ACIS Calibration Status
30 October 2001

- Response Matrix Products (FEF=FITS Encoded Function; RMF=Response Matrix File)
- Back-Illuminated (BI) chips
  - Released −120°C S3 FEFs August 2001
  - Status of −110°C S3 FEFs and S1 FEFs
- Non-CTI-corrected Front-Illuminated (FI) chips:
  - I3 prototype FEF in work; shaking out bugs in process
- CTI-corrected Front-Illuminated (FI) chips:
  - Depends on CTI corrector code. Expect progress 1Q 2002
- Background (Maxim Markevich)
- Cross-Calibration with XMM
  - Compare fits of E0102 and G21.5 SNR
- ACIS out-of-band response (Scott Wolk)

BI Response Matrix Products

S3 -120°C

- **Previous (version N0001) BI FEFs are modeled as up to 3 Gaussians at each energy (one each for main peak, escape peak, Si K fluorescence peak).**
- **New (version N0001) S3 FEFs for -120°C were released 7 Aug 2001 in CALDB 2.7.**
- **Other BI FEFs still in test. See figures below.**
- **Quantum Efficiencies (QEs) have not been changed with this release**
- **Fitted model spectra for soft, line-dominated sources may be impacted rather dramatically (see the supernova remnant E0102 results), but fits to such sources as clusters of galaxies do not appear to be significantly effected.**
- **Issues:**
  - **Gain continues to change with time, as expected.**
  - **Will need to issue gain-tweaked FEF products from time to time**

ACIS RMF Generation *Dramatis Personae*
6 September 2001

- MIT PI team: Mark Bautz, Gregory Prigozhin, Catherine Grant, Bev LaMarr, Peter Ford, Steve Kissel
- PSU PI team: Leisa Townsley, Pat Broos, John Nousek, Gordon Garmire, George Chartas, Eugene Moskalenko, George Pavlov
- CXC/MIT: Norbert Schulz, Sarah-Anne Taylor, Kevin Tibbetts, Mike Wise, Glenn Allen
- CXC/SAO: Steven Buczkowski, Dick Edgar, Mike Raley, Paul Plucinsky, Dan Schwartz, Eli Beckerman, Dale Graessle
- apologies to anyone I've left out...

ACIS RMF Generation & CTI Correction: Further Reading

CXC/Cal/ACIS page:

http://asc.harvard.edu/cal/Links/Acis/acis/WWWacis_cal.html

Select "ACIS Response Matrices"

ACIS RMF Generation Procedure

30 October 2001

1. $\sim 10^8$ model events were run with Gregory Prigozhin's MIT CCD simulator at 57 energies.
2. If for FI chip with CTI correction, run CTI corrector.
3. These were sorted into 32×32 pixel "tiles", and histograms were made. (For FI chips, 32×128 pixel "tiles" are used)
4. The resulting $O(10^5)$ pulse height distributions were fit to a model consisting of up to 10 Gaussians.
5. A sample fit for the central region of S3c1, energy=650.787 eV is shown.
6. FITS Encoded Function (FEF) files are prepared, containing the parameters of the fit functions.
7. Gains (all Gaussian centroids & mean PHA) adjusted to match released FEFs.
8. The on board calibration source data (containing lines Al K–α 1.486 keV, Ti K–α 4.50 keV, Mn K–α 5.90 keV, and a few weaker lines) were fit using the resulting RMFs. Gain corrections for each tile were obtained and fed back into the FEFs.
9. Compare to astrophysical sources (E0102, Cas A, others).
10. Iterate until energy scale good to less than 0.3% at all fitted energies on all tiles.
11. For a second temperature, or another chip, start at step 7.

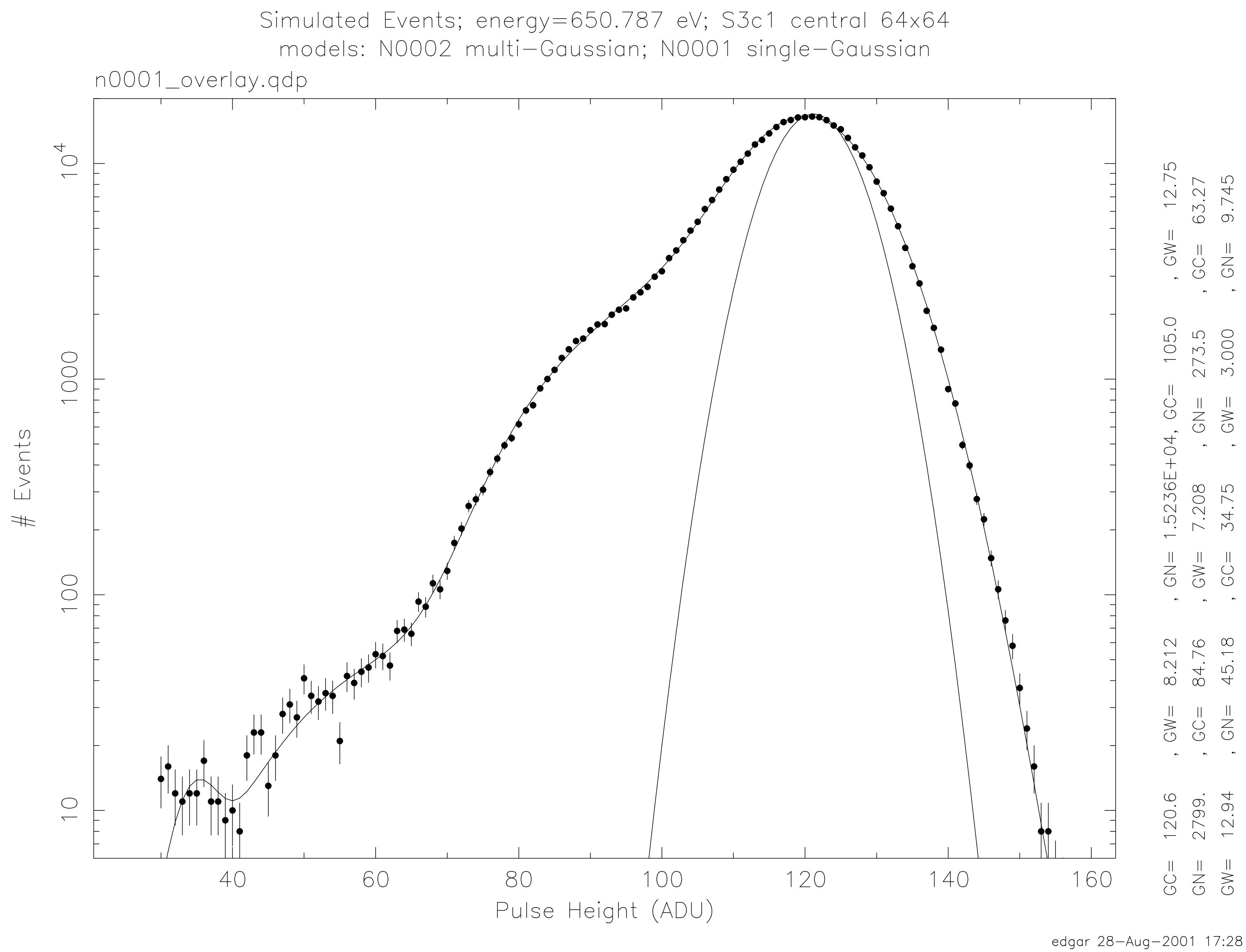


Figure 1: Fit to model PH distribution, central 64×64 pixel region, S3 quadrant 1, energy=650.787 eV. The narrow Gaussian is the N0001-released response at this energy.

- **Here follow some plots showing fits to the external calibration source using the new (N0002) S3 FEFs at -120°C.**

