Hot Gas Around Elliptical Galaxies

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Outline

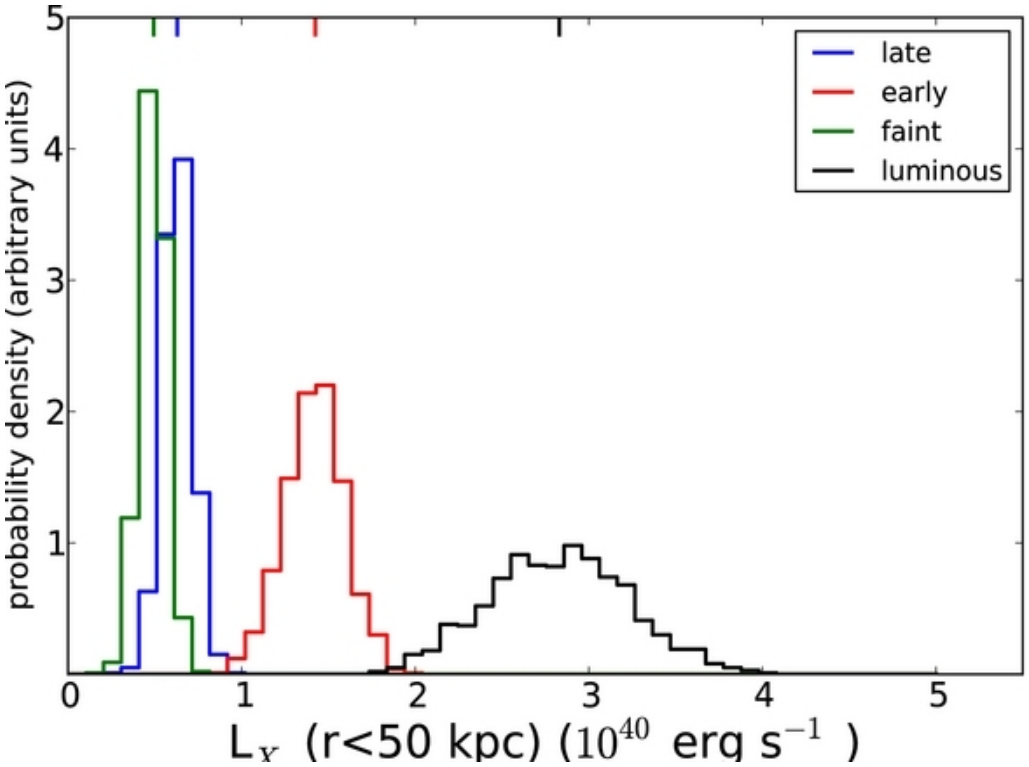
Very brief summary of properties of hot halos

Why do ellipticals have hot halos?

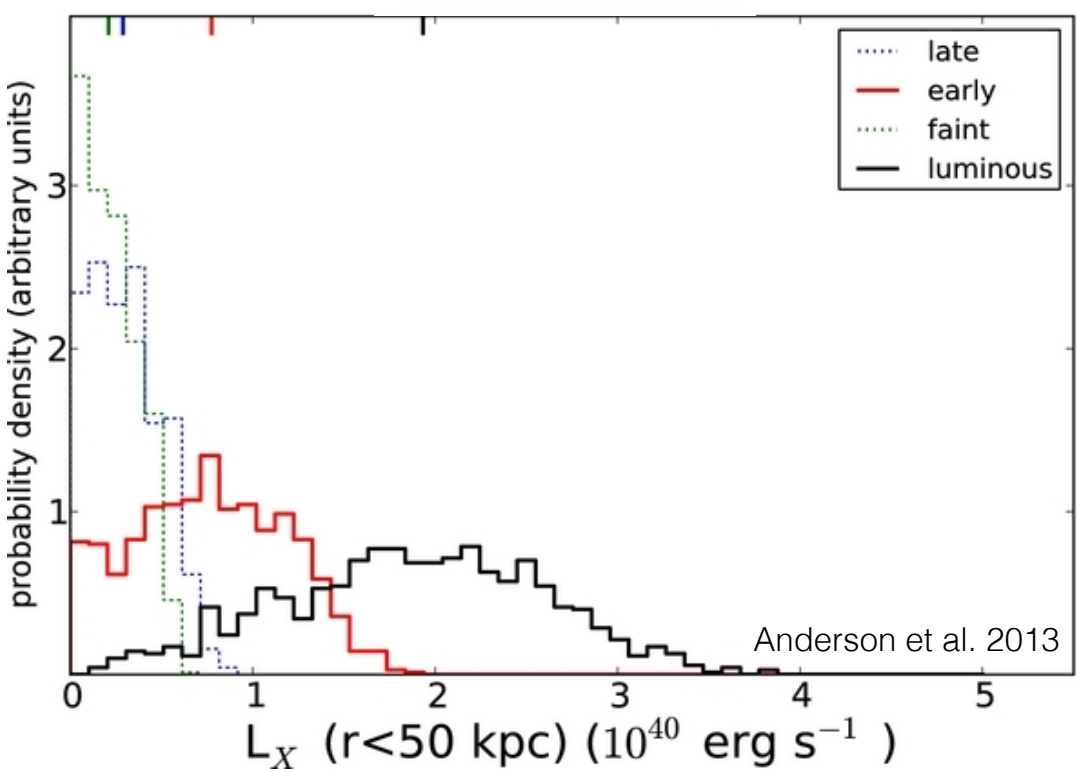
Connecting hot halos in galaxies, groups, and clusters

Hot Halo Basic Properties

Total X-ray luminosity



Extended emission only

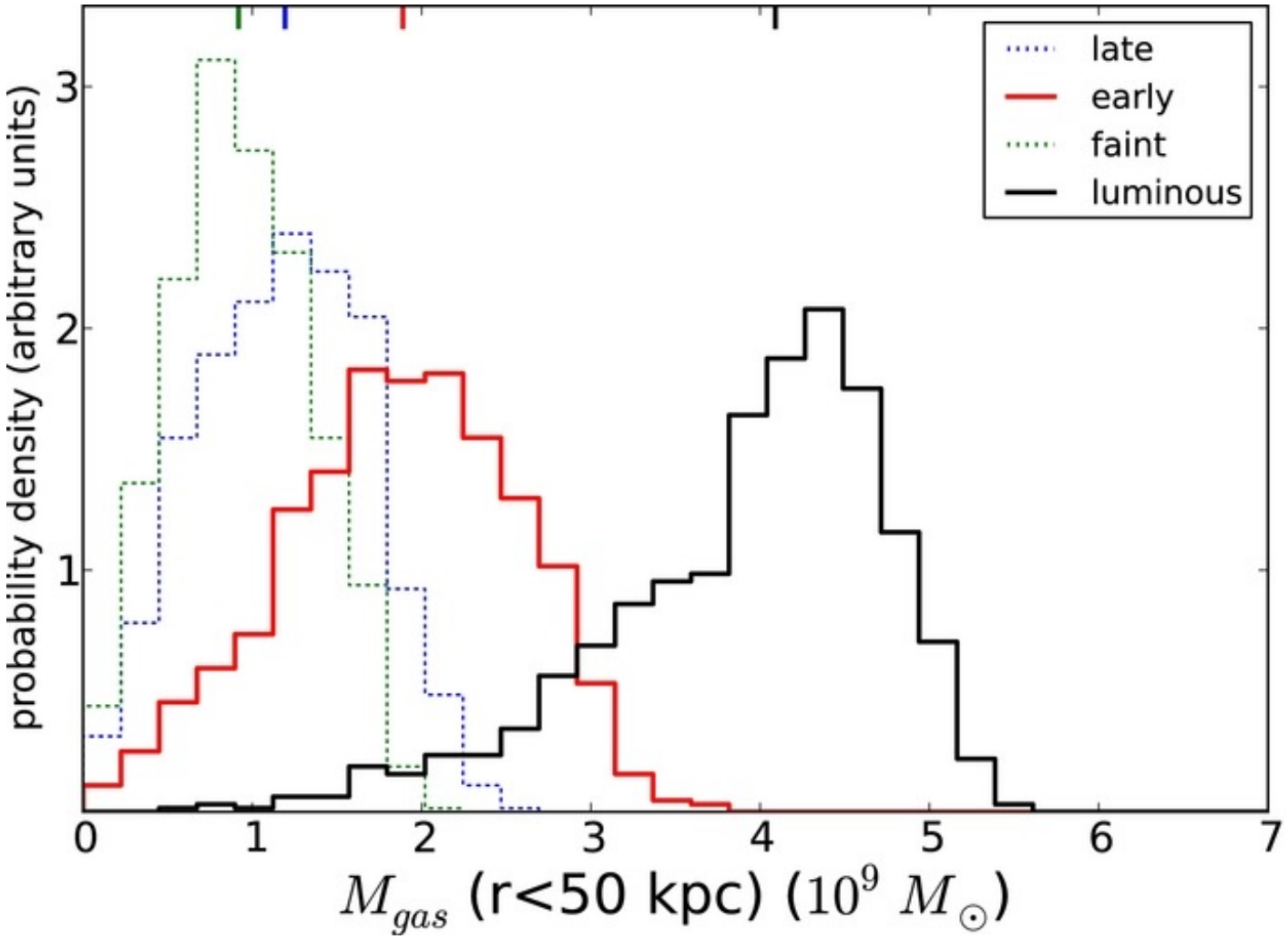


Ellipticals seem to have higher L_X than spirals:

- because of morphology?
- M/L ratio?
- halo mass?

