Overview

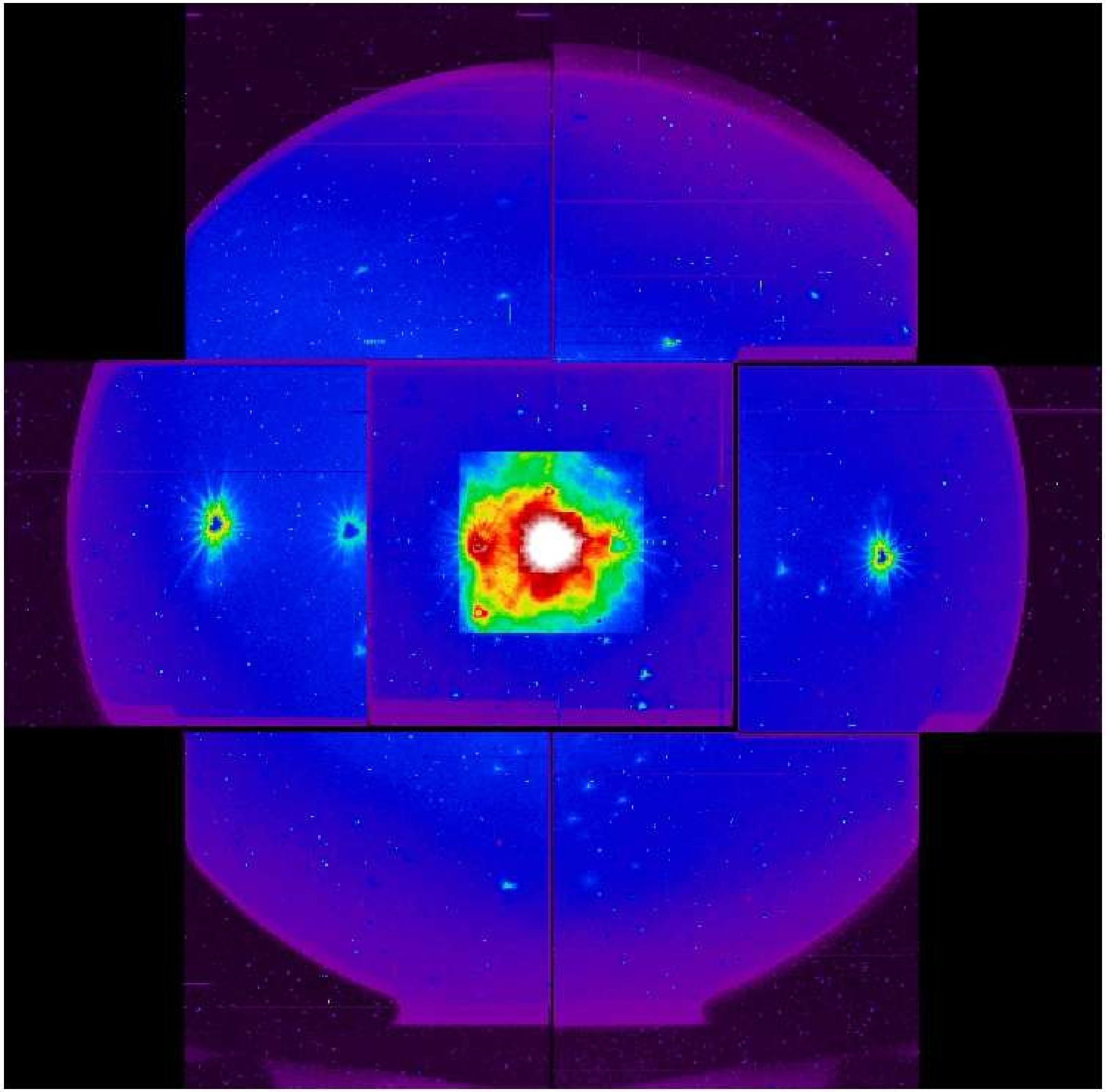
- Review of the Goddard method
- Update on instrument/detector evolution
  (a purely phenomenological approach)
- Characterization of the soft proton flares
  (spectral shape and spatial distributions)
- Testing the stability of this method
  (by looking at pointings with multiple obsids)

Method Review: Philosophy

- Emission from the Galactic ISM fills the FOV
  - Sufficiently faint that it must be summed over large regions in order to produce a good spectrum
- The same is true of extended extragalactic emission (e.g. galaxies & clusters)
- Background subtraction method must provide good statistics over large regions of the FOV
- but still be sensitive to the small-scale variations in the detector

Method Review

- The corner pixels are a measure of the particle background



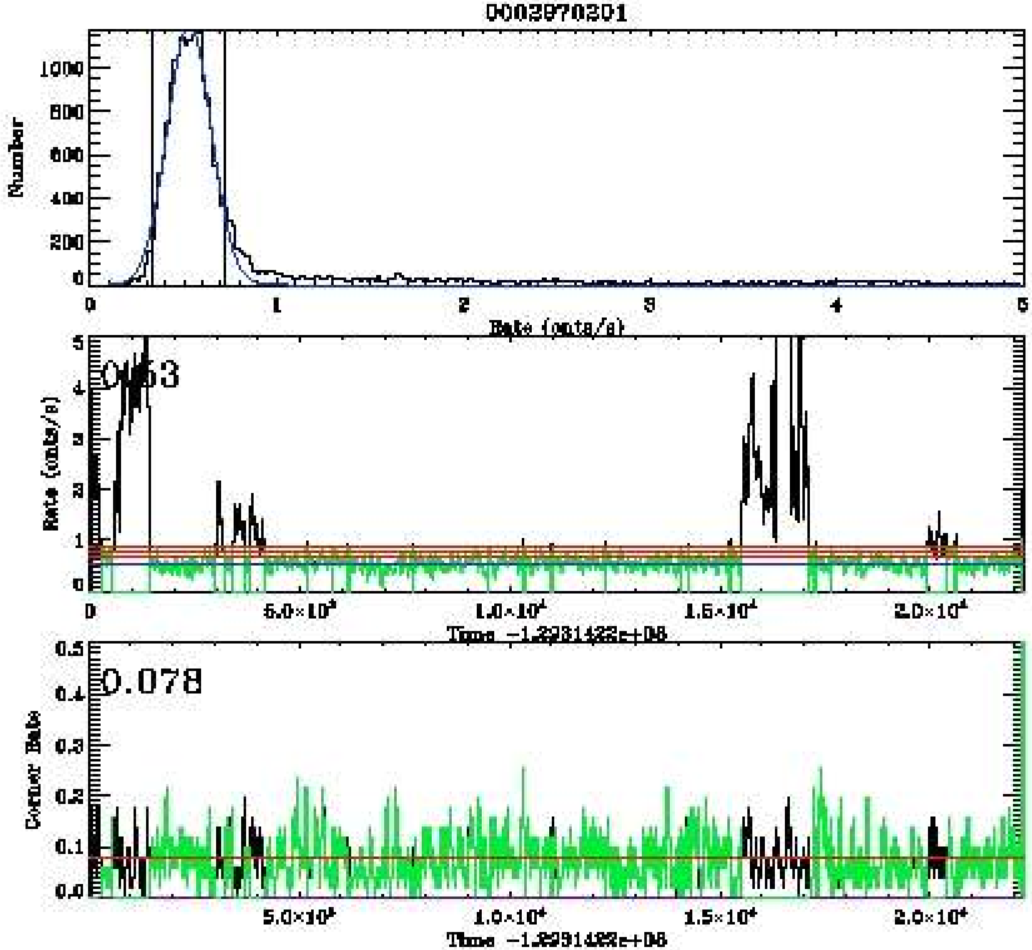
Method Review

- The corner pixels are a measure of the particle background
- There are not enough counts in the corner pixels of a single observation for a robust characterization of the background…
- …need to find some way of using corner data from other observations…
- ...need to characterize the temporal variations of the corner spectra.

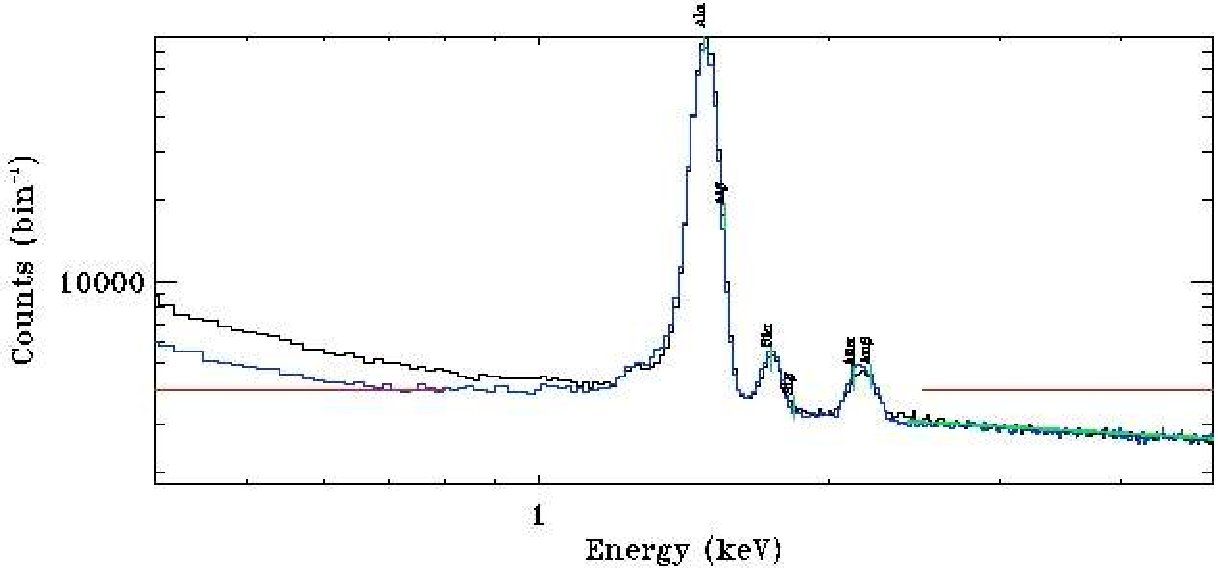
Method Review: Corner Data

- The Entire Public Archive, Revs 25-1128
  - 3500 observations, 8100 observation segments
  - 76 Ms/MOS camera
- Remove CalClosed and badly flared data
  - 2500 observation segments/MOS camera
  - 44 Ms/MOS camera
- 34% of MOS data affected by flares

Corner Data



For each obsid we formed a histogram of the rate, set the "quiescent level" to mean rate, and removed periods >3 above quiescent level.

