

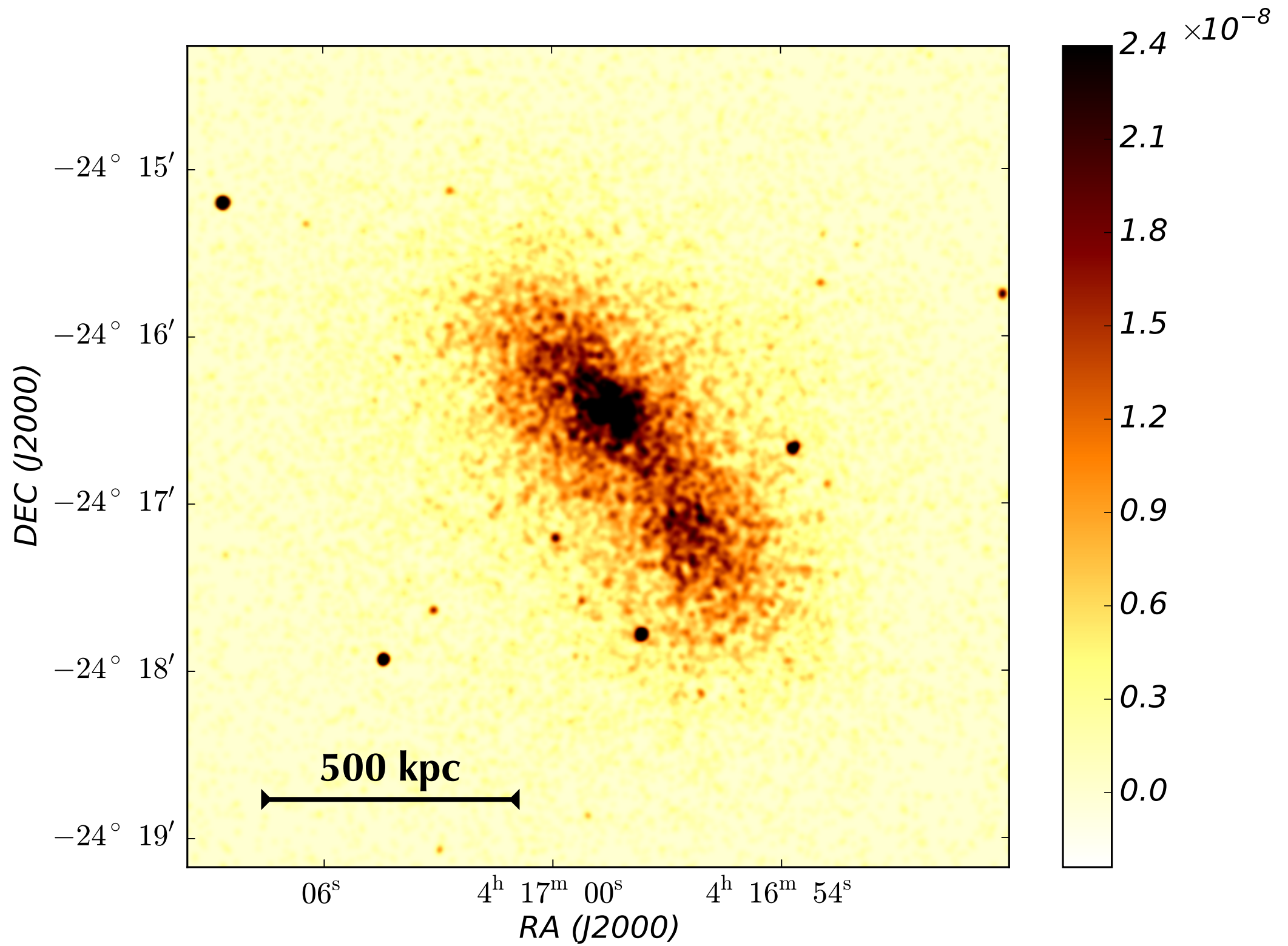
A Multiwavelength View of the HST Frontier Cluster MACS J0416.1-2403

Georgiana Ogrea

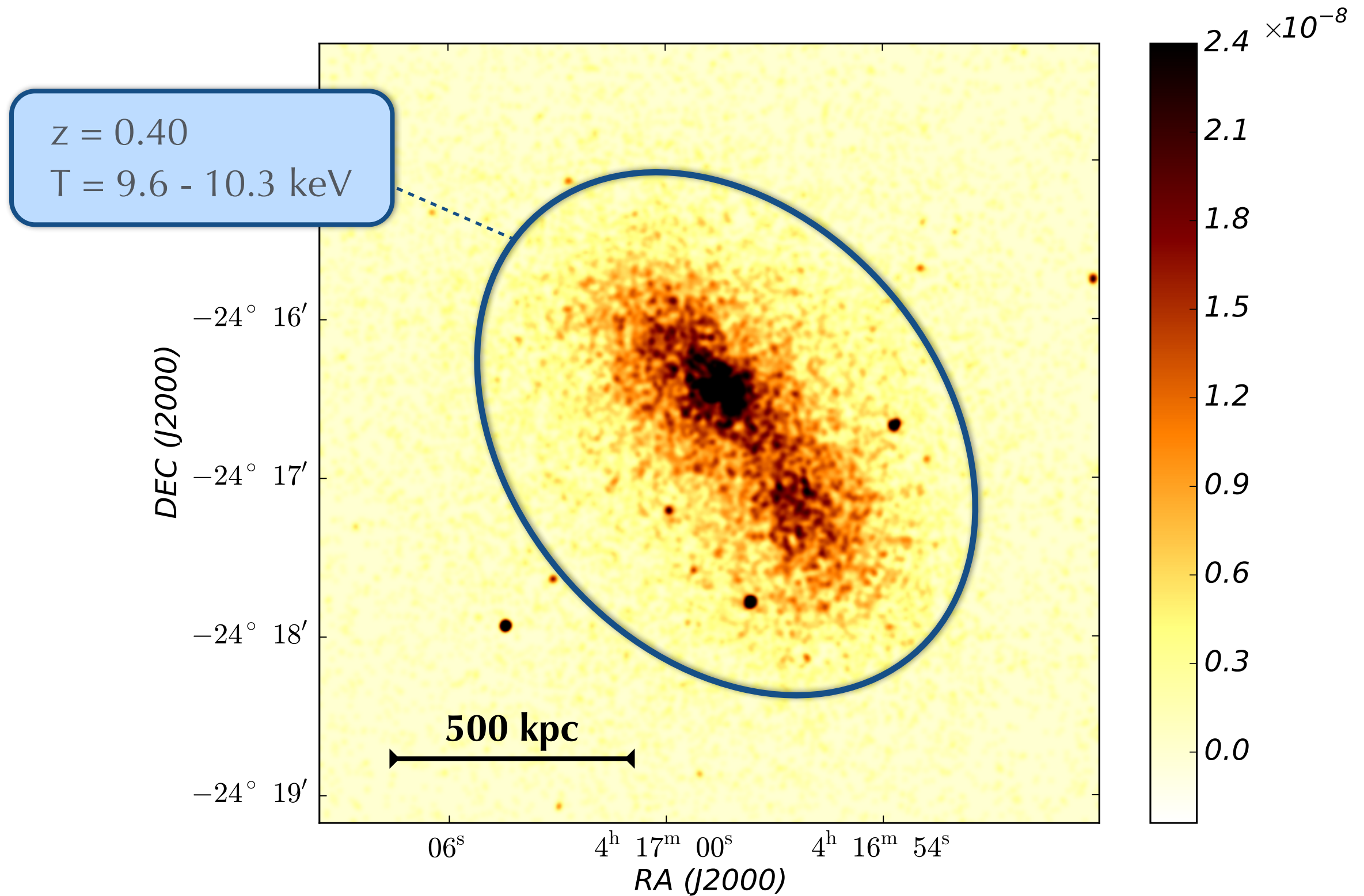
Hubble Fellow

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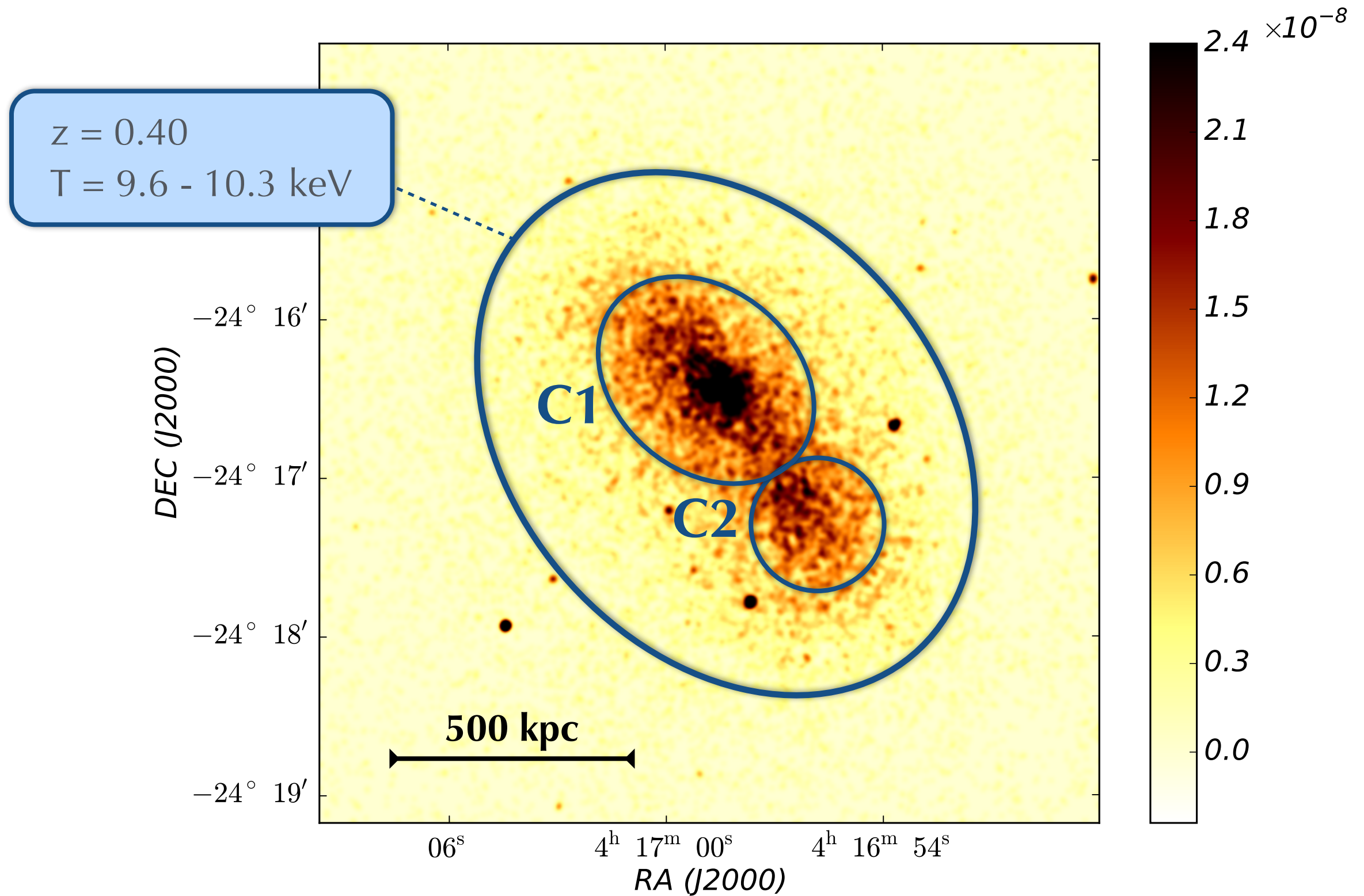
Christine Jones, Reinout van Weeren, William Forman,
Felipe Santos (CfA) , Stephen Murray (JHU)



0.5 - 3 keV Chandra surface brightness map, based on 180 ks of data (PIs: Murray, Jones).



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$\approx 200 \text{ kpc}$

Total mass within a radius of 950 kpc:
 $\sim 1e15 M_{\odot}$

S2

$M \sim 1e13 M_{\odot}$

C1

C2

S1

$M \sim 4e13 M_{\odot}$

Jauzac et al. (2014)

SCENARIO 1

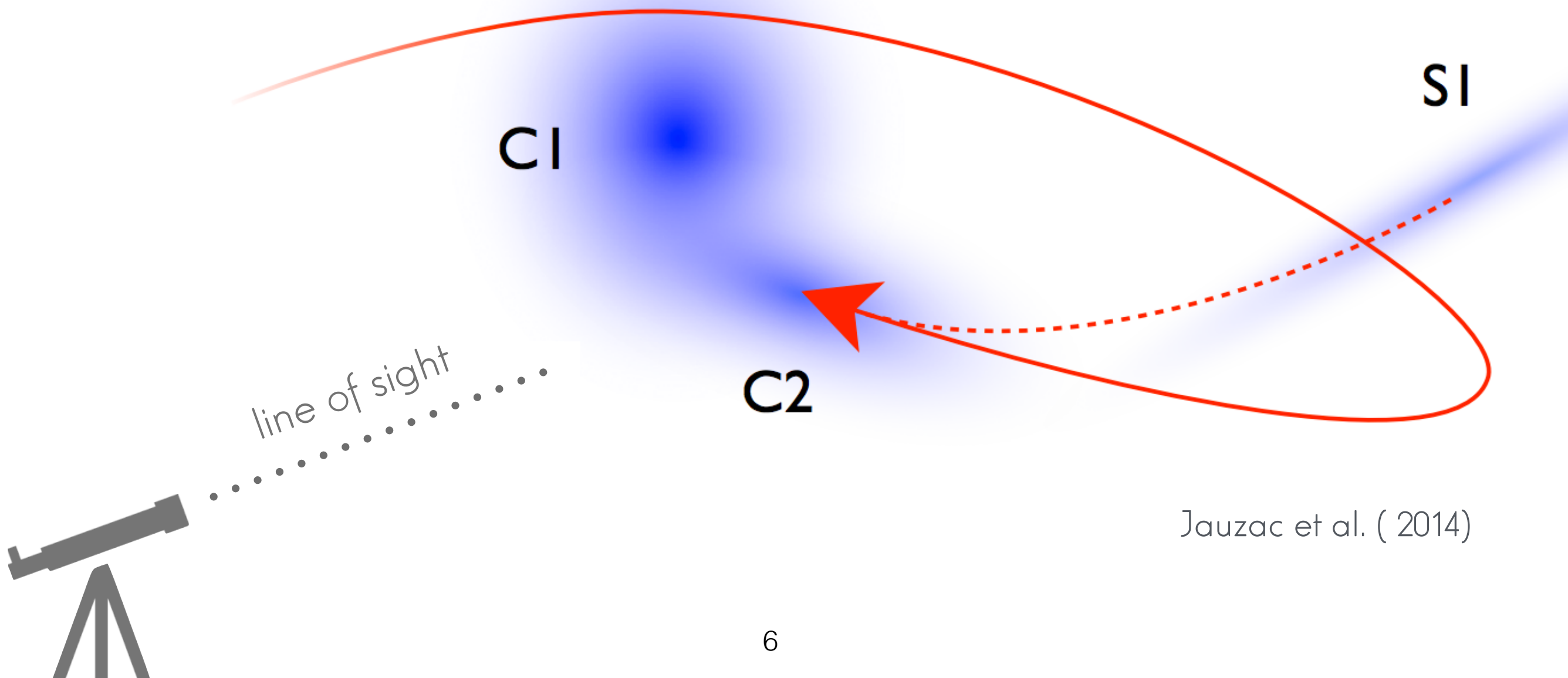
A **pre**-merger system:

C2 approaches C1 for the first time.