Hot Halo Basic Properties

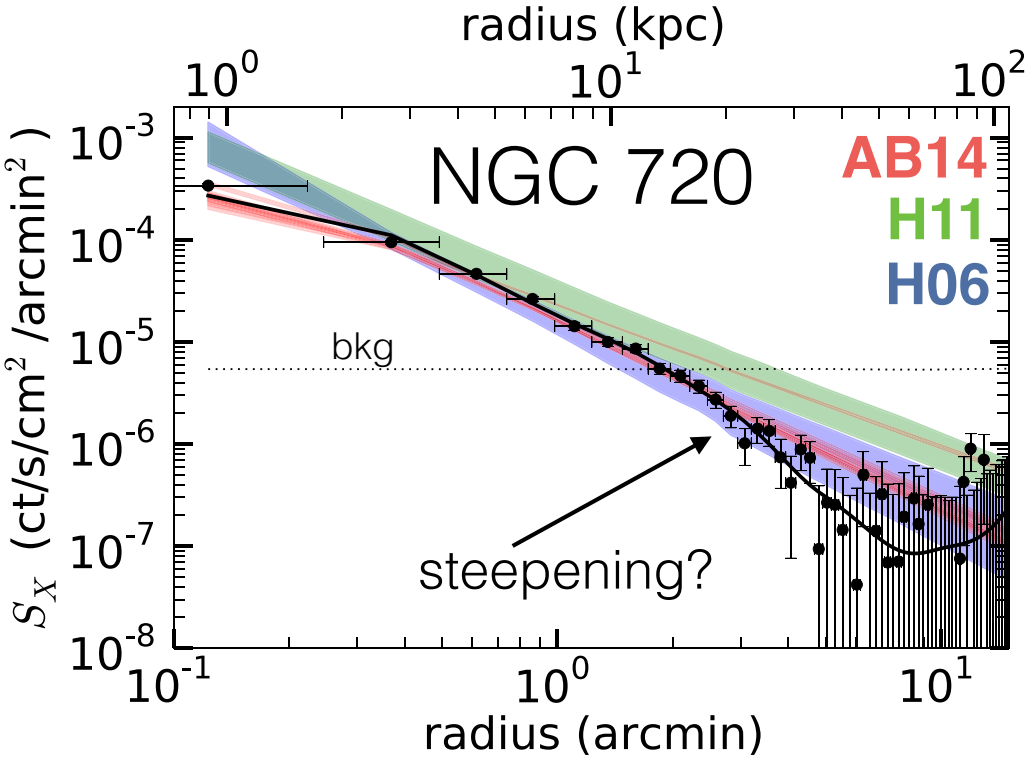
Anderson et al. 2013



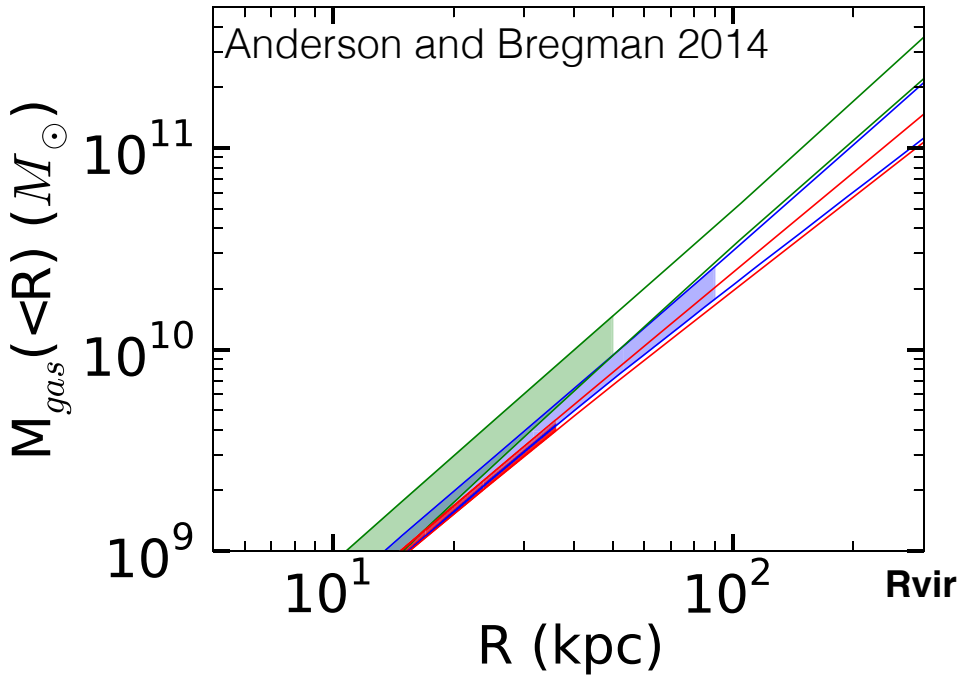
Assuming: Z = 0.3 Zsun, kT = 0.2 keV

Hot Gas Baryon Budgets

Hot gas surface brightness profile

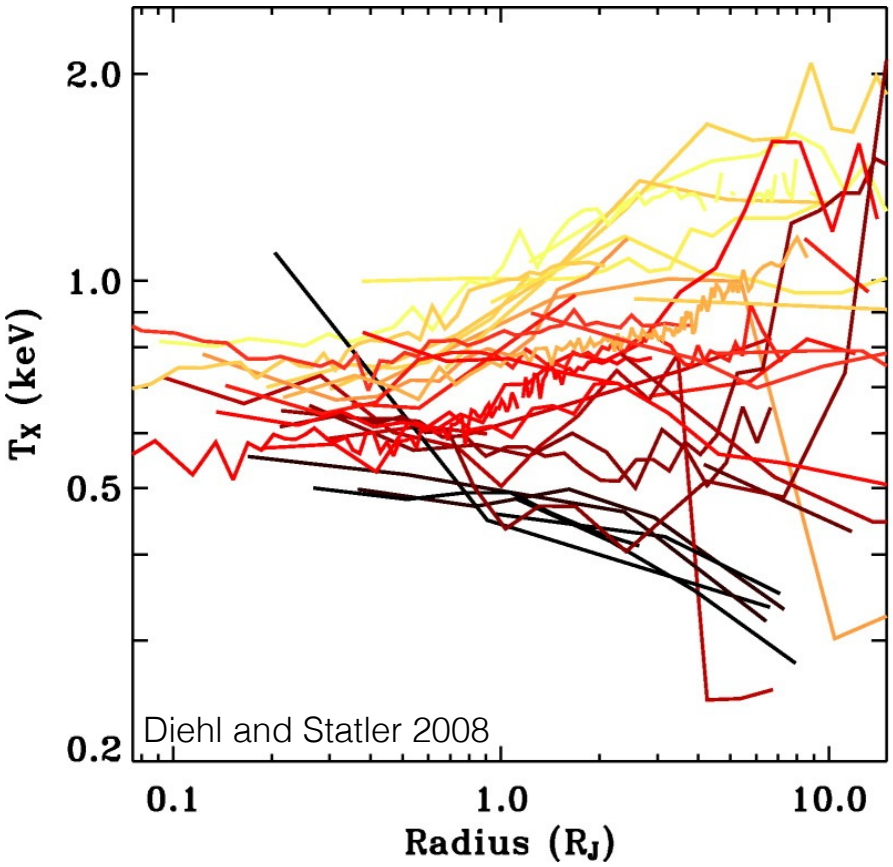


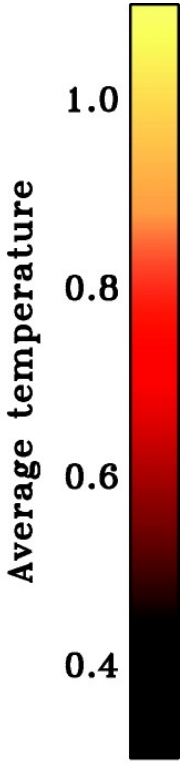
Enclosed Mgas profile



Surface brightness profiles are typically fairly well-behaved
But can be difficult to measure at large radii
Currently we must rely on large (&uncertain) extrapolations

