Thermal SNRs Working Group Report

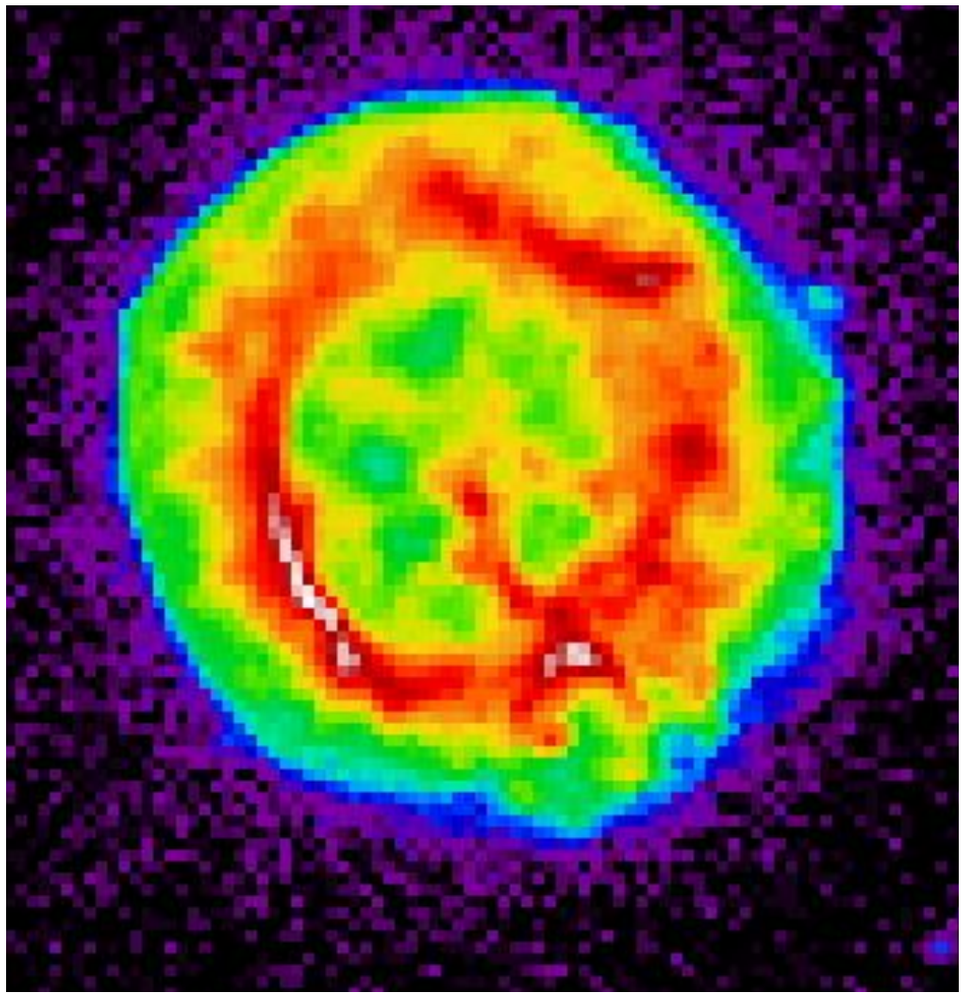
Paul Plucinsky on behalf of the IACHEC Thermal SNR Working Group

Thermal SNR Working Group

One of the "Standard candle" working groups.
This presentation is a summary report of this group's work:

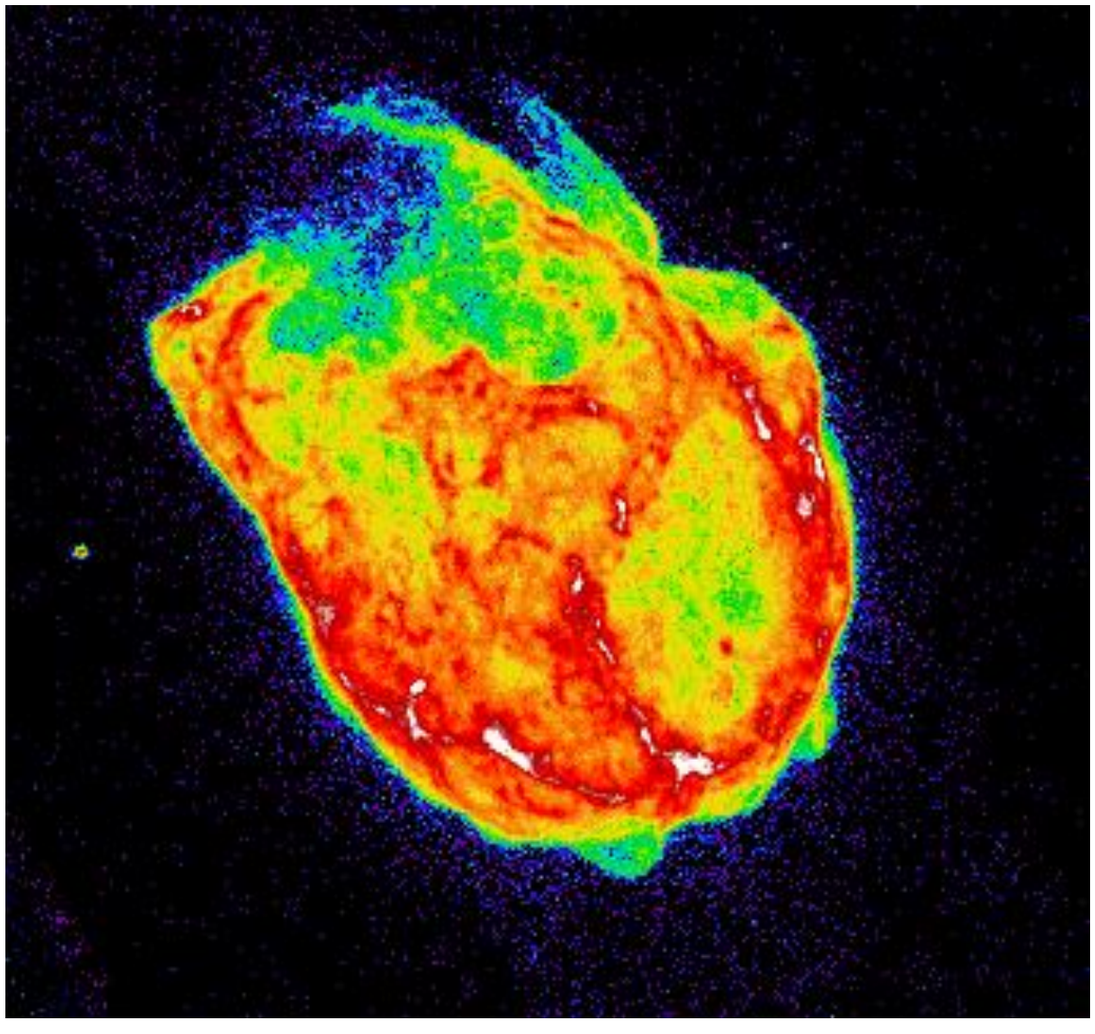
XMM-Newton	Andy Pollock(Sheffield), Michael Smith, Martin Stuhlinger (ESAC)
XMM-Newton MOS	Steve Sembay (Leicester)
XMM-Newton pn	Frank Haberl (MPE)
Chandra ACIS	Paul Plucinsky (SAO)
Suzaku XIS	Eric Miller (MIT)
Swift XRT	Andrew Beardmore (Leicester)
Models	Adam Foster (SAO)
Hitomi	Matteo Guainazzi(JAXA)
ASTROSAT	***K.P. Singh(TIFR) Firoza Sutaria(IIAP), Sunil Chandra(TIFR)***

E0102: X-ray brightest in the SMC
0.77X0.77 arcmin, 13X13 pc
t ~ 2,000 yr (Finklestein et al. 2006)
L_X(0.3-10.0 kev) = 2.5×10^{37} ergs s^{-1}
no compact object
"O-rich" core-collapse SNR



