



# THE SECOND XCS DATA RELEASE AND THE CLUSTERS IN THE SDSS AREA

Maria Manolopoulou *(manolo@roe.ac.uk)*

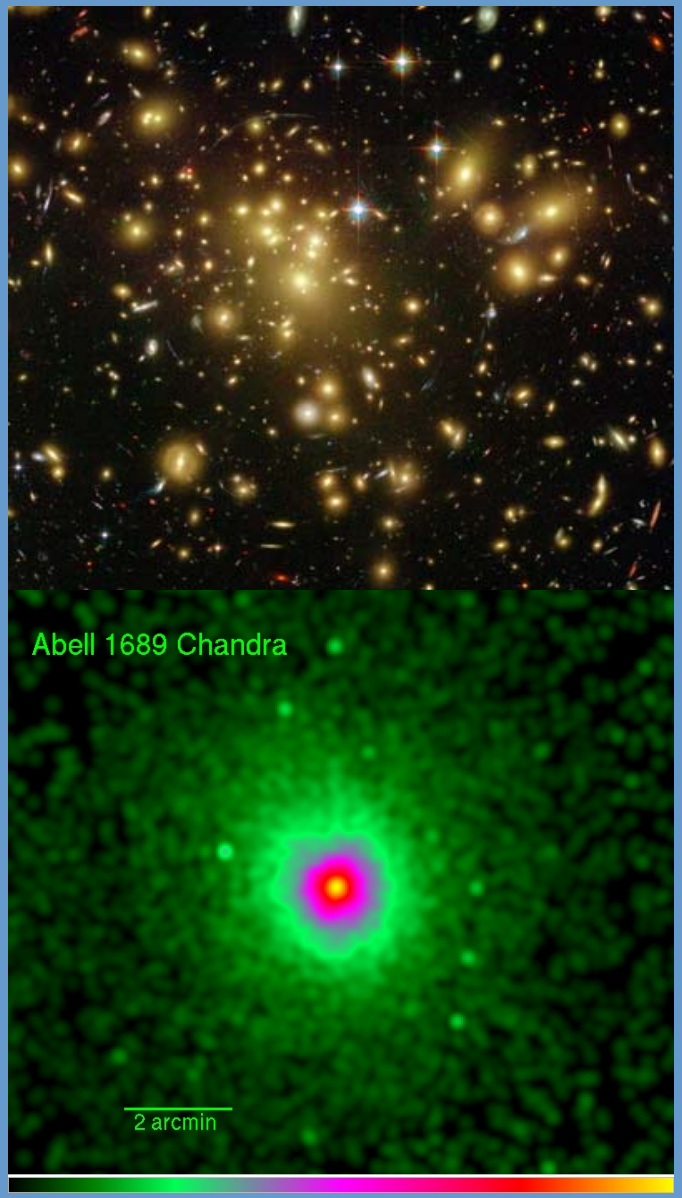
Supervisors: Bob Mann, Catherine Heymans

# Outline

- Galaxy clusters
- The XMM Cluster Survey (XCS)
- Optical confirmation
- Cluster redshifts
- Clusters in voids
- Future work

# Galaxy clusters

- Largest gravitationally bound objects
- Dark matter – 90%
  Hot gas – 9%
  Galaxies – 1%
- Optical: red sequence, brightest cluster galaxy (BCG)
  X-rays: bright, extended sources, intracluster gas emission
- - Cluster scaling relations ($L_x$, $T_x$, $\lambda$) → calculate cluster masses → constrain cosmological parameters (e.g. Allen, Evrard & Mantz 2011)
  - Study cluster galaxy (e.g. BCG) properties & evolution
- Need galaxy cluster catalogues!



# The XMM Cluster Survey (XCS)

Serendipitous search for galaxy clusters in the public data of the XMM-Newton Science Archive across the whole sky

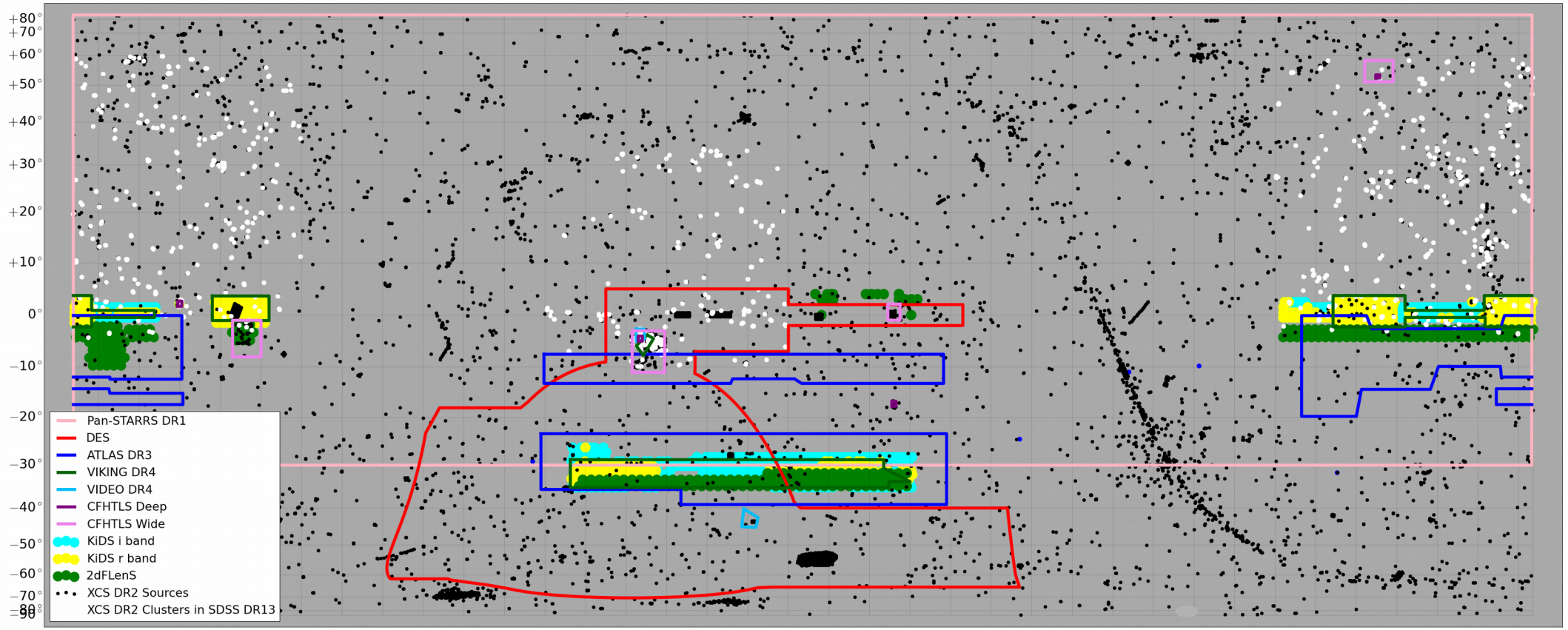
DR1: 503 optically confirmed X-ray clusters (Mehrtens et al 2012)

