The Decrease in the ACIS Low-Energy Sensitivity

Paul P. Plucinsky
Smithsonian Astrophysical Observatory

Contributors to the Analysis Effort

There is a large group working on these issues. Those contributing directly to the presentation:

Norbert S. Schulz, Herman L. Marshall, Catherine E. Grant,

George Chartas, Divas Sanwal, Marcus A. Teter

Alexey A. Vikhlinin, Richard J. Edgar, Michael W. Wise,

Glenn E. Allen, Shanil N. Virani, Joseph M. DePasquale,

Michael T. Raley, Allyn Tennant, Steve O'Dell

Many others have contributed directly or indirectly:

ACIS MIT and PSU instrument teams, MSFC Project Science, CXC

Decrease in the Low Energy Efficiency

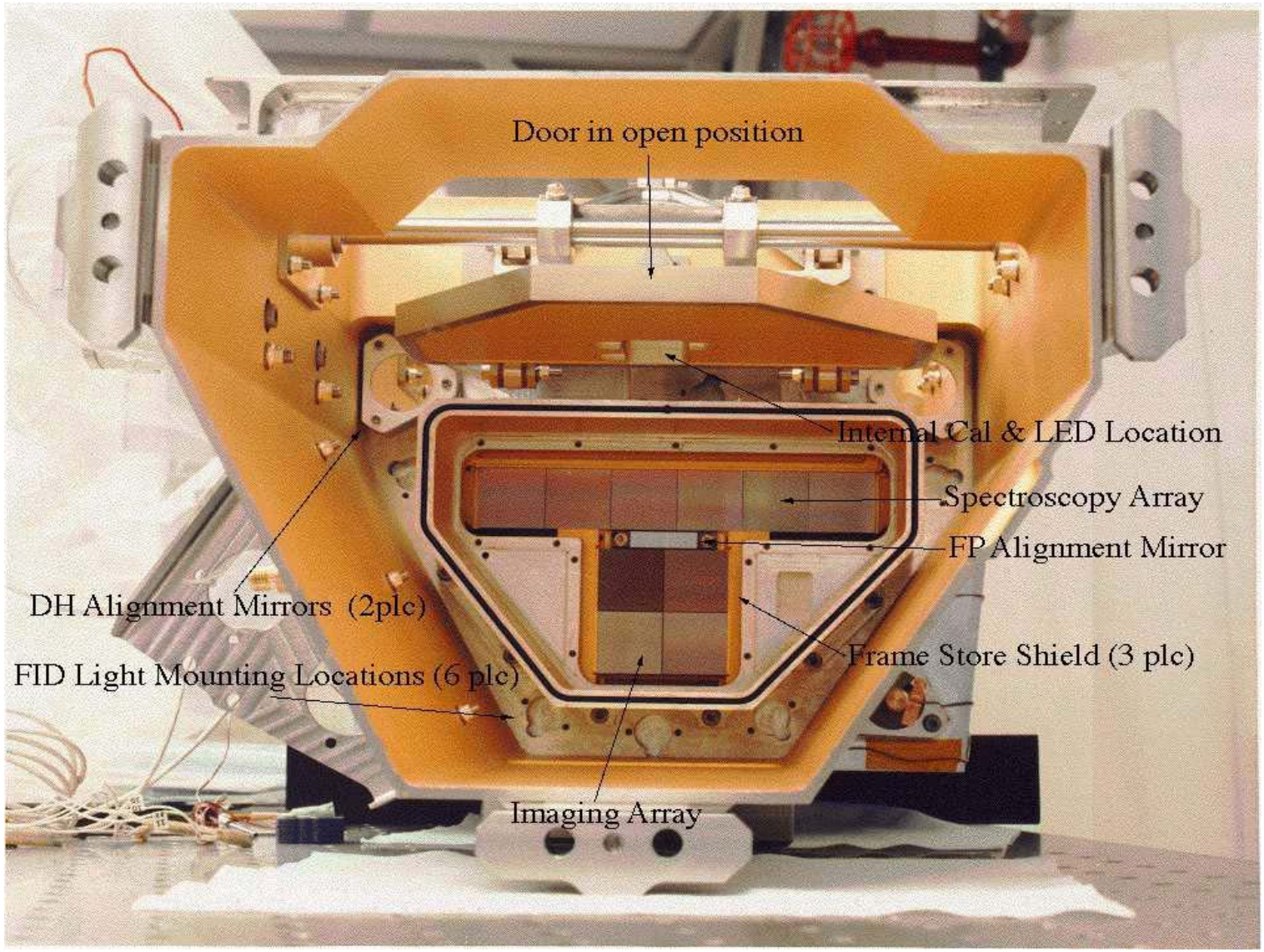
- The low-energy QE appears to be decreasing with time.
- The effect is energy-dependent, ~50% at 0.5 keV over the life of the mission, negligible above 1.5 keV
- It appears the reduction in sensitivity is due to a buildup of contamination on the filters/CCDs.
- The characterization of this effect is complicated by changes in the CCD response over the life of the mission.
- The chemical composition of the contaminants is under investigation, strong C edge, weak O edge, only upper limits on N and F .
- Two SW tools have been developed to correct the effective area for this time-dependent absorption, H:C:N:O == 20:10:1:2

