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

Astro-E2 Users' Group
14 February 2005

Mark Bautz, MIT CSR

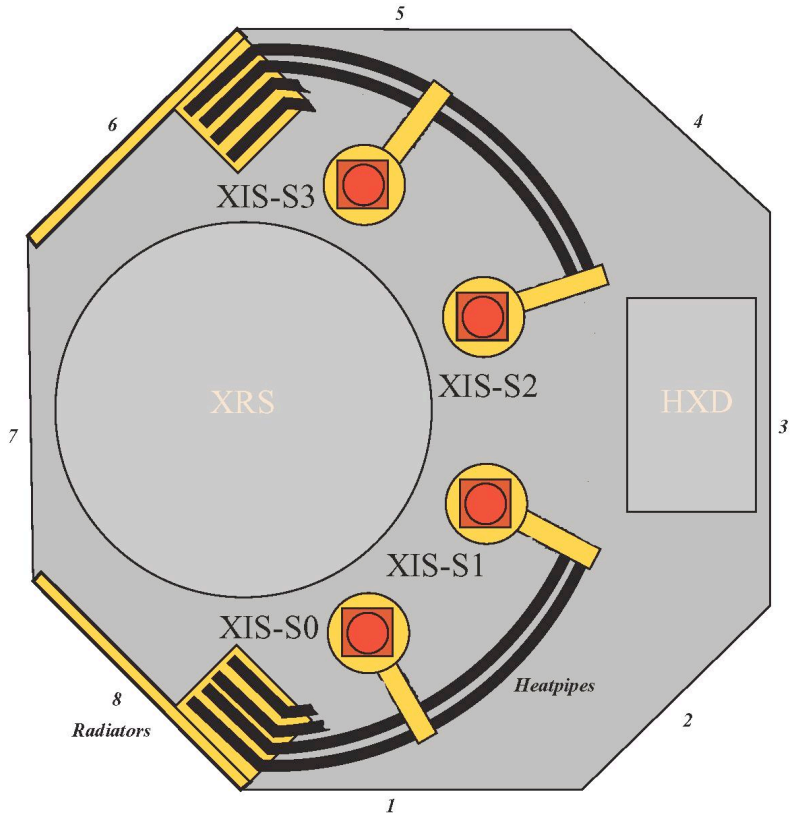
XIS Team Members
(Partial list)

Osaka University	*H. Tsunemi, K. Hayashida, K. Torii, M. Namiki*
Kyoto University	*K. Koyama (PI), T. Tsuru, H. Matsumoto*
ISAS/JAXA	*T. Dotani, H. Murakami, M. Ozaki*
Rikkyo University	*H. Awaki*
Ehime University	*S. Kitamoto*
MIT CSR	*M. Bautz (MIT PI), S. Kissel, B. LaMarr, G. Prigozhin, G. Ricker, J. Doty, R. Foster*
MIT Lincoln Lab.	*B. Burke, J. Gregory, A. Pillsbury*

