Hot Gas Halos in Early-Type Galaxies

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Santa Cruz Galaxy Workshop

August 17, 2010

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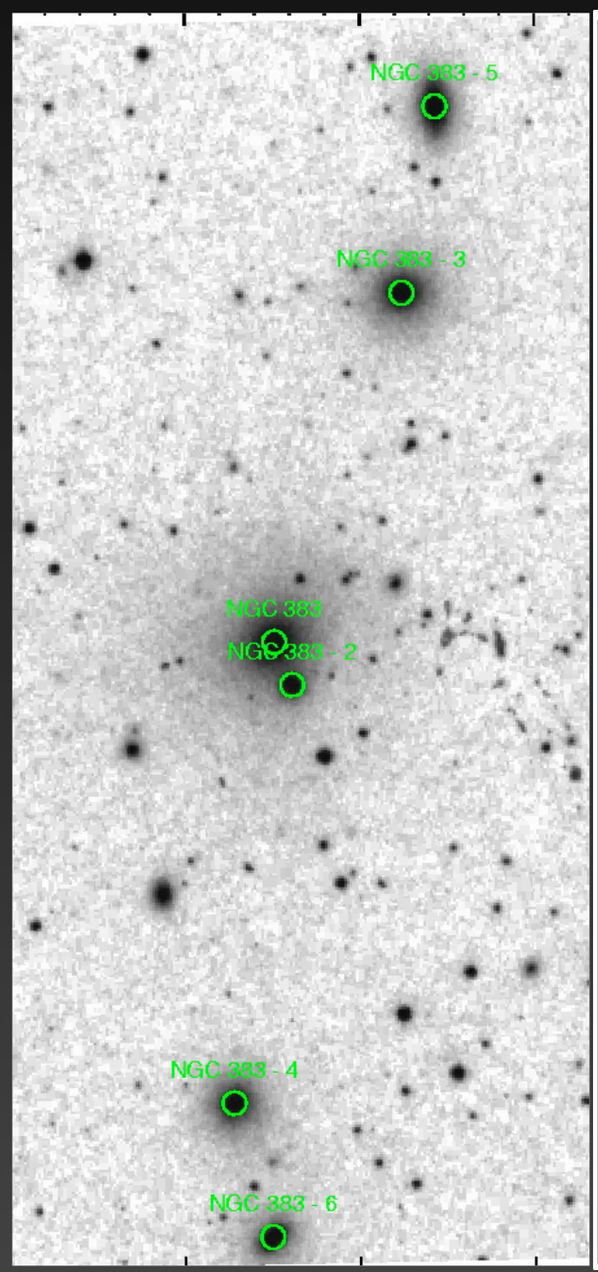
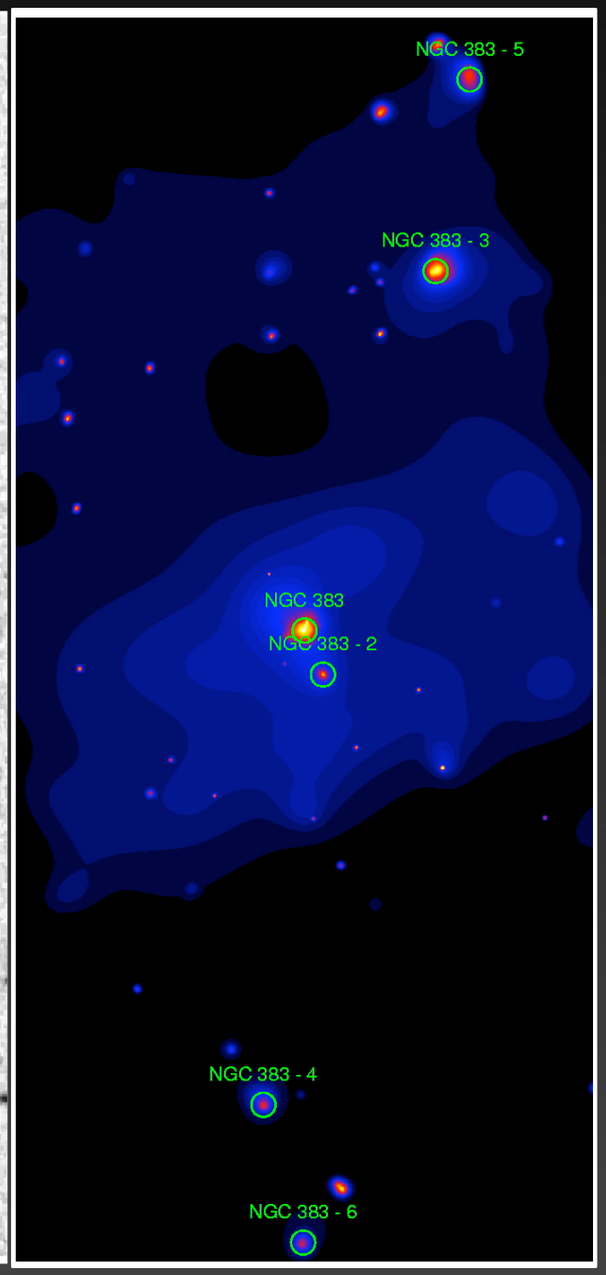
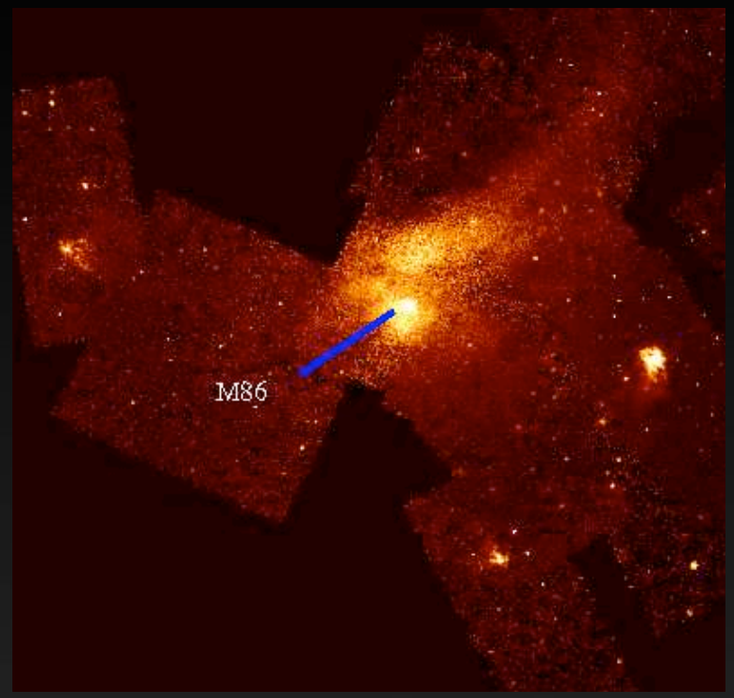
- Stripping of hot gas:
  - can quench star formation through strangulation (important for semi-analytic models of galaxy evolution)
  - may contribute to the enrichment of the ICM
  - may explain the large scatter in the scaling relations between X-ray and optical/near-IR luminosity

Hot Gas Stripping?