`ACISABS` – XSPEC model of absorption (see talk by Chartas for more details)

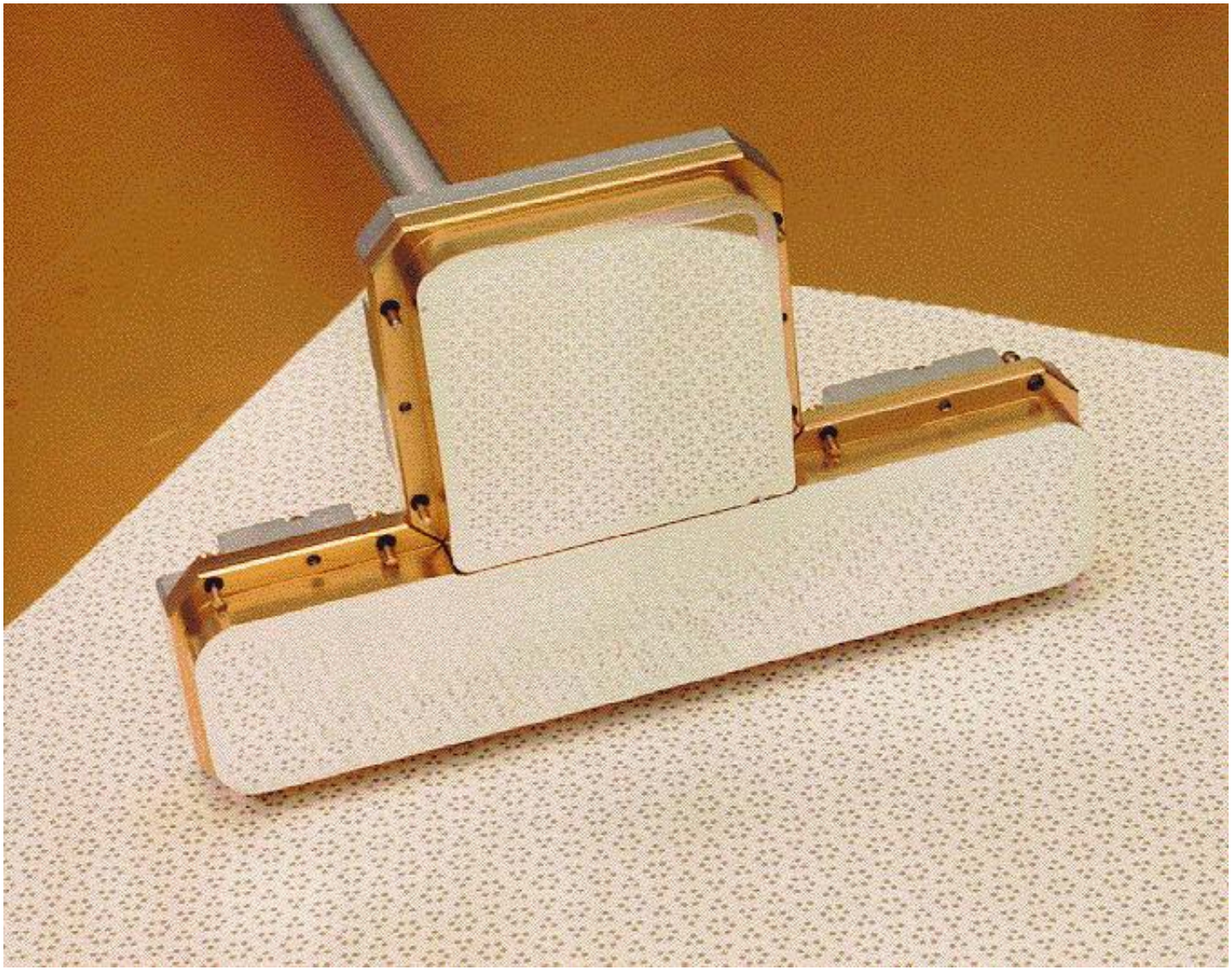
corr_arf – standalone FORTRAN, modifies arf file

- Available at "cxc.harvard.edu/cal/Links/Acis/acis/Cal_products/qeDeg"

