

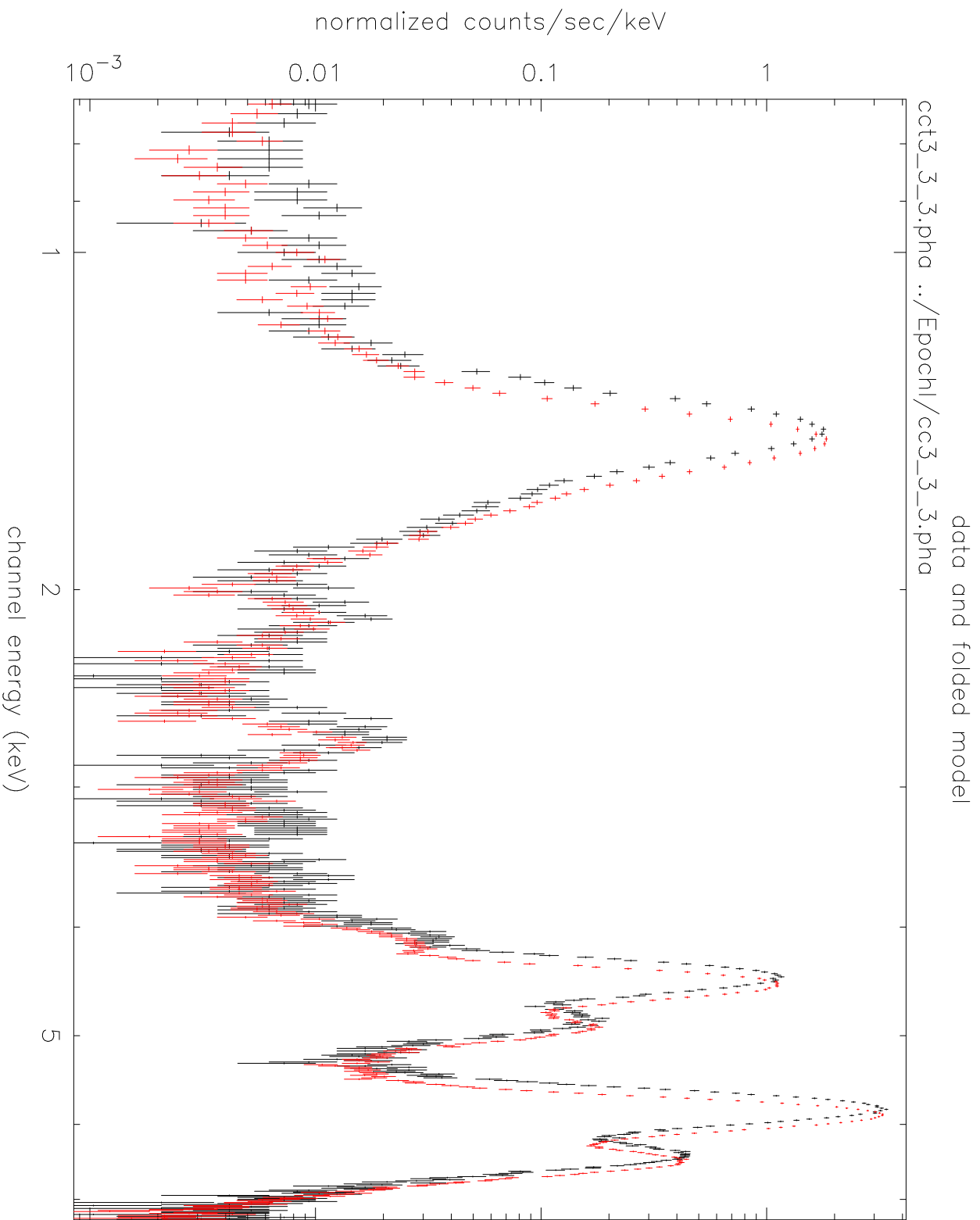
Introduction

PROBLEM: CTI (and detector gain in some CCDs) slowly changes with time.

PLAN:

- Effect on the ACIS response.
- Position and energy dependence.
- Effect on the response shape.
- Correction algorithm and validation.
- Software products.