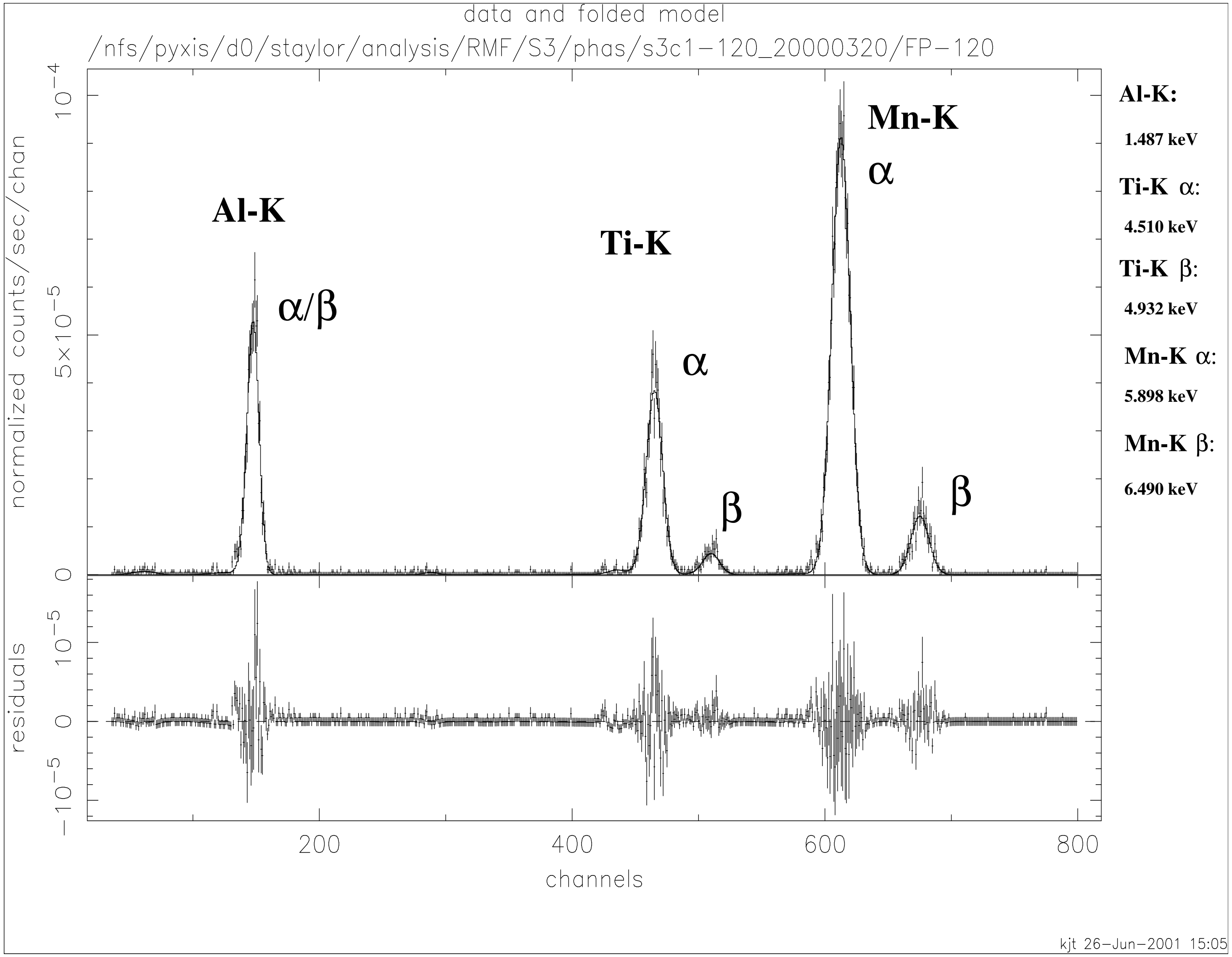


Figure 2: Spectrum of the External Cal Source

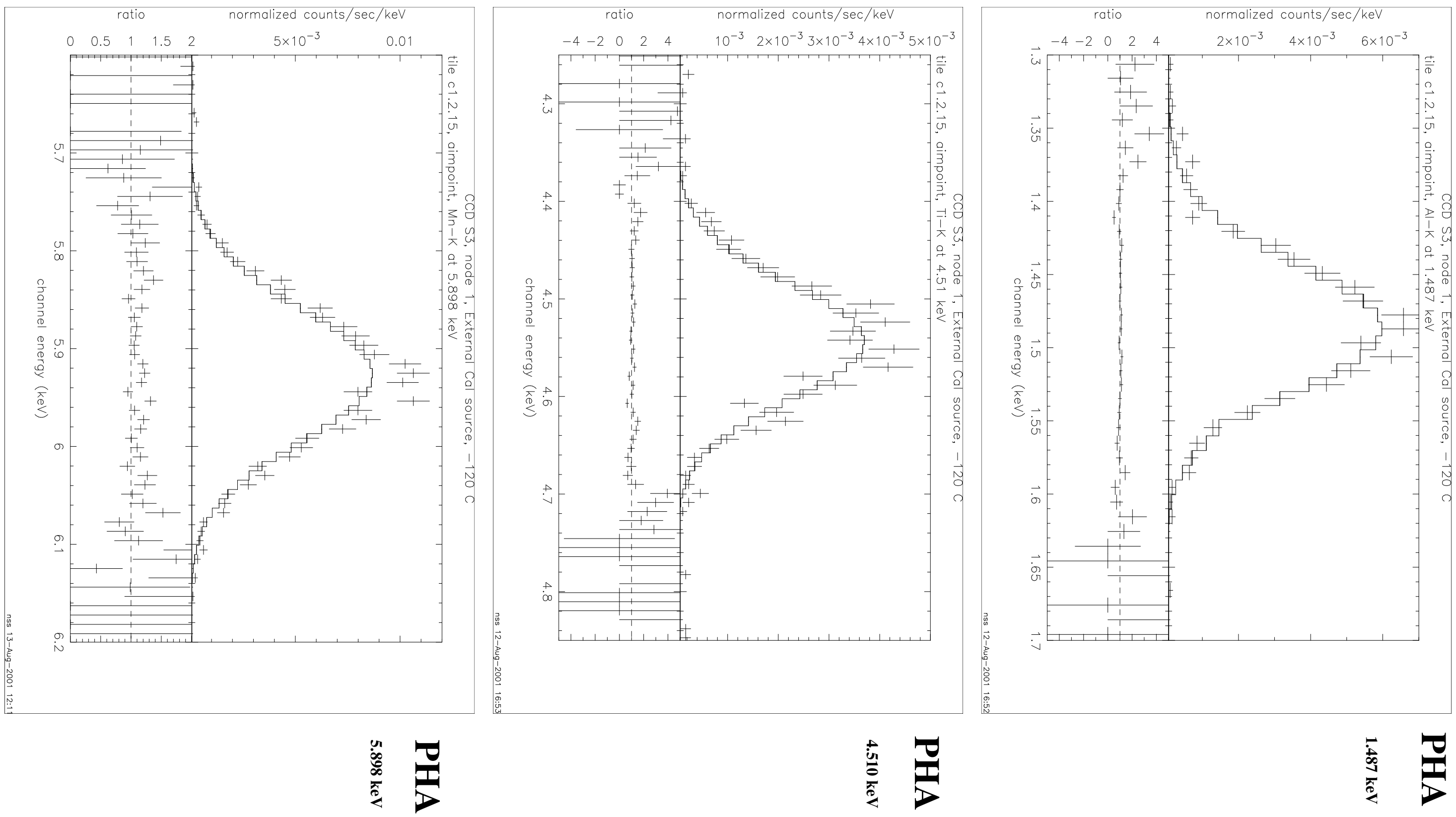
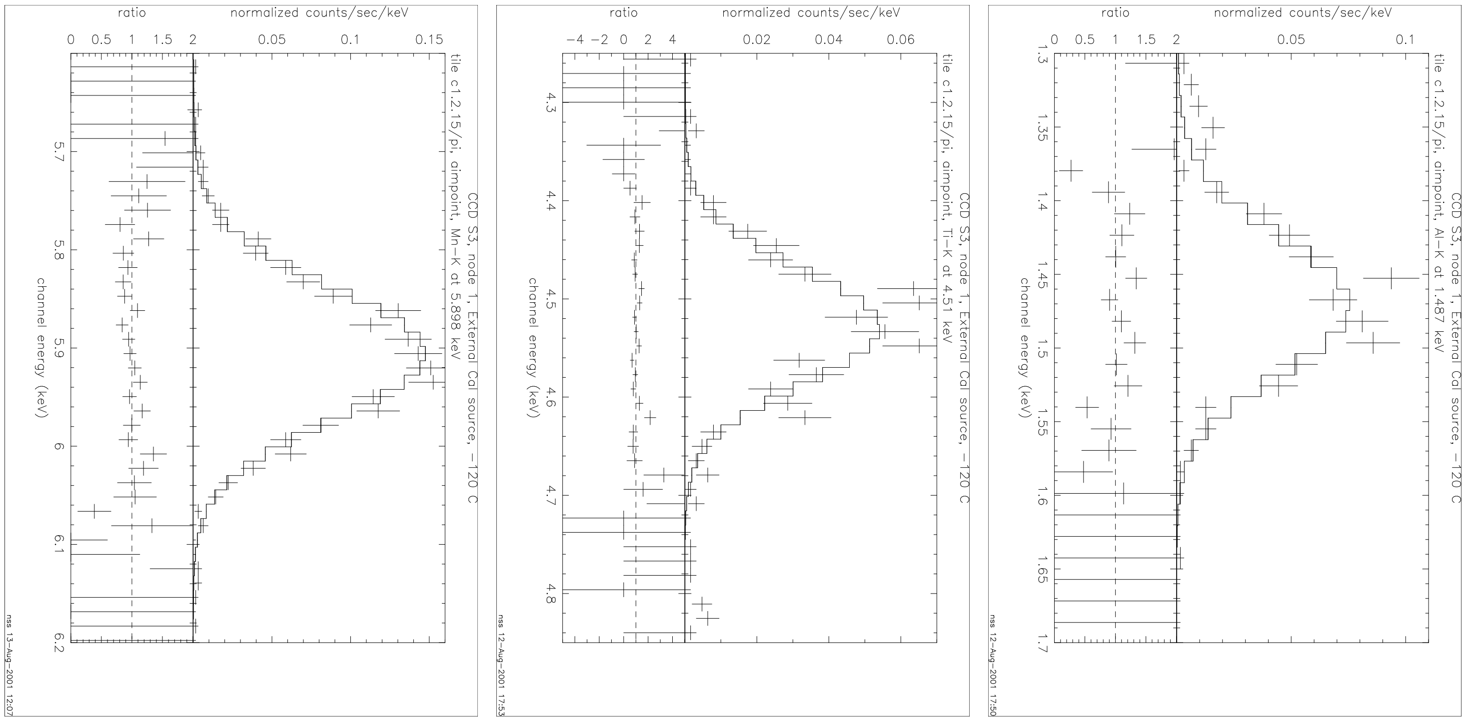