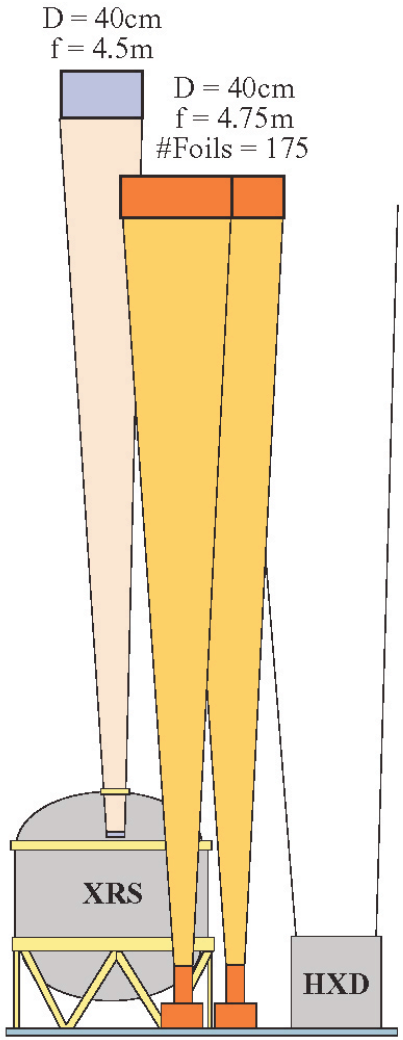
The XIS at a Glance

- 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



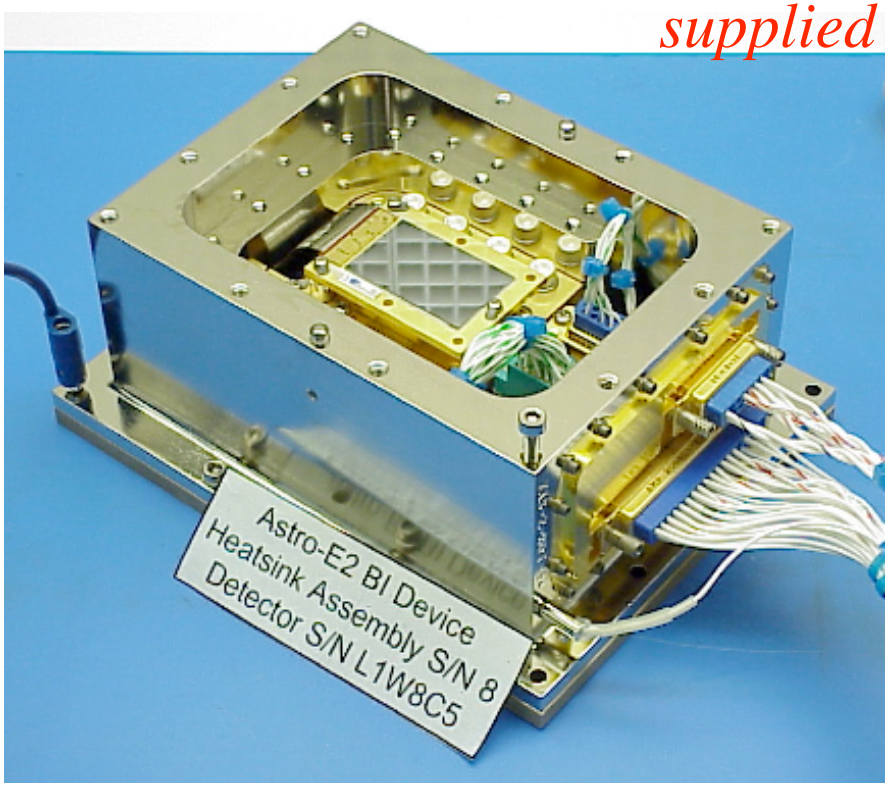
View from Mirrors



XIS
(2 of 4)

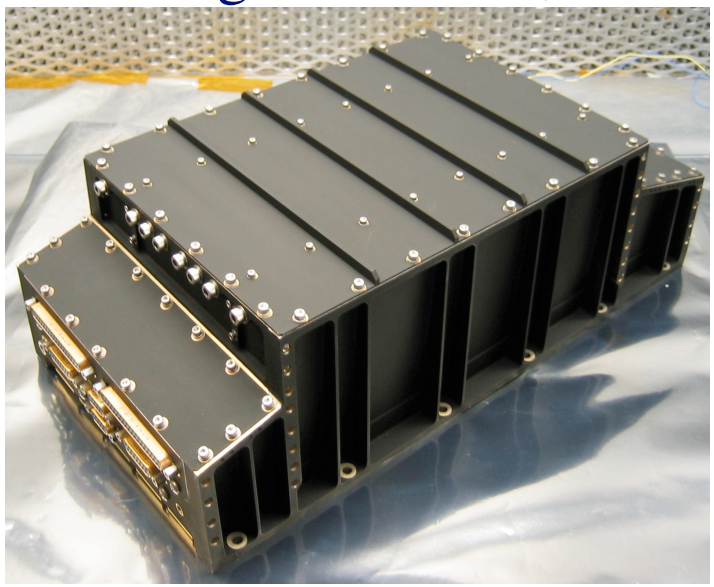
Astro-E2 XIS Flight Hardware