SCENARIO 2

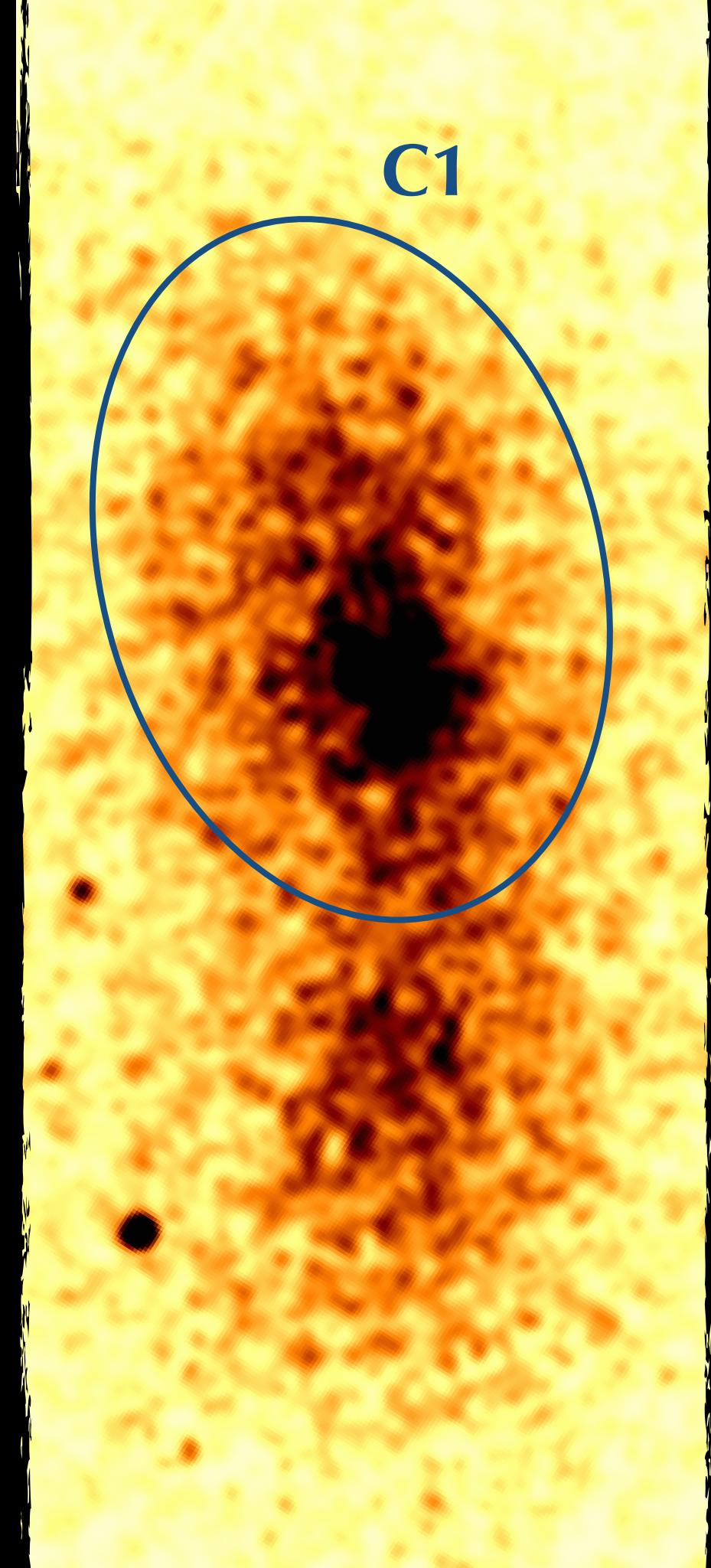
A **post**-merger system:

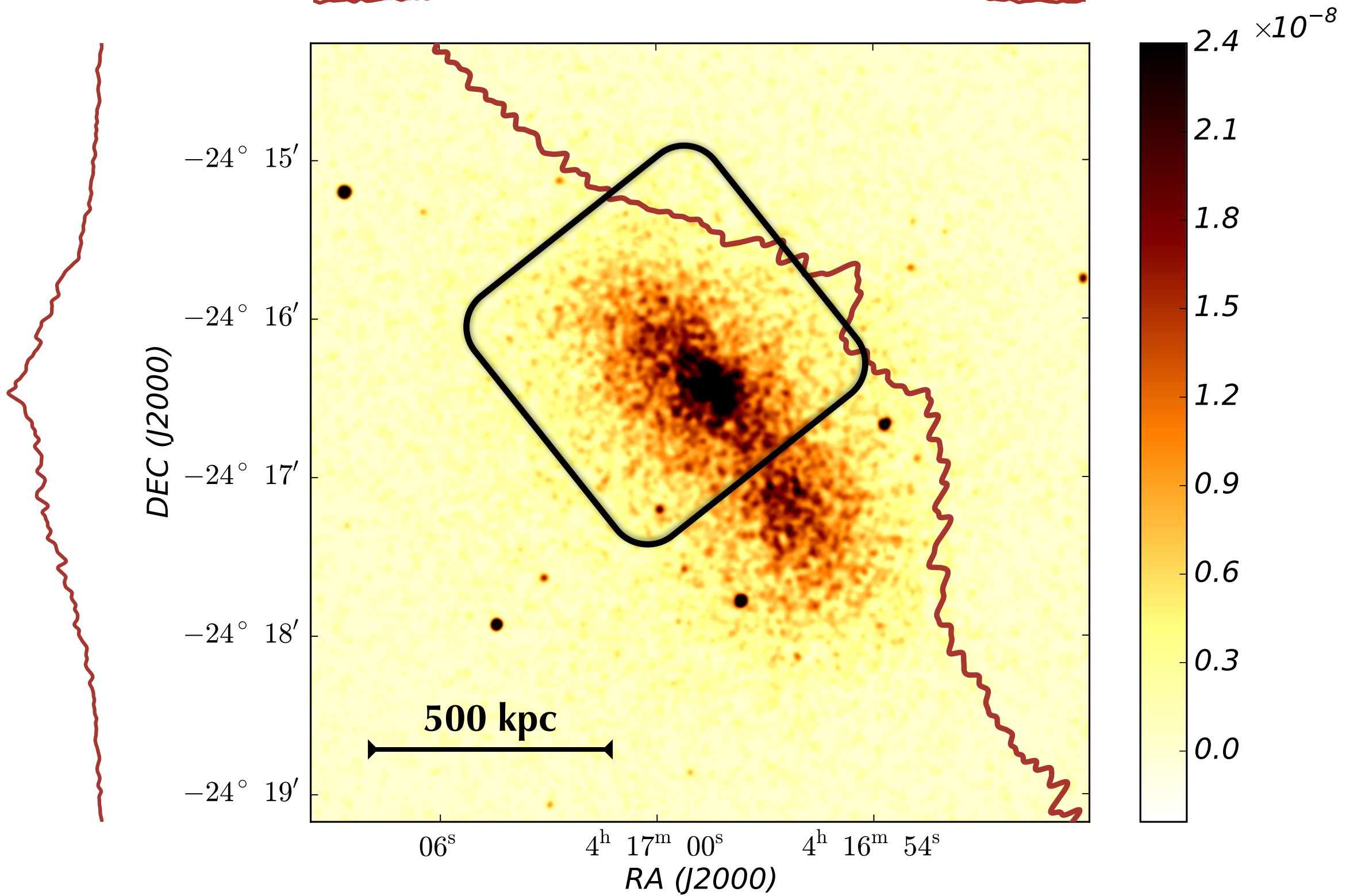
C2 approaches C1 for the second time.



Jauzac et al. (2014)

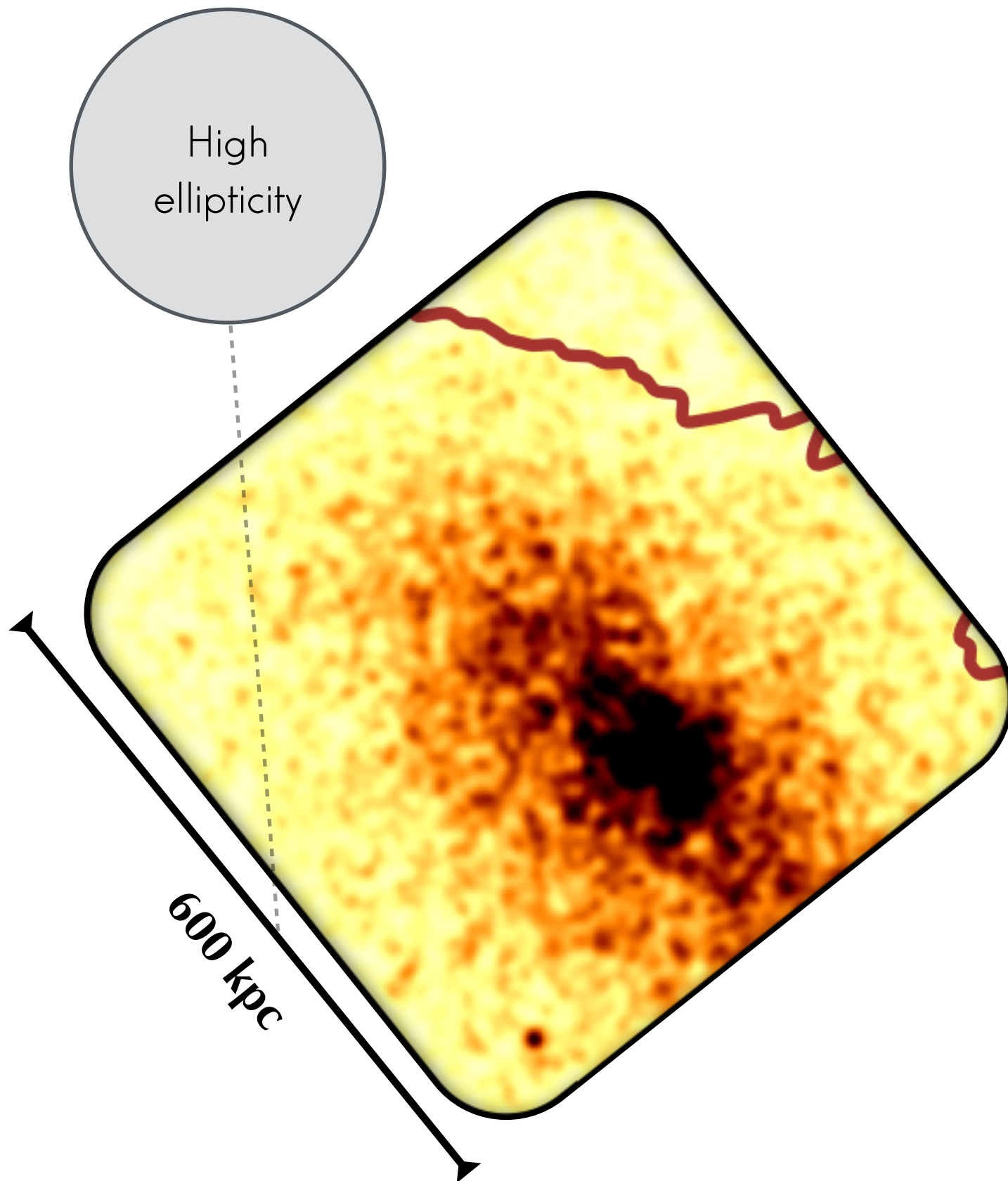
Is C1 a cool core?



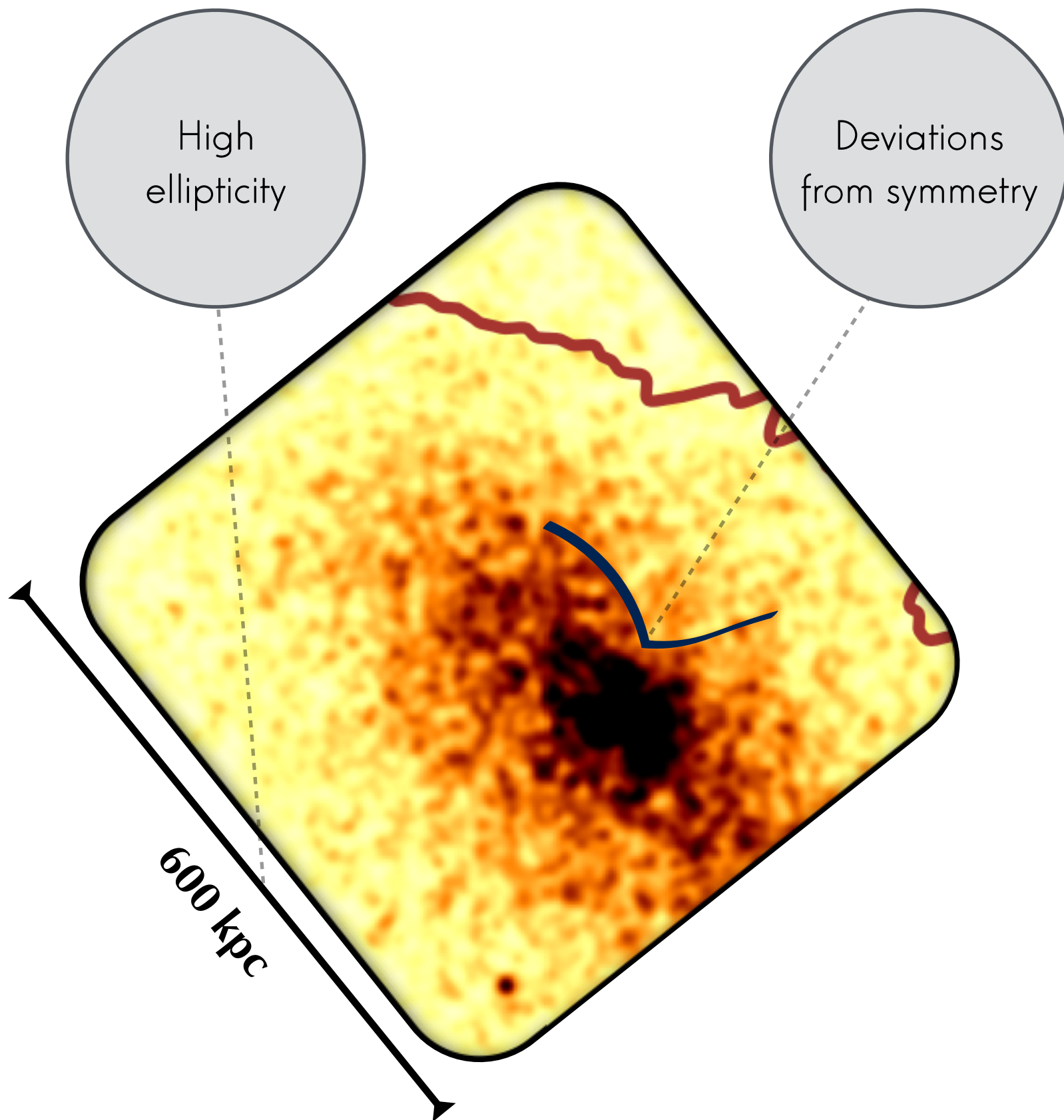


0.5 - 3 keV Chandra surface brightness map, based on 180 ks of data (Pls: Murray, Jones).

