ACIS MODELING AND ANALYSIS

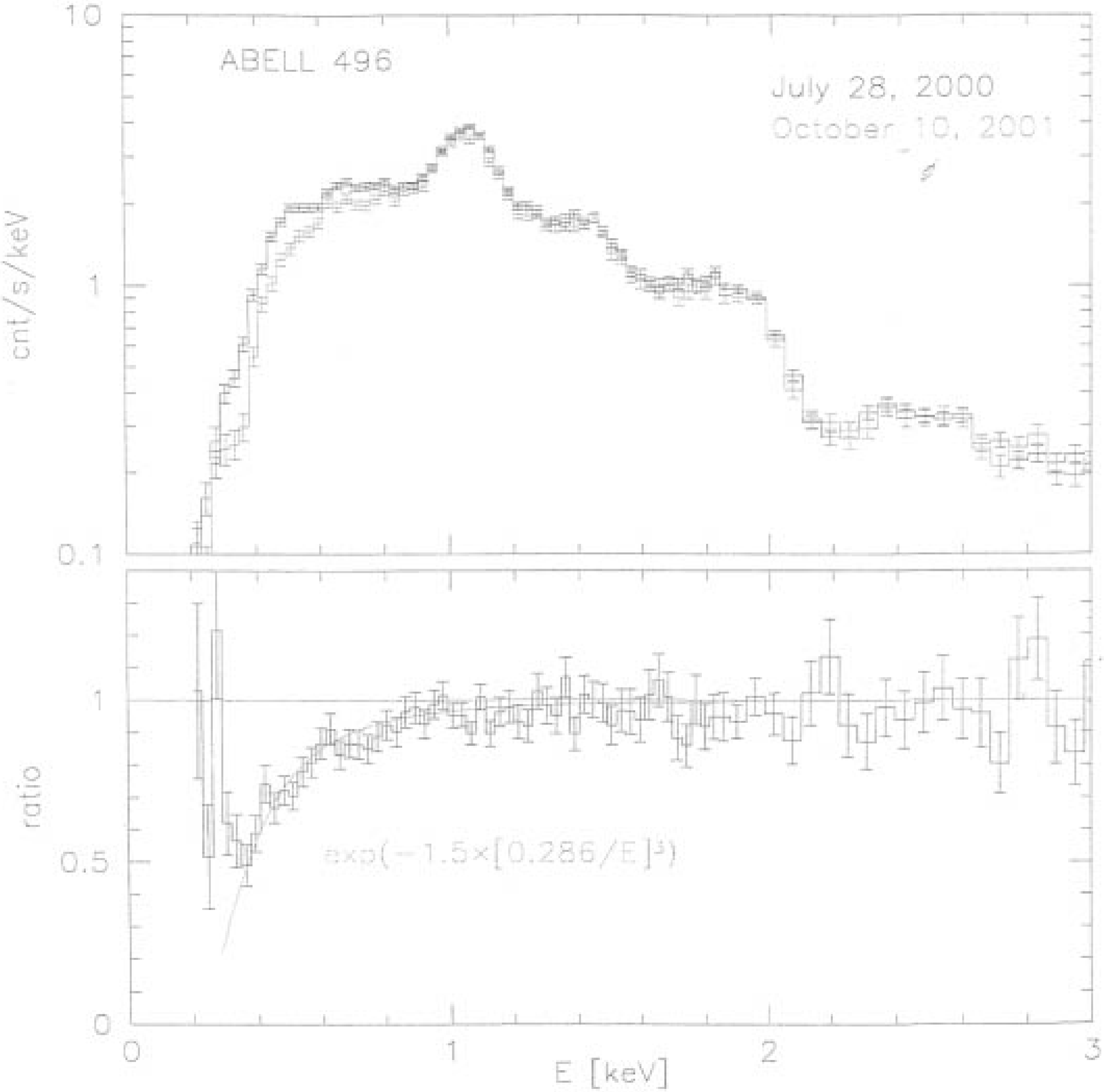
DECREASE OF LOW ENERGY QE

CTI CORRECTION of FI CHIPS

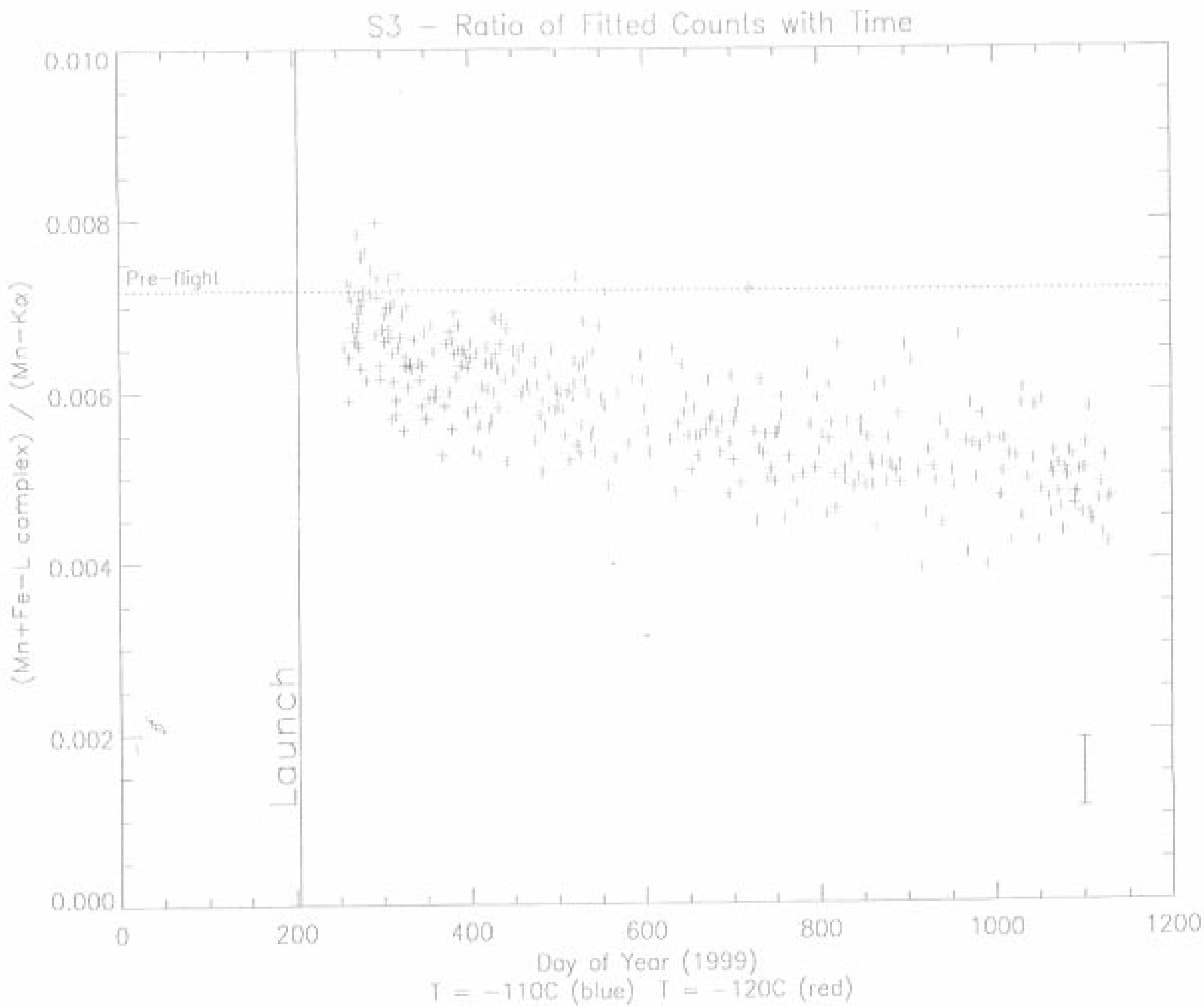
25 June 2002 CUC DAS

CHANGE IN ACIS LOW-ENERGY QE

- Caveat posted on CXC web site on 03 April 2002
- The low-energy QE of the ACIS instrument appears to be decreasing with time
- The effect is energy dependent, $\approx$ 20% at 0.67 keV over two years, negligible at 1 keV and up
- It appears that the reduction in sensitivity is due to a buildup of contamination on the filters and/or CCDs
- The characterization of this effect is complicated by changes in the CCD response over the life of the mission
- The chemical composition of the contamination is not well-determined. There appears to be a strong C absorption edge, the O edge is directly observed, but quantifying N and F require further analysis.
- New calibration observations are planned to better quantify the effect, to identify the chemical composition of the contaminants, and to monitor the decrease more accurately
- the CXC calibration team expects that time-dependent QE products will be released once the effect has been properly characterized



ABELL 496
July 28, 2000
October 10, 2001
cnt/s/keV
ratio
exp(−1.5×[0.286/E]³)
E [keV]

