



UNIVERSITY OF  
ALBERTA

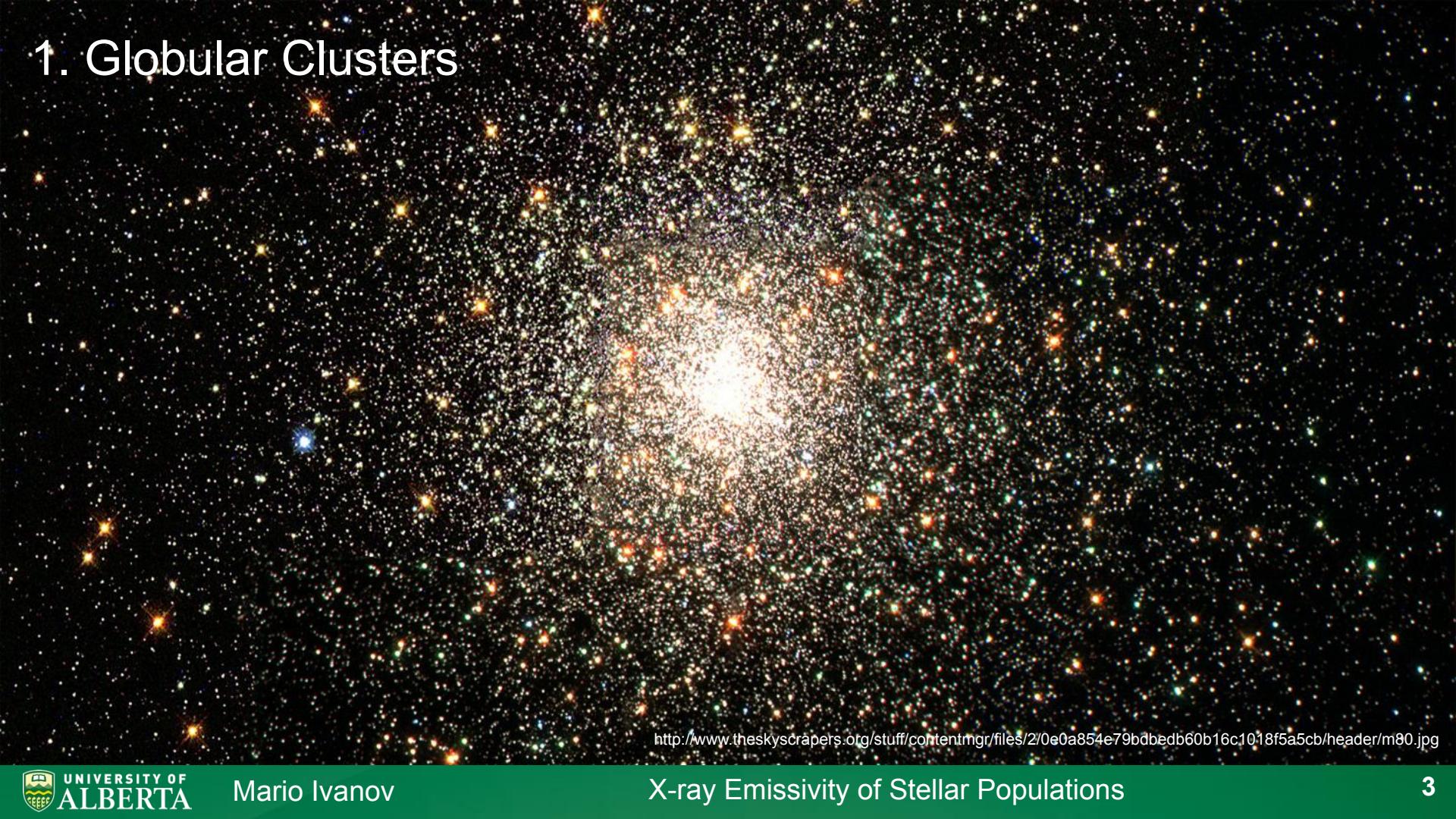
# X-ray Emissivity of Low-Density Stellar Populations

# Definition

“Investigating how the X-ray emissivity of fainter X-ray binaries varies between different stellar environments”

$$\text{X-ray emissivity} = \frac{\text{X-ray luminosity of object}}{\text{Mass of object}}$$

# 1. Globular Clusters



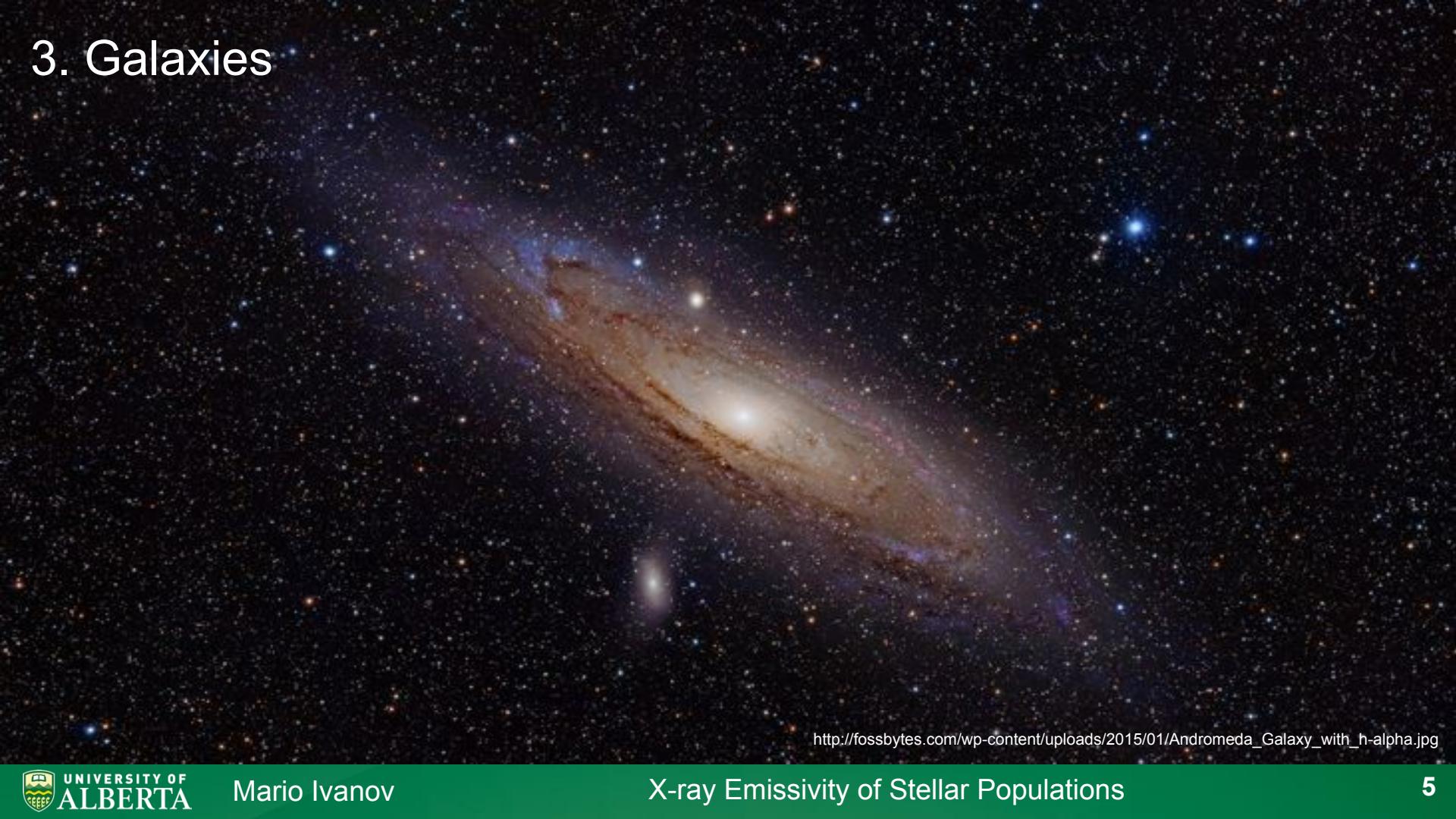
<http://www.theskyscrapers.org/stuff/contentmgr/files/2/0e0a854e79bdbedb60b16c1018f5a5cb/header/m80.jpg>

