

CHANDRA Calibration Workshop

November 6 – 7, 2002

The UV/Visible Light Sensitivity of the HRC

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Abstract: Effective area curves for the UV/Visible response of HRC-I and -S will be presented along with comparisons of predicted and observed count rates for Vega and Betelgeuse. Universal curves for the prediction of count rates for a star whose effective temperature is known will be presented.

The UV/Visible Light (non-)Sensitivity of the HRC

- The UV/Ion Shields for HRC were designed to block UV and Visible light
- The HRC sensitivity to out-of-band radiation is below the design specifications and is not varying with time
- Models for the UV/Visible response have been developed
- Models have been “verified” by in-orbit observations

UV/Visible Light Response Models

Based upon

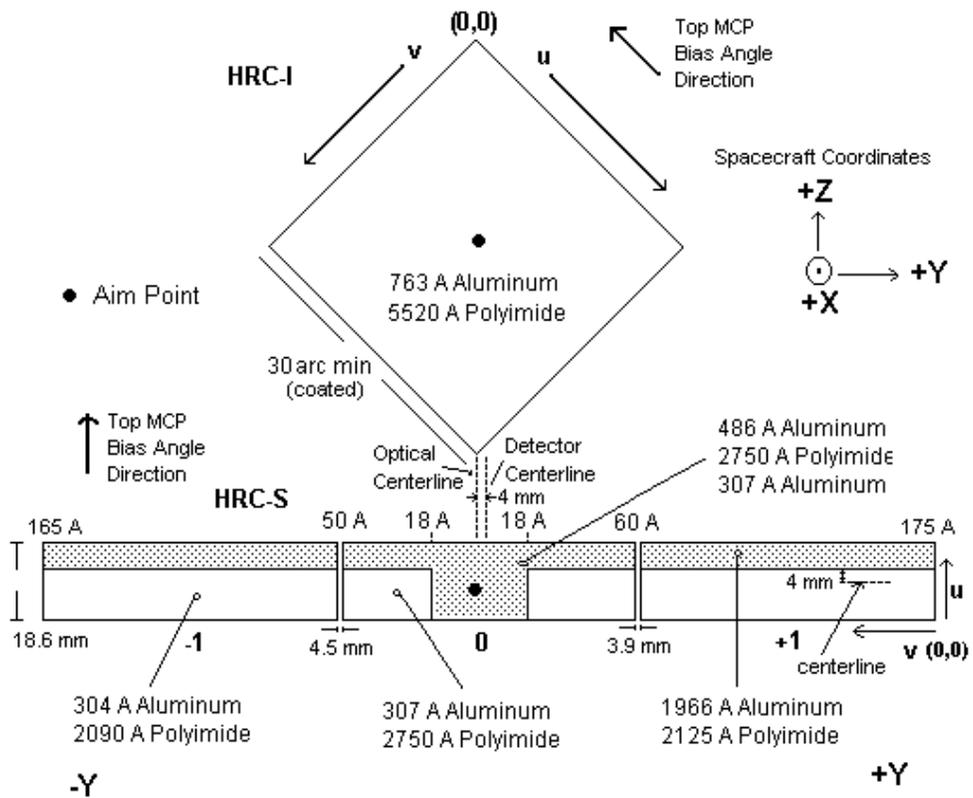
- MCP QE – values in the literature (100Å to 2537Å) and a single measurement in our laboratory at 5500Å

- UVIS/Shield transmission calculated from

 - polyimide attenuation coefficients, 100Å – 4000Å derived, from transmission measurements of polyimide sample; 4000Å – 8000Å transmission measurements of witness samples

