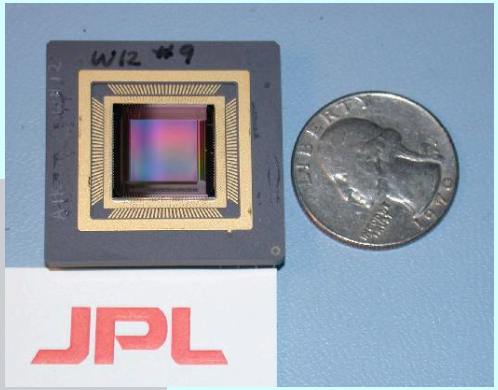
EUNIS – Why?

- To probe the structure and dynamics of the inner solar corona
- To obtain spectra with a cadence as short as 2 sec, allowing unprecedented studies of the physical properties of evolving and transient structures
- To study diagnostics of wave heating and reconnection at heights above 2 solar radii, in the wind acceleration region
- To provide absolute intensity calibration of orbital instruments, including SOHO/CDS and EIT, TRACE, Hinode/EIS, and STEREO/EUVI
- To demonstrate new technology in flight

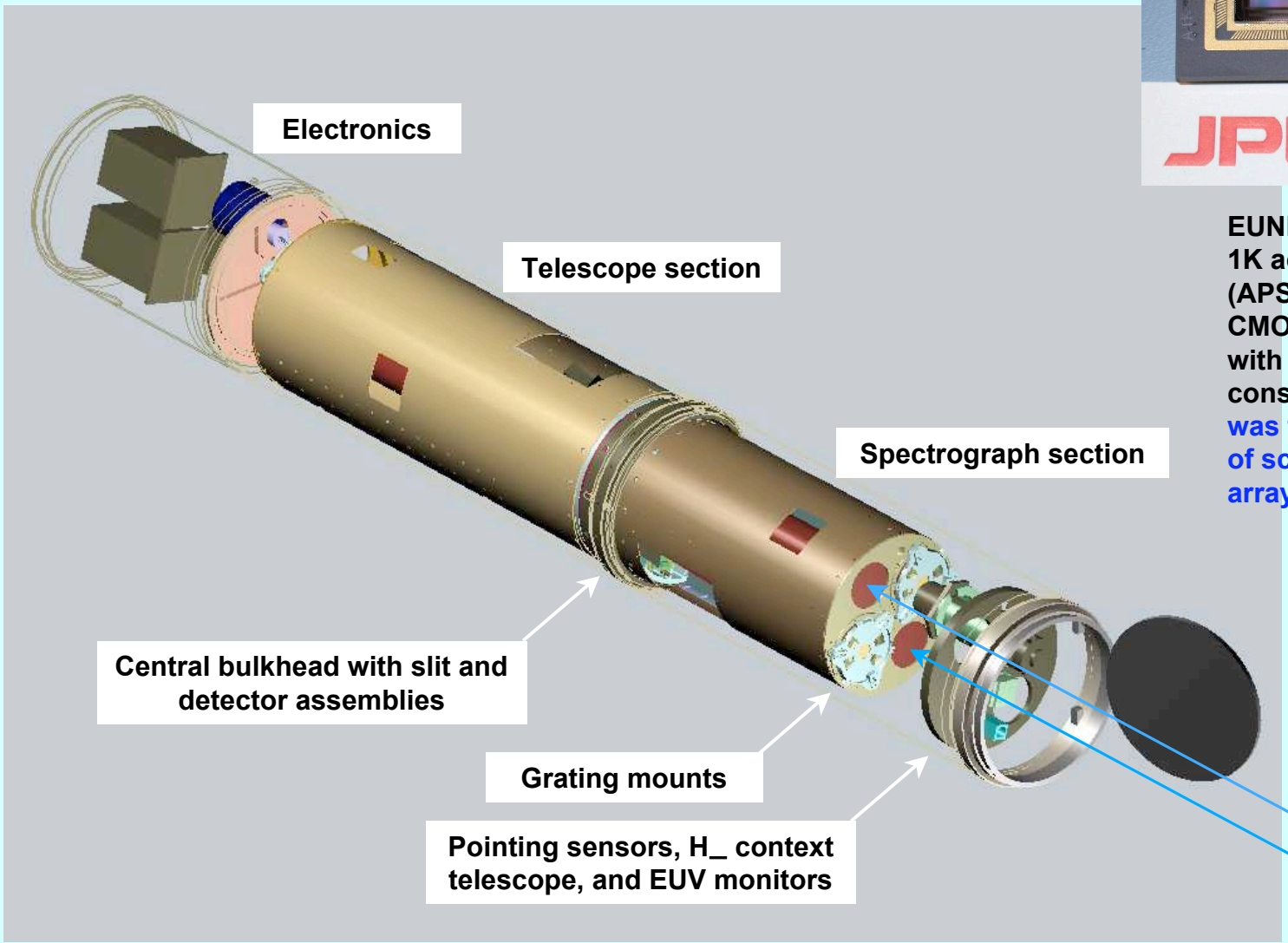
EUNIS – What?

