AXAF Science Center

Harvard–Smithsonian
Center for Astrophysics

MEMORANDUM

January 10, 1997

To: Distribution

From: M. Juda

Subject: HRC-I QE measurements

File: /data/juda1/juda/asc/hrc/tex/hrc-i_qe_analysis_1.tex

1 Introduction

During October 1996 the HRC IPI team performed a series of QE measurements on what was considered at the time to be the HRC-I flight unit. This assembly consisted of a CsI coated MCP stack from GEOC (SN 94M0051-23 and 94M0051-28) and an Al/polyimide/C UV/ion shield (Luxel SN 010). During November 1996, the UV/ion shield was found to be too transmitting in the FUV and was replaced. The MCPs also developed a dead spot in the central portion and as a result were also replaced. The new MCP stack was also from GEOC and CsI coated (SN 94M0051-17 and 94M0051-19). The UV/ion shield was Al coated polyimide (Luxel SN 016). QE measurements were performed on this assembly in late November. This memo is a presentation of the first look at the QE vs energy in the "sweet spot" of the HRC-I.

2 Measurement Setup and Procedure

The QE measurements described here were all performed on Pipe #1 in the HRC lab in Porter Exchange. The laboratory set-up and procedures are described in detail in ref [1]; the following is a summary. The HRC-I assembly was mounted on rotational stages in a vacuum chamber at the opposite end of the x-ray pipe from the x-ray source. The source to MCP distance was ~ 705 cm. A gas flow proportional counter, referred to as the BND, was also installed in the chamber with the MCPs. At the source end of the pipe, a second gas flow proportional counter, referred to as the Monitor, was mounted on a short arm perpendicular to the pipe. Sets of filters could be inserted between the source and the pipe and between the source and the Monitor.

The BND and the MCPs were never operated simultaneously, so as to avoid the possibility that a BND window leak would cause a break-down that would damage the MCPs. A QE measurement would start with the MCP HV turned off and the BND and Monitor both filled with gas. The x-ray source would be turned on and operating HV set for both the BND and Monitor. Pulse height distributions would then collected simultaneously from the BND and Monitor. The x-ray source would then be shut off and simultaneous background pulse height distributions collected from the BND and Monitor. The BND HV would then be turned off and the gas pumped out; the Monitor was left on. The MCP HV was then turned on and simultaneous backgrounds collected with the HRC-I assembly and the Monitor. Finally, the x-ray source would be turned on and data collected from the HRC-I assembly and the Monitor.

3 Data Reduction

Data for the QE measurements comes primarily from three sources: the HRC-I, the BND, and the Monitor. Other sources of data are temperature and pressure monitors and mechanical measurements.

The QE of the HRC-I is calculated by comparing the rate in the HRC-I to that in the BND, which has a known QE:

$$QE_{HRC} = QE_{BND} \times \frac{R_{HRC}/\Omega_{HRC}}{R_{BND}/\Omega_{BND}} \times \frac{R_{Mon_{BND}}}{R_{Mon_{HRC}}}$$

where:

QE_{HRC} is the HRC-I QE

QE_{BND} is the QE of the BND

R_{HRC} is the net rate due to the source in the HRC-I

Ω_{HRC} is the solid angle subtended by the HRC-I region

R_{BND} is the net rate due to the source in the BND

Ω_{BND} is the solid angle subtended by the BND

$R_{Mon_{BND}}$ is the net rate in the Monitor during the BND observation

$R_{Mon_{HRC}}$ is the net rate in the Monitor during the HRC observation

3.1 MCP Data

MCP data in the lab are generated in a pseudo-telemetry format. The ASCDS decom tool was used to convert these to QPOE files so that tools available in the ASCDS could be used for analysis. No degapping was performed when converting from raw data to QPOE files. Instrument "on-time" was determined from the number of raw data frames that were successfully processed. A deadtime correction based on the detected event rates was applied to generate a livetime; during the x-ray illuminations the deadtime correction was typically $\sim 5\%$. Only counts in a square box, 5120 pixels on a side, centered on the HRC-I (centered at pixel 7680, 7680) were used for the QE calculation. This region has an area of 10.836 cm^2 and at a distance of 704.9 cm subtends 2.181×10^{-5} steradians. For each QE measurement the net HRC-I rate (difference of the x-ray illuminated rate and background rate) is calculated for the region.

