# Chandra Instruments and Calibration

The pages below are maintained by the Chandra X-ray Center Calibration group and contain information on the calibration of Chandra instruments. Any data products provided are to be used by observers at their own risk.

A summary of Chandra Instruments and Calibration Status can be found in the Proposers' Observatory Guide

**For officially released data products for use in CIAO analysis software, refer to the Chandra Calibration Database (CALDB) Webpage.**



*COMMENTS:*
*CXC Cal*

Last modified:11/02/01

# CALIBRATION STATUS REPORT (CALDB 2.7)

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# 1.0 ACIS ARDs

## 1.1 GRADE

Description: The mapping from flight grades to ASCA grades
Most recent version in CALDB: acisD1996-11-01gradeN0001.fits
File Creation Date: 3/4/99
Known Errors: None
Status: Complete

## 1.2 BAD PIXELS

### 1.2.1 BADPIX at T=-120 C

Description: Detector bad pixel list
Most recent version in CALDB: acisD2000-01-29badpixN0001.fits
File Creation Date: 9/28/00
Known Errors: None
Status: Complete

### 1.2.2 BADPIX at T=-110 C

Description: Detector bad pixel list
Most recent version in CALDB: acisD1999-09-16badpixN0002.fits
File Creation Date: 6/24/00
Known Errors: None
Status: Complete

### 1.2.3 BADPIX at T=-100 C

Description: Detector bad pixel list
Most recent version in CALDB: acisD1999-08-13badpixN0003.fits
File Creation Date: 6/24/00
Known Errors: None
Status: Complete

### 1.2.4 BADPIX at T=-90 C

Description: Detector bad pixel list
Most recent version in CALDB: acisD1999-07-22badpixN0005.fits
File Creation Date: 6/24/00
Known Errors: None
Status: Complete

## 1.3 EVTSPLT

Description: Event thresholds and split thresholds
Most recent version in CALDB: acisD1996-11-01evtspltN0001.fits
File Creation Date: 3/3/99
Known Errors: None
Status: Complete

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## 1.4 GTI_LIM

Description: screening parameters for Good Time Intervals
Most recent version in CALDB: acisD1999-07-22gtilimN0003.fits
File Creation Date: 5/22/01
Known Errors: None
Status: Complete

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## 1.5 DETECTOR GAIN

### 1.5.1 DET_GAIN at T = -120C

Description: Detector Gain Table
Most recent version in CALDB: acisD2000-01-29gainN0003.fits
File Creation Date: 07/27/01
Known Errors: There are no known problems with the ACIS-S3
gain in this file. The gains for the other chips
are based on the assumption of a linear gain.
This produces offsets of approximately 20eV
between the mean pulse heights and true energies
for photon energies between about 0.4 and 1.0 keV,
and larger errors at lower energies.
Status: Update expected Nov 2001 for S1 chip
Feb 2002 for the FI chips
Contact: Norbert Schultz and Dick Edgar
More Information: CAL projects.

### 1.5.2 DET_GAIN at T = -110C

Description: Detector Gain Table
Most recent version in CALDB: acisD1999-09-16gainN0005.fits
File Creation Date: 12/15/00
Known Errors: Low energy gain (see 1.5.1)
Status: Update expected Nov 2001 for BI chips
Feb 2002 for FI chips
Contact: Norbert Schultz and Dick Edgar

### 1.5.3 DET_GAIN at T = -100C

Description: Detector Gain Table
Most recent version in CALDB: acisD1999-08-13gainN0002.fits
File Creation Date: 12/14/99
Known Errors: Low energy gain (see 1.5.1).
Status: No update planned at present.

### 1.5.4 DET_GAIN at T = -90C

CALIBRATION

# ACIS Calibration Data and Data Products

| Calibration Products |
|---|
| **NOTE: CTI-Induced Quantum Efficiency Loss in ACIS Front Illuminated Devices** |
| **Recent updates:** New S3 FEF release notes now availiable, 08/10/01 New S3 FEF's Available Soon , 07/17/01; **ACIS Calibration Issues in Progress** , 01/12/01; Bad pixel maps, 06/28/01 |

- **ACIS Background**
  Particle background measurements for ACIS-I, ACIS-S and Quiescent background in VF mode. *09/28/01*
- **Bad Pixel Locations**
  Table of bad pixels and columns. *06/28/01*
- **Detector geometry**
  ACIS Focal Plane Array. *11/20/97*
- **Effective Area**
  Plot of HRMA+ACIS FI and BI effective area vs energy. *06/03/99*
- **Energy Resolution**
  In-flight ACIS spectral resolution analysis. *01/18/00*
- **Event Grades**
  Branching ratios, techniques, and simulated branching ratios. *11/06/98*
- **The FEP0 Problem** *02/02/00*
- **Gain and CTI update memo**
  ACIS charge transfer inefficiency and gain corrections. *07/24/01*
- **Optical Blocking Filter Transmission**
  Global I-array and S-array maps; plots of transmission vs. energy and transmission vs. wavelength. *03/10/00*
- **Pileup**
  Pileup analysis using analytical model and PSF data. *10/07/98*
- **Point Spread Function**
  PSF analysis for all on-axis and off-axis XRCF PSF tests. *04/30/99*
- **Quantum Efficiency**
  Plot of ACIS FI and BI QE; map of ACIS spatial non-uniformities. *07/24/00*
- **ACIS Response Matrices**
  Release notes of new S3 Response Matrices, including caveats, limitations, error analysis, and tests against astrophysical sources. *10/09/2001*
- **ACIS Calibration Issues in Progress**
  Analysis of low energy response on the back-illuminated chips *01/12/01*

