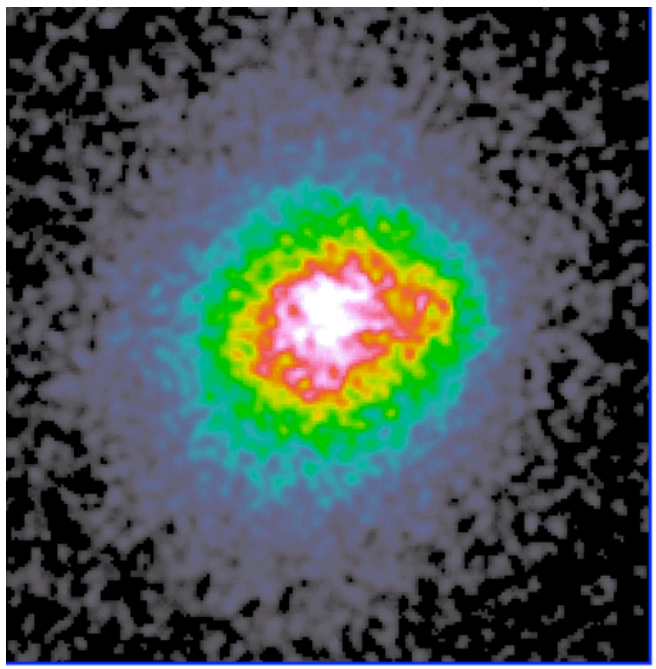
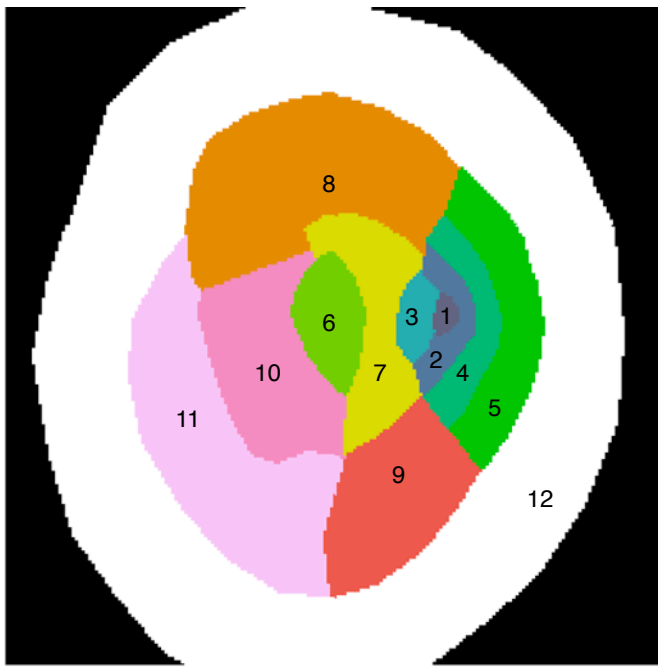
Spatial Fits

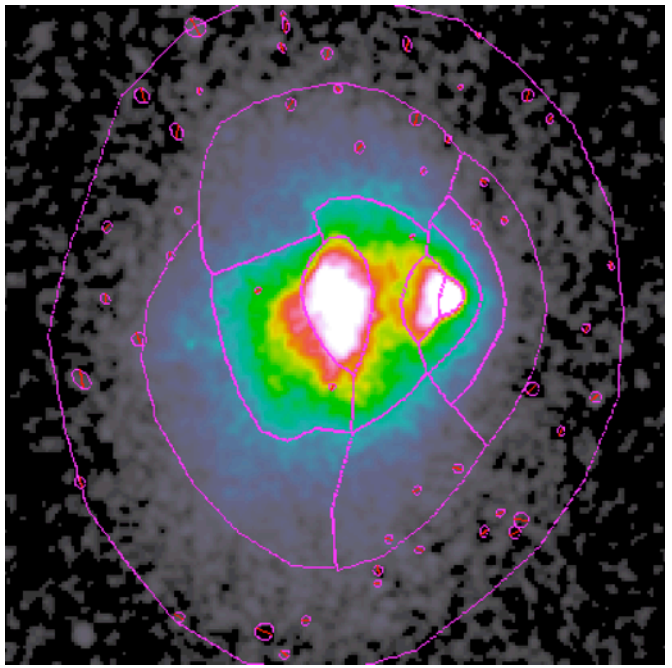
- Model data as realistically as possible in regions assumed to be isothermal