DR2: ~850 clusters just in SDSS DR13 area & improved pipelines for luminosities and temperatures

The largest galaxy cluster catalogue so far!!

| | XXL | XCLASS | XMM-LSS | REFLEX |
|---|---|---|---|---|
| Area ( $deg^2$ ) | 2x25 | All-sky | 11 | ~14000 |
| No. of clusters | 450 | 850 | 52 | 452 |

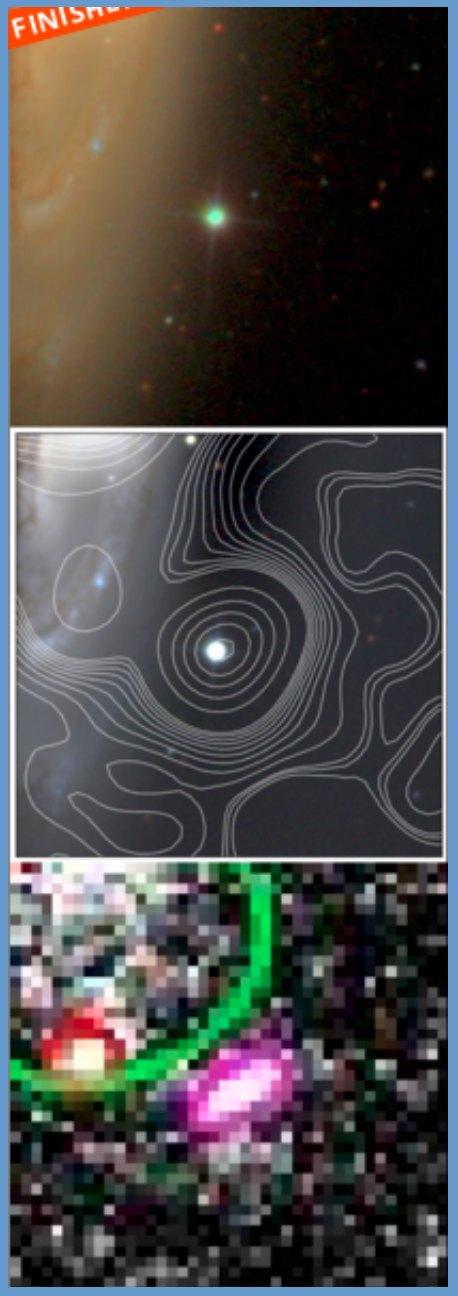
# The XMM Cluster Survey (XCS)



# The XMM Cluster Survey (XCS)

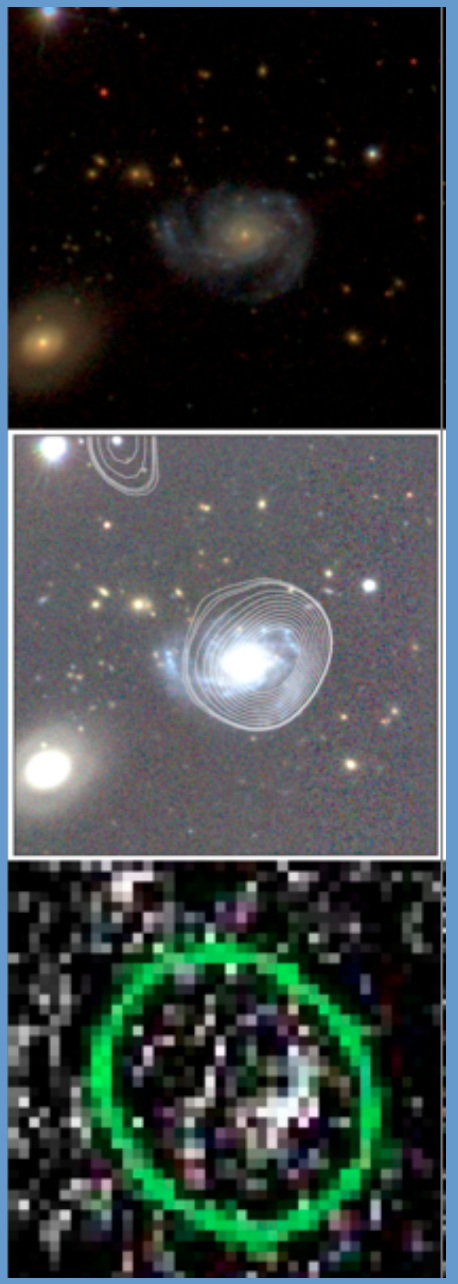
| | No. of objects |
|---|---|
| DR2 detections | ~280,000 |
| DR2 extended sources | ~30,000 |
| DR2 extended sources in SDSS DR13 with >200 counts | ~2,000 |
| DR2 clusters in SDSS DR13 with >200 counts | ~850 |
| DR2 clusters in SDSS DR13 with >200 counts with good quality $L_x$, $T_x$ | ~570 |
| DR2 clusters in SDSS DR13 with >200 counts with good quality $z$ | ~460 |

# Optical confirmation



XMM point spread function (PSF) is strong function of off-axis angle → Point sources (foreground AGN, stars) can appear as extended sources

