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

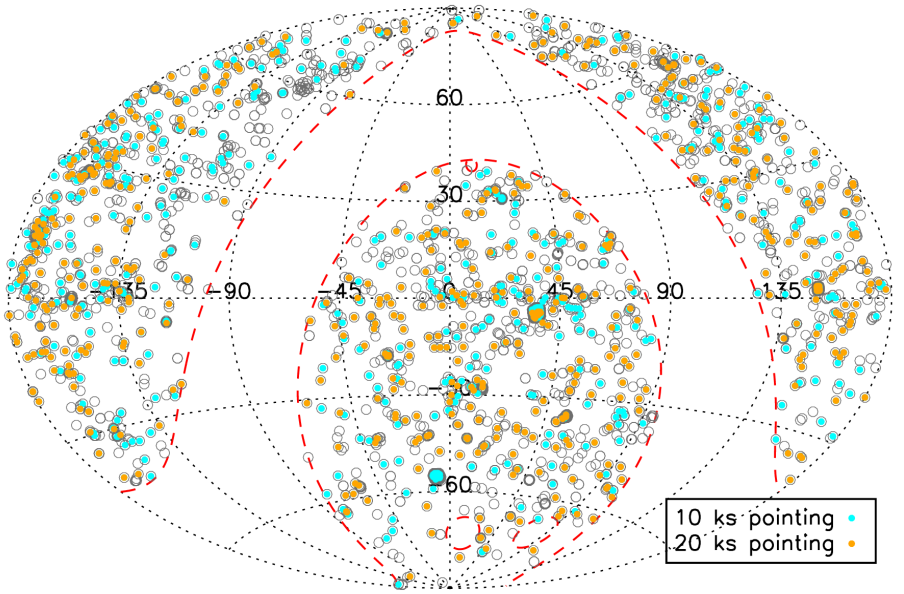
B. Altieri, N. Clerc, L. Faccioli, E. Gaynullina, A. Khalikova, M. Lieu, A. Mints, M. Molham, F. Pacaud, M. Pierre, M. Ramos, J. Ridl, T. Sadibekova, A. Takey I. Valtchanov

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***)
- Three papers already published: ***Clerc et al. 2012, Sadbekova et al. 2014, Ridl et al. 2017***; other papers upcoming

Building X-CLASS

- ***Entire XMM-Newton archive reprocessed***
- All extragalctic 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



Clerc et al. 2012

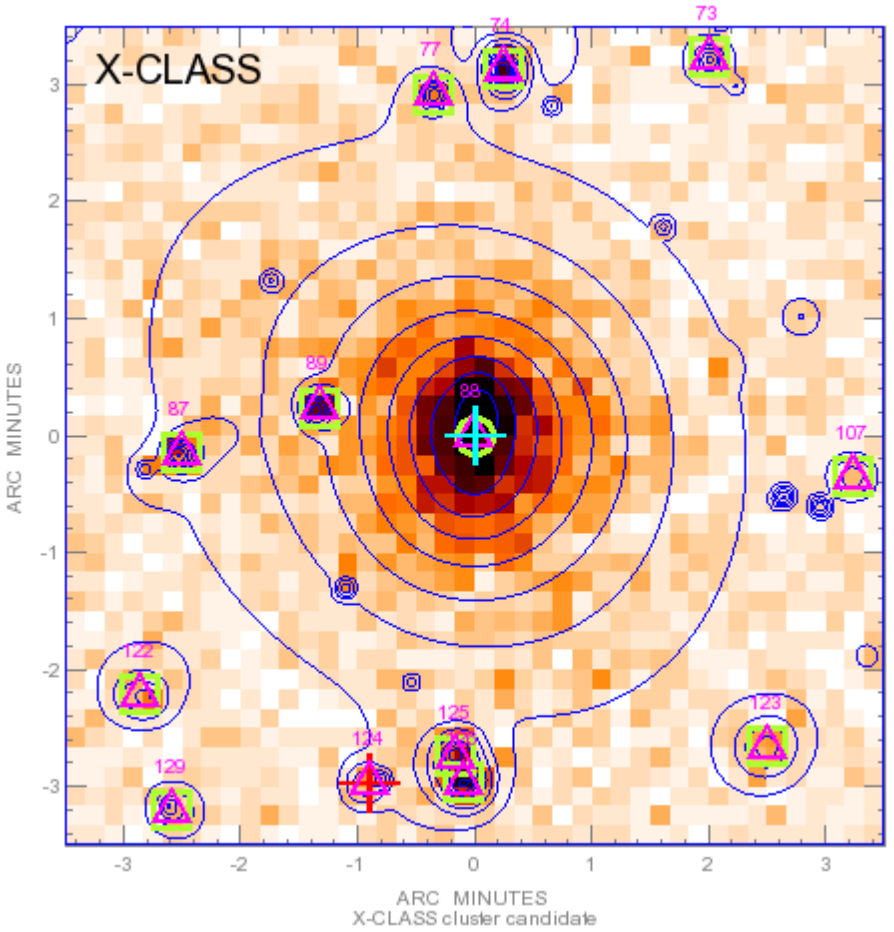
Building X-CLASS, cont

- 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

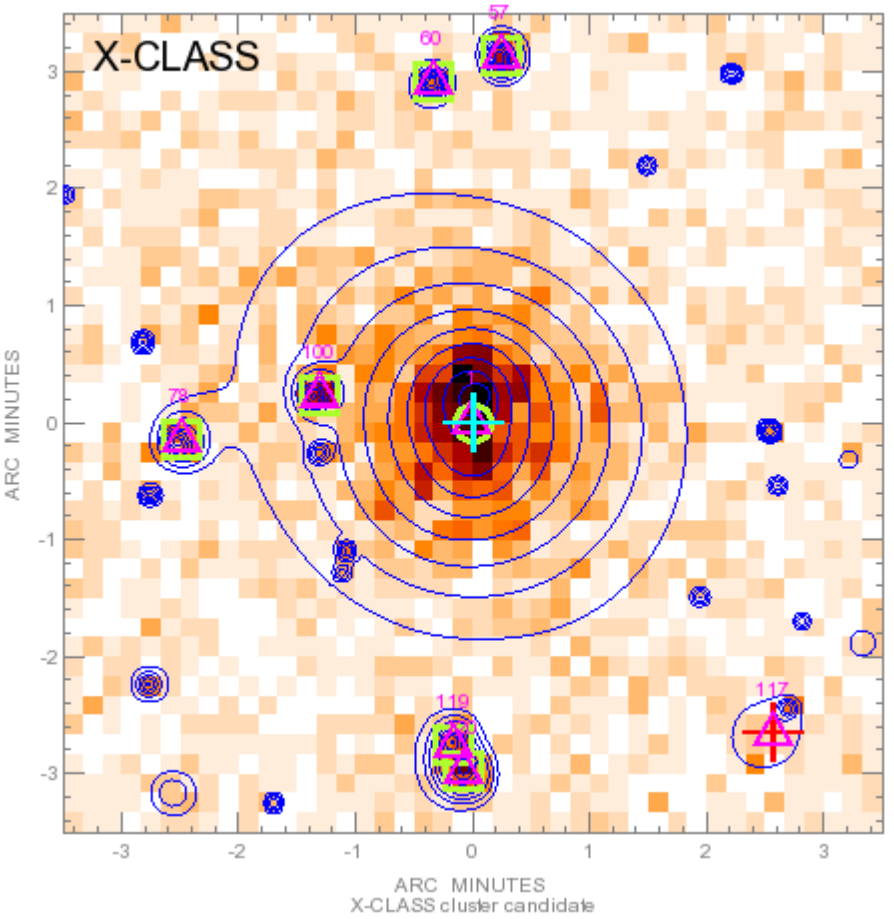
The X-CLASS sample

- ***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 data publicly available in our database http://xmm-lss.in2p3.fr:8080/l4sdb/
- 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

