X-ray Galaxy Cluster Properties with eROSITA

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Overview

Introduction - Galaxy Cluster Emission

Galaxy Clusters:

- largest gravitationally bound objects
- hydrostatic equilibrium

X-ray emission from the ICM

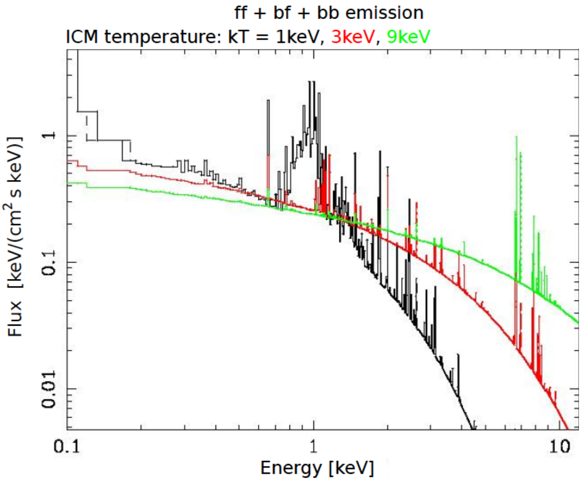
- temperatures of k$T \approx 1$ - 10 keV
- highly ionised metals

emission mechanisms:

- thermal bremsstrahlung emission (ff)
- line emission (bb)
- fb-emission

Galaxy Cluster Abell 1689; Credit: www.chandra.harvard.edu

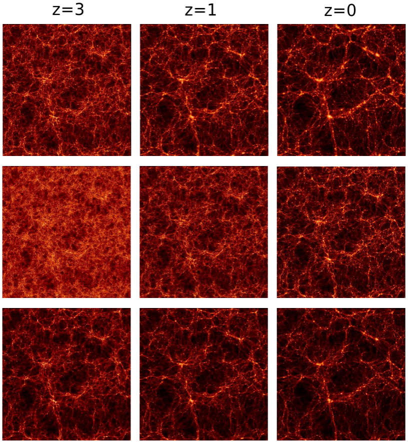
Introduction - Galaxy Cluster Emission



Credit: T. H. Reiprich

Introduction - Cosmology

Evolution of the **l**arge **s**cale **s**tructure (LSS)



$\Omega_m = 0.3$
$\Omega_\Lambda = 0.7$

$\Omega_m = 1.0$
$\Omega_\Lambda = 0$

$\Omega_m = 0.3$
$\Omega_\Lambda = 0$

Credit: VIRGO Collaboration, 1996

Introduction - The eROSITA Mission

- German X-ray instrument aboard the Russian SRG satellite
- 7 mirror modules
- energy range: 0.1 - 10 keV
- expected launch date: 2014 to an L2 orbit
- 4-year all sky survey

Credit: Merloni et al. 2012

Main science goals:

- study large samples of galaxy clusters up to $z > 1$
- trace the large scale structure of the Universe
- test the nature of **dark energy**!

Research Project

Project aim: forecasts of the precision and accuracy of eROSITA galaxy cluster characteristics

- What relative uncertainties can be expected for the cluster properties?

  ⇒ concentrating on the cluster temperature and redshift

- What biases arise due to the finite resolution of the instrument and the data analysis?

Motivation:

- tight constraints on the cosmological parameters
- precise and accurate interpretation of future eROSITA data
- optimizing optical follow-up observations

Simulation Methodology

Strategy to obtain the precision and accuracy of the cluster properties:

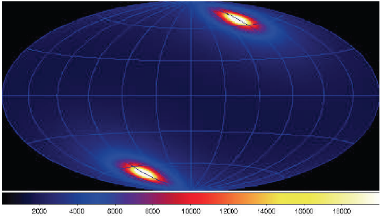
1. simulate cluster+background emission for defined cluster parameters
2. remove background emission
3. fit model of cluster emission to the data
4. repeat all steps $1,000$ times for good statistics

To obtain cluster parameters: define a cluster mass and move it in redshift

- applying the scaling relations by Reichert et al. (2011) and Vikhlinin et al. (2009)

