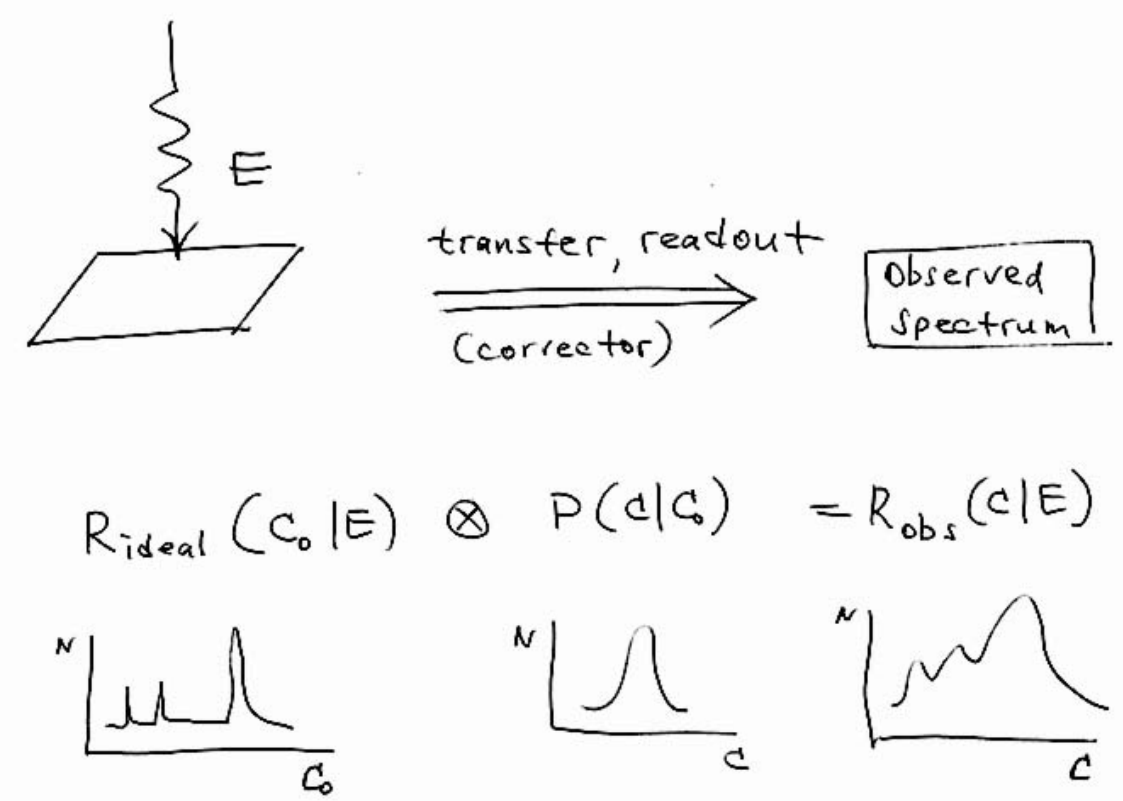
1 Factorize response into two components

