# AXAF Science Center

**Harvard–Smithsonian**
**Center for Astrophysics**

**MEMORANDUM**

May 14, 1996

**To:** Distribution

**From:** M. Juda

**Subject:** New HRC UV/Ion Shields

File: /data/juda1/juda/asc/hrc/tex/hrc_model_uvis_2.tex

## 1 Introduction

During transmission measurements of a flight type HRC-I UV/Ion shield a high transmission was found for the 2537 $\AA$ line from a Hg lamp. Further measurements of the transmission featured resonance transmission peaks[1]. Subsequent modeling of the HRC-I UV/Ion shield design[2] showed that the high transmission could be understood as originating from Fabry-Perot interference effects caused by the Al/Lexan/Al sandwich construction of the UV/Ion shield. This discovery has lead to a redesign of the flight UV/Ion shields for both the HRC-I and HRC-S. The basic fix is to replace the Lexan of the original design with polyimide, a material that is more UV absorbing. Additionally for the HRC-I UV/Ion shield, the aluminum coating on the side close to the MCP is changed to carbon.

## 2 New UV/Ion Shield Design

There are actually four UV/Ion Shields in the HRC, one for the imaging detector and three for the spectroscopy detector. Among these four there are three different material geometries and several thickness combinations. Figure 1 shows the physical layout of the new UV/Ion shield design with the currently planned material thicknesses labeled while table 1 lists the new baseline material thicknesses. The thick aluminum for the outer segments is designed to be used as a low energy suppression filter; it absorbs the expected first order diffracted x-rays with at least a factor of ten attenuation relative to the transmission in the thin aluminum region. A pair of spectra, one taken

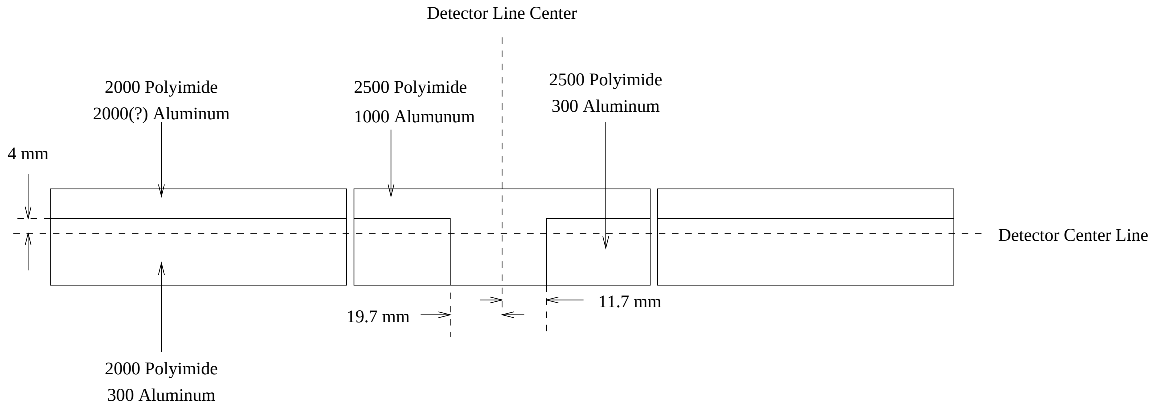


Figure 1: Physical layout of the new design for the HRC UV/Ion shields.

Table 1: HRC UV/Ion Shield Thicknesses

| Detector | Polyimide (Å) | Aluminum (Å) | Carbon (Å) |
|---|---|---|---|
| HRC-I | 5000 | 700 | 200 |
| HRC-S Inner "T" | 2500 | 1000 | 0 |
| HRC-S Inner | 2500 | 300 | 0 |
| HRC-S Outer | 2000 | 300 | 0 |
| HRC-S Outer "Strip" | 2000 | 2000 | 0 |

off the thick aluminum strip and one on, may be used to disentangle the higher order contributions to the source spectrum from first order. It is unclear a present whether the thick aluminum coating can actually be successfully fabricated; mechanical stresses at the edge of the thick coating may damage the polyimide membrane.

# 3 X-Ray Transmission

The x-ray transmission as a function of energy of one of the UV/Ion shields can be calculated given the elemental composition of its constituents, the density and thickness of each, and the atomic mass absorption cross sections. The polyimide formulation used for the HRC UV/Ion shields has a chemical stoichiometry $C_{14}H_6N_2O_4$ and a density of 1.4 g cm$^{-3}$. Bulk aluminum and carbon have densities of 2.7 g cm$^{-3}$ and 2.2 g cm$^{-3}$ respectively. The "as deposited" aluminum density is closer to 2.5 g cm$^{-3}$. Atomic mass absorption cross sections have been tabulated[3] and are accessible through the `saolib` routine `rdacon` and the script `atcon`. I have written a program to produce transmission curves of aluminum and carbon coated films of Lexan and/or polyimide. The executable can be found in:

