Interpreting ACIS Observations in Light of Recent Calibration Issues

Presented by: George Chartas

In collaboration with: Divas Sanwal, Marcus Teter, Konstantin Getman, Gordon Garmire (PSU),

Paul P. Plucinsky, Alexey A. Vikhlinin, Richard J. Edgar, Shanil N. Virani, Joseph M. DePasquale, and Michael T. Raley (CfA)

Norbert S. Schulz, Herman L. Marshall, Catherine E. Grant, Glenn E. Allen, and Michael W. Wise (MIT)

Premier : 6-7 November 2002

Outline

- **Description of ACIS quantum efficiency correction tools**

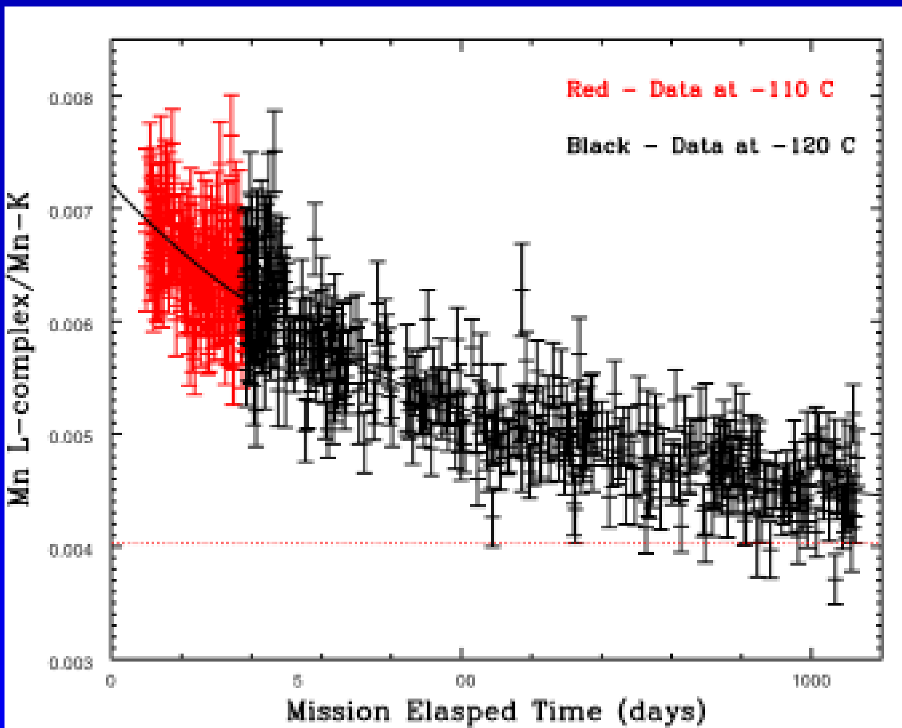
- ACISABS : XSPEC model and arf modifier
- Refining qe correction tools with ACIS calibration data

- **Application of quantum efficiency correction tools to ACIS spectra**

- Intervening absorption in ACIS spectra of distant quasars
- Properties of z>4 quasars
- Cross calibration between XMM and Chandra

- **ACIS Quantum Efficiency Predictions for A05**

Descsription of ACIS Quantum Efficiency Correction Tools



Observed decay in the ratio of the 0.67keV and 5.895keV line complexes. Measurements were performed by Catherine Grant (MIT). Plot from Plucinsky et al. 2002

ACISABS assumes a decrease in time of the ACIS quantum efficiency based on the observed decay in the ratio of the 0.67keV and 5.895keV line complexes of the external calibration source as observed with ACIS S3. The decay-rate measurements were performed by Catherine Grant (MIT). The decay rate is modeled by the function:

R(t) = norm*double(exp(-τinf*(1.d0 - exp(-t/tefold))))

norm = 0.00722 +/- 0.00007

tefold = 620. +/- 66.

τinf = 0.582 +/- 0.024

based on Allyn Tennant's and Steve O'Dells (MSFC) fits to the observed decay rate.

Descsription of ACIS Quantum Efficiency Correction Tools

1. Use observed decay $R_{obs}(t)$ in the ratio of observed X-ray transmissions at 0.67keV and 5.895keV.

2. Model decay :

$$Trans(E1,t) = T_{OBF}(E1)\ T_{cont}(E1,t)$$

The modeled decay is:

$$R_{model}(t) = (S1/S2)\ Trans(E1,t)/Trans(E2,t) = const\ \exp\{-\rho\ d(t)\ [\ \mu(E1) - \mu(E2)]\}$$