Effect on the observed spectra



ECS, I3, near aim point. Red: Feb–Apr, 2000. Black: Nov2002–Jan2003.

Calibration data

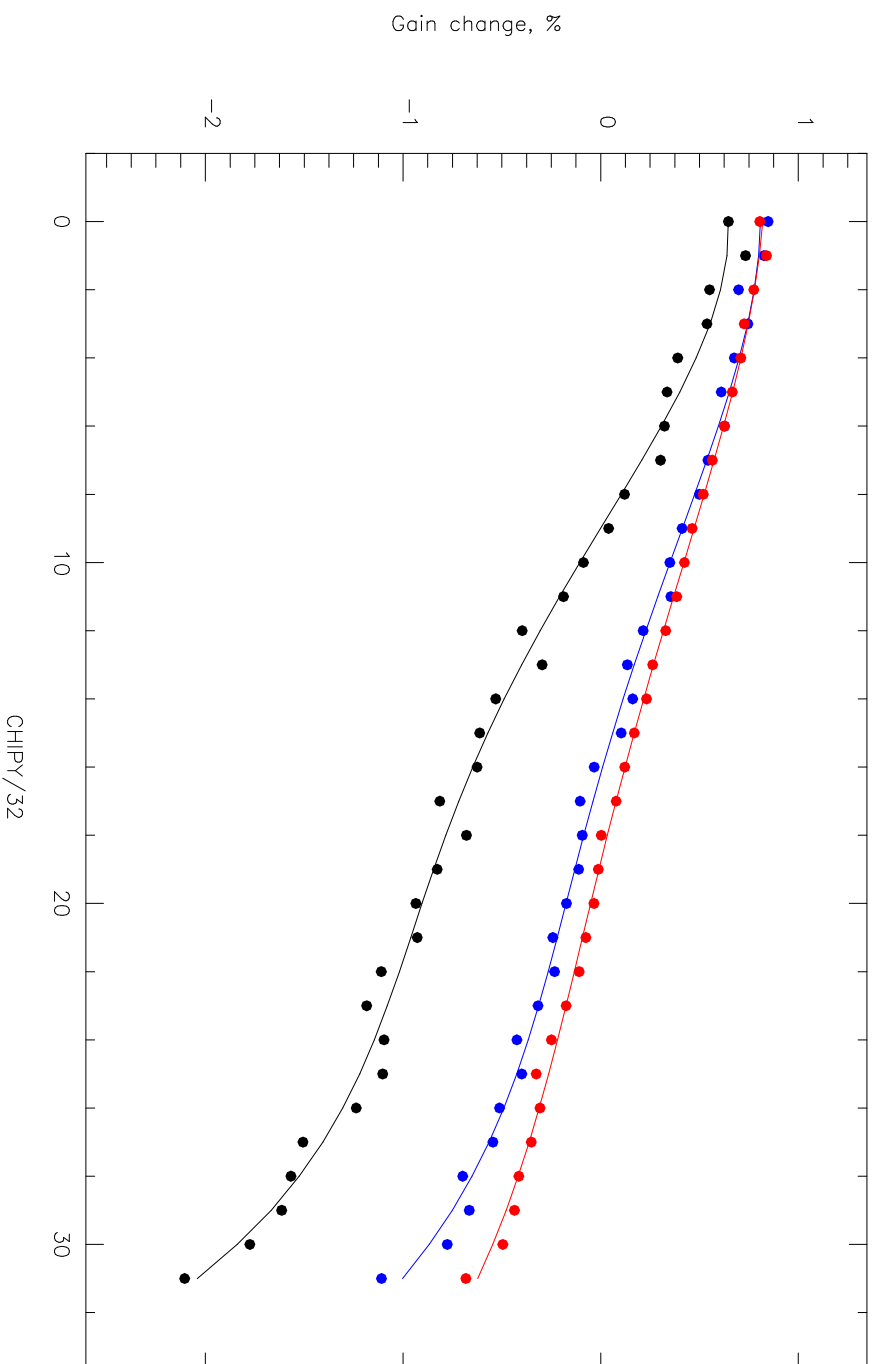
- *External cal source* (ECS). Regular measurements, cover entire ACIS. No bright emission lines below 1.49 keV.
- *E0102-72*. Line-dominated SNR, observed twice a year to the low-energy ($0.55 < E < 1.1$ keV) ACIS gain. Small number of locations.

