ACIS Gain Studies
Temporal, Spatial, and Temperature Dependencies

Nick Durham
Catherine Grant, Paul Plucinsky, Richard Edgar
and CXC ACIS Calibration Team

2000 Initial PHA -to- photon_energy transformation

energy= gain(X,Y,energy/PHA) X PHA

or

energy= response(X,Y,energy,flux/PHA) X PHA

2004 Time-evolution correction

energy= gain(X,Y,energy/PHA) X [PHA+ΔPHA(time,PHA)]

2010 Time and Temperature corrections

energy= gain(X,Y,energy/PHA) X [PHA(temperature)+ΔPHA(time,PHA)]

2017 Time and Temperature-time evolution corrections (BI chips)

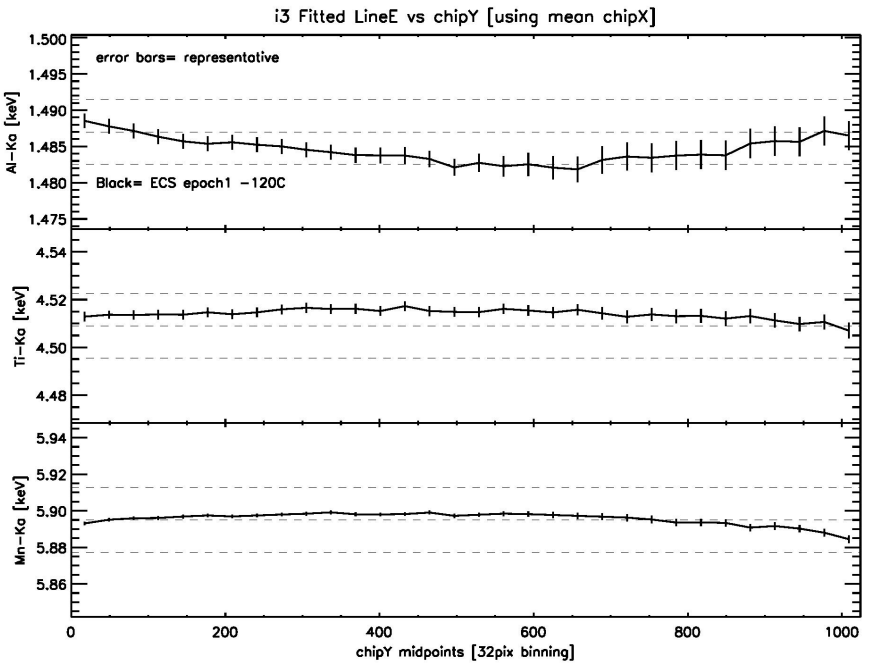
energy= gain(X,Y,energy/PHA) X [PHA(temperature(time))+ΔPHA(time,PHA)]

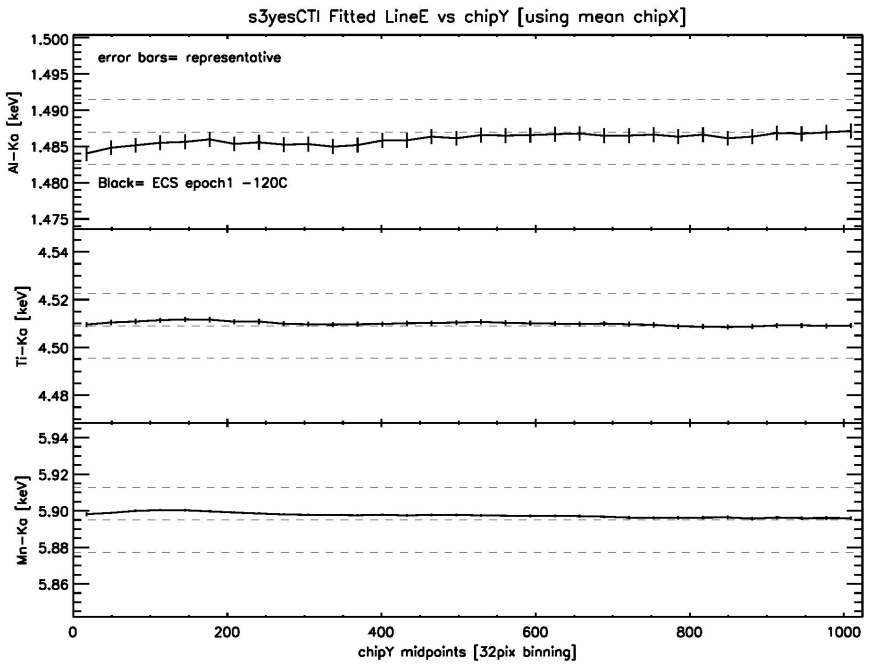
1. In the beginning…

energy= gain(X,Y,energy/PHA) X PHA

- ***Gain table:*** *Ground calibration of response vs PHA (ADU) at discrete energies*
  position-dependent CTI effect
- ***CALDB:*** RMF(X,Y,PHA)
  DET_GAIN(X,Y,PHA)

How accurate is (was) the PHA -to- Energy transformation?





