IACHEC: Thermal Supernova Remnant Working Group

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 RGS	Andy Pollock (ESAC)
Chandra HETG	Dan Dewey (MIT)
XMM-Newton MOS	Steve Sembay (Leicester)
XMM-Newton pn	Frank Haberl (MPE)
Chandra ACIS	Joe DePasquale, Paul Plucinsky (SAO)
Suzaku XIS	Eric Miller (MIT)
Swift XRT	Andrew Beardmore (Leicester)
Models	Randall Smith (SAO)

What Have We Done 2007 – 2010 ?

- worked exclusively on the SMC SNR 1E 0102.2-7219
- developed a coherent spectral model for E0102 which is consistent with the XMM/RGS, Chandra/HETG, XMM/MOS, & XMM/pn data
- fit Chandra (ACIS & HETG), XMM (RGS, pn, MOS), Suzaku (XIS), & Swift (XRT) data with this model
- model, data sets, and results are available for the community on the twiki page: "http://cxc.harvard.edu/twiki/bin/view/SnrE0102/WebHome"
- we used this spectral model to quantify the consistency of the effective area models of the various instruments by fitting observations of E0102 with the ***same*** spectral model and only allowing the normalizations of 4 line complexes to vary
- in particular, we compare the fitted normalizations of the OVII triplet (560-574 eV), the OVIII Ly-a (654 eV), the NeIX triplet (905-922 eV), and the NeX Ly-alpha line (1022 eV)
- results published in 2008 SPIE proceedings (Plucinsky et al. 2008, SPIE, Vol. 7011, arXiv: 0807:2176)

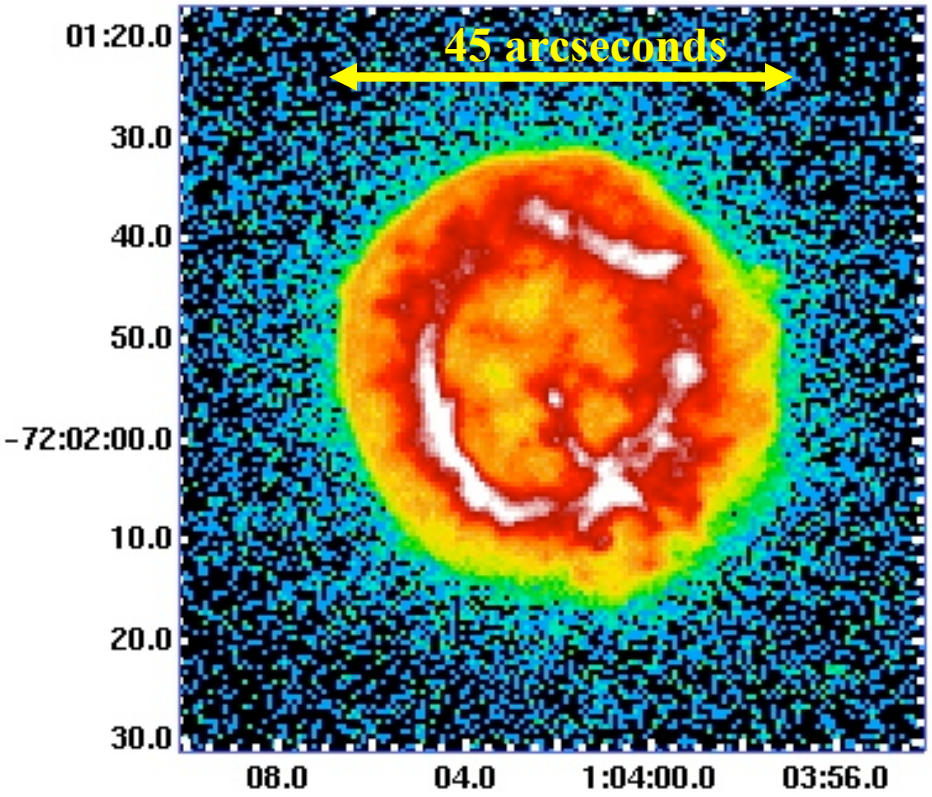
Why E0102 ? Chandra Images

DePasquale (SAO)