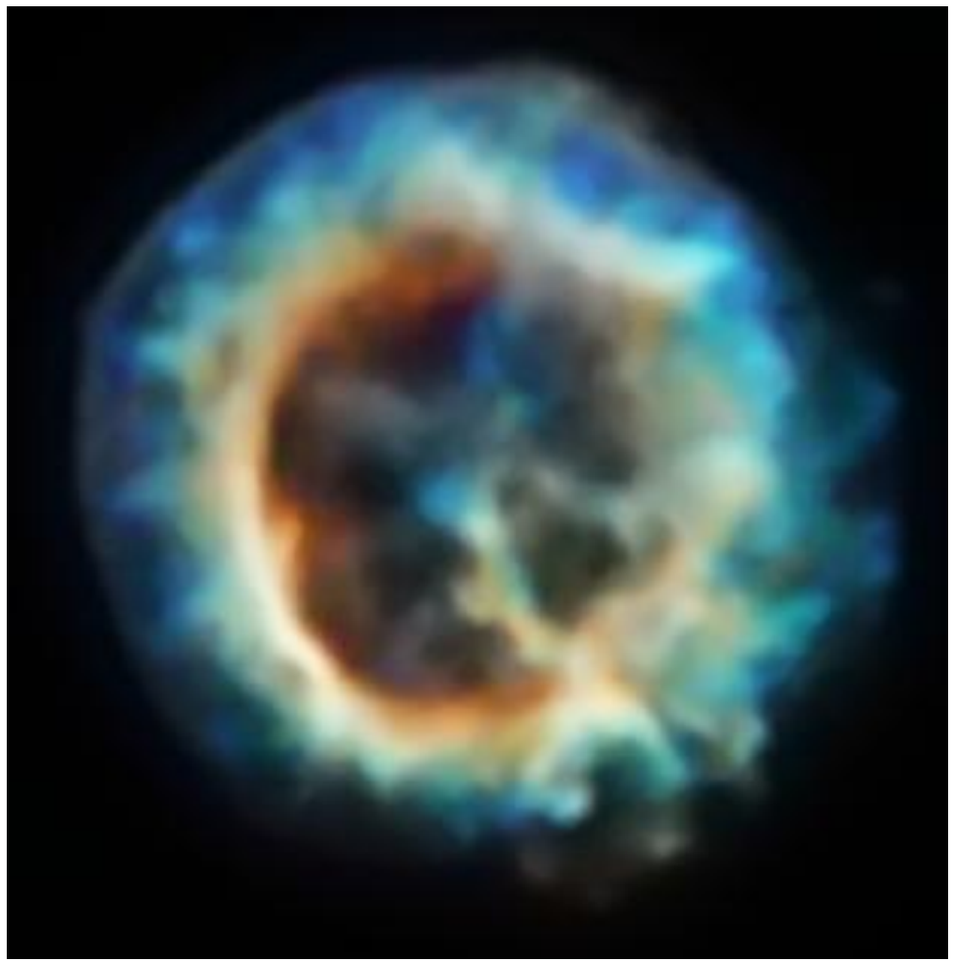
ACIS 0.35-8.0 keV

N132D: X-ray brightest in the LMC
1.7X2.3 arcmin, 25x33.5 pc
t ~ 3,000 yr (Morse et al. 1996)
L_X(0.3-10.0 kev) = 1.0×10^{38} ergs s^{-1}
no compact object
"O-rich" core-collapse SNR



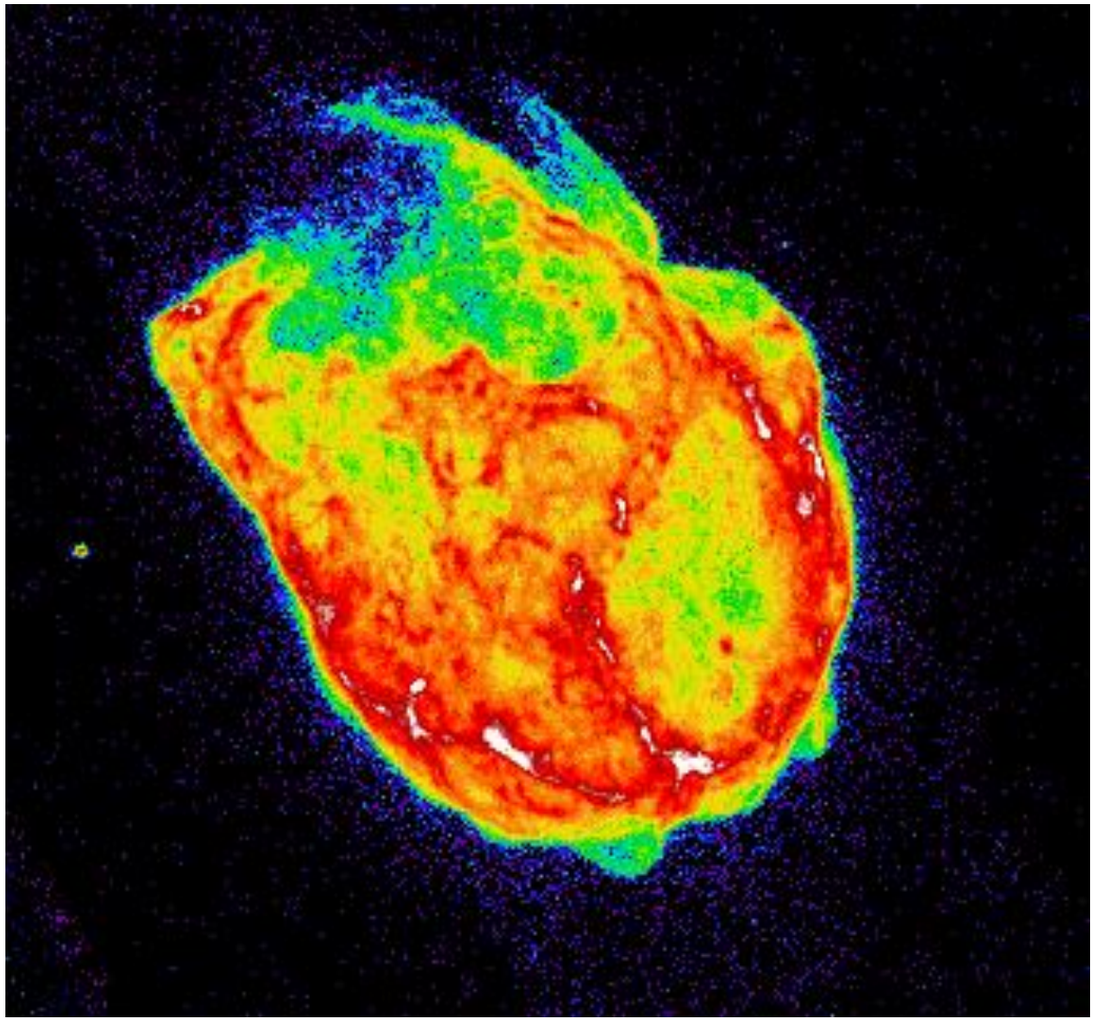
ACIS 0.35-8.0 keV

E0102: X-ray brightest in the SMC
0.77X0.77 arcmin, 13X13 pc
t ~ 2,000 yr (Finkelstein et al. 2001)
L_X(0.3-10.0 kev) = 2.5×10^{37} ergs s^{-1}
no compact object
"O-rich" core-collapse SNR