## 2. Open Clusters



<http://bf-astro.com/images/m67big.jpg>

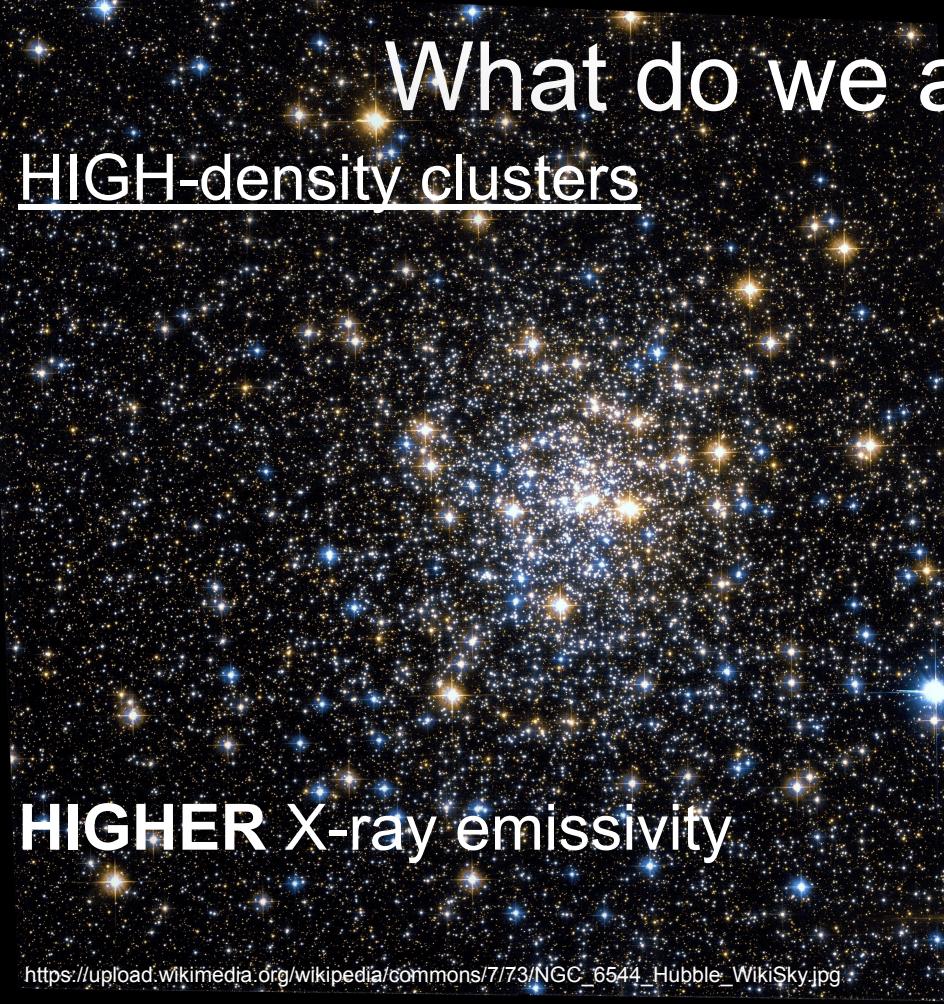
### 3. Galaxies



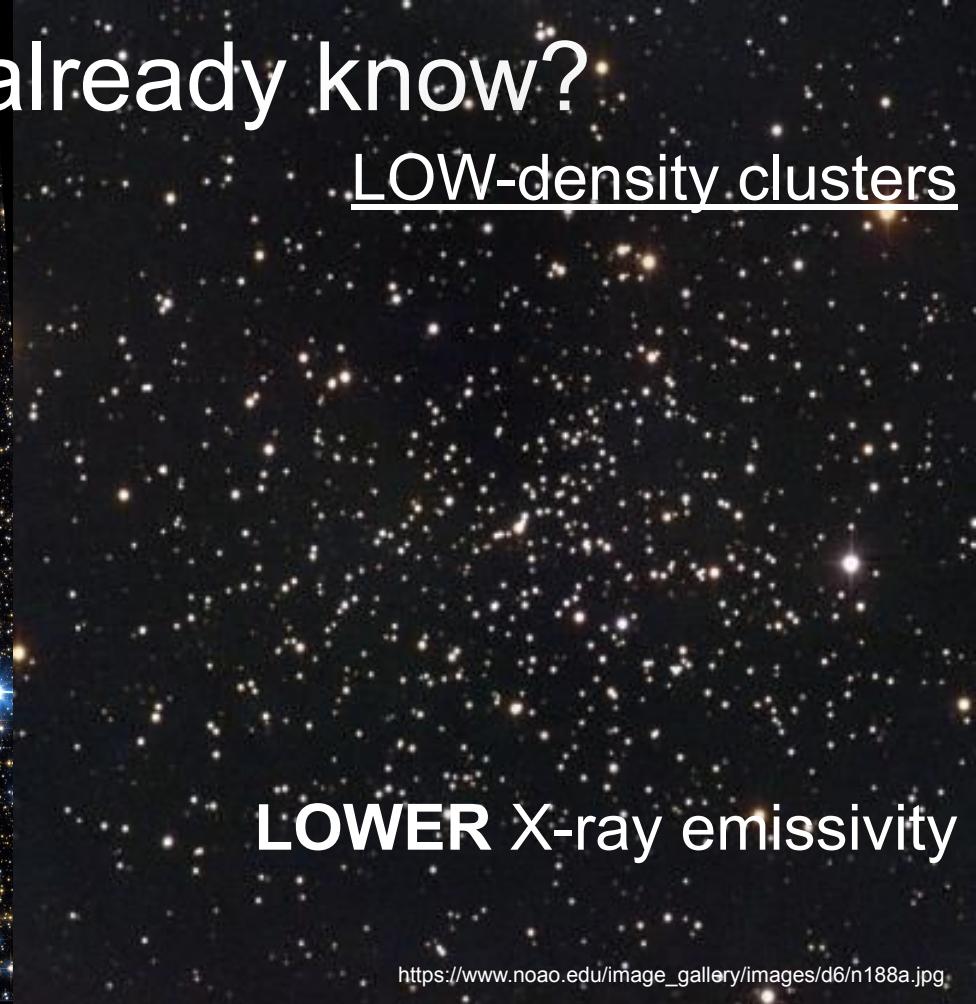
[http://fossbytes.com/wp-content/uploads/2015/01/Andromeda\\_Galaxy\\_with\\_h-alpha.jpg](http://fossbytes.com/wp-content/uploads/2015/01/Andromeda_Galaxy_with_h-alpha.jpg)

