Suzaku Operations & Calibration Status

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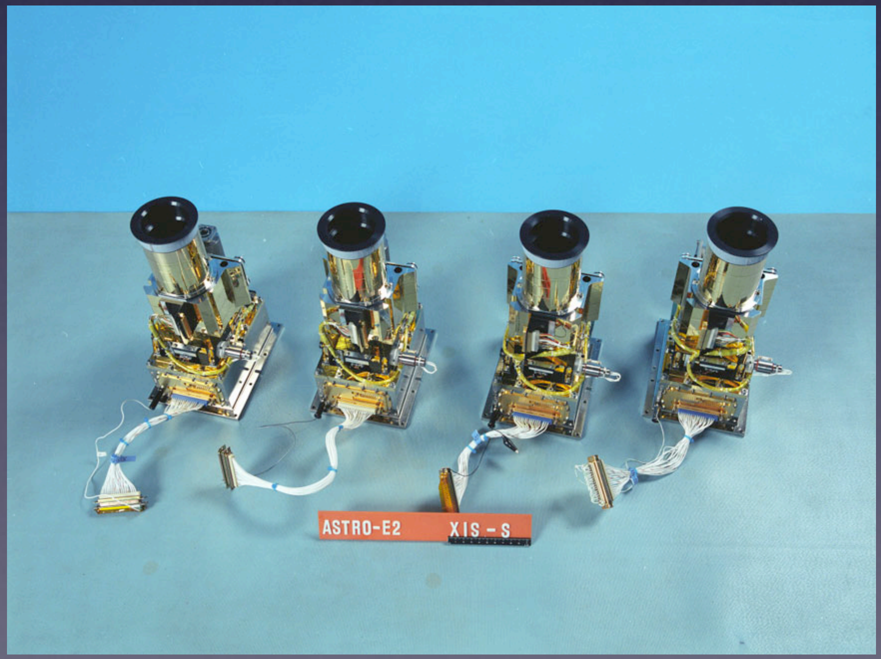
for the *Suzaku* Team

IACHEC 2016 – IUCAA

Suzaku – Overview

X-ray Imaging Spectrometer (XIS)

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



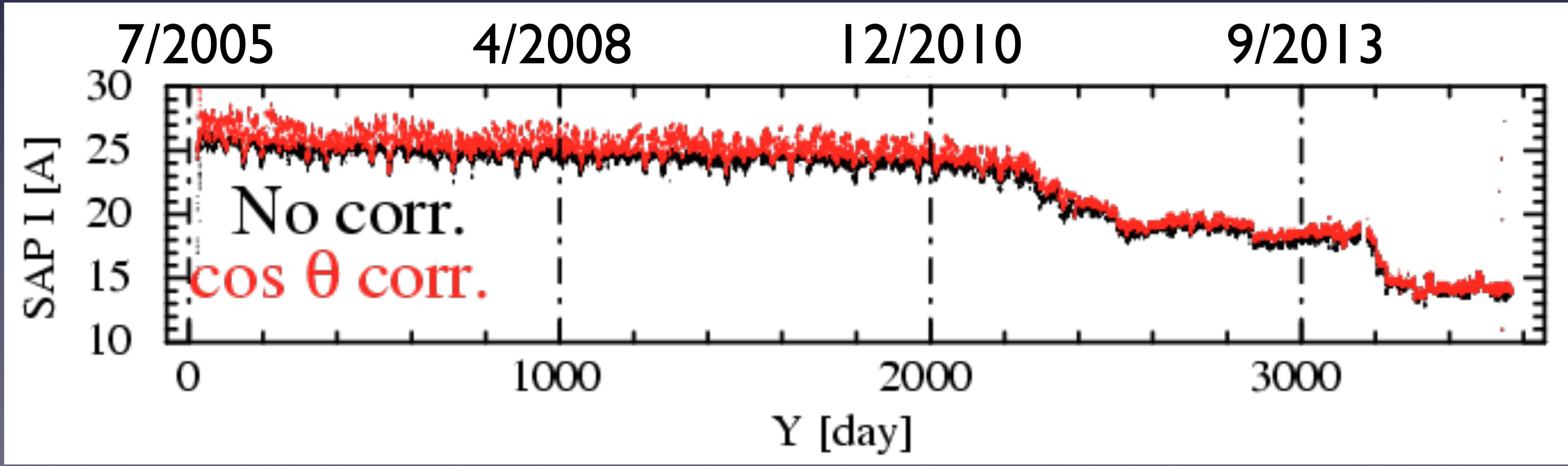
Hard X-ray Detector (HXD)