XMM CLuster Archive Super Survey - Mozilla Firefox

File Edit View History Bookmarks Tools Help

xmm-lss.in2p3.fr:8080/xclass/

X-CLASS
XMM CLuster Archive Super Survey

Home page | Database

X-CLASS

XMM **CL**uster **A**rchive **S**uper **S**urvey

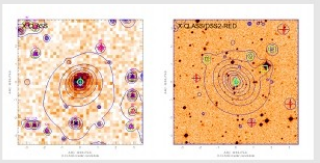
DEC pipeline measured	NED	obs	redshift	status	total rate	profile
10.195 10.195	-	0001930301_10ks			0.052	data
-10.280 -10.279	-	0032141201_10ks	0.33	photometric	0.047	data
-2.666 -2.666	1	0037981801_10ks			0.165	data
-2.827 -2.828	1	0037981801_10ks	0.280	confirmed	0.031	data
-3.434 -3.434	1	0037982601_10ks	0.330	confirmed	0.050	data
11.684 11.685	4	0041180801_10ks			0.086	data
-19.933 -19.934	-	0042341001_10ks			0.023	data
1.758 1.758	1	0044740201_10ks			0.037	data
16.739 16.738	20	0046940401_10ks	0.18	photometric	0.124	data
16.666 16.667	22	0046940401_10ks	0.25	confirmed	0.185	data
16.688	26	0046940401_10ks	0.25	confirmed	0.051	data

The XMM CLuster 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.

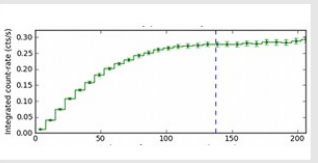
On your first visit you will be asked to choose a login and password which will grant you access to the catalogue. It is immediate and no other information is required !
Contact: Jean-Paul Le Fèvre (» **e-mail**)

Database overview



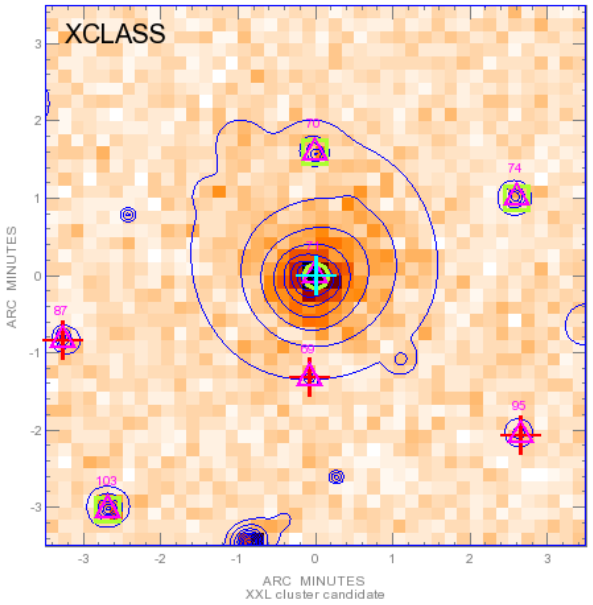
X-ray and optical images
Raw and spatially filtered X-ray images are given for each entry in

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

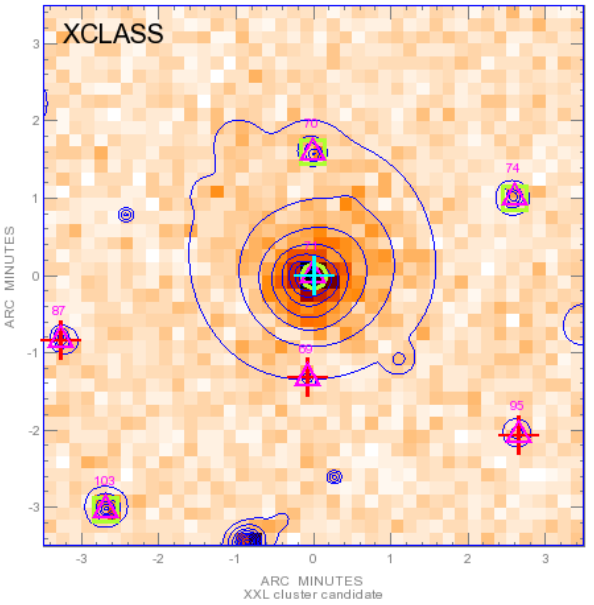


Detailed information about the X-ray data
Images of the XMM pointings and

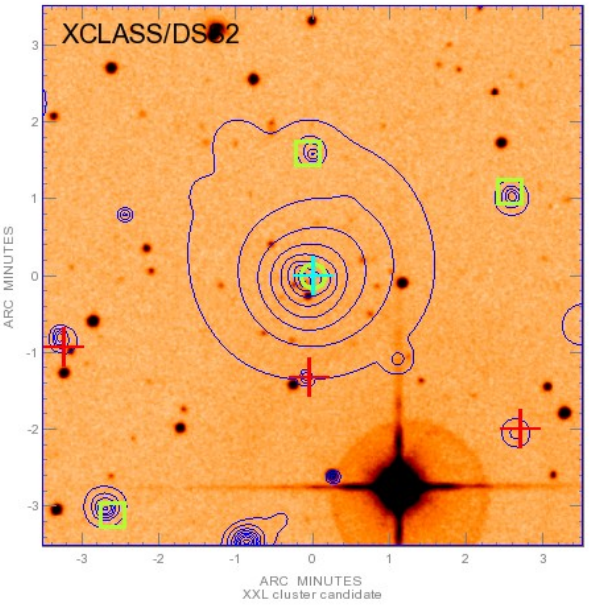
X-CLASS ID 3103: a typical X-CLASS cluster