# What do we already know?

HIGH-density clusters



LOW-density clusters

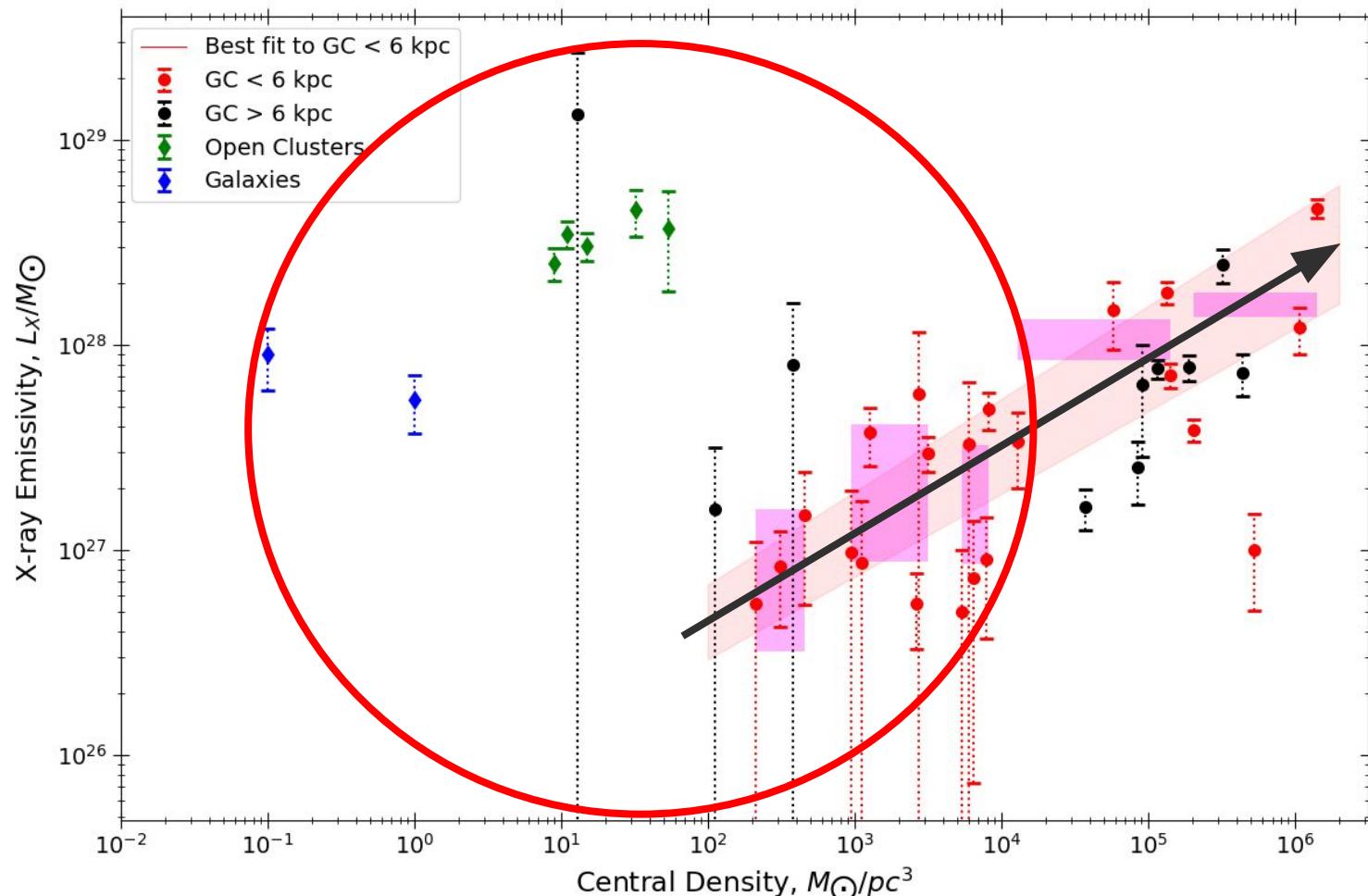


**HIGHER X-ray emissivity**

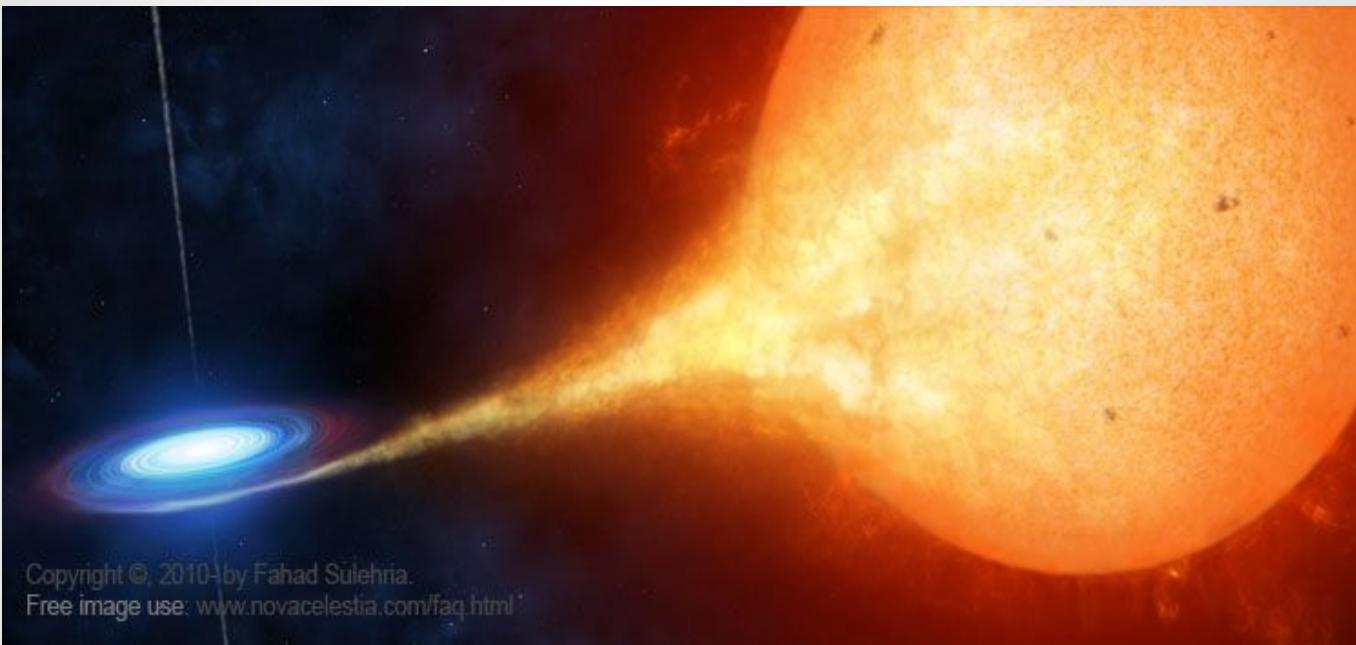
**LOWER X-ray emissivity**

[https://upload.wikimedia.org/wikipedia/commons/7/73/NGC\\_6544\\_Hubble\\_WikiSky.jpg](https://upload.wikimedia.org/wikipedia/commons/7/73/NGC_6544_Hubble_WikiSky.jpg)

[https://www.noao.edu/image\\_gallery/images/d6/n188a.jpg](https://www.noao.edu/image_gallery/images/d6/n188a.jpg)

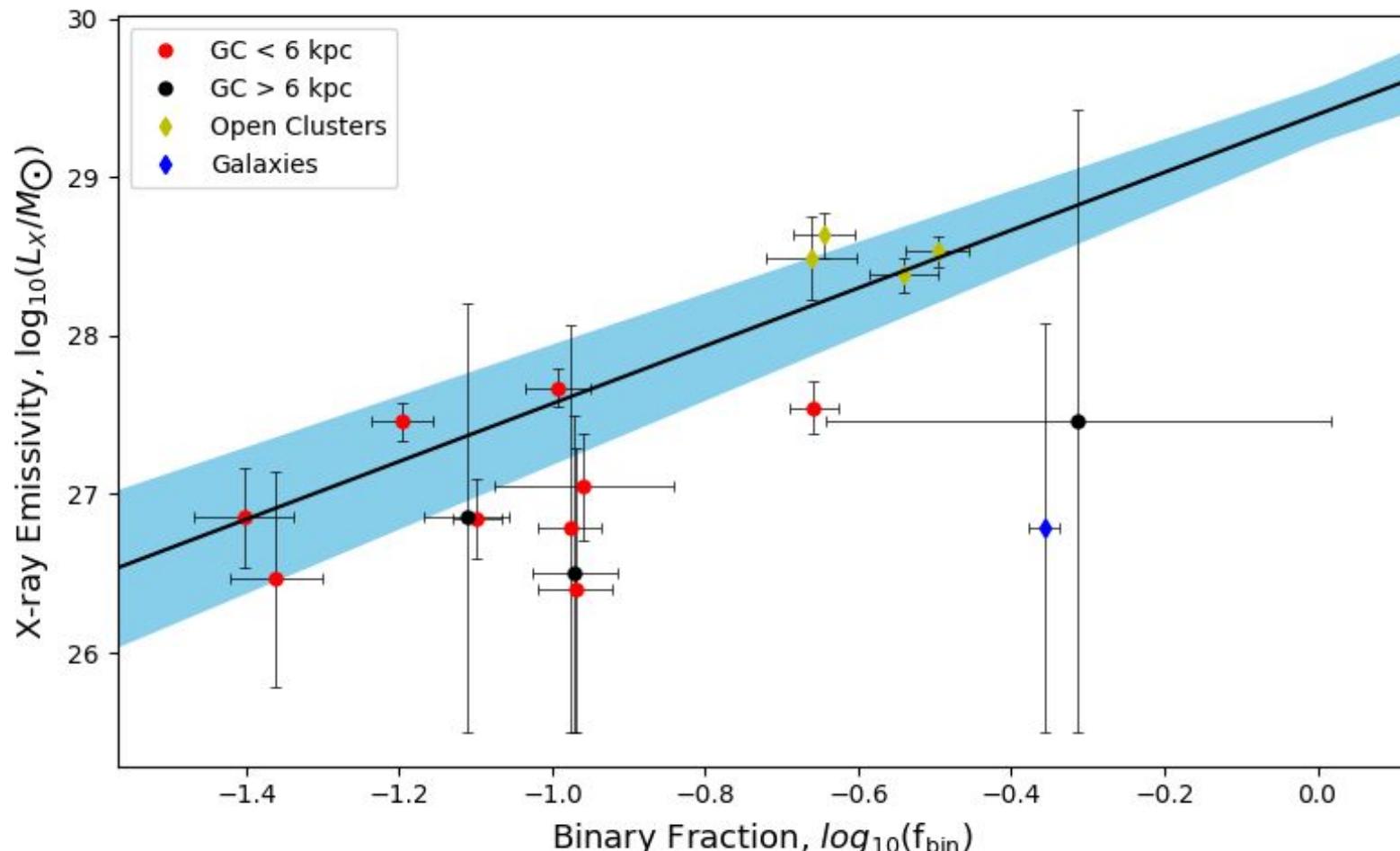


# Binary Fraction



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Higher binary fraction → More X-ray binaries

