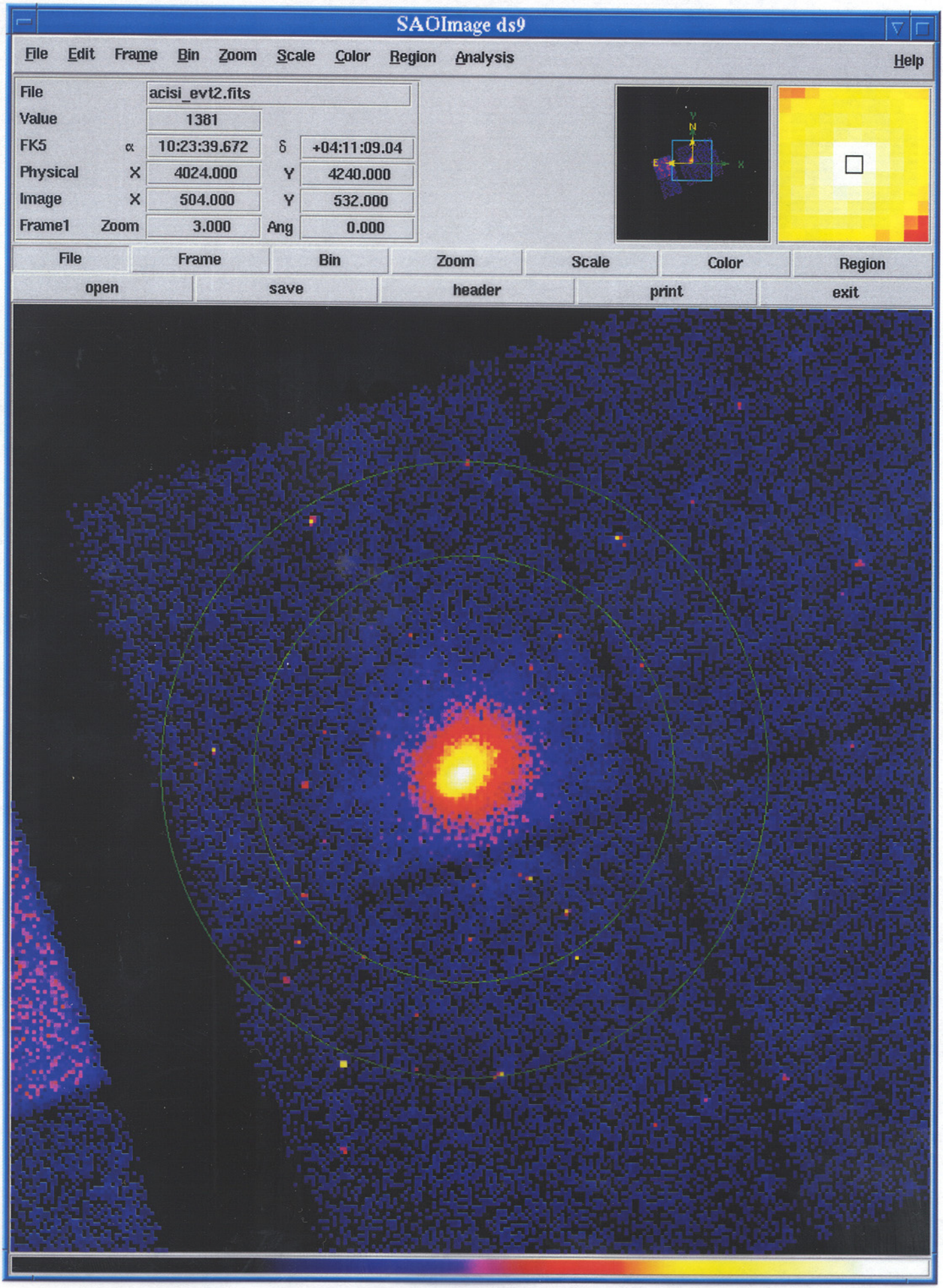
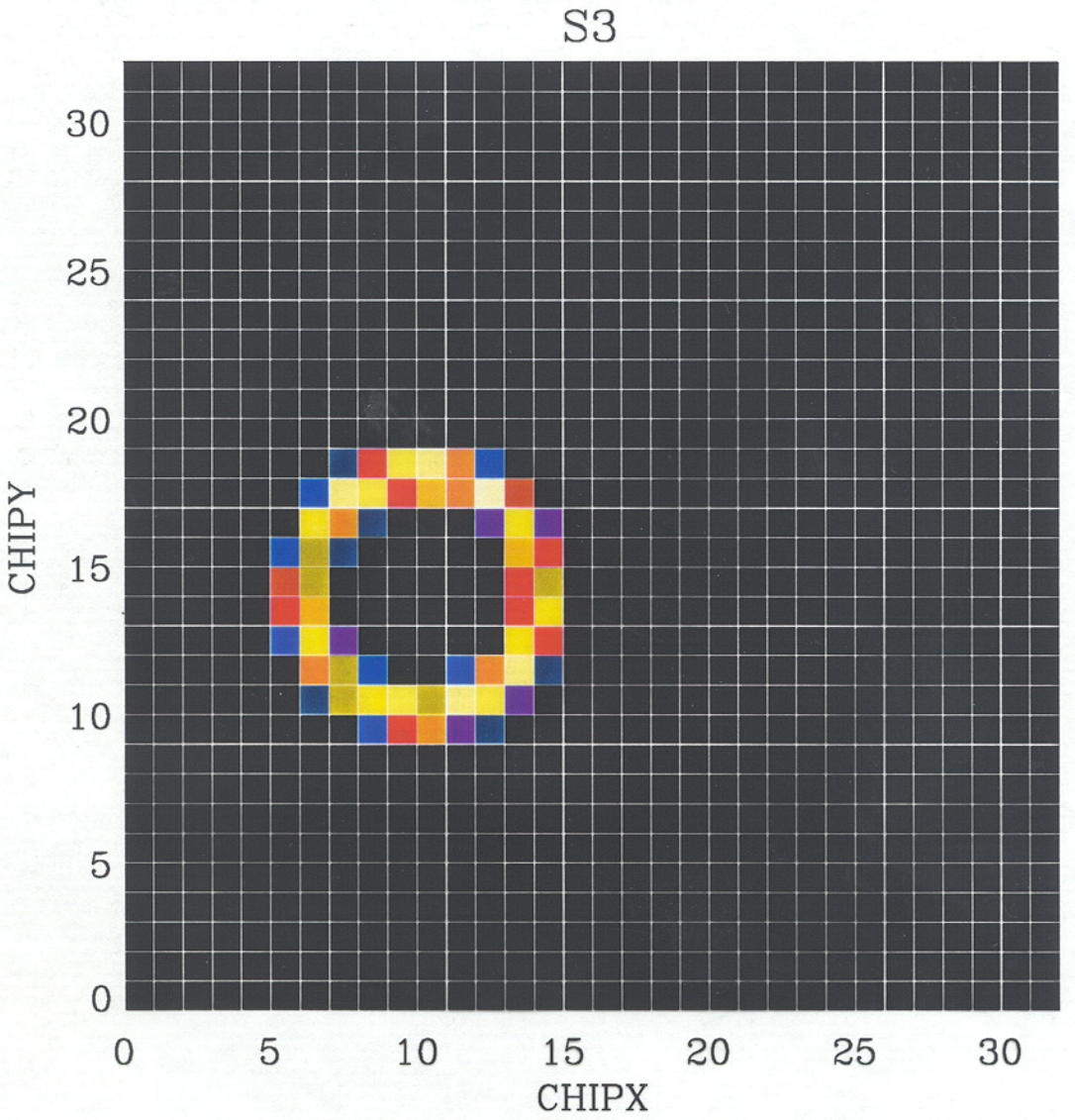
Spatially Dependent Detector Properties

- Discussion limited to ACIS
- Properties different for FI (ACIS-I) and BI (ACIS-S) chips
  - Calibration on 32x32 pixel scale on S3
  - Calibration on 64x64 pixel scale on S1
  - Calibration on 256x32 pixel scale on all FI chips
- Gain variations (photon energy → detector pulse height)
- Resolution variations ($E/\Delta E$)
- Quantum efficiency variations


SAOImage ds9
File Edit Frame Bin Zoom Scale Color Region Analysis Help
File acisi_evt2.fits
Value 1381
FK5 α 10:23:39.672 δ +04:11:09.04
Physical X 4024.000 Y 4240.000
Image X 504.000 Y 532.000
Frame1 Zoom 3.000 Ang 0.000
File Frame Bin Zoom Scale Color Region
open save header print exit

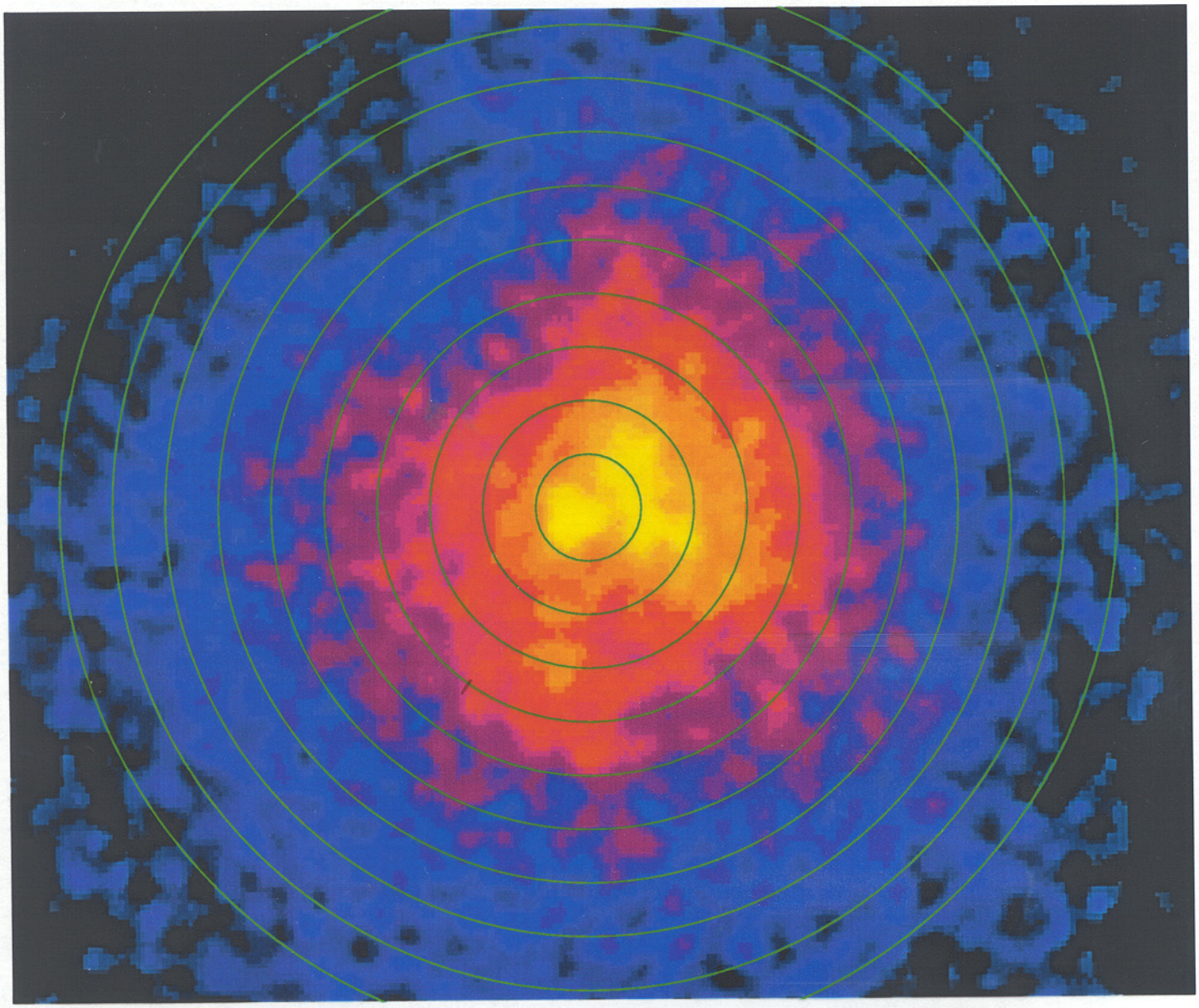

S3
30
25
20
15
10
5
0
CHIPY
0
5
10
15
20
25
30
CHIPX

Variations in Source Properties

- Temperature structure
  - Gradients, shocks, knots, etc
- Density structure
  - Shells, cavities, filaments
- Multiple sources
  - Star clusters, deep fields
- Hard versus Soft spectrum
- Data quality (S/N ratio)