X-ray image: MOS1,MOS2, pn



Smoothed image: MOS1,MOS2, pn



Optical image

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

From X-CLASS database: http://xmm-lss.in2p3.fr:8080/l4sdb/

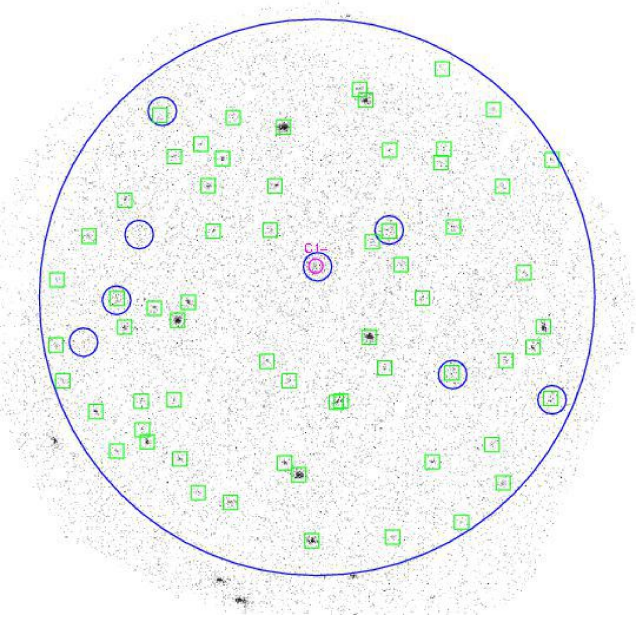
Data processing

- 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 away as XMM-LSS/XMM-XXL: ***almost pure selection***
- ***Cutting at 10ks and 20ks simplifies the calculation of the selection function***

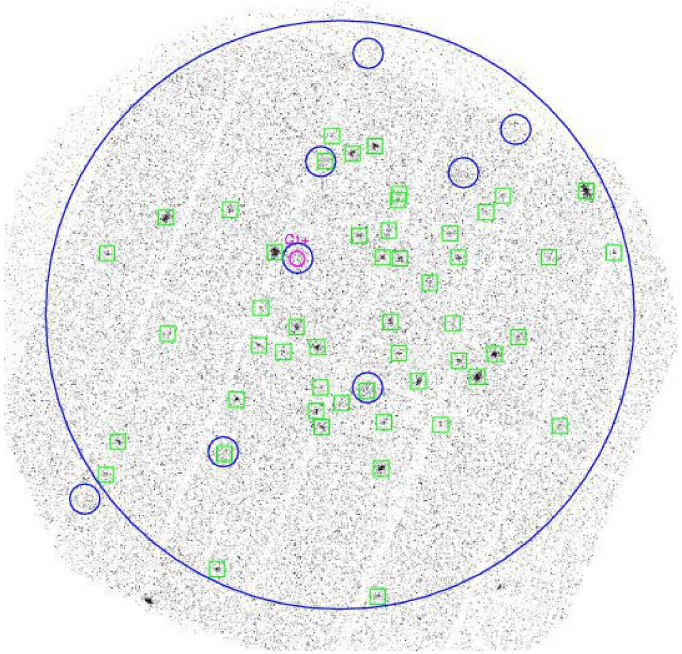
The XAmin pipeline

- 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 β profile, a PSF+β profile and two PSFs and choose the most significant fit
- Sources which pass the ***C1 selection criteria*** are identified and selected for study