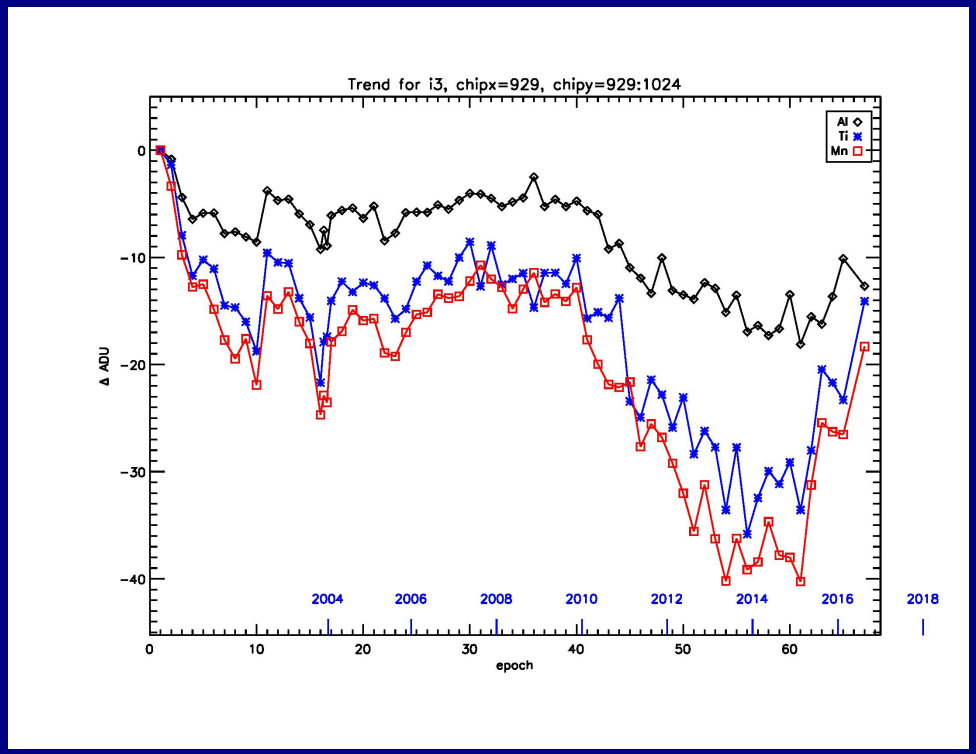
ECS epoch1 -120C 1/29/2000-4/30/2000

2. Time Dependence

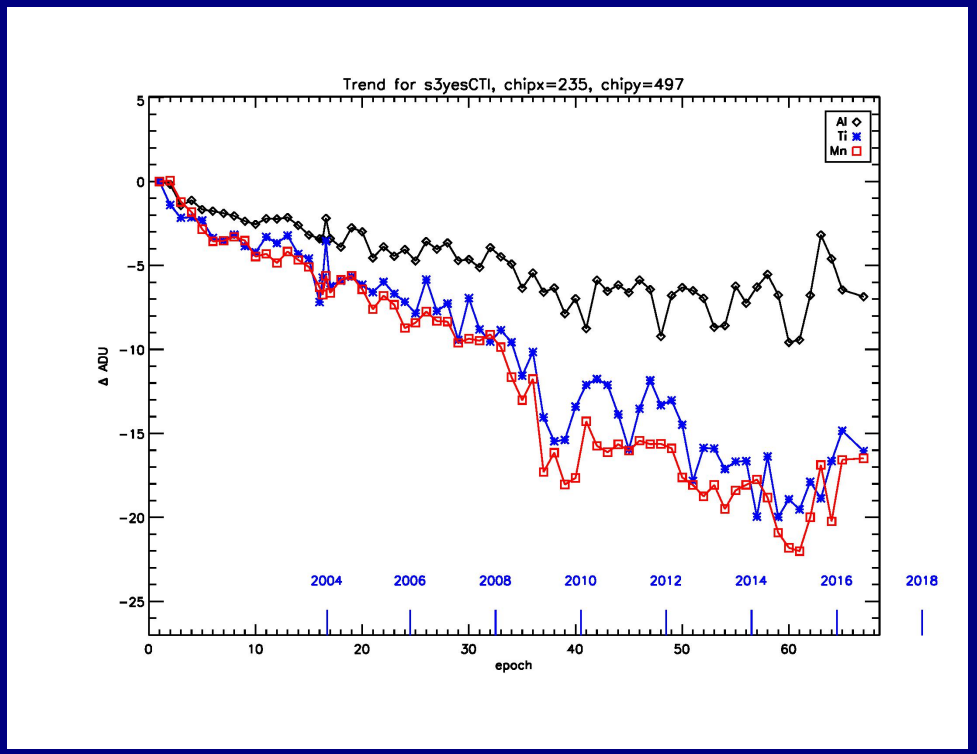
energy= gain(X,Y,energy/PHA) X [PHA+ΔPHA(time,PHA)]

- ***Problem:*** *CTI increases with time due to radiation damage; shifts event to a lower PHA*
  X-ray background affects CTI; charge trap density
  I0 and I2 electronic drift; can shift counts to lower or higher PHA channel
- ***Solution:*** Apply a time-dependent channel shift correction calculated every 3* months from ECS
- ***CALDB:*** TGAIN(X,Y,ΔPHA/PHA,time)