**ACIS Team Calibration Report**
V2.2, 1/15/99 (**55 Mb** postscript file)

## ACIS-Related Calibration Data

# ACIS CALIBRATION PRODUCTS

| Complete | Update Planned |
|---|---|
| GRADE | **Non CTI Corrected Products** |
| BADPIX at T=-90 | |
| BADPIX at T=-100 | DET GAIN at T=-120 |
| BADPIX at T=-110 | FEF PHA at T=-120 |
| BADPIX at T=-120 | FEF PI at T=-120 |
| EVTSPLT | OSIP at -120 |
| GTI LIM | DET GAIN at T=-110 |
| DET GAIN at T=-90 | FEF PHA at T=-110 |
| FEF PI at T=-90 | FEF PI at T=-110 |
| FEF PHA at T=-90 | OSIP at -110 |
| DET GAIN at T=-100 | QE |
| FEF PI at T=-100 | |
| FEF PHA at T=-100 | **CTI Corrected Products** |
| QEU before rad. damage | |
| QEU at -110 | DET GAIN at T=-120 |
| QEU at -120 | FEF PHA at T=-120 |
| PSF ACIS-I | FEF PI at T=-120 |
| PSF ACIS-S | QEU at T=-120 |
| OSIP at -90 | DET GAIN at T=-110 |
| OSIP at -100 | FEF PHA at T=-110 |
| Background Files | FEF PI at T=-110 |
| | QEU at T=-110 |

# ACIS TEMPERATURES

| TEMPERATURE | DATES |
|---|---|
| $-90°$ C | LAUNCH - Aug. 13, 1999 |
| $-100°$ C | Aug. 13 - Sept. 13, 1999 |
| $-110°$ C | Sept. 13, 1999 - Jan. 29, 2000 |
| $-120°$ C | Jan. 29, 2000 to present |

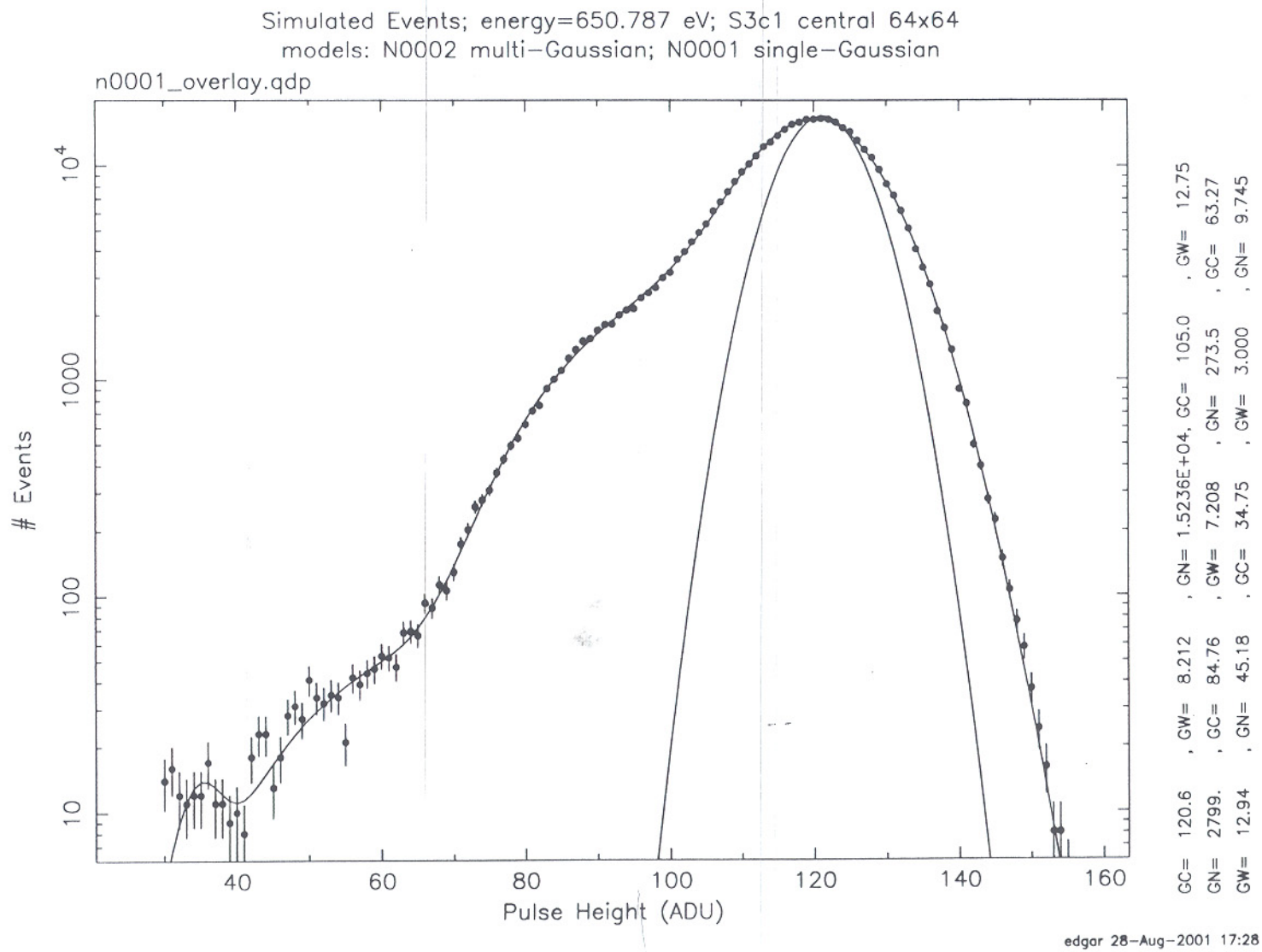



Figure 1: Fit to model PH distribution, central 64 × 64 pixel region, S3 quadrant 1, energy=650.787 eV. The narrow Gaussian is the N0001-released response at this energy.

