Thermal SNRs as Standard Candles

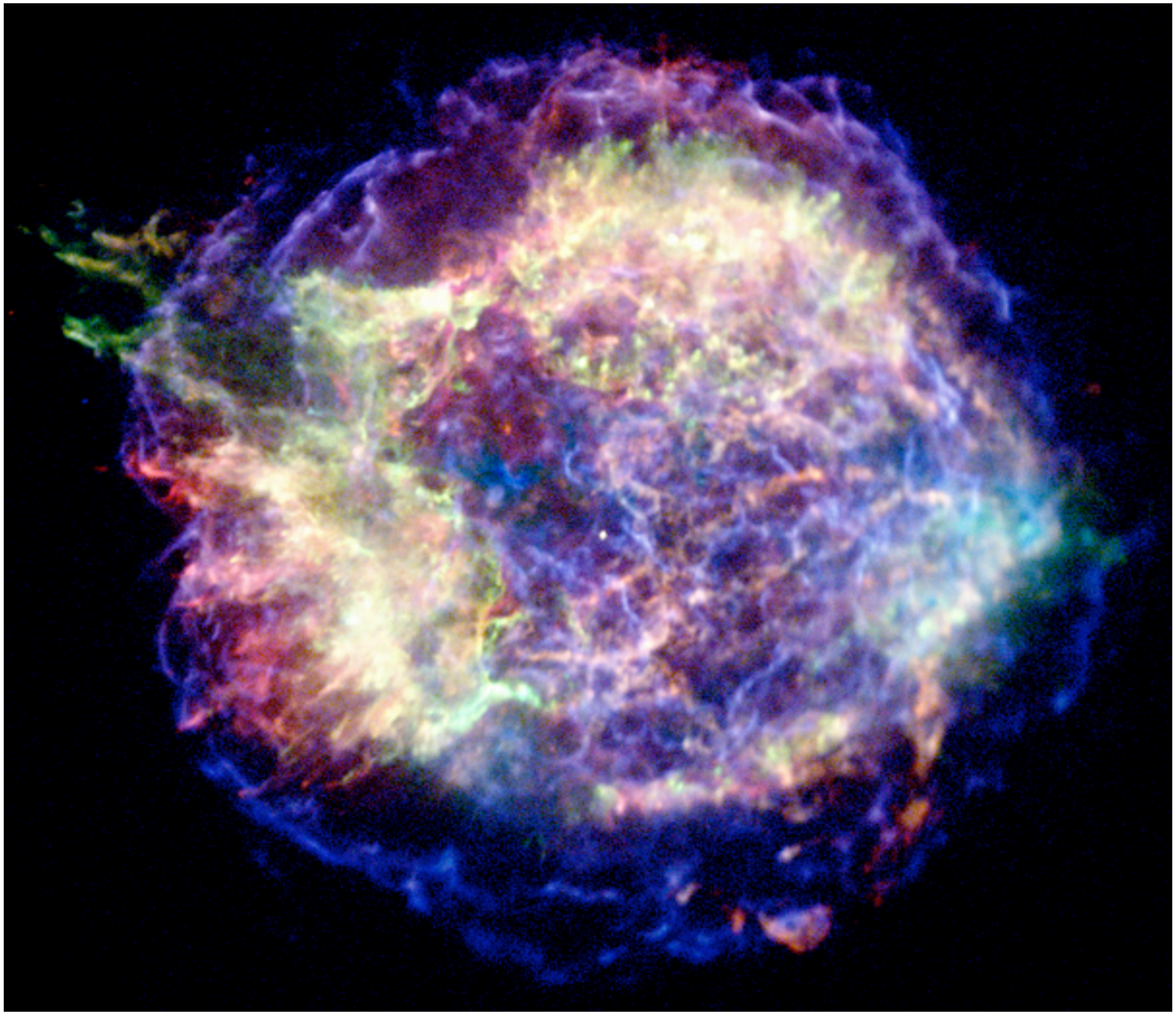
Why Use SNRs with Thermal Spectra as Standard Candles ?

- flux is constant in time (mostly true), need to exclude SNRs with central source
- typically have strong lines at energies of interest
- extended sources so pileup effects are reduced

Candidate Thermal SNRs Considered at IACHEC

1) Cas-A
2) N132D
3) E0102

Cas A: Chandra Three-color image



Red: 0.5-1.5 keV

Green: 1.5-2.5 keV

Blue: 4.0-6.0 keV

6 X 6 arcmin

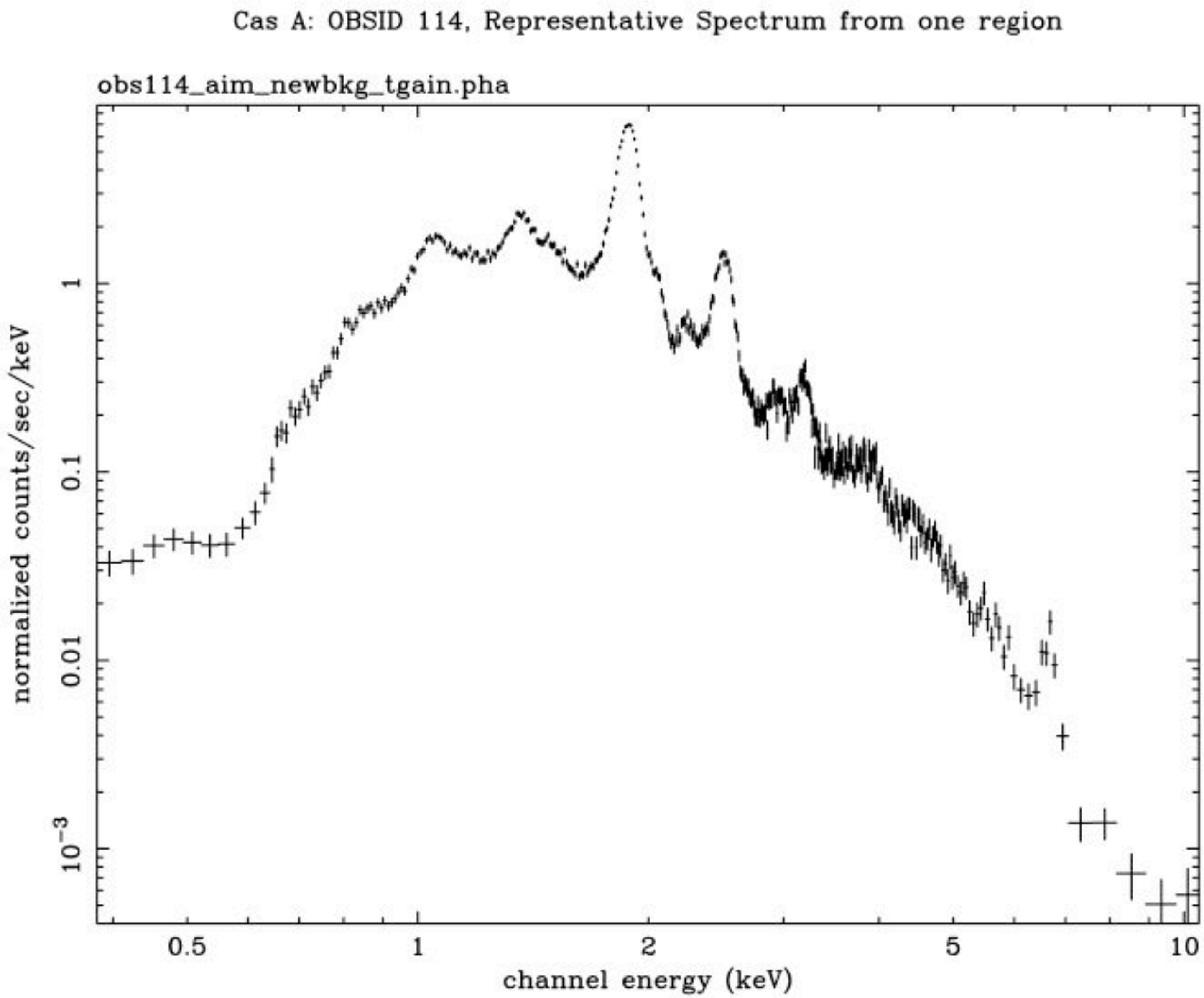
Significant spectral variations throughout the remnant