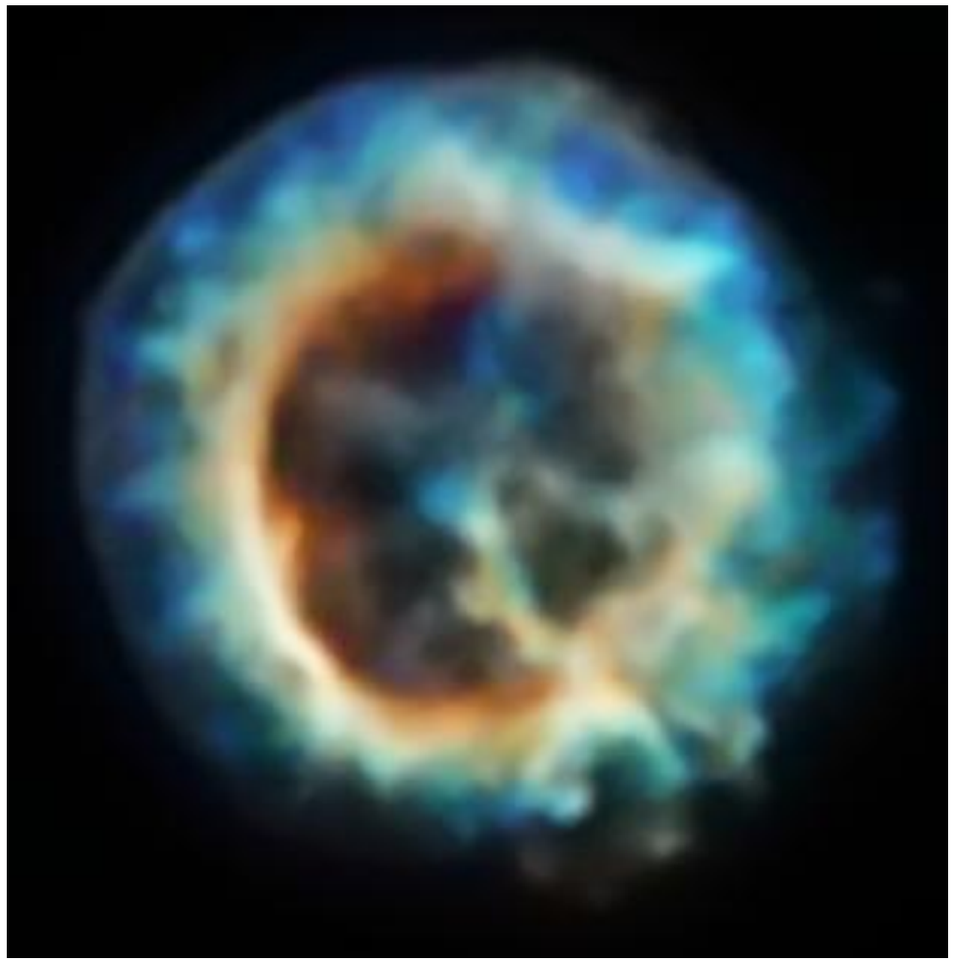
Red (0.3-0.5 keV), Green (0.5-0.75 keV)
Blue (0.75 – 7.0 keV)

N132D: X-ray brightest in the LMC
1.7X2.3 arcmin, 25x33.5 pc
t ~ 3,000 yr (Morse et al. 1996)
L_X(0.3-10.0 kev) = 1.0×10^{38} ergs s^{-1}
no compact object
"O-rich" core-collapse SNR



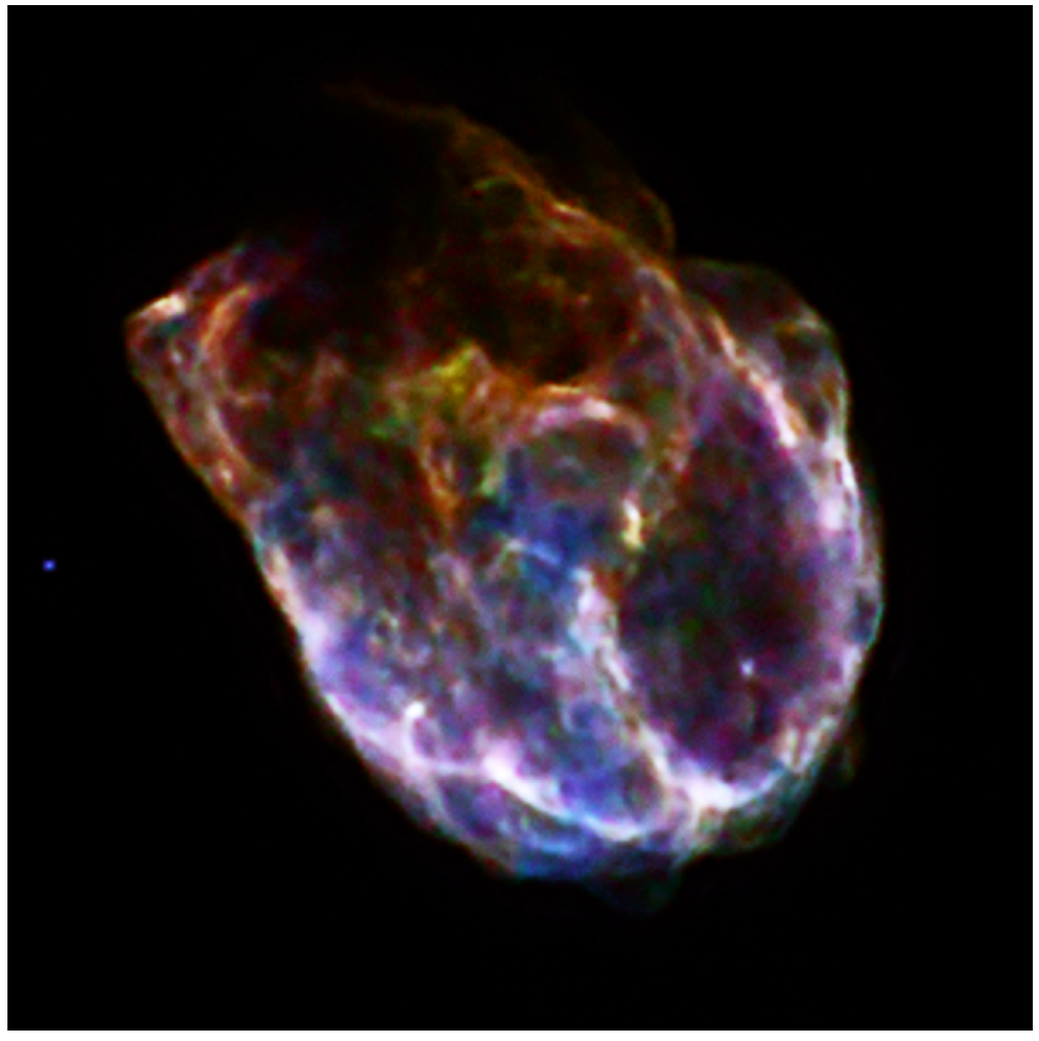
ACIS 0.35-8.0 keV

E0102: X-ray brightest in the SMC
0.77X0.77 arcmin, 13X13 pc
t ~ 2,000 yr (Finkelstein et al. 2001)
L_X(0.3-10.0 kev) = 2.5×10^{37} ergs s^{-1}
no compact object
"O-rich" core-collapse SNR



Red (0.3-0.5 keV), Green (0.5-0.75 keV)
Blue (0.75 – 7.0 keV)

N132D: X-ray brightest in the LMC
1.7X2.3 arcmin, 25x33.5 pc
t ~ 3,000 yr (Morse et al. 1996)
L_X(0.3-10.0 kev) = 1.0×10^{38} ergs s^{-1}
no compact object
"O-rich" core-collapse SNR