Approach: derive gain corrections from the ECS data and to verify their extrapolation to low energies by E0102-72 data.

Procedure: ECS spectra fit using an RMF adjusted to Feb-Apr 2000, gain corrections derived at 3 energies.

Positional dependence

I2, node2:



Black: Al ($E = 1.49$ keV), Blue: Ti ($E = 4.51$ keV) blue), Red: Mn ($E = 5.89$ keV).

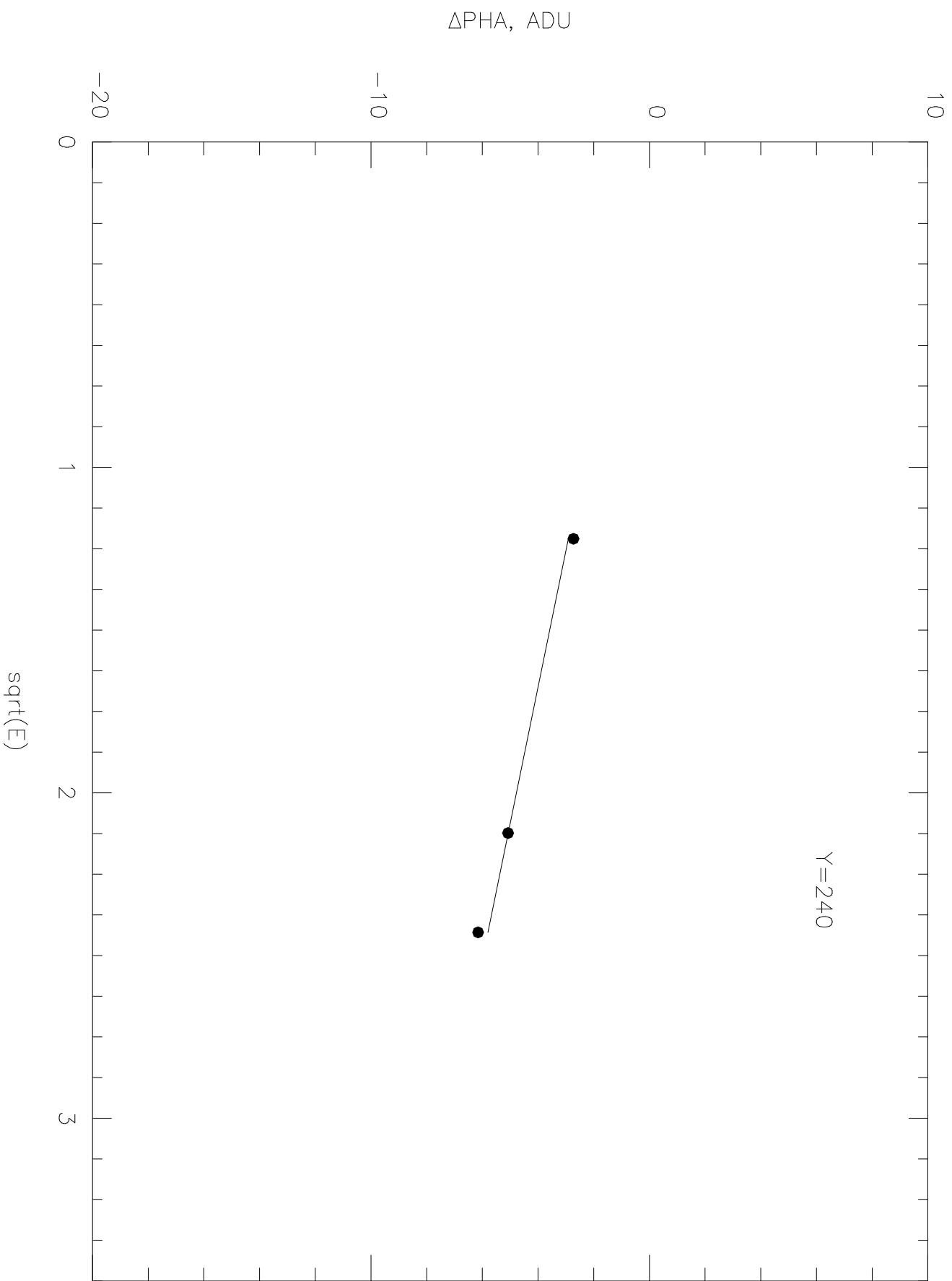
Solid lines is 4-th order polynomial fits.