** 1 ADU ~ 4eV **



I3 aimpoint



S3 aimpoint

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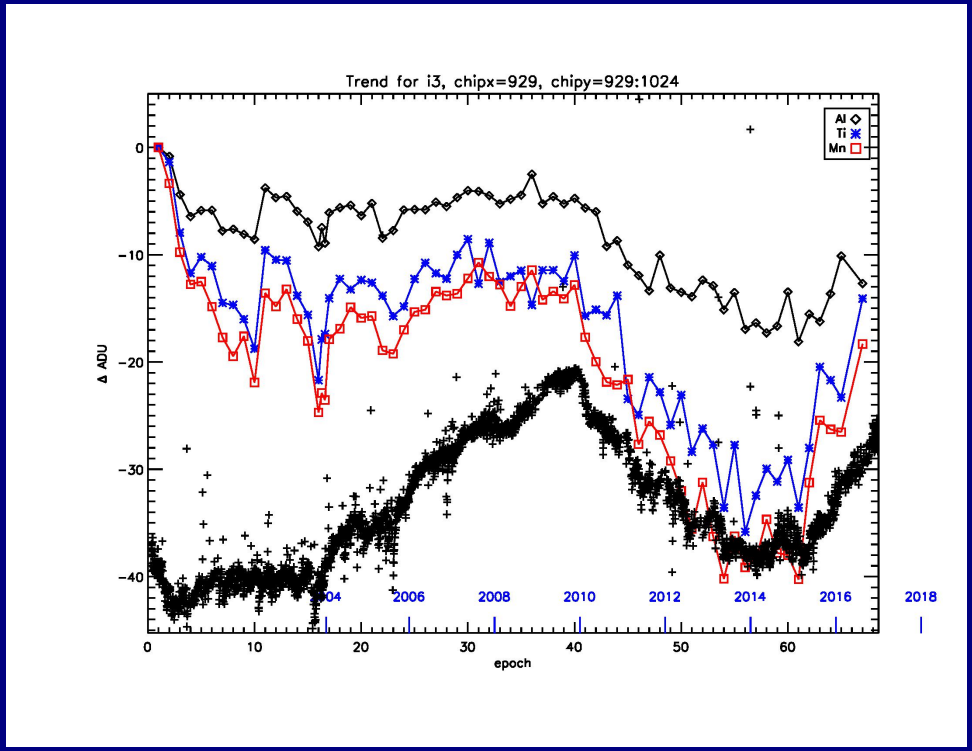
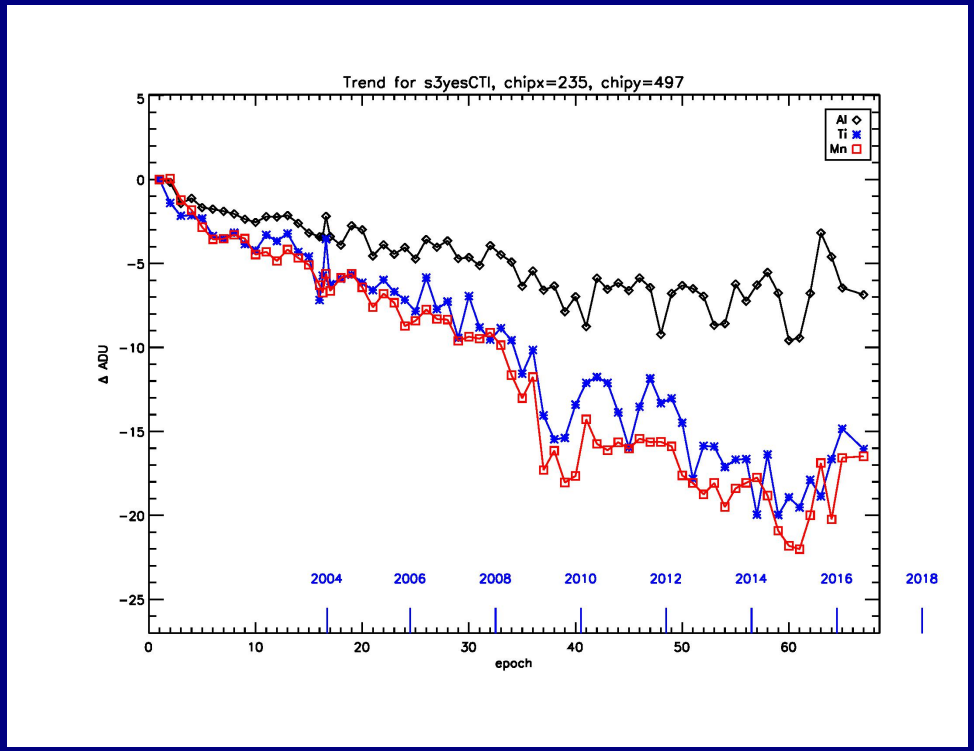