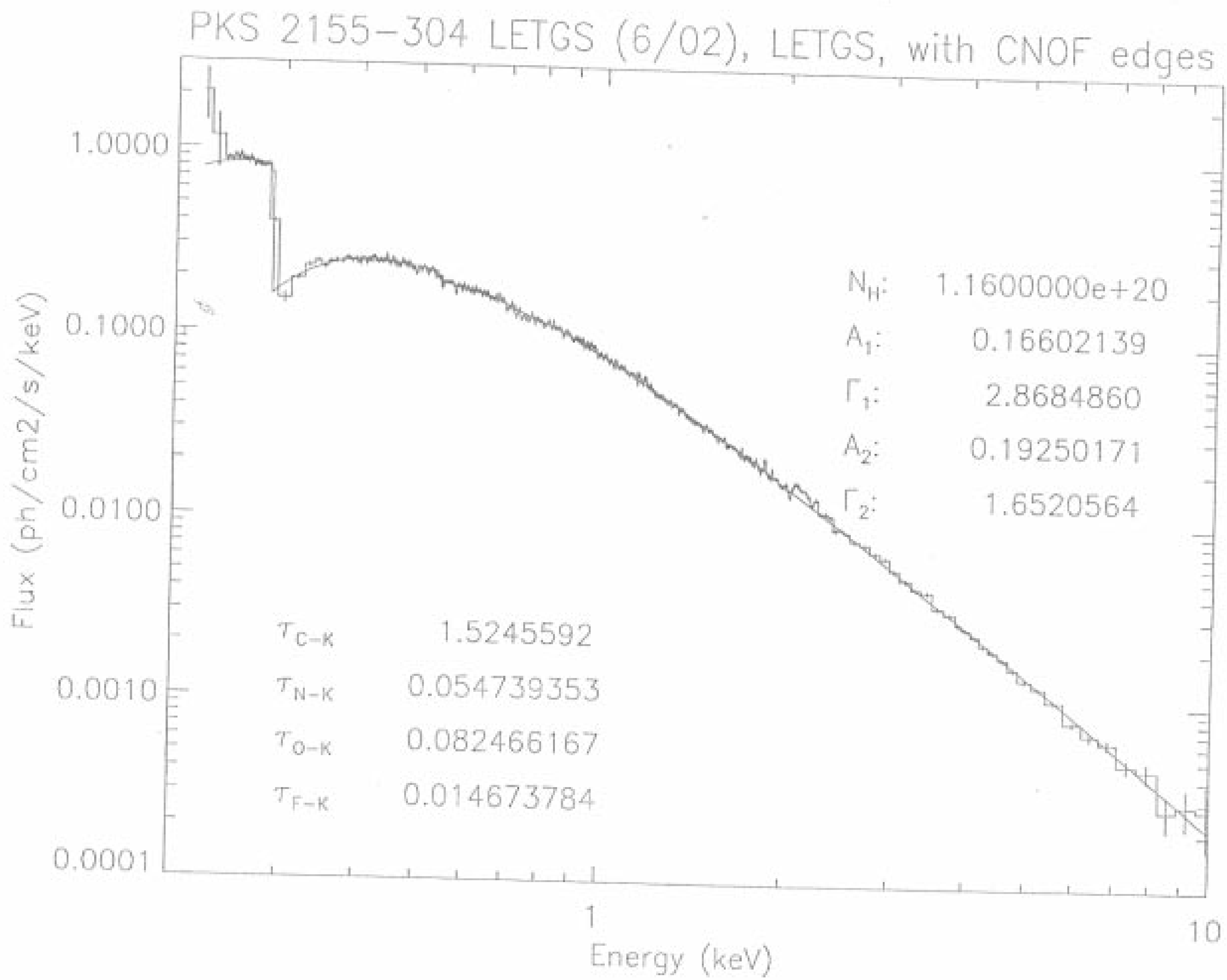

S3 - Ratio of Fitted Counts with Time
(Mn+Fe-L complex) / (Mn-Kα)
0.010
0.008
0.006
0.004
0.002
0.000
Pre-flight
Launch
0
200
400
600
800
1000
1200
Day of Year (1999)
T = -110C (blue) T = -120C (red)

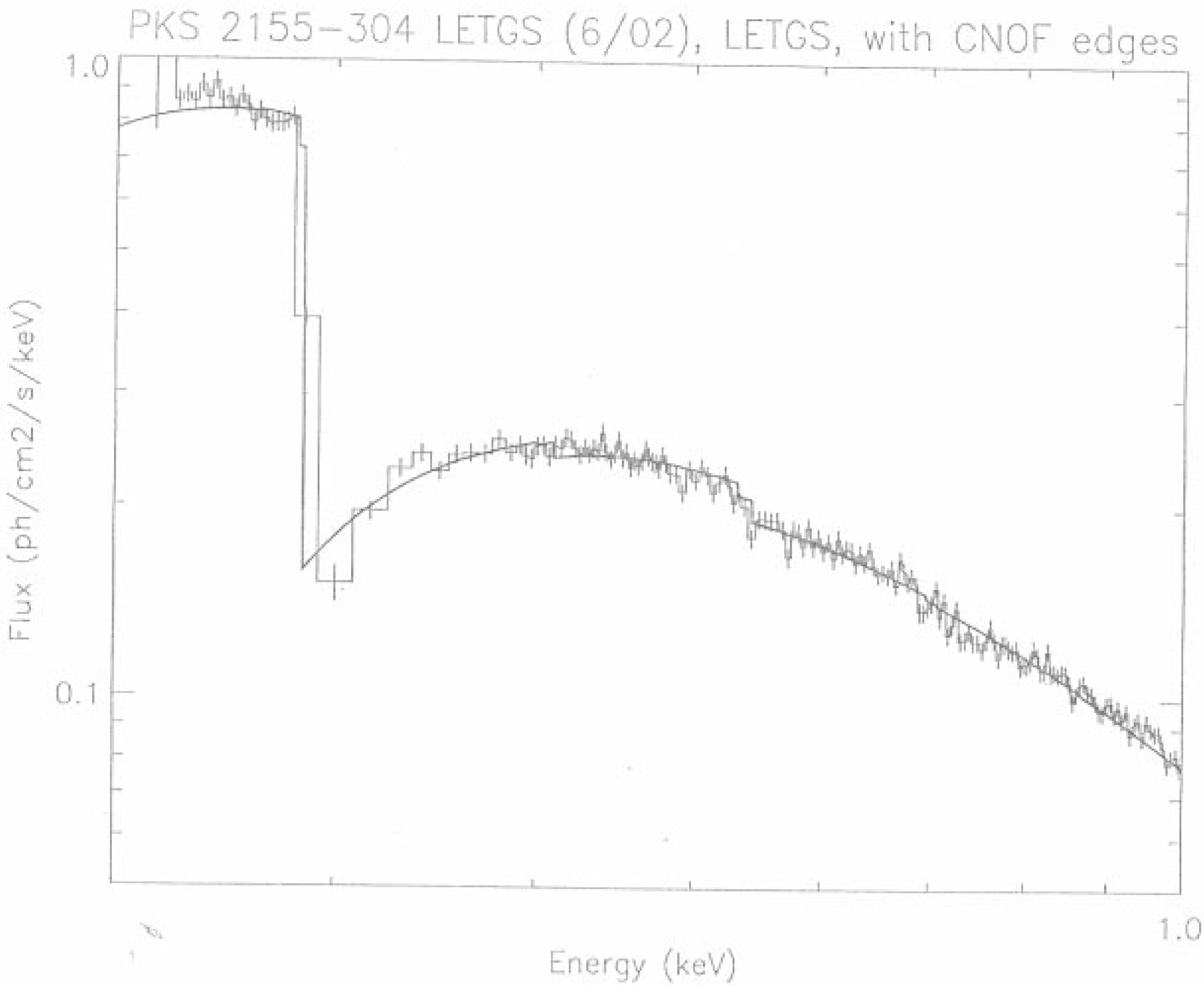
ACIS MODELING AND ANALYSIS

Low Energy QE Calibration/Diagnosis Plan

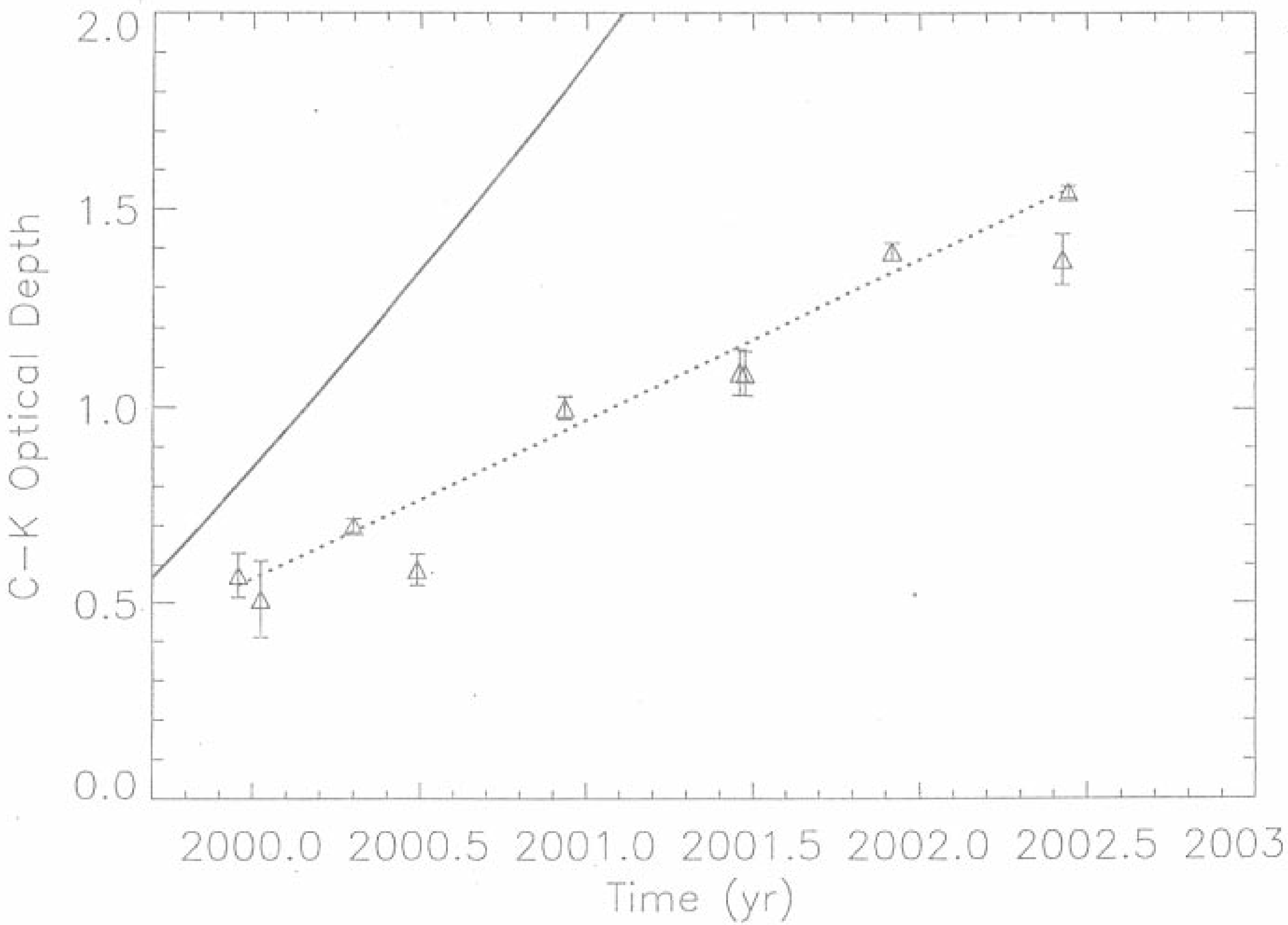
1. LETG with PKS 2155-304
   - Check for edges
   - We have a history of these observations
   - Done June 11, analyzed
2. PSR 0656+15
   - LETG observations, good .2 to .8 keV statistics, compare to 2155
   - Bare acis observations for broad band temporal monitoring
     - Point 8 arcmin offaxis, low pileup TE data
     - Compare with CC mode data
3. Abell 1795.
   - Steady source, good statistics around 1 keV,
   - Temporal monitoring and search for degradation above 1 keV.

We will assess whether to continue, and if so the frequency, for each of these measurements.


