The Suzaku/XIS: Calibration Status

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Outline

- E. Miller
  - instrument health and status
  - effective area (contamination) tracking and calibration
- B. LaMarr
  - changes in charge injection
- M. Nobukawa
  - CTI and gain correction
  - Si edge correction
- 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

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

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

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>2005 July 10</td>
<td>launch of Suzaku</td>
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<tr>
<td>2005 Aug 13</td>
<td>XIS doors open, start of observations</td>
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<tr>
<td>2006 Nov 9</td>
<td>anomaly (μ-meteorite?) in XIS2; 2/3 of chip affected, <strong>XIS2 switched off</strong></td>
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<tr>
<td>2009 June 23</td>
<td>anomaly (μ-meteorite?) in XIS0; 1/8 of chip affected, <strong>XIS0 safe for normal ops</strong></td>
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<tr>
<td>2009 Dec 18</td>
<td>anomaly (μ-meteorite?) in XIS1; no CCD damage, likely hole in XIS1 OBF</td>
</tr>
<tr>
<td>2011 June 1</td>
<td>XIS1 charge injection level raised for routine observations</td>
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</table>
XIS Status

from Tsujimoto’s “pocket guide”
Molecular OBF Contamination
Effective Area Tracking

\[ \frac{A_{\text{eff}}}{A_{\text{eff}}(t=0)} \]

\[ \tau \]

contamination, optical depth

XIS0, XIS1, XIS3

0.65 keV, 1.0 keV

2006 to 2014

total effective area, XIS0+XIS1+XIS3

from E0102
Contamination Model

- current model - H,C,O
  - composition from RXJ1856
  - time-dependence from E0102
  - spatial dependence from bright Earth, Cygnus Loop

- new model - H,C,N,O
  - composition, time dependence from E0102, RXJ1856, PKS2155
  - spatial dependence TBD
  - improve trend and improve composition
(Current) Contamination Model

\[ N_C \sim 4 \quad N_O \]
\[ N_H \sim 500 \quad N_O^* \]  

\(^*\) (probably not really)
(Current) Contamination Model

$N_C \sim 4 \, N_O$

$N_H \sim 500 \, N_O^*$

(probably not really)

from E0102
(New) Contamination Model

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(New) Contamination Model

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(New) Contamination Model

IACHEC 2012 - Suzaku/XIS
(New) Contamination Model

Tuning of the gain-offset significantly improves the fit.

$\text{offset} = \{-0.4, -4.1, -4.1, -9.7, -12.1, -8.2\} \text{eV}$

A ~ -10eV offset remains for SCI-on data even with makepi20080807.

RXJ1856 XIS1 correction with varabs(H,C,O) Gain-Fit.

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(New) Contamination Model

XIS1

XIS1 Contamination HCNO model at 2010/10/28 from RXJ1856
XIS1 Charge Injection Increase

• Since spaced row charge injection was implemented on board, the BI gain has evolved faster than the FI gains.

• The original BI injected charge level was below the FI level.
XIS Charge Injection

Charge Injection

Input Gate Voltage (volts) vs.Injected Charge (electrons)

- Clock S3 in transition
- Clock S3 closed
High Energy Response Improves

- Raising the injected charge level above the X-ray peak results in improved gain and resolution.
XIS1 Charge Injection Increase

- The current BI injected charge level results in performance evolution similar to the FI devices.
Calibration status of XIS Gain and Si-edge

26\textsuperscript{th} March 2012

IACHEC2012, Napa, San Francisco
Charge Injection (CI) for Restore of Energy Resolution

- SCI (spaced-row charge injection) started on Sep. 2006.
- Slope of the gain degradation became flatter.
- Discrepancy of FI/BI $\Leftrightarrow$ CI equiv. to 6 keV/2keV

CI value for XIS1 changed from 2 keV to 6 keV on June 2011.
=> Gain and resolution were restored.

*No CTI correction
CTI / Gain correction

- Saw-tooth function of CTI:
  one charge injection per 54 rows
- CTI correction in consideration of the saw-tooth shape

- Current status of energy scale after CTI/gain correction
  Uncertainty of energy scale

<table>
<thead>
<tr>
<th></th>
<th>@1 keV</th>
<th>@6 keV</th>
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</thead>
<tbody>
<tr>
<td>FI (XIS0/3)</td>
<td>&lt;10 eV</td>
<td>&lt;6 eV</td>
</tr>
<tr>
<td>BI (XIS1)</td>
<td>&lt;10 eV</td>
<td>&lt;6 eV</td>
</tr>
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</table>
Modification of RMF for Si-edge Problem

• ~10% Residuals at ~1.84 keV (Si-edge)
• Negative/Positive for FI/BI

• We have tried to modify the Si-edge problem by various treatments
  – Neutral Si-K line
  – Energy resolution
  => Unfortunately failed

• Semi-Phenomenological modifications with physical basis
  – BI: Sub/Main intensity ratio
  – FI: XAFS of Si-edge
BI: Discontinuous function of Sub/Main ratio at Si-edge
BI: Discontinuous function of Sub/Main ratio at Si-edge

Current version

New

Fraction

Energy (keV)

Fraction

Energy (keV)

Current ver.

XIS1
BI: Discontinuous function of Sub/Main ratio at Si-edge

![Graph showing the discontinuous function of Sub/Main ratio at Si-edge.](image)
Fl: XAFS of Si-edge

- Current QE model does not include XAFS.
- New model: XAFS => XAFS×3

  The residuals are significantly modified.

Quantum Efficiency (QE)

![Graph showing current and new models with XAFS and XAFS×3 adjustments.](image)
XIS Status - Summary

- 2.8 out of 4 detectors are operating normally
- charge injection change, Si edge modeling have greatly improved performance and calibration
- OBF contamination is the most pressing calibration issue

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


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