Tests for contamination of the HRMA

Flux-scale transfer

AXAF Project Science

AXAF XRCF Pre-Calibration Review

NASA Marshall Space Flight Center

1996 November 13-15

Summary

Validity of the flux scale requires verification of flux-scale transfer to orbit.

- Focal-plane science instruments (HRC and ACIS) use radioactive calibration sources to verify constancy of detector efficiencies.
- Flight Contamination Monitor (FCM) radioactive sources in the Forward Contamination Cover serve to verify flux-scale transfer.

Changes in molecular contamination alter HRMA effective area by as much as about 0.5% (Δl_{hc}/Å), depending upon x-ray energy.

- Goal is change in thickness $|\Delta l_{hc}| < 4$ Å.
  - $l_{hc} < 42$ Å at XRCF and $l_{hc} < 46$ Å in orbit.

Changes in particulate contamination alter HRMA effective area by about 0.3% ($-\Delta F_{dust}/10^{-5}$).

- Goal is change in fractional areal coverage $|\Delta F_{dust}| < 2.5\ 10^{-5}$.
  - $F_{dust} < 2.5\ 10^{-5}$ at XRCF and $F_{dust} < 5.0\ 10^{-5}$ in orbit.

Primary test for the flux-scale transfer is ACIS-2C imaging of the radioactive calibration sources of the Flight Contamination Monitor (FCM).

Primary test

Neither the XSS nor any BND is used in this test.

FCM radioactive sources are in Forward Contamination Cover (FCC).

- Cd^{109} electron capture results in Ag-Lα (2.98 keV).
- Fe^{55} electron capture results in Mn-Kα (5.90 keV).
- Au-L and other Ag-L and Mn-K lines are present at lower levels.

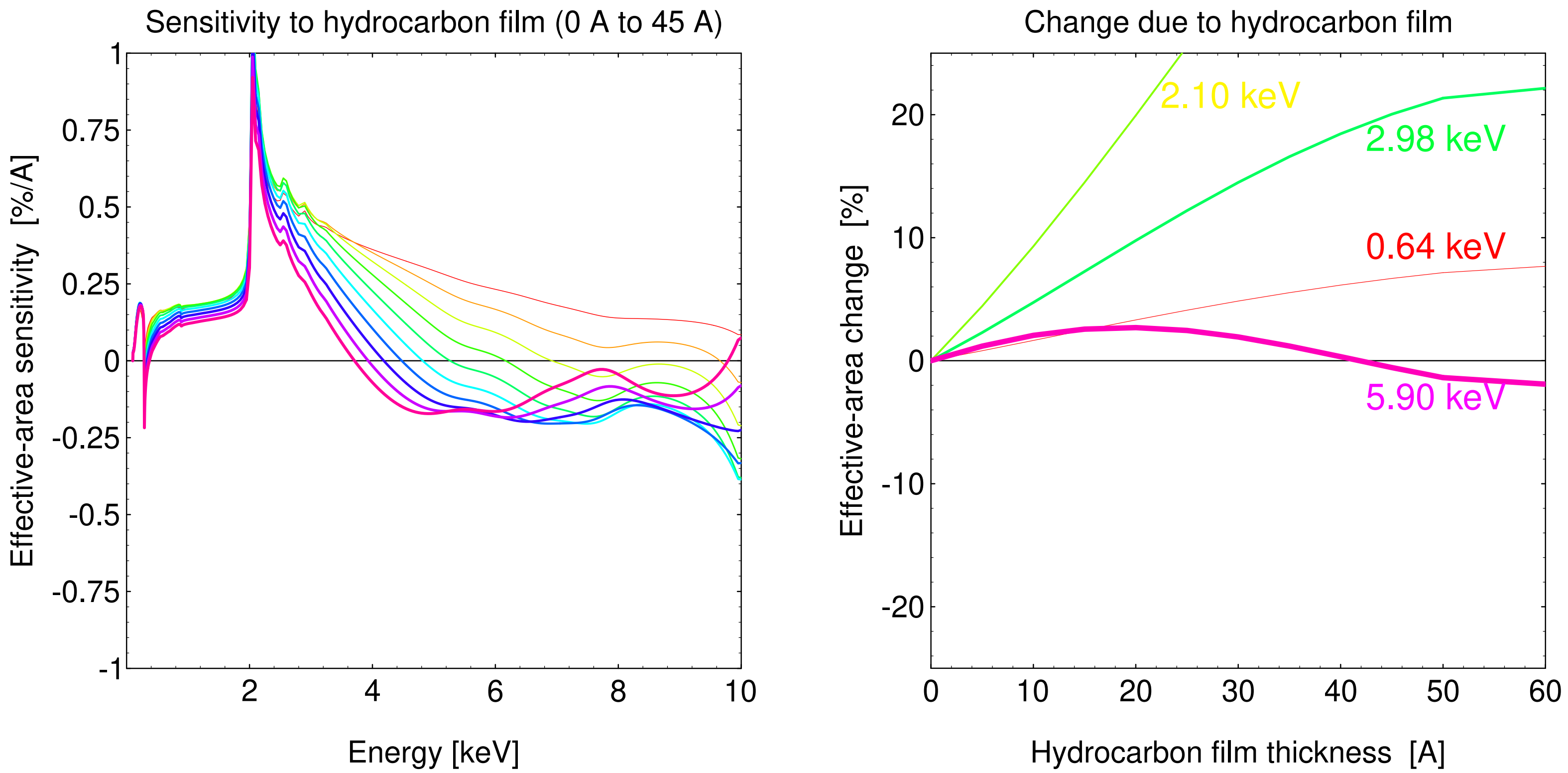
Configure HRMA for FCM measurement.