Emission in small regions is time-variable

Weak central source

Very bright, pileup in the brightest filaments with Chandra

Chandra X-Ray Observatory



Cas A

Spectrum from one region

Strong Si & S lines

Spectra are useful for gain calibrations

N132D: Chandra Three-color image

Red: 0.3-0.5 keV

Green: 0.5-0.75 keV

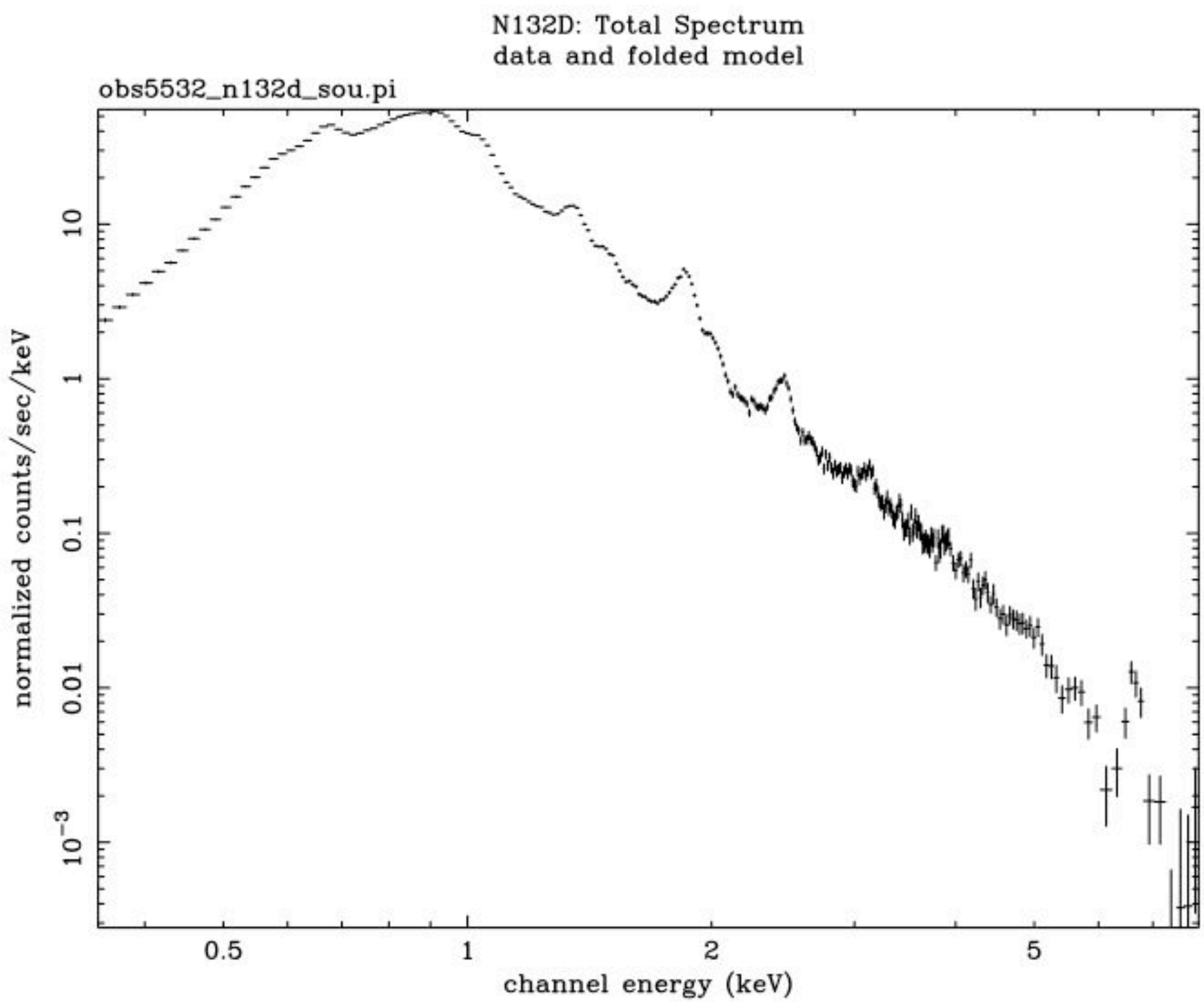
Blue: 0.75-7.0 keV

2.0 X 2.5 arcmin

Complicated morphology

Significant spectral variations as a function of position

Significant Fe emission which complicates spectrum below 1.2 keV



N132D

Significant

Fe emission

Complicates

Spectrum below

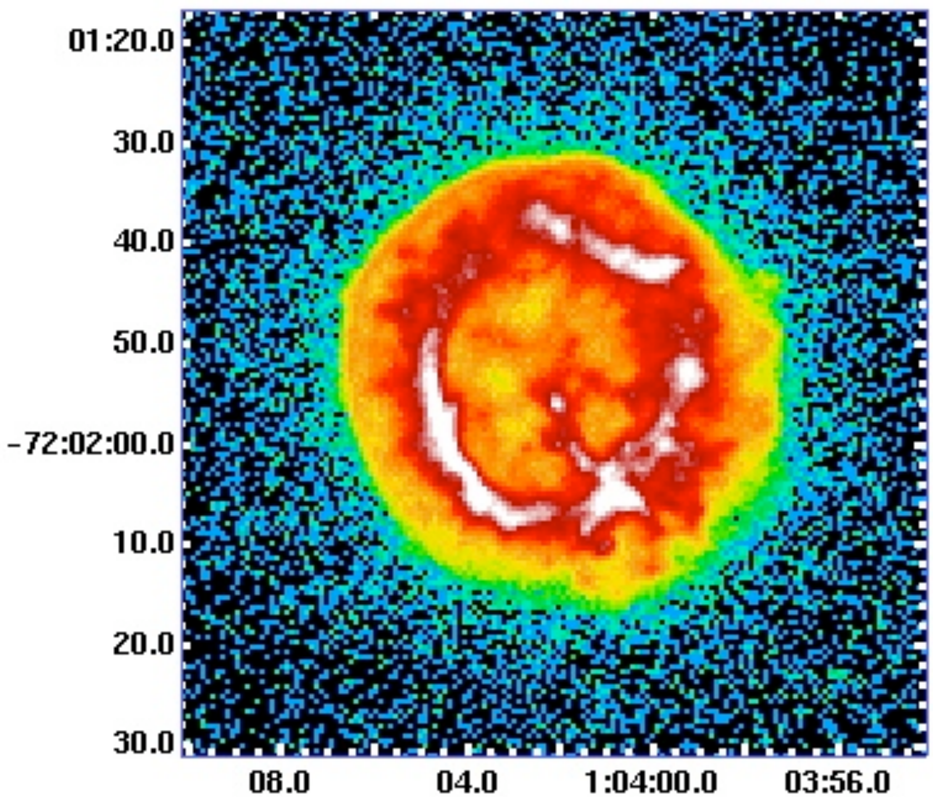
1.2 keV

Gratuitous Pretty Pictures of E0102, DePasquale (SAO)