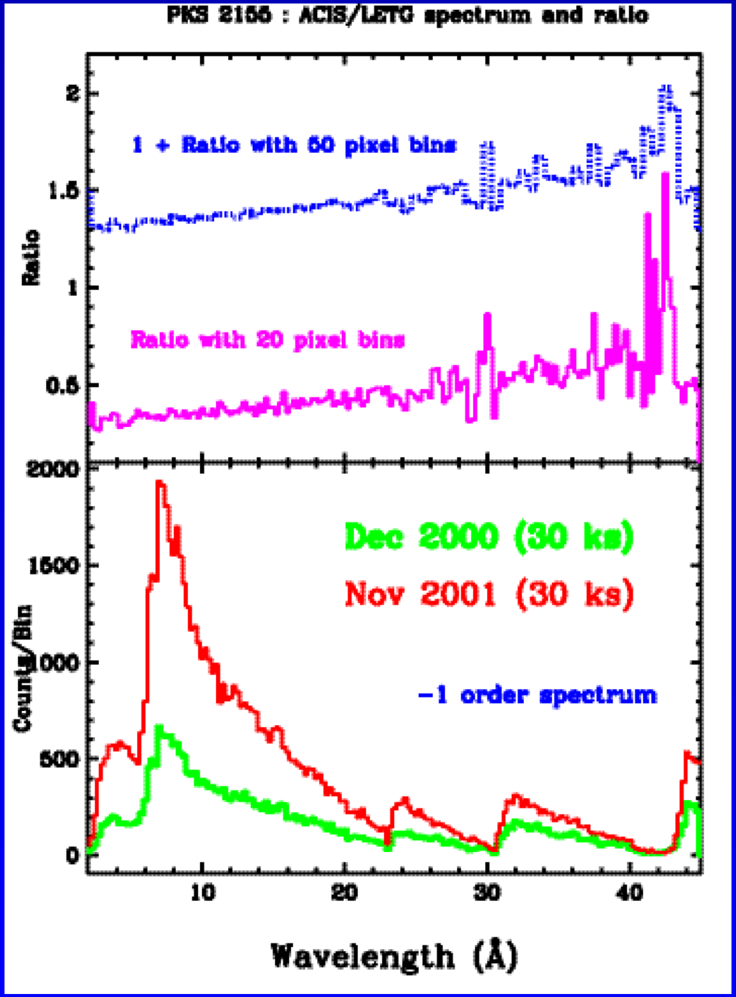
where : ρ is the density of the contaminant, $d(t)$ is the thickness of the contaminant, $\mu(E)$ is the mass absorption coefficient of the contaminant at energy E. S1 and S2 are the relative strengths of the calibration line complexes as measured with no filters present. $\mu(E)$ is calculated from atomic scattering factor files provided at http://www-cxro.lbl.gov/optical_constants/asf.html

The thickness*density of the contaminant vs. time is : $d(t)\rho = \ln(R(t)/const)\ /\ [\mu(E2) - \mu(E1)]$