 - aluminum attenuation coefficients from the literature

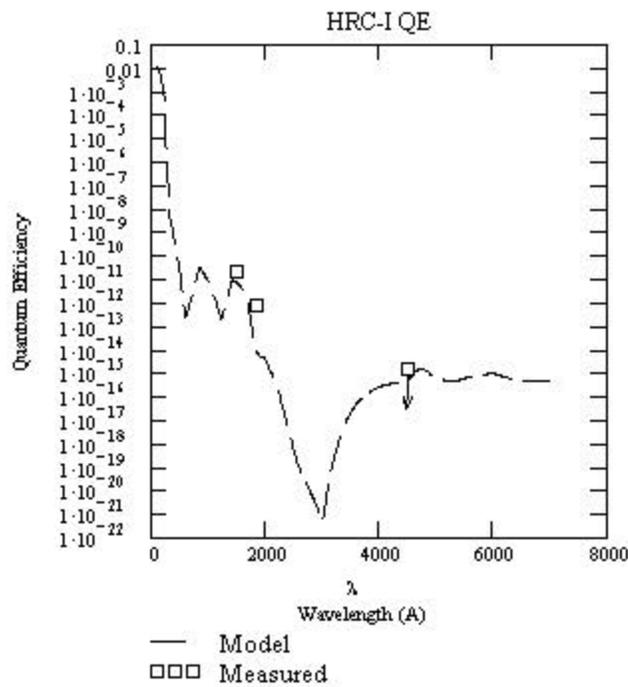
Focal Plane Layout



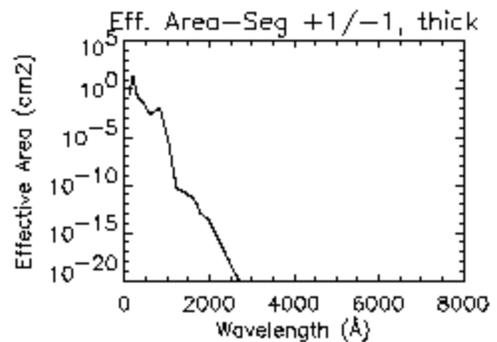
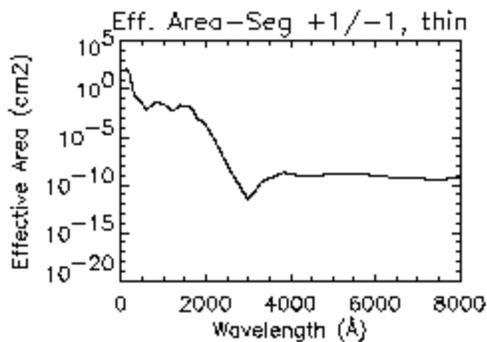
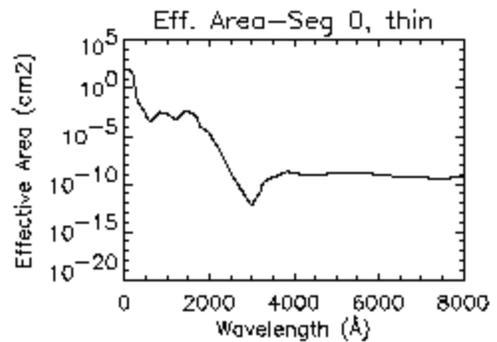
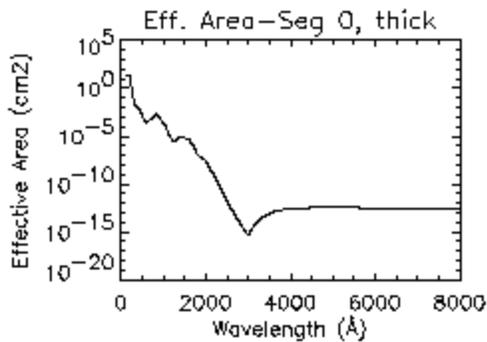
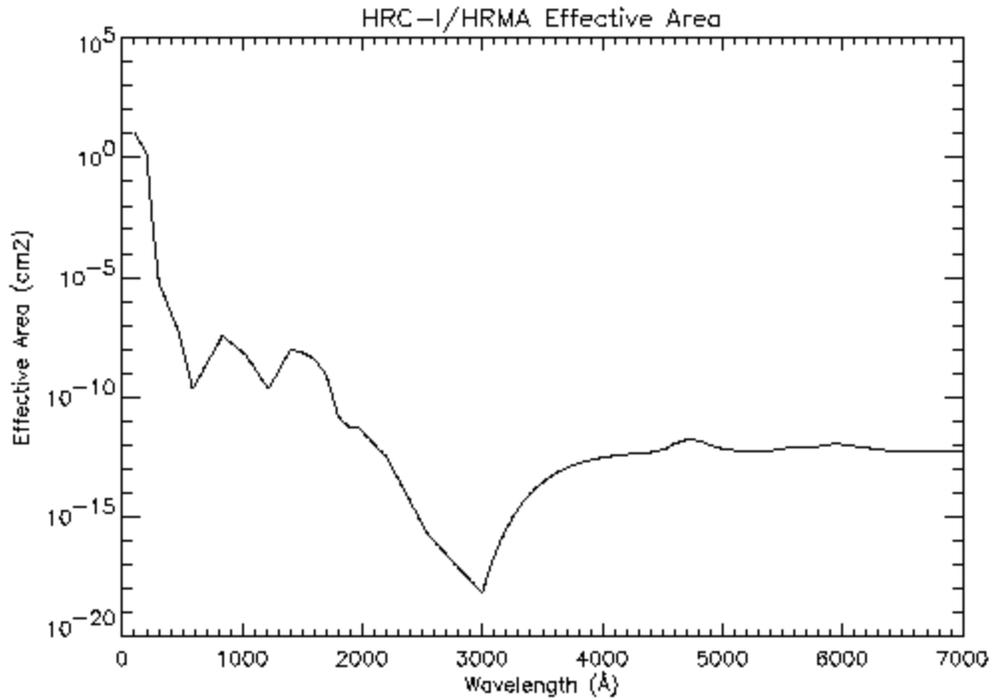
Configuration of the UV/Ion shields (blocking filters) of the HRC-I and HRC-S detectors.