I3 aimpoint

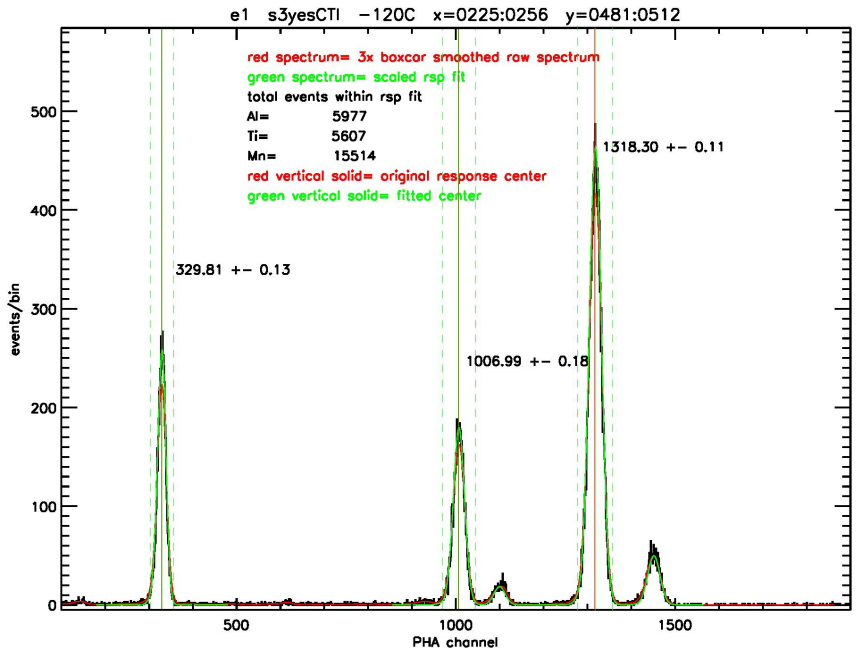


S3 aimpoint

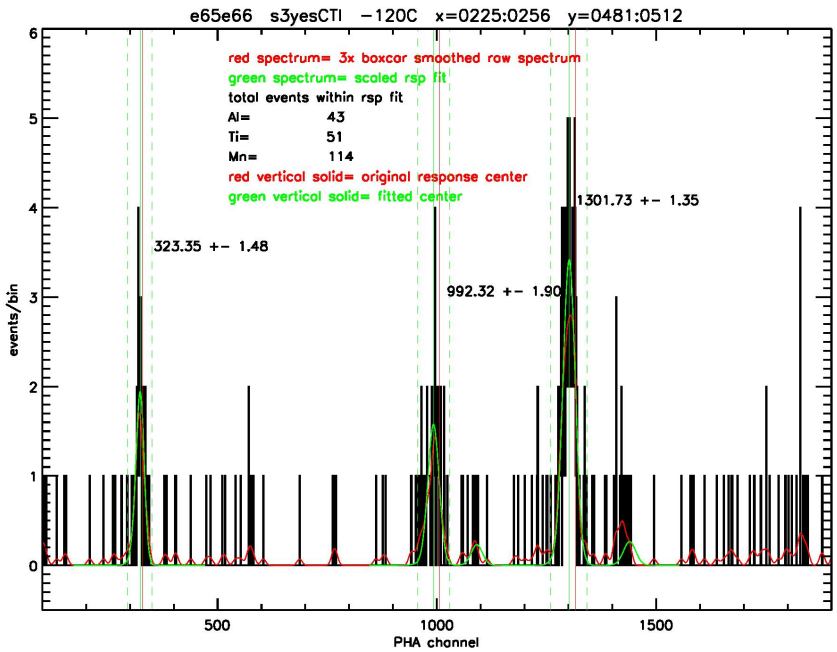
...plus Radioactive Decay

- ***Problem:*** ECS 55Fe source has a ½ life of 2.7 years
- ***Solution:*** Change TGAIN interval from 3 months to 6 months
  Fit line centroids with a very tailored c-stat script
  soon… Increase chipX/Y regions from 32x32 to 64x64 pixels
  soon… Include warmer FP_TEMP data

