A New Flight Model of the HRC-I MCP Quantum Efficiency

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Abstract

We present a new flight model of the HRC-I MCP quantum efficiency. Using several astrophysical sources, we have updated the original flight model to reflect the true broadband performance of the detector. In addition, we have adapted the relative response of the HRC-S at low energies (kT $\prec$ 626 eV) in order to improve the detailed relative response of the HRC-I which previously was poorly known. The new model more accurately represents our knowledge of the in-flight performance of the HRC-I and has significantly lower uncertainties at low energies relative to the original flight model.

Analysis of Orbital Data

The broadband orbital data used to update the original flight model derives from repeated observations of three x-ray sources which radiate in generally distinct regimes: G21.5-0.9 ($\geq$ 1 keV), Cas A (0.7 - 2.5 keV), and HZ43 (0.06 - 0.2 keV). For each observation, a count rate was extracted from the level 2 event list, and compared to a count rate predicted by convolving the source model with the HRMA effective area, UVIS transmission, and original flight model of the MCP QE. From this comparison, we generated a set of smoothly varying scale factors that we used to normalize the original flight model to the orbital data, creating a composite measurement of the detector response.

The composite measurement of the detector response is plotted alongside the original flight model with its associated uncertainty envelope and the pre-launch calibration data points in Figure 1.

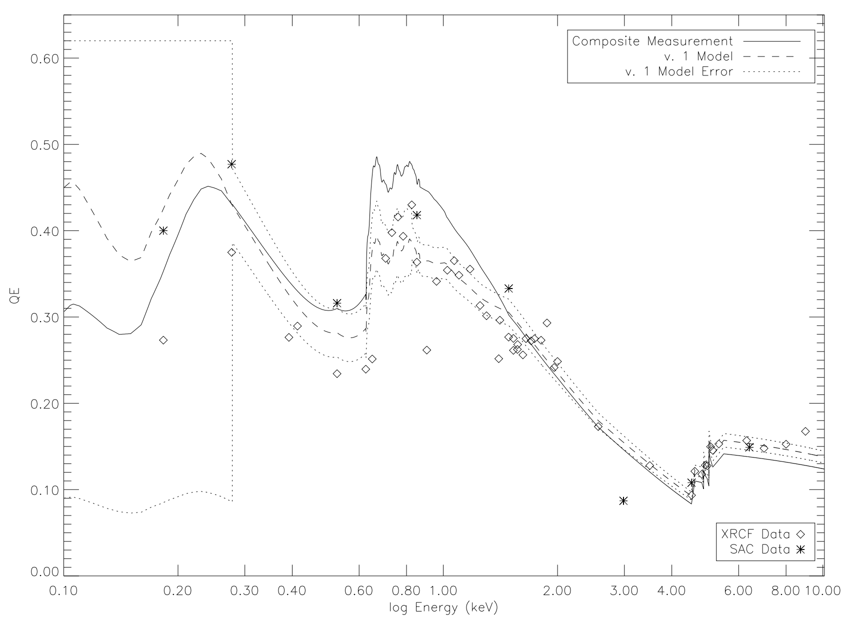


Figure 1: Ground Calibration Data, Composite Measurement, and Original QE Model

Updating the Original Flight Model

In order to combine the many discrete and well understood data points taken during ground testing with the orbital data, we combined the original flight model and the composite measurement of the flight response using standard error-weighted averaging techniques. This intermediate model (version 2.0) emphasizes the flight data at low energies, where there is a high uncertainty in the original flight model, but retains the very high resolution and quality data collected during ground testing at intermediate energies, where our new measurements are less certain. In the higher energy regime, the new model incorporates both measurements with approximately equal weight.

The uncertainty estimates for version 2.0 were calculated using the same error-weighting techniques, and most noticeably result in a large reduction of the uncertainties at lower energies relative to the original flight model.

Creating the New Flight Model

As a final refinement to the new response model, we have adapted the HRC-S QE model version 2.1 for use as a shape factor at energies below 626 eV where the previous relative response of the HRC-I was poorly known. This energy marks the beginning of a region where we currently have no observational data since Cas A emits primarily above 626 eV and HZ 43 emits primarily below 277 eV. We normalized the HRC-S QE model to that of the HRC-I below 626 eV. The new HRC-I QE model version 2.1 is the composite of this normalization below 626 eV and the unchanged v. 2.0 model above 626 eV. In Figure 2, we show a comparison of HRC-I QE models versions 2.0 and 2.1 below 1 keV.

The new MCP QE model is shown in Figure 3, with error bars and the original flight model. A new version of the total detector effective area was made by convolving the new QE model with the UVIS transmission and HRMA effective area models. This HRC-I EA model v. 2.1 is shown in Figure 4, with a comparison to the original effective area model.