- collimated PIN diode + GSO scintillator detector, 10–600 keV

Operations

Suzaku (2005-2015)

- Power Problems:
  - solar power system degraded (almost) as expected
  - batteries degraded in capacity and charging ability
  - several prolonged safe-holds, including all of Jan 2015



Suzaku (2005-2015)

- On June 1, 2015:
  Suzaku lost attitude control, started spinning slowly

intermittent illumination of solar panels
+
bad batteries
=
very short windows for contact

- controllers unable to troubleshoot or correct

Suzaku (2005-2015)

Japan Aerospace Exploration Agency

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Press Release

Home > Press Release > X-ray Astronomy Satellite “Suzaku” Completes Scientific Mission

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X-ray Astronomy Satellite “Suzaku” Completes Scientific Mission

August 26, 2015 (JST)

National Research and Development Agency
Japan Aerospace Exploration Agency (JAXA)

The Japan Aerospace Exploration Agency (JAXA) decided to complete the scientific mission of the X-ray Astronomy Satellite “Suzaku” (ASTRO-EII) after carefully considering the condition of the satellite.
JAXA launched the Suzaku on July 10, 2005, and has been operating it until recently, exceeding its target observation life of about two years. However, its communication with the ground had been established only intermittently since June 1, 2015, and JAXA had been trying to restore it.
In addition to communication, JAXA has also examined the condition of the Suzaku’s batteries and attitude control, and concluded that it is difficult to resume its scientific observations.
We will perform necessary procedures to complete its operation.

http://global.jaxa.jp/press/2015/08/20150826_suzaku.html

Suzaku (2005-2015)

Celebrating 10 Years of Suzaku

We are celebrating 10 years since the Institute of Space and Astronautical Science of Japan Aerospace Exploration Agency (ISAS/JAXA) launched Suzaku into orbit on July 10th, 2015. After a decade in the harsh radiation environment of space, Suzaku is winding down its operations while scientists at ISAS/JAXA and many other Japanese institutions, along with collaborators from US, Europe and Canada are busy preparing the next Japanese X-ray astronomy satellite (ASTRO-H) for launch in early next year. This seemed a perfect opportunity to look back at ten of Suzaku's greatest scientific hits.

Suzaku's launch on July 10, 2005. (Credit: Scott Porter/NASA)

Suzaku is Japan's fifth X-ray astronomy satellite with significant contributions from the US (NASA/GSFC and MIT). And even though Suzaku lost its revolutionary, microcalorimeter-based, X-Ray Spectrometer (XRS) instrument before it could make astronomical observations, the satellite has proven to be a very productive mission.

Artist's concept of Suzaku in space. (Credit: ISAS)

Operating simultaneously with two other major international X-ray observatories, NASA's Chandra X-ray Observatory and ESA's XMM-Newton, Suzaku managed to find several scientific niches.

- Suzaku has *wide-band capability* allowing it to observe the 0.2-600 keV band by simultaneously using its X-ray Imaging Spectrometer (XIS) operating in the 0.2-10 keV range and Hard X-ray Detector (HXD) operating in the 10-600 keV range.
- The XIS's CCDs are from a newer generation than those onboard Chandra and XMM-Newton, giving it *good spectral resolution*.
- The XIS has *low background, therefore high sensitivity, for extended X-ray sources*, which is the result of the shorter focal length of its X-Ray Telescopes (XRTs) and the observatory's location in a low Earth orbit.