ECS ~y2000, 3 months, S3 aimpoint 32x32pix



ECS ~y2016, 6 months, S3 aimpoint 32x32pix



...plus Radioactive Decay

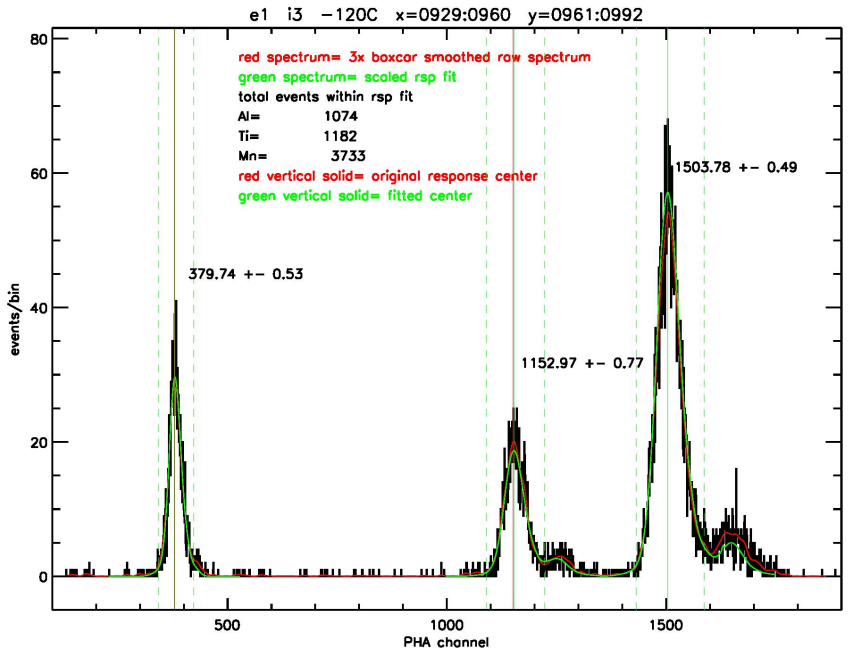
epoch1 y2000 line counts

- ✔ Al-Ka= 1,074
- ✔ Ti-Ka= 1,182
- ✔ Mn-Ka= 3,733

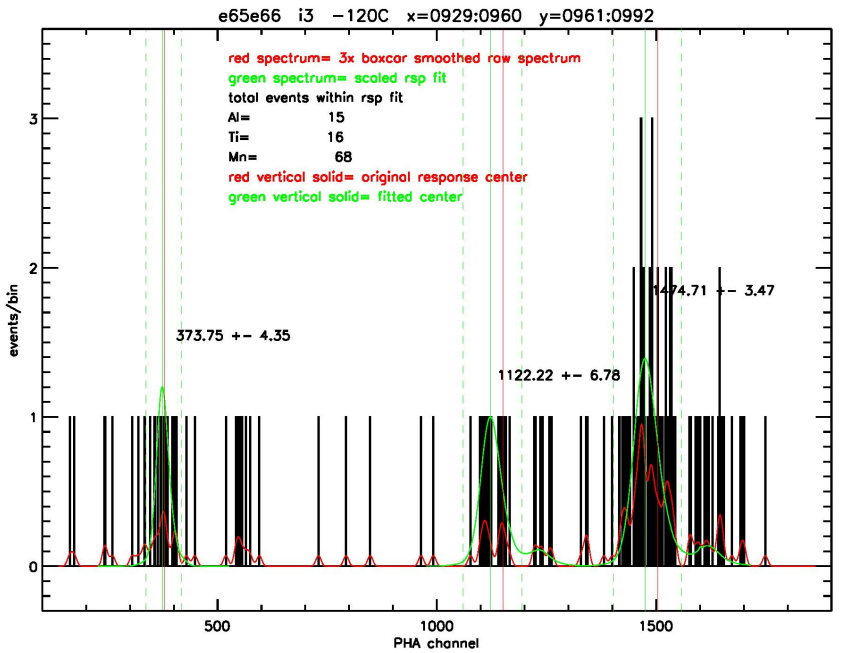
epoch65-66 y2016 line counts

- ✗ Al-Ka= 15
- ✗ Ti-Ka= 16
- ✗ Mn-Ka= 68

ECS 2000, 3 months, I3 aimpoint 32x32pix



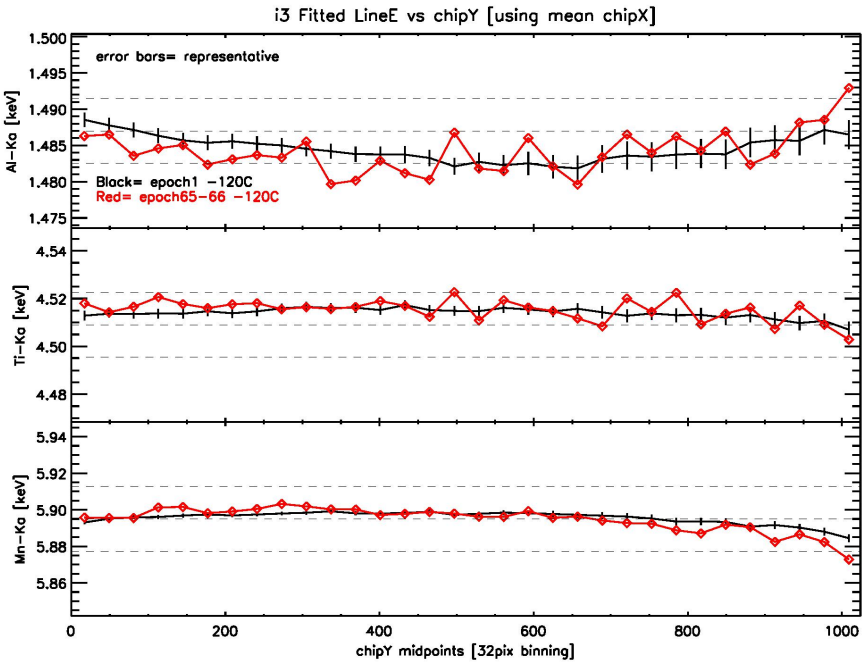
ECS 2016, 6 months, I3 aimpoint 32x32pix