1.2 X 1.2 arcmin

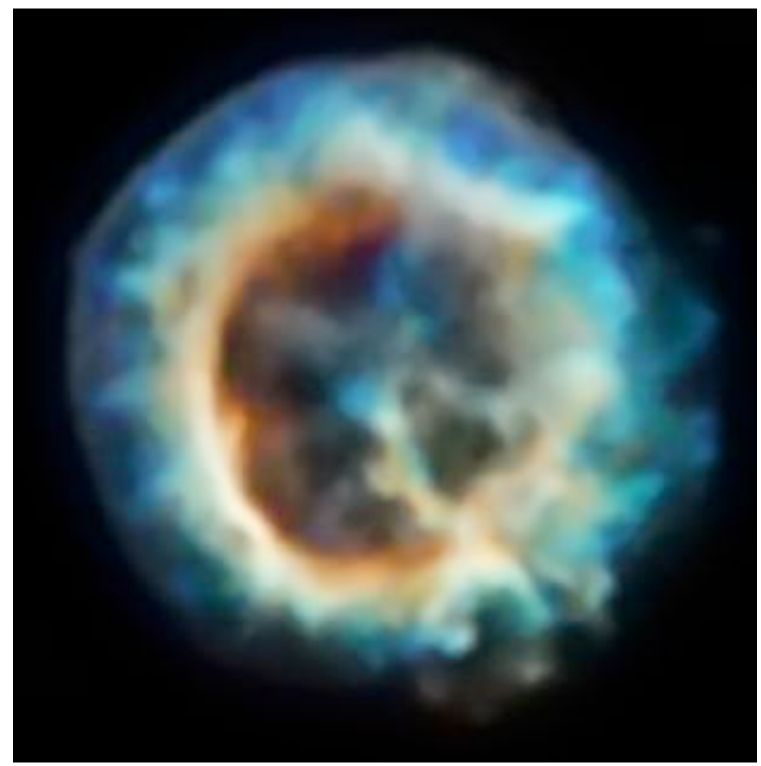
Least complicated morphology

S3 Summed Data ~100 ks

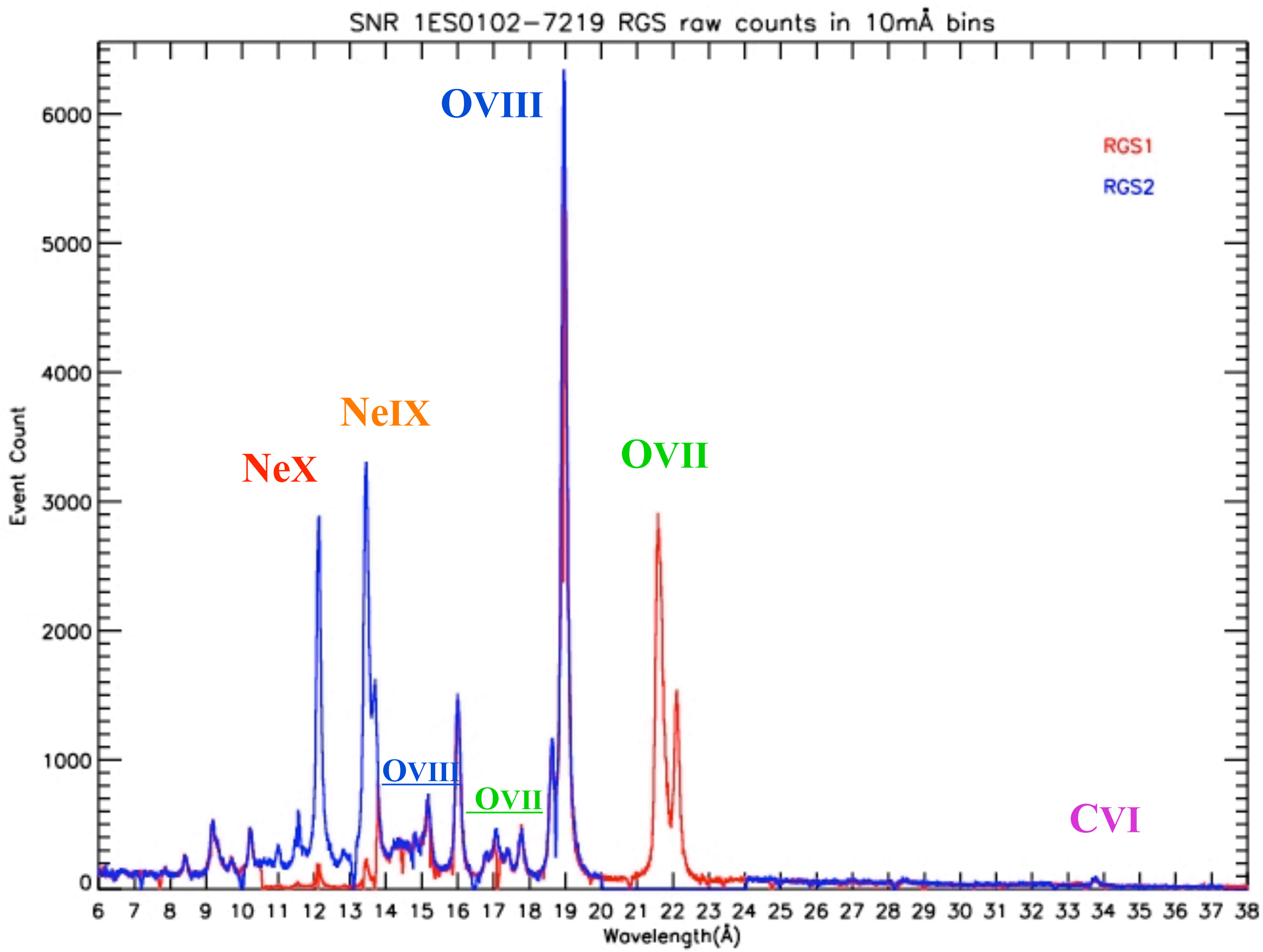


Three Color Image

Red: 0.2-75 keV, Green: 0.8-1.1 keV, Blue: 1.1-2.0 keV



RGS Spectrum of E0102, Pollock (ESAC):



Simplest spectrum of the three objects given the little or no Fe emission

Advantages of E0102 compared to Cas-A and N132D

E0102:

- small size - minimizes PSF and off-axis angles effects, degrades resolving power of the gratings the least
- simple spectrum - well-characterized by gratings
- O, Ne, Mg emission - provides line complexes at energies not covered by on-board sources
- morphology - most uniform of the three

Cas-A:

N132D:

- larger size - PSF and off-axis angles effects more important, resolving power of the gratings significantly degraded by source extent
- complex spectrum - lots of Fe which complicates spectrum
- O, Ne, Mg lines - provides line complexes at energies not covered by on-board sources

Disadvantages of E0102

- Chandra - brighter regions have some pileup
- Suzaku - nearby XRB can contaminate spectrum