Typical Analysis Tasks

- Spectral Fitting
  - Single spectral fit for extended region (larger than 32x32 pixels)
  - Measuring gradients using mulltiple extraction regions
  - 2D maps of spectral fit parameters
- Imaging Analysis
  - Flat fielding (using exposure maps)
  - Narrow and broad band images
  - Hardness ratios
  - Surface brightness profiles

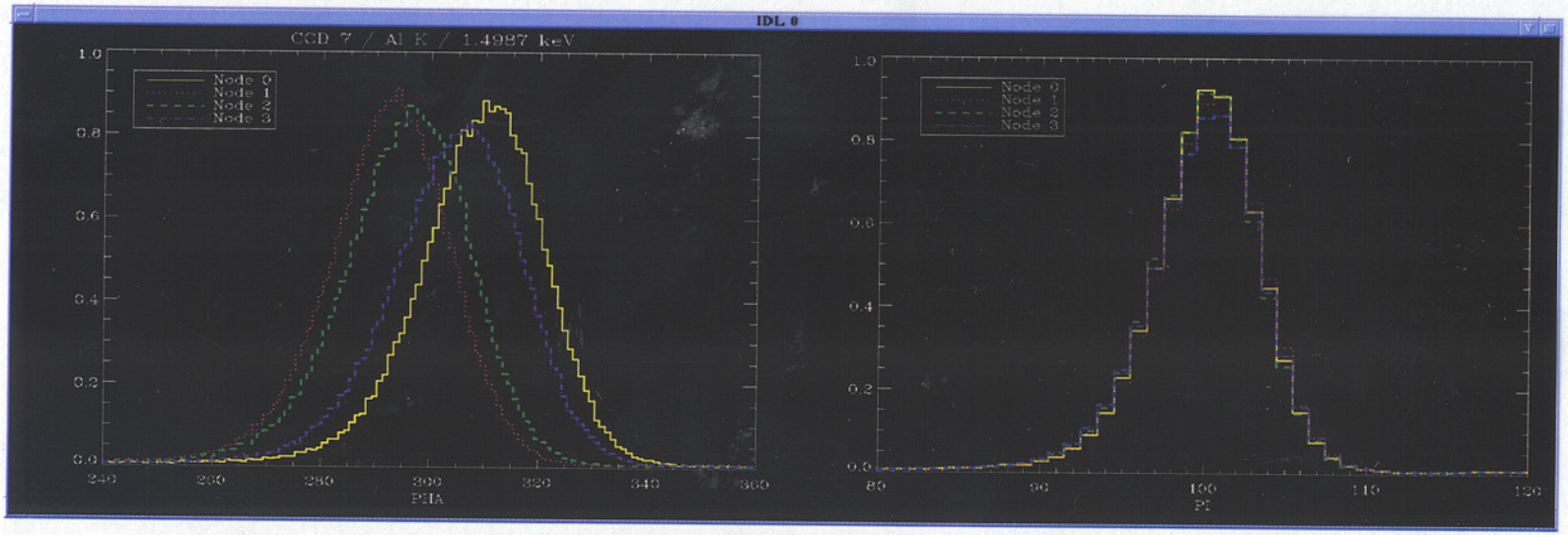


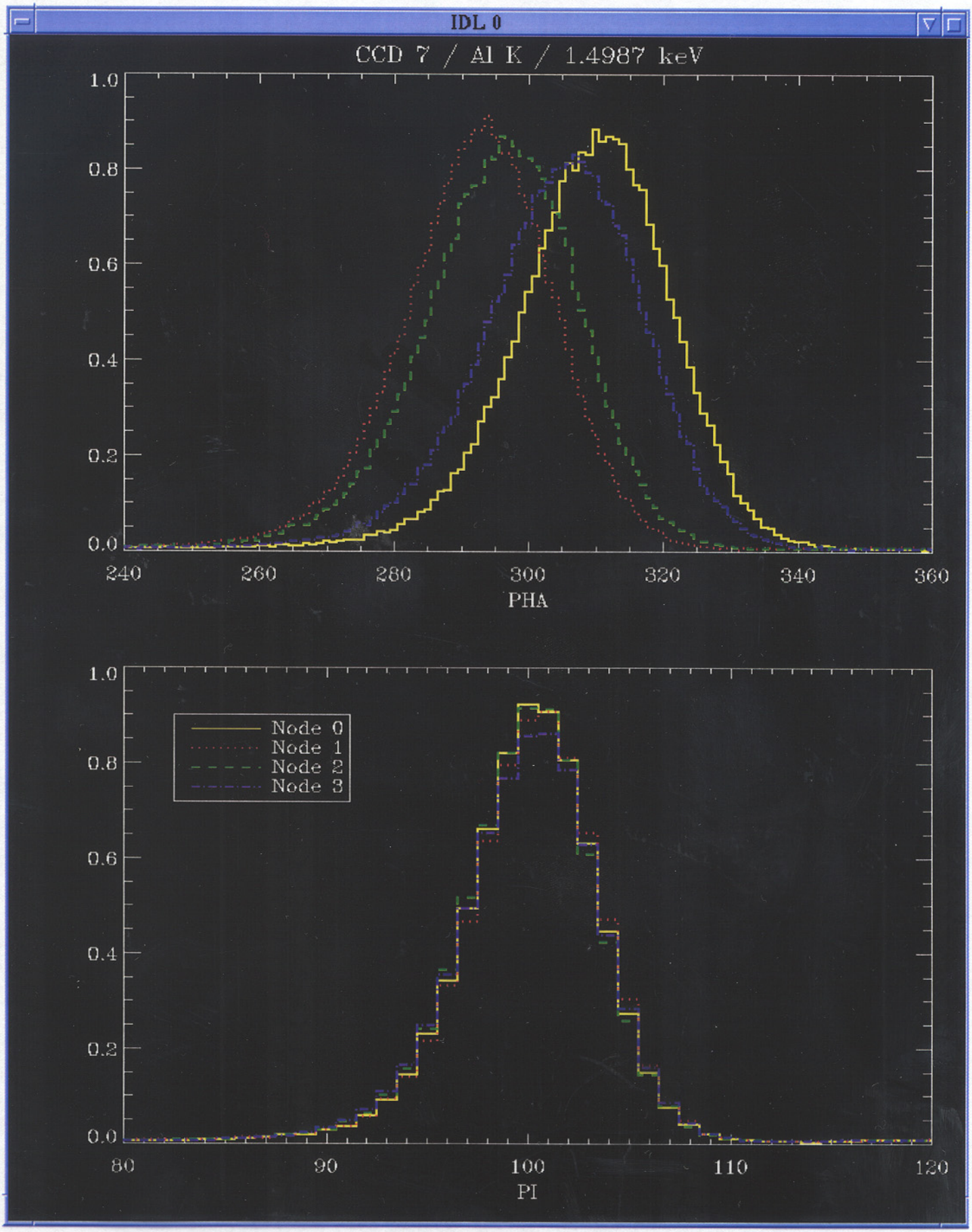
Gain Variations

- Appreciable on S3 (~5%)
- Stronger on I3 (~15%, due to CTI effects)
- Use of PI channels recommended
- PI values are gain corrected to a uniform linear scale
  - PI = INT(E/14.6) + 1 where E is in eV
- Intrinsic detector gain is non-linear below ~0.7 keV
- Linearization process less accurate at low energies
- Gain calibration less accurate at low energies
- Can contribute to fit residuals at low energies for high S/N

PHA versus PI

- Gain corrected detector channel
- Constructed from PHA FEF data files
- Scaling of PHA data preserves resolution: $(E/\Delta E)_{PI} = (E/\Delta E)_{PHA}$
- Linear energy scale $\Rightarrow$ PI = INT(E / 14.6 eV) + 1
- Does **not** correct for spatial variations in resolution
- Recommended for extended source analysis




IDL 0
CCD 7 / Al K / 1.4987 keV
1.0
0.8
0.6
0.4
0.2
0.0
240
260
280
300
320
340
360
PHA
Node 0
Node 1
Node 2
Node 3
1.0
0.8
0.6
0.4
0.2
0.0
80
90
100
110
120
PI