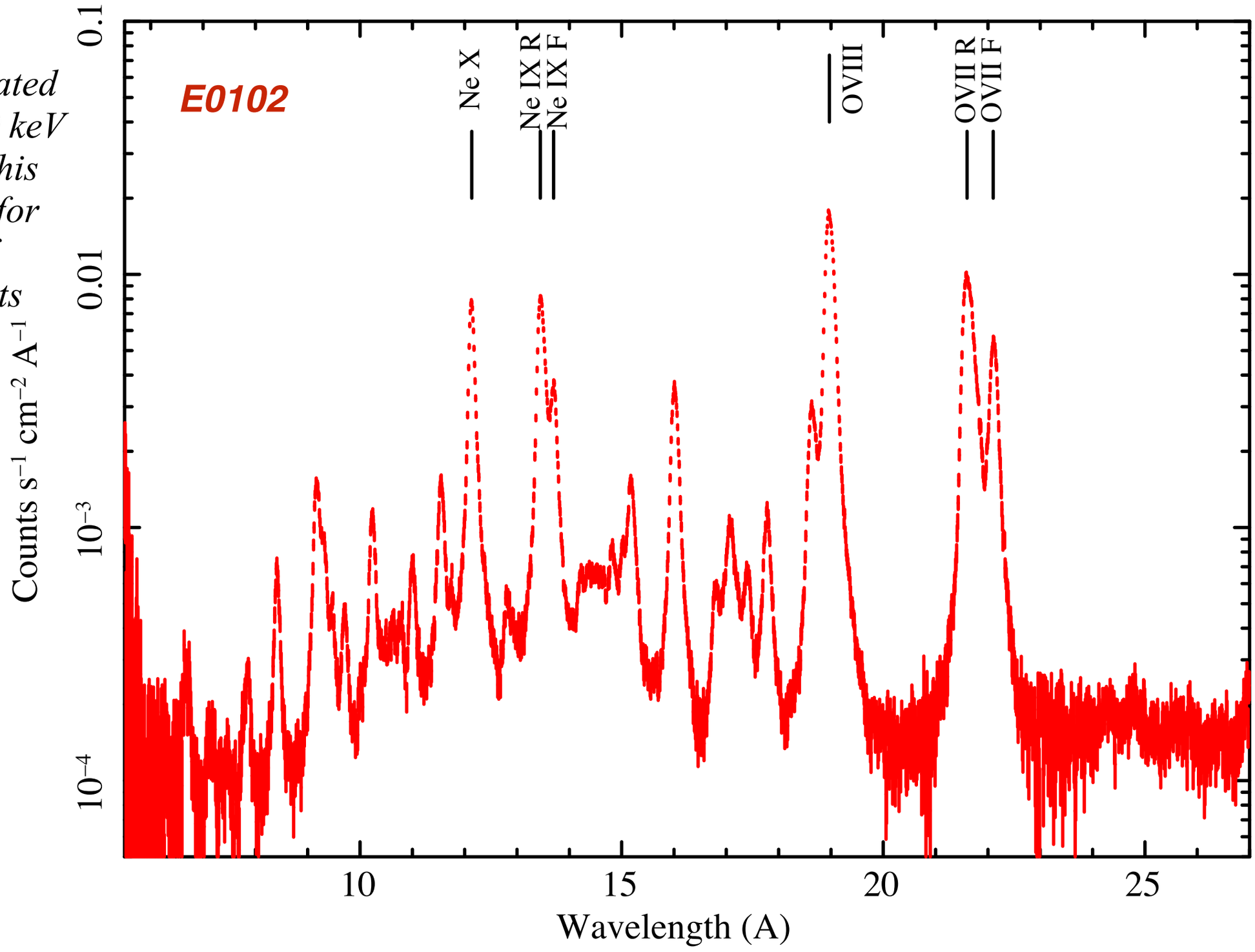


Red (0.3-0.75 keV), Green (0.8-1.1 keV),
Blue (1.1 – 2.0 keV)

RGS Spectra of E0102

Pollock (Sheffield)

Strong well-separated lines in the 0.5-1.0 keV bandpass make this target attractive for calibration of CCD instruments



The IACHEC Standard Model

The IACHEC Standard model for E0102 has been unchanged for 5 years

The development of the model has been described in 2 SPIE papers and in previous IACHEC meetings:

2008: introduction of the model and first attempt at cross-calibration (Plucinsky et al. 2008 SPIE)

2012: final model and second attempt at cross-calibration (Plucinsky et al. 2012 SPIE)

The Standard IACHEC Model

The IACHEC Standard model for E0102 has been unchanged for 6 years

The development of the model has been described in 2 SPIE papers and in previous IACHEC meetings:

2008: introduction of the model and first attempt at cross-calibration (Plucinsky et al. 2008 SPIE)

2012: final model and second attempt at cross-calibration (Plucinsky et al. 2012 SPIE)

2016: ??????????

The Next IACHEC Paper on E0102

Cross-calibration of the X-ray Instruments onboard the Chandra, Suzaku, Swift, and XMM Observatories in the 0.5–1.0 keV band using 1E 0102.2-7219: an IACHEC Study⋆

Paul P. Plucinsky[1], Andrew P. Beardmore[2], Adam Foster[1], Frank Haberl[5], Eric D. Miller[3], A.M.T. Pollock[4], and Steve Sembay[2]

[1] Harvard-Smithsonian Center for Astrophysics, MS-70, 60 Garden Street, Cambridge, MA 02138, USA
[2] Department of Physics and Astronomy, University of Leicester, Leicester LE1 7RH, United Kingdom
[3] MIT Kavli Institute for Astrophysics and Space Research, Cambridge, MA 02139,
[4] European Space Agency, European Space Astronomy Centre, E-28691 Villanueva de la Cañada, Madrid, Spain
[5] Max-Planck-Institut für Extraterrestrische Physik, Giessenbachstraße , 85748 Garching, Germany

Received / Accepted

ABSTRACT

Context. The flight calibration of the spectral response of CCD instruments below 1.5 keV is difficult in general because of the lack of strong lines in the on-board calibration sources typically available. This calibration is also a function of time due to the effects of radiation damage on the CCDs and/or the accumulation of a contamination layer on the filters or CCDs.
Aims. We desire a simple comparison of the absolute effective areas of the current generation of CCD instruments onboard the following observatories: *Chandra* ACIS, *XMM* EPIC (MOS and pn), *Suzaku* XIS, and *Swift* XRT and a straightforward comparison of the time-dependent response of these instruments across their respective mission lifetimes.
Methods. We have been using 1E 0102.2-7219, the brightest supernova remnant in the Small Magellanic Cloud, to evaluate and modify the response models of these instruments. 1E 0102.2-7219 has strong lines of O, Ne, and Mg below 1.5 keV and little or no Fe emission to complicate the spectrum. The spectrum of 1E 0102.2-7219 has been well-characterized using the RGS gratings instrument on *XMM* and the HETG gratings instrument on *Chandra*. As part of the activities of the *International Astronomical Consortium for High Energy Calibration* (IACHEC), we have developed a standard spectral model for 1E 0102.2-7219 and fit this model to the spectra extracted from the CCD instruments. The model is empirical in that it includes Gaussians for the identified lines, an absorption component in the Galaxy, another absorption component in the SMC, and two thermal continuum components with different temperatures. In our fits, the model is highly constrained in that only the normalizations of the four brightest line complexes (the O VII triplet, O VIII Ly α line, the Ne IX triplet, and the Ne X Ly α line) and an overall normalization are allowed to vary, while all

What is New in this Paper ?