Thermal SNR Working Group

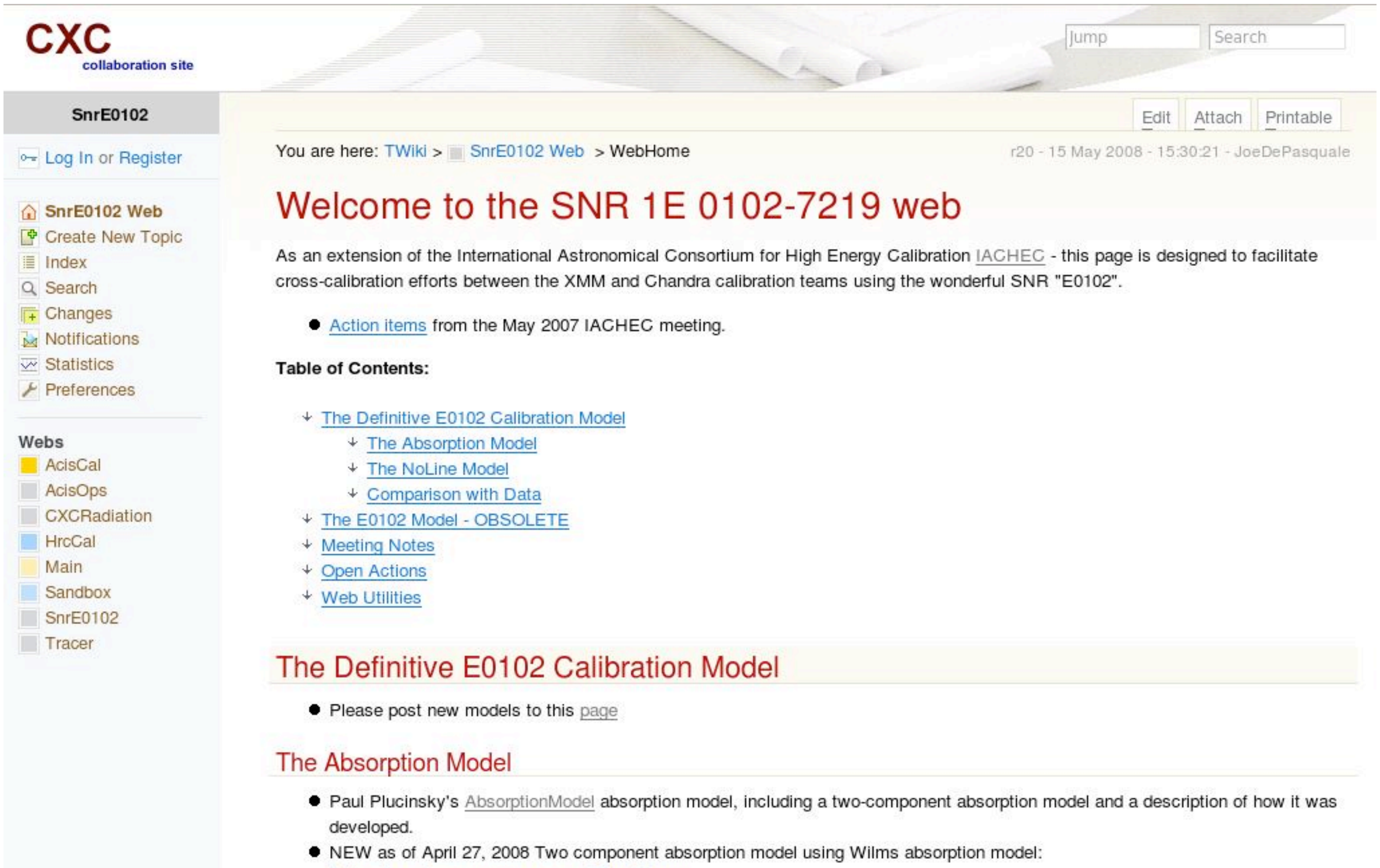
XMM-Newton RGS	Andy Pollock (ESAC)
Chandra HETG	Dan Dewey (MIT)
XMM-Newton MOS	Steve Sembay (Leicester)
XMM-Newton pn	Frank Haberl (MPE)
Chandra ACIS	Joe DePasquale, Paul Plucinsky (SAO)
Suzaku XIS	Eric Miller (MIT)
Swift XRT	Andrew Beardmore, Olivier Godet (Leicester)
Models	Randall Smith (JHU/GSFC)

Given the previous arguments we have focussed our efforts exclusively on E0102 since the last IACHEC meeting

Thermal SNR Working Group Process

8 telecons since July 2007, twiki page (DePasquale) set up to disseminate information:

cxc.harvard.edu/twiki/bin/view.cgi/SnrE0102/WebHome



CXC
collaboration site

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r20 - 15 May 2008 - 15:30:21 - JoeDePasquale

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- HrcCal
- Main
- Sandbox
- SnrE0102
- Tracer

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.

Table of Contents:

The Definitive E0102 Calibration Model

- Please post new models to this page

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:

Construction of the Definitive E0102 Model

Absorption:

- adopt Wilms et al. 2000 model as tbabs in XSPEC
- adopt a two-component absorption, Galactic and SMC, Galactic component fixed at 5.36 x 10^{20} cm^{-2} with Wilms abundances, SMC component is free to vary with abundances set to Russell & Dopita 1992 SMC abundances

Continuum:

- adopt APEC no-line continuum model
- adopt a two-component continuum, a relatively low-temperature component and a higher temperature component

Line Emission:

- use Gaussians for the lines, 30-40 lines, currently under discussion
- freeze energies to known values and set widths to zero
- constrain normalizations of lines of same ionization state to values determined by the RGS and HETG

This is NOT an astrophysical model, it is an empirical model !!!!

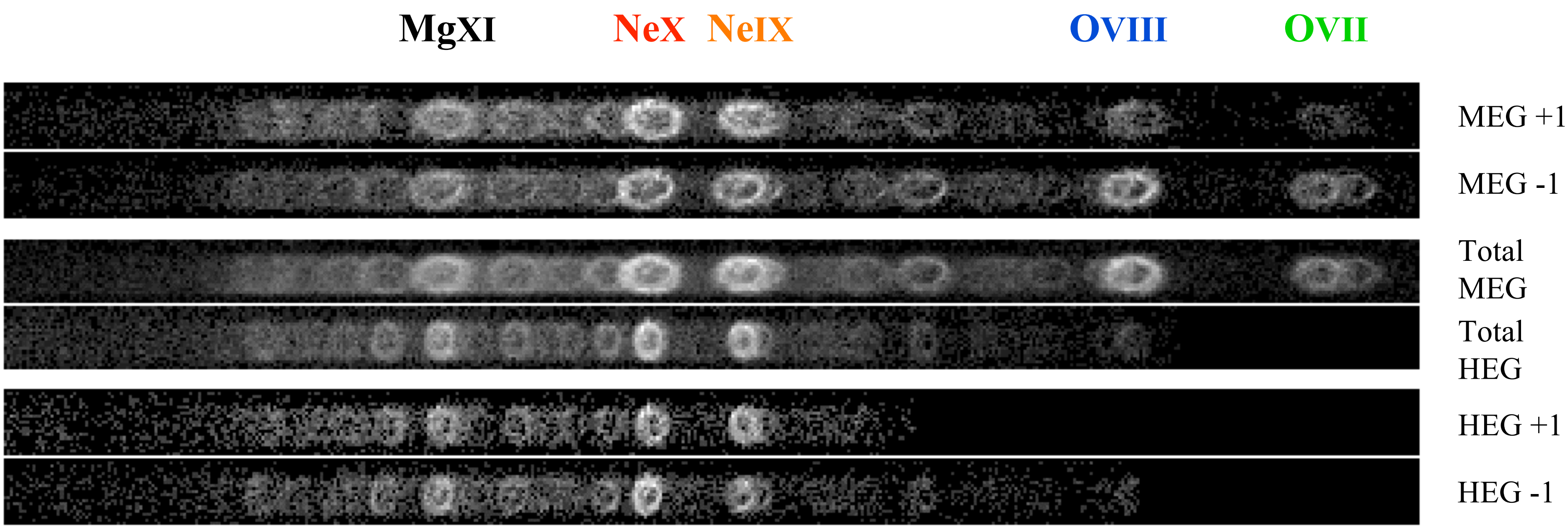
How to Constrain the Model Components

1) RGS and HETG constrain SMC N_H and normalization and temperature of low-temperature APEC no-line continuum
2) MOS, pn, & XIS determine normalization and temperature of high-temperature APEC no-line continuum
3) RGS and HETG determine line fluxes from 0.3-2.0 keV
4) MOS and pn determine line fluxes for lines above 2.0 keV
5) ALL instruments fit with the resulting model
6) Iterate to agree on the definitive model

My goal for this meeting would be to complete steps 1-4 and start iterating on step 5.

