Astro-E2
X-ray Imaging Spectrometer
Status, Performance and Calibration

Astro-E2 Users’ Group
14 February 2005

Mark Bautz, MIT CSR
# XIS Team Members

*(Partial list)*

<table>
<thead>
<tr>
<th>Institution</th>
<th>Members</th>
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<tbody>
<tr>
<td>Osaka University</td>
<td>H. Tsunemi, K. Hayashida, K. Torii, M. Namiki</td>
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<tr>
<td>Kyoto University</td>
<td>K. Koyama (PI), T. Tsuru, H. Matsumoto</td>
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<tr>
<td>ISAS/JAXA</td>
<td>T. Dotani, H. Murakami, M. Ozaki</td>
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<td>Rikkyo University</td>
<td>H. Awaki</td>
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<tr>
<td>Ehime University</td>
<td>S. Kitamoto</td>
</tr>
<tr>
<td>MIT CSR</td>
<td>M. Bautz (MIT PI), S. Kissel, B. LaMarr, G. Prigozhin, G. Ricker, J. Doty, R. Foster</td>
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<td>MIT Lincoln Lab.</td>
<td>B. Burke, J. Gregory, A. Pillsbury</td>
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</table>
The XIS at a Glance

- Four telescope + CCD camera units
- Effective area:
  - 1500 cm\(^2\) @ 1 keV (~2x Chandra/ACIS)
  - 600 cm\(^2\) @ 6 keV (~ XMM/EMOS)
  - 60 cm\(^2\) @ 0.25 keV
- Field of view:
  - 18 x 18 arcmin (~Chandra/ACIS-I)
- Spectral Resolution:
  - Silicon-limited E> 0.7 keV (R~2-10%)
  - ~60 eV @ 0.25 keV (x2 < CXO/XMM)
- Team:
  - ISAS (Digital electronics, integration)
  - Osaka (Door, filter, ground calibration)
  - Kyoto (Ground calibration)
  - MIT (CCD, TEC, analog electronics, ground calibration)
Astro-E2 Instrument Configuration

View from Mirrors

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Astro-E2 XIS Flight Hardware

Key Characteristics:
• Low noise (1-2 e⁻ RMS)
• Deep depletion (65 µm)
• Charge injection capability
• Front- & back-illumination
• CCDs fabricated at MIT/Lincoln
• CCD heritage: Chandra, ASCA

Components:
• 4 X-ray photon-counting CCD sensors, Peltier-cooled
• 2 low-noise front-end electronics sets with thermal controllers
XIS Effective Area Comparison: 1 BI Sensor vs 1 FI Sensor

Flight Complement: 3 FI + 1 BI

Includes XRT-I area & transmission of all filters.
XIS Spectral Resolution: FI & BI CCDs

See also LaMarr et al., poster 5501-51
XIS Spectral Resolution Comparison: BI vs FI

Simulated Spectra of SNR E0102 -72.3

Back-illuminated (2.3 c s\(^{-1}\) sensor\(^{-1}\))
Front-illuminated (1.2 c s\(^{-1}\) sensor\(^{-1}\))
BI CCD Spectral Resolution:
XIS, Chandra ACIS & XMM-Newton EPIC-PN

Simulated Spectra of SNR E0102 -72.3

Note: EPIC MOS Resolution comparable to XIS (but is not a BI CCD)

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Charge Injection: Motivation

• XRS has 30-36 month life before cryogen is exhausted
• XIS CCD performance late in Astro-E2 mission is thus especially important
• Some radiation damage to XIS is inevitable in the Astro-E2 orbit (600 km, 31 deg)
• Charge injection capability mitigates radiation damage two ways:
  * Improves charge transfer efficiency after radiation
  * Allows better ground calibration and correction for damage effects
XIS Spectral Resolution after Irradiation without Charge Injection

Pre-launch: FWHM: 132 eV.

Post-irradiation (2 yr on-orbit equivalent): Gain shift 1.3%; FWHM: 210 eV
XIS Spectral Resolution after Irradiation with Charge Injection

Pre-launch: FWHM: 132 eV.

Post-irradiation with charge injection: Gain shift 0.5%; FWHM: 144 eV
Ground Calibration Summary

• MIT: QE & Spectral Resolution vs position, 0.3 - 10 keV
• Osaka: QE & Spectral Resolution, 0.3-1.8 keV
• Kyoto: QE & Spectral Resolution, 1.4-12 keV
• Ehime: Filter Transmission 0.3-5 keV; optical
• Issues:
  * Low-energy (E < 0.5 keV) QE of BI sensor reference detector calibration, pileup(MIT)
    source stability (Osaka)
  * CTI correction in pipeline & response functions
Original XIS Flight Calibration Plan
_per H. Matsumoto et al.; revisions pending_

<table>
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</table>

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*Parasitic on science observations
XIS Status Summary

• XIS hardware is integrated on spacecraft and ready for launch.

• All planned ground calibration measurements completed; analysis is in progress and several issues remain open.

• Calibration products in development; CTI correction remains to be implemented.
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We can’t wait!
XIS Charge Injection Structure

See posters 5501-49 (Prigozhin et al.) & 5501-51 (LaMarr et al.)

MIT Lincoln Lab. CCID41  "Fill & Spill" Injection
XIS Charge Injection Structure

See posters 5501-49 (Prigozhin et al.) & 5501-51 (LaMarr et al.)

"Fill & Spill" Sequence

• An input register is added:
  * Location is “row 1025”
  * Input diode (ID) & input gate (IG) at “column 0”
  * Can be clocked to place charge above any/all CCD columns.

• 2 extra signals required:
  * ID timing determines columns injected
  * IG level controls injected charge quantity
  * Existing serial clocks((3) transfer charge in IR

MIT Lincoln Lab CCID41
Charge Injection to Improve Charge Transfer

• Charge injection is programmable.

• “Grid” program reduces charge transfer losses due to radiation damage:
  * Charge is injected in each column of every 54th row.
  * Injected charge (temporarily) fills radiation-induced traps.
  * Filled traps will not degrade charge transfer inefficiency.
  * Result is better spectral resolution.