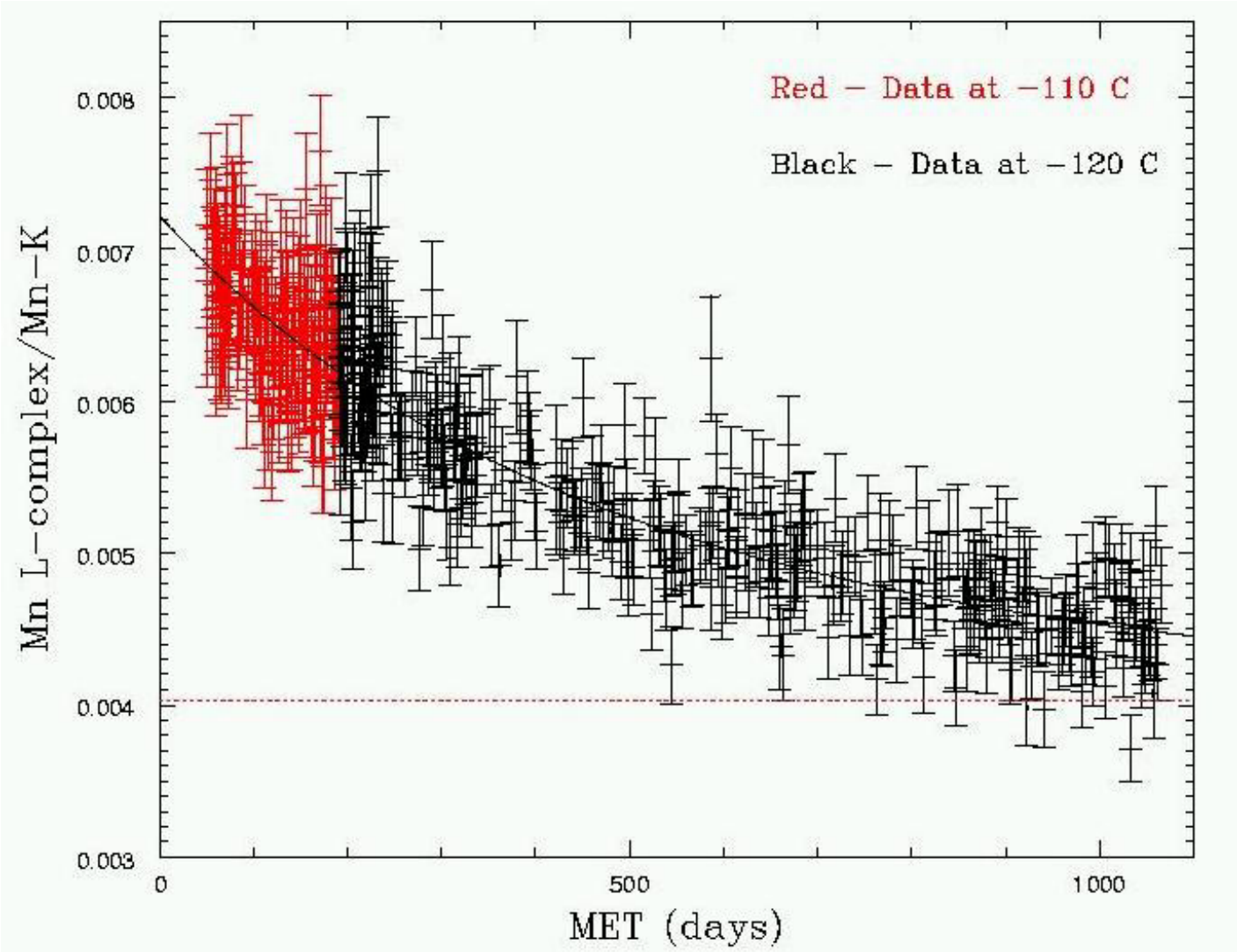
ACIS Test Unit



ACIS Filters



Mn-L complex/Mn-K vs Time



Grant (MIT)