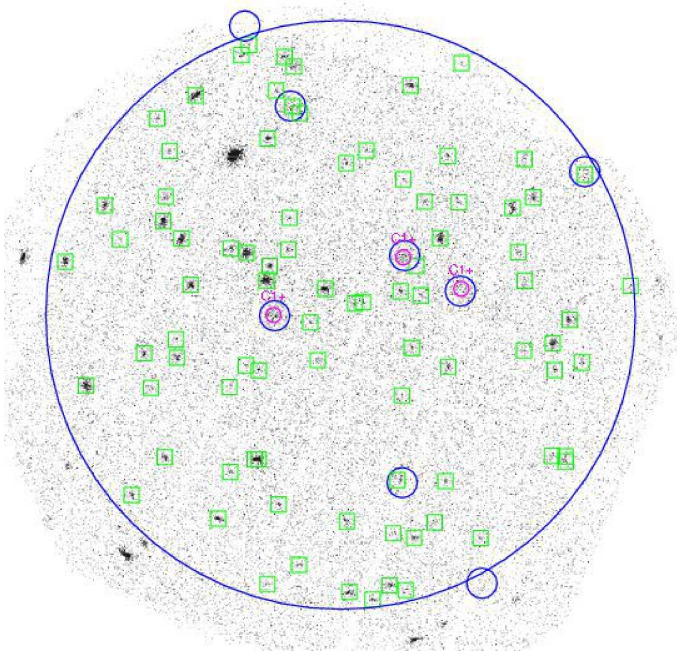
10ks, bkg=1

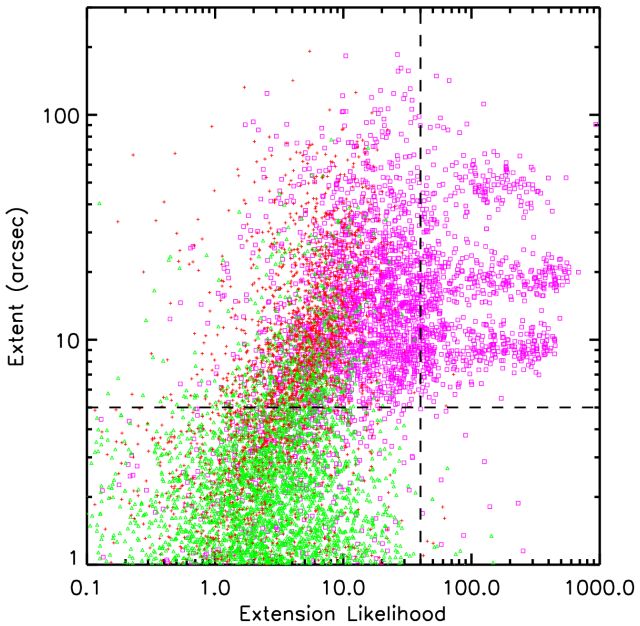


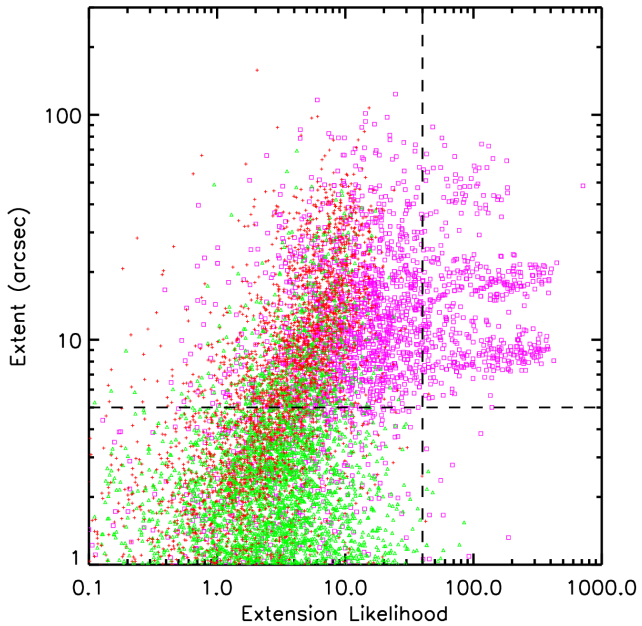
10ks, bkg=4

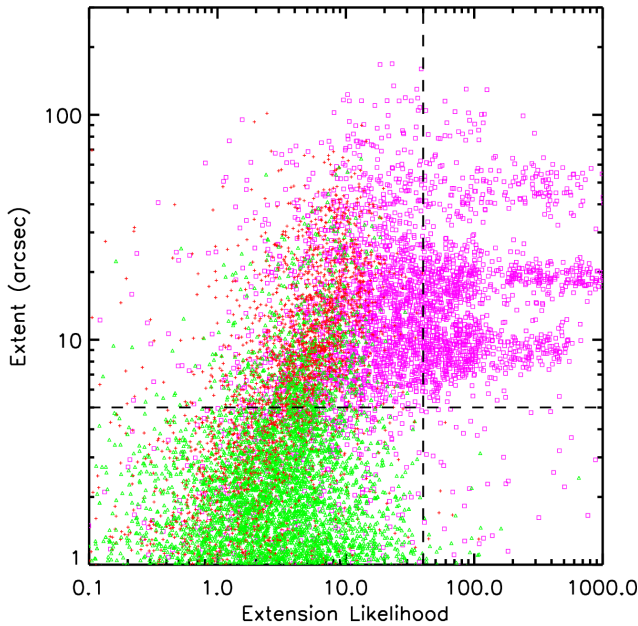


20ks, bkg=1



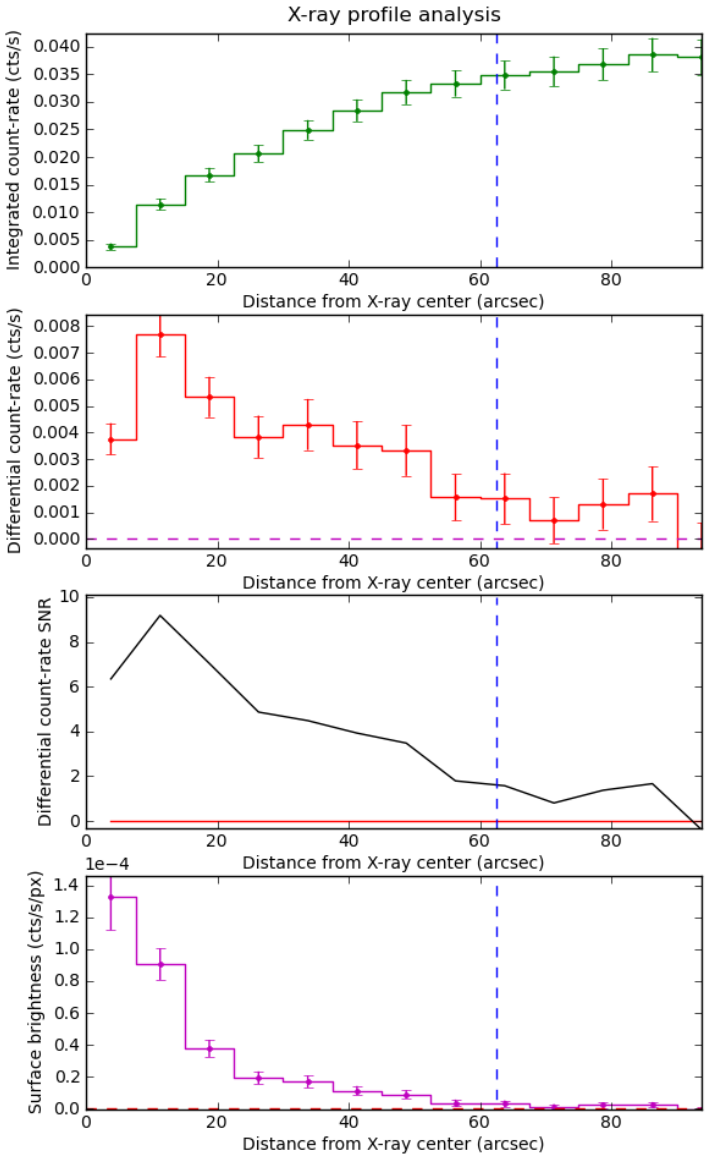


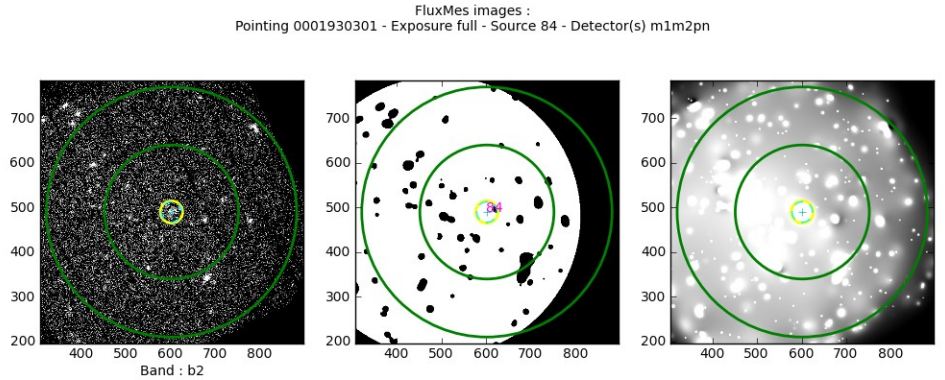




Clerc et al. 2012

Measuring cluster properties



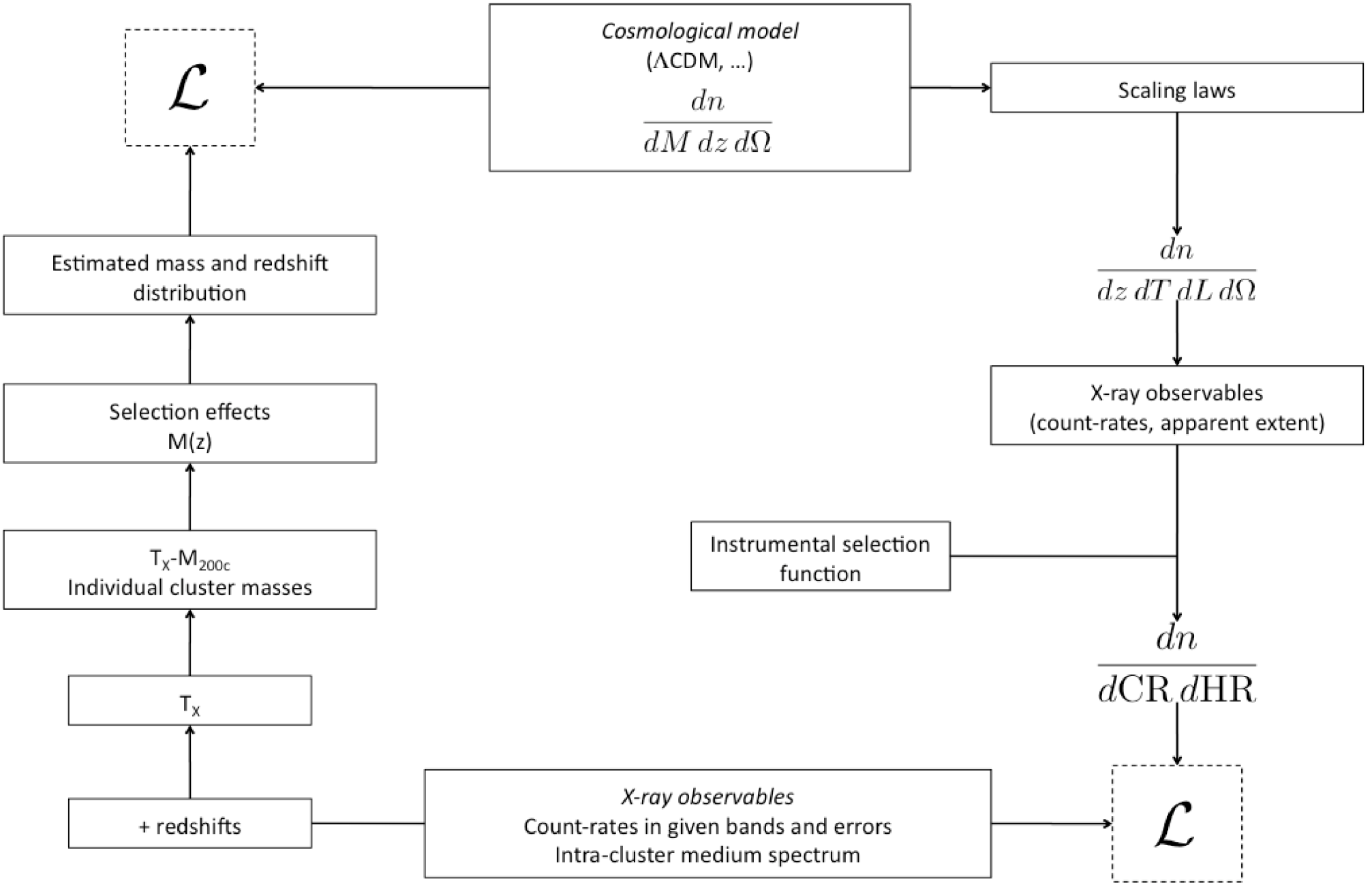