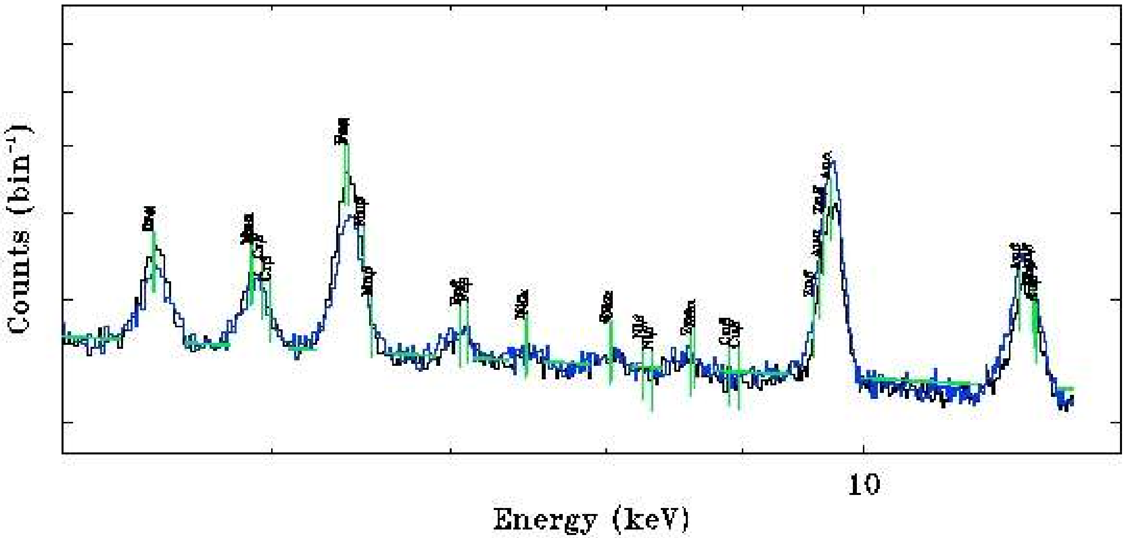


3 Parameters for the Spectral Shape

Rate:
0.3-10.0 keV

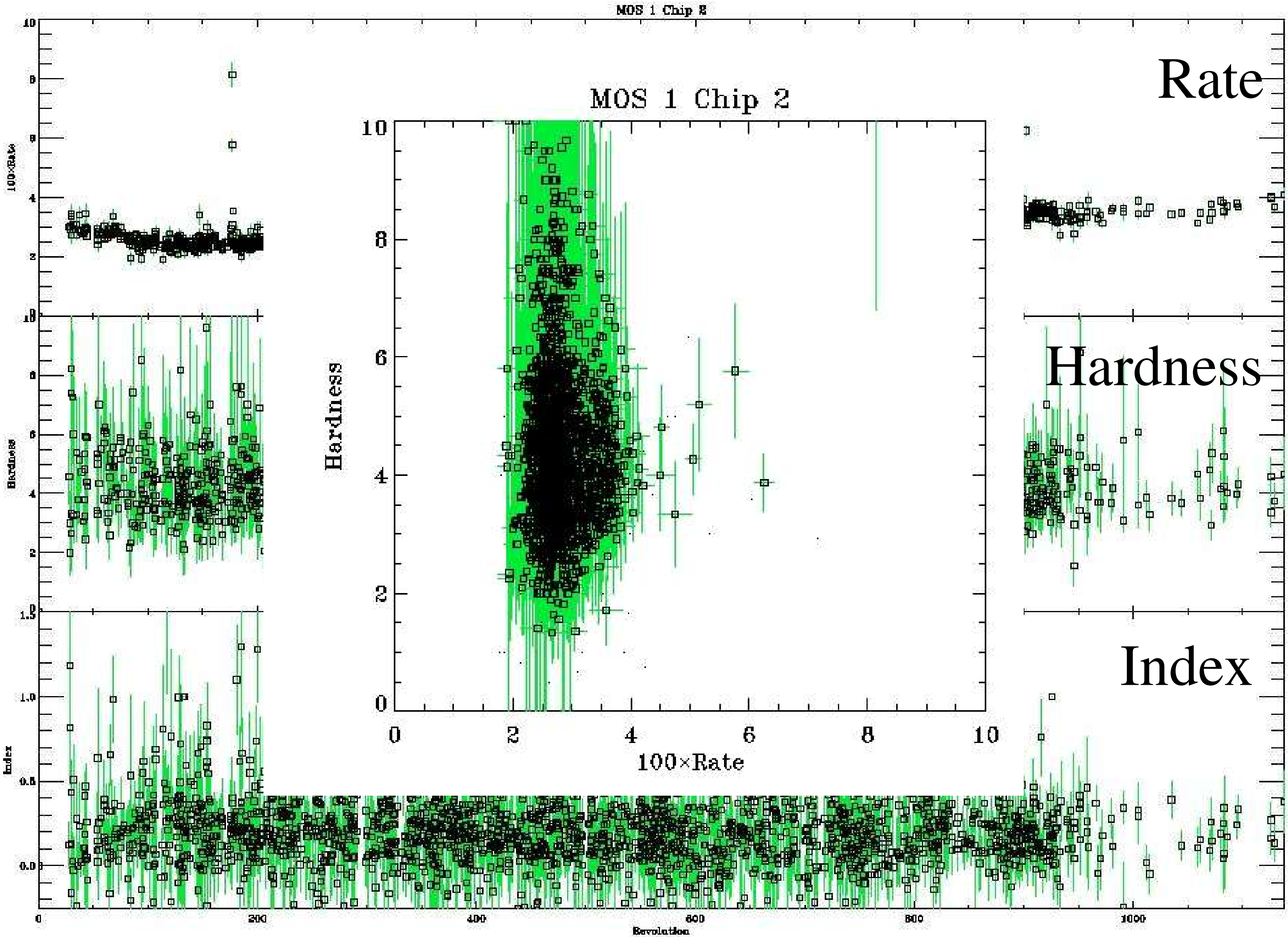
Hardness:
2.5-5.0/0.4-0.8 keV

PL Index
5-12 keV

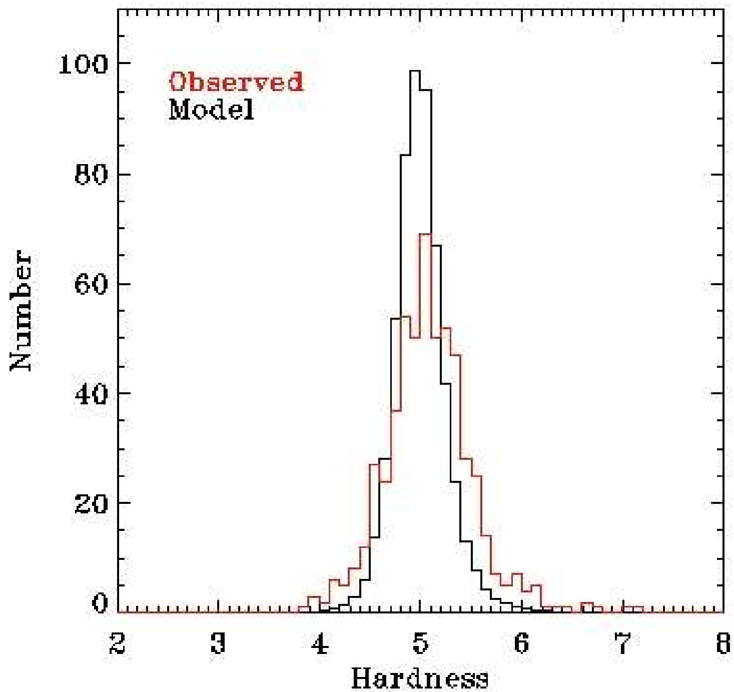


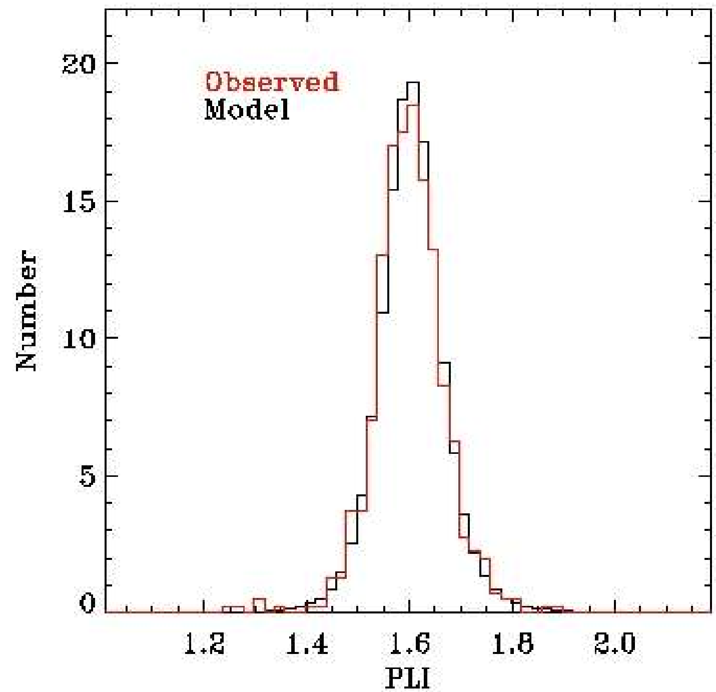
The mean corner spectrum

For A Typical Chip



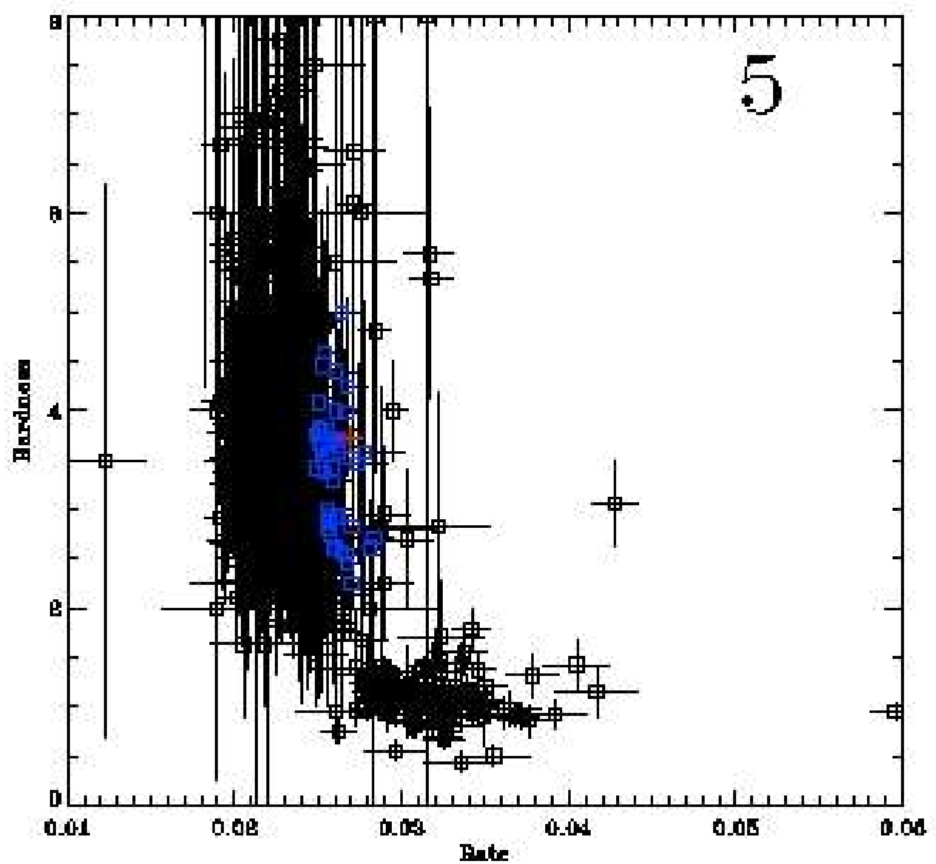
Method Review





- Variation in the Hardness is greater than statistical: Hardness is temporally variable
- Variation in Power Law Index is statistical

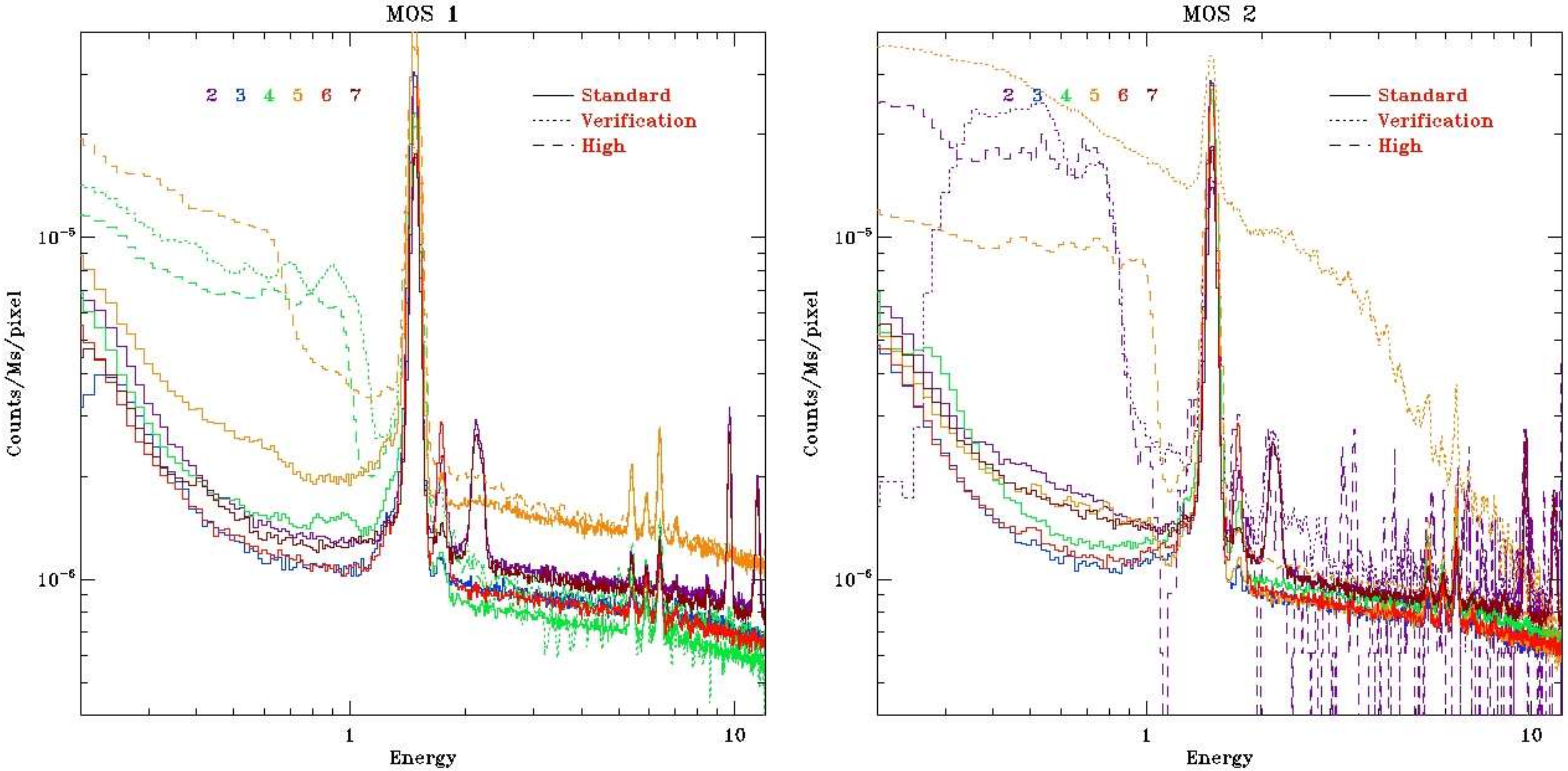
Method Review



Step 1: Augmentation

For a given observation, measure Rate and Hardness. From the database of corner data, extract more data with similar rates and hardness.