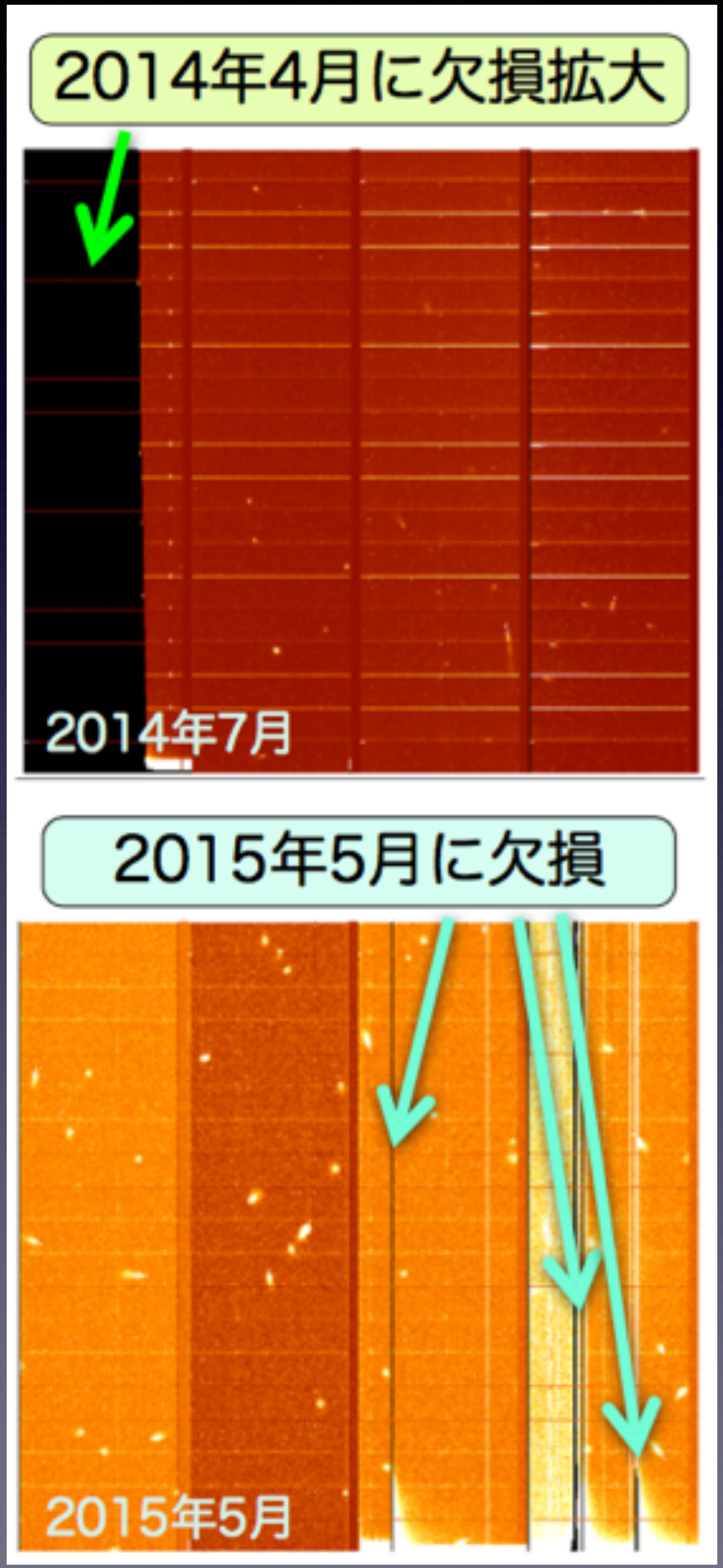
http://imagine.gsfc.nasa.gov/science/featured_science/suzaku_10yr

HXD
Calibration Updates

(none)