X-CLASS ID 0020 z=0.63

From X-CLASS database: http://xmm-lss.in2p3.fr:8080/l4sdb/

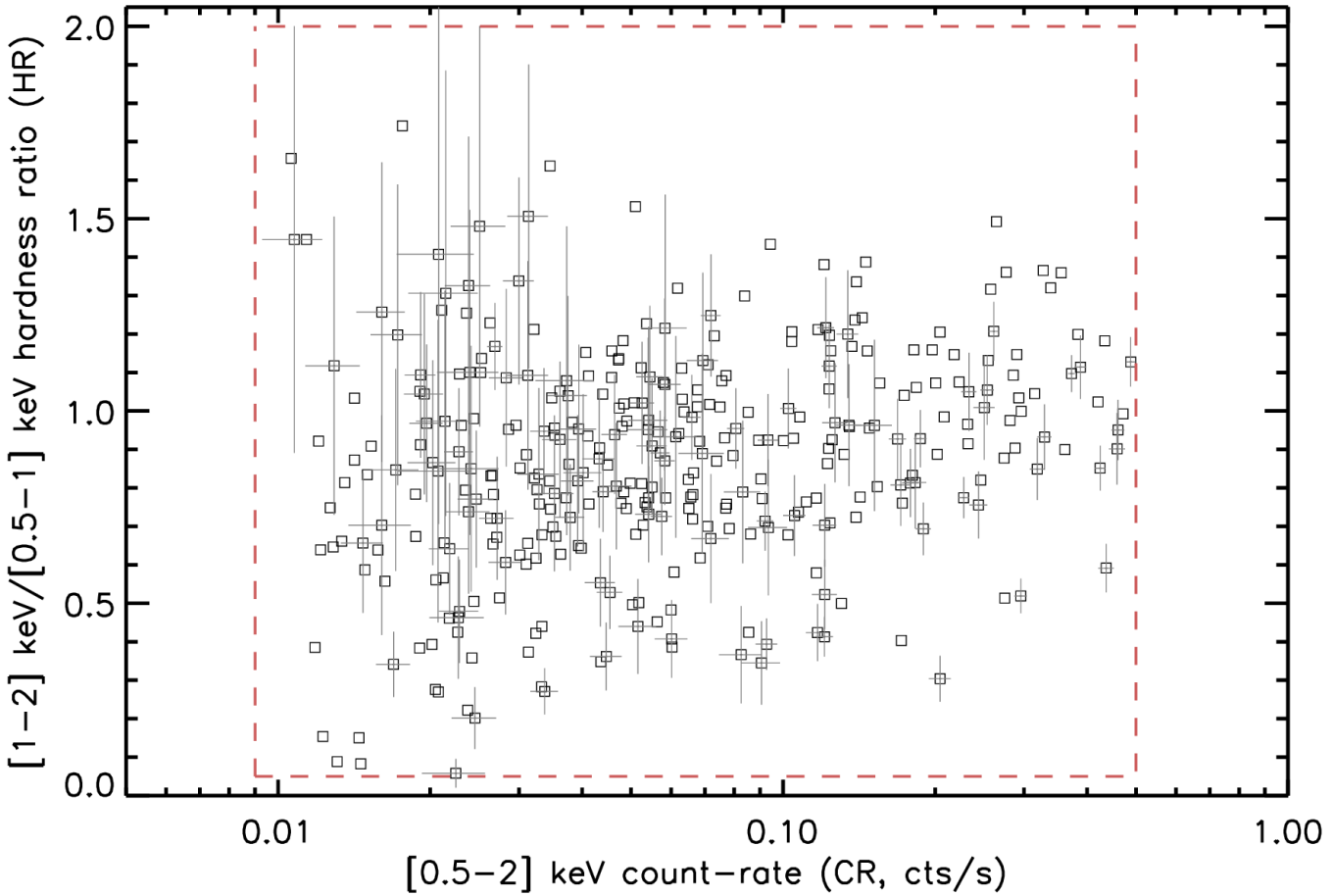
The CR-HR-(Rc-z) method

- ***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
  - Described in Clerc et al. 2011, Pierre et al. 2017, Valotti et al. 2018
- Applied to X-CLASS in the form ***CR, HR*** for now; being extended to ***CR, HR, z*** by J. Ridl