Analysis

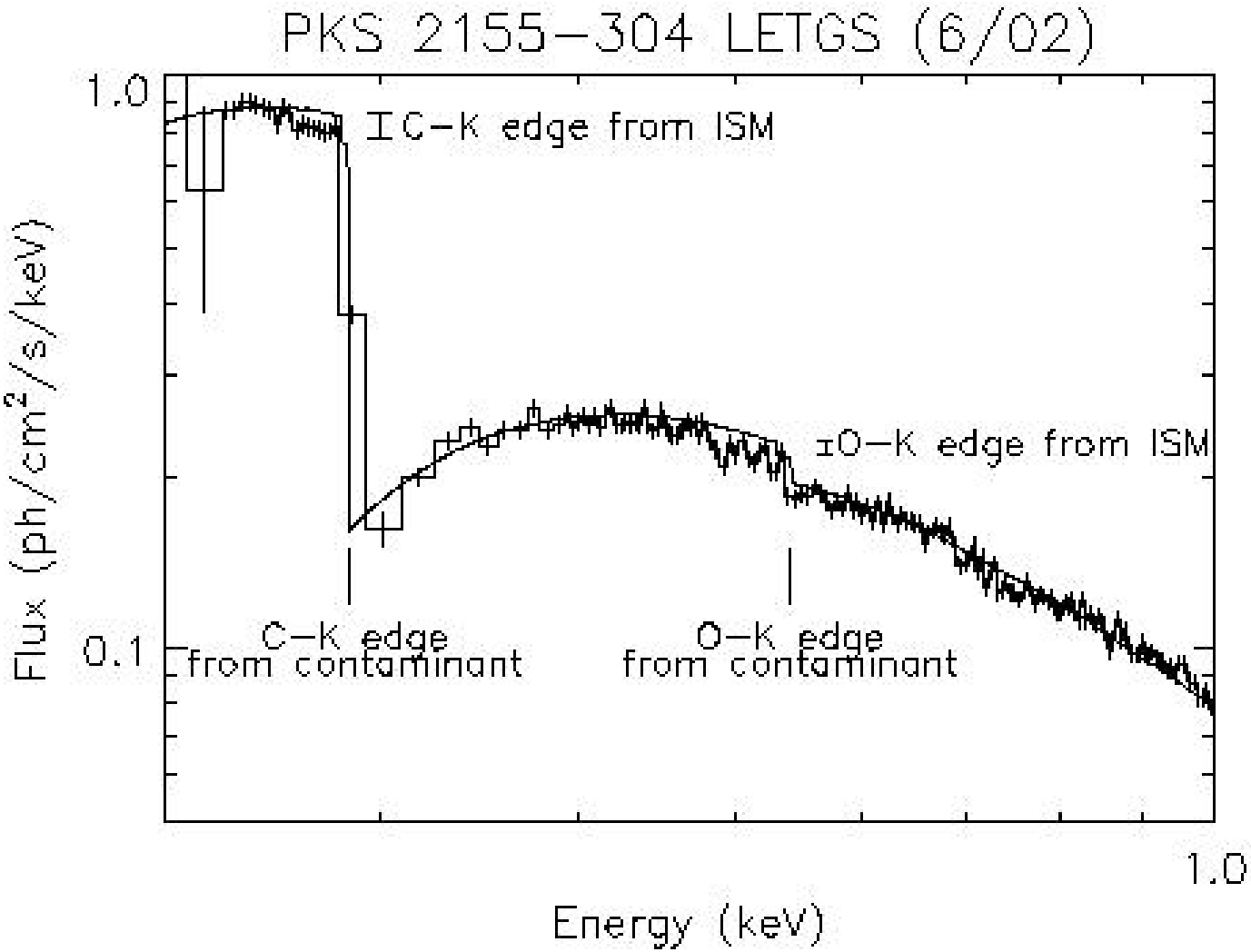
Tennant,

O'Dell (MSFC)