- Examples of X-ray tails are observed







Randall et al. 2008

- However,
  - ROSAT: no trend in L_X/L_K with environment (Ellis & O'Sullivan 2006)
  - Chandra: X-ray halos found in bright group and cluster galaxies (Jeltema et al. 2008, Sun et al. 2007)

Hot Halos in Different Environments

Early-Type Galaxies in Groups:

- 13 groups from the Chandra archive with $0.0085 < z < 0.035$
- Selected satellite galaxies (no BCGs) with $L_K > 10^{10.45}\ L_{K\odot}$

(Jeltema, Binder, & Mulchaey 2008)

Early-Type Field Galaxies:

- 23 isolated early-type galaxies observed with Chandra and XMM with $z < 0.03$ and similar range of L_K

(Mulchaey & Jeltema 2010)

Cluster galaxies from Sun et al. 2007

Data Analysis

- Search for extended X-ray emission

- Search for thermal emission

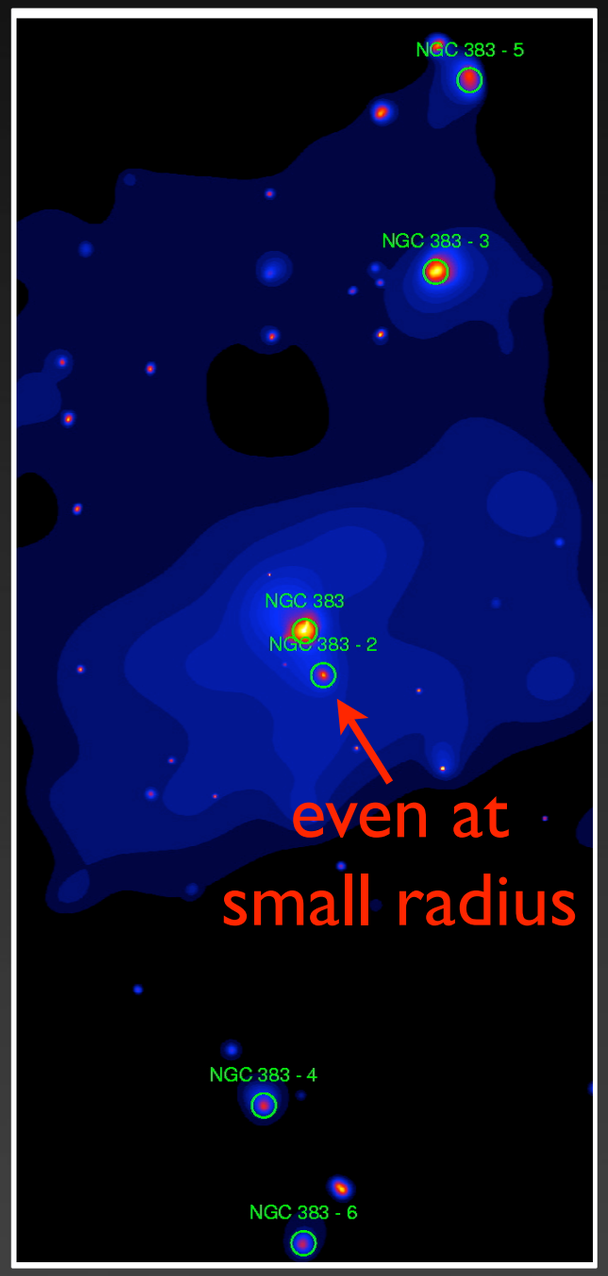
  - spectrum modeled as a combination of thermal gas and a power law for X-ray binaries/AGN contribution

- Derive upper limits on thermal emission for undetected galaxies and those consistent with having no thermal component

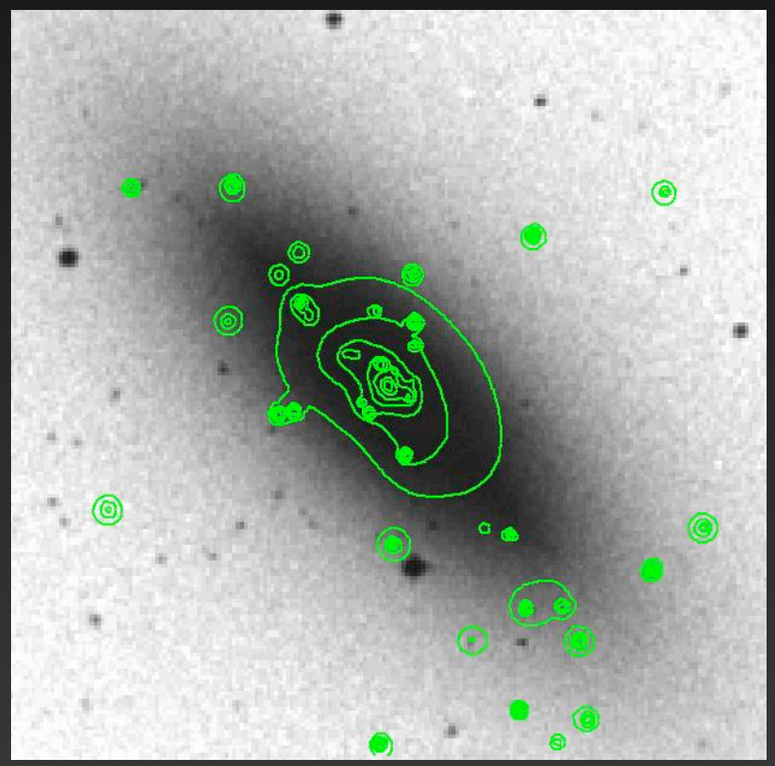
Example X-ray Halos

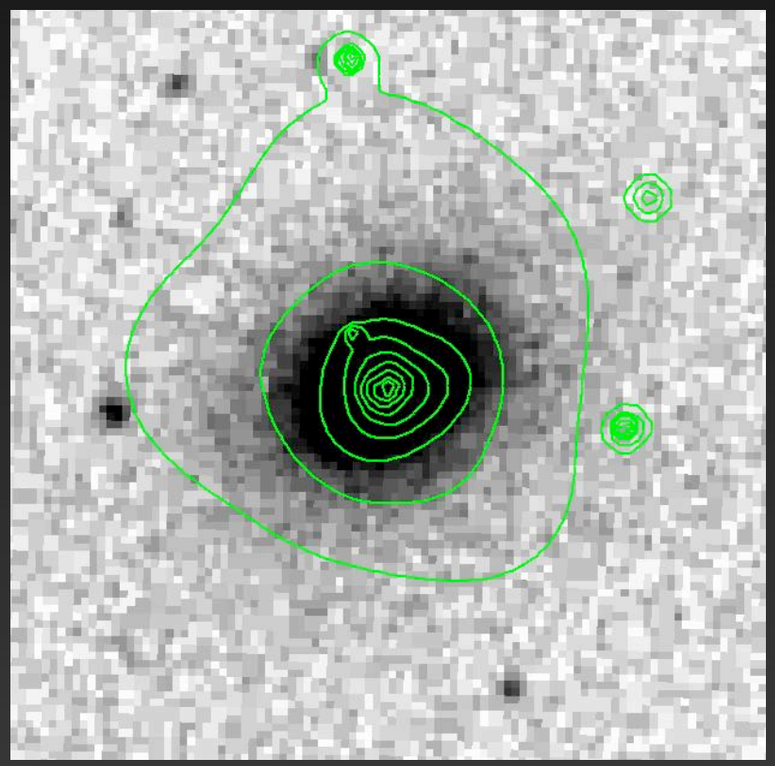
Extended, thermal X-ray emission detected around bright early-type galaxies in all environments.