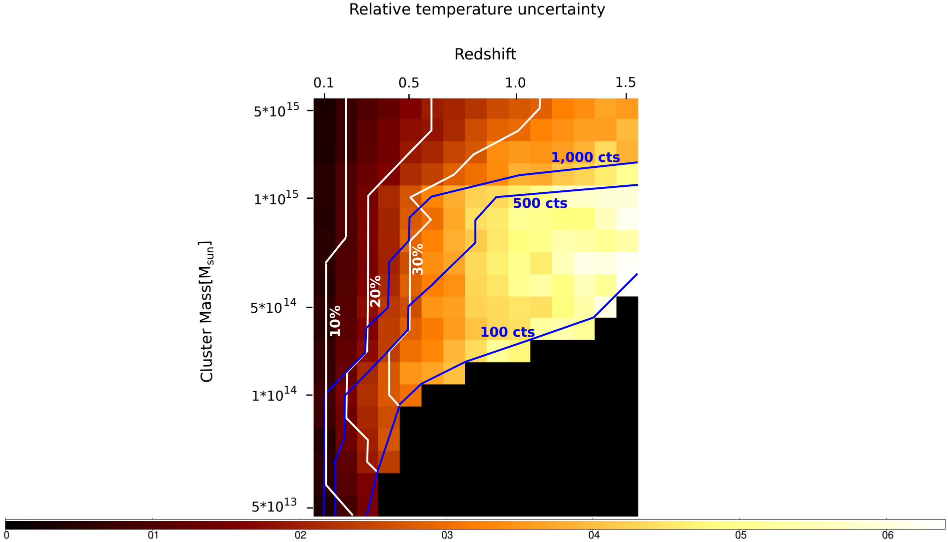
Simulation Methodology

analysing four different cases:

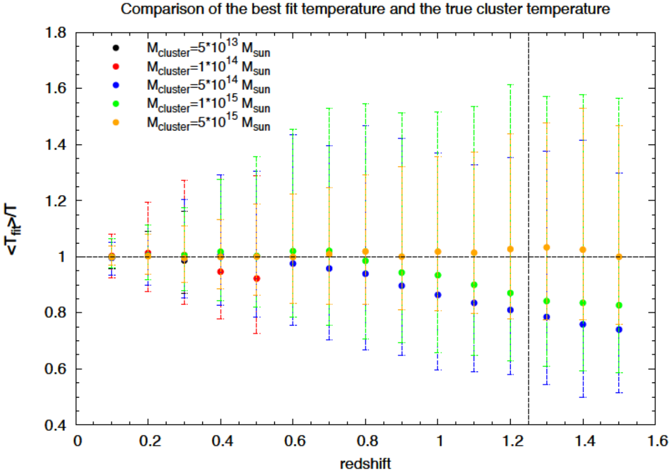


- exposure time
  - $t_{\mathrm{exp}} = 1.6$ ks: effective exposure time for the all sky survey
  - $t_{\mathrm{exp}} = 20$ ks: eROSITA deep fields at the ecliptic poles
- fit parameters
  - frozen redshift: redshift is known from optical follow-up observations
  - variable redshift: redshift needs to be determined from X-ray data

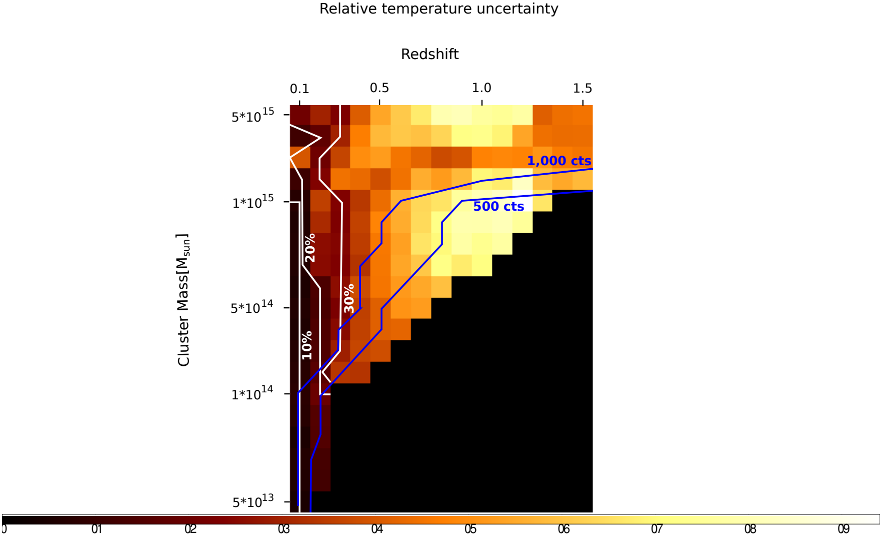
Results - $t_{\rm exp} = 1.6$ ks, known redshift