- Close Forward Contamination Cover (FCC).
- Open Aft Contamination Cover (ACC) and stow OTGs.

FAM positions ACIS-2C as close as possible to ACIS flight location.

- Place ACIS-2C X position as close as possible to HRMA true (infinite-conjugate) focus.
- Place ACIS-2C so that its 2 CCDs are at flight Y and Z positions of central 2 ACIS-S CCDs.

Sensitivity to changes in molecular contamination



Sensitivity of effective area to hydrocarbon film. The plots show (l) energy dependence of fractional change for initial thickness (l_{hc}), from 0 Å to 45 Å, in 5-Å increments, and (r) thickness dependence for 4 x-ray energies, including Ag-Lα and Mn-Kα.

FCM source activities

Parameter	**Units**	**Shell 1**	**Shell 3**	**Shell 4**	**Shell 6**	**HRMA**
Number	shell^{-1}	4	4	4	4	16
Diameter	mm	9.00	7.25	6.40	4.76	
Cd^{109}	mCi source^{-1}	2.2	1.4	1.1	0.6	
Fe^{55}	mCi source^{-1}	3.7	2.4	1.9	1.1	
Subtotal	mCi source^{-1}	5.9	3.8	3.0	1.7	
Total	mCi	23.6	15.2	12.0	6.8	57.6

Initial Flight Contamination Monitor (FCM) source activities (mCi).

- Cadmium Cd^{109} electron capture results in the silver Ag-L lines.
  - Half life is about 1.3 years.
- Iron Fe^{55} electron capture results in the manganese Mn-K lines.
  - Half life is about 2.6 years.

Source activities for each shell are scaled to geometric area of the shell.

FCM count rates at centered CCD quadrant

Line	E (keV)	Shell 1	Shell 3	Shell 4	Shell 6	HRMA
Ag Lα	2.98	2.22	1.63	1.27	0.66	5.78
Ag Lβ1	3.15	0.54	0.40	0.31	0.16	1.42
Ag Lβ2	3.35	0.13	0.10	0.07	0.04	0.34
Mn Kα	5.90	0.48	3.31	2.94	2.23	8.95
Mn Kβ	6.49	0.02	0.20	0.27	0.25	0.74
Total		3.39	5.64	4.86	3.34	17.23