Functional

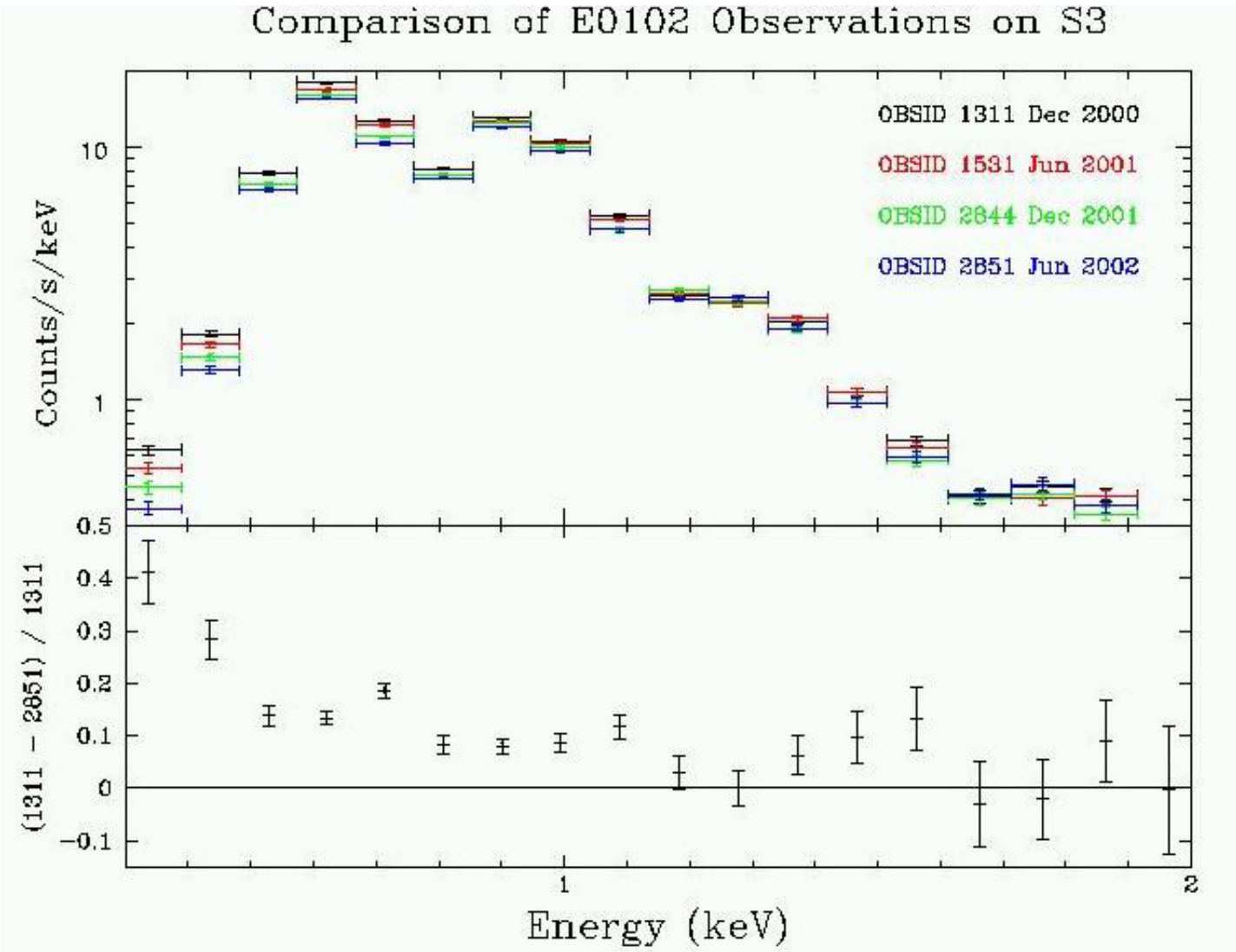
Form

LETG/ACIS Characterization of the Edges



Marshall (MIT)

Spectra of 1E0102.2-7219 vs. Time on S3(BI CCD)



Evaluation of Current Calibration Products Using Celestial Sources

- **Must use celestial sources for evaluation below 1.5 keV because there are no strong lines below 1.5 keV in the external cal source**
- **Test the effective area correction by examining observations of the same source at different epochs**
- **Use S3 data to minimize impact of temporal changes in detector response**
- **Use a variety of sources:**
  - **G21.5-0.9 – galactic SNR with a heavily absorbed power-law spectrum**
  - **1E0102.2-7219 – SMC SNR with a soft line-dominated spectrum**
  - **PSR 0656+14 – nearby pulsar with soft continuum spectrum**

See Poster by Marcus Teter for other examples of pulsar spectral fits

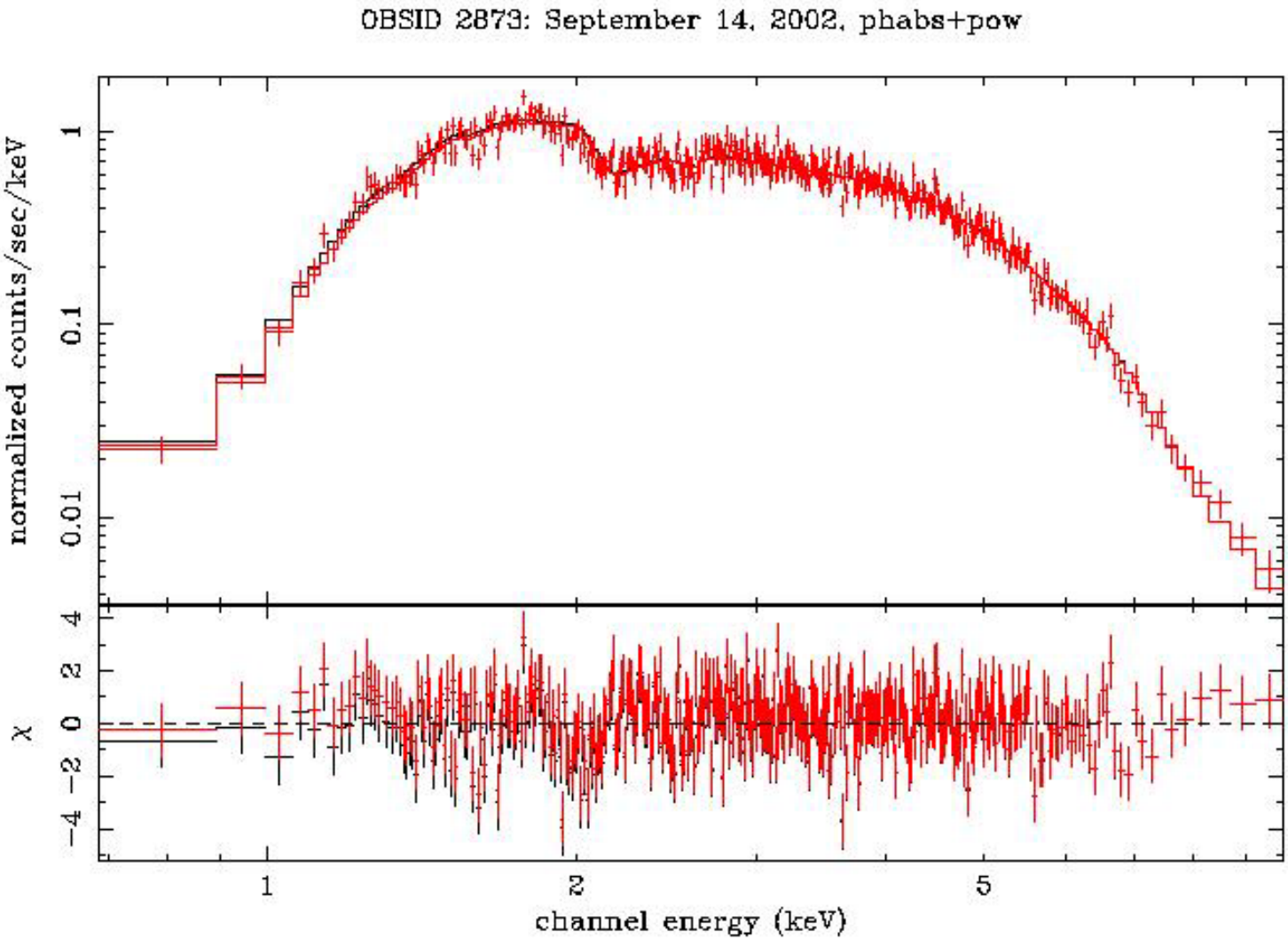
G21.5-0.9 with and without the Effective Area Correction