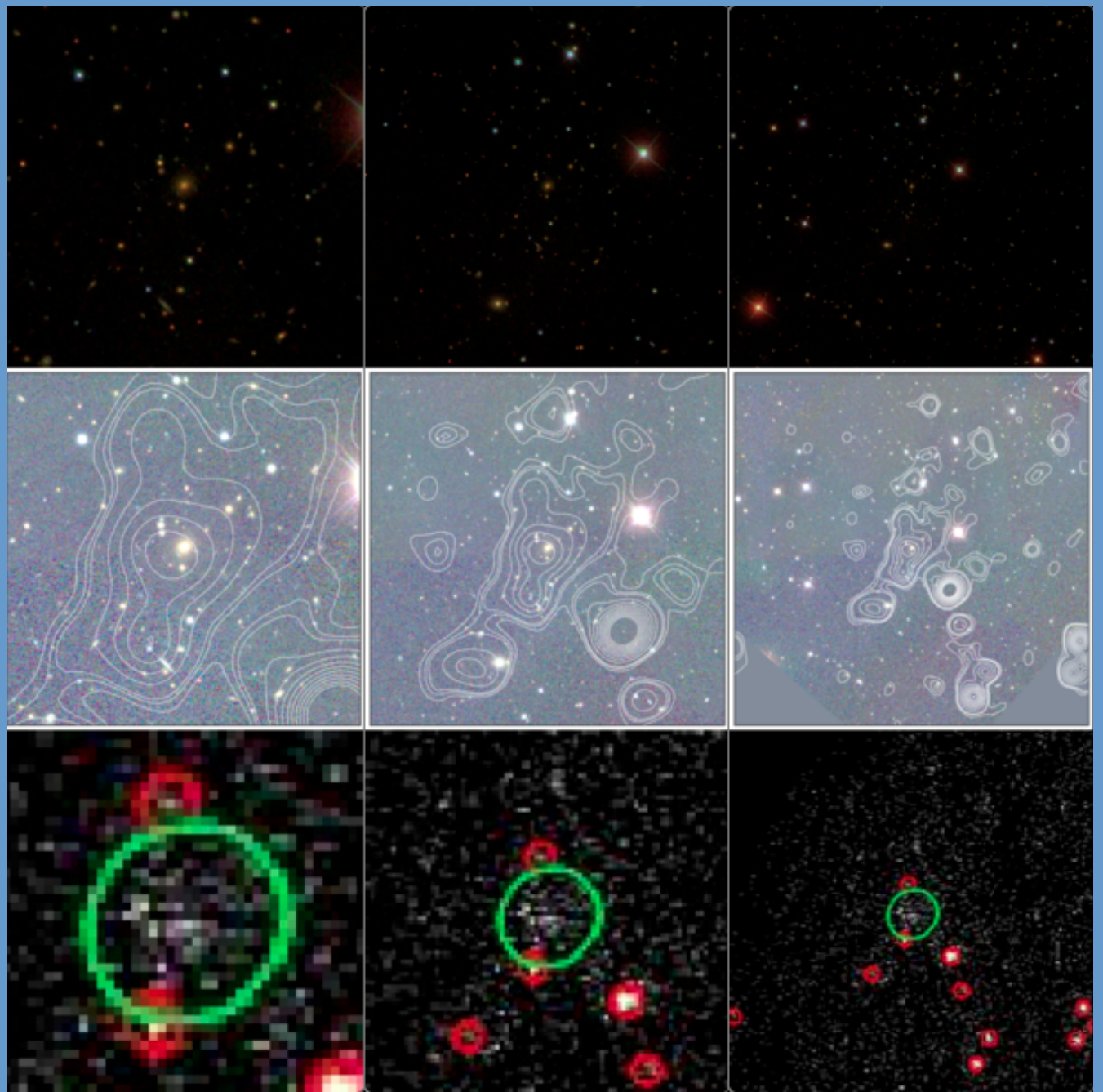
We need optical surveys to confirm our candidates → SDSS is good for the northern hemisphere



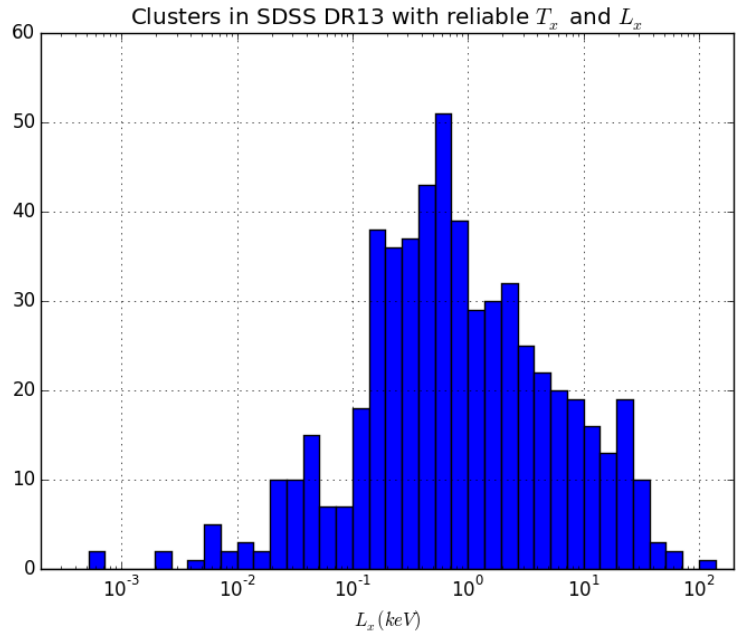
# Optical confirmation

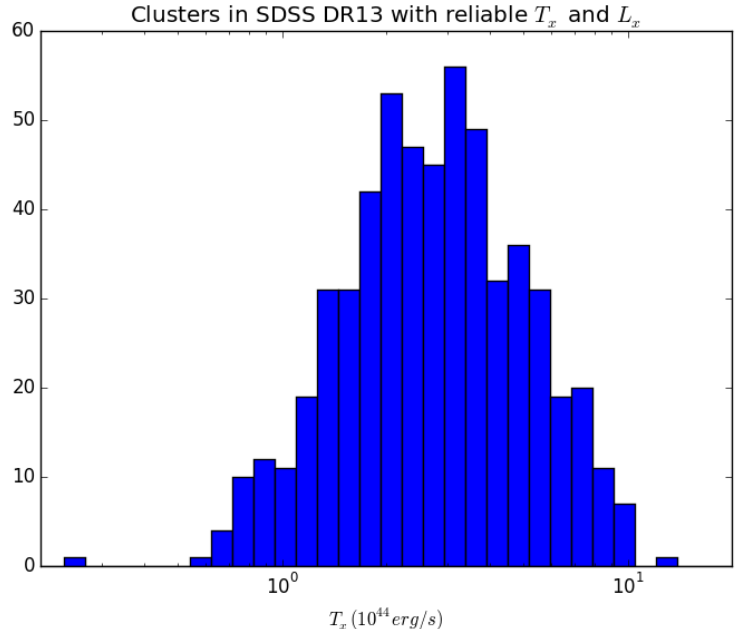
Cluster zoo for the XCS DR2 objects in SDSS DR13