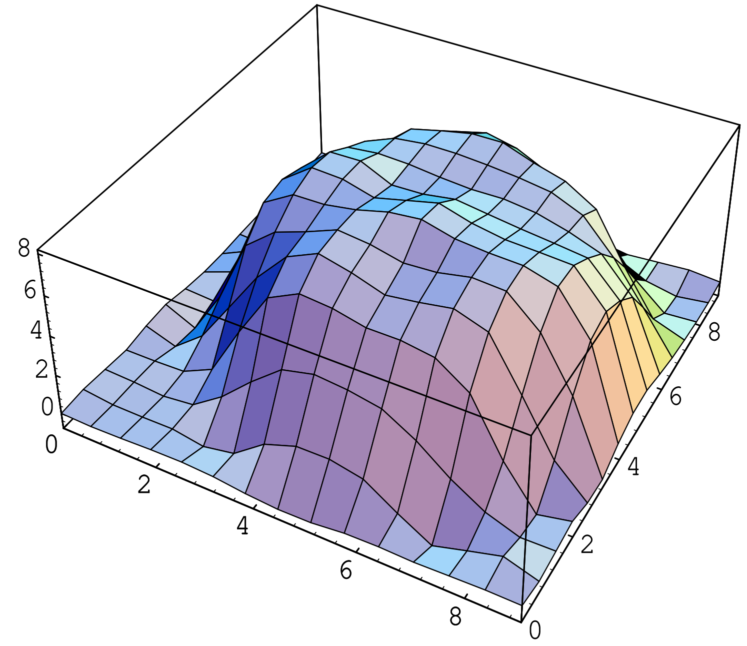
Initial Flight Contamination Monitor (FCM) count rates (ct s^{-1}) for the centered quadrant of a front-illuminated ACIS CCD, at the HRMA true focus

- Silver Ag-L lines originate from cadmium Cd^{109} electron capture.
  - Half life is about 1.3 years.
- Manganese Mn-K lines originate from iron Fe^{55} electron capture.
  - Half life is about 2.6 years.

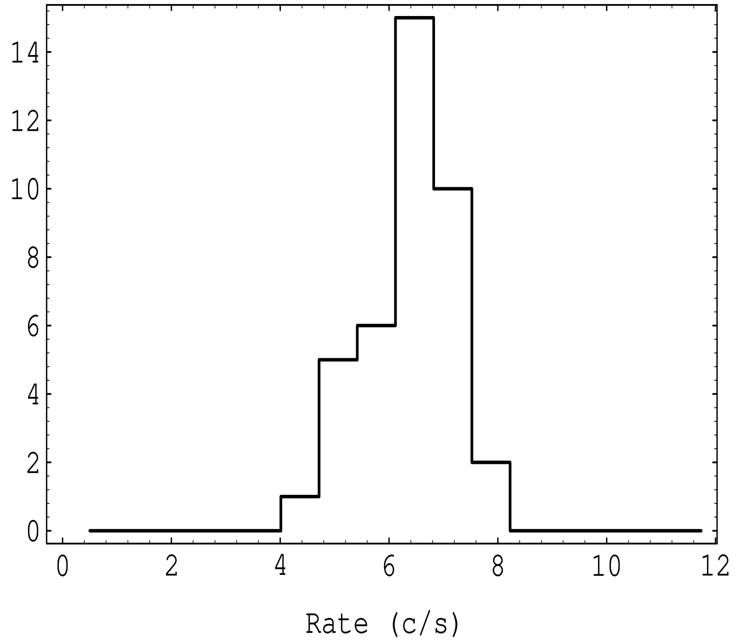
Count rates for a back-illuminated CCD would differ only slightly.

