Evolution of ACIS Performance

Catherine Grant
for the ACIS Instrument Team
Summary

• Slow gradual changes in performance due to increasing radiation damage and contamination

• Exceptions:
  – I2 anomalous gain
  – October 2003 solar activity
Monitoring Radiation Damage

- Radiation damage can
  - Increase density of charge traps
    • Measured by increasing CTI
  - Change distribution of trap properties
    • Measured by changing charge trailing
- Changes to calibrated quantities
  - Lower pulseheights
  - Higher spectral widths
  - Lower detection efficiency
ACIS Performance Evolution

Charge Transfer Inefficiency: A Reminder

- CTI, fractional charge loss per pixel transfer

![Graph showing ACIS-I3, Node 0, T = -120C with data points and trend lines.](image-url)
CTI Monitoring

- 5.9 keV CTI at -120C

<table>
<thead>
<tr>
<th>CTI</th>
<th>Jan 2000</th>
<th>Rate of Change (2000-2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI Parallel</td>
<td>1-2 x 10^{-4}</td>
<td>3 x 10^{-6} / yr</td>
</tr>
<tr>
<td>FI Serial</td>
<td>&lt; 3 x 10^{-6}</td>
<td>&lt; 5 x 10^{-7} / yr</td>
</tr>
<tr>
<td>S3 Parallel</td>
<td>1 x 10^{-5}</td>
<td>1 x 10^{-6} / yr</td>
</tr>
<tr>
<td>S3 Serial</td>
<td>7 x 10^{-5}</td>
<td>&lt; 3 x 10^{-7} / yr</td>
</tr>
</tbody>
</table>
Change in ACIS-I CTI

- FI parallel increase: $3.00 \pm 0.06 \times 10^{-6}$/yr
- FI serial CTI increase $< 5 \times 10^{-7}$/yr
ACIS Performance Evolution

Change in ACIS-S3 CTI

- S3 parallel increase: \(0.96 \pm 0.01 \times 10^{-6} / \text{yr}\)
- BI serial increase: \(< 3 \times 10^{-7} / \text{yr}\)
Trailing Charge Monitoring

- Fraction of charge lost to center pixel trailed into top pixel
- Dependent on distribution of charge trap time constants
- Changes are very small
ACIS Performance Evolution

Oct - Nov 2003 Solar Storm

- Multiple coronal mass ejections
- Most powerful X-ray flare ever recorded!
- Hard particles (≥MeV)
- 0.7 Ms science time lost
- Parallel CTI jump
  - FI CCD: $3 \times 10^{-6}$
  - BI CCD: $9 \times 10^{-7}$
- XMM reports no change
- Recovery indicates little real radiation damage
- Anomalous background?
Gain Monitoring

- PHA = Slope * E + Offset
- Bottom 20 rows, no CTI
- Most CCDs slow decay
  ΔPHA ≈ 0.3-0.5% at 6 keV since Jan 2000
- I2 anomalous increase
  ΔPHA ≈ 1.5% at 6 keV
ACIS Performance Evolution

Pulseheight Change at 5.9 keV

ACIS-S3

ACIS-I3

ACIS-I2

Bottom 64 rows
Top 64 rows

Catherine Grant (MIT)  Oct 25, 2004
ACIS Performance Evolution

ACIS-S3, 5.9 keV

ACIS-I3, 5.9 keV

ACIS-S3, 1.5 keV

ACIS-I3, 1.5 keV

Catherine Grant (MIT)  Oct 25, 2004
ACIS Performance Evolution

No change in Detection Efficiency at 6 keV

Fits to radioactive decay of Mn–Kα line

- Half-life of $^{55}$Fe calibration source is 2.73 years
- Model fits normalization only, half-life is fixed
Contamination Monitoring

S3 Transmission at 700 eV

Transmission

Time (year)

1999 2000 2001 2002 2003 2004 2005
ACIS Performance Evolution

For more information:

- ACIS performance monitoring web pages
  - Updated monthly
  - http://space.mit.edu/~cgrant/monitor.html

Go Sox!