Figure 3: Fit to External Cal Source, S3 chip, N0002 FEF, PHA



PI: 5.898 keV

PI: 4.510 keV

PI: 1.487 keV

Figure 4: Fit to External Cal Source, S3 chip, N0002 FEF, PI

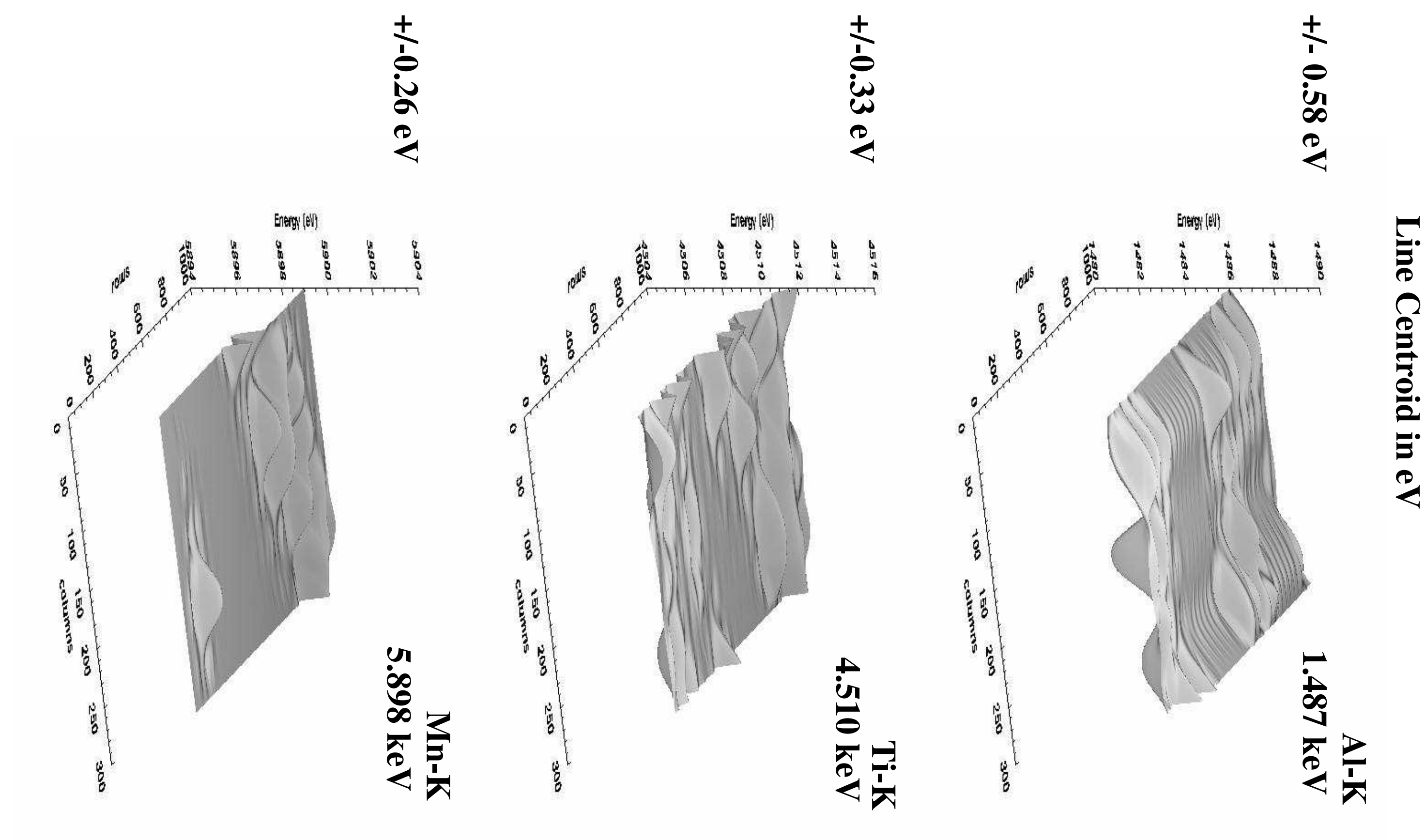


Figure 5: Variation of S3 fitted External Cal Source line centroids across a node