Cadmium-109 source uniformity

Mean Rate = 6.11826 c/s

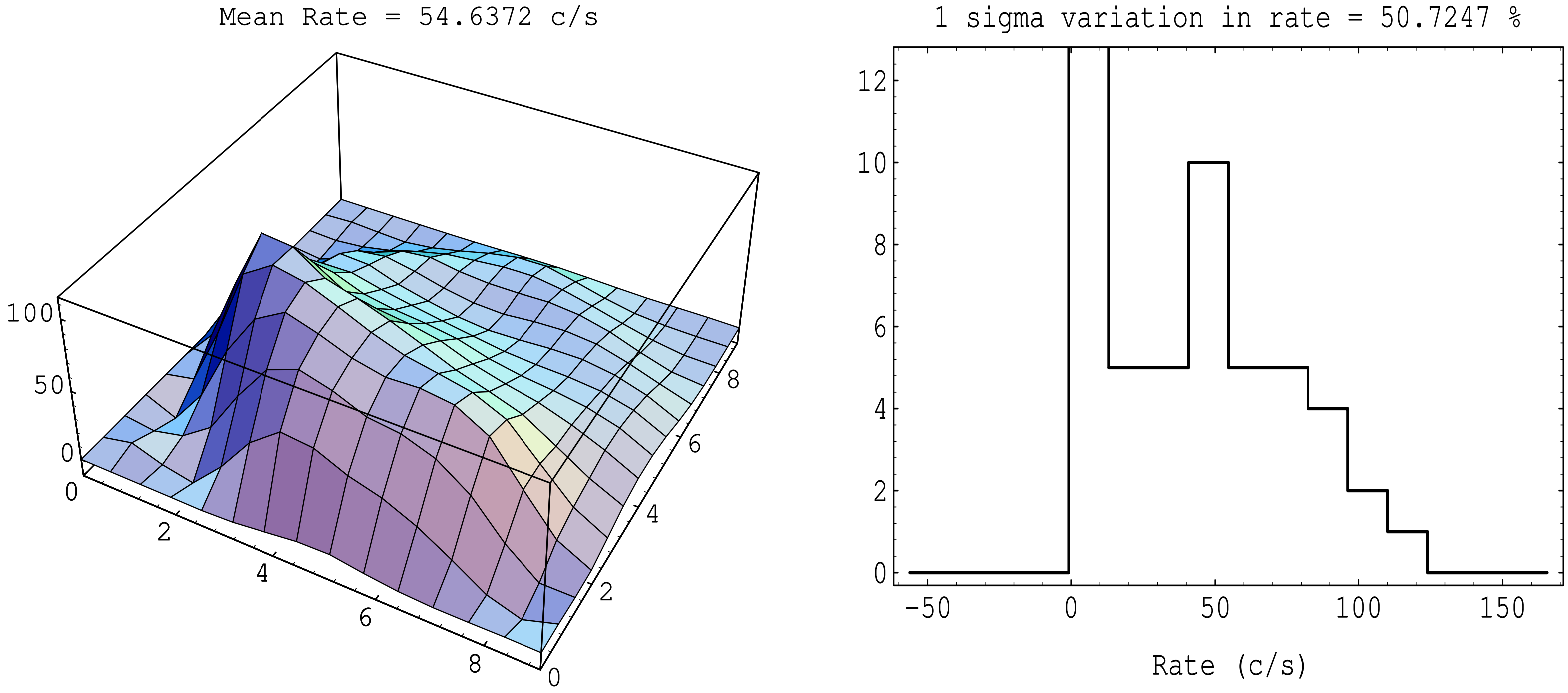


1 sigma variation in rate = 22.953 %



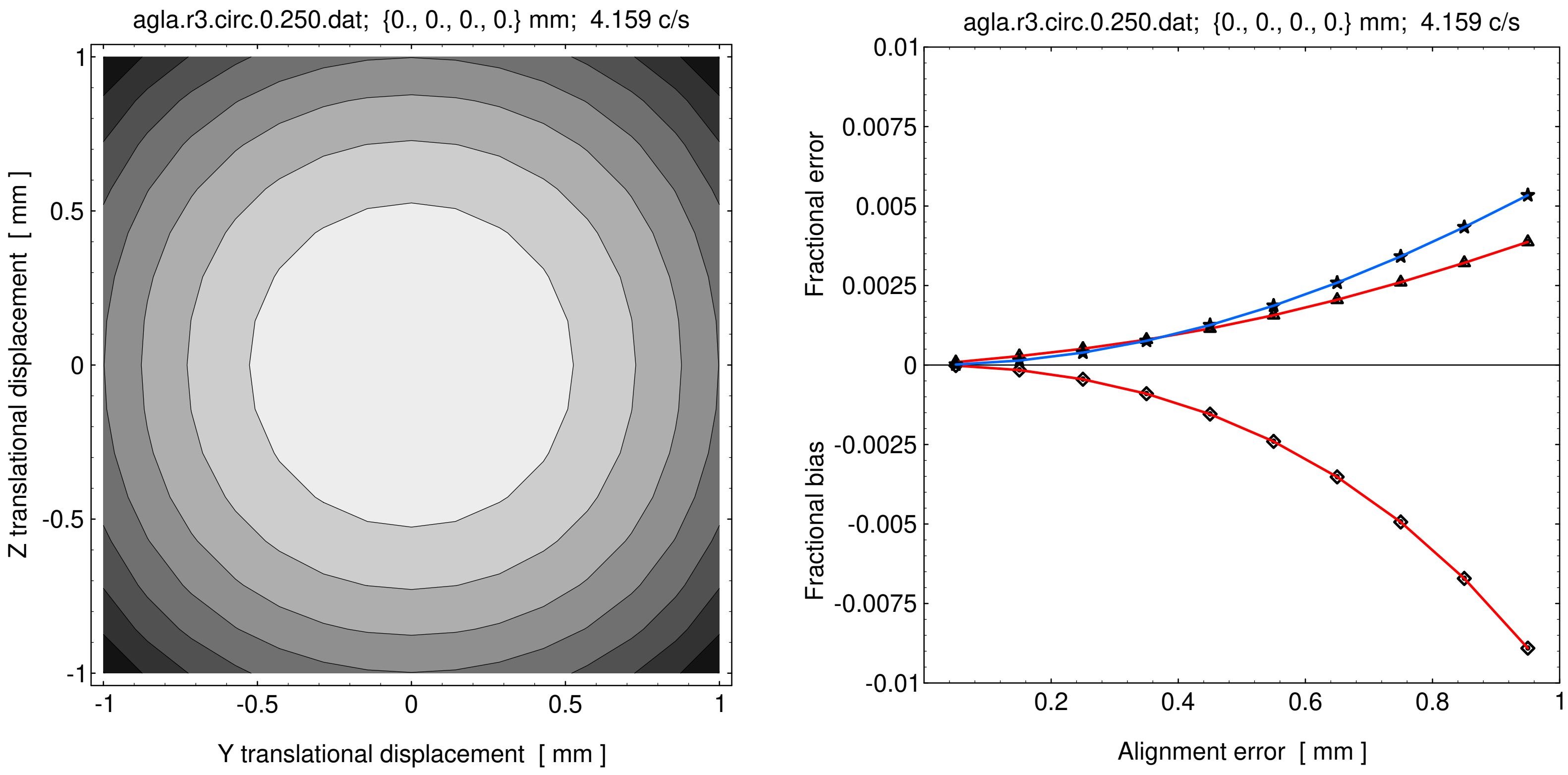
Uniformity measurement of a 9-mm (shell-1) Cd^{109} source at 3.0 keV (Ag-Lα), using a CZT detector with 1-mm aperture. The plots show (l) a surface plot of Ag-L rate and (r) a histogram of the rate variation over the source. Although the cadmium coating is uniform, this source was rejected because of nonuniformity of the iron coating.