NGC383 Group

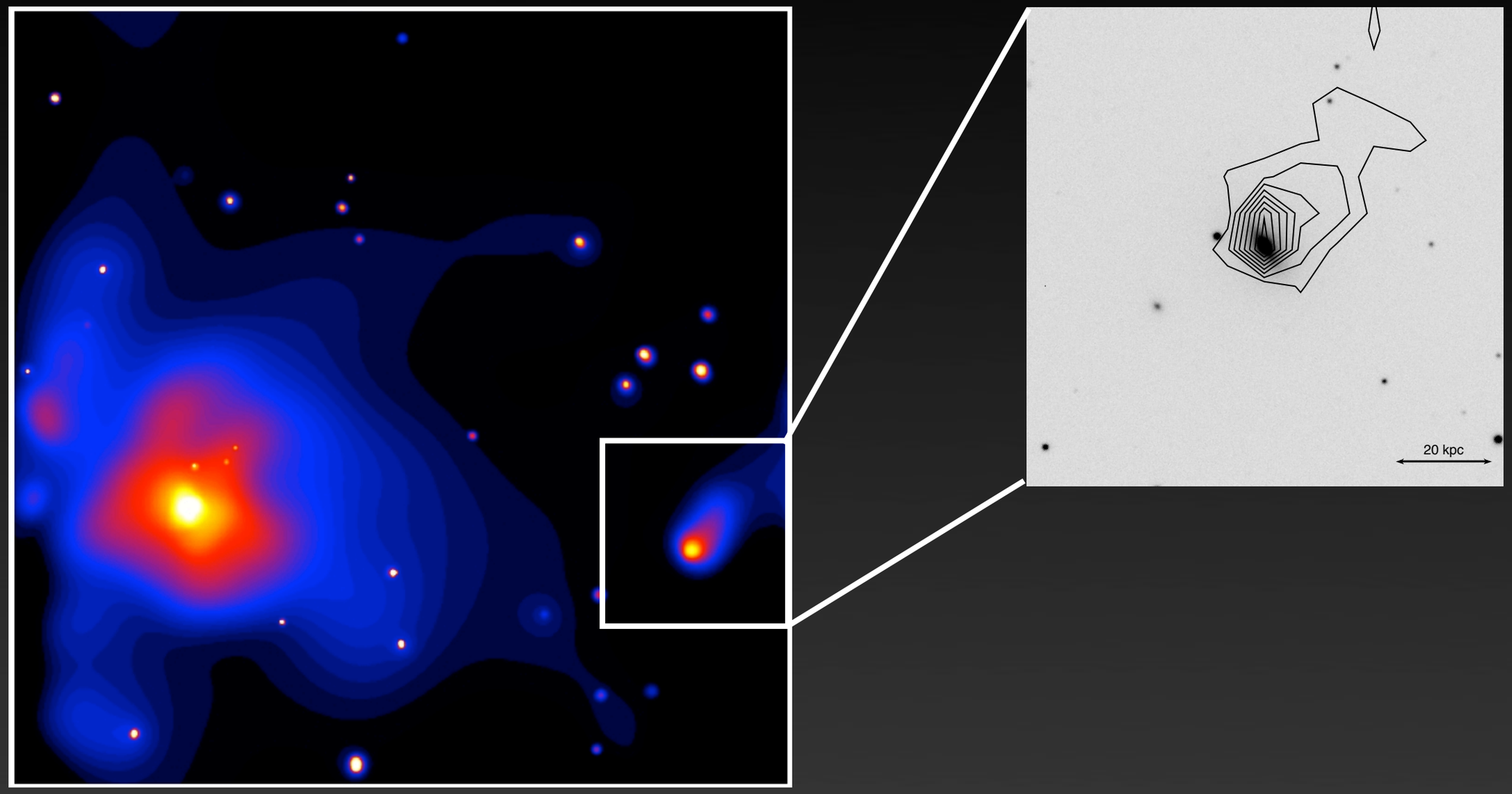


Isolated Galaxies



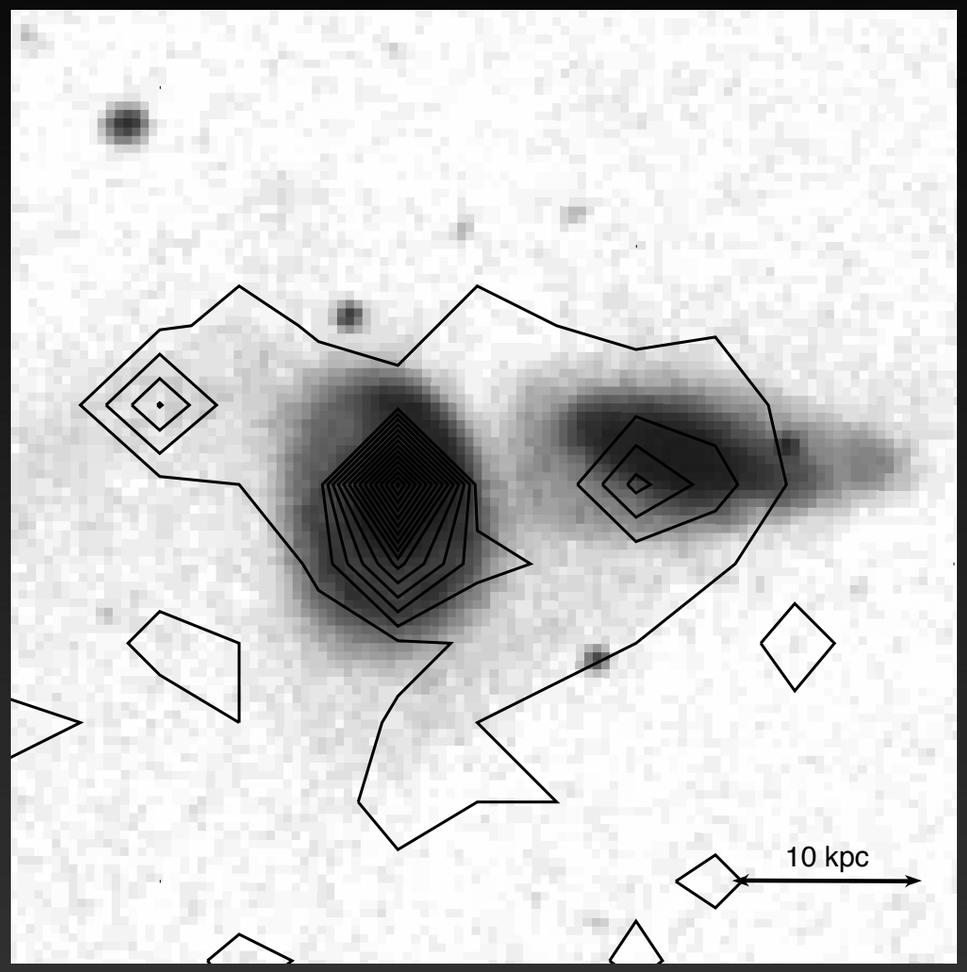


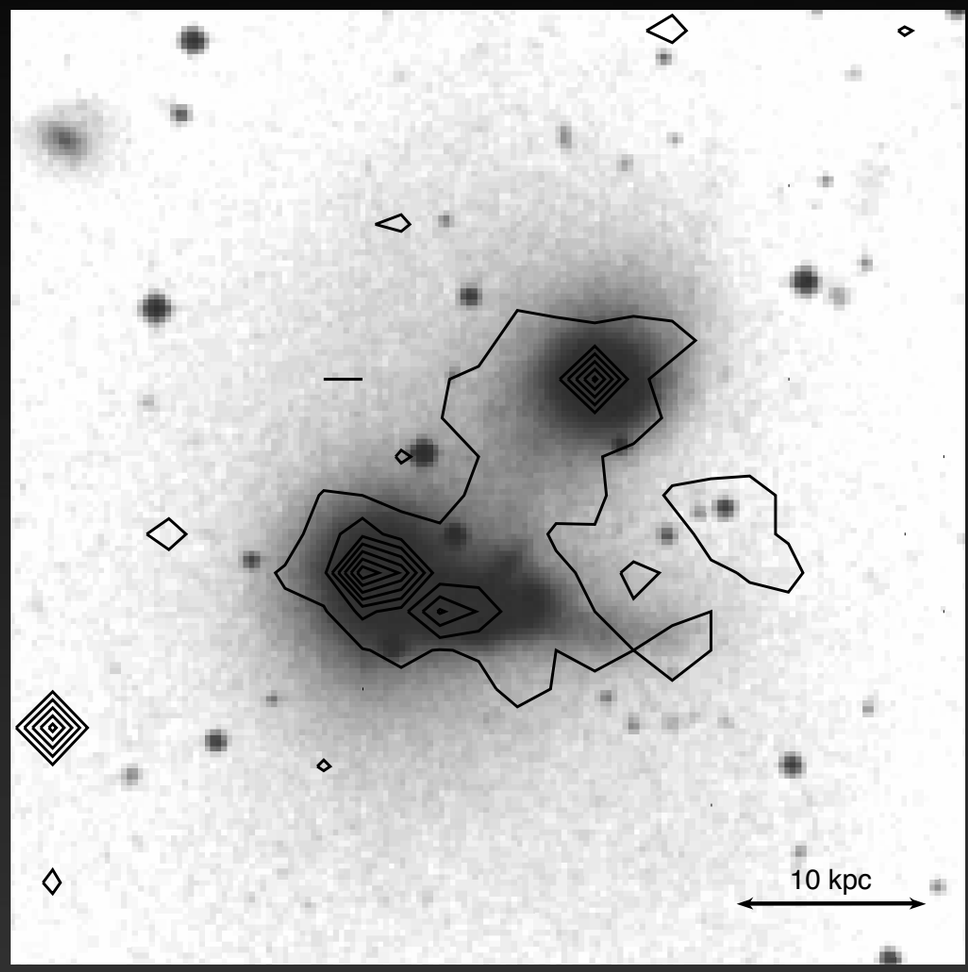
X-ray Tails: Evidence of Stripping



- We detect a ~50 kpc X-ray tail from an S0 galaxy