CORRECTIONS FOR TIME-DEPENDENCE OF ACIS GAIN

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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.

Calibration data

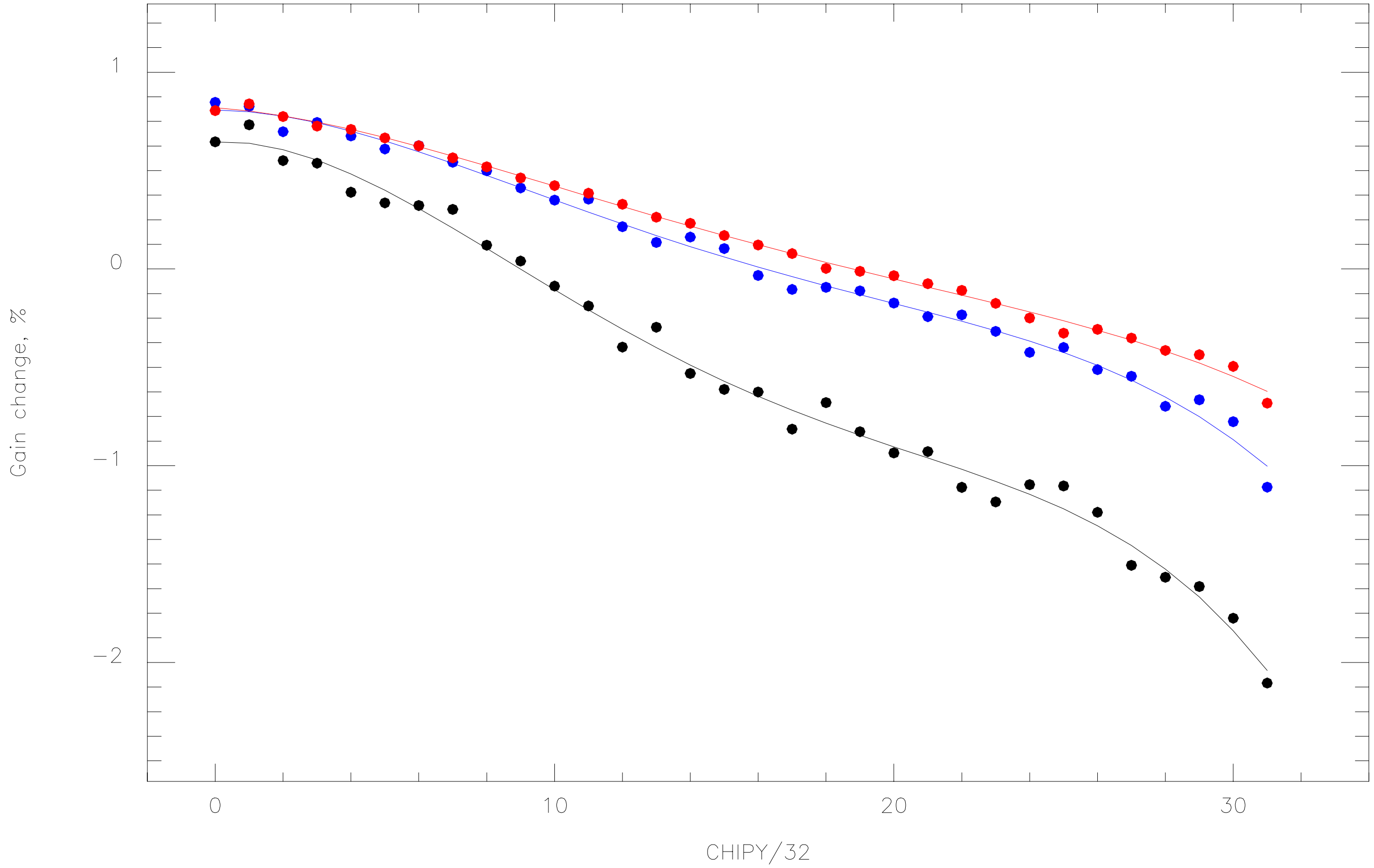
- *External cal source* (ECS). Regular measurements, cover entire ACIS. No bright emission lines below 1.49 keV.
- *E0102-72.* Line-dominated SNR, observed twice a year to the low-energy ($0.55 < E < 1.1$ keV) ACIS gain. Small number of locations.

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 Feb2000, 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).