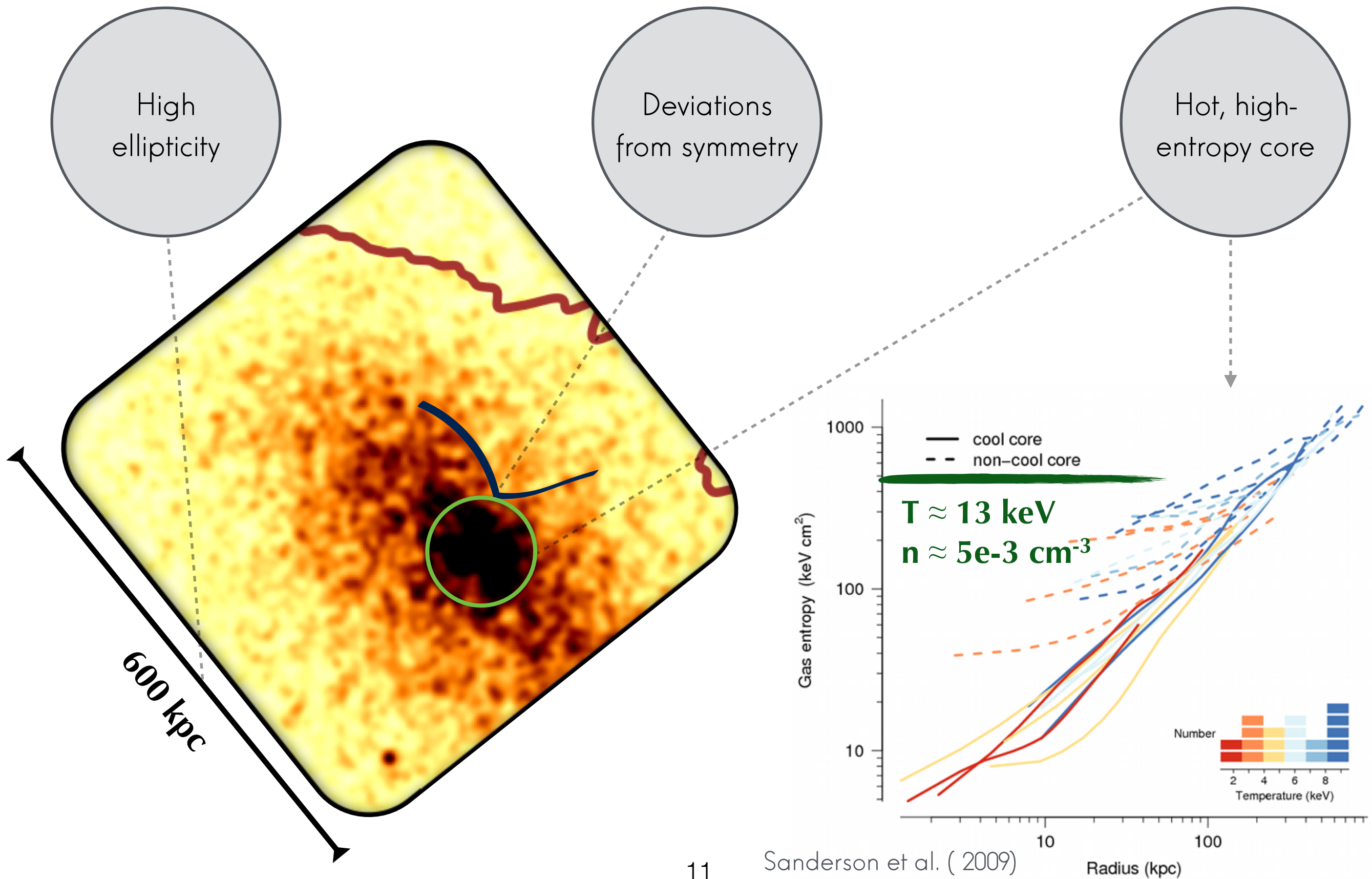
Peaked central brightness BUT...



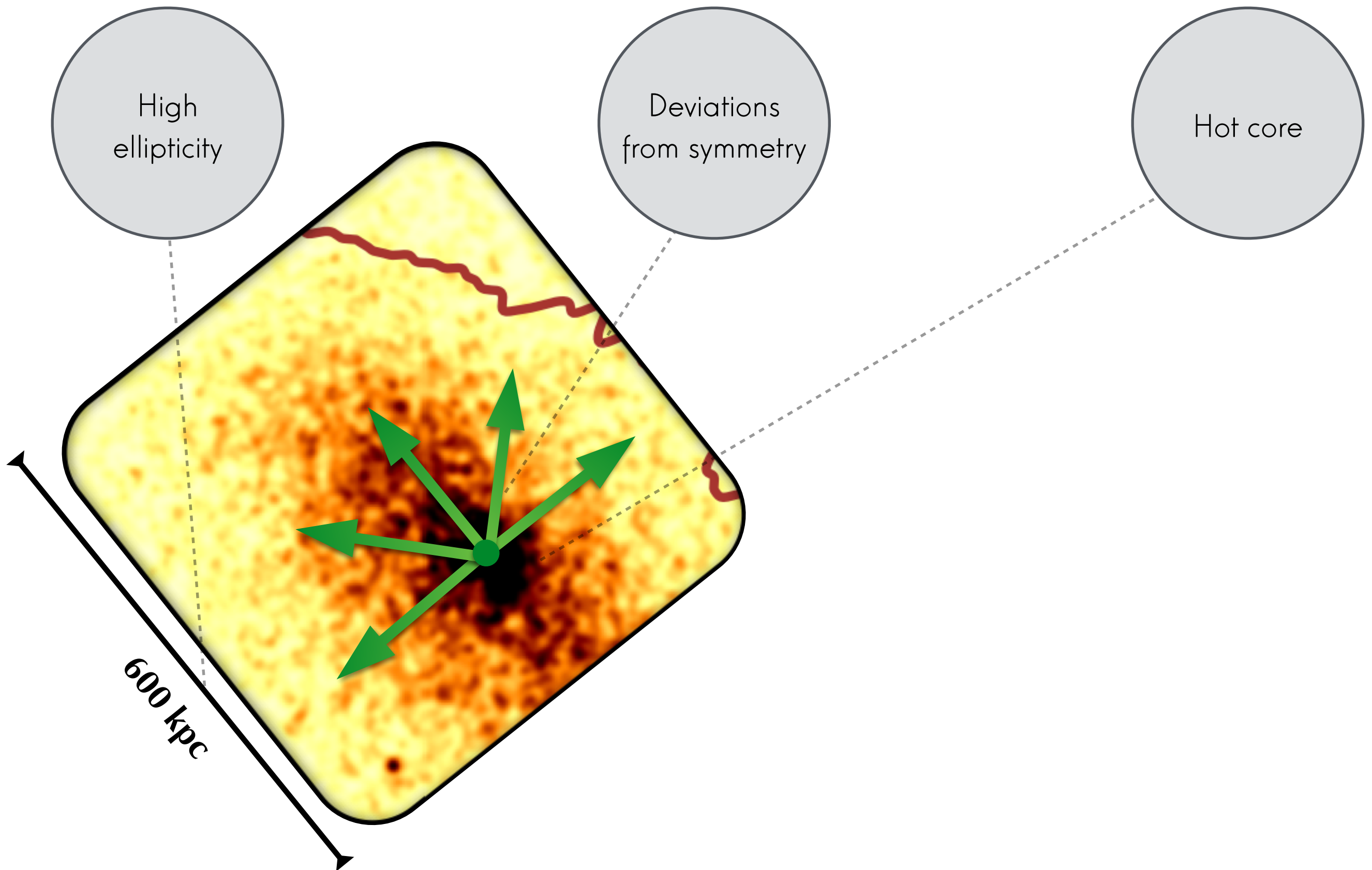
Peaked central brightness BUT...



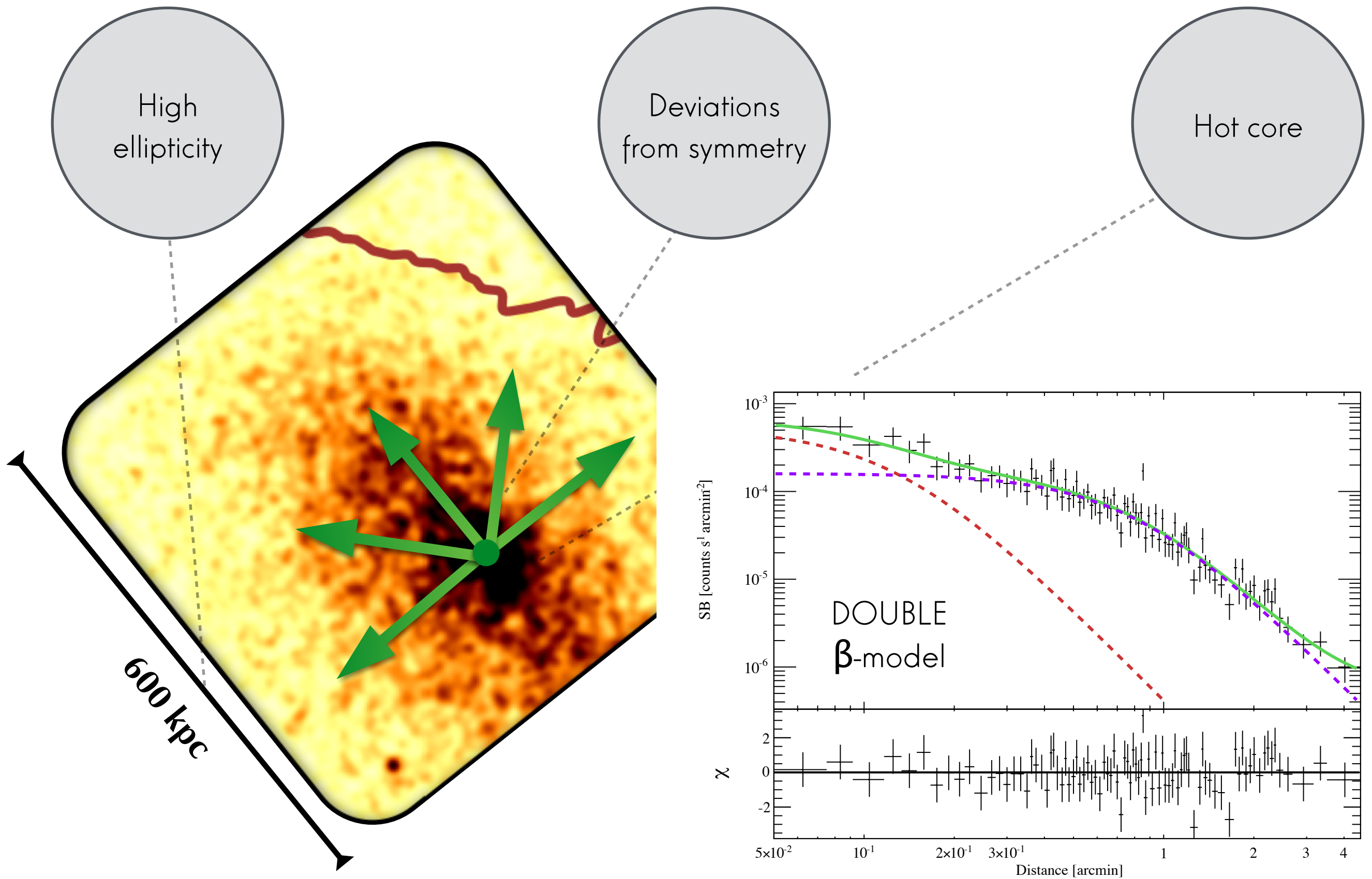
Peaked central brightness BUT...



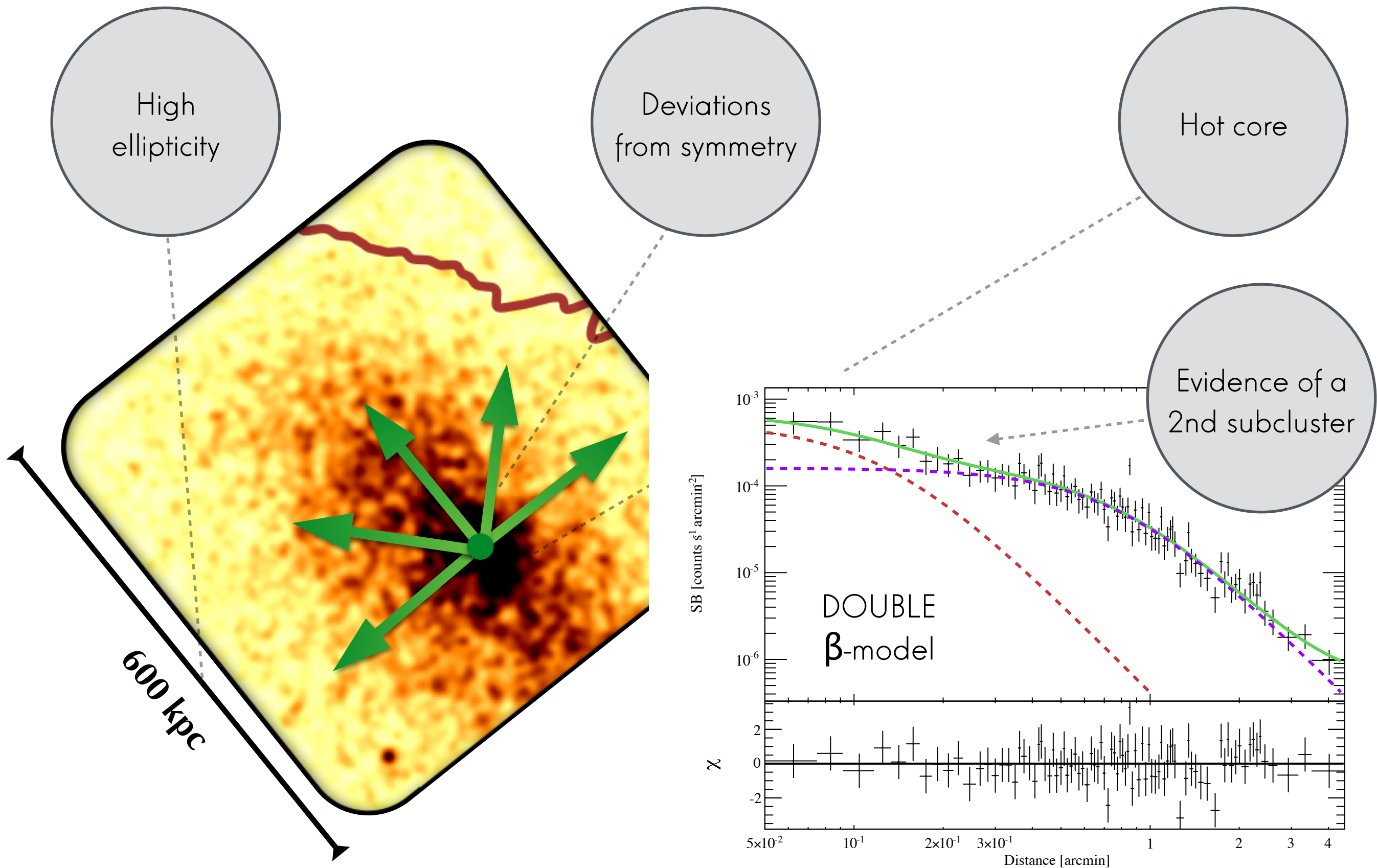
Peaked central brightness BUT...



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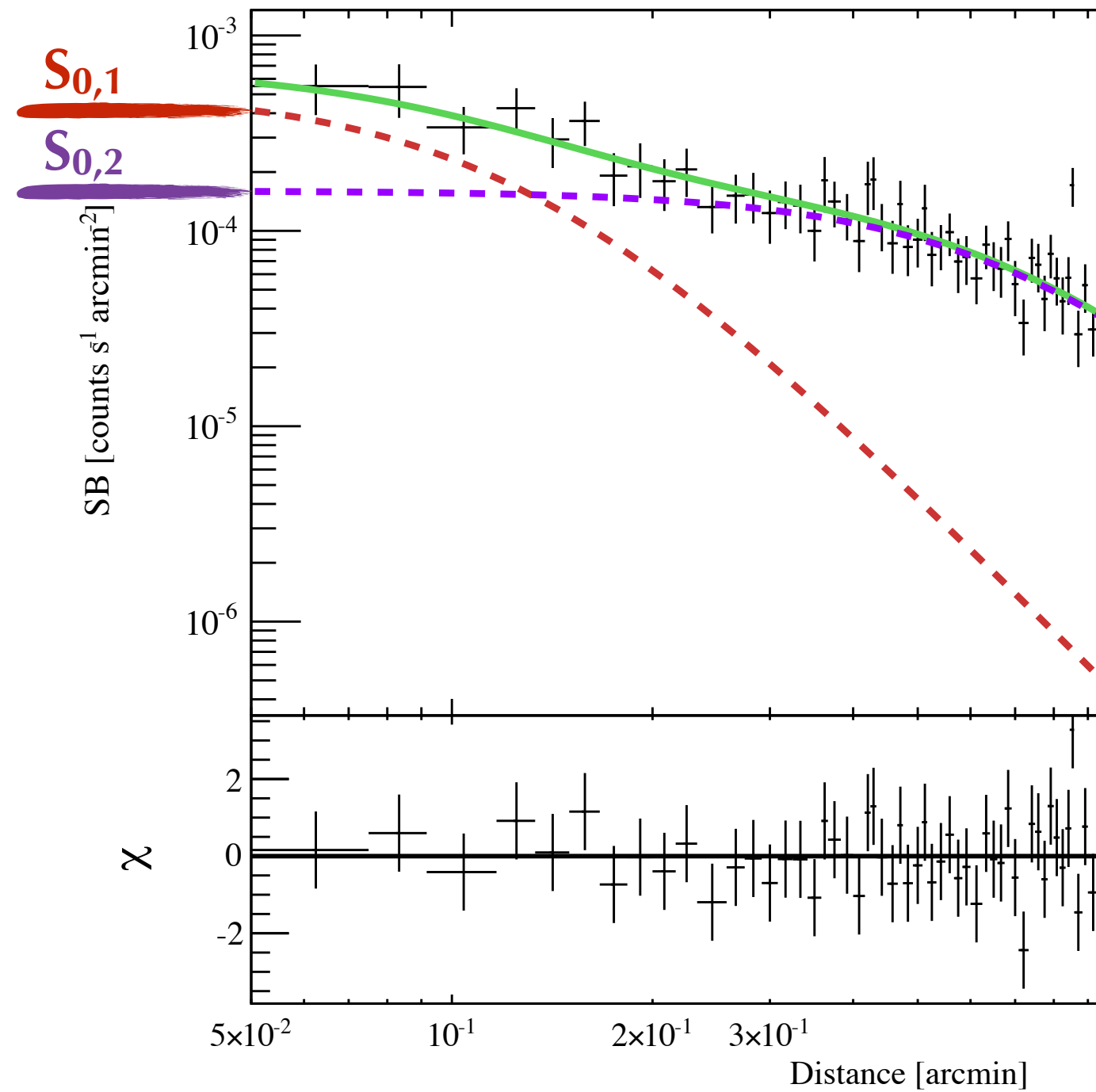
Peaked central brightness BUT...

