The XMM Cluster Survey:
The different evolution of X-ray clusters and groups of galaxies

Leyla S. Ebrahimpour

Supervisor

Pedro T. P. Viana

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Outline

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Introduction

Clusters and groups of galaxies

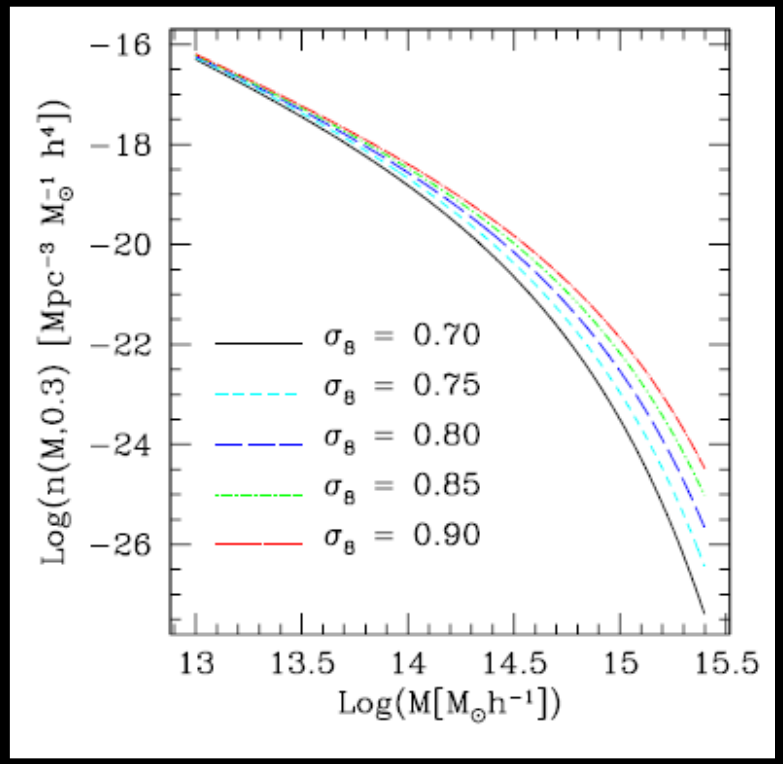
- The largest gravitational bound structures in the Universe
- Important tracers to study the large scale structure
- Constrain the cosmological parameters

Mass function : The abundance of galaxy clusters above a certain threshold as a function of mass and redshift

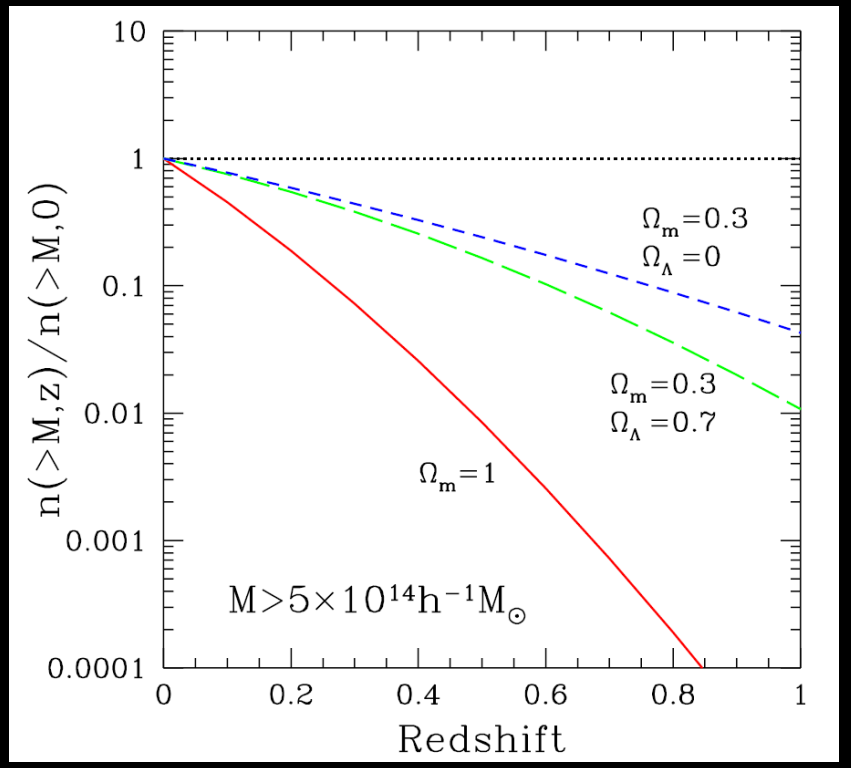
Introduction

Mass Function

- Decreasing function of M steepens at high M: Very high mass clusters extremely rare
- Changing cosmological parameters: Changing shape of mass function



S. Borgani ,2003



Fedeli et al , A&A, 486, 2008

Motivation

How to get the Mass Function?

To measure the MF observationally we need:

- **Detect and count clusters :**

  Cluster surveys

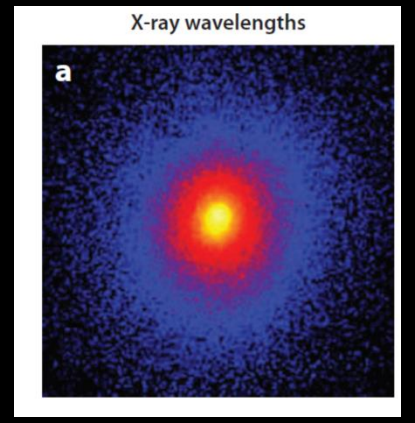
- **Estimate cluster/groups masses :**

✓ Scaling relations between galaxy clusters/groups properties detected through different wavelengths

