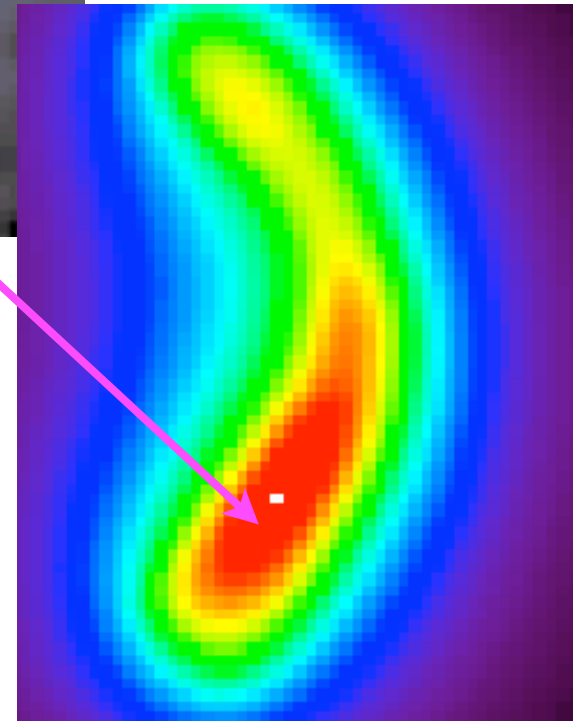
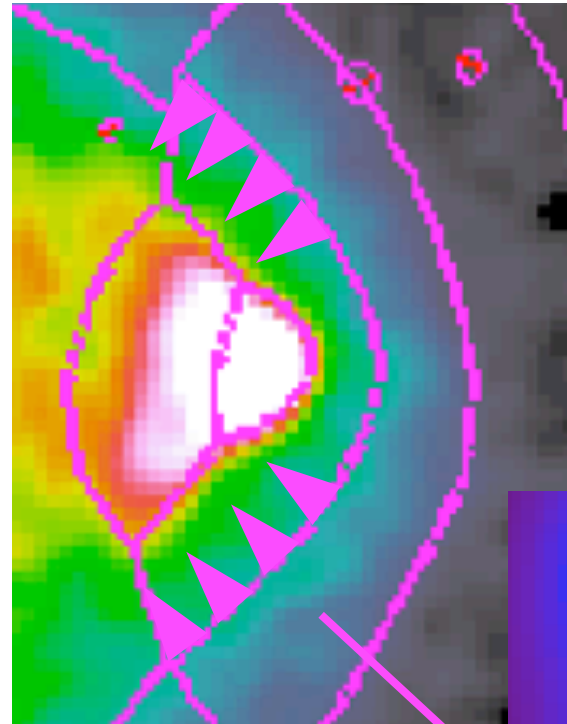
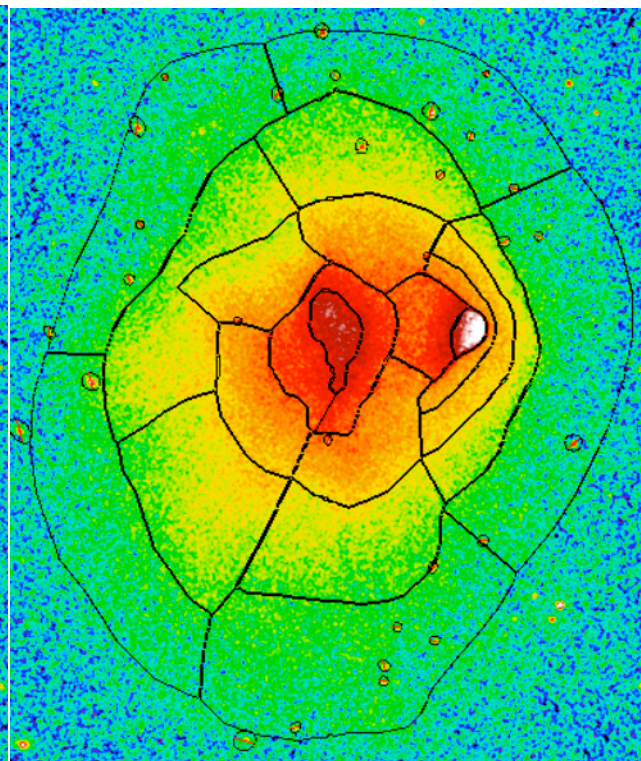
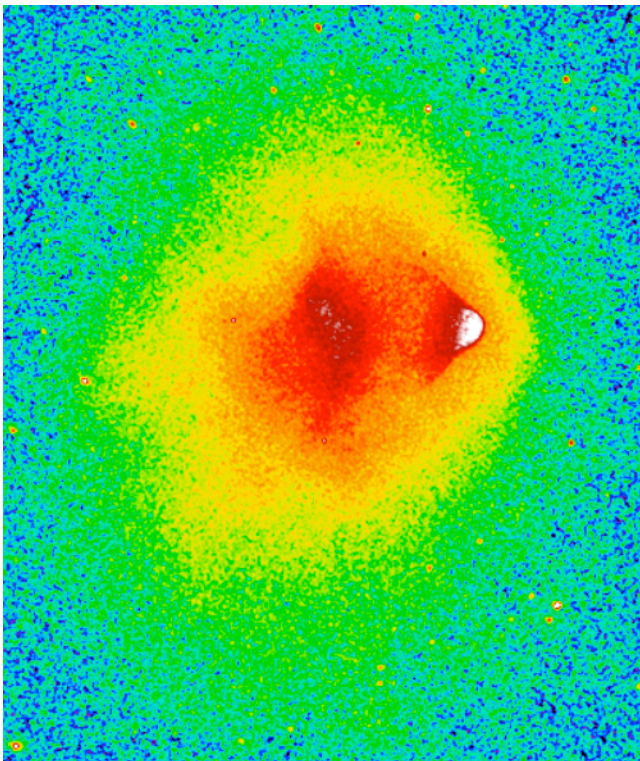