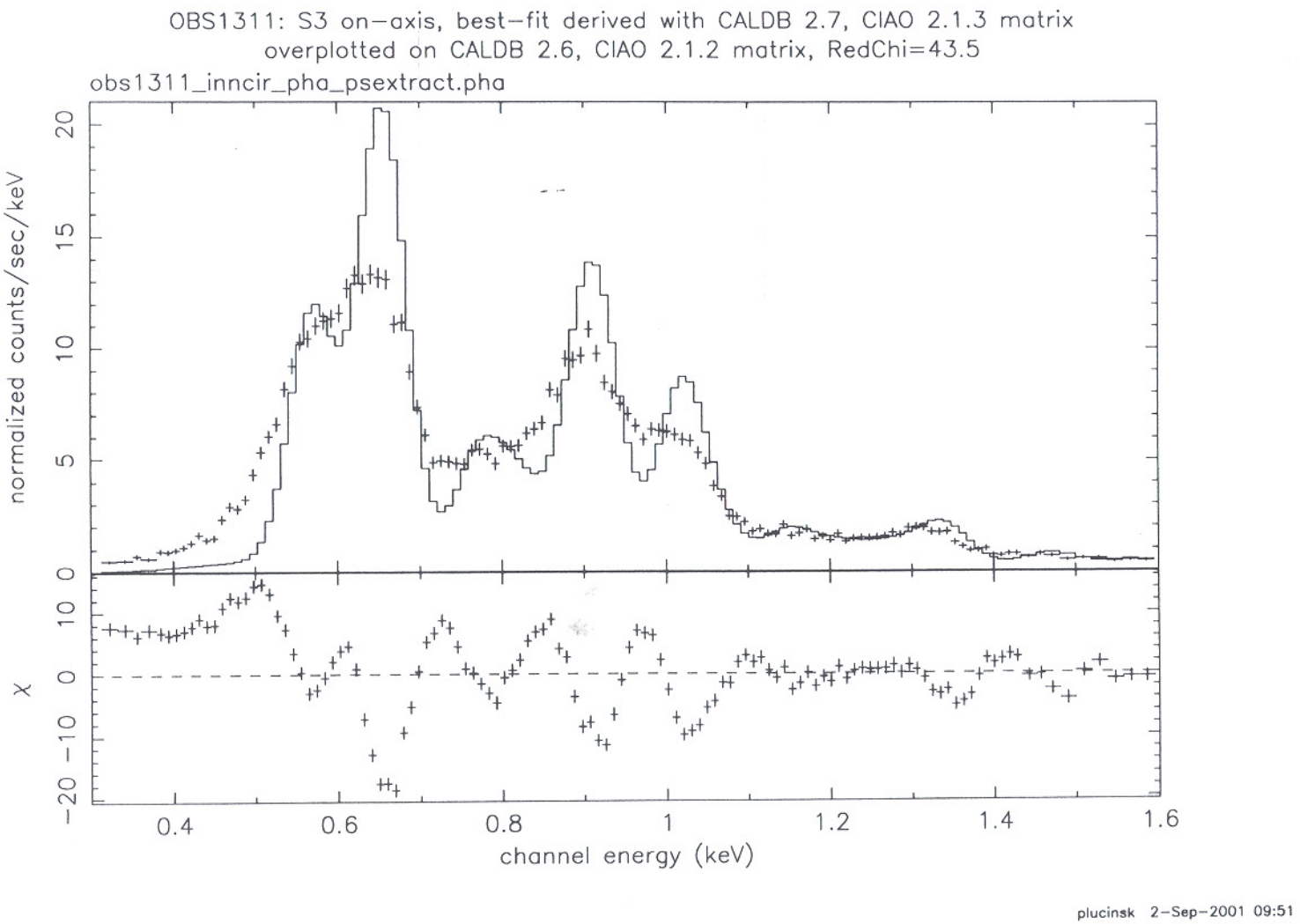



Figure 12: Over-plot of best-fit PHA E0102 new matrix model with old matrix

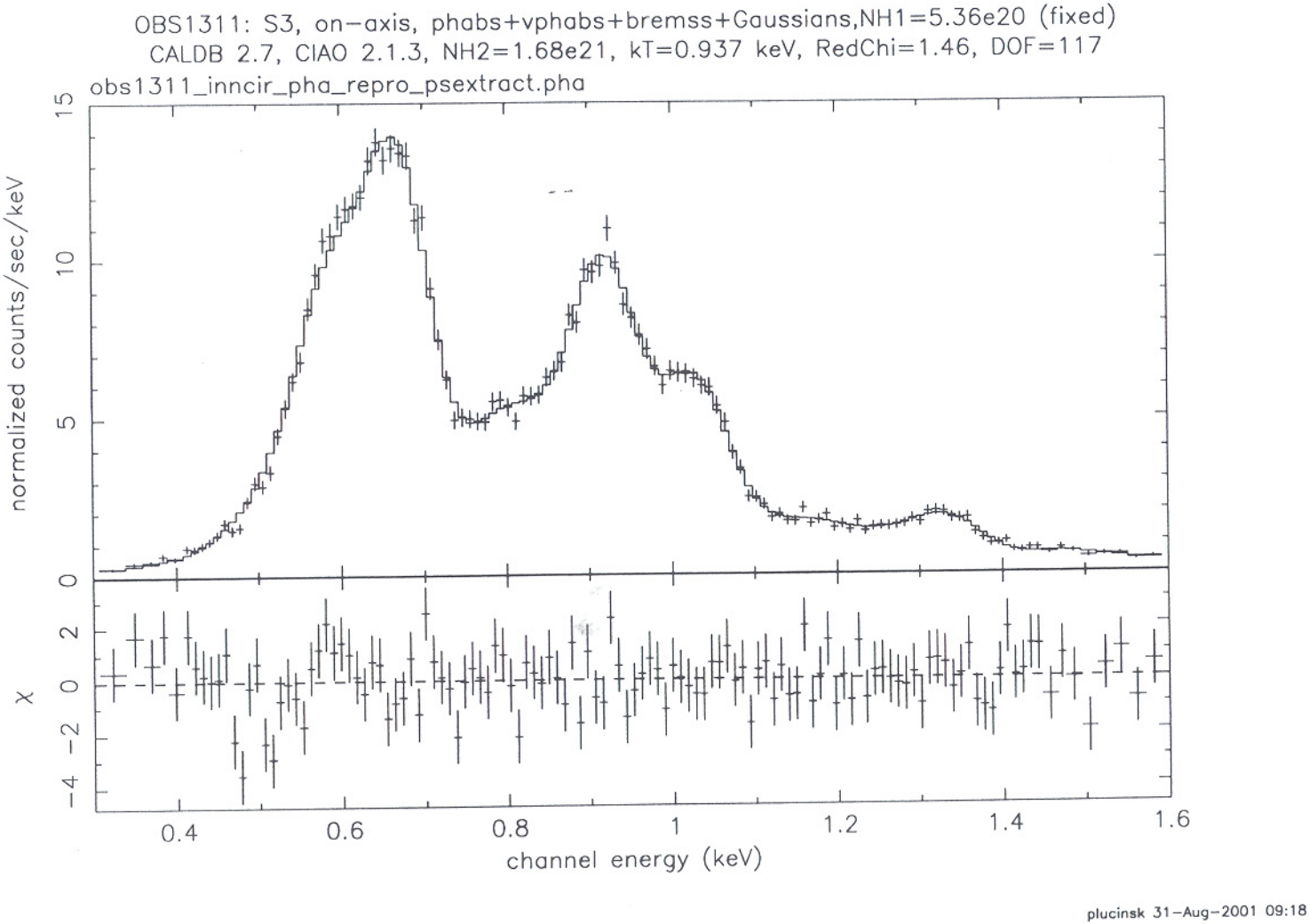


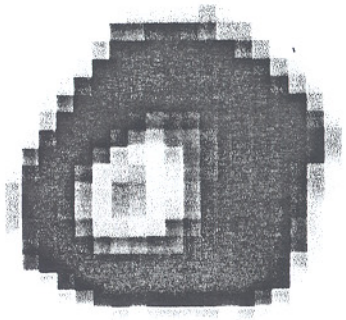

Figure 8: Best-fit E0102 PHA fit with N0002 (new) FEF

# Status of other BI matrices

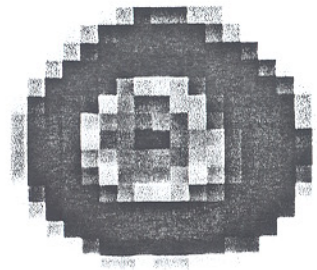
30 October 2001