Temperature Profiles of Hot Halos

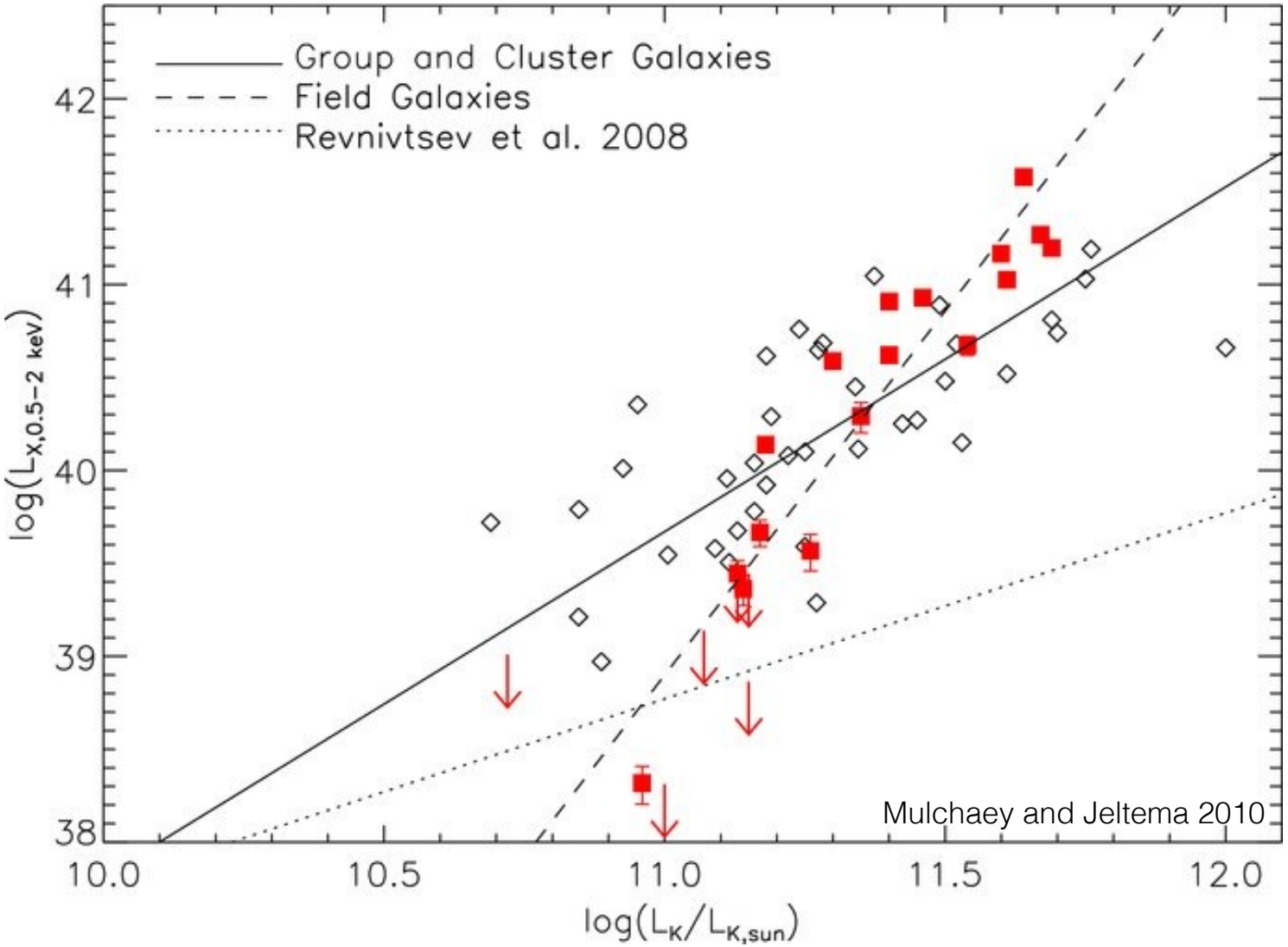




Competition between heating and cooling

- T slowly declines with r for galaxies
- flat-ish for massive galaxies
- cool core for galaxy groups

LX - LK Relation:
Diversity in Hot Gas Properties



effects of feedback? galactic dynamics? environment?

Why do ellipticals have hot gaseous halos?

Internal origin theories:

ISM converted to hot halo via **dynamical heating** + SNe
(Mathews and Baker 1971; Conroy et al. 2014)

and/or

AGN **feedback** (Silk and Rees 1998, Springel et al. 2005)

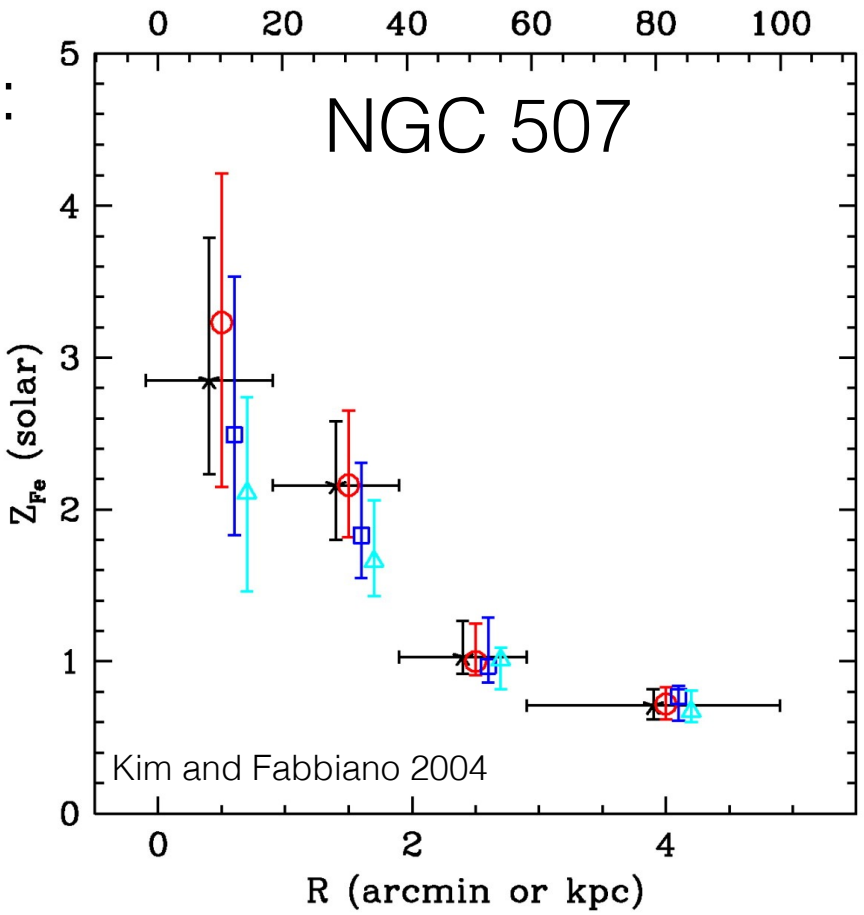
External origin theories:

Accretion shocks (White and Rees 1978)

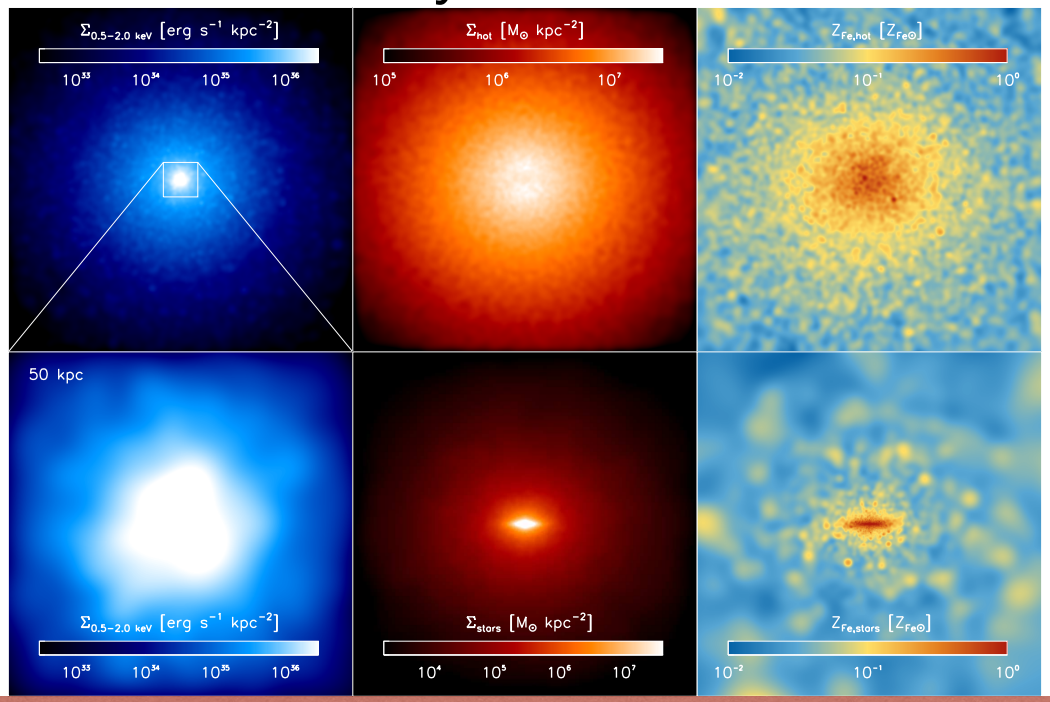
or, for cluster galaxies:

Intracluster medium

Generally internal origin is favored:

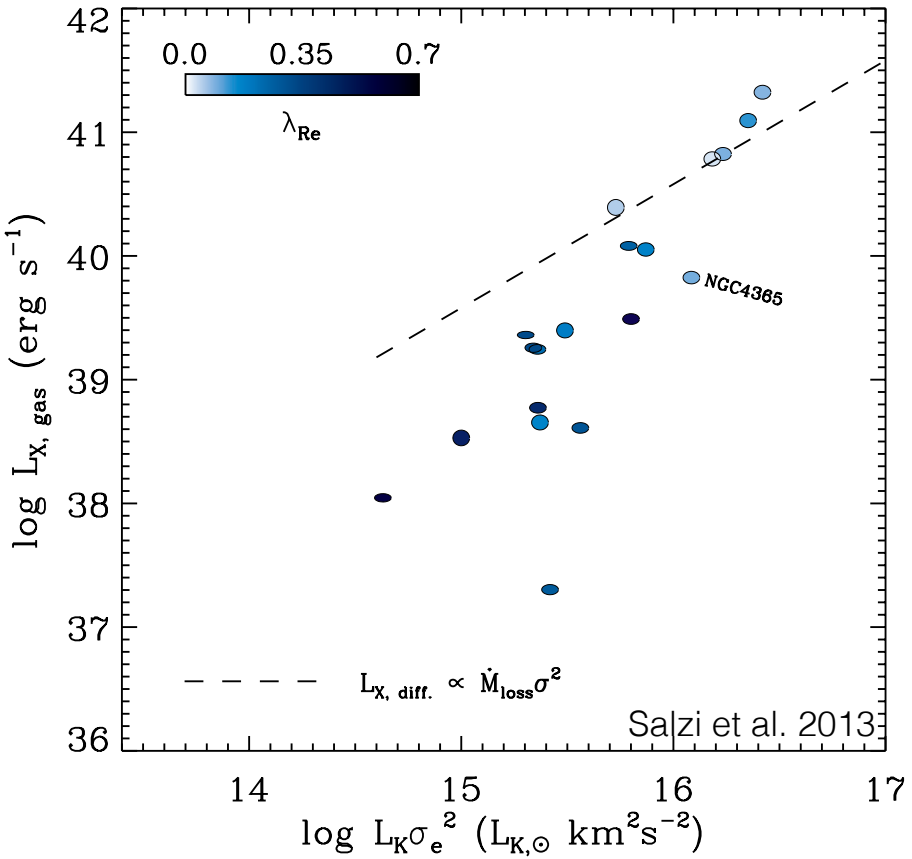


But low-metallicity accreted gas cannot totally be ruled out:



Crain et al. 2013

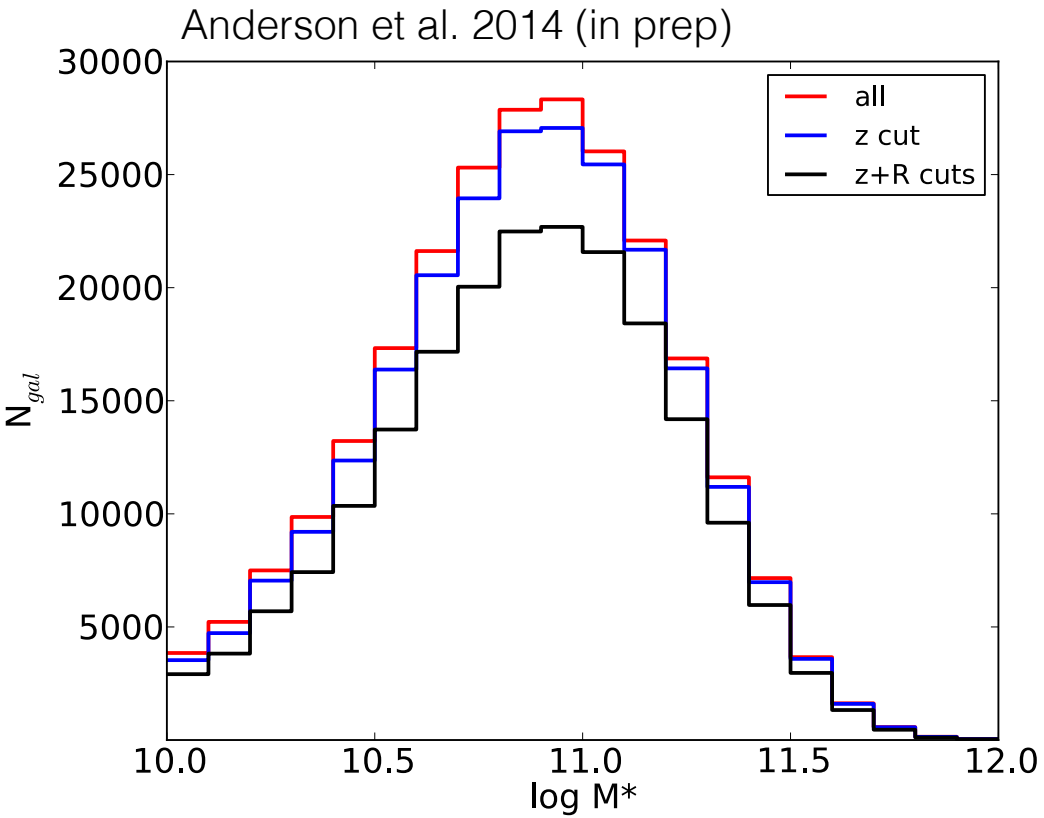
Rotation seems to matter -> dynamical heating?