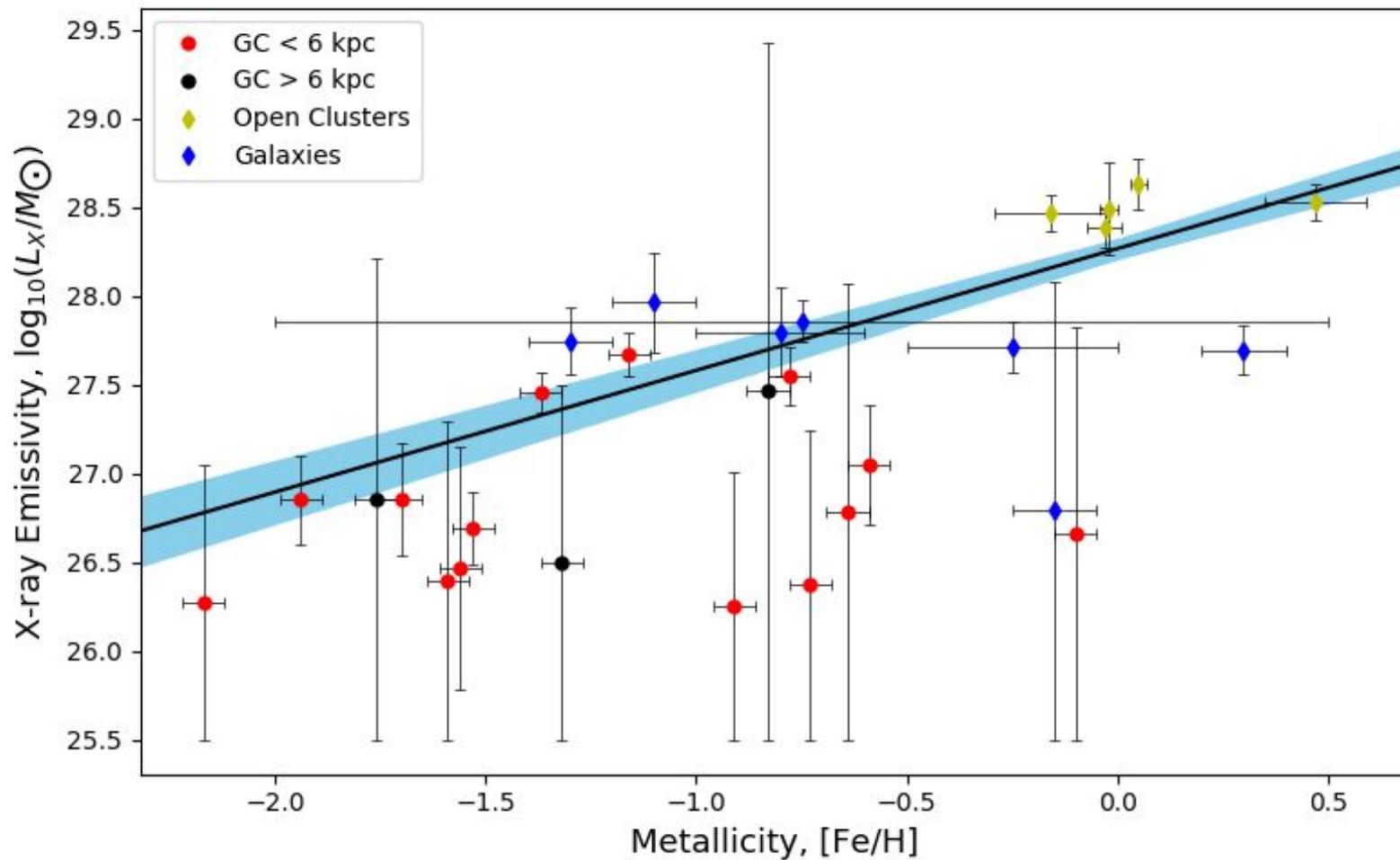




# Metallicity

Known to affect the frequency of bright LMXBs and MSP

No clear effect so far, but studied sources are sparse



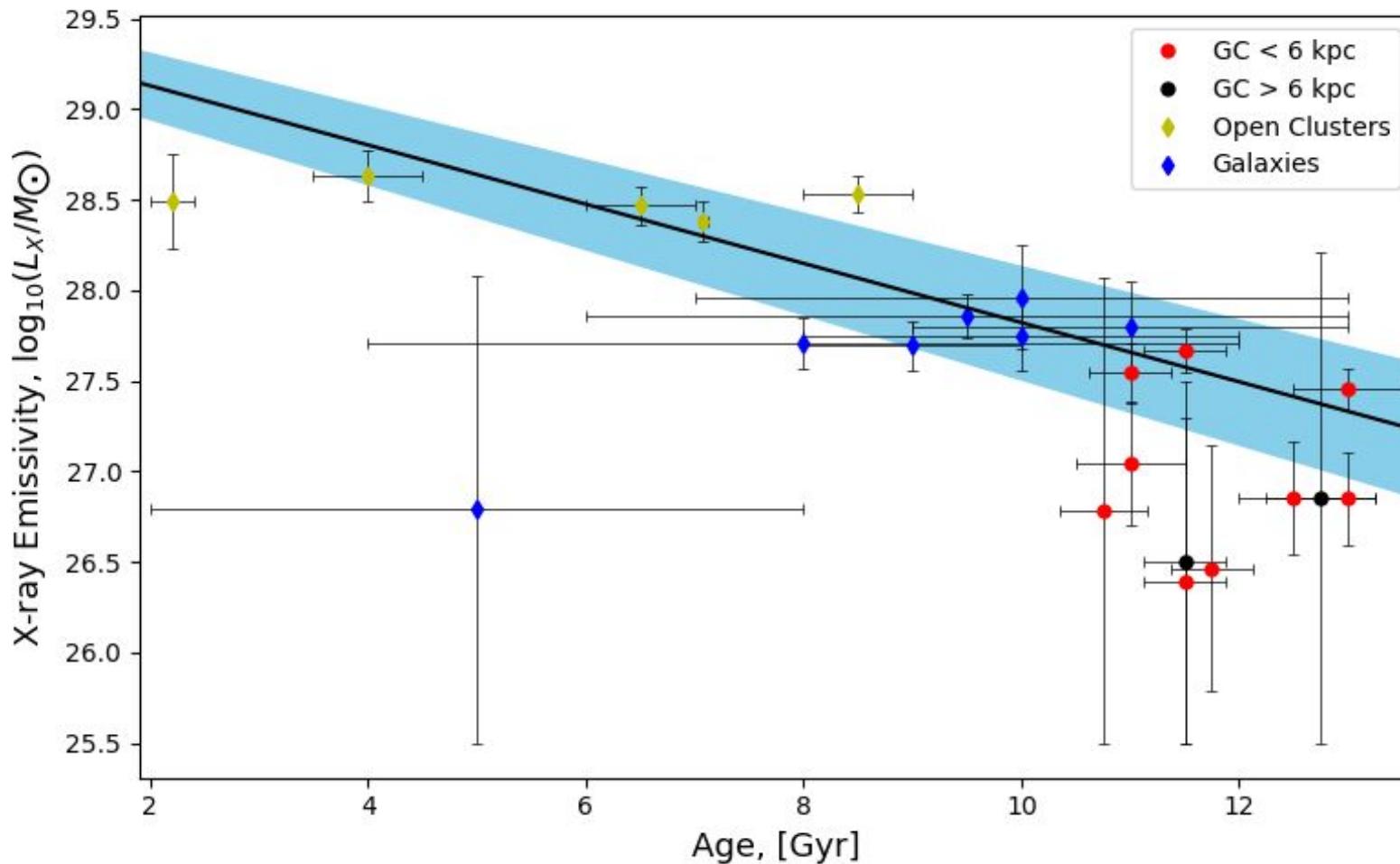


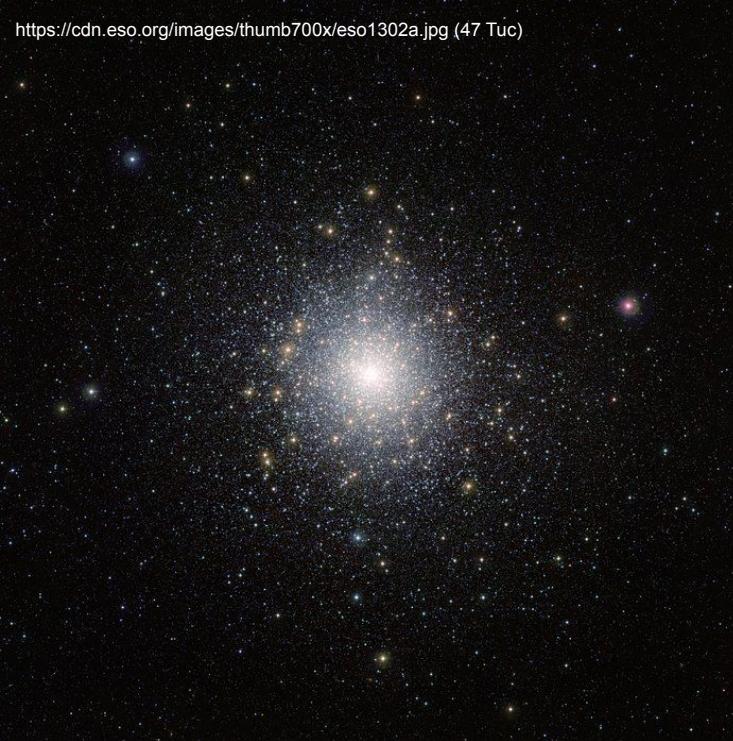
# Age



Younger clusters → bigger stars  
→ higher x-ray emissivity

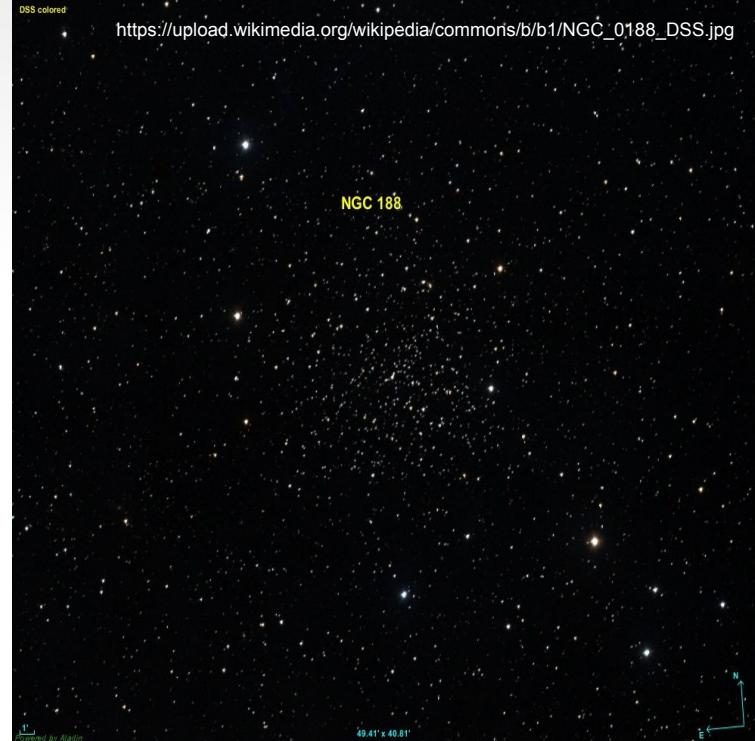
Older clusters → smaller stars  
→ lower x-ray emissivity