- **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**

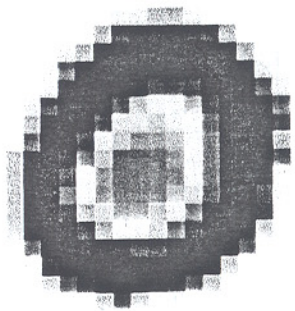
Uncorrected - 5th-order Degap



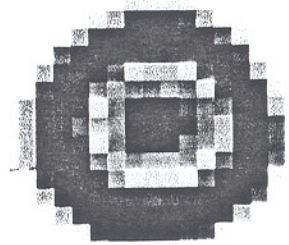
Uncorrected - Linear Degap

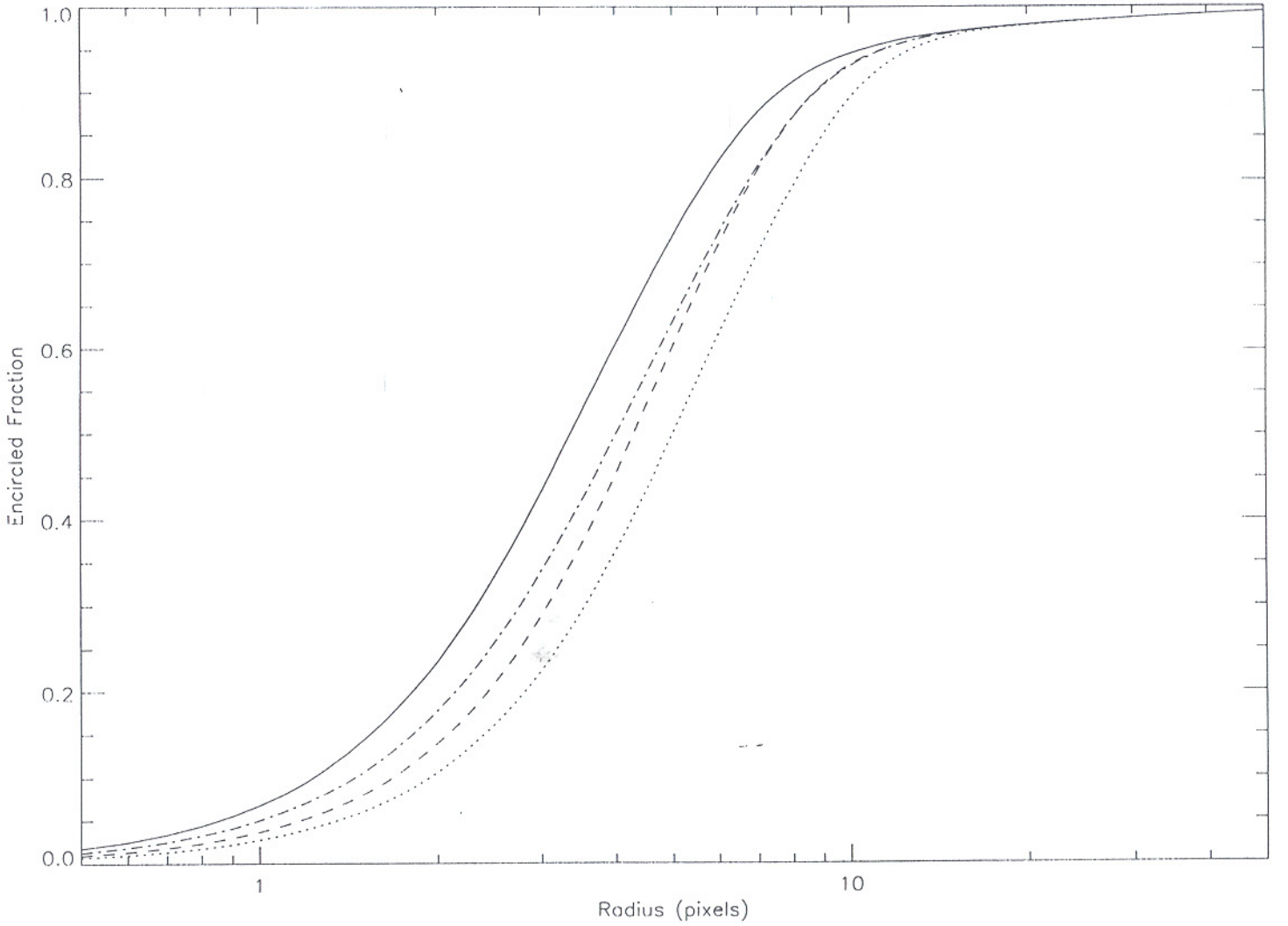


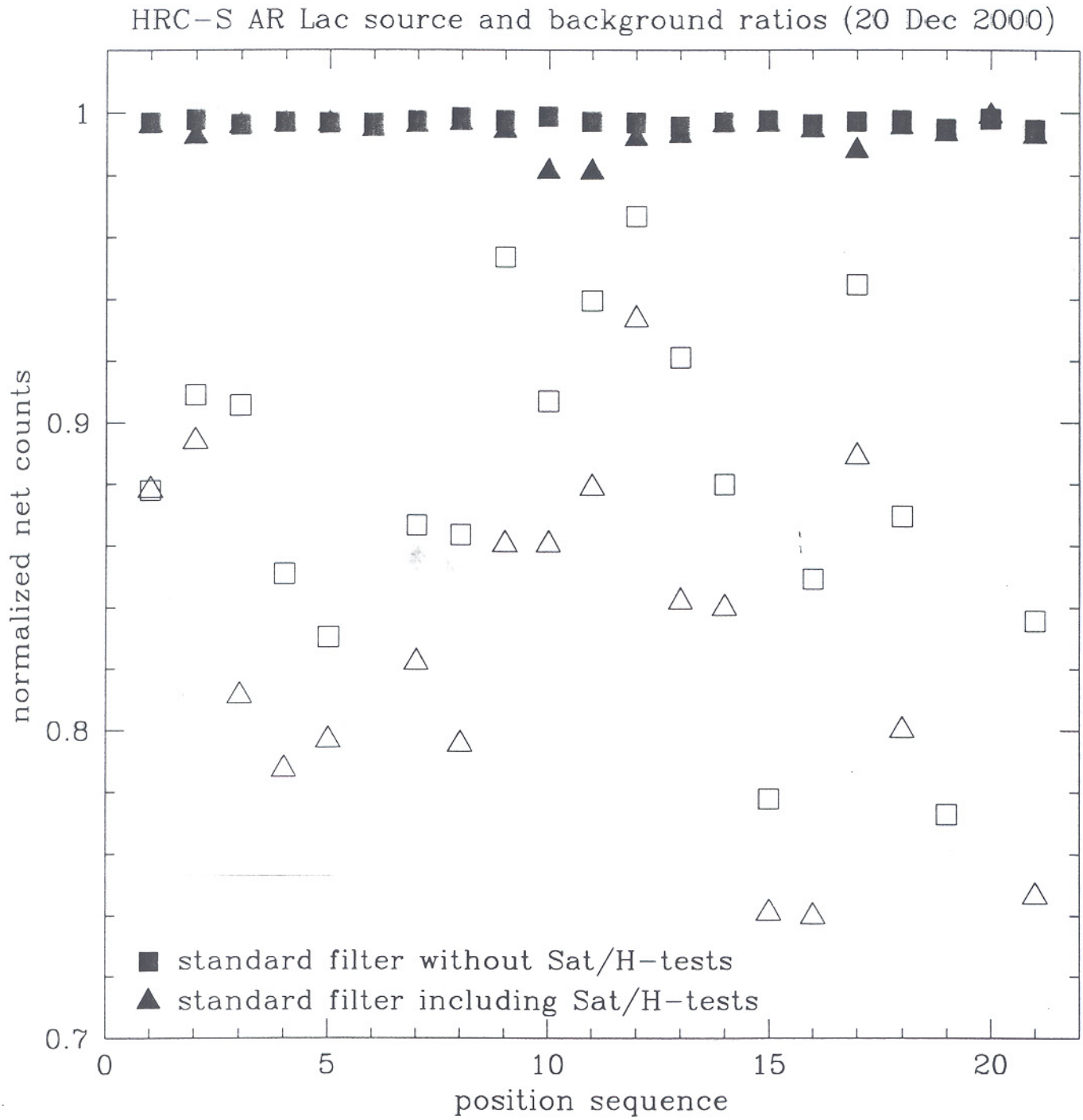
Corrected - 5th-order Degap

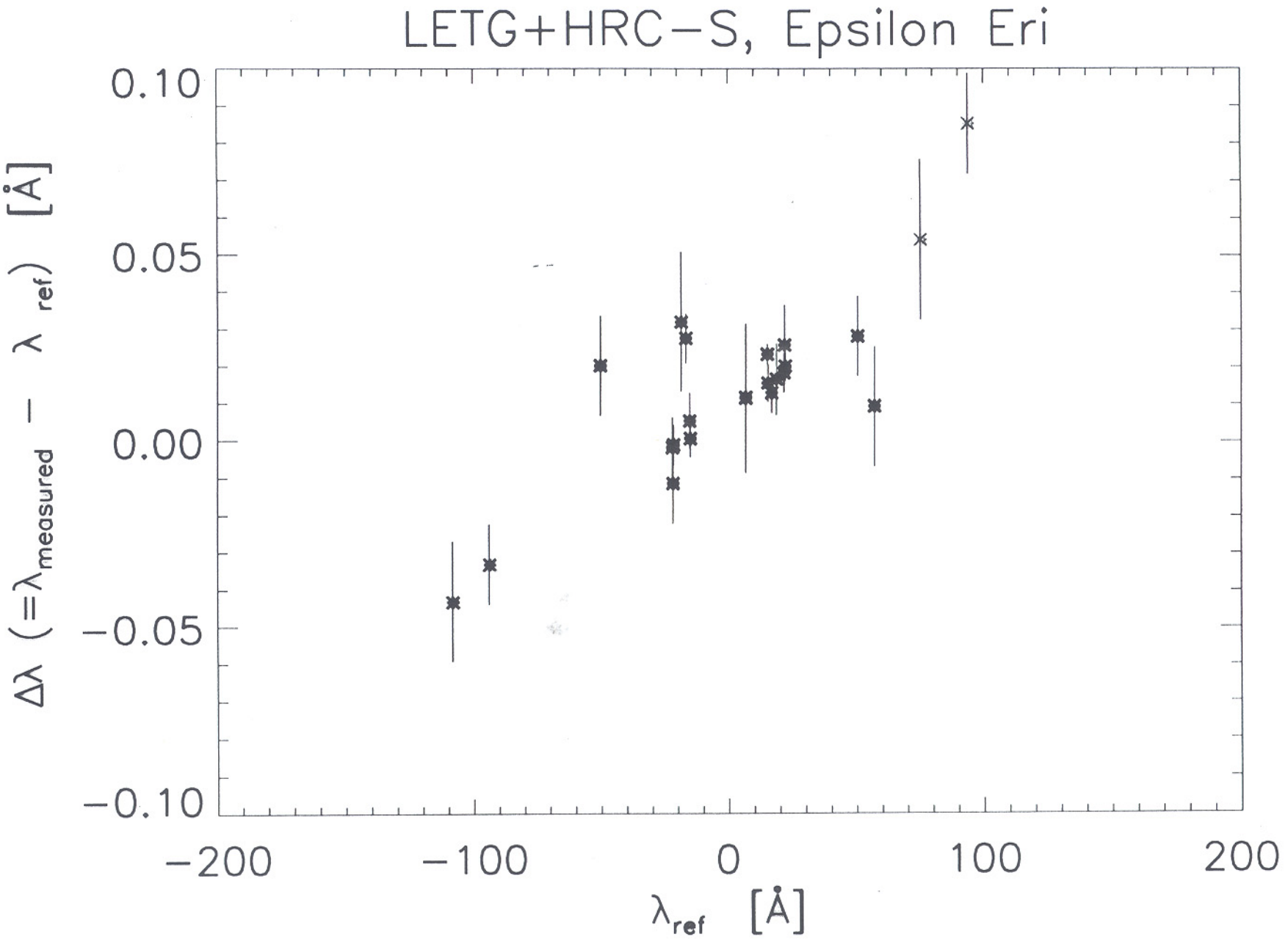