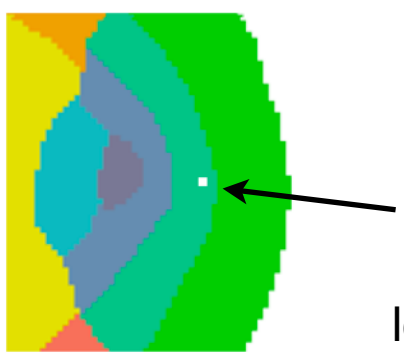
NuSTAR
Obs 1, FPMA
3-20 keV



12 regions



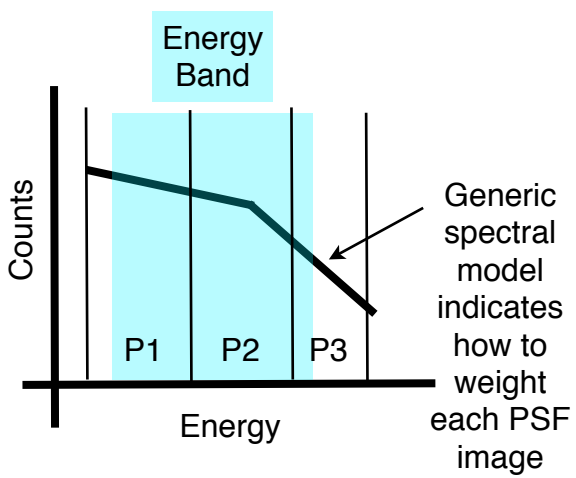
Chandra
500 ks mosaic
0.5-7 keV

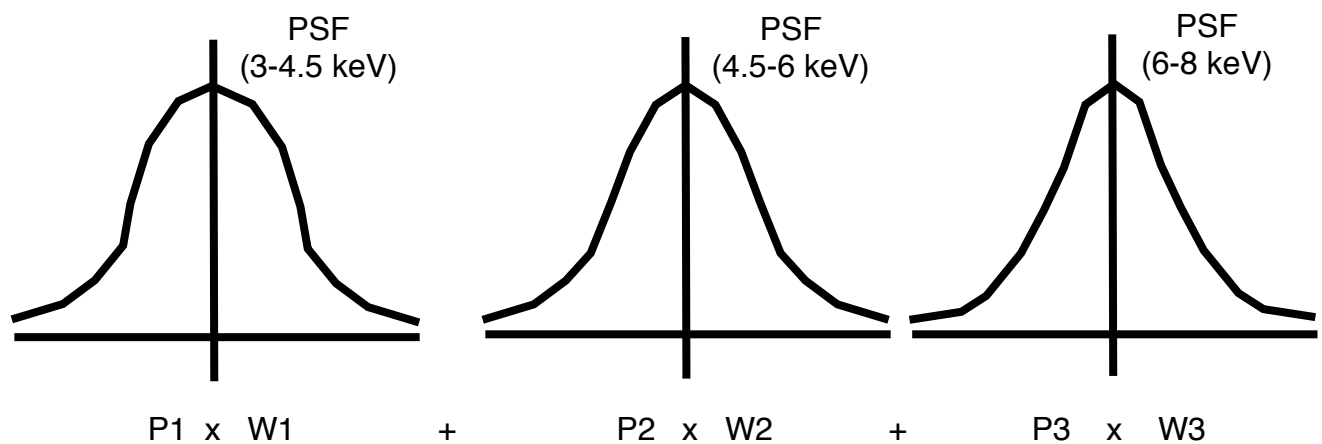


For a given region, create a PSF at each location w/in the region

Spatial Fits

- Create composite PSF assuming a generic spectral model
  - Approximate a ~14 keV plasma (broken power law with break at 10 keV and photon indices 1.9 and 2.7)
  - Fold through ARF (mirror response) at that position (account for variable off-axis angle) to get weights
  - Combine energy-dependent PSF images by relative weights and renormalize PSF by on-axis ARF

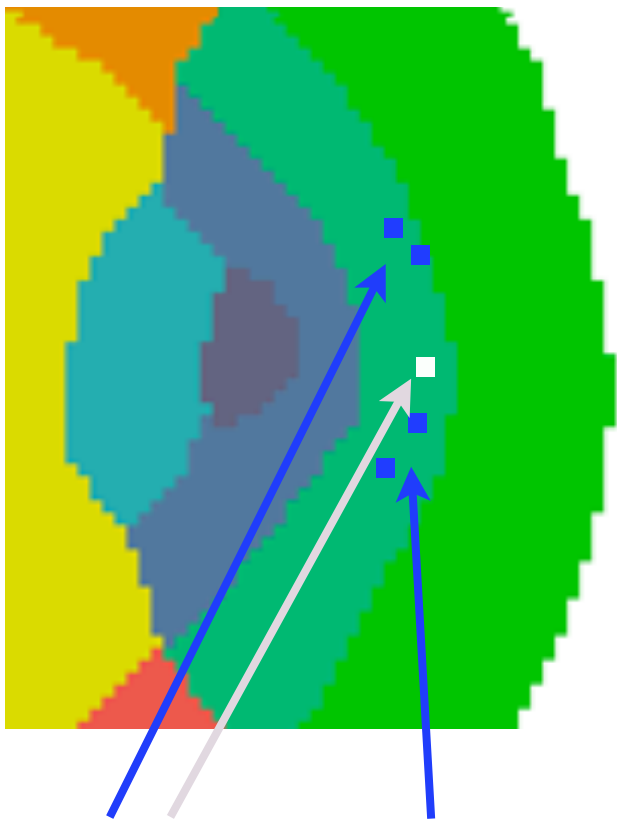




= Composite PSF (at a given RA/Dec)

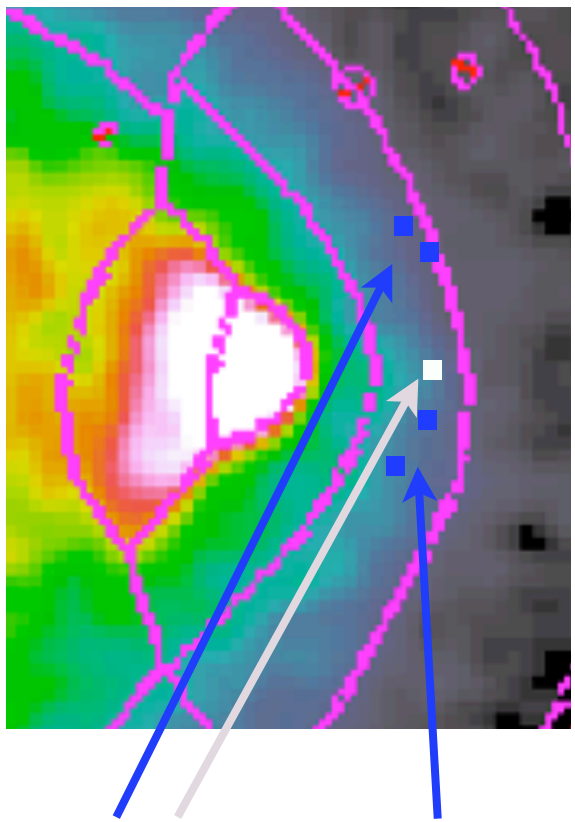
Spatial Fits

- Repeat across a predefined region, weighting by the expected distribution of flux in that region