3. The modification made to the ACIS arf files to account for contamination is:

$$T_{cont}(E,t) = \exp(-\ \mu(E)\rho\ d(t))$$

Descsription of ACIS Quantum Efficiency Correction Tools

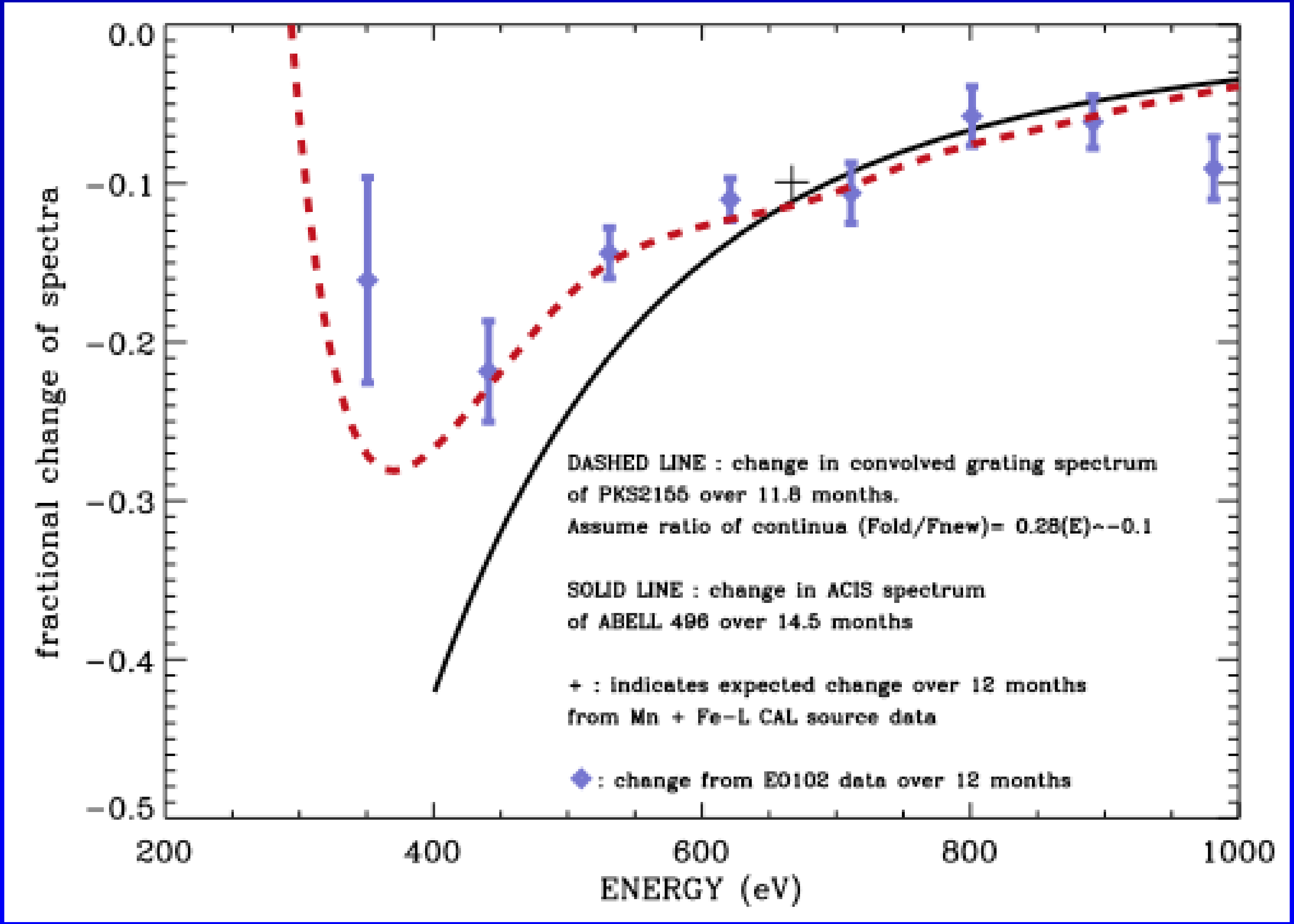


Two LETG/ACIS observations of PKS2155-304 performed in Dec 2000 and Nov 2001. The ratio plot is the ratio of old to new spectrum.
From PSU report by Sanwal, Chartas & Pavlov (2002)

The **ACISABS** software tool attempts at correcting for the absorption caused by molecular contamination of the ACIS optical blocking filters. The user needs to supply the number of days between Chandra launch and observation.
http://asc.harvard.edu/cont-soft/software/ACISABS.1.1.html

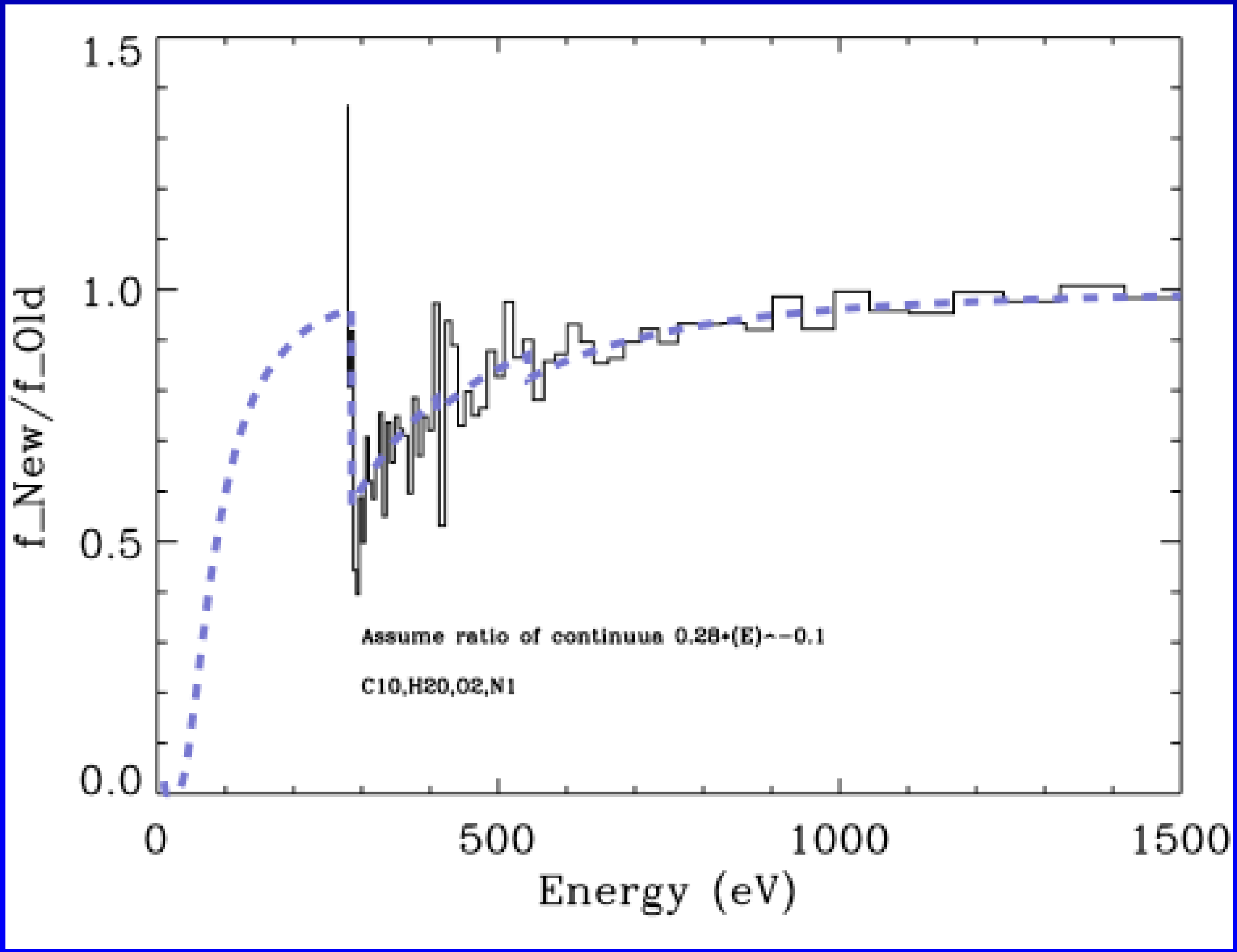
The composition of the contaminant was inferred from simple fits to grating observations of PKS2155 and probably will need to be updated when the composition of the contaminant is better constrained.