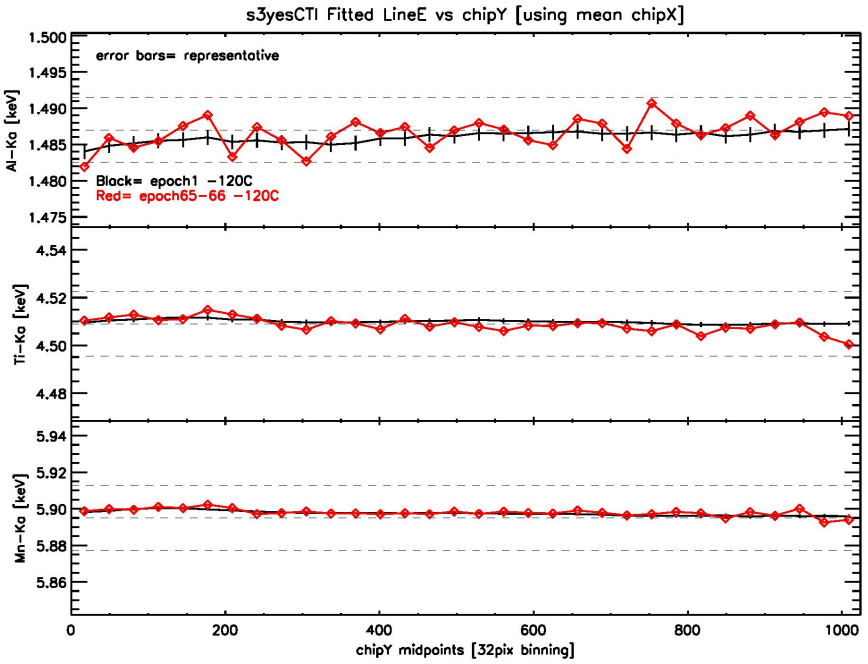
...and yet

TGAIN correction applied to 2016 ECS and re-fitted

I3 ~y2000 and ~y2016, 3 months



S3 ~y2000 and ~y2016, 3 months

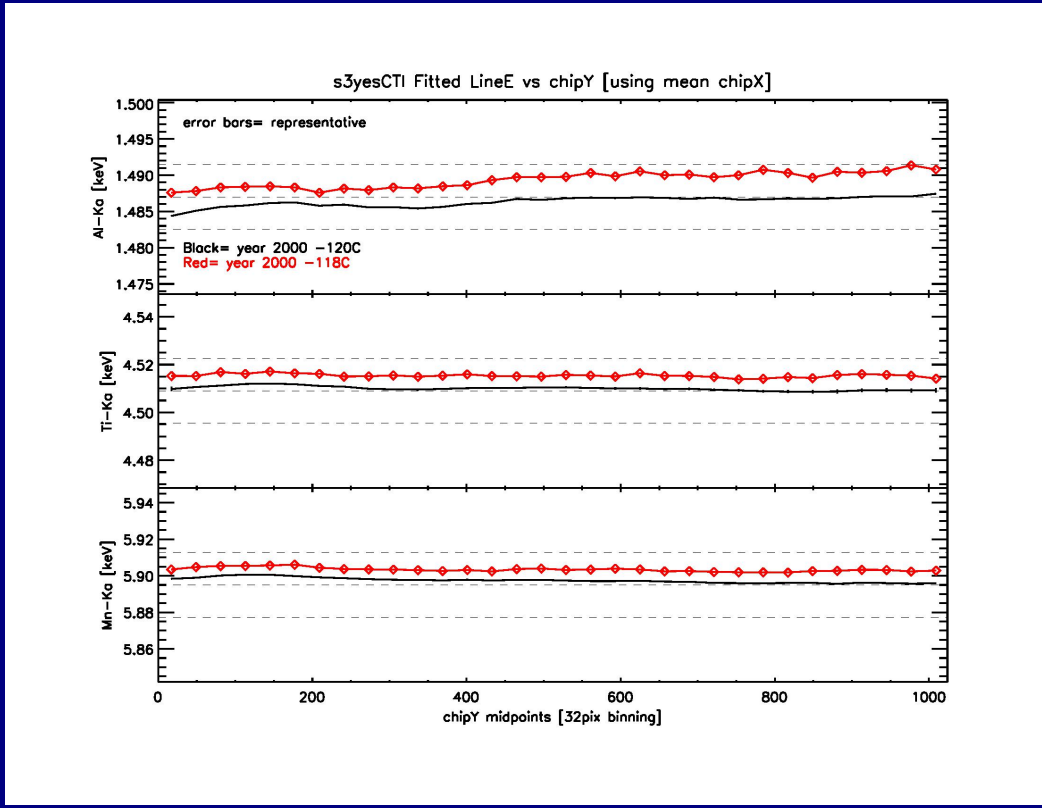


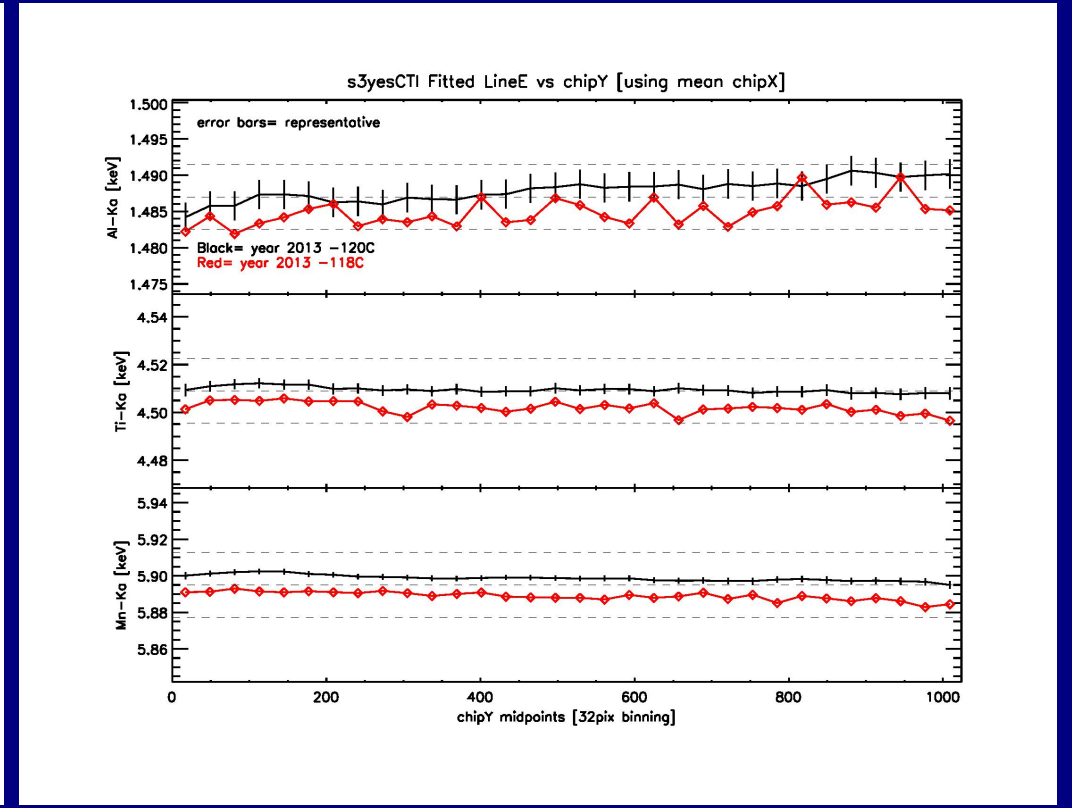
Static temperature-dependence

energy= gain(X,Y,energy/PHA) X [PHA(temperature)+ΔPHA(time,PHA)]

"Evolution of temperature-dependent charge transfer inefficiency correction for ACIS on the Chandra X-ray Observatory," Grant, Catherine E. et al, SPIE, 2016

- ***Problem:*** FP_TEMP effects charge trap time constants; resulting in increase or decrease to CTI