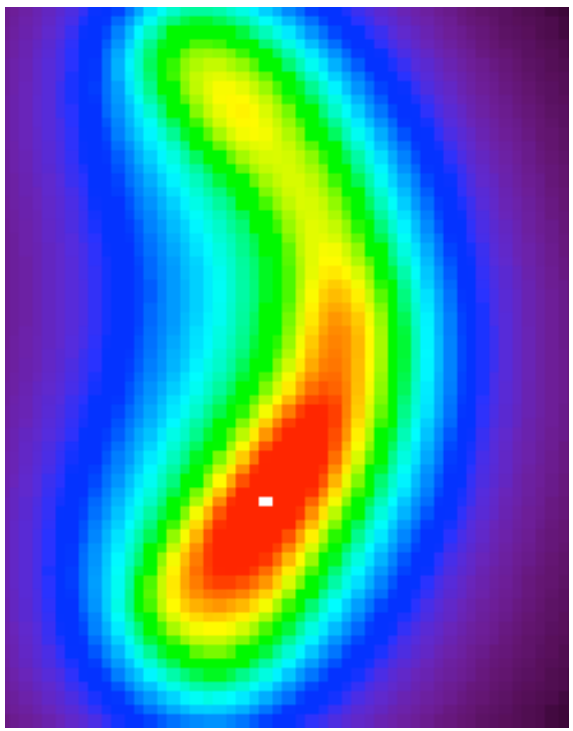
Composite PSFs created here (and for all pixels)

&



Summed together, weighted by rates here

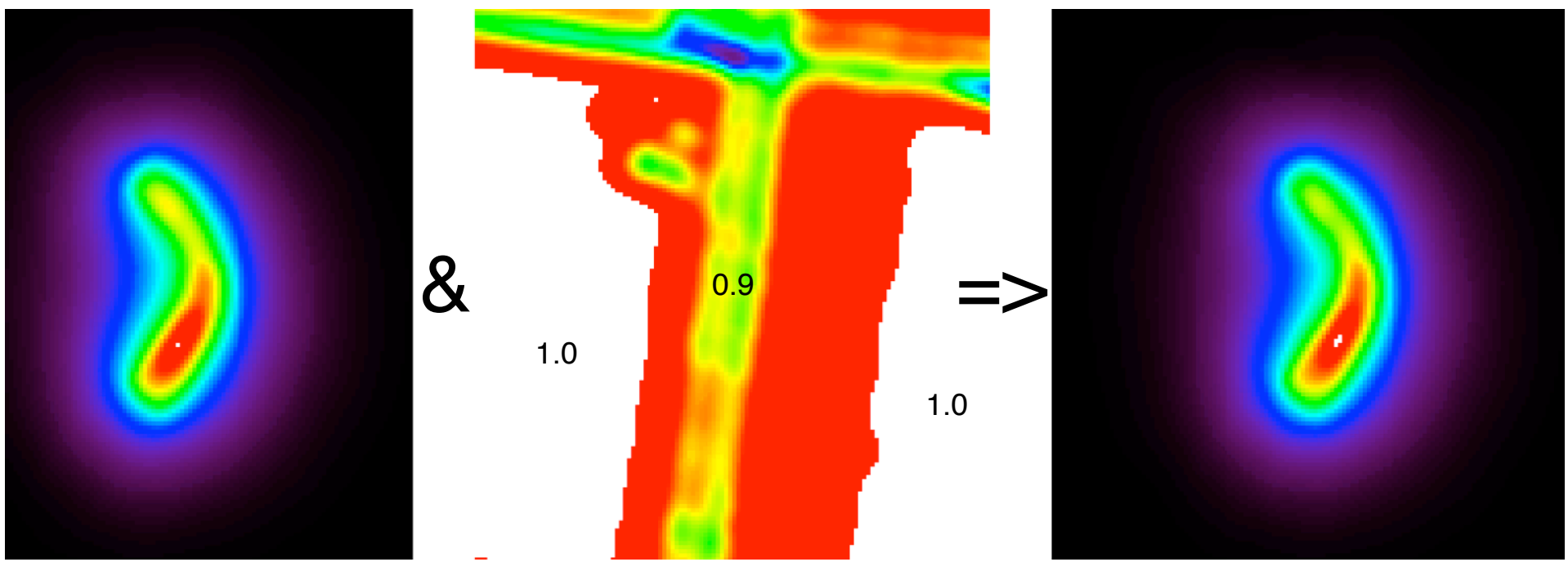
=>



PSF model for this region

Spatial Fits

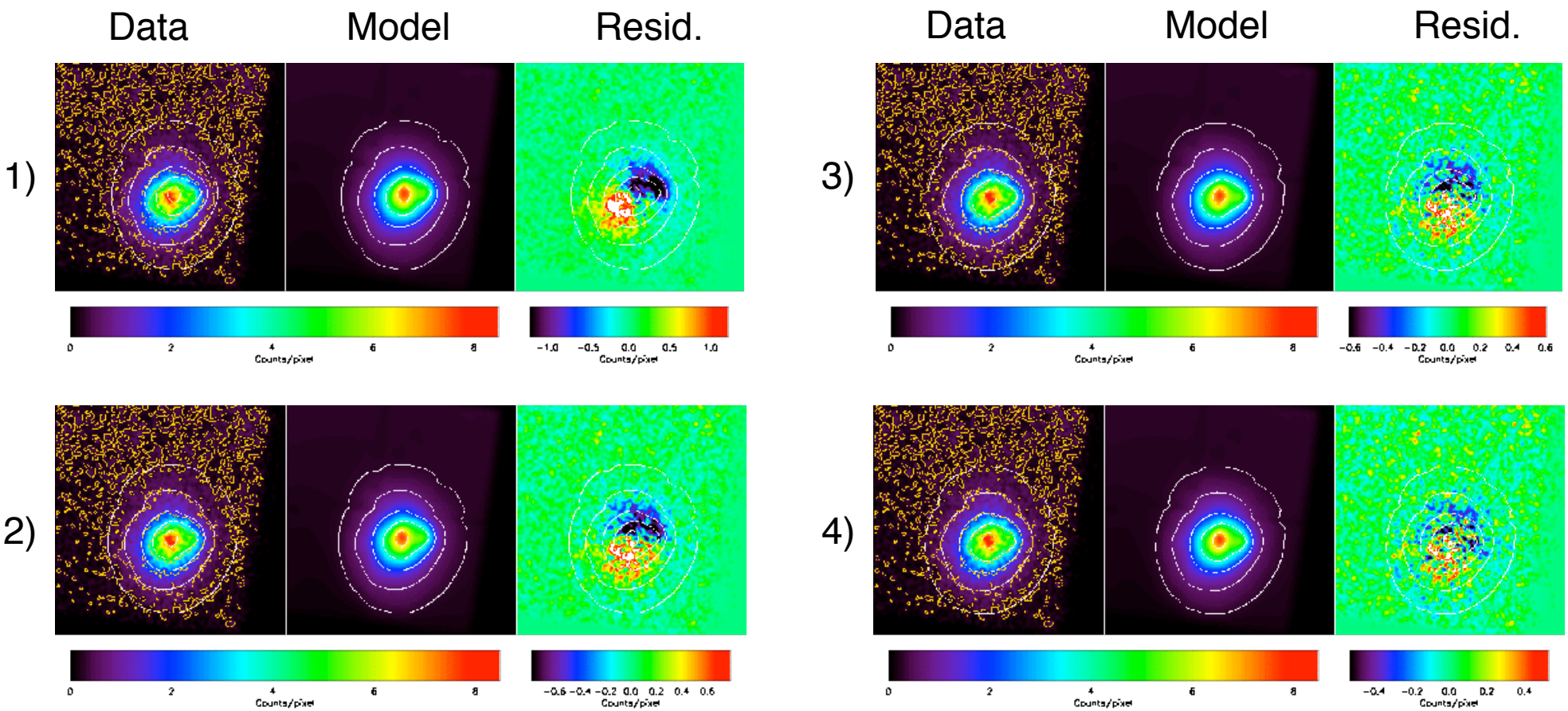
- Multiply PSF image by an unvignetted exposure map that includes detector absorption