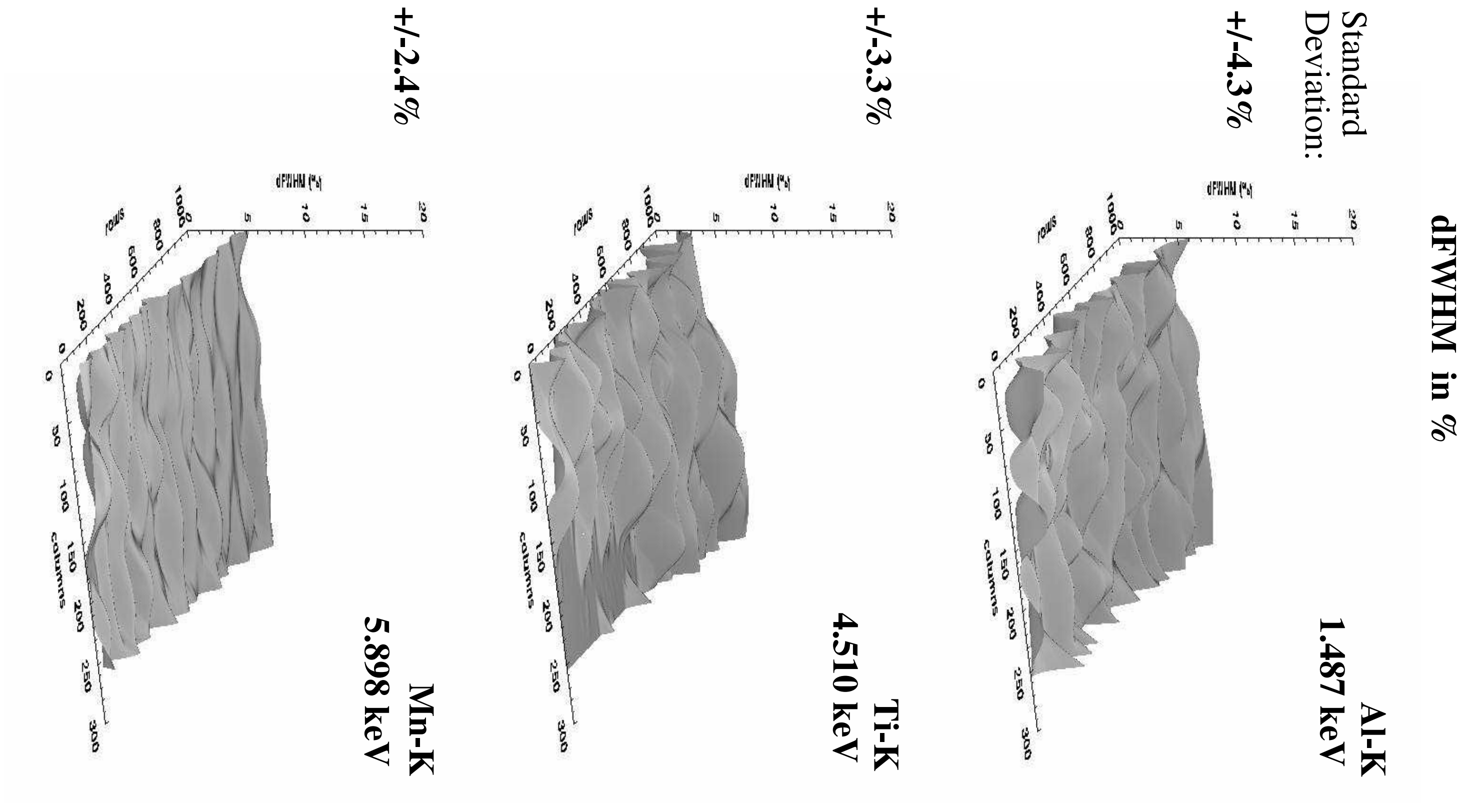


Figure 6: Variation of S3 External Cal Source fitted line widths

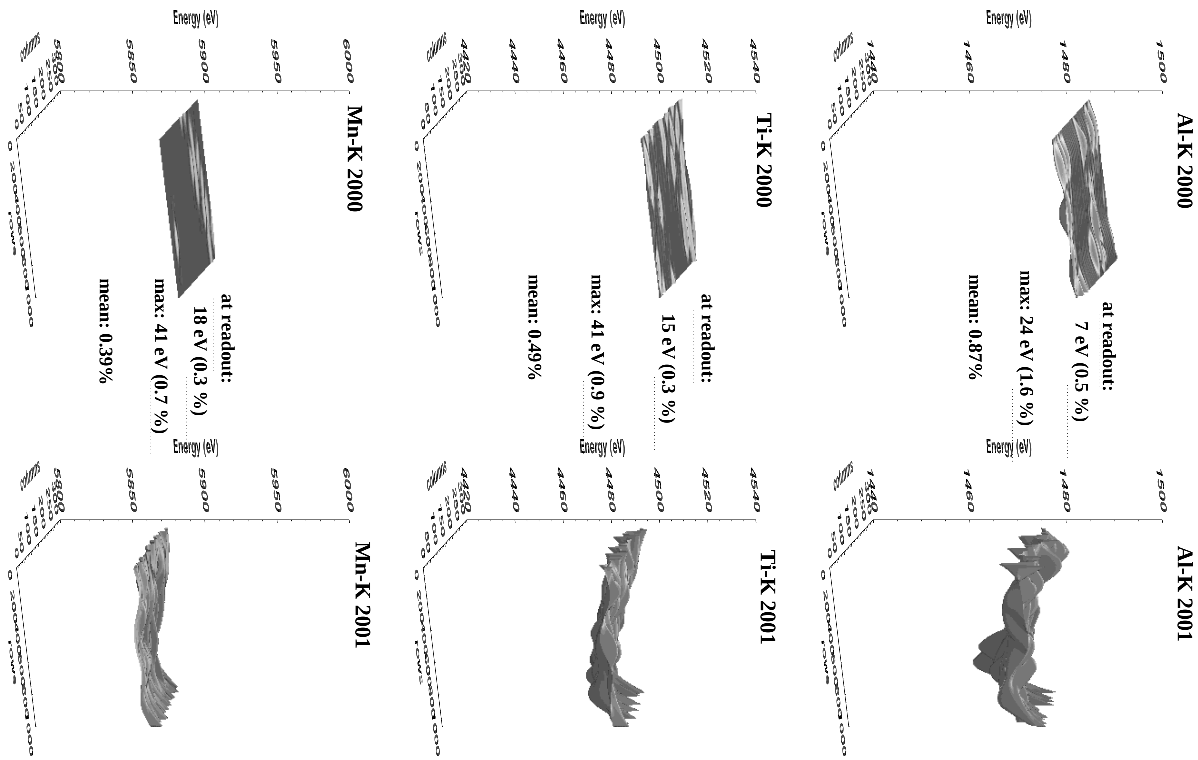


Figure 7: Comparison of spatial variation of S3c1 gain at two epochs

Astronomical Source Fits using New S3 FEFs
30 October 2001

- Here follow a few plots concerning fits to E0102 spectra.
- Residuals with new matrix are flat and consistent with zero down to c. 700 eV.
- Small gain problems persist below this energy.
- Line width and centroid problems are evident in comparison with N0001 FEFs.