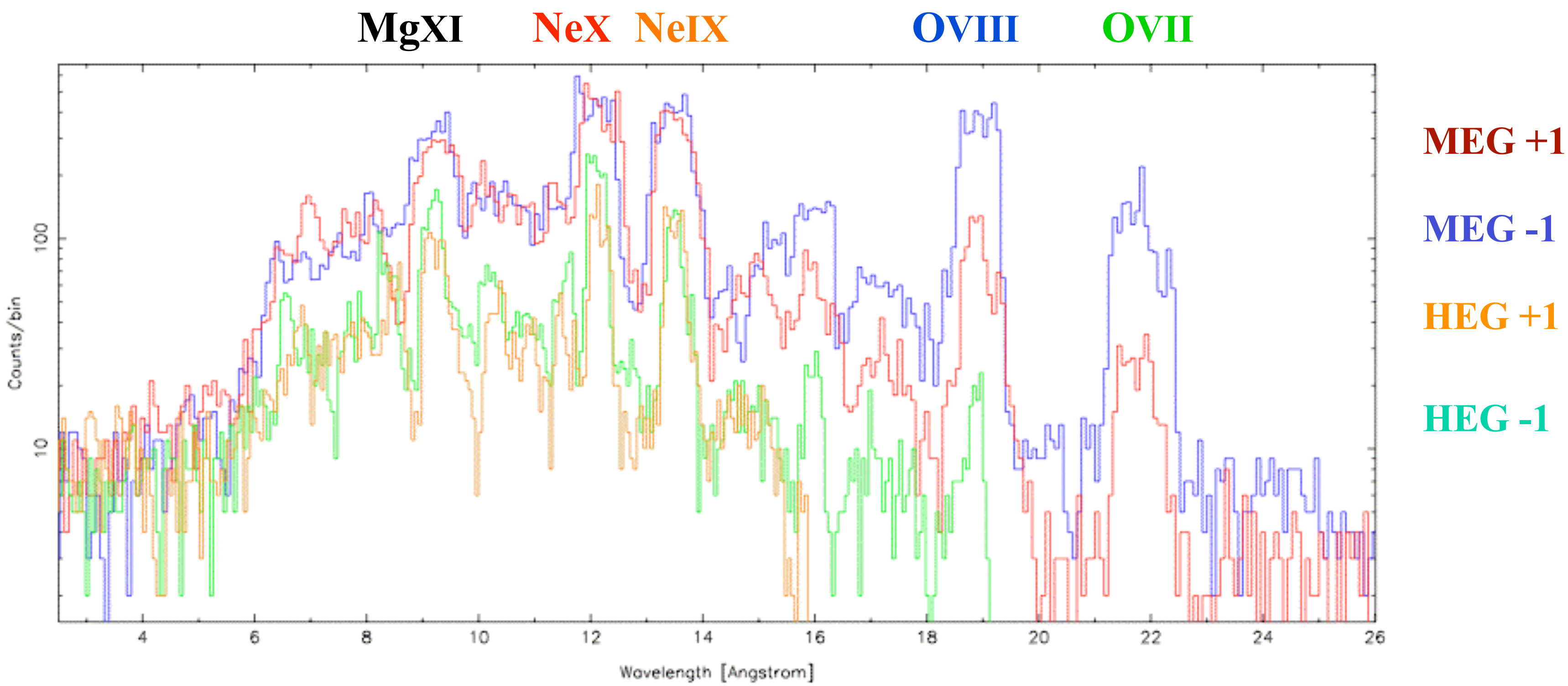
How Can the Gratings Constrain the Line Parameters ?

Raw images from the MEG and HEG, Dewey (MIT)



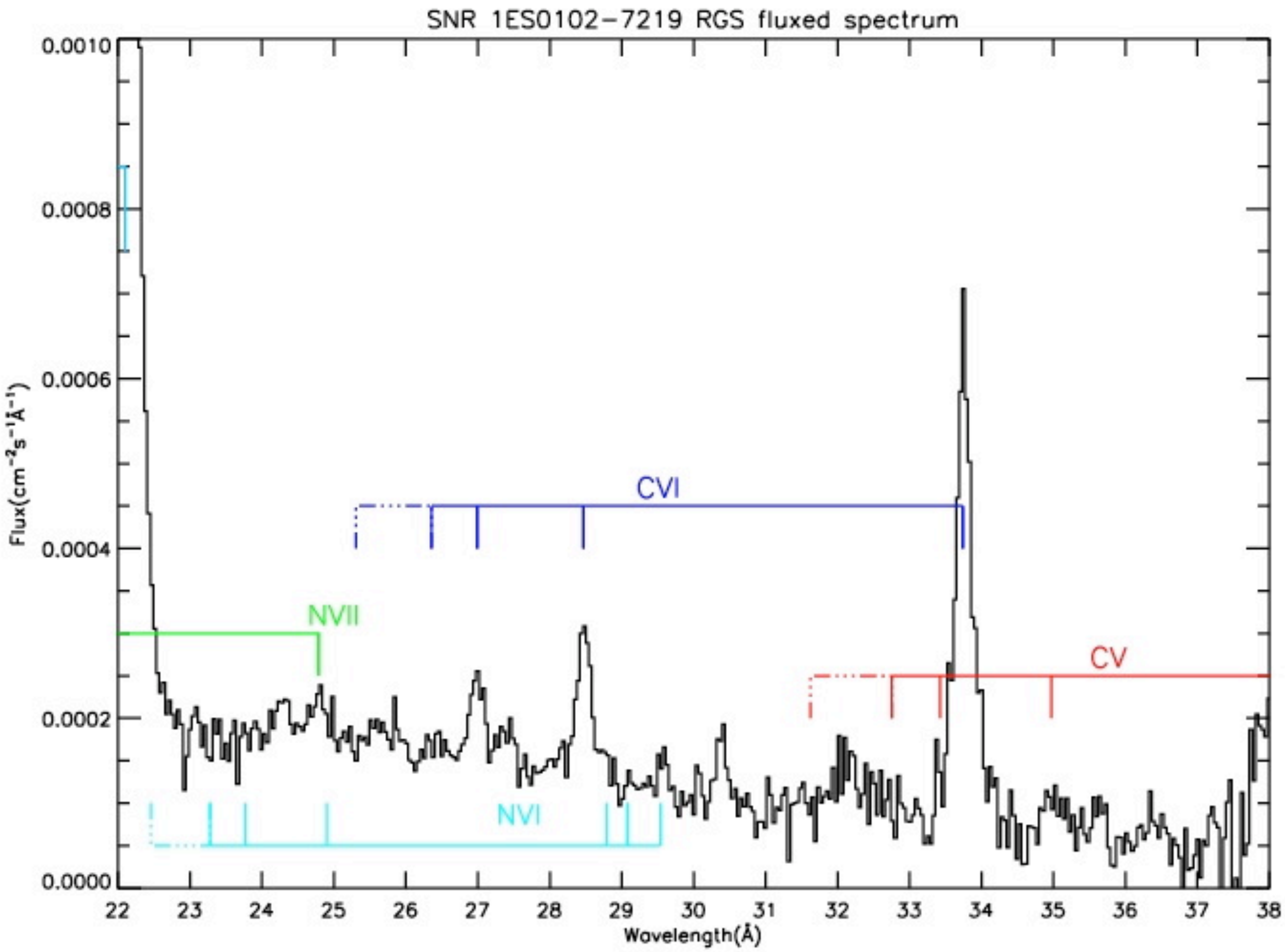
How Can the Gratings Constrain the Line Parameters ?