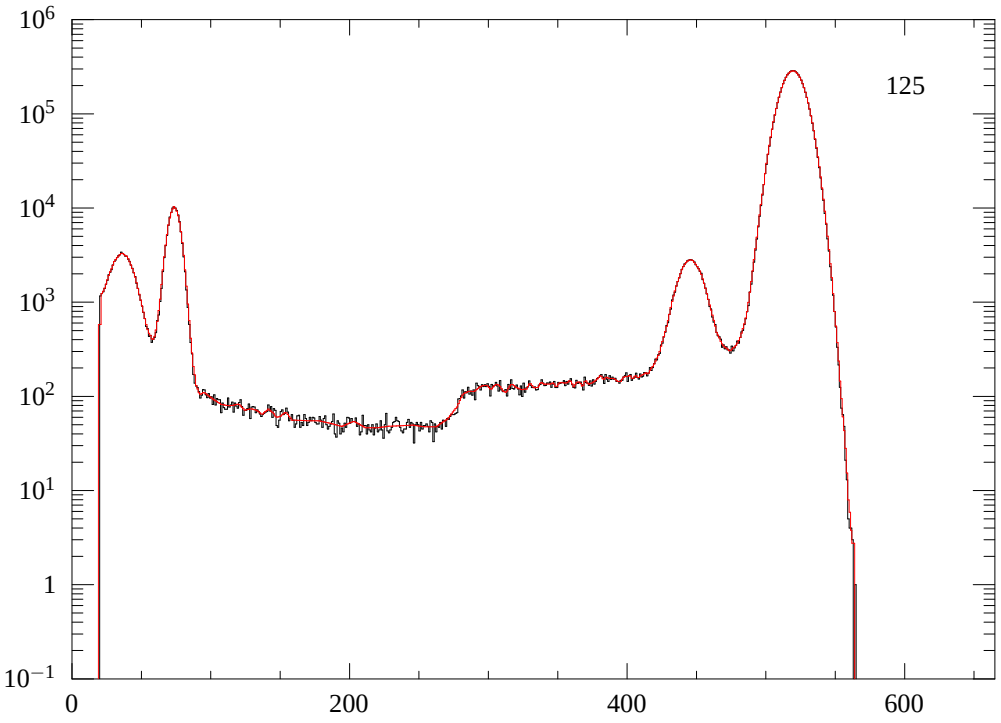


- **Original ("ideal", "pre-CTI") response**
  - Complex, multicomponent function of energy;
  - BUT single matrix per CCD flavor (FI or BI)
- **CTI scatter matrix**
  - Position-dependent;
  - BUT simple, unimodel, smooth function of PHA

2 Computing RMFs

- CTI scatter matrix can be represented by 2 Gaussians. Straightforward computation à la FEFs.
- **Use direct interpolation of the output from the simulator to compute the pre-CTI matrix**

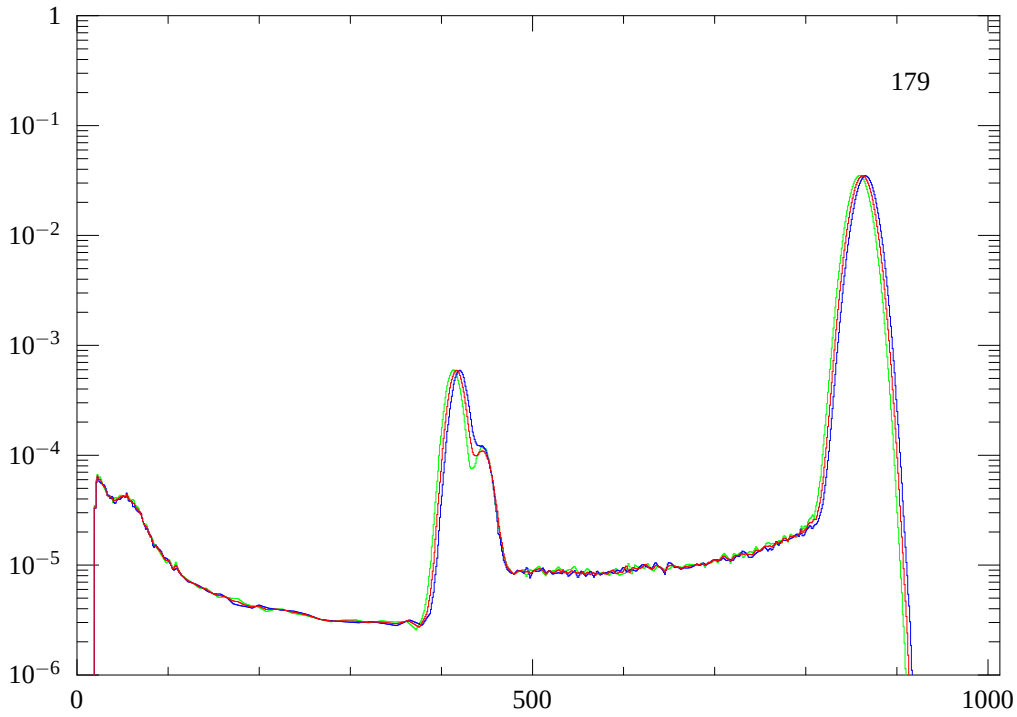
  1. Adaptively rebin PHA histograms at each energy:



     and store smoothed data

     — This is done with the 25 eV energy resolution (higher near the energies where CCD characteristics change sharply — e.g., Si edge).

  2. Use a special interpolation technique (which shifts the functions along the PHA axis instead of averaging intensities at the given PHA) to compute response at the intermediate energies. For example:



Green and blue is the tabulated response. Red is the interpolated response. This is an especially difficult situation when the fluorescence peak (on the right) "collides" with the escape peak (on the left). — *Works well.* (notice that the interpolation keeps the location of the fluorescence peak but shifts the escape peak appropriately).

Human intervention is not required on either step.

- Finally,

$$\text{RMF} = \text{pre-CTI matrix} \times \text{Scatter matrix}$$

- When flux-weighted RMFs are computed, only scatter matrices need to be averaged. — **this makes a big gain in speed**

  (It takes 3 minutes on an Ultra-10 to compute a flux-weighted RMF over the entire S3, 1024 individual tiles)

3 Status

- **Software** written (stand-alone FORTRAN program `calcrmf2`). Can compute flux-weighted RMFs on a user-specified grid of energies and channels (either PHA or PI).