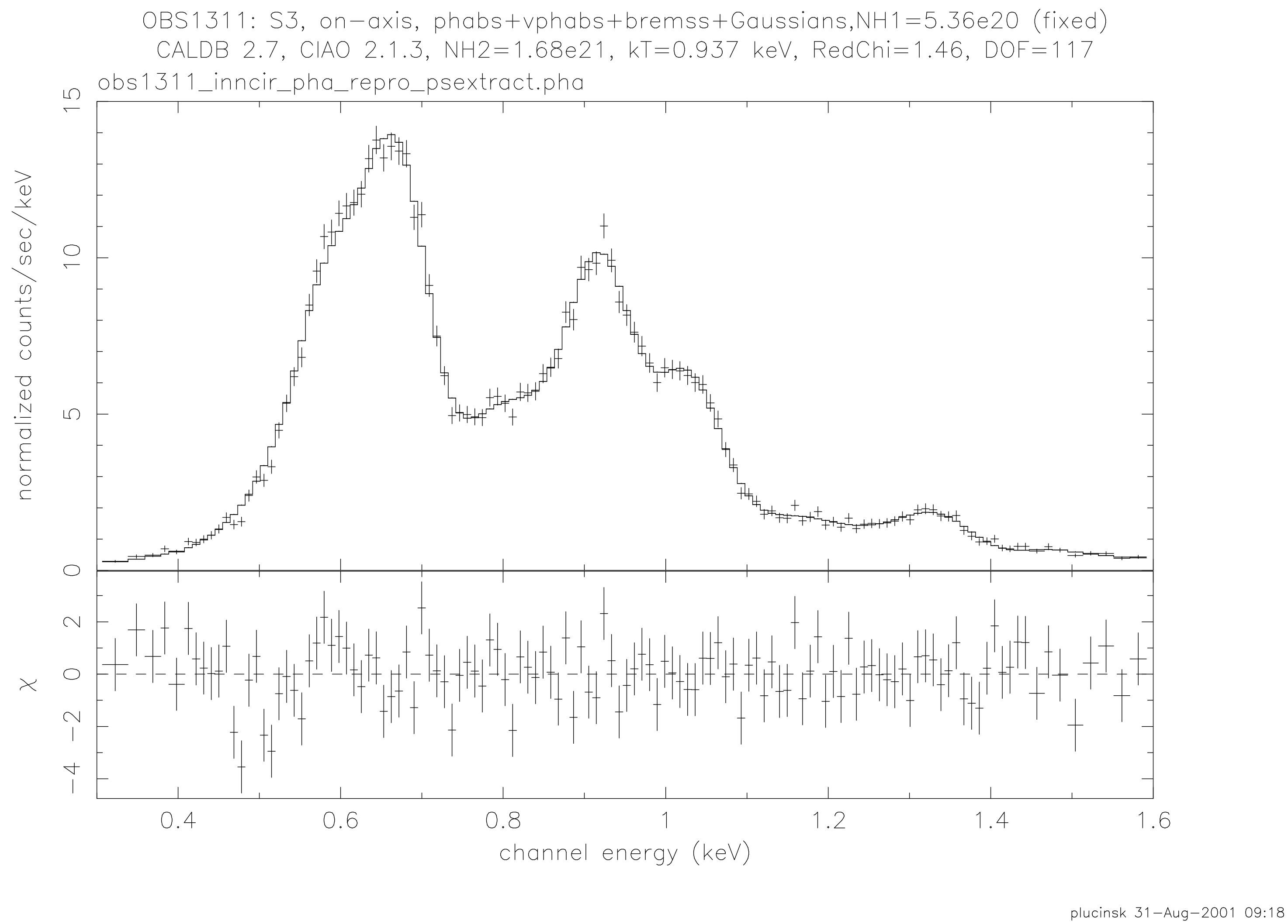


Figure 8: Best-fit E0102 PHA fit with N0002 (new) FEF

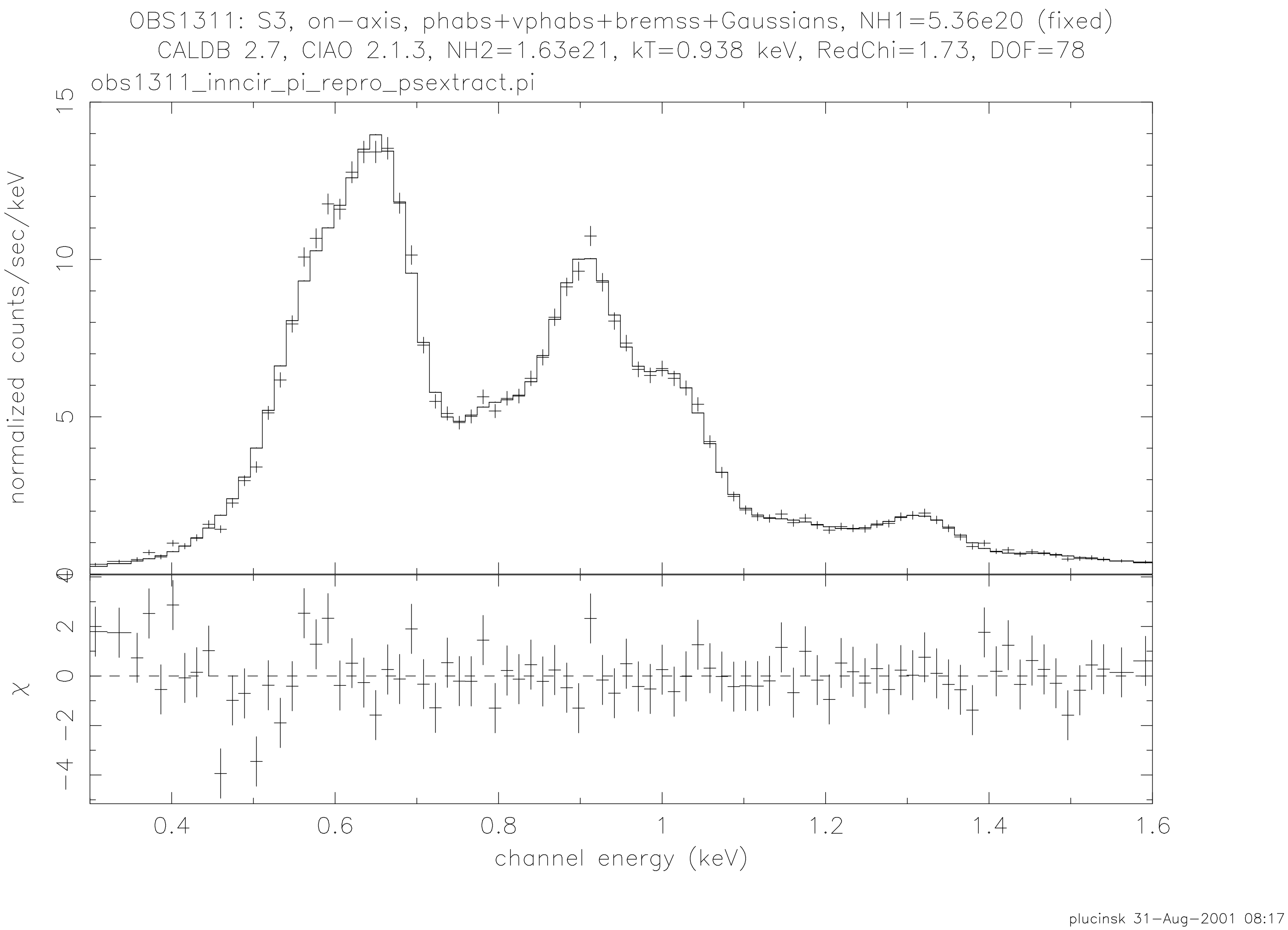


Figure 9: Best-fit E0102 PI fit with N0002 (new) FEF

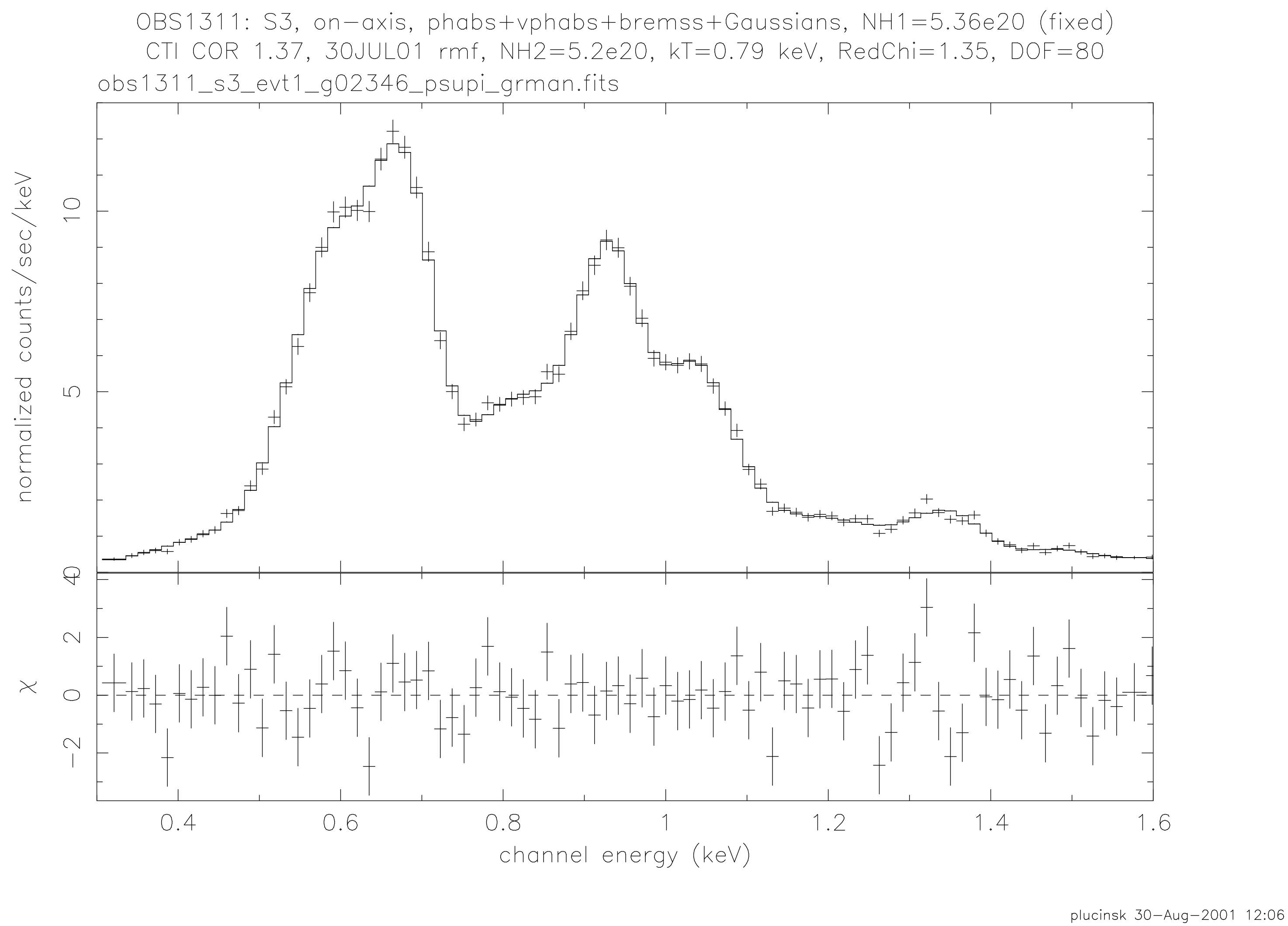


Figure 10: Best-fit E0102 fit with PSU CTI corrector and RMF

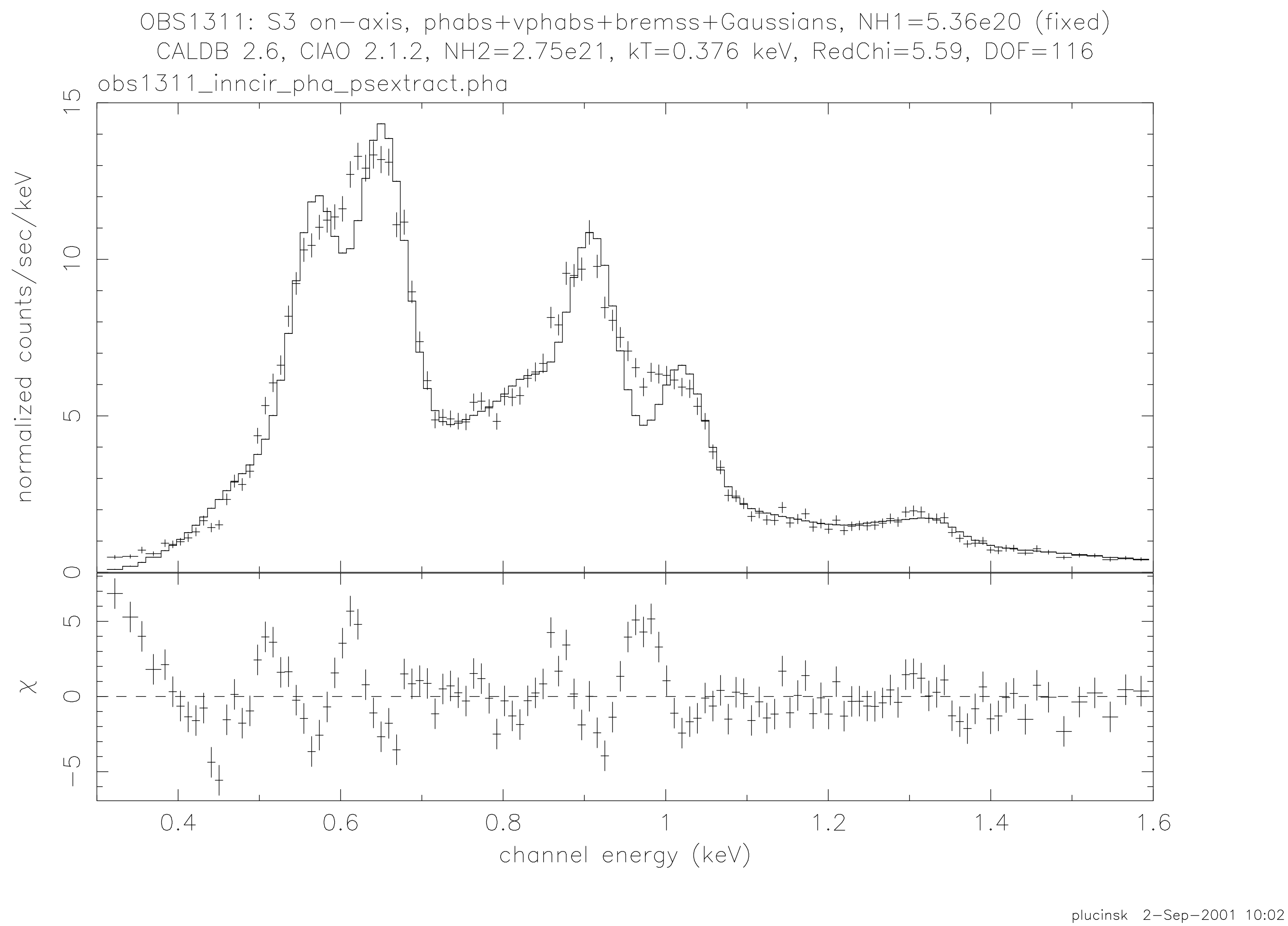