Black –

Default arf

Red –

corrected arf



G21.5-0.9 Spectral Fit Results with and without the Effective Area Correction

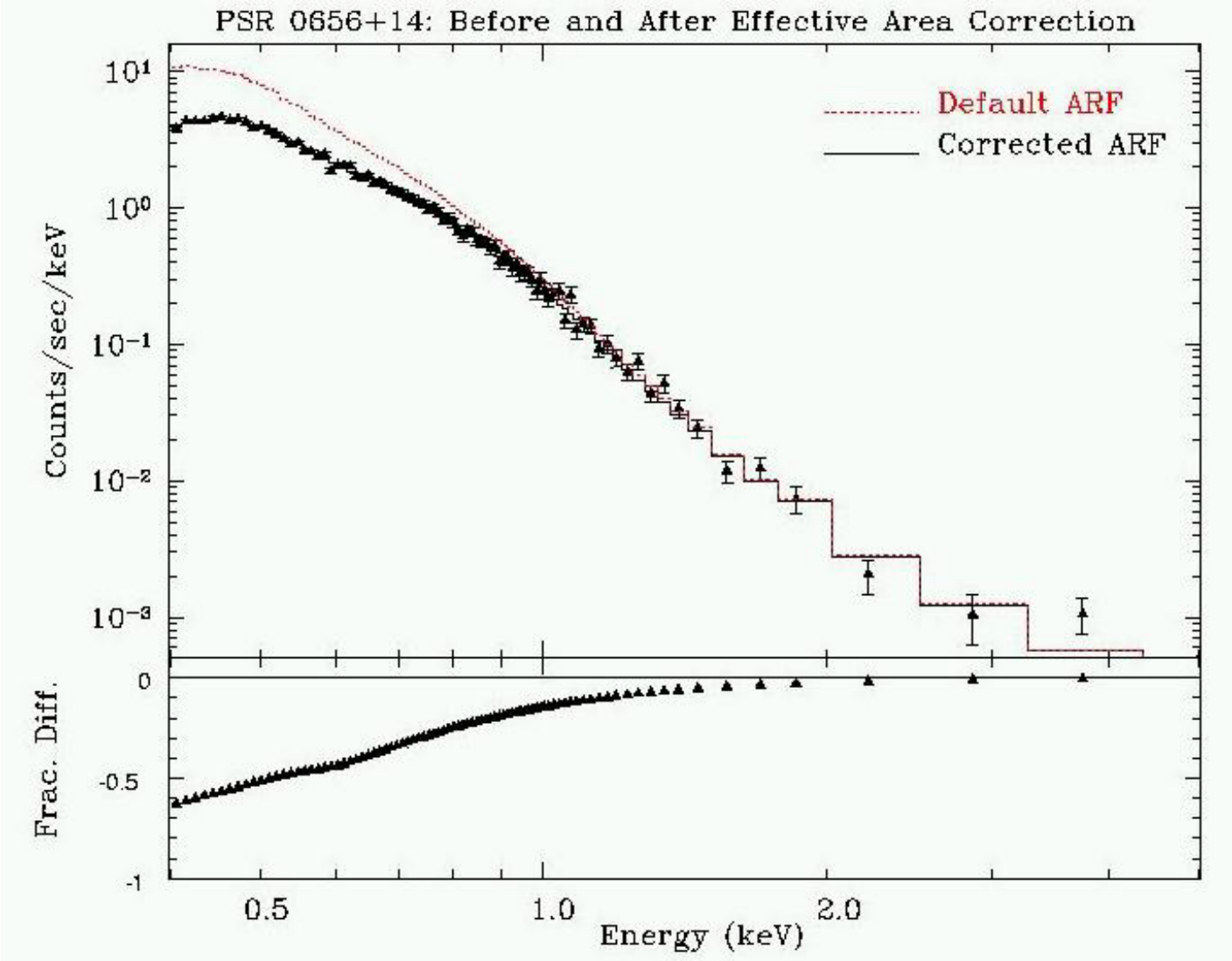
OBSID	DATE	E.A. Corr.	Frametime	NH(e22 cm^-2)	PL Index	Flux [0.5-9.0 keV] (e11 ergs/cm^2/s)
1711	2000-05-23	No	3.2s	2.25[2.18,2.32]	1.84[1.78,1.89]	5.33
1711	2000-05-23	Yes	3.2s	2.22[2.15,2.29]	1.83[1.78,1.89]	5.34
1553	2001-03-18	No	0.8s	2.28[2.22,2.34]	1.86[1.81,1.90]	5.55
1553	2001-03-18	Yes	0.8s	2.23[2.17,2.29]	1.83[1.81,1.90]	5.58
1554	2001-07-21	No	0.8s	2.23[2.18,2.30]	1.83[1.78,1.87]	5.54
1554	2001-07-21	Yes	0.8s	2.18[2.12,2.25]	1.83[1.77,1.87]	5.57
2873	2002-09-14	No	3.2s	2.21[2.15,2.27]	1.84[1.80,1.89]	5.27
2873	2002-09-14	Yes	3.2s	2.14[2.08,2.21]	1.84[1.79,1.88]	5.31

Model is a power-law with interstellar absorption.

