Energy Calibration RXTE/PCA in FTOOLS v5.3 and beyond

Keith Jahoda, GSFC Laboratory for High Energy Astrophysics

Introduction:
A new version of the response generator, `pcarmf v10.1`, will be released shortly as part of the FTOOLS v5.3 distribution. The new version fixes minor bugs, uses calibration data through the summer of 2003, and supplies new energy to channel coefficients and matrix parameters. Better detector to detector agreement is achieved than in the past, as well as better agreement with historical results for the Crab (by design). A draft describing the details of the response matrix and the determination of the parameters is being prepared; the current version is maintained at http://lheawww.gsfc.nasa.gov/~keith/pca_calibration_draft.ps This poster compares results from the imminent FTOOLS v5.3 release with the currently available v5.2, and gives insight into future improvements.

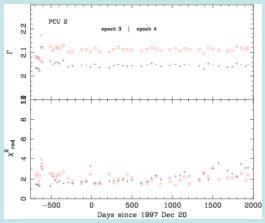
Summary:
Generating the response matrix requires a set of time dependent parameters that relate photon energy to detector channel and a further set of parameters which parameterize the quantum efficiency and detector redistribution function. The approach for the current version of pcarmf has been to determine the two sets of parameters sequentially.

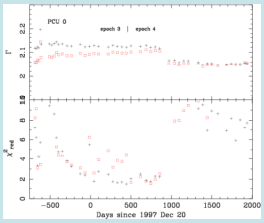
The **energy scale** is monitored by the continuous internal calibration provided by an Am^{241} source providing lines at 13, 17, 21, 26, 30, and 60 keV, by approximately annual observations of Cas-A which contains a bright Iron line at 6.59 keV, and by the regular monitoring observations of the Crab nebula, which offer an opprotunity to measure the energy of the Xenon L-edges. A set of energy to channel conversion coefficients is produced separately for each high voltage epoch.

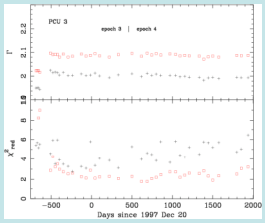
The parameters that describe **quantum efficiency and redistribution** are then fit to individual observations of the Crab. General consistency among many observations is observed, so mission long averages are then determined. The two step process is repeated over a range of one of the parameters which enters the energy to channel relationship. The best value is selected to have the minimum χ^2 residuals in the ensemble of fits to the Crab.

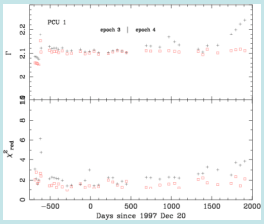
The panels of this poster illustrate
- the mission history of χ^2 as fit to the Crab
- residuals of the fits for a representative date
- the enegy fit to the Cas-A line
- an example of one future improvement

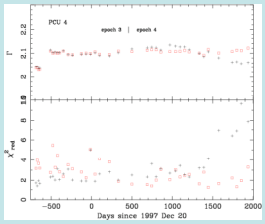
Spectral index from fits to the Crab:
The five figures of this panel show the power-law index fit to the Crab (nebula plus pulsar) as a function of mission time. The red squares gives results for FTOOLS v5.3; the black crosses for v5.2. The lower panels show the reduced χ^2 for fits to the first layer from 3-50 keV. Relative to v5.2, the current version provides more uniform fits from PCU to PCU, incorporates more data, does a better job at late times, and provides a better fit, as measured by χ^2.



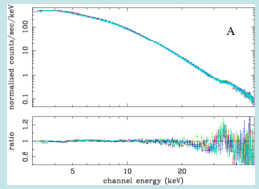


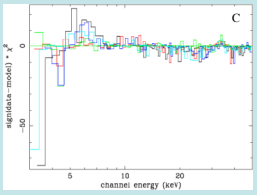


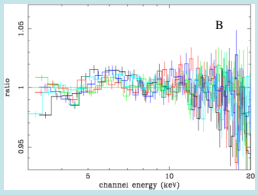


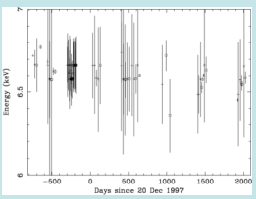


Residuals to power law fits to the Crab:
The upper panel of figure A shows the data and best fit power-law for all five PCU on 1999-02-24; the lower panel shows the ratio of the data to the model. As required for a successful model, the results are similar for each PCU. The data falls below the model above 20 keV, and there is a large feature just below the Xenon K-edge. Figure B provides an magnified view of the ratio below 20 keV, which is within 2% of 1.00 at all energies below 15 keV. Panel C shows the contributions to χ^2, which is dominated by energies below 10 keV where the signal is highest

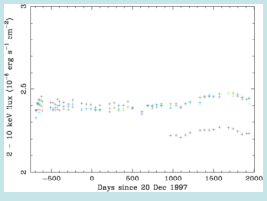








Energy Scale:
This figure shows the energy fit to the Iron line in Cas-A. Different symbols represent different detectors, and the times are slightly offset for clarity. The fits include data from 4-9 keV and fit a narrow gaussian on top of a steep ($\Gamma \sim 3$) power-law. This simple model is adequate for the limited energy range. The emission weighted average energy for this remnant is 6.59 keV, in good agreement with these results.



Normalization:
The default geometric area associated with each PCU has been adjusted upwards, moving derived fluxes downward. The figure shows the 2-10 keV flux fit to the Crab monitoring observations. Except for PCU 0 after the loss of the propane, there is excellent agreement at all mission times with the standard flux (2.4×10^{-8} erg s^{-1} cm^{-2}). The squares show the fluxes derived from the same analysis with FTOOLS v5.2. The new xpcaarf values of geometric area are 1567, 1536, 1563, 1631, and 1598 cm^2.

Future Improvements:
The figure shows the results of an alternate fitting process. For the individual fits to the Crab, the weight associated with each channel is set to the maximum of the Poisson weight and 3%. This ad-hoc prescription increases the apparent χ^2 (modestly) but improves the appearance of the ratio plot. As the un-modified χ^2 is dominated by systematic (un-modeled) effects, the addition of a systematics term is warranted.

Other improvements may require a more complex model for the Crab (the pulsed emission has a harder spectrum than the nebula) and a detailed examination of the physics near the Xenon K-edge