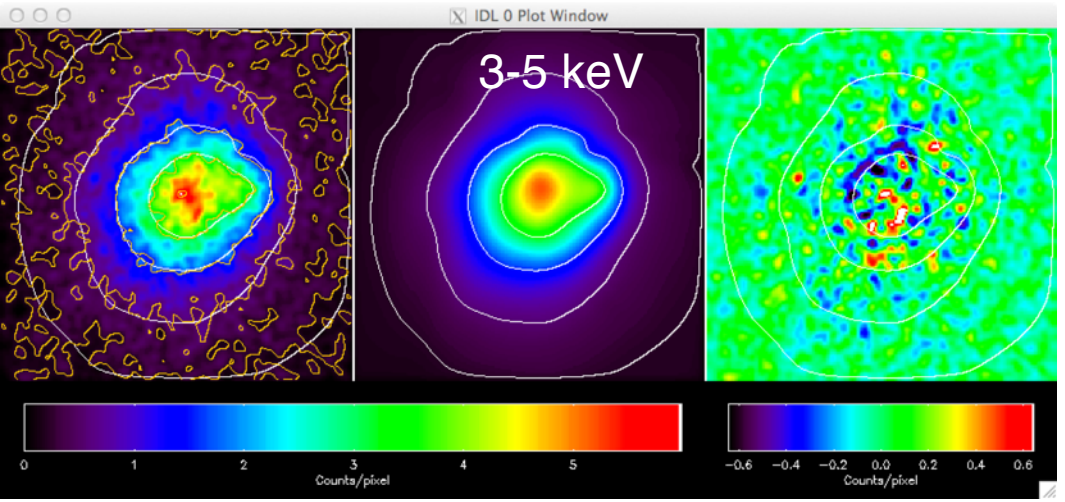
PSF model | Exposure Map | Modified PSF model

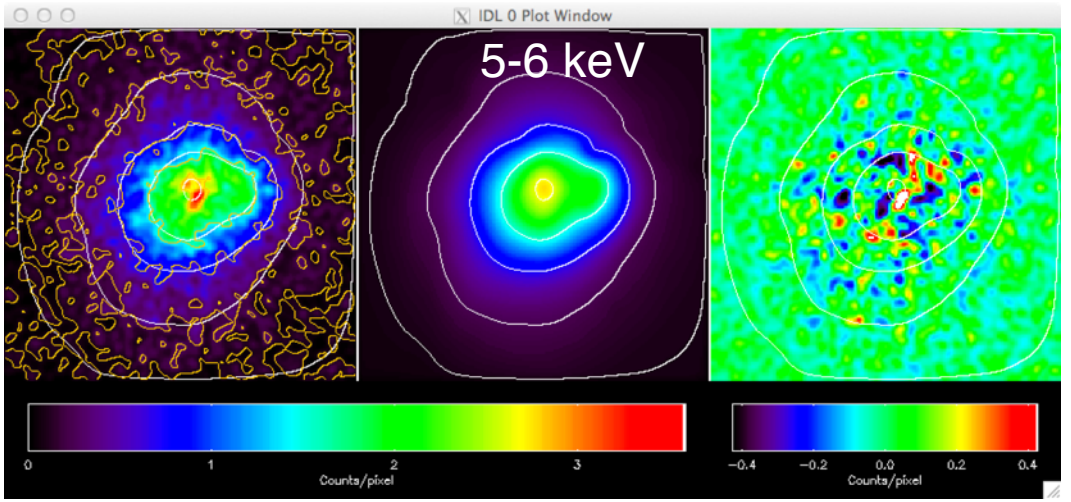
Spatial Fits

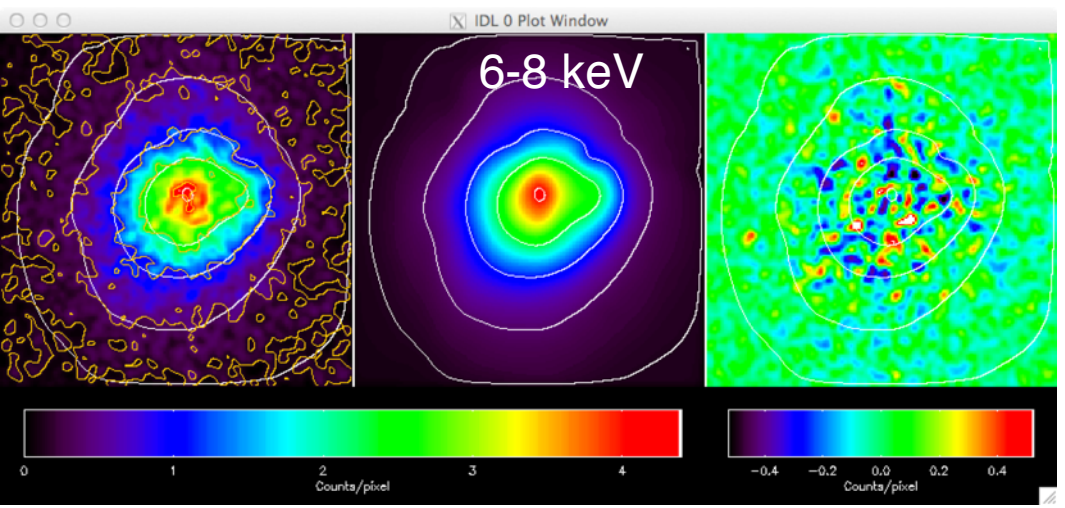
- Fit 2D model to image data, allowing for uncertain astrometry (x,y shifts and small rotations --> determine in a broad band first, keep fixed in narrower bands)