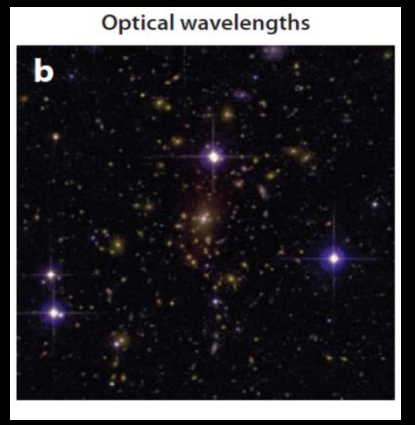
Different scaling behaviors depending on considering whether the cluster or the group regime

These structures have formed and/or evolved with time in different ways

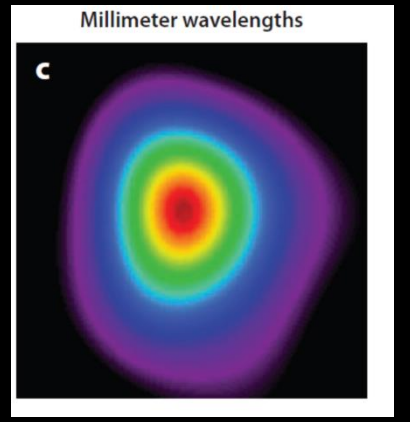
X-ray:
Luminosity,
Temperature



Optical:
Richness



Sub-mm/mm:
SZ flux



Motivation

The L_X -T relation

- Never been characterized simultaneously for groups and clusters of galaxies
- No distinction between clusters and groups/Assumptions to define cluster/group-only samples

$$2 < T < 3 \text{ (KeV)}$$

Motivation

The L_X -T relation

Self-similar Model	$L_X \propto T^2$	$L_X \propto \alpha(1+z)^{\gamma} T^2$	
		$\gamma > 0$	
Observations	$L_X \propto T^{2-3}$	$L_X \propto \alpha(1+z)^{\gamma} T^{\beta}$	
	Vikhlinin et al. 2002; Maughan et al. 2006; Pacaud et al. 2007; Pratt et al. 2009; Takey et al. 2011	$\gamma > 0$	$\gamma = 0$ or < 0
		Vikhlinin et al. 2002; Lumb et al. 2004; Maughanet al. 2006; Pacaud et al. 2007	Ettori et al. 2004; Reichert et al. 2011; Clerc et al. 2012

Work done

➢ The Sample

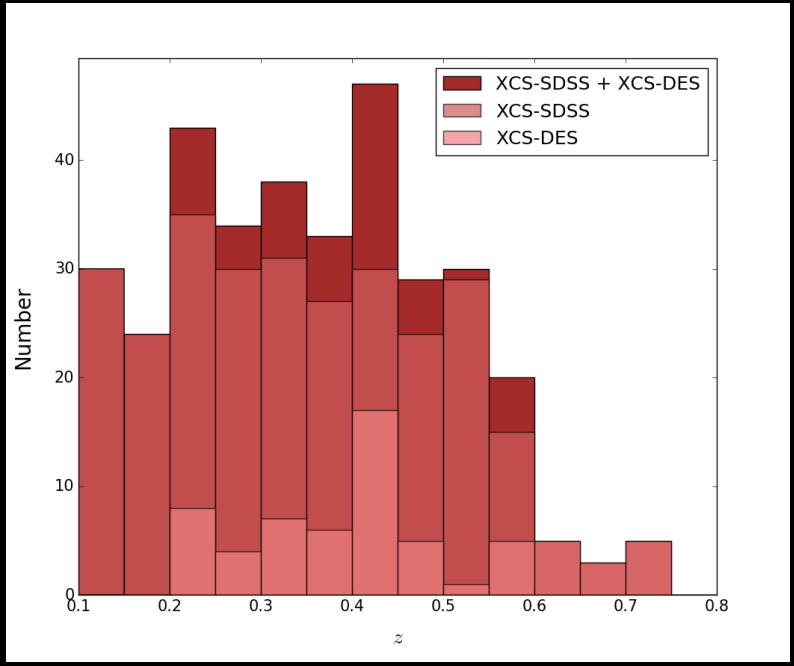
- XCS-redMaPPer SDSS-DR8: 275 clusters and groups with z > 0.1
- XCS-redMaPPer DES: 66 clusters and groups with z > 0.1