Descsription of ACIS Quantum Efficiency Correction Tools



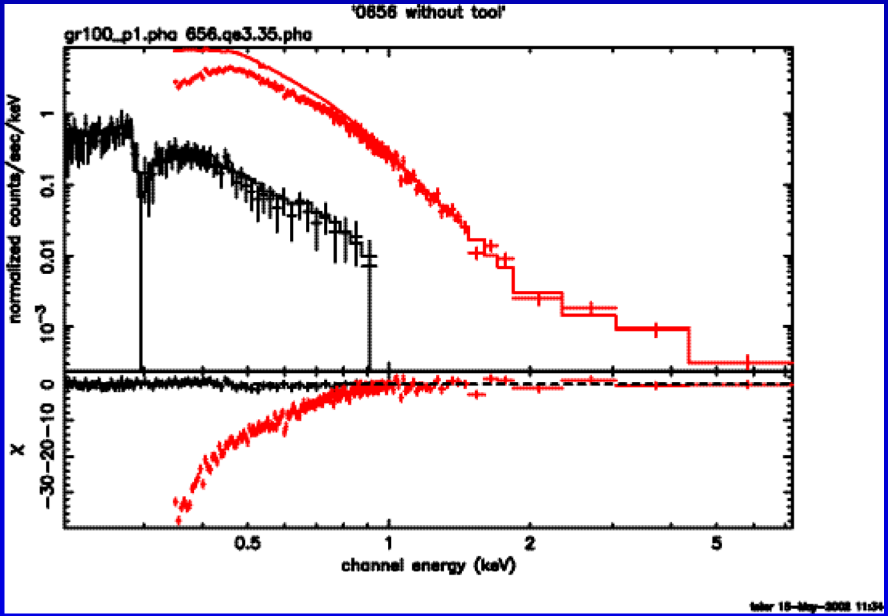
The fractional change of the two PKS 2155-304 spectra separated by ~11.8 months is fit by the ACISABS contamination model. We smooth the measured ratio in the ACIS/LETG spectrum by the bare ACIS response. This allows us to directly compare the fits to this ratio with the two observations of Abell 496 produced by Alexey Vikhlinin.

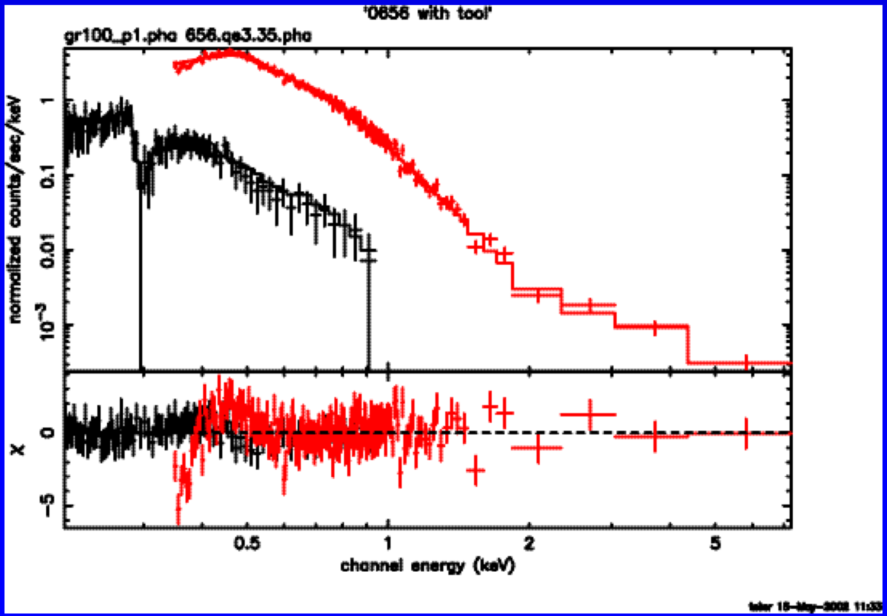
Descsription of ACIS Quantum Efficiency Correction Tools



The ratio of the renormalized fluxes for the two observations of PKS 2155 overlayed with the estimated ratio based on the ACISABSv1.1 contamination model ($C_{10}H_{20}O_2N_1$).