Biting the Bullet

- Preselect regions, presume emission isothermal
- Create surface brightness image (from Chandra: 3-7 keV) to use as a weighted PSF/ARF input map
- Find the APEC norm. N , for kT s between 4 and 40 keV, consistent with the Chandra spectrum (0.8-2 keV) in each region
- Define NuSTAR energy bands and find the count rate in each assuming an APEC with $N=1$ and kT s in the range 4-40 keV
- Simultaneously fit energy band images, linking the rate in a given PSF region based on kT (free parameter) and N (fixed to be consistent with Chandra rate)

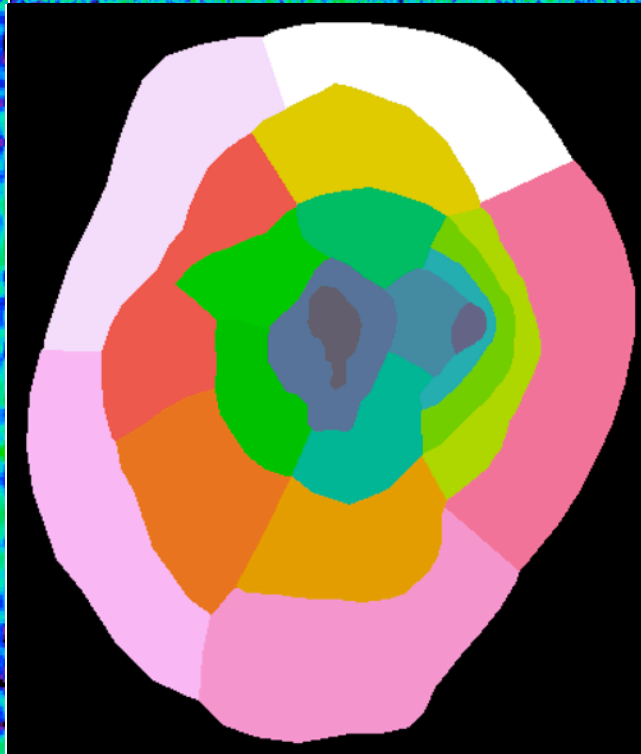
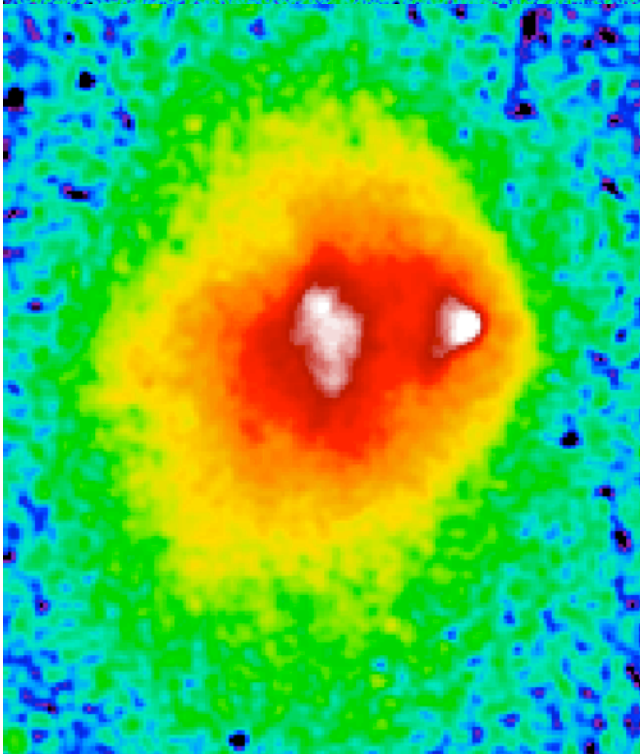