341 groups and clusters of galaxies

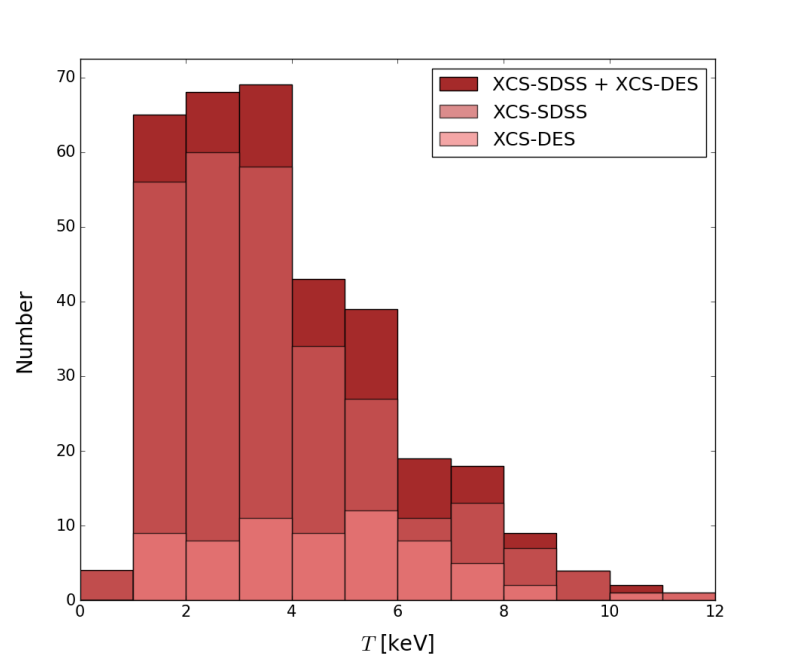
Work done

➢ The Sample

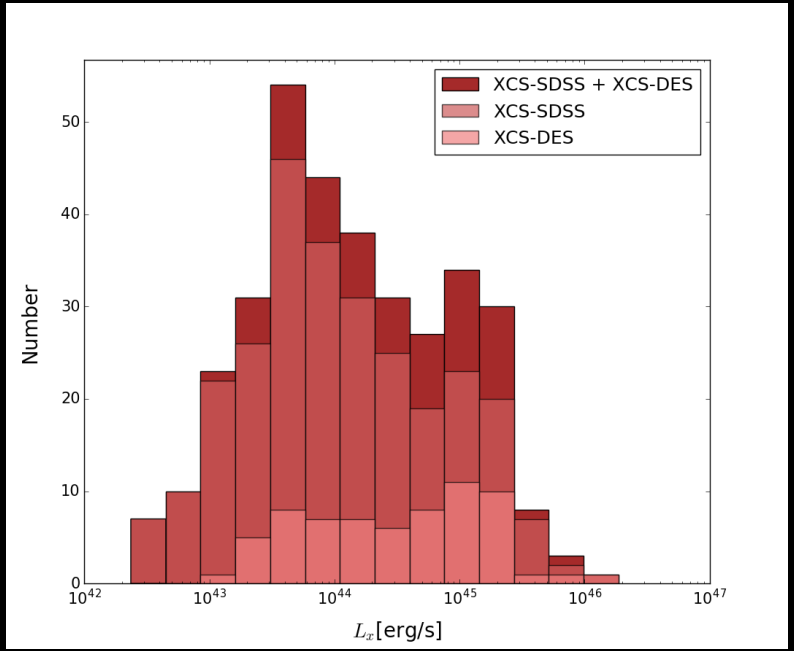
$0.1 < z < 0.8$



$0.36\ \text{keV} < T < 11.5\ \text{keV}$



$2.36\times10^{42}\ \text{erg/s} < L_x < 1.86\times10^{46}\ \text{erg/s}$



Work done

➢ Methodology

Statistical Framework : Hierarchical Bayesian Statistics

$$\mathbf{Y} \sim \alpha \mathbf{X}^{\beta} \boldsymbol{T}^{\gamma}$$

$$\log \mathbf{Y} = \alpha + \beta \log \mathbf{X} + \gamma \log \boldsymbol{T} + \epsilon$$

$$y_i \sim \mathrm{N}(Y_i, \delta_{y,i})$$

$$x_i \sim \mathrm{N}(X_i, \delta_{\mathrm{x},i})$$

$$\theta \equiv (\alpha, \beta, \gamma, \epsilon)$$

$$\underbrace{p(\theta, \psi | x, y)}_{\text{Posterior}} \propto \underbrace{\iint p(x, y | X, Y) p(\mathrm{Y} | X, \theta) p(X | \psi) \mathrm{dX} \mathrm{dY}}_{\text{Likelihood}} \underbrace{p(\theta, \psi)}_{\text{Prior}}$$

$$\log(\mathrm{L}/E_z) = \alpha + \beta \log(\mathrm{T}/5) + \gamma \log(1 + z) + \epsilon$$

