The Suzaku/XIS: Status Report

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for the Suzaku/XIS Team
Outline

• instrument health and status
• spacecraft and instrument anomalies
• gain and effective area tracking
• changes in background
• changes in charge injection
• calibration status
• CTI and RMF fine-tuning
• open issues
Suzaku/XIS - Overview

- 4 CCDs with independent X-ray telescopes (XRTs)
- 3 front-illuminated (FI) XIS0, XIS2, XIS3
- 1 back-illuminated (BI) XIS1

<table>
<thead>
<tr>
<th>Field of view</th>
<th>17.8' x 17.8'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy range</td>
<td>0.2-12 keV</td>
</tr>
<tr>
<td>Energy resolution</td>
<td>~180 eV @6keV</td>
</tr>
<tr>
<td>Effective area</td>
<td>340 (FI)/390 (BI) cm² @1.5keV</td>
</tr>
<tr>
<td>Time resolution</td>
<td>8 s (Normal) - 7.8 ms (Psum)</td>
</tr>
</tbody>
</table>

from Tsujimoto’s “pocket guide”
## Major XIS Events

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 10, 2005</td>
<td>launch of Suzaku</td>
</tr>
<tr>
<td>August 13, 2005</td>
<td>XIS doors open, start of observations</td>
</tr>
<tr>
<td>November 9, 2006</td>
<td>anomaly (μ-meteorite?) in XIS2; 2/3 of chip affected, <strong>XIS2 switched off</strong></td>
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<tr>
<td>January 30, 2008</td>
<td>CPU board malfunction in MPU; switch to redundant board</td>
</tr>
<tr>
<td>June 23, 2009</td>
<td>anomaly (μ-meteorite?) in XIS0; 1/8 of chip affected, <strong>XIS0 safe for normal ops</strong></td>
</tr>
<tr>
<td>December 18, 2009</td>
<td>anomaly (μ-meteorite?) in XIS1; no CCD damage, likely hole in XIS1 OBF</td>
</tr>
</tbody>
</table>
XIS Status

from Tsujimoto's “pocket guide”
• $^{55}$Fe cal sources $\rightarrow$ Mn K\(\alpha\) at 5.9 keV raw data, no CTI correction

• gain change with SCI on (% per yr)
  - XIS0: -0.399 ± 0.001
  - XIS3: -0.372 ± 0.001
  - XIS1: -0.997 ± 0.001

• FWHM change with SCI on (eV per yr)
  - XIS0: 16.1 ± 0.8
  - XIS3: 16.8 ± 1.4
  - XIS1: 30.4 ± 1.2
Effective Area Tracking

contamination optical depth
XIS0
XIS1
XIS3

0.6 keV (O lines)
1.4 keV (Mg line)

total effective area
1.4 keV (Mg line)
0.6 keV (O lines)
Background Tracking

NXB - XIS1, all COR, SCI, 1 week bins

- PI = 20–100 (73–365 eV)
- PI = 1370–4110 (5–15 keV)
Background Tracking

NXB – XIS1

normalized counts s⁻¹ keV⁻¹

Energy (keV)

2007

2010
Background Tracking

background increase from noisy pixels
does not affect science (yet)
Charge Injection Changes

- row of charge injected every 54 rows “spaced-row” (SCI)
- fills traps, reduces CTI
- FI: 6 keV
  BI: 2 keV (to reduce noise < 0.4 keV)

![Graph showing the trend of peak energy and width of Mn I Kα emission from 55Fe calibration source.](image)

There is a small amount due to the expected increase in noise in the low energy end of the spectrum, at which the BI device has an advantage over the FI device. The situation has changed since then. The accumulation of the contaminating material on the surface of the CCDs made the low-energy advantage of the XIS1 less prominent. The CTE for the BI device decreases at a faster rate. As a consequence, the astrophysically important lines of Fe XXV (6.7 keV) and Fe XXVI (7.0 keV) are no longer resolved. The XIS team revisited the 2006 decision and started to take steps to judge whether the CI increase to 6 keV equivalent is beneficial for XIS1.

