Research roject

Simulation Methodology

# X-ray Galaxy Cluster Properties with eROSITA

## Katharina Borm

T. H. Reiprich, L. Lovisari

20 September 2012



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## Overview

### Introduction

X-ray Emission from Galaxy Clusters Cosmology The eROSITA mission

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#### Results

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

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Galaxy Cluster Emission	

### Introduction - Galaxy Cluster Emission

Galaxy Clusters:

- largest gravitationally bound objects
- hydrostatic equilibrium
- X-ray emission from the ICM
  - $\blacktriangleright$  temperatures of kT  $\approx 1$  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

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### Introduction - Galaxy Cluster Emission





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## Introduction - Cosmology

### Evolution of the large scale structure (LSS)



#### Credit: VIRGO Collaboration, 1996

Galaxy Cluster Properties

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# 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

Main science goals:

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



Credit: Merloni et al. 2012

## Research Project

 $\label{eq:project aim: forecasts of the precision and accuracy of eROSITA galaxy cluster characteristics$ 

What relative uncertainties can be expected for the cluster properties?

 $\Rightarrow$  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)

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## Simulation Methodology

analysing four different cases:



#### exposure time

- $t_{exp} = 1.6$  ks: effective exposure time for the all sky survey
- $t_{exp} = 20$  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

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

Relative temperature uncertainty



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



Comparison of the best fit temperature and the true cluster temperature

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

Relative temperature uncertainty



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

Relative redshift uncertainty



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Interpretation		

### 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

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## Results - Interpretation



Credit: M. Irshad et al., in preparation

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### Results - Interpretation

#### Interpretation: number of high precision clusters

	$t_{\rm exp} = 1.6$ ks, $f_{\rm sky} = 0.658$	$t_{\mathrm{exp}}=20$ ks, $f_{\mathrm{sky}}=0.0034$
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



Relative temperature uncertainty depending on redshift

### The eROSITA X-ray Background



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Galaxy Cluster Properties

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

1 M<sub>cluster</sub>=5\*10<sup>13</sup> M<sub>sun</sub> Mcluster=5 10 Msun Mcluster=1\*10<sup>14</sup> Msun Mcluster=5\*10<sup>14</sup> Msun Mcluster=1\*10<sup>15</sup> Msun Mcluster=5\*10<sup>15</sup> Msun 0.9 **8.0** 0.7 0.6 <∆T/T∰> 0 0.5 0 8 0.4 8 0.3 0.2 0.1 0 0.2 0.4 0.8 1.2 0 0.6 1 1.4 1.6 redshift

Relative temperature uncertainty

### $t_{exp} = 20$ ks, known redshift

Relative temperature uncertainty



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