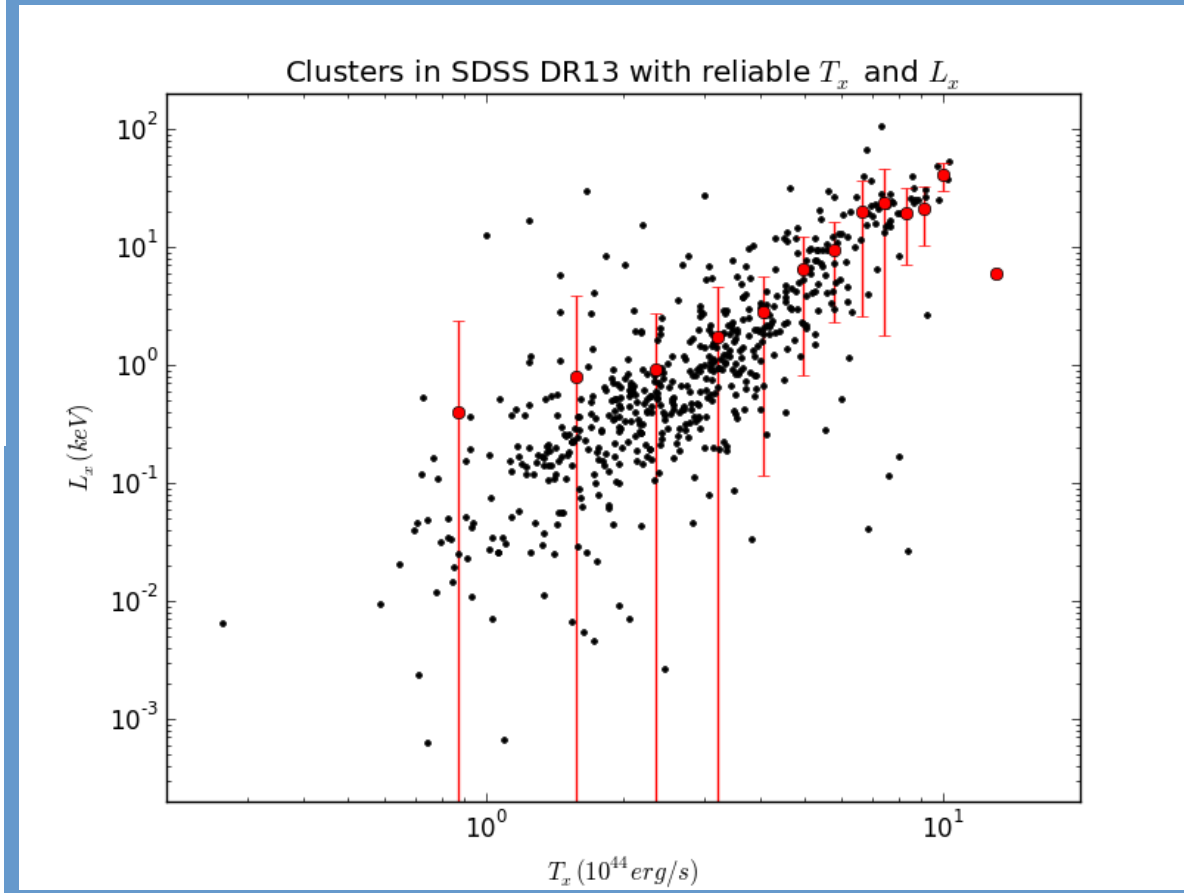
FOV: 3x3, 6x6, 12x12 arcsec



# Optical confirmation

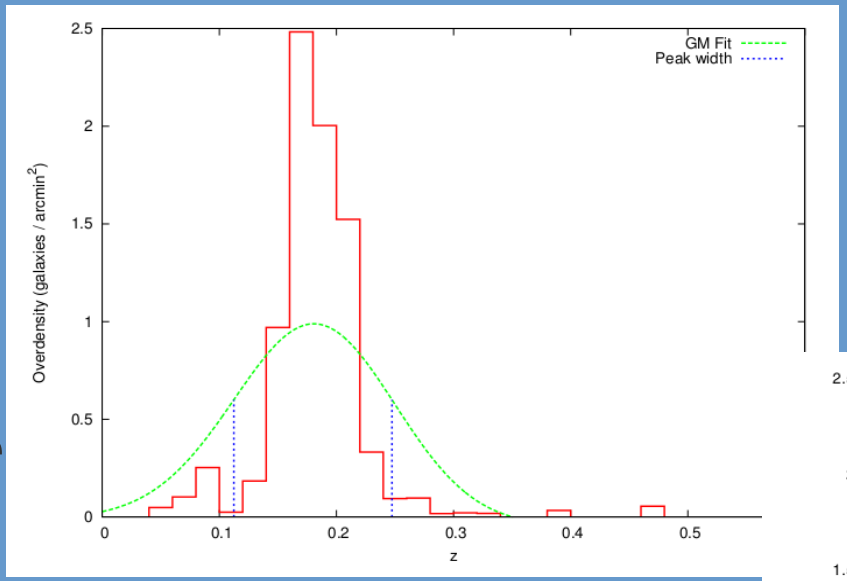


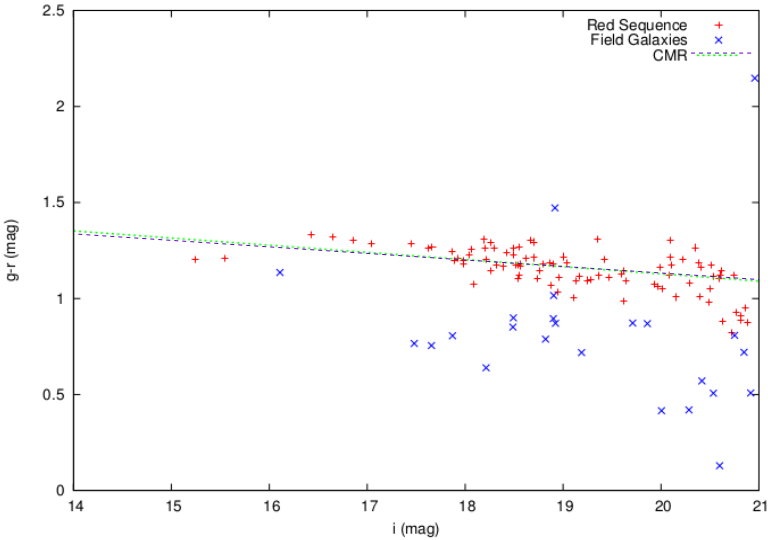



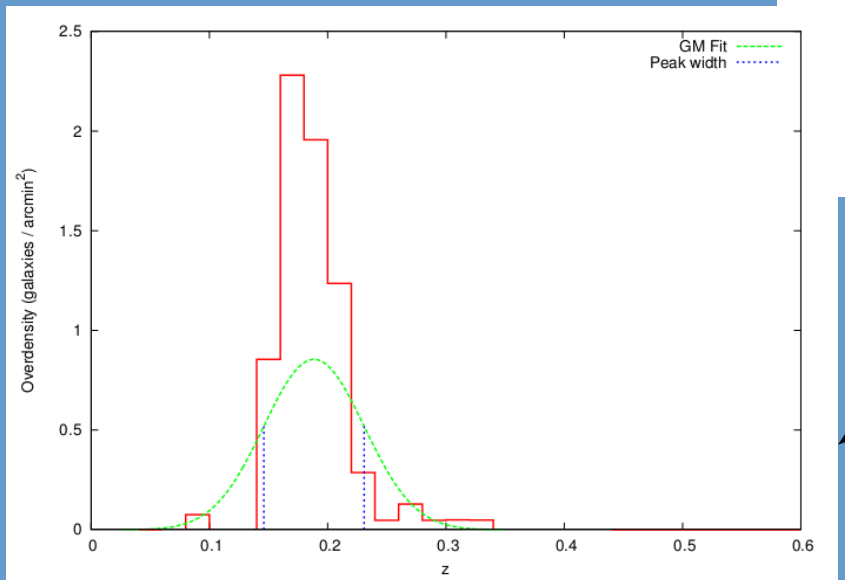



# Cluster redshifts

- GMPhoRCC (Hood & Mann 2016)
- Two main cluster characteristics: red-sequence and BCG
- Traces the overdensities in the galaxy redshift distribution
- Input: galaxy survey and cluster coordinates
- Output: optical cluster redshift, colour-magnitude relation, cluster richness
- Quality flags