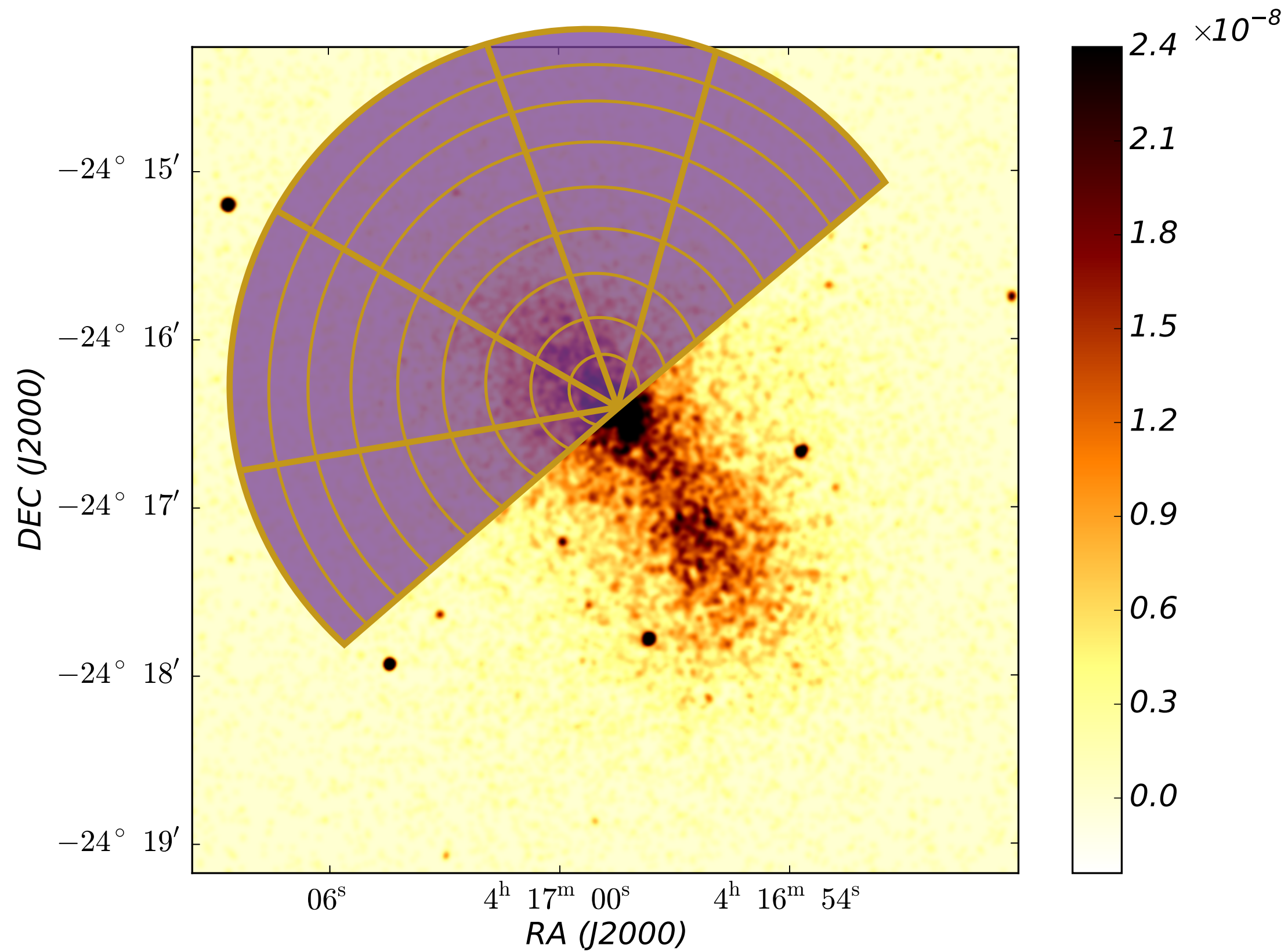


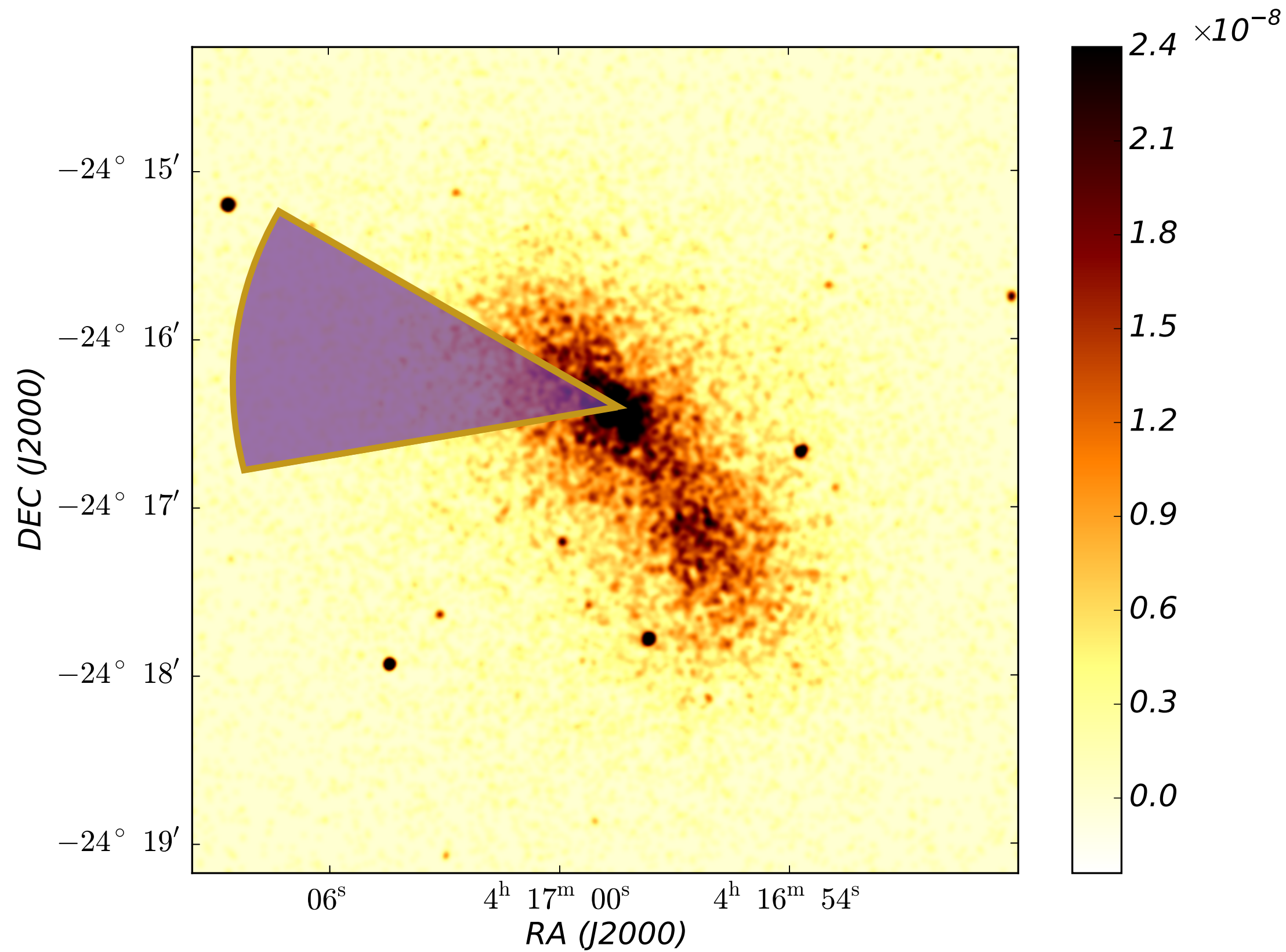
The ratio:

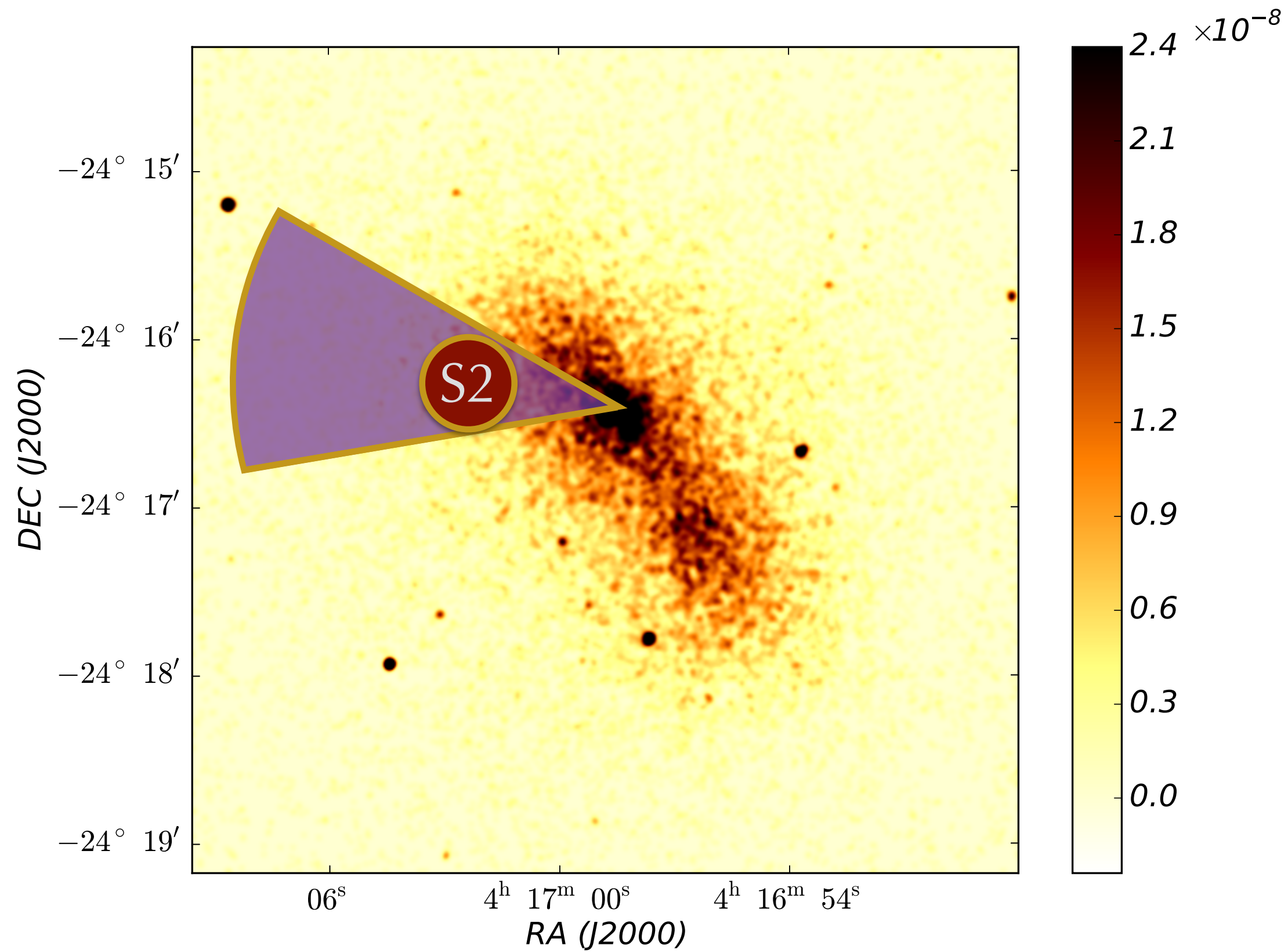
$$R_S = S_{0,1}/S_{0,2}$$

is closest to 1
in the direction of
the "hidden"
subcluster.