Relatively simple morphology, but significant spectral variations

Extended source minimizes pileup, small size minimizes off-axis effects

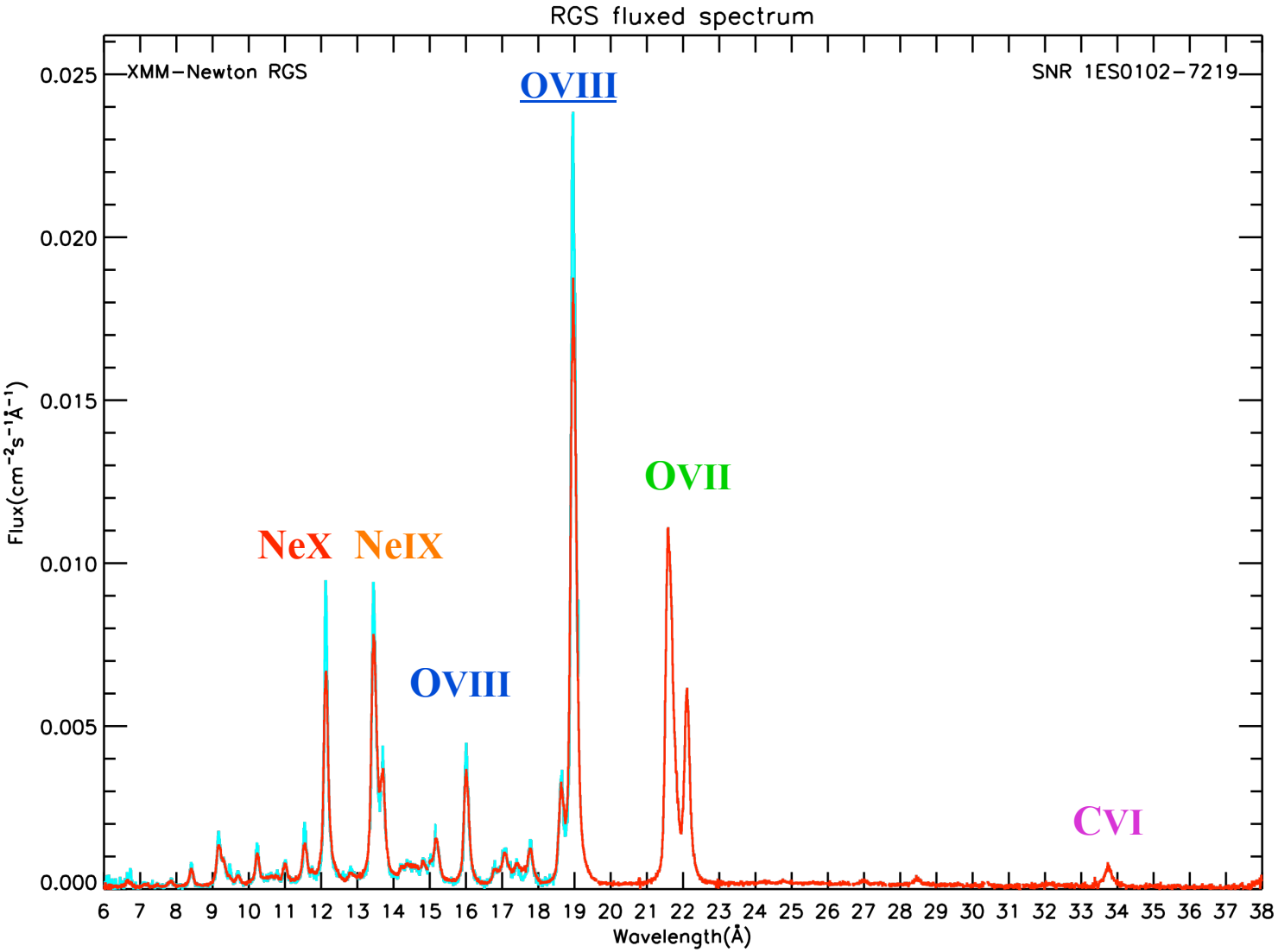
S3 Summed Data ~248 ks



Three Color Image

Red: 0.2-0.75 keV, Green: 0.8-1.1 keV, Blue: 1.1-2.0 keV

XMM-Newton RGS Spectrum of E0102:



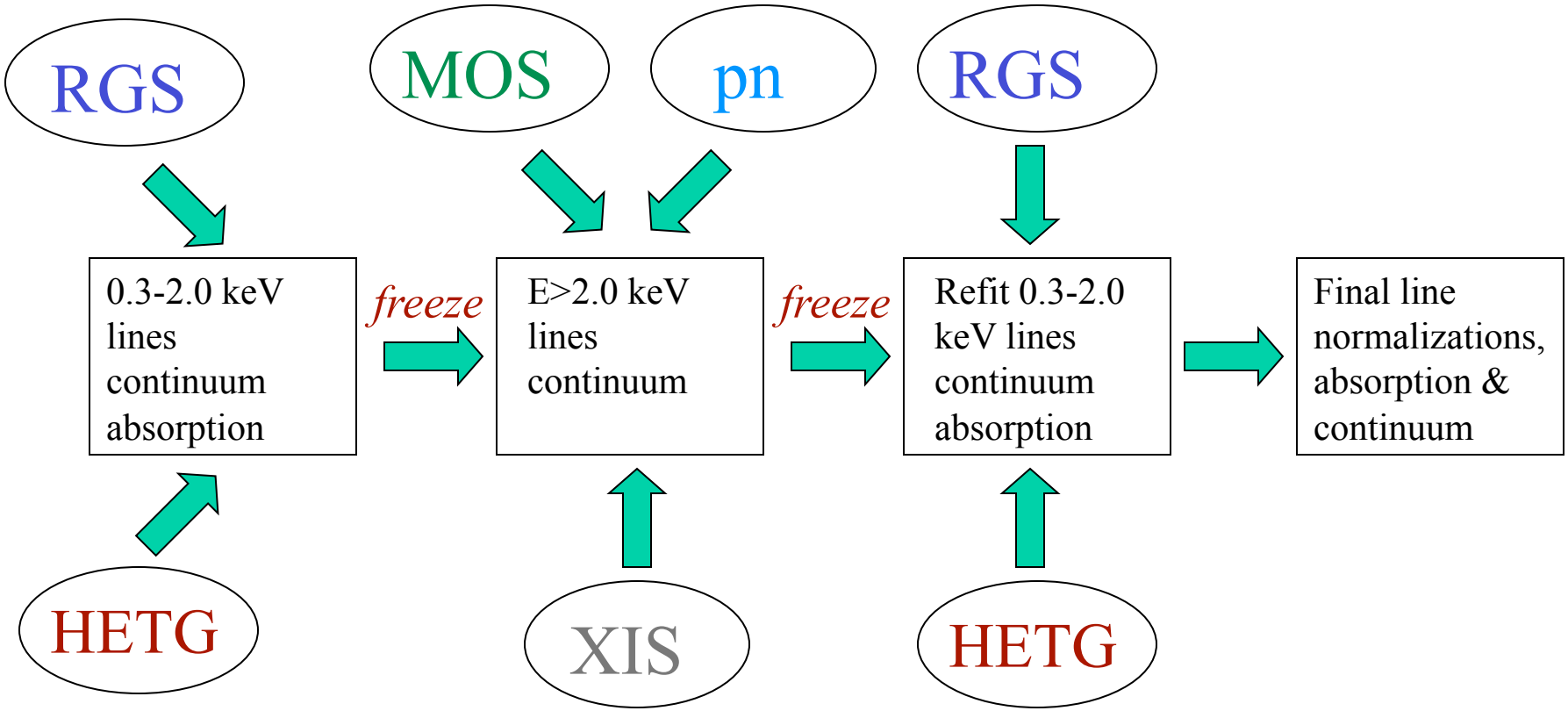
Pollock (ESAC)