supplied by MIT



Key Characteristics:

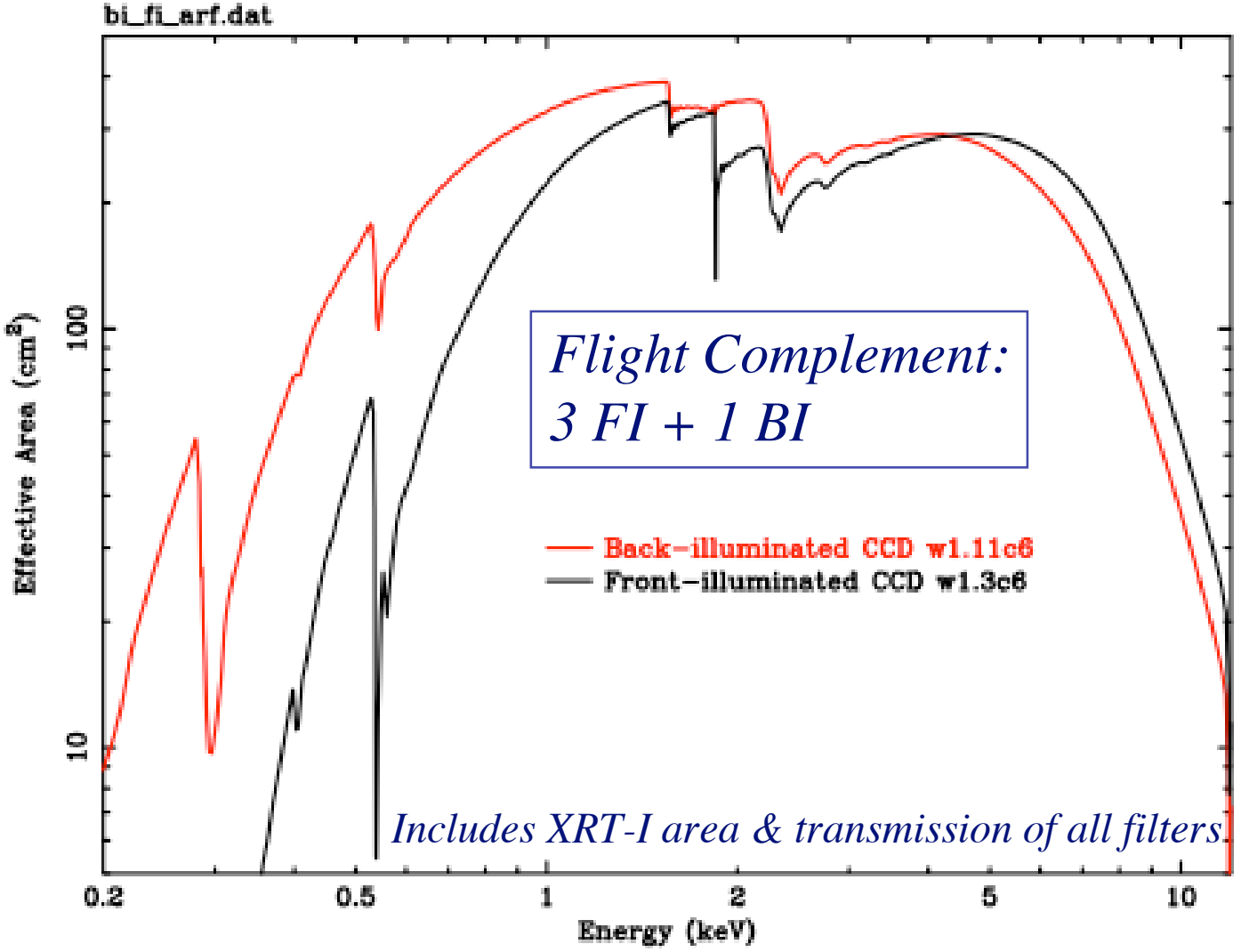
- Low noise (1-2 e^- RMS)
- Deep depletion (65 μm)
- Charge injection capability
- Front- & back-illumination
- CCDs fabricated at MIT/Lincoln
- CCD heritage: *Chandra*, ASCA