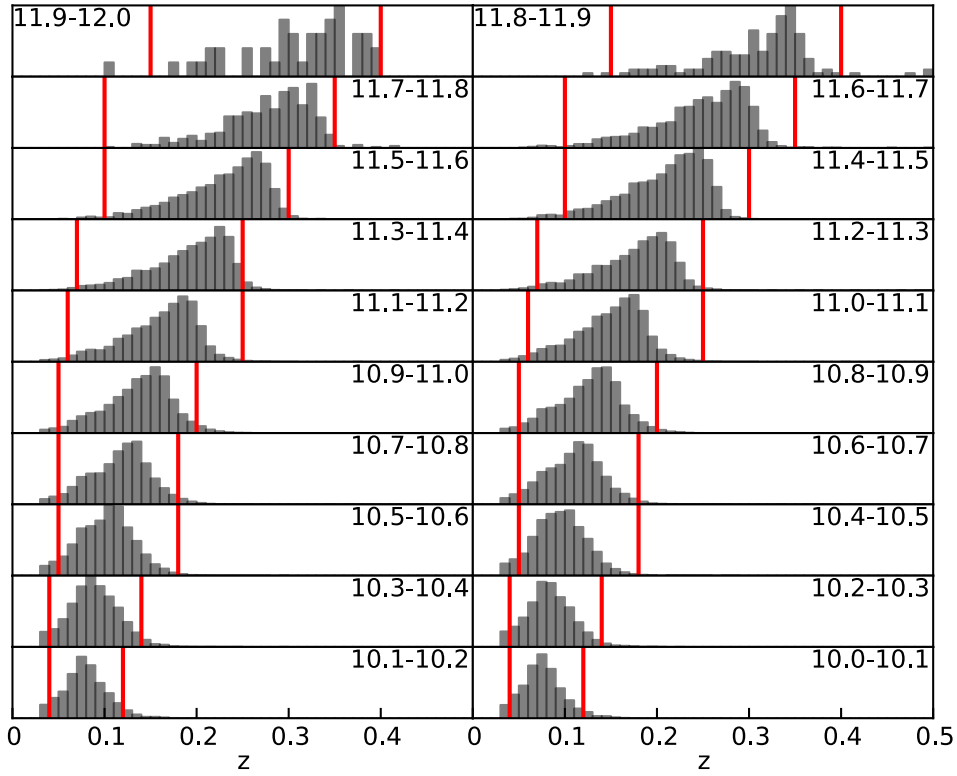


Environment could also be important though…

Will come back to this later in the talk

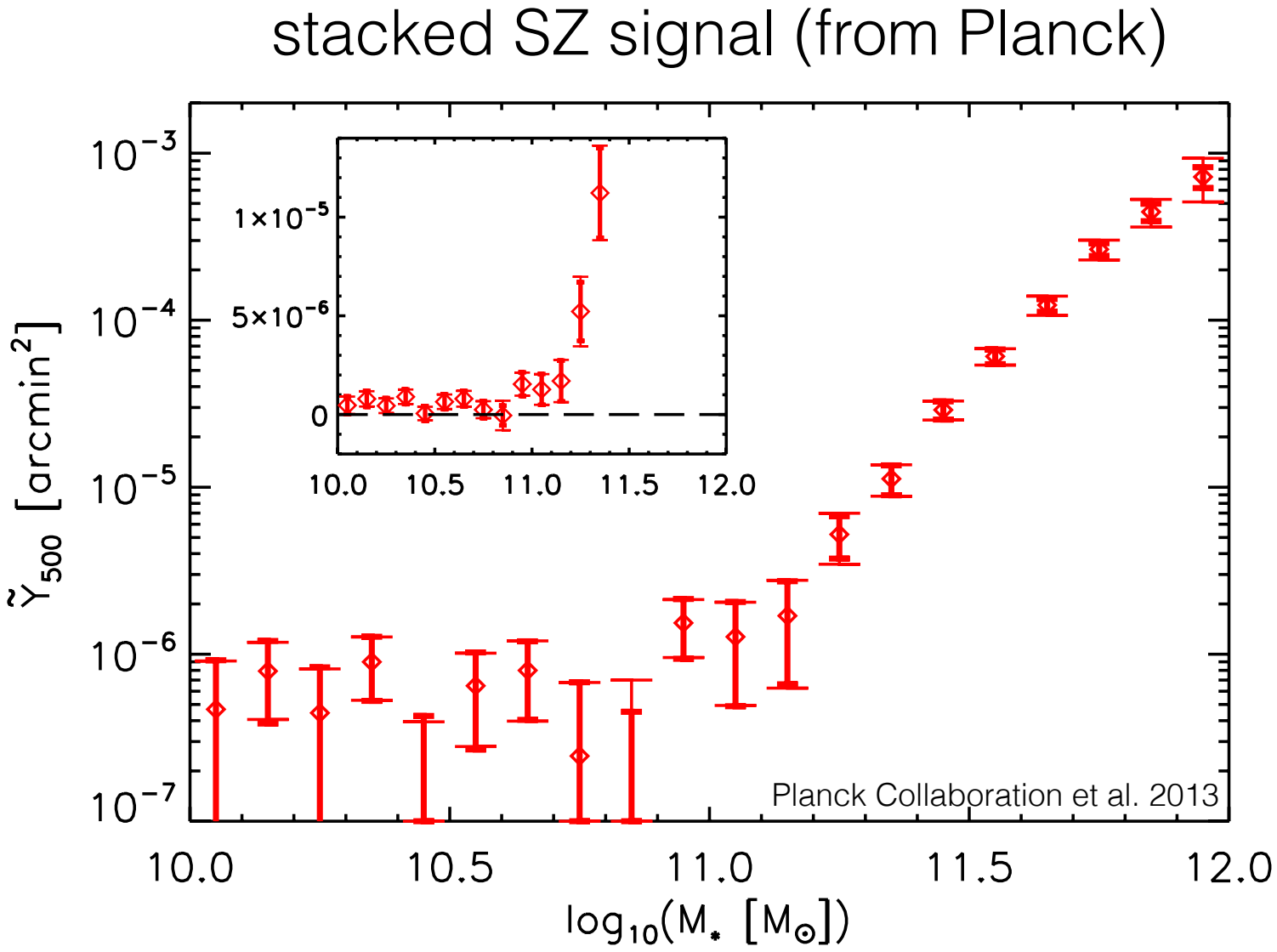
A Sample of Locally Brightest Galaxies

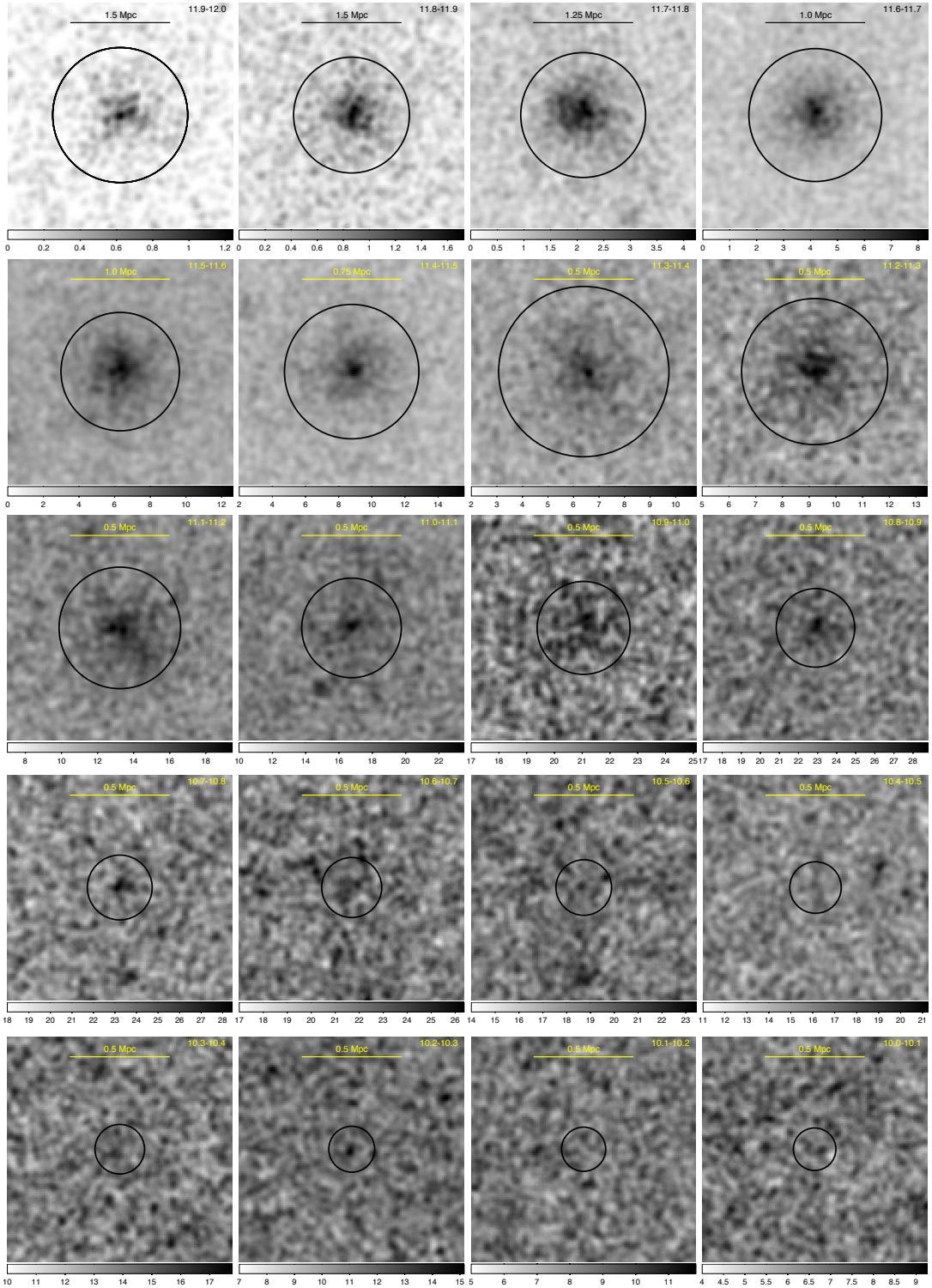




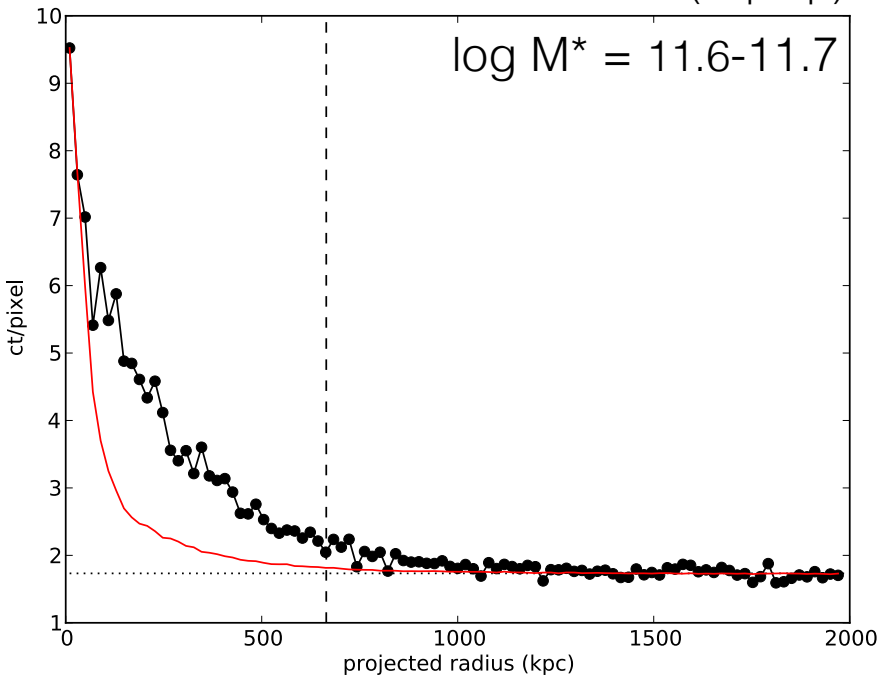
N = 259 759