PKS 2155−304 LETGS (6/02), LETGS, with CNOF edges
Flux (ph/cm2/s/keV)
1.0000
0.1000
0.0100
0.0010
0.0001
Energy (keV)
1
10
N_H: 1.1600000e+20
A_1: 0.16602139
Γ_1: 2.8684860
A_2: 0.19250171
Γ_2: 1.6520564
τ_C-K 1.5245592
τ_N-K 0.054739353
τ_O-K 0.082466167
τ_F-K 0.014673784



PKS 2155−304 LETGS (6/02), LETGS, with CNOF edges
1.0
0.1
Flux (ph/cm2/s/keV)
1.0
Energy (keV)


2.0
1.5
1.0
0.5
0.0
C−K Optical Depth
2000.0
2000.5
2001.0
2001.5
2002.0
2002.5
2003.
Time (yr)

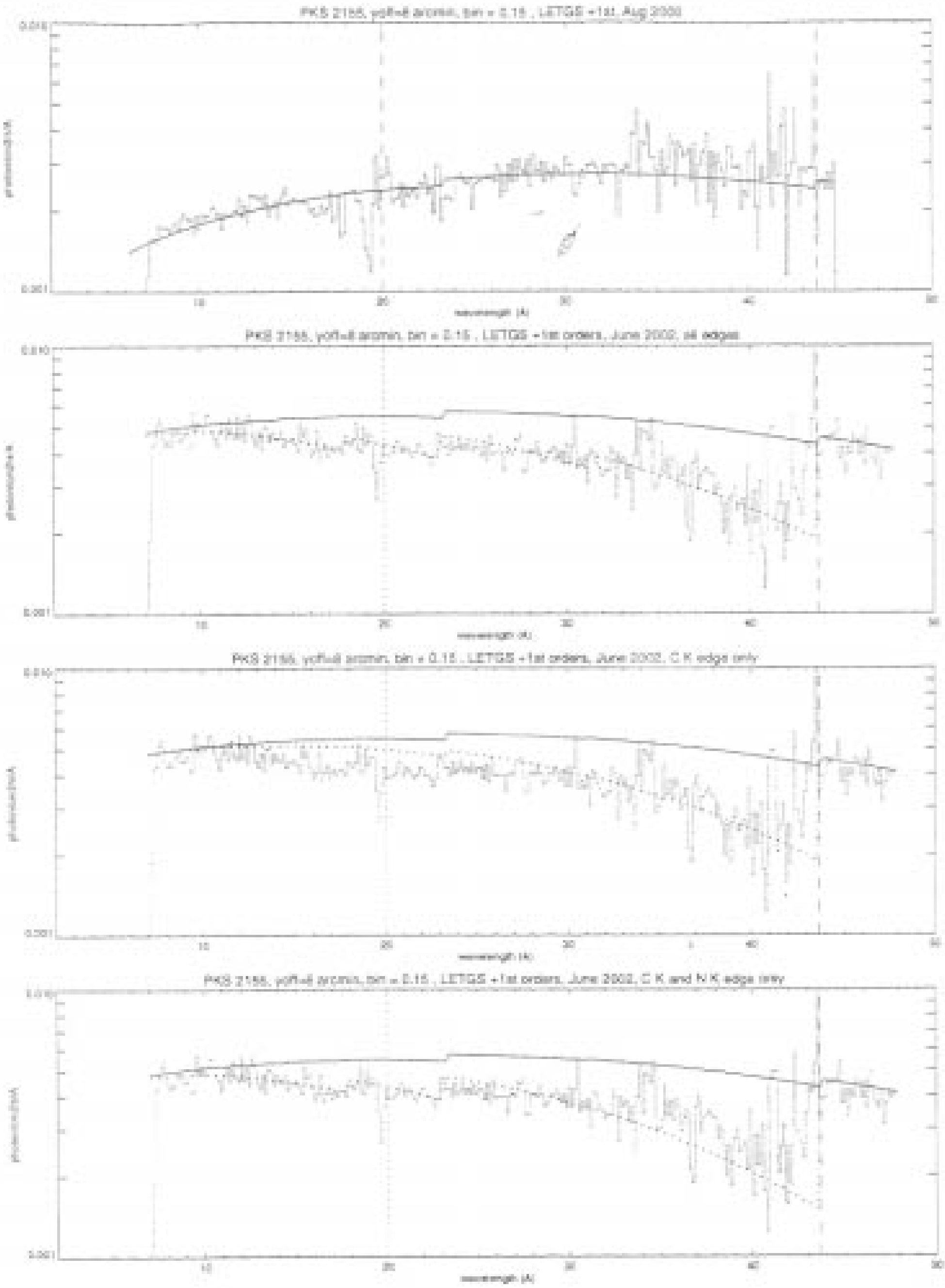
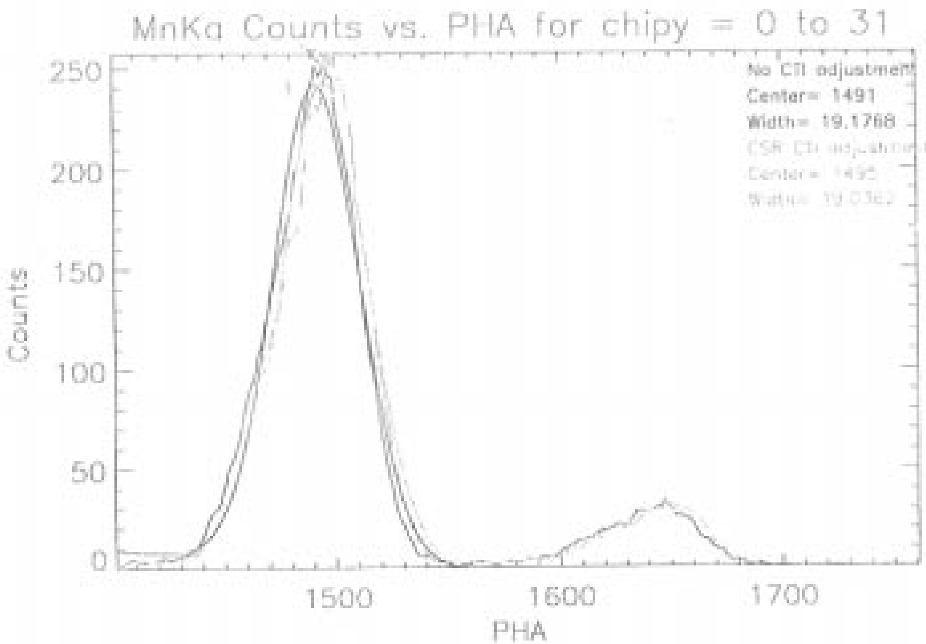


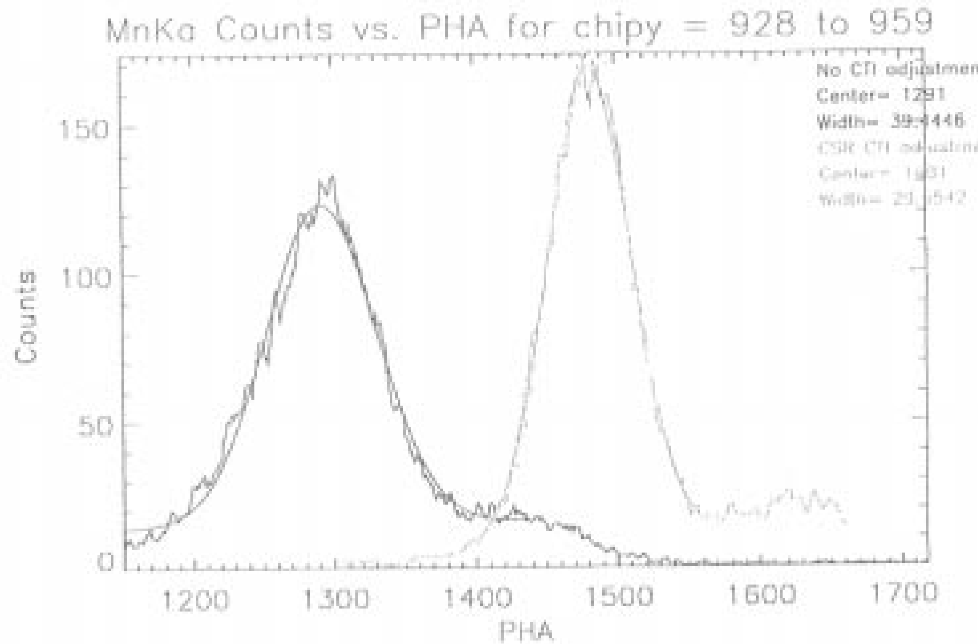
Fig. 2.— Spectral fits of LETGS +1st order spectra for the August 2000 case (blue) and the June 2002 case on device S3. The three red panels show different selections of edges and depths in the additional edge model (dotted line). The solid line shows the model as if nothing has changed since August 2000 but the source itself.