Figure 11: Best-fit E0102 PHA fit with N0001 FEF

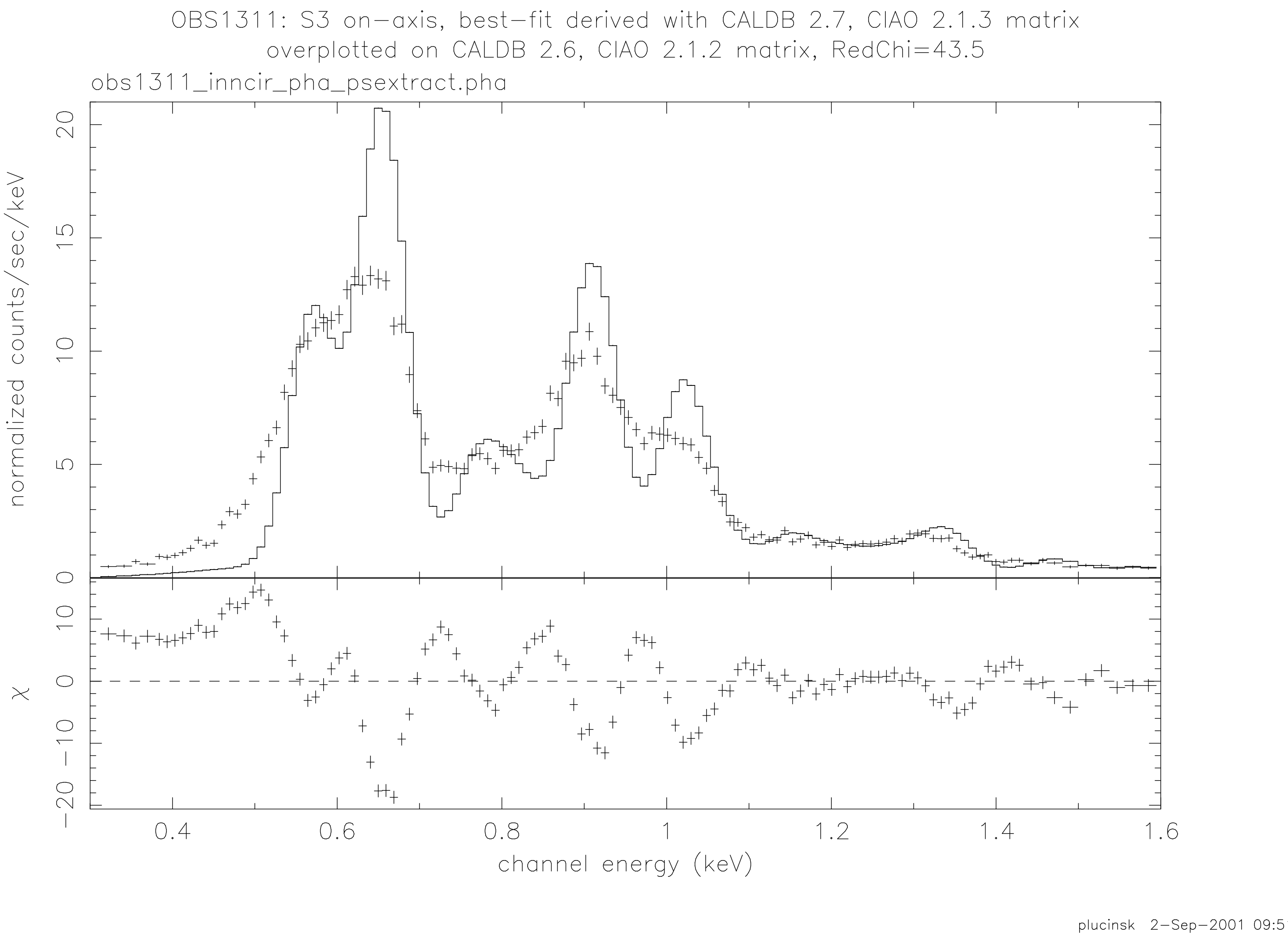


Figure 12: Over-plot of best-fit PHA E0102 new matrix model with old matrix

Astronomical Source Fits using New S3 FEFs
30 October 2001

- Here follow a few plots concerning fits to cluster of galaxies MS 2137.
- New and old matrices produce very similar results.