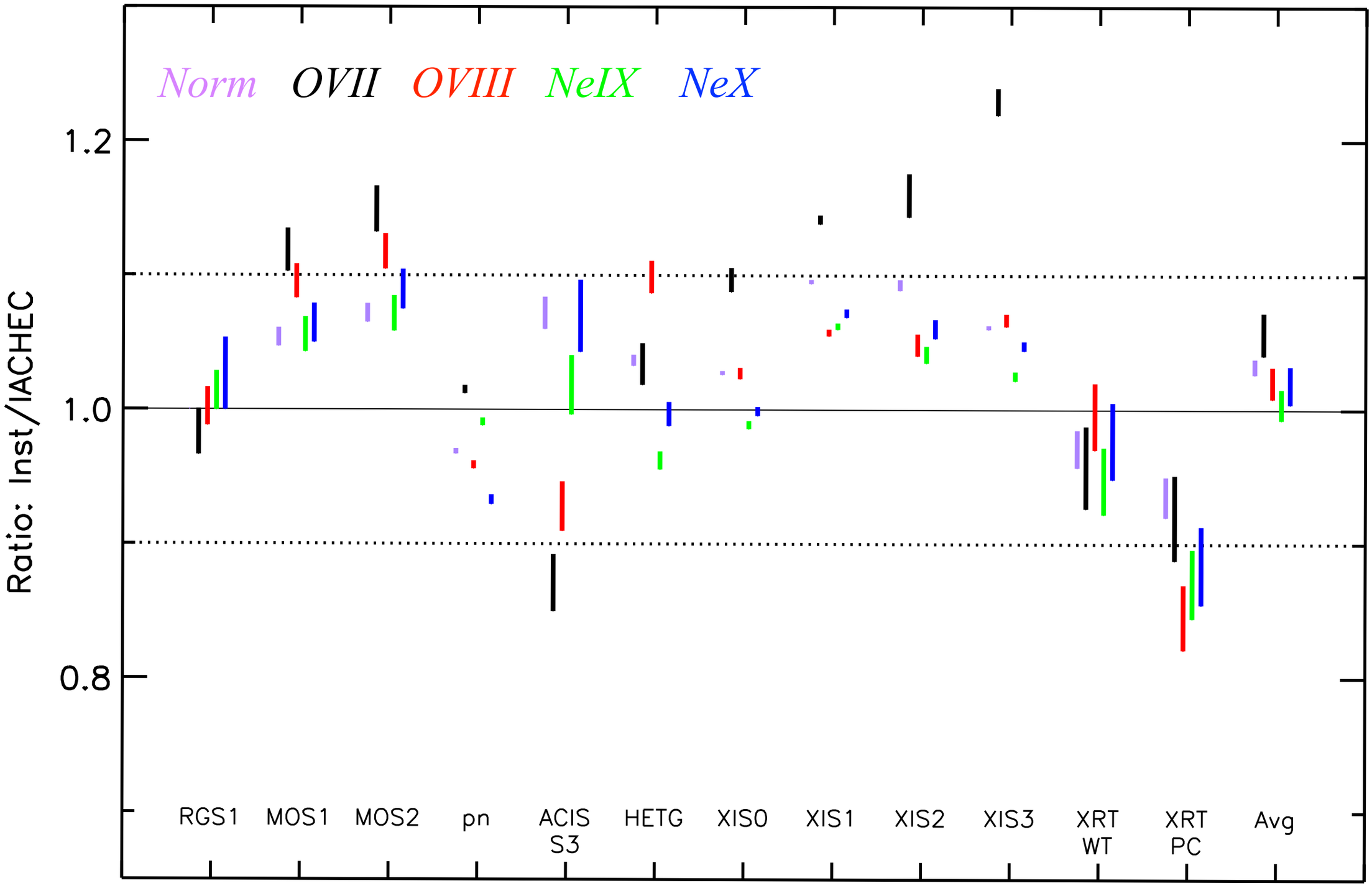
***Not the model*: the model has not changed !**

Calibrations: some of the instruments have revised calibrations, especially for the ones with contamination layers. These new calibrations effect the cross-calibration of the effective areas.

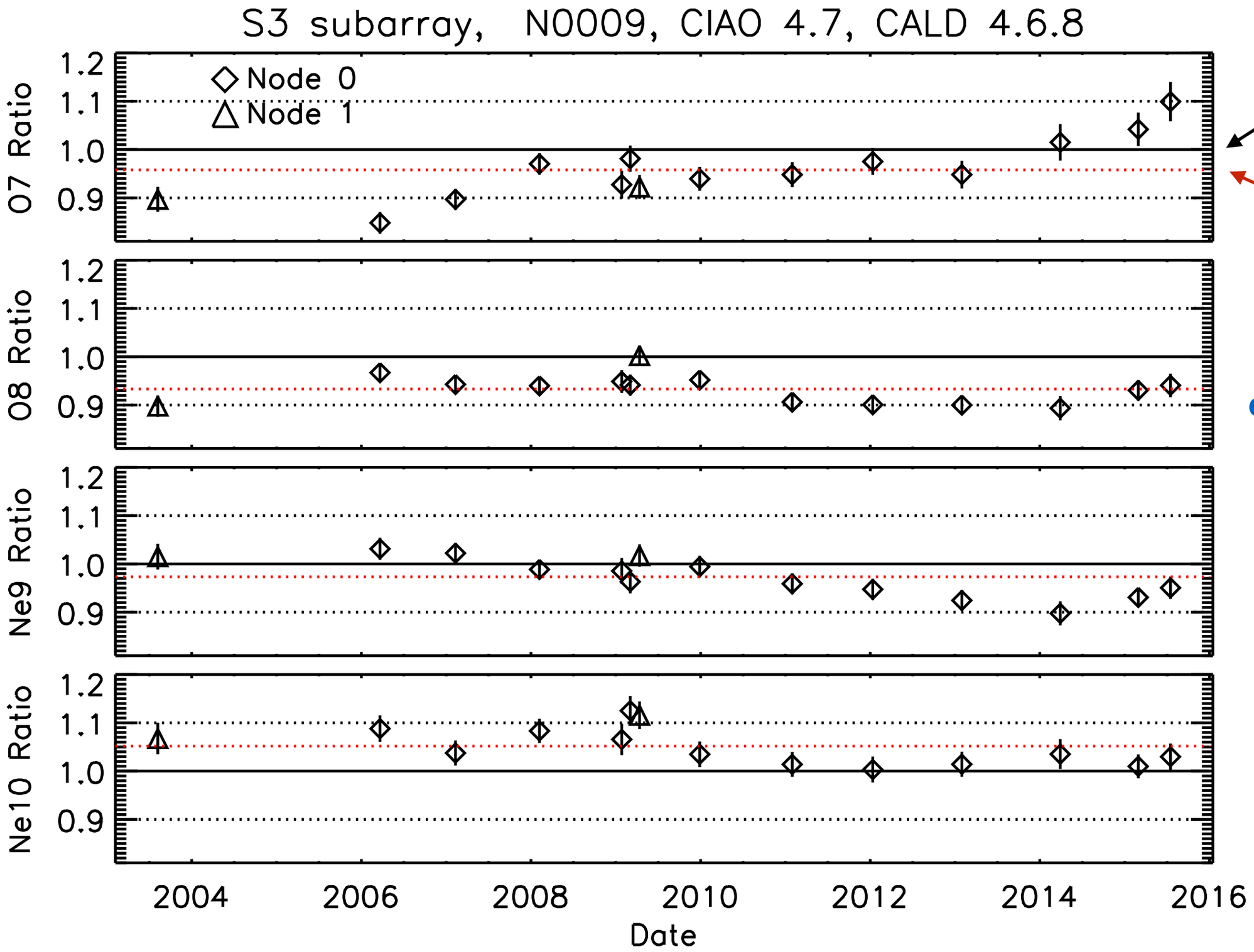
Time Dependence: we include descriptions of the time dependence of ACIS, MOS, XIS, and XRT. There are now 4 more years of data that needs an appropriate calibration. All of these missions have extensive archives that demand an accurate, time-dependent calibration in order to derive reliable results. Only the pn produces stable count rates in the 0.3-2.0 keV band without a temporal correction for the effective area.