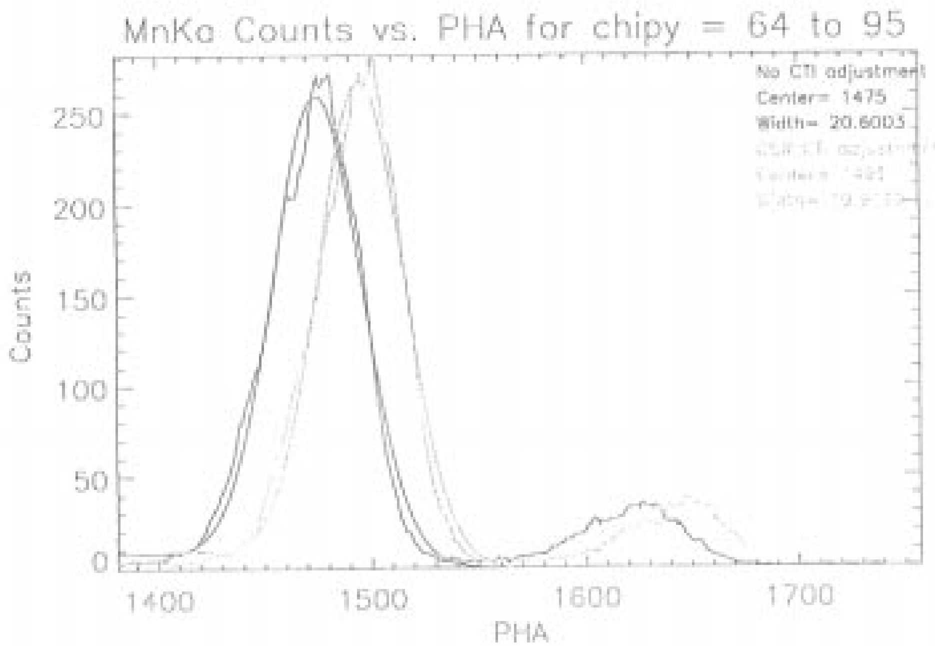
ACIS MODELING AND ANALYSIS

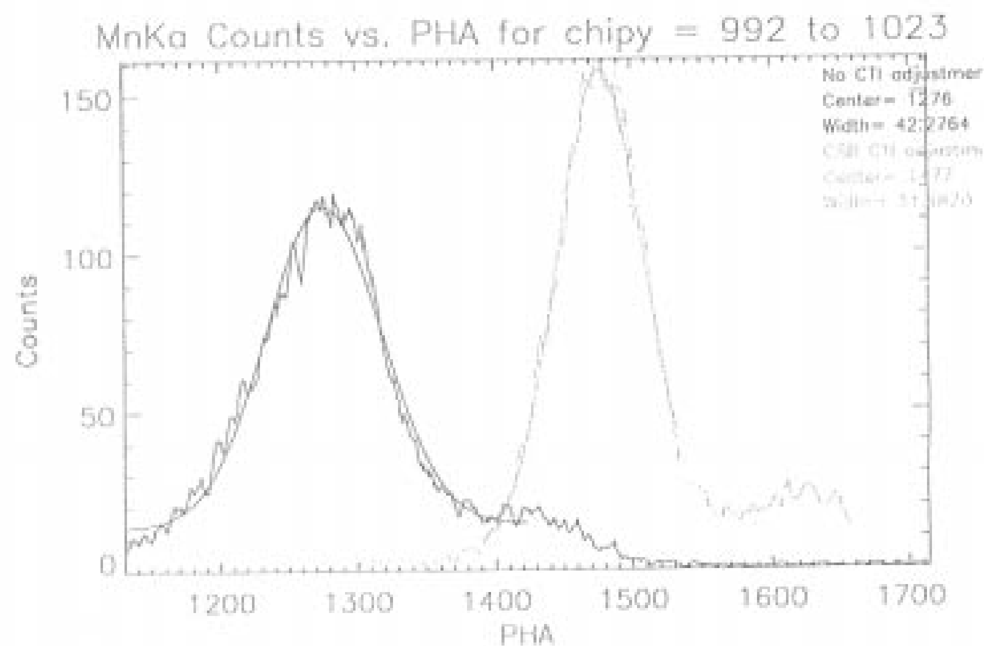
CTI CORRECTION of FI CHIPS

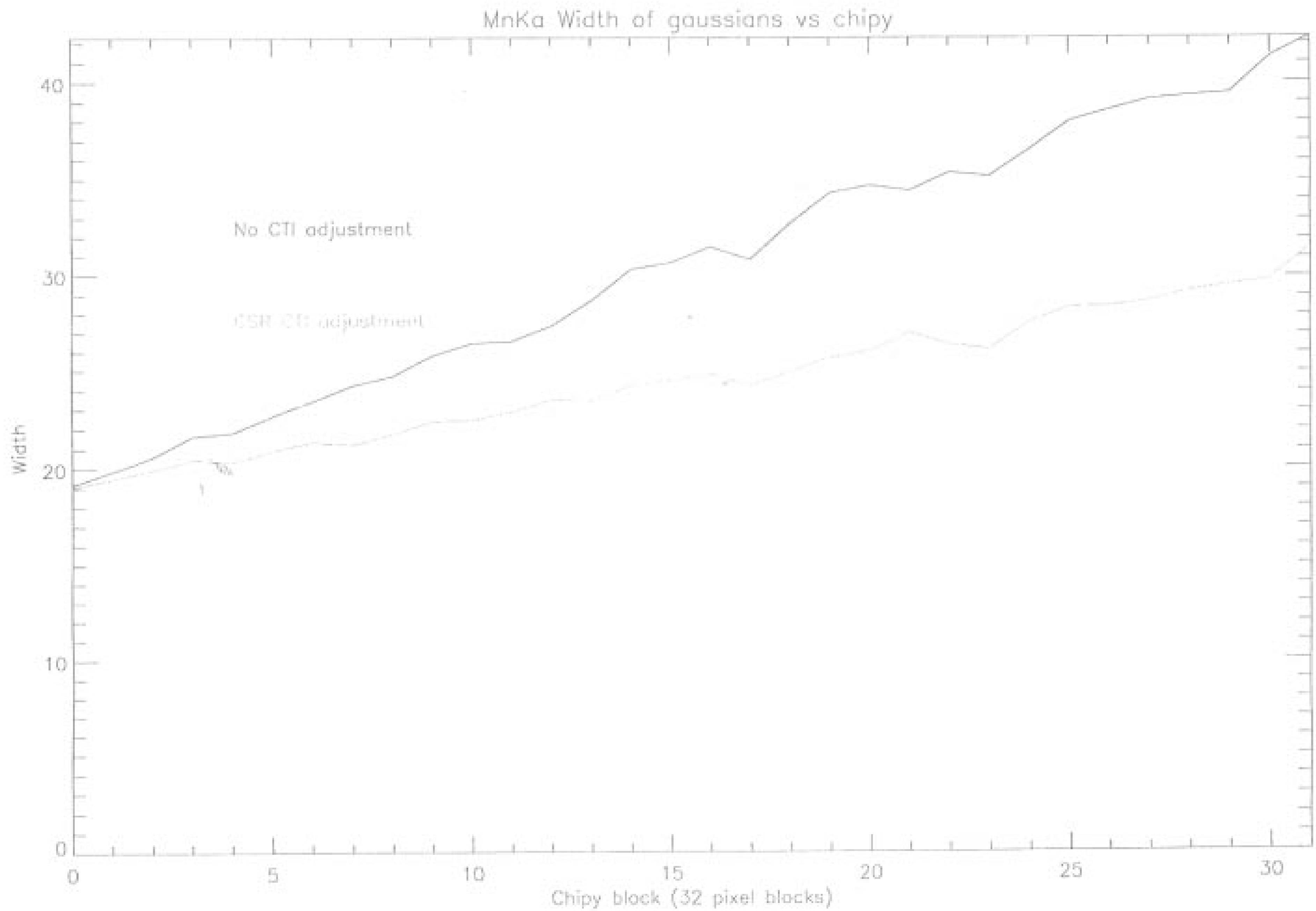
- Implemented a PSU/MIT IPI team recommended algorithm
- New acis_process_events module has been verified
- Works for TE, Faint or Very Faint
  - Not for graded mode, or CC
  - Correction calibration tuned for 3.2s frame time
- Correction is an improvement
- Amplitudes increase, FWHM decrease


MnKa Counts vs. PHA for chipy = 0 to 31
No CTI adjustment
Center= 1491
Width= 19.1768
Counts
PHA
0
50
100
150
200
250
1500
1600
1700


MnKa Counts vs. PHA for chipy = 928 to 959
No CTI adjustmen
Center= 1291
Width= 39.1446
Counts
PHA
0
50
100
150
1200
1300
1400
1500
1600
1700


MnKa Counts vs. PHA for chipy = 64 to 95
No CTI adjustment
Center= 1475
Width= 20.6003
Counts
PHA
0
50
100
150
200
250
1400
1500
1600
1700


MnKa Counts vs. PHA for chipy = 992 to 1023
No CTI adjustmen
Center= 1276
Width= 42.2764
Counts
PHA
0
50
100
150
1200
1300
1400
1500
1600
1700


MnKa Width of gaussians vs chipy
No CTI adjustment
CSR CTI adjustment
Width
Chipy block (32 pixel blocks)
0
10
20
30
40
0
5
10
15
20
25
30

ACIS RMF GENERATION

1. Run MIT simulator, generate electrons per pixel.
    - Use discrete energy inputs.
    - Randomly illuminate entire chip.
2. Detect "events" using on-board algorithms.
    - Get total electrons collected.
    - Convert to PHA with nominal gain.
3. For each energy fit the number of events per pulse height to the sum of 10 Gaussians.
4. Parameters of the Gaussians incorporated into Fits Extensible Functions, FEF.
    - Must use sherpa functions.
    - Make PHA FEF
    - Make separate PI FEF
5. FEF are a CALDB product.
6. Users create RMF at runtime.
    - use mkrmf,
        - make PHA RMF from PHA FEF
        - make PI RMF from PI FEF

Challenges

1. Gaussians are not basis functions.
   - fitting not well constrained
   - A given Gaussian tends not to preserve its distinct role as a function of energy.
2. THEREFORE: Large human labor required, subjective decisions needed.
   - At least 6 months calendar time.
3. Cannot support doing this for all conditions of 10 chips.
   - Spatial dependence
   - CTI correction or not
   - Counting rate dependence
   - Time,
     - CTI degrades throughout the mission
     - Gain changes
     - May need to go to warmer temperatures
4. PI FEF are intrinsically wrong, due to non-linearities in PHA $\rightarrow$ E transformation
   - Close approximation for Gaussians.