- EUNIS is an extreme ultraviolet solar spectrometer with high efficiency and high spectral resolution, carried on a Black Brant sounding rocket.
- EUNIS has over 100 times the throughput of the highly successful SERTS payloads that have preceded it.
- EUNIS will incorporate new technology on each sounding rocket flight, beginning with high-speed CMOS Active Pixel Sensors.

EUNIS Design



EUNIS employs six 1K x 1K active pixel sensors (APS), single-chip CMOS imaging systems with low power consumption. EUNIS-06 was the first space test of science-quality APS arrays.



Comparative Specifications

Characteristic	*Unit*	*EUNIS*	*SERTS-99*	*SERTS-95*	*Solar-B/EIS*
Spectral Bandpass	Å	170-205* 300-370	— 300-355	170-220* —	170-215 244-290
Spectral Resolution	mÅ	50* 100	— 100	60* —	55 55
Spatial Resolution	arcsec	2.5	3	7	2
Slit Length	arcsec	960	334	288	480
Total Bandwidth	Å	105	55	50	91

*Observed in second spectral order

Density-Sensitive Line Ratios

Ion	Ratio	Max / Min
Fe X	175.3 / 174.5	14.9
Fe XI	184.8 / 188.2	99.2
	184.8 / 182.2	33.4
Fe XII	196.6 / 195.1	15.9
	338.3 / 346.8	19.7
Fe XIII	203.8 / 202.0	56.2
	196.5 / 202.0	386
	359.6 / 348.2	22.1
Fe XIV	353.8 / 334.2	7.2
Fe XV	321.8 / 327.0	5.6

Theoretical (CHIANTI) line intensity ratios for $8 < \log n_e < 11$ (cm^{-3}) for lines observed by EUNIS

Density-Insensitive Line Ratios

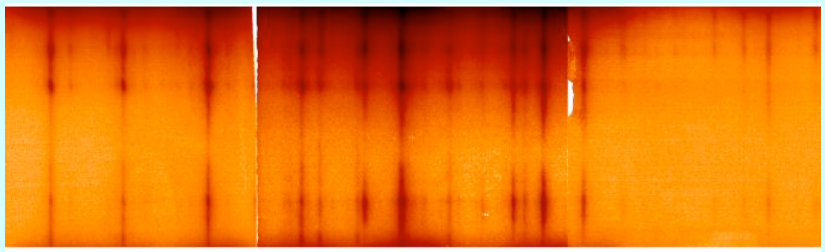
Ion	Line	Intensity
Fe X	174.5	1.000
	177.2	0.585 ± 0.007
	184.5	0.244 ± 0.030
Fe XI	188.2	1.000
	180.4	1.419 ± 0.154
	192.8	0.202 ± 0.015
	352.7	0.135 ± 0.005
Fe XII	195.1	1.000
	192.4	0.212 ± 0.002
	193.5	0.540 ± 0.063
	352.1	0.074 ± 0.008
	364.5	0.109 ± 0.010

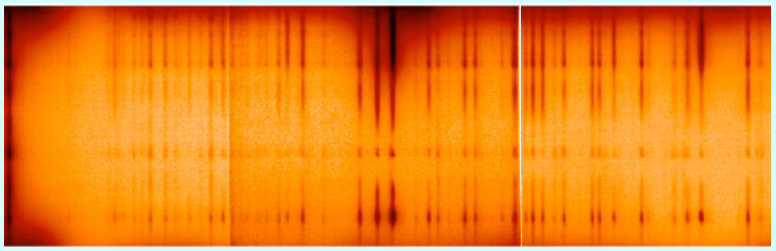
Ion	Line	Intensity
Fe XIII	312.1	1.000
	321.4	0.500 *
Fe XV	327.0	1.000
	312.6	0.580 *
Fe XVI	335.4	1.000
	360.8	0.481 *
Mg VIII	315.0	1.000
	311.8	0.193 *
	335.2	0.181 ± 0.011
	339.0	0.242 ± 0.015
Si IX	341.9	1.000
	344.9	0.571 *