Energy dependence

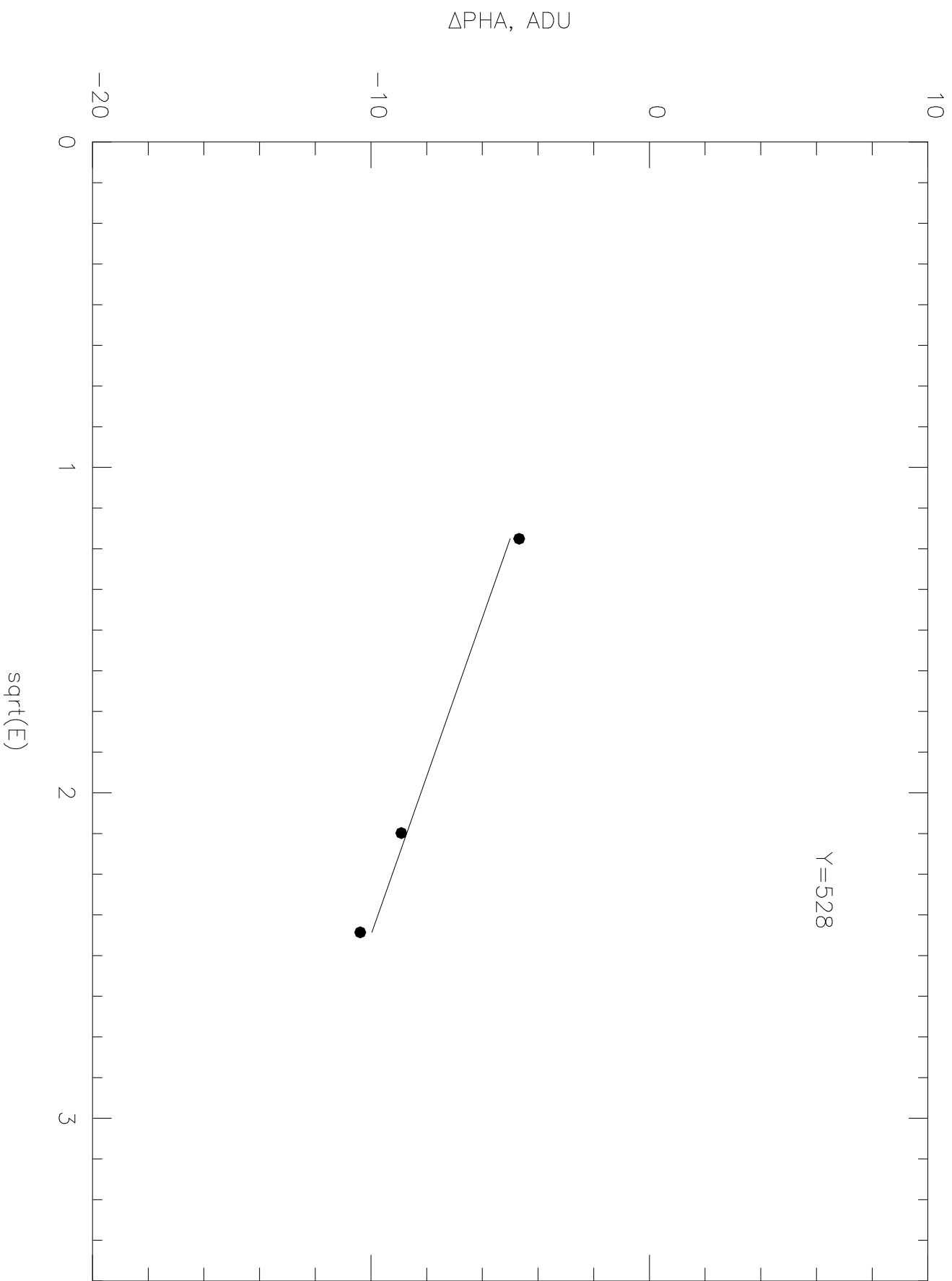
CTI model predicts that charge loss $\propto E^{1/2}$. Including evolution of detector gain,