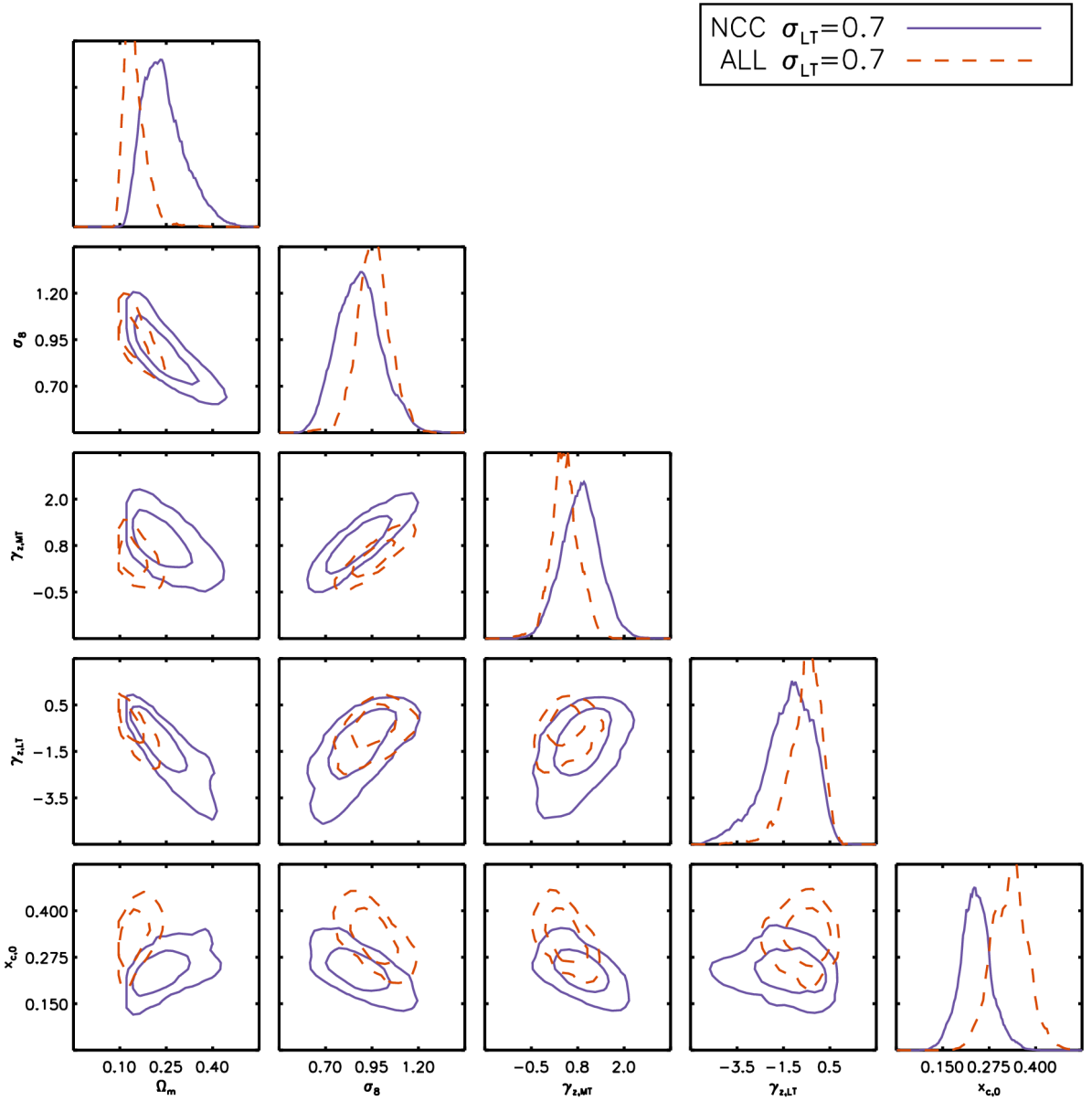
Clerc et al. 2011

The CR-HR diagram of X-CLASS clusters



Clerc et al. 2012

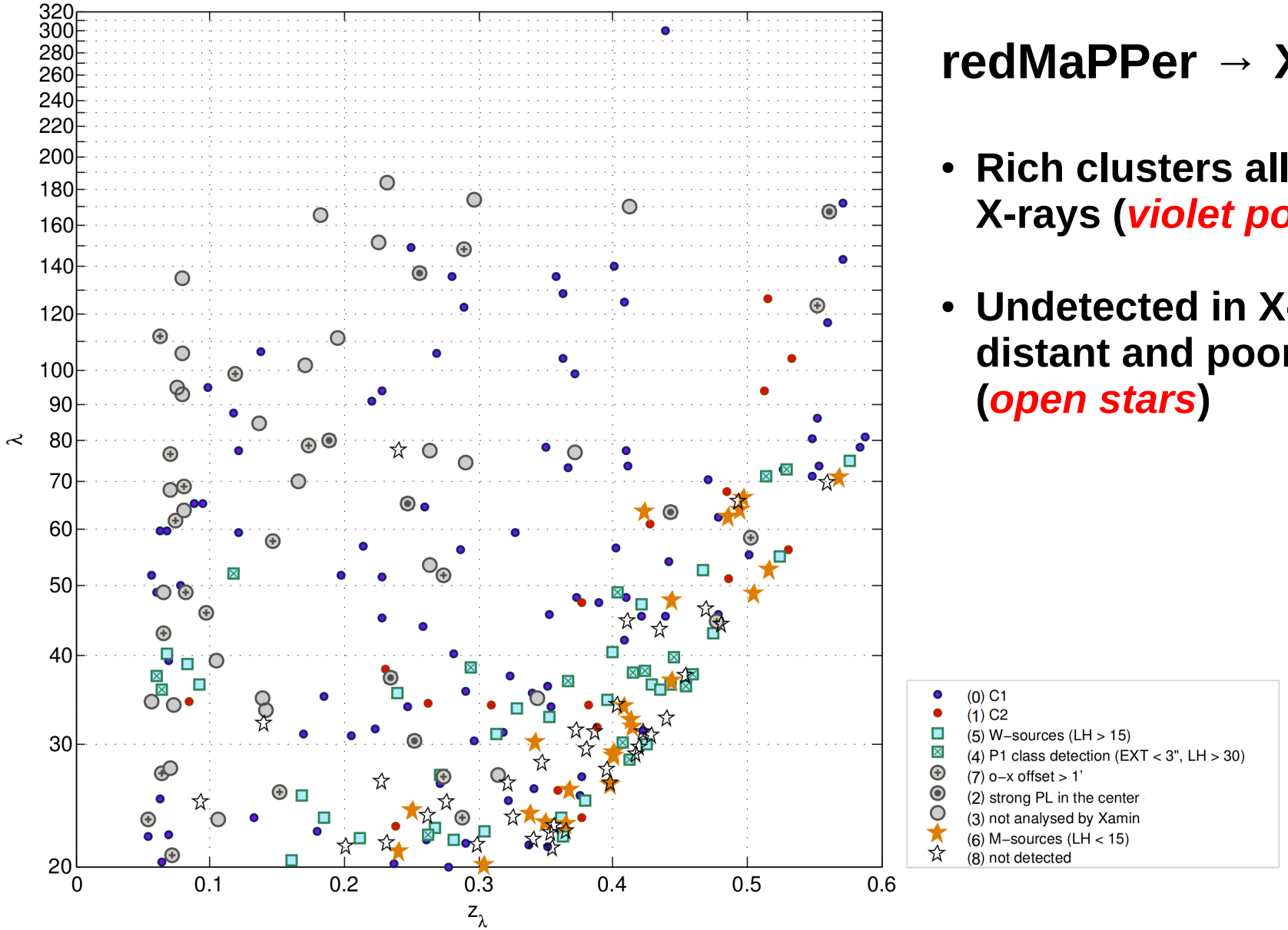
Cosmological constraints from X-CLASS



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

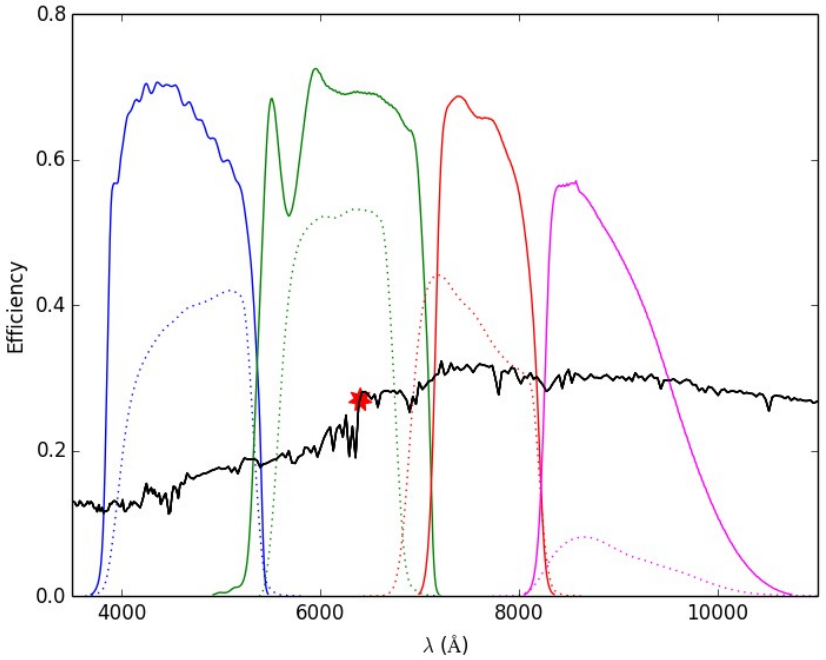
- **Rich clusters all found in X-rays (*violet points*)**