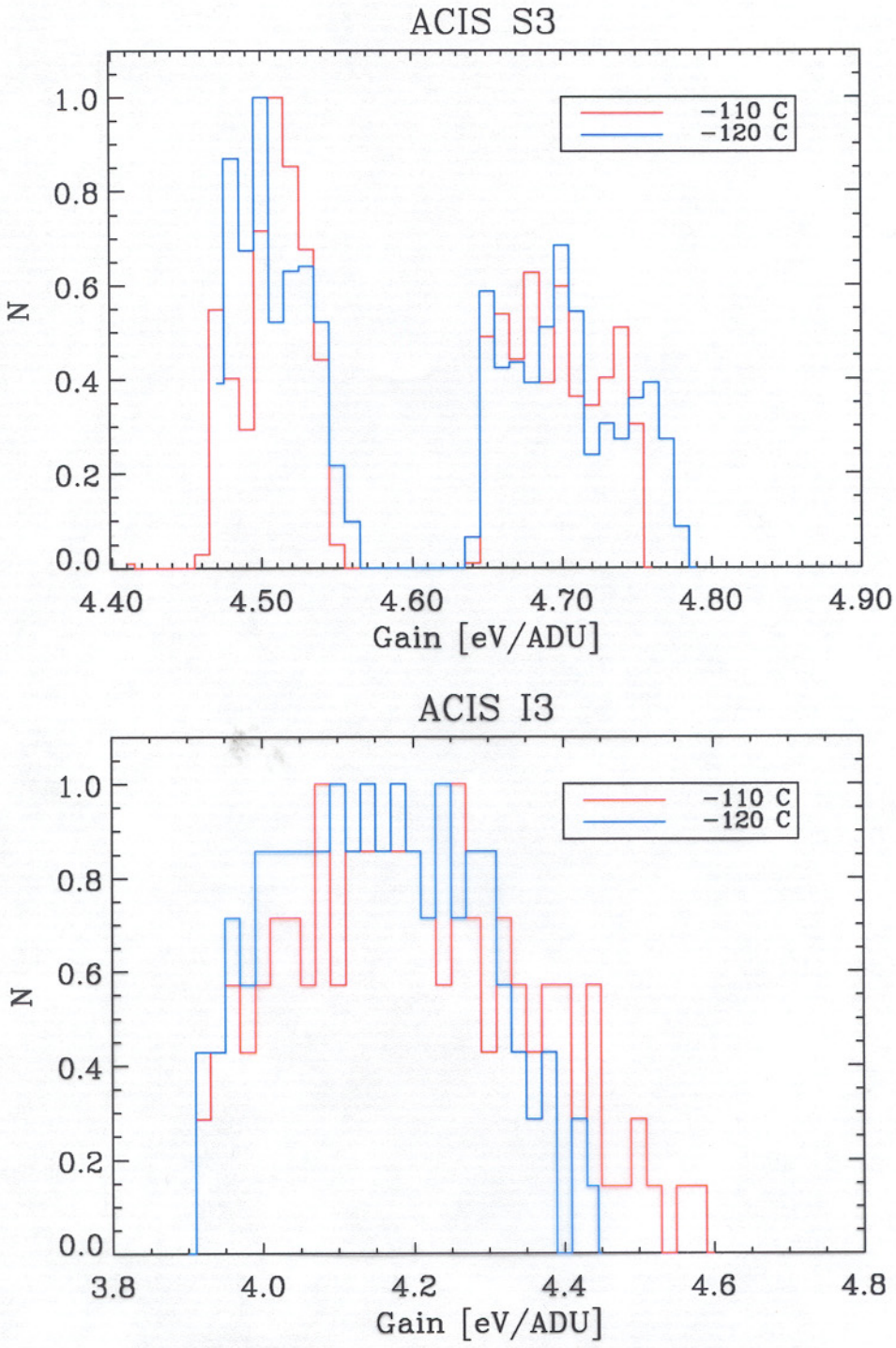


Figure 6: Histogram of ACIS S3 and I3 Gain Variations.

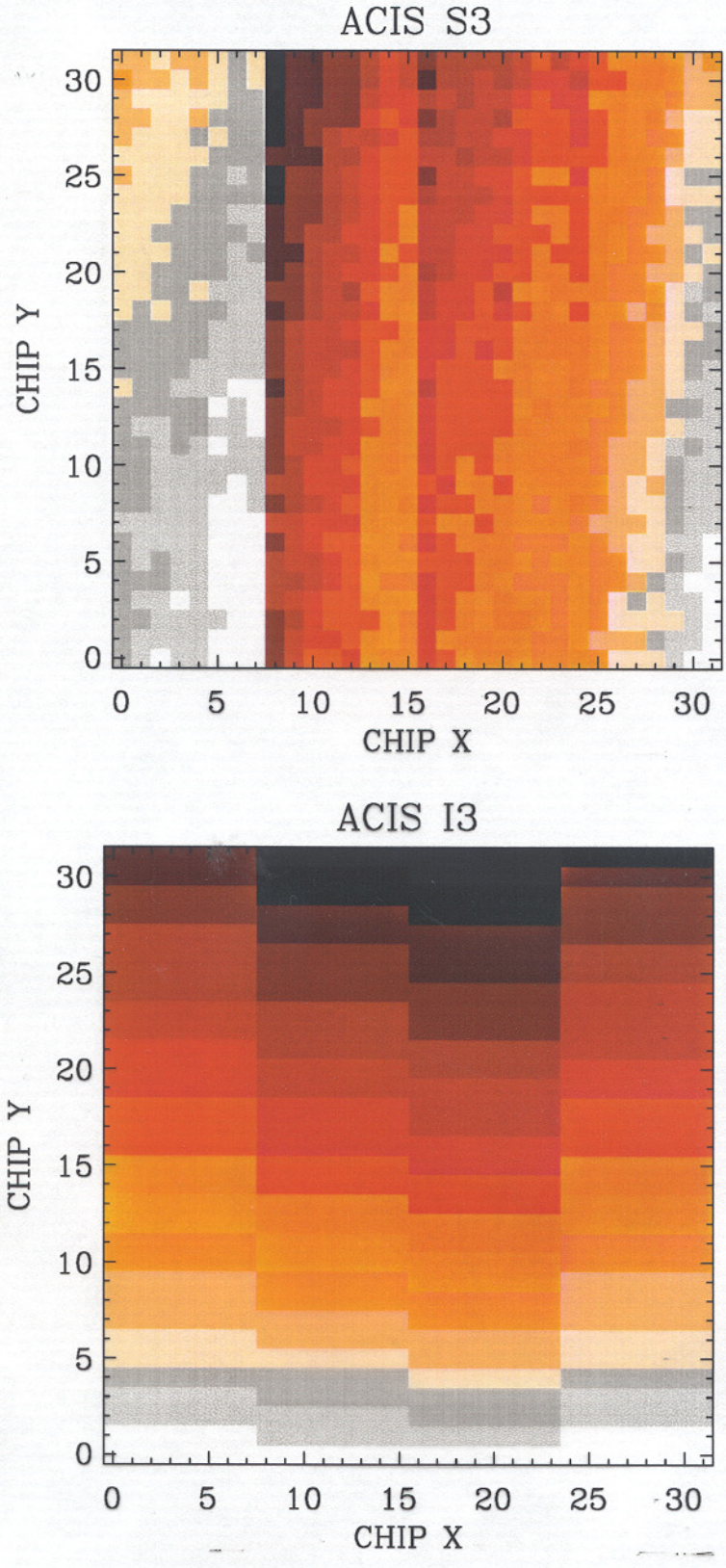


Figure 3: ACIS Gain variations. Notice the size of the squares.

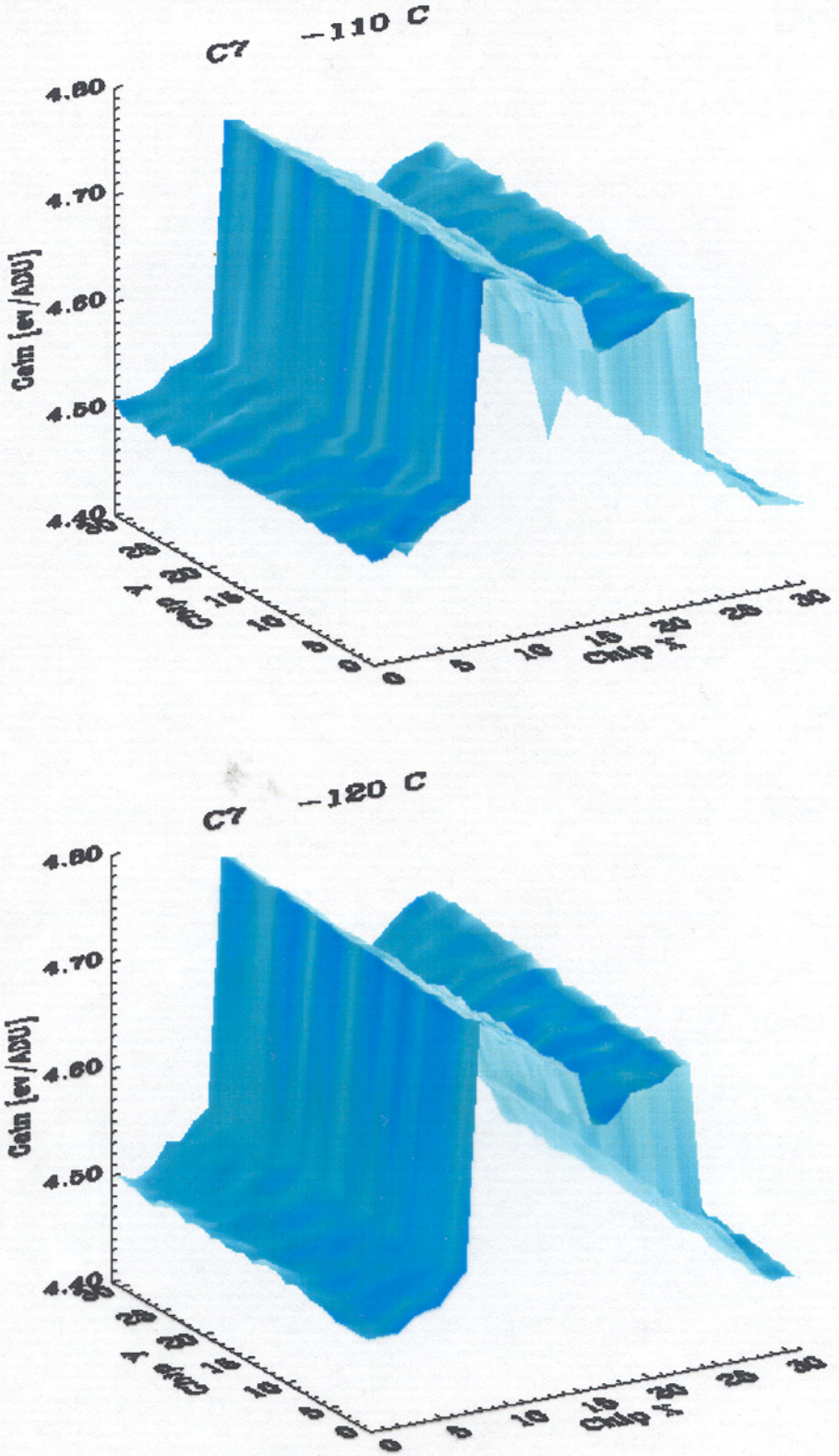


Figure 4: ACIS Gain variations. Notice the size of the squares.