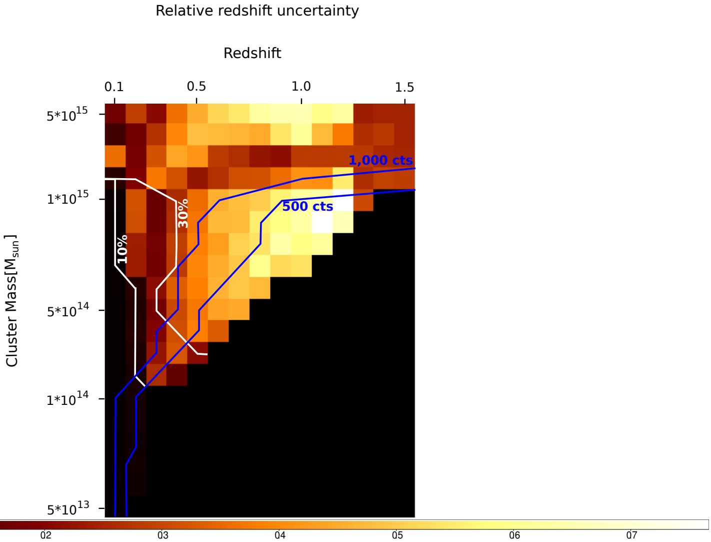
Results - $t_{exp} = 1.6$ ks, known redshift



$t_{\text{exp}} = 1.6$ ks, unknown redshift



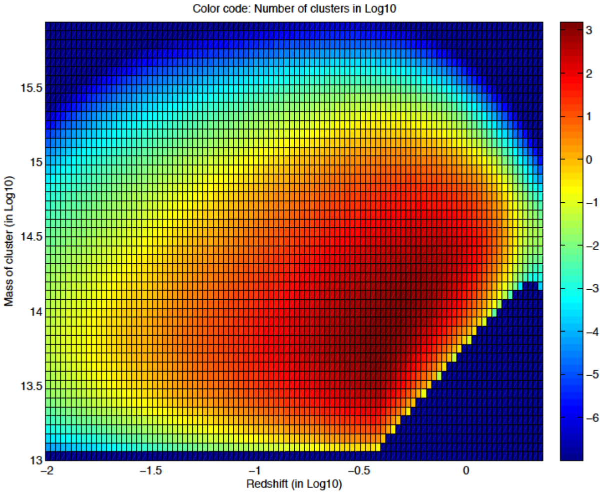
$t_{exp} = 1.6$ ks, unknown redshift



Results - Interpretation

- high precision in temperature and redshift for local clusters
  - optimize optical follow-up observations
- relative uncertainties do not depend on the number of photon counts, but mainly on the cluster redshift
- for high precision clusters no bias needs to be corrected for
  - no bias in temperature and redshift
  - no bias in the uncertainties