Method Review

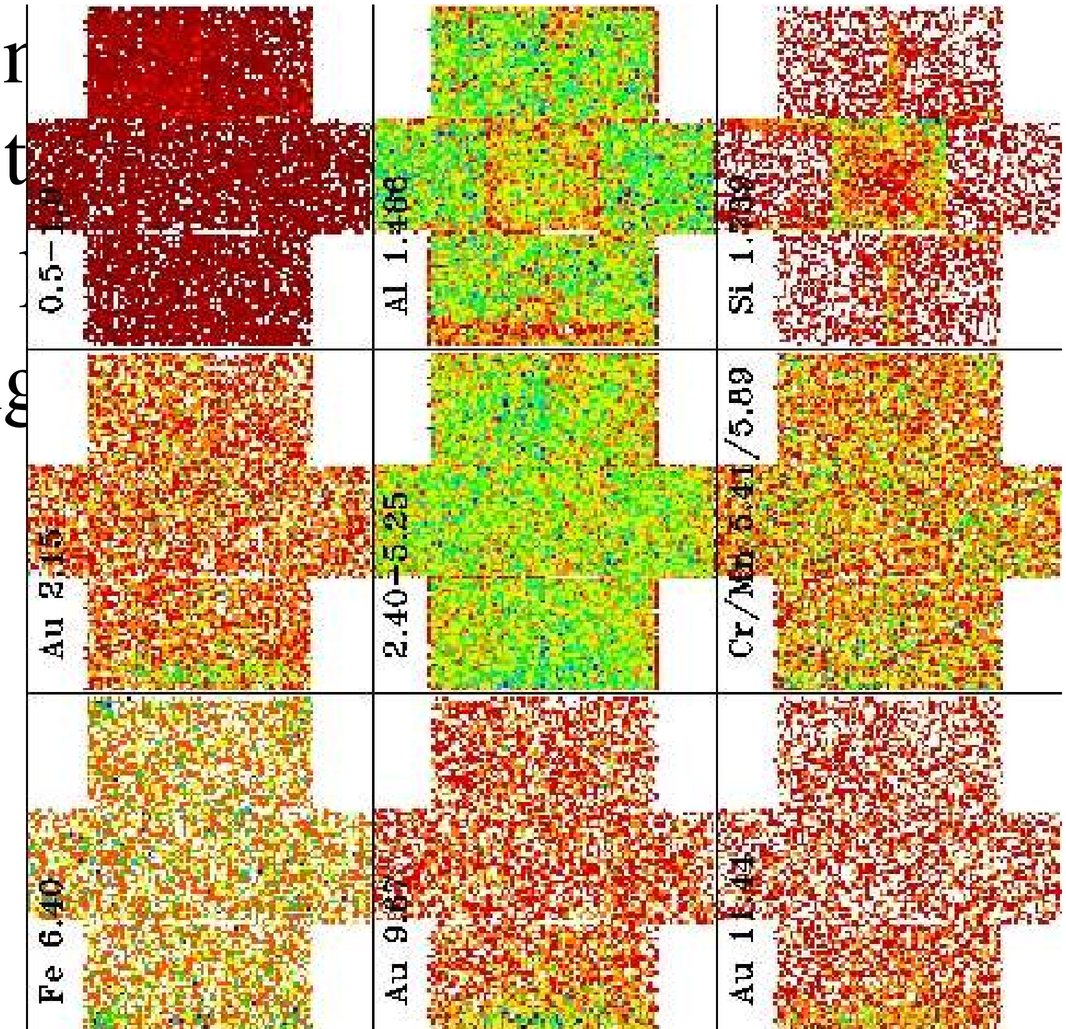


Step 1: Augmentation

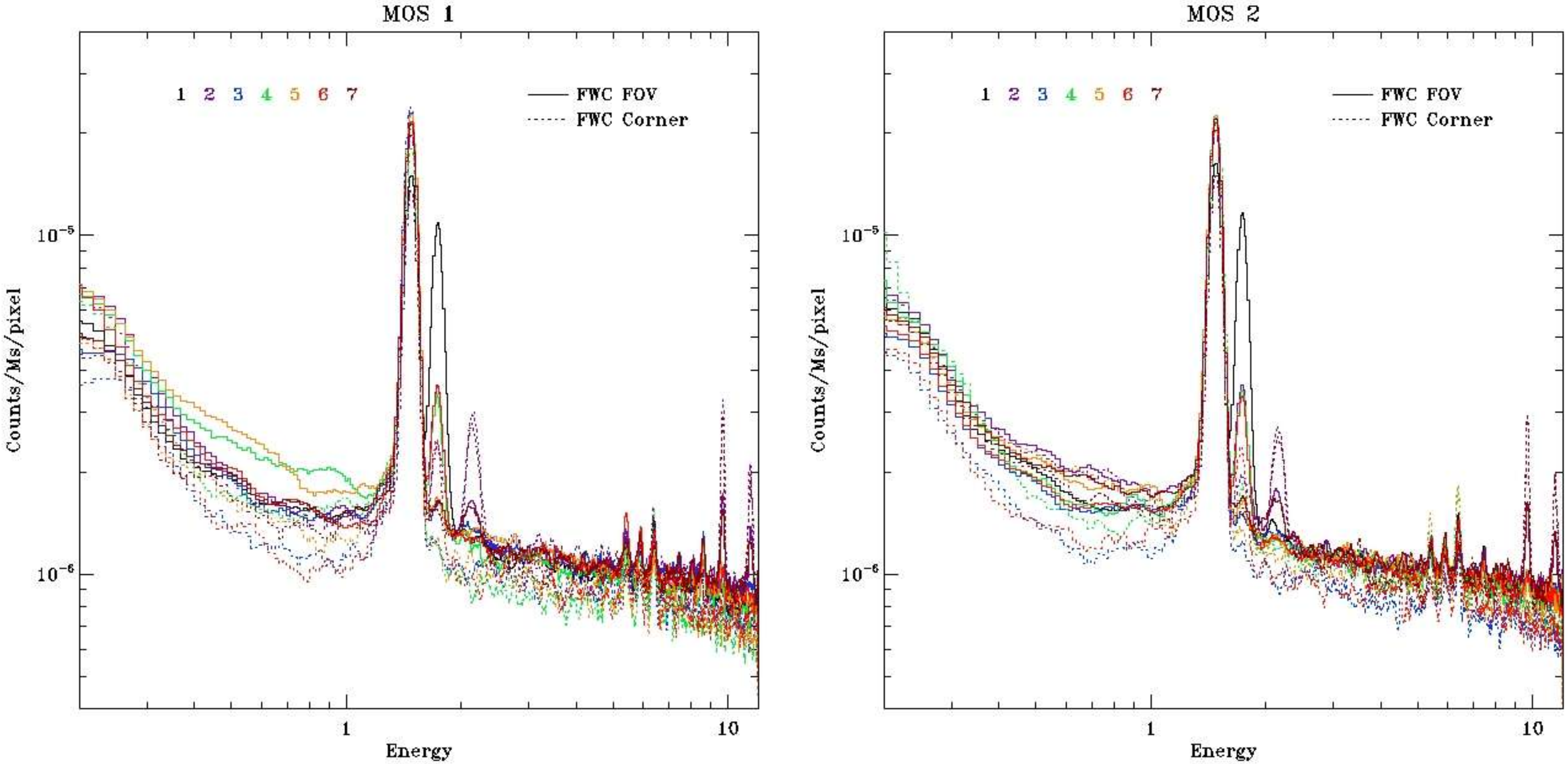
Since the mean spectrum varies from chip-to-chip, augmentation must be done on chip-by-chip basis.

Method Review

- The background spectrum measured by the corner data need r measured within t
- The instrumental l particularly strong



Method Review



The continuum also varies strongly

Method Review

Step 2: Correct spectrum to the FOV

Assume that temporal variations affect the corner pixels and the FOV in a similar manner.

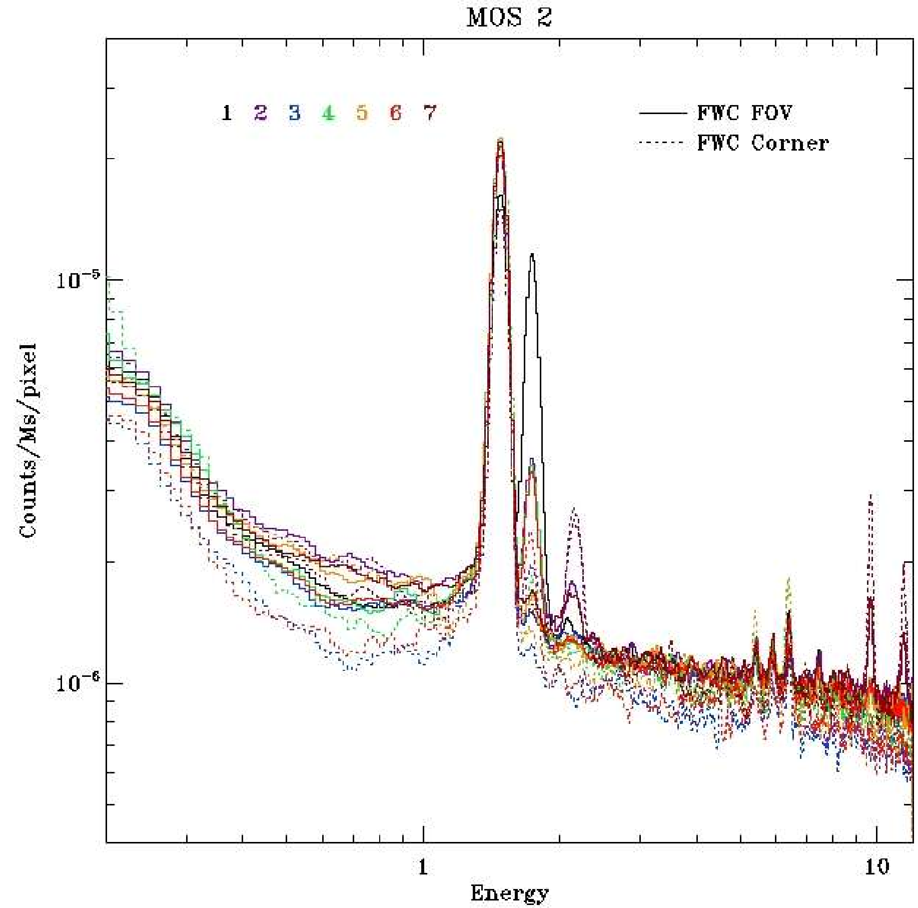
The background spectrum in the observation FOV is then given by

$$\frac{\text{Obs. Corner spectrum*FWC FOV spectrum}}{\text{FWC Corner spectrum}}$$

Method Review

Step 2: Correct spectrum to the FOV

- Chip 1 is a special case – corner data must be constructed from a subset of corner data for the other chips
  - MOS1 use 2, 3, 6, & 7
  - MOS2 use 3, 4, & 7



Method Review: FWC Data

- The Entire Public Archive
- For normal chip states
  - 60-85 observation segments
  - 0.7-1.1 Ms of exposure
  - $1.5\text{-}2.3\times10^5$ counts
- For anomalous chip states
  - ~10 observation segments
  - 60-200 ks of exposure
  - $1.6\text{-}6.2\times10^4$ counts

Method Review

Step 3: Ignore the Al and Si lines

Slight shifts in

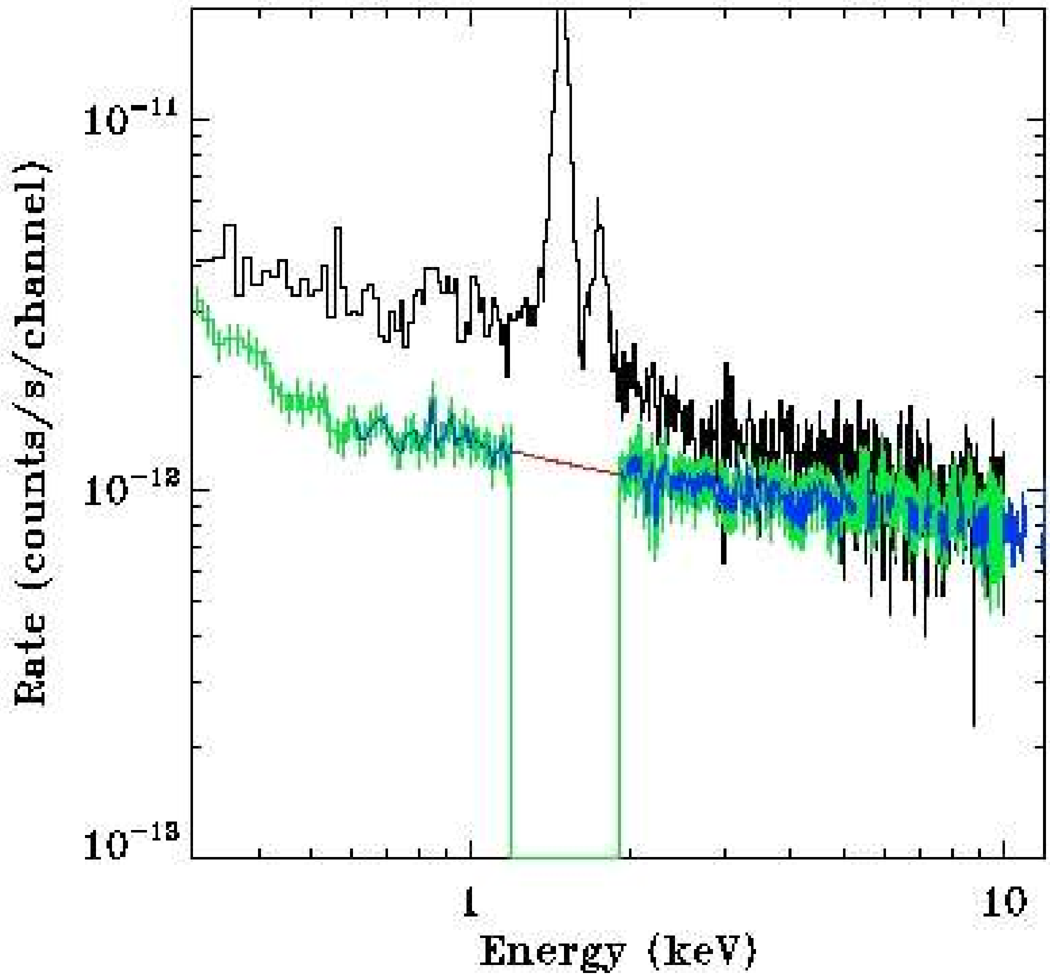
strong P-Cygni

Therefore interpola

forming the ba

Fit the Al and Si li

spectrum



Method Review

Implementation:

- Originally: Perl scripts calling SAS tasks,

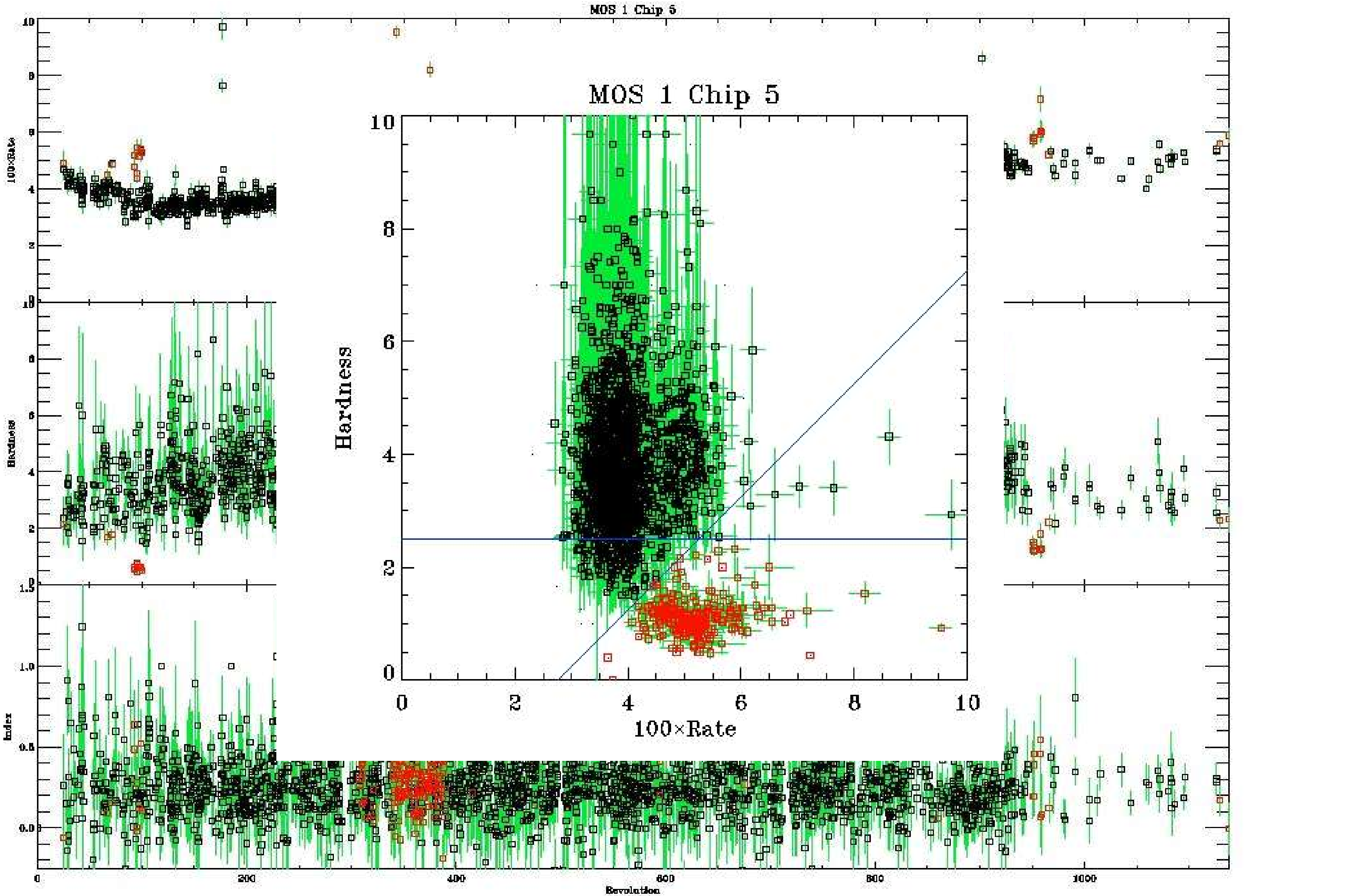
  IDL routines for light curve cleaning and background spectrum construction (mine)