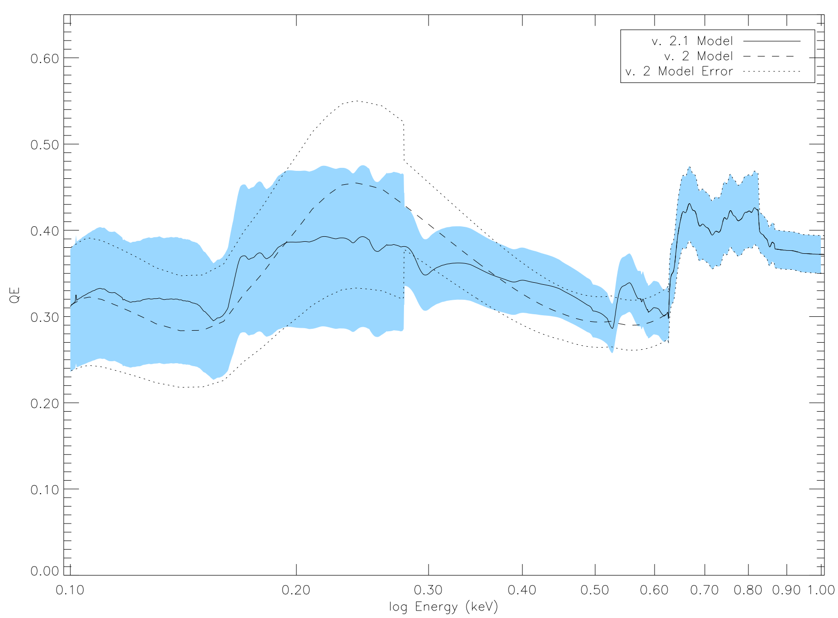


Figure 2: HRC-I QE models v. 2.0 and 2.1 at low energies

Figure 3: HRC-I MCP QE Model v. 2.1

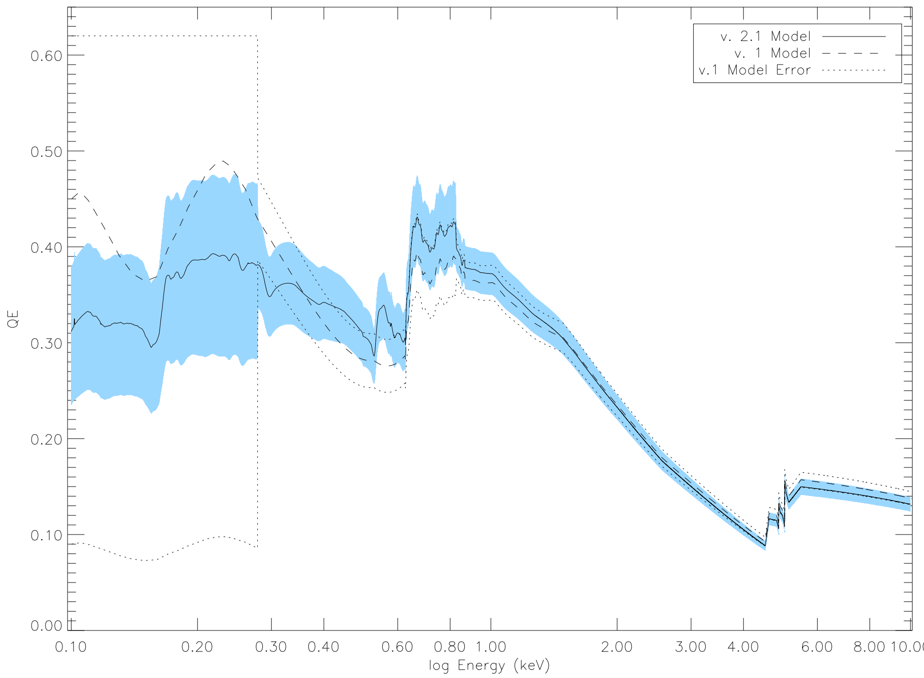
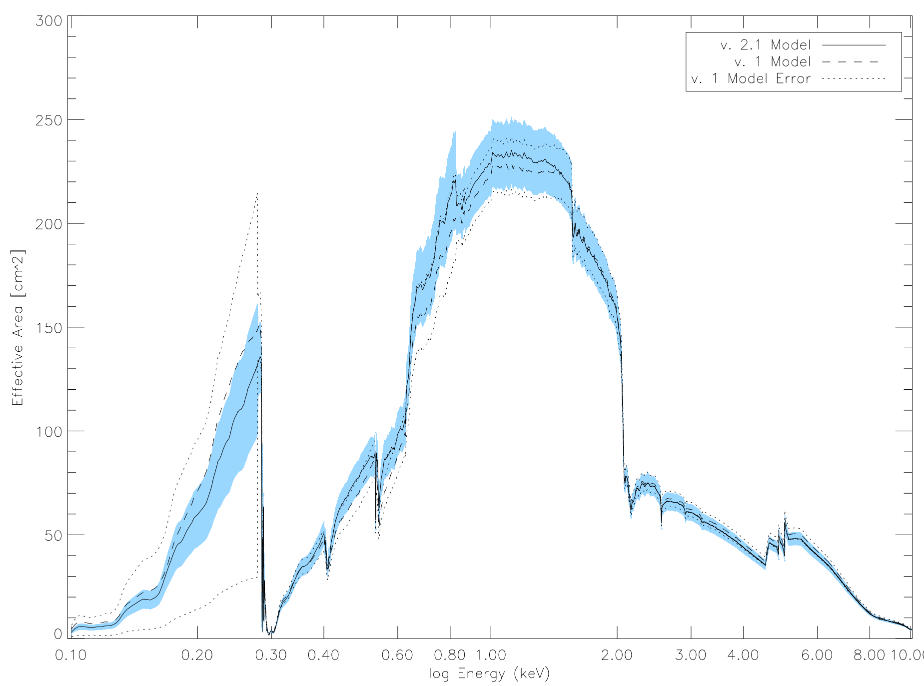


Figure 4: HRC-I EA Model v. 2.1



Conclusion

We present results of the convolution of on-orbit flight data from the HRC-I with previous ground calibration data. The new model (version 2.1) of the detector MCP quantum efficiency more accurately reflects our knowledge of the in-flight performance of the instrument. Independent observations of RXJ1856.5-3754 taken with the HRC-I appear to be consistent with our new flight model (see Wargelin, et al. in same proceedings). Further orbital data may lead to small adjustments in the normalization of the model. However, due to the low energy resolution of the HRC-I, it is unlikely that our model of the detailed relative response of the detector will change in any significant way.