Corrected - Linear Degap




1.0
0.8
0.6
0.4
0.2
0.0
Encircled Fraction
1
10
Radius (pixels)


HRC-S AR Lac source and background ratios (20 Dec 2000)
normalized net counts
1
0.9
0.8
0.7
0
5
10
15
20
position sequence
standard filter without Sat/H-tests
standard filter including Sat/H-tests


LETG+HRC−S, Epsilon Eri
0.10
0.05
0.00
−0.05
−0.10
−200
−100
0
100
200
Δλ (=λmeasured − λ ref) [Å]
λref [Å]

# Dispersion Relation Summary

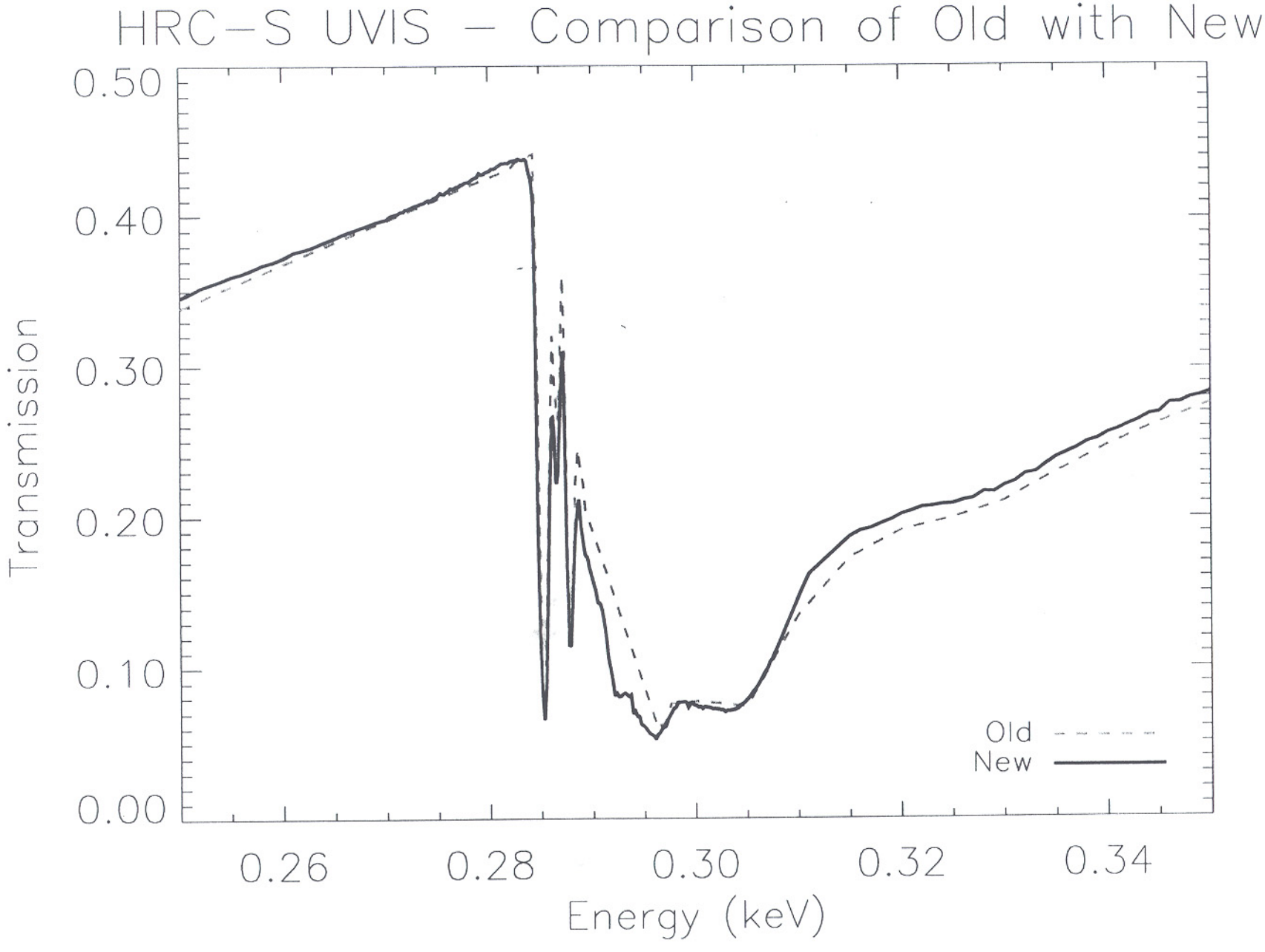
- The LETG+HRC–S dispersion relation is complicated by small, but observable, detector spatial non–linearities that are not yet understood and do not appear to be sensitive to degap parameters