Raw spectra from the MEG and HEG, Dewey (MIT)



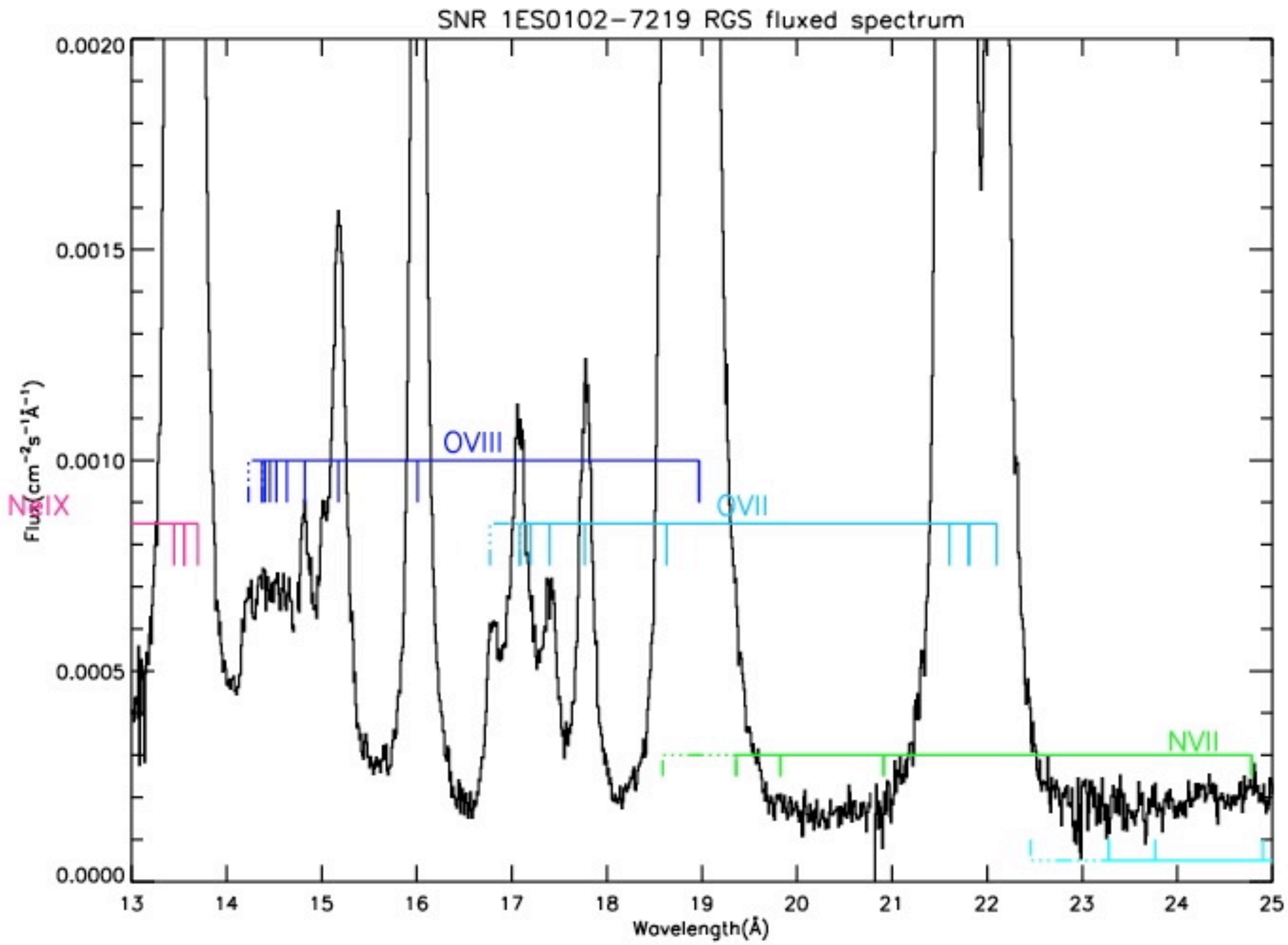
How Can the Gratings Constrain the Line Parameters ?

RGS spectra 22-38 A from Pollock (ESAC)



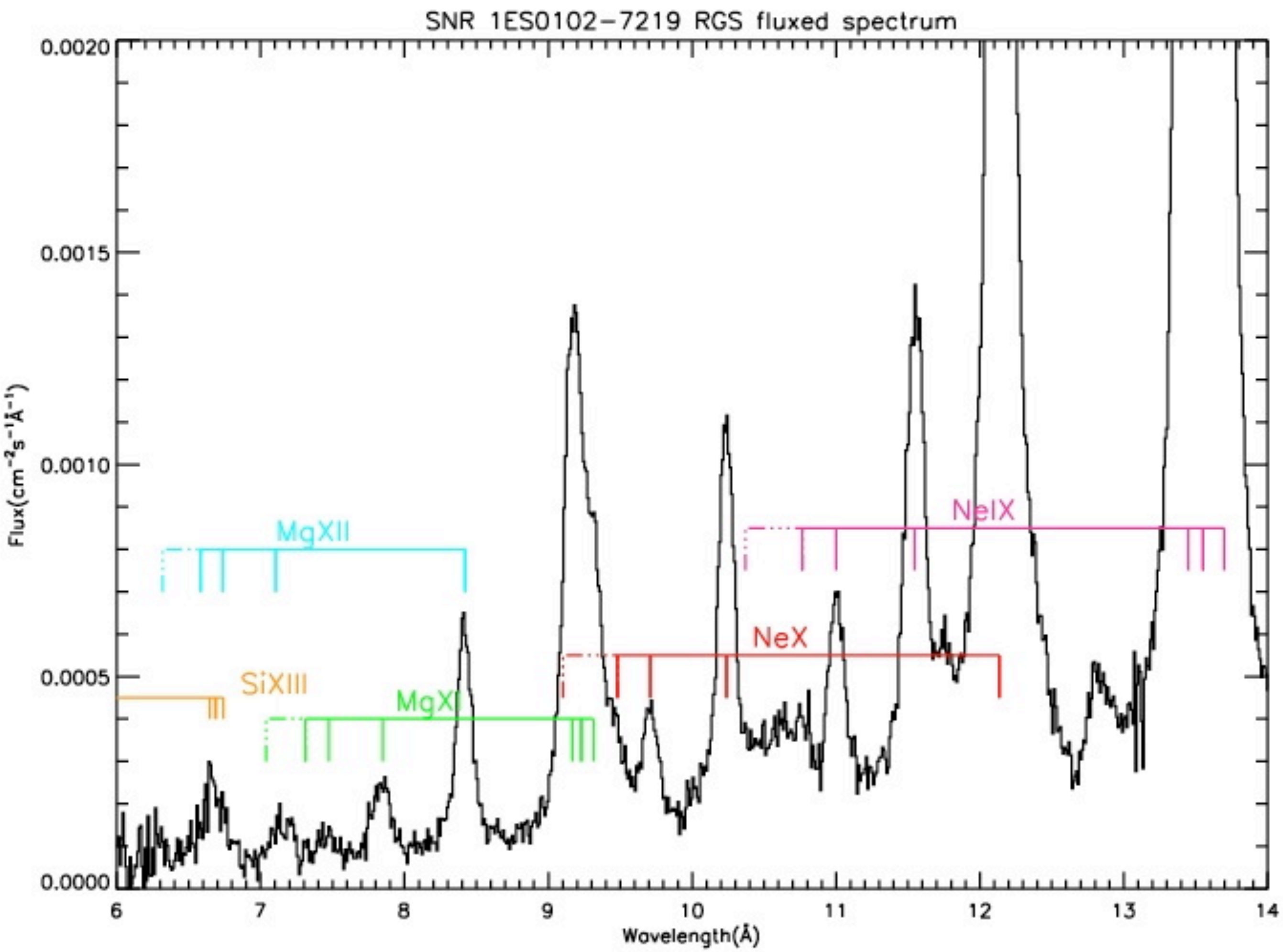
How Can the Gratings Constrain the Line Parameters ?

