The XMM CLuster Archive Super Survey (X-CLASS)

A cosmologically useful, X-Ray selected sample of galaxy clusters

L. Faccioli for the X-CLASS collaboration

The XMM CLuster Archive Super Survey: X-CLASS

- Aims at building a *cosmologically useful sample* of X-ray selected galaxy clusters found in the whole XMM-Newton archive
- *Sample selection based on rigorously defined X-ray criteria only*, extensively tested on simulation
- *Well defined selection function* based on extensive simulations
- Follow up to obtain photo-z: ongoing
- Many other ongoing projects, mainly limited by lack of manpower (*everyone can join if interested*)
Building X-CLASS

- **Entire XMM-Newton archive reprocessed**
- All extragalactic pointings away from M31 and the Magellanic clouds and with at least 5ks of observation in each EPIC instrument selected
  - **2774 pointings, up to May 2010**, reprocessed and published in Clerc et al 2012
  - **4192 pointings, up to August 2015**, reprocessed with updated pipeline (including the 2774 above) and analysis is ongoing; new catalog paper this year
Building X-CLASS, cont

• All sources are carefully screened by humans to identify detections that are not really clusters
  – Nearby galaxies, artifacts due to detector gaps, spurious detections at large off-axis angle identified

• Careful and painstaking correlation among pointings to identify multiple detections

• When all is done data is injected in our DB, with the results of human screening and the multiple detections properly taken into account
The X-CLASS sample

- **421 publicly available clusters, 347 of which used for cosmological analysis (they satisfy stricter criteria)**
- Definition of the cluster selection criteria and of the selection function, preliminary cosmological analysis in Clerc et al. 2012
- All XMM-Newton observations up to May 2010
Multiple detections correlated in X-CLASS DB

X-CLASS ID 0382, confirmed cluster, $z=0.396$
Main detection in 20ks

X-CLASS ID 64, secondary exposure 10ks

Only main detections normally visible in the DB but users may access all detections of the same cluster if desired
The X-CLASS Database

X-MCLASS
XMM Clusler Archive Super Survey

Home page Database

The XMM Clusler Archive Super Survey is an X-ray galaxy cluster search in XMM-Newton archival data.

This webpage provides access to the X-CLASS catalogue through a dedicated database.

On your first visit you will be asked to choose a login and password which will grant you access to the catalogue. It is immediate and no other information is required!

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Database overview

X-ray and optical images
Raw and spatially filtered X-ray images are given for each entry in

Nasa Extragalactic database cross-identification
For each cluster in the catalogue we

Detailed information about the X-ray data
Images of the XMM pointings and
X-CLASS ID 3103: a typical X-CLASS cluster

X-ray image: MOS1,MOS2, pn
Smoothed image: MOS1,MOS2, pn
Optical image

X-CLASS ID 3103, confirmed cluster, z=0.376

Data processing

- Event lists created with standard SAS software
- Event lists cut at 10ks and 20ks images in [0.5-2] keV created, with expo maps and detector masks
- Images processed with our dedicated pipeline XAmin (Pacaud et al 06, Faccioli et al. submitted) already developed for XMM-XXL
- Cluster selection based on purely instrumental criteria and extensively tested via simulations
- C1 selection defined in the same way as XMM-LSS/XMM-XXL: almost pure selection
- Cutting at 10ks and 20ks simplifies the calculation of the selection function
The XAmin pipeline

- Optimized for extended, low surface brightness sources
- Preliminary source detection performed on a wavelet smoothed MOS1+MOS2+pn image using SEXtractor
- Source characterization via *ML fit*: we fit a PSF model, a $\beta$ profile, a PSF+$\beta$ profile and two PSFs and choose the most significant fit
- Sources which pass the *C1 selection criteria* are identified and selected for study
Measuring cluster properties

X-CLASS ID 0020 $z=0.63$

The CR-HR-(Rc-z) method

• *Doing cluster cosmology with purely instrumental variables*

• Measure *CR, HR, Rc, z* for all clusters in a sample, create a *CR, HR, Rc, z* diagram and compare it to theoretical diagrams computed varying the cosmology; choose the best fit

• Applied to X-CLASS in the form *CR, HR* for now; being extended to *CR, HR, z* by J. Ridl
The CR-HR diagram of X-CLASS clusters

Clerc et al. 2012
Cosmological constraints from X-CLASS

Clerc et al. 2012
Comparing with optically selected cluster samples

- We cross correlated X-CLASS with redMaPPer (Sadibekova et al. 14)
  - Optically selected cluster catalog from SDSS data, z<0.6
- 270 redMaPPer and 355 X-CLASS clusters in region of overlap
- All rich (λ>80) redMaPPer detected in X-rays
- 50% redMapper clusters down to λ=20 detected in X-rays
- 40% X-CLASS clusters found in redMapper down to λ=20
- What are the non matches? They are as interesting as the matches
redMaPPer → X-CLASS

- Rich clusters all found in X-rays (*violet points*)
- Undetected in X-rays: distant and poor clusters (*open stars*)

Sadibekova et al. 2014
Photo $z$ for X-CLASS

- Follow up campaign using the Gamma-Ray Burst Optical and Near-Infrared Detector (GROND) instrument at ESO MPG 2.2-m telescope
- 7-channels (grizJHK)
- Accuracy $\Delta z=0.02(1+z)$
- 265 X-CLASS clusters with $\delta<20$ degrees observed
- Results published in Ridl. et al. 2017
GROND: filters and accuracy

GROND optical filters: $g',r',i',z'$

$\Delta z = 0.02(1+z)$

Ridl et al 2017
X-CLASS: Luminosity Function from GROND

Grey points from MCXC
Contours: eROSITA expectations

Ridl et al 2017
The next X-CLASS catalog

- All observations up to **August 2015** reprocessed with updated pipeline
- **4192 pointings** reprocessed
- Human screening under way
- Catalog paper expected this year
X-CLASS: ongoing projects

- Updated catalog
- Redshift confirmation
- Growth curve measurements for the new X-CLASS clusters
- $T_x$ measurements and $L-T_x$ scaling relations
- Cosmology with $z$-CR-HR using the X-CLASS/GROND sample
- Convolutional Neural Nets and a Galaxy Cluster Zoo
- Your project?