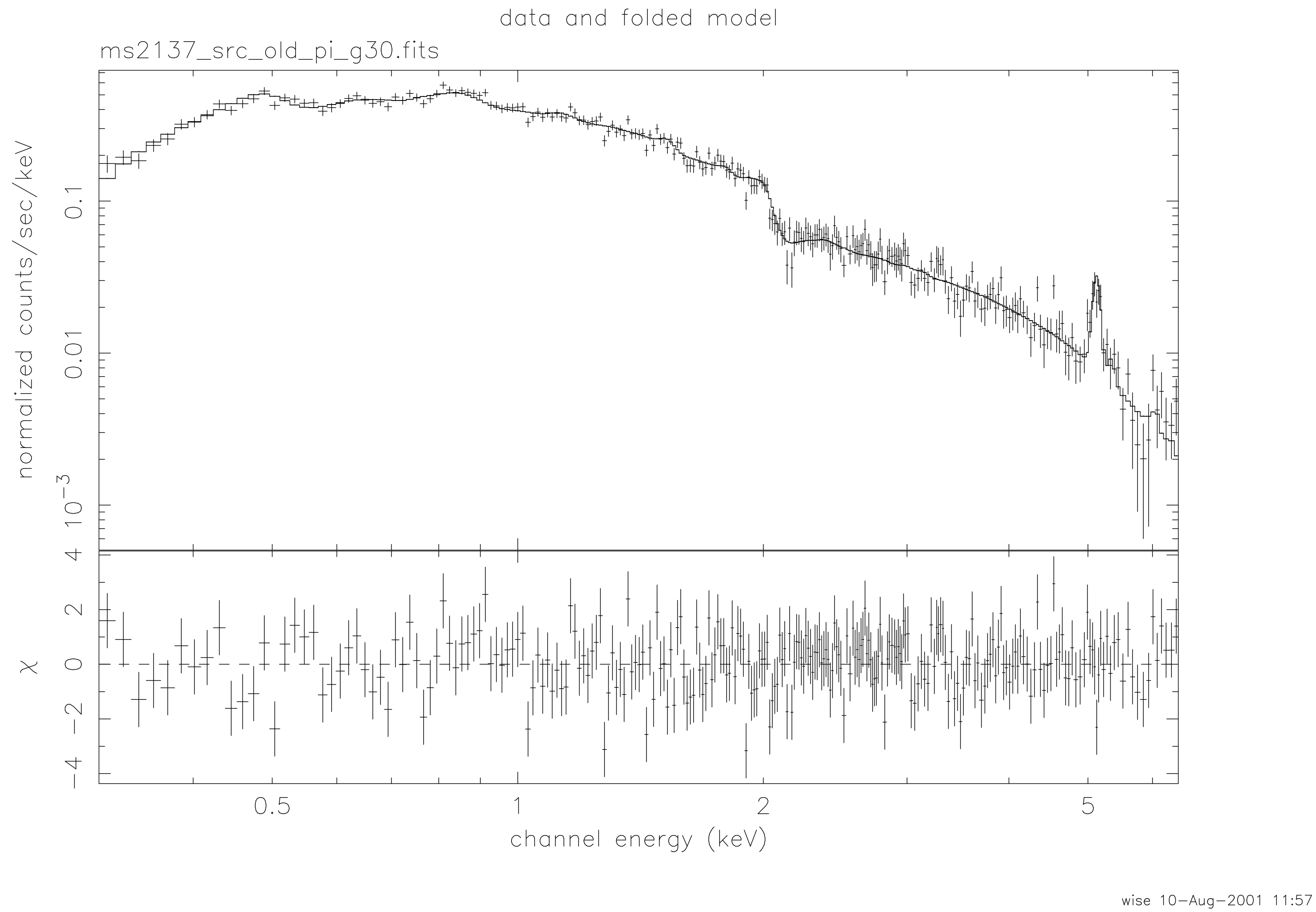


Figure 13: Best PI fit to cluster MS 2137 with old N0001 FEFs

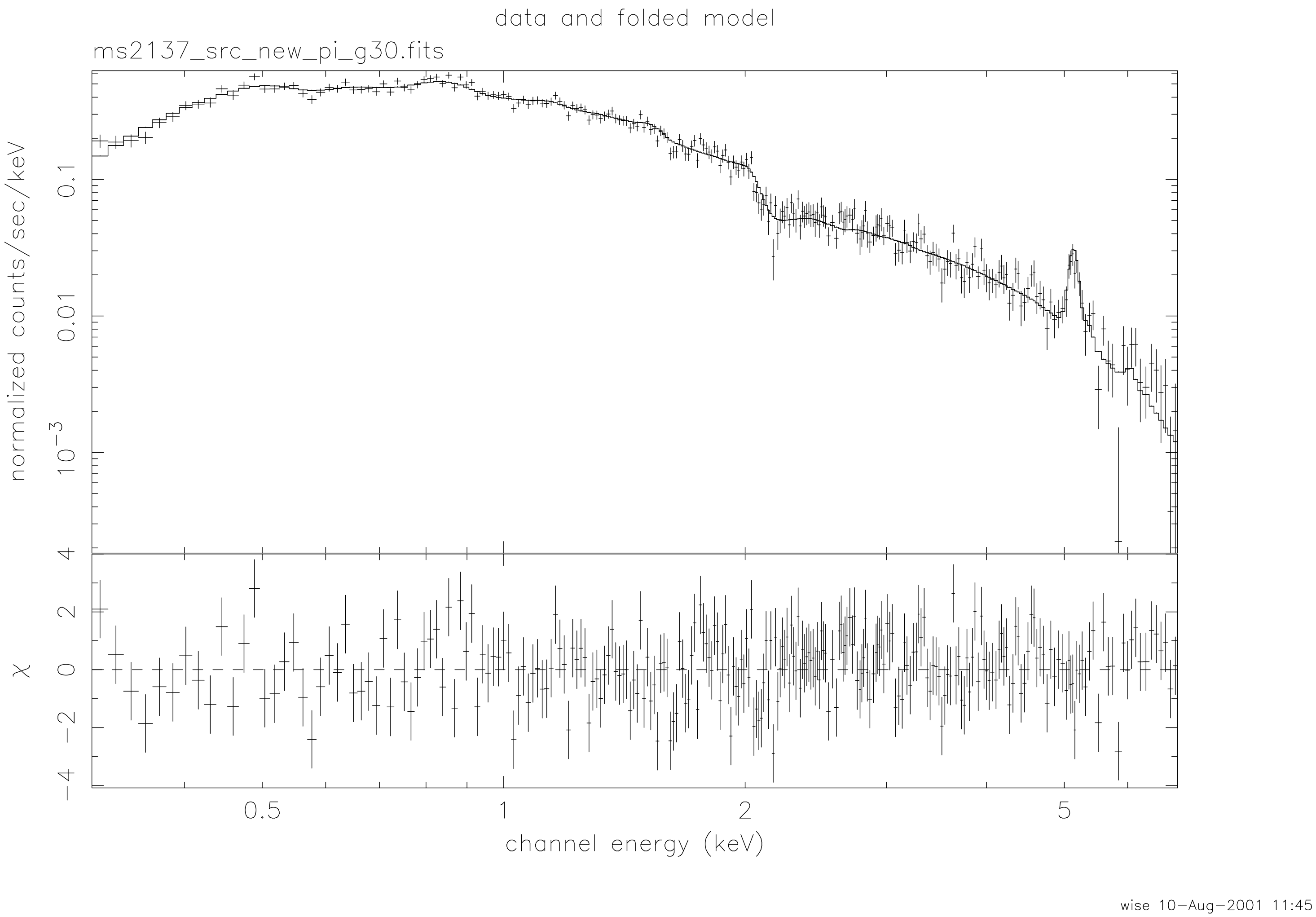


Figure 14: Best PI fit to cluster MS 2137 with new N0002 FEFs

Astrophysical Source Comparisons: G21.5

30 October 2001

- **Crab-like Galactic Supernova Remnant**
- **Bright continuum source, heavily absorbed**
- **Diffuse, so no pileup worries.**
- **Extracted spectrum of bright core, fit PI & PHA, new & old matrices.**
- **No significant differences**

FEF file	$N_H(10^{22}\mathrm{cm}^{-2})$	γ	ampl	χ^2_ν
acisD2000−01−29fef_phaN0001.fits	2.3910	1.4812	0.0020	0.575376
acisD2000−01−29fef_phaN0002.fits	2.5674	1.5445	0.0022	0.574181
acisD2000−01−29fef_piN0001.fits	2.4894	1.5166	0.0021	0.608428
acisD2000−01−29fef_piN0002.fits	2.5376	1.5345	0.0022	0.603198

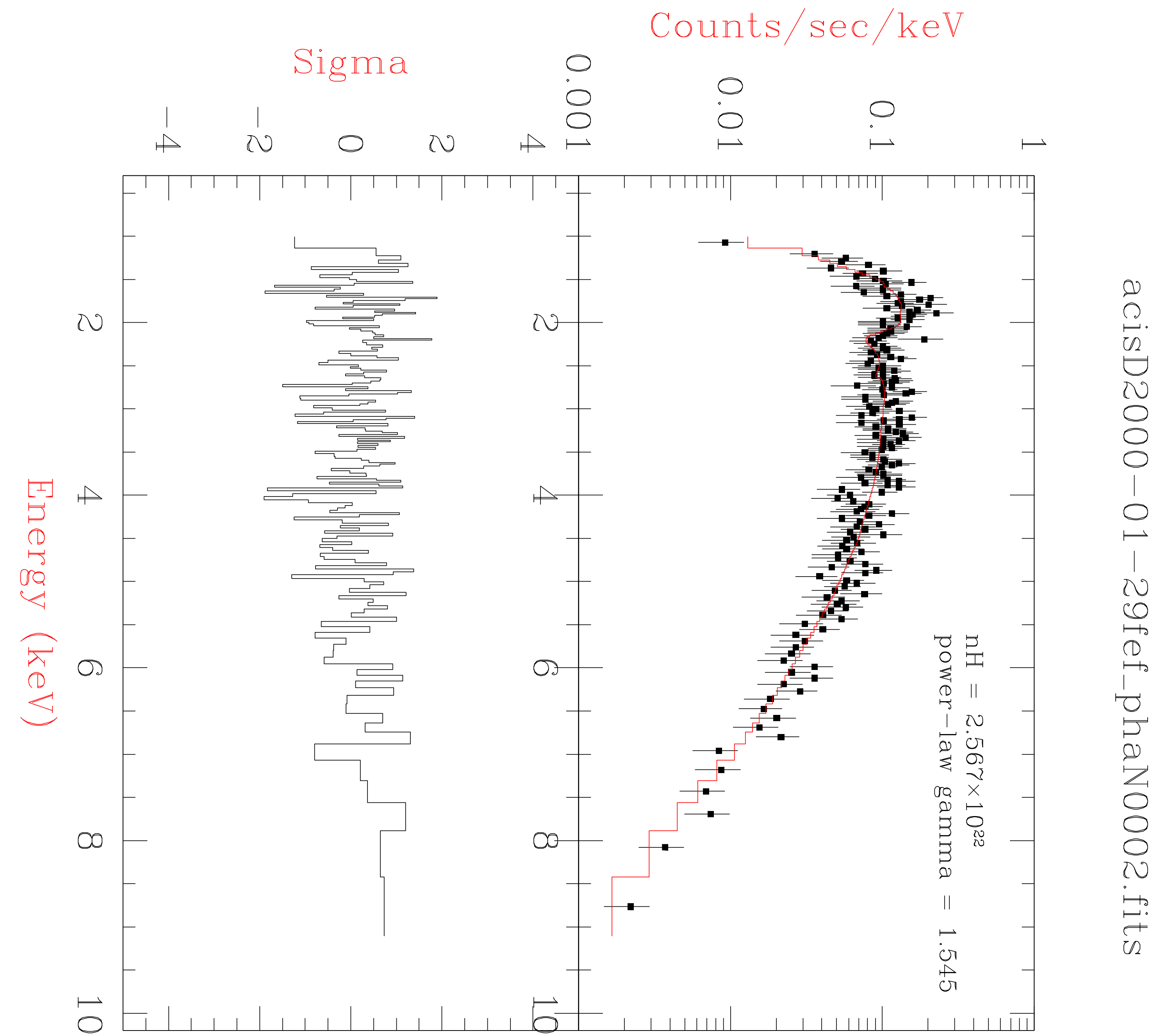


Figure 15: PHA Fit to G21.5 core using N0002 FEFs. PI and fits using N0001 FEFs are indistinguishable.