3.2 BND Data

The BND data are pulse height distributions. I am using counts in a region of interest rather than trying to fit the distributions. As a first cut, I have assumed that the spectra fairly clean (a single line with limited continuum) and use the total rate detected in the BND for calculation. (This is not valid for the QE

Table 1: QE of October HRC-I

Energy (keV)	HRC-I QE	Tranmission	MCP QE
0.183	0.055	0.173	0.316
0.277	0.207	0.461	0.448
0.525	0.083	0.403	0.205
0.852	0.267	0.694	0.385
1.487	0.255	0.921	0.276
2.984	0.151	0.980	0.155
4.511	0.122	0.994	0.123
6.404	0.152	0.998	0.152

Table 2: QE of November HRC-I

Energy (keV)	HRC-I QE	Tranmission	MCP QE
0.277	0.244	0.408	0.598
0.525	0.094	0.387	0.242
1.487	0.298	0.931	0.321
6.404	0.166	1.000	0.166

measurement at Be-K so I am ignoring it for this memo). The net BND rate due to x-rays is calculated and converted to photons/sec incident on the detector using models for the BND window and mesh transmission and gas stopping efficiency. The is a circular aperature (dia. = 2.2225 cm) in front of the BND that defines the solid angle it subtends.

3.3 Monitor Data

The Monitor data are also pulse height distributions. Once again, I use the total counts in the detector to determine the rates. The ratio of net Monitor rate observed during the HRC-I data collection to the net Monitor rate observed during the BND data collection is used to correct for variation in the flux from the x-ray source with with time.

4 Results

The tables 1 and 2 give summaries the QE vs energy for the two versions of the HRC-I as well as the derived QE of the CsI coated MCP assemblies accounting for the UV/ion shield transmission. The derived QE of the MCP assembly in the new HRC-I are higher at all of the energies at which the measurements were made but not by the same factor ($\sim$ 30% at 0.277 keV to $\sim$ 8% at 6.4 keV). Tables 3 to 14 give more detailed information about each of the QE derivations.

Table 3: 0.183 keV QE Measurement - 18 October 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961018b_evt.qp	218354	9924.02 s	22.00 s^{-1}
MCP (background)	P1961018a_evt.qp	1184	949.81 s	1.25 s^{-1}
Monitor with HRC (x-ray)	961018bm.chn	872232	10000.0 s	87.22 s^{-1}
Monitor with HRC (background)	9610186m.chn	480	1000.0 s	0.48 s^{-1}
BND (x-ray)	9610184b.chn	40900	1000.0 s	40.90 s^{-1}
BND (background)	9610185b.chn	453	300.0 s	1.51 s^{-1}
Monitor with BND (x-ray)	9610184m.chn	72073	1000.0 s	72.07 s^{-1}
Monitor with BND (background)	9610185m.chn	161	300.0 s	0.54 s^{-1}
HRC-I region area (pixels)				26214400
HRC-I region area				10.836 cm^2
Source to MCP distance				704.9 cm
HRC-I region solid angle				2.181×10^{-5} sr
BND aperture area				3.879 cm^2
Source to BND distance				655.0 cm
BND solid angle				9.043×10^{-6} sr
BND window transmission				0.3859
BND mesh transmission				0.815
BND effective depth				6.25 cm
BND fill gas				CH_4
BND gas pressure				100 torr
BND gas temperature				297 K
BND gas stopping efficiency				0.9654
QE_{BND}				0.3036
QE_{HRC}				0.055