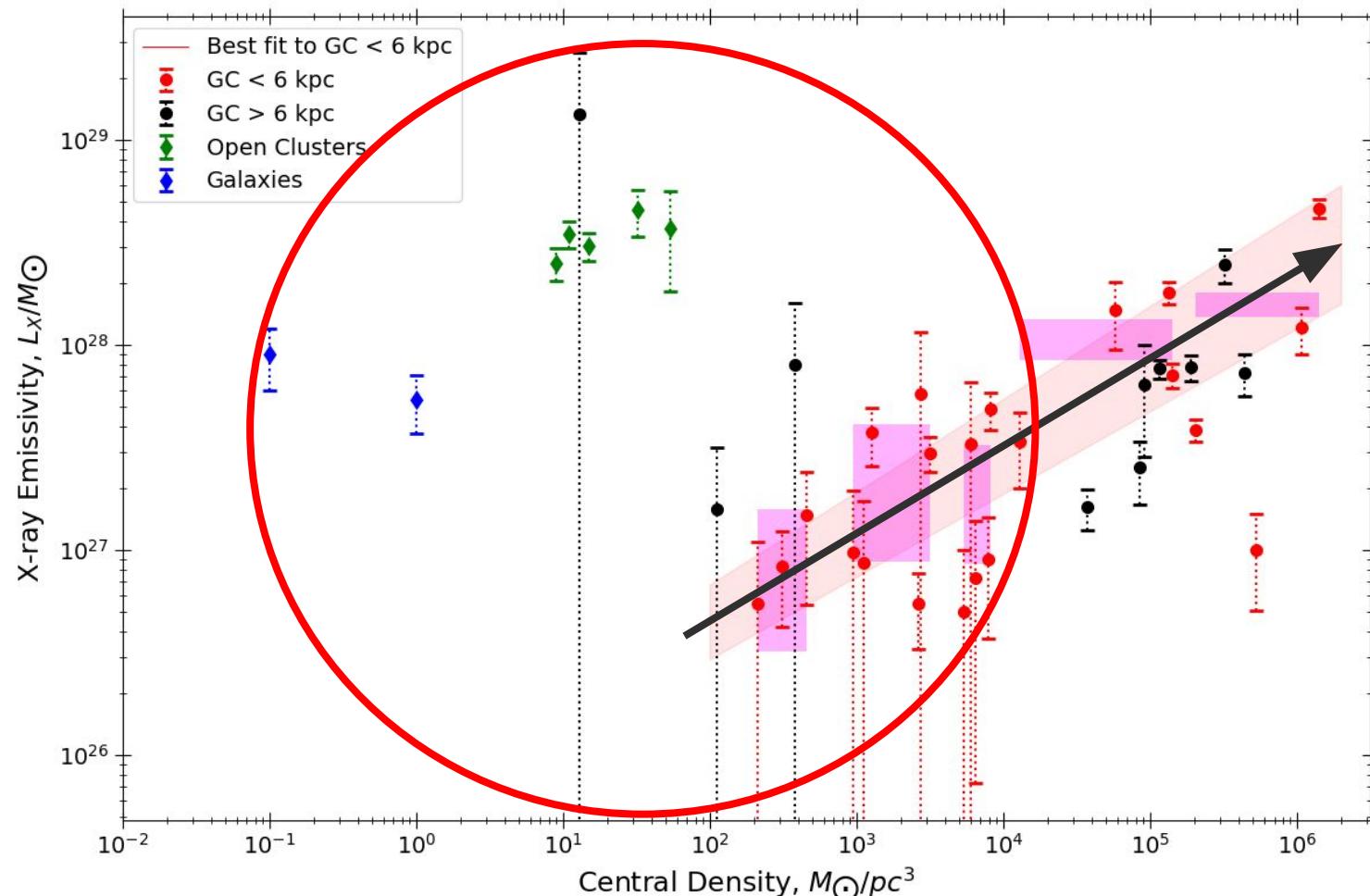
Age

Density



Denser clusters  
→ higher x-ray emissivity

Less dense clusters  
→ lower x-ray emissivity



# Markov Chain Monte Carlo (MCMC)

Statistical analysis in which you randomly sample a probability distribution which is based on “prior” information about the result.

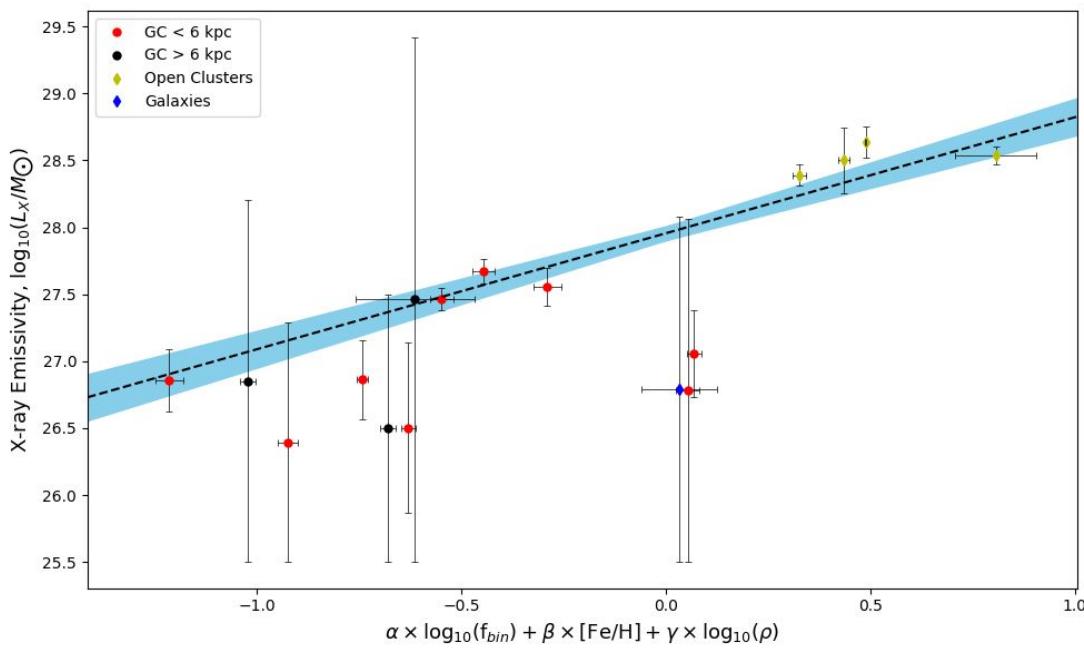
# Markov Chain Monte Carlo (MCMC)

Using this expression for X-ray emissivity:

$$\frac{L_X}{M} = (f_{\text{bin}})^\alpha \times (10^{[\text{Fe}/\text{H}]})^\beta \times (\rho)^\gamma \times 10^b$$

We use “uninformative priors” to sample the “likelihood function”