$$E_z = (0.27 \times (1 + z)^3 + 0.73)^{1/2}$$

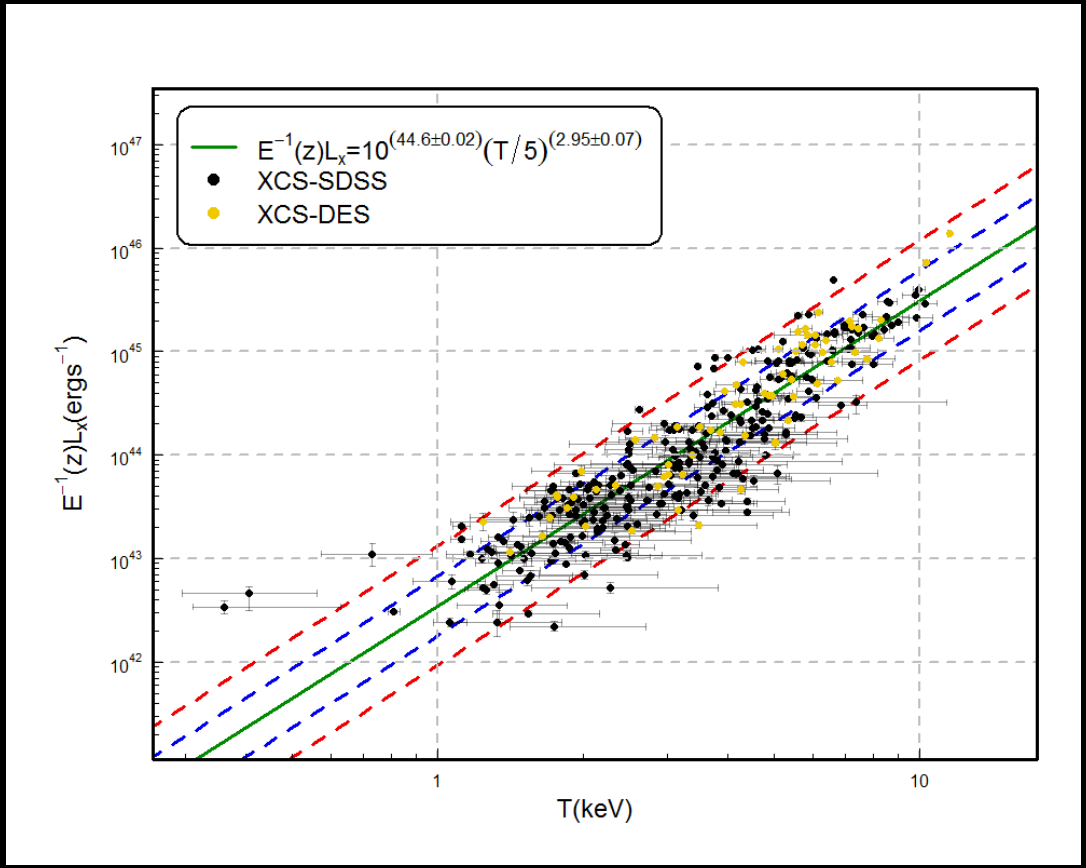
R programming :lira

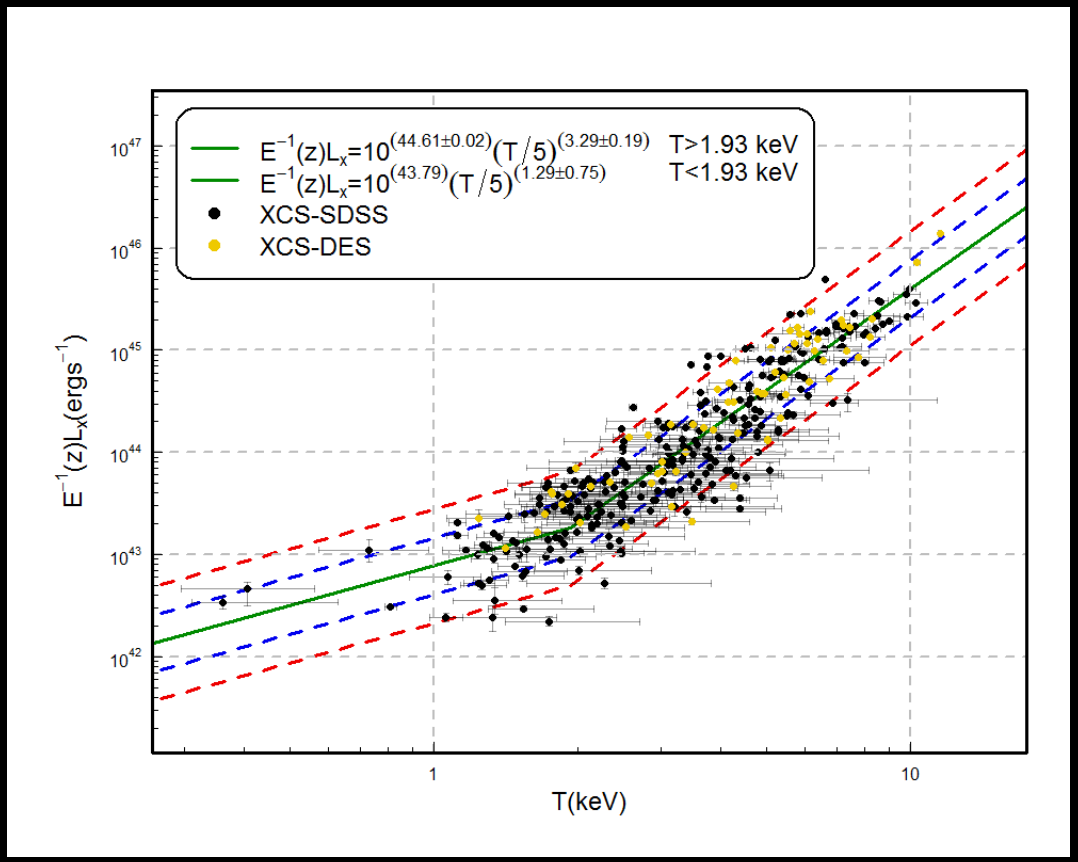
Mauro Sereno, http://arxiv.org/pdf/1509.05778v2.pdf16