HRC-I QE Model

Laboratory measurements of the flight detector at three wavelengths: 1470A, 1850A, and 4500A



HRC Effective Area Models (QE Models x 1100 cm²)



In-orbit observations

Spectra of Vega and Betelgeuse were convolved with effective area models to predict count rates

Vega observations (cts s⁻¹)
A0V, V = 0.03

Date	HRC-I	HRC-S	HRC-S	HRC-S	HRC-S	HRC-S
		Chip 2 thick	Chip 2 thin ¹	Chip 2 thin ²	Chip 3 thin	Chip 1 thin
10/99	$< 7 \times 10^{-4}$	0.16 +/- 0.01	253.0 +/- 0.4		483.5 +/- 0.7	
6/00	$< 7 \times 10^{-4}$	0.15 +/- 0.01				
8/6/00			248.1 +/- 0.4		486.8 +/- 0.7	
2/01	$< 1 \times 10^{-3}$	0.14 +/- 0.01		176.4 +/- 0.3		433.6 +/- 0.7
8/01	$< 7 \times 10^{-4}$	0.16 +/- 0.01		172.6 +/- 0.3		427.7 +/- 0.6
2/02	$< 2 \times 10^{-3}$	0.16 +/- 0.01		169.5 +/- 0.2		428.1 +/- 0.6
Prediction	7×10^{-4}	1.0	400	400	2000	2000

- 1 image located at end of segment near chip 3
- 2 image located at end of segment near chip 1

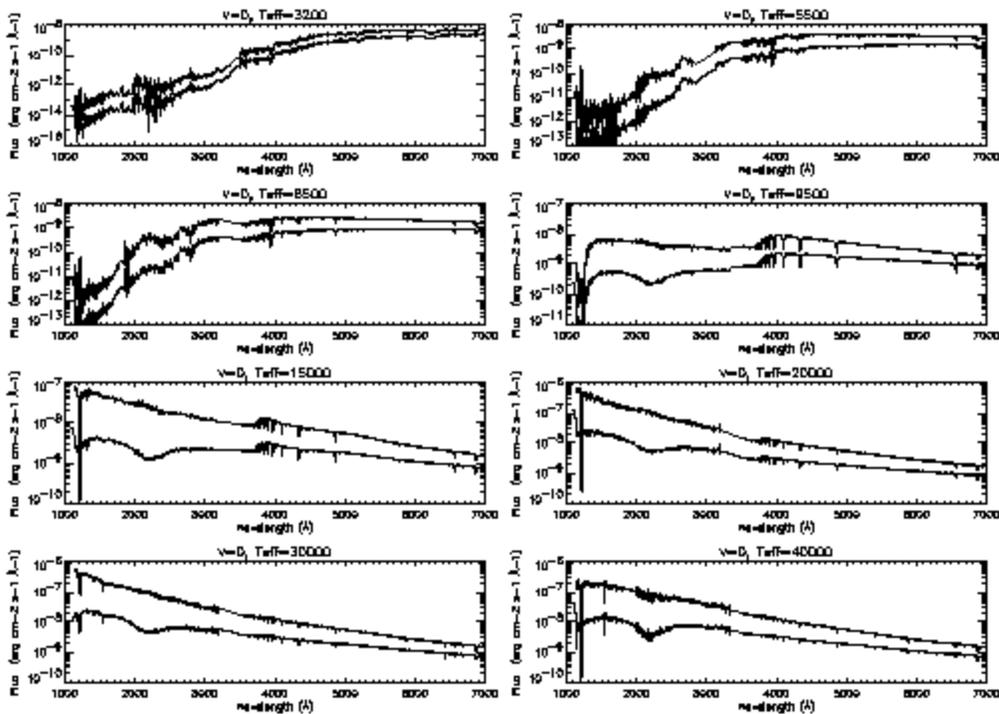
Betelgeuse observations: (ct s⁻¹)
M1I, V = 0.50