Components:

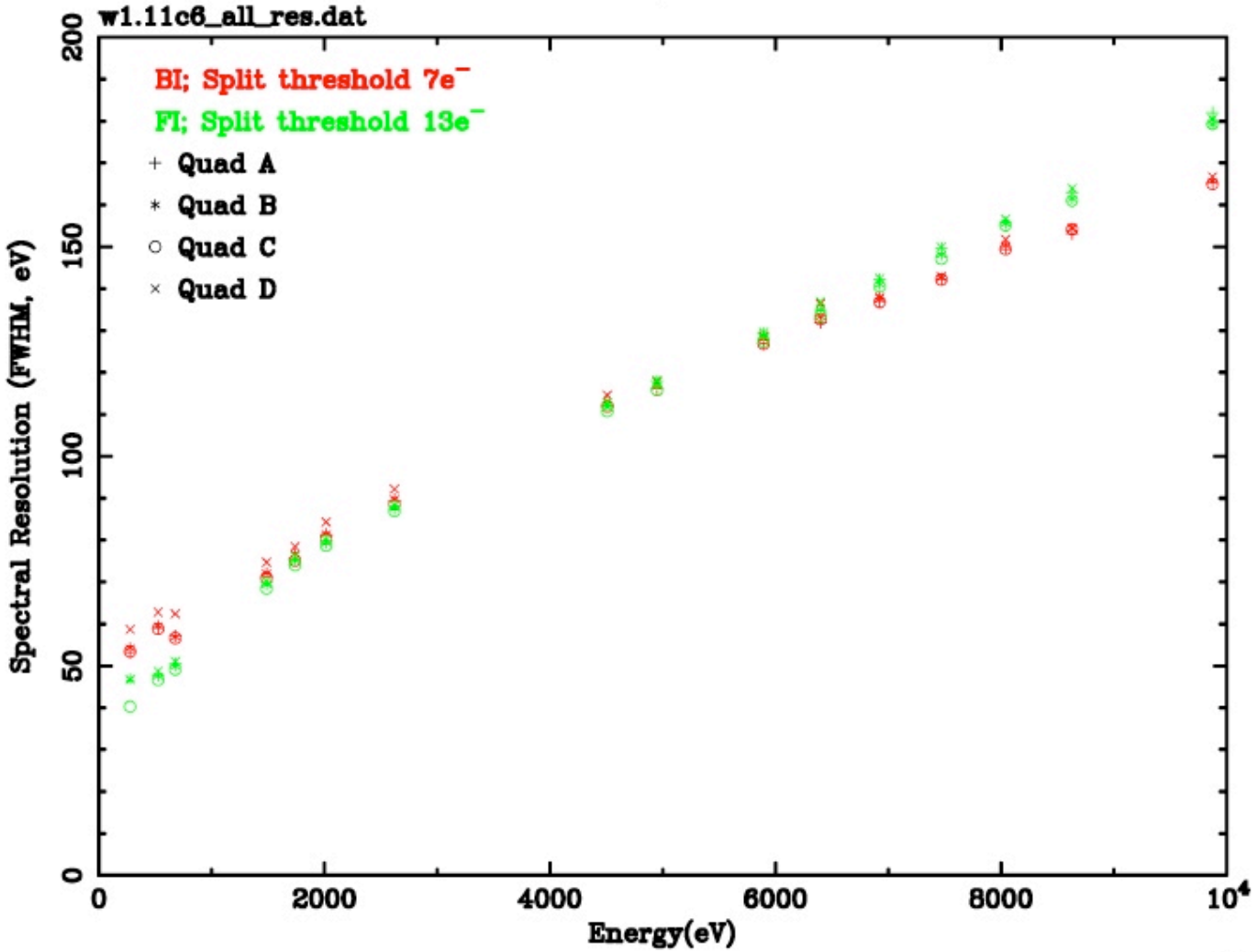
- 4 X-ray photon-counting CCD sensors, Peltier-cooled
- 2 low-noise front-end electronics sets with thermal controllers