Work done

➢ Results

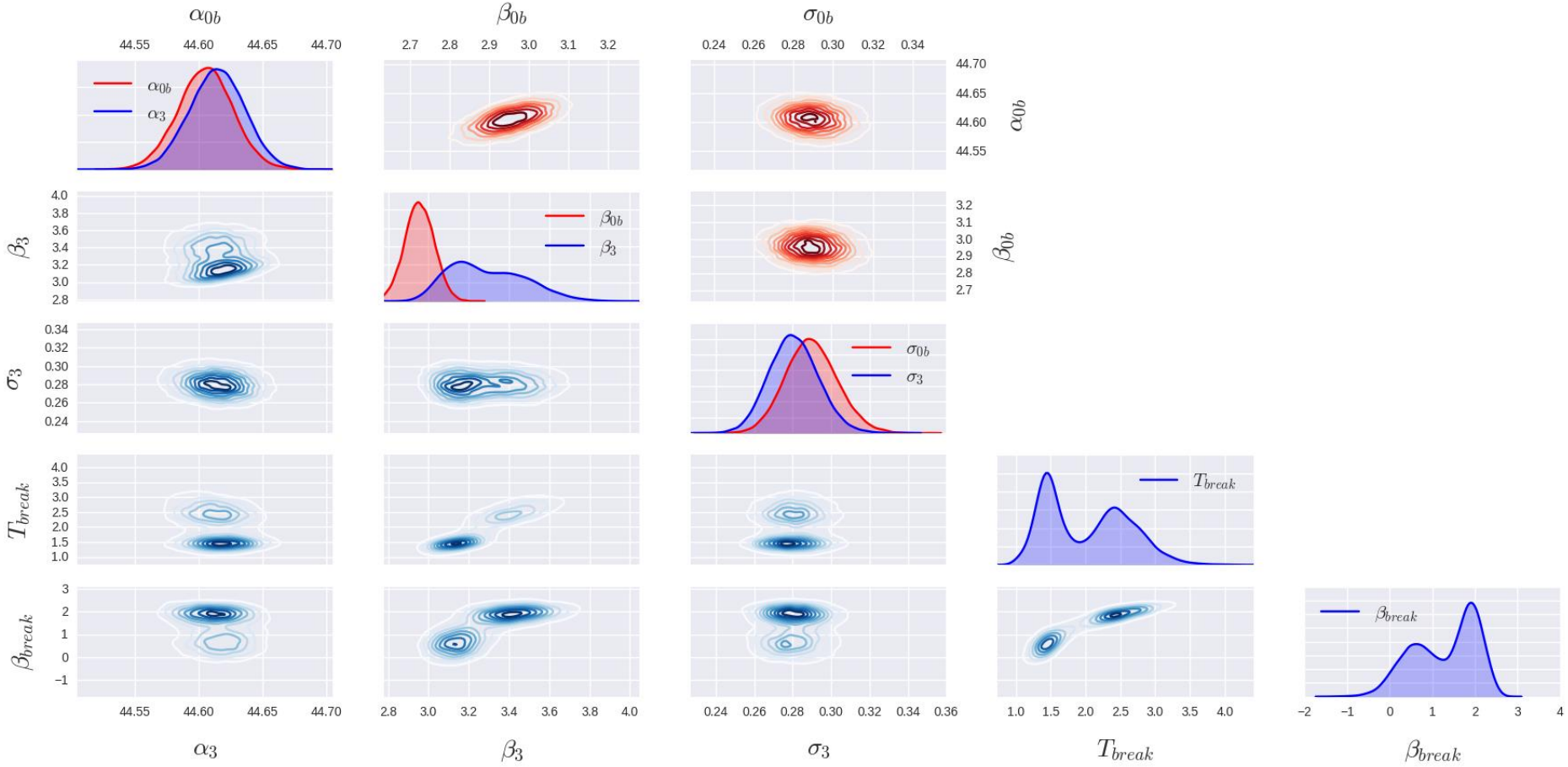
L-T scaling relation





Work done

➢ Results



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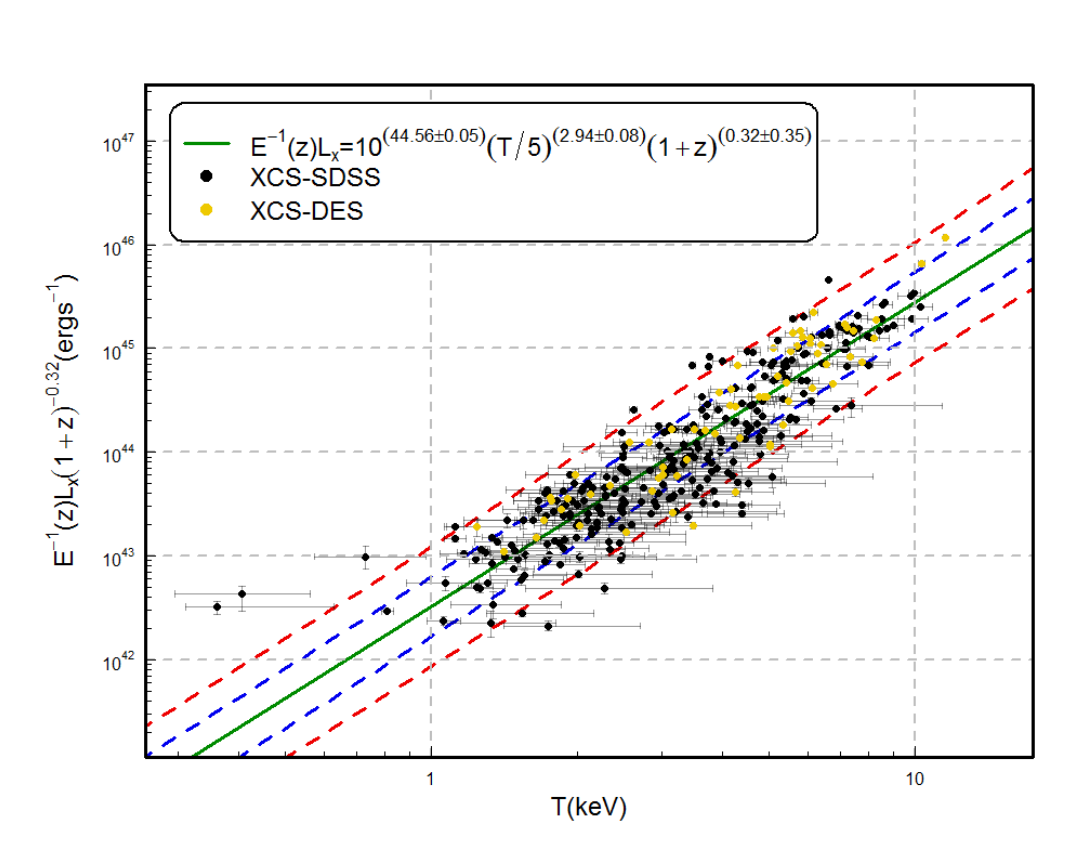
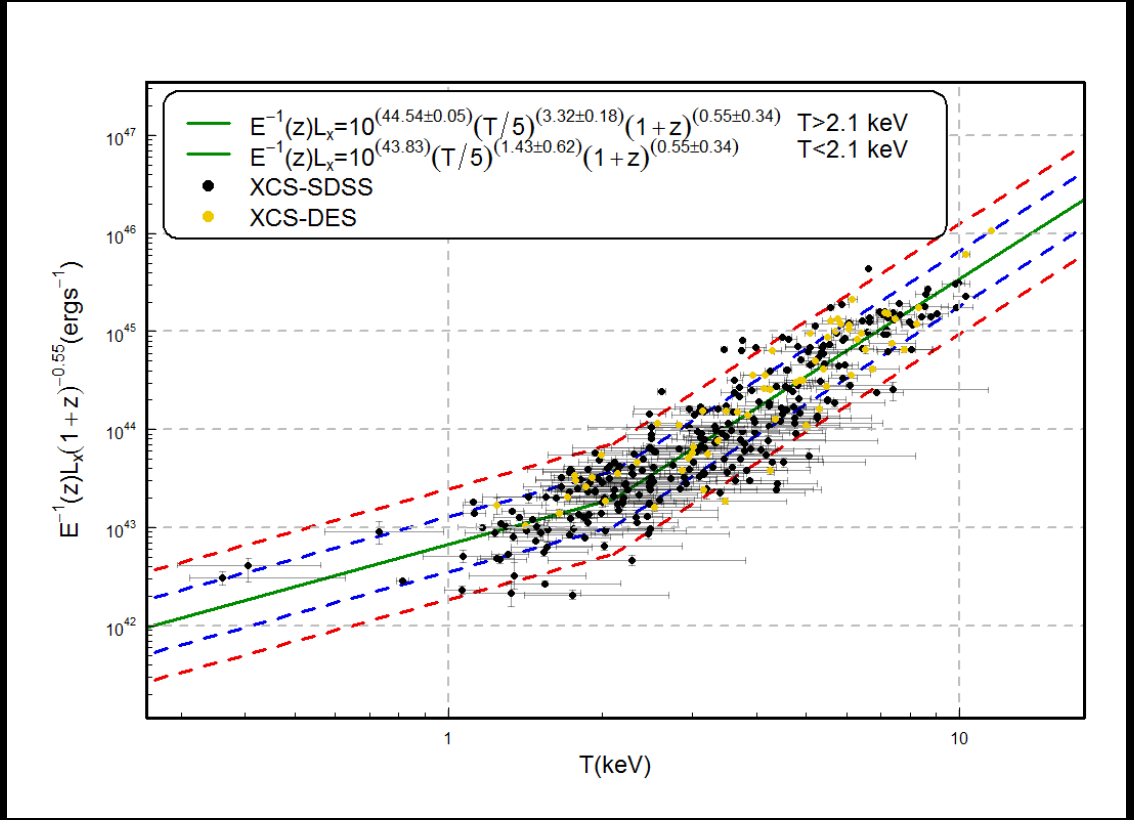
➢ Results