Status of other BI matrices

30 October 2001

- **S3** $-110°$**C:**
  - Lines are systematically narrower. We're looking at a test FEF with very narrow lines. Fits to this matrix will show how much we need to widen the lines for the production FEF.
  - Possible further problems with gain at low energies. At $-120°$C, the S3 chip gain seems to be about the same at 700 eV as at 1.49 keV.
- **S1 matrices:**
  - Lines systematically wider than S3
  - Gain more nonlinear at low energies
  - Using Claude's GTO HETG/ACIS-S observation of E0102
  - Also using many point-source grating spectra for calibration

FI FEF Development
30 October 2001

- **Non CTI-Corrected**
  - Using G. Prigozhin's pre-flight simulator, with addCti.pro CTI simulator from MIT.
  - Fitting process is converging, with a few bugs still to be addressed. Examples: large numbers of events have been a problem; fixed now (but not used yet). Many energies seem to want another component about 2σ below the main peak; this is a few percent effect.
  - Will release I3 FEF internally for testing within a week or two.
  - Other I-array chips and S2 will follow in a few weeks after that, if all goes well.
  - Testing against on-board cal source data, and E0102 pointings on each chip will be conducted.
- **CTI-Corrected**
  - Awaiting completion and testing of CXC CTI corrector software (part of acis_process_events).
  - Will process simulated (CTI degraded) events through the same CTI corrector to be released to the users, and fit PH distributions as before. Look for progress 1st quarter, 2002.

- XMM-Chandra cross calibration using SNR G21.5
- Discrepancy of 10–15% in normalizations for G21.5 seems to be real.
- Sense of the disagreement is that Chandra gets larger norm factors.
- Appears to be achromatic in the 1–10 keV band.
- Under investigation in collaboration with XMM (Snowden, Lumb)
- Similar comparisons with E0102 are somewhat closer.
- Gain, response file problems are evident.

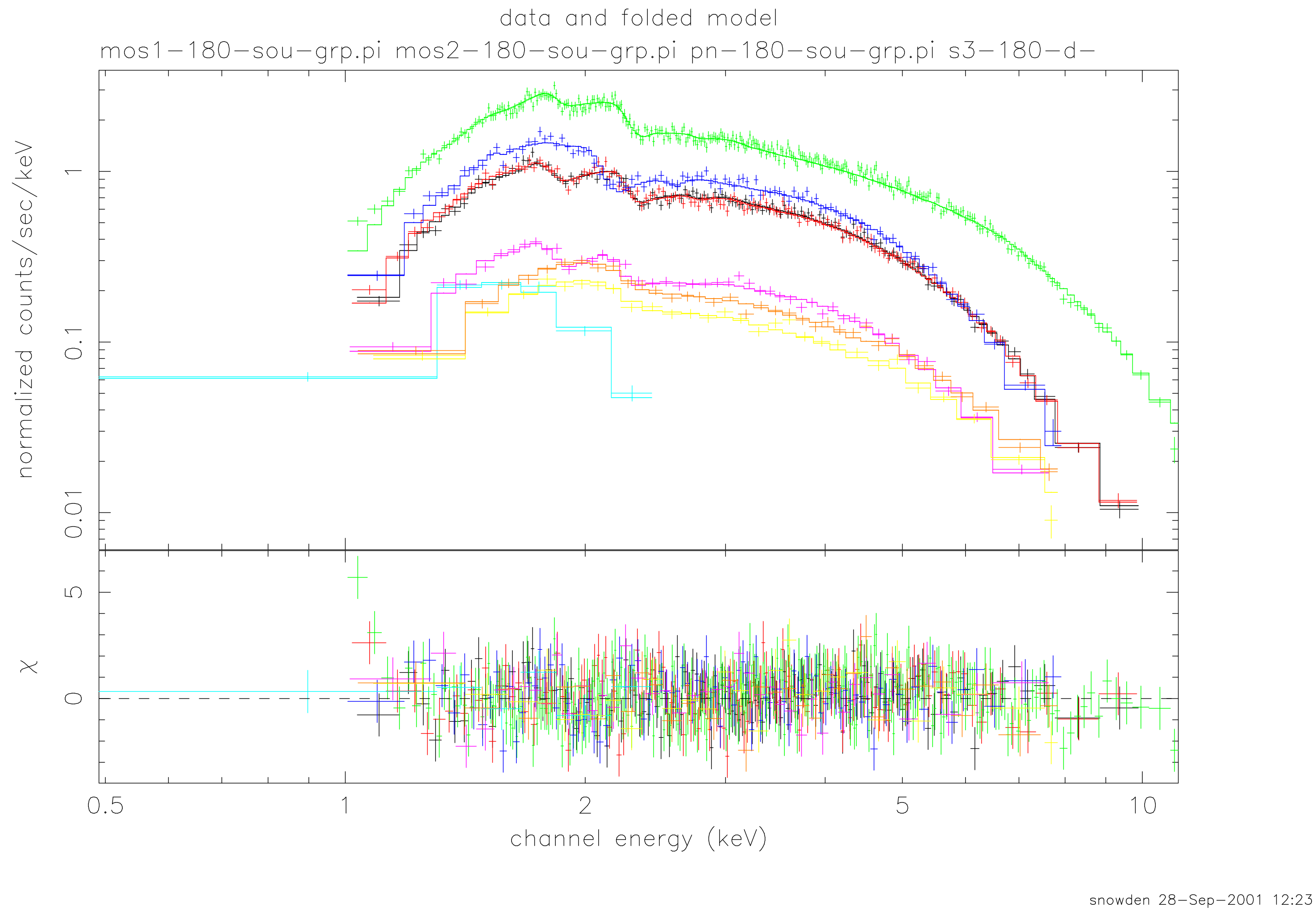


Figure 16: Fits to G21.5 with multiple instruments

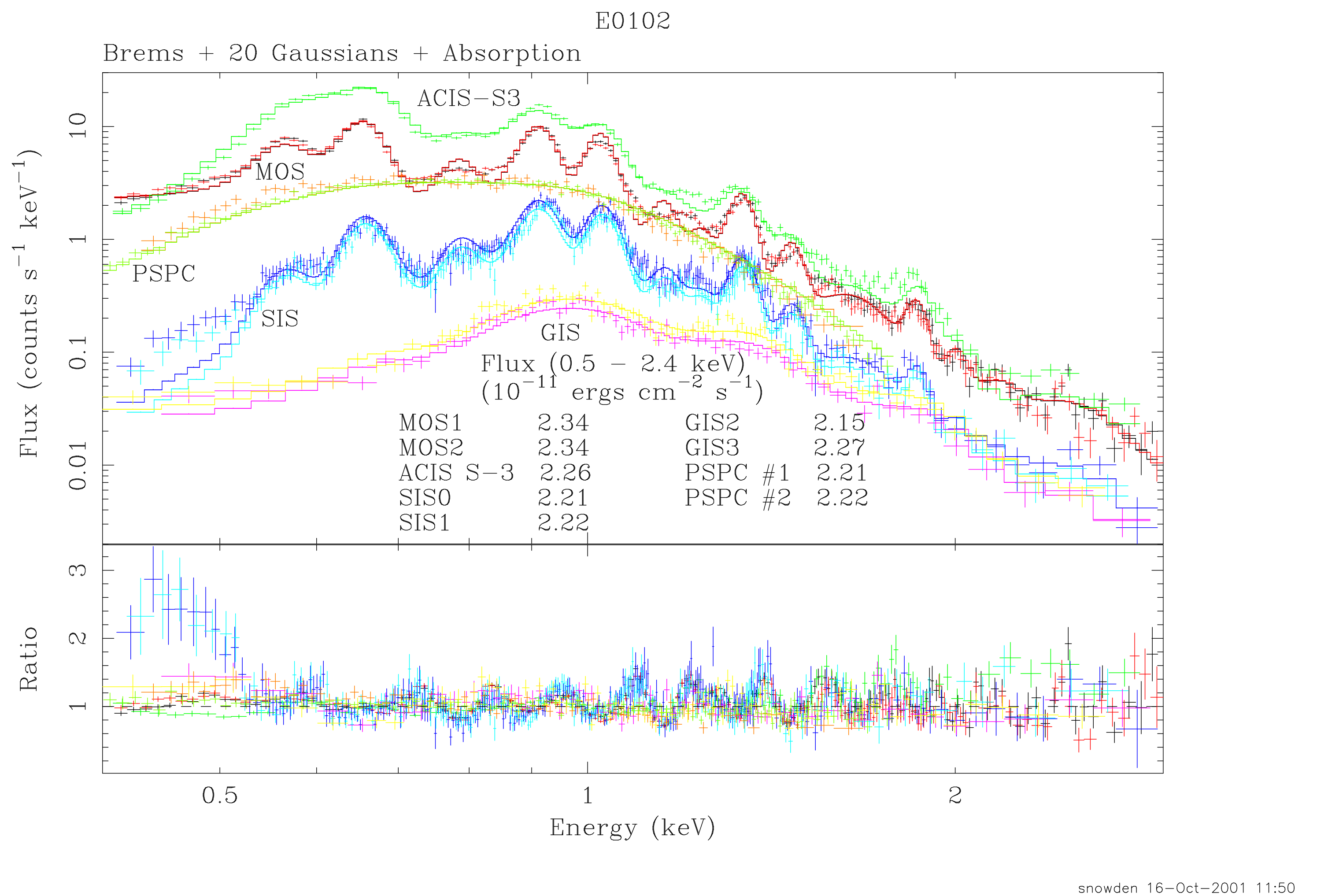


Figure 17: Fits to E0102 with multiple instruments