falling in to the X-ray bright group NGC 6269.
(only 2% of L^* galaxies)

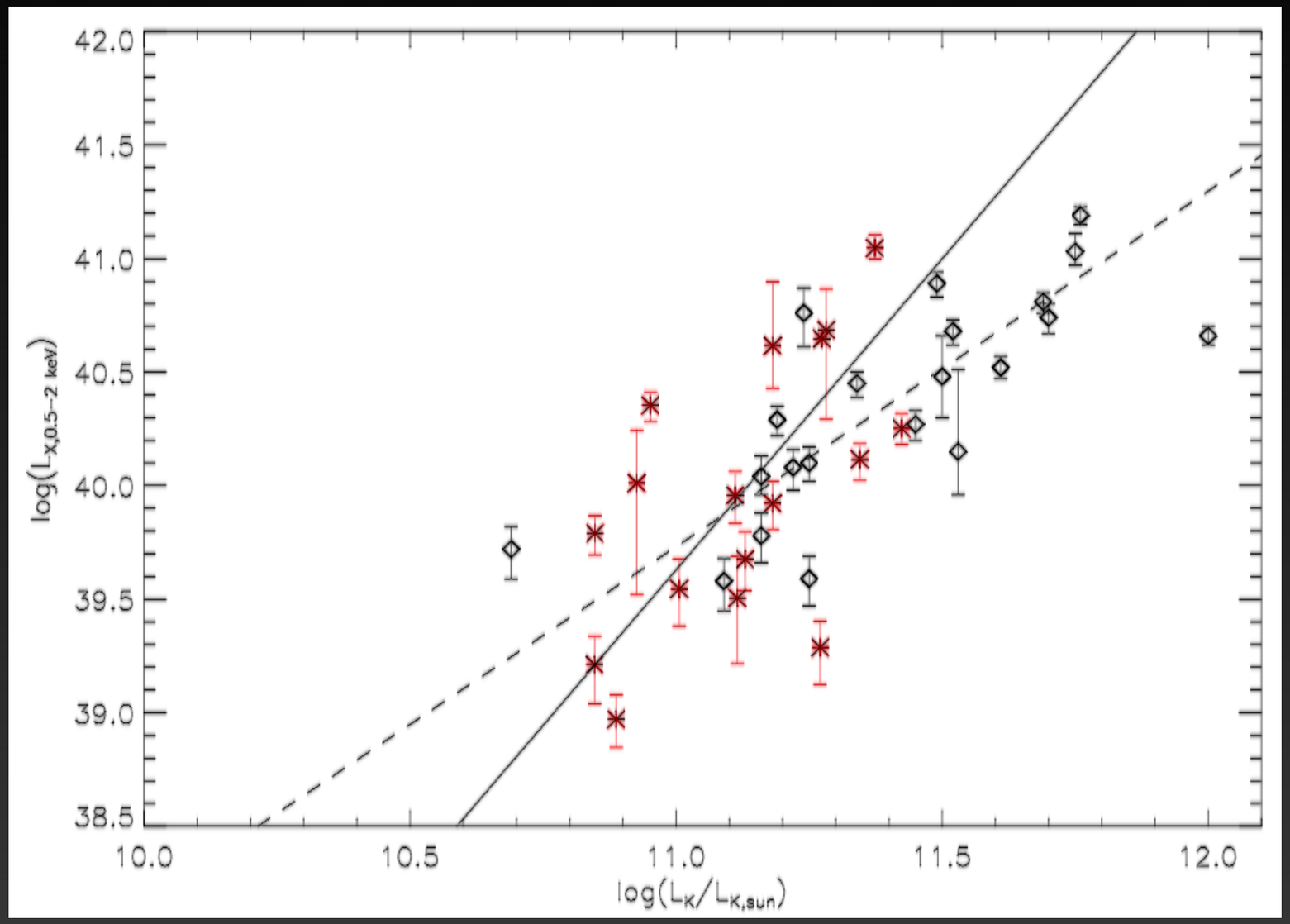
Galaxy-Galaxy Mergers in X-rays





- Galaxy-galaxy mergers in two HCGs show diffuse X-ray emission tracing tidal features in the optical.