L-T scaling relation





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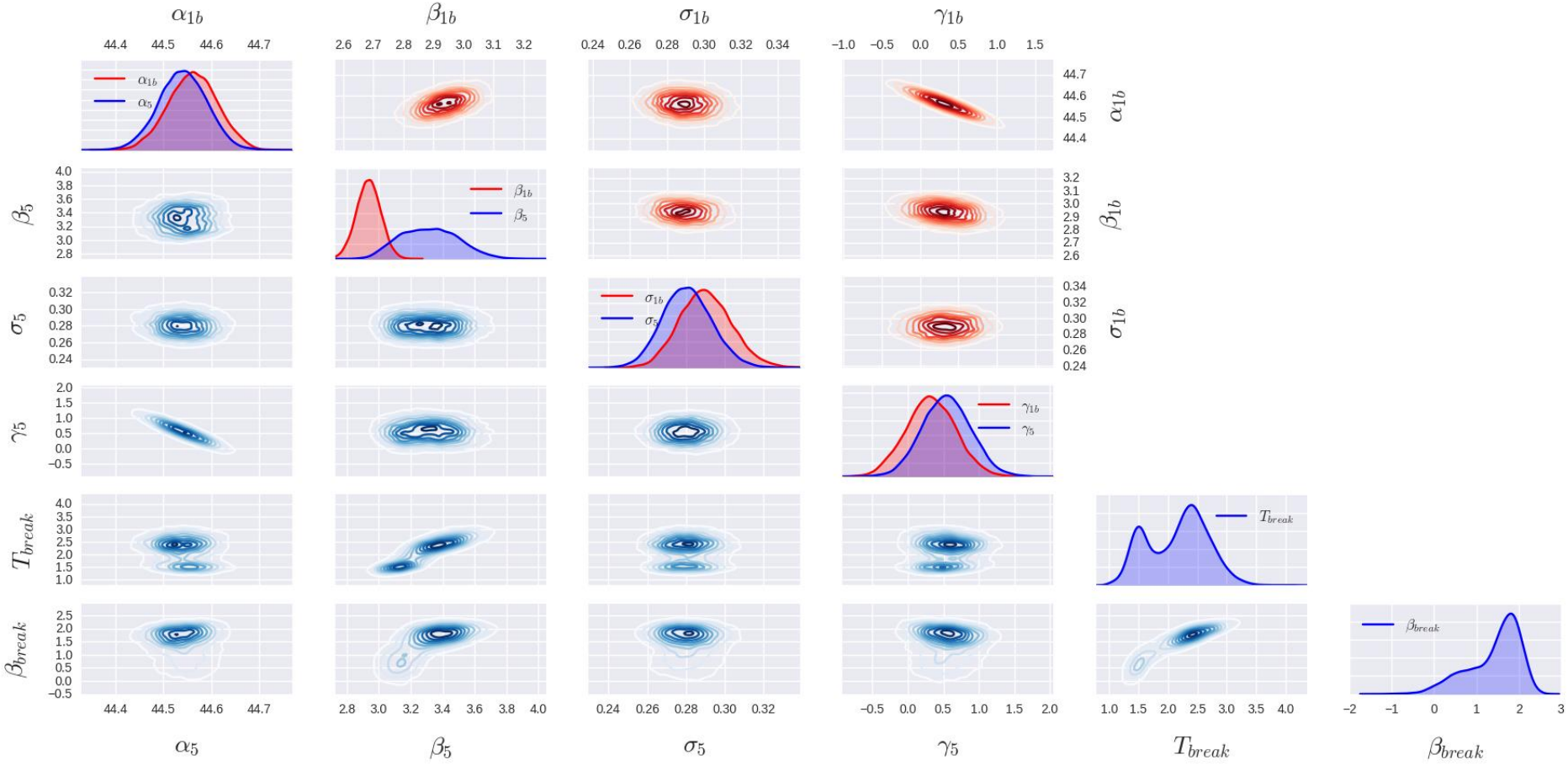