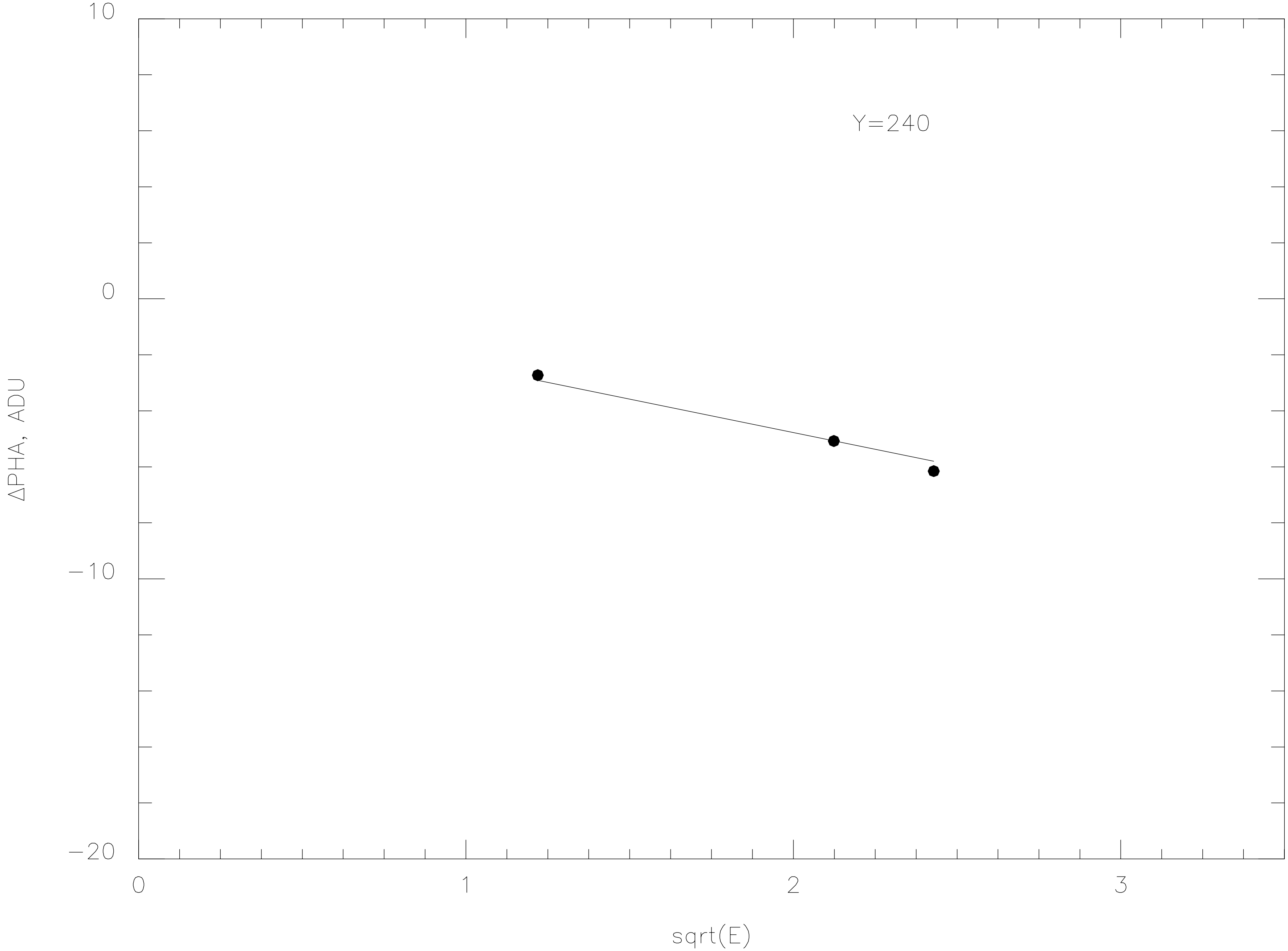
Solid lines is 4-th order polynomial fits.