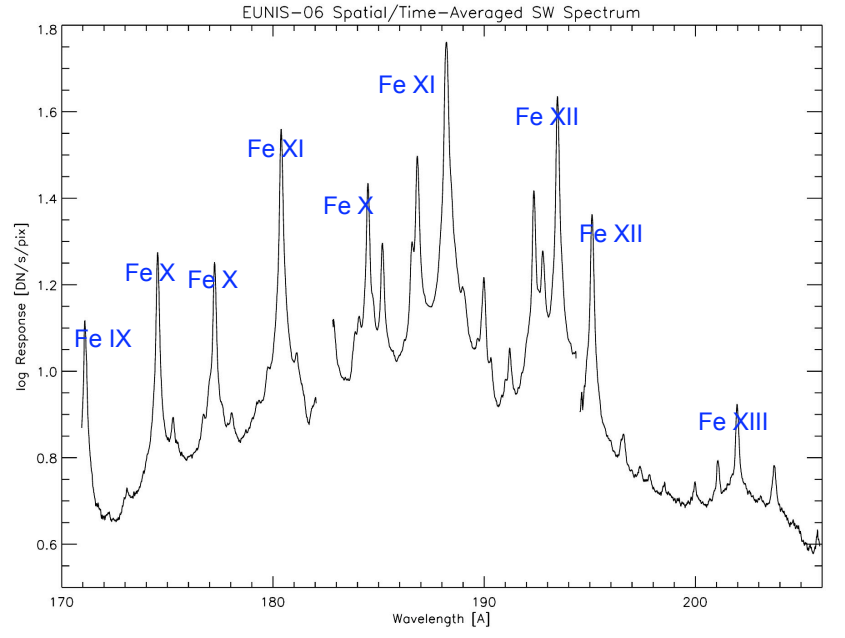
* **Branching Ratio**

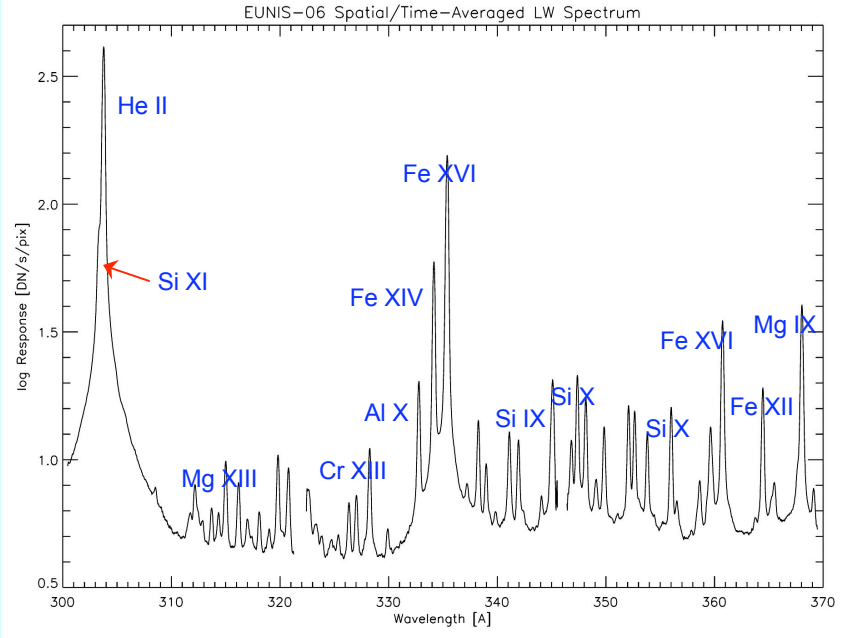
Theoretical (CHIANTI) normalized line intensities for line groups observed by EUNIS. Only a subset of the useful ratios is listed.