Results are consistent within the 90% confidence limits.

Note the different frametime between OBSIDs 1711/2873 and 1553/1554.

PSR 0656+14: Soft Continuum Spectrum



PSR0656+14 Spectral Fit Results with and without the Effective Area Correction

E.A. Corr.	NH(e20 cm^-2)	Flux [0.24-3.0 keV] (e11 ergs/cm^2/s)
No	4.75[3.12,6.31]	0.70
Yes	0.50[0.00,0.63]	2.60

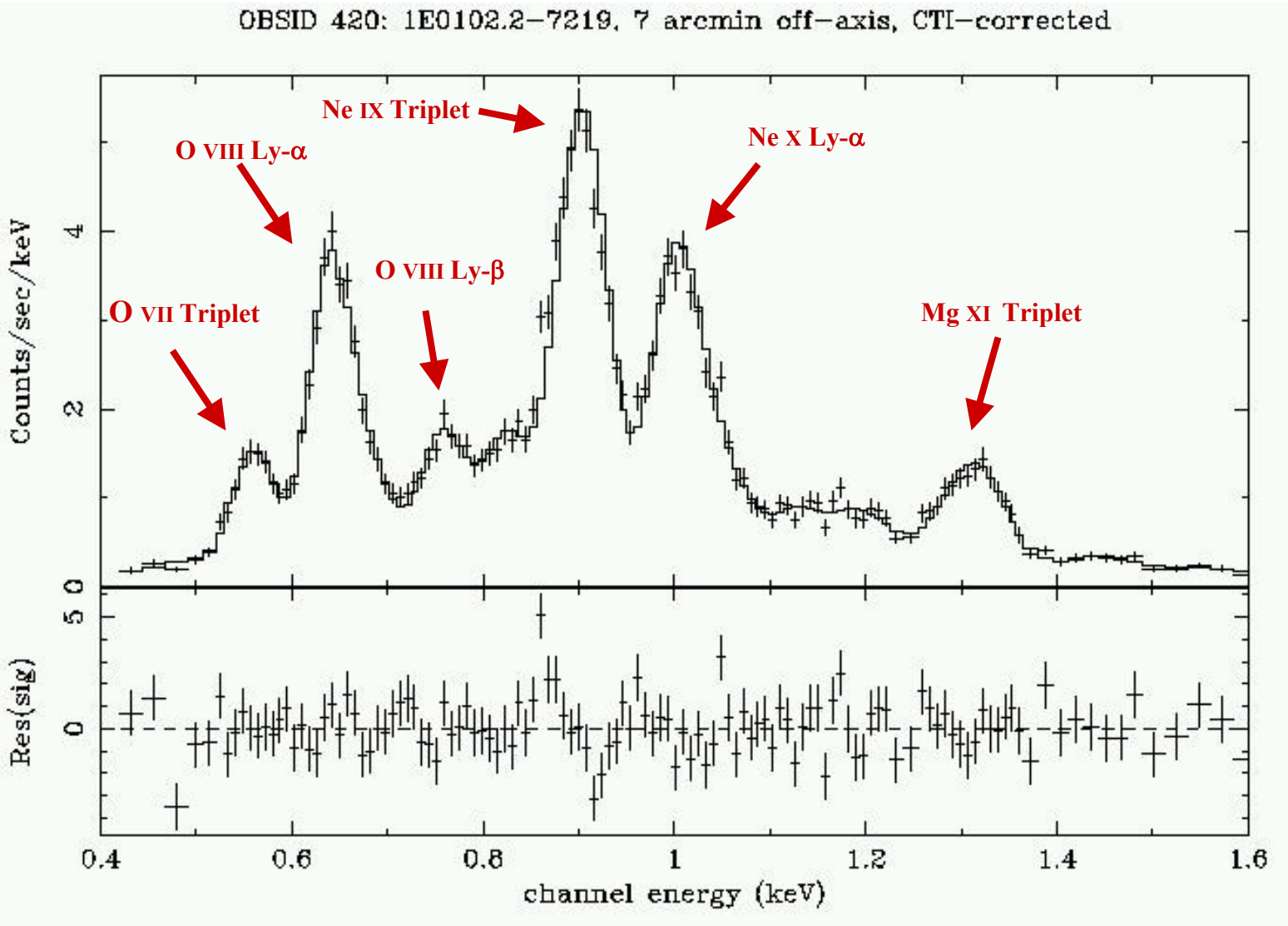
Model is two blackbodies, a power-law and interstellar absorption.