Cluster and Group Galaxies



Early-type galaxies with extended X-ray emission

∗ group gals

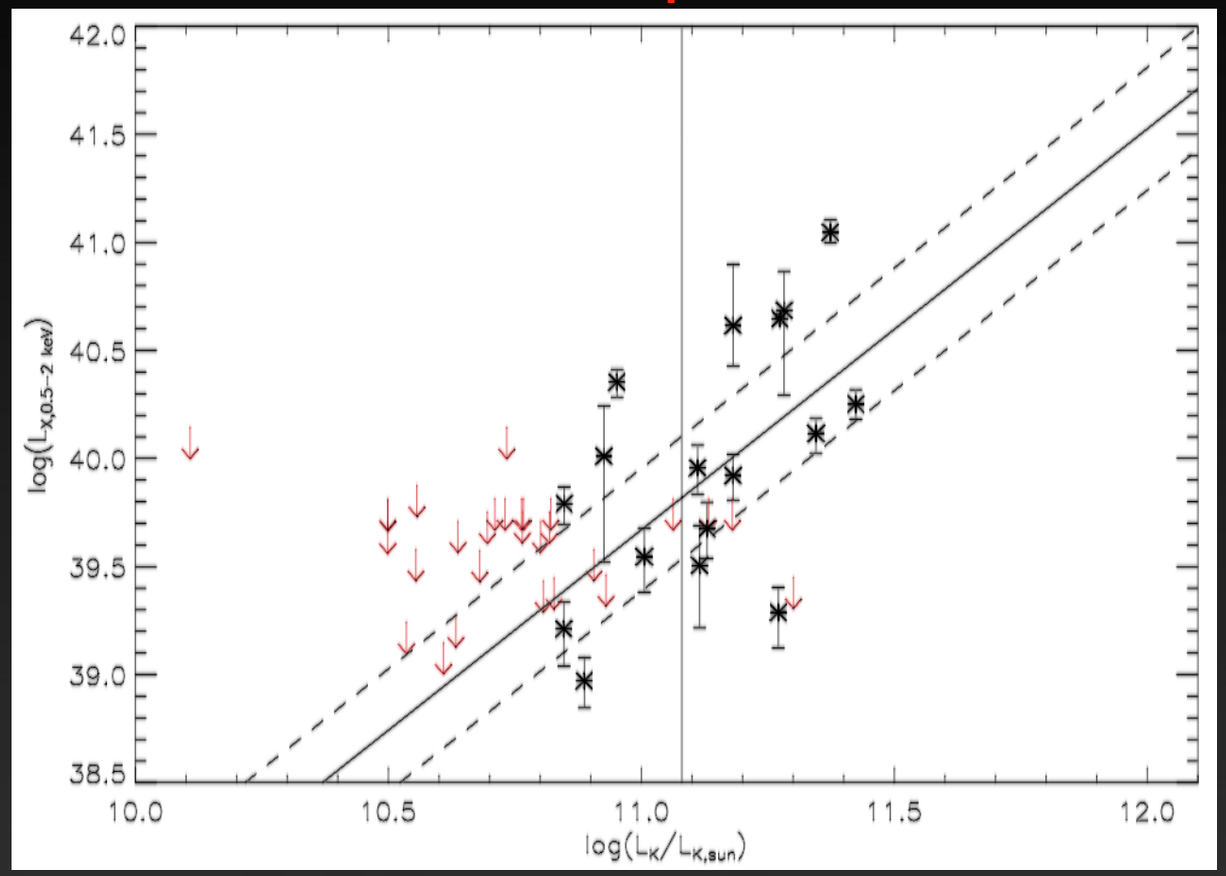
◇ cluster gals (Sun et al. 2007)

- L_X - L_K relation a bit steeper for groups than clusters but consistent within the errors