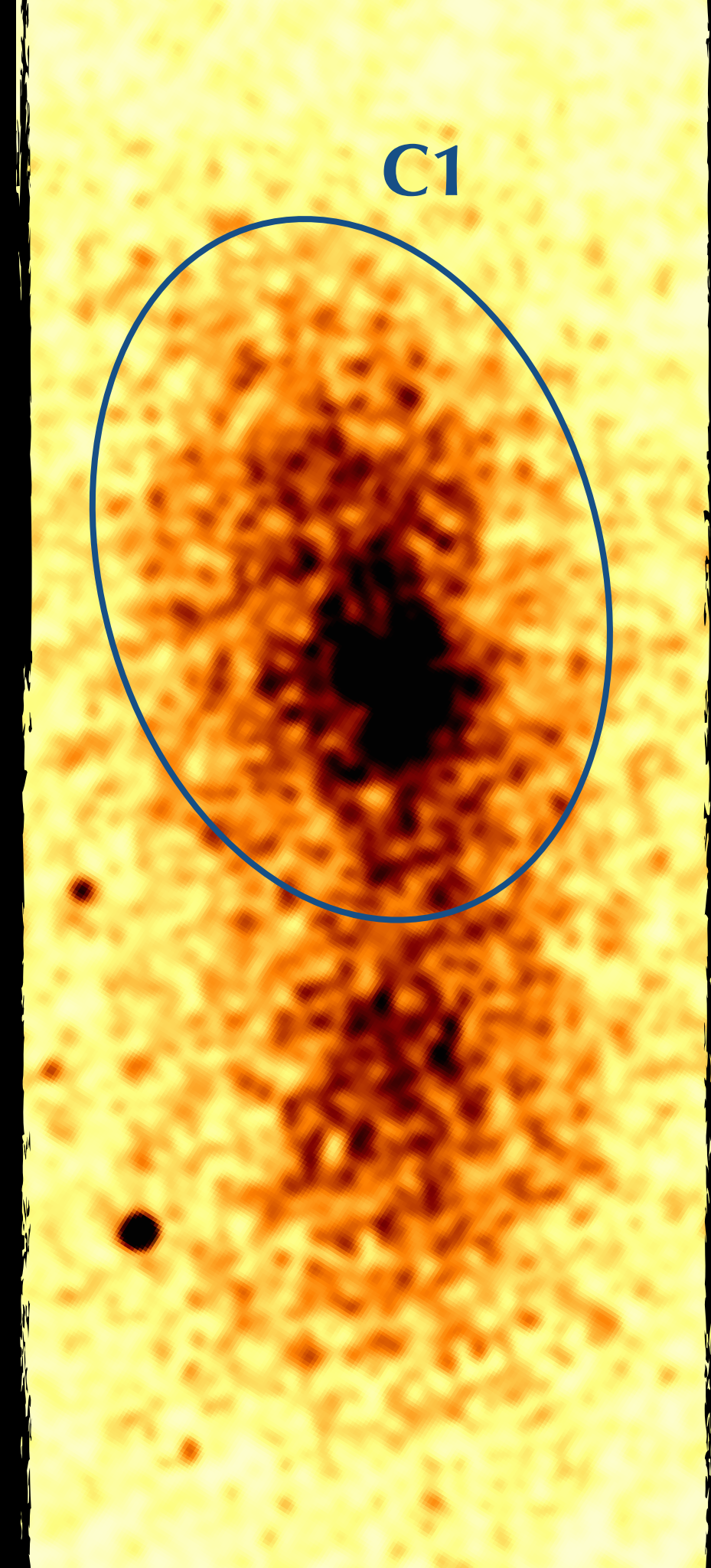




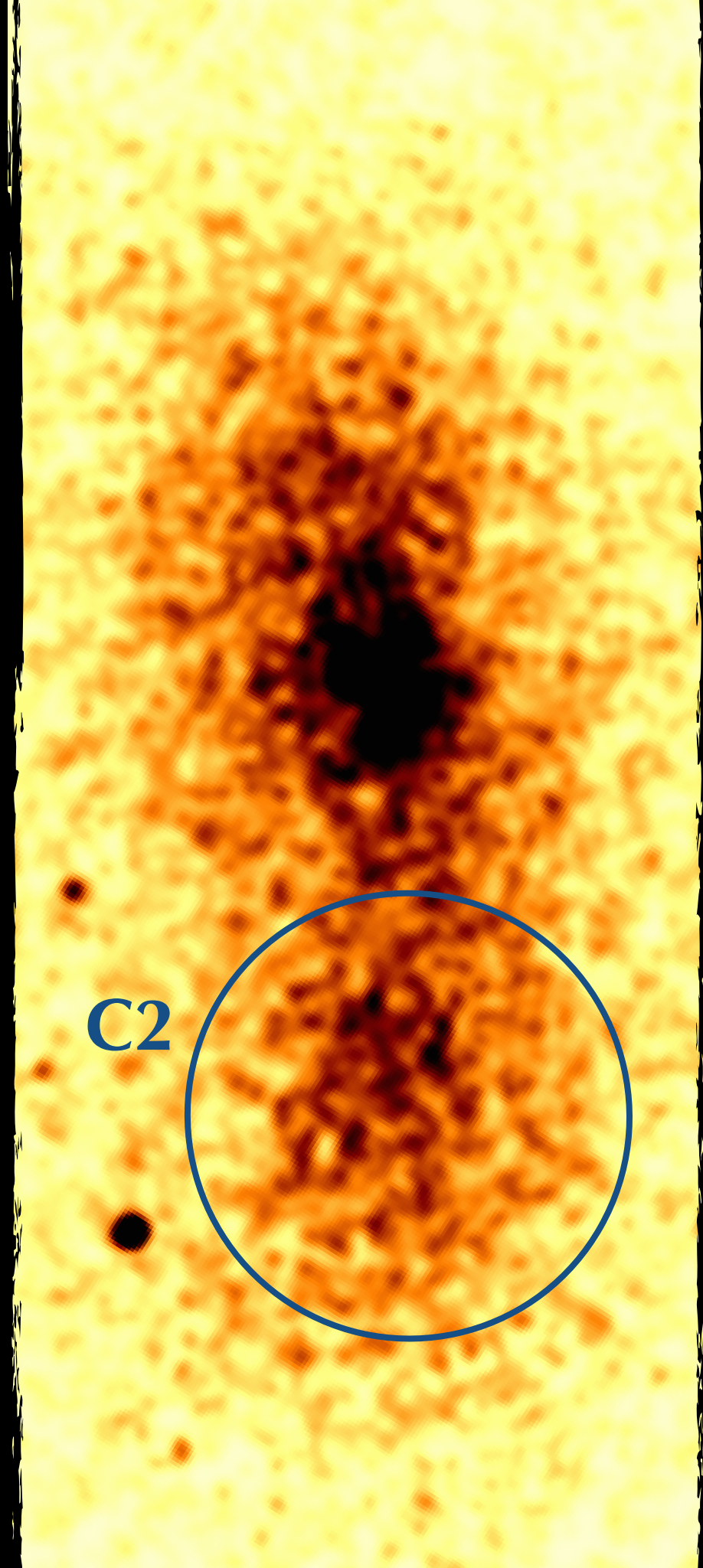


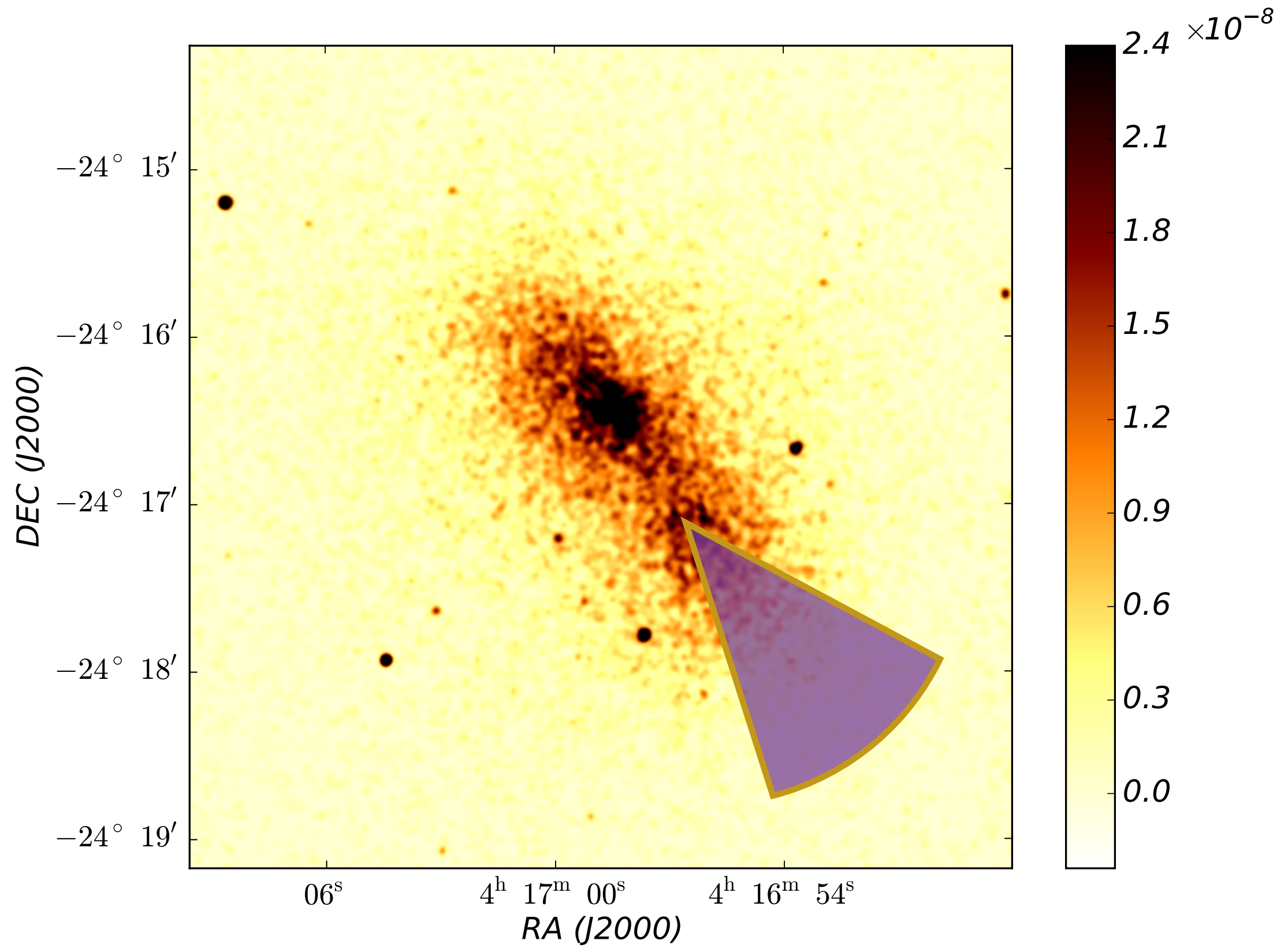


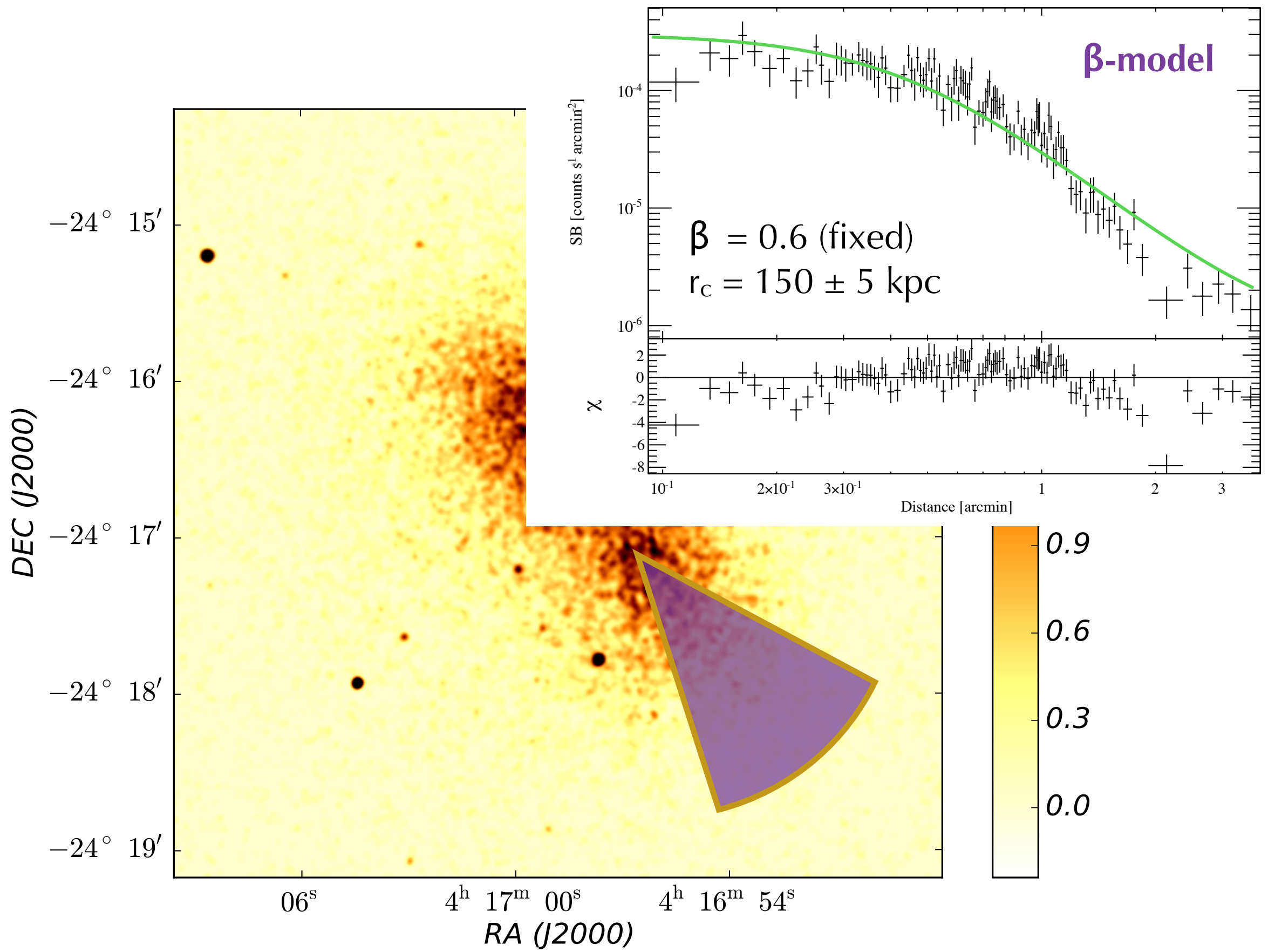
C1 is undergoing
a merger with a less
massive cluster not
immediately visible
in the X-ray map.