Refining qe correction tools with ACIS calibration data





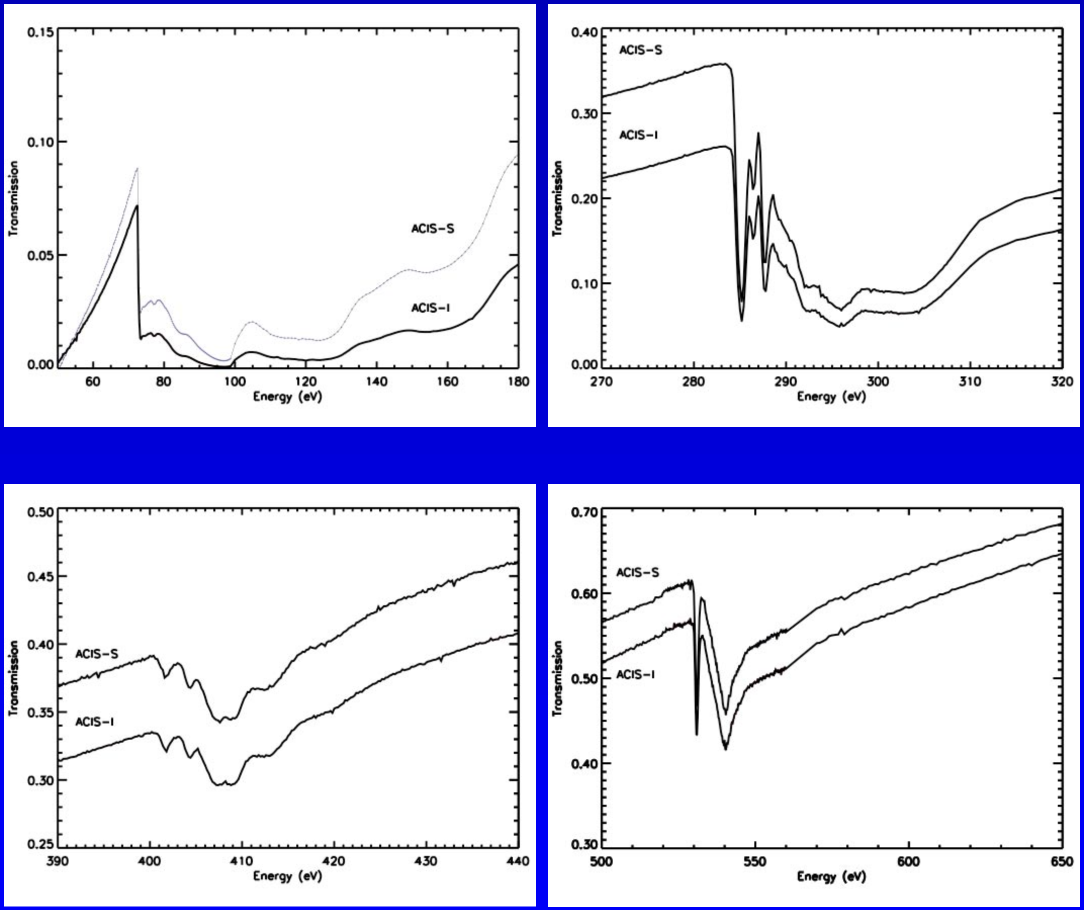
Combine observations of PSR 0656 performed with the HRC/LETG and ACIS CC mode data to refine qe correction.

In these examples the ACIS bare CC mode data are only fit above 0.9 keV and the solid line represents the best fit common model.

We ignored energies below 350eV in the ACIS fit because of the uncertainty in the ACIS gain below this energy.

The amount of contaminant estimated by ACISABS for the ~2 year separation between the observations seems to be consistent with the data.

Limitations of qe correction tool



No EXAFS are included in the contamination model. The EXAFS for the contaminant are most likely considerably different from those of polyimide($C_{22}H_{10}O_4N_2$).

The near and extended absorption fine structures of the Al-L, C-K, N-K and O-K absorption edges for the ACIS filters were measured at the Advance Light Source at Berkeley Labs.