ACIS MODELING AND ANALYSIS

Solution Ingredients

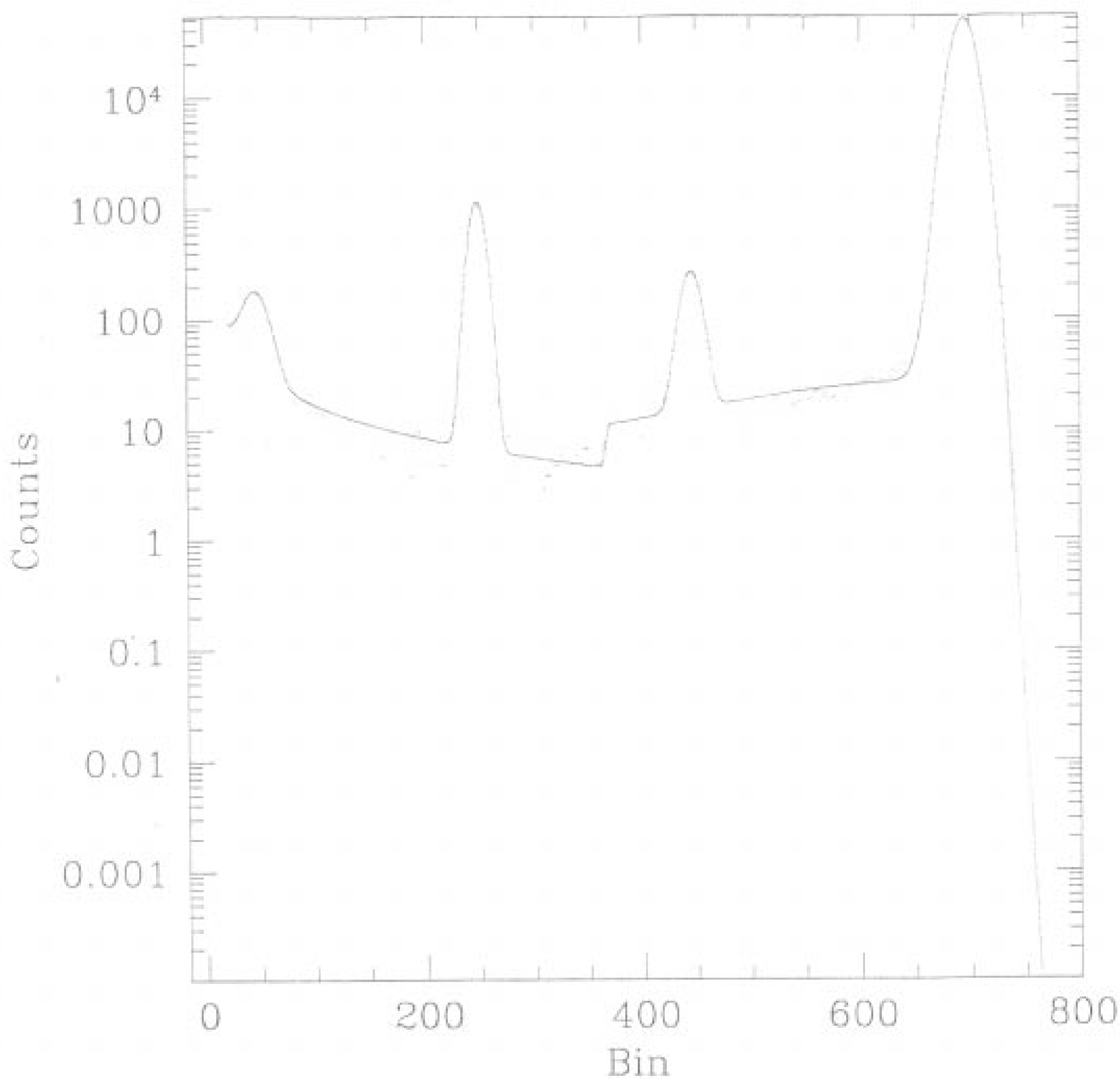
1. Use Arbitrary Sherpa Functions

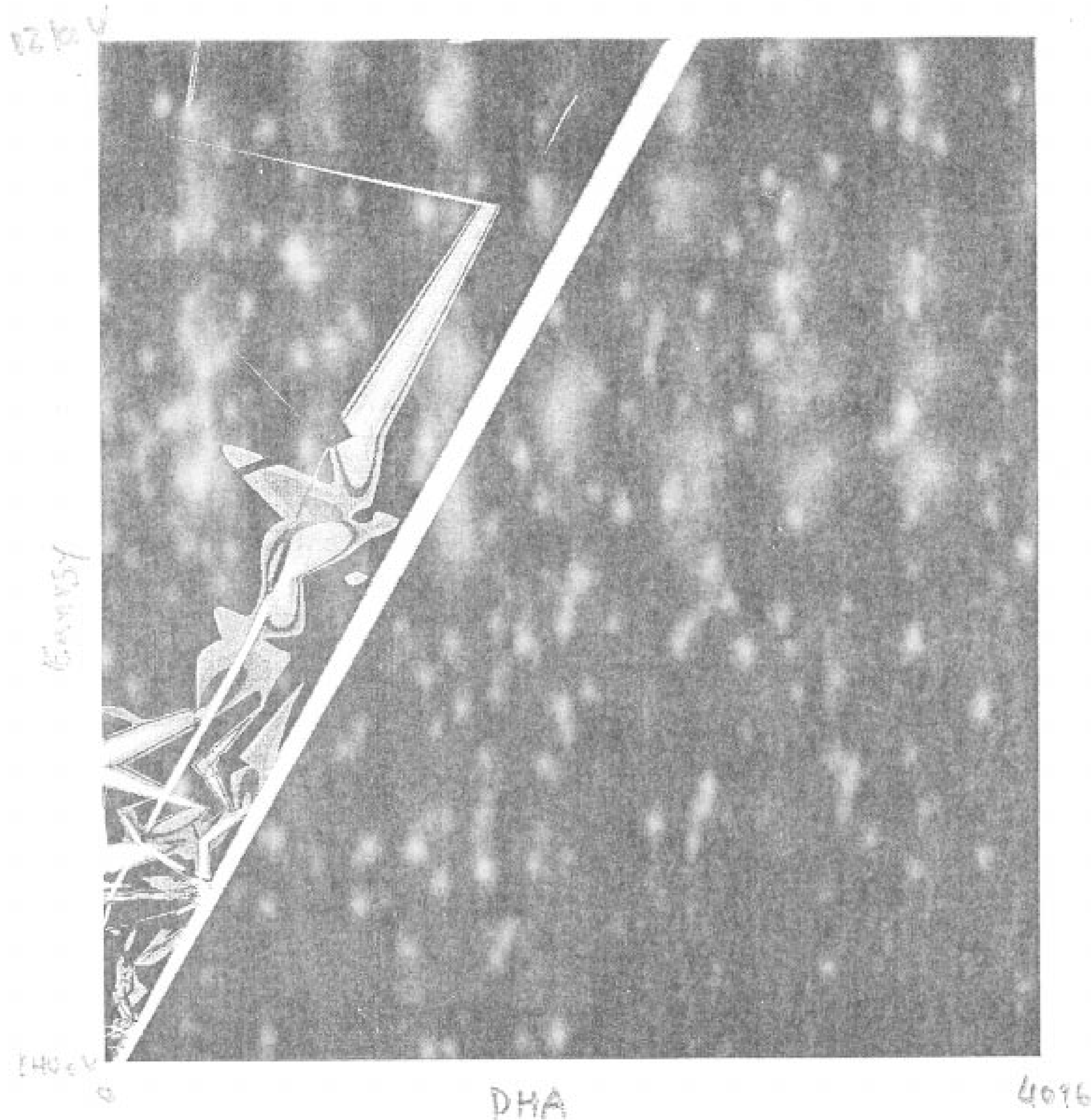
2. Separate ideal response from degradations