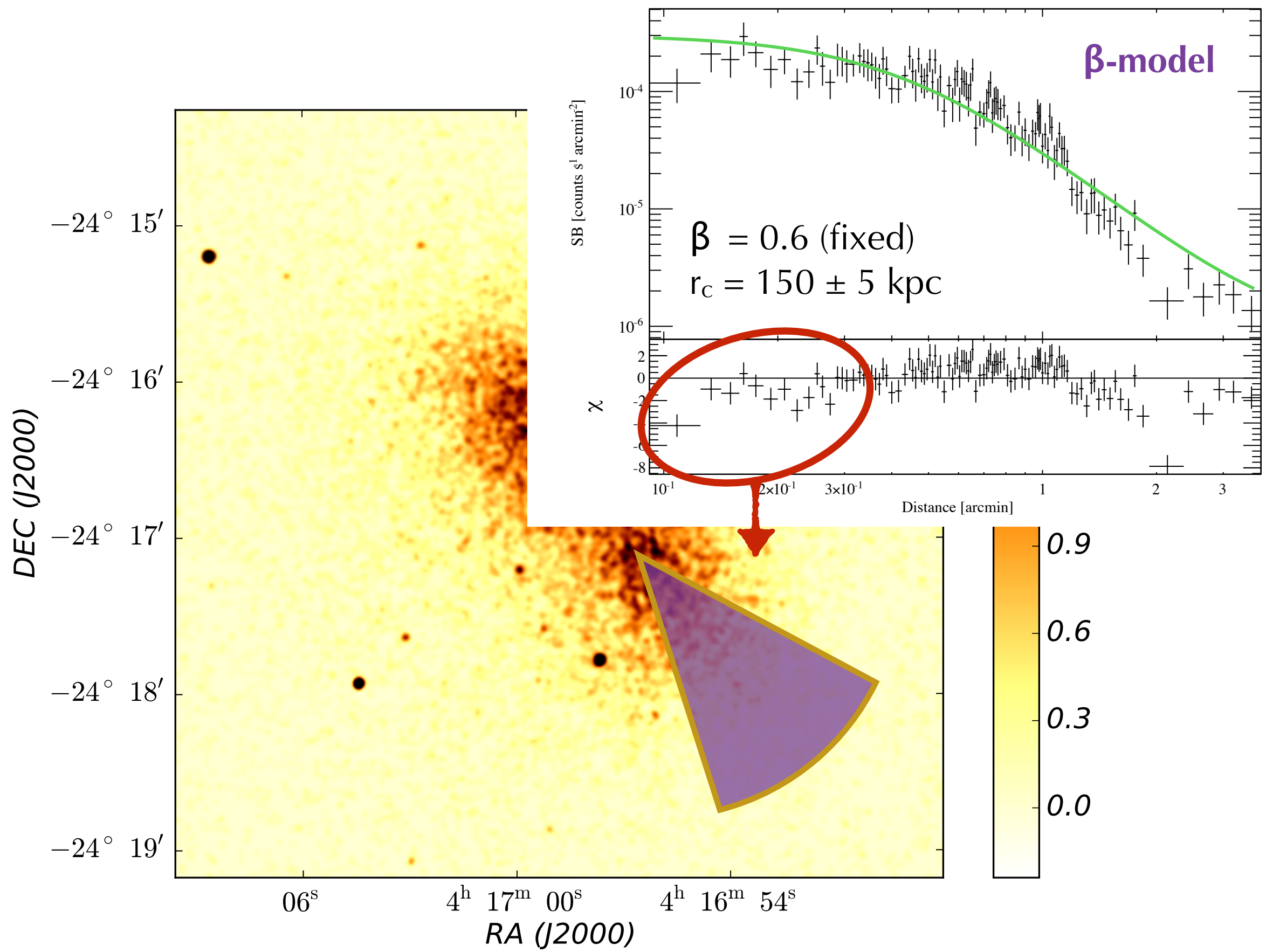


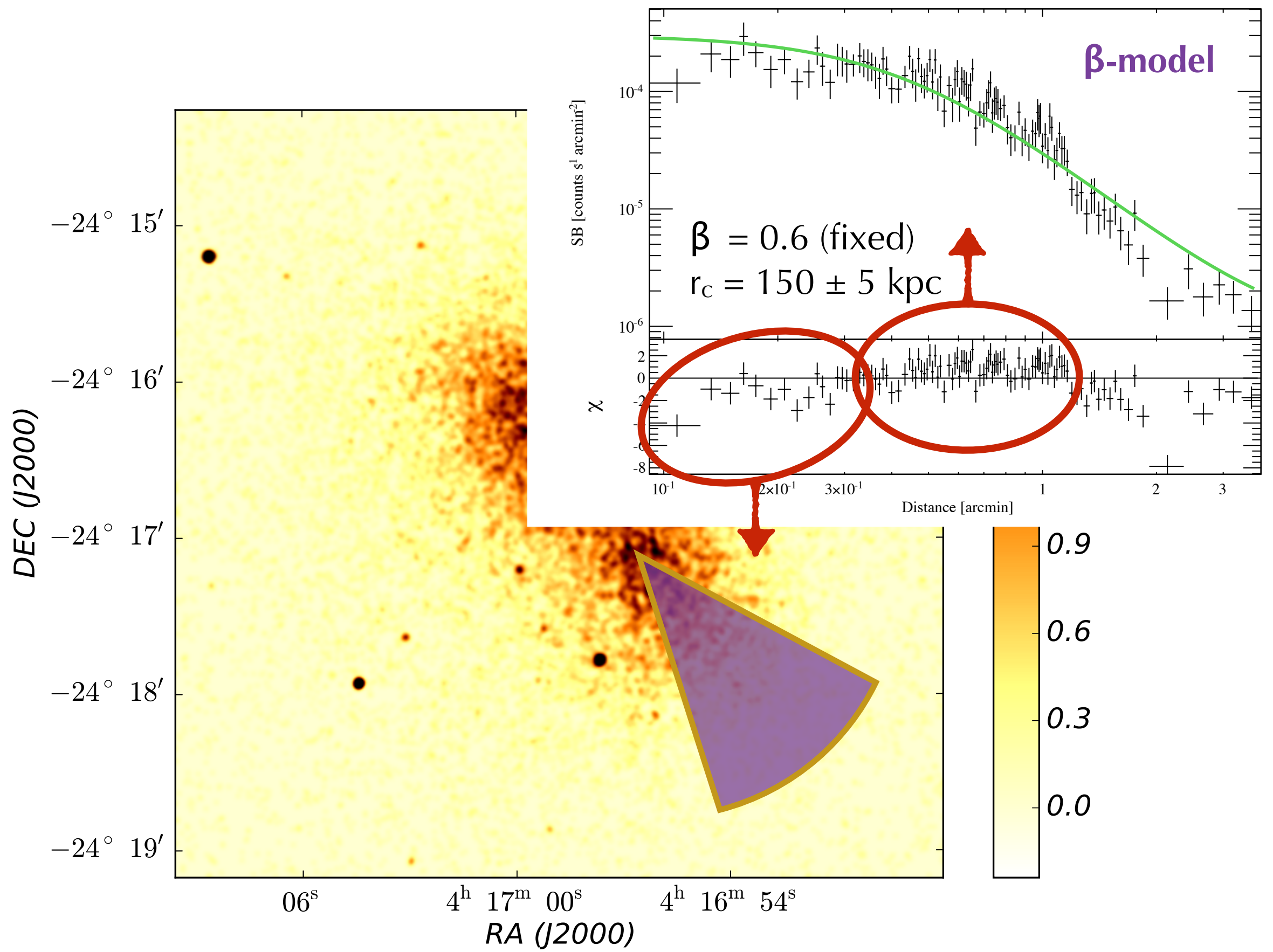
Is C2 a relaxed cluster?