- **Undetected in X-rays: distant and poor clusters (*open stars*)**

Sadibekova et al. 2014

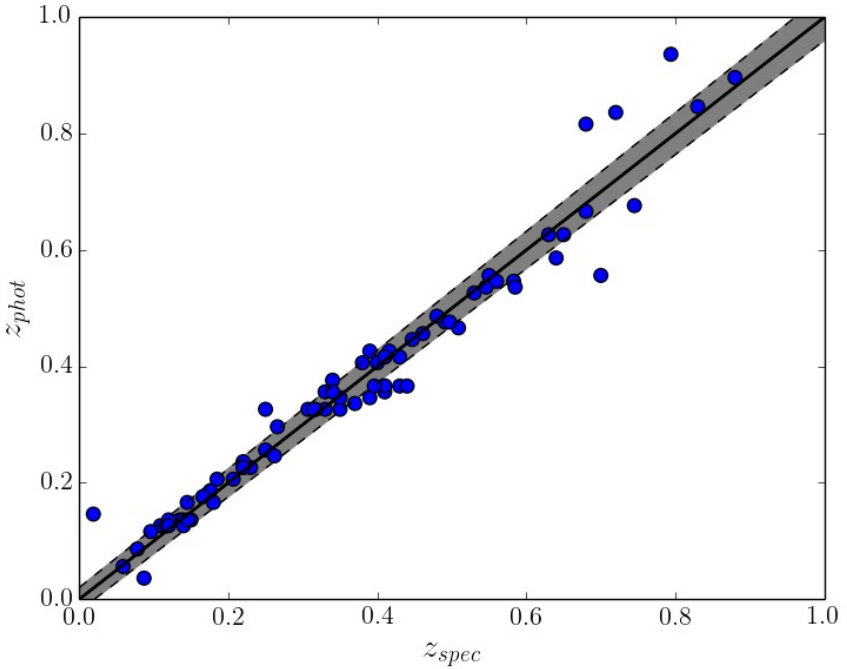
Photo z for X-CLASS

- 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 δ<20 degrees observed***
- Results published in Ridl. et al.2017

GROND: filters and accuracy



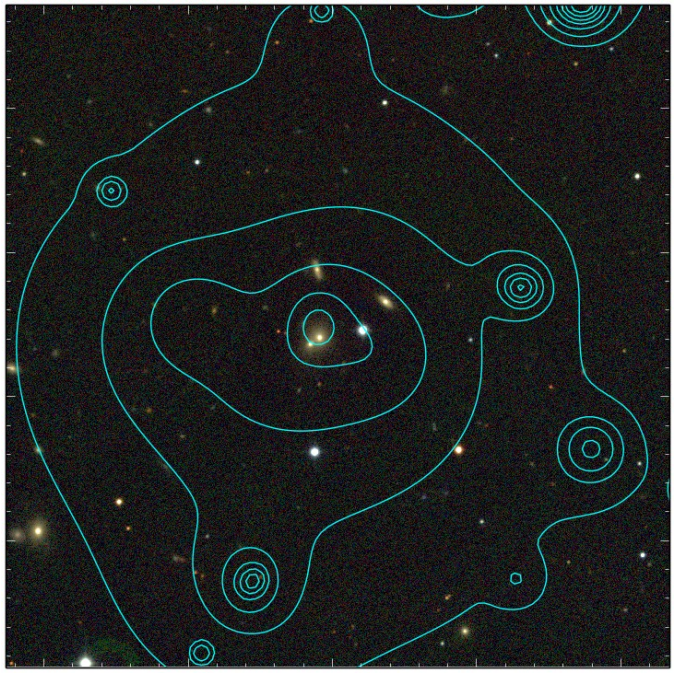
GROND optical filters: *g'*,*r'*,*i'*,*z'*