Temperatures of the BBs and PL index are consistent before and after the effective area correction.

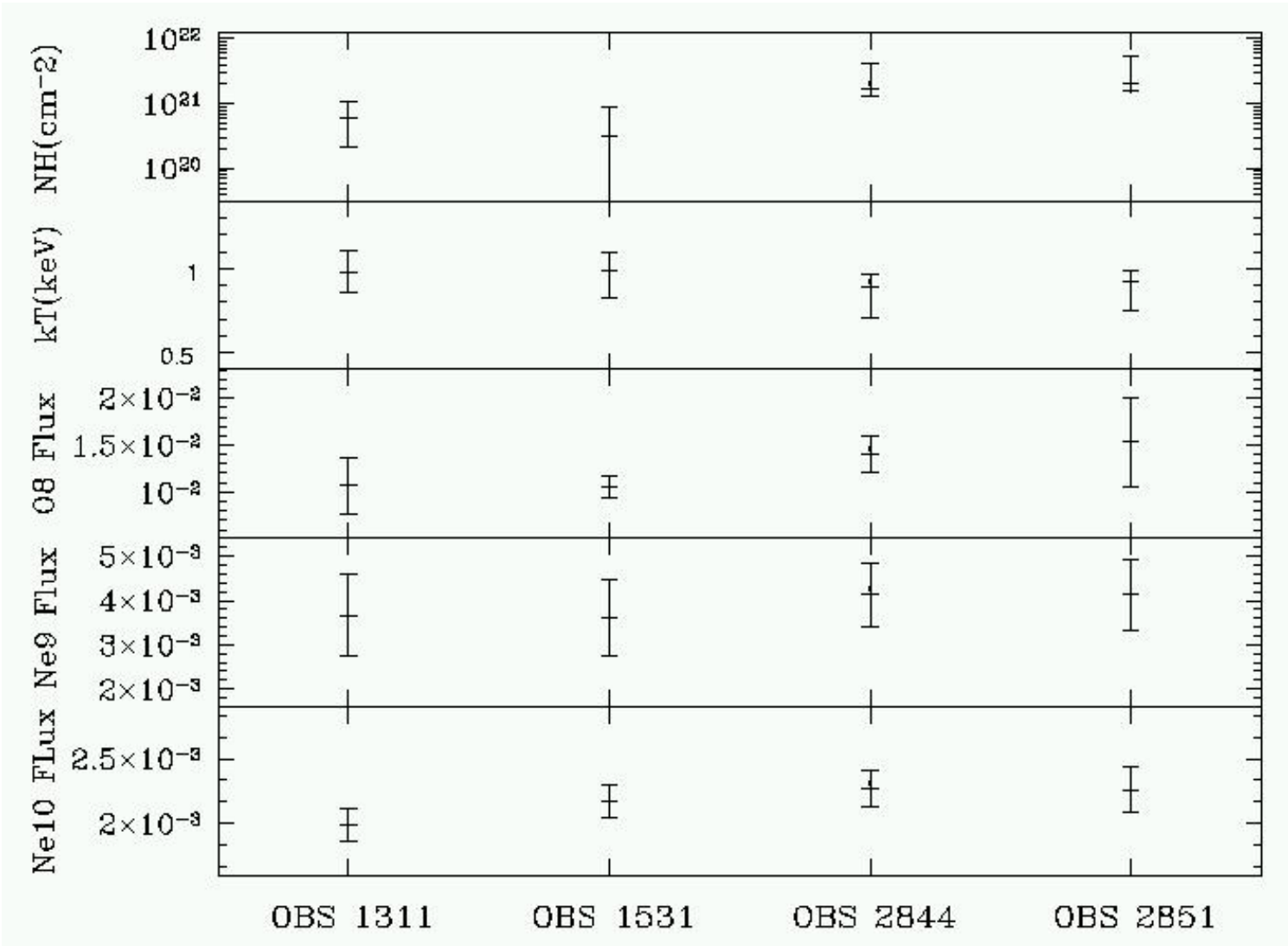
The NH and Flux are significantly different, flux by a factor 3.5.

Proprietary data compliments of Slava Zavlin (PI)

I3 Spectrum of 1E0102.2-7219: CTI Correction and Effective Area Correction



Comparison of Fitted Values for 1E0102.2-7219 on S3



Summary of Evaluation of Calibration Products

- **Application of the time-dependent effective area correction is crucial for accurate flux determination for sources with soft spectra**
- **Application of the time-dependent effective area correction results in less than a 2% difference in the fitted parameters for a heavily absorbed source like G21.5-0.9 over the course of the mission**
- **Consistent results from spectral fits are achieved after the application of the effective area correction and/or the CTI correction for the I3 and S3 CCD**
- **Need to investigate and characterize the temporal changes in the detector response in addition to the temporal changes of the filter transmission**
  (see talk and poster by Townsley)

We owe our gratitude to the thousands of engineers and technicians who built AXAF/Chandra !!!