ACIS QE: Investigating the BI/PI Ratio

ACIS QE: Instrumental, a reassessment.

This investigation is in response to two action items from the 2002 Nov Calibration Workshop.

Reassessment of QE at low energies.

Dead area due to cosmic ray blooms: larger effect on PI than BI (See Yousuf Butt's talk, this meeting)

Two effects:

- Absolute calibration from ground (XRF) data may settle the issue

- Wavelength dependent, especially noticeable for $E > 1.5$ keV.

  Size of effect: $\sim 10 - 15\%$

- Create ACIS cluster data with BI and PI ratios higher than CALDB
Re-analysis of XRCF flat field data at low energies

- Better modelling of spectral features, teasing apart continua and lines.
- Accounts for non-Gaussian line shapes, especially important at low energies.
- Comparison to synchrotron-calibrated flow proportional counter in same beam.

Agreement between last 2 rows is good.

<table>
<thead>
<tr>
<th>Energy (keV)</th>
<th>Copper</th>
<th>Oxygen</th>
<th>XRCF/CALDB</th>
<th>CALDB/XRCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9249 keV</td>
<td>0.900 ± 0.05</td>
<td>0.946 ± 0.05</td>
<td>1.083 ± 0.05</td>
<td>1.093 ± 0.05</td>
</tr>
<tr>
<td>0.7861 keV</td>
<td>0.220 ± 0.025</td>
<td>0.615 ± 0.025</td>
<td>0.228 ± 0.025</td>
<td>0.620 ± 0.025</td>
</tr>
<tr>
<td>0.5644 keV</td>
<td>2.467 ± 0.05</td>
<td>2.497 ± 0.05</td>
<td>2.497 ± 0.05</td>
<td>2.497 ± 0.05</td>
</tr>
</tbody>
</table>

Re-calculated QE and FWHM

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<tbody>
<tr>
<td>0.9249 keV</td>
<td>0.558 ± 0.014</td>
<td>0.558 ± 0.014</td>
</tr>
<tr>
<td>0.7861 keV</td>
<td>0.615 ± 0.013</td>
<td>0.615 ± 0.013</td>
</tr>
<tr>
<td>0.5644 keV</td>
<td>0.841 ± 0.024</td>
<td>0.841 ± 0.024</td>
</tr>
</tbody>
</table>

Comparison to synchrotron-calibrated flow proportional counter in same beam.
Figure 1: Fitted pulse-height spectrum for S2 (full chip).
Figure 2: Fitted pulse-height spectrum for S8 (node 1).
Figure 3: Fitted pulse-height spectrum for FPCJN.
For each detector, the source luminosity is given by:

\[
\frac{\nu p}{\nu p} \times \frac{\nu p}{\nu p} \times \frac{\nu p}{\nu p} \times \frac{\nu p}{\nu p} = S
\]

where:

- Beam Uniformity Factor (dimensionless)
- Source distance (cm)
- Quantum Efficiency (cts photon$^{-1}$)
- Active detector area (cm$^2$)
- Count rate in the line (cts s$^{-1}$)

Then:

\[
\text{Beam Uniformity Factor} = \nu p \text{ (dimensionless)}
\]

\[
\text{Source distance} = p
\]

\[
\text{Quantum Efficiency} = \nu p
\]

\[
\text{Active detector area} = \nu p
\]

\[
\text{Count rate in the line} = \nu p
\]
Figure 4: S2 and S3 quantum efficiency from CALDB N0003 (curves) and measured (data points).

Energy (keV)

ACIS QE

XRF ACIS QE at 0 K-x and Cu L-x. All data points are from CALDB N0003.
Marshall defines \( r(\lambda) \equiv \frac{QE_{FI}}{QE_{BI}} \) true \( \frac{QE_{FI}}{QE_{BI}} \) caldb.

This is his proposed correction to the FI QE curve (see fig 5).

Recommendations for flight calibration products:

- Increase BI QE curves by factor consistent with \( y/r \) (but details of energy dependence TBD).
- Decrease FI QE curves by factor \( y \) at all energies.