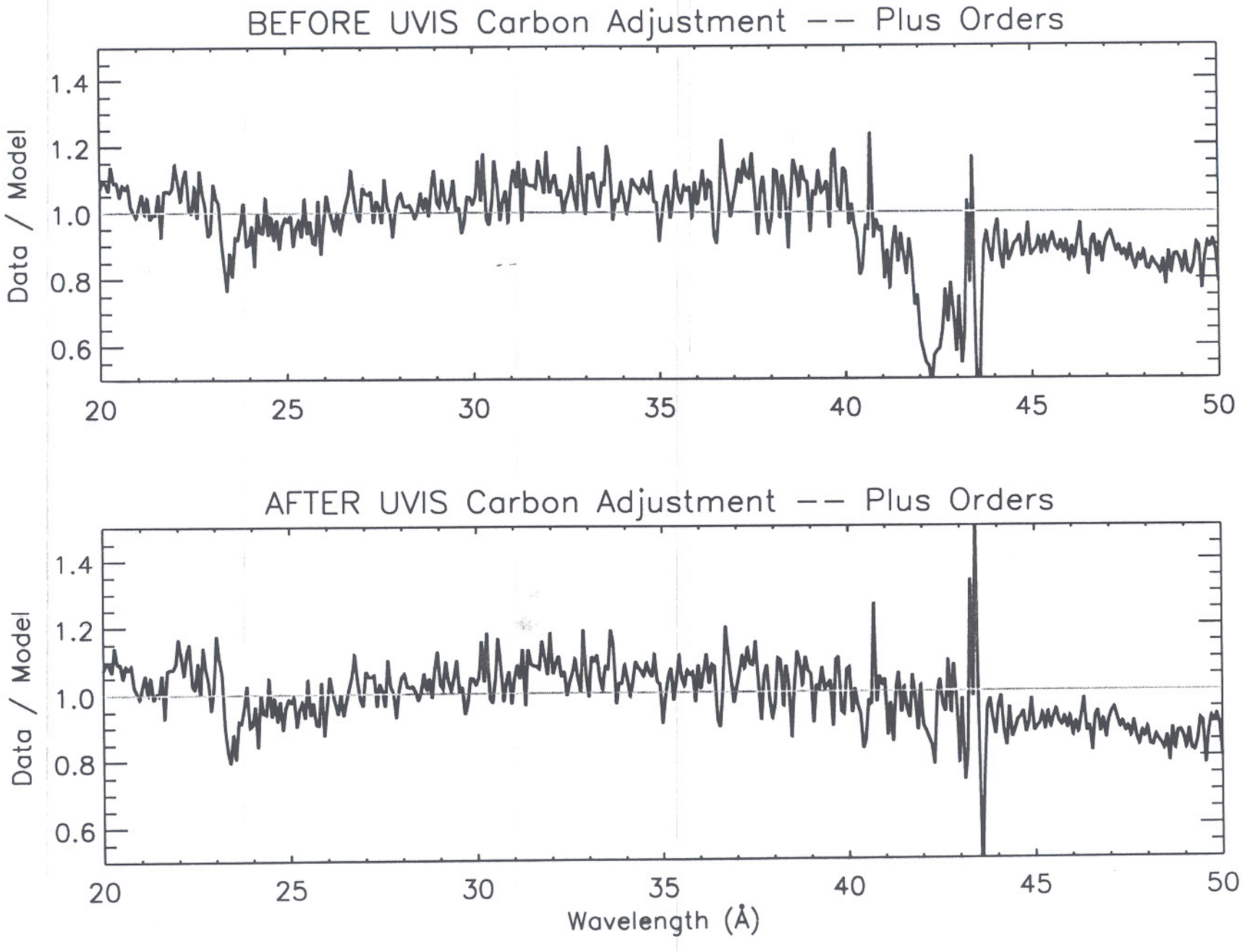
- The outer HRC–S plates appear to have a different dispersion relation than the inner plates; the reason for this is not understood in terms of constraints on detector build and geometry; plate gaps may need further adjustment.

- If stable, both above effects could be corrected for semi–empirically; aim–point sensitivity needs to be examined.

- ACIS–S has a slightly different dispersion relation to HRC–S; this could be explained if one of their pixel sizes were still slightly in error

- With linear dispersion relations, wavelengths are uncertain by ~200 km/s or less; errors are largely systematic and can be considerably improved with non–linear relations/fudges.