Iron-55 source uniformity



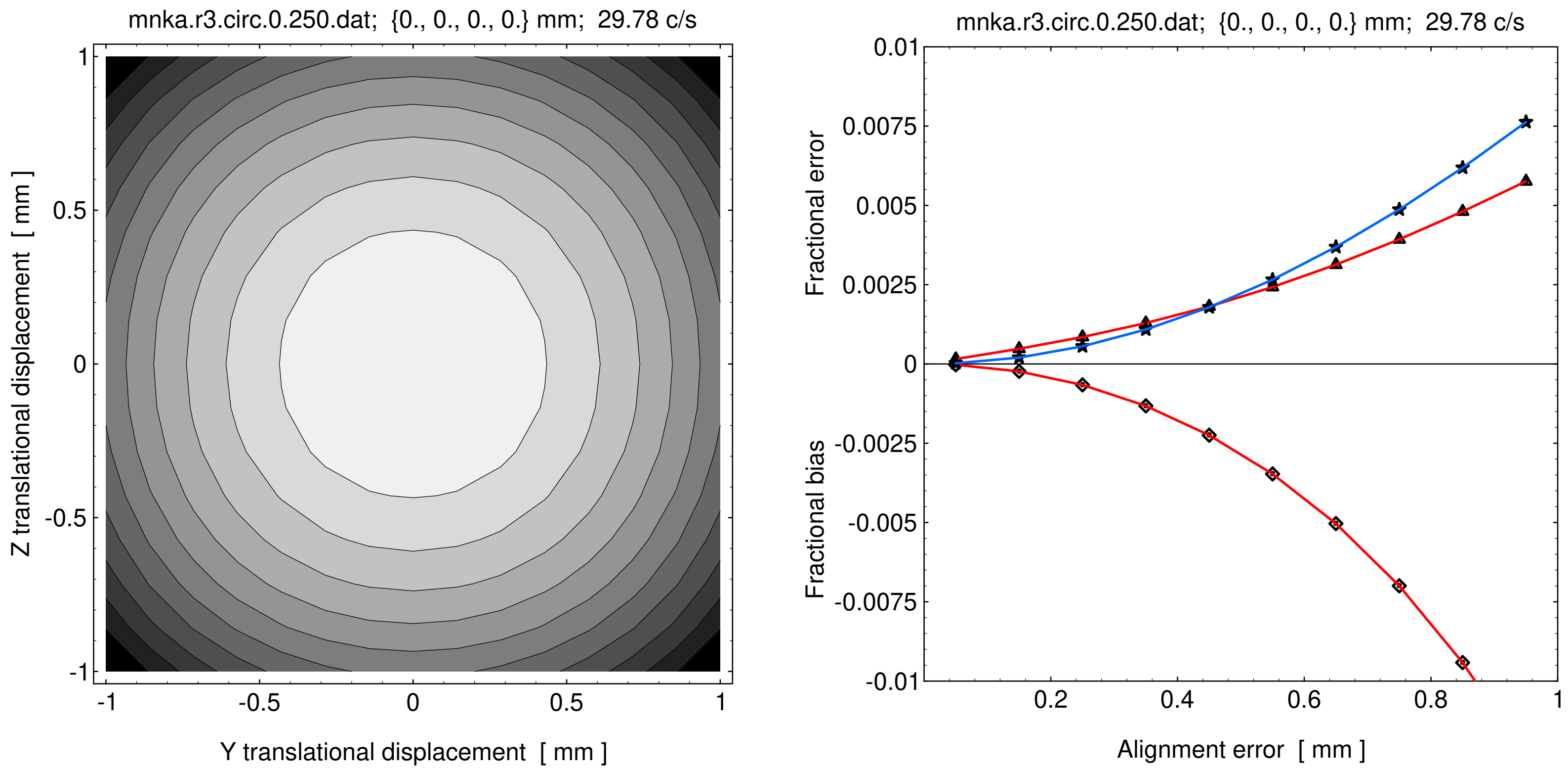
Uniformity measurement of a 9-mm (shell-1) Fe^{55} source at 5.9 keV (Mn-Kα), using a CZT detector with 1-mm-diameter aperture. The plots show (l) a surface plot of Mn-K rate and (r) a histogram of the rate variation over the source. This source was rejected because of the nonuniformity of the iron-55 coating.

Alignment sensitivity for Ag-La



Sensitivity of Ag-Lα (2.98 keV) rate on centered CCD quadrant to source alignment. The figures show (l) a contour plot in -0.1% steps of the sensitivity to translation and (r) the bias and error due to random displacement and the error due to translation.

Alignment sensitivity for Mn-Kα



Sensitivity of Mn-Kα (5.90 keV) rate on centered CCD quadrant to source alignment. The figures show (l) a contour plot in -0.1% steps of the sensitivity to translation and (r) the bias and error due to random displacement and the error due to translation.