- ***Solution:*** Assume FP_TEMP variations are small
  Assume no temperature-dependent evolution
  Add FP_TEMP dependence into CTI corrector algorithm at a rate of < -0.01%/deg
- ***CALDB:*** TCTI(X,Y,PHA,FP_TEMP)





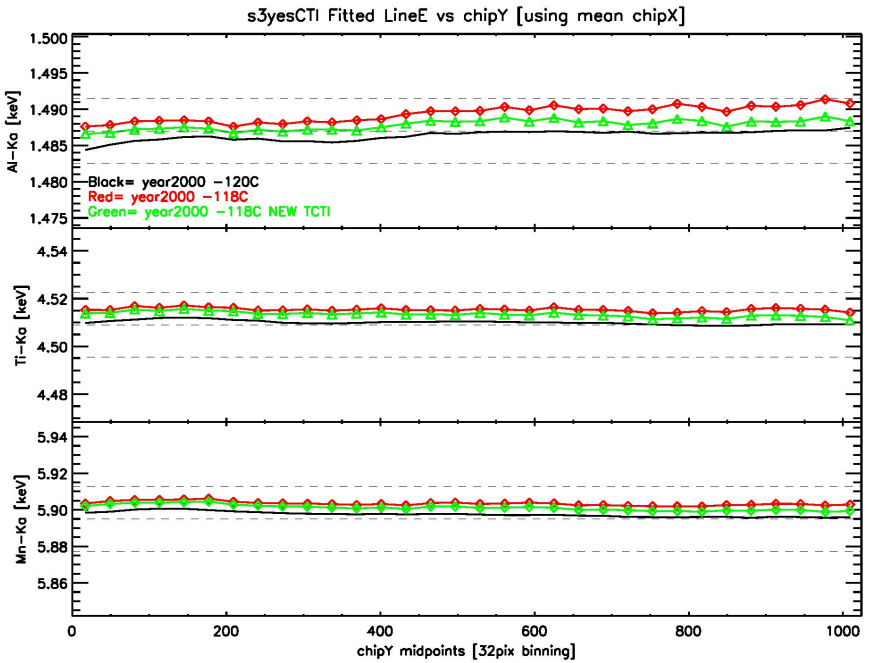
Temperature-Time Dependence BI chips

energy= gain(X,Y,energy/PHA) X [PHA(temperature(time))+ΔPHA(time,PHA)]

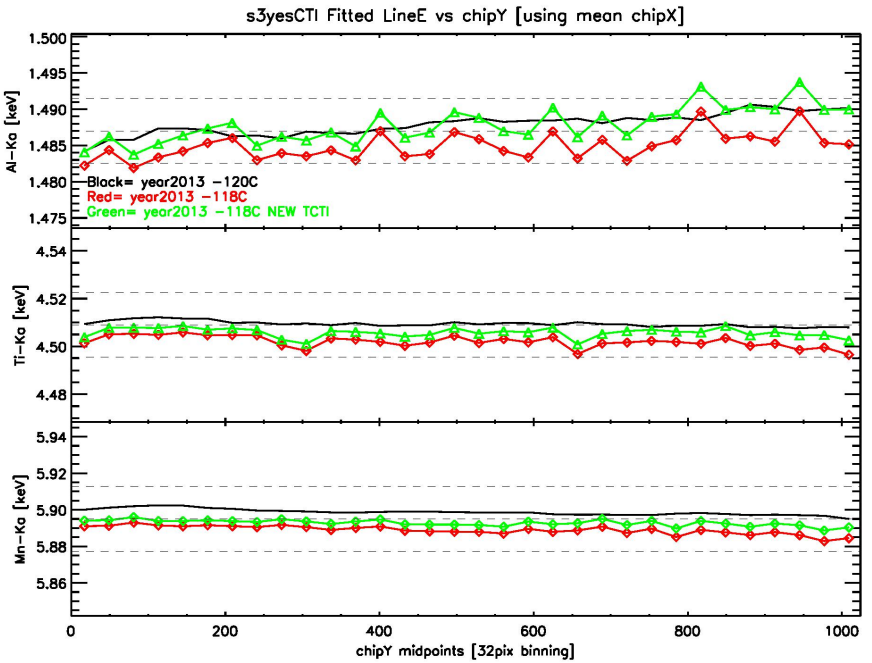
- ***Problem:*** FP_TEMP affect on CTI varies with time
- ***Solution:*** Vary TCTI correction from ~ -0.02%/deg in 2000 to +0.02%/deg in 2015
- ***CALDB:*** TCTI_2000, TCTI_2003, TCTI_2005, TCTI_2010, TCTI_2015
  Release Date ~April 2017