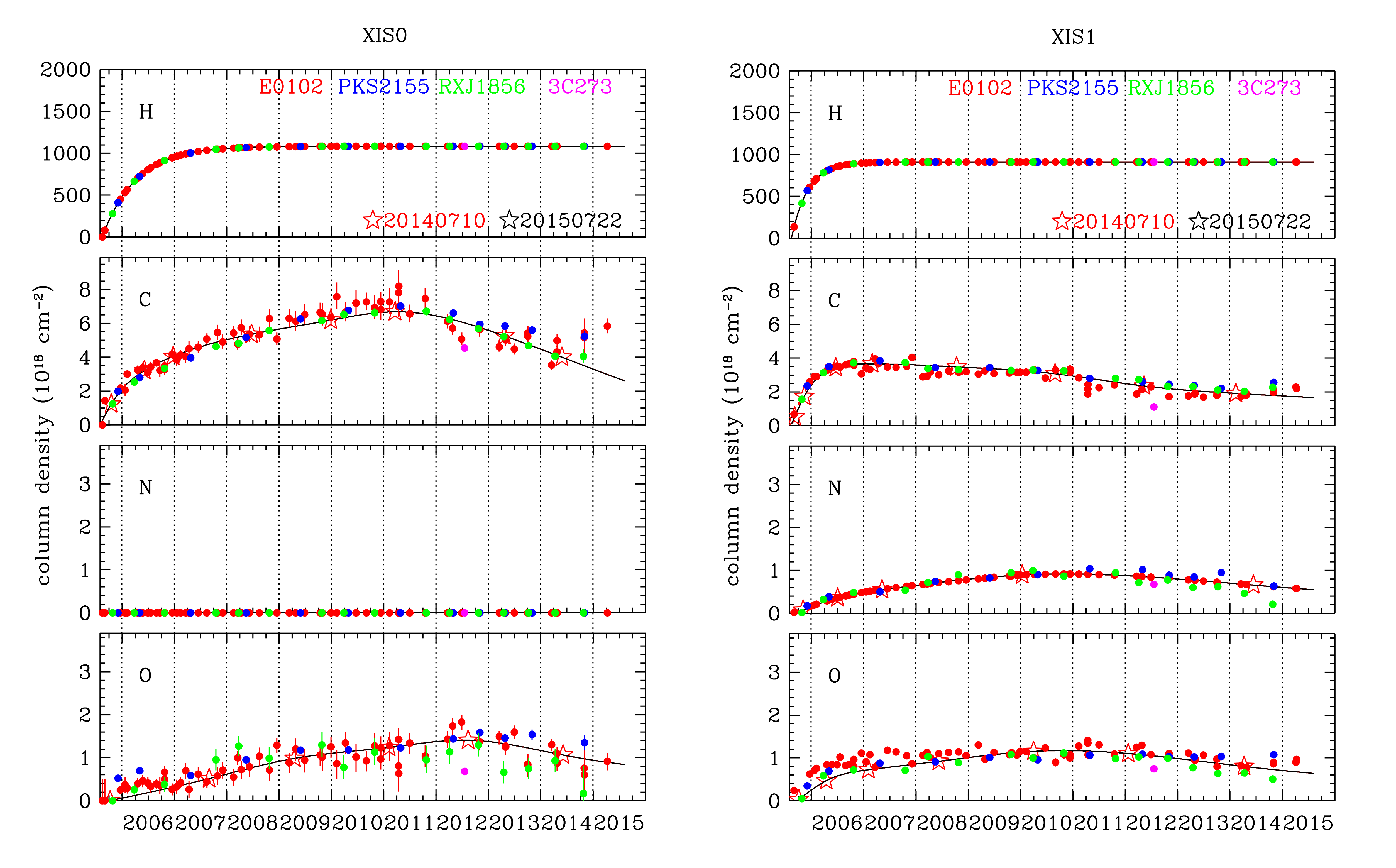
XIS
Calibration Updates

CCDs vs. Power Cycles

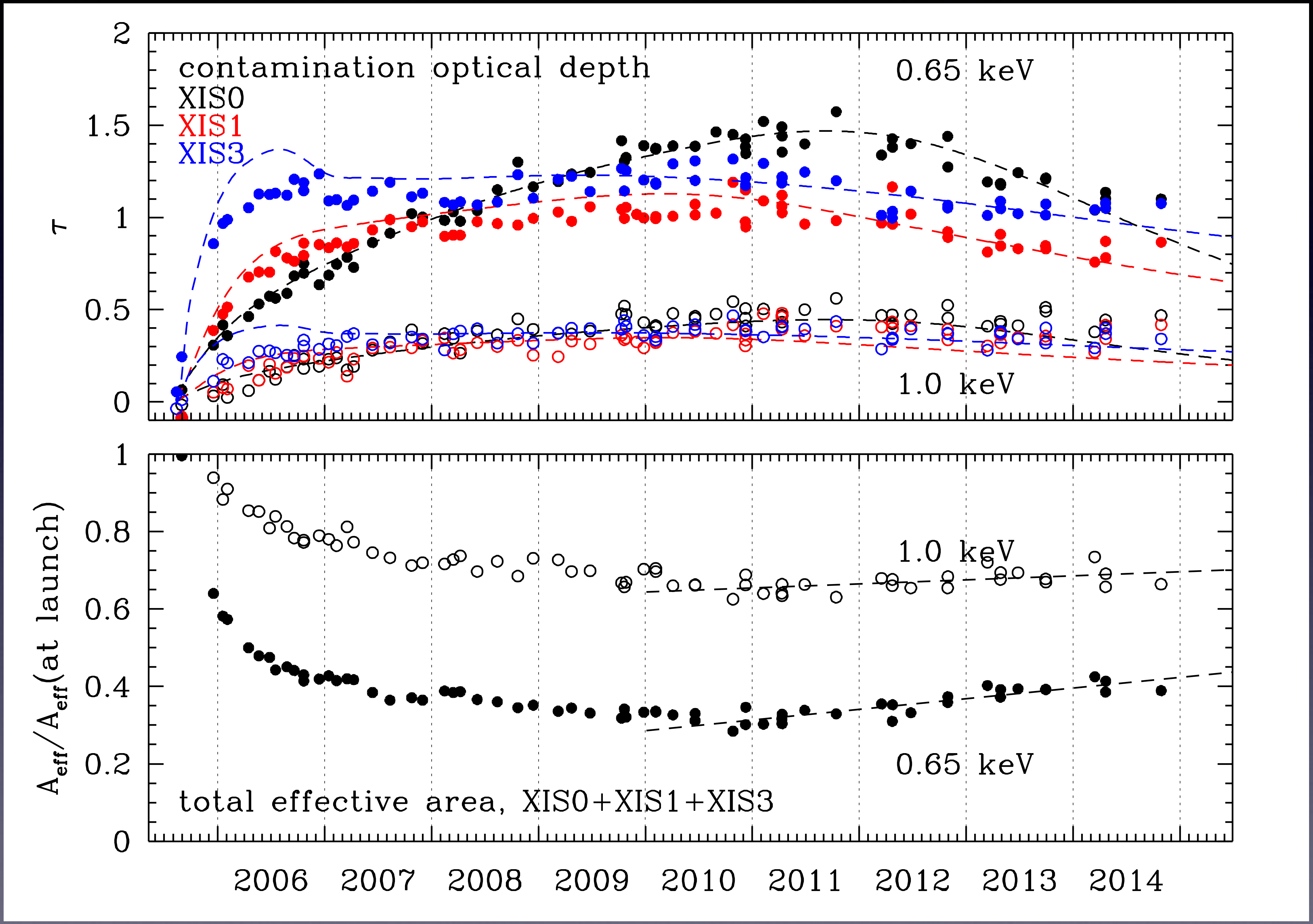


- dead region on XIS0, produced by micrometeoroid impact in 2009, has increased from 1/8 to 1/4 of CCD
  - increase of noise behind CI rows
- new dead/noisy regions on XIS3
- both occurred after extended power-offs for battery failure
- users must be aware of telemetry saturation for XIS0 in 2015
- more in CCD WG session