In 2010, we conducted a series of onboard experiments to evaluate the performance improvements and possible side effects of the CI increase for the XIS1. This article summarizes the results and argues for the routine operation of the increased CI of 6 keV equivalent starting from the AO6 cycle.

### 2 Data Acquisition

Table 1 summarizes the data set obtained in the experiment. We mainly used E0102–72 and Cygnus Loop, supernova remnants with a line-dominated soft emission, to measure the low-energy response, and the Perseus cluster, a cluster of galaxies with extended hard emission, to measure the high-energy response. We did not use 55Fe data for the CI=2 vs 6 keV comparison because they are too weak to use within the limited telescope time allocation for XIS calibration observations.

### 3 Results

#### 3.1 Image

Fig. 2 shows the frame dump images taken with the CI=4, 6, and 8 keV (data ID #1 in Table 1). All images appear healthy. The column-to-column variation is more apparent for a smaller amount of CI.

#### 3.2 High-energy response

High-energy response was checked with a comparison data set of data ID #5 and #6 using strong Fe XXV and Fe XXVI emission lines from the Perseus cluster. The emission is pervasive across the entire XIS1 field of view. Fig. 3 compares the result between CI of 2 vs 6 keV. The peaks are noticeably higher and narrower for the CI=6 keV data with a 33% improvement in the FWHM.

BI FWHM degrading rapidly!
Charge Injection Changes

- August 2010 start experiment w/ increased BI SCI
- FWHM improves; $180 \rightarrow 120$ km/s at 6.5 keV (Fano limit??)
- telemetry saturation from trailing row (mask onboard)

**Perseus – XIS1, 20100810 (normal SCI)**
- He-like peak = $6.557 +0.003−0.003$ eV
- He-like FWHM = $269 +7−7$ eV
- H-like peak = $6.895 +0.026−0.027$ eV
- H-like FWHM = $178 +71−24$ eV

**Perseus – XIS1, 20100809 (higher SCI)**
- He-like peak = $6.695 +0.002−0.001$ eV
- He-like FWHM = $179 +4−3$ eV
- H-like peak = $6.972 +0.006−0.009$ eV
- H-like FWHM = $121 +15−15$ eV
Charge Injection Changes

- August 2010 start experiment w/ increased BI SCI
- FWHM improves; 180 → 120 km/s at 6.5 keV (Fano limit??)
- telemetry saturation from trailing row (mask onboard)

Implement as standard mode during April 2011
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  • CTI and RMF fine-tuning
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Energy Scale Calibration

- at 1 keV, energy scale over-corrected at recent times
- fine tune CTI parameters to make low/high energy agree
Results for Ne Heα

- current release, ver.14, ID=20100929
- new makepi before fine tuning, ID=20110123
- new makepi after fine tuning, ID=20110219
Results for Mn Kα

- current release, ver. 14, ID=20100929
- new makepi before fine tuning, ID=20110123
- new makepi after fine tuning, ID=20110219
Results for Mn Kα

- current release, ver.14, ID=20100929
- new makepi before fine tuning, ID=20110123
- new makepi after fine tuning, ID=20110219

fine tuning CTI improves energy scale

0.1% @ 6 keV
0.5% @ 1 keV
1.0% @ 0.6 keV (!)
Response Calibration

- low-energy FWHM underestimated for XIS0, XIS1
- discrepancy increasing since 2008

residual $\sigma$
0.5-1 keV
from E0102
Problems with Response

direct modeling

- implicit boundary condition: \( \text{FWHM}_a = 0 @ E=0 \)
  FWHM slope is too steep at low \( E \)

- unexpected behavior of the model

- FWHM at O\( \text{VIII} \) for XIS0 and XIS1 is decreasing with time!

taken from Nobukawa report on 20110210

extrapolated period
New RMF Params (In Progress)
Open Calibration Issues

- P-Sum (timing) mode
  - only XIS3; response files soon to appear in CALDB
- OBF contamination
  - new composition/evolution model
  - rolled out in Jan 2011, broke FTOOLS, rolled back in
  - new CALDB and FTOOLS update ASAP
- Si edge
  - still working on it
XIS Status - Summary

- XIS0 has lost ~ 10% of area but is operating safely
- XIS1,3 are operating normally

http://space.mit.edu/XIS/monitor