*** T-TCTI improvement for warm S3 data ***

S3 y2000, 12months, -120C, -118C, -118C_Time-corrected



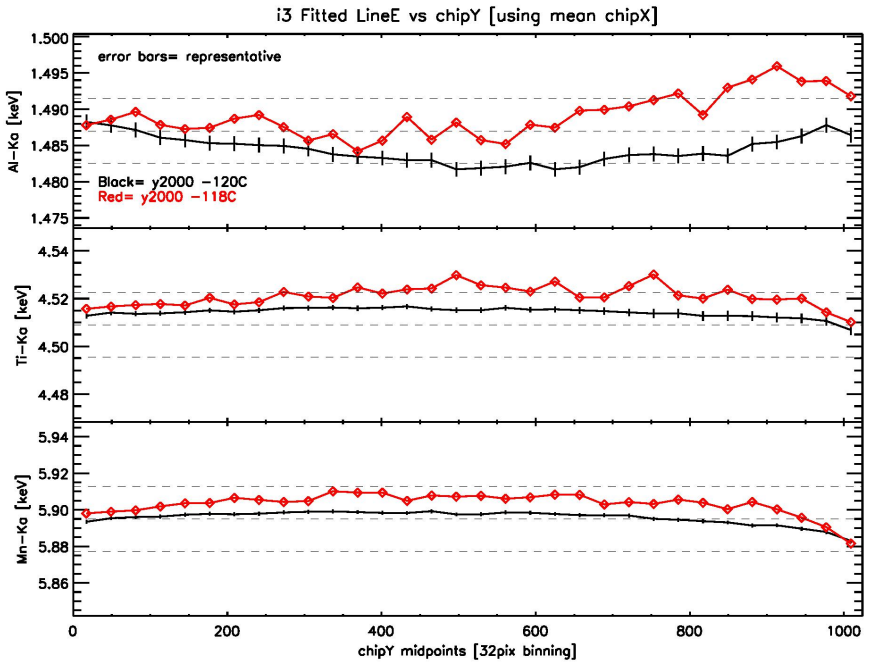
S3 y2013, 12months, -120C, -118C, -118C_Time-corrected



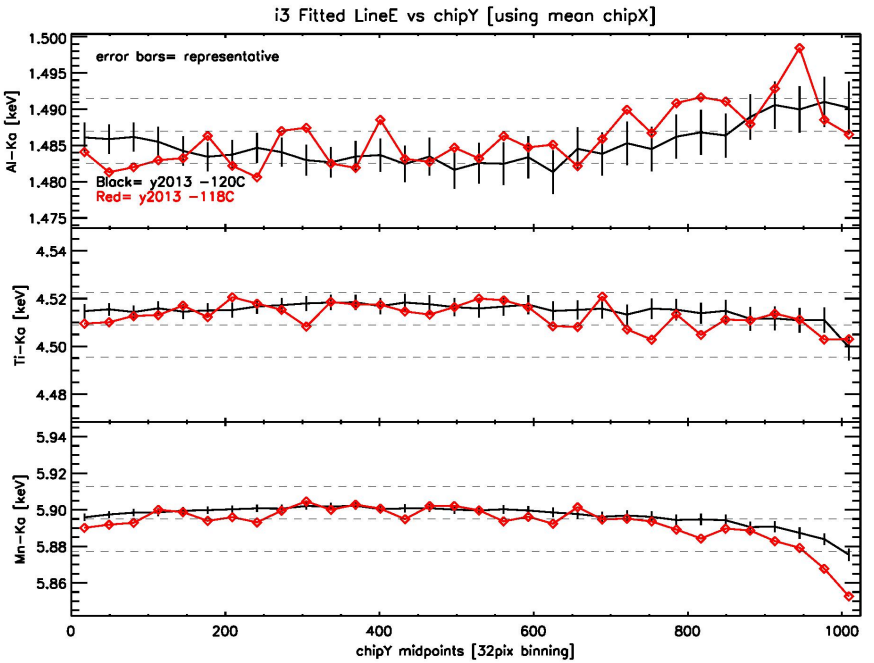
Temperature-Time Dependence FI chips

- Still using a static temperature dependence
- Weaker temperature evolution
- Data suggest CTI refinements needed for FI
  More analysis needed

I3 y2000, 12 months, -120C, -118C



I3 y2013, 12 months, -120C, -118C



~April 2017

New T-TCTI CALDB files for BI chips in ~5 year increments

~Spring/Summer 2017

Updated TGAIN memo

Detailed plots of line energy accuracy per TGAIN region

How accurate is my ~1.5keV line fit on I3 between 257:288x and 97:128y?

~2017

DET_GAIN and response updates

~2017+

CTI refinements for FI chips

ECS epoch1
-120C
1/29/2000-4/30/2000