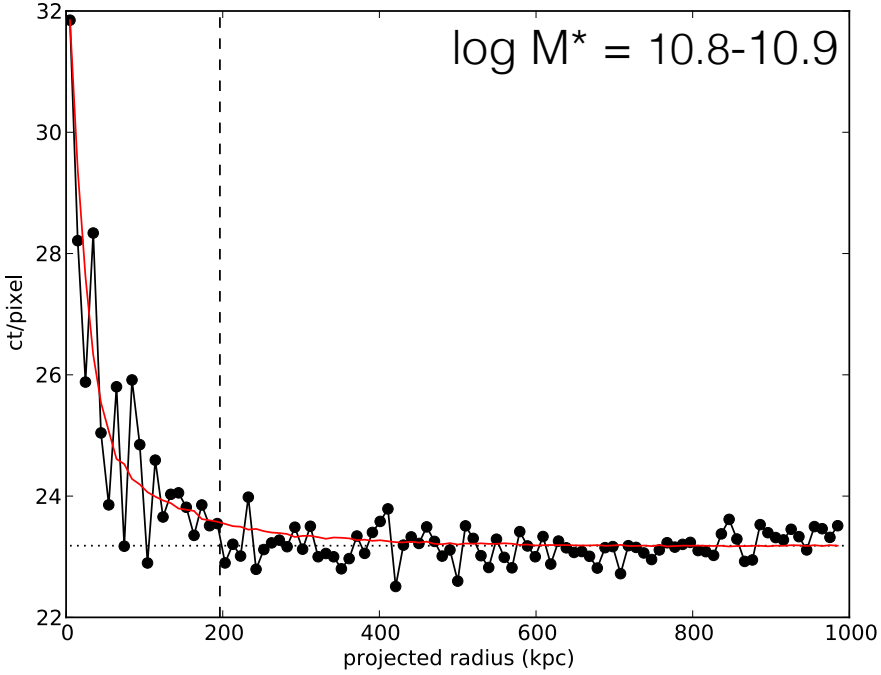
Pressure - Mass relation



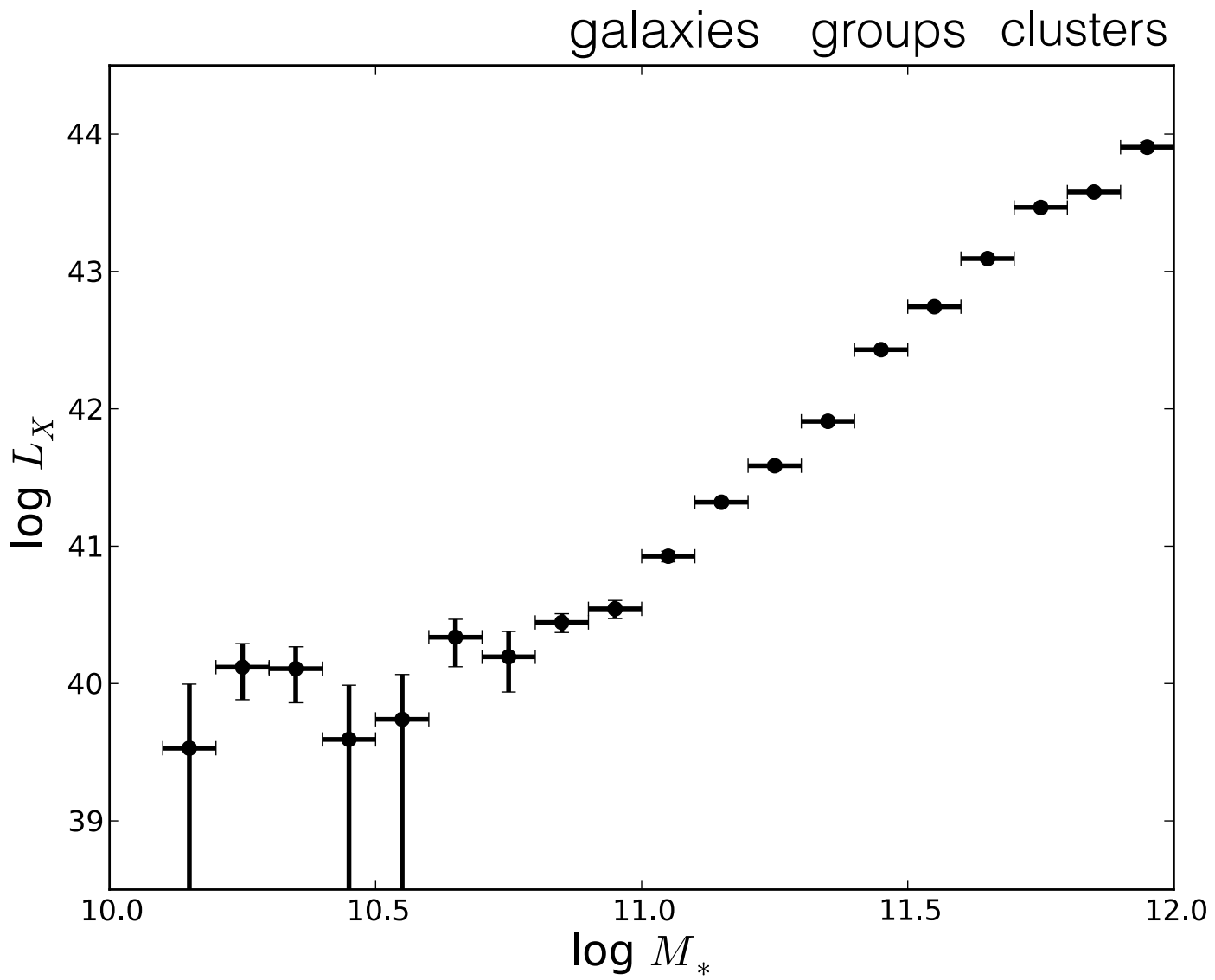


Anderson et al. 2014 (in prep)

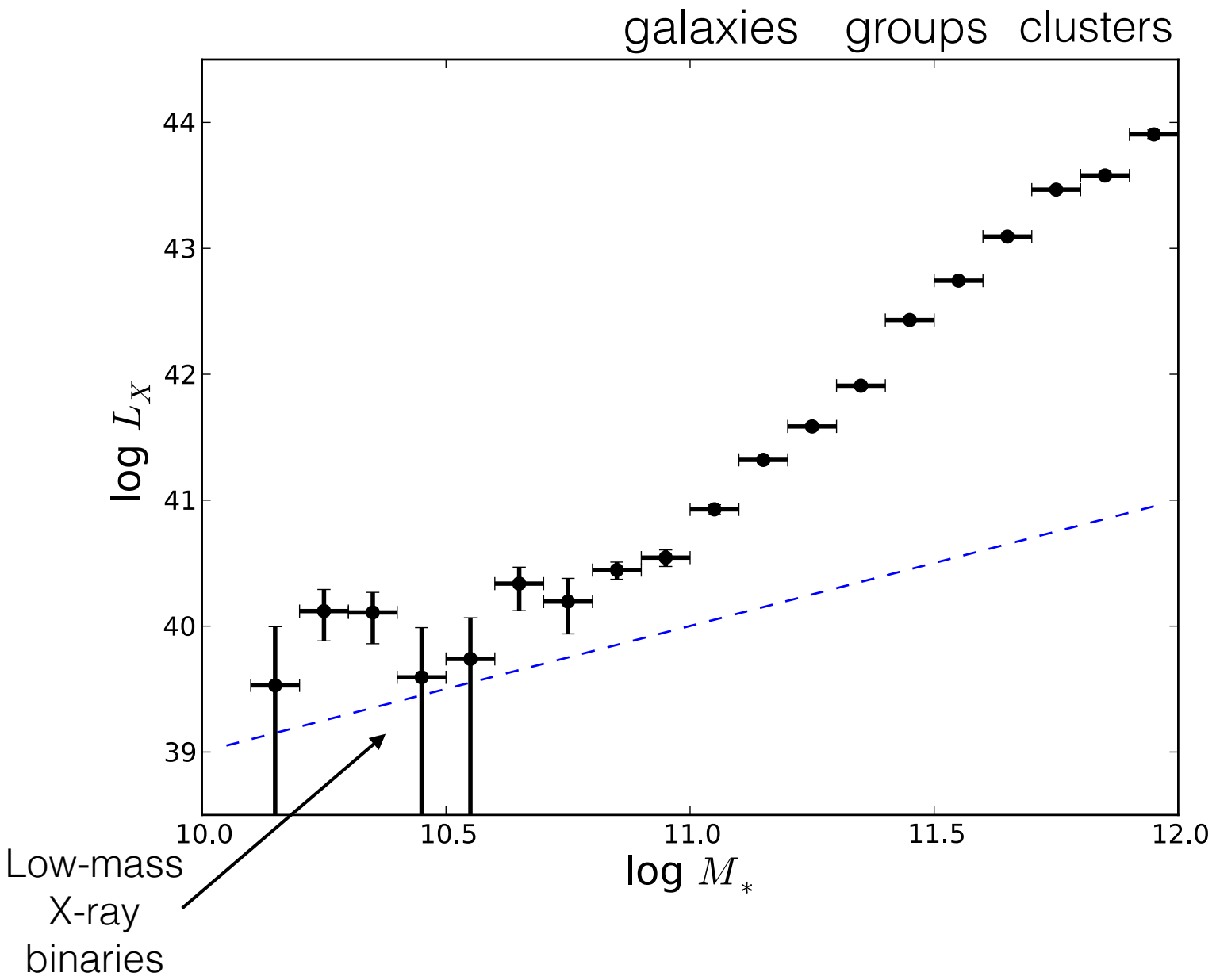




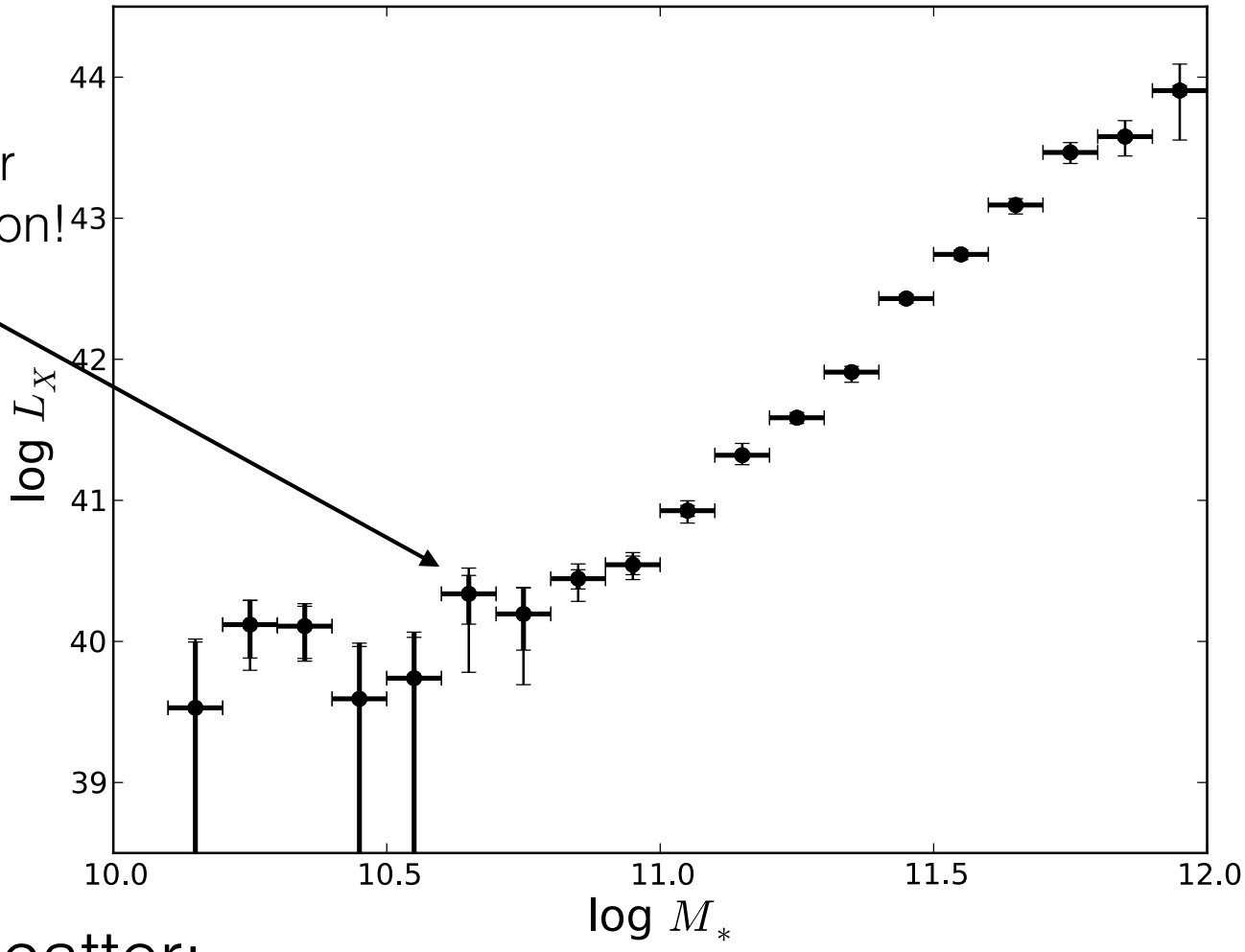
LX, 500 - Stellar Mass Relation



LX, 500 - Stellar Mass Relation



Same scatter
as LX-LK relation!