Relatively simple spectrum dominated by O & Ne,

little or no Fe emission

Process to develop a Definitive Model for E0102

- develop a model based on the high-resolution spectral data from the RGS (Rasmussen et al. 2001) and HETG (Flanagan et al. 2004) and fit all data with the ***SAME*** model
- use the high-resolution spectral data to identify and characterize the line emission from 0.3-2.0 keV
- use the MOS, pn, & XIS to determine lines and continuum above 2.0 keV



Chandra X-Ray Observatory

Table 1. Spectral Lines Included in the E0102 Reference Model (v1.9)

Line ID	E (keV)[a]	λ (Å)[a]	Flux[b]	Line ID	E (keV)[a]	λ (Å)[a]	Flux[b]
C VI Lyα	0.3675	33.737	175.2	Ne IX i	0.9148	13.553	249.6
Fe XXIV	0.3826	32.405	18.4	Fe XIX	0.9172	13.517	0.0
S XIV	0.4075	30.425	11.8	Ne IX r	0.922	13.447	1380.5
N VI f	0.4198	29.534	6.8	Fe XX	0.9668[c]	12.824	120.5
N VI i	0.4264	29.076	2.0	Ne X Lyα	1.0217	12.135	1378.3
N VI r	0.4307	28.786	10.5	Fe XXIII	1.0564	11.736	24.2
C VI Lyβ	0.4356	28.462	49.5	Ne IX Heβ	1.074	11.544	320.7
C VI Lyγ	0.4594	26.988	27.3	Ne IX Heγ	1.127	11.001	123.1
O VII f	0.561	22.1	1313.2	Fe XXIV	1.168[c]	10.615	173.5
O VII i	0.5686	21.805	494.4	Ne X Lyβ	1.211	10.238	202.2
O VII r	0.5739	21.603	2744.7	Ne X Lyγ	1.277	9.709	78.5
O VIII Lyα	0.6536	18.969	4393.3	Ne X Lyδ	1.308	9.478	37.1
O VII Heβ	0.6656	18.627	500.9	Mg XI f	1.3311	9.314	108.7
O VII Heγ	0.6978	17.767	236.1	Mg XI i	1.3431	9.231	27.5
O VII Heδ	0.7127	17.396	124.9	Mg XI r	1.3522	9.169	231.0
Fe XVII	0.7252	17.096	130.9	? ?	1.4317	8.659	8.1
Fe XVII	0.7271[c]	17.051	165.9	Mg XII Lyα	1.4721	8.422	110.2
Fe XVII	0.7389	16.779	82.3	Mg XI Heβ	1.579[c]	7.852	50.6
O VIII Lyβ	0.7746	16.006	788.6	Mg XI Heγ	1.659	7.473	16.0
Fe XVII	0.8124[c]	15.261	90.5	Mg XII Lyβ	1.745[c]	7.105	29.7
O VIII Lyγ	0.817	15.175	243.1	Si XIII f	1.8395	6.74	13.8
Fe XVII	0.8258	15.013	65.1	Si XIII i	1.8538	6.688	3.4
O VIII Lyδ	0.8365	14.821	62.7	Si XIII r	1.865	6.647	34.6
Fe XVIII	0.8503[c]	14.581	407.3	Si XIV Lyα	2.0052	6.183	11.2
Fe XVIII	0.8726[c]	14.208	89.6	Si XIII Heβ	2.1818	5.682	4.3
Ne IX f	0.9051	13.698	690.2	S XV f,i,r	2.45	5.06	12.7

[a] Theoretical rest energies; wavelengths are hc/E.
[b] Observed flux in 10^{-6} photons $cm^{-2}s^{-1}$
[c] This line is broader than the nominal width, see text

List of Lines in the Model

Model includes 52 lines

One unidentified, weak line

Fe line at 917 eV included with zero normalization for future investigations

E0102 Twiki:

CXC collaboration site

Jump | Search

SnrE0102

Hello Paul Plucinsky
Log Out

– Create personal sidebar

SnrE0102 Web
Create New Topic
Index
Search
Changes
Notifications
Statistics
Preferences

Webs
AcisCal
AcisOps
CXCRadiation
ChASeM33
HrcCal
Main
Sandbox
SnrE0102
TWiki
Tracer

TWiki > SnrE0102 Web > WebHome (24 Feb 2009, PaulPlucinsky) Edit Attach

Welcome to the SNR 1E 0102-7219 web

As an extension of the International Astronomical Consortium for High Energy Calibration IACHEC - this page is designed to facilitate cross-calibration efforts between the XMM and Chandra calibration teams using the wonderful SNR "E0102".