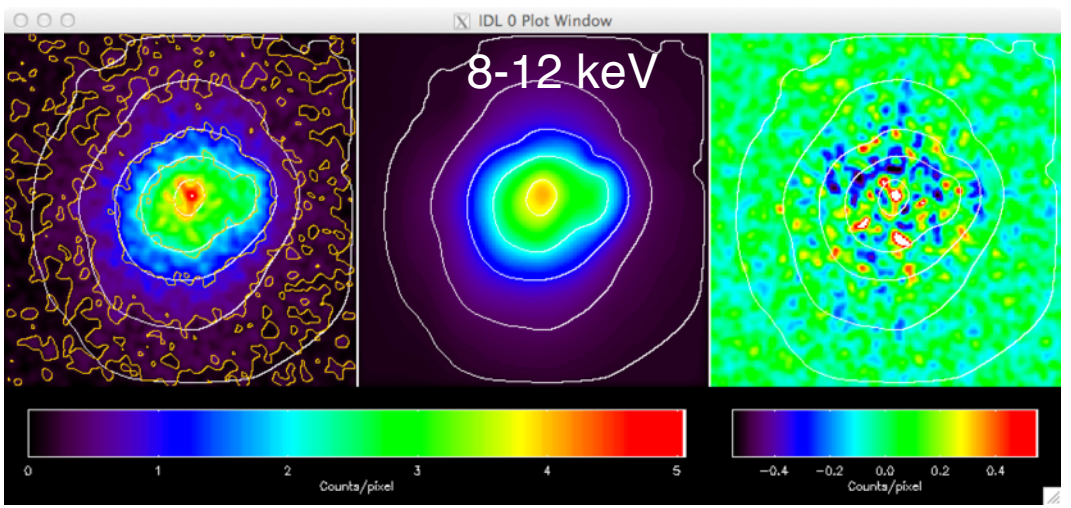


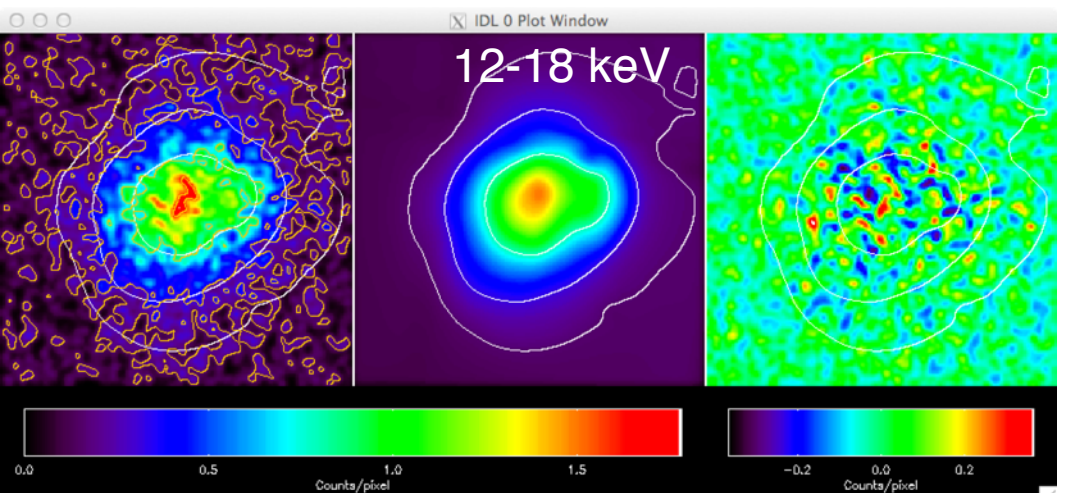
Example fits (previous version, lacking some refinements)