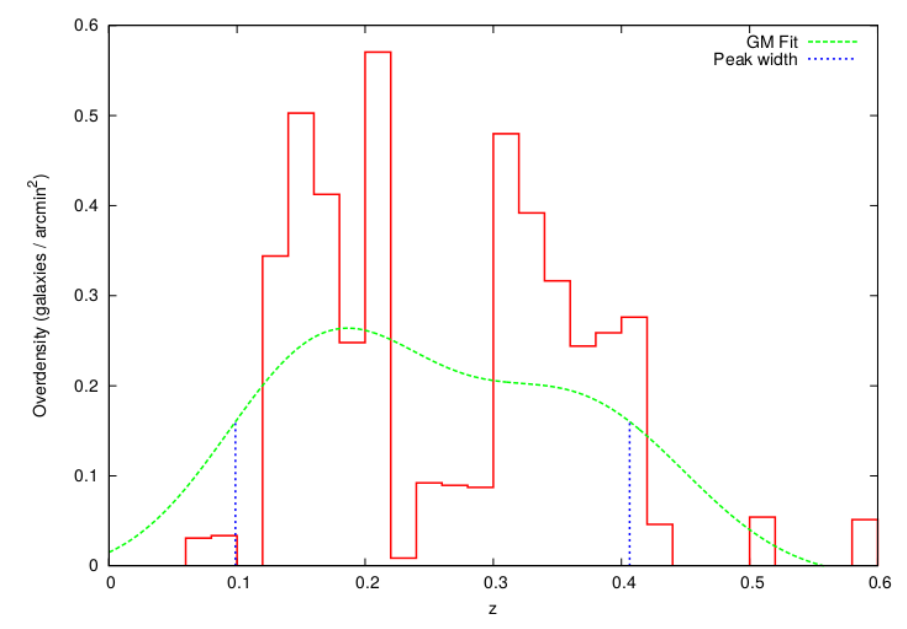


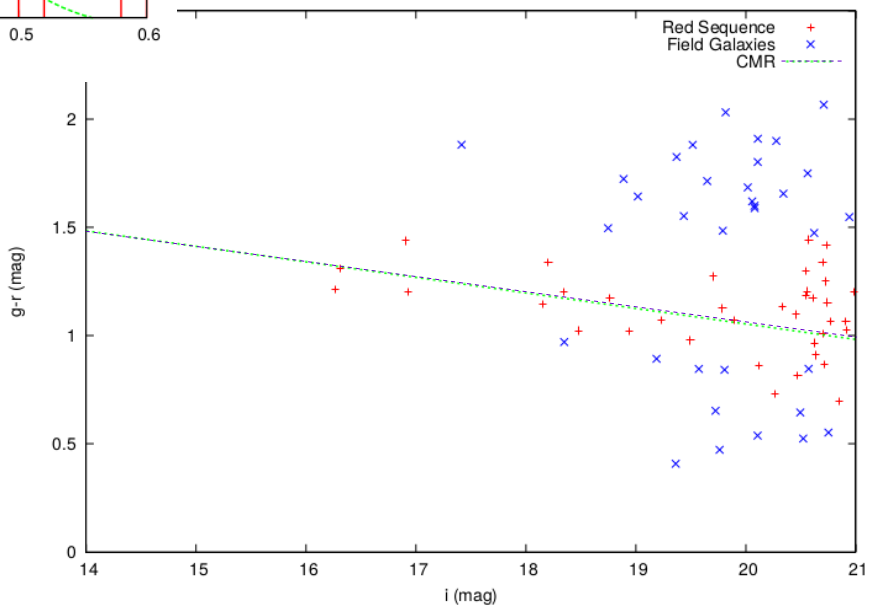
# Cluster redshifts

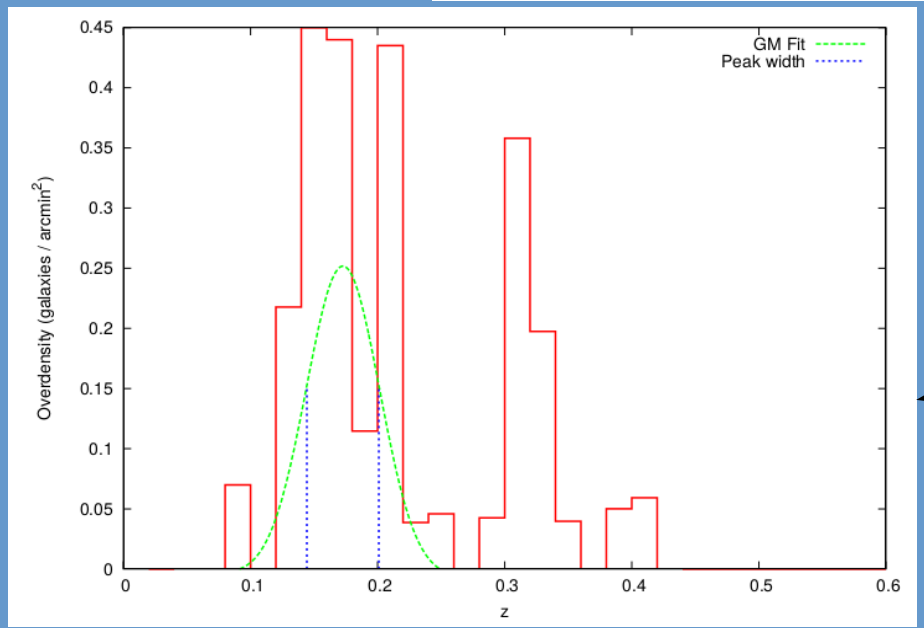
Analyses several candidates



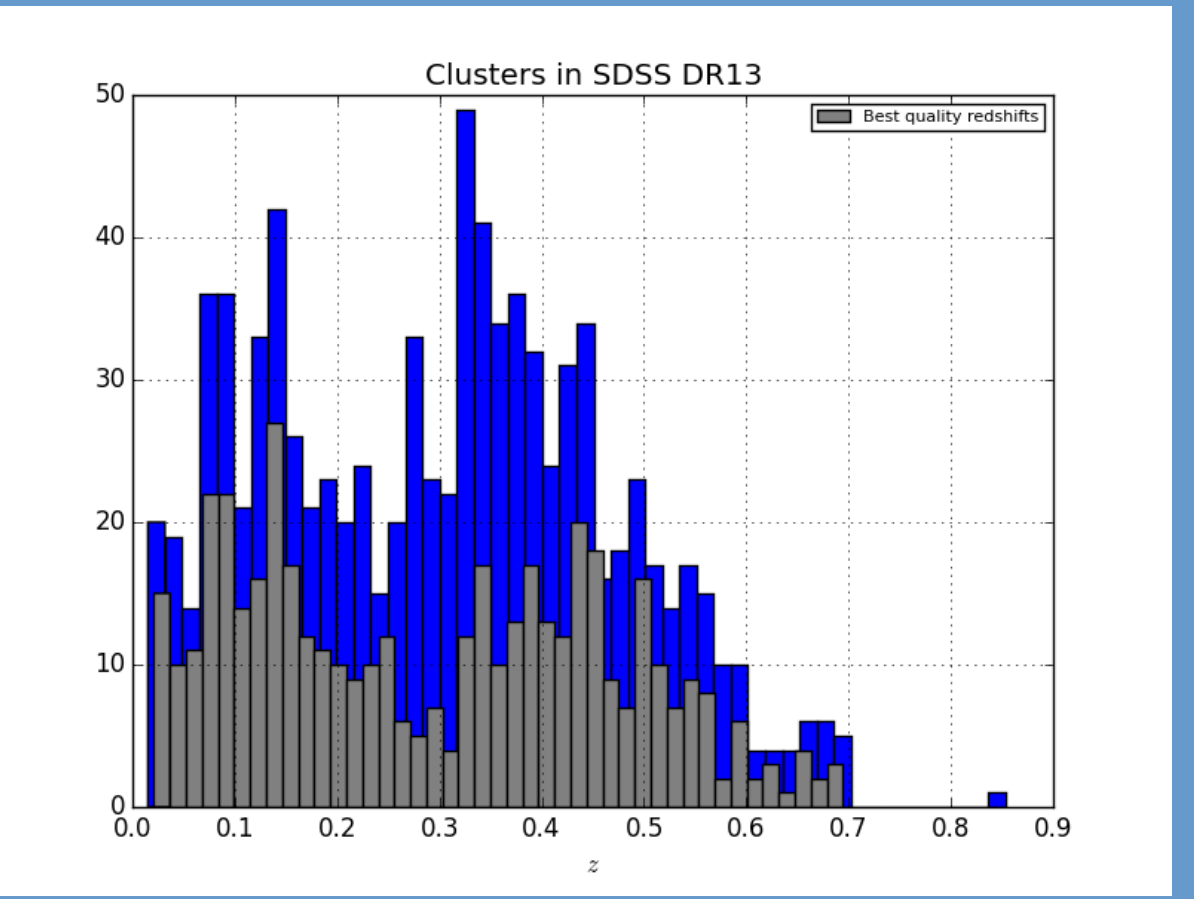

$z_{rs}$=0.172