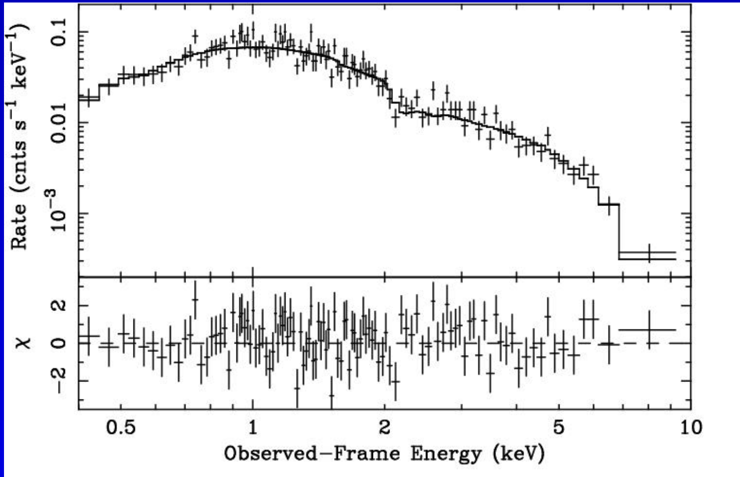
For the purposes of low energy resolution observations with bare ACIS-I and ACIS-S the present qe correction is adequate, however, for high resolution observations with gratings the EXAFS of the contaminant may need to be included.

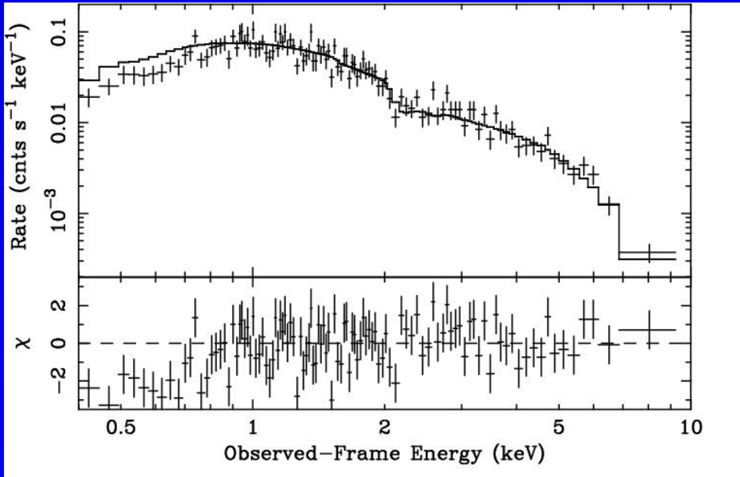
ACIS-S: Al/ Polyimide/Al ~ 1000Å/2000Å/300Å

ACIS-I: Al/ Polyimide/Al ~ 1200Å/2000Å/400Å

Applications of qe correction tools to ACIS spectra

Applications of qe correction tools to ACIS spectra





Estimate metallicity of intervening absorber

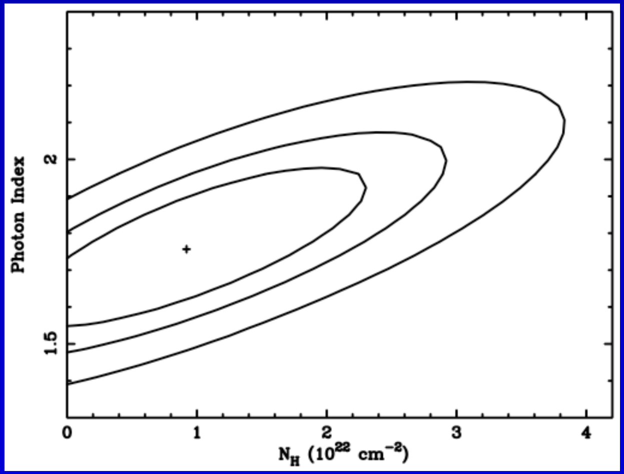
$z_{absorber}$ = 0.394, z_{qso} = 1.31
NHI_{Gal} = 0.89x10^{21} cm^{-2}, $NHI_{absorber}$ = 3.8x10^{21} cm^{-2}
Observation data : 27/09/2000

XSPEC Model: acisabs wabs zvarabs pow
Assume ISM metallicities for Galaxy (Wilms et al. 2000)

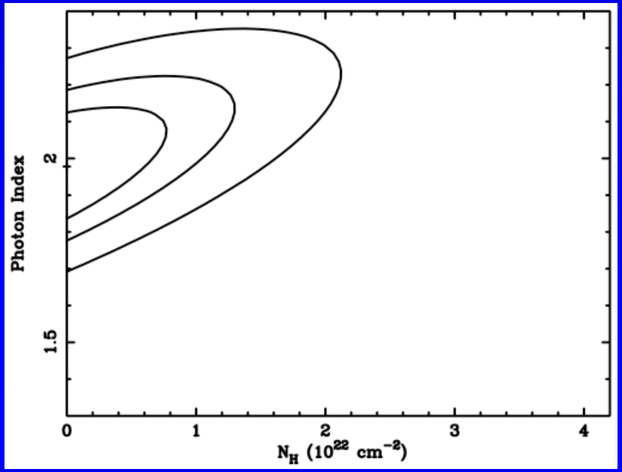
Results neglecting QE Contamination:
$Metallicity_{abs}$ = 0.46[-0.17,+0.18] (90% confidence)