XIS Effective Area Comparison: 1 BI Sensor vs 1 FI Sensor



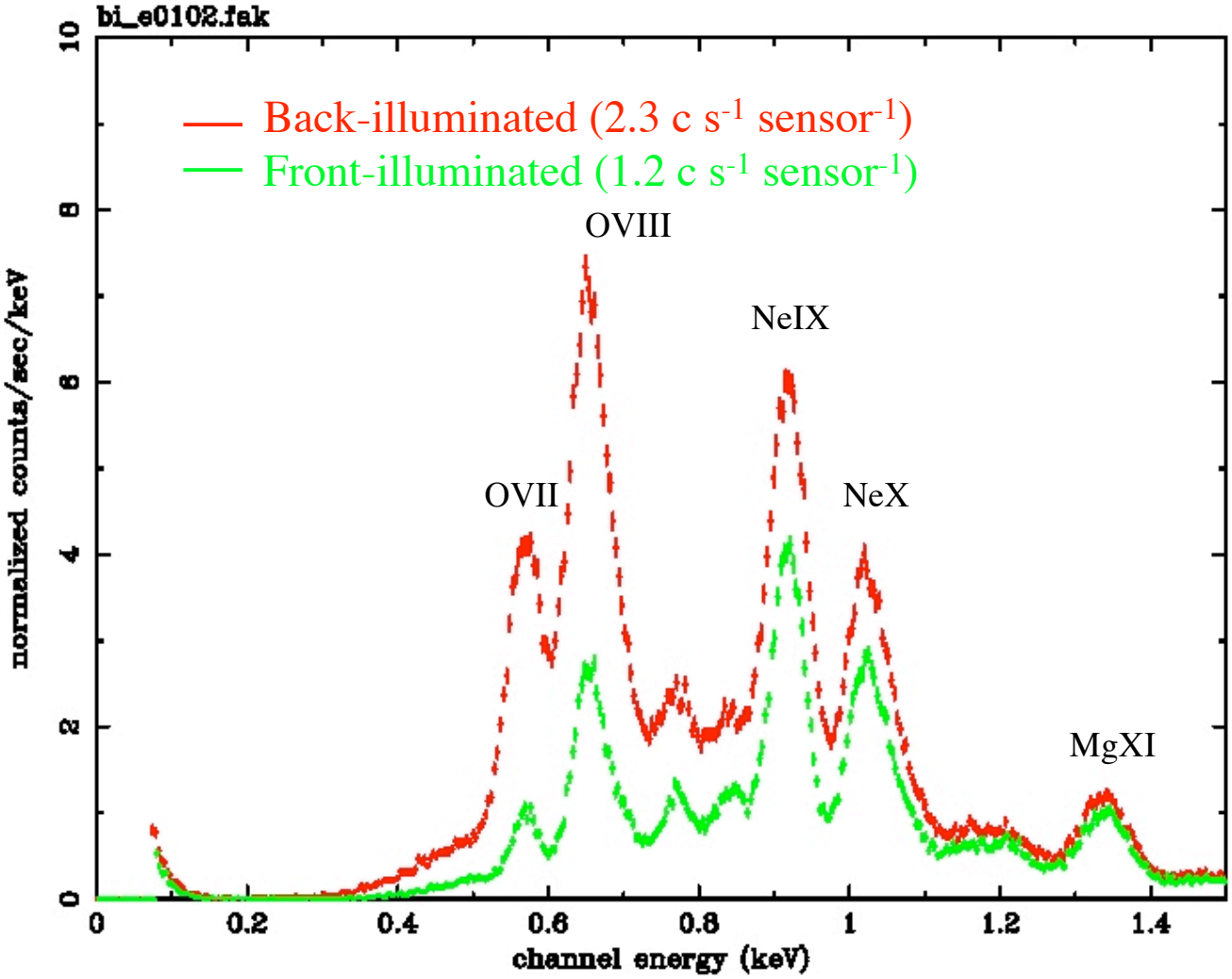
XIS Spectral Resolution: FI & BI CCDs

See also LaMarr et al., poster 5501-51



XIS Spectral Resolution Comparison: BI vs FI

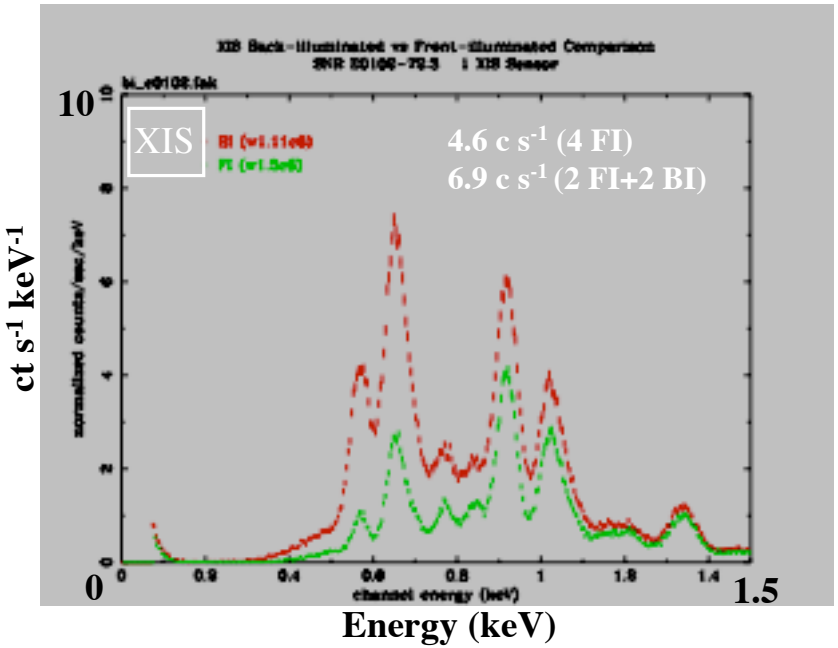
Simulated Spectra of SNR E0102 -72.3

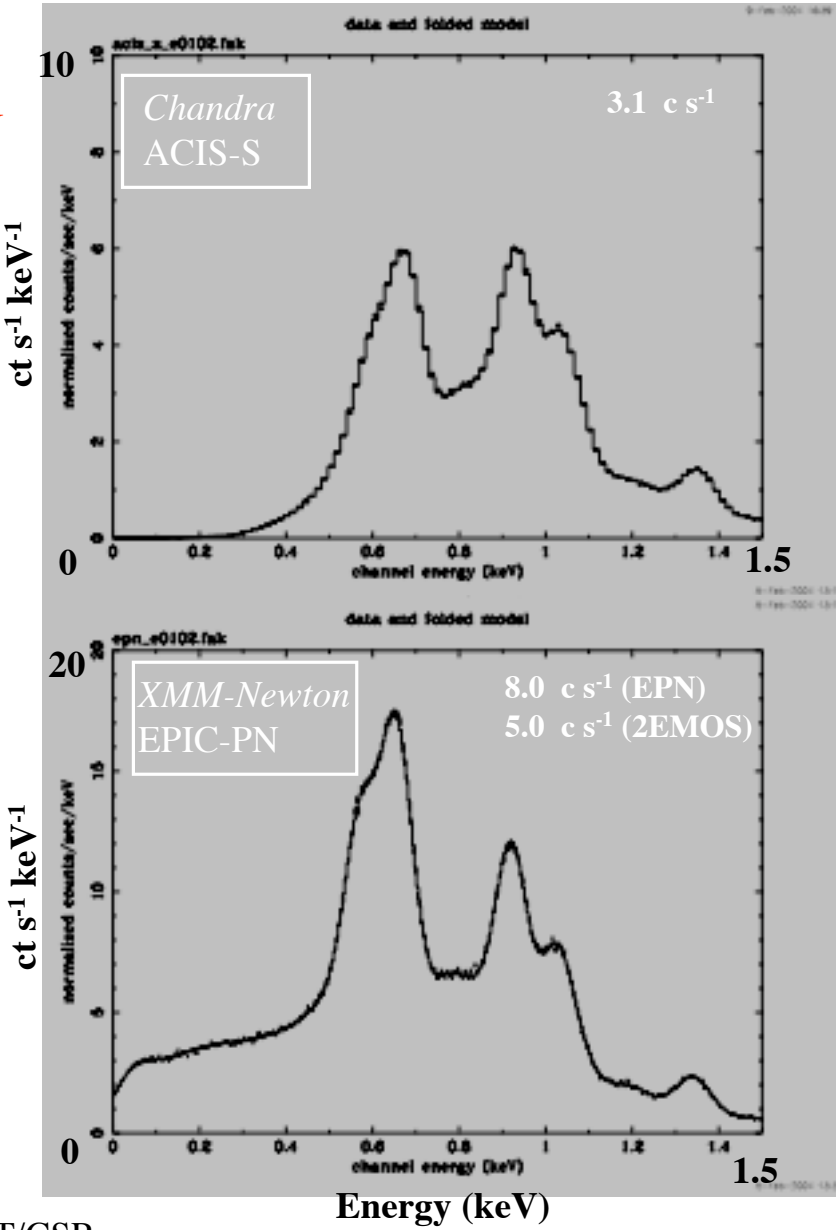


BI CCD Spectral Resolution:

XIS, *Chandra* ACIS & XMM-*Newton* EPIC-PN

Simulated Spectra of SNR E0102 -72.3



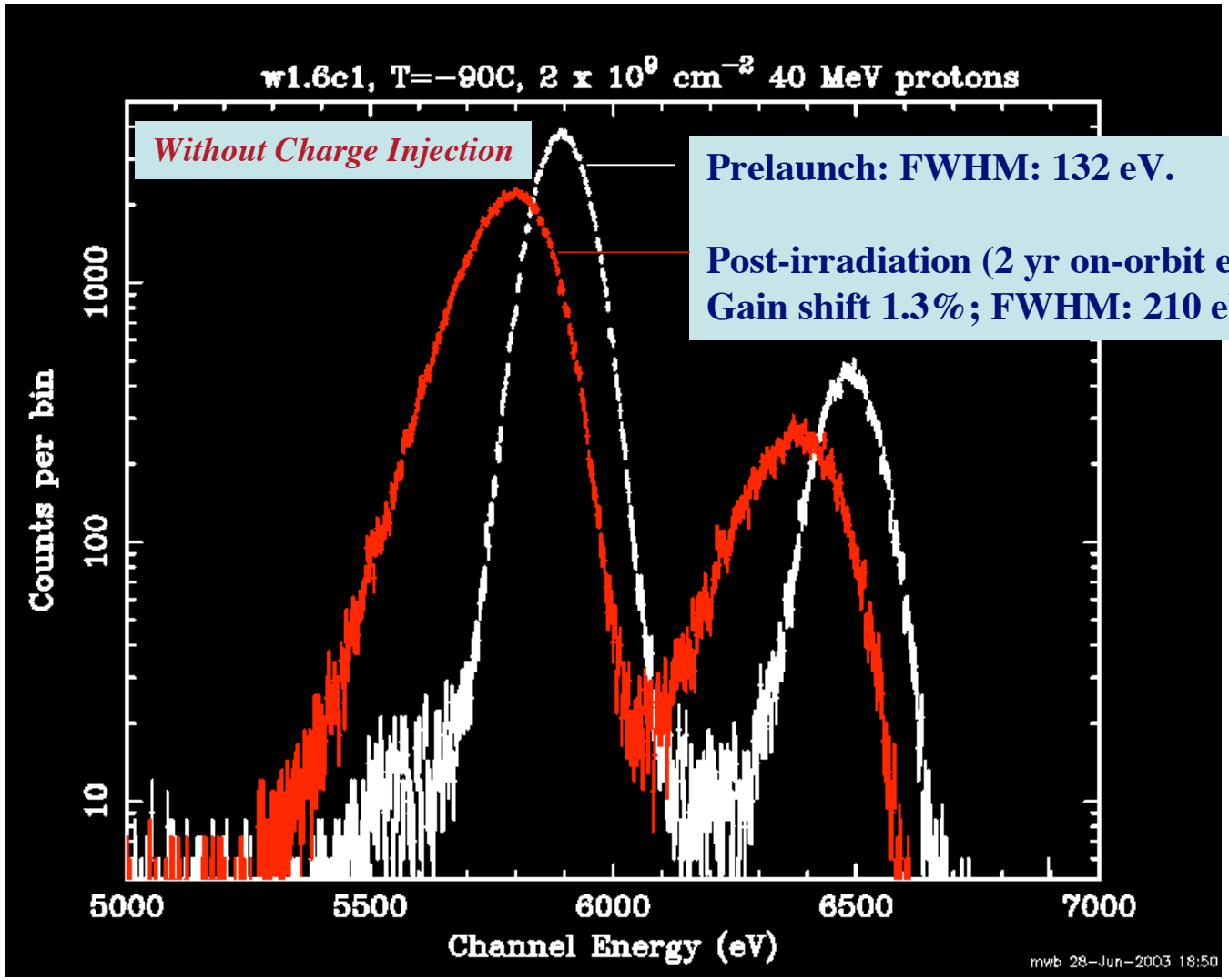


Note: EPIC MOS Resolution comparable to XIS (but is not a BI CCD)