Energy dependence

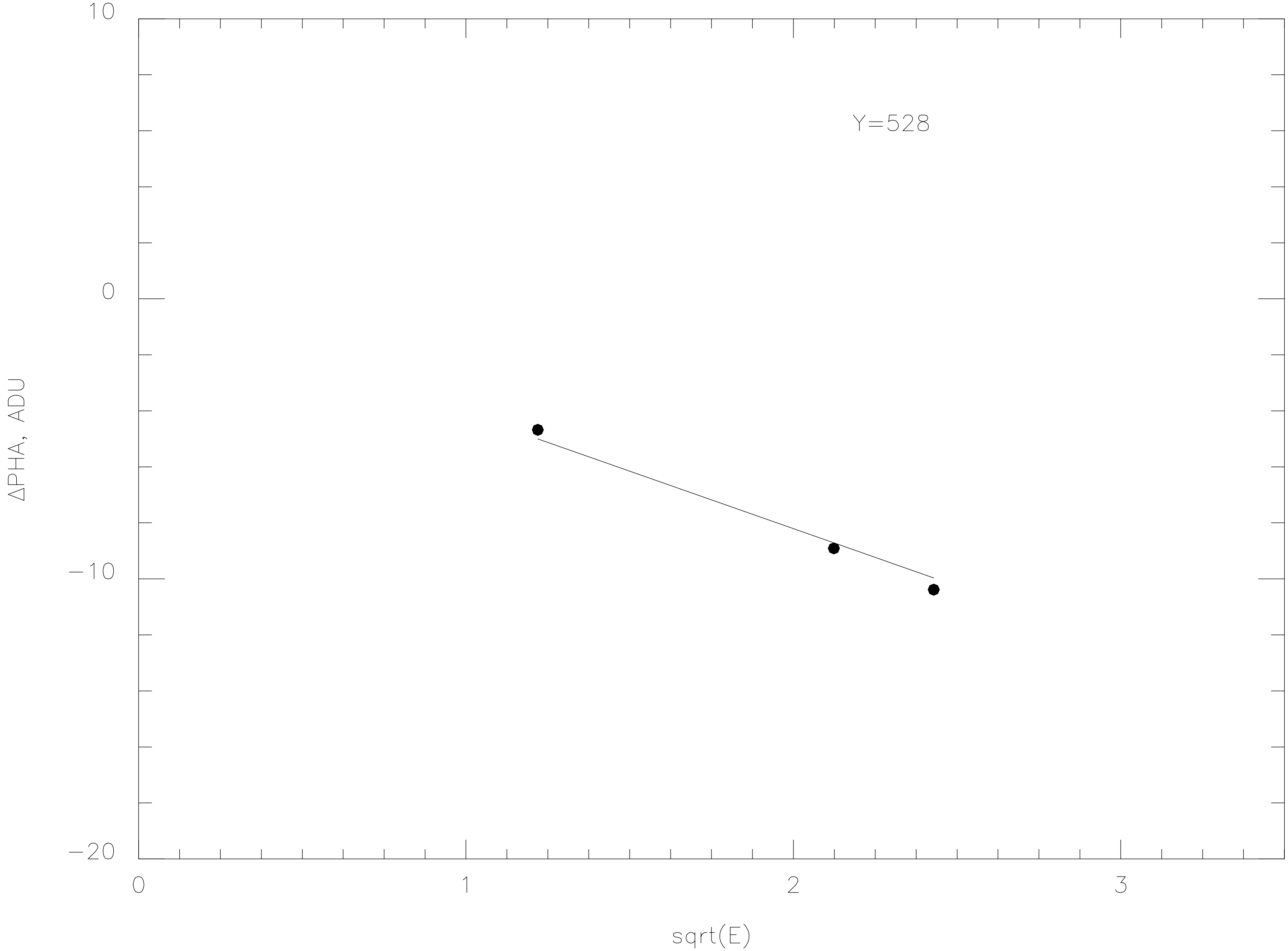
CTI model predicts that charge loss $\propto E^{1/2}$. Including evolution of detector gain,