  Tested internally. Will be posted on the contributed software page as/if needed.

  DS working on implementation of the algorithm within CIAO.

- **Calibration data** created for I0–I3, S1, S2, and S3.

I0–3, S2 — calibration equivalent to the FEFs released in 1/2003 for CTI-corrected data

S3 — calibration matches the released FEFs (has higher energy resolution near 1.8 keV)

S1 — major improvement over released FEFs (+ decent gain file)

- **Gain accuracy**:

I0–I3, S2:

E, keV	Source	Mean offset	Scatter
0.64	E0102, O-lines	+0.3%	±0.7%
0.95	E0102, Ne-lines	+0.0%	±0.4%
1.487	ECS, Al-Ka	+0.04%	±0.2%
4.510	ECS, Ti-Ka	+0.08%	±0.17%
5.898	ECS, Mn-Ka	−0.07%	±0.10%

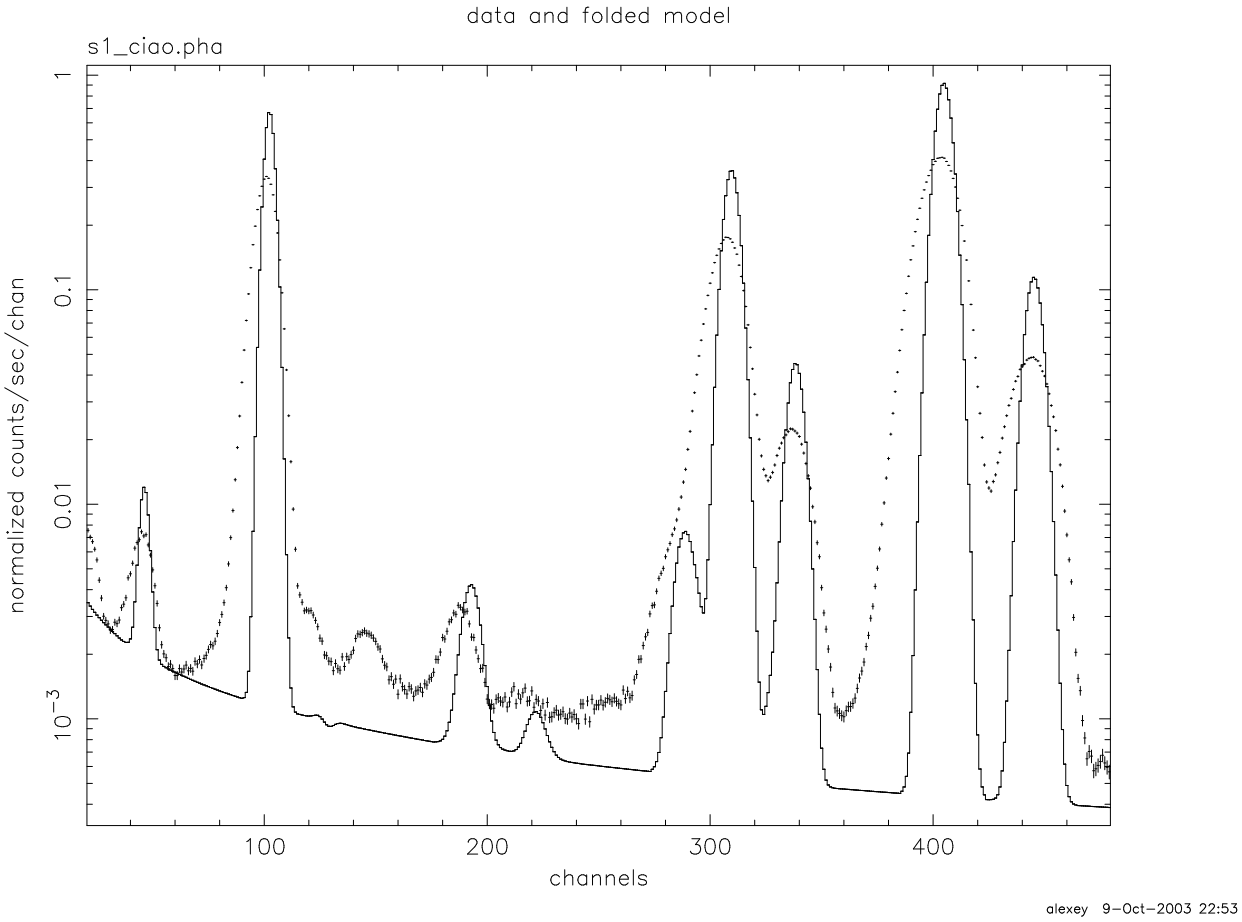
S3:

E, keV	Source	Mean offset	Scatter
0.64	E0102, O-lines	+0.4%	±0.6%
0.95	E0102, Ne-lines	−0.0%	±0.4%
1.487	ECS, Al-Ka	+0.00%	±0.17%
4.510	ECS, Ti-Ka	+0.00%	±0.07%
5.898	ECS, Mn-Ka	+0.00%	±0.03%

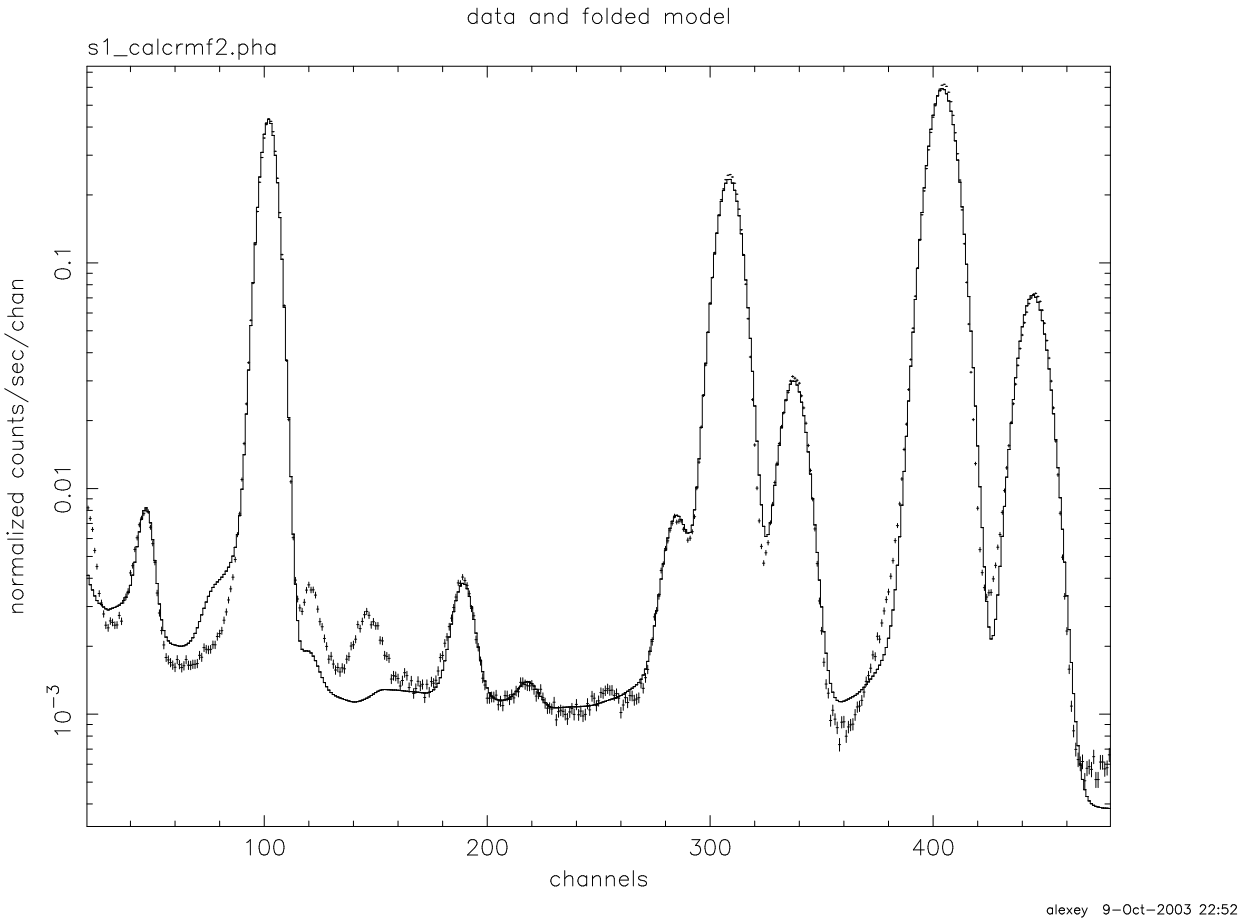
S1 scatter is a factor of 1.5 higher.

4 S1 example

CALDB gain/FEFs: (spectrum for whole chip, in PI channels, line energies fixed at nominal values, width=0



calcrfm2/new gain (spectrum for whole chip, in PI channels, line energies fixed at nominal values, width=0



calcrfm2 vs. released calibration (notice narrower and higher peaks in the *data* for the CALCRMF2 version — new gain works better