Results applying acisabs model:
$Metallicity_{abs}$ = 0.1[-0.1,+0.18] (90% confidence)

Applications of qe correction tools to ACIS spectra



X-ray spectral results with no contamination correction



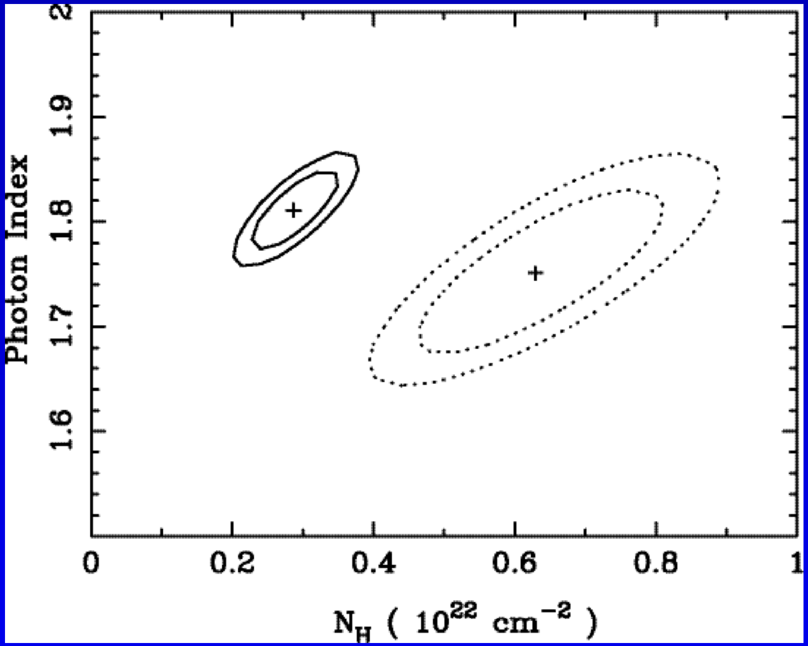
X-ray spectral results using ACISABS to modify individual ARFs.

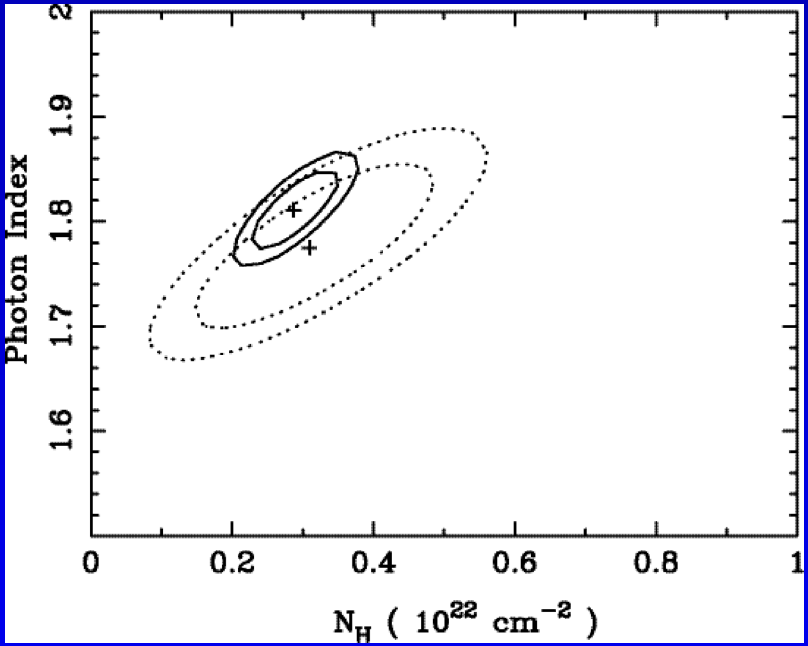
Properties of z>4 Quasars

The data are from 9 PSS quasars at z=4.1-4.5 observed at the ACIS-S aimpoint during Chandra Cycle 3 (with typical exposure times of 4-5 ks). In total there are about 350 source counts. The X-ray spectral results shown in these figures have been obtained using C-statistic.