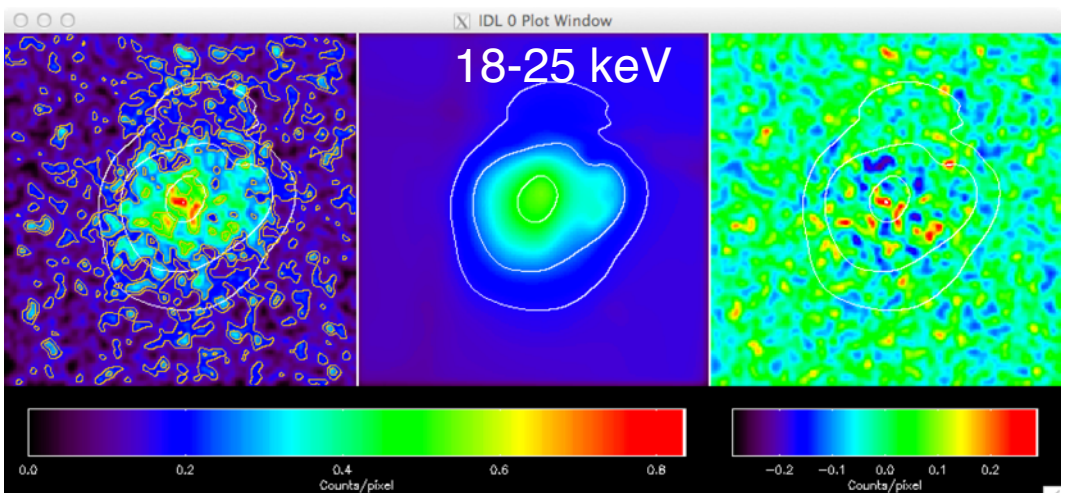






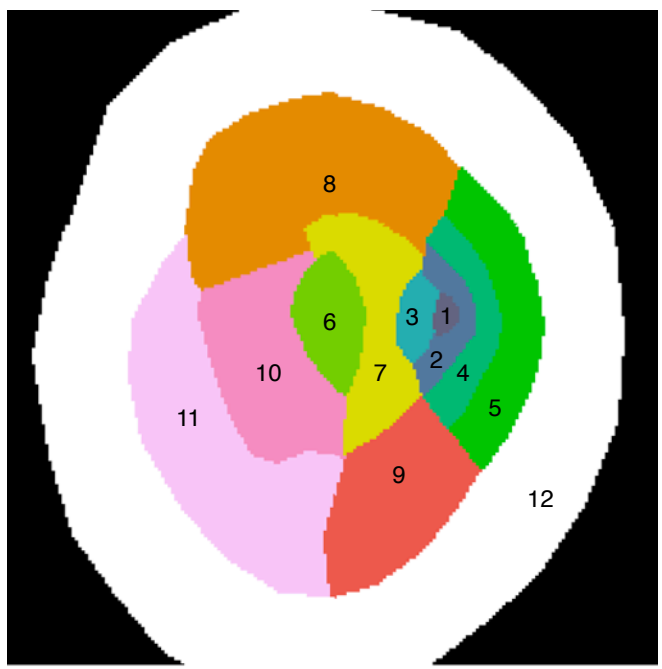






Spatial Fits

- The normalization of each region is equivalent to the total count rate coming from that region if it were an on-axis point source
- Values can be used to construct a spectrum that can be jointly fit with a Chandra (or other) spectrum




```
# 3-5 keV band fit

     56386.3                          C-stat
   -0.793318      0.00000            x shift (A)
    0.258570      0.00000            y shift (A)
     1.42909      0.00000            rotation (A)
    -1.91704      0.00000            x shift (B)
   -0.321540      0.00000            y shift (B)
     2.04512      0.00000            rotation (B)
1    0.00467508    56386.3
2    0.00427478    56386.3
3     0.0106528    56386.3
4    0.00537259    56386.3
5   0.000204346    56386.3
6     0.0306622    56386.3
7     0.0291167    56386.3
8     0.0157083    56386.3
9    0.00683749    56386.3
10    0.0369119    56386.3
11    0.0146040    56386.3
12    0.0165657    56386.3
B/A     1.06965    56386.3
bgdA    1.00000    0.00000
bgdB    1.00000    0.00000
```