Image of FCM sources at HRMA true focus

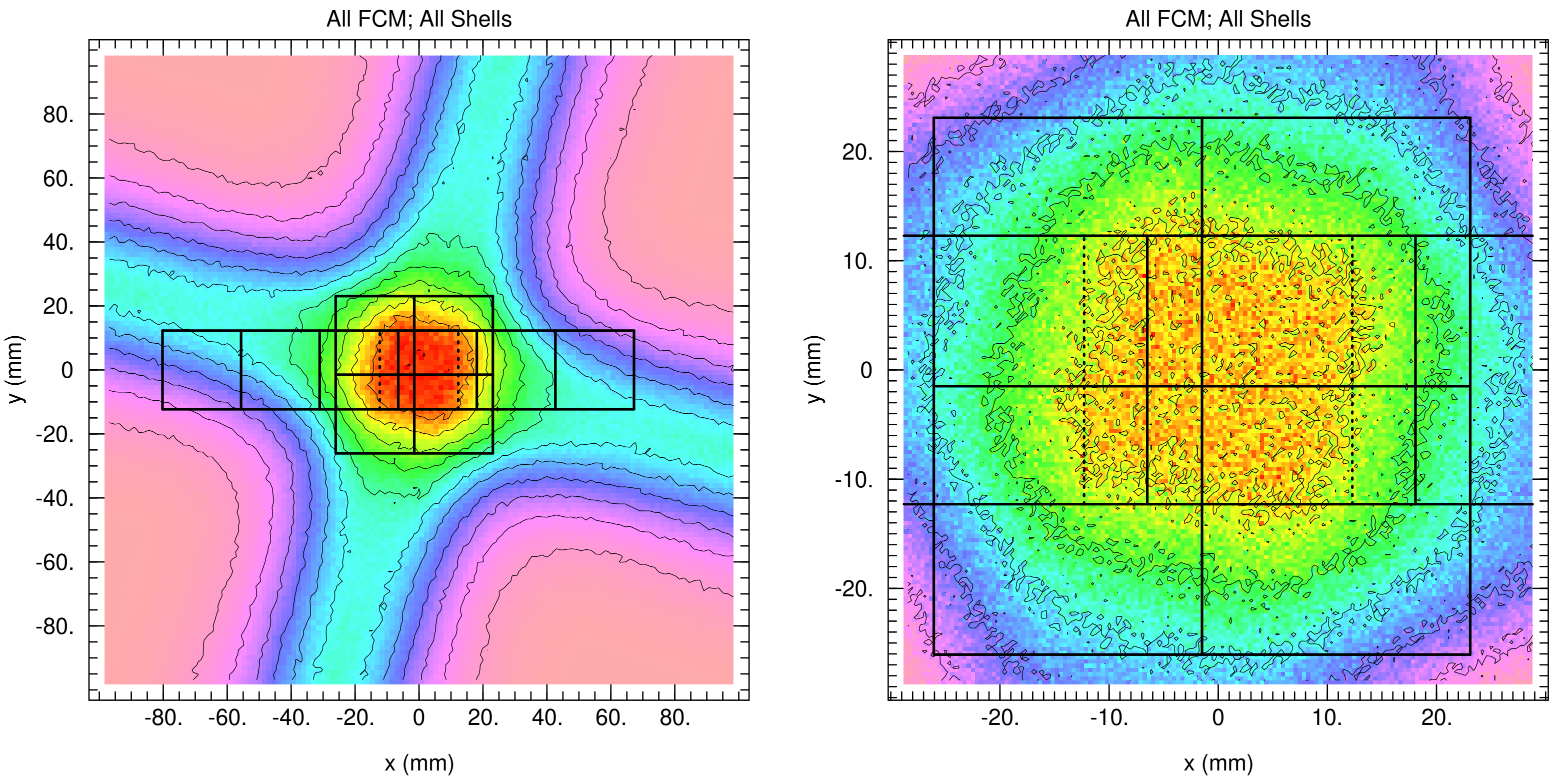


Image of Flight Contamination Monitor (FCM) sources at the HRMA true (infinite-conjugate) focus. Outlined squares represent ACIS CCDs for the ACIS-S (6×1) and ACIS-I (2×2) arrays, the former to be used for the flux-scale transfer.