HRC–S UVIS – Comparison of Old with New
Transmission
0.50
0.40
0.30
0.20
0.10
0.00
0.26
0.28
0.30
0.32
0.34
Energy (keV)
Old
New


BEFORE UVIS Carbon Adjustment -- Plus Orders
Data / Model
1.4
1.2
1.0
0.8
0.6
20
25
30
35
40
45
50
AFTER UVIS Carbon Adjustment -- Plus Orders
Data / Model
1.4
1.2
1.0
0.8
0.6
20
25
30
35
40
45
50
Wavelength (Å)

# Summary of HETGS Calibration

Herman L. Marshall
(MIT Center for Space Research)

## Dispersion Relation

- Found and eliminated systematic wavelength errors of about 0.05%
  - Rowland spacing was changed for reprocessing
    - --> accuracy of 0.02 - 0.01% is not possible
  - Later, we determined that the ACIS pixel size is smaller, instead
    - Was 24.000 μ, now will be 23.987 μ due to thermal contraction
    - Verification awaits reprocessing and more emission line IDs
- Line location uncertainties due to chip position uncertainties < 0.005Å
  - Outer chips (S0, S1, S5) are accurate to < 0.5 pix, others to < 0.2 pix
    - MEG (HEG): < 0.005 Å (0.0025 Å) at long wavelengths
    - MEG (HEG): < 0.002 Å (0.0005 Å) at short wavelengths
  - Better chip locations will be measured in new processing

## Effective Area

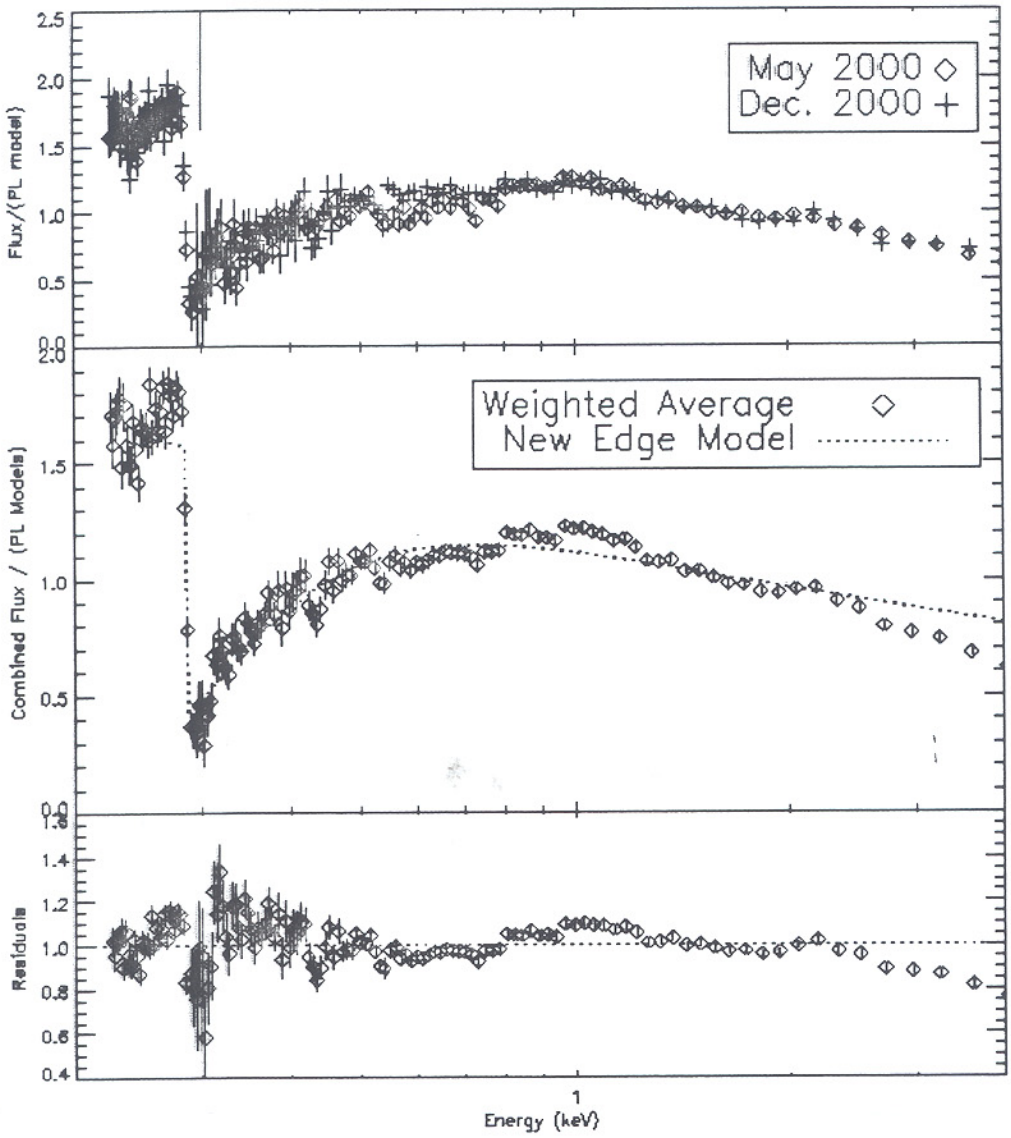
- Ratio of BI/FI data for a given grating indicates QE errors < 15%
  - Systematic errors are < 10% for 1.5 < E < 7 keV
  - FI/FI ratios are all consistent with pre-launch QE models
- Ratios of MEG/HEG data indicate efficiency errors up to 8%
  - New efficiencies have been released

## Line Profiles

- No deviations from ground-based models yet noted

## Cross Dispersion Profiles

- Flight data used to compute aperture losses
  - Results agree qualitatively with pre-flight models
  - Results added to Proposers' Observatory Guide


May 2000 ◇
Dec. 2000 +
Flux/(PL model)
Weighted Average ◇
New Edge Model
Combined Flux / (PL Models)
Residuals
Energy (keV)