$$\Delta PHA = AE^{1/2} + BE$$

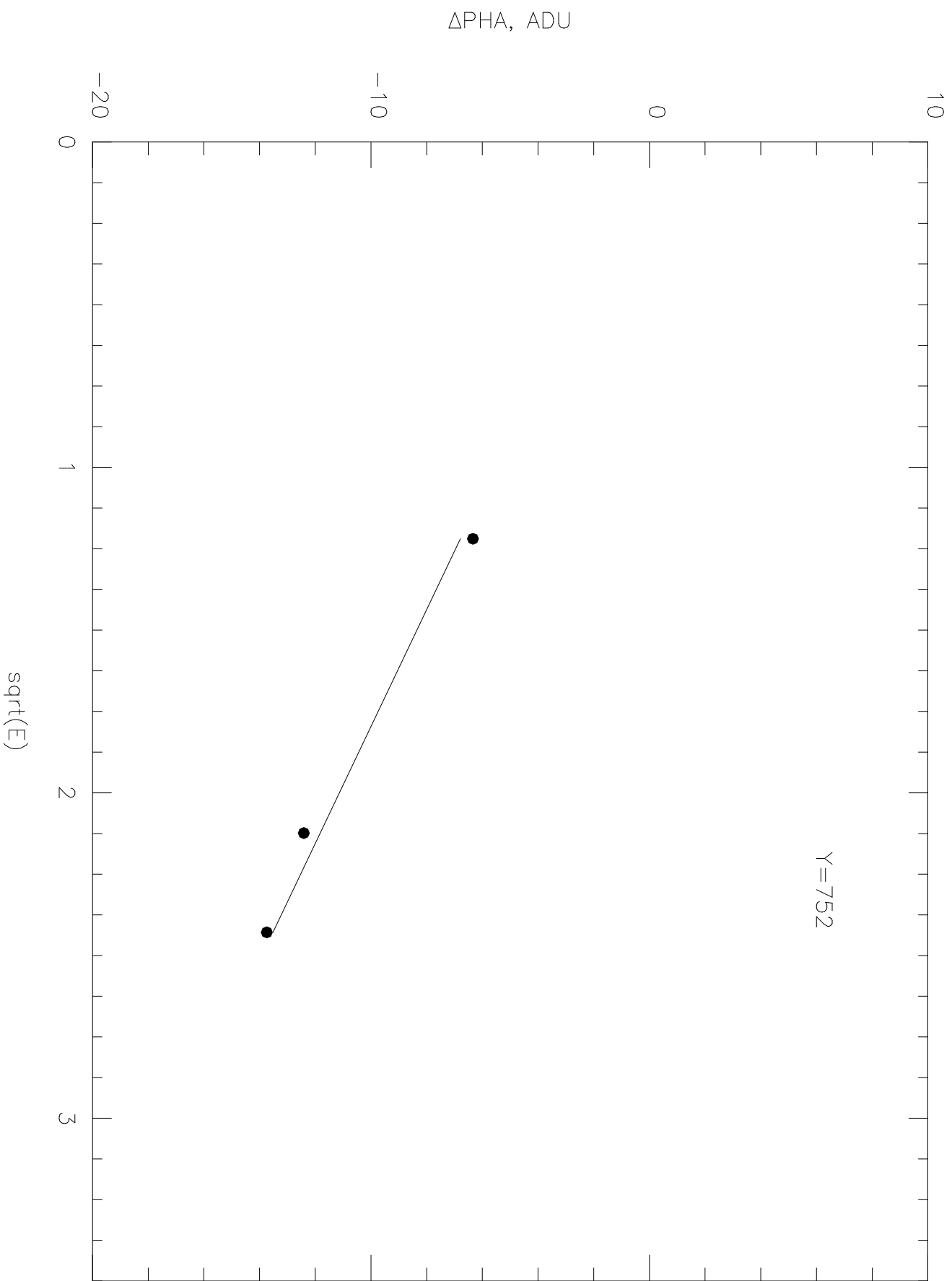
I3, Node 2, Y=240:



I3, Node 2, Y=528:



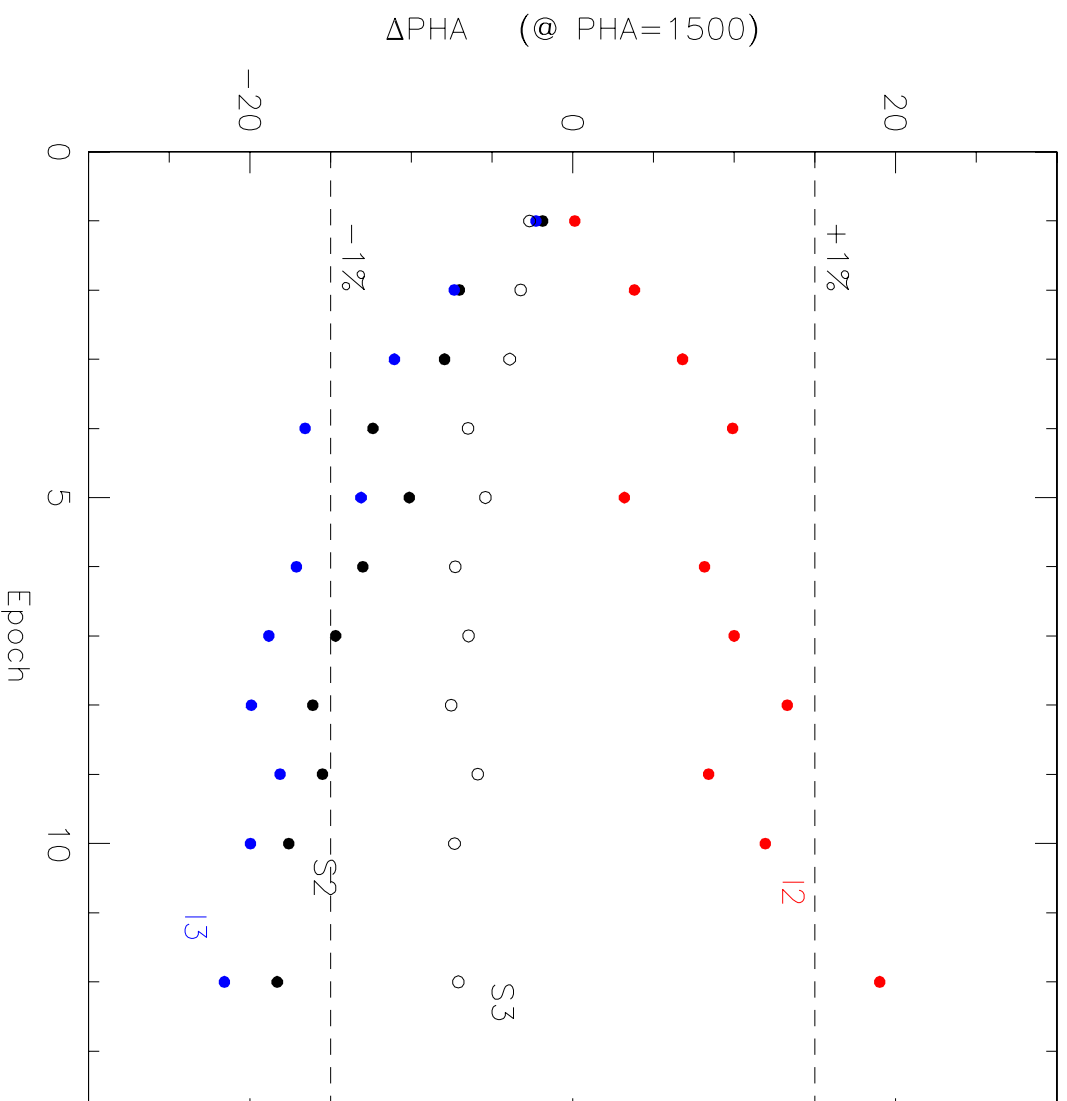
I3, Node 2, Y=752:



Fit procedure and correction algorithm

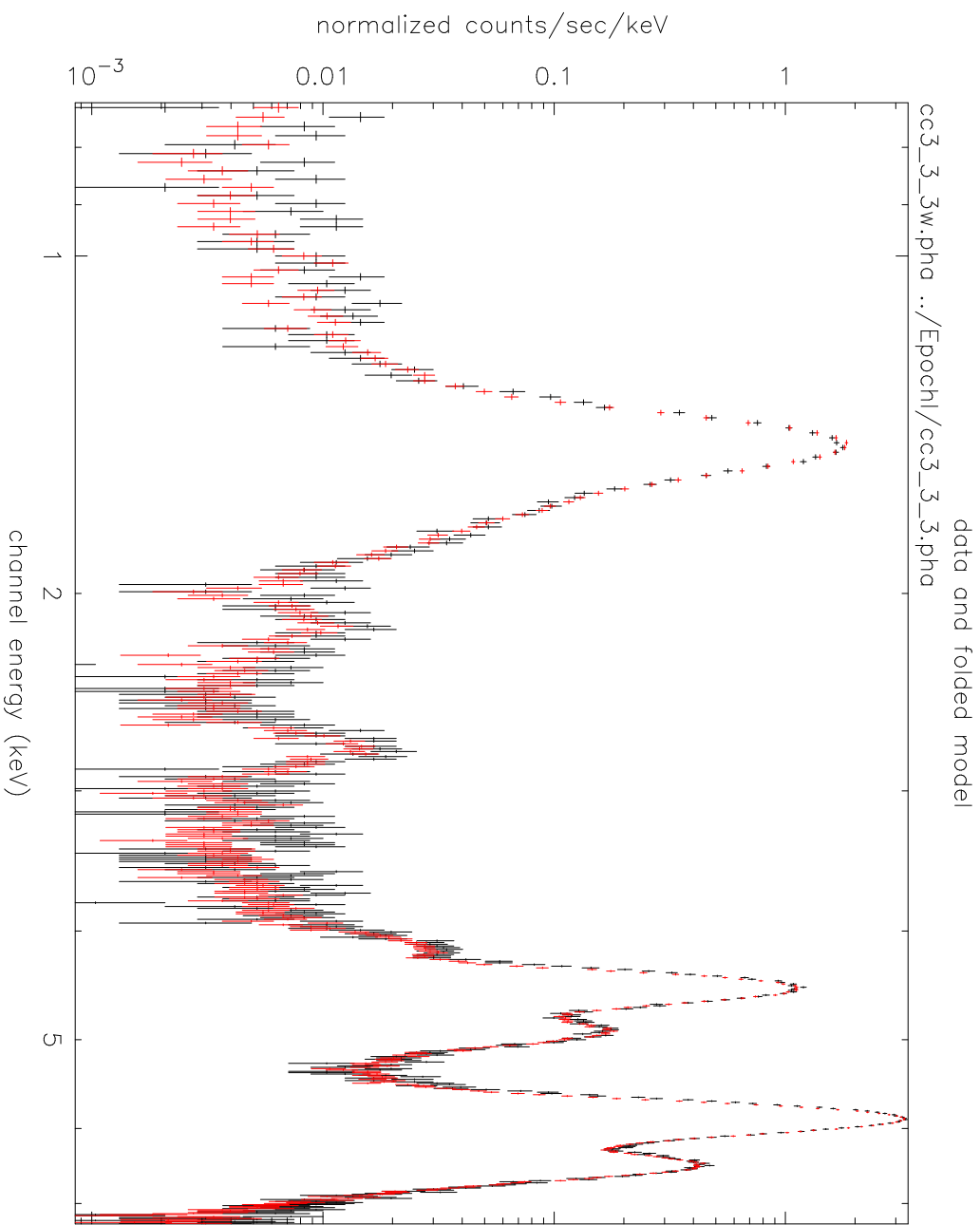
- $\Delta PHA = AE^{1/2} + BE$
- - In I0,I1,I3,S2,S3: fix $B = 0$, fit A at each location
 - In I2: same B within each node, fit A at each location
- Use A and B to compute lookup tables $\Delta PHA(PHA)$ at each location.
- Correction:
$$PHA' = PHA + \Delta PHA(PHA)$$
- N.B. This should be applied after the CTI correction (if applicable)