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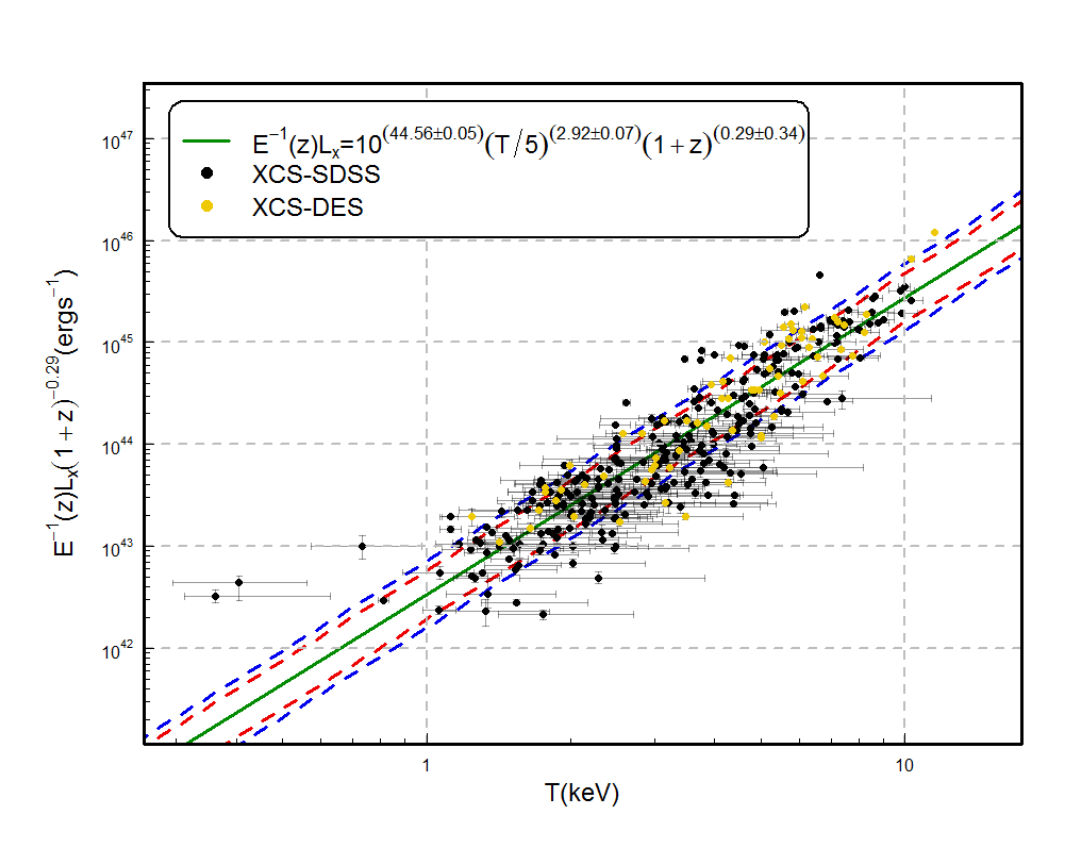
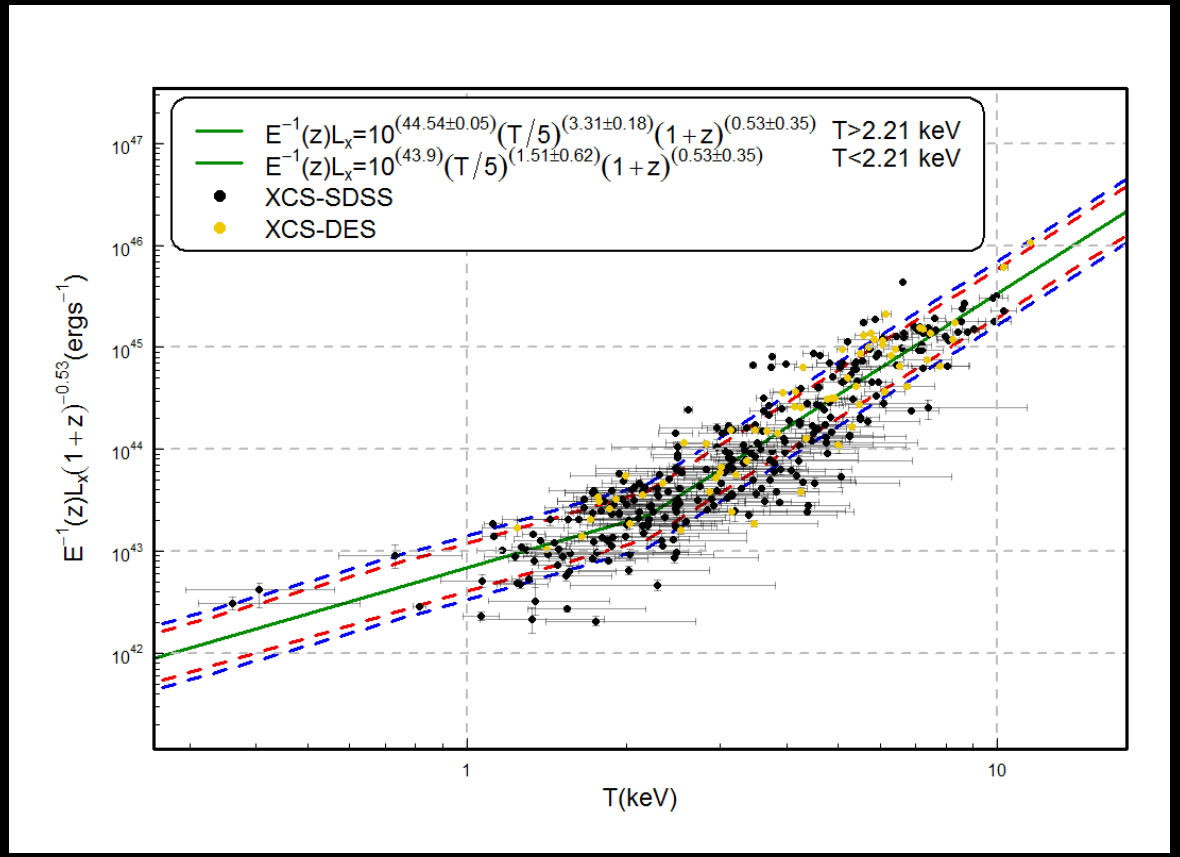
➢ Results