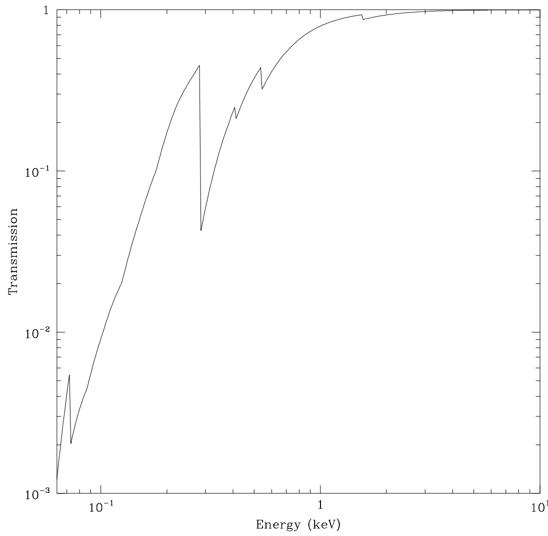


Figure 2: HRC-I UV/Ion Shield transmission as a function of energy. The calculation is for the baseline design with 5000 Å of polyimide, 700 Å of aluminum, and 200 Å carbon.

`/data/juda1/juda/asc/hrc/code/uvis/new_uvis_x_trans`.

This routine asks whether to include a material (Lexan, polyimide, aluminum, aluminum oxide, and carbon) and prompts for thicknesses in angstroms.

Figure 2 is the x-ray transmission as a function of energy for the new design of the HRC-I UV/Ion shield. Figures 3–6 are similar to figure 2 but for the UV/Ion Shields over the inner and outer segments of the HRC-S in areas with both the thin and thick aluminum coating. ASCII text files containing these calculated transmissions can be found in the directory

`/data/juda1/juda/asc/hrc/models/uvis`

in the files

| | |
|---|---|
| HRC-I | `uvis_x_polyimide5000_al700_c200` |
| HRC-S Inner "T" | `uvis_x_polyimide2500_al1000` |
| HRC-S Inner | `uvis_x_polyimide2500_al300` |
| HRC-S Outer | `uvis_x_polyimide2000_al300` |
| HRC-S Outer "Strip" | `uvis_x_polyimide2000_al2000` |

In practice the actual thicknesses for each of the materials will be determined by comparison of transmission measurements taken at several energies to model calculations such as these.

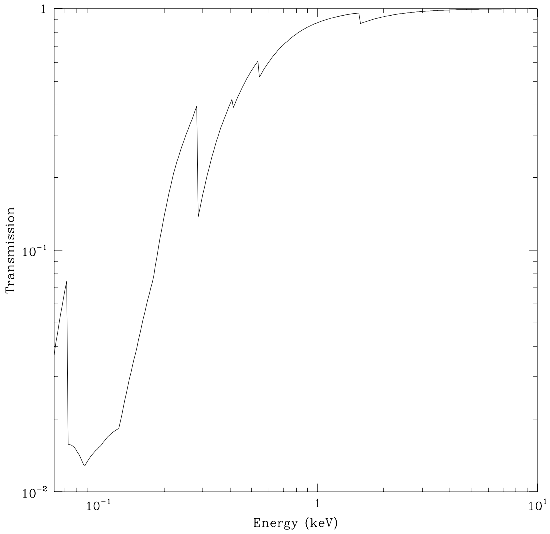


Figure 3: Transmission as a function of energy for the UV/Ion Shield over the "T" section of the inner segment of the HRC-S. The transmission is calculated for the baseline design with 2500 Å of polyimide and 1000 Å of aluminum. This is the UV/Ion shield transmission for the zeroth order spectroscopy image as well as the backup imaging detector.

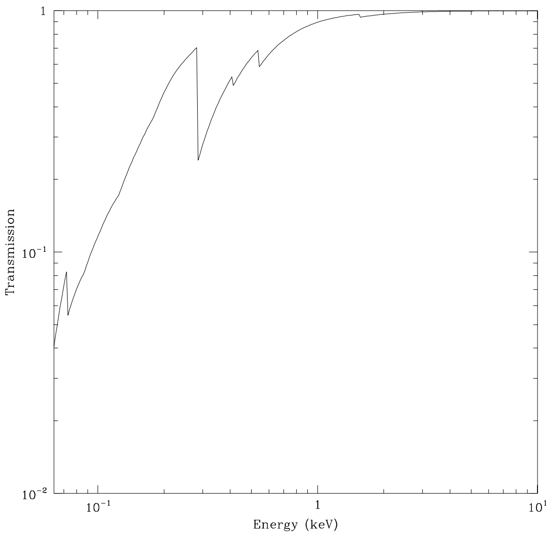


Figure 4: Transmission as a function of energy for the UV/Ion Shield over the non-"T" section of the inner segment of the HRC-S. The transmission is calculated for the baseline design with 2500 Å of polyimide and 300 Å of aluminum.