Table 4: 0.277 keV QE Measurement - 17 October 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961017b_evt.qp	1406816	9537.57 s	147.50 s^{-1}
MCP (background)	P1961017a_evt.qp	1119	951.87 s	1.18 s^{-1}
Monitor with HRC (x-ray)	961017am.chn	406231	10000.0 s	40.62 s^{-1}
Monitor with HRC (background)	9610174m.chn	932	2000.0 s	0.47 s^{-1}
BND (x-ray)	9610171b.chn	288147	1000.0 s	288.15 s^{-1}
BND (background)	9610172b.chn	458	300.0 s	1.53 s^{-1}
Monitor with BND (x-ray)	9610171m.chn	67836	1000.0 s	67.84 s^{-1}
Monitor with BND (background)	9610172m.chn	148	300.0 s	0.49 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	655.0 cm
BND solid angle	9.043×10^{-6} sr
BND window transmission	0.7486
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	CH_4
BND gas pressure	304 torr
BND gas temperature	304 K
BND gas stopping efficiency	0.9544
QE_{BND}	0.5823
QE_{HRC}	0.207

Table 5: 0.525 keV QE Measurement - 17 October 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961017f_evt.qp	1010839	6276.64 s	161.05 s^{-1}
MCP (background)	P1961017c_evt.qp	1291	998.08 s	1.29 s^{-1}
Monitor with HRC (x-ray)	610147m.chn	1031716	6600.0 s	156.32 s^{-1}
Monitor with HRC (background)				
BND (x-ray)	6101744b.chn	15426	200.0 s	77.13 s^{-1}
BND (background)	6101745b.chn	199	100.0 s	1.99 s^{-1}
Monitor with BND (x-ray)	6101744m.chn	20373	200.0 s	101.8 s^{-1}
Monitor with BND (background)	6101745m.chn	64	100.0 s	0.64 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	655.0 cm
BND solid angle	9.043×10^{-6} sr
BND window transmission	0.1768
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	CH_4
BND gas pressure	210 torr
BND gas temperature	297 K
BND gas stopping efficiency	1.0
QE_{BND}	0.1441
QE_{HRC}	0.083

Table 6: 0.852 keV QE Measurement - 19 October 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961019g_evt.qp	1500935	9480.39 s	158.32 s^{-1}
MCP (background)	P1961019e_evt.qp	1217	966.14 s	1.26 s^{-1}
Monitor with HRC (x-ray)	9610201m.chn	1270361	10000.0 s	127.04 s^{-1}
Monitor with HRC (background)				
BND (x-ray)	9610202b.chn	23859	200.0 s	119.29 s^{-1}
BND (background)	610196b.chn	416	200.0 s	2.08 s^{-1}
Monitor with BND (x-ray)	610202m.chn	25450	200.0 s	127.25 s^{-1}
Monitor with BND (background)	610196m.chn	97	200.0 s	0.48 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	655.0 cm
BND solid angle	9.043×10^{-6} sr
BND window transmission	0.6103
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	CH_4
BND gas pressure	202 torr
BND gas temperature	297 K
BND gas stopping efficiency	0.9648
QE_{BND}	0.4799
QE_{HRC}	0.267

Table 7: 1.487 keV QE Measurement - 16 October 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961016b_evt.qp	1600447	9481.09 s	168.80 s^{-1}
MCP (background)	P1961016a_evt.qp	1179	949.81 s	1.24 s^{-1}
Monitor with HRC (x-ray)	961016cm.chn	912909	10000.0 s	91.29 s^{-1}
Monitor with HRC (background)	961016dm.chn	552	1000.0 s	0.55 s^{-1}
BND (x-ray)	961016ab.chn	200211	1000.0 s	200.21 s^{-1}
BND (background)	961016bb.chn	619	300.0 s	2.06 s^{-1}
Monitor with BND (x-ray)	961016am.chn	91592	1000.0 s	91.59 s^{-1}
Monitor with BND (background)	961016bm.chn	214	300.0 s	0.71 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	655.0 cm
BND solid angle	9.043×10^{-6} sr
BND window transmission	0.9024
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	P-10
BND gas pressure	250 torr
BND gas temperature	297 K
BND gas stopping efficiency	0.9857
QE_{BND}	0.7249
QE_{HRC}	0.255