XIS Molecular Contamination



XIS Contamination Trend



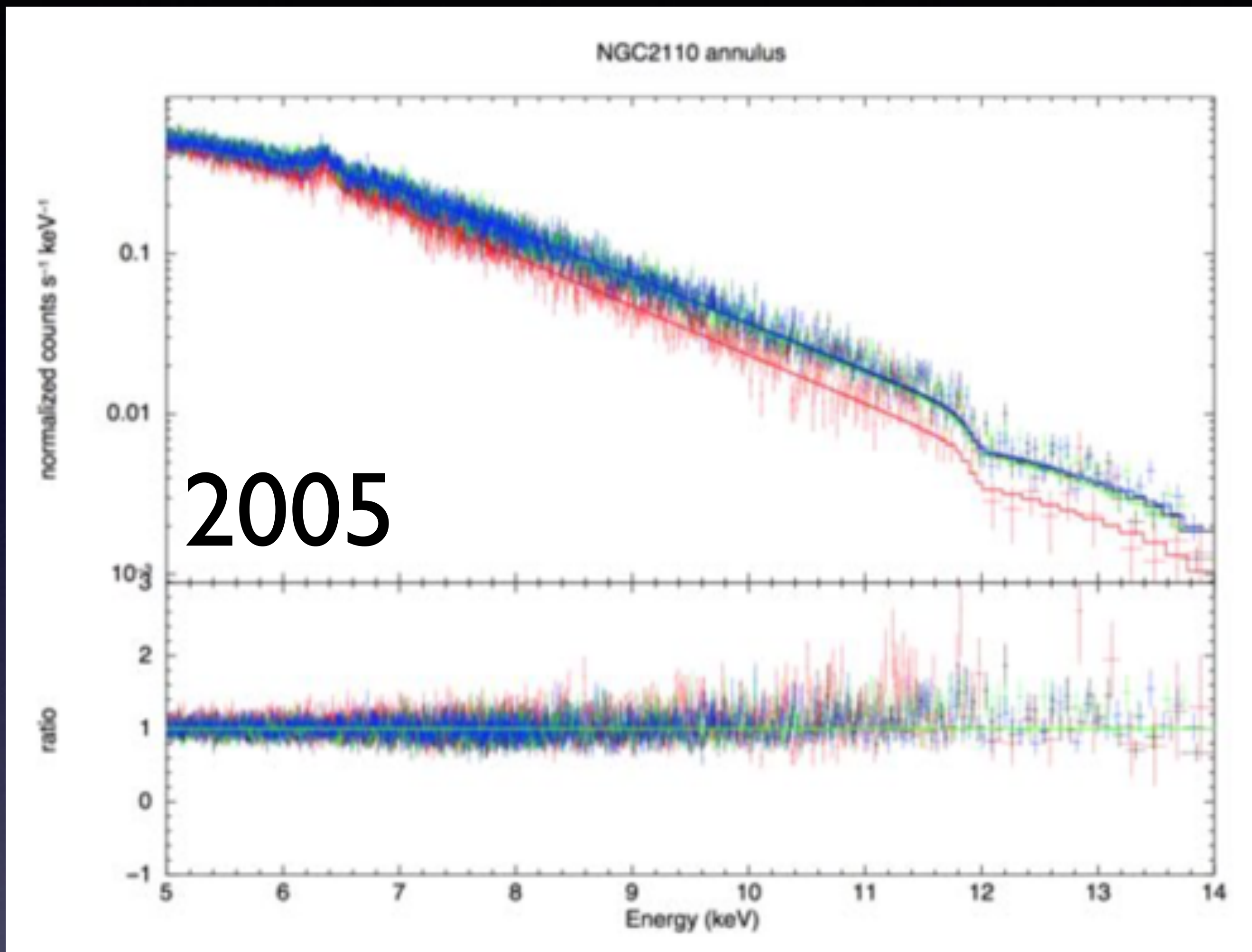
on-axis, from E0102

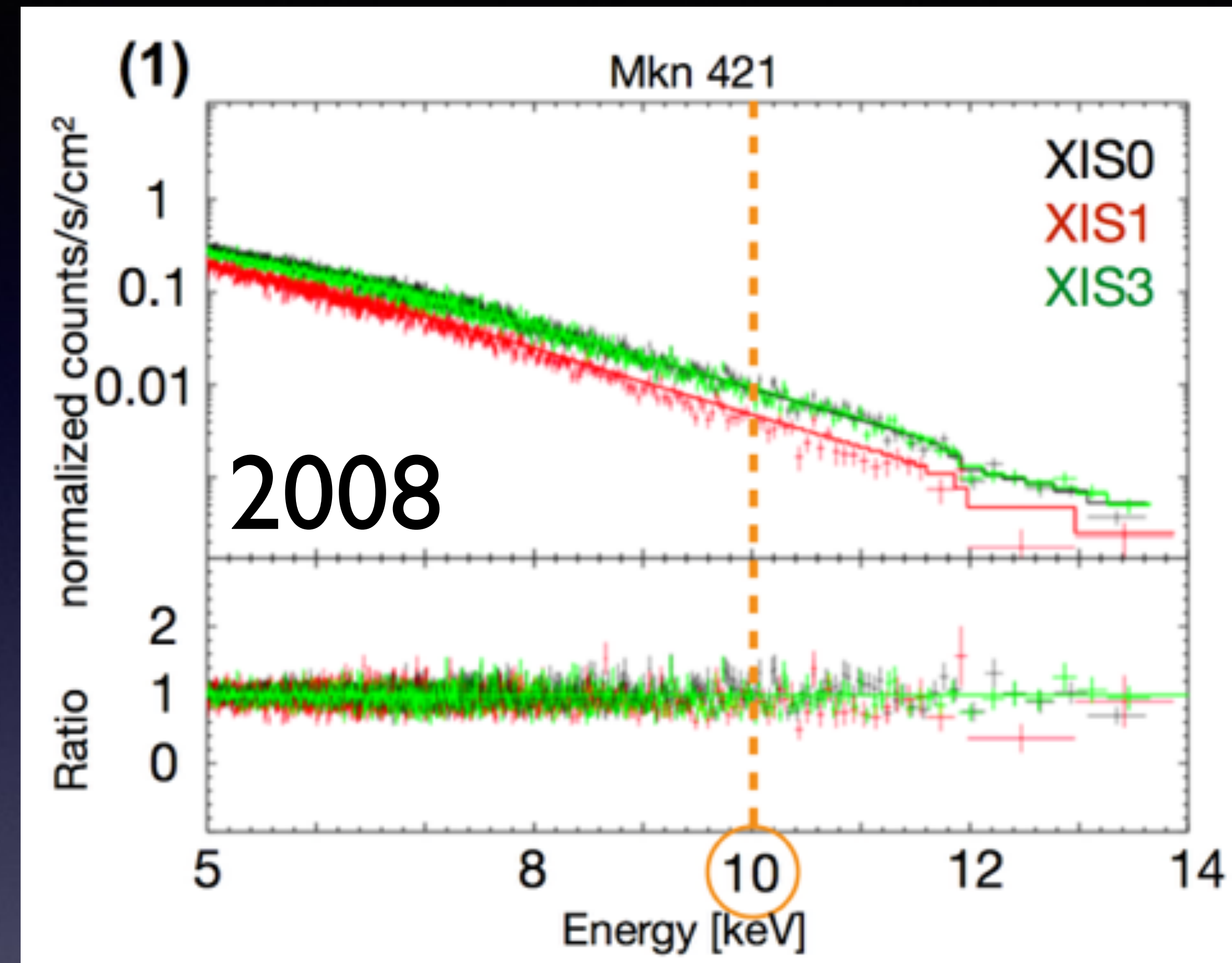
XIS Above 10 keV

JX-ISAS-SUZAKU-MEMO-2015-03
Title: Calibration above 10 keV
Category: XIS
Author: E. Kusunoki, M. Tsujimoto, Q. Wada, M. Mizumoto (ISAS)
Date: 2015-09-04 Version: 1

- XIS has effective area in 10–12 keV, but it's unused
- cross-cal of XISes using:
  PSR 1509-58
  NGC 2110
  RXJ 2056.6+4940
  Mkn 421
- independent of IACHEC
- cross-cal of XIS+NuSTAR:
  3C 273
  PKS 2155-304
  (cf. Madsen+2015)