all fixed

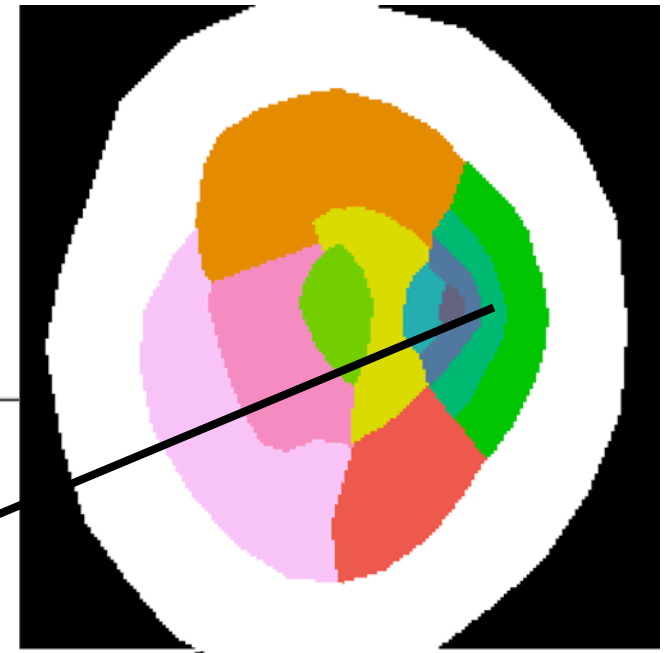
count rates for 12 regions

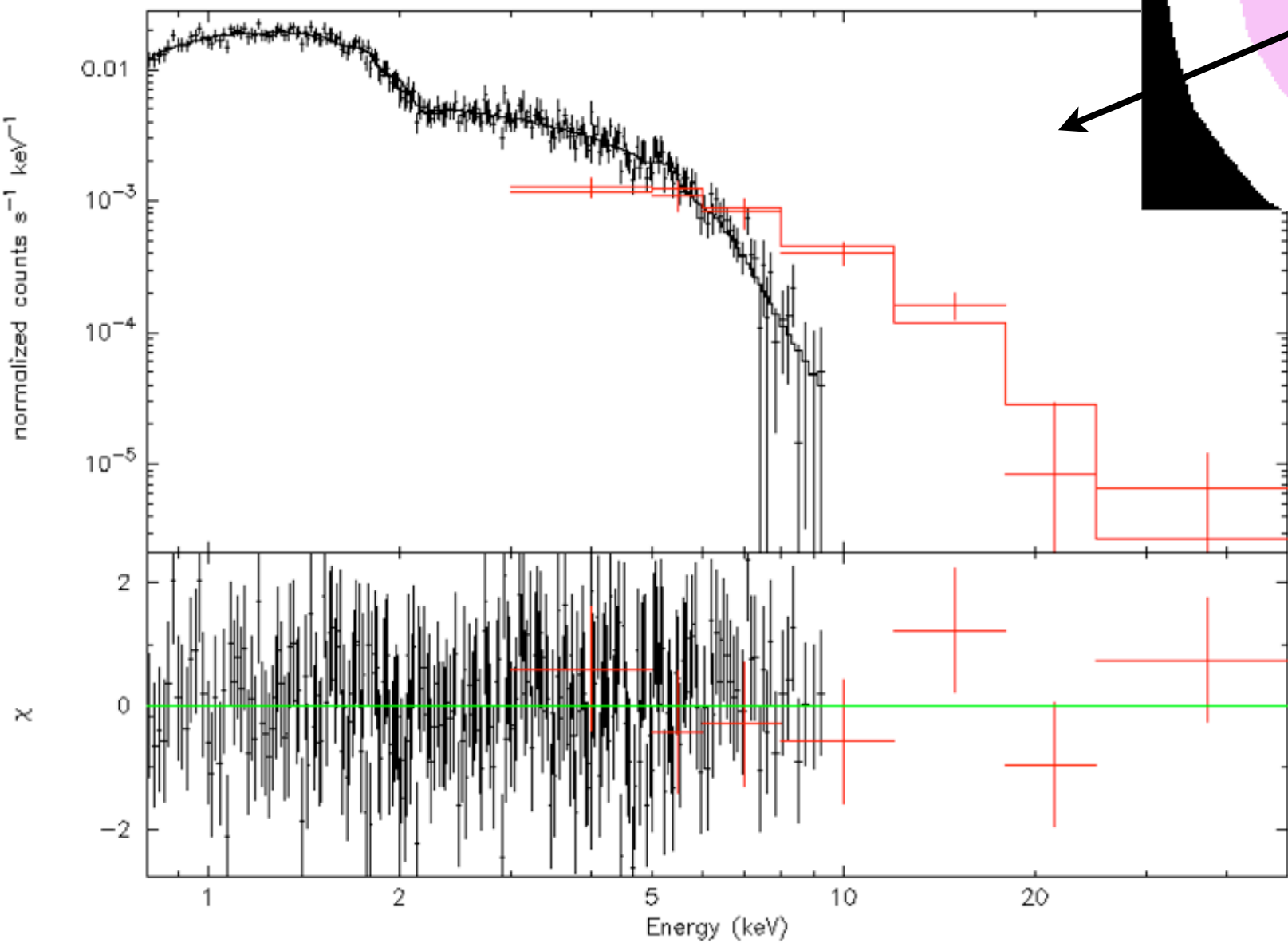
cross-norm. b/t A & B

bgd values fixed

Joint Spectral Fits (prev.)

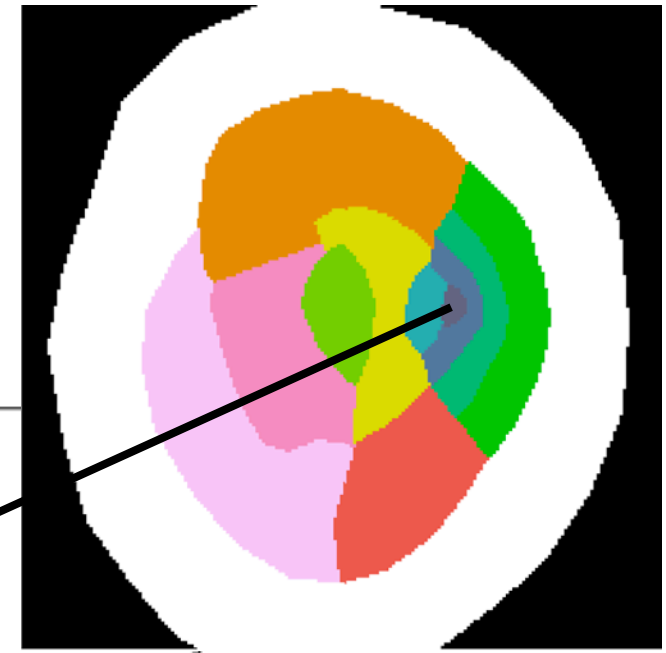
kT = 16.7 +2.8/-1.8 keV

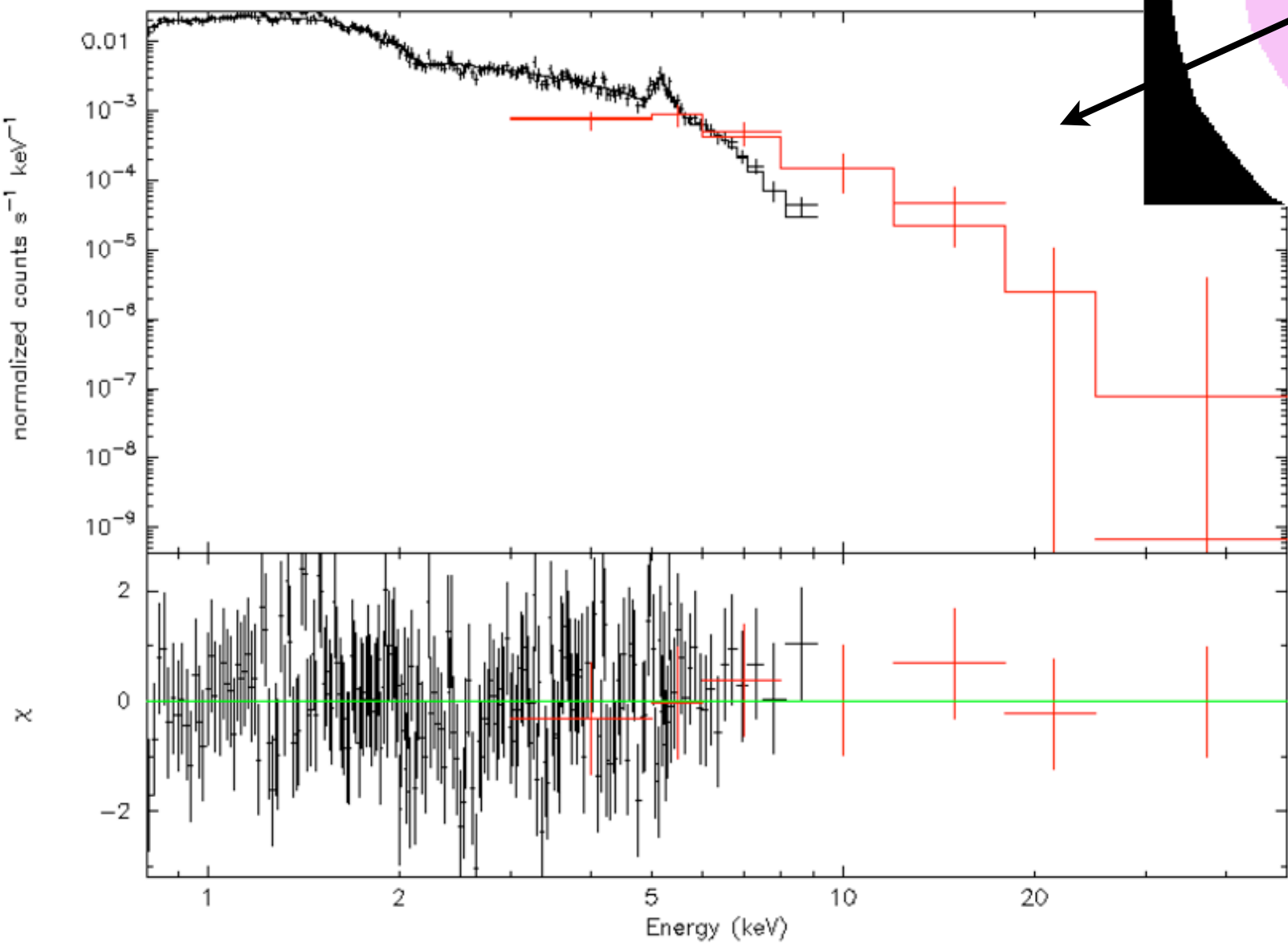




Joint Spectral Fits (prev.)