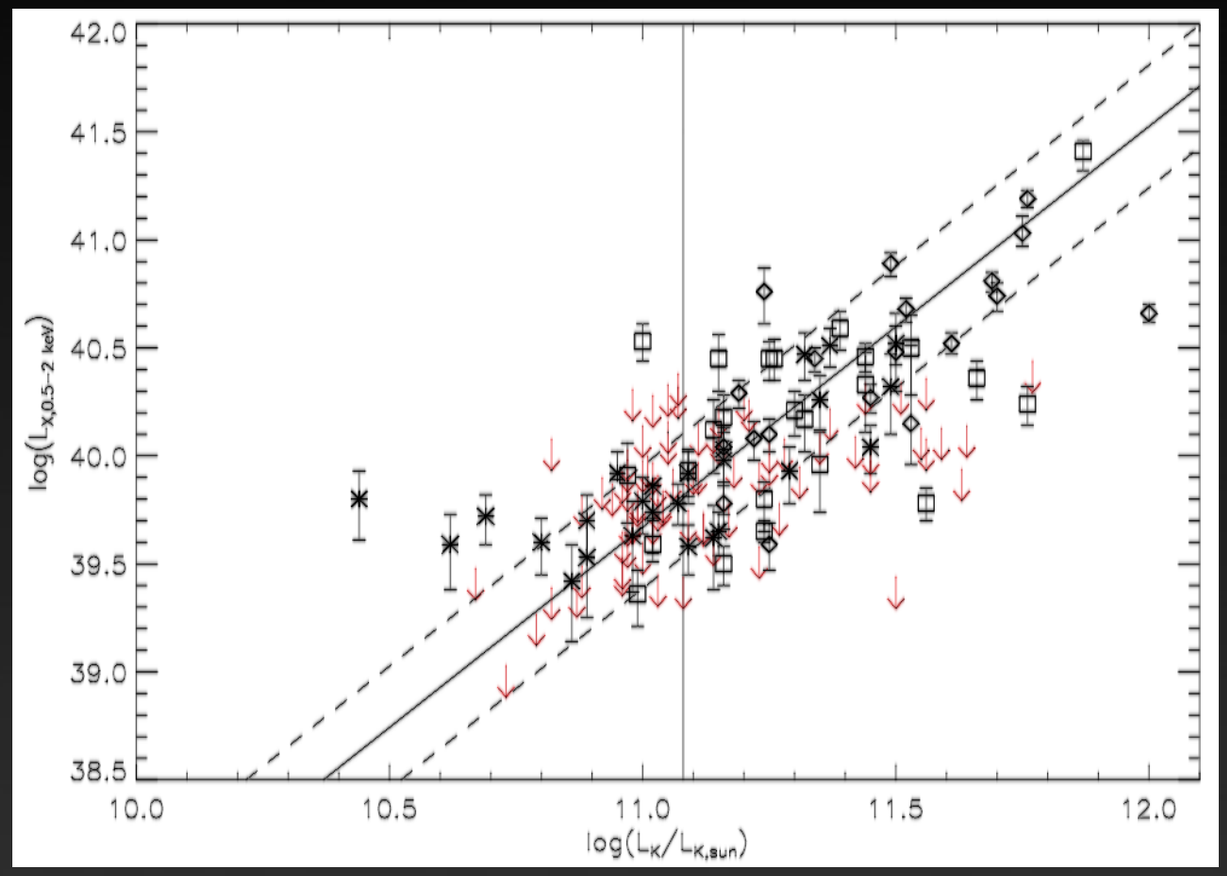
Jeltema, Binder, & Mulchaey 2008

Detection Rate

Groups



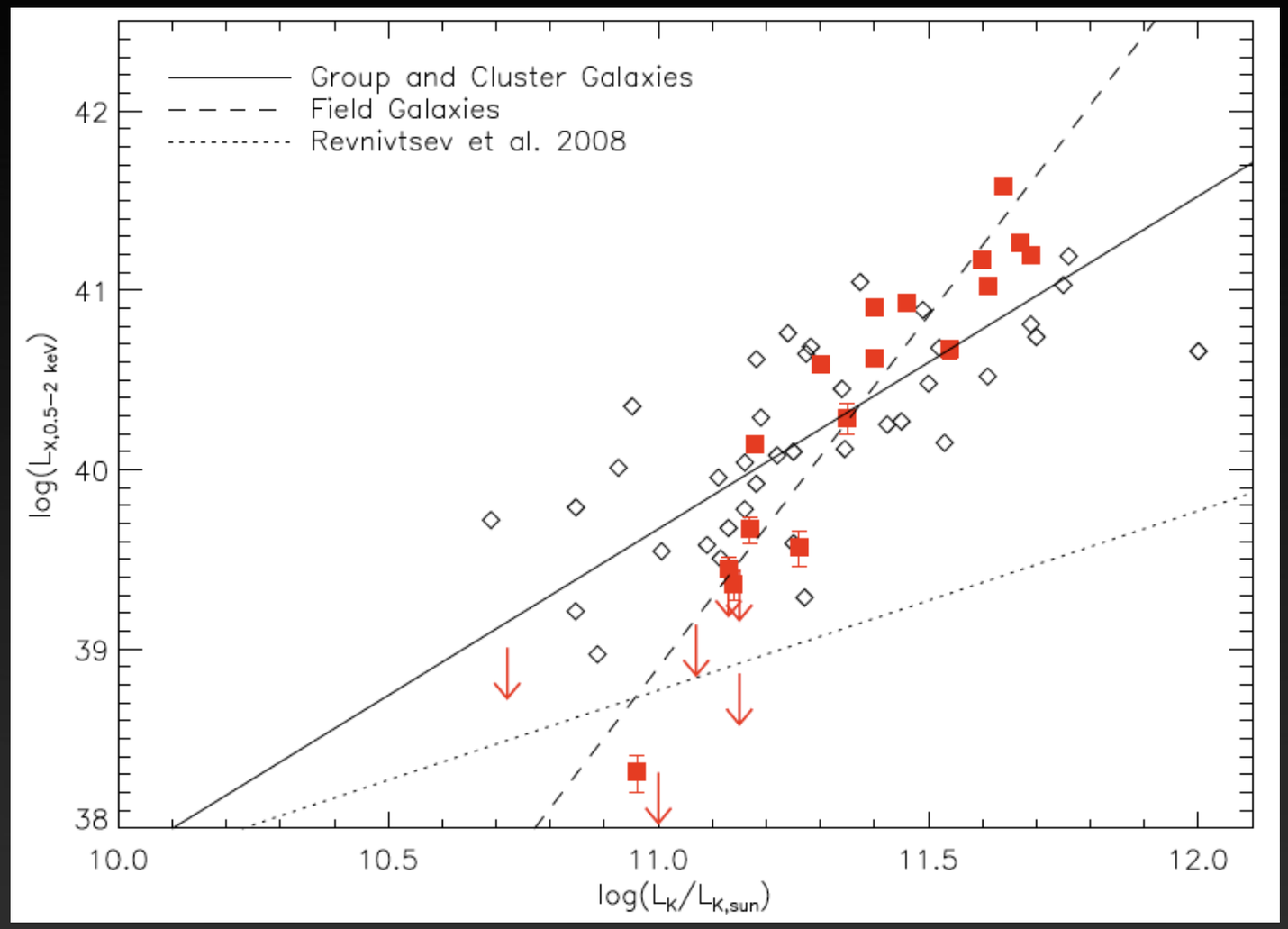
Clusters



- Detect 80% of L^* galaxies in groups vs. 43% in clusters
- Even considering the errors there are more non-detections in clusters.

Jeltema, Binder, & Mulchaey 2008

Early-Type Field Galaxies



* field gals

◇ group + cluster gals

- At high L_K, field galaxies have similar or brighter X-ray halos to cluster and group galaxies.
- At $L_K < L^*$, field galaxies are less luminous and mostly undetected.

Mulchaey & Jeltema 2010

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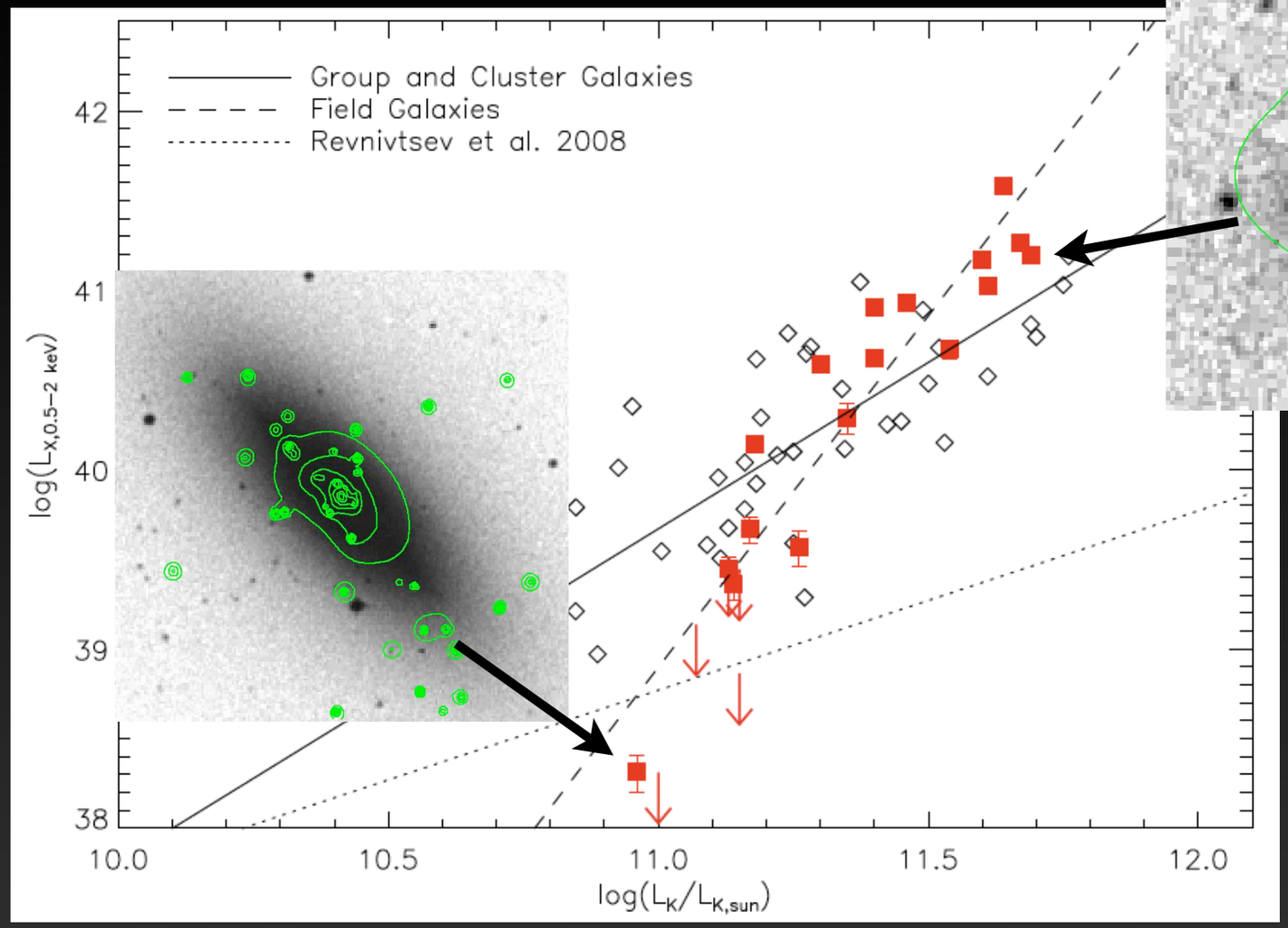