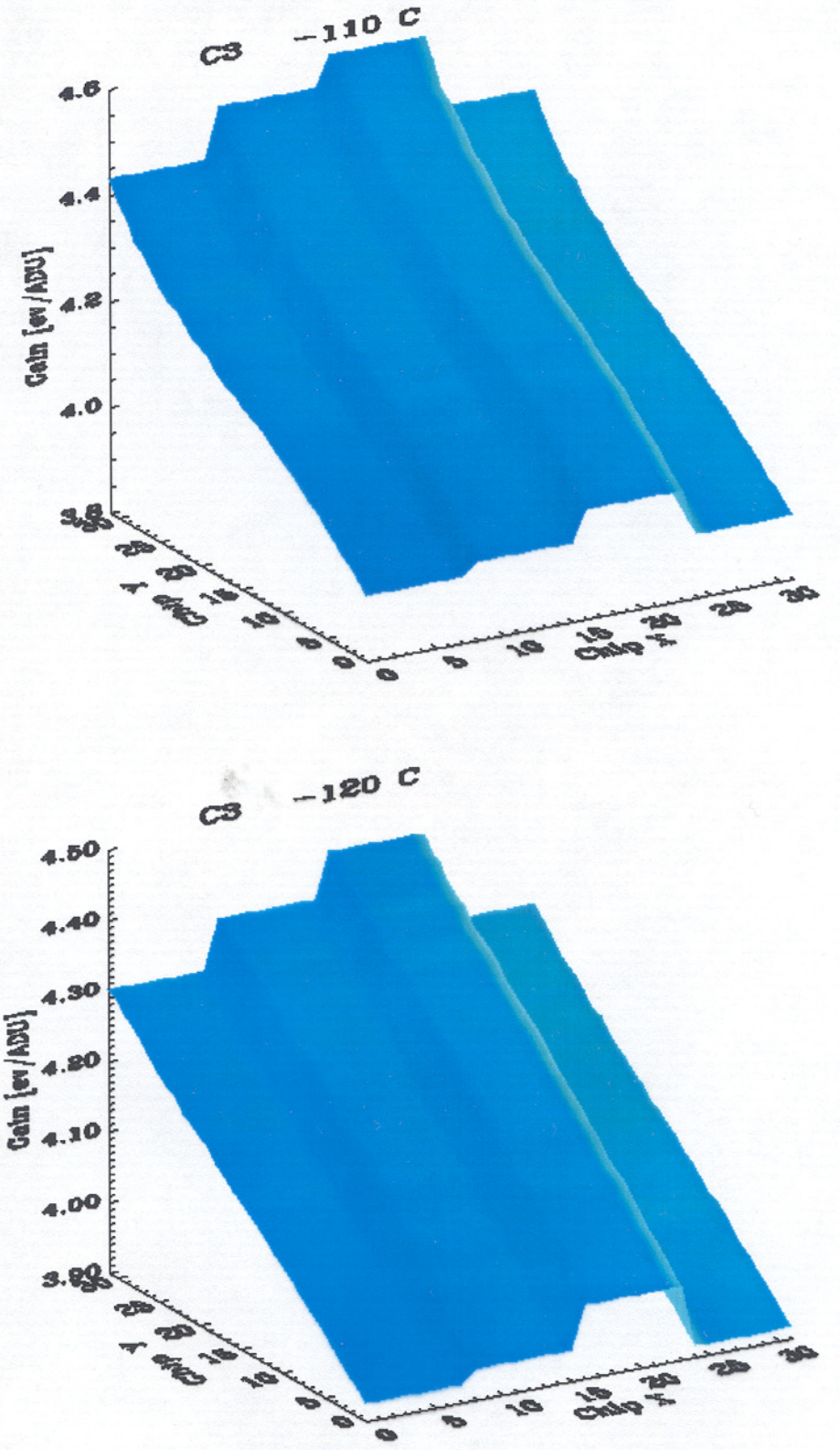
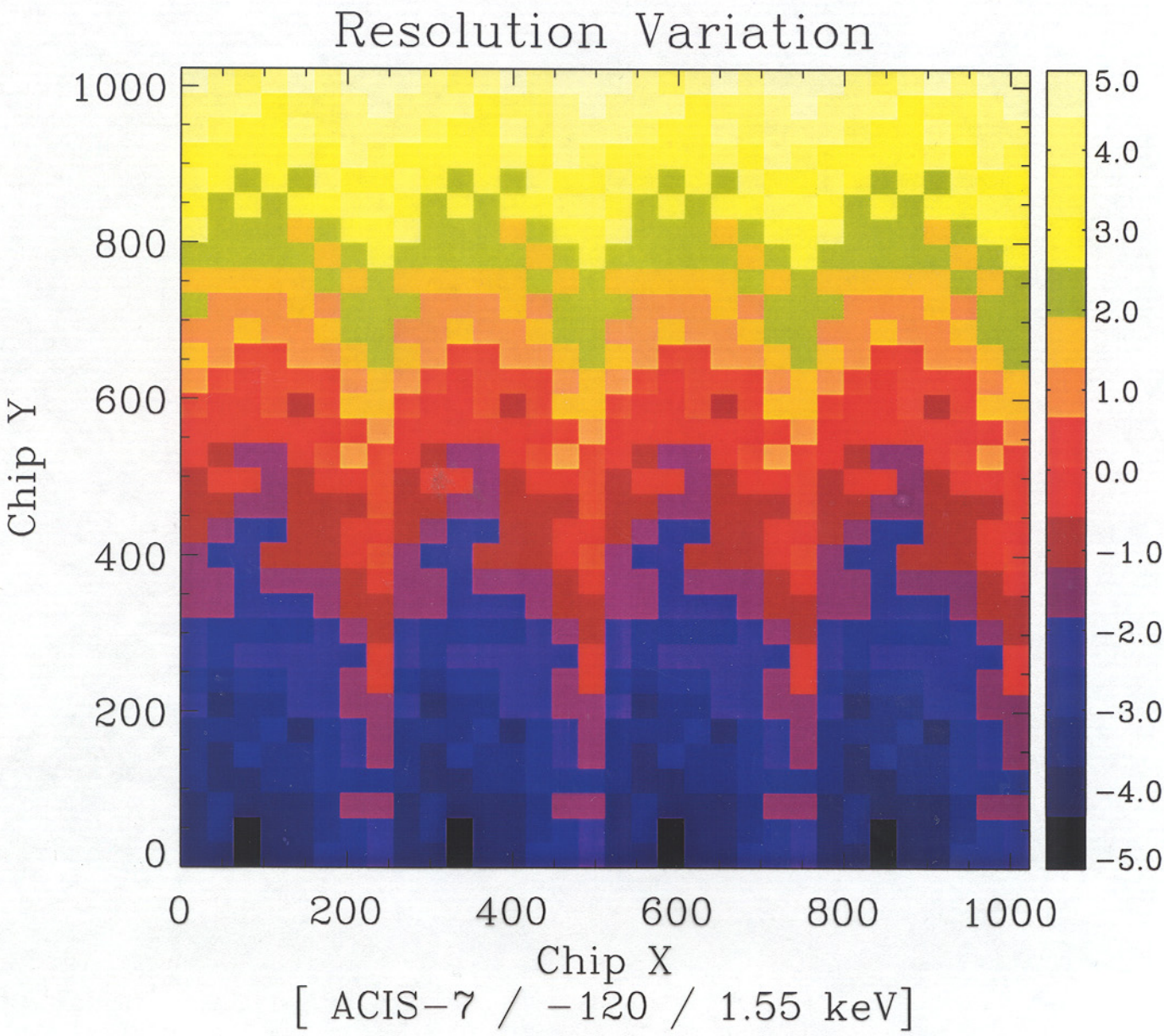


Figure 5: ACIS Gain variations. Notice the size of the squares.

Resolution Variations

- Small on S3 (~20% over chip)
- Very strong on I3 (~2-4 over chip)
- Variations larger at lower energies
- Linear decrease in resolution with CHIPY on I3
- Single position RMF typically adequate on S3
- Strong sources on I3
  - multiple RMFs, weighted RMF
- Weak sources on I3
  - single RMF, weighted RMF


Resolution Variation
1000
800
600
400
200
0
Chip Y
0
200
400
600
800
1000
Chip X
[ACIS-7 / -120 / 1.55 keV]
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0

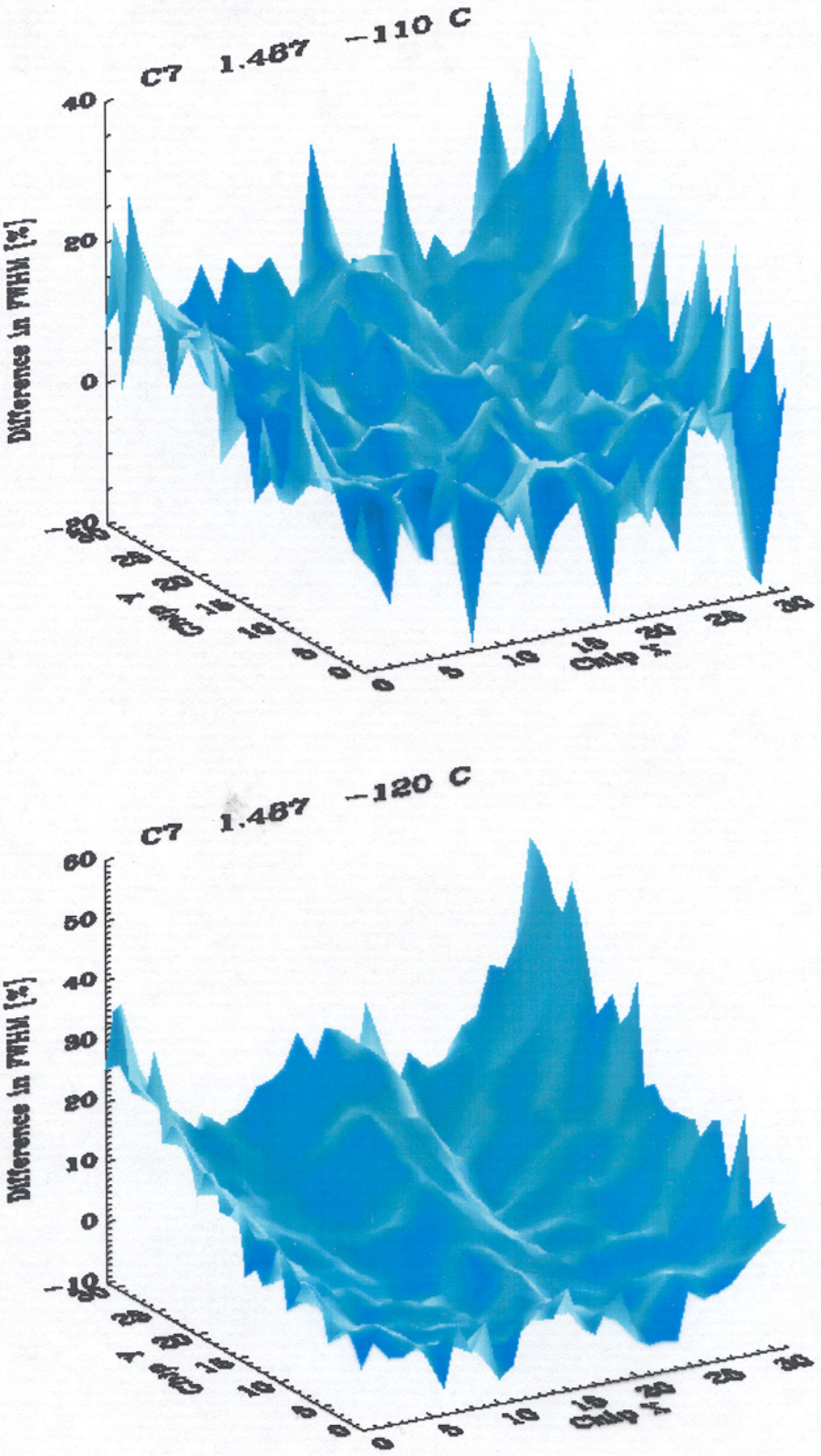


Figure 12: ACIS FWHM variations for S3 at 1.487 keV.