Results provided courtesy of Christian Vignali (Vignali et al. 2002, ApJ in press)

Cross Calibration between XMM and Chandra

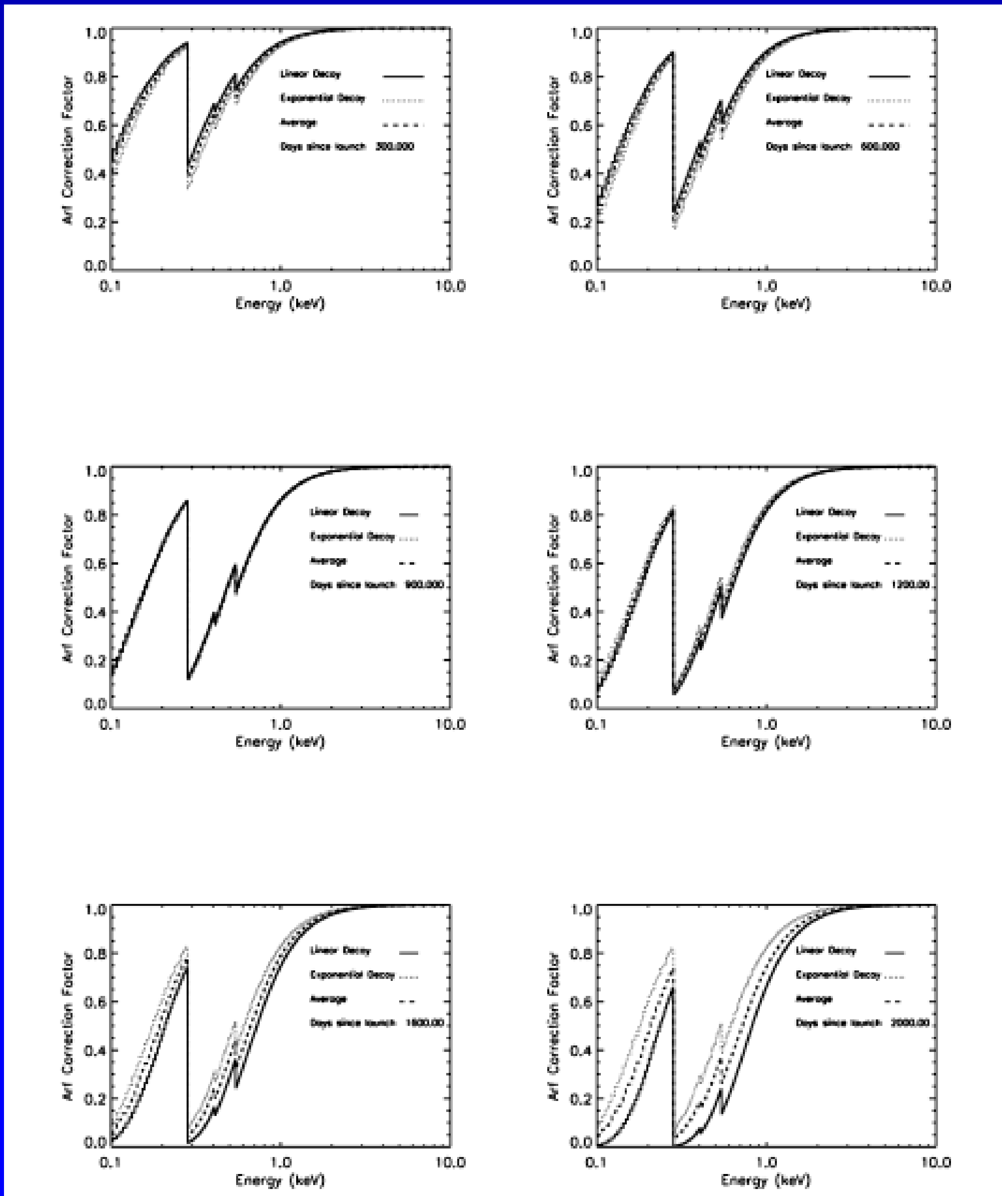




PG1115+080 z_s = 1.722 , z_l = 0.311

The source is a mini broad absorption line quasar observed with *Chandra* on June 2 2000 for 26.8ks, and with XMM-Newton on Nov 25 2001 for 62.6ks.

ACIS Quantum Efficiency Predictions for A05



It is not clear whether the qe decay is linear or exponential with time. The ACIS calibration source data slightly favor an exponential decay, however, the gratings data support a linear qe decay.

We calculated corrected arf files assuming linear and exponential qe decay rates. We also provided an average arf file of these two corrected arf files.

ftp ftp.astro.psu.edu
cd pub/gc/OBF/
bin
get acisabsv1.2_idl.tar.gz
get acisabs_a05_perl.tar.gz
get acisabs_a05_sl.tar.gz

CREDITS

Directed by
George Chartas

Actors
Divas Sanwal
Marcus Teter
Konstantin Getman (PSU)
Paul P. Plucinsky, Alexey A. Vikhlinin, Richard J. Edgar, Shanil N. Virani, Joseph M. DePasquale, and Michael T. Raley (CfA)
Norbert S. Schulz, Herman L. Marshall, Catherine E. Grant, Glenn E. Allen, and Michael W. Wise (MIT)

Digital Camera Personnel
Gordon Garmire