Time dependence



Gain changes (ΔPHA at $\text{PHA} = 1500$) at several representative locations in I2, I3, S2, and S3. Each epoch spans 3 months starting February, 2000. Positive drift in I2 caused by the evolution of the detector gain. — *3-month time resolution is adequate*

(No) change in the shape of the spectral response



ECS, I3, near aim point. Red: Feb-Apr, 2000. Black: Nov2002-Jan2003, corrected.

Validation: ECS

'% Diff' is defined as (E_measured-E_nominal)/E_nominal*100%

CCD: 3, NODE: 3,

AlKa,1.487keV

TiKa,4.510keV

MnKa,5.898keV

yseg	% Diff	% Diff	% Diff
0	-0.081	-0.120	-0.124
1	0.054	-0.111	0.036
2	-0.087	-0.089	0.010
3	0.087	-0.111	-0.014
4	0.101	-0.144	-0.073
.	.	.	.
27	0.256	-0.111	-0.110
28	0.101	0.031	-0.070
29	0.148	-0.111	-0.117
30	0.175	-0.111	-0.163
31	0.161	-0.222	-0.259

Mean 0.007
Standard deviation 0.129

-0.097
0.069

-0.085
0.052

Validation: E0102-72

O_gain and Ne_gain are defined as E_measured/E_nominal for the O and Ne complexes.

CCD	OBSID	Epoch	chipx	chipy	O_gain	Ne_gain
I0	1542	VI	257:512	513:544	1.0075	0.9970
I0	2840	VIII	257:512	513:544	1.0075	0.9970
I1	444	I	1:256	97:128	1.0073	1.0040
I1	445	I	1:256	481:512	1.0320	1.0240
I1	1543	VI	257:512	481:512	1.0072	1.0060
I1	2841	VIII	257:512	449:480	1.0073	1.0060
I2	1544	VI	257:512	513:544	0.9990	0.9970
I2	2842	VIII	257:512	513:544	1.0074	0.9970
I3	1537	VI	1:256	481:512	0.9987	1.0025
I3	2839	VIII	1:256	449:480	0.9988	0.9970
I3	1536	VI	257:512	481:512	1.0073	0.9970
I3	2838	VIII	257:512	449:480	1.0072	0.9970
I3	420	I	513:768	97:128	1.0083	1.0100
I3	140	I	513:768	289:320	1.0073	0.9970
I3	136	I	513:768	449:480	1.0128	1.0140
I3	1535	VI	513:768	481:512	1.0075	0.9970
I3	2837	VIII	513:768	449:480	1.0074	0.9970
I3	439	I	513:768	673:704	1.0085	1.0085
I3	440	I	513:768	897:928	1.0048	0.9970
I3	1533	VI	769:1024	97:128	1.0072	1.0060
I3	2835	VIII	769:1024	97:128	1.0074	1.0060
I3	1534	VI	769:1024	481:512	1.0075	0.9970
I3	2836	VIII	769:1024	449:480	0.9988	0.9970
S2	1539	VI	513:768	481:512	0.9988	0.9970
S2	2847	VIII	513:768	481:512	0.9987	0.9970

Implementation Status

- ARD files prepared for I array, S2 and S3, tested for compatibility with CALDB.
- corr_tgain released on the software exchange page (June 5).
- correction works in internal versions of acis_process_events. Should be out in the next CIAO release.
- Note that the TGAIN correction is incompatible with the PSU CTI corrector, which accounts for time-dependence in a different way.