Chandra
all events



w/regions
overlaid

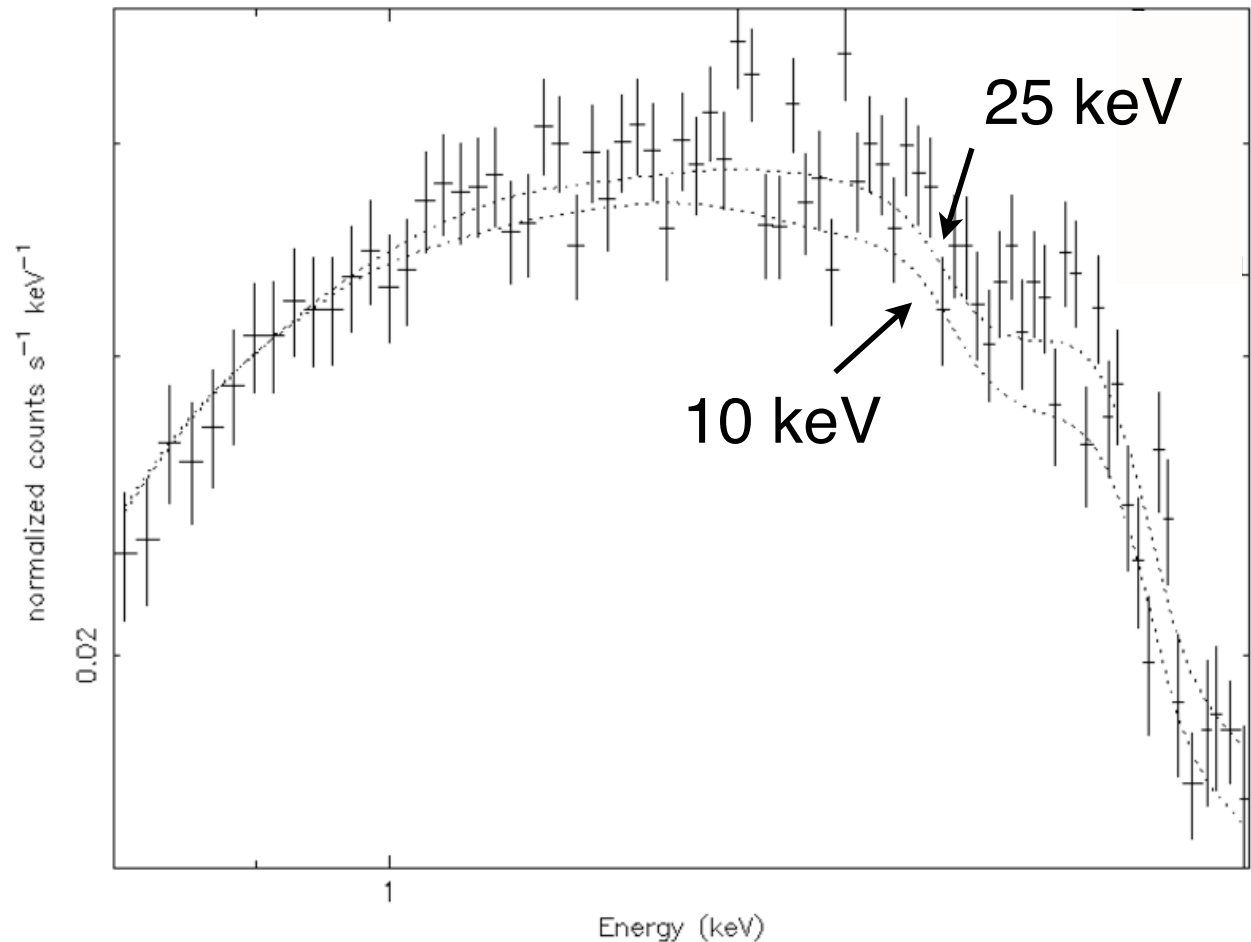
flux image
3-7 keV
smoothed



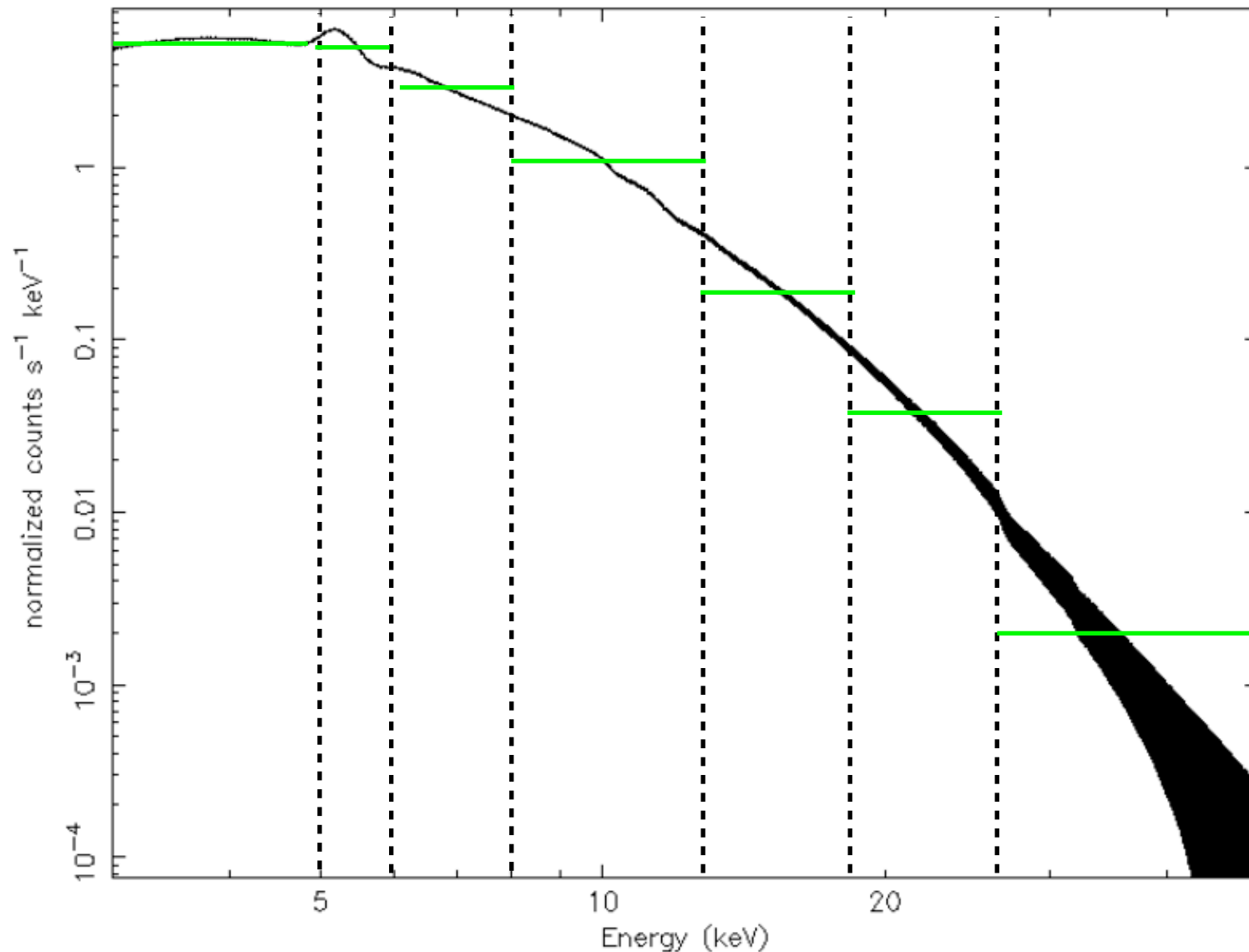
regions
for
NuSTAR
PSF map