Average Spectrum and Line Catalog







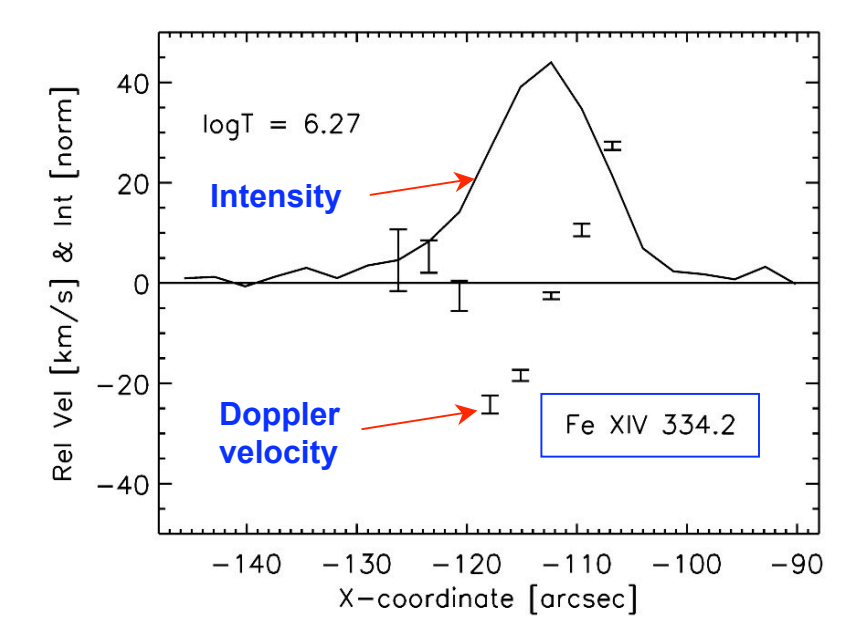


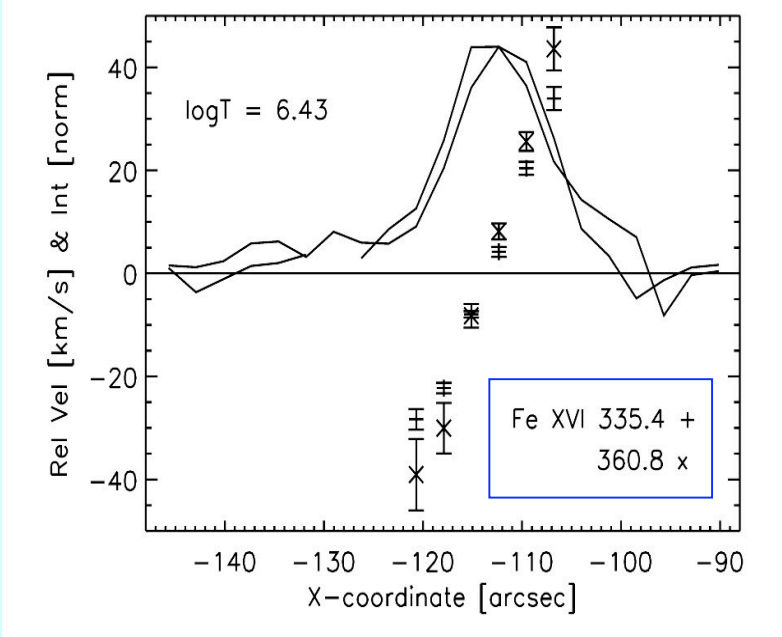
170 – 205 Å

300 – 370 Å

More than 140 lines have been measured in the two channels; more than 10 are new (not yet identified).

EUNIS First Result: Hot Flows in a Coronal Bright Point



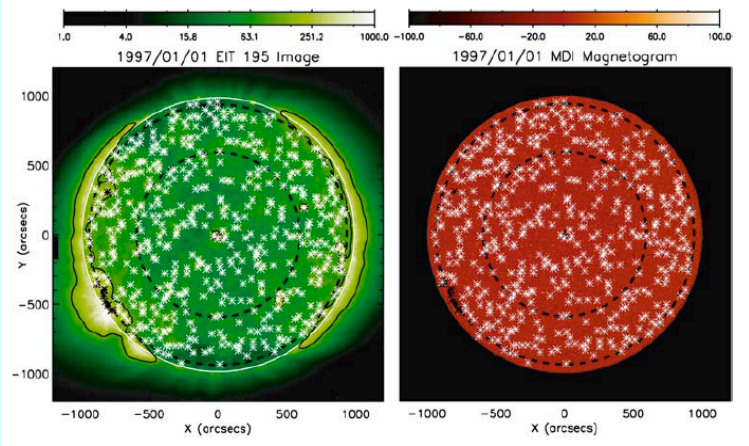


EUNIS measured both upflows and downflows of up to 40 km s^{-1} in a coronal bright point at temperatures in excess of 2 x 10^6 K, the highest temperatures at which flows have been reported in a bright point and a challenge to existing models.