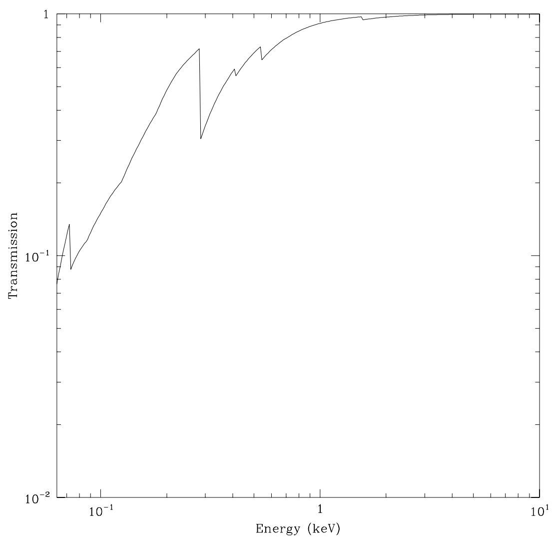


Figure 5: Transmission as a function of energy for the UV/Ion Shield over the thin aluminum section of the outer segment of the HRC-S. The transmission is calculated for the baseline design with 2000 Å of polyimide and 300 Å of aluminum.

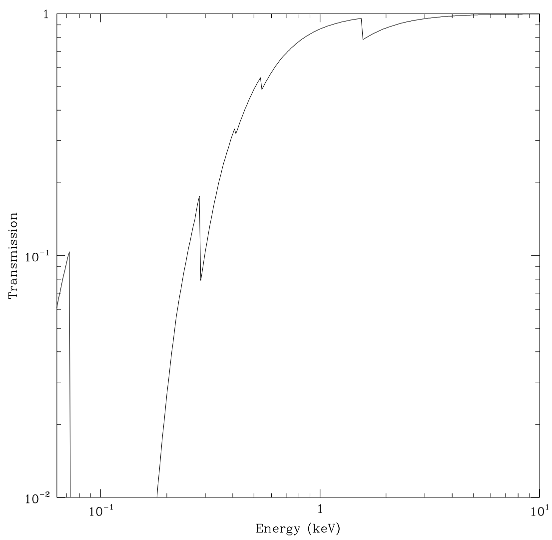


Figure 6: Transmission as a function of energy for the UV/Ion Shield over the thick aluminum strip of the outer segment of the HRC-S. The transmission is calculated for the baseline design with 2000 Å of polyimide and 2000 Å of aluminum.

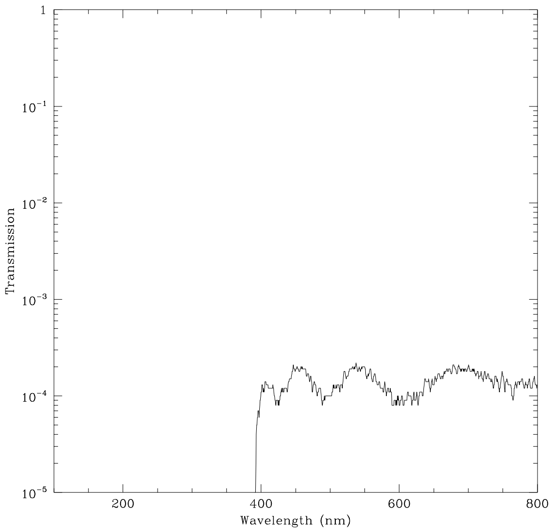


Figure 7: Transmission as a function of wavelength in the UV and visible for a sample filter similar to the new HRC-I UV/Ion shield design.

## 4 UV Transmission

The UV transmission of the UV/Ion shield can be calculated by modeling it as a multi-layered interference filter[2]. The complex indices of refraction as a function of wavelength of the constituent materials must be input to the model. Unfortunately, the index of refraction as a function of wavelength for polyimide are not well known in the UV. In order to asses the performance of the new HRC-I design, a sample filter was made by the UV/Ion shield vendor. The actual material thicknesses of the sample were 5555 Å polyimide with 705 Å of aluminum on one side and 218 Å of carbon on the opposite side. Figure 7 is a plot of the measured transmission of the sample as a function of wavelength.

## References

[1] Barbera, M., Collura, A., and Dara, A. 1996 March 22, Doc. No. OAPA-R2-96, "Preliminary UV transmission measurements of HRC imaging UV/Ion shield HRC-1007-1 Rev B S/N # 002".

[2] Zombeck, M. MathCAD model: `MULTFILT.MCD`, "Transmission of Multilayers".

[3] Henke, B. L., Gullikson, E. M., & Davis, J. C. 1993, *Atomic Data and Nuclear Data Tables*, **52:2**, 181.