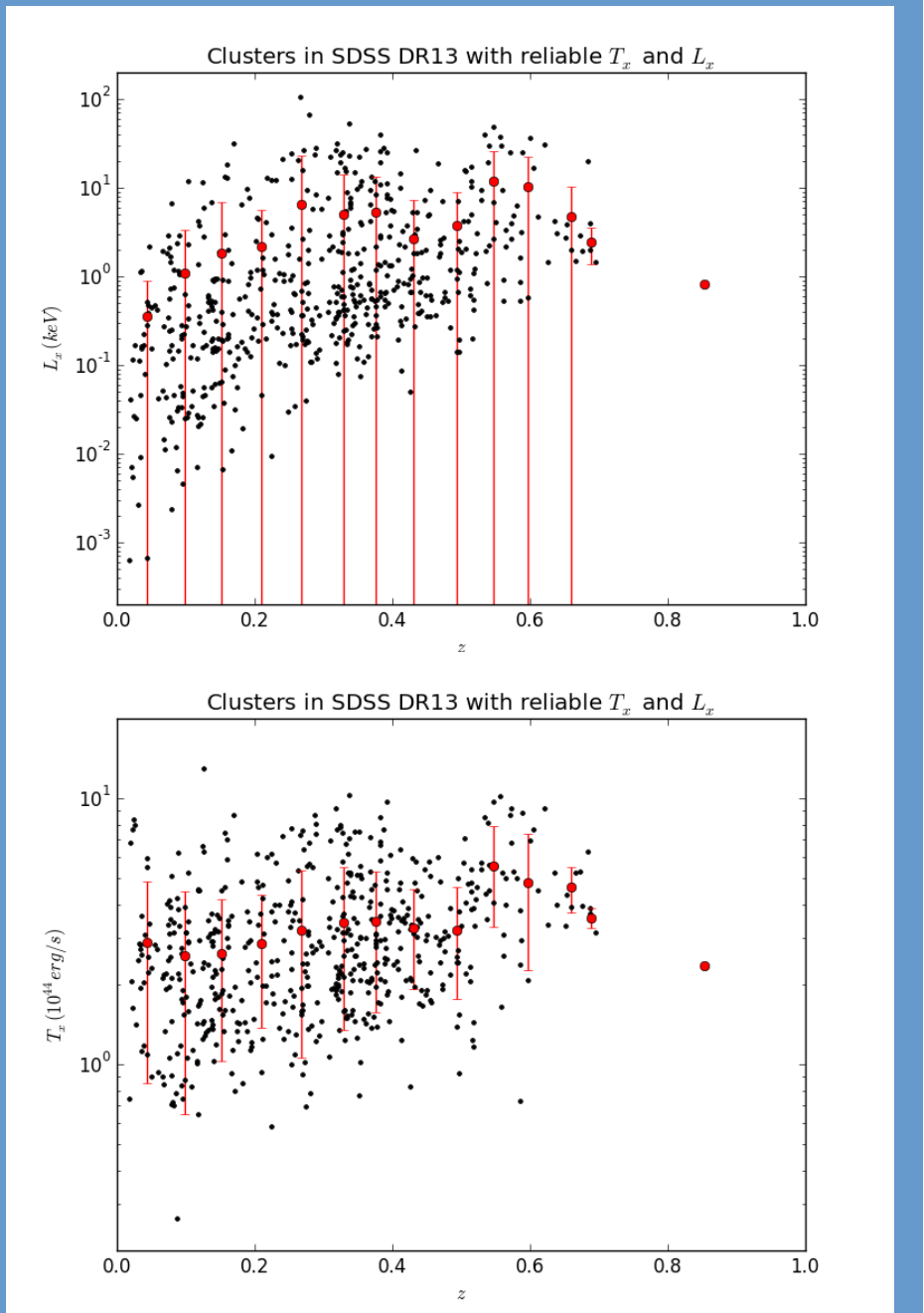
$z_{spec}$=0.179



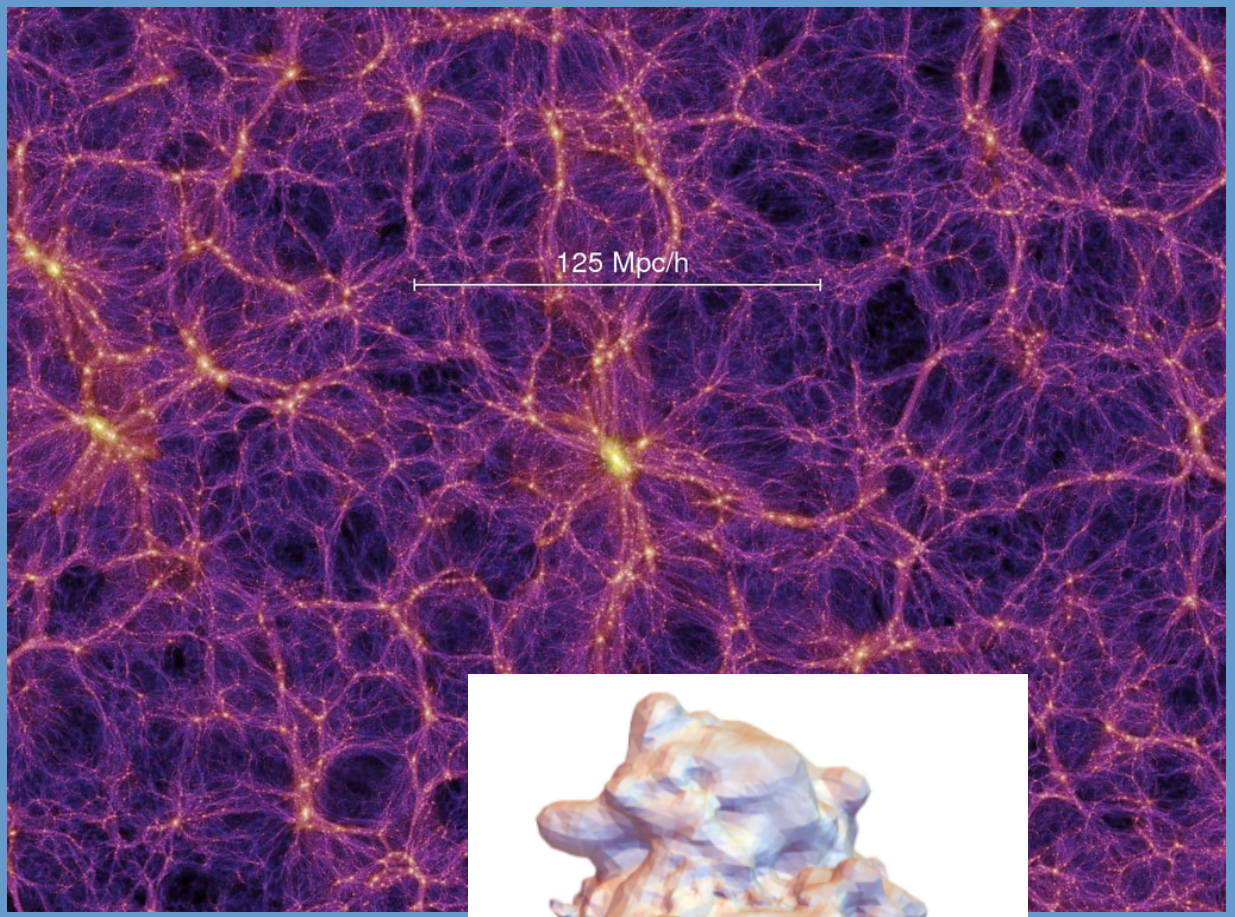
# Cluster redshifts

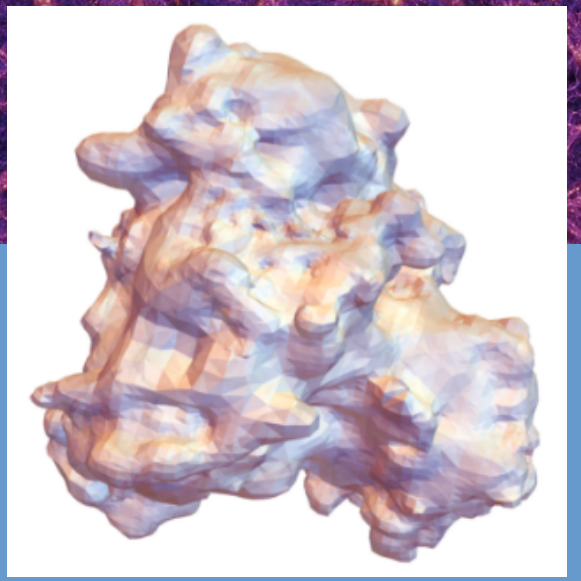


# Clusters in voids

- Underdense regions in LSS, complicated 3D void shapes
- Void catalogue in BOSS DR12 (Nadathur 2016)
- Different merger histories clusters in voids and not → developed different properties
- Expect less massive, less luminous clusters inside voids, more spread temperatures