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

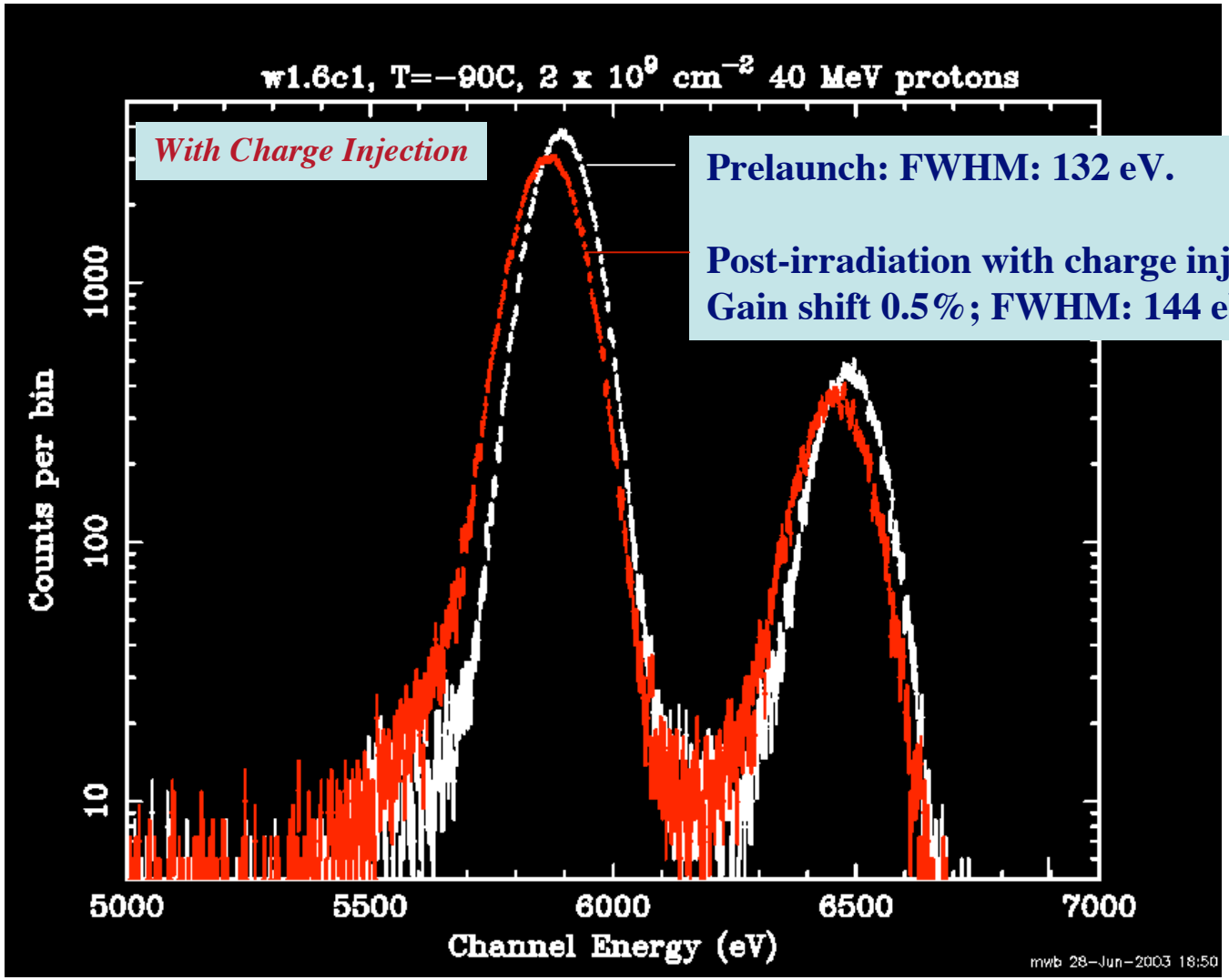
XIS Spectral Resolution after Irradiaton without Charge Injection



Prelaunch: FWHM: 132 eV.

Post-irradiation (2 yr on-orbit equivalent): Gain shift 1.3%; FWHM: 210 eV

XIS Spectral Resolution after Irradiaton *with* Charge Injection



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

Target	Mode	Date (MOL)	Exp (ks)	Pri.	Purpose/Remarks
Vega	5x5	1	10	1	OBF Check
E0102-72	5x5	1	10	1	low-E gain,res., QE
	P-sum	1	20	1	CXO reference spectrum
	Burst	1	10	3?	
Cas-A	5x5	6	1.2	1	CTE/gain check
	P-sum	6	1.2	1	(Pri.2: 4 corners @3 ksec)
	5x5	6	12	2	
	P-sum	6	12	2	
E0102-72	5x5	6	20	1	low-E CTE, gain, QE
	P-sum	6	20	1	(Priority 2: 4 corners @,50 ksec)
	5x5	6	200	2	
	P-sum	6	200	2	
Eta Carina	5x5	1-6	20*	1	low-E BI QE, gain (N line)
Cygnus Loop	5x5	1-6	10*	1	low-E BI QE, gain (C line)

*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.

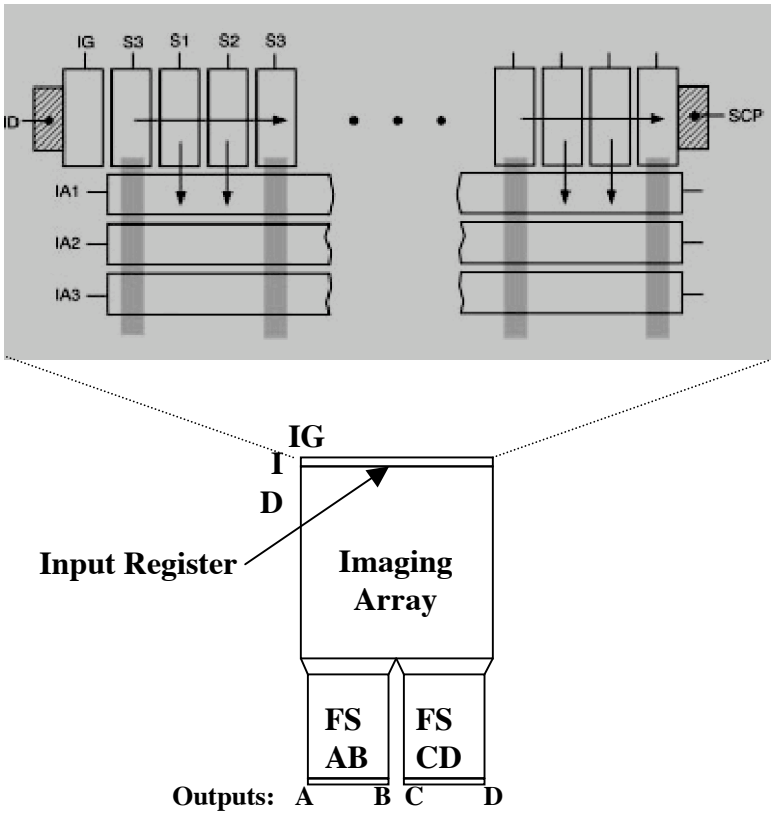
XIS Status Summary

- 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.