For comparison to ground data only, we will correct QE(S3) by factor \( y/r \).

Since based on flight data, \( y \) includes a factor of the FI cosmic ray QE decrement \( y = 0.9632 \).

This is the proposed correction to the FI QE curve (see fig 5).

\[
\frac{QE_{FI}}{QE_{BI}} \equiv (Y)_{r}
\]

Marshall defines

\[ 28 \text{ October 2003} \]

Richard J. Edgar

Results in Context
Figure 5: Marshall's plot of $r$ vs. wavelength. This is his proposed correction to the FIQE curve.
Figure 6: S2 and S3 quantum efficiency from CALDB N0003 (curves) and measured (data points). Now including corrected S3 QE curve for comparison.
Empirical QECorrections

30 October 2001

• Compare ball and flight external cal source data
• Correct flight data for cosmic ray dead area effect
• Evidence for excess BI/FI ratio at Mn K-α
• Empirical QE Corrections

28 October 2003

Chandra Calibration Workshop

Richard J. Edgar
ACIS QE BI/FI Ratio: Future Work

• Correct FI QE curves by factor $y = 0.9632$ to account for cosmic ray blooms.

• Analyze ground data at Fe Kα (0.705 keV), and at higher energies notably Fe Kα (6.4 keV).

• Investigate CR bloom effect for BI chips, and correlations with other radiation measures.

• Extend analysis to other chips (including the I array).

• Analyze ground data for BI chips at C Kα (to aid with extrapolation to low energy).

30 October 2003

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Separate photons into two groups, \( FG = 0, 8, 16, 64, 72, 80, 104, 208 \) ("GoodGood"), and \( FG = 2, 10, 18, 11, 22 \) ("BadGood").

Good-Good photons migrate into good ASCA grades because of the CTI. The ECS intensity in the Good-Good grades is flat.

Bad-Good photons migrate into bad ASCA grades. QEU effects are stronger, easier to study.

Final QE maps:

\[
\log(QEU) \propto E
\]

\[
QEU(E) \approx \text{const}
\]

Derive energy dependence of the QEU for BAD-Good photons.

\[QEU(x, y, E) = QEU_{Mn}(x, y) \times \text{GradeRatio}(E)\]

\[QEU(x, y, E) = QEU_{Mn}(x, y) \times \text{GradeRatio}(E)\]

Derive spatial dependence of QE for the Mn-K complex: 1-column resolution for BI, 4-column resolution for FI chips.

Derive energy dependence of the QE for BAD-Good photons.

Derive special dependence of QE for the Mn-K complex: 1-column resolution for BI, 4-column resolution for FI chips.

- Derive spatial dependence of QE for BI chips:

\[
\text{GradeRatio}(E) \propto E \text{ const}
\]

- Derive spatial dependence of QE for FI chips:

\[
\text{GradeRatio}(E) \propto E
\]

- Derive spatial dependence of QE for BI chips:

\[
\text{GradeRatio}(E) \propto E \text{ const}
\]

Separate photons into two groups, \( PG = 0.8, 16.64, 72, 104, 208 \), and \( PC = 2, 10, 18, 11, 22 \).
Figure 7: Image of the Si chip in the Mn Kα + Mn Kβ lines in the subset of AGIS grades that include both bad AGIS grades that migrate into bad AGIS grades because of the CTI "bad good" differences. Note strong column-to-column variations.
Figure 8: same as the previous one but binned by 16 along the chirp axis for clarity.
Figure 9: Image of the S3 chips in the Mn, Ti, A1 lines (top to bottom). The top image in each group is in the subset of grades which migrate into good ASCA grades ("good good" grades); the bottom one is for the "bad good" grades. Note that images for "good good" grades have flat images for "good good" grades and clear energy dependence of the QEU structure for the "bad good" grades.
Figure 10: Image of the S3 chip in the MnK complex before and after the 1-column-resolution QEF correction.
Figure 11: Results of the old and new OGE corrections to Se in the Mn, Ti, and Al lines (top to bottom). Old is on the left and new is on the right.
Figure 12. Same for the ACIS-I chips in Al (top) and Mn (bottom) lines.