3. Generate RMF directly from simulated data.

4. Generate PI-RMF from PHA RMF

U2710.03_i1.pha



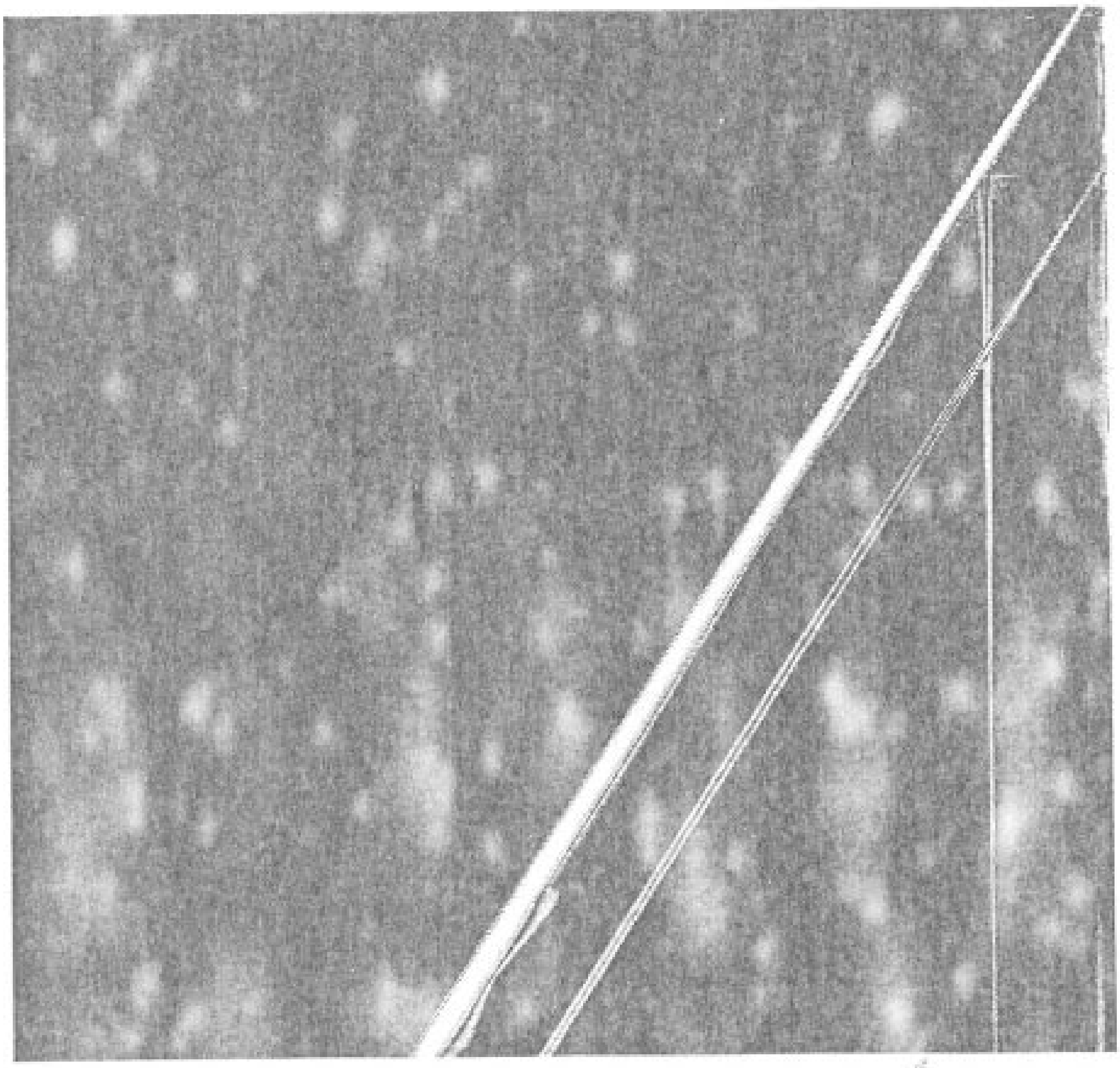


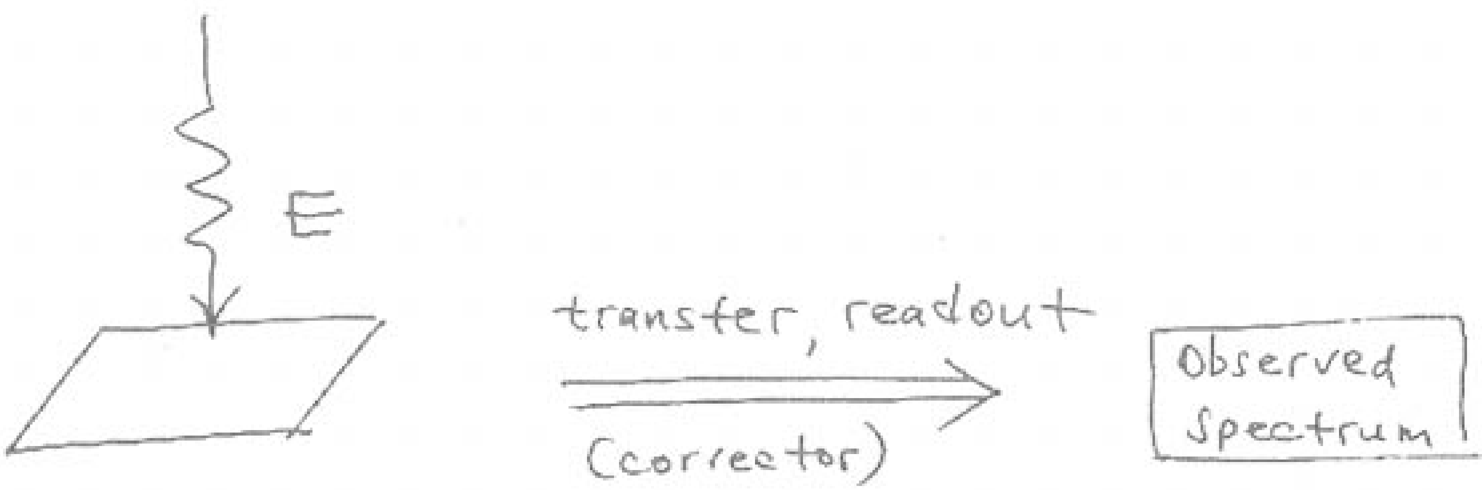
IJ FEE 2001-11-08

tile 384

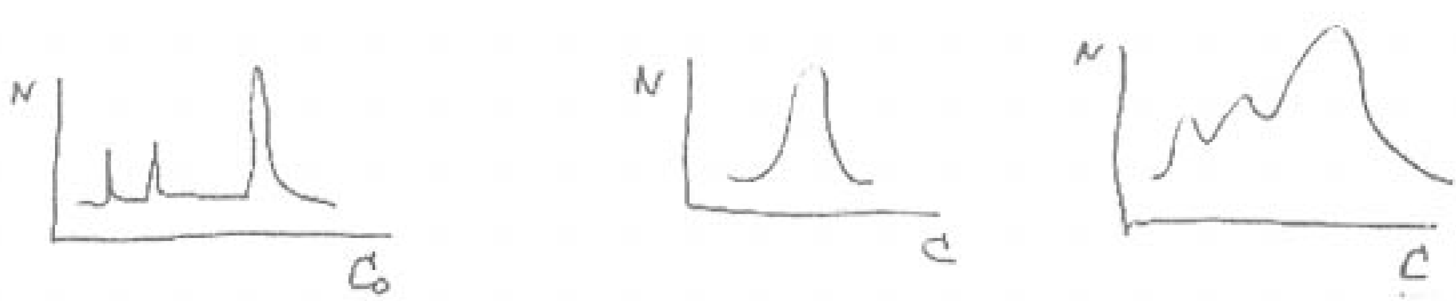
I30Ø,

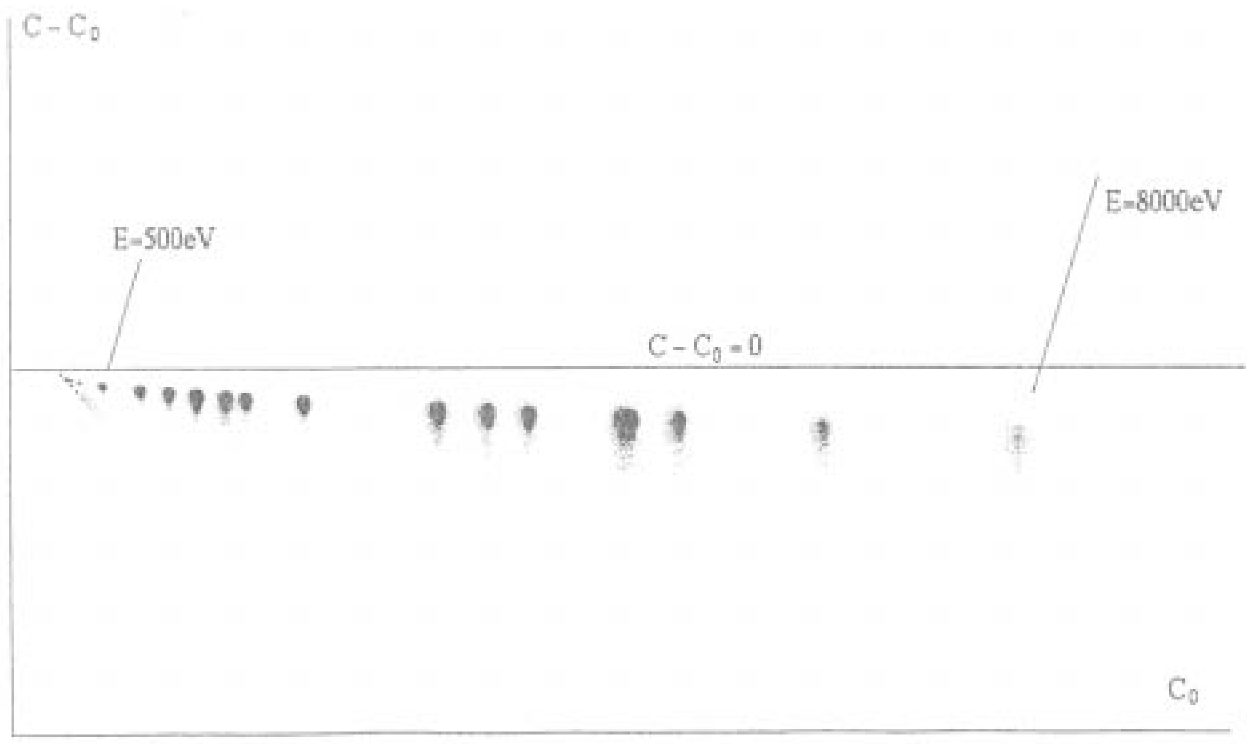
MW



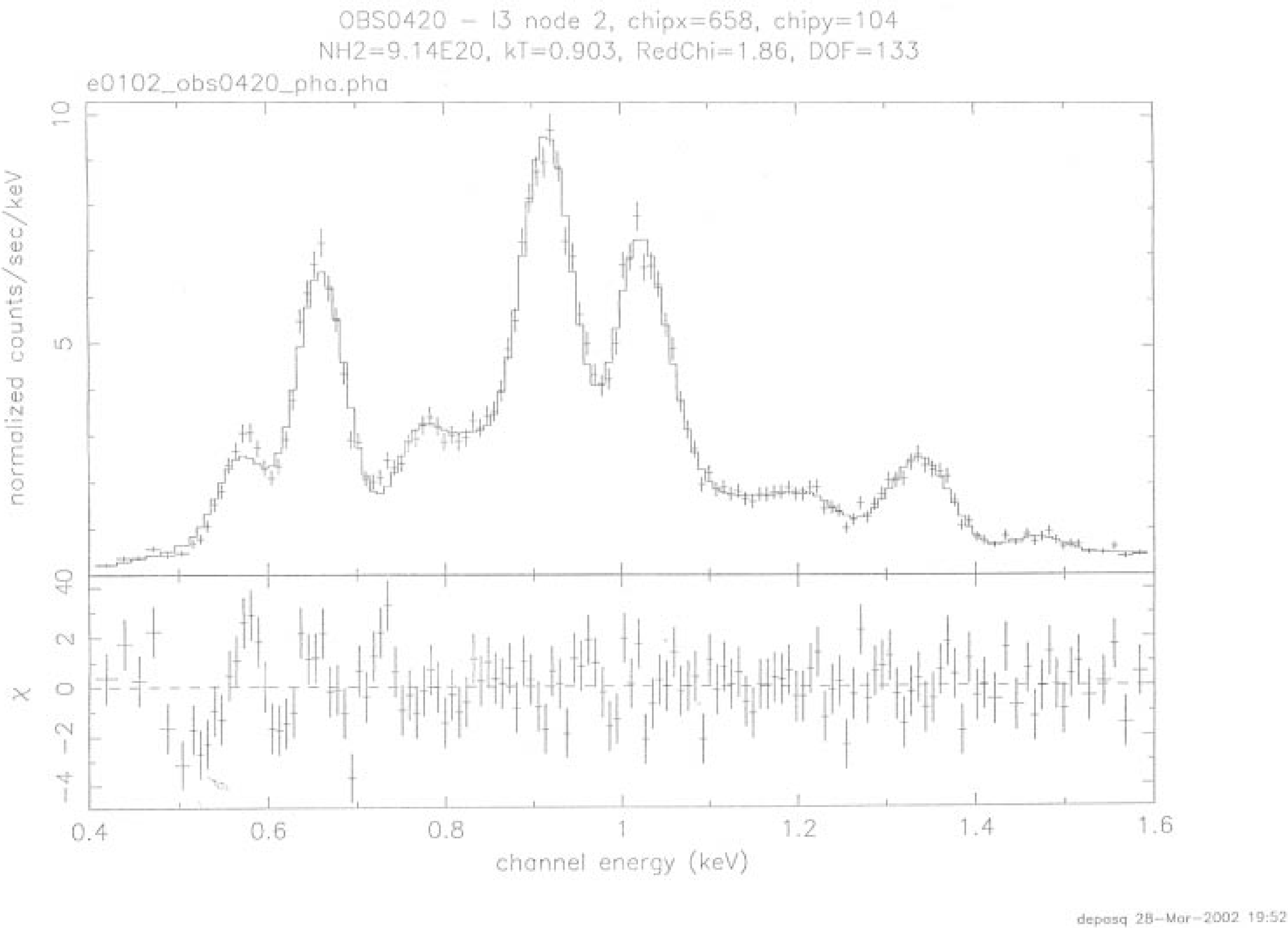


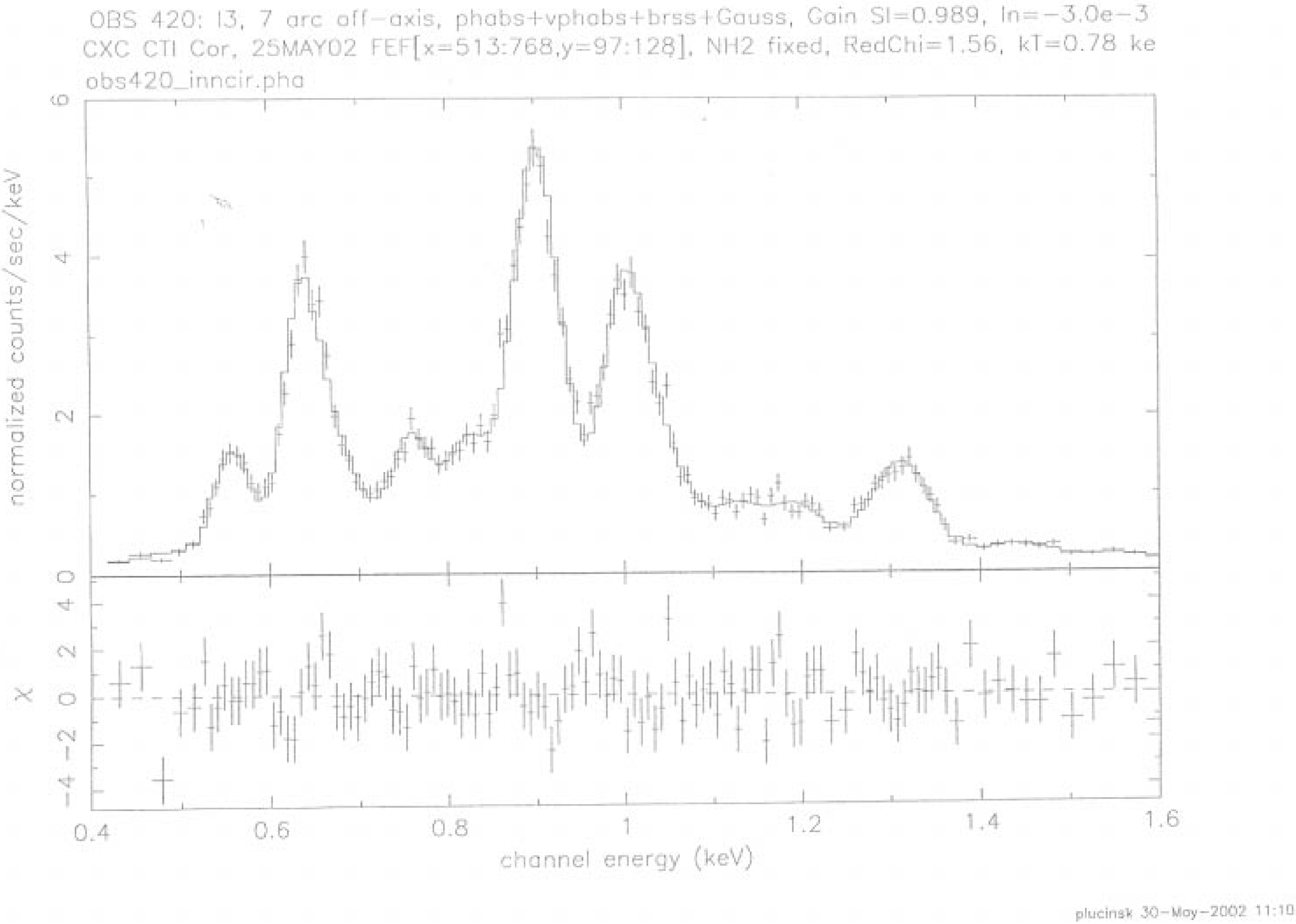
$$R_{ideal}(C_0|E) \otimes P(C|C_0) = R_{obs}(C|E)$$