- Action items from the May 2007 IACHEC meeting.
- Working Group web page for the May 2008 IACHEC meeting.

Table of Contents:

The Definitive E0102 Calibration Model

- Please post new models to this page
- Please post relevant data and/or images to the Data Analysis topic.

The Absorption Model

- Paul Plucinsky's AbsorptionModel absorption model, including a two-component absorption model and a description of how it was developed.
- NEW as of April 27, 2008 Two component absorption model using Wilms absorption model:
  tbabs_tbvarabs_apec_apec_ppp_27apr08.xcm

Constraining the Parameters in the Model

• model has ~200 parameters, we will reduce the number of free parameters to 5 or 7 for our calibration objective of measuring the OVII, OVIII, NeIX, & NeX normalizations

Absorption:
• Galactic component fixed at 5.36 x 10^{20} cm^{-2}

• SMC component fixed at 5.75 x 10^{20} cm^{-2} with abundances set to Russell & Dopita 1992 SMC abundances

Continuum:
• low temperature APEC "No-Line" kT=0.164 keV, Norm=3.48 x 10^{-2} cm^{-5}

• high temperature APEC "No-Line" kT=1.736 keV, Norm=1.85 x 10^{-3} cm^{-5}

Line Emission:
• freeze energies to known values and set widths to RGS-determined value

• freeze normalizations of all lines except for OVII For, OVIII Ly-a, Ne IX Res, and Ne X Ly-a

• for OVII triplet and Ne IX triplet only one normalization is allowed to vary, the other line normalizations are set to the ratio determined by the RGS

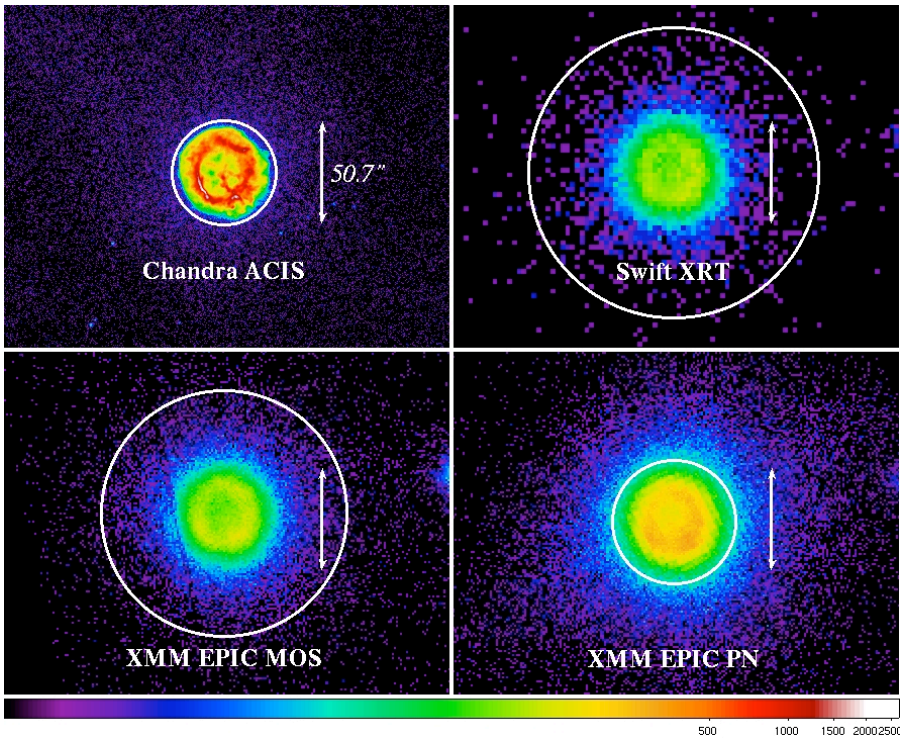
Scale Factor:
• overall normalization to account for different extraction regions