Date	HRC-I	HRC-S	HRC-S	HRC-S	HRC-S	HRC-S
		Chip 2 thick	Chip 2 thin ¹	Chip 2 thin ²	Chip 3 thin	Chip 1 thin
12/01	$< 1 \times 10^{-3}$	$< 3 \times 10^{-3}$		$< 2 \times 10^{-3}$		0 +/- 0.03
Prediction	1.3×10^{-6}	1.4×10^{-5}	1×10^{-2}	1×10^{-2}	0.05	0.05

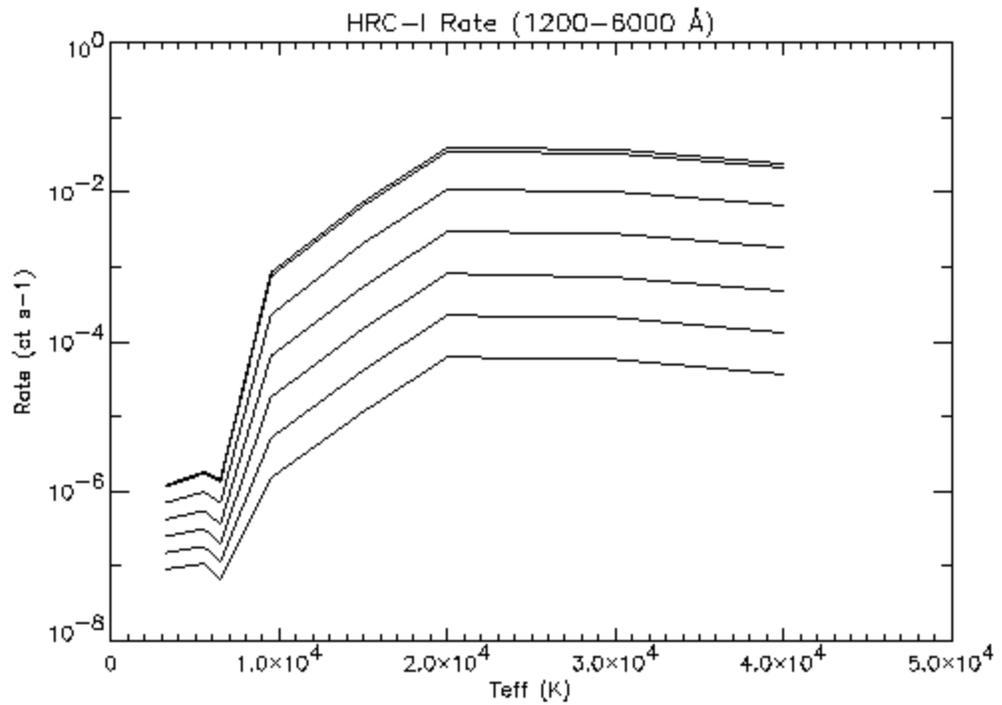
Prediction of UV/Visible count rates for any star for which T_{eff} , V , and N_{H} are known.

Sample stars covering a wide temperature range were used to generate universal count rate curves.