Table 8: 2.984 keV QE Measurement - 19 October 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961019d_evt.qp	1713503	9447.39 s	181.37 s^{-1}
MCP (background)	P1961019c_evt.qp	1093	935.51 s	1.17 s^{-1}
Monitor with HRC (x-ray)	6101911m.chn	1735480	10000.0 s	173.55 s^{-1}
Monitor with HRC (background)				
BND (x-ray)	9610199b.chn	258005	1000.0 s	258.01 s^{-1}
BND (background)	6101910b.chn	593	300.0 s	1.98 s^{-1}
Monitor with BND (x-ray)	9610199m.chn	141704	1000.0 s	141.70 s^{-1}
Monitor with BND (background)	6101910m.chn	159	300.0 s	0.53 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	655.0 cm
BND solid angle	9.043×10^{-6} sr
BND window transmission	0.9869
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	P-10
BND gas pressure	600 torr
BND gas temperature	297 K
BND gas stopping efficiency	0.7909
QE_{BND}	0.6361
QE_{HRC}	0.151

Table 9: 4.511 keV QE Measurement - 16 October 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961016d_evt.qp	1504650	9513.05 s	158.17 s^{-1}
MCP (background)	P1961016c_evt.qp	1143	957.99 s	1.19 s^{-1}
Monitor with HRC (x-ray)	961016jm.chn	1439640	10000.0 s	143.96 s^{-1}
Monitor with HRC (background)				
BND (x-ray)	961019kb.chn	399344	1000.0 s	399.34 s^{-1}
BND (background)	961019ib.chn	695	300.0 s	2.32 s^{-1}
Monitor with BND (x-ray)	961019km.chn	143282	1000.0 s	143.28 s^{-1}
Monitor with BND (background)	961019im.chn	155	300.0 s	0.52 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	655.0 cm
BND solid angle	9.043×10^{-6} sr
BND window transmission	0.9963
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	P-10
BND gas pressure	301.5 torr
BND gas temperature	297 K
BND gas stopping efficiency	0.9191
QE_{BND}	0.7463
QE_{HRC}	0.122

Table 10: 6.404 keV QE Measurement - 19 October 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961019b_evt.qp	1432566	9537.91 s	150.20 s^{-1}
MCP (background)	P1961019a_evt.qp	1113	953.95 s	1.17 s^{-1}
Monitor with HRC (x-ray)	961019bm.chn	1122736	10000.0 s	112.27 s^{-1}
Monitor with HRC (background)	9610196m.chn	558	1000.0 s	0.56 s^{-1}
BND (x-ray)	9610194b.chn	363552	1000.0 s	363.55 s^{-1}
BND (background)	9610195b.chn	671	300.0 s	2.24 s^{-1}
Monitor with BND (x-ray)	9610194m.chn	142948	1000.0 s	142.95 s^{-1}
Monitor with BND (background)	9610195m.chn	152	300.0 s	0.51 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	655.0 cm
BND solid angle	9.043×10^{-6} sr
BND window transmission	0.9988
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	P-10
BND gas pressure	600.5 torr
BND gas temperature	297 K
BND gas stopping efficiency	0.8550
QE_{BND}	0.6959
QE_{HRC}	0.152

Table 11: 0.277 keV QE Measurement - 25 November 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961017eg_evt.qp	1482773	9551.02 s	155.25 s^{-1}
MCP (background)	P1961017ef_evt.qp	1019	998.10 s	1.02 s^{-1}
Monitor with HRC (x-ray)	61125m7.chn	568106	10000.0 s	56.81 s^{-1}
Monitor with HRC (background)	61125m6.chn	511	1000.0 s	0.51 s^{-1}
BND (x-ray)	61125b4.chn	46532	300.0 s	155.11 s^{-1}
BND (background)	61125b5.chn	87	100.0 s	0.87 s^{-1}
Monitor with BND (x-ray)	61125m4.chn	16668	300.0 s	55.56 s^{-1}
Monitor with BND (background)	61125m5.chn	50	100.0 s	0.50 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	643.9 cm
BND solid angle	9.357×10^{-6} sr
BND window transmission	0.7486
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	CH_4
BND gas pressure	300 torr
BND gas temperature	297 K
BND gas stopping efficiency	0.9526
QE_{BND}	0.5812
QE_{HRC}	0.244