We can't wait!

XIS Charge Injection Structure

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

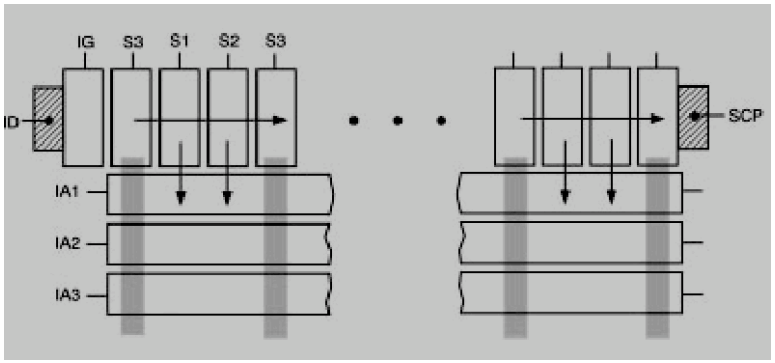


MIT Lincoln Lab. CCID41

"Fill & Spill" Injection

XIS Charge Injection Structure

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



- **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*

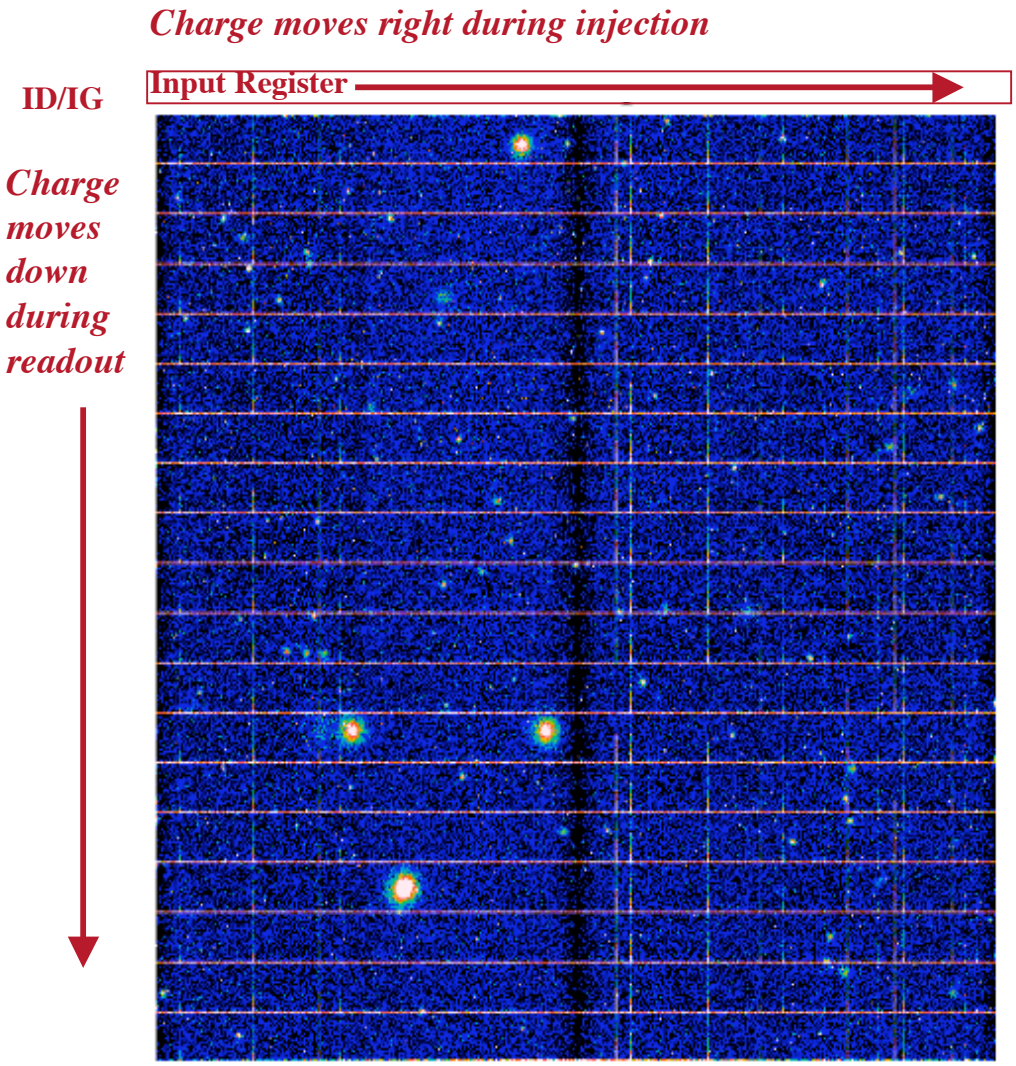
MIT Lincoln Lab CCID41

Fill:
ID low
Q~ IG-S3
Spill:
ID high

Transfer:
Clock S3 & IG with IG-S3 fixed

"Fill & Spill" Sequence

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.*