- Now: Perl scripts calling SAS tasks,

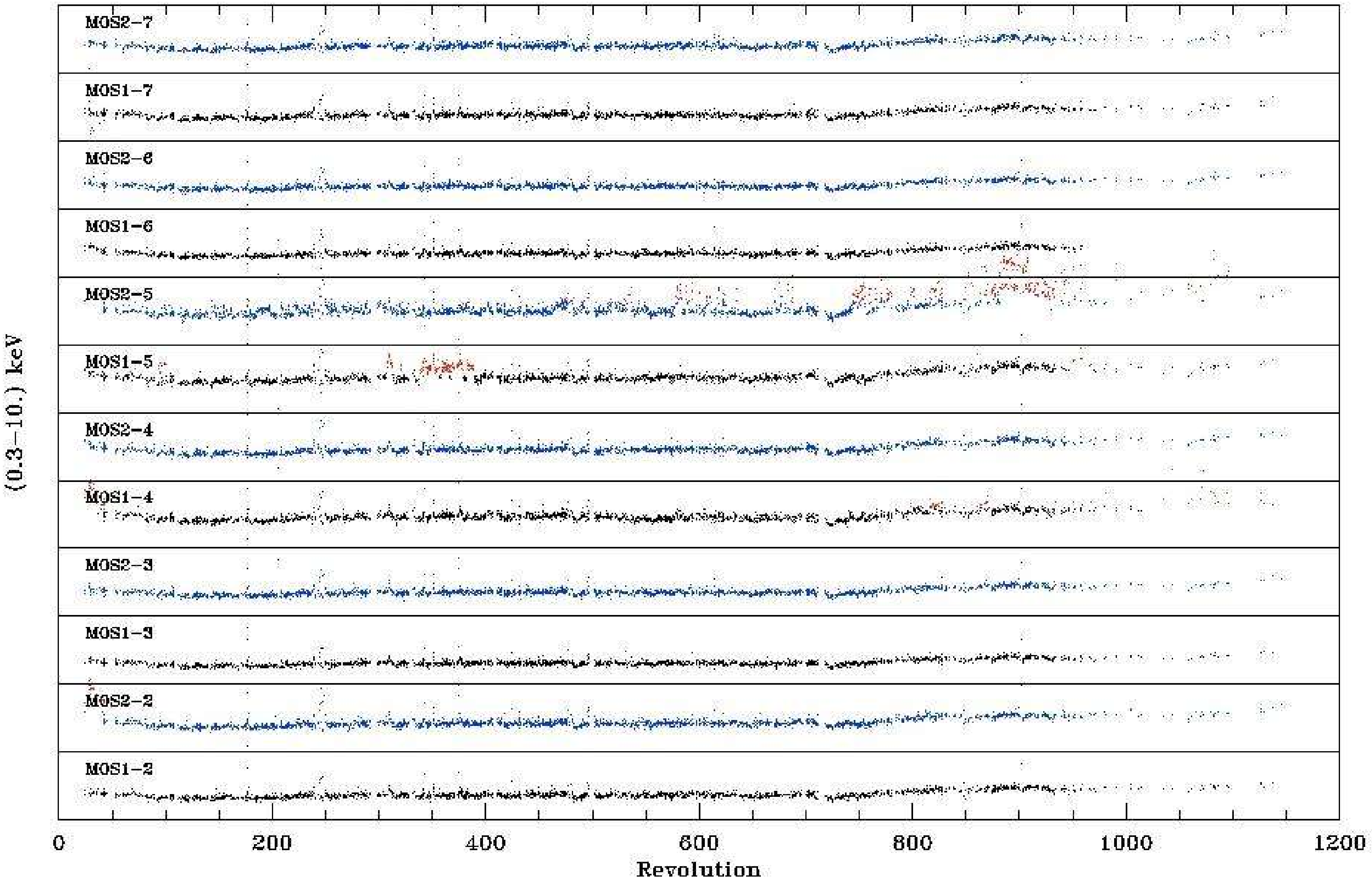
  FORTRAN routines for light curve cleaning and background spectrum construction (Snowden)

- Soon: Perl scripts calling SAS tasks (Perry)

Detector Phenomenology

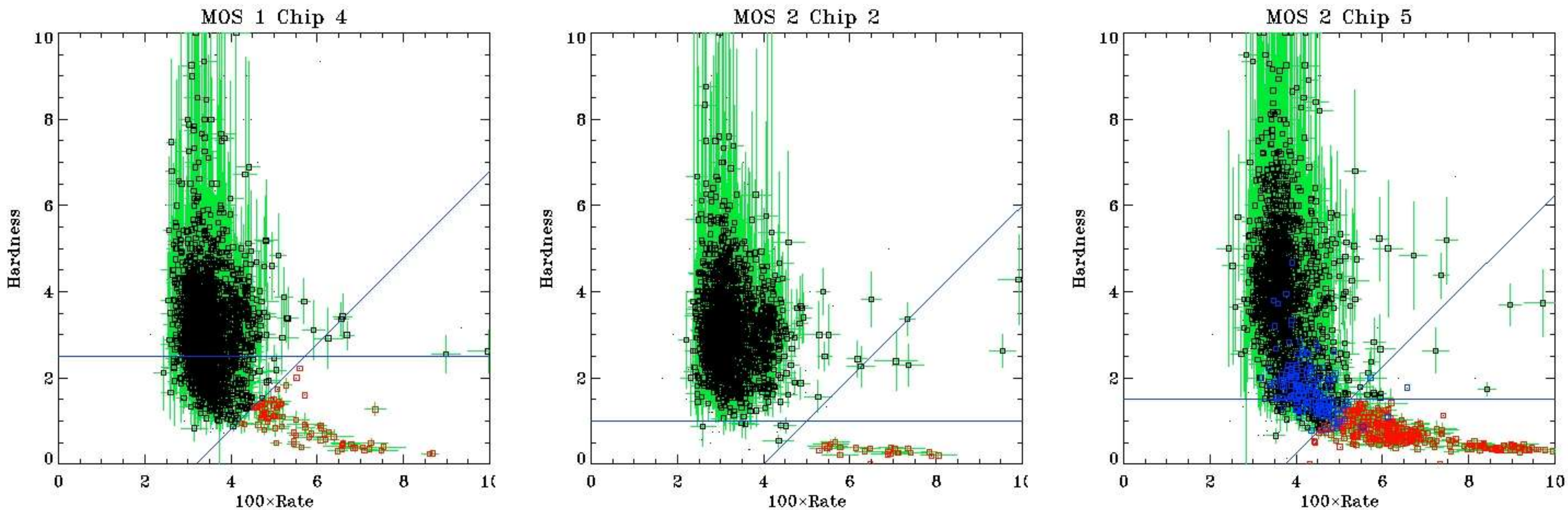


Detector Phenomenology



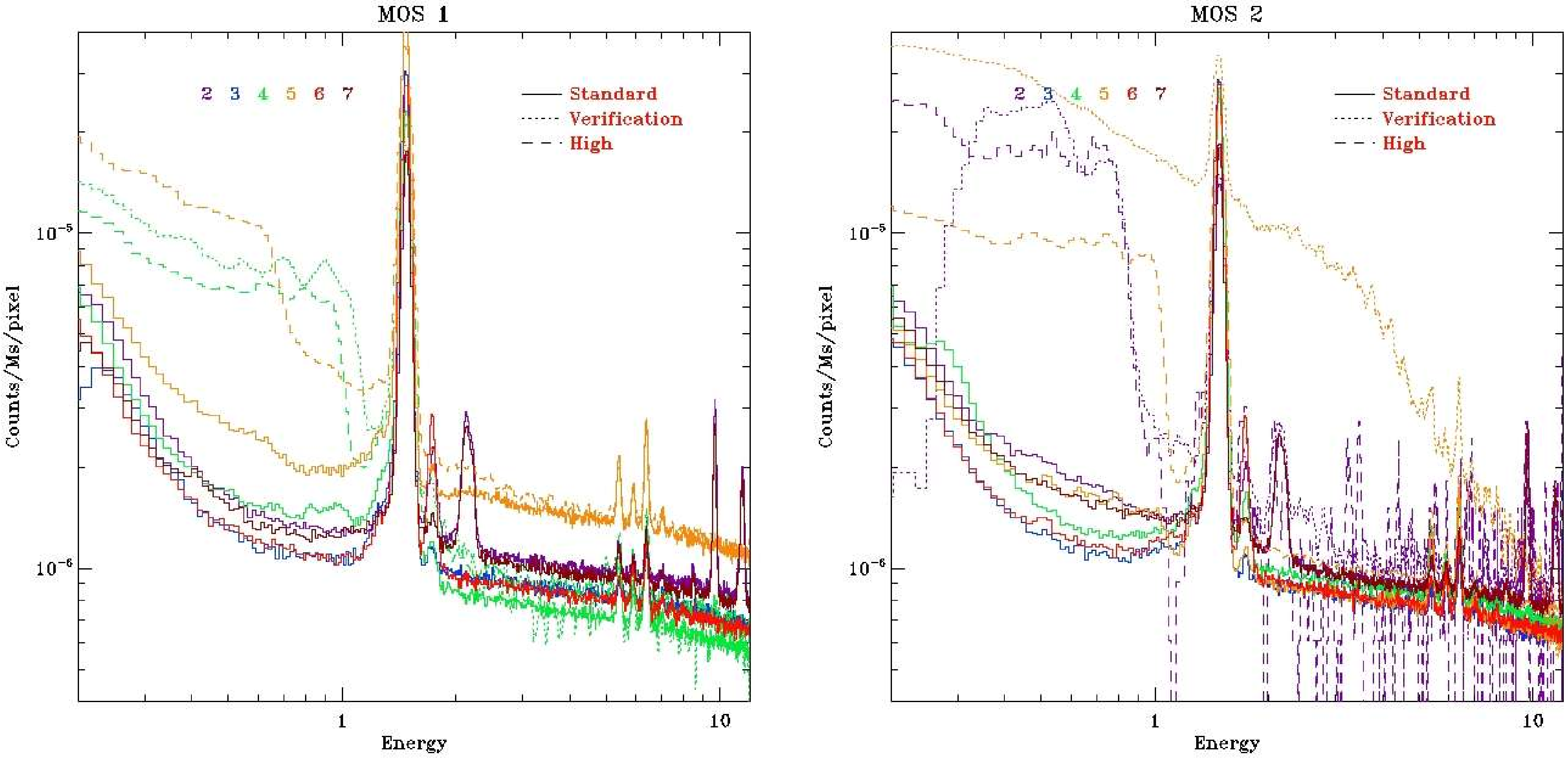
Detector Phenomenology

- Not all chips are well behaved…
- MOS1-4, MOS1-5, MOS2-2, MOS2-5
  - anomalous states occur at different times
  - always characterized by high rates and low hardness



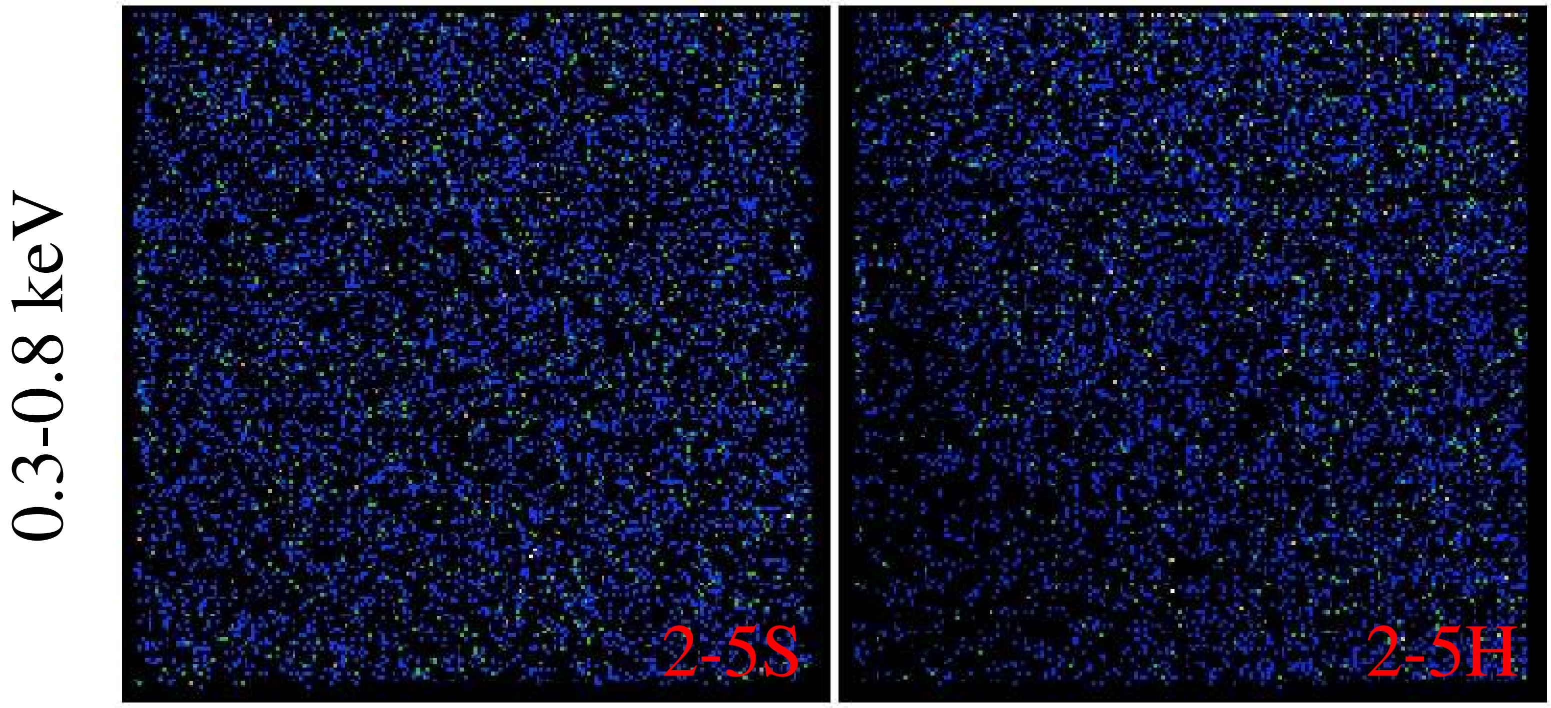
Detector Phenomenology

- MOS1-4, MOS1-5, MOS2-2, MOS2-5
  - always characterized by high rates and low hardness due to low energy “plateau”