E0102: Comparison of Fitted Normalizations relative to the IACHEC Model

Updated 20 Feb 2016



ACIS Time Dependence



IACHEC value

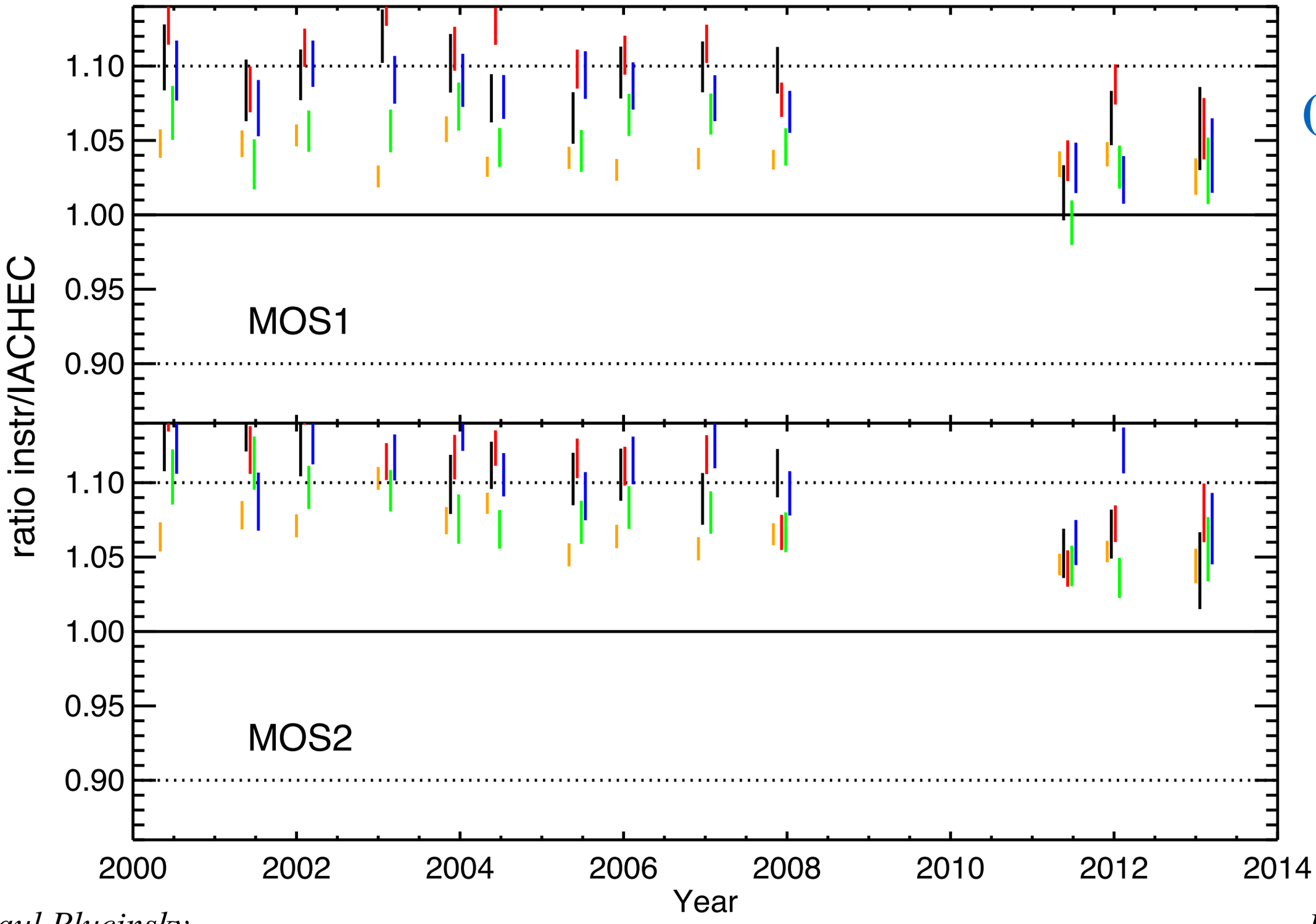
Average of ACIS values

ACIS contamination model:

Marshall, Vikhlinin (CXC)

MOS Time Dependence

Norm *OVII* *OVIII* *NeIX* *NeX*

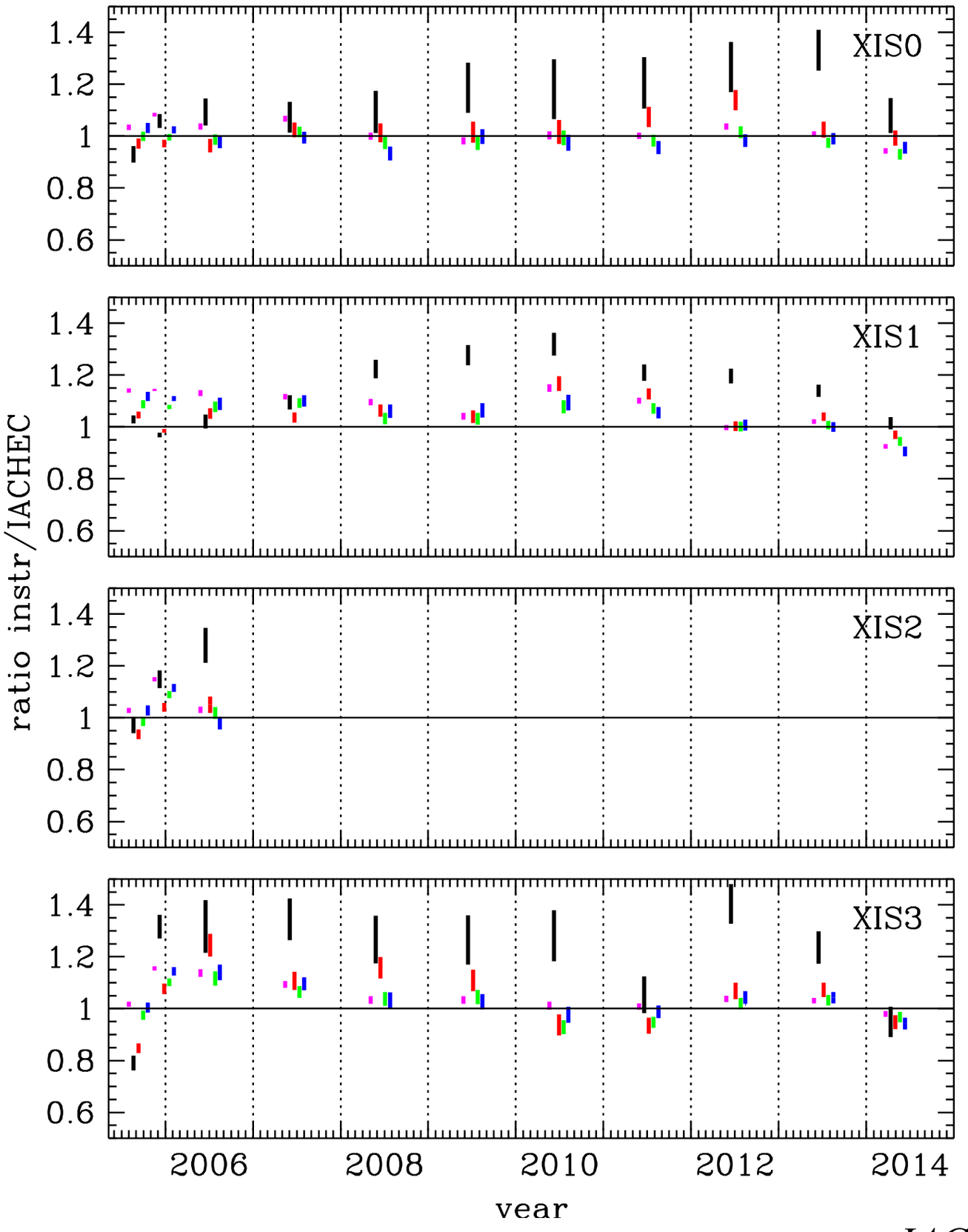


Sembay (Leicester)

XIS Time Dependence

Miller (MIT)