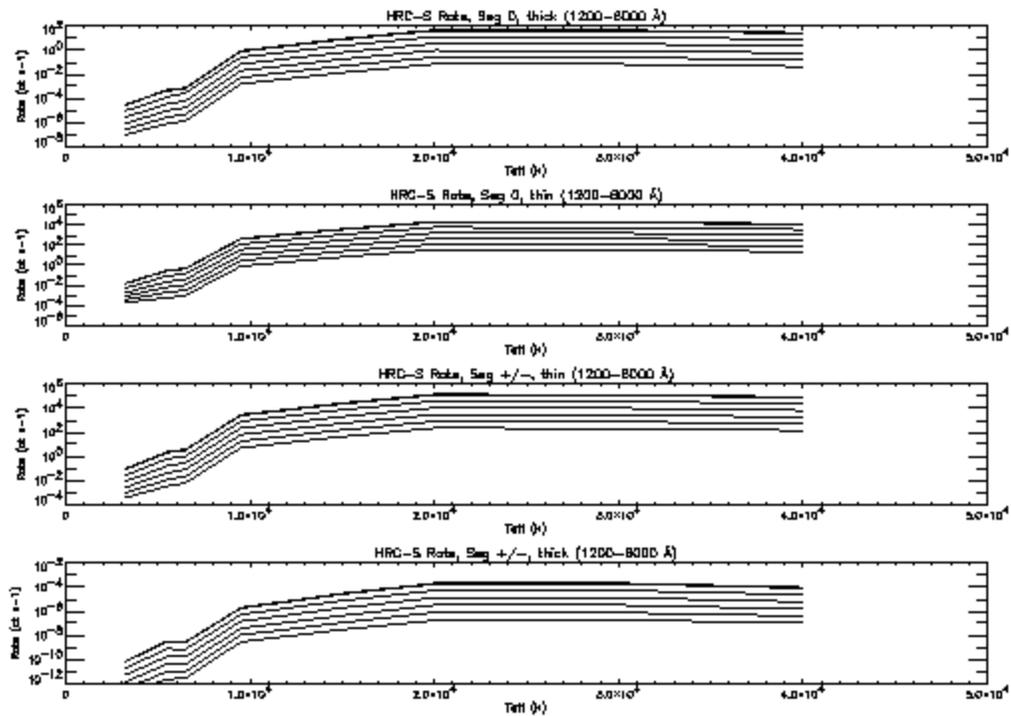
Star	HR	HD	Sp	V [mag]	T_{eff} [K]	$\log(N_{\text{H}})$ [cm^{-2}]	IUE Spectra
ν ORI	8023	199579	O6V	5.96	40000	21.04	SWP09429, LWP03855
λ LIB	1855	36512	B0V	4.62	30000	20.35	SWP08164, LWR07097
35 ERI	5902	142096	B2.5V	5.03	20000	21.09	SWP42326, LWR10778
Vega	1244	25340	B5V	5.28	15000	20.06	SWP49909, LWP27312
70 TAU	7001	172167	A0V	0.03	9500	18.00	SWP27024, LWP07904
V911 TAU	1391	27991	F7V	6.46	6500	19.00	SWP09853, LWR06639
		28099	G6V	8.12	5500	19.00	SWP09873, LWP02601
Betelgeuse	2061	39801	MII	0.50	3200	19.80	SWP37517, LWP19982



UV/Visible spectra of the sample stars (dereddened and normalized to $V=0$). The lower curve for each panel is the same spectrum attenuated by an N_{H} of $2 \times 10^{21} \text{ cm}^{-2}$.



Predicted HRC-I rates for stars normalized to $V = 0$ (dereddened) as a function of T_{eff} and for $N_{\text{H}} = 1 \times 10^{19}, 1 \times 10^{20}, 1 \times 10^{21}, 2 \times 10^{21}, 3 \times 10^{21}, 4 \times 10^{21}, 5 \times 10^{21} \text{ cm}^{-2}$ (top to bottom).



Predicted HRC-S rates for stars normalized to $V = 0$ (dereddened) as a function of T_{eff} and for $N_{\text{H}} = 1 \times 10^{19}, 1 \times 10^{20}, 1 \times 10^{21}, 2 \times 10^{21}, 3 \times 10^{21}, 4 \times 10^{21}, 5 \times 10^{21} \text{ cm}^{-2}$ (top to bottom).

To find the UV/Visible count rate for a star of apparent visual magnitude V , multiply the value obtained for a specific T_{eff} and N_{H} by $10^{-(V - 3.2E(B-V))/2.5}$, where $E(B-V)$ is the star's color excess.

Bibliography

Barbera, M., *et al.*, “In-flight Calibration of the ROSAT HRI Ultraviolet Sensitivity”, *Ap. J.*, **545**, 449, 2000.

Zombeck, M.V., *et al.*, “*The Out-of-band Response of the HRC on Chandra*”,
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