Use gas density inferred from Chandra as a prior

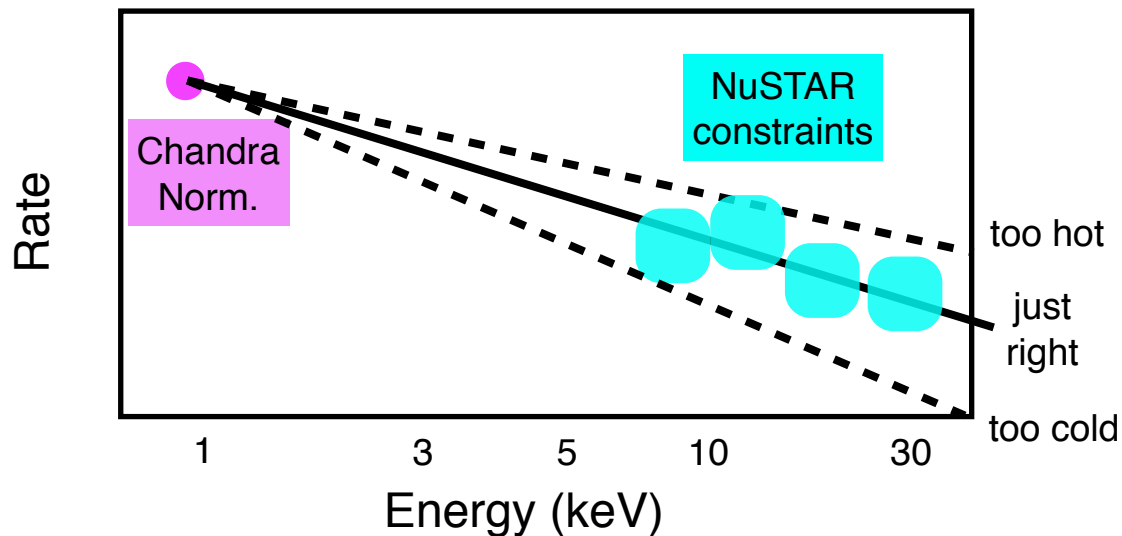
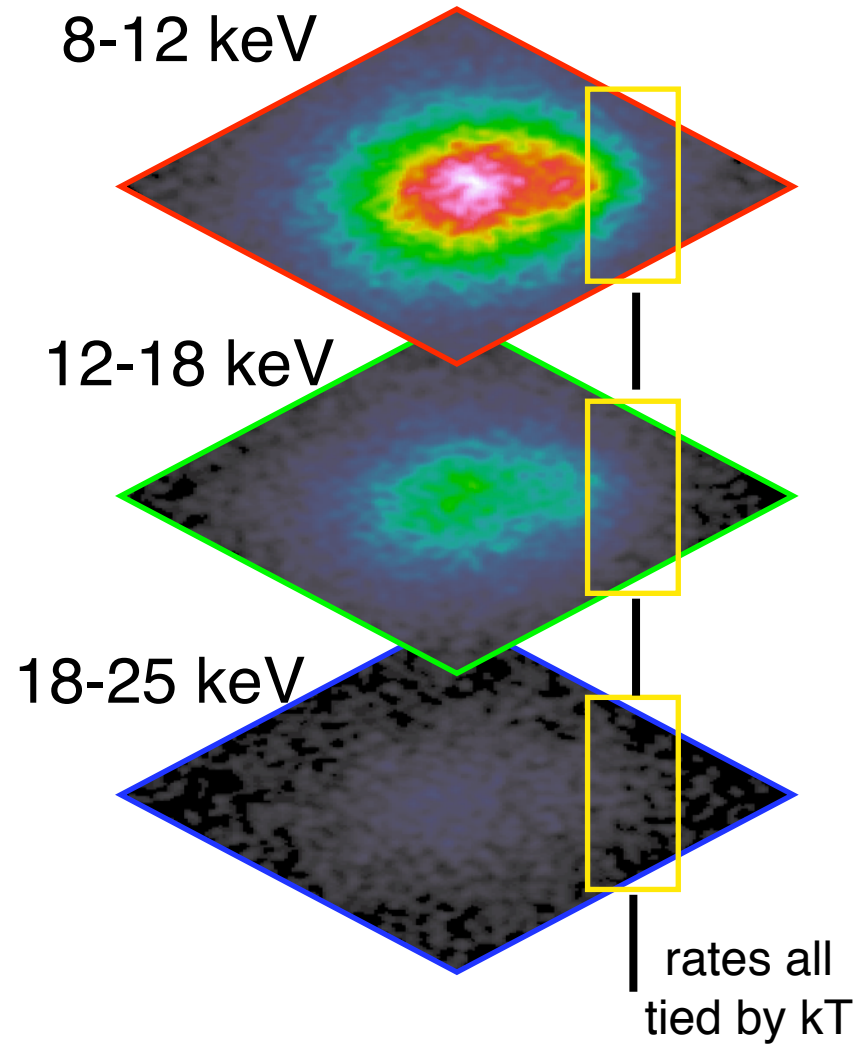
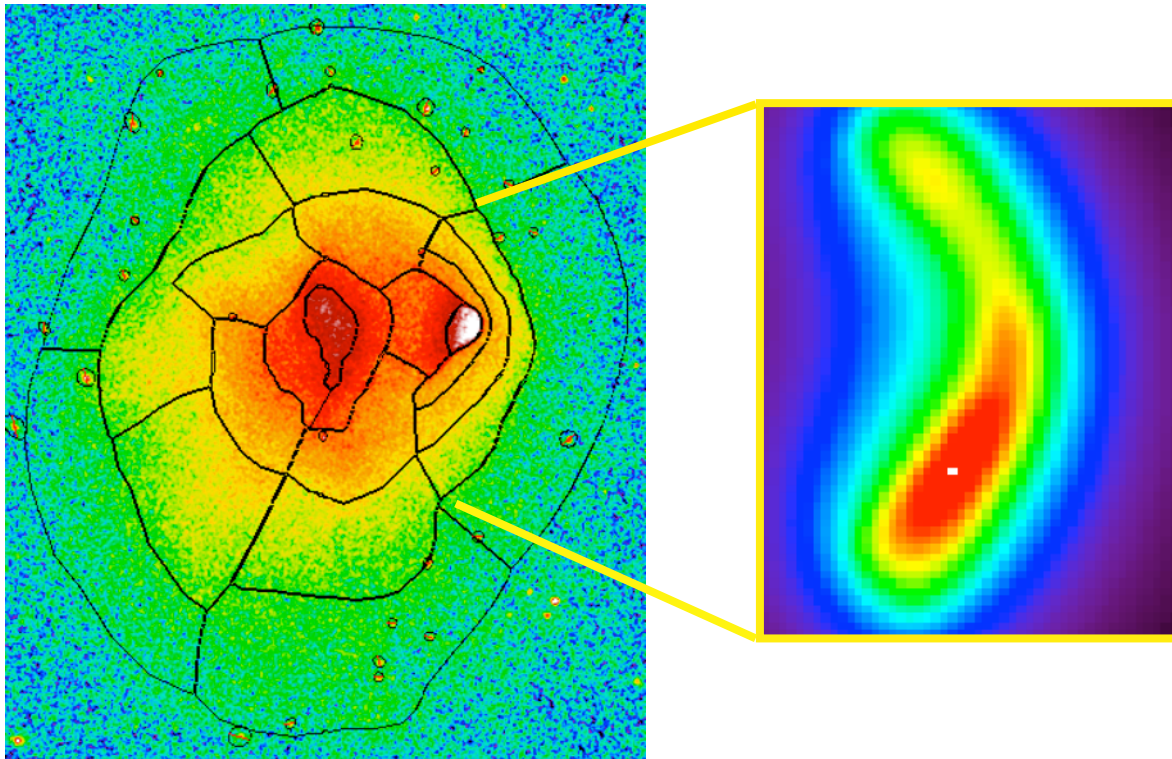
- The 0.8-2 keV band only slightly depends on temperature
- Characterize APEC normalization as function of kT
- Fix normalization by region during NuSTAR fits
- Chandra priors are not strongly temperature dependent