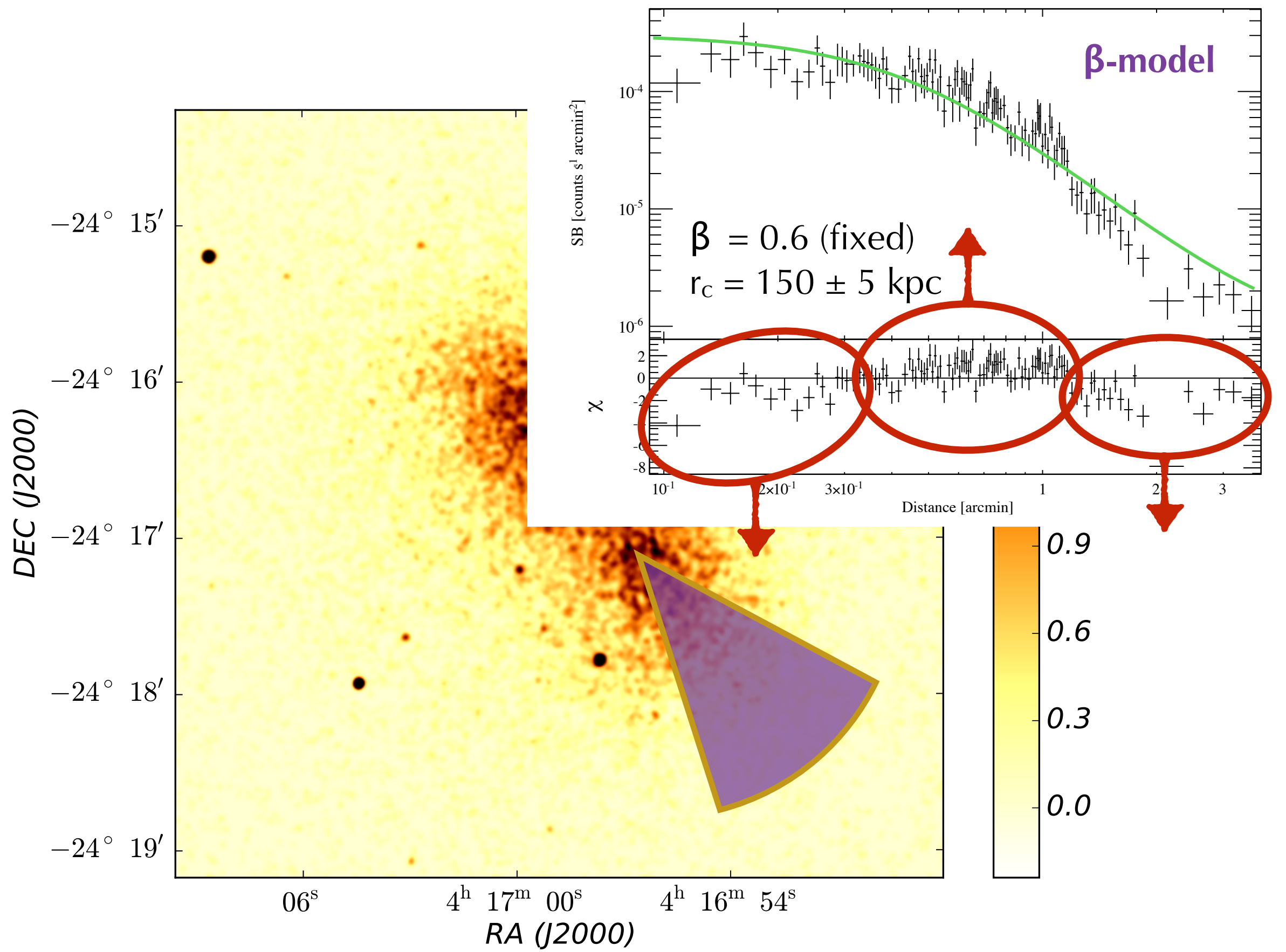


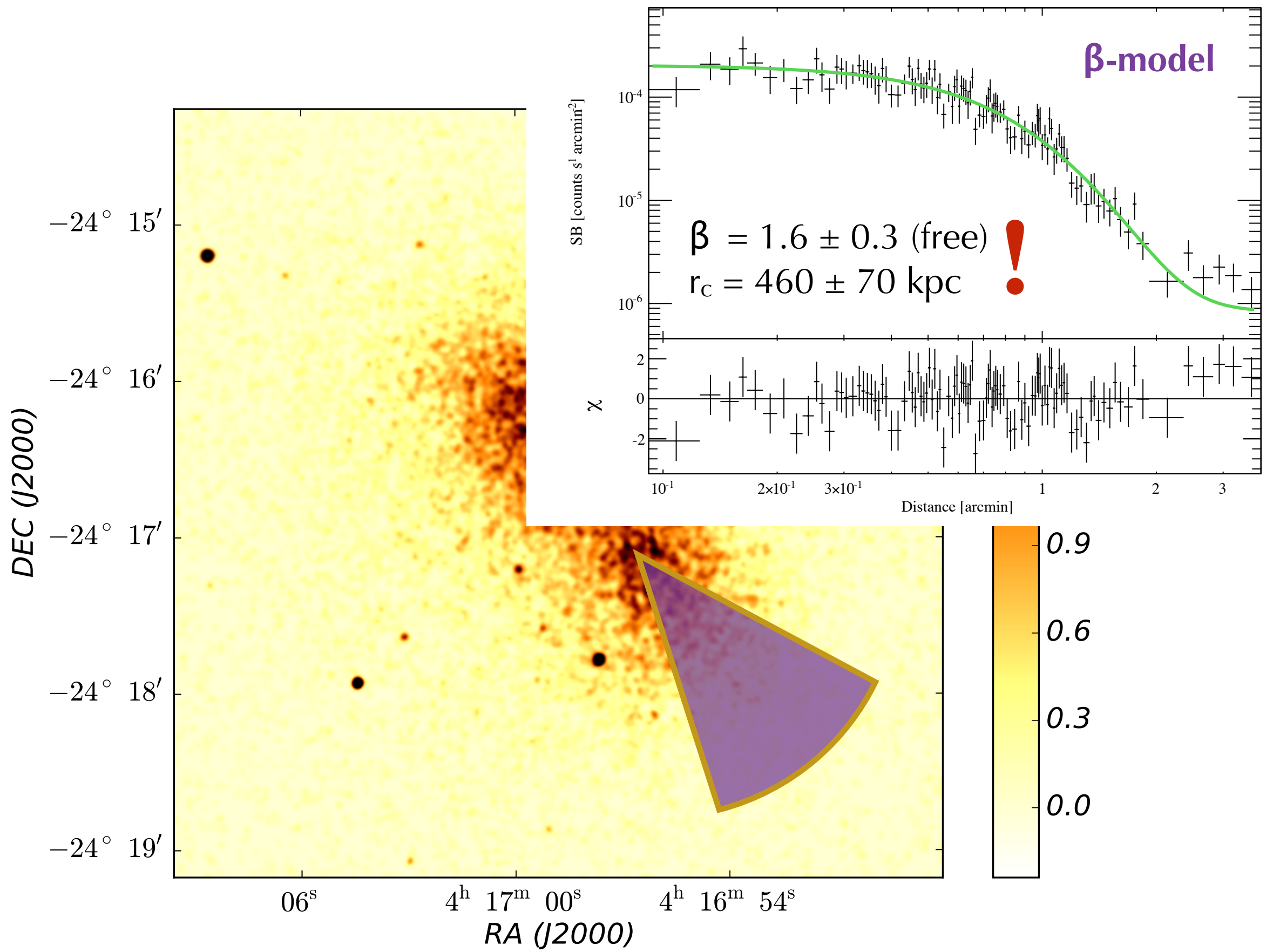


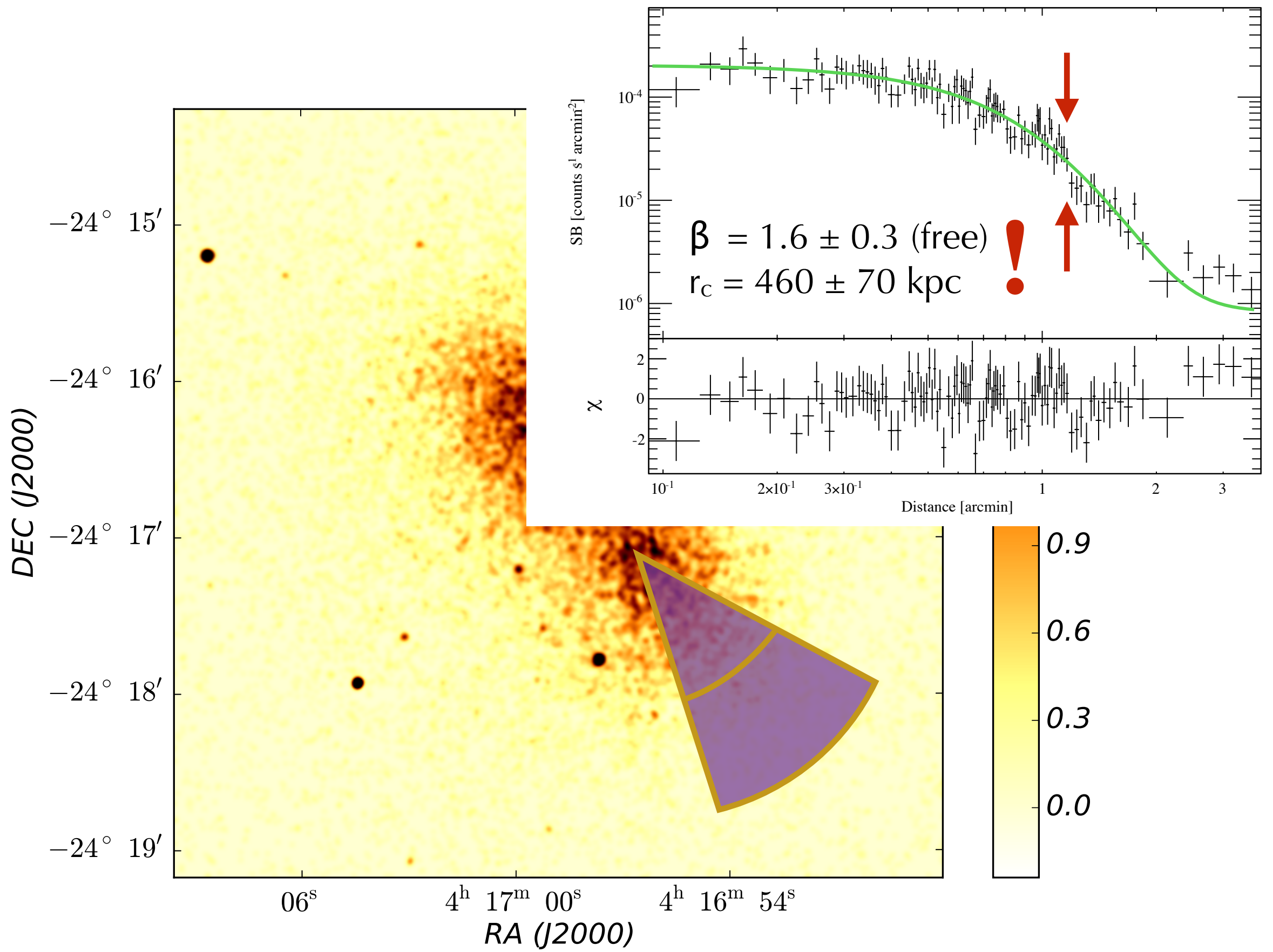


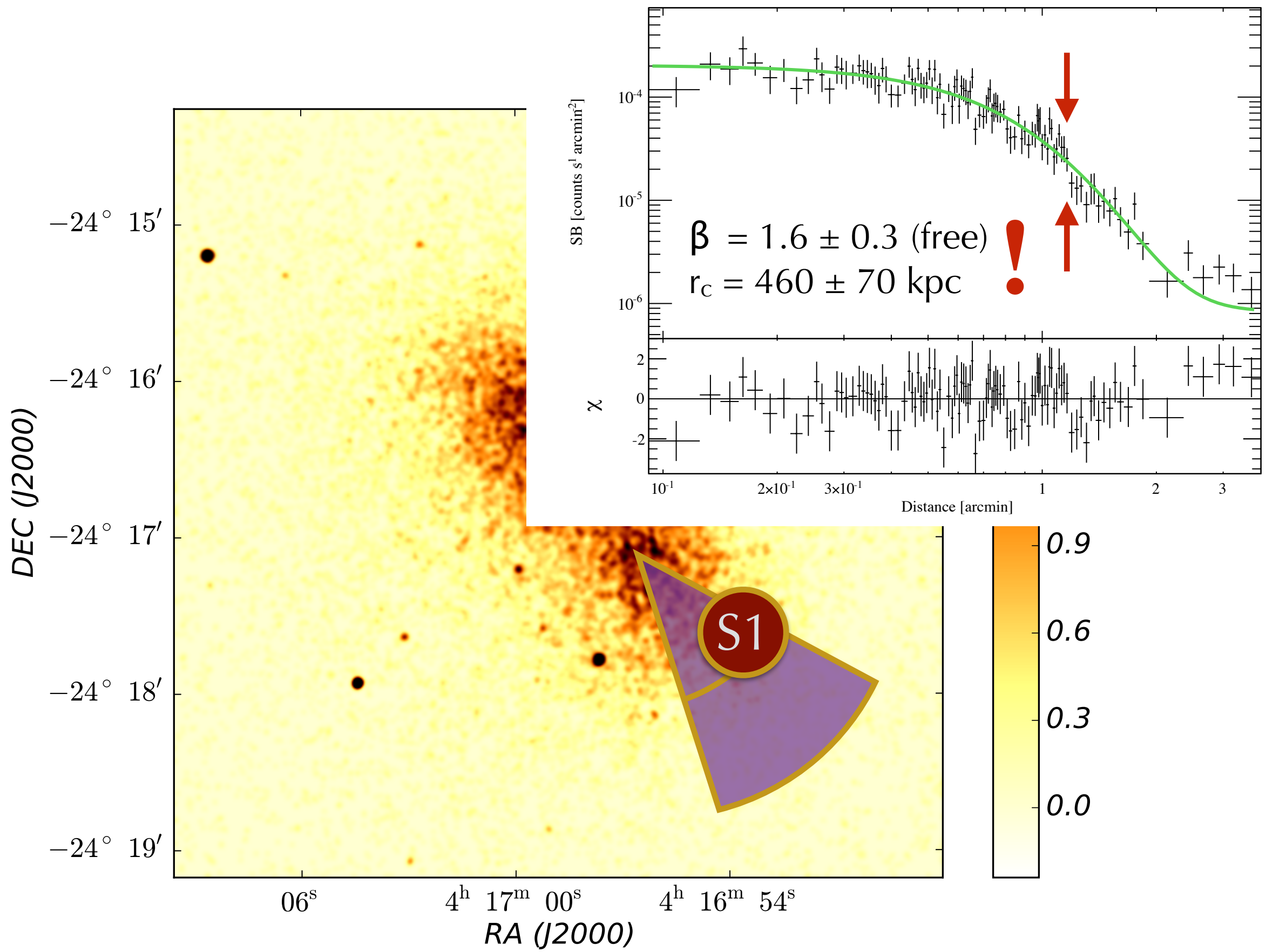




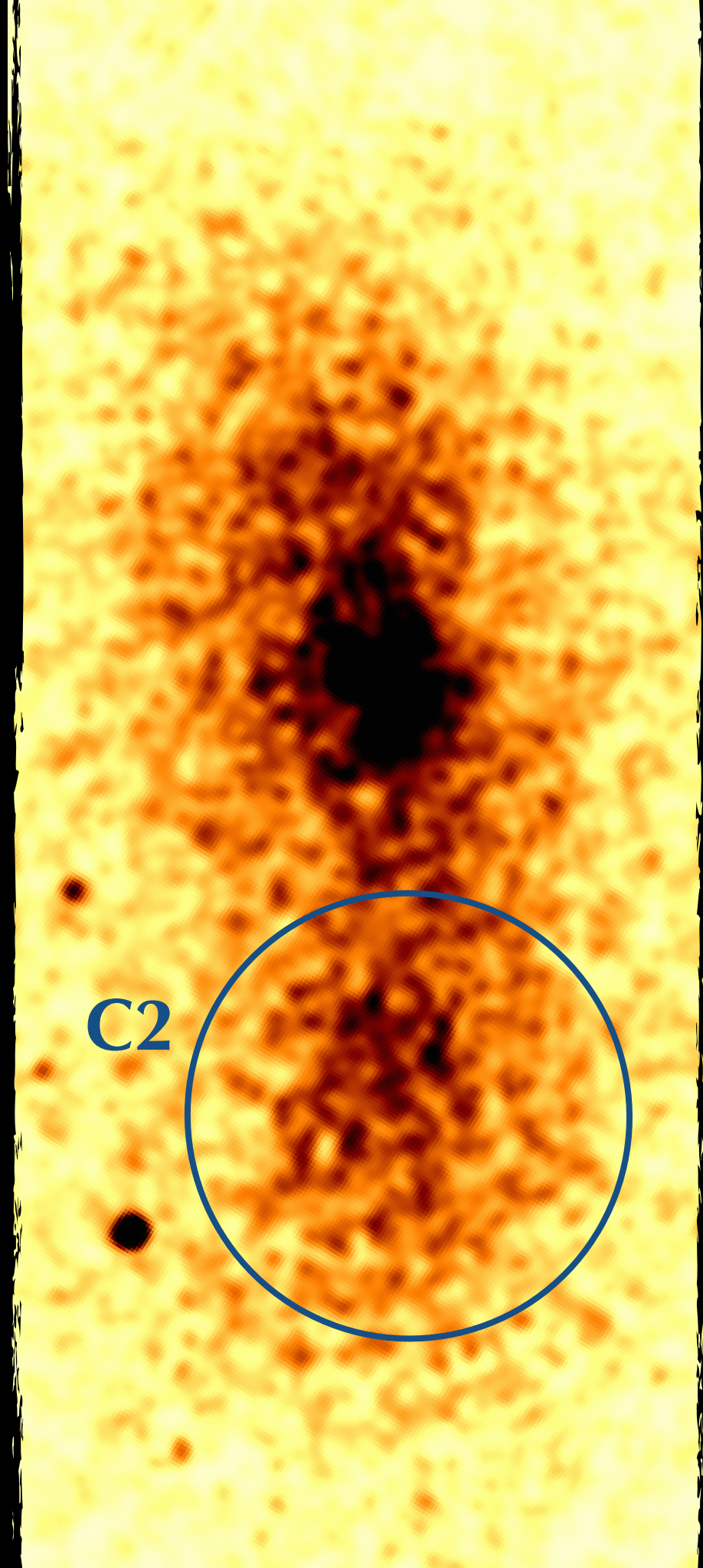








C2 is also undergoing
a merger with a smaller
cluster not immediately
visible in the X-ray map.



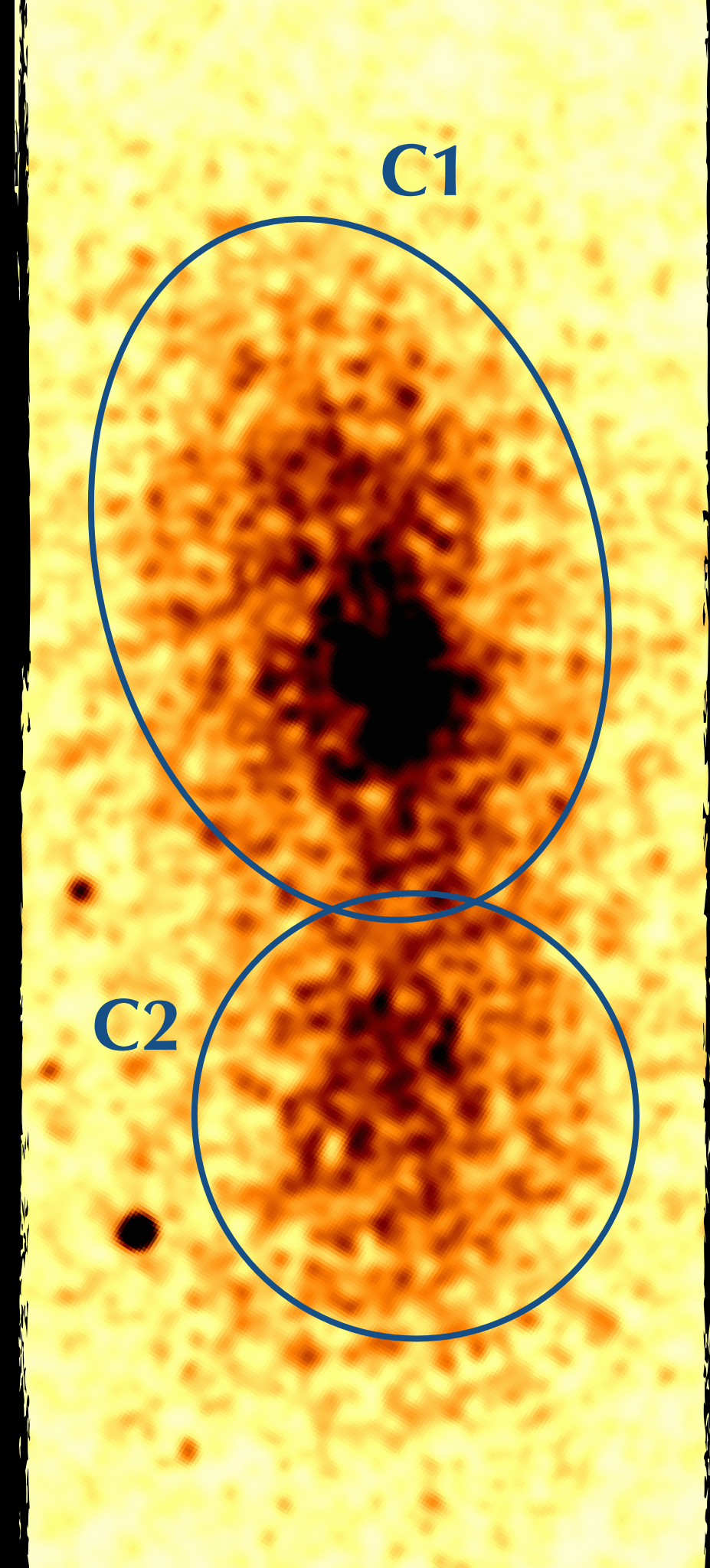
Provisional Summary

C1 is merging

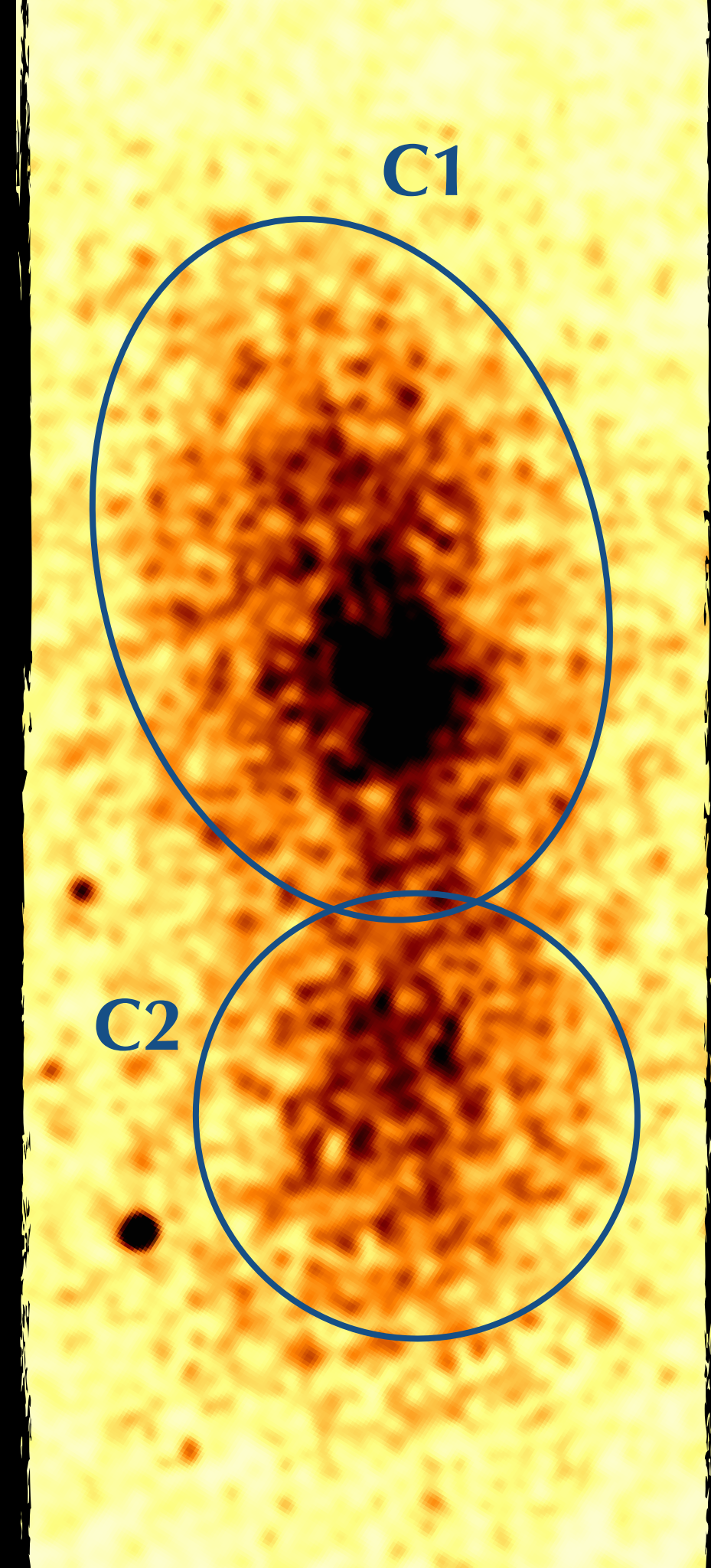
- strongly elongated
- hot core
- high central entropy
- ICM substructure
- C1 = multiple subclusters