Intrinsic scatter:

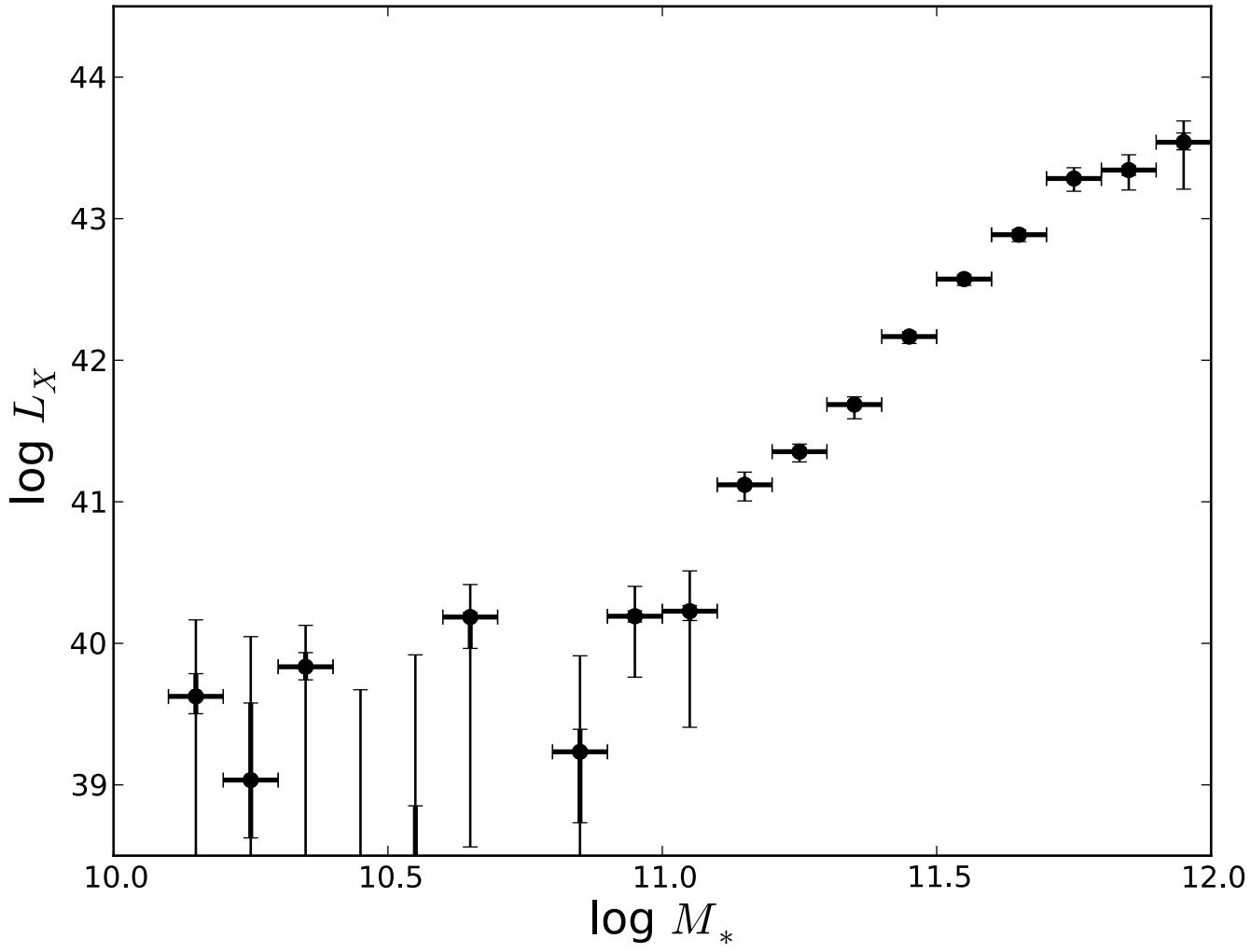
comparable to LX - LK relation for galaxies

(but these are all centrals!)

decreases significantly for groups

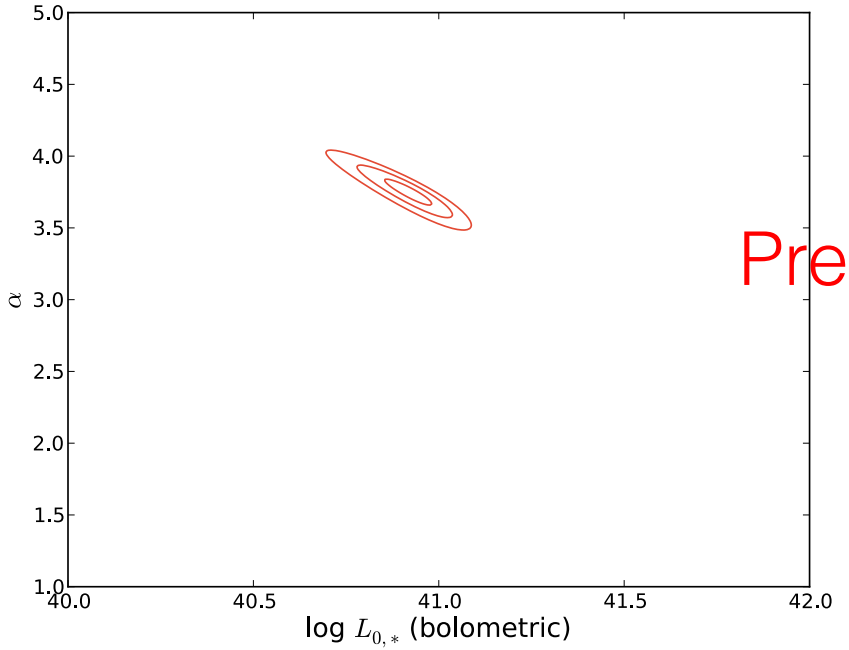
larger again for clusters (due to steep M*-Mhalo relation)

X-ray Luminosity (0.15-1.0 R500 annulus)

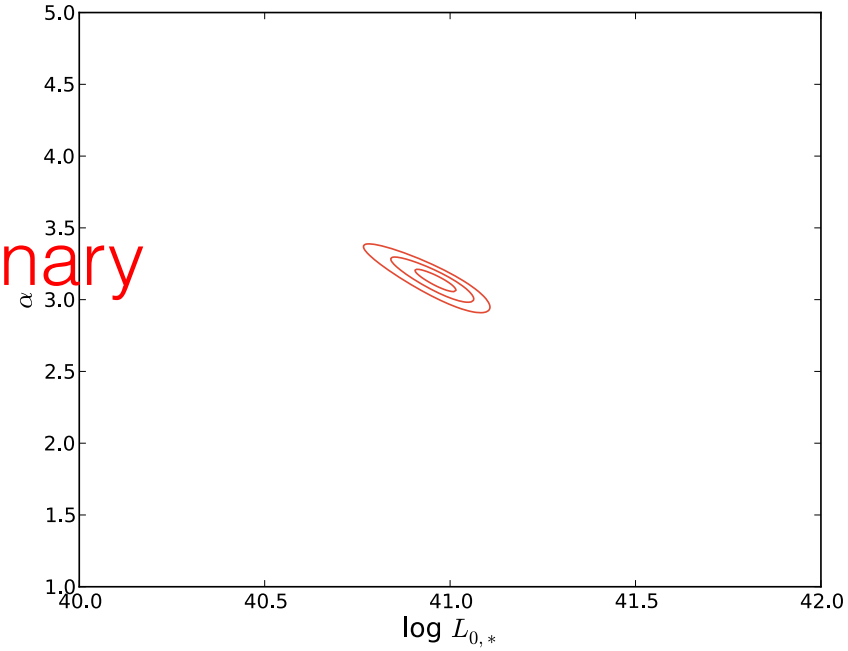


Hot halos around (almost) all galaxies with log M* ≈ 11.0

LX - M* relation
(measured from log M* = 11.0 - 12.0)