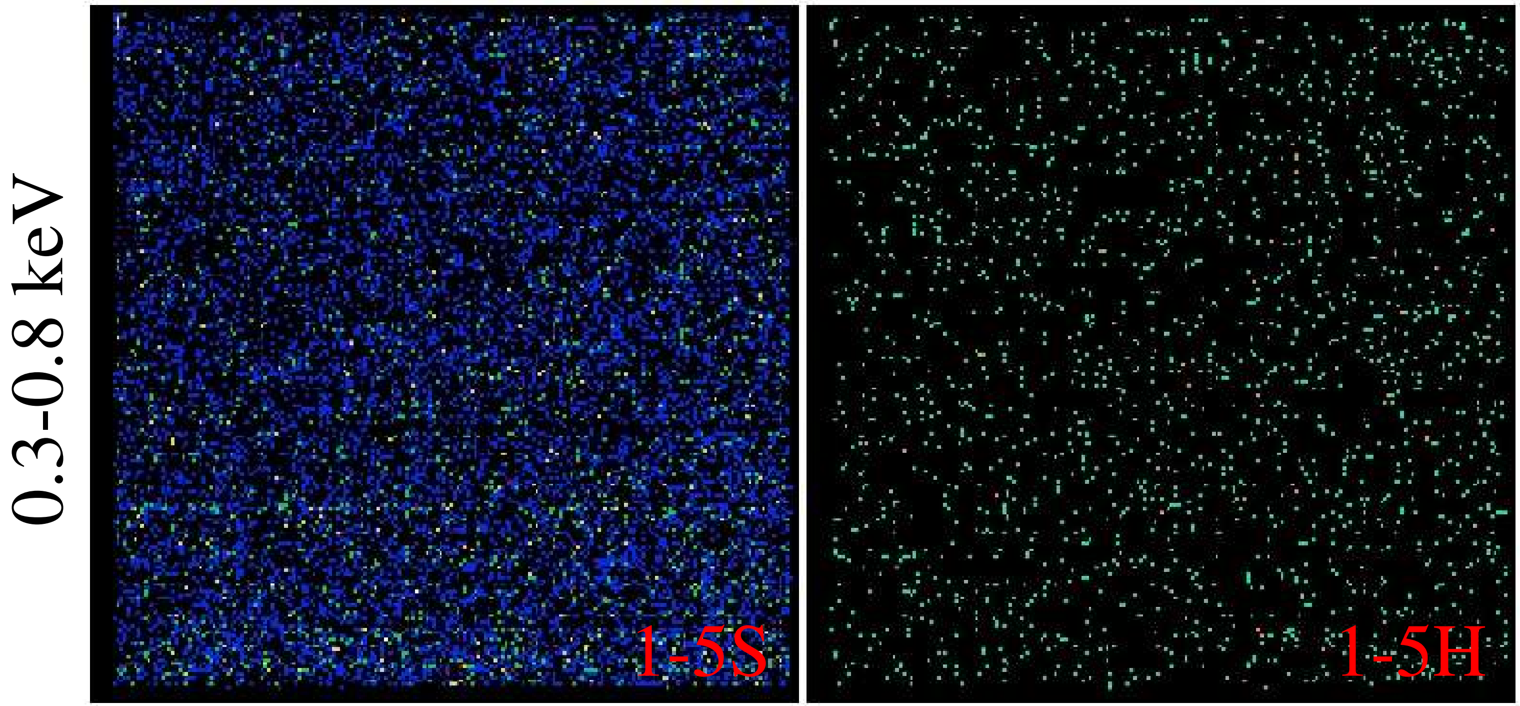
Detector Phenomenology

- MOS1-4, MOS1-5, MOS2-2, MOS2-5
  - always characterized by high rates and low hardness due to low energy “plateau”
  - “extra” component somewhat localized for some chips



Detector Phenomenology

- MOS1-4, MOS1-5, MOS2-2, MOS2-5
  - always characterized by high rates and low hardness due to low energy "plateau"
  - "extra" component somewhat localized for some chips, but not so clear in other cases



enomenology

OS2-2, MOS2-5

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in other cases

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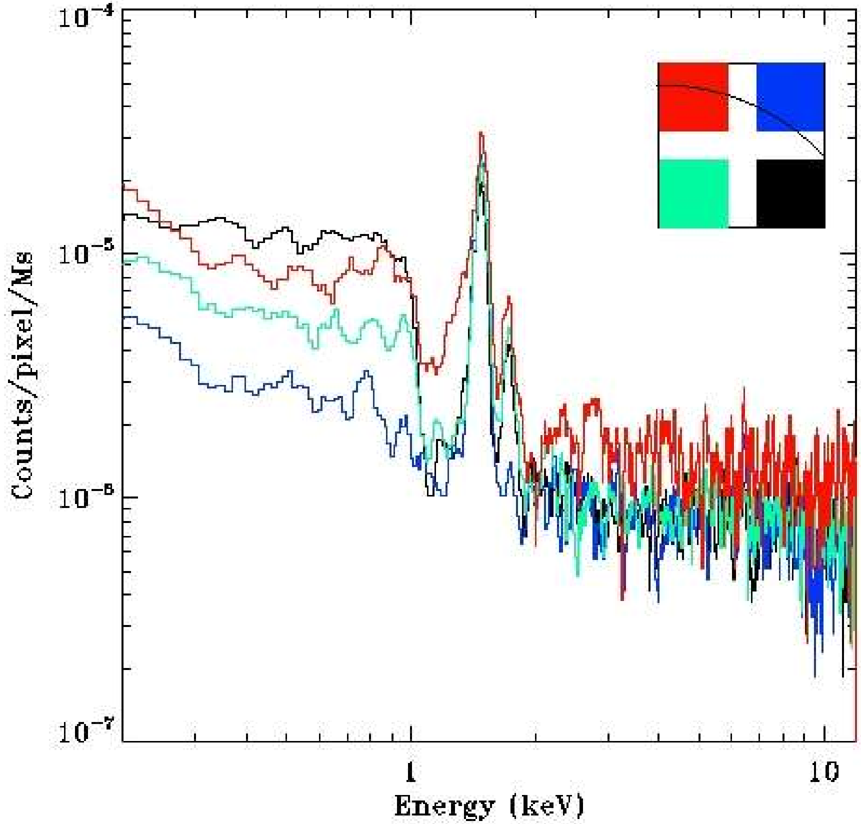
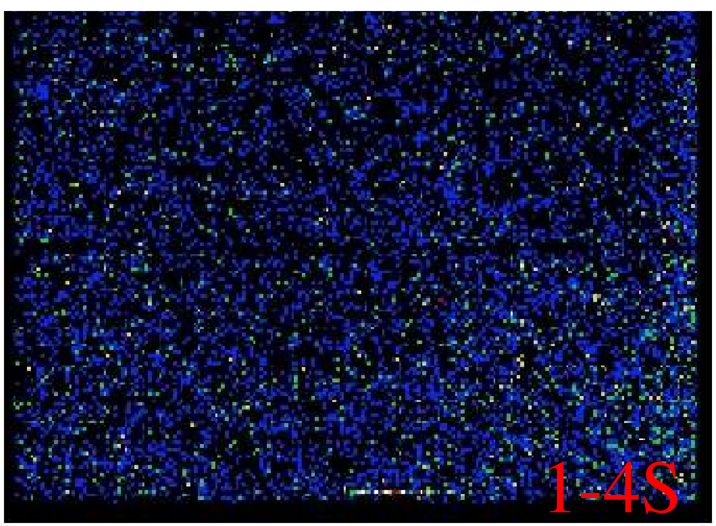
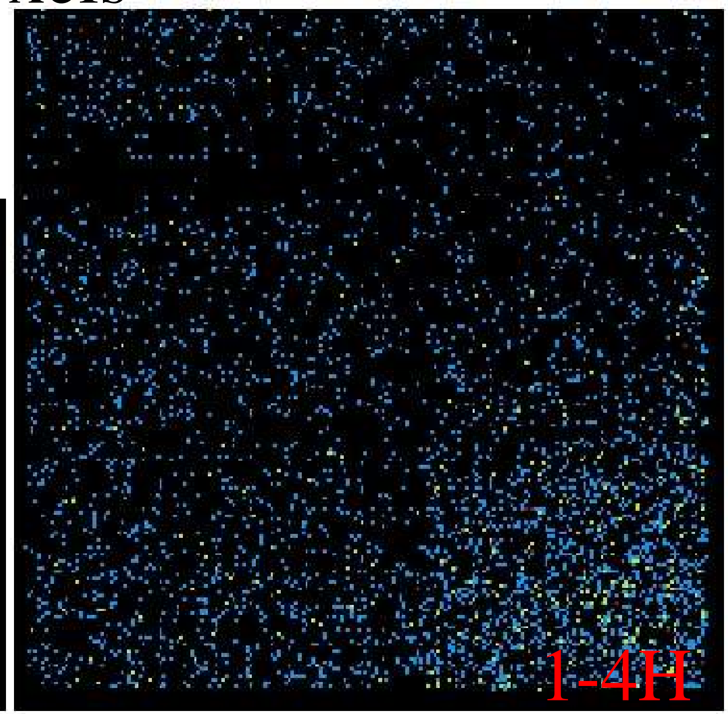
xels



0.3-0.8 keV





Detector Phenomenology

- Summary of States
  - S: “standard state”
  - V: “verification” : 1-4, 2-2, 2-5 for Rev<41.5
  - H: “high”:1-4, 1-5, 2-5, detectable in corner pixels
  - A: “anonymous”: 1-4, not detectable in corner pix.
    - No other chip has yet been detected in A state
    - But since A state can only be detected in FWC data…
- Need to understand what causes these states
  - Are there detector parameters that can be used to detect these states independently?
  - Particularly important for the A states!

Detector Phenomenology

- Handling multiple states
  - V state does not have enough effected data to justify significant effort
  - H state FWC data does exist, poor for 1-4 & 1-5
  - A state FWC data OK for 1-4 (not great)
- Modifications to ESAS
  - Detect chip state first
  - Extract appropriate state FWC data
  - ✘ Augmentation careful to exclude data from the wrong state
  - For now 1-4 is caveat emptor

Soft Proton Flare Characterization

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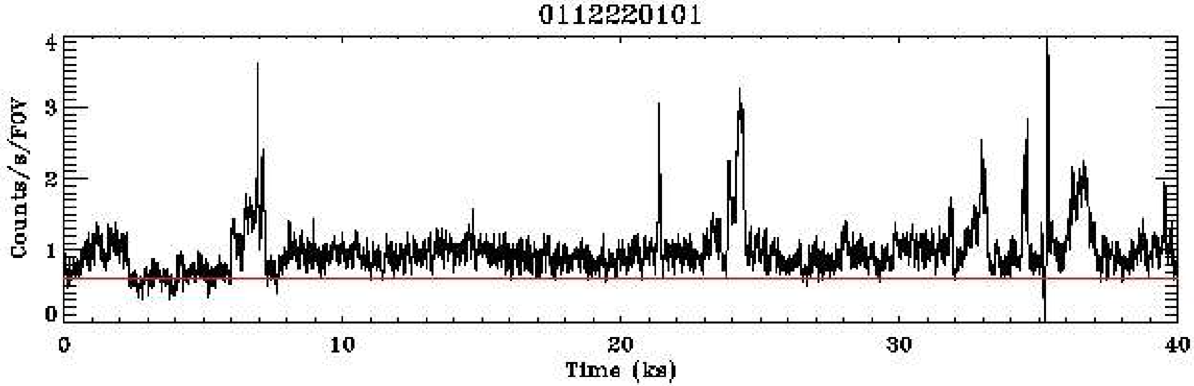
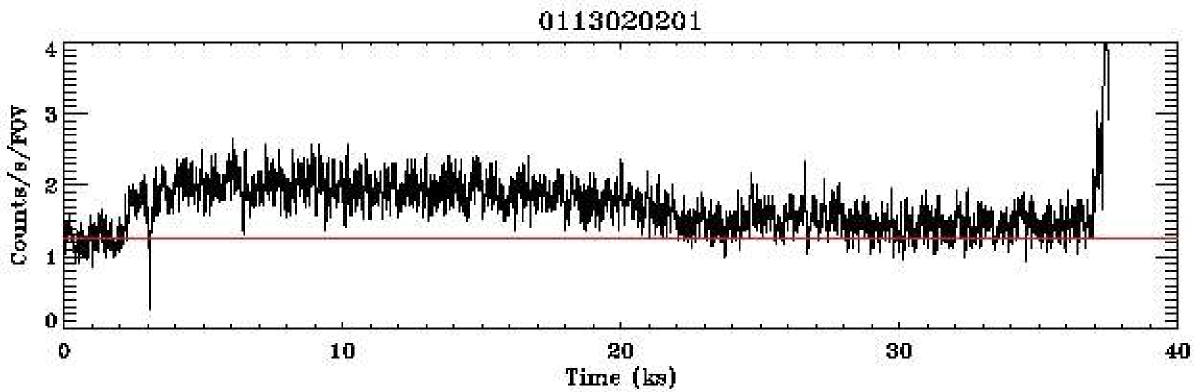
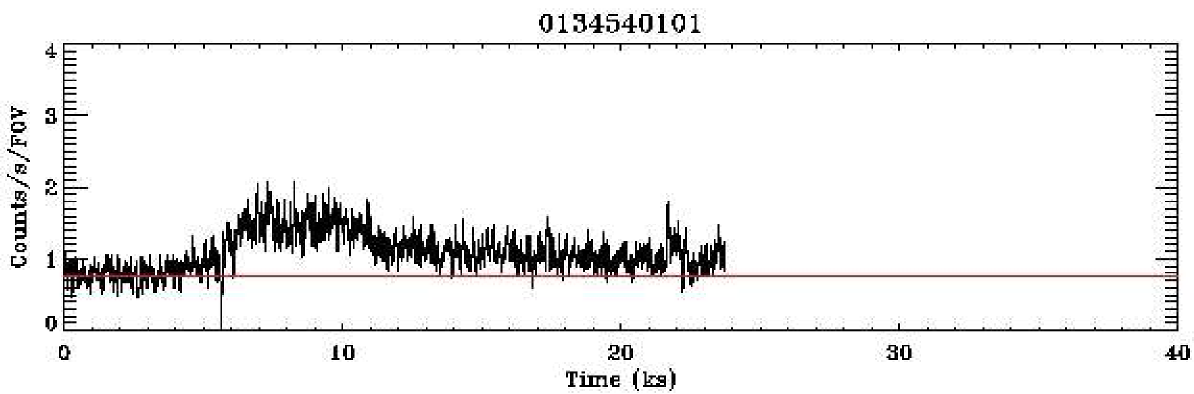
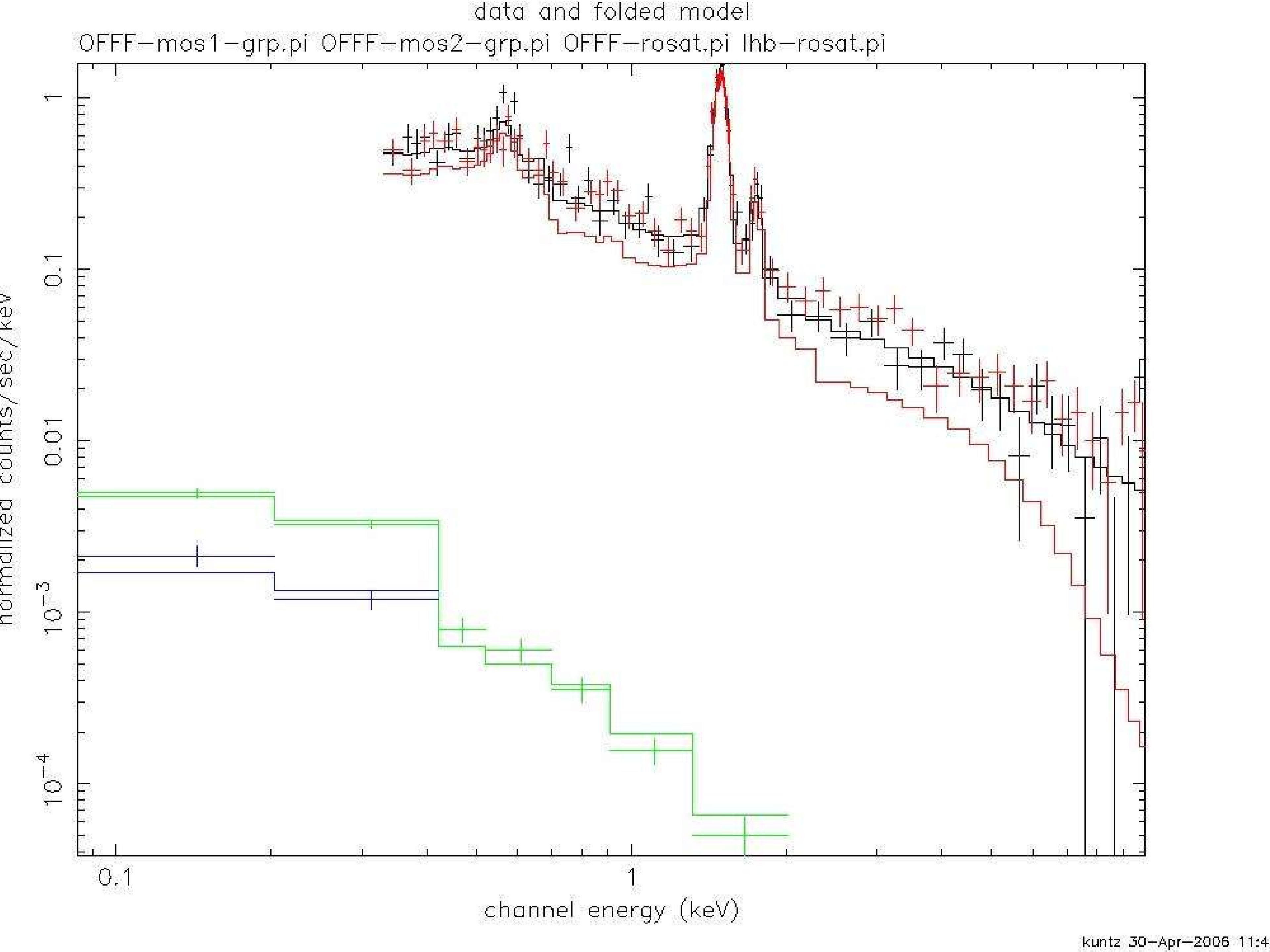
  – D
- Sinc ation,
  - M
  - M on
- Easi







