ACIS QE: Investigating the BI/FI Ratio

Grating & Cluster data want BI/FI ratio higher than CALDB

Size of effect: \( \sim 10 - 15\% \)

CrateTime x Cluster data want BI/FI ratio higher than CALDB

Size of effect: \( \sim 10 - 15\% \)

Absolute calibration from Ground (XRCP) data may settle the issue.

WaveLength dependent, especially notable for \( E > 1.5 \) keV.

Also: Quantum Efficiency Uniformity; 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 FI than BI (See Yousaf Butt's talk, this meeting)

Two Effects:

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

Reassessment of QE at low energies.
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.
- Agreement between last 2 rows is good.

<table>
<thead>
<tr>
<th>Element</th>
<th>Energy 0.5249 keV</th>
<th>Energy 0.9297 keV</th>
<th>S3/S2</th>
<th>QE(S3)</th>
<th>S3/S2</th>
<th>QE(S2)</th>
<th>XRCF/CALDB</th>
<th>CALDB/CALDB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>0.228 ± 0.005</td>
<td>0.558 ± 0.014</td>
<td>2.47</td>
<td>0.5230</td>
<td>1.508 ± 0.059</td>
<td>0.5644</td>
<td>1.093 ± 0.033</td>
<td>0.946 ± 0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>0.527 ± 0.005</td>
<td>0.841 ± 0.014</td>
<td>1.39</td>
<td>0.7861</td>
<td>1.397 ± 0.072</td>
<td>0.7861</td>
<td>1.093 ± 0.033</td>
<td>0.9297</td>
</tr>
</tbody>
</table>

Comparison to synchrotron-calibrated Poy Ppropotional Counter in same beam.
Figure 1: Fitted pulse-height spectrum for S2 (full chip).
Figure 2: Fitted pulse-height spectrum for S3 (node 1).
Figure 3: Fitted pulse-height spectrum for FCPCN.
For each detector, the source luminosity is given by:

\[
S_\text{ACIS} = \frac{\text{C}_\text{ACIS}}{\text{A}_{\text{ACIS}}} \times \text{QE}_{\text{ACIS}} \times \text{BU}_{\text{ACIS}} \times \text{d}_{\text{ACIS}}^2
\]

where:
- \(\text{C}_\text{ACIS}\) = countrate in the line (cts s\(^{-1}\))
- \(\text{A}_{\text{ACIS}}\) = active detector area (cm\(^2\))
- \(\text{QE}_{\text{ACIS}}\) = quantum efficiency (cts photon\(^{-1}\))
- \(\text{BU}_{\text{ACIS}}\) = Beam Uniformity factor (dimensionless)
- \(\text{d}_{\text{ACIS}}\) = source distance (cm)

Then:

\[\text{QE}_{\text{ACIS}} = \text{QE}_{\text{hn}} \times \frac{\text{C}_\text{ACIS}}{\text{A}_{\text{hn}}} \times \text{BU}_{\text{ACIS}} \times \text{d}_{\text{ACIS}}^2\]

For each detector, the source luminosity is given by:

\[\frac{\text{C}_\text{ACIS}}{\text{A}} \times \text{QE} \times \text{BU} \times \text{d}^2 = S\]
Figure 4: S2 and S3 quantum efficiency from CALDB N0003 (curves) and measured (data points).
Marshall defines $r(\lambda) \equiv \left( \frac{Q_{E} \cdot F_{I}}{Q_{E} \cdot B_{I}} \right)$

This is his proposed correction to the $F_{I}$ QE curve (see fig 5).

Recommendations for flight calibration products:

- Increase $B_{I}$ QE curves by factor consistent with $y/r$ (but details of energy dependence TBD).
- Decrease $F_{I}$ QE curves by factor $y$ at all energies.

For comparison to ground data only, we will correct $Q_{E}(S3)$ by factor $y/r$. (see eq 6).

Since based on flight data, $y$ includes a factor of the $F_{I}$ cosmic ray QE decrement $y = 0.9632$. This is the proposed correction to the $F_{I}$ QE curve (see fig 6).

Marshall defines

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 QC Corrections

30 October 2001

Chandra Calibration Workshop

Richard J. Edgar

- High energies: $\frac{Q(E)}{E} = \left(\frac{E}{1.05}\right)^{0.16} \ln\left(\frac{E}{1.05} - 0.16\right)$
- Low energies: $\frac{Q(E)}{E} = \left(\frac{E}{1.05}\right)^{0.16}$

For the S3 QE:

- If SQ2 curve is right (as suggested at low energies), we propose the following empirical tweaks:
  - Curvature of Marshall's suggested ratio correction around 700 eV not clear
  - Evidence for excess BL/PI ratio at Mn K-\alpha
  - Correct high level data for cosmic ray dead area effect
  - Compare Ball and Flight external cal source data

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

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

• Analyze ground data at Re-L and $K$- and at higher energies notably Re-K (6.4 KeV).

• Analyze ground data for BI chips at $C$-K (0.705 KeV) to aid with extrapolation to low energy.

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

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QEU Analysis Method

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

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

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

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

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

Final QEU maps:

- Derive energy dependence of the QEU for BI chips.
- Derive spatial dependence of the QEU for FI chips, and ACS simulator for PI chips.

- Deviation of the QEU for Mn-K complex into bad ASCA grades.
- QEU effects are stronger, easier to study.

Final QEU maps:

\[
\text{QEU}(E) = \text{GradeRatio}(E) \times \text{GradeRatio}(E) \times \text{ECS} \times \text{total flux for BI, 4-column resolution for FI}
\]

QEU for BI chips

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

QEU for FI chips

\[
\text{QEU}(x, y, E) = \text{QEU}_{Mn}(x, y) \times \text{GradeRatio}(E)
\]
Note strong column-to-column variations.
Figure 8: same as the previous one but binned by 16 along the chipy axis for clarity.
The QEU structure for the "bad good" grades. Note that images for "good good" grades, the top image in each group, are in the subset of grades which migrated into good ASCA grades; the bottom one is for the "bad good" grades. The top image in each group is in the subset of grades which migrated into good ASCA grades.
Figure 10: Image of the S3 chip in the MnK complex before and after the 1-column-resolution QERU correction.
Figure 11: Results of the old and new QEU corrections to S3 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 ACGS-I chips in Al (top) and Mn (bottom) lines.