What Are Coronal Bright Points and So What?

What

- First observed in x-rays, size ~2-5 Mm
- Live 2 hours to 2 days
- Release 10^{27}-10^{28} erg each
- ~10^3 on the Sun at any moment (varies in time and by detection criterion)
- Hotter BPs (T ▯ 10^6 K) much less common than cooler BPs (T ▯ 10^6 K)



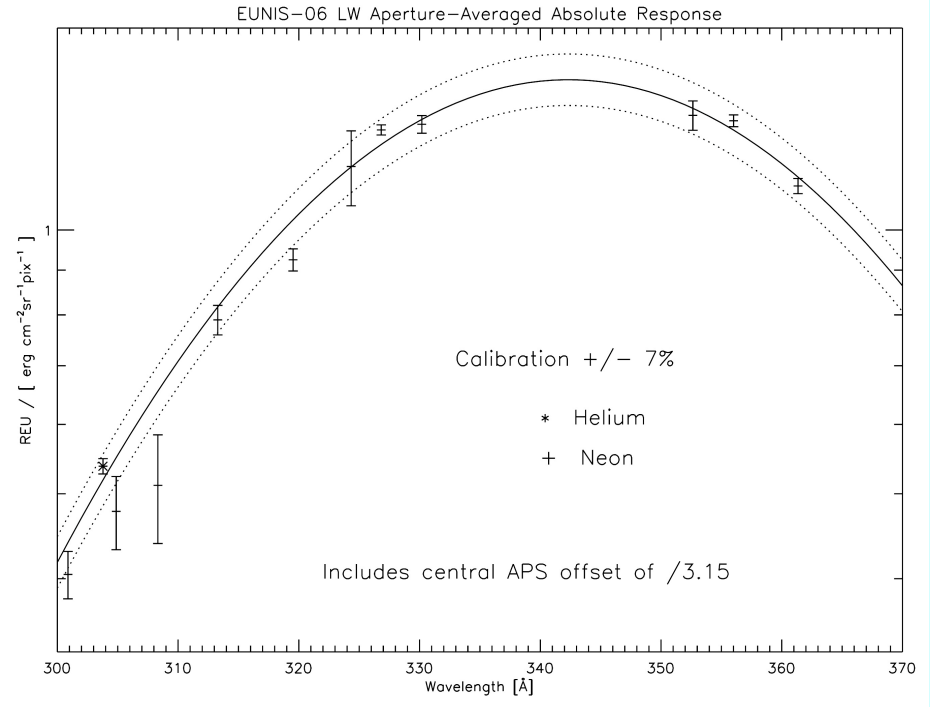
McIntosh & Gurman 2005

- BPs almost always (if not always) associated with changing photospheric magnetic flux
  - ~1/3 emerging flux (ephemeral regions)
  - ~ 2/3 “cancelling” flux
- To date, Doppler velocities in BPs measured only for lines formed at T < 10^6 K

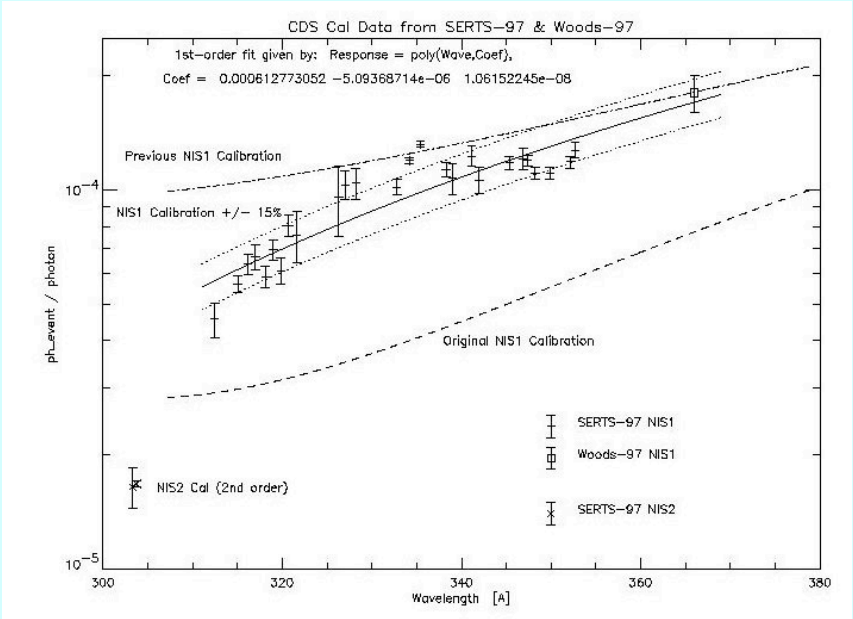
So What

- The quiet solar corona is predominantly heated by small-scale events
- Estimate that BPs contribute 20% or more of this heating

EUNIS Absolute Calibration of Orbital Instruments



Absolute intensity calibration of EUNIS-06 long wavelength channel with higher precision than any previous calibration. EUNIS-07 calibration will be applied to the Hinode EIS instrument.