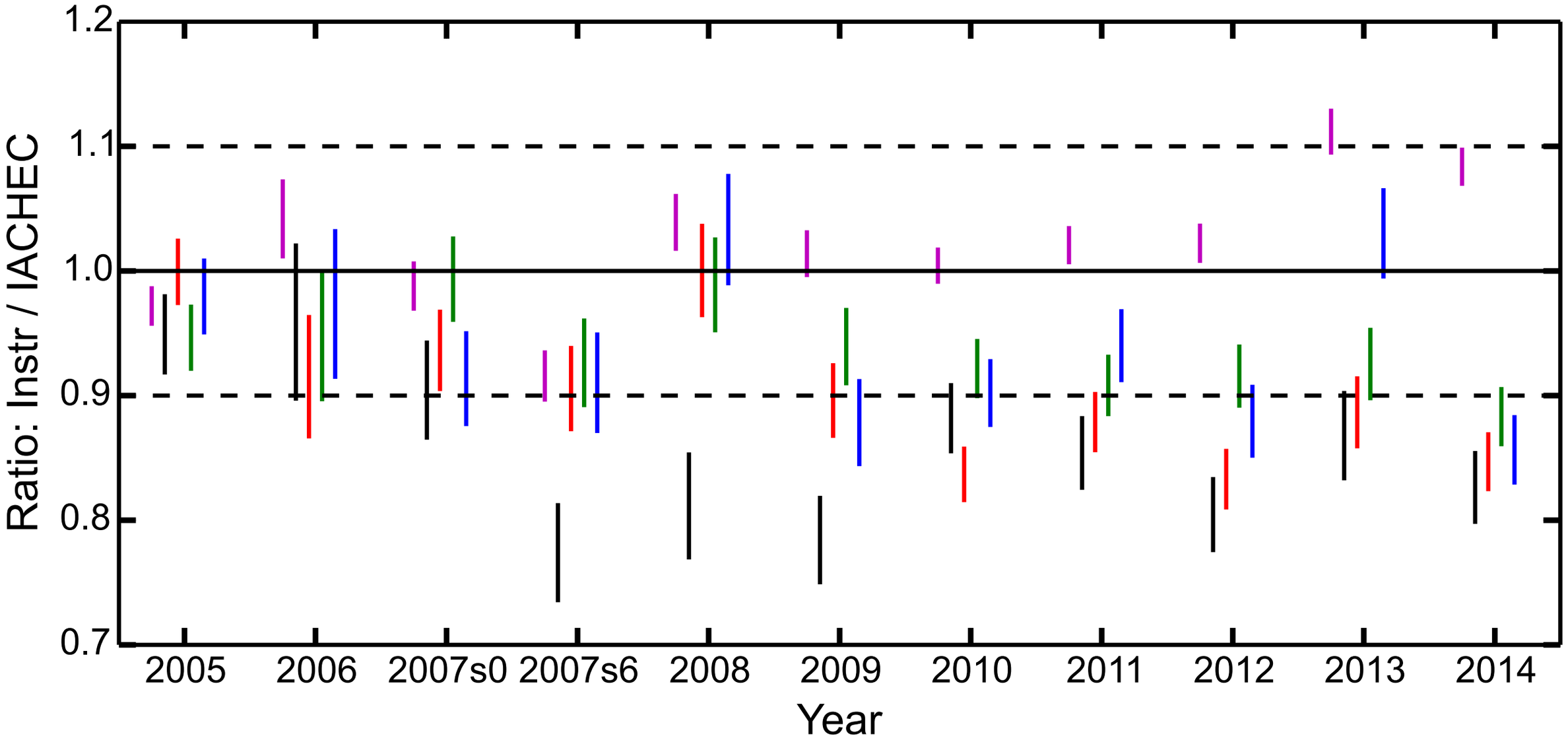
Norm
OVII
OVIII
NeIX
NeX



XRT Time Dependence

Norm *OVII* *OVIII* *NeIX* *NeX*

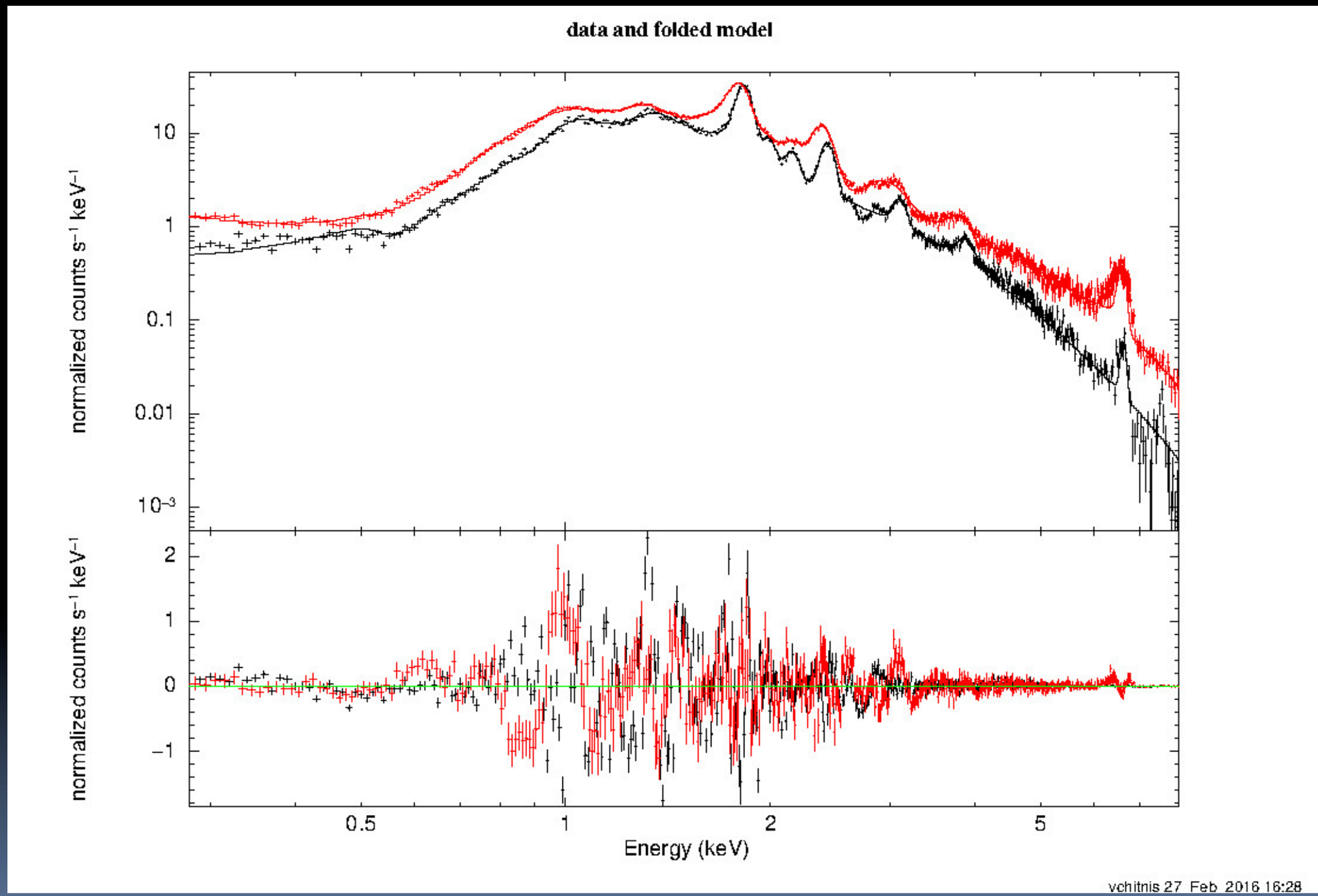
Beardmore (Leicester)