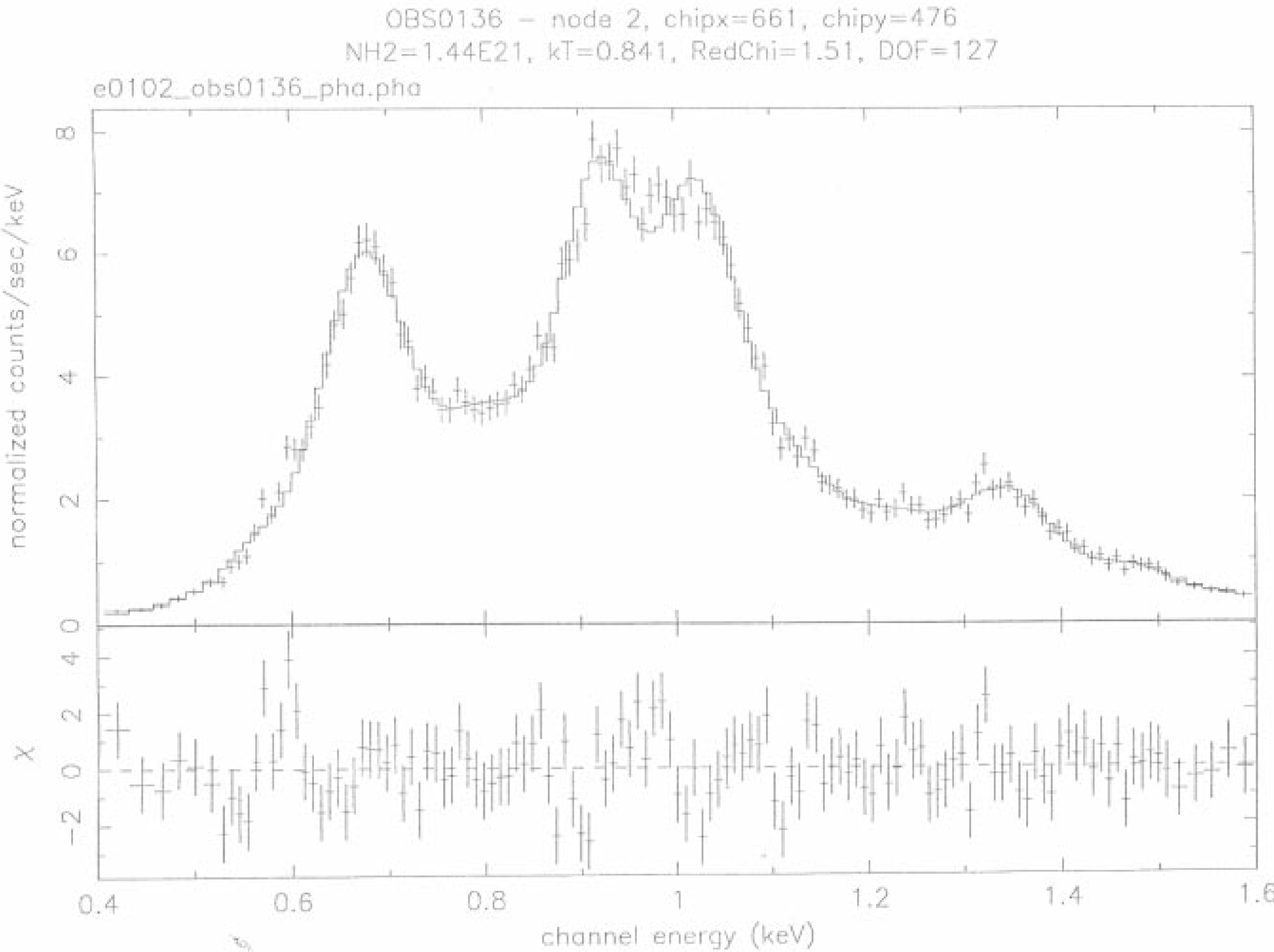


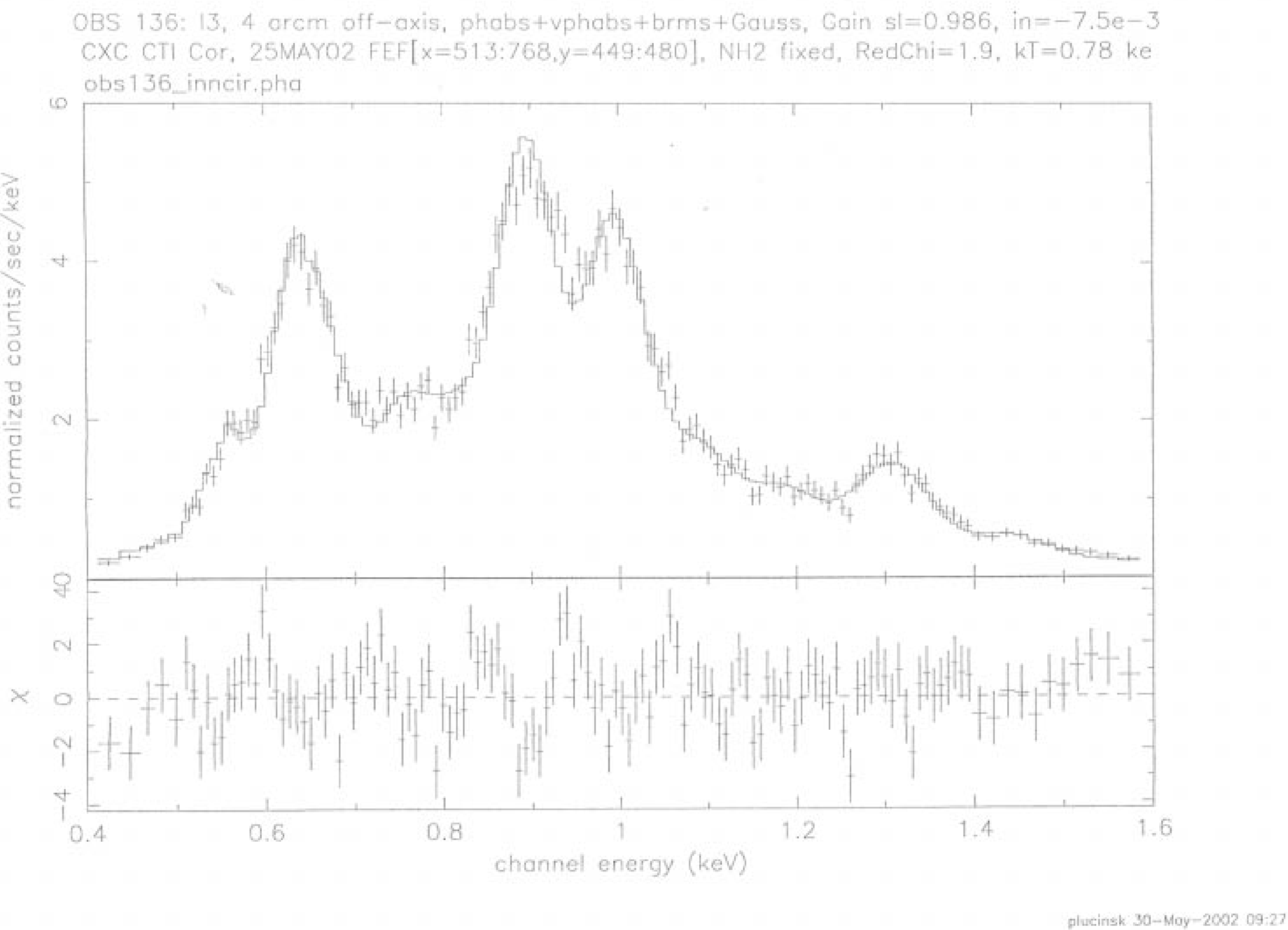
C - C0
E=500eV
E=8000eV
C - C0 = 0
C0

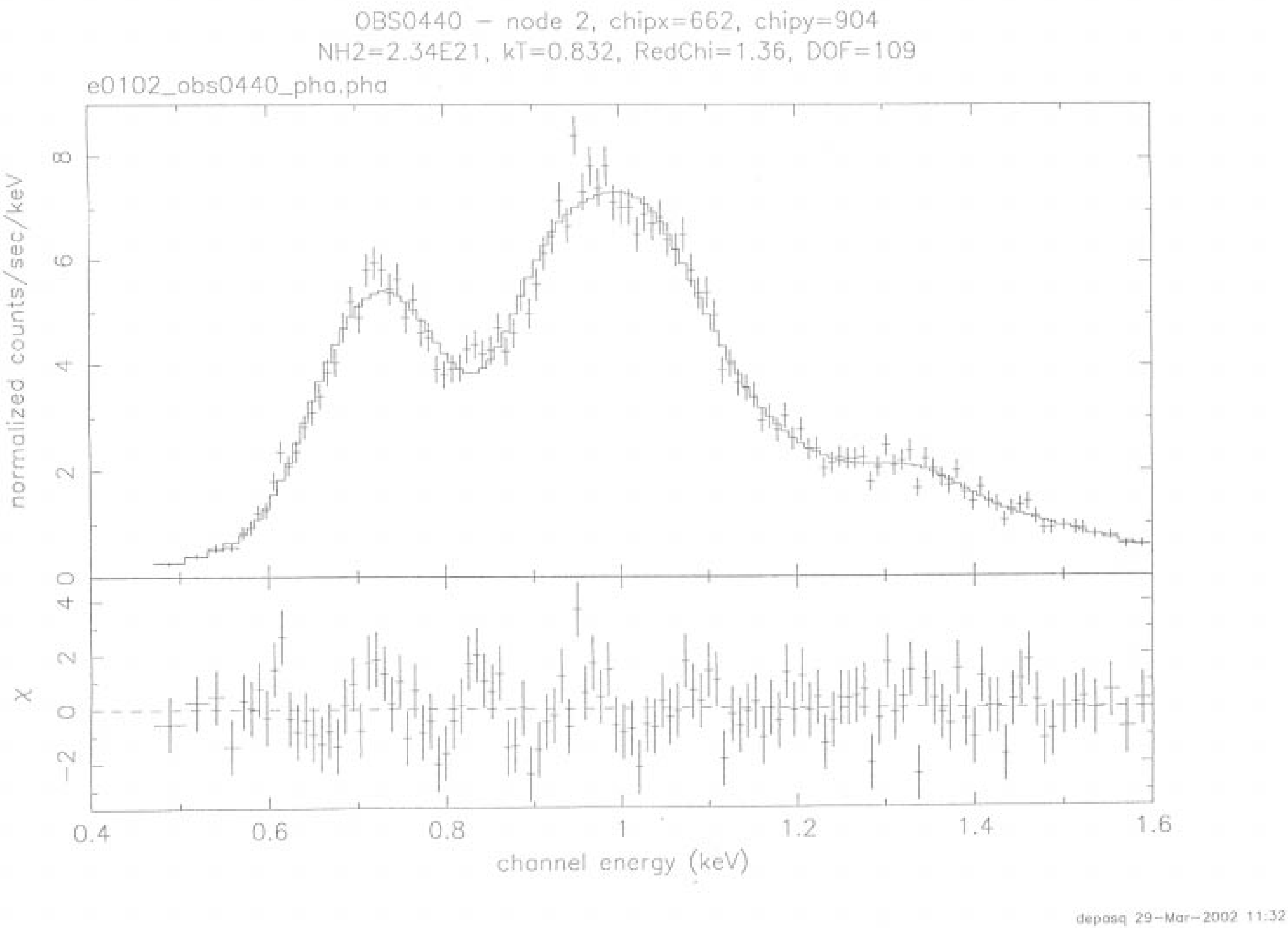

OBS0420 - I3 node 2, chipx=658, chipy=104
NH2=9.14E20, kT=0.903, RedChi=1.86, DOF=133
e0102_obs0420_pha.pha
normalized counts/sec/keV
10
5
40
2
0
-2
-4
χ
0.4
0.6
0.8
1
1.2
1.4
1.6
channel energy (keV)
deposq 28-Mar-2002 19:52

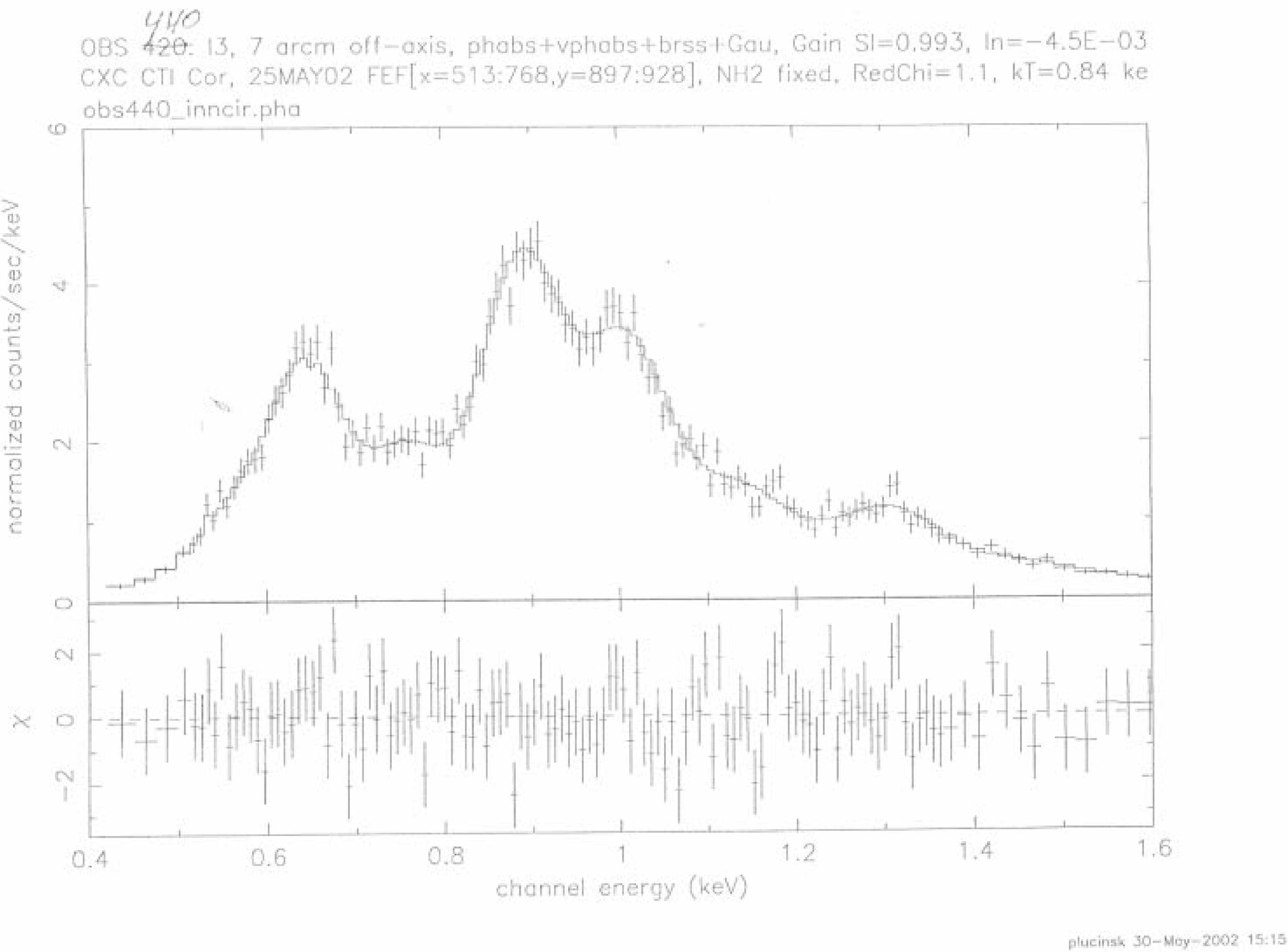


OBS 420: I3, 7 arc off-axis, phabs+vphabs+brss+Gauss, Gain Sl=0.989, In=-3.0e-3
CXC CTI Cor, 25MAY02 FEF[x=513:768,y=97:128], NH2 fixed, RedChi=1.56, kT=0.78 ke
obs420_inncir.pha
normalized counts/sec/keV
0
2
4
6
χ
-4
-2
0
2
4
0.4
0.6
0.8
1
1.2
1.4
1.6
channel energy (keV)
plucinsk 30-May-2002 11:10


OBS0136 - node 2, chipx=661, chipy=476
NH2=1.44E21, kT=0.841, RedChi=1.51, DOF=127
e0102_obs0136_pha.pha
normalized counts/sec/keV
χ
channel energy (keV)
depasq 29-Mar-2002 11:15


OBS 136: I3, 4 arcm off-axis, phabs+vphabs+brms+Gauss, Gain sl=0.986, in=-7.5e-3
CXC CTI Cor, 25MAY02 FEF[x=513:768,y=449:480], NH2 fixed, RedChi=1.9, kT=0.78 ke
obs136_inncir.pha
normalized counts/sec/keV
6
4
2
0
χ
4
2
0
-2
-4
0.4
0.6
0.8
1
1.2
1.4
1.6
channel energy (keV)
plucinsk 30-May-2002 09:27