Image of FCM sources at 25.4 mm beyond HRMA true focus

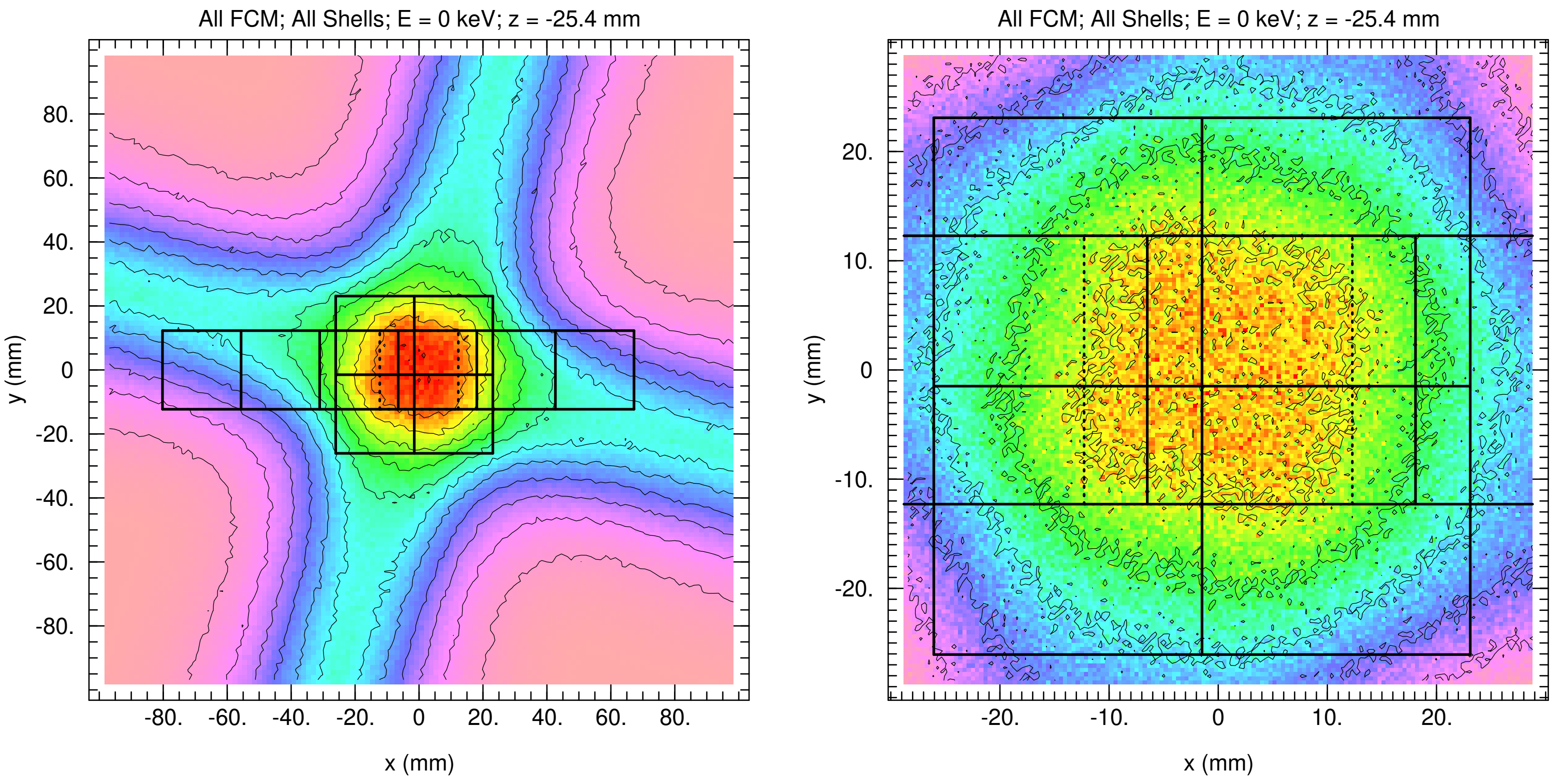


Image of FCM sources at 25.4 mm beyond the HRMA true (infinite-conjugate) focus. Outlined squares represent ACIS CCDs for the ACIS-S (6×1) and ACIS-I (2×2) arrays. Count rate on centered CCD quadrant is 99.2% of value at true focus.