Shortcut: get rates for kTs between 4 and 40 keV for relevant abundances

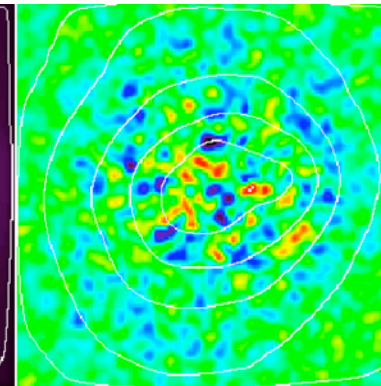
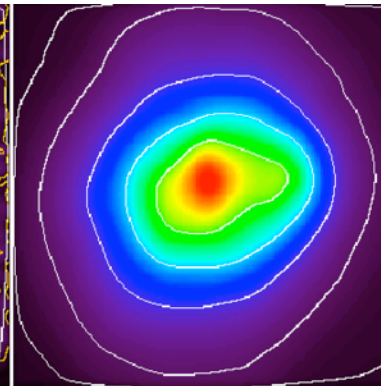
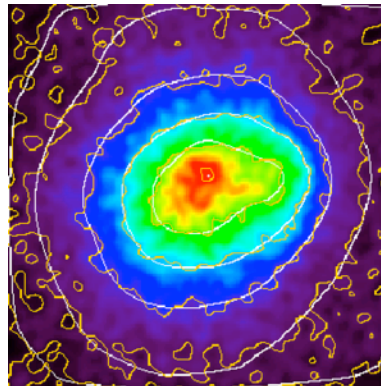


Convolve Chandra image with NuSTAR PSF

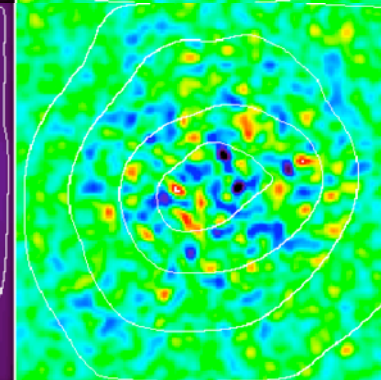
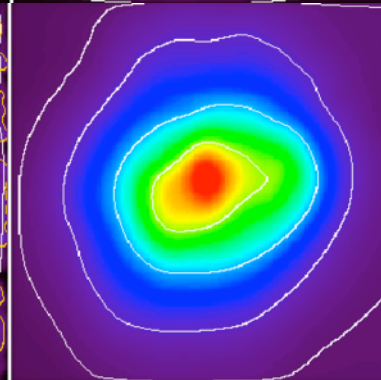
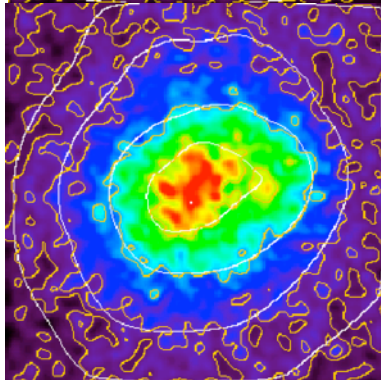