# Combining parameters for “low $\rho$ ”



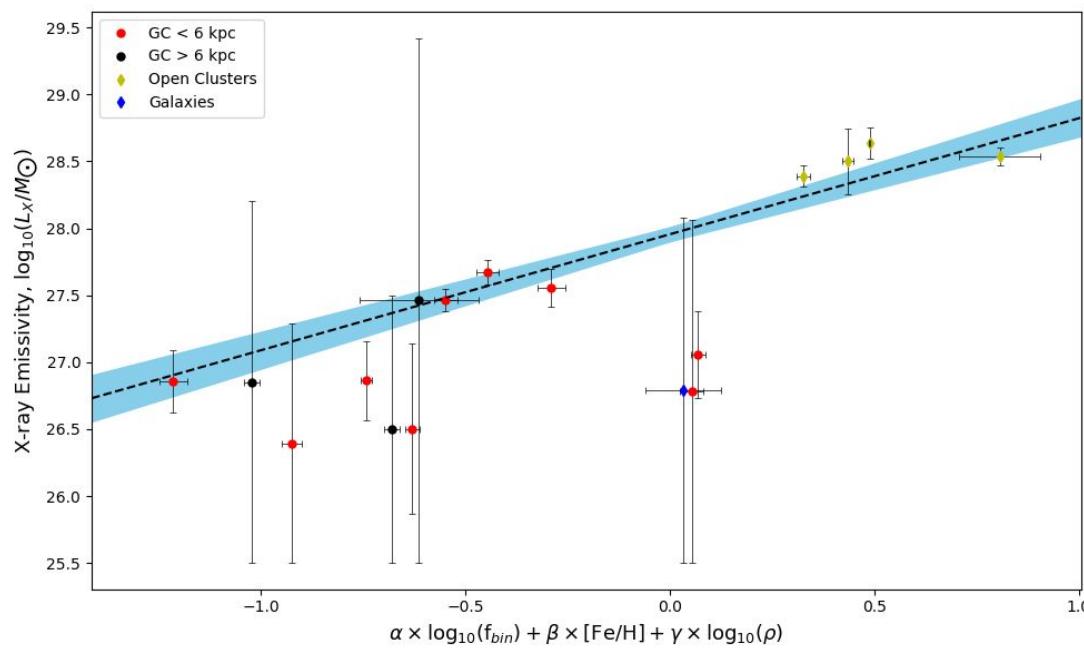
Open clusters define  
the upper limit

$$f_{\text{bin}}^\alpha \sim \alpha = -0.60^{+0.54}_{-0.49}$$

$$[\text{Fe}/\text{H}]^\beta \sim \beta = 1.01^{+0.21}_{-0.24}$$

$$\rho^\gamma \sim \gamma = 0.03^{+0.09}_{-0.08}$$

# Combining parameters for “low $\rho$ ”



Open clusters define  
the upper limit

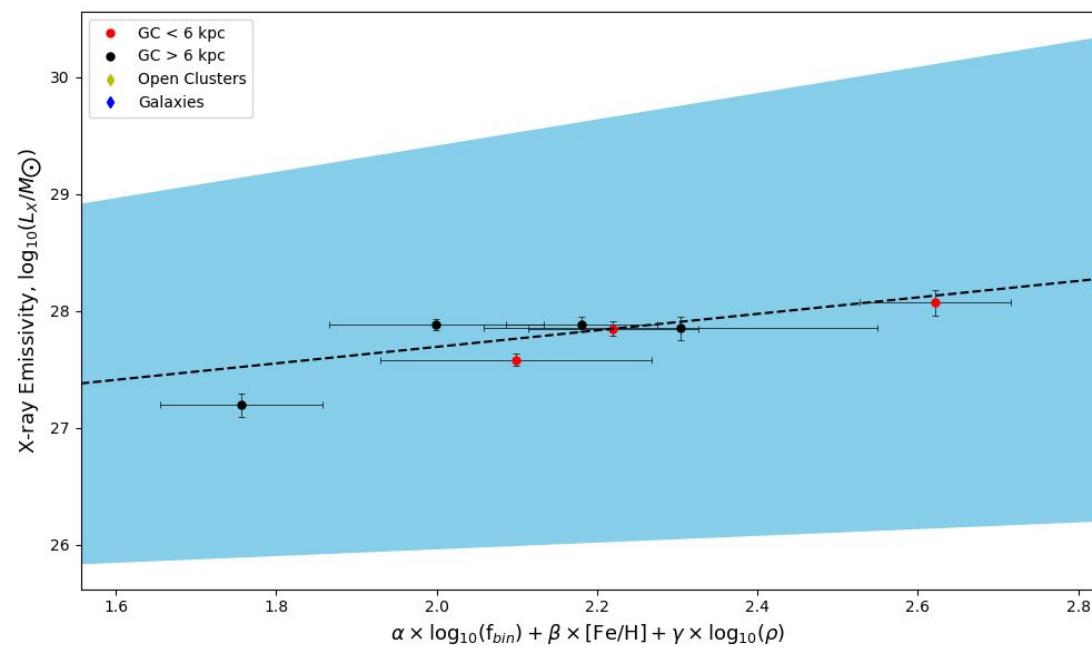
Pearson - 0.754

**p-value = < 0.01**

Spearman = 0.699

**p-value = <0.01**

# Combining parameters for “high $\rho$ ”



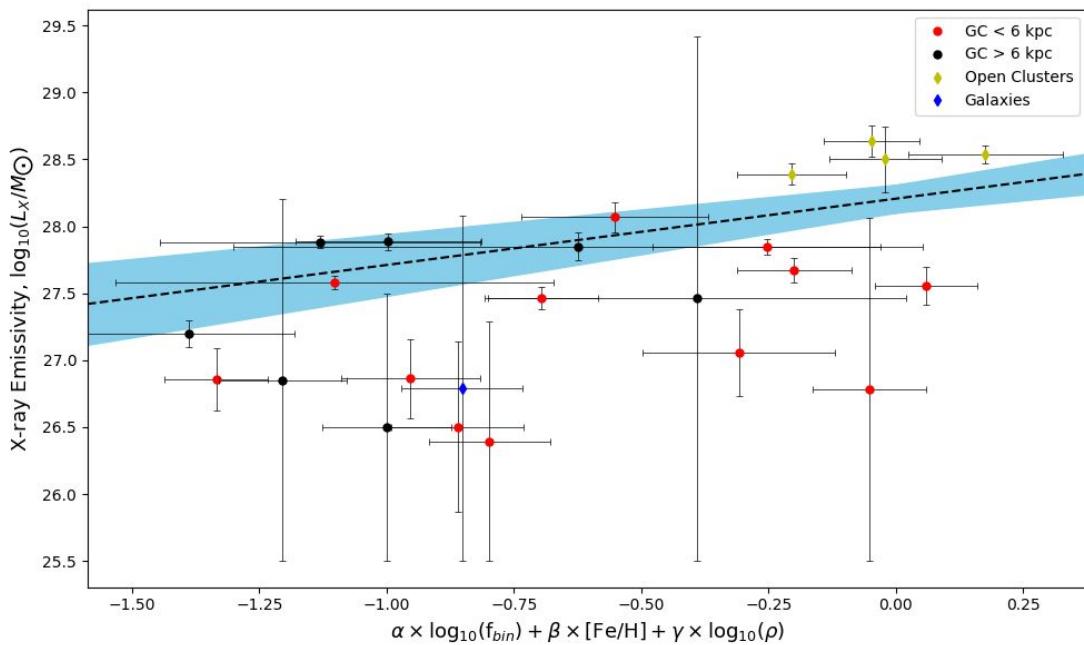
Only 7 sources have  
all three components

$$f_{\text{bin}}^\alpha \sim \alpha = 0.32^{+1.29}_{-1.07}$$

$$[\text{Fe}/\text{H}]^\beta \sim \beta = 0.10^{+0.16}_{-0.11}$$

$$\rho^\gamma \sim \gamma = 0.55^{+0.13}_{-0.14}$$

# Combining parameters for “all $\rho$ ”



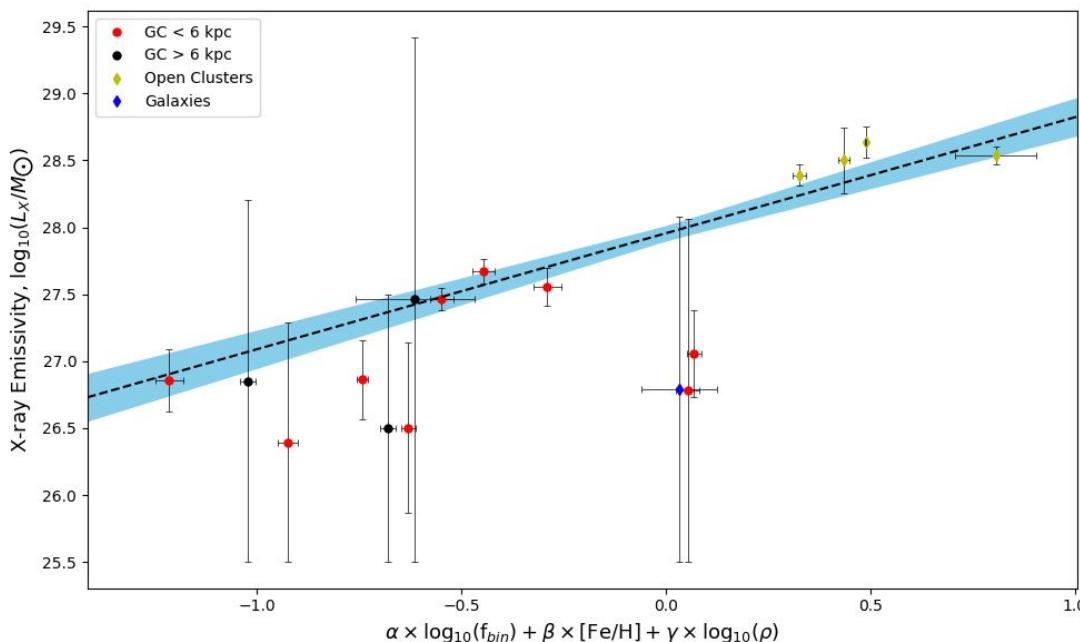
This does not limit  $\rho$  to  $< 10^4 M_\odot/\text{pc}^3$