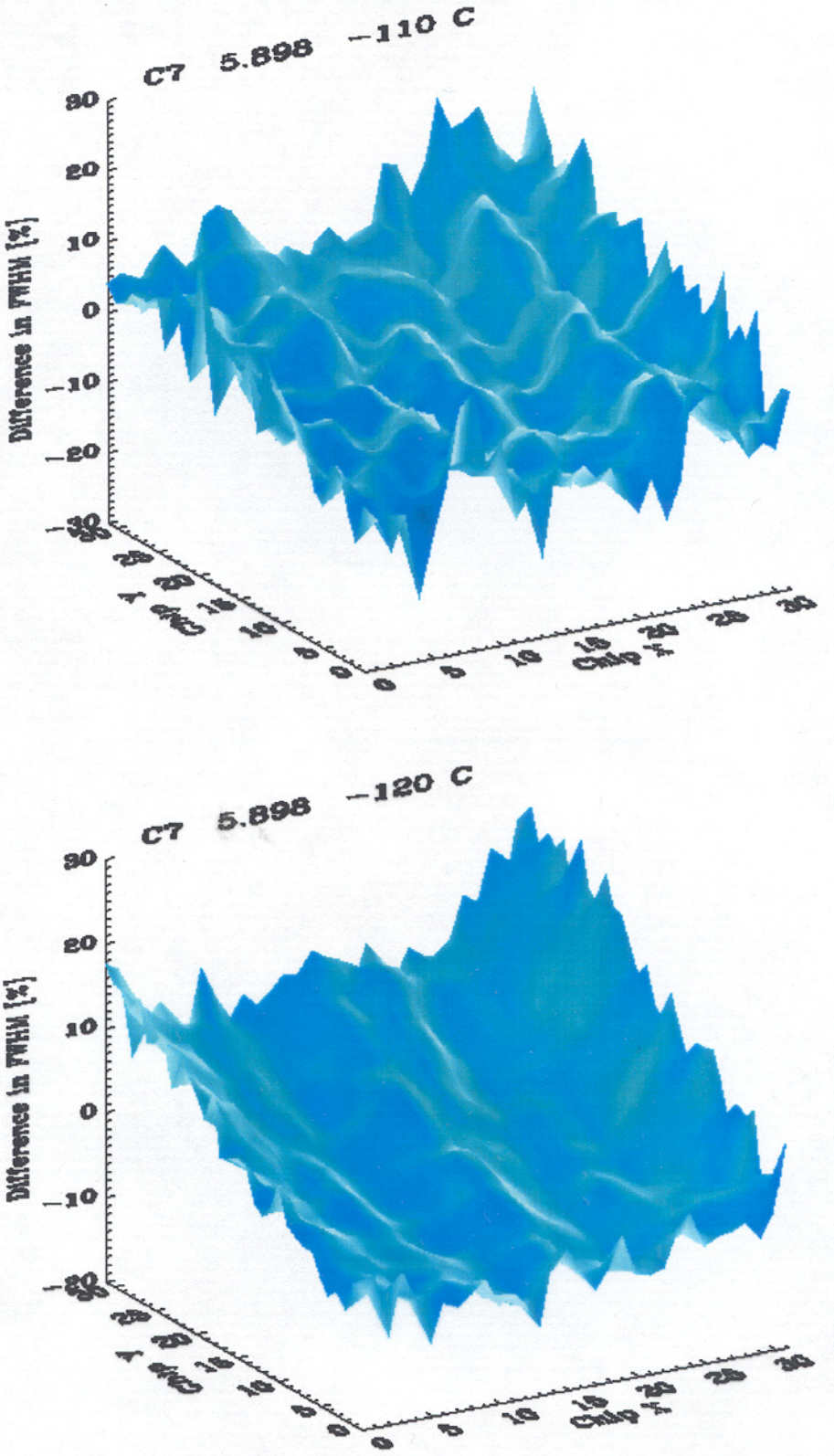


Figure 13: ACIS FWHM variations for S3 at 5.898 keV.

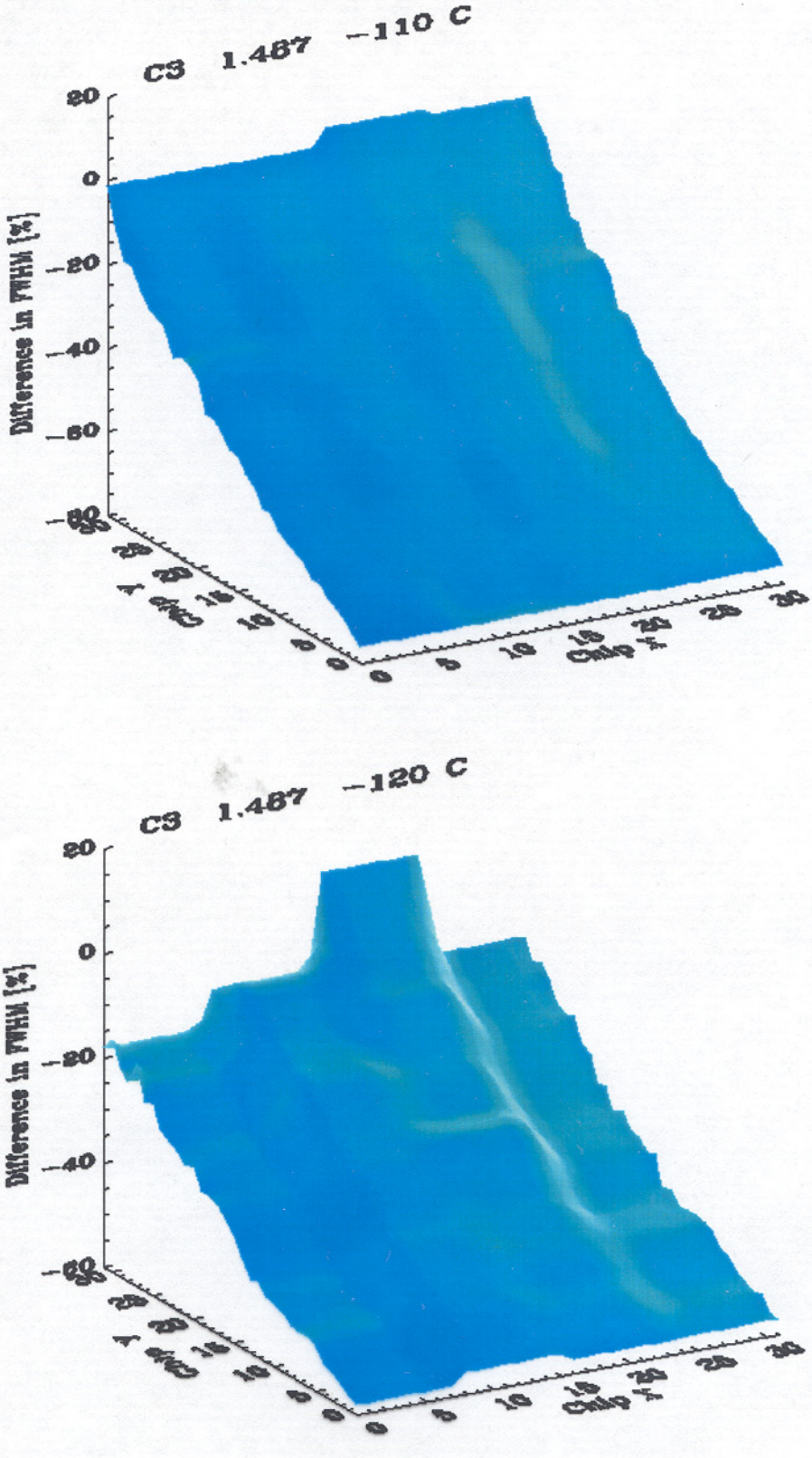


Figure 14: ACIS FWHM variations for I3 at 1.487 keV.