Table 12: 0.525 keV QE Measurement - 25 November 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961125ej_evt.qp	1545319	9543.53 s	161.92 s^{-1}
MCP (background)	P1961125ei_evt.qp	959	942.89 s	1.02 s^{-1}
Monitor with HRC (x-ray)	61125m15.chn	971618	10000.0 s	97.16 s^{-1}
Monitor with HRC (background)	61125m14.chn	552	1000.0 s	0.55 s^{-1}
BND (x-ray)	61125b12.chn	21299	200.0 s	106.50 s^{-1}
BND (background)	61125b13.chn	198	100.0 s	1.98 s^{-1}
Monitor with BND (x-ray)	61125m12.chn	19145	200.0 s	95.73 s^{-1}
Monitor with BND (background)	61125m13.chn	54	100.0 s	0.54 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	643.9 cm
BND solid angle	9.357×10^{-6} sr
BND window transmission	0.1768
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	CH_4
BND gas pressure	100 torr
BND gas temperature	297 K
BND gas stopping efficiency	0.9970
QE_{BND}	0.1437
QE_{HRC}	0.094

Table 13: 1.487 keV QE Measurement - 26 November 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961126c_evt.qp	1833059	9448.54 s	194.00 s^{-1}
MCP (background)	P1961126b_evt.qp	1075	949.89 s	1.13 s^{-1}
Monitor with HRC (x-ray)	61126mc.chn	1235859	10000.0 s	123.59 s^{-1}
Monitor with HRC (background)	61126mb.chn	569	1000.0 s	0.57 s^{-1}
BND (x-ray)	61126b4.chn	41549	200.0 s	207.74 s^{-1}
BND (background)	61126b5.chn	383	200.0 s	1.91 s^{-1}
Monitor with BND (x-ray)	61126m4.chn	25312	200.0 s	126.56 s^{-1}
Monitor with BND (background)				

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	6439 cm
BND solid angle	9.357×10^{-6} sr
BND window transmission	0.9024
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	P-10
BND gas pressure	250 torr
BND gas temperature	297 K
BND gas stopping efficiency	0.9857
QE_{BND}	0.7249
QE_{HRC}	0.298

Table 14: 6.404 keV QE Measurement - 26 November 1996

	File	Counts	Livetime	Rate
MCP (x-ray)	P1961126e_evt.qp	1556200	9525.82 s	163.37 s^{-1}
MCP (background)	P1961126d_evt.qp	1015	937.66 s	1.08 s^{-1}
Monitor with HRC (x-ray)	61126m11.chn	1024346	10000.0 s	102.43 s^{-1}
Monitor with HRC (background)	61126m10.chn	596	1000.0 s	0.60 s^{-1}
BND (x-ray)	61126b8.chn	118767	400.0 s	296.92 s^{-1}
BND (background)	61126b9.chn	185	100.0 s	1.85 s^{-1}
Monitor with BND (x-ray)	61126m8.chn	41441	400.0 s	103.60 s^{-1}
Monitor with BND (background)	61126m9.chn	56	100.0 s	0.56 s^{-1}

HRC-I region area (pixels)	26214400
HRC-I region area	10.836 cm^2
Source to MCP distance	704.9 cm
HRC-I region solid angle	2.181×10^{-5} sr
BND aperture area	3.879 cm^2
Source to BND distance	643.9 cm
BND solid angle	9.357×10^{-6} sr
BND window transmission	0.9988
BND mesh transmission	0.815
BND effective depth	6.25 cm
BND fill gas	P-10
BND gas pressure	597 torr
BND gas temperature	297 K
BND gas stopping efficiency	0.8533
QE_{BND}	0.6946
QE_{HRC}	0.166

References

[1] P-HRC-302 Rev. A, "Verification Test Procedure for the HRC Imaging Detector", 27 September 1996.