One parameter per region, all energy band images fit simultaneously

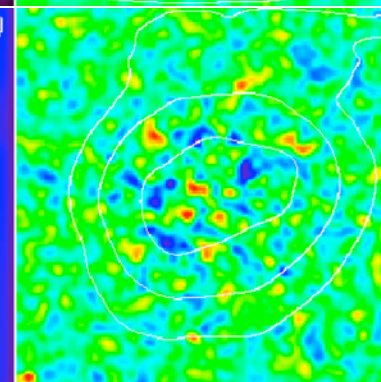
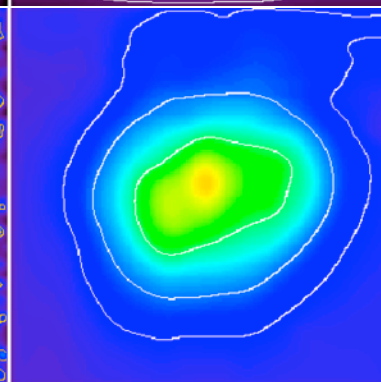
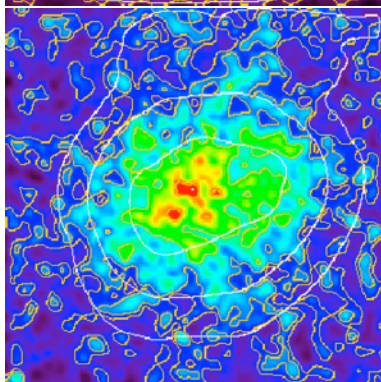
8-12
keV



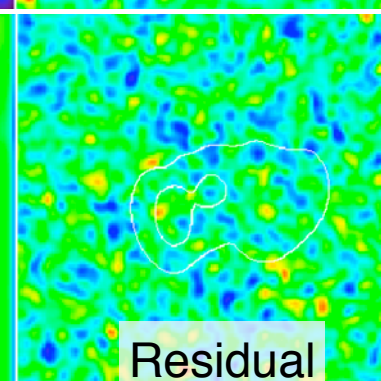
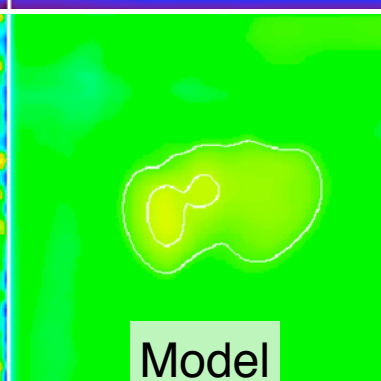
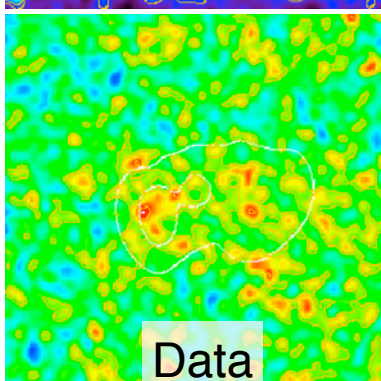
12-18
keV