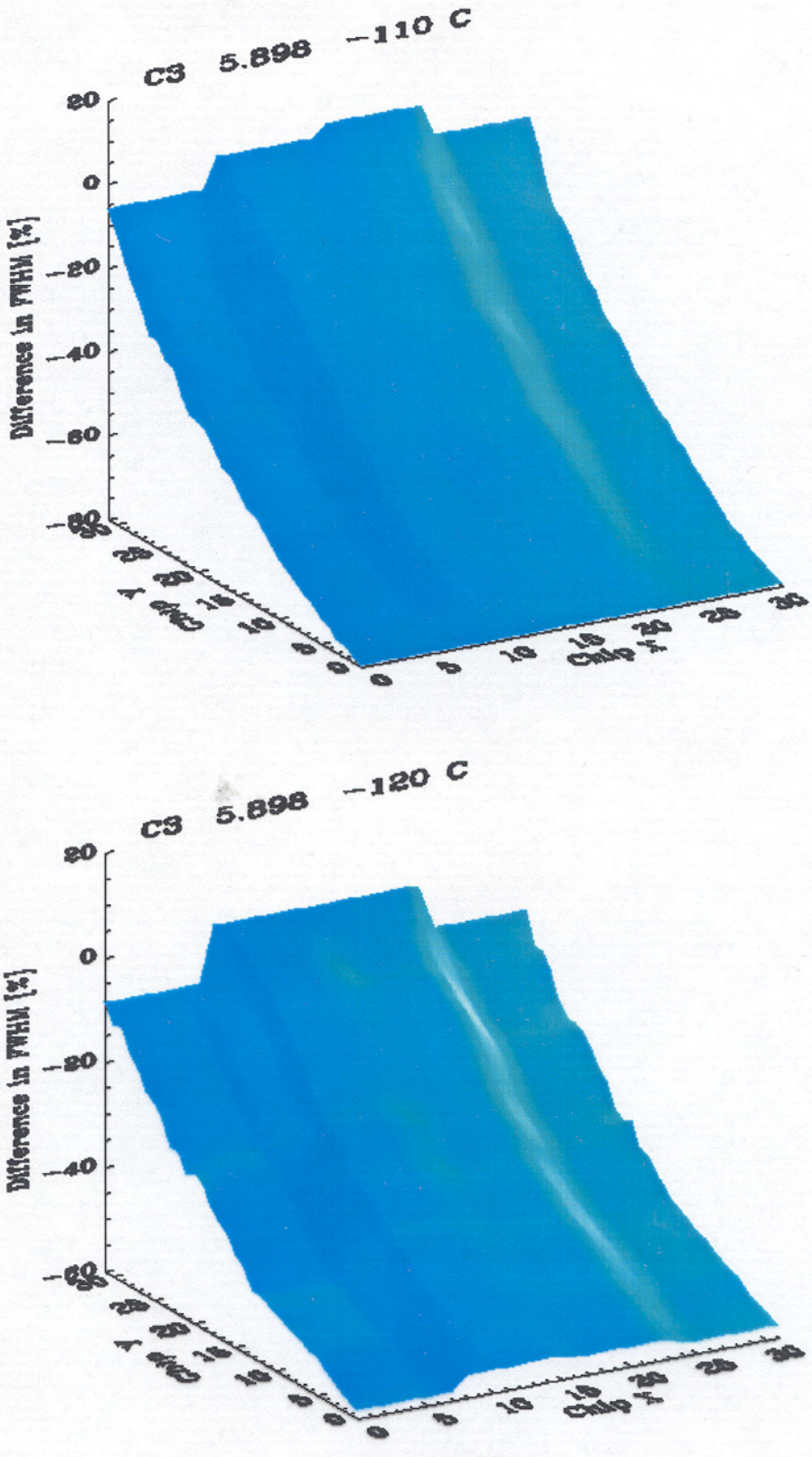
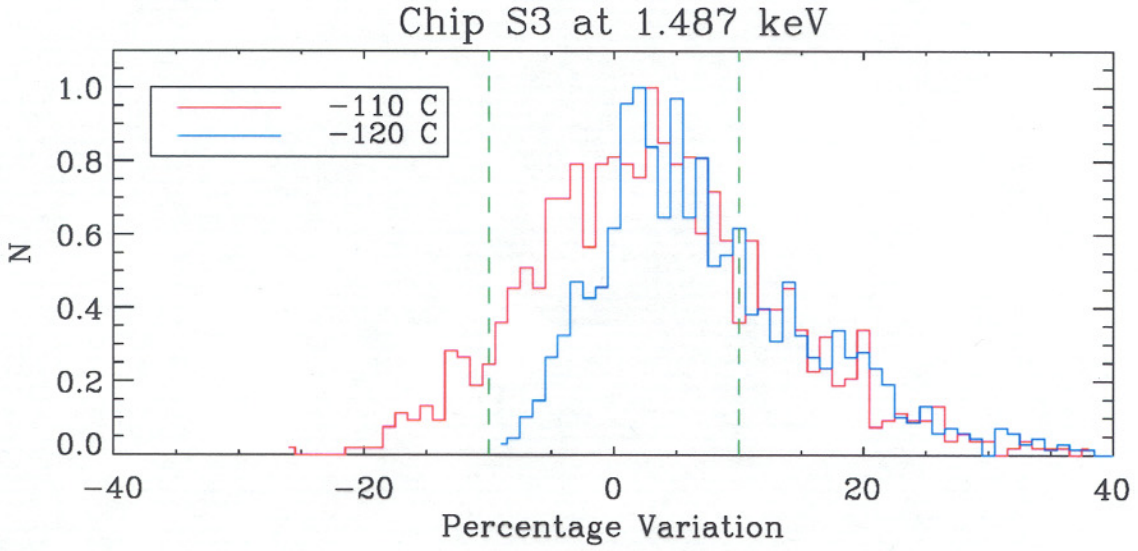
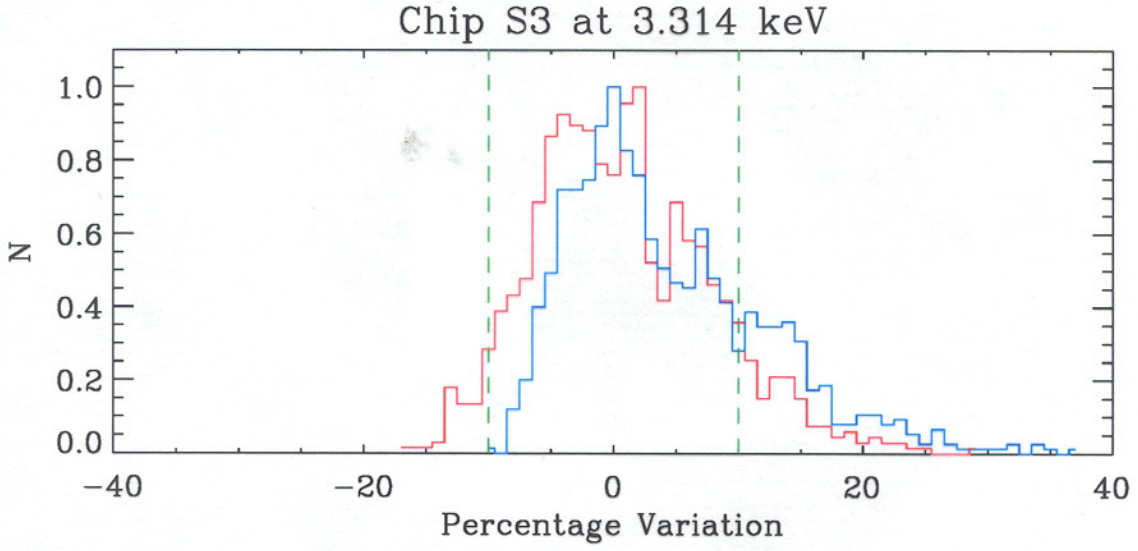


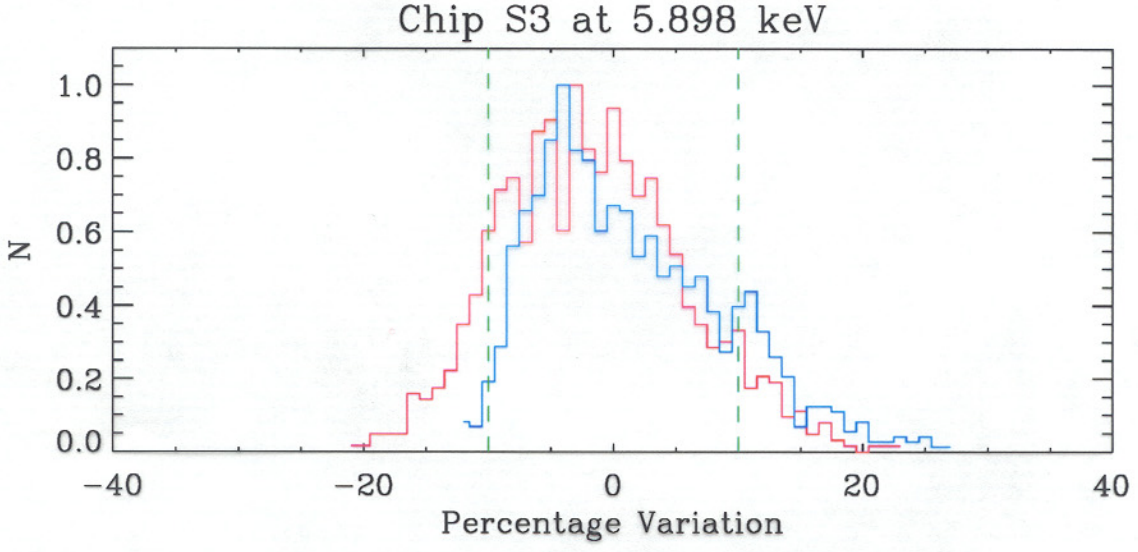
Figure 15: ACIS FWHM variations for I3 at 5.898 keV.

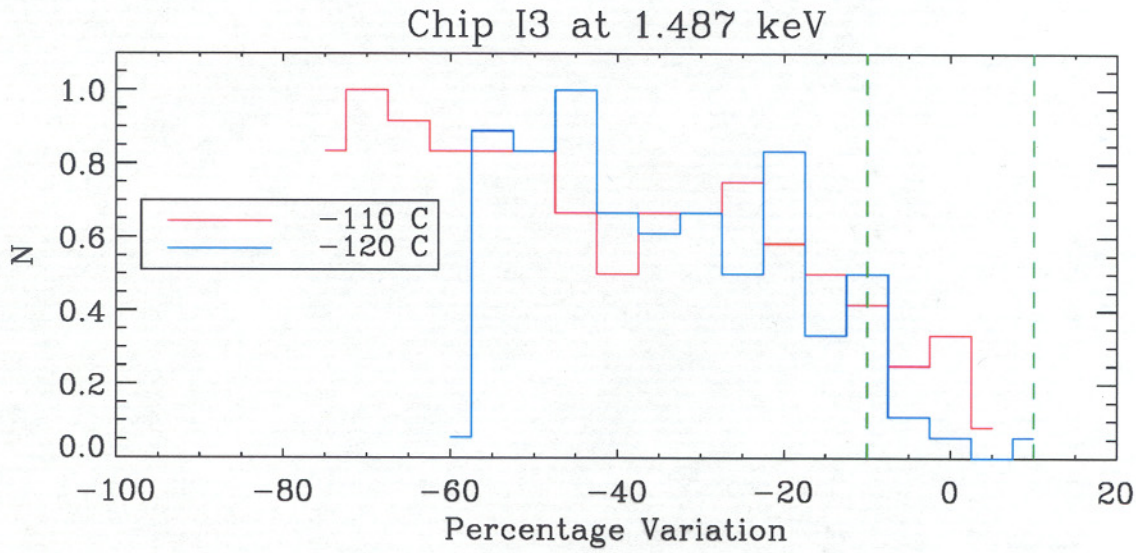
Quantum Efficiency Variations

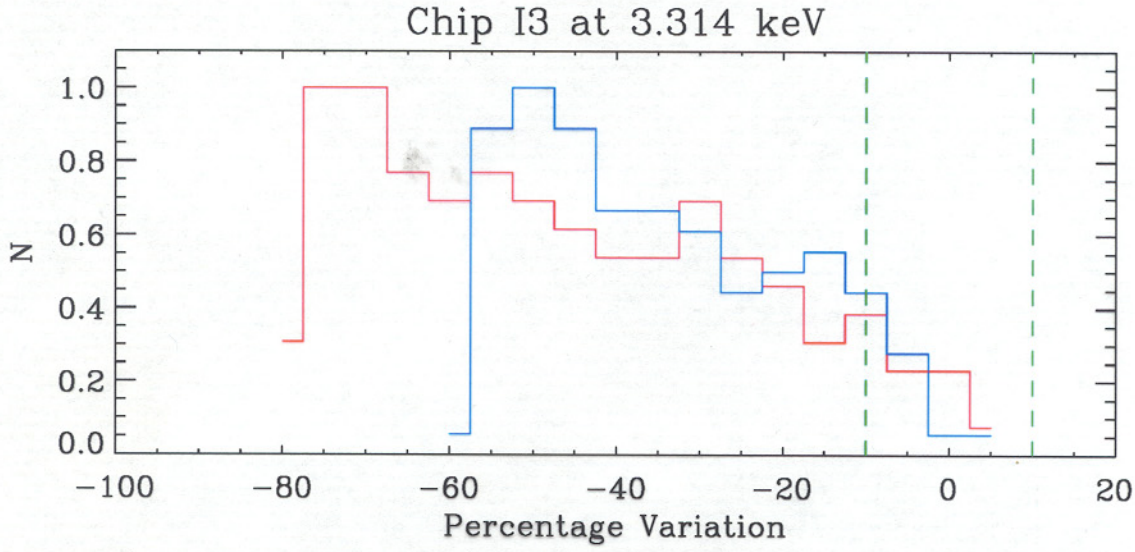
- Non-uniform on S3
- Small ~10% on S3 at all energies
- Correlated with CHIPY on I3 due to CTI
- Effect less than 5% below 1.0 keV on I3
- Variation ~30% at 6.0 keV over I3 chip
- Recommend weighted ARFs for very large regions