Results - Interpretation



Credit: M. Irshad et al., in preparation

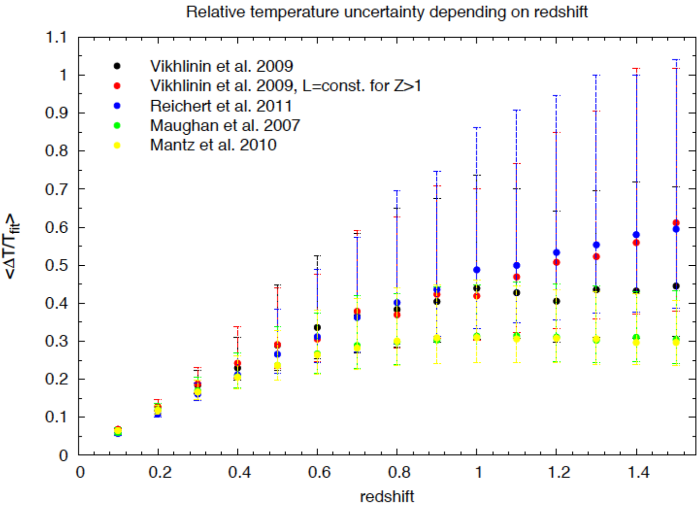
Results - Interpretation

Interpretation: number of high precision clusters

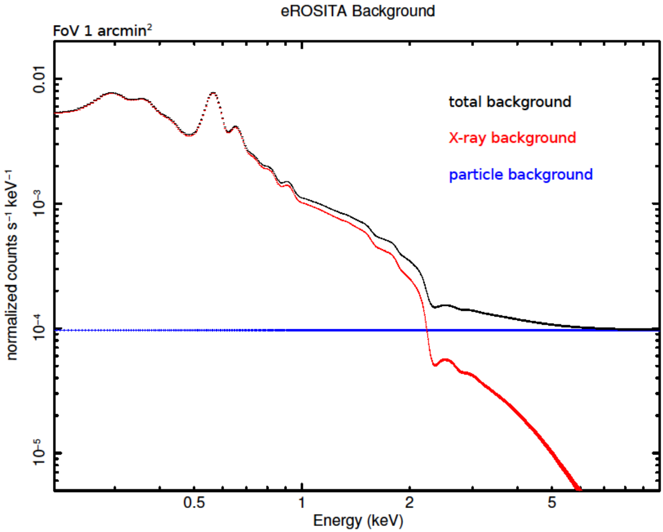
	$t_{exp} = 1.6$ ks, $f_{sky} = 0.658$	$t_{exp} = 20$ ks, $f_{sky} = 0.0034$
total	$\sim 164,400$	$\sim 5,800$
known z	$\sim 17,400$ ($\sim 10\%$)	$\sim 2,500$ ($\sim 44\%$)
unknown z	$\sim 12,600$ ($\sim 8\%$)	$\sim 1,600$ ($\sim 27\%$)

Credit: in cooperation with M. Irshad

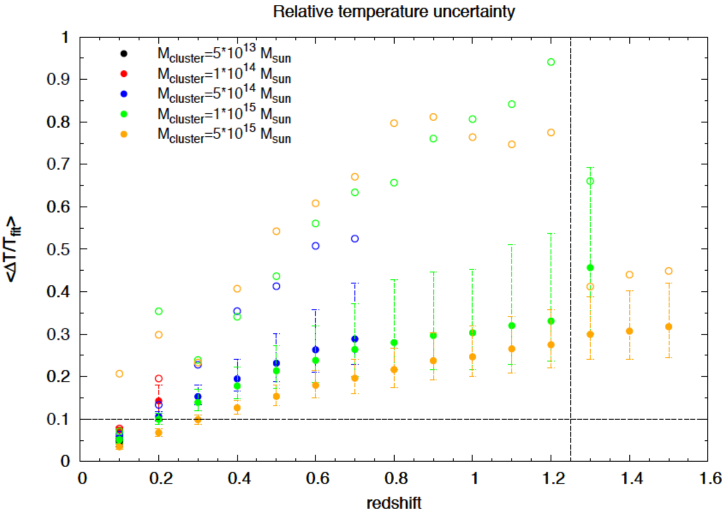
Simulation Methodology - Applied Astrophysics



The eROSITA X-ray Background



$t_{\text{exp}} = 1.6$ ks, unknown redshift



$t_{\mathrm{exp}} = 20$ ks, known redshift