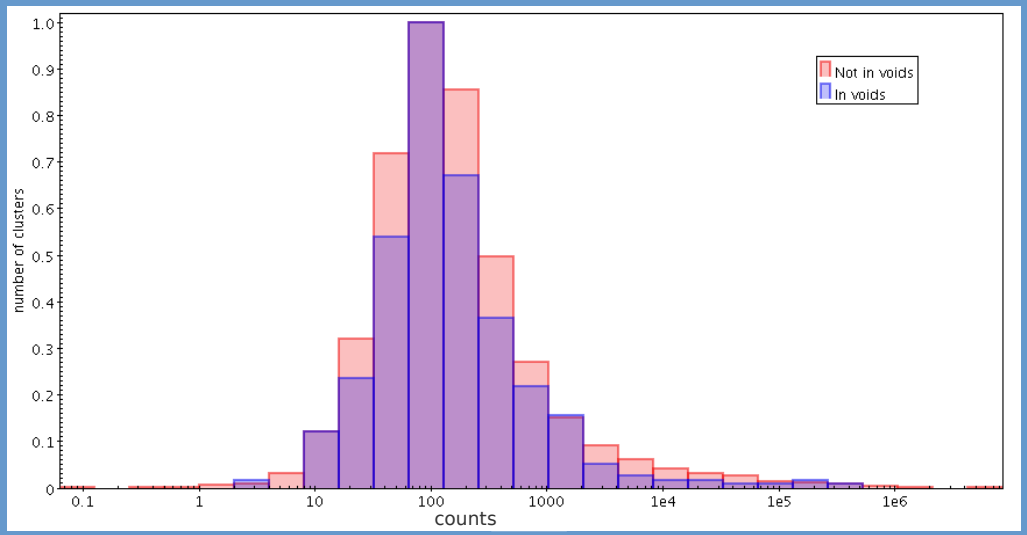


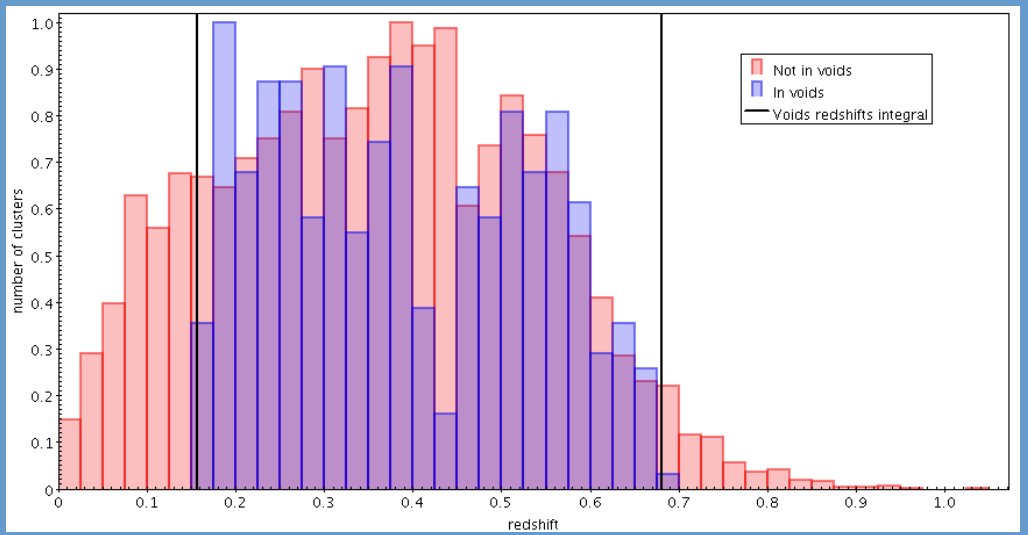



Nadathur 2016

# Clusters in voids

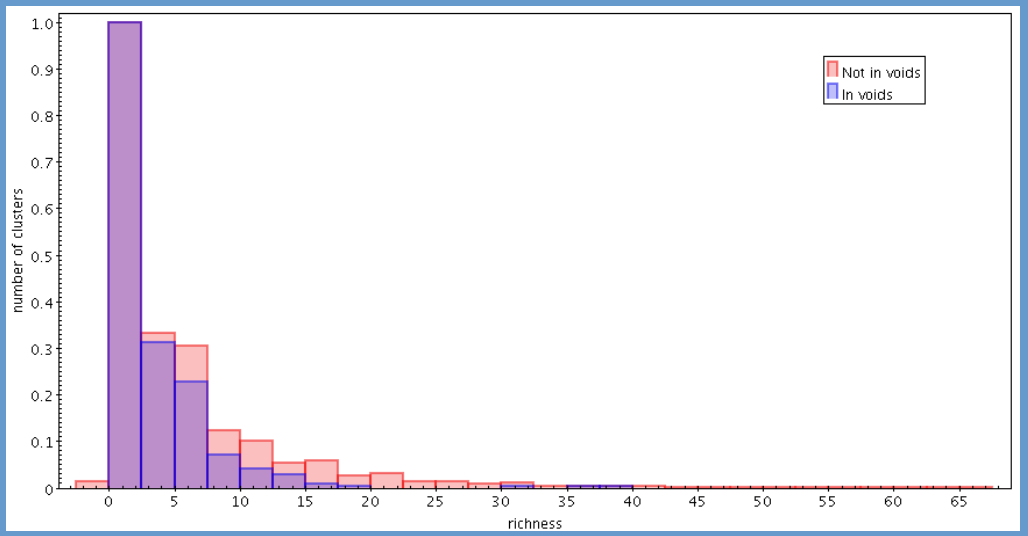
## First comparisons of clusters inside and outside voids




Developed algorithm which identifies if a cluster lies inside a void or not

Assumed spherical voids, no counts limit



# Future work

- Publish DR2
- Introduce 3D void shape
- Compare with Millennium simulation voids
- Introduce different flux limits in our cluster sample and study the effect of the resulting selection bias

# XCS DR2 is coming soon

Stay tuned!

# Extra material

| Red sequence band | redshift range |
|---|---|
| $g-r$ | $0.00 \leq z < 0.45$ |
| $r-i$ | $0.35 \leq z < 0.75$ |
| $i-z$ | $0.65 \leq z$ |