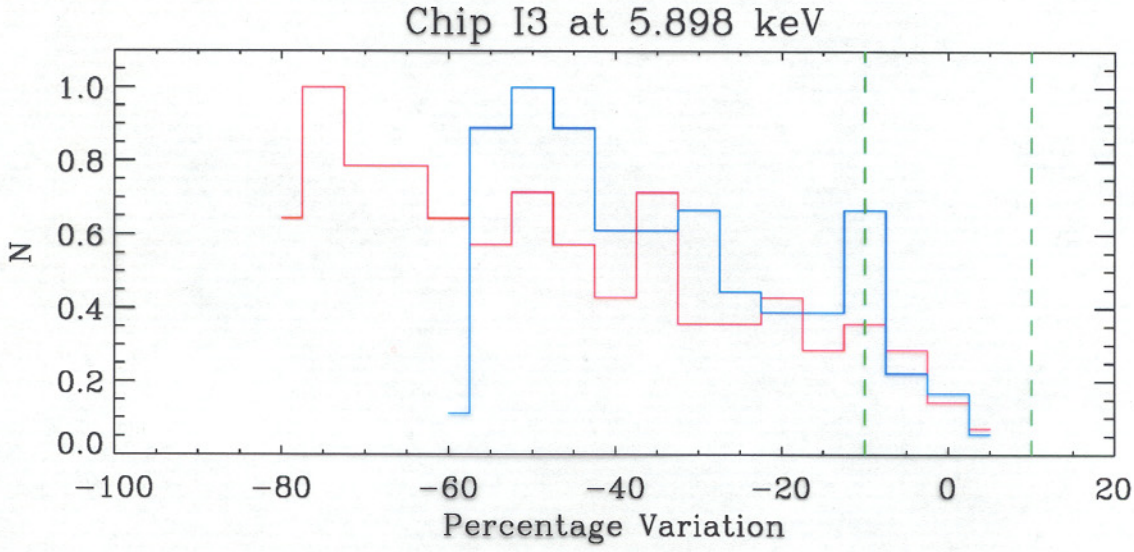

Chip S3 at 1.487 keV
−110 C
−120 C
N
1.0
0.8
0.6
0.4
0.2
0.0
−40
−20
0
20
40
Percentage Variation

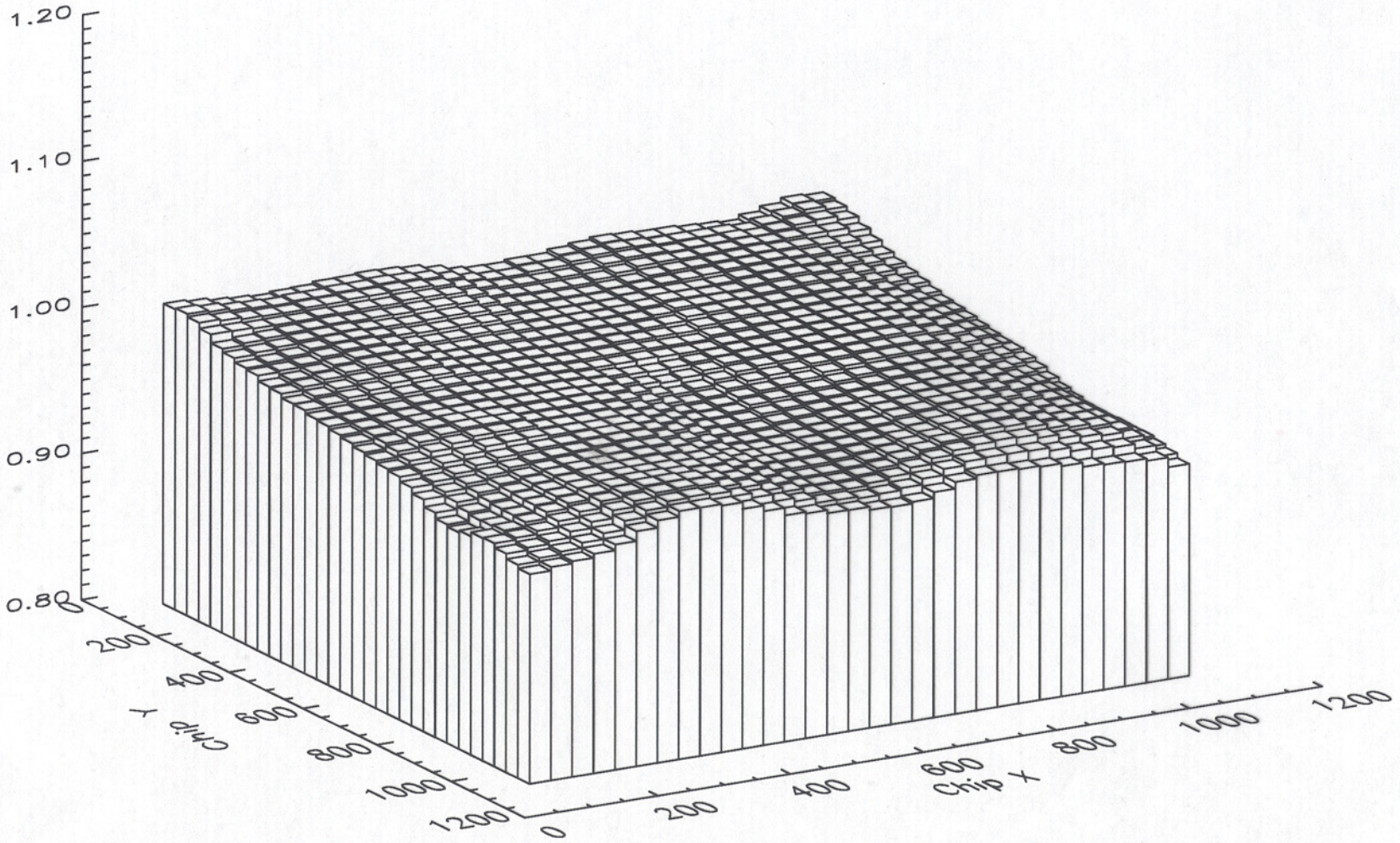

Chip S3 at 3.314 keV
N
1.0
0.8
0.6
0.4
0.2
0.0
−40
−20
0
20
40
Percentage Variation

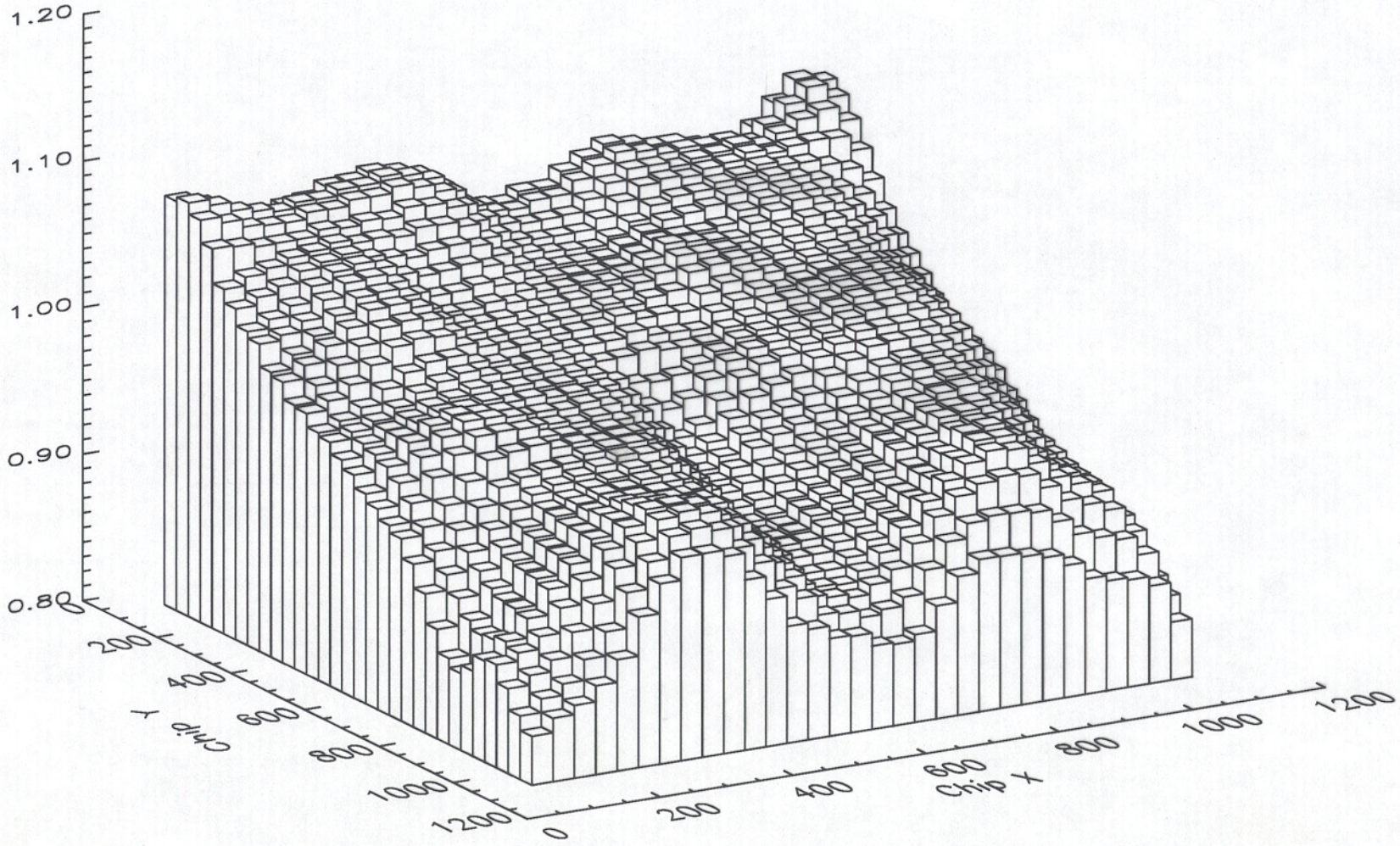

Chip S3 at 5.898 keV
N
1.0
0.8
0.6
0.4
0.2
0.0
−40
−20
0
20
40
Percentage Variation