Uses of the E0102 IACHEC Standard Model

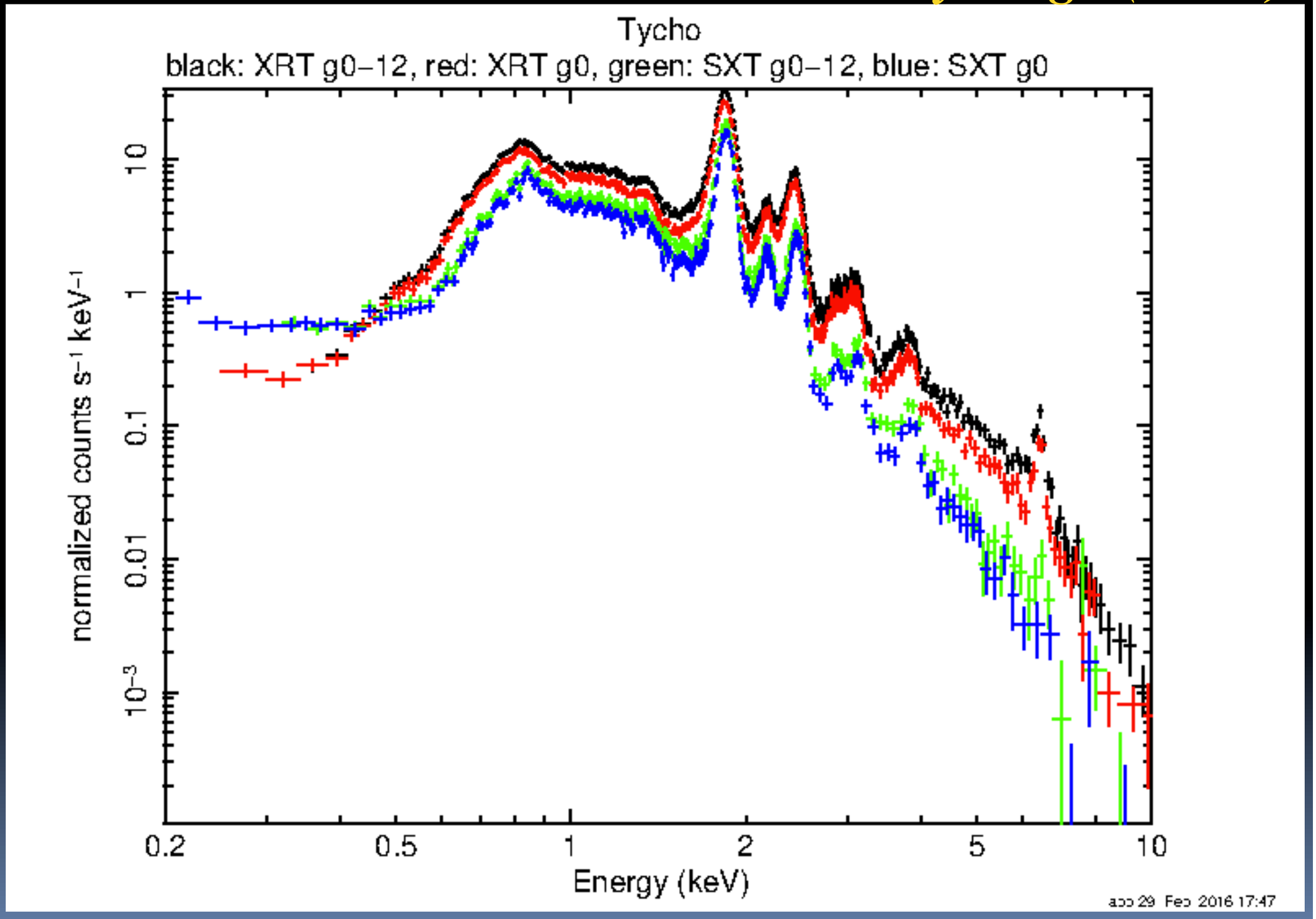
- ACIS - verify contamination model, check low energy gain, & monitor temporal changes
- MOS - verify contamination model, constrain redistribution function and monitor temporal changes
- pn - examine redistribution function at low energies
- XIS - develop contamination model, low energy gain and monitor temporal changes
- XRT - examine redistribution function at low energies and check response in PC and WT modes
- ***Konrad Dennerl's new method of generating rmfs for pn and eRosita***
- ***Prof. Meng's, Vinay's & Herman's "concordance" analysis***
- ***AND ASTROSAT has started using the E0102 model***

Cas A ASTROSAT Courtesy Singh (TIFR)



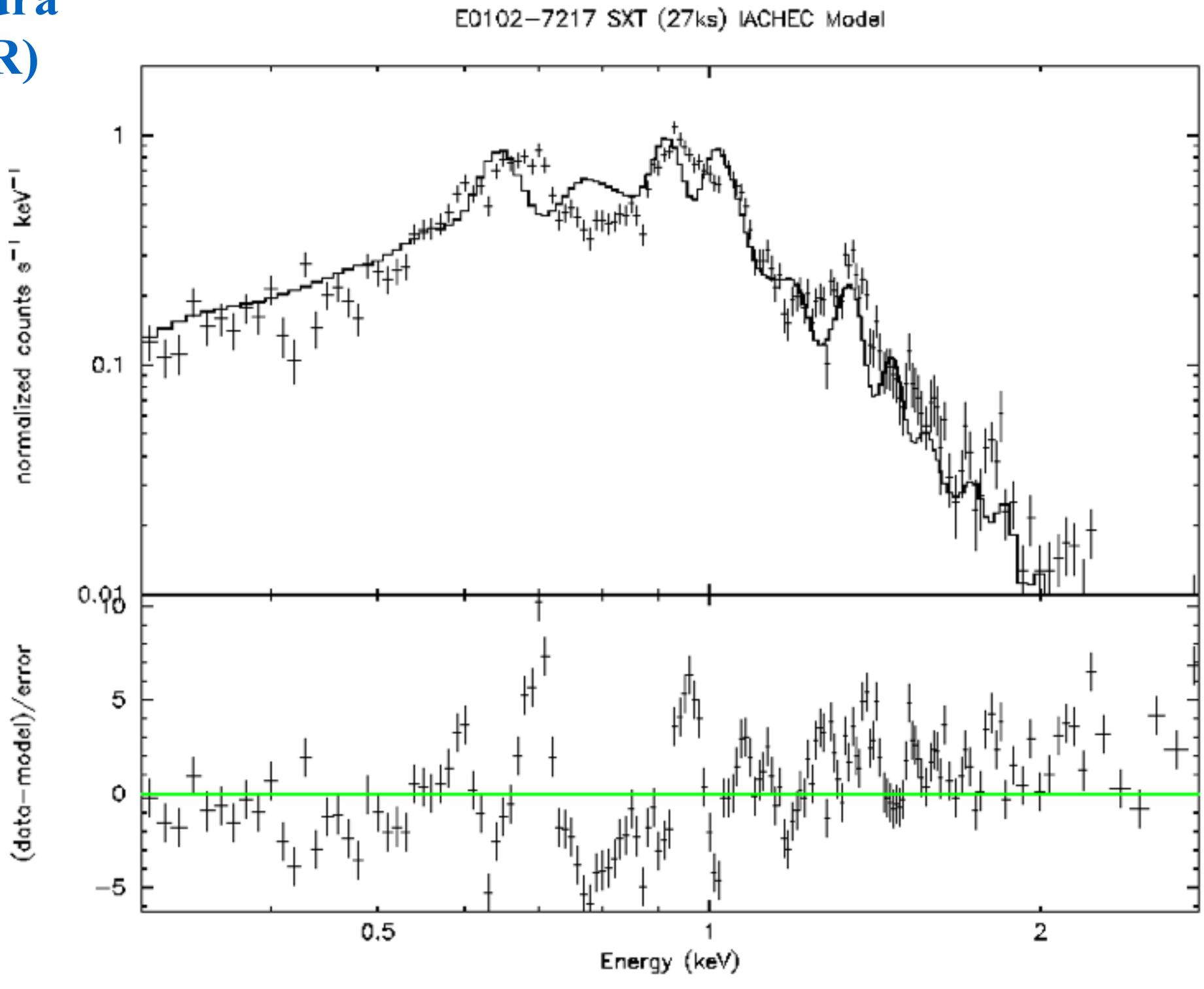
SWIFT XRT (in Red) and SXT Spectrum comparison
Courtesy: V. Chitnis

Tycho ASTROSAT Courtesy Singh (TIFR)



ASTROSAT SXT

Chandra (TIFR)



N132D ACTION ITEMS FROM 2015 IACHEC

- *Matteo volunteered to lead the effort to merge the v2.6 and v2.9 models to provide a good fit across the entire 0.3-10.0 keV band* **[NO progress]**
- *remove the power-law to model the sky and instrument background and each instrument will add a sky and instrument background model appropriate for their instrument* **[NO progress]**
- *MOS data need to be reprocessed with standard grade set* **[DONE]**
- *Steve needs to check bad column correction in MOS* **[DONE]**
- *Develop a non-linear gain correction for the pn data and apply the correction to the events and do NOT use "gain fit" in XSPEC* **[Some progress]**
- *the WG will then fit N132D and compare the normalizations for Si XIII, S XV, and Ar XVII* **[NO progress]**

N132D: Comparison of Fitted Norms for S XIII, S XV, & Ar XVII