RGS spectra 13-25 A from Pollock (ESAC)

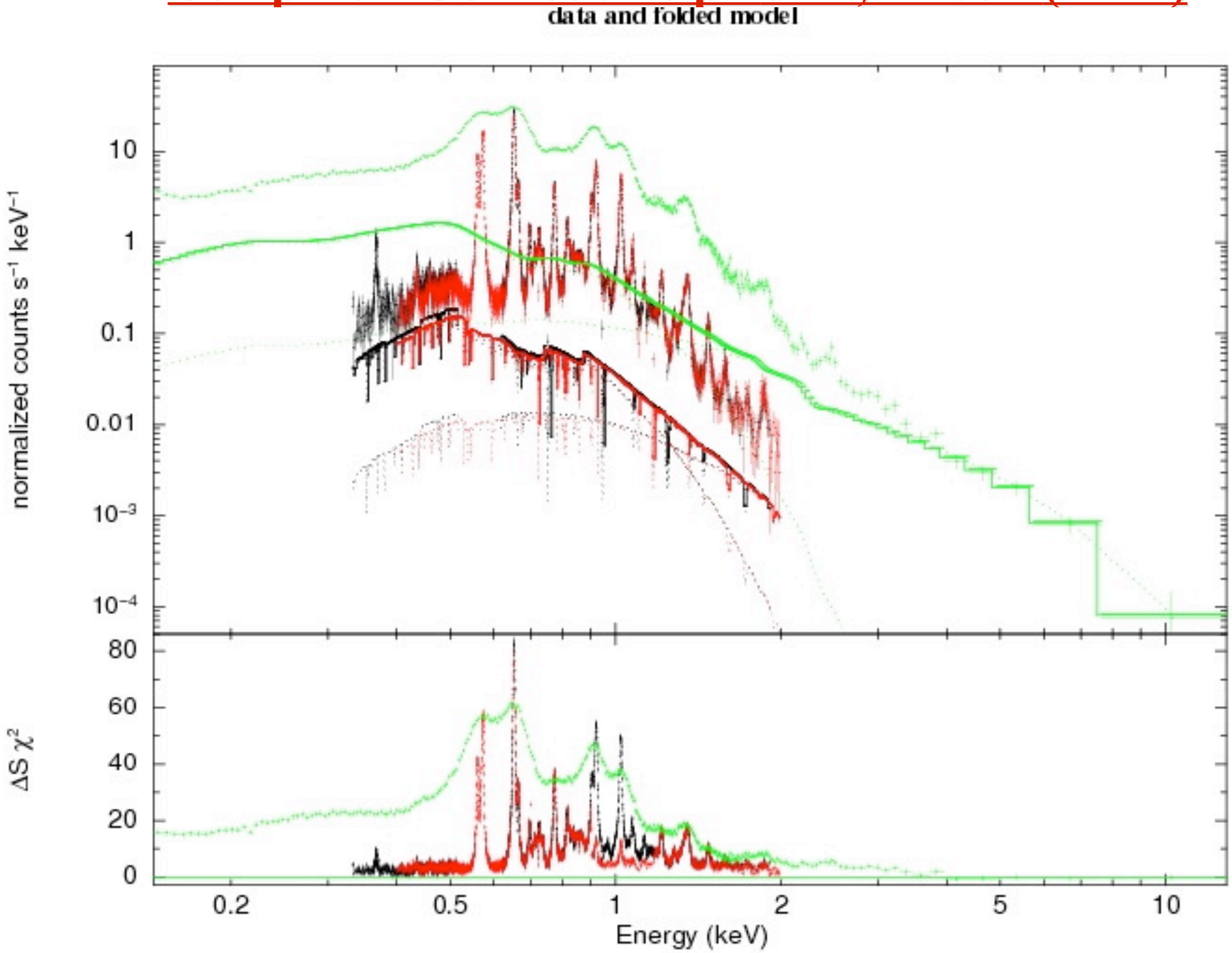


How Can the Gratings Constrain the Line Parameters ?

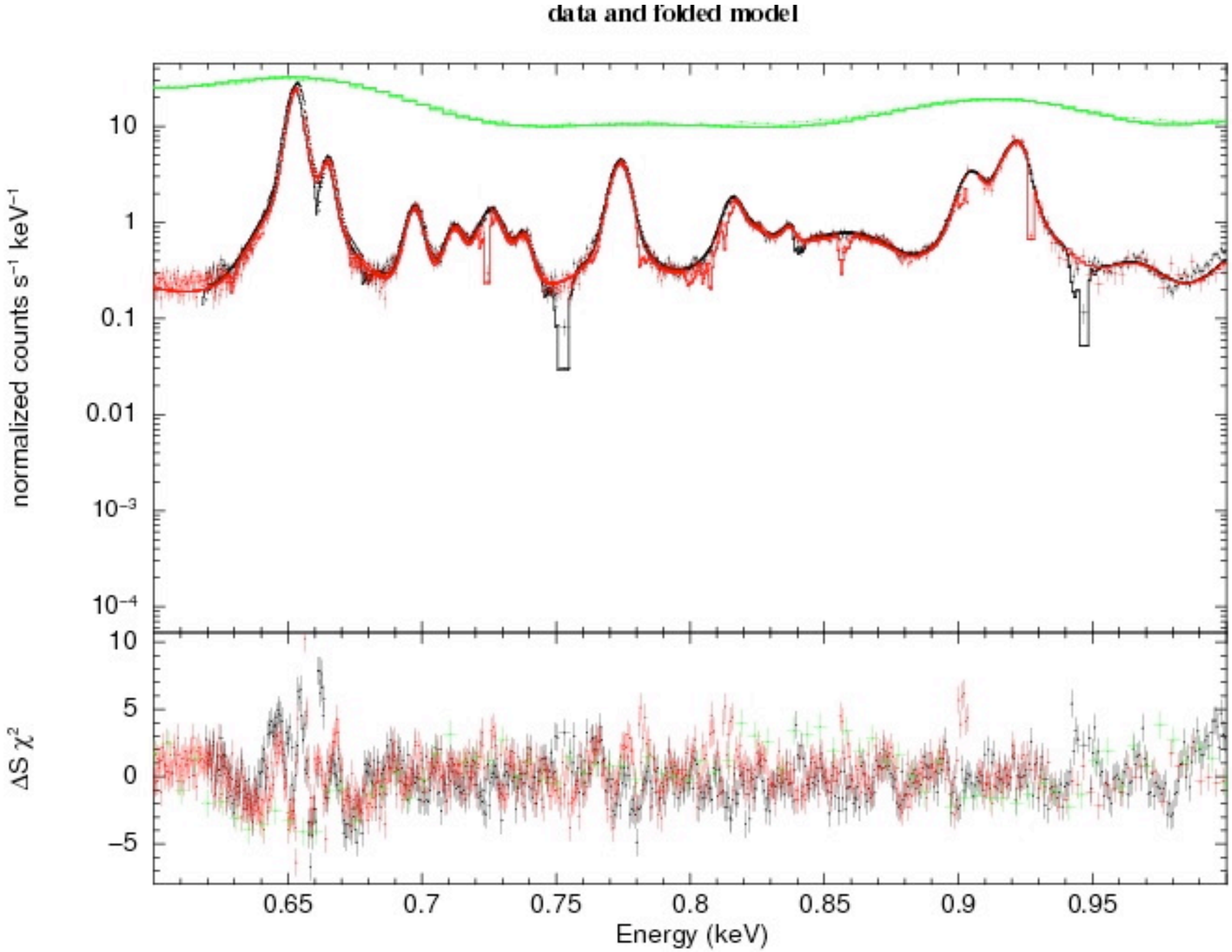
RGS spectra 6-14 A from Pollock (ESAC)



Compare RGS model to pn data, Haberl (MPE)