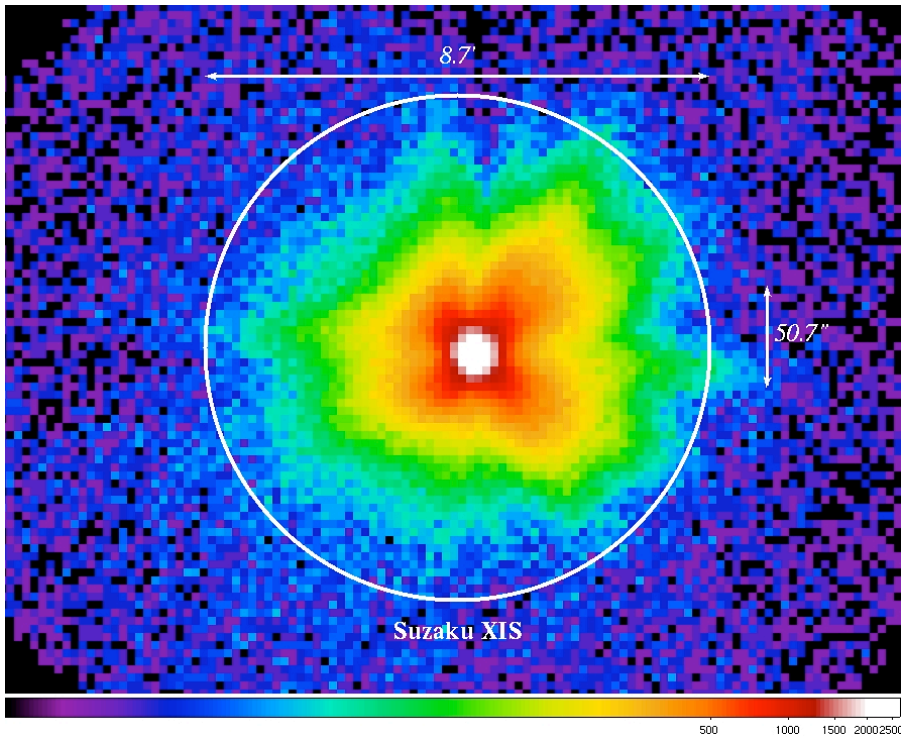
Gain:
• MOS and XIS saw a significant improvement with global gain adjustment

ACIS, pn, XRT have 5 free parameters, MOS, XIS have 7 free parameters

ACIS, XRT, MOS, pn, and XIS images of E0102

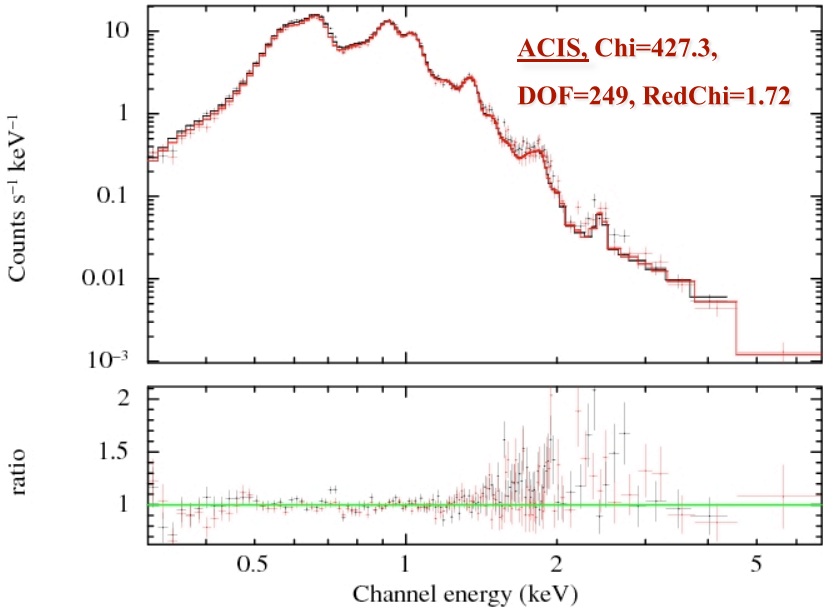
- ACIS has the smallest extraction region
- XIS has the largest extraction region which includes emission from a nearby XRB
- each team selected observations conducted in the modes for which they are most confident of the calibration