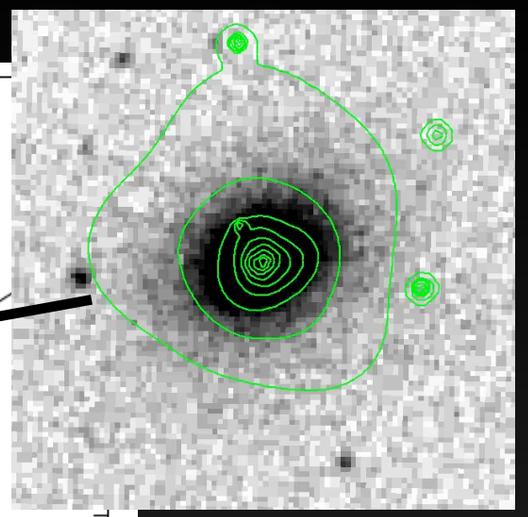

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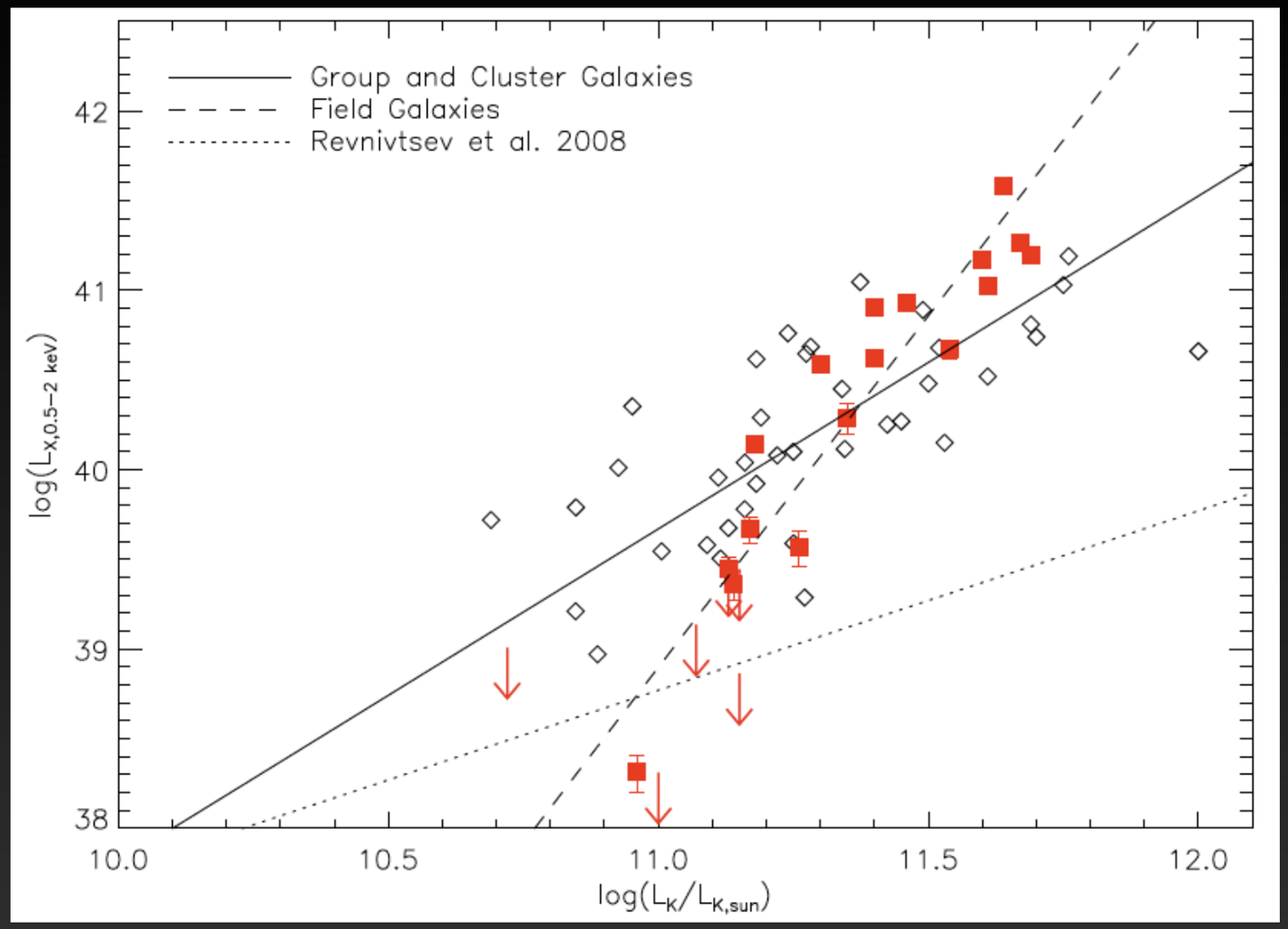