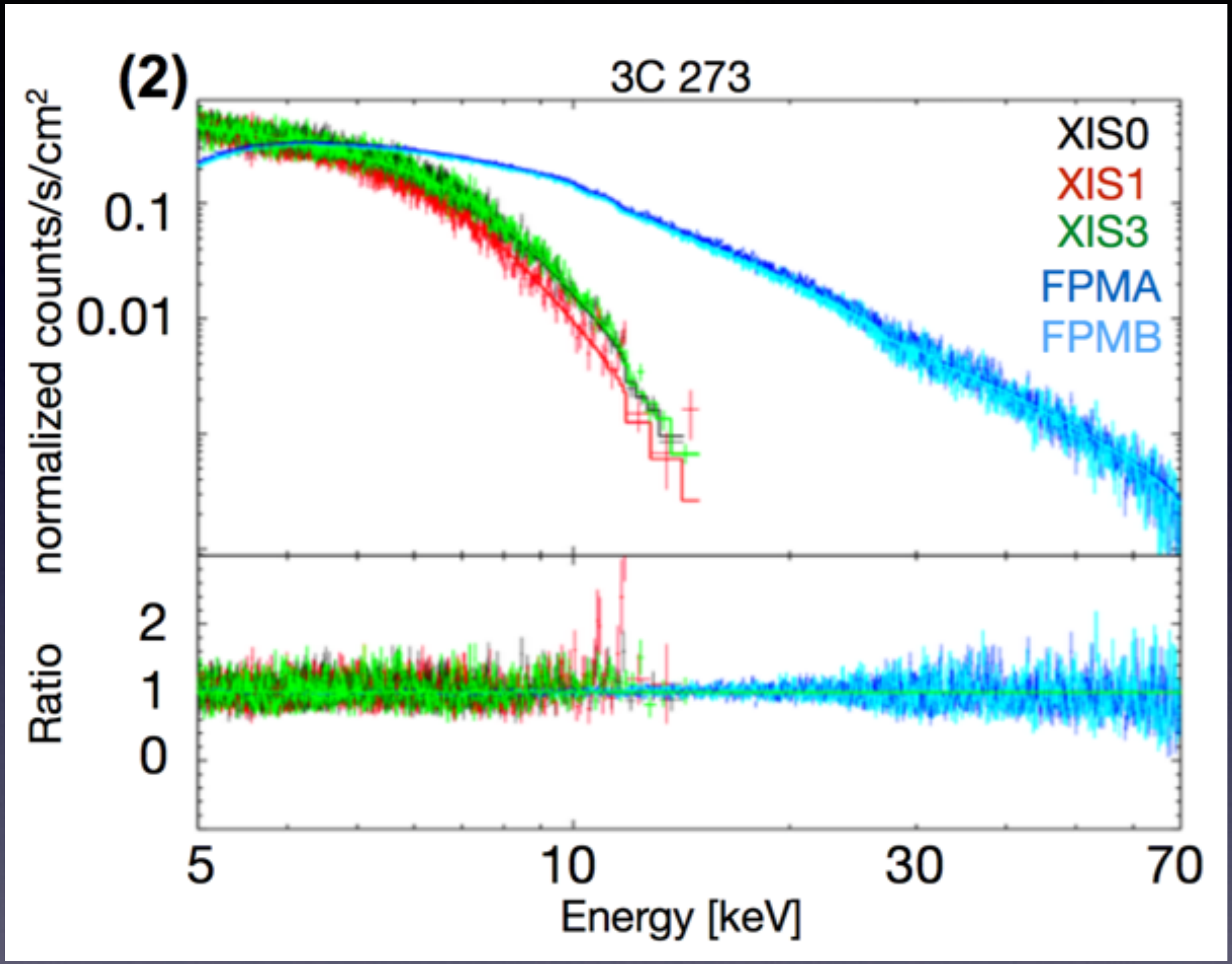
XIS vs. XIS at 10–14 keV





- fit over 1–14 keV, single absorbed power law
- residuals above 10 keV similar to those below, although XIS1 is off by ~10–20%

XIS vs. NuSTAR at 10–14 keV



- XIS fit 1–14 keV, NuSTAR fit 3–70 keV

XIS vs. XIS at 10–14 keV

	N_H [a]	Γ [b]	Flux [c]	Flux ratio
PKS 2155–304				
XIS0	0.015	2.77±0.04	0.91±0.04	1.00
XIS1	(tied)	2.84±0.05	0.89±0.05	0.98±0.07
XIS3	(tied)	2.77±0.04	0.94±0.04	1.03±0.06
FPMA	(tied)	2.73±0.03	1.02±0.02	1.12±0.05
FPMB	(tied)	2.70±0.03	1.07±0.03	1.17±0.06
3C 273				
XIS0	0.0179	1.624±0.015	21.89±0.30	1.00
XIS1	(tied)	1.673±0.017	20.76±0.35	0.95±0.02
XIS3	(tied)	1.648±0.015	21.93±0.30	1.00±0.02
FPMA	(tied)	1.678±0.002	23.26±0.04	1.06±0.01
FPMB	(tied)	1.674±0.002	24.25±0.04	1.11±0.02

Confidence range: 1 sigma.

[a] H-equivalent column density 10^{22} cm^{-2}.

[b] Photon index.

[c] 10–14 keV band flux in 10^{-12} erg s^{-1} cm^{-2}.

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XIS3	(tied)	2.77±0.04	0.94±0.04	1.03±0.06
FPMA	(tied)	2.73±0.03	1.02±0.02	1.12±0.05
FPMB	(tied)	2.70±0.03	1.07±0.03	1.17±0.06
XIS3	(tied)	1.648±0.015	21.93±0.30	1.00±0.02
FPMA	(tied)	1.678±0.002	23.26±0.04	1.06±0.01
FPMB	(tied)	1.674±0.002	24.25±0.04	1.11±0.02

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XIS is as "reliable" at 10–14 keV as it is at lower energies

Suzaku (2005-2015)

- instrument teams will finalize the processing and calibration ~ this year
- there's always…the archive!
- on to *Hitomi*