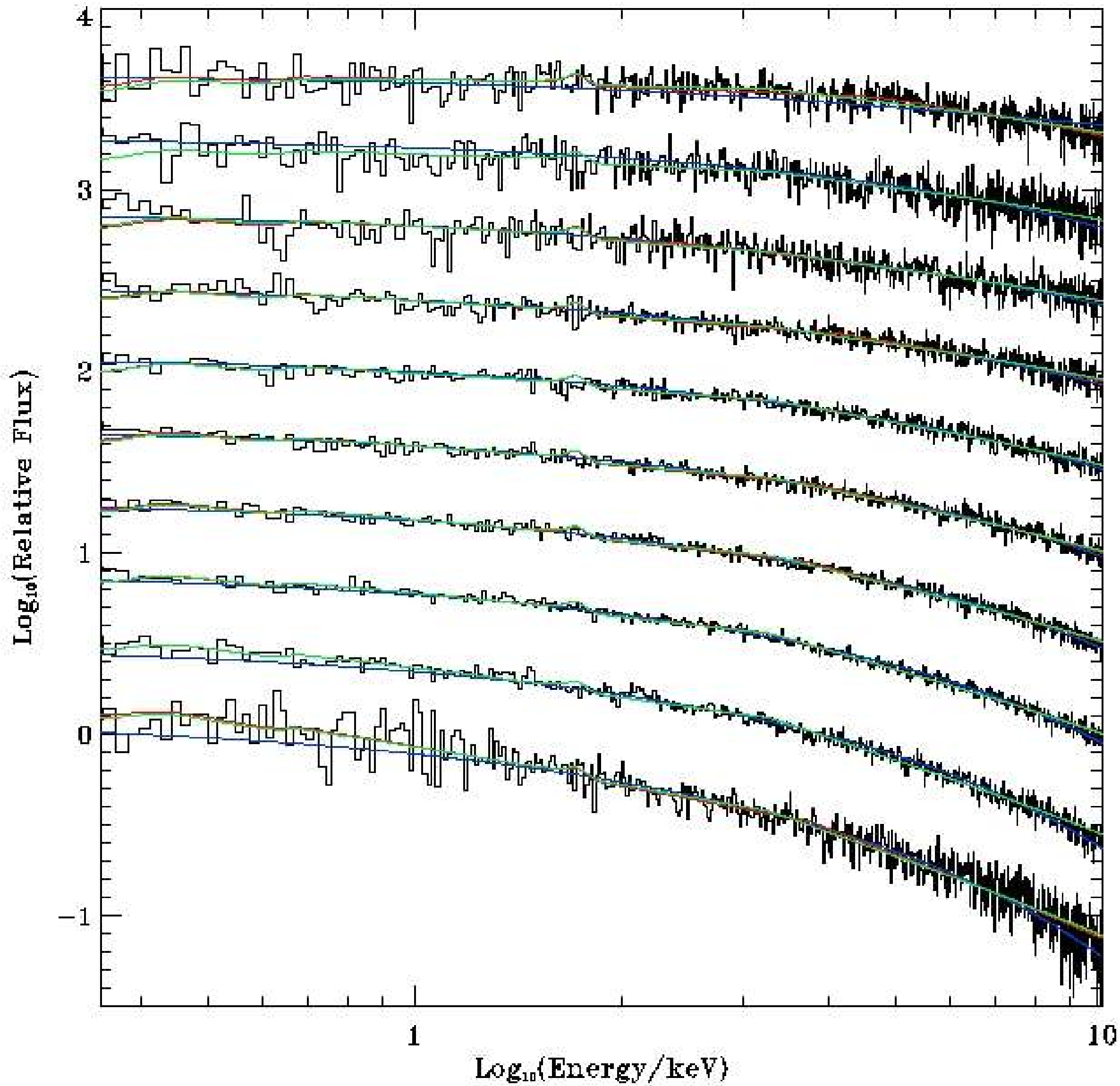

data and folded model
OFFF-mos1-grp.pi OFFF-mos2-grp.pi OFFF-rosat.pi lhb-rosat.pi
normalized counts/sec/keV
1
0.1
0.01
10^-3
10^-4
0.1
1
channel energy (keV)
kuntz 30-Apr-2006 11:4

Soft Proton Flares

- Use the entire public archive
- For each obsid, run light-curve cleaning
- If light-curve cleaning successful
  - Extract spectrum from full FOV for flare-free int.
  - Extract spectrum from full FOV from flare int.
  - Spectrum=flare–non-flare*$t_{flare}/t_{non\text{-}flare}$
    - since flare spectral shape depends upon the strength of the flare, select only weak flares for this analysis
  - Assumes that s.p. flare is additive.

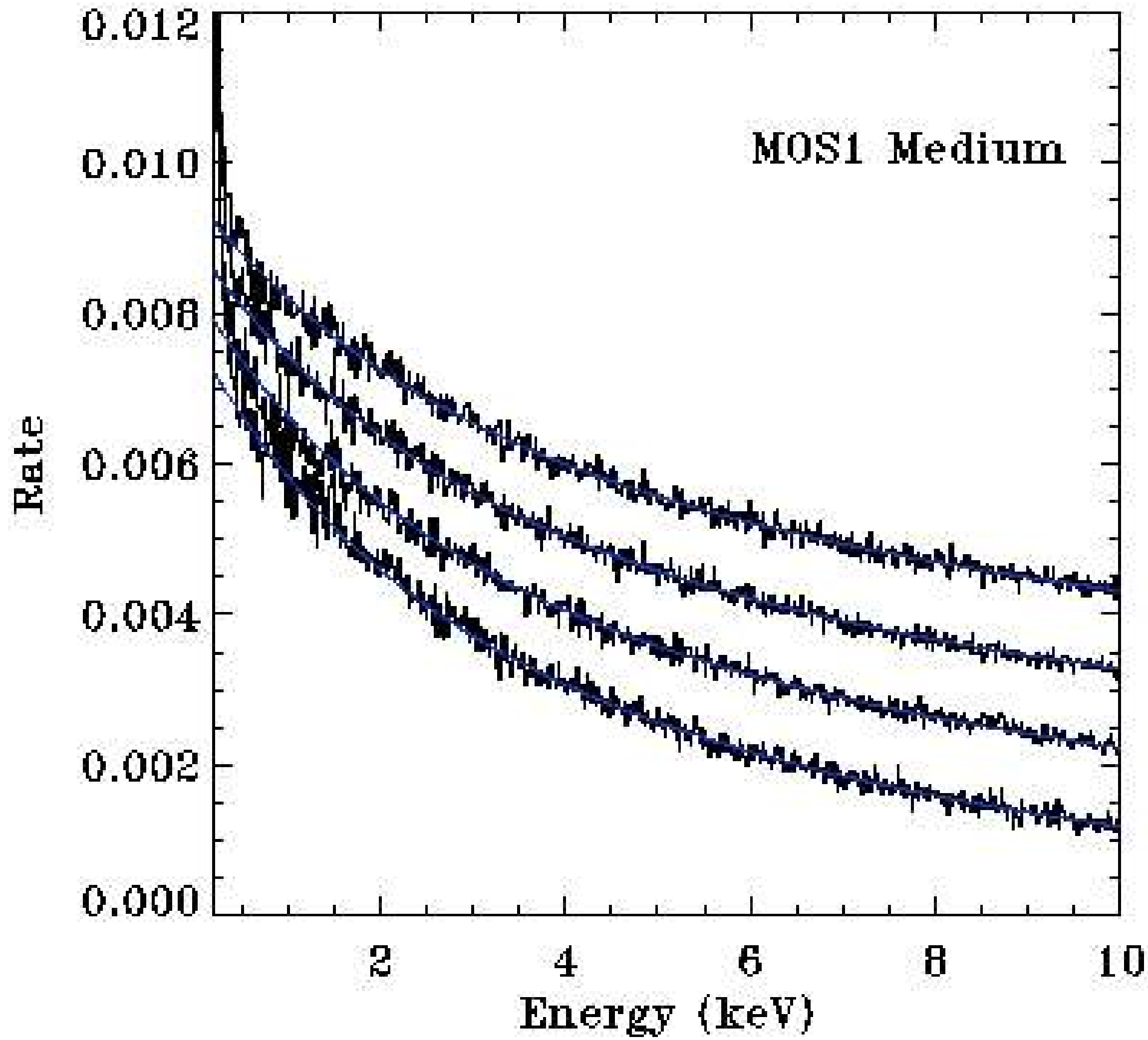
Soft Proton Flares

- Characterize
  (8.0-10.0 keV)
- Wide range o
  - Not clear wh
  - Moot point



Soft Proton Flares

- As… …variable
  - …
  - … …ength
- Ca… …um →
  mu…
- Fin… …neters
  to …
- RM… …protons