OBS0440 - node 2, chipx=662, chipy=904
NH2=2.34E21, kT=0.832, RedChi=1.36, DOF=109
e0102_obs0440_pha.pha
normalized counts/sec/keV
8
6
4
2
0
4
2
0
-2
χ
0.4
0.6
0.8
1
1.2
1.4
1.6
channel energy (keV)
deposq 29-Mar-2002 11:32



440
OBS 420: I3, 7 arcm off-axis, phabs+vphabs+brss+Gau, Gain SI=0.993, In=-4.5E-03
CXC CTI Cor, 25MAY02 FEF[x=513:768,y=897:928], NH2 fixed, RedChi=1.1, kT=0.84 ke
obs440_inncir.pha
normalized counts/sec/keV
6
4
2
0
χ
2
0
-2
0.4
0.6
0.8
1
1.2
1.4
1.6
channel energy (keV)
plucinsk 30-May-2002 15:15

ACIS MODELING AND ANALYSIS

IMPLEMENTATION ISSUES

1. Quantum Efficiency Uniformity
2. Which Chips to Correct? (I3, ACIS-I, ACIS-I & S3, All FI?)
3. Release of Data System products
   - Release of CTI corrector version of acis_process_events
   - CALDB handling of cti-corrected vs. non-corrected
   - Generation of PI-rmf from PHA-FEF
   - Sherpa library functions for new ECD representation
   - Documentation
4. Direct generation of rmf
   - A prototype generates rmf from simulated events
   - Need to develop a process to tweak gain and FWHM to match on-orbit calibration data
   - Will be required for maintainability in time, expansion to additional ACIS modes and conditions