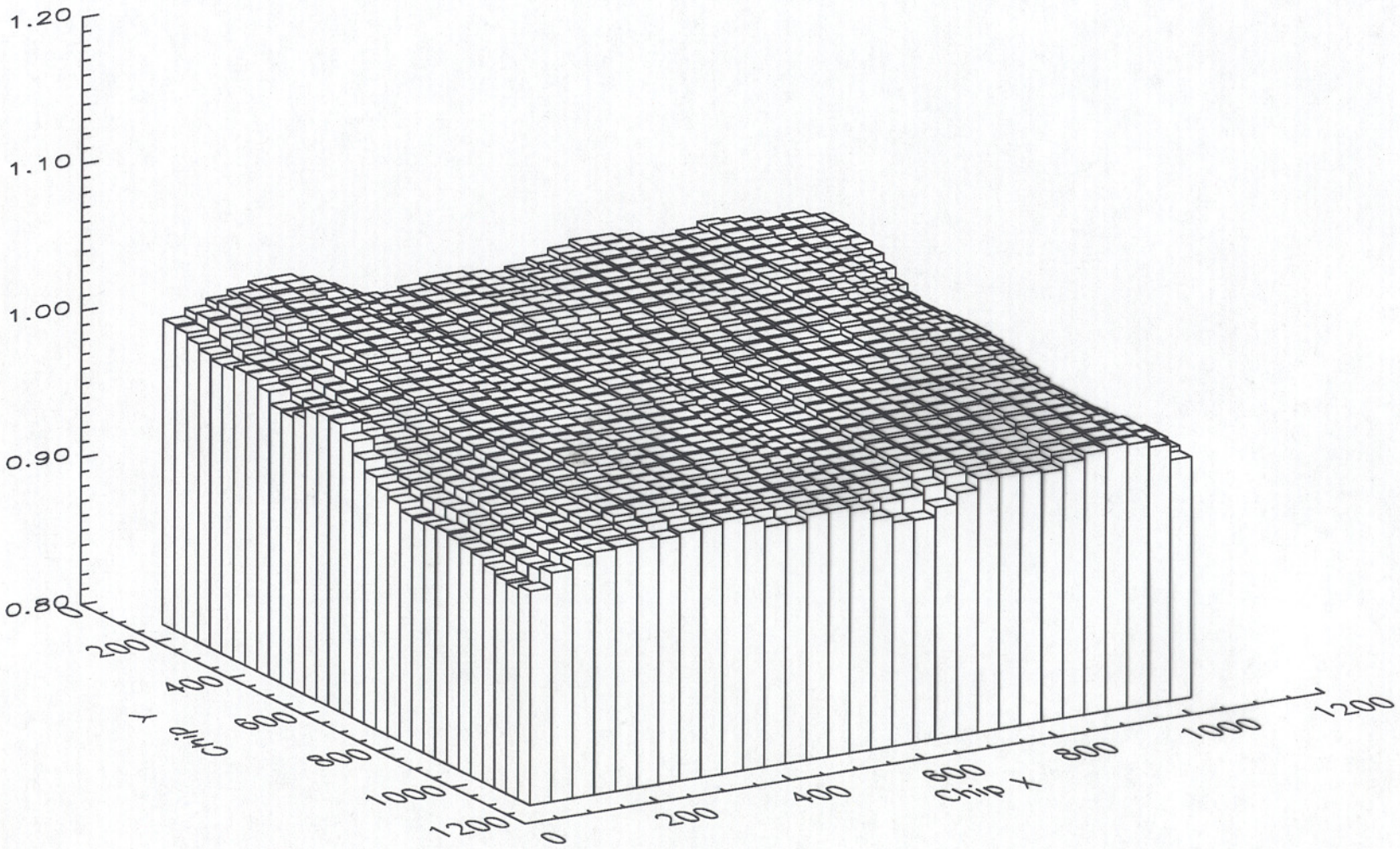

Chip I3 at 1.487 keV
−110 C
−120 C
N
Percentage Variation

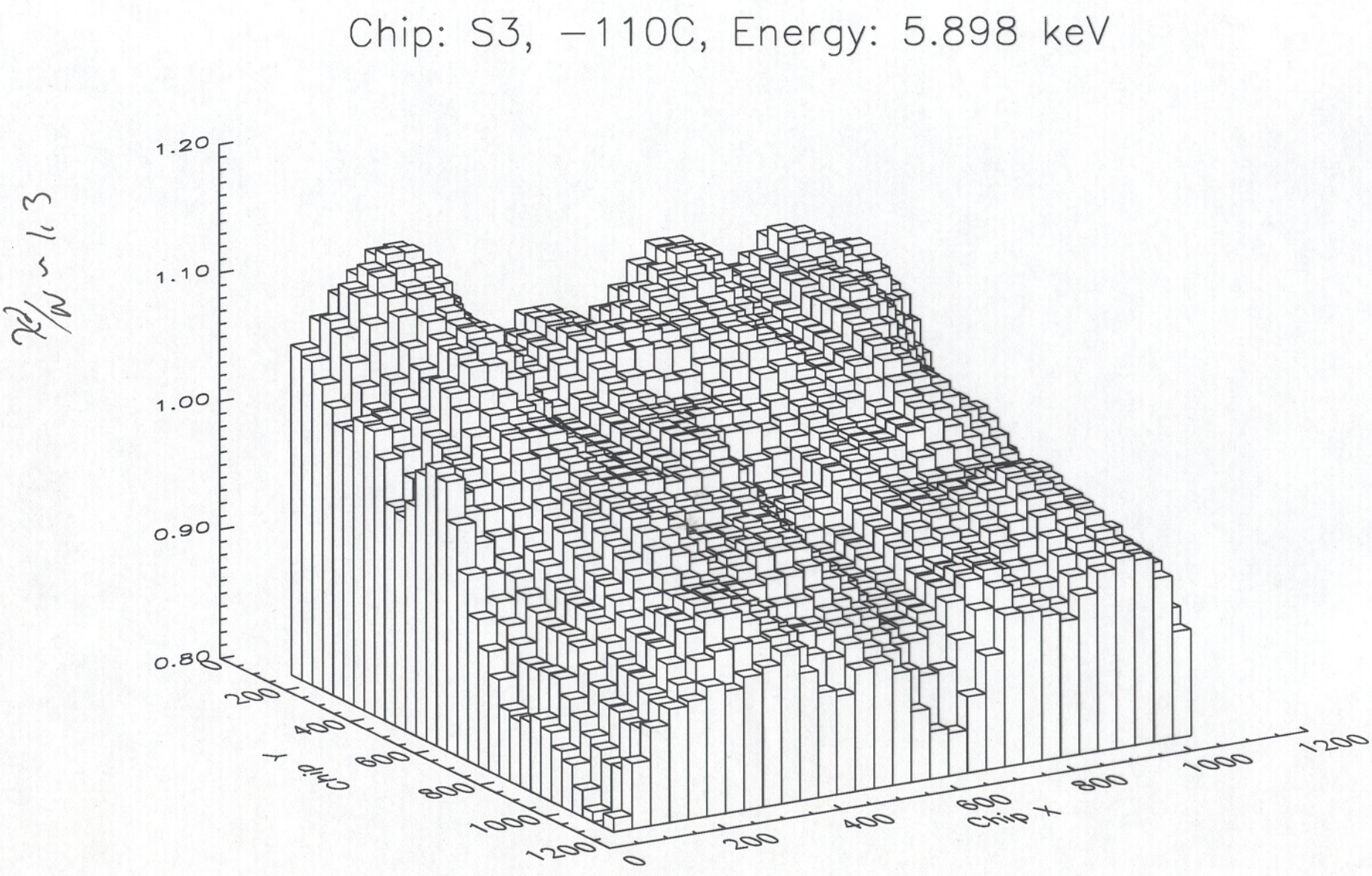

Chip I3 at 3.314 keV
N
Percentage Variation

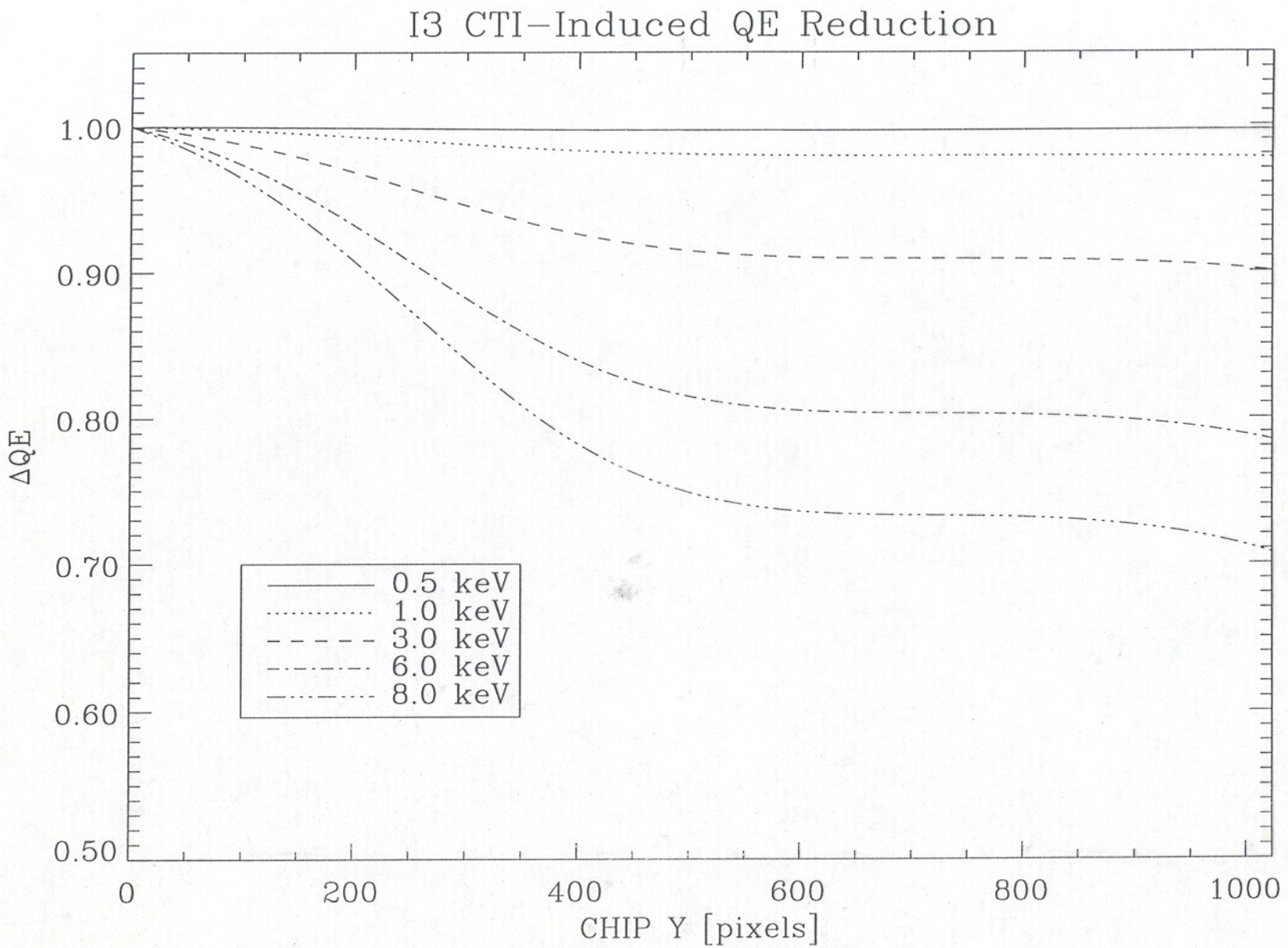

Chip I3 at 5.898 keV
N
Percentage Variation


Chip: S3, −120C, Energy: 1.487 keV
1.20
1.10
1.00
0.90
0.80
0
200
400
600
800
1000
1200
Chip Y
0
200
400
600
800
1000
1200
Chip X
MIT/CXC Tue Jun 27 12:03:02 2000


Chip: S3, −120C, Energy: 5.898 keV
1.20
1.10
1.00
0.90
0.80
0
200
400
600
800
1000
1200
Chip Y
0
200
400
600
800
1000
1200
Chip X
MIT/CXC Tue Jun 27 12:03:02 2000


Chip: S3, −110C, Energy: 1.487 keV
1.20
1.10
1.00
0.90
0.80
0
200
400
600
800
1000
1200
Chip Y
0
200
400
600
800
1000
1200
Chip X
MIT/CXC Tue Jun 27 11:19:07 2000


Chip: S3, −110C, Energy: 5.898 keV
1.20
1.10
1.00
0.90
0.80
200
400
600
800
1000
1200
Chip Y
0
200
400
600
800
1000
1200
Chip X
MIT/CXC Tue Jun 27 11:19:07 2000


I3 CTI-Induced QE Reduction
1.00
0.90
0.80
0.70
0.60
0.50
ΔQE
0
200
400
600
800
1000
CHIP Y [pixels]
0.5 keV
1.0 keV
3.0 keV
6.0 keV
8.0 keV