$$f_{\text{bin}}^\alpha \sim \alpha = 1.04^{+0.14}_{-0.15}$$

$$[\text{Fe}/\text{H}]^\beta \sim \beta = 0.60^{+0.09}_{-0.09}$$

$$\rho^\gamma \sim \gamma = 0.39^{+0.06}_{-0.07}$$

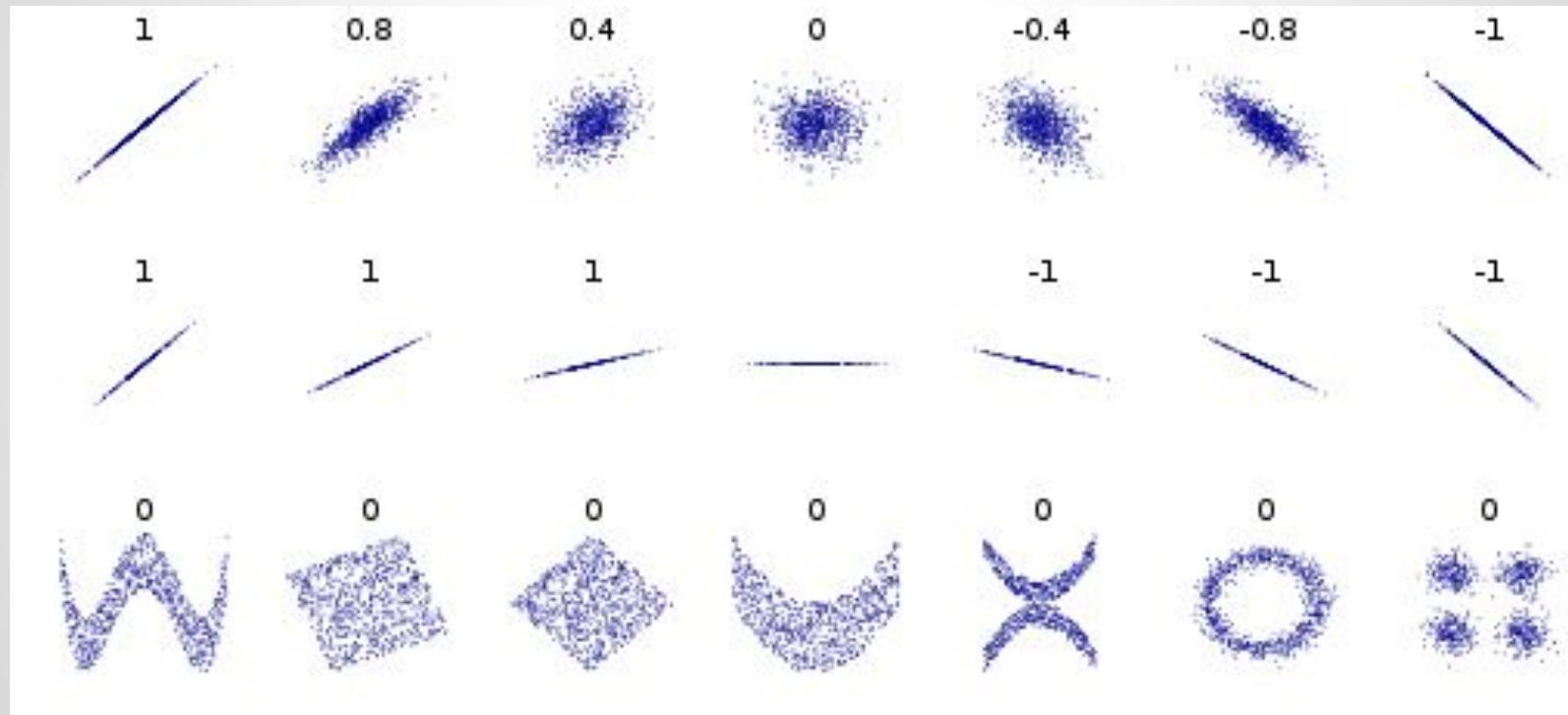
# Summary



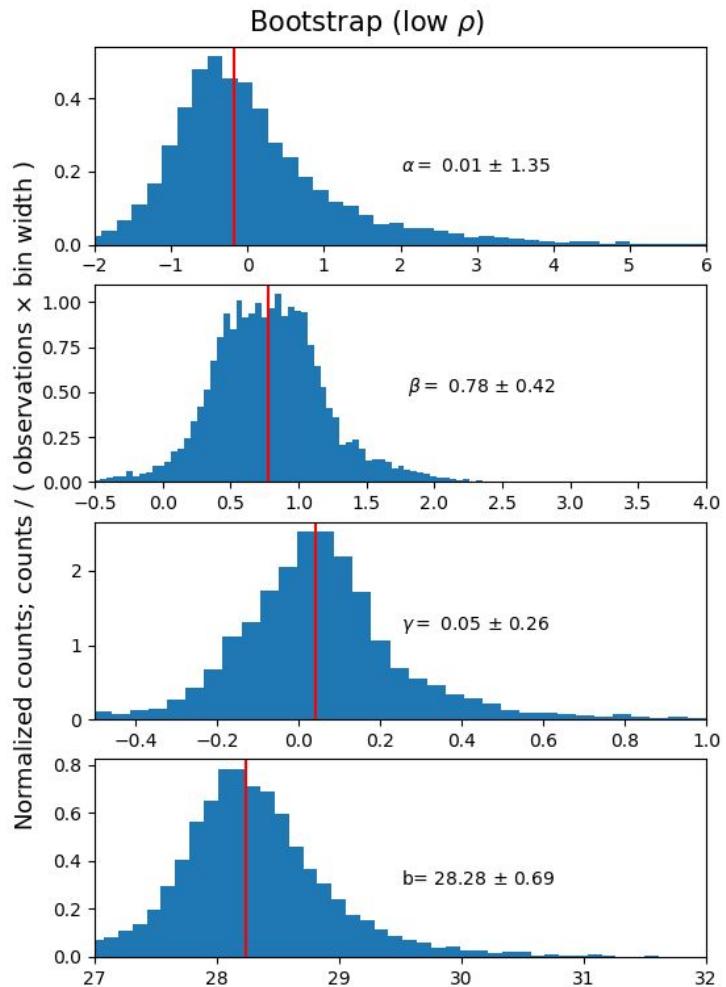
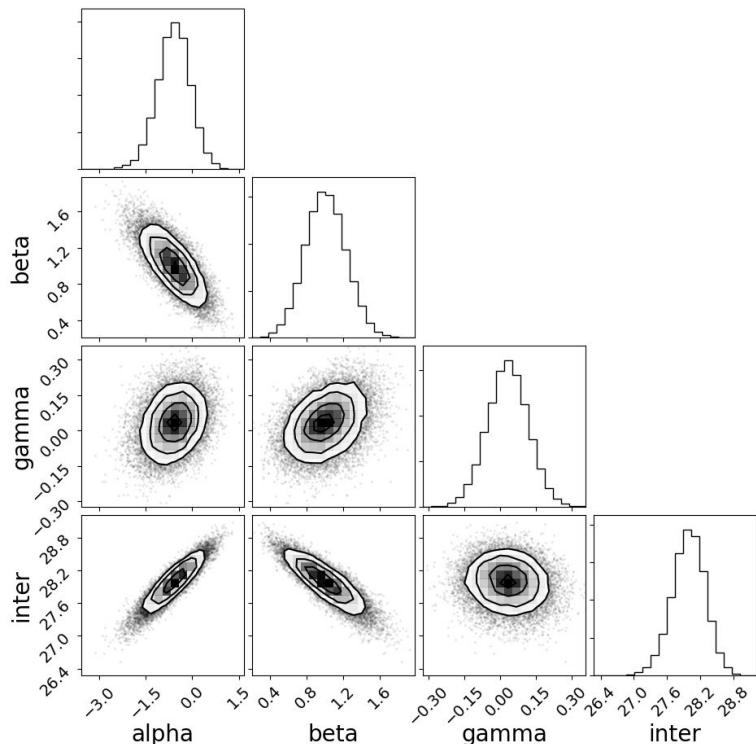
In the “low  $\rho$ ” limit:

- *Metallicity* dominates X-ray emissivity
- Confirmed with other statistical methods
  - Bootstrap
  - Pearson + Spearman