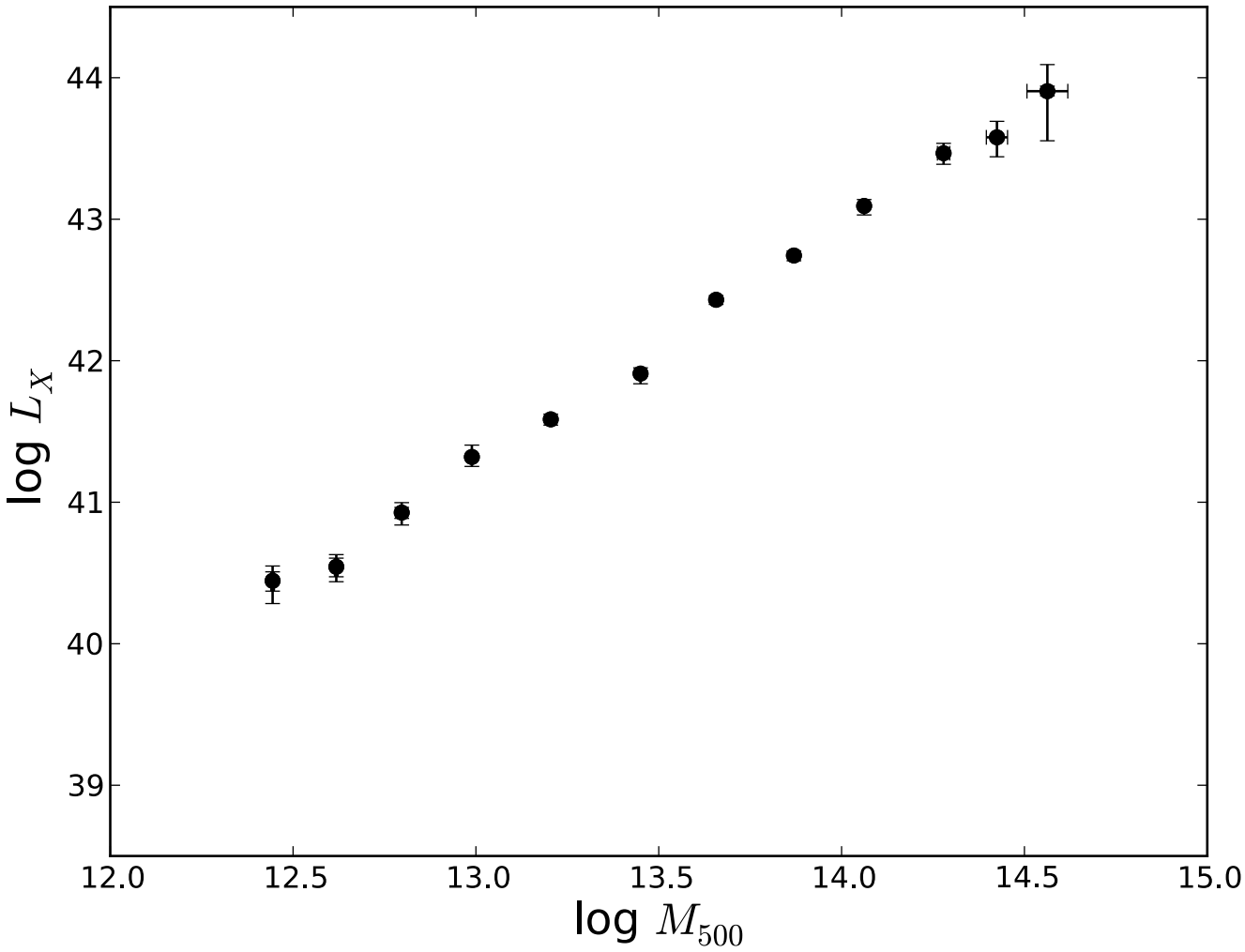


Preliminary



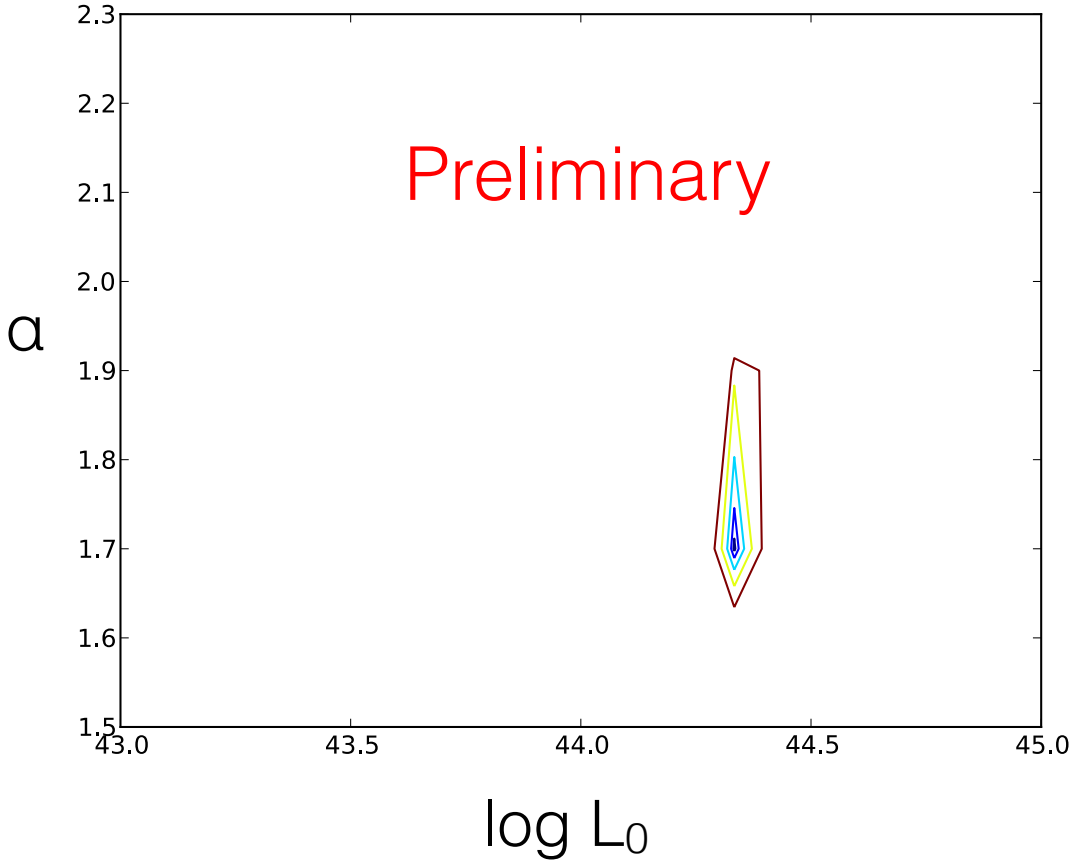
$$LX = L_0 \times (\text{bolo\_corr}) \times (M^* / 1e11)^{\alpha}$$

Estimate effective Mhalo for each bin….



… fit for LX - M500 relation

$$LX,\ bol = L_0 \times bolo\_corr \times E(z)^{7/3} \times (M/M0)^{\alpha}$$

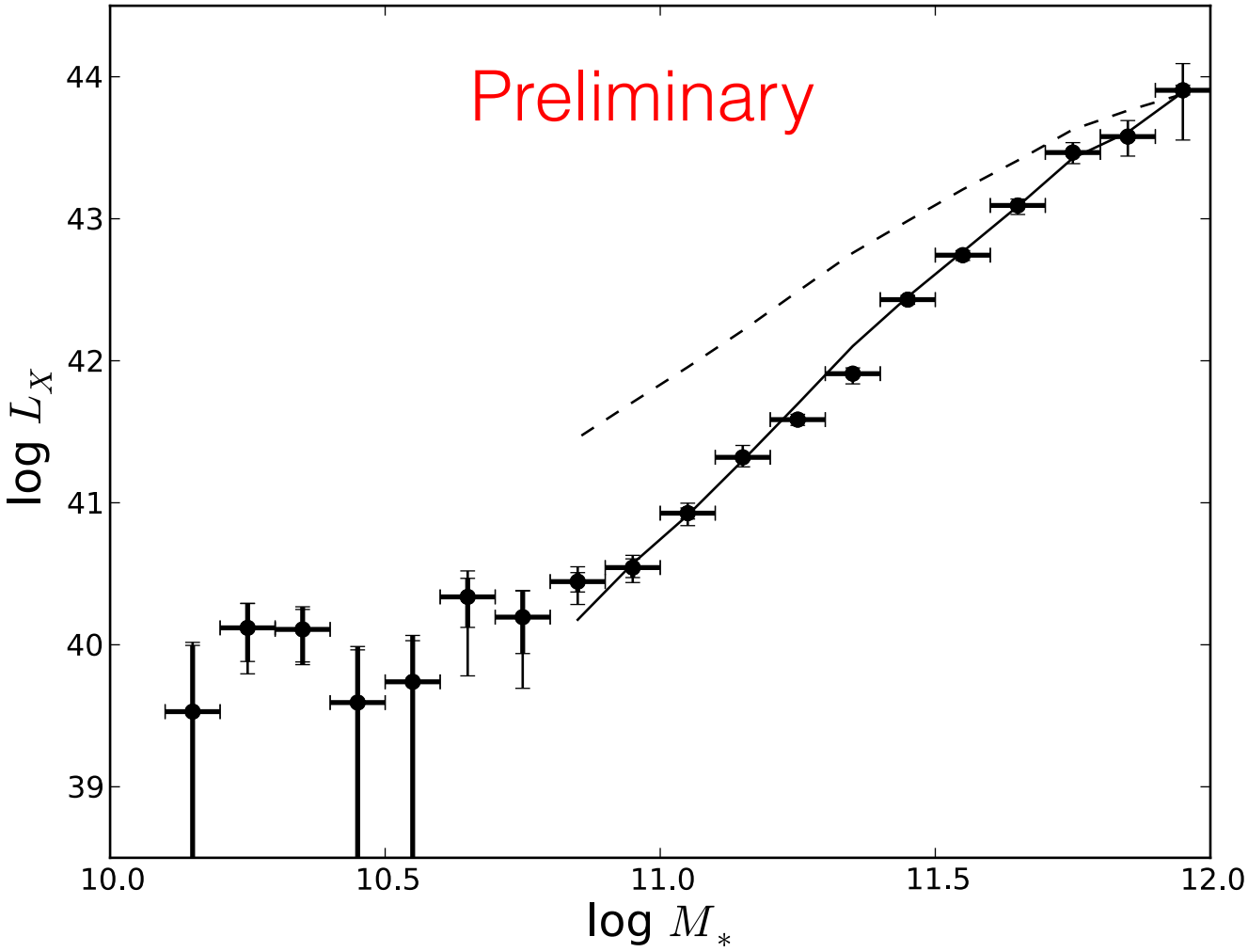


Self-similar: α = 4/3

Galaxy clusters: α = 1.7-2.0

(due to non-gravitational heating)

… fit for LX - M500 relation



Conclusions

- Isolated ellipticals do not seem to have their missing baryons in the hot halo
- Elliptical galaxies have diverse temperature profiles and LX
- Simple power-law relations hold from clusters to galaxies:
  - M* - Y
  - M* - LX
  - M500 - LX
- L-M relations are consistently steeper than self-similar