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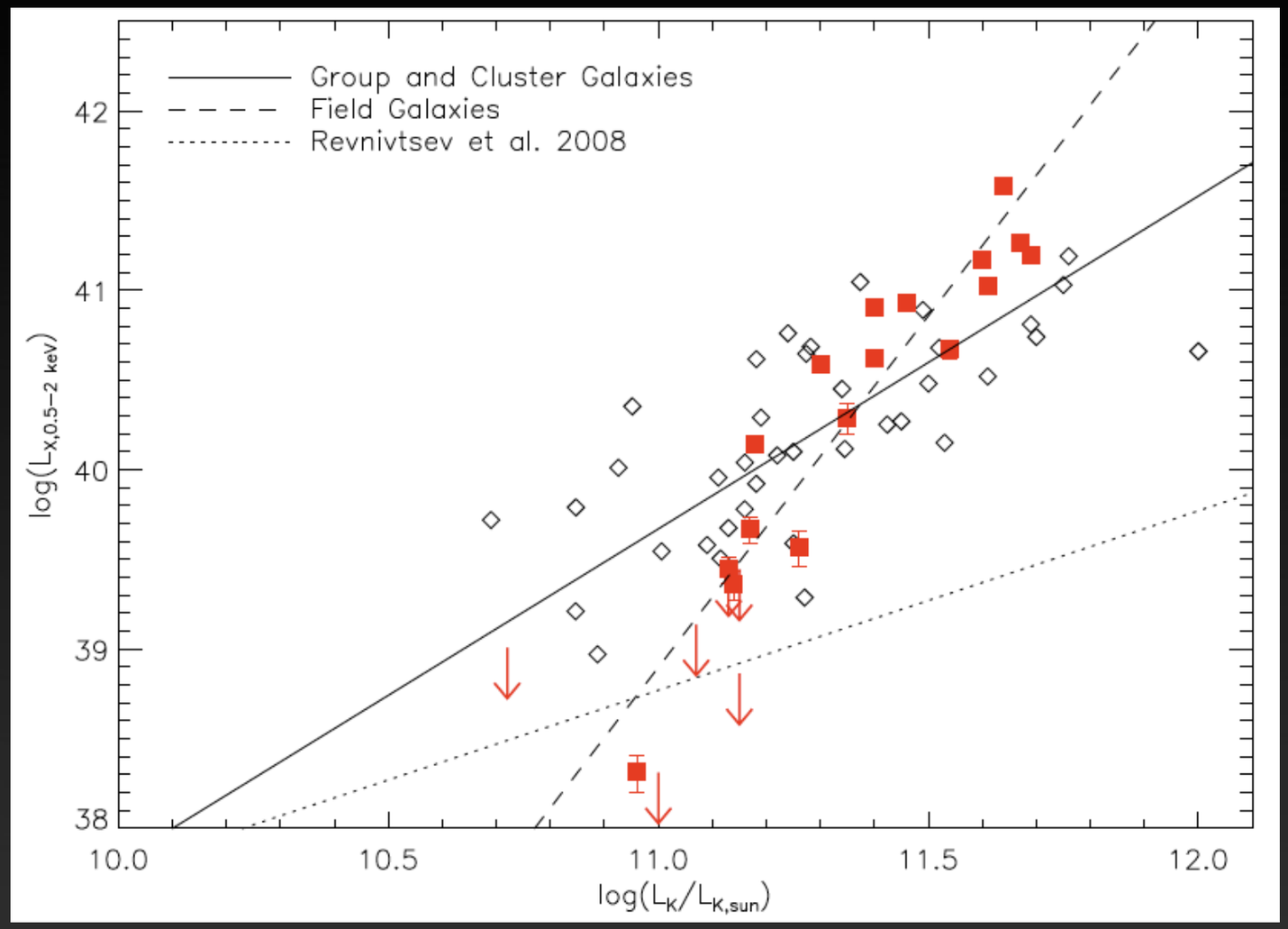

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➡ SN or AGN expell gas from smaller field galaxies while ICM confines gas in group/cluster galaxies? Or accretion from the ICM?

Mulchaey & Jeltema 2010

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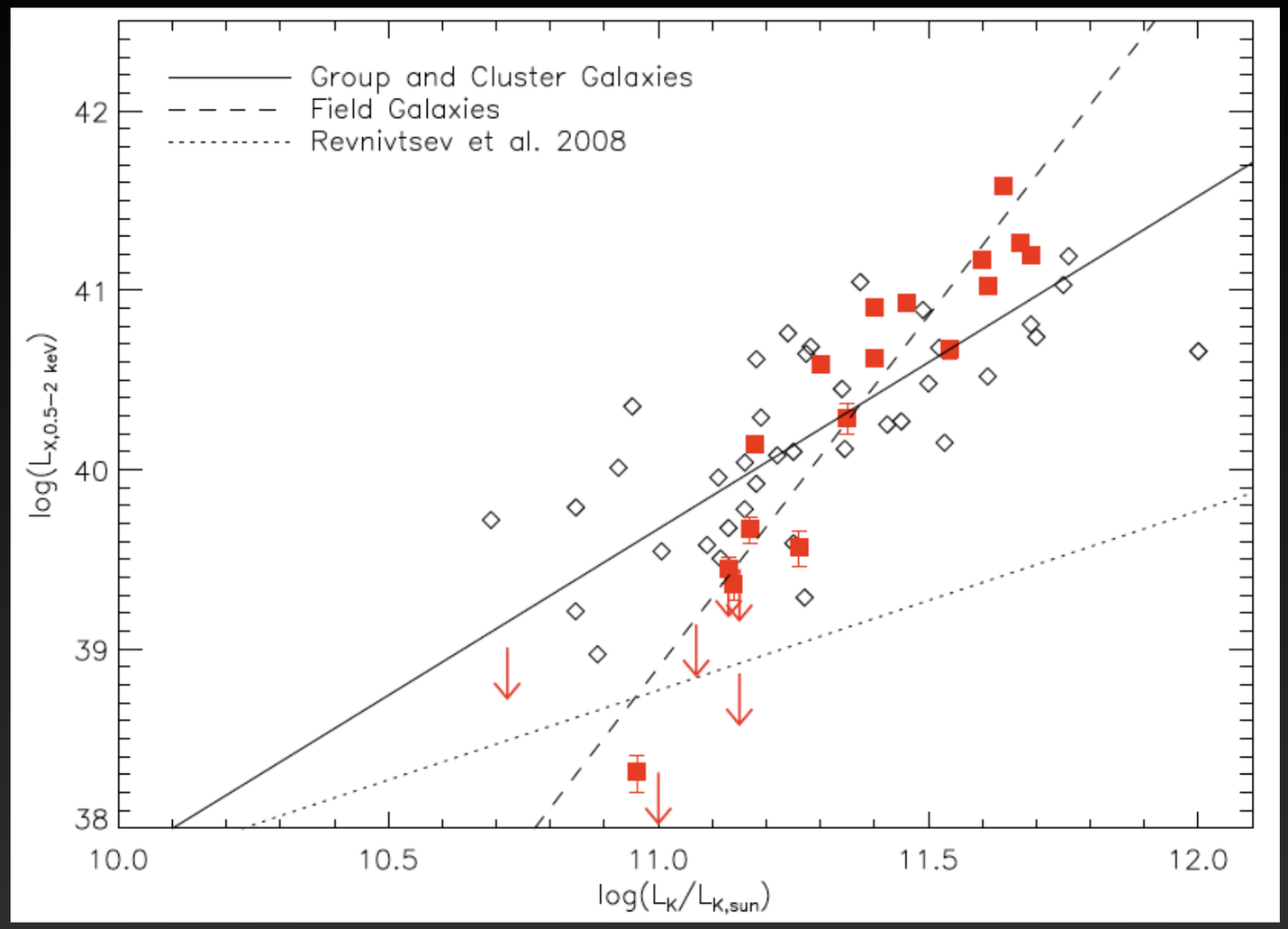

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➡ Some hot gas stripping in dense environments

Mulchaey & Jeltema 2010

Summary

- Field galaxies appear to have a steeper L_X - L_K relation than group and cluster galaxies.
- A higher detection rate of halos in groups and the field than in clusters, but many galaxies maintain extended hot gas halos even in group/cluster cores.
- Evidence for gas stripping (tails, tidal features) is seen in some galaxies.

➡ Complex interplay between galactic hot gas and ICM, which may act to both remove and maintain hot halos

➡ Hot gas stripping occurs with moderate/mild efficiency

➡ Larger samples, particularly at low L_K, are need