18-25
keV



25-50
keV



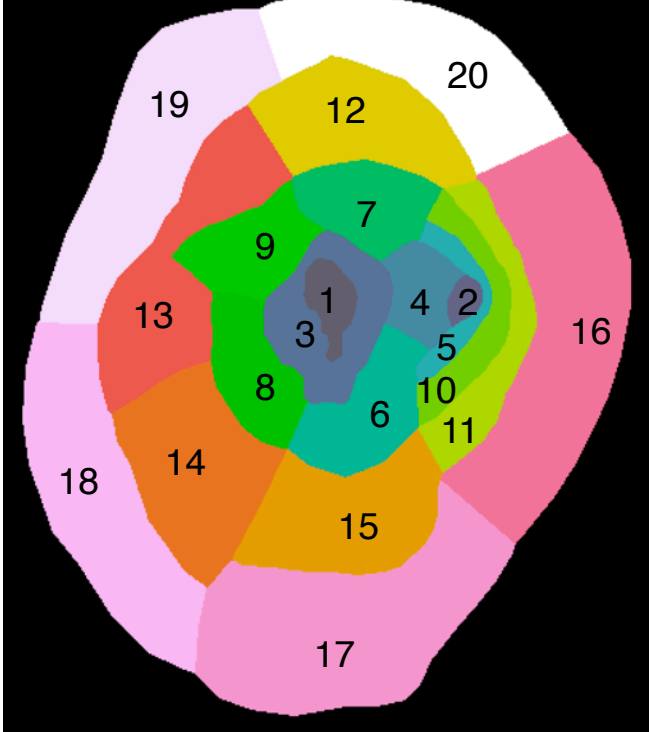
Data

Model

Residual

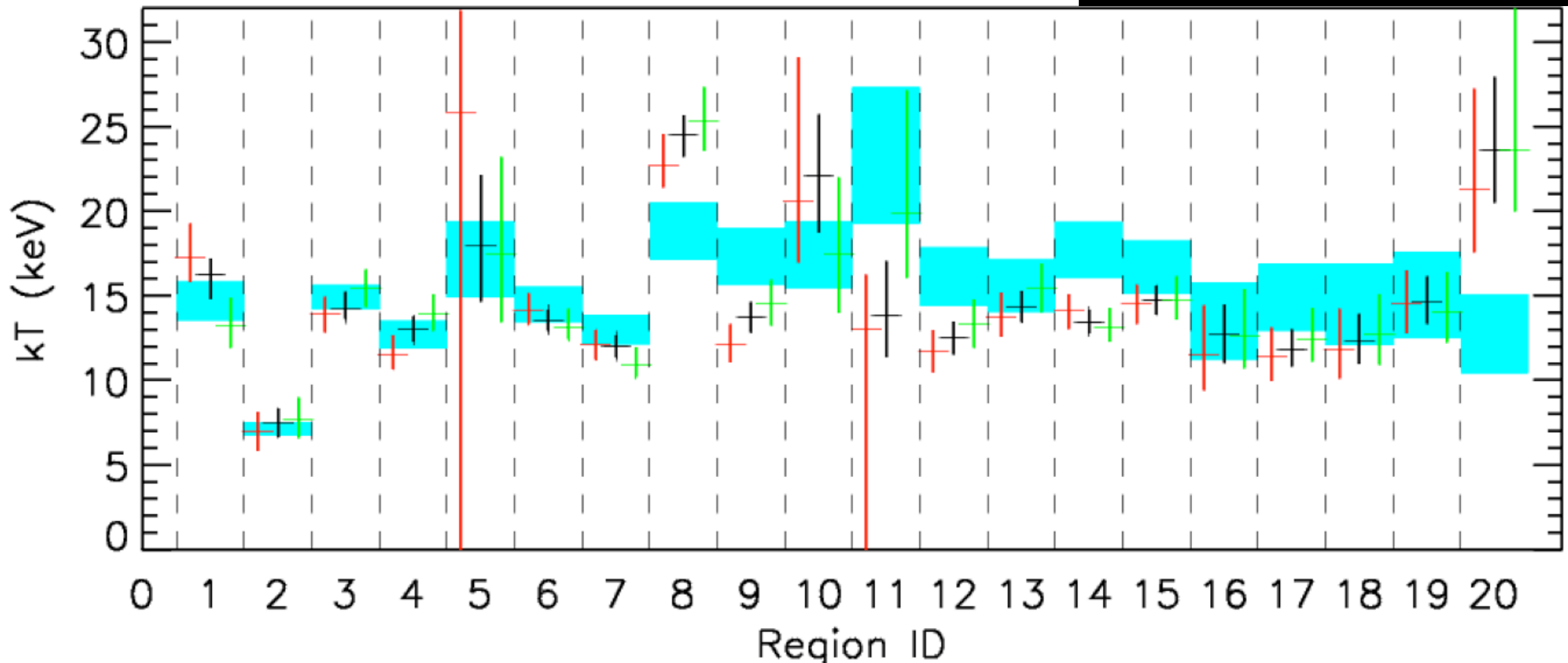
Both telescopes
of both epochs
combined before
fit, background
kept fixed, overall
Chandra/
NuSTAR cross-
normalization
allowed to vary

Comparison of **Chandra** (0.8-7 keV) best-fit kTs and NuSTAR (**Epoch 1**, **Epoch 2**, and **Epochs 1+2**) 8-50 keV constraints



Cool
Core

Shock



Systematics

- 2 Epochs largely agree, except near shock (annoyingly)
 - Lower kTs (relative to Chandra) unexpected, systematics not yet under control?
 - For NuSTAR 3-8 keV energies, Chandra model produces slight positive residuals in bright regions and negative residuals in fainter surrounding regions: sign of imperfect PSF calibration?
-
- Residual PSF shape bias
 - Tricky to assess (not well understood)
 - Can adjust PSF shape to be more lopsided in various ways and redo fits, use to quantify effect on kTs
 - Astrometry
 - Redo fits with ~ 0.5 pixel shifts (~ 1 sigma) in all directions, quantify effect on kTs
 - Multi-temperature structure within regions
 - Probably not a significant factor, given clean residuals
 - Expect to bias high (Region 8?), but what about many regions where kT is below best-fit Chandra value?
 - Underlying point sources (ignore, fraction of flux likely too small)

End Game

- To do
 - Revisit PSF calibration
 - Assess impact of systematics (incl. bgd)
 - Deproject kTs near shock and compare to electron-ion equilibration models
 - Write paper
 - Encourage Republicans to vote for Donald Trump
- Questions for you
 - Regions OK? Should other regions be tried?
 - Worth adding more freedom to fits (allow each region normalization to be free)?
 - Any qualms about using Chandra 0.8-2 keV data to anchor fits?
 - XMM/Chandra cross-calibration issue is more at low energies... OK to ignore contamination?
 - Others?