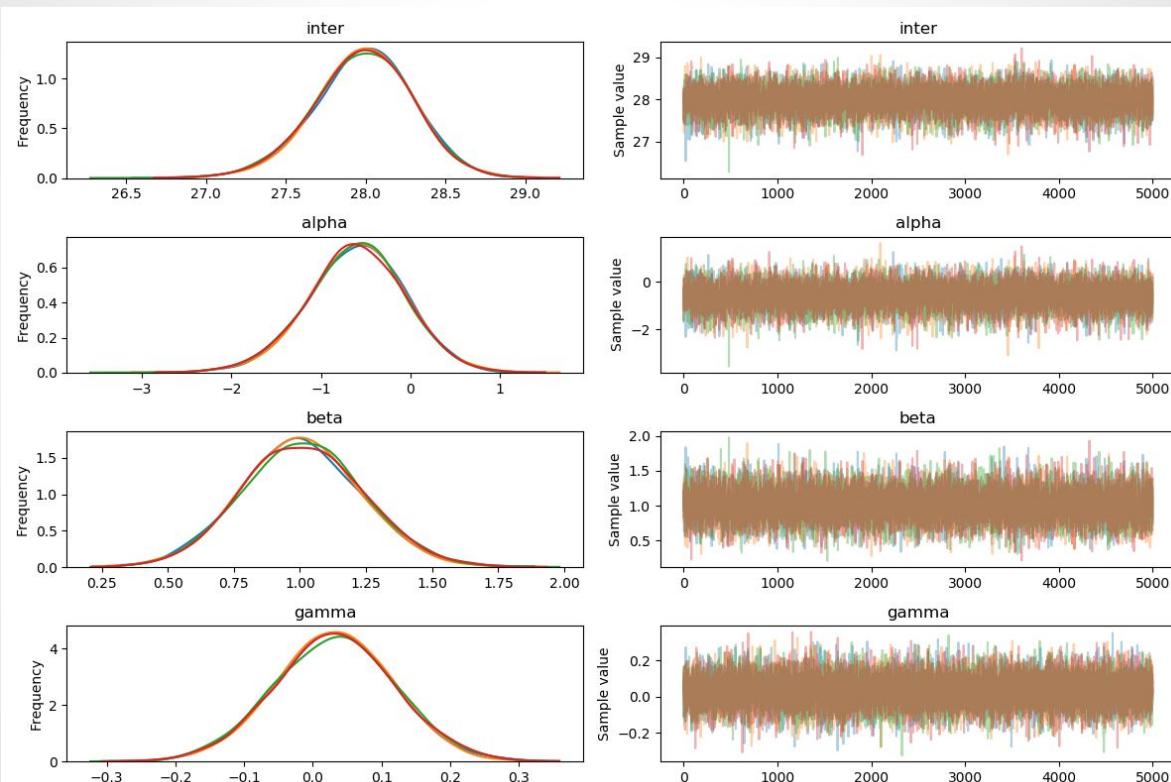
# Extra Slides



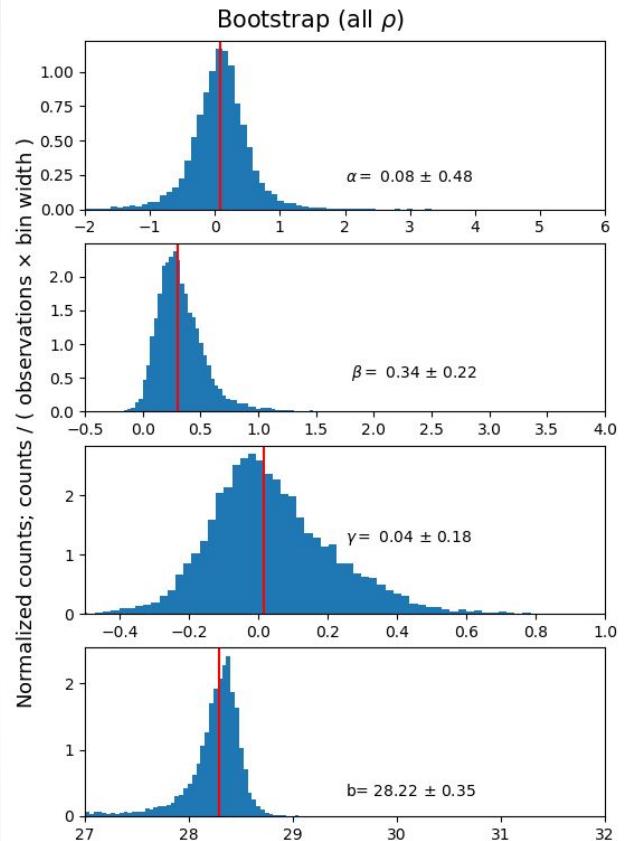
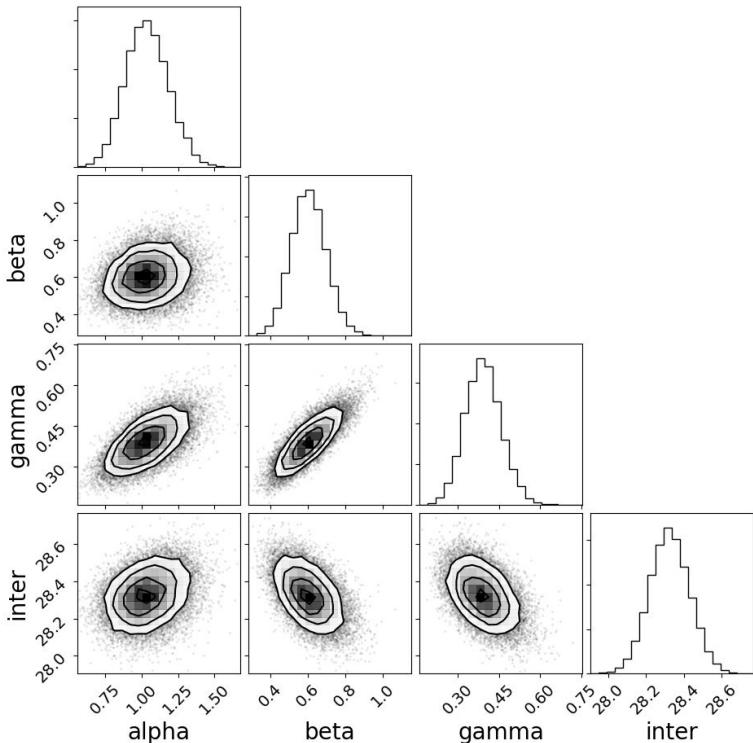
# Extra Slides (low $\rho$ )



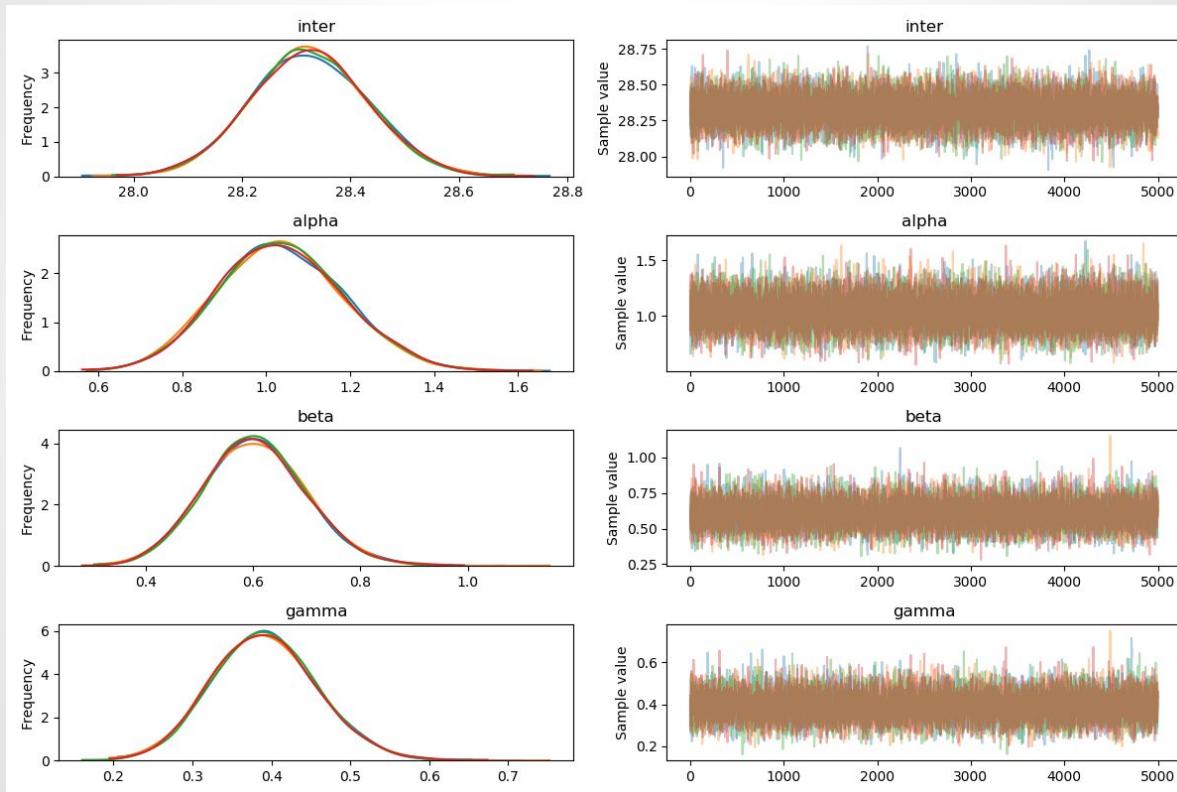
# Extra Slides (low $\rho$ )



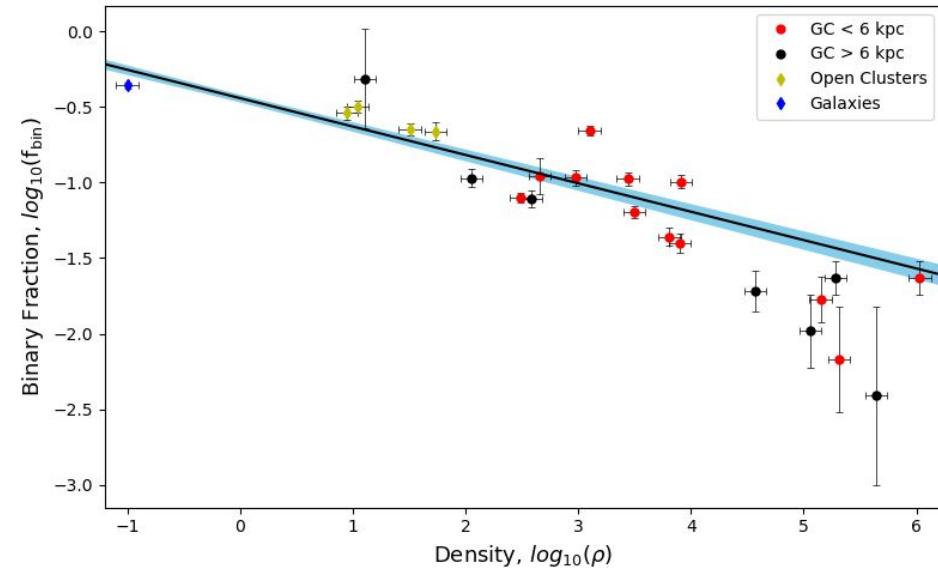
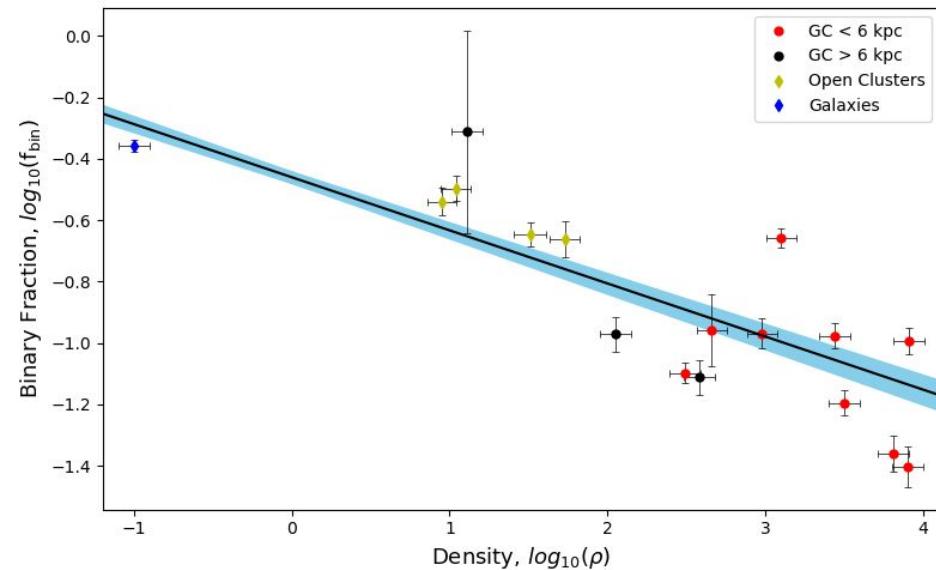
# Extra Slides (all $\rho$ )



# Extra Slides (all $\rho$ )



# Extra Slides (Bin frac vs density)



# Extra Slides (high $\rho$ )