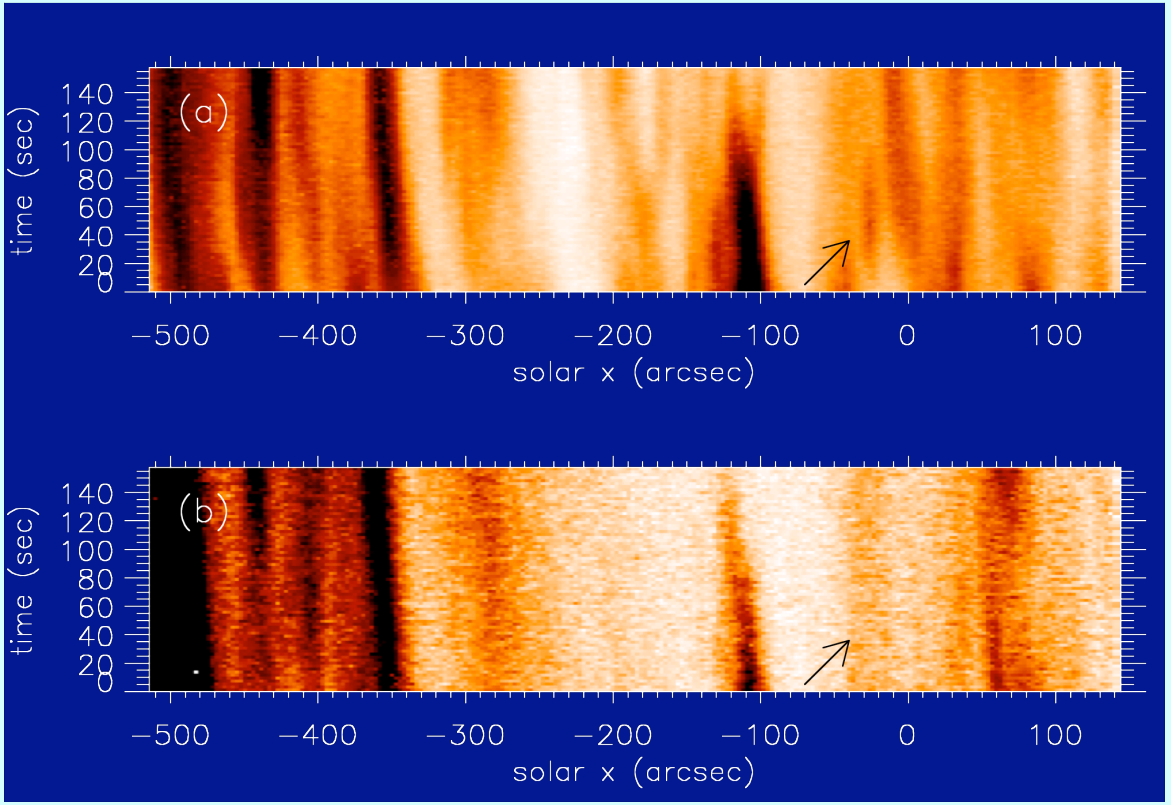


Example of earlier absolute calibration applied to the SOHO CDS instrument.

The Future: Transients and off-limb observations

He II 303.8 Å

Mg IX 368.1 Å



EUNIS integrated line intensities as functions of both space and time, displayed on a negative intensity scale. The x-axis corresponds to position along the slit; the y-axis corresponds to time since the first 1-sec exposure in the sequence. The arrow indicates the transient observed in He II by both EUNIS and EIT. Note that the brightening does not appear in Mg IX (or hotter) emission observed by EUNIS; it also does not appear in EIT's Fe IX and Fe XII wavebands.

EUNIS-07

- Projected for last week of October 2007
- Two primary objectives:
  1. Underflight absolute calibration of Hinode/EIS long wavelength channel
  2. Image cadence shortened to 1.2 sec, twice the time resolution of EUNIS-06