Soft Proton Flares

- Best fit

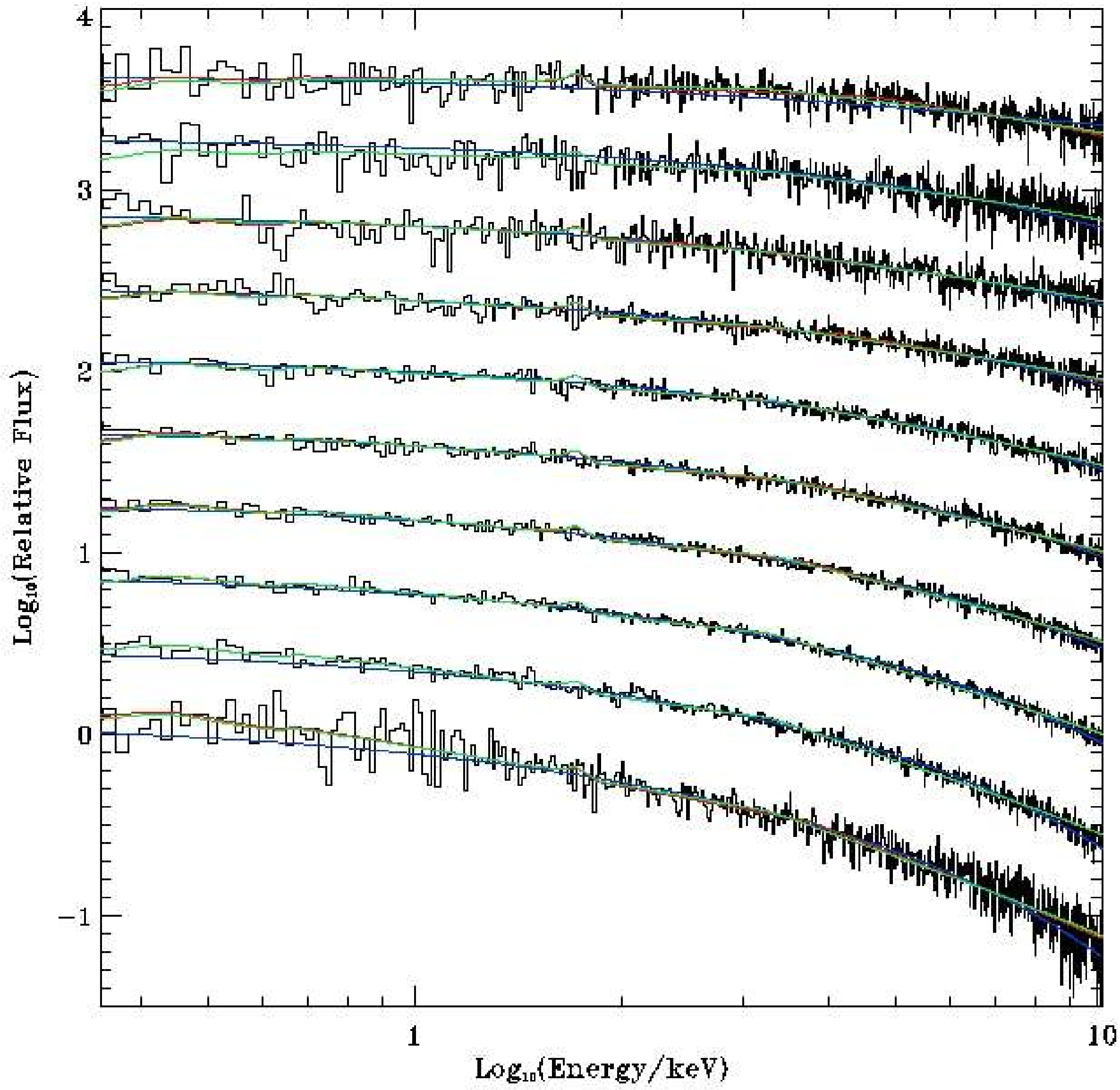
A_0ex

where

which provides

the a_i and b_i nee

but has the prob
implemented



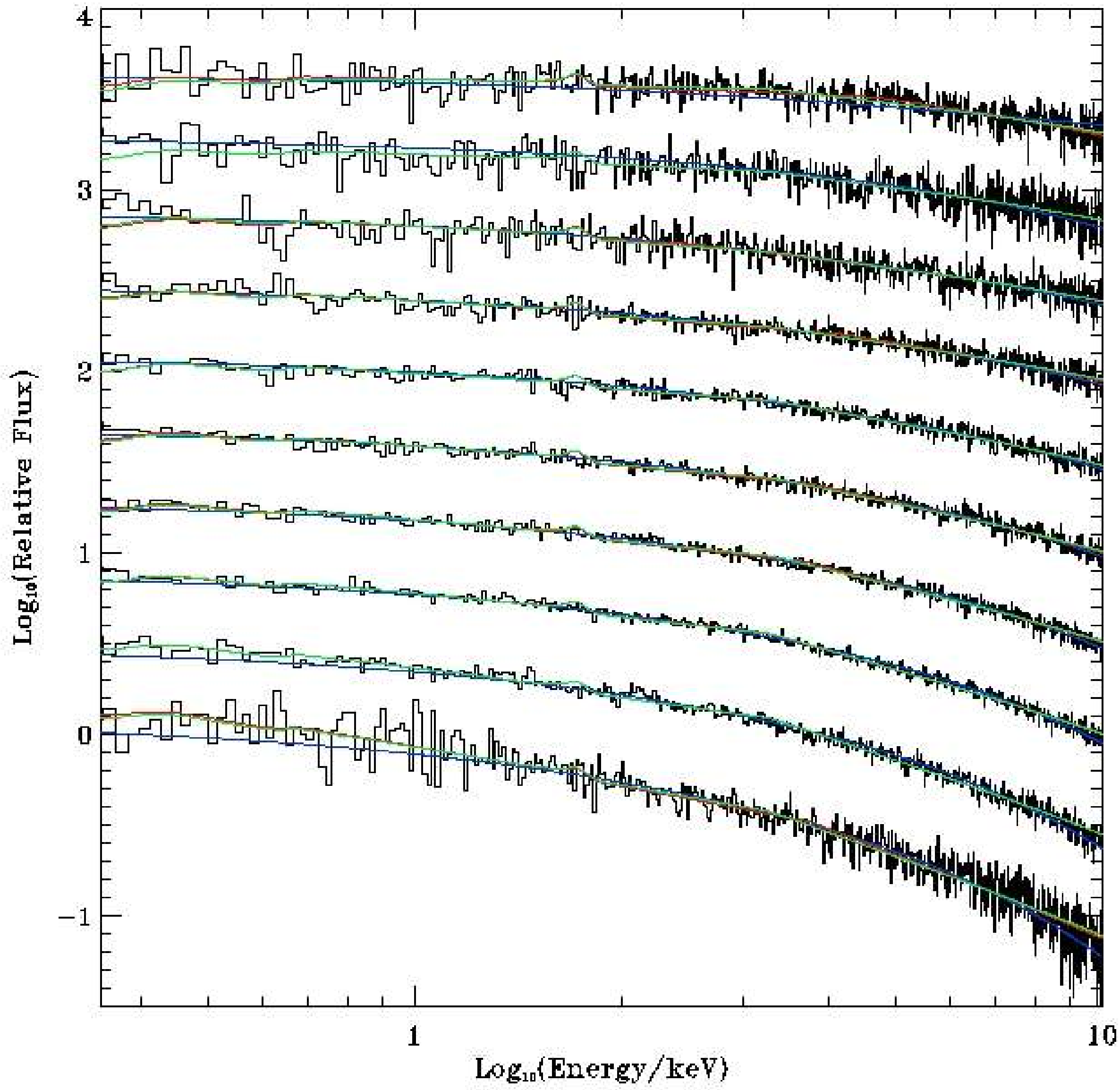
Soft Proton Flares

- Broken powe

A

- Broken powe

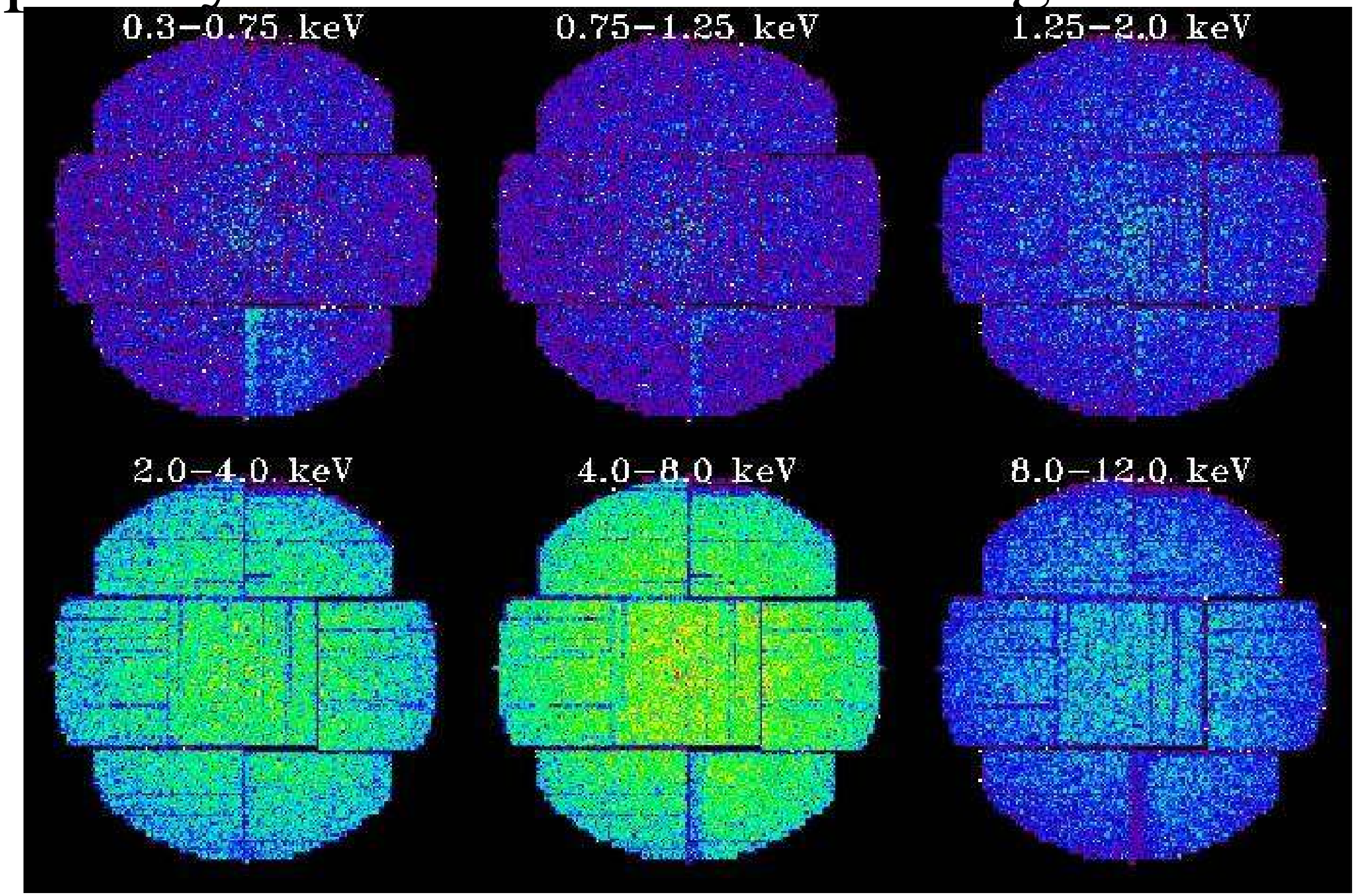
Is almost as gc



Soft Proton Flares

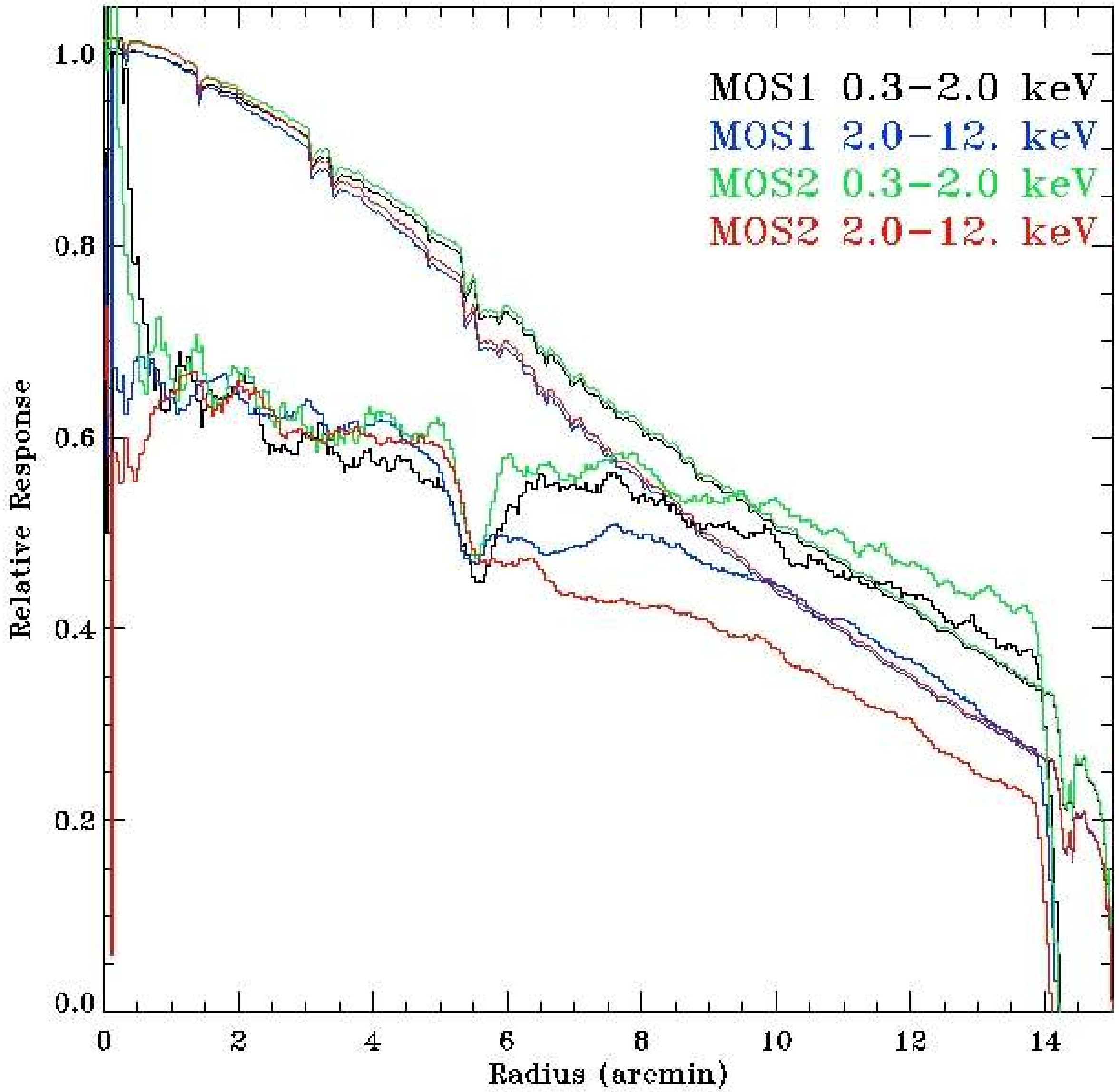
Soft Proton Flares

- Spatial distribution determined in same way as the spectrum but with bright point sources explicitly removed from the images