L-T scaling relation





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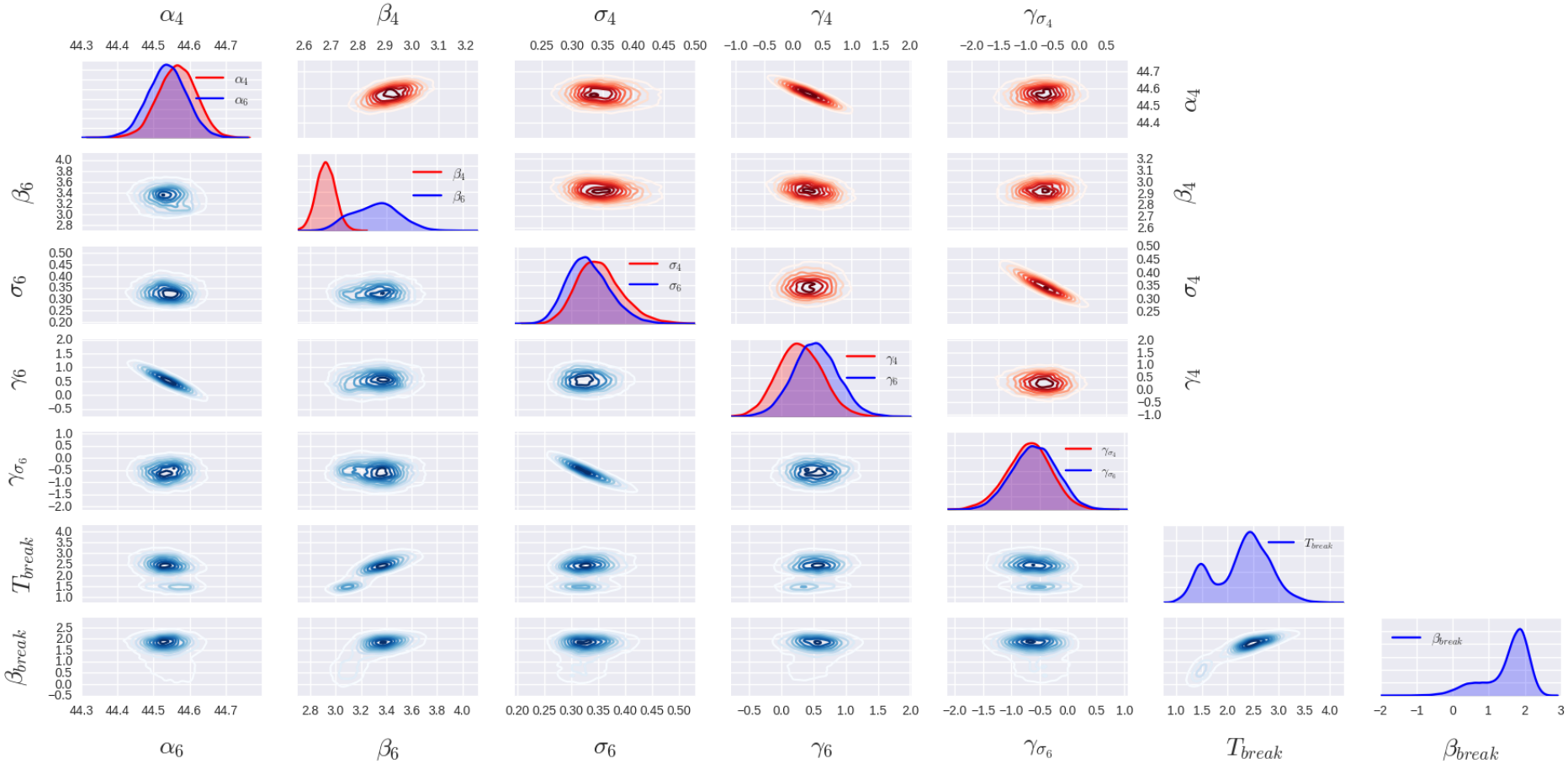

Conclusion

- Use hierarchical Bayesian statistics to estimate the X-ray luminosity of groups and clusters of galaxies applying the XCS data cross matched by redMaPPer SDSS-DR8 and redMaPPer DES data
- Different L-T relations are estimated for groups and clusters of galaxies together with the transition point
- A steeper slope than the self-similar expectation, which is $\boldsymbol{L/E_z \propto T^2}$, for clusters and a slower slope for groups of galaxies
- The redshift evolution is positive which leads to a stronger evolution in luminosity at fixed temperature than the self-similar model

Thanks for your attention