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

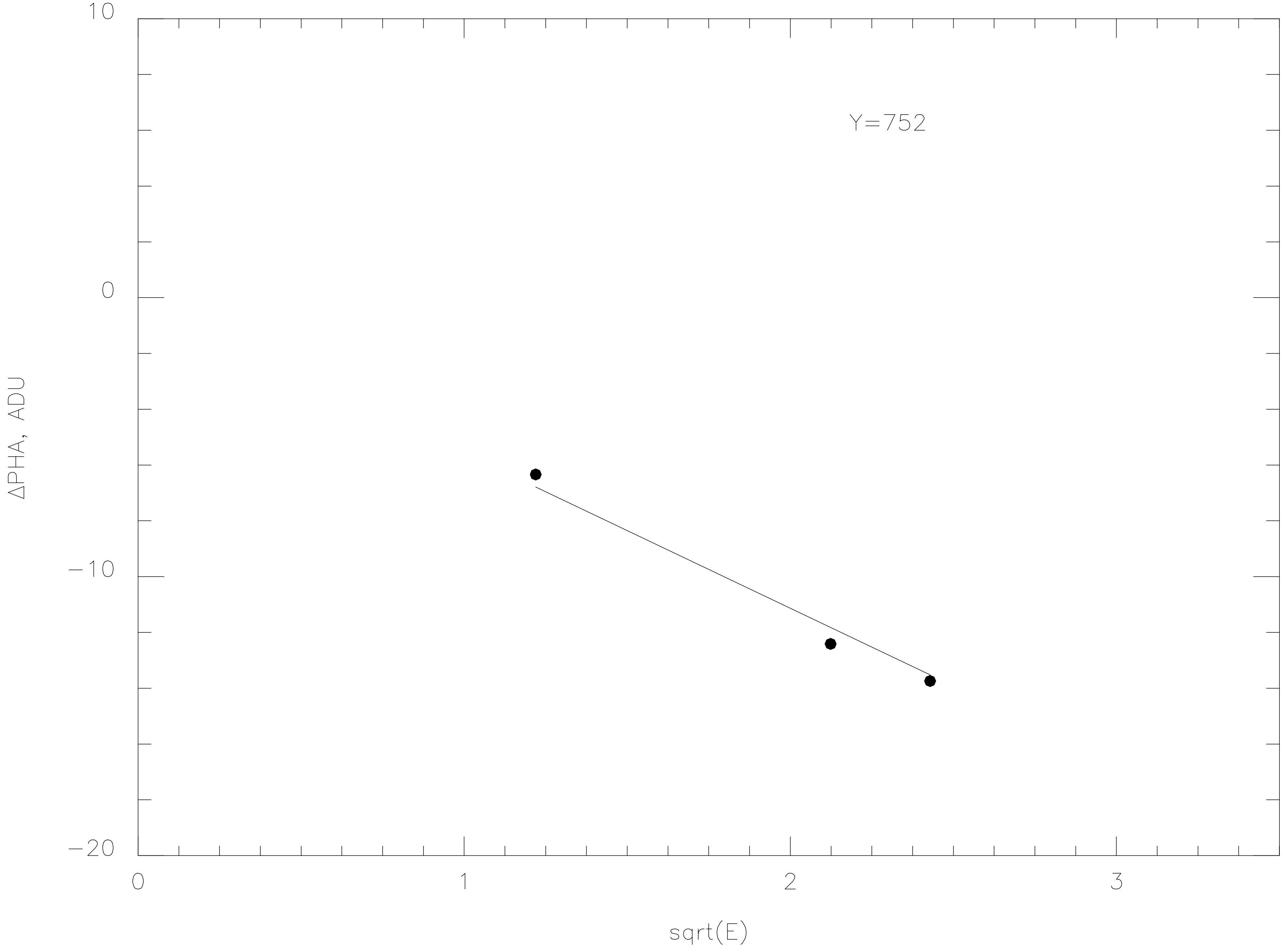
I3, Node 2, Y=240:



I3, Node 2, Y=528:



I3, Node 2, Y=752:



Fit procedure and correction algorithm

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

-

  In I0,I1,I3,S2: fix $B = 0$, $C = 0$, fit A at each location

  In I2: fix $C = 0$, same B within each node, fit A at each location

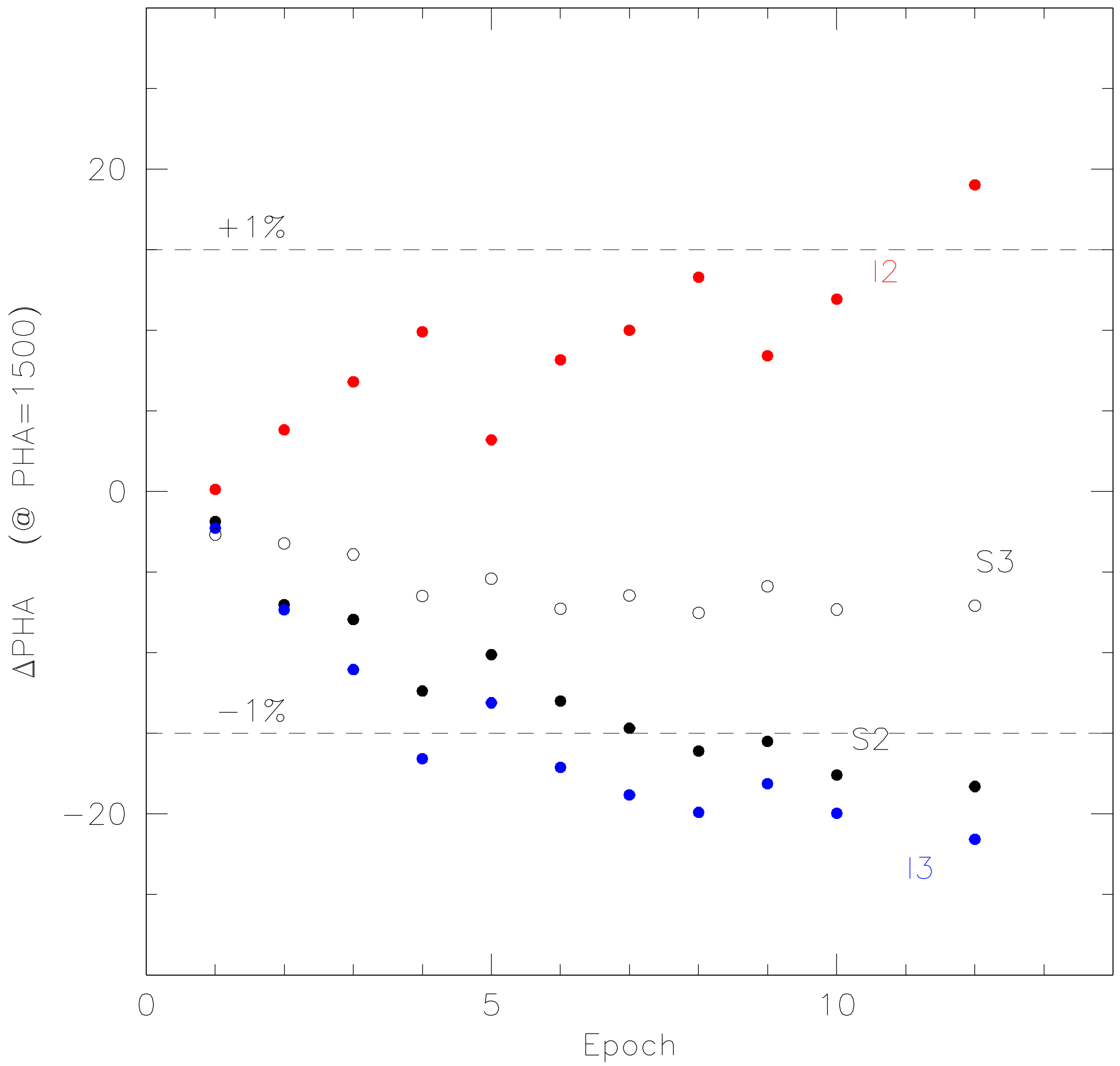
  In S3: fix $B = 0$, same C within each node, fit A at each location

- Use A, B, and C to compute lookup tables $\Delta\mathrm{PHA}(\mathrm{PHA})$ at each location.

- Correction:

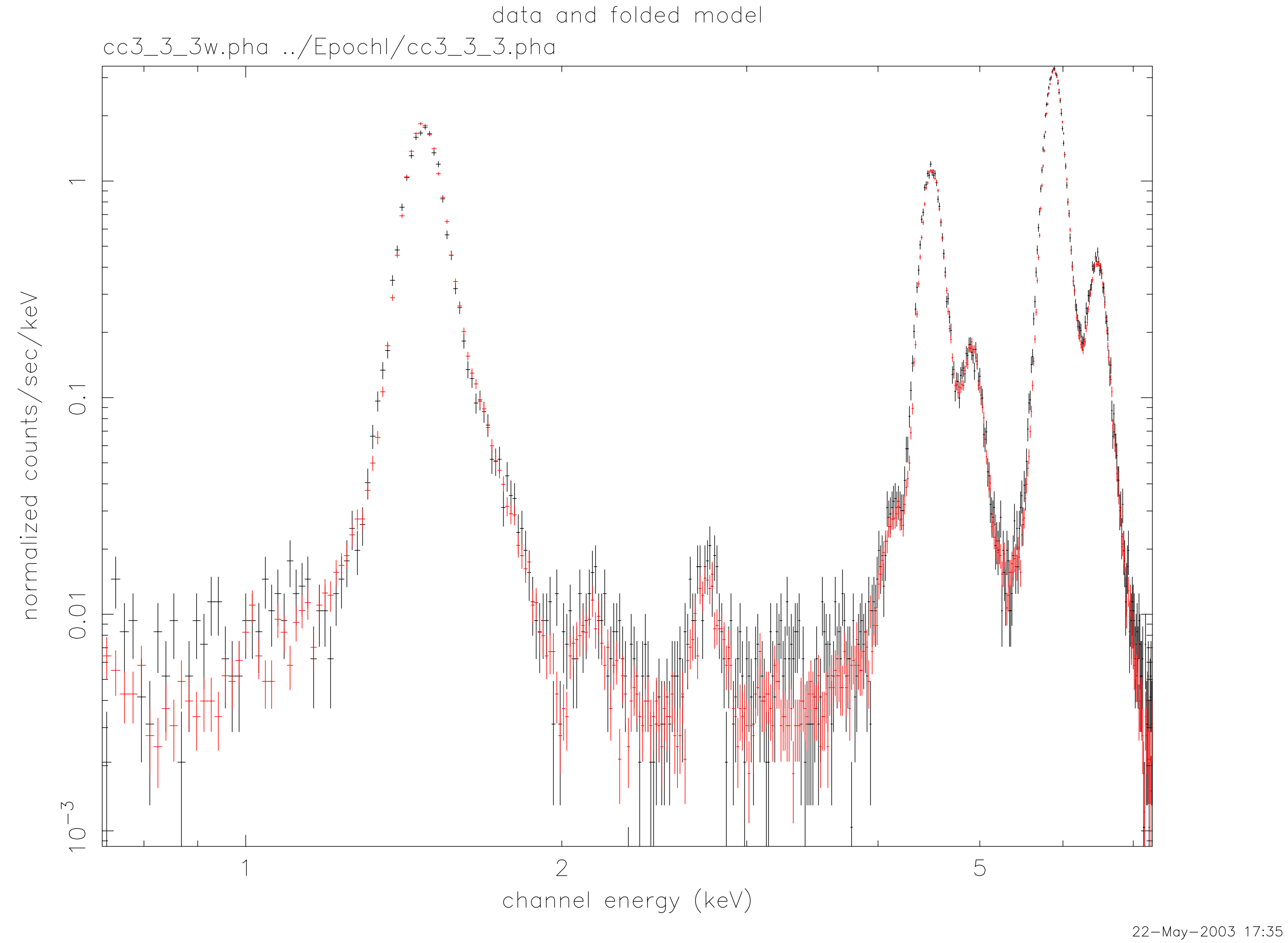
$$\mathrm{PHA}' = \mathrm{PHA} + \Delta\mathrm{PHA}(\mathrm{PHA})$$

Time dependence



Gain changes (ΔPHA at 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,

yseg	AlKa,1.487keV % Diff	TiKa,4.510keV % Diff	MnKa,5.898keV % 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	-0.097	-0.085
Standard deviation	0.129	0.069	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

Software

- ARD and software spec for `acis_process_events` prepared.
- expect correction implemented in CIAO 3.x where $x > 0$ (3–4 months?)
- `corr_tgain` released on the software exchange page (June 5).

`corr_tgain` thread

1. Save the data:
   ```
   cp evt2.fits evt2-save.fits
   ```
2. Select the appropriate calibration file (latest still appropriate for your data):
   ```
   % ls corrgain*.fits
   corrgain2000-01-29.fits  corrgain2001-02-01.fits  corrgain2002-02-01.fits
   corrgain2000-05-01.fits  corrgain2001-05-01.fits  corrgain2002-05-01.fits
   corrgain2000-08-01.fits  corrgain2001-08-01.fits  corrgain2002-11-01.fits
   corrgain2000-11-01.fits  corrgain2001-11-01.fits
   ```
3. `corr_tgain evt2.fits -tgain corrgain2002-02-01.fits`
4. Recompute the photon energies and PI values:
   ```
   acis_process_events infile=evt2.fits outfile=gov.fits\
   acaofffile=none stop=none\
   gainfile=/soft/ciao/CALDB/data/chandra/acis/bcf/gain/acisD2000-01-29gain_ct
   gradefile=none apply_cti=no doevtgrade=no calculate_pi=yes check_vf_pha=no\
   clobber+

   mv gov.fits evt2.fits
   ```

Conclusions

- Simple correction algorithm
- No RMF re-calibration
- Contributed software available, expect automatic correction in a future CIAO release