3.2.6 In-Flight QE/EA Verification

The on axis EA of the HRC-I/HRMA is presented in Figure 11. It is the product of the above discussed subassembly calibration models.

The inflight verification of HRC-I Quantum Efficieny (QE) and Effective Area (EA) presents a challenging problem. Celestial X-ray sources have complex spectra and many of these sources are temporally variable. Furthermore, the HRC detectors have very limited ($\frac{\Delta E}{E} \sim 1$) energy resolution and can not independently determine the nature of the input spectrum.

Two techniques for inflight QE and EA verification will now be discussed. At present only one of these techniques has been implemented for the HRC-I. The two techniques are a broad band verification over an entire input spectrum and narrow band verification using either the LETG or HETG.

Narrow band verification has been performed successfully with the HRC-S detector and the results are presented elsewhere in these proceedings[5,6]. In this narrow band technique, a well known source such as the white dwarf HZ43 is observed with the transmission gratings. The dispersed spectrum in conjunction with the mirror, grating, and source spectrum models allows one to make an in-flight measurement of QE. This measurement can then be used to verify the preflight model. Since the HRC-I is only considered as a backup grating readout, no such appropriate grating observations have yet been made.

The broad band technique relies on examining sources that are not temporally variable and for which a spectrum is known or can be determined. Ideal candidates are supernova remnants (SNRs) that have been observed with other instruments on the CXO (ACIS) or by other X-ray observatories. For the present analysis, we present results for Cassiopeia A and G21.5-09, two SNRs that have been observed during the calibration phase of the CXO mission with both the ACIS and the HRC-I detectors.

A region of the source image observed with ACIS is analyzed using the Chandra X-ray Science Center (CXC) spectral fitting tools (SHERPA)[29]. Using a counts spectrum and the appropriate response matrices for the observation, an incident photon spectrum is determined. This photon spectrum is multiplied by the HRC-I effective area and integrated to determine a predicted rate. This predicted rate is then compared with the actual rate obtained from the identical region of the HRC-I observation. The technique and the results are pictorially presented in Figures 12 and 13; the plots show the ACIS counts spectra, the photon spectra and the measured and predicted rates. The results are remarkably close given the uncertainties in determining spectra. The larger discrepancy for Cas A is understandable given the size and the spatial and spectral complexity of the source. The HRC-I broad band effective area verification has also been compared with HRC-S observations of

Source	HRC-I predicted rate	HRC-I measured rate	HRC-S predicted rate	HRC-S measured rate
Cas A	$10.cts\ s^{-1}$	$9.3cts\ s^{-1}$	$8.9cts\ s^{-1}$	$8.2cts\ s^{-1}$
G21.5-09	$0.50cts\ s^{-1}$	$0.51cts\ s^{-1}$	$0.37cts\ s^{-1}$	$0.36cts\ s^{-1}$

Table 4: Results of broad band EA verification. Comparison of predicted and measured rates of HRC-I and HRC-S.

the same two sources, G21.5-09 and Cassiopeia A. The results are presented in Table 4 and in (R. Kraft *et.al.* 2000) [5]. The rates are in agreement with the respective HRC-I and HRC-S effective area models. This broad-band QE verification will be an ongoing process throughout the entire CXO mission as more HRC-I observations are made.