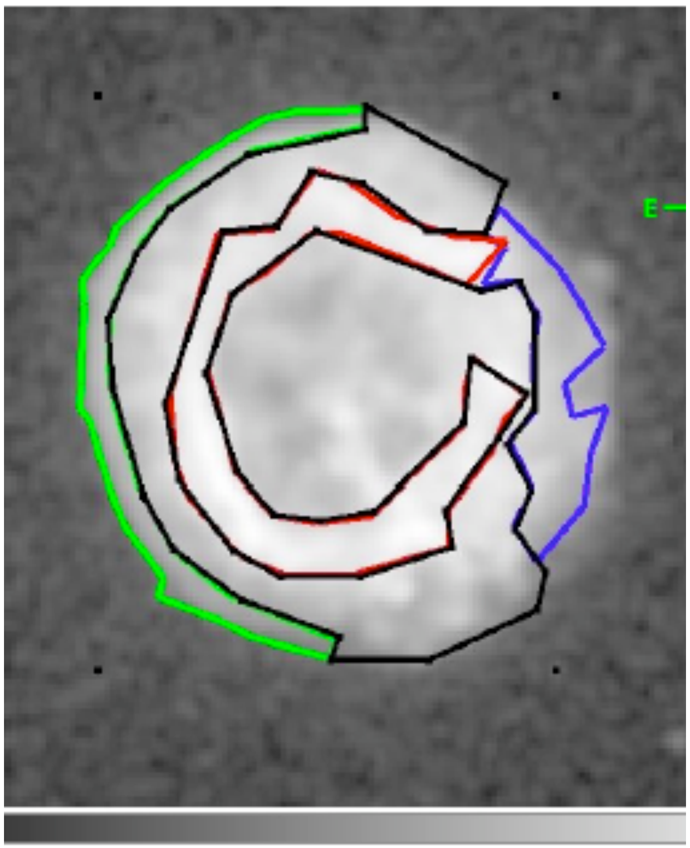


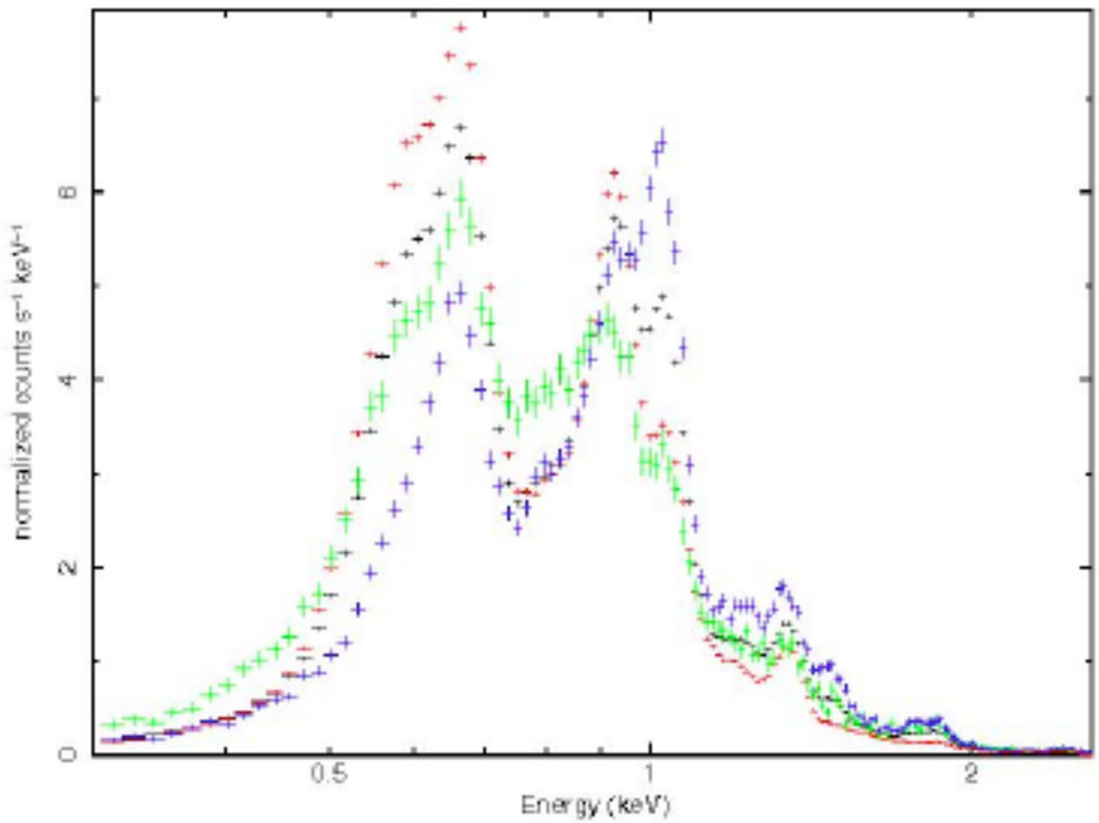
Compare RGS model to pn data, Haberl (MPE)



Astrophysics Will become More Important as We Refine the Model

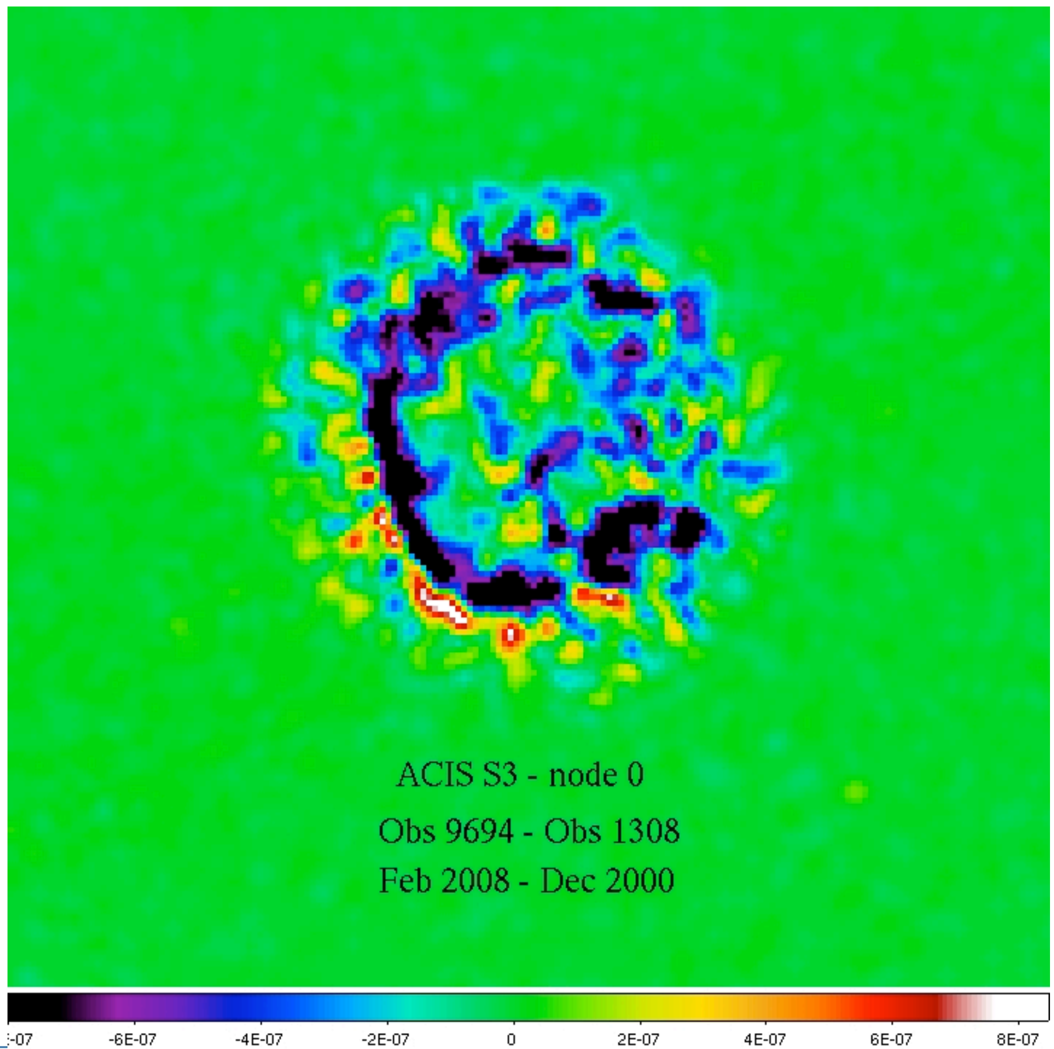
There are significant spectral variations within E0102, DePasquale (SAO)





Astrophysics Will become More Important as We Refine the Model

E0102 IS changing with time!!!!, DePasquale (SAO)



Conclusions

- we are close to a “definitive’’ spectral model for E0102
- we plan to quote agreement amongst the various instruments at OVII (560-574 eV), OVIII (654 eV), Ne IX (905-922 eV) and Ne X (1022 ev)
- we expect to write an SPIE paper immediately preceding this meeting for the June SPIE conference