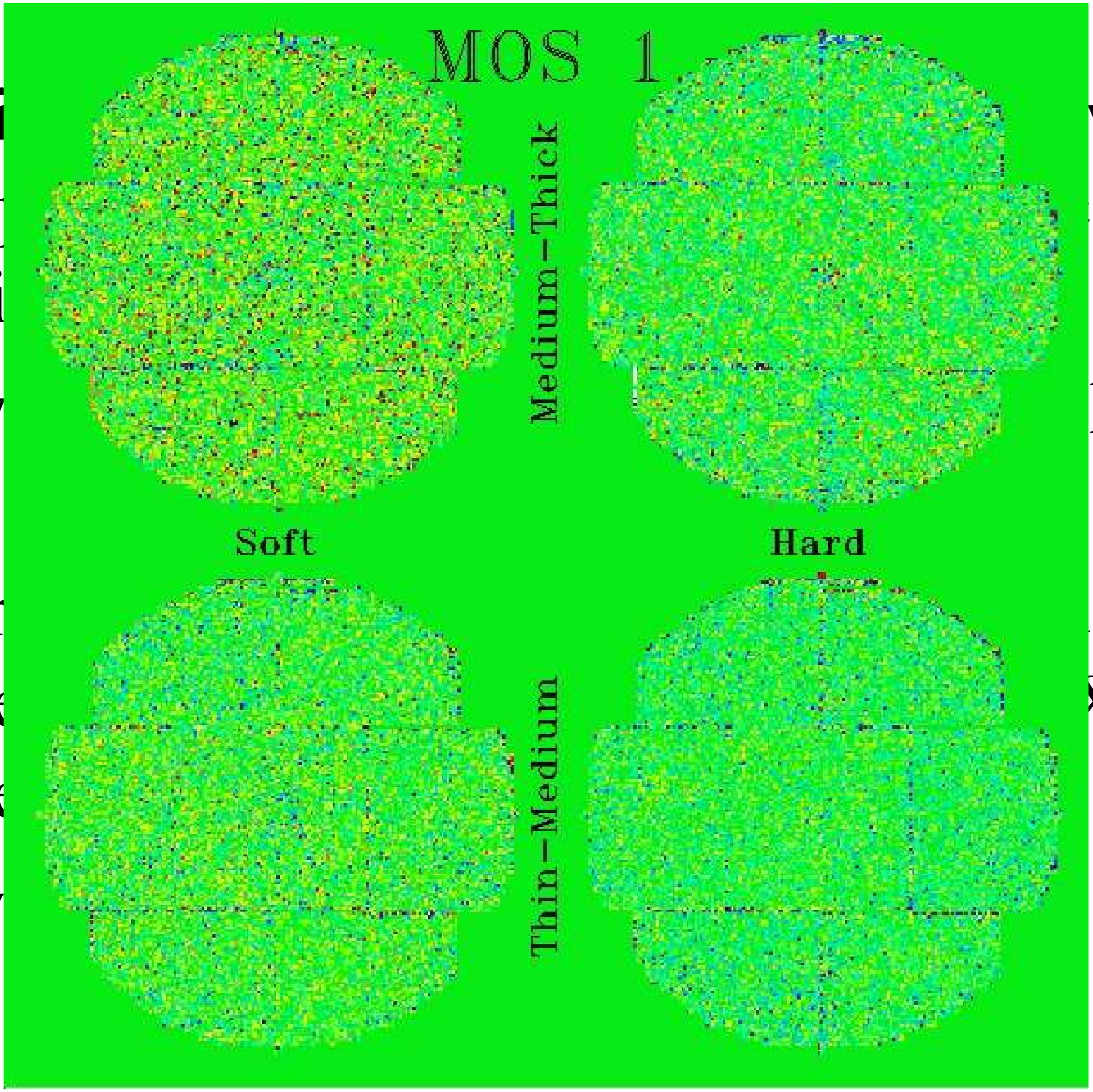


Soft Proton Flares

- Spat … ay as the s … s expl
- Only … ot" edge
- Dist … at high



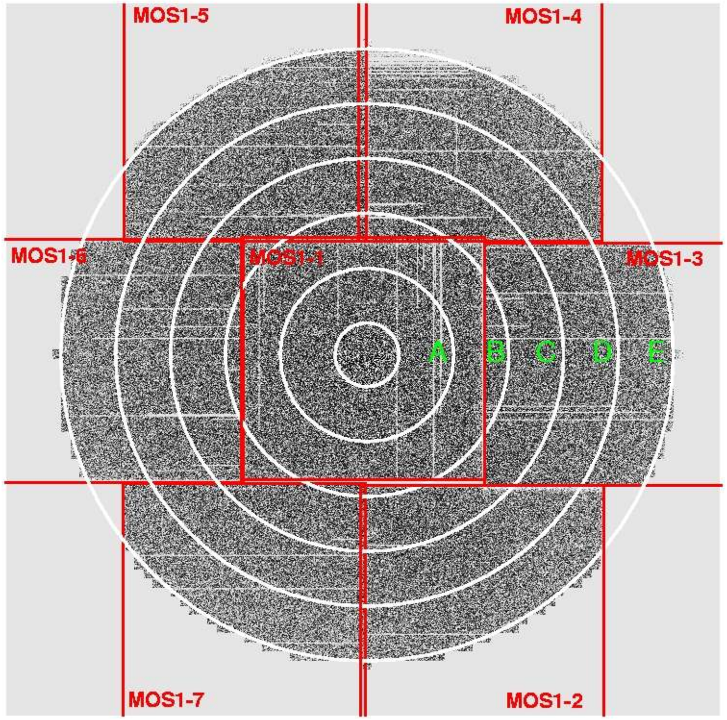
Soft Proton Flares

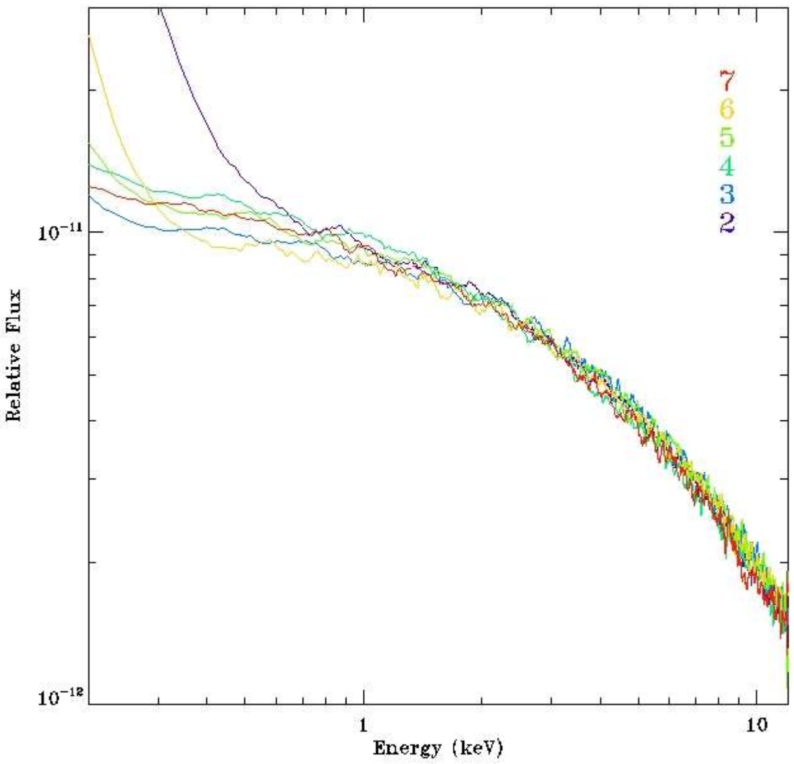


- Spati... way as the s... es expli...
- Only ... hot" edge...
- Distr... at highe... X-ray vigne...
- No v...

Soft Proton Flares

- Spectro-spatial variation
  - Spectrum becomes steeper with radius
  - Little difference between chips at the same radius
    - (with the exception of the “hot” spot on MOS1-2)





Soft Proton Flares

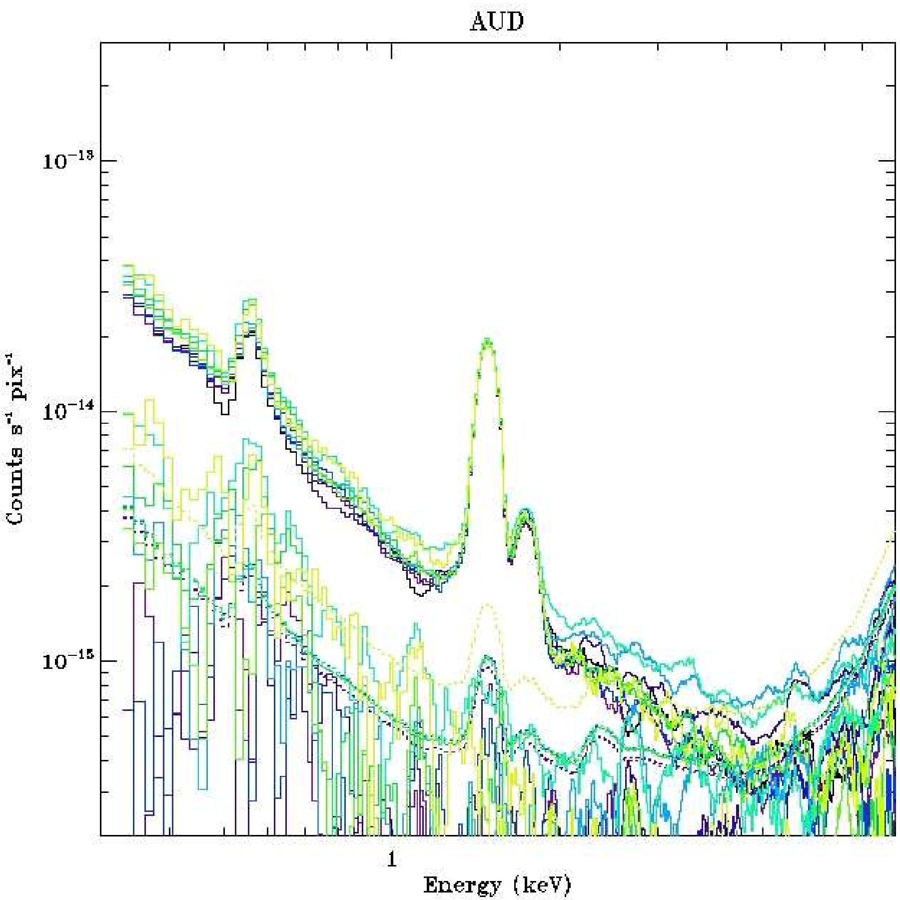
- If fitting multiple regions (i.e., a cluster)
  - The normalization of the S.P. contamination must be allowed to vary with radius.
  - The spectral shape of the S.P. contamination must be allowed to vary with radius.

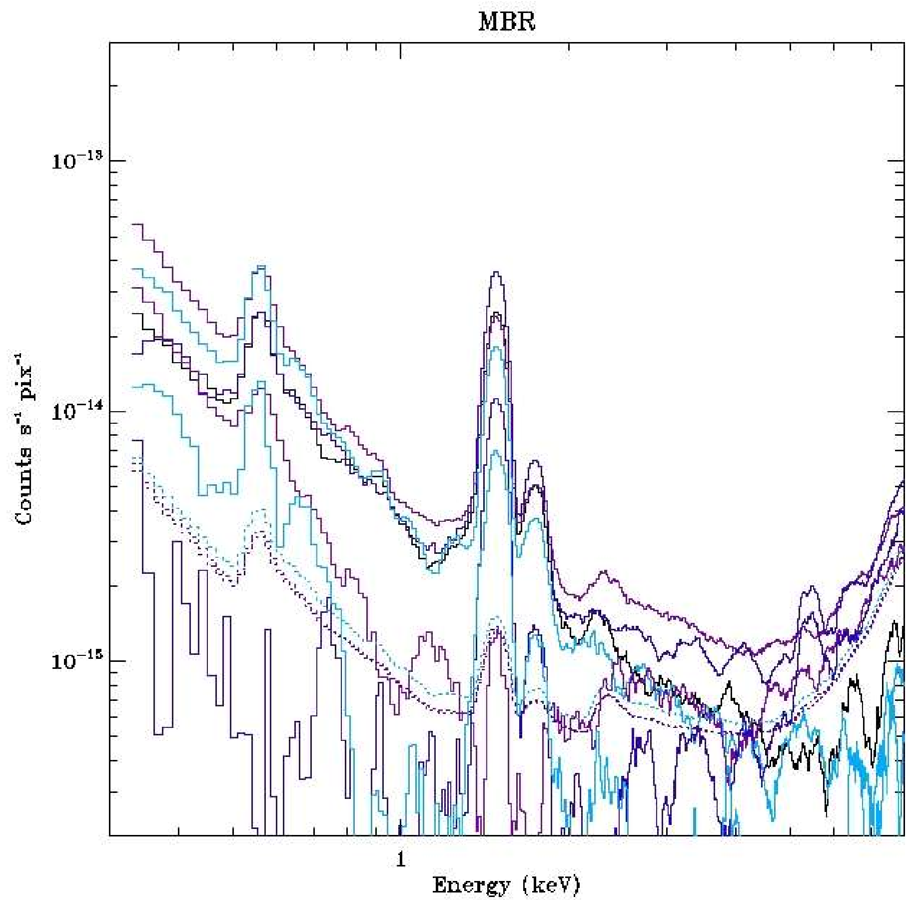
Application

- How good is the method?
  - Small number statistics for corner data
  - Marginal statistics for FWC corrections
  - Introducing systematics at low energies?
- Test
  - Find directions with multiple obsids
    - Divide MOS1 and MOS2 spectra by responses
    - Sum and smooth
    - Compare
- Chose 8 high b fields with a total of 40 obsids

Application

- Lowest spectrum set as fiducial
  - Dotted = uncertainty in difference

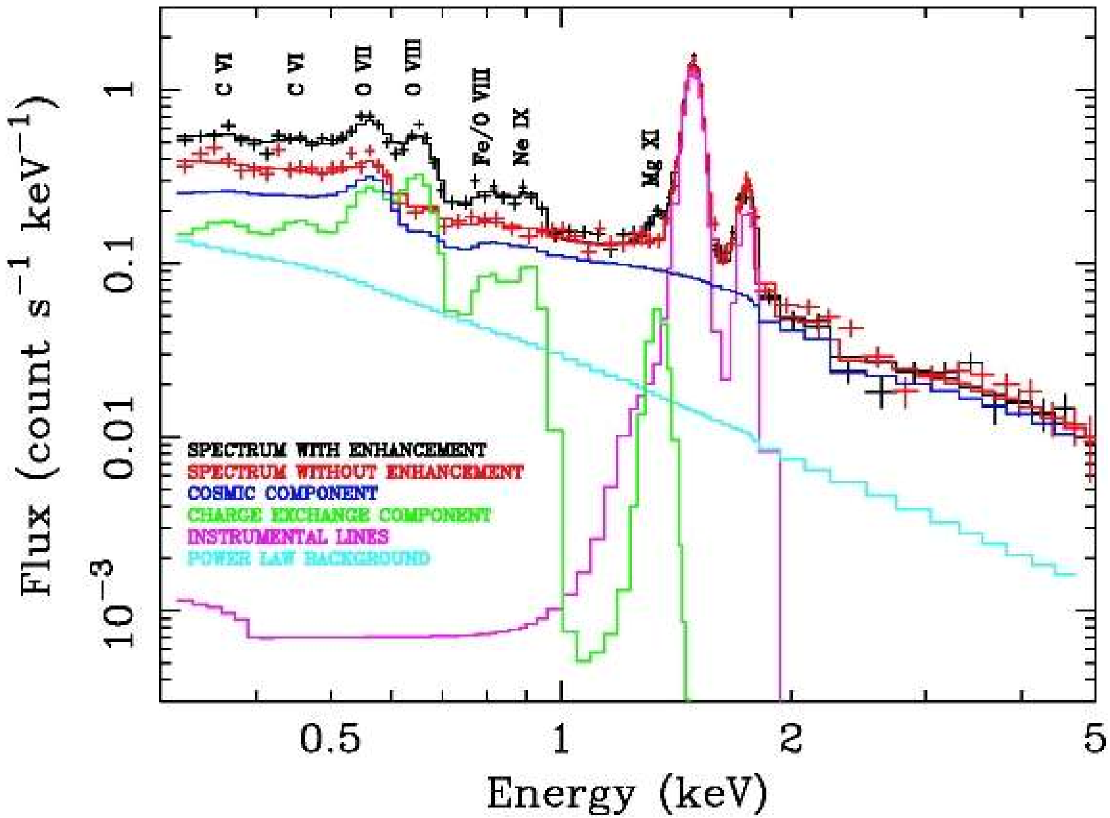




Application

- Lowest spectrum set as fiducial
- Statistics: of 40 obsids
  - 5-8 show signs of SWCX
  - 1 shows strong SPC
  - Several show minor SPC
- Differences between spectra (other than those due to SWCX) consistent within uncertainties

Application



Application