kT = 6.2 +/- 0.3 keV



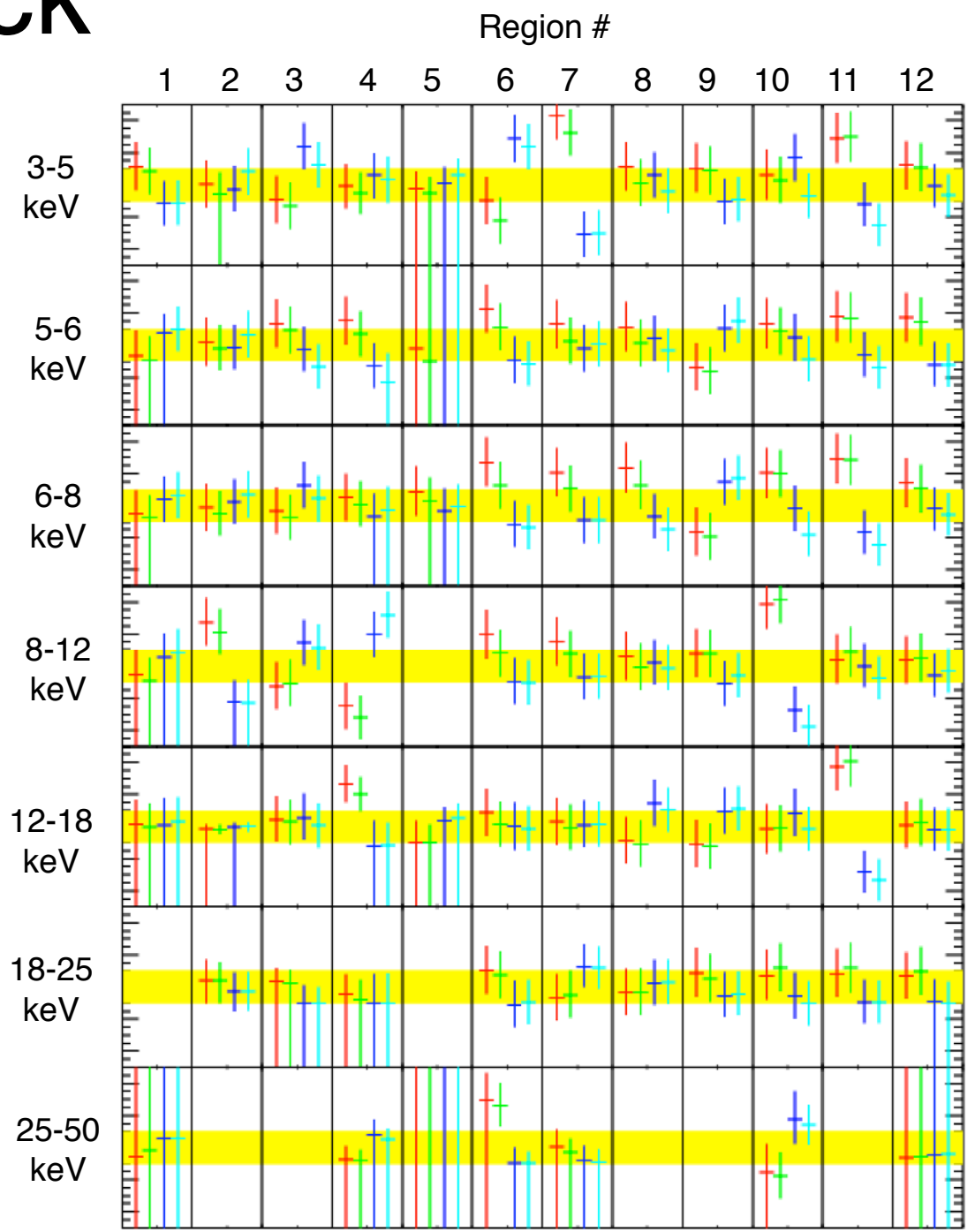


Systematics Check

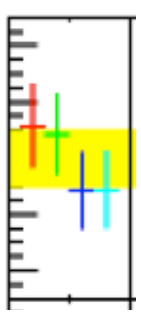
- Combine all epochs (Obs1+Obs2) and each camera (A+B) and fit to get count rates (yellow band)
- Fit each epoch separately, either
  - fit A&B simulateously but separate
  - combine A+B and fit
  - see below for color coding

- In most cases, all methods yield consistent rates
- Some possible systematics (region 6 and 7 trading counts b/t Obs1 and Obs2 in 3-5 keV band - could be astrometry (but not other bands?)

- Will repeat with improved code, but should get largely similar results



Rate measurement in each region in each energy band



(Obs1 A+B) + (Obs2 A+B) combined

Obs1 A&B simult.

Obs1 A+B combined

Obs2 A&B simult.

Obs2 A+B combined

End Game

- Final refinements
  - Make modified PSF for position angle ~180 degrees
    - second order effect, unlikely to matter much
  - Adjust regions?
    - Match shock region to Maxim's (have to get it from him)
    - Divide region 12 into quadrants (small if any impact)
  - Remake region PSFs and check astrometry (easy)
  - Refit to get new values and errors (easy)
- Systematics
  - Astrometry (modify shifts slightly)
  - Underlying point sources (removed from Chandra data)
  - others?
- Fit NuSTAR spectra alone (poor constraints, but can make Tmap)
- Check Chandra background (Maxim found an additional flared component, at the 1-2% level, in merged data, unlikely to be important for this but still)
- Fit Chandra+NuSTAR
  - deproject the best-fit temperature to constrain e-ion equil.