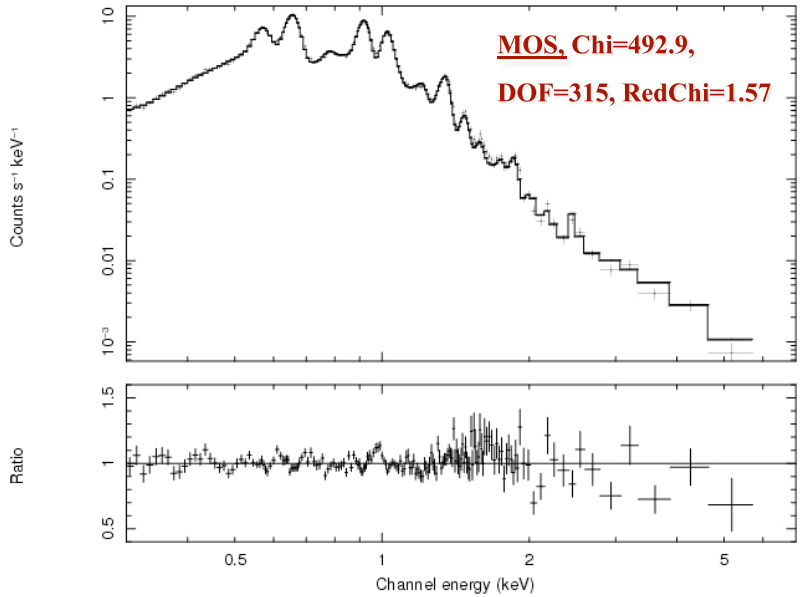


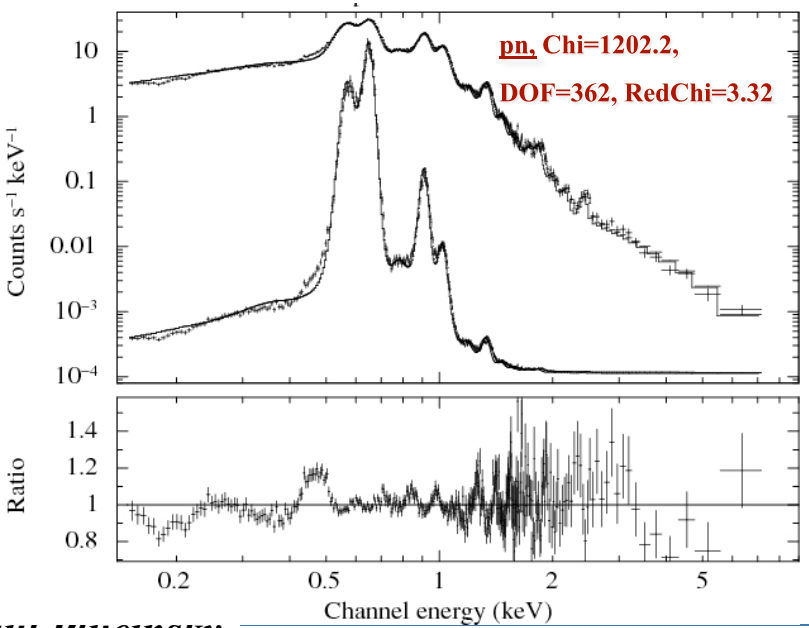


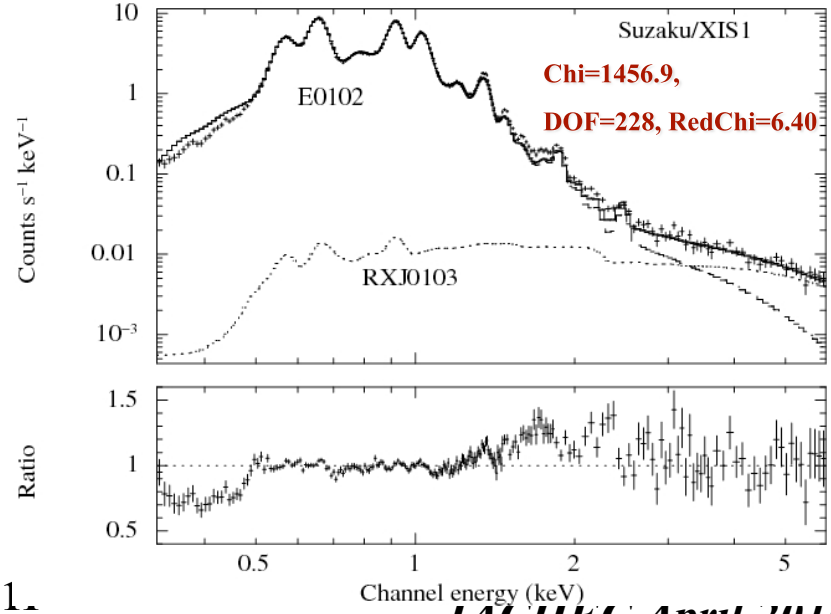
Chandra X-Ray Observatory

CXC



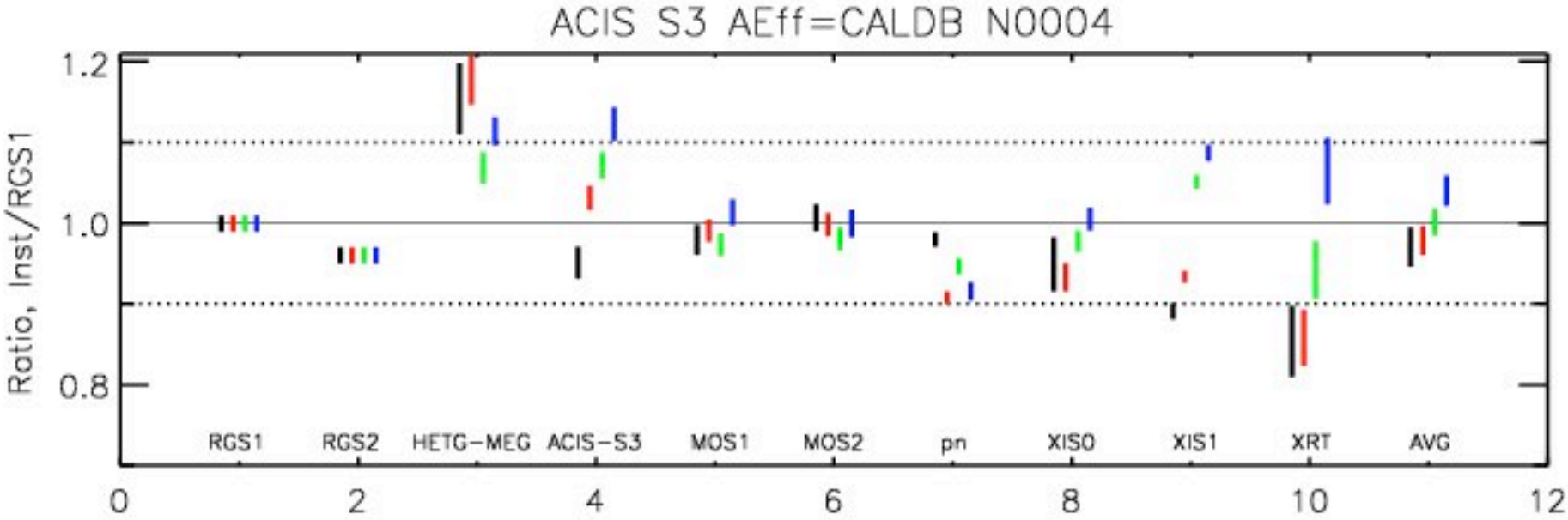






Comparison of OVII, OVIII, NeIX, & NeX Normalizations:

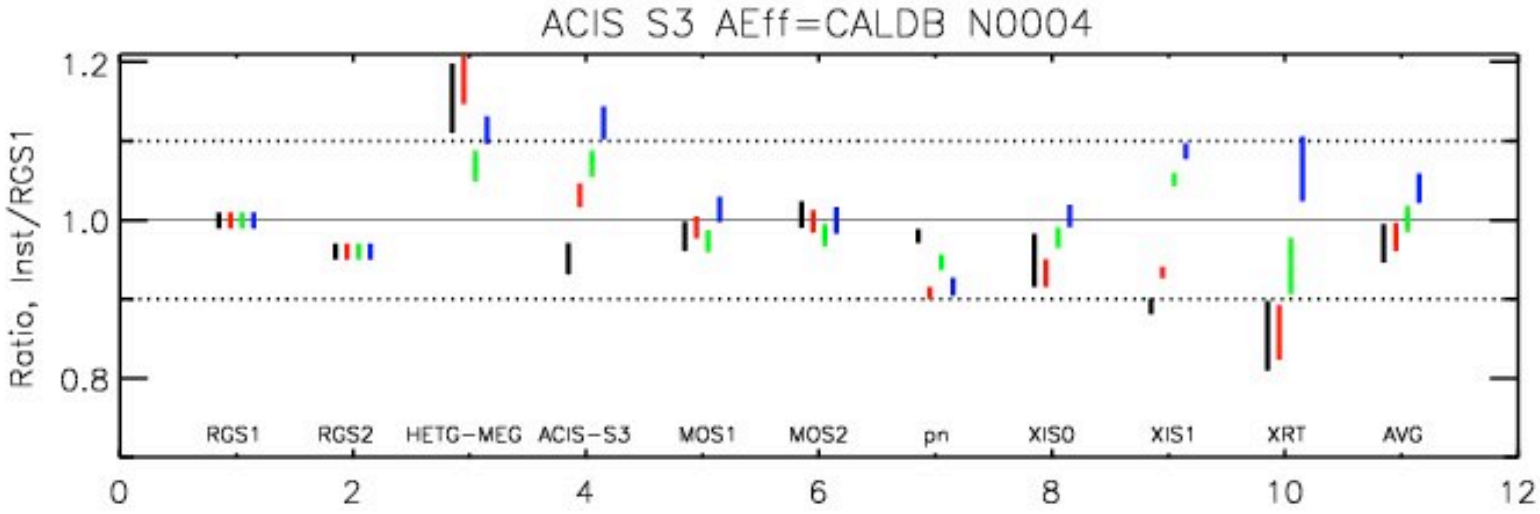
OVII black **OVIII red** **NeIX green** **NeX blue** ***Depasquale(SAO)***



- new HRMA effective area released before 2009 IACHEC meeting
- assume a 4% difference between RGS1 & RGS2 which is mostly independent of energy
- uncertainties are the statistical uncertainties and underestimate the true uncertainty
- ACIS, XIS, & XRT show similar trend with energy
- 27 of 32 normalizations agree with the RGS within 10%
- ***BUT***, new ACIS contamination model released in 12/2009

What's New Since IACHEC 2009:

OVII black **OVIII red** **NeIX green** **NeX blue** ***DePasquale(SAO)***

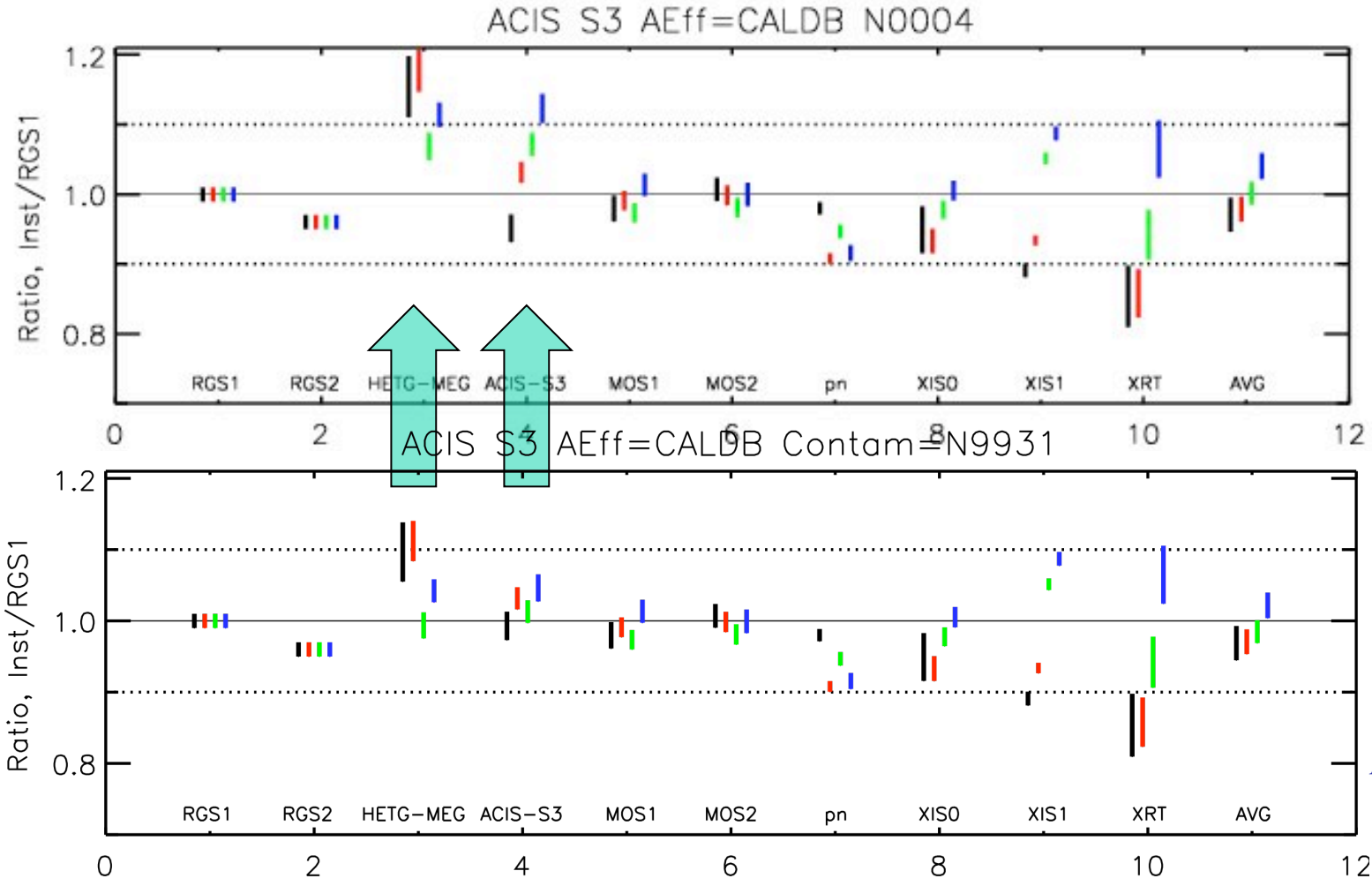


Old Cont

- the ACIS contamination model was updated in December 2009

What's New Since IACHEC 2009:

OVII black **OVIII red** **NeIX green** **NeX blue** ***DePasquale(SAO)***



Old Cont

New Cont

HETG results are preliminary !!!

What We Hope to Accomplish at this IACHEC:

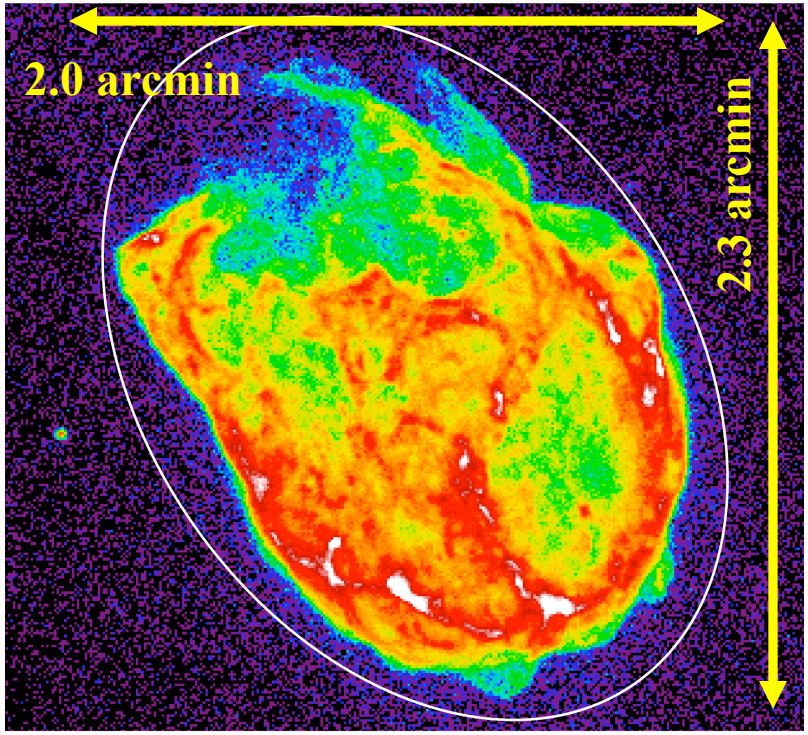
- refine weak lines in the model, O or Fe ? (RGS analysis from Pollock)
- refit instruments as necessary, new response matrix for pn, new contamination correction for RGS at late times (should not affect results from early in the mission)
- develop detailed outline for an A & A paper
- could we submit the clusters, G21.5-0.9, and E0102 calibration papers to be published in the same Journal and Issue ?

Finally, SNRs other than E0102 !!

- N132D, LMC SNR, already used by XMM for calibration, spatially and spectrally more complicated than E0102
- Cas A, used by previous missions, however, much more complicated spatially and spectrally than E0102, interesting temporal behavior (see talk on Wednesday by Patnaude)
- Tycho – less complicated spatially and spectrally than Cas A but much larger, off-axis affects will be important

N132D: Brightest SNR in the LMC

- spatial, larger than E0102 and more complicated, absorption varies significantly across the remnant
- spectrum is significantly more complicated due to significant Fe emission



ACIS S3: 89 ks, fit with RGS model