C2 is merging

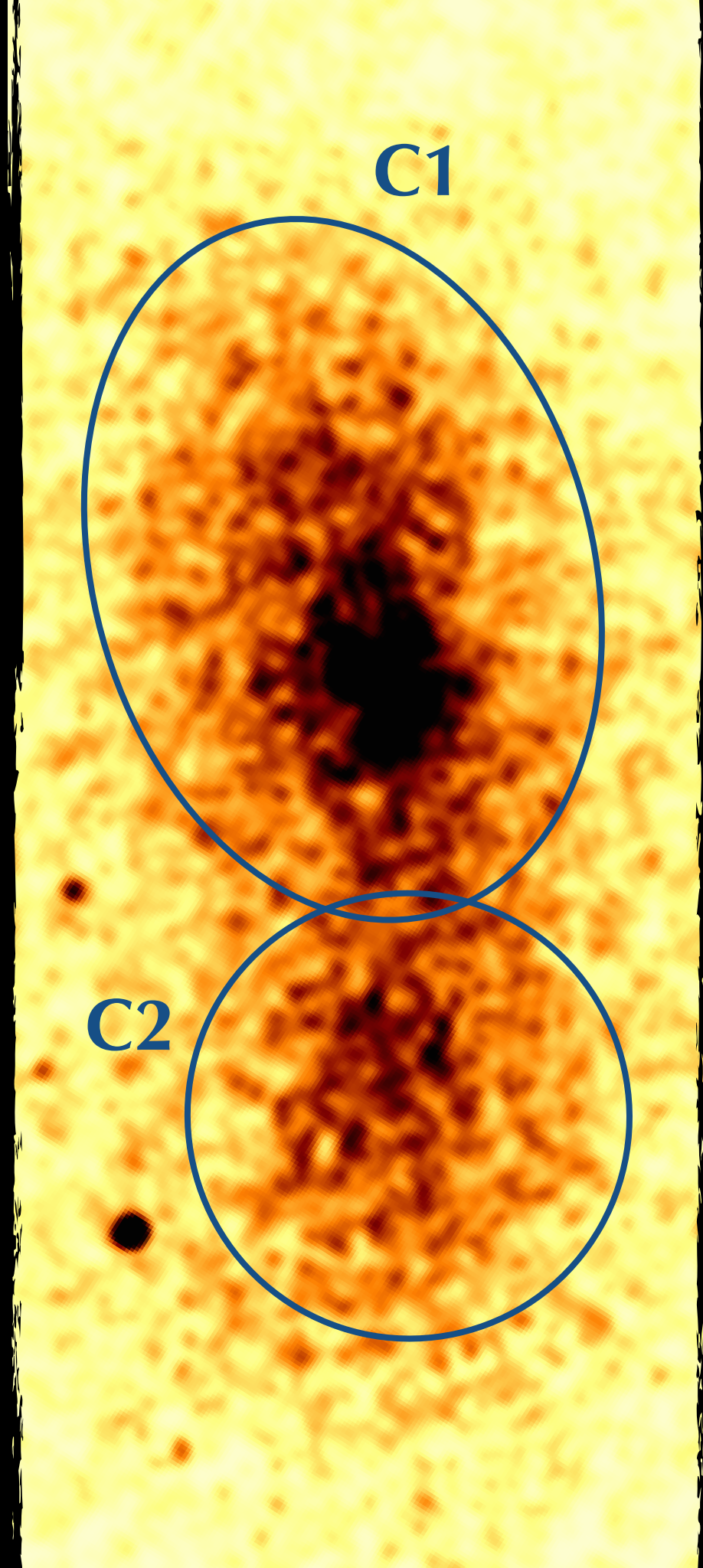
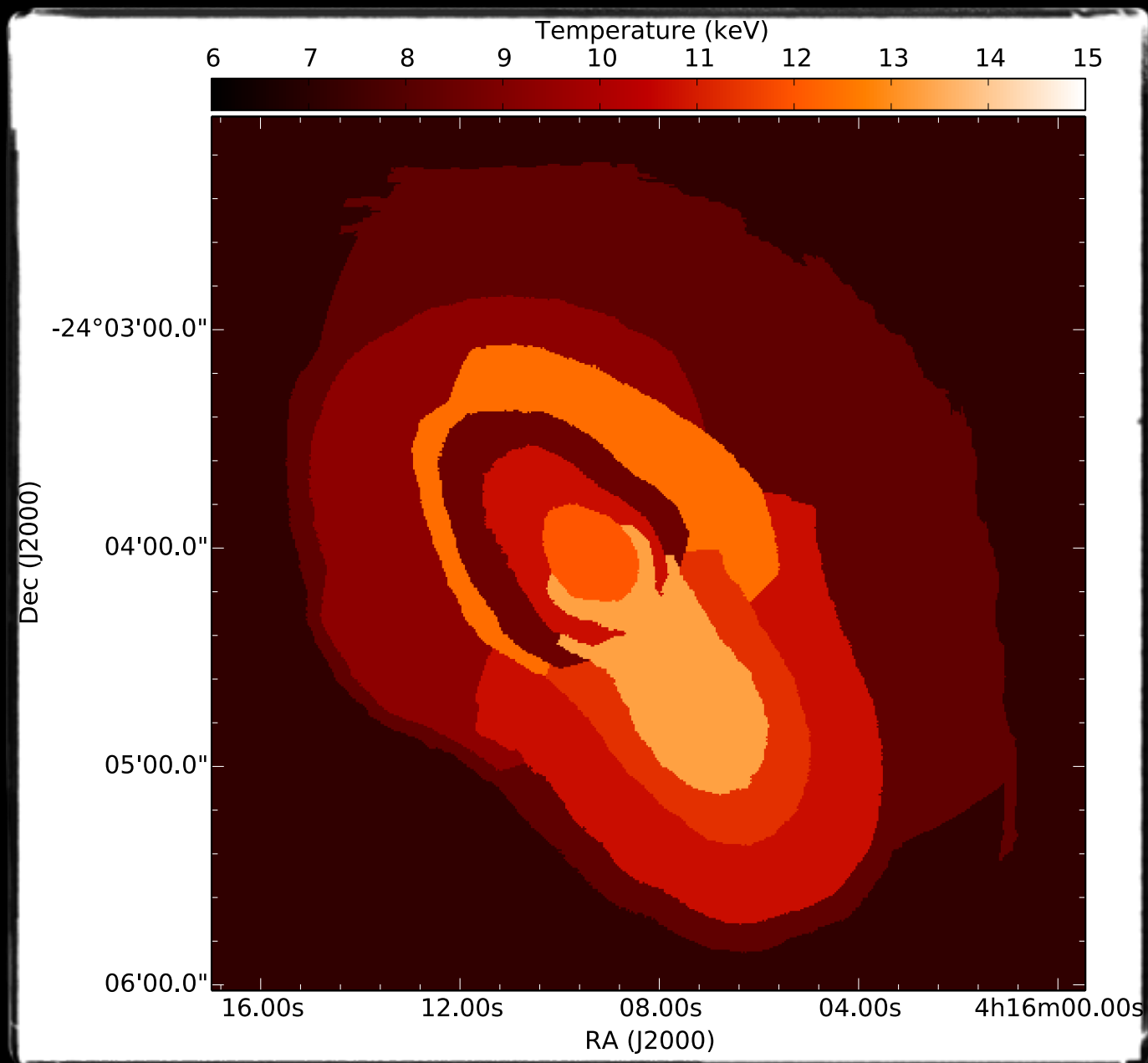
- flat X-ray brightness
- poor/unphysical β -model fit
- density discontinuity in the ICM



Are C1 and C2
interacting with
each other?



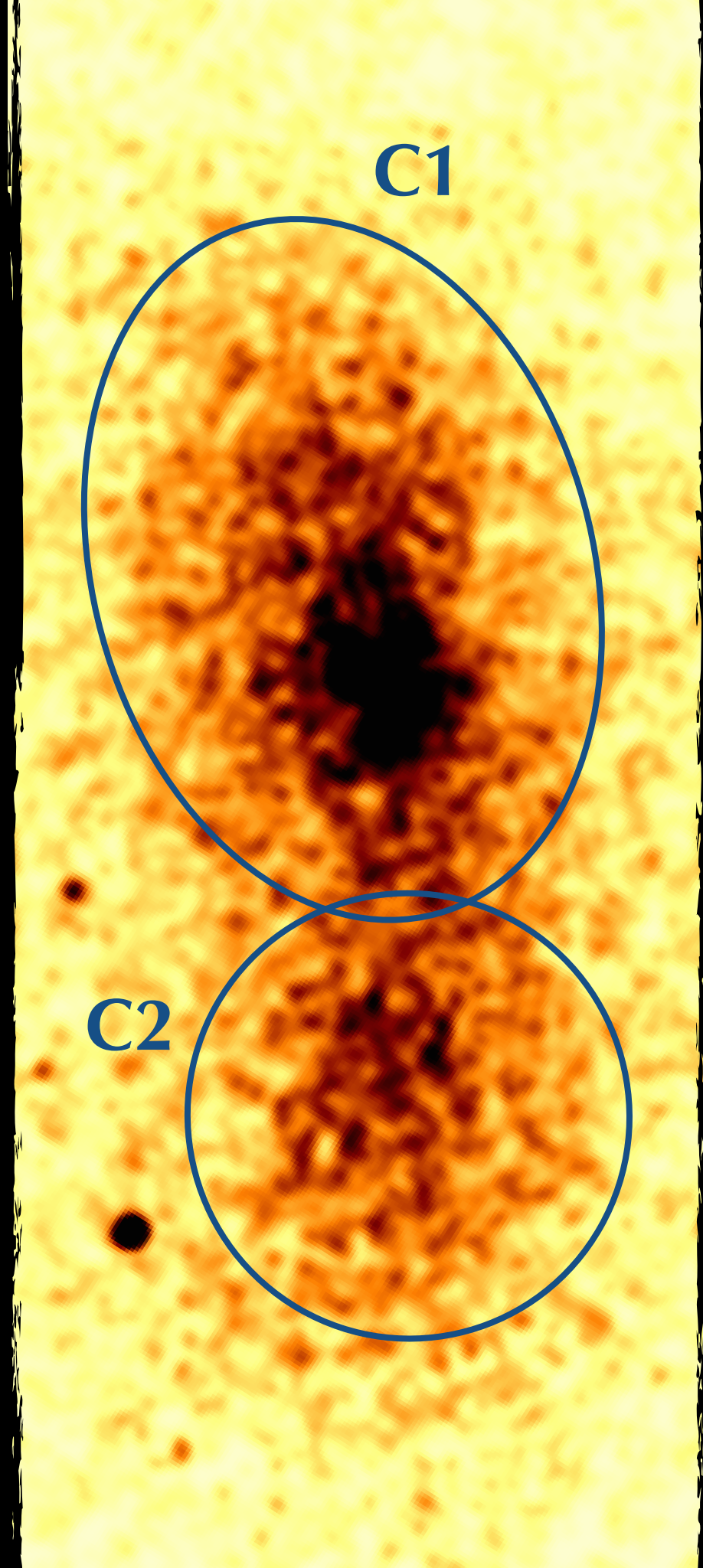
- no clear evidence of typical merger shocks



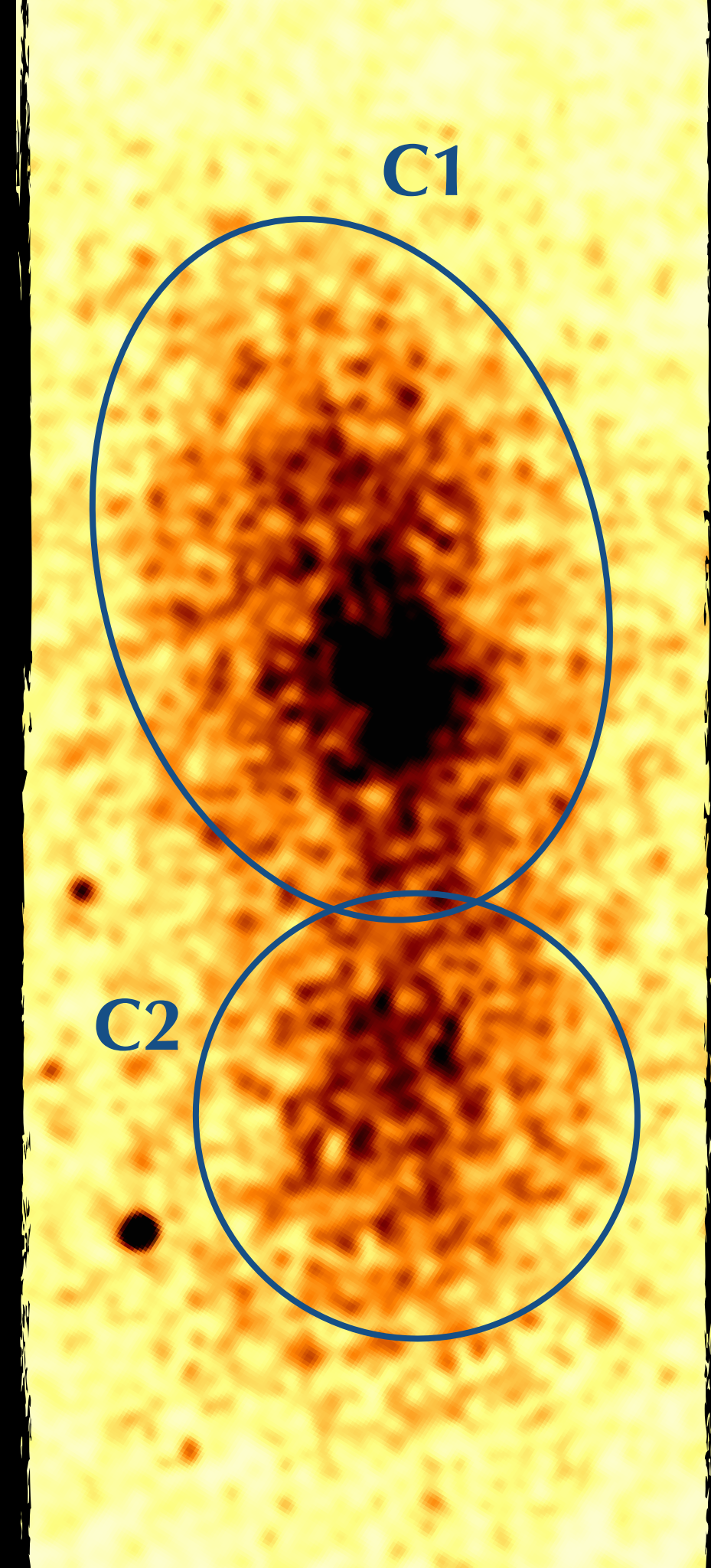
- no clear evidence of typical merger shocks
- no evidence of diffuse radio emission like, e.g., in the Bullet Cluster or A3667

VLA low resolution

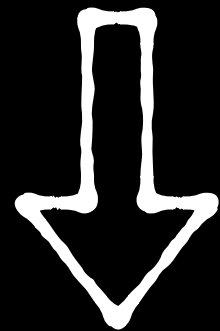
Chandra 0.5-3 keV



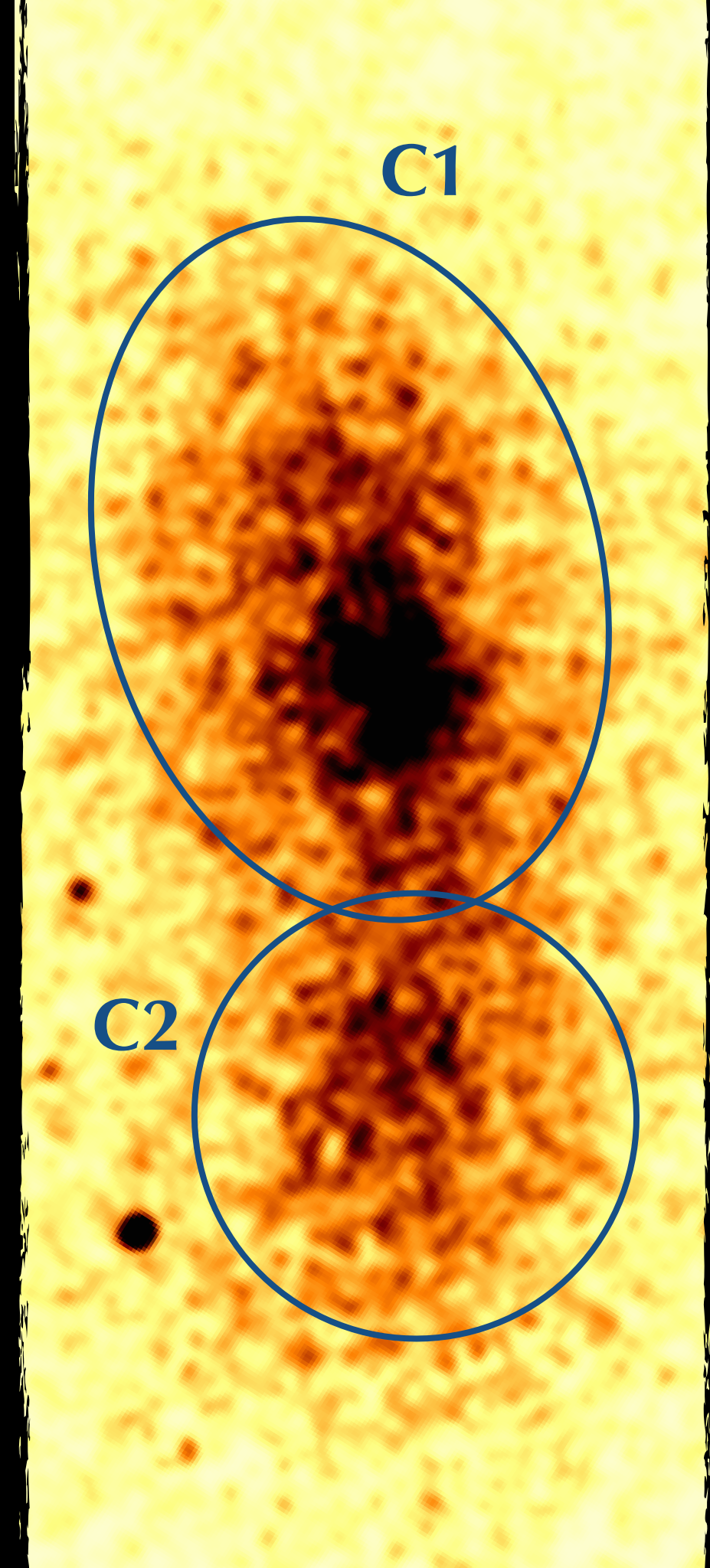
- no clear evidence of typical merger shocks
- no evidence of diffuse radio emission like, e.g., in the Bullet Cluster or A3667
- no large dissociation between the DM and the gas components (Jauzac et al. 2014)



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- no evidence of diffuse radio emission like, e.g., in the Bullet Cluster or A3667
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C1 and C2 have not yet merged with each other



Summary

- The HST Frontier cluster MACS J0416.1-2403 is a hot ($T \sim 10$ keV), massive ($M \sim 1e15 M_{\odot}$) merging cluster.
- The main subclusters are interacting with less massive galaxy groups, as evidenced by substructure and weak density discontinuities in the ICM.
- However, *no clear evidence of interaction between the two main subclusters.*
- **Likely scenario:** MACS J0416.1-2403 is a place of active cosmic structure growth. We are witnessing a pre-merging system.