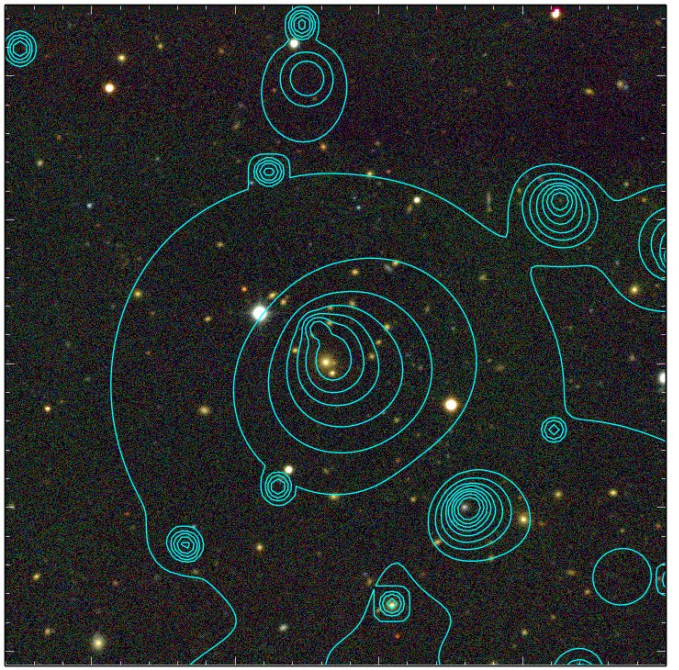
$\Delta z = 0.02(1+z)$

Ridl et al 2017

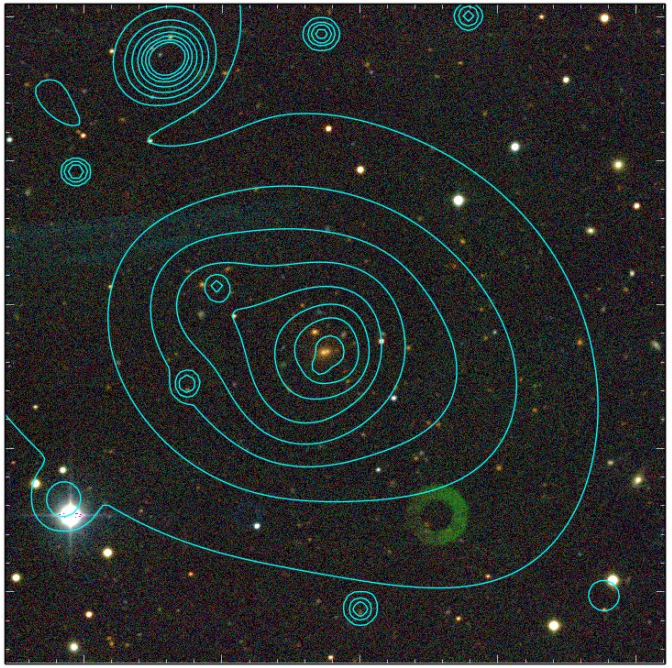
g' r' i'
4.5 arcmin



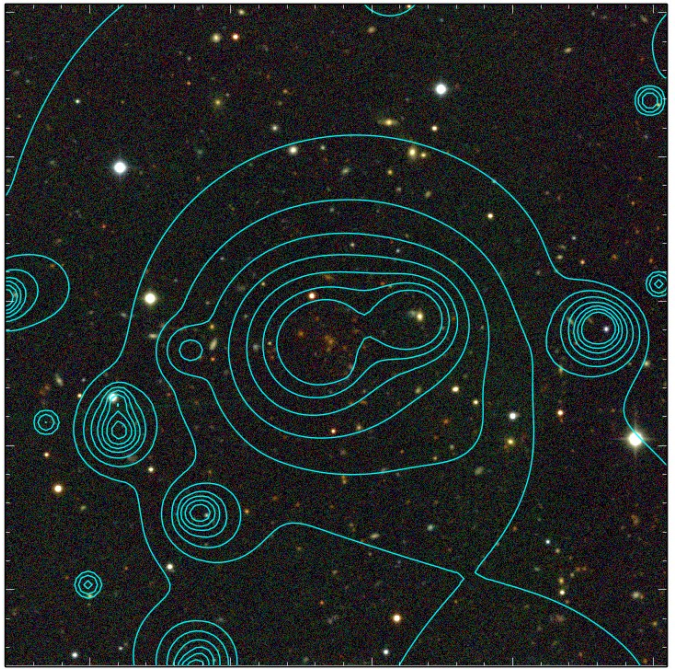
X-CLASS 2162 Zspec 0.12, Zphot 0.12



X-CLASS 40 Zspec 0.33, Zphot 0.32



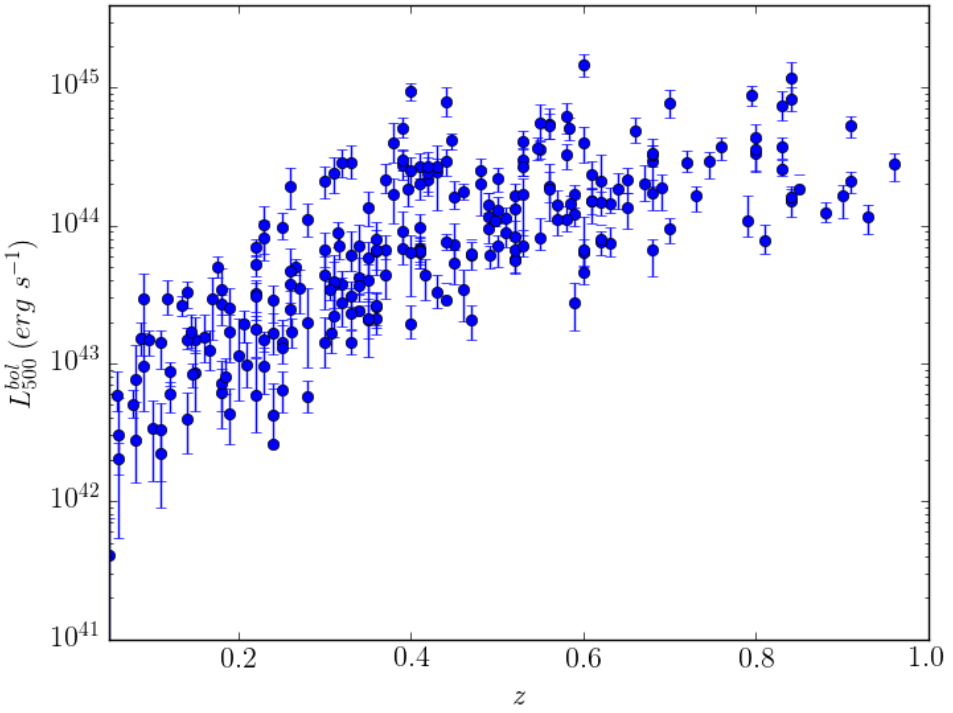
X-CLASS 459 Zspec 0.55, Zphot 0.54

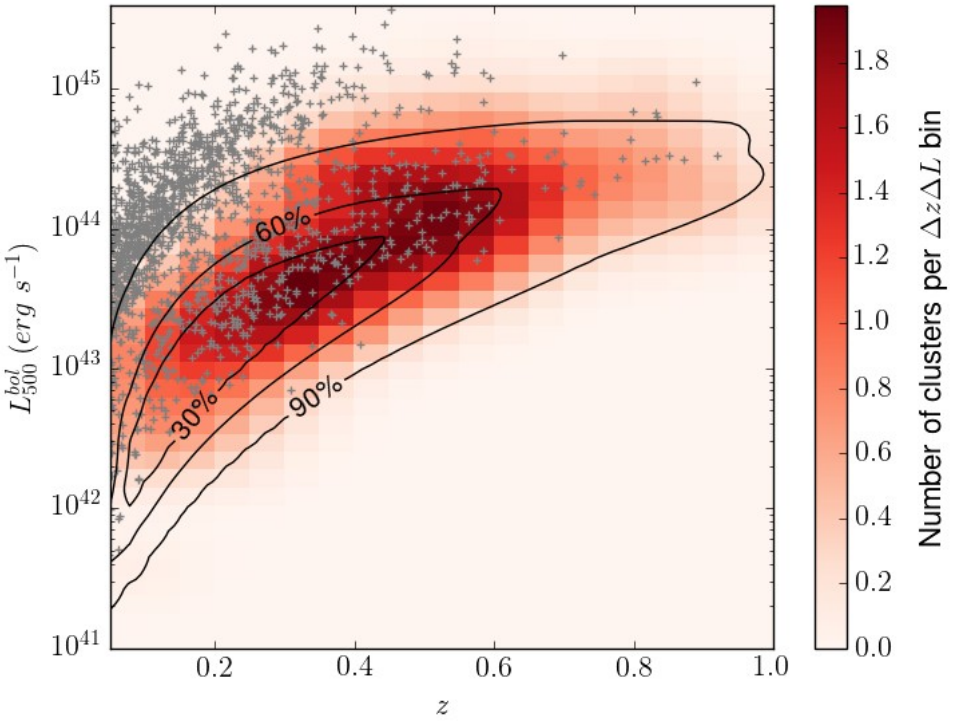


X-CLASS 505 Zspec 0.79, Zphot 0.81

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
- Data soon available in new DB at: http://xmm-lss.in2p3.fr:8080/xclass/

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?